APPENDIX S

HYDROGEOLOGY MODELLING REPORT

S-1 Hydrogeology Modelling Report
S-2 Detailed Response to Regulatory Comments on Draft EA Report (Version 2)

APPENDIX S-1

HYDROGEOLOGY MODELLING REPORT

RAINY RIVER

RAINY RIVER GOLD PROJECT
HYDROGEOLOGY MODELLING REPORT

Submitted by:

AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited
160 Traders Blvd., Suite 110
Mississauga, Ontario
L4Z 3K7

On behalf of:

Rainy River Resources Limited
1111 Victoria Avenue East
Thunder Bay, Ontario
P7C 1B7

May 2013
TC111504

amec

May 16, 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,

AMEC Environment & Infrastructure is pleased to submit the attached 2013 Hydrogeology Modelling Report for the Rainy River Gold Project.

This Hydrogeology Modelling Report was prepared to describe the groundwater model used to:

- Simulate existing groundwater conditions at the site;
- Predict potential impacts related to mine dewatering;
- Predict the flow of water emanating from the tailings management area; and
- Predict the flow of water emanating from the east mine rock stockpile. The report heavily references the hydrogeology baseline data collected by AMEC and described in the *2013 Hydrogeology Baseline Study*, and the two reports should be read together.

We greatly appreciate the opportunity to provide support for your Rainy River Gold Project. Should you have any questions regarding the study, please do not hesitate to contact us.

Yours sincerely,
AMEC Environment & Infrastructure,
a Division of AMEC Americas Limited

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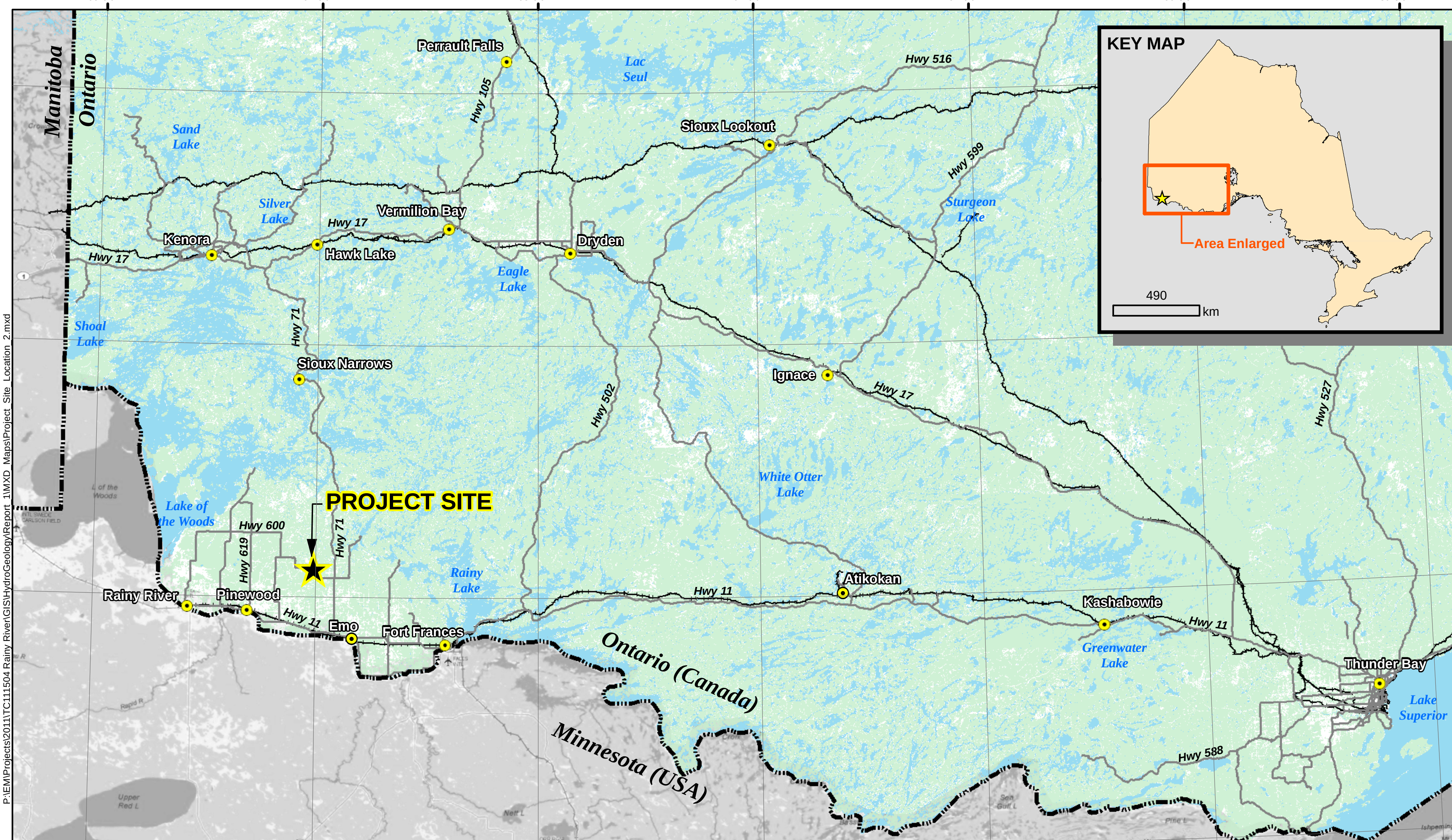
1.0 INTRODUCTION

AMEC Environment & Infrastructure (AMEC) was retained by Rainy River Resources Ltd. (RRR) to describe the current groundwater conditions and update existing information for the Rainy River Gold Project (RRGP) located in northwestern Ontario. RRR is planning to develop and operate an open pit and underground mine, the RRGP, in the Township of Chapple located approximately 65 kilometres (km) by road, northwest of Fort Frances, Ontario in northwestern Ontario (Figure 1-1). The proposed mine and RRGP site area defined for the purposes of this report, is positioned within the upper portion of the Pinewood River watershed (Figure 1-2).

1.1 General Approach

Hydrogeological and relevant other environmental information is available for a localized area relating to the RRGP site as part of previous baseline investigations initiated in 2008 (KCB 2011). AMEC conducted a comprehensive gap analysis to determine the extent and quality of existing relevant environmental data in the winter of 2011 to support future mine development. Additional baseline data were gathered by AMEC in 2011 and 2012 in order to complete a thorough characterization of the local groundwater environment, and to collect sufficient information to support numerical modelling to predict potential groundwater related impacts from mining. The characterization of the local groundwater environment is described in the AMEC (2013a) report titled *2013 Hydrogeology Baseline Study*. This report describes a groundwater model used to simulate existing hydrogeological conditions at the RRGP site and predict the potential groundwater related impacts due to mine dewatering, and the path of groundwater flow from onsite tailings management area (TMA) and the east mine rock stockpile. This report relies heavily on the information presentation in the 2013 Hydrogeology Baseline Study (AMEC 2013a) and the two reports should be read together.



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LEGEND

- Project Site
- Regional Communities
- Provincial / National Border
- Regional Road / Highway
- Railway

NOTES:
- Ontario base data extracted from Land Information Ontario (MNR) data warehouse.
- Base data outside of Ontario extracted from ESRI DeLorme World Basemap

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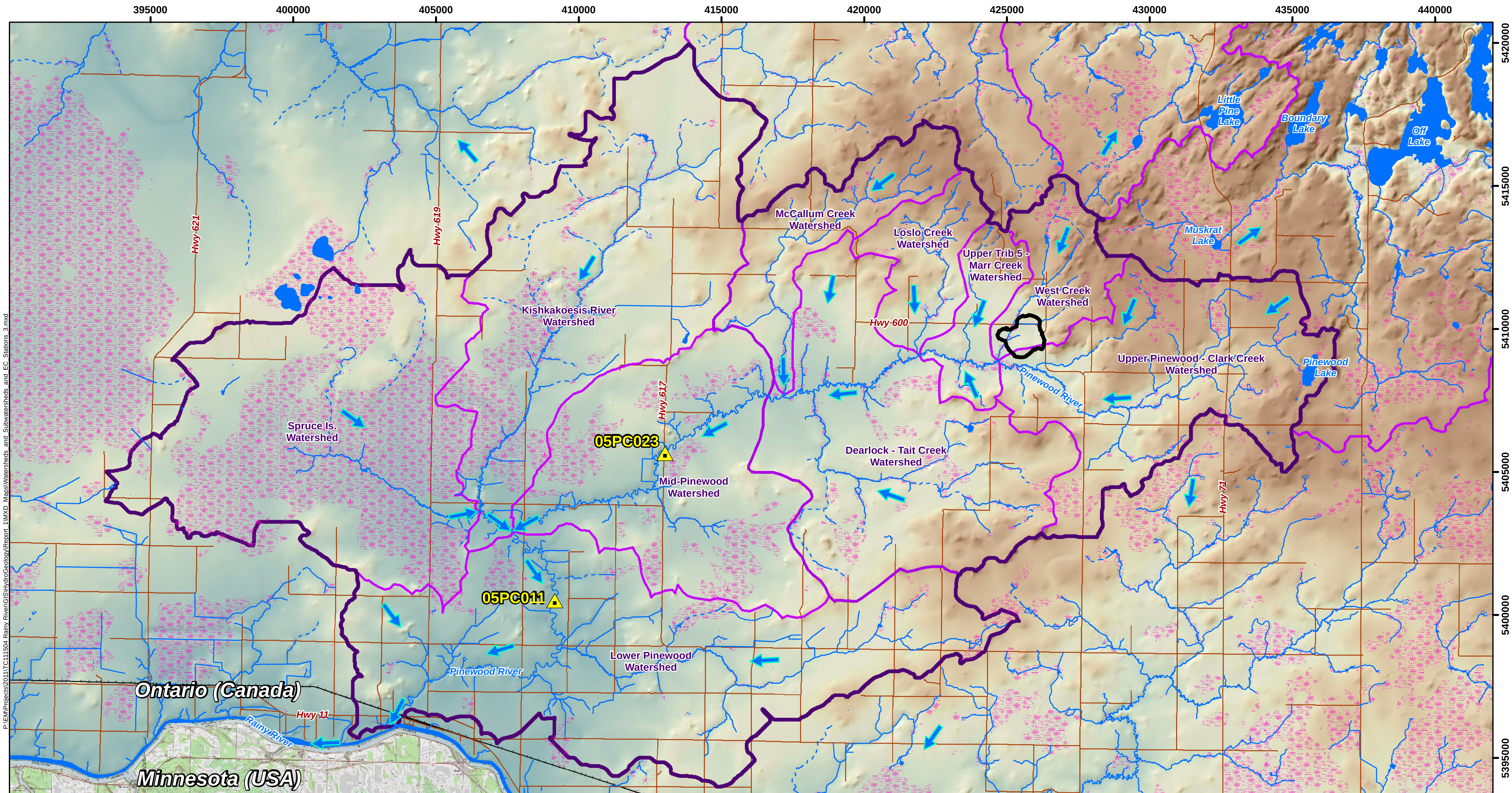
RAINY RIVER GOLD PROJECT

Project Location

Datum: NAD83
Projection: UTM Zone 15N

0 25 50 100 150 200 250 Kilometres

PROJECT N°: TC111504	**FIGURE: 1-1**
SCALE: 1:1,800,000	DATE: March 2013



LEGEND

- Approximate Open Pit Outline
- 05PC011 WSC Station
- Regional Road / Highway
- Railway
- Waterbody
- Low-Lying Wetland Area
- Permanent Watercourse
- Intermittent Watercourse
- General Surface Flow Direction

Elevation Colour Ramp
- High ground
- Low ground

- Pinewood River Watershed (approx. 57,450 ha)
- Main Project Area Watershed (approx. 20,700 ha)
- Subwatershed Areas (labelled on map)

-Upper Trib 5 - Marr Cr. approx. 1,230 ha
-Loslo Cr. approx. 1,620 ha
-West Cr. approx. 1,635 ha
-McCallum Cr. approx. 2,490 ha
-Upper Pinewood - Clark Cr. approx. 6,130 ha
-Mid-Pinewood approx. 6,530 ha
-Dearlock - Tait Cr. approx. 7,600 ha
-Kishkakoesis R. approx. 9,200 ha
-Spruce Is. approx. 9,580 ha
-Lower Pinewood approx. 11,435 ha

NOTES:
- Road data extracted from Land Information Ontario, Ontario Road Network, MNR
- Ontario base data extracted from Land Information Ontario (MNR) data warehouse.
- Base data outside of Ontario extracted from ESRI USGS Topographic maps
- Watershed delineations are approximate and are derived from MNR Ontario Digital Elevation Model and Quaternary Watershed boundaries

Datum: NAD83
Projection: UTM Zone 15N

0 3.5 7 14 21 28 35 Kilometres

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RAINY RIVER GOLD PROJECT

Regional Topography, Watershed and Subwatershed Boundaries

PROJECT N°: TC111504	FIGURE: 1-2
SCALE: 1:127,000	DATE: March 2013

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2.0 PREDICTIVE NUMERICAL MODELLING

A numerical three-dimensional, steady-state groundwater flow model has been developed and used to estimate:

- Seepage rate into the proposed open pit and the underground workings;
- Drawdown in Pleistocene Lower Granular Deposits (PLGD) / shallow bedrock, caused by the mine dewatering;
- Potential reduction in groundwater discharge to the surface water features; and
- Inflow from TMA and east mine rock stockpile area as well as their potential groundwater pathways.

The Modular Finite-Difference Groundwater Flow Model (MODFLOW), originally developed by McDonald and Harbaugh (1988) for the United States Geological Survey, was used to simulate groundwater flow in the RRGP area, as defined in the AMEC (2013a) report. MODFLOW is a groundwater flow simulator that has been accepted by regulatory agencies and used extensively for a variety of applications. It allows the simulation of steady-state and transient flow regimes in both two and three dimensions. A detailed description of MODFLOW is provided in the software package manual (McDonald and Harbaugh 1988).

Steady-state groundwater flow models were developed for the pre-mining, mined and post-closure conditions. The model corresponding to the pre-mining conditions was calibrated to the groundwater levels recorded for the monitoring wells under the existing condition and run using the calibrated parameters to simulate seepage into the dewatered open pit and underground mine workings.

The developed model was used to simulate groundwater flow in both the overburden and bedrock. Although MODFLOW was primarily developed to simulate flow in porous media it is often used for groundwater flow modelling in fractured rocks if they behave as equivalent porous media at the scale of study. This assumption was utilized in the presented study.

A fully integrated pre- and post-processor Visual MODFLOW (Version 4.6) developed by Schlumberger Water Services (SWS 2011) was used to assemble the input data for the RRGP area groundwater flow model and to present the MODFLOW output results.

2.1 Application of Conceptual Model

The conceptual model of the RRGP area is described in Section 3.6 of the Hydrogeology Baseline Report (AMEC 2013a). The hydrostratigraphy as described in these sections has been applied to the numerical groundwater flow model. However, in applying the conceptual model and its hydrostratigraphy a certain number of assumptions and/or simplifications were required in order to construct the model given the inherent limitations in subsurface geologic and hydrogeologic data, which are outlined further below. The unit surface elevations for the groundwater model have been derived from RRR data, water well records, AMEC's geotechnical and geomechanical investigations (AMEC 2013b and AMEC 2013c), and data from Nuinsco (1997). The principal geological surfaces that have been derived and that are consistently and readily identified from the geological data across the RRGP area are:

- Top of the bedrock surface; and
- Top of the PLGD.

In some significant borehole data sources, particularly the reverse circulation drilling data from Nuinsco (1997), it is difficult to distinguish between the clay bearing till units within the Pleistocene aquitard. In putting the overburden hydrostratigraphic units into the groundwater model the following assumptions have been made:

- The spatial distribution of the upper glaciolacustrine clay (Brenna Formation) was based on the available surficial geology maps shown in Figures 2-1 (Bajc 2001; Figure 2-2 of AMEC 2013a) In the model this unit was given a nominal 1 metre (m) thickness;

- Glaciolacustrine clay was also assumed to underlie areas of surficial peat and local surface water bodies (lakes and wetlands). This near surface unit was also given a nominal thickness of 1 m;

- Whitemouth Lake Till (Keewatin derived) and lower glaciolacustrine clay (Wylie Formation) were assumed to be continuous everywhere, except for the bedrock outcrops. The thickness of the lower glaciolacustrine clay unit was assumed to constitute about 25% of the Pleistocene Aquitard thickness; and

- Whiteshell (Labradorean derived) Till is the principal component of the PLGD and acts as the main water-bearing hydrostratigraphic unit confined by the overlying Pleistocene aquitard. The PLGD was assumed to be spatially continuous everywhere, except for the bedrock outcrops, although becoming very thin in some areas where data indicates it is absent.

In applying the bedrock hydrostratigraphic units to the groundwater model, the following assumptions have been made:

- The shallow bedrock has been assumed a constant 15 m thickness;

- The intermediate bedrock has been assumed approximately a 300 m thickness, with its base set at 0 metres above sea level (masl);

- The EFLT (Eastern Fault) has been assumed approximately 100 m thick with a dip of approximately 50° and a north-south strike that is continuous throughout the model domain. In terms of its hydraulic properties, it has been assumed one order of magnitude higher than the respective values of the intermediate and deep bedrock where it runs through these hydrostratigraphic units. Where the EFLT runs through the shallow bedrock no increase is made in the hydraulic conductivity as the shallow bedrock already has a hydraulic conductivity that is consistent with well fractured crystalline rock.

In applying recharge to the groundwater model the following assumptions have been made:

- Recharge was assumed to occur at the bedrock outcrops, where percolating water flows into the shallow weathered bedrock and PLGD units, as well as through Whitemouth Lake Till in the areas at higher elevations, where the upper glaciolacustrine clay (Brenna Formation) is absent (primarily east, north and northwest of the proposed open pit);

- Locally increased recharge through surficial sand can be expected along the nearshore and/or beach ridges of former glacial Lake Agassiz, to the west of the RRGP area (Bajc 2001);

- Abandoned sand and gravel pits, located within the RRGP area, are expected to act as localized areas of high recharge rates.

The majority of the creeks, rivers and wetlands, located within the RRGP area are expected to act as discharge zones (gaining groundwater). Some wetlands and lakes, located primarily to the north of the proposed open pit at relatively high elevations, can be losing water through the underlying Pleistocene aquitard.

2.2 Model Domain and Numerical Grid

The selected model domain for the RRGP groundwater flow model is shown in Figure 2-1. The northern and eastern boundaries were generally set along the groundwater divide in bedrock, described in the baseline report produced by KCB (2011). The southern boundary was set along Tait Creek, located about 4.5 km south of Pinewood River. The top of the model domain was set as the ground surface derived from the LiDAR survey data. Simulating the existing (pre-mining) conditions the bottom of the numerical model was established at an elevation of -500 masl (Figure 2-2). Areas located beyond the selected model domain (both vertically and horizontally) are expected to have negligible impact on the groundwater water flow within the RRGP area.

The total number of model layers equals nineteen. Model layer 1 represents the near surface deposits; primarily peat and Pinewood River alluvium along the course of the river. Model layer 2 represents the upper part of Pleistocene aquitard (predominantly Brenna Formation) and Pinewood River alluvium (along the river). Model layer 3 represents the middle part of Pleistocene aquitard (Whitemouth Lake Till). Model layer 4 represents the lower part of Pleistocene aquitard (predominantly Wylie Formation). Model layer 5 represents PLGD (primarily the Whiteshell Till). Layers 1 through 5 also represent shallow bedrock within the localized bedrock outcrop areas. Model layer 6 represents shallow bedrock. Intermediate bedrock is represented by model layers 7, 8 and 9. Deep bedrock is represented by model layers 10 through 19. For simulating groundwater seepage into the proposed open pit 14 more layers in the intermediate bedrock and 22 layers in the deep bedrock were added to the model. Note that in order to simulate seepage into the proposed underground mine workings the model bottom elevation was lowered from -500 m to -1,500 m and a corresponding increase in a number of model layers from 19 to 55.

Figure 2-2 shows representative model east-west cross section drawn through the area of the proposed open pit. It also shows the EFLT striking north-south and dipping to the east at about 50 degree angle. In the model, this fault was represented conservatively with hydraulic conductivity values greater than those for the surrounding rock mass in the Intermediate and Deep Bedrock. It should be noted that the Eastern Fault was the only permeable structure in the bedrock directly simulated by the developed numerical model.

Horizontal grid spacing varied from 10 m close to the proposed open pit area to about 100 m close to the model domain boundary. Vertical grid spacing (thickness of model layers) varied from about 1 m (layers 1 and 2) to about 500 m (deep bedrock, below the proposed underground mine workings).

2.3 Boundary Conditions and Input Parameters

The no-flow condition was specified along the majority of the northern, eastern and western boundaries of the model domain since these boundaries are expected to coincide with (or to be close to) the inferred groundwater flow divides.

All major simulated surface water features (creeks, lakes, ponds, wetlands) located within the model domain, were represented by the so-called MODFLOW river nodes (McDonald and Harbaugh 1988) with the specified stage elevations being close to the ground surface. Due to the unknown actual depth of the simulated surface water features the river nodes were specified in both model layers 1 and 2.

Input parameters (hydraulic conductivities and recharge rates) assigned to the various overburden and bedrock aquifer zones for the groundwater flow model are summarized in

Table 2-1. Some of these parameters were varied within the framework of the predictive sensitivity analysis (Section 3.1).

2.4 Model Calibration

Calibration of a groundwater flow model refers to a demonstration that the model is capable of reproducing field measured heads and flows, the 'calibration targets' (Anderson and Woessner 1992). The calibration of the model was achieved by adjusting hydraulic conductivity and recharge values in order to obtain a reasonable match between computed and observed groundwater levels.

The model was calibrated to water levels observed in September 2010 from 20 non-artesian monitoring wells mostly located relatively close to the proposed open pit (Table A-1, Appendix A). These groundwater levels are considered to be representative of the typical (average recharge) conditions, as discussed in Section 3.3 of AMEC (2013a). The correlation between groundwater levels in the non-flowing wells recorded in September 2010, and the computed ones is shown in Figure 2-3a. Results presented in this chart show good agreement between computed and observed data. The overall residual mean for the non-flowing wells is 0.04 m, the absolute mean is about 0.8 m and the correlation coefficient is 0.99. The ratio of the root mean squared error (about 1.1 m) to the total head loss (or water table relief) in the area of interest is approximately 4.1%. Therefore, the differences between observed and simulated represent only a relatively small portion of the overall model response (Anderson and Woessner 1992).

In addition to the non-artesian 20 monitoring wells described above, 6 observation wells (RR09213, NR07214, BH10-07A, BH10-07B, BH10-12A and BH10-14) were reported to be flowing artesian wells with unrecorded groundwater levels above their casings. For these wells, this model predicts groundwater levels to be on average about 1.2 m above local ground surface elevation.

Figure 2-3b shows the correlation between computed and observed water levels in June and October/November 2012. This data set, comprised of 136 wells with known and reliable water levels, but does not represent typical (average recharge) hydrogeological condition due to the abnormally dry weather over 2011/2012, as discussed in Section 3.3 of AMEC 2013a. Therefore, the low groundwater levels observed in the summer and fall 2012 monitoring data could not be used for the calibration of the steady-state model, representing long term average recharge conditions. Hence, higher discrepancies between computed water levels and data observed in 2012 were expected. The model still provides a reasonable approximation of this data set: the absolute mean error is about 1.6 m and the correlation coefficient is 0.94. The largest discrepancy between computed and observed water levels in 2012 occurs at BH12-7; this well is located at a distance of about 2.5 km from the proposed open pit.

Figure 2-4 shows the computed and inferred groundwater elevation contours for summer and fall 2012 in the PLGD/Shallow Bedrock, corresponding to the current, pre-mining conditions. Despite some local discrepancies between contours shown in this figure, the model replicates the inferred potentiometric surface and groundwater flow system in these hydrostratigraphic units.

The average low flow contribution to the Pinewood River has estimated from the flow gauging record at 05PCO23 to be in the range of about 0.003 to 0.03 cubic metres per second (m^3/s) (~250 to 2500 cubic metres per day; m^3/d) for summer conditions (June to September) and 0.01 to 0.2 m^3/s (~1,000 to 17,000 m^3/d) for winter conditions with a possible average of around 4,000 to 5,000 m^3/d.

According to the model flow budget, the annual average groundwater discharge into the Pinewood River and its tributaries within the model domain is computed to be about 6,400 m^3/d. From this amount, 5,200 m^3/d is predicted to be directly associated with a diffuse recharge, occurring in response to precipitation. The remaining 1,200 m^3/d is associated with a 'focused recharge', representing leakage from surface water features located on the higher ground, close to the inferred groundwater divide.

Based on the above, the average annual recharge rate over the entire model domain is estimated to be in the order of 11-14 millimetres (mm). This rate appears to be consistent with the long term annual groundwater recharge rates reported by Singer and Chen (2002) for the areas in Northern Ontario, characterized by surficial deposits of peat, silty clay till, silt and clay. From this it is concluded that given significant data scatter and uncertainty in the derivation of the groundwater discharge from field measurements, the model predicted total average groundwater flow rate is consistent with the available field and literature data.

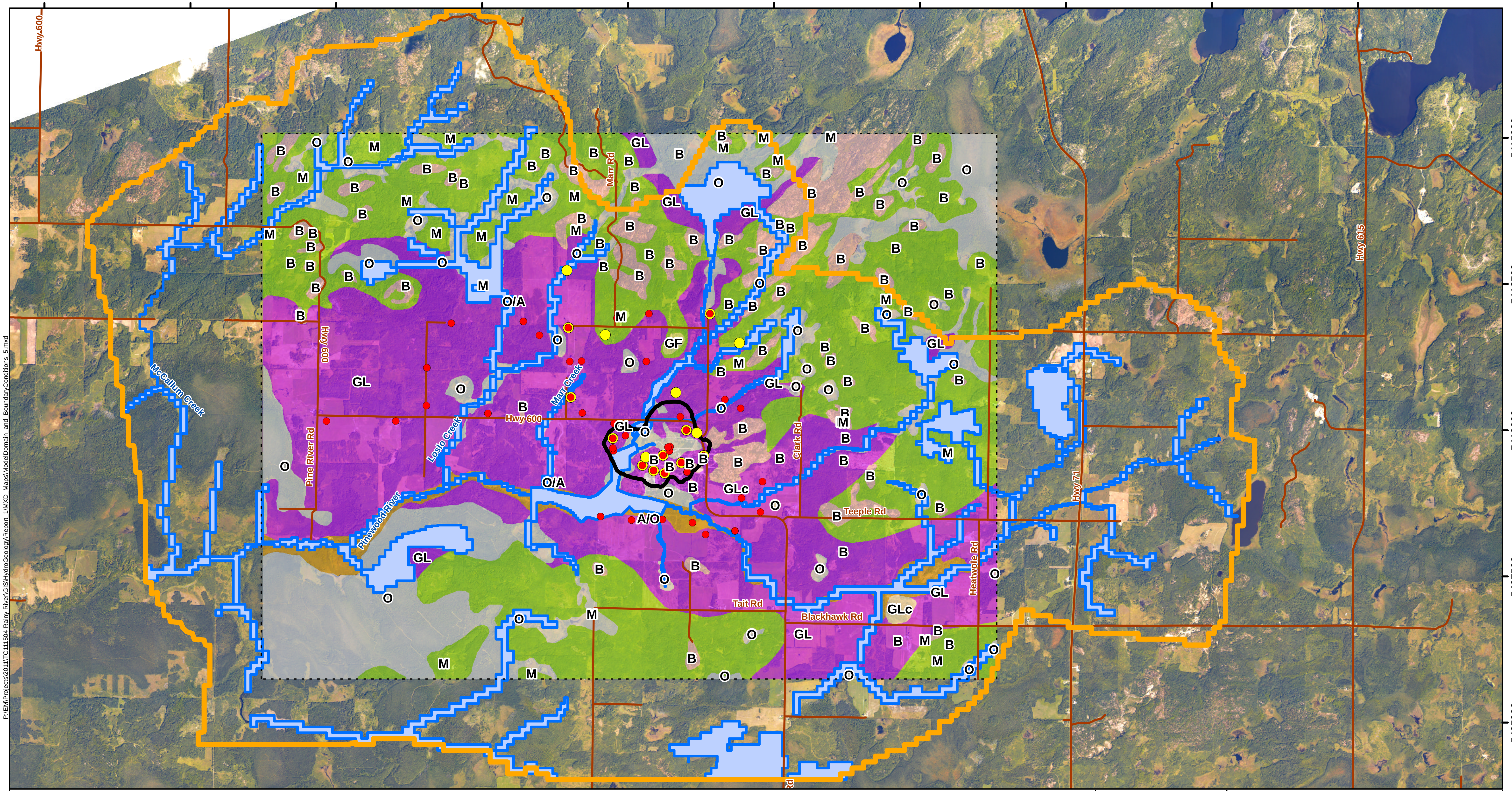
Table 2-1: Initial Estimates of Hydraulic Properties for Hydrostratigraphic Units (AMEC 2013a) and Input Parameters for Groundwater Flow Model (Base Case)

Hydrostratigraphic Unit	Geology	Model Layer	Hydraulic Conductivity (m/s)		
			Range[1]	Initial Estimate[1]	Model Value
Near surface system	Peat	1	5E-06 – 5E-05	1E-05	4E-05
	Pinewood River alluvium	1/2	1E-08 – 1E-04	1E-06	2E-05
Pleistocene aquitard	Brenna (glaciolacustrine)	2	1E-10 – 1E-08	1E-08	1E-08
	Whitemouth Lake Till (Keewatin derived)	3	1E-09 – 1E-06	5E-08	3E-07
	Wylie (glaciolacustrine)	4	1E-10 – 1E-08	1E-08	1E-08
PLGD	Whiteshell Till (Labradorean derived)	5	1E-06 – 1E-04	5E-05	5E-05
	Glaciofluvial sands				
Shallow bedrock	Undifferentiated Rainy River Greenstone Belt intermediate and felsic volcanics and intrusives	6	1E-07 – 1E-05	1E-06	1E-06[2]
Intermediate bedrock[3]	Undifferentiated Rainy River Greenstone Belt intermediate and felsic volcanics and intrusives	7 to 9	1E-09 – 1E-07	1E-08	3E-8[4] 1E-8
Deep bedrock[5] (greater than approximately 200 to 300 mbgs)	Undifferentiated Rainy River Greenstone Belt Intermediate and felsic volcanics and intrusives	10 to 19+	1E-10 – 1E-08	1E-09	1E-09
EFLT	Shallow Bedrock	6	1E-8 – 1E-06	1E-06	1E-06
	Intermediate Bedrock	7 to 9		1E-07	1E-07
	Deep bedrock	10 to 19+		1E-08	1E-08

Recharge

Unit at surface		(mm/year)
Wetlands/peat and near surface glaciolacustrine clay (Brenna Formation)	Expected to negligible	0
Areas without near surface glaciolacustrine clay	Expected to be small	10 and 50[6]
Abandoned sand and gravel pits	Expected to be relatively high	200
Bedrock, near surface PLGD	In the range of 10 - 50 mm/year	30

(1) see table 3.6 of AMEC 2013a for sources of estimates
(2) down to a depth of 15 m below bedrock surface
(3) below shallow bedrock, above the elevation of 0 masl
(4) elevation above 150 masl
(5) below the intermediate bedrock unit, i.e. below the elevation of 0 masl
(6) along a beach ridge of former glacial Lake Agassiz



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LEGEND

- Approximate Open Pit Outline
- Model Domain Boundary
- Roads
- Observation Wells (2012)
- Observation Wells (2010)
- Cells used to Simulate Surface Water Features

Quaternary Geology

- O — Organic: peat and organic clay; includes bogs, fens, marsh, ponds and standing water along poorly defined creeks.
- A — Alluvium: fine sand, silt, and clay; deposits of Pinewood River and tributaries
- B — Bedrock: exposures or with very thin cover
- GL — Glaciolacustrine: clay, silt, and minor sand; glacial lake bottom
- GLc — Glaciolacustrine Coarse Grained: sand and gravel; beach, bar and, near-shore deposits
- GF — Glaciofluvial: sand, gravel, and boulders, minor till; deposited from glacial meltwater in ice-contact environment.
- M — Moraine: glacial till with some interbedded glaciolacustrine clay and silt; inferred to mostly Whitemouth Lake Till, clay rich with carbonate rocks and matrix.

NOTES:
- Road data extracted from Land Information Ontario, Ontario Road Network, MNR Queen's Printer for Ontario, 2011-2012
- Surficial geology based on air photo analysis and review of published geology maps. Surficial materials may vary from those indicated

Datum: NAD83
Projection: UTM Zone 15N

0 1.5 3 6 9 12 15 Kilometres

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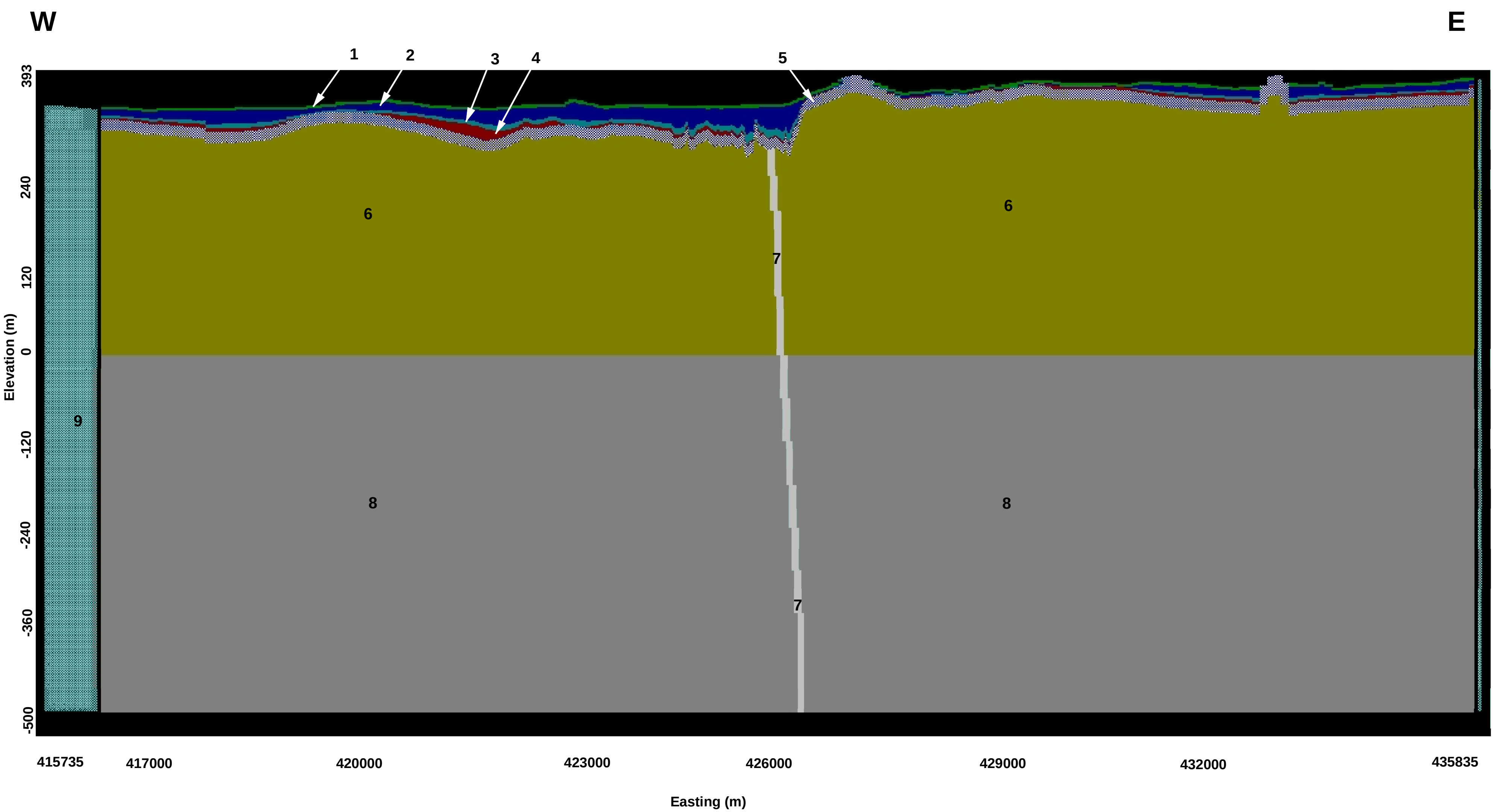
RAINY RIVER GOLD PROJECT

Groundwater Flow Model Domain and Boundary Conditions

PROJECT N^{o}: TC111504	FIGURE: 2-1
SCALE: 1:62,500	DATE: March 2013



LEGEND

- (1) Near-Surface System
- (2) Whitemouth Lake Till & Upper GL Clay (Brenna) — Pleistocene Aquitard
- (3) Lower GL Clay (Wylie) — Pleistocene Aquitard
- (4) PLGD
- (5) Shallow Bedrock
- (6) Intermediate Bedrock
- (7) EFLT Fault
- (8) Deep Bedrock
- (9) Area Outside of Model Domain (inactive cells)

NOTES:
-

Datum: NAD83
Projection: UTM Zone 15N

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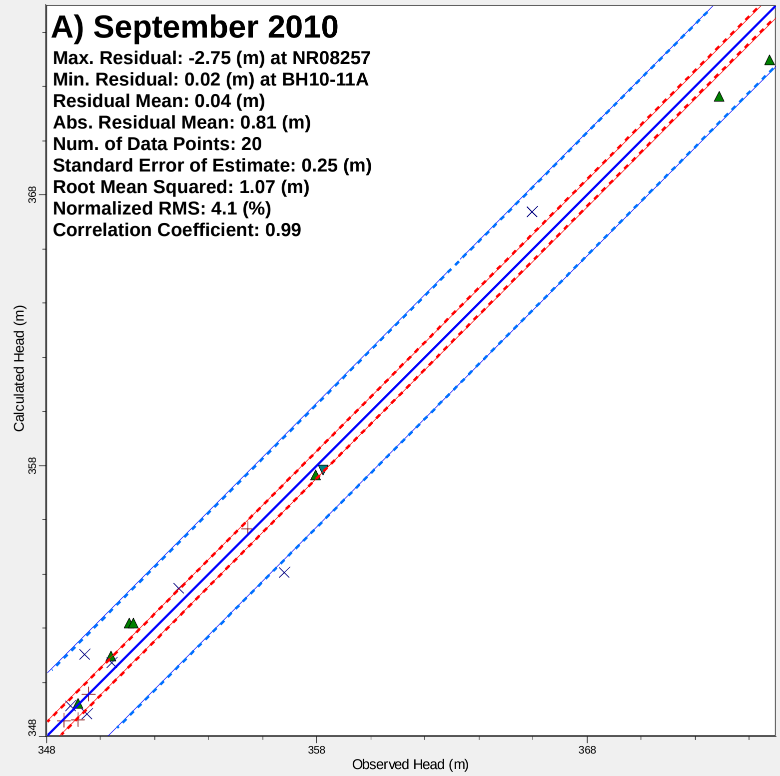
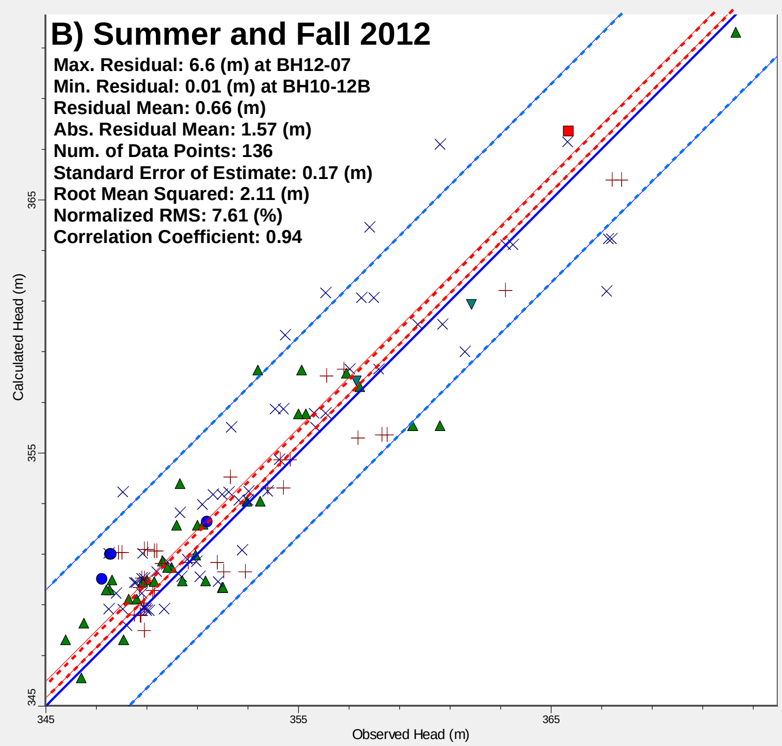
Representative Groundwater Model Cross Section

PROJECT N^{o}: TC111504	**FIGURE: 2-2**
SCALE: As Shown	DATE: March 2013





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LEGEND

- Layer #1
- Layer #2
- Layer #3
- Layer #4
- Layer #5
- Layer #6
- 95% confidence interval
- 95% interval

NOTES:

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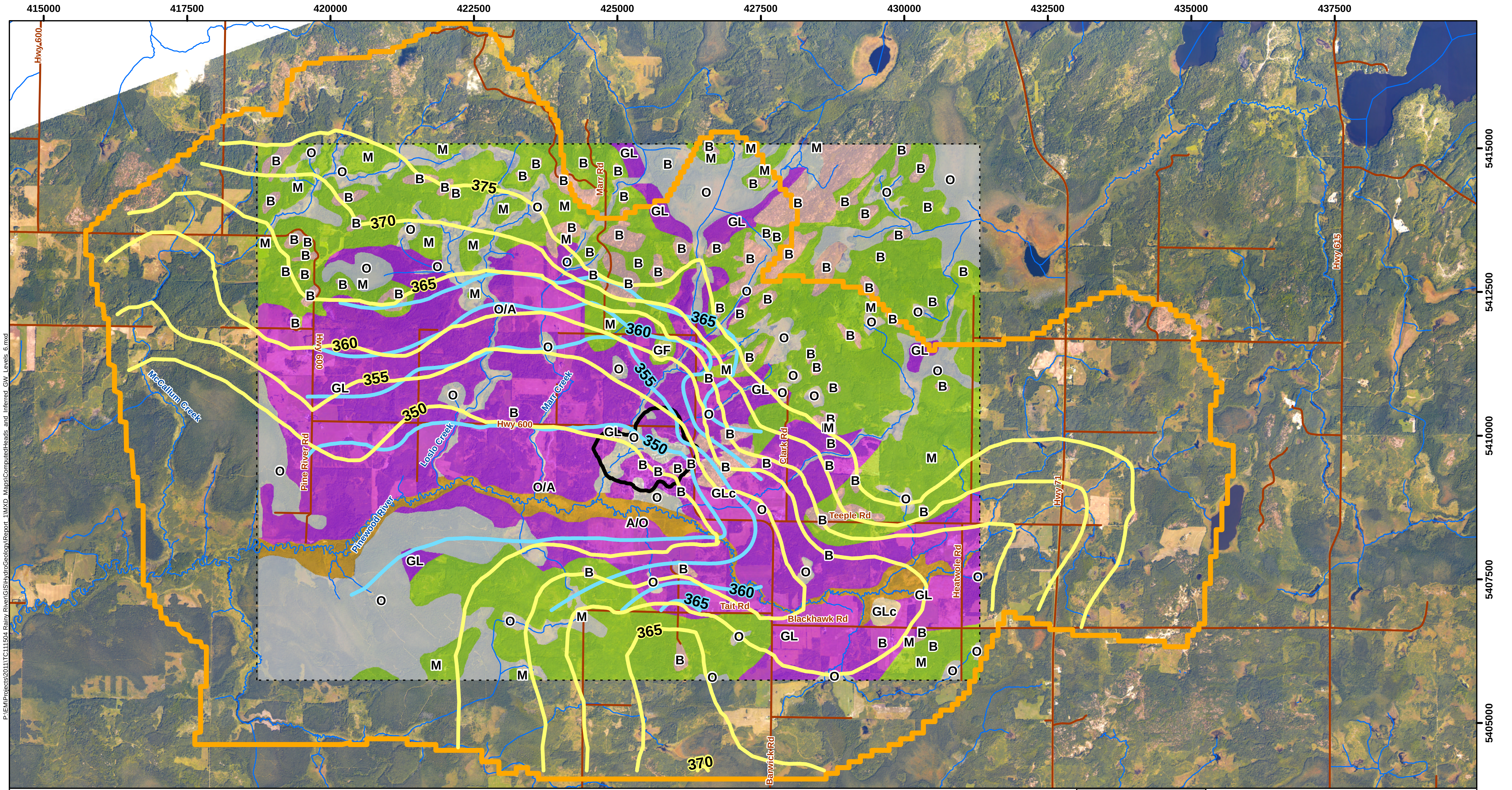
Computed versus Observed Groundwater Levels:
A) Average Conditions (Sept. 2010);
B) Dry Conditions (Summer and Fall, 2012)

PROJECT N^{o}: TC111504	**FIGURE: 2-3**
SCALE:	DATE: March 2013



LEGEND

- Approximate Open Pit Outline
- Model Domain Boundary
- Roads
- Watercourses
- 360 Inferred Groundwater Level Contours*, June-Oct.-Nov. Composite 2012
- 360 Computed Head Contours*, Base Case

* In pleistocene lower granular deposits/ shallow bedrock

Quaternary Geology

- **O** Organic: peat and organic clay; includes bogs, fens, marsh, ponds and standing water along poorly defined creeks.
- **A** Alluvium: fine sand, silt, and clay; deposits of Pinewood River and tributaries
- **B** Bedrock: exposures or with very thin cover
- **GL** Glaciolacustrine: clay, silt, and minor sand; glacial lake bottom
- **GLc** Glaciolacustrine Coarse Grained: sand and gravel; beach, bar and, near-shore deposits
- **GF** Glaciofluvial: sand, gravel, and boulders, minor till; deposited from glacial meltwater in ice-contact environment.
- **M** Moraine: glacial till with some interbedded glaciolacustrine clay and silt; inferred to mostly Whitemouth Lake Till, clay rich with carbonate rocks and matrix.

NOTES:
- Road data extracted from Land Information Ontario, Ontario Road Network, MNR Queen's Printer for Ontario, 2011-2012
- Surficial geology based on air photo analysis and review of published geology maps. Surficial materials may vary from those indicated

Datum: NAD83
Projection: UTM Zone 15N

0 1.5 3 6 9 12 15 Kilometres

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RAINY RIVER GOLD PROJECT

Computed and Inferred Groundwater Elevation Contours in PLGD/Shallow Bedrock

PROJECT N°: TC111504	FIGURE: 2-4
SCALE: 1:62,500	DATE: March 2013

3.0 MINE DEWATERING – PREDICTIVE SIMULATIONS AND SENSITIVITY ANALYSIS

The groundwater flow model described above was used to estimate:

- Seepage rates into the proposed dewatered open pit and underground mine workings at various stages of their development;
- The zone of influence (ZOI) or drawdown within the PLGD and shallow bedrock units, associated with the fully dewatered open pit and underground mine workings;
- Impact of pit dewatering on the average groundwater discharge to Pinewood River and its tributaries; and
- Potential inputs to the groundwater flow system from proposed TMA and mine rock stockpiles under the mine post-closure condition.

The dewatered open pit and underground mine workings corresponding to years 1 to 12 of the proposed mine development were simulated using yearly mine plans provided by RRR in late 2012. Figure 3-1 shows proposed open pit and underground mine workings used in the model in plan view. Slight changes were subsequently made to the mine plan after completion of the groundwater model, which slightly reduced the size of the underground workings including the ramp that extends from the pit to the east. As these changes only resulted in a small reduction of the mine footprint, it was concluded that they were unlikely to materially affect the modelled impacts.

Groundwater seepage into the fully dewatered open pit and underground mine workings was simulated by using MODFLOW drain nodes (McDonald and Harbaugh 1988), which are illustrated in Figure 3-2. Drain elevations were specified at the elevation of cells' centroids. The cells located within the interior of the relatively large dewatered openings were modelled as inactive, since seepage is expected to occur at the contact of the openings with the surrounding rock mass only. Conductance of the MODFLOW drain nodes, representing seepage faces, was specified as being two orders of magnitude higher than the transmissivity of the corresponding numerical cell(s) since the utilized grid spacing did not exceed the dimensions of the majority of the simulated openings by more than a factor of three (Zaidel et al. 2010).

Other significant infrastructure that will be constructed as part of the mine and incorporated into the model for the predictive simulations for estimating drawdown include parts of West Creek which was modelled as diverted where it crosses the open pit area to a new location south of the TMA, where it will join Marr Creek.

Features such as TMA to the northwest of the open pit and the east mine rock stockpile to the east of the open pit, were not included in the model used to predict drawdown, as the timing of the completion of these features was not known with enough certainty for inclusion in the transient model as the pit developed. As both these features will increase groundwater recharge either by introducing a flooded pond or by reducing evapotranspiration, they will have the effect of offsetting mine related drawdown. Not including them in the model, is therefore conservative in that the model will tend to slightly over predict the size of the drawdown cone towards these features.

The overburden stockpile which lies on the clay plain to the east of the open pit where it is not expected to significantly influence groundwater flow, and smaller, non-water features such as the plant were also not incorporated into the groundwater model used to estimate seepage rates and drawdown caused the mine dewatering.

For simulating the mine post-closure condition it was assumed that the mining infrastructure used in the drawdown simulations remained and that a pit lake formed in the open pit with a water level maintained at an elevation of 346 masl, which is the approximate level of the Pinewood River immediately downstream of the open pit based on LiDAR mapping. A connection from the open pit to the underground workings which are to be partially backfilled with a coarse material, was also assumed and the water level in the underground workings was also maintained at 346 masl. Potential seepage into a partially dewatered open pit occurring above this elevation was simulated by using the drain nodes. Groundwater flow into and/or out of the flooded portion of the open pit and mine workings (below the elevation of 346 masl) was modelled by using the general-head (GHB) package of MODFLOW (McDonald and Harbaugh 1988).

The TMA and east mine rock stockpile were incorporated into the model representing post-closure conditions and new surface water features were added around the TMA and east mine rock stockpile including perimeter ditches and water treatment ponds as either drain, river or constant head nodes. The dams around the TMA were modelled as clay filled features with toe drains discharging to the perimeter ditches. General-head nodes with an elevation of 378 masl were also prescribed within the TMA to simulate its water cover for the post-closure condition. The portions of the east mine rock stockpile to be constructed with a low permeability cap at the end of mining were modelled as reduced recharge areas.

3.1 Predicted Long Term Seepage Rates into the Open Pit and Underground Mine Workings

Long term seepage rates into the proposed open pit and underground mine workings were simulated by a series of 12 steady-state groundwater flow models, corresponding to the various stages (years) of the mine development. Figure 3-2 shows simulated groundwater flow into the fully dewatered open pit and underground mine workings in the west-east cross section.

Under the Base Case scenario, the stabilized seepage rates (neglecting storage component) into the proposed fully dewatered mine (open pit and underground mine workings) for years 1 to 12 were estimated to be about 3,000 to 3,500 m^3/d (Figure 3-3). A relatively small change in predicted seepage between years 1 and 12 is attributed to the fact that most of the groundwater flow occurs in the basal unit (PLGD) and shallow bedrock, and the drawdown cone stabilizes shortly after the excavation of the open pit removes the PLGD in the first year of mining.

In addition to the base case input parameters presented in Table 2-1, the groundwater flow model was also run with other sets of input data as part of the predictive sensitivity analysis. The main purpose of this analysis was to evaluate the influence of uncertainty in the input parameters on the model predictions. The conducted sensitivity analysis demonstrates that the model predicted seepage rate into the proposed fully dewatered mine is expected to vary within a range of about 3,000 to 4,000 m^3/d (Table 3-1). Note that the hydraulic conductivity of PLGD was varied within a narrower range compared with the hydraulic conductivity values for other hydrostratigraphic units since this parameter is subject to a lesser degree of uncertainty and calibration results appear to be more sensitive to this input parameter, compared with other hydraulic conductivity values.

3.2 Predicted ZOI in the PLGD and Shallow Bedrock Units

Figure 3-4 shows model predicted drawdown in shallow bedrock, caused by the dewatering of the fully developed open pit and underground mine workings (Year 12; Base Case).

Figure 3-5 shows the model predicted ZOIs for all the simulated scenarios (Table 3-1), defined as a 1 m drawdown in shallow bedrock. Note that portions of ZOIs extending beyond the model boundary (variants 3a and 4a) were extrapolated by kriging using Surfer (Golden Software, 2002). The model predicts the ZOI (a minimum one metre drawdown of the upper bedrock groundwater in the base case scenario) to extend approximately 2.5 to 3.5 km from the edge of the open pit.

Note that the developed model does not account for the possibly of additional induced recharge, associated with the capture of additional precipitation that would other runoff in high water table areas that become depressed under pumping/dewatering conditions, or from increased infiltration in the TMA and uncapped east mine rock stockpile, which would slightly reduce the ZOI. Therefore the model predicted ZOIs are expected to be conservative.

3.3 Predicted Effects of Mine Dewatering on the Groundwater Discharge into Surface Water Features

Based on the results presented above, annual average groundwater discharge into the surface water features can be potentially reduced by 3,000 to 4,000 m^3/d, primarily through the interception of groundwater by the open pit and underground workings that would otherwise flow to the Pinewood River or the wetlands in the Pinewood River valley downstream of the proposed mine.

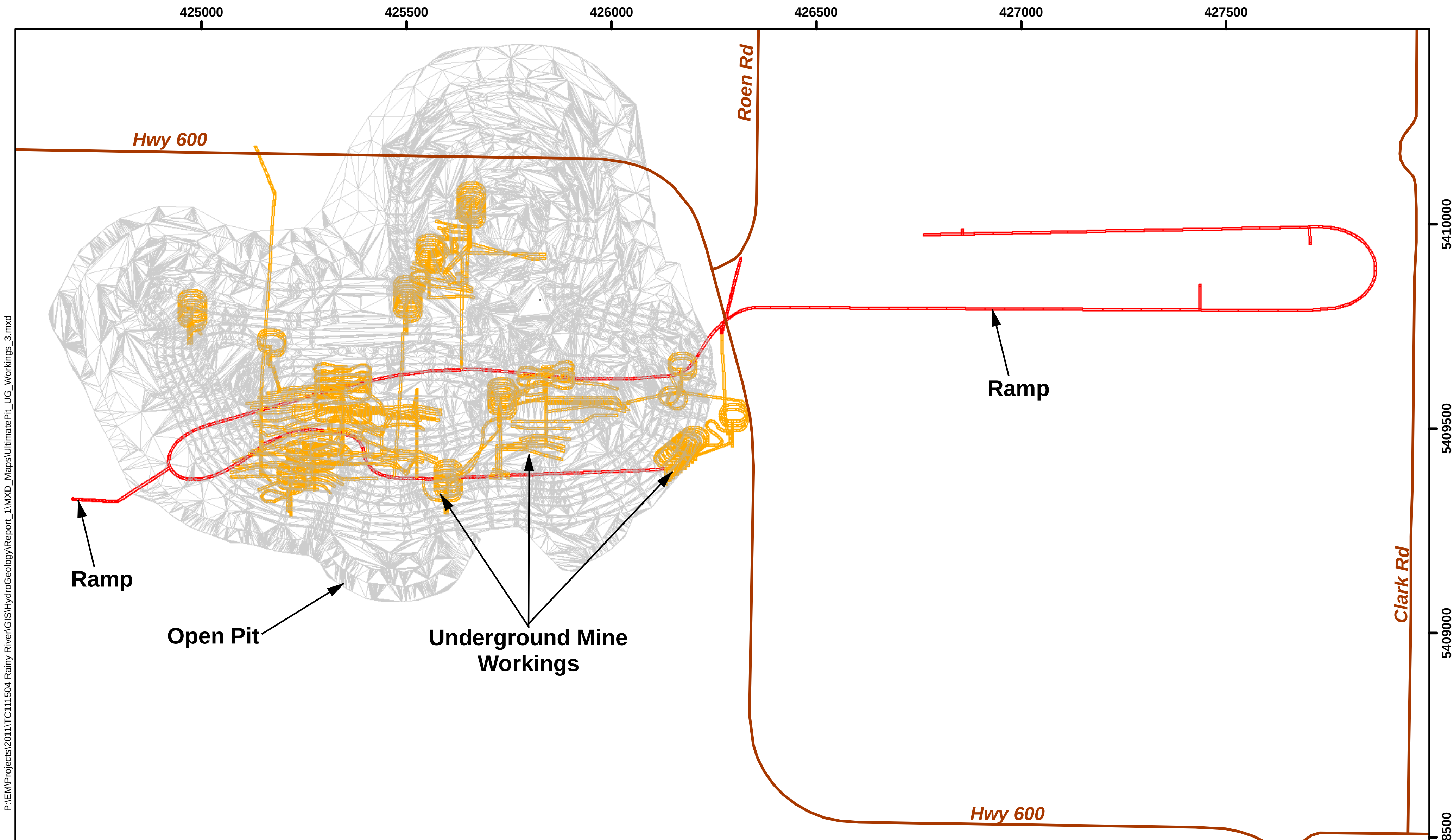
3.4 Predicted Effects of Mine Dewatering on the Local Privately Owned Water Wells

There are a number of water wells identified in the Ministry of the Environment water well record database and a door to door survey that fall within the drawdown cone of the mine. All the wells are thought to draw water from PLGD or shallow bedrock, and are therefore those within the drawdown cone of the mine are expected to experience declines in water levels. However, through land acquisitions, RRR will own all of the water supply wells prior within the anticipated ZOI prior to start of significant dewatering. As a result, there are no anticipated affects on private water wells, not owned by RRR, all of which lie outside the ZOI (Figure 3-6).

Table 3-1: Predicted Groundwater Inflow into Fully Dewatered Mine

Simulated Variant	Description/ Parameter Varied	Seepage into Proposed Open Pit and Underground Mine Workings (m^3/d) [(2)]
1	Base case[(1)]	3,400
2a	Hydraulic conductivity of PLGD increased by a factor of 1.5	3,930
2b	Hydraulic conductivity of PLGD decreased by a factor of 1.5	2,940
3a	Hydraulic conductivity of Shallow Bedrock increased by a factor of 2	3,650
3b	Hydraulic Conductivity of Shallow Bedrock decreased by a factor of 2	3,220
4a	Hydraulic Conductivity of Intermediate Bedrock increased by a factor of 2	3,820
4b	Hydraulic Conductivity of Intermediate Bedrock decreased by a factor of 2	3,110
5a	Hydraulic Conductivity of Deep Bedrock increased by a factor of 2	3,520
5b	Hydraulic Conductivity of Deep Bedrock decreased by a factor of 2	3,330
6a	Hydraulic Conductivity of EFLT increased by a factor of 2	3,500
6b	Hydraulic Conductivity of EFLT decreased by a factor of 2	3,360

[(1)] Input parameters shown in Table 2-1
[(2)] Numbers are rounded to the nearest 10 m^3/d



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LEGEND

Existing Roads

NOTES:
- Mine plan provided by RRR in December 2012

Datum: NAD83
Projection: UTM Zone 15N

0 0.25 0.5 1 1.5 2 Kilometres

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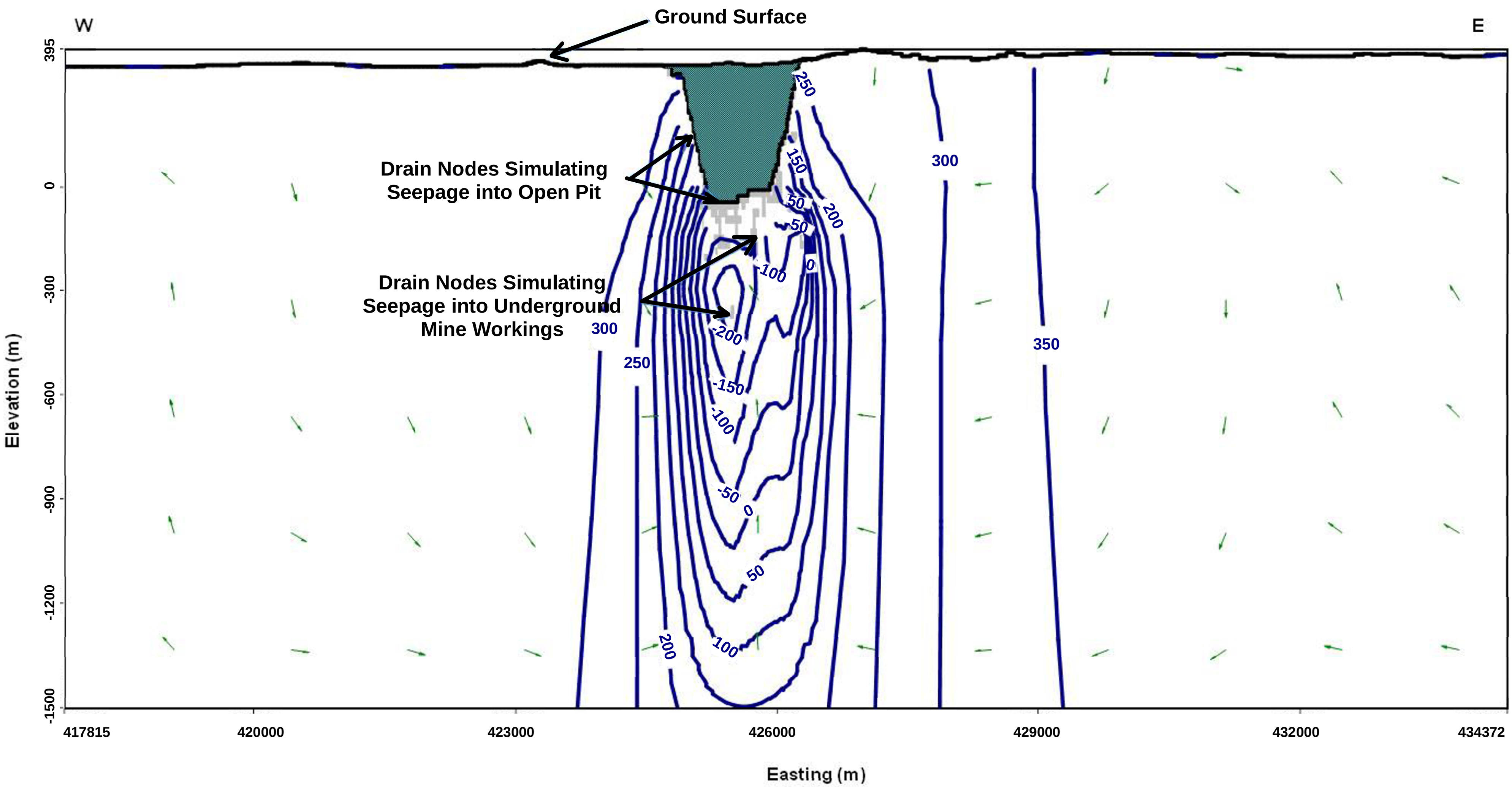
Simulated Ultimate Open Pit and Underground Workings (Plan View)

PROJECT N^{o}: TC111504

FIGURE: 3-1

SCALE: 1:13,000

DATE: March 2013



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LEGEND

- Computed Head Contours, Base Case
- Flow Direction

NOTES:
-

Datum: NAD83
Projection: UTM Zone 15N

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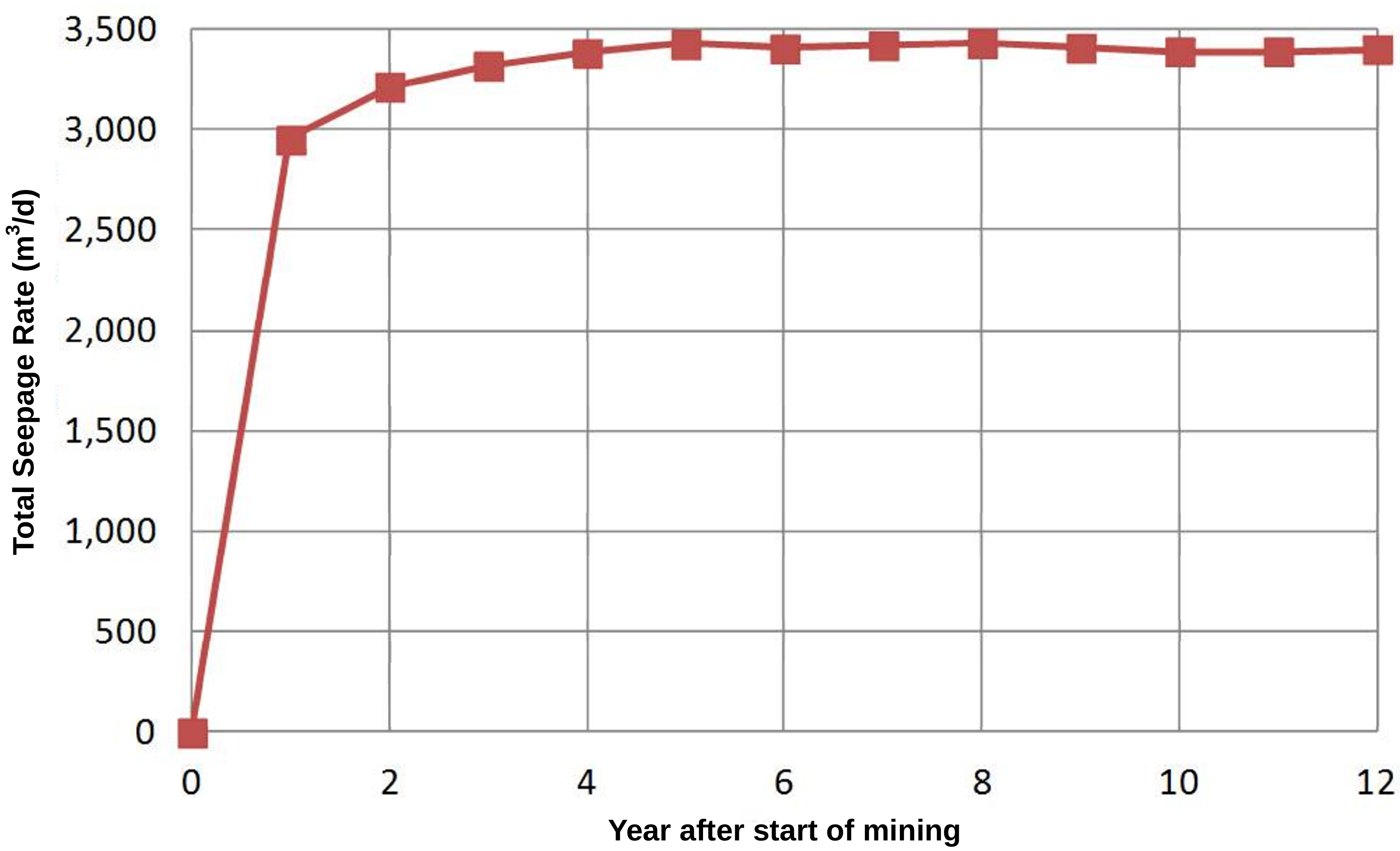
RAINY RIVER GOLD PROJECT

Simulated Groundwater Flow into Proposed Open Pit and Underground Workings (West-East Cross Section)

PROJECT N°: TC111504	**FIGURE: 3-2**
SCALE: As Shown	DATE: March 2013



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NOTES:
-

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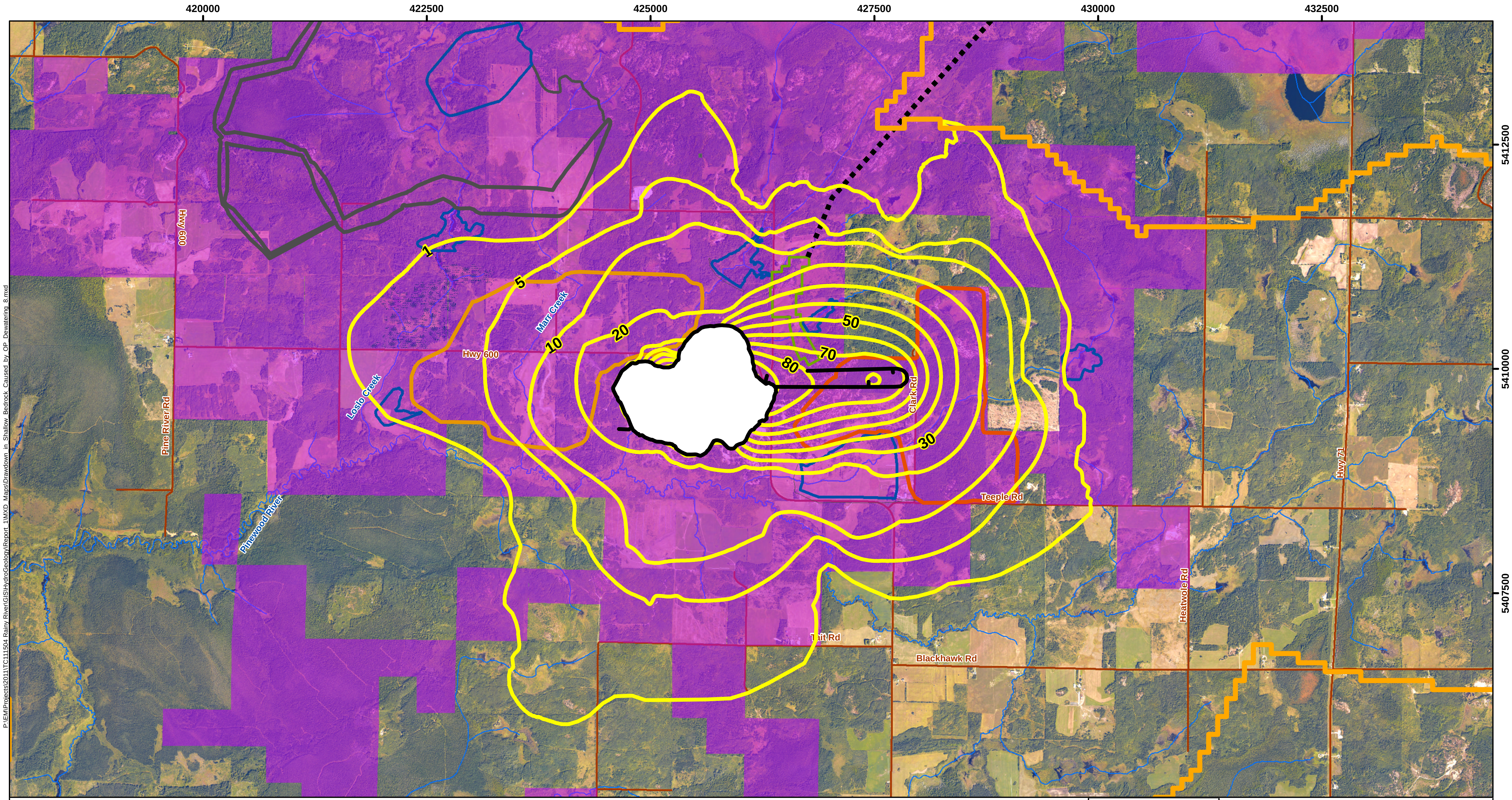
Model Predicted Seepage Rates into Proposed Open Pit and Underground Workings (Base Case)

PROJECT N^{o}: TC111504	**FIGURE: 3-3**
SCALE: As Shown	DATE: March 2013



LEGEND

- Approximate Open Pit Outline and Underground Ramp
- RRR Active Dispositions/Claims
- Model Domain Boundary
- Roads
- Watercourses corresponding to current conditions
- 20 Drawdown Contours (m) (Base Case)

Proposed Site Features

- Tailings Management Area
- Overburden / West Mine Rock Stockpile
- Ore / East Mine Rock Stockpile
- Plant Site / Ancillary Facilities
- Ponds
- Transmission Line

0 1 2 4 6 8 10 Kilometres

NOTES:
- Road data extracted from Land Information Ontario, Ontario Road Network, MNR Queen's Printer for Ontario, 2011-2012
- Surficial geology based on air photo analysis and review of published geology maps. Surficial materials may vary from those indicated

Datum: NAD83
Projection: UTM Zone 15N

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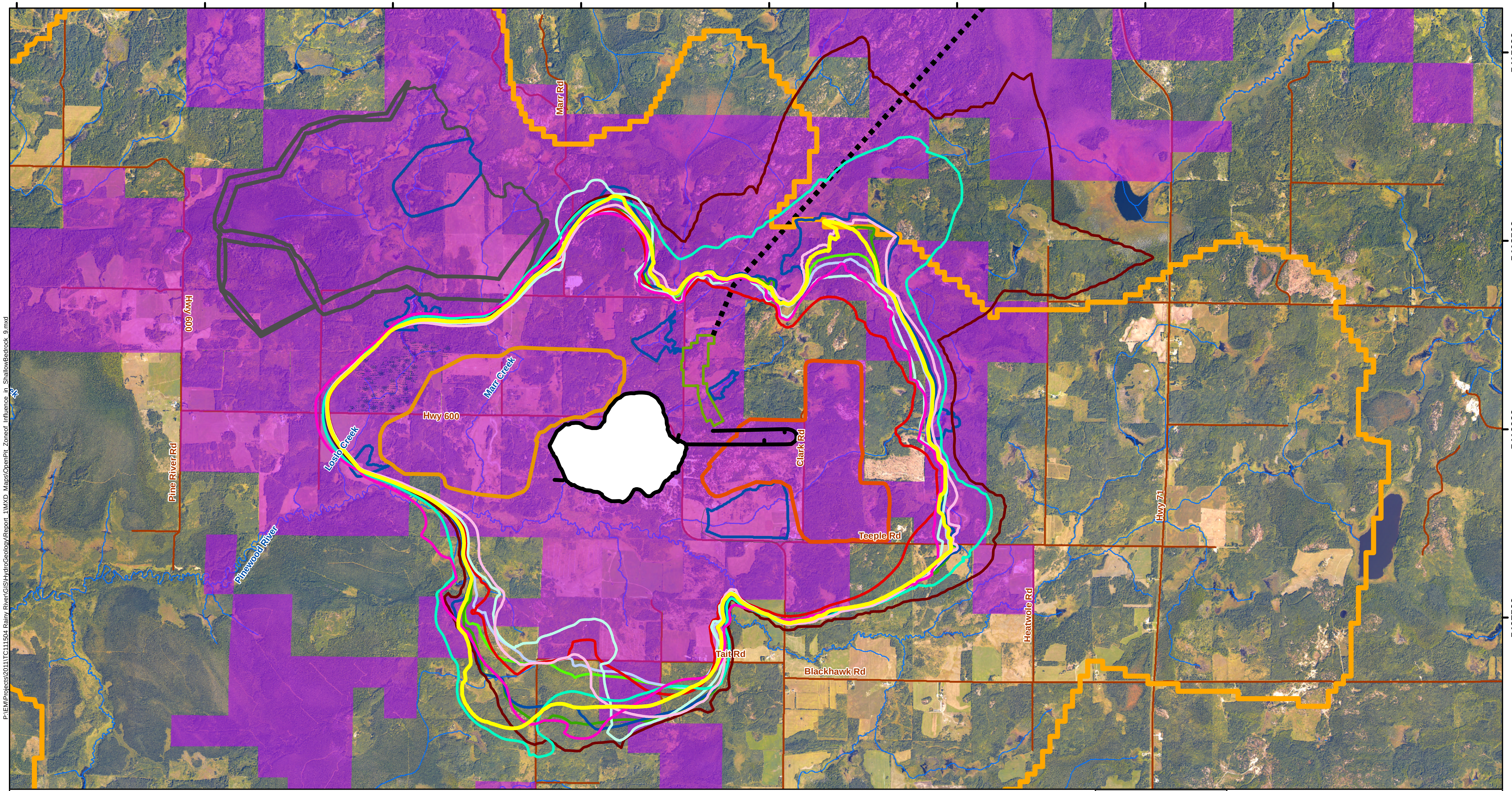
Model Predicted Drawdown in the PLGD/Shallow Bedrock for the Fully Developed and Dewatered Mine (Year 12, Base Case)

PROJECT N^{o}: TC111504	FIGURE: 3-4
SCALE: 1:40,500	DATE: March 2013



LEGEND

- Approximate Open Pit Outline and Underground Ramp
- RRR Active Dispositions/Claims
- Model Domain Boundary
- Roads
- Watercourses corresponding to current conditions

One metre Drawdown (ZOI) Contours by Case

- Simulated Variant (Base Case)
- Simulated Variant 2a
- Simulated Variant 2b
- Simulated Variant 3a*
- Simulated Variant 3b
- Simulated Variant 4a*
- Simulated Variant 4b
- Simulated Variant 5a
- Simulated Variant 5b
- Simulated Variant 6a
- Simulated Variant 6b

* ZOIs portions extending beyond model boundary were extrapolated

Proposed Site Features

- Tailings Management Area
- Overburden / West Mine Rock Stockpile
- Ore / East Mine Rock Stockpile
- Plant Site / Ancillary Facilities
- Ponds
- Transmission Line

0 1 2 4 6 8 10 Kilometres

NOTES:
- Road data extracted from Land Information Ontario, Ontario Road Network, MNR Queen's Printer for Ontario, 2011-2012
- Surficial geology based on air photo analysis and review of published geology maps. Surficial materials may vary from those indicated

Datum: NAD83
Projection: UTM Zone 15N

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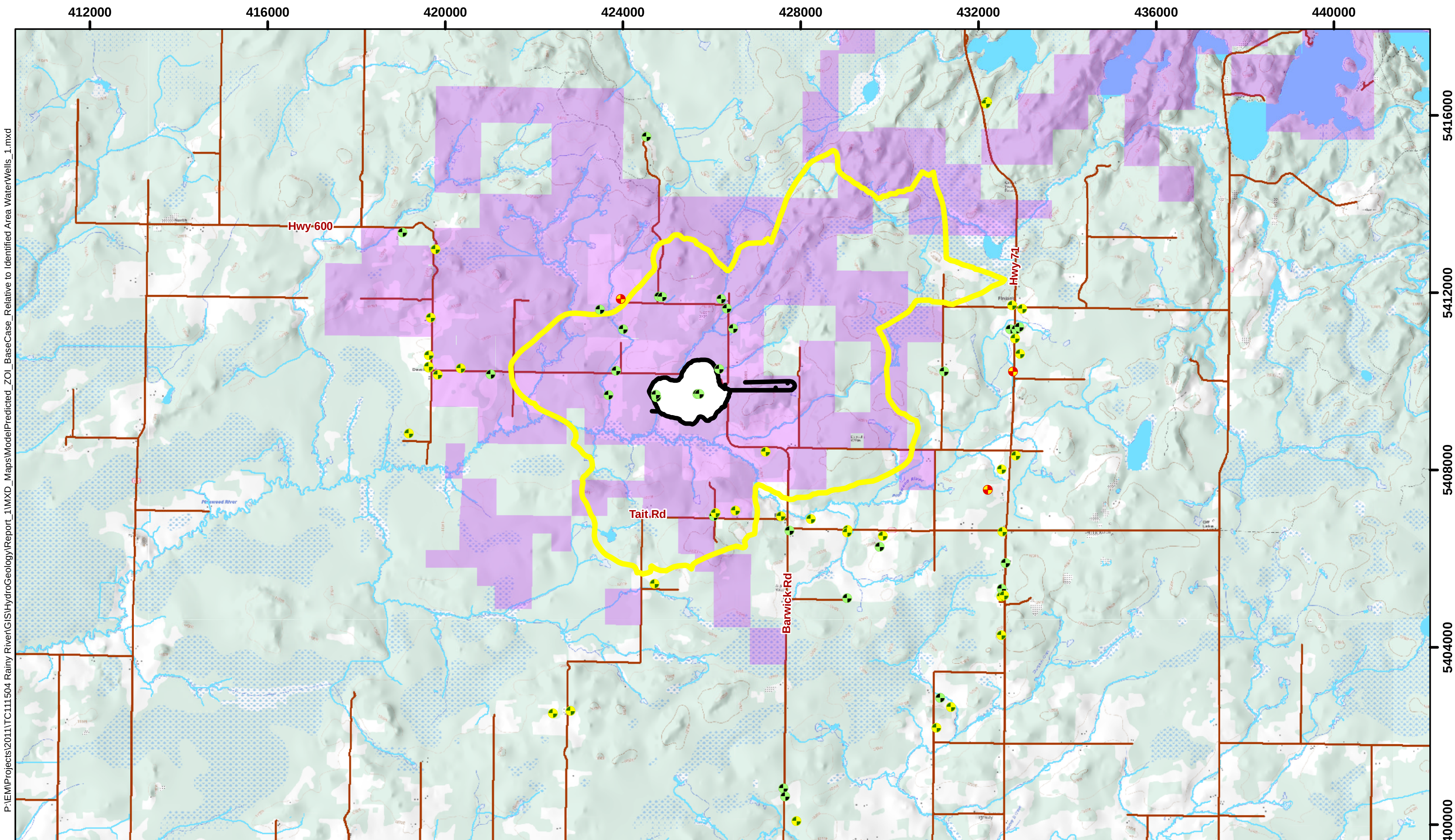
RAINY RIVER GOLD PROJECT

Model Predicted ZOIs in PLGD/Shallow Bedrock for Fully Developed and Dewatered Mine for Simulated Scenarios

PROJECT N^{o}: TC111504 | FIGURE: 3-5

SCALE: 1:48,500 | DATE: March 2013



LEGEND

- Approximate Open Pit Outline and Underground Ramp
- Model Predicted 1 m ZOI (envelope of all sensitivity runs)
- RRR Active Dispositions/Claims

Private Well Locations

- Very accurate location (GPS/private well survey)
- Moderately accurate (accurate MOE WWR location map)
- Not accurate (inaccurate MOE WWR location map)

0 1.5 3 6 9 12 15 Kilometres

NOTES:
- Land tenure information derived from MNDM Claimap service, data extracted on May 8, 2012
- RRR land current as of Aug. 2012
- Background topographic map extracted from Topograma, Geogratis, NRCan 1:50k DRG

Datum: NAD83
Projection: UTM Zone 15N

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Model Predicted ZOI (envelope of all sensitivity runs) Relative to Identified Area Water Wells

PROJECT N^{o}: TC111504	**FIGURE: 3-6**
SCALE: 1:120,000	DATE: April 2013

4.0 PREDICTED GROUNDWATER FLOWPATHS AND TRAVEL TIMES

4.1 Predicted Groundwater Flux and Travel Times from the TMA

The predicted groundwater flowpaths from the TMA have been prepared to illustrate the potential route of groundwater infiltrating beneath the TMA. It should be noted however, that the water within the TMA is expected to be treated before discharge into the TMA to remove or reduce cyanide and metals introduced in the mining process. Water within the TMA will be used to allow settling of suspended particles and removal of nitrogen compounds by bacteria mediated degradation. As such the final quality of water in the TMA is expected to meet or approach the Provincial Water Quality Objectives for the protection of aquatic life.

The groundwater model was used to estimate potential contribution of water emanating from the TMA after final reclamation, to local surface water features. A number of conservative assumptions were used to estimate potential contribution of TMA to groundwater. These assumptions include:

- For the base case scenario, surficial clay layer (Brenna Formation) was assumed to be absent (replaced by Whitemouth Lake till) within a significant area underlying the TMA;
- A relatively high vertical hydraulic conductivity of clay (1E-8 meters per second; m/s) was utilized in all simulated variants; and
- PLGD, the most transmissive hydrostratigraphic unit, was assumed to be continuous everywhere underneath the TMA, except for the bedrock outcrops. This assumption results in significant vertical gradients and downward flow component from the TMA into the PLGD unit.

According to the conducted flow budget analysis 1,690 m^3/d is predicted to be coming out of TMA after final closure with the water cover maintained at an elevation of 378 masl. The water management pond, located in the southwest corner of the TMA was simulated by constant head nodes, corresponding the elevation of 372 masl. Horizontal and vertical hydraulic conductivities of tailings were assumed to be 1E-6 and 1E-7 m/s, respectively.

For the base case scenario, the majority of the flow (about 76%) coming of the tailings is predicted to be captured by the seepage collection ditches, simulated to be 1.5 m deep; while the remaining 24%, or 411 $m^{3/}$d, is predicted to bypass the ditches, migrating underneath them. A relatively small component of this flow (31 m^3/d) is predicted to discharge into the partially flooded open pit. The remaining flow component of 380 m^3/d is expected discharge into Cowser Drain (part of Loslo Creek) and wetlands located along Pinewood River (Figure 4-1).

Table 4-1 shows sensitivity analysis results for the model predicted flow out of the TMA. The conducted sensitivity analysis demonstrates that the model predicted flow component, bypassing the seepage collection ditches and water management pond is conservatively predicted to be up to about 530 m^3/d for all modelled scenarios.

Figure 4-1 shows pathlines originating in the TMA under the Base Case scenario, corresponding to the post-closure conditions. Pathlines were obtained by using a particle tracking code MODPATH (Pollock 1994), linked to MODFLOW. According to the model particle tracking results, some of the flowpaths originating within TMA, have their trajectories in deep bedrock (below 0 masl). This result is likely an artefact of the equivalent porous medium assumption, utilized for simulating flow and advective transport component in all bedrock units. Note that pathlines, with the simulated trajectories through deep bedrock, are associated with a small portion of flow bypassing the seepage collection system (less than 5%).

The effective porosity values used to estimate the travel times are summarized in Table 4-2.

For the base case scenario, where 380 m^3/day reaches Loslo Creek and the Pinewood River, the simulated travel times for the non-reactive dissolved constituents (e.g. tracers, neglecting retardation by matrix diffusion) vary between:

- Approximately 10 years to reach the upstream portion of Loslo Creek where West Creek is diverted;
- Approximately 20 years to reach the mid portion of Loslo Creek;
- More than 40 years to reach the lower portion of Loslo Creek;
- Between 50 and 150 years to reach to pit lake; and
- Between 100 and 200 years to reach the Pinewood River.

The above estimates do not consider any parameter attenuation and/or retardation. Significant attenuation and retardation should be expected due to reaction with the overburden sediments (sorption, precipitation) as well as micro-diffusion from fractures into the bedrock matrix and from mobile to immobile pore water in clay and clay-rich sediments. Given the expected low initial concentrations in the TMA, the very low volumes of groundwater involved and the long flow path lines, it is likely that no detectable parameters above baseline conditions will reach any of the final receptors.

4.2 Predicted Groundwater Flux and Travel Times from the East Mine Rock Stockpile

The predicted groundwater flowpaths from parts of the east mine rock stockpile have been prepared to illustrate the potential route of groundwater infiltrating beneath the stockpile that will to hold potentially acid generating mine rock. The east mine rock stockpile will however, be capped with a very low permeability cover that will significantly reduce the amount of oxygen bearing water reaching the potentially acid generating rock. Seepage is hence, expected to be minimal.

The same assumptions used for the analysis of groundwater flux and travel times from TMA, discussed in Section 4.0 were applied to the analysis of groundwater emanating from the east mine rock stockpile. In addition, a bulk hydraulic conductivity of the mine rock was assumed to be 1E-4 m/s. The proposed 2.5 m thick silty clay cap, covering the east mine rock stockpile, was accounted for by the reduced infiltration into the PAG portion of the east mine rock stockpile. Under the base case scenario, the percolation through the clay cap was assumed to be 10 millimetres per year (mm/yr). Note that an alternative sandwich style cover is now being proposed for the east mine rock stockpile which is expected to reduce the infiltration rate even more. For the purpose of sensitivity additional variants with the assumed more conservative infiltration rates of 30 and 50 mm/yr were also simulated.

Figure 4-2 shows pathlines originating in/or immediately underneath the east mine rock stockpile for the Base Case scenario, corresponding to the post-closure conditions.

Table 4-3 shows sensitivity analysis results for the model predicted flow out of the east mine rock stockpile. The conducted sensitivity analysis demonstrates that the model predicted flow component, bypassing the seepage collection ditches and the open pit, is conservatively predicted to be up to about 120 m^3/d. A significant portion of this water (40 to 50%) ends up in the pit lake, with the remainder discharging to the Pinewood River. Approximately half of the water reaching the pit lake does so through the ramp in the underground workings to the east of the open pit.

The groundwater model was also used to estimate terms of travel times for water emanating from the east mine rock stockpile after closure, using the same assumptions and limitations described for the estimation of the travel times from the TMA described in section 4.0.

For the base case scenario, where 25 m^3/d reaches the Pinewood River under steady state conditions, water from the capped portion of the east mine rock stockpile begins to arrive in the former ramp within approximately 10 years. It takes up to approximately 25 years for water to begin to arrive in the open pit directly or the Pinewood River, with the full 25 m^3/d not arriving at Pinewood River until after 200 years.

The above estimates do not consider any parameter attenuation and/or retardation. Significant attenuation and retardation should be expected due contaminant reaction with the overburden sediments (sorption, precipitation) as well as micro-diffusion from fractures into the bedrock matrix and from mobile to immobile pore water in clay and clay-rich sediments. Given the expected low initial concentrations in the east mine rock stockpile, the very low volumes of groundwater involved, and the long flow path lines, it is likely that no detectable contamination will reach any of the final receptors.

Table 4-1: Model Predicted Flow Out of TMA – Post Closure Conditions

Flow Rates (m^3/d)	Base Case[1]	Whitemouth Lake Till Underneath Tailings[2]	Glaciolacustrine Clay (Brenna) Underneath Tailings[2]	K-value of Weathered Rock x 2	K-value of Weathered Rock /2	K-value of PLGD x 1.5	K-value of PLGD /1.5
Total flow out of TMA	1,690	1,757	1,028	1,867	1,590	2,020	1,423
Intercepted by seepage collection ditches and water management pond	1,279	1,334	671	1,383	1,221	1,430	1,130
Discharged into open pit	31	31	67	37	25	63	15
Bypassing ditches and open pit	380	393	290	447	354	527	278

(1) Input parameters shown in Table 2-1 - combination of glaciolacustrine clay (Brenna Formation), Whitemouth Lake Till and bedrock outcrops underneath tailings

(2) Everywhere underneath TMA, excluding bedrock outcrops

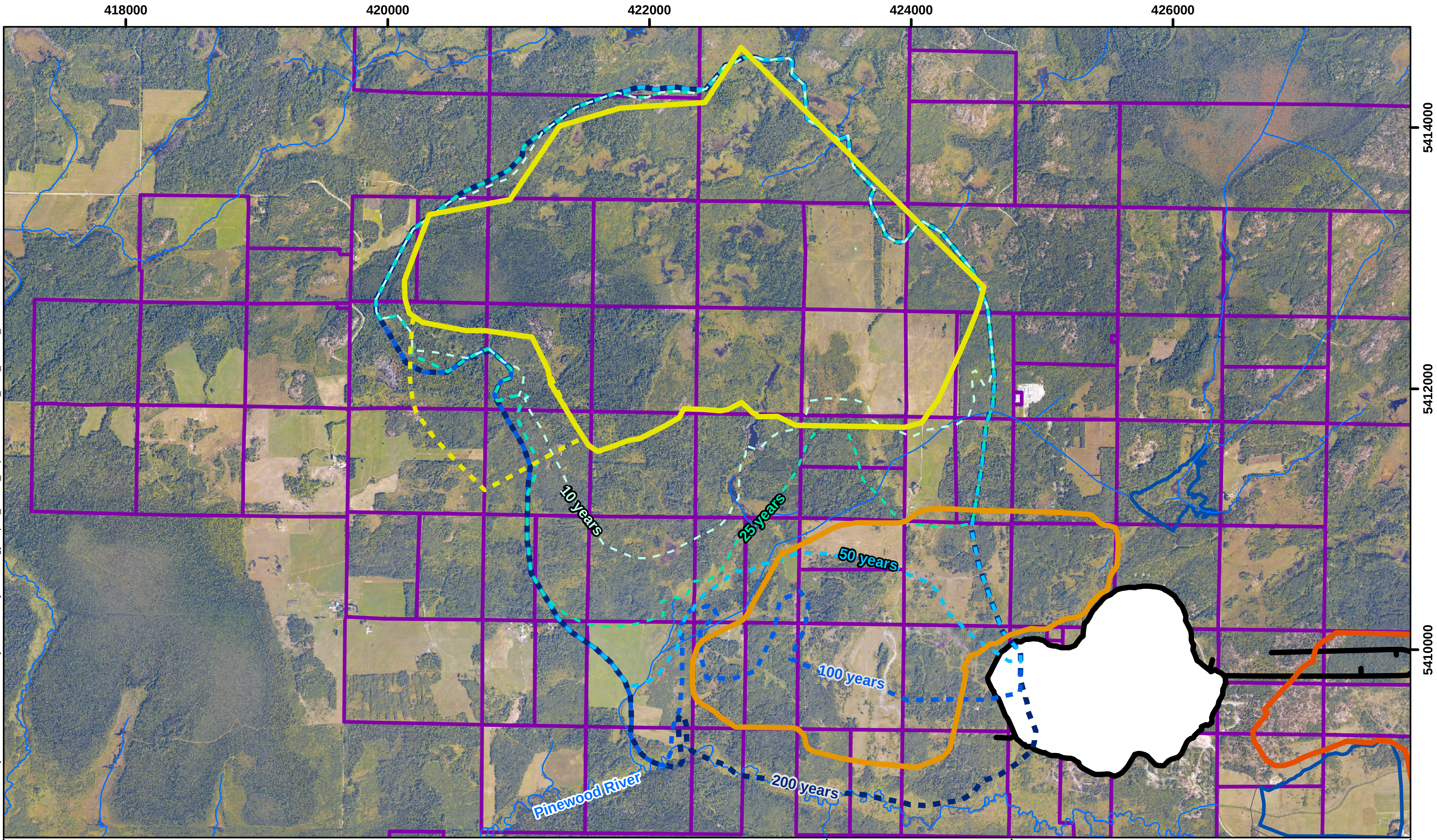
Table 4-2: Rainy River Groundwater Flow Model Effective Porosity Values

Hydrostratigraphic Unit	Effective Porosity (-)	Expected Range[1]
Peat	0.3	0.3 to 0.5
Pinewood River Alluvium	0.1	0.1 to 0.35
Glaciolacustrine Clay (Brenna)	0.05	0.01 to 0.2
Whitemouth Lake Till	0.05	0.05 to 0.2
Glaciolacustrine Clay (Wylie)	0.05	0.01 to 0.2
Whiteshell Till (PLGD)	0.15	0.1 to 0.35
Shallow Bedrock	0.01	-
Intermediate Bedrock	0.005	-
Deep Bedrock	0.001	-
EFLT Fault	0.01	-

(1) Sara (2003)

Table 4-3: Model Predicted Flow from the East Mine Rock Stockpile – Post Closure Conditions

Infiltration / Percolation Rate (mm/yr)	10	30	50
	Flow Rates (m^3/d)		
Total flow out of PAG portion of east mine rock stockpile	57	171	285
Intercepted by seepage collection ditches	8	30	72
Discharging into open pit and former mine workings	24	57	95
Bypassing ditches and open pit	25	84	118



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LEGEND

- Approximate Open Pit Outline and Underground Ramp
- Proposed TMA Footprint
- TMA Water Management Pond
- Watercourses
- RRR Active Dispositions/Claims

Envelope of Groundwater Pathlines Projected to Surface

- Closure to 10 years
- 10 years to 25 years
- 25 years to 50 years
- 50 years to 100 years
- 100 years to 200 years

Proposed Site Features

- Overburden / West Mine Rock Stockpile
- Ore / East Mine Rock Stockpile
- Ponds

NOTES:
-

Datum: NAD83
Projection: UTM Zone 15N

0 0.5 1 2 3 4 Kilometres

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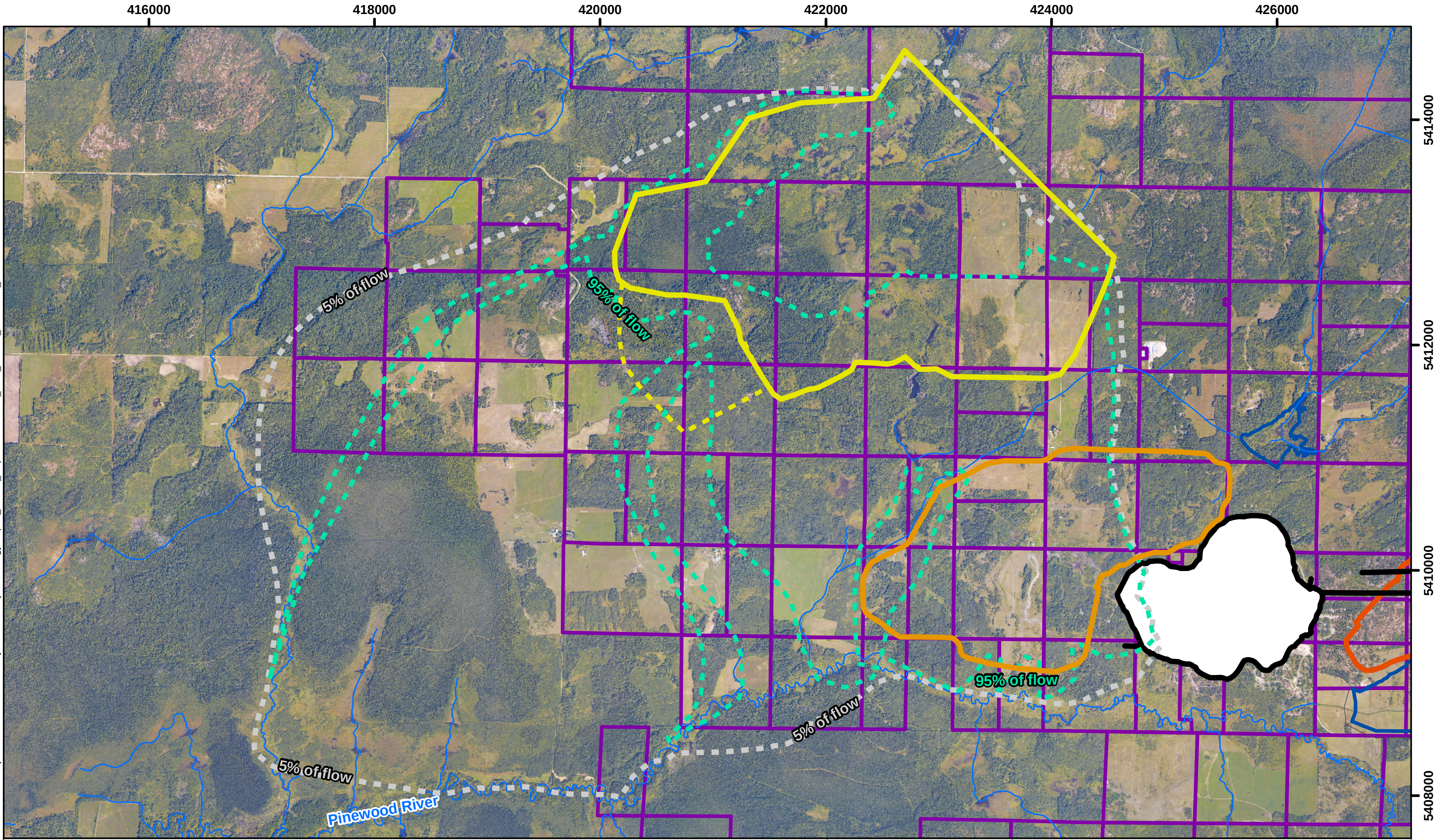
Particle Tracking Results from TMA After Closure

PROJECT N°: TC111504	**FIGURE: 4-1**
SCALE: 1:40,500	DATE: March 2013



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LEGEND

- Approximate Open Pit Outline and Underground Ramp
- Proposed TMA Footprint
- TMA Water Management Pond
- Watercourses
- RRR Active Dispositions/Claims

Proposed Site Features

- Overburden / West Mine Rock Stockpile
- Ore / East Mine Rock Stockpile
- Ponds

Envelope of Groundwater Pathlines Projected to Surface

- Relatively Shallow Groundwater Conditions (95% of flow)
- Groundwater Conditions through Deep Rock (5% of flow)

NOTES:
-

Datum: NAD83
Projection: UTM Zone 15N

0 0.5 1 2 3 4 Kilometres

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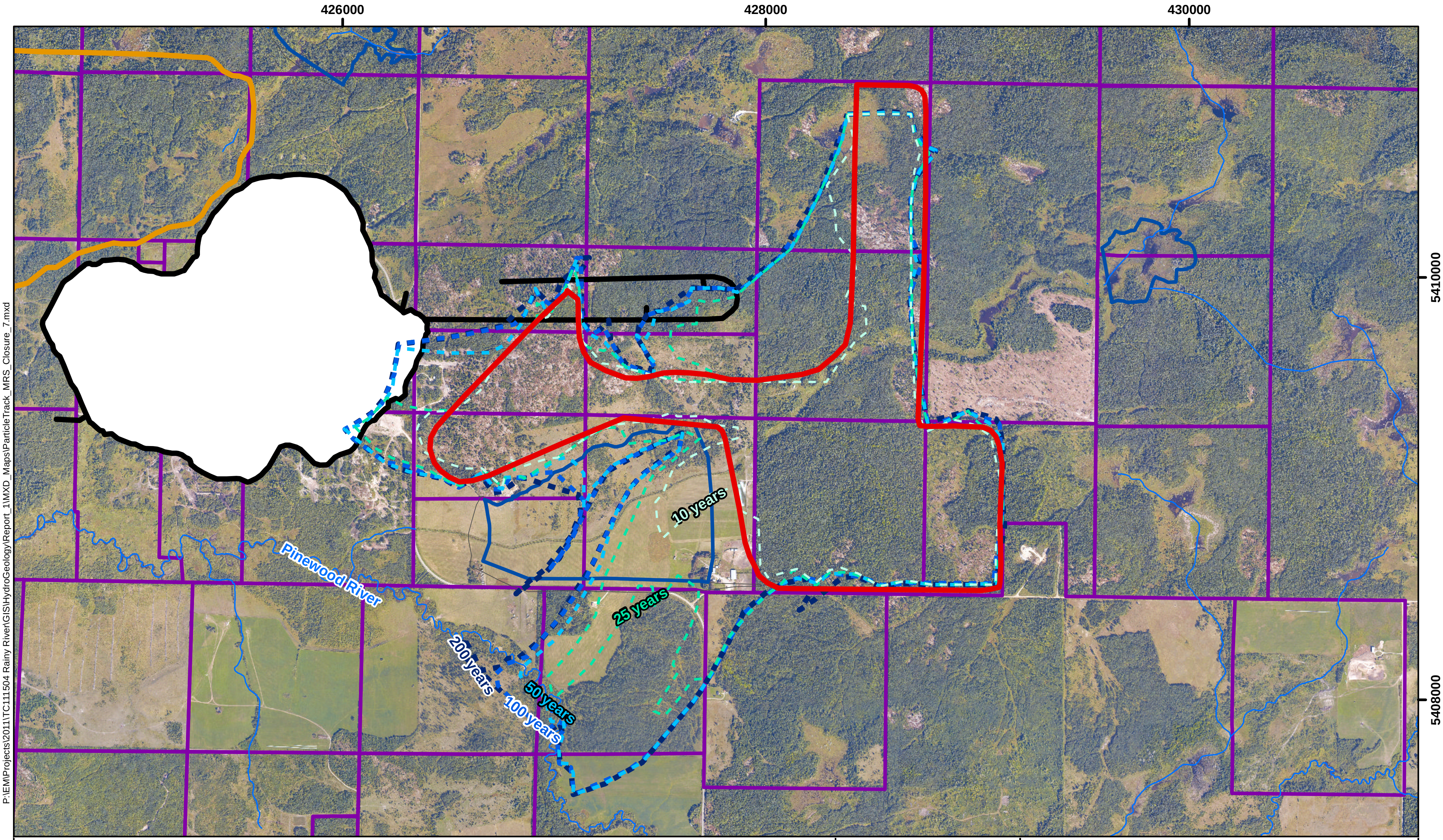
RAINY RIVER GOLD PROJECT

Particle Tracking results from TMA after closure: Steady-State Pathlines (Base Case)

PROJECT N^{o}: TC111504 | **FIGURE: 4-2**

SCALE: 1:47,000 | DATE: March 2013



LEGEND

- Approximate Open Pit Outline and Underground Ramp
- East Mine Rock Stockpile Footprint *
- Watercourses
- RRR Active Dispositions/Claims

* portion of east mine rock stockpile footprint to be used to store PAG rock.

Envelope of Groundwater Pathlines Projected to Surface

- Closure to 10 years
- 10 years to 25 years
- 25 years to 50 years
- 50 years to 100 years
- 100 years to 200 years

Proposed Site Features

- Overburden / West Mine Rock Stockpile
- Ponds

NOTES:
-

Datum: NAD83
Projection: UTM Zone 15N

N W E S

0 0.5 1 2 3 Kilometres

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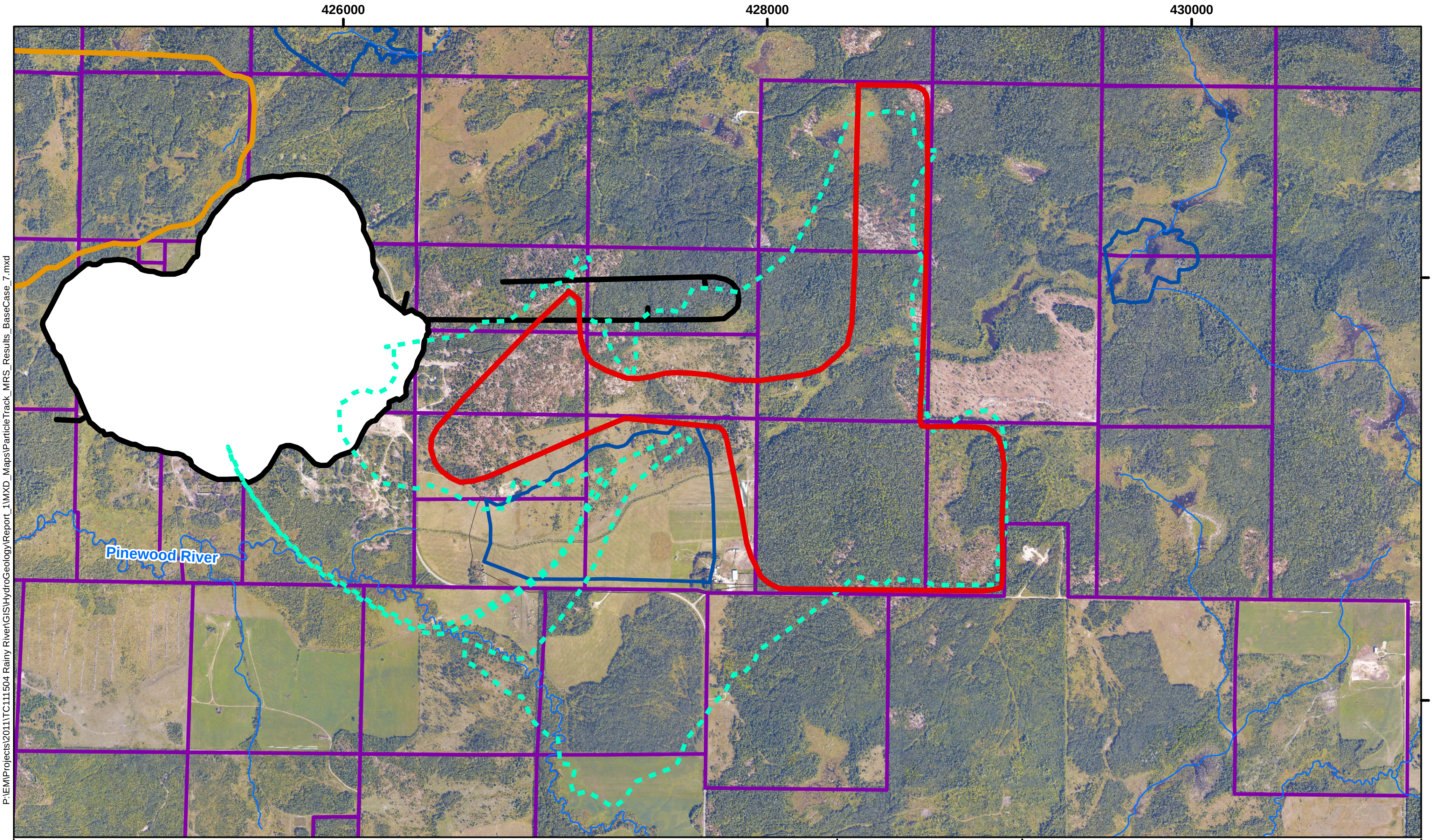
Particle Tracking Results from East Mine Rock Stockpile After Closure

PROJECT N°: TC111504	FIGURE: 4-3
SCALE: 1:25,000	DATE: March 2013



LEGEND

- Approximate Open Pit Outline and Underground Ramp
- East Mine Rock Stockpile Footprint *
- Watercourses
- RRR Active Dispositions/Claims

Envelope of Groundwater Pathlines Projected to Surface

- Steady-State Groundwater Conditions

Proposed Site Features

- Overburden / West Mine Rock Stockpile
- Ponds

* portion of east mine rock stockpile footprint to be used to store PAG rock.

0 0.5 1 2 3 Kilometres

NOTES:
-

Datum: NAD83
Projection: UTM Zone 15N

N W E S

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RAINY RIVER GOLD PROJECT

Particle Tracking Results from East Mine Rock Stockpile after Closure: Steady-State Pathlines

PROJECT N°: TC111504	**FIGURE: 4-4**
SCALE: 1:25,000	DATE: March 2013

5.0 SUMMARY OF ANTICIPATED GROUNDWATER EFFECTS

5.1 Overview

Modelling of the proposed open pit anticipates that the ZOI, defined by 1 m of drawdown that will eventually develop from the dewatered open pit, is expected to extend approximately 4 to 4,5 km to the north, east, south and west, and 7.5 km to the northeast from the centre of the open pit by the end of mining / cessation of dewatering activities. However, through land acquisitions, RRR will own all of the water supply wells prior within the anticipated ZOI prior to start of significant dewatering. As a result, there are no anticipated affects on private water wells, not owned by RRR, all of which lie outside the ZOI.

The long term reduction in the average groundwater contribution to flow the Pinewood River is predicted to vary between 3,000 to 4,000 m^3/d depending on the parameters used in the groundwater model (note these volume represent average conditions and the volumes will decrease during dry conditions when groundwater levels are low, and increase during wet periods when groundwater levels are high). The effect of this reduction in groundwater contribution to the Pinewood River is expected to be minimal, as the river often runs dry in its current condition, indicating groundwater discharge does not sustain flows in the river. During dry conditions when there is no flow in the Pinewood River, some groundwater discharge is expected to continue, but absorbed by evapotranspiration or lost to storage where water is ponded above Beaver dams, and will not be evident as flow in the river.

The expected groundwater flow into the proposed open pit, which is derived mainly from the PLGD and Shallow Bedrock, is predicted by the model to be of the order 3,000 to 4,000 m^3/d. It should be noted that the result of the groundwater flow model assumes there is only one major permeable structure in the bedrock that is significant for groundwater flow (the EFLT); no other permeable structures have been identified at this stage.

The groundwater model was also used to predict the travel paths of water emanating from the TMA and the east mine rock stockpile. In both cases, small quantities were predicted to bypass the perimeter drains and eventually discharge to the either the open pit, Cowser Drain (part of Loslo Creek) or the Pinewood River. Water discharged to the TMA will be treated to reduce concentrations of metals and cyanide, with additional treatment expected within the TMA. Water emanating from the east mine rock stockpile may contain some metals, however capping of this portion of the east mine rock stockpile is expected to minimize these concentrations, and the volumes of water are extremely small (25 m^3/d). In both cases, no detectable changes in the water quality of the receiving water are expected. Water captured by the perimeter drains will be treated as necessary before discharge.

5.2 Proposed Confirmatory Groundwater Monitoring Plans

Separate groundwater monitoring plans are proposed to confirm the predictions of the groundwater model in terms of drawdown and in terms of flow paths emanating from the TMA and east mine rock stockpile. The objectives of the drawdown monitoring are to measure the growth and decline of the drawdown cone in response to mining and flooding of the open pit post closure and ensure that local water supplies are maintained during the dewatering period. The objective of the monitoring of the TMA and east mine rock stockpile will be to confirm the groundwater emanating from these facilities does not degrade groundwater quality in surface water features or local wells on neighbouring properties.

5.2.1 Proposed Groundwater Level Monitoring Plan

A preliminary groundwater level monitoring program is proposed to confirm the drawdown predicted by the numerical groundwater model is correct. Three sets of monitoring wells are proposed:

- Near pit wells: these will be located approximately within 500 m of the pit rim. Their main purpose is to assess drawdown as the pit is constructed to confirm predicted amounts of drawdown. A subset of these will be located close to Pinewood River to assess impact, if any, on groundwater / surface water interaction;

- Sentinel wells: these will be located at approximately 3 to 4 km from the pit rim at the approximate edge of the predicted ZOI. Their main purpose is to assess drawdown, if any, in the immediate vicinity of private wells where groundwater level drawdown may be a concern; and

- Background wells: these will be located outside the predicted ZOI at approximately 6 km distance from the pit rim where negligible drawdown is expected.

Most installations are expected to comprise a nested piezometers with two screens:

- A lower screen will monitor groundwater levels in the PLGD or the Shallow Bedrock, if the former appears to be absent. This will assess groundwater levels in those hydrostratigraphic units that are likely to be the main source of water for private wells in the vicinity of the proposed open pit; and

- An upper screen will monitor groundwater levels close to the top of the Pleistocene Aquitard and is expected to be within 10 m of surface. This will monitor levels at the top of the Pleistocene Aquitard to assess any variation in vertical gradients as the open pit is developed.

Wells installed in areas with thin overburden or installed as background wells will have only one bedrock / PLGD screen.

The areas of the proposed monitoring installations are shown in Figure 5-1 and summarized in Table 5-1. Fifteen piezometers with 23 screens are expected to be monitored with transducers to measure water levels, of which eight will be near pit wells, six will be sentinel wells and one will be a background well.

5.2.2 Proposed Groundwater Quality Monitoring Plan - TMA and East Mine Rock Stockpile

High concentrations of metals, cyanide or nitrogen compounds are not anticipated from either the TMA or east mine rock stockpile, due to the treatment of water being discharged to the TMA and addition of a lo permeability cover over the east mine rock stockpile. However, monitoring is proposed to confirm these predictions and confirm that the predicted groundwater flow paths originating from these features are in line with model predictions. Based on the flow paths shown in Figures 4-1 and 4-2, 15 sets of monitoring wells are proposed around the TMA and east mine rock stockpile, with another three sets proposed along the down gradient RRR property line, and another monitoring well on Marr Road serving as a background well. Each of these wells will consist of one screen in the PLGD, or shallow bedrock where the PLGD is absent. Some wells close to the TMA or east mine rock stockpile will also have overburden completions.

The areas of the proposed monitoring installations are shown in Figure 5-1 and summarized in Table 5-1. Where possible these monitoring sites have been combined with the groundwater level monitoring wells. This monitoring program will be supplemented by sampling of the water in the TMA and surface water features.

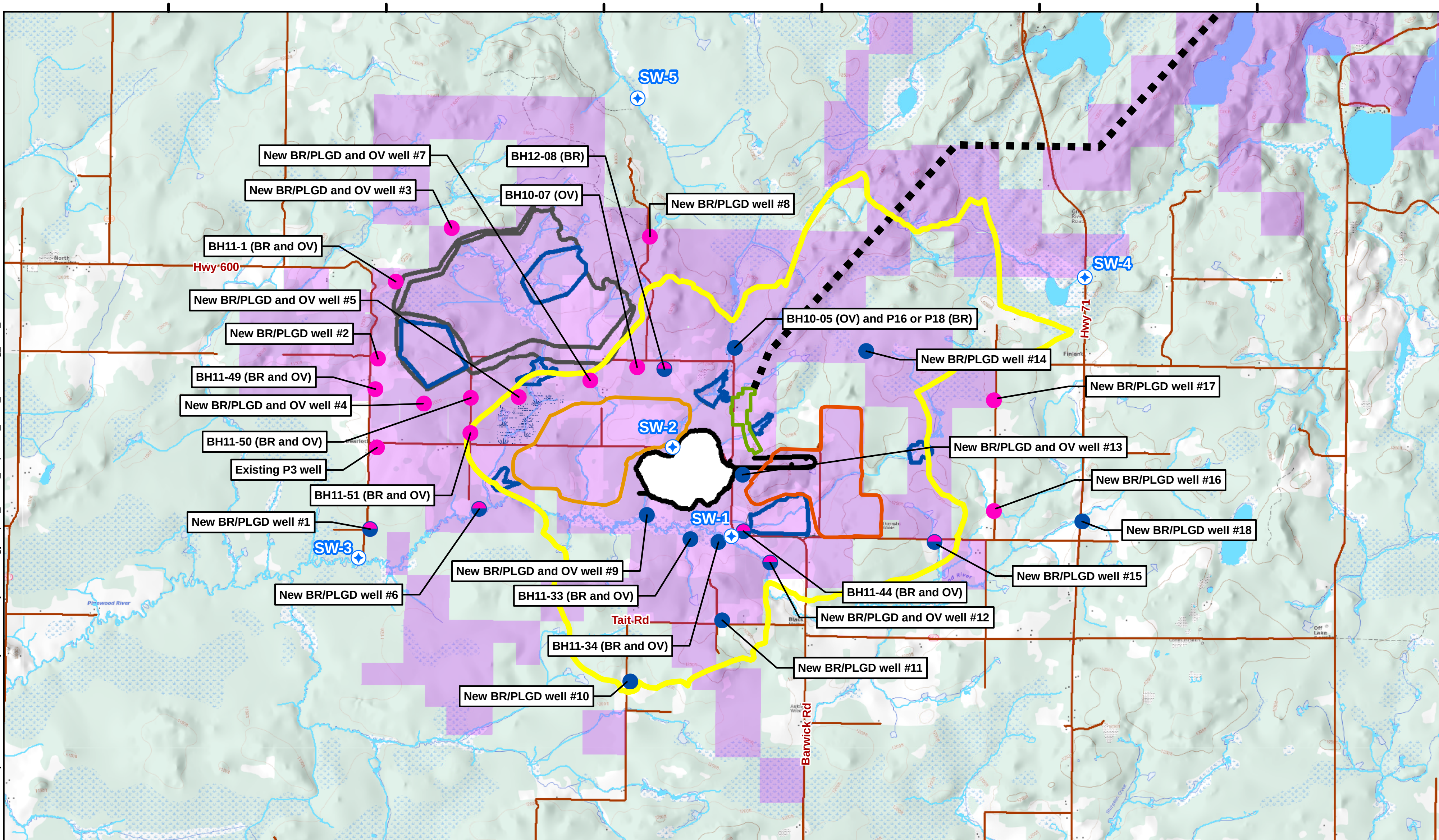
It is expected that all piezometers will be sampled four times per year. The following parameters (suites) are recommended:

- Metals (dissolved);
- Cyanide in monitoring wells around TMA (total, free and weak acid dissociable for first year; then total and weak acid dissociable thereafter);
- Major anions and cations; and
- *In situ* field parameters (temperature, eh, pH and dissolved oxygen).

Table 5-1: Summary of Confirmatory Groundwater Level and Groundwater Quality Monitoring Plan

Well ID	Location	Type	Screened Units	Monitoring Objective
BH10-05/ P16 or P18	Roen Road, north of pit	Quality and level	BR / PLGD and OV	Water levels north of open pit, and background water quality
BH10-07	Southeast of TMA	Quality	OV	Downgradient water quality and water levels northwest of open pit
BH11-1	Northwest of TMA	Quality	BR and OV	Downgradient water quality
BH11-33	South of open pit	Level	BR and OV	Water levels near Pinewood
BH11-34	South of open pit	Level	BR and OV	Water levels near Pinewood
BH11-44	Southwest of east mine rock stockpile, near Pinewood River	Quality and level	BR and OV	Water levels near Pinewood and water quality downgradient of east mine rock stockpile
BH11-49	Hwy 600, southwest of TMA	Quality	BR and OV	Downgradient water quality
BH 11-50	South of TMA	Quality	BR and OV	Downgradient water quality
BH 11-51	South of TMA	Quality	BR and OV	Downgradient water quality
BH12-08	Southeast of TMA	Quality and level	BR	Downgradient water quality
P3	Intersection of Pinewood River Rd and Hwy 600	Quality	BR / PLGD	Downgradient water quality
New well #1	Pinewood River Rd, near Pinewood River	Quality and level	BR / PLGD	Downgradient water quality and distal water levels near Pinewood
New well #2	Hwy 600, west of TMA	Quality	BR / PLGD	Downgradient water quality
New well #3	North of TMA	Quality	BR / PLGD and OV	Upgradient water quality
New well #4	South of water management pond	Quality	BR / PLGD and OV	Downgradient water quality
New well #5	South of TMA	Quality	BR and OV	Downgradient water quality
New well #6	Confluence of Cowser Drain and Pinewood River	Quality and level	BR / PLGD	Downgradient water quality and distal water levels near Pinewood
New well #7	South of TMA	Quality	BR and OV	Downgradient water quality
New well #8	Northeast of TMA on Marr Road	Quality	BR / PLGD	Upgradient water quality
New well #9	Southwest of open pit	Level	BR / PLGD and OV	Water levels near Pinewood
New well #10	South of Tait Road	Level	BR / PLGD	Water levels at south drawdown limit
New well #11	Tait Road, near closest private wells	Level	BR / PLGD	Water levels near closest private well
New well #12	South of east mine rock stockpile, near Pinewood River	Quality and level	BR / PLGD and OV	Water levels near Pinewood and water quality downgradient of east mine rock stockpile
New well #13	West of open pit	Level	BR / PLGD and OV	Water levels west of pit
New well #14	North of east mine rock stockpile	Level	BR / PLGD	Water levels northwest of open pit
New well #15	Upstream Pine River	Quality and level	BR / PLGD and OV	Water levels near Pinewood and water quality downgradient of east mine rock stockpile
New well #16	East of east mine rock stockpile	Quality	BR / PLGD	Downgradient water quality
New well #17	East of east mine rock stockpile	Quality	BR / PLGD	Downgradient water quality
New well #18	East of east mine rock stockpile on Hwy 71	Level	BR / PLGD	Background water levels

BR: Bedrock
PLGD: Pleistocene Lower Granular Deposits
OV: Overburden



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LEGEND

- Approximate Open Pit Outline and Underground Ramp
- RRR Active Dispositions/Claims
- 1 m Drawdown Envelope of all Sensitivity Runs
- Surface Water Level Monitoring Stations (labelled on map)

Proposed Monitoring Wells (labelled on map)

- Groundwater level monitoring location
- Groundwater quality monitoring location
- Groundwater level and quality monitoring location

Proposed Site Features

- Tailings Management Area
- Overburden / West Mine Rock Stockpile
- Ore / East Mine Rock Stockpile
- Plant Site / Ancillary Facilities
- Ponds
- Transmission Line

0 1 2 4 6 8 10 Kilometres

NOTES:
- Land tenure information derived from MNDM Claimap service, data extracted on May 8, 2012
- RRR land current as of Aug. 2012
- Background topographic map extracted from Topograma, Geogratis, NRCan 1:50k DRG

Datum: NAD83
Projection: UTM Zone 15N

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RAINY RIVER GOLD PROJECT

Proposed Groundwater Quality and Level Monitoring Well Network

PROJECT N°: TC111504	FIGURE: 5-1
SCALE: 1:100,000	DATE: April 2013

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APPENDIX A

TABLE OF GROUNDWATER LEVEL MEASUREMENTS

Table A-1 Summary Details of All Monitoring Wells/Piezometers and Groundwater Level Measurements for Selected Periods

Borehole ID	UTM 15		Ground Surface Elevation (masl)	Unit	Screen (mbgs)		Water Level (masl)						Comments
	Easting	Northing			top	bottom	Sept.22nd, 2009	Sept.18th 2010	March 8th 2011	Sept.22nd, 2011	June, 2012	Oct./Nov., 2012	
Existing piezometers and open boreholes with hydrographs monitored by RRR													
NR9628	425909.4	5409444.7	353.60	BR	8.0	203.1	348.61	348.63	348.59	347.47	348.03	347.48	June 25th, 2012
NR9664	426291.5	5409563.7	365.09	BR	3.9	182.5	353.20	352.91	353.30	351.74	352.30	348.06	June 15th, 2012
NR06104	425774.0	5409380.8	353.07	BR	2.8	398.3	349.86	---	---	---	---	---	Stopped monitoring Fall of the 2009
NR06115	425446.0	5409458.0	355.00	BR	4.6	680.3	347.70	---	---	---	---	---	Stopped monitoring Fall of the 2009
NR07151	425977.0	5409314.0	352.00	BR	23.2	417.8	351.44	---	---	---	---	---	Stopped monitoring Fall of the 2009
NR07190	425622.9	5409265.0	350.42	BR	16.8	350.4	349.71	349.49	349.06	348.51	349.69	348.97	June 25th, 2012
RR09213	425850.0	5409786.0	350.00	BR	3.5	46.5	---	>350.27	>350.27	>350.27	>350.27	>350.27	Bore hole dimensions taken from Klohn-Crippen-Beger Table 6.1, artesian (waterlevel higher than casing 0.27 m above ground), June 25th, 2012
NR07214	425160.0	5408952.0	347.00	BR	25.3	940.2	---	---	---	>347.50	>347.50	>347.50	Artesian (waterlevel higher than ground surface, no casing height information), June 25th, 2012
NR08246	425597.0	5409569.0	352.00	BR	28.5	542.5	350.95	352.38	---	351.66	351.83	350.97	Well located near a pumping station, water level in September 2009 affected by pumping, Frozen in March 2011, June 25th, 2012
NR08257	426174.0	5409956.0	363.00	BR	12.9	729.3	357.52	356.58	---	---	---	---	September 11th instead of September 18th, 2010 as this was the last reading
NR08278	425300.0	5409540.0	351.00	BR	7.7	514.8	349.36	348.87	---	---	---	---	September 11th instead of September 18th, 2010 as this was the last reading
NR08287	426316.0	5409249.0	351.00	BR	22.5	451.7	345.53	346.24	345.10	344.73	343.97	342.11	June 15th, 2012
NR09367	425814.0	5410139.0	352.00	BR	23.5	322.1	---	---	---	>352.50	>352.50	>352.50	Artesian (waterlevel higher than 0 m above ground, no casing height information), not monitored prior to June 28th, 2011, June 25th, 2012
NR09428	425835.0	5409700.0	350.00	BR	21.5	409.5	---	---	---	>350.38	>350.38	>350.38	Artesian (waterlevel higher than casing 0.38 m above ground), not monitored prior to June 28th, 2011, June 25th, 2012
BH10-04	425813.5	5410648.6	358.14	WS	18.5	21.5	---	355.44	---	354.83	---	354.85	Monitoring begins on September 18th, 2010, no access to site in March 2011, no access to site after March 31st 2012
BH10-05	426397.3	5411994.8	373.28	WML	3.0	6.0	---	372.89	372.62	371.37	372.65	372.90	Monitoring begins on September 18th, 2010, June 15, 2012
BH10-06	426901.3	5411494.2	375.50	WML	3.6	6.6	---	374.56	---	373.94	---	373.48	Monitoring begins on September 18th, 2010, Frozen in March of 2011, no access to site June 25th, 2012, October 29th, 2012
BH10-07A	424608.6	5411634.2	353.27	WML	22.0	25.0	---	354.20	>354.21	>354.21	>354.21	353.41	Artesian (waterlevel higher than casing 0.93 m above ground), monitoring begins on September 18th, 2010, March 21st (frozen March 8th, 2012), June 25th, 2012, October 31st, 2012
BH10-07B	424608.5	5411634.2	353.27	WML	1.4	4.4	---	>354.33	>354.33	>354.33	>354.33	355.12	Artesian (waterlevel higher than casing 1.04 m above ground), monitoring begins on September 18th, 2010, Frozen in March of 2011, June 25th, 2012, October 31st, 2012, Artesian conditions above well stick up, measured with an extention
BH10-08A	423987.7	5411777.5	358.14	WML	3.7	6.7	---	357.80	356.97	356.31	357.43	357.41	Monitoring begins on September 18th, 2010, June 25th, 2012, October 29th, 2012
BH10-08B	423987.7	5411777.5	358.14	A	11.7	14.7	---	358.08	357.98	357.81	357.14	356.82	Monitoring begins on September 18th, 2010, March 1st (frozen March 8th, 2012), June 25th, 2012, October 29th, 2012
BH10-09A	423949.4	5412734.9	366.70	BR	2.2	3.7	---	365.76	365.69	365.00	---	365.67	Monitoring begins on September 18th, 2010, no site access June, 2012, October 31st, 2012
BH10-09B	423949.5	5412734.9	366.70	WS	0.5	2.0	---	365.77	365.70	DRY	---	365.69	Monitoring begins on September 18th, 2010, no measurement on record in June 2012, October 31st, 2012
BH10-10A	425986.5	5409979.8	350.15	WML	27.2	30.2	---	350.92	---	>351.08	>351.08	351.01	Artesian (waterlevel higher than casing 0.86 m above ground), Monitoring begins on September 18th, 2010, Frozen in March of 2011, October 30th, 2012
BH10-10B	425986.5	5409980.0	350.15	WML	9.8	12.8	---	351.05	---	350.36	350.45	350.19	Monitoring begins on September 18th, 2010, Frozen in March of 2011, June 25th, 2012, October 30th, 2012
BH10-11A	424736.3	5409865.5	348.50	WS	26.7	29.7	---	349.40	---	348.93	349.08	349.28	Monitoring begins on September 18th, 2010, Frozen in March of 2011, June 25th, 2012, October 29th, 2012

BH10-11B	424736.3	5409865.5	348.50	WML	9.4	12.4	---	349.01	---	348.40	348.45	348.29	Monitoring begins on September 18th, 2010, Frozen in March of 2011, June 25th, 2012, October 29th, 2012
BH10-12A	423964.1	5410512.2	351.94	WS/BR	16.5	19.5	---	>352.82	>352.82	>352.82	>352.82	352.79	Artesian (waterlevel higher than casing 0.85 m above ground), Monitoring begins on September 18th, 2010, Frozen in March of 2011, June 25th, 2012, October
BH10-12B	423964.0	5410512.2	351.94	WML	6.0	9.0	---	350.32	350.39	350.56	350.65	349.63	Monitoring begins on September 18th, 2010, June 25th, 2012, October 29th, 2012
BH10-13	425432.6	5409306.5	349.47	WS	16.3	19.3	---	349.00	349.06	348.48	348.60	348.52	Monitoring begins on September 18th, 2010, June 25th, 2012, October 30th, 2012

Borehole ID	UTM 15		Ground Surface Elevation (masl)	Unit	Screen (mbgs)		Water Level (masl)						Comments
	Easting	Northing			top	bottom	Sept.22nd, 2009	Sept.18th 2010	March 8th 2011	Sept.22nd, 2011	June, 2012	Oct./Nov., 2012	
BH10-14	425173.1	5408923.5	346.84	WML/WS	16.5	19.5	---	>347.81	---	>347.81	>347.81	>347.81	Artesian (waterlevel higher than casing 0.85 m above ground), Monitoring begins on September 18th, 2010, Frozen in March of 2011, June 25th, 2012, October 31st, 2012, Artesian conditions above well stick up.
BH10-15	425241.2	5409399.8	349.65	WML/WS	15.5	18.5	---	348.49	---	348.40	348.64	348.75	Monitoring begins on September 18th, 2010, broken casing in March of 2011, June 25th, 2012, October 30th, 2012
Piezometers installed by AMEC 2011/2012													
BH11-04	421970.3	5411831.8	365.48	BR	13.4	16.5	---	---	---	---	360.71	359.74	June 8th, 2012, October 30th, 2012
BH11-08A	423205.2	5411863.4	356.56	BR	24.0	25.5	---	---	---	---	358.20	357.04	June 16th, 2012, October 31st, 2012
BH11-08B	423205.2	5411863.4	356.56	WS	19.8	21.3	---	---	---	---	356.77	---	June 16th, 2012, October 31st, 2012, Well under the influence of surface water
BH11-08C	423205.2	5411863.4	356.56	WML	4.6	6.1	---	---	---	---	356.86	---	June 16th, 2012, October 31st, 2012, Water level at top of casing
BH11-09A	424201.0	5411181.8	351.28	WML	4.6	6.1	---	---	---	---	350.29	349.70	June 11th, 2012
BH11-11A	425205.3	5410762.9	360.00	BR	36.3	37.8	---	---	---	---	354.58	354.41	June 10th, 2012, October 30th, 2012
BH11-11B	425205.3	5410762.9	360.00	WS	32.8	34.3	---	---	---	---	354.57	354.43	June 10th, 2012, October 30th, 2012
BH11-11C	425205.3	5410762.9	360.00	GS	6.1	7.6	---	---	---	---	355.71	354.84	June 10th, 2012, October 30th, 2012
BH11-12A	425311.2	5411177.9	355.72	BR	22.5	27.0	---	---	---	---	354.37	354.08	June 11th, 2012, October 29th, 2012
BH11-12B	425311.2	5411177.9	355.72	WML	4.6	6.1	---	---	---	---	354.98	355.30	June 11th, 2012, October 29th, 2012
BH11-13A	422597.1	5410290.3	347.06	LGL/BR	19.8	22.8	---	---	---	---	351.06	350.38	June 11th, 2012, October 30th, 2012
BH11-13B	422597.1	5410290.3	347.06	WML	13.4	14.9	---	---	---	---	348.98	347.62	June 11th, 2012, November 1st, 2012
BH11-17	424758.1	5410114.4	349.35	WML	10.7	12.2	---	---	---	---	349.96	349.84	June 11th, 2012, October 29th, 2012
BH11-19A	426009.5	5409287.1	350.32	BR	28.5	30.1	---	---	---	---	348.79	348.91	June 11th, 2012, October 30th, 2012
BH11-19B	426009.5	5409287.1	350.32	LGL/WS	22.8	24.3	---	---	---	---	348.79	348.91	June 11th, 2012, October 30th, 2013
BH11-19C	426009.5	5409287.1	350.32	WML	4.6	6.1	---	---	---	---	349.27	348.84	June 11th, 2012, October 30th, 2014
BH11-20A	425891.5	5410232.5	352.09	LGL/WS	25.0	26.5	---	---	---	---	---	352.31	Water Level measured on several days, but is very variable, October 30th, 2015
BH11-20C	425891.5	5410232.5	352.09	UG	1.5	3.0	---	---	---	---	351.42	---	June 8th, 2012
BH11-21A	425054.7	5408465.6	346.50	BR	37.8	39.3	---	---	---	---	348.18	---	June 14th, 2012 Water Level inconsistent between two measurements with no explanation, October 31st, 2012, Frozen
BH11-21B	425054.7	5408465.6	346.50	WML	16.8	18.3	---	---	---	---	348.10	---	June 14th, 2012, October 31st, 2012, Well under the influence of surface water
BH11-21C	425054.7	5408465.6	346.50	WML	7.6	9.1	---	---	---	---	345.80	---	June 13th, 2012, October 31st, 2012, Frozen
BH11-22	424953.5	5409907.9	349.00	BR	20.0	21.5	---	---	---	---	348.48	348.59	June 14th, 2012, October 30th, 2012
BH11-23A	425704.3	5409645.2	348.14	WS	36.3	37.8	---	---	---	---	347.92	348.02	June 14th, 2012, October 30th, 2012
BH11-23B	425704.3	5409645.2	348.14	UG	2.8	4.2	---	---	---	---	347.55	347.57	June 14th, 2012, October 30th, 2012
BH11-24A	426940.0	5408843.0	354.00	BR	18.3	22.8	---	---	---	---	353.78	353.04	June 8th, 2012, October 29th, 2012
BH11-24B	426940.0	5408843.0	354.00	WML	10.7	12.2	---	---	---	---	353.46	352.97	June 8th, 2012, October 29th, 2012
BH11-25	427302.2	5409121.8	358.78	WS	23.6	25.1	---	---	---	---	358.51	358.32	June 15th, 2012, October 29th, 2012
BH11-27	427268.7	5408603.3	355.10	WS	25.9	28.9	---	---	---	---	354.40	353.80	June 8th, 2012, November 1st, 2012
BH11-28	426325.2	5408217.7	349.44	WML	15.2	16.7	---	---	---	---	351.99	352.02	June 13th, 2012, October 31st, 2012
BH11-29	424525.6	5408528.1	345.78	WML	24.4	25.9	---	---	---	---	346.44	>345.78	June 15th, 2012, October 31st, 2012, Water level at top of casing
BH11-33A	425585.7	5408476.3	346.71	BR	42.4	43.9	---	---	---	---	347.55	348.04	June 13th, 2012, October 31st, 2012
BH11-33B	425585.7	5408476.3	346.71	WML	12.2	13.7	---	---	---	---	346.48	---	June 14th, 2012, Well under the influence of surface waterWater level at top of casing

BH11-34A	426102.3	5408419.0	347.65	BR	35.1	36.6	---	---	---	---	348.81	347.80	June 14th, 2012, October 31st, 2012
BH11-34B	426102.3	5408419.0	347.65	WML	9.2	10.6	---	---	---	---	347.40	347.53	June 14th, 2012, October 31st, 2012
BH11-35	426305.8	5410895.8	370.26	BR	11.8	13.3	---	---	---	---	362.85	361.60	June 11th, 2012, October 29th, 2012
BH11-36	426935.6	5410792.0	374.67	WS	5.2	6.7	---	---	---	---	---	---	June, 2012 Dry , October 29th, 2012, Dry
BH11-37	426657.8	5410527.7	369.99	BR	1.2	2.8	---	---	---	---	367.38	367.29	June 13th, 2012, October 29th, 2012
BH11-38	426927.5	5410377.4	371.59	WS	19.2	20.7	---	---	---	---	367.80	367.43	June 11th, 2012, October 29th, 2012
BH11-40	425356.1	5411994.4	370.10	BR	10.0	11.6	---	---	---	---	363.53	363.20	June 12th, 2012, October 29th, 2012
BH11-41	424215.0	5410296.0	350.44	WS	14.8	16.3	---	---	---	---	351.83	350.63	June 9th, 2012, October 30th, 2012
BH11-44A	426559.7	5408621.6	348.81	BR	16.2	17.7	---	---	---	---	348.82	349.41	June 9th, 2012, November 1st, 2012
BH11-44B	426559.7	5408621.6	348.81	UG	5.6	6.1	---	---	---	---	347.69	347.22	June 9th, 2012, October 29th, 2012

Borehole ID	UTM 15		Ground Surface Elevation (masl)	Unit	Screen (mbgs)		Water Level (masl)						Comments
	Easting	Northing			top	bottom	Sept.22nd, 2009	Sept.18th 2010	March 8th 2011	Sept.22nd, 2011	June, 2012	Oct./Nov., 2012	
BH11-50A	421550.9	5411071.0	361.59	BR	11.9	12.4	---	---	---	---	355.69	352.34	June 8th, 2012, October 30th, 2012
BH11-50B	421550.9	5411071.0	361.59	WML	3.0	4.5	---	---	---	---	360.57	359.52	June 8th, 2012, October 30th, 2012
BH11-51A	421543.2	5410423.4	351.54	BR	17.4	18.9	---	---	---	---	---	351.81	Water Level measured on several days, but is very variable, October 30th, 2012
BH11-51B	421543.2	5410423.4	351.54	WML	10.7	12.2	---	---	---	---	350.44	351.32	June 16th, 2012, October 30th, 2012
Monitored Private Wells (RRR Property)													
P3 / W11 (WWR 5400852)	419831.0	5410156.0	356.00	BR	15.2	32.3	---	---	---	---	351.97	351.62	June, 2012, Broken small shack
P7 (WWR 5400723)	421018.0	5410160.0	358.00	WS	21.3	21.3	---	---	---	---	352.87	352.04	June, 2012, WWR 5400723*
P8 (WWR 5401590)	423846.0	5410238.0	350.00	WS	23.5	23.5	---	---	---	---	---	---	June, 2012, Artesian, underground drain build into well casing to keep it from overflowing, Well under artesian pressure, but WL controlled by underground
P9 (WWR 5401835)	426165.0	5410281.0	363.00	WS	9.8	9.8	---	---	---	---	357.33	357.36	June, 2012, Two wells on the property (P9 and W5). Notes for the drilled well. WWR 5401835*
P13 / W9 (WWR 5401899)	424000.0	5411174.0	354.00	WS	10.4	10.4	---	---	---	---	353.01	352.64	June, 2012, WWR 5401899*
P14 (WWR 5400730)	426476.0	5411194.0	366.00	WS	18.9	18.9	---	---	---	---	358.15	357.83	June, 2012, WWR 5400730
P16 (WWR 5401589)	426336.0	5411643.0	371.00	BR	6.7	62.8	---	---	---	---	>340.77	338.17	June, 2012, Water level deeper than length of water level tape (30.60m). WWR 5401589* (60m tape used in Oct/Nov)
P19 (WWR 7133351)	424808.0	5411918.0	365.00	BR	7.6	38.1	---	---	---	---	358.00	357.49	June, 2012, RR core storage well. A070581. WWR 7133351*
P21B (WWR 5400481)	426828.0	5408280.0	349.00	WS	12.2	12.2	---	---	---	---	>349.56	>349.56	June, 2012, Artesian - flowing through outlet on side of concrete well casing outlet at 0.56 mabgs
RR1 (WWR 5401081)	426042.0	5406960.0	373.00	BR	3.4	31.7	---	---	---	---	368.22	367.21	June, 2012, RRR student house. WWR 5401079 or 5401081*
W1 (WWR 7150801)	424748.0	5409649.0	348.00	WS/BR	31.4	32.3	---	---	---	---	348.99	349.10	June, 2012, TW10-04. A091516
W2 (WWR 7150805)	425717.0	5409717.0	349.00	WS/BR	28.0	28.3	---	---	---	---	348.92	349.02	June, 2012, TW10-01. A091513
W7 (WRR 7150803)	425680.0	5409713.0	349.00	WS	23.5	23.5	---	---	---	---	349.29	349.38	June, 2012, TW10-02 A091514
W8 (WWR 5401149)	423479.0	5411625.0	358.00	WS	13.1	13.1	---	---	---	---	356.06	355.62	June, 2012, WWR 5401149
W10 (WWR 7133352)	424881.0	5411906.0	364.00	BR	8.5	74.7	---	---	---	---	352.99	356.09	June, 2012, RR core storage well. A070580*. WWR 7133352* Likley under influence of core shack operations.
W12 (WWR 7150802)	424738.0	5409697.0	348.00	WS	28.0	28.7	---	---	---	---	348.93	349.04	June, 2012
Piezometers installed by AMEC 2012													
BH12-01	421733.0	5413954.0	374.73	WS	6.3	11.9	---	---	---	---	---	---	

BH12-03	420323.0	5411646.1	362.57	WML/WS/BR	7.6	12.8	---	---	---	---	---	361.87	October 30th, 2012
BH12-04	422926.0	5411848.0	357.35	WS/BR	24.7	29.7	---	---	---	---	---	356.11	October 31st, 2012
BH12-07	424542.0	5412438.0	371.54	WML/LGL/WS	10.4	15.7	---	---	---	---	---	360.60	October 31st, 2012
BH12-08	425109.0	5411603.0	359.50	WML/LGL/WS/BR	15.2	19.8	---	---	---	---	---	354.49	October 29th, 2012
BH12-09	422611.9	5409548.4	347.42	WML/LGL/WS	21.2	24.7	---	---	---	---	---	---	October 30th, 2012, Frozen
BH12-10	424069.3	5409002.7	345.23	WML	21.7	25.1	---	---	---	---	---	---	October 31st, 2012, Frozen
BH12-13	425766.6	5409437.0	353.63	WML/WS	7.1	10.7	---	---	---	---	---	350.62	October 30th, 2012
BH12-14	425420.0	5409536.0	354.13	WML/WS/BR	4.9	10.2	---	---	---	---	---	348.72	October 30th, 2012
BH12-15	426116.0	5409732.0	351.34	WML/WS	36.1	40.1	---	---	---	---	---	350.33	October 30th, 2012
BH12-17	424634.0	5409329.0	346.59	LGL/WS	25.8	32.0	---	---	---	---	---	348.90	October 30th, 2012
BH12-18	424521.0	5409745.0	348.38	WS	28.9	33.7	---	---	---	---	---	348.87	October 30th, 2012

Borehole ID	UTM 15		Ground Surface Elevation (masl)	Unit	Screen (mbgs)		Water Level (masl)						Comments
	Easting	Northing			top	bottom	Sept.22nd, 2009	Sept.18th 2010	March 8th 2011	Sept.22nd, 2011	June, 2012	Oct./Nov., 2012	
BH12-19	425255.0	5410368.0	351.19	BR	31.2	34.3	---	---	---	---	---	351.20	October 30th, 2012
BH12-20	421225.0	5411780.0	362.40	WS/BR	21.3	28.4	---	---	---	---	---	363.19	October 30th, 2012
BH12-21	427994.9	5409431.0	372.77	UG/WS/BR	4.6	8.2	---	---	---	---	---	---	
BH12-22	428190.0	5410257.0	379.37	WML/LGL/WS/BR	11.3	16.1	---	---	---	---	---	---	
BBAF-BH-2002	426778.0	5410217.0	369.76	UG/WML/BR	1.2	6.3	---	---	---	---	---	---	
BBAF-BH-2015	426591.0	5410507.0	368.45	UG/WS/BR	1.2	6.1	---	---	---	---	---	---	
BBAF-BH-2051	426591.0	5410538.0	368.51	UG/WS/BR	0.5	4.0	---	---	---	---	---	---	
BBAF-BH-2054	426572.0	5410874.0	372.20	WS/BR	3.7	8.5	---	---	---	---	---	---	
BBAF-BH-2061	426687.0	5411001.0	374.06	LGL/BR	6.4	11.2	---	---	---	---	---	---	
BBAF-BH-2063	426562.0	5411008.0	372.40	UG/BR	0.6	4.3	---	---	---	---	---	---	
BBAF-BH-2065	426758.0	5411099.0	375.94	WML/WS/BR	4.3	9.2	---	---	---	---	---	---	
BBAF-BH-2069	426442.0	5411089.0	363.24	WML/WS/BR	22.0	27.1	---	---	---	---	---	---	
BBAF-BH-2073	426547.0	5411158.0	367.51	WML/BR	11.6	16.9	---	---	---	---	---	---	
BBAF-BH-2076	426698.0	5410335.0	365.06	WS/BR	13.4	19.1	---	---	---	---	---	---	
BH-04	426759.0	426759.0	369.08	WS/BR	15.3	18.4	---	---	---	---	---	---	
BH-05	426804.0	426804.0	371.00	WS/BR	5.0	8.0	---	---	---	---	---	---	
BH-07	426807.0	426807.0	369.49	WS/BR	13.6	20.0	---	---	---	---	---	---	

*** Interpreted stratigraphic units for the piezometer interval**
GL = Glaciolacustrine sediments, either from the Wylie or the Brenna Formations
GS = Glacial sand, most likely from the Brenna Formation
WML = Whitelake Mouth Till
WS = Whiteshell Till
BR = Bedrock

**** Hydrostratigraphic units for which the groundwater conditions at the piezometer interval are considered representative**
NSS = Near-surface system
PA = Pleistocene aquitard (in this case all Whitemouth Lake Till)
PLGD = Pleistocene lower granular deposits; in this case all Whiteshell Till, with the exception of BH11-21A which is interpreted as glacial sand; always assumed to be more dominant than shallow bedrock, when screen overlaps both
SBR = Shallow Bedrock
BR = Undifferentated bedrock