newgold Rainy River Project

APPENDIX T

PREDICTION OF POST-CLOSURE WATER QUALITY

RAINY RIVER

RAINY RIVER RESOURCES LTD.

PREDICTION OF POST-CLOSURE WATER QUALITY

RAINY RIVER GOLD PROJECT
TOWNSHIP OF CHAPPLE, ONTARIO

Rainy River Resources Ltd.
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Thunder Bay, Ontario
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June 2013
TC111504

amec

June 17, 2013
TC111504

Mr. Kyle Stanfield, P.Eng
Vice President, Environment & Sustainability
Rainy River Resources Ltd.
1111 Victoria Avenue East
Thunder Bay, Ontario
P7C 1B7

Dear Mr. Stanfield,

Re: Rainy River Gold Project: Prediction of Post-Closure Water Quality

The following report provides water quality predictions for post-closure conditions the Rainy River Gold Project. Please find enclosed a report outlining the methodology, assumptions and results predicted for the post-closure water quality of the east mine rock stockpile seepage, open pit lake and tailings management area discharge.

If you have any questions, please do not hesitate to contact our office.

Yours truly,

AMEC Environment & Infrastructure
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EXECUTIVE SUMMARY

AMEC Environment & Infrastructure was retained by Rainy River Resources Ltd. to develop mass balance water quality models to predict the long-term water quality for the Rainy River Gold Project (RRGP) site located in northwestern Ontario. Three site features: east mine rock stockpile, the tailings management area (TMA), and the open pit; have previously been identified as requiring mitigation planning to ensure long-term water quality objectives are met. This report describes the models developed to predict the post-closure water quality for these site features.

At closure, the east mine rock stockpile is proposed to be encapsulated with an engineered cover to minimize precipitation and oxygen infiltration to potentially acid generating (PAG) mine rock. Seepage from the east mine rock stockpile will drain to the open pit. The open pit will be flooded, either naturally or in an enhanced manner, to create a pit lake to assist with long term site water management. At the maximum pit lake elevation, the newly formed pit lake will reconnect to the surface water hydrology. The tailings beach exposed at the perimeter of the TMA will be covered by a layer of clay-rich overburden. The remainder of the tailings will be submerged under a water cover.

A simple constant rate mass balance model was developed for the Site. A subset of 362 mine rock samples analysed for acid base accounting and metals content were utilized to determine the propensity of the mine rock to generate metals and acidity. Source terms for non-potentially acid generating (NPAG), non-acidic PAG and acidic PAG mine rock were derived from ongoing humidity cell testing of RRGP mine rock (operating since February 2010).

Two model approaches were used to predict the potential site water quality by identifying the Expected Case and Least Preferred Case conditions for the east mine rock stockpile seepage and the open pit lake. The Expected Case model describes conditions in which the east mine rock stockpile cover limits water and oxygen migration to the encapsulated PAG rock. The open pit will be filled by enhanced drainage to reduce the time of exposure of any mineralized pit walls, and the east stockpile seepage will be discharged to the depths of the pit lake to limit mixing with the upper portion of the pit lake. The Expected Case assumes that the pit lake will be stratified long-term, and mixing will be limited to the upper 30 m of the pit lake. The Least Preferred Case scenario describes conditions where the east rock stockpile cover limits the amount of precipitation infiltration into the east mine rock stockpile; but does not limit the rate of oxygen influx. Under this scenario the pit lake fills by natural drainage, with no additional diversion of site-wide flows, and the east mine rock stockpile seepage discharges to the surface of the pit lake. The Least Preferred Case scenario assumes that the pit lake will undergo complete and continuous vertical mixing.

Both the Expected Case and Least Preferred Case scenarios estimate that the seepage water qualities from the east rock stockpile will be elevated. The Expected Case steady state annual average seepage concentrations are predicted to be below the Ontario Regulation 560/94 Municipal Industrial Strategy for Abatement (MISA) guidelines. The Expected Case initial pit lake concentrations were elevated due to the dominance of the east mine rock stockpile seepage, and decreased to concentrations similar to background values as the pit filling progressed. Annual steady state pit lake discharge concentrations were below all MISA guidelines for the Expected Case scenario.

The Least Preferred Case steady state annual average seepage concentrations were predicted to exceed all MISA guidelines. The Least Preferred Case predicted concentrations were between one and two orders of magnitude greater than the predicted concentrations from the Expected Case scenario east mine rock stockpile seepage. Annual steady state pit lake discharge concentrations gradually increased over time and were predicted to exceed MISA guidelines for arsenic, copper and zinc, and were below MISA guidelines for lead and nickel.

The Expected Case water quality predictions suggest that the pit lake water quality can be managed to produce water quality suitable for direct discharge to the Pinewood River. Loading from the east mine rock stockpile seepage has the greatest impact on the pit lake water quality. Further management of the east mine rock stockpile seepage will result in pit lake discharge water quality being suitable for direct discharge to the environment.

The tailings management area pond was modelled for expected conditions. The tailings pond dilution model assumes that the tailings will remain under cover (clay-rich overburden and/or water) at all times, no additional loading occurs from the submerged tailings; and that loadings were generated from tailings located beneath the covered beach area that were not under water cover. Concentrations steadily decrease and reach steady state levels approximately 20 to 30 years after closure. Active water management may be required during early post-closure years to ensure long-term water quality objectives are achieved.

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1.0 INTRODUCTION

AMEC Environment & Infrastructure (AMEC) was retained by Rainy River Resources Ltd. (RRR) to develop water quality models for the Rainy River Gold Project (RRGP) site. Three areas have been identified as having potential for acid rock drainage and metal leaching (ARD/ML) at the RRGP site post-closure: the east mine rock stockpile, the tailings management area (TMA) and the mineralized open pit walls. Mass balance water quality models were developed to predict the water quality generated from all three areas of concern following closure. The assumptions and source terms for each of the models are described, and model results and interpretation are discussed.

1.1 Site Description

The RRGP site is located in the Township of Chapple, District of Rainy River, ON. The project site is approximately 65 kilometres (km) northwest of Fort Frances, ON. Figure 1 provides the conceptual post-closure site plan. The open pit footprint area is approximately 161 hectares (ha), and the surrounding catchment area to the open pit is approximately 261 ha. The east mine rock stockpile has a footprint area of 329 ha, and the TMA is approximately 1,172 ha.

1.2 Scope of Work

Three models were developed to describe the post-closure water quality of the RRGP site, and include the following components:

- East mine rock stockpile;
- Open pit lake; and
- Tailings management area pond (tailings pond).

The models were developed to evaluate the potential impacts to site drainage from these sources. This report includes the following list of parameters: aluminum, antimony, arsenic, calcium, cadmium, chromium, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, sodium, sulphate and zinc. Total elemental content for other constituents of concern (i.e. selenium, cobalt, mercury etc.) were relatively low, and coincided with low leaching concentrations in experimental testing of the mine rock material.

2.0 CLOSURE SCENARIOS

2.1 East Mine Rock Stockpile

To reduce precipitation infiltration to PAG mine rock, a multilayer cover will be placed over the side slopes of the east mine rock stockpile, and a two layer cover will be placed over the flatter areas progressively during operations and at closure. The east mine rock stockpile will be covered with a multilayer clay-rich overburden and non-potentially acid generating (NPAG) rock cover. Seepage from the east mine rock stockpile will drain to the open pit. The water quality model of the mine rock stockpile drainage will be used to evaluate the impacts on the water quality of the flooded open pit after closure.

2.2 Open Pit

The open pit will be flooded on permanent cessation of mining, either naturally or in an enhanced manner, to create a pit lake to assist with long term site water management. Enhanced flooding will decrease the time that the pit wall rock is exposed to the environment. The open pit will be flooded with natural surface drainage and groundwater, and may be enhanced by the redirection of a portion of the runoff from the Pinewood River catchment during times of seasonally high flows to reduce the flooding timeline. At the maximum pit lake elevation, the newly formed pit lake will discharge to the Pinewood River.

2.3 Tailings Management Area

A water cover will be maintained over a portion of the tailings in the TMA. The central portion of the tailings surface will have enhanced flooding by raising the operating pond surface so that the pond will cover a larger area, but will not extend to the perimeter of the dams. The tailings beach located along the perimeter (continuously or potentially periodically exposed) will be covered by a thick layer of clay-rich overburden. The covered beaches will be approximately 200 m wide and will act as a buffer to ensure the tailings are not exposed during drought conditions. The pond water quality model does not account for any changes in water chemistry once discharged from the pond.

3.0 SOURCE TERMS

The following sections describe the hydrological, volumetric and geochemical source terms that were used for the site. All physical characteristics (e.g., flows, volumes and areas) used in the modelling were based on recent estimates currently being used for the study design.

3.1 Hydrologic Source Terms

A site-wide monthly, deterministic flow (water balance) model was developed to account for site-wide inflows and losses to the system based on monthly meteorological data. Individual excel-based models were developed for the open pit, mine rock stockpile and tailings pond.

Monthly climate data are summarized in Table 1, and key assumptions are summarized below:

- Daily precipitation data from Environment Canada Climate Station 6020559 in Barwick, Ontario from 1979 to 2011 was applied. The mean annual precipitation is 695 mm.

- Evaporation and evapotranspiration data were derived from Atikokan Climate Station (Station 6020379). An average annual pond evaporation of 538 mm was applied.

- Snow accumulation was considered 100% for January and February, and 50% for March, November and December. The annual snow accumulation is 103 mm.

- Snowmelt was assumed to occur in March, April, and May as a percentage of the total snow accumulation and based on the monthly distribution shown in Table 1.

- Precipitation available for runoff was computed in each month as the total precipitation minus the snow accumulation plus the snowmelt (water equivalent).

3.2 Volumetric Source Terms

The assumed areas and volumes for the relevant site components are provided in Table 2.

3.3 Geochemical Source Terms

The geochemical source terms are provided in Table 3, and key assumptions are described below:

- Surface water chemistry from native soils was assumed to be similar to West Creek runoff. Values for West Creek were determined from median values collected at surface water monitoring station #14, collected from June 2010 to December 2012.

- Groundwater quality is reported as the average of groundwater samples collected from 13 monitoring wells located throughout the site from October 2011 to July 2012 (AMEC 2013a).

- Precipitation chemistry was obtained from the National Atmospheric Deposition Program recorded at Voyageur National Park-Sullivan Bay, Minnesota (Site ID MN32). Data was available for sulphate, calcium, magnesium and potassium only. The RRGP is located approximately 100 km northwest of Voyageur National Park. Concentrations were averaged for data collected from 2001 to 2011.

- Loading rates from mine rock material were determined from humidity cell kinetic testing of mine rock core. Median loading rates were determined for the last 20 weeks of experimental data collected (steady state).

- Humidity cell loading rates were corrected for surface area. Surface areas of humidity cells were derived from geometric estimates by grain size measured in a sieved subsample.

- The humidity cell loading rates for mine rock with Neutralization Potential Ratios (NPRs) greater than two were applied to mine rock material that was classified as NPAG.

- Loading rates for mine rock with NPR values less than two were applied to mine rock that was classified as PAG.

- Loading rates for PAG material that had reached acid generating conditions had sulphate loading rates of approximately 18 to 20 mg/kg/wk, and likely do not represent full ARD conditions (>100 mg/kg/wk). Acidic source terms were increased to two orders of magnitude greater than the surface area corrected non-acidic loading rates from PAG cells (equivalent to approximately 570 mg/kg/wk).

- The inflated acidic loading rates were assumed to sustain over time, neglecting the potential decrease in loading rates that may occur following one to three3 decades following the onset of ARD conditions.

4.0 MODEL METHODOLOGY

4.1 Model Approach

Two model approaches were used to predict the potential site water quality by identifying the Expected Case and Least Preferred Case conditions for the east mine rock stockpile seepage and the open pit lake.

Conditions considered in the Expected Case model incorporated conservative assumptions regarding the east mine rock stockpile cover design (for example acidic source terms, convective / diffusive airflow, mine rock surface area, neglected organic carbon content etc.) but assumed that the complex cover would perform as expected in terms of reducing water and oxygen migration to the PAG rock. Inflated acidic source terms were applied to the generation of acid from exposed mineralized open pit walls and fractures throughout the pit walls. The Expected Case model assumed that the pit lake will undergo filling by enhancing drainage into the open pit to reduce the time of exposure of the mineralized open pit walls. The east mine rock stockpile seepage was assumed to be discharged to the depths of the pit lake as to limit mixing with the upper portion of the pit lake. The Expected Case model assumed that the pit lake will permanently stratify due to the temperature and/or density differentials, and that continuous mixing will be limited to the upper 30 m of the pit lake.

The Least Preferred Case model describes conditions in which the cover reduces the amount of precipitation infiltration; but does not limit the rate of oxygen influx into the stockpile. Inflated acidic source terms were applied, and were assumed to be constant over time and equivalent to oxidation rates when exposed to atmospheric conditions. The Least Preferred Case model assumes the open pit will fill slowly over time by natural drainage, with no additional diversion of site-wide flows. The Least Preferred Case model assumes complete mixing within the pit lake water column, and the east mine rock stockpile seepage was assumed to be continuously intermixed within the water column.

The tailings pond was modelled for expected conditions, where no additional loading from the submerged tailings was assumed. The clay-rich overburden covered beach and water cover are expected to perform as designed, where the tailings will remain under cover at all times. The tailings pond dilution model incorporated conservative assumptions where loadings were generated from the tailings beneath the clay-rich overburden beach area, and no loadings were lost due to dam seepage.

4.2 East Mine Rock Stockpile Model

The east mine rock stockpile will be covered with a multilayer clay-rich overburden and NPAG rock cover (Figure 2) to minimize infiltration and reduce oxygen availability to the underlying PAG rock. From top to bottom, the multilayer cover includes the following components:

1) 0.3 m growth media;
2) 0.5 m desiccated clay-rich overburden;
3) 2 m compacted clay-rich overburden;
4) 5 m NPAG; and
5) 1 m compacted clay-rich overburden (on stockpile slopes only).

A mass balance model for the proposed east mine rock stockpile was developed to estimate post-closure water quality of seepage from the covered stockpile. The mine rock stockpile seepage will be collected and managed throughout operations. At closure, the east mine rock stockpile drainage will be collected in the mine rock pond at the base of the stockpile and from there, directed to the open pit to facilitate flooding of the pit. Later in closure the east mine rock stockpile seepage may be directed to depth in the pit lake where natural reductive processes will reduce or eliminate the potential impacts from this water on the overall pit lake water quality.

Modelled Scenarios

Considering variability in cover performance, two models were developed to simulate seepage water quality from the east mine rock stockpile:

1) Expected Case: limits percolating water and oxygen availability to PAG mine rock; and

2) Least Preferred Case: limits percolating water, with no limitation of oxygen availability to PAG mine rock.

Cover Infiltration

A monthly water balance was determined for the east mine rock stockpile cover design, where runoff, evapotranspiration and percolation values were generated. The Hydraulic Evaluation of Landfill Performance (HELP) model version 3.07 was utilised to simulate percolation through the cover. Based on the current design, the east mine rock stockpile will have side slopes of 6H: 1V and 8H: 1V. The HELP model was utilised to examine the percolation through both the upper and lower clay-rich overburden layers. The model was compiled based on the following assumptions:

- The clay-rich material for the east mine rock stockpile cover will be obtained from the local overburden at the RRGP, and was assumed to have values typical of those presented in *Rainy River Gold Project Geotechnical and Hydrogeological Site Investigations, Rainy River, Ontario, Version 3.1* (AMEC 2013a).

- The upper 50 cm of the clay-rich overburden was assumed to be desiccated due to the freeze / thaw cycles at the RRGP (Benson et al., 1995).

- Runoff, evapotranspiration and percolation values were generated for 24 different scenarios that varied the hydraulic conductivity and depth of the desiccated clay-rich overburden. The results of the sensitivity analysis are reported in Appendix A.

- Percolation through the exterior clay-rich overburden layer was assumed to be 10.7% on the top and side slopes, and percolation through the interior clay-rich overburden layer on the slopes was 7.2%.

Sulphide Oxidation

The rate of acid generation and metal leaching within the east mine rock stockpile is assumed to be entirely dependent on the rate of sulphide oxidation. In addition to limiting percolation, the cover may result in decreased oxygen content within the stockpile that could limit sulphide oxidation.

The model methodology is based on the results of the geochemical testing program that determined pyrite to be the primary sulphide bearing mineral in the PAG mine rock. The rate of pyrite oxidation is dependent on the interaction of oxygen with the pyrite located on the mine rock surfaces. The predicted east mine rock stockpile seepage water quality was governed, and is simplified by the following equation:

$$FeS_2 + H_2O + 3.5O_2 \rightarrow 2H^+ + 2SO_4{}^{2-} + Fe^{2+} \qquad \text{Equation 1}$$

Sources of oxygen within the covered stockpile may include the initial void space oxygen content, infiltrating water, in addition to any diffusive and convective flow that may develop through a desiccated cover. The Expected Case cover performance scenario represents conditions in which the surface layer of the cover is maintained over time, and will hinder oxygen transport and availability within the east mine rock stockpile relative to rock exposed to atmospheric conditions. The Least Preferred Case cover performance scenario assumes sulphide oxidation is independent of oxygen content, and is governed by the rate of sulphide oxidation as determined by humidity cell testing.

Airflow

Diffusive and convective airflow were considered as mechanisms for the transport of oxygen into the interior of the covered mine rock pile for the Expected Case scenario. The Least Preferred Case scenario assumed continuous atmospheric oxygen content within the interior of the east mine rock stockpile.

<u>Diffusive Airflow</u>

Diffusive airflow through the cover was estimated using Fick's first law. Fick's law of diffusion describes the flux of oxygen from the atmosphere to the interior of the stockpile, and is governed by the following equation:

$$J = -D_e \frac{\delta C}{\delta z} \qquad \text{Equation 2}$$

Diffusive flux of oxygen J (mg/m^2/s) is governed by the concentration gradient δC (mg/m^3) and the thickness of the cover δz (m). The effective diffusivity D_e was calculated based on methods used to describe oxygen diffusion in tailings (Elberling et al. 1993). The degree of saturation of the clay-rich overburden cover was assumed to be maintained at 90%. The diffusive flux through the clay-rich overburden was calculated as a function of the internal and external oxygen content of the stockpile (C/C_o) on a monthly basis.

Convective Airflow

Convective and/or advective flow can result in accelerated movement of air through the cover and mine rock stockpile due to temperature and pressure gradients, the composition of the gas within the stockpile (Wels et al., 2003), and predominant wind speed and direction (Amos et al. 2009). Deep fractures inevitably occur in all cover systems due to mine rock settling over time and desiccation due to weathering. Assuming that deep fractures (50 µm apertures) will occur every 50 cm throughout the cover, the calculated permeability of the clay-rich overburden was $4.2E^{-14}$ m^2. Similar results were discussed for the study at the Questa mine site (Wels et. al. 2003) and results from Diavik (Pham 2013 pers. comm.) which suggest that little convective airflow would occur through a cover with this permeability.

In order to account for the possibility of convective flow through cracks and minor failures in the cover, atmospheric oxygen was assumed to influence 1% of the PAG rock volume (at any given time, 1% of the PAG material within the east mine rock stockpile was exposed to atmospheric oxygen content). The convective air flow into the stockpile was constant and neglected the influence of barometric pumping.

Model Assumptions

The following summarizes the key sources and constraints for the prediction of seepage water quality for the covered east mine rock stockpile:

- Simple constant rate mass balance model;
- Source terms for the NPAG, non-acidic PAG and acidic PAG were derived from ongoing humidity cell testing of RRGP mine rock;
- Due to the low loading rates observed in currently acidic (pH of approximately 4) PAG rock humidity cells, acidic PAG source terms were derived from non-acidic PAG loading rates multiplied by 100 (two orders of magnitude);
- The proportional void space volume in the rock stockpiles was 22.5% of the total volume;
- Based on experience at other projects, the waste rock surface area was assumed to be 50 m^2/tonne; and

- All (100%) of the rock stockpile surfaces were assumed to contribute loadings (independent of moisture content/flow volume).

The following summarizes the key sources and constraints specific to the Expected Case scenario for the east mine rock stockpile cover design:

- Initial oxygen concentrations within the void space of the covered stockpile were equal to atmospheric levels (21.1%);
- Oxygen content of infiltrating water is 10 mg/L;
- The diffusive flux through the clay-rich overburden was calculated as a function of the internal and external oxygen content (C/C_o) on a monthly basis;
- No oxygen was consumed within the clay-rich overburden (no organic content or microbial activity);
- Maintenance of the cover is assumed to be ongoing through closure to mitigate the effects of any observed deep cracks or failures in the outer clay-rich layer;
- The initial atmospheric oxygen content was assumed to decrease due to consumption by sulphide oxidation until a steady state condition was achieved where the rate of sulphide oxidation was controlled by the rate of oxygen ingress (infiltration / diffusion / convection) through the cover; and
- The distribution of oxygen within the rock stockpile was not considered. All oxygen passing through the cover was assumed to distribute evenly throughout the void spaces.

The following summarizes the key sources and constraints specific to the Least Preferred Case scenario for the east mine rock stockpile cover design:

- Oxygen concentrations within the void space of the covered stockpile were equal to atmospheric levels (21.1%) at all times;
- The distribution of oxygen within the mine rock stockpile was not considered. The influence of barometric pumping was disregarded as oxygen was assumed to be evenly distributed in void spaces; and
- Sulphide oxidation rates were assumed to be constant over time.

4.3 Pit Lake Model

At closure, the open pit will be flooded to create a pit lake. A mass balance water quality model was developed to assess the open pit water quality during and after flooding, in order to assess potential requirements for water treatment. The water management strategy may include either passive flooding through natural runoff, groundwater and precipitation inputs or by active filling of the open pit using diverted flows. The catchment areas and runoff coefficients were taken from AMEC's surface water flow model (AMEC 2013c).

The pit lake water quality was modelled to predict Expected Case and Least Preferred Case conditions. The specifications for both scenarios are described below:

<u>Expected Case:</u>

- Enhanced drainage to facilitate the pit flooding by optimizing the utilization of drainage from the site. Inflows include drainage from the east mine rock stockpile, a portion of runoff from the west mine rock and overburden stockpiles, direct precipitation on the pit and its perimeter, and natural drainage from upstream West Creek catchment (limited to 20% of the Pinewood watershed flows);

- Acidic mine rock source terms of 100 times those of currently non-acidic NPR<2 humidity cell rates;

- Inflow of east mine rock stockpile seepage water quality corresponding to that described in the Expected Case scenario;

- East mine rock stockpile seepage is directed to depth in the pit lake; and

- Permanent stratification of the pit lake water column (meromictic).

<u>Least Preferred Case:</u>

- Limited diversion of site runoff to pit. Inflows include direct precipitation on the pit and its perimeter, natural drainage from upstream West Creek catchment, and the diversion of east mine rock stockpile seepage (less than 20% of the Pinewood watershed flows);

- Acidic mine rock source terms of 100 times those of non-acidic NPR<2 humidity cell rates;

- Inflow of east mine rock stockpile seepage water quality corresponding to that described in the Least Preferred Case scenario;

- East mine rock stockpile seepage is directed to the pit lake surface; and
- Continuous vertical mixing within the pit lake water column.

Allowable Water Diversions

The monthly flow available in the Pinewood River just downstream of the confluence with Loslo Creek was determined using historical precipitation data and flow data based on the total catchment area of 10,700 ha. Daily precipitation data from the Barwick, Ontario climate station and flow data from the Pinewood River near Pinewood (Environment Canada gauge 05PC011) from the period of 1979 to 1998 was used.

Flow in the Pinewood was estimated using the upstream catchment areas of tributaries to the Pinewood River. A runoff coefficient of 26% was applied (AMEC 2013b). Flow taken from these catchments is considered as water taken from Pinewood River. The maximum allowable water takings from Pinewood River were assumed to be 20% during the spring melt (March to May), 15% during the summer and fall (June to November), and zero in the winter.

Groundwater Sources

A MODFLOW groundwater flow model was developed to estimate groundwater seepage rates into the fully dewatered pit and underground mine workings (AMEC 2013c), and was modified to estimate groundwater seepage rates into the partially flooded open pit after closure. Using this model, groundwater contribution to the partially flooded open pit was estimated at six flooding elevations. The modified groundwater flow model was run in steady-state mode for each successive flooded elevation and groundwater inflow rates were calculated. The approach assumed that redistribution of aquifer hydraulic head in response to changes in flooded pit elevation would occur faster than the rise of water level in the partially flooded pit.

The provided groundwater seepage rates were fitted to the rational formula:

$$y = \frac{a + bx}{1 + cx + dx^2} \qquad \text{Equation 3}$$

where y represents the groundwater inflow rate (m^3/day), x represents the pit elevation (m), a is 3300, b is -8.7, c is $2.4E^{-3}$ and d is $-4.3E^{-7}$, and yielded a correlation coefficient of 0.999. Groundwater inflow rates do not exceed 3,400 m^3/day, and decrease to 0 m^3/day as the pit lake elevation approaches 350 meters above sea level (masl). During the winter months (January and February), the groundwater component is the sole source of inflow into the open pit. Once the pit floods to the natural ground surface elevation, the pit lake will discharge into the Pinewood River.

Model Assumptions

The following summarizes the key sources and constraints assumed for the pit lake model:

- The open pit characteristics were determined based on Feasibility Study design criteria (Pit F);

- Total pit lake volume was estimated to be 249,770,550 cubic metres (m^3) when full;

- A stage storage curve was developed for each bench height and was interpolated to estimate the pit volume, pit wall surface area, and pit lake surface area;

- The overburden slopes of the pit lake range between 3 horizontal width to 1 vertical height (3H:1V to 4H:1V);

- The volume of the underground mine workings is less than 2% of that of the open pit volume, therefore the time to flood the underground workings is minor and is considered negligible;

- Seepage from the pit lake to groundwater is considered negligible;

- Once the pit lake surface elevation reaches the natural surface elevation (350 masl), groundwater seepage was excluded from pit lake inflows;

- Pit lake evaporation was a function of exposed lake surface area. Maximum pit lake evaporation was 1,011,659 m^3/a;

- To account for the additional surface area due to irregularities from faults and fractures on the rock surfaces, a fracture factor of 50 times the estimated pit wall surface area was applied;

- The proportion of pit wall PAG and NPAG was determined based on the current geologic block model for the open pit;

- Pit wall loadings were calculated based on humidity cell loading rates;

- All exposed PAG rock on the mineralized open pit walls was considered to be acidic at closure;

- To account for temperature effects, loading rates from the mineralized pit walls and PAG mine rock were decreased to 20% for the months of November, December, January and February, when average temperatures were assumed to be near or below freezing. The loadings generated during times of snow accumulation (January and February) were accounted for in the spring freshet;

- Once the pit lake elevation reached surface elevation and began to overflow, pit lake load was lost due to discharge;

- Metal loadings were completely flushed from the mineralized pit walls each month; no metals were retained on the pit walls due to precipitation of secondary minerals and/or adsorption reactions; and

- No metal loadings occurred from submerged mineralized open pit walls.

Mixing Scenarios

Vertical mixing within the pit lake is largely influenced by surface wind and temperature/density dependent seasonal turnover (Castendyk and Edmondary 1999). The pit lake is estimated to be approximately 350 m deep to the top of the bedrock and 415 m deep to the top of the overburden surface, and will likely result in incomplete vertical mixing within the water column. The bottom waters of pit lakes in temperate climates may become permanently disconnected from the surface waters, and may result in the formation of an anaerobic bottom layer.

At closure, the east mine rock stockpile seepage may be directed to depth in the pit lake, where natural reductive processes will reduce or eliminate the potential impacts from this water on the overall pit lake discharge water quality. However, differences in temperature, density, oxygen content and water chemistry of the east mine rock stockpile drainage relative to the bottom waters of the pit lake may influence mixing.

To account for the uncertainty in the pit lake mixing process, the pit lake water quality was modelled for the Expected and Least Preferred Case scenarios (Figure 3):

- Expected Case: meromictic system with continuous mixing occurring only in the epilimnion layer (east mine rock stockpile seepage was pumped to depth within the hypolimnion and does not reach the epilimnion); and

- Least Preferred Case: complete and continuous vertical mixing.

The meromictic model assumes that when the pit lake reaches approximately 300 m deep, stratification occurs and mixing is limited to the pit lake epilimnion (incomplete seasonal turnover). Based on field observations and predictive pit lake modelling at other locations, the epilimnion may range from 7 to 30 m deep (Sanchez-Espana et al. 2008; Gammons and Duaime 2006; Fisher and Lawrence 2006). The depth of the epilimnion was assumed to be 30 m, resulting in a steady state total mixing volume of 52,989,744 m^3.

4.4 Tailings Pond Model

A simple dilution model was developed to predict water quality of the tailings pond discharge post-closure. The tailings will be covered by a water cover approximately 1.15 m deep (Figure 4). The following summarizes the key sources and constraints assumed for the tailings pond water quality model:

- Pond water quality at time of closure is equivalent to the results of current 60 day aging tests on simulated tailings;
- During closure, the only inflows to the tailings pond will be direct precipitation and runoff;
- Approximately 400,000 m^2 of tailings beach will exist at closure. However this beach will be covered by a vegetated clay-rich overburden cover approximately 2 m thick. The cover will reduce infiltration and isolate the tailings from direct exposure to the atmosphere;
- Water infiltration through the clay-rich overburden cover is 15%. The overburden cover is assumed to be fully saturated;
- Tailings submerged under the water cover are assumed to be inert, and do not add load to the tailings pond;
- Average annual tailings dam seepage of approximately 360,000 m^3/a;
- Dam seepage will not result in a load reduction from the pond water;
- At closure, no additional settling / compaction of the tailings will occur; and
- Water in the pond was assumed to be completely mixed prior to discharge.

4.5 Geochemical Equilibration

Geochemical modeling was performed using PHREEQC (Parkhurst and Appelo 1999). PHREEQC modelling accounts for mineral saturation and the effects of pH on total metal concentrations in the resulting solution. Water quality and proportional volume inputs from this model were mixed and geochemically equilibrated to produce estimated concentrations in the pit water, east mine rock stockpile seepage and tailings pond.

The pH of the pit lake water was estimated by assigning a low pH (3) to the east mine rock stockpile seepage and pit wall runoff water, and was mixed with the remaining pit lake volume assuming near-neutral pH values from all other pit lake inputs.

5.0 RESULTS AND INTERPRETATION

5.1 East Mine Rock Stockpile Drainage

The equilibrated time series east mine rock stockpile seepage concentrations for the Expected Case and Least Preferred Case scenarios are provided in Table 4. Annual average concentrations were estimated from equilibrated monthly water quality estimates. Monthly estimates for sulphate, cadmium, copper and zinc for the initial five years following closure are provided in Figures 5 to 8. The predicted concentrations do not consider dilution due to mixing with other water sources upon drainage / collection. The model does not consider the contribution of biotic reductive processes that may occur in the presence of dissolved organic carbon and facilitative reducing bacteria.

Expected Case East Mine Rock Stockpile Seepage

- Monthly variability was attributed to the fluctuation in infiltration precipitation through the rock stockpile cover, and the rate of sulphide oxidation was influenced by the diffusive and convective transport of oxygen into the stockpile.
- Elevated concentrations within the initial 24 months following closure are due to the presence of atmospheric oxygen levels within the rock stockpile void space. Steady state values are obtained as atmospheric oxygen is consumed, and sulphide oxidation is governed by the inflow of oxygen from infiltration, diffusion and convection processes.
- Elevated concentrations were predicted during the time of the spring freshet due to the flushing of accumulated oxidation products within the winter months.
- The predicted steady state sulphate concentrations range from 830 to 4,340 mg/L, with an annual average concentration of approximately 1,300 mg/L.
- Concentrations of copper and zinc are similar in value, with annual average steady state concentrations of 0.14 mg/L. Concentrations of copper range from 0.07 to 0.86 mg/L, and concentrations of zinc range from 0.07 to 0.88 mg/L.
- Concentrations a cadmium range from 0.006 mg/L to 0.075 mg/L, with an annual average steady state concentration of 0.012 mg/L.

- The average annual seepage concentrations for copper, zinc, arsenic, lead and nickel were all below O. Reg 560/94 MISA guidelines. The predicted water quality of the east mine rock stockpile seepage exceeded all values established for the Provincial Water Quality Objectives (PWQO) for the protection of aquatic life, with the exception of molybdenum.

- Seepage concentrations may be lower than predicted due to the development of preferential flow paths within the east mine rock stockpile, and may limit the rock surface area flushed by percolating water. Solubility controls may also result in lower concentrations in the seepage water.

Least Preferred Case East Mine Rock Stockpile Seepage

- The variability of the predicted Least Preferred Case scenario east mine rock stockpile seepage concentrations is less than the variability observed in the Expected Case scenario as sulphide oxidation rates were a function of loading rates rather than limited by oxygen availability.

- Elevated concentrations were predicted during the time of the spring freshet due to the flushing of accumulated oxidation products within the winter months.

- Average annual steady state sulphate concentrations were predicted to be approximately 35,000 mg/L, annual concentrations for copper and zinc were approximately 8 mg/L and cadmium concentrations were 0.7 mg/L.

- Concentrations exceed values for O.Reg 560/94 and PWQO.

- The predicted concentrations were between one and two orders of magnitude greater than the predicted concentrations from the Expected Case scenario, with the exception of calcium.

- Elevated concentrations of sulphate and low pH in the seepage water will likely result in the precipitation of sulphate minerals (such as gypsum). Concentrations of calcium in the Least Preferred Case east mine rock stockpile seepage water quality predictions were low relative to the predicted Expected Case concentrations due to mineral precipitation.

- The east mine rock stockpile seepage is collected within the mine rock pond, and the pond waters were assumed to be at equilibrium with atmospheric PCO_2. Due to the assumed oxidative conditions of the mine rock pond, the redox potential for the modelled scenario maintained aerobic conditions over time, and did not favour the formation of reduced minerals.

- The model was designed to simulate worst case conditions with many conservative assumptions. Concentrations in the east mine rock seepage waters will likely be lower than the predicted Least Preferred Case water quality due to solubility limitations.

5.2 Pit Lake Water Quality

Loadings from surface water runoff, precipitation, groundwater and east mine rock stockpile seepage were estimated to flow into the open pit over time. Seepage from the east mine rock stockpile is assumed to be collected in the mine rock pond and exposed to atmospheric conditions for a period of time before being diverted to the open pit.

The initial discharge concentrations and steady state pit lake concentrations for the Expected Case and Least Preferred Case pit lake water quality scenarios are provided in Table 5. Estimates for pit lake water quality discharge concentrations over time are provided in Figures 9 to 25.

Expected Pit Lake Water Quality

The Expected Case pit lake scenario assumes permanent stratification will be achieved over time. Complete vertical mixing (i.e. constant concentrations with depth) was assumed until a pit lake depth of 300 m (corresponding to a pit lake surface elevation of 260 masl) was achieved. Once the pit lake depth is greater than 300 m, the provided pit lake concentrations describe the upper 30 m of the pit lake only, and assume the bottom waters are completely disconnected from the epilimnion layer. Seepage from the east mine rock stockpile was assumed to be pumped to depth, with no further influence on the upper pit lake water quality after stratification is assumed.

- Pit lake concentrations are initially high due to the dominance of the east mine rock stockpile seepage.

- At approximately 25 years after closure, the pit lake depth is predicted to be 300 m, at which time the pit lake waters are assumed to become stratified. Concentrations generally increase corresponding to the onset of lake stratification, and are due to loading from the mineralized open pit walls and the lesser total mixing volume of the epilimnion layer (approximately 22,000,000 to 53,000,000 m^3).

- At approximately 72 years after closure, the pit lake is predicted to reach the spillway discharge elevation (about 374 masl). Offloading of constituents due to pit lake discharge results in decreasing pit lake concentrations over time.

- Initial and steady state concentrations were below all MISA guidelines. Steady state concentrations were below PWQO values for all modelled parameters with the exception of aluminium and chromium.

- Initial sulphate discharge concentrations are approximately 170 mg/L, and long term steady state concentrations are approximately 33 mg/L.

- Initial discharge concentrations of copper and zinc are approximately 0.05 mg/L, and decrease to 0.0006 mg/L at steady state.

- Concentrations of cadmium are about 0.0012 mg/L at the time of initial discharge, and steady state concentrations are approximately 0.000028 mg/L.

- Steady state concentrations at 300 years post-closure approach levels similar to background surface water.

Least Preferred Case Pit Lake Water Quality

The Least Preferred Case pit lake scenario assumes continuous and complete vertical mixing of the pit lake over time. The model integrated many conservative assumptions and neglects influences of seasonal stratification. The Least Preferred Case scenario neglects the potential development of anaerobic zones that are conducive to the formation of reduced minerals. The water quality of the pit lake discharge will likely be lower than the reported Least Preferred Case predictions.

- Pit lake concentrations gradually increase over time and approach steady state concentrations at approximately 300 years.

- Concentrations of sulphate were approximately 3,300 mg/L at the time of initial discharge to the Pinewood, and were approximately 4,800 mg/L at steady state.

- Initial discharge concentrations of copper and zinc were about 0.7 mg/L and were predicted to reach steady state concentrations of approximately 1 mg/L.

- Concentrations for cadmium were approximately 0.06 mg/L at the time of initial discharge, and increased to approximately 0.1 mg/L at steady state.

- Concentrations were above MISA guidelines for copper, zinc and arsenic, and were below MISA guidelines for lead and nickel. All concentrations exceeded PWQO values.

- Conditions were favourable for the precipitation of gypsum, resulting in decreasing calcium concentrations over time within the pit lake column. Concentrations of calcium were low relative to the Base Case scenario as a result of elevated sulphate resulting in greater precipitation of gypsum.

5.3 Tailings Pond Water Quality

Estimated annual average water quality for the tailings pond discharge is presented in Table 5. The tailings pond discharge water quality over time is presented in Figures 26 to 42.

- The tailings pond model is a simple dilution model wherein initial pond concentrations are diluted over time until local ambient water quality is reached.
- Some loading from seepage derived from the covered tailings beaches occurs, but the overall effect is minimal.
- The model does not take into account any potential loading from pore water released from compacting tailings, mineral dissolution under subaqueous conditions, or oxidation of suspended tailings in the near surface of the water cover.
- Concentrations steadily decrease and reach steady state levels approximately 20 to 30 years after closure.
- Concentrations of sulphate are initially 100 mg/L and decrease to steady state concentrations of about 9 mg/L 20 years after closure.
- Initial concentrations of cadmium were 0.001 mg/L and decreased to $2E^{-6}$ mg/L. Initial concentrations of zinc were 0.06 mg/L and decreased to 0.02 µg/L. Initial concentrations of copper were 0.008 mg/L and decreased to 0.007 µg/L.
- Concentrations of the cadmium, zinc, copper and antimony exceed their applicable regulatory values for the first one to five years after closure. All other regulated concentrations were below PWQO values.

6.0 CONCLUSIONS

Based on the model results for the Expected Case and Least Preferred Case scenarios, the following preliminary conclusions and recommendations are made:

- The seepage water qualities from the east mine rock stockpile are estimated to be generally elevated; however the volume of seepage is relatively low due to reduced percolation through the clay-rich overburden cover (about 230,000 m^3 per year).

- Seepage concentrations from the east mine rock stockpile are likely exaggerated as the models do not consider the development of preferential flow of percolating waters. The assumed rates of sulphide oxidation are elevated relative to rates observed in high sulphide low carbonate deposits, and may not persist over time.

- The Expected Case water quality predictions suggest that the pit lake water quality can be managed to produce water quality suitable for direct discharge to the Pinewood River.

- Loading from the east mine rock stockpile seepage has the greatest impact on the pit lake water quality. Removal or treatment of the east mine rock stockpile seepage will result in pit lake discharge water quality suitable for direct discharge to the Pinewood River.

- Enhanced flooding of the pit lake will likely result in more favourable pit lake water quality in a shorter period of time.

- Tailings pond discharge water quality is predicted to progressively improve in concentration to ambient levels over 20 to 30 years after closure, and may be suitable for direct discharge to the environment.

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Table 1: Monthly Climate Data

Month	Precipitation (mm)	Snow Accumulation (mm)	Snowmelt (mm)	Precipitation and Snowmelt (mm)	Lake Evaporation (mm)
Jan	28.3	28.3	0	0	0
Feb	24.1	24.1	0	0	0
Mar	29.7	14.9	12.4	27.204	0
Apr	40.0	0	71.0	111.0355	0
May	68.3	0	19.6	87.8605	109
Jun	113.8	0	0	113.8	110
Jul	99.0	0	0	99	129
Aug	84.0	0	0	84	104
Sep	80.0	0	0	80	63
Oct	56.2	0	0	56.2	23
Nov	41.7	20.9	0	20.85	0
Dec	29.7	14.9	0	14.85	0
Total	694.8	103	103	694.8	538

Table 2: Volumetric Source Terms

Description	Area (ha)	Volume (m^3)	Runoff Coefficient
Open pit	161	249,770,550	90%
East mine rock stockpile	329	98,000,000	18%
Tailings pond	741	8,400,000	90%
Areas surrounding open pit	261	--	30%
Stockpile pond north	331	--	33%
Mine rock pond	101	--	90%
West mine rock stockpile	250	--	47%
Overburden stockpile	228	--	42%
Natural runoff from overburden and west rock stockpiles	104	--	45%
Tailings management area (TMA)	1172	--	74%
Exposed clay-rich overburden cover in TMA	40	--	42%

Table 3: Geochemical Source Terms

Source Term	Surface Water (mg/L	Groundwater (mg/L	Precipitation (mg/L)	Humidity Cells Source Terms			Inflated Acidic Source Terms
				Non-acidic (mg/m^2/month)		Acidic (mg/m^2/month)	100X Non-acidic PAG (mg/m^2/month)
Sulphate	3.40E+01	3.47E+01	6.00E-01	2.15E+00	3.63E+00	9.89E+00	363
Arsenic	7.02E-04	1.61E-02	--	2.04E-04	4.39E-04	1.59E-04	4.39E-02
Copper	6.39E-04	6.49E-02	--	5.17E-04	2.69E-04	2.06E-01	2.69E-02
Lead	1.77E-04	2.39E-02	--	1.31E-05	1.06E-05	1.52E-03	1.06E-03
Nickel	8.33E-04	6.27E-02	--	8.98E-05	9.98E-05	1.80E-03	9.98E-03
Zinc	4.11E-03	1.64E-01	--	5.94E-04	1.01E-03	1.39E-02	1.01E-01
Aluminum	8.47E-02	1.84E+01	--	3.31E-02	2.88E-02	6.68E-01	2.88E+00
Antimony	2.50E-04	5.74E-04	--	2.68E-04	2.25E-04	1.59E-04	2.25E-02
Beryllium	1.34E-04	5.62E-04	--	8.69E-06	8.21E-06	3.70E-05	8.21E-04
Bismuth	2.80E-04	5.47E-04	--	4.42E-06	4.28E-06	2.53E-06	4.28E-04
Boron	5.23E-03	1.01E-01	--	9.04E-04	1.11E-03	6.44E-04	1.11E-01
Cadmium	2.93E-05	5.78E-04	--	1.14E-05	2.54E-05	6.79E-05	2.54E-03
Chromium	1.44E-03	4.33E-02	--	2.17E-04	2.05E-04	9.97E-04	2.05E-02
Cobalt	4.27E-04	7.40E-03	--	1.49E-05	2.07E-05	2.75E-03	2.07E-03
Iron	5.36E-01	1.85E+01	--	2.46E-03	3.26E-03	2.80E-01	3.26E-01
Lithium	2.18E-03	5.62E-02	--	4.34E-04	5.31E-04	8.57E-04	5.31E-02
Manganese	2.38E-01	5.77E-01	--	1.11E-02	8.31E-03	2.20E-02	8.31E-01
Mercury	1.00E-05	1.22E-05	--	4.56E-03	4.27E-03	3.63E-03	4.27E-01
Molybdenum	2.98E-04	1.97E-02	--	3.84E-05	4.80E-05	3.01E-04	4.80E-03
Selenium	1.09E-03	1.93E-03	--	2.04E-05	3.40E-05	9.13E-05	3.40E-03
Silicon	3.66E+00	--	--	1.42E-01	1.55E-01	2.11E-01	1.55E+01
Silver	3.93E-05	1.56E-04	--	5.42E-06	6.68E-06	6.68E-06	6.68E-04
Strontium	3.19E-02	5.77E-01	--	1.15E-02	1.18E-02	3.38E-03	1.18E+00
Tin	2.55E-04	4.61E-04	--	1.22E-04	6.16E-05	1.10E-04	6.16E-03
Titanium	2.78E-03	9.91E-02	--	5.82E-05	5.79E-05	3.82E-05	5.79E-03
Thallium	2.14E-05	5.14E-04	--	1.13E-05	2.08E-05	2.58E-05	2.08E-03
Uranium	4.98E-05	7.23E-03	--	1.51E-06	2.33E-06	2.57E-04	2.33E-04
Vanadium	3.95E-04	1.87E-02	--	2.57E-04	1.75E-04	3.94E-05	1.75E-02
Zirconium	3.13E-04	1.20E-03	--	9.66E-06	4.84E-06	3.96E-06	4.84E-04
Calcium	1.98E+01	1.92E+02	1.67E-01	2.38E+00	2.77E+00	7.85E-01	2.77E+02
Magnesium	7.91E+00	7.01E+01	2.54E-02	2.59E-01	1.99E-01	1.53E-01	1.99E+01
Barium	1.17E-02	3.23E-01	--	6.33E-04	1.09E-03	1.56E-03	1.09E-01
Sodium	1.11E+00	1.64E+01	2.19E-02	4.84E-02	7.74E-02	1.13E-01	7.74E+00
Potassium	6.62E-01	7.59E+00	1.74E-02	8.02E-02	1.22E-01	5.16E-02	1.22E+01
Phosphorous	2.41E-02	2.95E+00	--	4.04E-03	3.87E-03	4.96E-03	3.87E-01
Alkalinity	7.34E+01	3.57E+02	--	6.83E+00	5.31E+00	5.01E-03	5.31E+02

Table 4: Steady State Annual East Mine Rock Stockpile Seepage Results

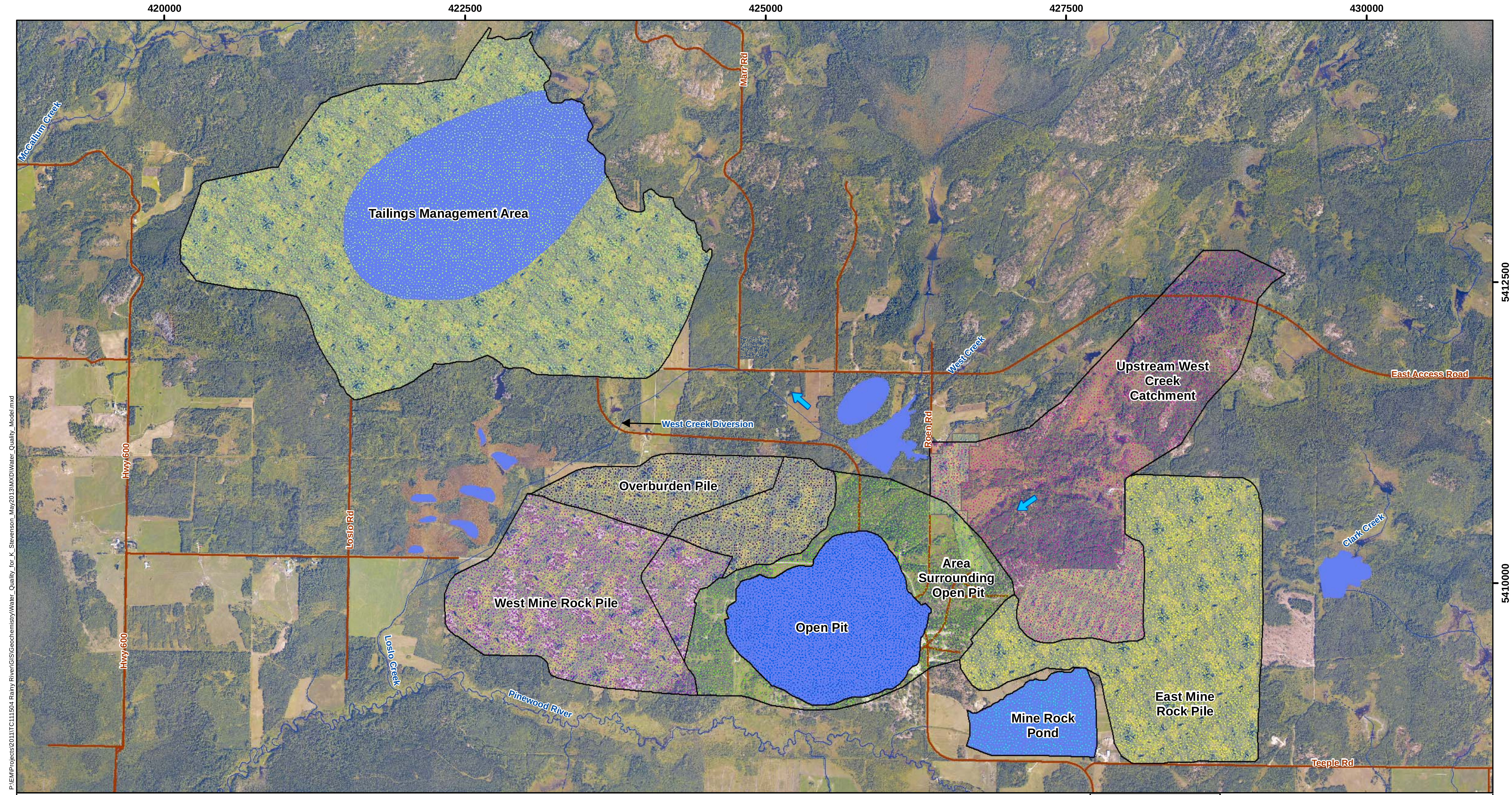
Parameter (mg/L)	Base Case Cover Performance	Least Preferred Case Cover Performance	PWQO	O.Reg 560/94
SO_4	1,296	35,474		
Cd	0.012	0.7	0.0002	
Cu	0.14	7.5	0.005	0.2
Zn	0.14	8.3	0.03	0.5
Ca	636	339		
Mg	97	5,550		
Na	36	2,161		
K	57	3,410		
Mn	4.1	232		
Fe	1.5	91	0.3	
As	0.20	12	0.1	0.5
Al	14	797	0.015	
Sb	0.11	6.0	0.02	
Cr	0.10	5.7	0.001	
Pb	0.005	0.30	0.005	0.2
Ni	0.047	2.8	0.025	0.5
Mo	0.023	1.3	0.04	

Table 5: Pit Lake Discharge Concentrations

Discharge (mg/L)	Base Case		Least Preferred Case		PWQO	O.Reg 560/94
	Initial Discharge	Steady State	Initial Discharge	Steady State		
Years	72	300	94	300		
SO_4	167	33	3,336	4,835		
Cd	0.0012	0.000028	0.06	0.10	0.0002	
Cu	0.049	0.00059	0.7	1.0	0.005	0.2
Zn	0.050	0.00061	0.7	1.0	0.03	0.5
Ca	248	19	278	132		
Mg	66	7.5	522	765		
Na	15	1.1	199	295		
K	9.6	0.64	301	453		
Mn	1.1	0.23	21	32		
Fe	13	0.51	14	14	0.3	
As	0.025	0.00067	1.1	1.7	0.1	0.5
Al	12	0.081	61	87	0.015	
Sb	0.0081	0.00024	0.5	0.8	0.02	
Cr	0.036	0.0014	0.5	0.8	0.001	
Pb	0.015	0.00017	0.03	0.04	0.005	0.2
Ni	0.043	0.00080	0.3	0.4	0.025	0.5
Mo	0.014	0.00028	0.13	0.18	0.04	

Table 6: Average Steady State Tailings Pond Discharge Concentrations

Parameter (mg/L)	Tailings Pond Discharge
SO_4	8.1
Cd	0.00000017
Cu	0.0000066
Zn	0.000017
Ca	0.33
Mg	0.024
Na	0.074
K	0.055
Mn	0.00014
Fe	0.00041
As	0.000029
Al	0.0014
Sb	0.00018
Cr	0.0000064
Pb	0.0000086
Ni	0.0000051
Mo	0.000049



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LEGEND

- Rock
- Revegetated
- Wetland
- Pond/Flooded
- Watercourses
- Roads
- Flow Direction

0 0.5 1 2 3 4 5 Kilometres

Notes:
- Aerial imagery provided by RRR scene date is summer 2011
- Only major facilities are shown. Connecting infrastructure and supporting facilities are generally not shown.

Datum: NAD83
Projection: UTM Zone 15N

RAINY RIVER | amec

RAINY RIVER GOLD PROJECT

Closure Site Schematic

PROJECT N^o: TC111504	**FIGURE: 1**
SCALE: 1:37,000	DATE: May 2013

Figure 2: East Mine Rock Stockpile Cover Conceptual Design

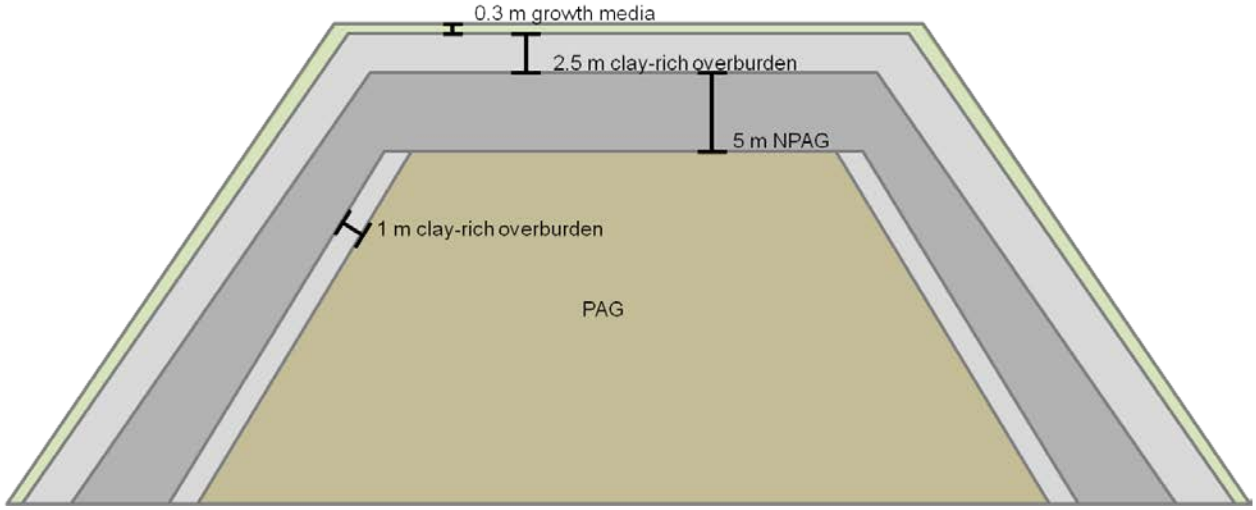


Figure 3: Conceptual Schematic for Pit Lake Mixing Scenarios

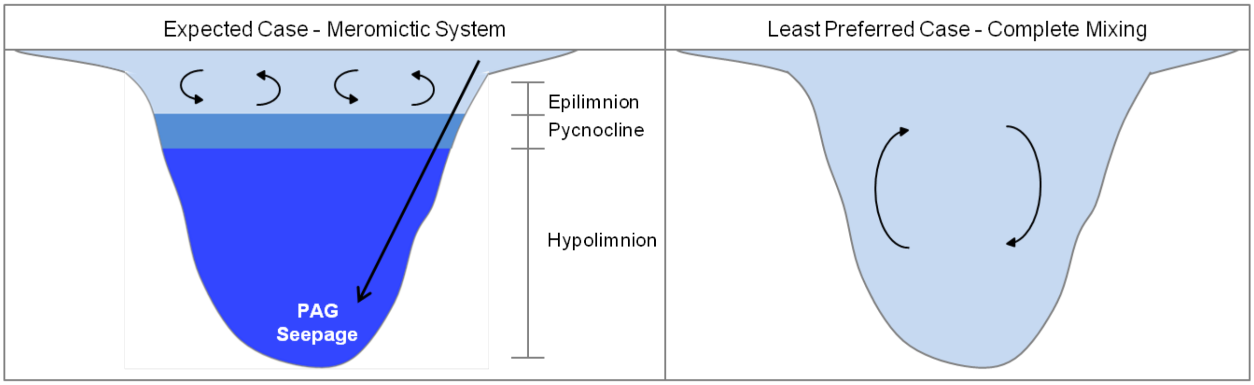
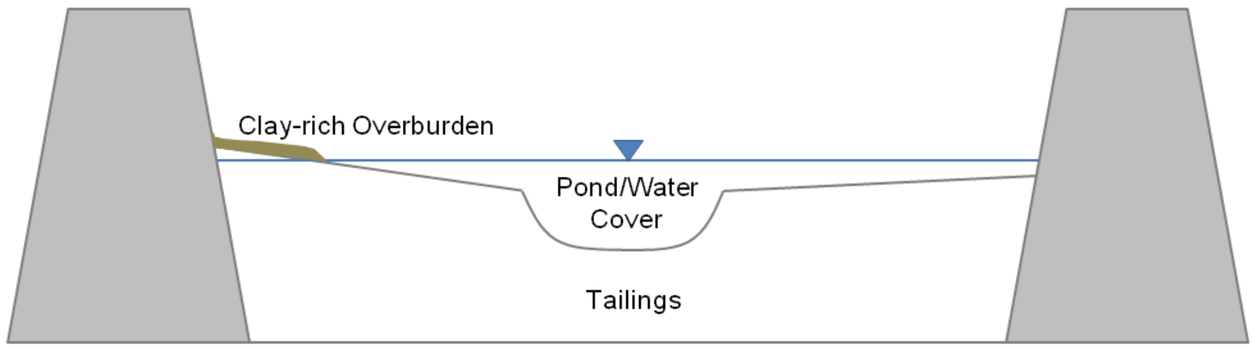
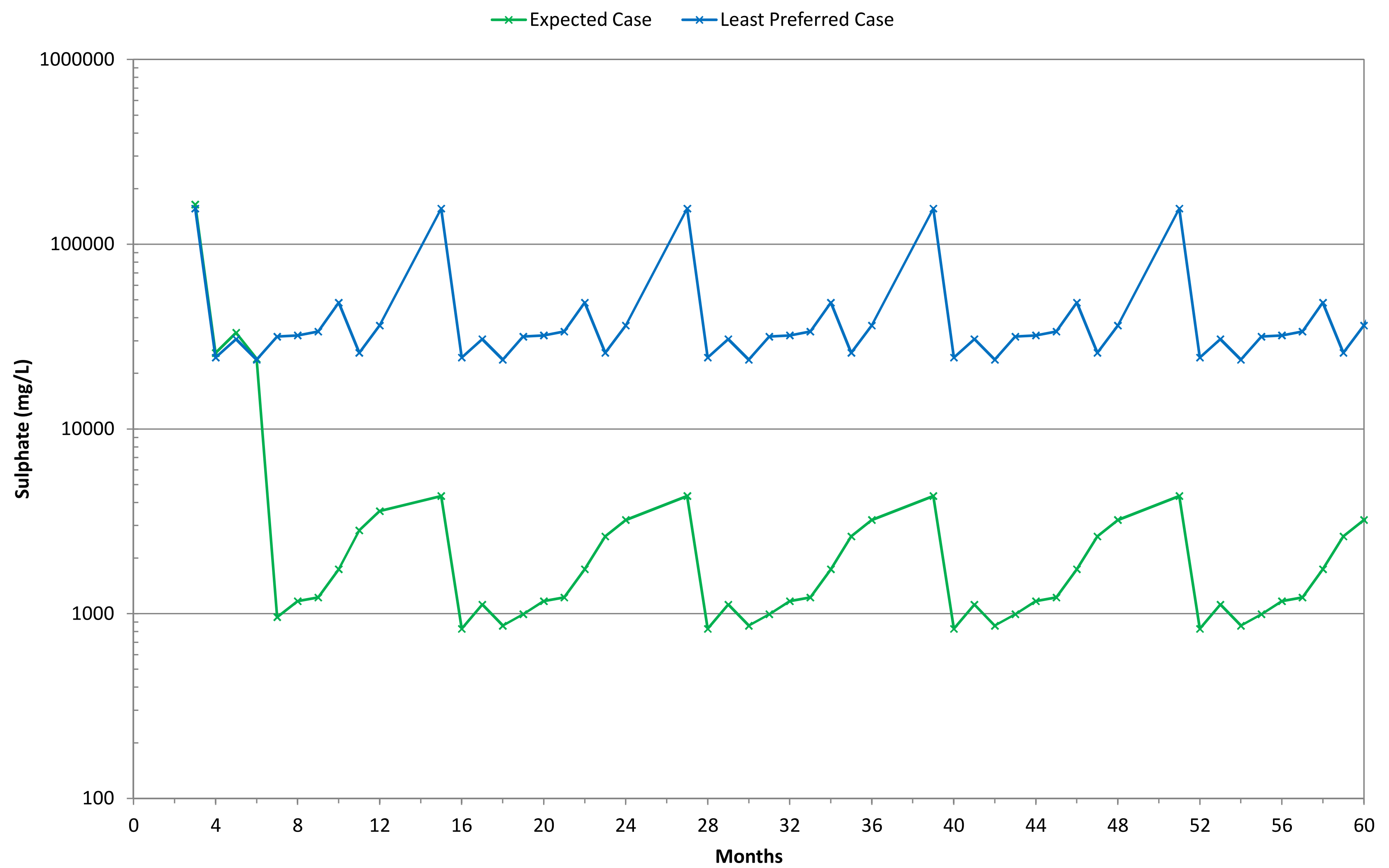


Figure 4: Conceptual Tailings Pond Design at Closure





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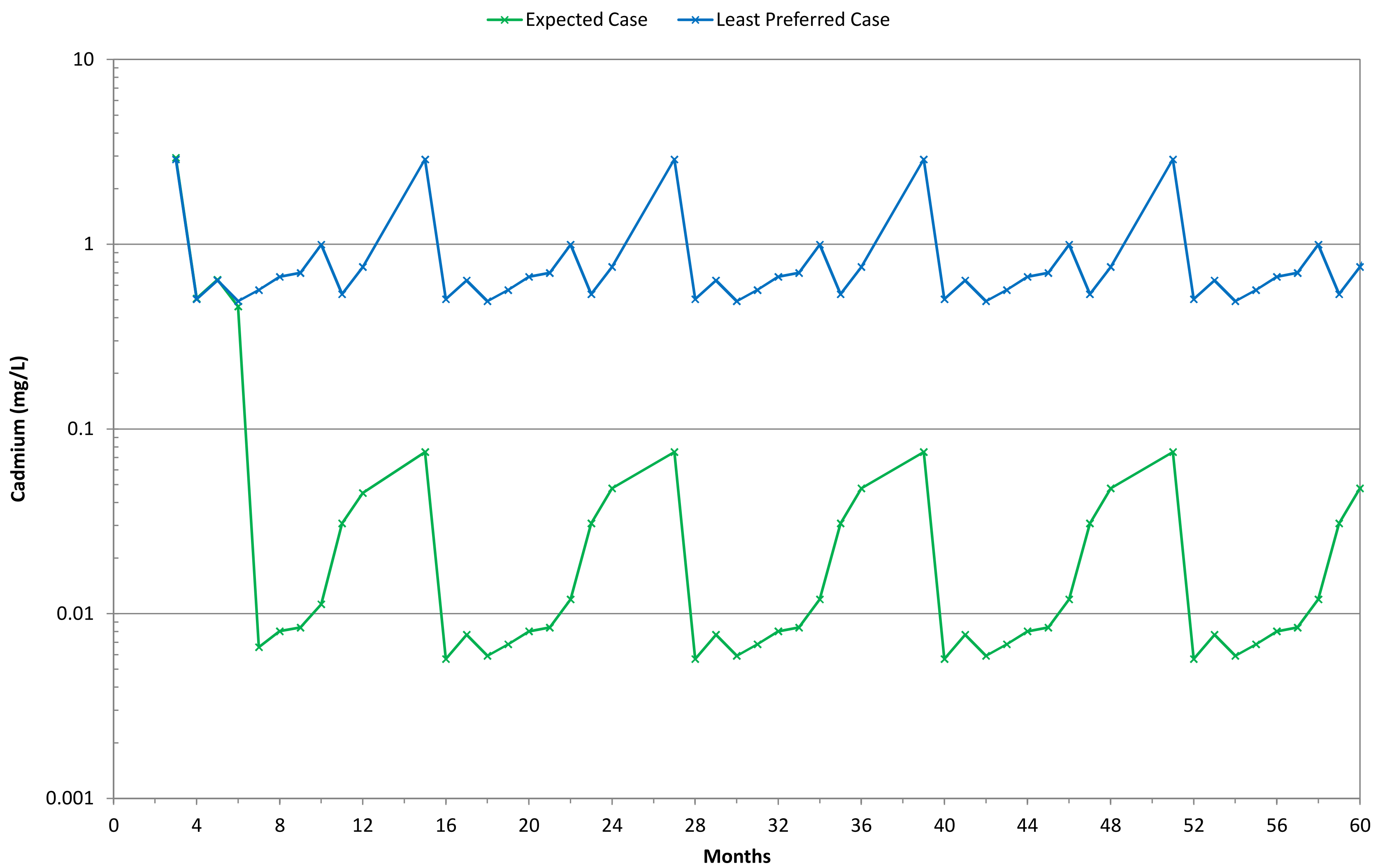
East Mine Rock Stockpile Seepage Results - SO_4	
Rainy River Water Quality Model	
Jun-13	Figure 5

Job No. TC111504



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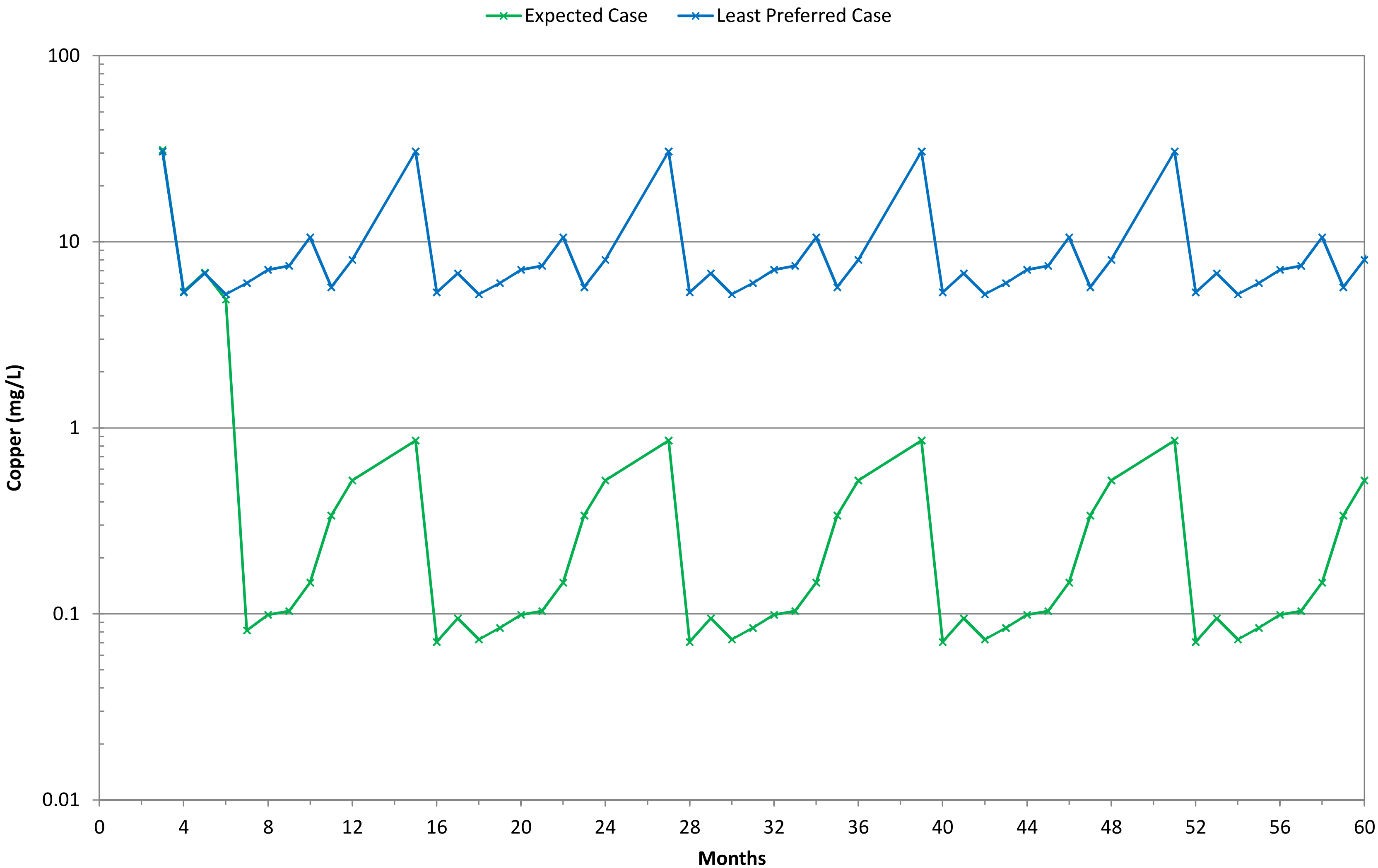
East Mine Rock Stockpile Seepage Results - Cd	
Rainy River Water Quality Model	
Jun-13	Figure 6



RAINY RIVER

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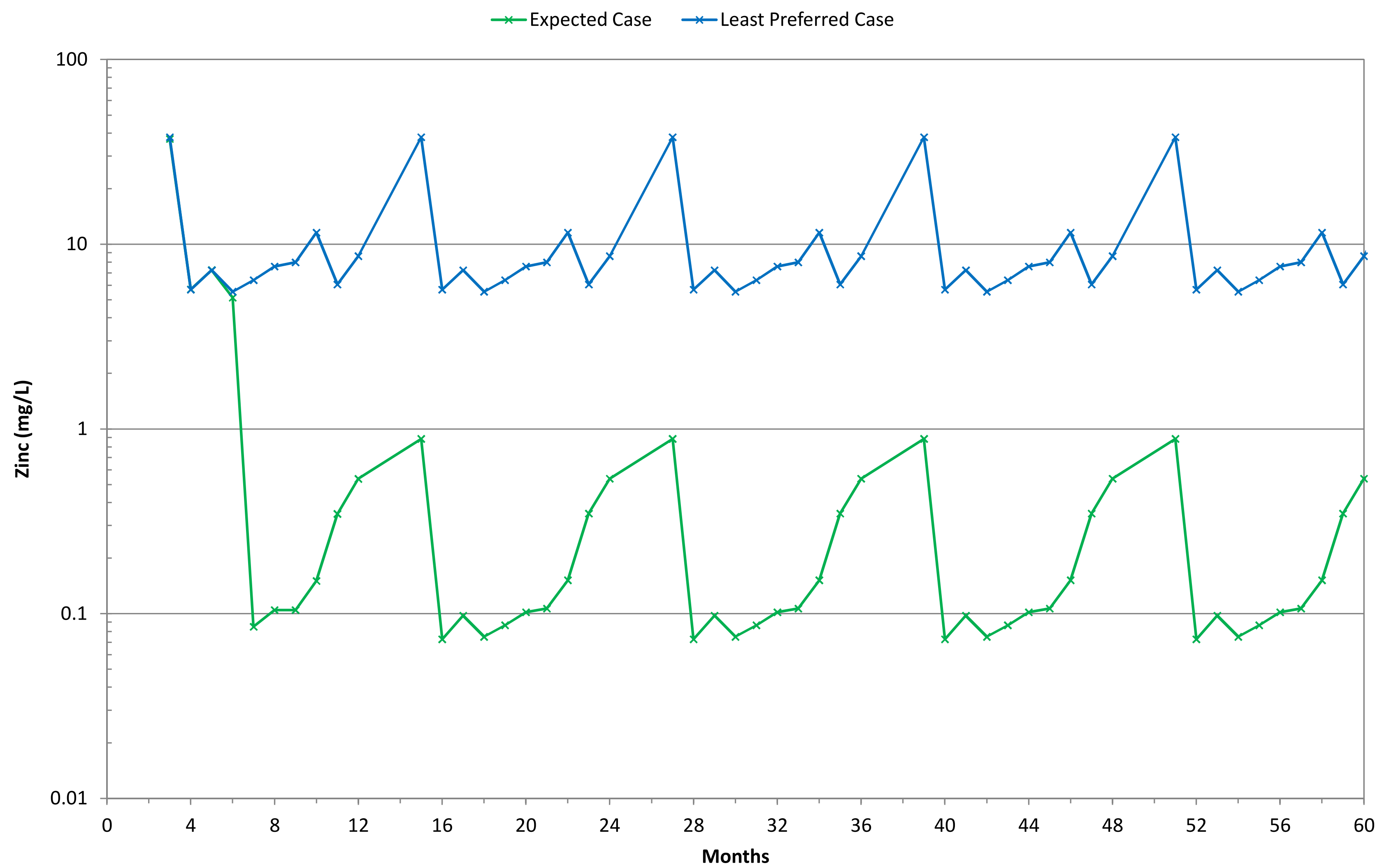
East Mine Rock Stockpile Seepage Results - Cu	
Rainy River Water Quality Model	
Jun-13	Figure 7

Job No. TC111504



RAINY RIVER

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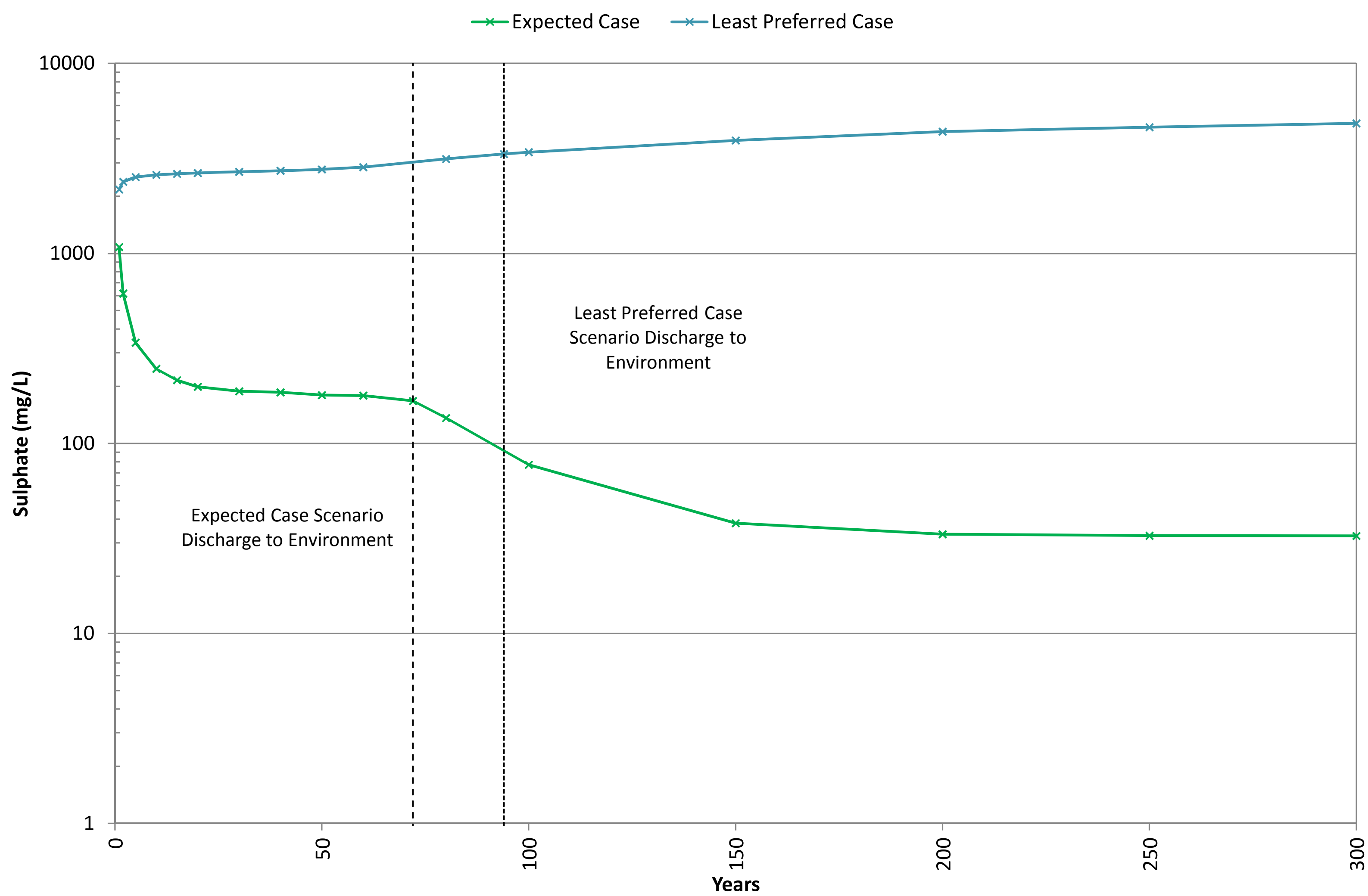
East Mine Rock Stockpile Seepage Results - Zn	
Rainy River Water Quality Model	
Jun-13	Figure 8



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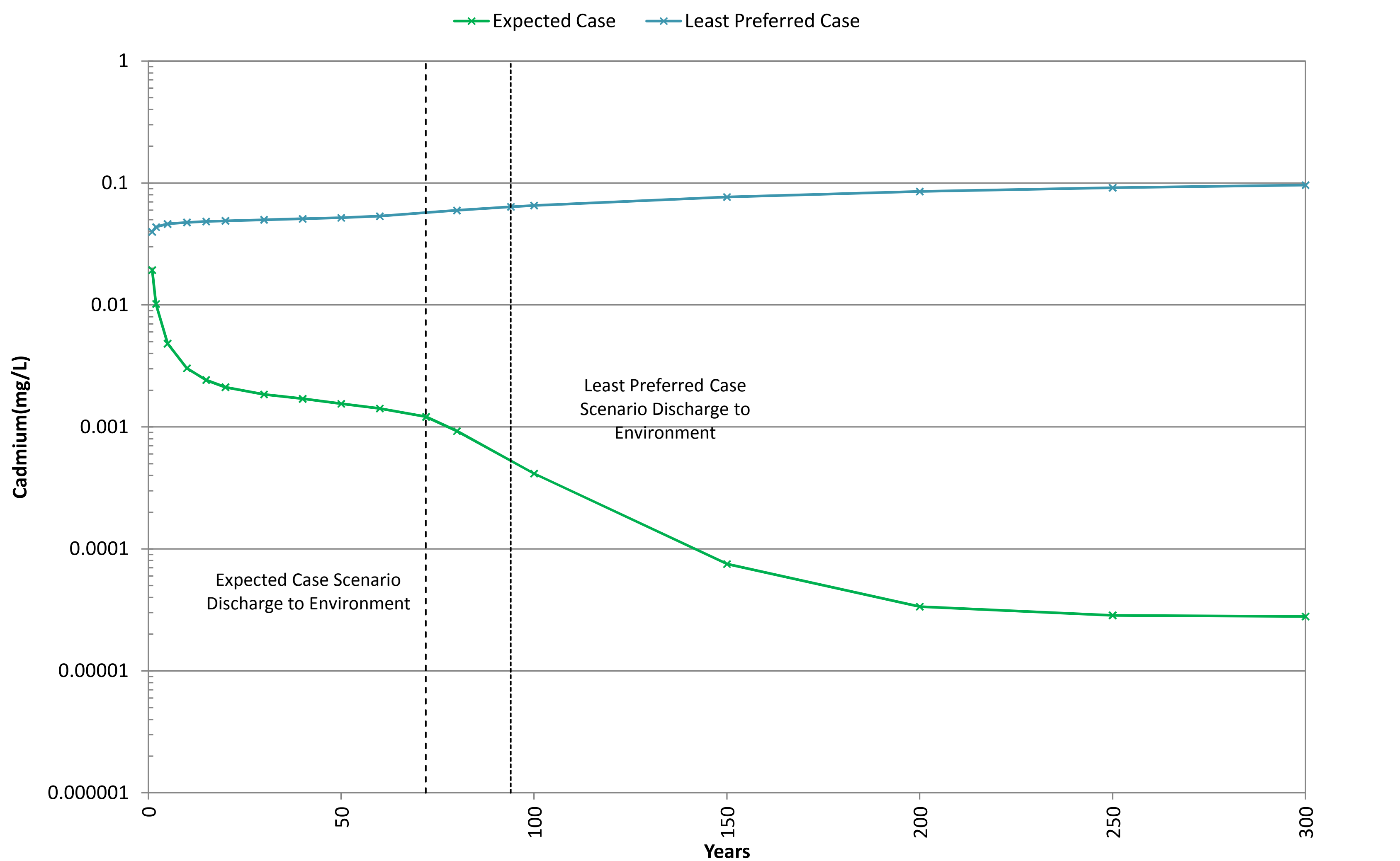
Pit Lake Water Quality - SO_4

Rainy River Water Quality Model	
June 2013	Figure 9

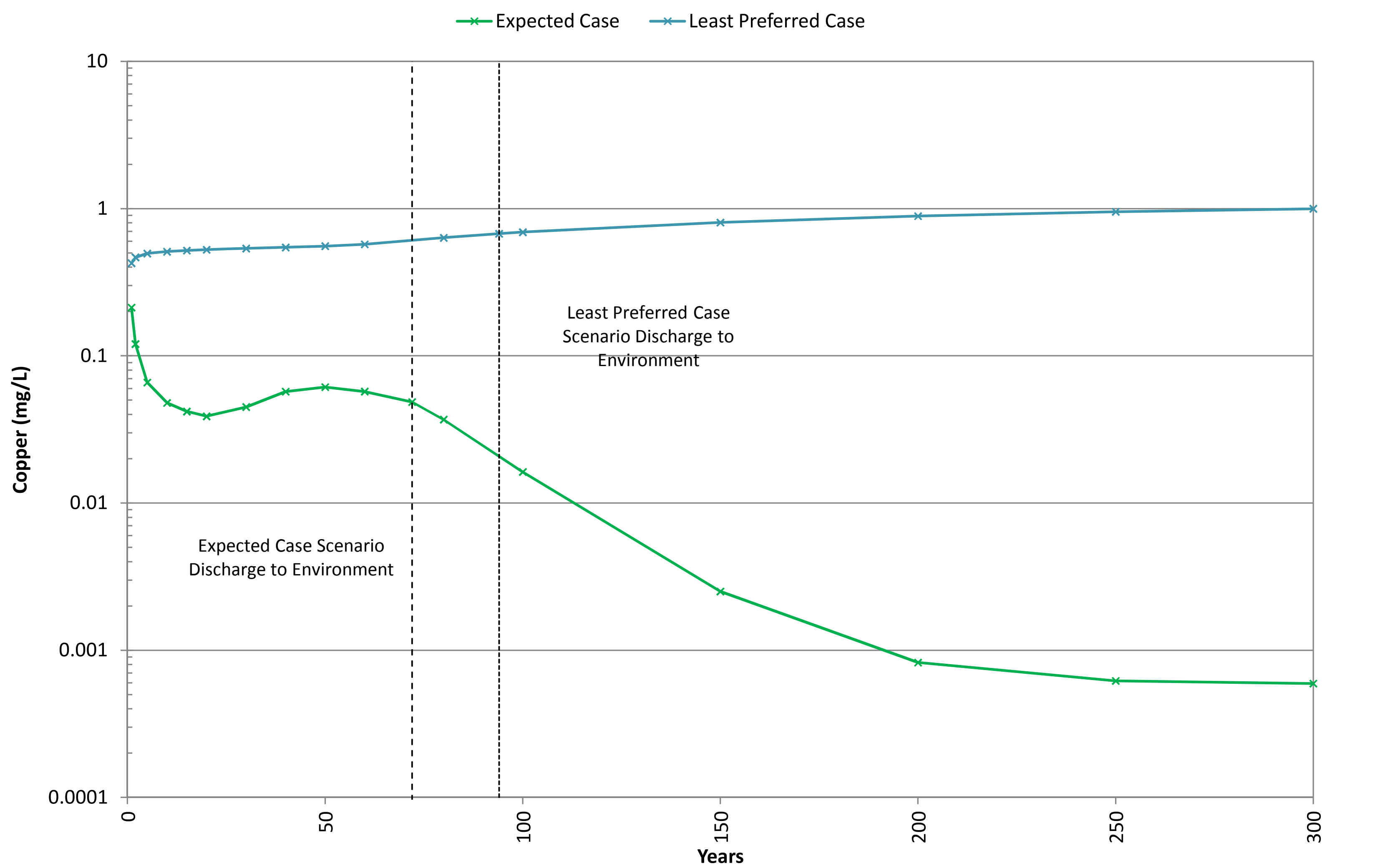
Job No. TC111504



RAINY RIVER

amec

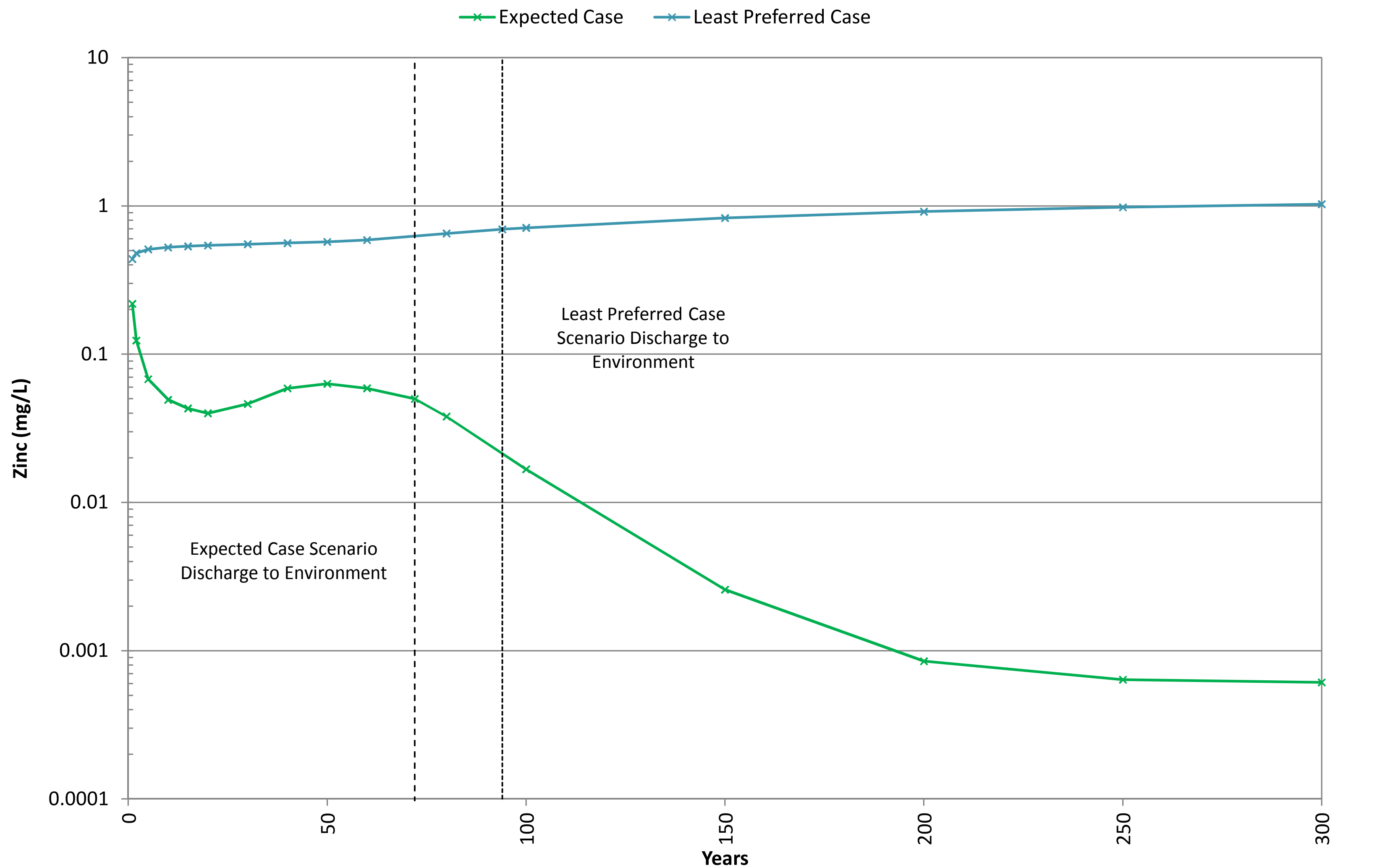
Pit Lake Water Quality - Cd	
Rainy River Water Quality Model	
June 2013	Figure 10



RAINY RIVER

amec

Pit Lake Water Quality - Cu	
Rainy River Water Quality Model	
June 2013	Figure 11



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June 2013	Figure 12

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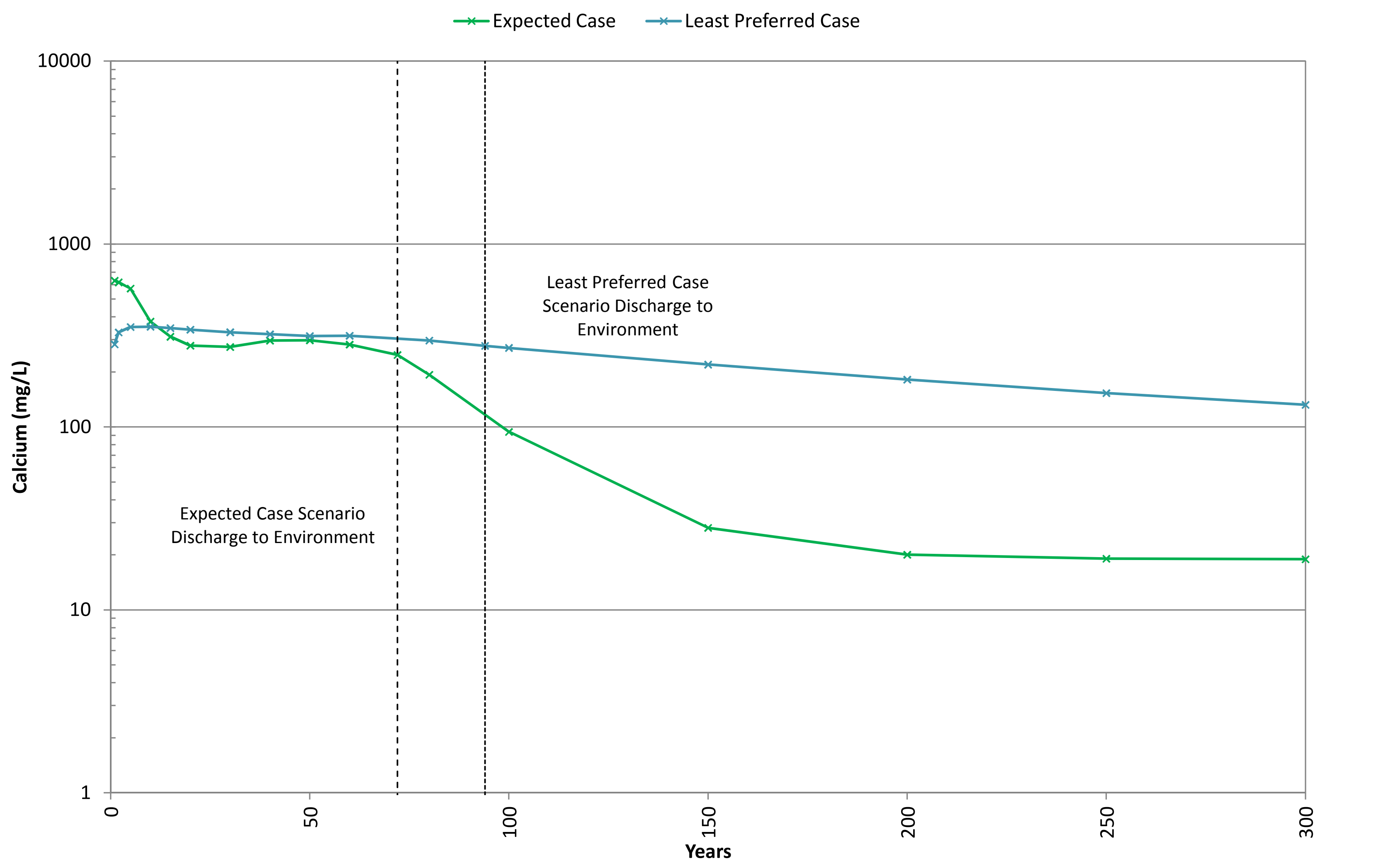

Pit Lake Water Quality - Ca	
Rainy River Water Quality Model	
June 2013	Figure 13

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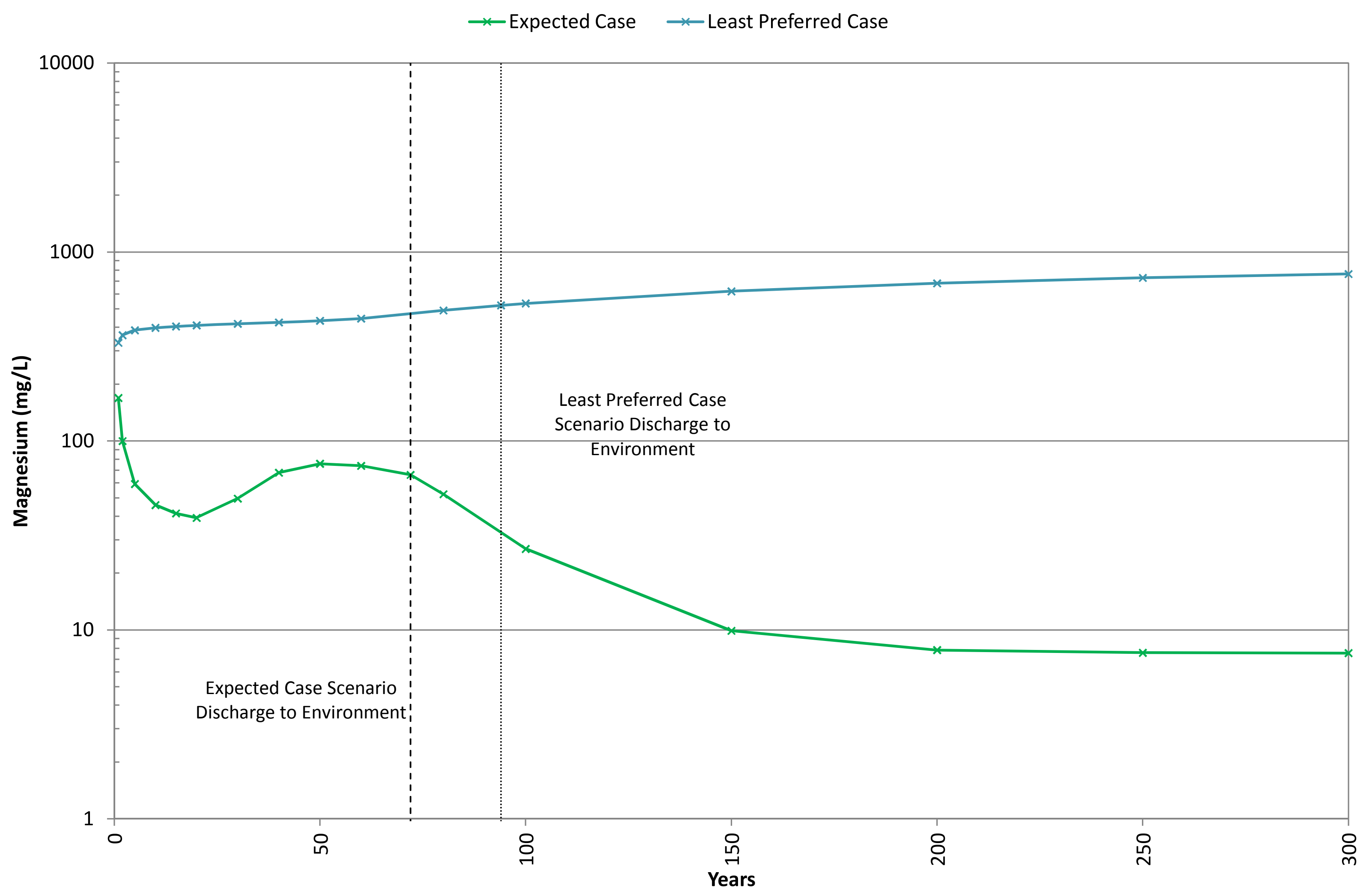
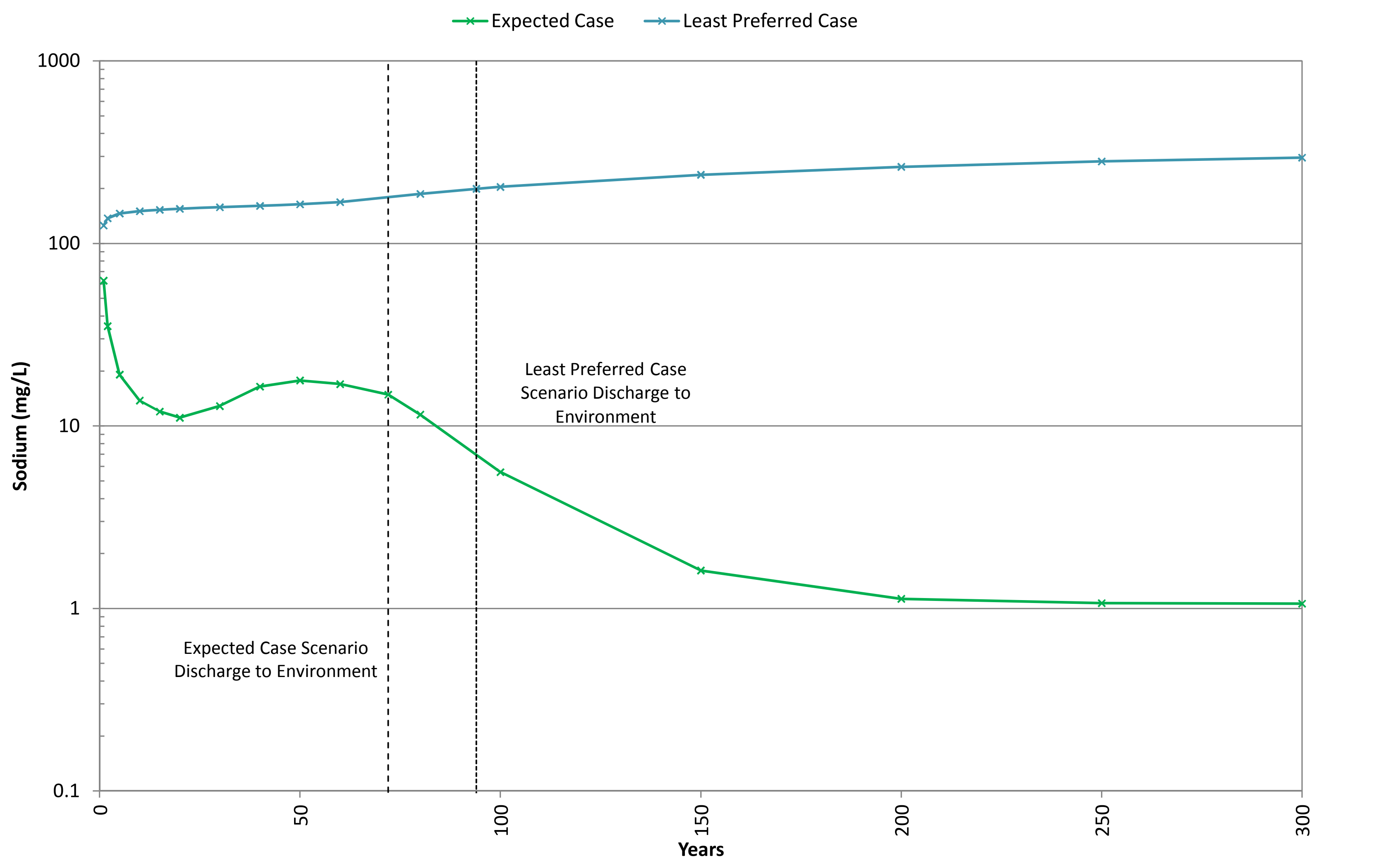


RAINY RIVER

amec

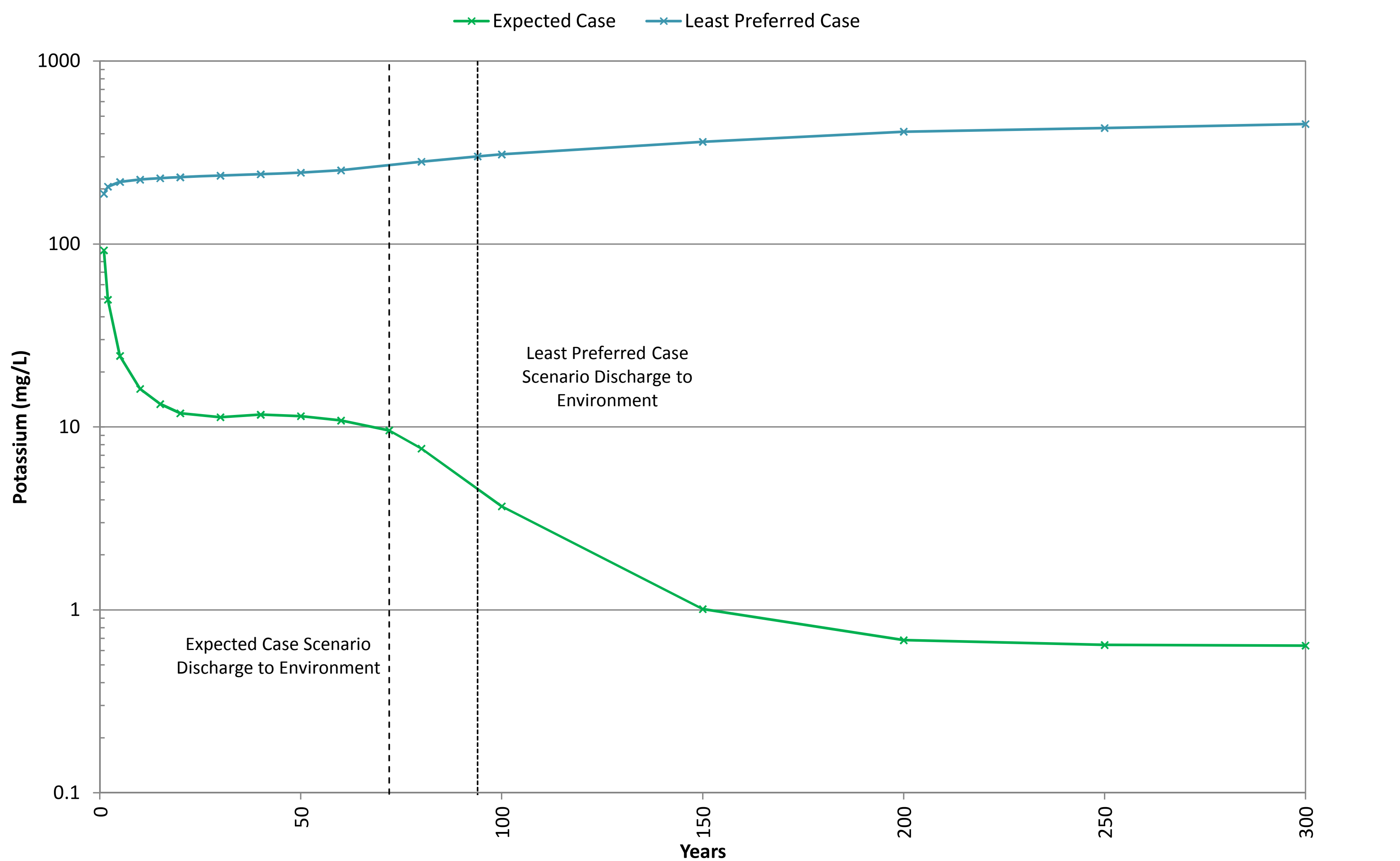
Pit Lake Water Quality - Mg	
Rainy River Water Quality Model	
June 2013	Figure 14



RAINY RIVER

amec

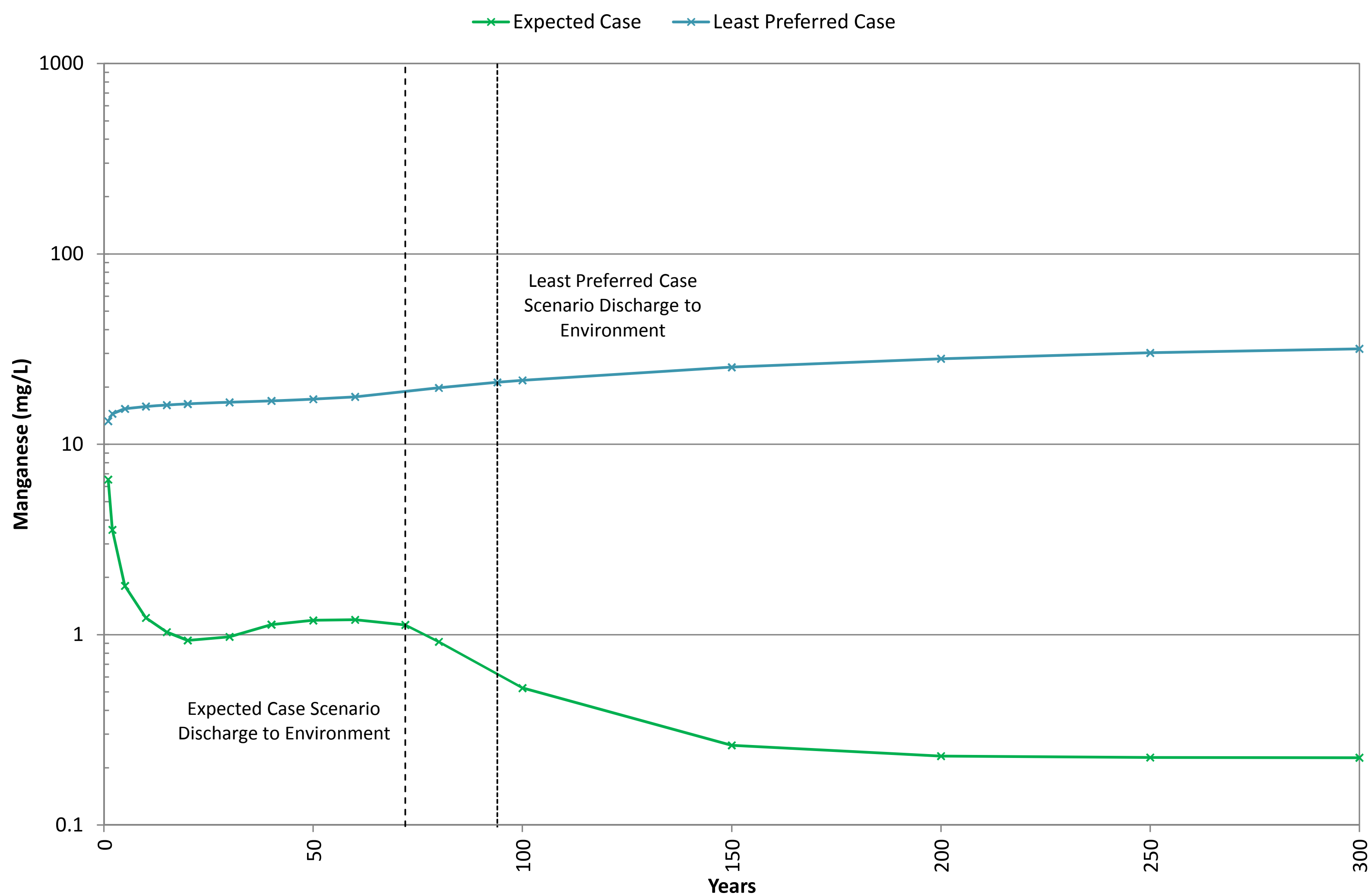
Pit Lake Water Quality - Na	
Rainy River Water Quality Model	
June 2013	Figure 15



RAINY RIVER

amec

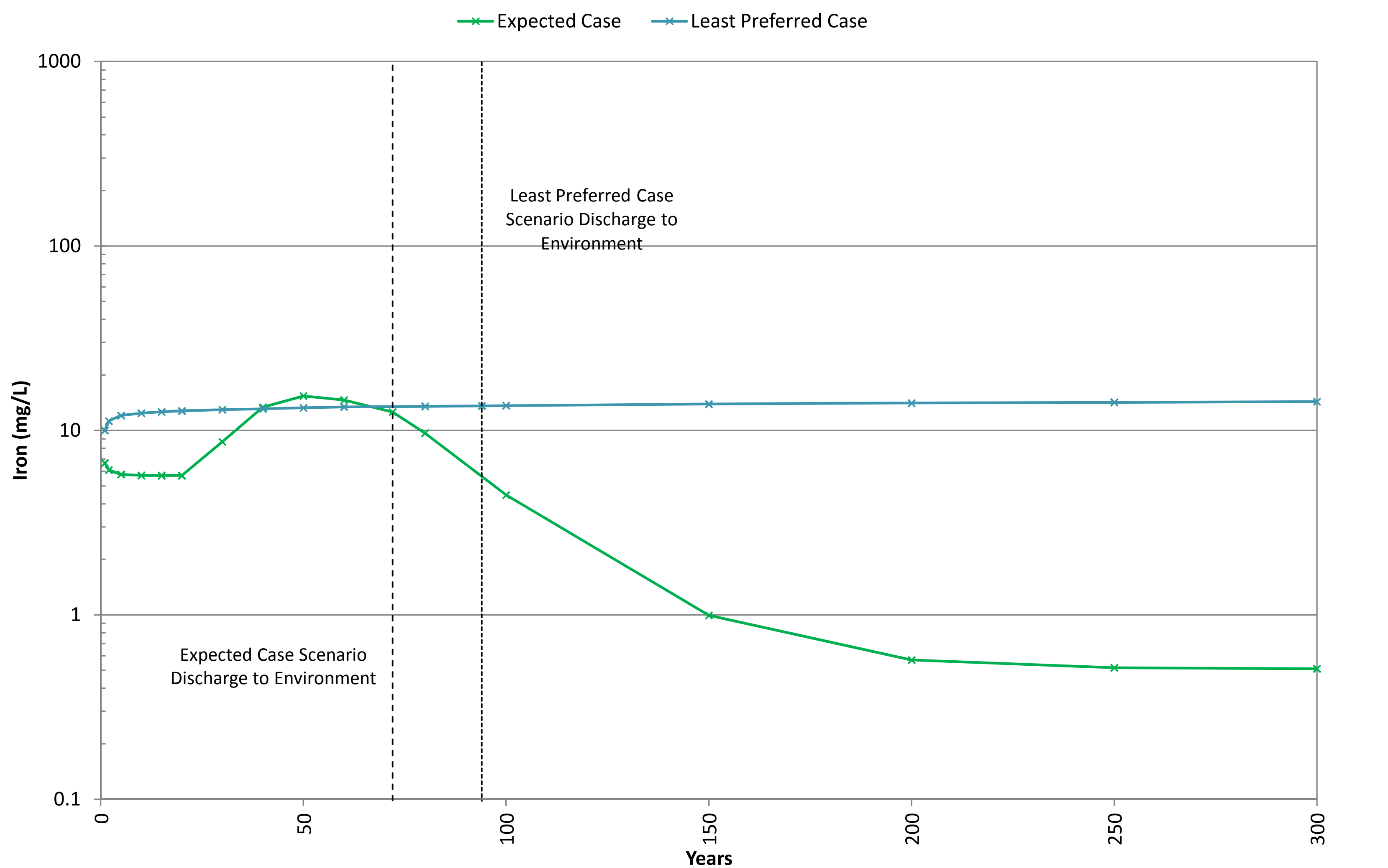
Pit Lake Water Quality - K	
Rainy River Water Quality Model	
June 2013	Figure 16



RAINY RIVER

amec

Pit Lake Water Quality - Mn	
Rainy River Water Quality Model	
June 2013	Figure 17

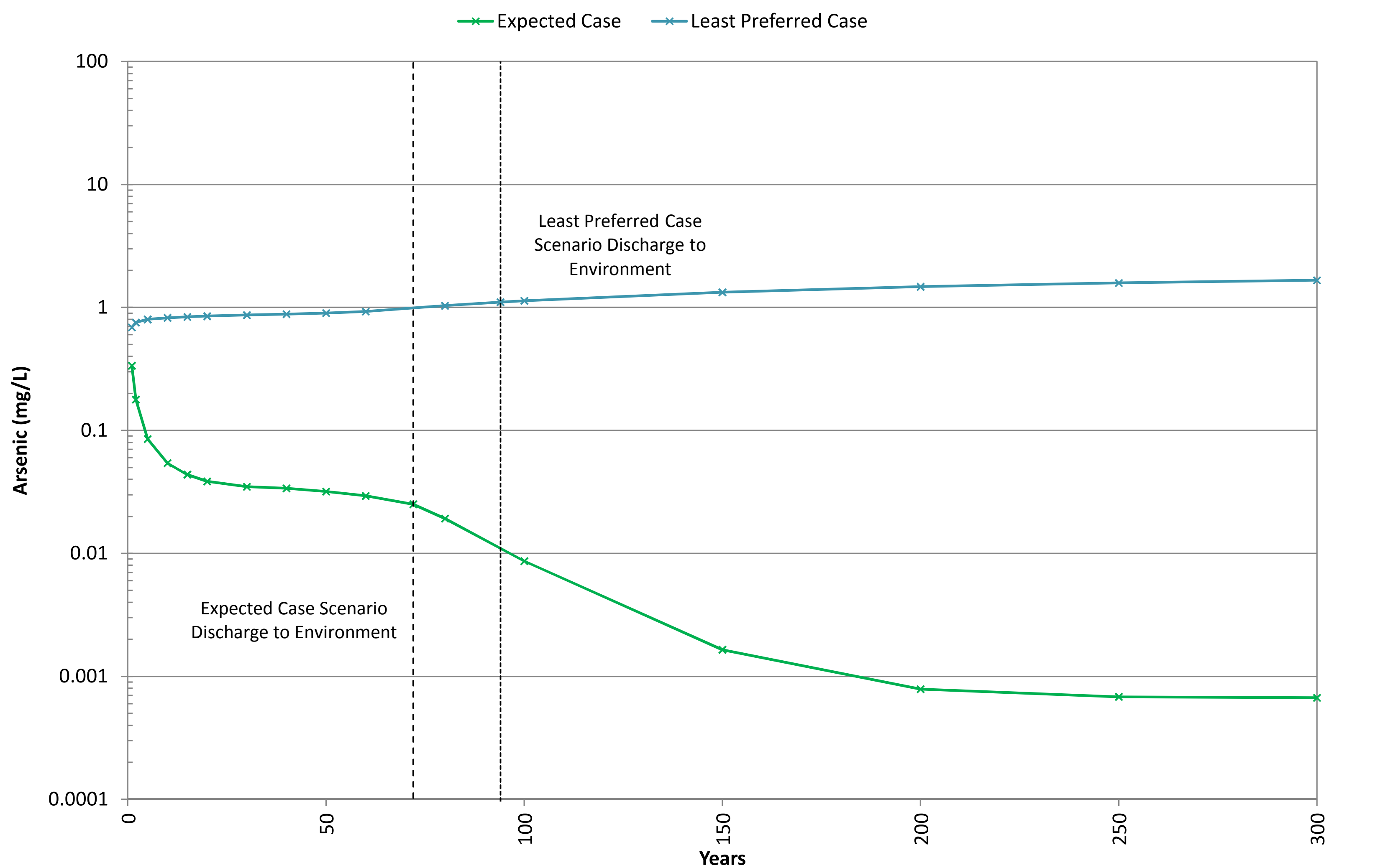


RAINY RIVER

amec

Pit Lake Water Quality - Fe	
Rainy River Water Quality Model	
June 2013	Figure 18

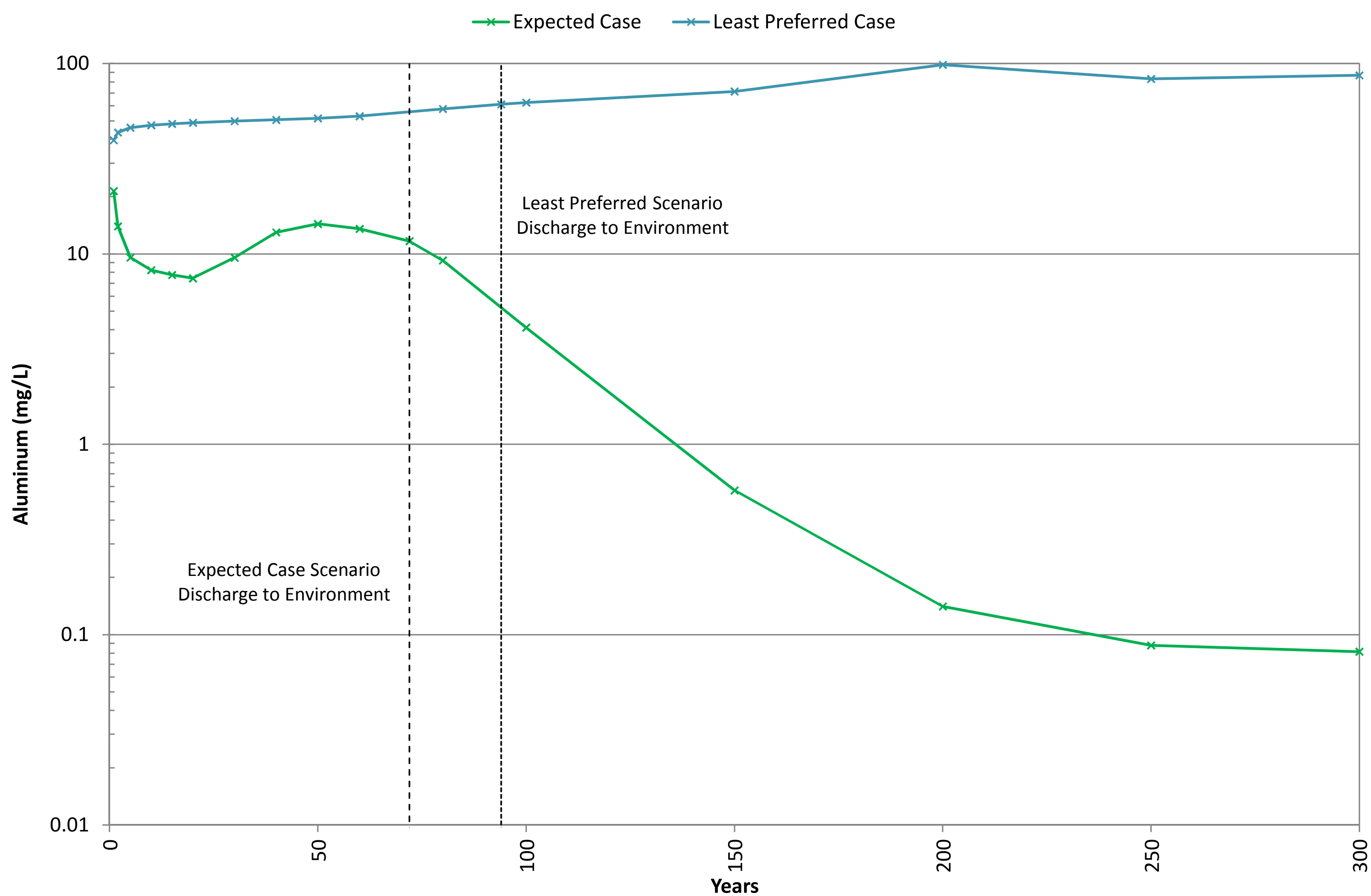
Job No. TC111504



RAINY RIVER

amec

Pit Lake Water Quality - As	
Rainy River Water Quality Model	
June 2013	Figure 19

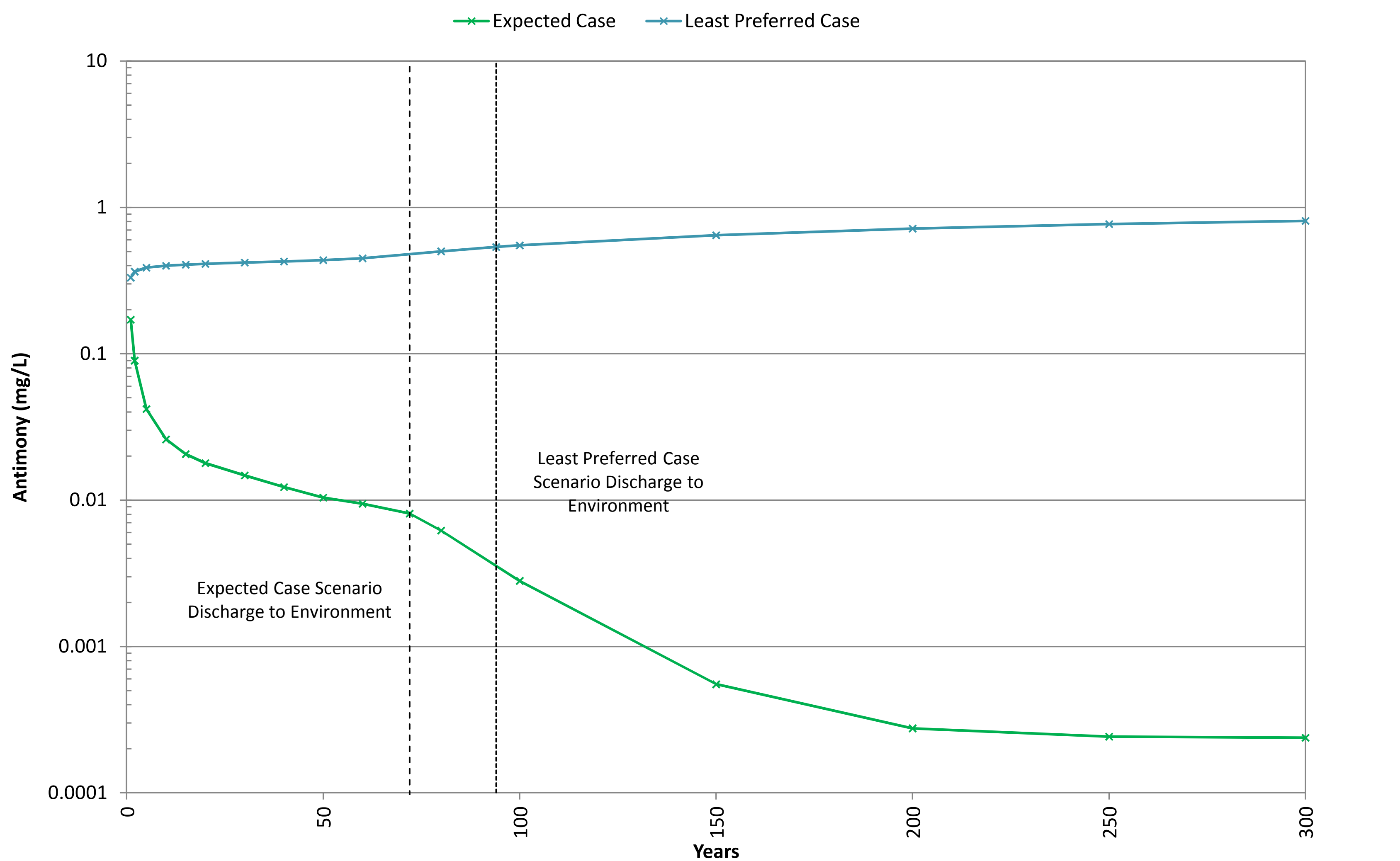


RAINY RIVER

amec

Pit Lake Water Quality - Al	
Rainy River Water Quality Model	
June 2013	Figure 20

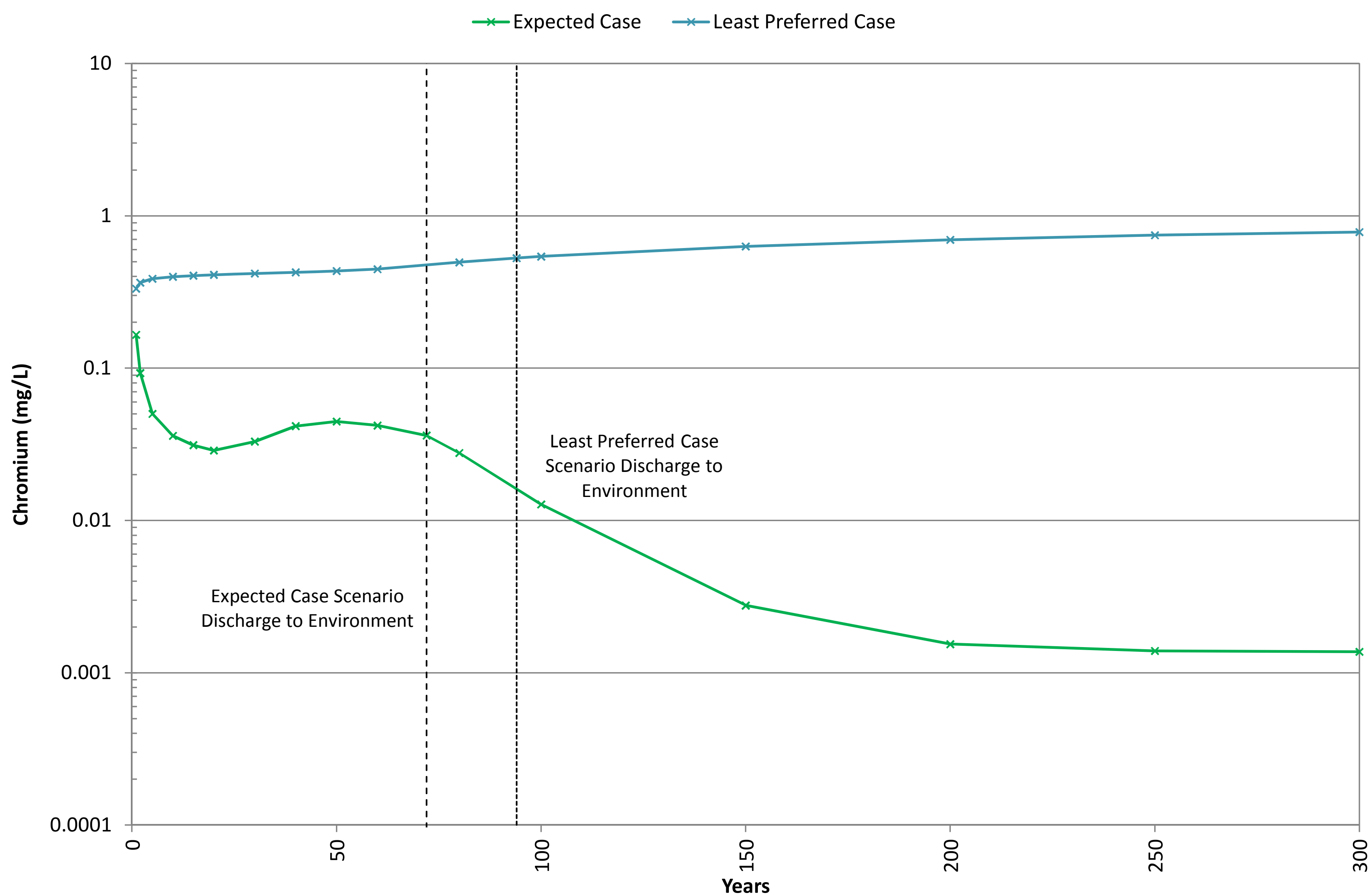
Job No. TC111504



RAINY RIVER

amec

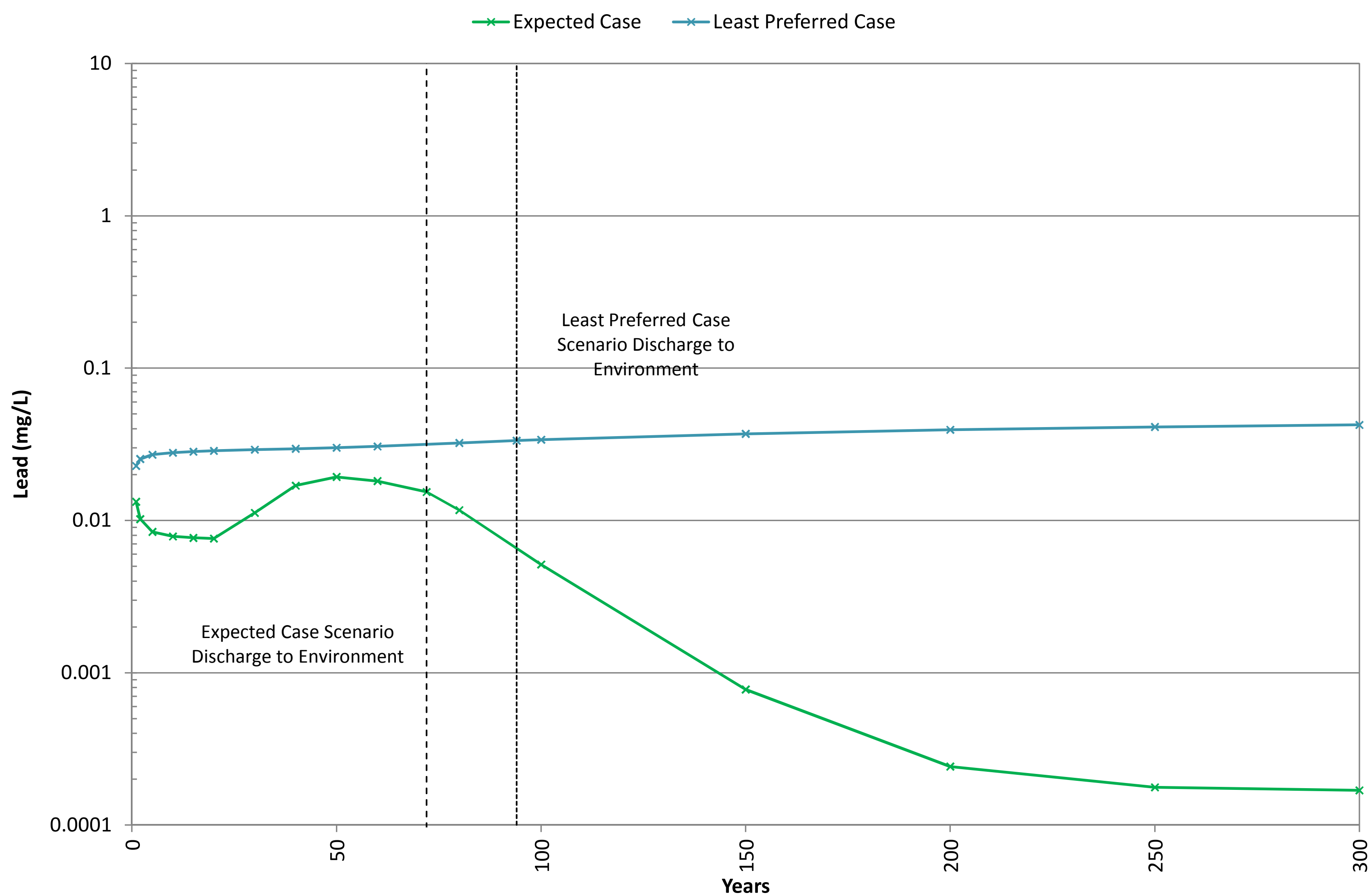
Pit Lake Water Quality - Sb	
Rainy River Water Quality Model	
June 2013	Figure 21



RAINY RIVER

amec

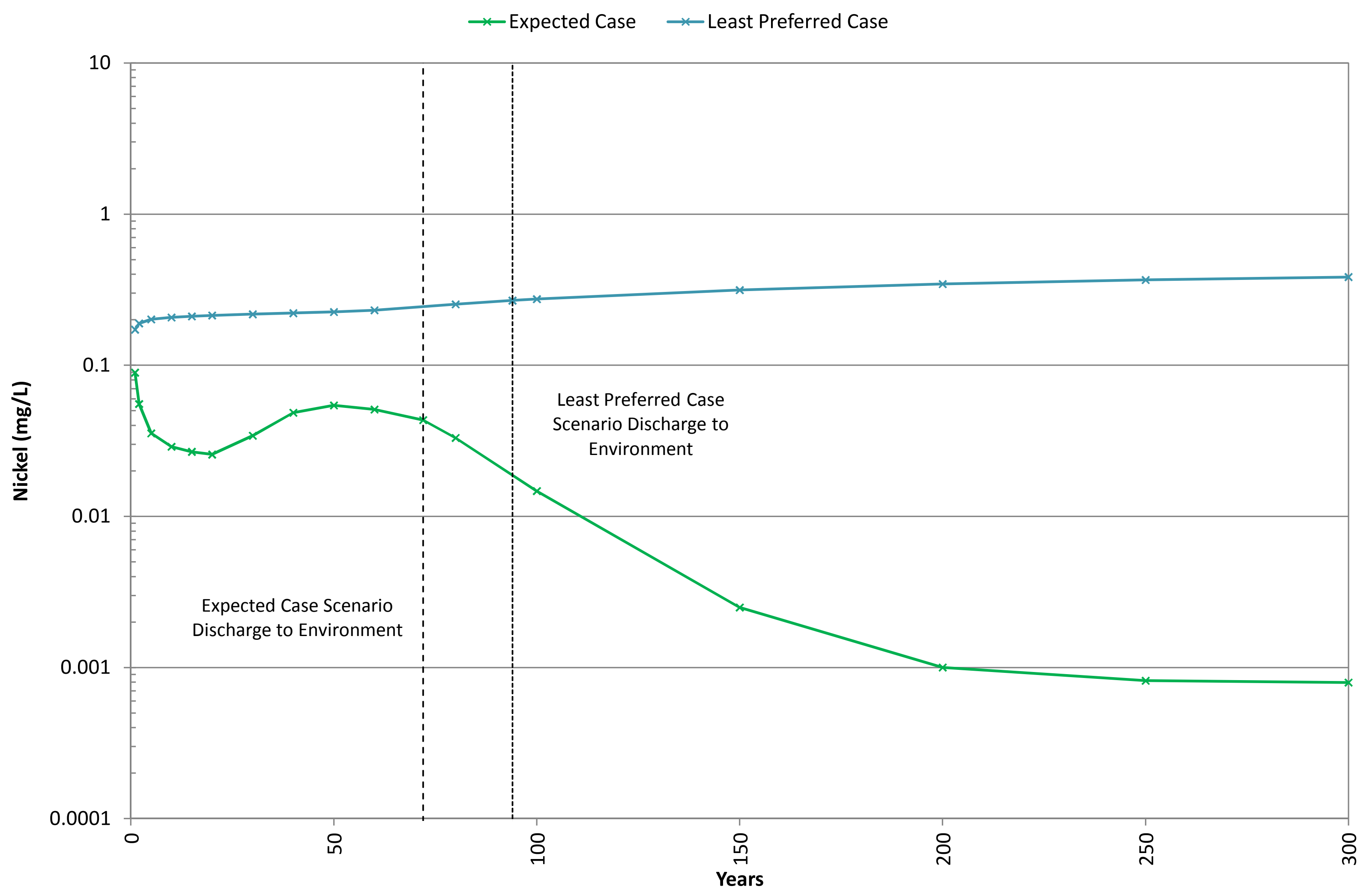
Pit Lake Water Quality - Cr	
Rainy River Water Quality Model	
June 2013	Figure 22



RAINY RIVER

amec

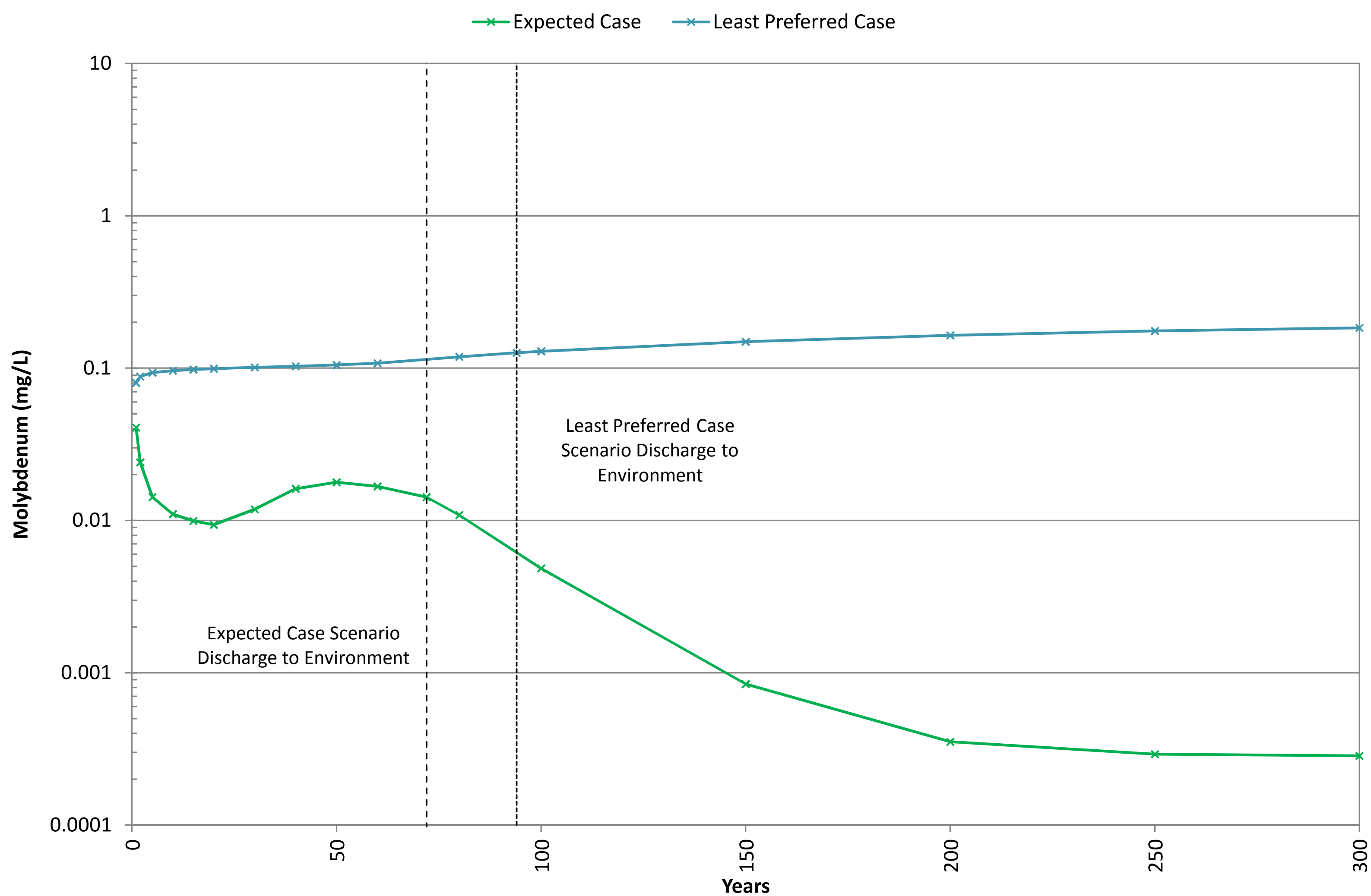
Pit Lake Water Quality - Pb	
Rainy River Water Quality Model	
June 2013	Figure 23



RAINY RIVER

amec

Pit Lake Water Quality - Ni	
Rainy River Water Quality Model	
June 2013	Figure 24

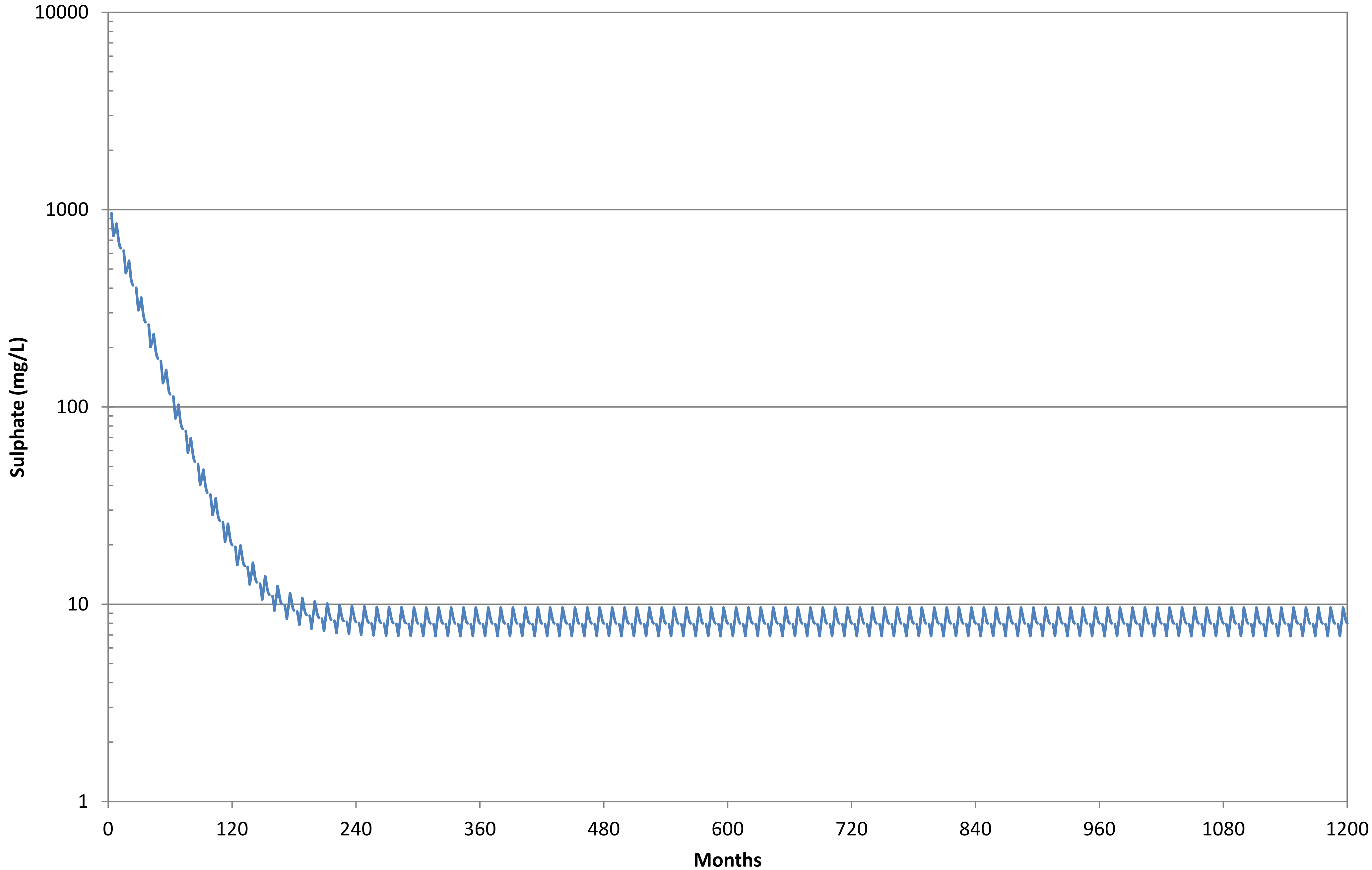


Pit Lake Water Quality - Mo

Rainy River Water Quality Model

June 2013 | Figure 25

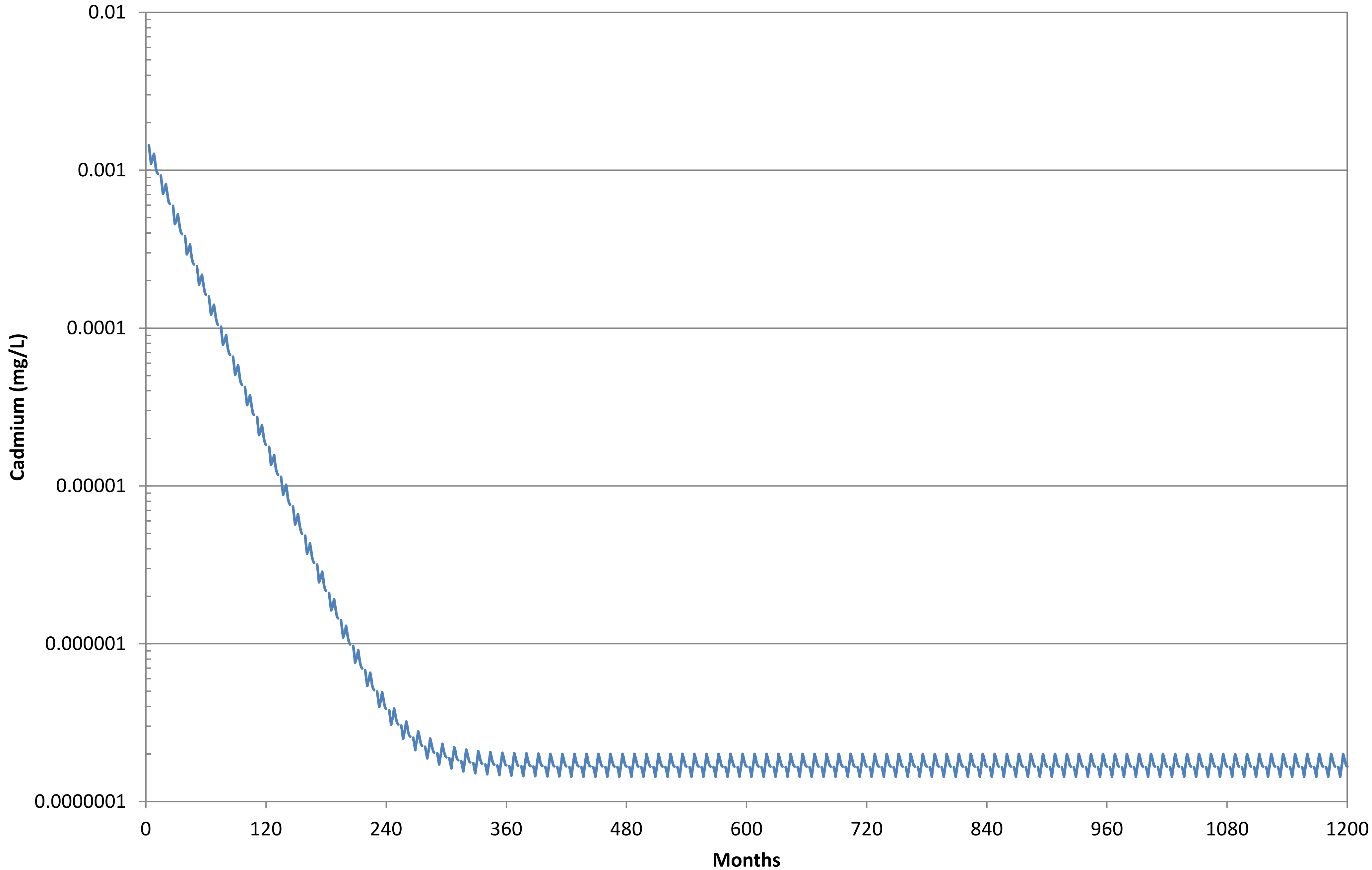
Job No. TC111504



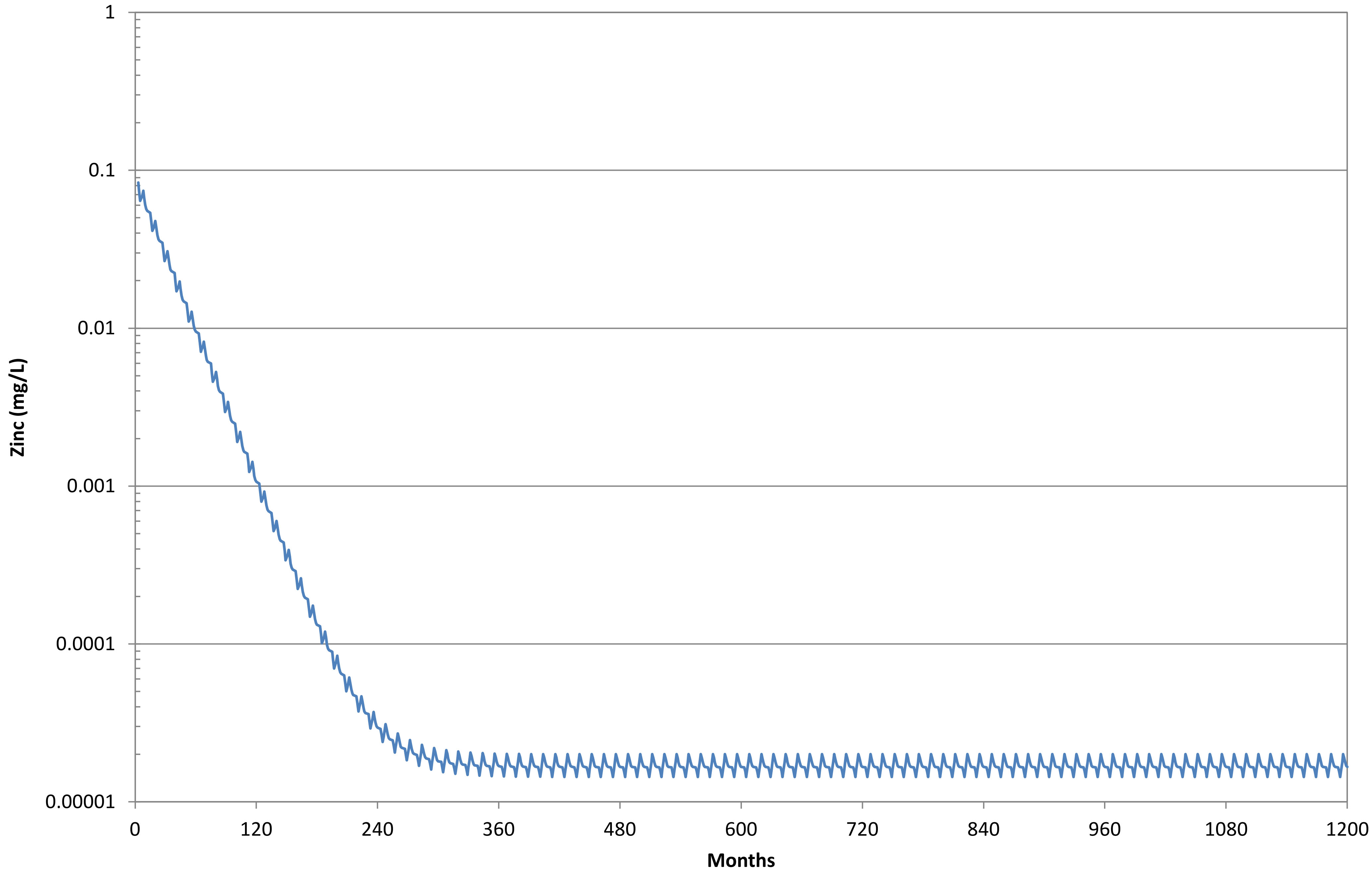
Tailings Pond Results - SO_4

Rainy River Water Quality Model

June 2013 | Figure 26



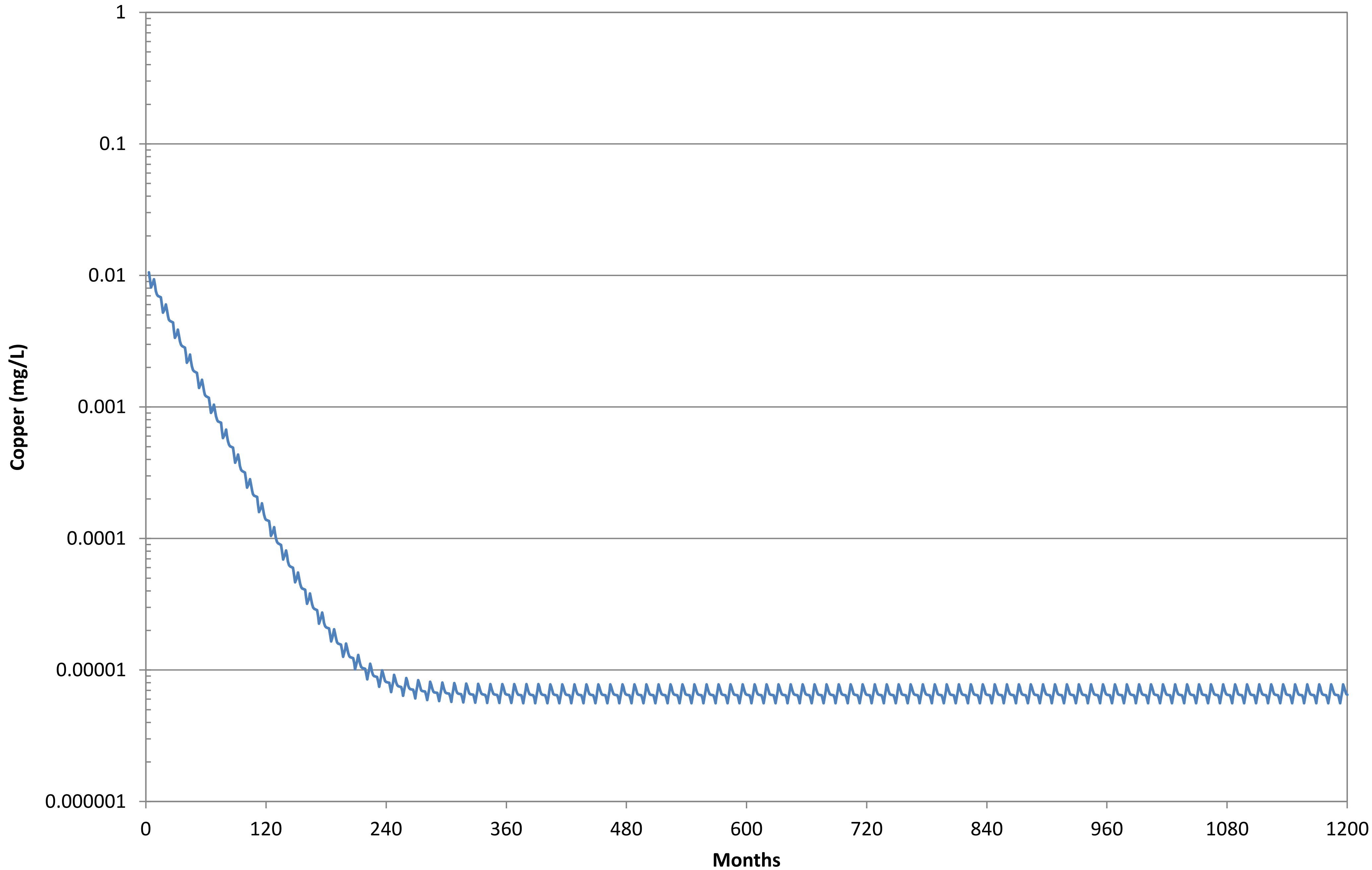
Tailings Pond Results - Cd	
Rainy River Water Quality Model	
June 2013	Figure 27



RAINY RIVER

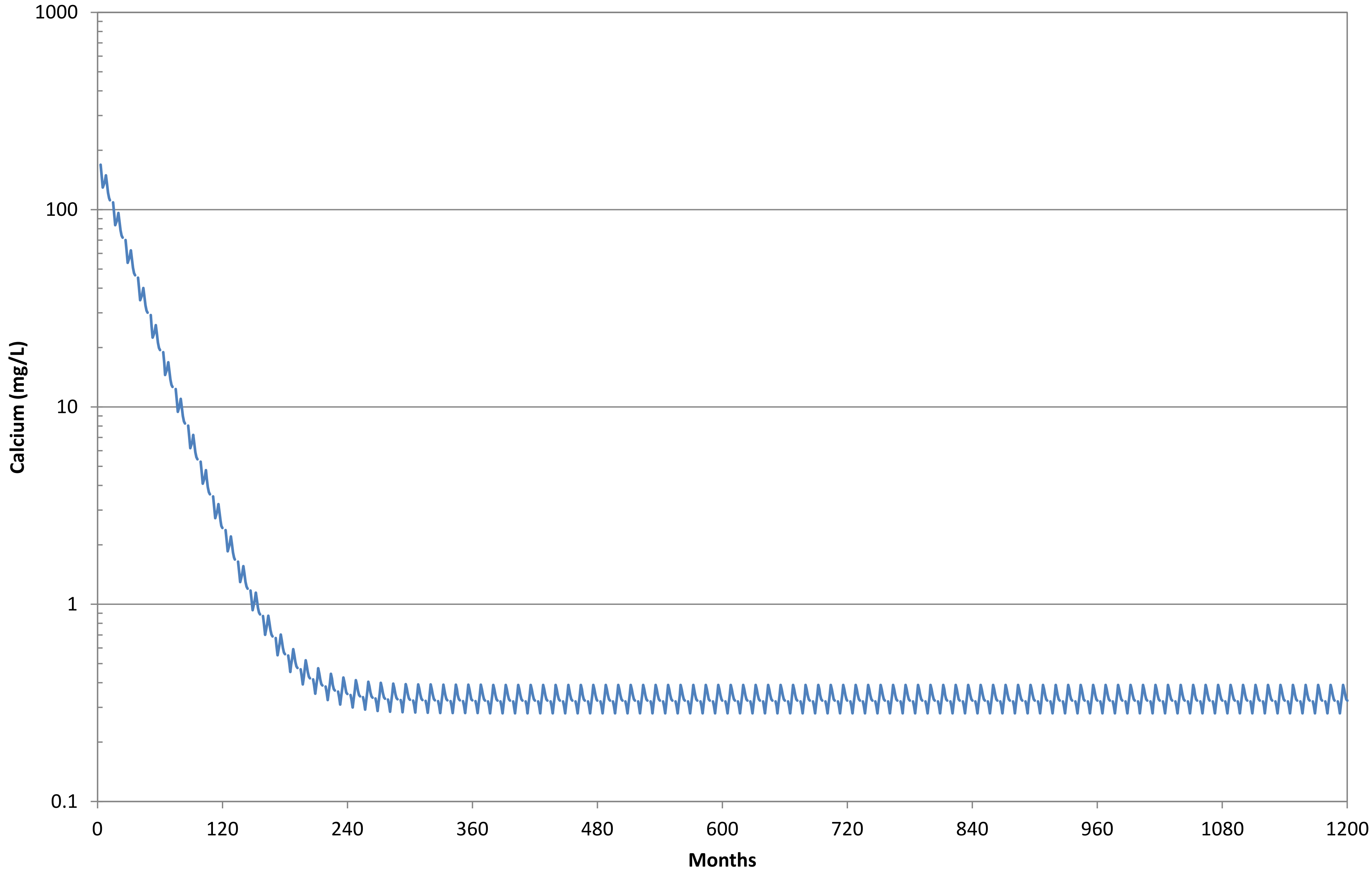
amec

Tailings Pond Results - Zn	
Rainy River Water Quality Model	
June 2013	Figure 29



Tailings Pond Results - Cu	
Rainy River Water Quality Model	
June 2013	Figure 28

Job No. TC111504



RAINY RIVER

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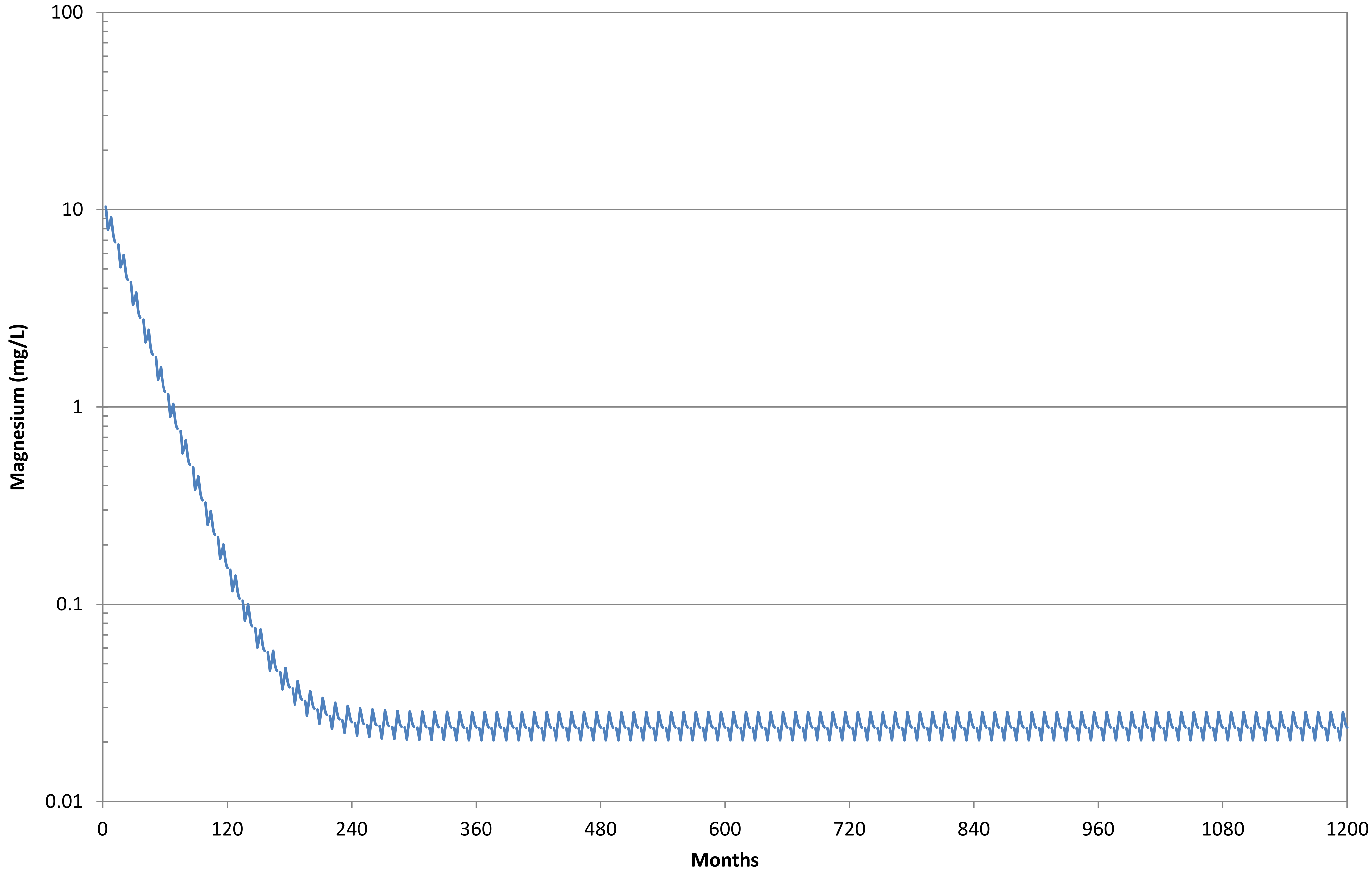
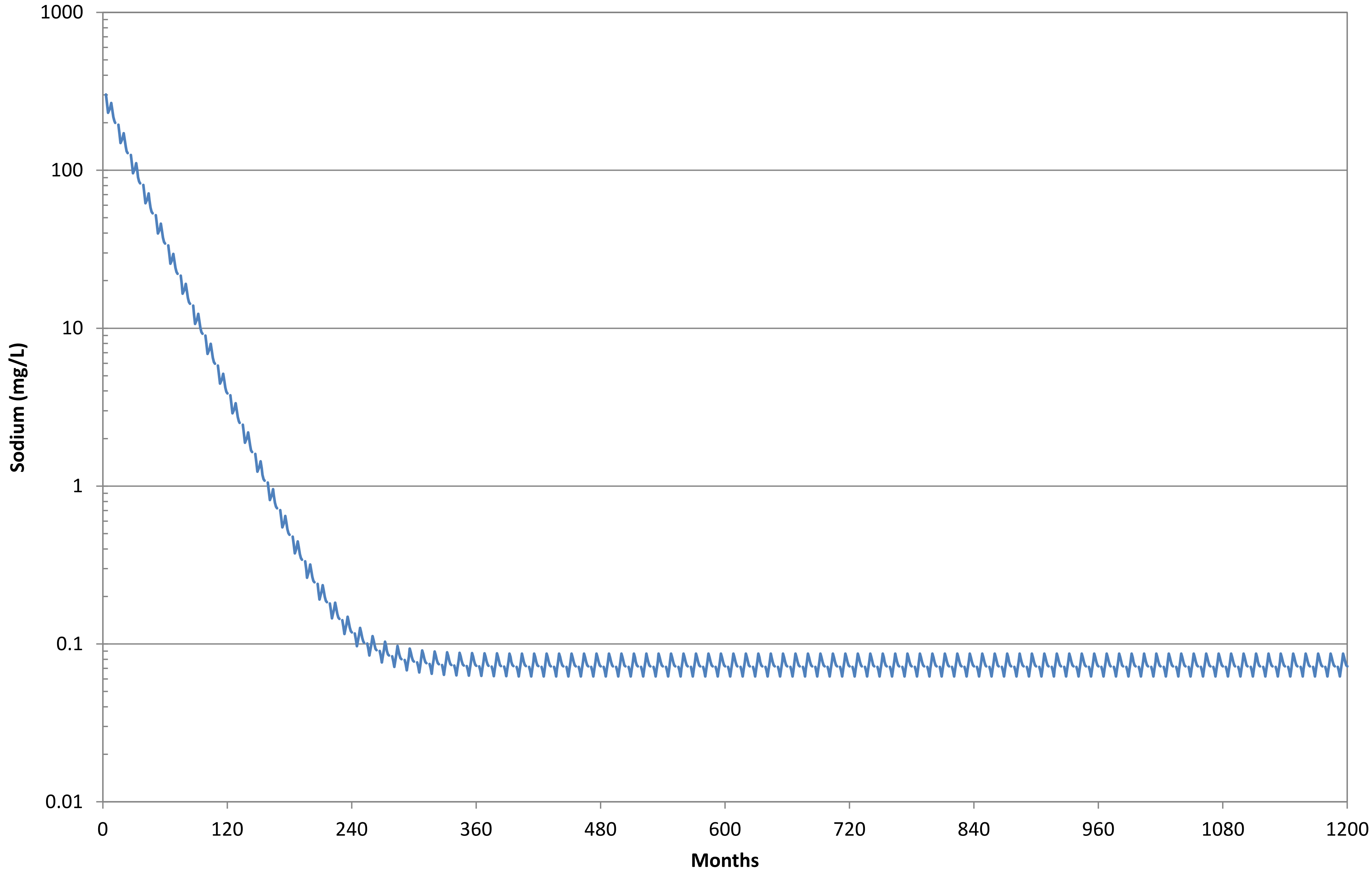
Tailings Pond Results - Ca	
Rainy River Water Quality Model	
June 2013	Figure 30



Tailings Pond Results - Mg	
Rainy River Water Quality Model	
June 2013	Figure 31



RAINY RIVER

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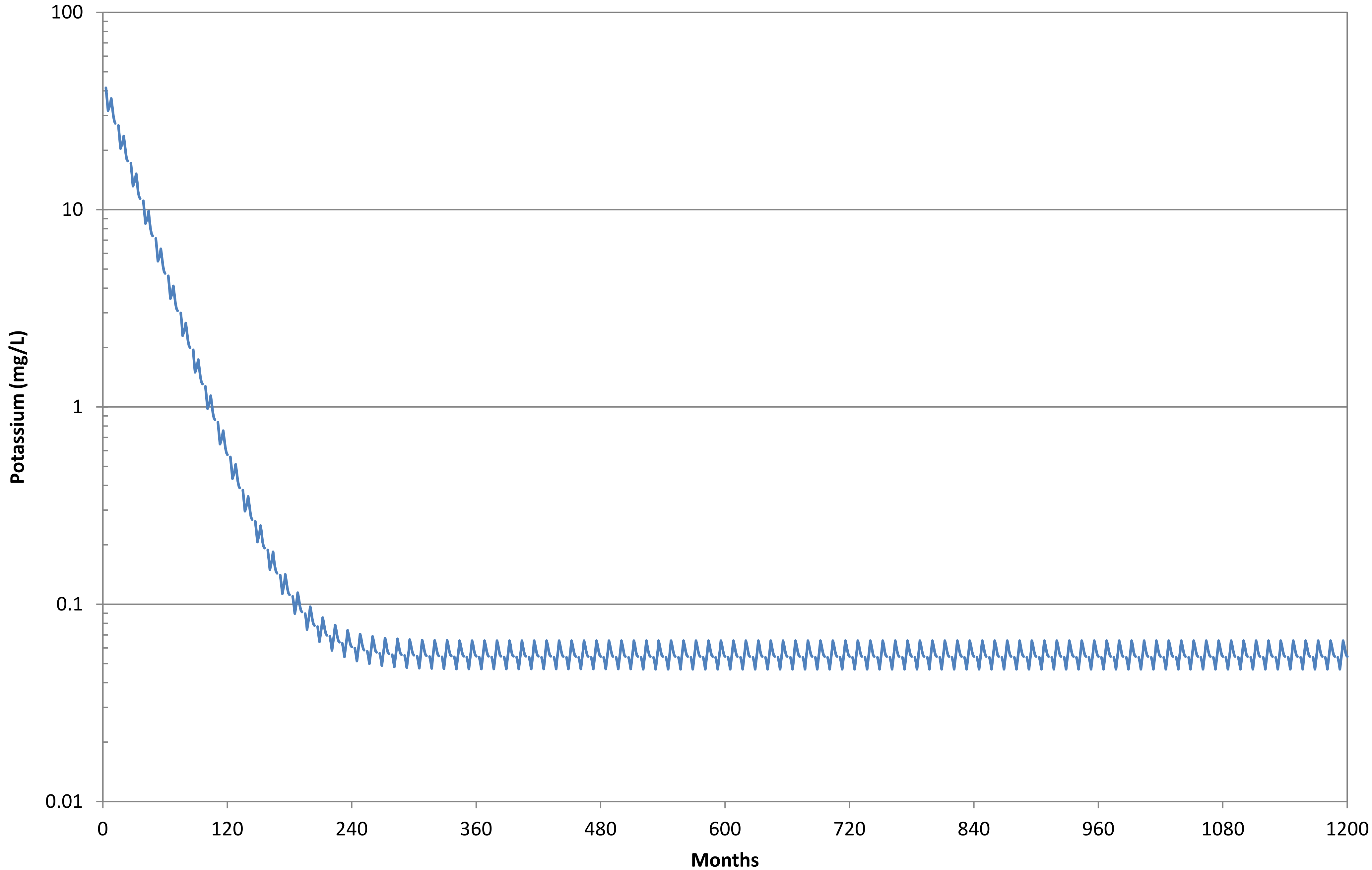
Tailings Pond Results - Na	
Rainy River Water Quality Model	
June 2013	Figure 32



RAINY RIVER

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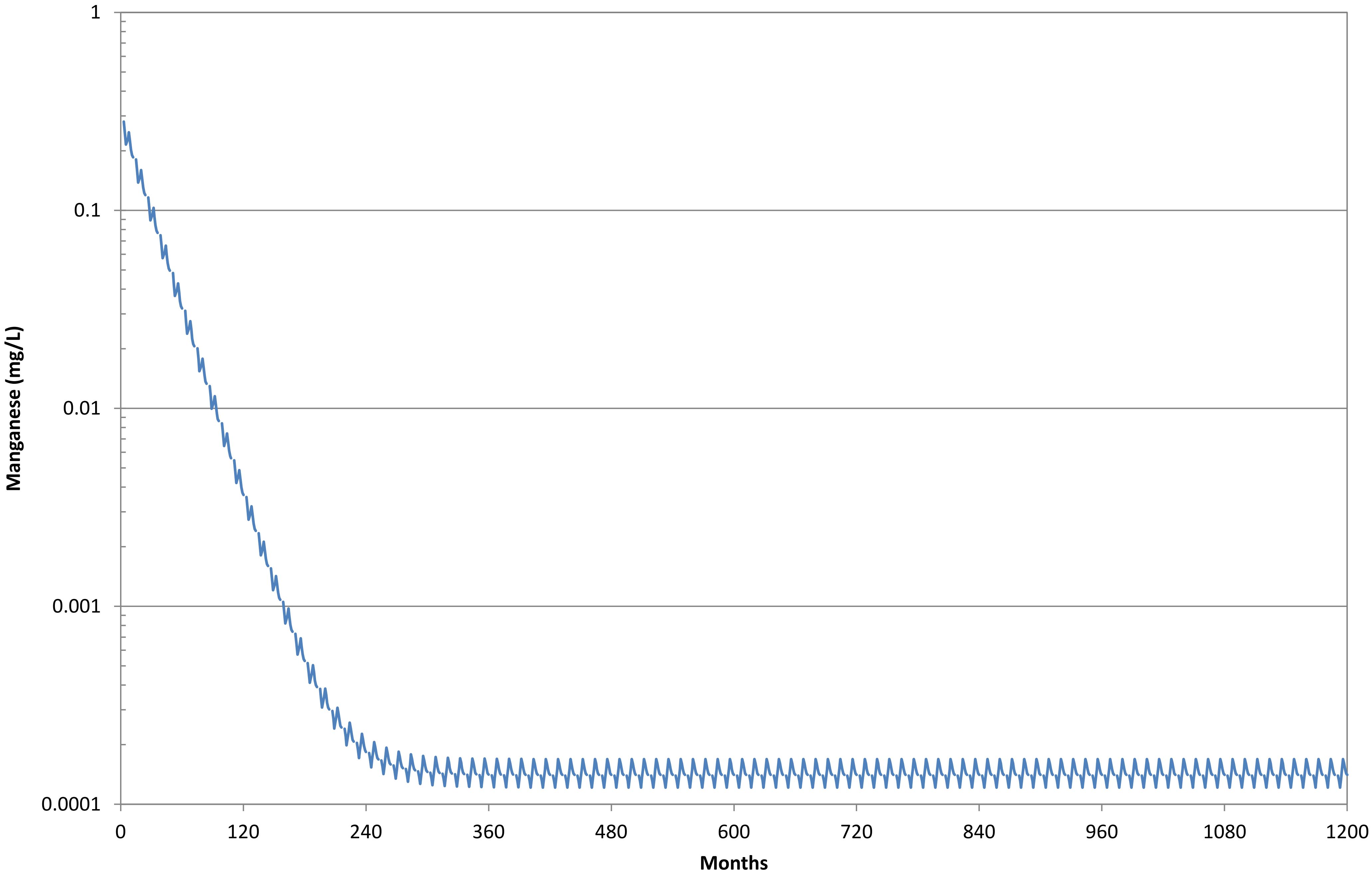
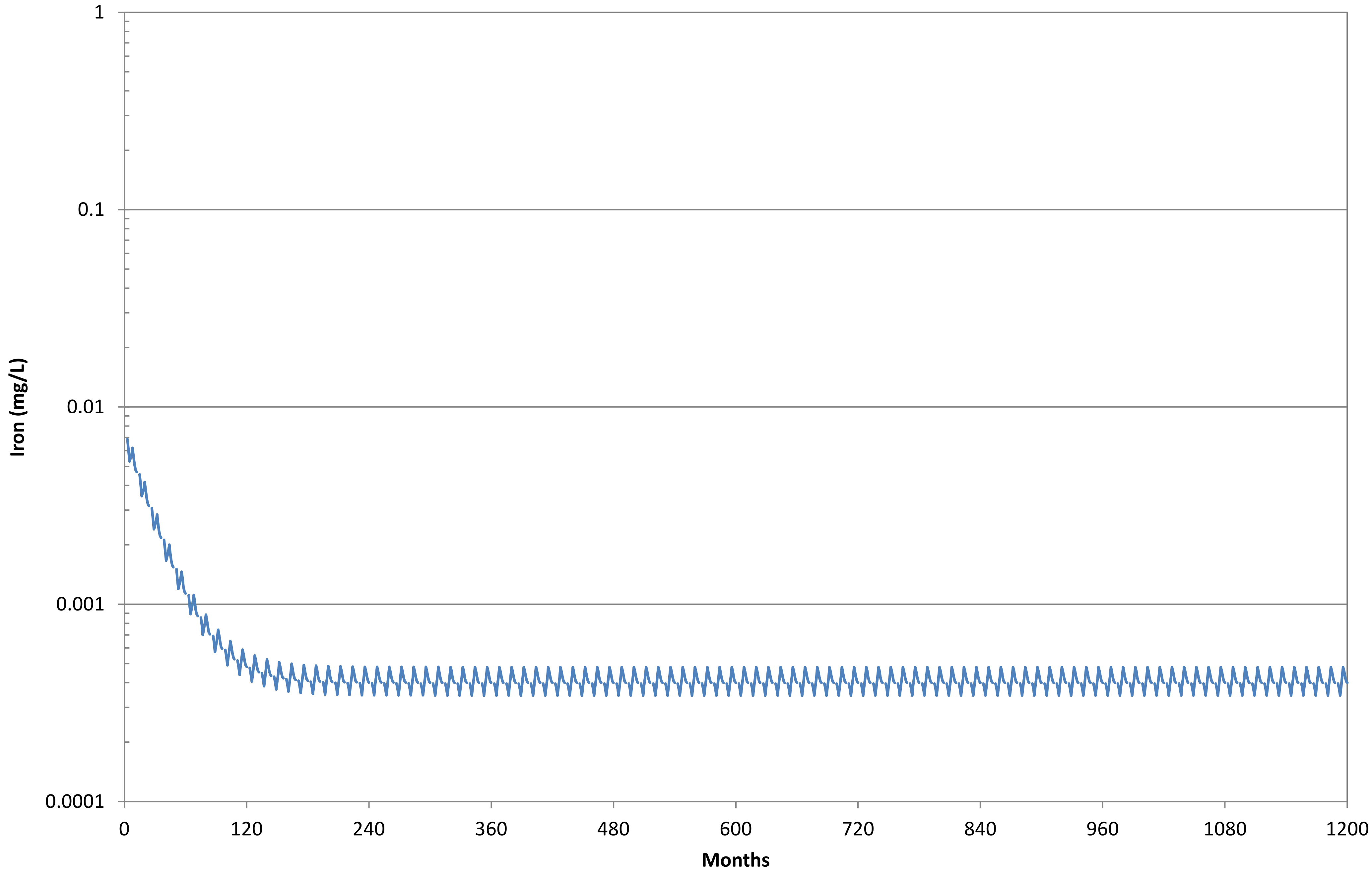
Tailings Pond Results - K	
Rainy River Water Quality Model	
June 2013	Figure 33



RAINY RIVER

amec

Tailings Pond Results - Mn	
Rainy River Water Quality Model	
June 2013	Figure 34



RAINY RIVER

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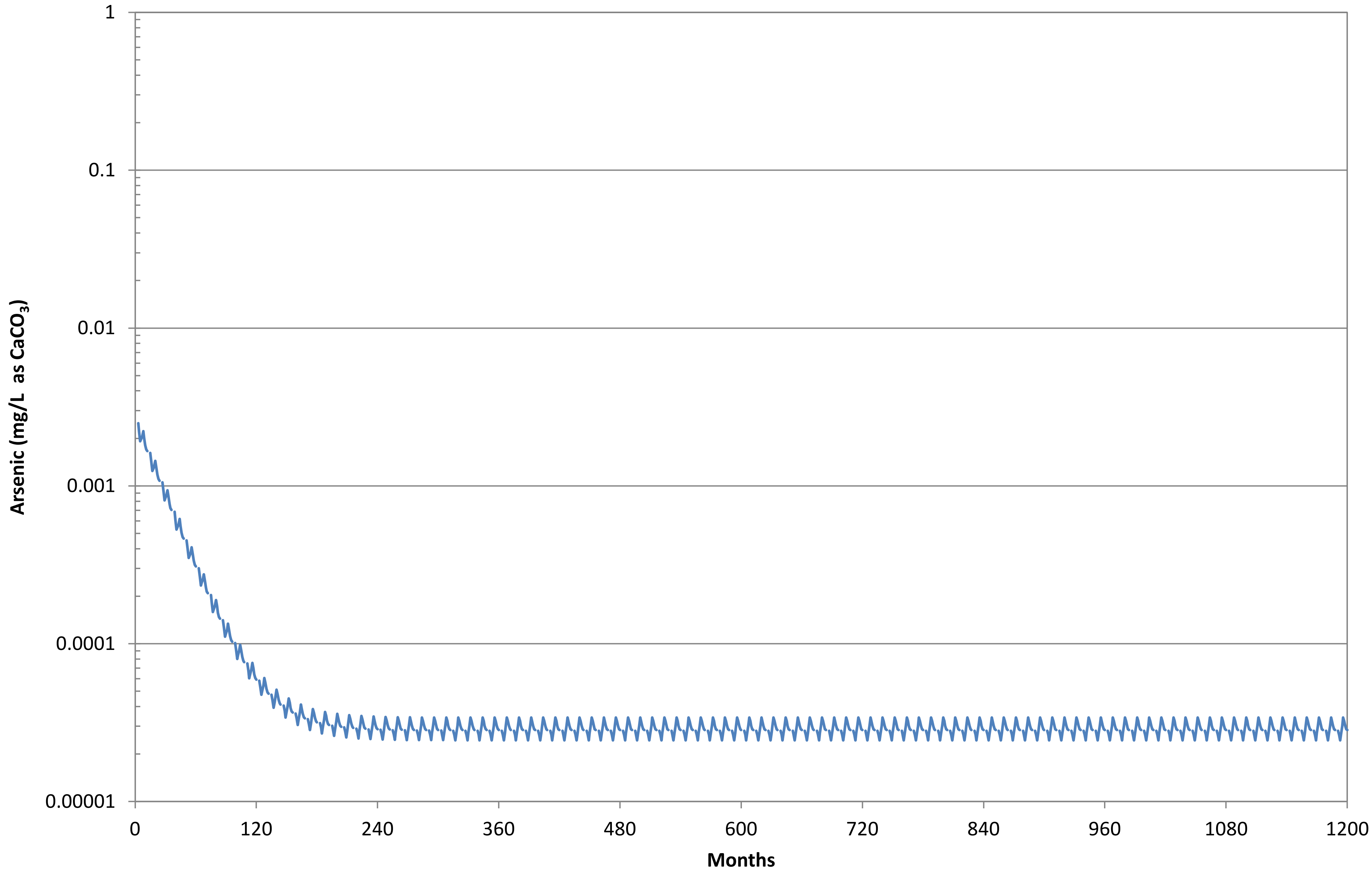
Tailings Pond Results - Fe	
Rainy River Water Quality Model	
June 2013	Figure 35

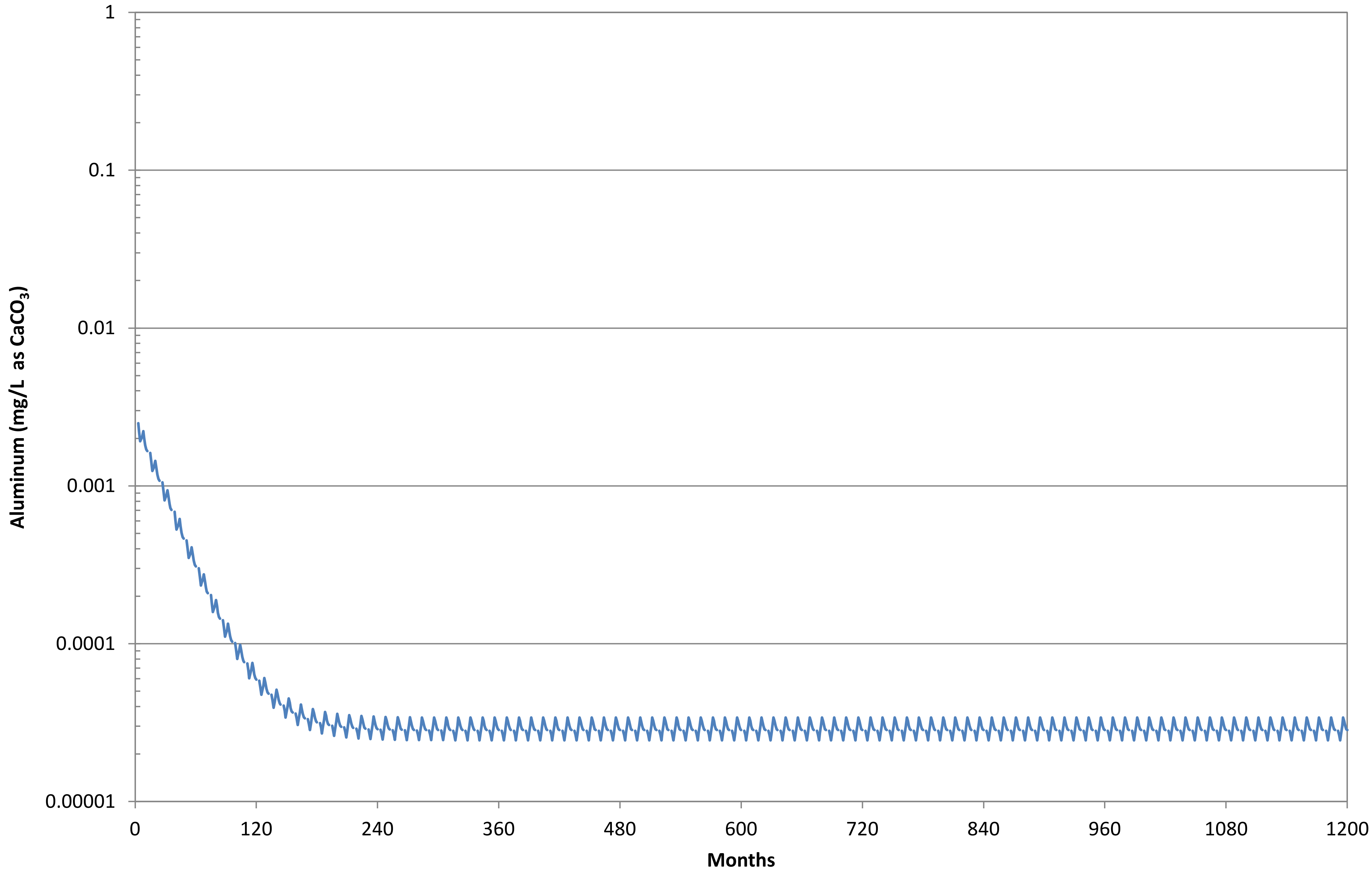
Job No. TC111504



RAINY RIVER

amec

Tailings Pond Results - As	
Rainy River Water Quality Model	
June 2013	Figure 36

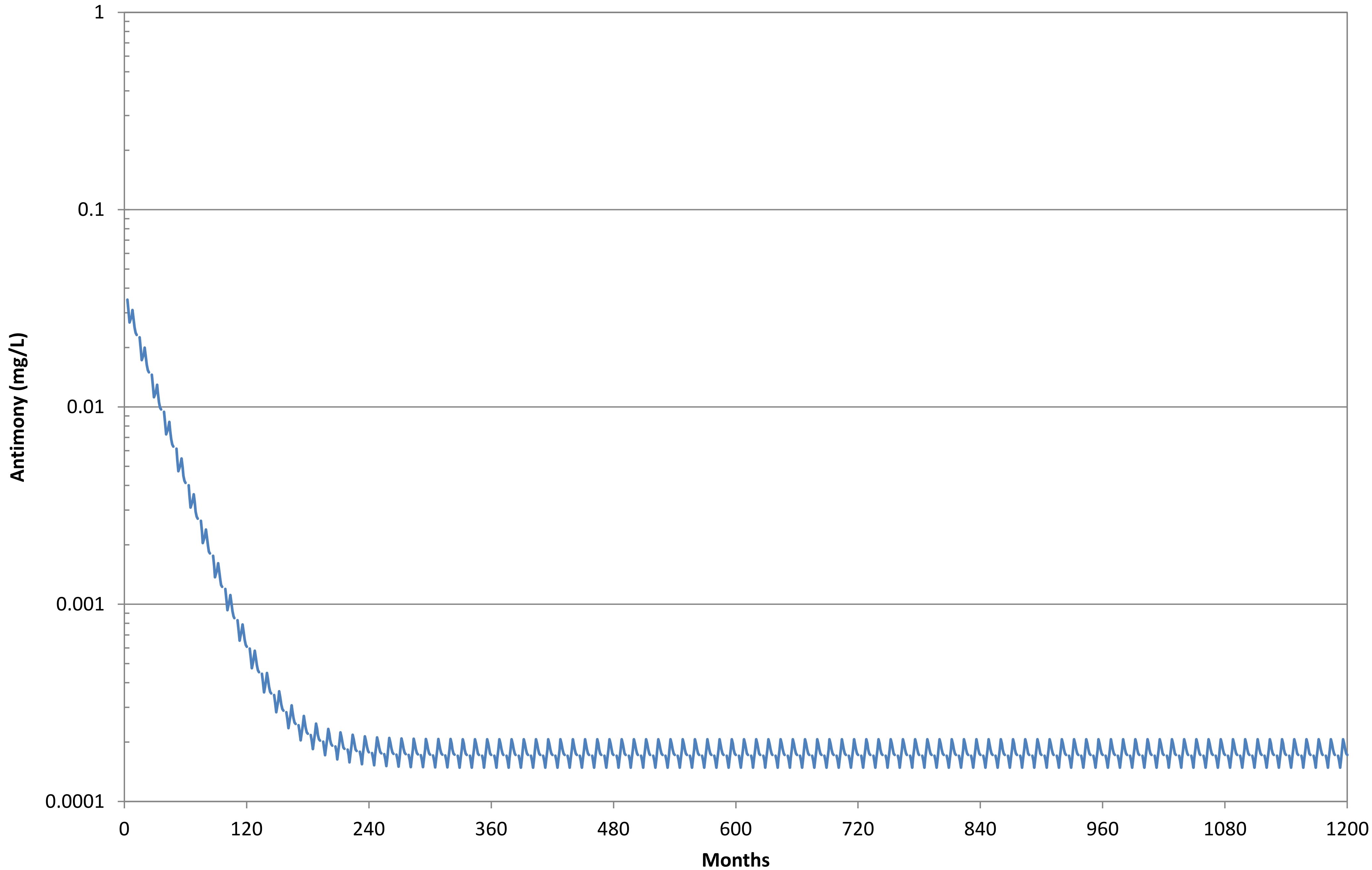


RAINY RIVER

amec

Tailings Pond Results - Al	
Rainy River Water Quality Model	
June 2013	Figure 37

Job No. TC111504

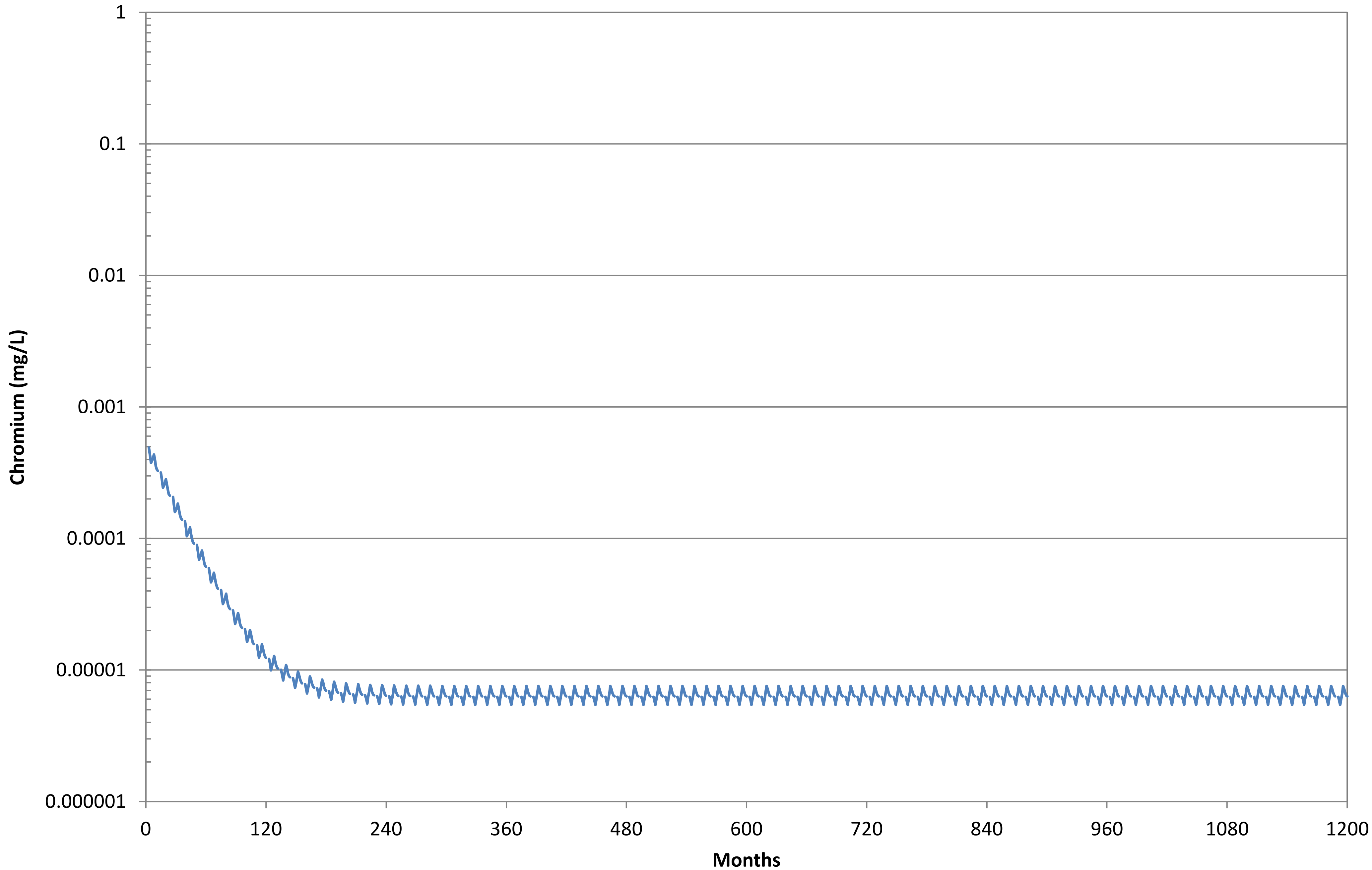


RAINYRIVER

amec

Tailings Pond Results - Sb	
Rainy River Water Quality Model	
June 2013	Figure 38

Job No. TC111504

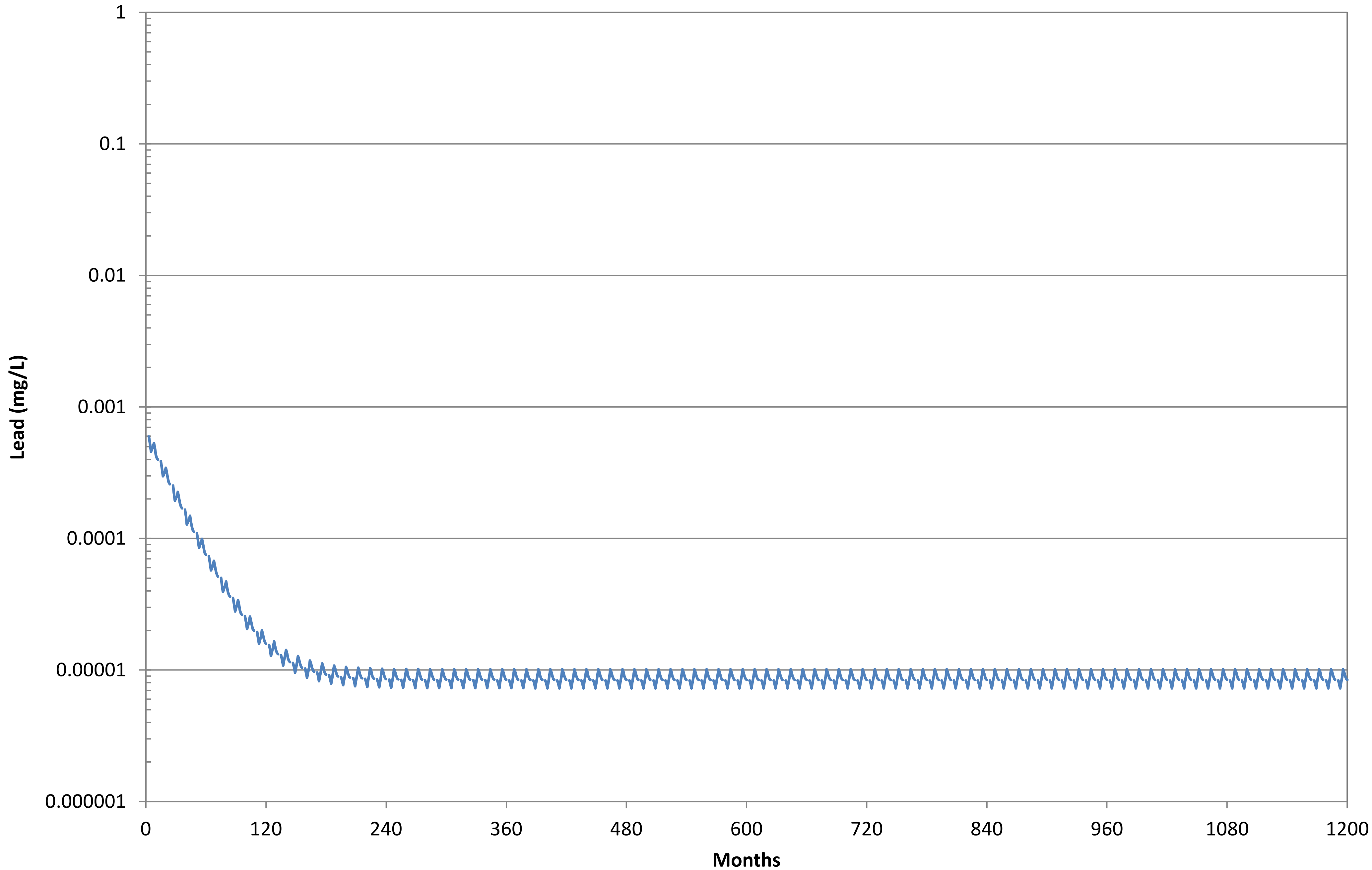


RAINYRIVER

amec

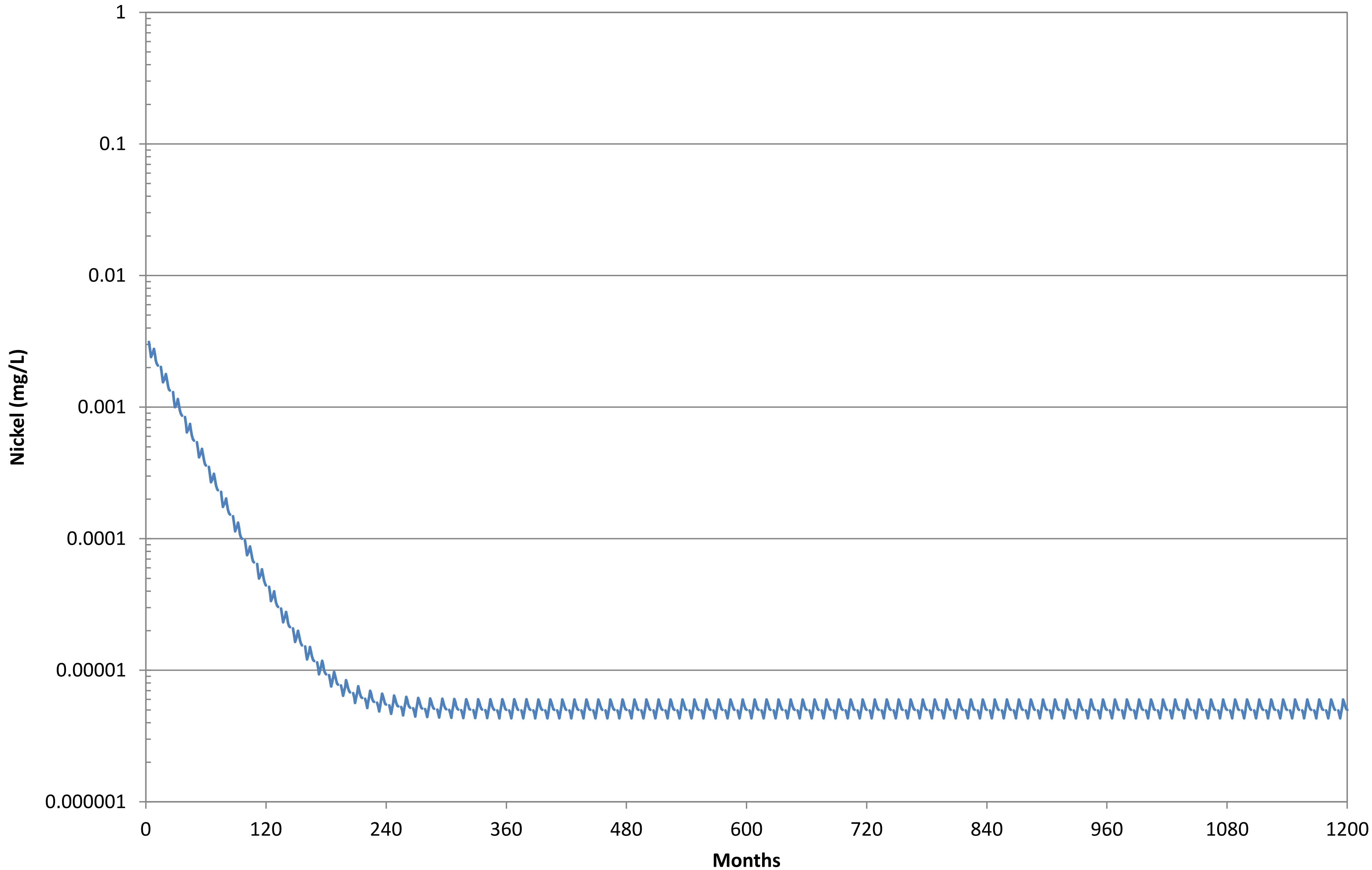
Tailings Pond Results - Cr	
Rainy River Water Quality Model	
June 2013	Figure 39

Job No. TC111504



Tailings Pond Results - Pb	
Rainy River Water Quality Model	
June 2013	Figure 40

Job No. TC111504

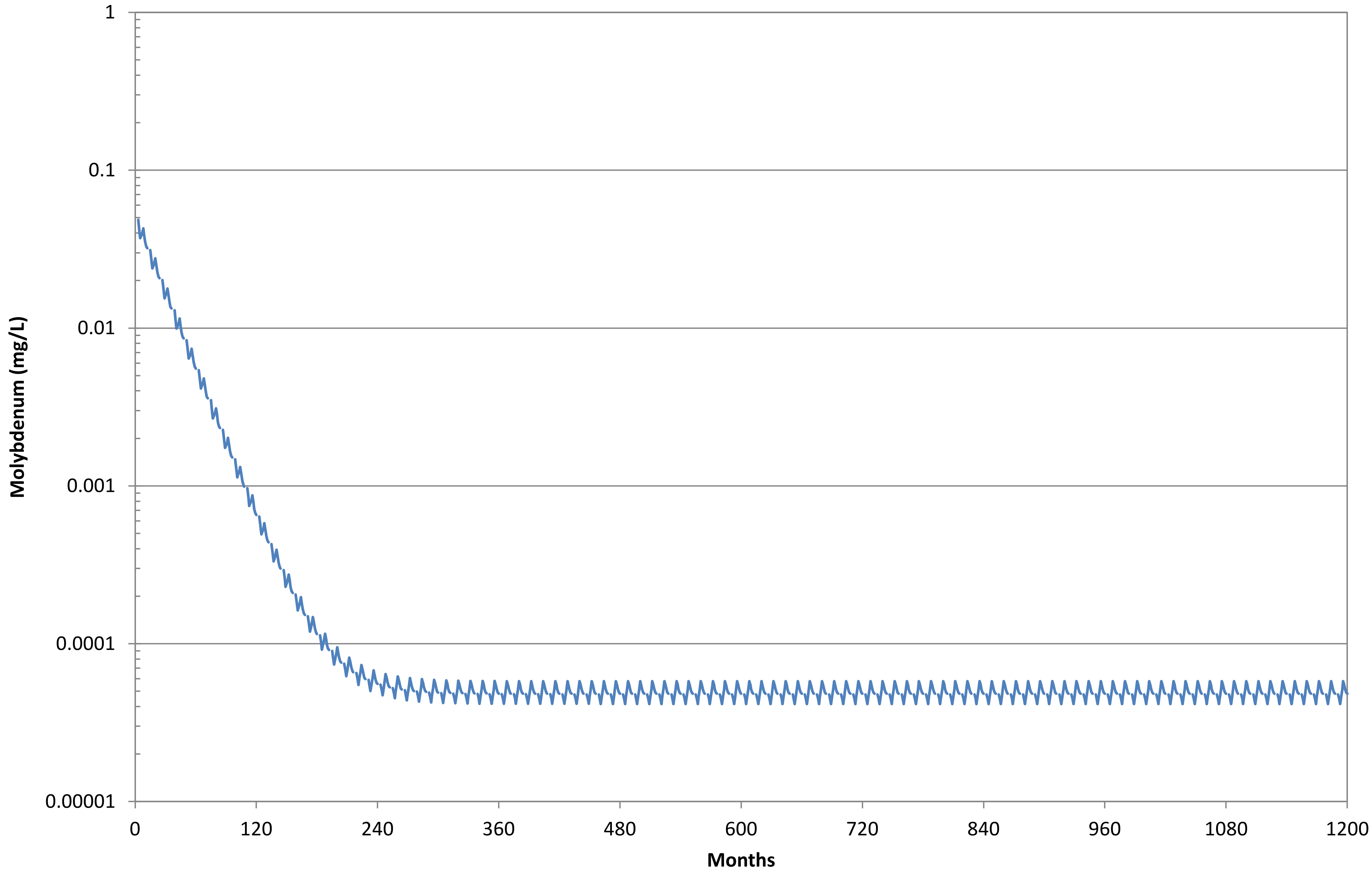


Tailings Pond Results - Ni

Rainy River Water Quality Model

June 2013	Figure 41

Job No. TC111504



Tailings Pond Results - Mo	
Rainy River Water Quality Model	
June 2013	Figure 42

APPENDIX A

Evaluation of Percolation through the East Mine Rock Stockpile Closure Cover

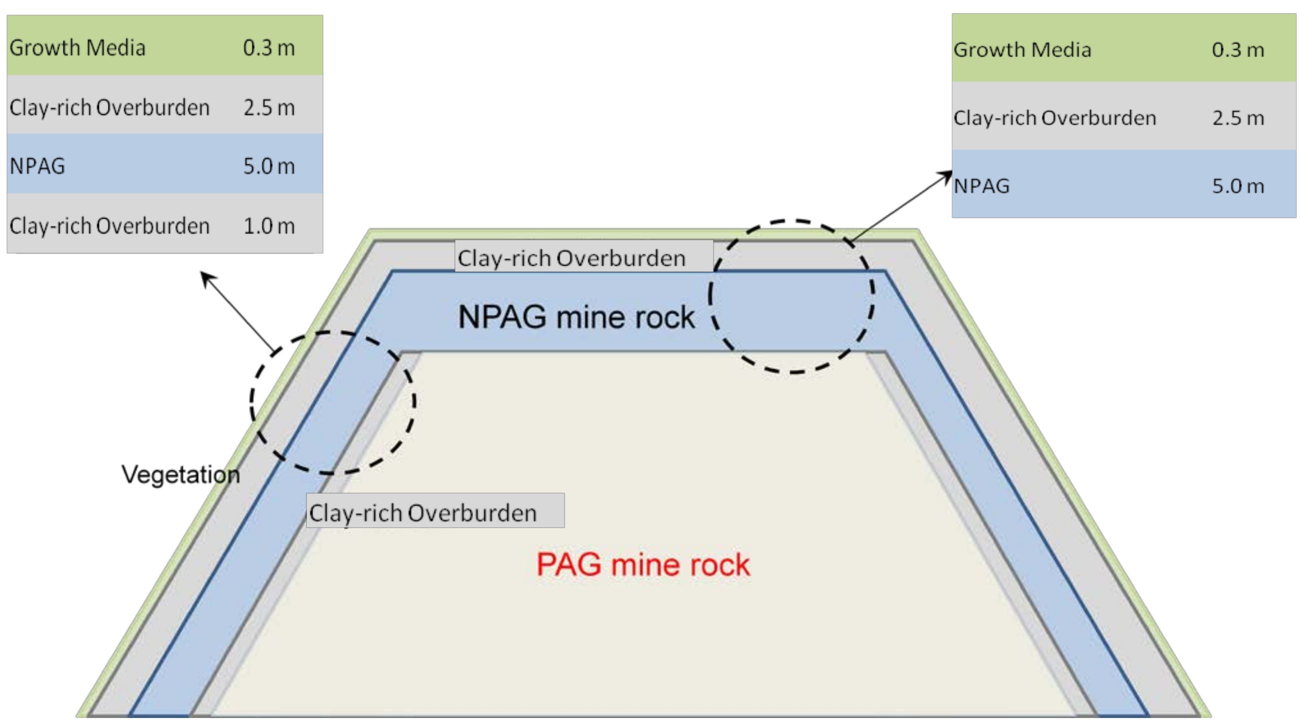
EVALUATION OF PERCOLATION THROUGH THE EAST MINE ROCK STOCKPILE CLOSURE COVER

1.0 INTRODUCTION

AMEC Environment & Infrastructure, a division of AMEC Americas Limited (AMEC) was retained by Rainy River Resources (RRR) to develop feasibility level designs for the Rainy River Gold Project (RRGP). As a task of the feasibility study, closure planning was examined for the RRGP. The percolation through the proposed cover configuration for the east mine rock stockpile is examined.

2.0 METHODOLOGY

The Hydraulic Evaluation of Landfill Performance version 3.07 (HELP) model was utilised to simulate percolation through the cover schematic as shown below (note schematic is not to scale).



As shown in the above schematic, the east mine rock stockpile closure cover will have two different cross sections on the top slopes and side slopes. Therefore, two separate models were developed. As presented on December 19, 2012 by BBA, the mine rock stockpile will have side slopes of 6H: 1V and 8H: 1V. Both slopes were examined for the side slope cover schematic.

The HELP model was utilised to examine the percolation through both the upper and lower clay rich soil layers illustrated in the cover schematic.

3.0 HELP MODEL INPUT PARAMETERS

3.1 Meteorological Data

Meteorological data were obtained from the weather station located at Barwick Station (Stn 6020559). Temperature and precipitation data were collected from 1971 through 2001. The average monthly data are presented in Table A.1. The average monthly temperature and precipitation data were input into the HELP model to simulate 100 years of daily data for the analyses.

The average wind was based on the average monthly wind speed from the Fort Frances Airport weather station. The average wind speed was 11 km/h. The average monthly wind speed data for the Fort France Airport are provided in Table A.1.

The average relative quarterly humidity data were based on the default parameters provided by the HELP model for Duluth Minnesota and corrected for the latitude of the RRGP.

3.2 Maximum Leaf Area Index

The HELP Model defines the leaf area index (LAI) as the ratio of the area that a leaf is transpiring vegetation to the nominal surface area of the land growing vegetation. The HELP model indicates the following typical LAI values:

- 0 – Bare ground;
- 1.0 – Poor stand of grass;
- 2.0 – Fair stand of grass; and
- 5.0 –Excellent stand of grass.

LAI values for the RRGP have been reported to range from 2 – 4 as shown in Figure A.1 (NRCAN, 2012). Previous studies on worldwide LAI values for a variety of land cover types have indicated that grasses and shrub LAI values typically range from 1 – 4 (Scurlock *et al.*, 2001). To be more conservative, the base case assumed an LAI value of 2.0.

3.3 Growing Season

The growing season for the site was selected based on the map provided in Figure A.2 from the National Atlas of Canada (NRCAN, 2010). Figure A.2 illustrates an approximate growing season for the site of about 175 days. As indicated on Figure A.2, the growing season was represented as the number of days where the temperature is above 5.6°C, this is consistent with the average temperature data provided in Table A.1.

3.4 Evaporative Zone Depth

The evaporative zone depth is the maximum depth from which water may be transpired as evaporation. This parameter is dependent on the land cover type and is utilised in determine percolation through the cover type. The following typical values are provided by the HELP model:

- Zero to several inches for gravel;
- 4 – 8 inches for sands;
- 8 – 18 inches for silts; and
- 12 – 60 inches for clays.

The evaporative zone depth was assumed to be the thickness of the growth media layer.

3.5 Solar Radiation Data

The solar radiation data for the RRGP was calculated by the HELP model bays on the data for St. Cloud, Minnesota and corrected for the latitude of the RRGP.

3.6 Cover Characteristics

Growth Media

The Growth Media layer was modelled as the HELP model default soil for a silty loam.

Clay-rich Overburden

The clay-rich overburden material for the east mine rock stockpile cover will be obtained from the local overburden at the RRGP and was assumed to have values typical to those presented in *Rainy River Gold Project Geotechnical and Hydrogeolgoical Site Investigations Version 3 – Draft Report* (2012). The clay-rich overburden layer(s) of the cover were assumed to be typical of the reported Silty Clay Till. The clay-rich overburden layer for the cover was modelled as the HELP model's default material for a silty clay. The default hydraulic conductivity value was changed based on the field investigations (AMEC, 2013). The following hydraulic conductivities were examined:

- 1.5×10^{-7} cm/s;
- 5.0×10^{-8} cm/s; and
- 2.0×10^{-5} cm/s.

The upper 50 – 100 cm of the clay-rich overburden material was assumed to become desiccated due to the freeze/thaw cycles at the RRGP (Benson *et al.*, 1995). It has been previously found that within the first three to nine freeze/thaw cycles, the changes in the hydraulic conductivity will cease (Othman and Benson, 1993). Indicating that desiccation will occur relatively quickly following placement of the cover. Previous studies have found that desiccation from freeze/thaw cycles will increase the hydraulic conductivity of clay-rich overburden by about 60 to 500 times (Albrecht and Benson, 2001 and Othman and Benson, 1992). Therefore the upper 50 to 100 cm of the uppermost clay layer of the cover was assumed to have a hydraulic conductivity about 500 times greater than the remaining clay-rich overburden. The following hydraulic conductivities were modelled:

- $7.0\text{x}10^{-5}$ cm/s;
- $3.0\text{x}10^{-5}$ cm/s; and
- $1.0\text{x}10^{-2}$ cm/s.

The non-potentially acid generating (NPAG) mine rock was modelled as the coarsest default material from the HELP model soils (gravel). The hydraulic conductivity was increased to $1\text{x}10^{-3}$ cm/s as per pervious investigations on the *Hydrogeology of Waste Rock Dumps* (MEND, 1995).

The base case and typical cover schematics are summarized in Table A.2.

3.7 CN Number

The CN number for the HELP model was assumed to be 81 – 85, as per the hydrology studies undertaken in conjunction with the *Rainy River Gold Project Water Management Plan* (2013).

4.0 SENSITIVITY ANALYSES

Sensitivity analyses were undertaken on the base case to assess the potential impact of LAI, evaporative zone depth and wind speed data on the percolation values. The sensitivity analyses parameters are summarized below:

- LAI – 1.0 - 3.0;
- Evaporative Zone Depth – 15 cm; and
- Wind speed – 12.5 km/h.

5.0 RESULTS

The HELP model results are provided in Table A.3. A statistical summary of the data is provided in Table A.4. The results for the 8H: 1V side slopes are summarized as follows:

- The average annual percolation through the full cover ranged from 2.3 – 14.1%.
- The average annual runoff ranged from 16.3 – 21.4%.
- The average annual evapotransipration ranged from 68.9 – 75.6%.
- The minimum and maximum average annual percolation modelled were <0.1% and 28.3% respectively.

The results for the 6H: 1V side slopes are summarized below.

- The average annual percolation through the full cover ranged from 2.3 – 14.1%.
- The average annual runoff ranged from 16.3 – 21.4%.
- The average annual evapotransipration ranged from 68.9 – 75.6%.
- The minimum and maximum average annual percolation modelled were <0.1% and 28.3% respectively.

The results for the top slopes are summarized below.

- The average annual percolation ranged from 2.9 – 14.8%.
- The average annual runoff ranged from 16.3 – 21.4%.
- The average annual evapotranspiration ranged from 68.9 – 75.6%.
- The minimum and maximum average annual percolation modelled were 2.3% and 27.4% respectively.

The results of the sensitivity analyses are presented in Table A.5. The sensitivity analyses were undertaken on the base case (Cases 1, 9 and 17) for comparison purposes only. As presented in Tables A.3 and A.5 no significant changes to the modelled average annual percolation values were observed (less than 1%) for the parameters examined.

6.0 RECOMMENDATIONS

Based on the results presented in Section 5.0, the following recommendations are provided for inclusion in the geochemical cover model for the east mine rock stockpile cover for utilisation as a base case:

- No significant changes in the percolation rates were identified between the Mine Rock Stockpile side slopes of 8H: 1V compared to 6H: 1V. Therefore, based on the above results it is recommended that the same percolation parameters be used for all the east mine rock stockpile side slopes.

- Case 4 is recommended as the base case for the side slopes. Case 4, results are comparable to the average annual percolation values for the upper and lower clay rich layers (Table A.3 and Table A.4). Case 4 was developed for a thicker desiccated clay

layer which is considered conservative, but within the anticipated range for desiccation. The Case 4 results are summarized below:
  - Average annual percolation (upper clay-rich overburden layer): 10.7% (73.2 mm/a); and
  - Average annual percolation (lower clay-rich overburden layer: 7.2% (49.2 mm/).

- It is recommended that the percolation rate for the top slopes be based on the comparable Case 4 for the top slopes (Case 20). The Case 20 results are provided below:
  - Average annual percolation: 10.7% (73.2 mm/a).

7.0 REFERENCES

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Table A.1: Average Monthly Precipitation, Temperature and Wind Speed Data

Month	Precipitation[1] (mm)	Temperature[1] (°C)	Wind Speed[2] (mm)
January	28.3	-15.9	10.4
February	24.1	-11.6	9.7
March	29.7	-4.4	11.6
April	40	4.2	12.1
May	68.3	11.7	11.6
June	113.8	16.2	11
July	99	18.8	9.4
August	84	17.8	9.5
September	80	12.1	11.6
October	56.2	5.5	12.5
November	41.7	-3.8	12.4
December	29.7	-12.7	10.7

Sources:
[1] Barwick Station (Stn 6020559)
[2] Fort Frances A Station (Stn 6022476)

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Table A.2: Summary of Input Parameters

Cover Parameters	Units	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13	Case 14	Case 15	Case 16	Case 17	Case 18	Case 19	Case 20	Case 21	Case 22	Case 23	Case 24
Slope	%	13	13	13	13	13	13	13	13	17	17	17	17	17	17	17	17	1	1	1	1	1	1	1	1
CN	-	81	81	81	81	81	81	85	85	81	81	81	81	81	81	85	85	81	81	81	81	81	81	85	85
Growth Media																									
Depth	cm	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Hydraulic Conductivity	cm/s	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04
Field Capacity	%	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4
Wilting Point	%	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Silty Clay (Desiccated)																									
Depth	cm	50	50	50	100	100	50	50	100	50	50	50	100	100	50	50	100	50	50	50	100	100	50	50	100
Hydraulic Conductivity	cm/s	7.0E-05	3.0E-05	1.0E-02	7.0E-05	3.0E-05	1.0E-02	7.0E-05	7.0E-05	7.0E-05	3.0E-05	1.0E-02	7.0E-05	3.0E-05	1.0E-02	7.0E-05	7.0E-05	7.0E-05	3.0E-05	1.0E-02	7.0E-05	3.0E-05	1.0E-02	7.0E-05	7.0E-05
Compacted Silty Clay																									
Depth	cm	200	200	200	150	150	200	200	150	200	200	200	150	150	200	200	150	200	100	100	100	100	100	100	100
Hydraulic Conductivity	cm/s	1.5E-07	5.0E-08	2.0E-05	1.5E-07	5.0E-08	2.0E-05	1.5E-07	1.5E-07	1.5E-07	5.0E-08	2.0E-05	1.5E-07	5.0E-08	2.0E-05	1.5E-07	1.5E-07	1.5E-07	5.0E-08	2.0E-05	1.5E-07	5.0E-08	2.0E-05	1.5E-07	1.5E-07
NPAG																									
Hydraulic Conductivity	cm/s	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Compacted Silty Clay																									
Depth	cm	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hydraulic Conductivity	cm/s	1.5E-07	5.0E-08	2.0E-05	1.5E-07	5.0E-08	2.0E-05	1.5E-07	1.5E-07	1.5E-07	5.0E-08	2.0E-05	1.5E-07	5.0E-08	2.0E-05	1.5E-07	1.5E-07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A - Not Applicable

Table A.3: Output Data

Cases	Average Annual Runoff (%)	Average Annual Evapotranspiration (%)	Average Percolation through Upper Clay Rich Layer (%)	Average Annual Percolation through Full Cover (%)
Case 1	19.2	72.4	8.3	7.1
Case 2	21.4	75.6	2.9	2.3
Case 3	16.3	68.9	14.8	14.1
Case 4	18.1	71.0	10.7	7.2
Case 5	21.0	75.0	3.9	2.4
Case 6	16.3	68.9	14.8	14.1
Case 7	19.7	71.9	8.3	7.1
Case 8	18.6	70.5	10.7	7.6
Case 9	19.2	72.4	8.3	7.1
Case 10	21.4	75.6	2.9	2.3
Case 11	16.3	68.9	14.8	14.1
Case 12	18.1	71.0	10.7	7.1
Case 13	21.0	75.0	3.9	2.4
Case 14	16.3	68.9	14.8	14.1
Case 15	19.7	71.9	8.3	7.1
Case 16	18.6	70.5	10.7	7.4
Case 17	19.2	72.4	N/A	8.3
Case 18	21.4	75.6	N/A	2.9
Case 19	16.3	68.9	N/A	14.8
Case 20	18.1	71.0	N/A	10.7
Case 21	21.0	75.0	N/A	3.9
Case 22	16.3	68.9	N/A	14.8
Case 23	19.7	71.9	N/A	8.3
Case 24	18.6	70.5	N/A	10.6

N/A - Not Applicable

RAINY RIVER

Table A.4: Statistical Summary

Slope	Case	Upper Clay-rich Overburden Layer						Full Cover					
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
		mm/a			%			mm/a			%		
Side Slope 8H:1V	Case 1	33.2	60.5	56.8	5.8	11.9	8.5	26.8	49.5	48.7	4.7	10.2	7.3
	Case 2	17.6	20.6	19.9	2.3	4.1	3.0	6.2	16.1	16.0	1.1	3.3	2.4
	Case 3	27.8	243.1	100.7	4.9	27.4	14.4	0.0	183.2	96.4	<0.1	28.3	14.3
	Case 4	33.5	79.7	73.2	5.9	15.5	10.9	0.0	52.9	49.2	<0.1	10.9	7.3
	Case 5	18.0	27.4	26.3	3.0	5.5	3.9	6.2	16.6	16.4	1.1	3.4	2.4
	Case 6	27.8	243.1	100.7	4.9	27.4	14.4	0.0	183.3	96.4	0.0	28.3	14.3
	Case 7	33.2	60.5	56.7	5.8	11.8	8.4	26.7	49.5	48.6	4.7	10.2	7.3
	Case 8	33.5	79.7	72.9	5.9	15.5	10.9	26.8	52.9	51.6	4.8	10.8	7.7
	Minimum	17.6	20.6	19.9	2.3	4.1	3.0	0.0	16.1	16.0	<0.1	3.3	2.4
	Maximum	33.5	243.1	100.7	5.9	27.4	14.4	26.8	183.3	96.4	4.8	28.3	14.3
	Average	28.1	101.8	63.4	4.8	14.9	9.3	11.6	75.5	52.9	2.0	13.2	7.9

Slope	Case	Upper Clay-rich Overburden Layer						Full Cover					
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
		mm/a			%			mm/a			%		
Side Slope 6H:1V	Case 9	33.2	60.5	56.8	5.8	11.9	8.5	26.8	49.1	48.3	4.7	10.1	7.2
	Case 10	17.6	20.6	19.9	2.3	4.1	3.0	6.2	16.0	15.9	1.1	3.3	2.4
	Case 11	27.8	243.1	100.7	4.9	27.4	14.4	0.0	183.2	96.4	<0.1	28.3	14.3
	Case 12	33.5	79.7	73.2	5.9	15.5	10.9	0.0	51.8	48.2	<0.1	10.7	7.2
	Case 13	18.0	27.4	26.3	3.0	5.5	3.9	6.2	16.4	16.2	1.1	3.4	2.4
	Case 14	27.8	243.1	100.7	4.9	27.4	14.4	0.0	183.3	96.4	0.1	28.3	14.3
	Case 15	33.2	60.5	56.7	5.8	11.8	8.4	26.7	49.1	48.2	4.7	10.1	7.2
	Case 16	33.5	79.7	72.9	5.9	15.5	10.9	26.8	51.8	50.7	4.8	10.6	7.6
	Minimum	17.6	20.6	19.9	2.3	4.1	3.0	0.0	16.0	15.9	<0.1	3.3	2.4
	Maximum	33.5	243.1	100.7	5.9	27.4	14.4	26.8	183.3	96.4	4.8	28.3	14.3
	Average	28.1	101.8	63.4	4.8	14.9	9.3	11.6	75.1	52.5	2.0	13.1	7.8

Slope	Case	Full Cover					
		Minimum	Maximum	Average	Minimum	Maximum	Average
		mm/a			%		
Top Slope	Case 17	33.2	60.5	56.8	5.8	11.9	8.5
	Case 18	17.6	20.6	19.9	2.3	4.1	3.0
	Case 19	27.8	243.1	100.7	4.9	27.4	14.4
	Case 20	33.5	79.7	73.2	5.9	15.5	10.9
	Case 21	18.0	27.4	26.3	3.0	5.5	3.9
	Case 22	27.8	243.1	100.7	4.9	27.4	14.4
	Case 23	33.2	60.5	56.7	5.8	11.8	8.4
	Case 24	33.5	79.7	72.9	5.9	15.5	10.9
	Minimum	17.6	20.6	19.9	2.3	4.1	3.0
	Maximum	33.5	243.1	100.7	5.9	27.4	14.4
	Average	28.1	101.8	63.4	4.8	14.9	9.3

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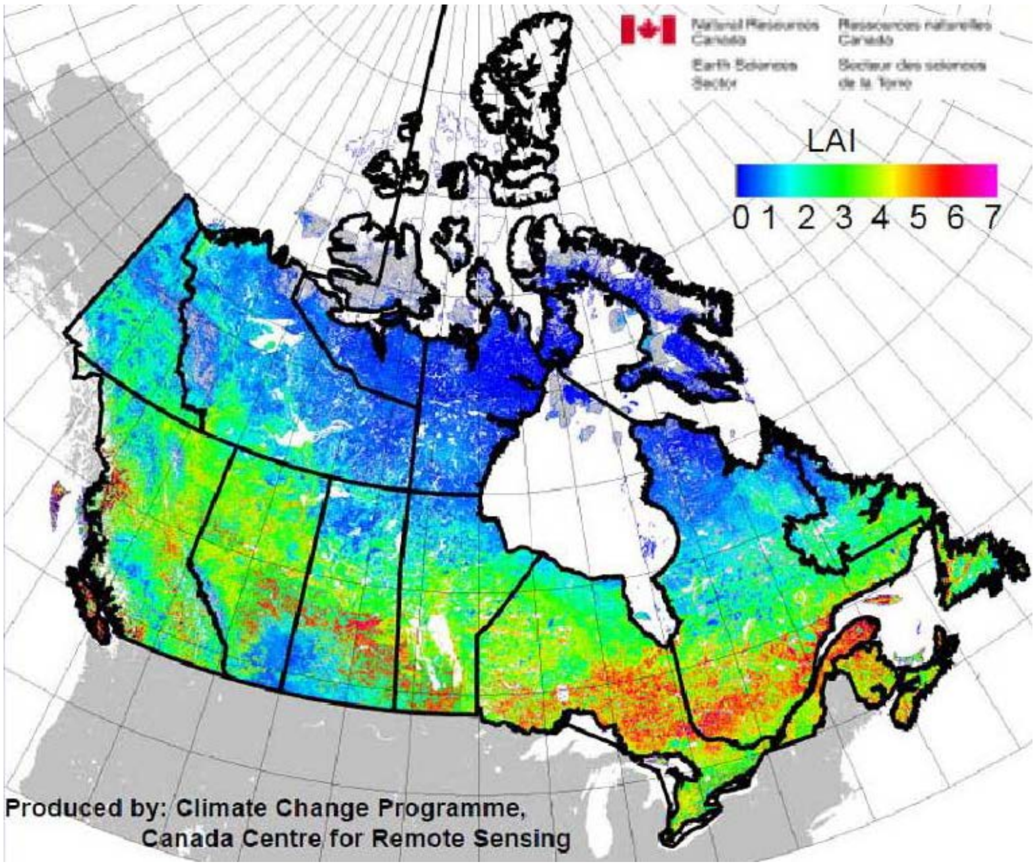
Table A.5: Sensitivity Analyses

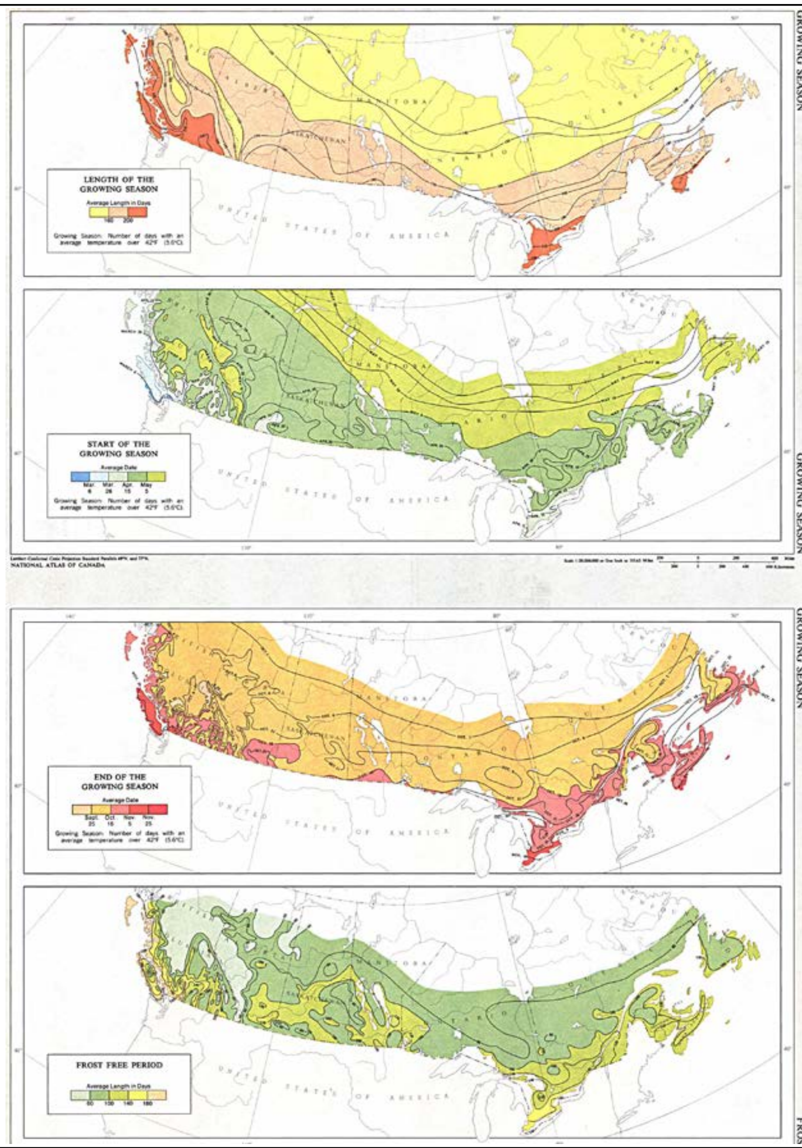
Cover Parameters	Units	Case 25	Case 26	Case 27	Case 28	Case 29	Case 30	Case 31	Case 32	Case 33
Slope	%	13	17	1	13	17	1	13	17	1
CN	-	81	81	81	81	81	81	81	81	81
Growth Media										
Depth	cm	30	30	30	30	30	30	30	30	30
Hydraulic Conductivity	cm/s	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04	1.9E-04
Field Capacity	%	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4
Wilting Point	%	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Silty Clay (Desiccated)										
Depth	cm	50	50	50	50	50	50	50	50	50
Hydraulic Conductivity	cm/s	7.0E-05	7.0E-05	7.0E-05	7.0E-05	7.0E-05	7.0E-05	7.0E-05	7.0E-05	7.0E-05
Compacted Silty Clay										
Depth	cm	200	200	200	200	200	200	200	200	200
Hydraulic Conductivity	cm/s	1.5E-07	1.5E-07	1.5E-07	1.5E-07	1.5E-07	1.5E-07	1.5E-07	1.5E-07	1.5E-07
NPAG										
Hydraulic Conductivity	cm/s	1.0E-03	1.0E-03	N/A	1.0E-03	1.0E-03	N/A	1.0E-03	1.0E-03	N/A
Compacted Silty Clay										
Depth	cm	100	100	N/A	100	100	N/A	100	100	N/A
Hydraulic Conductivity	cm/s	1.5E-07	1.5E-07	N/A	1.5E-07	1.5E-07	N/A	1.5E-07	1.5E-07	N/A
Output										
Average Annual Runoff	%	19.3	19.3	19.3	19.2	19.2	19.2	24.2	24.2	24.2
Average Annual Evapotranspiration	%	72.2	72.2	72.2	72.4	72.4	72.4	66.7	66.7	66.7
Average Percolation through upper SiCl	%	8.4	8.4	N/A	8.3	8.3	N/A	9.1	9.1	N/A
Lateral Drainage	%	1.2	1.3	N/A	1.2	8.4	N/A	1.7	1.8	N/A
Average Annual Percolation through Full Cover	%	7.2	7.1	8.4	7.1	7.0	8.3	7.3	7.2	9.1

N/A - Not Applicable

RAINY RIVER



NOTES:	CLIENT:		PROJECT:	PROJECT NO.:
Source: (NRCAN, 2012)	RAINY RIVER		**Rainy River Gold Project**	REVISION NO.:
			TITLE:	DATE: Mar 2013
	AMEC Environment & Infrastructure 160 Traders Boulevard East Mississauga, Ontario, Canada L4Z 3K7	amec	**Leaf Area Index Map**	FIGURE NO.: A.1
				SHEET NO.:



NOTES:	CLIENT:		PROJECT:	PROJECT NO.:
Source: (NRCAN, 2010)	RAINY RIVER		Rainy River Gold Project	REVISION NO.:
			TITLE:	DATE: Mar 2013
	AMEC Environment & Infrastructure 160 Traders Boulevard East Mississauga, Ontario, Canada L4Z 3K7	amec	**Growing Season Map**	FIGURE NO.: A.2
				SHEET NO.: