

Avalon Rare Metals Inc.

RESPONSE TO THE DEFICIENCY LIST FOR THE THOR LAKE RARE EARTH ELEMENT PROJECT DEVELOPER'S ASSESSMENT REPORT

PART 2

Submitted To: MACKENZIE VALLEY ENVIRONMENTAL IMPACT REVIEW BOARD

September 2011



Response to the Deficiency List for the Thor Lake Rare Earth Element Project Developer's Assessment Report

Part 2

Avalon Rare Metals Inc. (Avalon) is pleased to provide the following responses to Part 2 of the deficiency list provided in Mackenzie Valley Environmental Impact Review Board's (MVEIRB) letter dated August 25, 2011. The Part 1 responses were previously submitted to the MVEIRB on September 9, 2011.

This deficiency list provides specific direction from the MVEIRB to Avalon regarding the results of the conformity analysis and identifies two categories of information that require additional information:

- **Part 1:** includes information without which the environmental assessment cannot proceed. The developer must respond to these items before the process will move into the next phase.
- **Part 2:** includes information the Review Board needs to determine whether the proposed development is likely to cause a significant impact on the environment but may be submitted at a later date. The developer may submit responses to these items at its convenience but prior to the environmental assessment process reaching the technical reports step. For Part 2 items please provide a schedule of when and how these items will be addressed within the environmental assessment.

The numbering of headings and line items refers to sections and points within the Final Terms of Reference (MVEIRB 2011). Sections of the quoted Terms of Reference are in italics. Specific questions asked by the MVEIRB are highlighted in bold. For clarity, the request, response, and attachment numbering follows the sequence initiated in the Part 1 Response document.

1.0 SECTION 3.2.4 DESCRIPTION OF EXISTING ENVIRONMENT

MVEIRB Request #15

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

15. Ambient air quality, including baseline concentrations of criteria air contaminants [...] including dioxins and furans.

The information need identified by the Review Board is as follows:

The Terms of Reference requests baseline concentrations of air contaminants including dioxins and furans. Dioxins and furans have not been included in the baseline information provided by Avalon Rare Metals Inc. Please include baseline information of dioxins and furans at both sites.



Avalon Response #15

Dioxins and furans in the environment can be attributed to three principal sources: point source discharges (to water, air and soil), contamination from in situ dioxins and furans, and loadings from long-range transboundary air pollution. In particular, dioxins and furans are created as by-products in high-temperature processes, such as waste burning and metallurgical industries.

As described in CCME (2003, p.2) "polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), commonly known as dioxins and furans, are toxic, persistent, bioaccumulative, and result predominantly from human activity".

Dioxins and furans are managed under the *Canadian Environmental Protection Act* (CEPA), the federal Toxic Substances Management Policy and the Canadian Council of Ministers of the Environment's (CCME) Policy for the Management of Toxic Substances (CCME 2003). Canada-wide Standards were developed by CCME in 2001 for waste incineration, including municipal solid waste, hazardous waste, sewage sludge, and medical waste.

In addition, Environment Canada's *Technical Document for Batch Waste Incineration* (2009) and CCME's (1989) *Operating and Emission Guideline for Municipal Solid Waste Incinerators* provide guidance on appropriate incineration equipment and operating practices that, if followed, should minimize the release of contaminants from waste incineration (MVLWB 2011).

Emission limits are expressed as a concentration in the exhaust gas exiting the stack of the facility and emission concentration limits are specified in pico-grams of International Toxic Equivalency Quotients per cubic metre [pg I-TEQ/m³]. For this Project, the relevant Canada-wide Standard for a new municipal waste incinerator is 80 pg/m³ I-TEQ.

For the Thor Lake Project, the existing standards will be met by using generally available incineration and emission control technology and accepted waste diversion practices. The waste incinerator to be employed at the Nechalacho Mine site will be engineered and operated to meet the CCME emission standards for dioxins and furans (CCME 2001), and will be sized to meet the demand of the construction and operations workforces at the site.

As stated in Sections 4.7.3.5, 4.8.3.3, and 11.2.8 of the DAR, garbage at the Nechalacho Mine site will be collected daily and incinerated once per day in a manner consistent with current industry good management practices and in compliance with regulatory requirements. Hazardous materials waste will be disposed of in accordance with current GNWT hazardous waste management guidelines using standard best management practices.

Baseline concentrations have not been measured at either the proposed Thor Lake or Hydrometallurgical Plant sites. Environment Canada (A. Wilson, pers. comm. August 31, 2011) and RWDI (2011) confirmed that there is no background data for dioxins and furans in the Northwest Territories. The existing sources of dioxins and furans in the Project area are: Imperial Oil Hay River Terminal, two Northwest Territories Power Plants (Fort Resolution and Jackfish), Yellowknife airport, and the three diamond mines (Ekati Diamond Mine, Diavik Diamond Mines Inc. and Snap Lake Mine) (National Pollutant Release inventory 2009).

To identify potential baseline concentrations, RWDI (2011) selected monitoring stations from several provinces with similar emission sources as the Project area to provide a representative estimate of the ambient concentrations of dioxins and furans (Table 1). Of the four monitoring stations examined, Environment Canada's National Air Pollutant Surveillance (NAPS) station in Estevan, Saskatchewan is the most representative station for the Project area because there are similar industrial sources in the surrounding region. In the vicinity of the Estevan monitoring station, industries that report to the National Pollutant Release Inventory (NPRI) in 2009 included mining and quarrying, upstream oil and gas, electricity, and other.

Table 1 describes the maximum, 75^{th} percentile, 50^{th} percentile (median), 25^{th} percentile, and minimum TEQ measured at these monitoring stations. Background concentrations at each station are less than 1 pg/m³ I-TEQ.

| TABLE 1: TOXIC EQUIVALENTS FOR DIOXINS AND FURANS FROM SELECTED MONITORING STATIONS | | | | | | | |
|---|------------------------------|---------------|-------------|--------------------------------|--------|--------------------------------|---------|
| | | | TEQ (pg/m³) | | | | |
| number | Province | City | Maximum | 75 th Percentile | Median | 25 th Percentile | Minimum |
| 80501 | Saskatchewan | Estevan | 0.045 | 0.035 | 0.025 | 0.023 | 0.020 |
| 80401 | Saskatchewan | Prince Albert | 0.034 | 0.030 | 0.027 | 0.022 | 0.022 |
| 10301 | Newfoundland and Labrador | Corner Brook | 0.055 | 0.019 | 0.013 | 0.010 | 0.005 |
| 20101 | Prince Edward Island | Charlottetown | 0.048 | 0.033 | 0.018 | 0.016 | 0.014 |

Source: RWDI (2011)

References:

- Canadian Council of Ministers of the Environment (CCME). 2001. Canada-Wide Standards for Dioxins and Furans. Winnipeg, MB.
- Canadian Council of Ministers of the Environment (CCME). 2003. Canada-Wide Standards for Dioxins and Furans: Conical Waste Combustion of Municipal Waste. Retrieved from http://www.ccme.ca/assets/pdf/d_f_conicalwaste_cws_e.pdf
- Canadian Council of Ministers of the Environment (CCME). 2009. Canada-Wide Standards for Dioxins and Furans: Pulp and Paper Boilers Burning Salt Laden Wood, Waste Incineration, Iron Sintering Plants, Steel Manufacturing Electric Arc Furnaces and Conical Municipal Waste Combustion Progress Report. Retrieved from http://www.ccme.ca/assets/pdf/df_2009_prgs_rpt_e.pdf



- Mackenzie Valley Land and Water Board (MVLWB). 2011. Guidelines for Developing a Waste Management Plan. Retrieved from http://www.mvlwb.ca/WGDocs/MVLWB_Guidelines_Developing_Waste_Mg mt_Plan-Mar2011.pdf
- RWDI. May 3, 2011. Memorandum: Avalon Nechalacho Rare Earth Element DAR. Prepared by RWDI for Avalon Rare Metals Inc.

Units:

I-TEQ International Toxic Equivalency Quotient, relative to the toxic equivalent of 2,3,7,8-tetrachlorodibenzo-para-dioxin.

Definitions:

I-TEQ -Toxic Equivalency (relative International Quotients 2,3,7,8to tetrachlorodibenzopara-dioxin) internationally (through NATO) are established multiplication factors that are used to collectively express the toxicity of various dioxins, furans and co-planar PCBs (polychlorinated biphenyls) to humans, mammals, fish and birds relative to the most toxic of these substances: 2,3,7,8-tetrachlorodibenzo-paradioxin. The multiplication factors range from 0.000001 to 1.000000.

MVEIRB Request #16

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

6. Current and historic data on surface water and groundwater quality for the Pine Point processing site area.

The information need identified by the Review Board is as follows:

Historic groundwater samples for the Pine Point area are provided. However, no information is provided on current water quality in the pits (L-37, N-42) proposed for effluent deposition from the hydrometallurgical plant. Please provide water quality data for parameters listed in line item 5 of section 3.2.4 of the Terms of Reference for any surface water in the pits and as well as any pit wall seepage (Section 2.7.2.2) at the L-37 pit and the N-42 pit.

Avalon Response #16

In response to this item, Avalon is pleased to advise that in February 2011, Knight Piesold Consulting was retained to install six (6) groundwater monitoring wells in the area of the proposed hydrometallurgical facilities for the Thor Lake Project. The wells were developed and water samples were taken from them by Maskwa Engineering Ltd. (Maskwa) between February 22 and March 4, 2011 in general accordance with Groundwater Sampling Field Procedures provided by Knight Piesold.



In addition, during the field program, select surface water locations were sampled on February 28 and March 12, 2011 for the purpose of collecting baseline water quality data. The groundwater and surface water quality test results obtained during the sampling program were summarized in Knight Piesold's Memorandum entitled *Thor Lake Project – Pine Point Site Groundwater and Surface Water Quality Test Results*, a copy of which is provided as Attachment 4.

Figure 1 in this memorandum shows the locations of the monitoring wells and surface water sampling locations. Surface water sampling locations included SW1 from the T-37 Pit (original Process Water Source), SW2 and 3 from the L-37 Pit (Hydrometallurgical Tailings Facility), SW5 from the J-44 Pit (new Process Water Source) and SW6 from the N-42 Pit (Tailings Water Infiltration).

A total of 13 water samples (including six groundwater samples and seven surface water samples) were sent to ALS Laboratory Group (ALS) in Edmonton by Maskwa for a complete suite of analytical tests including:

- Physical Tests;
- Anions and Nutrients;
- Cyanides;
- Total metals; and
- Dissolved metals (groundwater only).

The results of the laboratory testing are summarized in Table 1 of the memorandum provided (Attachment 4). The test results confirmed that the water in the pits and in the local groundwater is typically characterized by high water hardness (193-2110 mg/L), high conductivity (825-2810) and elevated pH (7.7-8). Arsenic, copper, thallium and uranium values were typically similar in the groundwater and pit water sampled. Total suspended solids, aluminum and iron values were generally higher in the groundwater samples than in the pit water samples, while hardness, conductivity and zinc values were typically higher in the pit water samples.

A follow-up water quality sampling event was conducted in August 2011. The results of this sampling event will be provided to the Review Board when they become available.

Reference:

Knight Piésold Consulting. May 20, 2011. Memorandum: Thor Lake Project – Pine Point Site Groundwater and Surface Water Quality Test Results. Project No. NB11-00232. Prepared for Avalon Rare Metals Inc.



MVEIRB Request #17

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

- 7. Hydrology and hydrogeology, including surface water and groundwater amounts, direction of flow, likely surfacing points/discharge area (for groundwater), and maps and descriptions of associated watersheds, both in the local area of the project site as well as downstream until the confluence with Great Slave Lake.
 - f. relationship between the groundwater regime and permafrost and active layer conditions, including a characterization of those conditions, and how permafrost and active layer changes influence hydrogeology at both project sites.

The information need identified by the Review Board is as follows:

Please provide a discussion on how such changes would affect the hydrogeology of the project sites.

Avalon Response #17

This subject was discussed in considerable detail in the DAR. Section 2.7.1 of the DAR indicates that the Nechalacho Mine study area is relatively flat with a maximum elevation change of approximately 50 m. Lowlands in the area tend to have poor drainage and are commonly wet for prolonged periods. Permafrost is discontinuous but widespread.

In areas of widespread permafrost, the permafrost typically acts as an aquitard for groundwater, with flow being limited to the areas where permafrost is not present. Most commonly, the flows occur either above the permafrost table through the active layer in the summer months, below the bottom of the permafrost (year round) or within thawed zones through the permafrost (taliks).

For the Nechalacho Mine site area, it is expected that the presence of shallow, competent bedrock across the area will have the most significant control on the groundwater flows.

Section 2.7.1.5 of the DAR indicates that based on the analyses and interpretation of the data collected by Stantec during their 2008, 2009, and 2010 field programs, the local hydrogeological conceptual model of the area between Thor Lake and Long Lake consists of shallow (perched) and deep aquifers separated by permafrost. The shallow aquifer is composed of unconsolidated surficial material and, in some places the bedrock is porous and vuggy, perched on the permafrost.

The deep aquifer likely occurs below permafrost and is comprised of different bedrock lithologies in which groundwater flow mainly occurs along fractures and other rock discontinuities. Although this conceptual model can likely be extrapolated to other areas in the proposed Project footprint, more data (i.e., greater spatial – both vertically and horizontally - coverage of groundwater elevations and hydraulic properties) and information (i.e., surficial and bedrock maps, distribution of permafrost map) would be required to



develop a more detailed concept. The following summarizes our understanding of the hydrogeology based on the data gathered to date.

Shallow Aquifer

The shallow aquifer is composed of unconsolidated surficial material and, where spatially present, porous and vuggy bedrock within the active zone, which has been interpreted to be perched on the permafrost. The unconsolidated surficial material mainly consists of till and organic deposits in topographically low areas. The till varies throughout the study area but generally consists of a poorly compact, stony, matrix-supported diamicton. The organic deposits are poorly drained fine materials.

Recovery tests performed in shallow monitoring wells showed a hydraulic conductivity range over several orders of magnitude, from 7.56x10⁻⁷ m/s to 3.08x10⁻⁵ m/s. Groundwater flow within the shallow aquifer occurs in the active layer (i.e., in the layer of seasonal thawing and freezing). The highest groundwater levels are expected to occur during the snowmelt in late spring after thawing of the shallow (surficial) sediments. Groundwater flow is expected to be characterized by local, small-scale flow, and the flow direction is assumed to follow the local topography.

Deep Aquifer

A deeper bedrock aquifer underlies the permafrost. The bedrock lithology mainly consists of intrusive zoned syenite and granite, with dykes and sills throughout the pluton. Groundwater flow in the bedrock aquifer is expected to occur, predominantly in fractures and fault zones. Groundwater flow in fractured media is complex, depending on the local hydrogeological and structural geological conditions. Transmissivity values can differ over several orders of magnitude within the same rock mass, and groundwater flow may be largely controlled by a few conductive fractures or other rock mass discontinuities.

Groundwater within the bedrock aquifer is thought to occur beneath the permafrost, which may or may not be in hydraulic connection with some of the taliks surrounding the larger and deeper lakes. In general, though it is expected that there is very little connection between the shallow and deep aquifers. Due to the limited number of groundwater monitoring wells there is little information to estimate flow direction of water in the bedrock. From a conceptual perspective, it is likely that the deep aquifer flows southward and is ultimately in hydraulic connection with deeper sections of Great Slave Lake.

Packer tests performed in the deep aquifer suggest a hydraulic conductivity that ranges over several orders of magnitude $(4.1 \times 10^{-8} \text{ m/s to } 1.7 \times 10^{-6} \text{ m/s})$. The range of hydraulic conductivity is within the expected range for fractured crystalline rock, (Freeze and Cherry 1979). Hydraulic conductivity generally decreased with depth, which is expected due to the increasing competence of the bedrock with depth.

In addition, Section 2.5.3 of the DAR describes the effect of seasonal events, including snowmelt, precipitation and thawing of the active layer and the influence of such events on lake levels in the Project area. During summer, water levels rise briefly following significant rainfall events. An examination of lake level changes and corresponding rainfall amounts



indicates that in general, lake levels rise less than five centimetres following major storm events and return to previous levels within a few days. The seasonal changes in lake levels apparent in the data reflect the hydrological characteristics of this region. These characteristics have been studied extensively and are described and explained in Woo (1993):

Meltwater fills the many depressions on the land surface and then flows over frozen ground in sheets or rills. Because the shallow, seasonally thawed suprapermafrost layer cannot retain much meltwater or rainwater, the water table rises rapidly so that water is delivered quickly to lower slopes and stream channels. Fairly rapidly, the active layer increases in depth due to increased solar radiation, causing the water table to drop below the surface and a corresponding decline in surface flows.

Surface runoff follows pronounced diurnal cycles, reflecting daily variation of snowmelt contribution. The abundance of water at the surface, combined with large amounts of energy available, enables high evaporation in the spring. As summer advances, surface flow declines, because thawing of the active layer provides a thicker zone where suprapermafrost groundwater can be stored, and the water table drops below the surface. Also, most of the snow has been depleted and summer rainfall is the only major source of water-supply. Finally, evaporation and lateral flow continue to withdraw water from the active layer, leaving far less water to sustain surface flow than in the spring. Evaporation also decreases in the Arctic during summer as the surface dries out, while in the subarctic, transpiration of vascular plants speeds evaporation.

The outlets of many small lakes are blocked by thick snowdrifts accumulated in winter. As lake storage increases, water levels rise until the snow dam is breached. This usually yields the peak annual outflow, accompanied by rapid depletion of lake storage accumulated during melt. Afterward, ice decay enlarges open water areas on the lake where evaporation is effective. Then the slopes gradually become free of snow, exposed ground thaws, and surface runoff diminishes as meltwater supply declines and evaporation increases.

At the Hydrometallurgical Plant site, permafrost is highly localized and restricted to low lying organic deposits primarily to the north of the proposed development area. Permafrost was never encountered in upland areas developed as part of the Cominco plant site, which will also be used by the Hydrometallurgical Plant.



MVEIRB Request #18

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

h. a map indicating the location with rationale of all existing and planned wells, and seeps within the study area and other monitoring locations.

The information need identified by the Review Board is as follows:

Please confirm if a seep survey has been conducted. If not, please conduct a field seep survey and provide results of analysis. If one has been conducted, please provide results of survey and analysis.

Avalon Response #18

As discussed in Section 2.7.1, no specific seep survey was carried out at the Nechalacho Mine study area by either Stantec or Knight Piesold, both of whom were retained by Avalon to conduct hydrogeological investigations for the Nechalacho Mine site. At the Nechalacho Mine study area the majority of the structures will be founded on or very near bedrock (the majority of which is high quality with very low permeability). The various facilities and associated structures, specifically the TMF and surface runoff collection systems will be designed and constructed to prevent seepage to the downstream receiving environment.

As discussed in Section 2.7.2, at the Hydrometallurgical Plant site, several seepage points were observed in pit walls, indicating that there is some lateral flow within the unsaturated bedrock. The local surface water/groundwater flows through the till, then downwards through fractured bedrock towards the water table. This seepage is thought to be due to local infiltration being directed horizontally along bedding planes. These observations of seepage in the pit walls are not anticipated to have any effect on the use of the historic L-37 Pit for Hydrometallurgical Plant tailings containment and no additional seep surveys are warranted.

The installed monitoring wells at both the sites will allow for the ongoing monitoring of water quality upstream and downstream of the various facilities and will be the best measure for understanding the potential for seepage.

MVEIRB Request #19

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

16b. Physical and chemical make-up of water body sediments downstream [...] of the potentially affected water bodies of both project sites, including baseline concentrations of dioxins and furan.



The information need identified by the Review Board is as follows:

Appendix A section 7 describes water body sediments as required in the ToR, with the exception of dioxins and furans. Concentrations of these contaminants are not described and samples were not collected – as stated in Section 2.9.1.8 page 230 of the DAR Main Report. Please provide baseline data on sediments as required in the Terms of Reference.

Avalon Response #19

As discussed earlier in this Deficiency Response, dioxins and furans in the environment can be attributed to three principal sources: point source discharges (to water, air and soil), contamination from in situ dioxins and furans, and loadings from long-range transboundary air pollution (CCME 2003). In particular, dioxins and furans are created as by-products in high-temperature processes, such as waste burning and metallurgical industries.

Dioxins and furans are managed under the *Canadian Environmental Protection Act* (CEPA), the federal *Toxic Substances Management Policy* and the Canadian Council of Ministers of the Environment's (CCME) *Policy for the Management of Toxic Substances* (CCME 2003). Canada-wide Standards were developed by CCME in 2001 for waste incineration, including municipal solid waste, hazardous waste, sewage sludge, and medical waste.

Applicable sediment guidelines include the *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life* (CCME 2002). These guidelines describe the International Freshwater Sediment Quality Guidelines International Marine Sediment Quality Guidelines (ISQG) for polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzo furans (PCDF) is 0.85 ng TEQ/kg (dry weight), while the probable effect levels (PELS) is 21.5 ng TEQ/kg (dry weight), where TEQ is the toxic equivalency unit.

Additional related management guidelines include Environment Canada's (2009) Technical Document for Batch Waste Incineration and CCME's (1989) Operating and Emission Guideline for Municipal Solid Waste Incinerators. These guidelines provide guidance on appropriate incineration equipment and operating practices that, if followed, should minimize the release of contaminants from waste incineration (MVLWB 2011).

Baseline concentrations have not been measured at either the proposed Thor Lake or Hydrometallurgical Plant sites. The existing sources of dioxins and furans in the Project area are: Imperial Oil Hay River Terminal, two Northwest Territories Power Plants (Fort Resolution and Jackfish), Yellowknife Airport and the three diamond mines (Ekati Diamond Mine, Diavik Diamond Mines Inc., and Snap Lake Mine) (National Pollutant Release Inventory 2009). Furthermore, a foreseeable project in the Project area is the Pine Point Pilot project, a lead/zinc mining project.

To approximate the baseline concentrations at Thor Lake and Pine Point, the sediment reference testing conducted at Counts Lake, NWT is relevant. According to Wilson et al. (2011), Environment Canada conducted limited sediment sampling for dioxins and furans in the vicinity of Ekati Diamond Mine. Exploration activities occurred from the 1990s until



the start-up of the main Ekati Mine camp and waste incinerator in 1998. These facilities are located directly adjacent to Kodiak Lake. Reference samples were taken from Counts Lake for comparative purposes.

An estimate of the timeframe represented by each layer of the sample was based on the sedimentation rates for arctic lakes. Therefore, Layer 1 is estimated to represent approximately 10-11 years, Layer 2 represents approximately 13 years (occurring after 1997), and Layers 3 and 4 represent a period of approximately 10-20 years each (occurring before 1997).

Figure 1 shows the mean toxic equivalencies for each depth layer at Counts Lake. The figure indicates that the toxic equivalencies are below the ISQG threshold of 0.85 ng TEQ/kg and well below the probably effects level of 21.5 ng TEQ/kg (CCME 2003), particularly for Layers 2, 3, and 4.



Source: Wilson et al. 2011

Figure 1: Mean Toxic Equivalencies per Depth Layer at Counts Lake



Table 1 provides the total PCDD and PCDF concentrations for Counts Lake.

| TABLE 1: TOTAL DIOXINS AND FURANS MEASURED AT COUNTS LAKE, NWT (PG/G ¹) | | | | | | |
|---|---------------|---|------|---------------------|--|--|
| Layer ² | Polychlorinat | ated dibenzo- <i>p</i> -dioxin Polychlorinated dibenzo-fi | | nated dibenzo-furan | | |
| | Mean | Standard Deviation | Mean | Standard Deviation | | |
| 1 | 45.8 | 48.6 | 11.1 | 7.3 | | |
| 2 | 47.0 | 4.3 | 10.1 | 2.0 | | |
| 3 | 15.8 | | 11.9 | | | |
| 4 | 10.5 | | 7.1 | | | |

Source: Wilson et al. 2011

Notes: 1. pg/g = ng/kg; measured at dry weight.

2. Layers are based on the visually distinct core layers

(Layer 1 = -5 cm; Layer 2 = 0.75-1.5 cm; Layer 3 = -1 cm; Layer 4 = -1 cm)

The elevated baseline and effects concentrations of dioxins and furans located at Counts Lake may be attributable to long-range atmospheric transport (CCME 2003, Wilson et al. 2011). The observed increases in the top two layers are consistent with the period of operation of the incinerator at Ekati (Wilson et al. 2011).

According to Wilson et al. 2011, the dioxin and furan concentrations prior to Ekati mine operations and use of waste incinerators (pre-1998) is approximately measured by the concentrations in Layers 3 and 4. The concentrations presented in Figure 1 and Table 1 are likely representative of baseline concentrations for these parameters in the Thor Lake and Pine Point areas.

References:

- Canadian Council of Ministers of the Environment (CCME). 2001. Canada-Wide Standards for Dioxins and Furans. Winnipeg, MB.
- Canadian Council of Ministers of the Environment (CCME). 2002 (updated from 1999 and 2001). Canadian Sediment Quality Guidelines for the Protection of Aquatic Life: Summary Tables. Retrieved from http://www.ccme.ca/assets/pdf/sedqg_summary_table.pdf
- Canadian Council of Ministers of the Environment (CCME). 2003. Canada-Wide Standards for Dioxins and Furans: Conical Waste Combustion of Municipal Waste. Retrieved from http://www.ccme.ca/assets/pdf/d_f_conicalwaste_cws_e.pdf
- Canadian Council of Ministers of the Environment (CCME). 2009. Canada-Wide Standards for Dioxins and Furans: Pulp and Paper Boilers Burning Salt Laden Wood, Waste Incineration, Iron Sintering Plants, Steel Manufacturing Electric Arc Furnaces and Conical Municipal Waste Combustion Progress Report. Retrieved from http://www.ccme.ca/assets/pdf/df_2009_prgs_rpt_e.pdf



- Mackenzie Valley Land and Water Board (MVLWB). 2011. Guidelines for Developing a Waste Management Plan. Retrieved from http://www.mvlwb.ca/WGDocs/MVLWB_Guidelines_Developing_Waste_Mg mt_Plan-Mar2011.pdf
- Wilson, A., D. Fox, G. Poole and R. Bujold. April 2011. Linking Incineration to Dioxins and Furans in Lakebed Sediments (or, the Case of the Missing Water License Condition). Journal of Integrated Environmental Assessment and Management. Volume 7, Issue 2, pp. 302–304.

Units:

ng TEQ/kg nano grams TEQ per kilogram (dry weight).

Definitions:

TEQ Values are expressed as toxic equivalency (TEQ) units, based on WHO 1998 TEF values for fish.

MVEIRB Request #20

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

See the previously described Terms of Reference.

The information need identified by the Review Board is as follows:

In addition Appendix A, Executive Summary notes that data on radionuclides and rare earth elements in sediments is not available at this time (p. ii). Avalon is deficient for this item from the Terms of Reference. Please provide baseline data on sediments as required in the Terms of Reference.

Avalon Response #20

Avalon acknowledges that the Executive Summary of Stantec's Volume 3 (Final Interim Report) Environmental Baseline Report – Aquatics and Fisheries (provided as Appendix A.1 of the DAR) indicated that "data on radionuclides and rare earth elements in sediments are not available at this time". In reviewing the version history of the Stantec Volume 3 report, it was noted that the version provided was not the most final version, and thus Avalon is pleased to provide the updated final Stantec report (as Attachment 5 to this response document) entitled: *Thor Lake Rare Earth Metals Baseline Project Environmental Baseline Report: Volume 3 – Aquatics and Fisheries* (Final Report) dated January 2011.

This finalized version of the report includes all of the baseline lake sediment radionuclide data obtained by Stantec during the baseline study period. In particular, Section 6.2.2 of the Final Report summarizes the radionuclide results, and Appendix G in the Final Report presents all of the lake sediment radionuclide data for each of the lakes sampled.



However, it should be noted that these results were reported in Section 2.6.2.4 of the DAR, where it was stated that in 2009, radionuclide values (in lake sediment samples) were generally low and ranged from <0.01 to 0.07 Bq/g for radium-226, <0.03 to 0.4 Bq/g for radium-228, <0.02 to 0.055 Bq/g for thorium-230 and <0.02 to 0.08 for thorium-232. Lead-210 was higher than other radionuclides and ranged from <0.04 to 1.4 Bq/g. A large range of values were reported for REEs across the study area in 2009. Tantalum and hafnium were always low, being reported at less than detection at all sample stations.

Reference:

Stantec Inc. January 2011. Thor Lake Rare Earth Metals Baseline Project Environmental Baseline Report: Volume 3 – Aquatics and Fisheries. Final Report. Report prepared for Avalon Rare Metals Inc., Toronto, ON.

2.0 SECTION 3.2.5 DEVELOPMENT DESCRIPTION

MVEIRB Request #21

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

8. A description of the milling process from initial separation to concentrate, including primary and secondary crushing and flotation and filtration processes.

The information need identified by the Review Board is as follows:

Section 4.7.2.4 provides a list of reagents currently planned for use in the flotation plant although the section notes that optimization test work continues. A complete list of reagents and estimated quantities or reagents is required during the EA phase in order to accurately characterize tailings, process plant effluent and impacts to water quality and the environment. Please provide a complete list of reagents for use in the flotation plant.

Avalon Response #21

As requested by the MVEIRB, Table 4.7-1 from the DAR has been updated and provides a complete list of reagents and estimated quantities required for the Nechalacho Flotation Plant. The values in Table 4.7-1 are based on a 2,000 tpd mining rate.



| TABLE 4.7-1: FLOTATION PLANT - AVERAGE REAGENT CONSUMPTION ESTIMATE | | | | | |
|---|----------------|-------------------|--------|-----------------------|--|
| Reagent Scheme | LCT F-6 Dosage | | Dosage | Annual Consumption | |
| LCT F-6 & Minipilot | (g/t) | Reagent Breakdown | (g/t) | (tonnes per year) | |
| Calgon | 150 | Calgon | 150 | 109.5 | |
| Sodium silicate | 150 | Sodium silicate | 150 | 109.5 | |
| Si/Fe aerosol | 775 | Sodium silicate | 646 | 471.6 | |
| | | Ferric chloride | 129 | 94.2 | |
| MX3 | 475 | Oxalic acid | 190 | 138.7 | |
| | | Citric acid | 190 | 138.7 | |
| | | Lactic acid | 95 | 69.4 | |
| MLC6 | 300 | Alginic acid | 120 | 87.6 | |
| | | Acumer 9400 | 120 | 87.6 | |
| | | Alcomer 74A | 60 | 43.8 | |
| KBX36 | 850 | Flotinor 1682 | 340 | 248.2 | |
| | | Flotinor S72 | 212.5 | 155.1 | |
| | | Aero 845 | 170 | 124.1 | |
| | | Stepanate SXS | 127.5 | 93.1 | |
| Froth modifier | 440 | Froth modifiers | 440 | 321.2 | |
| | | Ammonium oxalate | 127.5 | 93.1 | |
| SOA | 850 | Octyl phosphonic | | | |
| | | acid | 255 | 186.2 | |
| | | Ester alcohol | 467.5 | 341.3 | |
| Flocculant | | Magnafloc 156 | 50 | 36.5 | |
| | | Sodium hydroxide | 200 | 146.0 | |

MVEIRB Request #22

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

10. A description of the expected physical properties of paste backfill, including mineralogy, chemical characterization, as well as expected long term stability, reactivity and structural integrity.

The information need identified by the Review Board is as follows:

The DAR does not discuss paste backfill mineralogy, chemical characterization, long term stability, reactivity or structural integrity. An understanding of paste geochemistry is important, particularly in terms of geochemistry and interaction with groundwater during operations and at closure. Please provide a more thorough answer to address these deficiencies.



Avalon Response #22

As indicated in the DAR, Avalon is planning to use paste backfill to assist in maximizing underground resource recoveries and to reduce the volume of process tailings requiring permanent storage in the Tailings Management Facility at the Nechalacho Project site.

In late 2010, Avalon retained Golder Paste Technology Ltd. (Golder PasteTec) to carry out laboratory testing on Nechalacho Project Flotation Plant tailings to assess the material characteristics, rheological, dewatering and strength properties. The purpose of the work was to assess the suitability of the tailings to produce cemented backfill in support of the proposed underground mining operations.

Avalon is pleased to provide as Attachment 6 to this response, a copy of Golder PasteTec's (2011) detailed laboratory report entitled: *Tailing Testing – Thor Lake Project Northwest Territories*.

Reference:

Golder Paste Technology Ltd. March 4, 2011. Tailing Testing – Thor Lake Project Northwest Territories. Report No. 10-9002-0059. Prepared for Avalon Rare Metals Inc.

MVEIRB Request #23

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

See the previously described Terms of Reference.

The information need identified by the Review Board is as follows:

In Section 10.6.2.2, groundwater quality in the cumulative effects segment of the DAR there is a statement that the current mine plan estimates that 95% of void space underground will eventually be filled with paste backfill. Please confirm this statement.

Avalon Response #23

Avalon is pleased to confirm that this statement is correct. All mined-out stopes are anticipated to be paste backfilled with only the main development decline, crusher station and main access to the ventilation raises remaining open at the end of mine life.



MVEIRB Request #24

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

11. Mine rock management area including location, underlying ground conditions and volume of waste rock over the life of the mine.

The information need identified by the Review Board is as follows:

In Section 4.7.3.2 Avalon indicates that waste rock and low grade rock to be removed from underground is roughly 400,000 tonnes. Please describe total volume of waste rock to be stored on surface during the life of the mine and the volume of waste rock to remain on surface at closure.

Avalon Response #24

As indicated in Section 4.7.3.2 of the DAR, during construction of the main underground access decline ramp, approximately 400,000 tonnes of waste rock and low grade ore will be hauled to the surface. The material will be temporarily stockpiled on the surface in a designated area, where natural drainage can be collected in the planned settling pond (utilized for Flotation Plant site runoff).

The waste rock will be utilized during construction of the airstrip, road upgrades and tailings management facility berms. No waste rock will be left stockpiled on surface as a result of underground development beyond the construction phase of the Project. During operations, no waste rock will be hauled to surface and stockpiled as any waste rock generated during operations will be backfilled in mined-out stopes and paste back-filled. No waste rock or ore stockpiles will be on the surface during operations.

MVEIRB Request #25

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

30. The water collection, management and treatment systems and all of their component parts...

The information need identified by the Review Board is as follows:

In section 4.7.3.2, a settling pond is proposed to collect drainage from the waste rock pile as well as floatation plant site runoff. It is unclear whether or not this settling pond is the same project component as the "plant site runoff collection sump" shown on Figure 4.5-1 as well as 4.7-6. No information on the settling pond or the sump is provided. Please describe the location, size, volume capacity, liner characteristics of the settling pond and sump and confirm whether they are the same design feature or different project components.



Avalon Response #25

Avalon is pleased to advise that the term "settling pond", as referenced in the DAR, is the same as the term "plant site runoff collection sump", as shown in Figures 4.5-1 and 4.7-6 of the DAR.

The sump/pumping system has been designed to collect all runoff associated with regular precipitation as well as the 1 in 20 year storm event. The settling pond/sump will be approximately 8 m wide, 24 m long, and 3 m deep, with open access and a ramp for a loader to clean out sludge. Since the settling pond is located on bedrock, no liner is anticipated to be needed. Water collected in the runoff collection sump will be pumped to the Flotation Plant for use in the process and ultimate discharge to the TMF. A freshwater intercept ditch along the southwest side of the plant site area will intercept non-impacted runoff water and divert it away from the plant site runoff collection system.

Runoff collection ditches (approximately 1 m wide at the base and 0.5 m deep) will be excavated along the perimeter of the plant site area to intercept any potentially impacted runoff water from the Flotation Plant site area. The ditches will be graded to direct flow into the runoff collection sump.

MVEIRB Request #26

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

13. The proposed upgrade to the Thor Lake-Great Slave Lake access road, including construction (width of ROW, vegetation removal, road bed type) and the expected number of trips on that road, water crossings, as well as the type and weight of load, any related storage.

The information need identified by the Review Board is as follows:

The single sentence on the access road upgrade in Section 4.5.2.1 does not address the requirements of the ToR. Please provide a more thorough answer to upgrade of the road.

Avalon Response #26

The existing Nechalacho Mine access road will be used with some modification to widen the existing road and to remove, where possible and necessary, any sharp turns that could be deemed hazards for transportation (Figure 1). During the access road improvement program, the limited vegetation and any surface organic material in the road footprint area will be removed and stored for future reclamation purposes. The access road will also be capped and crowned to facilitate grading and water runoff. The material for this cap will consist of the materials specified in Table 1 and volumes and tonnages specified in Table 2.





Note: All dimensions are in millimetres.

Figure 1: Typical Access Road Cross-section

| TABLE 1: ACCESS ROAD MATERIAL SPECIFICATIONS | | | | |
|--|-----------|--------------|--|--|
| Material | Size (mm) | Quantity (%) | | |
| Quarry | 6- 76 | 60 - 80 | | |
| Quarry | 0.75 - 6 | 20 - 40 | | |
| Quarry | <0.75 | 8 - 15 | | |

| TABLE 2: VOLUME OF REQUIRED MATERIALS FOR ACCESS ROAD TO DOCK | | | | | | |
|---|--------|-------|----------------------|----------|-----------------------------|--|
| | Length | Width | Cross-Sectional Area | Volume | Volume of Material Required | |
| | (m) | (m) | (m²) | (m³) | (m³) | |
| Current | 5,500 | 4 | 1.286 | 7,073 | - | |
| Proposed | 5,500 | 8 | 3.085 | 16,967.5 | 9,894.5 | |

The road will be widened from the existing 4 m wide roadway to an 8 m wide road with ditching on either side to facilitate drainage. Refer to Figure 1 for details.

Once construction is complete and operations are started, truck haulage will include concentrate haulage to the docking facility, backhaul of reagents and other supplies to the operations site at the Flotation Plant, and haulage of fuel from the temporary storage area to the main storage tanks at the Flotation Plant. The estimated number of truck haulages are listed in Table 3.



| TABLE 3: TOTAL TRUCK HAULAGE DURING NORMAL OPERATIONS | | | | | |
|---|----------------|-----------------|--------------------------------|--|--|
| Trips per Day | Trips per Week | Trins per Month | Trips per Year (Round-trip) | | |
| mpo por Bay | | | (Round tilp) | | |
| 14 | 100 | 422 | 4,218 | | |

The assumptions used to determine the values in Table 3 are:

- the reagents and supplies will be backhauled and are not included in the total number of trips.
- the number of trips represent one-way or round trips.

MVEIRB Request #27

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

15. A description of the entire hydrometallurgical cycle.

The information need identified by the Review Board is as follows:

Section 4.8.2.1 provides a general overview of the hydrometallurgical plant. Please provide a scale drawing of the actual hydrometallurgical plant showing the physical structures in the process steps identified in Figure 4.8-2.

Avalon Response #27

As requested, Avalon is pleased to provide a scaled plan view drawing of the proposed Hydrometallurgical Plant layout (Figure 1). Also provided is a Pine Point topographical map showing all components of the Hydrometallurgical Plant facility (Figure 2). It is important to note that Figure 2 shows the Hydrometallurgical Plant in its newly proposed location, as previously provided to the MVEIRB on August 12, 2011. This figure also shows the location of the new process water source at the nearby J-44 Pit.







MVEIRB Request #28

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

See the previously described Terms of Reference.

The information need identified by the Review Board is as follows:

Section 4.8.2.2 provides a preliminary list of reagents in Table 4.8-1 and acknowledges that the list is incomplete and that quantities may change as the process is optimized. A complete list of reagents and estimated quantities or reagents is required during the EA phase in order to accurately characterize tailings, hydrometallurgical plant effluent and impacts to water quality and the environment. Please update Table 4.8-1 with a complete list of reagents to be used in the hydrometallurgical plant along with quantities to be used annually.

Avalon Response #28

As requested by the MVEIRB, Table 4.8-1 from the DAR has been updated and provides a complete list of reagents and estimated quantities required for the Hydrometallurgical Plant. The values in Table 4.8-1 are based on a mining rate of 2,000 tpd.

| TABLE 4.8-1: HYDROMETALLURGICAL PLANT AVERAGE REAGENT CONSUMPTION 100% BASIS ESTIMATE | | | | |
|---|-----------------------------------|--|--|--|
| Reagent | Life of Mine (Tonnes per Year) | | | |
| Dolomite (Limestone) | 44,000 | | | |
| Lime | 1,400 | | | |
| Magnesia | 3,900 | | | |
| Elemental Sulphur (Used on site to produce acid and SO ₂) | 32,000 | | | |
| H ₂ SO ₄ (produced on site from sulphur) | 99,000 | | | |
| Flocculant | 7 | | | |

MVEIRB Request #29

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

17. A description of the tailings management facility or facilities proposed in existing open pits at Pine Point including storage capacity, operational life of each facility, pit floor conditions and permeability, presence of standing water, distance to groundwater table, rock types, presence of faults, pit wall stability and any containment dams or dykes.



The information need identified by the Review Board is as follows:

The DAR briefly discusses the use of the L-37 pit as the Hydrometallurgical Tailings Facility and the N-42 pit as the discharge point for supernatant water from the HTF. There is no discussion of pit floor conditions and permeability, presence of standing water, distance to groundwater table, rock types, presence of faults, or pit wall stability for either pit. Avalon is deficient for this item from the Terms of Reference – please address these deficiencies.

Avalon Response #29

As discussed in Section 2.9.2.2 of the DAR, the bedrock geology of the Pine Point area has been studied extensively due to past mining activities. Generally the stratigraphy includes sedimentary rocks overlying a west dipping surface or Precambrian igneous and metamorphic rocks. The Pine Point Zn-Pb ore deposits are located within the Presqu'ile barrier reef complex consisting of Devonian carbonates which separates the Mackenzie basin made up of shales and limestones to the north and the Elk Point basin made up of evaporites and carbonates to the south.

The barrier reef complex includes the Sulphur Point formation (limestone/dolostone) and Pine Point (or Upper Keg) formation (dolostone) which are the principle hosts of the Zn-Pb mineralization. Some interpretations include a Presqu'ile formation at the top of the Pine Point formation which is a described as a coarse crystalline dolomite. The mineralization within the barrier reef complex is cited to be due to karstification of the host rocks as the ore bodies are pervasive within interconnected paleokarst networks. Tabular karst is the most common solution network which occurs along a crude stratabound horizon that coincides with the base of the Presqu'ile dolomite.

As stated in Section 2.7.2.2 of the DAR, the Presqu'ile and Pine Point bedrock formations host the main aquifer in the Hydrometallurgical Site area, consisting of highly porous, highly fractured dolomite. Groundwater within the saturated bedrock is expected to flow along solution channels, bedding planes and fractured zones. The permeability of the Presqu'ile aquifer formation is very high with transmissivities in the order of $1 \times 10^{-2} \text{ m}^2/\text{s}$ (GTC 1983).

The current groundwater levels exposed in historic open pits around the Hydrometallurgical Site area are approximately 191 masl, which corresponds to approximately 27 to 32 m below the original ground surface around the pit perimeters. Photos 1 and 2 show the L-37 and N-42 pits, respectively.





Photo 1: L-37 Pit, looking southwest.



Photo 2: N-42 Pit, looking west-southwest.

Investigations are currently underway to better define and understand the conditions associate within and around the L-37 and N-42 pits. This work includes further site reconnaissance, surface mapping, test pitting, drilling and core logging, packer testing and groundwater monitoring well installations. The results of these investigations will be summarized upon completion of the work.

Reference:

GTC Geologic Testing Consultants. 1983. Hydrogeologic Evaluation of the Pine Point - Great Slave Lake Region, GTC Geologic Testing Consultants.



MVEIRB Request #30

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

See the previously described Terms of Reference.

The information need identified by the Review Board is as follows:

Please confirm whether the information for the N-42 pit is included in the input parameters for the groundwater model. If yes, please provide clarification on where these parameters are. If no, please provide results from an updated model that includes these parameters.

Avalon Response #30

As discussed in Section 2.7.2.2 of the DAR, based on work completed by Stevenson (1984), the groundwater flow direction in the Pine Point area is generally northwards towards Great Slave Lake while to the south of the Pine Point area, the groundwater flow direction trends from west to east (see Figure 2.7-4 in the DAR). The local gradient in the northern area is approximately 0.004 towards Great Slave Lake. The average elevation of Great Slave Lake is approximately 156 masl. Groundwater levels exposed in historic open pits around the Hydrometallurgical Site area are approximately 191 masl.

As discussed in Section 6.5.2.1, a groundwater flow model was created (using visual MODFLOW software) to simulate the current hydrogeological flow conditions at the Pine Point site and to estimate the effects of implementing the water management plan for the Hydrometallurgical Site, including the pumping of water from the T-37 pit and the infiltration of excess water into the N-42 pit.

The boundary conditions used in the model included:

- Constant head boundaries to represent Buffalo River and Little Buffalo River;
- River boundaries to represent Great Slave Lake and regional inflow from south of the Pine Point area; and
- Recharge boundary within higher permeability zones to represent infiltration of water at the model surface. Recharge was not applied to areas near Great Slave Lake where groundwater is expected to be discharging.

Several geologic units were used to define the hydrostratigraphic units on site, as presented in Table 6.5-3 (reproduced from the DAR). The aerial extent of each geologic unit was based on the geologic plan of the area, as shown in Figure 6.5-2 in the DAR. The geologic units in the Hydrometallurgical Site area were simplified for the purpose of the model by representing the hydrostratigraphy as a single layer.



| TABLE 6.5-3: PINE POINT REGIONAL HISTORICAL HYDROGEOLOGY SUMMARY AND GROUNDWATER FLOW MODEL – MODELLED HYDROSTRATIGRAPHIC UNITS | | | | | |
|--|------------------------------|----------|--|--|--|
| Hydrostratigraphic Unit | Hydraulic Conductivity (m/s) | Porosity | | | |
| Basal Glacial Till | 1E-08 | 0.1 | | | |
| Slave Point Formation | 5E-08 | 0.001 | | | |
| Watt Mountain Limestones | 5E-07 | 0.01 | | | |
| Presqu'ile Formation | 5E-04 | 0.1 | | | |
| Sulphur Point Formation | 2E-04 | 0.01 | | | |
| Buffalo River Shales | 5E-08 | 0.005 | | | |
| Muskeg Evaporites | 5E-08 | 0.001 | | | |
| Pine Point Formation | 5E-05 | 0.005 | | | |

Source: Knight Piésold (2011h)

Notes:

- 1. Hydraulic conductivity from Geologic Testing Consultants (1983) and adjusted for model simulation.
- 2. Porosity values are assumed based on knowledge of the site and from ranges provided in Domenico and Schwartz (1998).

The model was run using steady state conditions. Hydrogeologic properties and boundary conditions were adjusted to simulate groundwater flow that is consistent with the conceptual model of the site. Modelling results were compared to existing water levels in the historic open pits nearby the proposed Hydrometallurgical Plant Site. Particle tracking was used to simulate the groundwater flow path from the N-42 pit and to estimate the travel time from the N-42 pit to Great Slave Lake.

Based on the conceptual model of the site and the steady state modelling results, groundwater flowing through the N-42 pit would take approximately 80 years to discharge into Great Slave Lake. The average groundwater velocity along the flow path from the N-42 pit to Great Slave Lake was simulated as 0.75 m/day. Within the Presqu'ile Formation, the average simulated velocity was about 0.5 m/day. The travel time estimation assumes that groundwater will not discharge to surface between the N-42 pit and Great Slave Lake.

The baseline groundwater flow model was modified to include pumping of groundwater from the T-37 pit and discharge/infiltration of water into the N-42 pit. This model was completed using transient conditions where pumping and discharge/infiltration was simulated for the projected 20 year operational life. The simulated pumping rate from the T-37 pit was 1,950 m³/day and the simulated discharge rate into the N-42 pit was 420 m³/day, based on the design criteria (presented in KPL memo NB11-00102) and the water/solids balance analysis (presented in KPL memo NB11-00024).

Results of the groundwater flow model suggest that there is expected to be very little effect on the groundwater regime at the Pine Point site in response to the pumping and discharge/infiltration proposed as part of the Hydrometallurgical Site water management plan, given the rates used in the model. Groundwater drawdown in the vicinity of the T-37 pit is estimated to be approximately 1 m below the expected



pre-pumping level after 20 years of pumping. Groundwater levels in the vicinity of the N-42 pit are expected to increase by approximately 0.1 m above the simulated pre-discharge conditions after 20 years of discharge/infiltration.

Particle tracing was used to track flow from the N-42 pit to Great Slave Lake during the 20 year operations life and there were no noticeable effects to the groundwater flow directions or travel times over existing conditions. Figure 6.5-4 in the DAR illustrates simulated piezometric contours and particle tracking for the Pine Point area after 20 years of pumping and discharge. Figure 6.5-5 in the DAR illustrates the expected groundwater drawdown in response to pumping from the T-37 pit.

Reference:

Stevenson International Groundwater Consultants Ltd. 1984. A study of the Great Slave Reef Pine Point Mines Aquifer, based on analyses of selected Pine Point Mines pumping test data, Stevenson International Groundwater Consultants Ltd.

MVEIRB Request #31

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

23. The volume and management of sludge produced at the water treatment facilities.

The information need identified by the Review Board is as follows:

The DAR does not address the management of sludge from the sanitary wastewater treatment facilities, although it does discuss the management of the liquid effluent. Please provide a response to this line item for both sites through all project phases.

Avalon Response #31

Sewage and greywater waste from both the Nechalacho Mine and Flotation Plant site and the Hydrometallurgical Plant site will be processed through the use of modular sewage treatment plants designed to handle the construction and operations workforces at each site. At the Nechalacho Mine site, the treated sewage effluent will report to the tailings sump that will be comingled into the tailings slurry. The slurry will report to the Tailings Management Facility. At the Hydrometallurgical Plant site, the treated effluent will also report to the tailings slurry that will report to the L-37 Pit.

The modular sewage treatment plants from Biodisk Corp., called Little John, each have capacity for approximately 166 persons or 45 m³/day (45,000 litres/day) and can operate within temperature ranges of -40°C to 25°C. The Nechalacho camp is proposed to accommodate 150 persons during operations. The Hydrometallurgical Plant will have approximately 70 people working on-site each day during operations.



The Little John is a complete stand-alone component with wastewater treatment using rotating biological contactor (RBC) as the form of aeration, ultraviolet disinfection, flow meter, effluent pumps, sludge return pumps and RBC cover. It is housed in a 6.1 m (20 ft) insulated container.

The plant includes secondary treatment and effluent disinfection. The effluent at design will meet secondary discharge with 20 mg/litre BOD_5 , 20 mg/litre SS and 500 CFU/100 ml Faecal Coliforms, which is criteria suitable for direct discharge to the receiving environment. The Little John is designed to hold sludge for 6 to 9 months for convenient and occasional disposal. The stored sludge is a source of heat and it can promote the stability of the biological process.

Sludge handling requirements are limited to once or twice per year. The sludge volume is reduced by up to 75% during operations. It can be handled at convenient times without daily or weekly handling requirements.

Sludge from both sites will be stored, as appropriate, for use in progressive or future surface reclamation and revegetation activities.

MVEIRB Request #32

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

30. The water collection, management and treatment systems and all of their component parts, reagents, including drainage and other control structures, water and sewage treatment facilities, water storage facilities, and water transport components. Indicate how treatment systems will function to achieve stated mitigation objectives.

The information need identified by the Review Board is as follows:

The DAR provides a general description of the water treatment systems, but does not provide fully describe how these systems will achieve water quality objectives. Please provide a thorough description sufficient to explain "how treatment systems will function to achieve stated mitigation objectives" for all water collection, treatment and management systems as described in line item 30.

Avalon Response #32

As described in the DAR, the primary effluent "treatment" systems related to the Thor Lake Project will be the Tailings Management Facility (TMF) to be located at the Nechalacho Mine and Flotation Plant site and the Hydrometallurgical Tailings Facility (HTF) at Pine Point. Sewage and greywater treatment at both Project sites was discussed in the response to MVEIRB Request #31.



As also described in the DAR, it is anticipated that the effluent discharged from the TMF will be able to comply with the terms and conditions, including effluent quality criteria, of the future MVLWB Water Licence and the effluent quality criteria of the Metal Mining Effluent Regulations. Based on the predicted quality of the TMF effluent, apart from tailings effluent retention in the TMF to settle the solids, and possible secondary polishing of the decanted effluent in a polishing pond, no further treatment of the TMF effluent is envisaged at this time.

At the Hydrometallurgical Plant site, the process effluent will initially be discharged into the historic L-37 pit which will serve as the Hydrometallurgical Tailings Facility. The supernatant water is subsequently expected to infiltrate into the underground Presqu'ile formation under conditions to be specified in the future MVLWB Water Licence.

As indicated in the DAR, the concentrations of all metals parameters in the tailings water are expected to be lower than or within the same range of concentrations for these parameters in the existing groundwater of the area. In particular, the concentrations of arsenic, mercury, iron, lead and zinc are expected to be lower, and the concentrations of copper and nickel will be within the same range as existing conditions.

The pH of the tailings water is expected to be slightly above neutral (7.7), while conductivity, sodium, chloride and other parameters that contribute to water hardness, including calcium, magnesium and sulphate will be elevated compared to current background conditions.

However, these elevated levels are expected to rapidly diffuse and dilute to natural background values within the Presqu'ile Formation. The radionuclide parameters including ²²⁶Ra, ²²⁸Ra and ²¹⁰Pb are all expected to be at or below detection limits.

Since the projected concentrations of all of the parameters of potential concern will be lower than or within the range of existing conditions, the anticipated effects on groundwater quality are expected to be insignificant. Thus no further form of treatment of the HTF effluent is expected to be required.

MVEIRB Request #33

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

3.3.2: Water quality after mitigation at last point of control (water quality objectives) Section 4.8.4.1 states that water released from the L-37 pit is expected to meet regulatory licensing criteria. During the EA phase the developer is required to predict water quality objectives for effluent into the environment after the last point of control.



The information need identified by the Review Board is as follows:

Please describe the specific water quality objectives (WQO) for discharge of effluent from the hydromet plant end of pipe into the L-37 pit and WQO from the L-37 pit to the N-42 pit.

Avalon Response #33

As described in response to the previous question the concentrations of all metals parameters in the tailings water are expected to be lower than or within the same range of concentrations for these parameters in the existing groundwater of the area. In particular, the concentrations of arsenic, mercury, iron, lead and zinc are expected to be lower, and the concentrations of copper and nickel will be within the same range as existing conditions.

The pH of the tailings water is expected to be slightly above neutral (7.7), while conductivity, sodium, chloride and other parameters that contribute to water hardness, including calcium, magnesium and sulphate will be elevated compared to current background conditions.

However, these elevated levels are expected to rapidly diffuse and dilute to natural background values within the Presqu'ile Formation. The radionuclide parameters including ²²⁶Ra, ²²⁸Ra and ²¹⁰Pb are all expected to be at or below detection limits.

Since the projected concentrations of all of the parameters of potential concern will be lower than or within the range of existing conditions, the anticipated effects on groundwater quality are expected to be insignificant.

Based on the predicted quality of the HTF tailings water, and the relatively poor quality of the existing groundwater in the Pine Point area, Avalon would anticipate that if it is determined that groundwater quality objectives should be established for the HTF tailings water, such objectives should be related to the existing groundwater quality in the area. More specifically, if objectives are deemed to be necessary, they should be based on parameters that could change the quality of the existing groundwater in a potentially negative manner.

Based on the tailings water quality presented in the DAR, Avalon is confident that the infiltration of the HTF tailings water into the Presqu'ile Formation will have minimal and insignificant effects on the groundwater quality of the Pine Point area.