6.0 ENVIRONMENTAL ASSESSMENT

6.1 ENVIRONMENTAL AND SOCIO-ECONOMIC ASSESSMENT METHODS

The environmental and socio-economic assessment for the Thor Lake Project has been prepared in general accordance with the Terms of Reference developed by the MVEIRB (2011) to assist the MVEIRB, regulatory agencies, First Nations organizations, and other interested parties in understanding the anticipated environmental and socio-economic effects of the proposed development. This section of the DAR identifies and examines the predicted effects of the proposed TLP on both the biophysical and human environment components in the proposed development area and surrounding region.

The discussion of potential effects on the human and socio-economic environment (including a description of methods) is provided in Section 7.0. Potential effects resulting from accidents and malfunctions are presented in Section 9.0. The discussion of potential cumulative effects (including a description of methods) is provided in Section 10.0.

The environmental and socio-economic effects assessment approach used for the proposed TLP is consistent with MVEIRB and Canadian EA guidelines and methods and involved the phases described below:

Project Scoping: This phase determines the key issues and potential effects (for both the biophysical and human environment), identifies areas that will likely require additional study, identifies appropriate spatial and temporal boundaries for the assessment, and involves the preparation of a terms of reference that outlines the EA reporting requirements.

Project scoping focuses the assessment on key issues of concern, commonly referred to as Valued Components (VCs). VCs are elements of the natural and human world considered to be of value by participants in the public review process (Beanlands and Duinker 1983) and are often ecological, social, cultural, economic, aesthetic, or ethical in nature. Use of the term VC in this DAR follows the preference identified by the MVERIB (2004), wherein VC includes, and replaces, the narrower terms "Valued Ecosystem Components" and Valued Social Components. VCs are presented in Table 6.1-1 and are discussed more specifically by discipline in the effects assessment sections that follow.

Baseline Conditions: This phase characterizes the pre-development or current biophysical and socio-economic conditions of the proposed development area. It is during this phase that additional investigations are conducted to address the data deficiencies identified during the Project scoping phase.

Effects Assessment: Potential environmental and socio-economic effects associated with the proposed TLP are evaluated using baseline data, an understanding of the proposed TLP components and activities, available mitigation measures, standard assessment tools, and professional judgement. Project-related effects are typically described according to a set of criteria. For the TLP, the following criteria were provided in the Terms of Reference (MVEIRB 2011):

- The nature of the effect;
- The geographic range of the effect;
- The timing of the effect (including duration, frequency, and extent);
- The magnitude of the effect (i.e., what degree of change is expected);
- The reversibility of the effect; and
- The likelihood and certainty that the effect will occur.

For human and socio-economic parameters, the capacity of potentially affected groups, responsible authorities, and/or the developer to manage the effect is an additional criterion that is commonly considered.

Identification of Mitigation: Appropriate management and mitigation measures for environmental and socio-economic components have been integrated into the assessment of effects for the proposed TLP, where applicable. Mitigation strategies to avoid or minimize anticipated effects have been implemented throughout the design of the proposed TLP. The current design represents a balance between effective Project operations and environmental and social responsibility. Design alternatives that were considered, rejected, and/or implemented are discussed in more detail in Section 4.3.

Evaluation of Consequence: Residual effects, which are effects remaining after the application of appropriate mitigation measures, were assessed according to the criteria provided in Table 6.1-2 below. Consequence has been defined as the result of an activity that may partially or totally change the environment (either biophysical or social) in a negative or positive way. Determining the environmental consequence of a residual effect has been used in this DAR as a step that precedes, but influences, the determination of significance.

Evaluation of Significance: Determining the significance of potential residual effects that remain following the application of appropriate mitigation measures often relies on the consideration of personal and/or societal values. Significance determination in this DAR has relied, in part, on ecological principles, identified environmental consequences, ecological context, likelihood of the residual effect occurring, and best professional judgement.

Follow-up: Assuming the proposed TLP is approved and implemented, specific monitoring programs will be undertaken to confirm the accuracy of the environmental and social predictions made during the assessment phase. Corrective actions, if necessary, will be implemented as issues are identified.

6.1.1 Project Scoping

Pursuant to Section 117(1) of the *MVRMA*, the MVEIRB determined that the scope of development for the proposed TLP should include as a minimum the items listed in

Appendix I of the Terms of Reference (MVEIRB 2011). The scope of development includes all of the physical works and activities required for the Project to proceed during the construction, operation, and closure phases.

6.1.1.1 Construction

Nechalacho Mine Site

- Construction of the waste rock management area;
- Construction of any tailings pond and tailings management area, including any water management systems;
- Construction of the underground mine and associated support structures;
- Construction of a waste disposal facility;
- Construction of facilities for milling, initial separation and concentration of ore;
- Construction of power generation and heat recovery facilities;
- Construction of any water treatment facility that will treat water from the tailings pond and other sources;
- Construction of any sewage treatment facilities;
- Construction of drainage control structures, process pipelines and waste water pipelines from mine to surface, on surface at the mine site, run-off collection trenches and sedimentation pond;
- Construction of water management facilities, including the pump house and water intake, water discharge system (including seasonal water storage areas, all drainage ditches and discharge points), potable water supplies for camp and a sewage treatment plant;
- Construction of fuel storage facilities on-site;
- Construction of the permanent camp south of Thor Lake;
- Upgrades to the Nechalacho Mine site-Great Slave Lake access road as well as construction of any new roads at the mine site;
- Expansion or any other modification to the existing airstrip;
- Development of borrow sources for aggregate production at the mine site or along the Nechalacho Mine site-Great Slave Lake access road;
- Seasonal construction and demobilization of the barge-docking facility on the north shore of Great Slave Lake’s Hearne Channel;
- Construction of the concentrate and supply storage/laydown area adjacent to barge docking facility.

Hydrometallurgical Plant Site

- Construction of the Hydrometallurgical Plant;
- Construction of Project-related buildings including garages, maintenance and administration;
- Construction of a waste disposal facility;
- Construction of power generation and heat recovery facilities;
- Construction of storage facilities for fuel, coal, sulphur, limestone and other reagents;
- Construction of any water treatment facility that will treat water from the tailings pond and other sources;
- Construction of any sewage treatment facilities;
- Construction and/or upgrade of the haul road from the hydrometallurgical facility to Great Slave Lake shore and any other new roads;
- Development of borrow sources for aggregate production at the mine site or along the facility-Great Slave Lake access road;
- Seasonal construction and demobilization of the barge-docking facility on the south shore of Great Slave Lake near the Hydrometallurgical Plant site;
- Construction of the concentrate and supply storage/laydown area adjacent to barge docking facility near the Hydrometallurgical Plant site;
- Construction of any water treatment facility that will treat water from the hydrometallurgical facility or tailings pond and other sources;
- Construction of drainage control structures, process pipelines and waste water pipelines from mine to surface, on surface at the mine site, run-off collection trenches and sedimentation pond;
- Construction of water management facilities, including the pump house and water intake, water discharge system (including seasonal water storage areas, all drainage ditches and discharge points), potable water supplies for camp and a sewage treatment plant; and
- Construction of any tailings management facilities, including any water management systems.

6.1.1.2 Operations – Mining and Materials Storage

Nechalacho Mine Site

- Development of underground workings, including crosscut and drift development;
- Extraction and crushing of ore-bearing rock;
- Transport, storage and use of explosives;

- Transport, storage and management of fuel and reagents;
- Mine dewatering and deposit of mine water on surface;
- Transportation of materials, management of ore and tailings, the mine rock management area;
- Operation of tailings management facility, including waste management systems and paste backfill plant;
- Management of a waste disposal facility;
- Management of initial separation and concentration reject materials, ore and tailings stockpiles on surface, including construction of any associated foundations, buildings, and water treatment and management systems; and
- Operation of mining equipment, including vehicles and materials conveyance systems.

Hydrometallurgical Plant Site

- Hydrometallurgical facility equipment operation, including vehicles and material conveyance systems;
- Transport, storage and use of fuel and all reagents, including sulphur, limestone and site-manufactured reagents such as sulphuric acid;
- Transport, storage and use of all fuel, reagents, and other materials bound for the Nechalacho Mine site;
- Transport, storage and use of coal;
- Transportation of materials, management of ore and tailings, tailings pond and tailings management facility, including waste management systems;
- Transport and storage of concentrate;
- Management of a waste disposal facility within the tailings management area.

6.1.1.3 Operations – Milling

Nechalacho Mine Site

- Use of facilities for milling, initial separation and concentration of ore including:
  - Conventional concentrator with ball mills;
  - Initial flotation, secondary flotation of bulk rougher concentrate, bulk cleaner flotation and any other processing;
  - Extraction, transportation, consumption, recycling, treatment and discharge to the environment of mine water and process water;
  - Storage, handling, use and disposal of milling process additives and chemicals; and
  - Thickening, filtration and packaging of concentrate for transportation.

Hydrometallurgical Plant Site

- Use of facilities for processing concentrate via any of the proposed refining techniques, as well as the regeneration of reagents;
- Storage, handling, use and disposal of milling process additives and chemicals;
- Use of facilities to create useable reagents such as sulphuric acid;
- Use of coal-burning or other heat-producing facility; and
- Extraction, transportation, consumption, recycling, treatment and discharge to the environment of mine water and process water.

6.1.1.4 Other On-site Facilities and Activities

Both Sites

- Power generation and heat recovery facilities;
- Paste backfill facility;
- Water usage, management and treatment actions, including Avalon's proposed points of control
- Use of any water treatment plant;
- Use during mine operations of the pump house and water intake, water discharge system (including seasonal water storage areas, all drainage ditches and discharge points) and potable water supplies for camps;
- Use of fuel storage facilities on-site;
- Use of the exploration camp at the Nechalacho Mine site and permanent camp south of Thor Lake;
- Sewage treatment plants;
- Service complex and mine equipment management building;
- Use of vehicles and all other emissions sources both the Nechalacho Mine site and Hydrometallurgical Plant site;
- Use of any water treatment facility that may treat water from the tailings pond and other sources;
- Use of drainage control structures, process pipelines and waste water pipelines from mine to surface, on surface at the mine site, run-off collection trenches and sedimentation pond;
- Use of roads at both sites;
- Use of waste incinerators.

6.1.1.5 Support/ancillary Facilities and Activities

Both Sites

- Transportation activities by air that support the Project's operation, including transportation of goods, fuel, contractors, and employees into and out of the mine;
- Use of the airstrip at the mine site;
- Transportation activities by road (including the Project-site-Great Slave Lake access road) that support the Project's operation, including transportation of goods, fuel, contractors, and employees into and out of the mine as well as the road transport of goods, fuel, contractors, employees and product between Pine Point and Hay River, as well as between Pine Point and Fort Resolution and Fort Smith;
- Transportation activities by water including the barging corridor between the Nechalacho Mine site and Hydrometallurgical Plant site barge loading sites for concentrate, goods, and fuel;
- Loading/unloading activities at the barge docking and transfer facilities as well as the transfer of concentrate, goods and fuel on and off the barges;
- Transportation activities by rail between the Hay River railhead through Woodland Caribou habitat to the NWT-Alberta border;
- Removal and disposal of wastes or other materials;
- Any sites for the alternative energy sources (wind, solar, geothermal, etc.) for either Project site;
- Use of borrow sources for aggregate production at the Nechalacho Mine site or along the access road; and
- Use of borrow sources for aggregate production at or near the Hydrometallurgical Plant Site.

6.1.1.6 Closure and Reclamation

Both Sites

- Removal or stabilization of all structures and equipment;
- Reclamation of tailings management facilities, as well as any and all other site water management facilities at both the Nechalacho Mine site and Hydrometallurgical Plant site;
- Decommissioning and reclamation of all waste management facilities;
- Reclamation of the waste rock management area;
- Reclamation of the access and haul roads at the Nechalacho Mine site and Hydrometallurgical Plant site, including the airstrip at the Nechalacho Mine site;
- Reclamation of infrastructure foundations, piping, and all built structures at the Nechalacho Mine site and Hydrometallurgical Plant site;

- Reclamation of any stockpiles and materials storage locations;
- Re-vegetation of areas affected by mining, access road, Nechalacho Mine site airstrip or other support activities;
- Bulkhead installation and other capping of the underground works at the Nechalacho Mine site; and
- Long-term mine water outflow monitoring and water management around the mine site.

6.1.2 Valued Components

Representative valued components (VCs) were selected, in part, using information provided in the Terms of Reference (MVEIRB 2011), feedback received during the public consultation process and scoping sessions, knowledge and understanding of the biophysical and social aspects of the area, and applicable scientific principles.

Potential VCs were initially identified by considering the following:

- Species currently listed under *SARA*, assessed under COSEWIC, or ranked under the NWT *Wildlife Act* or the newly proposed *Species at Risk (NWT) Act*;
- Species or species groups considered of cultural importance (e.g., traditional use plants);
- Species or species groups considered to be particularly sensitive to disturbance; and
- Species or species groups dependent upon particular environmental features (e.g., specific ecosystem types)

Specific environmental VCs considered in the evaluation of potential Project effects are provided in Table 6.1-1. Socio-economic VCs that were assessed are summarized in Section 7.0, Human Environment Assessment.

TABLE 6.1-1: SELECTED ENVIRONMENTAL VALUED COMPONENTS

Valued Component	
Indicators of Air/Noise Quality	
Indicators of Surface/Groundwater Quality	
Fish and Fish Habitat (including Species at Risk)	
Indicators of Terrain and Permafrost Integrity	
Ecosystem and plant species including sensitive ecosystems, traditional use plants, and Species at Risk	
Wildlife Species at Risk and species of cultural importance including:	
-Barren-ground Caribou	-Short-eared Owl
-Woodland Caribou	-Common Nighthawk
-Moose	-Olive-sided Flycatcher
-Wood Bison	-Rusty Blackbird
-Black Bear	-Yellow rail
-Other furbearers (treated collectively)	-Horned Grebe
-Peregrine Falcon	-Whooping Crane

6.1.3 Assessment Boundaries

The assessment of potential effects associated with the TLP requires the identification of appropriate spatial and temporal boundaries (space and time limits of potential effects). As indicated by the MVEIRB (2011) the spatial and temporal boundaries for the TLP environmental assessment should be set according to appropriate boundaries for the VCs being assessed.

6.1.3.1 Spatial Boundaries

Local and regional spatial boundaries were identified for biophysical and socio-economic components based on their respective characteristics and anticipated interaction with Project activities. Spatial boundaries were based primarily on the Project footprint and a zone of influence beyond which effects are expected to be non-detectable. For the biophysical components, three main assessment areas were defined.

Local Study Area (LSA): The LSA at the Nechalacho Mine site encompasses the proposed Project footprint and areas extending up to 500 m away from the outer Project edges (Figure 6.1-1). The total LSA covers approximately 2,188 ha. At the Hydrometallurgical Plant site, the LSA covers approximately 8,434 ha and was also based on the anticipated configuration of Project infrastructure.

Regional Study Area (RSA): For most biophysical components, the RSA at the Nechalacho Mine site is approximately 45,319 ha in size, represented by a 15 km radius that extends out from the proposed Project footprint (Figure 6.1-1). This area covers all of Avalon's mineral leases and the expected home ranges of many wildlife species considered in the assessment of Project effects. Due to the pre-existing disturbance at the Hydrometallurgical Plant site, no RSA was defined for biophysical components, with the exception of air quality.

For the assessment of potential effects to air quality, a 20 km x 20 km area, centred on the ramp portal and process plant, was defined at both the Nechalacho Mine site and Hydrometallurgical Plant site, respectively (Figure 6.1-1).

Human Environment Study Area – As specified in the Terms of Reference (MVEIRB 2011), the geographic scope for assessing potential effects to the human environment has included the communities of Yellowknife and N'Dilo, Dettah, Lutse K'e, Fort Resolution, Hay River, Hay River Reserve, and Fort Smith. Additionally, members of the Akaitcho and Métis cultural communities who may use the assessment area have also been included.

6.1.3.2 Temporal Boundaries

The MVEIRB (2011) determined that the temporal scope of Project-specific effects should reflect the construction, operations, and closure phases, as well as any longer-term effects that may persist beyond closure. For the purposes of this assessment, the temporal boundaries have been limited to the initial 20-year projected mine life, a subsequent closure period of two years, and five years of post-closure monitoring. These time periods are also represented, in part, by the "Duration" attribute in Table 6.1-2.

6.1.4 Effects Assessment

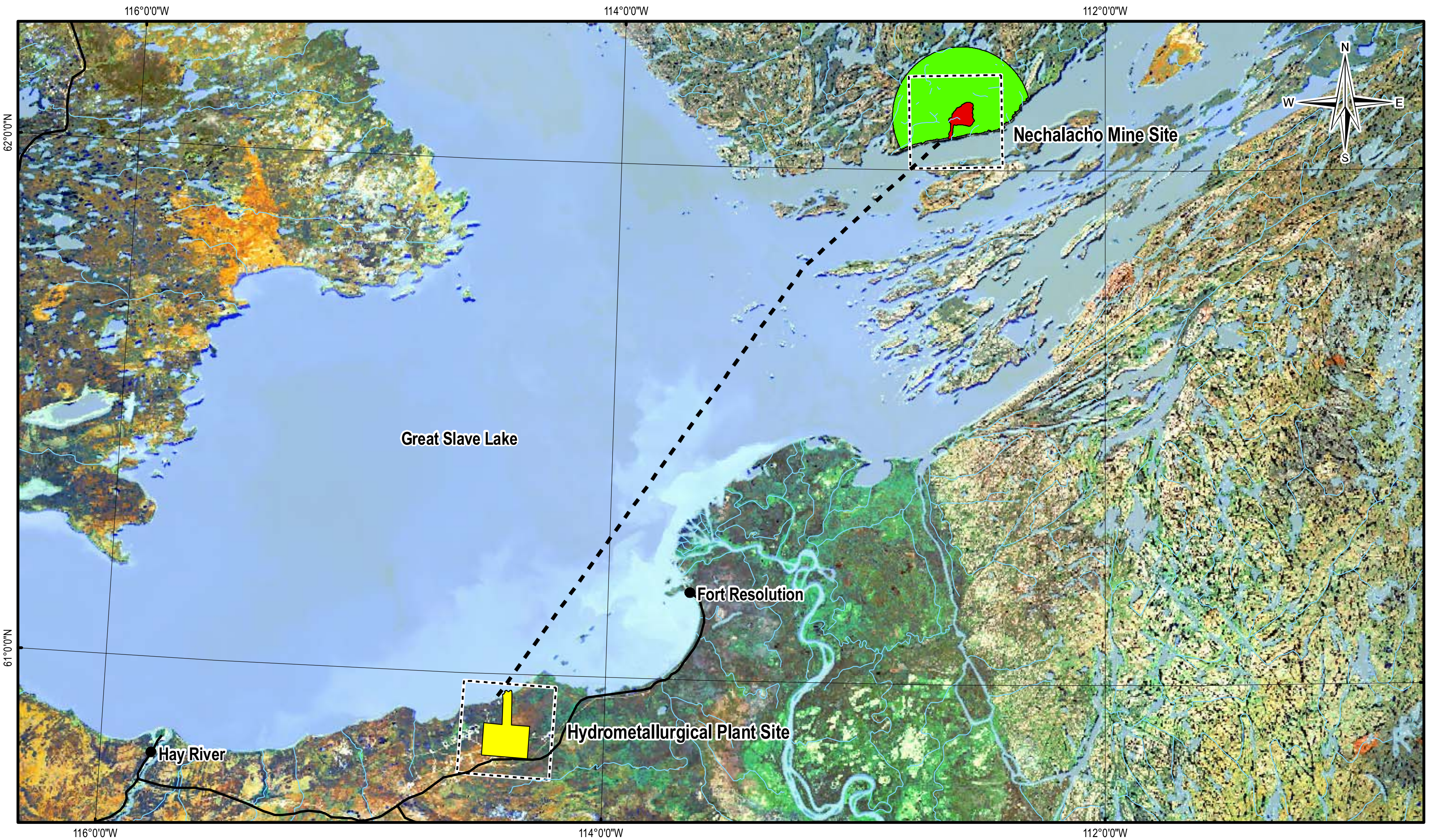
The full assessment of anticipated Project effects can be broken down into specific steps. The first is the identification and description of potential effects, using VCs as the primary focus. Wherever possible, the assessment of effects is quantitative, and incorporates data collected during baseline studies, previous studies relevant to the area, scientific literature, government publications, and other applicable effects assessments. Traditional Knowledge and community information is also incorporated wherever possible and available.

The description of potential effects then provides the basis for the application of mitigation and management strategies which serve to reduce the extent, severity, or likely occurrence of adverse effects, and to enhance positive effects.

6.1.4.1 Assessment of Residual Effects

Effects that remain after mitigation measures have been applied (termed residual effects) are evaluated further for their environmental consequence and overall significance. If no residual effects were predicted to occur, no further evaluation of the effect was carried out. In cases such these, the rationale as to why no residual effects were anticipated were clearly presented. The assessment criteria and definitions used to evaluate residual effects are presented in Table 6.1-2.

Q:\Vancouver\GIS\ENGINEERING\V151\V15101007_ThorLake\Maps\006_DAR\V15101007_DAR_Map048_TLP.mxd



LEGEND

- Air Quality Study Area
- Nechalacho Mine Site LSA
- Nechalacho Mine Site RSA
- Hydrometallurgical LSA
- Community
- All-Weather Road
- Approximate Barging Route
- Watercourse
- Waterbody

NOTES
Base data source: ESRI Data Maps

ISSUED FOR USE

Scale: 1:1,200,000
20 10 0 20
Kilometres

PROJECTION	DATUM
NWT Lambert	NAD83

FILE NO.
V15101007_DAR_Map048_TLP.mxd

AVALON RARE METALS INC. EBA Engineering Consultants Ltd. eba

THOR LAKE PROJECT

TLP Spatial Boundaries

PROJECT NO.	DWN	CKD	REV
V15101007.006	SL	TP	0

OFFICE	DATE
EBA-VANC	April 5, 2011

Figure 6.1-1

TABLE 6.1-2: RESIDUAL EFFECTS ASSESSMENT AND CONSEQUENCE CRITERIA

Criterion	Descriptor	Definition
Magnitude	Negligible	Effect will produce no detectable change from baseline conditions
	Low:	Effect is within the range of baseline conditions or natural variation
	Moderate:	Effect is at or slightly exceeds baseline conditions or the limits of natural variation
	High:	Effect will produce a notable change beyond baseline conditions or the upper or lower limit of natural variation
Geographic Extent	Local	Effect is confined to the LSA
	Regional	Effect is confined to the RSA
	Beyond Regional	Effect extends beyond the RSA
Duration	Short-term	Effect occurs or lasts for short periods of time – hours, weeks, months
	Medium-term	Effect occurs or lasts for the life of the Project
	Long-term	Effect extends or lasts beyond the life of the Project
Frequency	Isolated	Effect is confined to a discrete or specific period of time
	Sporadic	Effect occurs on occasion and at irregular intervals
	Periodic	Effect occurs intermittently but repeatedly during the life of the Project
	Continuous	Effect will occur continually during the life of the Project
Reversibility	Reversible Short-term	Effect can be reversed during the life of the Project
	Reversible Long-term	Effect can be reversed within 100 years
	Irreversible	Effect cannot be reversed
Likelihood	Low	Effect is unlikely but could occur
	Moderate	Effect is likely but may not occur
	High	Effect will occur
Consequence	Negligible	Effect may result in a slight decline in condition of the VC in the study area for a very short duration but the VC should return to baseline conditions
	Low	Effect may result in a slight decline in condition of the VC in the study area during the life of the Project. but the VC should return to baseline conditions.
	Moderate	Effect could result in a noticeable but stable change in the condition of the VC compared to baseline conditions which persists in the study area after Project closure and into the foreseeable future. **OR** Effect could result in a noticeable change in the condition of the VC in that established guidelines or thresholds are exceeded but the VC should return to baseline conditions.
	High	Effect results in notable changes to the condition of the VC.

6.1.4.2 Evaluation of Consequence

To determine the level of consequence associated with a residual effect, the magnitude, duration, and location of the effect were used as primary considerations. Negligible consequences result from low magnitude and short duration events, while low consequences result from moderate or high magnitude and medium or long-term duration events. Moderate consequences, the highest rating possible within the LSA, result from events that are of low to high magnitude and of medium-term to irreversible duration.

In the RSA, the highest consequence rating is high. Negligible consequences result from low magnitude and short duration events; whereas high consequences result from events that are of moderate to high magnitude and of long-term to irreversible duration.

Consequence ratings for residual effects evaluated within the LSA and RSA are depicted using the schematics below (Table 6.1-3). The "X" identifies the level of consequence according to the criteria presented in Table 6.1-2. Magnitude levels are described as L (low), M (medium) and H (high), while the duration is described as S (short-term), M (medium-term), L (long-term), and I (irreversible).

TABLE 6.1-3: SAMPLE RESIDUAL EFFECTS ASSESSMENT TABLE

Evaluation of Residual Effects in the Local Study Area

Description of Residual Effect (after Mitigation)	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Consequence
Example residual effect	Low	Local	Short-term	Isolated	Reversible Short-term	Moderate	(see matrix below)

Consequence (Local Study Area)

Magnitude	S	M	L	I
H				
M				
L	X			
	Duration			

Evaluation of Residual Effects in the Regional Study Area

Description of Residual Effect (after Mitigation)	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Consequence
Example residual effect	Low	Regional	Short-term	Isolated	Reversible Short-term	Moderate	(see matrix below)

Consequence (Regional Study Area)

Magnitude	S	M	L	I
H				
M				
L	X			
	Duration			

6.1.4.3 Evaluation of Significance

Significance determination of residual effects has relied, in part, on ecological principles, identified environmental consequences, ecological context, likelihood of the residual effect occurring, and best professional judgement. For each residual effect, the level of significance was evaluated according to the expected change in overall condition of the VC being assessed. When evaluating significance the precautionary principle was adhered to, such that where there was uncertainty about how a VC would be affected, the final evaluation was based on the greater of the possible effects.

6.2 AIR QUALITY AND NOISE

The MVEIRB Terms of Reference (MVEIRB 2011) directed Avalon to evaluate the development's potential impacts on air quality due to Project emissions. RWDI Consulting Engineers and Scientists (RWDI) were retained to conduct the necessary quality assessment for the Thor Lake Project. The following sections draw heavily on the RWDI (2011) report, which is provided in its entirety as Appendix J to the DAR.

6.2.1 Greenhouse Gas Emissions

There are no standards for GHG emissions and therefore Project GHG emissions are typically assessed by comparison with territorial and national totals as well as emissions from other, similar projects. Environment Canada's National Inventory Report (Environment Canada 2010c) provides an estimate of Canada's GHG releases to the environment on an annual basis. In 2008, Canadians contributed about 734 Mt of GHGs while Northwest Territories and Nunavut contributed 1.81 Mt.

Environment Canada has a GHG emissions reporting program: if a facility emits more than 50 kt of CO2 equivalent (reporting threshold), the facility has to report its GHG emissions in accordance with the requirements under the Canadian Environmental Protection Act, 1999.

Greenhouse gases are generally aggregated into "CO_2 equivalents" (CO_2E). The equivalence factor has generally been agreed to be the relative global warming potentials (GWP) of the gas as estimated by the Intergovernmental Panel on Climate Change (IPCC), the major international science body that is co-ordinating research on the climate change issue. The IPCC estimates GWPs for a number of GHGs for various time periods related to the effect of a quantity of the gas released on future atmospheric temperature rise. These numbers vary widely from gas to gas, and they also vary from time period to time periods for a given gas, depending on physical and chemical properties. The 100-year GWPs are generally used. The most recent estimates of 100-year GWPs used by Environment Canada are sanctioned by the IPCC and are shown in Table 6.2-1.

TABLE 6.2-1: GLOBAL WARMING POTENTIALS			
	CO_2	CH_4	N_2O
Global Warming Potential	1	21	310

These numbers mean, for example, that one kilogram of N_2O has 310 times the global warming effect of a kilogram of CO_2 over a period of 100 years from the year of release.

For the Thor Lake Project, GHGs are expected to be emitted from six main sources: underground and surface equipment, mine air heater, diesel generators, ANFO explosives, acid bake kiln, and sulphuric acid plant.

The GHG emissions for underground and surface equipment were estimated using emission factors from Environment Canada (2010c) based on the expected fuel consumption. It was indicated by Avalon that underground equipment will consume 1,800,000 L/yr of diesel while surface equipment will consume 200,000 L/yr of diesel. The annual GHG emissions from underground and surface equipment are presented in Table 6.2-2.

TABLE 6.2-2: ANNUAL GHG EMISSIONS FROM UNDERGROUND AND SURFACE EQUIPMENT				
	CO_2	CH_4	N_2O	CO_2E
Underground Equipment	4,793	0.2	0.7	5,022
Surface Equipment	533	<0.1	0.1	558
Total Equipment	5,326	0.3	0.8	5,580

The mine air heater for the Nechalacho Mine is expected to have a fuel consumption of 969 L/hr (ACI-CANEFCO, personal communication, 2011) and will operate for approximately 4,516 hr/yr. GHG emissions from the mine air heater, shown in Table 6.2-3, were estimated using emission factors obtained from Environment Canada (2010c).

TABLE 6.2-3: ANNUAL GHG EMISSIONS FROM MINE AIR HEATER				
	Emissions (t/y)			
	CO_2	CH_4	N_2O	CO_2E
Mine Air Heater	11,653	0.6	2	12,208

CO_2 emissions associated with the diesel generators were estimated in accordance with the US EPA NONROAD2005 model. Emissions of CH_4 and N_2O were estimated by scaling the CO_2 emissions based on Environment Canada emission factors for non-road diesel. The GHG emissions associated with diesel generators are shown in Table 6.2-4.

TABLE 6.2-4: ANNUAL GHG EMISSIONS FROM DIESEL GENERATORS				
	Emissions (t/y)			
	CO_2	CH_4	N_2O	CO_2E
Diesel Generators	27,152	2	11	30,661

The underground mining operation will use approximately 292 tpa of ANFO explosives. Explosives are identified as one of the common sources of GHG emissions in the mining sector (Mining Association of Canada 2009). The Energy and GHG Emissions Management Guidance Document of the Mining Association of Canada indicates that 0.189 tonne of CO_2 is emitted for each tonne of ANFO explosives used. With 292 tpa of ANFO explosive used, approximately 55 tpa of CO_2 will be emitted.

GHG emissions from the sulphuric acid plant at the Hydrometallurgical Plant were estimated following the methodology described in US EPA AP-42 Section 8.10. For a typical double absorption plant, 4.05 kg of CO_2 is emitted for each tonne of sulphuric acid produced. It was estimated that 1,013 tpa of CO_2 will be emitted for the Hydrometallurgical Plant production rate of 78,840 tpa of sulphuric acid.

It was estimated by Avalon that the acid bake kiln at the Hydrometallurgical Plant will emit approximately 11,000 tpa of CO_2 in the acid leach/bake system.

The total estimated annual GHG emissions from the Thor Lake Project are summarized in Table 6.2-5. The Project is expected to emit 60.5 kt/y of CO_2 E or 0.06 Mt/yr during normal operations. As would be expected, the diesel generators are expected to be the largest source, contributing approximately half of total Project-related GHG emissions.

TABLE 6.2-5: SUMMARY OF THOR LAKE PROJECT ANNUAL GHG EMISSIONS				
	Emissions (t/y)			
	CO_2	CH_4	N_2O	CO_2E
Underground Equipment	4,793	0.2	0.7	5,022
Surface Equipment	533	<0.1	0.1	558
Mine Air Heater	11,653	0.6	2	12,208
Diesel Generators	27,152	2	11	30,661
ANFO Explosive	55	-	-	-
Subtotal - Mine	**44,187**	**2**	**14**	**48,504**
Sulphuric Acid Plant	1,013	-	-	1,013
Acid Bake Kiln	11,000	-	-	11,000
Subtotal – Hydrometallurgical Plant	**12,013**	**-**	**-**	**12,013**
Total	**56,199**	**2**	**14**	**60,516**

Total Project-related emissions could represent a 0.08% increase compared to the estimated Canadian total emissions in 2008 and a 3% increase compared to Northwest Territories and

Nunavut's total reported GHG emissions in 2008. The expected GHG emissions during operation are greater than the Environment Canada reporting threshold of 50,000 tonnes.

Greenhouse gas emissions from other mining projects in the NWT, including the three diamond mines, the proposed Tamerlane Pilot Project and the Thor Lake Project components are presented in Table 6.2-6.

Total Project GHG emissions during operations are roughly equivalent to total GHG emissions from Snap Lake Mine (63 kt/y) and less than half the GHG emissions from Diavik Diamond Mine (159 kt/y) and Ekati Diamond Mine (210 kt/y). Project GHG emissions during operations are expected to be an order of magnitude greater than GHG emissions from the Pine Point Pilot Project; however, this is likely because the latter is a pilot project.

TABLE 6.2-6: ANNUAL GHG EMISSIONS SUMMARY FOR MINING PROJECTS IN THE NORTHWEST TERRITORIES

Project	Total Annual GHG Emissions ($kt\ CO_2\ E$)	Year and Comments
Pine Point Pilot Project[1]	6	2008 estimate
Snap Lake Mine[2]	63	2008 actual
Diavik Diamond Mine[3]	159	2006 actual
Ekati Diamond Mine[4]	210	2006 actual
Thor Lake Project	60.5	2011 estimate

Sources: 1: RWDI (2008); 2. De Beers Canada (2008); 3. Diavik (2007); 4. BHP Billiton (2007)

As discussed, the Thor Lake Project operations will result in an increase in territorial and national GHG emissions. Greenhouse gas emissions are a contributor to global climate change and therefore the spatial extent is global. GHGs have a long atmospheric lifetime that will extend beyond the life of the Project and therefore the duration is rated long term. Emissions will occur continuously for the life of the Project. The lifetime of GHGs is long but finite and therefore the potential effect of GHGs is reversible.

Since the estimated GHG emissions associated with the Thor Lake Project represent approximately 3% of GHG emissions in the Northwest Territories and less than 0.01% of the total GHG emissions in Canada, the magnitude of emission is rated medium. Since GHGs will be emitted during the operation of the mine, the probability of occurrence is high. The level of confidence is rated moderate because emissions were estimated using a top-down approach based on total fuel consumption and emission factors from Environment Canada. Since the magnitude is medium and the effect is reversible, the potential residual effect of Project GHG emissions is considered not significant.

6.2.2 Air Quality

6.2.2.1 Scope of Air Quality Assessment

The scope of RWDI's air quality assessment of the Thor Lake Project was defined by the MVEIRB Terms of Reference in combination with discussions with Avalon.

The Thor Lake Project will be a source of criteria air contaminants (CACs) from mining equipment, generators, vehicles, barges, and aircraft. It will be a source of fugitive dust emissions from crushing, processing and handling the ore. There will also be process CAC emissions from the sulphuric acid plant, acid bake kiln and product dryer associated with the Hydrometallurgical Plant.

CACs are the measureable parameters of this assessment and the measurement endpoints are ambient concentrations or deposition levels of CACs.

The specific CACs included in the scope of this assessment are:

- nitrogen dioxide (NO_2);
- sulphur dioxide (SO_2);
- carbon monoxide (CO);
- total particulate matter (TSP);
- particulate matter with diameter less than 2.5 μm ($PM_{2.5}$); and,
- dustfall.

The specific GHGs included in the scope of this assessment are:

- carbon dioxide (CO_2);
- methane (CH_4); and,
- nitrous oxide (N_2O).

Increases in ambient concentrations of CACs are of concern due to their potential to affect human and wildlife health whereas increases in deposition levels of particulate matter can affect vegetation and water quality.

Oxides of nitrogen (NO_x) are produced when fossil fuels are burned at high temperatures and are composed primarily of nitric oxide (NO) and NO_2. In humans, NO_2 acts as an irritant affecting the mucous membranes of the eyes, nose, throat, and respiratory tract. Continued exposure to NO_2 can irritate the lungs and lower resistance to respiratory infection, especially for people with pre-existing asthma and bronchitis. For this reason, ambient air quality standards are based on NO_2, not NO or NO_x. Nitrogen dioxide can combine with other air contaminants to form fine particulates, which can reduce visibility. It can be further oxidized to form nitric acid, a component of acid rain. Nitrogen dioxide also plays a major role in the secondary formation of ozone.

Sulphur dioxide is produced primarily by the combustion of fossil fuels containing sulphur. Sulphur dioxide reacts in the atmosphere to form sulphuric acid, a major contributor to acid rain, and particulate sulphates, which can reduce visibility. Sulphur dioxide is irritating to the lungs and is frequently described as smelling of burning sulphur.

Carbon monoxide is produced by incomplete combustion of fossil fuels. It is the most widely distributed and commonly occurring air pollutant and comes primarily from motor vehicle emissions. Space heating and commercial and industrial operations are also contributors. Short-term health effects related to CO exposure include headache, dizziness, light-headedness and fainting. Exposure to high CO concentrations can decrease the ability of the blood to carry oxygen and can lead to respiratory failure and death.

Particulate matter is often defined in terms of size fractions. Dustfall refers to the amount of particulate matter of all size classes that settles onto a collection surface in a given amount of time. It is a measure of the amount of particulate present in the ambient air that is deposited on the ground. Particles less than 40 μm in diameter typically remain suspended in the air for some time. This is referred to as total suspended particulate (TSP). Suspended particulate matter less than 2.5 μm in diameter is termed $PM_{2.5}$. Exposure to particulate matter aggravates a number of respiratory illnesses and may even cause premature death in people with existing heart and lung disease. The smaller particles ($PM_{2.5}$) are generally thought to be of greater concern to human health than the larger particles (TSP).

6.2.2.2 Air Quality Assessment Endpoints

The assessment endpoints for CACs are ambient air quality standards. Air quality standards are developed by environmental and health authorities to provide guidance for environmental protection decisions. They are based on scientific studies that consider the effects of the contaminant on such receptors as humans, wildlife, vegetation, as well as aesthetic qualities such as visibility. The Government of the Northwest Territories (GNWT) Environmental Protection Act has ambient air quality standards for NO_2, SO_2, CO, TSP and $PM_{2.5}$ (Table 6.2-7).

There are no air quality standards for dustfall in the NWT but there are objectives for dustfall in other jurisdictions such as British Columbia, Alberta and Ontario. Table 6.2-8 shows the dustfall objectives in these jurisdictions to provide context for dustfall predictions in this air quality assessment.

TABLE 6.2-7: NWT AMBIENT AIR QUALITY STANDARDS FOR CRITERIA AIR CONTAMINANTS

Contaminant	Averaging Period	NWT Standards (μg/m^3)
NO_2	1-hour	400
	24-hour	200
	Annual	60
SO_2	1-hour	450
	24-hour	150
	Annual	30

TABLE 6.2-7: NWT AMBIENT AIR QUALITY STANDARDS FOR CRITERIA AIR CONTAMINANTS		
Contaminant	**Averaging Period**	**NWT Standards ($\mu g/m^3$)**
CO	1-hour	15,000
	8-hour	6,000
TSP	24-hour	120
	Annual	60
$PM_{2.5}$	24-hour	30

TABLE 6.2-8: EXISTING DUSTFALL CRITERIA		
Jurisdiction	**Criteria**	**Notes**
BC	52.5 mg/dm²/30 day	In residential areas (Equivalent to 1.75 mg/dm²/day)
	87 mg/dm²/30 day	In all other areas (Equivalent to 2.9 mg/dm²/day)
Alberta	53 mg/dm²/30 day	In residential and recreation areas
	158 mg/dm²/30 day	In commercial and industrial areas
Ontario	0.08 mg/ dm²	½-hour Point-of-impingement
	46 mg/ dm² (annual) + 70 mg/ dm² (30-day)	

6.2.2.3 Air Quality Modelling Approach

The air quality effects assessment focused on the Thor Lake Project operations since the majority of emissions will occur during this phase and therefore it could be used to bound the overall effects assessment, i.e., if the potential effect of emissions during operations was found to be not significant then the potential effect of construction and closure emissions, which are expected to be of lower magnitude and shorter duration, would also be not significant. Thus, the operation phase was assessed quantitatively, while construction and closure were assessed qualitatively.

The quantitative assessment of emissions during operations consisted of four steps:

1. Use professional judgment to rank sources as being either major or minor.
2. Estimate emissions and other stack parameters for major sources of emissions. In general, CACs were estimated using a bottom-up approach.
3. Predict ground-level concentrations of CACs in the two LSAs using a dispersion model.
4. Compare ground-level concentrations of CACs to GNWT air quality standards.

Ranking of Emission Sources

For the estimation of CAC emissions using a bottom-up approach, sources were ranked as being either major, moderate or minor sources of emissions using professional judgment based on previous experience with similar projects. Those sources considered to be major or moderate were assessed quantitatively, whereas minor sources were assessed qualitatively.

Using this approach, the emission sources identified at the Nechalacho Mine and Flotation Plant and the Hydrometallurgical are listed and ranked in Tables 6.2-9 and 6.2-10, respectively. Justifications for the rankings are also provided in the tables.

TABLE 6.2-9: EMISSION SOURCES AT THE NECHALACHO MINE AND FLOTATION PLANT

Source	Type of Emissions	Rank	Comments
Underground mining activities and processing	CACs and GHGs	Major	CAC, GHG and fugitive dust emissions from all mining and crushing activities will be concentrated through two ventilation raises
Exhaust from mine air heater stacks	CACs and GHGs	Major	Mine air heater will heat 300,000 cfm when the ambient temperature is less than 0°C
Exhaust from diesel generator stacks	CACs and GHGs	Major	Six diesel generators will be used to supply all power to the mine and flotation plant
Surface equipment	GHGs	Major	Fuel combustion in equipment is a large source of GHGs
Transfer and handling of ore	CACs	Moderate	Ore transfer and handling is a moderate source of PM emissions
ANFO explosives	GHGs	Moderate	ANFO explosives are a moderate source of CO_2 emissions
Fuel combustion in vehicles	CACs and GHGs	Minor	Not a continuous source so CACs not modelled but GHG emissions estimated
Fugitive dust emissions from haul truck/roads	Fugitive dust	Minor	Fugitive dust emissions from trucks will be short-term and localized.
Waste incineration	CACs	Minor	Waste incineration is a batch process that will occur only once a day.
Fuel combustion in aircraft	CACs and GHGs	Minor	Limited effect on ground-level ambient concentrations with infrequent operating hours
Fuel combustion in tugs used to tow barges	CACs and GHGs	Minor	Operates only in the summer

TABLE 6.2-10: EMISSION SOURCES AT THE PINE POINT HYDROMETALLURGICAL PLANT			
Source	**Type of Emissions**	**Rank**	**Comments**
Sulphuric acid plant	CACs and GHGs	Major	Large source of SO2
Acid bake kiln	GHGs	Major	Large source of CO2
Product dryers	CACs	Minor	Product dryers will be equipped with sufficient dust collection to ensure ambient air quality standards are met
Backup diesel generators	CACs and GHGS	Minor	Backup power for emergencies only
Limestone stockpile	Fugitive dust	Minor	Limestone will be slaked so fugitive emissions should be negligible

Emission Estimation

The emissions associated with the Thor Lake Project were estimated using a systematic approach. Since the Project has not yet been constructed, there are no direct measures of emissions. Manufacturers' specifications were used for emission estimation when available. Otherwise, industry-specific emission factors were used to calculate emission rates. An emission factor is a representative value that relates the quantity of a contaminant released into the atmosphere to an activity associated with the release of that contaminant. In most cases, emission factors from the United States Environmental Protection Agency's (US EPA) compilation of Air Pollutant Emission Factors, known as AP-42, were employed.

To estimate emissions from the underground mine ventilation stacks, it was assumed that the quality of the ambient air underground will be maintained to meet the Mine Health and Safety Standards in NWT. The Mine Health and Safety Regulations R-125-95 for NWT states that threshold limit values (TLV) set out in the handbook Threshold Limit Values for Chemical Substances and Physical Agents issued by American Conference of Governmental Industrial Hygienists (ACGIH) are to be followed (ACGIH 1997).

ACGIH is a professional organization of industrial hygienists and practitioners of related professions. Since the ambient air underground will meet standards outlined in the Mine Health and Safety Regulations, emission rates through the ventilation raises were conservatively estimated using the design air flow rate and the appropriate TLVs. ACGIH standards were obtained for NO_2, SO_2, CO and TSP. The US EPA NONROAD2005 model was used to estimate emissions from the diesel generators.

Dispersion Modelling

Dispersion modelling was conducted using the US EPA CALPUFF dispersion model. CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model. It simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and deposition. CALPUFF can use three-dimensional meteorological fields developed by the CALMET model or simple, single-station winds in a format consistent with the meteorological files used to drive the ISCST3 steady-state Gaussian model. For this assessment, insufficient meteorological information was available to initialize the CALMET model and therefore CALPUFF was driven using meteorology from a single nearby meteorological station (e.g., Yellowknife, Hay River).

Since the GNWT does not have dispersion model guidelines, CALPUFF modelling for the Thor Lake Project components was performed in accordance with the Guidelines for Air Quality Dispersion Modelling in BC. Table 6.2-11 summarizes the CALPUFF model switch settings that were used. Table 6.2-12 summarizes the emissions source types and whether constant or variable emission profiles were used.

NOX emissions are comprised of NO_2 and NO. The primary emission is in the form of NO with reactions in the stack and atmosphere resulting in the conversion of NO to NO_2. However, ambient standards are for NO_2 not NO_x or NO_2 and therefore the conversion of NO_x to NO_2 must be determined. For this study, it was conservatively assumed that all NO_X would be converted to NO_2.

TABLE 6.2-11: CALPUFF MODEL SWITCH SETTINGS

Parameter	Default	Project	Comments
MGAUSS	1	1	Gaussian distribution used in near field
MCTADJ	3	3	Partial plume path terrain adjustment
MCTSG	0	0	Scale-scale complex terrain not modelled
MSLUG	0	0	Near-field puffs not modelled as elongated
MTRANS	1	0	Transitional plume rise modelled
MTIP	1	1	Stack tip downwash used
MBDW	2	1	ISC type building downwash used
MSHEAR	0	0	Vertical wind shear not modelled
MSPLIT	0	0	Puffs are not split
MCHEM	1	0	Chemical transformation not modelled
MAQCHEM	0	0	Aqueous phase transformation not modelled
MWET	1	0	Wet removal modelled for fugitive dust sources
MDRY	1	0 or 1	Dry deposition modelled for fugitive dust sources
MDISP	2 or 3	2	Near-field dispersion coefficients internally calculated from sigma-v, sigma-w using micrometeorological variables
MTURBVW	3	3	This variable is not used for MDISP = 2
MDISP2	3	2	This variable is not used for MDISP = 2
MROUGH	0	0	PG □y and □z not adjusted for roughness
MPARTL	1	0	No partial plume penetration of elevated inversion
MTINV	0	0	Strength of temperature inversion computed from default gradients
MPDF	0	1	PDF used for dispersion under convective conditions as recommended for MDISP = 2
MSGTIBL	0	0	Sub-grid TIBL module not used for shoreline
MBCON	0	0	Boundary concentration conditions not modelled
MFOG	0	0	Do not configure for FOG model output
MREG	1	0	Do not test options specified to see if they conform to regulatory values

TABLE 6.2-12: CALPUFF EMISSION SOURCE TYPES			
Emission Sources		CALPUFF Source Type (Point, Area or Volume)	Nature of Emissions (Constant or Variable)
Nechalacho Mine and Flotation Plant	Ventilation Raises	Point	Constant
	Mine Air Heater	Point	Variable
	Diesel Generators	Point	Constant
	Transfer and Handling of Ore	Point	Constant
Hydrometallurgical Plant	Sulphuric Acid Plant	Point	Constant

6.2.2.4 Air Quality Effects Assessment

Construction

Equipment and vehicles used for site preparation, access road development and construction of the Thor Lake Project facilities and associated infrastructure will emit CACs. These activities will also be sources of fugitive dust. A small ROM stockpile that will be developed on the surface during the construction phase before the flotation plant is commissioned will also be a short-term source of fugitive dust. Based on previous experience and professional judgment, it is expected that Project construction emissions will be of smaller magnitude and shorter duration than emissions during operation.

Therefore, it is assumed that potential effects due to construction are bounded by the potential effects due to Project operations. Thus, residual effects due to construction emissions are assessed qualitatively in the residual effects assessment section (Section 6.2.5). Furthermore, emissions during Project construction will be managed using best practices outlined in the Air Quality and Dust Control Plan (Section 6.14).

Operations

As previously indicated, there are four main sources of CAC emissions at the Nechalacho Mine and Flotation Plant: underground mining activities, mine air heater, diesel generators, and transfer and handling of ore. The main source of CAC emissions at the Hydrometallurgical Plant is the sulphuric acid plant. There are no CAC emissions expected from the acid bake kiln since it is electric. Residual effects due to operations-related emissions are further assessed in the residual effects assessment section (Section 6.2.5).

Closure

The reclamation of the two Thor Lake Project sites will include site decommissioning activities such as the removal of facilities. Equipment and vehicles used for site decommissioning will emit CACs and GHGs; however, these emissions will be of smaller magnitude and shorter duration than emissions during operations. Therefore, it is assumed that potential effects due to closure are bounded by the potential effects due to Project operations. Thus, residual effects due to emissions of CACs and GHGs during the closure phase are assessed qualitatively in Section 6.2.5. In addition, emissions during Project closure will be managed using best practices outlined in the Air Quality and Dust Control Plan (Section 6.14)

6.2.2.5 Nechalacho Mine and Flotation Plant Site

The LSA for the Nechalacho Mine and Flotation Plant is a 20 km by 20 km area centred on the ramp portal of the underground mine. For the assessment, one year of site-specific surface meteorological data were used (September 2009 to September 2010). Figure 6.2-1 shows the joint frequency distributions of wind direction and wind speed in a polar histogram format (i.e., a wind rose) based on the pre-processed meteorological data from Nechalacho Mine and Flotation Plant. The orientation of each bar indicates the direction from which the wind is blowing; with directions being shown for the 16 compass points. The length of each bar indicates the frequency of occurrence. The most frequent winds in this area are from the east.

Missing data from the Nechalacho Mine and Flotation Plant were filled by data obtained from the Yellowknife Airport meteorological station. Upper air data from Fort Smith were employed to determine mixing heights at both sites. These data were processed with CPrammet, the meteorological pre-processor for CALPUFF, to create an ISC-type meteorological file.

To assess the potential effect of emissions from a facility on ambient air quality, concentrations are predicted beyond the facility boundaries, where ambient air quality objectives apply. Within the facility boundaries, occupational health and safety guidelines apply; therefore, receptors inside the boundaries are excluded from the modelling. In this LSA, two areas were excluded. The area above the mine was excluded as no public access is expected. The other area is the flotation plant facility boundary. A Cartesian receptor grid was adopted with the following receptor spacing:

- 20-m spacing along the plant boundaries where no public access is expected;
- 50-m spacing for a 4.0 by 4.0 km area centred on the ramp portal;
- 250-m spacing for a 7.0 by 7.0 km area centred on the ramp portal;
- 500-m spacing for a 13 by 13 km area centred on the ramp portal; and,
- 1000-m spacing for the remainder of the 20 km by 20 km LSA.

In addition to the Cartesian grid described above, discrete receptors were defined at the trailer camp, tent camp, and employee facilities. The terrain elevations for these receptors were extracted from 1: 250,000 scale Canadian Digital Elevation Data. A map of the LSA for the Nechalacho Mine and Flotation Plant area with the receptors is shown in Figure 6.2-2.

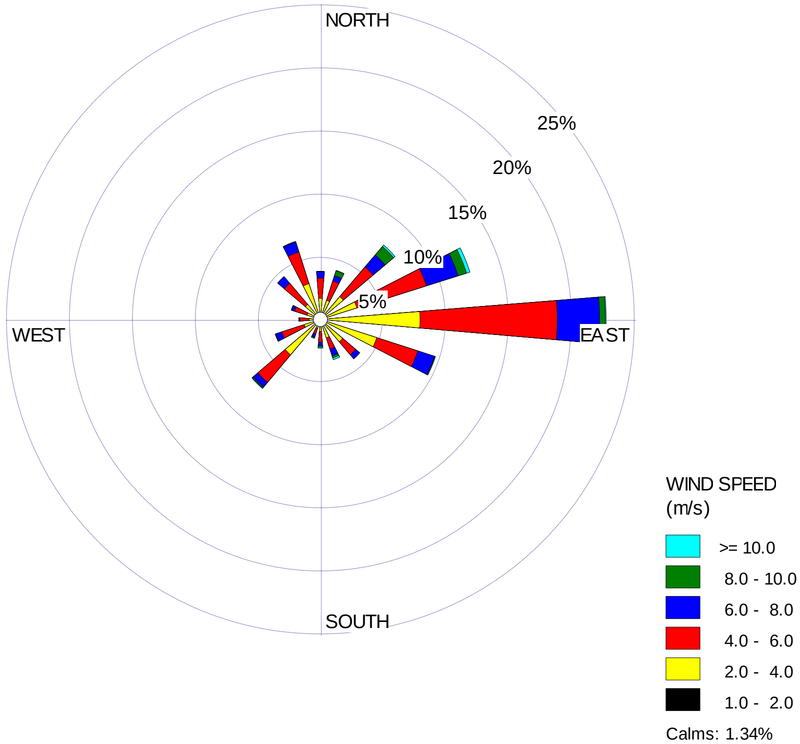


Figure 6.2-1
Joint Frequency Distribution of Wind Direction and Wind Speed Observed at the Nechalacho Mine and Flotation Plant from September 2009 to September 2010

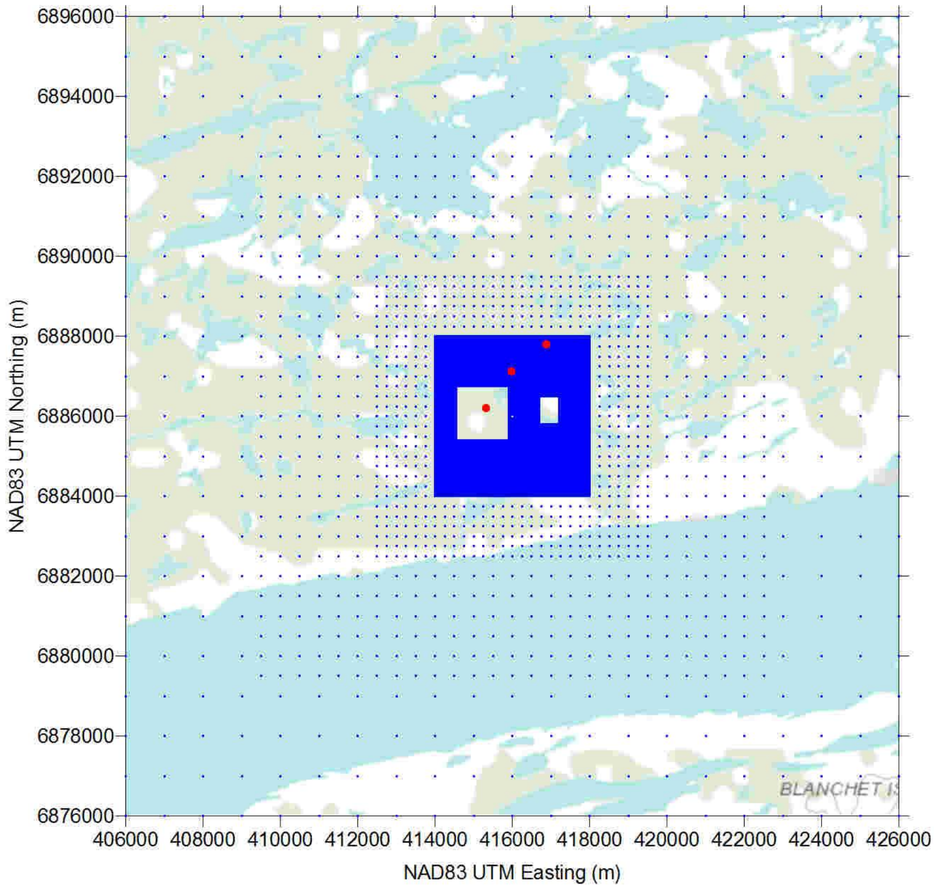


Figure 6.2-2
Nechalacho Mine Air Quality Local Study Area Showing Gridded Receptors (Blue Dots) and Discrete Receptors (Red Dots)

Sources of Emission

In this section, the main sources of CAC emissions at the Nechalacho Mine and Flotation Plant are assessed quantitatively by first estimating emission rates and then predicting ground-level concentrations that could result from those emissions using the CALPUFF dispersion model.

Ventilation Raises

There are two ventilation raises: the primary upcast is located at the ramp portal and the secondary upcast is located approximately 500 m west of the main ramp. The stack heights for both upcasts were assumed to be 1 m above ground. The primary upcast will have dimensions of 6 m x 5 m. The secondary upcast has a diameter of 3 m. The ventilation rate for the mine is expected to be 300,000 cfm. Sixty-seven percent (67%) of this air will be vented through the primary upcast (the mine portal) and 33% through the secondary upcast. The exit velocities were calculated based on the air flow and the cross-sectional area of the upcasts. Since the primary upcast will be at a 15% decline, only the vertical component of the exit velocity was included in momentum flux calculations in the modelling.

Emissions from the ventilation raises were estimated by assuming that the ACGIH standards for NO_2, SO_2, CO and TSP, shown in Table 6.2-13, would be met. $PM_{2.5}$ was assumed to be 7.5% of TSP according to Particulate Matter Speciation Profiles by California Emission Inventory and Reporting System (CEIDARS 2009) for mineral crushing and screening. The estimated emissions of the two ventilation upcasts are shown in Table 6.2-14.

TABLE 6.2-13: THRESHOLD LIMIT VALUES FOR MINE HEALTH AND SAFETY STANDARDS IN NWT

	NO_2	SO_2	CO	TSP	$PM_{2.5}$
ACGIH TLV (mg/m^3)	5.6	5.2	29	10	0.75

TABLE 6.2-14: ANNUAL CAC EMISSIONS FROM VENTILATION UPCASTS

	Air Flow Rate (cfm)	Emissions (t/y)				
		NO_2	SO_2	CO	TSP	$PM_{2.5}$
Primary ventilation upcast (ramp portal)	201,000	17	15	86	30	2
Secondary ventilation upcast	99,000	8	8	42	15	1
Total	**300,000**	**25**	**23**	**128**	**44**	**3**

Mine Air Heater

The mine air heater will only operate when the temperature is less than 0°C. According to the temperatures measured at the onsite meteorological station, there were 4,516 hours per year when the temperature is less than 0°C, mostly in the period from October to May. Emissions from the mine air heater were estimated using emission factors obtained from US EPA AP-42, based on a fuel consumption rate of 969 L/hr and a diesel heating value of 145,000 BTU/gal (ACI-CANEFCO, personal communications, 2011). Emissions of SO_2 were estimated using a 15 ppm sulphur content in diesel that came into effect in October 2010. The mine air heater annual emissions are presented in Table 6.2-15.

The diesel air heater was modelled using two stacks with a stack height of 7.5 m and a stack diameter of 0.6 m. The exit velocity was assumed to be 10 m/s and it was assumed that the heater only operates when the temperature is less than 0°C. Modelling of hourly-variable emissions depending on the ambient temperature was conducted using an external PTEMARB file.

TABLE 6.2-15: ANNUAL CAC EMISSIONS FROM MINE AIR HEATER

	NO_x	SO_2	CO	TSP	$PM_{2.5}$
Mine Air Heater	10	0.1	3	2	1

Diesel Generators

Six 1.45-MW CAT 3516 diesel generators are required to operate continuously to meet the power demand of 8.4 MW. Two additional diesel generators will be available for emergency standby. Since the standby diesel generators will not operate continuously, emissions associated with the standby generators were not assessed.

Emissions from the diesel generators were estimated using the US EPA NONROAD2005 model. A load factor of 43% was assumed, which is the US EPA's default load factor for diesel generators. The annual emissions from the diesel generators are shown in Table 6.2-16. The diesel generators were assumed to have a stack height of 20 m. The exit temperature of 404.3°C and exit velocity of 24.3 m/s were provided by Finning.

TABLE 6.2-16: ANNUAL CAC EMISSIONS FROM DIESEL GENERATORS

	Emissions (t/y)				
	NO_x	SO_2	CO	TSP	$PM_{2.5}$
Diesel Generators	123	0.2	4	4	3

Transfer and Handling

There are two transfer points of dry ore; the first one is mid-point along the ramp from the underground mine and the other one is inside the process plant. Since the first transfer is underground, it is included in the modelling of the ventilation raises. The second transfer point from the ramp conveyor to the mill feed conveyor located in the process plant was included in the modelling of the building ventilation stack of the flotation plant building. The building ventilation stack was assumed to be 10 m high with an exit velocity of 20 m/s. The ventilation flow rate through the stack is three building exchanges per hour and therefore the stack diameter was calculated to be 3.1 m. After this transfer point, all the processes will be wet, and emissions will be negligible. The emissions from the second transfer point from the ramp conveyor to the mill feed conveyor were estimated using emission factors from AP-42 Section 11.24. Emissions of PM2.5 were assumed to be 7.5% of TSP according to particle size distribution for rock screening and handling (CEIDARS, 2009). The annual emissions for transfer and handling are presented in Table 6.2-17.

TABLE 6.2-17: ANNUAL CAC EMISSIONS FROM TRANSFER AND HANDLING

	Emissions (t/y)				
	NO_x	SO_2	CO	TSP	$PM_{2.5}$
Transfer and handling	-	-	-	44	3

Summary of Emissions and Other Dispersion Model Inputs

Table 6.2-18 summarizes the total annual emissions for the Nechalacho Mine and Flotation Plant from the four main sources. Diesel generators are the largest source of NO_x emissions and ventilation raises are the largest sources of SO_2 and CO emissions.

Ventilation raises and the transfer and handling of dry ore are the largest sources of TSP and $PM_{2.5}$.

The hourly emission rates that were used as input to the dispersion modelling for the Nechalacho Mine and Flotation Plant are summarized in Table 6.2-19. The hourly emissions rates were calculated using design capacities (maximum obtainable output) when available. For the sources without maximum design capacities, annual production rates were converted to hourly emission rates based on operating 365 days per year. The stack parameters use in the modelling, including stack height, stack diameter, exhaust exit velocity and temperature, are summarized in Table 6.2-20.

TABLE 6.2-18: SUMMARY OF ANNUAL CAC EMISSIONS FOR NECHALACHO MINE

Source	Emissions (t/y)				
	NO_x	SO_2	CO	TSP	$PM_{2.5}$
Ventilation Raises	25	23	128	44	3
Mine Air Heater	10	0.1	3	2	1
Diesel Generator	123	0.2	4	4	3
Transfer and Handling	-	-	-	44	3
Total	**158**	**23**	**134**	**93**	**10**

TABLE 6.2-19: NECHALACHO MINE EMISSION RATES USED FOR DISPERSION MODELLING

Source	Emission Rate (g/s)				
	NO_2	SO_2	CO	TSP	$PM_{2.5}$
Primary Ventilation Upcast (ramp portal)	0.53	0.49	2.75	0.95	0.07
Secondary Ventilation Upcast	0.26	0.24	1.35	0.47	0.04
Mine Air Heater1	0.65	0.01	0.16	0.11	0.05
Diesel Generator	3.89	0.01	0.12	0.11	0.11
Transfer and Handling	-	-	-	1.67	0.13

Note: (1) Mine air heater emissions shown indicate emission rates while mine air heater is operating. Mine air heater will operate approximately 4516 h/y.

TABLE 6.2-20: STACK PARAMETERS USED FOR NECHALACHO MINE DISPERSION MODELLING

Source	Stack Height (m)	Stack Inner Diameter (m)	Stack Exit Temperature (°C)	Stack Exit Velocity (m/s)
Primary Ventilation Upcast (ramp portal)	1	6.2	0	0.5
Secondary Ventilation Upcast	1	3	0	6.6
Mine Air Heater	7.5	0.6	0	10
Diesel Generator1	20	0.4	404.3	24.3
Transfer and Handling	16.1	3.1	15	20

Note: (1) Stack parameters indicated for diesel generators are for one stack. There are six stacks for diesel generators.

Predicted Ambient CAC Concentrations and Dustfall Levels

The maximum ambient concentrations of CACs and dustfall levels predicted using the CALPUFF model are shown in Table 6.2-21 and Table 6.2-22, respectively. The maximum predicted CAC concentrations are less than the corresponding NWT Air Quality Standards for all contaminants. The maximum predicted 30-day and annual dustfall deposition levels for Nechalacho Mine and Flotation Plant are much less than the most stringent criteria. Maximum predicted concentrations at the existing trailer camp, tent camp and employee facilities were all less than the ambient AQ standards.

TABLE 6.2-21: MAXIMUM PREDICTED CAC CONCENTRATIONS FOR NECHALACHO MINE AND FLOTATION PLANT

Pollutant	Averaging Period	Maximum Concentration (µg/m³)	NWT AQ Standard (µg/m³)
NO_2	1-hour	185	400
	24-hour	134	200
	Annual	8	60
SO_2	1-hour	101	450
	24-hour	35	150
	Annual	2	30
CO	1-hour	561	15,000
	8-hour	350	6,000
TSP	24-hour	68	120
	Annual	4	60
$PM_{2.5}$	24-hour	10	30

TABLE 6.2-22: MAXIMUM PREDICTED DUSTFALL DEPOSITION LEVELS FOR NECHALACHO MINE AND FLOTATION PLANT

Dustfall	Averaging Period	Maximum Deposition Level (mg/dm²)	Most Stringent Criteria (mg/dm²)
	30	0.03	52.5
	Annual	0.009	46

The spatial distribution of maximum predicted concentrations and dustfall levels is presented in the form of isopleth maps. Since all predicted concentrations are less than the ambient objectives, only one plot is shown per contaminant for the shortest relevant averaging period.

The highest one-hour NO_2 concentration were predicted to occur immediately north of the employee facilities, power, dry, and maintenance/administration buildings, at the ramp portal, and approximately 1 km north-northeast of the power generation building (Figure 6.2-3).

The highest one-hour SO_2 (Figure 6.2-4), one-hour CO (Figure 6.2-5) and 24-hour TSP (Figure 6.2-6) concentrations, were predicted to occur immediately east of the mine ramp portal.

The highest 24-hour $PM_{2.5}$ concentrations were predicted to occur approximately 1 km north-northwest of the power generation building (Figure 6.2-7). The highest 30-day dustfall levels were predicted to occur west of all the flotation plant buildings at the fence line (Figure 6.2-8).

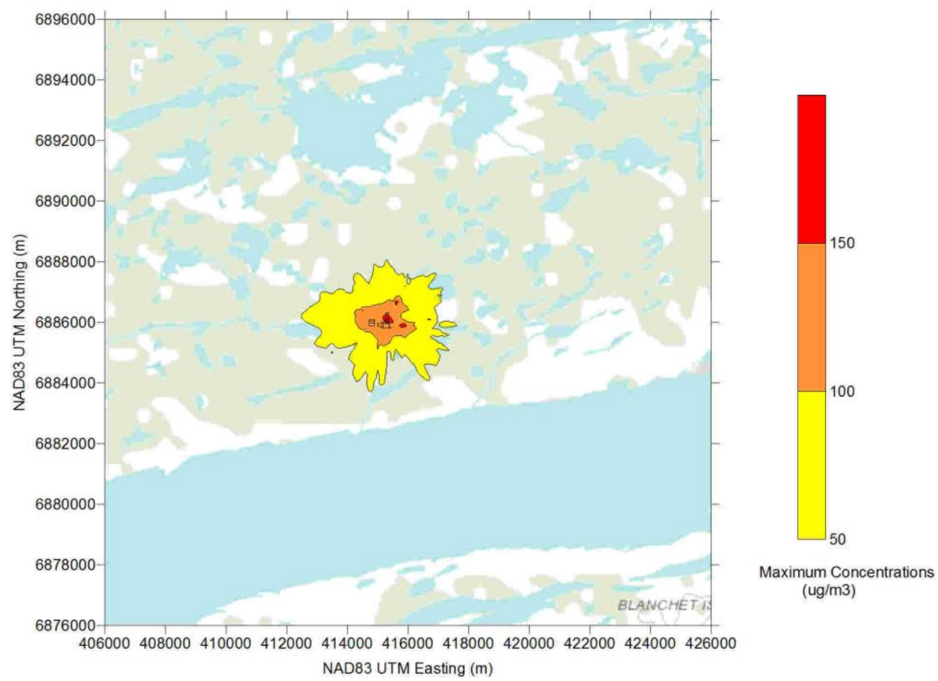


Figure 6.2-3
Isopleths of Maximum Predicted One-Hour Average NO_2 Concentrations