5.0 EXISTING ENVIRONMENT

5.1 Climate and Meteorology

Climate and meteorology represent two important, and related aspects of the weather that are relied on in the EIS. Climate is defined by Environment and Climate Change Canada (2017) as the “prevalent or characteristic weather conditions of a place or region over a period of years”, while meteorology is defined simply as the “…weather of a region” (Webster’s, 2017). In other words, climate is the weather you expect, while meteorology is the weather you get.

The long-term climate information is relied on the EIS for characterizing the expected rainfall, precipitation and evaporations patterns in the region that will be relied on for understanding the water budgets and balances for the Project. This information is directly relied on in evaluating the surface water quantity (hydrology) patterns, as well as providing information relied on in the design and sizing of the facilities and structures for managing the water at the Project.

The primary use for meteorological information is as inputs to the numerical modelling completed to assess the effects of the Project on air quality. Specifically, the regulatory approved model used for assessing air quality effects requires a meteorological data set containing five years of hourly meteorological observations.

5.1.1 Study Area and Data Sources

In characterizing the existing climatic conditions for the Project, it is necessary to find stations that provide a sufficiently long period of record (at least 30 years). It is also important that the selected stations have data that is representative of the current conditions within the region. A review of the information available from Environment and Climate Change Canada (formerly Environment Canada) identified that the closest relevant stations are located in Dryden Ontario. Over the years the stations in Dryden have moved several times, and have been upgraded to make use of advances in technology. The current station operated in Dryden is referred to as Dryden A (aut). The station is located at Dryden airport, and has been operating since 1999. This station was commissioned beside the Dryden A station, which was operating from at Dryden airport from 1970 through 2005. Other stations in operated in Dryden include the Dryden Regional (2010–2011) and Dryden (1914–1997). The Dryden A and Dryden A (aut) are considered to be the same station and are relied on in the assessment for characterizing the climate used in the assessment. Table 5.1.1-1 provides a listing of the available climate data for Dryden.

Table 5.1.1-1: Climate Data Availability for Dryden

EC Station	Station Number	Period of Record	Distance from Project	Elevation
Dryden Regional	6032125	2010–2011	12.2	412.7
Dryden	6032117	1914–1997	16.0	371.9
Dryden A (aut)	6032120	1999–2017	12.5	412.7
Dryden A	6032119	1970–2005	12.9	412.7

5.1.2 Climate Overview

The Project site is located in the west-central portion of the Boreal Shield Ecozone, experiencing a continental climate, generally characterized by short mild summers and long cold winters with relatively low precipitation. The terrain is generally flat and absent of orographic features which can block air masses or produce localized increases in precipitation.

5.1.3 Climate Conditions

Table 5.1.3-1 provides the long-term climate data relied on in the assessment in addition to the average (normal) conditions. The table lists the 1 in 20 dry year (5th percentile) and 1 in 20 wet year (95th percentile) precipitation data used to evaluate the range of conditions likely over the relatively short life of the Project.

5.2 Air Quality

This section provides a description of the existing air quality conditions in the Project area. As part of the Environmental Air Quality Assessment, completed by RWDI Air Inc., a Baseline Ambient Air Quality assessment was completed (Appendix J). The relevant details have been summarized in the following sections. The full Baseline Ambient Air Quality assessment is presented in Section 3.2 of the Environmental Air Quality Assessment in Appendix J-2.

5.2.1 Air Quality Study Area

The Project study area is located in a mostly forested area between the communities of Dryden and Wabigoon and north of Highway 17 (Figure 5.2.1-1). The proposed Project site is at least 10 km from any existing sources of significant air emissions. There are several aggregate operations on the east side of Airport Road in Dryden. The town of Dryden, located approximately 15 km to the west, is home to a kraft pulp mill operated by Domtar, which would contribute to the background air quality in the area, primarily due to emissions from the natural gas and wood-waste fired boilers, recovery boiler and lime kiln. Due to the distance between sources at the Domtar pulp mill, the aggregate operations and the Project site, significant interaction between these sources are expected to be minimal. 44 receptors of interest have been identified in the study area. These include a campground within Aaron Provincial Park, a trailer on otherwise vacant land, and 42 residences, mostly contained within the residential developments along Thunder Lake.

5.2.2 Assessment Criteria and Methods

The ambient air quality assessment has been completed based on a combination of Canadian Ambient Air Quality Standards (CAAQSs), National Ambient Air Quality Objectives (NAAQOs) and the Ontario Ministry of the Environment and Climate Change (MOECC) Ontario Ambient Air Quality Criteria (OAAQC) including Schedule 3 Standards, Guidelines, and Jurisdictional Screening Levels (JSL's) as prescribed under Ontario Regulation 419/05 (O.Reg.419/05).

Table 5.1.3-1: Climate Data Used in Assessment

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Percent
Dryden A (6032119) 1981 - 2010 Climate Normals														
Precipitation (mm) (1,4)	26.5	20.0	29.9	39.6	73.4	115.2	103.1	83.7	88.9	63.6	46.7	29.1	719.7	100.0%
Rain (mm) (1)	0.2	2.1	6.7	24.7	69.2	115.2	103.1	83.5	87.7	49.2	13.0	1.2	555.8	77.2%
Snow (mm equivalent) (2)	26.3	17.9	23.2	14.9	4.2	0.0	0.0	0.2	1.2	14.4	33.7	27.9	163.9	22.8%
Monthly Distribution of Rain, Snow, and Precipitation as Percentage of Total Annual Precipitation														
Precipitation (%)	3.7	2.8	4.2	5.5	10.2	16.0	14.3	11.6	12.4	8.8	6.5	4.0	100.0	—
Rain (%)	0.0	0.3	0.9	3.4	9.6	16.0	14.3	11.6	12.2	6.8	1.8	0.2	77.2	—
Snow (%, mm equivalent)	3.7	2.5	3.2	2.1	0.6	0.0	0.0	0.0	0.2	2.0	4.7	3.9	22.8	—
Monthly Rain, Snow, and Precipitation for the Project – Average Year														
Precipitation (mm) (3,4)	24.7	18.7	27.9	36.9	68.5	107.5	96.2	78.1	82.9	59.3	43.6	27.1	671.4	100.0%
Rain (mm)	0.2	2.0	6.3	23.0	64.6	107.5	96.2	77.9	81.8	45.9	12.1	1.1	518.5	77.2%
Snow (mm equivalent)	24.5	16.7	21.6	13.9	3.9	0.0	0.0	0.2	1.1	13.4	31.4	26.0	152.9	22.8%
Monthly Rain, Snow, and Precipitation for the Project – Dry Year														
Precipitation (mm) (3)	17.1	12.9	19.3	25.6	47.4	74.4	66.6	54.1	57.4	41.1	30.2	18.8	465.1	100.0%
Rain (mm)	0.1	1.4	4.3	16.0	44.7	74.4	66.6	54.0	56.7	31.8	8.4	0.8	359.2	77.2%
Snow (mm equivalent)	17.0	11.6	15.0	9.6	2.7	0.0	0.0	0.1	0.8	9.3	21.8	18.0	105.9	22.8%
Monthly Rain, Snow, and Precipitation for the Project – Wet Year														
Precipitation (mm) (3)	32.3	24.4	36.5	48.3	89.5	140.5	125.7	102.1	108.4	77.6	57.0	35.5	877.7	100.0%
Rain (mm)	0.2	2.6	8.2	30.1	84.4	140.5	125.7	101.8	107.0	60.0	15.9	1.5	677.8	77.2%
Snow (mm equivalent)	32.1	21.8	28.3	18.2	5.1	0.0	0.0	0.2	1.5	17.6	41.1	34.0	199.9	22.8%

Notes:

(1) Environment Canada Climate Normals 1981 to 2010 for Dryden A (6032119) were obtained from Environment Canada's website: <http://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?searchType=stnName&txtStationName=dryden&searchMethod=contains&txtCentralLatMin=0&txtCentralLatSec=0&txtCentralLongMin=0&txtCentralLongSec=0&stnID=3953&dispBack=0>; accessed on December 6, 2016.

(2) Snow values are calculated as precipitation minus rainfall and are reported as mm of water equivalent. Values here do not directly match 1981 to 2010 climate normals for the Dryden A (6032119) station, which are reported as cm as snow, due to variation in snowfall density leading to some minor deviations from reported climate normals.

(3) Total annual precipitation values for average and 20 year wet and dry scenarios were determined from annual totals from three Environment Canada climate stations covering a period of 1970 - 2015. The stations were: Dryden A (6032119) from 1970 - 2004; Dryden A (AUT) (6032120) from 2005 - 2009; and Dryden Regional (6032125) from 2011 to 2015. Data for 2010 was excluded from the analysis as it was incomplete, missing values for October through December. A normally distributed random variable with a mean of 671.4 mm and a standard deviation of 125.4 mm was fit to the annual precipitation totals. The 20 year dry and wet scenarios are represented by the 5th and 95th percentiles, respectively, of the normally distributed random variable.

(4) It is noted that the 1981 to 2010 climate normals for Dryden A have a total annual precipitation of 719.7 mm, while the average annual precipitation for the 1970 to 2015 is only 671.4 mm (Note 3). This difference may be partially explained by the inclusion of 2011 to 2015 years, all of which had total annual precipitation below 600 mm, and which had an average annual precipitation of 497.5 mm. If only the years 1981 - 2010 are considered in the set of annual precipitation data generated in Note 3, then the annual average precipitation is 698.8 mm, which is still less than the 1981 to 2010 climate normals for Dryden A, but is a deviation of only 2.9%. This remaining difference is likely due to the merging of different data sets; however, this was necessary to do since access to the Dryden A precipitation data was not available from the Environment Canada website beyond the year 2004

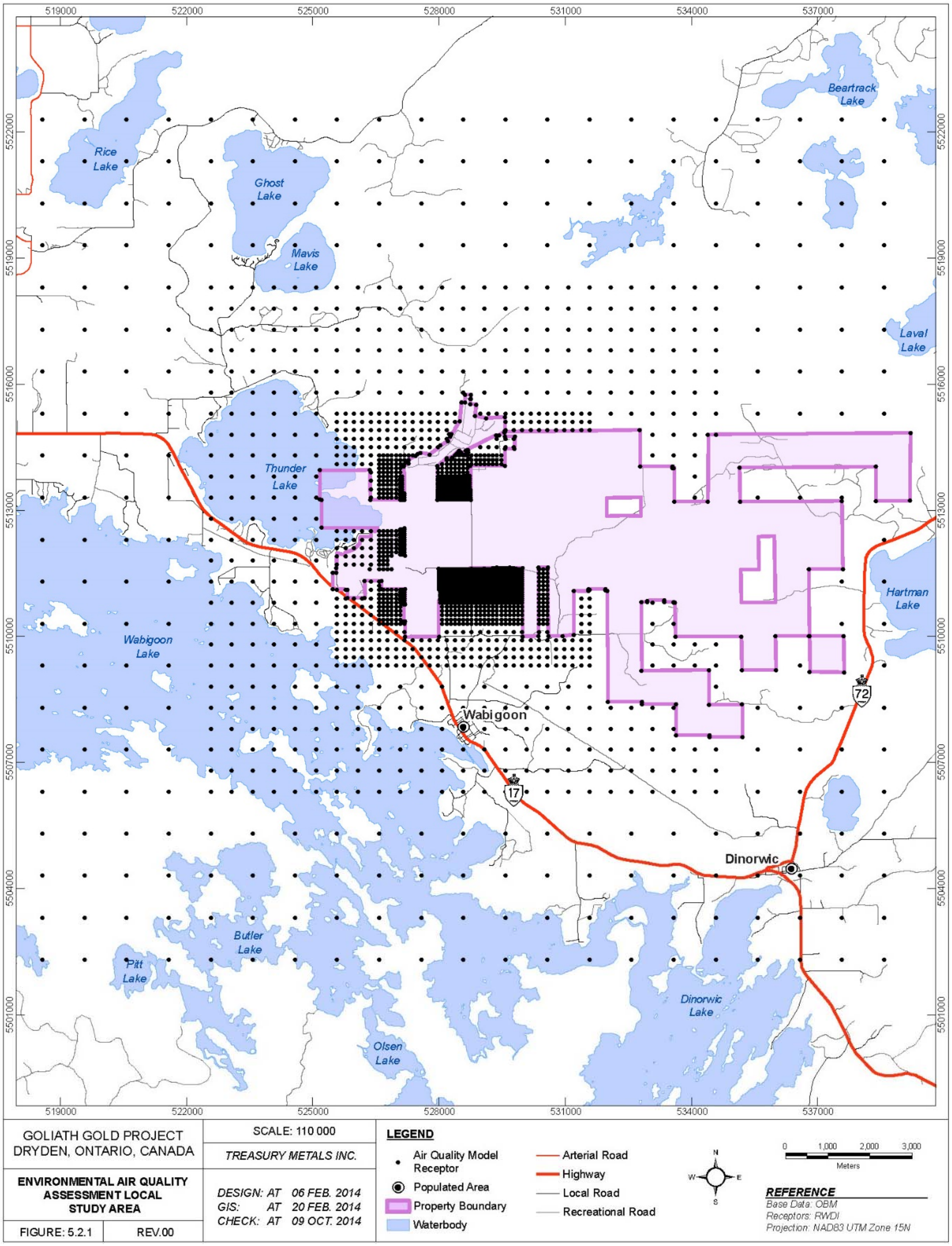

Figure 5.2.1-1: Air Quality Local Study Area

The assessment criteria employed are presented in detail in Table 5.2.2-1. These criteria are intended to guard against adverse effects including health, odour, vegetation, soiling, visibility, corrosion or other suitable end-points. A number of different averaging periods are required under the relevant regulatory regimes to account for potential short-term acute exposures and long-term chronic exposures. Where more than one criteria is presented, the most stringent criteria were selected as the threshold for each contaminant of concern.

Table 5.2.2-1: Air Quality Assessment Criteria

Air Quality Indicator	Averaging Time	National Air Quality Objectives			Canadian Ambient Air Quality Standards (μg/m³)	Ontario Ambient Air Quality Criteria (μg/m³)	Threshold (μg/m³)
		Desirable (μg/m³)	Acceptable (μg/m³)	Tolerable (μg/m³)			
TSP	24 hr	-	120	400	-	120	120
	Annual	60	70	-	-	60	60
PM10	24 hr	-	-	-	-	50	50
PM2.5	24 hr	-	-	-	28 27 [2]	-	27
	Annual	-	-	-	10 8.8 [2]	-	8.8
Dustfall [1]	30 day	-	-	-	-	7	7
	Annual	-	-	-	-	4.6	4.6
SO_2	1 hr	450	900	-	-	690	450
	24 hr	150	300	800	-	275	150
	Annual	30	60	-	-	55	30
NO_2	1 hr	-	400	1000	-	400	400
	24 hr	-	200	300	-	200	200
	Annual	60	100	-	-	-	60
CO	1 hr	15,000	35,000	-	-	36,200	15,000
	8 hr	6,000	15,000	20,000	-	15,700	6,000
Aluminum	24 hr	-	-	-	-	4.8 (JSL)	4.8
Antimony	24 hr	-	-	-	-	25	25
Arsenic	24 hr	-	-	-	-	0.3	0.3
Barium	24 hr	-	-	-	-	10	10
Beryllium	24 hr	-	-	-	-	0.1	0.1
Bismuth	24 hr	-	-	-	-	-	N/A
Cadmium	24 hr	-	-	-	-	0.025	0.025
Calcium	24 hr	-	-	-	-	-	N/A
Chromium	24 hr	-	-	-	-	0.5	0.5
Cobalt	24 hr	-	-	-	-	0.1	0.1
Copper	24 hr	-	-	-	-	4	4
Gallium	24 hr	-	-	-	-	-	N/A
Gold	24 hr	-	-	-	-	-	N/A
Iron	24 hr	-	-	-	-	25	25
Lanthanum	24 hr	-	-	-	-	-	N/A
Lead	24 hr	-	-	-	-	0.5	0.5
Lithium	24 hr	-	-	-	-	20	20
Magnesium	24 hr	-	-	-	-	120	120
Manganese	24 hr	-	-	-	-	0.4	0.4

Table 5.2.2-1: Air Quality Assessment Criteria (continued)

Air Quality Indicator	Averaging Time	National Air Quality Objectives			Canadian Ambient Air Quality Standards (µg/m³)	Ontario Ambient Air Quality Criteria (µg/m³)	Threshold (µg/m³)
		Desirable (µg/m³)	Acceptable (µg/m³)	Tolerable (µg/m³)			
Molybdenum	24 hr	-	-	-	-	120	120
Nickel	24 hr	-	-	-	-	0.04	0.04
Palladium	24 hr	-	-	-	-	10	10
Phosphorous	24 hr	-	-	-	-	0.35 (JSL)	0.35
Platinum	24 hr	-	-	-	-	0.2	0.2
Potassium	24 hr	-	-	-	-	28	28
Rhodium	24 hr	-	-	-	-	0.4 (JSL)	0.4
Scadium	24 hr	-	-	-	-	-	N/A
Selenium	24 hr	-	-	-	-	10	10
Silver	24 hr	-	-	-	-	50	50
Sodium	24 hr	-	-	-	-	10	10
Strontium	24 hr	-	-	-	-	120	120
Sulphur	24 hr	-	-	-	-	20 (JSL)	20
Thallium	24 hr	-	-	-	-	0.24	0.24
Thorium	24 hr	-	-	-	-	-	N/A
Tin	24 hr	-	-	-	-	10	10
Titanium	24 hr	-	-	-	-	120	120
Tungsten	24 hr	-	-	-	-	4 (JSL)	4
Uranium	24 hr	-	-	-	-	0.03	0.03
Vanadium	24 hr	-	-	-	-	2	2
Yttrium	24 hr	-	-	-	-	2.4 (JSL)	2.4
Zinc	24 hr	-	-	-	-	120	120

5.2.3 Baseline Air Quality Sources

The existing baseline ambient air quality indicator levels at the Project site were estimated based on data from two (2) MOE monitoring stations in the Thunder Bay area (MOE Stations No. 63203 and 63064; Figure 5.2.3-1). As these stations are located in a more urbanized area than the project site the recorded data is expected to reflect an overestimate of typical concentrations of contaminants of concern. As the maximum measured values represent peak events which occur infrequently, the 90th percentile values (i.e., exceeded <10% of the time), which are more representative of the typical maximum background conditions have been used. These 90th percentile values are more likely to coincide with maximum contributions from the project related emissions. These values are then compared against the relevant criteria.

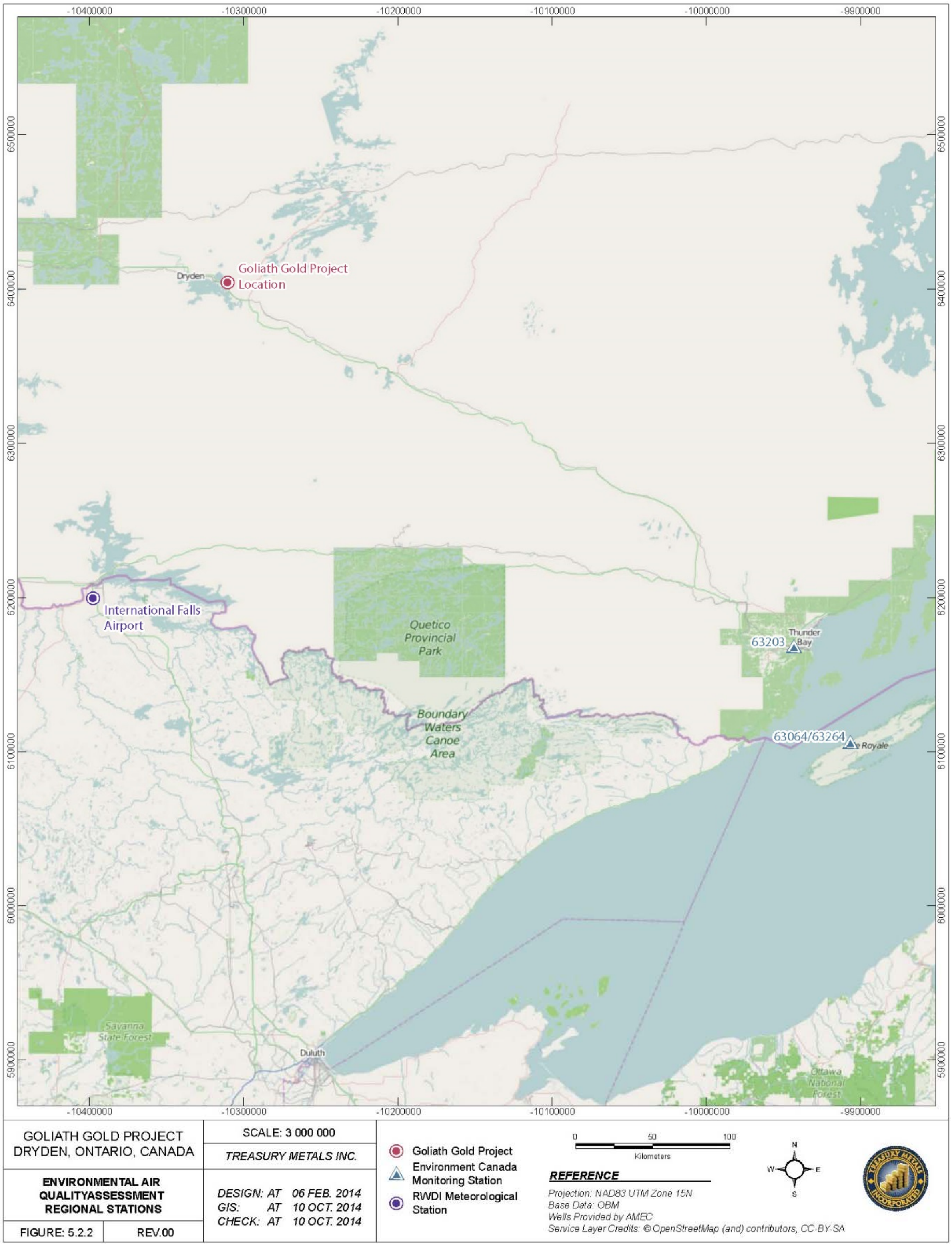

Figure 5.2.3-1: Regional Air Quality Monitoring Stations

5.2.4 Existing Baseline Air Quality

The measured ambient air quality data from the MOE monitoring stations is presented in Table 5.2.4-1 along with a comparison of each value to the relevant assessment criteria. The MOE monitoring station results indicate that the existing baseline ambient air quality levels do not exceed the relevant assessment criteria.

Table 5.2.4-1: Measured Ambient Air Quality Data from the MOE Monitoring Stations

Air Quality Indicator	Monitoring Period	Averaging Period	90th Percentile Concentration (µg/m^3)	Threshold (µg/m^3)	Percent of Threshold
TSP	2007 - 2011	24 hr	33	120	28%
		Annual	14	60	23%
PM10	2007 - 2011	24 hr	15	50	30%
PM2.5	2007 - 2011	24 hr	10	27	37%
		Annual	4.3	8.8	49%
SO_2	1999 - 2003	1 hr	4	400	1%
		24 hr	4	200	2%
		Annual	1	60	2%
NO_2	2007 - 2011	1 hr	33	450	7%
		24 hr	33	150	22%
CO	2000 - 2003	1 hr	1,248	15,000	8%
		8hr	1,248	6,000	21%

There is very little variation in concentrations over the course of the day, as can be seen by the negligible variation in the 1 hour average and 24 hour average concentrations measured for NO_2 and SO_2. The existing ambient air quality levels near the Project site are expected to be typical of other forested areas of Northern Ontario. However; as the only available data near the Project site is from an urban area, this data is expected to be a conservative overestimate of current local conditions.

Although no ambient metals data were available from the existing stations, a conservative estimate of airborne metals for use to support the assessment was done using the metals assay results on waste rock material to represent the average crustal composition in the area for arsenic (As), chromium (Cr), manganese (Mn), and lead (Pb). The calculations are considered conservative as the actual surface soils in the area would contain a large portion of organic material, which would have virtually no metals present. Additionally, the background concentrations for airborne particulate matter was taken from the Thunder Bay Stations, which is expected to have higher background concentrations than we would collect in the relatively undeveloped area of the mine site. Table 5.2.4-2 provides the predicted background concentrations of airborne metals based on the background particulate levels from Thunder Bay, and the metals assay results for the waste rock.

Table 5.2.4-2: Estimated Background Concentrations of Airborne Metals

Compound	Average Composition in Waste Rock (ppm)	Background Concentration[(a)] (µg/m³)
TSP	—	33
As	32	0.001056
Cr	143	0.004719
Mn	562	0.018546
Pb	143	0.004719

Note: (a) Background concentrations are calculated as the product of the background TSP value for Thunder Bay, and the relative metal assay composition for the waste rock.

5.3 Acoustic and Light Environment

This section provides a description of the existing noise and light conditions at the Project.

5.3.1 Baseline Noise Levels

A baseline noise study was conducted in December 2011 and July 2013 and the results have been summarized in the following sections. The full study report is presented in Appendix H-1.

5.3.1.1 Study Area

The Project study area is in a rural location between the communities of Dryden and Wabigoon and north of Highway 17 with characteristics of a Class 3 area (MOE 1995). Potential receptors include the City of Dryden, the community of Wabigoon, and Aaron Provincial Park and residential developments along Thunder Lake. Potential sources of noise include the above developments as well as Highway 17 and the mainline of the Canadian Pacific Railway. Sampling locations were selected based on the location of the emission sources, potential receptor locations, and the expected transport and propagation of noise (Figure 5.3.1.1-1).

5.3.1.2 Assessment Criteria and Methods

In Class 3 areas, rural, recreational, or wilderness, the applicable MOE "Stationary Source" guidelines are provided in MOE Publication NPC-232 (MOE 1995). The guidelines state that one-hour sound exposures (L_{EQ}, 1-hr dBA values) from stationary noise shall not exceed that of the background, where the background is defined as the sound level present in the environment produced by noise sources other than those associated with the facility under assessment. The MOE Publication NPC-232 sound level limits are as follows:

- The higher of 45 dBA or background noise, during the daytime hours (0700 to 1900 h);
- The higher of 40 dBA or background noise, during the evening hours (1900 to 2300 h); and

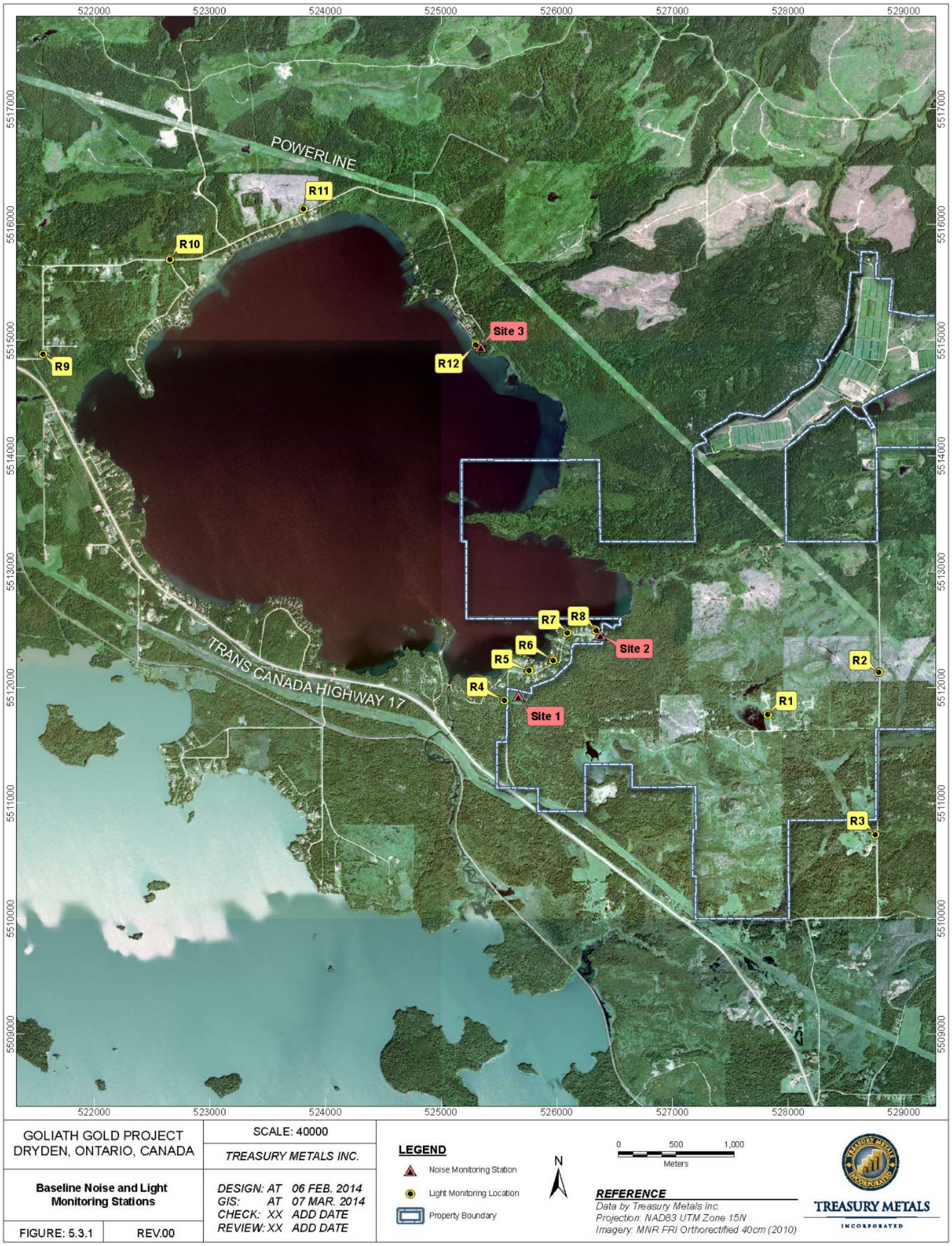

Figure 5.3.1.1-1: Baseline Noise and Light Monitoring Stations

- The higher of 40 dBA or background noise, during the night-time hours (2300 to 0700 h).

The applicable guideline limit is the higher of the measured background sound level and the guideline minimum sound level limit. The above sound level limits are the applicable for the receptors surrounding the Project.

The basic procedures for the baseline assessment consists of long-term background sound level measurements of receptors near the Project, validation of measured hourly data based on weather information, and comparing the validated lowest hourly sound level data to the guideline limits. Long-term measurements of background ambient sound levels at one location were conducted from December 5 to December 7, 2011, near the Project site (Figure 5.3.1.1-1). Monitoring was also conducted at three representative locations from July 3 to July 9, 2013 (Figure 5.3.1.1-1). All measurements were conducted in accordance with the applicable requirements of MOE Publication NPC-103 (MOE 1977).

5.3.1.3 Existing Noise Levels

The measured ambient sound levels at the Project site (Tables 5.3.1.3-1) were similar to background ambient sound levels characteristic of remote areas (25 to 45 dBA). The sound from these levels would be described as faint. Noise observed during the study consisted mostly of wind, small animals, bird noise and vehicle noise from the TransCanada Highway. The difference between daytime and nighttime sound levels were generally small, and are attributed mainly to very low level of noise from human activity which could not be screened out. The noise measurement results indicate that the existing baseline sound levels did not exceed the guideline sound level limits (MOE 1995). The existing baseline noise levels are typical of northwestern Ontario conditions.

Table 5.3.1.3-1 Ambient Sound Levels at the Goliath Gold Project

Location	Time Period	L_{EQ} (1hr)	L_{MIN}	L_{MAX}	NPC-232 Minima[1]	Resultant Limit
Site 1	Day	39	30	70	45	45
	Evening	38	30	66	40	40
	Night	35	29	67	40	40
Site 2	Day	38	20	68	45	45
	Evening	37	27	63	40	40
	Night	32	19	68	40	40
Site 3	Day	32	21	69	45	45
	Evening	35	24	69	40	40
	Night	28	20	62	40	40

[1] MOE (1995)

5.3.2 Baseline Light Levels

A baseline light assessment study was conducted in July 2013 and the results have been summarized in the following sections. The full study report is presented in Appendix I.

5.3.2.1 Study Area

The area surrounding the Project site is a mix of mostly forested and some open rural land cover. The topography in the area is generally low, rolling hills, with elevation decreasing along the shoreline of Thunder Lake to the west of the Project site, and again along Wabigoon Lake to the west/southwest of the Project site. The closest residences are located along East Thunder Lake Road, which runs along the western edge of the Project property boundary. Additionally, there are other pockets of houses/cottages along the shore of Thunder Lake and Wabigoon Lake further away from the Project site. Generally, the surrounding area is sparsely populated and the land is heavily treed.

Light effects beyond 1 km are typically comparable to general lighting in the vicinity of the receptor (e.g., streetlights, garage lights). A light study area extending 1 km from the Project property boundaries was therefore selected to determine receptors/sampling sites that could be directly affected by the Project. Representative receptors on the far side of Thunder Lake were also sampled since the lake body provides an unobstructed line of sight to the Project property. Therefore, the light study area was therefore conservative as the Project infrastructure will be centrally located on the property and screened from the potential receptors by terrain.

A total of 12 receptor locations were determined for the purpose of the baseline light assessment. Receptors R1 through R3 are located on/within the Project site boundary, while receptors R4 through R8 and R12 are neighbouring residences or cottages within 1 km of the property boundary on the shoreline of Thunder Lake (see Figure 5.3.1.1-1). Receptors R9 through R11 are the representative receptors for clusters of cottages located on the far (west) shoreline of Thunder Lake from the Project Site, and were grouped for reasons of sharing similar viewscapes and topographic features.

5.3.2.2 Assessment Criteria

In Ontario, there are no provincial guidelines or regulations governing light trespass. Therefore, the study relied on information from other sources. Lighting criteria for illuminance are available from the U.S. Green Building Council Leadership in Energy and Environmental Design (LEED; USGBC 2007. The Illuminating Engineering Society (IES) of North America recommends a minimum lighting level of 5.4 lux for safety. The IES also recommends 5 to 22 lux for outdoor pedestrian walkways, and about 100 lux for interior stairways (malls). Interiors of buildings typically measure in the hundreds of lux.

The light that escapes the Project site (known as light trespass) can be regarded as a nuisance by property owners immediately adjacent or in relatively close proximity to the Project. For the baseline light assessment, only measurements of illuminance, the perceived power of light per unit area, were taken, which is the appropriate measurement to assess baseline conditions. Relative brightness, also known as glare, was not measured as the Project has not been constructed or exterior lighting installed.

5.3.2.3 Existing Light Levels

Existing (baseline) conditions represent the current light levels within the light study area and are presented in Table 5.3.2.3-1. Baseline illuminance measurements at the selected receptors were all below the LEED criteria for rural residential areas (1.1 lux) with the exception of sample sites that were directly influenced by a local light source such as a street light or exterior house light near the measurement location. Any areas, including the three sample sites that were on the Project property, that were away from these types of direct sources were generally measured to be 0.0 lux.

Table 5.3.2.3-1: Baseline Light Levels within the Light Study Area

Receptor ID	Site ID	Type	UTM Northing	Easting	Illuminance (lux)				Description
					Direct				
					2-Jul-13	2-Jul-13	3-Jul-13	3-Jul-13	
R1	1	Goliath Gold Site	527822	5511764	0.00	0.00	0.00	0.00	Center of Proposed Pit
R2	2	Goliath Gold Site	528782	5512129	0.00	0.00	0.00	0.00	East of Proposed Pit
R3	3	Goliath Gold Site	528751	5510726	0.00	0.00	0.01	0.00	Nystrom House on Tree Nursery Road
R4	4	Receptor	525549	5511888	0.00	0.00	0.01	0.00	Field to east of E Thunder Lake Road (Noise Site #1)
R5	5	Receptor	525760	5512145	2.40	4.00	2.70	4.30	249 E. Thunder Lake Road, next to street light on road, edge of pavement and gravel
R6	6	Receptor	525969	5512235	0.21	3.00	0.21	3.20	Measured ~14 m from road near the hydro station (SW2), next to street light near location 1A
R7	7	Receptor	526092	5512473	0.00	0.00	0.00	0.03	352 E. Thunder Lake Road
R8	8	Receptor	526338	5512493	0.00	0.50	0.00	0.00	At Noise Site # 2, light from resident, front door light on house
R9	9	Receptor	521559	5514880	0.00	15.20	0.00	15.10	65 Thunder Lake Road. Edge of road pavement to gravel. Pointed at streetlight.
R10	10	Receptor	522658	5515699	1.40	0.00	4.10	0.00	Taken under street light corner of North Shore and Thunder Lake Road (Stop sign)
R11	11	Receptor	523810	5516134	0.03	0.22	0.02	0.19	North side of Thunder Lake, pointed at residence, measured from edge of road, approximately 12 m from light source
R12	12	Receptor	525296	5514963	0.05	0.19	0.02	0.17	Johnsons Beach (by Noise Site 3)

5.4 Geology

5.4.1 Geological Setting

The Project area is located within the volcano-plutonic Eagle-Wabigoon-Manitou Greenstone Belt in the Wabigoon Subprovince of the Archaean Superior Province, and is on the north side of the regional Wabigoon fault. This Greenstone Belt consists of a 150 km-wide domain that has an exposed strike extent of 700 km. The full strike length of the Greenstone Belt is unknown since it is overlain by Palaeozoic strata on both ends.

The geology on the northern side of the Wabigoon Fault is characterized by generally southward-facing, alternating panels of metavolcanic and metasedimentary rock.

Geohazards (e.g., landslides, avalanches) associated with mountainous environments are not expected due to the topographic characteristics of the Project site which is located in a relatively flat area within low relief surroundings with a 140 m vertical variability within 20 km of the site. In addition, the Project site is located within the Interior Platform Seismic Zone which is defined as a "Low" relative hazard region by Natural Resources Canada.

There are no known sites of paleontological or palaeobotanical significance in the Project area.

5.4.2 Deposit Geology

Major lithological units within the project area were identified on the basis of visual examination of rock type in outcrops, drill core, and trenches. These rocks have been grouped into the Thunder Lake Assemblage; a volcanogenic-sedimentary complex of felsic metavolcanic rocks and clastic metasedimentary rocks that underlies much of the Project area, and the Thunder River Mafic metavolcanic rocks, which are generally massive but are pillowed locally and include amphibolite and mafic dykes, characterized as chlorite schists, and underlie the south part of the project area (Figure 5.4.2-1).

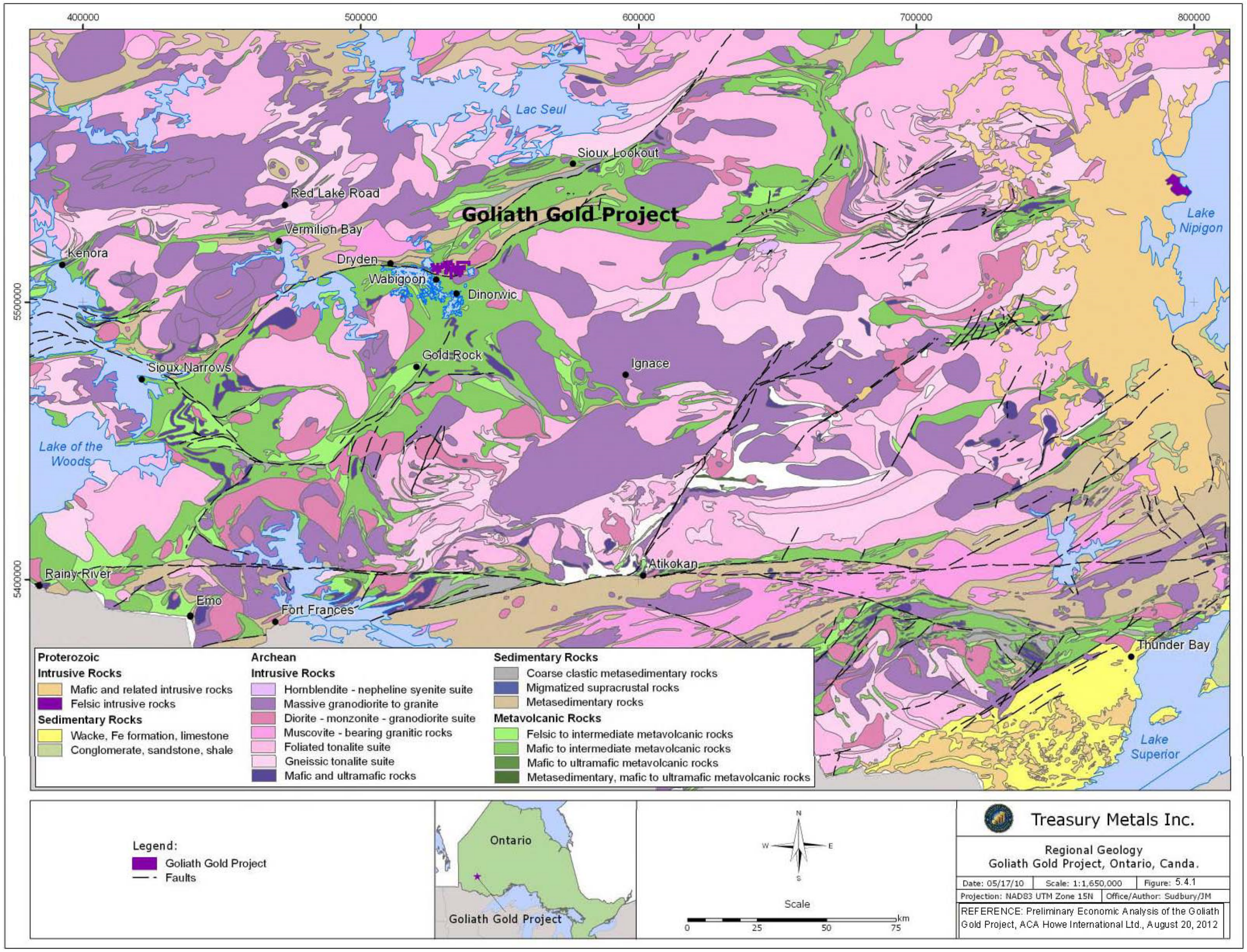

Figure 5.4.2-1: Regional Geology

5.4.2.1 Thunder Lake Assemblage

The main sedimentary unit within the Thunder Lake Assemblage is described as being dominated by biotite-muscovite and biotite schist (greywackes) with subordinate inter-layered metasediment (probably pyroclastic siltstone and arkose sandstone) which exhibits highly strained and well-preserved primary sedimentary structures such as graded bedding, scour, rip-up clasts etc. This unit also includes ink blue magnetite layers that are closely associated with distinctive garnet-rich layers and calc-silicate rock. The felsic metavolcanic rocks within the Thunder Lake Assemblage comprise quartz-porphyritic felsic to intermediate metavolcanic rosk represented by biotite gneiss, mica schist and quartz-porphyritic mica schist, which are conformably inter-layered with wacke-siltstone, and with lenses of metasedimentary rocks, which are similar in composition to the main sedimentary unit.

All of the rocks have been subjected to folding and moderate to intense shearing with local hydrothermal alteration, quartz veining, and sulphide mineralization. Schistosity is commonly developed within both the metasedimentary rocks and volcanic rocks, exhibiting a similar orientation with a strikes of around 90° and dips from 70° to 80° south-southeast.

The primary components of the Thunder Lake Assemblage are described as follows:

- Biotite muscovite schist: Dark grey to grey, fine to medium grained mica schist. Usually it consists of intercalated leucocratic and melanocratic bands. This unit contains a high number of grey to milky white quartz veins. Most of the veins are 1 to 15 cm wide, parallel or crosscutting the foliation. Some veins are associated with highly chloritized and silicified intervals with tourmaline and sulphides.

- Muscovite sericite schist: Light grey to beige grey, fine to medium grained quartz- sericite schist. It is variably siliceous, commonly contains interbedded, dark grey biotite-muscovite bands and grey to milky white quartz veins. It is characterized by the presence of moderate to strong pervasive sericite alteration and gold and silver bearing disseminated sulphides.

- Iron formation: Dark greenish grey calc-silicate metamorphic rocks, which include coarse to medium grained gneiss, biotite schist, 10 to 15 cm wide distinctive layers enriched with garnet, chlorite and narrow ink blue magnetite bands. The rock unit is magnetic and contains disseminated pyrite.

- Metasediment: Grey to dark grey-green medium grained massive unit, which consists of biotite, feldspar, quartz, muscovite with a weak patchy potassium and sericite alteration and rare hematite (rusty brown) alteration. Foliation is poorly developed but more prominent in contact and altered areas. Quartz veins, parallel or crosscutting the foliation are very common. This unit can be distinguished by presence of numerous “quartz eyes” or quartz porphyroblast. This unit may contain 1 to 5% bleb-finely disseminated pyrite and chalcopyrite.

- Biotite schist: Dark grey to black, fine to medium grained, slightly to well-foliated schist. Locally contains disseminated pyrite in the foliation planes and fractures.

- Chloritic-Biotite schist: Dark grey to greenish grey medium grained, slightly to well-foliated schist. Locally it contains disseminated pyrite along foliation planes and fractures.

5.4.2.2 Thunder River Mafic Metavolcanics

The Thunder River Mafic Metavolcanic rocks are described as follows:

- Mafic dyke: Usually narrow dark green to almost black massive or slightly foliated fine to medium grained biotite-chlorite schist. The width of the layers can reach up to 5 m. The dykes can be either parallel to or crosscut the foliation.

- Amphibolite: Coarse to medium-grained, dark green to black to green units, which consist mainly of 30% to 50% amphibole (hornblende and actinolite), 30% to 40% feldspar and pyroxene with rare post genetic quartz veins and layers of chlorite schist. It has typical “salt and pepper” appearance and nematoblastic texture.

- Green schist: Usually dark green to almost black foliated fine to medium grained schist, which consists mainly of chlorite, biotite, feldspar, amphibole. The width of the layers can reach up to 5 m.

5.4.2.3 Deposit Area Geology

Three major rock groupings are consistently recognized from south to north at the Project site, and consist of the following (Figure 5.4.2.3-1):

- A hanging-wall unit of altered felsic metavolcanic rocks (sericite schist, biotite-muscovite schist) and metasedimentary rocks.

- A central unit of approximately 100 m to 150 m true thickness, which hosts the most significant gold concentrations and consists of intensely deformed and variably altered felsic, fine to medium grained, quartz-feldspar-sericite schist and biotite-quartzfeldspar-sericite schist (BMS) with minor metasedimentary rocks.

- A footwall unit of predominantly metasedimentary rocks with some porphyritic units and minor felsic gneiss and schist.

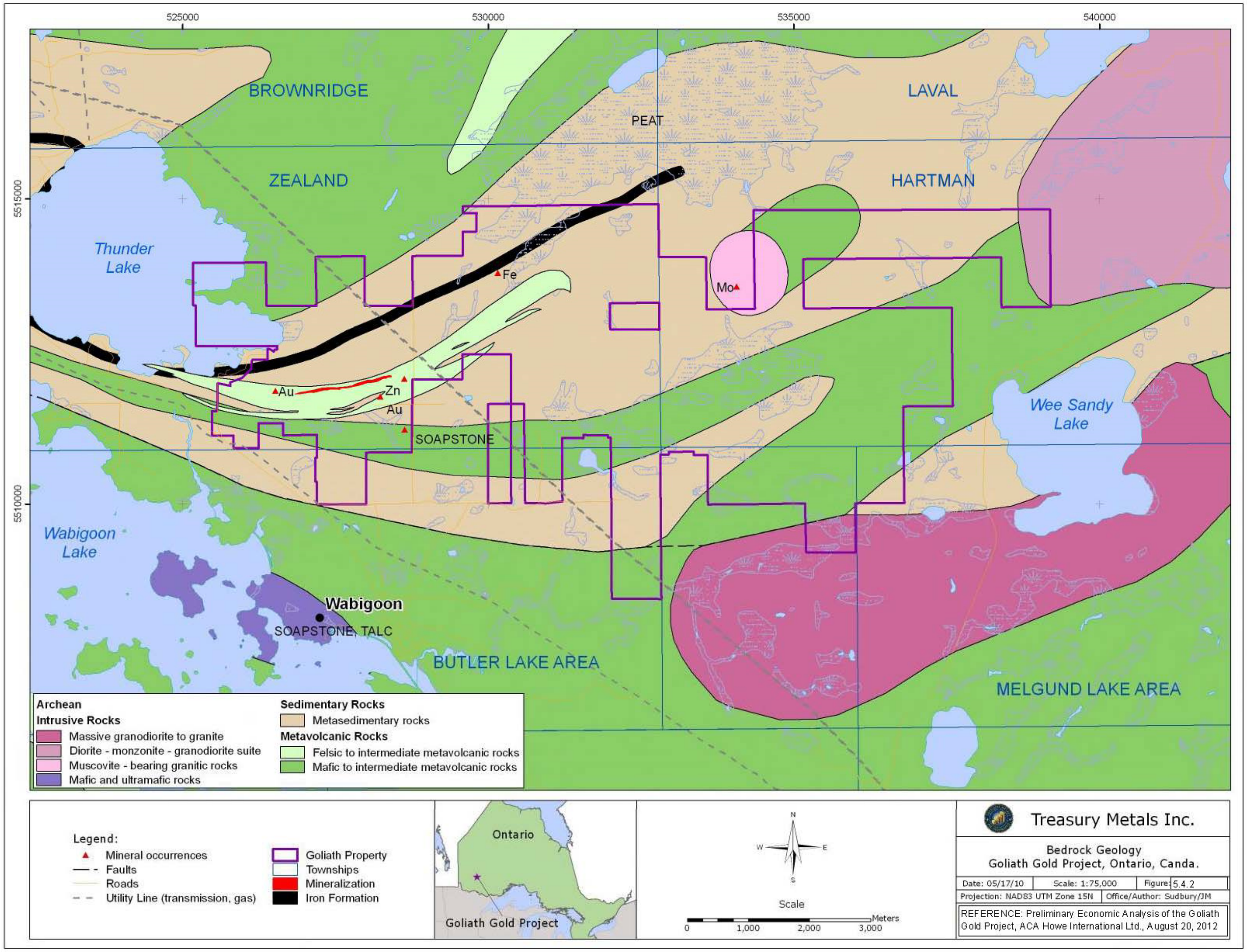

Figure 5.4.2.3-1: Bedrock Geology

The gold mineralization is located primarily in the central unit, and is concentrated in a pyritic (phyllic) alteration zone, consisting of the muscovite sericite schist, quartz-eye gneiss and quartz-feldspar geniss. This area of mineralization appears to extend to a maximum drill-tested depth of 805 m below grade, over a strike length of approximately 2,300 m, with the possibility of this strike length extending to greater than 5,000 m (Figure 5.4.2.3-2).

5.4.3 Geochemistry

5.4.3.1 Acid Rock Drainage and Metal Leaching

Acid-rock drainage (ARD) is a natural process whereby sulphuric acid is produced when sulphides present in rocks are exposed to air and water. Metal leaching (ML) is the release of dissolved metal concentrations in rock leachate. The evaluation and control of these two items is vital to maintaining a clean environment during construction, operation and post-closure around the mining activities. An ARD/ML geochemical characterization was undertaken for the Goliath Gold Project mine rock components with the potential to leach acid and metals during mining. These data and information have been used in the development of the overall mine plan and applicable environmental management plans, as well as in the predictive water quality assessments to assist in predicting possible effects and mitigation requirements for the Project.

The ARD/ML characterization and prediction studies were completed by EcoMetrix Inc. (EcoMetrix) in accordance with recommendations presented in the Mine Environment Neutral Drainage (MEND) "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1 (MEND, 2009). This document represents an update to the "Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia" prepared for the British Columbia Ministry of Energy and Mines (Price, 1997), and referenced in Regulation 240/00 of the *Ontario Mining Act*.

History of Geochemical Characterization Studies

The first record of geochemical characterization for the Project site is from 1997 when NAR Environmental collected five rock samples for acid-base accounting (ABA) analyses as part of their closure plan (NAR, 1997). The preliminary results from these five samples triggered the collection of an additional 25 samples for ABA analyses. There was limited activity on the Project between 1999 and 2008. Treasury assumed ownership of the Project in 2008, and initiated additional geochemical characterization analyses in 2012 as part of the environmental baseline studies.

As part of these baseline studies, 54 drill core samples were selected and submitted for ABA and whole rock metals analysis (KCB 2012). These studies subsequently led to the ongoing geochemical characterization work being completed by EcoMetrix which is outlined in the following sections. Samples collected and analyzed prior to 2012 have not been considered in the ongoing geochemical characterization program. The information presented in this EIS references the "Geochemical Evaluation of the Goliath Gold Project (Draft)" (EcoMetrix, 2014).

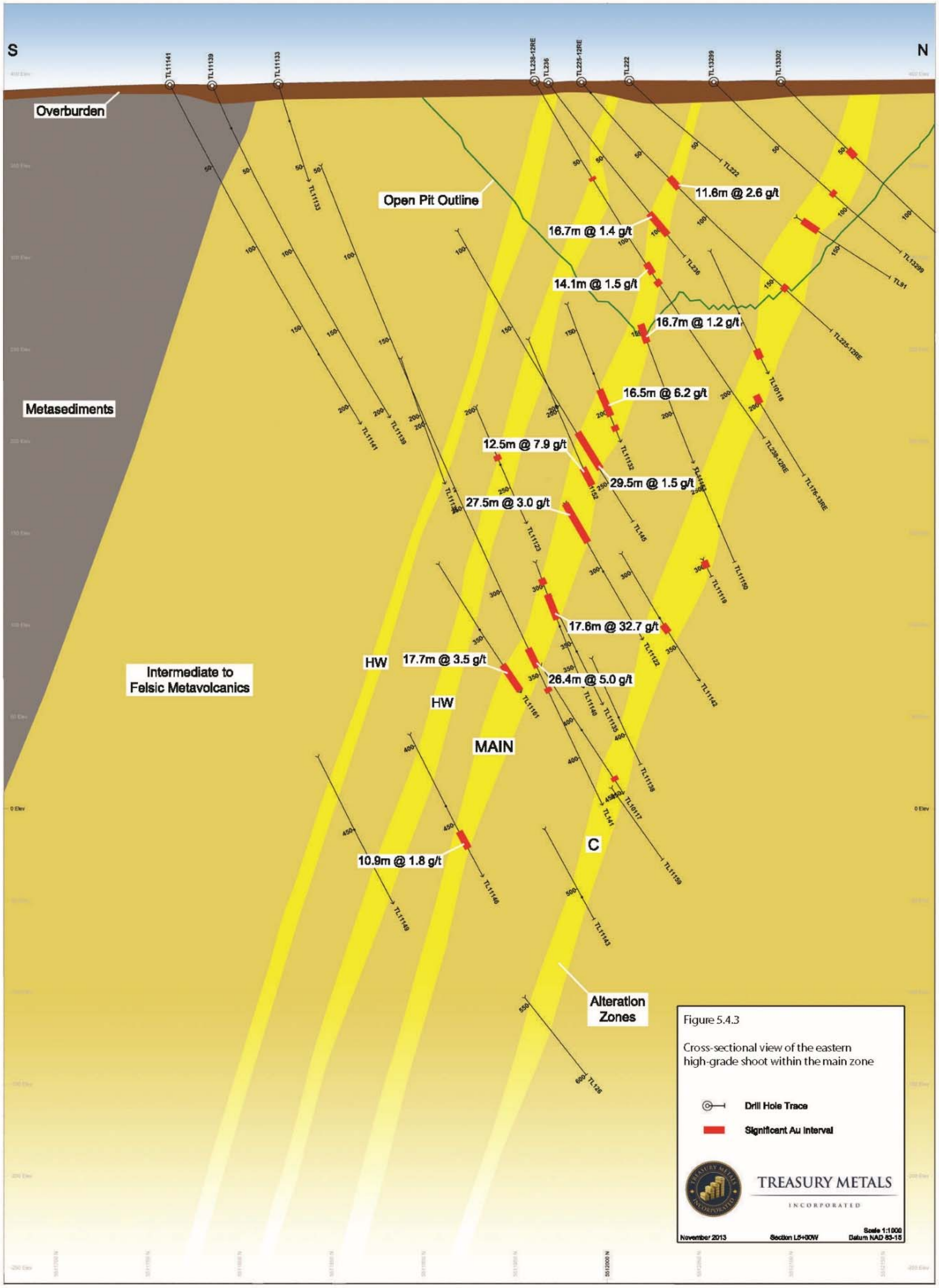

Figure 5.4.2.3-2: Cross-sectional View of the Eastern High-Grade Shoot within the Main Zone

5.4.3.2 Deposit Geology and Geochemical Setting

The deposit mineralized zones are tabular composite units defined on the basis of anomalous to strongly elevated gold concentrations, increased sulphide content and distinctive altered rock units and are concordant to the local stratigraphic units. Stratigraphically, gold mineralization is contained in an approximately 100 m to 150 m wide central zone composed of intensely altered felsic metavolcanic rocks (quartz-sericite and biotite-muscovite schist) with minor metasedimentary rocks. Overlying hanging-wall rocks consist of altered felsic metavolcanic rocks (sericite schist, biotite-muscovite schist and metasedimentary rocks) with the footwall comprising metasedimentary rocks with minor porphyries, felsic gneiss and schist. Gold within the central unit is concentrated in a pyritic (phyllic) alteration zone, consisting of quartz-sericite schist (MSS), quartz-eye gneiss, and quartz-feldspar gneiss.

5.4.3.3 Project Components

The proposed open pit will produce ore and four primary types of mine waste rock. The ore processing component of the Project will generate tailings. Additional quarry sources have been identified to supply construction material needed for the Project. The geochemical characterization considers the range of rock materials generated over the life of the mine. Estimate volumes of mined materials are presented in Table 5.4.3.3-1.

Table 5.4.3.3-1: Estimated Volumes of Mined Materials

Mined Material	Relative Proportions of Each Mined Material Type	
	Tonnage (Millions of Metric Tonnes)	Proportion of Total (%)
Waste Material		
Biotite Muscovite Schist (BMS) and Biotite Schist (BS)	17.50	38%
Muscovite Sericite Schist (MSS)	3.75	8%
Meta-Sediment (MSED)	3.75	8%
Tailings	11.82	26%
Ore		
Open Pit Mill Feed	2.98	7%
Low-grade Stockpile	2.29	5%
Underground Mill Feed	3.70	8%
Total	**45.79**	**100%**

Mine Waste Rock

Mine waste rock is defined as rock that will be excavated from the active mining areas, and does not have sufficient ore grades to process for mineral extraction. It is estimated that approximately 25 million tonnes of mine waste rock will be generated from both underground and open pit operations over the over the life of the mine.

The mine waste rock (Table 5.4.3.3-2) has been subdivided into three primary rock types, which include Biotite Muscovite Schist (BMS), Muscovite Sericite Schist (MSS), and Meta-Sediment (MSED). A fourth unit, Biotite Schist (BS), was used in the geochemical characterization program to characterize samples. The BMS and BS are now grouped together because of geological similarity.

Table 5.4.3.3-2: Estimated Volumes of Mine Waste Rock

Waste Rock Type	Relative Proportions of each Waste Rock Type	
	Tonnage (millions of metric tonnes)	Proportion of Total (%)
Biotite Muscovite Schist (BMS) and Biotite Schist (BS)	17.5	70%
Muscovite Sericite Schist (MSS)	3.75	15%
Meta-Sediment (MSED)	3.75	15%
Total	**25**	**100%**

Tailings

Lycopodium Minerals Canada Ltd. (Lycopodium) produced a Process Optimization Study (Lycopodium, March 2014) for the Project, identifying the Project as a free-milling gold deposit with ore material containing coarse gold that is readily amenable to conventional processing options. The ore processing plant will process approximately 2,700 tonnes per day over the mine life using gravity concentration of free gold, followed by carbon-in-leach (CIL) cyanidation. Process tailings will be placed and stored in an engineered TSF.

Low-grade Ore

A low-grade ore stockpile (LGO) will be maintained over the mine life to allow blending of lower grade and higher grade ores to ensure a more consistent grade of ore to the processing plant. The LGO will be maintained throughout the initial years of mining and will be used to blend with the underground material until it is wholly consumed and fed to the process plant at the end of the mine life. It is expected that the ore stockpiles will be temporary, and that there will be ongoing replacement and turnover as the stockpiled ore is processed, and new ore from mining is placed in the stockpile.

Geochemical characterization of the low grade ore has not yet been completed. For the purposes of geochemical characterization, the MSS host rock has been used as a surrogate for the low grade ore as a preliminary approximation Up to three separate stockpiles of varying grade will be used to feed the process plant.

Other Project Components

Geochemical characterization for quarry, excavation, and other potential construction materials has not yet been carried out, and will be done as the Project design advances.

5.4.3.4 Materials Characterization and Management Studies

The geochemical characterization program has been an iterative process consisting of several sampling and analysis programs. The programs have served to obtain ARD/ML prediction information to be used for the water quality effects assessment and to determine mitigation requirements for the Project.

A preliminary geochemical assessment was completed in 2011 as part of the baseline studies for the site and involved the characterization of 54 drill core samples. An additional 112 drill core samples of potential mine rock material were selected and characterized in June 2012.

A summary of the characterization programs completed to date, including methodologies, analyses, and conclusions, are presented in Appendix K. The geochemical characterization programs are ongoing with the intent and purpose of further refining the geochemical predictions and informing the mine rock management and handling strategies.

Methodology

The geochemical characterization program has included a suite of static and kinetic tests to evaluate short term static conditions and long term potential for acid generation and metal leaching. Characterization methods for the various Project components included static and kinetic geochemical characterization tests. This includes acid-base accounting (ABA), whole rock metals (ICP-MS), shake flask extraction (SFE), humidity cell tests (HCT) and field cell tests (Table 5.4.3.4-1). A complete summary of the geochemical characterization program and methodology for ARD/ML prediction is provided in Appendix K.

Table 5.4.3.4-1: Sample Numbers for Static Tests on Waste Rock Material

Waste Rock Type	Number of Samples			
	Acid Base Accounting	Whole Rock Metals Analysis	Shake Flask Extraction	
			Deionized Water	0.1M HCl Acid
Biotite Muscovite Schist (BMS)	52	67	13	5
Biotite Schist (BS)	16	20	4	2
Muscovite Sericite Schist (MSS)	35	59	8	3
Meta-sediment (MSED)	9	15	3	1
Total	**112**	**161**	**28**	**11**

ABA testing included paste pH, total sulphur, sulphate-sulphur, sulphide-sulphur, Modified Sobek NP, total carbon, total organic carbon, and total carbonate analyses. The results from these analyses were utilized to calculate the carbonate NP (Carb-NP), acid generating potential (AP), net neutralization potential (NNP), and Sobek NPR (ratio of Sobek NP to AP) and Carbonate NPR (Carb-NPR).

Elemental analysis was completed to quantify the concentration of elements in the rock samples. An aqua regia digestion process was followed by an Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) scan. Shake flask extraction (SFE) metal leaching tests were used to assess the presence of potentially soluble elements and to understand their release during the initial stages of weathering. The shake flask extraction leachate was evaluated for pH, conductivity, hardness, sulphate and dissolved metals. SFE tests were run using both deionized water and a 0.1 M HCl acid dissolution.

Three humidity cell tests (HCT) with different sulphur content ranges were initiated for each of the BMS, MSS, and BS materials, respectively. Drill core samples were selected to create composite samples representing humidity cell samples with sulphur ranges of less than 0.25%S, 0.25%S to 1.00%S, and greater than 1.00%S for each of the three rock types. For the MSED material, two columns were initiated, less than 0.60%S and greater than 0.60%S. These ranges allow for appropriate evaluation of potential metal leaching from mine rock material and were designed to be suitable for water quality modeling required as part of a feasibility study and Environmental Assessment.

Four barrel tests were initiated in September 2012 at the Goliath Gold site. The barrels were constructed using one-half of a clean 170 L plastic barrel. Selected drill core segments (50 cm to 100 cm long), including both half cores and full cores, were placed in each barrel to represent mine rock material from each of the four material types. Approximately 78, 87, 90, and 88 kg of core samples were placed in the BMS, BS, MSS, and MSED barrels, respectively. The top of each barrel remained open so that mine rock samples were exposed to air and precipitation falling as rain or snow. Each barrel has a bottom drain spout connected with tubing to pails where water collects between sampling events. Leachates from the barrel tests were analyzed at an accredited lab for general chemistry (pH, hardness, conductivity, total dissolved solids, alkalinity, acidity, chloride, sulphate, phosphorus, nitrate/nitrate, and ammonium), cyanide (total, weak acid dissociable (WAD), and free), and total and dissolved trace metals.

Tailings samples were produced by metallurgical bench scale testing. Two duplicate HCTs were set-up using a prepared composite tailings sample. A single composite tailings sample was submitted for ICP-MS (1 test), ABA (1 test) and SFE analysis (3 tests with deionized water, 2 tests with 0.1M HCl acid).

Classification Method and Screening Criteria

ARD classification criteria are as documented in the MEND guidelines (Price, 2009) stipulating that material with an NPR value of less than 1 (i.e., NPR<1) is classified as potentially acid generating (PAG). Material with an NPR value of greater than 2 (i.e., NPR>2) is classified as non-acid generating (NAG). And material with an NPR value of between 1 and 2 (i.e., 1<NPR<2) is classified as Uncertain.

Shake flask and humidity cell results were compared against the Ontario Provincial Water Quality Objectives (PWQO; MOEE, 1994) to evaluate constituents of potential concern (COPCs).

Material Characterization for ARD/ML Potential

Waste Rock

All rock types were characterized by carbonate NPR (Carb-NPR) geomean values below 1.0. Similarly, with the exception of the BS samples, all mine rock samples had geomean values for Sobek-NPR below 1.0. Therefore, all four mine rock types were classified as potentially acid generating (PAG), as per the MEND guidelines (Price, 2009).

The average sulphide-sulphur contents amongst all the samples ranged between 0.01 and 8.58 percent sulphur (%S), whereas the average sulphate-sulphur contents ranged between 0.01 and 1.00%S. The geomean sulphide-sulfur contents of BMS, BS, MSS, and MSED were 0.0.44, 0.40, 0.78, and 0.52%S, respectively, while sulphate-sulphur values were 0.24, 0.22, 0.23, and 0.16%S, respectively. For all four mine rock types, the high sulphide-sulphur content standard deviation (0.43, 0.38, 1.24 and 0.53%S) relative to the geomean values demonstrates the broad range of sulphide contents.

The total carbonate values for all four rock types, measured as percent carbon (%C), ranged between 0.01 and 0.71%C. Total carbonate values were higher in BS and MSED samples with geomean values of 0.09 and 0.08% C. Conversely, BMS and MSS samples both had geomean values of 0.03%C.

The measured Sobek-NP values were relatively low, ranging from 2.10 to 20.8 kg $CaCO_3$/t with geomeans of 7.19, 8.57, 5.69, and 8.90 kg $CaCO_3$/t for BMS, BS, MSS, and MSED, respectively. Typically, Carb-NP values were lower than and only represent less than one-half of the Sobek-NP values, ranging from 0.08 to 16.7 kg $CaCO_3$/t with geomean values for BMS, BS, MSS, and MSED of 0.74, 1.37, 0.72, and 1.87 kg $CaCO_3$/t, respectively.

As expected, higher soluble concentrations were generally observed in samples for all four mine rock types in the acid extractions compared to those in the deionized water extractions. Deionized water extraction values exceeded acid-wash values for antimony and sulphate for the BMS samples; cadmium, zinc, and sulphate for the MSS sample; and sulphate for the MSED samples. The screening values were exceeded for aluminum (BS, MSED), copper (MSED), and lead (BMS, BS, MSED) in the acid-wash SFEs. Conversely, no screening values were exceeded for any of the deionized-water SFE for all four mine rock types.

Tailings

The tailings material was classified as PAG, as per the MEND guidelines (Price, 2009), with an NPR ratio of well below one in the composite tailings sample (Appendix K). The tailings sample was analyzed with a total-sulphur content of 1.53%S, occurring dominantly as sulphide sulphur (1.23%S). All carbon in the sample was in the form of carbonate at a concentration of 0.02%C.

Mineralogy information for material reported in the Lycopodium report (Appendix B) indicate that total sulphide accounts for ~2.1% of the sample mass, with 10% of the sulphide minerals occurring as pyrrhotite The dominant non-sulphide gangue minerals present were quartz (56%), micas (22%), and feldspars (22%).

Time for Onset of Acidic Conditions

A range of times to onset of acid conditions in waste rock stockpiled on surface can be estimated from the HCT results and calculated loading rates. The BMS, BS, MSS, and MSED rock samples, used for the HCTs, reached acidic conditions (pH values less than 5.5) after approximately 60 weeks. These HCT results can be considered as conservative estimates for the onset of acidic conditions, as they incorporate smaller grain size distributions, higher average temperatures, and higher precipitation infiltration rates than those anticipated for mine rock during mining operations. Therefore the higher rates of oxidation in the HCT tests than those expected in the WRSF will result in shorter times to the onset of acid drainage. Acidic drainage in the WRSA is expected to be delayed to a greater extent than was observed in the HCTs.

It is conservatively estimated that the time to acid onset for the PAG rock, based on the samples examined in this investigation, will potentially range between a few tens of years to many tens of years. However, the low Carb-NP values, relative to the calculated AP values, observed for a large majority of the mine rock samples selected for this investigation suggest that any mine rock management methods take a conservative approach to the onset of acid production. If segregation of PAG and non-PAG mine rock is completed, any material used for construction purposes should be evaluated for acid generation potential and metal leaching prior to use.

5.4.3.5 Mine Material Management and Storage Strategy

All (100%) mined materials, including waste rock, tailings, and low-grade ore, have been classified as PAG. The following sections document the proposed management, material handling and disposal plans for mine rock and related materials. Mitigation strategies and contingency plans are identified in the context of mine material management and strategies.

Waste Rock Material Management

Approximately 12.9 million tonnes of waste rock will be permanently stored in the dedicated WRSA, while the remaining 12.1 million tonnes will be backfilled to the main pit as part of site reclamation. All waste rock has been classified as PAG; therefore there will be no segregation of materials. All waste rock material will be handled appropriately to minimize potential impacts of ARD/ML. As all waste rock has been found to be unsuitable for road aggregate, the necessary aggregate for construction purposes will need to be obtained from an approved outside source.

Waste Rock Storage Area

A WRSA will be constructed for the permanent storage of waste rock generated throughout the life of the mine. The WRSA is expected to be constructed on the north side of the proposed open pit. The WRSA will have a capacity of approximately 12.8 million m^3 or 26 million tonnes. It will have a footprint area of approximately 675,000 m^2 and a maximum vertical stack height of 20 m. Current design criteria suggest that the slopes will be set at a 3:1 ratio, and that vertical stack height will be limited to reduce the potential visual impact for neighbouring residents. Prior to commissioning, the WRSA site will be cleared and perimeter ditching installed to collect all WRSA runoff. Collected water will be directed to the water management system for treatment.

Tailings Storage

A TSF will be constructed for the permanent storage of all tailings material generated during the life of the mine. The facility is proposed for construction within the watershed of the Blackwater Creek Tributary #2.

The TSF will have a capacity of approximately 10 million m^3 and a total final footprint area of approximately 600,000 m^2. Due to the flat terrain, a compound-style dam will be constructed. In the current design, the primary dam structure is located on the downstream side and a secondary dam is constructed to contain potential upstream flooding, effectively creating a deeper TSF with a smaller lateral footprint. In accordance with the water management strategy (Lycopodium, June 2014), all tailings will be deposited sub-aqueously.

A fence may be installed around the TSF to limit possible interactions with wildlife, particularly large mammals such as moose, deer and wolves. The fence will be constructed in consultation with the Ministry of Natural Resources.

Low Grade Ore Stockpiles

The low grade ore will be stockpiled in a location adjacent to the processing plant site to facilitate transport to the processing plant. The low grade stockpile will have a maximum volume of 900,000 m^3 or 1.8 million tonnes, and occupy a footprint of approximately 62,500 m^2.

At the end of mining operations, the LGO will be depleted and no material will be left behind. Treasury understands that conditions may change over the life of the mine. For this reason, a contingency plan is presented in Section 3.14.3 to address potential for a low grade stockpile at closure.

Mitigation and Contingency Plans

Mitigation strategies will be required to manage mine rock and tailings at the site to prevent potential negative effects on water quality at the site in post closure and during operation. The following mitigation measures may be used: prevention, sub-aqueous disposal, capping of PAG rock material, engineered barriers, and liners. Best practices and handling of materials guidelines will be incorporated into site management plans. Contingency plans will be in place to minimize the impacts of ARD/ML if they should occur. Based on the monitoring program, the schedule of capping or flooding could be amended as soon as possible to reduce the impact time.

5.5 Terrain & Soil

5.5.1 Regional Soil Classification

The dominant regional landform within the LSA is predominately Glaciolacustrine Plain (Figure 5.5.1-1). The regional soils were categorized based on visual observations by Klohn Crippen Berger (KCB 2012) and by mapping available from the Ontario Institute of Pedology (OIP 1984) for the Dryden-Kenora Area. The three major soil classifications found in the regional study area (RSA) that will play a role in Project development, land use, reclamation, and water management are:

- Gray Luvisols: characterized by an illuviated Bt horizon (i.e., subsoil with accumulation of silicate clays). The typical gray luvisol in the Dryden-Kenora area has clay, clay loam, sand loam, or silt loam texture. They are well drained and have a moderate agricultural capability.

- Gleysols: characterized by their saturated nature and reducing conditions that occur either continuously or seasonally. Gleysols can be identified by hue and mottling in the lower horizons, which is an indication of reducing conditions, associated with saturation. The Gleysols of the Dryden-Kenora area are poorly drained and are silt loam to medium-coarse in texture. They are underlain by outwash that is calcareous and lacustrine in origin.

- Podzols: Soils of the Podzolic order have B horizons (i.e., subsoil) in which the dominant accumulation product is amorphous material composed mainly of humified organic matter combined in varying degrees of aluminum and iron. Typically these soils occur in coarse- to medium-textured, acid parent materials, under forest or heath vegetation in cool to very cold humid to perhumid climates (Soil Classification Working Group (SCWG) 1998). The podzols of the Dryden-Kenora area are well drained and overlay fine outwash material that is non-calcareous in origin.

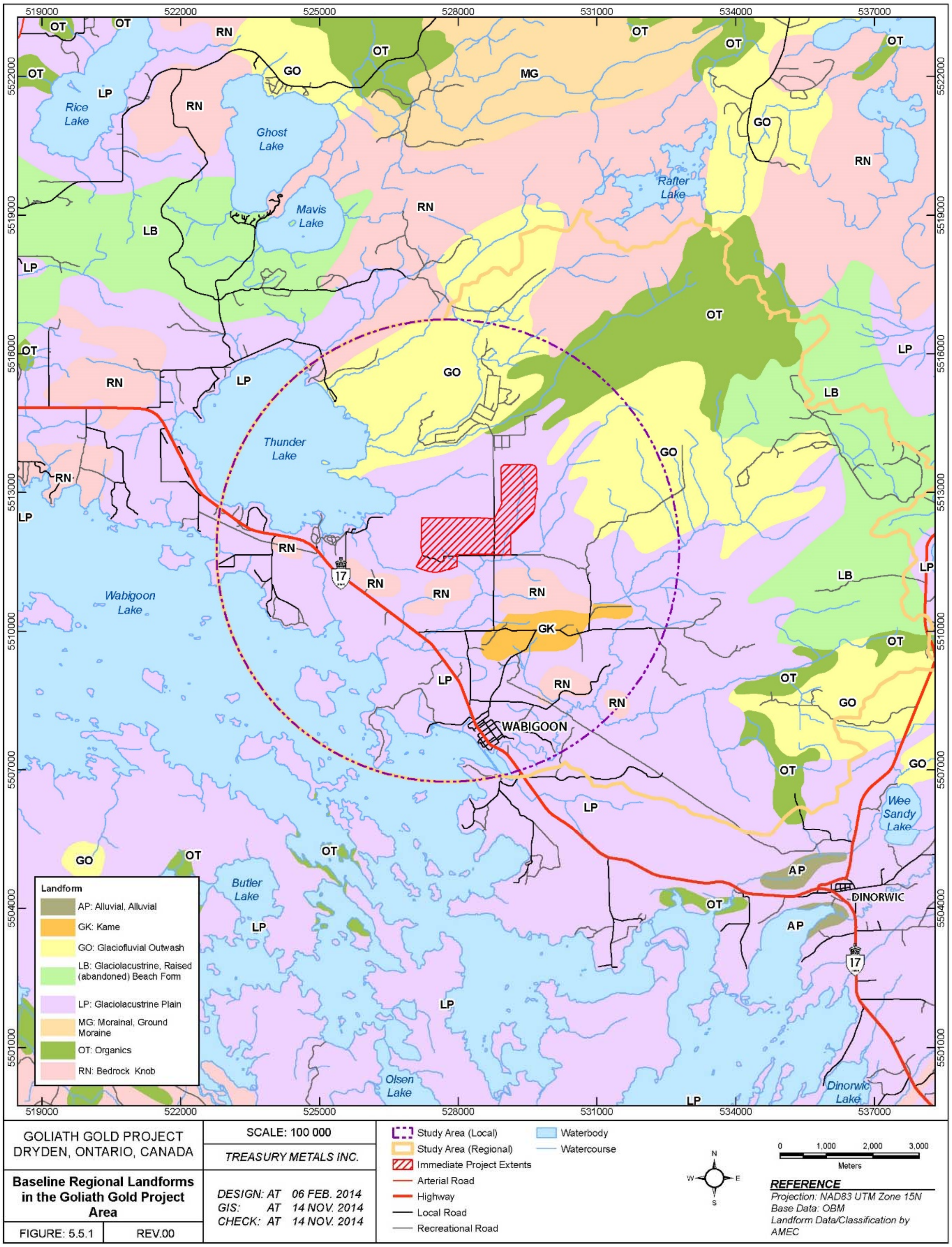

Figure 5.5.1-1: Regional Landforms

5.5.2 Local Soil Classification

The soils found in the RSA and the LSA are fairly similar with a slight variation related to micro scale changes in ground elevation during the soil investigation by Klohn Crippen Berger in 2010. The LSA is characterized regionally by the Broadtail and Deception humo-ferric Podzols, the Minnitaki orthic Gleysol, and the Sioux grey Luvisol (Figures 5.5.2-1 and 5.5.2-2). All soil types were determined to be present locally; however, the difference in drainage and variable elevation allow for more local variation in soil type. An area of marshland was identified in the local survey and is evident in the topography surrounding Blackwater Creek and a beaver pond on the northwestern section of the LSA. The soils in the Broadtail group are limited in agricultural capability due to low fertility and moisture limitations with stoniness and bedrock. The Deception group is also limited in agricultural capability with an additional limitation due to topography. More capable land use areas are found in areas where the soil is less stony and the soils are less limited such as the Minnitaki group. The Minnitaki group has moderate capability and a limitation due to excess water. The Sioux soil group is limited in agricultural capability due to undesirable soil structure, topography, and erosion.

The soil type in the LSA ranges from loamy sand to silty clays. The soils with coarser textures are generally moderately to well-drained, and finer textures have poorer drainage due to hydraulic conductivities. The soil type in the LSA was confirmed during a drilling investigation by TBT Engineering Ltd. in March 2014 (Figures 5.5.2-3 and 5.5.2-4). The O horizon (i.e., organic material) was generally encountered to approximately 0.2 m below grade to a maximum depth of 1.4 m in some areas. The O horizon is underlain by B horizon (i.e., subsoil) of predominantly clay and/or silt to bedrock, which was encountered at depths ranging from 1.05 m to 18.6 m below grade.

5.5.3 Soil Nutrient Baseline

The purpose of the soil nutrient baseline by Klohn Crippen Berger (Appendix G) was to determine the productivity level of current surface soils and to predict the potential productivity of the soils for reclamation.

5.5.3.1 Soil Organic Matter

Soil organic matter (SOM) improves both physical and chemical properties of the soil. SOM improves soil structure and particle stability, increase water retention capacity, increases aeration, and stores and supplies nutrients for plants and micro-organisms.

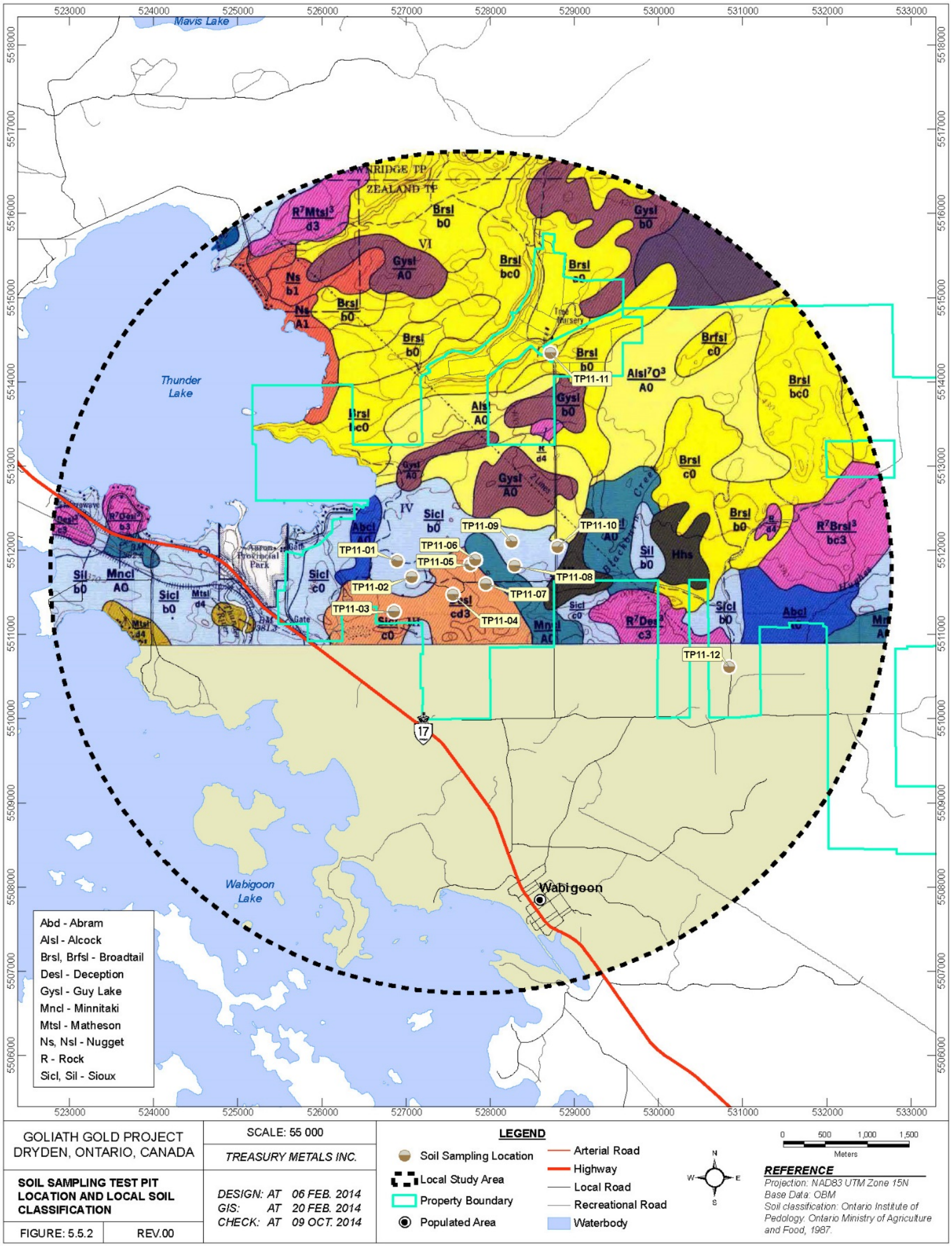

Figure 5.5.2-1: Soil Sampling Test Pit Location and Local Soil Classification

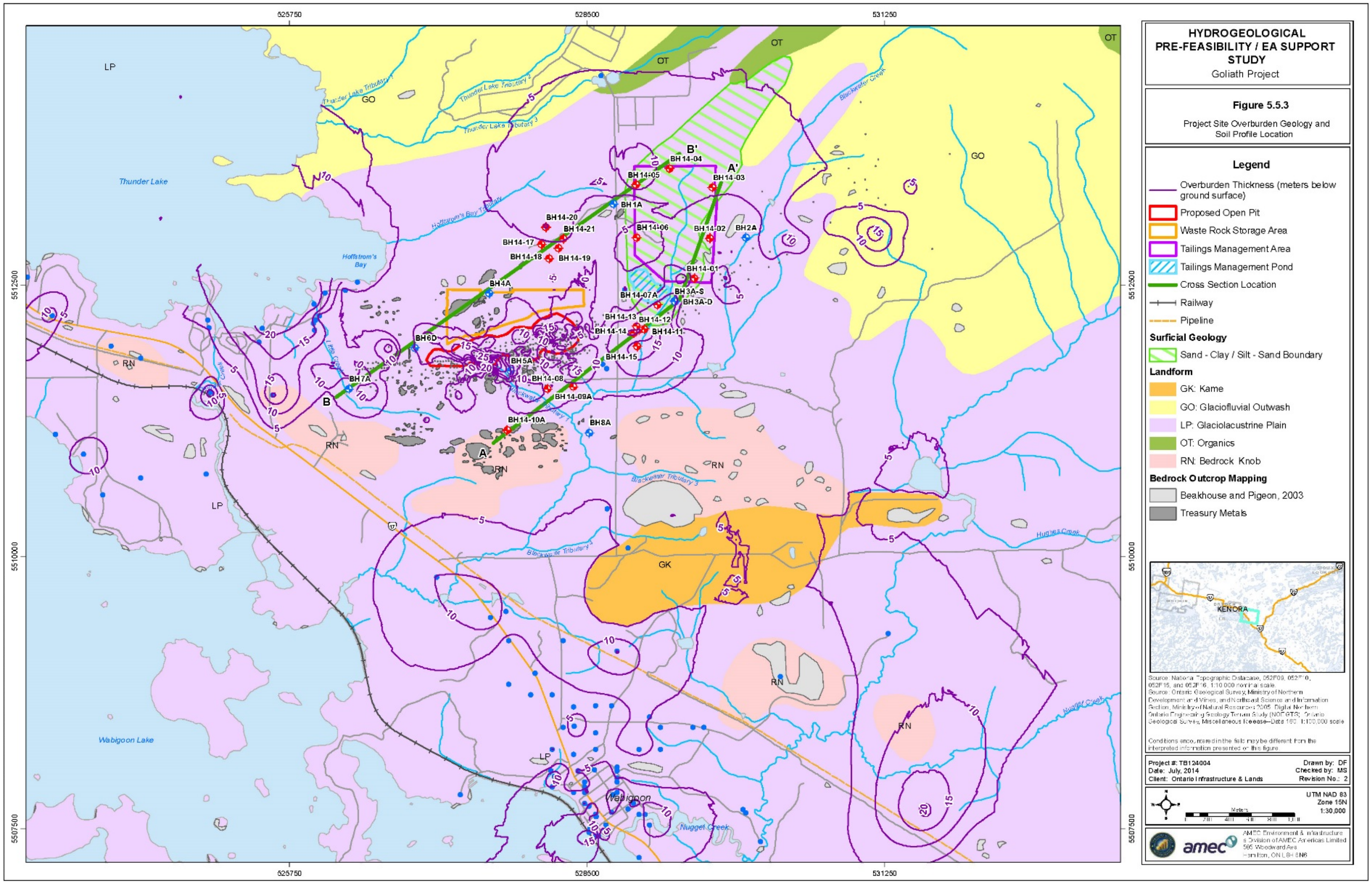

Figure 5.5.2-2: Project Site Overburden Geology and Soil Profile Location

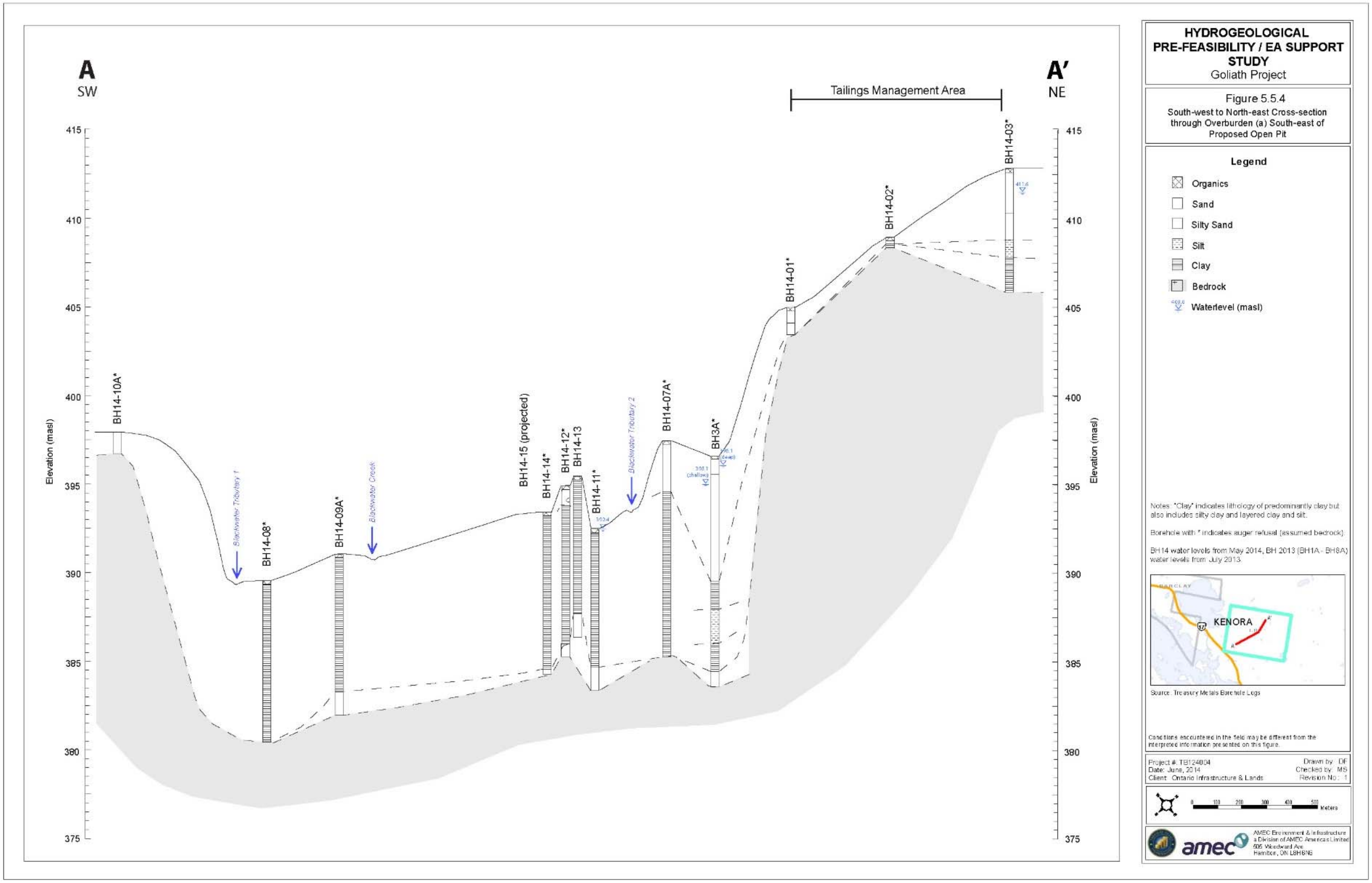

Figure 5.5.2-3: Southwest to Northeast Cross-Section through Overburden (a) Southeast of Proposed Open Pit

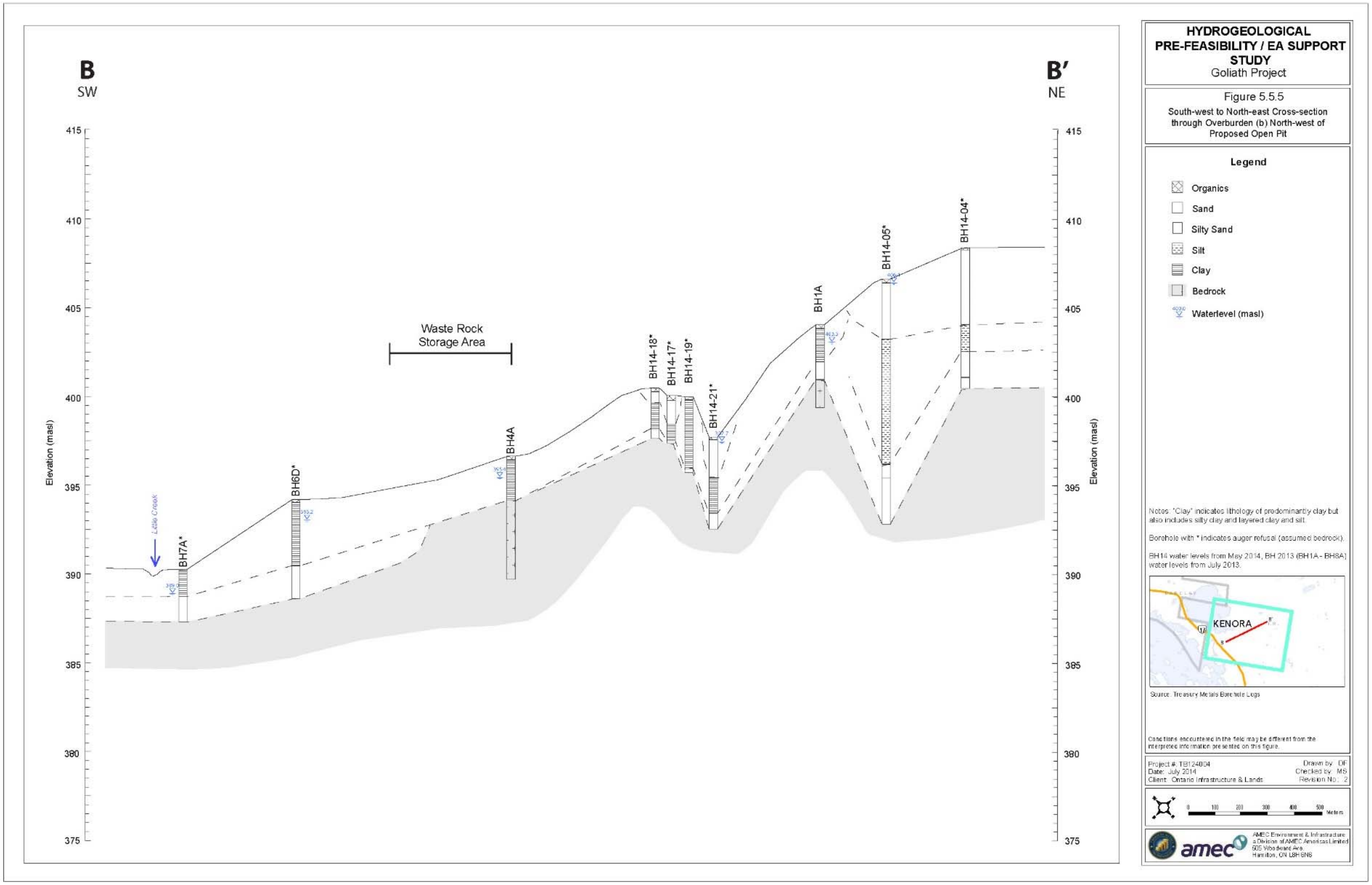

Figure 5.5.2-4: Southwest to Northeast Cross-Section through Overburden (a) Northwest of Proposed Open Pit

The SOM content correlates with the sampling horizon. The O horizon (i.e., organic matter) has the highest organic matter content at an average of 35%, followed by the Ah horizon (i.e., topsoil with illuvial accumulation of organic matter) at an average of 7%, and minimal to no organic matter in the mineral (B) horizons. Although there is an abundance of organic matter in the O horizons, the poor drainage often associated with the soil formation minimizes agricultural capability. The potential for use of these materials in reclamation is high because of the elevated organic matter and the ability of the SOM to improve the chemical and physical properties of soil.

5.5.3.2 Major Nutrients (N, P and K)

Available nitrogen (N) in the LSA is low and is typically less than the method of detection limit of 2 mg/kg. Nitrogen has only been detected in the Om soil horizon due to the high organic matter content. The low nitrogen content in the LSA indicates little to no amendment done and/or low microbial activity. An increase in spring precipitation and runoff has also been known to decrease soil available nitrogen through leaching.

The available phosphorous (P) in the LSA ranges from below the detection limit of 2 mg/kg to 20 mg/kg. The higher available phosphorous levels are generally associated with the higher organic matter horizons. Soil phosphorous levels are relevant for soil fertility in relation to the crops produced. Excess phosphorous is a concern in terms of entry into surrounding water bodies. The relatively low concentration in these soils indicates that there should not be a concern of excess phosphorous entering the watershed. Phosphorous is generally most available in soil with a pH between 5.5 and 7.0.

The potassium (K) content was measured to be below the method of detection limit of 2 mg/kg.

Generally, the nutrient content of the soils is low with the highest measureable nutrients found in the organic containing O and Ah horizons.

5.5.3.3 Cation Exchange Capacity

The cation exchange capacity (CEC) is a measure of the nutrient or cation buffering capacity of the soil and is an important function of soil fertility as it is a measure of the capacity of the soil to adsorb and exchange nutrients (i.e., K^+, Ca^{2+}, Mg^{2+}, NH_4^+). The CEC of soil is primarily driven by organic matter content and secondarily by clay content. Plant available nutrients will only exist in soil pore water at minimal concentrations; therefore, it is important for the soil to have a reservoir of these nutrients to exchange when required by the plant.

The CEC of the soil ranges from 4.5 meq/100g to 82 meq/100g. Organic soils have a good degree of CEC for reclamation purposes; however, the deeper mineral horizons (i.e., the sandy loam soils) have a much lower CEC due to the low organic matter. The clay content of the LSA soils is low and therefore does not contribute significantly to CEC.

The optimal concentrations of calcium, magnesium, and sodium should have a higher proportion of Ca, followed by Mg, with smaller amounts (~5%) of Na. The exchangeable calcium (Ca) in the soil ranges from less than 2 meq/100g to greater than 103 meq/100g. Soils are considered to be Ca deficient if the exchangeable Ca value is less than 1 meq/100g. The highest Ca contents were found in the C horizons (i.e., parent rock), which is likely related to the presence of carbonates in the parent material.

The soils in the LSA have exchangeable Mg ranging from less than 2 meq/100 g to 27 meq/100 g. Soils are considered to be Mg deficient if the exchangeable Mg value is less than 0.2 meq/100 g.

The exchangeable sodium in the soil ranges from 5.2 meq/100 g to 18 meq/100 g.These values are generally low indicating that these soils are not sodic in nature, which is expected in the region, and beneficial for reclamation.

Overall, the exchangeable cations are moderate throughout the soil profile in the LSA. The Ca:Mg ratios are predominantly greater than 1, indicating a generally healthy soil.

5.5.4 Soil Chemical Baseline

The purpose of the soil chemical baseline was intended to measure the baseline metal concentrations and measure the potential for large stockpiled volumes of soil to produce metal leaching. It is not common for soils to leach large quantities of metals, and the reducing nature of gleysols and the soils of the poorly drained areas on the LSA tend to keep metals and metalloids relatively immobile in their reduced forms. Some metals are mobile in this reduced state; however, the natural state of the soils maintains a balance in metal mobility/immobility. The stockpiling and draining of the soils will allow for oxidation and may alter the potential mobility of elements into the receiving environment.

5.5.4.1 Soil pH

The pH of the soils in the LSA ranges from 5.0 to 8.1 The more acidic pHs are typically related to the organic acid content of the soils, while the more alkaline pHs are related to the higher clay content and calcareous material present in some of the soil horizons. More acidic conditions are also found to be present in the Bf horizons (i.e., subsoil).

The pH of the soils are rarely low or high enough to present significant impacts of H^+ and OH^- ions on roots and microorganisms (McBride, 1994). Soil pH below 5.5 will generally encourage an increase in the solubility levels of aluminum and manganese to the point of being biologically toxic. A pH value greater than 7 is often associated with low solubility of micronutrient cations, and pH higher than 8.5 is associated with high soluble and exchangeable Na^+ (McBride, 1994). However, the relationship between soil pH and exchangeable nutrients (i.e., Ca^{2+}, Mg^{2+}, NH_4^+) in the LSA show no apparent trend.

5.5.4.2 Soil Metal Content (Solid Phase)

The soil metal concentrations in the LSA are generally low and consistent with the parent material and underlying bedrock of the area. Trace elements, such as silver, antimony, molybdenum, mercury, selenium, and thallium are present in some locations at low levels but are generally below the method of detection limits.

Elements that have a low cause for concern for phytotoxicity include Cd, Hg, and Zn based on the total metal contents and potential for metal leaching. Other metals, including Cu, Ni, Fe, Mn, and Pb are present in the solid phase at higher levels; however, the potential for these metals to leach and become bioavailable is low.

The maximum Cd concentration in the area was found to be 1.4 ug/g. Cadmium concentrations greater than 0.5 ug/g are considered to be evidence of soil influences from anthropogenic sources; however, the association of Cd with the peaty organic matter in the Om horizon indicates that the precipitation of sulphide minerals in the poorly drained soil may be contributing to the concentration of Cd. Similar mechanisms can influence the concentration of mercury in surface horizons, as mercury accumulations correlate with organic matter levels. It is unlikely that these forms of mercury will become soluble and mobile; however, the complex nature of this parameter makes predication difficult (McBride, 1994).

The maximum recorded zinc level in the LSA exceeds the worldwide mean soil concentration. However, the Zn mobility in neutral soils is generally very low (McBride, 1994) and it is unlikely that the higher Zn concentrations associated with the O horizons will become bioavailable.

5.5.4.3 Soil Metal Content in Soil Solution

The potential for metals to leach into solution is the more distinguishing factor for the potential for metal toxicity. Plants will take up metals from the soils through the soil solution and an accumulation of metals in the root zone.

The concentrations of all metals analyzed were below the limit of detection in the soil solution. The cadmium concentration was also very low with only one measurable concentration above the detection limit, which is associated with the Om horizon. As discussed above, the precipitation of sulphide minerals in the poorly drained soil may contribute to the increased concentration of cadmium. Zinc concentrations were detected but were generally below 1 mg/L, which is well below the applicable water quality guidelines for the protection of agriculture.

5.5.5 Summary of Soils in the LSA

The potential for the soils in the LSA to be used as material in reclamation is good. Soil management would be required for stockpiling to maintain the nutrient content and the physical and chemical stability of the organic material. Mixing the organic topsoil with the finer textured subsoils would be beneficial for soil structure and provide optimal rooting conditions and water holding capacity.

The soil testing indicates the presence of some metals at higher, potentially phytotoxic levels, although the metal leaching testing indicates that the potential for the higher solid phase metal contents to leach into the soil solution and become bioavailable is low.

There were no unexpected land conditions or soil characteristics identified in the LSA. The potential for metal leaching is low and the nutrient content of the soils is moderate.

5.5.6 Sediment

Sediment quality in the LSA was assessed by analyzing the following: grain size, nutrients (total organic carbon), metals, and polycyclic aromatic hydrocarbons (PAHs). Metals are the constituents expected to have the highest potential to be introduced to or mobilized in the environment as a result of the Project. PAHs could also potentially be introduced to the environment as a result of the Project, due to the use and disposal of hydrocarbon-based fuels and solvents during Project construction and operations.

Based on the Project understanding at the time the sediment samples were collected during Klohn Crippen Berger's field program in 2011, the sediment sample locations were as follows:

- At a crossing of Norman's Road on Blackwater Creek;
- Downstream of a roadway and beaver dam downstream of the unnamed tributary of Blackwater Creek south of the Project portal;
- At the crossing of Blackwater Creek and Anderson Road;
- At the confluence of Blackwater Creek and the unnamed tributary immediately south of the Project portal; and
- At the outlet of Blackwater Creek at Wabigoon Lake.

The Blackwater Creek watershed consists mainly of glaciolacustrine silt and fine sand substrates with a large peat deposit upstream of the Norman's Road crossing on Blackwater Creek. Sediment at all locations were described as having a slight sulphur odour.

5.5.6.1 Grain Size

Sediment in the area is predominantly fine-grained. Fine-grained sediments, such as silts and clays, facilitate the transport of certain constituents since their surface area to volume ratio is greater than coarse-grained sediments (Ongley 1996).

5.5.6.2 Nutrients – Total Organic Carbon

The total organic carbon (TOC) ranged from 2.32% to 16.4%, which all exceed the low effect limit (LEL) of 1%. The TOC at the outlet of Blackwater Creek at Wabigoon Lake also exceeded the severe effect limit (SEL) of 10%. Higher TOC levels are commonly associated with wetlands. Fine-grained sediments (i.e., silts and clays) are also known to have generally higher levels of nutrients, such as TOC, than coarse-grained sediments (Gascon et al. 2006).

5.5.6.3 Metals

Concentrations of 32 metals were determined in the sediment; however, only nine of the metals listed in the *Ontario Provincial Sediment Quality Guidelines (OPSQGB) for Metals and Nutrients* (i.e., arsenic, cadmium, chromium, copper, lead, manganese, nickel, zinc and iron) are discussed.

Levels of arsenic, cadmium, and lead did not exceed the LEL or SEL in any of the locations. The following parameters exceeded the LEL at the identified locations:

- Chromium: exceeded at all sample locations;
- Copper: exceeded downstream of the unnamed tributary of Blackwater Creek south of the Project portal, at the crossing of Blackwater Creek and Anderson Road, and at the outlet of Blackwater Creek at Wabigoon Lake;
- Iron: exceeded at all sites except at the crossing of Norman's Road on Blackwater Creek;
- Nickel: exceeded at all sites except at the crossing of Norman's Road on Blackwater Creek;
- Manganese: exceeded downstream of the unnamed tributary of Blackwater Creek south of the Project portal, at the crossing of Blackwater Creek and Anderson Road, and at the confluence of Blackwater Creek and the unnamed tributary immediately south of the Project portal; and
- Zinc: exceeded at the outlet of Blackwater Creek at Wabigoon Lake.

The only parameter determined to exceed the SEL was manganese at the confluence of Blackwater Creek and the unnamed tributary immediately south of the Project portal.

The reason for the higher levels of some metals at the outlet of Blackwater Creek at Wabigoon Lake are likely related to the wetland environment surrounding the area, the influence of backwaters from Wabigoon Lake, and its proximity to the railroad tracks.

5.5.6.4 Polycyclic Aromatic Hydrocarbons

Sediment samples from each location were analyzed for 24 PAHs. Benzo[b]fluoranthene and naphthalene were detected at the outlet of Blackwater Creek at Wabigoon Lake. Benzo[k]fluoranthene was detected at all locations.

Baseline concentrations of PAHs are generally below concentrations considered protective of benthic organisms (i.e., both LEL and SEL), with the exception of benzo[k]fluoranthene, with a concentration of 0.25 mg/kg, which slightly exceeds the LEL of 0.24 mg/kg.

There is the potential for additional exceedances at the outlet of Blackwater Creek at Wabigoon Lake based on the fact that the detection limit of 0.25 mg/kg exceeded LEL values of anthracene, perylene, dibenzo[a,h] anthracene, fluorene, and andindeno[1,2,3-cd]pyrene. High organic carbon content of the sediment at the outlet of Blackwater Creek at Wabigoon Lake may have led to instrument interferences that resulted in elevated detection limits at this location.

Therefore, PAHs, were generally not detected at the site, and those which were detected are not present at levels of concern for benthic organisms. Overall, PAHs are not expected to be currently affecting the health or survival of benthic organisms at the site.

5.5.6.5 Sediment Sampling Quality Assurance/Quality Control (QA/QC)

The water depth at each sampling location ranged between 20 cm and 30 cm. Surficial sediment was sampled from the surface to a depth of between 10 cm to 15 cm. Sediment samples were consistently collected from pools at each site.

A petite ponar grab was used to sample surficial sediments at all sampling locations. Three subsamples were randomly collected within a 10 m x 10 m area at each location and pooled to comprise each site's sediment sample. The petite ponar grab was manually cleaned of residual sediment after each sample and then rinsed in stream water. At each new sampling site, the petite ponar grab was rinsed again before the next sample was collected. New disposable nitrile gloves were also worn during each sediment sample collection to minimize the possibility of cross-contamination.

Samples were placed in jars provided by the laboratory, field-labelled, and kept cool (between 0°C and 8°C) before being submitted to the laboratory for analysis. None of the samples were frozen before being submitted. All sediment samples were provided to the laboratory within the recommended hold time for sediment analyses and were documented by a chain of custody.

The laboratory followed its own QA/QC procedures that are required in order to maintain its accredited status.

5.6 Hydrogeology

The hydrogeology of the project area, as described below, has been adapted from the August 2014 report entitled *Hydrogeological Pre-Feasibility/EA Support Study Goliath Project*, AMEC Environment & Infrastructure, August, 2014. This report described the various initial hydrogeological investigations undertaken at the site, primarily in 2013, with limited site work done in 2012 and 2014. Supplementary work has been proposed to further develop and refine the understanding of the local hydrogeological conditions including the installation of additional groundwater monitoring wells in the basal sand unit and the shallow bedrock, continued groundwater elevation monitoring with both manual and automated methods, and quarterly groundwater quality sample analyses.

5.6.1 Hydrogeological Setting

The proposed mine site is located in the west-central portion of a hydrological basin containing low to moderate relief topographic features, including low lying marsh type lands and exposed bedrock ridges. This basin has been defined by inferred groundwater divides associated with topographic watersheds, and is bordered by upland areas to the east, in the vicinity of Hartman Lake, and to the north, part of which is occupied by a significant wetland area; the Thunder Lake Tributary drainage basin to the west; and Wabigoon Lake to the south. This basin contains the Thunder Lake drainage area to the west, Blackwater Creek drainage area through the central region, and the Hughes and Nugget Creek drainage areas in the east. Blackwater Creek and Hughes Creek both drain southerly into Wabigoon Lake. The extent of this area is shown in Figure 5.6.1-1.

The regional hydrogeology of this study area reportedly consists of relatively shallow (less than 10 m), localized overburden aquifers, as well as fractured metamorphic bedrock aquifer conditions.

5.6.2 Overburden Aquifer Conditions

As described in the 2014 study report, the hydrogeological investigations conducted to date for this area were based on the following infrastructure:

- Nine monitoring wells/groundwater quality wells were constructed in the overburden and bedrock contact in May 2013.
- 20 geotechnical boreholes were drilled in March/April 2014 with four of these completed with shallow stand pipes for groundwater monitoring.
- Groundwater elevations were manually recorded in the water quality wells on near monthly intervals between June 2013 and January 2014, and in the standpipes on one occasion in May 2014.

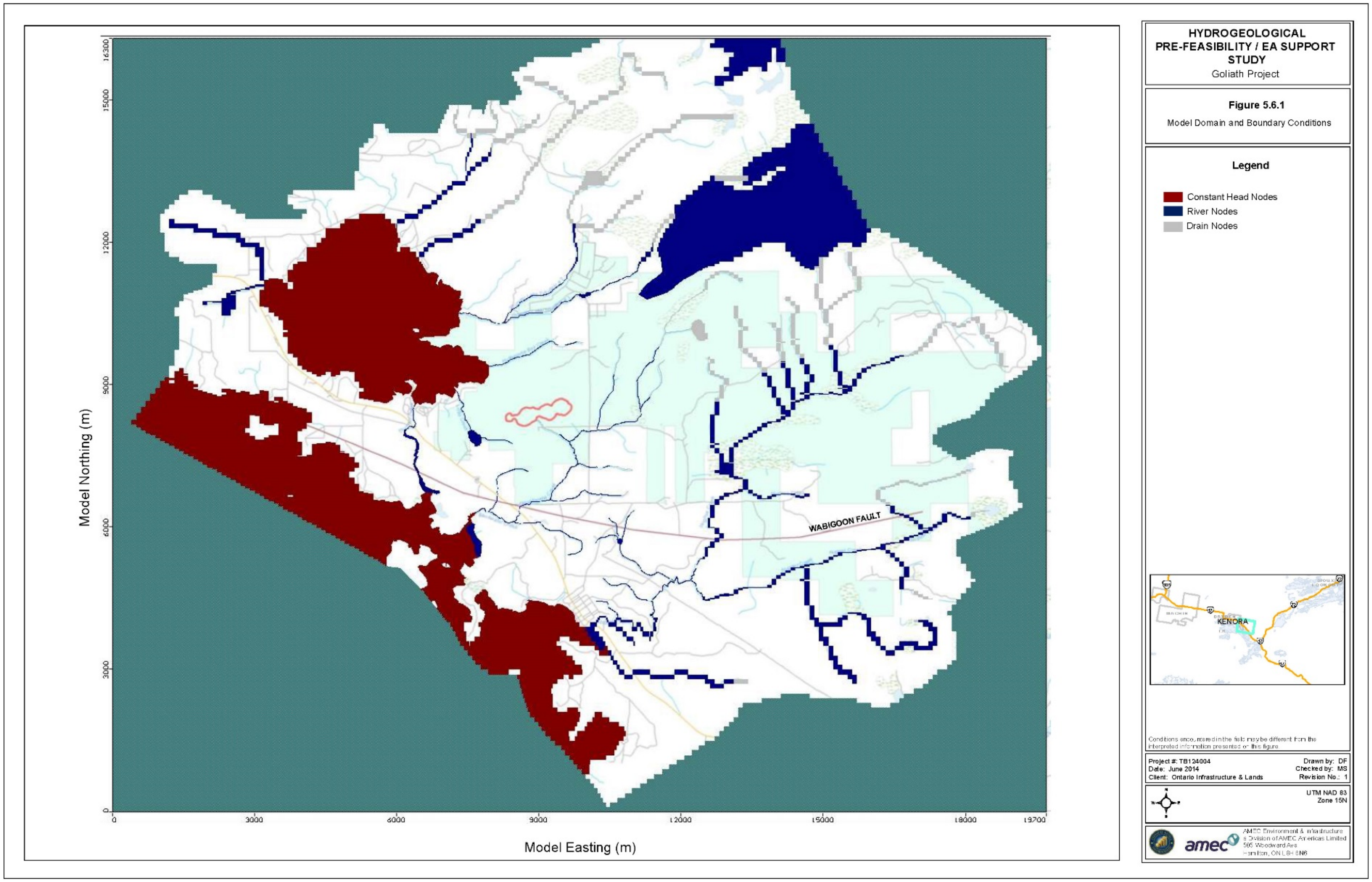

Figure 5.6.1-1: Hydrogeological Model Domain and Boundary Conditions

- Hydraulic conductivity testing of the overburden soils was performed on six of the water quality wells in February 2014.

Borehole logs and well construction details for these monitoring wells are provided in the AMEC report.

5.6.2.1 Overburden Geology

Overburden throughout the area consists of fine grained lacustrine deposits and coarser grained glaciofluvial outwash deposits, distributed over shallow, irregular bedrock. This overburden has an average thickness of around 7.5 m, but does vary from non-existent where bedrock outcrops at surface in various locations in the vicinity of the project site, as well as to the north and south, to depths of around 15 m in limited areas, with a maximum depth of 40 m below grade. The distribution of this surficial geology is shown in Figure 5.6.2.1-1. For additional details relating to the surficial geology, including cross section through the study area, please refer to Section 5.5.

For the most part, the lacustrine deposits of clay, silt and sand-clay or silt-sand, have a low hydraulic conductivity (10^{-8} m/s), and are expected to act as an aquitard. These deposits are generally not expected to provide any significant base flow to the local creeks or streams, or to be suitable for development as a groundwater resource through use of private wells.

Through portions of this area (exploratory drilling suggest 40% of borehole locations), there is a basal sand of variable but generally limited thickness (3 to 4 m maximum), underlying the lacustrine clay-rich unit. Hydraulic conductivities of the basal sand unit are in the order of 10^{-6} m/s, so there is the potential for development of this water bearing zone as a localized groundwater resource. These deposits generally infill the low areas of the variable bedrock surface.

Across the northeastern portion of the study area, the overburden geology is dominated by sand and sand and gravel glacial deposits, associated with the Hartman Moraine, a northwest to southeast trending feature running parallel to the shoreline of Thunder Lake. These outwash deposits are expected to provide base flow to various tributaries draining into Thunder Lake, and are suitable for development as a groundwater resource. A second area of deeper sand and gravel deposits is present in the southeast portion of the study area in the form of a Kame deposit.

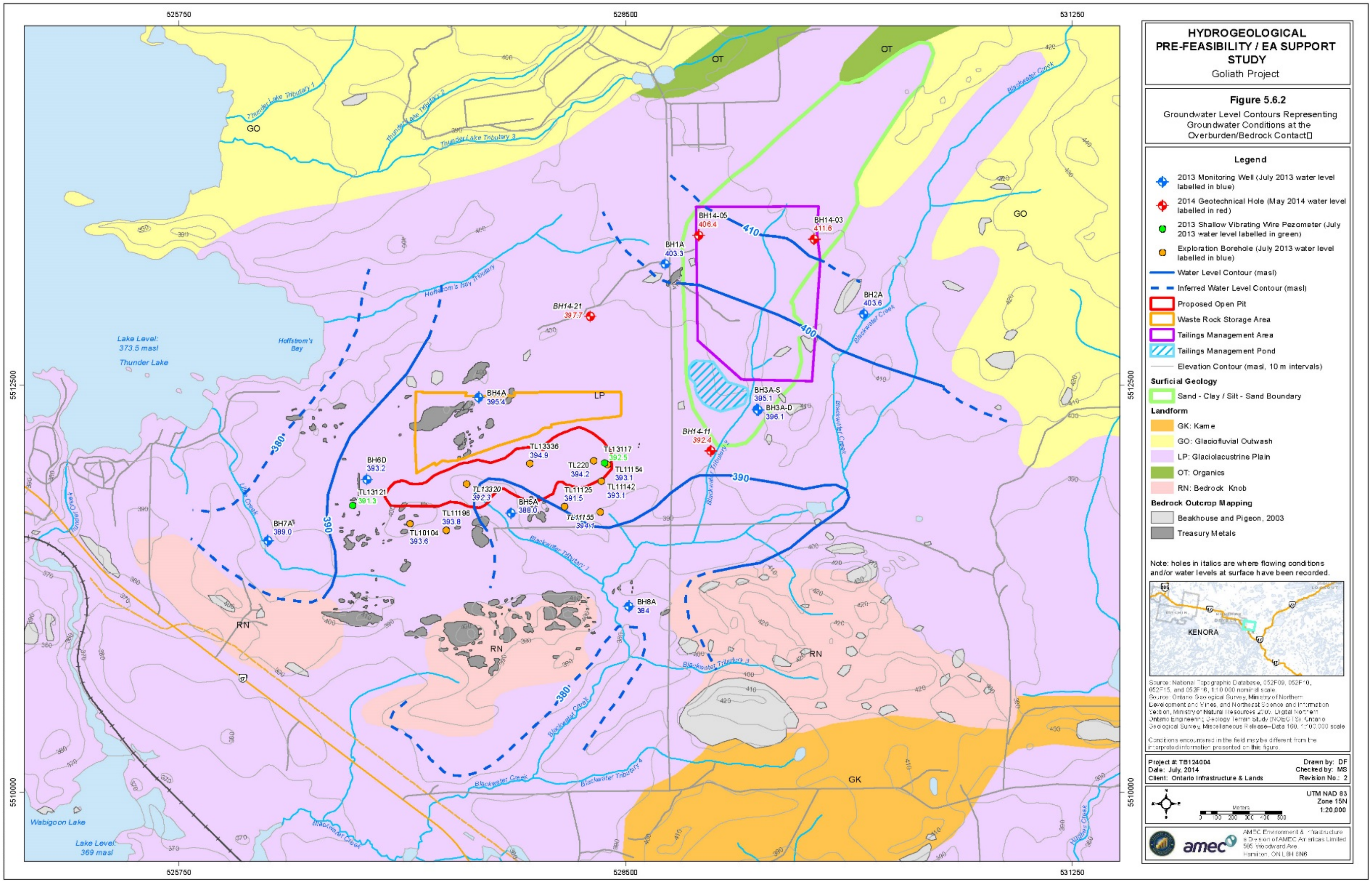

Figure 5.6.2.1-1: Groundwater Level Contours

5.6.2.2 Aquifer Characteristics

In February 2014, rising head slug tests were conducted by Treasury on six of the groundwater quality wells installed in the overburden and overburden/ bedrock interface. Hydraulic conductivities ranged from 4.6E-07 m/s to 1.3E-06 m/s with a geometric mean of 9.2E-0.7 m/s and arithmetic mean of 9.8E-07 m/s. In most of the wells in which rising head slug tests were conducted, the screened portion of the well extended through a mixture of clay and sand immediately above the contact with the bedrock surface (location of auger refusal) or the screen straddled the basal sand and bedrock contact surface. Details relating to the well construction, stratigraphy and conductivity values are summarized in Table 5.6.2.2-1. The resulting hydraulic conductivity values are generally representative of silty sand conditions.

Table 5.6.2.2-1: Overburden Hydraulic Conductivity Testing Summary

Well ID	Screened Depth (m below grade)	Screened Stratigraphy	Depth to Water (m below grade)	Hydraulic Conductivity (m/s)
1A	3.1 – 4.6	Basal sand and bedrock	1.06	1.3×10^{-6}
3AS	3.1 – 6.1	Sand	1.66	7.1×10^{-7}
3AD	10.9 – 12.9	Clay and basal sand	1.20	4.6×10^{-7}
5A	6.6 – 9.6	Clay	2.0	1.0×10^{-6}
6D	3.0 – 6.0	Clay and basal sand	1.91	1.1×10^{-6}
7A	4.0 – 7.0	Clay and silt and sand	1.43	1.2×10^{-6}

5.6.2.3 Groundwater Flow

During the limited period of groundwater elevation monitoring (June 2013 to January 2014), the depth to groundwater ranged from 0.14 m to 1.9 m below grade. Seasonal fluctuations of the water table were noted as a slight rise in the fall and then a decrease in the winter, with the range of fluctuation in the individual wells being 0.5 m to 1.7 m. The groundwater elevations recorded are summarized in Table 5.6.2.3-1.

Based on limited monitoring of various wells (water quality monitoring and geotechnical boreholes) installed throughout the area, groundwater flow in the basal sand feature appears to be southwesterly, from the elevated wetland to the north, then splitting off in the general vicinity of the project site to the south towards Wabigoon Lake and to the west towards Thunder Lake, suggesting that this flow is largely controlled by local topography. The groundwater contours and apparent flow direction is shown in Figure 5.6.3 of the Hydrogeological Pre-Feasibility/EA Support Study Goliath Project, AMEC Environment & Infrastructure, August, 2014, report.

Based on this flow system, the recharge area for the basal sand aquifer is expected to be in higher elevation, outwash areas to the north, and the Kame deposit to the southeast, or along the edges of the localized bedrock outcrops.

Table 5.6.2.3-1a: 2013/2014 Quality Monitoring Data

2013/2014 Groundwater Quality Monitoring Wells						Groundwater Levels[2,3]								
	Easting[1] (m)	Northing[1] (m)	Screened Units	Surface Elevation (masl)	Stick Up (m)	10-11/06/13 (masl)	9/7/13 (masl)	14/8/13 (masl)	16/10/13 (masl)	27/11/13 (masl)	28/11/13 (masl)	19/12/13 (masl)	30/1/14 (masl)	3/2/14 (masl)
BH1A	528705	5513251	Basal Sand/Bedrock	404.20	0.92	404.06	403.33	403.27	403.89			403.61		403.14
BH2A	529978	5512931	Clay/Basal Sand/Bedrock	403.91	0.99	403.79	403.57	403.00		403.77		403.57		
BH3A - S	529283	5512359	Sand (top Sand-Clay/Silt-Sand)	396.77	0.78	395.51	395.12	395.15	395.31		395.01	395.12	395.11	
BH3A - D	529281	5512360	Clay/Sand (bottom Sand-Clay/Silt-Sand)	397.00	0.86	396.26	396.11	395.95	396.23		395.73	395.09	395.80	
BH4A	527699	5512263	Clay/Bedrock	396.38	1.02	396.22	395.42	395.03	395.94		396.27	395.99	394.53	
BH5A	527800	5511717	Clay	389.07	0.87	388.31	387.98	387.87				387.97	387.07	
BH6D	526905	5511901	Clay/Basal Sand	394.25	0.88	393.93	393.24	393.14	393.20		392.95	392.81	392.34	
BH7A	526307	5511546	Clay/Basal Sand	390.28	0.64	389.64	388.99	388.73	389.02		388.38	389.01	388.85	
BH8A	528560	5511072	Basal Sand/Bedrock	388.63	0.85	384.73	384.03	383.91	383.94	383.63		383.33		382.81

Notes:
1. Coordinates in NAD 83, UTM Zone 15N
2. Groundwater levels shaded in grey used for groundwater model calibration
3. Groundwater levels italicized when water is at surface/hole is flowing

Table 5.6.2.3-1b: 2013/2014 Groundwater Monitoring Data

2014 Geotechnical Holes Shallow Standpipes						Groundwater Levels[2,3]
	Easting[1] (m)	Northing[1] (m)	Screened Units	Surface Elevation (masl)	Stick Up (m)	1/5/14 (masl)
BH14-03	529660	5513406	Silty Sand (top Sand-Clay/Silt-Sand)	411.87	0.17	411.57
BH14-05	528946	5513426	Silty Sand (top Sand-Clay/Silt-Sand)	406.64	0.31	406.41
BH14-11	529025	5512091	Clay	392.35		*392.35*
BH14-21	528280	5512927	Clay	397.65		*397.65*

Notes:
1. Coordinates in NAD 83, UTM Zone 15N
2. Groundwater levels shaded in grey used for groundwater model calibration
3. Groundwater levels italicized when water is at surface/hole is flowing

Table 5.6.2.3-1c: 2013/2014 Groundwater Monitoring Data

Exploration Boreholes (all in bedrock)								Groundwater Levels[2,3]						
	Easting[1] (m)	Northing[1] (m)	BH Length (m)	BH Dip (Degrees[4])	Azimuth (Degrees[5])	Surface Elevation (masl)	Stick Up (m)	21/3/12 (masl)	25/3/13 (masl)	12/4/13 (masl)	6/5/13 (masl)	27/5/13 (masl)	17/6/13 (masl)	5/7/13 (masl)
TL10,104	527173	5511648	321	-70	360	396.00	0.2		395.63	395.65	395.72	394.98	394.74	393.62
TL11,125	528124	5511753	411	-64	309	394.74	0.5		390.75	390.81	392.41	392.16	392.02	391.52
TL11,142	528352	5511909	447	-69	360	394.87	1.0	392.93	392.26	392.30	393.52	393.38	393.38	393.06
TL11,154	528389	5512010	249	-64	360	396.32	1.1	394.62	392.87	392.96	394.52	394.48	394.49	393.11
TL11,155	528342	5511720	585	-67	311	393.00	1.1		*394.13*	393.76	*394.13*	*394.13*	*394.13*	*394.13*
TL11,196	527396	5511608	429	-65	350	395.89	0.2		391.86	392.10	394.37	394.71	394.58	393.83
TL13,320	527521	5511892	123	-44	360	390.90	1.4		391.87	391.78	*392.27*	*392.27*	*392.27*	*392.27*
TL13,336	527910	5512018	105	-44	360	396.10	1.1		393.54	393.70		395.51	395.53	394.86
TL220	528302	5512035	66	-45	360	396.09	0.8		393.77	393.59	394.63	394.71	394.58	394.21

Notes:
1. Coordinates in NAD 83, UTM Zone 15N
2. Groundwater levels shaded in grey used for groundwater model calibration
3. Groundwater levels italicized when water is at surface/hole is flowing
4. Measured from ground surface
5. Measured from north

Monitoring of stream flows in Blackwater and Little Creek during the regional dry/low precipitation year of 2011 found that these creeks had no flow or not enough flow for accurate measurement beyond the spring freshet. This was considered to be an indication that there was no significant groundwater discharge to these creeks, as otherwise some baseflow could be expected during very dry conditions. In 2012 and 2013, precipitation was again below the 30 year average, but near continuous flow was noted in both of these creeks, which was then assumed to account for part of the recharge to the overburden aquifer system.

5.6.2.4 Groundwater Quality

Groundwater quality was monitored through sampling conducted on six occasions during 2013 from the groundwater quality wells which were screened within the basal sand and bedrock contact. These results indicated that the groundwater was typically calcium-magnesium-bicarbonate type water. Dissolved metal concentrations were found to exceed the Ontario PWQO for the Protection of Aquatic Life at one or more of the eight monitoring wells during one or more of the sampling events as follows: Aluminum (BH3A, BH6D, and BH7A), Arsenic (BH3A) Chromium (BH3A, BH6D), Cobalt (BH1A, BH2A, BH3A, BH4A, BH6D), Copper (BH3A, BH6D, BH8A), Iron (BH2A, BH3A, BH4A, BH5A, BH6D, BH7A), Tungsten (BH8A), Vanadium (BH3A, BH6D) and Zinc (BH3A, BH6D).

A summary of the groundwater quality is provided in Table 5.6.2.4-1.

5.6.3 Bedrock Aquifer Conditions

As described in the 2014 AMEC study report, the hydrogeological investigations conducted to date for the bedrock system were based on the following infrastructure.

- Records for available geological exploration boreholes were initially reviewed and six of these were incorporated in to the hydrogeological assessment program.
- Three additional boreholes were drilled into the bedrock in February 2013 to assess hydrogeological conditions.
- All nine of these hydrogeological purposes bedrock boreholes are located in the immediate vicinity of the proposed mine development site.
- In February 2014, multi-level hydraulic conductivity testing was conducted on three existing geological exploration boreholes and in the three bedrock boreholes drilled for hydrogeological assessment.
- The three drilled boreholes were equipped with vibrating wire piezometers to allow for continuous water level fluctuation monitoring through 2013.

Table 5.6.2.4-1: Groundwater Quality

Station Name	Easting[1]	Northing[1]	Date	pH	Conductivity (µS/cm)	Total Ammonia As N (mg/L)	Dissolved Chloride (mg/L)	Nitrate As N (mg/L)	Nitrite As N (mg/L)	Nitrate + Nitrite As N (mg/L)	Sulphate (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Acidity as $CaCO_3$ (mg/L)	Total Cyanide (mg/L)	Hardness as $CaCO_3$ (mg/L)
BH1A	528742	5513247	11-Jun-13	6.88	319	< 0.020	48	0.33	< 0.020	0.33	18.3	63	24.8	< 0.0020	124
BH1A			10-Jul-13	6.84	339	< 0.020	49.6	0.304	< 0.020	0.304	21.5	73.1	15	< 0.0020	122
BH1A			14-Aug-13	7.14	321	< 0.020	48	0.22	< 0.020	0.22	20.1	61.2	11	< 0.0020	121
BH1A			17-Oct-13	6.79	321	< 0.020	46.6	0.153	< 0.020	0.153	21.7	66.9	19	< 0.0020	105
BH1A			28-Nov-13	6.79	306	< 0.020	46.5	0.104	< 0.020	0.104	18.8	60	15	< 0.0020	117
BH1A			19-Dec-13	6.8	316	< 0.020	46.2	0.066	< 0.050	0.066	14.7	65	12	< 0.0020	114
BH2A	529967	5512940	11-Jun-13	7.38	475	0.288	26.2	0.065	< 0.020	0.065	51.4	160	21.2	< 0.0020	231
BH2A			10-Jul-13	6.83	475	0.105	34.5	< 0.030	< 0.020	< 0.030	57.2	138	18.0	< 0.0020	219
BH2A			14-Aug-13	7.14	451	0.327	36.5	< 0.030	< 0.020	< 0.030	58	114	9	< 0.0020	203
BH2A			17-Oct-13	6.97	487	0.0999	45.9	< 0.030	< 0.020	< 0.030	75.1	98.9	22	< 0.0020	199
BH2A			28-Nov-13	6.84	494	0.195	51.7	< 0.030	< 0.020	< 0.030	86.6	94	18	< 0.0020	222
BH2A			19-Dec-13	6.95	555	0.106	59.6	< 0.050	< 0.050	< 0.050	101	77	8	< 0.0020	224
BH3 A-D	529308	5512354	11-Jun-13	8.11	356	0.237	6.33	< 0.030	< 0.020	< 0.030	30.2	1270	3.4	< 0.0020	314
BH3 A-D			10-Jul-13	7.59	379	0.209	0.33	0.128	< 0.020	0.128	4.76	239	10	< 0.0020	203
BH3 A-D			14-Aug-13	8.19	359	0.181	6.87	< 0.030	< 0.020	< 0.030	29.6	156	3	< 0.0020	172
BH3 A-D			17-Oct-13	8	353	0.309	6.76	< 0.030	< 0.020	< 0.030	29.8	160	4	< 0.0020	154
BH3 A-D			28-Nov-13	8.02	334	0.349	6.33	< 0.030	< 0.020	< 0.030	27.7	158	6.0	< 0.0020	178
BH3 A-D			19-Dec-13	8	376	0.042	6.8	< 0.050	< 0.050	< 0.050	27.7	160	2	< 0.0020	177
BH3 A-S	529308	5512354	11-Jun-13	7.8	323	0.051	0.37	0.151	< 0.020	0.151	3.8	174	11.2	< 0.0020	169
BH3 A-S			10-Jul-13	8.03	371	0.257	7.15	< 0.030	< 0.020	< 0.030	30.4	309	3	< 0.0020	186
BH3 A-S			14-Aug-13	7.81	294	0.024	0.49	0.165	< 0.020	0.165	3.34	152	3.0	< 0.0020	156
BH3 A-S			17-Oct-13	7.65	371	0.111	0.24	0.14	< 0.020	0.14	4.14	190	10.0	< 0.0020	175
BH3 A-S			28-Nov-13	7.45	341	0.084	1.11	0.185	< 0.020	0.185	4.07	217	6	< 0.0020	200
BH3 A-S			19-Dec-13	7.7	500	< 0.020	< 2 .0	< 0.105	< 0.050	< 0.105	4.7	251	7.0	< 0.0020	220
BH4A	527596	5512426	11-Jun-13	7.48	376	0.030	0.56	0.177	< 0.020	0.177	35.3	161	5	< 0.0020	159
BH4A			10-Jul-13	7.22	347	0.262	0.91	0.031	< 0.020	0.031	35	155	15	< 0.0020	168
BH4A			14-Aug-13	7.63	343	0.049	0.3	< 0.030	< 0.020	< 0.030	33.9	146	15	< 0.0020	170
BH4A			17-Oct-13	7.54	326	0.096	0.27	< 0.030	< 0.020	< 0.030	28	149	10	< 0.0020	140
BH4A			28-Nov-13	7.21	313	0.058	0.33	< 0.030	< 0.020	< 0.030	34.9	141	15	< 0.0020	143
BH4A			19-Dec-13	7.39	359	0.027	< 2 .0	< 0.050	< 0.050	< 0.050	34.2	152	9	< 0.0020	155

Table 5.6.2.4-1: Groundwater Quality (continued)

Station Name	Easting[1]	Northing[1]	Date	pH	Conductivity (µS/cm)	Total Ammonia As N (mg/L)	Dissolved Chloride (mg/L)	Nitrate As N (mg/L)	Nitrite As N (mg/L)	Nitrate + Nitrite As N (mg/L)	Sulphate (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Acidity as $CaCO_3$ (mg/L)	Total Cyanide (mg/L)	Hardness as $CaCO_3$ (mg/L)
BH5A	527794	5511715	11-Jun-13	7.71	486	0.346	0.91	< 0.030	< 0.020	< 0.030	17	430	15.2	< 0.0020	255
BH5A			10-Jul-13	7.70	517	0.362	3.54	< 0.030	< 0.020	< 0.030	18.1	593	12	< 0.0020	269
BH5A			14-Aug-13	7.82	503	0.322	0.76	< 0.030	< 0.020	< 0.030	17.5	264	11	< 0.0020	258
BH5A			17-Oct-13	7.6	506	0.42	0.52	< 0.030	< 0.020	< 0.030	19.4	276	12	< 0.0020	252
BH5A			28-Nov-13	7.57	499	0.394	0.52	< 0.030	< 0.020	< 0.030	19.9	274	10	< 0.0020	264
BH5A			19-Dec-13	7.67	538	0.326	< 2 .0	< 0.050	< 0.050	< 0.050	19.6	286	9	< 0.0020	267
BH6 D	526907	5511924	11-Jun-13	7.77	393	0.119	0.94	0.619	< 0.020	0.619	24.2	2160	25	< 0.0020	301
BH6 D			10-Jul-13	7.77	254	0.197	0.69	0.087	< 0.020	0.087	4.68	313	6	< 0.0020	116
BH6 D			14-Aug-13	7.98	331	0.246	0.51	0.114	< 0.020	0.114	5.24	175	6.0	< 0.0020	133
BH6 D			17-Oct-13	7.90	225	0.115	0.41	0.1	< 0.020	0.1	4.58	99.3	15.0	< 0.0020	89.8
BH6 D			28-Nov-13	7.25	228	0.098	0.53	0.205	< 0.020	0.205	6.99	100	14.0	< 0.0020	201
BH6 D			19-Dec-13	7.43	255	0.17	< 2.0	0.244	< 0.050	0.244	7.8	158	5.0	< 0.0020	109
BH7A	526298	5511547	11-Jun-13	8.14	540	0.255	0.29	0.037	< 0.020	0.037	8.57	671	11.8	< 0.0020	304
BH7A			10-Jul-13	7.77	457	0.203	0.64	< 0.030	< 0.020	< 0.030	12.2	1810	11	< 0.0020	245
BH7A			14-Aug-13	7.98	434	0.203	0.44	0.099	< 0.020	0.099	11.4	228	7.0	< 0.0020	175
BH7A			17-Oct-13	7.89	393	0.317	0.41	0.056	< 0.020	0.056	13.5	237	7.0	< 0.0020	222
BH7A			28-Nov-13	7.77	311	0.266	0.47	< 0.030	< 0.020	< 0.030	13.6	167	6.0	< 0.0020	182
BH7A			19-Dec-13	7.75	338	0.314	< 2 .0	< 0.050	< 0.050	< 0.050	14.1	169	4.0	< 0.0020	161
BH8A	528520	5511143	11-Jun-13	7.76	561	0.054	< 0.10	0.061	< 0.020	0.061	1.01	335	19.0	< 0.0020	318
BH8A			10-Jul-13	7.42	593	0.026	0.18	0.049	< 0.020	0.049	1.76	324	22.0	< 0.0020	327
BH8A			14-Aug-13	7.73	572	0.026	0.17	0.045	< 0.020	0.045	0.94	313	24	< 0.0020	334
BH8A			17-Oct-13	7.39	568	0.083	< 0.10	0.041	< 0.020	0.041	0.83	340	47	< 0.0020	301
BH8A			28-Nov-13	7.27	535	0.022	0.15	0.033	< 0.020	0.033	0.81	329	23	< 0.0020	313
BH8A			19-Dec-13	7.36	603	< 0.020	< 2.0	< 0.050	< 0.050	< 0.050	< 2.0	354	16	< 0.0020	302

5.6.3.1 Geology

Bedrock throughout the area consists of metasedimentary rock, with mafic to intermediate metavolcanic rock to the north and south. Groundwater availability and flow through these units is dependent on fracture frequency and fracture interconnectivity which allows for groundwater storage movement from the recharge areas. The areas of higher conductivity in the metasedimentary unit are most commonly in the upper portion, which has been subjected to historical weathering, and in a central unit of more highly altered rock (e.g., schists) which shows an east–west structural trend. Please refer to Section 5.4 for additional details relating to the bedrock geology.

For the most part, the rocks outside of the surficial portion and the central unit are fairly competent with fracture frequency decreasing with depth, as indicated by Rock Quality Designation (RQD) recovery values of around 90%, and therefore are unlikely to produce any significant amount of groundwater. The central unit, although more conductive as a result of the higher fracturing rate, still shows a limited potential for groundwater flow (RQD value of 83%), typical of Canadian Shield bedrock environments.

5.6.3.2 Aquifer Characteristics

Hydraulic conductivity testing was conducted in three existing exploration boreholes and in three boreholes drilled in part for hydrogeological purposes, to estimate the hydraulic conductivity in the bedrock along the east-west structural trend. This conductivity testing involved the use of packers to isolate a limited portion of the borehole, either starting at the base of existing exploration boreholes and moving upward to increase the length of exposed fractured zone, or moving downward as drilling progressed in new boreholes. The groundwater within the isolated zone was pumped out and a rising head slug test performed.

A total of six boreholes were tested in this way, with each borehole being tested over between five to nine intervals. The estimated bedrock hydraulic conductivities that resulted from the packer testing in the existing exploration boreholes ranged from 2E-06 m/s near the surface due to weathering and fracturing of the bedrock, down to 1E-08 m/s, decreasing with depth. The exception was within the central mineralized zone where hydraulic conductivity values were in the order of 1E-07 m/s. This coincided with anecdotal information from the construction of the portal which indicated that groundwater flow was associated with the mineralized zones.

A summary of the packer test results averaged over the length of the individual boreholes is provided in Table 5.6.3.2-1.

Table 5.6.3.2-1: Hydraulic Conductivity Summary of Bedrock Units

Well ID	Tested Zone (m below grade)	Geological Unit Penetration Sequence	Average Depth to Water (m below grade)	Average Hydraulic Conductivity (m/s)
TL13321	18 – 254	Hanging-wall – Central – Foot-wall	5.0	1.3×10^{-7}
TL13317	17 – 210	Hanging-wall – Central	3.4	6.5×10^{-7}
TL13315	15 – 225	Foot-wall – Central	1.7	3.9×10^{-7}
TL0855	27 – 237	Hanging-wall – Central	3.0	2.2×10^{-8}
TL10111	27 – 168	Hanging-wall – Central	3.2	4.8×10^{-7}
TL11195	45 – 224	Hanging-wall – Central (intercepts NW Fault at 130 m downhole)	0.6	1.8×10^{-8}

The locations of the boreholes in which packer testing was conducted is shown in Figure 5.6.2.1-1 displays. The table in Appendix D of the *Hydrogeological Pre-Feasibility/EA Support Study Goliath Project, AMEC Environment & Infrastructure,* August, 2014 provides additional details relating to the individual rising head tests performed.

5.6.3.3 Groundwater Flow

Between March and July 2013, groundwater levels were measured on seven occasions in the nine bedrock boreholes identified for hydrogeological purposes. During this period, groundwater was found to show flowing well conditions in two boreholes, with water heights of 0.8 m to over 1.4 m above grade (the height of the casing). Groundwater levels in the remaining seven wells ranged from 0.3 m to 4.0 m below grade, and generally showed an increase in the spring (April to June) and then either stabilized or decreased, with a total range of fluctuation of 0.4 m to 2.9 m. A summary of groundwater monitoring results is provided in Table 5.6.2.3-1. Review of the vibrating wire piezometer levels reportedly indicated a groundwater elevation rise following the spring freshet, followed by a gradual decline through to the winter of 2013/2014. Total water level fluctuations in these wells was reported to be between 1.0 m and 1.5 m.

Based on limited monitoring of these bedrock boreholes situated in the immediate vicinity of the proposed mine site, the groundwater flow appears to be suggest an outward radial flow to the east and southwest. These elevations also suggest an upward vertical flow gradient within the bedrock, and from the bedrock into the overburden units, which may then result in some groundwater discharge to the adjacent Blackwater Creek.

During excavation of the exploration ramp at the proposed mine site, few seeps were encountered, most of which contained a limited volume of water which drained out in 24 to 48 hours. Within the mineralized zone, increased groundwater inflow was noted; however this was readily controlled through pumping to small (20 m^2) on-site settling ponds.

5.6.3.4 Groundwater Quality

Groundwater samples have not been collected from any of the bedrock exploration wells for laboratory analysis so no information is available relating to water quality in the bedrock unit at the site.

5.6.4 Groundwater Development

Groundwater development has occurred in the western and southern portions of the study area, primarily for private residential use, with approximately 140 well records identified for the area within 5 km of the proposed mine site. This development is concentrated to the south, in the vicinity of the community of Wabigoon, and to the east, along the shoreline of Thunder Lake. There are also a few wells are located in the central portions of the study area, as shown in Figure 5.6.4-1. These wells are completed in each of the potential water bearing zones, with the majority of the well development (70%) being in the shallow bedrock, to depths of up to 25 m below grade, and the remaining wells being completed in the overburden units with depths ranging from 7 m to 15 m below grade. Most of these overburden wells have been completed in the outwash sand and gravel deposits in the area around Thunder Lake.

5.6.5 Conceptual Hydrogeological Model

Based on data collected during 2012 to 2014, it appears that there is limited groundwater flow that provides a minimal contribution to creeks in the vicinity of the project site and across much of the project area.

There have been five hydro stratigraphic units identified during the investigation that contribute to the surface water interaction in the watershed and the shallow groundwater flow patterns in the project area. These five units are described in the following:

1. A clay unit consisting of fine grained glaciolacustrine deposits of dominantly clay composition (clay, silty clay, layered clay and silt) that is located around the project site and creating the main unit of the southern project area. This clay unit acts as an aquitard that provides little to no flow to creeks in the area.

2. A Basal sand unit which is a relatively thin discontinuous sand layer beneath the clay unit approximately 3 m to 4 m thick where present. This unit acts as a minor aquifer with a hydraulic conductivity of approximately 1E-06 m/s that provides limited groundwater flow.

3. Bedrock knolls where bedrock outcrops at the surface or has a very thin sand cover and therefore contains no overburden groundwater.

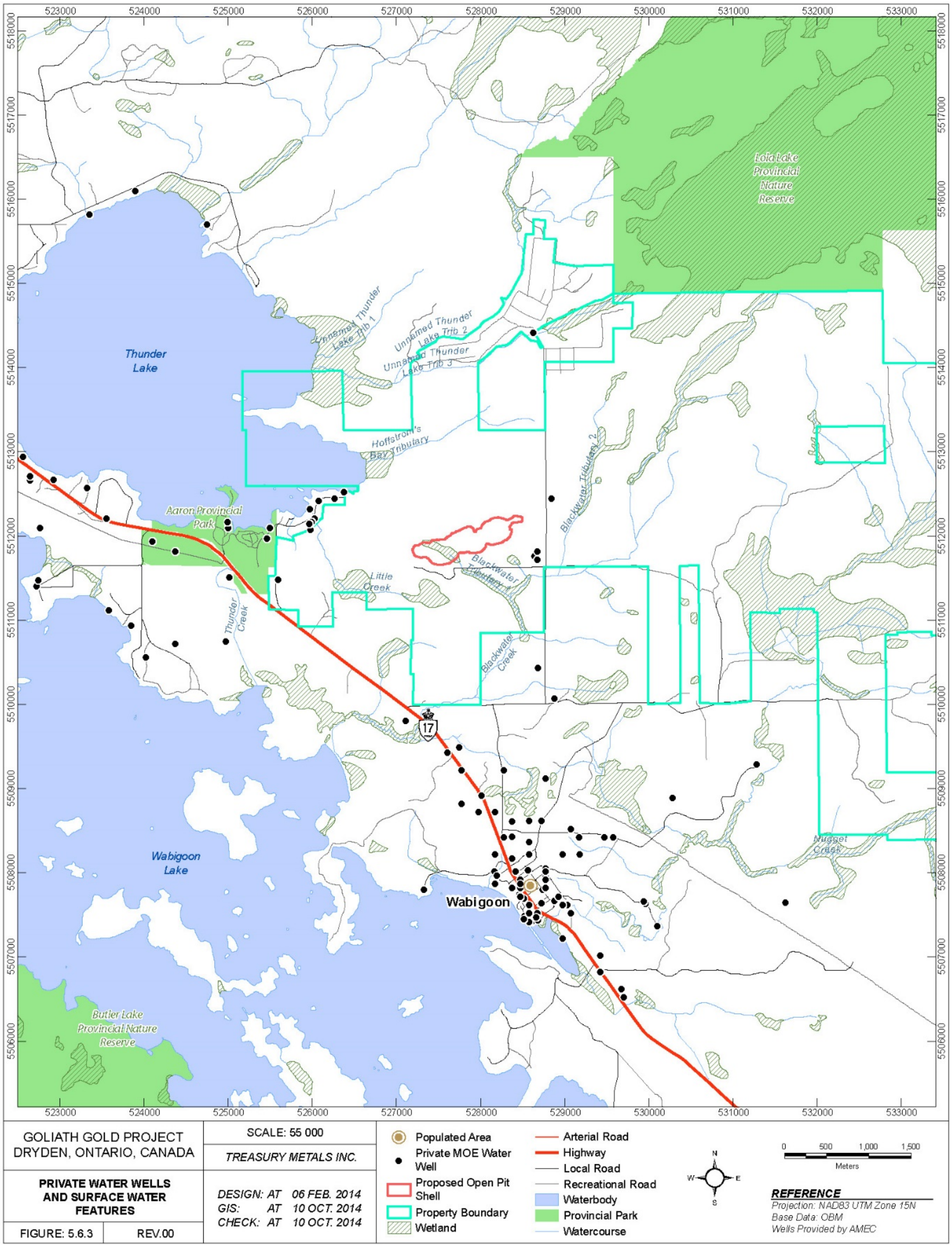

Figure 5.6.4-1: Private Water Wells and Surface Water Features

4. A sand-clay/silt-sand unit consisting mainly of silty sand overlying a mainly continuous silty clay above the basal sand unit. This unit is mainly found in the northwestern portion of the Blackwater Creek Watershed (near the top of Blackwater Tributary #2). This silty sand does provide some groundwater flow to Blackwater Creek and likely has a hydraulic conductivity similar to the basal sand.

5. A sand and gravel unit consisting of coarse glacial deposits located on the northern and northeastern edge of the project area. This unit provides the most groundwater flow to the unnamed tributaries leading to Thunder Lake.

The data collected from 2012 to 2014, appears to indicate that most of the groundwater flow with the project site follows the topography with greatest flow rates present along the contact between the upper weathered/fractured bedrock and basal san units with groundwater flow rates being much lower in the deeper bedrock. There were four hydro stratigraphic units identified during the investigation in the bedrock:

1. The shallow bedrock unit occurring within the initial 10 m from the bedrock surface where a bulk hydraulic conductivity of 1E-06 m/s was recorded due to the near surface fractures and weathering.

2. The intermediate bedrock unit present from approximately 10 mbg to around 400 mbg where a range of bulk hydraulic conductivity of 1E-07 m/s to 1E-08 m/s was recorded.

3. The deep bedrock unit present below 400 mbg where there are very few fractures and low hydraulic conductivities of approximately 1E-09 m/s.

4. The deformation zone of the central unit – this unit is a steeply inclined zone occurring in all of the shallow, intermediate and deep bedrock units and likely has hydraulic conductivities up to an order of magnitude higher in the units that are not affected by near surface weather - the intermediate and deep bedrock.

5.7 Surface Hydrology

The project is located near two lakes in which the watersheds affected by the project flow into. Wabigoon Lake is located to the south of the properties affected by the project and Thunder Lake is located to the west of the properties affected by the Project (Figure 5.7-1).

The primary source of baseline hydrologic information relied on in the EIS is the report prepared by DST Consulting Engineers (DST, 2014d) included as Appendix N. Detailed methodologies used to assess the hydrology of the project area can be found in Appendix N. This baseline work built on the earlier investigations by Klohn Crippen Berger (KCB, 2012).

Figure 5.7-1: Hydrographic Network in the Goliath Gold Project Area

Hydrological baseline studies conducted included hydrological monitoring measurements of stream flow at up to eight locations (hydrometric stations) within the local study area (LSA) dating back to November 2010. Four automatic stream water level logging devises were installed in March 2011 and an additional three were installed in 2012 in order to record stream (Figure 5.7-2).

Hydrometric monitoring stations were located within the project area watersheds as shown follows:

- The largest sub-watershed within the study area which discharges into Wabigoon Lake was monitoring by hydrometric stations TL1A, JCTA and TL3 located on Blackwater Creek.

- Hydrometric station HS4 was installed contributed monitoring data from the second largest sub-watershed located on unnamed tributary 2 of Thunder Lake.

- Hydrometric station HS7 was installed on the north branch of unnamed tributary to Thunder Lake.

- Hydrometric station HS5 was installed on Hoffstrom Bay Tributary in the fourth largest sub-watershed.

- Hydrometric station HS6 was installed on unnamed tributary 3 of Thunder Lake in the smallest of the sub-watersheds in the project area.

A summary of the average daily during 2012 and 2013 from each of the hydrometric stations can be found in Table 5.7-1.

Table 5.7-1: Average Daily Discharge, 2012 to 2013

Site	2012			2013		
	Min	Max	Mean	Min	Max	Mean
TL1A	0.1	173.3	27.0	9.6	356.3	53.0
TL3	2.7	81.4	17.2	19.9	100.6	66.2
HS4	13.1	77.2	26.8	26.5	569.2	111.6
HS5	0.4	6.2	1.9	0.003	46.6	1.9
HS6	9.2	12.5	10.6	0.1	22.0	3.6
HS7	19.7	127.7	53.0	15.2	791.6	91.0
JCTA				16.1	930.9	85.1

Average daily discharges are reported in L/s

Dryden Airport weather station recorded precipitation data and indicated significant amounts of rainfall in July, August and October 2012 and May, July, September and October in 2013 which generally corresponds to the maximum average daily discharges at several of the hydrometric stations.

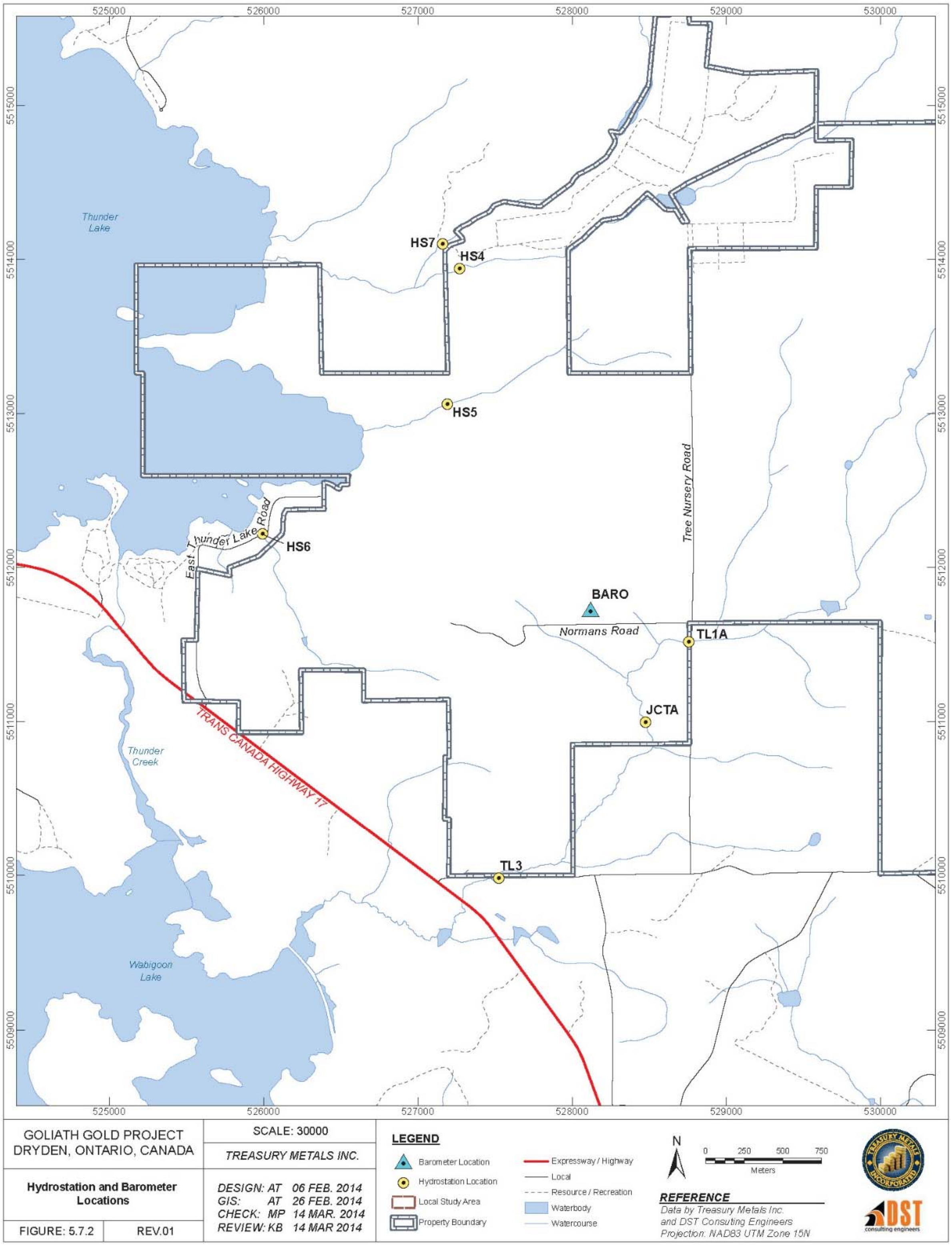

Figure 5.7-2: Hydrostation and Barometer Locations

Discharge data obtained from Environment Canada that was recorded at the Wabigoon River hydrometric monitoring station indicated the spring freshet occurring in April 2013.

Discharge yields from each of the sub-watersheds were compared and the higher discharge yields were observed at hydrometric stations TL1A, TL3, HS6 in 2012 and at JCTA and TL3 in 2013. The highest discharge yields observed were as follows:

- In 2012 were 26 L/s/km^2 (TL1A), 26 L/s/km^2 (TL3) and 12 L/s/km^2 (HS6); and
- In 2013 were 567 L/s/km^2 (JCTA) and 36 L/s/km^2 (TL3).

5.8 Aquatic Resources

The aquatic resources of the Project area, as described below, have been adapted from various reports prepared to support the EIS. The first of these was prepared by Klohn Crippen Berger (2012), and represent a broadly based evaluation of the existing environmental conditions. This report was included as Appendix G to the original EIS, but has been largely replaced by subsequent studies completed since 2012. Where information from the KCB (2012) report are still relied on in the EIS, the information has been incorporated into subsequent studies. Specifically, Appendix Q (Summary Fisheries Baseline Report [2011 to 2016]) to the revised EIS consolidates the fisheries information used from KCB (2012), the baseline fisheries information compiled by DST Consulting Engineers (included as Appendix Q to the original EIS), as well as additional fisheries work completed since the filing of the EIS. The surface water quality information is derived from the sampling work completed in 2012/2013 by DST (Appendix P to the revised EIS).

5.8.1 Surface Water Quality

More than two years of surface water quality samples have been collected in or near the Project area beginning November 2010 (KCB 2012) and again in 2012/2013. Sites were initially selected to capture pre-development site conditions and, during the planning process, considered the distribution of catchments, creeks, rivers, and other waterbodies to characterize the spatial and/or temporal variability in water chemistry (KCB 2012). The 2010/2011 survey identified sample locations in the local study area (LSA) that included Blackwater Creek, which is of concern because it is the primary watercourse draining the proposed Project. Blackwater Creek drains into the Wabigoon Lake Watershed. The larger regional study area (RSA) also included areas of Blackwater Creek, Hughes Creek, and Thunder Lake sub-catchment and their associated tributaries. Also during the 2010/2011 survey, a far-field station (SW3 at McHugh Creek and Highway 17) was sampled to capture information in a catchment that will not likely be impacted by mining developments as planned at the time of study.

Following the 2010/2011 survey, the specific location of sampling sites evolved as additional information about the Project footprint was developed. Nine locations were added and three locations were discontinued during the 2012/2013 sampling program. Additional sites include tributaries to Thunder Lake and locations along Blackwater Creek. A summary of water quality sampling locations and for all sample years is provided in Figure 5.8.1-1 and Table 5.8.1-1.

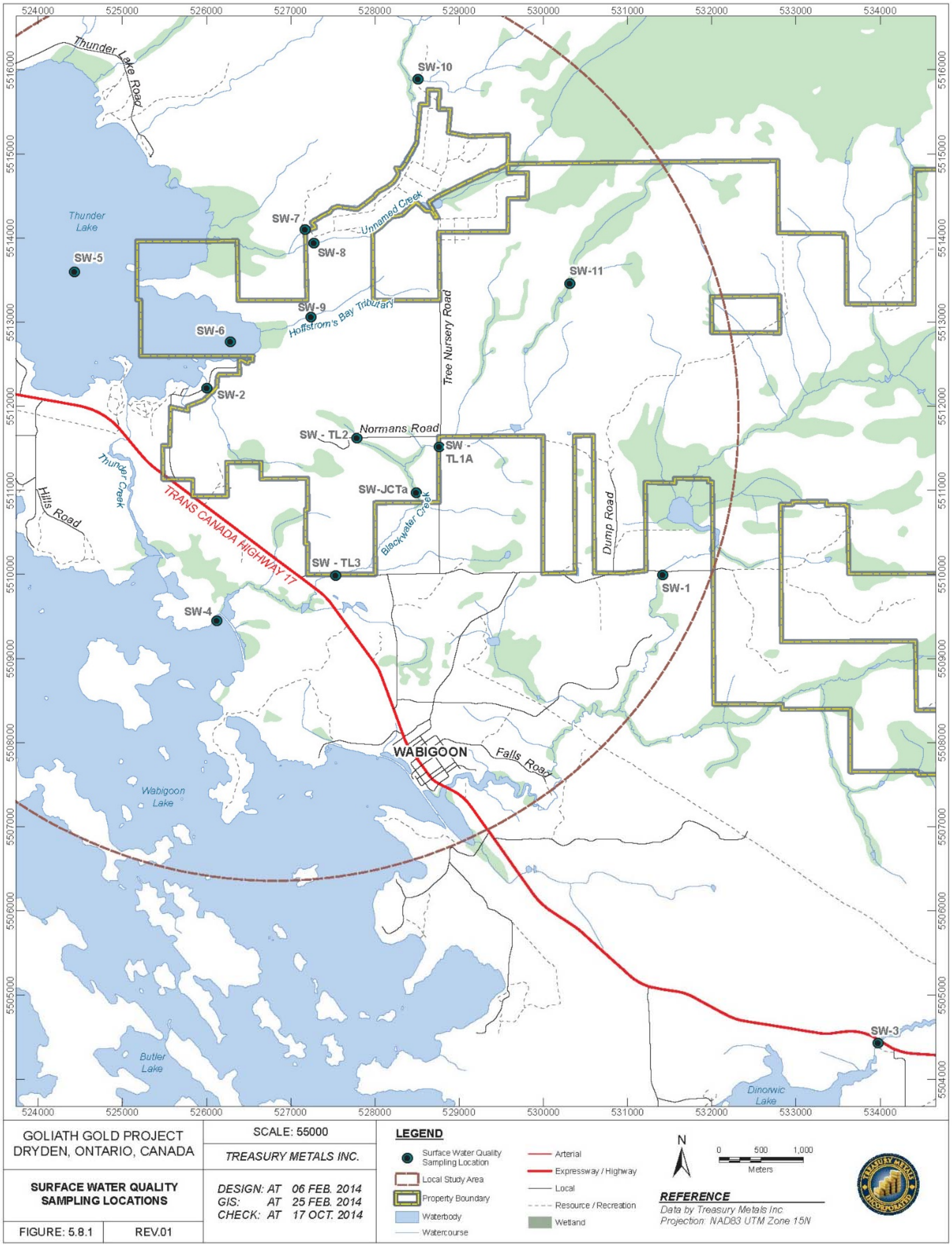

Figure 5.8.1-1: Surface Water Quality Sampling Locations

Table 5.8.1-1: Location and Dates for Surface Water Sample Collection

Station	Description and Purpose	Sample Year	
		2010/2011	2012/2013
TL1	Located at a crossing of Norman's Road on Blackwater Creek and captures runoff upstream of the project site on Blackwater Creek	Yes	
TL1a	Located below the confluence of Blackwater Tributary 2 and Blackwater Creek		Yes
TL2	Located downstream of a roadway and beaver dam downstream of the unnamed tributary of Blackwater Creek south of the Project site. This station collects runoff from the Project site which drains southward	Yes	Yes
TL2a	Located downstream of Station TL2 is a stand of poplar trees. This Station was established to collect runoff from the Project Site	Yes	
TL3	Located at the crossing of Blackwater Creek and Anderson Road and captures runoff from the Project site including potential upstream influences to the east	Yes	Yes
JCT	Located at confluence of Blackwater Creek and the unnamed tributary immediately south of the Project site	Yes	
JCTa	Located downstream of the confluence of Blackwater Creek and the unnamed tributary south of the Project site	Yes	Yes
SW1	Located on Hughes Creek at the Anderson Road crossing. This was established as a local reference station	Yes	Yes
SW2	Located at the culvert crossing under Thunder Lake Road on the unnamed tributary to Thunder Lake southwest of the Project site. This location captures sample runoff from the LSA to the west	Yes	Yes
SW3	Located on McHughes Creek at the Hwy 17 crossing was established as a regional reference site. Samples are taken downstream of the box culvert	Yes	Yes
SW4	SW4 is the field duplicate station and rotates locations with the schedule	Yes	Yes
SW5	Located in the eastern end of Thunder Lake		Yes
SW6	Located in the southeast end of Thunder Lake. This area captures water coming into the lake from Hoffstrom's Bay Tributary		Yes
SW7	Located along Thunder Lake Tributary 2		Yes
SW8	Located along Thunder Lake Tributary 3		Yes
SW9	Located along Hoffstram's Bay Tributary prior to confluence with Thunder Lake.		Yes
SW10	Located along an unnamed tributary to Thunder Lake Tributary 2		Yes
SW11	Located along Blackwater Creek, upstream from Norman's Road		Yes

At each surface water sampling site, in situ field measurements included: water and air temperature, pH, conductivity, total dissolved solids, dissolved oxygen, and turbidity. Oxidation reduction potential was measured during 2012/2013 only. Samples were also collected and analyzed for physical and inorganic parameters, as well as total and dissolved metals (Table 5.8.1-2). Detailed sampling protocols and analytical methods are provided in Appendix G and Appendix P.

Table 5.8.1-2: Water Quality Parameters Measured

Analysis	Parameter	Sample Year	
		2010/2011	2012/2013
Conventional	pH	Yes	Yes
	Temperature	Yes	Yes
	Dissolved oxygen	Yes	Yes
	Conductivity	Yes	Yes
	Alkalinity	Yes	Yes
	Hardness (as $CaCO_3$)	Yes	Yes
	Oxidation-reduction Potential		Yes
	Total Suspended Solids (TSS)	Yes	Yes
Anions and Nutrients	Acidity (as $CaCO_3$)	Yes	Yes
	Ammonia, total (as N)	Yes	Yes
	Chloride (Cl)	Yes	Yes
	Nitrate-N (NO_3-N)	Yes	Yes
	Nitrite-N (NO_2-N)	Yes	Yes
	Phosphorus, total (TP)	Yes	Yes
	Sulphate (SO_4)	Yes	Yes
Other	Oil and Grease	Yes	
Cyanides	Cyanide, weak acid dissociable	Yes	Yes
	Cyanide, total	Yes	Yes
	Cyanide, free	Yes	Yes
Metals, total and dissolved	Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Rb, Sb, Se, Si, Sn, Sr, Te, Ti, Tl, U, V, W, Zn, Zr		Yes

There are two surface waterbodies in the LSA/RSA that are known to be sources for potable water: Wabigoon Lake and Thunder Lake. Wabigoon Lake provides raw water for the City of Dryden and some residences along the shore. The City of Dryden provides water treatment prior to distribution. Some residences along the shore of Thunder Lake draw water for residential use. As these are private dwellings it is unknown whether secondary treatment is conducted.

5.8.1.1 Quality Assurance/Quality Control

Details on blind field duplicate, trip blanks and field blanks were collected during each sampling event and submitted to the laboratory as part of a quality assurance/quality control (QA/QC) program and are further described in Appendix G and Appendix N.

5.8.1.2 Water Quality Regulatory Information

The results of inorganics and dissolved and total metals surface water analyses were compared to the Ministry of Environment and Energy Provincial Water Quality Objectives (PWQO) for the protection of aquatic life and recreation in freshwater (MOEE 1994) (Table 5.8.1.2-1). A firm objective for total phosphorus in surface water is not provided in the PWQOs; however, general guidelines are provided to avoid nuisance concentrations of algae in lakes, excessive plant growth, and general aesthetic deterioration.

Table 5.8.1.2-1: PWQO for Freshwater

Analysis	Parameter	Unit	PWQO
Inorganics	pH	n/a	6.5 – 8.5
	Phosphorus, total	mg/L	See note 1
	Cyanide, free	mg/L	0.002
Dissolved Metals	Aluminum (Al)	mg/L	0.075
	Mercury (Hg	mg/L	0.0002
Total Metals	Antimony (Sb)	mg/L	0.02
	Arsenic (As)	mg/L	0.005
	Beryllium (Be)	mg/L	0.011 – 1.1 (see note 2)
	Boron (B)	mg/L	0.2
	Cadmium (Cd)	mg/L	0.0001 – 0.0005 (see note 3)
	Cobalt (Co)	mg/L	0.0009
	Copper (Cu)	mg/L	0.005
	Iron (Fe)	mg/L	0.3
	Lead (Pb)	mg/L	0.001 – 0.005 (see note 4)
	Molybdenum (Mo)	mg/L	0.04
	Nickel (Ni)	mg/L	0.025
	Selenium (Se)	mg/L	0.1
	Silver (Ag)	mg/L	0.0001
	Thallium (Ti)	mg/L	0.0003
	Tungsten (W)	mg/L	0.03
	Uranium (U)	mg/L	0.005
	Vanadium (V)	mg/L	0.006
	Zinc (Zn)	mg/L	0.02

Notes:
1. For the ice-free period should not exceed 0.02 mg/L; a high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 0.01 mg/L or less. This should apply to all lakes naturally below this value; Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 0.03 mg/L.
2. Criteria is 0.011 mg/L if Hardness as $CaCO_3$ is = 75 mg/L; criteria is 1.1 mg/L if the sample hardness is >75 mg/L.
3. Criteria is 0.0001 mg/L if the sample hardness is = 0-100 mg/L; criteria is 0.0005 mg/L if the sample hardness is >100 mg/L.
4. Criteria is 0.001 mg/L if the sample hardness is 30 mg/L; criteria is 0.003 mg/L if the sample hardness is = 30-80 mg/L; criteria is 0.005 µg/L if the sample hardness is = >30-80 mg/L

5.8.1.3 Water Quality Results

A summary of the base water quality conditions has been provided in Table 5.8.3.1-1. The values in the table represent the 50th percentile of the available monitoring data available from the 2012/2013 monitoring program completed by DST (Appendix P). Of those watercourses and waterbodies, six (i.e., Blackwater Creek, Thunder Lake Tributary 2/3, Hoffstrom's Bay Tributary, Little Creek, Thunder lake, Wabigonn Lake) are potentially affected by the Project. Table 5.8.4.3-2 provides a summary of the baseline water quality by waterbody.

Table 5.8.1.3-1: Summary of Baseline Surface Water Quality Results

Parameter	SW-TL1a Blackwater Creek mg/L	SW-TL2 Blackwater Creek Tributary #1 mg/L	SW-TL3 Blackwater Creek mg/L	SW-JCTa Blackwater Creek mg/L	SW11 Blackwater Creek mg/L	SW1 Hughes Creek mg/L	SW2 Little Creek mg/L	SW3 McHughes Creek mg/L	SW4 Wabigoon Lake mg/L	SW5 Thunder Lake mg/L	SW6 Thunder Lake mg/L	SW7 Thunder Lake Tributary #2 mg/L	SW10 Thunder Lake Tributary #2 mg/L	SW8 Thunder Lake Tributary #3 mg/L	SW9 Hoffstrom's Bay Tributary mg/L
Aluminum	0.13700	0.31650	0.47000	0.17100	0.65400	0.06200	0.55500	0.07485	0.69150	0.01300	0.02100	0.10000	0.07180	0.06960	0.07805
Antimony	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060	0.00060
Arsenic	0.00100	0.00115	0.00100	0.00100	0.00110	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Beryllium	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Boron	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
Cadmium	0.00002	0.00003	0.00002	0.00002	0.00004	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Chloride	0.44000	0.46000	1.67000	0.92000	0.44000	0.59000	1.21000	11.65000	3.23500	4.20000	4.21000	0.23000	0.24000	0.29500	0.38500
Chromium	0.00100	0.00205	0.00120	0.00100	0.00160	0.00100	0.00140	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Cobalt	0.00275	0.00077	0.00050	0.00050	0.00061	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050
Copper	0.00100	0.00480	0.00170	0.00100	0.00130	0.00100	0.00200	0.00100	0.00215	0.00115	0.00120	0.00100	0.00100	0.00110	0.00100
Cyanide	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200
Iron	1.90500	0.96550	1.05000	1.37000	1.70000	0.42750	1.01000	0.26150	0.45850	0.03250	0.03600	0.62000	1.28000	0.75600	0.36500
Lead	0.00100	0.00140	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Mercury	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Molybdenum	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Nickel	0.00200	0.00235	0.00200	0.00200	0.00200	0.00200	0.00210	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200
Nitrate	0.03000	0.03000	0.03000	0.04200	0.06300	0.03000	0.03900	0.03000	0.03000	0.03000	0.03000	0.12000	0.05800	0.10650	0.10050
Phosphorus	0.02240	0.04135	0.03110	0.02470	0.02450	0.00955	0.04720	0.01525	0.02360	0.00740	0.00770	0.01100	0.01060	0.01545	0.01055
Selenium	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Silver	0.00010	0.00041	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
Thallium	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030
Uranium	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500
Vanadium	0.00100	0.00185	0.00150	0.00100	0.00160	0.00100	0.00200	0.00100	0.00110	0.00100	0.00100	0.00100	0.00100	0.00100	0.00100
Zinc	0.00305	0.00755	0.00440	0.00300	0.00640	0.00300	0.00500	0.00300	0.00300	0.00300	0.00300	0.00300	0.00300	0.00300	0.00300
Alkalinity	34.10000	61.65000	57.80000	47.60000	6.00000	64.10000	63.30000	52.20000	—	45.90000	45.80000	50.00000	57.20000	68.70000	114.50000
Hardness	37.15000	66.95000	66.00000	57.00000	19.30000	63.65000	67.60000	55.50000	—	48.50000	48.00000	52.00000	60.00000	73.40000	116.00000
pH	6.81500	7.29500	7.42000	7.28500	5.76000	7.27500	7.56000	7.34000	7.68500	7.76000	7.76000	7.59000	7.54000	7.67000	7.87000

Table 5.8.1.3-2: Summary of Baseline Surface Water Quality by Waterbody

Parameter	Thunder Lake Tributaries 2 and 3 (mg/L)	Hoffstrom's Bay Tributary (mg/L)	Little Creek (mg/L)	Blackwater Creek (mg/L)	Thunder Lake (mg/L)	Wabigoon Lake (mg/L)
Aluminum	0.077	0.078	0.555	0.251	0.016	0.692
Antimony	0.001	0.001	0.001	0.001	0.001	0.001
Arsenic	0.001	0.001	0.001	0.001	0.001	0.001
Beryllium	0.001	0.001	0.001	0.001	0.001	0.001
Boron	0.050	0.050	0.050	0.050	0.050	0.050
Cadmium	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Chloride	0.3	0.4	1.2	0.9	4.2	3.2
Chromium	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	0.001	0.001	0.001	0.001	0.001	0.001
Copper	0.001	0.001	0.002	0.001	0.001	0.002
Cyanide	0.002	0.002	0.002	0.002	0.002	0.002
Iron	0.862	0.365	1.010	1.450	0.036	0.459
Lead	0.001	0.001	0.001	0.001	0.001	0.001
Mercury	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Molybdenum	0.001	0.001	0.001	0.001	0.001	0.001
Nickel	0.002	0.002	0.002	0.002	0.002	0.002
Nitrate	0.090	0.101	0.039	0.030	0.030	0.030
Phosphorus	0.011	0.011	0.047	0.027	0.008	0.024
Selenium	0.001	0.001	0.001	0.001	0.001	0.001
Silver	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Thallium	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Uranium	0.005	0.005	0.005	0.005	0.005	0.005
Vanadium	0.001	0.001	0.002	0.001	0.001	0.001
Zinc	0.003	0.003	0.005	0.004	0.003	0.003

Note: Background surface water quality based on 50th percentile data

Field-measured pH was generally neutral with the occasional pH value below the PWQO for pH of 6.5 at TL1 (at 6.2) measured during the 2010/2011 survey. During the 2012/2013 survey, pH measurements were similarly neutral with several measurements below the PWQO at SW7 (one occurrence) and SW11 (eight occurrences). Measurements of pH at SW11 were below the MMER of 6.0 on six occurrences. Mean conductivity measured during the 2010/2011 survey ranged from 131 µS/cm at JCTa to 264 µS/cm at SW3 and from 23.6 µS/cm at SW7 to 450 µS/cm at SW3 in 2012/2013. Conductivity is a measurement of water's capacity to conduct electrical current which is positively correlated with increases in metal and salt content in water. Increased conductivity is common during spring runoff events as road salts applied during winter are washed away. Sites associated with the Project area with higher conductivity are more closely associated with or downstream roadways or infrastructure.

Laboratory results of samples collected during both surveys that exceeded PWQO are provided in Table 5.8.1.3-1. In general, PWQO exceedances were measured on at least one occasion for dissolved aluminum and total silver, cobalt, copper, iron, lead, selenium, zinc, and vanadium.

Dissolved aluminum exceedances were found at TL1, TL2, TL3, JCTa, and SW2. Total cobalt exceedances were found at SW3, SW10, SW11, TL1a, TL2, TL2a, TL3, JCTa, and SW3. Total silver was exceeded in two of eight samples from TL2a. Dissolved aluminum exceeded PWQO at TL1, TL2, TL3, JCTa, and SW2. Total copper exceedances were found at TL1 (2010/2011) and SW1 (2012/2013); however, the measurement at TL1 is believed to be an outlier and the result from SW1 has a detection limit above the PWQO. Total iron exceedances were found at SW1, SW2, SW4, SW6, SW7, SW9, SW10, SW11, TL1, TL1a, TL2, TL2a, and JCTa. Total iron is often elevated in the Canadian Shield region of Ontario due to high iron presence in the bedrock and soils. One exceedance of total lead was found at TL2a as well as one exceedance of total selenium at JCTa. Exceedances of total zinc were found at SW3, SW7, SW9, SW10, SW11, and JCTa. One exceedance of vanadium was found at SW10.

Table 5.8.1.3-1: Surface Water PWQO Exceedances

Parameter	Station	Description of PWQO Exceedance (Range of Measurements)	
		2010/2011	2012/2013
pH	SW7	-	1 of 15 (6.24 - 7.95)
	SW11	-	8 of 9 (5.06 - 6.61)
	TL1	3 of 13 (6.2 - 7.41)	-
Total Phosphorus		See note 1	See note 2
Total Ag	TL2a	-	2 of 8 samples (0.00072 mg/L - 0.00083 mg/L)
Dissolved Al	**TL1**	12 of 13 samples (0.072 mg/L - 0.24 mg/L)	-
	TL2	5 of 13 (0.050 mg/L to 0.19 mg/L)	-
	TL3	1 of 13 samples (0.0050 mg/L - 0.11 mg/L)	-
	JCTa	2 of 13 samples (0.0098 mg/L - 0.11 mg/L)	-
	SW2	5 of 13 samples (0.033 mg/L - 0.15 mg/L)	-
Total Co	SW10	-	1 of 15 samples (0.00162 mg/L)
	SW11	-	1 of 9 samples (0.0011 mg/L)
	TL1	8 of 13 samples (0.00025 mg/L - 0.0030 mg/L)	-
	TL1a	-	8 of 16 samples (0.00216 mg/L - 0.00723 mg/L)
	TL2	6 of 13 samples (0.00025 mg/L - 0.0060 mg/L)	-
	TL2a	-	2 of 8 samples (0.00095 mg/L - 0.00103 mg/L)
	TL3	1 of 13 samples (0.00025 mg/L - 0.0016 mg/L)	-
	JCTa	3 of 13 samples (0.00025 mg/L - 0.0018 mg/L)	4 of 14 samples (0.0096 mg/L - 0.00314 mg/L)
	SW2	1 of 13 samples (0.00025 mg/L - 0.0015 mg/L)	-
	SW3	1 of 13 samples (0.00025 mg/L - 0.0016 mg/L)	-
Total Cu	TL2a	-	2 of 8 samples (0.0075 mg/L - 0.0087 mg/L)
	TL1	1 of 13 samples (0.00050 mg/L - 0.015 mg/L)	-
Total Fe	SW1	9 of 13 samples (0.21 mg/L - 1.3 mg/L)	11 of 16 samples (0.333 mg/L - 1.71 mg/L)
	SW2	11 of 13 samples (0.62 mg/L - 3.4 mg/L)	13 of 13 samples (0.658 mg/L - 2.34 mg/L)

Table 5.8.1.3-1: Surface Water PWQO Exceedances (continued)

Parameter	Station	Description of PWQO Exceedance (Range of Measurements)	
		2010/2011	2012/2013
	SW3	6 of 13 samples (0.064 mg/L - 3.0 mg/L)	4 of 14 samples (0.323 mg/L - 1.23 mg/L)
	SW4	-	8 of 10 samples (0.440 mg/L - 0.788 mg/L)
	SW6	-	1 of 9 samples (0.734 mg/L)
	SW7	-	14 of 15 samples (0.350 mg/L - 1.03 mg/L)
	SW9	-	9 of 14 samples (0.315 mg/L - 0.797 mg/L)
	SW10	-	15 of 15 samples (0.685 mg/L - 8.71 mg/L)
	SW11	-	9 of 9 samples (1.17 mg/L - 2.82 mg/L)
	TL1	13 of 13 samples (0.90 mg/L - 6.1 mg/L)	-
	TL1a	-	14 of 16 samples (0.353 mg/L - 10.40 mg/L)
	TL2	12 of 13 samples (0.23 mg/L - 2.9 mg/L)	-
	TL2a	-	8 of 8 samples (0.615 mg/L - 2.0 mg/L)
	TL3	13 of 13 samples (0.57 mg/L - 3.0 mg/L)	14 of 15 samples (0.301 mg/L - 6.47 mg/L)
	JCTa	3 of 13 samples (0.59 mg/L - 3.7 mg/L)	14 of 14 samples (0.305 mg/L - 9.11 mg/L)
Total Pb	TL2a	-	2 of 8 samples (0.0018 mg/L - 0.0043 mg/L)
Total Se	**JCTa**	-	1 of 14 samples (1.1 mg/L)
Total Zn	SW3	-	1 of 14 samples (0.0267 mg/L)
	SW7	-	1 of 14 samples (0.158 mg/L)
	SW9	-	1 of 14 samples (0.0267 mg/L)
	SW10	-	1 of 14 samples (0.0267 mg/L)
	SW11	-	1 of 9 samples (0.051 mg/L)
	JCTa	-	1 of 14 samples (0.024 mg/L)
Total V	SW 10	-	1 of 15 samples (0.0096 mg/L)

Notes:

Stations in **bold** are associated with Blackwater Creek

1. All sample locations in 2010/2011 exceeded the interim PWQO guidance of 0.01 mg/L on nearly all sample occasions except SW1 which has the fewest exceedances.
2. All sample locations in 2012/2013 exceeded the interim PWQO guidance of 0.01 mg/L on nearly all sample occasions except SW5 which had no exceedances. SW1 had exceedances in less than half the samples collected.

Based on general guidelines provided in the interim PWQO for total phosphorus, nearly all samples from both survey years were in exceedance of the most conservative guidance (0.01 mg/L or less during the ice-free period to provide a high level of protection against aesthetic deterioration). Notable exceptions included SW1 which had the fewest exceedances during both survey periods and SW5 which had no exceedances in 2012/2013. Overall, the highest total phosphorus concentrations were measured from TL2 during 2011/2012 (average of 0.08 mg/L) and from SW2 during 2012/2013 (average 0.07 mg/L).

5.8.2 Sediment Samples

Sediment samples were collected from 19 locations in 2012 (Figure 5.8.2-1) by DST Consulting Engineers (Appendix P). Sample sites were spread across the study area, with multiple sample locations within the same waterbodies. Specific analyses completed are presented in Table 5.8.2-1. Detailed sampling protocols and analytical methods, including method detection limits, are provided in Appendix P. The sediment analysis presented in Appendix P, and summarized herein, built of eh earlier study by Klohn Crippen Berger (KCB, 2012).

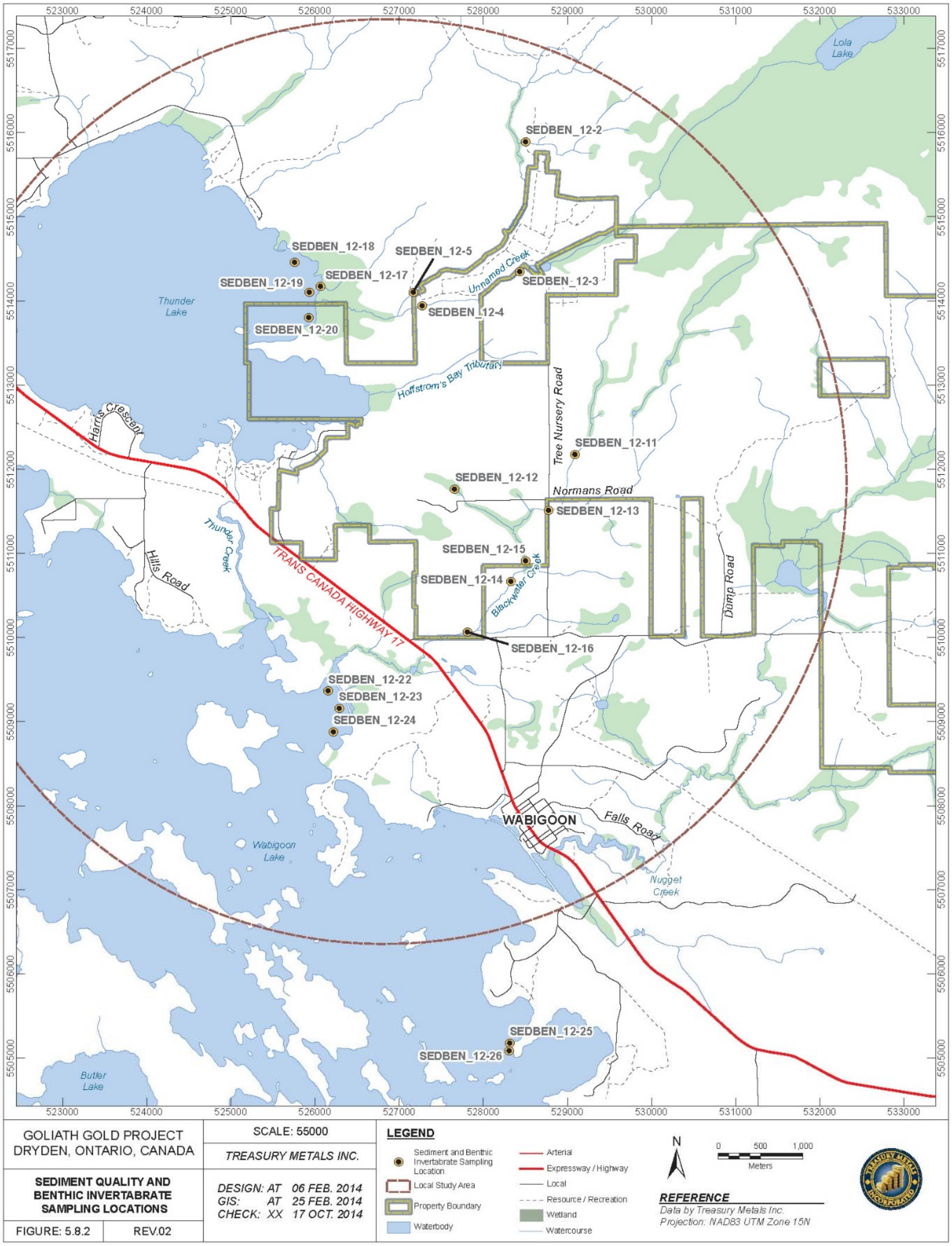

Figure 5.8.2-1: Sediment Sampling Location

Table 5.8.2-1: Sediment Parameters Measured

Parameter		Sample Year	
		2010/2011	2012/2013
Organics	PAH	Yes	
Metals	Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mb, Ni, K, Se, Ag, Na, Sr, S, Tl, Sn, Ti, U, V, Zn		
	Br, Cl, F, S, Hg, Zr		Yes
Nutrients	Ammonia, total (as N)		Yes
	Nitrate-N (NO_3-N)		Yes
	Nitrite (NO_2-N)		Yes
	Phosphorus, total (TP)	Yes	Yes
	Nitrate + Nitrite (TN)		Yes
	Total Kjeldahl Nitrogen (TKN)		Yes
	TOC	Yes	

5.8.2.1 Sediment Quality Regulatory Information

Sediment samples (metals) were compared to the Ontario Provincial Sediment Quality Guidelines (PSQG) (MOE 1993). The guidelines have established three levels of effect – No Effect Level (NEL), Lowest Effect Level (LEL) and Severe Effect Level (SEL). The LEL and SEL are based on long-term effects which contaminants may have on sediment dwelling organisms (Table 5.8.2.1-1). The purpose of the PSQG is to protect the aquatic environment by setting safe levels for metals, nutrients and organic compounds (Fletcher et al. 2008).

Table 5.8.2.1-1: MOE Sediment Effects Levels

Effect Level	Description
No Effect Level (NEL)	This is the level at which the chemicals in the sediment do not affect fish of the sediment-dwelling organisms. At this level no transfer of chemicals through the food chain and no effect on water quality is expected.
	Sediment at the NEL rating is considered clean and no management decisions are required. Furthermore, it may be placed in rivers and lakes provided it does not physically affect the fish habitat or existing water uses.
Lowest Effect Level (LEL)	This indicates a level of contamination which has no effect on the majority of sediment-dwelling organisms. The sediment is deemed to be marginally polluted. Dredged sediments containing concentrations of organic contaminants - PCBs or pesticides, for example - that fall between the NEL and LEL may not be disposed of in an area where the sediment at the proposed disposal site has been rates at the NEL or better.
	Contamination in sediment that exceeds the LEL may require further testing and a management plan.
Severe Effect Level (SEL)	At this level, the sediment is considered heavily polluted and likely to affect the health of sediment-dwelling organisms. If the level of contamination exceeds the SEL then testing is required to determine whether or not the sediment is acutely toxic.
	At the SEL a management plan may be required. The plan may include controlling the source for the contamination and removing the sediment.

Source: MOE (1993)

5.8.2.2 Sediment Quality Results

Sediment Particle size

Sediment particle size can confound interpretation of sediment chemistry data (Lapota et al. 2000). That is, due to the high surface area to volume ratio of fine grain sediments, silts and clays are capable of transporting certain constituents compared to coarser grain sediments (Ongley 1996) and there is a strong positive correlation between decreased grain size and increased trace metal concentrations (Horowitz 1985). Sediments collected from three of the five sites in 2011 were dominated by silt, particularly TL2 and, to lesser degrees, JCTa and BC. Stream sites monitored in 2012 were typically dominated by sand; however, SB12-11a and SB12-12 were dominated by silt. Conversely, all sediments collected Wabigoon Lake were dominated by silt and clay while sediments from Thunder Bay were dominated by sand.

Nutrients

Total organic carbon (TOC) was measured from sediment samples collected in 2011. All samples exceeded the LEL of 1%, and one site, BC (located at the outlet of Blackwater Creek at Wabigoon Lake) also exceed the SEL of 10% (Table 5.8.2.2-1). During the 2012 study, three samples (SB12-3, SB12-25, and SB12-26) exceeded the total phosphorus (TP) LEL of 600 mg/kg (Table 5.8.2.2-1).

Table 5.8.2.2-1: PSQG Exceedances

Parameter	Waterbody	Site(s)	Sample Year	Units	Analytical Result(s)	LEL	SEL
TOC	Blackwater Creek at Norman's Road	TL1	2011	%	2.32	1	10
TOC	Blackwater Creek below unnamed tributary	Tl2	2011	%	3.97	1	10
TOC	Blackwater Creek at Anderson Road	TL3	2011	%	2.62	1	10
TOC	Blackwater Creek below unnamed tributary; south of Project	JCTa	2011	%	3.7	1	10
TOC	Blackwater Creek at Wabigoon Lake	BC	2011	%	16.4	1	10
TP	Unnamed Creek	SB12-3	2012	mg/kg	680	600	2000
TP	Wabigoon Lake	SB12-24	2012	mg/kg	644	600	2000
TP	Wabigoon Lake Reference	SB12-25	2012	mg/kg	853	600	2000
TP	Wabigoon Lake Reference	SB12-26	2012	mg/kg	793	600	2000
Cr	Various creeks	TL1, TL2, TL2, JCTa, and BC	2011	µg/g	27.7 - 54.0	26	110
Cu	Various creeks	TL3 and BC	2011	µg/g	19.0 - 51.6	16	110
Mn	Various creeks	TL2 and TL3	2011	µg/g	616 - 637	460	1100
Ni	Various creeks	TL2, TL2 and JCTa	2011	µg/g	20.8 - 30.8	16	75
Zn	Outlet of Blackwater Creek to Wabigoon Lake	BC	2011	µg/g	268	120	820
Fe	Various creeks	TL2, TL2, JCTa, and BC	2011	%	2.38 - 2.94	2	4

Sediment samples collected in 2012 which were submitted for analysis of anions and nutrients were not compared to Sediment Quality Guidelines as the leachable anions and nutrients requested by Treasury Personnel cannot be compared to those guidelines.

Metals

Of the 32 metals analyzed in sediment samples collected in 2011, nine are listed in the PSQG (Arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc). With the exception of the following, all other constituents were detected below the LEL in sediments. Chromium concentrations at all 2011 sample sites was above the LEL of 26 µg/g but below the SEL guideline of 110 µg/g. Copper concentrations from sediments collected in 2011 from TL2, TL3 and BC were above the LEL of 16 µg/g but below the LEL of 110 µg/g. Manganese concentrations in sediments from sites TL2 and TL3 were above the LEL of 460 µg/g but below the SEL of 1100 µg/g. Nickel concentrations in sediments from sites TL2, TL3, and JCTa were above the LEL of 16 µg/g but below the SEL of 75 µg/g. The concentration of zinc collected from BC was above the LEL of 120 µg/g. The percentage of iron in samples collected from all sites except TL1 were above the LEL of 2%; however, all samples were below the SEL of 4%.

Of the two metals analyzed in sediment samples collected in 2012, one (mercury) is listed in the PSQS. None of the sediment samples collected from any site in 2012 exceeded the LEL of 0.2 µg/g for mercury.

5.8.3 Benthic Invertebrate Community

Benthic invertebrate samples were collected in October of 2011 and 2012 at the locations shown in Listed in Table 5.8.3-1 and shown in Figure 5.8.3-1. In 2011, three replicate samples were collected from six locations in the Blackwater Creek watershed using a Ponar grab. In 2012, samples were collected from 6 locations in the Blackwater Creek watershed and four locations in the Thunder Lake Tributary 2 and Tributary 3 watershed using the Ontario Benthic Biomonitoring Network travelling kick and sweep method, with samples from two riffles and one pool at each location combined in the field to form one composite sample. In 2012 benthic invertebrates samples, consisting of three composited Ponar grabs, were also collected from the bay in Thunder Lake that Unnamed Tributary 2 drains to and from two locations in Wabigoon Lake. The lake samples were collected for possible use as ‘before’ stations in future monitoring and were not intended to characterize existing habitat quality in Wabigoon Lake or Thunder Lake. As those samples were not relied upon in the EIS they are not discussed in this report. The raw data are, however, provided in Appendix Q to the revised EIS.

The preserved benthic samples were sent to ALS Environmental, a certified laboratory, for benthic invertebrate sorting and identification to family level. A number of metrics were calculated for the stream samples including taxon richness, relative abundance, percent EPT (Ephemeroptera, Plecoptera, Tricoptera), percent oligochaete worms and percent chironomids.

Table 5.8.3-1: Benthic Invertebrate Sample Locations

Site No.	Description and Purpose	Sample Year	
		2010/2011	2012/2013
13	Blackwater Creek upstream of the Project site	Yes	
6	Blackwater Creek Tributary 1	Yes	
65	Confluence of Tributary 1 and Blackwater Creek	Yes	
28	Blackwater Creek downstream of the Project site at Anderson Road	Yes	
23	Outlet of Blackwater Creek into Wabigoon Lake	Yes	
SB12-11A	Blackwater Creek Tributary 2		Yes
SB12-12	Blackwater Creek Tributary 1		Yes
SB12-13	Blackwater Creek downstream of confluence with Tributary 2		Yes
SB12-14	Blackwater Creek downstream of the project site		Yes
SB12-15A	Blackwater Creek downstream of the project site		Yes
SB12-16	Blackwater Creek downstream of the project site		Yes
SB12-2	Unnamed Thunder Lake Tributary 3		Yes
SB-3	Unnamed Thunder Lake Tributary 2		Yes
SB-4	Unnamed Thunder Lake Tributary 2		Yes
SB-5	Unnamed Thunder Lake Tributary 3		Yes
SB12-22	Wabigoon Lake		Yes
SB12-23	Wabigoon Lake		Yes
SB12-24	Wabigoon Lake		Yes
SB12-25	Wabigoon Lake Reference		Yes
SB12-26	Wabigoon Lake Reference		Yes
SB12-17	Thunder Lake		Yes
SB12-18	Thunder Lake		Yes
SB12-19	Thunder Lake		Yes
SB12-20	Thunder Lake		Yes

5.8.3.1 Benthic Invertebrate Quality Assurance/Quality Control

Identification to Family level was completed by ALS, where possible. The QA/QC process for invertebrate identification involves periodic testing of Senior Taxonomists with voucher samples, and resampling by third parties.

5.8.3.2 Benthic Invertebrate Results

The 2011 benthic invertebrate metrics are summarized in Table 5.8.3.2-1. The raw data are provided in the Appendix Q. The mean number of individuals in the 2011 benthic invertebrate samples ranged 26 to 200. The samples from the Blackwater Creek sites were composed primarily of oligochaete worms and chironomids with few or, at site 13, no EPT taxa. This is consistent with the low gradient habitat with fine substrates and, at least in the beaver ponds, low dissolved oxygen concentrations. The sample from location 23, where Blackwater Creek enters Wabigoon Lake, had the most taxa and EPT taxa accounted for 13.6% of the sample. The lake/wetland habitat at that location is quite different from the stream habitats at the other locations.

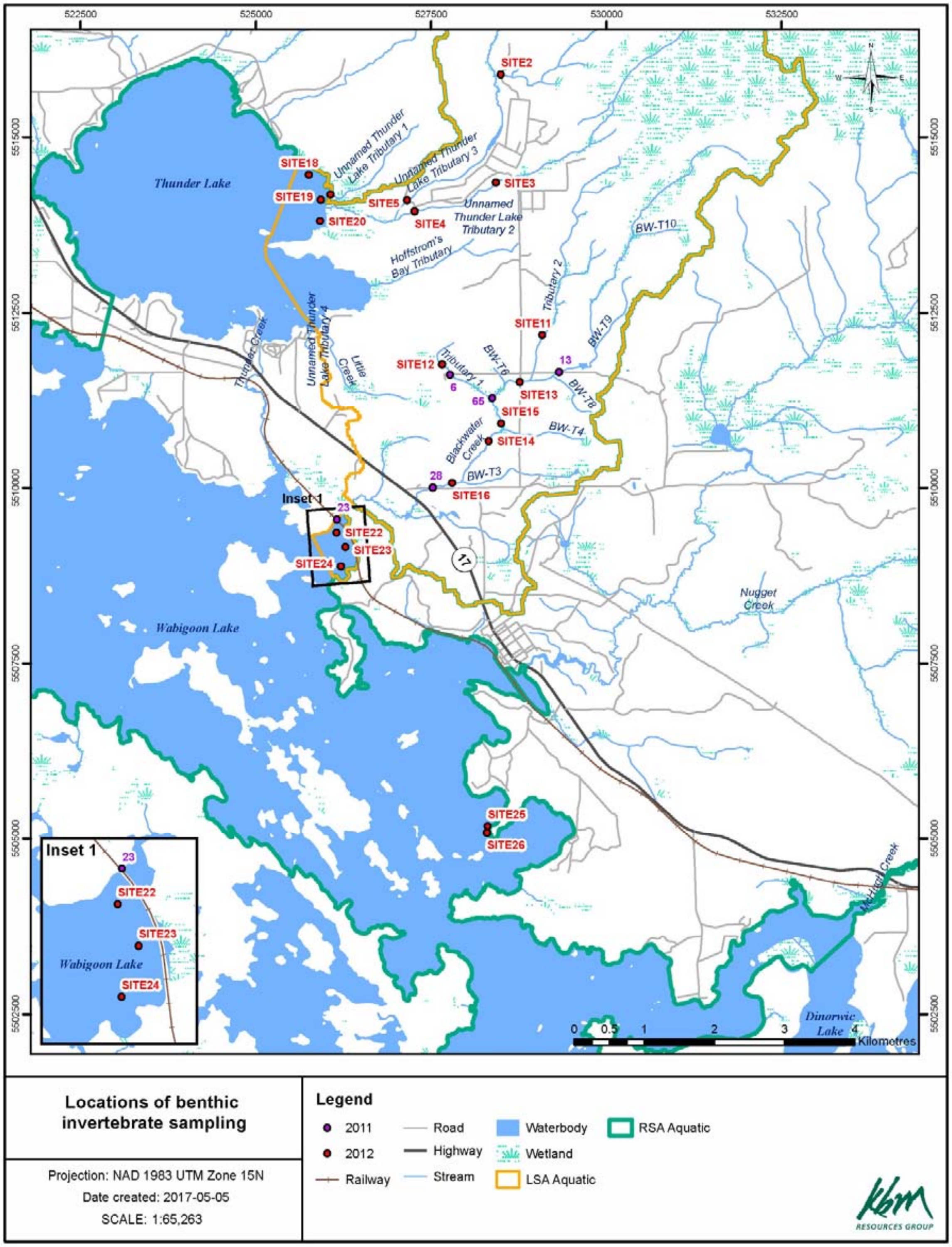

Figure 5.8.3-1: Benthic Invertebrate Sampling Locations

Table 5.8.3.2-1: Summary Indices for Benthic Invertebrate from Blackwater Creek, 2011

Description	Site				
	13	6	65	28	23
Mean # individuals	26	107	200	141	94
Mean # of taxa per sample	4	7	11	12	15
Mean % oligochaetes per sample	64	40	35	10	7
Mean % chironomids per sample	34	26	45	56	54
Mean % EPT taxa per sample	0.0	0.1	1.4	1.0	13.6

The 2012 benthic invertebrate metrics for the Blackwater Creek sites are provided in Table 5.8.3.2-2, which also provides the substrate particle size data. The number of individuals in the samples ranged from 147 to 568 and the number of taxa ranged from 9 to 23. The samples were composed primarily of chironomids at Sites 11, 13, 14 and 15. More than 80 % of the sample at site 12 was composed of fingernail clams belonging to the family Pisiidae. Hydropsychid caddisflys were abundant at site 16, where they accounted for 50% of the sample.

Table 5.8.3.2-2: Summary Indices for Benthic Invertebrate from Blackwater Creek, 2012

Description	Sampling Site					
	11	12	13	14	15	16
Number of individuals	196	147	329	277	568	206
Number of taxa	15	9	21	18	23	15
% oligochaetes	21	3	5	10	5	5
% Chironomids	64	7	57	55	63	21
% EPT taxa	1	1	3	1	5	50
% Pisiidae	7	82	1	1	1	1

The lower number of taxa and higher proportion of oligochaetes in the 2011 samples from Blackwater Creek, compared to the samples from 2012, is thought to be a reflection of the different sampling methods. The 2011 samples were collected by Ponar grab, presumably from slow moving locations dominated by soft substrates. The 2012 samples were composites of kick and sweep samples from two riffles, which presumably would have coarser and/or firmer substrate, and from one pool.

The 2012 benthic invertebrate data for the Thunder Lake Tributary 2 and Thunder Lake Tributary 3 sites are summarized in Table 5.8.3.2-3. The number of individuals in the samples ranged 156 to 2744. The number of taxa in the samples was, on average, higher than in Blackwater Creek and ranged from 23 to 31. Chironomids and EPT taxa accounted for most of the samples, with EPT taxa dominant at two sites and chironomids dominant at the other two.

Table 5.8.3.2-2: Summary Indices for Benthic Invertebrate from Thunder Lake Tributary 2 and Thunder Lake Tributary 3, 2012

Description	Site			
	2	3	4	5
Number of individuals	156	2744	249	357
Number of taxa	23	22	31	27
% oligochaetes	3.8	0.2	12.9	0.3
% Chironomids	28.2	46.9	24.5	68.9
% EPT taxa	52.6	32.4	46.6	19.0
% Pisiidae	0.0	13.3	3.2	2.2

The greater percentage of EPT taxa in Thunder Lake Tributary 2 and 3, relative to Blackwater Creek, suggests better habitat conditions are present in the former. This is consistent with less beaver activity (and thus fewer ponds with low dissolved oxygen) and may also reflect the finer substrates in Blackwater Creek, which is underlain by lacustrine deposits, compared to the outwash deposits that underlay Thunder Lake Tributary 2.

5.8.4 Fish and Fish Habitat

The study area is in the English River watershed, which is tributary to the Winnipeg River and in the Nelson River primary watershed. There are two large lakes, Thunder Lake and Wabigoon Lake, within the Regional Study Area for fish and fish habitat (Figure 5.8.4-1). The Local Study Area includes the tributaries that may be affected by the Project that drain to Thunder and Wabigoon Lakes. Blackwater Creek drains to Keplyn's Bay of Wabigoon Lake. Based on the current Project design, there will be direct impacts by the Project to two tributaries of Blackwater Creek referred to as Tributary 1 and Tributary 2. In addition, flows will be altered and, during operations, effluent will be discharged to Blackwater Creek. There are potential predicted Project related effects to the tributaries to Thunder Lake referred to as Unnamed Tributary 2 and Unnamed Tributary 3; the former tree nursery ponds on these watercourses are expected to provide water to the Project. Changes to flows in two smaller tributaries to Thunder Lake, Hoffstrom's Bay Tributary and Little Creek (formerly referred to as Unnamed Thunder Lake Tributary 4) are also anticipated. Field investigations were conducted in the LSA, focusing on Blackwater Creek and its tributaries and on the Thunder Lake tributaries. Characterization of the RSA relied on existing information.

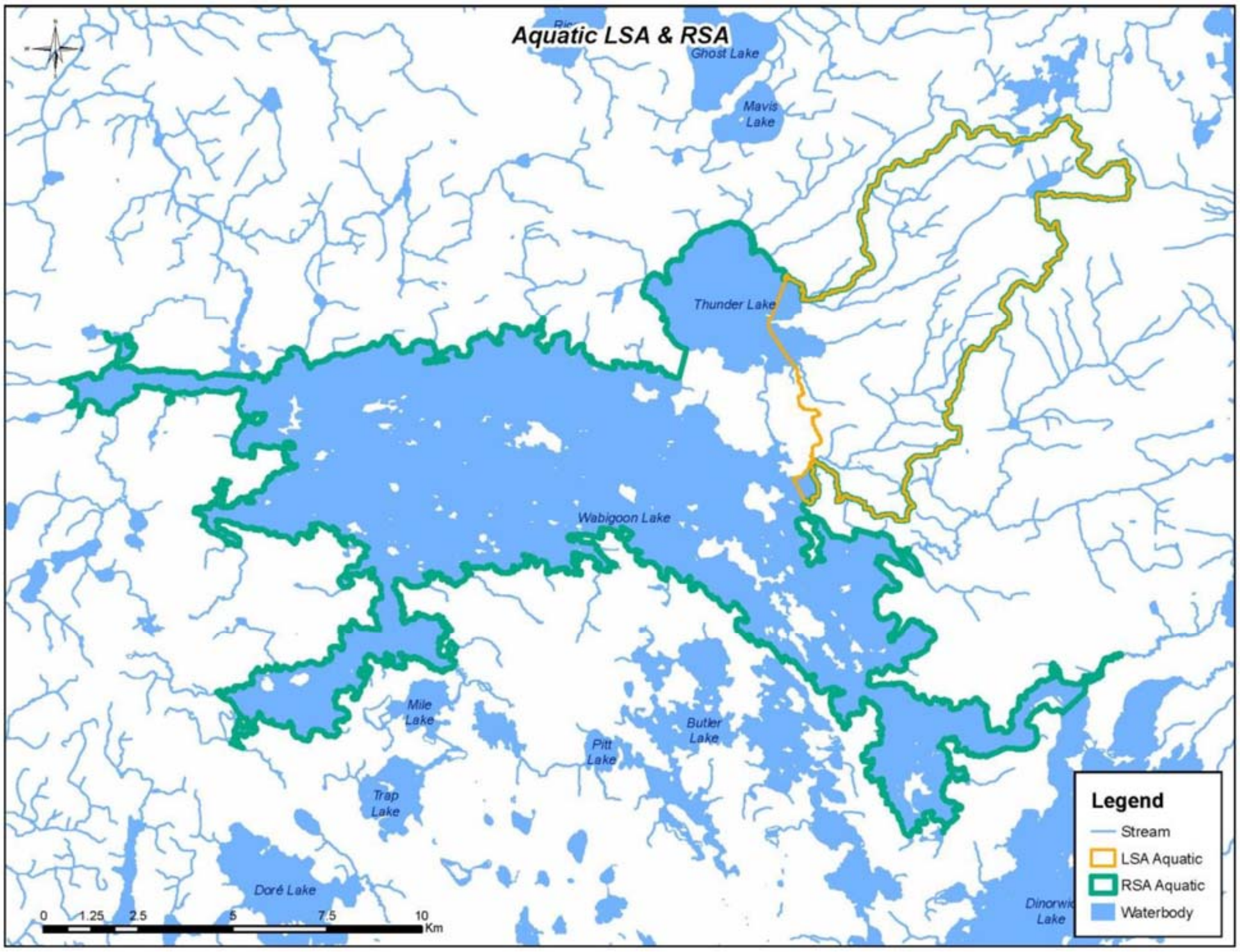

Figure 5.8.4-1: Local Study Area (LSA) and Regional Study Area (RSA) for Fish and Fish Habitat

Baseline fish and fish habitat investigations were conducted by Klohn Crippen Berger Ltd. in 2010 and 2011 (KCB 2012) and DST Consulting Engineers Inc. in 2012 and 2013 (DST 2014). Additional fish sampling was conducted by TMI staff in 2014. C. Portt and Associates (C. Portt) conducted reconnaissance level investigations at a number of locations and side-scan sonar investigations of Keplyn's Bay on Wabigoon Lake and an unnamed bay of Thunder Lake in 2016. The relevant fish and fish habitat information from the KCB (2012) and DST (2014) reports and additional fish and fish habitat baseline information acquired by Treasury Metals in 2014 and C. Portt and Associates in 2016 was consolidated in a single summary report, which is provided as Appendix Q to this report. The information relied upon to prepared the effects assessment contained in Section 6.14 is summarized below.

5.8.4.1 Thunder Lake

Thunder Lake is a coldwater lake and has a surface area of 1,123 ha, a mean depth of 11.1 m and a maximum depth of 23.5 m. It supports a coldwater fish community including populations of Lake Trout, Lake Whitefish and Lake Cisco and also populations of coolwater species including Walleye, Northern Pike, Yellow Perch and Smallmouth Bass. A list of fish species documented to occur in Thunder Lake is presented in Table 5.8.4.1-1. Thunder Lake drains to Wabigoon Lake via Thunder Creek. Water levels in Thunder Lake are controlled by a small dam at the head of Thunder Creek in Aaron Provincial Park.

Table 5.8.4.1-1: Fish Species Present in Thunder Lake

Common name	Scientific name
Lake Trout	*Salvelinus namaycush*
Lake Whitefish	*Coregonus clupeaformis*
Cisco	*Coregonus artedii*
Walleye	*Sander vitreus*
Sauger	*Sander canadensis*
Northern Pike	*Esox lucius*
Smallmouth Bass	*Micropterus dolomieu*
Yellow Perch	*Perca flavescens*
Burbot	*Lota lota*
Rock Bass	*Ambloplites rupestris*
White Sucker	*Catostomus commersonii*
Trout Perch	*Percopsis omiscomaycus*
Johnny Darter	*Etheostoma nigrum*
Mottled Sculpin	*Cottus bairdii*
Deepwater sculpin[1]	*Myoxocephalus thompsonii*

Note: First reported in 2015. (D. Brunner, MNRF biologist. Personal communication with C. Portt. May 1, 2017).

The east shore of Thunder Lake is largely undeveloped in comparison to the remaining shoreline of the lake which is dominated by private homes, seasonal camps and public campgrounds.

The east end of Thunder Lake consists of two shallow (less than 2 m deep) sandy bays separated by a bedrock point. Cobble and boulder shoals extending out from the bedrock point between the two bays and from the island off that point (Figure 5.8.4.1-1) are known Lake Trout and Lake Whitefish spawning areas and may also be Walleye spawning areas although this has not been confirmed. Other areas of potential Lake Trout and Lake Whitefish spawning habitat have been identified by MNRF based on the presence of coarse substrate but spawning has not been confirmed.

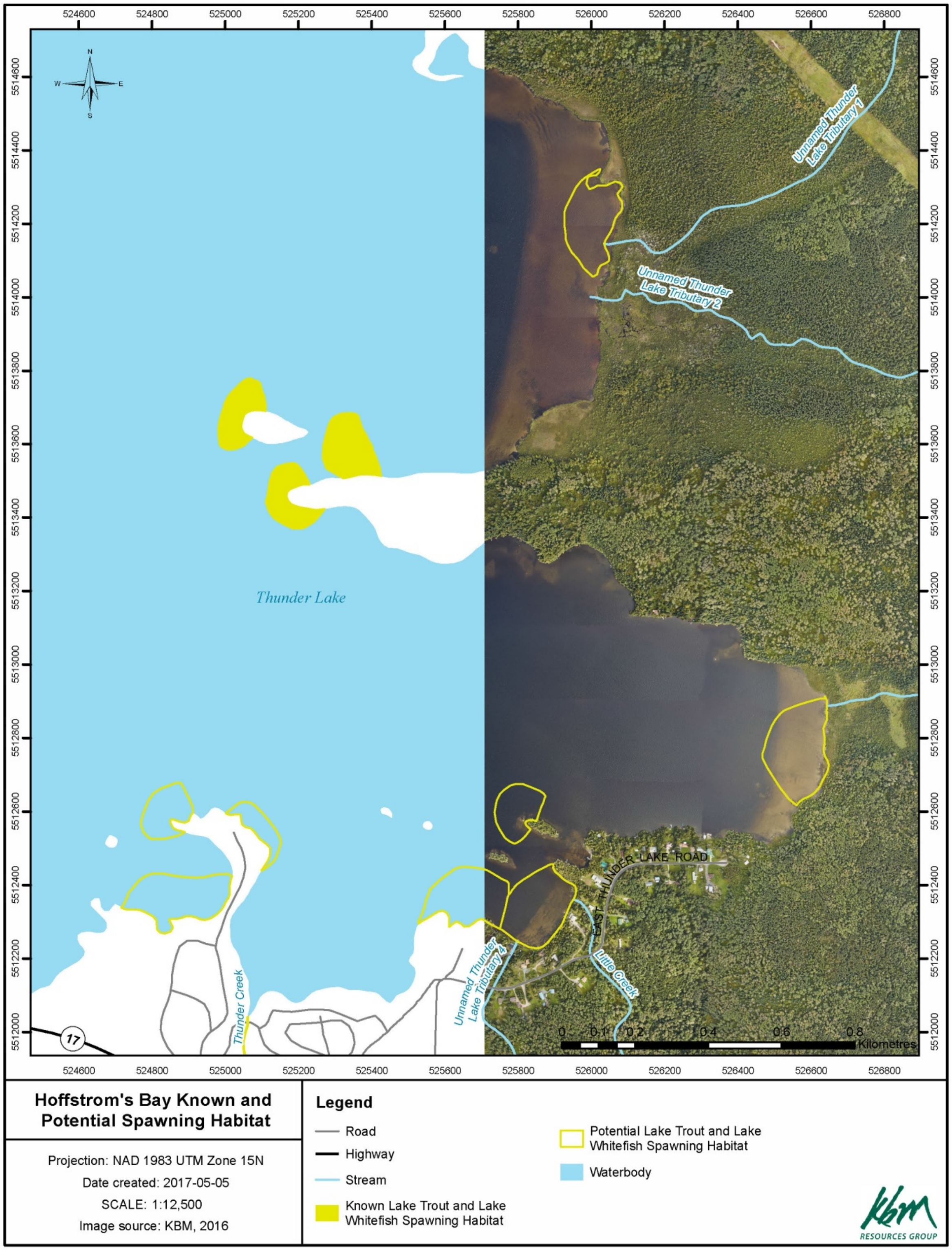

Figure 5.8.4.1-1: Locations of Known and Potential Lake Trout and/or Lake Whitefish Spawning Habitat in Bays at East End of Thunder Lake

Fish habitat in Hoffstrom's Bay was described and mapped by DST (Figure 5.8.4.1-2). The peninsula that forms the north shore of Hoffstrom's Bay has a generally rocky shoreline composed of a mix of bedrock, cobble and gravel with small areas of sparse aquatic vegetation. At the western end of the peninsula there is a large area of rock and cobble that has been identified as one of several areas where habitat improvement work was conducted by MNRF to enhance Lake Whitefish spawning habitat. Most of the northwest facing inlets along the south shore of the bay are similar and have sandy/silty substrates, sparse aquatic vegetation and sandy shorelines. Other areas along the south shore are a mix of rock and sparse aquatic vegetation similar to those observed on the north shore. The peninsula that forms the southwest boundary of the study area has a large area of boulders and cobble that has been also been identified as a habitat improvement area.

There are four small islands in Hoffstrom's Bay. The three smallest islands are predominantly rocky and have very little aquatic vegetation. The largest island has a rocky shoreline with sparse aquatic vegetation and coarse woody debris. The northwest tip of the large island has a large bedrock cobble shoal extending northwest into deeper water.

At the head of Hoffstrom's Bay a large area has been flooded by beaver activity. The area upstream of the beaver dam is dominated by aquatic vegetation, coarse woody debris and a mix of willow (*Salix* sp.) and alder (*Alnus* Sp.) shrubs around the margins. The shoreline in front of the dam is mostly sandy and silty with sparse submergent aquatic vegetation. Potential Northern Pike spawning habitat is present in meadow marsh and shore fen communities at the mouth of the Hoffstrom's Bay Tributary; however, a beaver dam across the mouth of the stream prevented fish access to the potential spawning area in 2013.

The bay which Thunder Lake Tributaries 1 and 2 flow into is separated from Hoffstrom's Bay by the peninsula described above. With the exception of one shoal of boulder and cobble shown on Figure 5.8.4.1-2, that was mapped using side-scan Sonar on August 4, 2016, the substrate in this bay is composed of sand and silt. There are extensive emergent reed beds and scattered beds of submergent vegetation in the inner portion of the bay. Potential northern pike spawning habitat is present in meadow marsh and shore fen communities associated with the mouth of Tributary 2 and a young-of-the-year Northern Pike was observed in this bay in 2011.

5.8.4.2 Wabigoon Lake

Wabigoon Lake is a coolwater lake with a surface area of 9,922 ha, a mean depth of 6.1 m and a maximum depth of 14.6 m. A list of fish species in Wabigoon Lake is provided in Table 5.8.4.2-1. The lake has an irregular shoreline that is 204 km in length including islands; this in combination with the generally shallow depth results in a high proportion of littoral zone. The water level of Wabigoon Lake is controlled by a dam at the outflow into the Wabigoon River in Dryden, Ontario. Water Levels range between 368.5 and 369.23 metres above sea level (mASL) annually. Changing water levels due to the dam have caused erosion along the shoreline of Wabigoon Lake releasing sediments that contribute to the turbidity of the lake.

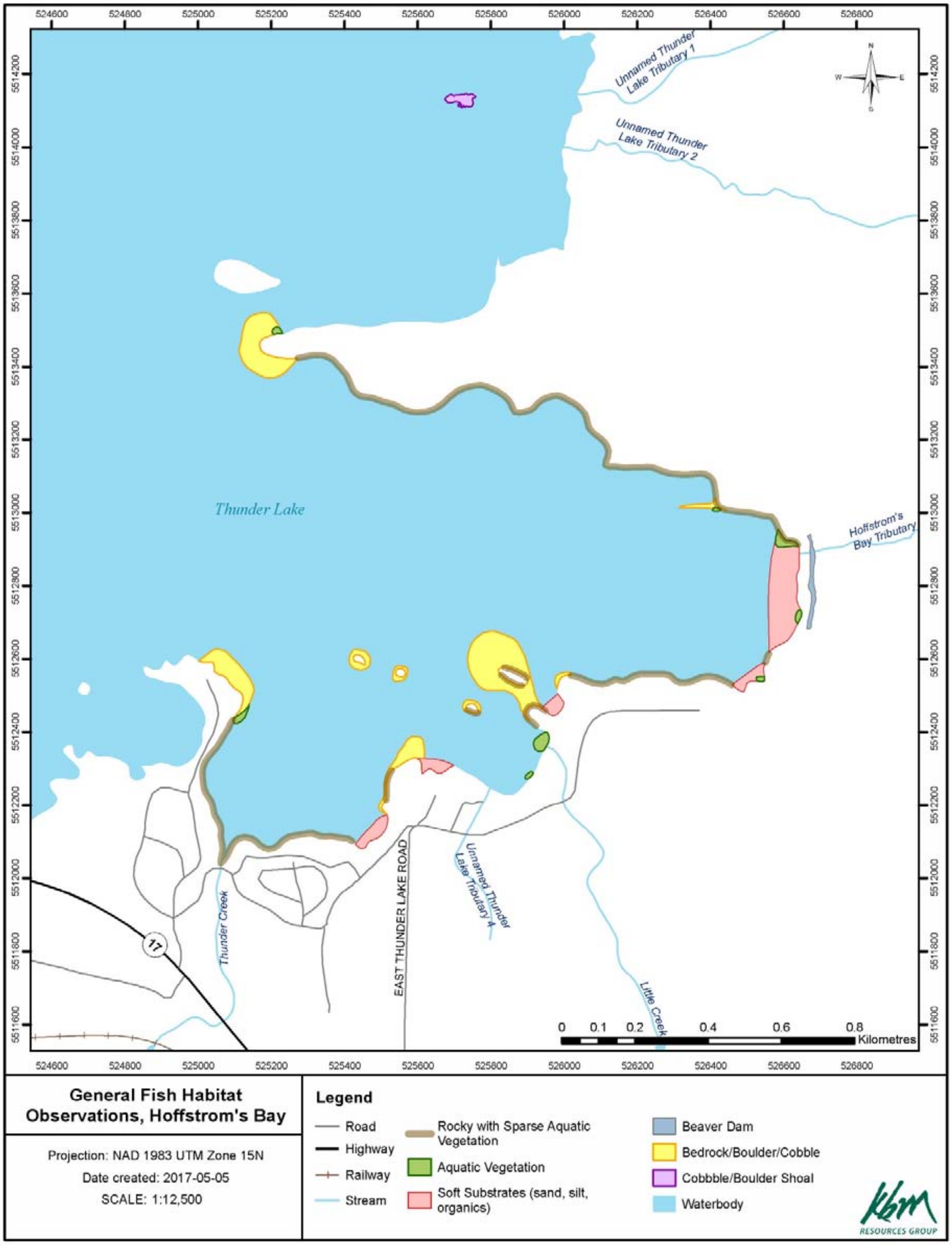

Figure 5.8.4.1-2: Fish Habitat Characterization for Hoffstrom's Bay, Thunder Lake

Table 5.8.4.2-1: Fish species present in Wabigoon Lake

Common name	Scientific name
Lake Whitefish	*Coregonus clupeaformis*
Cisco	*Coregonus artedii*
Walleye	*Sander vitreus*
Sauger	*Sander canadensis*
Northern Pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Smallmouth Bass	*Micropterus dolomieu*
Black Crappie	*Pomoxis nigromaculatus*
Yellow Perch	*Perca flavescens*
Burbot	*Lota lota*
Rock Bass	*Ambloplites rupestris*
White Sucker	*Catostomus commersonii*
Longnose Sucker	*Catostomus catostomus*
Shorthead Redhorse	*Moxostoma macrolepidotum*
Trout-perch	*Percopsis omiscomaycus*
Johnny Darter	*Etheostoma nigrum*
Mottled Sculpin	*Cottus bairdii*
Emerald Shiner	*Notropis atherinoides*
Mimic Shiner	*Notropis volucellus*
Fathead Minnow	*Pimephales promelas*
Spottail Shiner	*Notropis hudsonius*
Logperch	*Percina caprodes*
Nine-spine Stickleback	*Pungitius pungitius*

There are a number of private homes and seasonal camps on Wabigoon Lake, primarily along the Trans-Canada Highway and in other road accessible areas. There are also eight active tourist outfitters operating on Wabigoon Lake. Wabigoon Lake is one of six Specially Designated Waters in FMZ 5 and receives enhanced management and supports an active sport fishery focused on Walleye and Muskellunge angling.

There are two fish sanctuaries on Wabigoon Lake that were created to protect spawning Walleye and Sauger. One of these is along the shoreline of Christie Island, which is just outside (west) of Keplyn's Bay where Blackwater Creek enters the lake. The other is at the mouth of Nugget Creek. Nugget Creek itself, upstream to the spawning area, is also part of that sanctuary. Walleye are also known to spawn in Thunder Creek, which flows from Thunder Lake to Wabigoon Lake. Potential muskellunge spawning areas in Keplyn's Bay and the vicinity, identified by MNRF based on the habitat, are presented in Figure 5.8.4.2-1.

Fish habitat observations in Keplyn's Bay are summarized in Figure 5.8.4.2-2. The north and south shorelines of Keplyn's Bay are mainly composed of sand, silt and gravel. The shoreline of the rail causeway that forms the East shore of the bay is composed of rip-rap and boulder/cobble. The bay has a soft bottom composed of a mix of sand, silt, gravel and organic material with sparse submergent vegetation. It is generally flat and shallow with a maximum recorded depth of 4.9 m. In the northeast corner of the bay near the inflow of Blackwater Creek there is a large area of aquatic vegetation and another is present on the southwest corner at the entrance to the bay. Submergent vegetation was also observed across the head of Keplyn's Bay during an August 3, 2016, site visit.

A portion of Keplyn's Bay was separated from Wabigoon Lake by the construction of the railway (Figure 5.8.4.2-2) and flow from Blackwater Creek is conveyed beneath the railway in two corrugated steel culverts (based on observations from the surface). The area upstream from the railway is described below as Reach 1 of Blackwater Creek but it could, alternatively, be considered part of Wabigoon Lake.

5.8.4.3 Blackwater Creek

The main branch of Blackwater Creek originates in an area of glaciofluvial outwash and flows southwest across a glaciolacustrine plain (Figure 5.8.4.3-1), before discharging into Keplyn's Bay of Wabigoon Lake. The main creek is 10.4 km long and has several tributaries. Most of the watershed is within the flat, silty-clay glaciolacustrine plain with low relief and fine substrates.

As indicated in the previous section, flow from Blackwater Creek is conveyed under the railway by at least two corrugated steel pipes. Under the conditions observed on August 3, 2016, it appeared that fish would be able to move freely through the culverts. It is possible, however, that during periods of high flow the culverts are a barrier to upstream fish migration due to high velocities.

The reach of Blackwater Creek from the railway upstream to approximately the limit of lake water level influence includes the portion of Keplyn's Bay that was separated from Wabigoon Lake by the construction of the railway. The water velocities in this reach are low and most of the reach can be characterized as sheltered coastal wetland habitat. The substrates are soft organics and dense beds of submergent and emergent aquatic vegetation are present over most of the area. The maximum depth is 2.6 m. On August 7, 2011, the dissolved oxygen concentration was 8.22 mg/L at 0.3 m depth and 0.39 mg/L at 2.0 m depth. Given the dense aquatic vegetation, night-time oxygen depletion is to be expected during the summer when aquatic vegetation is abundant and may also occur during the winter.

Many schools of minnows and many juvenile fish were observed here in August 2011. Potential Northern Pike spawning habitat (flooded grasses and sedges) is common in this reach. Based on the habitat characteristics, if fish are able to pass through the culverts into this area in the spring, Reach 1 may provide spawning and nursery habitat for a number of species that are present in Wabigoon Lake and spawn in wetlands, including Northern Pike and Muskellunge.

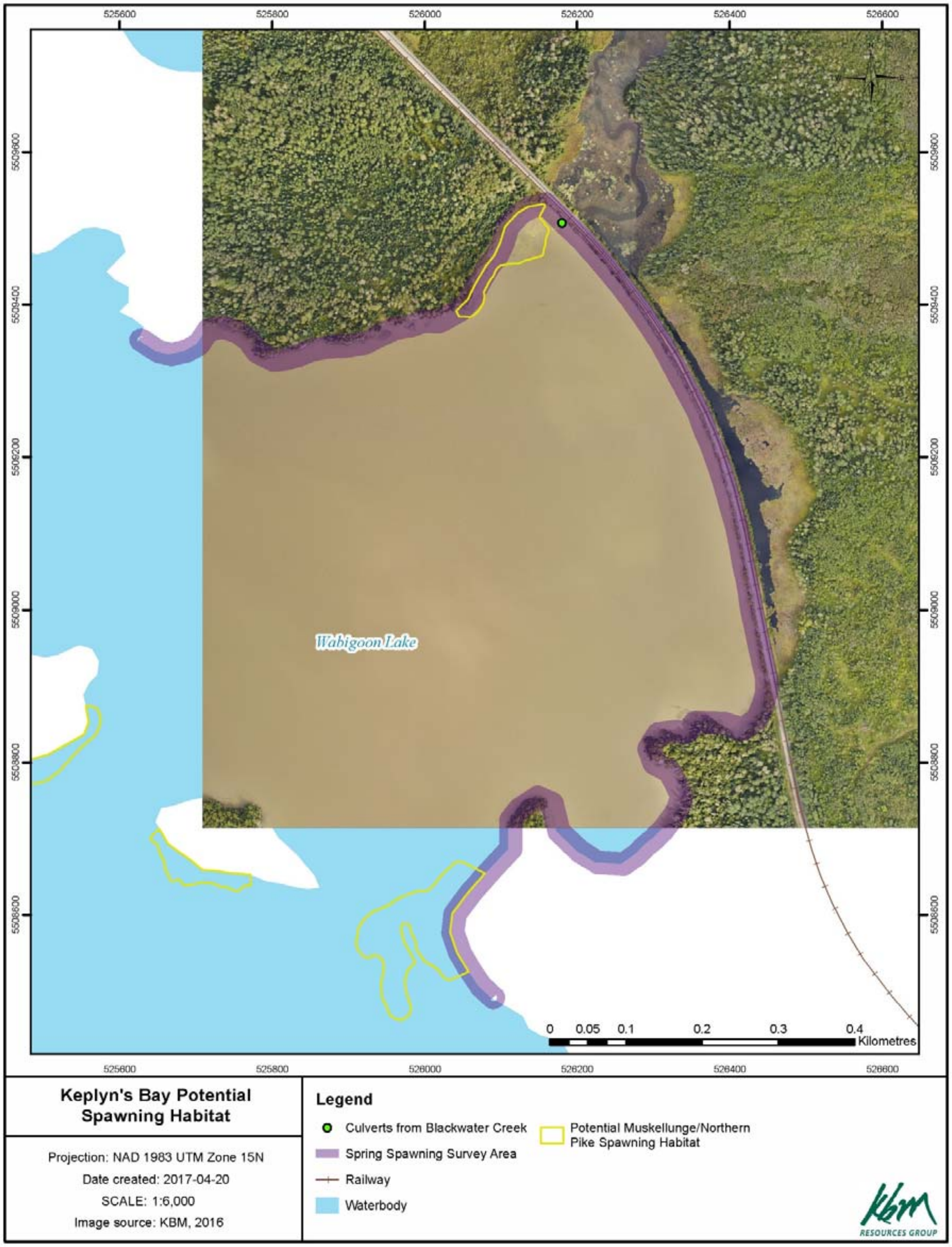

Figure 5.8.4.2-1: Potential Muskellunge and Northern Pike spawning habitat in and adjacent to Keplyn's Bay, Lake Wabigoon

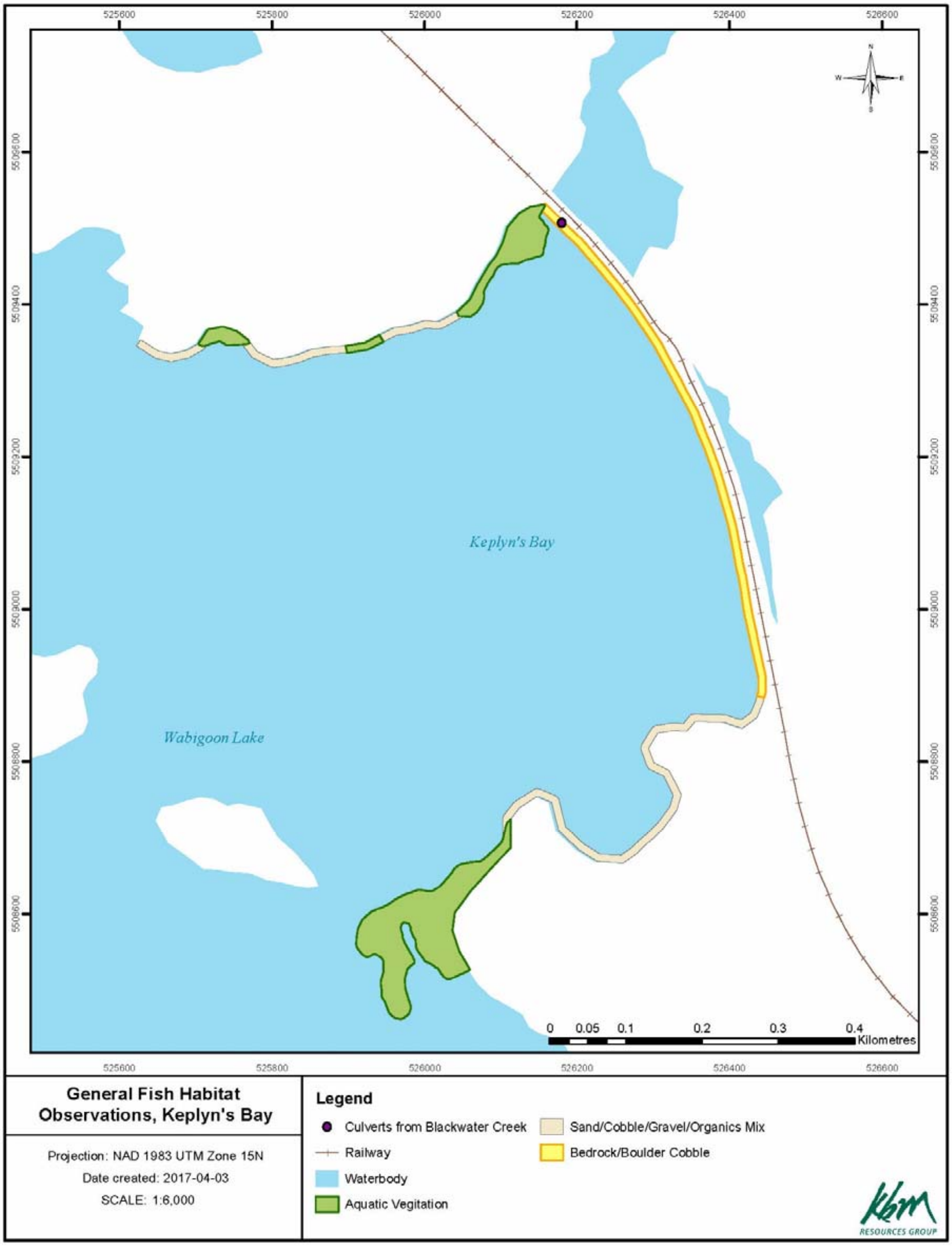

Figure 5.8.4.2-2: Fish Habitat Features in Keplyn's Bay, Lake Wabigoon

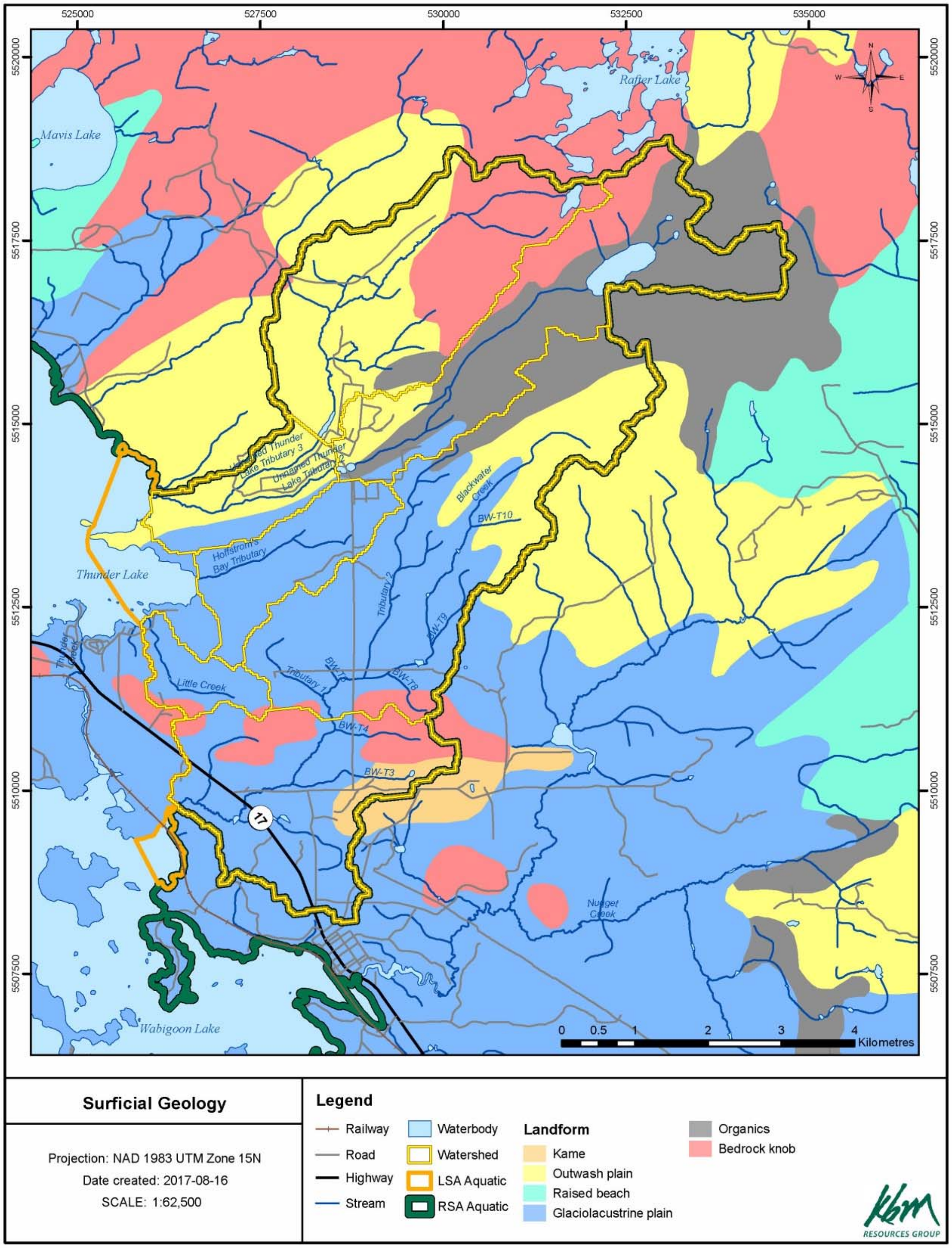

Figure 5.8.4.3-1: Surficial Geology and Watercourses in the Local Study Area

The remainder of Blackwater Creek and its tributaries provide low gradient stream habitat punctuated by active and inactive beaver dams and ponds. The creek channels are sinuous and primarily pool and run habitat, which is consistent with the low gradient. Consistent with the surficial geology, the substrates are primarily fine silt and clay. Only three areas of gravel, each located downstream from road crossings and thought to have originated from road construction and maintenance, were observed during the 2011 field investigations. A reach with cobble substrate was identified at a pipeline crossing between Anderson Road and Highway 17 and is thought to have been placed there during the reconstruction of the creek channel through the pipeline right-of-way. As is expected, channel width decreases with distance upstream. Wetted widths of the main branch measured during field investigations in 2011 ranged from approximately 3.5 m downstream from Highway 17, to 0.5 – 2.5 m between Highway 17 and Norman Road, and were generally less than 1 m upstream from Norman Road.

The effect of past and current beaver activity is evident in the pattern of riparian vegetation that alternates between dense willows and alders, open 'beaver meadows' with dense grasses and sedges, and active beaver ponds. Woody debris is plentiful, in part as a consequence of beaver activity.

No permanent obstructions to fish passage were identified during the 2010 and 2011 field investigations although beaver dams can be impediments and create temporary barriers to upstream movement, depending on flows. A culvert on Tributary 2 is probably a barrier to upstream fish migration under some flow conditions, based on observations in August 2016.

Fish sampling was conducted in the Blackwater Creek watershed in 2010, 2011, 2012 and 2014. Most of the sampling was conducted with minnow traps (152 trap sets) supplemented with electrofishing (3 sites). One short-duration gill net set, which caught one Yellow Perch, was conducted near the mouth, just upstream from the railway. One seine haul, which caught two White Suckers, was conducted on Tributary 2 near its confluence with the main branch.

The fish catches are summarized in Table 5.8.4.3-1. In total, 8,182 fish were captured in the Blackwater Creek watershed. The most abundant and widely distributed taxa were the *Chrosomus* species (Northern Redbelly Dace and Finescale Dace; 63% of the total catch), Brook Stickleback (22% of the total catch), and Pearl Dace (10% of the total catch). Fathead Minnow was captured less frequently and in lower numbers (2% of total catch). White Sucker (1% of the total catch) were more common in catches from the downstream reaches of Blackwater Creek; 59 of the 80 individuals captured were in a single minnow trap set. A single Burbot was captured by electrofishing on two occasions between Highway 17 and Anderson Road. In addition, there were 42 Cyprinids captured that were not identified to species.

Four taxa were identified in 23 minnow trap sets in Blackwater Creek Tributary 1 (Table 5.8.4.3-1). *Chrosomus* spp. dominated the catches (78% of total catch), followed by Brook Stickleback (34% of total catch) and Pearl Dace (18% of total catch). Fathead Minnow were also present (2% of total catch) and 11 captured fish were identified as "shiners". No White Sucker were captured in Tributary 1.

Table 5.8.4.3-1: Fish Catches in Blackwater Creek and Thunder Lake Tributaries

Common and Scientific Names	Blackwater Creek Watershed			Thunder Lake Watershed				
	All Locations except Tributaries 1 and 2	Tributary 1	Tributary 2	Tributary 2 - from dam to Thunder Lake	Tributary 2 - tree nursery pond	Tributary 3	Hoffstrom's Bay Tributary	Little Creek
Northern Redbelly and Finescale Dace *Chrosomus* spp.	2857	2032	306	61	63	101	28	61
Brook Stickleback (*Culaea inconstans*)	1393	224	217	11	138	92	14	12
Pearl Dace (*Margariscus nachtriebe*)	434	304	113	42	101	156	8	—
Fathead Minnow (*Pimephales promelas*)	127	50	—	11	167	91	—	106
White Sucker (*Catostomus commersonii*)	78	—	2	5	—	12	—	—
Burbot (*Lota lota*)	2	—	—	1	—	—	—	—
Yellow Perch (*Perca flavescens*)	1	—	—	—	—		72	—
Central Mudminnow (*Umbra limi*)	—	—	—	6	—	13	—	—
Blacknose Shiner (*Notropis heterolepis*)	—	—	—	9	—	—	—	—
Creek Chub (*Semotilus atromaculatus*)	—	—	—		—	6	—	—
Iowa Darter (*Etheostoma exile*)	—	—	—	1	2	1	—	—
Rock Bass (*Ambloplites rupestris*)	—	—	—	—	—		2	—
Trout- perch (*Percopsis omiscomaycus*)	—	—	—	—	—	2	—	—
Mottled Sculpin (*Cottus bairdii*)	—	—	—	—	—	1	1	—
Cottus sp.	—	—	—	—	—	1	—	—
Cyprinid sp.	25	—	—	—	—	1	—	—
Shiner sp.	6	11	—	—	—	1	20	—

Four taxa were identified in catches from 56 minnow trap sets in Blackwater Creek Tributary 2 (Table 5.8.4.3-1). *Chrosomus* spp. dominated the catches (48% of total catch), followed by Pearl Dace (11.6% of total catch) and Brook Stickleback (8.5% of total catch). In addition, 11 fish were captured that were identified as “shiners”. Catches were lower in the upper reaches of Tributary 2, where only Brook Stickleback and Pearl Dace were captured and there was no catch in many of the minnow trap sets.

A small number of spawning White Sucker were observed in Tributary 1 at Anderson Road during a spawning survey in the spring of 2011. It is not known if these fish were resident in Blackwater Creek or migrants from Wabigoon Lake. Based on the absence of suitable spawning habitat, it is unlikely that Walleye spawn in Blackwater Creek.

5.8.4.4 Thunder Lake Tributaries

There are three tributaries to Thunder Lake within the LSA. They are, from north to south, Thunder Lake Tributary 2, Hoffstrom’s Bay tributary, and Little Creek. The north branch of Thunder Lake Tributary 2, also within the LSA, is referred to as Thunder Lake Tributary 3.

Unnamed Thunder Lake Tributary 2

Thunder Lake Tributary 2 originates in the organic deposits associated with the Lola Lake wetland (Figure 5.8.4.3-1). From the pond on the former tree nursery property downstream to Thunder Lake, it flows through the sandy soils of the outwash plain (KCB 2012). There is a waterfall approximately 1.7 m high, created by a bedrock outcrop, just downstream from the pond on the former tree nursery. Both the falls and the concrete dam that creates the pond are complete barriers to upstream fish migration.

There is a section of coarse substrate for a short distance downstream from the bedrock outcrop. The substrate then changes to fine silts and sands which are the predominant substrates from that point downstream to Thunder Lake. The stream is sinuous and consists primarily of runs and pools with abundant fine and coarse woody debris. The channel becomes braided after it enters the wetland adjacent to Thunder Lake. Iron precipitates were observed at several points in the watershed of Tributary 2, indicating groundwater discharge (KCB 2012). The outlet of Unnamed Thunder Lake Tributary 2 is densely vegetated with marsh vegetation and is considered to be potential Northern Pike spawning habitat (KCB 2012).

A total of nine taxa were identified in catches in Thunder Lake Tributary 2 between the dam that forms the former tree nursery pond and Thunder Lake (Table 5.8.4.3-1). Pearl dace and *Chrosomus* spp. were the most abundant species. In the former tree nursery pond on Tributary 2 Fathead Minnow, Brook Stickleback, Pearl Dace and *Chrosomus* spp. were all common and two Iowa Darter were captured. Only Pearl Dace were captured in a short (2 hr) gill net set in the former tree nursery pond.

The areas of coarse substrate downstream from the falls on Thunder Lake Tributary 2 is potential Walleye and White Sucker spawning habitat but no spawning runs have been reported to occur in these streams.

Unnamed Thunder Lake Tributary 3

Thunder Lake Tributary 3, which is actually the north branch of Thunder Lake Tributary 2, flows through the outwash plain for most of its length (Figure 5.8.4.3-1). There is a dam on Tributary 3, on the former tree nursery property, which creates a pond and is a complete barrier to upstream fish migration. Except for a short section of cobble and gravel downstream from this dam, the substrate from the dam downstream is primarily fine sands and silt.

Thirteen fish species were captured Tributary 3 (Table 5.8.4.3-1). Catches were dominated by Pearl Dace, *Chrosomus* spp., Brook Stickleback, and Fathead Minnow. No fish were captured in two short gill net sets (1.6 hr and 0.4 hr) in the former tree nursery pond.

The areas of coarse substrate downstream from the dam on Thunder Lake Tributary 3 is potential Walleye and White Sucker spawning habitat but no spawning runs have been reported to occur in these streams.

Hoffstrom's Bay Tributary

The Hoffstrom's Bay Tributary has not been characterized in detail as it lies entirely within the glaciolacustrine plain (Figure 5.8.4.3-1: Surficial Geology and Watercourses in the Local Study Area). It can be anticipated that the substrate is fine throughout. Aerial imagery indicates that beaver activity occurs. The outlet of Hoffstrom's Bay Tributary is densely vegetated with marsh vegetation and is considered potential northern pike spawning habitat. Many schools of juvenile fish were observed there during the field work.

The fish catches are summarized in Table 5.8.4.3-1. Yellow Perch were the most abundant species in the catches from 2 seine hauls at the mouth of the Hoffstrom's Bay tributary, where a Rock Bass was also captured and a Mottled Sculpin was caught in a minnow trap. Further from the lake, in the Hoffstom's Bay Tributary proper, only *Chrosomus* spp. and Brook Stickleback were captured in 8 minnow trap sets.

Little Creek

Little Creek, which flows into Thunder Lake south of Hoffstrom's Creek, also lies entirely within the glaciolacustrine plain (Figure 5.8.4.3-1), which results in a low gradient watercourse with fine substrates. Active beaver dams were observed in at least two locations in 2011. In Little Creek only Fathead Minnow, *Chrosomus* spp. and Brook Stickleback were captured in 16 minnow trap sets (Table 5.8.4.3-1).

5.8.4.5 Metals in Fish Tissue

Metal concentrations were determined in muscle tissue samples taken from 11 Walleye from Thunder Lake and from 30 Walleye and one Sauger from Wabigoon Lake. The total mercury results (Table 5.8.4.5-1) were compared to the guidelines provided in Ontario Ministry of Environment and Climate Change (MOECC) *Guide to Eating Ontario Sport Fish 2013-2014* ("MOE Guidelines") and to Canadian Council of Ministers of the Environment (CCME) *Tissue Residue Guideline Values for the Protection of Wildlife Consumers of Aquatic Biota: Methylmercury* (2000) ("CCME Guidelines"). MOE guidelines consider two populations: sensitive (includes children under 15 and women of childbearing age) and general. Two restriction categories were applied within each population: minimum levels that result in recommended consumption limits and "do not eat" advisory levels.

Table 5.8.4.5-1: Total Mercury Concentrations in Walleye and Sauger Muscle

Waterbody	Species/Sample ID	# Submitted	Mercury Concentration (mg/kg)
Thunder Lake	**Walleye**	**11**	
	F31		**0.108**
	F32		**0.121**
	F33		**0.155**
	F34		**0.0975**
	F35		**0.105**
	F36		**0.0978**
	F37		**0.136**
	F38		**0.114**
	F39		**0.105**
	F40		**0.143**
	F41		**0.142**
Wabigoon Lake	**Walleye**	**30**	
	F1		**0.228**
	F10		**0.335**
	F11		**0.184**
	F12		**0.245**
	F13		**0.24**
	F14		**0.194**
	F16		**0.0865**
	F18		**0.117**
	F19		**0.176**
	F2		**0.149**
	F20		**0.165**
	F21		**0.241**
	F22		**0.196**
	F23		**0.442**
	F24		**0.18**
	F25		**0.195**
	F26		**0.173**
	F27		**0.245**

Table 5.8.4.5-1: Total Mercury Concentrations in Walleye and Sauger Muscle (continued)

Waterbody	Species/Sample ID	# Submitted	Mercury Concentration (mg/kg)
Wabigoon Lake (cont'd)	F28		**0.206**
	F29		**0.207**
	F3		**0.23**
	F30		**0.14**
	F4		***0.331***
	F5		**0.102**
	F6		**0.157**
	F7		***0.272***
	F8		**0.195**
	F9		***0.261***
	GN1		**0.191**
	GN3		***0.503***
	Sauger	1	
	F17		***0.473***

Guidelines:			
Ontario MOE	Guide To Eating Ontario Sport Fish		
	Sensitive Population	Minimum Level	0.26 mg/kg
		"Do Not Eat" Advisory	0.52 mg/kg
	General Population	Minimum Level	0.61 mg/kg
		"Do Not Eat" Advisory	1.84 mg/kg
CCME	Values for the Protection of Wildlife Consumers of Aquatic Biota (Methylmercury)		0.033 mg/kg

Legend:
BOLD Result exceeds CCME Guideline
Italic/shaded Result exceeds MOE Guideline (Minimum Level in a Sensitive Population)

Total mercury concentrations exceeded the CCME methylmercury guideline for the protection of wildlife consumers in all of the Walleye and Sauger muscle samples. None of the Thunder Lake walleye exceeded the MOE Guideline Minimum Level of 0.25 mg/kg for a sensitive population but six of the 30 Walleye samples and the one Sauger sample from Wabigoon Lake exceeded that value. There were too few large walleye captured to generate reliable mercury concentrations standardized for length.

Elevated mercury levels are known throughout the region. Mercury occurs naturally (at low levels) and historical industrial effluents were introduced to the Wabigoon River System between 1962 and 1970. The point of discharge has been attributed to the Dryden pulp mill and chemical plants downstream of Wabigoon Lake and the Dryden dam prevents the upstream movement of fish into Wabigoon Lake.

Table 5.8.4.5-2: Collection Location and Year, Species Composition and Mercury Concentration of Forage Fish 2011 and 2012

Location	Sampling site	Year	Species				Total Mercury (mg/kg wet weight)
			Pearl Dace	*Chrosomus* spp.	White Sucker	Fathead Minnow	
Blackwater Creek at Anderson Road	28	2011		10			**0.082**
	28	2011	10				**0.105**
	TS-2	2012	2		3		**0.111**
Blackwater Creek Tributary 1	6	2011				10	0.025
	6	2011		10			**0.043**
	TS-7	2012		12			**0.045**
Blackwater Creek at Tree Nursery Road	TS-5	2012		8			**0.088**
Thunder Lake Tributary 3	TS-13	2012		3			**0.098**
Thunder Lake Tributary 2	4 and 5	2011	10				0.033
Tree Nursery pond	4 and 5	2011		10			0.027
	TS-15	2012	5	8			0.030
Blackwater Creek Tributary 7	12				1		**0.064**
	12	2011			1		**0.092**
	TS-16	2012	4	1			**0.123**
Isolated pond beside Tree Nursery Road	TS-21	2012		9			**0.057**
Unknown location	TS-22	2012	5				**0.067**

Note: Total mercury values exceeding 0.033 mg/kg are in bold

Whole body total mercury concentrations in composite forage fish samples ranged from 0.027 mg/kg to 0.123 mg/kg and most samples exceeded the CCME methylmercury guideline for the protection of wildlife consumers of 0.033 mg/kg (Table 5.8.4.5-2). The total mercury concentrations were lowest in the samples from the Tree Nursery ponds and Blackwater Creek Tributary 1. The highest concentrations were in samples from the Blackwater Creek at Anderson Road and Blackwater Creek Tributary 2. When the same species was sampled at the same general locations in both 2012 and 2013, the results were similar. For example, the total mercury concentration *Chrosomus* spp. from Blackwater Creek Tributary 1 was 0.043 mg/kg wet weight in the 2011 sample and 0.045 mg/kg wet weight in the 2012 sample.

5.9 Terrestrial Resources

As part of the work to respond to the Round 1 information requests, the terrestrial baseline information relied on in the EIS was compiled into the following two baseline summary documents:

- Summary Wildlife Baseline Report (2011–2016), included as Appendix R to the revised EIS; and

- Wetlands Baseline Study (2016), included as Appendix S to the revised EIS.

These reports compile the baseline information still relied on from the baseline reports prepared by Klohn Crippen Berger (KCB 2012), included as Appendix G to the original EIS, and DST Consulting Engineers (DST 2014b), included as Appendix R to the original EIS, as well as DST (2014c), included as Appendix S to the original EIS.

5.9.1 Natural Heritage Areas

No internationally recognized areas (e.g., UNESCO Biosphere Reserve) or nationally protected sites (e.g., National Park) are located within the RSA. Two provincial parks occur within the LSA. Aaron Provincial Park is a 117 ha recreation-class park situated at the Thunder Lake outflow, approximately 2.5 km west of the existing mine portal. Lola Lake Provincial Park is a large (6,572 ha) Class 1 Strict Nature Reserve/Scientific Reserve-classed park that serves to protect an extensive peatland. Access and usage of this class of protected area are strictly regulated. This park partially overlaps the LSA to the northeast of the existing portal.

5.9.2 Vegetation

5.9.2.1 Environmental Setting

The Project is located within the Ontario Shield Ecozone, which is characterised by extensive wetlands and boreal forests. Within the ecozone, the Project occurs within the Wabigoon Ecoregion (Ecoregion 4S) in the Lower English River Section of the Boreal Forest Region. This ecoregion is composed of a range of forest types (mixed forest 25%, sparse forest 24%, and coniferous forest 14%) and open water (24%; Crins et al. 2009). Typical tree species include trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), white and black spruces (*Picea glauca*, *Picea marina*), white birch (*Betula papyrifera*) and willow (*Salix* spp.).

The Project area lies within the Dryden Forest Management Unit (FMU), but a portion of the RSA extends into the adjacent Wabigoon FMU (OMNRF 2014). Both FMUs fall within the boundaries of the Wabigoon Ecoregion and are located on the Precambrian Shield. The bedrock in the area is primarily granite and greenstone composed of metavolcanic and metasedimentary rocks, with granitoid intrusions. The landscape of the Wabigoon Ecoregion is a gently sloping plain of shallow tills over bedrock in conjunction with moraine of varying depths. Sediments consist of sandy-silt, sand and gravel deposits overlain by lacustrine sand, silt and varved clays. Localized pockets of clay and silt are scattered in low-lying areas.

Landcover in the RSA is 61% forest, 20% wetland, 14% water, 5% development land and <1% barren land; landcover in the LSA is 62% forest, 21% water, 9% developed land, 8% wetland, and <1% barren land (KCB 2012). The diversity of underlying landforms within Ecoregion 4S creates a wide diversity of ecosites within the RSA (Table 5.9.2.1-1, Figure 5.9.2.1-1; see Appendix G and Appendix R for a full description of ecosite characteristics).

Table 5.9.2.1-1: Ecosites of the RSA and LSA

Ecosite	RSA		LSA	
	(km^2)	%	(km^2)	%
Agricultural / Developed	7.6	5	6.81	9
Open Water	19.97	14	16.13	21
ES7 Rock Barren	0.06	<1	0.06	<1
ES9 Sand Barren	0.38	<1	0.38	<1
ES11 Red Pine-White Pine-Jack Pine: Very Shallow Soil	0.18	<1	-	-
ES12 Black SpruceJack Pine: Very Shallow Soil	2.63	2	1.9	2
ES13 Jack Pine-Conifer: Dry Moderately Fresh, Sandy Soil	9.95	7	4.92	6
ES14 Pine-Spruce Mixedwood: Sandy Soil	1.26	1	0.81	1
ES16 Hardwood-Fr Spruce Mixedwood: Sandy Soil	0.51	<1	0.51	1
ES17 White Cedar: Fresh Moist, Coarse-Fine Loamy Soil	0.18	<1	0.12	<1
ES19 Hardwood Fir Spruce Mixedwood: Fresh, Sandy-Coarse Loamy Soil	2.75	2	1.05	1
ES20 Spruce-Pine / Feathermoss: Fresh, Sandy Coarse Loamy Soil	11.13	8	4.17	5
ES21 Fr Spruce Mixedwood: Fresh, Coarse Loamy Soil	6.14	4	1.78	2
ES22 Spruce Pine/Ledum/Feathermoss: Most, Sandy Coarse Loamy Soil	1.72	1	1.27	2
ES24 Red Pine-White Pine: Fresh, Fine Loamy Soil	0.05	<1	0.05	<1
ES25 Pine Spruce / Feathermoss: Fresh, Silty Soil	8.1	6	3.03	4
ES26 Spruce-Pine / Feathermoss: Fresh, Fine Loamy-Clayey Soil	12.34	8	5.95	8
ES27 FirSpruce Mixedwood: Fresh, Fine Loamy Soil	1.69	1	1.19	2
ES29 Hardwood-FirSpruce Mxedwood: Fresh, Fine Loamy-Clayey Soil	22.12	15	14.34	18
ES30 Black Ash Hardwood: Fresh, Silty-Clayey Soil	0.41	<1	0.41	1
ES31 Spruce-Pine / Feathermoss: Moist, Silty-Clayey Soil	2.59	2	1.32	2
ES32 Fir Spruce Mixedwood: Moist, SiltyClayey Soil	1.73	1	0.94	1
ES33 Hardwood-Fir Spruce Mixedwood: Moist, Silty-Clayey Soil	3.28	2	1.71	2
ES34 Treed Bog: Black Spruce: Organic Soil	0.54	<1	0.09	<1
ES35 Poor Swamp: Black Spruce: Organic Soil	35	2	0.4	1
ES36 Intermediate Swamp: Black Spruce (Tamarack): Organic Soil	7.82	5	2.19	3

Table 5.9.2.1-1: Ecosites of the RSA and LSA (continued)

Ecosite	RSA		LSA	
	(km²)	%	(km²)	%
ES37 Rich Swamp: Cedar (Other Conifer): Organic Soil	1.55	1	0.46	1
ES38 Rich Swamp: Black Ash (Other Hardwood): Organic Mineral Soil	0.32	<1	0.24	<1
ES40 Treed Fen: Tamarack Black Spruce / Sphagnum: Organic Soil	2.86	2	1.69	2
ES41 Open Poor Fen Ercaceous Shrub / Sedge / Sphagnum: Organic Soil	0.08	<1	0.05	<1
ES42 Open Mod. Rich Fen: Eric. Shrub / Sedge / Sphagnum: Organic	3.33	2	0.26	<1
ES43 Open Extr. Rich Fen: Eric. Shrub / Sedge/ Brown Moss: Organic	1.19	1	0.41	1
ES44 Thicket Swamp: Mineral Soil	3.62	2	1.83	2
ES45 Shore Fen: Organic Soil	1.94	1	1.01	1
ES46 Meadow Marsh: Organic-Mineral Soil	2.17	2	0.84	1
ES47 Sheltered Marsh: Emergent: Sedimentary Peat Substrate	0.04	<1	0.04	<1
Ecosites Identified in 2011 Fieldwork				
ES48 Exposed Marsh: Emergent: Mineral Substrate	+	<1	+	<1
ES49 Open Water Marsh: Subm. / Floating-leaved: Sed. Peat Substr.	+	<1	+	<1
ES50 Open Water Marsh: Submergent: Mineral Substrate	+	<1	+	<1
TOTAL	**145.73**	**100**	**79.17**	**100**

Note: Based on Table 9.5 KCB 2012.

5.9.2.2 Forest Composition

The Dryden Forest is composed of coniferous (53%), mixed wood (42%) and broadleaf (5%) forests, 29% of which is considered mature or late stage forest (DFMC 2010). The relative abundance of forest types within the RSA and LSA match that of the larger Dryden Forest (Figure 5.9.2.2-1).

5.9.2.3 Other Terrestrial Land Cover

The non-forested areas within the RSA and LSA are primarily agricultural lands (i.e., pasture or hayfield). A former tree nursery is located at the north edge of the LSA. Other developed areas within the LSA include the Village of Wabigoon (south LSA) and the local landfill site (central-east LSA).

5.9.2.4 Field Surveys

Vegetation surveys were conducted in 300 sites across the LSA during the 2010-2011 field season. Sampling methods were based on the OMNRF Ontario Parks Inventory and Monitoring Program (McCaul et al. 2008). A total of 270 vascular plant species were identified in the LSA (KCB, 2012), 25 of which were introduced species commonly associate with disturbed habitats. Most of the remaining species are typical of Ontario’s southern boreal forest.

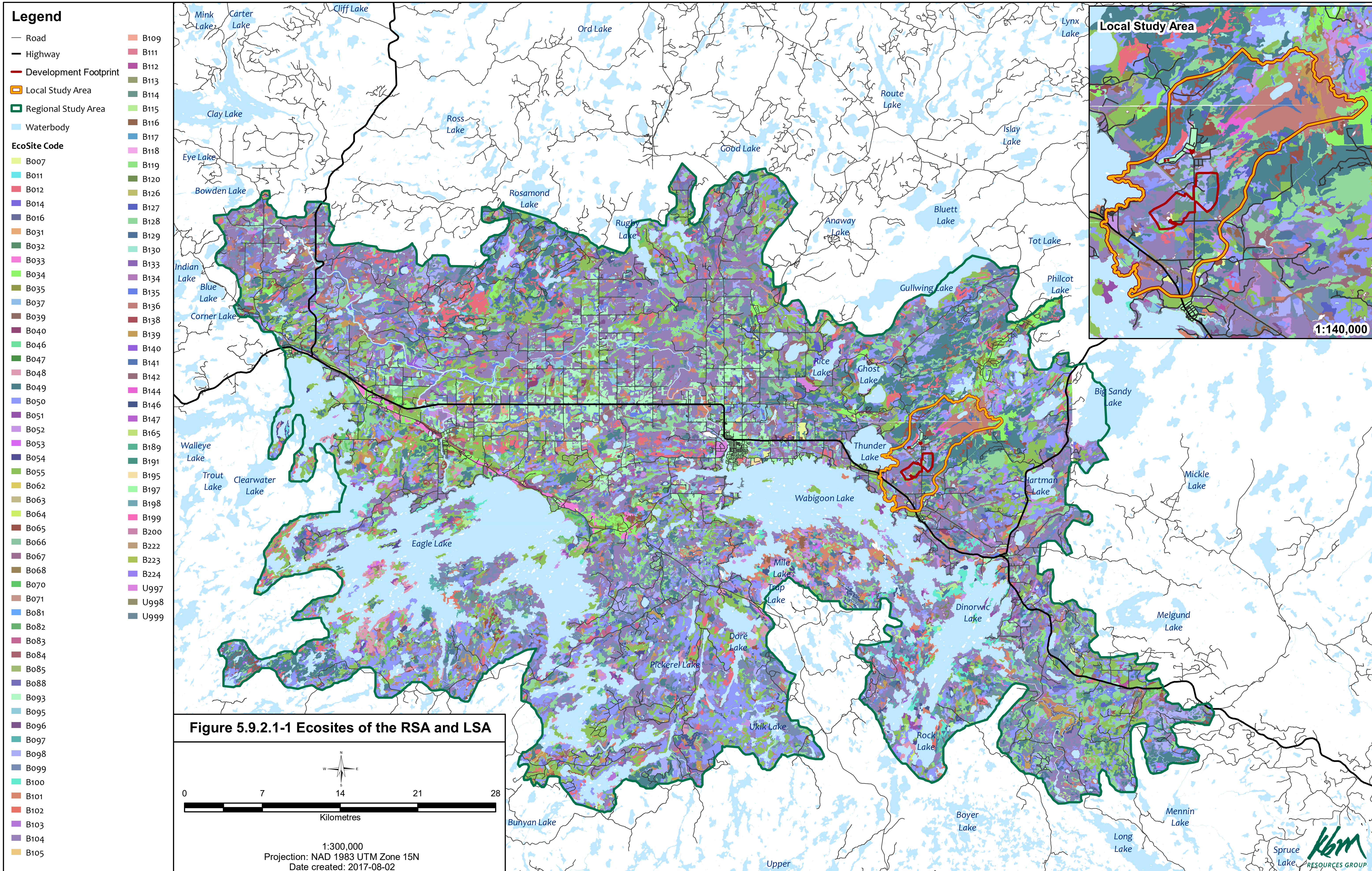

Figure 5.9.2.1-1 Ecosites of the RSA and LSA

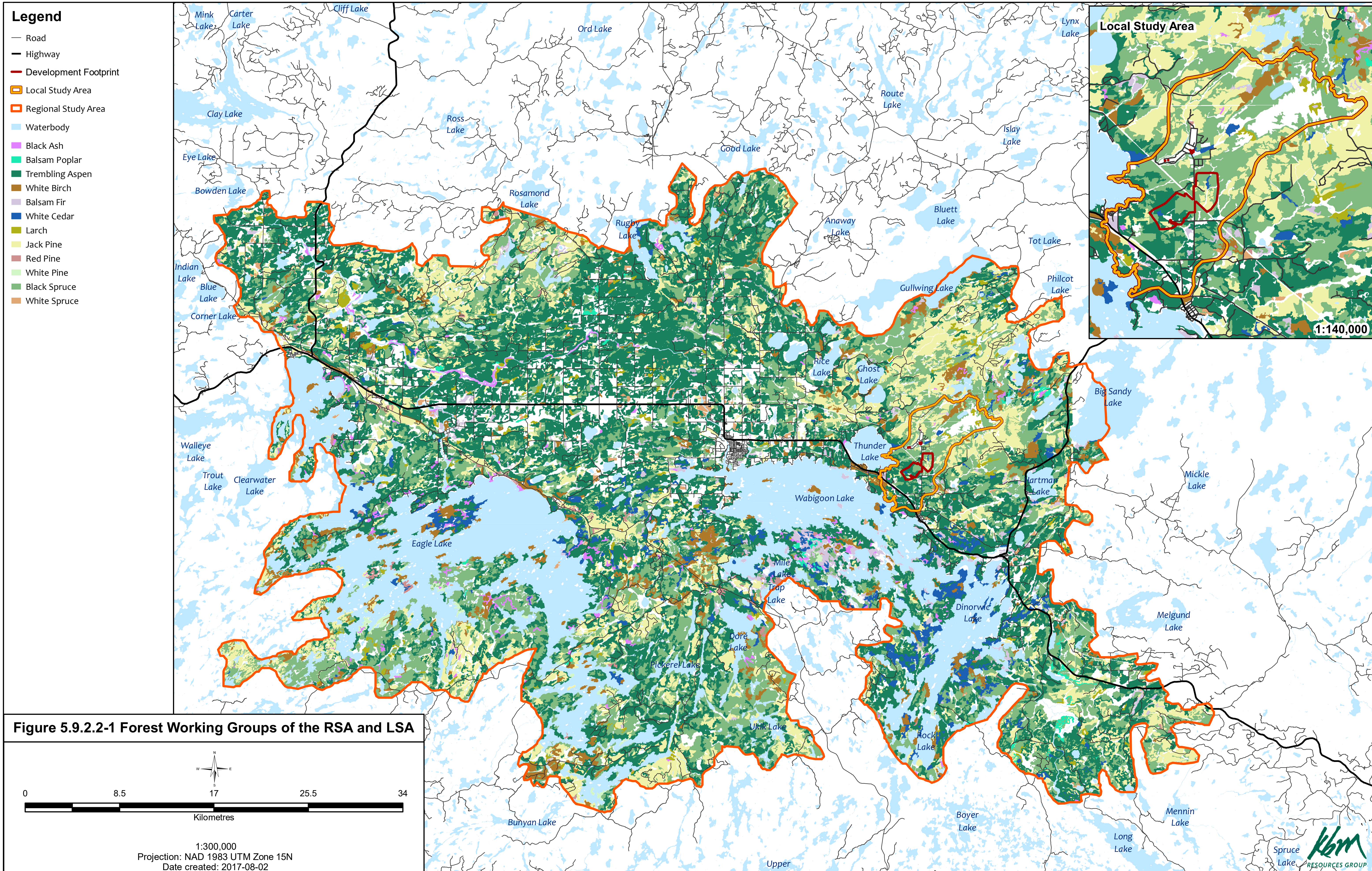

Figure 5.9.2.2-1 Forest Working Groups of the RSA and LSA

5.9.3 Wetlands

5.9.3.1 Environmental Setting

The environmental setting of the Project area is described in detail in Section 5.9.2, and descriptions of wildlife and associated habitat are presented in subsequent sections.

5.9.3.2 Assessment Methods

Initial surveys of nine wetlands were conducted in 2012 by DST. Wetlands were selected based on the potential for adjacent developments. Supplementary surveys were conducted in 2016, which expanded data collection to 11 wetlands (Figure 5.9.3.2-1). Upon request, KBM also compiled all available historical data for Lola Lake Provincial Nature Reserve. The purpose of completing the wetland evaluations within the Project area was to acquire baseline data on all wetlands, peatlands, and riparian plant communities, as well as to map and describe wetlands following the Ontario Wetland Evaluation System (OWES). The specific objectives were to:

- Characterize all riparian/wetland vegetation communities according to the appropriate classification guides (OWES).
- Describe individual wetland vegetation community distribution, structure, and diversity.
- Identify any provincially significant wetlands (PSWs).
- Wetlands are defined by OWES as "lands that are seasonally or permanently flooded by shallow water as well as lands where the water table is close to the surface; in either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants." There are four recognized OWES wetland types: bog, fen, swamp and marsh. Any discrete wetland may be composed of one or more of these wetland types.
- Prior to fieldwork, Forest Resource Inventory (FRI) data and 1:6,500 Google Earth satellite images of each wetland were examined. A first estimate of wetland boundaries and vegetation community boundaries were interpreted and marked onto each image. All vegetation communities were visited in the field to confirm vegetation community boundaries and to identify vegetation forms and species. Wetland boundaries on satellite images were corrected as required in the field.

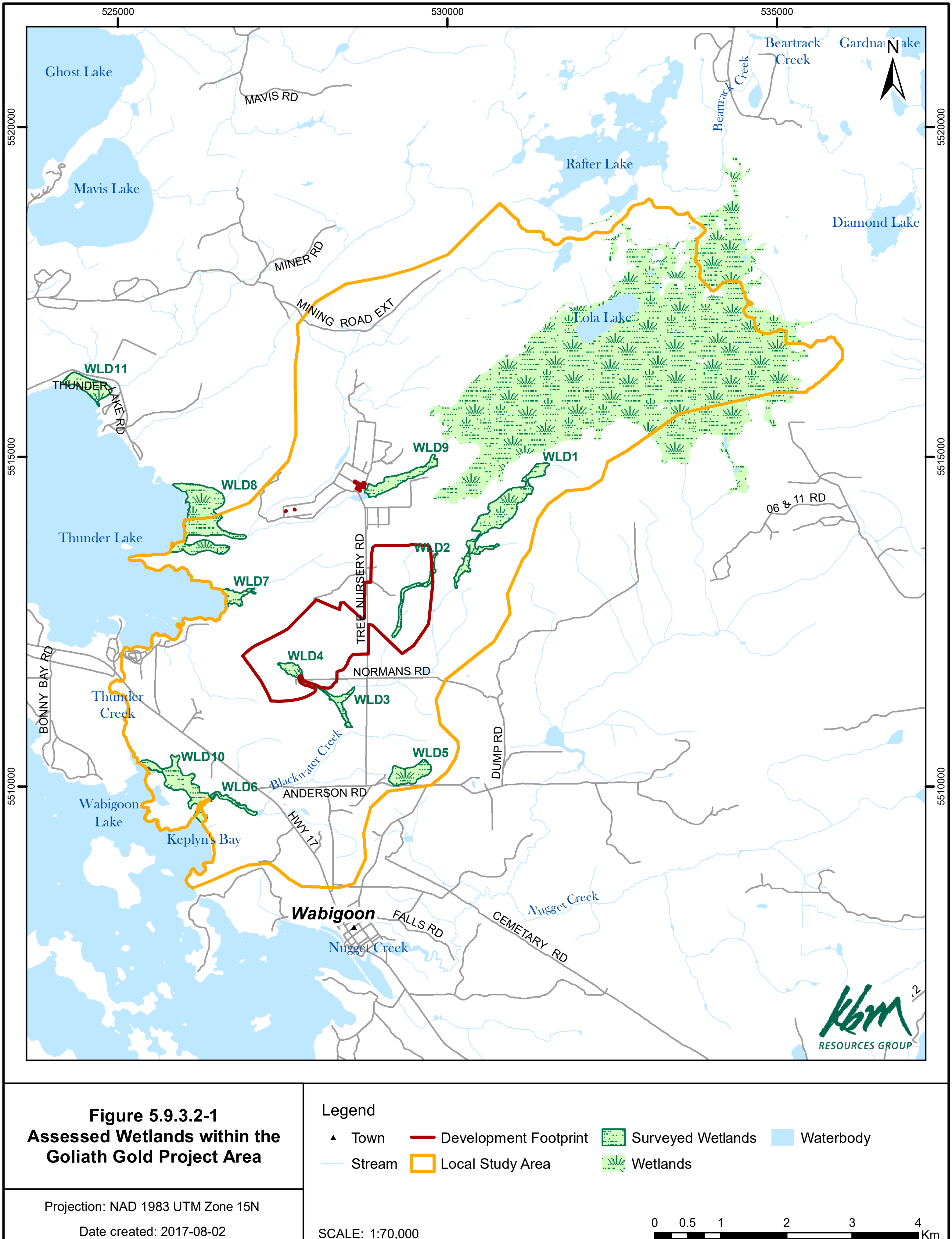

Figure 5.9.3.2-1
Assessed Wetlands within the Goliath Gold Project Area

Projection: NAD 1983 UTM Zone 15N

Date created: 2017-08-02

Each wetland evaluation included an in-depth information gathering phase, which involved contact with the following organizations, agencies, and resources:

- Forest Resource Inventory (FRI) maps;
- LIDAR digital imagery aerial photography;
- Watershed data from Land Information Ontario (LIO);
- Dryden District OMNRFF;
- Ontario Parks;
- Natural Resources Values Information System (NRVIS), Land Information Ontario (LIO), Crown Land Use Policy Atlas (CLUPA);
- Wabigoon Lake Ojibway Nation, Eagle Lake First Nation, Whitefish Bay First Nation, Wabaskang First Nation, Lac Seul First Nation, Grassy Narrows First Nation, Aboriginal Peoples of Wabigoon and Métis Nation of Ontario;
- Natural Heritage Information Centre (NHIC);
- Review of topographic and soil maps; and
- Previous studies including fish habitat, waterfowl surveys, breeding bird surveys, and vegetation surveys.

Wetlands with areas greater than 0.5 ha were considered for evaluation. Data collected during field observations included:

- Plant surveys (vegetation forms, common species and identification of rare plants);
- Soil/substrate types;
- Wetland boundaries;
- Delineating wetland types;
- Delineating vegetation communities;
- Identifying presence of special features, wildlife, furbearers, wild rice etc.; and
- Recording fish habitat information.

The OWES evaluation procedure involved assigning points to the different features of a wetland, based on four components: social, hydrological, biological and special features. As the score for each component is capped at 250 points, a wetland can score a maximum of 1,000 points. Wetlands that achieve a total score of 600 or more points, or score 200 or more points in either the biological or special features components are considered to be provincially significant.

5.9.3.3 Findings

Lola Lake Provincial Nature Reserve

For the purposes of this report, the Lola Lake wetland complex was not surveyed in the field due to: a) the availability of previous surveys and reports on the wetland; b) the vast size and inaccessibility of large portions of the wetland; and c) the fact that the entire wetland lies upstream of any proposed Project components and will have a very small chance of being negatively impacted by the Project after all necessary mitigation measures are in place.

The Lola Lake wetland is a large wetland complex, approximately 1,487 ha in size, surrounding Lola Lake. The peatland supports open graminoid bogs, open low-shrub bogs, and treed bog communities, including raised bogs and some basin bogs. Black spruce is the dominant tree species, and leatherleaf (*Chamaedaphne calyculata*), sweet gale (*Myrica gale*), and/or bog birch (*Betula pumila* var. *glandulifera*) are the dominant shrub species. Few-seeded sedge (*Carex oligosperma*) dominates the graminoid bogs. Sphagnum mosses are abundant throughout.

The wetland complex also includes sloping, patterned fen formations (string or ladder fens). Larch, birch, speckled alder (*Alnus rugose*), willow (*Salix* spp.), alder-leaved buckthorn (*Rhamnus alnifolia*), tussock bulrush (*Scirpus cespitosus*), and wiregrass (*Carex lasiocarpa*) are the main species in the fens, with relative prevalence depending on the amount of open water and overall saturation of the site. The moss layer thickness varies and is dominated by sphagnum and/or ribbed bog moss (*Aulacomnium palustre*).

Wetland Evaluation

As per the description in the methodology there are four major components within the data scoring record: biological, social-economic, hydrological, and special features. None of the original nine wetlands surveyed, nor the two additional wetlands surveyed in 2016 scored greater than 600 points overall, and thus none were identified as being provincially significant. All scores by components and subsections are summarized in Table 5.9.3.3-1. The average score across all 11 wetlands evaluated was 362, the maximum score was 448 (WLD8), and the minimum score calculated was 277 (WLD2). Individual wetland maps, wetland species lists and wetland scoring records can be found in Appendix S.

Table 5.9.3.3-1: Summary of OWES Scores for Evaluated Wetlands

Wetland ID:		WLD1	WLD2	WLD3	WLD4	WLD5	WLD6	WLD7	WLD8	WLD9	WLD10	WLD11
BIOLOGICAL COMPONENT												
Productivityj	Growing Degree-Day/soils (max 30)	8	7	10	9	8	8	13	9	8	11	9
	Wetland Type (max 15)	7	8	9	13	7	15	11	8	9	8	10
	Site Type (max 5)	2	2	2	2	2	5	2	2	2	5	3
Biodiversity	Number of Wetland types (max 30)	20	13	13	13	13	9	13	20	20	20	13
	Vegetation Communities (max 45)	5	5	3	5	5	3	5	5	7	7	5
	Diversity of Surrounding Habitat (max 7)	6	7	6	7	7	7	7	7	6	7	7
	Proximity to other wetlands (max 8)	8	8	8	8	8	8	8	8	8	8	8
	Interspersion (max 30)	9	6	9	12	12	15	12	18	6	9	9
	Open water type (max 30)	8	0	14	20	8	30	30	14	14	8	8
	Size (max 50)	10	7	9	17	8	25	25	21	9	8	7
Total Biological Component (not to exceed 250)		83	63	83	106	78	125	126	112	89	91	79
SOCIAL COMPONENT												
Economically Valuable Products	Wood products (max 14)	0	0	0	0	0	0	0	6	4	4	4
	Low Bush Cranberry (max 2)	2	2	0	0	2	0	0	0	2	0	0
	Wild rice (max 10)	0	0	0	0	0	10	0	0	0	0	0
	Commercial fish (max 12)	0	12	12	12	0	12	12	12	12	12	12
	Furbearers (max 12)	3	0	3	3	0	3	6	0	3	0	0
Recreational Activities	Hunting/Fishing/Nature (max 80)	0	0	0	0	0	8	0	0	0	16	36
	Landscape Distinctness (max 3)	3	3	3	3	3	3	3	3	3	3	3
	Absence of human disturbance (max 7)	7	4	4	4	7	4	7	7	4	4	4
	Educational Uses (max 20)	0	0	0	0	0	0	0	0	0	0	0
	Facilities and Programs (8)	0	0	0	0	0	0	0	0	0	0	0
	Research and Studies (max 12)	8	5	5	5	0	5	5	5	5	5	5
	Proximity to human settlement (max 40)	10	10	10	10	10	10	10	10	10	10	8
	Ownership (max 10)	8	5	4	8	4	4	8	8	4	8	8
	Size (max 20)	7	2	2	2	3	5	5	11	7	5	7
	Aboriginal and cultural (max 30)	0	0	0	0	0		0	0	0	0	0
Total Social Component (not to exceed 250)		48	43	43	47	29	64	56	62	54	67	87

Table 5.9.3.3-1: Summary of OWES Scores for Evaluated Wetlands (continued)

Wetland ID:		WLD1	WLD2	WLD3	WLD4	WLD5	WLD6	WLD7	WLD8	WLD9	WLD10	WLD11
HYDROLOGICAL COMPONENT												
Groundwater Recharge	Flood attenuation (max 100)	59	35	10	14	34	0	0	0	30	0	0
	Site type (20)	20	20	20	20	20	0	0	0	20	0	0
	Hydrological Soils (max 10)	7	7	4	4	4	0	0	0	7	0	0
Downstream Water Quality improvement	Watershed Improvement (max 30)	30	30	30	30	21	30	30	30	30	30	16
	Adjacent Watershed Land Use (max 60)	4	4	4	4	14	29	14	29	4	29	29
	Vegetation form (max 10)	8	8	8	10	8	10	10	8	8	8	8
	Carbon Sink (max 15)	15	9	9	9	0	9	9	9	9	9	9
	Shoreline erosion control (max 15)	0	0	0	0	0	8	15	8	0	8	15
	Groundwater Discharge (max 30)	22	21	18	17	12	22	17	17	21	17	17
Total Hydrological Component (not to exceed 250)		165	134	103	108	113	108	95	101	129	101	94
SPECIAL FEATURES												
Rarity	Wetlands (max 70)	50	30	30	30	40	20	30	50	50	50	30
	Endangered/Threatened spp. Breeding habitat (no max.)	0	0	0	0	0	0	0	0	0	0	0
	Traditional use by endangered/ threated species (no max.)	0	0	0	0	0	0	0	0	0	0	0
	Provincially significant animals (no max.)	0	0	0	50	0	50	50	80	50	0	0
	Provincially significant plants (no max.)	0	0	0	0	0	0	0	0	0	0	0
	Regionally significant spp. (no max)	0	0	0	0	0	0	0	0	0	0	0
	Locally significant spp. (no max.)	0	0	0	0	0	0	0	0	0	0	0
	Species of Species Status (Black Duck) (max 25)	0	0	0	10	0	10	10	10	0	10	10

Table 5.9.3.3-1: Summary of OWES Scores for Evaluated Wetlands (continued)

Wetland ID:		WLD1	WLD2	WLD3	WLD4	WLD5	WLD6	WLD7	WLD8	WLD9	WLD10	WLD11
Significant Features and Habitat	Colonial Waterbirds (max 50)	0	0	0	0	0	0	0	0	0	0	0
	Winter Cover for Wildlife (max 100)	0	0	0	0	0	0	0	0	0	0	0
	Waterfowl Staging/Moulting (max 150)	0	0	0	0	0	0	0	0	0	0	0
	Waterfowl Breeding (max 100)	0	0	0	10	0	10	10	10	0	10	10
	Migratory Passerine, Shorebird or Raptor stopover (max 100)	0	0	0	0	0	0	0	0	0	0	0
	Ungulate habitat (max 100)	0	0	0	0	0	0	0	0	0	20	20
	Fish nursery habitat (max 100)	2	1	4	1	1	7	3	1	1	9	7
	Fish staging/migration habitat present (max 25)	5	0	0	1	0	25	5	5	5	25	25
	Ecosystem age (max 25)	16	6	30	1	18	0	1	17	6	6	2
	Great lake coastal wetlands (max 75)	0	0	0	0	0	0	0	0	0	0	0
Total Special Features (not to exceed 250)		73	37	74	103	59	122	109	173	112	130	104
TOTAL		**369**	**277**	**303**	**364**	**279**	**419**	**386**	**448**	**384**	**392**	**364**

The 11 surveyed wetlands ranged in size from 5 ha to 54 ha and included swamps, fens, and marshes. The Swamp wetland type occupied the largest area of all the wetlands evaluated (112 ha), followed by Fen (58 ha), and Marsh (30 ha). All wetlands were either palustrine (inland with no flow or intermittent inflow and either permanent or intermittent outflow), or lacustrine (associated with a lake - Thunder Lake or Wabigoon Lake, in this case).

A total of 177 plant species were identified across the 11 wetlands, though several were only identified to genus. Although the 2012 baseline report identified 21 provincially tracked plant species occurring within the LSA or RSA, an updated search of the Natural Heritage Information Centre (NHIC) database in 2016 resulted in occurrence records for only three plant species within the Dryden District: heart-leaved Alexander (*Zizipa aptera*), Vasey's rush (*Juncus vaseyi*), and western wheat grass (*Pascopyrum smithii*). These occurrences were all located outside of the LSA and the RSA. The other species listed in 2012 occurred in neighbouring forest management units, even further from the LSA and RSA. Species at Risk are further discussed in Section 5.11.

As indicated in the Dryden Forest Management Plan (2010), there are several locally rare tree species in the Dryden FMU, including yellow birch (*Betula alleghaniensis*), burr oak (*Quercus macrocarpa*), and white elm (*Ulmus laevis*). None of these species were observed during 2012 nor 2016 baseline field studies, and burr oak is not typically associated with wetland habitats.

Three wildlife SAR were also encountered during wetland surveys, all of which were birds (Table 5.9.3.3-2).

Table 5.9.3.3-2: Species at Risk Encountered During Wetland Surveys

Wetland ID	Scientific Name	Common Name
WLD9	*Contopus cooperi*	Olive-sided Flycatcher
WLD4, WLD7, WLD6, WLD 8	*Haliaeetus leucocephalus*	Bald Eagle
WLD 8	*Wilsonia canadensis*	Canada Warbler

5.9.4 Mammals

Several mammal surveys were conducted within the LSA, including:

- Encounter surveys (i.e., meandering transects through potential habitat) focused on key ungulate habitats (e.g., winter deer yards) and SAR habitats (e.g., grasslands for American Badger (Taxidea taxus taxus; 2011 to 2012);
- Small mammal trapping (2012 and 2016);
- Presence/absence acoustic monitoring for bats (2011 and 2012); and
- An extensive monitoring program established to identify bat maternity roost (2015).

Twenty mammal species were documented in the LSA across the 2011 to 2016 field seasons. Several large mammals and furbearers were regularly observed in the Project area (Table 5.9.4-1).

Table 5.9.4-1. Summary of Large Mammals and Furbearers identified in the LSA

Large Mammals		Furbearers	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Moose	*Alces alces*	American Beaver	*Castor canadensis*
White-tailed Deer	*Odocoileus virginianus*	Mink	*Mustela vison*
Black Bear	*Ursus americanus*	River Otter	*Lontra canadensis*
Gray Wolf	*Canis lupus*	Red Fox	*Vulpes vulpes*
		Muskrat	*Ondantra zibethicus*
		Woodchuck	*Marmota monax*
		Snowshoe Hare	*Lepus americanus*

Small mammal trapping surveys in October 2012 and July 2016 documented six species over a total of 119 and 160 trap-nights, respectively (Table 5.9.4-2).

Table 5.9.4-2. Small Mammal Trapping Summary

Common Name	Scientific Name	2012	2016
Southern Red-Backed Vole	*Clethrionomys gapperi*	18	7
Deer Mouse	*Peromyscus maniculatus*	12	
Northern Short-tailed Shrew	*Blarina brevicauda*	1	
Red Squirrel	*Tamiasciurus hudsonicus*	1	
Least Chipmunks	*Tamias minimus*		2
Meadow Jumping Mouse	*Zapus hudsonius*		1

Passive acoustic monitoring of bat activity in 2011 and 2012 detected five species: Hoary Bat (*Lasiurus cinereus*), Silver-haired Bat (*Lasionycteris noctivagans*), Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*) and Big Brown Bat (*Eptesicus fuscus*). Both the Little Brown Myotis and Northern Myotis are listed as endangered in Canada.

Potential bat maternal roosts were sparse within the Project area. Although snag density ranged from 40-50 snags/ha, only five high quality roosts were identified in roughly 22 ha of forest assessed. These snags represent a highly limited resource. No bat species were observed using the roosts during an exit survey in 2015, but two bats of unknown species were observed flying over the area.

5.9.5 Birds

Several bird surveys were conducted within the LSA and RSA, including:

- Breeding Bird Surveys (2011 to 2012, 2016);
- Bird Migration Surveys (2011);
- Marshbird and Waterfowl Surveys (2011 to 2012, 2016);
- Bobolink Surveys (2011);
- Whip-poor-will and Common Nighthawk Surveys (2011 to 2012); and
- Stick Nest Surveys (2010 to 2011, 2015).

A total of 100 bird species were encountered across 140 breeding bird surveys stations. Avian species richness was highest in developed areas (76 species) when compared to deciduous (65), coniferous (63), wetland (37), successional (35), and upland habitats (28). The most frequently encountered species were: White-throated Sparrow (*Zonotrichia albicollis*, 177 observations), Red-eyed Vireo (*Vireo olivaceus*, 104), Nashville Warbler (*Oreothlypis ruficapilla*, 97), American Robin (*Turdus migratorius*, 85), Swanson's Thrush (*Catharus ustulatus*, 75), Ruby-crowned Kinglet (*Regulus calendula*, 72), Ovenbird (*Seiurus aurocapilla*, 67), Hermit Thrush (*Catharus guttatus,* 57), Red-breasted Nuthatch (*Sitta canadensis*, 50), and Magnolia Warbler (*Dendroica magnolia*, 49).

No active stick nests were detected within the LSA; however, active nests were detected for several species:

- Common Loon (*Gavia immer*): active nest on Thunder Lake;
- Barn Swallow (Hirundo rustica): active nests on buildings on the grounds of the former tree nursery; and
- Common Grackle (Quiscalus quiscala): nest in the central LSA (grackle nests are not protected by the *Migratory Birds Convention Act*).

Seven avian SAR were encountered within the LSA (Table 5.9.5-1). Generally, the bird communities observed during the environmental baseline surveys are typical of Ontario's boreal forest.

Table 5.9.5-1 Summary of Bird SAR observed in the LSA

Species	Scientific Name	SARA/COSEWIC	SARO
Bald Eagle	*Haliaeetus leucocephalus*	Not at Risk	Special Concern
Barn Swallow	*Hirundo rustica*	Threatened	Threatened
Black Tern	*Chlidonias niger*	Not at Risk	Special Concern
Common Nighthawk	*Chordeiles minor*	Threatened	Special Concern
Olive-sided Flycatcher	*Contopus cooperi*	Threatened	Special Concern
Peregrine Falcon	*Falco peregrinus*	Special Concern	Special Concern
Rusty Blackbird	*Euphagus carolinus*	Special Concern	-

5.9.6 Amphibians and Reptiles

Several reptile and amphibian field surveys were conducted in the LSA and RSA, including:

- Visual Encounter Surveys (2011); and
- Roadside Call Surveys (2011 and 2012).

Further, passive acoustic monitors were deployed in 2011 to record calls from birds, frogs, and bats (33 recorder location-nights). Six amphibian species have been recorded within the LSA: Spring Peeper (*Pseudacris crucifer*), Boreal Chorus Frog (*Psuedacris maculata*), Grey Treefrog (*Hyla versicolor*), Wood Frog (*Lithobates sylvaticus*), American Toad (*Anaxyrus americanus*), and Blue-spotted Salamander (*Ambystoma jeffersonianum-laterale* “complex”).

Extensive visual encounter surveys specifically targeting Snapping Turtles (*Chelydra serpentine*) were conducted in appropriate habitats (e.g., basking logs, soil banks) throughout the field program. Western Painted Turtle (*Chrysemys picta belli*) and Eastern Garter Snake (*Thamnophis sirtalis sirtalis*) were regularly detected within the LSA, but no reptile or amphibian SAR were encountered.

5.9.7 Invertebrates

Incidental observations gathered during the 2011 field efforts included four butterflies (*Papilo glaucus candensis*, *Colias eurytheme*, *Celastrina ladon*, *Nymphalis antiopa*), two damselflies (*Calopteryx aequabilis*, *Nehalennia irene*) and 16 dragonflies (*Aeshna canadensis*, *Aeshna interrupta*, *Arigomphus cornutus*, *Boyeria grafiana*, *Dorocordulia libera*, *Dromogomphus spinosus*, *Epitheca cynosura*, *Gomphus graslinellus*, *Gomphus lividus*, *Hagenius brevistylus*, *Leucorrhinia hudsonica*, *Libbellula lydia*, *Libellula pulchella*, *Libellula quadrimaculata*, *Macromia illinoiensis*, *Sympetrum danae*).

Only one invertebrate SAR, Monarch (*Danaus plexippus*) is known to occur within the RSA, but was not observed throughout the field program.

5.9.8 Significant Wildlife Habitat

An inventory of significant wildlife habitat, as described in OMNRF (2000), was conducted across the LSA in 2010 to 2011 and 2015. Specifically, these habitats include colonial and raptor nest sites, migratory bird staging and stopover areas, ungulate wintering areas and calving/fawning sites, winter deer yards, moose aquatic feeding areas (MAFAs), mineral licks and hibernacula (reptiles and bats). Summaries of Specialized Wildlife Habitat (Table 5.9.8-1) and the Assessment of Seasonal Concentrations of Wildlife (Table 5.9.8-2 in the LSA are presented below.

Table 5.9.8-1: Assessment of Specialized Wildlife Habitat in the LSA

Natural Feature	Likelihood of Occurrence in the LSA	Comments
Habitat for Area Sensitive Species	Yes	Twenty-nine area sensitive species observed in site investigation.
Forest providing high diversity of habitats	Yes	Relatively large, old, and undisturbed forest stands present.
Amphibian Woodland Breeding Pools	Yes	Suitable habitat noted during site investigation. Seven amphibian species observed.
Foraging Areas with Abundant Mast	Possible	No oaks or other nut-bearing trees. Fruit bearing shrubs (blueberries, June berries, pin cherries) common.
Osprey, Bald Eagle nesting habitat	Possible	None documented or observed in site investigation but Bald Eagles observed during nesting season and suitable habitat present.
Turtle Nesting Habitat	Yes	None documented or observed in site investigation but Western painted turtle is present.
Moose aquatic feeding areas	Possible	None documented or observed in site investigation. Suitable habitat present.
Mink and otter feeding/denning sites	Possible	Dens not observed or documented, but both species present in the LSA.
Marten and fisher denning sites	Possible	Dens not observed or documented, but suitable habitat present and both species present in surrounding area.
Areas of High Diversity (e.g., seeps, springs, cliffs, and caves)	No	None documented or observed in site investigation.

Table 5.9.8-2: Assessment of Seasonal Concentrations of Wildlife in the LSA

Type of Seasonal Concentration	Likelihood of Occurrence in the LSA	Comments
White-tailed deer winter yard	Possible	Not documented or observed in field investigation. Potential habitat present.
Moose late winter habitat	Possible	Not documented or observed in field investigation. Potential habitat present.
Waterfowl stopover and staging areas	Yes	Marshes at Blackwater, Nugget, and Thunder Creek supported significant numbers of migrating waterfowl in October 2011.

Table 5.9.8-2: Assessment of Seasonal Concentrations of Wildlife in the LSA (continued)

Type of Seasonal Concentration	Likelihood of Occurrence in the LSA	Comments
		There are fairly extensive areas of wild rice (important duck food) at these sites.
Waterfowl nesting areas	Yes	Eight waterfowl species observed during the nesting season. Marshes at Blackwater, Nugget, and Thunder Creek may be significant nesting habitat.
Colonial bird nesting sites	Possible	No evidence of heronries or nesting of other colonial species documented or observed in site investigation. Potential habitat present for Great Blue Heron.
Shorebird migratory stopover areas	Possible	No significant numbers of shorebirds observed during site investigation. Stopover of some species may occur in fields and marshes in some years.
Landbird migratory stopover area	No	Not documented. Stopover of some species may occur, but unlikely to be significant at more than the local scale given the absence of large lakes, ravines, and other landforms likely to concentrate migrants.
Raptor wintering areas	Possible	None documented or observed in site investigation. Some potential habitat is present but wintering raptors are generally uncommon in northwestern Ontario.
Bald Eagle winter, feeding and roosting sites	Possible	Bald Eagles observed in May to October 2011. Wintering not documented. No open water present in most winters, but the dump is a potential source of food.
Wild turkey winter range	No	Wild Turkeys do not occur in the area.
Turkey vulture summer roost	No	None documented or observed in site investigation.
Reptile hibernacula	Possible	None documented or observed in site investigation. Potential habitat present.
Bat hibernacula	No	None documented. No suitable habitat present.
Butterfly migratory stopover areas	No	None documented or observed in site investigation. Suitable habitat present on Wabigoon Lake shoreline, but significant butterfly migration has apparently not been documented in northwestern Ontario.
Bullfrog concentration areas	No	Bullfrogs do not occur in the area.

5.10 Migratory Birds

A migratory bird survey was conducted in 2011, following the *Hawk Migration Association of North America protocol* (HMANA 2011). The survey was intended to identify the potential for migratory route and/or stopover habitat based on known regional bird migration patterns in the LSA. Six survey stations, focusing on shoreline and wetland habitats, were established to describe potential stopover habitats. These stations offered an unimpeded view for at least several hundred meters to the north, east, and/or west to observe birds migrating south. Only migratory birds (i.e., bird species known to migrate and that were purposively flying south or southwest at the time of the survey) were documented during the surveys.

5.11 Species at Risk

5.11.1 Definition

For the purposes of this EIS, Species at Risk (SAR) are defined as:

- Any species listed as Special Concern, Threatened or Endangered by the Committee on the Status of Species at Risk in Ontario (COSSARO) under the auspices of the provincial *Endangered Species Act*;
- Any plant species identified as provincially rare by the OMNRF Natural Heritage Information Centre (NHIC);
- Any species listed as Special Concern, Threatened or Endangered on Schedule 1 of the federal *Species at Risk Act; and*
- Any species listed as Special Concern, Threatened or Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

5.11.2 Potential Species at Risk

While the 2012 baseline report identified 20 plant SAR potentially occurring within the LSA or RSA, an updated search of the Natural Heritage Information Centre (NHIC) database in 2016 resulted in occurrence records for only three plant SAR in the Dryden District (Table 5.11.2-1): heart-leaved Alexander (*Zizipa aptera*), Vasey's rush (*Juncus vaseyi*), and western wheat grass (*Pascopyrum smithii*). These occurrences were all located outside of the LSA and the RSA. The other species listed in 2012 occurred in neighboring forest management units, even further from the LSA and RSA. Two additional provincially listed plant species are known to occur within the Kenora region and outside of the RSA: Showy Goldenrod (*Solidago speciosa*) occurs in one single population on an island near Kenora proper, and Western Silvery Aster (*Symphyotrichum sericeum*) has only been identified near Lake of the Woods in prairie habitats.

Table 5.11.2-1: Listed and Locally Rare Vascular Plants with Known or Potential Occurrence within the RSA

Scientific Name	Common Name	Rank/ Status	Data Type/ Source/Location	Observed During Baseline studies?
Juncus vaseyi	Vasey's Rush	S3	NHIC occurrence records in the Dryden and Wabigoon FMUs	N
Zizia aptera	Heart-leaved Alexanders	S2	NHIC occurrence record in the Dryden FMU	N
Pascopyrum smithii	Western Wheatgrass	S2	NHIC occurrence records in the Dryden FMU	N
Carex parryana	Parry's Sedge	S1	NHIC occurrence records in the Crossroute FMU	N

Table 5.11.2-1: Listed and Locally Rare Vascular Plants with Known or Potential Occurrence within the RSA (continued)

Scientific Name	Common Name	Rank/ Status	Data Type/ Source/Location	Observed During Baseline studies?
Carex praticola	Northern Meadow Sedge	S2	NHIC occurrence records in the Crossroute FMU	N
Crassula aquatic	Water Pygmyweed	S2	NHIC occurrence records in the English River and Lac Seul FMUs	N
Hudsonia tormentosa	Beach Heather	S3	NHIC occurrence record in the Wabigoon FMU	N
Leucophysalis grandiflora	Large-flowered Ground Cherry	S3	NHIC occurrence records in the Crossroute FMU	N
Limosell aquatic	Northern Mudwort	S2	NHIC occurrence records in the English River FMU	N
Moehringia macrophylla	Large-leaved Sandwort	S2	NHIC occurrence records in the Black Spruce, Dog River-Matawin, and Lakehead FMUs	N
Opuntia fragilis	Brittle Prickly Pear Cactus	S3	NHIC occurrence record	N
Polystichum braunii	Braun's Holly Fern	S3	NHIC occurrence records in the Dog River-Matawin and Lakehead FMUs	N
Potentilla rivalis	Brook Cinquefoil	SH	NHIC occurrence records in the Wabigoon and English River FMUs	N
Schoenoplectus heterochaetus	Slender Bulrush	S3	NHIC occurrence records in the English River and Kenora FMUs	N
Subularia aquatica	Water Awlwort	S3	NHIC occurrence records in the Sapawe FMU	N
Symphotrichum ericodies var. pansum	Prairie White Heath Aster	S2	NHIC occurrence records in the Crossroute and Kenora FMUs	N
Caltha natans	Floating Marsh Marigold	S2	NHIC occurrence records in Crossroute, English River, Lac Seul, Trout Lake, Whiskey Jack, and Kenora FMUs	Potentially identified by KCB during 2011 vegetation baseline field studies (Thunder Creek at Wabigoon Lake)
Solidago speciosa	Showy Goldenrod	S1	Ontario Species at Risk List: Kenora region (known occurrence isolated to one island near Kenora)	N
Symphyotrichum sericeum	Western Silvery Aster	S1	Ontario Species at Risk List: Kenora region (known occurrence in Lake of the Woods area); also present in NHIC database in Crossroute and Kenora FMUs	N

Table 5.11.2-1: Listed and Locally Rare Vascular Plants with Known or Potential Occurrence within the RSA (continued)

Scientific Name	Common Name	Rank/ Status	Data Type/ Source/Location	Observed During Baseline studies?
Betula alleghaniensis	Yellow Birch	Locally Rare	Dryden Forest Management Plan; species occurs over a range of habitats with some potential to occur within or adjacent to wetlands	N
Quercus macrocarpa	Burr Oak	Locally Rare	Dryden Forest Management Plan; species not typically associated with wetland habitats	N
Ulmus laevis	White Elm	Locally Rare	Dryden Forest Management Plan; species occurs over a range of habitats with some potential to occur within or adjacent to wetlands	N

A further 29 wildlife SAR are known to occur within, or have ranges that include the LSA and RSA (Table 5.11.2-2).

Table 5.11.2-2: Wildlife Species at Risk Potentially Occurring or Known to Occur within the LSA and RSA

Species	Scientific Name	Designation		
		SARA	COSEWIC	SARO
Birds				
American White Pelican	*Pelecanus erythrorhynchus*	-	Not at Risk	Threatened
Bald Eagle	*Haliaeetus leucocephalus*	-	Not at Risk	Special Concern
Bank Swallow	*Riparia riparia*	-	Threatened	Threatened
Barn Swallow	*Hirundo rustica*	-	Threatened	Threatened
Black Tern	*Chlidonias niger*	-	Not at Risk	Special Concern
Bobolink	*Dolichonyx oryzivorus*	-	Threatened	Threatened
Canada Warbler	*Cardellina canadensis*	Threatened	Threatened	Special Concern
Chimney Swift	*Chaetura pelagica*	Threatened	Threatened	Threatened
Common Nighthawk	*Chordeiles minor*	Threatened	Threatened	Special Concern
Eastern Loggerhead Shrike	*Lanius ludovicianus*	Endangered	Endangered	Endangered
Eastern Whip-poor-will	*Caprimulgus vociferous*	Threatened	Threatened	Threatened
Eastern Wood Pewee	*Contopus virens*	-	Special Concern	Special Concern
Golden Eagle	*Aquila chrysaetos*	-	Not at Risk	Endangered
Least Bittern	*Ixobrychus exilis*	Threatened	Threatened	Threatened
Olive-sided Flycatcher	*Contopus cooperi*	Threatened	Threatened	Special Concern
Peregrine Falcon	*Falco peregrinus*	Special Concern	Special Concern	Special Concern
Rusty Blackbird	*Euphagus carolinus*	Special Concern	Special Concern	-
Short-eared Owl	*Asio flammeus*	Special Concern	Special Concern	Special Concern

Table 5.11.2-2: Wildlife Species at Risk Potentially Occurring or Known to Occur within the LSA and RSA (continued)

Species	Scientific Name	Designation		
		SARA	COSEWIC	SARO
Yellow Rail	*Coturnicops noveboracensis*	Special Concern	Special Concern	Special Concern
Wood Thrush	*Hylocichla mustelina*	Threatened	Threatened	Special Concern
Mammals				
American Badger	*Taxidus taxus taxus*	Endangered	Endangered	Endangered
Eastern Cougar	*Puma concolor*	-	-	Endangered
Gray Fox	*Urocyon cinereoargenteus*	Threatened	Threatened	Threatened
Little Brown Myotis	*Myotis lucifugus*	Endangered	Endangered	Endangered
Northern Myotis	*Myotis septentrionalis*	Endangered	Endangered	Endangered
Wolverine	*Gulo gulo*	-	Special Concern	Threatened
Woodland Caribou	*Rangifer tarandus caribou*	Threatened	Threatened	Threatened
Invertebrates				
Monarch	*Danaus plexippus*	Special Concern	Special Concern	Special Concern
Skillet Clubtail Dragonfly	*Gomphus ventricosus*	-	Endangered	-

Note: SARA – Federal Species at Risk Act; COSEWIC – Committee on the Status of Endangered Wildlife in Canada; SARO – Species at Risk Ontario

5.11.3 Observed Species at Risk

5.11.3.1 Plants

The only plant SAR observed within the LSA (during all field work activities) was the floating marsh marigold observed in the Thunder Creek wetland near the mouth of Thunder Creek.

Wild rice (*Zizania palustris*) stands were also detected at the mouths of Thunder Creek, Blackwater Creek, Nugget Creek and at Hughes Creek Pond. These stands occupy an estimated area of 12.8 ha within the LSA. Although not considered a SAR, wild rice is a traditional food source for many Indigenous peoples and the general public.

No provincially rare plant communities were documented within the LSA or RSA, nor were any prairie or savannah communities observed. However, both the LSA and RSA contain relatively large stands of old, undisturbed forest.

5.11.3.2 Animals

Two terrestrial mammal SAR were observed within the LSA during field survey efforts: Little Brown Myotis (2011 and 2012) and Northern Myotis (2012). The maternity roost survey (2015) determined that high quality roosts are present in the Project area, but at very low densities. No bat species were observed using the roosts during an exit survey in 2015, but two bats of unknown species were observed flying over the area.

Eight bird SAR were observed within the LSA during the field survey efforts. Bald Eagle, Barn Swallow, Black Tern, Canada Warbler, Common Nighthawk, Olive-sided Flycatcher, Peregrine Falcon and Rusty Blackbird. Of these, only Barn Swallows are listed as *Threatened*, and are therefore afforded additional protection.

No reptile or amphibian SAR were observed during the field surveys.

No terrestrial invertebrate SAR were observed during field surveys.

5.12 Human Environment

Two baseline studies have been conducted for the Project relevant to the human environment:

- Socioeconomic Baseline Report: Conditions in Northwestern Ontario (gck Consulting Ltd., May 2014; hereafter GCK 2014).
- Stage One and Two Archaeological and Heritage Assessment (Boreal Heritage Consulting, December 2012; hereafter BHC 2012).

Refer to Appendix T and Appendix U for a detailed treatment of methods and results.

5.12.1 Land Use

The Project is located between the City of Thunder Bay and The City of Kenora. Both Cities are recognized for its natural resources and outdoor characteristics making them tourist destinations. The City of Thunder Bay is the region's commercial, administrative and medical hub; a strategically located service and transportation centre in Northwestern Ontario. The City of Kenora is a tourists and cottagers destination; where leisure industry, tourism-related services, recreation and cottage building and services are the main sources of income.

The Project area includes the following towns and communities within the Kenora and Thunder Bay Districts:

- Village of Wabigoon;
- City of Dryden;
- Township of Ignace;
- Municipality of Sioux Lookout;
- Municipality of Machin;

- Wabigoon Lake Ojibway Nation;
- Eagle Lake First Nation; and
- Lac Seul First Nation.

All of the above locations are characterized by being situated in natural beauty and spectacular scenery that provide significant outdoor recreational opportunities all year-round. In addition most of the localities are in close proximity to the TransCanada Highway making them important transportation and service hubs that support the local industry. The beautiful parks, hiking trails and sandy beaches provide a variety of outdoor recreational and sporting opportunities in the area; and recent announcements from the forestry and mining sectors indicate opportunities for growth. The Canadian Pacific Railway and Canadian National Railway also pass through or near several of the communities with specific use for the forestry industry in the manufacturing and product handling areas. In particular, the City of Dryden rail yard would be the most likely receiving point for freight destined for the Project.

5.12.2 Social Factors

5.12.2.1 Population

According to the Statistics Canada 2011 census data the City of Thunder Bay represents the highest concentration of population (108,359), the City of Kenora, the second largest (15,345) followed by the City of Dryden (7,617) and Sioux Lookout (5,053) for the Project. The other locations have smaller populations but in general all are roughly equally divided based on gender with more marked difference in the age class distribution. For most populations the median age is over the provincial and Canadian national median. This along with a percentage decrease on the 20 to 24 age group in comparison with 2006 points to an outmigration of young adult population. In most cases this patter is due to the pursuit of school and work opportunities outside of their work communities due to the reduction of the mining and forest industry in the area.

5.12.2.2 Education

Most education facilities in the Study Area are at the elementary level (Table 5.12.2.2-1). The population of Ontario is highly educated. In Ontario, 24.7% of the population aged 15 years and older has a university degree, higher than any other province or territory in Canada. In addition, 29.2% of its population has obtained College or Trade certification.

Table 5.12.2.2-1: Education Facilities in the Study Area

Community	Elementary School	Middle School	High School	Secondary Institution	Post-Secondary Institution	Private School	Adult Education Institution
Thunder Bay	38	3		8	3	2	1
Kenora	9		2		1		
Dryden	4		1		1		
Ignace	1		1				
Sioux Lookout	1		1		2		
Machin	1						

Approximately 78% of the population in Thunder Bay and 77% of the population in Kenora aged 15 and over has attained education or training at or beyond the high school level (Table 5.12.2.2-2).

Table 5.12.2.2-2: Level of Education in Thunder Bay and Kenora

Community	High School Certificate or Equivalent	Apprenticeship or Trade Certificate	College Equivalent Certificate	University Diploma or Degree
Thunder Bay	25%	10%	22%	21%
Kenora	29%	11%	19%	15%

5.12.2.3 Health Services and Programs

A range of health-care services and programs are available in the Study Area (Table 5.12.2.3-1).

Table 5.12.2.3-1: Health Services and Programs in the Study Area

Community	Primary Health Care Facility	Services Offered
Thunder Bay	Thunder Bay Regional Health Sciences Centre	Thunder Bay Regional Health Sciences Centre (THRHSC) is state-of-the-art acute care facility with 375 acute care beds serving the healthcare needs of people living in Thunder Bay and Northwestern Ontario. The THRHSC Emergency Department has approximately 95,000 annual visits. THRHSC has 12 OR theatres, a 28-bed Post Anesthetic Recovery Unit, and a 40-bed Day Surgery Recovery Area.
Kenora	Lake of the Woods District Hospital	Lake of the Woods District Hospital treats about 30,000 people per year, and is a fully accredited hospital under the national standards of the Canadian Council on Health Services Accreditation. It is the largest hospital in Northwestern Ontario outside of Thunder Bay.
Dryden	Dryden Regional Health Centre	Dryden Regional Health Centre is a fully modern 41 bed acute care hospital. There are thirty-one acute and ten chronic/rehabilitation beds in the hospital. The centre provides a full range of inpatient services, including medical, surgical, obstetrical, chronic and critical care.

Table 5.12.2.3-1: Health Services and Programs in the Study Area (continued)

Community	Primary Health Care Facility	Services Offered
Ignace	Mary Berglund Community Health Centre	Health care services are provided by physicians, nurse practitioners and registered nurses. Other services available include physiotherapy, chiropody, lab specimen collection, screening programs for blood sugar and blood pressure.
Sioux Lookout	Meno-Ya-Win Health Centre	The health centre includes a hospital, long term care facility, community services, patient hostel and other related services, and is characterized by its unique blending of mainstream and traditional Aboriginal healing. It has been designated Ontario's Center of Excellence for First Nation Health Care.
Machin	Community Health Centre	Health Services are available through the Machin Family Health Team. Dr. Yvon-Rene Gagnon is the doctor. Further care, as well as home care, may be sought in the nearby City of Dryden.

5.12.2.4 Housing

Traditionally Sioux lookout has maintained a relatively high number of owned dwellings compared to the number of apartments and duplexes in the area (Table 5.12.2.4-1). This trend has consistently been higher than the provincial average and could partially be attributed to the higher median incomes in Sioux Lookout than the provincial median, allowing more people the ability to buy rather than rent.

Table 5.12.2.4-1: Housing Supply in the Study Area

Community	Total Private Dwellings	Owned Dwellings	Rented Dwellings	Average Value of Owned Dwelling
Dryden	3417	2310	900	$162,551.00
Wabigoon	204	N/A	N/A	N/A
Ignace	680	515	55	$83,976.00
Sioux Lookout	2080	1250	655	$189,919.00
Machin	560	335*	60*	$145,600.00*

Source: Statistics Canada, 2011 Census Community Profiles
* 2006 data used where 2011 data was unavailable

5.12.2.5 Crime and Justice

Most local communities have experience some increase in criminal activity in recent years (Table 5.12.2.5-1).

Table 5.12.2.5-1: Police Services and Crime in the Study Area

Community	Police Service	Crime
Dryden	Dryden Police Services	From 2010-2012, reported violent crimes in Dryden have increased slightly by 3.73%. Overall major crime activity remained consistent with a significant increase in impaired driving charges. Also notable is the significant decrease in drug-related charges.
Ignace	Ontario Provincial Police	The period from 2010-2012, reported violent crimes in Ignace have increased slightly by 3.73%. Most notably, Ignace has experienced a significant increase in alcohol and drug related crimes, which contribute to impaired driving charges.
Sioux Lookout	Ontario Provincial Police	From 2010 to 2012, major crimes in Sioux lookout increased significantly by 10%. In contrast to the increase in major crimes, drug-related offenses have reduced by 30.77% since their height in 2011. This was due to the oxycodone epidemic, which is no longer available in the same format in 2012. The largest contributors to major crimes in the community are attributed to sexual offences and domestic assaults, which constitute 43% of total crimes.
Machin	Ontario Provincial Police	The single most significant threat to public safety within the Machin area remains travelling to and from communities on area roadways. Severe weather patterns and wildlife contribute significantly to motor vehicle collisions in the area; however, the main cause can still be attributed to apparent driver action (speeding, aggressive driving, following too closely, speed too fast for conditions).

5.1.1.1 Poverty and Social Issues

The median household income for Dryden families dropped by 7% from 2006 to 2011 as result of the continued economic depression of the community from the downturn of the Domtar pulp mill.

Between 2006 and 2011, median household incomes also decreased by 10% in Ignace. This decrease over a five-year period generally corresponds to the economic downturn in Canada during that period.

Several community-based organizations serving low income households (food banks, second-hand shops, free recovery and counselling programs, temporary shelter and financial assistance programs, etc.) operate in the Study Area to serve community needs.

5.12.3 Economic Factors

5.12.3.1 Labour Force, Labour Participation and Employment

Ontario

On the provincial level, Ontario's unemployment rate was 7.4% in April 2014, up from 7.3% in March. By comparison, in April 2014 the Canadian unemployment held steady at 6.9%. Employment in Ontario relies heavily on the Service sector, which accounted for 79.6% of Ontario jobs in April 2014. Unemployment rates in the Study Area ranges from 4 to 20% (Table 5.12.3.1-1).

Table 5.12.3.1-1: Labour Force, Labour Participation and Employment in the Study Area

Community	Total Labour Force (individuals)	Labour Force Participation (%)	Employment Rate (%)	Unemployment Rate (%)
Thunder Bay	55,115	61	56.4	8
Kenora	8,375	66	61.4	7.6
Dryden	3,935	63	58.1	7.6
Ignace	640	58	46	20
Sioux Lookout	2,920	74	70	5
Machin	535	66	63	4

Source: Statistics Canada, 2011 and 2006 Census Community Profiles

Historically, northwestern Ontario's economy has been tied to its landscape and the abundant natural resources contained therein, particularly in forestry and mining as well as tourism. In Thunder Bay the largest amount of labour force participation is in the Sales and Services category. The lowest participation in the labour force is in Natural Resources and Manufacturing occupations.

The main sources of income in Kenora come from different industries that include tourism and tourism-related service businesses, recreation businesses, cottage building and services, value-added forestry, mining and mining services. The two largest private employers in Kenora are the Trus Joist Weyerhaeuser TimberStrand mill and the Canadian Pacific Railway.

5.12.3.2 Income Levels

- Lower median household incomes in some communities in the Study Area (Table 5.12.3.2-1) may be attributed to an aging population reaching or entering into retirement. Pension or retirement income is considerably lower than working income, which may partially contribute to lower median incomes.

Table 5.12.3.2-1: Income Levels in the Study Area Compared to Provincial Average

	Median Household Income	Median Family Income
Ontario	$60,455	$72,734
Dryden	$60,058	$79,977
Ignace	$51,601	$57,064
Sioux Lookout	$67,034	$86,347
Machin	$55,616	N/A

Source: Statistics Canada, 2011 and 2006 Census Community Profiles

5.12.3.3 Economic Development

Historically, northwestern Ontario's economy has been tied to its landscape and the abundant natural resources contained therein, particularly in forestry and mining as well as tourism. Prior to 2006, northwestern Ontario's primary economic driver was the forestry sector. However, the global recession combined with recent falling lumber prices resulted in devastating impacts on forestry sector. Many local mills were closed or significantly downsized as a result of falling demand. Recently, the forestry sector has seen increased activity, such as the re-opening of the Eacom Forest Products (Ear Falls) and Mckenzie Forest Products (Hudson) sawmills in 2014, but it seems unlikely the industry will return to its previous levels of activity. Many communities are now struggling to diversify their economies to keep dollars circulating locally, meanwhile many workers and families continue to migrate out of the region in search of employment opportunities.

The rich mineral deposits of the Canadian Shield have attracted many mining companies to the region for exploration and extraction. In the wake of the recent recession of the forestry sector, mining activity in the region has received increased attention as major employer in the region. Speculation regarding the Ring of Fire has also lead to increased political interest in current mining infrastructure and development projects. There are currently six active mines in the region, with many more exploration activities ongoing.

Dryden

Economic development has been a primary focus of City of Dryden staff and leadership for over a decade. As the pulp and paper mill began reducing operations and downsizing its workforce, the City recognized the imperative need to diversify its economic base and attract new industry. The City is currently focusing its industry expansion efforts in the areas of Exploration and Mining, Renewable Energy, Manufacturing, Tourism, Agriculture and Retail/Distribution.

Village of Wabigoon

Inhabitants in the Village of Wabigoon can pursue a number of economic development opportunities mainly concentrating on the tourism and services sectors. Business owners in the community focus on the tourism and retail/service sectors offering hospitality and service employment to residents.

One of the most important economic contributors to the community is the tourism industry and the Village of Wabigoon has a number of businesses to capture the demand for northern adventure.

Township of Ignace

The economy of Ignace is based largely on transportation and tourism, but forestry is recovering and on the rise. The forestry industry has been a major employer in Ignace since the 1940's. Although there have been significant losses of employment in this sector in the last decade, there is renewed optimism with the announcement of the planned reopening of the Resolute Forest Products Ignace Sawmill, which was idled in 2006.

Municipality of Sioux Lookout

Sioux Lookout has an economic development plan that was approved in 2011 with targeted sectors as follows:

- Health care and service industries;
- Manufacturing, specifically value-added forestry;
- Arts, culture and heritage tourism; and
- First Nation government and economic development.

Sioux Lookout completed over $250 million dollars in capital projects over the last five years. These projects include:

- The Sioux Lookout Meno Ya Win Health Centre;
- An extension of water and sewer infrastructure along Highway 72; and
- New downtown revitalization initiatives.

Sioux Lookout has a great selection of commercial, industrial and residential land with development opportunities in the rural, urban, lakefront and beautiful lake view settings.

Municipality of Machin

Machin boasts a variety of successful businesses. Many of the businesses and economics in Machin depend on seasonal tourism dollars, so they benefit from its location on the TransCanada Highway and its proximity to several excellent fishing lakes. Beyond the current businesses available in Machin, many residents access the businesses and services available in the City of Dryden 45 km east of Vermillion Bay.

5.12.4 Heritage Resources

A Stage 1 and Stage 2 archaeological and cultural heritage assessment was completed for the Project area (Appendix U).

5.12.4.1 Archaeological Context

Several cultural traditions are represented in the prehistory of Northwestern Ontario extending from about 10,000 years ago to the present.

Palaeo-Indian Period (ca. 10.000 B.P. to 7,000 B.P.): Colonization of the northern part of Ontario by vegetation and animals was later than the south due to the northward retreat of the glaciers and subsequent flooding of the glacially depressed landscape by pro- and post-glacial lakes. As a result, it appears that people may have not entered the Thunder Bay area until about 10,000 years ago while archaeological work in the Hudson's Bay Lowland suggests that human occupation maybe limited to about the last 7,000 years.

The first inhabitants of the area most likely arrived by following herds of caribou across the tundra/parkland environment of newly opened lands left by the retreating glaciers. Within a few hundred years succession to a boreal forest environment led to the concentration of peoples along lakes and river systems. Several types of spear points, made of different types of material indicate that different groups of early hunters moved in at various times.

Archaic Period (ca. 7,000 B.P. to 2,500 B.P.): About 7,000 B.P. the environment in the area became warmer and drier which brought about changes in plant and animal communities and in the subsistence patterns of humans. The changes are reflected in the artifact assemblages where the hunting of smaller game resulted in smaller notched projectile points and stone knives replacing large spear points. A new technology involving the production of stone tools by grinding rather that chipping was also utilized.

About 5,000 years ago people started making use of cold-hammered copper to form spear points, knives, and gaff hooks. One of the most complete copper artifact assemblages for Northwestern Ontario was found at a burial site south of Lake Nipigon that dated to about 3,500 years ago. The Lac Seul area has produced an abundance of copper artifacts reflecting many tool types.

Initial Woodland Period (ca. 2,500 B.P. to 900 A.D.): This tradition is marked by the introduction of fired-clay pottery vessels with conical bases made using the coil method. The vessels were smooth with the exception of the neck and rim which were decorated with distinctive toothed or sinuous edged tools. The makers of these vessels are known as the Laurel people who practiced a way of life similar to the region's Archaic people - fishing, hunting, and collecting wild plants on the major waterways. There are two major theories concerning the origin of the Laurel culture in the area. One is that it arose out of an Archaic base differing only by the adoption of pottery. The other is that the people of the Laurel culture moved into the area following the expansion of wild rice into the area about 2,500 B.P.

Terminal Woodland Period (ca.900 A.D. to 1,600 A.D.): Two distinctive cultures, both of which appear to have developed from a Laurel base are present in the Terminal Woodland Period. The Black Duck culture is characterized by globular pottery vessels textured by cord-wrapped paddle and rims decorated with cord wrapped object impressions. Most Archaeologists believe the Black Duck culture to be ancestral to the modem day Ojibway or Anishnabeg Aboriginal Peoples and First Nations.

The Selkirk tradition is found farther north and is characterized by fabric-impressed vessels. These people are thought to be ancestral to the Cree Aboriginal Peoples and First Nations.

Contact Period (ca. 1,650 A.D. to present): This tradition starts with the arrival of Non-Aboriginal Peoples into the area, first the French then English traders bringing with them trade goods such as axes, guns, beads and metal and woolen goods.

5.12.4.2 Historical Context

Zealand Geographic Township has been divided into lots and concessions but is largely undeveloped. A former Ministry of Natural Resources tree nursery was located on the property but is not a historic feature. No historic settlements or historic transportation routes have been identified on or in proximity to the property. No historic atlas of the area is available.

5.12.4.3 Local Study Area

The Project is located in the DgJc Borden block. A site registration database information request made through the Ministry of Tourism, Culture and Sport resulted in no reported archaeological sites within two kilometers of the Project.

Archaeological sites are most often associated with well-drained, sandy soils. The soils in the LSA are silt and wet clay over bedrock which suggests low archaeological potential. Site inspection of the LSA disturbances and access roads with disturbed exposures found no cultural material. The several small areas of elevated topography were observed to have been disturbed by past wood harvesting activities. The LSA therefore does not have topological, surface water, or soil characteristics that would indicate any archaeological potential.

5.12.5 Aboriginal Peoples

Treasury evaluated the use of the Project area by Aboriginal peoples using pre-existing reports and publically available information and the results of engagement with local communities (Appendix EE). People that harvest country foods from the study area may include:

- Local residents (i.e., residents of the local area, Wabigoon, Dryden), including both Aboriginal and non-Aboriginal peoples; and

- Residents from other communities that have travelled to the area to engage in hunting or fishing activities.

Hunting and gathering activities conducted in the vicinity of the Project include:

- Gathering of vegetation: blueberries, raspberries, pin cherries, wild cranberries, chanterelle mushrooms and wild rice;

- Hunting: moose, deer, grouse, and waterfowl;

- Trapping: Fur-bearing species identified within the RSA include: beaver, muskrat, marten, fisher, otter, fox, lynx, and rabbit; and

- Fishing: no large-bodied fish occur in Project waterbodies. However, Wabigoon Lake supports a number of large-bodied fish species of value to the public and Indigenous peoples: Walleye, Muskellunge, and Northern Pike.

5.12.5.1 Vegetation

Indigenous communities and the public have not identified any specific plants or berries which may be negatively affected by the development of the Project, nor have any locations been identified within the Project area from which plants and berries are being gathered been identified**.** Treasury recognizes that the gathering of plants and berries by Aboriginal people is part of a traditional life style which continues to this day. However, it must also be recognized that while the gathering of plants and berries is a part of a traditional lifestyle, the presence of the plants and berries to be gathered is dependent on a wide variety of factors including: forest ecotype; Soil type; moisture regime; and stage of forest succession. Consequently, although the gathering of plants and berries may be ongoing from year to year, the specific area where gathering may take place can change within a very short time.

Blueberries have been identified as a country food that is commonly used though the RSA and LSA (Figures 5.12.5.1-1 and 5.12.5.1-2). Blueberries are common to the boreal forest but not on all sites. Blueberries prefer the sandy or rocky soils associated with jack pine forests but also occasionally can be found on clays rich soils. Blueberries are an early succession species and thrive for a few years following disturbance such as fire or logging, but decline rapidly as the newly regenerating forest reaches crown closure. Generally the period in which blueberry crops proliferate on a site is approximately four to six years. Blueberries are also very dependent on an absence of late spring frost and rely on adequate sunshine and moisture during growing season to allow berries to mature. Consequently, even on ideal sites and at the right stage of forest development, there is no guarantee that blueberries will be available. It is not realistic to expect blueberry crops to be available for picking on the same specific location over an extended period of time. However, disturbance and change within the boreal forest is common and blueberry crops can usually be found at similar sites which are at an earlier stage of forest development. Such sites can frequently be found in close proximity to sites where blueberries have previously been picked.

Chanterelle mushroom picking activity has been documented within the LSA.

A wild rice harvesting and processing business known as Kawiosa Manomin was established by Wabigoon Lake Ojibway Nation in 1987. Several locations of wild rice are documented with the RSA (Section 5.10.3.1).

5.12.5.2 Hunting and Trapping

Game species that have been identified as valued components as part of hunting community include:

- Moose;
- White-tailed Deer;
- Waterfowl;
- Fur-bearing species; and
- Ruffed Grouse.

The mine site area is fully enclosed within Wildlife Management Unit (WMU) 8; WMU 5 and WMU 9A are within the LSA. Trapping locations within the LSA include Trap lines DR026, DR027, and DR021. Current numbers for active hunters within the region are detailed in Table 5.12.5.2-1 and Table 5.12.5.2-2.

Table 5.12.5.2-1: White-Tailed Deer Hunting Activity

Year	Estimates for Resident Hunters	
	Estimated Number of Active Hunters	Estimated Total Harvest
2008	1,394	1,206
2009	1,352	1,055
2010	1,394	1,216
2011	1,475	1,148
2012	1,552	1,304

Source: OMNRF, 2013 and Tetra Tech, 2014

Table 5.12.5.2-2: Moose Hunting Activity

Year	Estimates for Resident Hunters	
	Estimated Number of Active Hunters	Estimated Total Harvest
2006	1,398	218
2007	1,485	166
2008	1,184	166
2009	1,261	110
2010	1,145	123
2011	975	106
2012	809	89

Source: OMNRF, 2013 and Tetra Tech, 2014

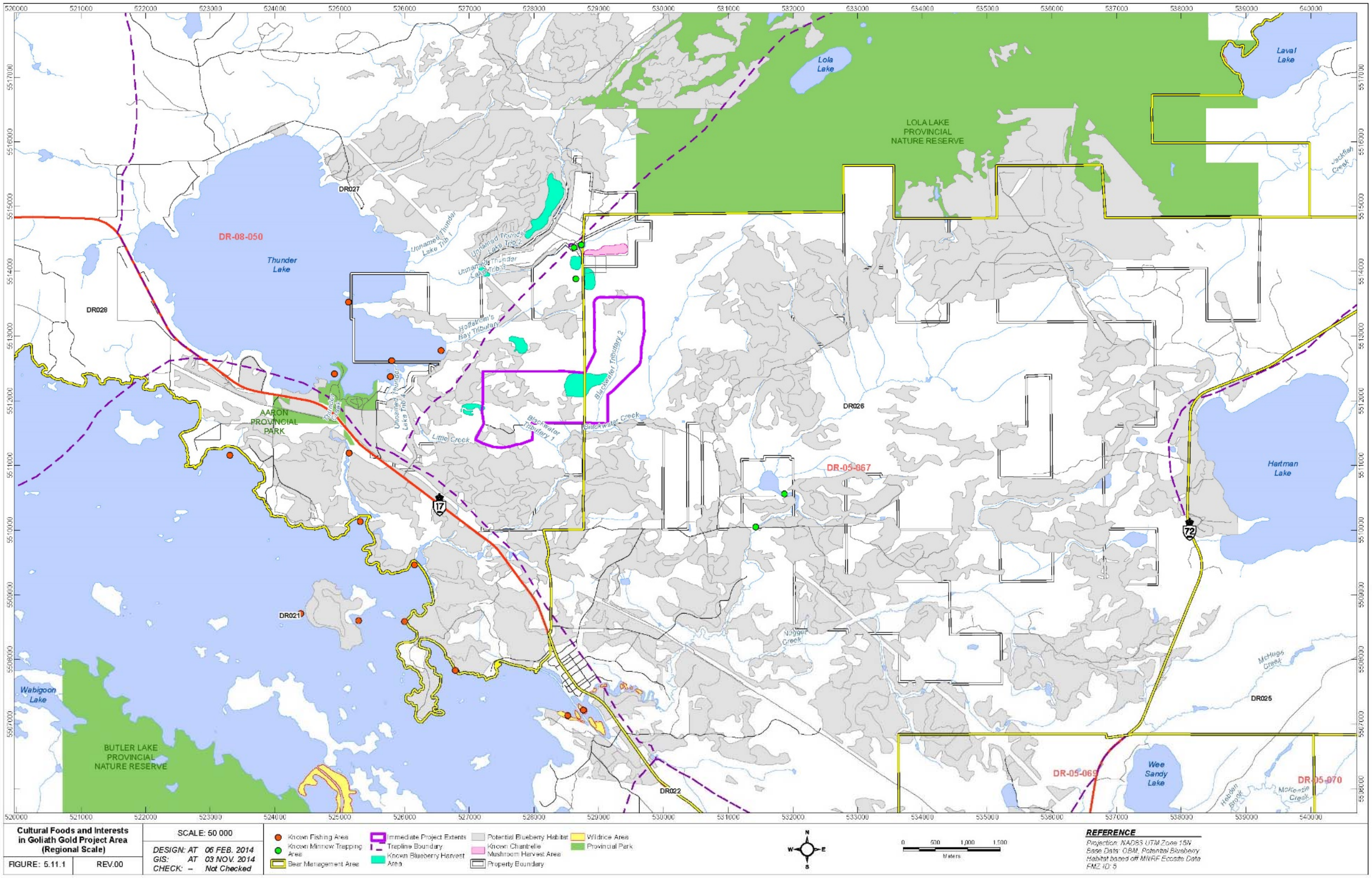

Figure 5.12.5.1-1: Country Foods (Regional)

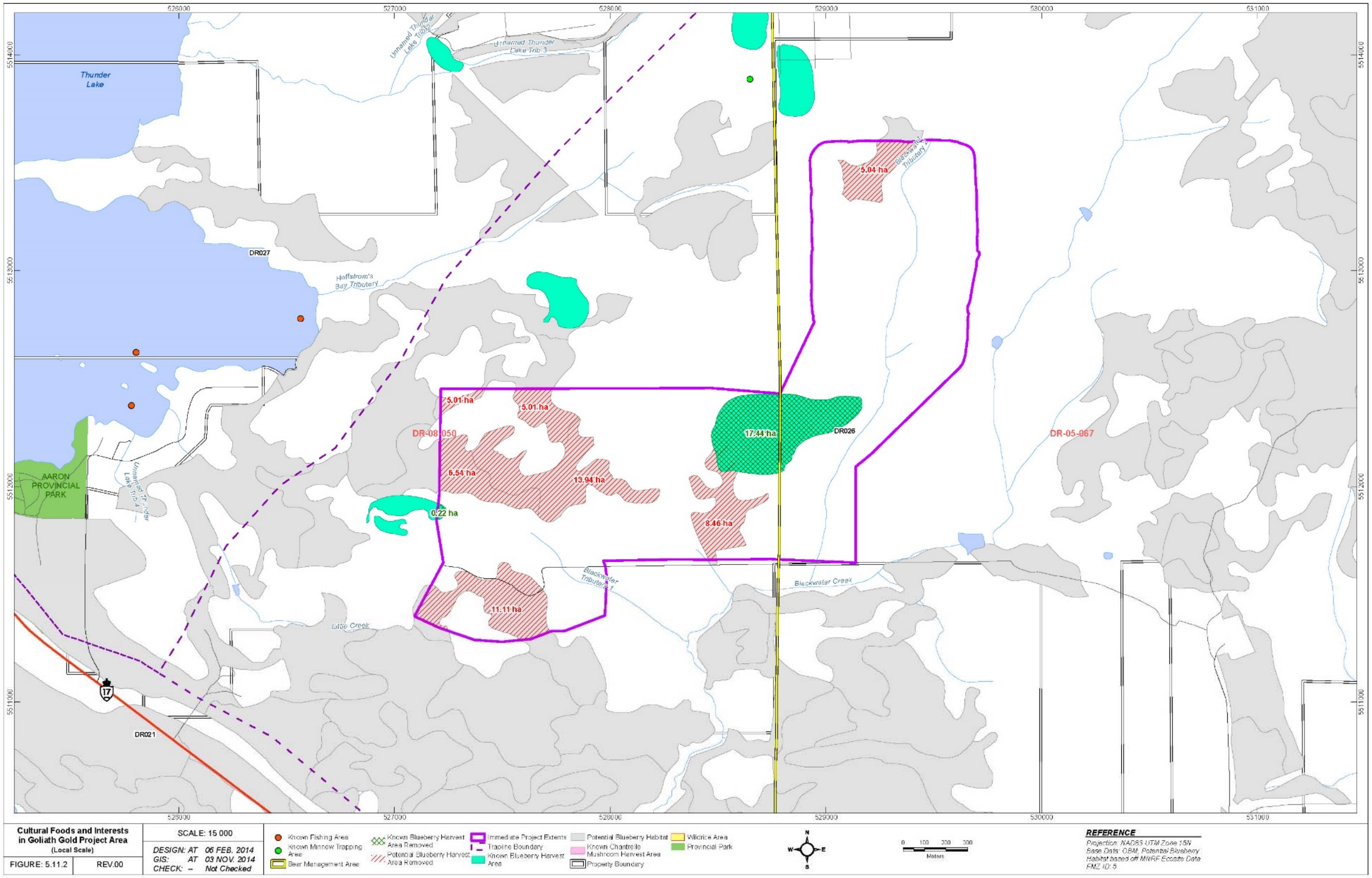

Figure 5.12.5.1-2: Country Foods (Local)

5.12.5.3 Fishing

The Project is located within the Lower English River Section of the Boreal Forest Region, of the Lake Wabigoon Ecoregion (Ecoregion 4S). It is also within the northern limits of the OMNRF FMZ 5. Ranging from the Manitoba border east to Quetico Provincial Park and the United States border north to the Wabigoon River Watershed, the total area covers 44,360 km^2 (KCB 2012, DST 2014).

Aquatic habitat surrounding the Project site is generally of low to moderate value (KCB 2012, DST 2014). Substrates of lakes and streams are primarily dominated by fines (silts and clays), spawning gravels required for some species (i.e., Walleye, White Sucker, Lake Whitefish) are limited. The aquatic vegetation required for Northern Pike and Muskellunge spawning is more abundant. In-stream cover is available mostly in the form of pools, woody debris and vegetation (overhanging, emergent and submergent). Additional areas that have been considered include the spawning areas associated with Thunder Creek, and Nugget Creek. The mouth of Nugget Creek at Wabigoon Lake is designated a Provincial Fish Sanctuary to protect spawning Walleye and fishing is prohibited in this area during the Walleye spawning season; therefore it is seen as a culturally important and relevant to country food harvesters as a valued component.

Additionally Naotkamegwanning First Nation holds commercial fishing licenses on both Thunder and Wabigoon Lakes. Indigenous communities including Eagle Lake First Nation, the Métis Nation of Ontario, and the Aboriginal People of Wabigoon have all expressed an interest in the fishery of Wabigoon Lake.

Thunder Lake and Wabigoon Lake support diverse fish populations that include large predatory fish such as Walleye and Northern Pike; therefore these water bodies must contain suitable spawning and rearing habitat. Assessed streams indicate that suitable habitat is present for small forage fish species (KCB 2012, DST 2014, KBM 2016).