6.0 EFFECTS ASSESSMENT

This chapter presents the predicted effects of the project on the physical, biological and social environment. The effects assessment follows the methodology described in Chapter 2. This chapter describes the changes that are predicted to occur as a result of carrying out the Project, the modeling that was used to predict changes in the physical environment, the results of the modeling, and the potential effects these predicted changes can have on the environment.

The effects assessment uses the Project Description provided in Chapter 5 and the predicted changes in the physical conditions as a consequence of developing the Project (Section 6.1) to identify and assess effects on the biological (Section 6.2) and socio-economic conditions (Section 6.3).

6.1 Physical Effects Assessment

The effects of the Project on the physical environment are discussed in this section. This includes consideration of the following environmental components:

- Geology and Geochemistry**,** including terrain and soils (Section 6.1.1).
- Atmospheric environment**,** including air quality, noise and vibration (Section 6.1.2).
- Water including:
- Water quantity and quality (Section 6.1.3).
- Hydrogeology (Section 6.1.3).
- Water and sediment quality (Section 6.1.3).

The effect assessment includes all project phases. The effects during the closure and post-closure phase are assessed together unless noted otherwise. In addition, where the changes during one phase are greater than similar changes in other phases they are said to “bound” the effects of the Project and the assessment is limited to that one bounding phase.

6.1.1 Geology, Geochemistry and Soils

The geology and geochemistry are described in the Geochemistry, Geology and Soil TSD.

There are no direct environmental effects from geology or geochemistry. However, these physical environment components influence mine planning, mitigation measures, and the ultimate water quality discharged (Section 6.1.3 and Site Water Quality TSD).

The results of using this information in the overall effects assessment are provided in this chapter and in the Aquatic Environment TSD, Terrestrial Ecology TSD, and Human Health and Ecological Risk Assessment (HHERA) TSD.

Depending on the geology and mineralogy of the materials mined, at some mine sites geochemical processes acting on the materials exposed during construction and operations may potentially generate acidic conditions in the waste rock or tailings that in turn can mobilize metals. Under certain conditions, at some mine sites, both the acid generation potential of the rock (generally termed "acid rock drainage" [ARD]) and metal leaching (ML) can potentially affect water quality. Thus, geochemical modeling is an integral part of predicting water quality from mining operations.

Key Project activities that are influenced by the geological and geochemical properties of the materials include:

- Mining and mining sequence.
- Processing.
- Material handling protocols.
- Waste storage planning and engineering design.
- Water management planning (water quality estimates, necessity of treatment).
- Final discharge water quality (Section 6.1.3).

These activities are described in Chapters 4 and 5.

Overall, as described in the Geochemistry, Geology and Soil TSD, gold was introduced into the Hammond Reef Deposit probably during the late Archean (Neoarchean) hydrothermal or metamorphic episode, along with pyrite and accessory sulfides and tellurides (Geochemistry, Geology and Soils TSD). The gold occurs within the mineralized zone as free grains on mineral surfaces concentrated along micro-fractures and quartz veins within the altered granitic rock. The boundary of the ore zone is defined by grade which roughly corresponds to the degree of brecciation and quartz stockwork veining within the altered granitoid (Hydrogeology TSD). The association of gold with fracture infilling has resulted in the overall deposit rock types being the same in either ore zones or waste zones; however, ore zones are differentiated by slightly more fracturing resulting in the occurrence of more sulphide and gold.

Where mineralization occurs, the ore (and tailings) is predominantly composed of quartz with lesser percentages of chlorite, calcite and sericite with less than about 0.3% pyrite by weight including trace amounts of galena, chalcopyrite, sphalerite, pyrrhotite, bornite, chalcocite and native gold. Telluride, strometerite and molybdenite have also been identified. Neutralizing minerals include carbonate ranging from 2.6 to 20% overall. The veins and stockwork are generally composed of quartz, carbonate (ankerite-calcite), chlorite and sulfides. The aluminosilicate mineral potassium feldspar is a component of the tonalite that will occur in the pit faces and the waste rock (Geochemistry, Geology and Soils TSD). Given that only gold will be removed from the mined ore, the tailings will be reflective of the blended ore. Blending of the ore will be required to provide a consistent "head grade" to the mill for processing, hence the tailings are expected to be relatively homogeneous in nature.

For the OHRG Project, the ore to be mined, as well as the waste rock and the tailings produced, are non-acid generating with excess neutralizing potential. Sulphide concentrations are generally very low. Leachate concentrations of metals and major ions from the materials show values near PWQO or baseline water quality values. The leachate concentration values from the materials are provided in the Geochemistry, Geology and Soil TSD and summarized in Chapter 3, and were used to develop inputs to the site water quality model as described and presented in Section 6.1.3 and the Site Water Quality TSD.

Waste rock characterization is discussed in Chapter 3. The waste rock analyses provided information to characterize local geological conditions. The waste rock assessment also provides the basis for evaluating the potential for waste rock stored in the Waste Rock Management Facility (WRMF) to affect groundwater and surface water quality. The results are summarized in Chapter 3.

Processing of ore will include crushing, grinding, flotation, cyanidation-leaching, carbon-in-pulp gold recovery, gold elution, gold electro-winning, smelting using an induction furnace, cyanide destruction and tailings production. In 2009, ten individual drillhole composite samples (BR-2, BR-13, BR-23, BR-28, BR-64, BR-67, BR-68, BR-87, BR-88 and BR-102) were collected from various locations in the deposit (Brett, 2009). Acid base accounting (ABA) and net acid generation (NAG) testwork was carried out at the SGS analytical laboratory in Lakefield, Ontario (SGS) on 9 of the 10 individual drill hole composites (BR-2, BR-13, BR-23, BR-28, BR-64, BR-67, BR-87, BR-88 and BR-102) as well as the Master Composite, LG A-Zone Variability Composite, HG A-Zone Variability Composite and the EHG Variability Composite samples.

As can be observed and discussed in the Supplemental Information package of the Geochemistry, Geology and Soil TSD, the ore zones are relatively homogeneous with respect to assay concentrations of the various parameters, and particularly with respect to the sulphide and carbonate content. The sulphide content of the ore is typically less than 0.3% by weight, with a maximum concentration in the “extreme high grade” (EHG) sample of 0.42% sulphide by weight. The carbonate contents are typically greater than 3% with a minimum value of 2.11%. For the EHG sample the carbonate neutralization potential ratio (CaNP Ratio) is greater than 4 indicating the material will be non-acid generating with excess neutralizing potential from carbonate minerals. For all other metallurgical samples representing the variability of the deposit, the CaNP ratio is greater than 6 confirming that all expected zones of the deposit as used in metallurgical evaluation testing are expected to be non-acid generating with excess neutralizing potential.

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Table 6-1: Location, Lithology, Acid Base Accounting and Net Acid Generation Test Results for 2009 Ore and Composite Samples

Parameter	Collar location				From (m)	To (m)	Lithology ID[c]	Acid Base Accounting											Net Acid Generation Testing
	Zone	Section	Easting	Northing				Paste pH	NP[d]	AP[d]	NPR[d]	CaNPR[d]	Total Sulphur	Sulphate	Sulphide	Total Carbon	Carbonate	Carbonate NP	Final NAG-pH
								s.u.	t CaCO3/1000 t	t CaCO3/1000 t	ratio	ratio	%	%	%	%	%	%	s.u.
Drill Hole Composites																			
BR-2	41	3470E	613783.11	5422056.3	145	191	11, 20, 50	9.31	73.2	5.43	**13.5**	**14.0**	0.16	< 0.01	0.17	1.02	4.55	75.8	10.8
BR-13	41	3370E	613613.95	5422128.9	40.5	126	20, 32, 33, 34	9.23	70.4	6.59	**10.7**	**10.7**	0.33	0.12	0.21	0.98	4.23	70.5	10.1
BR-23	41	3270E	613543.79	5422052.9	63	139.5	20, 33, 40, 60	9.23	102	4.51	**22.6**	**24.2**	0.26	0.12	0.14	1.47	6.56	109.4	10.1
BR-28	A	1820E	612237.07	5421397.1	21.5	102.5	20, 33, 34, 40	9.15	51.2	4.41	**11.6**	**11.8**	0.26	0.11	0.14	0.72	3.11	51.8	10.1
BR-64	A	1670E	612220.71	5421160.8	91.5	292.5	11, 15, 20, 32, 40	9.29	59.8	6.42	**9.3**	**8.8**	0.35	0.14	0.21	0.84	3.40	56.7	10.6
BR-67	A	1670E	611838.62	5420825.7	NR	NR	NR	9.36	71.3	5.27	**13.5**	**13.1**	0.43	0.26	0.17	0.96	4.13	68.8	10.9
BR-68 [a]	A	1800E	612374.18	5421187.2	141	256.5	13, 15, 40	-	-	-	**-**	**-**	-	-	-	-	-	-	-
BR-87	A	1420E	611912.97	5421162.9	3.74	88.5	12, 15, 20	9.37	46.9	3.23	**14.5**	**13.8**	0.35	0.25	0.1	0.60	2.67	44.5	10.9
BR-88	A	1420E	611985.14	5421059.7	160.5	252	20	9.6	37.8	4.68	**8.1**	**7.6**	0.37	0.22	0.15	0.50	2.13	35.5	10.3
BR-102	A	1670E	612149.06	5421258	6.52	213	20, 33, 40	9.47	53	4.71	**11.3**	**10.9**	0.26	0.11	0.15	0.70	3.08	51.3	10.9
Zone Composites																			
A-Zone [b]	A	---	---	---	---	---	---	9.12	57.7	5.09	**11.3**	**11.3**	0.31	0.14	0.16	0.85	3.46	57.7	10.3
41-Zone [b]	41	---	---	---	---	---	---	9.39	85.2	3.54	**24.0**	**24.6**	0.39	0.28	0.11	1.17	5.22	87.0	9.8
Master Composite[b]	A and 41	---	---	---	---	---	---	9.32	66.3	7.8	**8.5**	**7.4**	0.31	0.1	0.3	0.93	3.5	57.8	10.6
Grade Composites																			
LG A-Zone [b]	A	---	---	---	---	---	---	9.05	55.9	2.83	**19.7**	**18.8**	0.19	0.1	0.09	0.75	3.19	53.2	10.5
HG A-Zone [b]	A	---	---	---	---	---	---	9.31	54.8	7.22	**7.6**	**7.0**	0.45	0.22	0.23	0.74	3.05	50.8	10.2
EHG[b]	41	---	---	---	---	---	---	9.07	71.2	13.00	**5.5**	**4.2**	0.80	0.38	0.42	1.02	3.26	54.3	9.3

Note:

0.1 = Non-Potentially Acid Generating (Non- PAG), according to MEND (2009) guidelines.

A dash "-" indicates that no data was reported. A triple dash "---" indicates that the data is presented in the Brett Resources Inc., 2009. An investigation of gold recovery from Hammond Reef Project samples, Project 11734-002 – Final Report. "NR" indicates that no information was recorded.

(a) Acid base accounting (ABA) and net acid generation (NAG) testing were not conducted on the drill composite sample BR-68.

(b) For further detail on sample composition of the composite samples see the Supplemental Information package provided as part of the Version 2 Geochemsitry TSD.

(c) Description of the lithology ID codes is as follows: 11- fine grained granite; 12- contaminated granite; 15 - chloritic granite porphyry; 20 - altered granitoid; 32- sheared granitoid; 33 - chlorite schist; 34 - tectonized-sheared vein zone/brecciated pegmatite; 40 - pegmatite; 50 - mafic dyke; 60 - intermediate dyke.

(d) NP = neutralization potential; AP = acid potential; NPR = neutralization potential ratio; and CaNPR = carbonate neutralization potential ratio.

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In 2011, an additional combined tailings composite sample was created from 10 Metallurgical (Met) Composite samples, obtained from across the ore deposit and selected based on the type and degree of alteration, which is correlated to the expected ore composition as determined from the overall deposit assay database (to be described as part of the feasibility study report) (Ounpuu 2011). The samples were selected to evaluate variability within the deposit, which would then be used to provide an expected head grade sample based on the relative proportions of the materials expected to be milled and processed. The sample locations and results of ABA testing from each of the composite samples are provided in the Supplemental Information package of the Geochemistry, Geology and Soil TSD. The available information when combined with the 2009 data provides suitable information on possible deposit and tailings heterogeneity.

The combined composite sample from 2011 provides the expected tailings that are to be deposited at the site (Geochemistry, Geology and Soils TSD). This sample was split and submitted for additional geochemical testing at two different laboratories: SGS Lakefield and Lakehead University. The elemental composition, ABA results and NAG results of the composite tailings sample are provided in Table 6-2.

Table 6-2: Summary of Elemental Composition, ABA and NAG testing of Combined Tailing Composite Sample

Elemental Composition

Laboratory	SiO_2	Al_2O_3	Fe_2O_3	Cr_2O_3	Ag	As	Cu	Mo	V	Cd	Zn
	%	%	%	%	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
SGS Lakefield	67.8	13.3	3.61	0.01	0.22	2.5	30	3.6	35	0.33	46
Lakehead	67.4	13.4	3.65	0.01	< 0.5	5.3	39	5.0	43	<0.5	64

ABA and NAG Results

Rock Type	Sulphur Species (wt%)			CO_3 wt%	Potentials (*t $CaCO_3$/1000t*)			NPR	CaNPR	NAG
	Total	Sulphate	Sulphide		NP	AP	CaNP			pH
SGS Lakefield	0.175	0.08	0.09	4.84	77	2.85	80	27	28	11
Lakehead	0.26	—	—	—	103.8	—	—	—	—	10.7/11.5

The tailings sample reported an alkaline net acid generation (NAG) pH between 10.7 and of 11.5 and, therefore, is classified as non-acid generating.

The results of the short term leach test are presented in Table 6-3. The results are compared with the CCME CWQGs for protection of aquatic life, the PWQOs and the MISA guidelines.

Table 6-3: Summary of Short Term Leach Test Results for Combined Tailings Composite Sample

Parameter	Unit	MISA	CWQG Aquatic Life	PWQO	SGS Lakefield		Lakehead
					SFE Leach	NAG Leach	NAG Leach
pH	units	6 - 9.5	6.5 - 9.0	6.5 - 8.5	**8.65**	**11.1**	**11.4**
SO_4	mg/L	—	—	—	55	19	—
Ag	mg/L	—	0.0001	0.0001	<0.00001	**0.00033**	< 0.01
Al	mg/L	—	0.1[(a)]	0.075[(a)]	**0.14**	**1.6**	**2.31**
As	mg/L	1.0	0.005	0.005	0.001	0.0006	< 0.025
B	mg/L	—	—	0.2	0.0038	**0.801**	—

Table 6-3: Summary of Short Term Leach Test Results for Combined Tailings Composite Sample (Continued)

Parameter	Unit	MISA	CWQG Aquatic Life	PWQO	SGS Lakefield		Lakehead
					SFE Leach	NAG Leach	NAG Leach
Cd	mg/L	—	0.0001	0.000017	0.000005	<0.000003	<0.0005
Cr(total)	mg/L	—		0.009	<0.0005	**0.021**	**0.024**
Cr(VI)	mg/L	—	0.001	0.001	<0.00002	**0.02**	—
Cu	mg/L	0.6	0.002 - 0.004	0.001	**0.0013**	<0.0005	<0.005
Se	mg/L	—	0.001	0.1	<0.001	<0.001	<0.05
V	mg/L	—	—	0.006	0.00005	0.000003	—
Zn	mg/L	—	0.03	0.02	<0.001	<0.001	**0.048**

Note:

Bolded values do not meet one or more of the guidelines.

(a) Criteria for aluminum based on observed pH values greater than 6.5.

The leach testing showed that tailings have the potential to leach elevated aluminum concentrations with respect to surface water quality guidelines over both the long and short term, as identified by short term and kinetic tests. Short term leach testing and first flush results from kinetic testing also showed elevated copper concentrations, decreasing to below the guidelines in the long term.

Aging tests were conducted at both laboratories on the water associated with the tailings sample. The samples were analyzed for total and dissolved concentrations, when possible. Several metals in the process waters generated as part of the initial tailings program are also greater than the surface water quality guidelines considered. These metals include aluminum, cobalt, copper, cadmium, molybdenum, lead and uranium. The results of the aging tests are provided in Table 6-4.

Table 6-4: Aging Tests Results – Combined Tailing Composite Sample – Process Water

Parameter	Unit	MISA	CWQG Aquatic Life	PWQO	SGS Lakefield				Lakehead			
					Day 0	Day 7	Day 15	Day 30	Day 0	Day 7	Day 15	Day 30
pH	units	6 - 9.5	6.5 - 9.0	6.5 - 8.5	8.46	8.39	8.36	8.31	7.9	7.9	7.7	7.7
SO_4	mg/L	—	—	—	210	240	240	280	160	256	275	270
Total Concentrations												
Al	mg/L	—	0.1	0.075	**0.44**	0.04	0.01	0.04	**0.48**	**0.75**	**0.18**	**0.27**
Cd	mg/L	—	0.000017	0.0001	0.000012	0.000016	<0.000003	**0.00005**	<0.0002	0.0002	<0.0002	<0.0002
Co	mg/L	—	—	0.0009	**0.0028**	**0.0029**	**0.0028**	**0.003**	**0.0027**	**0.0025**	**0.0028**	**0.0029**
Cu	mg/L	0.3	0.002	0.001	**0.0047**	**0.015**	**0.0093**	**0.0045**	**0.019**	**0.057**	**0.16**	**0.16**
Mo	mg/L	—	—	0.04	**0.076**	**0.086**	**0.08**	**0.087**	**0.065**	**0.062**	**0.06**	**0.06**
Ni	mg/L	0.5	0.025	0.025	0.0077	0.0077	0.0067	0.0073	0.012	**0.029**	**0.039**	**0.034**
Pb	mg/L	0.2	0.001)	0.001	0.00089	**0.0032**	0.00024	0.00062	<0.0025	<0.0025	0.0026	<0.0025
U	mg/L	—	—	0.005	**0.0065**	**0.0062**	**0.0074**	**0.0094**	<0.05	<0.05	<0.05	<0.05
Zn	mg/L	0.5	0.03	0.02	<0.002	<0.002	<0.002	0.002	**0.032**	**0.031**	**0.043**	**0.051**
Dissolved Concentrations												
Al	mg/L	—	0.1	0.075	0.04	0.02	<0.01	0.04	0.017	—	—	—
Cd	mg/L	—	0.000017	0.0001	0.000009	**0.000026**	<0.000003	0.000028	<0.0002	—	—	—
Co	mg/L	—	—	0.0009	<0.0005	<0.0005	<0.0005	<0.0005	<0.005	—	—	—
Cu	mg/L	0.3	0.002	0.001	**0.0027**	**0.016**	**0.0091**	**0.0044**	**0.012**	—	—	—
Mo	mg/L	—	—	0.04	**0.072**	**0.083**	**0.079**	**0.091**	**0.06**	—	—	—
Ni	mg/L	0.5	0.025	0.025	0.007	0.0078	0.0066	0.0079	0.011	—	—	—
Pb	mg/L	0.2	0.001)	0.001	0.00006	0.00008	0.00004	0.00044	<0.025	—	—	—
U	mg/L	—	—	0.005	**0.0063**	**0.0060**	**0.0072**	**0.0086**	<0.08	—	—	—
Zn	mg/L	0.5	0.03	0.02	<0.002	<0.002	<0.002	<0.002	0.002	—	—	—

Note:

Bolded values do not meet one or more of the criteria considered.

The geochemistry of the waste rock and tailings does not by itself have an effect on the environment. Rather, the results of the geochemical testing that are used in the water quality modeling provide the basis for predicting future water quality during the operations, closure and post-closure phases of the Project, as discussed in Section 6.1.3.

6.1.1.1 Terrain and Soils

An assessment is provided of direct effects of changes to terrain and soil (e.g., soil quality, and erosion) in the Terrain and Soil Local Study Area (LSA). The effects assessment evaluates the construction, operations and closure/post-closure phases.

Indirect and cumulative effects have been incorporated into the assessment. Specifically, effects from the Project are considered in combination with other developments, activities and natural factors that influence terrain and soil within the Terrain and Soil LSA.

The terrain and soil assessment involved both quantitative and qualitative methods. Terrain and soil units directly affected by the Project were identified and quantified by GIS analysis using the following process:

- The GIS quantified areas of terrain and soil map units within the Terrain and Soil LSA for the existing conditions and Project phases.
- The changes in terrain and soil map unit disturbance were calculated for the Project phases by subtracting from the existing conditions case.
- Soil quality changes with respect to soil compaction, reduction in fertility, wind and water erosion and terrain stability are discussed qualitatively.

6.1.1.1.1 Alteration or Loss of Soil and Terrain Units

Screening of Project activities shows that the activities resulting in the direct loss or alteration of soil units in the Terrain and Soil LSA include site clearing and surface disturbance to permit construction and operation. Site preparation for facility construction will involve the removal of the soil cover. Surface soil will be salvaged for progressive reclamation. Plant and associated mine facilities will be progressively reclaimed, which minimizes effects to soils. However, there will still be a net increase in surface disturbance associated with the Project.

Terrain features that will be altered during plant and associated mine facility construction and as a result, topography, site elevation and drainage patterns will be altered at the local scale. Since the topography of the Terrain and Soil LSA varies from level to rolling, cut and fill will be necessary in constructing facilities. While progressive reclamation will restore terrain, there will be short to moderate- term disturbances to terrain.

Soil Quality/Capability

Surface disturbance from the Project may result in the following soil quality/capability effects:

- Soil wind and water erosion that could alter and/or decrease soil quality.
- Soil compaction that could alter soil structure and decrease soil quality.
- Soil admixing that could decrease soil fertility.

- Soil disturbance that could alter and decrease soil capability for forestry.
- Soil contamination that could decrease soil quality.
- Reclamation that could restore soil quality/capability.

The effects on soil quality/capability can be mitigated by minimizing the amount and extent of surface disturbance at any one time. In addition, although not quantifiable, soil quality changes can be minimized through careful construction and operation practices.

Terrain

Terrain will be altered during mine and associated facility construction phases of the Project. As a result, topography, site elevation and drainage patterns will be altered on a local scale. While progressive reclamation will restore terrain, there will be short to long-term terrain disturbances. The specific mitigation for terrain stability for the Project is to assess terrain characteristics prior to any mining. Geotechnical assessments will be made of mine facilities to ensure long-term stability. Monitoring of stockpiles will also be undertaken to verify that the materials are stable over time.

Restoration of Soil Quality during Reclamation

Reclamation will play an important part in mitigating soil and terrain changes. Mitigation will include implementing progressive reclamation for the Project where possible to minimize the net area disturbed at any one time. Existing natural soils will be stockpiled during construction to the extent practicable for use in closure and reclamation of the mine site area. Soil will not be placed on either the TMF or WRMF; however, active revegetation of the TMF will be conducted at closure to reduce the potential for erosion. An evaluation of appropriate soil mixtures will be completed prior to implementation of closure or progressive closure and reclamation to ensure soil amendments are appropriate for the intended use.

6.1.1.1.2 Soil Assessment in Local Study Area

The Project will require construction of mine pits and associated infrastructure. The total area of soil and terrain disturbance associated with all facilities will be 1,074 ha (13% of the Terrain and Soil LSA) for the Project (Tables 6-5 and 6-6). The largest area of disturbed soils will be Dystric Brunisol-Gleysol-fine (315 ha, 4% of Terrain and Soil LSA) followed by terric Organic-Gleysol 281 ha (3% of Terrain and Soil LSA) and Dystric Brunisol-fine (125 ha, 1% Terrain and Soil LSA). All other soil types are less than these. Development and implementation of the reclamation plan for disturbed soils will minimize loss in soils due to the Project.

Table 6-5: Loss/Alterations to Soil Series in Local Study Area

Soil Map Unit	Baseline		Project Disturbance	
	Area (ha)	% LSA	Area (ha)	% LSA
Dystric Brunisol-fine	382	4	125	1
Dystric Brunisol-Gleysol –coarse	142	2	11	<1
Dystric Brunisol-Gleysol –fine	1,097	13	315	4
Dystric Brunisol-Regosol	205	2	75	1
Gleysol-Regosol	120	1	116	1
Gleysol-Terric Organic	125	1	15	<1
Terric Organic-Gleysol	693	8	281	3

Table 6 5: Loss/Alterations to Soil Series in Local Study Area (Continued)

Soil Map Unit	Baseline		Project Disturbance	
	Area (ha)	% LSA	Area (ha)	% LSA
Regosol-bedrock	4,816	57	64	1
Water	915	11	40	1
Total	**8,495**	**100**	**1,074**	**13**

For terrain the largest disturbance will for the bedrock class (632 ha, 7% of Terrain and Soil LSA) followed by glaciolacustrine (371 ha, 4% of Terrain and Soil LSA).

Table 6-6: Loss/Alterations to Terrain units in the Local Study Area

Terrain Unit	Baseline		Project Disturbance	
	Area (ha)	% LSA	Area (ha)	% LSA
Bedrock	5,633	66	632	7
Glaciolacustrine	1,277	15	371	4
Glaciofluvial ice contact deposits	187	2	36	<1
Fluvial	70	1	0	0
Water	902	4	36	<1
Total	**8,494**	**100**	**1,074**	**13**

6.1.1.1.3 Effect of Soil and Terrain Alteration

The direct loss of soil use and alteration of terrain may have implications with respect to wildlife use of the Terrain and Soil LSA and with respect to the use of the area as a timber resource.

Further assessment of direct effects of the Project for soils and terrain was not conducted as these are not endpoints of the assessment but rather contribute to effect evaluation for wildlife and economic development. These indirect effects are addressed in the Terrestrial Ecology TSD and the Socio-economic Environment TSD respectively.

6.1.2 Atmospheric Environment

The atmospheric environment assessment consists of air quality, noise and vibration.

6.1.2.1 Air Quality

As described in Chapter 3, baseline air quality is considered to be similar to regional conditions, since there has been no previous development in this area. The assessment of air quality changes is therefore based on predictive modeling of emissions sources from the Project, based on the description of the Project provided in Chapter 5.

6.1.2.1.1 Modelling

The identification of emission sources was based on the list of Project Components and activities in Chapter 5. Air emissions were calculated using accepted methods, such as emission factors. The assessment was conducted for emissions during the operations phase. As discussed below, emissions from all other phases are bounded by the operations phase. Details of the specific emission calculation methods are provided in the Atmospheric Environment TSD.

Table 6-7 provides a summary of the Project Components and associated activities for which emissions were calculated along with a summary of the compounds released.

Table 6-7: Activities and Compounds Released for the Mine Site

Project Component	Activity	Compounds Released												
		TSP	**PM_{10}**	**$PM_{2.5}$**	**DPM**	**Metals**	**NO_X**	**CO**	**SO_2**	**HC**	**HCN**	**HCl**	**NH_3**	**NaOH**
Open Pit Extraction	Blasting – fugitive dust and explosives	X	X	X	—	X	X	X	—	—	—	—	—	—
	Material Handling	X	X	X	—	X	—	—	—	—	—	—	—	—
	Bulldozing	X	X	X	—	X	—	—	—	—	—	—	—	—
	Grading	X	X	X	—	X	—	—	—	—	—	—	—	—
	Vehicles – Exhaust Emissions	X	X	X	X	—	X	X	X	X	—	—	—	—
	Vehicles – Unpaved Fugitive Road Dust	X	X	X	—	X	—	—	—	—	—	—	—	—
Low Grade Ore Stockpile	Material Handling	X	X	X	—	X	—	—	—	—	—	—	—	—
	Bulldozing	X	X	X	—	X	—	—	—	—	—	—	—	—
	Grading	X	X	X	—	X	—	—	—	—	—	—	—	—
Waste Rock Stockpile	Material Handling	X	X	X	—	—	—	—	—	—	—	—	—	—
	Bulldozing	X	X	X	—	—	—	—	—	—	—	—	—	—
	Grading	X	X	X	—	—	—	—	—	—	—	—	—	—
Surface Roads	Vehicles – Exhaust Emissions	X	X	X	X	—	X	X	X	X	—	—	—	—
	Vehicles – Unpaved Fugitive Road Dust	X	X	X	—	X	—	—	—	—	—	—	—	—
Ore Crushing and Screening	Material Handling	X	X	X	—	X	—	—	—	—	—	—	—	—
	Ore Crushing	X	X	X	—	X	—	—	—	—	—	—	—	—
	Ore Screening	X	X	X	—	X	—	—	—	—	—	—	—	—
Ore Processing and Refining	CIP Adsorption			—	—	—	—	—	—	—	—	—	X	X
	Acid Wash			—	—	—	—	—	—	—	—	X	—	—
	Carbon Regeneration	X	X	X	—	X	—	X	—	—	—	—	—	—
	Regeneration Furnace			—	—	—	X		X	—	—	—	—	—
	Cyanide Destruction			—	—	—	—	—	X	—	—	—	X	—
	Electrowinning			—	—	—	—	—	—	—	—	—	X	X
	Smelting Furnace	X	X	X	—	X	—	—	—	—	—	—	—	—
	Sodium Cyanide Use	—	—	—	—	—	—	—	—	—	X	—	—	—
Emergency Power Generators	Stationary Diesel Combustion	X	X	—	X	—	X	X	X	—	—	—	—	—
Comfort Heating	Propane Combustion	X	X	X	—	—	X	X	X	—	—	—	—	—

Note:

TSP = total suspended particulates; DPM = diesel particulate matter; — = Compound not released.

In order to assess the air emissions relating to the Project under worst case conditions, a number of assumptions were made about the operations of the Mine Site. It was assumed that emissions during the operations phase bound those during all other phases. Only the worst case scenario was considered in the assessment since all other scenarios would produce less emissions. Modeling was based on the following assumptions:

- The maximum extraction rates of 65,000 tonnes/day and 100,000 tonnes/day of ore and waste rock respectively were used in the emission calculations.
- Open pit extraction operations occur simultaneously in both pits.
- Emissions from open pit extraction operations were divided between the pits based on the maximum pit volumes.
- The longest haul truck routes were assessed.
- The maximum ore processing rate of 22,000,000 tonnes/year was used in the emission rate calculations.

Since not all of these assumptions may be true at any one given time (i.e., maximum productions rates may not occur at the same time as the longest haul truck routes) this scenario is unlikely to underestimate the emissions at any stage of the Project

The emissions associated with the operation of the Access Road include fugitive road dust and vehicle tailpipe exhaust and included the following parameters:

- Fugitive road dust (i.e., TSP, PM_{10}, $PM_{2.5}$).
- Exhaust gases (i.e., NO_X, SO_2, and CO).

Modeling of air emissions along the Access Road was also based on worst case conditions, including the following assumptions:

- A 1 km stretch of the road was assessed to determine the distance from the road at which emissions from the road are negligible.
- Fugitive road dust (i.e., TSP, PM_{10}, $PM_{2.5}$) emissions were calculated using the emission factors presented in Sections 13.2.2 of AP-42 (U.S. EPA 2010a) using Equation 1b and the vehicle activity levels in Table 3-12 of the Atmospheric Environment TSD. Inputs to the calculation included an assumed vehicle speed of 80 km/hr, silt content of 10% and a moisture content of 6.5%.
- A 50% control for natural road dust mitigation (i.e., precipitation) and best management practices such as watering, etc.
- Exhaust emissions were calculated using the U.S. EPA MOBILE6 emissions model and the vehicle activity levels in provided in the Atmospheric Environment TSD.

A summary of the daily Access Road fleet traffic is provided in Table 6-8.

Table 6-8: Access Road (Hardtack/Sawbill) Fleet Traffic

Vehicle Type	Number of Trips per Day (1-way)
Pickup	3
Passenger Car	85
Passenger Van	1
Transport Truck	18

In order to estimate emissions associated with mobile vehicles, the number of trucks, the number of vehicle kilometers traveled (VKT) and fuel consumption are used as inputs into the emission rate calculations. The air quality assessment (and bounding scenario) is based on the worst case operating year as described in Appendix 3.I of the Atmospheric TSD.

For both the Construction and Operation Phase of the Project, the activities that will generate the most emissions are as follows:

- Fugitive dust from hauling materials which is based on distance travelled;
- Tailpipe exhaust emissions from mobile vehicles which is based on fuel usage; and
- Primary power generation (during Construction Phase only).

These input parameters have been estimated based on equipment fleet information and fuel consumption estimates for both Project phases. Although the Construction Phase fuel consumption estimates and kilometers travelled were provided for each construction activity occurring at different times over a 2-3 year time span, the estimates provided in the Table below are conservative as they assume all activities are occurring simultaneously within the same year. The table 6-9 provides a comparison between these input parameters for the Construction Phase and Operations Phases.

Table 6-9: Comparison of Mobile Emissions Sources in Construction and Operations Phases

Parameter	Construction Phase	Operations Phase
No. of trucks greater 2,000 HP	10	20
Total distance travelled (VKT/day) (indicator for dust emissions)	4,332	8,248
Diesel fuel consumption (L/yr) mobile sources (indicator for exhaust gases emissions)	12,849,208	61,773,535
Diesel fuel consumption (L/yr) stationary sources (indicator for electricity exhaust gases emissions)	7,078,080	Emergency testing only
Total diesel fuel consumption (L/yr)	19,927,288	61,773,535

As shown in the table, for each input parameter, the values for the Operations Phase are higher than those for the Construction Phase. Based on this comparison, it can be reasonably concluded that the modelled concentrations, if predicted for the Construction Phase, would be lower than the values reported in the Atmospheric TSD.

The emissions from mobile sources are included in the daily emission rates presented in Appendix 3.I of the Atmospheric TSD. In addition, the Human Health and Ecological Risk Assessment TSD considers vehicle exhaust emissions and fugitive dust emissions from haul vehicles in the open pit as well as those on the surface access road.

The AERMOD-PRIME (AERMOD) dispersion model (Version 11103) was used for this assessment because it is the regulatory default model under s. 7 of O. Reg. 419/05. Air modelling guidance for the province of Ontario was followed where appropriate; therefore, the dispersion modelling approach for this assessment is in accordance with the MOE *publication Guideline A-11: Air Dispersion Modelling Guideline for Ontario, Version, 2.0*, dated March 2009 (ADMGO) PIBS 5165e02.

The dispersion modelling was carried out for the Ontario compliance assessment using the emission rates for the activities identified in Table 6-10 in order to determine the point of impingement (POI) concentrations along the Project property boundary and receptors shown in Figure 6-1 for indicators with MOE POI Limits. Percentage contributions for daily emission rates are provided in Table 6-11.

Ambient concentrations resulting from Mine Site emissions were predicted at selected groups of receptors and at other locations of interest in order to provide a better understanding of the potential effects of the Project.

The property boundary for the air quality assessment was created based on OHRG surface rights. Since these extend well past the property boundary used to demonstrate compliance with O. Reg. 419, the property boundary was selected to cover an area close to the MSA used for the assessment.

In addition, 51 discrete human health locations within the Air Quality LSA were identified by the socio-economic team for assessment under the Human Health Risk Assessment (results are provided in the HHERA TSD).

O. Reg. 419/05 considers the emissions from selected stationary sources only. Ontario exempts emission sources associated with construction activities or mobile sources from evaluation (O. Reg. 524/98 [MOE 1998]). Therefore, certain emissions from the Project are not included in the O. Reg. 419/05 assessment, including the following:

- The surface mobile vehicle exhaust emissions.
- Fugitive dust emissions when a best management practices plan is implemented however the metals emissions with POI Limits associated with the dust must still be included.
- Emergency power systems.

Based on the assumptions and operation scenario discussed previously, the following tables summarize the daily emissions associated with the Mine Site. A detailed description of how these emissions were developed can be found in the Atmospheric Environment TSD.

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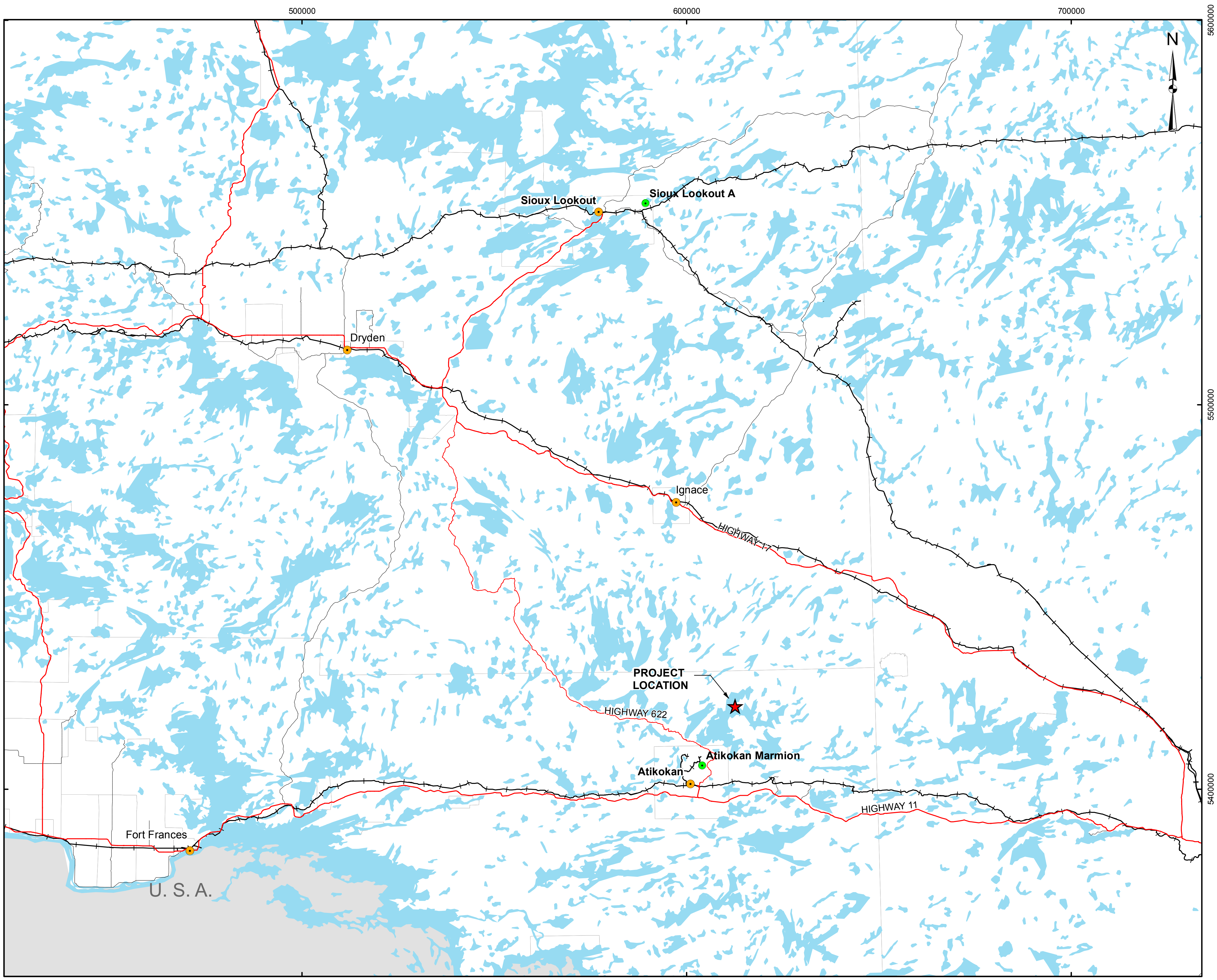

LEGEND

- Project Location
- Climate Station
- City/Town
- Provincial Highway
- Road
- Existing Railway
- Lake
- Municipal Boundary

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

10 0 10 20 30 40
SCALE 1:1,000,000 KILOMETERS

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

CLIMATE STATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	14 Nov. 2008	FIGURE: 6-1	
GIS	JO	2 Dec. 2013		
CHECK	NCH	2 Dec. 2013		
REVIEW	SC	2 Dec. 2013		

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Table 6-10: Daily Emission Rates for the Mine Site

Project Component	Activity	Daily Emission Rates (g/s)												
		TSP	PM_{10}	$PM_{2.5}$	DPM	Metals	NO_X	CO	SO_2	HC	HCN	HCl	NH_3	NaOH
Open Pit Extraction	Blasting – fugitive dust and explosives	0.877	0.456	0.026	—	0.345	0.213	2.449	—	—	—	—	—	—
	Material Handling	9.549	3.819	1.528	—	3.762	—	—	—	—	—	—	—	—
	Bulldozing	5.072	1.089	0.533	—	1.998	—	—	—	—	—	—	—	—
	Grading	0.001	0.001	0.000	—	0.001	—	—	—	—	—	—	—	—
	Vehicles – Exhaust Emissions	0.702	0.702	0.681	0.702	—	19.504	12.165	0.003	2.827	—	—	—	—
	Vehicles – Unpaved Fugitive Road Dust	81.469	23.618	2.362	—	8.147	—	—	—	—	—	—	—	—
Low Grade Ore Stockpile	Material Handling	1.586	0.634	0.254	—	1.586	—	—	—	—	—	—	—	—
	Bulldozing	1.268	0.272	0.133	—	1.268	—	—	—	—	—	—	—	—
	Grading	0.000	0.000	0.000	—	0.000	—	—	—	—	—	—	—	—
Waste Rock Stockpile	Material Handling	5.787	2.315	0.926	—	—	—	—	—	—	—	—	—	—
	Bulldozing	1.268	0.272	0.133	—	—	—	—	—	—	—	—	—	—
	Grading	0.000	0.000	0.000	—	—	—	—	—	—	—	—	—	—
Surface Roads	Vehicles – Exhaust Emissions	0.801	0.801	0.777	0.801	—	22.249	13.878	0.003	3.225	—	—	—	—
	Vehicles – Unpaved Fugitive Road Dust	92.936	26.942	2.694	—	9.294	—	—	—	—	—	—	—	—
Ore Crushing and Screening	Material Handling	0.978	0.391	0.115	—	0.978	—	—	—	—	—	—	—	—
	Ore Crushing	0.527	0.196	0.362	—	0.527	—	—	—	—	—	—	—	—
	Ore Screening	0.047	0.016	0.002	—	0.047	—	—	—	—	—	—	—	—
Ore Processing and Refining	CIP Adsorption	—	—	—	—	—	—	—	—	—	—	—	0.469	0.268
	Acid Wash	—	—	—	—	—	—	—	—	—	—	1.973	—	—
	Carbon Regeneration	0.104	0.104	0.104	—	0.104	—	0.038	—	—	—	—	—	—
	Regeneration Furnace	—	—	—	—	—	0.024	—	0.000	—	—	—	—	—
	Cyanide Destruction	—	—	—	—	—	—	—	19.831	—	—	—	0.002	—
	Electrowinning	—	—	—	—	—	—	—	—	—	—	—	0.589	0.214
	Smelting Furnace	0.199	0.199	0.199	—	0.199	—	—	—	—	—	—	—	—
	Sodium Cyanide Use	—	—	—	—	—	—	—	—	—	0.462	—	—	—
Emergency Power Generators	Stationary Diesel Combustion	0.781	0.372	—	0.781	—	32.002	7.262	13.879	—	—	—	—	—
Comfort Heating	Propane Combustion	0.166	0.166	0.166	—	—	3.085	1.780	0.004	—	—	—	—	—

Note:

— = Compound not emitted from this source.

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Table 6-11: Percentage Contributions for Daily Emission Rates

Project Component	Percentage Contributions for Daily Emission Rates (%)												
	TSP	PM_{10}	$PM_{2.5}$	DPM	Metals	NOx	CO	SO_2	HC	HCN	HCl	NH_3	NaOH
Open Pit Extraction	48%	48%	47%	31%	50%	26%	39%	<1%	47%	—	—	—	—
Low Grade Ore Stockpile	1%	1%	4%	—	10%	—	—	—	—	—	—	—	—
Waste Rock Stockpile	3%	4%	10%	—	—	—	—	—	—	—	—	—	—
Surface Roads	46%	44%	32%	35%	33%	29%	37%	<1%	53%	—	—	—	—
Ore Crushing and Screening	<1%	<1%	4%	—	5%	—	—	—	—	—	—	—	—
Ore Processing and Refining	<1%	<1%	3%	—	1%	<1%	<1%	59%	—	100%	100%	100%	100%
Emergency Power Generators	<1%	<1%	—	34%	—	42%	19%	41%	—	—	—	—	—
Comfort Heating	<1%	<1%	2%	—	—	4%	5%	<1%	—	—	—	—	—

Note:

— = Compound not emitted from this source.

Access Road

Table 6-12 summarizes the emissions associated with the access road (Hardtack/Sawbill). Traffic along the access road (Hardtack/Sawbill) was assumed to be the same every day of the week, year-round.

Table 6-12: Daily Emission Rates for the Access Road (Hardtack/Sawbill)

Vehicle Type	Emission Rate (g/s)					
	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO
Pickup	0.79	0.34	0.03	0.003	0.00001	0.01
Passenger Car	22.42	9.62	0.96	0.026	0.00025	0.87
Passenger Van	0.26	0.11	0.01	0.001	0.00000	0.02
Transport Truck	4.75	2.04	0.20	0.052	0.00011	0.01

6.1.2.1.2 Dispersion Modelling Results

The dispersion modelling was carried out using the emission rates for the activities identified in Table 6-7 in order to determine the point of impingement (POI) concentrations along the Project property boundary shown in Figure 6-1. The dispersion modelling was conducted in accordance with the MOE *publication "Guideline A-11: Air Dispersion Modelling Guideline for Ontario, Version, 2.0"*, dated March 2009 (ADMGO) PIBS 5165e02.

Table 6-13 shows the comparison between the modelled concentrations and the Schedule 3 standards and guidelines. In particular, the last column on the right provides an assessment of emissions compared with the applicable standard/guideline.

Table 6-13: Ontario Compliance Status of the Project

Compound	Averaging Period	POI Concentration (µg/m³)	Schedule 3 Standard/ Guideline	% of Standard/ Guideline
NO_X	24-hr	2.10	200	1%
NO_X	1-hr	103.30	400	26%
TSP	24-hr	76.97	120	64%
SO_2	24-hr	23.91	275	9%
SO_2	1-hr	221.90	690	32%
CO	1/2-hr	1,432.39	6,000	24%
HCl	24-hr	15.37	20	77%
Ammonia	24-hr	11.09	100	11%
HCN	24-hr	4.83	8	60%
NaOH	24-hr	5.04	10	50%
Silver	24-hr	1.00×10^{-4}	1	<1%
Arsenic	24-hr	4.58×10^{-4}	0.3	<1%
Beryllium	24-hr	1.97×10^{-4}	0.01	2%
Cadmium	24-hr	1.34×10^{-5}	0.025	<1%
Cobalt	24-hr	1.69×10^{-3}	0.1	2%
Chromium	24-hr	6.82×10^{-3}	0.5	1%

Table 6-13: Ontario Compliance Status of the Project (Continued)

Compound	Averaging Period	POI Concentration (µg/m³)	Schedule 3 Standard/ Guideline	% of Standard/ Guideline
Copper	24-hr	3.87×10^{-3}	50	<1%
Manganese	24-hr	7.80×10^{-2}	0.4	19%
Nickel	24-hr	4.73×10^{-3}	2	<1%
Lead	24-hr	3.85×10^{-3}	0.5	1%
Antimony	24-hr	3.42×10^{-5}	25	<1%
Selenium	24-hr	2.53×10^{-4}	10	<1%
Tin	24-hr	2.24×10^{-4}	10	<1%
Tellurium	24-hr	7.85×10^{-5}	10	<1%
Vanadium	24-hr	7.29×10^{-3}	2	<1%

The results provided in Table 6-13 show that the Project can operate in compliance with s.20 of O. Reg. 419/05 for the Operations Phase in the peak production year as defined by the worst-case operating conditions. The effects of air emissions on human health are assessed in the HHERA TSD and are summarized in Section 6.3.5.

Air emissions modeling also included predicted $PM_{2.5}$ and NO_2 concentrations at identified human heath receptors. These predicted values incorporate emissions from both the mobile and stationary sources, and compare the values to the selected National Ambient Air Quality Objectives (NAAQO) or Canadian Ambient Air Quality Standards (CAAQS). The model predicts concentrations that are below the appropriate NAAQO or CAAQS criteria at the identified receptors. The results of this modeling and the potential effects to human health are described in the Human Health and Ecological Risk Assessment TSD and Section 6.3.4 of this effects assessment.

6.1.2.2 Noise

6.1.2.2.1 Modeling

The noise assessment is consistent with the accepted practice in the Province of Ontario. This includes describing the existing environment, establishing noise emissions associated with the Project and predicting noise levels at sensitive locations due to Project activities. The noise assessment presented in this section has been undertaken to assess potential changes to the noise conditions under a worst case operating scenario.

Activity levels and noise emissions from the Project will vary during the life of the mine. However, the operations phase of the Project will involve the greatest quantity of equipment with the highest noise emissions (i.e., highest sound power levels). Therefore, the operations phase of the Project has been identified as the bounding case for the noise assessment.

The assessment used the noise assessment methodology based on MOE publication NPC 232 “Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)” (MOE 1995). The noise assessment was carried out at the most sensitive Points of Reception (PORs) which have been identified within the vicinity of the Project. All POR locations in this study are located in a Class 3 area in accordance with NPC 232 (MOE 1995).

A Class 3 area can best be described as rural with the existing noise environment dominated by sounds of nature with little or no road traffic.

Daytime and evening / night time hours for Class 3 areas are defined as follows:

- Daytime: 0700 – 1900 hours.
- Evening / night time: 1900 – 0700 hours.

The assessment of potential noise associated with the Project, including the description of existing noise levels, was conducted based on activities within the MSA, including the Mine Site and associated infrastructure, and the access road.

Noise from the operations of the Project activities is evaluated using the 1-hour equivalent noise level (L_{eq}) during the predictable worst-case hour operation. The 1-hour L_{eq} is the energy equivalent continuous sound level, which has the same energy as the time varying signal over a one hour period at the same location. However, other noise indicators are available that are not appropriate for the evaluation of noise, but are appropriate for evaluating the indirect effects of changes in noise on other VECs (e.g., human health).

Noise emissions assumptions were the same as the assumptions used in the air quality modeling and are based on worst-case assumptions.

The Computer Aided Noise Attenuation (Cadna/A) prediction model, developed by DataKustik GmbH is widely accepted for evaluating noise from industrial projects, including mining projects world-wide. The model algorithms are based on ISO 9613 Acoustics: Attenuation of Sound during Propagation Outdoors (International Organization for Standardization, 1993 and 1996).

Forty Points of Reception (POR) were originally identified for the noise assessment. Twenty of these PORs (POR 5-19, POR 34, POR36-38 and POR 40) were identified in the MNR mapping data as designated campsites. These locations are simply suggested areas with Crown Land that could be used for camping by the public. No amenities or services are provided and no payment is required to camp there, just as is the case with all Crown Land. OHRG does not have the ability to restrict access to Crown Land, and these identified PORs are not considered specific sites that are required to be included in noise modeling predictions.

Based on this, the number of PORs considered in the noise assessment has been reduced from 40 to 20. The PORs considered in the revised noise conclusions are now the Town of Atikokan, local tourism establishments, trapper's cabins and cottages. Of the 20 Crown land campsites that were originally considered in the noise assessment and have been subsequently removed from the list of PORs, three locations were identified as having noise levels that could exceed guidelines. OHRG plans to post signs at crown land locations in the vicinity of the Project site that, in the past, may have been known to be used for camping to indicate the potential for campers to become annoyed by noise levels. The maximum predicted noise level at these locations was 45 dBA. Predicted noise levels at all other locations comply with MOE noise guidelines.

The modeling results predicted that noise levels associated with the Project would exceed MOE noise level limits at one tourist operation. A private agreement is currently in place with the tourist operator that provides for restricted access during the Project's construction and operations phases.

Health Canada has published a draft national guideline for evaluating health effects of noise (Health Canada 2005). This guideline considers the following:

- Characteristics of the noise level.
- Construction noise effects based on increased levels of annoyance in the population.
- Operations noise effects based on increased levels of annoyance in the population.
- Effect on special land uses such as schools, hospitals and seniors' residences.
- Sleep disturbance effects.

The guidance includes a measure of the percentage of the population that could be "highly annoyed" by increased noise levels. Of the 20 locations assessed, one trapper's cabin was identified as having potential to reach levels at which the population could be "highly annoyed." A private agreement is currently in place with the trapline holder that provides for restricted access to the trapline and cabin during the Project's construction and operations phases. Although the crown land campsites were removed from the required assessment, OHRG plans to post signs at crown land locations in the vicinity of the Project site that, in the past, may have been known to be used for camping to indicate the potential for campers to become annoyed by noise levels. Noise effects are not predicted to reach settled areas which are located a considerable distance from the Mine Site.

6.1.2.3 Vibration

Vibrations from the operations of the Project activities are evaluated in two components. The effects of blasting on air vibrations are evaluated using Peak Air Pressure Level in dBL and effects of blasting on ground vibrations are evaluated using Peak Particle Velocity (PPV) in mm/s.

A preliminary vibration assessment was conducted as part of the environmental assessment studies. The assessment was conducted with regard to the ToR with the objectives of evaluating potential changes to vibration levels at sensitive receptors. The vibrations assessment methodology used in this study is based on MOE publication NPC 119 "Blasting" (MOE 1978). In addition, guidelines provided by Fisheries and Oceans Canada (DFO) have also been used to assess vibration levels in water. Fisheries and Oceans Canada (DFO) has established a set of guidelines for the use of explosives in or near Canadian fisheries waters (Wright and Hopky 1998). DFO guidelines set out that: *"No explosive may be used that produces or is likely to produce, a PPV greater than 13 mm/s in a spawning bed during egg incubation."* Sawbill Bay and Lynxhead Bay are the nearest potential locations for both the spawning beds and the nearest fisheries to the proposed mine blasting operations.

It is not possible to realistically assess potential effects on fish without site-specific data on PPV values since this depends to a great extent on the nature of the rock, and the transmissivity. Therefore, operational blasting monitoring to assess the intensity of blast vibrations at the receptor locations will be required. During the initial stages of pit development, blast intensities will be monitored and site-specific PPV will be calculated in order to more accurately predict potential vibration intensities in adjacent aquatic habitats. Based on initial operational monitoring the need for additional assessment of adjacent aquatic habitats will be considered to assess the habitats present and the use of these habitats by fish species in Upper Marmion Reservoir, particularly during sensitive life stages.

This information will be used to determine what mitigation measures may be needed during later stages of pit development, as the pit is expanded, and the distance between the blast holes and aquatic habitats decreases.

The intensity of blast vibrations is primarily influenced by the maximum explosive weight detonated per delay period within a blast and the distance between the blast and the receptor. Thus, two primary means of reducing the effect on the spawning beds and active fisheries are by: a) increasing the distance to these environmental receptors or b) reducing the weight of explosive charge detonated per delay period.

The development of appropriate mitigation measures will depend on the site-specific PPV and the distance between the pit perimeter and the nearest active nearest spawning beds. With appropriate mitigation measures, the potential effects of blast vibrations on aquatic life can be minimized.

6.1.2.4 Light

Artificial Lighting is required to safely operate during nighttime and lowlight conditions. Lighting is required for both construction and operations phases of the Project, and would only occur during the night; however, lighting effects during the operations phase of the Project are likely to be greatest due to the number of permanent fixtures. Effects are related to the potential for:

- Light escaping from the Project to illuminate areas adjacent to the Project Site, effectively creating a brighter environment (called trespass); and
- Light escaping from the Project to brighten the night sky, such that normal contrast (e.g., stars against the natural dark sky) is reduced, effectively making stars harder to see (called sky glow).

Light effects are most likely to be experienced by those living in close proximity to the Project Site. To describe the potential effects of the Project on light, the following indicators can be used:

- Light trespass in Lux
- Percentage change in sky brightness, or “sky glow.”

The lighting on the Project Site will be positioned in a manner as to not directly illuminate the surrounding areas or the sky. During the detailed engineering for the Project, options will be selected to avoid or reduce negative effects and will be considered for incorporation into the Project’s design, including:

- Using lighting fixtures that are fully shielded whenever possible (i.e., full cut-off) to minimize uplight to the atmosphere. For example, lighting fixtures that meet the Commission Internationale de l’Eclairage’s (CIEs) specified limits on the Upward Light Ratio (or ULR, the percentage of light rising above 90° nadir), or full-cutoff luminaires as described by the Illuminating Engineering Society of North America (IESNA) that meet the ULR guidelines for Environmental Light Classification zone E1.
- The lighting design for the Site will be optimized (i.e., minimize over lighting).

The above light control practices are considered to be integral to the operations of the Project. As a result, it is expected that the Project will have limited effects through light trespass and sky glow.

6.1.3 Water Quantity and Quality

This section integrates the assessments by the various disciplines relating to water quantity and quality. The assessment provides the basis for predicting effects on the terrestrial ecosystem, the aquatic ecosystem and human uses.

Important inputs to the water quality and quantity predictions include information from the Geochemistry TSD, ongoing mine planning, preliminary engineering design and conclusions of the Alternatives Assessment TSD and the Site Water Balance as described below.

Geochemistry – provides initial input data for use in developing water quality estimates that result from blasting, processing of ore, and leaching of waste materials. This data is used in site water quality predictions and in determining chemical stability of the waste materials over time. The geochemical evaluation and testing is described in Geochemistry, Geology and Soil TSD.

Mine Planning, Preliminary Engineering Design and Alternative Assessment – Preliminary feasibility data and closure planning is used to define the project and is included in the operations and closure analyses including flow linkages, processing, and waste disposal. Based on this information an appropriate site water balance and water quality assessment was completed and is used to develop an appropriate water management strategy.

Site Water Balance – compiles hydrogeology, site hydrology, water management on site, and mine waste management on site (tailings, waste rock and ore stockpiles), process water requirements, potable water requirements, water collection from seepage, pumping on site and all other various aspects of the site water management that are required or influence water taking or discharge requirements. These aspects are described in more detail in the Site Water Quality TSD.

An assessment of each of the Project phases is discussed with respect to Hydrology, Hydrogeology, Water and Sediment Quality is provided in the following sections as described below.

Hydrology – defines the surface water flow regime in the Hydrology RSA, and also in the Hydrology LSA and MSA. The information collected or used in the hydrologic assessment includes:

- Regional flow regime – Lake and river distribution and flow patterns (drogue analyses, flow measurements, bathymetry).
- Meteorology and climate data (precipitation, evaporation).
- Land topography and terrain (catchment areas, runoff factors).
- External information (Power generation water taking requirements and history; Seine River Management).
- Site runoff – this is developed separately from the main hydrologic assessment as part of the engineering studies and designs and presented in the Site Water Quality TSD.

Hydrogeology defines and describes groundwater flow, primarily as it relates to mine water inflow and also the lowering of groundwater levels and changes in stream flows around the pit and the TMF. Seepage from the waste facilities is dominated by the site hydrology but is also a function of the bedrock topography, sediment thickness and engineering design of these facilities and is determined as part of engineering studies to design the drainage system for the site. The data produced through the hydrogeological evaluation is used in:

- Site water balance.
- Mine planning and engineering.
- Site water quality evaluation.
- Hydrology evaluation (groundwater seepage from the lake to the pit).
- Lake water quality evaluation.
- Aquatic habitat assessment, such as wetlands.

Water and Sediment Quality

Site Water Quality – uses the site water balance, groundwater chemistry, surface water chemistry, geochemistry, process and tailings chemistry test work, treatment evaluation and other information to develop an understanding of possible changes to water quality due to Project activities. The detailed site water quality model and results are summarized in this section and presented in the Site Water Quality TSD. Project activities that are considered include:

- Mine method and exposure.
- Mineral processing.
- Waste disposal (mine waste and sewage)
- Water collection and treatment.
- Closure and post closure conditions.

Lake Water Quality (Lake Water Quality TSD) – Lake water concentrations are predicted for several variability scenarios considering all phases of the project. Predictions to determine potential water quality of the receiving water bodies are based on appropriate mixing models using inputs from:

- The hydrology evaluation to define a range of flow conditions (Hydrology TSD).
- Baseline water quality evaluation for a range of existing conditions as provided in the Water and Sediment Quality TSD).
- A range of site water balance and site water quality discharge conditions for applicable discharge locations.
- This information is then used to predict effects on biological receptors in the Aquatic Ecology TSD and the Terrestrial Ecology TSD.

6.1.3.1 Hydrology

The hydrologic assessment is provided in detail in the Hydrology TSD. The following description is provided for three subcomponents:

- Streamflows.
- Lake water levels.
- Navigability.

Data from the hydrologic assessment are used in the development of the water quality estimates (Site Water Quality TSD and Lake Water Quality TSD). Data were also used to assess potential effects on wetland habitats (Terrestrial Ecology TSD) and the effects on aquatic life (Aquatic Environment TSD) as discussed in Sections 6.2.1 and 6.2.2.

6.1.3.1.1 Streamflows and Lake Water Levels

Changes to flows and lake water levels in site, local and regional scale watercourses and water bodies compared to baseline conditions are expected to occur in all four phases of the Project, as discussed in this section. The assessment of effects focuses on the bounding, or worst case, scenario where the combination of Project activities results in the greatest changes to flows. Based on the analyses as provided in the Hydrology TSD for all project phases, the greatest potential for hydrologic change occurs during operations.

Existing conditions with respect to hydrology (Chapter 3) provide the basis for estimating changes in flow, lake water level and navigability conditions as a result of the Project activities. Results from the prediction of the hydrological changes are used to assess the effect on downstream water users, terrestrial ecology and the aquatic environment.

During the construction phase, flows in watercourses and lake water levels are expected to be altered from baseline conditions by changes in land cover, runoff diversion, runoff interception, lake dewatering, water taking and effluent discharge. These changes are expected to occur during general construction works and the development of linear infrastructure, Open Pits, Overburden Stockpile, Waste Rock Management Facility, TMF, and Support and Ancillary Facilities (including the worker accommodation camp).

During the operations phase, flows in watercourses and lake water levels will continue to be influenced by ongoing changes in land cover, runoff interception, water taking and effluent discharge that commenced during the Construction phase. Additional changes are expected as a result of:

- Increased runoff collection with the progressive expansion of the open pits, Overburden Stockpile, WRMF and TMF. The Project footprint and the quantity of runoff intercepted by the water collection system will therefore increase over time.
- The stockpiling of waste rock in Unnamed Lake 3 (API #11 as identified in the Aquatic Environment TSD) in the WRMF and the deposition of tailings in Unnamed Lake 4 (API #2) in the TMF.
- Increased water taking from Sawbill Bay to supply fresh water to the Processing Plant in addition to water taking to supply potable water to the worker accommodation Camp.

- The discharge of treated wastewater from the mine site, in excess of water requirements, in addition to the discharge of treated sewage from the worker accommodation camp.
- Mine dewatering as the open pits are developed. Flows will increase as the mine is developed due to increased runoff rates and volumes from the expanding footprint, and groundwater inflow into the open pits as a result of the growing hydraulic gradient between water in the reservoir and in the open pits.

During the closure phase, flows and lake water levels will continue to be altered by runoff collection and effluent discharge. However, the changes are expected to be smaller than during the operations phase. The worker accommodation camp, explosives plant, detonator storage area, plant site and office area will be decommissioned and land occupied by these facilities will be progressively reclaimed and pre-development drainage patterns restored where possible. In addition, water taking for potable water supply to the camp and freshwater supply to the Processing Plant, together with the discharge of treated sewage from the camp and discharge of treated effluent from the processing plant, will cease. At the end of mining, the dewatering system will be taken out of service and back-flooding of the open pits will be allowed to commence.

During the post-closure phase, flows and lake water levels will initially continue to be affected by the same Project activities as during the closure phase, with the exception that the discharge of treated wastewater from the mine site will cease at closure. Runoff collected from the TMF, WRMF, Low Grade Ore Stockpile and Overburden Stockpile will initially be routed to the open pits. However, when water quality improves to an acceptable quality, runoff from these facilities will be allowed to discharge directly to the environment. In addition, approximately 218 years after closure, the flooded open pits will begin to overflow and this overflow will be directed into the Upper Marmion Reservoir.

6.1.3.1.2 Changes in Streamflows

Using the Operations Phase as the bounding scenario, changes in streamflows were assessed for:

- Mine Study Area watercourses: these include the small perennial and intermittent/ephemeral streams within the footprints of the various facilities to be constructed.
- Local Study Area watercourses: these include those watercourses that form part of the larger drainage network which encompasses the Mine Study Area watercourses, and therefore could be indirectly affected by the Project. Local Study Area watercourses include Sawbill Creek, Lumby Creek and the Seine River system in the vicinity of the Upper Marmion Reservoir.
- Regional Study Area watercourses: these include the Seine River system downstream of the Raft Lake Dam and upstream of the Upper Marmion Reservoir.

Mine Study Area Watercourses

Regional analysis of natural (unregulated) flows indicated strong linear relationships between various flow statistics and tributary drainage area. On this basis, the evaluation of changes in the magnitude, duration, timing and frequency of flows in the MSA watercourses as a result of Project operations was based on changes in tributary drainage areas.

Changes in the magnitude of flows in the MSA watercourses under normal, dry and wet hydrologic conditions as a result of runoff diversion and runoff collection are expected to be roughly proportional to changes in their tributary drainage areas at any given location.

Predicted changes in the 29 watersheds in the MSA were assessed, based on the percentage area directly impacted by the Project footprint:

- Five are not affected by the Project footprint (0% change in tributary drainage area).
- Three are reduced in size by less than 10% (runoff is intercepted by the Project water management system).
- Six are reduced in size by greater than 1% but less than 50%.
- Nine are reduced in size by greater than 50% but less than 90%.
- Six are reduced in size by more than 90%, including the total area of one watershed.

The following effects can be expected as a result of the changes in the tributary drainage areas of the watercourses under average, wet and dry hydrologic conditions:

- Changes in the magnitude of flows in watercourses will be roughly proportional to the changes in drainage area.
- The percent changes in the flows in watercourses apply strictly to the lower reach of the stream draining the watershed. The percent change in flow may be slightly greater in the reach immediately downstream of the point of runoff diversion or interception, and no change to flow is expected upstream of the point of runoff diversion/interception.
- Shorter durations of flows of a given magnitude where there is a reduction in tributary drainage area (the opposite may be expected where there is an increase in drainage area).
- Lower frequencies of occurrence (return periods) of flows of a given magnitude where there is a reduction in tributary drainage area (the opposite may be expected where there is an increase in drainage area).
- Where streams are intermittent/ephemeral, there may be longer periods when these are dry (the change may be expected to be roughly proportional to the reduction in tributary drainage area).

Changes to the general timing of seasonal flows are unlikely.

The overall predicted change in flows is not expected to have a significant effect on the outflow at Raft Lake Dam. The sum of the changes in tributary drainage areas in the Mine Study Area watersheds is -1,480 ha, which represents 0.33% of the tributary drainage area to Raft Lake Dam.

Hydrology Local Study Area Watercourses

During the operations phase, changes in flows from baseline conditions are expected in Lumby Creek in the Lynxhead-Trap-Turtle Bays watershed and in Sawbill Creek in the Sawbill Bay watershed. Changes in flows in Lumby Creek will occur as a result of the interception of runoff from areas within the Project footprint by the water collection system. Flows in Sawbill Creek may be influenced by the discharge of treated sewage effluent from the worker accommodation camp.

A reduction in the magnitude of flows in Lumby Creek during normal, wet and dry hydrologic conditions as a result of runoff collection and loss of drainage area from areas within the Project footprint is expected. This change will affect inflows to Lizard Lake and the lower reach of Lumby Creek between Lizard Lake and

Turtle Bay. The change in the magnitude of flows in Lumby Creek will be roughly proportional to the reduction in its tributary drainage area (Table 6-14).

Table 6-14: Change in the Tributary Drainage Area to Lumby Creek

Watercourse Name	Existing Watershed Area (ha)	Change due to Runoff Diversion (ha)	Change due to Runoff Interception (ha)	New Watershed Area (ha)	Total Change as Percent of Existing Watershed Area (%)
Lumby Creek	6,272	+9.67	-439	5,842	-6.9%

Similar to the watercourses in the MSA, shorter durations and lower frequencies of occurrence of flows of a given magnitude may be expected; however, changes in the general timing of seasonal flows are unlikely.

Table 6-15 shows potential changes in monthly mean flows in Lumby Creek obtained using hydrologic modelling. Changes range from -7.7% to 0.0%, with the greatest changes generally occurring in the spring and the smallest changes occurring in the winter.

Table 6-15: Changes to Monthly Mean Flows in Lumby Creek

Month	Maximum Change in Flow (%)	Minimum Change in Flow (%)
Jan	-3.3	-0.6
Feb	-2.2	0.0
Mar	-6.8	0.0
Apr	-7.7	-4.4
May	-7.6	-6.2
Jun	-7.5	-5.8
Jul	-7.4	-3.8
Aug	-7.1	-2.8
Sep	-6.7	-2.1
Oct	-6.8	-2.3
Nov	-6.1	-2.3
Dec	-5.5	-1.1
Overall	-7.7	No change

Table 6-16 shows the expected flow statistics for Sawbill Creek.

Table 6-16: Flows in Sawbill Creek

Flow Statistic	Magnitude (m^3/s)
Annual Mean	0.861
Fall Mean	0.638
Winter Mean	0.425
Spring Mean	1.393

Table 6-16: Flows in Sawbill Creek (Continued)

Flow Statistic	Magnitude (m^3/s)
Summer Mean	0.957
7Q20[a]	0.149

Note:

(a) Annual minimum 7-day mean flow with a 20-year return period.

There will be no change to the timing of seasonal flows in the creek.

Regional Scale (Hydrology Regional Study Area) Watercourses

During the operations phase, outflows from Upper Marmion Reservoir which contribute to flows in the Seine River downstream of the Raft Lake Dam could be influenced by:

- The interception of runoff from areas within the Project footprint by the water collection system;
- Water taking from Sawbill Bay in the Upper Marmion Reservoir for potable water supply to the Camp and for freshwater supply to the Processing Plant;
- Discharges of treated sewage effluent from the worker accommodation camp to Sawbill Bay and of treated wastewater effluent from the mine site to the Upper Marmion Reservoir;
- Increased runoff rates and volumes from areas within the Project footprint from which runoff is not collected, due to changes in land cover; and
- Mine dewatering due to the interception of runoff in the Mine footprint and the seepage of water from Upper Marmion Reservoir into the open pits.

A site water balance prepared for the mine site, excluding the worker accommodation camp which is treated separately as described above, is presented in the Site Water Quality TSD, and provides the expected water taking and water discharge requirements during operations and post closure conditions. Water taking for and treated effluent discharge from the Project will fluctuate depending on the time of the year and hydrological conditions.

Freshwater supply and treated wastewater effluent discharge requirements for the mine site during operations for various scenarios (wet and dry years) were developed and analysed in the Site Water Quality TSD. The results are summarized on a monthly basis in Tables 6-17 and 6-18.

Table 6-17: Freshwater Supply to the Processing Plant

Month	Freshwater Supply (m^3/hr)								
	Average Year	Wet Year Return Period (yrs)				Dry Year Return Period (yrs)			
		10	25	50	100	10	25	50	100
Jan	301.5	301.5	301.5	301.5	301.5	490.9	858.0	861.6	864.8
Feb	301.5	301.5	301.5	301.5	301.5	898.0	898.0	898.0	898.0
Mar	301.5	301.5	301.5	301.5	301.5	808.2	819.1	826.2	832.4
Apr	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
May	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	349.9
Jun	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
Jul	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
Aug	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
Sep	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
Oct	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	397.3
Nov	301.5	301.5	301.5	301.5	301.5	301.5	301.5	477.6	684.3
Dec	301.5	301.5	301.5	301.5	301.5	301.5	558.1	791.4	800.2
Year	**301.5**	**301.5**	**301.5**	**301.5**	**301.5**	**406.4**	**460.2**	**495.4**	**526.2**

Table 6-18: Discharges of Treated Wastewater Effluent from the Mine Site

Month	Discharges of Treated Wastewater Effluent (m^3/hr)								
	Average Year	Wet Year Return Period (yrs)				Dry Year Return Period (yrs)			
		10	25	50	100	10	25	50	100
Jan	46.9	202.0	259.2	255.4	228.5	0.0	0.0	0.0	0.0
Feb	46.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mar	46.9	139.9	32.9	3.2	0.4	0.0	0.0	0.0	0.0
Apr	46.9	236.7	328.6	394.9	442.9	0.0	0.0	0.0	0.0
May	46.9	235.6	326.4	391.8	439.3	0.0	0.0	0.0	0.0
Jun	46.9	236.7	328.6	394.9	442.9	0.0	0.0	0.0	0.0
Jul	46.9	235.6	326.4	391.8	439.3	0.0	0.0	0.0	0.0
Aug	46.9	235.6	322.6	389.8	452.8	0.0	0.0	0.0	0.0
Sep	46.9	230.5	339.6	386.4	467.2	0.0	0.0	0.0	0.0
Oct	46.9	250.9	309.6	349.1	384.1	0.0	0.0	0.0	0.0
Nov	46.9	202.0	259.2	297.7	331.8	0.0	0.0	0.0	0.0
Dec	46.9	202.0	259.2	297.7	331.8	0.0	0.0	0.0	0.0
Year	**46.9**	**202.0**	**259.2**	**297.7**	**331.8**	**0.0**	**0.0**	**0.0**	**0.0**

This information in the above tables, together with estimates of changes in inflows to the reservoir due to the interception of runoff by the Project's water management system, seepage losses from the reservoir into the open pits, as well as potable water taking and treated sewage discharge from the camp site, were used to predict changes in reservoir inflows and outflows.

According to the site water balance prepared for the mine site (Site Water Quality TSD), there will be a net water taking of 254.6 m³/hr (0.071 m³/s) in the average year during operations. Additional water losses will be:

- Reduction in inflows to Upper Marmion Reservoir as a result of runoff interception by the Project's water collection system (drainage area reduction). A reduction in the annual mean inflow to the reservoir of 0.115 m³/s has been estimated for the average year (Hydrology TSD).
- Seepage losses from Upper Marmion Reservoir into the open pits at a rate of 523 m³/d (0.006 m³/s) under steady state conditions (Hydrogeology TSD).

The Hydrology TSD estimates a total net reduction in annual mean inflows to the reservoir of 0.192 m³/s in an average year and 0.188 m³/s and 0.215 m³/s in a dry year and wet year, respectively, with a return period of 100 years.

Table 6-19 shows the relative changes in annual mean inflows to Upper Marmion as a result of the Project activities. Table 6-20 shows the combined influence of the Project activities on monthly and annual mean inflows in an average year, dry and wet year with return periods of 10, 25, 50 and 100 years.

Table 6-19: Changes in Annual Mean Inflows to Upper Marmion Reservoir

Project Activity	Changes to Annual Mean Inflows (m³/s)		
	Average Year	100yr Dry	100yr Wet
Runoff Interception	0.115	0.035	0.218
Potable Water Supply to Camp Site	0.001	0.001	0.001
Process Water Supply to Mine Site	0.084	0.147	0.084
Treated Effluent Discharges from Camp and Mine Sites	-0.014	-0.001	-0.093
Mine Dewatering	0.006	0.006	0.006
Total Net Reduction	0.192	0.188	0.216

Table 6-20: Combined Project Influences on Upper Marmion Reservoir Inflows (Net Reduction)

Month	Net Reduction in Upper Marmion Inflows (m³/s)								
	Average Year	Wet Year Return Period (yrs)				Dry Year Return Period (yrs)			
		10	25	50	100	10	25	50	100
Jan	0.137	0.114	0.108	0.109	0.126	0.192	0.284	0.275	0.276
Feb	0.127	0.150	0.160	0.160	0.170	0.295	0.285	0.285	0.275
Mar	0.127	0.111	0.151	0.149	0.170	0.261	0.264	0.266	0.257
Apr	0.177	0.194	0.189	0.180	0.177	0.180	0.160	0.150	0.130
May	0.307	0.514	0.549	0.571	0.588	0.230	0.210	0.180	0.183

Table 6-20: Combined Project Influences on Upper Marmion Reservoir Inflows (Net Reduction) (Continued)

Month	Net Reduction in Upper Marmion Inflows (m^3/s)								
	Average Year	Wet Year Return Period (yrs)				Dry Year Return Period (yrs)			
		10	25	50	100	10	25	50	100
Jun	0.307	0.364	0.369	0.380	0.397	0.200	0.170	0.160	0.140
Jul	0.257	0.244	0.239	0.251	0.248	0.180	0.160	0.140	0.130
Aug	0.187	0.174	0.180	0.172	0.174	0.140	0.140	0.120	0.120
Sep	0.187	0.156	0.135	0.132	0.120	0.130	0.120	0.110	0.110
Oct	0.177	0.150	0.144	0.143	0.143	0.160	0.150	0.130	0.156
Nov	0.167	0.154	0.158	0.157	0.158	0.140	0.140	0.169	0.226
Dec	0.147	0.134	0.138	0.127	0.128	0.130	0.201	0.256	0.248
Annual	0.192	0.205	0.210	0.211	0.216	0.186	0.190	0.187	0.188

The combined influence of runoff interception, water taking, effluent discharge and mine dewatering on outflows from the reservoir was evaluated using single-year and continuous lake water balance models as described in the Hydrology TSD:

- Single-year lake water balance models were used to predict changes on a monthly basis in an average year and wet and dry years with return periods of 10, 25, 50 and 100 years.
- Continuous lake water balance models were used to account for the potential year to year carryover of changes occurring as a result of the Project activities, by simulating outflows and lake water levels using a 27-year sequence of historic monthly climatic data and derived monthly inflows to the reservoir.

Single Year Lake Water Balance Modelling

Baseline outflows from Upper Marmion Reservoir under average, wet and dry hydrologic conditions were estimated by satisfying minimum outflow requirements from Lac des Mille Lacs (1.5 m^3/s) and Upper Marmion Reservoir (10 m^3/s) as specified in the 2004 to 2014 Seine River Water Management Plan, and meeting target operating water levels where possible, in the single-year lake water balances. Target operating water levels were developed based on a review of the objectives of reservoir operation at Lac des Mille Lacs and Upper Marmion Reservoir and the operating rules for Lac des Mille Lacs Dam and Raft Lake Dam.

Under existing conditions, modeled minimum outflows from Upper Marmion Reservoir occurred in one month in the average year, and four, seven, eight and nine months in dry years with return periods of 10, 25, 50 and 100 years, respectively. This is considered to be realistic, given the large number of recorded occurrences of minimum and below minimum outflows during the period from 2004 to 2011 (Hydrology TSD Table 5-15, Section 5.1.2).

Potential changes to outflows from Upper Marmion Reservoir during the operations phase were predicted for the case where reservoir water levels under baseline conditions remained unchanged in order to directly assess the Project influences on outflows. Under this scenario, outflows were allowed to fall below the minimum requirement due to the net reduction in inflows to the reservoir as a result of the combined influences of the Project.

Table 6-21 provides the predicted changes in flows, as a percentage change from existing conditions, for an average year, and wet and dry years with different return periods.

Table 6-21: Predicted Changes in Upper Marmion Reservoir Outflows (Single-Year Lake Water Balances)

Month	Average Year	Wet Year Return Period (yrs)				Dry Year Return Period (yrs)			
		10	25	50	100	10	25	50	100
	Percentage Change in Outflows								
Jan	-0.34	-0.26	-0.22	-0.21	-0.22	-0.49	-0.80	-0.86	-1.40
Feb	-0.29	-0.33	-0.34	-0.32	-0.33	-0.77	-0.81	-0.86	-0.88
Mar	-0.40	-0.30	-0.38	-0.36	-0.40	-0.82	-0.92	-1.03	-1.06
Apr	-0.93	-0.66	-0.53	-0.49	-0.43	-1.16	-1.35	-1.50	-1.30
May	-3.10	-1.54	-1.02	-0.84	-0.72	-2.30	-2.10	-1.80	-1.80
Jun	-0.63	-0.38	-0.35	-0.33	-0.32	-2.00	-1.70	-1.60	-1.40
Jul	-0.43	-0.31	-0.28	-0.27	-0.26	-1.80	-1.60	-1.40	-1.30
Aug	-0.38	-0.30	-0.28	-0.24	-0.23	-0.77	-1.40	-1.20	-1.20
Sep	-0.55	-0.36	-0.28	-0.24	-0.21	-0.87	-1.20	-1.10	-1.10
Oct	-1.23	-0.65	-0.49	-0.44	-0.42	-1.60	-1.50	-1.30	-1.60
Nov	-0.50	-0.33	-0.32	-0.30	-0.27	-0.77	-1.40	-1.70	-2.30
Dec	-0.31	-0.26	-0.23	-0.22	-0.21	-0.35	-0.70	-1.90	-2.50

The results of the single-year lake water balance modelling indicate that potential changes in outflows range from -3.10% (May) to -0.21% (January, September and December), occurring in the average year and wet years with return periods of 50 and 100 years, respectively. Outflow reductions did not exceed 1.25% during any month in the average year, except in May.

Outflows at the Raft Lake Dam fell below the minimum requirement as defined in the Seine River Water Management Plan in one month in the average year, and in four, seven, eight and nine months in dry years, respectively, with return periods of 10, 25, 50 and 100 years, which corresponded to the same months when minimum outflows occurred under baseline conditions. There was no increase in the frequency of occurrence of minimum outflows as a result of the Project.

Continuous Lake Water Balance Modelling

The continuous model existing outflows from Upper Marmion Reservoir were also estimated by satisfying minimum outflows from Lac des Mille Lacs (1.5 m^3/s) and Upper Marmion Reservoir (10 m^3/s) as the primary objective. Under existing conditions, minimum outflows occurred in 90 out of 324 months (28% of the time) over the 27 year period that was modelled. This is considered to be realistic, given the large number of recorded occurrences of minimum and below minimum outflows during the period from 2004 to 2011 (Table 5-15 and Section 5.1.2 of the Hydrology TSD).

Outflows during the operations phase of the Project were predicted using monthly net water takings (water taking less effluent discharge) from the reservoir for an average year, and wet and dry years with return periods of 100-years determined from site wide water balance modelling (Site Water Quality TSD). Similar to the single year lake water balance modelling, the baseline reservoir water levels remained unchanged in order to directly assess the Project influences on outflows (i.e., the model assumed that reservoir levels would not be managed to accommodate the loss of water to the reservoir due to the Project).

Table 6-22 shows the potential changes in outflows from Upper Marmion Reservoir as a result of combined Project influences during the operations phase if reservoir water levels remain unchanged from baseline conditions.

Table 6-22: Predicted Changes in Upper Marmion Reservoir Outflows (Continuous Lake Water Balances)

Month	Water Taking Scenario					
	Average Year		100 Year Wet		100 Year Dry	
	Maximum Percent Change	Minimum Percent Change	Maximum Percent Change	Minimum Percent Change	Maximum Percent Change	Minimum Percent Change
Jan	-1.30	-0.32	-0.70	-0.15	-2.90	-0.66
Feb	-0.74	-0.26	-0.88	-0.32	-1.96	-0.69
Mar	-0.44	-0.27	-0.51	-0.31	-1.07	-0.62
Apr	-1.40	-0.68	-0.49	0.00	-1.50	-0.71
May	-4.70	-1.06	-3.60	-0.30	-4.90	-1.11
Jun	-3.00	-0.41	-1.90	-0.20	-3.20	-0.42
Jul	-2.60	-0.36	-1.50	0.00	-2.70	-0.37
Aug	-2.40	-0.34	-1.30	0.20	-2.60	-0.35
Sep	-1.80	-0.36	-0.60	0.30	-1.90	-0.37
Oct	-2.40	-0.50	-1.50	0.00	-2.80	-0.55
Nov	-1.40	-0.39	-0.70	-0.10	-2.60	-0.53
Dec	-4.70	-0.33	-0.60	-0.09	-2.90	-0.57
Overall	-4.70	-0.26	-3.60	0.30	-4.90	-0.35

The results of the continuous lake water balance modelling indicate that maximum potential changes in outflows range from -4.90% (May) to 0.30% (September) occurring in the water taking scenarios for the dry and wet years with return periods of 100 years, respectively. Outflows at the Raft Lake Dam fell below the minimum requirement in 80 out of 324 months (25% of the time) and 90 out of 324 months (28% of the time) in simulations using the net water taking in a wet and a dry year, respectively, with return periods of 100 years. There was no increase in the frequency of occurrence of minimum outflows as a result of the Project.

Summary of Predicted Changes

The greatest changes in flows as a result of Project activities during the Operations phase are expected to occur in Mine Study Area watercourses as a result of changes to their tributary drainage areas. Of the 29 watersheds evaluated, five will be unaffected, three will be reduced in size by less than 10%, six will be reduced in size by less than 50%, nine will be reduced in size by less than 90%, and six will be reduced in size by more than 90% (one by 100%). Changes to tributary drainage areas will occur due to the interception of runoff from areas within the Project footprint by the water collection system. Changes in flows are expected to be roughly proportional to changes in tributary drainage area.

The expected changes in flows in local scale watercourses are as follows:

- A reduction in flows in Lumby Creek of approximately 7% to 8% as a result of the interception of runoff from the Project footprint by the water collection system.
- An increase in flows in Sawbill Creek of less than 1% due to the discharge of treated sewage effluent from the worker accommodation camp.

Changes in inflows to Upper Marmion Reservoir due to the Project activities during the operations phase may result in changes to the outflows from the reservoir and flows in the Seine River downstream of the Raft Lake Dam. Inflows to the reservoir are expected to be influenced by runoff interception, water taking, effluent discharge and mine dewatering. Total net reduction in annual mean inflows to the reservoir is estimated to be 0.190 m^3/s in an average year. This represents less than 1% of the average annual outflow at Raft Lake Dam under the 2004 to 2014 Seine River Water Management Plan estimated as 32.4 m^3/s (Table 4-16 of the Hydrology TSD).

Changes in monthly mean outflows from Upper Marmion Reservoir are expected to be:

- In the range -3.10% (average year) to -0.21% (wet years with return periods of 50 and 100 years) based on single-year lake water balance modelling. The magnitude of the changes (outflow reduction) did not exceed 1.25% during any month in an average year, except in May. The frequency of occurrence of minimum outflows was not increased by the Project.
- In the range -4.90% (100 year dry water taking scenario) and 0.30% (100 year wet water taking scenario) based on continuous lake water balance modelling. The frequency of occurrence of minimum outflows was not increased by the Project.

It should be noted that the predicted changes in Upper Marmion Reservoir outflows above are well within the generally accepted accuracy limits (i.e., ± 10 of flow measurements in natural rivers and streams. Thus, in reality, the effects of the Project on reservoir outflows could not be measured in the field. Similarly, no measurable changes in flows are predicted to occur in the Seine River downstream of the Reservoir.

6.1.3.1.3 Changes in Lake Water Levels

Changes in lake water levels because of the Project were assessed for:

- MSA water bodies: these include the small lakes within the footprints of the various facilities to be constructed that will be directly affected by the Project.
- Hydrology LSA water bodies: these include those water bodies that form part of the larger drainage network of which encompasses the MSA watercourses and water bodies and therefore could be indirectly affected by the Project. Local Study Area water bodies include Lizard Lake and Upper Marmion Reservoir.

Mine Study Area Water Bodies

Four MSA water bodies are completely contained within the Project footprint and will be lost. They are discussed further in Section 6.2.2, Aquatic Ecology. The four water bodies are:

- Mitta Lake (API #12), located within the footprint of the open pit mine. This water body will be dewatered and the sediment on the lake bottom will be removed and stockpiled. Mitta Lake will be lost with the development of the west pit.
- Unnamed Lake 1 (API #13), which is to be used as the Mine Water Emergency Spill Pond. Water levels in this water body will be influenced by mine dewatering and runoff collection from areas within the Project footprint. Unnamed Lake 1 forms part of the water collection system for the Project.
- Unnamed Lake 3 (API #11), located within the footprint of the WRMF. This water body will be in-filled with waste rock from the open pit mining, and will be completely covered over by the WRMF.
- Unnamed Lake 4 (API #2), located within the footprint of the TMF. This water body will be in-filled with tailings, and will be completely covered over by the TMF.

Only one MSA water body, Unnamed Lake 5 (API #8), will be affected by a reduction in its tributary drainage area, and the corresponding changes in inflows to and outflows from the lake, as well as water levels. This water body is located to the east of the TMF and is tributary to Lumby Creek located in the Trap-Turtle-Lynxhead Bay watershed. The expected changes in monthly mean water levels in the lake were assessed using hydraulic and hydrologic modelling. Details of the modelling approach are provided in the Hydrology TSD.

Reductions in the magnitude of water levels in Unnamed Lake 5 (API #8) during normal, wet and dry hydrologic conditions as a result of runoff collection in the TMF are expected. Table 6-23 presents the results of hydraulic and hydrologic modelling to evaluate changes in lake water levels in this water body:

Table 6-23: Changes to Monthly Mean Water Levels in Unnamed Lake 5 (API #8)

Month	Maximum Change in Water Level (cm)	Minimum Change in Water Level (cm)
Jan	-0.6	-0.2
Feb	-0.3	-0.1
Mar	-1.0	-0.1
Apr	-1.7	-0.1
May	-2.1	-0.3

Table 6-23: Changes to Monthly Mean Water Levels in Unnamed Lake 5 (API #8) (Continued)

Month	Maximum Change in Water Level (cm)	Minimum Change in Water Level (cm)
Jun	-1.6	-0.3
Jul	-1.5	-0.1
Aug	-1.7	0.0
Sep	-1.7	-0.1
Oct	-1.5	-0.2
Nov	-1.2	-0.3
Dec	-0.8	-0.2
Overall	-2.1	No change

Table 6-23 indicates potential changes in monthly mean water levels in Unnamed Lake 5 (API #8) ranging from -2.1 cm (May) to 0.0 cm (August), with the greatest changes occurring in the spring/summer/fall seasons and the smallest changes occurring in the winter season. As a result of the reduction in tributary drainage area to the lake, shorter durations and lower frequencies of occurrence (return periods) of lake water levels of a given magnitude are also expected. Changes to the general timing of seasonal lake water levels are unlikely.

Hydrology Local Study Area Water Bodies

During the Operations phase, changes in lake water levels from baseline conditions are expected in Lizard Lake. This lake is part of the Lumby Creek drainage system in the Trap-Turtle-Lynxhead Bay watershed.

Reductions in the magnitude of water levels in Lizard Lake under normal, wet and dry hydrologic conditions as a result of runoff collection in the TMF are expected. Table 6-24 presents the results of hydrologic modelling to evaluate changes in water levels in this water body.

Table 6-24: Changes in Monthly Mean Water Levels in Lizard Lake

Month	Maximum Change in Water Level (cm)	Minimum Change in Water Level (cm)
Jan	-0.3	0.0
Feb	-0.3	0.0
Mar	-1.0	0.0
Apr	-2.1	-0.2
May	-2.7	-0.5
Jun	-2.1	-0.5
Jul	-2.0	-0.2
Aug	-2.2	-0.3
Sep	-2.3	-0.1
Oct	-1.9	-0.2
Nov	-1.3	-0.2
Dec	-0.8	0.0
Overall	**-2.7**	**No change**

Table 6-24 indicates potential changes in monthly mean water levels in Lizard Lake ranging from -2.7 cm (May) to 0.0 cm (December to March), with the greatest changes occurring during the spring and summer (April to September) and the smallest changes occurring during the winter/early spring (December to March). As a result of the reduction in tributary drainage area to the lake, shorter durations and lower frequencies of occurrence (return periods) of lake water levels of a given magnitude are also expected. Changes to the general timing of seasonal lake water levels are unlikely.

During the Operations Phase, lake water levels in the Upper Marmion Reservoir are expected to be influenced by Project activities.

Changes in reservoir water levels will occur as a result of changes in inflows to the reservoir. Changes in inflows occurring as a result of runoff interception were evaluated based on changes in the tributary drainage area to the reservoir. Changes in inflows due to water taking, effluent discharge and seepage due to mine dewatering were accounted for by adding or subtracting estimates of these quantities.

Similar to the prediction of streamflows, the combined influence of all these Project activities was evaluated using single-year and continuous lake water balance models as described in the Hydrology TSD.

Single Year Water Balance Modelling

For the single year reservoir water balance modelling, the potential changes to water levels in Upper Marmion Reservoir during the operations phase of the Project were predicted by maintaining the same outflows from the reservoir as under baseline conditions (i.e., there is no change in reservoir operating procedures) in order to directly assess the full potential of Project influences on reservoir water levels.

Table 6-25 shows the number of months that monthly mean water levels in Upper Marmion Reservoir fell below the monthly averages of the minimum water levels stipulated in the operating plan in the average year and in dry years, under baseline conditions and during the operations phase of the Project. Table 6-25 indicates that the frequency of occurrence of reservoir water levels falling below minimum requirements during the operations phase of the Project remains similar to that under baseline conditions. Water levels will fall below minimum requirements in one additional month (April) in each of the dry years with return periods of 10, 25 and 50 years as a result of the Project, assuming baseline reservoir outflows are maintained.

Table 6-25: Frequency of Below-Minimum Water Levels in Upper Marmion Reservoir

Year	Frequency	
	Baseline	**Reservoir Outflows Unchanged**
Average	1 (May)	1 (May)
10-year dry	2 (May – Jun)	3 (Apr – Jun)
25-year dry	5 (May – Sep)	6 (Apr – Sep)
50-year dry	6 (May – Oct)	7 (Apr – Oct)
100-year dry	8 (Apr – Nov)	8 (Apr – Nov)

Table 6-26 shows the potential changes in the magnitude of water levels in Upper Marmion Reservoir as a result of Project activities in the operations phase if outflows under baseline conditions remain unchanged. Potential changes in water levels range from -9.0 cm (May) during both wet and dry years with return periods of 100 years to -0.4 cm (June) occurring in dry years with return periods of 50 and 100 years. In an average year, the maximum reduction in water levels is 8.1 cm (May).

Table 6-26: Changes in Upper Marmion Reservoir Water Levels (Single Year Lake Water Balances)

Month	Average Year	Wet Year Return Period (yrs)				Dry Year Return Period (yrs)			
		10	25	50	100	10	25	50	100
	Change in Water Levels (cm)								
Jan	-5.3	-4.9	-4.9	-4.9	-5.0	-4.5	-5.1	-5.2	-5.4
Feb	-5.8	-5.6	-5.6	-5.6	-5.7	-5.8	-6.3	-6.5	-6.6
Mar	-6.4	-6.1	-6.3	-6.3	-6.5	-7.0	-7.6	-7.7	-7.9
Apr	-7.3	-7.1	-7.2	-7.1	-7.4	-7.9	-8.3	-8.4	-8.5
May	-8.1	-8.5	-8.8	-8.8	-9.0	-8.5	-8.9	-9.0	-9.0
Jun	-0.8	-1.0	-1.0	-1.0	-1.1	-0.5	-0.5	-0.4	-0.4
Jul	-1.6	-1.7	-1.7	-1.7	-1.8	-1.1	-0.9	-0.8	-0.7
Aug	-2.1	-2.2	-2.2	-2.2	-2.3	-1.4	-1.3	-1.2	-1.1
Sep	-2.6	-2.6	-2.6	-2.6	-2.6	-1.8	-1.6	-1.5	-1.4
Oct	-3.1	-3.0	-3.0	-3.0	-3.0	-2.3	-2.1	-1.8	-1.8
Nov	-3.9	-3.7	-3.7	-3.7	-3.7	-2.9	-2.7	-2.6	-2.9
Dec	-4.6	-4.4	-4.4	-4.4	-4.4	-3.5	-3.7	-3.9	-4.1

Continuous Water Balance Modelling

Continuous water balance modelling allows potential changes to water levels in Upper Marmion Reservoir during the operations phase of the Project to be simulated over an extended period of time. For the assessment of Project influences, reservoir water levels were predicted by incrementally adjusting outflows (versus those in the baseline model) to minimize changes in reservoir water levels while continuing to satisfy minimum outflow requirements. Under baseline conditions, continuous lake water balance modelling predicted that monthly mean water levels in Upper Marmion Reservoir would fall below the monthly averages of the minimum water levels stipulated in the reservoir operating plan 65 out of 324 months (20% of the time). By comparison, the model simulations for the operations phase of the Project predicted monthly mean water levels in Upper Marmion Reservoir would fall below minimum requirements 66 out of 324 months under the average year and the 100-year dry water taking scenarios, and 65 out 324 months under the 100-year wet water taking scenario. The model results showed that the frequency of occurrence of reservoir water levels falling below minimum requirements was not increased as a result of the Project.

Table 6-27 shows the potential changes in the magnitude of water levels in Upper Marmion Reservoir as a result of Project activities in the operations phase. Potential changes in water levels range from -6.8 cm (Jan) occurring in the 100-year dry water taking scenario to 0.0 cm (multiple months) occurring in the average year, 100-year dry and the 100-year wet water taking scenarios. In an average year, the maximum reduction in water levels is 4.4 cm.

Table 6-27: Changes in Upper Marmion Reservoir Water Levels (Continuous Lake Water Balances)

Month	Water Taking Scenario					
	Average Year		100 Year Wet		100 Year Dry	
	Maximum Change (cm)	Minimum Change (cm)	Maximum Change (cm)	Minimum Change (cm)	Maximum Change (cm)	Minimum Change (cm)
Jan	-4.3	0.0	-1.0	0.0	-6.8	0.0
Feb	0.0	0.0	0.0	0.0	0.0	0.0
Mar	0.0	0.0	0.0	0.0	0.0	0.0
Apr	-0.6	0.0	-0.1	0.0	-0.7	0.0
May	-1.3	0.0	-1.0	0.0	-1.4	0.0
Jun	-1.8	0.0	-1.2	0.0	-1.9	0.0
Jul	-2.3	0.0	-1.0	0.0	-2.5	0.0
Aug	-2.8	0.0	-1.1	0.0	-3.1	0.0
Sep	-3.2	0.0	-1.2	0.0	-3.5	0.0
Oct	-3.7	0.0	-1.4	0.0	-4.1	0.0
Nov	-3.8	0.0	-1.1	0.0	-4.8	0.0
Dec	-4.4	0.0	-1.3	0.0	-6.1	0.0
Overall	-4.4	0.0	-1.4	0.0	-6.8	0.0

Regional Study Area Water Bodies

Given the small percentage change in outflows from Upper Marmion Reservoir (< 5%), no measurable changes are predicted to occur in water bodies downstream of the reservoir.

Summary of Predicted Changes

Water levels in Unnamed Lake 5 (API #8) located to the east of the TMF in site scale watershed R are expected to be influenced by Project activities. Changes in the range of -2.1 cm to 0.0 cm are expected during the Operations phase, with the greatest changes occurring during the spring and the smallest changes occurring during the late fall/winter.

Changes in water levels in Lizard Lake, ranging from -2.7 cm to 0.0 cm, are also expected as a result of Project activities during the operations phase. The greatest changes are expected to occur during the spring and summer months, and the smallest changes during the late fall/winter.

Changes in water levels in the Upper Marmion Reservoir due to Project activities during the operations phase are expected to be:

- In the range -9.0 cm (100-yr wet and dry years) to -0.4 cm (100-yr and 50-yr dry years) based on single-year water balance modelling. In an average year, the predicted maximum reduction in water levels is 8.1 cm. The frequency of occurrence of reservoir water levels falling below the minimum requirements stipulated in the operating plan for Raft Lake Dam is expected to remain essentially unchanged from baseline conditions.

- In the range -6.8 cm (100-yr dry water taking scenario) to 0.0 cm (all water taking scenarios) based on continuous water balance modelling. With the average year water taking scenario, the predicted maximum reduction in water levels is 4.4 cm. The frequency of occurrence of reservoir water levels falling below the minimum requirements stipulated in the operating plan for Raft Lake Dam is expected to remain unchanged from baseline conditions.

The predicted changes in monthly water levels in Upper Marmion Reservoir represent less than 6% of the average annual range in monthly water levels (1.58 m) recorded in the reservoir since 2004.

6.1.3.1.4 Navigability

During the construction phase, the navigability of waterways and water bodies is expected to be altered from baseline conditions as a result of:

- Upgrades to the Access Road and Mine Site Road and construction of On-site Roads. Upgrades to the Access Road may involve modifications to 15 existing water crossings. Since navigation in these waterbodies is already affected by the existing road, there is essentially no change to navigability in these streams. It is anticipated that all or most of these crossings will need to be modified as part of the upgrades.
- Construction of the Fibre Optics Line and the Power Transmission Line. Construction will require approximately 16 water crossings. However, it is expected that the fibre optics line and power transmission line will be supported by structures built on or away from the banks of the watercourses/water bodies and that these structures will not enter the water nor will their construction require entry into the water.
- Construction of the water intake and effluent discharge structures will result in temporary restrictions in the immediate vicinity of the work area until the work has been completed.
- Changes in flows and water levels as a result of changes in land cover, runoff diversion, runoff interception, lake dewatering, water taking and effluent discharge.

Upgrades and construction of roads, and construction of the communications and power lines have the potential to produce the greatest changes in navigable water since navigation will be aggravated by the operation of construction equipment, which typically creates a temporary interference that can extend beyond the footprint of the structure that is being built.

During the operations phase, the navigability of waterways and water bodies will continue to be influenced by the presence and use of the Access Road, Mine Site Road and On-site Roads. In addition, the progressive expansion of the Mine, Overburden Stockpile, WRMF and TMF will entirely cover sections of several small watercourses, encompass Mitta Lake, and three smaller unnamed lakes and reduce the tributary drainage area to a fifth unnamed lake in the Mine Study Area. The presence and use of the water intake and effluent discharge structures should be minimal as they will be constructed well below navigable water depth; however, changes in flows and water levels as a result of changes in land cover, runoff interception, lake dewatering, water taking and effluent discharge are all expected to be greater in the Operations phase than in the Construction phase

During the closure phase, changes to the flows and water levels in navigable waters are expected to be smaller than during the operations phase as a result of the following activities. The worker accommodation camp, Emulsion Plant, Detonator Storage Area, plant site and office area will be decommissioned and land occupied by these facilities will be reclaimed and pre-development drainage patterns restored where possible. Water taking for potable water supply to the camp and freshwater supply to the mine site, and the discharge of treated sewage from the camp, will cease. In addition, the mine dewatering system will be taken out of service and back-flooding of the open pits will be allowed to commence, thus restoring navigability to the lakes and streams that were previously affected by mine operations.

During the post-closure phase, changes in flows and water levels in navigable water are expected to be smaller than during the closure phase as vegetative cover in reclaimed areas continues to mature, thus reducing peak runoff rates and volumes. In addition, decommissioning of the mine site roads will restore navigability to several site scale watercourses. Navigability will continue to be affected by the continued presence and use of the Access Road (stream crossings).

Based on the above, it is concluded that the bounding (worst case) scenario for navigability occurs during the Operations phase of the Project. Potential changes to navigability during the Operations phase (bounding scenario) can be broadly categorized as follows:

- Changes to streamflows and lake water levels affecting navigation.
- Physical obstructions (structures) affecting navigation.

Physical obstructions potentially affecting navigability are expected to result from the presence and use of the following Project structures/components:

- Mine Site Road (Reef Road) existing stream crossing upgrades (site and local scales).
- On-site Road (new) stream crossings (site scale).
- Water intake and effluent discharge structures in Upper Marmion Reservoir (regional scale).
- Access Road (Hardtack/Sawbill) existing stream crossing upgrades (local and regional scales).

Upgrading of the existing stream crossings along the Mine Site Road (Reef Road) and Access Road (Hardtack/Sawbill Road) is expected to involve widening of the roadways and replacement or extension of existing culverts with longer culverts. The potential effect on navigability is to nominally increase the length of the portage around these existing obstructions.

The new stream crossings along the proposed on-site roads will create new obstructions to navigation, in addition to the numerous natural obstructions that currently exist on most of these streams. The potential effect on navigability is to create a requirement to portage around these new obstructions.

Both the potable and mine process water supply intake structures and the treated wastewater discharge structures to Sawbill Bay are expected to be constructed in water depths that will provide adequate clearance (draft) for recreational boat traffic. In addition, signage warning boaters of potential underwater hazards can be installed if necessary to ensure that boaters stay clear of these locations Therefore, the effect on navigability is likely to be small.

Changes to Navigability due to Changes in Streamflows

Navigation in some streams within the Mine Study Area may be affected by reduced flows. However, the streams within the Mine Study Area are small, and currently lead only to ponds and wetlands, and are unlikely to be used for navigation under existing conditions.

The predicted changes in flows in Lumby Creek affected by the Project are not expected to affect navigability in these streams. Lumby Creek is predicted to experience a flow reduction of approximately 7% as a result of the interception of runoff from the Project footprint.

On a regional scale, the predicted changes in outflows from the Upper Marmion Reservoir due to Project operations are less than 5% (reduced flows) and less than 1% (increased flows). These changes are very small and are not expected to affect navigability of the Seine River downstream of Raft Lake Dam.

Changes to Navigability due to Changes in Lake Water Levels

In the MSA, four small water bodies are completely contained within the Project footprint and will be lost as development of the Project progresses. The following lakes will no longer retain any potential for navigation:

- Mitta Lake (API #12), located within the footprint of the open pit mine. This water body will be dewatered and the sediment on the lake bottom will be removed and stockpiled. Mitta Lake will be lost with the development of the west pit.
- Unnamed Lake 1 (API #13), which is to be used as the Mine Water Emergency Spill Pond. Water levels in this water body will be influenced by mine dewatering and runoff collection from areas within the Project footprint. Unnamed Lake 1 forms part of the water collection system for the Project.
- Unnamed Lake 3 (API #11), located within the footprint of the WRMF. This water body will be in-filled with waste rock from the open pit mining, and will be completely covered over by the WRMF.
- Unnamed Lake 4 (API #2), located within the footprint of the base case TMF. This water body will be in-filled with tailings, and will be completely covered over by TMF.

Also in the MSA, changes in the water levels in Unnamed Lake 5 (API #8) located to the east of the TMF in watershed R are expected to be in the range of -2.1 cm to 0.0 cm during the Operations phase, with the greatest changes occurring during the spring and the smallest changes occurring during the late fall/winter.

In the Hydrology LSA, changes in water levels in Lizard Lake, ranging from -2.7 cm to 0.0 cm, are predicted. The greatest changes are expected to occur during the spring and summer months, and the smallest changes during the late fall/winter.

Changes in the mean monthly water levels in the Upper Marmion Reservoir during the Operations phase are expected to be:

- In the range -9.0 cm to 0.4 cm based on single-year water balance modelling.
- In the range -6.8 cm to 0.0 cm based on continuous water balance modelling.

In the case of Unnamed Lake 5 (API #8), Lizard Lake and the Upper Marmion Reservoir, the predicted maximum changes in water levels are small (i.e., less than 10 cm). Relative to the depths of water in these locations, the changes are unlikely to result in an appreciable change to navigation potential. As a result there is no predicted effect on navigation in these waterbodies.

Changes to Navigability due to Stream Crossings along Roadways

Upgrading of the existing stream crossings along the Access Road (Hardtack-Sawbill Road) and Mine Site Road (Reef Road) and the presence of the new crossings created along the proposed On-site Roads may affect navigable waters by modestly increasing the length of the portage, in the case of the former and by creating the requirement to portage around new obstructions in the case of the latter.

Changes to Navigability due to Water Intake and Effluent Discharge Structures

The operation of the potable and mine process water intake structures in Sawbill Bay as well as the treated effluent discharge structures in Sawbill Bay are expected to be minimal in terms of their potential effects on navigable waters and can be mitigated with the use of signage.

6.1.3.2 Hydrogeology

The assessment of the effects of the Project on hydrogeology includes consideration of water levels in the MSA and seepage inflows into the open pits. Changes in groundwater levels and flows can affect stream flows. Changes in groundwater levels and groundwater quality can occur during the construction and operations phases as a result of the activities on the Mine Site, such as pit dewatering, construction of stockpiles, and operation of the TMF.

Data from the hydrogeology assessment is used in development of the site water quality estimates (Site Water Quality TSD) and the Lake Water Quality estimates (Lake Water Quality TSD).

6.1.3.2.1 Groundwater Levels

Predictions of changes in groundwater levels associated with steady state pit dewatering were developed using the calibrated flow model as described in the Hydrogeology TSD. This model was first calibrated to the observed existing conditions and then modified to incorporate the fully excavated open pit mine along with increases to the infiltration rate over the footprint of the adjacent stockpiles.

During operations, groundwater levels will decline with the excavation of and pumping from the open pit mine. Groundwater levels will decline on a continuous basis as the pits are progressively deepened throughout the operations phase reaching a maximum at the end of mining. Therefore, the point at which dewatering ceases (end of mining) has been identified as the temporal boundary in the assessment of hydrogeology for the Project.

A minor rise in groundwater levels may occur in the immediate vicinity of the stockpiles (waste rock, low-grade ore, and overburden), the TMF and the PPCP during operations. Changes in groundwater levels that may occur during the construction phase will be associated with development of infrastructure. These changes, if any, will be minor and bounded by changes expected during operations. As such, a temporal boundary for the construction phase has not been established for hydrogeology.

During the closure/post-closure phases, pumping from the open pits will cease and groundwater levels will begin to rise. As discussed in the Conceptual Closure and Rehabilitation Plan, it is expected that it will take approximately 218 years for pit water levels to rise to an elevation of 420.0 metres above sea level (masl), the proposed spill over elevation from the pits to the environment. Groundwater levels in the vicinity of the pit will rise progressively along with pit water levels and approach pre-mining elevations over much of the area that experienced changes during operations. It is expected that any residual changes in groundwater levels will be minor and evident only in the immediate vicinity of the open pits, the TMF or the WRMF. As such, a temporal boundary for post-closure, when groundwater levels recover to an equilibrium level, has not been established for hydrogeology.

The effects of closure on the stockpiles (waste rock, low-grade ore, overburden), the TMF and the PPCP are addressed in the Site Water Quality TSD.

6.1.3.2.1.1 Pit Inflow

Seepage rates into the open pits have been estimated from a MODFLOW 3-Dimensional groundwater flow model as described in the Hydrogeology TSD.

Model results estimate a steady state seepage rate into the east and west pits of 740 m^3/day of which approximately 523 m^3/day is inflow from the adjacent Marmion Reservoir. These values influence the site water model, overall site discharge and overall site water quality.

An analysis of the initial stages of pit development was conducted to estimate inflows as excavation progresses below the water table and into the upper fractured rock. Drainage of rock exposed at the pit perimeter will release a significant volume of water (described as storage), during early mining primarily because of the higher volume of water stored in the upper fractured rock relative to the less fractured rock at greater depth. Groundwater inflows of approximately 1,200 m^3/d could be experienced during early mining. As excavation progresses below the upper fractured zone, the amount of water draining from the pit perimeter will decrease as the amount of fracturing decreases. Thus groundwater inflows from storage will decrease with the progressive excavation of the open pit.

Steady state model simulations were performed to develop predictions of groundwater inflow to the final pit shell for a base case with the hydraulic conductivity of the Shear Zones assigned as 5×10^{-8} m/s. Additional predictive runs were performed to develop a range of inflow estimates with higher hydraulic conductivity values assigned to the Shear Zones (10^{-6} and 10^{-5} m/s).

Estimated groundwater seepage into the completed open pit under steady state conditions is estimated at 740 cubic metres per day (m^3/d). As indicated in Table 6-28, the bulk of this inflow originates from below 30 m, with the bulk of the inflow originating from the Ore Zone and the relatively narrow Shear Zones. About half of this inflow is sourced from Marmion Reservoir with the balance originating as seepage from the adjacent stockpiles.

Table 6-28: Predicted Groundwater Inflow to Open Pit

Unit	Steady State Pit Inflow (m^3/d)	% Of Inflow
0 to 30 mbgs	0	0
Shear Zones (30+ mbgs)	268	36%

Table 6-28: Predicted Groundwater Inflow to Open Pit (Continued)

Unit	Steady State Pit Inflow (m^3/d)	% Of Inflow
Ore Zone (30+ mbgs)	370	50%
Host Rock Zone (30+ mbgs)	102	14%
Total	**740**	**100%**

Note:
mbgs = Metres below ground surface.

Simulated pre-mining groundwater elevations and surface water subwatersheds are shown in Figure 6-2 while simulated end of mining groundwater elevations are shown in Figure 6-3. The simulated groundwater drawdown extends to the shoreline of Marmion Reservoir on three sides of the open pit, except for a localized area in the vicinity of the PPCP. To the north and northeast, the cone of depression (as defined by the 1 m drawdown contour) extends about 700 m from the pit perimeter and underlies a portion of the WRMF and overburden stockpiles (Figure 6-4). If unmitigated a portion of the seepage losses from each of these stockpiles will discharge to the nearby Marmion Reservoir (Lynxhead Bay and/or Trap Bay) as shown in Table 6-29, of note is that there is a water management system in place to collect seepage from the site facilities including the stockpiles (WRMF, overburden and low grade ore) and the TMF. All potential seepage water is included in the assessment of overall site water quality as presented in the Site Water Quality TSD.

Table 6-29: Predicted Seepage Losses from Stockpiles and PPCP

Stockpile	Total Seepage (m^3/d)	Receptor	Receiving Discharge (m^3/d)
WRMF	241	east pit	133
		Marmion Reservoir (or water management system)	108
Low grade ore	32	west and east pits	32
Overburden	52	east pit	16
		Marmion Reservoir (or water management system)	36
PPCP	37	primarily west pit	36
		Marmion Reservoir (or water management system)	1

It should be noted that additional investigations will be conducted in the area of the PPCP to refine the understanding of subsurface conditions locally during the detailed design phase.

The estimated inflow of 740 m^3/d represents steady state conditions at the end of mining. The progressive dewatering of the bedrock perimeter during mining will result in higher inflows that will decline over time to this steady state estimate. Also, if unmitigated, seepage losses from the adjacent stockpiles and PPCP will initially report primarily to the adjacent Marmion Reservoir. Mitigation includes installation of a water management system utilizing ditching and seepage collection ponds. As dewatering progresses and groundwater levels beneath these stockpiles progressively decline, a greater percentage of the seepage losses will report to the open pit.

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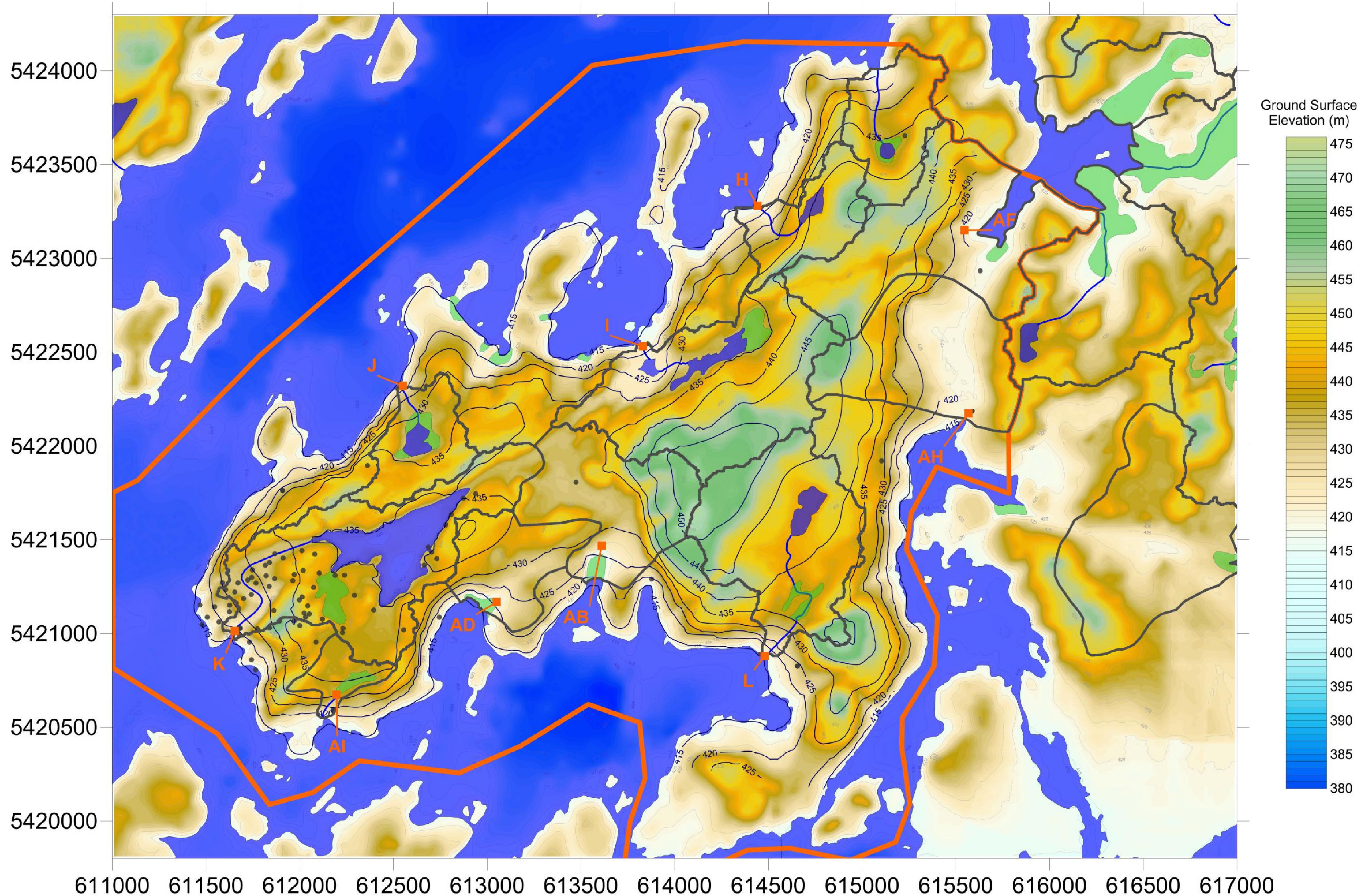

Notes

1. The current modelling work considers the pit shell provided by Osisko dated July 26, 2012.
2. The contour lines shown reflect the simulated water table elevations under Pre-Pit (current) conditions (5m contour interval).

Legend

Model Extent	Lakes	Streams/Rivers
Active Model Domain	Wetlands	Surface Water Subwatersheds
Simulated Water Table Elevation (m)	SW Flow Stations	GW Head Calibration Point

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
SIMULATED REGIONAL GROUNDWATER ELEVATIONS – PRE-MINING

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN / VERSION 2
DESIGN	CGE	14 Nov. 2008	
GIS	JO	2 Dec. 2013	
CHECK	SP	2 Dec. 2013	
REVIEW	SP	2 Dec. 2013	

FIGURE: 6-2

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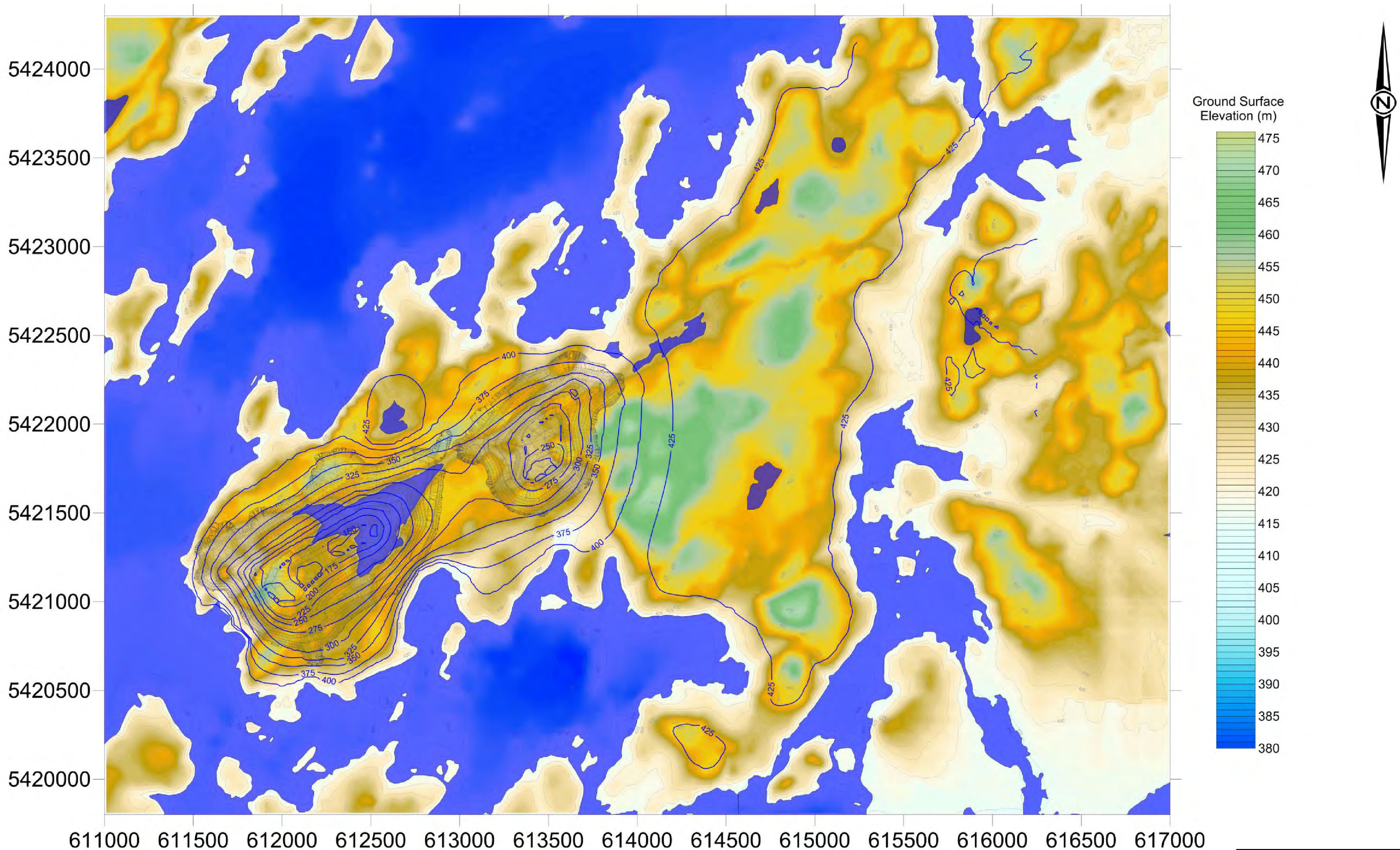

LEGEND

Simulated Groundwater Elevation

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

SIMULATED REGIONAL GROUNDWATER ELEVATIONS - END OF MINING

Golder Associates Mississauga, Ontario	PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
	DESIGN	CGE	14 Nov. 2008	**FIGURE: 6-3**	
	GIS	JO	2 Dec. 2013		
	CHECK	SP	2 Dec. 2013		
	REVIEW	SP	2 Dec. 2013		

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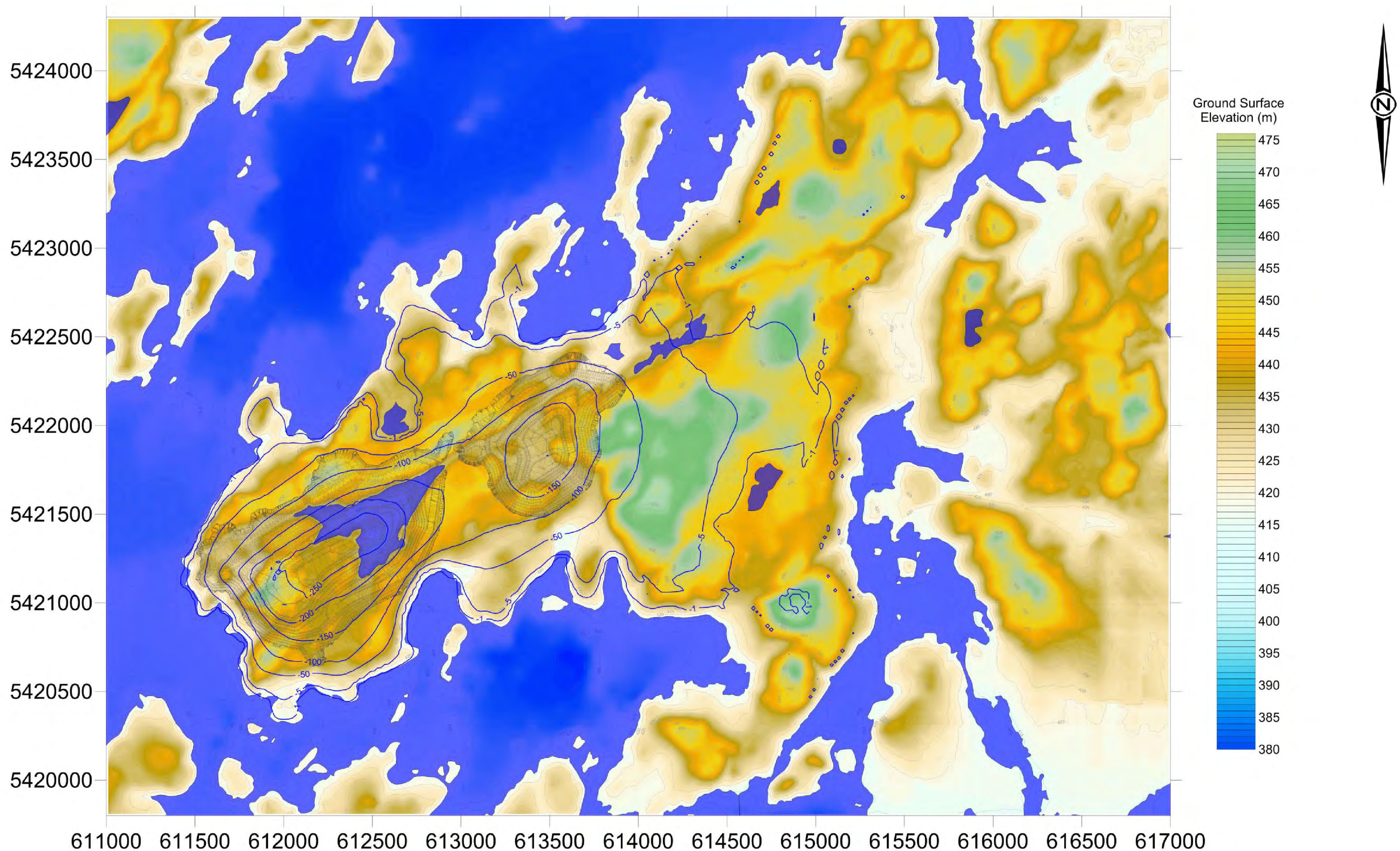

LEGEND

Simulated Groundwater Elevation

NOTES:

1.The contour lines shown reflect the change in simulated groundwater elevations from the calibrated Pre-Mining Model (Contour Interval -1. -5, -50, -100, -150, -200, -250, and -300m).

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

SIMULATED GROUNDWATER DRAWDOWN - END OF MINING

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	14 Nov. 2008	**FIGURE: 6-4**	
GIS	JO	2 Dec. 2013		
CHECK	SP	2 Dec. 2013		
REVIEW	SP	2 Dec. 2013		

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6.1.3.2.1.2 Effects Assessment – Hydrogeology

As discussed above, the cone of depression (as defined by the 1 m drawdown contour) extends about 700 m from the pit perimeter and underlies a portion of the WRMF and overburden stockpiles (Figure 6-4). Within the area of the cone of depression, groundwater levels have been lowered by pit dewatering resulting in a reduction or even elimination of flows in some local streams. Also within this area, seepage losses from the stockpiles may result in flow increases in the water management system.

About 344 m^3/d of the steady state inflow to the pit is derived from the surrounding regional system (including seepage from the PPCP and stockpiles). As a result, some baseflow loss occurs at hillside seeps (a total decrease from 152 to 82 m^3/d) and wetlands and streams (a total decrease from 68 to 37 m^3/d). However, additional seepage emanating from the stockpiles ultimately results in greater discharge to nearby surface water features or the seepage collection system.

Table 6-30 details changes to groundwater baseflow on a subwatershed level.

Table 6-30: Simulated Subwatershed Groundwater Discharge to Seeps, Wetlands and Streams

Subwatershed	Pre-Pit Discharge (m^3/d)	Ultimate Pit In-Place Discharge (m^3/d)	% Change
AB	32	0	-100%
AD	7	0	-100%
AF	17	25	+47%
AH	38	55	+45%
AI	1	0	-100%
G	8	8	0%
H	0	0	0%
I	41	25	-39%
J	13	1	-92%
K	42	0	-100%
L	21	0	-100%

Figure 6-2 provides the location of these sub-watersheds. It should be noted that in general, local streams in the vicinity of the open pit and stockpiles are intermittent and have been observed to be dry at times during the summer months. With the reduction or even elimination of baseflows in some streams, the period of time when any stream is dry will increase. Flow will still occur in these streams during the spring freshet and storm events. Further discussion of these effects is contained in the Hydrology TSD and in the Aquatic Environment TSD.

The existing geological conditions (Chapter 3) indicate that the upper section of the bedrock (the Upper Fractured Bedrock) to a depth of about 30 m appears more fractured than the underlying rock. Test data indicates low to moderate hydraulic conductivities (in the order of 10^{-6} to 10^{-7} m/s) for the Upper Bedrock where fractured and much lower values in unfractured bedrock. Groundwater hydrographs show that the bedrock is readily recharged where fractured. Most notably in the area near the proposed pits, groundwater discharge is evident from flowing wells and the numerous swampy wet areas at the base of sloped lands. The seasonal raising and lowering of the Marmion Reservoir is reflected in the groundwater hydrograph from only one monitoring location (BRH-0009) suggesting that direct hydraulic connections between the Reservoir and the upper fractured rock are limited.

The dominant structural features in bedrock at the area of the proposed pits comprise the Upper and Lower Shears and associated splays. Test pumping of 47 exploration boreholes that intersected these structures suggests that, for the most part, these features are not obviously more permeable than the bulk rock mass between the shears (i.e., the Ore Zone) although indications of structurally controlled flow within these Shear Zones have been observed.

Groundwater flow occurs primarily through a moderately well interconnected fracture network in the shear and Ore Zones in the area of the proposed open pits. This fracture network extends at least to approximately 350 m below ground (the base of the open pit) although fracturing shows a general frequency decrease with depth. Test data suggest hydraulic conductivity values range between 10^{-8} and 10^{-7} m/s with higher values encountered in the upper fractured zone and occasionally in the deeper rock. Where unfractured, hydraulic conductivity values of less than 10^{-10} m/s are expected.

Numerical modelling of the area around the proposed open pits indicates that steady state groundwater inflows of about 740 m^3/d are expected at the end of mining. About half of this inflow is derived from the adjacent Upper Marmion Reservoir with flow through the shears and ore zone with most of the balance derived from infiltration that by-passes the engineered collection systems at the adjacent stockpiles.

The Project is predicted to affect the flow in local streams. Within the cone of depression that develops around the open pits, flows at some streams are reduced or even eliminated while at other locations, seepage losses from the stockpiles may result in flow increases in the seepage collection system or some local streams. These effects are addressed in the Hydrology TSD and the Aquatic Environment TSD.

Given the lateral continuity of the Shear Zones beneath the adjacent Upper Marmion Reservoir and the high hydraulic gradients that will develop around the pit, more permeable fracture connections to Upper Marmion Reservoir could develop as mining progresses. Computer simulations suggest that steady state inflows of about 1,800 m^3/d could develop where more permeable Shear Zones develop. Inflows in excess of this amount would occur in the unlikely situation that unconsolidated fracture infill material was completely flushed (because of the progressive increase in hydraulic gradients) forming an open fracture connection between the pit and Upper Marmion Reservoir.

Groundwater inflows to the pit will be managed utilizing in-pit sumps and inflows from the upper fractured rock could be gravity drained via bench channels at higher elevation areas of the pit wall.

In the event that areas of persistent seepage develop on pit slopes and/or slopes are not adequately depressurized, angle drain holes may be required to maintain stability. In the event of greater than expected inflows, additional mitigation such as vertical wells or grout curtains could be required.

6.1.3.3 Water and Sediment Quality

Changes to site discharge and water quality in site, local and regional scale watercourses from baseline conditions are expected to occur in all four phases of the Project. However, the assessment considers the average conditions and uses a bounding, or worst case scenario where the combination of Project activities results in the greatest changes to water and sediment quality.

Based on a review of the anticipated activities performed in each phase the greatest potential for water quality effects occurs during the operations phase. The changes in water quantity and quality that may occur during the Construction Phase will be associated with development of infrastructure. These changes, if any, will be minor and encompassed by changes expected during operations. The presence of a flooded open pit will also have an influence on water quality and thus a post-closure assessment was completed. For lakebed sediment quality, the potential TSS discharge from the site and air deposition was considered at the end of mine life.

6.1.3.3.1 Model Development

In general, for each Project phase an assessment of alternatives was completed as defined and provided in Chapter 4. Following this, the preferred alternative was carried forward for more detailed evaluation and modelling. The Project definition and understanding of the hydrogeology, hydrology, geochemical conditions was used to develop a water management plan (Site Water Quality TSD) which was used as model input to the Water Balance Model and the Site Water Quality model, and to develop water quantity and quality results for site discharge. Hydrological and bathymetric information from the lakes was then used to develop a hydrodynamic model (Lake Water Quality TSD).

A mixing model based on the hydrodynamic modelling was developed which used the results of the hydrodynamic model combined with the existing baseline water quality and predicted discharge water quality to develop estimates of lake water quality for a range of water quality parameters and conditions. The ultimate discharge water quality and lake water quality concentrations were developed for operations and post-closure conditions for all parameters where information was available (Site Water Quality TSD; Lake Water TSD). Additional mixing modelling was undertaken to understand near-field diffuser mixing as presented in supplemental hydrology information in the Lake Water Quality TSD.

Variability was assessed by running the models for various site conditions, geochemical conditions, baseline conditions, and discharge conditions (Site Water Quality TSD; Lake Water Quality TSD).

6.1.3.3.1.1 Upper Marmion Reservoir

Modeling was undertaken for Upper Marmion Reservoir, since the Reservoir would receive discharge from the effluent treatment plant (ETP) during operations, and overflow from the flooded open pits in post-closure. The objectives of the modelling were two-fold:

- To understand the mixing characteristics of the basin and to predict water quality during operations to allow for subsequent evaluation of potential for effects on humans or non-human biota.
- To predict water quality in the Reservoir in post-closure to allow for subsequent evaluation of potential for effects on humans or non-human biota.

The development of lake water quality model followed the approach described below:

- Input flows to be used for water quality modelling (from the Hydrology TSD; Water and Sediment Quality TSD; and Site Water Quality TSD) were defined, including the following:
- Average and low flow.
- Average and maximum percentile water quality.

Hydrodynamic modelling based on drogue studies, data from ADCPs (Acoustic Doppler Current Profilers), and data from the Seine River Management Plan was completed to determine mixing proportions throughout the basin(s) and lake bodies for each of the following key lake locations:

- Upper Marmion Reservoir.
- Lizard Lake.

Boundary scenarios modeled for lake water quality predictions were defined for the following temporal conditions:

- Operations (water flows and quality) and post closure (water flows and quality).
- Key scenarios were defined for site discharge water quality from the Site Water Quality TSD that will be used in combination with the proportions as defined in the mixing model.
- The calculations to develop the final predicted lake water quality concentrations were completed.
- Details on the development of the model are presented in full in the Lake Water Quality TSD.

A number of combinations of lake water quality were developed depending on the possible input scenarios from which an expected case and upper bound scenario were determined. The scenarios described were:

- Upper Marmion Basin during operations.
- Upper Marmion Basin post closure.
- Upper Marmion Basin runoff.
- Lizard Lake during operations.
- Lizard Lake Post Closure.

The modeling included the following assumptions:

- To be conservative in the evaluation of the effects of the Project on Lizard Lake, an allowance was provided for seepage to Lizard Lake that was equivalent to 10% of the seepage reporting to the collection system along the east side of the TMF.
- Operations input water quality for the TMF seepage was derived from the water quality from process tailings during operations (details are provided in the Site Water Quality TSD).

- Post closure input water quality for TMF seepage was derived from the average of steady state conditions of the final five weeks of humidity cell testing as described in the Site Water Quality TSD.
- Climatic variations were not applied to TMF seepage values as seepage water quality is assumed to be independent of surface climate effects.
- It was assumed that no discharge will occur in 1-in-10 year dry climate, therefore predictive mixing does not apply.

For the hydrodynamic modeling, the Upper Marmion Reservoir was divided into a number of compartments corresponding to different flows and mixing characteristics. Within each compartment, water movements were modeled. These results provided the basic water movement patterns upon which the predicted water concentrations for the selected parameters are based. The details are provided in the Lake Water Quality TSD.

- Most of the basins in the modelled area have a residence time of less than 10 days. The exceptions are the northern and central basins of Sawbill Bay and unnamed basin #10 which have residence times that are over 300 days. The northern and central basins of Sawbill Bay can be represented as a single basin (as determined above). Table 6-31 also shows that the residence time for these two basins is approximately 910 days when they are treated as a single model basin.

Subsequent to the initial modelling, a preliminary diffuser design and supplemental mixing model was completed in response to government requests to predict and demonstrate near-field mixing characteristics at the proposed discharge. The results of this modelling show that mixing occurs in a small localized zone, as detailed in the supplement information package to the Lake Water Quality TSD).

Table 6-31: Summary of Basin Volumes and Residence Time

Basin	Common Name	Volume (m^3)	% of Total	Residence Time (days)
1	Trap Bay	2,300,000	1.1%	0.78
2	Lynxhead Bay	19,900,000	9.1%	6.8
3	—	2,400,000	1.1%	1.0
4	—	1,500,000	0.7%	2.6
5	—	4,600,000	2.1%	2.3
6	—	9,100,000	4.2%	12
7a	Southern Sawbill Bay	16,600,000	7.6%	110
7b	Central Sawbill Bay	90,900,000	41.5%	730[(a)]
7c	Northern Sawbill Bay	43,500,000	19.9%	310[(a)]
7b and 7c	Central and Northern Sawbill Bay	134,400,000[(b)]	61.4%[(b)]	910[(b)]
8	—	10,500,000	4.8%	3.5
9	—	6,700,000	3.1%	2.2
10	—	3,100,000	1.4%	1,200
11	—	7,900,000	3.6%	2.6
Total	**Upper Marmion Reservoir**	**219,000,000**	—	**73**

Note:

(a) Estimated residence time for Central and Northern Sawbill Bay does not include effect of wind driven exchange flows.

(b) Estimated volume and residence time when model basins 7B and 7C are considered as one basin in the model.

6.1.3.3.1.2 Lizard Lake

Modeling was also undertaken for Lizard Lake as a conservative measure, assuming a worst case scenario of 10% seepage loss from the TMF to the lake. A summary of the compartment (basin) volumes and average residence times based on the output from the screening level model is provided in Table 6-32.

Table 6-32 shows that approximately 60% of the total volume of Lizard Lake is in the southern basin. As a result, the retention time of the southern basin is approximately double the retention times of the central and northern basins. The total retention time of Lizard Lake is approximately 184 days.

Table 6-32: Summary of Basin Volumes and Retention Times

	Lizard Lake			
	Northern	**Central**	**Southern**	**Total**
Model Basin	**1**	**2**	**3**	
Approximate Volume (m^3)	1,970,000	2,310,000	6,100,000	10,390,000
Fraction of Total Volume	19%	22%	59%	100%
Average Inflow (m^3/s)	0.52	0.58	0.65	0.65
Retention Time (days)	44	46	108	184

Over the 30-year simulation period, the water level in Lizard Lake is expected to have a range of approximately 0.6 m between 426.4 masl and 427.0 masl.

6.1.3.3.2 Water Quality Predictions during Operations Phase

Water quality predictions during operations were modeled for the two active discharges: discharge from the PPCP to the south end of Sawbill Bay during those periods when there is excess water not required for the process resulting in treated effluent discharge, and discharge of the domestic sewage treatment system to the north end of Sawbill Bay.

While no active discharge will occur from the TMF, the potential for some seepage to by-pass the seepage collection system has been considered, and changes in water quality in Lizard Lake due to seepage from the TMF has also been predicted.

6.1.3.3.2.1 Upper Marmion Reservoir

As noted in Chapter 5, the Project will re-use water during processing to the maximum extent practicable. However, make up water will still be required, and this will be sourced from Sawbill Bay. Table 6-33 provides a summary of the average daily makeup water requirements on a monthly basis.

Since water will be re-used to the maximum extent possible and additional makeup water will be required on a daily basis, it is predicted that during some periods, there will be minimal or no discharge of treated effluent from the ETP. In particular, during drier than average years, there are extended periods when all water will be re-used, and there will be no active discharge from the site. The predicted intake and discharge flows to Sawbill Bay are summarized in Table 6-33 on a monthly basis.

Table 6-33a shows that under most conditions, the average monthly intake flow will be 301.5 m^3/hr. In dry years, the intake flow is predicted to increase up to 898 m^3/hr.

Table 6-33b shows that no effluent discharge is expected in dry years or during some of the winter months. The discharge rate is expected to increase in extremely wet conditions.

Table 6-33a: Estimated Monthly Mine Intake Flows for Return Period Conditions for Operations Phase

Return Period[a]		Estimated Mine Intake from Sawbill Bay (m^3/h)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Return Period	100	864.8	898.0	832.4	301.5	349.9	301.5	301.5	301.5	301.5	397.3	684.3	800.2
	50	861.6	898.0	826.2	301.5	301.5	301.5	301.5	301.5	301.5	301.5	477.6	791.4
	25	858.0	898.0	819.1	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	558.1
	10	490.9	898.0	808.2	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
Average[b]		301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
Wet return period	10	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
	25	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
	50	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5
	100	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5	301.5

Note:

(a) Return periods based on precipitation records at Atikokan.

(b) Average conditions based on a 2-year return period.

Table 6-33b: Estimated Monthly Mine Discharge Flows for Return Period Conditions for Operations Phase

Return Period[a]		Estimated Mine Discharge into South End of Sawbill Bay (m^3/h)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Return Period	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average[b]		56.3	0.0	0.0	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3
Wet return period	10	202.0	0.0	0.4	236.7	235.6	236.7	235.6	235.6	230.5	250.9	202.0	202.0
	25	259.2	0.0	3.2	328.6	326.4	328.6	326.4	322.6	339.6	309.6	259.2	259.2
	50	255.4	0.0	32.9	394.9	391.8	394.9	391.8	389.8	386.4	349.1	297.7	297.7
	100	228.5	0.0	139.9	442.9	439.3	442.9	439.3	452.8	467.2	384.1	331.8	331.8

Note:

(a) Return periods based on precipitation records at Atikokan.

(b) Average conditions based on a 2-year return period.

Based on predicted flows and lake mixing characteristics, the south end of Sawbill Bay was identified as the optimum location for the discharge from the ETP (the discharge location is shown on Figure 6-5a). This location offered the best mixing characteristics within a reasonable distance from the ETP (the selection of discharge alternatives was discussed in Chapter 4; details on mixing characteristics of each basin are provided in the Lake Water Quality TSD). Predicted discharge water quality is provided in the Site Water Quality TSD and Lake Water Quality TSD and is compared to relevant discharge water quality values in Table 6-34.

The predicted average water quality in the south end of Sawbill Bay was calculated and the results are provided in Table 6-35. The estimates in Table 6-35 are based on average baseline Upper Marmion Reservoir water quality data, average site discharge concentration, steady-state climatic conditions and average mixing for the operations scenario.

In addition to the basin mixing model predictions, modeling of near-field mixing was completed for the key parameters copper and cyanide for the operations phase and the results are provided in Figure 6-5a and 6-5b for far field (Upper Marmion Reservoir) and near field (in the vicinity of the diffuser). Results show that a 10:1 dilution is reached within approximately 10 m of the diffuser and that a 50:1 dilution is reached within approximately 50 m of the dilution. For key parameters cyanide and copper, the SSWQO are predicted to be reached within distances of 29 m and 18 m, respectively, from the diffuser ports (equal to dilution ratios of approximately 16:1 for copper and 26:1 for cyanide at the maximum design discharge). Details of the near-field mixing model and initial diffuser design are provided in the supplemental information package of the Lake Water Quality TSD.

Table 6-34: Point of Discharge Comparison to Discharge Guidelines

Parameter	Units	Guidelines		Point of Discharge (Marimion Basin)[c]
		MMER[a]	MISA[b]	
Total Cyanide	mg/L	1	1	0.19
Arsenic	mg/L	0.5	0.5	0.000047
Copper	mg/L	0.3	0.3	0.11(e)
Lead	mg/L	0.2	0.2	0.00032
Nickel	mg/L	0.5	0.5	0.009
Zinc	mg/L	0.5	0.5	0.0093
TSS[d]	mg/L	15	15	<15
Ra 226[e]	Bq/L	0.37	—	—

Note:

(a) Metal Mining Effluent Regulations. SOR/2002-222. Schdule 4, Column 2, Maximum Authorized Monthly Mean Concentration

(b) Municipal/Industrial Strategy for Abatement (MISA). O. Reg. 560/94 Effluent Monitoring and Effluent Limits - Metal Mining Sector. Schedule 1, Monthly Average Concentration Limit

(c) Average Maximum concentrations provided as indicated in Lake Water Quality TSD and Site Water Quality TSD for main discharge point at diffuser. Discharge from the sewage treatment plant will be actively treated to meet appropriate guidelines.

(d) TSS will be maintained at <15 mg/L through active treatment if necessary

(e) Ra 226 is not expected at this site based

— no guideine or value not calculated as it is not expected

Table 6-35: Results for Average Water Quality Predictions in Sawbill Bay, South End, During Operations

Parameter	Unit	Receiving WQ Guidelines(a)		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir near Raft Lake Dam
		CCME CWQG	PWQO		Proportion (%)	
					0.00118	**0.00087**
Physical-Chemical						
pH	—	6.5-9	6.5-8.5	6.5	6.5 – 7.8	6.5 – 7.8
Acidity	mg/L	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	19	19	19
Conductivity	µS/cm	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	53	-	-
Major Ions						
Calcium	mg/L	—	—	6.4	6.5	6.5
Chloride	mg/L	120	—	1.1	1.1	1.1
Fluoride	mg/L	—	—	0.031	-	-
Magnesium	mg/L	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	0.68	0.71	0.7
Sodium	mg/L	—	—	1.3	1.4	1.3
Sulphate	mg/L	—	—	1.6	1.8	1.8
Hardness	mg($CaCO_3$)/L	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	0.001	0.0012	0.0012
Cyanide (total)	mg/L	—	—	0.001	0.0012	0.0012
Nutrients						
Nitrate-N	mg/L	13	—	0.063	0.065	0.064
Ammonia-N	mg/L	—	—	0.023	0.041	0.036
Un-ionized ammonia	mg/L	0.019	0.02	0.000067	0.00027	0.00022
Phosphorus	mg/L	—	0.02	0.013	0.013	0.013
Dissolved Metals						
Aluminum (b)	mg/L	0.005-0.1	0.015-0.075	0.03	0.03	0.03
Antimony	mg/L	—	0.02	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	0.0071	0.0071	0.0071
Beryllium (d)	mg/L	—	0.011-1.1	0.00028	-	-
Bismuth	mg/L	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	0.014	0.014	0.014
Cadmium (c)	mg/L	see notes	0.0001-0.0005	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	0.00017	0.00017	0.00017
Copper (d)	mg/L	0.002-0.004	0.001-0.005	0.0011	0.0012	0.0012

Table 6-35: Results for Average Water Quality Predictions in Sawbill Bay, South End, During Operations (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir near Raft Lake Dam
		CCME CWQG	PWQO		Proportion (%)	
					0.00118	**0.00087**
Dissolved Metals (Continued)						
Iron (total)	mg/L	0.3	0.3	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	0.00036	0.00043	0.00041
Nickel [d]	mg/L	0.025-0.15	0.025	0.00099	0.001	0.00099
Selenium	mg/L	0.001	0.1	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	0.013	0.013	0.013
Thallium	mg/L	0.0008	0.0003	0.000084	0.000084	0.000084
Tin	mg/L	—	—	0.00071	0.00074	0.00073
Titanium	mg/L	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	0.0045	-	-
Uranium	mg/L	0.015	0.005	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	0.0015	-	-

Note:

Underlined values exceed PWQO criteria. **Bold** values exceed CCME CWQGs.

- = Site water quality data was not modeled for this parameter.

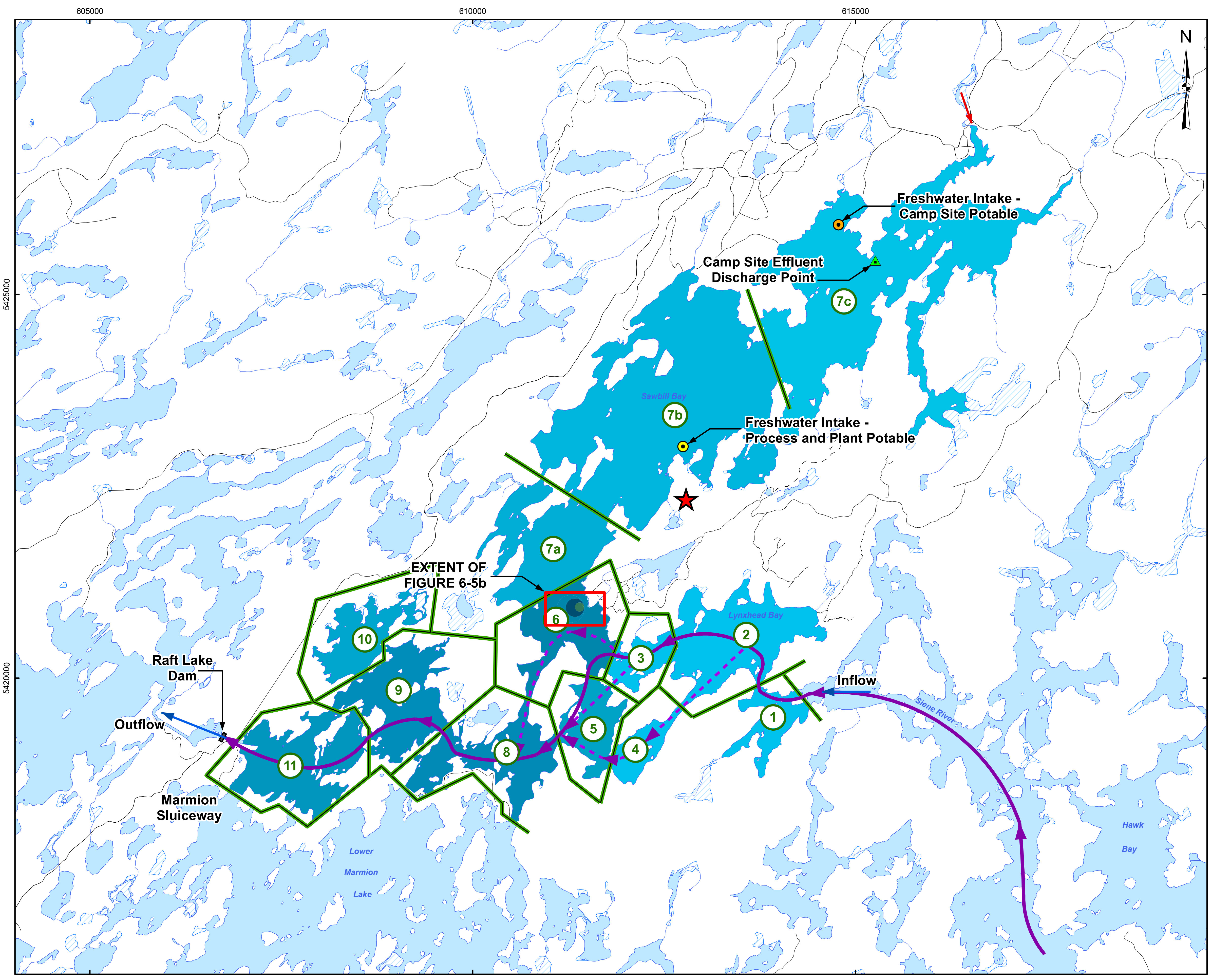
— = Receiving water quality criteria do not exist for this parameter.

(a) See Lake Water Quality TSD Appendix III for the list of all parameters, criteria and notes.

(b) Aluminum PWQO and CWQG range is pH dependent. See Lake Water Quality TSD Appendix III for details.

(c) Cadmium CWQG is calculated using a formula (See Lake Water Quality TSD Appendix III) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel criteria are hardness dependent. See Lake Water Quality TSD Appendix III for details.



LEGEND

- Proposed Location of Mine Processing Plant
- Effluent Discharge Point
- Freshwater Intake - Camp Site Potable
- Freshwater Intake - Process and Plant Potable
- Main River Flow
- Secondary Flow Path
- Major Tributaries
- Road
- River/Stream
- Lake
- Wetland
- Model Compartment

Average Mixing Proportion (%)	Worst Case Cu Concentration (µg/L)	Worst Case CN Concentration (µg/L)
0	1.00	1.00
0.011	1.01	1.02
0.012	1.01	1.03
0.045	1.05	1.10
0.076	1.08	1.17
0.085	1.09	1.19
0.087	1.09	1.19
0.089	1.10	1.20
0.09	1.10	1.20
0.118	1.13	1.26
0.2	1.22	1.45
1	2.09	3.24
5	6.45	12.2
10	11.9	23.4

NOTE:

Plume dilution shown for maximum design discharge (Q = 0.12m^3/s)

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500 1,000 1,500 2,000
SCALE 1:50,000 METRES

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

LAKE WATER MIXING MODEL RESULTS - FAR FIELD IN UPPER MARMION RESERVOIR

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010		
DESIGN	CGE	14 Nov. 2008
GIS	JO	2 Dec. 2013
CHECK	KDV	2 Dec. 2013
REVIEW	KDV	2 Dec. 2013

SCALE AS SHOWN VERSION 2

FIGURE: 6-5a

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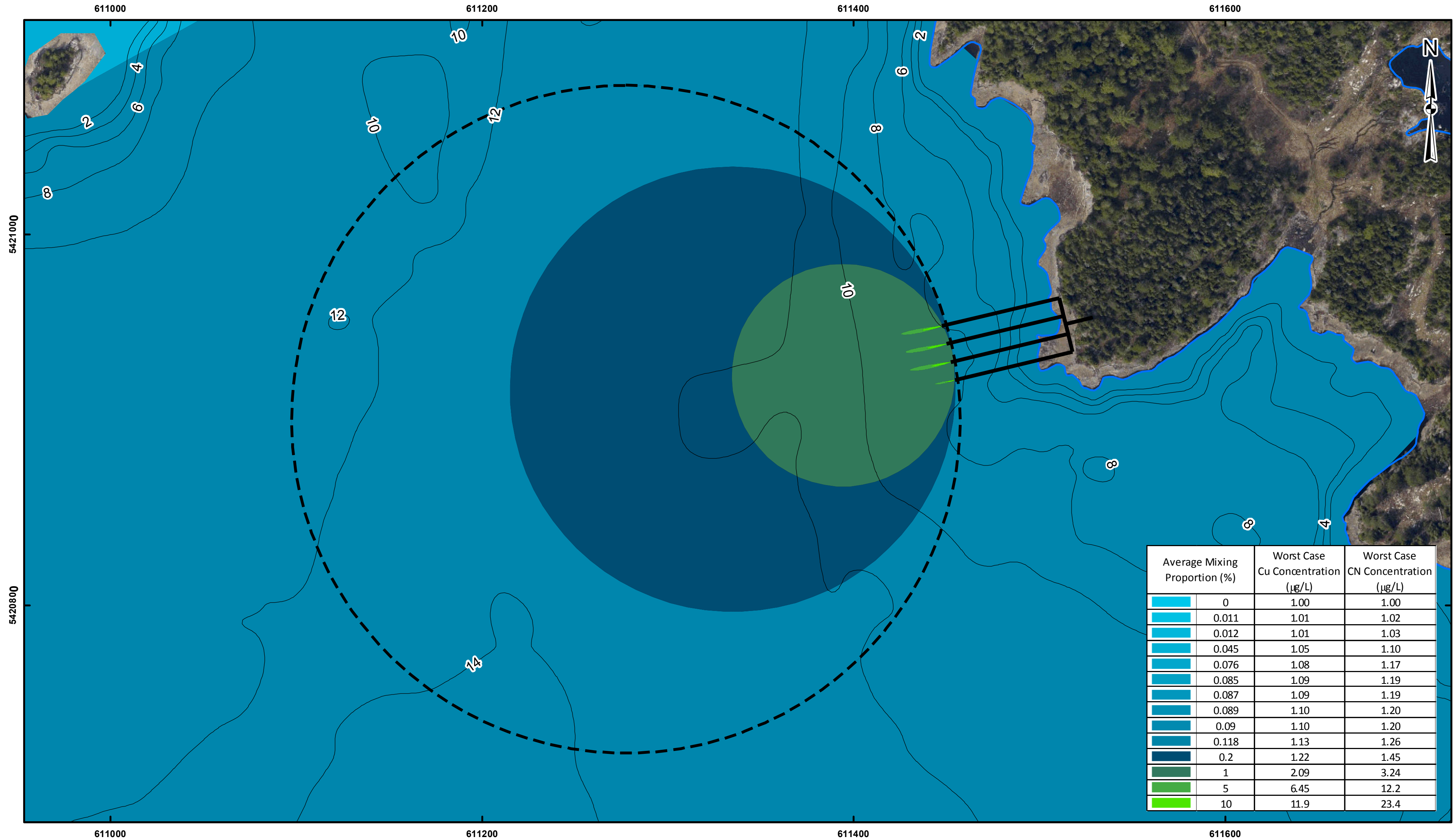

Average Mixing Proportion (%)	Worst Case Cu Concentration (µg/L)	Worst Case CN Concentration (µg/L)
0	1.00	1.00
0.011	1.01	1.02
0.012	1.01	1.03
0.045	1.05	1.10
0.076	1.08	1.17
0.085	1.09	1.19
0.087	1.09	1.19
0.089	1.10	1.20
0.09	1.10	1.20
0.118	1.13	1.26
0.2	1.22	1.45
1	2.09	3.24
5	6.45	12.2
10	11.9	23.4

LEGEND

- Conceptual Effluent Pipeline
- Bathymetry Contour
- Shoreline

25 12.5 0 25 50 75 100

SCALE 1:3,000 Meters

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

NOTE:

Plume dilution shown for maximum design discharge (Q = 0.12m^3/s)

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

LAKE WATER MIXING MODEL RESULTS - NEAR FIELD AT DIFFUSER DISCHARGE

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	16 Mar. 2012		
GIS	JO	2 Dec. 2013		
CHECK	KDV	2 Dec. 2013		
REVIEW	KDV	2 Dec. 2013		

FIGURE: 6-5b

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At the point of discharge concentrations are lower than the MMER and MISA criteria (Table 6-34). Following initial mixing (within 50 m of discharge) all predicted concentrations during average site discharge conditions during operations are lower than the CWQG, and PWQO, criteria. In general, the predicted results are the same as or marginally greater than average Upper Marmion Reservoir baseline concentrations.

- The sulphate concentrations in the water column during average conditions are predicted to increase marginally from 1.6 mg/L as measured in the baseline studies to 1.8 mg/L. Methyl mercury production has been identified as a process that typically occurs in the deeper anoxic waters and sediments of lakes (Ullrich et al. 2001). The water column profiles for Sawbill Bay (discussed in Chapter 3) indicate that anoxic conditions are unlikely to occur in the deeper basin of the lake. As a result, the slight change in sulphate levels is considered likely to result in negligible change in methyl mercury concentrations in Sawbill Bay since any increased methylation in the sediments is likely to be counteracted by demethylation in the water column.

In addition to assessing water quality under average conditions, water quality was also predicted under upper bounding (or worst case) conditions whereby average baseline data, maximum predicted lab data for site discharge, and low flow conditions were used. These are presented in Table 6-36.

Table 6-36: Upper Bound Water Quality Predictions in Sawbill Bay, South End, During Operations.

Parameter	Unit	Receiving WQ Guidelines[(a)]		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir near Raft Lake Dam
		CCME CWQG	PWQO		Proportion (%)	
					0.01518	**0.00974**
Physical-Chemical						
pH	—	6.5-9	6.5-8.5	6.5	6.5 – 8.3	6.5 – 8.3
Acidity	mg/L	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	19	19	19
Conductivity	µS/cm	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	53	-	-
Major Ions						
Calcium	mg/L	—	—	6.4	6.7	6.6
Chloride	mg/L	120	—	1.1	1.8	1.5
Fluoride	mg/L	—	—	0.031	-	-
Magnesium	mg/L	—	—	1.3	1.4	1.4
Potassium	mg/L	—	—	0.68	1.2	1
Sodium	mg/L	—	—	1.3	2.7	2.2
Sulphate	mg/L	—	—	1.6	4.9	3.7
Hardness	mg($CaCO_3$)/L	—	—	21	22	22
Cyanide (free)	mg/L	0.005	0.005	0.001	0.0012	0.0012
Cyanide (total)	mg/L	—	—	0.001	0.0012	0.0012
Nutrients						
Nitrate-N	mg/L	13	—	0.063	0.085	0.077
Ammonia-N	mg/L	—	—	0.023	0.251	0.17
Un-ionized ammonia	mg/L	0.019	0.02	0.000067	0.0096	0.0062
Phosphorus	mg/L	—	0.02	0.013	0.013	0.013
Dissolved Metals						
Aluminum [(b)]	mg/L	0.005-0.1	0.015-0.075	0.03	0.03	0.03
Antimony	mg/L	—	0.02	0.00078	0.0008	0.00079
Arsenic	mg/L	0.005	0.1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	0.0071	0.0072	0.0071
Beryllium [(d)]	mg/L	—	0.011-1.1	0.00028	-	-
Bismuth	mg/L	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	0.014	0.014	0.014
Cadmium [(c)]	mg/L	see notes	0.0001-0.0005	0.000036	0.000039	0.000038
Chromium (total)	mg/L	0.009	0.009	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	0.00017	0.0002	0.00019
Copper [(d)]	mg/L	0.002-0.004	0.001-0.005	0.0011	**0.0028**	**0.0022**

Table 6-36: Upper Bound Water Quality Predictions in Sawbill Bay, South End, During Operations (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir near Raft Lake Dam
		CCME CWQG	PWQO		Proportion (%)	
					0.01518	**0.00974**
Dissolved Metals (Continued)						
Iron (total)	mg/L	0.3	0.3	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	0.024	0.025	0.025
Mercury	mg/L	0.000026	0.0002	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	0.00036	0.0014	0.001
Nickel [d]	mg/L	0.025-0.15	0.025	0.00099	0.0011	0.0011
Selenium	mg/L	0.001	0.1	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	0.013	0.018	0.016
Thallium	mg/L	0.0008	0.0003	0.000084	0.000085	0.000085
Tin	mg/L	—	—	0.00071	0.0011	0.00099
Titanium	mg/L	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	0.0045	-	-
Uranium	mg/L	0.015	0.005	0.0022	0.0023	0.0023
Vanadium	mg/L	—	0.006	0.0005	0.0005	0.0005
Zinc	mg/L	0.03	0.02	0.0052	0.0053	0.0052
Zirconium	mg/L	—	0.004	0.0015	-	-

Note:

Underlined values exceed PWQO criteria. **Bold** values exceed CCME CWQGs.

- = Site water quality data was not modeled for this parameter.

— = Receiving water quality criteria/guidelines do not exist for this parameter.

(a) See Lake Water Quality TSD Appendix III for the list of all parameters, criteria and notes.

(b) Aluminum PWQO and CWQG range is pH dependent. See Lake Water Quality TSD Appendix III for details.

(c) Cadmium CWQG is calculated using a formula (See Lake Water Quality TSD Appendix III) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Lake Water Quality TSD Appendix III for details.

All predicted concentrations under upper bounding site discharge to Upper Marmion Reservoir for the operations phase are lower than both the PWQO and CWQG criteria. In general, the predicted results are the same as, or marginally greater than, average Upper Marmion Reservoir baseline concentrations. Addition of predicted air deposition data for metals from the air quality modeling (described in the Atmospheric Environment TSD and the Lake Water Quality TSD), did not result in any change to the predicted dissolved metal concentration (accounting for rounding to significant digits), indicating that atmospheric deposition to surface waters would have a negligible effect on water quality in Upper Marmion Reservoir.

Copper showed a slight increase when using the upper bound discharge conditions to predicted concentrations slightly above the CWQG (predicted maximum concentration was 0.0028 mg/L compared to the CWQG of 0.002 mg/L) and the PWQO (adjusted for water hardness of 21 mg/L). The significance of this exceedance is assessed in the Human Health and Ecological Risk Assessment TSD, and is discussed in Section 6.2.2 with respect to potential effects on the aquatic environment.

An increase in sulphate concentrations may affect mercury methylation rates; however, this would be dependent on other factors. In particular, mercury methylation has been associated with anoxic conditions, as would persist in the deeper water of lakes that experience periods of anoxia. The water column profiles for Sawbill Bay indicate that the deep basins do not experience periods of anoxia, and, therefore, the increased sulphate concentrations would not be expected to have a significant effect on mercury methylation rates. As numerous studies have indicated (e.g., Ullrich et al. 2001, Eckley et al. 2005, Roy et al. 2009), mercury methylation occurs mainly under anoxic conditions with wetlands identified as a major site of mercury methylation.

No changes are predicted to sediment concentrations of metals since there is no predicted change in metals concentrations in surface waters. The slight increase in sulphate, as discussed above could result in a slight increase in sediment concentrations, but is unlikely to result in an increase in sediment methyl mercury generation. The marginal increase in cyanide concentrations (0.0012 mg/L) compared to baseline in surface waters (0.001 mg/L) under predicted worst case conditions are not expected to result in increased concentrations in sediments. Since approximately 99% of free cyanide is present as HCN at circum-neutral pH (Eisler 1991), and HCN is highly water soluble, free cyanide is not predicted to accumulate in sediments. Cyanides under the oxic conditions that have been documented in Lizard Lake and Sawbill Bay will be rapidly metabolized and therefore are unlikely to persist in the water column.

Worker Accommodation Camp Discharge

Water quality changes as a result of operation of the worker accommodation camp were also predicted based on the design criteria for the camp sewage treatment plant.

In the water quality model, the water quality and flow rate of camp discharge was conservatively assigned values based on the sewage treatment plant (STP) design criteria as follows:

- Design flow of 300 m^3/day
- Outflow chemistry of 10 mg/L nitrate, 10 mg/L ammonia, 0.5 mg/L phosphorus, 1 mg/L carbonaceous biochemical oxygen demand (cBOD), and 15 mg/L TSS.

The mixing model assumed that discharge would occur during operations and would be in addition to discharge from the PPCP.

The predicted nutrient mixing concentrations using average input values identified above and an average flow rate of water out of the basin of 1.28 x 10^7 L/d did not result in nutrient concentrations in exceedances of any water quality guidelines with the exception of phosphorus. This flow rate was conservatively assigned a 7-day 1 in 20 year low flow for the hydrology monitoring station SW-01, (Hydrology TSD). Table 6-37 presents the sum of average baseline nutrient concentrations and predicted sewage input concentrations in Sawbill Bay.

Table 6-37: Predicted Mixing and Predicted Total Nutrient Concentrations for Mixing In Sawbill Bay

Parameter	Units	Receiving WQ Guidelines[(a)]			Sawbill Bay		
		ODWS	*CCME CWQG*	PWQO	Predicted Mixing STP Discharge	PPCP Discharge	STP + PPCP
Nitrate	mg/L	10	13	—	0.23	0.086	0.32
Ammonia	mg/L	—	—	—	0.23	0.020	0.26
Unionized Ammonia[(b)]	mg/L	—	0.02	0.02	0.00016	0.00010	0.00026
Phosphorus	mg/L	—	—	0.02	0.23	0.009	0.24
cBOD	mg/L	—	—	—	0.35	—	0.35
TSS	mg/L	—	+5-25	—	0.35	2.24	2.59

Note:

(a) See Appendix 2.IV for detailed notes for water quality guidelines.

(b) Unionized ammonia calculated as ƒ x [NH3 + NH4]: ƒ = 1/(10pKa-pH +1), where ƒ is the fraction of NH3; pKa = 0.09018 + 2729.92/T; T = ambient water temperature in Kelvin (K = °C + 273.16).

Predicted concentrations of nutrients at the Raft Lake Dam did not exceed guidelines for any of the parameters (details are provided in the Lake Water Quality TSD).

For phosphorous, it is expected that site camp controls such as use of phosphorous free detergents will be effective in maintaining phosphorous values in Sawbill Bay at levels below or near PWQO. These values will be monitored during operations and adjustments to the domestic waste water treatment system (such as addition of a phosphorous removal circuit) may be necessary if management controls are ineffective.

6.1.3.3.2.2 Lizard Lake

During the operations phase, seepage water from the TMF will be collected in sumps at the toe of the TMF containment dam and pumped back into the TMF. However, in order to conservatively estimate the effects on Lizard Lake, an assumption that 10% of the seepage may bypass the seepage collection system and drain to Lizard Lake was incorporated. Therefore, the potential effects of seepage on Lizard Lake were also modeled in the operations phase

TMF seepage rates were based on a preliminary seepage analysis as described in the Site Water Quality TSD, and were assumed to drain to one of the three basins of Lizard Lake. The predicted proportions (in %) of seepage from TMF seepage in the three Lizard Lake basins show that:

- The highest average seepage concentrations occur in Southern Lizard Lake (0.41%).
- The highest predicted seepage concentrations occur in Central Lizard Lake (0.95%) and Northern Lizard Lake (0.81%). This is likely the result of the relatively low volumes of the Northern and Central Basins when compared to the volume of the Southern Basin.

Results for average water quality predictions in Lizard Lake during operations are presented in Table 6-38. The predictions are based on the average baseline Lizard Lake water quality, average TMF seepage discharge, and average mixing for the operational scenario.

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Table 6-38: Average TMF Seepage Water Quality Predictions for Lizard Lake during Operations

Parameter	Unit	Receiving WQ Guidelines[a]		Lizard Lake Baseline	Northern	Central	Southern
		CCME CWQG	PWQO		Proportion (%)		
					0.0028	**0.0039**	**0.0041**
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	7	7.0 – 7.8	7.0 – 7.8	7.0 – 7.8
Acidity	mg/L	—	—	2.9	-	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	27	-	-	-
Conductivity	µS/cm	—	—	63	-	-	-
Total Suspended Solids	mg/L	-20	—	2.1	-	-	-
Total Dissolved Solids	mg/L	—	—	55	-	-	-
Major Ions							
Calcium	mg/L	—	—	10	10	10	10
Chloride	mg/L	120	—	0.25	0.34	0.37	0.38
Fluoride	mg/L	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	0.9	0.94	0.96	0.96
Potassium	mg/L	—	—	0.65	0.76	0.81	0.82
Sodium	mg/L	—	—	0.67	0.97	1.1	1.1
Sulphate	mg/L	—	—	1.9	2.6	2.8	2.9
Carbonate (CO_{32}-)	mg/L	—	—	5	-	-	-
Bicarbonate ($H(CO_3)$-)	mg/L	—	—	30	-	-	-
Hardness	mg($CaCO_3$)/L	—	—	30	31	31	31
Cyanide (free)	mg/L	0.005	0.005	0.001	0.0011	0.0011	0.0011
Cyanide (total)	mg/L	—	—	0.001	0.0011	0.0011	0.0011
Nutrients							
Nitrate-N	mg/L	13	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	0.022	0.078	0.1	0.1
Un-ionized ammonia	mg/L	0.019	0.02	0.000047	0.00075	0.001	0.0011
Phosphorus	mg/L	—	0.02	0.0082	0.0082	0.0082	0.0082
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	0.00097	0.00097	0.00097	0.00097
Arsenic	mg/L	0.005	0.1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	0.0069	-	-	-
Beryllium [d]	mg/L	—	0.011-1.1	0.00023	-	-	-
Bismuth	mg/L	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.009	0.009	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	0.00012	0.00013	0.00013	0.00013

Table 6-38: Average TMF Seepage Water Quality Predictions for Lizard Lake during Operations (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Lizard Lake Baseline	Northern	Central	Southern
		CCME CWQG	PWQO		Proportion (%)		
					0.0028	**0.0039**	**0.0041**
Dissolved Metals (Continued)							
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.00087	0.0012	0.0013	0.0013
Iron (total)	mg/L	0.3	0.3	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	0.00032	0.00054	0.00063	0.00065
Nickel [d]	mg/L	0.025-0.15	0.025	0.0008	0.00083	0.00084	0.00084
Selenium	mg/L	0.001	0.1	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	0.000068	-	-	-
Tin	mg/L	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	0.005	-	-	-
Uranium	mg/L	0.015	0.005	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	0.002	-	-	-

Note:

Underlined values exceed PWQO criteria. **Bold** values exceed CCME CWQGs.

- = Site water quality data was not modeled for this parameter.

— = Receiving water quality criteria/guidelines do not exist for this parameter.

(a) See Lake Water Quality TSD Appendix III for the list of all parameters, criteria and notes.

(b) Aluminum PWQO and CWQG range is pH dependent. See Lake Water Quality TSD Appendix III for details.

(c) Cadmium CWQG is calculated using a formula (See Lake Water Quality TSD Appendix III) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Lake Water Quality TSD Appendix III for details.

All predicted concentrations of average case TMF seepage to Lizard Lake for the operational scenario are lower than the the CWQG and PWQO criteria. In general, the predicted results are the same as or marginally greater than average Lizard Lake baseline concentrations for most parameters.

Upper bounding water quality conditions were also predicted for Lizard Lake during operations, and the results are presented in Table 6-39. The predictions were based on average baseline Lizard Lake water quality, maximum TMF seepage discharge and maximum mixing during operations.

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Table 6-39: Upper Bound TMF Seepage Water Quality Predictions for Lizard Lake during Operations

Parameter	Unit	Receiving WQ Guidelines[a]		Lizard Lake Baseline	Northern	Central	Southern
					Proportion (%)		
		CCME CWQG	PWQO		**0.0081**	**0.0095**	**0.0071**
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	7	7.0 – 7.7	7.0 – 7.7	7.0 – 7.7
DOC	% wt	—	—	8.2	-	-	-
TOC	% wt	—	—	8.5	-	-	-
Acidity	mg/L	—	—	2.9	-	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	27	-	-	-
Conductivity	µS/cm	—	—	63	-	-	-
Total Suspended Solids	mg/L	-20	—	2.1	-	-	-
Total Dissolved Solids	mg/L	—	—	55	-	-	-
Major Ions							
Calcium	mg/L	—	—	10	11	11	10
Chloride	mg/L	120	—	0.25	0.81	0.91	0.74
Fluoride	mg/L	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	0.9	1.1	1.1	1
Potassium	mg/L	—	—	0.65	1	1.1	1
Sodium	mg/L	—	—	0.67	1.7	1.9	1.6
Sulphate	mg/L	—	—	1.9	4.1	4.5	3.9
Hardness	mg($CaCO_3$)/L	—	—	30	32	32	31
Cyanide (free)	mg/L	0.005	0.005	0.001	0.0011	0.0011	0.0011
Cyanide (total)	mg/L	—	—	0.001	0.0011	0.0011	0.0011
Nutrients							
Nitrate	mg/L	13	—	0.034	0.034	0.034	0.034
Ammonia	mg/L	—	—	0.022	0.18	0.21	0.16
Un-ionized ammonia	mg/L	0.019	0.02	0.000047	0.0017	0.0019	0.0015
Phosphorus	mg/L	—	0.02	0.0082	0.0084	0.0084	0.0083
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	0.00097	0.00098	0.00099	0.00098
Arsenic	mg/L	0.005	0.1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	0.0069	-	-	-
Beryllium [d]	mg/L	—	0.011-1.1	0.00023	-	-	-
Bismuth	mg/L	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.009	0.009	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	0.00012	0.00014	0.00015	0.00014

Table 6-39: Upper Bound TMF Seepage Water Quality Predictions for Lizard Lake during Operations (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Lizard Lake Baseline	Northern	Central	Southern
		CCME CWQG	PWQO		Proportion (%)		
					0.0081	0.0095	0.0071
Dissolved Metals (Continued)							
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.00087	**0.0022**	**0.0024**	**0.002**
Iron (total)	mg/L	0.3	0.3	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	0.0094	-	-	-
Mercury	mg/L	0.000026	0.0002	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	0.00032	0.001	0.0012	0.00096
Nickel [d]	mg/L	0.025-0.15	0.025	0.0008	0.00087	0.00089	0.00087
Selenium	mg/L	0.001	0.1	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	0.000068	-	-	-
Tin	mg/L	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	0.005	-	-	-
Uranium	mg/L	0.015	0.005	0.0025	0.0026	0.0026	0.0026
Vanadium	mg/L	—	0.006	0.00037	0.00037	0.00037	0.00037
Zinc	mg/L	0.03	0.02	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	0.002	-	-	-

Note:

Underlined values exceed PWQO criteria. Bold values exceed CCME CWQGs. .

- = Site water quality data was not modeled for this parameter.

— = Receiving water quality criteria do not exist for this parameter.

(a) See Lake Water Quality TSD Appendix III for the list of all parameters, criteria and notes.

(b) Aluminum PWQO and CWQG range is pH dependent. See Lake Water Quality TSD Appendix III for details.

(c) Cadmium CWQG is calculated using a formula (See Lake Water Quality TSD Appendix III) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Lake Water Quality TSD Appendix III for details.

All predicted concentrations of upper bound TMF seepage to Lizard Lake during operations are lower than the CWQG, and PWQO criteria. In general, the predicted results are the same as or marginally greater than average Lizard Lake baseline concentrations for most parameters. The exceptions are copper and free cyanide.

Copper concentrations were predicted to increase to 0.0022 mg/L, which is slightly above the CWQG of 0.002 mg/L. The significance of these increases is assessed in the Human Health and Ecological Risk Assessment TSD with respect to the potential for adverse effects on humans and non-human biota, and are discussed in Section 6.2.2 with respect to effects on the aquatic environment.

Prediction of copper in groundwater is considered conservative in that it does not provide for attenuation of copper concentrations along the flow path. Attenuation of copper concentrations in groundwater would be expected, particularly where flow may occur through soil layers. Under most conditions, copper is present in aqueous solution as the divalent cation, Cu^{2+}, or as Cu(II) hydroxide or carbonate complexes. However, copper is not especially mobile in aquatic environments due to the relatively low solubility of Cu(II)-bearing solids and high affinity of copper for mineral and organic surfaces." (U.S. EPA, 2007).

6.1.3.3.3 Water Quality Predictions for Post-Closure Phase

For a year or two after closure, (until such time that the TMF water quality is deemed suitable for direct discharge into Sawbill Bay), water will continue to be pumped from the TMF Reclaim Pond. However, pumping of this water to the PPCP / ETP will cease and instead the reclaim water will be discharged into the open pits. Similarly, water pumped from the seepage collection ponds around the toes of the waste rock stockpile, the low-grade ore stockpile (if it still exists) and the overburden stockpile, will be pumped into the open pits rather than to the PPCP.

Once the processing plant and other Project infrastructure are demolished, the remaining runoff reporting to the PPCP should no longer require treatment. At that time, the Effluent Treatment Plant (ETP) will be decommissioned. The PPCP will then be decommissioned, the perimeter dykes will be breached and normal runoff flow directions will be restored.

About 218 years after the operations phase, the water in the flooded open pits will overflow, and this overflow will be directed through a ditch into Upper Marmion Reservoir (Golder 2012b). Based on the post-closure flow model, it is estimated that about 253,000 m^3/yr will overflow from the open pit. After pit flooding is sufficiently advanced and prior to pit overflow, the water quality at the surface of the flooded open pits will be evaluated, and a decision will be made regarding post-overflow treatment if required. It is expected that stratification of water in the flooded open pits will result in surficial water quality that is suitable for discharge to Upper Marmion Reservoir.

6.1.3.3.3.1 Pit Water Quality

During the post-closure phase, the open pits are expected to fill over a period of approximately 218 years, after which the pits will overflow. As described in Chapter 5, the overflow will be directed via a channel to the south where it will drain to Upper Marmion Reservoir (Figure 6-6).

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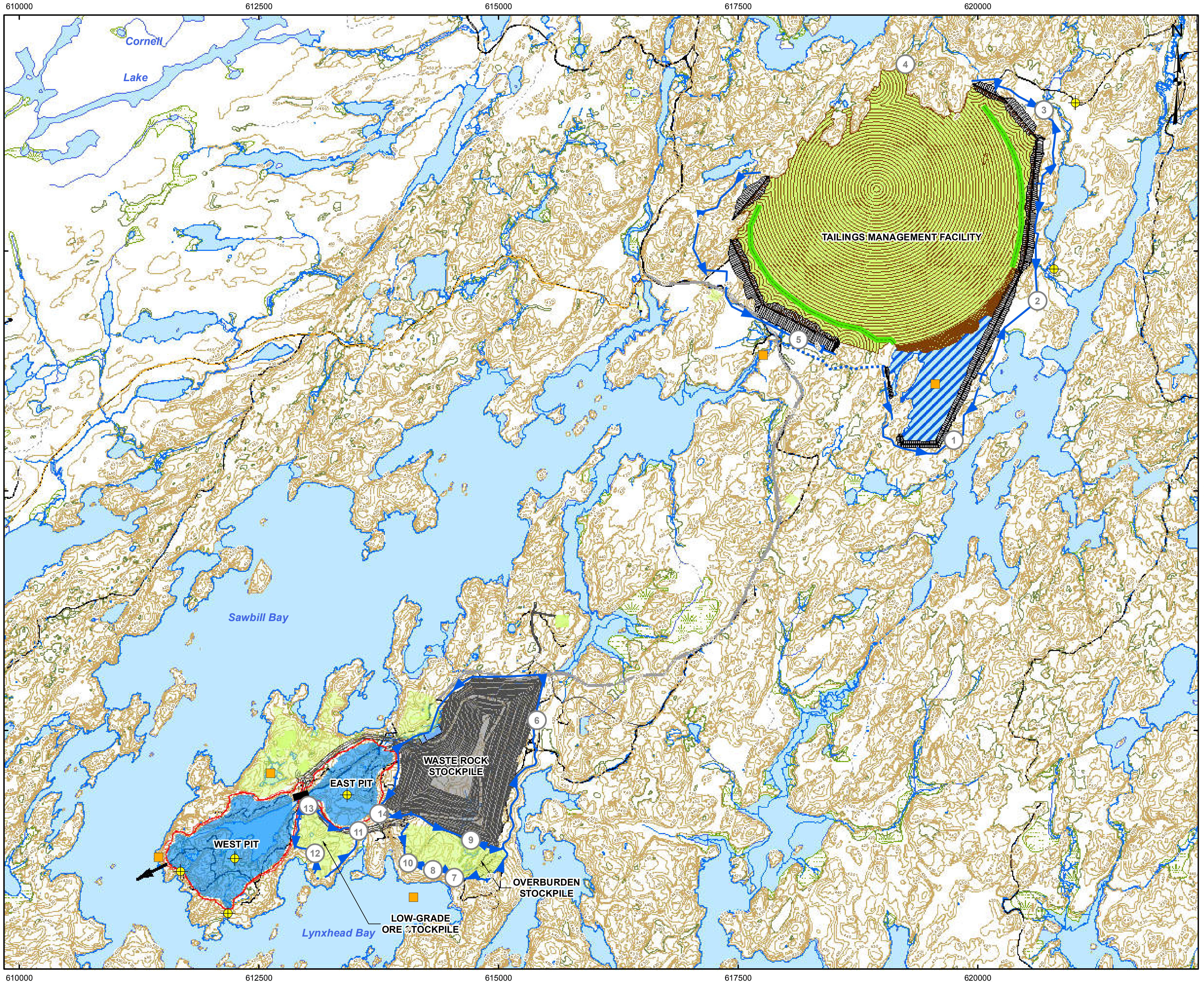

LEGEND

- Index Contour (5m interval)
- Ditch
- Marsh/Swamp
- River/Stream
- Road
- Trail
- Lake
- Wetland
- Groundwater Monitoring Location
- Surface Water Monitoring Locaton
- Decommissioned Pumping Station
- Proposed Ditch
- Pit Spillover Point
- Excavated Channel
- Tailings Drainage Channel Alignment
- Erosion Protected Channel
- Mine Site Road
- Access Road (Hardtack / Sawbill)
- Intermediate Collection Pond
- Revegetated Surface
- Open Pit Pond
- Waste Rock Stockpile
- Open Pit
- Tailings Management Facility Reclaim Pond

NOTES

1. Water in Tailings Management Facility Reclaim Pond will be redirected by ditch to Sawbill Bay once water quality is acceptable.

2. When the water quality in individual seepage collection ponds is acceptable for discharge, the ponds will be decommissioned.

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

500 0 500 1,000 1,500 2,000
SCALE 1:40,000 METERS

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
EXPECTED LONG-TERM POST-CLOSURE SITE CONDITIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	14 Nov. 2008	FIGURE: 6-6	
GIS	JO	2 Dec. 2013		
CHECK	SP	2 Dec. 2013		
REVIEW	SP	2 Dec. 2013		

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The discharge rates for the pit lake at overflow were predicted for a range of wet and dry conditions (Site Water Quality TSD). The results for the monthly average overflow rate predictions are provided in Table 6-40.

Table 6-40 shows that there is little or no discharge expected under dry conditions or during some of the months. The discharge rate is expected to increase during extremely wet conditions and during the spring freshet.

Table 6-40: Estimated Monthly Pit Lake Discharge Flows for Return Period Conditions for Post-closure Phase

Return Period[(a)]		Estimated Pit Lake Drainage into South End of Sawbill Bay (m^3/h)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Return Period	100	6.0	1.0	11.0	22.0	0.0	0.0	0.0	0.0	14.0	36.0	32.0	15.0
	50	6.0	1.0	12.0	34.0	0.0	0.0	0.0	0.0	21.0	41.0	34.0	17.0
	25	7.0	1.0	13.0	48.0	0.0	0.0	0.0	0.0	29.0	47.0	37.0	18.0
	10	8.0	1.0	14.0	68.0	0.0	0.0	0.0	0.0	42.0	56.0	41.0	20.0
Average[(b)]		10.0	1.0	19.0	126.0	0.0	0.0	0.0	16.0	78.0	82.0	52.0	27.0
Wet return period	10	12.0	1.0	23.0	185.0	0.0	49.0	11.0	54.0	114.0	108.0	64.0	33.0
	25	13.0	1.0	25.0	207.0	0.0	64.0	25.0	68.0	128.0	118.0	68.0	35.0
	50	14.0	1.0	26.0	222.0	0.0	74.0	34.0	77.0	137.0	124.0	71.0	37.0
	100	14.0	1.0	27.0	235.0	6.0	83.0	42.0	85.0	145.0	130.0	74.0	38.0

Note:

(a) Return periods based on precipitation records at Atikokan.

(b) Average conditions based on a 2-year return period.

Average water quality in Upper Marmion Reservoir was predicted and the results are presented in Table 6-41. The prediction is based on average baseline Upper Marmion Reservoir water quality, Pit Lake discharge for the expected case, and average mixing for the post-closure scenario.

Table 6-41: Pit Lake Discharge Water Quality Predictions in Upper Marmion Reservoir under Average Conditions in Post-closure

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir (near Raft Lake Dam)
		CCME CWQG	PWQO		Proportion (%)	
					0.00062	0.00042
Physical-Chemical						
pH	—	6.5-9	6.5-8.5	6.5	6.5 – 7.1	6.5 – 7.1
DOC	% wt	—	—	8.8	-	-
TOC	% wt	—	—	9.3	-	-
Acidity	mg/L	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	19	-	-
Conductivity	µS/cm	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	53	-	-
Major Ions						
Calcium	mg/L	—	—	6.4	6.4	6.4
Chloride	mg/L	120	—	1.1	1.05	1.05
Fluoride	mg/L	—	—	0.031	-	-
Magnesium	mg/L	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	0.68	0.68	0.68
Sodium	mg/L	—	—	1.3	1.3	1.3
Sulphate	mg/L	—	—	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	0.005	-	-
Cyanide (total)	mg/L	—	—	0.002	-	-
Nutrients						
Nitrate-N	mg/L	13	—	0.063	0.063	0.063
Ammonia-N	mg/L	—	—	0.023	-	-
Un-ionized ammonia	mg/L	0.019	0.02	0.000067	0.00014	0.00012
Phosphorus	mg/L	—	0.02	0.013	0.013	0.013

Table 6-41: Pit Lake Discharge Water Quality Predictions in Upper Marmion Reservoir Under Average Conditions in Post Closure (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir (near Raft Lake Dam)
		CCME CWQG	PWQO		Proportion (%)	
					0.00062	0.00042
Dissolved Metals						
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	0.03	0.03	0.03
Antimony	mg/L	—	0.02	0.00078	0.0008	0.0008
Arsenic	mg/L	0.005	0.1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	0.0071	-	-
Beryllium [d]	mg/L	—	0.011-1.1	0.00028	-	-
Bismuth	mg/L	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	0.00048	0.00048	0.00048
Cobalt	mg/L	—	0.0009	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	0.00036	0.00036	0.00036
Nickel [d]	mg/L	0.025-0.15	0.025	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	0.013	-	-
Thallium	mg/L	0.0008	0.0003	0.000084	-	-
Tin	mg/L	—	—	0.00071	-	-
Titanium	mg/L	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	0.0045	-	-
Uranium	mg/L	0.015	0.005	0.0022	0.0022	0.0022

Table 6-41: Pit Lake Discharge Water Quality Predictions in Upper Marmion Reservoir Under Average Conditions in Post Closure (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir (near Raft Lake Dam)
		CCME CWQG	PWQO		Proportion (%)	
					0.00062	**0.00042**
Dissolved Metals (Continued)						
Vanadium	mg/L	—	0.006	0.0005	-	-
Zinc	mg/L	0.03	0.02	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	0.0015	-	-

Note:

Underlined values exceed PWQO criteria. Bold values exceed CCME CWQGs.

- = Site water quality data was not modeled for this parameter.

— = Receiving water quality criteria do not exist for this parameter.

(a) See Lake Water Quality TSD Appendix III for the list of all parameters, criteria and notes.

(b) Aluminum PWQO and CWQG range is pH dependent. See Lake Water Quality TSD Appendix III for details.

(c) Cadmium CWQG is calculated using a formula (See Lake Water Quality TSD Appendix III) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness-dependent. See Lake Water Quality TSD Appendix III for details.

All predicted concentrations for pit overflow discharge to Upper Marmion Reservoir in post-closure under average conditions are lower than the CWQG and PWQO criteria. In general, the predicted results are the same as or marginally greater than average Upper Marmion Reservoir baseline concentrations.

In addition, water quality was predicted based on the predicted upper bounding pit water quality using average baseline Upper Marmion Reservoir water quality, Pit Lake discharge for the worst case, and maximum mixing for the post-closure scenario. The results are provided in Table 6-42.

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Table 6-42: Results for Upper Bound Pit Lake Discharge Water Quality Predictions in Basin 5 of Upper Marmion Reservoir for Post-Closure Scenario

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir (near Raft Lake Dam)
					Proportion (%)	
		CCME CWQG	PWQO		0.0056	0.00337
Physical-Chemical						
pH	—	6.5-9	6.5-8.5	6.5	6.5 – 7.0	6.5 – 7.0
DOC	% wt	—	—	8.8	-	-
TOC	% wt	—	—	9.3	-	-
Acidity	mg/L	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	19	-	-
Conductivity	µS/cm	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	53	-	-
Major Ions						
Calcium	mg/L	—	—	6.4	6.5	6.5
Chloride	mg/L	120	—	1.1	1.1	1.1
Fluoride	mg/L	—	—	0.031	-	-
Magnesium	mg/L	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	0.68	0.68	0.68
Sodium	mg/L	—	—	1.3	1.3	1.3
Sulphate	mg/L	—	—	1.6	1.6	1.6
Hardness	mg($CaCO_3$)/L	—	—	21	21	21
Cyanide (free)	mg/L	0.005	0.005	0.005	-	-
Cyanide (total)	mg/L	—	—	0.002	-	-
Nutrients						
Nitrate	mg/L	13	—	0.063	0.063	0.063
Ammonia	mg/L	—	—	0.023	-	-
Un-ionized ammonia	mg/L	0.019	0.02	0.000067	0.00102	0.00064
Phosphorus	mg/L	—	0.02	0.013	0.013	0.013
Dissolved Metals						
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	0.03	0.03	0.03
Antimony	mg/L	—	0.02	0.00078	0.00078	0.00078
Arsenic	mg/L	0.005	0.1	0.00049	0.00049	0.00049
Barium	mg/L	—	—	0.0071	-	-
Beryllium [d]	mg/L	—	0.011-1.1	0.00028	-	-
Bismuth	mg/L	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	0.000036	0.000036	0.000036
Chromium (total)	mg/L	0.009	0.009	0.00048	0.00049	0.00048
Cobalt	mg/L	—	0.0009	0.00017	0.00017	0.00017
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	0.24	0.24	0.24
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.00029	0.00029	0.00029
Manganese	mg/L	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	0.00036	0.00036	0.00036

Table 6-42: Results for Upper Bound Pit Lake Discharge Water Quality Predictions in Basin 5 of Upper Marmion Reservoir for Post Closure Scenario (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir (near Raft Lake Dam)
		CCME CWQG	PWQO		Proportion (%)	
					0.0056	**0.00337**
Dissolved Metals (Continued)						
Nickel [d]	mg/L	0.025-0.15	0.025	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	0.000087	0.000087	0.000087
Strontium	mg/L	—	—	0.013	-	-
Thallium	mg/L	0.0008	0.0003	0.000084	-	-
Tin	mg/L	—	—	0.00071	-	-
Titanium	mg/L	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	0.0045	-	-
Uranium	mg/L	0.015	0.005	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	0.0005	-	-
Zinc	mg/L	0.03	0.02	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	0.0015	-	-

Notes:

Underlined values exceed PWQO criteria. Bold values exceed CCME CWQGs.

- = Site water quality data was not modeled for this parameter.

— = Receiving water quality criteria do not exist for this parameter.

[a] See Lake Water Quality TSD Appendix III for the list of all parameters, criteria and notes.

[b] Aluminum PWQO and CWQG range is pH dependent. See Lake Water Quality TSD Appendix III for details.

[c] Cadmium CWQG is calculated using a formula (See Lake Water Quality TSD Appendix III) that is hardness-dependent.

[d] Beryllium, copper, lead and nickel guidelines are hardness dependent. See Lake Water Quality TSD Appendix III for details.

The results in Table 6-42 show that all predicted concentrations for discharge of pit overflow water to Upper Marmion Reservoir during post-closure under upper bound conditions are lower than the CWQG, and PWQO criteria. In general, the predicted results are the same as or marginally greater than average Upper Marmion Reservoir baseline concentrations for most parameters.

6.1.3.3.3.2 Runoff Water Quality

During closure the existing water management system will be modified. During operations all site runoff water from the TMF reclaim pond and the stockpiles (WRMF, overburden and low grade ore) will be directed to the PPCP. At closure, the PPCP will be decommissioned, and site runoff and seepage water from the processing plant area, the TMF reclaim pond and the stockpiles will be pumped to the open pits. When the quality of water in the seepage collection ponds is suitable for direct discharge to the environment, pumping to the open pits will cease and runoff will return to natural drainage patterns. Therefore, site runoff water flows and quality in post-closure was also predicted.

The total runoff from the Project Site was predicted for a range of wet and dry conditions (Site Water Quality TSD). Table 6-43 shows that the total runoff is lowest during the winter (February) and the highest during the spring freshette (April). Table 6-43 also shows that even during the driest years, there is still runoff from the Project Site.

Table 6-43: Estimated Monthly Total Project Site Runoff for Return Period Conditions for Post-closure Phase

Return Period[a]		Estimated Total Runoff from Facility (m^3/h)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Return Period	100	34	1	66	740	400	413	286	478	637	378	212	98
	50	37	1	72	821	438	453	320	519	681	403	228	107
	25	41	1	79	913	481	499	359	566	732	433	246	117
	10	46	1	90	1,054	546	569	419	638	810	477	274	132
Average[b]		62	1	120	1,451	730	765	588	842	1,029	603	352	175
Wet return period	10	78	1	151	1,856	918	966	760	1,049	1,253	732	432	219
	25	84	1	162	2,006	988	1,040	824	1,126	1,335	779	461	235
	50	88	1	170	2,106	1,034	1,090	867	1,177	1,391	811	481	246
	100	91	1	177	2,196	1,076	1,134	904	1,223	1,440	840	499	256

Note:

(a) Return periods based on precipitation records at Atikokan.

(b) Average conditions based on a 2-year return period.

The total site runoff in the post-closure phase is based on runoff from nine areas and can drain into several of the modelled basins.

Table 6-44 provides a summary of the individual areas and the percentage of each area that drains into one of five modelled basins. These preliminary runoff rates are based on information provided in the Site Water Quality TSD. Since the post-closure site drainage has not been finalized, the total drainage percentages have been rounded off to the nearest 5%. Since the Upper Marmion Reservoir Model does not include Lizard Lake, any runoff that was expected to drain to Lizard Lake was assumed to drain into Trap Bay (Basin 1).

Table 6-44 shows that the majority of the site runoff is expected to drain into Sawbill Bay. Approximately 55% of the site runoff is expected to drain into Northern Sawbill Bay (Basin 7C).

Table 6-44: Assumed Partitioning of Facility Runoff to Upper Marmion Reservoir Model Basins

Facility	Estimated Runoff Percentage to Model Basin				
	Lizard Lake	Lynxhead Bay 2	South End of Sawbill Bay 6	Northern Sawbill Bay 7C	Trap Bay 1
Open Pit	0.0	0.0	5.1	0.0	0.0
Waste Rock Stockpile	0.0	1.3	8.3	0.0	12.8
TMF	5.8	0.0	0.0	55.7	0.0
Detonator Storage Area	0.0	0.0	0.0	0.0	0.0
Emulsion Plant	0.0	0.0	0.0	0.2	0.0
Process Plant	0.0	0.0	4.2	0.0	0.0
Overburden	0.0	1.4	0.0	0.0	1.4
Low Grade Ore Stockpile	0.0	1.8	0.1	0.0	0.0
ICP	0.0	0.0	1.7	0.0	0.0
Total	**5.8**	**4.6**	**19.5**	**55.9**	**14.2**
Rounded Values Used[1]	**0[2]**	**5**	**20**	**55**	**20[2]**

Note:

Percentages rounded to nearest 5%.

Runoff into Lizard Lake was assumed to drain to Trap Bay (Lizard Lake is included in Marmion Lake Model).

Results for site runoff water quality predictions during the post-closure phase are presented in Table 6-45. The predictions are based on average baseline Upper Marmion Reservoir water quality, site runoff discharge and maximum mixing for the post-closure scenario.

Table 6-45: Site Runoff Discharge Water Quality Predictions in Basin 7C of Upper Marmion Reservoir for Post-closure Scenario

Parameter	Unit	Receiving WQ Guidelines[(a)]		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir (near Raft Lake Dam)
		CCME CWQG	PWQO		Proportion (%)	
					0.08952	0.02776
Physical-Chemical						
pH	—	6.5-9	6.5-8.5	6.5	6.5 – 6.8	6.5 – 6.8
DOC	% wt	—	—	8.8	-	-
TOC	% wt	—	—	9.3	-	-
Acidity	mg/L	—	—	2.9	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	19	-	-
Conductivity	µS/cm	—	—	49	-	-
Total Suspended Solids	mg/L	-20	—	4.5	-	-
Total Dissolved Solids	mg/L	—	—	53	-	-
Major Ions						
Calcium	mg/L	—	—	6.4	7	6.6
Chloride	mg/L	120	—	1.1	1.1	1.1
Fluoride	mg/L	—	—	0.031	-	-
Magnesium	mg/L	—	—	1.3	1.3	1.3
Potassium	mg/L	—	—	0.68	0.68	0.68
Sodium	mg/L	—	—	1.3	1.3	1.3
Sulphate	mg/L	—	—	1.6	1.7	1.6
Hardness	mg($CaCO_3$)/L	—	—	21	23	22
Cyanide (free)	mg/L	0.005	0.005	0.005	-	-
Cyanide (total)	mg/L	—	—	0.002	-	-
Nutrients						
Nitrate	mg/L	13	—	0.063	0.063	0.063
Ammonia	mg/L	—	—	0.023	-	-
Un-ionized ammonia	mg/L	0.019	0.02	0.000067	0.000067	0.00007
Phosphorus	mg/L	—	0.02	0.013	0.014	0.013

Table 6-45: Site Runoff Discharge Water Quality Predictions in Basin 7C of Upper Marmion Reservoir for Post-closure Scenario (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir (near Raft Lake Dam)
		CCME CWQG	PWQO		Proportion (%)	
					0.08952	**0.02776**
Dissolved Metals						
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	0.03	0.05	0.036
Antimony	mg/L	—	0.02	0.00078	0.00089	0.00081
Arsenic	mg/L	0.005	0.1	0.00049	0.0005	0.00049
Barium	mg/L	—	—	0.0071	-	-
Beryllium [d]	mg/L	—	0.011-1.1	0.00028	-	-
Bismuth	mg/L	—	—	0.00054	-	-
Boron	mg/L	1.5	0.2	0.014	0.014	0.014
Cadmium [c]	mg/L	see notes	0.0001-0.0005	0.000036	0.000037	0.000036
Chromium (total)	mg/L	0.009	0.009	0.00048	0.00052	0.0005
Cobalt	mg/L	—	0.0009	0.00017	0.0002	0.00018
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.0011	0.0011	0.0011
Iron (total)	mg/L	0.3	0.3	0.24	**0.33**	0.27
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.00029	0.0003	0.0003
Manganese	mg/L	—	—	0.024	0.024	0.024
Mercury	mg/L	0.000026	0.0002	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	0.00036	0.00038	0.00037
Nickel [d]	mg/L	0.025-0.15	0.025	0.00099	0.00099	0.00099
Selenium	mg/L	0.001	0.1	0.0005	0.0012	0.0012
Silver	mg/L	0.0001	0.0001	0.000087	0.000088	0.000088
Strontium	mg/L	—	—	0.013	-	-
Thallium	mg/L	0.0008	0.0003	0.000084	-	-
Tin	mg/L	—	—	0.00071	-	-
Titanium	mg/L	—	—	0.0012	-	-
Tungsten	mg/L	—	0.03	0.0045	-	-
Uranium	mg/L	0.015	0.005	0.0022	0.0022	0.0022
Vanadium	mg/L	—	0.006	0.0005	-	-

Table 6-45: Site Runoff Discharge Water Quality Predictions in Basin 7C of Upper Marmion Reservoir for Post-closure Scenario (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Upper Marmion Reservoir Baseline	Sawbill Bay south end (near discharge)	Upper Marmion Reservoir (near Raft Lake Dam)
		CCME CWQG	PWQO		Proportion (%)	
					0.08952	**0.02776**
Dissolved Metals (Continued)						
Zinc	mg/L	0.03	0.02	0.0052	0.0052	0.0052
Zirconium	mg/L	—	0.004	0.0015	-	-

Note:

Underlined values exceed PWQO criteria. Bold values exceed CCME CWQGs.

- = Site water quality data was not modeled for this parameter.

— = Receiving water quality criteria do not exist for this parameter.

(a) See Lake Water Quality TSD Appendix III for the list of all parameters, criteria and notes.

(b) Aluminum PWQO and CWQG range is pH dependent. See Lake Water Quality TSD Appendix III for details.

(c) Cadmium CWQG is calculated using a formula (See Lake Water Quality TSD Appendix III) that is hardness-dependent.

(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Lake Water Quality TSD Appendix III for details.

All predicted concentrations of site runoff discharge to Upper Marmion Reservoir for the post-closure scenario are lower than the CWQG and PWQO criteria, with the exception of iron. In general, the predicted results are the same as or marginally greater than average Upper Marmion Reservoir baseline concentrations for most parameters with the exception of iron.

Iron concentrations are predicted to reach 0.33 mg/L in Upper Marmion Reservoir at the location shown on Figure 6-6. Given that it is an aesthetic objective and it is expected that iron would precipitate out of solution prior to reaching the reservoir it is considered that the values would meet the PWQO/CWQG in post closure for the purposes of this assessment.

6.1.3.3.3.3 Lizard Lake

During the closure phase, the TMF will be graded to shed water and reduce infiltration. The seepage collection system will continue to operate in post-closure, directing seepage to the open pits, until monitoring indicates that the water will be suitable for discharge. The seepage collection ponds would then be allowed to drain naturally to adjacent waterbodies. As a result, an assessment of the effect of seepage of water from the closed TMF on Lizard Lake was also considered in the post-closure phase.

Results for water quality predictions of average case TMF seepage in Lizard Lake during the post-closure scenario are presented in Table 6-46. The prediction is based on average baseline Lizard Lake water quality, average TMF seepage discharge during operations (this likely over-estimates actual seepage water quality in post-closure), and maximum mixing for the post-closure scenario.

Table 6-46: Average TMF Seepage Water Quality Predictions for Lizard Lake During Post-closure

Parameter	Unit	Receiving WQ Guidelines[(a)]		Lizard Lake Baseline	Northern	Central	Southern
		CCME CWQG	PWQO		Proportion (%)		
					0.0047	0.0055	0.0041
Physical-Chemical							
pH	—	6.5-9	6.5-8.5	7	7.0 – 7.3	7.0 – 7.3	7.0 – 7.3
Acidity	mg/L	—	—	2.9	-	-	-
Alkalinity	mg($CaCO_3$)/L	—	-25%	27	-	-	-
Conductivity	µS/cm	—	—	63	-	-	-
Total Suspended Solids	mg/L	-20	—	2.1	-	-	-
Total Dissolved Solids	mg/L	—	—	55	-	-	-
Major Ions							
Calcium	mg/L	—	—	10	10	10	10
Chloride	mg/L	120	—	0.25	0.3	0.3	0.3
Fluoride	mg/L	—	—	0.03	-	-	-
Magnesium	mg/L	—	—	0.9	0.9	0.9	0.9
Potassium	mg/L	—	—	0.65	0.7	0.7	0.7
Sodium	mg/L	—	—	0.67	0.7	0.7	0.7
Sulphate	mg/L	—	—	1.9	1.9	1.9	2
Hardness	mg($CaCO_3$)/L	—	—	30	30	30	30
Cyanide (free)	mg/L	0.005	0.005	0.005	-	-	-
Cyanide (total)	mg/L	—	—	0.002	-	-	-

Table6-46: Average TMF Seepage Water Quality Predictions for Lizard Lake During Post Closure (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Lizard Lake Baseline	Northern	Central	Southern
		CCME CWQG	PWQO		Proportion (%)		
					0.0047	0.0055	0.0041
Nutrients							
Nitrate-N	mg/L	13	—	0.034	0.034	0.034	0.034
Ammonia-N	mg/L	—	—	0.022	-	-	-
Un-ionized ammonia	mg/L	0.019	0.02	0.000047	4.65E-05	6.50E-04	6.50E-04
Phosphorus	mg/L	—	0.02	0.0082	0.0082	0.0082	0.0082
Dissolved Metals							
Aluminum [b]	mg/L	0.005-0.1	0.015-0.075	0.018	0.018	0.018	0.018
Antimony	mg/L	—	0.02	0.00097	0.001	0.001	0.001
Arsenic	mg/L	0.005	0.1	0.00043	0.00043	0.00043	0.00043
Barium	mg/L	—	—	0.0069	-	-	-
Beryllium [d]	mg/L	—	0.011-1.1	0.00023	-	-	-
Bismuth	mg/L	—	—	0.00058	-	-	-
Boron	mg/L	1.5	0.2	0.011	0.011	0.011	0.011
Cadmium [c]	mg/L	see notes	0.0001-0.0005	0.00003	0.00003	0.00003	0.00003
Chromium (total)	mg/L	0.009	0.009	0.00049	0.00049	0.00049	0.00049
Cobalt	mg/L	—	0.0009	0.00012	0.00012	0.00012	0.00012
Copper [d]	mg/L	0.002-0.004	0.001-0.005	0.00087	0.0009	0.0009	0.0009
Iron (total)	mg/L	0.3	0.3	0.053	0.053	0.053	0.053
Lead [d]	mg/L	0.001-0.007	0.001-0.005	0.00024	0.00024	0.00024	0.00024
Manganese	mg/L	—	—	0.0094	0.009435	0.009435	0.009435

Table6-46: Average TMF Seepage Water Quality Predictions for Lizard Lake During Post Closure (Continued)

Parameter	Unit	Receiving WQ Guidelines[a]		Lizard Lake Baseline	Northern	Central	Southern
					Proportion (%)		
		CCME CWQG	PWQO		0.0047	0.0055	0.0041
Dissolved Metals (Continued)							
Mercury	mg/L	0.000026	0.0002	0.000005	0.000005	0.000005	0.000005
Molybdenum	mg/L	0.073	0.04	0.00032	0.0003	0.0003	0.0003
Nickel [d]	mg/L	0.025-0.15	0.025	0.0008	0.0008	0.0008	0.0008
Selenium	mg/L	0.001	0.1	0.0005	0.0005	0.0005	0.0005
Silver	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Strontium	mg/L	—	—	0.015	-	-	-
Thallium	mg/L	0.0008	0.0003	0.000068	-	-	-
Tin	mg/L	—	—	0.00055	-	-	-
Titanium	mg/L	—	—	0.0013	-	-	-
Tungsten	mg/L	—	0.03	0.005	-	-	-
Uranium	mg/L	0.015	0.005	0.0025	0.0025	0.0025	0.0025
Vanadium	mg/L	—	0.006	0.00037	-	-	-
Zinc	mg/L	0.03	0.02	0.0055	0.0055	0.0055	0.0055
Zirconium	mg/L	—	0.004	0.002	-	-	-

Note:
Underlined values exceed PWQO criteria. Bold values exceed CCME CWQG.
- = Site water quality data was not modeled for this parameter.
— = Receiving water quality criteria do not exist for this parameter.
(a) See Lake Water Quality TSD Appendix III for the list of all parameters, criteria and notes.
(b) Aluminum PWQO and CWQG range is pH dependent. See Lake Water Quality TSD Appendix III for details.
(c) Cadmium CWQG is calculated using a formula (See Lake Water Quality TSD Appendix III) that is hardness-dependent.
(d) Beryllium, copper, lead and nickel guidelines are hardness dependent. See Lake Water Quality TSD Appendix III for details

All predicted concentrations of average/maximum mixing case TMF seepage to Lizard Lake for the post-closure scenario are lower than the CWQG, and PWQO criteria. In general, the predicted results are the same as or marginally greater than average Lizard Lake baseline concentrations for all parameters.

6.1.4 Summary of Potential Effects to the Physical Environment

6.1.4.1 Geology, Geochemistry and Soils

No adverse effects to geology, geochemistry or soils are predicted to occur from the Project. Geochemical testing was conducted to confirm whether the waste rock and tailings deposits could be potentially acid generating and metal leaching. The conclusions of the completed analysis show that the waste rock will be non-acid generating with excess neutralization potential primarily resulting from carbonate minerals. The results of the short term leach testing and kinetic testing support this classification.

Waste rock and tailings samples indicated elevated aluminum concentrations and other metals such as arsenic, copper, selenium and vanadium reported sporadic concentrations slightly greater than the comparison criteria in waste rock leach testing. Where these sample values were above the comparison criteria, additional water quality evaluation within an overall site wide context was conducted with results as provided in Section 6.1.3.

Construction of the Project will result in vegetation removal which will expose the soil and increase the risk of erosion. Project activities will also include the potential for spills, leaks and seepage of substances, which could alter the chemistry of soils and reduce soil capability.

Soil erosion may influence slope stability and water quality, spills may degrade soil quality and the direct loss of soil and alteration of terrain may have implications with respect to wildlife use of the Local Study Area and with respect to the use of the area as a timber resource.

Further assessment of the effects of the Project on soils and terrain was considered as an indirect effect to wildlife under the terrestrial biology assessment and land use under the socio-economic assessment.

6.1.4.2 Atmospheric Environment

The potential effects of the Project to the atmospheric environment focused on air quality, noise, light and vibration.

Forty Points of Reception (POR) were originally identified in the air quality and noise assessment. Twenty of these PORs (POR 5-19, POR 34, POR36-38 and POR 40) were identified in the MNR mapping data as designated campsites. These locations are simply suggested areas within Crown Land that could be used for camping by the public. No amenities or services are provided and no payment is required to camp there, just as is the case with all Crown Land. OHRG does not have the ability to restrict access to Crown Land, and these identified PORs are not considered specific sites that are required to be included in air and noise modeling predictions.

Based on this, the number of PORs considered in the air quality and noise assessment has been reduced from 40 to 20. The PORs considered in the revised air quality and noise conclusions are now the Town of Atikokan, local tourism establishments, trappper's cabins and cottages. Of the 20 suggested campsites that were originally considered in the air quality and noise assessment, three locations were identified as having potentially high noise levels and six were identified as potentially exceeding particulate matter guidelines. OHRG plans to post signs at crown land locations in the vicinity of the Project site that, in the past, may have been known to be used for camping to indicate the potential for campers to become annoyed by noise levels. A further assessment on health effects due to the potential increase in particulate matter is presented in the Human Health Risk Assessment TSD. Human health risks are not considered to be increased significantly by the Project.

Air dispersion modelling was carried out for the Ontario compliance assessment using defined emission rates to determine the point of impingement (POI) concentrations along the Project property boundary and receptors. Ambient concentrations resulting from Mine Site emissions were predicted at selected groups of receptors and at other locations of interest in order to provide a better understanding of the potential effects of the Project. In addition, discrete human health locations within the LSA were identified for assessment under the Human Health Risk Assessment.

The results of air modelling show that the Project can operate in compliance with s.20 of Ontario Regulation 419/05 for the Operations Phase in the peak production year as defined by the worst-case operating conditions. This is considered to be a conservative assessment since not all scenarios comprising worst-case conditions are likely to be active at any given time. The effects of air emissions on human health are assessed in the human health risk assessment.

A noise assessment was carried for twenty sensitive Points of Reception (PORs) which were identified within the vicinity of the Project. These PORs included tourist establishments, cottages and cabins within the LSA. The modelling results predicted that noise levels associated with the Project would comply with MOE noise guidelines.

Fish habitat is sensitive to vibration, particularly active spawning beds and nurseries. Vibration during blasting of open pits could cause blast-induced water overpressure level changes at the shoreline, potentially effecting sensitive fish species during critical life stages.

It is not possible to realistically assess potential effects on fish without site-specific data on peak particle velocity (PPV) values since this depends to a great extent on the nature of the rock, and the transmissivity. Therefore, operational blasting monitoring to assess the intensity of blast vibrations at the receptor locations will be required. During the initial stages of pit development, blast intensities will be monitored and site-specific PPV will be calculated in order to more accurately predict potential vibration intensities in adjacent aquatic habitats.

The lighting on the Project Site will be positioned in a manner as to not directly illuminate the surrounding areas or the sky. During the detailed engineering for the Project, options will be selected to avoid or reduce negative effects and will be considered for incorporation into the Project’s design. As a result, it is expected that the Project will have limited effects through light trespass and sky glow.

6.1.4.3 Water Quantity and Quality

The potential effects of the Project to water quantity and quality focused on hydrology, water and sediment quality and hydrogeology.

The Project could affect hydrology through changes to streamflows, lake water levels and navigability of water courses and waterbodies during all four phases of the Project.

The greatest changes to streamflows as a result of Project activities during the Operations phase are expected to occur in Mine Study Area watercourses as a result of changes to their tributary drainage areas. Of the 29 watersheds evaluated, five will be unaffected.

The expected changes in flows in local scale watercourses include a reduction in flows in Lumby Creek of approximately 7% to 8% and an increase in flows in Sawbill Creek of less than 1% due to the discharge of treated sewage effluent from the worker accommodation camp.

Changes to the outflows from the Marmion Reservoir and flows in the Seine River downstream of the Raft Lake Dam may occur due to the Project. Total net reduction in annual mean inflows to the Reservoir is estimated to be 0.190 m^3/s in an average year. Changes in monthly mean outflows from Upper Marmion Reservoir are expected to be in the range of -3.10% to -0.21% based on single-year lake water balance modelling.

Changes to water levels will occur in two lakes, and the Upper Marmion Reservoir. Water levels in Unnamed Lake 5 located to the east of the TMF are expected to be in the range of -2.1 cm to 0.0 cm during the Operations phase. Changes in water levels in Lizard Lake are expected to be in the range of -2.7 cm to 0.0 cm. Changes in water levels in the Upper Marmion Reservoir due to Project activities are expected to be in the range of -9.0 cm to -0.4 cm based on single-year water balance modelling. In an average year, the predicted maximum reduction in water levels of the Upper Marmion Reservoir is 8.1 cm.

The Project could result in changes to water quality in site, local and regional scale watercourses in all four phases of the Project. The water quality assessment considers the operations phase to be the worst case scenario and the focus is on this phase. The presence of a flooded open pit also will also influence on water quality and thus a post-closure assessment was also completed. For lakebed sediment quality the potential Total Suspended Solids (TSS) discharge from the site and air deposition was considered at the end of mine life.

All parameters are below Municipal/Industrial Strategy for Abatement (MISA) levels and Metal Mining Effluent Regulation (MMER) discharge guidelines at the point of discharge to the Upper Mamion Reservoir (the diffuser ports). Site Specific Water Quality Objectives (SSWQO) for cyanide and copper are predicted to be reached within distances of 29 m and 18 m, respectively, from the diffuser ports. Following initial mixing, (i.e., within 100 m of the diffuser ports), all predicted concentrations during average site discharge conditions during operations are lower than the CWQG and PWQO criteria. In general, the predicted results after initial mixing are the same as or marginally greater than baseline concentrations. The sulphate concentrations in the water column during average conditions are predicted to increase marginally from 1.6 mg/L as measured in the baseline studies to 1.8 mg/L.

The Project could result in changes to groundwater levels. No groundwater users were identified in the vicinity of the Project that could potentially be affected by changes in groundwater levels from Project activities. The cone of depression from pit dewatering extends about 700 m from the pit perimeter and underlies a portion of the WRMF and overburden stockpiles. Within the area of the cone of depression, groundwater levels are expected to be resulting in a reduction or even elimination of flows in some local streams. Also within this area, seepage losses from the stockpiles results in flow increases in the seepage collection system or some local streams.

6.1.5 Summary of Mitigation Measures for the Physical Environment

6.1.5.1 Geology, Geochemistry and Soils

Mitigation for potential effects to terrain and soils will include minimizing the amount and extent of surface disturbance at any one time. Soil quality changes will also be minimized through implementation of best practices during construction and operation, such as the development and implementation of an Erosion Management Plan and Spill Management Plan. A geochemical monitoring plan will also be developed as further outlined in Chapter 8 Environmental Monitoring.

Existing pre-construction topography, elevations and drainage patterns have been documented and will be used to inform reclamation planning. Throughout all project phases, site drainage will be managed to ensure that runoff does not cause erosion, flooding, or contamination in downstream areas. The water management system will include collection of runoff from the stockpiles (WRMF, overburden and low grade ore) and the TMF, which will be captured and directed to the PPCP.

An Erosion Management Plan will be developed prior to construction and implemented throughout all phases of the Project. The Plan will include topsoil salvage procedures, soil stabilization measures such as the construction of temporary berms, and a progressive rehabilitation plan. Changes to terrain will be further mitigated by the development of a reclamation plan that will be prepared to meet regulatory requirements. Topsoil and overburden will be stockpiled, protected against erosion and used in reclamation of sites where possible. Waste rock and tailings will be stored appropriately to minimize erosion.

A Spill Management Plan will be developed to mitigate the potential effects of spills. The Spill Management Plan is further outlined in Chapter 8 and will include potential sources of leaks and subsequent collection systems for these sources, a recommendation of regular inspection intervals during drilling for early leak identification, and a the construction of waste storage and disposal pits and ponds to eliminate the potential for leakage and subsurface migration. A standard spill response procedure and protocol will be developed and roles and responsibilities will be communicated through the environment department and management teams. Worker training on spill response protocols will be implemented and a spill response database will be maintained.

6.1.5.2 Atmospheric Environment

With appropriate mitigation measures in place, the Project will operate in compliance with all applicable air, noise and vibration regulations and guidelines.

In estimating the air emissions associated with the Project certain mitigation measures were considered to be integral to the design and implementation of the works and activities. These mitigation measures, which are considered to be typical and consistent with best practices, were incorporated into the emission estimates, and therefore were incorporated in the effects predictions. These included implementation of best management practices to control fugitive particulate emissions from haul roads, management of exhaust emissions from non-road vehicles through regular and routine maintenance of vehicles, and use of enclosures at the Ore Processing Facility to reduce fugitive emissions.

The noise assessment of the Project included tourism establishments, communities and trapper cabins as the twenty (20) Points of Reception (PORs). Noise levels were deemed to be potentially high at one tourism establishment. OHRG has an agreement in place with the owner of the tourism establishment to restrict access during the Construction and Operations phases of the project. Three potential camping areas within the

Crown Land surrounding the Project site were also identified as having potentially high noise levels. OHRG proposes posting signs that indicate the potential for campers to experience elevated noise levels at these locations should they choose to camp at these locations.

An adaptive management approach is the proposed mitigation for blasting activities, especially as excavation approaches the pit perimeter. This approach will include on-site measurements of ground and air vibration as well as overpressure to develop actual separation distances needed between environmental receptors in order to meet regulations. The mitigation of vibration effects on sensitive fish habitats could include increasing the distances between environmental receptors, or reducing the weight of explosive charge detonated per delay period. The actual location of the pit perimeter (and therefore between environmental receptors) will be determined during the detailed design stage of the Project.

6.1.5.3 Water Quantity and Quality

Mitigation that has been included in the water quality predictions include in-design mitigation measures, ongoing monitoring and data collection, development and implementation of management plans, contingency plan of treatment as needed and ongoing consultation and discussion with other local water users.

The Project will be designed to ensure slope stability. Interception wells will be used to maintain pit wall pressure if necessary. The design of facility and flow patterns of the water management system will be optimized for the local environment

A Spill Management Plan will be implemented implement preventative measures and ensure appropriate reporting and clean-up of any spills that occur. An Erosion Management Plan will be developed to identify ongoing measures to be put in place during construction activities to limit total suspended solids (TSS) discharge. Additionally, water will be collected and stored if necessary until it can be appropriately treated and discharged;

An Effluent Treatment Plant will be included as a contingency measure. A treatment facility for suspended solids, nutrient loading or metals would be operated if necessary. Treatment for suspended solids may be required as a contingency measure if the water within the reclaim pond and PPCP do not naturally allow for solids to settle. Nutrient loading will be mitigated through the implementation of management controls such as low phosphorus soaps. Treatment for metals is not anticipated to be required but is possible if necessary.

The Project design will include a Water Management System. The water collection system will operate through the use of seepage collection ponds, ditches and active pumping. Water management will be implemented throughout the Project life cycle to capture runoff and seepage. At closure and post closure, pumping will cease and direct drainage from Project Site will be re-establish to lakes and reservoirs once monitoring demonstrates that the water is suitable for direct discharge to the environment.

Discussion with water users and members of the Seine River Watershed Management Plan will be ongoing throughout the Project. Water quality, climate and hydrology data will be collected and used to inform Project design and management. Precipitation records will be used for design and flow management.

Water quality, hydrology and hydrogeology monitoring programs will be implemented as further detailed in Chapter 8 Environmental Management.

6.2 Biological Effects Assessment

Predictions made of the changes in the physical environment in the preceding section are used in this section to assess the effects of the project on the biological environment. The section includes an assessment of the effects of the Project on the following:

- Terrestrial Ecology (Section 6.2.1).
- Aquatic Ecology (Section 6.2.2).

6.2.1 Terrestrial Ecology

Effects of the Project on terrestrial environments consist of direct loss of habitat from vegetation clearing, or, in the case of semi-aquatic wildlife species and wetland habitats, the reduction in water levels and stream flows. As noted in Chapter 2, the effects on wildlife species are considered with respect to the potential effects on populations, rather than individuals.

The terrestrial ecology assessment considers the following:

- Effects of habitat loss or altered drainage patterns on wildlife (bird and mammals species due to loss of wetland and forest vegetation).
- Effects of reduced lake levels on emergent vegetation, and semi-aquatic reptiles, birds and mammals.
- An ecological risk assessment describing and assessing effects of emissions from the operation of the Project.
- Displacement of wildlife species due to noise and human activity or changes in habitat suitability.
- Direct loss of wildlife individuals through accidents such as vehicle collisions.

The effects of the Project during the construction and operations phases are considered together, since the removal of habitat and alteration of drainage during construction will not be reversed until the closure phase when site decommissioning commences. Effects during the construction and operation phases are assumed to be similar.

6.2.1.1 Vegetation

Vegetation loss is considered in the two main habitats that occur in the MSA, specifically: wetlands and upland forests. The loss of habitat is considered mainly with respect to the loss of available habitat for wildlife species.

6.2.1.1.1 Wetland Vegetation

Wetland vegetation will be removed or altered due to clearing associated with the mine footprint and associated infrastructure. In addition, the removal and fragmentation of wetland communities by the development of the mine facilities, site access road and transmission corridor can result in the isolation of plant populations as the developed spaces act as barriers to plant distribution. New openings created by site clearing for construction can attract light demanding species and may limit colonization by other species.

To quantify the direct loss of wetland vegetation due to the mine development, the footprint of the mine facilities and the proposed access road and transmission corridor were overlaid on the ecosite mapping generated for the Terrestrial Ecology LSA. The entire mine footprint will require clearing of approximately 1,200 ha of vegetation (excluding existing infrastructure and open water areas). Of the approximately 1,800 ha of wetland in the Terrestrial Ecology LSA, the mine footprint will require clearing of approximately 380 ha. This is approximately 21% of the wetland occurring in the Terrestrial Ecology LSA and approximately 0.06% of the wetland in the Terrestrial Ecology RSA.

Some locally rare plant species were found in these wetland ecosites. Ecosites with the moderate to high potential to support locally rare plant species occupy approximately 790 ha in the Terrestrial Ecology LSA. The development of the mine footprint will result in the removal and disturbance of approximately 170 ha or 21.5% of this habitat for locally rare species in the Terrestrial Ecology LSA.

A rich conifer swamp (ecosite W32, discussed in the Terrestrial Ecology TSD) was identified as having the potential to support a high number of traditional use plants. Other swamp communities were identified as having the potential to support a moderate number of traditional use species. Based on this evaluation, there will be a loss or disturbance of approximately 215 ha of these swamp ecosites out of approximately 1,000 ha in the Terrestrial Ecology LSA. This swamp wetland community loss equals approximately 21% of the habitat for a moderate to high number of these traditional use wetland plant species. However, the traditional knowledge studies identified that plants and berries are harvested in the larger Terrestrial Ecology RSA. The removal of all wetland communities due to the Project footprint equals 0.03% of the habitat available in the Terrestrial Ecology RSA and thus is expected to have a negligible effect on the traditional use plants in wetlands.

The potential effects on wetland vegetation communities were mitigated to the extent possible through Project design. The design and layout of the mine infrastructure was developed to avoid ecologically sensitive areas (e.g., Lizard Lake) and limit the amount of vegetation removal. The alignment of the access road is situated along an existing road (Hardtack Road). As such, the extent to which intact vegetation communities will be disturbed will be limited. The pathway of the transmission line will be cleared but not graded and stripped of topsoil, thus allowing for quick regrowth of vegetation in the transmission corridor. Vegetated riparian buffers will remain around watercourses at access road crossings to the extent possible and disturbed soils will be stabilized to assist vegetation regrowth and control erosion.

Mitigation of wetland vegetation loss also includes implementing progressive reclamation for the Project to minimize the net area disturbed at any one time. The Soil Salvage Plan developed for the Project includes the salvage of suitable overburden and topsoil material. Organic material (peat) will be salvaged where practicable in wetland areas for subsequent use in reclamation.

As detailed in the Conceptual Closure and Rehabilitation Plan. the resulting habitat after reclamation will include a mixture of several habitat types which will create a diverse landscape. With implementation of the above mitigation measures, the residual effect of wetland habitat loss is considered to be of low significance.

6.2.1.1.2 Forest Cover

Forest cover will be removed or altered due to clearing associated with the mine footprint (e.g., excavation of the open pits; construction of the WRMF, access road, transmission corridor, tailings management facility, processing plant, etc.). In addition, the removal and fragmentation of forest communities by the development of the mine facilities, site access road and transmission corridor can result in the isolation of plant populations as the developed spaces act as barriers to plant distribution.

To quantify the direct loss of forest cover due to the mine development, the footprint of the mine facilities and the proposed access road and transmission corridor were overlaid on the ecosite mapping generated for the Terrestrial Ecology LSA. The entire mine footprint will require clearing of approximately 1,200 ha of vegetation, of which 770 ha is forest cover. The overall forest cover loss is approximately 15% of forest available in the Terrestrial Ecology LSA and 0.21% of the forest occurring in the Terrestrial Ecology RSA.

Based on the OMNR's landcover data, the ecosites identified in the Terrestrial Ecology LSA were grouped into comparable forest landcover types in Table 6-47 below to allow for a comparison with the forest cover in the Terrestrial Ecology RSA. The forest cover lost based on the Project footprint is approximately 0.21% of the forest cover available in the Terrestrial Ecology RSA.

Table 6-47: Forest Losses in the Terrestrial Ecology RSA

Forest Ecosite/Type	Forest Cover Available in the RSA (ha)	Forest Cover Lost (ha)	% Lost in the RSA
Dense Coniferous Forest (ES-A, ES-B, ES-C, ES-D, ES-H)	74,297.4	430.43	0.58%
Dense Deciduous (ES-E)	72,974.4	191.22	0.26%
Dense Mixed Forest (ES-F, ES-G, ES-I)	220,707.9	150.50	0.07%
Total	**367,979.7**	**772.15**	**0.21%**

The provincially rare Blue sedge (*Carex glaucodea*) was recorded in one ecosite (ES-E deciduous forest type, discussed in the Terrestrial Ecology TSD). Deciduous forest occupies 1200 ha of the Terrestrial Ecology LSA. The mine footprint will remove and disturb 200 ha or 16% of these ecosites in the Terrestrial Ecology LSA and 0.26% of the deciduous forest in the Terrestrial Ecology RSA.

Of the forested ecosites with a potential to support a high number of traditional use plants, there will be a loss or disturbance of approximately 400 ha out of 3000 ha available in the Terrestrial Ecology LSA. This forest community loss equals approximately 14% of the habitat available in the Terrestrial Ecology LSA for a high number of these traditional use plant species. As determined through the Traditional Use Study, aboriginal people harvest traditional use plants from a vast area, comparable to the Terrestrial Ecology RSA. Therefore, the loss of forested ecosites with a high potential to support traditional use plants in the Terrestrial Ecology RSA would be <1% and therefore negligible.

The design and layout of the mine infrastructure was developed to avoid ecologically sensitive areas and minimize the amount of vegetation removal. The alignment of the access road is situated along an existing road (Hardtack Road). As such, the extent to which intact vegetation communities will be disturbed will be limited. The pathway of the transmission line will be selectively cleared but not graded and stripped of topsoil, thus allowing for quick regrowth of vegetation in the transmission corridor.

Progressive reclamation of disturbed lands will be executed, where appropriate. When the temporary construction work spaces are cleared, topsoil will be stockpiled and subsequently used as a seed source for quick rehabilitation/restoration of vegetative species.

Vegetated riparian buffers will remain around watercourses at access road crossings to the extent possible. Disturbed soils will be stabilized to assist vegetation regrowth and control erosion. During the operations phase, the encroachment into areas adjacent to established facilities will be strictly prohibited to prevent further encroachment and loss of vegetation.

At closure, developed areas will be re-vegetated to the extent practicable (regraded, replanted, reseeded, etc.) with the exception of the WRMF. As a result, much of the habitat lost during construction and operation will re-generate in post-closure, though full restoration of existing habitat will likely not occur in some areas. Native species of trees, shrubs and other vascular plants will be used for re-vegetation at closure. Where feasible, the same variety of plant species currently composing the different forest ecosites will be used for reclamation.

With implementation of the above mitigation measures, the residual effect of forest habitat loss is considered to be of low significance.

6.2.1.1.3 Flows and Drainage Patterns in Wetlands

Activities within the Project footprint will alter surface water flows and interrupt natural drainage patterns. Thus, the hydrological conditions of wetlands will be altered which can lead to changes in wetland soils and vegetation. Removal of vegetation leads to changes in drainage patterns, drying out of soils, especially the deep, organic soils of the wetland communities and a change in the soil pH and a change in the mineralization of the soils.

Based on the information in Section 6.1.3, the greatest changes in flows as a result of Project activities during the operations phase are expected to occur in watercourses in the MSA as a result of changes to their tributary drainage areas Of the watersheds evaluated, five will be unaffected, three will be reduced in size by less than 10%, six will be reduced in size by less than 50%, nine will be reduced in size by less than 90%, and six will be reduced in size by more than 90% (one of the six by 100%). Changes to tributary drainage areas will occur due to the interception of runoff from areas within the Project footprint by the water collection system. Changes in flows are expected to be roughly proportional to changes in tributary drainage area.

The expected changes in flows in watercourses in the MSA isa reduction in flows in Lumby Creek of approximately 7% to 8% as a result of the interception of runoff from the Project footprint by the water collection system.

The water levels and flows in the wetlands that are located outside of the footprint of the Project infrastructure but in the upper part of the watersheds are not expected to change as any runoff to the mine footprint will be collected in the site drainage system and used in the mine operation. The wetlands that are not being directly removed in the mine footprint but that are located in the lower portion of the catchment basin will have a reduction in flows and water levels. This may result in the reduction in area of some of these wetlands, with resultant changes in the vegetation communities.

The water management plan has been designed to convey drainage across the site with minor disruption to the habitats surrounding the project footprint. As a result, wetlands that are located outside of the footprint of the Project infrastructure but in the upper part of the watersheds are not expected to change.

6.2.1.1.4 Flows and Drainage Patterns In Forests

Removal of vegetation leads to changes in drainage patterns, drying out of soils, and potential changes in the soil pH in forested areas.

The predicted losses and alterations of flows and drainage patterns from the Project footprint on the site watersheds are summarized in the Hydrology TSD. The predicted changes are minor on the local watershed scale (those draining through Lizard Lake and to Sawbill Bay) and represent a maximum reduction of 8% in the Lizard Lake Watershed. The site drainage system has been designed to convey drainage across the Project Site with minor disruption to the habitats surrounding the Project footprint. As a result, these changes are not expected to have a measurable effect on forest cover.

6.2.1.1.5 Lake Water Levels

Based on the reduced tributary drainage areas and the proposed water taking activities from the Upper Marmion Reservoir , it is predicted that during the operations of the Project the maximum relative change (decreases) in monthly mean water levels in Upper Marmion Reservoir ranges from -8 to -9 cm for average, wet and dry year conditions, and the maximum relative change (decreases) in monthly mean outflows range from -0.8% to -4.0% for average, wet and dry year conditions, between baseline conditions and project conditions. Water taking from Upper Marmion Reservoir is expected to decrease/lower the water level in Sawbill Bay by 5-7 cm annually. The existing water level fluctuations in Upper Marmion Reservoir annually are up to 2 m. Therefore, an incremental change of up to 8 cm annually is expected to have a negligible effect on the shoreline wetlands in Upper Marmion Reservoir.

Surface water modelling was completed for Lizard Lake based on the bathymetry survey in 2011. The estimated maximum change in monthly mean water level in Lizard Lake is -3 cm as a result of runoff interception at the TMF. The estimated maximum change in monthly mean inflows and outflows to Lizard Lake using the same model is -8%. The reduction in tributary drainage area to the lake outlet is 7%. The greatest changes are expected to occur during the spring and summer months, and the smallest changes during the late fall/winter. An incremental decrease of 3 cm annually is expected to have a negligible effect on the shoreline wetlands in Lizard Lake.

Water levels changes from the Project could potentially affect wild rice growing areas. Wild rice harvesting has been identified as a potential activity of the Aboriginal communities and therefore baseline investigations included specific focus on identifying any wild rice growing areas in Upper Marmion Reservoir, Lizard Lake and downstream in the Seine River. No wild rice was identified within these water bodies, and interviews with Aboriginal land users in the area have confirmed that wild rice is not currently harvested in the LSA, largely due to the existing water level fluctuations. .

Water levels in an Unnamed Lake (API #8 in the Aquatic Environment TSD) located to the east of the TMF in site scale watershed R are expected to be influenced by Project activities. Changes in the range of -2.1 cm to 0.0 cm are expected during the Operations phase, with the greatest changes occurring during the spring and the smallest changes occurring during the late fall/winter. An incremental decrease of 2 cm is expected to have a negligible effect on the riparian wetland downstream of this lake.

Environmental design features that will be implemented to reduce the amount of water required for plant operations and domestic uses include the capture and reuse of site water. The water requirements for the Project are not expected to change drainage flows and surface water levels beyond the natural variability of the baseline conditions in Upper Marmion Reservoir, and should result in a minor change to wetlands. This pathway is expected to have negligible effects to the persistence of wetland plant populations and wetland communities in the Terrestrial Ecology LSA.

One concern is the effects of water level changes on wild rice growing areas in downstream areas of the Seine River. The changes in water levels are not likely to result in measurable changes in water levels downstream. Due to natural fluctuations, water level changes of less than 10% cannot be reliably measured. As well, the hydro-electric facility at Valerie Falls would tend to minimize any changes in downstream areas due to the Project activities through regulation of flows at the facility. As a result, no effects are predicted on wild rice growing areas in the Seine River.

6.2.1.1.6 Surface and Groundwater Quality

Surface runoff from the newly cleared lands during construction could potentially carry sediments and deposit in forested areas. Surface water that collects in the open pits and runs off of the WRMF, and the processing plant could potentially affect surface water and groundwater quality and thus vegetation in wetlands.

Leaching of dissolved metals from WRMF may cause changes to groundwater and surface water quality and soils, which may affect vegetation growth and health. The effects of contaminants in the environment are assessed in the Human Health and Ecological Risk Assessment TSD.

The assessment also considered the potential effects of discharges on aquatic vegetation, specifically the potential for sulphate concentrations in surface waters to affect wild rice. As noted in Chapter 3, wild rice was not found in the Upper Marion Reservoir, although wild rice does occur downstream of Upper Marmion Reservoir in the Seine River system. Therefore, the potential effects of sulphate levels in surface waters downstream of the Raft Lake Dam were also considered.

While CWQGs and PWQOs are not available for sulphate, the State of Minnesota has developed a water quality guideline of 10 mg/L specifically for protection of wild rice (MPCA website 2013). The water quality predictions under the different Project phases described in Section 6.1.3 show that worst case concentrations of sulphate are predicted to reach 3.7 mg/L at the Raft Lake Dam during the operations phase. Predicted concentrations under average operating conditions and in post-closure are the same as under baseline conditions (<2 mg/L). The predicted concentrations are well below the guideline developed by Minnesota and as a result there is no identified potential effect on wild rice downstream in the Seine River. Since the other water quality parameters as predicted at the Raft Lake Dam are similar to background levels, there is no predicted effect on wild rice or other aquatic vegetation in the Seine River from operation of the mine.

6.2.1.1.7 Invasive Plant Species

The construction and operation phases of the Project have the potential to introduce non-native plant species and disrupt native plant communities (Mack et al. 2000). The ground disturbance associated with construction activities can create the type of habitat favoured by invasive plant species.

The development and use of transportation corridors can also lead to the introduction and invasion of non-native plant species into previously pristine areas. The main contributor to the introduction of invasive and noxious weeds is human transport (Mack et al. 2000). Transportation corridors to and from construction areas provide a means of ingress for invasive plant species, as well as additional habitat in the form of disturbed road edges.

Vehicles and machinery can serve as dispersal mechanisms for plant propagules (seeds and/or vegetative parts) that can get lodged in tires, the undercarriage, or mud on the surface of the vehicle.

Non-native invasive plant species, or weeds, may alter nutrient cycling, competition, and the energy budget of an ecosystem, which may lead to a decrease in native plant community structure and species diversity (Jager et. al. 2009), and lower native species survival and abundance (Mack et. al. 2000). Invasive plant species are those species whose rapid establishment and spread can adversely affect ecosystems, habitats and/or other species (Haber 1997). Specific surveys aimed at searching for weeds were not completed during baseline surveys; however, had they been present within vegetation plots they would have been recorded.

An invasive species management plan will be developed. The plan should address the introduction, spread, and effects of invasive species on the environment (Haber 1997), and will be designed and implemented to prevent, detect, control (remove), and monitor areas with invasive plant species.

To mitigate the transport and introduction of non-native plant species into native plant communities, construction equipment will be regularly cleaned on-site, particularly before moving into sensitive vegetation areas. Also, areas undergoing natural regeneration may need to be isolated until native vegetation established.

The residual effect to the persistence of wetland plant populations and communities from the introduction of non-native species is predicted to be negligible.

6.2.1.2 Wildlife

Effects on wildlife were assessed using the VECs identified in Chapter 2.

The assessment of large wildlife species focuses on the moose, since moose are the primary large herbivore in the Project Site. However, the potential effects on moose can be considered as representative of other large mammals with large foraging ranges, including black bear and wolf.

The assessment considers the effects of the Project on furbearing animals, using marten and muskrat as two indicator furbearer species. The potential effects of the Project on Species At Risk is also evaluated and reported in the Terrestrial Ecology TSD.

6.2.1.2.1 Moose

The assessment of effects to moose included the evaluations of changes in the habitat availability and suitability for moose as a result of the Project.

Habitat Loss and FragmentationThe total area of the Project footprint is estimated to be 1200 ha (excludes open water). Of the approximately 3900 ha of highly suitable moose habitat in the Terrestrial Ecology LSA: regenerating forest (summer foraging), non-forested wetland (spring foraging), spruce/fir forest, and deciduous forest; approximately 400 ha will be removed for the Project footprint. This corresponds to 10.5% of the highly suitable habitat available in the Terrestrial Ecology LSA and approximately 0.1% in the Terrestrial Ecology RSA.

There are no MNR identified moose aquatic feeding areas within the footprint of the Mine site. Movement corridors to these special habitats will not be affected by the mine footprint. New roads are not being constructed near the identified moose aquatic feeding areas in the Terrestrial Ecology LSA.

The Project layout, design and infrastructure placement has been selected in order to minimize the ecological footprint. The intent has been to keep intact as much existing forest and wetland as possible by avoiding options to put facilities further to the east (southeast of Lizard Lake) and by using existing access routes for linear infrastructure. Lizard Lake provides somewhat of a natural barrier to the movement of certain species from east to west into the MSA/Terrestrial Ecology LSA. By placing the TMF to the west of Lizard Lake, the existing movement corridors for moose and other large mammals would not be as interrupted as it would have otherwise. Similarly by utilizing the Hardtack Road corridor for the new access road and transmission corridor it avoid further fragmenting new areas.

The Project footprint will leave large natural patches intact in the Terrestrial Ecology LSA and beyond. The Project mine footprint is confined to the peninsula. The access road follows existing road corridors. Research on moose habitat fragmentation has indicated that it is the size of remaining habitat patches that seems to be most relevant to moose, as small patches were less used (Stewart and Komers 2011). Therefore, the layout of the Project facilities is not expected to leave small habitat patches and habitat fragmentation is expected to have a negligible effect on moose.

Changes to Habitat Suitability for Moose

To determine Project effects on moose habitat quality, movement, and behaviour, the Lake Superior Habitat Suitability Index (HSI) Model (Allen et. al. 1987) was used to evaluate the habitats available to moose in the Terrestrial Ecology LSA and in the Terrestrial Ecology RSA. The details of the model and assessment are provided in the Terrestrial Ecology TSD.

Based on the Habitat Suitability assessment for moose in the Terrestrial Ecology RSA, which compared the baseline conditions to the application of the Project footprint and a conservative estimate of a zone of influence (zone in which moose are sensitive to sensory disturbances) there is no change predicted to the most suitable moose habitat in the Terrestrial Ecology RSA. The area of suitable moose habitat is predicted to decrease by 10km^2 due to the presence of the Project, which is a decrease of 0.39%. The area of least suitable habitat is not predicted to change due to the Project. The area of unsuitable habitat is expected to increase by 10 km^2 and this is an increase of 0.26%. These changes are expected to have a negligible effect on moose population and distribution in the Terrestrial Ecology RSA.

Alteration of Flows and Water Levels on Moose Habitat

The effects of changing water levels on moose habitat were also assessed since moose will browse extensively on emergent vegetation. The existing water levels in Upper Marmion Reservoir fluctuate annually up to 2 m. Therefore, an incremental annual change of up to 9 cm as predicted in the Hydrology assessment (Section 6.1.3) is expected to have a negligible effect on the suitability of shoreline wetlands in Upper Marmion Reservoir for moose.

Sensory Disturbances

Moose may also be affected by noise and human activity, resulting in an avoidance of the area. The highest noise levels are predicted to be centered around the open pits (70-85 dB). However, since most of the habitat near the open pits will be cleared, moose will tend to avoid the area so it is not likely that moose will be exposed to the maximum noise levels near the pits.

At the location of the WRMF (northwest of the open pits), the predicted noise level ranges between 50-60 dB which is an increase of only 5-15 dB maximum. Then further northeast, the predicted noise levels quickly attenuate back to normal ranges of 45-50 dB which corresponds to habitat areas outside of the mine footprint.

Populations of species in the Terrestrial Ecology RSA with moderate to large home ranges (e.g., moose, black bear, marten) and species with low densities (e.g., waterbirds) are not expected to be affected by noise from the Project because noise is expected to attenuate at 6.7 km for normal operations.

In summary, while the predicted noise levels near the open pits could alter wildlife behaviour, it is not anticipated that moose will inhabit these areas once development occurs. The areas they may inhabit after development are further to the northeast of the open pits and predicted noise levels in this area are within the baseline ranges. Moose tend to be more sensitive to the presence of humans rather than mechanical noise (Lykkja et. al. 2009). Therefore, the predicted noise levels from the operations of the Project are not expected to alter moose behavior.

Vehicle Collisions and Moose

The construction and operation phases will result in an increase in the volume of traffic in the Terrestrial Ecology LSA. As such the potential for collisions of vehicle with wildlife may increase. Traffic speed and volume are the primary factors that contribute to road-related wildlife mortality. Roads offer an easy travel route for some animals like moose, especially in the winter (Rost and Bailey 1979). Moose may also be attracted to the presence of deciduous vegetation in roadside ditches (Laurian et. al. 2008) as well as the runoff from salted roads in the spring. Therefore, there is an increased risk for vehicle collisions with moose.

To mitigate the effects of vehicle collisions, speed limits will be posted and enforced on the mine roads. The maximum speed will be 60 km/h on the access road and mine site road. The lower speed will permit motorists and animals to avoid collisions. Warning signs will be posted near high collision sections of the access road and mine site road. Additionally, awareness training of this hazard to wildlife and workers will be provided.

Attraction of Predators

The Project has the potential to attract predators such as black bears and wolves to the camp food wastes and other garbage. An increase in predators around the Project has the potential to affect prey species such as moose through increased predation.

An industrial and domestic waste management plan will be developed and implemented for the construction, operations and closure phases of the Project. This plan will include using appropriate waste receptacles that limit attraction of wildlife. Food wastes will be managed to prevent the attraction of wildlife, and littering and feeding of wildlife will be strictly prohibited.

All workers will be educated on the risk associated with feeding wildlife and careless disposal of food wastes. Proper waste management techniques will be conveyed to all workers and visitors to the site. Periodic, ongoing review of the efficiency of the waste management program and improvement through adaptive management practices. Animals that become a nuisance will be trapped and moved to remote locations for release.

With diligent application of these mitigation measures, the Project is anticipated to have a negligible effect on the attraction of predatory species.

6.2.1.2.2 Furbearers

Furbearers will likely be displaced from the footprint of the Project site once land clearing activities are underway. However, should an individual be encountered during Project construction, operations or closure activities, appropriate steps will be taken to minimise risk to the animal. The proposed project works and activities will be conducted in accordance with the Fish and Wildlife Conservation Act, 1997, in that wildlife shall not be knowingly (or with any intent) killed, harmed or harassed during construction, operations or closure activities. For instance, if initial clearing and construction activities disturb a den or hibernation site, the work will temporarily be stopped until the risk of killing, harming or harassing the animal(s) has been managed.

Habitat Loss

The removal of vegetation communities during site clearing will remove and alter some wildlife habitat for furbearers. The assessment of these habitat losses/alterations for furbearers is conducted on the indicator species; marten and muskrat. These two species were chosen as they require very different habitats to carry out their life stages; marten being primarily a forest species and muskrat being an aquatic mammal living in marshes and other aquatic systems. Additionally, these two species make up the majority of the trapping harvest in the Terrestrial Ecology LSA (MNR data 2012).

Marten

Of the approximately 1,300 ha of high suitability marten habitat present in the Terrestrial Ecology LSA, 65 ha (0.01% of total Terrestrial Ecology LSA) or 5% is effectively lost due to mine development activities. Of the approximately 2,800 ha of moderately suitable marten habitat present in the Terrestrial Ecology LSA, 455 ha or 16% is lost to mine development.

Overall this corresponds to a loss of 13% of the moderate to high quality marten habitat in the Terrestrial Ecology LSA. This is evaluated as a moderate magnitude. Therefore, approximately 16% of the local population of marten in the Terrestrial Ecology LSA could be displaced to adjacent habitats due to development of the Project. Most displaced individuals are expected to find suitable habitat in the Terrestrial Ecology LSA and RSA.

Muskrat

Of the 30 ha of high suitability muskrat habitat present in the Terrestrial Ecology LSA, 3 ha (.03% of total Terrestrial Ecology LSA) or 9% is effectively lost due to mine development activities. Of the approximately 70 ha of moderately suitable muskrat habitat present in the Terrestrial Ecology LSA, 6 ha or 8% is lost to mine development. Overall this corresponds to a loss of 8% of the moderate to high quality muskrat habitat in the Terrestrial Ecology LSA. Most displaced individuals are expected to find suitable habitat in the Terrestrial Ecology LSA and RSA.

The home ranges of small mammals are relatively small; therefore local populations of furbearer species will be affected by loss of habitat within existing home ranges. There are enough similar type habitats in the areas adjacent to the mine footprint and a low amount of existing habitat fragmentation in the landscape. Displaced individuals will find their habitat needs in adjacent areas. The furbearers displaced will need to establish new home ranges in adjacent areas which could create a change in the fitness of individuals; however; it is not anticipated to affect local populations of furbearers. Populations of these species are resilient and are not expected to be negatively affected by a 5-15% habitat loss.

Furbearers will likely be displaced from the footprint of the Project site once land clearing activities are underway. However, should an individual be encountered during Project construction, operations or closure activities, appropriate steps will be taken to eliminate risk to the animal. The proposed project works and activities will be conducted in accordance with the Fish and Wildlife Conservation Act, 1997, in that wildlife shall not be knowingly (or with any intent) killed, harmed or harassed during construction, operations or closure activities. For instance, if initial clearing and construction activities disturb a den or hibernation site, the work will temporarily be stopped until the risk of killing, harming or harassing the animal(s) has been managed.

Alteration of Flows and Drainage Patterns in Habitat

As muskrat and other aquatic furbearers are dependent on water levels to maintain overwintering conditions, a change in water levels has the potential to affect their habitats. Water taking from Upper Marmion Reservoir is expected to decrease/lower the water level in Sawbill Bay by 5-7 cm annually. The existing water level fluctuations in Upper Marmion Reservoir annually are up to 2 m. Therefore, an incremental change of up to 9 cm annually is expected to have a negligible effect on the suitability of shoreline wetlands in Upper Marmion Reservoir for furbearers. Similarly the predicted change in water level in Lizard Lake of up to 3 cm is expected to have a negligible effect on the shoreline wetlands in Lizard Lake and thus a negligible effect on furbearer habitat.

Environmental design features to reduce the amount of water required for processing plant operations and domestic uses include the capture and reuse of site water. The water requirements for the Project are not expected to change drainage flows and surface water levels beyond the natural variability of the baseline conditions in Upper Marmion Reservoir, and should result in a minor change to shoreline wetlands in the reservoir. Therefore, this pathway is expected to have negligible effects on the persistence of marsh wetland and riparian communities and therefore aquatic furbearer habitat in Upper Marmion Reservoir is not expected to be altered.

Populations of these species are resilient and are not expected to be negatively affected by a 5-15% habitat loss or an incremental change in hydrology in a system that is heavily influenced by hydro-electric development. Overall, residual effects are expected to be of low significance to furbearer populations.

6.2.1.3 Upland Breeding Birds

Habitat Loss

Habitat loss as a result of the development of the Project is expected to have a direct effect on upland breeding bird abundances in the Terrestrial Ecology LSA. Upland breeding bird habitats in the Terrestrial Ecology LSA include, dense coniferous, dense deciduous, dense mixed; edge, marsh, conifer swamp, thicket swamp, open fen, treed bog and treed fen open bog, deciduous swamp, and rock barren.

The decline in bird abundance within the Terrestrial Ecology LSA is expected to average 16% across all habitat types. Bird abundance within the Terrestrial Ecology LSA is predicted to decline by approximately 3,900 birds as a result of direct habitat loss. The largest decline in absolute numbers is expected to occur in the dense coniferous forest where the expected decline is approximately 1,500 birds representing 21% of bird abundance. The largest proportional decline is expected to occur in the open fen habitats where the expected decline of approximately 170 birds represents a decline of 29%.

Habitat loss is the threat to many breeding birds. The largest decline in numbers as a result of the Project is predicted to occur in birds that breed in dense coniferous forest. The MSA and Terrestrial Ecology LSA are surrounded by the same types of forest. At closure, the site will be rehabilitated to forest. Therefore, habitat loss due to the Project is expected to have a low significance to populations of upland breeding birds.

Land clearing activities have the potential to destroy bird nests and injure or kill the offspring. The Migratory Birds Convention Act 1994 protects migratory bird species including their nests and eggs. In order to avoid the destruction of nests and the potential injury or mortality of migratory birds, land clearing shall take place outside of the nesting period for birds, where applicable. However, if clearing cannot be restricted to outside of the nesting period, a biological monitor must be on site to precede the land clearing activities and conduct nest searches of the entire area to be cleared. Any nest found should be protected with a buffer zone appropriate for the species and the surrounding habitat until the young have left their nest. Appropriate species-specific buffers can be determined by notifying the Canadian Wildlife Service regional office.

Change in Habitat Suitability

The mine site operation will create noise and other sensory disturbances. Changes to the quality of habitats on the MSA will occur. These sensory changes in habitat quality have the potential to affect the population size and distribution of breeding birds, through the altered movement and behaviour of individuals.

Effects on the suitability of habitat (e.g., noise, presence of humans, and vehicles) in the 1 km zone of influence surrounding the Project footprint are predicted to reduced upland breeding bird abundance in the Terrestrial Ecology LSA by a total of 0.01% relative to baseline conditions. The largest decline in relative abundance from changes in habitat suitability for breeding birds is expected to occur in the deciduous swamps and cutover/disturbed areas where the expected decline is 0.03 and 0.04% respectively.

The effect of the change in habitat suitability occurs in the Terrestrial Ecology LSA and occurs mainly during construction and operations. The effect is reversible once the operation of the mine has ceased. The magnitude of change is <1% and thus is expected to be of negligible magnitude.

The effect of the presence of the mine on the suitability of habitat for upland breeding birds is considered to be of negligible significance due to the availability of breeding bird habitat in the Terrestrial Ecology LSA and the reversibility of the effect at closure and the minor magnitude of change.

Sensory Disturbances

Upland breeding birds use vocal communication signals for many functions, including mate attraction, territory advertisement, predator alarms, and social group cohesions (Henry and Lucas 2008). Ambient low-frequency noise is present in all urban and industrial areas. Some species of bird have been shown to adapt their songs in reaction to the disturbance of urban noise by singing with a higher minimum frequency than conspecifics in quiet environments. This adaptive behaviour is thought to minimize the effects of noise-masking by predominantly low-frequency urban noise

Due to site clearing and development, upland breeding birds will be displaced from the MSA. The following year the birds will migrate back to the area and search for other habitats within which to breed and nest in the Terrestrial Ecology LSA and beyond. The noise in the Terrestrial Ecology LSA and beyond will be barely detectable above normal background noise. Therefore, the elevated noise is not expected to have a negative effect on the remaining breeding birds in the Terrestrial Ecology LSA.

Risk of Collisions

Birds, especially waterfowl and raptors are susceptible to collisions with transmission lines. Bald eagles fly along the shoreline of Sawbill Bay looking for food and, as such, may unknowingly fly into the proposed transmission wires that are proposed across this bay. Additionally, bald eagles are susceptible to electrocution on transmission wires. Transmission line will be designed to minimize collisions by installing markers to increase visibility and limiting the use of guy wires. Wires and towers will be created such that accidental electrocution of perching birds will be minimized.

Speed limits will be posted and enforced on the mine roads. The maximum speed will be 60km/h on the access road and mine site road. The lower speed will help motorists and animals to avoid collisions.

Collisions and electrocutions can be reduced by using avian safe construction design techniques for the transmission corridor. These techniques include equipping the facilities with devices to deter Bald eagles from building nests on the towers, fitting poles/towers with perches and guards and lines with orange balls or late diverters and modification of the transmission facility to include insulators and adequate spacing of conductors (APLIC1999, Nelson and Nelson 1976). Additionally, it has been studied that forest-dwelling raptors are rarely found in electrocution records because natural perches are abundant in forests (Lehman et. al. 2006). Therefore, maintenance of forest patches around the transmission corridor will act to reduce the likelihood of raptors perching on the transmission facilities. These management practices will effectively reduce the risk of injury or mortality with the transmission corridor.

6.2.1.4 Species at Risk

Habitat Loss (Canada Warbler)

Canada warbler is known to breed within the MSA and Terrestrial Ecology LSA and therefore will lose some nesting habitat as a result of the Project footprint. The habitats that have a high suitability for nesting Canada warbler occupy approximately 4000 ha in the Terrestrial Ecology LSA, of which 465 ha will be removed for the mine site footprint. This represents 12% of the highly preferred habitat for Canada warbler in the Terrestrial Ecology LSA.

Habitat loss is the primary threat to many SAR including Canada warbler. Populations of this warbler have declined steadily over the past 30 years, likely in response to forest succession and loss of forested wetlands (Reitsma et. al. 2010). They are known to be somewhat resilient to the disturbances from forestry practices but are more susceptible to habitat fragmentation that occurs on a scale such that natural communities become isolated (Sherwick 2011). This type of habitat fragmentation is not anticipated to occur in this area as large intact landscapes remain outside of the Terrestrial Ecology LSA. Generally, the same types of impacts threaten other SAR such as the Bald eagle. The location and arrangement of the mine facilities on a peninsula do not fragment vast tracts of intact habitat that is available for SAR on the landscape. Therefore, habitat loss due to the Project is expected to have low significance to SAR populations and is not expected to prevent the establishment of self-sustaining populations of any known SAR.

Alteration of Flows and Drainage Patterns (Snapping Turtles)

Snapping turtles rely on permanent and intermittent aquatic features for many of their life processes. As such, changes to the hydrology in habitats that they utilize have the potential to effect this SAR.

The Project footprint will alter surface water flows and interrupt natural drainage patterns. Thus, the hydrological conditions of wetlands will be altered which can led to changes in wetland soils and vegetation. Removal of vegetation leads to changes in drainage patterns, drying out of soils, especially the deep, organic soils of the wetland communities and a change in the soil pH, and a change in mineralization of the soils.

The result is a reduction or even elimination of flows in some local streams. Also within this area, seepage losses from the stockpiles results in flow increases in the seepage collection system or some local streams. These changes are expected to be of minor consequence to snapping turtles that use more permanent water bodies and watercourses.

The estimated maximum change in monthly mean water level in Lizard Lake is approximately 3 cm as a result of runoff interception at the TMF. Surface water modelling was completed for Lizard Lake based on the bathymetry survey in 2011. The estimated maximum change in monthly mean inflows and outflows to Lizard Lake using the same model is -8%. The reduction in tributary drainage area to the lake outlet is 7%. An incremental decrease of 3 cm annually is expected to have a negligible effect on the water levels and extent of aquatic habitat in Lizard Lake.

The predicted changes in water levels as a result of the Project are not anticipated to be a threat to the survival or recovery of any SAR. The changes are not anticipated to prevent the achievements of a self-sustaining population of any known SAR. Under existing conditions, the water management for hydro-electric development in the area is having an influence on hydrology in the MSA, LSA, and beyond. Therefore, the incremental modification of flow by the Project footprint is considered to have a low significance for SAR populations.

Risk of Vehicle Collisions (Snapping Turtles)

One of the main threats to snapping turtles is vehicular injury and mortality. They cross roads in search of mates, food and nest sites. This is a high risk activity as they are slow moving and cannot get out of the way of moving vehicles. Posting vehicle speed limits and educating drivers on the importance of avoiding wildlife can result in reducing losses of wildlife.

Speed limits will be posted and enforced on the mine roads. The maximum speed will be 60 km/h on the access road and mine site road. The lower speed will permit motorists and animals to avoid collisions. Warning signs will be posted near areas where turtles are known to cross. Additionally, awareness training of this hazard to SAR, in particular the snapping turtle, will be provided as standard training to mine staff. Safe handling procedures will also be taught to mine workers to instruct on how to safely remove an individual from harms way during encounters. Additional mitigation for turtles may include funnelling them through culverts under roads using roadside silt fencing.

The Project mitigation measures and the anticipated low frequency of occurrence are expected to result in a negligible to low risk of injuring or causing the death of a SAR. This effect is irreversible to the individual but is not anticipated to affect the populations of SAR in the LSA. Overall, the residual effect is of low significance.

Risk of Collision with Transmission Lines (Bald Eagle)

Birds, especially waterfowl and raptors are susceptible to collisions with transmission lines. Large birds are also at risk of being electrocuted by power lines. The risk of injury or mortality is higher if the transmission lines bisect movement corridors. Bald eagles fly along the shoreline of Sawbill Bay looking for food and as such may unknowingly fly into the proposed transmission wires that are situated across this bay. Bald eagle electrocution is another matter due to the fact that it is cited as one of the most common causes of death in raptors in the United States (Kochert and Olendorff 1999). Large birds are more prone to electrocution because they are large, and can easily span distances between energized or grounded components of power poles (Lehman 2006). The majority of electrocutions are of inexperienced juvenile birds.

Collisions and electrocutions can be reduced by using avian safe construction design techniques for the transmission corridor. These techniques include equipping the facilities with devices to deter Bald eagles from building nests on the towers, fitting poles/towers with perches and guards and lines with orange balls or late diverters and modification of the transmission facility to include insulators and adequate spacing of conductors (APLIC1999, Nelson and Nelson 1976). Additionally, it has been studied that forest-dwelling raptors are rarely found in electrocution records because natural perches are abundant in forests (Lehman et. al. 2006). Therefore, maintenance of forest patches around the transmission corridor will act to reduce the likelihood of Bald eagles perching on the transmission facilities. These management practices will effectively reduce the risk of Bald eagle injury or mortality with the transmission corridor.

The Project mitigation measures and the anticipated low frequency of occurrence are expected to result in a negligible to low risk of injuring or causing the death of a SAR. This effect is irreversible to the individual but is not anticipated to affect the populations of SAR in the Terrestrial Ecology LSA. Overall, the residual effect is of low significance.

Loss of Habitat (Bats)

The assessment of effects to bats is most relevant in the LSA. The habitat loss that will occur is confined to the Project mine site and thus the geographic extent is evaluated as low. Of the preferred bat maternity roost habitat present in the LSA, 12% of it will be removed for the Project mine site development. The loss of maternity roost habitat is of moderate magnitude.

The loss of the potential hibernation habitat will also occur. The loss of both types of habitat will be offset by the creation or enhancement of other habitats for bats. The details of the compensation plan have yet to be determined, however preliminary concepts include the installation of bat condos and boxes as well as the improvement of other mine adits for use as hibernation sites.

The loss of maternity roosting habitat will take place during site preparation. The constructed maternity roosting structures will be in place prior to the first maternity season of land clearing (June). Therefore, this effect of this habitat loss on bats will not persist. Habitat loss is reversible with time, and will take a number of years for the rehabilitated mine site to mature into quality maternity roosting habitats for bats. The duration is evaluated as moderate.

The loss of potential hibernacula is being considered within the framework of the Endangered Species Act. If a permit under 17(c) of the ESA is required, an overall benefit package will be developed in consultation with MNR which will include compensation for the loss of the potential hibernation site. The magnitude of this effect will be offset by the benefit to SAR bats developed in the ESA permit process. Therefore, although the entire hibernation site is lost due to the project, the overall benefit under the ESA will need to provide no net loss to the species. Therefore, the magnitude of this loss is downgraded to moderate.

The loss of the old mine adits will take place during the site preparation period. The objectives of the ESA overall benefit package will be initiated as soon as the permit is issued. These activities should take place at the same time or if feasible, the habitat enhancement should be undertaken before the habitat loss. Therefore, the effect of hibernation habitat loss on bats will not persist as bats will find other suitable locations in the area. The duration is evaluated as moderate.

Alteration of Flows and Drainage Patterns (Bats)

To assess the effect of changes in hydrology on bats, the LSA was determined to be the most relevant study area. The geographic extent is evaluated as moderate. The incremental predicted change in flows at a local watershed scale range from +1% to -8% as a result of interception of flow in the site water collection system and the discharges from the treatment facilities. The magnitude of residual effect on bats and bat habitat would be considered low.

The effect will take place during the construction period and continue into the operations and closure. Some wetlands will be created through fish habitat compensation during construction, which may create some additional foraging habitat for bats.

At closure, the Project will no longer be taking water from the surrounding resources. Secondly, the majority of the lands that were developed for the Project facilities will be returned back to natural states (i.e., rehabilitated and restored). Certain areas will be re-graded with contours that will be continuous with the landscape. Those flow and drainage patterns that were interrupted in these areas will be reconnected where possible. Overall, the duration of effects is considered moderate.

6.2.1.5 Dust Deposition and Emissions

The effects of dust and air emissions from the Project on vegetation and wildlife were assessed based on predicted concentrations of metals emitted during the processing of the ore. Predictions focused on contributions from atmospheric sources to soil that could directly affect vegetation through uptake from soil, and indirectly affect wildlife through incidental ingestion of soil.

A detailed description of the particulate deposition modelling used to determine the dry and wet deposition rates is provided in the Atmospheric Environment TSD. Deposition onto soil was assumed to occur throughout the construction, operations and closure phases of the Project. Atmospheric emissions are not expected during the post-closure phase. All substances deposited onto soil were assumed to mix within the top 2 cm of soil. Soil was assumed to have a bulk density of 1.5 g/cm^3.

Chemicals of potential concern in soil were identified using a three-tiered screening approach. In the first tier of screening, the predicted concentrations in soil were compared to soil quality standards. Concentrations were compared to the Ontario Ministry of the Environment (MOE) Table 1 Full Depth Background Site Condition Standards for Soil for Agricultural or Other Property Use (MOE 2011). If a Table 1 Standard was not available for a chemical, the Ontario Typical Range (OTR_{98}) of Chemical Parameters in Soil (MOE 2011) was used as the standard. A second tier screening was conducted by comparing the predicted soil concentrations in soil to the maximum measured baseline concentrations plus 10%. During the third tier of screening, substances with predicted concentrations higher than the MOE Table 1 Standards and OTR_{98} values (for substances without Table 1 Standards) and maximum measured baseline concentration plus 10% were compared to the CCME Canadian Soil Quality Guidelines for the Protection of Environmental Health (SQG_Es) for agricultural land use (CCME 2012b internet site).

Predicted concentrations of copper, molybdenum, nickel and silver are greater than the Table 1 Standards; however, predicted concentrations are lower than the maximum measured baseline concentrations plus 10%. There are no Table 1 Standards for bismuth, lithium, tin, yttrium and thiophene; however, predicted concentrations are lower than the maximum measured baseline concentrations plus 10%. The predicted concentration of sodium (1,525 mg/kg) is within the range of background soil concentrations measured in Ontario (approximately 25 to 1,600 mg/kg) (MOEE 1994a). As a result, no COPCs were identified in soil for further assessment in the ERA and no adverse effects on wildlife are predicted.

6.2.1.6 Water Quality in the TMF and PPCP

Since wildlife could be exposed to ponded water in the TMF reclaim pond during operations, water quality in the TMF was also considered with respect to the potential for ingestion by wildlife. The predicted water quality in the reclaim pond is provided in the Lake Water Quality TSD. The predicted concentrations were compared against guidelines for livestock consumption, since these would also protect wildlife. None of the parameters exceeded the guidelines and as a result there is no predicted effect on wildlife from ingestion of water from the TMF reclaim pond.

Wildlife are not expected to use the PPCP as a source of drinking water. Since the pond is located close to the processing plant, which is a source of noise and disturbance it is expected that wildlife will avoid the area. Use of the PPCP as a source of drinking water will be monitored, particularly in the spring when other sources of water may not yet be available. If wildlife are observed to be frequently accessing the ponds, measures will be implemented to restrict access.

6.2.2 Aquatic Ecology

Potential effects on the aquatic environment include the effects of habitat loss or alteration, and potential exposure to substances in surface waters that may originate from the Project Site. Effects are considered during all phases of the Project. Effects during the closure and post-closure phases are considered together.

The Project will involve the elimination of Mitta Lake because of development of the open pits, as well as a number of small streams and ponds for the construction of associated infrastructure. The development of the TMF will result in the elimination of a small lake, as well as the headwaters of some of the small streams that originate within the proposed area of the TMF. As noted in Chapter 3, many of these streams are intermittent and as such provide limited habitat for some species.

As noted in the Hydrology Assessment, the Project is predicted to result in a change of 3 cm to lake levels in Lizard Lake, and up to 9 cm in Sawbill Bay. These changes are less than the measured annual water level fluctuations in these waterbodies.

In addition to the elimination of aquatic features in the MSA that will be directly overlapped by the Project footprint, it is anticipated that, prior to mitigation, there will be effects to the aquatic environment in the lower reaches of the water courses (streams and Mitta Lake).

Potential effects from the mine and associated infrastructure on the aquatic environment result from the following:

- Elimination of waterbodies and water courses.
- Reductions in drainage areas for local watercourses.
- Changes in lake levels as a result of flow reductions and water taking.
- Discharge of water from the PPCP and domestic wastewater treatment facility.
- Changes in channel alignments from road construction.

Fish species impacted through elimination of watercourses under the footprints of proposed infrastructure, such as the TMF and WRMF, are generally baitfish species with the exception of Northern Pike which are anticipated to be impacted by the Tailings Management Facility (TMF).

6.2.2.1 Construction Phase

The loss or alteration of habitat and drainage areas will occur mainly in the construction phase, as the mine infrastructure is constructed. The following sections identify:

- Habitat that will be lost through the construction of Project facilities.
- Habitat that will be altered through changes in stream flows.

Loss of Habitat

Mitta Lake will be drained during the construction phase to allow mining of the open pits to commence during operations. Mitta Lake will be drained by pumping the water into Sawbill Bay. Since water quality in Mitta Lake and Sawbill Bay are similar (data are provided in the Water and Sediment Quality TSD), there is no predicted effect from this activity. As the water levels decrease during pumping there is increased potential for entrainment of suspended solids as the water level approaches the lake bottom. TSS levels will be monitored, and when levels increase above the CWQGs then pumped water will be directed to the PPCP for settling of particulates prior to release to surface waters.

The direct loss of habitat through the destruction of existing surface water features within the Project footprint are summarized in Table 6-48 (the locations of the APIs are shown on Figure 6-7). These habitat losses have been discussed with federal and provincial regulators, assigned specific values and will form the basis of the No Net Loss Plan.

Table 6-48: Aquatic Habitats Directly Affected by Site Development

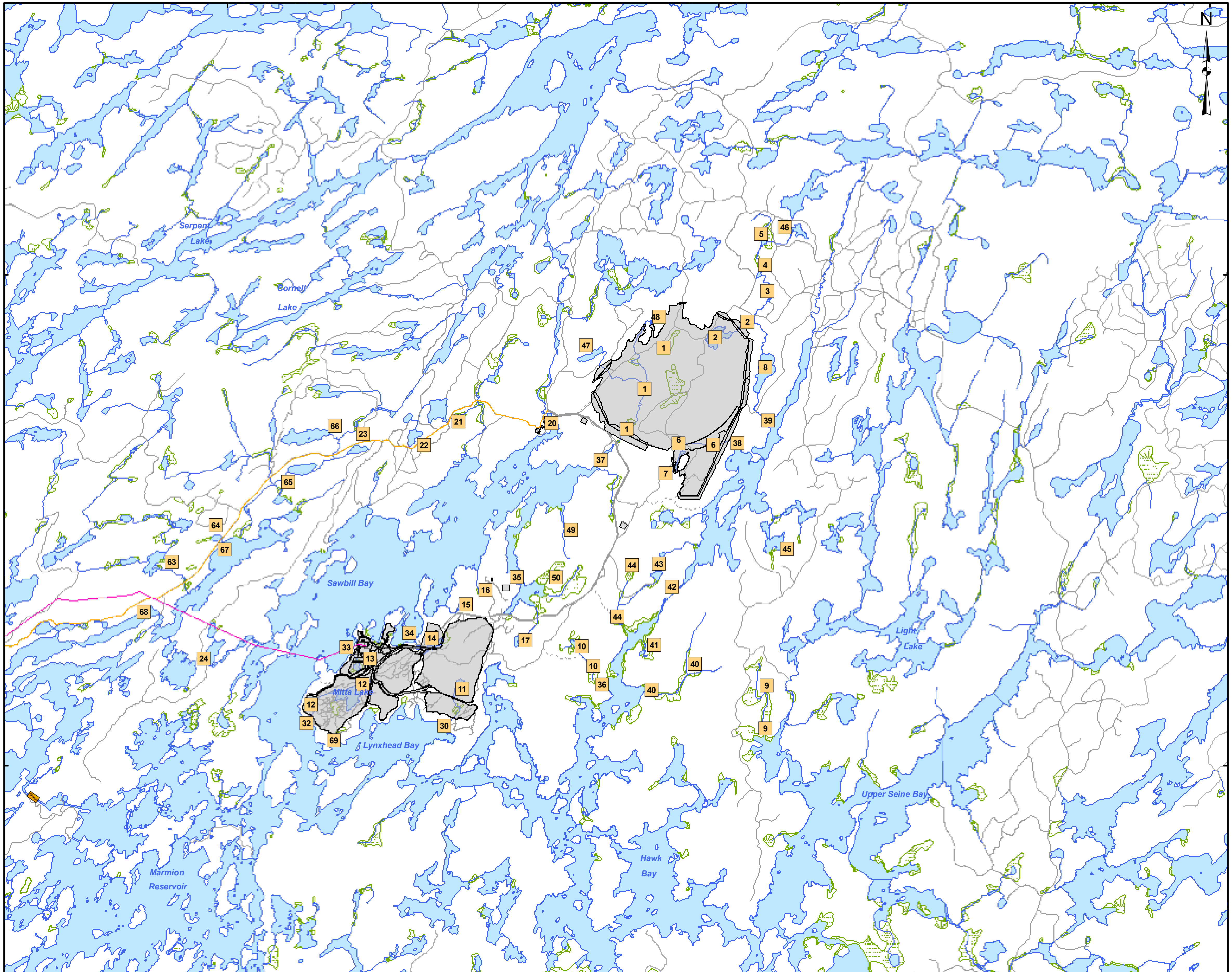
Infrastructure Feature	Aquatic API	Description	Description of Potential Effect
Open Pit	■ Mitta Lake (API #12) and its outlet stream	■ 172,737 m^2 lake; approximately 449 m of stream; empties into Sawbill Bay; supports common white sucker (*Catostomus commersoni)*, ninespine stickleback (*Pungitius pungitius)*, brook stickleback (*Culaea inconstans*), fathead minnow (*Pimephales promelas)*, Iowa darter (*Etheostoma exile)*, mottled sculpin (*Cottus bairdi*)and finescale dace (*Chrosomus neogaeus)*.	■ Mitta Lake forms the active pit. The destruction of Mitta Lake results in the loss of 396 HU of useable littoral habitat and 7,311 HU of useable open water habitat.

Table 6-48: Aquatic Habitats Directly Affected by Site Development (Continued)

Infrastructure Feature	Aquatic API	Description	Description of Potential Effect
Open Pit (Continued)	■ API #14	■ Upper portions of approximately 1,169 m stream; empties into Sawbill Bay; supports finescale dace, northern redbelly dace (*Chrosomus eos)*, fathead minnow; juvenile common white sucker captured in lower reach.	■ API #14 will be removed for the construction of the Support and Ancillary Structures near the open pit. Destruction of API #14 results in a loss of 45 HU of useable low gradient stream habitat and 119 HU of useable high gradient stream habitat.
	■ API #69	■ 9,871 m^2 pond and 165 m of stream; pond supports common white sucker, pearl dace, Iowa darter, central mudminnow (*Umbra limi*), blacknose shiner, finescale dace and northern redbelly dace. No fish were found to exist within the outlet stream.	■ Headwater pond and upper reaches of API #69 will be destroyed through the construction of the open pit. Destruction of API #69 results in a loss of 224 HU of useable littoral habitat, 1080 HU of useable open water habitat.
Mine Water Spill Emergency Pond	■ API #13	■ 19,375 m^2 headwater pond; approximately 396 m of stream consisting of 476 m^2 of beaver impoundments; both pond and stream are fishless. Empties into Lynxhead Bay.	■ No useable habitat will be lost through the destruction of API #13 for purposes of Support and Ancillary Structure development.
Waste rock Stockpile	■ API #11	■ 27,777 m^2 head water pond; approximately 787 m of stream including several 1030 m^2 of beaver impoundments; empties into Lynxhead Bay; supports finescale dace, northern redbelly dace, fathead minnow.	■ API#11 will be destroyed through the construction of the Waste Rock Stockpile. 32 HU of useable low gradient stream, 13 m of useable high gradient stream, 58 HU of useable pond, 173 HU of useable littoral and 1701 HU of useable open water habitat will be lost.
Tailings Management Facility	■ API #47	■ Approximately 762 m of stream including 29,944 m^2 of beaver impoundments; supports finescale dace, pearl dace (*Semotilus margarita),* and northern redbelly dace.	■ The streams and beaver impoundments of API #47 will be impacted by the proposed Tailings Management Facility. This will result in a loss of 11 HU of useable low gradient habitat, 34 HU of useable high gradient habitat and 1824 m^2 of useable pond habitat.

Table 6-48: Aquatic Habitats Directly Affected by Site Development (Continued)

Infrastructure Feature	Aquatic API	Description	Description of Potential Effect
Tailings Management Facility (Continued)	■ API #48	■ Approximately 123 m of ephemeral/seasonal stream, 430 m of permanent stream and several beaver ponds (10,198 m^2 total); approximately 2,051 m^2 headwater pond; no hydraulic connection to downstream aquatic features. Finescale dace captured in one of the beaver ponds.	■ The outlet stream and associated beaver impoundments will be impacted by the proposed TMF. This will result in the loss of 239 HU of useable pond habitat.
	■ API #1	■ Approximately 894 m of stream, including 5,836 m^2 of beaver impoundments; empties into Sawbill Bay; upper sections support pearl dace, finescale dace and fathead minnows; juvenile and young-of-the-year (YOY) common white suckers captured in lower sections.	■ API #1 is entirely contained within the footprint of the TMF and thus we be destroyed. This will result in the loss of 266 HU of useable low gradient habitat, 21 m of useable high gradient habitat, and 2722 HU of useable pond habitat.
	■ API #7	■ 10,962 m^2 headwater pond; partially in-filled; fishless; connected to API #6 by a series of small beaver ponds (approximately 721 m^2).	■ Though API #7 will be destroyed by the proposed TMF, no useable habitat will be eliminated since the feature is fishless and isolated from API #6.
	■ API #6	■ 5,385 m^2 pond, 437 m of stream, and 1004 m of ephemeral stream; empties into Lizard Lake; pond and ephemeral stream are fishless; common white sucker and Iowa dater captured in lower segment of stream.	■ APi #6 is contained within the footprint of the proposed TMF. This will result in the loss of 21 HU of useable low gradient stream habitat.
	■ API #2	■ 124,351 m^2 lake and 2217 m of stream and 3,808 m^2 of beaver impoundments; supports pumpkinseed (*Lepomis gibbosus)*, northern pike, yellow perch (*Perca flavescens)*, Iowa darter (*Etheostoma exile),* common white sucker, blacknose shiner (*Notropis heterolepis)*.	■ The destruction of API #2 results in the loss of 632 HU of useable littoral habitat and 9476 HU of useable open water habitat.



LEGEND

- Area of Potential Impact (API); Assessed 2010 - 2012
- Raft Lake Cut Location
- Trail
- Road
- River/Stream
- Lake
- Wetland
- Mine Site Road
- Access Road (Hardtack / Sawbill)
- Project Transmission Line
- Project Facilities

REFERENCE

Base Data - Provided by OSISKO Hammond Reef Gold Project Ltd.
Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

1,000 0 1,000 2,000 3,000
METRES

PROJECT

HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE

AREAS OF POTENTIAL IMPACT

PROJECT NO. 13-1118-0010			SCALE AS SHOWN
DESIGN	CGE	14 Nov. 2008	VERSION 2
GIS	JO	2 Dec. 2013	
CHECK	BH	2 Dec. 2013	
REVIEW	GA	2 Dec. 2013	

Golder Associates
Mississauga, Ontario

FIGURE: 6-7

G:\Projects\2013\13-1118-0010_Osisko_Hammond_Reef\GIS\MXDs\Reporting\EIS\Chapter 6\foot_print_api.mxd

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Alteration of Habitat

Reduction in the drainage area in a number of catchments will result in flow reductions to a number of inflowing streams.

Predicted changes in the drainage area within the MSA are summarized below:

- Catchments experiencing less than 10% reduction in drainage area and/or reductions to ephemeral/ intermittent streams. These include catchments C, F, G, H (APIs 15, 16, and 17 impacted). Effects are predicted to be negligible in these catchments.
- Catchments experiencing between 10 – 25% reduction in drainage area to permanent streams. These include catchments AJ, R (API 8 impacted). Effects are predicted to be minor in these catchments.
- Catchments experiencing greater than 25% reduction in drainage area to permanent streams. Effects are predicted to be variable depending on the catchment. These include:
- Catchments I, J, K, L, P, Q, B, which will experience a 100% loss of drainage area on a permanent basis (API 6, 7, 11, 12, 13, 14, 47, and 48 impacted and are addressed in Table 6-48). Effects are predicted to be major.
- Catchments AB, AD, AI, AR, AS (no APIs) will result in a greater than 70% loss. No fish habitat has been recorded in these catchments. Effects to the aquatic environment are predicted to be negligible.
- Catchments AF, AH, AK, AL, AM, AN, AO, AP, AQ, AS (no APIs identified) will experience between 25% and 70% loss of drainage areas. Since no fish habitat is present in these catchments effects to the aquatic environment are predicted to be negligible.

Effects of Habitat Loss and Alteration

Effects on specific VECs due to loss of habitats are discussed in the following paragraphs.

Effects on northern pike, in API #2, will occur as a consequence of loss of habitat as the TMF is developed. A fish rescue plan will be implemented in this and other bodies of water that will be eliminated. As a result, direct loss of fish will be kept to a minimum, and it is expected that the effects on the local populations will be minor. The loss of northern pike habitat has been considered in the conceptual compensation plan.

Northern pike habitat in the downstream reaches of the tributaries that are directly affected by development of site infrastructure, used as spawning and rearing habitat, may also be affected due to flow reductions, and some nearshore habitat may not be available, particularly during low water periods. Given the water levels fluctuations that typically occur as a result of reservoir management (up to approximately 2 m), exposure of nearshore habitats is likely to be a function of the management of the reservoir rather than an effect of the Project on water levels. As noted in Section 6.1.3, water level changes as a consequence of the Project are likely to be less than 9 cm in Upper Marmion Reservoir under average conditions, and less than 3 cm in Lizard Lake. These predictions include water taking from Upper Marmion Reservoir, which will occur only during the operations phase. Water levels changes during construction will therefore be less than the predicted changes since water levels during construction will only be affected by loss of drainage area.

Walleye do not inhabit any of the aquatic features within the mine footprint that will be directly affected through elimination. There is also no indication that walleye use the lower reaches of the streams in which flow reductions due to drainage alteration will occur.

Some effect on walleye habitat may occur during construction of stream crossings where walleye habitat has been identified, specifically at API #62. Since the disturbance will be limited to a small area, during non-critical periods, and will be of short duration, there is no significant effect predicted on walleye from this activity. Walleye habitat is not predicted to be affected by lake levels changes since these are minor. Therefore there is no predicted effect on walleye populations from the minor changes in lake levels that are predicted to occur during construction.

Smallmouth bass do not inhabit headwater ponds and streams within the Project Site. Smallmouth bass could potentially be affected at some of the stream crossings along the access road. Since the disturbance will be limited to a small area, during non-critical periods, and will be of short duration, there is no significant effect predicted on smallmouth bass from this activity. Smallmouth bass habitat is not predicted to be affected by lake levels changes since these are minor.

Baitfish (small-bodied forage fish) will be affected by habitat loss through direct elimination of some habitats, and flow reductions in the lower reaches of some streams. Some habitats will be eliminated entirely and the compensation plan will address habitat loss. Reductions in flow in other habitats, particularly the downstream reaches of streams in which headwater areas have been eliminated, will also experience some loss of habitat. These form part of the compensation plan as well, since there is no effective means of mitigating these effects.

Benthic communities will be directly affected within those habitats that are eliminated. Since benthic communities are confined to permanent aquatic habitats (a very limited number of organisms can colonize temporary habitats), the loss of benthic communities will be confined to those waterbodies that are permanent habitat. Flow reductions in some streams will also directly affect benthic communities downstream through reduction in available habitat.

The loss of benthic communities is small relative to the availability of aquatic habitats in the Aquatic Environment LSA and RSA, and local populations would not be directly affected. The small areas affected would also not be expected to affect availability of food resources to those aquatic and terrestrial species that feed on benthic organisms. Terrestrial insectivorous species would be displaced to adjacent habitats, where benthic resources would not be affected. Aquatic species, such as fish in the affected waterbodies would also be removed through loss of these habitats. Since benthic species are primarily sedentary, benthic productivity in these upstream areas would not be expected to contribute significantly to fish food resources in downstream habitats. As a result, elimination of some habitats is not expected to affect downstream fish food resources to any measurable degree.

Results of removal of the site drainage areas on lake water levels are predicted to be minor. The hydrology assessment has considered a bounding scenario that includes elimination of on-site drainage features as well as water taking during operations and has concluded that levels in Lizard Lake are predicted to change by 2.7 cm, while lake levels in Lynxhead Bay and Sawbill Bay of Upper Marmion Reservoir are predicted to change by up to 9 cm. These changes are less than the seasonal changes currently experienced in these water bodies.

The water level in Upper Marion Reservoir is actively managed to maintain sufficient flood control capacity and also to provide a sustainable source of hydro-electric power at the downstream generating stations. As a result, water levels in Upper Marmion Reservoir can change by up to 2 m on an annual basis as the reservoir is drawn down. The 9 cm change in water levels would be encompassed within this fluctuation and as a result there would be no predicted increased effect on aquatic life.

Littoral areas are currently impacted by the large drawdown in the system that can leave large areas of the littoral zone exposed. As a result, the additional change in water level will have minimal effect on the productivity of the littoral areas, and the availability of habitat in these areas, since these areas are currently significantly affected by the existing drawdown regime. Photo 6-1 shows an example of the exposed littoral zone in Sawbill Bay due to drawdown.

Photo 6-1: Sawbill Bay - Large bay to the west of the Project Site, showing drawdown and exposure of littoral zone – April 2010.

The cumulative effect of seasonal low water levels and reductions in lake levels due to loss of drainage areas results in an incremental increase in the area of nearshore habitat exposed during low water levels. This effect would occur infrequently (e.g., only during dry years) and be of short duration, primarily in the spring as the reservoir is refilling.

Negligible effects are predicted from erosion and sedimentation resulting from construction activities. Erosion control measures will be implemented early in the construction phase to intercept runoff to local water bodies. Runoff will be routed to the PPCP for settling of solids prior to release to surface waters.

Water intake and discharge structures in Sawbill Bay for process water and domestic water use will result in losses of small areas of lake bottom habitat. Intake structures will be set at an approximate height above the lake bottom to minimize entrainment of aquatic organisms. To the extent practicable the intake structure will be designed to minimize inflow velocities to minimize entrainment of fish and other organisms from the water column. If possible discharge structures (diffusers) will also be elevated above the lake bottom to minimize effects on aquatic life.

To the extent practicable stream crossings will be constructed during non-critical periods (timing windows will be determined through consultations with DFO and MNR). Effects of construction are predicted to be confined to a small area around the road crossing and will result in limited habitat disturbance. Road crossings are constructed relatively quickly, so the duration of the effect is predicted to be limited to a few days. As a result, effects on aquatic life are predicted to be minor, since recolonization of the area is expected to begin once construction has been completed.

6.2.2.2 Operations Phase

During the operations phase, no additional habitat loss in water courses or water bodies within the Project footprint are expected since all construction of site infrastructure will have been completed. Potential effects during the operations phase include those from blasting, water taking, changes to water quality, changes to water levels and seepage from the TMF.

Blasting

Blasting in the open pit is predicted to result in negligible effects on fish species, provided an appropriate blasting plan is implemented to limit blast intensities such that DFO guidelines are met. Blasting will not be a potential concern during the initial stages of pit development due to the distance from the blast sites to the margins of Sawbill Bay and Lynxhead Bay, but may be a concern in later stages of pit development as the pit expands and the pit walls approach Upper Marmion Reservoir. Therefore, blasting will be monitored during the initial stages of pit development to assess transmissivity of vibrations.

Based on initial operational monitoring the need for additional assessment of adjacent aquatic habitats will be considered to assess the habitats present and the use of these habitats by fish species in Upper Marmion Reservoir, particularly during sensitive life stages. These data will be used in the later stages of operations as the area of the pit expands and blasting approaches the margins of Sawbill Bay and Lynxhead Bay to develop an appropriate blasting plan to mitigate potential effects for sensitive fish species during critical life stages.

Water Taking

During operations, water taking from Upper Marmion Reservoir for operation of the mine combined with the loss of drainage areas from site development during construction will result in the predicted decreases in lake levels as described in bounding scenario in the hydrology effect assessment (Section 6.1.3). As noted in the preceding section, this is predicted to result in minor effects on aquatic life through temporary loss of littoral habitat in the spring. The water level in Lizard Lake is predicted to decrease by approximately 2.7 cm from existing lake levels (the maximum change in water level in Lizard Lake is predicted to occur during operations). As a result, the changes in water levels are not expected to have a measurable effect on the available aquatic habitat and VEC species.

The reductions in flows and lake levels are also not predicted to result in significant changes at the outflow at Raft Lake Dam. The predicted changes in water levels of Upper Marmion Reservoir ranged up to 9 cm. Therefore, downstream flows into Finlayson Lake and the Seine River would not be affected and effects on aquatic life in these water bodies are predicted to be negligible. Under average conditions, flows at the Raft Lake Dam could be reduced up to 0.7%, which is predicted to result in negligible changes in flows and water levels downstream in the Seine River system. Water quality predictions at the Raft Lake Dam indicate that there is no increased risk to aquatic life in downstream habitats from operation of the Project. As a result, there are no predicted effects to aquatic life in downstream habitats in the Seine River system.

Particular attention has been focused on the walleye population in Upper Marmion Reservoir. Walleye are of significant cultural importance to Aboriginal communities, and have been identified as an important local resource by First Nations in the area. The walleye fishery has also been the focus of management by the MNR.

The change in water levels during operations under maximum water taking or discharge conditions is unlikely to result in adverse effects on sensitive life stages of walleye, for example during spawning or development of eggs, larvae and juveniles. The current drawdown as a result of the ongoing operation of the reservoir for power generation presents a greater challenge to walleye recovery in Upper Marmion Reservoir than the minor changes expected due to operations.

The freshwater intakes for the worker accommodation camp and for the mine water intake will be screened to prevent entrainment of small-bodied fish in accordance with the DFO operational statement for screening of intakes.

Water Quality

Discharge of excess water from the PPCP and the domestic sewage treatment facility are predicted to meet water quality discharge guidelines. The water quality effect assessment has noted that during operations, water quality in Upper Marmion Reservoir and Lizard Lake are not predicted to differ substantially from baseline (existing) conditions.

Water quality predictions indicate there will be no increase in the concentrations of most metals, nutrients and major ions in surface water over existing baseline conditions. A slight increase was noted for molybdenum under average conditions, but predicted concentrations were below the available guidelines (PWQO and CWQG). As a result, there will be no predicted increase in fish exposure to metals and no predicted increase in fish tissue residues.

Mercury is of particular concern in fish tissues, and some walleye currently exceed consumption restrictions for some sensitive groups, such as women of child-bearing age and children under 15 years of age (discussed in Chapter 3). Water quality modeling (Section 6.1.3) predicts no change in mercury concentrations in surface water or sediments during operation and into post-closure. Therefore, concentrations of mercury in walleye or other fish species are not predicted to increase as a result of discharges from the site (concentrations in geologic material are currently below detection limits). The slight increases in sulphate levels are also not predicted to result in increases in methyl mercury production. As described in Section 6.1.3, conditions in Sawbill Bay would not favour net methyl mercury production due to oxygenated conditions that appear to persist throughout the water column.

Concentrations of chloride are predicted to increase to a maximum of 1.8 mg/L in Sawbill Bay under worst case conditions (Section 6.1.5). While the CCME has not developed a guideline for chloride, the B.C. Ministry of the Environment has derived a chronic value of 150 mg/L for the protection of aquatic life (Nagpal et al. 2003). Since the maximum predicted concentrations are well below this guideline, no effects on aquatic life are predicted from chloride.

As noted in Section 6.1.3, sulphate concentrations are predicted to increase to a maximum of 4.9 mg/L under worst case conditions (Section 6.1.5) at the south end of Sawbill Bay. While there is no CWQG for sulphate, the State of Minnesota has developed a guideline of 10 mg/L for the protection of wild rice, which appears to be particularly sensitive to sulphate. The B.C. Ministry of Environment has developed a chronic guideline of

100 mg/L for the protection of aquatic life. The predicted concentrations in Sawbill Bay are less than these guidelines, and no effects are predicted on aquatic life from sulphate.

Predicted concentrations of copper around the discharge at the south end of Sawbill Bay were above the guidelines for protection of aquatic life under worst case conditions (maximum predicted concentration was 0.0028 mg/L compared to the CWQG of 0.002 mg/L). Similarly, under worst case conditions, the maximum predicted copper concentration in Lizard Lake was 0.0024 mg/L. As a result, a site-specific water quality objective (SSWQO) was developed for copper that takes into account the naturally occurring factors such as hardness and dissolved organic carbon that can modify copper toxicity. The approach is described in the Human Health and Ecological Risk Assessment TSD, and is based on the biotic ligand model (BLM) that is currently used by the U.S. EPA to derive copper guidelines.

Based on the BLM, a SSWQO of 0.0079 mg/L was developed for Upper Marmion Reservoir and Lizard Lake. The predicted copper concentrations are less than this value, and as a result adverse effects on the species present in Upper Marion Reservoir and Lizard Lake are not anticipated.

Similarly, a SSWQO was also developed for free cyanide. Based on a review of toxicity data (details are provided in the Human Health and Ecological Risk Assessment TSD), a SSWQO of 0.01 mg/L was developed for free cyanide.

Following initial mixing, concentrations of free cyanide under average conditions are all predicted to be below the PWQO and CWQG (0.0012 mg/L as compared to the PWQO and CWQG of 0.005 mg/L). The predicted concentration is well below the SSWQO of 0.01 mg/L and no adverse effects are expected on any of the species present in Upper Marmion Reservoir or Lizard Lake.

A review of cyanide toxicity data (recent data have been summarized in Gensemer et al. 2007) provides chronic thresholds for warm water fish species and invertebrates. No effects concentrations (NOECs) for fathead minnow and bluegill were reported for values as high as 0.016 mg/L and 0.009 mg/L, while lowest effects levels (LOECs) for these same species are reported as 0.02 mg/L. Invertebrates appeared to be less sensitive, with reported NOECs and LOECs for amphipods of 0.016 mg/L and 0.021 mg/L respectively. Reported NOECs and LOECs for isopods (*Asellus* sp.) were 0.029 mg/L and 0.04 mg/L. As a result, predicted worst case concentrations of free cyanide are not expected to have adverse effects on aquatic life. Furthermore, as noted in Chapter 5, there is no predicted discharge during dry years, which represents the modeled worst case conditions (i.e., highest concentrations during lowest water levels). Since lowest water levels would occur only during dry years, it is unlikely that the predicted worst case condition would actually occur, since during dry years all excess water would be re-used and there would be no discharge.

Seepage

Seepage from the all site facilities including the TMF to Lizard Lake during operations will be managed through a seepage collection system that will direct seepage from the TMF back to the TMF. In the event that some seepage bypasses the system, the evaluation conservatively considered the implications assuming 10% of the seepage bypassed the collection system and migrated to Lizard Lake. Predictions of worst case conditions resulted in free cyanide concentrations in Lizard Lake of up to 0.0011 mg/L. Since the predicted concentration is below the guideline of 0.005 mg/L and below the SSWQO of 0.01 mg/L, there are no predicted adverse effects due to free cyanide.

For Waste Rock and Ore, the predicted worst case groundwater concentrations of aluminum (0.25 mg/L), arsenic (0.03 mg/L), copper (0.009 mg/L), and uranium (0.007 mg/L) are greater than the PWQO protection of aquatic life guidelines (PWQO) as presented in the Site Water Quality TSD, Table 4-8 and Table 4-9. These values, while above the PWQO values are below the GW3 criteria as developed by MOE under O.Reg 153/04 (with the exception of aluminum for which there is no GW3 criteria). When accounting for a 10 times dilution along the flow path (similar to the rationale used in developing the GW3 criteria) it is considered that there is no anticipated adverse effect on aquatic life due to these concentrations. Attenuation of these values has not been considered, however attenuation along groundwater flow pathways has the potential to substantially reduce concentrations of many parameters (U.S. EPA 2007).

Since PWQOs do not provide acute guidelines, concentrations of the above parameters were compared to the U.S. EPA Ambient Water Quality Criteria CMC (Freshwater Acute) values. These represent acute concentrations to which aquatic life should only be exposed to for short periods of time.

Aluminum – no guideline available

Arsenic – 0.34 mg/L

Copper – 0.013 mg/L

Uranium – no guideline available.

Based on comparison with the above guidelines, the undiluted groundwater concentrations expressing to surface waters would not be considered as acutely toxic.

Given the current accounting of flows and mass load, and the geochemical conditions of the materials on site, it is considered that the groundwater component from stockpiles including the Ore and Waste Rock is negligible with respect to influencing the overall results or conclusions of the EIS/EA with respect to potential for water quality impacts from the site.

6.2.2.3 Closure and Post-Closure Phases

Habitat

Habitat lost during the construction phase will be unchanged through the closure and post-closure phases for those Project components that will be permanent. These include the TMF, the waste rock facilities and much of the mine infrastructure base (buildings will be demolished). These losses will be addressed in the habitat compensation plan.

Final grading will create drainage features to collect surface drainage from mine site and discharge to Sawbill Bay. There will be a small increase in total runoff to the Bay as a result of reduced permeability of overall mine site. Discharge is in the order of 70 m^3/hour = 20 l/s.

The open pits will be allowed to fill naturally. It is predicted that it will take approximately 218 years before the pits fill to the point where they will overflow.

Mitta Lake currently stratifies thermally in summer, and appears to undergo some chemical stratification during winter months, likely due to the small surface area of the lake relative to depth. As a result of the small surface area the lake will resist wind-induced mixing as the water column becomes isothermal. The open pits will be much deeper with a much smaller surface area relative to depth, that will further resist full mixing of the water column, and it is expected that the pits will permanently stratify (i.e., the pits will become meromictic). Currently the deeper waters of Mitta Lake (up to depths of 14 m) experience periods of low oxygen and during some periods, anoxia. As a result, the deeper waters of the pits are also expected to become anoxic as oxygen is consumed and mixing of the water column is prevented. Therefore, the deeper waters of the pits are not expected to provide suitable conditions for aquatic life.

The pits at closure will be steep-sided (the existing benching from the operations phase will remain), with limited potential for development of fish habitat. At closure the open pits may develop some littoral zone habitat for fish, and this could potentially be enhanced, although safety concerns and closure regulations would need to be considered. Potential creation of new fish habitat from pit flooding has not been considered as a credit to OHRG in fish habitat accounting. Further details of fish habitat compensation are provided in the No Net Loss Plan.

Water Quality

Water quality predictions for the open pit indicate that pit water quality in post-closure will meet guidelines for the protection of aquatic life. Therefore, when water levels reach the 420 masl elevation, the pit is predicted to overflow south into Upper Marmion Reservoir approximately 218 years after operations cease. An overflow channel will be cut at a natural low point directly south of the open pits (Figure 6-6). Overflow water quality is not predicted to affect water quality in Upper Marmion Reservoir, and no effects on aquatic life are predicted to occur (see discussion on water quality in Section 6.1.5). Geochemical testing has shown limited potential for (Geochemistry Geology and Soil TSD), leaching of metals from the rock types that form the deposit, and therefore the areas around the open pit, which are expected to result in in low concentrations of most metals in surface waters. Aluminum and iron concentrations have been elevated in some baseline monitoring data, and as the water quality summary (Section 6.1.5) has shown, are elevated regionally due to the geology of the region. Similarly, mercury and selenium concentration under baseline conditions exceed the CWQGs, though mercury is most likely due to atmospheric deposition of mercury from anthropogenic sources rather than local geologic sources. Predicted concentrations in Upper Marmion Reservoir at the pit overflow are not altered from existing levels and there are no predicted increased effects on aquatic life.

Seepage and Water Levels

During Closure, Seepage and runoff water from other areas of the site, in particular the WRMF and overburden stockpiles, will initially be directed to the open pits. Water quality in post-closure will be monitored, and when water quality is acceptable for release, based on protection of aquatic life, the seepage and runoff will be directed to Upper Marmion Reservoir. Water quality predictions show that there will be no exceedances of the guidelines for protection of aquatic life for the parameters that currently meet guidelines.

The TMF will be graded to shed runoff, with runoff collecting in a small pond at the western edge of the TMF. Post closure runoff water from the TMF will initially be pumped to the open pit. Once water quality has reached acceptable levels, the runoff from the TMF will be directed to Sawbill Bay. During the initial years of closure and post-closure seepage from the TMF will continue to be collected in the seepage collection system. In order to take a conservative approach to water quality modelling, water quality predictions conservatively assumed that approximately 10% of the seepage from the TMF could bypass the seepage collection system and drain to Lizard Lake. Water quality modeling indicates that the seepage would result in no exceedances of the guidelines in any of the parameters in Lizard Lake that currently meet PWQOs or CWQGs. Therefore there are no predicted increased effects on aquatic life due to closure of the TMF in post-closure.

Water levels in Upper Marion Reservoir in post-closure when the pits overflow are predicted to return to baseline levels, since the loss of drainage area experienced during construction and operations will be reversed. Drainage from the waste rock and overburden stockpiles, the TMF and open pits, as well as site runoff will all be directed to Upper Marion Reservoir. Since there is no additional water taking in post-closure, there is no predicted effect on aquatic habitats.

6.2.3 Summary of Potential Effects to the Biological Environment

Potential effects to the terrestrial environment were evaluated through identified VECs including wetlands, forest cover and wildlife species. Specific attention was given to Species at Risk. Consideration was also given to those physical components that have been identified as having potential changes and how these physical changes would affect terrestrial biology VECs.

Potential effects to the terrestrial environment could result mainly through the physical loss and fragmentation of terrestrial habitat, including birds' nests. Other physical changes include alteration of flows and drainage patterns described by the hydrology component that can affect wildlife habitat or habitat suitability. Changes to surface water and groundwater quality based on the discharge of treated effluent, runoff from WRMF and other mine facilities may also affect vegetation, soils, sediments and wildlife habitat.

Some terrestrial biology effects could occur due to water use and Project emissions to water and air. Changes to water levels in Marmion Reservoir due to planned water taking from Upper Marmion Reservoir for process and potable water supply could affect vegetation in wetlands and wildlife habitat. Air emissions and dust deposition can cause changes to the chemical and physical properties of surface water, soils, and vegetation which in turn affect wildlife health.

Activities during operations which have the potential to effect the biological environment include introduction of invasive plant species which could out-compete native vegetation and accidental spills on the mine site or along the access road can affect soils and vegetation. Sensory disturbance during construction and operations including noise, vibrations and proximity to humans can also cause the disturbance and displacement of wildlife. The Project will also result in improved access to the area which could affect wildlife population sizes through increased hunting activities.

Potential effects to the aquatic environment were evaluated through identified VECs including headwaters, lower reaches, receiving water bodies and identified fish species. Consideration was also given to those physical components that have been identified as having potential changes and how these physical changes would affect aquatic biology VECs.

During construction, the main effect of the Project on the aquatic environment will be habitat loss. A summary of habitat losses is provided in Section 6.2.2 and includes 0.8 ha of Sawbill Bay, 4 ha of inlet streams, 0.5 ha of baitfish ponds in the lower reaches, 1.8 ha of headwater streams, 30 ha of lakes and 3.7 ha of baitfish and northern pike ponds in the headwaters. There are also 15 stream crossings or crossing upgrades on the proposed access road that will result in the loss of habitat within the footprint of the culvert/bridge structure. All of these habitat losses will be offset by compensation projects outlined in the No Net Loss Plan (NNLP) prepared for the project, and as a result, there will be no residual effects from these losses.

In addition to habitat loss, construction activities have the potential to cause mortality of fish present in these water bodies. A fish rescue plan will be developed for Mitta Lake and API #2 and implemented as part of the construction phase of the Project.

During operations, there are a number of potential effects to the aquatic environment. Water withdrawal and water discharge, vibrations from blasting, groundwater flow, and dust creation all interact with the aquatic environment.

Water withdrawal from Sawbill Bay will result in a reduction in water levels in Upper Marmion Reservoir of about 9 cm, which can be accommodated within the current operating regime of the reservoir. As a result there are no significant effects. The discharge of mine waste water from the PPCP will be intermittent and is predicted to meet water quality guidelines and objectives (PWQOs or CWQGs) or site-specific water quality objectives. Therefore, there is no predicted effect on aquatic life and this impact is considered to be negligible. Sewage discharge to Sawbill Bay from the worker accommodation camp will meet MOE regulatory requirements, and, therefore, there will be no impact on the receiving waterbodies or VECs.

Operational blasting of the east and west pits will be monitored for vibration effects to fish and fish habitat. A mitigation management program will be implemented to ensure that Fisheries and Oceans Canada (DFO) guidelines are met, and, therefore, there will be no impact on fish life cycle stages.

There is potential for atmospheric deposition of contaminants from mining activities, however predictive modeling studies carried out in the Atmospheric TSD have concluded that the effects of atmospheric deposition of dust and contaminants on aquatic life will be negligible.

During Project closure groundwater flow, and dust creation will continue to interact with the aquatic environment. As the open pits begin to fill, there is potential for lake water to enter the pits through rock fissures. During the closure phase, the Mine water inflow will be monitored. It is estimated that in about 218 years, the open pits will overflow into Sawbill Bay at which time any inflows to the pit would be balanced by pit overflows to Upper Marmion Reservoir. There is no anticipated effect on Upper Marmion Reservoir water levels.

During the closure phase, the seepage collection system will remain in place to ensure that contaminated seepage does not migrate to receivers until such a time as monitoring shows that the seepage is acceptable for direct release. There is potential for atmospheric deposition of contaminants from closure activities. The Atmospheric TSD has demonstrated that there will be no atmospheric contamination of aquatic habitats during closure activities.

A number of potential residual effects to the aquatic environment were identified including the loss of fish communities, effluent discharge water quality, and potential movement of water from the Upper Marmion Reservoir into the open pits at closure.

6.2.4 Summary of Mitigation for the Biological Environment

Mitigation measures were developed for the terrestrial and aquatic environment. These mitigation measures are closely linked to the Environmental Monitoring Plan and Objectives outlined in Chapter 8 of the EIS/EA Report. Mitigation measures for the biological environment are focussed on potential residual effects and consider both indirect physical effects and direct biological effects.

Mitigation measures for potential effects to the terrestrial environment will include in design measures, planning and management measures, training and education measures, and monitoring strategies.

The Project design and layout of the mine footprint and linear corridor was created to limit the amount of vegetation that is disturbed. Overburden and topsoil will be stockpiled as a potential seed source. This measure will increase re-vegetation success of temporary work spaces. Limiting the use of all-terrain vehicles on trails and maintaining major transportation routes will also reduce habitat disturbance.

Clearing of vegetation shall take place outside of the nesting bird season (May 15th-July 30th), where possible. If clearing must take place within this period, a biologist will undertake a nest search to determine if there are any active nests in the habitat being cleared. If a nest is observed a protected buffer is placed around the nest until the bird and its young have left the nest. Opportunities for enhancing habitat for a species at risk identified in the LSA, common nighthawk, will be considered at closure.

The Processing Plant will be designed with emission controls, as will the construction and operations equipment. Operating procedures will be developed to reduce dust generation and emissions. Noise will be mitigated by housing stationary equipment in buildings and incorporating baffles and/or noise suppressors on equipment.

Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and the workers and demarked areas will be established for the storage and handling of hazardous wastes.

Water taking for the processing and make-up water will be minimized by reusing the on-site water supply for processing. Runoff from the Project site and processing facility will be captured and diverted to the Process Plant Collection Pond (PPCP) for re-use. Sewage will be treated prior to discharge.

The water management system will be designed to have enough capacity to store both operating flow and storm events. Installation of culverts will minimize alteration of flows and drainage patterns along linear corridor. Creation of wetlands as described in the No Net Loss Plan will attenuate flows.

Development and implementation of management plans will include an Invasive Species Management Plan, an Emergency spill management program, Dust management plan and the implementation of a strict "no hunting, harvesting, trapping or fishing" policy for workers while at the onsite worker accommodation camp.

Workforce training and education measures are also important mitigation measures. Enforcing speed limits on access roads and mine road, proper cleaning and maintenance of equipment and Species at Risk worker education are all important measures to reduce potential effects to the terrestrial environment.

Mitigation measures for potential effects to the aquatic environment include the development of a No Net Loss Plan, water quality modelling and effluent diffuser design, the implementation of a water management system and ongoing monitoring of the aquatic environment. The freshwater intakes for the worker accommodation camp and for the mine water intake will be screened to prevent entrainment of small-bodied fish in accordance with the DFO operational statement for screening of intakes.

The following is a summary of the fish habitat compensation projects identified as part of No Net Loss Plan:

- Fish salvage and rescue operations: during the construction phase.
- Stream restoration works at 14 culvert crossings
- Stocking of Four fishless headwater lakes/ponds.
- Constructing berms to create three new headwater ponds.
- Creating northern pike spawning habitat adjacent to the mouth of Sawbill Creek

The loss of fish communities in Lizard Lake and Upper Marmion Reservoir includes loss of indirect fish habitat and genetic diversity. Loss of indirect fish habitat will be included in the No Net Loss Plan. Effects to genetic diversity will be mitigated through fish salvage protocols during which the majority of impacted fish will be released in other waterbodies in the area, including Lizard Lake, API #8 and Upper Marmion Reservoir. In addition, fish salvaged from these operations will be used to stock a number of fishless lakes as part of the NNLP. As a result, this residual effect is considered to be negligible.

The effluent discharge from the PPCP may exceed guidelines during “wet years”, which is predicted to be a less than 1 in 25 year occurrence. The mixing zone at the effluent discharge point was modelled for water quality predictions and mixing potential. This analysis included preliminary diffuser design work, and concluded the mixing zone will be small. The Project design will include locating the diffuser in an area of low fish use. The potential for exposure of fish to this area will be low and the concentration/duration of effect will be very low. As a result, there will be no effect of this discharge on fish populations in Upper Marmion Lake. No effects are expected on smallmouth bass, northern pike, walleye or baitfish populations in Upper Marmion Lake.

During Mine operations, closure and post-closure, there is potential for “piping” of surface water in Upper Marmion Reservoir to move via cracks and fissures in the bedrock into the open pits. Once the pits are full and overflow into Upper Marmion Lake, there will be a small net increase in flow into Marmion Lake. The water level in Upper Marion Reservoir is actively managed to maintain sufficient flood control capacity and also to provide a sustainable source of hydro-electric power at the downstream generating stations. As a result, water levels in Upper Marmion Reservoir can change by up to 2 m on an annual basis as the reservoir is drawn down. As a result, there is no impact on Upper Marmion Reservoir water levels and the effect on VECs is considered negligible.

During the operations phase, a Mine water collection and pumping system will ensure that there is no impact on Upper Marmion Reservoir water levels. Once the Mine is closed and the Mine water intake from Sawbill Bay is decommissioned, this inflow of water to the pits can easily be accommodated within the current operating regime for Upper Marmion Lake.

An Environmental monitoring program to assess the performance of fish compensation measures will also be undertaken, as further detailed in Chapter 8 Environmental Monitoring Plan.

6.3 Social Effects Assessment

The social effects assessment includes the effects on the Project on the following:

- Socio-economic assessment (Section 6.3.1).
- Aboriginal Interests Assessment (Section 6.3.2).
- Physical and Cultural Heritage (Section 6.3.3).

6.3.1 Socio-Economic Effects Assessment

This section predicts and describes the changes to the socio-economic environment that are likely to result from the Project. The assessment is conducted separately for each of the Project phases, beginning with the construction phase. The changes are then assessed to determine if an adverse effect is likely, whether any identified adverse effect can be mitigated, and for adverse effects that cannot be fully mitigated (residual effects), the significance of the effect is determined.

While the focus of the environmental assessment is generally on potential adverse effects, many of the socio-economic effects of the Project are positive and beneficial. A number of opportunities are available to enhance the positive effects and these are identified as appropriate. In addition, when an effect is identified as being positive it is credited as a benefit of the Project and advanced to the “Economic and Social Benefits of the Project” section of EIS/EA Report (Chapter 11).

As part of social management planning discussed in Chapter 8, establishment of an “Atikokan/OHRG Committee” is proposed to act as a liaison or conduit for information exchange between OHRG and the community. This Committee could have an important role in monitoring and disseminating the positive effects of the Project on the socio-economic fabric of the community. Areas where the Committee may provide this function are identified in the following sections.

6.3.1.1 Screening of Project Activities and VEC Interactions

Tables 6-49 and 6-50 identify which Project activities may have a direct interaction with the VECs of the socio-economic environment by Project phase.

Table 6-49: Project Phase Activities and Direct Interactions with the Socio-community VECs

Project Activities	Population and Demographics	Labour Market	Government Finances	Public Services and Infrastructure	Housing and Accommodation	Transportation
Construction Phase						
Management Permitting and Employment	X	X	X	X	X	X
Linear Infrastructure	—	—	—	—	—	X
Support and Ancillary Infrastructure	—	—	—	X	—	X
Operations Phase						
Management, Permitting and Employment	X	X	X	X	X	X
Linear Infrastructure	—	—	—	—	—	X
Support and Ancillary Infrastructure	—	—	—	X	—	X
Closure Phase						
Management, Permitting and Employment	X	X	X	X	X	X
Support and Ancillary Infrastructure	—	—	—	X	—	X
Post-Closure Phase						
Management, Permitting and Employment	X	X	X	X	X	X
Support and Ancillary Infrastructure	—	—	—	X	—	X

Note:

X = Direct interaction.

— = No interaction identified.

Table 6-50: Project Phase Activities and Direct Interactions with the Land and Resource Use VECs

Project Activities	Outdoor Tourism and Recreation	Hunting	Trapping	Fishing	Water Use and Access	Mining	Forestry
Construction Phase							
Management, Permitting and Employment	X	X	X	—	—	—	X
Operations Phase							
Management, Permitting and Employment	X	X	X	—	—	—	X
Closure Phase							
Management, Permitting and Employment	X	X	X	—	—	—	X
Post-Closure Phase							
Management, Permitting and Employment	X	X	X	—	—	—	X

Note:

X = Direct interaction.

— = No interaction identified.

6.3.1.2 *Effects Assessment of the Construction Phase*

6.3.1.2.1 Population and Demographics

The Project is likely to affect population and demographics in the Socio-economic Environment LSA through direct and indirect employment and associated family members since some workers are expected to be accompanied by family. Indirect employment occurs as a result of Project-related expenditures on equipment, materials and services. Changes to the population and demographics in the RSA (and further afield) are likely too small to be measured.

The Project is likely to result in an increase in population in the Socio-economic Environment LSA as a result of the in-migration of workers and their families that in turn will result in a change in age and gender ratios and dependency ratios in the local population

Population Change: An increase in population is expected in the Socio-economic Environment LSA over the construction phase. This increase is primarily due to indirect employment in the Socio-economic Environment LSA as a result of Project-related expenditures. Population effects are compounded by the family dependents associated with each worker.

The average construction phase full-time equivalent workforce is anticipated to be 416 persons, with a peak of approximately 1,200. It is assumed that workers will work an average of 200 hours/month.

Figure 6-8 provides the anticipated place-of-residence distribution of the construction workforce. Based on the occupations required for the construction phase, and knowledge of the available workforce in the Socio-economic Environment LSA, it is assumed that 10% of the construction workforce would reside in the Socio-economic Environment LSA. Of the construction workforce, 10% or 42 workers are anticipated to reside in Atikokan. It is assumed that the majority of these workers currently reside in Atikokan. The remainder of the temporary construction workforce is anticipated to reside at the worker accommodation camp. Accordingly, it is not anticipated that the population or demographics of the Socio-economic Environment LSA will change measurably as a result of direct Project employment over the 30-month construction period.

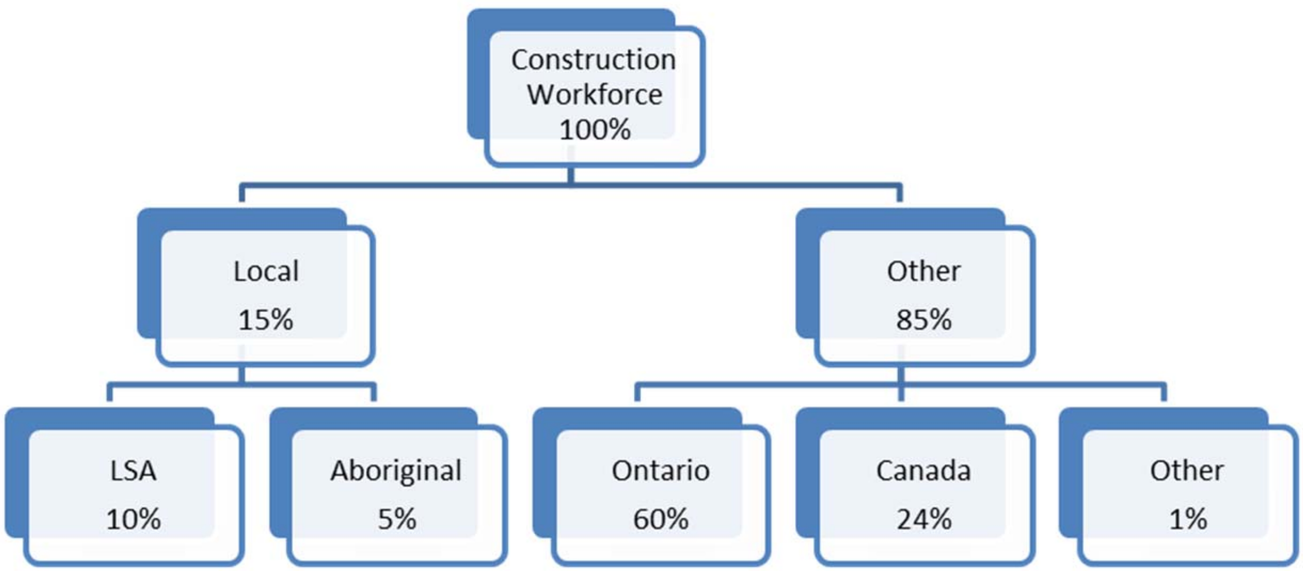


Figure 6-8: Assumed Place-of-Residence Distribution of Construction Workforce

A change in population and demographics may be expected if a substantial number of opportunities are realized through new or expanded businesses. It is estimated that the increase in the indirect workforce resulting from the Project as a result of increased business opportunities is 40 workers of which half currently reside in Atikokan, and the other half (20) would move to the town from elsewhere, bringing average-sized families (2.7 persons/family) with them [StatsCan 2012]. The total increase in the population of permanent residents in the Socio-economic Environment LSA for the construction phase is estimated as 54 persons. This corresponds to ~2% of the current population of 2,787 for the Socio-economic Environment LSA. This is a positive effect and, though small, serves to mitigate the recent population decline in the Socio-economic Environment LSA.

Mobility: Population mobility is measured by Statistics Canada as the percentage of persons who report living at a different address one or five years prior to the Census date. Based on this statistic, it is anticipated that approximately 36.4% of the population of the Socio-economic Environment LSA would be expected to move residence in a 5-year period. Some of this mobility would be as a result of people moving out of the community. The in-migration of 54 persons or ~2% of the current population during the construction phase is a positive effect as it may serve to offset and reverse the out-migration from and population decline observed in the Socio-economic Environment LSA.

Age and Gender: The in-migration of twenty families moving into the Socio-economic Environment LSA would add some children and working-age persons to the community. Although small during the construction phase, this effect would be positive because it represents a reversal in the out-migration of youth and working-age individuals from the Socio-economic Environment LSA.

Dependency Ratios: The slight increase in working-age population in the Socio-economic Environment LSA during the construction phase may reduce the elderly dependency ratio. Because it is assumed that in-migrating families would be typical average Canadian families, the overall child dependency ratio is not expected to change as a result of the construction phase of the Project. The construction phase of the Project is not likely to have any measurable effect on the dependency ratio in the population of the Socio-economic Environment LSA.

Mitigation: No mitigation measures are required because the effects related to population and demographics are anticipated to be beneficial as workers and their families move into the Socio-economic Environment LSA. While these effects are small during the construction phase, they represent an important reversal of recent out-migration and population decline in the Socio-economic Environment LSA.

A number of benefit enhancement measures may be implemented to maximize the positive effects associated with workers moving to Atikokan for the construction phase of the Project, including:

- Encouraging job applicants to consider relocating their families to the Town of Atikokan.
- Providing incentives (e.g., transport to and from the Project Site) for workers to live in the Town rather than in the on-site worker accommodation camp.
- Implementing spousal hiring program to help fill community needs (e.g., doctors and nurses).
- Working with the Town of Atikokan and the Atikokan Economic Development Corporation to identify opportunities for local businesses to develop or expand.

The Atikokan/OHRG Committee identified in Chapter 8 as part of social management planning could have a role in communicating and supporting these initiatives.

6.3.1.2.2 Labour Market

Interactions between construction phase Project activities and the labour market are assessed using five indicators: regional and local supplier base, labour force, employment and unemployment, median income, and education and training. The Project is likely to affect the labour market (employment and income) in the Socio-economic Environment LSA and RSA (or province-wide) through the hiring of the construction workforce and through sourcing and obtaining equipment and materials. Changes are anticipated on median income and training and education.

Regional and Local Supplier Base: Total cost to construct the Project is estimated at $1.4 billion. Total labour costs are estimated at $288 million, or 21% of the total capital expenditure. Of the remaining $1.1 billion, 3% or $33 million is anticipated to be spent in the Local Study Area (primarily Atikokan, with some expenditure in Ignace), 30% ($330 million) in Ontario (including the RSA) and 25% in the rest of Canada. The remaining 40% will be spent in the US or overseas. Figure 6-9 provides the anticipated geographic distribution of construction expenditures.

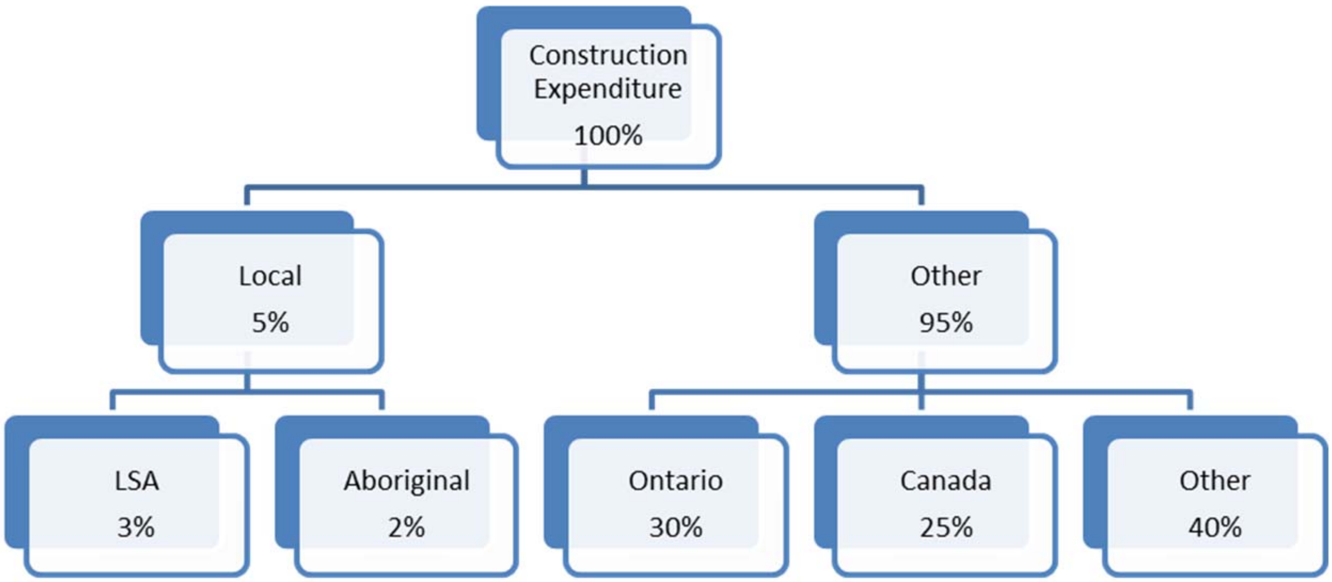


Figure 6-9: Assumed Distribution of Construction Expenditures

The supply of goods and services for the Project provides opportunities for the establishment or growth of businesses in the Socio-economic Environment LSA, Ontario and Canada. A mining sector impact analysis was developed for Atikokan [McSweeney and Associates 2011], which identifies the following business opportunities that would be able to service an expanding mining sector in Atikokan:

- Safety supply and equipment.
- Repair shops (road vehicles, quarry and heavy duty equipment, other mechanical equipment).
- Drill parts and repair.
- Electrical repair and supply.
- Blasting supplies.
- Transportation service.
- Part suppliers (mining and heavy equipment, truck and road vehicles).
- Tire sales and repair.
- Assay and testing lab.
- Lumber supply.
- Welding, machining and fabrication.
- Steel supply.

- Mobile repair service.
- Fuel and lubricant supply.
- Diesel and regular gas.
- Heating fuels.

Based on this assessment of the capabilities within Atikokan, it is likely that some existing local businesses, in addition to new businesses, will be able to capitalize on the opportunity offered by the $33 million expenditures over the 30-month construction phase. This is a positive benefit that should contribute to growing the economic activity of the Socio-economic Environment LSA. Although the effects on specific businesses or sectors outside of the Socio-economic Environment LSA have not been quantified, the direct Project expenditures of $330 million in Ontario and $275 million in the rest of Canada are major economic benefits of the Project (see Appendix 2.II of the Socio-economic Environment TSD). These expenditures will contribute both to employment and economic activity.

Labour Force: Measurable changes to the labour force during the construction phase likely will be experienced in the Socio-economic Environment LSA and the RSA. Total direct employment during construction is 416 full-time equivalents (FTE) over the 30-month construction period. The majority of these workers will be temporary, will come from elsewhere in Ontario, including the RSA, and will reside in the worker accommodation camp. Generally the skills-based and available employees required are not available in the Socio-economic Environment LSA. However, these employment opportunities are a major benefit of the Project locally. In addition there will be an estimated 42 direct and 40 indirect jobs within the Socio-economic Environment LSA as discussed above, during the construction phase. These 82 jobs are assessed relative to the current labour force of 1,650 persons in the Socio-economic Environment LSA [StatsCan 2007].

The addition of 82 FTE jobs in the Socio-economic Environment LSA will be split primarily among construction (approximately 50% of the added workforce or 41 FTEs), manufacturing (20% or 16 FTEs), other services (20% or 16 FTEs) and retail trade (10% or 8 FTEs). This increases the proportion of the workforce in construction from 4% to 6%, or approximately 50% increase in this industry. This is a positive effect of the Project and represents growth in an important sector of the overall economy in the Socio-economic Environment LSA.

Employment and Unemployment: Of the 82 FTE created by the construction phase in the Socio-economic Environment LSA, it is conservatively assumed that 25% of these workers (20 FTE) were previously unemployed in Atikokan. Another 20 persons are assumed to move into the community and be employed. Thus, the overall net increase in employed permanent residents in the Socio-economic Environment LSA is 40. This would increase the number of employed persons from 1,520 (56.8% current employment rate) to approximately 1,560 (57.4% employment rate) and reduce the number of unemployed persons from 150 (9.0% unemployment rate) to approximately 130 (7.7% unemployment rate). Some businesses in the Socio-economic Environment LSA may experience a loss of employees to the Project; however, Project-related employment is considered a net benefit to the Socio-economic Environment LSA labour market. These changes are positive and represent a reversal in the recent growth in unemployment in the Socio-economic Environment LSA.

Median Incomes: The median income of workers in the Socio-economic Environment LSA is $26,410 (StatsCan 2007). Mine construction projects typically pay high hourly rates. Accordingly, the addition of 42 new jobs during the construction phase will increase the median income in the Socio-economic Environment LSA. The remaining 40 indirect jobs may be expected to pay the current median wage. The Project will have a positive effect on median incomes by bringing higher-paying jobs to the Town and reversing the dependence on the public or service sectors. Some of the increased income in the Socio-economic Environment LSA will be spent locally, serving as a benefit to local businesses.

Education and Training: The Project may be expected to result in increased demand and opportunities in education and training. Because of the short duration of the construction phase, any changes to post-secondary completion rates and other training opportunities are unlikely to be evident. Education and training requirements and opportunities are likely in the operations phase and are discussed as part of that assessment.

The Atikokan/OHRG Committee identified in Chapter 8 as part of social management planning could have a role in monitoring and communicating these benefits to the community.

6.3.1.2.3 Government Finances

The effects of the Project on government finances are assessed using one indicator, namely changes to government revenues. Interactions between construction phase Project activities and government finances are identified in Section 6.2.1. Potential effects during the construction phase are likely to affect government finances through additional tax revenue to the Government of Canada, Government of Ontario and Municipal Government (Town of Atikokan)

Government Revenues: Government finance will benefit from the construction of the Project at three levels: Federal, Provincial and Municipal. Additional revenues will accrue to the following:

- Government of Canada
- Income taxes, both personal and corporate.
- EI contributions.
- Sales taxes.
- CPP contributions.
- Government of Ontario:
- Income taxes, both personal and corporate.
- Workplace safety contributions.
- Employer health tax.
- Sales taxes.
- Municipal government (Town of Atikokan):
- Property taxes.
- Fees.

Because the Project is located in the Unorganized District of Rainy River, there will be no Project-specific property taxes that will accrue to the Town of Atikokan. However, inasmuch as the Project causes residential and other construction in the Town to increase, the assessment levied on such additional construction will increase the financial base of the Town. The extent of additional construction in Town depends to some degree on current vacancy rates and suitability of existing structures to accommodate new demand. However, given an estimated overall permanent population increase of 54 persons or 20 households, it is unlikely that additional houses will be constructed in the Town for the 30-month short construction phase.

Some increase in user fees for services, such as permit applications and waste disposal fees, during the construction phase will provide limited increased revenue to the Town of Atikokan.

Altogether, the three levels of Government derive considerable revenue from a Project such as proposed. In a 2007 study entitled *"The Economic Impacts of a "Representative Mine" in Ontario"* by Peter Dungan and Steve Murphy, it was found that about 33% of the total construction cost ultimately ends up in the hands of Government, through the sources outlined above.

The economic study presented in Appendix 2.II of the Socio-economic Environment TSD presents an estimate of the revenues that will be accrued by the provincial and federal governments from the construction of the Project. In summary, provincial tax revenues during the 30-month construction phase are predicted to be $36.2 million and federal tax revenues over this period are predicted to be $115.5 million, for a combined predicted total tax revenue of $151.7 million over the construction phase. This is a positive effect of the Project.

6.3.1.2.4 Public Services and Infrastructure

The effects of the Project on public services and infrastructure during the construction phase is assessed using indicators that characterize protection and emergency services, health services, social services, education, recreation, water, wastewater and waste management, and utilities. For the construction phase assessments these services are assessed collectively with specific reference to any individual services where an adverse effect is anticipated. Effects are limited to the Socio-economic Environment LSA.

Interactions between construction phase Project activities and public services and infrastructure could affect public services and infrastructure in the Socio-economic Environment LSA through increased demand for services and infrastructure resulting from employment-related population change and due to requirements for non-hazardous waste management.

Public Services and Infrastructure: Employment and related increase in population resulting from management, permitting and employment has the potential to increase demand on public services and infrastructure in the Socio-economic Environment LSA. As identified above, the permanent resident population in the Socio-economic Environment LSA during the construction phase is expected to increase by 20 workers, or 54 persons. The description of existing conditions in Chapter 3 shows that all of the public services and infrastructure in the Socio-economic Environment LSA are currently below capacity and could readily accommodate the additional demands of the small increase in population due to the construction phase of the Project. Thus, the construction phase of the Project would have no adverse effect on public services and infrastructure.

Water, Wastewater and Waste Management: The need to dispose of non-hazardous waste in a licensed off-site waste management facility during the construction phase could place additional strain on public waste management infrastructure in the Socio-economic Environment LSA. The capacity of the Town's existing waste management facility is currently nearing its approved limit. If the Project is going to avail of local waste management capacity it will be necessary to expand or replace the Town's existing landfill. This represents a likely adverse effect of the Project and mitigation is required to reduce or eliminate it.

6.3.1.2.5 Housing and Accommodation

The effects of the Project on housing and accommodation are assessed using three indicators: housing supply, occupancy rates, and cost and availability. Housing supply and occupancy rates are discussed together. Effects are limited to the Socio-economic Environment LSA because no workers are anticipated to move anywhere else for Project-related employment.

Potential effects during the construction phase on housing and accommodation in the Socio-economic Environment LSA are likely to occur through increased demand resulting from employment-related population increase.

Housing Supply and Occupancy Rates: The population in the Socio-economic Environment LSA is predicted to increase over the construction phase through the in-migration of 20 workers and their families (total increase = 54 persons). The corresponding housing need is for up to 20 temporary homes, although it is expected that some of these workers will not bring families and will not require family housing. Information in the existing conditions shows that there is an adequate supply of housing in the Socio-economic Environment LSA to meet the demand resulting from the construction phase from direct and indirect workers and their dependants. Despite the population decline in the Socio-economic Environment LSA over the past 20 years, housing availability in the Town of Atikokan remains limited. The 2006 occupancy rate for private dwellings in Atikokan was 92.4%, representing 108 unoccupied dwellings. This is considered sufficient to house the minor increase in population anticipated for the construction phase. This increase is assessed to be positive since it represents a reduction in the number of vacant or unoccupied homes in the Socio-economic Environment LSA serving to help stabilize the housing market and provide additional property tax revenue to the Town.

The Atikokan/OHRG Committee identified in Chapter 8 as part of social management planning could have a role in monitoring and communicating changes to housing supply and demand as a result of the Project.

Cost and Availability: A modest increase in the demand for housing might be expected to have a modest effect on the cost of available units. However, the magnitude of the additional demand, predicted to be 20 units, is unlikely to have an effect other than a minor upward effect on the current cost of housing in the Socio-economic Environment LSA. This effect is assessed as being positive since it will likely to serve to stabilize or increase prices modestly.

6.3.1.2.6 Transportation

The Project could affect level of service and safety on local roads in the Socio-economic Environment LSA through the movement of Project workers, equipment, supplies and products.

Level of Service: To assess potential impacts due to future traffic volumes, the following periods were considered in order to determine the full impacts of the Project:

- Background Traffic – 2016, 2021 and 2028: background traffic is generated for each period by projecting existing counts to the analysis year based on historical growth rates.
- Construction Site Traffic – analyzed to consider the traffic impacts associated with the construction period (2014 - 2016).

In order to consider future traffic conditions, existing counts were projected forward for each period. The traffic growth rates were applied based on consideration of historical traffic data. Historic data showed that annual traffic growth rates on local highways were generally less than 2%, with growth rates on Highway 11 at 0%.

In addition to the existing traffic, there is potential for increased traffic due to other developments or planned road improvements. The Atikokan Generating Station is projected to see an increase in traffic resulting from their Biomass Re-Fuelling Project. However, according to the Atikokan GS Biomass Re-fuelling Project Traffic Impact Study from March, 2011, the Project is only expected to generate 10 trucks trips in the peak hour. As a result, the effect on the future road network is essentially negligible based on our current understanding of road utilization and capacity.

A number of assumptions were developed based on similar mining Traffic Impact Study (TIS) reports and application of engineering judgment. Although the average construction workforce is expected to be 416, the maximum expected workforce of 1,200 was used for this study in order to be more conservative in analyzing impacts on the road network.

The Project is expected to generate about 230 trips / day during the peak of the construction period, which translates to about 44 vehicles per hour in the AM and PM peak hours during construction.

Network distribution was assumed based on the road layout and common destinations in the area, and two scenarios were developed for trip distribution in the inbound (i.e., into mine site) and outbound directions:

- All traffic is headed to/originates from the south of the mine site at Atikokan (80%) and Highway 11 (20%).
- Some traffic originates/heads north on Highway 622 to eventually meet up with Highway 17 (20%).

Since 80% of the workforce is projected to be bussed to the site, and the remaining 20% is projected to drive from Atikokan, employee traffic to/from the site will rely solely on Highway 622. The majority of trips during the construction phase come from employee traffic or supply/camp trucks. As a result, the distribution scenarios show high percentages of traffic to and from Atikokan. The results indicate that all intersections will continue to operate at levels of service “A” – “C” and volume-to-capacity ratios less than 0.20. This level of service is satisfactory and will not result in any traffic congestion. However, it constitutes a measurable change and may be viewed as an adverse effect by current road users.

6.3.1.2.7 Outdoor Tourism and Recreation

Effects on land and resource use that could affect outdoor tourism and recreation are expected to result directly from Project activities in the immediate vicinity of the Project, and the assessment is limited to the Socio-economic Environment LSA. The potential for effects in the RSA were not considered because they are not anticipated to be measurable.

The outdoor tourism and recreation VEC is assessed using three indicators: tourism activities, number and type of visitors, and tourism revenues. The Project is not anticipated to change the number and types of visitors to the RSA or Socio-economic Environment LSA, nor change the revenue generated in the RSA and Socio-economic Environment LSA from tourism. Accordingly, the assessment is focussed on the changes to use and access to existing recreational opportunities in the Socio-economic Environment LSA and/or through other indirect pathways identified by other disciplines (air quality and noise, aquatic environment, terrestrial environment, and visual aesthetics).

In addition, a screening of Project-induced changes to the physical environment identified in the Atmospheric Environment TSD, Aquatic Environment TSD, Terrestrial Ecology TSD and through visual impact may result in indirect effects on outdoor tourism and recreation as follows:

- Adverse effects on air quality or noise were considered to potentially affect the use and enjoyment of lands and resources for recreation and tourism. Signage notifying prospective campers of potentially high noise levels will be posted at select locations where appropriate. OHRG has agreements in place with the owners of the two identified receptors (one trapper`s cabin and one tourism establishment), that have been shown could potentially exceed guidelines. These provide for restricted access and limited use of the identified receptors during construction and operations as necessary. Following this mitigation no residual adverse effect remains.
- Adverse effects on the aquatic environment were considered to potentially affect the use and enjoyment of lands and resources for recreation and tourism. No adverse effects of moderate or greater significance have been identified in the Aquatic Environment TSD, and therefore no assessment or mitigation related to indirect effects from the aquatic environment on outdoor tourism and recreation is required.
- Adverse effects on the terrestrial environment were considered to potentially affect the use and enjoyment of lands and resources for recreation and tourism. No residual adverse effects of moderate or greater significance have been identified in the Terrestrial Ecology TSD, and therefore no assessment or mitigation related to indirect effects from the terrestrial environment on outdoor tourism and recreation is required.
- Adverse effects on visual aesthetics were considered to potentially affect the use and enjoyment of lands and resources for recreation and tourism. Results from the visual assessment indicate that effects on the perception of the Socio-economic Environment LSA as a remote, pristine wilderness may negatively affect outdoor tourism and recreation in the Socio-economic Environment LSA (from locations from which the Project is visible). Mitigation measures are provided below.

Recreational Opportunities: the effects on outdoor tourism and recreation within the Socio-economic Environment LSA can result from direct effects (e.g., physical disturbance, relocation or removal of land) or indirectly through adverse effects on air quality, noise, aquatic or terrestrial environment or aesthetic effects. Potential direct or indirect changes to existing land uses as a result of the Project will affect recreational opportunities, facilities and businesses located close to the Project. This could include camping opportunities, outfitting businesses or access to certain sites.

The direct effects of the Project on the outdoor tourism and recreation resources are adverse effects and are further considered for mitigation and significance. In particular, adverse effects are possible where access to recreational sites is restricted or removed because of Project-related activities. However, practicable mitigation measures are possible to ensure the adverse effects on outdoor tourism and recreation resources are avoided or minimized.

In many cases, similar land or recreational opportunities exist within the Socio-economic Environment LSA or RSA. For example, although some Crown land near the project site will likely be less desirable for camping, this is not likely to adversely affect the overall camping opportunities or experience for wilderness campers in the Socio-economic Environment LSA and RSA given the large amounts of undeveloped land in these areas.

In other cases, where there is a potential for a business or recreational opportunity to be affected, an agreement has been developed between OHRG and the potentially affected party. An example of this agreement is one with a tourism operator relating to restricted access to certain areas. At the request of both parties, details of this agreement are confidential.

There may be some perception of negative effects on outdoor tourism and recreation due to construction of a mine project in the area, and associated effects on visual aesthetics. However, these negative perceptions can be mitigated by reinforcing the positive outdoor tourism and recreational reputation of the Socio-economic Environment LSA. One example of this is the Atikokan Bass Classic, which is a major attraction to fishers of all levels of experienced. OHRG has provided sponsorship to this event for several years and is committed to continuing this sponsorship. As a result of a meeting in May 2013 with several tourism operators, OHRG made a commitment to provide capacity support for advertising for recreation and tourism in the Atikokan area.

The Atikokan/OHRG Committee identified in Chapter 8 as part of social management planning could have a role in identifying appropriate sponsorship opportunities with the potential to offset any negative perceptions because of the Project.

6.3.1.2.8 Hunting

Direct effects on hunting may result from physical disturbance, relocation or removal of land. Indirect effects may result from changes to air quality, noise, aquatic or terrestrial environment or aesthetics.

No change is predicted in licence sales or harvest volumes as these are based on government-set quotas which are not expected to change as a result of the Project. The focus of the assessment is on the change to hunting opportunities as a result of changes to wildlife management areas.

The potential resulting direct effects from the Project on hunting would be through the removal of land associated with the restriction of site access. In addition, the assessment considers any Project-induced changes to the terrestrial habitat or species identified in the Terrestrial Ecology TSD that may result in indirect effects on hunting. Since no residual adverse effects of moderate or greater significance have been identified in the Terrestrial Ecology TSD assessment, the indirect effects on hunting are not considered.

Within the Socio-economic Environment LSA, the Project is expected to remove approximately 2,000 ha of land from Wildlife Management Unit 12B and Bear Management Areas 12B-014 and 12B-016 that would otherwise have been available for hunting. This 2,000 ha represents 0.3% of the total area of Wildlife Management Unit 12B, and 2.0% of the total area of Bear Management Areas 12B-014 and 12B-016. The loss of this resource may result in increasing hunting pressure on similar areas in the Socio-economic Environment LSA. Accordingly, this residual adverse effect is assessed for significance below. In addition, to reduce hunting pressure from workers residing at the camp, OHRG will implement a firearms policy to restrict hunting for workers while at camp.

6.3.1.2.9 Trapping

Potential effects of the Project on trapping would occur through the removal and fragmentation of land and through restriction of site access.

No change is predicted in harvest volumes, however government-set quotas may be adjusted to reflect the lands taken up in tenured area for the Project. OHRG currently has agreements in place with local trapline holders which provide direct compensation for restricted access as needed throughout the Project phases. These agreements are mutually beneficial and fully mitigate any effect to trapping.

Adverse effects on the terrestrial environment may affect species or habitats important to trapping were also considered in the assessment. No residual adverse effects of moderate or greater significance have been identified in the Terrestrial Ecology TSD, and therefore no further assessment or mitigation related to effects on tenured trapline areas is required.

Tenured Trapline Areas: Within the Socio-economic Environment LSA, the Project is expected to remove approximately 2,000 ha of land from tenured trapline Areas AT025, AT032, AT039 and AT040 that would otherwise have been available for trapping. The 2,000 ha represents 2.0% of the total area of these trapline areas. Mitigation, in the form of Agreement with trap-line holders have been negotiated for the adverse effects on tenured trapline areas that have been directly affected by the restriction of site access/removal of land as part of the construction of the Project.

6.3.1.2.10 Fishing

Fishing is assessed using three indicators: recreational fishing participation; fishing areas, licence sales and harvest volumes; and baitfish areas and harvest volumes.

A fisheries management program focusing on walleye (though other sport fish species are considered equally important) has been in effect in Upper Marmion Reservoir for several decades and monitoring the status of sport fish populations is ongoing (Jackson 2007). The fishery in Upper Marmion Reservoir is of major cultural significance to Aboriginal communities and an important source of traditional foods. The fishery is also important for the local economy, and the Town of Atikokan hosts annual events around the fishery. As well, a number of local outfitters operate fishing camps in the area. Introduction of a large workforce could exert unsustainable pressure on the local fishery, affecting the sustainability of fish populations. As a result, to help maintain fish stocks, fishing by camp personnel while on-site will be restricted through an Osisko policy preventing fishing while residing at the worker accommodation camp.

The Project will not result in the removal of any commonly-used public fishing areas. Furthermore the Project will not restrict access to any of these areas. An Agreement was negotiated with the baitfish license holder in the vicinity of the project to mitigate any losses within the Project area. Accordingly the Project is not likely to result in any measurable changes or direct effects on fishing opportunities. However, there may be indirect effects caused by Project-induced changes to the physical environment identified in the Aquatic Environment TSD. Although indirect effects may be expected to result from the alteration of fish habitat through changes in water quality or water levels as identified in the Aquatic Environment TSD, no such adverse effects are identified.

With additional workers entering the area there may be some associated indirect increase in fishing pressure since some of the workers and their families may choose to live in town. It is not possible to anticipate at this time the degree of change in fishing pressure and this has not been assessed as part of the EIS/EA. Monitoring for fishing pressure increase would include conducting a biannual fishing questionnaire of the project workforce to estimate the level of fishing pressure resulting from the project. Should the results of the questionnaire show substantive changes in fishing pressure that may affect local aquatic resources then OHRG would initiate discussions with the MNR at that time to develop an appropriate mitigation plan as part of an adaptive management program.

6.3.1.2.11 Mining

It is too early in the Project life cycle to determine any effects of the Project on future exploration or development projects. However, the Project is likely to have beneficial effects on future development and extraction in the study areas by maintaining the skills and resources in the area to further develop the mining sector. As a result, effects on mining are not considered further in the assessment.

6.3.1.2.12 Forestry

Potential effects of the Project during the construction phase on forestry could occur through the removal of land associated with the restriction of site access.

Within the Socio-economic Environment LSA, the Project is expected to remove approximately 2,000 ha of land from the Rainy Lake Tribunal Forest Management Unit and the Resolute Forest Management Unit that would otherwise have been available for forestry. The 2,000 ha represents 0.2% of the total area of these two forest management units. This represents an adverse effect of the Project and warrants mitigation. Identified mitigation measures include negotiation of a timber harvest agreement with the local Forest Management Unit holders, direct compensation or investigation of other practicable measures to reduce the loss of timber harvest in the LSA.

6.3.1.2.13 Water Use and Access

Water use and access is assessed using a single indicator: water use for hydro-electric power and for other industrial and commercial uses. Assessment of direct effects is focused on the predicted changes in use, access and availability of water resources for hydro-electric power for other industrial and commercial uses.

The Hydrology TSD has conducted an assessment of the changes on water levels and flows as a result of constructing the Project, including changes in the local hydrology that may affect water use for hydro-electric power or other industrial and commercial uses. As identified in the Hydrology TSD, water use during the construction phase is negligible, and therefore no further assessment on water use and access is required

6.3.1.3 Effects Assessment of the Operations Phase

The effects assessment of the operations phase is carried out using the same VSCs and indicators as the assessment of the effects of the construction phase. .

6.3.1.3.1 Population and Demographics VEC

Potential effects of the Project that could affect population and demographics in the Socio-economic Environment LSA are likely to occur through direct, indirect and induced employment and associated family members. Indirect and induced employment occurs as a result of Project-related expenditures on equipment, materials and services.

Population Change: An increase in population is expected in the Socio-economic Environment LSA over the operations phase due to direct and indirect employment. An eleven year (2017 – 2028) operations phase is assumed. While there may be differences from year to year, for the purpose of the assessment annual average employment and expenditure levels are assumed through the entire operations phase. For the purposes of the modelling presented in the Socio-Economic Environment TSD a total workforce of 550 was assumed. Approximately 50% of the total workforce (~325) will be on site during operations at all times (single rotation). Figure 6-10 identifies the assumptions used in the assessment of the place of residence of the permanent workforce.

Of the operations workforce, 30% or 195 workers are anticipated to consider the Socio-economic Environment LSA their permanent place-of-residence. It is assumed that half of these workers currently reside in Atikokan. The remainder of the workforce is anticipated to move to Atikokan from elsewhere. It is assumed that these workers would bring average-sized families (2.7 persons/family) with them [StatsCan 2012]. The total direct increase in the permanent resident population in the Socio-economic Environment LSA for the operations phase is 223 persons.

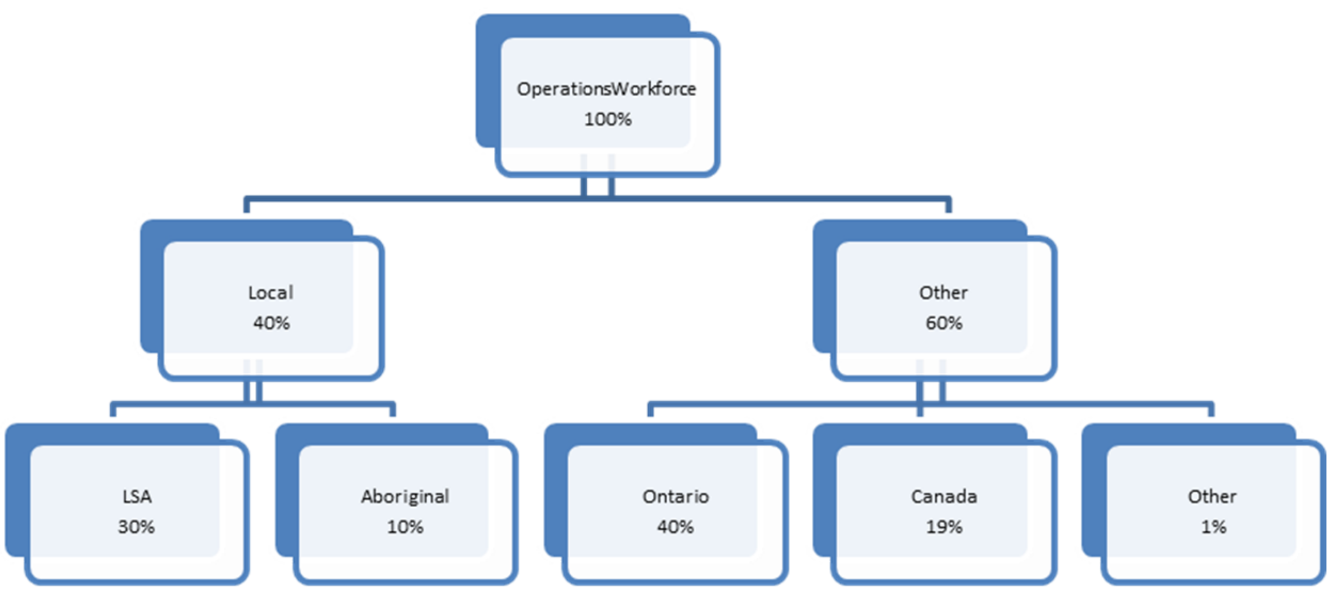


Figure 6-10: Assumed Place of Residence Distribution of Operations Workforce

An increase in indirect employment may be expected if a substantial number of business opportunities are realized through new or expanded businesses. The economic assessment (Appendix 2.II of the Socio-Economic Environment TSD) predicts 19 permanent jobs. Assuming half of these workers are current residents and half (9.5) would move to the Town and have average sized families, the increase in population resulting from growth in supply industries is predicted to be 26 persons.

The total increase in the permanent resident population for the operations phase directly or indirectly attributable to the Project is predicted to be 249 persons (223 direct plus 26 indirect). The increase in population in the Socio-economic Environment LSA anticipated for the operations phase, compared to existing conditions, is ~9% of the current population of 2,787. This is a positive effect that continues the reversal in population decline begun in the construction phase.

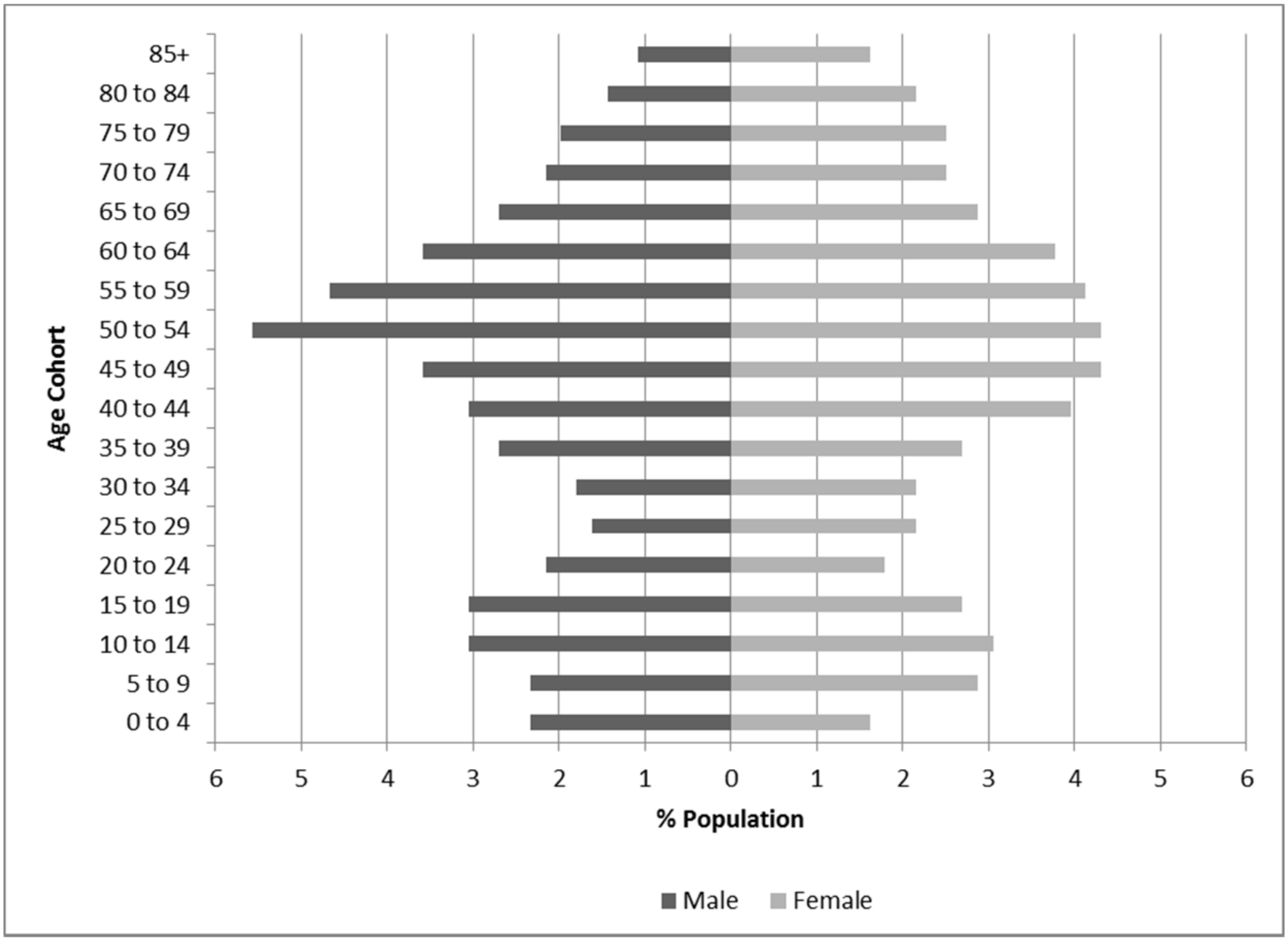
Mobility: Based on StatsCan data on general mobility rate, it is anticipated that approximately 36.4% of the population of the Socio-economic Environment LSA would be expected to move residence in a 5-year period. Some of this mobility would be as a result of people moving out of the community. The in-migration of 249 persons or ~9% of the current population during the operations phase is a positive effect as it should offset and reverse the out-migration from the Socio-economic Environment LSA.

Age and Gender: The age and gender profile of the Socio-economic Environment LSA is described in Figure 6-11. Ninety-two (92) families moving into the Socio-economic Environment LSA would add some children and working-age persons to the community and it is believed that this will cause a measurable change to the age and gender profile of the Socio-economic Environment LSA. As a result the community would more closely represent the provincial age and gender profile, which does not exhibit a pronounced negative growth scenario as observed for the Socio-economic Environment LSA. This is a positive effect because it will help reverse the population decline in the Socio-economic Environment LSA.

Dependency Ratio: An increase in the working-age population and young families in the Socio-economic Environment LSA during the operations phase is likely to reduce the elderly dependency ratio, which would have a positive effect on the community because the ratio of care-givers to elderly dependents would increase. The child dependency ratio is not expected to change as a result of the operations phase of the Project, because families would be expected to bring their children if they move to Atikokan. No measurable effect is likely.

No additional mitigation measures are required because the effects related to Population and Demographics are either not measurable or positive.

Similar enhancement measures to those suggested for the construction phase are recommended to maximize the number of families that move into Atikokan for the operations phase. Further, the Atikokan/OHRG Committee identified in Chapter 8 could continue to have a role in communicating and supporting the initiatives focussed on enhancing the Town as a place to live and work.



Source: StatsCan 2012.

Figure 6-11: Age Profile for Atikokan (2011)

6.3.1.3.2 Labour Market

Potential effects during the operation phase are considered with respect to the potential to affect the labour market (employment and income) in the Socio-economic Environment LSA and RSA (or province-wide) through the hiring of the operations workforce and through sourcing and obtaining materials and supplies. Changes are anticipated on median income and training and education.

Regional and Local Supplier Base: Total annual operating costs are estimated at $395 million. Total labour costs are estimated at $68 million, or 17% of the total capital expenditure. Of the remaining $327 million, 3% or $9.8 million per year is anticipated to be spent in the Local Study Area over the operations phase. This is anticipated to create opportunities for the establishment or growth of businesses in Atikokan to supply goods and services for the Project.

Figure 6-12 provides the anticipated geographic distribution of operations expenditures. The geographic distribution of operations expenditures for equipment and materials including consumables, energy and fuel, is estimated based on similar projects and professional judgement.

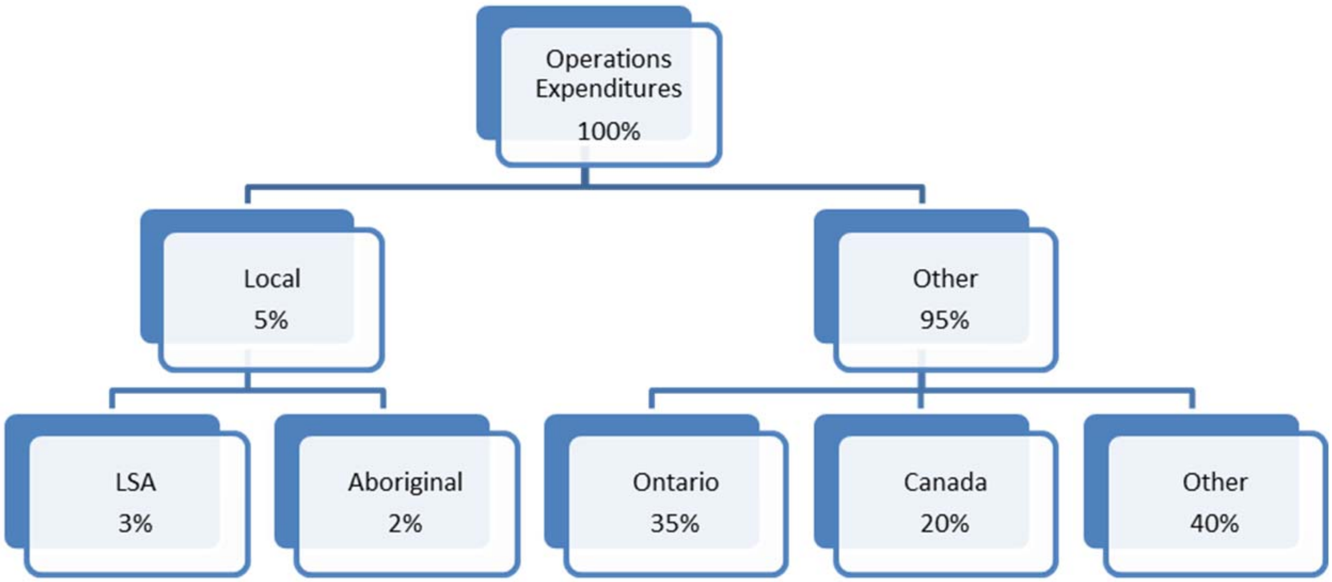


Figure 6-12: Distribution of Operations Expenditures

The effects of Project spending comprise a positive effect that builds on and amplifies the positive effects on Socio-economic Environment LSA economic activity begun during the construction phase. Similar to the construction phase, direct expenditures during operations of $119 million in the rest of Ontario including the RSA and $99 million in the rest of Canada will make a positive contribution to the regional, provincial and national economy.

Labour Force: Measurable changes in labour force during the operations phase will be seen primarily in the Socio-economic Environment LSA and RSA. The focus of this assessment is on the effects in the Socio-economic Environment LSA. Effects on communities in the RSA are expected to be too diffuse to be measurable.

An increase in the Socio-economic Environment LSA workforce of 184 (165 direct plus 19 indirect) is expected in the operations phase. The remaining workforce (385 direct) will reside at the Mine Site camp and are assumed to live in the RSA and elsewhere in Ontario or Canada. Based on Statistics Canada multiplier the Project results in an additional 1,720 indirect and induced jobs spread over the RSA, Ontario and Canada as a whole. This is a positive effect of the Project.

The labour force in the Socio-economic Environment LSA is 1,650 persons [StatsCan 2007]. The addition of 184 full-time equivalent (FTE) jobs in the Socio-economic Environment LSA will be split primarily among the following StatsCan industry categories: Agriculture and Other Resource-Based Industries (approximately 50% of the additional workforce or 92 FTEs), Manufacturing (15% or 28 FTEs), Other Services (15% or 28 FTEs), Construction (approximately 10% of the added workforce or 18 FTEs) and Retail Trade (10% or 18 FTEs). This increases the proportion of the workforce in Agriculture and other resource-based industries from 11% to 14.9% (36% increase), which bounds the effects on all other industries. This is a positive effect of the Project, providing new long-term employment opportunities in the Socio-economic Environment LSA.

Employment and Unemployment: Measurable changes in employment and unemployment rates during the operations phase will be most evident in the Socio-economic Environment LSA.

Of the 184 FTE created by the operations phase in the Socio-economic Environment LSA it is assumed that 25% of these workers (46 FTE) are previously unemployed in Atikokan. Another 92 persons are assumed to move into the community and be employed. This would increase the number of employed persons from 1,520 (56.8% employment rate) to approximately 1,758 (61.5% employment rate) and reduce the number of unemployed persons from 150 (9.0% unemployment rate) to approximately 104 (5.9% unemployment rate). This is a positive effect continuing the reduction in the unemployment rate begun in the construction phase, and bringing the Socio-economic Environment LSA close to the provincial average.

Median Incomes: Similar to the construction phase, the Project will continue to have a positive effect on median incomes by bring higher-paying jobs to the Town and reversing the dependence on the public or service sectors. This is a positive effect.

Education and Training: The educational requirements for mine workers are continuing to increase. Most jobs require high-school diploma with many requiring post-secondary trades or academic qualification. Accordingly, the Project may be expected to result in increased demand and opportunities in education and training. Although training opportunities within the Socio-economic Environment LSA are limited, the opportunities in the RSA are extensive. These include Lakehead University and Confederation College. The Project provides an opportunity for these educational organizations to offer skills training to people in the Socio-economic Environment LSA and RSA.

Mitigation: Because any measurable effects of the Project on the labour force VEC are positive, no further assessment is required and no mitigation is identified or warranted. The positive aspects of the Project could be enhanced through cooperation between OHRG and post-secondary organizations in the RSA by encouraging and focusing training of local residents to better equip them for possible employment at the Project.

6.3.1.3.3 Government Finances

As noted earlier, there will be no Project-specific property taxes that will accrue to the nearest municipality of the Town of Atikokan, though any increase in residential and other construction in the Town will increase the financial base of the Town. The extent of additional construction in the Town depends to some degree on current vacancy rates and suitability of existing structures to accommodate new demand. However, given an estimated overall permanent population increase of 249 persons or 92 households, it is not unreasonable to expect that some additional houses will be constructed in the town (assume 46 to accommodate half the increase in households, while the other half will find housing in the existing stock).

The current number of occupied dwellings in Atikokan is 1,420. Forty-six new houses represent an increase of 3.24% in the housing stock. New housing will have an assessed value that is considerably higher than the current average assessment per house. Using a tax rate of 1.0%, and an assessed value of new houses of $180,000, the annual property taxes collected from 46 new houses will be $82,800. There will also be an increase in taxation from new businesses and user fees for services; both are difficult to quantify.

The economic study presented in Appendix 2.II of the Socio-Economic Environment TSD presents an estimate of the revenues that will be accrued by the provincial and federal governments from the operations of the Project. In summary, annual provincial income tax revenues during the operations phase are $12.7 million and annual federal income tax revenues are $18.1 million, for a combined total income tax revenue over the 11-year operations phase of $339.1 million. This is a positive effect of the Project.

Mitigation: Because any measurable effects of the Project on the government finances VEC are positive, no further assessment is conducted.

6.3.1.3.4 Public Services and Infrastructure

The public services and infrastructure is assessed using indicators that characterize protection and emergency services, health services, social services, education, recreation, water, wastewater and waste management, and utilities. For the operations phase, these services are assessed collectively with specific reference to any individual services were an adverse effects is anticipated. Effects are limited to the Socio-economic Environment LSA because population or direct Project-related effects on services and infrastructure would predominantly be experienced in the Socio-economic Environment LSA.

Potential effects on public services and infrastructure in the Socio-economic Environment LSA are expected to result through increased use and requirements for services and infrastructure resulting from employment-related population change and due to requirements for hazardous and non-hazardous waste management.

Public Services and Infrastructure: Employment and related increase in population resulting from management, permitting and employment has the potential to increase demand on public services and infrastructure in the Socio-economic Environment LSA. The population during the operations phase is expected to increase by 92 workers, or 249 persons. The description of existing conditions shows that all of the public services and infrastructure in the Socio-economic Environment LSA is currently below capacity and could readily accommodate the additional demands of the small increase in population due to the operations phase of the Project. Thus, the operations phase of the Project would not adversely affect public services and infrastructure.

Water, Wastewater and Waste Management: As described under the assessment of impacts during the construction phase, it will be necessary to expand or replace the Town's existing landfill if the Project is going to use local waste management. This effect was assessed previously and no further assessment is required.

6.3.1.3.5 Housing and Accommodation VEC

The potential effects are likely to be focused in the Socio-economic Environment LSA through and will occur through increased demand resulting from employment-related population increase. No measurable effects are anticipated in the RSA.

Housing Supply and Occupancy Rates: The predicted population increase in the Socio-economic Environment LSA over the operations phase is 92 workers and their families (total increase = 249 persons). The corresponding housing need is for up to 92 permanent homes, although it is expected that some of these workers will not bring families and will not require permanent housing.

Despite the population decline in the Socio-economic Environment LSA over the past 20 years, housing availability in the Town of Atikokan remains limited. The 2006 occupancy rate for private dwellings in Atikokan was 92.4%, representing 108 unoccupied dwellings. This is not considered sufficient to house the increase in population anticipated for the operations phase. It is assumed that 46 new houses will be required to accommodate the operations workforce. However, there is capacity within the Town of Atikokan for residential housing development of this scale and new housing construction is a positive effect.

Cost and Availability: A modest increase in the demand for housing might be expected to have a modest effect on the cost of available units. However, the magnitude of the additional demand, approximately 46 units, is unlikely to have an effect other than a minor upward effect on the current cost of housing in the Socio-economic Environment LSA. This effect is assessed as being positive since it will likely to serve to stabilize or increase prices modestly.

6.3.1.3.6 Transportation

The potential effects on transportation are assessed using one indicator, namely the traffic level of service on the existing road network. Effects are limited to the Socio-economic Environment LSA and are considered with respect likely to level of services and safety on local roads through the movement of Project workers, equipment, supplies and products.

Level of Service: The approach is the same as described in the construction phase assessment. In order to consider future traffic conditions, existing counts were projected forward for each period.

A number of assumptions were developed based on similar mining Traffic Impact Study (TIS) reports and application of engineering judgment. Trip generation assumptions for the operations phase are provided in the Socio-economic Environment TSD.

Road traffic associated with the Project during the operations phase is predicted to generate approximately 110 trips / day. Based on the peak hour assumptions, this translates to about 20 vehicles per hour in the AM and PM peak hours during operations.

Trip distribution was based on the scenarios considered under the construction phase assessment. Effects were estimated for the years 2021 and 2028. Because effects are more pronounced for the year 2028 due to increased projected background traffic levels, this year is used for purposes of the effects assessment.

Mine Site operations are not expected to generate a significant amount of truck traffic, so the majority of the trips are predicted to come from employee traffic or supply trucks. As a result, the distribution scenarios show high percentages of traffic to and from Atikokan. The resulting effects predicted on levels of services (LOS) and volume-capacity ratios (V/C) at the relevant intersections and roads (mainlines) of these two scenarios indicate that all intersections will continue to operate at levels of service ‘A’ or ‘B’ and volume-to-capacity ratios less than or equal to 0.20. This level of service is satisfactory and will not result in any unacceptable traffic congestion. However, it constitutes a measurable change and may be viewed as an adverse effect by current road users.

6.3.1.3.7 Outdoor Tourism and Recreation

The assessment of effects on outdoor tourism and recreation is generally limited to the Socio-economic Environment LSA since effects in the RSA are not likely to be measurable. Generally, direct effects of the Project on land and resource use occur during the construction phase when access to, or use of, land is restricted by Project activities. The effects on outdoor tourism and recreation are assessed using three indicators: tourism activities, number and type of visitors, and tourism revenues. The Project is not anticipated to change the number and types of visitors to the RSA or Socio-economic Environment LSA, nor change the revenue generated in the RSA and Socio-economic Environment LSA from tourism. Accordingly, the assessment is focussed on the changes to use and access to recreational opportunities in the Socio-economic Environment LSA.

In addition, Project-induced changes to the physical environment identified in the Atmospheric Environment TSD, Aquatic Environment TSD, Terrestrial Ecology TSD and through visual impact may result in indirect effects on outdoor tourism and recreation as follows:

- Adverse effects on air quality or noise were considered to potentially affect the use and enjoyment of lands and resources for recreation and tourism. The adverse effect can be mitigated through continuing the restriction of access to the MSA, signage, and negotiations with specific land owners as identified in the construction phase.
- Adverse effects on the aquatic environment may affect the use and enjoyment of lands and resources for recreation and tourism. No adverse effects of moderate or greater significance have been identified in the Aquatic Environment TSD, and therefore no assessment or mitigation related to indirect effects from the aquatic environment on outdoor tourism and recreation is required.
- Adverse effects on the terrestrial environment may affect the use and enjoyment of lands and resources for recreation and tourism. No residual adverse effects of moderate or greater significance have been identified in the Terrestrial Ecology TSD, and therefore no assessment or mitigation related to indirect effects from the terrestrial environment on outdoor tourism and recreation is required.
- Adverse effects on visual aesthetics may affect the use and enjoyment of lands and resources for recreation and tourism. Negative perception-related effects on the Socio-economic Environment LSA as a pristine wilderness destination are likely to be experienced through adverse effects on visual aesthetics. Mitigation measures are described in this previous section, and no further assessment is warranted.

Where measurable changes have been identified as adverse in these other disciplines, the effects are assessed as indirect effects in this assessment. To be considered as an indirect effect for assessment in the socio-economic assessment, an adverse effect must have been identified by the original discipline.

Recreational Opportunities: Those resources identified to have been directly affected by the restriction of site access/removal of land (approximately 2,003 ha) for the purposes of recreation and tourism have been assessed in construction phase. No additional impacts are expected in the operations phase and effects on recreational opportunities.

6.3.1.3.8 Hunting

Indicators for assessing effects on hunting include: wildlife management areas, license sales, and harvest volumes. No change is predicted in licence sales or harvest volumes as these are based on government-set quotas and which are not expected to change as a result of the Project. The focus of the assessment is on the change to hunting opportunities as a result of changes to wildlife management areas.

Direct effects on hunting within the Socio-economic Environment LSA from the removal of land or restriction of site access were considered and assessed during the construction phase. No changes are predicted to occur during the operations phase since no additional land will be removed and there will be no additional restrictions on site access.

Mitigation to reduce impacts on hunting for residents and tourists was identified in the assessment of effects during the construction phase and would be continued through the operations phase.

6.3.1.3.9 Trapping

Potential effects on trapping and mitigation required were assessed during the construction phase. No additional effects are predicted to occur during the operations phase.

6.3.1.3.10 Fishing

Potential effects on fishing were assessed during the construction phase. No additional effects are predicted to occur during the operations phase and the mitigation measures identified would continue through the operations phase.

6.3.1.3.11 Forestry

Potential effects on forestry were assessed during the construction phase. No additional effects are predicted to occur during the operations phase, and the mitigation measures identified would carry through the operations phase.

6.3.1.3.12 Water Use and Access

Assessment of direct effects is focused on the predicted changes in use, access and availability of water resources for hydro-electric power for other industrial and commercial uses. The Hydrology TSD has conducted an assessment of the changes on water levels and flows as a result of operating the Project. The assessment considers changes in the local hydrology that may affect water use for hydro-electric power for other industrial and commercial uses.

Predicted changes in flows as a result of the Project, for example at Raft Lake Dam, are not measurable compared to annual variability, and are therefore unlikely to affect downstream water users for hydroelectricity or other commercial or industrial uses. Any minor changes in water levels and flows could be accommodated by minor changes in reservoir management procedures. Where changes cannot be accommodated through reservoir management procedures, negotiations with hydro-electric power producers may be required to provide direct compensation due to loss in power production capability from changes in water levels and flows. Initial discussions with power producers have indicated that compensation for this loss would be a reasonable mitigation measure that could result in a mutually beneficial outcome. Ongoing discussions will be carried out with water users and regulators, as appropriate. No further assessment is required.

6.3.1.4 Effects Assessment of the Closure and Post-Closure Phase

The effects assessment of the closure and post-closure phases is carried out using the same VECs and indicators as the assessment of the effects of the construction and operations phases. The discussion of the closure and post-closure phases is presented together in the following section.

6.3.1.4.1 Population and Demographics

Effects on Population and Demographics in the closure and post-closure phases will occur through changes to workforce requirements. Any changes from existing conditions expected during the closure and post-closure phases are bounded by the construction and operations phases, which have greater workforce requirements. Further no adverse effects compared to baseline conditions are anticipated for the closure and post-closure phases.

6.3.1.4.2 Labour Market

Effects on the labour force in the closure and post-closure phases will occur through changes to workforce requirements, Changes from existing conditions are bounded by the construction and operations Phases, which have greater workforce requirements.

6.3.1.4.3 Government Finance

Effects on government finances during the closure and post-closure phases are not likely adverse compared to existing conditions, and will be bounded by effects during the construction and operations phases.

6.3.1.4.4 Housing and Accommodation VEC

The effects of the closure and post-closure phases on housing and accommodation are not likely to be adverse compared to existing conditions and are expected to be bounded by effects during the construction and operations Phases.

6.3.1.4.5 Traffic and Transportation

Effects on traffic and transportation during the closure and post-closure phases are expected to be bounded by effects during the construction and operations phases. No further assessment or mitigation is required.

6.3.1.4.6 Land and Resource Use VECs

Any adverse effects on the land and resource use during the closure and post-closure phases are bounded by effects predicted during the construction and operations phases.

6.3.2 Aboriginal Interests

Project works and activities that have the potential to affect the identified Aboriginal Interests VSCs are identified and advanced for additional consideration. A summary table is provided for each of the Project phases showing the potential interactions. All potential effects identified in the Table 6-51 through 6-53 are advanced for a prediction of their likely effects.

Table 6-51: Aboriginal Interests and Project Interactions in Construction Phase

Project Activity	Likely Effect on VSC		
	Aboriginal Community Characteristics	**Aboriginal Heritage and Resources**	**Traditional Use of Land and Resources**
Management, Permitting and Employment	Yes	No	No
Project physical activities (including all activities below)	No	Yes	Yes

Table 6-52: Aboriginal Interests and Project Interactions in Operations Phase

Project Activity	Likely Effect on VEC		
	Aboriginal Community Characteristics	**Aboriginal Heritage and Resources**	**Traditional Use of Land and Resources**
Management, Permitting and Employment	Yes	No	No
Project physical activities	No	Yes	Yes

Table 6-53: Aboriginal Interests and Project Interactions in Closure and Post-closure Phase

Project Activity	Likely Effect on VEC		
	Aboriginal Community Characteristics	**Aboriginal Heritage and Resources**	**Traditional Use of Land and Resources**
Management, Permitting and Employment	Yes	No	No
Project physical activities	No	No	No

6.3.2.1 Aboriginal Interests Effects Assessment

An Aboriginal Interests effects assessment was conducted to evaluate the likely effects of the Project on Aboriginal groups' interests and on asserted or established Aboriginal and treaty rights. Based on published information and ongoing communication with identified Aboriginal communities, the assessment identified any likely measurable effects on:

- Social and/or economic effects to Aboriginal communities that may arise as a result of environmental effects of the Project. These effects relate primarily to employment, business activity and training.
- Current and proposed uses of land and resources by Aboriginal persons for traditional purposes. This includes trapping, hunting, fishing and plant harvesting.
- Lifestyle, culture and quality of life of Aboriginal communities.
- Heritage and archaeological resources in the Project Site that are of importance or concern to Aboriginal communities. This includes heritage sites and areas of traditional interest to Aboriginal people.

6.3.2.2 Project-Environment Interactions

An evaluation of interactions between the Project and potential effects to Aboriginal Interests was conducted. Of particular focus to Aboriginal Interests, are those Project activities which affect:

- Economics and labour force.
- Physical activities relating to the disturbance of land and water.

The Project work or activity that best allows an assessment of the effects of the Project as a whole on economics and labour force is "**Management, Permitting and Employment.**" This activity includes the size and nature of the Project workforce, procurement of equipment, goods and services, and control of Project Site access.

All physical activities have the potential to interact with the environment. This includes construction activities at the Mine Site and those associated with infrastructure development. For the purpose of the Aboriginal Interests effects assessment, these activities are collectively referred to as "**Project physical activities.**"

6.3.2.3 Study Areas

The study areas used for the Aboriginal Interests effects assessment include an Aboriginal Interests RSA and LSA. These study areas exist within a broader regional context.

The study areas were selected based on consideration of the following factors:

- Traditional territory (Treaty 3) and Treaty 3/Lake of the Woods/Lac Seul/Rainy River/Rainy Lake (Metis Nation of Ontario (MNO)).
- District identified by the Fort Frances Chiefs Secretariat and Lac des Mille Lacs First Nation.
- Area within which there is a potential for biological effects from the Project, identified in other TSDs.

These areas were identified based on published information and were discussed with Aboriginal people throughout land use workshops and consultation activities, as described in Chapter 7of the EIS/EA Report.

The Regional Study Area (RSA) is defined as the Rainy River District, extended to include Lac des Mille Lacs First Nation.

The economic effects on Aboriginal communities from the Project identified and assessed in Aboriginal effects assessment are assumed to occur primarily within the RSA.

The Aboriginal Interests LSA is defined as the area likely to be affected by the direct environmental effects of the Project, focussed specifically on land use (the land use study area is equivalent to the local study area). Land use may be affected by temporary restriction of access for safety during Project operations, direct change of land use due to Project construction and operations, or indirect change of land use due to environmental changes from the Project.

The Aboriginal Heritage Resources and Traditional Land Use effects on Aboriginal communities from the Project identified and assessed are assumed to occur primarily within the Aboriginal Interests LSA.

6.3.2.4 Valued Social Components

In order to focus the Aboriginal Interests effects assessment on those components that are of greatest relevance in terms of value and sensitivity, Valued Social Components (VSCs) have been identified and selected as endpoints for the assessment.

The VSCs for the Aboriginal Interests effects assessment were selected based on the following considerations:

- Engagement with Aboriginal communities, as detailed in Section 7 of the EIS/EA Report.
- Literature pertaining to Aboriginal treaties, land claims, fishing and harvesting rights.
- Previously published EAs for mining projects with Aboriginal interests accepted by CEAA.

The VECs were characterized using indicators; where indicators are the attributes of the VEC that might be affected by the Project. These indicators, and the rationale for their selection, are summarized in Table 6-54.

Table 6-54: Valued Social Components Selected for Aboriginal Interests

Valued Social Component	Rationale for Selection	Indicators	Measures
Aboriginal community characteristics	The Project may affect the economic base and educational attainment of Aboriginal communities Aboriginal right	Project Aboriginal employment Project contracts awarded to Aboriginal businesses Education and training of Aboriginal people	Project-related employment opportunities Project-related expenditures Project-related education and training
Aboriginal heritage resources	Aboriginal heritage resources such as archaeological sites may be affected by the development of Project lands Specific cultural or spiritual sites may be affected by the development of Project lands Aboriginal right	Identified archaeological sites and artefacts Cultural or spiritual sites	Project-related disturbance of archaeological sites Restricted access or disturbance of cultural or spiritual sites
Traditional use of land and resources	Aboriginal people have traditionally made use of lands and resources for their personal and community needs The Project may affect plants, animals and fish that have been traditionally harvested and consumed by Aboriginal people Treaty right	Adverse effects identified on the aquatic environment Adverse effects identified on the terrestrial environment Availability and quality of country foods	Loss of fishing opportunities Loss of hunting, trapping and plant harvesting opportunities Project-related changes to source and safety of country foods

6.3.2.5 Summary of Effects to Aboriginal Interests

The assessment examined the effects of the Project on the VSCs identified for Aboriginal Interests, namely: Aboriginal Community Characteristics, Aboriginal Heritage Resources and Traditional Use of Land and Resources. Interactions were identified between the Project activities and each of the VSCs. These interactions were predicted to result in a total of twelve possible effects.

Effects on Aboriginal Community Characteristics are anticipated to be positive namely those effects on Employment, Business Activity, and Training and Education. The Project will contribute to the economic opportunities and development of Aboriginal communities in the RSA, as summarized below.

- Based on the occupations required for the construction and operations phases, and knowledge of the available Aboriginal workforce, it is estimated that approximately 5% (21 jobs) of the total construction workforce may be Aboriginal people.
- The proportion of Aboriginal workforce is expected to increase to 10% (55 jobs) during the operations phase, reflecting the opportunities for skills training during the early construction phase of the Project.
- The percentage of Aboriginal people in the workforce during the closure phase is anticipated to increase to up to 50% (25 jobs) reflecting an opportunity for ongoing inclusion of local Aboriginal people in the stewardship of the land.
- OHRG aims to promote the utilization of Aboriginal enterprises whenever possible in supplying goods and/or services required during each phase of the Project.
- An estimated $22 million over approximately 30 month construction period is anticipated to be spent on goods and services obtained from Aboriginal businesses. This expenditure depends upon the ability of Aboriginal businesses to meet the requirements of the goods and services needed.
- An estimated $7.9 million annually is anticipated to be spent on goods and services obtained from Aboriginal businesses throughout the operations phase. This level of expenditure is anticipated to create opportunities for the establishment or growth of Aboriginal businesses to supply goods and services for the Project.
- Because OHRG is present in the RSA, engaged with Aboriginal communities on potential job opportunities, and providing Aboriginal youth opportunities, the level of education attainment is expected to increase.

Effects on Aboriginal Heritage and Resources through Project-related disturbance of archaeological sites or restricted access or disturbance of cultural or spiritual sites were identified as being unlikely to occur. The Project will not result in any physical disturbance of any known sites. Development of a protocol is planned to ensure that in the unlikely event a currently unknown site is discovered during construction, appropriate action can be taken. In the event that there is an effect because of the need to restrict access to a Special Site, the effect will be fully mitigated through the negotiation of an agreement. As part of the research studies for the environmental assessment, Stage 1 and 2 archaeological assessments were conducted on the area likely to be affected by Project physical activities. No Aboriginal archaeological sites or artefacts were indicated.

Effects on Traditional Use of Land and Resources, specifically loss of fishing opportunities, hunting opportunities and plant harvesting opportunities were assessed as being negligible because any effects would be limited to the Aboriginal Interests LSA and would not measurably reduce the overall land use opportunities provided within the RSA.

The Project is located in an area with a healthy and robust fishery, and a strong hunting resource. Hunting and fishing by Aboriginal people occurs within the RSA. Effects on hunting and fishing within the Aboriginal Interests LSA as a result of the Project are small or negligible compared to the overall opportunities and resources in the RSA. Since most Aboriginal people practice hunting and fishing with the RSA, the effects of the Project on the Aboriginal use of fish and game for dietary or commercial purposes is negligible.

Effects on the consumption of country foods was determined to be unlikely since neither their source nor safety would be affected.

The environmental assessment included an Ecological Risk Assessment (ERA) that evaluated the potential for adverse effects to ecological (including wildlife and aquatic life) health associated with changes in environmental quality due to chemical releases from the Project. The ERA did not identify any Contaminants of Potential Concern in soil or surface water for further evaluation. As such, the ERA did not proceed beyond the chemical screening stage of the problem formulation. This indicates that adverse effects to ecological health as a result of the Project are not expected, and an effect on the safety of country foods is not anticipated as a result of the Project.

The removal of land base within traplines in the Aboriginal Interests LSA, will be mitigated through agreements with the trapline holders. .

6.3.2.6 Mitigation and Consideration of Aboriginal Interests

Mitigation is only necessary when an adverse effect is identified. In the case of positive effects, recommendations are made that might enhance the nature or extent of the effect. In many cases, mitigation has been included in the Project design or in the plans made by OHRG for the implementation of the Project. For example, early and ongoing investment in Aboriginal cultural practices and the incorporation of traditional protocols in Project meetings identified potential adverse effects and allowed OHRG to take steps to avoid them.

The Aboriginal Interests effects assessment did not identify any adverse effects of the Project that could not be mitigated or compensated on any of the selected VECs. The assessment considers in–design mitigation measures and plans designed to avoid adverse effects or address the concerns of Aboriginal people identified through OHRG's extensive engagement program.

Furthermore, adverse effects on Aboriginal Interests are minimized or avoided entirely, and positive effects are enhanced, through the Resource Sharing Agreement developed by OHRG and the identified First Nations communities. At the request of all parties, details of the agreement are confidential.

The following sections make a number of recommendations that could seek to enhance the positive benefits and/or ensure that implementation of the Project will occur in harmony with Aboriginal Interests to the extent possible. These recommendations could serve to enhance the continuing relationship between OHRH and the Aboriginal communities.

6.3.2.6.1 Aboriginal Community Characteristics

It is recommended that OHRG continue its practice of informing Aboriginal communities about the nature and timing of the skills required for site workers. The role of OHRG's Director of Aboriginal Affairs is to lead and develop this effort.

It is recommended that OHRG investigate ways to encourage existing Aboriginal workers to share working experiences within their own communities, thereby helping to overcome some of the barriers to Aboriginal participation in the wage economy.

It is recommended that OHRG make the workplace a welcoming environment to Aboriginal people by providing cultural sensitivity training to all members of the Project workforce.

6.3.2.6.2 Aboriginal Heritage and Resources

Although no Aboriginal heritage sites or artefacts are identified with the area likely to be affected by the Project physical activities, there remains the low possibility that a heritage site or artefacts could be encountered during excavation or earth moving activities. Accordingly, it is recommended that a protocol be established between OHRG and the First Nations regarding actions to be taken in the event, however unlikely, a heritage sire and/or artefacts are discovered during the construction phase.

It is recommended that OHRG and Aboriginal communities to cooperate in the protection of special sites. This requires OHRG to identify and review mine site development plans with First Nations and Metis people where they have the potential to impact special sites. This approach has been agreed to by the Aboriginal communities.

6.3.2.6.3 Traditional Use of Land and Resources

Because Aboriginal people will likely continue to occupy the land after mine closure, and because of their continued stewardship of the land, it is recommended that they be included in remediation planning. This could include the selection of native plant species or specific species that are of special interest to Aboriginal people to be used during re-vegetation of the Project Site.

6.3.3 Physical and Cultural Heritage Resources

The results of the archaeological investigations are provided in the Cultural Heritage Resources TSD.

No significant archaeological sites and artifacts were found, with the exception of two late 19th century to mid-20th century mine sites, which are likely to be affected by the Project. Two historic mining operations reside within the footprint of the proposed development, the Hammond Gold Reef Mine, located on the northern limit of the Mitta Lake Peninsula, and the Sawbill Mine, located north of the east end of the east Pit. In both cases cultural remains exist that illustrate the location of the abandoned mining operations.

Potential effects on the two former mine sites described above are limited to the LSA since both sites lie outside of the mine footprint. While potential effects include the destruction, alteration, disturbance, exposure or isolation of attributes or features of these sites, they are unlikely to be affected by mining activities.

As both of these sites date well into the 20th century the information potential related to archaeological studies is considered to be low and no further archaeological assessment was conducted. However, given the available historical literature in the form of government mining reports and the presence of remains such as mine shafts, adits, dams and tramways, it is recommended that a Cultural Heritage Evaluation Report (CHER) be undertaken for the two historic mining operations to document as much detail as possible; to evaluate the cultural heritage landscapes under the Ontario Heritage Act Reg. 9/06 Criteria for Determining Cultural Heritage Value or Interest and Reg. 10/06 Criteria for Determining Cultural Heritage Value or Interest of Provincial Significance; and to recommend further mitigation if required prior to these areas being impacted by ground disturbance activities.

6.3.4 Human Health Effects Assessment

Potential effects of the project on human health were assessed with respect to air emissions from the Project, noise and effects on surface water quality. The assessment is based on the human health risk assessment conducted following methods developed by Health Canada and the MOE. Details on the risk assessment are provided in the Human Health and Ecological Risk Assessment TSD. The pathways considered were inhalation for air emissions and ingestion for surface water quality.

- Inhalation Assessment focused on exposure to substances that could be emitted to air. The human health risks associated with changes in air quality for both short-term or acute exposures (i.e., 1-hour maximum concentration) and long-term or chronic exposures (24-hour and annual average concentrations) were assessed.
- Noise Assessment evaluated noise levels potentially generated by the Project and the potential impacts to identified receptors.
- Particulate Matter Risk Assessment focused on exposure to particulate matter emitted to air (i.e., particulate matter less than 10 microns in diameter [PM_{10}], particulate matter less than 2.5 microns in diameter [$PM_{2.5}$], total suspended particulate [TSP] and diesel particulate matter [DPM]).
- The Multi-Media Risk Assessment focuses on exposure to substances that are released to the environment, including soil and water.

Potential effects on human health were assessed for a variety of receptors including members of the Aboriginal community, community residents (i.e., Town of Atikokan), off-duty workers living at the worker accommodation camp, trappers, and recreational users. Receptor locations ranged from the on-site worker accommodation camp to a nearby trapper cabin and nearby select crown land locations (possible camping sites should people choose) on Upper Marmion Reservoir, to residents of the Town of Atikokan. Members of nearby Aboriginal communities were assumed to use nearby areas within the RSA for fishing, hunting and harvesting plants. Exposure assessments were based on conservative estimates of how long each receptor would reasonably be exposed to a potential source. Conservative benchmarks for assessing effects (based on documented thresholds) were used to evaluate potential risks.

Human health risks associated with changes in air quality were evaluated for the operations phase, which is the phase of the project that has the highest air emissions. Air concentrations for acid gases, VOCs, petroleum hydrocarbons and VOCs were predicted for each receptor location for 1-hour, 24-hour and annual averaging periods. The 1-hour concentrations were used to evaluate acute exposure and the 24-hour and annual averaging periods were used to evaluate chronic exposure. Air screening guidelines from relevant regulatory agencies (e.g., OMOE, CCME, ATSDR, CalEPA, WHO, TCEQ) were compiled for each averaging period and the most conservative (i.e., lowest) of the health-based screening guidelines was selected for each substance, for each averaging period. These health-based screening guidelines have been derived to be protective of human health, meaning that if predicted concentrations are below the guidelines, adverse health effects are not expected. If predicted concentrations are above the guidelines a more detailed exposure assessment must be carried out to determine whether health effects are likely to occur. The maximum predicted concentrations for each averaging period were compared to the selected screening guidelines. For acute exposure (1-hour averaging period), all predicted concentrations were below the guidelines, therefore no adverse health effects are expected. Considering chronic exposure, acrolein exceeded the 24-hour screening guideline at one campsite and one trapper cabin location and nitrogen dioxide exceeded the annual guideline at the worker accommodation camp. An exposure assessment was carried out to identify the anticipated exposure dose that may be received by the off-duty worker, recreational user and trapper that may be present at the receptor locations with identified exceedances. The calculated exposure doses were below toxicity reference values that represent safe exposure levels. Therefore, there are no adverse health effects expected based on chronic inhalation exposure.

In the noise assessment, measures prescribed by Health Canada (2005) for assessing exposure to noise and potential human health effects were utilized, specifically targets based on the percent highly annoyed (%HA) and the specific critical noise level (HCII). The noise predictions for the Project are described in the Atmospheric Environment TSD. The predicted%HA and HCII values for the Project are less than the targets prescribed by Health Canada. However, further literature review has shown that adverse effects such as sleep disturbance and hypertension may be associated with noise levels below the target levels. At receptor locations surrounding the Project, noise levels are within the ranges reported for increased risk of hypertension and sleep disturbance. The magnitude of effect for noise is considered to be low based on comparison to Health Canada targets and considering that predicted levels are in the lower end of ranges for hypertension effects.

Inhalation of particulate matter was evaluated based on comparison of predicted PM_{10}, $PM_{2.5}$,TSP and DPM to health-based regulatory guidelines. Predicted particulate matter concentrations were below the guidelines except for 24-hour PM_{10} and annual DPM. The predicted concentration of DPM was above the annual guideline for carcinogenic effects at all receptor locations. An exposure assessment was carried out using the maximum concentration predicted at each receptor location type for the off-duty worker, recreational user, trapper and resident. The predicted exposure doses were used along with the inhalation unit risk factor for DPM to determine incremental lifetime cancer risks (ILCR). The ILCRs were less than the MOE target of 1×10^{-6} for all receptors except for the trapper at receptor location #32 and #29, where the predicted ILCRs were both 1.6×10^{-6}.

Surface water assessment was based on potential for consumption of surface water during operations and into post-closure. The predicted surface water concentrations as discussed in Section 6.1.3 were used as the exposure concentrations. The predicted concentrations were initially screened against existing drinking water guidelines including the Guidelines for Canadian Drinking Water Quality (Health Canada 2012). Then, maximum predicted concentrations in surface water were compared to the maximum measured baseline concentrations. Substances were identified as requiring further assessment and were passed on for evaluation in the multi-media assessment if predicted concentrations were greater than guidelines and baseline concentrations. If a chemical only exceeded baseline concentrations and not its respective health-based screening criterion, it was not considered to be present at levels that would affect human health. If a chemical exceeded its respective health-based screening criterion but was present in the environment at levels less than baseline concentrations, then it was not considered to be significantly different from baseline and no health effect was predicted to occur. Following these screening steps, no substances were predicted to exceed both guidelines and baseline concentrations in surface waters and therefore no risks to human health from the Project were predicted through consumption of surface water.

Potential for accumulation of substances in soil, and transfer to vegetation that may be consumed by humans was evaluated first by comparing predicted soil concentrations to available guidelines. Soil concentrations were predicted based on deposition of metals and PAHs due to air emissions from mining and material handling activities, vehicle exhaust and vehicle movement, which creates fugitive dust. The details of the modeling are provided in the Atmospheric Environment TSD. Prediction of soil concentrations is based on incremental soil concentrations calculated using protocols provided in the Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (U.S. EPA 2005). The maximum predicted soil concentrations were subsequently used in the risk assessment (the details on the prediction methods are provided in HHERA TSD). Predicted soil concentrations were compared first to baseline concentrations plus 10%. Next, predicted soil concentrations were compared to the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health, agricultural land uses (CCME 2012b) and the Ontario Ministry of the Environment Table 1 Full Depth Background Soil Standards for agricultural land uses (MOE 2011). The substances in soil were retained for evaluation in the risk assessment if the predicted soil concentrations exceeded baseline concentrations plus 10% and exceeded a soil screening level. The predicted metal and PAH concentrations (incremental + baseline) were less than the baseline plus 10% concentrations for all substances. Therefore, further screening against soil screening levels was not required and no risks to human health due to operation of the Project were predicted from deposition to soils. Since concentrations did not exceed baseline + 10%, there is no predicted increase in vegetation uptake, and there is no predicted additional risk to humans from consuming vegetation on-site.

6.3.5 Summary of Potential Effects to the Social Environment

The social effects assessment considers potential socio-economic effects, Aboriginal interests, Cultural heritage resources and human health risk assessment.

6.3.5.1 Socio-Economics

The Project will have a positive economic effect through jobs and increased government revenues during the construction and operations phase. The provision of 550 new direct jobs and an estimated 1,739 indirect jobs during operations alone is a considerable benefit from the Project.

The tax revenues from the Project are a positive effect and they represent a major contribution of approximately $340 million to federal and provincial revenues over the 11-year operations phase. The Project’s municipal tax contribution to the Town of Atikokan will be indirect through the potential construction of new housing, new local businesses and an increased population.

The effect on population and demographics is expected to be small during construction and moderate during operations. Overall, population increase is expected to contribute to the net benefits of the Project. An increase in the number of Atikokan residents (workers and their families) should serve to reverse the current population decline in the LSA.

The existing public services and infrastructure in the LSA, including the Town’s plans for a new waste management facility, are capable of accommodating the small additional demand from the Project and increased population as a result of the construction phase. Accordingly, no adverse effects are anticipated on this VEC.

Overall, the effect of the Project on housing and accommodation is positive. The Project is anticipated to result in an increase in the demand and cost of housing in the LSA which should contribute to the stabilization of the local housing market.

The Project is anticipated to result in an increase in traffic, resulting in a category ‘C’ level of service on Highway 11B, and an increased volume-to-capacity ratio. The increase still provides for service levels well within acceptable ranges and the Project should not result in unacceptable traffic congestion.

The Project could result in effects to hunting because of loss of habitat. The magnitude of the effect is low because the amount of land removed is less than 5% of the wildlife management unit. The frequency and reversibility are both high since the effect occurs continuously and is reversible; therefore, the overall assessment of significance of this effect is assessed as low.

Outdoor tourism and recreation could be affected by the Project because of changes in perception caused by effects to the visual landscape. This is a permanent change that will be mitigated through ongoing consultation with tourism operators and OHRG’s commitment to invest in advertising to promote the local industry.

6.3.5.2 Aboriginal Interests

Effects on Aboriginal Community Characteristics are anticipated to be positive namely those effects on Employment, Business Activity, and Training and Education. The Project will contribute to the economic opportunities and development of Aboriginal communities.

Effects on Aboriginal Heritage and Resources through Project-related disturbance of archaeological sites or restricted access or disturbance of cultural or spiritual sites were identified as being unlikely to occur. The Project will not result in any physical disturbance of any known sites. As part of the Cultural Heritage studies for the environmental assessment, Stage 1 and 2 archaeological assessments were conducted on the area likely to be affected by Project physical activities. No Aboriginal archaeological sites or artefacts were found.

Effects on Traditional Use of Land and Resources, specifically loss of fishing opportunities, hunting opportunities and plant harvesting opportunities were assessed as being negligible because any effects would be limited to the Aboriginal Interests LSA and would not measurably reduce the overall land use opportunities provided within the RSA. Effects on the consumption of country foods was determined to be unlikely since neither their source nor safety would be affected. The removal of land base within traplines in the Aboriginal Interests LSA, will be mitigated through agreements with the trapline holders. .

6.3.5.3 Physical and Cultural Heritage Resources

No significant archaeological sites and artifacts were found, with the exception of two late 19th century to mid-20th century mine sites, which are likely to be affected by the Project. Two historic mining operations reside within the footprint of the proposed development, the Hammond Gold Reef Mine, located on the northern limit of the Mitta Lake Peninsula, and the Sawbill Mine, located north of the east end of the east Pit. In both cases cultural remains exist that illustrate the location of the abandoned mining operations.

Potential effects on the two former mine sites described above are limited to the LSA since both sites lie outside of the mine footprint. While potential effects include the destruction, alteration, disturbance, exposure or isolation of attributes or features of these sites, they are unlikely to be affected by mining activities.

As both of these sites date well into the 20th century the information potential related to archaeological studies is considered to be low and no further archaeological assessment was conducted.

6.3.5.4 Human Health Risk Assessment

No Contaminants of Potential Concern (COPCs) were identified following the conservative screening process. Therefore, no adverse health effects are expected as a result of changes in soil and water concentrations.

There are no residual effects from the acute inhalation assessment based on comparison of chemical-specific predicted maximum 1-hour air concentrations from all receptor locations against the lowest available health-based screening thresholds.

The chronic inhalation assessment considered anticipated exposure times for each receptor as well as receptor-specific parameters such as inhalation rate and body weight. All of the HQs were well below MOE target levels, indicating negligible health effects.

In the particulate matter assessment, concentrations of $PM_{2.5}$ were below guidelines, indicating negligible adverse health effects from $PM_{2.5}$. Annual concentrations of PM_{10} were also below guidelines and not expected to cause adverse health effects.

Concentrations of DPM exceeded the screening threshold for carcinogenic effects, therefore DPM was evaluated following the chronic inhalation assessment method. The calculated levels were less than the target cancer risk of 1×10^{-6} for all receptors except for one trapper cabin.

In the noise assessment, measures prescribed by Health Canada for assessing exposure to noise and potential human health effects were utilized. At receptor locations surrounding the Project, noise levels are within the ranges reported for increased risk of hypertension and sleep disturbance. The magnitude of effect for noise is considered to be low based on comparison to Health Canada targets and considering that predicted levels are in the lower end of ranges for hypertension effects.

6.3.6 Summary of Mitigation for the Social Environment

The Town of Atikokan is currently planning to construct a new waste management facility and is undergoing the permitting process for this facility. Upon approval of the EA and a decision to construct OHRG is committed to working with the Town of Atikokan to support the licensing, construction and operation of this new landfill site. The new site will be designed to accommodate any construction-related waste from the Project.

Mitigation will be required for the adverse effects on outdoor tourism and recreation resources that will be directly affected by the restriction of site access/removal of land as part of the construction of the Project.

Because there may be some perception of negative effects on outdoor tourism and recreation due to construction of a mine project in the area, and associated effects on visual aesthetics, OHRG has begun to take steps to reinforce the positive outdoor tourism and recreational reputation of the LSA. As outlined in Chapter 7 Public Consultation, communications with Tourist Operators has been ongoing including a workshop which discussed concerns. As a result of this workshop, OHRG has committed to providing support for advertising efforts to promote the local tourism industry. OHRG also plans ongoing sponsorships of community events such as the Atikokan Bass Classic.

Effects to hunting was determined to be a potential residual adverse effect of the Project. In order to mitigate any increase in hunting pressures that could occur as a result of the Project HRG will implement a firearms policy to restrict hunting for workers while at camp. OHRG will also administer a bi-annual hunting and fishing questionnaire to its workforce in cooperation with MNR to evaluate hunting and fishing pressure and will work with the MNR to develop adaptive management policies if necessary based on the results.

Mitigation is required for the adverse effects on trap line areas, bait fish blocks and bear management areas that will be directly affected by the restriction of site access/removal of land as part of the construction of the Project. The approach to mitigation is compensation and/or relocation based on negotiation with the land user. Mitigation for adverse effects on trapping, bait fishing and bear hunting will involve negotiated agreements and benefits upon approval of the EA and a decision to construct. Agreements are currently in place with the adjacent tourism operator, overlapping trap line holder, bait fish block holder. Satisfactory completion of negotiations and execution of agreements fully mitigate this effect.

Mitigation to forestry will involve discussions facilitated by MNR between OHRG and Atikokan Forest Products and Abitibi Consolidated to negotiate compensation, as required. Satisfactory completion of these negotiations should mitigate any adverse effects of the Project on timber harvest land base.

During the closure phase, OHRG will help communities transition into the loss of Project-related employment and opportunities for businesses to provide goods and services to the Project. Similar programs have been in place for changes in workforce when the exploration phase came to a close and included employee transition planning, training and placement support to assist employees in finding other employment in the community or elsewhere in the resource extraction sector.

The Aboriginal Interests effects assessment did not identify any adverse effects of the Project that could not be mitigated or compensated on any of the selected VECs.OHRG plans to continue its practice of informing Aboriginal communities about the nature and timing of the skills required for site workers. Existing Aboriginal workers will be encouraged to share their working experiences within their own communities, thereby helping to overcome some of the barriers to Aboriginal participation in the wage economy. OHRG will make the workplace a welcoming environment to Aboriginal people by providing cultural sensitivity training to all members of the Project workforce.

Although no Aboriginal heritage sites or artefacts are identified with the area likely to be affected by the Project physical activities, there remains the low possibility that a heritage site or artefacts could be encountered during excavation or earth moving activities. Accordingly, a protocol will be established between OHRG the First Nations and Metis regarding actions to be taken in the event, however unlikely, a heritage sire and/or artefacts are discovered during the construction phase.

Because Aboriginal people will likely continue to occupy the land after mine closure, and because of their continued stewardship of the land, they will be included in remediation planning. This could include the selection of native plant species or specific species that are of special interest to Aboriginal people to be used during re-vegetation of those areas of the Project Site that will undergo active revegetation (e.g. roadways, the plant site proper and the TMF.

Additional consideration of benefits to the public and Aboriginal communities is detailed in Chapter 8 Social Management Planning. This plan includes the use of structured committees for two-way information sharing and the ongoing inclusion of Aboriginal and public stakeholders in the Project planning process.

Two historic mine sites were identified within the Project area. Given the available historical literature in the form of government mining reports and the presence of remains such as mine shafts, adits, dams and tramways, it is recommended that a Cultural Heritage Evaluation Report (CHER) be undertaken for the two historic mining operations to document as much detail as possible; to evaluate the cultural heritage landscapes under the Ontario Heritage Act Reg. 9/06 Criteria for Determining Cultural Heritage Value or Interest and Reg. 10/06 Criteria for Determining Cultural Heritage Value or Interest of Provincial Significance; and to recommend further mitigation if required prior to these areas being impacted by ground disturbance activities.

Mitigation for potential human health effects includes private agreements that are in place with local land users for temporary restriction of land access during the Project phases.

6.4 Residual Effects Assessment

The potential environmental effects described in the preceding sections and supported by the detailed studies in the various TSDs have been compiled into a matrix of effects for each Project phase. These are provided in Tables 6-55 through 6-57. The matrix assesses each project activity as described in Chapter 5 against the specific assessment measures as described in Chapter 2.

The effects of the predicted changes on the terrestrial and aquatic ecology, and on human health are assessed. Where effects are likely to result in adverse effects, practicable mitigation measures are identified and the residual effect described.

6.4.1 Physical and Biological Environment

Changes in physical components in and of themselves are not considered to be significant unless they result in a measurable adverse effect on biological receptors. Therefore, residual effects are considered for significance assessment only with respect to changes in ecological receptors that could affect the survival of populations.

Based on the application of this approach, an adverse environmental effect would be categorized as low, moderate or high according to the following definitions:

- **Low:** Environmental effects which, taking into account mitigation measures, would not result in measurable changes in terrestrial or aquatic species populations in the LSA or RSA. The assessment recognizes that there may be localized effects within the MSA, typically related to habitat loss and displacement of individuals, but that these would not affect the viability of terrestrial or aquatic populations in the LSA or RSA. No risks to human health would be predicted.
- **Moderate:** Environmental effects which, taking into account mitigation measures, could result in measurable changes in terrestrial or aquatic species populations that could affect the viability of the species in the LSA or RSA. Predicted risks to human health could occur under prolonged exposure.

- **High:** Environmental effects which, taking into account mitigation measures, would result in measurable changes in terrestrial or aquatic species populations that would likely severely affect the viability of the species in the LSA or RSA. Predicted risks to human health would be likely under prolonged exposure.

A summary of the assessment of the significance of the predicted environmental effects for each major project component, and for each project phase, is provided below. As noted above, residual effects are considered for significance assessment only with respect to changes in ecological receptors that could affect the survival of populations. As a result, the summary tables assess changes in physical components (e.g., surface water flows, lake levels, water quality) with respect to the effects of these changes on ecological receptors.

Table 6-55: Environmental Impacts Assessment Matrix for Construction Phase

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Site Preparation (clearing and grubbing, site levelling, etc.)	Air quality	Dust and emissions from equipment	Emissions controls are inherent in Project design. Receptors will be relocated	No predicted effects on human health or terrestrial life for most receptors Predicted risks to some human receptors close to site.	Can extend into Local Study Area	Confined to initial stages of construction phase	Continuous activity during construction	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no impacts predicted for human health or ecological receptors.
	Noise	Noise from equipment	Noise controls are inherent in Project design. Receptors will be relocated	No predicted effects on human health or terrestrial life for most receptors.	Can extend into Local Study Area	Confined to initial stages of construction phase	Continuous activity during construction	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations.	Low: no impacts predicted for human health or ecological receptors.
	Soils	Removal and stockpiling	Soil stockpiles will be protected against erosion.	Soils will be re-used at closure to promote revegetation.	Confined to Mine Study Area	Confined to initial stages of construction phase	Intermittent as sites are developed.	Partly reversible at closure	Low: Soils will be re-used	Low: localized impacts on terrestrial habit. Soils will be reused to restore habitat.
	Water Quality	Erosion and sedimentation	Construct ditching and sediment and erosion controls prior to commencing construction.	TSS will be managed through sediment and erosion controls that will be implemented prior to construction.	Can extend into Local Study Area	Confined to initial stages of construction phase	Could occur intermittently throughout construction	Immediately reversible upon cessation of activities	Low: TSS increase is not predicted in local watercourses and waterbodies	Low: no impacts predicted to surface water and aquatic life.
	Hydrology	Alteration of drainage	Habitat loss will be addressed through a fish compensation plan	Changes in drainage will affect aquatic life in some habitats.	Can extend into Local Study Area	Changes in drainage will be permanent.	Occurs once.	Changes to site drainage are not reversible	Low: Flow reductions and changes in lake levels are minor.	Low: small areas of aquatic habitat lost will be addressed through compensation.
	Groundwater	Change in recharge area	None required	Changes in groundwater contribution to surface waters will have a negligible effect on lake water levels and aquatic life.	Confined to Mine Study Area	Changes in drainage will be permanent	Occurs once	Change in infiltration areas will be permanent in most areas.	Low: Minor increases or decreases in groundwater levels are confined to small areas around infrastructure..	Low: no effects on terrestrial or aquatic life.
	Vegetation	Removal of vegetation	Merchantable timber will be harvested.	Insignificant loss of habitat within RSA. Extensive areas of similar habitat are available.	Confined to Mine Study Area	Vegetation removal will occur continuously during construction.	Continuous activity during construction.	Loss of vegetation will be reversible in most areas at closure.	Moderate: Overall loss from all development is 21% of wetland habitat and 15% of forest habitat in area of LSA	Low: loss of terrestrial habitat will displace some species.
	Terrestrial Biota	Loss of habitat	Clearing will avoid sensitive periods, such as nesting and denning. Compensation will be provided for lost bat habitat, if necessary.	Some species will be displaced but most will find alternate habitat in LSA and RSA. No effect in LSA or RSA.	Can extend into Local Study Area	Habitat loss will occur continuously during construction.	Loss of habitat will occur continuously as the site is developed.	Most habitat will be restored in closure.	Moderate: small mammals and nesting birds will be displaced	Low: loss of terrestrial habitat will displace some species. small areas of bat habitat lost in MSA will be addressed through compensation, if necessary.
	Aquatic Biota	Loss of habitat	Mitigation is not possible for most areas, and compensation will be provided for lost habitat.	Small waterbodies and watercourses will be affected in the MSA, some permanently. These comprise a small amount of the aquatic habitat within the LSA. No effects on fish populations within the LSA are expected	Can extend into Local Study Area	Loss of habitat in will occur continuously during construction.	Intermittent as sites are developed.	Some habitat will be restored in closure, but loss of habitat in other areas will be permanent.	Moderate: Some aquatic habitat in MSA will be lost permanently. Flow reductions may affect some habitats in adjacent areas of LSA.	Low: small areas of habitat lost in MSA will be addressed through compensation.

Table 6-55: Environmental Impacts Assessment Matrix for Construction Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
TMF Construction	Air Quality	Dust and emissions from equipment	Emissions controls are inherent in Project design. Receptors will be relocated.	No predicted effects on human health or terrestrial life for most receptors. Predicted risks to some human receptors close to site.	Can extend into Local Study Area	Will occur only during construction phase.	Continuous during construction of the TMF	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions.	Low: no impacts predicted for human health or ecological receptors.
	Noise	Noise from equipment	Noise controls are inherent in Project design. Receptors will be relocated	No predicted effects on human health or terrestrial life for most receptors.	Can extend into Local Study Area	Will occur only during construction phase.	Continuous during construction of the TMF	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates	Low: no impacts predicted for human health or ecological receptors.
	Soils	Removal and stockpiling	Stockpiles will be protected against erosion.	Removal is confined to the footprint of the containment berms.	Confined to Mine Study Area	Will occur only during construction phase.	Continuous during construction of the TMF	Reversible in closure as TMF is graded and soil amendment is added.	Low: Soils will be removed and stockpiled for re-use.	Low: localized impacts on terrestrial habit. Soils will be reused to restore habitat.
	Water Quality	Erosion and sedimentation	Mitigation measures will be implemented prior to commencing construction.	Ditching and erosion control measures will limit TSS in adjacent surface waters.	Can extend into Local Study Area	Will occur only during construction phase.	Intermittent during construction.	Immediately reversible upon cessation of activities	Low: TSS levels predicted to be low and within guidelines.	Low: no impacts predicted to surface water and aquatic life
	Hydrology	Alteration of drainage	Compensation plan will be developed for effects on fish and fish habitat.	Loss of drainage affects fish habitat in on-site waterbodies and in watercourses downstream. Loss of drainage has negligible affect on lake levels in Lizard Lake and Upper Marmion Reservoir.	Can extend into Local Study Area	Changes in drainage persist throughout all project phases	Continuous	Not reversible.	Low: Loss of drainage area has minimal effect on lake levels.	Low: small areas of aquatic habitat lost will be addressed through compensation.
	Groundwater	Loss of recharge area	None possible	Changes in groundwater contribution to surface waters will have a negligible effect on lake water levels and aquatic life.	Confined to Mine Study Area	Changes in infiltration persist throughout all project phases	Continuous	Not reversible.	Low: Geology and lack of soil cover limit infiltration capacity	Low: no effects on terrestrial or aquatic life are predicted.
	Vegetation	Removal of vegetation	Merchantable timber will be harvested.	Insignificant loss of habitat within RSA.	Confined to Mine Study Area	Throughout construction persisting through operations.	One time activity.	Some restoration is possible in closure.	Moderate: Overall loss from all development is 21% of wetland habitat and 15% of forest habitat in area of LSA	Low: loss of terrestrial habitat will displace some species.
	Terrestrial Biota	Loss of habitat	Clearing will avoid sensitive periods, such as nesting and denning.	Displaced species will find alternate habitat in LSA and RSA.	Can extend into Local Study Area	Throughout construction persisting through operations.	One time activity	Some restoration of habitat is possible in closure	Moderate: small mammals and nesting birds will be displaced	Low: loss of terrestrial habitat will displace some species.
	Aquatic Biota	Loss of habitat and effects on water quality and quantity	Effects of habitat loss cannot be mitigated. A compensation plan will be developed to address habitat loss.	Some aquatic features are lost entirely. Others will experience changes to natural hydrographs that can limit available habitat. Negligible effect on lake water levels with no affect on lake dwelling aquatic species. No effects on fish populations within the LSA are expected Sediment and erosion controls will minimize impacts of TSS on aquatic life in downstream habitats.	Loss of habitat confined to Mine Study Area. Water quality and quantity effects can extend into Local Study Area	Loss of habitat extends through all project phases. Water quality effects are confined to construction and operations phases.	One time activity for habitat loss. Intermittent for water quality depending on climatic conditions.	Habitat loss in some areas is not reversible.Water quality effects are reversible at closure	Moderate to High: Partial to complete loss of habitats in local waterbodies in MSA. Loss of drainage areas may affect some habitats in adjacent areas of LSA. No changes predicted in Upper Marmion Reservoir.	Low: compensation plan will address loss of small habitat areas affected. No effects on aquatic life due to water quality.

Table 6-55: Environmental Impacts Assessment Matrix for Construction Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Infrastructure Construction	Air Quality	Dust and emissions from equipment	Emissions controls are inherent in Project design. Receptors will be relocated.	No predicted effects on human health or terrestrial life for most receptors. Predicted risks to some human receptors close to site.	Can extend into Local Study Area	Will occur only during construction phase.	Continuous during construction.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no impacts predicted for human health or ecological receptors.
	Noise	Noise from equipment	Noise controls are inherent in Project design. Receptors will be relocated	No predicted effects on human health or terrestrial life for most receptors.	Can extend into Local Study Area	Will occur only during construction phase.	Continuous during construction.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no impacts predicted for human health or ecological receptors.
	Soils	Removal and stockpiling	Soils will be stockpiled for later re-use. Stockpiled will be protected against erosion.	Removal is confined to the footprint of the infrastructure.	Confined to Mine Study Area	Will occur only during construction phase.	Continuous during construction of the infrastructure	Reversible in closure in some areas as site is decommissioned.	Low: Soils will be removed and stockpiled for re-use.	Low: localized impacts on terrestrial habit. Soils will be reused to restore habitat.
	Water Quality	Erosion and sedimentation	Mitigation measures will be implemented prior to commencing construction.	Ditching and erosion control measures will limit TSS in adjacent surface waters.	Can extend into Local Study Area	Will occur only during construction phase.	Intermittent during construction.	Immediately reversible upon cessation of activities	Low: TSS levels predicted to be low.	Low: no impacts predicted to surface water and aquatic life
	Groundwater	Alteration of infiltration	None possible	Changes in groundwater contribution to surface waters will have a negligible effect on lake water levels and aquatic life.	Confined to Mine Study Area	Changes in infiltration persist throughout all project phases	Continuous	Not reversible in most areas. Decommissioning will restore natural infiltration in some areas.	Low: Geology and lack of soil cover limit infiltration capacity	Low: loss of infiltration will not affect terrestrial or aquatic life.
	Hydrology	Alteration of drainage	Effects cannot be mitigated. to address habitat loss. A compensation plan will be developed	Some habitats are lost entirely. Others will experience water levels reductions that can limit available habitat.	Can extend into Local Study Area	Changes in drainage persist until closure.	Occurs once only.	Decommissioning in closure will restore natural drainage in most areas.	Low: Drainage changes have minor effect on lake levels.	Low: small areas of aquatic habitat lost will be addressed through compensation.
	Vegetation	Removal of vegetation	Merchantable timber will be harvested.	Insignificant loss of habitat within LSA and RSA.	Confined to Mine Study Area	Throughout construction persisting through operations.	One time activity.	Some restoration is possible in closure.	Moderate: Overall loss from all development is 21% of wetland habitat and 15% of forest habitat in area of LSA	Low: loss of vegetation will displace some species.
	Terrestrial Biota	Loss of habitat	Clearing will avoid sensitive periods, such as nesting and denning. Temporary bat habitat replacement.	Displaced species will find alternate habitat in LSA and RSA.	Can extend into Local Study Area	Throughout construction persisting through operations.	One time activity	Some restoration of habitat is possible in closure	Moderate: small mammals and nesting birds will be displaced	Low: loss of habitat will displace some species. small areas of bat habitat lost in MSA will be addressed through compensation, if necessary.
	Aquatic Biota	Loss of habitat and effects on water quality and quantity. ; Blast Vibration.	Effects of habitat loss cannot be mitigated. A compensation plan will be developed to address habitat loss. Sediment and erosion controls are included in Project design.	Some aquatic features are lost entirely. Others will experience changes to natural hydrographs that can limit available habitat. Negligible effect on lake water levels will not affect on lake dwelling aquatic species. No effects on fish populations within the LSA are expected Sediment and erosion controls will minimize impacts of TSS on aquatic life in downstream habitats. Distance from shoreline will limit effects of blasting.	Can extend into Local Study Area	Loss of habitat extends through all project phases.	Throughout construction phase	Not reversible.	Moderate to High: Partial to complete loss of habitats in lsome MSA waterbodies. No predicted effects on aquatic habitats or aquatic life in LSA.	Low: compensation plan will address loss of small areas of habitat affected. No effects on aquatic life due to water quality. No predicted effects on habitat in the LSA.

Table 6-55: Environmental Impacts Assessment Matrix for Construction Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Site Access Roads	Air quality	Dust and emissions from equipment	Dust suppression as required	No predicted effects on human health or terrestrial life.	Can extend into Local Study Area	Will occur only during construction phase.	Continuous during construction.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no predicted effects on human health or ecological receptors
	Noise	Noise from equipment	None required	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Can extend into Local Study Area	Will occur only during construction phase.	Continuous during construction.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effects on human health or ecological receptors.
	Soils	Removal and stockpiling	Soil stockpiles will be protected against erosion	Soils will be stockpiled for reclamation in closure. Stockpile will be protected against erosion to protect aquatic habitats.	Confined to Mine Study Area	Will occur only during construction phase.	Continuous during construction of roads.	Partly reversible in closure		Low: localized impacts on terrestrial habitat. Soils will be reused to restore habitat.
	Water Quality	Erosion and sedimentation	Road design will have ditching and sediment controls.	Sediment controls will be implemented to minimize TSS generated during construction. Short construction period minimizes potential impacts on aquatic life.	Can extend into Local Study Area	Will occur only during construction phase.	Continuous during construction of roads.	Immediately reversible upon cessation of activities	Low: short term increase in TSS as crossing is constructed	Low: no impacts predicted to surface water or aquatic life.
	Hydrology	Alteration of drainage	Flow will be maintained during construction	Road will not alter drainage system since channels will not be altered or blocked.	Can extend into Local Study Area	Throughout construction and operations phases.	Continuous	Fully reversible	Low: Minor restriction of flow during construction..	Low: temporary construction works will have minimal effect on aquatic life.
	Groundwater	Loss of recharge area	None required	Road surface will divert runoff to margins where infiltration can occur.	Confined to Mine Study Area	Throughout construction and operations phases.	Continuous	Partly reversible in closure	Low: small areas affected.	Low: changes in groundwater levels will not affect terrestrial or aquatic habitats.
	Vegetation	Removal of vegetation	Merchantable timber will be harvested.	Insignificant loss of habitat within RSA.	Confined to Mine Study Area	Throughout construction and operations phases.	Removal occurs once only as road is constructed.	Partly reversible in closure as some road are decommissioned	Moderate: Overall loss from all development is 21% of wetland habitat and 15% of forest habitat in area of LSA	Low: loss of habitat in small areas may displace some species
	Terrestrial Biota	Loss of habitat and disturbance of wildlife	Clearing will avoid sensitive periods, such as nesting and denning.	Displaced species will find alternate habitat in LSA and RSA.	Can extend into Local Study Area	Continuous through construction and operations.	Loss of habitat occurs once only. Disturbance of wildlife is continuous.	Partly reversible in closure	Moderate: small mammals and nesting birds will be displaced	Low: loss of habitat in small areas and disturbance will displace some species.
	Aquatic Biota	Disturbance during construction of stream crossings	Flows will be maintained during construction. Sedimentation will be minimized by constructing during low flow conditions.	Crossing construction will be timed to occur in low flow conditions and to avoid critical periods to minimize impacts on aquatic life.	Can extend into Local Study Area	Short term disturbance, limited to a few days at each crossing.	Once only at each crossing..	Immediately reversible upon completion of construction.	Low: small areas and short term disturbance.	Low: disturbance will be temporary and confined to non-critical periods for aquatic life.

Table 6-55: Environmental Impacts Assessment Matrix for Construction Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Main Access Road	Air Quality	Dust and emissions from equipment	Dust suppression as required	No predicted effects on human health or terrestrial life.	Confined to Linear Infrastructure Study Area	Will occur only during construction phase.	Continuous during construction.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no predicted effects on human health or ecological receptors.
	Noise	Noise from equipment	None required	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Confined to Linear Infrastructure Study Area	Will occur only during construction phase.	Continuous during construction.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effects on human health or ecological receptors.
	Soils	Removal and stockpiling	Stockpiles will be protected against erosion.	Soils will be stockpiled for mine site reclamation in closure. Stockpile will be protected against erosion to protect aquatic habitats.	Confined to Linear Infrastructure Study Area	Will occur only in construction phase	Continuous during construction.	Partly reversible in closure	Low: soils will be re-used where practicable.	Low: localized impacts on terrestrial habit. Soils will be reused to restore habitat.
	Water Quality	Erosion and sedimentation	Design includes ditching and sediment traps that will minimize runoff to local streams.	Sediment controls will be implemented to minimize TSS generated during construction. Short construction period minimizes potential impacts on aquatic life.	Confined to Linear Infrastructure Study Area	Will occur only during construction phase.	Continuous during construction of roads.	Immediately reversible upon cessation of activities	Low: short term increase in TSS as crossing is constructed	Low: no impacts predicted to surface water or aquatic life.
	Hydrology	Alteration of drainage	Flow will be maintained during construction	Road will not alter drainage system since channels will not be altered or blocked.	Confined to Linear Infrastructure Study Area	Throughout construction and operations phases.	Continuous	Fully reversible	Low: Road will not alter drainage patterns.	Low: temporary construction works will have minimal effect on aquatic life.
	Groundwater	Loss of recharge area	None required	Road surface will divert runoff to margins where infiltration can occur.	Confined to Linear Infrastructure Study Area	Throughout construction and operations phases.	Continuous	Not reversible since road will not be decommissioned	Low: small areas affected.	Low: changes in groundwater level will nto affect terrestrial or aquatic life.
	Vegetation	Removal of vegetation	Merchantable timber will be harvested.	Insignificant loss of habitat within RSA.	Confined to Linear Infrastructure Study Area	Throughout construction and operations phases.	Removal occurs once only as road is constructed.	Not reversible since road will not be decommissioned	Low: loss of habitat is restricted ot margins of road	Low: loss of habitat in small areas will displace some species.
	Terrestrial Biota	Loss of habitat	Clearing will avoid sensitive periods, such as nesting and denning.	Displaced species will find alternate habitat in LSA and RSA. No predicted effects in LSA or RSA	Confined to Linear Infrastructure Study Area	Throughout construction and operations phases.	Removal occurs once only as road is constructed.	Not reversible since road will not be decommissioned	Moderate: small mammals and nesting birds will be displaced	Low: loss of habitat may displace some species.
	Aquatic Biota	Disturbance and sedimentation during construction of stream crossings	Flows will be maintained during construction. Sedimentation will be minimized by constructing during low flow conditions.	Crossing construction will be timed to occur in low flow conditions and to avoid critical periods to minimize impacts on aquatic life. Fish passage will be maintained.	Confined to Linear Infrastructure Study Area	Short term disturbance, limited to a few days at each crossing.	Once only at each crossing..	Immediately reversible upon completion of construction.	Low: small areas and short term disturbance.	Low: disturbance will be temporary and confined to non-critical periods for aquatic life.

Table 6-55: Environmental Impacts Assessment Matrix for Construction Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Drainage of Mitta Lake	Air Quality	Emissions from pumping and excavating equipment	None required	No predicted effects on human health or terrestrial life. Emissions are considered within bounding estimates.	Confined to Mine Study Area	Will occur only during construction phase.	Continuous during draining operation.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no effects on human health or terrestrial receptors.
	Noise	Noise from equipment	None required	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Confined to Mine Study Area	Will occur only during construction phase.	Continuous during draining operation.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no effects on human health or terrestrial receptors.
	Soils	No soils present			Not applicable					
	Water Quality	Changes in water quality in Upper Marmion Reservoir	Water from final stages of pumping will need to be held on–site prior to release to allow for settling of entrained sediment.	No impact predicted on aquatic life since water quality is similar to Upper Marmion Lake.	Can extend into Local Study Area	Confined to pumping period	One time occurrence	Reversible upon cessation of pumping	Low: Water quality in Mitta Lake is similar to background levels in Upper Marmion Reservoir.	Low: no predicted effects on surface water and aquatic life.
	Groundwater	Alteration of groundwater flows	None possible	Alteration of groundwater flow to Upper Marmion Reservoir will have a negligible effect on aquatic habitats.	Can extend into Local Study Area	Extends throughout all project phases.	Occurs continuously once lake is pumped out	Not reversible	Low: groundwater flow to Mitta Lake is minor.	Low: no predicted effect on terrestrial or aquatic life.
	Hydrology	Alteration of drainage to Upper Marmion Reservoir	None possible	Mitta Lake contributes minor flow to Upper Marmion Reservoir. No effect predicted on aquatic habitats in Upper Marmion Lake.	Can extend into Local Study Area	Extends throughout all project phases.	One time occurrence	Not reversible	Low: Loss of outflow to Upper Marmion Reservoir has minor effect on lake levels.	Low: negligible effect on aquatic habitats in Upper Marion Reservoir.
	Vegetation	Loss of vegetation	Merchantable timber will be harvested.	Insignificant loss of habitat within RSA.	Confined to Mine Study Area	Extends throughout all project phases.	One time occurrence	Not reversible	Moderate: Overall loss from all development is 21% of wetland habitat and 15% of forest habitat in area of LSA	Low: loss of habitat will displace some species to LSA and RSA
	Terrestrial Biota	Loss of habitat in staging areas	Clearing will avoid sensitive periods, such as nesting and denning.	Displaced species will find alternate habitat in LSA and RSA. No predicted effects in LSA or RSA.	Confined to Mine Study Area	Confined to construction phase.	One time occurrence	Not reversible	Moderate: small mammals and nesting birds will be displaced	Low: loss of habitat will displace some species to LSA and RSA.
	Aquatic Biota	Loss of habitat	No mitigation possible. Loss will be compensated for in compensation plan.	Complete loss of lake habitat.	Confined to Mine Study Area	Extends throughout all project phases.	One time occurrence	Not reversible	High: All habitat will be removed.	Low: compensation will be provided for loss of habitat.

Table 6-56: Environmental Impacts Assessment Matrix for Operations Phase

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Development of Open Pits	Air Quality	Dust and emissions from blasting and equipment	Emissions controls are inherent in Project design. Receptors will be relocated.	No predicted effects on human health or terrestrial life for most receptors. Predicted risks to some human receptors close to site.	Can extend into Local Study Area	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no impacts predicted for human health or ecological receptors.
	Noise	Noise from blasting and equipment	Noise controls are inherent in Project design. Receptors will be relocated	No predicted effects on human health or terrestrial life for most receptors.	Can extend into Local Study Area	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Effects are considered within bounding estimates and meet provincial regulations	Low: no impacts predicted for human health or ecological receptors.
	Soils	Soil removal and stockpiling	Soils will be stockpiled for later re-use. Stockpiled will be protected against erosion.	Removal is confined to the footprint of the pits.	Confined to Mine Study Area	Progressive soil removal will occur as pits are developed during operations phase.	Intermittent as pits are expanded	Not reversible.	Soils will be removed and stockpiled for re-use.	Low: loss of habitat will displace some species.
	Water Quality	Pumping of water from the pits.	Re-use of water and treatment of excess water prior to discharge will mitigate any adverse effects on aquatic life in receiving waterbodies.	Water will be re-used in processing plant or treated prior to discharge. No effects predicted on lake water quality or aquatic life.	Can extend into Local Study Area	Will occur throughout operations phase.	Continuous during operations	Reversible at end of mine operations.	Any water discharged to surface waters will meet guidelines or background levels.	Low: no predicted effects on surface water and aquatic life.
	Hydrology	Alteration of drainage to Upper Marmion Reservoir	None possible	Loss of drainage areas has minor impact on lake water levels and aquatic life.	Can extend into Local Study Area	Occurs progressively as pits are developed during operations phase.	Intermittent as pits are expanded.	Mainly not reversible, but some drainage will be restored in post-closure when pits overflow.	Water course in pit footprints contribute minor flows to adjacent waterbodies.	Low: no predicted effect on lake levels and aquatic life.
	Groundwater	Effect on local groundwater levels from seepage into pit	None possible	Inflow to pits is not predicted to affect water levels in adjacent waterbodies or aquatic life.	Can extend into Local Study Area	Throughout all project phases	Continuous	Some reduction in inflow to pits in post-closure as pits fill	Groundwater flow to pits is predicted to be low.	Low: no predicted effect on terrestrial or aquatic habitats.
	Vegetation	Removal of vegetation	Merchantable timber will be harvested.	Insignificant loss of habitat within LSA and RSA.	Confined to Mine Study Area.	Throughout operation and into post-closure	Progressively during closure as pits are expanded.	Not reversible	Overall loss from all development is 21% of wetland habitat and 15% of forest habitat in area of LSA	Low: loss of habitat in pit areas will displace some species.
	Terrestrial Biota	Loss of habitat	Clearing will avoid sensitive periods, such as nesting and denning.	Displaced species will find alternate habitat in LSA and RSA.	Confined to Mine Study Area.	Throughout operation and into post-closure	Progressively during closure as pits are expanded.	Not reversible	Small mammals and nesting birds will be displaced	Low: loss of habitat will displace some species.
	Aquatic Biota	Vibrations from blasting.	Blast intensities may need to be modified at locations close to sensitive habitats in Upper Marmion Reservoir, depenmding on transmissivity and habitat studies.	Blasting will be monitored during initial stages of pit development to understand vibration transmissivity on a site-specific basis. Habitat assessment will be undertaken to assess sensitive habiats and critical use periods.	Can extend to Local Study Area	In later stages of pit development	Intermittent	Immediately reversible	To be determined through testing during initial stages of pit development.	Residual impacts will be managed to result in low impacts.

Table 6-56: Environmental Impacts Assessment Matrix for Operations Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Operation of Processing Plant	Air Quality	Dust and emissions	Emissions controls are inherent in Project design. Receptors will be relocated.	No predicted effects on human health or terrestrial life for most receptors. Predicted risks to some human receptors close to site.	Can extend into Local Study Area	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no impacts predicted for human health or ecological receptors.
	Noise	Noise	Noise controls are inherent in Project design. Receptors will be relocated	No predicted effects on human health or terrestrial life for most receptors.	Can extend into Local Study Area	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no impacts predicted for human health or ecological receptors.
	Soils	No additional impacts to soils.								
	Water Quality	Effects on surface water quality	None required. Re-use of water and treatment prior to release are inherent in the project design.	Water will be treated as required prior to discharge. No effects predicted on aquatic life.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations	Reversible at closure	Low: discharged water will meet guidelines and/or background water quality.	Low: no predicted effects on surface water or aquatic life.
	Hydrology	Effects on lake water levels from water taking	None required. Re-use of water is inherent in project design.	Water taking will be minimized by re-use of water. Lake levels predicted to change by less than 9 cm. No effects predicted on aquatic life.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations	Reversible at closure	Low: minor effect on lake levels	Low: no predicted effects on aquatic habitats
	Groundwater	Changes in groundwater quantity and quality	None required	Groundwater quality and quantity are not predicted to change.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations	Reversible at closure	Low: negligible change in groundwater levels predicted.	Low: no predicted effect.
	Vegetation	Effects of emissions on vegetation	None required	No incremental increase in soil concentrations due to emissions. No predicted increase in uptake in vegetation or effects on vegetation.	Confined to Mine Study Area.	Throughout operations phase	Continuous during operations	Reversible at closure	Low: predicted soil concentrations are below guidelines and background levels.	Low: no predicted risk to vegetation.
	Terrestrial Biota	Effects of emissions on wildlife	None required	On incremental increase in soil concentrations and no predicted increase in vegetation. No incremental increased risk to wildlife form soil or vegetation ingestion.	Confined to Mine Study Area.	Throughout operations phase	Continuous during operations	Reversible at closure	Low: predicted soil concentrations are below guidelines and background levels.	Low: no predicted risks to terrestrial biota.
	Aquatic Biota	Discharges to aquatic habitats	A treatment facility has been included in the project design.	No effects predicted on aquatic life form any discharges.	Can extend into Local Study Area	Throughout operations phase	Intermittent depending on need for re-use water	Reversible at closure	Low: discharge water will meet guidelines or background	Low: no predicted risks to aquatic life.

Table 6-56: Environmental Impacts Assessment Matrix for Operations Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Operation of TMF	Air Quality	No air emissions since tailings will be wet.								
	Noise	Noise	None required	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Confined to Mine Study Area.	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted risks to human health or ecological receptors.
	Soils	Loss of soils	None feasible	Soils in TMF footprint will be covered over permanently. Soils will not be salvaged under the TMF.	Confined to Mine Study Area	Progressive covering of soils throughout operations.	Continuous during operations	Not reversible. Soils will be covered over permanently.	Low: area of loss is relatively small within the RSA.	Low:
	Water Quality	Effects on surface water quality	Design includes seepage collection and reclaim pipeline from TMF to PPCP to eliminate direct release of TMF water to the environment..	Collection of seepage and re-use of tailings water will eliminate discharge of water from the TMF to receiving environments. No effects predicted on aquatic or terrestrial life.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations	Reversible in post-closure	Low: water quality guidelines/background levels in receiving water will not be exceeded	Low: no effects predicted on surface water or aquatic life.
	Groundwater	Effects on groundwater quality	None require. Low ARD potential in tailings minimizes metals leaching and mobility.	Water quality in TMF seepage is not predicted to result in risks to aquatic life where groundwater expresses to surface waters	Confined to Mine Study Area	Throughout operations and into post-closure	Continuous	Not reversible	Low: water quality in TMF seepage not predicted to affect groundwater quality	Low: no predicted effects on terrestrial or aquatic life.
	Hydrology	No additional effects on drainage over construction phase								
	Vegetation	Loss of vegetation	Merchantable timber will be harvested.	Moderate loss within LSA but insignificant loss of habitat within RSA.	Confined to Mine Study Area	Progressive loss of vegetation in operations phase as TMF is filled	Continuous during operations phase.	Not reversible. Terrestrial habitat in footprint will be permanently lost.	Moderate: Overall loss from all development is 21% of wetland habitat and 15% of forest habitat in area of LSA	Low: habitat loss will displace some terrestrial wildlife species.
	Terrestrial Biota	Loss of habitat	Clearing will avoid sensitive periods, such as nesting and denning.	Displaced species will find alternate habitat in LSA and RSA. Low effect in RSA.	Can extend into Local Study Area	Progressive loss of habitat in operations phase as TMF is filled.	Continuous during operations phase.	Not reversible. Habitat loss in footprint of TMF is permanent.	Moderate: small mammals and nesting birds will be displaced	Low: habitat loss will displace some species.
	Aquatic Biota	Effects on surface water quality	Design includes seepage collection and reclaim pipeline from TMF to PPCP to eliminate direct release of TMF water to the environment..	Collection of seepage and re-use of tailings water will eliminate discharge of water from the TMF to receiving environments. No effects predicted on aquatic or terrestrial life.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations.		Low: water quality guidelines/background levels will not be exceeded in receiving waters.	Low: no effects predicted on aquatic life.

Table 6-56: Environmental Impacts Assessment Matrix for Operations Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Waste Rock and Ore Stockpiles	Air Quality	Dust	Emissions controls are inherent in Project design. Receptors will be relocated.	No predicted effects on human health or terrestrial life.	Can extend into Local Study Area	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no impacts predicted for human health or ecological receptors.
	Noise	Noise	Noise controls are inherent in Project design. Receptors will be relocated	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Can extend into Local Study Area	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no impacts predicted for human health or ecological receptors.
	Soils	Loss of soils	None	Soils in waste rock stockpile will be covered over permanently. Soils will not be salvaged under either the waste rock or the ore stockpiles.	Confined to Mine Study Area.	Progressive covering of soils throughout operations.	Continuous during operations	Not reversible in waste rock disposal facility	Low: area of loss is relatively small within the RSA.	Low
	Water Quality	Effects on surface water quality	None required. Project design includes ditching and holding ponds for stormwater management. Water will be treated as required prior to discharge	Runoff and seepage will be collected by ditching and routed to the PPCP for re-use or treatment prior to discharge. No effects predicted on aquatic life.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations	Reversible at closure	Low: water quality guidelines/background levels in receiving water will not be exceeded	Low: no predicted effects on aquatic life.
	Hydrology	Loss of drainage area	Drainage to Upper Marmion Reservoir will be restored in closure	The small drainage area affected will not affect water levels in adjacent waterbodies. No effects predicted on aquatic life.	Can extend into Local Study Area	Throughout operations and into closure.	Continuous during operations phase.	Not reversible	Low: small drainage area affected	Low: no predicted effects on aquatic life.
	Groundwater	Effects on recharge	None	Changes in infiltration are not predicted to result in changes in lake levels and effects on aquatic life. Water quality is not predicted to result in risks to aquatic life where groundwater expresses to surface waters	Confined to Mine Study Area.	Throughout operations and into post-closure	Continuous.	Not reversible	Low: permeability of subsurface is low.	Low: no predicted effects on aquatic life.
	Vegetation	Loss of vegetation	Merchantable timber will be harvested.	Insignificant loss of habitat within RSA.	Confined to Mine Study Area.	Progressive loss of vegetation throughout operations.	Continuous during operations.	Not reversible.	Moderate: Overall loss from all development is 21% of wetland habitat and 15% of forest habitat in area of LSA	Low: some species will be displaced.
	Terrestrial Biota	Loss of habitat	Clearing will avoid sensitive periods, such as nesting and denning.	Displaced species will find alternate habitat in LSA and RSA.	Can extend into Local Study Area	Progressive loss of habitat during operations.	Continuous during operations	Not reversible	Moderate: small mammals and nesting birds will be displaced	Low: some species will be displaced during operations.
	Aquatic Biota	Loss of habitat and water quality.	Mitigation for habitat loss is not possible. Loss will be addressed in compensation plan.	Small areas of aquatic habitat will be eliminated. Water will be directed to the PPCP and will be treated as required prior to discharge. No effects predicted on aquatic life.	Confined to Mine Study Area.	Progressive loss of habitat during operations.	Continuous during operations	Not reversible	Moderate: Some aquatic habitats will be eliminated.	Low: habitat loss will be compensated. No predicted effects from water quality.

Table 6-56: Environmental Impacts Assessment Matrix for Operations Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Operation of Site Water Management System	Air Quality	No predicted emissions from WTF								
	Noise		None required	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Confined to Mine Study Area.	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effects on human health.
	Soils	No additional effects on soils								
	Water Quality	Effects on surface water quality	None required. Treatment of discharge is inherent in the Project design.	Discharge will not affect aquatic life. No risks to wildlife from exposure to water in TMF reclaim pond.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations	Reversible in closure	Low: Discharges will meet guidelines and/or baseline conditions.	Low: no predicted effects on aquatic life.
	Hydrology	Water taking and discharge	None required. Project has been designed to minimize taking of freshwater from surface waters by re-use of water wherever possible.	Water taking will be modified by discharge. Net change will result in minor change in lake level. Change will not adversely affect aquatic life.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations	Reversible in closure	Low: Minor decrease in lake levels	Low: no predicted effects on aquatic life.
	Groundwater	Effects on water quality	None required. Project design includes partial lining of the PPCP to limit infiltration and collect seepage from the TMF reclaim pond	Part of PPCP will be lined to minimize seepage to groundwater and migration to surface waters. No impacts predicted on aquatic life Water quality is not predicted to result in risks to aquatic life where groundwater expresses to surface waters	Mine Study Area	Throughout operation phase	Continuous during operations	Reversible at closure	Low: design minimizes seepage to groundwater	Low: no predicted effects on terrestrial or aquatic life.
	Vegetation	No additional effects on vegetation								
	Terrestrial Biota	Wildlife exposure to site water impoundments	None required. Measures may be required to keep wildlife away from PPCP if future monitoring shows wildlife are accessing the ponds.	Wildlife exposure to water in the TMF reclaim ponds do not result in predictions of risk. Wildlife exposure to water in the PPCP is not expected due to proximity to processing plant. Noise and activity will discourage wildlife in this area.	Mine Study Area	Throughout operations phase	Continuous	Reversible in closure	Low: concentrations in TMF reclaim pond are below effects levels.	Low: no predicted effects on terrestrial biota.
	Aquatic Biota	Effects on surface water quality and quantity	None required. Treatment of discharge is inherent in the Project design.	Small change in lake levels would not affect aquatic life. Discharge water will meet guidelines and/or baseline conditions in receiving waterbodies. No effects predicted on aquatic life. No increase in fish tissue residues predicted.	Can extend into Local Study Area	Throughout operations phase	Continuous during operations	Reversible in closure	Low: Minor change in lake levels. Discharges will meet guidelines and/or baseline.	Low: no predicted effects on aquatic life.

Table 6-56: Environmental Impacts Assessment Matrix for Operations Phase (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Accommoda-tions Camp	Air Quality	Emissions	None required	No predicted effects on human health or terrestrial life.	Confined to Mine Study Area.	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no predicted effect on human health or ecological receptors.
	Noise	Noise	None required	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Confined to Mine Study Area.	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effect on human health or ecological receptors.
	Soils	No additional impacts on soils over those noted for construction phase.								
	Water Quality	Domestic wastewater	Treatment facility is inherent in the Project design	No effect on aquatic life is predicted	Can extend into Local Study Area	Throughout operations phase	Continuous	Reversible at closure	Low: discharges will meet regulations	Low: no predicted effects on surface water or aquatic life.
	Groundwater	No additional impacts on groundwater. Potable water will be sourced from surface water.								
	Hydrology	Water taking	None required	Minor change in lake levels not predicted to affect aquatic life	Can extend into Local Study Area	Throughout operations phase	Continuous	Reversible at closure	Low: effect on lake levels is included in bounding scenario.	Low: no predicted effects on aquatic life.
	Vegetation	No additional impacts on vegetation. Impacts on vegetation occurred during construction.								
	Terrestrial Biota	Disturbance and hunting pressure	Restrictions on hunting by camp personnel will be implemented	Hunting could affect local populations of some species, and affect Aboriginal use of these resources.	Regional Study Area	Throughout operations phase	Occasional	Fully reversible at closure	Moderate: could affect local populations of some species.	Low: effects on wildlife will be regulated.
	Aquatic Biota	Fishing pressure	Restrictions on fishing by camp personnel will be implemented.	Fishing in local waterbodies could deplete stocks of some species, with potential socio-economic impacts as well.	Local Study Area	Throughout operations phase	Occasional	Fully reversible at closure	Moderate to High: could affect local populations of some species.	Low: effects on fish population will be regulated.
Access Road (Hardtack-Sawbill)	Air Quality	Dust and emissions	Dust supprsion as required	No predicted effects on human health or terrestrial life.	Confined to Linear Study Area.	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no predicted effects on human health or ecological receptors.
	Noise	Noise	None required	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Confined to Linear Study Area.	Will occur throughout operations phase.	Continuous during operations.	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effects on human health or ecological receptors.
	Soils	No additional impacts on soils. Soils removal will occur in construction phase.								
	Water Quality	Road runoff	Regular maintenance of sediment control measures along road.	Road maintenance will include maintenance of sediment and erosion controls (e.g., sedimentation ponds). TSS concentrations are not expected to affect aquatic life.	Confined to Linear Study Area.	Throughout operations phase	Intermittent depending on precipitation events	Not reversible since road will remain after closure	Low: TSS concentrations are predicted to be low.	Low: no predicted effect on aquatic life.
	Groundwater	No additional impact above those noted for construction phase.								
	Hydrology	No flow alterations or obstruction will occur during operations								
	Vegetation	Brush clearing along ROW	Merchantable timber will be harvested.	Insignificant loss of habitat within RSA.	Confined to Linear Study Area.	Throughout operations phase	Intermittent: removal will be seasonal	Not reversible since road will remain after closure	Low: Habitat loss is confined to margins of road.	Low: some species may be displaced.
	Terrestrial Biota	Brush clearing along ROW. Wildlife-vehicle collisions	Clearing will avoid sensitive periods, such as nesting and denning.	Displaced species will find alternate habitat in LSA and RSA.	Confined to Linear Study Area.	Throughout operations phase	Intermittent: removal will be seasonal	Not reversible since road will remain after closure	Low: Habitat loss is confined to margins of road.	Low: some species may be displaced.
	Aquatic Biota	Road drainage effects on water quality	Regular maintenance of sediment control measures along road.	Road maintenance will include maintenance of sediment and erosion controls (e.g., sedimentation ponds). TSS concentrations are not expected to affect aquatic life.	Confined to Linear Study Area.	Throughout operations phase	Intermittent depending on precipitation events	Not reversible since road will remain after closure	Low: TSS concentrations are predicted to be low.	Low: no predicted effects on water quality or aquatic life.

Table 6-57: Environmental Impacts Assessment Matrix for Closure and Post-Closure Phases

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Site Decommissioning	Air Quality	Dust and emissions from equipment	None required	No predicted effects on human health or terrestrial life.	Can extend into Local Study Area	Confined to closure phase	Continuous during closure	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no predicted effects on human health or ecological receptors
	Noise	Noise from equipment.	None required	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Can extend into Local Study Area	Confined to closure phase	Continuous during closure	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effects on human health or ecological receptors.
	Soils	Restoration of disturbed areas	None	Some disturbed areas can be restored.	Confined to Mine Study Area	Confined to closure phase	Intermittent as areas are decommissioned	Reversibility is not desirable.	Low positive: restoration of some disturbed areas.	Low: habitat resporation wil permit return of some species.
	Water Quality	Erosion and sedimentation.	None	Erosion and sediment controls will be in place during closure. In post-closure revegetation of site will minimize TSS in runoff.	Can extend into Local Study Area	Confined to closure phase	Intermittent depending on precipitation events.	Reversible upon cessation of events.	Low: TSS increase is expected to be low and within guidelines.	Low: no predicted effect on water quality or aquatic life.
	Hydrology	Alteration of drainage	None	Natural drainage in some disturbed areas can be restored during closure. Minimizes lake level changes in post-closure due to the project, minimizing impacts on aquatic life.	Can extend into Local Study Area	Confined to closure phase	One time occurrence	Reversibility is not desirable	Low positive: natural drainage will be restored where feasible.	Low positive: minor changes in lake levels will be reversed as drainage is restored.
	Groundwater	Alteration of infiltration	None	Restoration of groundwater infiltration will assist in restoring some habitats such as wetlands. Water quality is not predicted to result in risks to aquatic life where groundwater expresses to surface waters	Confined to Mine Study Area	Confined to closure phase	One time occurrence	Not reversible	Low: groundwater infiltration will be restored in some areas.	Low positive: localized effects on habitats will be reversed in some areas.
	Vegetation	Effects of site restoration on vegetation	None	Restoration of small areas of habitat lost during construction an operations will promote return of wildlife.	Confined to Mine Study Area	Confined to closure phase	Intermittent as areas are decommissioned and restored	Reversibility is not desirable	Low positive: Moderate gain in vegetated areas lost.	Low positive: wildlife habitat will be progressively restored.
	Terrestrial Biota	Effects of site restoration on habitat	None	Restoration of small areas of habitat lost during construction and operations will promote return of wildlife.	Can extend into Local Study Area	Confined to closure phase	Intermittent as areas are decommissioned and restored	Reversibility is not desirable	Low positive: Moderate gain in habitat lost.	Low positive: wildlife habitat will be progressively restored.
	Aquatic Biota	Effects of site restoration on aquatic life	None	Sediment and erosion controls will be in place until end of closure. Re-vegetation will minimize sediment erosion in post-closure, minimizing effects on aquatic life.	Can extend into Local Study Area	Confined to closure phase	Intermittent depending on precipitation events.	Reversible at end of closure	Low: site runoff will be controlled to minimize TSS.	Low: no predicted effects on aquatic life.

Table 6-57: Environmental Impacts Assessment Matrix for Closure and Post-Closure Phases (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Closure of TMF	Air Quality	Dust and emissions from equipment	None	No predicted effects on human health or terrestrial life.	Can extend into Local Study Area	Confined to closure phase	Continuous during closure	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low;: no predicted effects on human health or ecological receptors
	Noise	Noise from equipment	None	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Can extend into Local Study Area	Confined to closure phase	Continuous during closure	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effects on human health or ecological receptors.
	Soils	No additional impacts on soils								
	Water Quality	Effects on water quality	TMF will be sculpted to promote runoff and minimize infiltration. Soil amendment will promote vegetation growth minimizing TSS in runoff to local waterbodies. Excess water will be diverted to open pit until water quality is acceptable for aquatic life.	Seepage from TMF in post-closure is not predicted to affect aquatic life. Runoff will be released to local waterbodies when quality is acceptable for aquatic life.	Can extend into Local Study Area	Confined to closure phase	Continuous during closure	Reversible at end of closure	Low: Discharges will meet guidelines/background levels.	Low: no predicted effects on surface waters or terrestrial or aquatic life.
	Hydrology	Alteration of drainage	Drainage will be routed to Sawbill Bay when water quality is acceptable.	Drainage from the TMF will be routed to surface waters, reducing effects of construction and operation on lake levels.	Can extend into Local Study Area	Extends into post-closure	Continuous	Not reversible	Low: drainage from TMF in post-closure will be routed to surface waters.	Low: restoration of drainage will restore lake levels minimizing effects on aquatic life.
	Groundwater	Effects on groundwater quality and quantity	None	Sculpting of TMF will reduce infiltration, reducing groundwater levels under the TMF. Reducing seepage of TMF water to local aquifer will minimize effects of TMF seepage on groundwater quality. Water quality is not predicted to result in risks to aquatic life where groundwater expresses to surface waters	Confined to Mine Study Area	Throughout closure and post-closure	One time occurrence	Not reversible	Low: reduced infiltration due to sculpting of TMF	Low: no predicted effects on surface waters or ecological receptors.
	Vegetation	Effects on vegetation	None	Addition of soil amendment to TMF will promote vegetation growth on TMF in post-closure, restoring some habitat lost during construction and operations.	Confined to Mine Study Area	During closure phase	Throughout closure and post-closure	Reversibility is not desirable	Low positive: Moderate increase in vegetated area.	Low positive: some habitat will be restored permitting return of some species.
	Terrestrial Biota	Effects on habitat	None	Addition of soil amendment to TMF will promote vegetation growth on TMF in post-closure, restoring some habitat lost during construction and operations and facilitating return of some wildlife.	Can extend into Local Study Area	During closure phase	Throughout closure and post-closure	Reversibility is not desirable	Low positive: Moderate increase in vegetated area.	Low positive: some habitat will be restored permitting return of some species.
	Aquatic Biota	Effects on surface water quality and quantity	TMF will be sculpted to promote runoff and minimize infiltration. Soil amendment will promote vegetation growth minimizing TSS in runoff to local waterbodies. Excess water will be diverted to open pit until water quality is acceptable for aquatic life.	Seepage from TMF in post-closure is not predicted to affect aquatic life. Runoff will be released to local waterbodies when quality is acceptable for aquatic life.	Can extend into Local Study Area	During closure phase	Continuous during closure	Reversible at end of closure	Low: Discharges will meet guidelines and/or background levels.	Low: no predicted effects on aquatic life.

Table 6-57: Environmental Impacts Assessment Matrix for Closure and Post-Closure Phases (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Closure of Waste Rock Stockpile	Air Quality	Dust and emissions from equipment	None	No predicted effects on human health or terrestrial life.	Can extend into Local Study Area	Confined to closure phase. No emissions in post-closure	Continuous during closure	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no predicted effect on human health or ecological receptors.
	Noise	Noise from equipment	None	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Can extend into Local Study Area	Confined to closure phase. No sources of noise in post-closure	Continuous during closure	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effect on human health or ecological receptors.
	Soils	No additional impacts								
	Water Quality	Effects on water quality	None	Water will be routed to open pits at closure until seepage water is of acceptable quality to discharge to local waterbodies. No predicted impact on aquatic life.	Can extend into Local Study Area	Closure phase into post-closure	Continuous during closure	Reversible in post-closure	Low: water discharged to local waterbodies will meet guidelines and/or background levels.	Low: no predicted effects on surface waters or aquatic life.
	Hydrology	Effects on drainage	None	Small reduction in drainage area until water is of acceptable quality to release to surface waters.	Can extend into Local Study Area	Closure phase potentially into post-closure	Continuous during closure	Reversible in post-closure	Low: drainage area contribution to lake levels is small.	Low: effects on lake levels and aquatic habitat will be progressively reversed.
	Groundwater	Effects on groundwater quality and quantity	None	Shallow groundwater will be intercepted by ditches minimizing impacts of seepage via groundwater to surface waters. Loss of groundwater contribution to surface waters will be restored in post-closure when drainage can be directed to surface waters. Water quality is not predicted to result in risks to aquatic life where groundwater expresses to surface waters	Confined to Mine Study Area	Closure phase potentially into post-closure	Continuous during closure	Reversible in post-closure.	Low: ditches will intercept shallow groundwater.	Low: effects on lake levels and aquatic habitat will be progressively reversed.
	Vegetation	Restoration of vegetation	None	The waste rock stockpile will be left to re-vegetate naturally. Vegetation may not revert fully to pre-development habitat.	Confined to Mine Study Area	Into post-closure	Continuous	Reversibility is not desirable	Low positive: Some species are expected to colonize the stockpile	Low positive: some habitat will be restored permitting return of some species.
	Terrestrial Biota	Restoration of habitat	None	Wildlife will gradually move in as the stockpile re-vegetates. Habitat may not revert fully to pre-development habitat.	Can extend into Local Study Area	Into post-closure	Continuous	Reversibility is not desirable	Low positive: some habitat lost in construction will be restored.	Low positive: some habitat will be restored permitting return of some species.
	Aquatic Biota	Effects on surface water quality and quantity	None	At closure seepage and runoff water will be directed to the open pits until water is of acceptable quality to discharge directly to local waterbodies. No effects are predicted on aquatic life.	Can extend into Local Study Area	Into post-closure	Continuous until water quality is acceptable	Not reversible	Low: Water quality will be acceptable for aquatic life upon release to surface waters	Low: no predicted effects on aquatic life.

Table 6-57: Environmental Impacts Assessment Matrix for Closure and Post-Closure Phases (Continued)

Activity	VEC Affected	Potential Effect	Proposed Mitigation	Residual Environmental Effect	Predicted Degree of Impact after Mitigation					Significance of Residual Effect
					Extent	Duration	Frequency	Reversibility	Magnitude	
Open Pits	Air Quality	Dust and emissions from equipment	None	No predicted effects on human health or terrestrial life.	Confined to Mine Study Area	Throughout closure and post-closure	Continuous during closure	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates of emissions and meet provincial regulations.	Low: no predicted effect on human health or ecological receptors.
	Noise	Noise from equipment	None	No predicted effects on human health. Wildlife will avoid the area due to noise and activity.	Confined to Mine Study Area	Throughout closure and post-closure	Continuous during closure	Immediately reversible upon cessation of activities	Low: Effects are considered within bounding estimates and meet provincial regulations	Low: no predicted effect on human health or ecological receptors.
	Soils	No effect on soils predicted since no soils will be in the open pit								
	Water Quality	Effects on water quality	Water quality will be monitored during post-closure to verify that overflow will not affect aquatic life	Pits will overflow after approximately 218 years and drain to Upper Marmion Reservoir. Pit water quality at overflow is predicted to be acceptable for aquatic life.	Can extend into Local Study Area	Throughout closure and post-closure	Continuous	Not reversible	Low: Pit water quality at overflow will be acceptable for aquatic life	Low: no predicted effect on human health or ecological receptors.
	Hydrology	Effects on drainage	None	Pit overflow will restore some of the drainage to Upper Marmion Reservoir that was lost due to the project.	Can extend into Local Study Area	Throughout closure and post-closure	Continuous	Not reversible	Low positive: Some restoration of original drainage	Low: effects on lake levels and aquatic habitat will be progressively reversed.
	Groundwater	Effects on groundwater quality and quantity	None	Loss of groundwater contribution to adjacent surface waters is minor. Groundwater contribution to surface waterbodies will be restored when pits overflow. Groundwater quality is not predicted to be affected.	Confined to Mine Study Area	Throughout closure and post-closure	Continuous	Not reversible	Low: groundwater flow to Marmion Reservoir will be restored in post-closure. Quality is not predicted to be affected.	Low: effects on lake levels and aquatic habitat will be progressively reversed.
	Vegetation	No effects on vegetation predicted since pits will be aquatic habitat								
	Terrestrial Biota	Effects on habitat and wildlife	None	Pit water quality will be of acceptable quality for consumption by wildlife.	Confined to Mine Study Area	Throughout closure and post-closure	Continuous	Not reversible	Low: Water quality in pits will be acceptable quality for wildlife consumption	Low: no predicted effects on ecological receptors.
	Aquatic Biota	Effects on surface water quality and quantity	None	Water quality at overflow is predicted to meet background levels in Upper Marmion Reservoir and/or guidelines for protection of aquatic life. No impacts are predicted on aquatic life.	Can extend into Local Study Area	Throughout closure and post-closure	Continuous	Not reversible	Low: Overflow water quality will meet guidelines and/or background levels.	Low: no predicted effects on aquatic life.

6.4.2 Social Environment

Social environment included an assessment of socio-economics, Aboriginal interests, Cultural heritage and Human health. The socio-economic assessment and Human health risk assessment both identified the potential for residual effects as described below.

6.4.2.1 Socio-Economic

The socio-economic impact assessment of the Project has yielded detailed results that are presented in the Socio-Economic TSD. The overall effect of the Project is summarized in Table 6-58.

Table 6-58: Summary of Overall Socio-economic Effects Assessment Results

Valued Ecosystem Component	Overall Residual Effect	Description
Population and Demographics	Positive	The population increase associated with the Project will first stem the decline and then augment the population of the Town. This will have an overall beneficial effect on the community.
Labour Market	Positive	The increase in employment and training and corresponding decrease in unemployment will bring additional income into the LSA, which will contribute to the overall economic wellbeing of the community.
Government Finance	Positive	Beyond additional revenue to the federal and provincial governments, new construction in the LSA will generate additional property assessment for the Town of Atikokan resulting in revenues that can be applied to the provision of services.
Public Services and Infrastructure	Neutral	There is sufficient capacity for existing infrastructure and service delivery to absorb the increases in demand associated with the Project.
Housing and Accommodation	Positive	The vacancy rate in the Town of Atikokan will be reduced by the influx of workers and their families, and new housing will be constructed. This will help stabilize the local housing market.
Transportation	Low-level adverse effect	The local transportation network currently operates well below capacity levels; hence the increase created by the Project can readily be absorbed.
Outdoor Tourism and Recreation	Low-level adverse effect	Upon the application of mitigation measures required for air quality and/or noise compliance, residual adverse effects on tourism and recreation are unlikely. The overall attractiveness of Atikokan and environs is not likely to be affected by the Project; however a low-level effect through loss of visual aesthetics is anticipated. Of note is that given the mining history in the vicinity of Atikokan, many people coming to Atikokan understand that mining activities take place in this area.
Hunting	Low-level adverse effect	No effect is anticipated on the number of hunting licences issued or on general hunting activity in the area. A relatively small amount of land will no longer be available for hunting, which will have a low-level effect on hunting in the LSA.

Table 6-58: Summary of Overall Socio-economic Effects Assessment Results (Continued)

Valued Ecosystem Component	Overall Residual Effect	Description
Trapping	Neutral	Upon the application of mitigation for the loss of some portions of tenured trapline areas, no residual adverse effect on trapping is anticipated.
Fishing	Neutral	Overall fishing activity in the study areas is not likely to be affected.
Mining	Positive	Beyond the positive effects of the Project described in this TSD, the Project would likely have net beneficial effects on local or regional exploration and development in this sector.
Forestry	Neutral	Upon the application of mitigation, no residual adverse effect on forestry is likely.
Water Use and Access	Neutral	Ongoing discussions with the downstream hydro-electric facilities to further understand the potential financial implications of the predicted changes to outflows from the Raft Lake Dam. Upon the application of mitigation, no residual adverse effect other commercial or industrial water users is likely.

6.4.2.2 Human Health

Residual effects to human health were determined to include noise and increased particulate matter.

Increased noise has the potential to result in an increased risk of hypertension or sleep disturbance to nearby recreational users or trapline holders. Best management practices will be implemented to minimize activities that may generate noise (e.g., mine and materials handling, vehicle movement) in particular close to the property boundaries adjacent to identified receptor locations. To the extent possible, noise will be minimized at night in these areas as well, to reduce the potential for sleep disturbance.

The particulate matter assessment identified the potential for a residual effect of increased cancer risk for trappers at two trapper cabins.

Residual effects were evaluated using the assessment criteria identified. The direction of all the residual effects is negative (i.e., decrease in health from baseline conditions). Table 6-59 provides more details on the residual effects evaluation, and Table 6-60 provides magnitude levels for human health residual effects.

Table 6-59: Human Health Residual Effects Evaluation by Assessment Criteria

Assessment Criteria	Noise Effects		Particulate Matter			
			DPM Effects		(PM_{10}) Effects	
	Level	Rationale	Level	Rationale	Level	Rationale
Geographic Extent (of effect)	High	Noise levels that may cause effects extend into RSA	Low	Cancer risks above target levels were only predicted at two trapper's cabins within the LSA	Low	PM_{10} concentrations above screening thresholds were not identified at receptors within the LSA

Table 6-59: Human Health Residual Effects Evaluation by Assessment Criteria (Continued)

Assessment Criteria	Noise Effects		Particulate Matter			
			DPM Effects		(PM_{10}) Effects	
	Level	Rationale	Level	Rationale	Level	Rationale
Frequency (of effect)	High	Noise is expected to be generated daily	Medium	Cancer risk is a result of long-term exposure	Low	Concentrations are below the screening threshold 95% of the time
Duration (of conditions causing effect)	High	Noise is expected during constructions, operations and closure	High	Diesel emissions may occur on a daily basis due to vehicle traffic within the MSA	High	Emissions of PM_{10} may occur on a daily basis due to activities within the MSA
Degree of Irreversibility (of effect)	Medium	Effects on sleep disturbance will not occur once the Project is finished	High	Cancer effects are irreversible	Medium	Cardiopulmonary effects may decrease once the Project is finished

Table 6-60: Magnitude Levels for Human Health Residual Effects

Noise Effects		DPM Effects		PM_{10} Effects	
Level	Rationale	Level	Rationale	Level	Rationale
Low	■ Predicted health measures are below Health Canada guidelines ■ Additional literature search identified potential noise effects at levels below guidelines ■ Assumed the receptors are subject to the predicted noise concentrations on a long-term basis	Low	■ The ILCR for both locations is 1.6×10^{-6} ■ DPM concentration based on maximum emissions during operation phase and assumed to apply for the entire constructions, operations and closure phases ■ The ILCR exceeded the target cancer risk level at one location only ■ Assumed that trapper is exposed to the maximum annual DPM concentration for 8 hours per day, 105 days per year for 15.5 years	Low	■ The maximum predicted 24-hour concentration was within 10 µg/m^3 of the screening threshold ■ The PM10 concentration was only above the screening threshold at one receptor location ■ 95% of the time the PM10 concentration would be below the screening threshold at that receptor location

6.5 Effects of the Environment on the Project

The preceding sections provide the results of the assessment of the effects of the Project on the environment. The environment can also affect the operation of the Project and these environment-induced changes may result in unanticipated environmental impacts. This section discusses changes in the environment that may affect the operation of the Project.

Effects of the environment on the Project include potential natural hazards that could affect the Project Site along with changes in the environment that could reasonably affect the Project. These include the following:

- Forest fires.
- Floods and droughts.
- Seismic activity.
- Climate change.

6.5.1 Forest Fires

Cleared areas around site facilities and the design of the layout of the Mine Site will minimize the likelihood of direct damage by fire to site infrastructure. Design considerations include protection of fuel and reagent storage areas by clearing of trees and brush around the facilities. In addition, these facilities will be equipped with emergency fire-fighting equipment. The site will be equipped with fire fighting equipment with personnel trained in their use. Water for emergency fire-fighting will be identified in detailed design. Floods and Droughts

Excess rainfall or snow melt could cause local flooding and presents a risk to the Project.

The mine process facility and supporting infrastructure are constructed on higher ground that would not be susceptible to flooding within the Marmion Reservoir system. However local flooding could occur in some areas. The storm water drainage system would divert excess non-contact water to local water bodies in order to maintain capacity in the PPCP for contact water. Some mining activities may need to be curtailed if flooding of the pit interferes with mining. Tailings facility has been designed with a spillway and excess water would be released via the spillway before the integrity of the TMF could be affected. The effects of a spill of tailings reclaim water are addressed in Section 6.6.4.

Drought may affect the ability to provide the water required for processing. In severe conditions, the lack of water could affect processing operations. During periods of drought, water storage in the TMF could be increased to provide sufficient water to meet operating needs.

The effects of drought can be mitigated through careful water management, and storing of excess water when climatic conditions indicate that a potential water shortage may occur. This will minimize the effects of the Project on water levels in Upper Marmion Reservoir and permit the Project to continue operations.

6.5.2 Seismic Activity

The Project is located in an area of the Canada that is characterized by low seismic activity.

Dams, structures and buildings constructed will be constructed to appropriate code accounting for seismic risk in the area, as such potential seismic activity is not projected to result in adverse effects.

Project tailings dams were designed according to Canadian Dam Association (CDA) Guidelines and Ontario MNR Guidelines. The MNR has authority to approve dams in Ontario and CDA guidelines are referenced in the Ontario Mine Closure regulations. The design of the tailings dam was completed by Golder and will be peer reviewed by an independent expert in tailings dam construction and operation.

In addition, the Mining Association of Canada (MAC) provides guidelines for best practices for management of tailings dams. OHRG intends to develop a customized tailings management system, (an Operations Management and Surveillance (OMS) Manual), that address the specific needs of OHRG, local regulatory and community requirements. The management system will include:

- A framework for tailings management.
- Sample checklists for implementing the framework through the life cycle of a tailings facility.

The framework will offer a foundation for managing tailings in a safe and environmentally responsible manner through the full life cycle of a tailings facility from site selection and design, through construction and operation, to eventual decommissioning and closure.

The tailings management framework will be expanded into checklists that address the various stages of the life cycle. These checklists will provide a basis for developing a customized management system, operating procedures and manuals, exposing gaps within existing procedures, identifying training requirements, communicating with Communities of Interest, obtaining permits, conducting internal audits, and aiding compliance and due diligence, at any stage of the life cycle.

6.5.3 Climate Change

Climate change predictions are described in detail in the Atmospheric Environment TSD. The climate change predictions for the Atikokan area of northwestern Ontario are based on a description the current climate, documenting how the climate has changed over the past 40 years (1970 to 2010) in the region, and using general climate predictions for future climate change (2041 to 2070) to predict changes in the RSA. The assessment is based on an analysis and summary of the current climate conditions for the region for both the 1971 through 2000 (the currently recognized climate period by Environment Canada) and the longer period of 1970 through 2010 where data is available. A review of the data for the Atikokan Marmion Station and the Sioux Lookout Station indicates that from 1979 onwards there has been a slight increase in warming.

Temperature in the RSA is projected to be warmer when compared to all climate models analyzed and observed historic values for the 2050s horizons. Precipitation shows a smaller increase than temperature and the agreement in projections among the climate models analyzed is dependent on season. For the two climate parameters (temperature, precipitation), the size of the projected deviation depends on whether the suite of model projections are being analyzed annually or seasonally. In general, the fall and winter show the largest projected increases in temperature, while the spring and winter show the largest increases in precipitation. The average projected climate trend deviations from the observed historic values are provided in Table 6-61. The deviations are calculated as the shift in the peak of the normal distribution from the historic dataset to the future forecasts in the histograms for the given periods of interest.

Table 6-61: Summary of Average Projected Climate Trend Deviations from Observed Historic Values

Station/Period			Temperature [°C]	Precipitation [mm (equiv.)]
Sioux Lookout	2050s	Annual	+ 2.5 to 3.0	+ 30 to 40
		Spring	+ 2.0 to 2.5	+ 15 to 20
		Summer	+ 2.0 to 2.5	+ 5 to 10
		Fall	+ 2.5 to 3.0	+ 10 to 20
		Winter	+ 2.5 to 3.0	+ 15 to 20

Climate change may result in an environment that is different from the current environment as less severe winters, changing precipitation patterns or other considerations may affect future operations and effect the operation of infrastructure associated with the Project. A qualitative assessment of how a changing climate may affect Project aspects has been completed. Table 6-62 presents a climate risk matrix for the Project for the 2050s based on the Climate Trends described above.

This table identifies those climate change risk factors that may impact the Project, those which are unlikely to have an impact on the Project and those for which the potential impact on the Project is unknown.

Table 6-62: Climate Risk Matrix

Climate Factor	Trend	Justification
Frequency of Drought	Qualitative	
Freeze-Thaw Cycles	Increasing	Slight increase based increasing winter precipitation and average temperatures
High Humidity Periods	Increasing	Slight increase based on increasing precipitation from analysis of all models, and increase in temperatures.
Frequency of Extreme Temperatures	Unknown	Possible increase in extreme temperatures but strength of trend is unknown
Frequency of Rainfall	Unknown	Trend is unclear due to unknown distribution of rain events in future projections
Heavy Rain	Increasing	Slight increase based on higher rainfall volume in the summer season
Total Rainfall	Increasing	Increase of ~50 mm annually above historic baseline
Freezing Rain	Increasing	Slight increase in temperature will create a vertical profile that is conducive to freezing rain events
Rain on Snow Events	Increasing	Slight increase in temperature will create a vertical profile that is conducive to rain on snow events
Flash Freeze Event (Rain/Freeze-Thaw)	Qualitative	Further assessment of Trend is required due to unknown distribution of rain events in future projections
Snow Accumulation	Qualitative	Further assessment of Trend is required due to unknown distribution of precipitation events in future projections

Table 6-62: Climate Risk Matrix (Continued)

Climate Factor	Trend	Justification
Snowmelt	Qualitative	Further assessment of Trend is required due to unknown distribution of precipitation events in future projections
Sunny days	Qualitative	Further assessment of Trend is required due to lack of information on future dynamics (cloud cover)
Extreme Heat	Increasing	Slight increase based on increase in average summer temperatures
Extreme Cold	Decreasing	Slight decrease based on increase in average winter temperatures
Cooling Degree Days	Increasing	Slight increase based on increase in average summer temperatures
Heating Degree Days	Decreasing	Slight decrease based on increase in average winter temperatures
Average Temperature	Increasing	Analysis of all models indicates and average increase of ~3°C above historic baseline

The Project does not rely on an ice road or other highly weather dependent infrastructure for its operations, has a relatively short operational life (11 years) and therefore it was concluded that the effects of a potentially changing climate on the Project are not significant.

6.6 Potential Effects of Malfunctions and Accidents

This section considers the effects on accidents that may reasonable be predicted or foreseen on the Project. The potential accidents and malfunctions that are considered are those that could be expected to occur under unusual or extreme operating conditions.

Monitoring plans and mitigations are described in Chapter 8 and are designed to rapidly evaluate, respond to malfunctions and accidents, as such malfunctions and accidents are not expected to result in any adverse long term impacts.

Potential accidents that could occur during the operating phase include the following:

- Road accident on main access road resulting in a fuel spill from a tanker truck.
- Fuel tank rupture on Mine Site.
- Tailings pipeline rupture.
- Spill of tailings water from TMF reclaim pond.
- TMF tailings dam failure.
- Flyrock

Each of these potential accident scenarios is discussed below. An overall assessment of the effects of the accident is provided, taking into account its likelihood and possible environmental effects. Specific scenarios are presented for each potential accident and the consequences identified. Measures incorporated into the Project design to reduce the likelihood of an accident and/or minimize its potential effects are described.

Additional accidents and malfunctions which are included in emergency management planning but are considered to have negligible effects due to in-design mitigation, short duration and/or reversibility are listed below and discussed further in Chapter 8.

- Transportation accidents (non-fuel shipments, including hazardous materials) (short duration, reversible)
- Chemical spills within contained facilities (in-design mitigation, short duration, reversible)
- Explosives accidents (low probability, short duration, mitigation through management protocols)
- Failure of the effluent management system to capture surface and seepage within the mine operations area (low consequence based on water quality estimates).
- Pit slope failure (in-design mitigation, monitoring and engineering controls).
- Slope failure associated with the waste rock or overburden stockpile (in-design mitigation, monitoring and engineering controls, short duration, low consequence).
- Tailings impoundment area seepage and related water quality concerns (low consequence based on water quality estimates).
- Fires associated with the Project (monitoring and engineering controls, mitigation through management protocols).
- Medical emergency (short duration, reversible).

6.6.1 Diesel Fuel Spill from Road Accident

A potential spill of diesel fuel from a tanker truck as a result of a road accident is considered as a plausible accident scenario.

A fuel spill could affect terrestrial and aquatic habitats. Therefore, the primary objective should a spill occur would be to contain the material to minimize the areas affected in order to prevent migration to surface waters.

Spills to terrestrial habitats would be cleaned up as soon as possible following the spill and would include soils testing to ensure that any contaminated soils are also removed. Spills to aquatic habitats would require containment followed by cleanup of spills. Effects on aquatic life would be minimized though appropriate containment measures implemented immediately following any spill. Amounts will be small, the emergency response plan will be activated, cleanup will be quickly implemented to minimize potential effects.

The potential for damaging fuel spills can be minimized by ensuring that fuel will be shipped to the site using licensed carriers, using compartmentalized vehicles equipped with spills containment materials. Drivers will be trained in the use of the materials. Clean-up will be provided by professional operators, and will be assisted by OHRG staff trained in the cleanup of spills. As a result, the effects of a fuel spill would be contained within a limited area around the spill, and would be cleaned up, and would have minor impact on the terrestrial or aquatic environment.

6.6.2 Fuel Storage Tank Rupture

The rupture of an on-site diesel fuel storage tank is considered as a possible accident scenario. The accident scenario assumes that there is a rupture of the fuel storage tank that results in the release of the entire contents of the tank.

Consistent with good operating practice, the fuel storage area has been designed with a double wall tank designed to hold 110% of the volume of a fuel storage tank. As a result, there is no predicted release of any spilled fuels to the environment and no effects are anticipated. Spilled fuels would be contained within the bermed area. Spilled fuels would be removed by licensed contractors. As a result, a fuel tank rupture would have a minor impact on the terrestrial or aquatic environment.

6.6.3 Tailings Pipeline Rupture

A break in the tailing pipeline could result in a spill of tailings to the terrestrial environment. The accident scenario assumes that a break has occurred in a section of the tailings pipeline. A break in the tailings pipeline would likely be detected immediately, but for purposes of assessing a worst case accident it is assumed that the break is not detected for up to 2 hours. It should be noted that pressure monitoring equipment would detect changes in pressure in the pipeline that would be immediately investigated through inspection of the pipeline

As described below, the tailings pipeline has been designed to contain spills within an engineered structure and prevent spills to the aquatic environment. The tailings pipeline has been designed with berming to prevent lateral migration of any spilled materials from a pipeline rupture, and with containment areas in low points along the route. While the system will be equipped with flow monitoring devices that will provide automatic shutoff of the pumps in the event of a rupture, additional containment has been provided along the pipeline route that are designed to contain 2 hours pumping volume of tailings.

Berming of the route and containment areas will prevent migration of tailings to adjacent areas of the environment. As a result, spills will collect in the containment areas constructed at low points along the pipeline route that are designed to contain 2 hours pumping volume of tailings. Spilled material will be contained in these areas that will prevent migration to surface water bodies. Some seepage of tailings water into the ground surface would be expected in the containment areas, and local migration of tailings water may affect soils in adjacent areas. The soils would therefore be tested during the spills cleanup and adjacent soils that exceed acceptable levels will also be removed and disposed of in the TMF. Some additional land disturbance will result from a spill that would affect limited areas of adjacent terrestrial habitat, primarily through subsequent cleanup activities. The effects are predicted to be localized, and affected areas can be revegetated to restore most of the original habitat function. As such the effects from a tailings pipeline rupture would be minor on the terrestrial environment. No impacts are predicted on the aquatic environment.

6.6.4 Emergency Spill from TMF Reclaim Pond

A spill from the TMF reclaim pond could result in a loss of tailings reclaim water to adjacent aquatic environments. Since the reclaim pond has been designed to contain the 24 hr 1:10,000 year rainfall event, the accident scenario assumes that an extreme rainfall event occurs during a period of much higher than average precipitation, resulting in water accumulating in the reclaim pond at a faster rate than it can be re-used in the processing plant.

The TMF has been designed to retain water for re-use in the processing plant. Excess water will be stored in the reclaim pond and under normal operating conditions there will be no release of water from the TMF to the natural environment. However, under severe precipitation events or unusually wet years, more water may accumulate in the reclaim pond than can be pumped back to the PPCP. To account for unusual precipitation events, the TMF has been designed with an emergency spillway through which excess water can be released. This is a typical safety feature of most tailings facilities to ensure that the containment dams do not overtop and the integrity of the dams is maintained. The emergency spillway invert elevation will be raised with each dam raise stage.

As a result, emergency release of water from the TMF is considered a reasonably conceivable scenario that may occur under extremely rare climatic conditions (e.g., severe precipitation event or unusually wet year). Table 6-63 provides predictions for water quality in the TMF reclaim pond under a worst case scenario of a 1:100 return period wet year. The prediction is based on the highest measured/humidity cell results for contact water and the highest values measured for process water.

Table 6-63: Predicted Water Quality in Tailings Management Facility Reclaim Pond

Solution Description		100 Year Wet		50 Year Wet	
		Average/Steady State	**Worst Case**	**Average/Steady State**	**Worst Case**
Input Definition					
pH	s.u.	7.8	7.6	7.8	7.6
Alkalinity	mg/L as CaCO3	104	119	105	119
Nitrate[(a)]	mg/L as N	0.000005	0.000006	0.000005	0.000006
Nitrate[(b)]	mg/L as N	3.7	4.7	3.8	4.7
Ammonia	mg/L as N	3.7	4.7	3.8	4.7
Aluminum	mg/L	0.01	0.01	0.01	0.01
Antimony	mg/L	0.002	0.002	0.002	0.002
Arsenic	mg/L	0.00002	0.00003	0.00002	0.00003
Boron	mg/L	0.001	0.002	0.001	0.002
Barium	mg/L	0.01	0.02	0.01	0.02
Calcium	mg/L	21	33	22	33
Cadmium	mg/L	0.00002	0.0003	0.00002	0.0003
Chloride	mg/L	21	48	21	49
Cobalt	mg/L	0.002	0.002	0.002	0.002
Chromium	mg/L	0.0002	0.0003	0.0002	0.0003
Copper	mg/L	0.08	0.11	0.08	0.11
Iron	mg/L	0.00007	0.00008	0.00007	0.00008
Mercury	mg/L	0.000009	0.000009	0.000009	0.000009
Potassium	mg/L	28	38	29	38
Magnesium	mg/L	12	18	12	18
Manganese	mg/L	0.04	0.07	0.04	0.07
Molybdenum	mg/L	0.06	0.07	0.06	0.07
Sodium	mg/L	73	93	74	94
Nickel	mg/L	0.008	0.009	0.008	0.009
Phosphorous	mg/L-P	0.02	0.03	0.02	0.03
Lead	mg/L	0.0001	0.0003	0.0001	0.0003
Selenium	mg/L	0.0006	0.00093	0.0006	0.00093
Silver	mg/L	0.00001	0.00001	0.00001	0.00001

Table 6-63: Predicted Water Quality in Tailings Management Facility Reclaim Pond (Continued)

Solution Description		100 Year Wet		50 Year Wet	
		Average/Steady State	Worst Case	Average/Steady State	Worst Case
Input Definition					
Sulfate	mg/L	168	227	170	228
Strontium	mg/L	0.22	0.32	0.23	0.32
Tin	mg/L	0.02	0.03	0.02	0.03
Vanadium	mg/L	0.00002	0.00002	0.00002	0.00002
Thallium	mg/L	0.0001	0.0001	0.0001	0.0001
Uranium	mg/L	0.005	0.007	0.005	0.007
Zinc	mg/L	0.002	0.01	0.002	0.01
Cyanide	mg/L	0.19	0.19	0.19	0.19

Note:

(a) Nitrate concentrations assuming no oxidation of ammonia.

(b) Nitrate concentrations assuming complete oxidation of ammonia.

Emergency spills from the TMF would likely occur when water levels in adjacent receiving waters such as Lizard Lake are also at unusually high levels. Therefore, a conservative assumption is made that emergency overflow of the TMF will spill to Lizard Lake, and at the time of the spill, water levels would also be unusually high in Lizard Lake and there will be sufficient mixing to achieve a minimum 10:1 dilution in Lizard Lake.

Under this scenario, concentrations of most parameters will be at concentrations that are not predicted to result in adverse effects on aquatic life. The predicted concentrations of copper and free cyanide as listed in Table 6-63 indicate that there may be potential concern due to these substances. With 10:1 dilution, copper concentrations would be at concentrations that would not be expected to result in adverse effects on aquatic life. Free cyanide concentrations could be sufficiently elevated to result in adverse effects on fish species in localized areas.

The TMF reclaim pond spillway has been designed to the 24 hour, 1:10,000 year rainfall event. A severe rainfall event that would result in discharge from the reclaim pond emergency spillway would also result in a significant increase in flow and water levels in the receiving water body. The emergency spillway will discharge to Lizard Lake for the first 6 years of operation and Sawbill Bay thereafter. The result would be a substantial increase in dilution within the receiving water body that would mitigate the potential effects of higher concentrations. As a result, effects on aquatic life, if any, would likely be confined to a small mixing area where the overflow enters the receiving water body.

6.6.5 Tailings Dam Failure

A tailing dam failure could result in the spill of tailings to the adjacent terrestrial environment. As described below, the tailings are not predicted to flow to aquatic environment. The accident scenario assumes that a section of the tailings containment structure experiences a localized failure, resulting in a release of tailings to adjacent areas.

The Project Description in Chapter 5 notes that tailings will be deposited in the TMF as thickened tailings (i.e., discharged at 50% to 70% solids by mass). A benefit of thickened tailings is that, if there was a perimeter containment dam failure, thickened tailings will maintain a steeper slope and will not runout or flow as far as slurry tailings (e.g., discharged at 30% solids by mass). As well, surface water will runoff the thickened tailings surface and collected in a reclaim pond at the south end of the TMF with no ponded water over the tailings. As a result, a failure of a perimeter containment dam may result in a localized slumping of the tailings into adjacent areas, but the tailings are unlikely to flow any distance. As such, there is no concern that the tailings could migrate to surface water bodies, and the environmental effect would be limited to terrestrial environments adjacent to the TMF. The consequences of a tailings dam failure would therefore be a localized impact on adjacent terrestrial habitats that could be regenerated after the dam is repaired and the escaped tailings are returned to the TMF. Cleanup would include testing of soils to ensure any contaminated soils are removed and disposed of in the TMF.

The potential for tailings dam failure will be significantly reduced through proper design, operation, inspection and maintenance. The OHRG tailings dams were designed according to Canadian Dam Association (CDA) Guidelines and Ontario MNR Guidelines. The MNR has authority to approve dams in Ontario and CDA guidelines are referenced in the Ontario Mine Closure regulations. The design of the OHRG tailings dam was completed by Golder and will be peer reviewed by an independent expert in tailings dam construction and operation.

In addition, the Mining Association of Canada (MAC) provides guidelines for best practices for management of tailings dams. OHRG intends to develop a customized tailings management system, (an Operations Management and Surveillance (OMS) Manual), that address the specific needs of OHRG, local regulatory and community requirements. The management system will include:

- A framework for tailings management.
- Checklists for implementing the framework through the life cycle of the tailings facility.

The framework will offer a foundation for managing tailings in a safe and environmentally responsible manner through the full life cycle of the tailings facility from site selection and design, through construction and operation, to eventual decommissioning and closure.

The tailings management framework will be expanded into checklists that address the various stages of the life cycle. These checklists will provide a basis for developing a customized management system, operating procedures and manuals, identifying gaps within existing procedures, identifying training requirements, communicating with Communities of Interest, obtaining permits, conducting regular inspections and maintenance, conducting internal audits of the management system, and aiding compliance and due diligence, at all stages of the mine life cycle.

6.6.6 Fly Rock

"Flyrock" means rock that is thrown through the air as a result of blasting. Flyrock is an integral part of blasting that needs to be properly controlled. If flyrock is uncontrolled the rocks, which can travel significant distances, pose a risk to persons involved with blasting as well as anyone else in the area of the blast. There is also the potential for damage to nearby property or equipment. Blasting will be done only by certified blasters. In addition, these blasters must make sure that all of the regulations are observed. A blasting protocol including hazard assessments and the definition of clear lines of responsibility, supervision and communication for blasting will be developed.

6.7 Capacity of Renewable Resources

The Project is expected to make use of the following renewable resources:

- Surface waters for processing and domestic use.

Use of water for processing and domestic use at the worker accommodation camp will represent a small draw on the available resources. Process water will be re-used to the extent possible, and therefore only 7,200 m^3/day will be required during mine operations under average operating conditions. Water use will cease upon completion of closure activities. Adequate water resources for operation of the Project, including process water and domestic water needs, can be met from existing water resources without affecting other water uses.

Restrictions on fishing and hunting by mine personnel will be implemented to protect fish and wildlife stocks from over-harvesting. The influx of workers is expected to increase hunting and fishing pressure in the area that, without restrictions, could deplete local fish and wildlife populations. Since fishing and hunting are relied upon by Aboriginal communities and are an integral part of their culture, and sport fishing is currently an important economic resource of the local community in Atikokan, protection of these resources from over-exploitation is required. Fishing pressure will be monitored through the use of questionnaires and OHRG will work with MNR to develop adaptive management plans and policies if necessary.

The Project will not require local forest resources, and therefore there is no predicted impact on forestry resources.

6.8 Cumulative Effects

The cumulative effects of the Project have been assessed within the context of the predicted effects of the Project. The assessment considers the geographic extent of the predicted effects from the Project to assess whether there is a potential for environmental or socio-economic interaction of the Project with other past, existing and proposed activities in this region of the province.

6.8.1 Method for Identifying, Predicting and Assessing Cumulative Effects

The approach to assessing potential cumulative effects uses the results of the impact assessment, as described in this chapter, to assess the potential effects of the Project on the same physical, biological and socio-economic factors in consideration with the effects of other past, existing and reasonably foreseeable projects and activities in the same geographic region as the Project. Appropriate past, existing and proposed projects and activities that could potentially interact with the project were selected for inclusion in the assessment in consideration of the following:

- The predicted effects of the Project;
- The spatial and temporal extent of the predicted effects;
- The location, timing, size and nature of other projects and their potential effects; and,
- The availability of existing data and knowledge of the projects and their potential effects.

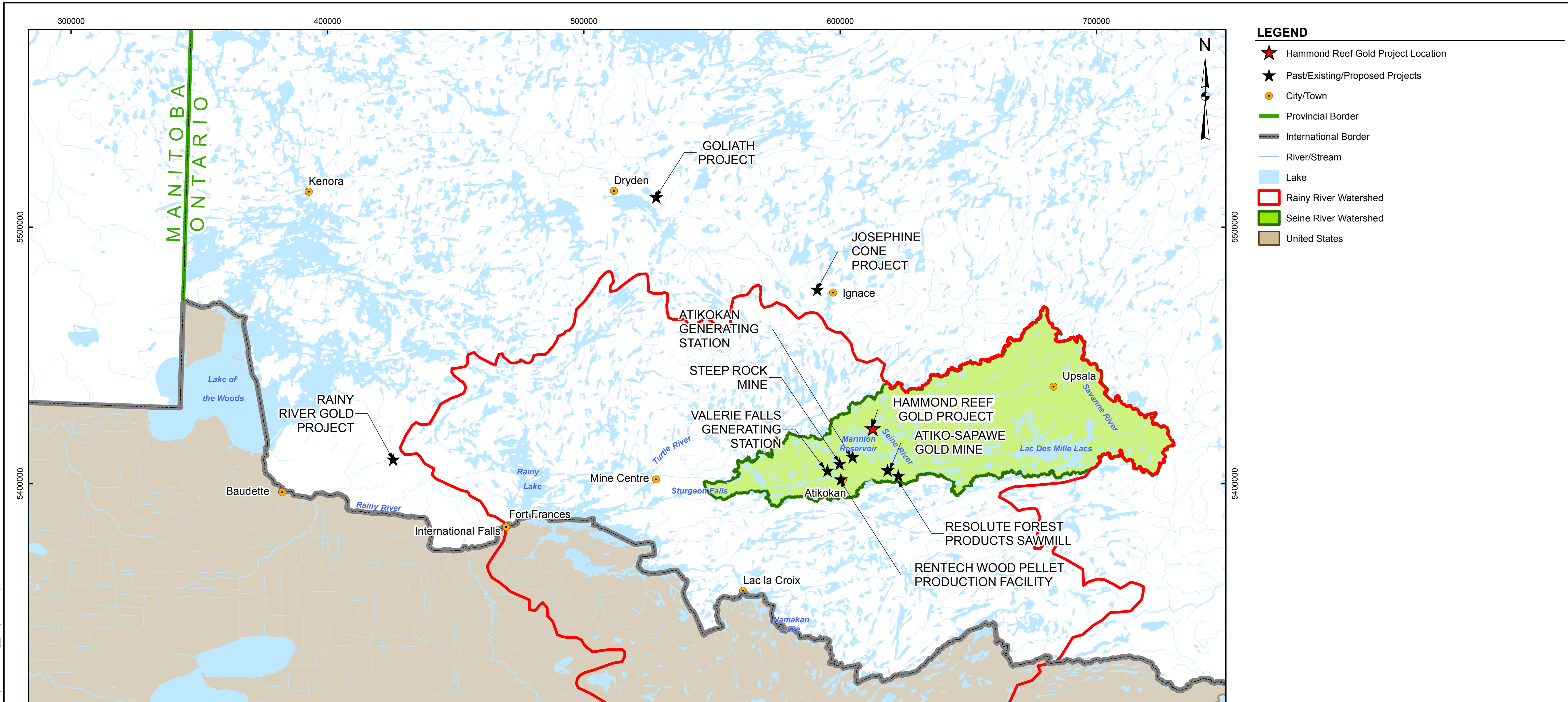
The predicted effects of the Project were then considered against each other project or activity to determine if there is potential for interaction. If a potential for interaction is identified, an assessment of potential cumulative effects is performed.

6.8.2 Scope of Assessment

Past, existing and proposed projects or activities in the vicinity of the Project Site that could potentially interact with the Project are shown on Figure 6-13 and are limited to the following:

- The former Steeprock Iron Mine site near Atikokan;
- Existing hydro-electric facilities on the Seine River system downstream of the Raft Lake Dam, the closest of which being the Valerie Falls Generating Station;
- Ontario Power Generation's Atikokan Generating Station near Atikokan;
- Planned wood processing facilities, including the Resolute Forest Products Sawmill near Atikokan and the Rentech Wood Pellet Production Facility in Atikokan (formerly known as the Atikokan Renewable Fuels Mill);
- The former Atiko-Sapawe Gold Mine near Atikokan;
- Rainy River Resources proposed Rainy River Gold Project near Fort Frances, Ontario;
- Bending Lake Iron Group proposed Josephine Cone Iron Mine project near Ignace, Ontario; and,
- Treasury Metals proposed Goliath Gold Project near Dryden, Ontario.

A single project, the proposed Rainy River Resources mine near Fort Frances, located approximately 160 km to the west is the only reasonably foreseeable new development project in the area.



REFERENCE

Base Data - Global Dataset, LAND INFO Worldwide Mapping, LLC
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Drainage Basin and Sub-Basin digitized from Winnipeg River Drainage Basin, Lake of Woods Control Board (2000/12/01)
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 15N

20 0 20 40 60 80
SCALE 1:1,500,000 KILOMETERS

PROJECT
HAMMOND REEF GOLD PROJECT
ATIKOKAN, ONTARIO, CANADA

TITLE
PAST, EXISTING AND PROPOSED PROJECTS NEAR THE PROJECT STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 13-1118-0010			SCALE AS SHOWN	VERSION 2
DESIGN	CGE	14 Nov. 2008		
GIS	SC	17 Jul. 2013		
CHECK	CC	17 Jul. 2013		
REVIEW	THW	17 Jul. 2013		

FIGURE: 6-13

G:\Projects\2013\13-1118-0010_Osisko_Hammond_Reef\GIS\MXDs\Reporting\EIS\Chapter6\Existing_ProposedProjects.mxd

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6.8.3 Environmental Effects

6.8.3.1 Steeprock Iron Mine

The Steeprock Iron mine is a legacy site resulting from the former operation of the Steeprock Iron Mines. The mine ceased production in 1979, and currently the site includes two large open pits that are in the process of flooding (as well as smaller pits), and areas of waste rock that are currently scattered around the site. The larger of the flooding open pit, the Hogarth Pit, has been the subject of a number of studies focusing on pit water quality, which is considered to be of poor quality.

The Hogarth Pit is filling naturally, and is predicted to overflow into the Seine River system when water in the Hogarth Pit reaches the 396 m elevation, currently predicted to occur after 2030. The overflow will drain to Steep Rock Lake, and ultimately to the Seine River, at a point approximately 20 km downstream of Marmion Reservoir. The overflow of the pit is expected to negatively affect the quality of water in Steep Rock Lake and the Seine River.

Since the Project is located upstream on the Seine River system, the cumulative effects of the Steeprock Mine and the Project on water quality in the Seine River are considered.

As noted in Chapter 6 water quality discharging from the Hammond Reef mine during mine operations is not expected to exceed guidelines and/or background conditions in Upper Marmion Reservoir. A treatment system has been included in the mine design, and will be operated if necessary to ensure that water quality in the Upper Marion Reservoir is not affected. Upon closure, generation of effluent from the processing operations will cease, and the treatment facility will be decommissioned once monitoring has confirmed that water quality is suitable for discharge to the environment.

In post-closure, the Hammond Reef pits are predicted to overflow in approximately 218 years after closure, with the overflow being released to the Upper Marmion Reservoir. Pit water quality in the post-closure phase has been predicted on the basis of geochemical testing to meet background water quality at the point of release (Section 6.1.3).

There is no change in overall water quality predicted to occur downstream of Upper Marmion Reservoir, during either operations, closure or into post-closure however there may be minor increases in some parameters that are not predicted to affect aquatic life. Therefore, the Project is not predicted to contribute to a change in water quality conditions downstream in the Seine River in future should the Hogarth Pit overflow. There is no predicted cumulative effect of the Project with the Steep Rock site.

Since there are no current activities at this site, there is no source of potential impact on other environmental (e.g., air quality, noise). Therefore, there are no pathways by which the Project could interact with the Steeprock site.

6.8.3.2 Existing Hydro-Electric Facilities

A number of small hydro-electric facilities exist downstream on the Seine River, the nearest of which is the Valerie Falls Generating Station (GS). The station is operated by Valerie Falls Limited Partnership, and is located downstream of the outlet of Finlayson Lake. The Raft Lake Dam controls approximately 97% of the inflow into the headpond that feeds the generating station (Seine River Water Management Plan 2004 to 2014). As a result, changes in outflows from Upper Marmion Reservoir could affect the operation of the Valerie Falls GS.

Changes to the outflows from the Upper Marmion Reservoir as a result of the Project could act cumulatively with other contributors.

As noted in Section 6.1.3, changes in outflow from Upper Marmion Reservoir as measured at the Raft Lake Dam are in the order of a 0.7% reduction over current outflows. This is predicted to occur during the operations phase of the Project, when maximum drainage loss and water taking are predicted to occur. Natural variability and operational management of the reservoir for power generation are much larger influencing factors on flow than the Project, therefore, no cumulative effect is anticipated.

6.8.3.3 Atikokan Generating Station

The Atikokan Generating Station, operated by Ontario Power Generation, is located about 15 km southwest of the Project site outside the LSA of all environmental components. It is a former coal burning power plant that is currently undergoing a Biomass Conversion Project through which the station's fuel source is being converted to wood pellets. It is planned to begin producing electricity again by the end of 2014. Future operations are not predicted to interact with any of the environmental components of the Project.

The Atikokan GS uses water from Lower Marmion Reservoir for cooling purposes, and therefore is not predicted to result in any changes in water levels in Upper Marmion Reservoir. As a result there is no predicted interaction of the Project with the operation of the Atikokan GS for any physical or biological assessment components.

Potential emissions from the Project were considered with respect to the future return to operation of the Atikokan GS. The air quality assessment of Project emissions was conducted using two separate approaches. The first approach focussed on demonstrating that the Project would be capable of meeting the regulatory permitting requirements in Ontario (i.e., O.Reg. 419/05). The Project would be subject to O.Reg. 419/05 under which the air emissions from the facility would be regulated. In predicting air quality changes from the Project, all of the emissions and sources of emissions at the Project, whether regulated under O.Reg. 419/05 or not, were used as inputs to the AERMOD dispersion model and the results were provided to other disciplines that assessed the effects of changes in air quality on the receiving environment (e.g., Human Health). The assessment noted that air quality would meet regulatory limits within the Air Quality and Human Health LSA. Therefore, there is no predicted interaction with future emissions from the Atikokan GS.

6.8.3.4 Planned Wood Processing Facilities

There are two planned wood processing facilities in the vicinity of the Project site. Rentech is planning to convert a former particleboard factory, located in the Town of Atikokan, to a wood pellet production facility and Resolute Forest Products is planning the construction of a new sawmill near Sapawe Lake. Both facilities will produce wood pellets for use by the Atikokan Generating Station. The Resolute Forest Products sawmill will also produce finished lumber. Production at both facilities is expected to begin by the end of 2014.

Rentech's planned Wood Pellet Production Facility is located about 23 km southwest of the Project site and the Resolute Forest Products Sawmill is located about 20 km southeast of the Project site. Both facilities are located downstream of the Project within a different sub-watershed of the Seine River watershed. Runoff from the facility areas will not mix with water from Upper Marmion Reservoir until downstream of the Raft Lake dam. As there is no predicted change in water quality in the Upper Marion Reservoir during either operations, closure or into post-closure, the Project is not predicted to contribute to a change in water quality conditions downstream of the Raft Lake dam. Therefore, there is no predicted cumulative effect with respect to water quality and the aquatic environment.

The planned facilities are also located outside of the Air Quality and Human Health LSA. As air quality is predicted to meet regulatory limits within the Air Quality and Human Health LSA, there is no predicted cumulative effect with respect to air quality and human health.

There are no other physical or biological pathways identified through which the Project could interact with the Rentech Wood Pellet Production Facility and the Resolute Forest Products Sawmill.

6.8.3.5 Atiko-Sapawe Gold Mine

The Atiko-Sapawe Gold Mine is a former underground mine operated from 1963 to 1966. The site is located just south of Osinawi Lake, about 17 km southeast of the Project site.

As noted above for the planned wood processing facilities, the former Atiko-Sapawe Gold Mine is located downstream of the Project within a different sub-watershed of the Seine River watershed. Runoff and seepage from the abandoned mining area will not mix with flows from Upper Marmion Reservoir until downstream of the Raft Lake dam. As there is no predicted change in water quality in the Upper Marion Reservoir during either operations, closure or into post-closure, the Project is not predicted to contribute to a change in water quality conditions downstream of the Raft Lake dam. Therefore, there is no predicted cumulative effect with respect to water quality and the aquatic environment.

Since there are no current activities at this site, there is no source of potential impact on other environmental (e.g., air quality, noise). Therefore, there are no pathways through which the Project could interact with the former Atiko-Sapawe Gold Mine.

6.8.3.6 Rainy River Resources – Rainy River Gold Project

Rainy River Resources' Rainy River Gold Project is a proposed mining project currently in the environmental assessment phase.

The Rainy River Resources project is located northwest of Fort Frances approximately 187 km from the Project. As a result the Project is unlikely to interact in any meaningful way with the Rainy River Resources project. There is no significant change in downstream flows at the Raft Lake Dam and, therefore, water resources in the Rainy River system will not be affected. Air emissions from the Project will meet provincial guidelines at the Project boundary and, accordingly, there will be no cumulative effect between the two projects. The distance between the two projects precludes cumulative impacts on biological resources (terrestrial and aquatic life).

The Rainy River Resources project may affect socio-economic factors, particularly through employment opportunities. However, these effects are likely to be positive. The Project will compete with a large number of resource projects in Canada, and will not likely have a measurable effect on the local workforce in the area of the Rainy River Resources project.

6.8.3.7 Bending Lake Iron Group – Josephine Cone Project

The Bending Lake Iron Group proposed Josephine Cone Project, located near Ignace, Ontario, is currently in the environment assessment phase. The proposed Josephine Cone Project is located approximately 50 km, north northwest of the Hammond Reef site. The project is located in a different watershed, and up-wind of the prevailing wind direction. As a result there is no potential for the identified physical or biological effects of the Hammond Reef Gold Project to extend to, and interact with, the Josephine Cone Project.

6.8.3.8 Treasury Metals – Goliath Project

The Treasury Metals proposed Goliath Project, located approximately 20 km east of the Town of Dryden, Ontario, is currently in the environment assessment phase. The project is located approximately 135 km northwest of the Hammond Reef site. The project is located in a different watershed, and up-wind of the prevailing wind direction. As a result there is no potential for potential impacts of the Hammond Reef Gold Project to extend to, and interact with, the Goliath Project.

6.8.3.9 Summary of Cumulative Environmental Effects

A summary of the predicted effects, and extent of any effects, is provided in Table 6-64.

The summary below shows that the predicted environmental impacts from the Project components are confined to the mine footprint and immediately adjacent areas of the local study area. Within the area of impact, the changes in the environmental components are minor and none of these are predicted to adversely affect local plant or animal populations, nor adversely affect surface or groundwater quality.

Since the predicted effects are being managed and mitigated such that only local changes will occur that will have no predicted significant impact on the environmental components, the cumulative effects assessment is conducted as a limited scope assessment. The lack of physical or biological effects from the Project beyond the immediate area of the mine development precludes far-reaching environmental effects that could interact with other projects, and reduces the need for a detailed assessment of cumulative effects against the VECs considered in the EA.

Table 6-64: Summary of Predicted Cumulative Environmental Effects

Project Component	Predicted Effect	Extent of Predicted Effect	Summary
Air Quality	Changes in air quality	Changes in air quality are confined to the Local Study Area	Changes in air quality beyond the local study area that could interact with other emissions sources are not predicted. There are no cumulative effects with respect to the atmospheric components of the Project and the four possible existing or reasonable future projects or activities that could potentially interact with the Project.
Noise	Increased noise levels due to project activities	Increases in noise levels are confined to the Local Study Area	Changes in noise levels beyond the local study area that could interact with other noise sources are not predicted.
Hydrology	Changes in water flows in mine area streams, and changes in lake levels in Lizard Lake and Upper Marmion Reservoir	Changes in stream flows are confined mainly to the MSA, with minor changes in some streams in the LSA. Lake level changes are less than 3 cm in Lizard Lake and less than 10 cm in Upper Marmion Reservoir.	Effects of the Project are confined to the mine area and immediately adjacent waterbodies. No downstream effects are predicted.
Hydrogeology	Changes in groundwater quantity and quality within the footprint of the mine due to development of the open pits and construction of infrastructure.	Effects are confined to the LSA.	Effects of the Project on groundwater are not predicted to extend beyond the mine footprint and adjacent areas of the LSA.
Water Quality	Changes in water quality due to operation of the mine and post-closure flooding of the open pits.	Minor changes in some parameters are predicted in Upper Marmion Reservoir and Lizard Lake during operations and in post-closure. These are not predicted to adversely affect aquatic life or other water uses. Effects are confined to the LSA.	No changes in water quality are predicted to occur downstream of Upper Marmion Reservoir. Predicted changes are minor increases in some parameters that are not predicted to affect aquatic life.
Terrestrial Ecology	Removal of vegetation and construction of infrastructure will eliminate some habitat in the MSA, and displace some species into the LSA and RSA.	Effects are confined to the mine and access road footprints. No effects are predicted beyond the LSA.	Habitat loss will be confined mainly to the MSA with some effects on immediately adjacent areas of the LSA. Wildlife species within the MSA will be displaced to the LSA and RSA. Effects beyond the LSA are not predicted to occur.
Aquatic Ecology	Loss of small aquatic habitats within the MSA, and some flow reduction in small stream in the LSA. Minor changes in lake levels in Lizard Lake and Upper Marmion Reservoir	Loss of aquatic habitats is confined to the footprint of the mine. Flow reductions and changes in lake levels are confined to immediately adjacent water bodies in the LSA. No effects predicted into the RSA.	Effects are confined to water bodies immediately adjacent to the proposed mine. No downstream effects on aquatic life are predicted due to changes in flows, changes in lake levels, and water quality.

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6.8.4 Socio-economic Effects

The planned projects in the vicinity of the Town of Atikokan, including the return to operation of the Atikokan Generating Station and the proposed wood processing facilities may affect socio-economic factors through creation of additional employment opportunities. This effect is likely to be positive, resulting in increased employment that is expected to result in higher wages locally as a result of competition for workers. Currently, unemployment in the town is higher due to the recent closure of two forest product mills in Atikokan and Sapawe. As a result, local workers are expected to fill the jobs that become available in Atikokan from the employment opportunities that result from the opening of the new wood processing facilities. Therefore, these employment opportunities are not expected to result in a significant increase in the work force that could result in an increased demand for public services in the Town of Atikokan.

The more distant projects, including the Rainy River Resources Project, the Josephine Cone Project and the Goliath Project may also affect socio-economic factors through employment opportunities. However, these effects are also likely to be positive. The Project will compete with a large number of resource projects in Canada, and will not likely have a measurable effect on the local workforce in the area of these projects as skilled workers will also be drawn from broader areas of Ontario and Canada. Workers attracted to these projects would not be expected to require resources from the Town of Atikokan. While the cumulative effects of a number of projects could drive up wages for skilled workers as demand increases, this is primarily an issue for the project proponents to address.

A summary of the potential cumulative effects to the socio-economic environment is provided in Table 6-65.

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Table 6-65: Potential Cumulative Effects to the Socio-economic Environment

VEC	Potential Effect	Interaction with Other Projects	Predicted Cumulative Effect
Population and Demographics	■ Direct job opportunities will attract workers to the area for short-term (i.e. construction) and longer term (i.e., operations) ■ Population change will result in changes in demand on social and physical services and infrastructure ■ The influx of workers due to the Project could benefit long-term economic and community development, supporting community vibrancy and improved social infrastructure (e.g., housing, organized recreation, support for local business, etc.)	■ Competition for skilled workers. ■ Increased employment in Atikokan. Local workers are expected to fill the new jobs from the projects in Atikokan, with minimal influx of new workers anticipated. ■ Other projects located outside of the local area would not affect services and infrastructure in Atikokan.	■ None
Labour Market (Employment, Income and Training)	■ Sustainable employment and training opportunities can develop transferable skills, and have long-term regional and local economic benefits ■ Creation of opportunities for local contractors and suppliers ■ Local recruitment, training and employment opportunities ■ Timing and number of employment opportunities may affect labour market	■ Potential employment opportunities for workers at other projects. ■ Impetus for creation of local supply network that could enhance business opportunities for future projects.	■ Potential for wage increases regionally through competition for skilled workers
Government Finances	■ Governments will benefit through increased tax and fee for service revenues ■ Governments incur costs related to the provision of services	■ Regional contribution to tax base will increase	■ Regional tax base will increase.
Public Services and Infrastructure	■ Population increase in the LSA increases demand on services (health, emergency and protection, education, recreation) and water and waste infrastructure ■ Project activities may increase demand for health, emergency services and waste/water infrastructure if existing capacity is exceeded	■ Other local projects are not predicted to affect demand for services in the LSA. ■ Impacts from more distant projects are expected to be confined to their respective local communities.	■ None
Housing and Accommodation	■ Influx of workers and families may lead to changes in demand, availability and cost of temporary and permanent housing and tourism accommodation	■ Other local projects are not predicted to affect demand for housing in the LSA. ■ Impacts from more distant projects are expected to be confined to their respective local communities.	■ None
Transportation	■ The Project will affect existing road and transportation network due to movement of Project workers, equipment, supplies and products	■ Other local projects will be developed at sites of former projects with existing road access ■ Regional projects are not expected to impact existing road and transportation networks in the Project area	■ None
Outdoor Tourism and Recreation	■ The Project may affect tourism and recreation activities and opportunities ■ The Project may affect employment and income generation by tourism operators	■ Other local and regional projects are not expected to affect tourism and recreational activities in the Project area	■ None
Hunting	■ The Project may occupy or affect the land base which supports hunting	■ Other local and regional projects are not expected to affect hunting activity in the Project area	■ None

Table 6-65: Potential Cumulative Effects to the Socio-economic Environment (Continued)

VEC	Potential Effect	Interaction with Other Projects	Predicted Cumulative Effect
Trapping	■ The Project may occupy or affect the land base which supports trapping	■ Other local and regional projects are not expected to affect trapping activity in the Project area	■ None
Fishing	■ The Project may occupy land and water which supports fishing activities	■ Other local and regional projects are not expected to affect fishing activity in the Project area	■ None
Mining	■ The Project may affect current and future mining activity	■ Future mining activity will depend on the presence of economic resources and is independent of other projects	■ None
Forestry	■ The Project may occupy productive forest land ■ The Project may affect existing or future land use for forestry	■ The Project footprint is small relative to the available forest resources in the area, therefore, the project is not expected to affect forestry	■ None
Water Use and Access	■ The Project has the potential to directly affect the use of and access to water bodies such as the Marmion Reservoir. ■ The Marmion Reservoir is an important resource for recreational fisheries and tourism, hydro-electric power and other commercial and industrial uses.	■ The predicted changes in water levels and flows from Marmion Reservoir due to the Project are not predicted to adversely affect navigation and downstream water use ■ All other local and regional projects are located downstream of the Project or in different watersheds and are not expected affect water use within the Marmion Reservoir – Seine River system	■ None