newgold Rainy River Project

APPENDIX W

WATER MANAGEMENT APPROACH

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APPENDIX W-1

WATER MANAGEMENT PLAN

newgold Rainy River Project

WATER MANAGEMENT PLAN

RAINY RIVER PROJECT

Submitted by:

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October 2013
TC111504

amec

October 30, 2013

Mr. Kyle Stanfield, P.Eng.
Director, Environment & Sustainability
New Gold Inc.
1111 Victoria Avenue East
Thunder Bay, Ontario
P7C 1B7

Dear Mr. Stanfield,

AMEC Environment & Infrastructure is pleased to submit the attached Water Management Plan for the Rainy River Project. The report has been prepared in response to comments received on the draft Environmental Assessment Report (Version 2). It is complementary to the final Environmental Assessment Report and provides additional details to clarify water management aspects of the project.

We greatly appreciate the opportunity to provide this support for the Rainy River Project. Should you have any questions regarding the plan, 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

1.1 Background

Rainy River Resources (RRR) has been exploring the Rainy River Project (RRP) property since 2005, with the objective of developing a gold mine and process plant on the site. To progress the RRP, RRR has initiated a Federal and Provincial Environmental Assessment (EA) process. This Water Management Plan has been prepared in order to support the EA for the proposed RRP by providing further details regarding water management at the RRP site.

The plan has been prepared to more fully address comments received on the draft EA Report (Version 2) from stakeholders. Copies of the comments received and the summary responses provided by RRR are contained in Appendix D of the final EA Report (AMEC 2013a; Appendix D).

1.2 Approach to Water Management

The RRP water management system is designed for water conservation and environmental protection. Best engineering efforts have been made to ensure maximum reasonable recycling of water while reducing the volume of excess water that must be returned to the natural environment.

Water management for the RRP has been designed to the extent practicable to achieve the following specific functions:

- Dewater the open pit and underground mine workings to ensure worker safety and operability;
- Generate a reliable water source for process plant operations and ancillary uses by maximizing the rate of water recycled to the process plant;
- Collect and control all site effluents in accordance with *Metal Mining Effluent Regulations* (MMER) and anticipated Provincial approval requirements;
- Manage acid rock drainage potentials both during operations, and following mine closure;
- Minimize the number of final effluent discharge points and the quantity of water discharged;
- Protect receiving water quality, recognizing that the Pinewood River is a flow-sensitive receiver;

- Minimize adverse receiving water flow effects;
- Protect wildlife; and
- Maintain system operability and flexibility to respond to varying circumstances, including wet and dry hydrological cycles.

Excess water discharged to the environment must be capable of meeting applicable Federal and Provincial guidelines for the protection of aquatic life, or other scientifically defensible alternatives, in the receiving watercourse (the Pinewood River). To achieve these objectives, an integrated and adaptable water management system has been developed as shown in Figure 1.

The principal water supply requirements for the RRP site are:

- Water for process plant operations (at start-up and continuously during operations), including 'clean' recycle water for specialized functions, such as gland and seal water, and water for reagent mixing;
- Clean recycle water for truck wash facility make-up water, and water to be used for dust control;
- Drill water to support open pit and underground mining; and
- Potable water for staff consumption and washing / showers and sanitary uses.

The principal water discharges requiring management at the site will consist of the following:

- Mine water from the open pit and underground mine;
- Water associated with the treated (SO_2/Air) tailings effluent from the process plant;
- Runoff and seepage from the tailings management area (TMA) and stockpiles (mine rock, ore, low grade ore, and overburden);
- Water from the truck wash facility and other minor sources;
- Treated domestic sewage water; and
- General site area runoff.

An integrated water management and treatment system has been designed that relies on recycling water from various constructed ponds for process water and other uses, in order to minimize the volume of fresh water taken from local watercourses, and to reduce the quantity of treated water requiring discharge. The system has been designed to ensure a reliable water supply at all times of the year and to allow for contingencies, such as sequences of wet and dry years.

1.3 Water Management System Overview

The system includes six primary constructed ponds for water management (i.e., the tailings management pond, water management pond, water discharge pond, mine rock pond, and sediment ponds #1 and #2), in addition to a small number of sediment and runoff / seepage control ponds that will ultimately report to one or more of these primary ponds, and one direct fresh water source for potable water (West Creek pond). The Pinewood River will provide a fresh water source to help build an initial water inventory to support process plant start-up, and early phase processing operations, and is proposed as a contingency water source during the remainder of mine life, recognizing that such contingency use is unlikely to be required. A constructed wetland is proposed downstream of the TMA to provide additional water treatment for a portion of the TMA effluent that is discharged to the environment.

A schematic of water use and flows between the different system facility components is shown in Figure 2. The schematic shows system flexibilities that are required to manage mine site water under varying circumstances during the project operations phase.

To provide for development of an initial water inventory to support process plant start-up and early phase ore processing, water collected in the TMA and mine rock ponds would be directed to water management pond, along with fresh water taken directly from the Pinewood River.

The purpose of the two final effluent discharges to the Pinewood River (i.e., pipeline discharge directly to the Pinewood River to a point below McCallum Creek, and discharge further upstream, through the constructed wetland) is to both optimize the quality of the final effluent discharged to the Pinewood River, and to minimize adverse flow effects to the river.

The Pinewood River is a moderate sized receiver (watershed area 574.5 square kilometres; km^2) that drains to the Rainy River and from there to Lake of the Woods. The RRP is located within the upper portion of the Pinewood River basin, where the watershed opposite the project site, at the Loslo Creek outflow point, measures approximately 106 km^2 (Figure 3). All project related water management functions will take place within the Pinewood River watershed.

Further details on these and other aspects are presented below.

2.0 CLIMATE DATA

Regional baseline climate data (climate normal data) were obtained from Environment Canada (EC) for Barwick, Ontario (EC ID 6020559) located approximately 23 km south of the RRP site (EC 2012). Canadian Climate Normal data available for the Barwick Station are restricted to temperature and precipitation. Rainfall Intensity Duration Frequency (IDF) data are available for the Town of Rainy River. Rainfall plus snowmelt data are available for Fort Frances. The Ministry of Transportation (MTO) website also provides IDF rainfall data for any site in Ontario based on geographic coordinates (MTO 2010).

A local climate station was established on the RRP site in 2009 to supplement longer term published data. This station measures temperature, precipitation, relative humidity, wind speed and direction, barometric pressure and solar radiation. As a result of the short term nature of the record from this site, reliance is placed in the shorter-term on climate data from the regional stations. As the site climate data base expands, greater reliance will be placed on this developing data base to meet project water balance information requirements.

2.1 Temperature

Temperature data for Barwick, derived from the 1971 to 2000 Canadian Climate Normals, are provided in Table 1. The average daily temperature is 18.8 degrees Celsius (°C) in July and -15.9°C in January.

2.2 Precipitation

Based on Canadian Climate Normals for the period of 1970 through 2000, Barwick exhibits an annual average precipitation rate of 694.7 millimetres (mm), with 552 mm of this total falling as rain and the remainder as snow. Most precipitation occurs in the summer months and the Canadian Climate Normals show an extreme daily rainfall precipitation event of 152 mm. Canadian Climate Normal values are shown in Table 2.

Year to year annual precipitation data for the Barwick station for the period of record (1979 through 2012) are shown in Table 3. The average annual precipitation for the period of 1979 through 2005, of 680.7 mm, is approximately 2% less that the annual average Climate Normal value of 694.7 mm, reflecting lower average annual precipitation rates in the years since 2000. The annual average precipitation rate for the period of 2001 through 2012 was 655.5 mm. There is a slight overall downward trend in Barwick annual precipitation values for the period of record, but the correlation is very weak (r^2 = 0.026) and the data are highly variable ranging from 352.2 to 965.1 mm/annum (a).

The MTO provides a tool which interpolates IDF data published by Environment Canada for any location in Ontario (MTO 2010). The IDF return period event quantities are provided for latitude 48.83 °N, longitude -94.00 °E in Table 4.

2.3 Evapotranspiration and Lake Evaporation

Annual evapotranspiration for the RRP site can be estimated as the differential between the annual average precipitation for the Barwick climate station (694.7 mm) minus the average annual runoff value derived for the Pinewood River (194.8 mm), assuming that there is no long term change in groundwater storage. The resultant evapotranspiration value is 500 mm. Details relating to derivation of the 194.8 mm Pinewood River annual average runoff value are provided in Section 3.2.

The nearest Canadian climate station to the project site, for which there are lake evaporation data, is the Atikokan Climate Station (Station 6020379) located approximately 175 km east of the RRP. Data from the Atikokan station are summarized in Table 5. The mean annual lake evaporation estimate for this station is 560 mm, which was derived from EC data for the period 1966 through 1988. The Hydrological Atlas of Canada (1978) shows computed lake evaporation isopleths for all of Canada based on data from 1957 through 1966. These data indicate a lake evaporation value of approximately 580 mm for Atikokan, and a value of approximately 650 mm for the RRP site, as there is a westward increasing trend to the data.

More recent lake evaporation data for the region are available from Dadaser-Celik and Stefan (2008) for Minnesota. These authors reviewed data from six climate stations across Minnesota for the period of 1964 through 2005. The closest station to the project site was International Falls, Minnesota located opposite Fort Frances, Ontario approximately 70 km east, southeast of the RRP site. Four different lake evaporation models were applied to these stations, with the average value for International Falls being 580 mm. Average values for the four different models were 463, 572, 634 and 650 mm. No preferences were expressed by the authors for any particular model, and no significant long term temporal trends were indicated by the data.

Based on these results an average annual lake evaporation rate of 600 mm is considered to be the best estimate for the RRP site (Table 5). Year to year variations in lake evaporation rates for International Falls, derived from the Dadaser-Celik and Stefan (2008) data are shown in Table 6. There is a weak negative correlation between annual lake evaporation rates calculated for International Falls and annual precipitation rates calculated for Barwick (r^2 = 0.132), (Figure 4).

3.0 HYDROLOGICAL DATA

3.1 Watersheds

The Pinewood River watershed boundary was extracted directly from the Land Information Ontario data warehouse of Ministry of Natural Resources (MNR) and used as the base watershed to further delineate subwatersheds. The Ontario 20 m digital elevation model was then extracted from the Land Information Ontario data warehouse for the Pinewood River watershed. Standard flow direction and flow accumulation surface models were generated using the Ontario Digital Elevation Model applying the D8 (eight cardinal direction) surface flow model. Using raster-based hydrology modelling tools, the Pinewood River watershed was subdivided into a series of rational subwatersheds based on the positioning of outlet points (pour points) for Pinewood River tributaries and at specific locations along the Pinewood River. Outlet points contributing area divide lines were generated using the surface models and these lines represented a set of subwatersheds within the Pinewood River watershed (Figure 3).

Subwatersheds shown in Figure 3 are in relation to the Pinewood River, such that watershed areas at different key points along the river are shown, as opposed to the subwatersheds of individual tributaries. Subwatersheds were divided in this manner to allow for determinations of receiving water assimilative capacity at different points along the Pinewood River, as well as to allow for the calculation of water supply potentials from the Pinewood River, and the derivation of project flow effects on the river.

The Pinewood River has a total watershed area of 575.5 km^2. Opposite the RRP site, where Loslo Creek (Cowser Drain) enters the Pinewood River, the watershed measures 106.2 km^2 (Figure 3). The Pinewood River watershed area increases significantly at two points downstream where major inflows enter the river: downstream of the McCallum Creek and Tait Creek outlets, where the watershed expands to 207.1 km^2, and downstream of the Kinhkakoesis River outflow, where the Pinewood River watershed expands to 460.2 km^2. The McCallum Creek outlet location (Pinewood River watershed area 207.1 km^2) is of particular importance to the RRP because this is one of two proposed locations for final effluent discharge to the Pinewood River, as well as the proposed water taking point from the Pinewood River required to help build an initial water inventory for the RRP to support process plant start-up. The second final effluent discharge point to the Pinewood River will occur at the Loslo Creek (Cowser Drain) outflow.

The RRP site on the north side of the Pinewood River is drained by four small creek systems, which from east to west are: Clark Creek (Teeple Drain), West Creek, Marr Creek and Loslo Creek (Cowser Drain). These creek basins range in size from 7.3 km^2 (Marr Creek) to 16.35 km^2 (West Creek). Major portions of the Clark Creek, Marr Creek and Loslo Creek basins will be overprinted by RRP developments, principally the TMA and the east and west mineral waste stockpiles. West Creek currently flows through the proposed open pit and will have to be diverted around the pit in order for the RRP to proceed. It should be also noted that the lower approximately 3.3 km reach of Loslo Creek and 2.3 km of Clark Creek leading to the outflow into the Pinewood River have been previously designated as Municipal drains under the *Drainage Act* (respectively, the Cowser Drain constructed in 1980, and the Teeple Drain constructed in 1994).

The Rainy River has a watershed area in excess of 50,000 km^2 where the Pinewood River enters the Rainy River. At the Water Survey of Canada (WSC) hydrological station at Manitou Rapids, located approximately 35 km upstream of the Pinewood River outlet, the Rainy River watershed measures 50,200 km^2. Hence, there is an approximate 100:1 mixing ratio provided by the Rainy River, relative to the Pinewood River flow.

The Rainy River is an international waterway that separates Ontario (Canada) from Minnesota (United States). The Rainy River flows into the south end of Lake of the Woods, itself an international waterbody, which borders Ontario, Manitoba (Canada) and Minnesota. Lake of the Woods drains by way of the Winnipeg River to Lake Winnipeg, which in turn drains to Hudson Bay via the Nelson River.

3.2 Surface Water Flows

Runoff data for the Pinewood River are available from WSC Stations 05PC011 and 05PC023. WSC Station 05PC011 has a watershed area of 461 km^2 and is located a considerable distance downstream on the system near the community of Pinewood (UTM NAD 83, Zone 15N, 409345E, 5400705N). This station was operated seasonally (March through October) from 1952 to 1998. WSC Station 05PC023 has a watershed area of 233 km^2 and is located further upstream, closer to the RRP site, where the Pinewood River crosses Highway 617 (UTM NAD 83, Zone 15N, 413011E, 5405672N). Station 05PC023 has been operated year-round since April 2007. Both stations exhibit natural flow and are not regulated, such as by damming. RRR plans to enter into an agreement with the WSC and the MNR to share in the operation of Station 05PC023 that will be used to provide real-time flow data for project water management functions.

Runoff data from the Rainy River are available for the Rainy River at Manitou Rapids (watershed area 50,200 km^2) and at Fort Frances (watershed area 38,600 km^2). The Fort Frances station has operated since late 1905 and the Manitou Rapids Station has operated since mid-1928. The Rainy River is a regulated (impounded) system.

3.3 Pinewood River Flow Statistics

The WSC Station 05PC023 (at Highway 617) is located approximately 4 km downstream of the McCallum Creek outlet (Figure 3). Unfortunately, the period of record for this station is short (five years) and the data for 2011 are provisional. Monthly and average annual flow data for Station 05PC023 are shown in Table 7. The 5-year average runoff value of 215 mm appears somewhat high based on longer term data available for Station 05PC011 (see below). Flow data for the open water period are available from Station 05PC023 in real time. This station is therefore well suited to provide operating data for RRP water taking and effluent discharge management functions described in Section 6.

Greater reliance is placed on data from WSC Station 05PC011 (near Pinewood) for deriving longer term annual average and return period flow statistics for the system, as these data are more extensive covering a period of 47 years (1952 to 1998; Table 8). This station, however, was operated only seasonally such that there are no data for the months of January, February, November and December. Mean flows for these four months can be estimated from year round data available from Station 05PC023 by determining proportional flows for these months in comparison to flows for the period of March through October. The derived monthly runoff proportions can then be applied to the longer term monthly averages available for Station 05PC011 to derive flow estimates for the missing months of January, February, November and December.

For example, the mean monthly flow for January of 0.218 m^3/s shown in Table 8, for Station 05PC011, was calculated by multiplying the average annual flow for the months of March through October collectively for Station 05PC011 (i.e., a value of 3.940 m^3/s) by the 0.0553 proportional factor shown for January in the right-hand column of Table 7 for Station 05PC023. Mean monthly Table 8 values for February, November and December, for Station 05PC011, were calculated similarly.

Deriving estimated monthly average flows for the months of January, February, November and December in the above manner, for Station 05PC011, allows calculation of an annual runoff value for this station based on the longer-term data set. The derived average annual runoff value for the entire calendar year is 194.8 mm (Table 8). This is an important statistic required for the RRP water balance. The 195 mm (rounded) annual runoff value derived for the Pinewood River drainage basin agrees well with the Hydrological Atlas of Canada (NRCan 1978) value for this area of approximately 200 mm, providing a good check on the result. The annual average runoff coefficient for the Pinewood River watershed is calculated as 194.8 mm / 694.7 mm, or 0.28; rounded to 0.3.

Extreme low and high flow annual estimates for Pinewood River are also of interest from water management, water supply, and environmental management perspectives. Annualized 5^{th} percentile and 95^{th} percentile flow values were derived for Station 05PC011 to provide an indication of water supply and receiving water assimilative capacities in relation to RRP needs (Table 8). To estimate annualized 5^{th} percentile low flow monthly values, the derived mean monthly flows shown in Table 8 for all months were multiplied by a factor of 1.357 / 4.034, where 1.357 is the 5^{th} percentile m^3/s value for the March through October annual flow data set, and 4.034 is the average m^3/s value for the March through October annual data set (Table 8). To derive annualized 95^{th} percentile high flow monthly values, the derived mean monthly flows shown in Table 8 for all months were multiplied by a factor of 8.160 / 4.035. The resultant estimates of annual runoff values for 5^{th} and 95^{th} percentile low and high flow years are 66 mm and 394 mm, respectively. These values are also used in annual site water balance calculations.

Use of the above method to estimate mean, and 5th and 95th percentile, monthly and annual flows, and associated annual runoff values for the Pinewood River, was considered the best approach to developing annualized flow data statistics for the system. This approach relies only on data derived from the two Pinewood River WSC flow monitoring stations, and takes maximum advantage of both sets of data. As more flow data become available over the coming years, the resulting calculated values can be refined to better assist with site water management.

It is stressed that the 5th and 95th percentile monthly values shown in Table 8 are annualized monthly values, and not 5th and 95th percentile values calculated from individual monthly data. Monthly 5th and 95th percentile data calculated from individual monthly data would be much more extreme than 5th and 95th percentile monthly values calculated form annualized data. For example, 5th and 95th percentile monthly values calculated for Station 05PC011 for September, for the period 1952 to 1997, would be 0.000 m^3/s and 6.885 m^3/s, respectively; as compared with the annualized values of 0.601 m^3/s and 3.615 m^3/s, respectively for September. This annualized approach to calculating monthly percentile values was taken because the water management system developed for the RRP relies on large reservoir water inventories, which are not sensitive to month to month changes in input and discharge, but the inventory is sensitive to year to year inputs and discharges.

For example, in determining water taking requirements from the Pinewood River, needed to help build an initial water inventory to support process plant start-up, it is important to understand the probability of being able to acquire a sufficient amount of water from the river in an extreme low flow year, such as a 5th percentile low flow condition. Calculating monthly values in an annualized manner as per the lower component table at the bottom of Table 8 provides the appropriate values. If one were to base the projected water taking on 5th percentile values determined from individual monthly data, the resulting summary of potentially available water would be grossly underestimated.

Return period low flow estimates, which are frequently used for determining receiving water assimilative capacities under extreme low flow conditions, can be derived from the Pinewood River at Highway 617 station, recognizing that the period of record is limited to five years. The resulting values are shown in Table 9 for the lowest average 7-day period, for annual return periods varying from 2 to 20 years. The results were derived from application of the log-normal distribution. Data from Station 05PC023 (at Highway 617) were used to calculate 7Q20 (20-year return period 7-day average low flow) statistics, rather than data from Station 05PC011 (near Pinewood), because Station 05PC023 provides year-round data, albeit over a limited period of record.

The Ministry of the Environment (MOE) typically interprets the 7Q20 value as being indicative of extreme low flow conditions for determining receiving water assimilative capacity. The 7Q20 value for the Pinewood River is effectively zero, as are the 7Q5 and 7Q10 values (Table 9).

The lowest flow period for Station 05PC023 appears to occur most frequently during the late summer, based on the limited period of record, but may also occur during the late winter. The derived flow values are excessively low for a watershed of this size (233 km^2), in comparison to Provincial norms, and reflect two conditions: first that the Pinewood River is located near to the western border of Ontario and precipitation values generally decrease towards the west; and second that the Pinewood River watershed is characterized for the most part by clay tills and Lake Agassiz lacustrine clays which offer limited groundwater recharge potential and hence restricted stream baseflow potential.

The data presented in Table 8 show that Pinewood River further downstream, near Pinewood (watershed area 461 km^2), also experiences extreme low flow values; with zero, or near zero, monthly average flows being recorded in 10 out of 40 years for March (25% occurrence), and for 4 out of 46 years for September (8.7% occurrence). All of the March zero flow monthly averages occurred prior to 1983. No zero monthly average flows have as yet been recorded for the upper Pinewood River flow station (Station 05PC023 at Highway 617) during the period of record. The September zero monthly average flows recorded for Station 05PC011 (at Pinewood) may not be fully reflective of actual watershed flows at this time, as there is extensive Beaver activity in the area, which would impound water in the system, especially during the late summer and fall months when dam building by Beaver is at its greatest thereby possibly accentuating the appearance of drought conditions. Nonetheless, extreme low flows can and periodically do occur during the late summer / early fall period.

3.4 Smaller RRP Area Tributary Flow Statistics

Attempts were made by Klohn Crippen Berger, RRR and AMEC to measure flows in the local creeks that drain to the Pinewood River in the RRP site area (i.e., Clark, West, Marr and Loslo Creeks). Unfortunately, due to the complications of low gradient, small systems and frequent Beaver impoundment, no useful data could be obtained from these attempts. During summer and early fall periods, spot flow measurements showed that these creeks can and frequently do go to a zero flow condition, as would be expected from the Pinewood River data. In winter all of these local creeks were found to exhibit non-measurable (effectively zero) under-ice flows. Therefore, for determining tributary creek flows in site area water balance calculations, runoff conditions have been directly prorated from data developed in Table 8 for the Pinewood River. Annualized, prorated flows for the smaller site area creeks are provided in Table 10.

3.5 Rainy River Flow Statistics

The longer-term mean annual runoff value generated for the Rainy River, measured at the Manitou Rapids WSC Station 05PC018, is 230 mm. This value is higher than the measured value of 215 mm for Pinewood River Station 05PC023 (at Highway 617) and the longer-term derived value of 195 mm calculated for the Pinewood River Station 05PC011 (near Pinewood).

The Rainy River watershed in Ontario extends east as far as the Thunder Bay area. The Hydrological Atlas of Canada (NRCan 1978) shows typical annual runoff for this area as transitioning from approximately 300 mm near to Thunder Bay to approximately 200 mm closer to Lake of the Woods; thus the Rainy River watershed is in a transitional runoff regime. The higher runoff value for the Rainy River stream flow station reflects this transitional effect, and is not considered representative of the Pinewood River watershed and RRP site area, which exhibit an expectedly lower annual average runoff value (i.e., 195 mm).

3.6 Temporal Trends in Annual Flow Statistics

Inspection of the Rainy River flow data shows a slight, but weakly expressed trend to increasing annual flows (Figure 5). If the data prior to 1940 are however excluded, the trend is essentially flat as the 1930’s represented an exceptionally dry period. Data for the Pinewood River (1952 through 1998) also show an essentially flat, though highly variable, trending profile (Figure 6).

4.0 DESIGN CRITERIA

The overall Project design and operating objective is to develop a water management plan which is practical, adaptive, cost effective, and sensitive to environmental and regulatory constraints. General design criteria and operating parameters were developed within this context, as per the following subsections.

4.1 General Design Criteria

The general design objectives of the water management plan are to:

- Ensure adequate process plant water supply under all conditions, including allowance for ice losses, and temporary or prolonged drought conditions;
- Optimize water re-use for processing, thereby minimizing freshwater demands to the extent practicable;
- Minimize effluent discharge volumes to receiving waters to the extent practicable;
- Optimize final effluent quality to protect aquatic life in receiving waters;
- Maintain Pinewood River and RRP area tributary flows that are supportive of fish habitat, to the extent practicable;
- Control sedimentation;
- Provide flexibility to accommodate wet and dry conditions; and
- Prevent flooding of the open pit by the Pinewood River.

To facilitate the above design objectives, a site wide water balance was developed to approximate Year 2, Year 7 and Year 15 of development, assuming staged development of the open pit and mineral stockpiles.

In addition, the following design criteria were adopted:

- Ponds will be constructed with low permeability dams;
- Ponds containing mine-affected water (contact water) will store the environmental design flood (EDF) runoff above the maximum operating pond water level (MOWL), (at future design stages routing of the EDF by pumping will be considered instead of storage);
- Spillways are provided to ensure safe discharge to the environment for events exceeding the EDF;

- Site contact water will be collected and managed in accordance with MMER and anticipated Provincial approvals;
- Seasonal low flow to the constructed wetland will be maintained from the water discharge pond discharging to Loslo Creek; and
- Excess effluent not discharged through the constructed wetland will be pumped to Pinewood River downstream of McCallum Creek for discharge to the environment.

4.2 Design Flood

No mine-affected runoff or seepage is to be discharged from the RRP site to the environment, except as provided for by MMER and Provincial approvals, up to and including the EDF which is defined as the 1 in 100-year, 24-hour storm event. The MOWL of mine-affected water ponds will be based on the largest pond volume expected to occur within the context of the 20-year return period annual wet condition.

To achieve the design flood criteria, stormwater management facilities (ponds, and any other surface water storage facilities such as pits or quarries) and conveyance facilities (pumping and ditches/diversions) will be sized to contain the EDF runoff, on top of the MOWL.

For dry conditions the ponds will be sized to maintain pumping to the process plant for a single cycle of the 100-year annual dry conditions, together with possible allowances for contingency storage in the event of sequences of dry years.

4.3 Inflow Design Flood

The inflow design flood is the event used to size emergency spillways on dams. Based on the *Lakes and Rivers Improvement Act* (LRIA) bulletin, the ponds located upstream of the open pit pose a threat to life and have a very high classification. The inflow design flood used to size spillways containing mine-affected water is the 24-hour probable maximum flood (PMF), which for these facilities is defined as the runoff from the 24-hour probable maximum precipitation (PMP) event.

The sedimentation ponds and the water discharge pond will be sized to manage the 25-year storm event with a duration of 24 hours. The dam for sediment pond #1, does not pose a loss of life threat and is anticipated to result in minimal damage to the surrounding property in the event of a potential failure. Based on the LRIA regulations the inflow design flood for this pond will be the 100-year 24-hour storm event. Sediment pond #2 has a higher risk to the downstream Pinewood River. Based on the LRIA regulations, the spillway for sediment pond #2 will be designed for the greater event of the 1000 year 24-hour storm event or the Timmins storm. For the RRP area, the larger event was the Timmins storm (193 mm), the regional design event.

4.4 Open Pit Wall Seepage

Estimated seepage inflows to the open pit and underground mine have been estimated as 3,400 m^3/d for the fully dewatered condition (AMEC 2013; Appendix S). Pit dewatering operations are typically dominated by runoff from precipitation. As such, the lower benches of the open pit may flood temporarily during extreme rainfall events. Open pit water will be directed to either the mine rock pond, or to the TMA pond, or directly to the process plant for re-use; but not directly to the environment. Contingency pumping may be provided to empty the open pit following the occurrence of extreme precipitation events. Any such water pumped from the open pit would be to mine rock pond, or to the TMA pond.

4.5 Freshwater Diversions

West Creek and the upper reaches of Clark Creek will be diverted to reduce inflows to the open pit and mine rock pond, respectively. Channels for these diversions will be sized to convey the 100-year 24-hour storm event based on the Soil Conservation Service (SCS) Curve Method. This method was used as it accounts for the effect of catchment size and response time, which are major determinants of peak flow along the catchment area.

The small tributary to West Creek in the area immediately east of the proposed plant site that will be captured by the stockpile will also be diverted as part of the overall West Creek diversion.

4.6 Process Plant Effluent and East Mine Rock Stockpile Effluent Control

Process plant effluent will be treated in plant using the SO_2/Air process to destroy cyanide. On discharge to the TMA, associated heavy metals will precipitate to low levels in the TMA pond(s) so as not to pose a threat to wildlife. In conjunction with subsequent effluent aging and wetland treatment, final effluent quality will be achieved which is consistent with protection of aquatic life guidelines, or scientifically defensible alternatives, in the receiving water.

Runoff and seepage from the east mine rock stockpile and low grade ore stockpile will be collected and directed, to the process plant as process water, or otherwise directed to the TMA for containment and management as part of the overall site water inventory.

TMA effluent suitable for discharge to the environment will be discharged seasonally either directly to the Pinewood River by pipeline; or to the Pinewood River by way of the constructed wetland and the lower reaches of Loslo Creek (Cowser Drain) to the Pinewood River.

4.7 Sediment Control

Sediment ponds #1 and #2 will be designed with a retention period to meet the MMER requirement for total suspended solids (TSS) during a 1 in 25-year 24-hour storm event plus an allowance for sediment storage to limit the amount of maintenance required. Excessive sediment that would otherwise report to these sediment ponds, will be reduced by stockpile management and check dams in the runoff and seepage collection ditches, as required to maintain effective sediment control at the final effluent discharge point from the ponds. The ponds will require scheduled maintenance during operations to maintain the required storage volume to allow for TSS settlement.

Runoff from all other runoff and seepage collection facilities (other than sediment ponds #1 and #2) will be directed to the mine rock pond, the TMA, or to the constructed wetland; except for those elements specific to the project construction phase which are described in Section 5.

4.8 Pit Flood Protection

A flood protection embankment will be positioned between the open pit and the Pinewood River, and will be sized to protect the open pit from Timmins Design Storm flood conditions in the Pinewood River. A warning system will ensure worker safety in the event of more severe flooding. An ice jam detection, inspection, and removal strategy will be developed as part of the Environmental Management System to prevent ice jams in the Pinewood River from overtopping the flood protection embankment.

4.9 Runoff and Seepage Control

Runoff and seepage collection are required from all mine waste facilities, regardless of whether the mine waste is potentially acid generating or not. If the water quality is suitable for discharge it can be released directly to the environment in accordance with MMER and Provincial approval requirements. Provision should available for pumping all contact water to the TMA, process plant or other contact water ponds, if required.

4.10 Derivation of Runoff Coefficients

To help develop the RRP water balance, runoff coefficients were developed for the following terrain types:

- Natural ground;
- Cleared ground;
- Paved ground;
- Tailings beach and pond;
- Open pit;
- Mine rock dump slopes; and
- Overburden stockpile slopes.

For natural ground, a runoff coefficient of 30% was developed from precipitation data available from Barwick, and WSC data developed for Station 05PC011. The resulting runoff coefficient was calculated as 195 mm / 695 mm, for a rounded value of 30%. This same runoff value was used for cleared ground, based on the expectation that following the removal of trees, ground vegetation would remain largely intact.

For paved (compacted) ground, a value of 90% was used to reflect a low permeability surface, with a small allowance for losses due to depression storage and evaporation.

For tailings, two area types were identified: dry tailings, and wet tailings and pond surface. For the dry tailings condition it was assumed that most (effectively all) water will run off the dry tailings surface due to the sloped tailings beach, the highly impervious tailings material and a high water table, and that any water that infiltrates the tailings surface will report to the tailings pond. A runoff coefficient of 100% was used for these areas. For wet tailings and pond surfaces it was assumed that these areas also generated a runoff coefficient of 100%, but that lake evaporative losses were then deducted from the wet tailings and ponded areas. Fifty percent of the tailings surface was assumed to consist of wet tailings and ponded areas.

A runoff coefficient of 90% was used for the open pit due to its low permeability surface, together with a small allowance for losses due to depression storage and evaporation.

For mine rock stockpiles, a runoff coefficient of 50% was considered representative. Mine rock stockpiles are sloped, but can also absorb a large volume of precipitation due their porosity, and this moisture can become available for evaporation. In addition, during winter, blowing snow from exposed slopes can significantly reduce the snow cover. A higher runoff coefficient of 70% was assigned to the overburden stockpile because of steeper slopes operating in concert with low permeability of the mainly clay till substrates. Some depressional storage is expected to occur on the overburden stockpile surface.

5.0 CONSTRUCTION PHASE WATER MANAGEMENT PLAN

5.1 Construction Phase Water Management Overview

Water management facilities needed to support the RRP operations phase are described in Section 6. Once these operations phase facilities are in place they will be sufficient for managing all RRP waters; but it will take time to develop these facilities. As a result, interim water management facilities will be needed to support initial construction phase operations.

Water taking requirements to support initial construction phase operations will include:

- Removal of water entering the open pit from groundwater and precipitation / runoff, while overburden and mine rock are being stripped from the pit surface in preparation for mining;
- Removal of water from process plant site area foundation excavations, to support facility construction;
- Removal of water from tailings and pond dam foundation excavation areas to support dam construction;
- Water required to supply potable needs for the on-site construction workforce;
- Water required for concrete manufacture;
- Removal of water (if any) from off-site quarry excavations to supply rock fill materials needed for construction of the Highway 600 road re-alignment, and construction of the new East Access Road; and possibly
- Removal of water (if any) from the RRP aggregate pit.

Permits to Take Water (PTTW) will be required from the MOE to support all of these water taking requirements.

Any waters that require discharge to the environment in association with the above water takings, or from site runoff and seepage, will have to be managed in accordance with applicable MMER and Provincial approval requirements.

Water management facilities required to support initial construction phase operations will include:

- Development of a preliminary phase mine rock pond that will be used to collect and treat water, runoff and seepage deriving from pit stripping and early mining, plant site construction, and early phase east mine rock stockpile development;

- Development of sediment pond #1 to manage runoff and seepage deriving from the overburden stockpile;

- Sump facilities to pump water from TMA and water management pond dam foundation excavation areas to sediment pond #1;

- A package sewage treatment plant to treat workforce domestic sewage, anticipated to discharge to West Creek or to the West Creek diversion; and

- Separate sediment ponds to remove suspended solids contained in excavation waters (if any) discharged from off-site quarry excavations needed to support road construction, and from the RRP aggregate pit.

In addition to the above, fresh water diversions will be needed during the very early construction phase, to divert Clark Creek and West Creek. The developing open pit will also provide low areas and sumps that will be used to provide temporary and contingency water storage.

5.2 Preliminary Phase Mine Rock Pond

The preliminary phase mine rock pond will collect and treat groundwater, runoff and seepage deriving from: initial pit stripping and early mining, plant site construction, and early phase east mine rock stockpile development; and would be constructed within operations phase mine rock pond footprint (Figure 1). Unlike the operations phase mine rock pond, which would not discharge directly to the environment; the preliminary phase mine rock pond may discharge to the environment under some circumstances if regulatory requirements are met, until such time as the TMA and the water management ponds were capable of receiving and containing water from this pond.

Water directed to the preliminary phase mine rock pond will contain clay fraction materials and ammonia residuals from the use of blasting agents. In cases where effluent from this pond is discharged to the environment (Pinewood River), retention times of approximately five days (subject to further test work confirmation), together with the option of adding either a flocculant or a coagulant to assist with TSS removal, will be required. The preliminary phase mine rock pond will also be required to provide sufficient time for the degradation / removal of residual ammonia, where direct discharge to the environment is considered. The settling pond is expected to be divided into two cells, to enhance performance efficiencies. A freshwater diversion channel will be constructed around the pond to limit clean runoff inflow to the pond. A flow measuring device capable of measuring flows to an accuracy of +/-15% would be installed at the pond outlet, as per MMER and Provincial approval requirements.

To construct the preliminary phase mine rock pond in a timely manner, Clark Creek upstream of the east mine rock stockpile would need to be diverted. Once Clark Creek has been diverted, the Department of Fisheries and Oceans (DFO) has directed that the remaining remnant downstream portion of the creek channel would no longer be regarded as providing fish habitat or constituting waters frequented by fish, once the lower channel is suitably abandoned. As part of the lower channel abandonment process, fish within the downstream remnant channel would be removed once the diversion is complete, and the remnant channel would have to be closed to potential fish re-colonization.

5.3 Sediment Pond #1

Sediment pond #1 will be required to manage suspended solids loadings in runoff from the overburden stockpile, which will contain material removed from the open pit area during initial pit stripping (Figure 1). Sediment pond #1 is required for future operations in any event, such that its use for early construction would avoid the need to construct a separate temporary system to support construction activities. Discharge from sediment pond #1 would be to the West Creek diversion, so this pond would not be functional until the West Creek diversion is developed. Alternatively, treated effluent from sediment pond #1 could be pumped to the existing West Creek before it is diverted, if the diversion is not yet in place.

Sediment pond #1 would be designed to provide a retention time of approximately five days (subject to further test work confirmation), together with the option of adding either a flocculant or a coagulant to assist with effective solids removal. The pond is expected to be divided into two or more cells, to enhance performance efficiencies. A flow measuring device would be installed at the pond outlet.

5.4 TMA and Water Management Pond Sump Collection Facilities

Excavation of TMA and water management pond dam foundations will intersect shallow groundwater and surface water runoff. This water will contain suspended solids requiring settling, prior to discharge. Water collected in these excavations will be pumped to sediment pond #1, until such time as the water management pond dams are capable of retaining water, at which time excavation water will be pumped to the water management pond.

5.5 Domestic Sewage Treatment

Domestic sewage will be treated using a package sewage treatment plant (rotating biological contactor, sequencing batch reactor, or membrane bioreactor). Effluent from the sewage treatment plant will be discharged to either West Creek, or to the West Creek diversion downstream of the West Creek pond, which will serve as the Project potable water source.

5.6 Sediment Ponds to Support Road Quarry and Aggregate Pit Operations

If the temporary quarries used to generate materials to construct the Highway 600 re-alignment and the East Access Road are developed below grade, such that water removal is required to continue quarry operations, water discharged from these quarries will be treated in temporary settling ponds designed to remove suspended solids, in accordance with standard procedures used for road construction. At present it is not believed that rock quarrying below the water table will be required for the construction of either road.

Re-development and expansion of the RRP aggregate pit, located northwest of the plant site, may or may not require excavation below the water table. If excavation is required below the water table, requiring water to be pumped from the excavation, this water would be pumped either to sediment pond #1, or to another portion of the excavated pit, where reinjection into the groundwater system would occur.

6.0 OPERATION PHASE WATER MANAGEMENT PLAN

6.1 Operation Phase Water Management Overview

Water taking requirements to support the RRP operation phase include:

- Water taking from the Pinewood River to build an initial water inventory to support process plant start-up;
- Removal of water entering the open pit from groundwater and precipitation / runoff;
- Removal of water from process plant site area foundation excavations, to maintain steady state conditions (may not be required because of proximity to the open pit and underground workings, depending on the state of pit dewatering);
- Water required to supply potable needs for the on-site workforce; and possibly
- Removal of water (if any) from the RRP aggregate pit.

Permits to Take water (PTTW) will be required from the MOE to support all of these water taking requirements. There will be maximum use of re-cycled contact water to support processing and other operations, to reduce freshwater demands to the lowest level reasonably practicable.

Waters that require discharge to the environment in association with the above water takings, or from site runoff and seepage collection, will be managed in accordance with applicable MMER and Provincial permitting requirements. Water management facilities required to support the Project operations phase include:

- In-plant effluent treatment for the destruction of cyanide and associated heavy metals using the SO_2/Air process;
- Development of a TMA and associated water management pond for site effluent (and runoff / seepage) storage and treatment, and to provide recycle water for process plant operations;
- Development of a constructed wetland to serve as effluent polishing for that portion of the effluent discharged to the environment from the water management pond by way of the water discharge pond;
- Development of the mine rock pond for the collection and storage of runoff and seepage from the east mine rock and low grade ore stockpiles, as well as from the open pit and underground workings; with all such water to be used for plant process water supply,

and with any excess water not so used to be pumped to the TMA, or to the water management pond;

- Sediment ponds #1 and #2 to manage runoff and seepage deriving from the overburden and west mine rock stockpile;
- Perimeter ditching systems to collect contact water runoff and seepage in accordance with MMER requirements;
- A package sewage treatment plant to treat workforce domestic sewage, with discharge expected to be to West Creek or to the West Creek diversion (or with tailings to the TMA); and
- RRP Aggregate Pit water management facilities.

Water diversions needed to support construction phase activities, namely the Clark Creek and West Creek diversions and at the process plant, would be permanent and retained throughout the Project operations phase, and through closure and post-closure phases as well.

6.2 Operation Phase Water Balance Overview

The water management approach developed herein, results in an overall site water balance for the operation phase as shown graphically in Figure 7 for the average runoff condition, at the end of the mine life (Year 15) and described briefly below:

- The open pit and underground mine will be dewatered year round by pumping to the mine rock pond. For modelling purposes, it was assumed that dewatering from the open pit to the mine rock pond will require pumping for 10 months of the year from March through December. The quantities of minewater from the underground are of sufficiently low volume in comparison to the open pit minewater volume to be immaterial to the overall water balance.
- The process plant make-up water will be supplied by the mine rock pond (50%) and TMA pond (50%). The mine rock pond will supply process water to the process plant primarily during the open water period, supplemented as required by the TMA pond (and the water management pond). During the winter, and during excessively dry periods, most or all of the process water demand will derive from the TMA pond, with the freshwater processing requirement deriving from the water management pond.
- Fresh water for the process plant will be taken year round from the water management pond, with potable water being taken from the West Creek pond. Overflow from the West Creek pond will be to the West Creek diversion.

- Surplus water from the TMA pond will normally be transferred to the water management pond from June through August where it will be subject to further effluent aging to optimize effluent quality. A portion of the water management pond discharge will be to the Pinewood River by way of the water discharge pond and the constructed wetland (the last effluent control point); with the remainder of the water management pond discharge being by pipeline direct to the Pinewood River, downstream of the McCallum Creek outflow. Water will normally be discharged from the water management pond through the constructed wetland in all months except February and March. This discharge is intended to be at a more or less constant rate of approximately 2.4 Mm^3 from year to year, with an anticipated discharge rate of approximately 10,000 m^3/d in most months. During low runoff years less water would be available to discharge through the constructed wetland. Excess water management pond water not required for processing, and not discharged through the constructed wetland (via the water discharge pond), will be discharged by the pipeline directly to the Pinewood River mainly in the months of October, November, April and May.

- Under the normal operating scenario, the water management pond will be largely emptied by the end of May, to begin the new annual cycle of water transfer from the TMA pond to the water management pond in June through August.

The total pond inflows and major water transfers (TMA pond, water management pond transfer and the total effluent volume discharged to the environment) are shown in Figure 7, for the average annual runoff condition for Year 15 of operations.

The system will have sufficient flexibility to accommodate sequences of wet and dry years by extending the period of transfer from the TMA pond to the water management pond, and from the water management pond to the Pinewood River via pipeline in wet years, and by reducing water discharge to the environment during sequences of dry years.

6.3 Water Supply to Support for Process Plant Start-Up

A water inventory of not less than 3 to 4 Mm^3 would be required to support process plant start-up during the open water period (depending on the exact date of start-up), and an inventory of not less than 5 Mm^3 (and preferably 6 Mm^3) would be required going into the winter months. A larger water inventory is required going into the winter months because a substantial portion of the inventory will be temporarily lost to ice formation, reducing the amount of free water available, and because there will be no new water added to the inventory during the winter months other than mine water. A portion of the water inventory referred to as ‘bottom water’ will also not be available to reclaim pump systems, as it will not be possible to effectively pump water which is too shallow without entraining sediment and organic debris which would be detrimental to portions of the processing circuit, especially where activated carbon is used.

The primary water reservoir to support process plant start-up will be the water management pond located immediately adjacent to, and southwest of the TMA. Runoff collected in the mine rock pond and in the TMA pond will also be used to support development of the initial water inventory, depending on the timing of construction for these two facilities. Construction of the water management pond (and of the mine rock and TMA ponds) is planned to start once regulatory approvals are obtained. RRR expects that the water management pond will be sufficiently constructed and ready to receive water inflow by late 2015, or by early 2016 at the latest.

Water to build the initial start-up inventory will be sourced from the Pinewood River, site runoff captured by the mine rock pond and in the TMA pond, and pit water inflow; and stored in the water management pond for future use. A water intake structure will be constructed on the Pinewood River downstream of McCallum Creek. This location was chosen because the Pinewood River catchment area (and therefore flow) increases substantially downstream of the inflow of two major tributaries: Tait Creek and McCallum Creek. A pumping station is expected to be developed by RRR on southern bank of the Pinewood River to draw water through an intake pipe placed on the river bed (pending regulatory approval).

It is proposed that up to 20% of the spring flow (April to June; or starting in March in the event of an early spring thaw), and up to 15% of the Pinewood River flow from July through November, will be withdrawn from the river and stored in the water management pond to help develop the RRP water inventory required for process plant start-up and early operations. This approach is consistent with approvals obtained for other Ontario mining projects. Under average annual (or higher) river flow conditions it would only be necessary to take water from the Pinewood River during a single year period (or a portion thereof) to develop the required water inventory. However, if extreme low flow conditions were to be encountered in two successive years, such as two 5th percentile years in a row, it would be necessary to take water from the Pinewood River over a two year period to build the required water inventory to support process plant start-up and early operations. After development of the required initial water inventory, RRR does not intend to take water directly from the Pinewood River, except possibly for intermittent contingency purposes, which is not expected.

The available water from the Pinewood River under the proposed percentage flow restrictions described above is shown in Table 11 for average and low runoff conditions. If flows approaching or above mean annual flow conditions are encountered, the percentage and/or duration of the takings from the river will be reduced, as there will be excess water available under these conditions.

Water taking rates at the proposed Pinewood River intake location will be determined according to prorated river flows measured at the Station 05PC023 (Pinewood River at Highway 617, watershed area 233 km^2). This station has been in operation since 2007 and records daily flows as real time data throughout the year. RRR anticipates entering into agreement with the WSC and the MNR to share joint operation of this station.

The available watershed catchment for the Pinewood River water intake location (207 km^2) will be adjusted for any watershed capture developed by the RRP upstream of this location. For example, if the mine rock pond and/or the TMA impoundments were to be in place at the time of water taking such that these facilities were capable of collecting runoff, then any water taken or captured by these facilities would be deducted from the calculation of available water at the Pinewood River water intake. Groundwater and precipitation / runoff captured by the open pit would also be routed to the water management pond, or to the mine rock pond, as applicable, to help build the initial water inventory to support process plant start-up and early phase operations.

Overall, the system for building the initial water inventory needs to be sufficiently flexible to accommodate site developments at the time, with the understanding that the maximum water taking effect on the Pinewood River would be within the 20% and 15% criteria stated above, including allowances for water captured by site infrastructure, such as the mine rock and TMA ponds, and the open pit.

6.4 Water Supply for Process Plant Operations

Once ore processing begins, the target will be to maintain a total water inventory in the system of approximately 7 to 9 Mm^3 as of November 30 of each year. This inventory would include approximately 2 to 3 Mm^3 in the water management pond and 5 to 6 Mm^3 in the TMA pond. There would be limited water in the mine rock pond at the end of November. Losses to ice cover in a severe year are expected to be approximately 3 Mm^3 with a further approximately 1.5 Mm^3 being difficult to recover 'bottom' water. This would leave approximately 2.5 to 4.5 Mm^3 of available water to support processing over the winter months, which is sufficient for RRP needs. The winter period is defined to potentially extend from December 1 to April 30. The water balance will be optimized and refined during mine operations as appropriate based on operational data.

The process plant will require on an ongoing basis, approximately 20,400 m^3/d of water, virtually all of which will be derived from water recycle. Process plant outputs will include an estimated 20,000 m^3/d of water discharged to the TMA with the tailings slurry and 400 m^3/d of water lost to evaporation in the process plant.

Water for process plant operations will consist of recycled water from the mine rock pond, as well as water from the TMA pond, and the water management pond. Under typical, average annual operating conditions, the process plant requirements will be met as follows:

- 9,660 m^3/d will derive from the mine rock pond;
- 8,630 m^3/d from the TMA pond;
- 1,610 m^3/d from the water management pond; and
- 500 m^3/d will enter the process plant with the ore.

Ample water storage is available in the water management pond and the TMA pond to provide process plant water during the winter months or during prolonged summer or fall drought conditions.

In regards to water availability in the TMA pond, a portion of the water contained in the process plant slurry discharged to the TMA will be retained within the pore space of the deposited tailings solids. This expected water loss into permanent storage is calculated to average 7,092 m^3/d. This value is based on a specific gravity of 2.82 for the ore and a settled tailings solids density of 1.41 t/m^3. The difference between the volume of water in the tailings slurry discharged to the TMA, and the volume of water permanently stored within the tailings solids void space, will be available water for recycling back to the plant for processing. Excess TMA water not needed for processing will be discharged to the water management pond for further aging (effluent polishing), before being discharged to the environment. Water discharged to the environment, by way of the water management pond, will be either directly to the Pinewood River or to the Pinewood River by way of the constructed wetland and the lower reach of Loslo Creek, as described in Section 6.6.

Modelling indicates that once steady state conditions are achieved, minewater will need to be removed from the mine workings at a net rate of approximately 6,600 to 9,800 m^3/d (including precipitation and runoff to the pit area) in order to maintain a reasonably dry and safe working environment. Excess minewater will be pumped to the mine rock pond and will become part of the water inventory. The mine rock pond will also collect natural runoff and seepage from the east mine rock stockpile area and the low grade ore stockpile. Water from upstream areas of the Clark Creek watershed will be routed away from the east mine rock stockpile by the Clark Creek diversion. The stockpile pond, which will collect runoff that would otherwise flow through the plant site area to the open pit, will collect non-contact water that will be diverted to the West Creek pond.

The mine rock pond will provide direct process water feed to the process plant and will be designed with a storage capacity of approximately 2.93 Mm^3. As the east mine rock stockpile will store potentially acid generating and non-potentially acid generating (NPAG) rock, the mine rock pond will contain water with increased TSS, possibly low levels of dissolved metals and residual ammonia from blasting agents. Any excess water from the mine rock pond that cannot be used for processing will be directed to the TMA pond or the water management pond, to maintain a sufficient system water inventory for process plant operations during periods of low runoff (dry summer and fall periods, and winter).

A small amount of water will also be required for the truck wash facility which will be provided by either the mine rock pond or the water management pond. The truck wash system will primarily operate on an internal water recycle system but will still require approximately 5 to 10% new water to meet water losses and to prevent mineral build-up. This water will not need to meet discharge standards as the truck wash is an enclosed system, but will need to meet any requirements for human contact.

6.5 Fresh Water and Other Water Requirements

Nominal fresh water requirements that are needed for specialized process plant functions, such as pump gland seal uses and reagent mixing, will be taken as reclaim water from the water management pond. Dust suppression water will also be taken from water management pond reclaim water or potentially other source on receipt of Provincial approvals.

The West Creek pond will be established in line with West Creek to supply potable water for domestic and sanitary uses. This is a small water requirement of nominally 100 to 200 m^3/d. The West Creek pond will contain natural, non-contact water, and therefore does not require further management or treatment prior to release.

Domestic and sanitary needs for freshwater will be met from the West Creek pond supported as required by local well water and bottled water, especially during the early construction phase before the West Creek pond has been established. Single wells in the area are expected to yield approximately 20 m^3/d. Potable water will be distributed to the process plant area and maintenance shop. Outlying areas will be supplied with bottled potable water.

The West Creek diversion channel will be kept separate from the constructed wetland downstream of the TMA, and the west stockpile perimeter runoff and seepage collection ditch, so as not to mix the natural creek water with excess water discharged from the TMA, or stockpile contact water.

6.6 Process Plant Effluent Treatment

The process plant will use whole ore cyanidation as the most effective means of gold recovery. Cyanide is the only technically and cost-effective means of gold recovery from gold-bearing ore at a commercial scale for this ore type, and is standard practice throughout the industry, including virtually all other active gold mines in Ontario. The cyanide leaching process at the RRP will be designed to meet all conditions for responsible management of cyanide as defined by industry best practices. This includes transportation and storage of sodium cyanide at the RRP (generally expected to be transported to site in a pellet format in sealed approved containers), as well as best practices during the mixing and use in the process plant, and in the destruction of cyanide components in tailings prior to pumping to the TMA.

Cyanide in liquid form (as dissolved sodium cyanide) will be added to the leach circuit at a rate of approximately 0.3 kg of cyanide per solid tonne of ore feed. Cyanide will be partially consumed during the leaching and CIP processes as a result of reactions with sulphur, oxygen and various metals. As a result, the final expected concentration of total cyanide in the leach circuit discharge (the tailings slurry prior to the cyanide destruction circuit) will be in the order of 100 to 200 mg/L. A pre-detoxification thickener will be installed to enable recycling of some of the residual cyanide back to the plant process water system. Total cyanide will occur as both free cyanide and as cyanide complexed with heavy metals.

Tailings produced in the process plant after the gold has been recovered will contain all of the process plant feed (minus the gold and silver), plus residual process chemicals, most notably cyanide in its various forms, as well as lime and heavy metals dissolved in cyanide solution. Various processes are available for destroying or otherwise removing cyanide, but the most effective and proven process for destroying cyanide within the tailings slurry before it leaves the process plant is the SO_2/Air treatment process or one of its derivatives.

In-plant SO_2/Air treatment of cyanide and metallo-cyanide complexes involves the following (or equivalent) reactions:

$$CN^- + SO_2(g) + H_2O + O_2(g) \rightarrow CNO^- + H_2SO_4(aq)$$

where the cyanide ion (CN^-) is oxidized to the cyanate ion (CNO^-) by sulphur dioxide (SO_2) using copper as a catalyst. Cyanate then reacts with water (hydrolyzes) to form ammonia (NH_3) and carbon dioxide (CO_2) in accordance with the following reaction:

$$CNO^- + 2H_2O \rightarrow OH^- + NH_3 + CO_2$$

Cyanate hydrolyzation is a longer term reaction that will take place mainly in the TMA pond and the water management pond. Often, sodium metabisulphite ($Na_2S_2O_5$) or elemental sulphur is used in the process instead of SO_2, for easier reagent management, but the overall reaction produces a similar result, as per the following:

$$2CN^- + Na_2S_2O_5 + O_2(g) + H_2O \rightarrow 2CNO^- + Na_2SO_4 + H_2SO_4$$

Metallo-cyanide complexes are oxidized according to the following general reaction:

$$\text{Metal }(CN)_x^{y-x} + xSO_2(g) + xH_2O + xO_2(g) \rightarrow xCNO^- + xH_2SO_4(aq) + \text{Metal}^{y+}$$

The free metal ions are then precipitated by adding lime to form insoluble metal hydroxides, which subsequently become adsorbed onto tailings particle solids, and will be settled out of the slurry in the TMA.

Cyanide destruction will occur in tank(s) in a concrete containment area, outside the process plant building. Tailings will be retained in the tank for approximately 90 minutes to allow sufficient reaction time. Test work on two representative composite tailings slurry samples for the RRP was undertaken by SGS Lakefield. Study results (slurry liquid fraction) showed that the SO_2/Air treatment process is expected to be very effective for the destruction of cyanide and the precipitation of heavy metals. Test results show that total cyanide can be reduced from a pretest initial concentration of 130 to 150 mg/L to an after test concentration of <1 mg/L in the tailings supernatant.

6.7 TMA Water Management

The tailings slurry (after treatment for cyanide destruction) will be pumped from the process plant to the TMA for permanent storage of the barren ore solids (the tailings), along with water permanently stored within the tailings pore spaces. The TMA will also provide temporary storage of the remainder of the water portion for future re-use, with excess water discharged periodically to the Pinewood River by pipeline from the water management pond and the constructed wetland via Loslo Creek (Cowser Drain).

In addition to providing permanent and temporary storage functions, the TMA has been designed to optimize natural degradation processes to provide further water treatment. Natural degradation involves the removal of excess concentrations of elements and compounds contained in ponded waters through several complementary natural processes. RRP proposes to enhance these natural processes by ensuring there is sufficient retention time to allow the reactions to occur.

As cyanide and metallo-cyanide complexes are inherently unstable, if effluent is retained in a pond for a sufficient length of time under the right conditions of temperature and ultraviolet light, the low quantities of residual cyanide and metallo-cyanide complexes, following in-plant cyanide destruction, will break down to simpler compounds without the use of chemical reagents or other active treatment systems. The principal cyanide loss mechanism in natural degradation is the volatilization of hydrogen cyanide gas to the atmosphere in extremely low concentrations. Once hydrogen cyanide enters the atmosphere, it reacts with hydroxyl radicals and oxygen found in the air and in the presence of sunlight (photolysis) through a series of reactions, to form carbon monoxide and nitrous oxide (Lary 2004). The metal ions left behind in the water solution react with hydroxyl ions to form insoluble metal hydroxide precipitates, or to otherwise adsorb onto suspended solids. Through these reactions, metals that were previously dissolved in solution, form a solid precipitate and settle by gravity with the tailings solids. This results in a clear water TMA pond above the tailings surface that is low in cyanide, dissolved metals and total metals. This clear water is then discharged to the water management pond for further aging, and subsequently for controlled release to the environment, either directly to the Pinewood River, by pipeline, or to the Pinewood River by way of the constructed wetland and lower Loslo Creek (Cowser Drain), all in accordance with Federal and Provincial standards for the protection of aquatic life in the receiving water.

The treated tailings slurry will also contain ammonia from explosives residuals on the ore, and as a by-product of the in-plant treatment process. The cyanide destruction process proposed (SO_2/Air treatment process) converts cyanide to cyanate, which in turn breaks down (hydrolyzes) to form ammonia and carbon dioxide, as described in Section 6.4. Ammonia is readily broken down through natural processes within a TMA if given sufficient retention time as proposed at the RRP. Ammonia is taken up as a nutrient (food source) in tailings ponds by bacteria and algae, and is also volatized to the atmosphere. AMEC internal data from the Holt-

McDermott Mine indicates that ammonia reductions of up to 100 fold can be achieved in well managed aging ponds.

These natural degradation processes are most effective during warm weather conditions when biophysical activity is optimal. Natural degradation processes are also augmented by exposure to sunlight. RRR proposes to hold effluents that are planned for discharge to the environment for a sufficient period of time under warm weather conditions, to maximize the effects of natural degradation. Such effluent aging will take place mainly during the summer months (June through mid-September) in both the TMA pond and water management pond. Once the excess water is determined to be of suitable quality, it will be released to the Pinewood River; either directly through a pipeline discharge below the McCallum Creek outlet, or by way of the constructed wetland and Loslo Creek (Cowser Drain) downstream of the TMA.

Natural degradation processes are also effective for the removal of cyanate and thiocyanate. Cyanate hydrolyzes (reacts with water) to form ammonia and bicarbonate ion. Thiocyanate degrades with the help of naturally occurring bacteria, to form sulphate, carbon dioxide and ammonia.

The transfer of water from the TMA pond to the water management pond will normally occur during the months of June through August, but could potentially extend into September (and October) if sequences of excessively wet years are encountered, requiring the discharge of a greater quantity of water to the environment. To facilitate this process, the water would be drawn down by the end of May in each year, leaving a sufficient residual in the water management pond to support specialized processing plant water recycle needs.

6.8 Final Effluent Quality and Discharge

The following aspects were considered in developing an optimal final effluent discharge strategy for the RRP:

- Achieving Provincial water quality objectives (PWQO) for the protection of aquatic life, or other scientifically defensible criteria, in the receiving water (the Pinewood River) under all flow conditions;
- Minimizing flow reduction effects on the Pinewood River so as to maintain fish habitat in the river;
- Providing optimal operating flexibility to accommodate a wide range of precipitation and runoff conditions, including sequences of wet and dry years; and
- Developing a system which can be operated in a practical, efficient and adaptable manner.

The ability to achieve PWQO values for the protection of aquatic life or other scientifically defensible criteria in the Pinewood River, is a function of final effluent quality and receiving water assimilative capacity.

To help assess expected final effluent quality, pilot plant process effluent, treated using the SO_2/Air process, was allowed to age for approximately 60 days under laboratory conditions that mimicked summer conditions. This included temperatures averaging approximately 20^oC, under a natural lighting regime; but without some of the biological components which further enhance natural degradation processes. Results are shown in Table 12 and are compared with PWQO and Canadian Environmental Quality Guidelines (CEQG) for the protection of aquatic life. The results indicate that a high quality effluent approaching PWQO values can be achieved through a combination of in-plant cyanide destruction using the SO_2/Air process combined with natural aging in the TMA and the water management pond.

Receiving water assimilative capacity is a function of receiving water flows, effluent flows, and receiving water background water quality. Pinewood River flows are a function of watershed area, and seasonal variations in precipitation. All other factors being equal, river flow increases in the downstream direction as watershed area increases. Relative to the RRP, the Pinewood River watershed opposite the RRP site area immediately downstream of the Loslo Creek inflow, measures 106 km^2. The watershed increases substantively a little further downstream, immediately downstream of the McCallum and Tait Creek inflows, where the watershed measures 207 km^2. The next major increase in watershed area, at the Kishkakoesis River inflow, occurs too far downstream for practical access.

If receiving water quality was the only consideration, the optimal strategy would be to discharge all final effluent to the Pinewood River at a point just downstream of McCallum Creek, where the watershed is larger and river assimilative capacity is greatest. However, discharging all of the effluent to this location would result in greater river flow losses between the Loslo Creek outflow and the McCallum Creek / Tait Creek outflows, than is desirable from a fish habitat flow maintenance perspective. River flow losses occur because runoff contact water from an approximate area of 21 km^2 will be intercepted by site water management facilities. This contact water (i.e., water exposed to processing or to potentially reactive mine rock) requires collection and treatment. A portion of this water will be lost to tailings voids and other processes, as described in Section 6.2, but a large portion of this collected contact water is suitable for discharge back to the environment after treatment.

To optimize both water quality and river flow effects, final effluent release to the Pinewood River at two separate locations is proposed: through the constructed wetland to the Pinewood River at the Loslo Creek outflow (via lower Loslo Creek); and directly to the Pinewood River just downstream of the McCallum Creek outflow, by pipeline. Figure 8 shows a schematic of the flow arrangements and typical annual average discharge rates.

The rationale for using two separate discharge locations derives from the need to achieve effective water quality treatment while at the same time minimizing adverse flow effects on the Pinewood River, under varying hydrologic operating conditions. As the constructed wetland is located further upstream on the Pinewood River, and as the constructed wetland will provide additional effluent treatment beyond that provided by aging in the TMA and water management ponds, it might appear advantageous to discharge all treated effluent to the Pinewood River through the constructed wetland. However, discharging too much effluent through the constructed wetland would reduce the retention time, and assimilative capacity of the wetland, and could also potentially cause excess erosion though the system. The release of effluent from the water management pond to the constructed wetland has therefore been capped at a nominal flow rate of 10,000 m^3/d. If operational experience with the constructed wetland indicates that greater flow through rates can be achieved, while still maintaining effective water quality treatment, this nominal 10,000 m^3/d discharge rate could potentially be increased.

All effluent from the water management pond which is not discharged through the constructed wetland will be discharged by pipeline to the Pinewood River downstream of McCallum to take advantage of increased river assimilative capacity at this point, since wetland polishing would not be available for this portion of the discharged effluent.

Under average runoff conditions, from 60 to 90% of the effluent discharged from the water management pond would pass through the constructed wetland, with higher percentage values (90%) applying to early phase (year 2) operations, and lower percentage values (60%) applying to later phase (Year 15) operations. The reason for this change is that the total quantity of effluent discharge is expected to gradually increase over the life of the mine. In low runoff years, virtually all of the effluent discharged from the water management pond would pass through the constructed wetland; but during or following years with higher than normal precipitation large qualities of effluent will also be discharged through the pipeline.

Further details are provided below.

6.8.1 Effluent Release at the Loslo Creek Outflow reflecting Wetland Polishing

To minimize river flow losses in the area between the Loslo Creek and McCallum Creek outflows, it is desirable to return as much water as reasonably practical at the Loslo Creek intersection with the Pinewood River. To facilitate this need, use of a constructed wetland is proposed as a means of further enhancing final effluent quality, to offset assimilative capacity limitations of the Pinewood River in this area due to its smaller watershed. In particular, it will be necessary to return water to the Pinewood River at times when there is very little flow in the river, such that reliance cannot always be placed on mixing with river water to achieve protection of aquatic life criteria.

This constructed wetland will be an active component of the treatment works. The constructed wetland will consist of a sequence of five wetland areas, developed in series, with a collective water volume of approximately 300,000 m^3. Wetlands adsorb residual heavy metals and take up residual ammonia as a nutrient. The principal agents of nutrient uptake will be naturally occurring algae and bacteria. The efficiency of such uptake is seasonally dependant and is greatest during the active growing season. To maximize wetland effect on water quality treatment, it is proposed to limit the discharge rate of water released from the water management pond to the constructed wetland at an approximate rate of 10,000 m^3/d. Discharge at this rate will result in a retention time of approximately 30 days, excluding any direct precipitation to the wetland area during discharge.

Aged treated effluent from the water management pond will be discharged to the constructed wetland during all months of the year, except February and March, and with more limited discharges in December and January, depending on temperatures. The wetland discharge regime in relation to Pinewood River flows (mean, 5th and 95th percentile annualized flows) is shown in Table 13. The logic behind the discharge regime is as follows:

- Effluent discharged during April and May will occur when the biological reactivity of the wetland is low, but the effluent being released to wetland from the water management pond will be of very high quality as it will have normally been aging without new effluent input from the TMA pond since the end of August of the previous year (or perhaps September during sequences of wet years – see below). Pinewood River assimilative capacity is also at its maximum during April and May when flows are highest.

- Effluent discharged to the constructed wetland in the summer months (June through August) will be of lesser quality, as discharge from the water management pond to the wetland will occur when aged effluent from the TMA pond is being actively discharged to the water management pond. Wetland assimilative processes are greatest in the summer months, which will offset this limitation.

- Effluent discharge through the constructed wetland in the fall months and into the early winter will have undergone more extensive aging in the water management pond, without new input from the TMA pond, such that reduced levels of biological activity in the wetland at this time will be acceptable as the influent water quality will be better.

In deep winter, discharge through the constructed wetland would be discontinued, as any such discharge would freeze in the wetland and would provide no benefit.

By controlling the rate and timing of water release through the constructed wetland in the above manner, it will be possible to release an average of approximately 2.44 Mm^3 of water annually through the constructed wetland to the Pinewood River, by way of lower Loslo Creek (Cowser Drain), except during low runoff years, when less water will be available to discharge through the wetland. In an average hydrological year, the 2.44 Mm^3 value translates to approximately 90% of the water management pond annual discharge during early phase (year 2) operations, and about 60% of the discharge during late phase (Year 15) operations. The proposed discharge plan would be to release this approximate quantity of treated water through the wetland in all years, irrespective of Pinewood River flows, and to release all other treated effluent from the water management pond by pipeline to the Pinewood River, seasonally (spring and fall), further downstream just below the river confluence with McCallum Creek (Figure 8). In low runoff years, virtually all final effluent discharge would be through the constructed wetland.

It is proposed that final effluent from the constructed wetland meet the water quality objectives and limits shown in Table 13. The proposed effluent objectives, for Ontario Regulation 560/94 and related parameters, are based on the development of scientifically-based protection of aquatic criteria developed from the application of United States Environmental Protection Agency (US EPA) hardness equations in the case of copper, lead, nickel and zinc; and on the absence of salmonid (trout) species in the case of free cyanide. The toxicity of copper, lead, nickel and zinc to aquatic life is a function of hardness, where hardness reduces metal toxicity by inhibiting metal uptake by aquatic organisms.

US EPA hardness equations applicable to copper, lead, nickel and zinc are the following:

- Cu (conc) = $e^{(0.8545 [\ln(\text{hardness})]-1.702)}$ ug/L;
- Pb (conc) = $e^{(1.273[\ln(\text{hardness})]-4.705)}$ ug/L;
- Ni (conc) = $e^{(0.846[\ln(\text{hardness})]+0.0584)}$ ug/L; and
- Zn (conc) = $e^{(0.8473[\ln(\text{hardness})]+0.884)}$ ug/L.

Background hardness values measured over two years, at monthly intervals, in the Pinewood River just downstream of the RRP site area, are shown in Table 13. The median and 75th percentile hardness values are 195 and 208.5 mg/L, respectively. An analysis of hardness versus river flow data shows that hardness increases during periods of reduced river flow, when water ionic strength becomes more concentrated, which means that hardness yields its greatest effect when it is most needed (i.e., when river assimilative capacity based purely on flow is low). Effluent released from the water management pond is expected to have a hardness value in excess of 200 mg/L, because of the use of lime ($CaCO_3$) in the milling process. Use of a 200 mg/L hardness level to calculate modified receiver targets for the protection of aquatic life is therefore scientifically defensible. The modified receiver targets for copper, lead, nickel and zinc, base on application of US EPA hardness equations for a hardness of 200 mg/L, are shown in Table 13.

The PWQO for protection of aquatic life value for free cyanide is 0.005 mg/L. However, Gensemer et al. (2007) recently conducted a review of the current ambient water quality criteria for cyanide and determined a recommended, revised continuous chronic criterion (CCC) value for the protection of aquatic life of 0.0098 mg/L for free cyanide for waters without salmonids. The Pinewood River does not contain salmonid (trout) species, so a 0.01 mg/L free cyanide concentration is considered scientifically defensible for this parameter.

The last parameter for which a modified receiver target is proposed is arsenic. Established protection of aquatic life water quality guidelines for arsenic include:

- 0.100 mg/L Ontario PWQO;
- 0.005 mg/L Ontario Interim PWQO;
- 0.005 mg/L CEQG; and
- 0.150 current US EPA CCC value for freshwater organisms.

The Interim PWQO and CEQG value of 0.005 mg/L is based on toxicity test results for a common algal species (*Scenedesmus obliquus*) identified by the Canadian Council of Ministers of the Environment (CCME) as the most sensitive freshwater species to arsenic. Growth inhibition has been shown for this species with arsenic concentrations as low as 0.05 mg/L, multiplied by a factor of 0.1 to generate the 0.005 mg/L Interim PWQO and CEQG value. Comparable arsenic chronic toxicity thresholds for rainbow trout, *Daphnia magna* and *Ceriodaphania duba*, using the same 10% criteria, would be 0.055 mg/L, 0.052 mg/L and 0.100 mg/L, respectively. The current freshwater US EPA (2009) CCC value of 0.150 mg/L for arsenic was developed on the basis of a broad range test organisms. There are no applicable toxicity modifying factors, such as hardness applied to the metals discussed above, which can be applied to arsenic.

The 0.005 mg/L protection of aquatic life value is viewed as being overly conservative, as it is based on growth inhibition to a single algal specie, and there is little evidence of a credible risk to other freshwater species, including fish, invertebrates and plants, so long as arsenic values are retained at ≤0.05 mg/L (CCME 2001). A modified receiver target of 0.01 mg/L is therefore proposed for arsenic as being more than adequate, and scientifically defensible, for the protection of aquatic life in the Pinewood River.

Proposed final effluent objectives (as monthly averages), for the constructed wetland discharge to the environment, are shown in Table 13, as being equivalent to the rounded modified receiver targets. It is proposed that final effluent limits (as monthly averages) be set at twice the objective values, recognizing that the receiver will generally provide some level of assimilation even under low flow conditions, and that hardness effects become more pronounced at lower receiver flows. For example, the data presented in Table 13 show Year 15 expected annual average receiver to effluent mixing ratios of 6.51:1, 3.15:1 and 13.16:1 for the annualized average, 5th percentile and 95th percentile river flow conditions, recognizing that river flows can and do go to a zero or near zero flow condition in the late summer / early fall of some years. Effluent would not be discharged to the Pinewood River during the mid to late winter months, when zero or near zero flows are also frequently experienced, and where the discharged effluent would be expected to freeze within the wetland.

Receiver flow to hardness values shown in Figure 9 for 2011 for Pinewood River water quality station SW3, the only year for which both water quality and flow data are available. The flow to hardness relationship is important because when river flows are very low, hardness values (which protect against metal toxicity) are at their highest.

6.8.2 Effluent Release below the McCallum Creek Outflow

All treated effluent released from the water management pond to the Pinewood River, that is not released through the constructed wetland, would be discharged by pipeline direct to the Pinewood River immediately downstream of the McCallum Creek outflow during the spring and fall periods.

Pinewood River assimilative capacity is greater at this point because of the increased watershed (207 km^2), and hence higher river flows compared with areas of the Pinewood River further upstream. The 207 km^2 catchment area requires adjustment to calculate actual assimilative capacity because a portion of the Pinewood River watershed, approximately 21 km^2, is intercepted as site catchment areas comprising contact water capture zones which are directed ultimately to the TMA.

The release of water management pond effluent to Pinewood River downstream of the McCallum Creek outflow would occur during the spring and fall, to take advantage of extended aging in the TMA and water management ponds, and higher receiver assimilative capacity. Water which is not discharged from the water management pond in the fall (mainly October and November) would be held over, without any further inputs from the TMA pond, until the following spring for release. Release to the Pinewood River in this manner, unlike the much more regular discharge through the constructed wetland, would occur at variable rates, depending on surplus water inventories. On average mixing ratios in excess of 5:1 (receiver to effluent flows) are expected for this discharge, including provision for effluent loading released upstream through the constructed wetland (Table 14).

Proposed effluent objectives / limits for the pipeline discharge to the Pinewood River at McCallum Creek are the following:

- Final effluent meets modified receiver target objectives defined in Table 13 for all Provincial Environmental Compliance Approval (ECA) parameters, allowing discharge without restriction to a maximum limit of 50,000 m^3/d; or

- Undertake loading calculations for final effluent parameters which do not meet modified receiver target objectives.

Effluent contained within the water management pond is expected to be of good quality, and is expected to slowly improve over time as the effluent ages, especially after the transfer of effluent from the TMA pond ceases (normally at the end of August of each year). Abrupt changes in water management pond effluent quality are therefore not expected to occur.

The rationale behind the proposed hierarchical approach to discharge criteria relates to operator simplicity and ensuring environmental protection as per the following. If all parameters meet the modified receiver target objectives, then the effluent without provision for mixing would meet protection of aquatic life criteria for long term exposure. In this case, there would be no restriction on effluent discharge quantity, except that posed by pumping and pipeline constraints. The pumping system for discharging water from the water management pond to the Pinewood River would have a nominal capacity limit of approximately 50,000 m^3/d. In this case the operator would only have to be assured that all final effluent parameters were consistent with the modified receiver target objectives. This would be the simplest case for system operation.

If one or more Provincial ECA parameters do not meet the first criterion (all parameters consistent with modified receiver targets), then critical receiver to effluent mixing ratios would need to be attained, as per the second criterion, to ensure that modified receiver target objectives were attained in the Pinewood River, itself. The critical parameters in this case are likely to be copper and zinc, and possibly un-ionized ammonia. All other ECA parameters of potential concern (cyanide, arsenic, lead, and nickel) are expected to occur at very low concentrations as residual cyanide is easily degraded and arsenic, lead and nickel are present in the ore at very low levels.

In the case of the second criterion, the allowable discharge would be restricted by loading calculations determined for the most critical parameter. To determine allowable loadings, the operator would have to know receiver quality and flows, and final effluent quality, to calculate an allowable daily discharge volume, with such calculations to be performed on a daily basis.

For example, if copper was the critical parameter and the following conditions were present:

- Receiver flow (RF) – 100,000 m^3/d;
- Receiver concentration (RC) – 0.0044 mg/L;
- Final effluent concentration (FEC) – 0.08 mg/L; and
- Modified receiver target concentration (RTC) – 0.02 mg/L

then the allowable daily discharge would be calculated as:

[(RC x RF) – (RTC x RF)] / [RTC – FEC] = 26,000 m^3/d; or an effective 3.85:1 mixing ratio.

The RF value would be taken as the Pinewood River flow calculated for the day (or 2 days) before the discharge day, based on real-time, prorated data available from WSC Station 05PC023. The RC would be calculated as the dissolved Pinewood River copper concentration measured immediately upstream of the pipeline discharge point, and downstream of the McCallum Creek outflow; calculated as the running average of the last three available weekly copper concentrations. The FEC would be calculated as the last weekly concentration value measured for the water management pond; with the modified RTC being set at 0.02 mg/L, as per the above.

In the event that receiver and final effluent quality conditions were such that neither of the two discharge criteria could be met, then water management pond discharge would be discontinued (or not initiated) until at least one of the criteria could be met. Such a condition could arise in the fall for example, if receiver flows were to go to zero, or near zero, and where critical parameter concentrations in the water management pond exceeded the modified receiver target concentration. The water management plan for the RRP has been designed with considerable reserve storage in both the TMA pond and the water management pond to accommodate this eventuality.

The critical aspect of using the loading-based approach is the achievement of rapid mixing in the receiver, as the loading-based approach assumes instantaneous mixing. Various means are available for achieving rapid mixing, including in-channel structures positioned to generate turbulence within focused mixing zones, and various types of diffuser arrangements. Details of a preferred mixing arrangement are still under development and will be proposed at the environmental approvals stage. The achievement of rapid and efficient mixing will also be important for that portion of the final effluent discharged to the Pinewood River by way of the constructed wetland. In this in-stream works will be required to achieve rapid mixing as there would be no pipeline discharge at this point that would lend itself to the use of a diffuser.

6.9 Managing Sequences of Wet and Dry Years for TMA Operations

The intent is to operate the TMA pond with a nominal average maximum capacity of 5 to 6 Mm^3, but the TMA pond will have capacity to hold from 8 to 20 Mm^3, depending on the stage of dam development. The system will have less capacity earlier in the mine life and greater capacity in later mine life to accommodate wet year sequences. To assess the robustness of the TMA to accommodate sequences of wet years, a comparison was made to precipitation records from the Barwick climate station for the period of record of 1979 through 2012 (Table 3). Calculations were based on an assumed need to discharge 4.22 Mm^3 per annum from the TMA pond in an average year, at full development. To consider the effects of wet and dry years, evaporation and evapotranspiration from site area sources were assumed to be constant from year to year, such that additional water losses and gains to the TMA pond inventory would be a direct function of the deviation of precipitation from the 680.7 mm long term annual average precipitation rate measured over a developed functional catchment of 21 km^2. Results are shown in Table 15 for the period of record.

The data show that with an annual discharge of 4.22 Mm^3, the TMA pond inventory would exceed the lower range 8 Mm^3 TMA pond capacity in response to several series of wet years, and that to avoid such a condition, the annual discharge rate during such periods would have had to be increased by a further approximately 3 Mm^3/a. Such an increase would be achievable with the present TMA pond and water management pond configurations, if the normal June through August TMA pond effluent transfer period shown in Figure 8 was extended by an additional month into September (and potentially October).

This action would reduce the natural degradation time available in the water management pond and so would have some effect on water management pond water quality; but this effect would be manageable, as receiver mixing potentials would increase during sequences of wet years. If necessary, system water quality conditions could be improved by splitting the TMA basin into two parts thereby creating two TMA ponds. Such action has already been contemplated using NPAG mine rock to construct a splitter dyke in preparation for closure.

Drier than average year sequences can be managed by discharging less effluent to the receiver in dry years. Calculations shown in Table 15 indicate that pipeline discharge from the water management pond to the Pinewood River would not likely be required during extreme dry years.

6.10 Sediment Ponds #1 and #2

Sediment ponds #1 and #2 would operate independent of the main RRP water inventory during the operations phase (i.e., runoff and seepage collected by these facilities would discharge their effluents directly to the environment, and not to the TMA water inventory, either directly or indirectly). Runoff and seepage discharging to these sediment ponds would contain TSS and residual ammonia (from the use of blasting agents) adhering to NPAG mine rock. NPAG mine rock is not expected to be chemically reactive, such that soluble metals requiring treatment through lime addition (or other means) are not expected to occur in drainage to either of sediment ponds #1 or #2. The primary concern will be for the control of sediment fines concentrations (clays and fine silts).

To provide for the effective settlement of suspended fines, a pond retention time of approximately five days, together with the option of adding either a flocculant or a coagulant to assist with solids removal, will be required, as per Section 5.2. The settling ponds are expected to be divided into two or more cells, to enhance performance efficiencies. A flow measuring device capable of measuring flows to an accuracy of +/-15% would be installed at the pond outlet, as per MMER and Provincial approval requirements.

Sediment pond #1 will discharge to the West Creek diversion. Sediment pond #2 will also discharge to the West Creek diversion; or it could be made to discharge directly to the Pinewood River.

Modified receiver targets for sediment ponds #1 and #2 are shown in Table 16, based on application of US EPA hardness equations, and consideration of arsenic as per Section 6.6. Sediment ponds #1 and #2 would only discharge to the environment under runoff conditions, where the discharge flows from these two ponds would be proportional to their watershed areas in relation to the West Creek diversion watershed area. For sediment pond #1 this watershed ratio is 17:1, and for sediment pond #2 the watershed ratio is 3.5:1. Proposed final effluent limits are therefore double the respective modified receiver targets for West Creek for these two ponds (Table 16).

6.11 Runoff and Seepage Collection Facilities

Runoff and seepage collection facilities would be developed, consistent with MMER requirements, around all site facilities where there is a potential for contact water development (Figure 10). This includes the following site features and facilities:

- TMA and water management pond areas;
- West mine rock and overburden stockpile;
- East mine rock and low grade ore stockpile;
- Process plant site area; and
- Open pit.

In developing ditching and terminal pond systems for compliance with MMER and anticipated ECA requirements, the following design criteria will be applied:

- Surface drainage and seepage collection ditches should be developed, as required, around the final footprint perimeters of mine rock and overburden stockpiles, TMA facilities, the process plant area, the open pit, and other such features, which have the potential to release a deleterious substance directly to the environment through runoff and seepage;

- Surface drainage and seepage collection ditches will be designed to accommodate the 25-year return period, 24-hour storm event condition;

- Surface drainage and seepage collection ditches will generally be positioned approximately 50 m from final toe of the features that they are intended to collect drainage and seepage from;

- All surface drainage and seepage collection ditches will discharge to terminal settling ponds, where the final effluent will be monitored in accordance with MMER requirements for effluent quality and flows (where there is an intent to release effluent directly to the environment); or in the case of ponds that will comprise part of the general RRP water inventory system, the collected effluent will be pumped to TMA either directly, or indirectly through the mine rock pond (in which case the collected runoff and seepage would not be monitored in accordance with MMER requirements as there would be no direct release to the environment);

- Terminal settling ponds (where there is an intent to release of effluent directly to the environment) will provide a minimum 5-day retention period under the 25-year return period, 24-hour storm condition for the settlement of suspended solids;

- Terminal settling ponds (where there is an intent to release of effluent directly to the environment) are expected to be comprised of a minimum of two chambers (cells) to effect greater solids setting efficiency, with cell partitioning to be achieved through the use of silt curtains and/or rock fill splitter dykes;

- Additional, intermediate position settling ponds may be used as required to trap suspended solids en route along the perimeter ditches, to maximize TSS removal of the entire perimeter ditch / settling pond systems; and

- Surface drainage and seepage collection ditches will be revegetated as quickly as practicable to limit the generation of suspended solids from the ditches themselves.

The water table is close to surface throughout the RRP area. Overburden is comprised mainly of clay-rich tills and Glacial Lake Agassiz lacustrine clays. Comparatively shallow ditching will therefore prove effective for runoff and seepage collection. Consequently, subject to detailed design, site runoff and seepage collection ditches will generally be developed to a nominal depth of 2 to 2.5 m, with an invert width of 2 m, and side slopes of 2 to 3H:1V.

Runoff and seepage collected from the plant site area through drainage ditches and other collection systems will be directed to sumps and pumped to the mine rock pond directly, or indirectly in the case of any runoff and seepage that bypasses these facilities and enters the open pit. The majority of the east mine rock stockpile area will drain by gravity to the mine rock pond, but portions of the northern, eastern and southeastern boundary of the mine rock stockpile will require separate constructed collection systems to direct runoff and seepage to the mine rock pond.

Runoff and seepage from the west mine rock stockpile will be collected in perimeter ditches and directed to sediment ponds #1 and #2 for direct release to the environment, after meeting applicable final effluent criteria as prescribed by MMER and the Provincial ECA.

Runoff and seepage collected in ditches along much of the south perimeter of the TMA will be routed through ditches to the water discharge pond. Ditches bordering the northwest and west margins of the TMA will drain by gravity to one or more runoff collection ponds. This water may be:

- Released directly to the environment if of suitable quality (determined by monitoring);

- Pumped back to the water management pond if the water quality is not suitable for direct discharge to the environment; or

- Maintained in the water management system to enhance the existing water inventory.

6.12 Water Course Diversions

6.12.1 West Creek

West Creek currently passes through the proposed pit development area and requires diversion for the RRP to proceed (Figure 11). A diversion of approximately 4.5 km length is required to avoid site facilities. This diversion will entail construction of the West Creek pond to block flow to the future open pit area, together with development of a westward flowing new channel, exiting the West Creek pond, and passing north and west of the west mine rock and overburden stockpile, before connecting with the lower portion of Loslo Creek (Cowser Drain), south of the current Highway 600 alignment (Figure 10). The newly constructed West Creek diversion, bordering the west margin of west mine rock and overburden stockpile, will pass between the constructed wetland to the west, and the stockpile perimeter runoff and seepage collection ditch to the east. Care will be required in the design and operation of the West Creek diversion to ensure separation of West Creek, as a non-contact clean water system, from the constructed wetland and the mine rock and overburden stockpile runoff and seepage collection ditch, both of which will receive contact water (Figure 12).

The West Creek diversion will be constructed to provide like-for-like fish habitat replacement and will be stabilized before the original channel is closed in order to ensure continual safe passage of fish. A trapezoidal channel is proposed, having a base width of 5 m, and side slopes of approximately 4H:1V. Pending further consultation and environmental approvals, West Creek could be re-routed through the flooded open pit after closure once the pit is fully flooded, although this is not planned and consultation to date indicates this is not preferred.

The initial 450 m of the West Creek diversion channel will also operate as the emergency spillway for the West Creek pond and has been sized to convey the PMF without overflowing. An emergency spillway will be constructed in the channel to direct excess flow to the surrounding lands.

The small tributary to West Creek, positioned to the immediate east of the proposed processing plant site, currently drains through the proposed plant site and open pit area, and therefore also requires diversion, as part of the general West Creek diversion plan. To divert this small drainage, a small dam will be constructed bordering the east side of the plant site, and the resultant pond (the stockpile pond) outlet will be directed north and westward to the merge with the West Creek pond. Flow from this stockpile pond will comprise clean, non-contact water.

6.12.2 Clark Creek

The lower reaches of Clark Creek and the Teeple Drain will be overprinted by the east mine rock stockpile. The upper reach of Clark Creek will be routed south, connecting to an unnamed tributary to the Pinewood River to reduce the volume of water requiring management in the mine rock pond and to avoid unnecessary environmental effects to aquatic habitats. A diversion of approximately 1.35 km is required to allow connection of the upper Clark Creek with an unnamed drainage connecting to the Pinewood River (Figure 10). A small impoundment (the Clark Creek pond) will be developed at the north end of the diversion to direct creek flow southward, and away from the east mine rock stockpile. This pond is expected to form part of the RRP fish habitat compensation works. A second pond may also be constructed at the south end of the diversion to help attenuate creek flows during high precipitation events, and to provide additional fish habitat. The Clark Creek diversion is proposed to be permanent and will be constructed as like-for-like fish habitat replacement. The channel will be sized to pass the environmental design flood and will consist of a trapezoidal shape with an approximate 3 m wide base and 4H:1V side slopes.

6.13 Water Management Ponds

A brief description of each of the primary water management ponds required for the site water balance is provided below. The preliminary design characteristics of each pond are summarized in Table 17. The descriptions herein are tentative, pending detailed design.

6.13.1 TMA Pond

The TMA has a catchment of 1,172 ha, and is designed to contain 115 Mt of tailings solids, as well as sufficient water holding capacity to meet processing plant water supply needs and overall water management and treatment needs for environmental protection. The TMA pond will provide water to the processing plant during the winter months, and during dry non-winter periods, when the mine rock pond is not capable of supplying all of the processing plant water requirements. The TMA pond has been sized to contain from 8 to 20 Mm^3 storage capacity, depending on the stage of dam construction; but will normally be operated with a pond size ranging from about 6 to 8 Mm^3. The large upper range capacity is to provide for the containment and management of site area contact waters during sequences of wet years, when increased temporary storage of effluent will be required to meet water management and discharge objectives for environmental protection.

The TMA has ample capacity to contain water from the EDF event (100 yr 24 hr storm event). The perimeter dams will be constructed to an ultimate dam crest elevation of 379.5 masl, with downstream and upstream side slopes constructed at 5.5H:1V, and 3H:1V, respectively, for the ultimate dam. The dams will be constructed primarily with NPAG mine rock with a low permeability clay-rich core, and fine and processed sand and processed rock for filter zones. An emergency spillway will be provided to safely pass events exceeding the EDF, up to the PMF.

6.13.2 Water Management Pond

The water management pond will receive flow from the TMA pond for additional effluent aging and has a catchment area of 109 ha. It has been designed with a water holding capacity of approximately 6 Mm^3, and will be capable of containing the EDF (100 yr 24 hr storm event). The dam crest of the water management pond is 373.0 masl, with downstream and upstream side slopes constructed at 4H:1V and 4H:1V, respectively. The dams will be constructed primarily with clay-rich till, with an outer facing of NPAG mine rock to prevent surface erosion. The pond spillway will be designed to pass the PMP event.

The water supply required for process plant start-up and early phase operations will be developed by constructing the water management pond in a single stage, early in the construction phase in order to retain sufficient water, derived from various site catchments and the Pinewood River, to support process plant start-up. During the plant operations phase, beyond processing plant start-up, the water management pond will also supply process plant fresh water needs.

6.13.3 Water Discharge Pond

The water discharge pond will receive decanted water from the water management pond, for discharge to the constructed wetland. It will also collect seepage from the major portion of the TMA dam, in accordance with MMER requirements. The water discharge pond will be constructed to a dam crest elevation of 355.2 masl, and will be fitted with an emergency spillway capable of passing the 25 yr 24 hr storm event.

6.13.4 Constructed Wetland

The constructed wetland will be developed as a series of manmade wetlands designed to improve water quality through the enhancement of natural water treatment processes. As constructed wetlands rely in part on biological processes, they are most effective during the warmer months, but will also provide a net benefit during other times of the year as well. The Musselwhite Mine treatment wetland located further north than the RRP for example, has been successfully operating for 13 years.

The RRP constructed wetland has been designed as a free water surface wetland. The wetland will resemble a natural marsh having areas of open water intersected by low height dams or berms. The preliminary design includes placement of five low height, low permeability dams or berms across the Loslo Creek (Cowser Drain) valley to impede flow and allow the establishment of open water marsh environments. Once the wetland system is established and sufficient water is available, appropriate non-invasive wetland plants will be planted if natural colonization is considered insufficient, or if a specific species mix is desired. Open water within the system is expected to cover a maximum of 60 ha, with a contained collective pond volume of approximately 300,000 m^3.

Water will be released from the water discharge pond at a flow rate designed to ensure sufficient retention time within the constructed wetland, and that the capacity of the wetland and the downstream channel to transport water is not exceeded with respect to potential erosive forces. A sump may be placed in the southernmost wetland pond to allow greater flexibility in the release of wetland discharges to the Pinewood River.

6.13.5 Mine Rock Pond

The mine rock pond dam crest will be constructed to an elevation of 362.0 masl, with downstream and upstream side slopes constructed at 4H:1V. The dams will be constructed of NPAG mine rock fill with a low permeability clay till core. Spillways will be designed to pass the PMP event.

The mine rock pond has been sized to operate based on the largest monthly pond volume for the 20-year wet annual precipitation conditions on the ultimate footprint of the east mine rock stockpile and the open pit prior to the EDF. Approximately 60% of the process plant make-up water will be provided from the mine rock pond. This rate was selected to ensure that the pond can be kept in balance year over year in mean annual precipitation conditions. Regulation of water recycling to the process plant will ensure there is adequate storage available to contain the environmental design flood with no discharge to the environment.

6.13.6 West Creek Pond

The West Creek pond will be constructed in line with West Creek. The West Creek pond dam crest will be constructed to an elevation of approximately 364.9 masl, with downstream and upstream side slopes constructed at 4H:1V. The dams will be constructed of NPAG mine rock fill with a low permeability clay till core. The dam outflow will be constructed with an invert elevation of 365.5 masl, and with a design flow of 141 m^3/s (equivalent to the PMP), passing water to the West Creek diversion.

6.13.7 Clark Creek Pond

The Clark Creek pond dam will be constructed as a low grade impoundment, from locally available clay-rich till materials faced with NPAG rock as needed to prevent surface erosion. It will be constructed to an elevation of 380.25 masl, and will divert the Clark Creek flows south, and away from the east mine rock stockpile.

6.13.8 Stockpile Pond

The stockpile pond will collect non-contact water from an area of approximately 304 ha thereby avoiding contact with project operations. The collected water will be diverted through a constructed channel to the West Creek pond. The stockpile pond dam crest will be constructed to an elevation of 369.0 masl. The dams will be constructed of NPAG mine rock fill with a low permeability clay till core. Spillways will be designed to pass the PMP event.

7.0 RECEIVING WATER EFFECTS – CONSTRUCTION PHASE

Receiving water effects during the construction phase will involve both flow reduction effects on the Pinewood River, and water quality effects to West Creek and the Pinewood River.

7.1 Flow Reduction Effects

Flow reduction effects will occur due to the capture and holding of site runoff from the TMA, water management pond, and mine rock pond catchments, that would otherwise report to the Pinewood River; and through the direct taking of water from the Pinewood River, to build the necessary water inventory to support process plant start-up and early phase operations. Flow reduction to the Pinewood River during this initial period would be held to an amount of not greater than 20% during the spring period (April through June) and to an amount not greater than 15% during other times of the year; as measured below the McCallum Creek outflow. Flow reduction in that portion of the Pinewood River adjacent to the mine rock pond and to a location just upstream of the Loslo Creek outflow is expected to be in the order of 34%, once the West Creek diversion is put in place, which would re-locate the point of outflow of this drainage from the existing West Creek confluence with the Pinewood River to the Loslo Creek and Pinewood River confluence.

In the case of water taken to build the initial site water inventory in 2015 and 2016 to support process plant start-up, any waters taken from site catchments to build this inventory (i.e., from the TMA, water management pond, and mine rock pond catchments) would be included as part of the Pinewood River water taking.

The intent would be to begin building the initial water inventory to support process plant start-up in August 1, 2016, as soon as the water management pond dams are sufficiently developed to begin holding water. This could be sometime in mid 2015 if construction proceeds in late 2014. To support the proposed process plant start-up date of August 1, 2016, dams containing the water management pond area, and the TMA and mine rock pond areas, would need to be sufficiently functional by March 1, 2016 to be able to capture runoff from these areas for the entire year of 2016, onward. This assumes that water accumulated in these basins as ice and snow during January and February is released in spring melt after March 1, 2016. Additional water would be needed from the Pinewood River to help build the initial water inventory.

Direct water taking needs from the Pinewood River would depend on runoff conditions for that year. The objective would be to develop an initial water inventory of not less than 5 Mm^3 of water in the water management pond by the end of November 2016 to support process plant operations through the winter of 2017. Runoff in an average year (in 2016) would be capable of providing more than the required inventory, such that direct water taking from the Pinewood River would only be required for the spring months (Table 18). However, if extreme low runoff conditions (e.g., 5^{th} percentile low flow runoff conditions) were to be encountered in 2016, and to be followed by similarly low runoff conditions in 2017, it would be necessary to take the full water taking allotment (20% of spring flows and 15% of non-spring open water flows) from the Pinewood River in both of 2016 and 2017, as shown in Table 19. Encountering such an extreme low flow runoff condition leading up to and during process plant start-up has a low probability of occurrence, but were this condition to happen there might be insufficient water to operate the process plant through the entire winter of 2017.

A short-term flow reduction in the Pinewood River of up to 20% in the spring months, and up to 15% during the remainder of the open water period, is not expected to have a significant adverse effect on fish habitat. This is partly because the Pinewood River is a low gradient system, with an average slope of 0.07%, such that flow reductions of this magnitude would be expected to translate to much lesser reductions in water surface area and depth (AMEC 2013; Appendix X).

Once the RRP is past the process plant start-up and early production phase, there is no anticipated need to take water directly from the Pinewood River.

7.2 Effluent Discharge Effects

Effluent discharges to the environment during the mine construction phase will include those from the following facilities:

- Preliminary phase mine rock pond positioned within the lower Clark Creek basin;
- Sediment pond #1;
- Domestic sewage treatment plant; and
- Sediment ponds to support road quarry and aggregate pit operations.

The preliminary phase mine rock pond would collect runoff and seepage deriving from early phase open pit development (pit stripping and early phase ore and mine rock production), plant site construction, and early phase east mine rock stockpile development. Water collected in this pond would be held, to the extent practicable, to help build the initial water inventory in the water management pond to support process plant start-up. Excess water which cannot be retained, due to pond capacity constraints, would be discharged to the Pinewood River. The main water treatment function of this pond for waters discharged to the Pinewood River, if any, would be TSS and residual ammonia control. Residual ammonia would derive from the use of blasting agents for early phase ore and mine rock production from the open pit.

Any pond discharge to the Pinewood River from the preliminary phase mine rock pond would be expected to meet the same effluent objectives and limits shown in Table 13 for the constructed wetland discharge to the Pinewood River, as the same metal toxicity modifier considerations would apply to this discharge. The only exception would be cyanide species, as there would be no cyanide effluents discharged, or otherwise reporting to, this pond. Cyanide species would not be monitored for this pond. Effluent monitoring frequencies would be as per O. Reg. 560/94 and MMER requirements. Effluent objectives and limits defined in Table 13 have been developed to be fully protective of the receiving water, therefore so long as these objective values are met, there would be no expected adverse effect to the Pinewood River from the discharge of treated effluent. Appropriate physical arrangements would need to be approved and constructed at the discharge point to the river to achieve rapid mixing of the effluent with receiver flows in the case where discharge values exceed the modified receiver objectives.

Sediment pond #1 would be used to manage runoff and seepage deriving from the overburden stockpile, which could also include some early phase NPAG mine rock. Sediment pond #1 would discharge to the West Creek diversion and would therefore meet effluent discharge limits shown in Table 16. As described in Section 6.8, sediment pond #1 would only discharge during runoff conditions, where the discharge effects from this pond would be proportional to its watershed area in relation to the West Creek diversion watershed area. For sediment pond #1 this watershed ratio is 17:1. Proposed final effluent limits are therefore double the respective modified receiver targets for West Creek for this pond (Table 16).

The domestic sewage treatment plant would have its own ECA and final effluent limits. Effluent from this plant is expected to be discharged to West Creek, for a limited time prior to construction of the West Creek diversion; and then to the West Creek diversion, just downstream of the West Creek pond, once the diversion is in place. Effluent discharged from the sewage treatment plant is expected to be of high quality and is not expected to adversely affect the quality of West Creek, or the West Creek diversion.

Temporary quarries used to develop the Highway 600 re-alignment and the East Access Road, will be high ground bedrock exposure areas, which may or may not require that excess runoff and seepage into the quarries be managed, depending on final plans for quarry development. Effluent quality management, if such management is required, would consist of the use of settling pond(s) for the removal of TSS, and wetland or overland flow to remove residual ammonia to protect receiving waters. Details relating to these minor applications will be developed at the environmental approvals stage.

Similarly, the RRP aggregate pit, located northwest of the plant site, may or may not require excavation below the water table. If excavation is required below the water table, such that water needs to be pumped from the excavation, this water would be pumped either to sediment pond #1, or to another portion of the excavated pit, where reinjection into the groundwater system would occur. In either case, no associated adverse effects to local receiving waters would be expected from such operations.

8.0 RECEIVING WATER EFFECTS – OPERATIONS PHASE

8.1 Pinewood River - Water Flow Effects

Once fully operational, a collective watershed area of approximately 21 km^2 will flow directly or indirectly to the TMA (Section 6.6). This collective 21 km^2 watershed area will consist of the following catchments:

- Upper Loslo Creek;
- Most of Marr Creek;
- Lower Clark Creek (Teeple Drain); and
- Parts of the West Creek catchment that drain to the process plant and open pit areas.

System water losses, beyond those that currently occur in the natural state will include water stored permanently in the tailings voids (2.59 Mm^3/a), evaporative water lost in the process plant (0.15 Mm^3/a), and water used for dust suppression (0.26 Mm^3/a). Additional water added to the system will be limited to groundwater intercepted by the open pit and underground workings (1.24 Mm^3/a), together with additional runoff resulting from an overall net increase in area runoff coefficients as the mine site area is developed.

Collected waters that are not lost or added to the integrated tailings and overall water management system as described above, will be returned to the Pinewood River as seasonal water management pond discharge to the Pinewood River either just downstream of the McCallum Creek outflow, or by way of the constructed wetland (Figure 8).

The effects of this capture and release of water by and from the integrated water management system on the Pinewood River flows, will depend on river flow regimes (average flow year; low flow year, 5th percentile condition; high flow year, 95th percentile condition), and on the RRP development phase (represented by early phase, Year 2; mid phase, Year 7; and late phase, Year 15). It is expected that there will be a surplus of treated water in the system requiring controlled discharge to the Pinewood River under all conditions, as per Table 20. This surplus is expected to occur despite considerable recycling and water losses to storage in the system, because of added water intercepted by the mine workings, and the development of enhanced site runoff conditions. Relative to the latter, as the RRP site is developed, the general site area is expected to shed runoff more effectively, resulting in less water lost to natural evapotranspiration processes. For example, total annual runoff during average and 5th percentile low flow years is expected to increase from 195 and 66 mm in the baseline condition, respectively, to 285 and 117 mm, respectively at full development (Table 20). The 285 mm value is calculated as the sum of the water management pond discharge (4,217,233 m^3/a), plus water lost to tailings voids, process plant evaporation and dust suppression (3,000,000 m^3/a), minus the mine water input (1,241,000 m^3/a), all divided by the total collective watershed area of 21 km^2. Runoff in the current baseline condition is influenced by the low gradient, micro topographic conditions and associated wetlands that act to enhance evapotranspiration.

The volume of discharge during high runoff years will be constrained by system pump and water quality treatment capacity (residence time). This will result in additional water being temporarily stored in the TMA pond during high runoff years, and particularly during sequences of higher runoff years. This stored water will be used to augment final effluent discharge through the constructed wetland during low runoff years, to minimize project-related flow effects to the river at such times, as described below. The net effect will be to better maintain Pinewood River flows during low flow years when water is needed to maintain fish habitat, and to proportionately reduce Pinewood River flows during high flow years when water to maintain fish habitat is less critical.

The Pinewood River has limited baseflow due to the prevalence of clay-rich substrates in the area. Consequently, the river can experience extreme low to zero flow conditions in the late summer and early fall during drought years, and during the mid to late winter (Section 3.2). During these drought periods, the flow contribution of local minor creeks / RRP site catchments (Loslo, Marr, West and Clark Creeks) is negligible. By purposefully adding treated water to the Pinewood River through the constructed wetland during these low flow periods as proposed, it is possible to improve river flows during drought periods, in the summer and fall months, compared with the base condition. The only months where it will not be practical to add water to the Pinewood River through the constructed wetland during low flow periods, will be in mid to late winter. Water added to the constructed wetland during such periods would accumulate as ice build-up. The flow contribution of local RRP catchments to the Pinewood River during the mid to late winter is effectively zero in any event, such that integrated water management proposed, will not materially change Pinewood River flows at such times.

Flow effects to the Pinewood River are assessed below for four locations (Pinewood River above Loslo Creek, Pinewood River below Loslo Creek, Pinewood River below McCallum Creek, and Pinewood River below the Kishkakoesis River); for three flow regimes (average flow, 5th percentile low flow, and 95th percentile high flow), and for three project time periods (Years 2, 7 and 15 of operations).

8.1.1 Pinewood River above Loslo Creek

The Pinewood River above the existing Clark Creek and Loslo Creek has a watershed area of 53 km^2 and 90 km^2, respectively During operations approximately 9.3 km^2 of this watershed area will be intercepted by mine development features (open pit, east mine rock stockpile and the plant site area), the runoff from all of which will be routed directly or indirectly to the TMA. In addition, West Creek, which enters the Pinewood River upstream of Loslo Creek and Marr Creek, will be diverted such that in future it will enter the Pinewood River at Loslo Creek. Portions of the original Marr Creek drainage will also be directed further downstream to the Loslo Creek outflow area. As a result an estimated 8.1 to 34.2% of the Pinewood River watershed between the current Clark Creek and Loslo Creek outflows will be more or less permanently removed from the Pinewood River. This removal is directly proportional to watershed areas. The effect will therefore be independent of Project development phase and runoff regime. Fish habitat compensation may or may not be required to offset this flow loss (AMEC 2013; Appendix X).

8.1.2 Pinewood River below Loslo Creek

Flow reduction effects to the Pinewood River below Loslo Creek (Cowser Drain) are shown in Table 21 and Figure 13. Flow loss effects are directly related to watershed area changes, and to the rate of water return to the Pinewood River through the constructed wetland, estimated at 2.4 Mm^3 annually during average annual and 95^{th} percentile high runoff conditions, and at lesser rates during low flow conditions (Table 13).

The resultant annualized reduction in Pinewood River flows at this location are calculated at 8.01% and 13.97% for the average and 95^{th} percentile high flow conditions, respectively; and from 9.93% to a net increase of 4.59% for the 5^{th} percentile low flow condition, depending on the year of operation. As per Section 3.2, the 5^{th} and 95^{th} percentile flow values are annualized values.

Expected monthly changes to Pinewood River flows for this location, under average, 5^{th} percentile and 95^{th} percentile flow conditions are shown in Table 21 and Figure 13, relative to the base zero condition. The greatest calculated flow effect would be in mid- to late winter (February and March) when no flow is returned to the river through the constructed wetland. In this case the calculated flow reduction is directly proportional to the intercepted portion of the watershed (approximately 21 km^2, or 19.8% of the watershed). The depiction of this flow reduction is somewhat misleading, as site water flow measurements have shown little to no contributing flow from the small site catchments (Clark, West, Marr and Loslo Creeks) during this period (Section 3.2).

8.1.3 Pinewood River below McCallum Creek

Pinewood River flows increase substantively below the McCallum Creek outflow, as McCallum Creek and Tait Creek enter the river near this location, expanding the natural watershed to 207 km^2. Pinewood River flows at this location will be influenced negatively by runoff losses at the RRP site due to runoff capture and site operations, and positively by water released back to the Pinewood River through the constructed wetland, and by direct pipeline discharge from the water management pond.

Predicted monthly and annual flow changes to the Pinewood River are shown in Tables 22, 23 and 24 for operations Years 2, 7 and 15, with graphical presentations in Figures 14, 15, and 16, respectively. The amount of water returned to the Pinewood River increases as the RRP footprint develops because of increasing runoff coefficients, as the landscape changes. Over the life of the mine, annual river flows are expected to change from -3.45 to +0.30% for the average flow condition; from -5.09 to +2.35% for the 5th percentile low flow condition; and from -4.62 to -2.25% for the 95th percentile high flow condition (Table 25). The greatest net positive effect occurs in low flow years in later mine life because the annual water return through the constructed wetland has a greater proportional effect during these conditions.

As per the upper section of the Pinewood River, the greatest calculated negative flow effect below the McCallum Creek outflow is for the mid to late winter (February and March) when no flow is returned to the Pinewood River from the RRP. The depiction of this flow reduction is again somewhat misleading, as site water flow measurements have shown little to no contributing flow from the small site catchments (Clark, West, Marr and Loslo Creeks) during this period. The second period of greatest flow reduction occurs in June because no water would be returned to the river during the first half of June to allow for some effluent aging in the water management pond during the early transfer period of water from the TMA pond to the water management pond, which is scheduled to commence at the beginning of June.

Overall flow reductions below the McCallum Creek outflow would be less than 10% of background conditions at all times, with generally increasing flow changes occurring in the second half of the year (Figures 14, 15 and 16).

8.1.4 Pinewood River below Kishkakoesis River

The Pinewood River watershed has an area of 460 km^2 below the Kishkakoesis River outflow (Figure 3). Flow percentage changes for the Pinewood River at this point follow a similar pattern to that described above for the McCallum Creek outflow location, except that the flow changes are proportionately smaller at the Kishkakoesis River inflow location because of the expanded Pinewood River watershed location (Tables 26, 27, and 28; and Figures 17, 18 and 19).

Overall flow reductions at the Kashkakoesis River location would be less than 5% of background conditions at all times, and with generally increasing positive flow changes occurring in the second half of the year (Figures, 17, 18 and 19).

8.2 Pinewood River – Water Quality Effects

Optimal TMA final effluent quality will be achieved through a combination of in-plant SO_2/Air cyanide destruction and heavy metal precipitation, followed by aging in the TMA, coupled with the use of wetland polishing for a substantial portion of the mine return water. Aging of treated water in the TMA will occur in both the TMA pond and the water management pond (Section 6.5). The discharge of treated excess water from the TMA pond to the water management pond will normally occur from June through August, as shown in Figure 8. In sequences of wet years where there would be greater quantities of water to discharge, the transfer of water from the TMA pond to the water management pond would extend into September, and possibly even into October if necessary.

Mine return water discharged to the Pinewood River by way of the constructed wetland will not be dependent upon receiver mixing ratios to achieve modified PWQO or equivalent values. The rationale behind the wetland discharge concept is to discharge a substantial portion of treated effluent from the system in most months, while at the same time helping to maintain receiver flows during low flow periods further up in the Pinewood River watershed (i.e., at the Loslo Creek inflow). Wetland water treatment effects would be achieved as described in Section 6.6, including reductions in selected parameters through biological nutrient conversion and uptake, and oxidative and adsorption processes.

The constructed wetland will measure approximately 60 ha in area and will hold an estimated 300,000 m^3 of water. Discharging mine return water through the wetland at a rate of approximately 10,000 m^3/d, will generate a residence time of approximately 30 days excluding any direct precipitation effects during the discharge period. As well, during the June through September period, the wetland would be biologically active and will exhibit warm temperatures that will drive biophysical natural degradation processes. Conditions will therefore be optimal for ammonia conversion and uptake, and for the breakdown of cyanate and thiocyanate, during the period when water is being transferred from the TMA pond to the water management pond, and from this pond to the constructed wetland.

Proposed objectives and limits for effluent at the discharge point from the constructed wetland are shown in Table 13. The objective values are considered to be fully protective of the receiving water, over the longer-term, without the benefit of any mixing with the receiver. The proposed constructed wetland discharge limits take into consideration some level of receiving water mixing, and the fact that receiver hardness values (which reduce metal toxicity) are inversely proportional to receiver flow (Figure 9), thereby providing a further measure of receiver protection under extreme low flow conditions. It is the expectation that the ECA issued by the Province, for RRP water discharges through the constructed wetland, will contain provisions that the proponent must diligently pursue the attainment of the proposed discharge objectives, and that continuing to simply meet the less stringent proposed limits, without investigating and implementing measures that would reasonably and practically improve the quality of the discharge, would not be acceptable.

Proposed final effluent discharges directly to the Pinewood River by pipeline from the water management pond would normally occur during the months of October and November, in the fall, and during April and May in the spring. Under conditions of wet sequence years, to avoid the accumulation of excess water inventory in the TMA pond, it might be necessary to extend the fall discharge period into September. Also, in years when the spring melt starts early, the spring discharge may start in March. In drier sequences of years there would be less discharge to the Pinewood River through the pipeline.

Proposed discharge limits are provided in Section 6.6 for the direct pipeline discharge from the water management pond. The limits provide for unrestricted discharge to the receiver, to a maximum of 50,000 m^3/d, in the case where all discharge parameters meet modified receiver targets for the protection of aquatic life; and for loading calculations to be performed to achieve modified parameter targets in the receiver, where the water management pond discharge quality exceeds the modified receiver targets for one or more parameters. In the second instance it would be important to achieve rapid mixing in the receiver to be fully protective of aquatic life.

As per Section 6.6, the critical aspect of using the loading-based approach is the achievement of rapid mixing in the receiver, as the loading-based approach assumes instantaneous mixing. Also, in viewing the data from Table 13, it is evident that there is a reasonable potential for achieving receiver objective values for all parameters.

Methods for achieving rapid mixing in the receiver are still under development, but various methods are potentially available including the use of in-water structures to enhance turbulence, and diffuser systems. Effective mixing in the case of discharge from the constructed wetland would also be desirable.

Consequently, irrespective of whether the RRP discharge to the environment is from the water management pond by pipeline to the Pinewood River downstream of McCallum Creek, or through the constructed wetland and Loslo Creek (Cowser Drain); it is fully expected that protection of aquatic life equivalent values will be maintained in the Pinewood River at all times in consideration of the baseline water quality data collected to date. There will consequently be no expected adverse water quality effects to aquatic life in the Pinewood River or to aquatic life in the Rainy River or further downstream in Lake of the Woods.

Overall the main mitigation measures implemented to protect receiving water quality are:

- Extensive contact water recycling for process plant needs to reduce overall water demands and to minimize final effluent discharge volumes to the Pinewood River;

- Use of SO_2/Air treatment for cyanide destruction and heavy metal precipitation in the process plant followed by extended effluent aging in the TMA pond and in the water management pond;

- Provision for contingency water retention capacity in the TMA pond to accommodate sequences of wet and dry years;

- Use of a constructed wetland system for final polishing of a portion of the discharge, to optimize final effluent quality, and to maintain receiving water flows during the greater part of the year;

- Optimization of water management discharge to minimize adverse effects to receiving water flows, to the extent practicable;

- Management of the site for acid rock drainage (ARD) control during operations and following closure to prevent adverse water quality impacts to the Pinewood River; and

- Implementation of an extensive monitoring plan for water quality and flow discharges (Section 11).

These mitigation measures are expected to be effective for their intended purposes and in many instances can be further optimized in response to monitoring data.

9.0 RECEIVING WATER EFFECTS – CLOSURE PHASE

One of the primary concerns after operations cease is the potential for ARD effects in the future. During reclamation and closure a number of activities will occur to help manage site ARD potentials over the longer-term that will influence site water management and flow and water quality effects on the Pinewood River. These activities include the following items as will be described more fully in the Closure Plan being prepared pursuant to the Ontario *Mining Act*:

- Developing a combination water and overburden cover on the tailings to restrict oxygen exposure;
- Flooding the open pit;
- Developing (or completing) the clay till cover over the east mine rock stockpile; and
- Otherwise preparing the site for long term post-closure maintenance.

9.1 TMA Closure

The RRP tailings are PAG and will therefore be isolated from oxygen contact at closure to prevent ARD development. The reactivity of the tailings is low, such that the onset of ARD conditions is expected to take approximately 25 years. During operations, deposited tailings will be covered with fresh tailings, such that normal exposure times of deposited tailings to the atmosphere are expected to be less than two years. At closure, the plan is to flood the tailings with a minimum 2 m depth water cover, and to cover remaining exposed tailings along with the potential zone of water cover fluctuation with low permeability overburden. This approach will avoid intermittent long term exposure of the perimeter tailings beaches, and keep the water cover away from the tailings dams, for increased long term dam stability from erosion.

The total quantity of water required to generate the 2 m plus water cover is estimated at about 25 Mm^3. At any given time the quantity of water contained in the TMA and water management ponds is expected to in the order of 8 Mm^3. It will therefore be necessary to collect an additional approximately 17 Mm^3 of water into the tailings basin to provide the water cover. The TMA basin has a surface catchment of approximately 12 km^2. At an annual average tailings basin runoff rate of 0.25 m, it would take approximately six years to build a sufficient water inventory to flood the basin after operations cease to the desired level.

The TMA could be flooded at a faster rate by taking additional water directly from the Pinewood River to augment flooding. Preliminary calculations show that by restricting the water take from the Pinewood River (measured at the McCallum Creek outflow) to approximately 10% of the Pinewood River flow, the TMA could be flooded in about 3 to 4 years, under average annual precipitation conditions. This 10% value includes allowance for water captured by mine site catchments.

Flooding the TMA in a shorter timeline would be beneficial for ARD protection, and would also allow the TMA to become stabilized at a faster rate. Once the TMA is stabilized, likely within 1 to 2 years after flooding is complete, it is expected that runoff from the TMA can be allowed to drain passively to the Pinewood River by way of the constructed wetland, in a manner that would be fully protective of Pinewood River water quality. Once passive TMA drainage is achieved, watershed site capture to flood the open pit, and to manage ARD potentials associated with the east mine rock stockpile, will be reduced to an area of approximately 8 km^2. This would reduce long term flow reduction effects to the Pinewood River measured at Loslo Creek to approximately 8%, and flow reduction effects to the Pinewood River at the McCallum Creek inflow to about 4%.

The drawback of reducing flow effects on the Pinewood River as quickly as reasonably possible, as described above, is that it will take longer to flood the open pit. A balanced approach is required to address both needs.

Tailings pond water quality is expected to stabilize to levels consistent with the protection of aquatic life (i.e., consistently able to meet modified receiver targets at the TMA discharge) within 1 to 2 years of completing development of the full water cover. At this point, the TMA would be allowed to drain passively to the Pinewood River through the constructed wetland.

9.1.1 Potential Effects of Climate Change

During review of the draft EA Report (Version 2) comments were received regarding the ability of the TMA to retain a water cover, capable of providing an effective oxygen barrier, under all reasonably foreseeable climatic conditions, including considerations related to climate change. At closure, once the water cover is fully developed, approximately 5.0 km^2 of the TMA basin will be occupied by pond surface, and the remaining 6.7 km^2 will be occupied by natural ground, or by man-made fill terrain that will evolve to function hydrologically as natural ground.

Under average annual precipitation conditions (695 mm), and evapotranspiration and lake evaporation values of 500 and 600 mm, respectively, the net annual water surplus on the basin, at steady state, is calculated at 1,800,000 m^3. This value translates to an average annual runoff for the basin of 153 mm. In viewing annual precipitation records from Barwick, the only multiple year worst case negative precipitation differential from the mean condition, which exceeded 153 mm was for the three year running average for the years 2010 to 2012, which measured at -162.2 mm. The next most extreme multiple year, negative precipitation differential from the mean condition was for the seven year running average for the period 2006 to 2012, measured at -128.2 mm.

Multiple years of low precipitation, based on the existing climate record, would therefore not be sufficient under current climatic conditions to appreciably reduce the TMA pond water cover thickness by a significant amount.

AMEC conducted a climate change analysis to determine likely adjustment factors that could reasonably be applied to the annual net water balance (AMEC 2013; Appendix W-2). These adjustment factors were provided for three future periods (2020, 2050 and 2080) and for the 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} non-exceedance percentile values across the ensemble of General Circulation Model projections of future climate. The ensemble consists of 346 General Circulation Model runs from both the Coupled Model Intercomparison Project Phase 3 (112) and the Coupled Model Intercomparison Project Phase 5 (234) ensembles. The results showed an expected net annual increase in the water balance (Table 29), indicating that a protective water cover over the deposited tailings can continue to be maintained during the post closure phase.

9.2 Flooding the Open Pit

Flooding the open pit is expected to take several decades, depending on the quantity of runoff that is intercepted to fill the pit. By the time the pit floods to surface, such that there would be a passive outflow from the pit lake to the Pinewood River, the pit lake is expected to become stratified into an upper oxygenated layer and a lower deoxygenated layer. The upper oxygenated layer is expected to be in the order of 30 m in depth, and the water in this layer is expected to contain generally low concentrations of metals. The lower deoxygenated layer will exhibit higher metal concentrations; but due to chemical stratification, the two layers are not expected to mix to any appreciable degree.

Once the pit has been completely flooded the catchment to the pit lake can be reduced to an area of approximately 5 km^2. The pit lake will derive runoff from this catchment area. The pit lake will also receive an estimated average annual 900 m^3/d input from groundwater, once it is fully flooded and hydrologic gradients are stabilized. This groundwater will enter the pit primarily at the overburden / bedrock interface (average depth 24 m below surface) and will consist of non-contact groundwater. The pit lake outflow will enter the Pinewood River, at a point where the river watershed area for mixing will be about 60 km^2.

Table 30 shows expected pit lake water quality for the upper stratified layer once pit is flooded and the lake will begin to discharge (AMEC 2013; Appendix T). The average annual receiver to pit lake outflow mixing ratio at this time, including allowance for groundwater inflow to the flooded open, is expected to be approximately 7.16:1 (Table 30). Blended receiver / pit lake outflow water quality data are presented in Table 30b. Modified receiver targets to protect aquatic life, based on the application of US EPA equations to determine continuous chronic criteria, are also shown in Table 30b, for metals where equations are available (US EPA 2009, Gensemer 2009). The CCC value for aluminum is from Gensemer (2009). The continuous chronic criteria are relatively high because of the elevated hardness value expected for the open pit outflow of 891 mg/L as $CaCO_3$. The only parameter concentration calculated in Table 30b which does not achieve PWQO or US EPA modified hardness continuous chronic criteria equivalents is iron.

The calculated blended value for iron is 2.4 mg/L compared with a PWQO value of 0.3 mg/L. Iron at pH values above 6, under moderate oxidative conditions, will occur entirely as the Fe^{3+} ion phase, and will tend to occur in solid phase in the Pinewood River. Iron is not toxic but iron precipitates have the potential to smother fish eggs and aquatic invertebrates if present in sufficient quality. The calculated 2.4 mg/L value for the Pinewood River is too small to have any such effect, especially when it is considered that the Pinewood River is a clay / silt rich system that regularly experiences high TSS loadings. Median, 75th percentile and maximum TSS values recorded for the Pinewood River just downstream of the project site (at the SW3 station) are 12.4, 18.0 and 45.2 mg/L (AMEC 2013a).

Metal concentrations derived for the Pinewood River after pit outflow mixing in Table 30b, are based on preliminary pit lake modeling, and assumed watershed areas contributing to the pit outflow once the pit lake is stabilized after a currently estimated 72 years. As operational and post-closure monitoring data become available these concentration estimates will be further refined. If necessary, additional water quality treatment will be provided to achieve acceptable final effluent quality from the pit outflow. The blend receiver / open pit water quality values also assume instantaneous mixing. Further investigations are underway to determine the best means of achieving effective passive mixing within the Pinewood River.

9.3 East Mine Rock Stockpile Seepage and Mine Rock Pond Management

Runoff and seepage from the east mine rock stockpile will be managed at closure through development, or completion, of a combination clay-rich till and NPAG cover over the stockpile; and through direction of seepage exiting the toe of the stockpile to the open pit by way of the mine rock pond. The function of the combination clay till and NPAG cover will be to limit precipitation and oxygen infiltration into the rock stockpile to limit ARD development as described in AMEC (2013); Appendix T. The clay-rich till cover will vegetated at closure to prevent erosion of the cover, and to provide wildlife habitat.

Once it can be demonstrated that runoff from the majority of the surface of the east mine rock stockpile is suitable for direct release to the environment, this runoff will be allowed to pass directly to the Pinewood River. Adverse effects to Pinewood River water quality from release of this clean runoff are not expected, as the runoff would be completely isolated from the underlying mine rock. Seepage exiting to toe of the stockpile will follow along the former remnant channel bed of lower Clark Creek to the mine rock pond. This seepage is expected to contain elevated levels of dissolved metals and sulphate deriving from ARD reactions of PAG materials in the stockpile, and will be directed to the deep-water zone of the open pit lake, as per AMEC (2013); Appendix T.

9.4 Preparing the Site for Long Term Post-closure Maintenance

The TMA, open pit and east mine rock stockpile will be closed out as described above, with the passive release of clean runoff to the Pinewood River once runoff quality is suitable for direct release. Passive release of TMA runoff would continue to be through the constructed wetland. The west mineral stockpile containing clay till overburden and NPAG would also be capped with a clay-rich till cover and would be vegetated to prevent erosion of the cover, and to provide wildlife habitat. Once this vegetated cover is in place it is anticipated that the runoff from this stockpile would be clean and suitable for direct release to the environment without the need for further treatment (i.e., the use of sediment ponds #1 and #2). The process plant site area would also be covered with overburden and vegetated after the removal of all related site infrastructure, with runoff from the plant site area reporting to the open pit.

The West Creek and Clark Creek diversions would be permanent, and would continue to function as they do during the project operations phase.

9.5 Post Closure Groundwater Seepage Effects on the Pinewood River

Project facilities which pose a potential groundwater seepage concern over the longer-term are limited to the TMA and the east mine rock stockpile. Seepage travel times from these facilities to the Pinewood River are expected to be on the order of decades to centuries, which is sufficient time for steady state conditions to be considered. Average annual seepage rates for water that is expected to bypass the TMA and east mine rock collection ditches, and eventually enter the Pinewood River, are extremely low, due to the presence of thick sequences of clay substrates, being calculated at 400 m^3/d and 25 m^3/d, respectively (AMEC 2013b).

The above seepage estimates compare with groundwater model estimates for background average annual seepage rates entering the Pinewood River downstream of the locations of these two facilities of 5,200 m^3/d and 1,500 m^3/day respectively. The contribution of seepage flow from the TMA and east mine rock stockpile will therefore account for only a small portion of the natural groundwater flow, such that considerable seepage dilution will occur within the groundwater regime.

Estimates of the initial seepage quality from the TMA and the east mine rock stockpile are provided in Table 31. Background water quality for the Pinewood River is also provided in Table 31. For the TMA, the quality of groundwater seepage can be conservatively estimated as the quality of water that will be discharged from the processing plant, as treated slurry, and therefore constitute TMA tailings pore water at the time of deposition. At closure, the TMA pond water will become diluted with rainwater within a few years of closure, such that the quality of the TMA seepage would be expected to improve very gradually over time. This presumes that ARD potentials are controlled as described in Section 9.1.

Table 31 also provides PWQ values and modified receiver target values for those metals for which hardness equation constants have been derived, as described elsewhere in this document. A nominal hardness value of 200 mg/L has been assumed, as the Pinewood River median and 75th percentile hardness values are 195 and 208.5 mg/L, respectively. The modified receiver value of 1 mg/L for total iron is based on updated data available from British Columbia

Ministry of the Environment and the US EPA as described in Section 9.2. The modified receiver target for arsenic is 0.01 mg/L (Section 6.8.1).

A comparison of TMA pore water quality with the greater of PWQO, or the modified receiver targets, shows that the only parameters of potential concern are silver, cobalt, copper, and marginally, molybdenum.

Estimates of the quality of seepage from the east mine rock stockpile were modeled for selected parameters with the results shown in the right-hand column of Table 31. The results show that aluminum, arsenic, cadmium, copper and iron are predicted to exceed the greater of values based on PWQO, or the modified receiver targets.

The flow path for that portion of the TMA and the east mine rock stockpile seepage, that will bypass the perimeter ditches and reach the Pinewood River, will pass through the overburden cover at these facilities, move into the lower granular till and bedrock, and then move upwards through thick clayey overburden near the discharge zones beneath the river. The expected travel times will be measured in terms of decades to centuries. During this travel, significant changes to the pore water chemistry are expected from the reaction with the bedrock and overburden sediments. In particular the pH of the groundwater is expected to be buffered by the calcium rich sediments within the clay sediments, which will push the pH of the groundwater towards 8, which is the existing pH of these waters. The solubility of some elements, such as aluminum, iron and chromium, will decrease as the pH increases, resulting in the precipitation of metal hydroxides. Other metals such as copper will also precipitate as insoluble sulphides. The clay minerals themselves will be negatively charged, and will thus adsorb the positively charged metal ions. The net effect of these factors and processes will be to retain the metal cations within the soil matrix, thus preventing them from passing through the calcareous clay soils and surfacing in the Pinewood River.

As an example of this effect, data from Newmont Canada Corporation's Golden Giant Mine in northern Ontario, where over 15 years of tailings seepage data are available, showed that the long term average total copper concentration in the seepage collection facility, positioned near the toe of the tailings dam, was reduced by a factor 160, compared with long term average tailings pond total copper concentration. The seepage collection facilities in the case were close to the tailings dam, and did not involve a long flow path through calcareous clays, as would be the case for the RRP. Metal ion reductions in seepage from the TMA and the east mine rock, by a factor well in excess of 100, could therefore be reasonably expected for the RRP.

As such, it is expected that seepage quality from both the TMA and the east mine rock pond will not exceed the greater of either PWQO values, or the modified receiver targets, and that the low volumes of predicted seepage from these two facilities is not expected to adversely affect the water quality of the Pinewood River.

10.0 MONITORING

Surface and groundwater monitoring will be carried out in accordance with overall project water management needs, and in accordance with MMER and Provincial approvals. This will include:

- Internal flow and water quality management of effluents discharged within the confines of site water management facilities, including water discharged from the processing plant to the TMA, water discharged from the mine rock pond to the process plant, water discharged from the TMA to the water management pond, and water discharged from the water management pond to the constructed wetland;
- Water quality of runoff and seepage collected peripherally to site facilities, where such water is transferred to other site water management facilities, and not discharged directly to the environment;
- Flow monitoring to an accuracy of +/-15% of final effluent discharges from the water management pond, the constructed wetland, and from sediment ponds #1 and #2;
- Flow monitoring of the Pinewood River at station 05PC023;
- Water quality monitoring of final effluent discharges from the water management pond, the constructed wetland, and from sediment ponds #1 and #2, as well as from any runoff and seepage collection facilities that might discharge directly to the environment, if any;
- Receiver water quality monitoring at stations upstream and downstream of proposed final effluent discharges to the Pinewood River and the West Creek diversion;
- Water quality stations on the Rainy River upstream and downstream of the Pinewood River outflow;
- Water levels in groundwater monitoring wells in and around the project site area; and
- Water quality in groundwater monitoring wells in and around the project site area, including wells downstream of the TMA and the mineral waste stockpiles.

Further details will be developed through the Provincial approvals process.

11.0 REFERENCES

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Table 1: Mean Monthly Temperature

Climate Station	Distance to Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Barwick (°C)	23 km south	-15.9	-11.6	-4.4	4.2	11.7	16.2	18.8	17.8	12.1	5.5	-3.8	-12.7	3.2

Source: Environment Canada (2012)

Table 2: Mean Monthly Precipitation at Barwick Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation (mm)	28.3	24.1	29.7	40	68.3	113.8	99	84	80	56.2	41.7	29.7	694.7
Rainfall (mm)	0.3	3.3	11	30.4	67.3	113.8	99	84	79.4	50.4	12.8	0.8	552.4
Snowfall (cm)	28	20.8	18.7	9.6	1	0	0	0	0.6	5.8	28.9	28.9	142.3

Source: Environment Canada (2012)

Table 3: Barwick Annual Precipitation 1979 to 2012

Year	Precipitation (mm)	Change from Average (mm)
1979	648.3	-32.4
1980	637.4	-43.3
1981	636.2	-44.5
1982	776.8	96.1
1983	809.2	128.5
1984	687.7	7
1985	922.5	241.8
1986	579.6	-101.1
1987	530.7	-150
1988	600.1	-80.6
1989	608.3	-72.4
1990	589.8	-90.9
1991	849.6	168.9
1992	747.1	66.4
1993	691.7	11
1994	804.4	123.7
1995	640.1	-40.6
1996	802.3	121.6
1997	566.4	-114.3
1998	582.4	-98.3
1999	905	224.3
2000	662.9	-17.8
2001	753.6	72.9
2002	823.2	142.5
2003	566.4	-114.3
2004	889.8	209.1
2005	965.1	284.4
2006	474.8	-205.9
2007	352.2	-328.5
2008	738.3	57.6
2009	746.9	66.2
2010	696.7	16
2011	428.5	-252.2
2012	430.2	-250.5
Average	680.7	

Table 4: Interpolated IDF Return Event for Rainy River Project (mm)

Return Period (year)	Storm Duration								
	5 min	10 min	15 min	30 min	1 hr	2 hr	6 hr	12 hr	24 hr
2	8.5	12.3	15.2	19.8	24.2	29.4	38.1	44.6	50.8
5	10.8	15.4	19.6	24.1	29.4	33.4	40.9	44.9	50.9
10	12.9	17.7	21.8	27.8	39.4	48.7	72.2	86.7	92.5
25	13.4	20.3	26.6	39.5	49.7	62.8	80.4	93.8	102.0
50	14.7	22.6	29.8	44.6	56.7	71.4	91.0	106.0	116.0
100	16.1	25.1	33.0	49.8	63.1	80.0	101.0	118.0	129.0

Source: Ministry of Transportation (2012; IDF Curve Lookup)
Notes: min: minutes; hr: hours

Table 5: Mean Monthly Evaporation at Atikokan Station (mm)

	May	Jun	Jul	Aug	Sep	Oct	Annual
Pan Evaporation	141	149	167	133	79	45	713
Lake Evaporation	111	116	129	104	63	36	560
Scaled Lake Evaporation to 600 mm	119	124	138	111	68	39	600

Source: Environment Canada (2012)

Table 6: International Falls Lake Evaporation 1964 to 2005

Year	Calculated Annual Loss (mm)	Adjusted Annual Loss (mm)
1964	564	583
1965	568	588
1966	619	640
1967	607	628
1968	551	570
1969	570	590
1970	608	628
1971	623	644
1972	601	622
1973	574	593
1974	533	552
1975	590	610
1976	642	664
1977	574	593
1978	579	599
1979	555	574
1980	581	601
1981	584	604
1982	558	578
1983	593	614
1984	565	584
1985	543	562
1986	603	624
1987	609	630
1988	634	656
1989	605	626
1990	600	621
1991	578	598
1992	516	534
1993	475	492
1994	546	565
1995	603	624
1996	577	597
1997	545	564
1998	611	632
1999	559	579
2000	581	601
2001	608	629
2002	597	618
2003	600	620
2004	538	556
2005	581	601
Average	580	600

Source: Dadaser-Celik and Stefan (2008)

Table 7: Pinewood River Flows - WSC Station 05PC023 (Watershed Area 233 km^2)

Month	2007 (m^3/s)	2008 (m^3/s)	2009 (m^3/s)	2010 (m^3/s)	2011 (m^3/s)	Average (m^3/s)	Proportions	Runoff (mm)	Monthly Runoff as a Proportion of Mar - Oct Average Proportions
Jan	ND	0.064	0.043	0.147	0.232	0.122	0.0064	1.397	0.0553
Feb	ND	0.028	0.021	0.112	0.161	0.081	0.0042	0.836	0.0366
Mar	ND	0.028	2.560	3.570	0.424	1.646	0.0863	18.915	-
Apr	2.050	2.820	12.800	1.790	11.296	6.151	0.3225	68.429	-
May	0.393	4.640	3.410	4.040	3.309	3.158	0.1656	36.307	-
Jun	7.430	2.800	0.894	4.490	0.936	3.310	0.1736	36.822	-
Jul	1.380	1.030	0.492	4.910	0.169	1.596	0.0837	18.349	-
Aug	0.013	0.213	0.740	0.130	0.003	0.220	0.0115	2.527	-
Sep	0.004	0.054	0.049	2.730	0.002	0.568	0.0298	6.315	-
Oct	0.702	2.840	0.214	0.934	0.007	0.939	0.0493	10.799	-
Nov	0.372	3.240	0.977	0.736	0.013	1.068	0.0560	11.876	0.4856
Dec	0.107	0.270	0.306	0.365	0.022	0.214	0.0112	2.460	0.0973
Annual Average	1.383	1.502	1.876	1.996	1.381	1.589	-	-	-
Total	-	-	-	-	-	19.072	1	-	-
Runoff (mm)	187.2	203.3	253.8	270.2	186.9	215.1	-	215.0	-

Notes: ND: no data

Table 8: Pinewood River Flows - WSC Station 05PC011 (Watershed Area 461 km^2)

Year	Jan (m^3/s)	Feb (m^3/s)	Mar (m^3/s)	Apr (m^3/s)	May (m^3/s)	Jun (m^3/s)	Jul (m^3/s)	Aug (m^3/s)	Sep (m^3/s)	Oct (m^3/s)	Nov (m^3/s)	Dec (m^3/s)	Mean Mar – Oct (m^3/s)	Annual Runoff (mm)
1952	ND	ND	ND	ND	2.300	4.130	7.690	0.714	0.000	0.076	ND	ND	-	-
1953	ND	ND	ND	0.849	2.160	7.940	1.560	0.709	3.280	0.867	0.364	ND	-	-
1954	ND	ND	ND	12.800	10.100	2.820	0.922	0.183	0.645	0.284	0.541	ND	-	-
1955	ND	ND	ND	13.000	3.770	11.300	0.931	0.150	1.180	4.340	ND	ND	-	-
1956	ND	ND	ND	18.700	9.600	3.840	2.690	0.485	0.105	0.117	ND	ND	-	-
1957	ND	ND	ND	12.900	3.800	3.000	2.610	0.168	0.815	1.330	ND	ND	-	-
1958	ND	ND	0.240	1.360	0.894	2.710	11.700	0.523	0.117	0.514	ND	ND	2.257	-
1959	ND	ND	0.091	6.970	5.470	4.950	0.538	0.026	0.294	1.030	ND	ND	2.421	-
1960	ND	ND	ND	4.830	1.740	1.770	0.570	0.257	0.124	0.370	ND	ND	1.380	-
1961	ND	ND	1.610	5.050	3.530	0.391	0.632	0.339	5.350	2.120	ND	ND	2.378	-
1962	ND	ND	0.000	13.600	22.000	10.900	9.030	5.170	3.960	0.942	ND	ND	8.200	-
1963	ND	ND	1.080	7.700	5.700	12.000	1.680	0.820	0.056	0.034	ND	ND	3.634	-
1964	ND	ND	0.000	4.440	10.300	8.370	1.770	3.590	7.190	7.690	ND	ND	5.419	-
1965	ND	ND	0.000	14.700	12.600	7.010	4.490	0.383	3.810	7.720	ND	ND	6.339	-
1966	ND	ND	0.378	27.400	15.500	4.610	1.210	5.880	1.080	0.898	ND	ND	7.120	-
1967	ND	ND	0.798	22.000	10.600	11.100	2.810	0.952	0.016	0.252	ND	ND	6.066	-
1968	ND	ND	1.060	6.810	2.780	19.300	6.420	9.090	11.700	12.800	ND	ND	8.745	-
1969	ND	ND	0.000	18.000	5.860	3.490	0.317	3.170	0.173	1.570	ND	ND	4.073	-
1970	ND	ND	0.000	13.500	16.800	6.660	1.320	0.015	0.298	1.180	ND	ND	4.972	-
1971	ND	ND	0.000	10.000	5.360	2.850	1.200	0.348	0.247	7.800	ND	ND	3.476	-
1972	ND	ND	0.028	10.600	7.760	2.340	0.455	0.052	0.159	0.415	ND	ND	2.726	-
1973	ND	ND	0.872	1.790	0.754	0.727	0.812	3.580	3.640	6.440	ND	ND	2.327	-
1974	ND	ND	0.000	14.400	15.900	12.200	1.460	0.858	0.552	1.410	ND	ND	5.848	-
1975	ND	ND	0.000	13.600	9.190	3.040	1.800	0.019	0.044	0.271	ND	ND	3.496	-
1976	ND	ND	0.136	8.440	1.290	2.290	0.910	0.014	0.000	0.009	ND	ND	1.636	-
1977	ND	ND	0.311	0.945	3.600	3.830	0.698	0.066	2.970	2.730	ND	ND	1.894	-
1978	ND	ND	0.002	16.400	9.010	10.600	7.680	1.780	1.120	0.550	ND	ND	5.893	-
1979	ND	ND	0.123	25.600	8.250	4.690	0.702	0.157	0.170	0.158	ND	ND	4.981	-
1980	ND	ND	0.000	7.020	1.510	0.085	0.049	0.375	2.340	2.130	ND	ND	1.689	-
1981	ND	ND	0.138	1.180	1.500	7.310	2.240	0.633	0.513	3.940	ND	ND	2.182	-
1982	ND	ND	0.000	10.500	12.600	3.770	4.710	2.020	0.660	8.450	ND	ND	5.339	-
1983	ND	ND	0.263	3.860	2.400	7.710	2.190	0.016	0.398	2.680	ND	ND	2.440	-
1984	ND	ND	0.228	6.180	2.690	12.600	1.610	0.026	0.000	6.640	ND	ND	3.747	-

Year	Jan (m^3/s)	Feb (m^3/s)	Mar (m^3/s)	Apr (m^3/s)	May (m^3/s)	Jun (m^3/s)	Jul (m^3/s)	Aug (m^3/s)	Sep (m^3/s)	Oct (m^3/s)	Nov (m^3/s)	Dec (m^3/s)	Mean Mar – Oct (m^3/s)	Annual Runoff (mm)
1985	ND	ND	1.650	9.850	14.100	16.500	5.820	4.770	5.970	6.600	ND	ND	8.158	-
1986	ND	ND	1.550	17.000	10.800	0.142	0.036	0.004	0.082	0.058	ND	ND	3.709	-
1987	ND	ND	0.419	0.839	2.390	1.480	0.129	0.728	0.251	0.215	ND	ND	0.806	-
1988	ND	ND	0.028	3.430	0.272	0.399	0.579	0.502	1.610	0.549	ND	ND	0.921	-
1989	ND	ND	0.131	11.900	6.820	8.070	13.400	2.310	0.198	0.080	ND	ND	5.364	-
1990	ND	ND	1.570	2.560	2.970	3.990	2.840	0.047	0.001	0.015	ND	ND	1.749	-
1991	ND	ND	0.109	2.260	5.590	1.710	6.400	0.055	2.010	1.940	ND	ND	2.509	-
1992	ND	ND	0.749	14.100	10.700	1.560	5.120	8.390	12.400	1.930	ND	ND	6.869	-
1993	ND	ND	1.530	5.840	5.340	7.170	10.500	3.600	3.380	1.100	ND	ND	4.808	-
1994	ND	ND	0.682	2.710	3.510	3.130	9.080	5.530	2.360	2.490	ND	ND	3.687	-
1995	ND	ND	4.560	2.540	4.650	0.913	3.370	1.240	0.752	2.990	ND	ND	2.627	-
1996	ND	ND	0.214	11.400	26.000	2.980	1.620	0.892	0.192	2.050	ND	ND	5.669	-
1997	ND	ND	0.269	20.600	7.400	0.557	1.200	0.022	0.000	0.435	ND	ND	3.810	-
1998	ND	ND	0.682	1.210	7.470	ND	ND	ND	ND	ND	ND	ND	-	-
Mean[2]	0.218[1]	0.144[1]	0.538	9.595	7.135	5.412	3.163	1.536	1.787	2.352	1.913[1]	0.383[1]	2.848[2]	194.8
5th Percentile[3]	0.073	0.049	0.181	3.228	2.400	1.820	1.064	0.517	0.601	0.791	0.644	0.129	0.958	65.5
95th Percentile[4]	0.440	0.292	1.087	19.409	14.432	10.947	6.398	3.107	3.615	4.758	3.870	0.776	5.761	394.1

Pinewood River Prorated to Pinewood River Downstream of McCallum Creek - Watershed area 207 km^2

Mean[2]	0.097755	0.064772	0.241362	4.308316	3.203642	2.429941	1.420282	0.68972	0.802503	1.05627	0.859025	0.1721914		
5th Percentile[3]	0.032884	0.021789	0.081192	1.449277	1.077675	0.81741	0.47777	0.232015	0.269955	0.355319	0.288968	0.0579236		
95th Percentile[4]	0.19774	0.131021	0.488228	8.714887	6.480347	4.9153	2.872955	1.39517	1.623309	2.13663	1.737641	0.3483097		

Water availability Pinewood River downstream of McCallum Creek - 20% of spring flow and 15% of post spring open water period

												Total (T)	T. Apr-Jun	
Mean[2]	-	-	-	2,233,431	1,716,127	1,259,682	570,612	277,102	312,013	424,367	333,989	7,127,323	5,209,239	
5th Percentile[3]	-	-	-	751,305	577,289	423,745	191,949	93,215	104,958	142,753	112,351	2,397,565	1,752,340	
95th Percentile[4]	-	-	-	4,517,798	3,471,392	2,548,092	1,154,238	560,524	631,142	858,412	675,595	14,417,193	10,537,281	

Average M-O (m^3/s)	4.034
5th P. M-O (m^3/s)	1.357
95th P. M-O (m^3/s)	8.160

Notes: 1 - Mean monthly data for January, February, November and December prorated from WSC Station 05PC023 monthly proportions
2 - Mean annual runoff January through December
3 - Calculated as mean monthly flow x (1.357/4.034) (i.e., the monthly values are annualized)
4 - Calculated as mean monthly flow x (8.160/4.034) (i.e., the monthly values are annualized)
M: March; O: October

Table 9: Measured and Predicted Pinewood River at Highway 617, 7Q Low Flows

Table 9a: Recorded Lowest 7-Day Average Flow Values at Highway 617 (Watershed Area 233 km^2)

Year	Lowest 7-Day Flow at Highway 617 (m^3/d)	Ln Values
2007 (Aug 30 - Sep 5)	111	4.714
2008 (Aug 26 - Sep 1)	432	6.068
2009 (Feb 24 - Mar 1)	1,172	7.067
2010 (Aug 23 - Aug 29)	3,231	8.081
2011 (Sep 14 - Sep 20)	12	2.493
Mean	**992**	
Mean Ln	5.684	
SD of Mean Ln	2.175	

Notes: Ln - natural logarithm; SD - standard deviation

Table 9b: Projected Return Period 7-Day Low Flows at Highway 617

Return Period	7Q Ln Value	Predicted Lowest 7Q Flow (m^3/d)
2 Years	5.684	294
3 Years	4.745	115
5 Years	3.853	47
10 Years	2.896	18
20 Years	2.106	8

Notes: Ln: natural logarithm

Table 10: Flow Estimates for Site Area Small Creeks

Creek / Condition	Watershed Area (km^2)	Calculated Flow (m^3/s)												Mean Annual Runoff (mm)
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Clark Creek														
Mean[1]		0.0041	0.0027	0.0102	0.1819	0.1353	0.1026	0.0600	0.0291	0.0339	0.0446	0.0363	0.0073	194.8
5th Percentile[2]	8.74	0.0014	0.0009	0.0034	0.0612	0.0455	0.0345	0.0202	0.0098	0.0114	0.0150	0.0122	0.0024	65.5
95th Percentile[3]		0.0083	0.0055	0.0206	0.3680	0.2736	0.2075	0.1213	0.0589	0.0685	0.0902	0.0734	0.0147	394.1
West Creek														
Mean[1]		0.0077	0.0051	0.0191	0.3403	0.2530	0.1919	0.1122	0.0545	0.0634	0.0834	0.0679	0.0136	194.8
5th Percentile[2]	16.35	0.0026	0.0017	0.0064	0.1145	0.0851	0.0646	0.0377	0.0183	0.0213	0.0281	0.0228	0.0046	65.5
95th Percentile[3]		0.0156	0.0103	0.0386	0.6883	0.5119	0.3882	0.2269	0.1102	0.1282	0.1688	0.1372	0.0275	394.1
Marr Creek														
Mean[1]		0.0035	0.0023	0.0087	0.1561	0.1161	0.0880	0.0515	0.0250	0.0291	0.0383	0.0311	0.0062	194.8
5th Percentile[2]	7.50	0.0012	0.0008	0.0029	0.0525	0.0390	0.0296	0.0173	0.0084	0.0098	0.0129	0.0105	0.0021	65.5
95th Percentile[3]		0.0072	0.0047	0.0177	0.3158	0.2348	0.1781	0.1041	0.0505	0.0588	0.0774	0.0630	0.0126	394.1
Loslo Creek														
Mean[1]		0.0077	0.0051	0.0189	0.3372	0.2507	0.1902	0.1112	0.0540	0.0628	0.0827	0.0672	0.0135	194.8
5th Percentile[2]	16.20	0.0026	0.0017	0.0064	0.1134	0.0843	0.0640	0.0374	0.0182	0.0211	0.0278	0.0226	0.0045	65.5
95th Percentile[3]		0.0155	0.0103	0.0382	0.6820	0.5072	0.3847	0.2248	0.1092	0.1270	0.1672	0.1360	0.0273	394.1

Notes:
1 Prorated directly from Pinewood River flow derivations (from Table 8) on the basis of watershed areas
2 Annualized values prorated by a factor of 1.357/4.034 derived from Pinewood River flow statistics (as per Table 8)
3 Annualized values prorated by a factor of 8.160/4.034 derived from Pinewood River flow statistics (as per Table 8)

Table 11: Water Availability from the Pinewood River below the McCallum Creek Outlet

Condition	Month								Total (m^3)
	Apr (m^3)	May (m^3)	Jun (m^3)	Jul (m^3)	Aug (m^3)	Sep (m^3)	Oct (m^3)	Nov (m^3)	
Mean	2,233,400	1,716,100	1,259,700	570,600	277,100	312,000	424,400	334,000	7,127,300
5th Percentile	755,900	580,800	426,400	193,100	93,800	105,600	143,600	113,000	2,412,300
10th Percentile	927,700	712,900	523,300	237,000	115,100	129,600	176,300	138,700	2,960,600
25th Percentile	1,305,700	1,003,300	736,4200	333,600	162,000	182,400	248,100	195,300	4,166,700

Notes: Tabled values represent a 20% taking of the spring flow (April to June) and a 15% taking for other months; no winter water taking (December to March) is proposed
Percentile values are calculated as annualized, not monthly, percentiles

Table 12: Laboratory Aging of Synthetic Process Plant Discharge

Parameter	Receiver[1] Target (mg/L)	Modified[2] Receiver Target (mg/L)	Canadian Environmental Quality Guideline (CEQG)	Cyanide Destruction Test at Time 0 (mg/L)	Cyanide Destruction 60-day Aging Test Results (mg/L)
Free cyanide	0.005	0.01[3]	0.005	0.07	<0.01
Total cyanide	-	-	-	0.2	<0.01
Aluminum	0.075	3.54[4]	0.1	0.1	<0.1
Antimony	0.02	-	-	0.07	0.036
Arsenic	0.005	-	0.005	0.004	0.003
Barium	-	-		0.023	0.029
Boron	0.2	-	1.5	0.04	0.05
Cadmium	0.0005	-	Equation[7]	0.00002	0.0015
Chromium	0.0089	-	0.0089	0.0008	<0.0005
Cobalt	0.0009	0.004[5]	-	0.0089	0.0016
Copper	0.005	0.017	Equation[7]	0.055	0.012
Iron	0.3	1.0[6]	0.3	0.038	<0.003
Lead	0.005	0.008	Equation[7]	0.0002	0.0005
Mercury	0.0002	-	0.000026	<0.00001	0.00001
Molybdenum	0.04	-	0.073	0.046	0.049
Nickel	0.025	0.094	0.025[7]	0.003	0.003
Selenium	0.1	-	0.001	0.009	0.002
Vanadium	0.006	-	-	0.0004	0.0003
Zinc	0.020	0.215	0.03	0.004	0.086
Un-ionized Ammonia	0.02	-	19	0.044	0.153
Cyanate	-	-	-	130	85
Thiocyanate	-	-	-	24	25

Notes:
1 Provincial Water Quality Objectives for the protection of aquatic life
2 Modified values for applicable metals derived from application of US EPA hardness equations assuming a blended river / effluent hardness of 200 mg/L as $CaCO_3$
3 Value for free cyanide derived from Gensemer et al. 2007
4 Value for aluminum derived from Gensemer 2009
5 Value for cobalt derived from Nagpal 2004
6 Value for iron derived from BC MOE 2008 and US EPA 2009
7 CEQG Notes: Cadmium = 10^0.86[log10(hardness)]-3.2 µg/L
CEQG for hexavalent chromium is 1 µg/L, CEQG for trivalent chromium is 8.9 µg/L
Copper = e0.8545[ln(hardness)]-1.465 * 0.2µg/L; Minimum of 2 µg/L
Lead = e1.273[ln(hardness)]-4.705; Minimum of 1 µg/L
Nickel is a minimum of 25 µg/L regardless of water hardness

Table 13: Constructed Wetland Operation and Proposed Effluent Objectives and Limits - V1

Table 13a: Receiver to Effluent Mixing Ratio Calculations

Month	Calculated Flows Pinewood River at Loslo Creek - Effective Watershed 85 km² (m³/month)			Proposed Discharge through Constructed Wetland – Year 15 (m³/month)			Typical Ratio of Receiver to Effluent Flows (m³/month)		
	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff
Jan	107,514	36,167	217,479	50,000	34,758	50,000	2.15	1.04	4.35
Feb	64,344	21,645	130,156	0	0	0	-	-	-
Mar	265,456	89,297	536,965	0	0	0	-	-	-
Apr	4,585,546	1,542,535	9,275,671	300,000	208,550	300,000	15.29	7.40	30.92
May	3,523,449	1,185,255	7,127,254	310,000	215,502	310,000	11.37	5.50	22.99
Jun	2,586,303	870,008	5,231,589	150,000	104,275	150,000	17.24	8.34	34.88
Jul	1,562,063	525,463	3,159,751	310,000	215,502	310,000	5.04	2.44	10.19
Aug	758,572	255,177	1,534,445	310,000	215,502	310,000	2.45	1.18	4.95
Sep	854,143	287,326	1,727,765	300,000	208,550	300,000	2.85	1.38	5.76
Oct	1,161,713	390,790	2,349,921	310,000	215,502	310,000	3.75	1.81	7.58
Nov	914,301	307,562	1,849,455	300,000	208,550	300,000	3.05	1.47	6.16
Dec	189,381	63,706	383,080	100,000	69,517	100,000	1.89	0.92	3.83
Total / Average		-	-	2,440,000	1,696,208	2,440,000	6.51	3.15	13.16

Table 13b: Effluent Treatability Test Work Results, Receiver Standards, and Suggested Final Effluent Objectives / Limits

Parameter	Receiver Target (mg/L)	Modified Receiver Target (mg/L)	CND Test Time 0 (mg/L)	CND Test 60-day Aging (mg/L)	Additional Treatment	Receiver 75th Percentile (mg/L)	Wetland Monthly Average Objective (mg/L)	Wetland Monthly Average Limit (mg/L)	Comments on Objective Concentration
CNt	-	-	0.19	0.02	no	0.000	0.05	0.1	5 x CNf
CNf	0.005	0.01	0.07	<0.01	no	0.000	0.01	0.02	mod receiver
As	0.005	0.01	0.004	0.003	no	0.003	0.01	0.02	double IPWQO
Cu	0.005	0.017	0.055	0.012	no	0.002	0.02	0.04	mod receiver rounded
Pb	0.005	0.008	0.0002	0.0005	no	0.001	0.01	0.02	mod receiver rounded
Ni	0.025	0.094	0.003	0.003	no	0.003	0.1	0.2	mod receiver rounded
Zn	0.02	0.215	0.004	0.086	no	0.006	0.2	0.4	mod receiver rounded
NH3-U	0.02	0.02	0.07	0.153	yes	-	0.02	0.04	PWQO
Hardness	-	-	510	486	-	195 / 209			

Notes: Modified receiver targets for Cu, Pb, Ni and Zn based on application of US EPA hardness equations for a hardness value of 200 mg/L
Modified receiver target for CNf free based on non-salmonid recommended continuous chronic criterion of 0.01 mg/L from Gensemer et al. 2007
Modified receiver target for As based on a consideration of MOE PWQO and interim PWQO values, the CEQG value and US EPA value for this parameter

Table 13c: Metal Values based on Application of US EPA Hardness Equations

Parameter	Cu	PB	Ni	Zn
Hardness	200	200	200	200
Ln hardness	5.298	5.298	5.298	5.298
Factor	2.825	2.040	4.541	5.372
Concentration(ug/L)	16.868	7.689	93.763	215.222
Concentration (mg/L)	0.017	0.008	0.094	0.215
PWQO	0.005	0.005	0.025	0.02

Table 13d: Pinewood River Station S3 Hardness Data (mg/L)

Statistic	Value
Minimum	83
Maximum	450
Median	195
Standard Deviation	75.7
75th percentile	208.5
Number of samples	23

Table 14: Pinewood River Annualized Monthly Discharge Potential and Mixing Ratios at McCallum Creek for Year 15 (m^3)

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total / Mean
Pinewood River Flows													
Mean	230,206	137,772	568,388	9,818,464	7,544,326	5,537,731	3,344,653	1,624,237	1,828,870	2,487,433	1,957,681	405,497	35,485,257
5^{th} Percentile	77,439	46,345	191,200	3,302,840	2,537,841	1,862,841	1,125,110	546,378	615,215	836,749	658,546	136,405	11,936,910
95^{th} Percentile	465,662	278,686	1,149,738	19,860,849	15,260,709	11,201,756	6,765,585	3,285,517	3,699,450	5,031,595	3,960,009	820,242	71,779,797
Proposed Discharge[1]													
Mean	50,000	-	-	998,617	998,617	150,000	310,000	310,000	300,000	500,000	500,000	100,000	4,217,234
5^{th} Percentile	34758	-	-	208,550	215,502	104,275	215,502	215,502	208,550	215,502	208,550	69517	1,696,208
95^{th} Percentile	50,000	-	-	1,741,860	1,741,860	150,000	310,000	310,000	300,000	872,137	872,137	100,000	6,447,994
Mixing Ratios[2]													
Mean	4.6	-	-	9.8	7.6	36.9	10.8	5.2	6.1	5.0	3.9	4.1	8.4
5^{th} Percentile[3]		-	-	-	-	17.9	5.2	2.5	2.9	3.9	3.2	-	7.0
95^{th} Percentile[3]	9.3	-	-	11.4	8.8	74.7	21.8	10.6	12.3	5.8	4.5	8.2	11.1

Notes:
1. Discharge to occur to the Pinewood River downstream of McCallum Creek (effective watershed 207 - 21 km^2);
2. Mixing ratios assume that the discharge condition water storage (e.g., mean annual condition) matches with the discharge condition river flow, which is not necessarily the case, as wetter accumulation conditions could be followed by drier receiver conditions, and vice versa
3. Mixing ratios for 5^{th} percentile and 95^{th} percentile conditions are based on annualized monthly values

Table 15: Historic Barwick Precipitation Effects on Tailings Management Area Water Balance

Year	Precipitation (mm)	Average (mm)	TMA Pond Inventory with Removal of 4.22 m^3/year (m^3)	Change (mm)	TMA Pond Inventory with Additional Removal of 3 Mm^3/year (m^3)
Start			6,000,000		
1979	648.3	680.7	5,319,600	-32.4	
1980	637.4	680.7	4,410,300	-43.3	
1981	636.2	680.7	3,475,800	-44.5	
1982	776.8	680.7	5,493,900	96.1	
1983	809.2	680.7	8,192,400	128.5	5,192,400
1984	687.7	680.7	8,339,400	7	2,339,400
1985	922.5	680.7	13,417,200	241.8	4,417,200
1986	579.6	680.7	11,294,100	-101.1	-705,900
1987	530.7	680.7	8,144,100	-150	
1988	600.1	680.7	6,451,500	-80.6	
1989	608.3	680.7	4,931,100	-72.4	
1990	589.8	680.7	3,022,200	-90.9	
1991	849.6	680.7	6,569,100	168.9	
1992	747.1	680.7	7,963,500	66.4	4,963,500
1993	691.7	680.7	8,194,500	11	2,194,500
1994	804.4	680.7	10,792,200	123.7	
1995	640.1	680.7	9,939,600	-40.6	6,939,600
1996	802.3	680.7	12,493,200	121.6	6,493,200
1997	566.4	680.7	10,092,900	-114.3	
1998	582.4	680.7	8,028,600	-98.3	5,028,600
1999	905	680.7	12,738,900	224.3	6,738,900
2000	662.9	680.7	12,365,100	-17.8	3,365,100
2001	753.6	680.7	13,896,000	72.9	1,896,000
2002	823.2	680.7	16,888,500	142.5	1,888,500
2003	566.4	680.7	14,488,200	-114.3	
2004	889.8	680.7	18,879,300	209.1	
2005	965.1	680.7	24,851,700	284.4	
2006	474.8	680.7	20,527,800	-205.9	
2007	352.2	680.7	13,629,300	-328.5	
2008	738.3	680.7	14,838,900	57.6	
2009	746.9	680.7	16,229,100	66.2	
2010	696.7	680.7	16,565,100	16	
2011	428.5	680.7	11,268,900	-252.2	
2012	430.2	680.7	6,008,400	-250.5	
Average	680.7				

Note 1: The tabled values assume a base case removal of 4.22 Mm^3 per year from the TMA water inventory (transferred to the water management pond [WMP] in June through August). The precipitation change is applied over a catchment of 21 km^2, which reports to the TMA. In sequences of wet years the TMA pond water inventory would build-up beyond the 8 Mm^3 system capacity unless more water is removed. Removal of an additional 3 Mm^3 of water during wet year sequences, as shown in the right-hand column, would be sufficient to balance the system. Such removal could be achieved by extending the TMA to WMP transfer into September during wet year sequences. To guard against sequences of dry years it would be necessary to discharge less water from the system at such times to maintain the desired inventory.

Note 2: The TMA Pond Inventory column does not show the 3 Mm3/a additional water removal provided for in the right hand column.

Table 16: West Creek Modified Receiver Targets - Metals for Sediment Pond #1 and #2 Discharges

Sediment Pond #1

Table 16a: Metal Values based on Application of US EPA Hardness Equations

Parameter	Cu	Pb	Ni	Zn
Hardness	96	96	96	96
Ln hardness	4.564	4.564	4.564	4.564
Factor	2.198	1.105	3.920	4.750
Concentration (ug/L)	9.009	3.020	50.392	115.584
Concentration (mg/L)	0.009	0.003	0.050	0.116
PWQO	0.005	0.02*	0.025	0.02

Note: Ln - natural logarithm

Table 16b: West Creek US Station S14 Hardness Data (mg/L)

Statistic	Value
Minimum	48.2
Maximum	169
Median	96
Standard Deviation	32.4
75^{th} Percentile	110
Number of samples	23

Sediment Pond #2

Table 16c: Metal Values based on Application of US EPA Hardness Equations

Parameter	Cu	Pb	Ni	Zn
Hardness	210	210	210	210
Ln hardness	5.347	5.347	5.347	5.347
Factor	2.867	2.102	4.582	5.413
Concentration (ug/L)	17.586	8.181	97.714	224.303
Concentration (mg/L)	0.018	0.008	0.098	0.224
PWQO	0.005	0.02*	0.025	0.02

Note: Ln - natural logarithm

Table 16d: West Creek DS Station S7A Hardness Data (mg/L)

Statistic	Value
Minimum	110
Maximum	462
Median	210
Standard Deviation	82.6
75^{th} Percentile	258
Number of samples	19

Sediment Ponds #1 and #2

Table 16e: Proposed Modified Monthly Average Objectives and Limits for Sediment Pond #1 and #2 Discharges based on Application of US EPA Hardness Equations

Parameter	Sed Pond #1 Final Effluent Objectives (mg/L)	Sed Pond #2 Final Effluent Objectives (mg/L)	Sed Pond #1 Final Effluent Limits (mg/L)	Sed Pond #2 Final Effluent Limits (mg/L)
As	0.01	0.01	0.02	0.02
Cu	0.01	0.02	0.02	0.04
Pb	0.003	0.008	0.006	0.016
Ni	0.05	0.1	0.1	0.2
Zn	0.1	0.2	0.2	0.4
NH_3-U	0.02	0.02	0.04	0.04

Notes: For further reference refer to Table 13. US EPA equations are provided in Section 6.6
Sed Pond: Sediment Pond; NH_3-U: unionized ammonia

Table 17: Summary of RRP Ponds

Pond	Flow Pumped (P) / Decant or Spillway (D)	Water Requirement	Maximum Operating Pond (20-year wet year) (Mm^3)	Environmental Design Flood		Dam			Operating Period
				EDF Runoff (Mm^3)	Pond Volume including the EDF (Mm^3)	Crest Elevation (masl)	Average Height (m)	Length (m)	
Mine Rock Pond	Process plant (P)	Process water	2.93	0.31	3.24	362.0	5.4	1,650	January to December
Stockpile Pond	Mine Rock Pond (P)	Freshwater diversion	0.08	0.00	0.08	369.0	4.0	155	January to December
West Creek Pond	Process plant (P)	Potable and sanitary	0.20	N/A	N/A	364.9	4.0	450	January to December
TMA Pond	Water Management Pond (D)	Decanting for discharge	651	0.97	7.48	379.5	-	-	June to August
Water Management Pond	Environment (Pinewood River below McCallum Creek; P)	Process water, with excess discharged to the environment	6.64	0.13	6.77	373.0	6.7	3,750	October, November, March, April, May
	Water Discharge Pond (D)								January, June to September, December
Water Discharge Pond	Constructed Wetland (D)	Excess discharged to the environment	0.08	0.03	0.111	355.2	1.2	360	January, June to September, December

Notes: The maximum operating pond volume represents the largest monthly pond volume 20-year wet year
EDF - Environmental Design Flood, the 1:100 year 24 hour storm event for ponds collecting mine affected water
All elevations are based on preliminary pond capacity information and required confirmation

Table 18: Water Balance Assuming August 2016 Process Plant Start-up and No Water Collection during 2015 (Mean Annual Average Runoff Condition V1)

Month (2016)	Water Inventory System Inputs (m^3)						Water Inventory System Losses (m^3)				Monthly Total (m^3)	Monthly Cumulative Total (m^3)
	Pinewood River	TMA	WMP	MRP	Pinewood River Adjustment	Open Pit GW	Tailings Voids	Plant Evap	Dust Suppress	Seepage		
Jan	0	14,844	1,381	4,952	0	45,000	0	0	0	30,000	36,177	36,177
Feb	0	8,856	824	2,955	0	45,000	0	0	0	30,000	27,635	63,812
Mar	0	36,634	3,407	12,222	0	45,000	0	0	0	30,000	67,263	131,075
Apr	2,233,431	632,276	58,804	210,938	-902,018	45,000	0	0	0	30,000	4,052,467	4,183,542
May	1,716,127	485,843	45,185	162,086	-693,114	45,000	0	0	15,000	30,000	3,102,355	7,285,898
Jun	1,259,682	356,631	33,168	118,979	-508,778	45,000	0	0	30,000	30,000	2,262,238	9,548,135
Jul	570,612	215,378	20,031	71,854	-307,263	45,000	0	0	30,000	30,000	1,170,138	10,718,273
Aug	0	104,591	9,727	34,893	0	45,000	110,714	6,000	30,000	30,000	17,497	10,735,770
Sep	0	117,757	10,952	39,286	0	45,000	150,000	8,400	30,000	30,000	-5,406	10,730,364
Oct	0	160,155	14,895	53,430	0	45,000	199,286	10,800	15,000	30,000	18,394	10,748,759
Nov	0	126,060	11,724	42,056	0	45,000	221,429	12,000	0	30,000	-38,589	10,710,170
Dec	0	26,080	2,425	8,701	0	45,000	221,429	12,000	0	30,000	-181,223	10,528,947

Assumptions:

1. TMA, WMP and MRP dams are functional by March 1 of 2016 so that all runoff from the entire year (including snow melt) can be captured and retained for 2016
2. Per unit area monthly runoff rates from the TMA, WMP and the MRP in 2016 are the same as for the Pinewood River basin (representing natural ground)
3. Water taking from the Pinewood River is 20% of the spring flow (April to June), and 15% of the July flow for an average year
4. No direct water taking occurs from the Pinewood River occurs once process plant start-up commences
5. Pinewood River water takings have to allow for water captured from the TMA, WMP and MRP basins - hence the negative Pinewood River adjustment values
6. Open pit dewatering averages 1,500 m^3/d for the entire year with this water being captured (direct precipitation to the pit is ignored)
7. Process plant start-up commences on August 1, 2016
8. Process plant operations (and TMA void losses) are at the following percentages of capacity (20,000 tpd); August - 50%; September - 70%; October - 90%; November onward - 100%
9. Process plant evaporative losses (400 m^3/d at full capacity) are in proportion to operational capacity
10. Dust suppression water losses are at 1,000 m^3/d during June to September, and at half this rate for May and October (volumes may be under estimated).
11. Collective seepage losses from the TMA, WMP and MRP dams are 1,000 m^3/d

Notes: TMA : TMA Pond; WMP: Water Management Pond; MRP: Mine Rock Pond; GW: Groundwater; Evap: Evaporation

Table 19: Water Balance Assuming August 2016 Process Plant Start-up and No Water Collection during 2015 (5th Percentile Dry Year Runoff Condition followed by Second 5th Percentile Dry Year - V1)

Month (2016, 2017)	Water Inventory System Inputs (m^3)						Water Inventory System Losses (m^3)				Monthly Total (m^3)	Monthly Cumulative Total (m^3)
	Pinewood River	TMA	WMP	MRP	Pinewood River Adjustment	Open Pit GW	Tailings Voids	Plant Evap	Dust Suppress	Seepage		
Jan	0	4,971	462	1,658	0	45,000	0	0	0	30,000	22,091	22,091
Feb	0	3,014	280	1,005	0	45,000	0	0	0	30,000	19,299	41,391
Mar	0	12,325	1,146	4,112	0	45,000	0	0	0	30,000	32,583	73,974
Apr	751,305	212,714	19,783	70,965	-303,462	45,000	0	0	0	30,000	1,373,228	1,447,202
May	577,289	163,423	15,199	54,521	-233,143	45,000	0	0	15,000	30,000	1,043,575	2,490,777
Jun	423,745	119,931	11,154	40,011	-171,097	45,000	0	0	30,000	30,000	750,938	3,241,715
Jul	191,949	72,451	6,738	24,171	-103,360	45,000	0	0	30,000	30,000	383,669	3,625,384
Aug	93,215	35,204	3,274	11,745	-50,223	45,000	110,714	6,000	30,000	30,000	61,946	3,687,330
Sep	104,958	39,604	3,683	13,213	-56,500	45,000	150,000	8,400	30,000	30,000	44,557	3,731,888
Oct	142,735	53,862	5,009	17,969	-76,840	45,000	199,286	10,800	15,000	30,000	86,329	3,818,217
Nov	112,351	42,437	3,947	14,158	-60,542	45,000	221,429	12,000	0	30,000	15,006	3,833,223
Dec	0	8,784	817	2,930	0	45,000	221,429	12,000	0	30,000	-205,897	3,627,326
Jan	0	0	0	0	0	75,000	221,429	12,000	0	30,000	-188,429	3,438,897
Feb	0	0	0	0	0	75,000	221,429	12,000	0	30,000	-188,429	3,250,469
Mar	0	0	0	0	0	75,000	221,429	12,000	0	30,000	-188,429	3,062,040
Apr	751,305	233,023	21,672	77,741	-303,462	75,000	221,429	12,000	0	30,000	1,198,773	4,260,814
May	577,289	163,423	15,199	54,521	-233,143	75,000	221,429	12,000	30,000	30,000	825,146	5,085,960
Jun	423,745	119,931	11,154	40,011	-171,097	75,000	221,429	12,000	60,000	30,000	517,510	5,603,470
Jul	191,949	72,451	6,738	24,171	-103,360	75,000	221,429	12,000	60,000	30,000	150,240	5,753,710
Aug	93,215	35,204	3,274	11,745	-50,223	75,000	221,429	12,000	60,000	30,000	-54,768	5,698,942
Sep	104,958	39,604	3,683	13,213	-56,500	75,000	221,429	12,000	60,000	30,000	-30,472	5,668,471
Oct	142,735	53,862	5,009	17,969	-76,840	75,000	221,429	12,000	30,000	30,000	77,986	5,746,457
Nov	112,351	42,437	3,947	14,158	-60,542	75,000	221,429	12,000	0	30,000	45,006	5,791,463
Dec	0	8,784	817	2,930	0	75,000	221,429	12,000	0	30,000	-175,897	5,615,566

Notes: TMA : TMA Pond; WMP: Water Management Pond; MRP: Mine Rock Pond; GW: Groundwater; Evap: Evaporation

Assumptions (2016):

1. TMA, WMP and MRP dams are functional by March 1 of 2016 so that all runoff from the entire year (including snow melt) can be captured and retained for 2016
2. Per unit area monthly runoff rates from the TMA, WMP and the MRP in 2016 are the same as for the Pinewood River basin (representing natural ground)
3. Water taking from the Pinewood River is 20% of the spring flow (April to June), and 15% of the July to November flow for an average year
4. Pinewood River water takings have to allow for water captured from the TMA, WMP and MRP basins - hence the negative Pinewood River adjustment values
5. Open pit dewatering averages 1,500 m^3/d for the entire year with this water being captured (direct precipitation to the pit is ignored)
6. Process plant start-up commences on August 1, 2016
7. Process plant operations (and TMA void losses) are at the following percentages of capacity (20,000 tpd): August - 50%; September - 70%; October - 90%; November onward - 100%
8. Process plant evaporative losses (400 m^3/d at full capacity) are in proportion to operational capacity
9. Dust suppression water losses are at 1,000 m^3/d during Jun - Sep, and at half this rate for May and Oct. (volumes may be under estimated)
10. Collective seepage losses from the TMA, WMP and MRP dams are 1,000 m^3/d
11 All system water at end of 2016 held in water management pond to restrict overall pond surface and late winter losses to ice formation

Assumptions (2017):

1-4 Assumptions 1 through 4 the same as for 2016
5. Open pit dewatering averages 2,500 m^3/d for the entire year with this water being captured (direct precipitation to the pit is ignored)
6. Mill operations (and TMA void losses) are at capacity (20,000 tpd)
7. Mill evaporative losses are at full capacity (400 m^3/d)
8. Dust suppression water losses are at 2,000 m^3/d during June to September, and at half this rate for May and October (volumes may be under estimated)
9. Collective seepage losses from the TMA, WMP and MRP dams are 1,000 m^3/d

Conclusion:

Marginally just enough water to make it through the winter of 2017 if 2016 is an exceptionally dry (5^{th} percentile) low flow year. If 2017 is also a 5^{th} percentile low flow year there would still be enough water in the system for 2017 and the winter of 2018, but the issue will be managing pond surface area in winter to limit temporary losses to ice, which could reach 3 to 4 Mm^3 by late winter in a severe year depending on pond geometries.

Table 20: Annual Water Balance Data and Calculations Relating to Waters Reporting to the Water Management Pond

Component	Average Condition (m^3/a)	5th Percentile Condition (m^3/a)	95th Percentile Condition (m^3/a)
Pre-development Runoff[1]	4,095,000	1,386,000	8,274,000
Runoff Equivalent (mm)	195	66	394
Operating Water Losses			
Tailings Voids	2,590,000	2,590,000	2,590,000
Process Plant Evaporation	150,000	150,000	150,000
Dust Suppression	260,000	260,000	260,000
Operating Additions			
Mine Water (groundwater only)	1,241,000	1,241,000	1,241,000
Water Management Pond Discharges			
Year 2	2,703,543	186,877	5,012,742
Year 7	3,658,848	650,346	6,419,337
Year 15	4,217,233	696,208	7,447,994
Developed Site Net Water Production[2]			
Year 2	4,462,543	1,945,877	6,771,742
Year 7	5,417,848	2,409,346	8,178,337
Year 15	5,976,233	2,455,208	9,206,994
Developed Site Net Runoff Equivalent (mm)			
Year 2	213	93	322
Year 7	258	115	389
Year 15	285	117	438
Discharge through the Constructed Wetland[3]			
Year 2	2,440,000	686,877	2,440,000
Year 7	2,440,000	1,150,346	2,440,000
Year 15	2,440,000	1,696,208	2,440,000
Direct Pipeline Discharge			
Year 2	263,543	0	2,072,742
Year 7	1,218,848	0	3,479,337
Year 15	1,777,233	0	4,007,994
Predevelopment Runoff			
Pinewood River Runoff at Loslo Creek (106.2 km^2)	20,709,000	7,009,200	41,842,800
Pinewood River Runoff at McCallum Creek (207.1 km^2)	40,384,500	13,668,600	81,597,400

Notes:
1 Values apply to RRP site capture area directed to the tailings management area / water management pond (21 km^2)
2 Values calculated as water management pond discharge - mine water + (water lost to tailings voids, mill evaporation and dust suppression)
3 Values for the 5th and 95th percentiles include a storage transfer of 0.5 Mm^3 to the 5th percentile condition during Years 2 and 7, and 1 Mm^3 during Year 15, from the 95th percentile condition

Table 21: Pinewood River at Loslo Creek - Monthly Flow Reduction Effects - Years 2 to 15 – V4

Month	Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/s)			Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/month)			Calculated Flows Pinewood River at Loslo Creek - Watershed 106 km² (m³/month)			Calculated Flows Pinewood River at Loslo Creek - Effective Watershed 85 km² (m³/month)		
	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff
Jan	0.218	0.073	0.440	583,104	196,151	1,179,506	134,076	45,102	271,210	107,514	36,167	217,479
Feb	0.144	0.049	0.292	348,972	117,391	705,902	80,241	26,992	162,312	64,344	21,645	130,156
Mar	0.538	0.181	1.087	1,439,707	484,304	2,912,248	331,039	111,358	669,628	265,456	89,297	536,965
Apr	9.595	3.228	19.409	24,869,846	8,365,984	50,306,877	5,718,446	1,923,632	11,567,308	4,585,546	1,542,535	9,275,671
May	7.135	2.400	14.432	19,109,529	6,428,268	38,654,873	4,393,948	1,478,083	8,888,105	3,523,449	1,185,255	7,127,254
Jun	5.412	1.820	10.947	14,026,890	4,718,515	28,373,679	3,225,272	1,084,951	6,524,100	2,586,303	870,008	5,231,589
Jul	3.163	1.064	6.398	8,471,896	2,849,867	17,137,003	1,947,985	655,284	3,940,395	1,562,063	525,463	3,159,751
Aug	1.536	0.517	3.107	4,114,139	1,383,958	8,322,105	945,984	318,220	1,913,543	758,572	255,177	1,534,445
Sep	1.787	0.601	3.615	4,632,467	1,558,319	9,370,584	1,065,166	358,312	2,154,624	854,143	287,326	1,727,765
Oct	2.352	0.791	4.758	6,300,587	2,119,459	12,744,865	1,448,725	487,338	2,930,490	1,161,713	390,790	2,349,921
Nov	1.913	0.644	3.870	4,958,741	1,668,074	10,030,571	1,140,188	383,549	2,306,379	914,301	307,562	1,849,455
Dec	0.383	0.129	0.776	1,027,111	345,511	2,077,646	236,169	79,445	477,723	189,381	63,706	383,080
Total				89,882,987	30,235,799	181,815,859	20,667,238	6,952,266	41,805,816	16,572,785	5,574,930	33,523,532

Month	Treated Effluent Discharge					Calculated Net Flows Pinewood River at Loslo Creek - Watershed 85 km² + Treated Effluent Discharge (m³/month)					Calculated Net Flows Pinewood River at Loslo Creek - Watershed 85 km² + Treated Effluent Discharge (net change %)				
	Average	5th Perc. Year 2	5th Perc Year 7	5th Perc Year 15	95th Perc	Average	5th Perc. Year 2	5th Perc Year 7	5th Perc Year 15	95th Perc	Average	5th Perc. Year 2	5th Perc Year 7	5th Perc Year 15	95th Perc
Jan	50,000	14,075	23,573	34,758	50,000	157,514	50,242	59,739	70,925	267,479	17.48	11.40	32.45	57.25	-1.38
Feb	0	0	0	0	0	64,344	21,645	21,645	21,645	130,156	-19.81	-19.81	-19.81	-19.81	-19.81
Mar	0	0	0	0	0	265,456	89,297	89,297	89,297	536,965	-19.81	-19.81	-19.81	-19.81	-19.81
Apr	300,000	84,452	141,436	208,550	300,000	4,885,546	1,626,987	1,683,971	1,751,085	9,575,671	-14.57	-15.42	-12.46	-8.97	-17.22
May	310,000	87,267	146,151	215,502	310,000	3,833,449	1,272,523	1,331,406	1,400,757	7,437,254	-12.76	-13.91	-9.92	-5.23	-16.32
Jun	150,000	42,226	70,718	104,275	150,000	2,736,303	912,234	940,726	974,283	5,381,589	-15.16	-15.92	-13.29	-10.20	-17.51
Jul	310,000	87,267	146,151	215,502	310,000	1,872,063	612,731	671,614	740,965	3,469,751	-3.90	-6.49	2.49	13.08	-11.94
Aug	310,000	87,267	146,151	215,502	310,000	1,068,572	342,444	401,327	470,678	1,844,445	12.96	7.61	26.12	47.91	-3.61
Sep	300,000	84,452	141,436	208,550	300,000	1,154,143	371,778	428,762	495,876	2,027,765	8.35	3.76	19.66	38.39	-5.89
Oct	310,000	87,267	146,151	215,502	310,000	1,471,713	478,057	536,940	606,291	2,659,921	1.59	-1.90	10.18	24.41	-9.23
Nov	300,000	84,452	141,436	208,550	300,000	1,214,301	392,015	448,998	516,113	2,149,455	6.50	2.21	17.06	34.56	-6.80
Dec	100,000	28,151	47,145	69,517	100,000	289,381	91,857	110,851	133,223	483,080	22.53	15.62	39.53	67.69	1.12
Total	2,440,000	686,877	1,150,346	1,696,208	2,440,000	19,012,785	6,261,807	6,725,276	7,271,138	35,963,532	-8.01	-9.93	-3.26	4.59	-13.97

Table 22: Pinewood River at McCallum Creek - Monthly Flow Reduction Effects - Year 2 – V6

Month	Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/s)			Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/month)			Calculated Flows Pinewood River at McCallum Creek - Watershed 207 km² (m³/month)			Calculated Flows Pinewood River at McCallum Creek - Effective Watershed 186 km² (m³/month)		
	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff
Jan	0.218	0.073	0.440	583,104	196,151	1,179,506	261,827	88,076	529,626	235,265	79,141	475,896
Feb	0.144	0.049	0.292	348,972	117,391	705,902	156,697	52,711	316,967	140,800	47,364	284,811
Mar	0.538	0.181	1.087	1,439,707	484,304	2,912,248	646,463	217,464	1,307,669	580,880	195,402	1,175,007
Apr	9.595	3.228	19.409	24,869,846	8,365,984	50,306,877	11,167,154	3,756,527	22,588,988	10,034,254	3,375,430	20,297,351
May	7.135	2.400	14.432	19,109,529	6,428,268	38,654,873	8,580,635	2,886,445	17,356,960	7,710,135	2,593,618	15,596,109
Jun	5.412	1.820	10.947	14,026,890	4,718,515	28,373,679	6,298,408	2,118,726	12,740,459	5,659,439	1,903,783	11,447,948
Jul	3.163	1.064	6.398	8,471,896	2,849,867	17,137,003	3,804,083	1,279,658	7,694,923	3,418,162	1,149,838	6,914,279
Aug	1.536	0.517	3.107	4,114,139	1,383,958	8,322,105	1,847,347	621,430	3,736,824	1,659,935	558,387	3,357,726
Sep	1.787	0.601	3.615	4,632,467	1,558,319	9,370,584	2,080,088	699,722	4,207,616	1,869,065	628,736	3,780,756
Oct	2.352	0.791	4.758	6,300,587	2,119,459	12,744,865	2,829,114	951,687	5,722,749	2,542,102	855,139	5,142,180
Nov	1.913	0.644	3.870	4,958,741	1,668,074	10,030,571	2,226,593	749,005	4,503,966	2,000,707	673,019	4,047,042
Dec	0.383	0.129	0.776	1,027,111	345,511	2,077,646	461,197	155,142	932,913	414,409	139,403	838,269
Total				89,882,987	30,235,799	181,815,859	40,359,606	13,576,595	81,639,659	36,265,153	12,199,260	73,357,375

Month	Treated Effluent Discharge			Calculated Net Flows Pinewood River at McCallum Creek - Watershed 186 km² + Treated Effluent Discharge (m³/month)			Calculated Net Flows Pinewood River at McCallum Creek - Watershed 186 km² + Treated Effluent Discharge (net change %)		
	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile
Jan	50,000	14,075	50,000	285,265	93,216	525,896	8.95	5.84	-0.70
Feb	0	0	0	140,800	47,364	284,811	-10.14	-10.14	-10.14
Mar	0	0	0	580,880	195,402	1,175,007	-10.14	-10.14	-10.14
Apr	494,286	84,452	1,097,074	10,528,540	3,459,882	21,394,426	-5.72	-7.90	-5.29
May	494,286	87,267	1,097,074	8,204,421	2,680,885	16,693,183	-4.38	-7.12	-3.82
Jun	150,000	42,226	150,000	5,809,439	1,946,009	11,597,948	-7.76	-8.15	-8.97
Jul	310,000	87,267	310,000	3,728,162	1,237,105	7,224,279	-2.00	-3.33	-6.12
Aug	310,000	87,267	310,000	1,969,935	645,654	3,667,726	6.64	3.90	-1.85
Sep	300,000	84,452	300,000	2,169,065	713,188	4,080,756	4.28	1.92	-3.01
Oct	247,485	87,267	549,297	2,789,588	942,407	5,691,477	-1.40	-0.98	-0.55
Nov	247,485	84,452	549,297	2,248,192	757,471	4,596,339	0.97	1.13	2.05
Dec	100,000	28,151	100,000	514,409	167,554	938,269	11.54	8.00	0.57
Total	2,703,543	686,877	4,512,742	38,968,696	12,886,137	77,870,117	**-3.45**	**-5.09**	**-4.62**

Table 23: Pinewood River at McCallum Creek - Monthly Flow Reduction Effects - Year 7 – V6

Month	Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/s)			Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/month)			Calculated Flows Pinewood River at McCallum Creek - Watershed 207 km² (m³/month)			Calculated Flows Pinewood River at McCallum Creek - Effective Watershed 186 km² (m³/month)		
	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff
Jan	0.218	0.073	0.440	583,104	196,151	1,179,506	261,827	88,076	529,626	235,265	79,141	475,896
Feb	0.144	0.049	0.292	348,972	117,391	705,902	156,697	52,711	316,967	140,800	47,364	284,811
Mar	0.538	0.181	1.087	1,439,707	484,304	2,912,248	646,463	217,464	1,307,669	580,880	195,402	1,175,007
Apr	9.595	3.228	19.409	24,869,846	8,365,984	50,306,877	11,167,154	3,756,527	22,588,988	10,034,254	3,375,430	20,297,351
May	7.135	2.400	14.432	19,109,529	6,428,268	38,654,873	8,580,635	2,886,445	17,356,960	7,710,135	2,593,618	15,596,109
Jun	5.412	1.820	10.947	14,026,890	4,718,515	28,373,679	6,298,408	2,118,726	12,740,459	5,659,439	1,903,783	11,447,948
Jul	3.163	1.064	6.398	8,471,896	2,849,867	17,137,003	3,804,083	1,279,658	7,694,923	3,418,162	1,149,838	6,914,279
Aug	1.536	0.517	3.107	4,114,139	1,383,958	8,322,105	1,847,347	621,430	3,736,824	1,659,935	558,387	3,357,726
Sep	1.787	0.601	3.615	4,632,467	1,558,319	9,370,584	2,080,088	699,722	4,207,616	1,869,065	628,736	3,780,756
Oct	2.352	0.791	4.758	6,300,587	2,119,459	12,744,865	2,829,114	951,687	5,722,749	2,542,102	855,139	5,142,180
Nov	1.913	0.644	3.870	4,958,741	1,668,074	10,030,571	2,226,593	749,005	4,503,966	2,000,707	673,019	4,047,042
Dec	0.383	0.129	0.776	1,027,111	345,511	2,077,646	461,197	155,142	932,913	414,409	139,403	838,269
Total				89,882,987	30,235,799	181,815,859	40,359,606	13,576,595	81,639,659	36,265,153	12,199,260	73,357,375

Month	Treated Effluent Discharge			Calculated Net Flows Pinewood River at McCallum Cr - Watershed 186 km² + Treated Effluent Discharge (m³/month)			Calculated Net Flows Pinewood River at McCallum Cr - Watershed 186 km² + Treated Effluent Discharge (net change %)		
	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile
Jan	50,000	23,573	50,000	285,265	102,714	525,896	8.95	16.62	-0.70
Feb	0	0	0	140,800	47,364	284,811	-10.14	-10.14	-10.14
Mar	0	0	0	580,880	195,402	1,175,007	-10.14	-10.14	-10.14
Apr	812,574	141,436	1,565,723	10,846,828	3,516,866	21,863,074	-2.87	-6.38	-3.21
May	812,574	146,151	1,565,723	8,522,710	2,739,768	17,161,832	-0.68	-5.08	-1.12
Jun	150,000	70,718	150,000	5,809,439	1,974,501	11,597,948	-7.76	-6.81	-8.97
Jul	310,000	146,151	310,000	3,728,162	1,295,988	7,224,279	-2.00	1.28	-6.12
Aug	310,000	146,151	310,000	1,969,935	704,537	3,667,726	6.64	13.37	-1.85
Sep	300,000	141,436	300,000	2,169,065	770,172	4,080,756	4.28	10.07	-3.01
Oct	406,850	146,151	783,946	2,948,952	1,001,290	5,926,126	4.24	5.21	3.55
Nov	406,850	141,436	783,946	2,407,557	814,455	4,830,988	8.13	8.74	7.26
Dec	100,000	47,145	100,000	514,409	186,549	938,269	11.54	20.24	0.57
Total	3,658,848	1,150,346	5,919,337	39,924,001	13,349,606	79,276,712	**-1.08**	**-1.67**	**-2.89**

Table 24: Pinewood River at McCallum Creek - Monthly Flow Reduction Effects - Year 15 – V6

Month	Calculated Flows WSC Station 05PC011 - Watershed 461 km^2 (m^3/s)			Calculated Flows WSC Station 05PC011 - Watershed 461 km^2 (m^3/month)			Calculated Flows Pinewood River at McCallum Creek - Watershed 207 km^2 (m^3/month)			Calculated Flows Pinewood River at McCallum Creek - Effective Watershed 186 km^2 (m^3/month)		
	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff
Jan	0.218	0.073	0.440	583,104	196,151	1,179,506	261,827	88,076	529,626	235,265	79,141	475,896
Feb	0.144	0.049	0.292	348,972	117,391	705,902	156,697	52,711	316,967	140,800	47,364	284,811
Mar	0.538	0.181	1.087	1,439,707	484,304	2,912,248	646,463	217,464	1,307,669	580,880	195,402	1,175,007
Apr	9.595	3.228	19.409	24,869,846	8,365,984	50,306,877	11,167,154	3,756,527	22,588,988	10,034,254	3,375,430	20,297,351
May	7.135	2.400	14.432	19,109,529	6,428,268	38,654,873	8,580,635	2,886,445	17,356,960	7,710,135	2,593,618	15,596,109
Jun	5.412	1.820	10.947	14,026,890	4,718,515	28,373,679	6,298,408	2,118,726	12,740,459	5,659,439	1,903,783	11,447,948
Jul	3.163	1.064	6.398	8,471,896	2,849,867	17,137,003	3,804,083	1,279,658	7,694,923	3,418,162	1,149,838	6,914,279
Aug	1.536	0.517	3.107	4,114,139	1,383,958	8,322,105	1,847,347	621,430	3,736,824	1,659,935	558,387	3,357,726
Sep	1.787	0.601	3.615	4,632,467	1,558,319	9,370,584	2,080,088	699,722	4,207,616	1,869,065	628,736	3,780,756
Oct	2.352	0.791	4.758	6,300,587	2,119,459	12,744,865	2,829,114	951,687	5,722,749	2,542,102	855,139	5,142,180
Nov	1.913	0.644	3.870	4,958,741	1,668,074	10,030,571	2,226,593	749,005	4,503,966	2,000,707	673,019	4,047,042
Dec	0.383	0.129	0.776	1,027,111	345,511	2,077,646	461,197	155,142	932,913	414,409	139,403	838,269
Total				89,882,987	30,235,799	181,815,859	40,359,606	13,576,595	81,639,659	36,265,153	12,199,260	73,357,375

Month	Treated Effluent Discharge			Calculated Net Flows Pinewood River at McCallum Creek - Watershed 186 km^2 + Treated Effluent Discharge (m^3/month)			Calculated Net Flows Pinewood River at McCallum Creek - Watershed 186 km^2 + Treated Effluent Discharge (net change %)		
	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile
Jan	50,000	34,758	50,000	285,265	113,899	525,896	8.95	29.32	-0.70
Feb	0	0	0	140,800	47,364	284,811	-10.14	-10.14	-10.14
Mar	0	0	0	580,880	195,402	1,175,007	-10.14	-10.14	-10.14
Apr	998,617	208,550	1,741,860	11,032,871	3,583,980	22,039,212	-1.20	-4.59	-2.43
May	998,617	215,502	1,741,860	8,708,752	2,809,120	17,337,970	1.49	-2.68	-0.11
Jun	150,000	104,275	150,000	5,809,439	2,008,058	11,597,948	-7.76	-5.22	-8.97
Jul	310,000	215,502	310,000	3,728,162	1,365,340	7,224,279	-2.00	6.70	-6.12
Aug	310,000	215,502	310,000	1,969,935	773,888	3,667,726	6.64	24.53	-1.85
Sep	300,000	208,550	300,000	2,169,065	837,286	4,080,756	4.28	19.66	-3.01
Oct	500,000	215,502	872,137	3,042,102	1,070,641	6,014,317	7.53	12.50	5.09
Nov	500,000	208,550	872,137	2,500,707	881,569	4,919,179	12.31	17.70	9.22
Dec	100,000	69,517	100,000	514,409	208,920	938,269	11.54	34.66	0.57
Total	4,217,233	1,696,208	6,447,994	40,482,386	13,895,468	79,805,369	**0.30**	**2.35**	**-2.25**

Table 25: Summary of Pinewood River Flow Effects

Location / Year of Operation	River Flow Condition and Calculated Percent Flow Change		
	Average	5^{th} Percentile	95^{th} Percentile
Pinewood River at Loslo Creek			
Year 2	-8.01	-9.93	-13.97
Year 7	-8.01	-3.26	-13.97
Year 15	-8.01	4.59	-13.97
Pinewood River at McCallum Creek			
Year 2	-3.45	-5.09	-4.62
Year 7	-1.08	-1.67	-2.89
Year 15	0.30	2.35	-2.25
Pinewood River at the Kishkakoesis River			
Year 2	-1.55	-2.29	-2.08
Year 7	-0.49	-0.75	-1.30
Year 15	0.14	1.06	-1.01

Table 26: Pinewood River at Kishkakoesis River - Monthly Flow Reduction Effects - Year 2 – V4

Month	Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/s)			Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/month)			Calculated Flows Pinewood River at Kishkakoesis River - Watershed 460 km² (m³/month)			Calculated Flows Pinewood River at Kishkakoesis River - Effective Watershed 439 km² (m³/month)		
	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff
Jan	0.218	0.073	0.440	583,104	196,151	1,179,506	581,839	195,725	1,176,947	555,277	186,790	1,123,217
Feb	0.144	0.049	0.292	348,972	117,391	705,902	348,215	117,136	704,371	332,318	111,789	672,215
Mar	0.538	0.181	1.087	1,439,707	484,304	2,912,248	1,436,584	483,253	2,905,931	1,371,001	461,192	2,773,269
Apr	9.595	3.228	19.409	24,869,846	8,365,984	50,306,877	24,815,898	8,347,837	50,197,751	23,682,998	7,966,740	47,906,115
May	7.135	2.400	14.432	19,109,529	6,428,268	38,654,873	19,068,077	6,414,323	38,571,023	18,197,578	6,121,496	36,810,172
Jun	5.412	1.820	10.947	14,026,890	4,718,515	28,373,679	13,996,463	4,708,280	28,312,131	13,357,494	4,493,336	27,019,620
Jul	3.163	1.064	6.398	8,471,896	2,849,867	17,137,003	8,453,518	2,843,685	17,099,829	8,067,597	2,713,864	16,319,185
Aug	1.536	0.517	3.107	4,114,139	1,383,958	8,322,105	4,105,214	1,380,956	8,304,053	3,917,803	1,317,912	7,924,955
Sep	1.787	0.601	3.615	4,632,467	1,558,319	9,370,584	4,622,419	1,554,939	9,350,257	4,411,395	1,483,952	8,923,397
Oct	2.352	0.791	4.758	6,300,587	2,119,459	12,744,865	6,286,919	2,114,861	12,717,219	5,999,908	2,018,313	12,136,651
Nov	1.913	0.644	3.870	4,958,741	1,668,074	10,030,571	4,947,984	1,664,456	10,008,813	4,722,098	1,588,470	9,551,889
Dec	0.383	0.129	0.776	1,027,111	345,511	2,077,646	1,024,883	344,761	2,073,140	978,095	329,022	1,978,496
Total				89,882,987	30,235,799	181,815,859	89,688,013	30,170,212	181,421,465	85,593,561	28,792,876	173,139,181

Month	Treated Effluent Discharge			Calculated Net Flows Pinewood River at Kishkakoesis River - Watershed 439 km² + Treated Effluent Discharge (m³/month)			Calculated Net Flows Pinewood River at Kishkakoesis River - Watershed 439 km² + Treated Effluent Discharge (net change %)		
	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile
Jan	50,000	14,075	50,000	605,277	200,865	1,173,217	4.03	2.63	-0.32
Feb	0	0	0	332,318	111,789	672,215	-4.57	-4.57	-4.57
Mar	0	0	0	1,371,001	461,192	2,773,269	-4.57	-4.57	-4.57
Apr	494,286	87,267	1,097,074	24,177,284	8,054,007	49,003,189	-2.57	-3.52	-2.38
May	494,286	84,452	1,097,074	18,691,864	6,205,948	37,907,246	-1.97	-3.25	-1.72
Jun	150,000	42,226	150,000	13,507,494	4,535,562	27,169,620	-3.49	-3.67	-4.04
Jul	310,000	87,267	310,000	8,377,597	2,801,132	16,629,185	-0.90	-1.50	-2.75
Aug	310,000	87,267	310,000	4,227,803	1,405,179	8,234,955	2.99	1.75	-0.83
Sep	300,000	84,452	300,000	4,711,395	1,568,404	9,223,397	1.92	0.87	-1.36
Oct	247,485	87,267	549,297	6,247,393	2,105,580	12,685,948	-0.63	-0.44	-0.25
Nov	247,485	84,452	549,297	4,969,583	1,672,922	10,101,186	0.44	0.51	0.92
Dec	100,000	28,151	100,000	1,078,095	357,173	2,078,496	5.19	3.60	0.26
Total	2,703,543	686,877	4,512,742	88,297,104	29,479,753	177,651,923	-1.55	-2.29	-2.08

Table 27: Pinewood River at Kishkakoesis River - Monthly Flow Reduction Effects - Year 7 – V4

Month	Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/s)			Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/month)			Calculated Flows Pinewood River at Kishkakoesis River - Watershed 460 km² (m³/month)			Calculated Flows Pinewood River at Kishkakoesis River - Effective Watershed 439 km² (m³/month)		
	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff
Jan	0.218	0.073	0.440	583,104	196,151	1,179,506	581,839	195,725	1,176,947	555,277	186,790	1,123,217
Feb	0.144	0.049	0.292	348,972	117,391	705,902	348,215	117,136	704,371	332,318	111,789	672,215
Mar	0.538	0.181	1.087	1,439,707	484,304	2,912,248	1,436,584	483,253	2,905,931	1,371,001	461,192	2,773,269
Apr	9.595	3.228	19.409	24,869,846	8,365,984	50,306,877	24,815,898	8,347,837	50,197,751	23,682,998	7,966,740	47,906,115
May	7.135	2.400	14.432	19,109,529	6,428,268	38,654,873	19,068,077	6,414,323	38,571,023	18,197,578	6,121,496	36,810,172
Jun	5.412	1.820	10.947	14,026,890	4,718,515	28,373,679	13,996,463	4,708,280	28,312,131	13,357,494	4,493,336	27,019,620
Jul	3.163	1.064	6.398	8,471,896	2,849,867	17,137,003	8,453,518	2,843,685	17,099,829	8,067,597	2,713,864	16,319,185
Aug	1.536	0.517	3.107	4,114,139	1,383,958	8,322,105	4,105,214	1,380,956	8,304,053	3,917,803	1,317,912	7,924,955
Sep	1.787	0.601	3.615	4,632,467	1,558,319	9,370,584	4,622,419	1,554,939	9,350,257	4,411,395	1,483,952	8,923,397
Oct	2.352	0.791	4.758	6,300,587	2,119,459	12,744,865	6,286,919	2,114,861	12,717,219	5,999,908	2,018,313	12,136,651
Nov	1.913	0.644	3.870	4,958,741	1,668,074	10,030,571	4,947,984	1,664,456	10,008,813	4,722,098	1,588,470	9,551,889
Dec	0.383	0.129	0.776	1,027,111	345,511	2,077,646	1,024,883	344,761	2,073,140	978,095	329,022	1,978,496
Total				89,882,987	30,235,799	181,815,859	89,688,013	30,170,212	181,421,465	85,593,561	28,792,876	173,139,181

Month	Treated Effluent Discharge			Calculated Net Flows Pinewood River at Kishkakoesis River - Watershed 439 km² + Treated Effluent Discharge (m³/month)			Calculated Net Flows Pinewood River at Kishkakoesis River - Watershed 439 km² + Treated Effluent Discharge (net change %)		
	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile
Jan	50,000	23,573	50,000	605,277	210,363	1,173,217	4.03	7.48	-0.32
Feb	0	0	0	332,318	111,789	672,215	-4.57	-4.57	-4.57
Mar	0	0	0	1,371,001	461,192	2,773,269	-4.57	-4.57	-4.57
Apr	812,574	146,151	1,565,723	24,495,572	8,112,890	49,471,837	-1.29	-2.81	-1.45
May	812,574	141,436	1,565,723	19,010,152	6,262,932	38,375,895	-0.30	-2.36	-0.51
Jun	150,000	70,718	150,000	13,507,494	4,564,054	27,169,620	-3.49	-3.06	-4.04
Jul	310,000	146,151	310,000	8,377,597	2,860,015	16,629,185	-0.90	0.57	-2.75
Aug	310,000	146,151	310,000	4,227,803	1,464,063	8,234,955	2.99	6.02	-0.83
Sep	300,000	141,436	300,000	4,711,395	1,625,388	9,223,397	1.92	4.53	-1.36
Oct	406,850	146,151	783,946	6,406,758	2,164,464	12,920,596	1.91	2.35	1.60
Nov	406,850	141,436	783,946	5,128,948	1,729,906	10,335,835	3.66	3.93	3.27
Dec	100,000	47,145	100,000	1,078,095	376,167	2,078,496	5.19	9.11	0.26
Total	3,658,848	1,150,346	5,919,337	89,252,409	29,943,222	179,058,518	-0.49	-0.75	-1.30

Table 28: Pinewood River at Kishkakoesis River - Monthly Flow Reduction Effects - Year 15 – V4

Month	Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/s)			Calculated Flows WSC Station 05PC011 - Watershed 461 km² (m³/month)			Calculated Flows Pinewood River at Kishkakoesis River - Watershed 460 km² (m³/month)			Calculated Flows Pinewood River at Kishkakoesis River - Effective Watershed 439 km² (m³/month)		
	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff	Average Runoff	5th Percentile Low Runoff	95th Percentile High Runoff
Jan	0.218	0.073	0.440	583,104	196,151	1,179,506	581,839	195,725	1,176,947	555,277	186,790	1,123,217
Feb	0.144	0.049	0.292	348,972	117,391	705,902	348,215	117,136	704,371	332,318	111,789	672,215
Mar	0.538	0.181	1.087	1,439,707	484,304	2,912,248	1,436,584	483,253	2,905,931	1,371,001	461,192	2,773,269
Apr	9.595	3.228	19.409	24,869,846	8,365,984	50,306,877	24,815,898	8,347,837	50,197,751	23,682,998	7,966,740	47,906,115
May	7.135	2.400	14.432	19,109,529	6,428,268	38,654,873	19,068,077	6,414,323	38,571,023	18,197,578	6,121,496	36,810,172
Jun	5.412	1.820	10.947	14,026,890	4,718,515	28,373,679	13,996,463	4,708,280	28,312,131	13,357,494	4,493,336	27,019,620
Jul	3.163	1.064	6.398	8,471,896	2,849,867	17,137,003	8,453,518	2,843,685	17,099,829	8,067,597	2,713,864	16,319,185
Aug	1.536	0.517	3.107	4,114,139	1,383,958	8,322,105	4,105,214	1,380,956	8,304,053	3,917,803	1,317,912	7,924,955
Sep	1.787	0.601	3.615	4,632,467	1,558,319	9,370,584	4,622,419	1,554,939	9,350,257	4,411,395	1,483,952	8,923,397
Oct	2.352	0.791	4.758	6,300,587	2,119,459	12,744,865	6,286,919	2,114,861	12,717,219	5,999,908	2,018,313	12,136,651
Nov	1.913	0.644	3.870	4,958,741	1,668,074	10,030,571	4,947,984	1,664,456	10,008,813	4,722,098	1,588,470	9,551,889
Dec	0.383	0.129	0.776	1,027,111	345,511	2,077,646	1,024,883	344,761	2,073,140	978,095	329,022	1,978,496
Total				89,882,987	30,235,799	181,815,859	89,688,013	30,170,212	181,421,465	85,593,561	28,792,876	173,139,181

Month	Treated Effluent Discharge			Calculated Net Flows Pinewood River at Kishkakoesis River - Watershed 439 km² + Treated Effluent Discharge (m³/month)			Calculated Net Flows Pinewood River at Kishkakoesis River - Watershed 439 km² + Treated Effluent Discharge (net change %)		
	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile	Average	5th Percentile	95th Percentile
Jan	50,000	34,758	50,000	605,277	221,548	1,173,217	4.03	13.19	-0.32
Feb	0	0	0	332,318	111,789	672,215	-4.57	-4.57	-4.57
Mar	0	0	0	1,371,001	461,192	2,773,269	-4.57	-4.57	-4.57
Apr	998,617	215,502	1,741,860	24,681,615	8,182,242	49,647,975	-0.54	-1.98	-1.10
May	998,617	208,550	1,741,860	19,196,194	6,330,046	38,552,032	0.67	-1.31	-0.05
Jun	150,000	104,275	150,000	13,507,494	4,597,611	27,169,620	-3.49	-2.35	-4.04
Jul	310,000	215,502	310,000	8,377,597	2,929,366	16,629,185	-0.90	3.01	-2.75
Aug	310,000	215,502	310,000	4,227,803	1,533,414	8,234,955	2.99	11.04	-0.83
Sep	300,000	208,550	300,000	4,711,395	1,692,502	9,223,397	1.92	8.85	-1.36
Oct	500,000	215,502	872,137	6,499,908	2,233,815	13,008,787	3.39	5.62	2.29
Nov	500,000	208,550	872,137	5,222,098	1,797,020	10,424,026	5.54	7.96	4.15
Dec	100,000	69,517	100,000	1,078,095	398,539	2,078,496	5.19	15.60	0.26
Total	4,217,233	1,696,208	6,447,994	89,810,794	30,489,084	179,587,175	0.14	1.06	-1.01

Table 29: Climate Change Adjustments to the Net Annual Water Balance

Percentile	Year		
	2020 (mm)	2050 (mm)	2080 (mm)
5	55	48	20
25	83	78	69
50	100	110	100
75	120	130	140
95	150	170	190

Table 30: Open Pit Outflow Values at Closure in Relation to Pinewood River

Table 30a: Calculated Pinewood River to Open Pit Discharge Mixing Ratios at Closure - Average Runoff Condition

Month	WSC Station 05PC011 – Watershed 461 km^2 (m^3/mo)	Open Pit Watershed 5 km^2 (m^3/mo)	Open Pit Runoff plus GW of 900 m^3/d (m^3/mo)	Pinewood River at Watershed 61 km^2 (m^3/mo)	Monthly Average Mixing Ratio Receiver to Pit Outflow
Jan	583,104	6,324	33,324	77,157	2.32
Feb	348,972	3,785	30,785	46,176	1.50
Mar	1,439,707	15,615	42,615	190,504	4.47
Apr	24,869,846	269,738	296,738	3,290,804	11.09
May	19,109,529	207,262	234,262	2,528,593	10.79
Jun	14,026,890	152,135	179,135	1,856,053	10.36
Jul	8,471,896	91,886	118,886	1,121,010	9.43
Aug	4,114,139	44,622	71,622	544,387	7.60
Sep	4,632,467	50,244	77,244	612,973	7.94
Oct	6,300,587	68,336	95,336	833,700	8.74
Nov	4,958,741	53,782	80,782	656,146	8.12
Dec	1,027,111	11,140	38,140	135,908	3.56
Total/Average	89,882,987	974,870	1,298,870	11,893,410	7.16

Table 30b: Predicted Pit Outflow Water Quality in relation to Applicable Protection of Aquatic Life Values (mg/L)

Parameter	Point of Overflow 72 Years	Pinewood River 75th Percentile Values	Blended Value at 7.16:1	US EPA Hardness Modified CCC	PWQO for Parameters where no US EPA CCC Values
Hardness	891	195	280	-	
Al	12	0.015	1.4838	5.6100	
As	0.025	0.0031	0.0058	-	0.005
Cd	0.0012	0.0001	0.0002	0.0055	
Cr	0.036	0.005	0.0088	0.4810	
Cu	0.049	0.002	0.0078	0.0225	
Fe	13	0.93	2.4092	-	0.3
Mo	0.014	0.001	0.0026	-	0.04
Ni	0.043	0.0033	0.0082	0.1246	
Pb	0.015	0.001	0.0027	0.0118	
Sb	0.0081	0.00053	0.0015	-	0.02
Zn	0.05	0.063	0.0614	0.2862	

Table 30c: Metal Values based on Application of US EPA Hardness Equations

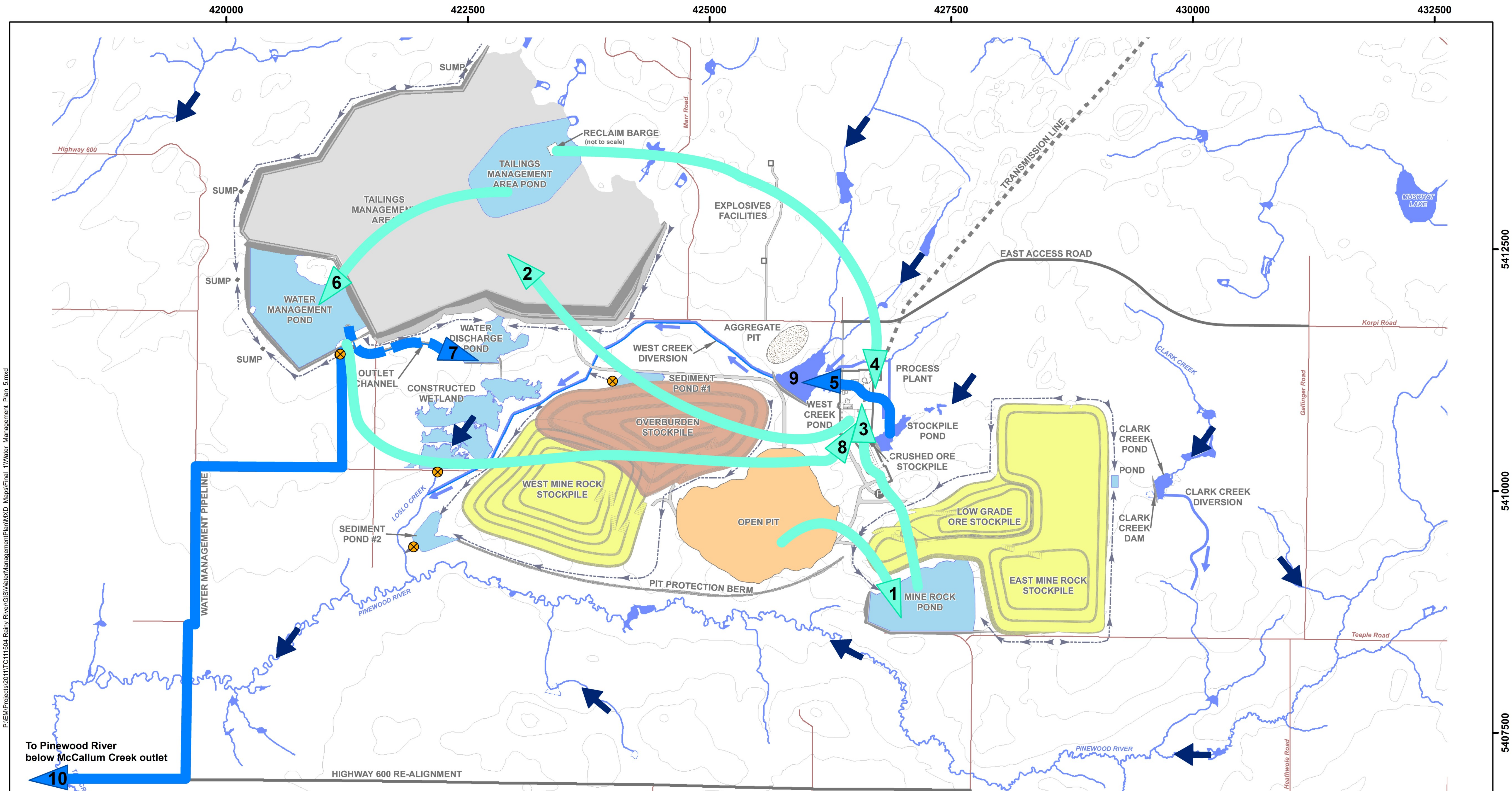
Parameter	Al	Cd	Cr(III)	Cu	Ni	Pb	Zn
Hardness	280	280	280	280	280	280	280
Ln hard	5.634789603	5.634789603	5.634789603	5.634789603	5.634789603	5.634789603	5.634789603
Factor	8.633044362	1.709436796	6.175892685	3.112927716	4.825432004	2.468087165	5.656666794
Concentration ug/L	5614.111145	5.525842069	481.0102265	22.48673595	124.6398973	11.79983448	286.1920214
Concentration mg/L	**5.6141**	**0.0055**	**0.4810**	**0.022**	**0.125**	**0.012**	**0.286**
PWQO	0.075	0.0005	0.00089	0.005	0.025	0.02*	0.02

Note: Ln - natural logarithm
CCC – continuous chronic criterion
* Interim PWQO value

Table 31: TMA and East Mine Rock Stockpile Post Closure Seepage Estimates

Parameter	PWQO (mg/L)	Modified Receiver Target based on Hardness of 200 mg/L (mg/L)	Pinewood River (75th percentile) (mg/L)	TMA Tailings Pore Water[2] (mg/L)	Modelled East Mine Rock Stockpile Seepage[3] (mg/L)
Hardness	-		208.5	510	
Ag	0.0001			**0.00077**	
Al	0.075[I,A]	3.54	0.015	0.1	**13.9**
As	0.1(0.005[I])		0.0031	0.0038	**0.20**
Ba				0.0229	
Be				< 0.00002	
B	0.2[I]		0.037	0.0415	
Bi				< 0.00001	
Ca				195	636
Cd	0.0002 (0.0001/ 0.0005[I])	0.0042	0.0001	0.000017	**0.01**
Co	0.0009		0.0065	**0.00891**	
Cr	0.001 / 0.0089[B]	0.365	0.005	0.0008	0.10
Cu	0.005 (0.005[I])[C]	0.017	0.002	**0.0545**	**0.14**
Fe	0.3	1	0.93	0.038	**1.53**
Hg	0.0002		0.0001	< 0.00001	
K				43.0	56.8
Li				0.011	
Mg				5.63	97.1
Mn				0.0707	4.1
Mo	0.04[I]		0.001	**0.0458**	0.02
Na				324	35.9
Ni	0.025	0.094	0.0033	0.0031	0.05
P	0.03[I]		0.105	0.014	
Pb	0.020 / 0.025 (0.001 / 0.005[I])[D]	0.008	0.001	0.00021	0.005
Sb				0.0669	0.11
Se	0.1		0.002	0.009	
Si				1.74	
Sn				0.0105	
Sr				0.565	
Th	0.0003[I]		0.00011	0.000033	
Ti				0.0003	
Tl				< 0.0002	
U	0.005[I]		0.0027	0.000709	
V	0.006[I]		0.002	0.00043	
W				0.00061	
Y				0.000010	
Zn	0.03(0.02[I])	0.215	0.0063	0.004	0.14

Notes:
- 100 indicates exceedance of the greater of (1) an interim PWQO or PWQO, and (2) modified receiver targets based on hardness
- I indicates interim PWQO
- TMA pond water quality taken from Ageing Test - CND-1 Comp, time zero
- 2 Post-closure Base Case Cover Performance. (AMEC 2013, Rainy River Gold Project: Prediction of Post-Closure Water Quality. June 2013)
- A PWQO is for total aluminum measured in a clay-free sample; analyzed samples are not clay-free
- B PWQO / CCME for hexavalent chromium is 1 µg/L, PWQO/CCME for trivalent chromium is 8.9 µg/L; total chromium reported
- C PWQO for copper is 5 µg/L; IPWQO is 5 µg/L where hardness is >20 mg/L
- D PWQO for lead is 20 µg/L where alkalinity is 40-80 mg/L and 25 µg/L where alkalinity is >80 mg/L; IPWQO is 3 µg/L where alkalinity is 30-80 mg/L and 5 µg/L where alkalinity is >80 mg/L



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LEGEND

- Integrated Water Recycle
- Excess Water Discharge
- General Surface Water Flow Direction
- Final Compliance Point

ID (on this Figure)	Flow		Method	Purpose	Control Logic
	From	To			
1	Open Pit	Mine Rock Pond	Pumped	Dewatering of the Open Pit	Rate to match inflows (lower bench may flood during storm events).
2	Process Plant	TMA	Pumped	Tailings slurry discharge.	Pumped at fixed rate.
3	Mine Rock Pond	Process Plant	Pumped	Process Plant Make-up.	Fixed rate with on/off float switch at minimum pond level.
4	TMA	Process Plant	Pumped	Process Plant Make-up.	Pumped at fixed rate adjusted according to Mine Rock Pond supply.
5	Stockpile Pond	West Creek Pond	Gravity	Divert clean runoff.	Free draining to match inflow.
6	TMA	Water Management Pond	Pumped	Seasonal transfer. Net annual inflow to the system.	Transfer net annual inflow after effluent is released from the Water Management
7	Water Management Pond	Water Discharge Pond /Constructed Wetland	Gravity	Discharge treated effluent to the Pinewood River via the constructed wetland.	Seasonal discharge to constructed wetland (all months except Feb./March) for added treatment and maintain Pinewood River flows.
8	Water Management Pond	Process Plant	Pumped	Mill process fresh water and make-up requirements	Pumped at variable rates as needed.
9	West Creek Pond	Potable	Pumped	Provide potable water	Pumped at variable rates as needed.
10	Water Management Pond	Pinewood River / McCallum Creek	Pumped	Discharge treated effluent to the Pinewood River.	Discharge treated effluent to the Pinewood River.

NOTES:
- Nominal monthly pump rates indicate on figure are based on average annual conditions.
- Pump rates are provided on table 9

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RAINY RIVER PROJECT

Water Management Plan

0 1.25 2.5 5 7.5 10 Kilometres

Datum: NAD83
Projection: UTM Zone 15N

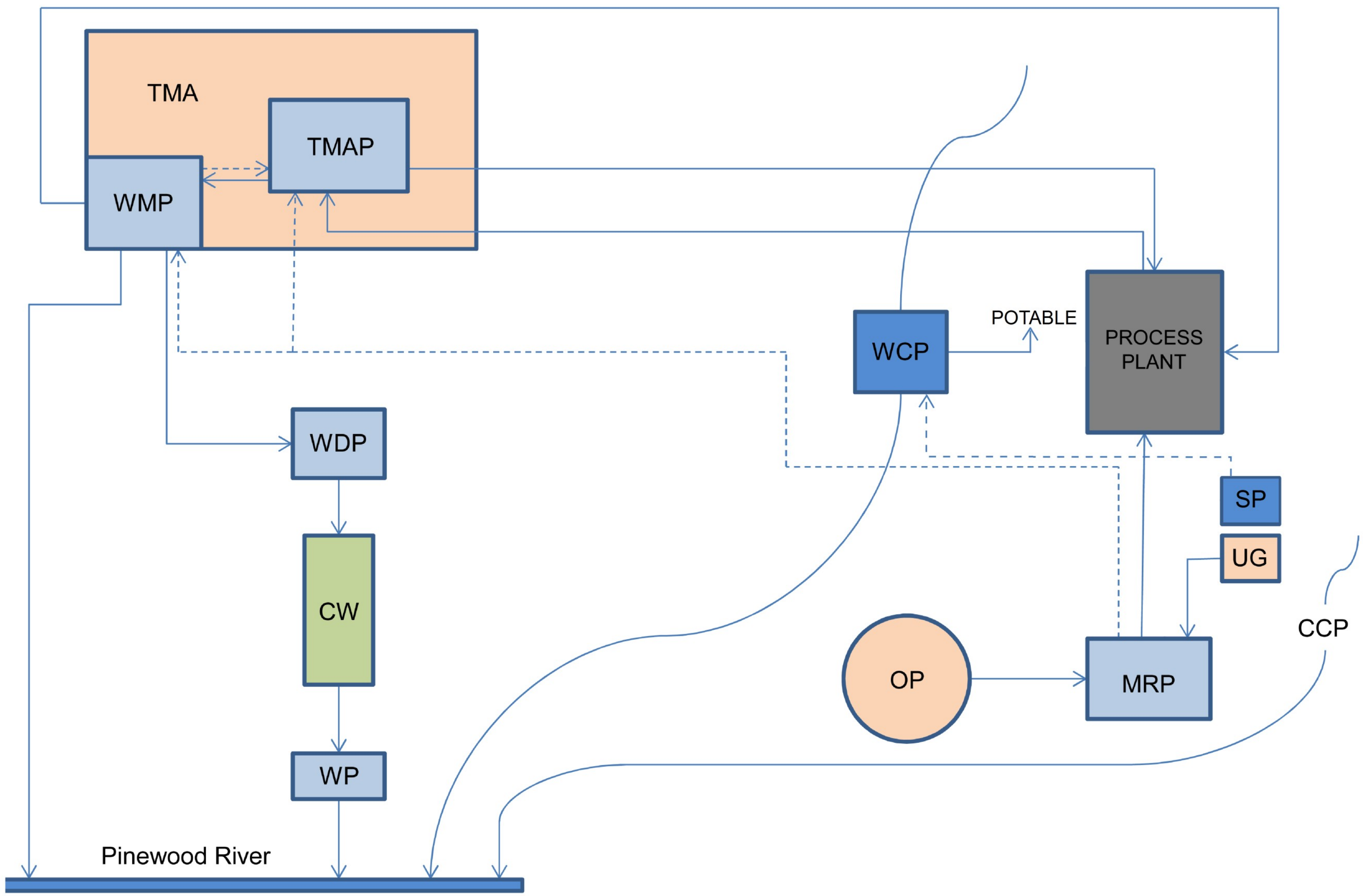
N S E W

PROJECT N°: TC111504

FIGURE: 1

SCALE: 1:37,500

DATE: October 2013



Notes: TMA – Tailings Management Area; WMP – Water Management Pond; TMAP – TMA Pond; WDP – Water Discharge Pond; CW – Constructed wetland; OP – Open Pit; UG – Underground; WP – Wetland Pond; WCP – West Creek Pond / Diversion; MRP – Mine Rock Pond; SP – Stockpile Pond: CCP – Clark Creek Diversion

→ Ongoing Flow - - → Intermittent Flow

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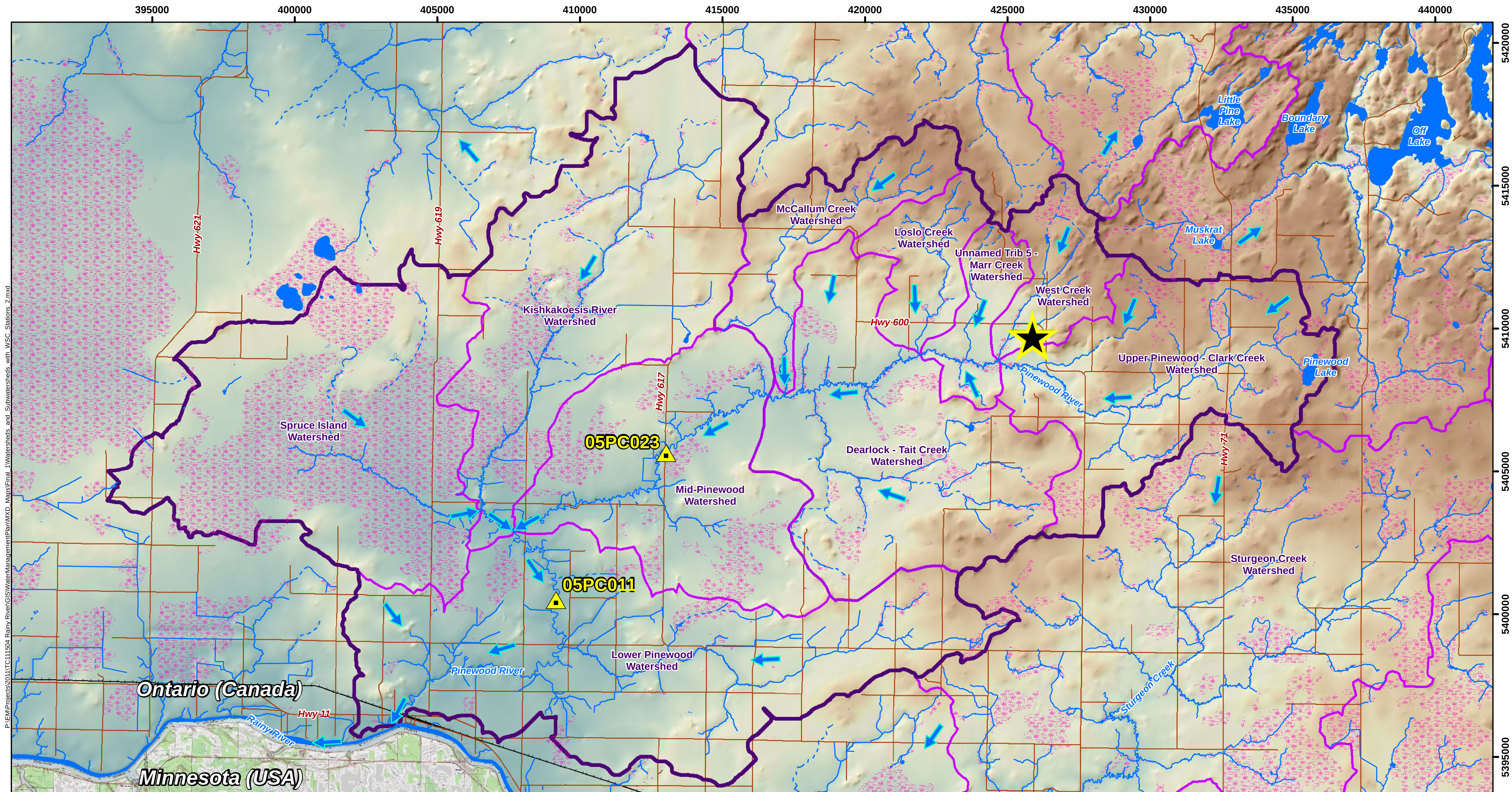
RAINY RIVER PROJECT

Water Management System
Full Operations

PROJECT N°: TC111504	**FIGURE: 2**
SCALE:	DATE: October 2013



LEGEND

- ★ Project Site
- 05PC011 ▲ Water Survey of Canada Station
- Regional Road / Highway
- Railway
- Waterbody
- Permanent Watercourse
- Intermittent Watercourse
- Low-Lying Area
- 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)

-Unnamed 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
-Sturgeon Cr. approx. 21,477 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

N W E S

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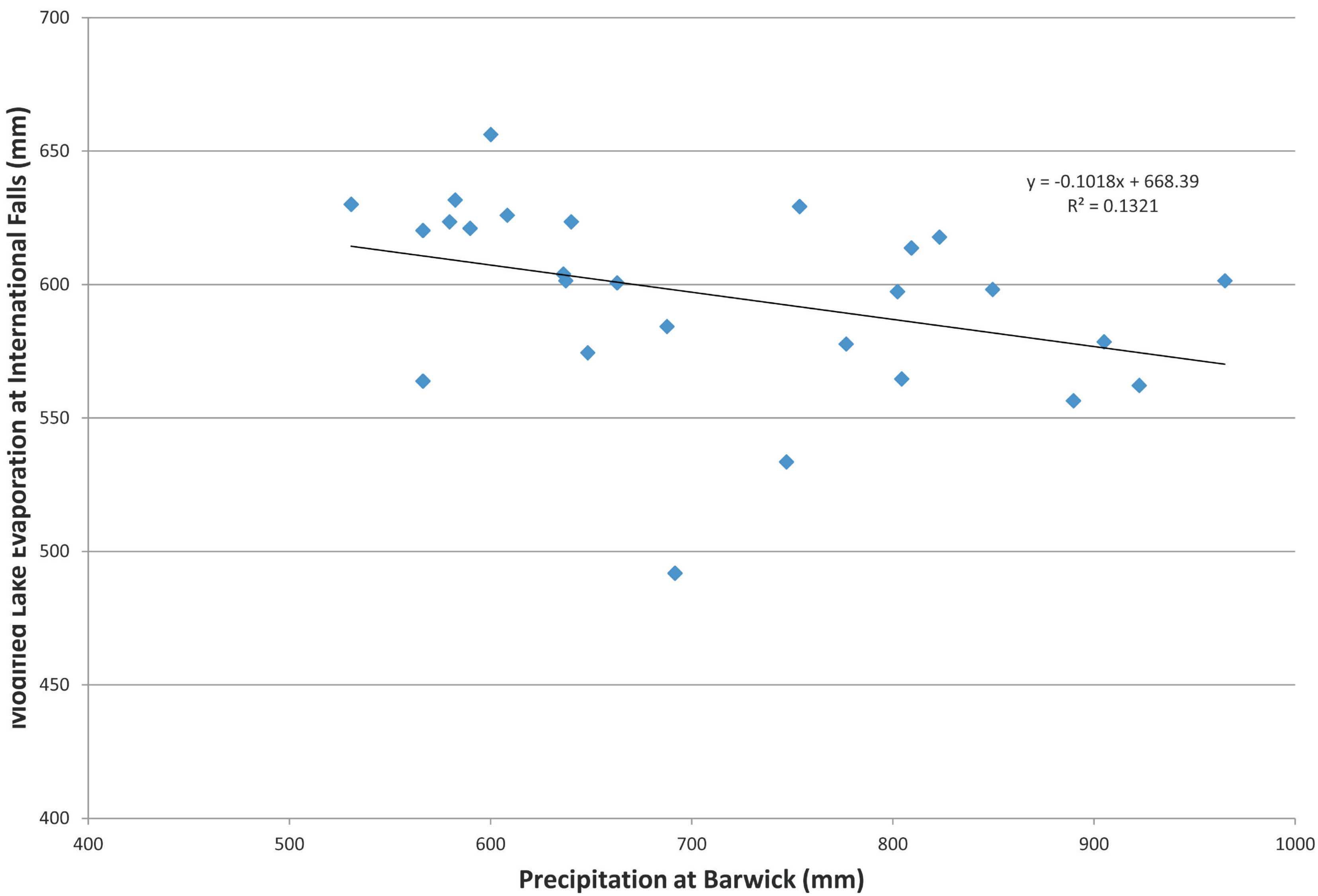
RAINY RIVER PROJECT

Regional Topography, Watershed Boundaries and Water Survey of Canada Stations

PROJECT N°: TC111504	**FIGURE: 3**
SCALE: 1:127,000	DATE: October 2013



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NOTES:

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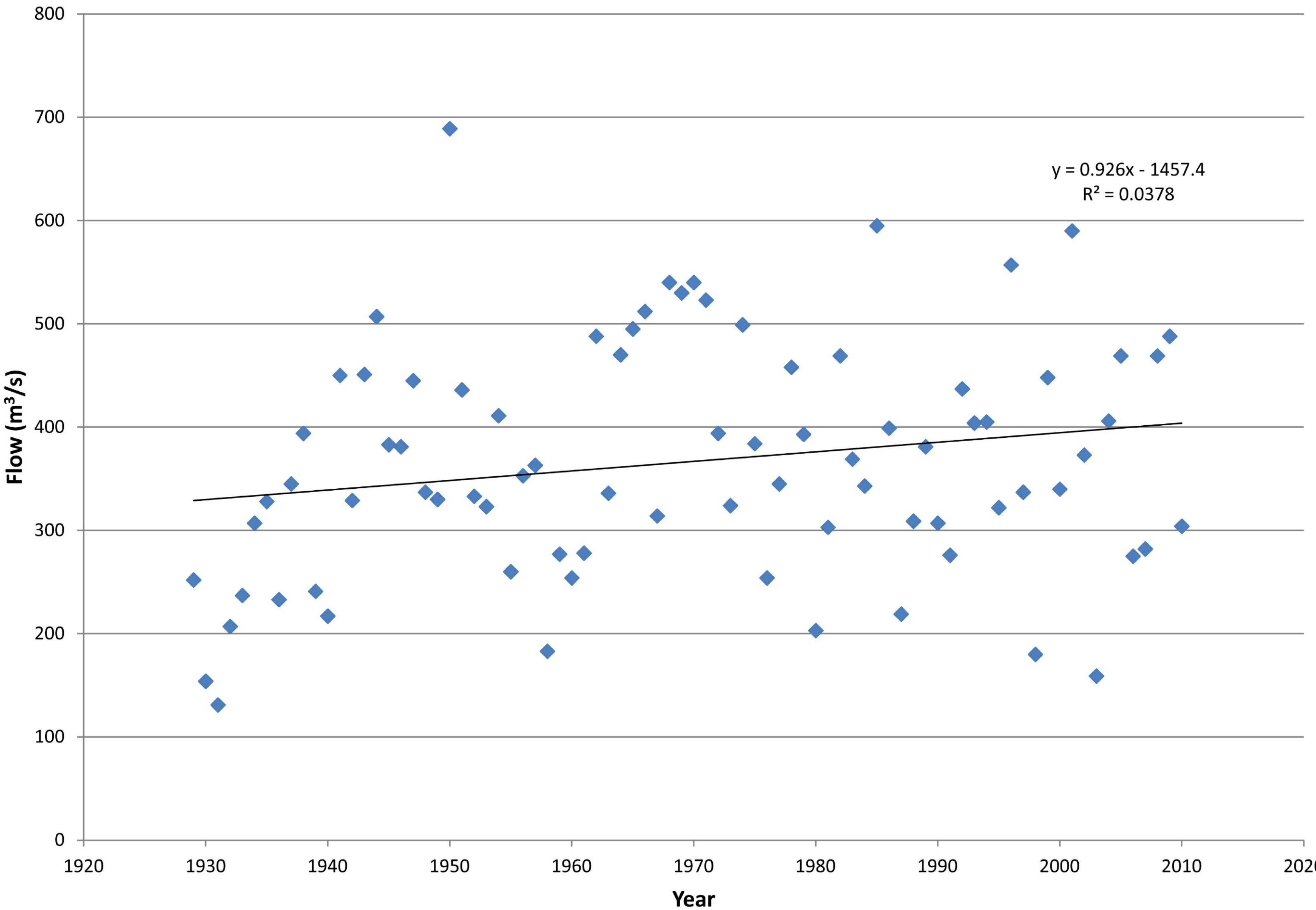
RAINY RIVER PROJECT

Lake Evaporation as a Function of Precipitation

PROJECT N°: TC111504	**FIGURE: 4**
SCALE:	DATE: October 2013



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NOTES:
- Mean annual flow
WCS Station 05PC018 at
Manitou Rapids

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RAINY RIVER PROJECT

Rainy River Hydrologic Analysis

PROJECT N°: TC111504 | **FIGURE: 5**

SCALE: | DATE: October 2013

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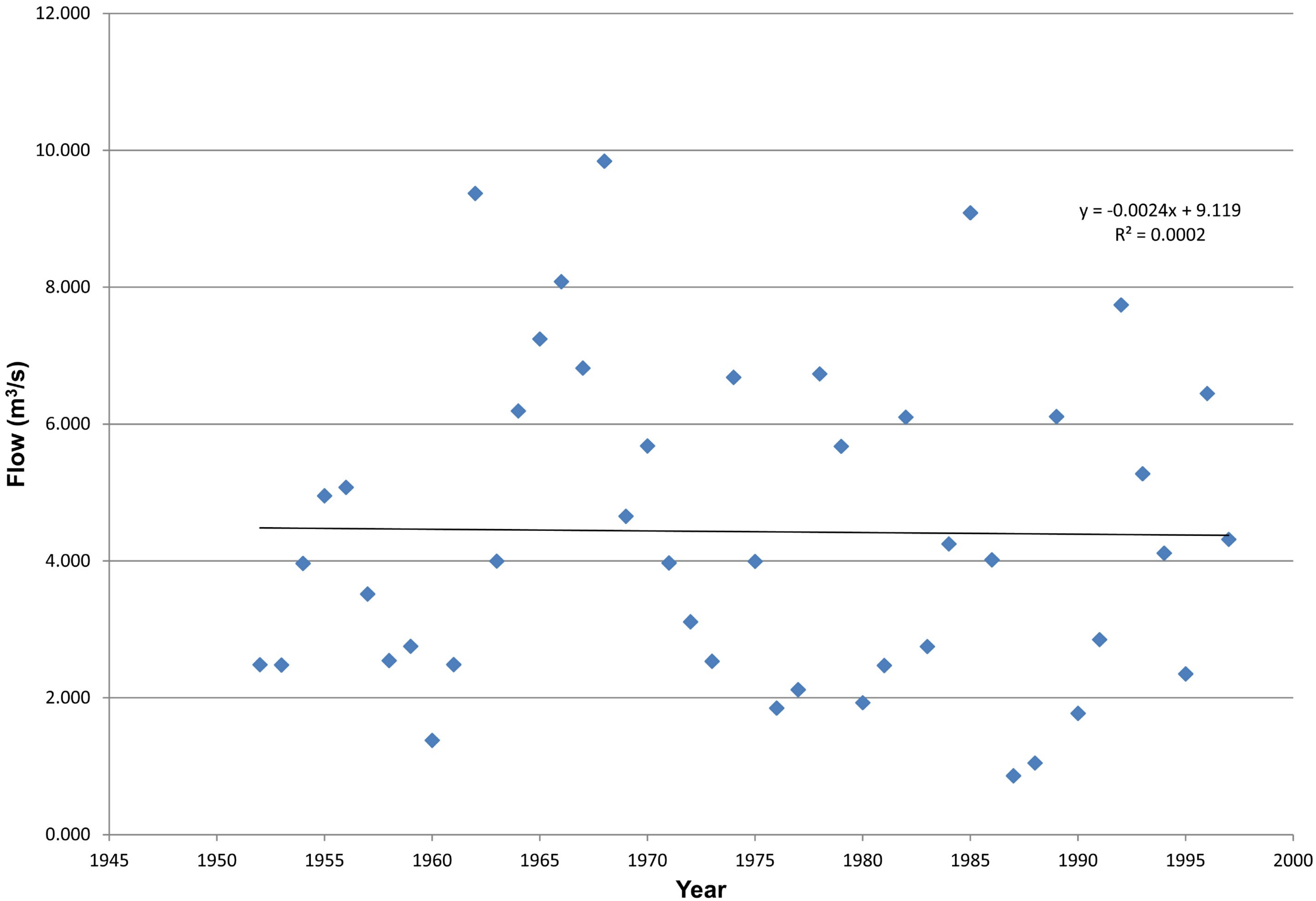

NOTES:
- Mean Flow, March - October
WSC station 05PC011

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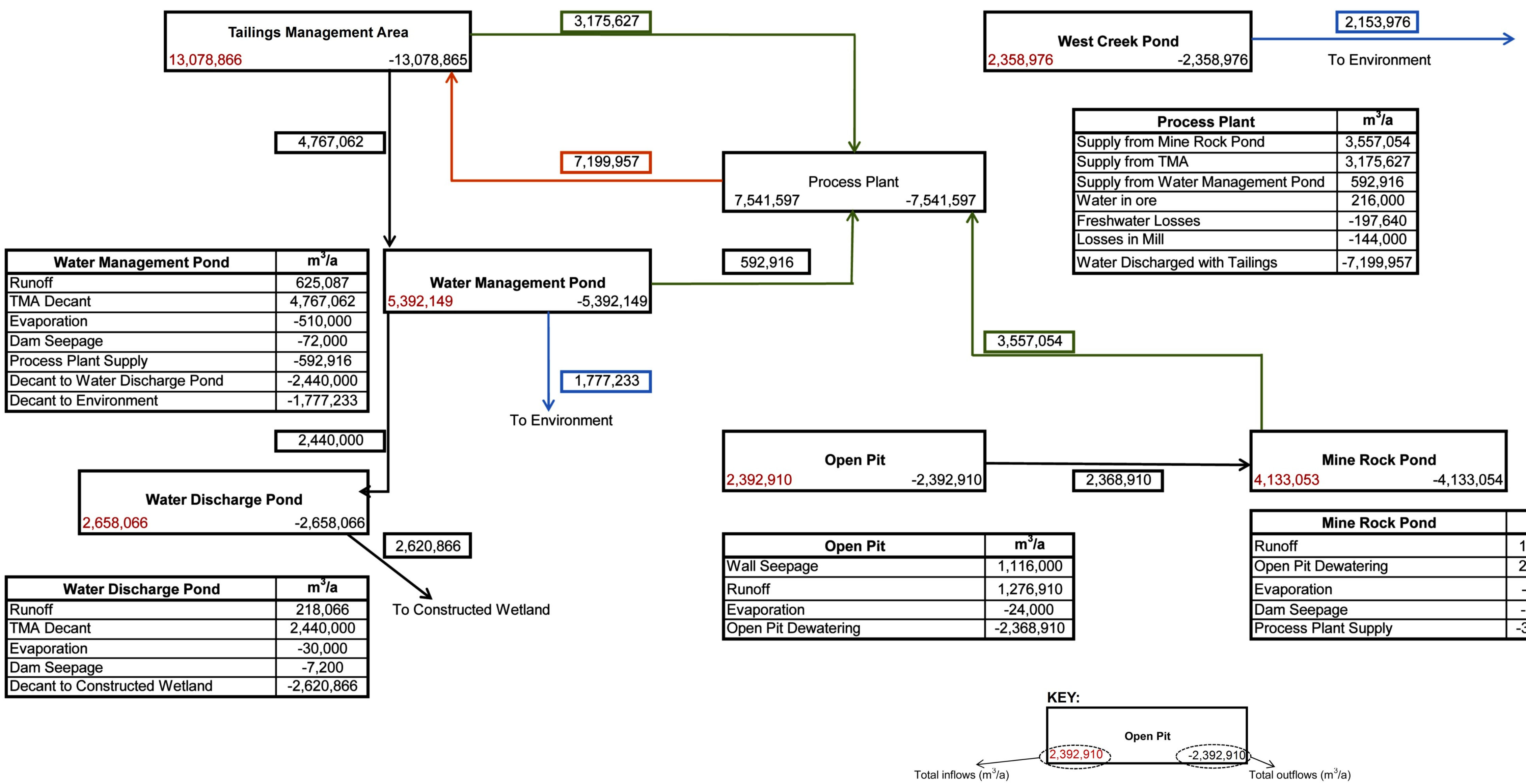
RAINY RIVER PROJECT

Pinewood River Hydrologic Analysis

PROJECT N°: TC111504	**FIGURE: 6**
SCALE:	DATE: October 2013



Tailings Management Area	m^3/a
Water Discharged with Tailings	7,199,957
Runoff	5,878,909
Retained Pore Water	-2,553,176
Evaporation	-2,223,000
Dam Seepage	-360,000
Process Plant Supply	-3,175,627
Decant to Water Management Pond	-4,767,062

West Creek Pond	m^3/a
Runoff	2,358,976
Evaporation	-96,000
Dam Seepage	-36,000
Potable Water	-73,000
Overflow to Environment	-2,153,976

Process Plant	m^3/a
Supply from Mine Rock Pond	3,557,054
Supply from TMA	3,175,627
Supply from Water Management Pond	592,916
Water in ore	216,000
Freshwater Losses	-197,640
Losses in Mill	-144,000
Water Discharged with Tailings	-7,199,957

Water Management Pond	m^3/a
Runoff	625,087
TMA Decant	4,767,062
Evaporation	-510,000
Dam Seepage	-72,000
Process Plant Supply	-592,916
Decant to Water Discharge Pond	-2,440,000
Decant to Environment	-1,777,233

Water Discharge Pond	m^3/a
Runoff	218,066
TMA Decant	2,440,000
Evaporation	-30,000
Dam Seepage	-7,200
Decant to Constructed Wetland	-2,620,866

Open Pit	m^3/a
Wall Seepage	1,116,000
Runoff	1,276,910
Evaporation	-24,000
Open Pit Dewatering	-2,368,910

Mine Rock Pond	m^3/a
Runoff	1,764,143
Open Pit Dewatering	2,368,910
Evaporation	-396,000
Dam Seepage	-180,000
Process Plant Supply	-3,557,054

LEGEND

Water Transfers
- Flows to the Environment
- Process Plant Supply
- Process Plant Discharge
- Water Transfer

Water Volume
- Flows to the Environment (m^3/a)
- Process Plant Supply (m3/a)
- Process Plant Discharge (m3/a)
- Water Transfer (m^3/a)

NOTES:
- Changes in pond storage (losses and gains) are not accounted for in this schematic

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RAINY RIVER PROJECT

Water Balance Operations

PROJECT N°: TC111504 | **FIGURE: 7**

SCALE: | DATE: October 2013

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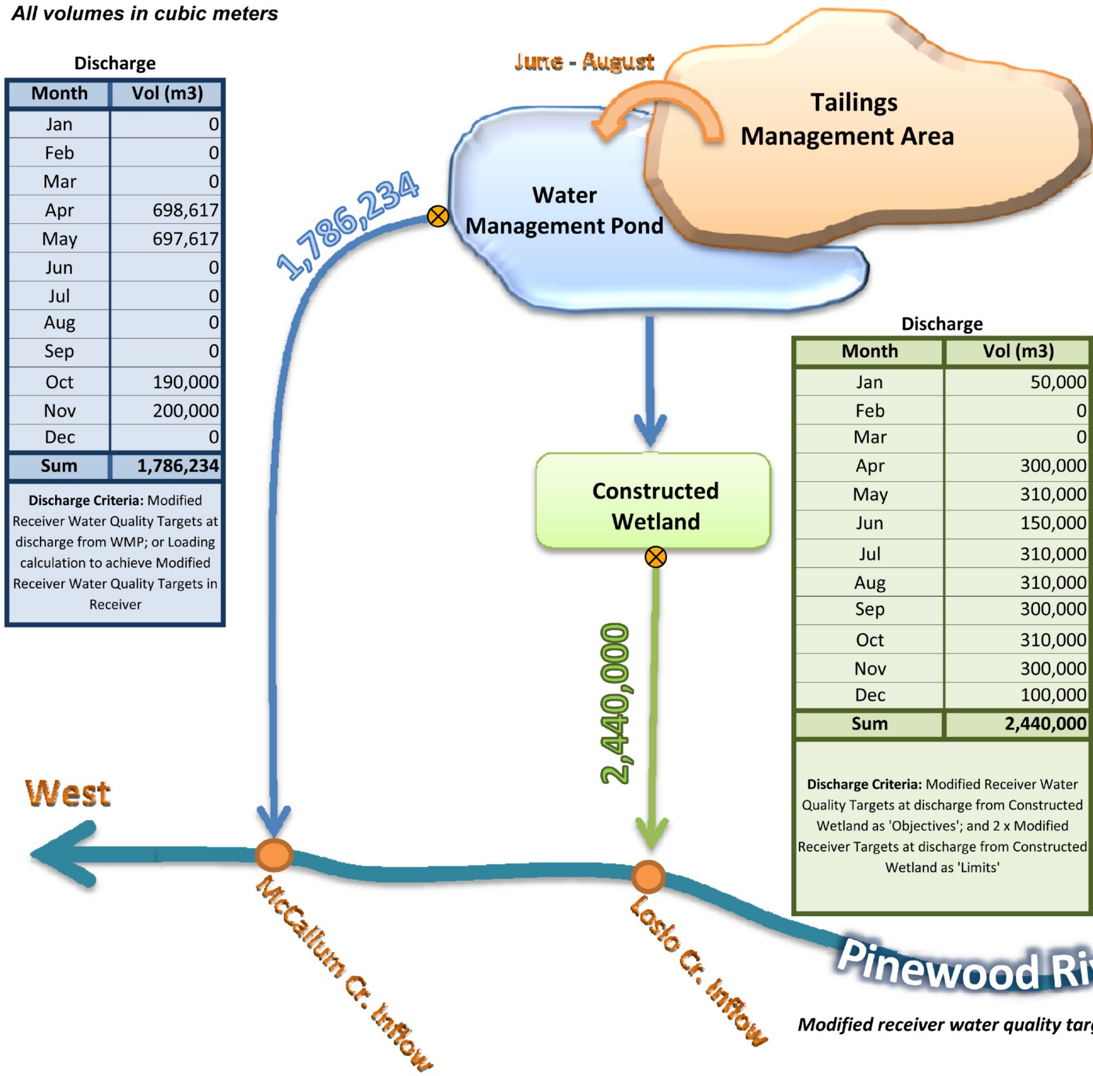
All volumes in cubic meters



Discharge (Water Management Pond)

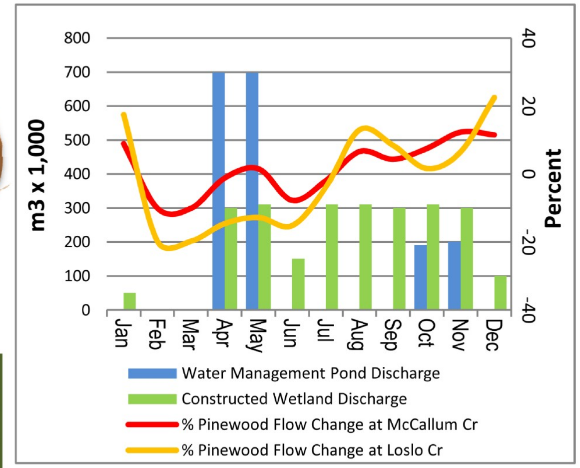
Month	Vol (m3)
Jan	0
Feb	0
Mar	0
Apr	698,617
May	697,617
Jun	0
Jul	0
Aug	0
Sep	0
Oct	190,000
Nov	200,000
Dec	0
Sum	**1,786,234**

Discharge Criteria: Modified Receiver Water Quality Targets at discharge from WMP; or Loading calculation to achieve Modified Receiver Water Quality Targets in Receiver

Discharge (Constructed Wetland)

Month	Vol (m3)
Jan	50,000
Feb	0
Mar	0
Apr	300,000
May	310,000
Jun	150,000
Jul	310,000
Aug	310,000
Sep	300,000
Oct	310,000
Nov	300,000
Dec	100,000
Sum	**2,440,000**

Discharge Criteria: Modified Receiver Water Quality Targets at discharge from Constructed Wetland as 'Objectives'; and 2 x Modified Receiver Targets at discharge from Constructed Wetland as 'Limits'



Pinewood Flow Change at McCallum Creek

Month	%
Jan	8.9
Feb	-10.1
Mar	-10.1
Apr	-1.2
May	1.5
Jun	-7.8
Jul	-2
Aug	6.6
Sep	4.3
Oct	7.5
Nov	12.3
Dec	11.5
Average	**0.30**

Pinewood Flow Change at Loslo Creek

Month	%
Jan	17.5
Feb	-19.8
Mar	-19.8
Apr	-14.6
May	-12.8
Jun	-15.2
Jul	-3.9
Aug	13
Sep	8.4
Oct	1.6
Nov	6.5
Dec	22.5
Average	**-8.01**

Modified receiver water quality targets maintained in Pinewood River at all times

LEGEND

⊗ **Final Compliance Point**

NOTES:

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RAINY RIVER PROJECT

Water Management Schematic
Average Annual Balance - Year 15

PROJECT Nº: TC111504 | **FIGURE: 8**

SCALE: | DATE: October 2013

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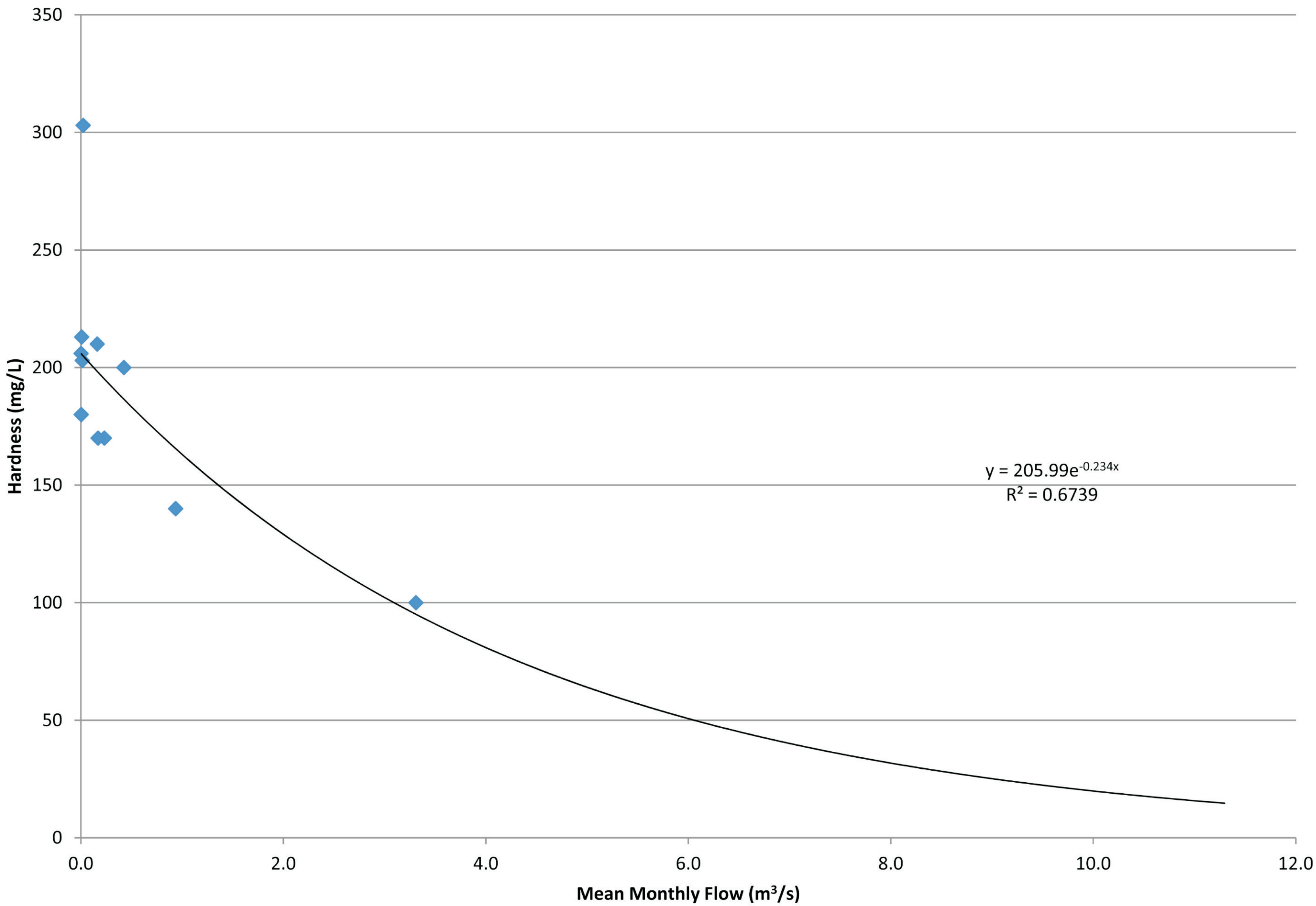

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NOTES:

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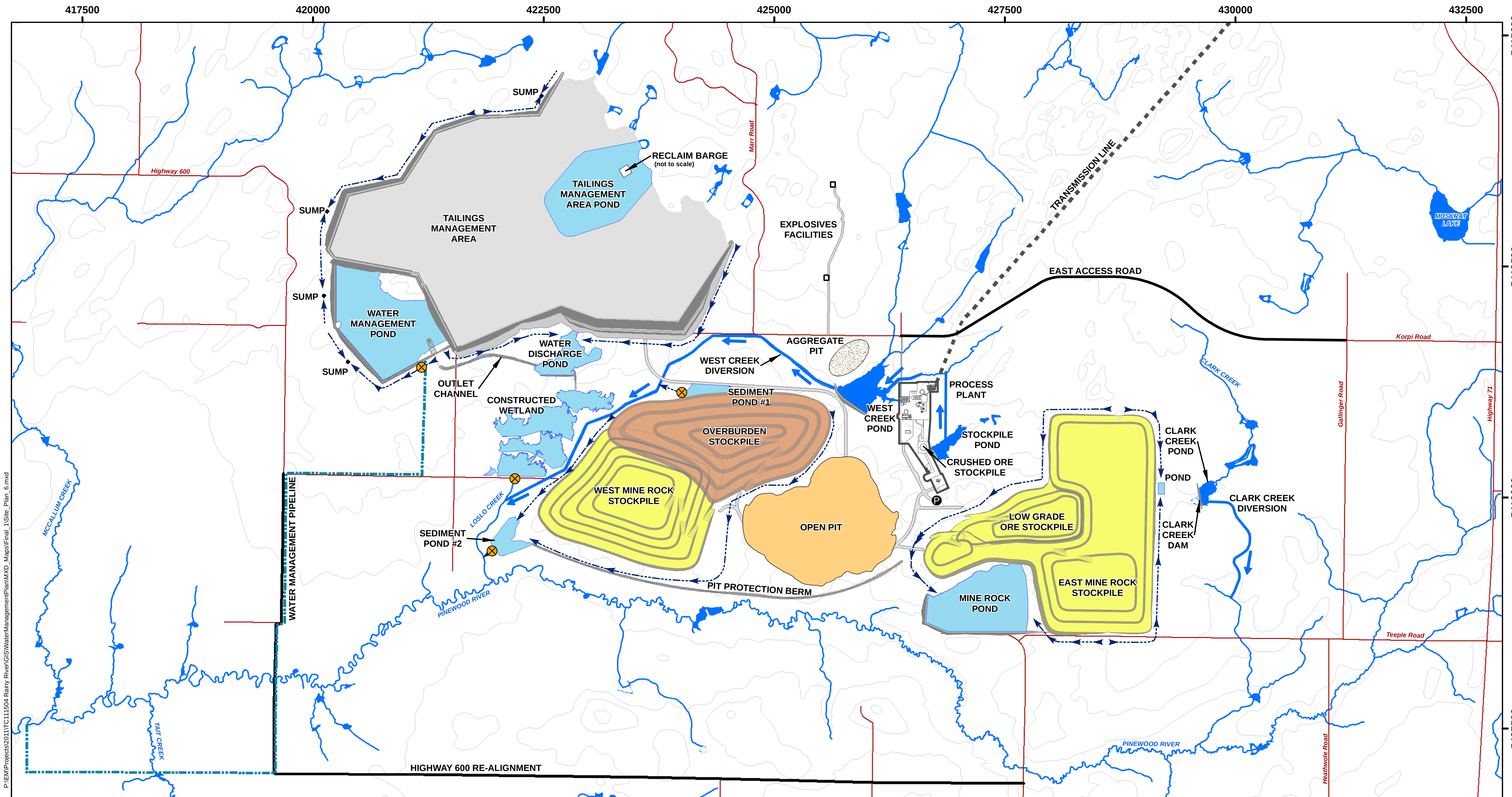
RAINY RIVER PROJECT

Pinewood River
Water Hardness vs River Flow

PROJECT N°: TC111504	**FIGURE: 9**
SCALE:	DATE: October 2013



LEGEND

Proposed Site Features

- Underground Portal
- Open Pit
- Process Plant
- Water Management Pipelines
- Site Roads
- Pond
- Aggregate Pit
- 230 kV Transmission Line
- Deposited Tailings
- Overburden Stockpile
- Rock Stockpile
- Ditch
- Watercourse Diversion
- Flow Direction
- Final Compliance Point

0 1.25 2.5 5 7.5 10 Kilometres

NOTES:
- Site Plan from AMEC CAD drawing May 3, 2013, derived from BBA drawing 3098003-003000-41-D20-0001, April 29, 2013
- Stockpile modification provided by BBA, Sept 30, 2013

Datum: NAD83
Projection: UTM Zone 15N

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RAINY RIVER PROJECT

Water Management Ponds and Associated Runoff and Seepage Collection Facilities

PROJECT N°: TC111504	FIGURE: 10
SCALE: 1:39,500	DATE: October 2013

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LEGEND

- Approximate Principal RRP Facilities
- Existing Watercourse (Labelled with name)
- Proposed Watercouses/Waterbodies for RRP Site (Labelled with name)

NOTES:
-Road and watercourse data extracted from Land Information Ontario (MNR).
-Main background imagery collected in 2011 late summer, and provided by Rainy River Resources.
-Other background imagery provided by ESRI World Image service.

Datum: NAD83
Projection: UTM Zone 15N

0 1 2 4 6 8 10 Kilometres

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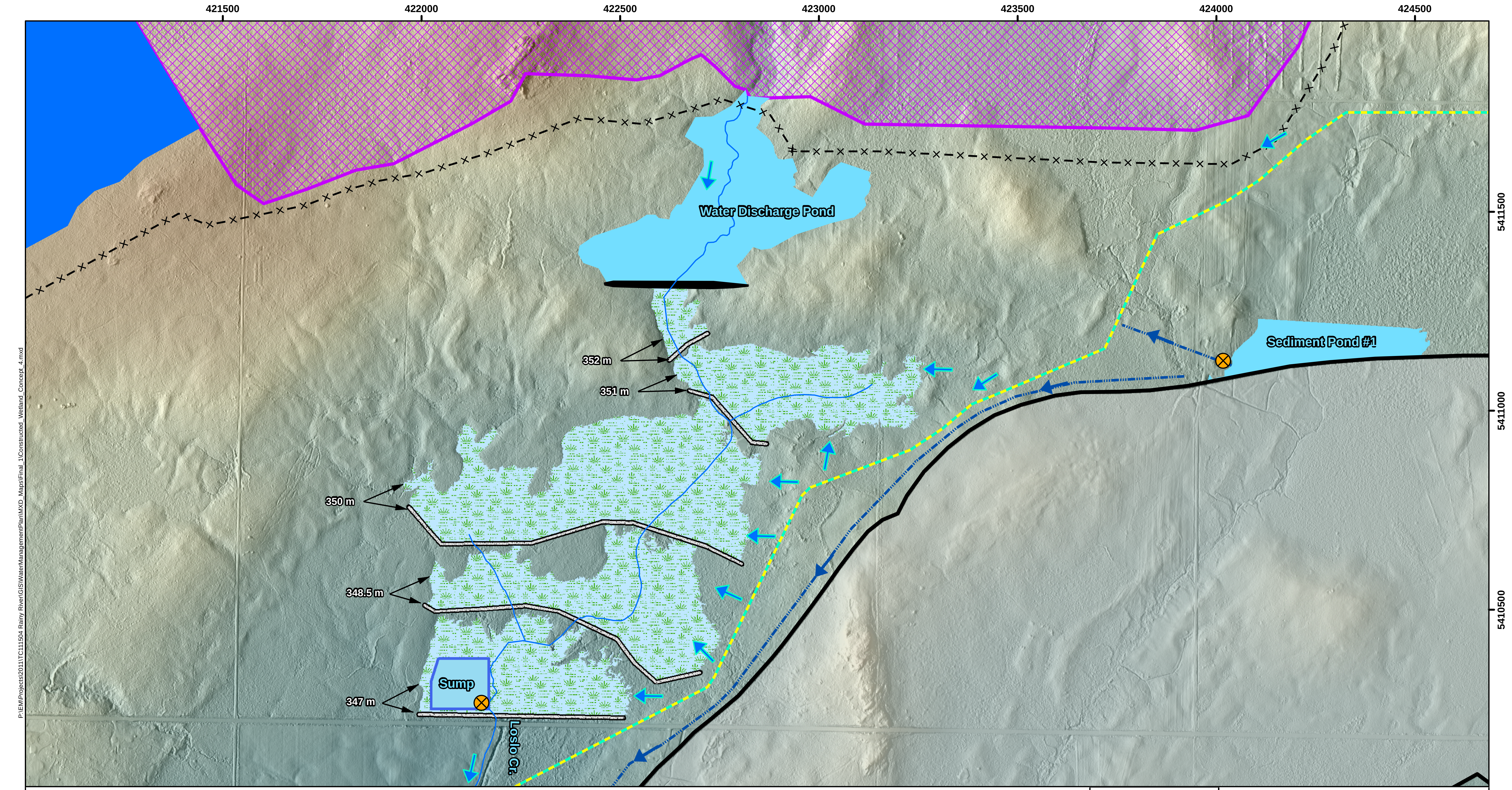
RAINY RIVER PROJECT

Existing and Proposed Watercourses and Waterbodies on the Rainy River Project Site

PROJECT N°: TC111504	**FIGURE: 11**
SCALE: 1:38,000	DATE: October 2013



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LEGEND

- West Creek Diversion Route
- Water Discharge Pond Dam
- Pond / Sump
- Rock Groyne / Dam
- Constructed Wetlands (labelled with crest elevation of groyne/dam)
- General Flow Direction
- Runoff and Seepage Collection Ditch
- Water Discharge Pond and Sediment Pond #1
- Water Management Pond
- Tailings Management Area
- Proposed Overburden/NPAG Mine Rock Stockpile
- Fence (approximate location)
- Final Compliance Point

Elevation Colour Ramp

High ground

Low ground

NOTES:

-

Datum: NAD83
Projection: UTM Zone 15N

N W E S

0 0.25 0.5 1 1.5 2 Kilometres

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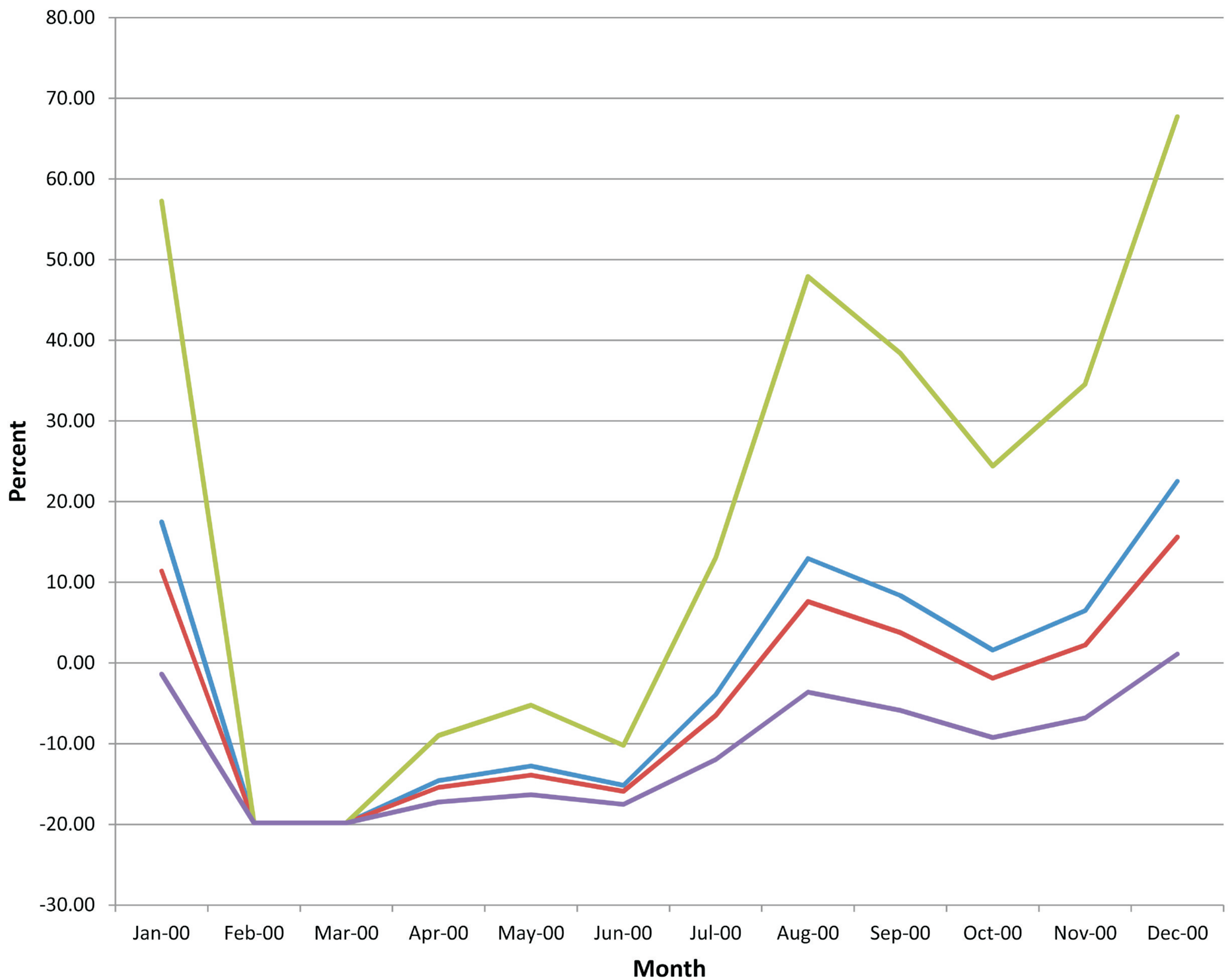
RAINY RIVER PROJECT

Constructed Wetland Concept

PROJECT N^{o}: TC111504	FIGURE: 12
SCALE: 1:9,000	DATE: October 2013



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LEGEND

- Average
- 5th Perc - Yr2
- 5th Perc - Yr15
- 95th Perc

NOTES:

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RAINY RIVER PROJECT

Expected Changes to Pinewood River Flow at Loslo Year 2-15 (V4)

PROJECT N°: TC111504

FIGURE: 13

SCALE:

DATE: October 2013

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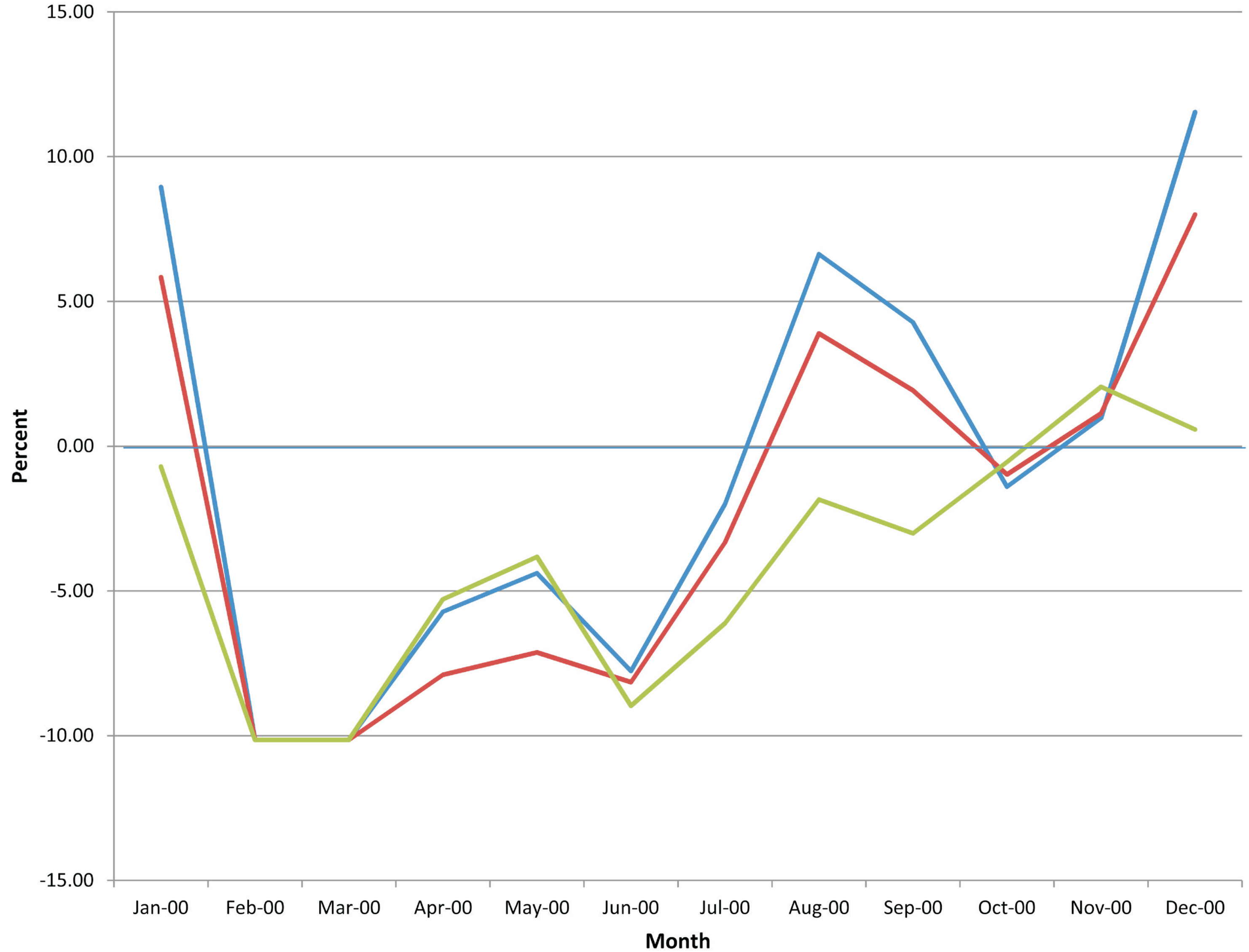

LEGEND

- Average
- 5th Perc
- 95th Perc

NOTES:

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RAINY RIVER PROJECT

Expected Changes to Pinewood River Flow at McCallum Creek Year 2 (V6)

PROJECT N°: TC111504	**FIGURE: 14**
SCALE:	DATE: October 2013

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LEGEND

- Average
- 5th Perc
- 95th Perc

NOTES:

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RAINY RIVER PROJECT

Expected Changes to Pinewood River Flow at McCallum Creek Year 7 (V6)

PROJECT N°: TC111504	**FIGURE: 15**
SCALE:	DATE: October 2013

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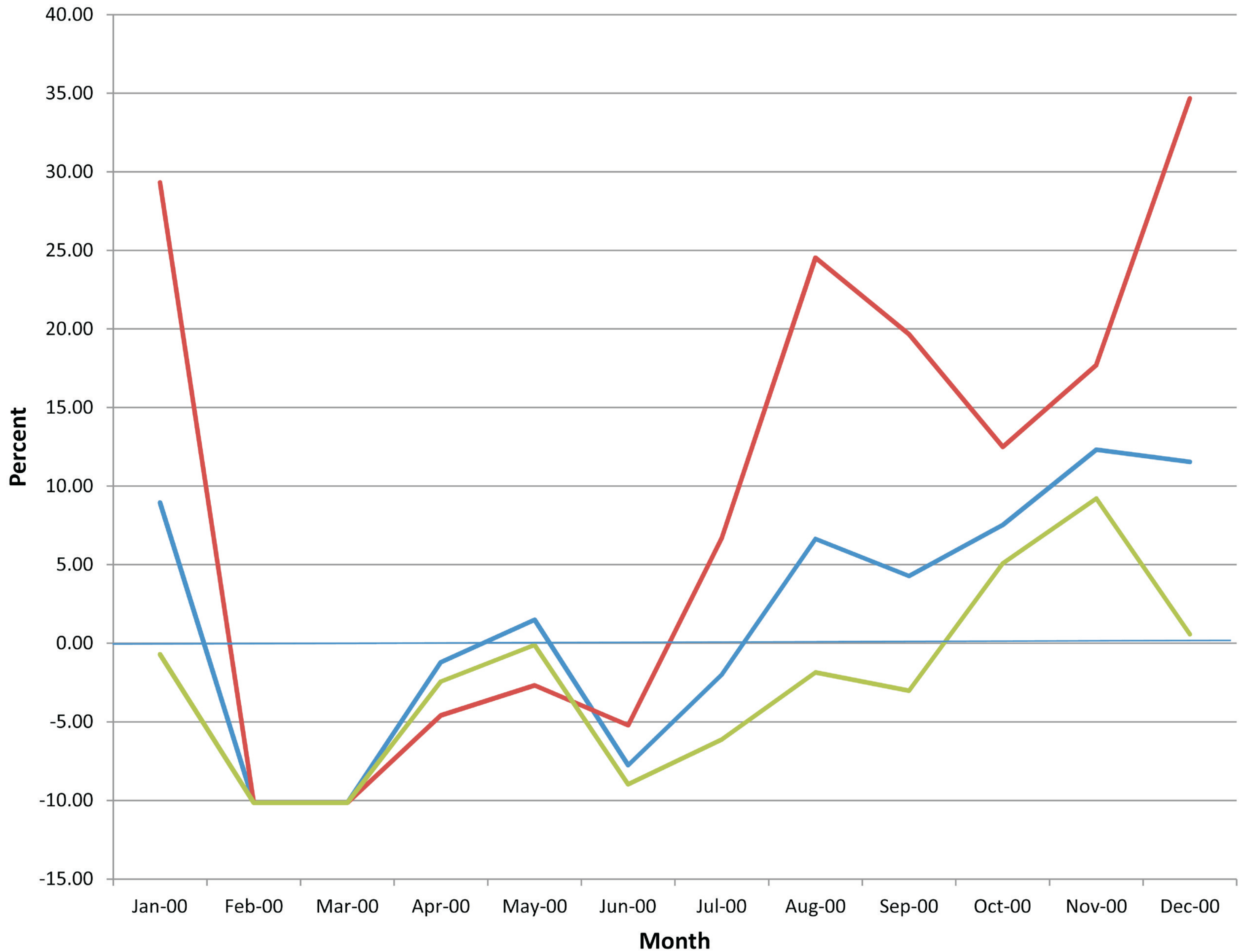

LEGEND

- Average
- 5th Perc
- 95th Perc

NOTES:

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RAINY RIVER PROJECT

Expected Changes to Pinewood River Flow at McCallum Creek Year 15 (V6)

PROJECT N°: TC111504 | **FIGURE: 16**

SCALE: | DATE: October 2013

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LEGEND

- Average
- 5th Perc
- 95th Perc

NOTES:

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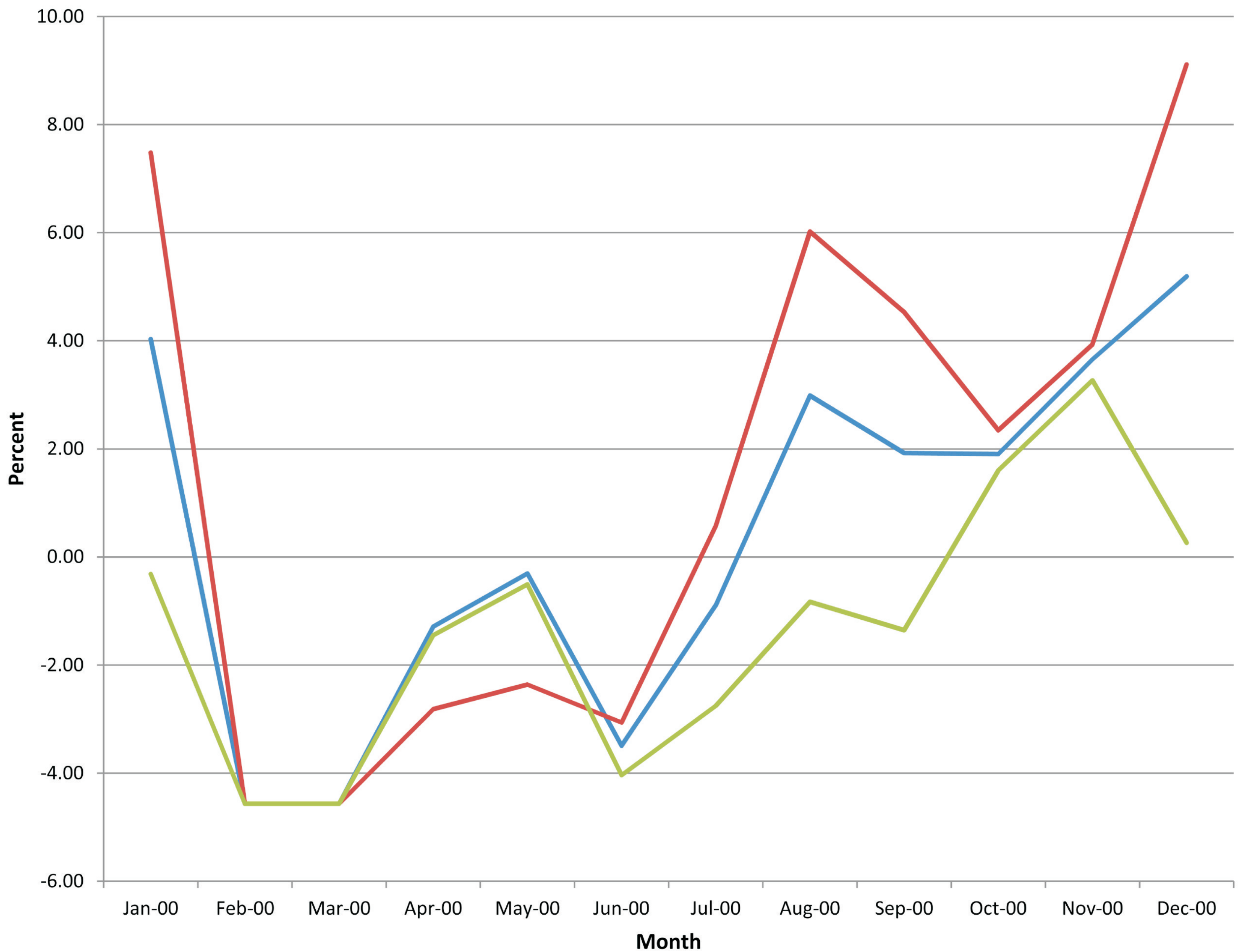
RAINY RIVER PROJECT

Expected Changes to Pinewood River Flow at Kishkakoesis River - Year 2 (V4)

PROJECT N°: TC111504	**FIGURE: 17**
SCALE:	DATE: October 2013



LEGEND

- Average
- 5th Perc
- 95th Perc

NOTES:

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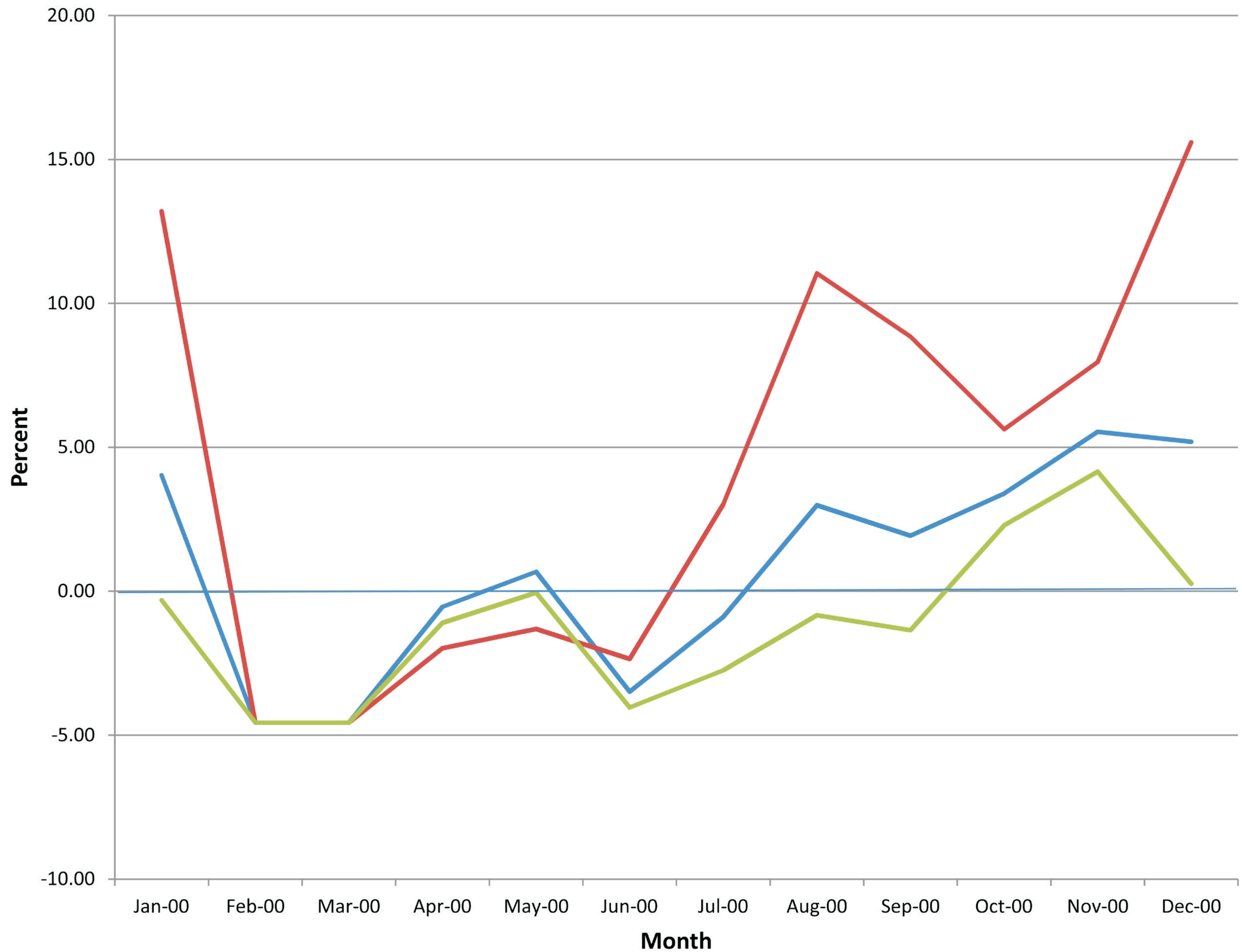
RAINY RIVER PROJECT

Expected Changes to Pinewood River Flow at Kishkakoesis River - Year 7 (V4)

PROJECT N°: TC111504	**FIGURE: 18**
SCALE:	DATE: October 2013



LEGEND

- Average
- 5th Perc
- 95th Perc

NOTES:

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RAINY RIVER PROJECT

Expected Changes to Pinewood River Flow at Kishkakoesis River - Year 15 (V4)

PROJECT N^{o}: TC111504	**FIGURE: 19**
SCALE:	DATE: October 2013