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**Project Memorandum**

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| **To:** | **KGHM Ajax Mining Inc.** | **Doc. No.:** | **BGC-017** |
| **Attention:** | **Nettie Ore** | **cc:** | |
| **From:** | **Cassandra Koenig** | **Date:** | **July 6, 2016** |
| **Subject:** | **Ajax Project EA/EIS – Responses to Information Requests CEAA-047; COK-SLR569 and -570; ECCC-020 and -085; FLNRO-208 and -226; SSN-683, -813, -889, -891, -896 and -898.** | | |
| **Project No.:** | **1125011-10-04** | | |

## 1.0 INTRODUCTION

The Environmental Assessment Certificate Application/Environmental Impact Statement (the Application/EIS) for the Ajax Project (the Project) was issued in January 2016 (KAM 2016). Following a review of the Application/EIS, comments and information requirements (IRs) were provided to KGHM Ajax Mining Inc. (KAM) by the review bodies listed below:

- The Canadian Environmental Assessment Agency (CEAA);
- SLR Consulting (SLR) on behalf of the City of Kamloops (COK);
- Environment and Climate Change Canada (ECCC);
- The Ministry of Forests, Lands & Natural Resource Operations (FLNRO); and
- The Stk'emlupsemc Te Secwepemc Nation (SSN).

This memorandum documents responses to the following IRs.

- CEAA-047;
- COK-SLR569 and COK-SLR570;
- ECCC-020 and ECCC-085;
- FLNRO-208 and FLNRO-226; and
- SSN-683, SSN-813, SSN-889, SSN-891, SSN-896 and SSN-898.

## 2.0 PERMIT INFORMATION REQUIREMENT RESPONSES

### 2.1. Information Requirement Issue ID # CEAA-047

*RE: SSN-309 and SSN-312 Jacko Lake and Peterson Creek (Jacko Lake water level regime)*

*The present Jacko Lake outlet consists of a spillway with a crest elevation of 892 metres above sea level (masl) and a low level outlet which maintains Jacko Lake levels during spring freshet to a little above the spillway crest (i.e., just below 892 masl). As part of the water management system, the existing dam at Jacko Lake will be replaced with a four dam system with a higher crest height (given as 894.5 masl in Section 11.7.3.3 and 895.5 masl in Appendices 3-F and 17.4-D).*

*The purpose of raising the Jacko Lake dam is to fully contain the Inflow Design Flood, which is defined as the runoff associated with a 24-hour Probable Maximum Precipitation (PMP) event. Appendix 17.4-D, Appendix A (Table 3, page 5) notes that the spring 24-hour PMP with snowmelt (PMP of 221 mm plus 108 mm of snowmelt) produces a flood volume of 9.65 million $m^3$; to fully contain this flood volume, crest elevation would need to be 902.3 masl.*

*A pumping system is also being built to divert flow to the Peterson Creek Diversion System (PCDS) to maintain water in lower Peterson Creek; however, the PCDS is not designed to carry flood event volumes. Due to the raised elevation of the four dam system, Jacko Lake could increase several metres over its current flood elevation. Such a change in water level regime could have effects on Jacko Lake aquatic and terrestrial valued components.*

*IR: Describe the design of the Jacko Lake dams, including final elevation (i.e., reconcile the difference in final crest elevation for the Jacko Lake dams noted in Section 11.7.3.3 and Appendices 3-F and 17.4-D), and the normal operating level of Jacko Lake and describe how water levels will be managed.*

*Describe the water management strategy for a 24-hour flood event, taking into account the limited outflow capacity to the Peterson Creek Diversion System (pump discharge of 0.08 $m^3$/s).*

*Provide an assessment of the environmental effects to Jacko Lake and any associated valued components (e.g. wetlands, vegetation, migratory birds, etc.) resulting from raising the elevation of Jacko Lake dams that takes into account the magnitude, extent, and timing of the flood event inflows.*

<u>Response</u>

It should be noted that, through stakeholder and Aboriginal feedback, evaluations are currently underway to make changes to the Jacko Lake dams and Peterson Creek culvert designs to preserve the Aboriginal fisheries, and provide fish compensation for the loss of the North East arm of the lake. The flow capacity of the current Peterson Creek culvert system is designed to carry up to 0.3 $m^3$/s. The reviewer is referred to Supplementary Response Memorandum “0706_KAM_Fish Offsetting Plan” for updated design information.

Dam locations are shown on Figure 2.2-1 (KAM 2015). All dams will be constructed with minimum crest widths of 5 m and design slopes of 3H:1V (upstream and downstream). The normal water level of Jacko Lake will be maintained at an elevation of 892.0 masl using a diversion pumping system (Peterson Creek Diversion System) that includes a single pump station with two independent pump sets.

As noted in IR #MOE-012 and #SSN-309, an updated analysis has been conducted for the Peterson Creek Diversion System (PCDS) pumping system. There will be a single pump station with two independent pump sets inside. Both will utilize the same dedicated pipeline. Each pump set will have a separate duty, specifically:

1. Pump Set 1 (252 $m^3/h$ x 2) (0.070 $m^3/s$ x 2) will handle normal operation flows. These are seasonally variable flows maintaining downstream water license holders during operations, drawing only from water above the conservation level.
2. Pump Set 2 (1440 $m^3/h$ x 2) (0.40 $m^3/s$ x 2) will handle the 200-year, 24-hour storm event volume pumped out over a three-day period. The pump station will prevent overflow of Jacko Lake that could potentially cause flooding of downstream mine infrastructure.

The purpose of the dams is to manage stormwater that causes the lake to rise above the normal water level of 892.0 masl during large rainfall/runoff events. The dams have been designed to store runoff into Jacko Lake greater than twice the estimated Probable Maximum Flood (PMF) as described in Appendix 3-F. The PMF volume has been estimated at 0.8 $Mm^3$, while the estimated storage capacity at a dam crest elevation of 895.5 masl is approximately 2.2 $Mm^3$ (see Section 3.1, Appendix 3-F). The PMF flood volume of 9.65 $Mm^3$ noted in Appendix 17.4-D, Appendix A (Table 3, page 5) is work conducted by Knight Piésold during an earlier phase of the work, which has since been superseded by the work of Norwest (Appendix 3-F).

Assessment of the environmental effects to Jacko Lake and any associated valued components (VCs) resulting from the increased impoundment level of the Jacko Lake dams is provided by others as part of the Application/EIS. The preliminary design report for modifications to Jacko Lake is included as Appendix 3-F of the Application/EIS. The reviewer is also referred to Section 8.7 (Supporting Topic – Jacko Lake) of the Application/EIS, which discusses various aspects of the changes to Jacko Lake and their impact to other VCs.

## 2.2. Information Requirement Issue ID # COK-SLR569

*The southwest edge of the pit will intersect the permeable glaciofluvial sediments in the bottom of the Peterson Creek Valley. It is unclear from the modelling report if and how this intersection was modeled to assess effects of pit dewatering on groundwater levels (particularly in relation to potential water level effects in the Peterson Creek Aquifer) and to estimate volumes of water flowing to the mine pit.*

*Clarification is requested explaining specifically how this aspect was addressed.*

<u>Response</u>

The southwest edge of the proposed pit intersects a zone of overburden materials that were interpreted as glaciofluvial deposits based on published regional mapping and depositional models, local surficial mapping, stereo aerial photograph pairs and correlation of geological materials intercepted in boreholes advanced through overburden (Drawings K-1 and K-2, Appendix K of Appendix 6.6-A of the Application/EIS). These materials were interpreted to form as a result of glaciofluvial processes that generated highly heterogeneous aquifer complexes, which comprise zones of low hydraulic conductivity silts and clays (i.e., diamicton) and not strictly permeable sands and gravels.

This geological interpretation is discussed in detail Section 5.2 of Appendix 6.6-A of the Application/EIS and is substantiated by:

- A lack of direct lateral correlation between the lithology of surface materials over short distances (e.g., between: BGC14-PW01 and BGC14-018, which are 10m apart; and KAX-14-107 and KAX-14-114, which are 75m apart)
- A wide range in hydraulic conductivity estimates within test wells advanced into overburden as a part of investigations for the Project (i.e., $3x10^{-5}$ m/s to $1x10^{-7}$ m/s, as measured during slug testing in AJGW01-D, AJGW07-D/S, KAX-14-114S, and KAX-14-128S)
- The type stratigraphy for deposits within the Peterson Creek Valley near Kamloops, as interpreted by Armstrong and Fulton (1965), Fulton (1967) and Fulton and Smith (1978)
- The glacial retreat depositional model (presented in Section 5.2.5.2 of Appendix 6.6-A of the Application/EIS) associated with the decay of the Cordilleran Ice Sheet that covered the RSA, which discusses:
  - Proglacial and/or subglacial deposition and erosion within depressions that were occupied by active and/or stagnating glacier ice and ice dammed lakes
  - Deltaic or fan deposition by meltwater discharging from deglaciated uplands into ice-dammed lakes.

Thus, although the glaciofluvial complex itself may be laterally continuous within the Peterson Creek Valley (and may extend to Jacko Lake, as suggested by interpretation with the stereo aerial photographs in Appendix K of Appendix 6.6-A), glacial processes such as meltwater scour and fill are likely to have truncated and subsequently filled scour voids with different materials at depth. This would have resulted in isolated pockets of permeable sands and gravels truncated by finer grained silts and clays (as observed within boreholes on site), and as such, limit the ability of the complex as a whole to transmit appreciable volumes of groundwater.

Despite the observed lack of continuity of permeable sediments within the glaciofluvial deposits that occupy the Peterson Creek Valley, a conservative case for potential Project impacts to groundwater quantity was simulated with the groundwater model. This was done by implementing the lateral limits of the glaciofluvial materials (i.e., as mapped by the various sources noted in Drawing 07 and Section 5.2 of Appendix 6.6-A of the Application/EIS) and the Peterson Creek Aquifer (i.e., as mapped by the MOE) as a single hydrostratigraphic unit within the groundwater flow model. The calibrated hydraulic conductivity (K) for this unit was $1.4 \times 10^{-5}$ m/s in the groundwater flow model. This is comparable to the geometric mean K of fluvial and glaciofluvial sands and gravels in the regional study area (RSA) of $1 \times 10^{-5}$ m/s (Figure 11, Appendix 6.6-A of the Application/EIS). This is approximately one order of magnitude higher than the K measured in KAX-14-114-S (the test located closest to the area of concern), and is therefore considered a conservative value for the materials logged near the southwest edge of the proposed pit. Stratification of the deposits was not explicitly represented in the groundwater flow model, however, a vertical K of $1.4 \times 10^{-6}$ m/s was assigned to this unit in order to simulate layering within the glaciofluvial complex.

The thickness of the glaciofluvial complex (and all surficial deposits in the model) were represented by varying model grid elevation to coincide with an isopach generated from depth to bedrock observations in boreholes within the LSA and RSA (See Figures 2 and 4 in Appendix 6.6-A of the Application/EIS). Near the southwest edge of the proposed open pit, the thickness of these deposits in the model is approximately 10m to 40m (i.e., comparable to 34 m of overburden observed in well KAX-14-130 and 39 m of overburden observed in well KAX-14-107); within the area mapped as the Peterson Creek Aquifer, the thickness of these deposits in the model was 80 m (i.e., comparable to the 80 m of overburden noted in BGC14-PW01 and 81 m in BGC14-018).

Modelling of mining operations was carried out by implementing the proposed open pit shells as drain boundaries, as described in Section 6.4.6 in Appendix 6.6-d of the Application/EIS. The pit shells intercepted the glaciofluvial materials represented in the model near the southwest edge of the proposed open pit, and groundwater was allowed to passively flow from the model cells representing the glaciofluvial deposits into the proposed open pit (i.e., no mitigations to maintain groundwater levels in the glaciofluvial materials were implemented in the groundwater model). Further east, the modelled open pit did not intercept the Peterson Creek Aquifer, as the Aquifer's mapped limits do not extend to the pit. Volumes of groundwater entering the open pit were estimated using the program ZONEBUDGET in the area of the advancing pit shell, and are summarized in Table 13 of Appendix 6.6-D of the Application/EIS. A sensitivity analysis was conducted by varying the hydraulic conductivity of all hydrostratigraphic units in the model by a factor of five, and the results from these simulations are summarized in Table 14 of Appendix 6.6-D of the Application/EIS.

The simulated mine site water table and groundwater flow directions are shown on Figure 29 of Appendix 6.6-D of the Application/EIS for mining years -2 to 20, and in Figure 32 for post closure conditions. Near the southwest edge of the proposed open pit, a maximum drawdown of approximately 20 m compared to existing conditions is simulated (Drawing 06, Appendix 6.6-D of the Application/EIS).

Within the area mapped by the MOE as the Peterson Creek Aquifer, a maximum drawdown of approximately 50m compared to existing conditions is simulated (Drawing 06, Appendix 6.6-D of the Application/EIS). For additional discussion regarding the section of the Peterson Creek aquifer located adjacent to the southeast corner of the pit, the reader is referred to the response to IR COK-SLR570.

### 2.3. Information Requirement Issue ID # COK-SLR570

*The interpreted north edge of the Peterson Creek Aquifer passes very close to the southeast edge of the pit (within ~100 m). As in any geologic mapping of subsurface units, uncertainties about the exact edge of the aquifer would be expected. Drawing 6.6-E-4 in Appendix 6.6-E suggests there may be gap of approximately 500 m between DH14-060 and AJGW06-D where there are no boreholes to confirm whether the Peterson Creek Aquifer sediments could extend further* *northward in this area than currently interpreted and therefore, potentially intersect the pit wall. If the southeast edge of the pit were to intersect the Peterson Creek Aquifer, the outcome could be larger drawdown effects on groundwater levels in the Peterson Aquifer and larger volumes of groundwater discharging into the pit. Clarification is requested to specifically summarize the information supporting the current interpretation that the Peterson Creek Aquifer does not intersect the planned southeast edge of the pit and what mitigation actions would be taken should, in future investigations, it is found that the pit does intersect the aquifer.*

Response

The mapped extent of the Peterson Creek Aquifer was downloaded from the Water Resources Atlas of BC (WRBC) in January 2015 (BC MOE, 2015). The WRBC Atlas relies on existing geologic, hydrologic and topographic data, and only delineates and classifies aquifers if sufficient groundwater development data is available. In cases where aquifers could not be fully delineated, especially confined unconsolidated aquifers and bedrock aquifers, the BC MOE defined aquifer boundaries by areas of groundwater development. Aquifer boundaries within the inventory therefore range from reasonable assessments (where detailed information is available) to general approximations (scarce information availability). In general, aquifers with areas less than 1 km$^2$ have not been mapped (BC MOE 2015). Due to resource or data constraints at the time of mapping, the BC MOE defined some boundaries within the dataset to coincide with mapsheet boundaries (BC MOE 2015).

The boundaries defined by the Water Resources Atlas are generally supported by core logs from the 20+ drill holes located within and adjacent to Peterson Creek Aquifer (see Drawings 01 and 02 in Appendix 6.6-C, and core logs in Appendix 6.6-A). Without direct evidence suggesting that the mapped extent of the aquifer is incorrect, there is no reason to alter the mapped boundaries.

To address the specific concern: there are two test pits located between DH14-060 and AJGW06-D (i.e., TP14-279 and TP14-278, see Drawing 03 in Appendix 6.6-A). In TP14-279 bedrock was reached at a depth of 4 m (894 m asl). Bedrock was not reached in TP14-278, which extended to a depth of 3.5 m (879.5 m asl). The groundwater table was not reached in either test pit. Bedrock was reached within 0.3 m of the surface in both AJGW06-D (el. 890 m asl) and DH14-060 (el. 914.3 m asl). In the location of concern, the pit crest will be at an elevation of approximately 900 m asl, and it is possible that the PC Aquifer will extend towards and daylight within the open pit between TP14-278 and AJGW06-D, though this is not anticipated based on the shallow depth to bedrock observed at AJGW06-D.

As shown in Figure 05 of Appendix 6.6-D, the groundwater elevation in the Peterson Creek Aquifer ranges between 900 m asl and 875 m asl in the vicinity of the proposed pit, with flow directed towards Peterson Creek (away from the pit). As shown in Figure 29 and Drawing 05 of Appendix 6.6-D, the groundwater elevation in the Peterson Creek Aquifer will be significantly altered during the course of mining and flow is anticipated to be directed towards the pit during operations. Although not anticipated, if significant flow from the PC Aquifer into the pit is observed during operations, then an appropriate mitigation strategy will be developed. KAM will be monitoring the PC Aquifer regardless of whether significant flow is observed and will mitigate if effects on the Aquifer are realized. Appropriate mitigations will be developed based on conditions encountered; examples that might be appropriate include interception wells/local scale depressurization, hydraulic cutoff (e.g. bentonite slurry wall in unconsolidated deposits or targeted grouting in rock).

## 2.4. Information Requirement Issue ID # ECCC-020

*This water table elevation change figure indicates an increased water table height under the TSF on closure compared to existing conditions. Text (p. 6.6-47) states level is expected to subside over time.*

*Predict and present when water table equilibrium is expected.*

Response

Detailed estimates of tailings properties affecting post-closure consolidation are not available at this stage of the Project. Therefore, the time required for water levels within the Tailings Storage Facility (TSF) to reach a state of equilibrium with the underlying groundwater flow system is subject to uncertainty. Results of consolidation modelling based on laboratory testing suggest that consolidation seepage from the tailings will decline rapidly in the first few years to decades following closure (KP, 2015). However, based on the Project water balance model, it is currently estimated that it may take several hundred years for the tailings column to reach a generally unsaturated state (Section 8.5, Appendix 6.4-C).

As a result, the approach taken by the Proponent to simulate the TSF at closure was to specify a general head boundary condition at the location of the tailings beach. This is a conservative assumption from an ongoing source of seepage perspective (i.e., over-predicts seepage), but not conservative from a water quantity perspective (i.e., overestimates the quantity of water supplied to the subsurface). Both seepage from the TSF and groundwater levels within the footprint of the TSF will decline in the post-closure period as the tailings consolidate and drain. As actual tailings properties (i.e., hydraulic conductivity and storage) become available at future Project stages (i.e. during Operations from testing of tailings deposited in the TSF and fro operating water balance performance), additional simulations could be conducted to better represent the nature of the thickened tailings.

Reference: Knight Piésold Ltd., 2015. Report on laboratory geotechnical testing of tailings materials and tailings consolidation modelling – Rev A. Report prepared for KGHM Ajax Mining Inc., data May 15, 2015.

## 2.5. Information Requirement Issue ID # ECCC-085

a. *It is indicated in the application that with the pit design as proposed Jacko Lake would contribute approximately 60-300 $m^3$ /day of the groundwater flow that discharges to the open pit (Volume 4, page 8.7-14).*

b. *The loss of water from seepage will mean that the volume available to flow into Peterson Creek is expected to be reduced.*
c. *The maps in this Appendix 6.6-A show an inconsistency with regards to extent of the intrusion of the pit into Jacko lake (for example Figure 2 Site Plan, 2014 Drilling Site Investigation Figure 1, Piezometric Surface (Overburden Groundwater Contours) Figure 7 and Potentiometric Surface (Bedrock Groundwater Contours) Figure 8. The maps which show intrusion into Jacko Lake appear to also be inconsistent in the Appendix 6.6-D section.*
d. *What are the confidence levels for the rate and volume of seepage entering the pit from Jacko Lake? What is the groundwater depth at the eastern boundary of Jacko Lake to the Pit? Please provide confidence limits and more specific values for the flow rates. What portion of the water leaving Jacko Lake over the various seasons will be attributed to seepage?*
e. *What proportion of seepage from Jacko Lake that would normally flow into Peterson Creek will enter the pit? What portion of the water leaving Jacko Lake will be left to sustain the aquatic biota in Peterson Creek? Please clarify how the water level in the lake is to be maintained at the different stages of mining operation through development, production and closure.*
f. *To what extent will the mining activity intrude into Jacko Lake? Please provide detailed dimensions covering the pit to the lake for the entire length of the western boundary of the pit.*

Response

a. *It is indicated in the application that with the pit design as proposed Jacko Lake would contribute approximately 60-300 m$^3$ /day of the groundwater flow that discharges to the open pit (Volume 4, page 8.7-14).*

Thank you for the comment. Further temporal resolution in estimated seepage from Jacko Lake is provided in the response to part d., below.

b. *The loss of water from seepage will mean that the volume available to flow into Peterson Creek is expected to be reduced.*

The reviewer is correct in stating that the volume of water seeping to the Open Pit from Jacko Lake would result in a reduction in the volume of water available to flow into Peterson Creek. As summarized in Table 6.4-7 (Section 6.4.5 of the Application/EIS), on an annual basis outflows from Jacko Lake to Peterson Creek are estimated to be reduced due to increased seepage to the pit by the following amounts:

- Existing conditions and construction : 1% or 48 m$^3$/d
- Operations, Decommissioning and Closure : 6% or 192 m$^3$/d
- Post-Closure: 5% or 168 m$^3$/d.

The reduction in groundwater discharge into Jacko Lake will be mitigated by implementation of the Water Management and Hydrometric Monitoring Plan (Section 11.7 of the Application/EIS). Discussions with stakeholders on streamflow mitigation options for Peterson Creek and Jacko

Lake are currently ongoing. The options being considered are discussed in supplementary response memorandum “0706_Streamflow Mitigation Options”.

c. *The maps in this Appendix 6.6-A show an inconsistency with regards to extent of the intrusion of the pit into Jacko lake (for example Figure 2 Site Plan, 2014 Drilling Site Investigation Figure 1, Piezometric Surface (Overburden Groundwater Contours) Figure 7 and Potentiometric Surface (Bedrock Groundwater Contours) Figure 8. The maps which show intrusion into Jacko Lake appear to also be inconsistent in the Appendix 6.6-D section.*

The map inconsistencies with respect to the extent of the intrusion of the Open Pit into Jacko Lake in Appendix 6.6-A were reviewed. It is noted that extents of the Open Pit as shown on the following figures are out of date:

- Figure 2: Site Plan (Appendix A of Appendix 6.6-A)
- Figure 7: Piezometric Surface (Overburden Groundwater Contours) (Appendix A of Appendix 6.6-A)
- Figure 8: Potentiometric Surface (Bedrock Groundwater Contours) (Appendix A of Appendix 6.6-A)
- Figure 1: 2014 Drilling Site Investigation (Appendix I, Appendix A of Appendix 6.6-A).

The Open Pit outline has been reviewed on all relevant drawings from Appendix 6.6-D and is confirmed to be correct and consistent with the limits provided in the Project description. This pit limit, which was used for the groundwater flow model development and simulations is the appropriate limit for the Application/EIS. The out of date pit boundaries in the figures listed above were conceptual for use in studies conducted in advance of finalization of the boundary for the Application/EIS.

d. *What are the confidence levels for the rate and volume of seepage entering the pit from Jacko Lake? What is the groundwater depth at the eastern boundary of Jacko Lake to the Pit? Please provide confidence limits and more specific values for the flow rates. What portion of the water leaving Jacko Lake over the various seasons will be attributed to seepage?*

The groundwater flow model developed by the Proponent (Appendix 6.6-D, EA/EIS Application) was used to estimate seepage losses from Jacko Lake to the groundwater flow systems at all phases of the Project (i.e., existing conditions, construction, operations, closure and post-closure). The range in potential seepage losses were estimated using a traditional sensitivity analysis approach with a calibrated base case scenario along with several sensitivity scenarios that incorporated a range in observed parameter values. Based on this assessment, net seepage losses (i.e., total seepage minus groundwater discharge into Jacko Lake) were predicted to increase from:

- Existing conditions and construction: 0 $m^3$/d
    - o Range: 0 $m^3$/d (several scenarios) to -50 $m^3$/d (i.e., net discharge conditions; high recharge scenario)

- Operations, Decommissioning and Closure: 130 $m^3/d$
    - o Range: 50 $m^3/d$ (low hydraulic conductivity scenario) to 270 $m^3/d$ (high hydraulic conductivity scenario)
- Post-Closure: 130 $m^3/d$
    - o Range: 60 $m^3/d$ (low hydraulic conductivity scenario) to 270 $m^3/d$ (high hydraulic conductivity scenario)

Thus, predicted seepage from Jacko Lake was generally similar (i.e., difference of less than about 6 $m^3/d$) from the end of Operations, Decommissioning and Closure periods to the Post-Closure period.

Further assessment of potential seepage losses from Jacko Lake was conducted in response to several IRs that were received by the Proponent using several additional higher hydraulic conductivity sensitivity scenarios including:

- <u>Case 1:</u> The conductance of general head boundary cells used to represent Jacko Lake was increased by an order of magnitude (i.e., the base case vertical lake bed hydraulic conductivity was increased from $1x10^{-8}$ m/s to $1x10^{-7}$ m/s).
- <u>Case 2:</u> The hydraulic conductivity of surficial deposits between Jacko Lake and the open pit (i.e., glaciofluvial/fluvial sands and gravels and glacial till) was increased to equal or exceed third quartile values from all available measurements (Figure 20, EA/EIS Application Appendix 6.6-D). The hydraulic conductivity of anthropogenic materials was also increased by half an order of magnitude within this scenario.
- <u>Case 3:</u> The hydraulic conductivity of all of the bedrock hydrostratigraphic units between Jacko Lake and the open pit (i.e., Nicola Volcanics, Sugarloaf Diorite, Iron Mask Hybrid, and Picrite) was increased to measured geometric mean values. The hydraulic conductivity of undifferentiated shallow/outcropping bedrock was also increased by half an order of magnitude within this scenario.
- <u>Case 4:</u> The high hydraulic conductivity sensitivity case (i.e., hydraulic conductivity of all materials increased by a factor of five) described in the Application/EIS (Section 8.3, EA/EIS Application Appendix 6.6-D) was modified to include the same factor of 5 increase in conductance of general head boundary cells used to represent Jacko Lake (i.e., assumed a vertical lake bed hydraulic conductivity of $5x10^{-8}$ m/s).

For this additional assessment, simulations were limited to existing conditions/construction and post-closure phases of the Project (i.e., operations, decommissioning and closure were not simulated). Further details of this assessment were documented in 0530_KAM_Jacko_Model_BGC-006. Based on the results of the expanded sensitivity analysis, seepage from Jacko Lake is predicted to range from:

- Existing conditions and construction: 0 $m^3/d$
    - Range: 0 $m^3/d$ (several scenarios) to 26 $m^3/d$ (Case 4 above)

- Post-Closure: 130 $m^3$/d
    - Range: 60 $m^3$/d (low hydraulic conductivity scenario) to 660 $m^3$/d (Case 4 above).

Hydraulic head calibration statistics for the Project area were degraded for the additional cases (i.e., normalized root mean square error increased from 3.5% [base case] up to almost 6%), indicating that the observed hydrogeologic system was not as well represented. Nevertheless, the maximum seepage rate from Jacko Lake was predicted to increase by just over a factor of 2, providing a reasonable degree of confidence in the robustness of the assessment.

Jacko Lake is estimated to remain an overall gaining system through all phases of the Project based on estimated surface flows and the range of predicted seepage rates (i.e., including sensitivity simulations) to the groundwater system. At post-closure, the proportion of water lost to seepage relative to total estimated water outflows (i.e., groundwater and surface water outflow [Table 6.4-7, Application/EIS]) from Jacko Lake is estimated at 4% (2 to 20% range; Table 2-1) on an annual basis. On a seasonal basis, this proportion is estimated to range from 1 to 2% (0.4 to 10%) in the months of May through August. For the remaining months when there is no stream outflow from the lake, the proportion is increased to 100% (all scenarios).

**Table 2-1. Predicted Monthly and Annual Seepage from Jacko Lake Relative to Estimated Total Water Outflow in Post-Closure**

| Month | Streamflow ($m^3$/d) | Groundwater Seepage (% Total Outflow) | | |
|---|---|---|---|---|
| | | Base Case | Minimum [1] | Maximum [1] |
| January | 0 | 100 | 100 | 100 |
| February | 0 | 100 | 100 | 100 |
| March | 0 | 100 | 100 | 100 |
| April | 0 | 100 | 100 | 100 |
| May | 10,900 | 1.2 | 0.5 | 6.1 |
| June | 13,700 | 0.9 | 0.4 | 4.8 |
| July | 6,900 | 1.8 | 0.9 | 9.5 |
| August | 6,900 | 1.8 | 0.9 | 9.5 |
| September | 0 | 100 | 100 | 100 |
| October | 0 | 100 | 100 | 100 |
| November | 0 | 100 | 100 | 100 |
| December | 0 | 100 | 100 | 100 |
| **Annual Average** | **3,200** | **3.9** | **1.8** | **20** |

Note:

1. Minimum and maximum groundwater seepage based on respective low hydraulic conductivity and Case 4 sensitivity scenarios.

At the western edge of the proposed open pit, measured groundwater elevations are about 892 masl (891.7 to 893.2 masl range) based on data collected in 2014 from wells KAX-14-107S, KAX-14-108S, KAX-14-114S, and KAX-14-128S (Drawing 03, Appendix 6.6-A of EA/EIS Application), equivalent to a depth to water of less than 1 m to greater than 20 m.

e. *What proportion of seepage from Jacko Lake that would normally flow into Peterson Creek will enter the pit? What portion of the water leaving Jacko Lake will be left to sustain the aquatic biota in Peterson Creek? Please clarify how the water level in the lake is to be maintained at the different stages of mining operation through development, production and closure.*

Under existing conditions Jacko Lake is predicted to be a net groundwater discharge zone, with 10 $m^3$/d seeping into the groundwater system from the lake (Table 11, Appendix 6.6-D of EA/EIS Application) and 14 $m^3$/d discharging into the lake from the surrounding groundwater flow system (Table 12, Appendix 6.6-D of EA/EIS Application). Conceptually, seepage from the lake would be expected to occur near the east and west limits of the lake towards areas that are lower lying, while groundwater flow into the lake would be expected to occur from areas with locally higher topography (north and south of the Lake).

Simulated seepage from the lake under current conditions is predicted to occur at the east limit of the lake towards the existing pits and Lower Peterson Creek/the Peterson Creek Aquifer. At the end of mining through to the post-closure period, all seepage from the lake is predicted to report to the open pit/pit lake (Appendix D, Appendix 6.6-D of EA/EIS Application). Therefore, the loss of baseflow to Peterson Creek is estimated to be 10 $m^3$/d or less. However, surface water discharge from Jacko Lake is predicted to continue throughout all stages of the Project, decreasing from 3,400 $m^3$/d under existing conditions to 3,200 $m^3$/d in post-closure (Table 6.4-7, EA/EIS Application).

The outlet of Jacko Lake is currently controlled by an existing dam and overflow spillway (invert elevation 892 m) that discharges into Peterson Creek on the east side of the lake. Thus the current water level in Jacko Lake is 892.0 m, and the intent is for this level to be maintained during all mine phases. The reviewer is referred to supplementary response memorandum “0706_KAM_Fish Compensation Plan” for design information.

Inflow to Jacko Lake is currently monitored at station, JACINF and outflow is monitored at stations JACLAKE and JACSEEP. As shown in Table 8-2 of Appendix 6.4-C, outflow from Jacko Lake currently peaks in June at 586 $m^3$/hr, and averages 142 $m^3$/hr over the year. In Year 23 of operations outflow from Jacko Lake is anticipated to peak in June at 576 $m^3$/hr, and averages 134 $m^3$/hr over the year. This represents a decrease in outflow from Jacko Lake of approximately 5%, based on the yearly averages.

f. *To what extent will the mining activity intrude into Jacko Lake? Please provide detailed dimensions covering the pit to the lake for the entire length of the western boundary of the pit.*

The Open Pit will take part of the northeast arm of Jacko Lake, where a small dam will be constructed to provide a safety setback zone between the Open Pit and the Lake. Drawing 01 provides dimensions between the eastern extent of Jacko Lake and the western boundary of the proposed Open Pit.

### 2.6. Information Requirement Issue ID # FLNRO-208

*KGHM must address how losses to groundwater will affect groundwater license holders (existing groundwater wells have rights under the Water Sustainability Act). It has been determined that there is hydraulic connectivity between Peterson Creek and aquifers that are used by groundwater users with prior rights. Losses to these groundwater users must be quantified and mitigated.*

<u>Response</u>

KAM is committed to monitoring private groundwater wells for potential effects to groundwater quantity due to the Project. If impacts to groundwater quantity are identified from monitoring, KAM is also committed to mitigating impacts to these wells. The potential for groundwater losses to affect registered well users within the regional study area (RSA) was considered in the Project Application/EIS according to the following methodology:

1. Registered water users within the RSA were identified using the British Columbia Ministry of Environment (BC MOE) Water Resources Atlas (WRBC) (summarized in Table 7 and Appendix E of Appendix 6.6-A of the Application/EIS).
2. Prediction and quantification of water table changes within the RSA from existing conditions through Construction, Operations, Decommissioning and Closure and Post Closure phases of mining was completed using a numerical groundwater flow model (Sections 5, 6 and 7 of Appendix 6.6-D of the Application/EIS).
3. Mitigation options were proposed, should groundwater losses predicted by the numerical groundwater flow model occur to those registered wells considered as potentially impacted by proposed Project activities (Section 6.6.5.4 of the Application/EIS).

As discussed in section 6.6.4.3 of the Application/EIS, the numerical groundwater flow model predicted groundwater elevation changes as a one metre (or more) water table elevation change from existing conditions with groundwater quantity changes expected to be limited to within approximately two kilometres (or less) of mine infrastructure. The Application/EIS states that four registered wells were found to be inside this zone. These include: one private/domestic well (well tag number 84992) and three commercial/industrial wells registered to Afton Mines (well tag numbers 56944, 58711 and 58712). Note one of the Afton Mines wells was listed as abandoned (i.e., 56944) (Drawing 6.6-G-3 in Appendix 6.6-E and Drawing 03 in Appendix 6.6-A of the Application/EIS), leaving three registered wells for consideration. The numerical groundwater flow model predicted a reduction in water table elevation (i.e., between 2 - 5 metres) at the end of mine operations for only one of the registered wells (i.e., private/domestic well 84992) located southeast of the proposed pit (Drawing 05 Appendix 6.6-D of the Application/EIS). As described in Section 6.6.5.4 of the Application/EIS, should such a reduction in well productivity be observed as a result of mine activities, mitigation measures could include well relocation or well deepening to meet the water supply demand. Potential losses to private/domestic well 84992 (which is owned by KAM) may be quantified through ongoing monitoring throughout all phases of the Project.

The reviewer is correct in stating that there is potential for a hydraulic connection between Peterson Creek (Lower) and the Peterson Creek Aquifer; however, it should be noted that results of site investigations to date have not suggested a direct connection between the creek and the aquifer (please refer to the Proponent's response to Comment ID # SSN-330 and supplementary response memorandum "0426_KAM_PCPT_BGC-003" for additional clarification on the interpreted connection between the creek and aquifer). As stated in Section 6.6.4.2 of the Application/EIS, Peterson Creek (Lower) the Peterson Creek Aquifer is conceptualized as a system of gaining and losing reaches, with interaction between the creek and aquifer generally considered as damped by lower hydraulic conductivity materials in this area. As described in Appendix 6.6-A of the Application/EIS, there are a total of seven registered wells interpreted to be completed within the Peterson Creek Aquifer (well tag numbers 58934, 106786, 60441, 46577, 1322, 2572 and 18385), six of which are used for domestic purposes while usage of the remaining well is unknown. The groundwater flow model did not predict changes to water levels in any of these wells as a result of the Project. Changes to the Peterson Creek (Lower) groundwater balance and mitigation measures for groundwater quantity were discussed in Sections 6.6.4.2 and 6.6.4.3 of the Application/EIS, respectively. In general, potential changes in baseflow to Peterson Creek (Lower) are somewhat uncertain, as small changes in hydraulic conductivity resulted in differing patterns of gaining/losing creek reaches. However, the simulated range in hydraulic conductivity for the glaciofluvial materials (i.e., including sensitivity simulations) did bracket the range observed along the southwest edge of the proposed open pit. Baseline monitoring to evaluate current water levels would need to occur for these 6 wells and licensed withdrawal rates established prior to Project initiation and with permission from the owner(s) in order to quantify any potential effects from the Project. This monitoring could be completed at future stages of the Project as a permit condition.

As written in Section 6.6.4.2 of the Application/EIS, environmental management plans (EMPs) will be developed to monitor groundwater conditions during Project activities. The monitoring of private/domestic wells may be included in the EMPs. Monitoring results may be used to compare actual conditions to predictions and to provide input to adaptive management plans, if needed. In the event of a reduction in well capacity as a result of the Project, mitigation options (e.g., deepening of well) would be discussed with the owner(s) to determine the best path forward.

Water licenses are considered for potential effects to surface water quantity. Water license withdrawal rates for groundwater wells would need to be established prior to an evaluation of how these rights may be affected. However, given the predicted minor effects on water quantity, the proposed monitoring plan and the practical mitigation alternatives available, as indicated in the Application/EIS, determining current groundwater withdrawal rates is not considered to be necessary at this time; evaluation of withdrawal rates for existing groundwater wells could be considered in the future based on monitoring results on an as needed basis.

## 2.7. Information Requirement Issue ID # FLNRO-226

*Water quality data from the PW-01 pumping test was used to represent groundwater inputs in the open pit area. This well is completed across several hydrostratigraphic units. As such the analytical results used represent flow from several (three?) hydrostratigraphic units. Is flow expected to be uniform within those three units based on evaluation of those units hydraulic properties? If not, please indicate how the results of the water quality model may be affected. How does this correlate with the calibrated hydraulic conductivities presented in Figure 20 of App 6.6-D? How does the commingled PW-01 chemistry result compare to representative chemistry results from each hydrostratigraphic unit?*

Response

The reviewer is correct in stating that the pumping well near Jacko Lake (i.e., BGC10-PW01) is screened over three interpreted hydrostratigraphic units (HSUs), including the Nicola Volcanics, Sugarloaf Diorite and Picrite unit. The maximum, minimum and geometric mean hydraulic conductivity, K, values for these units (as reported in Appendix 6-A of the Application/EIS) as well as the model calibrated values in the open pit area are shown below in Table 2-2.

**Table 2-2. Summary of Hydraulic Conductivity Estimates for the Nicola Group Sediments, Picrite Unit and Sugarloaf Diorite Based on Field Data and Model Calibration**

| Hydrostratigraphic Unit | Estimates from Field Data | | | Model Calibrated K (m/s) |
|---|---|---|---|---|
| | Minimum K (m/s) | Maximum K (m/s) | Geometric Mean K (m/s) | |
| Nicola Volcanics | 2 E-11 | 8 E-06 | 2 E-08 | 1 E-09 |
| Picrite | 4 E-10 | 3 E-06 | 4 E-08 | 1 E-09 |
| Sugarloaf Diorite | 3 E-09 | 1 E-06 | 2 E-08 | 2 E-08 |

As shown by Table 2-2, the maxima and geometric means of field estimated K values for all three units are similar, whereas lower bound estimates are 2E-11 m/s, 4E-10 m/s and 3E-09 m/s for the Nicola Volcanics, Picrite unit and Sugarloaf Diorite, respectively. The calibrated K values for the Sugarloaf Diorite is approximately one order of magnitude higher than the other two units as represented in the numerical groundwater flow model (Appendix 6.6-D of the Application/EIS). Based on the above, estimates from field data suggest that overall flow within these units would be uniform; however, the groundwater model simulates slight preferential flow within the Sugarloaf Diorite as a result of a higher calibrated K value.

It should be noted, however, that groundwater flow within bedrock at the site is expected to be driven primarily by connected networks of fractures that exhibit locally elevated hydraulic conductivity compared to the intact rockmass. Fracture networks may extend within, across and/or along contacts between individual bedrock hydrostratigraphic units and therefore the 'composite' water quality and larger scale estimate of hydraulic conductivity from BGC10-PW01 are considered to be the best available data for representing the rate and quality of groundwater discharging into the open pit. Furthermore, the results of the groundwater quality sampling program did not identify any strong correlations between water quality and hydrostratigraphic unit or rock type (Appendix 6.3-A of the Application/EIS).

The composite water quality results from BGC10-PW01 were only used to represent inflows to the open pit in the Application/EIS. During mining, all water from the pit will be pumped to the central collection pond, and from there to the process plant before ultimately discharging to the TSF. Evaporation and interstitial pore water quality within the TSF are the dominant controls on TSF water qualities, and as such, the effects of using the composite water quality sample results from BGC10-PW01 on the water quality model results for predicting Project effects on Valued Components (VCs) during Construction, Operation and Closure are negligible. Similarly, the effects of using the composite water quality sample results from BGC10-PW01 on the water quality model results during the Post Closure period are negligible because the open pit is predicted to be a permanent groundwater sink.

## 2.8. Information Requirement Issue ID # SSN-683

*SEE memo: 0314_SSN 360 Evaluation Report_FINAL: SSN #9. Simulation modelling with appropriate spatial and temporal boundaries, along with consideration of climate change, would provide more meaningful information for an SSN review of the project and understanding of its residual and cumulative effects.*

<u>Response</u>

Thank you for the comment. The Proponent advocates that appropriate spatial and temporal boundaries were used in simulation modelling, and that climate change was considered in the Application/EIS. These points are discussed below.

<u>Spatial Boundaries:</u>

The spatial boundaries utilized by the Proponent were defined based on the Application Information Requirements (AIRs) outlined in the Table of Concordance submitted with the Application/EIS. In particular, AIR0318 provides the following definitions:

- Local study area (LSA) is defined as the Project footprint and surrounding within which there is a reasonable potential for immediate impacts to occur to the specific VC due to Project components or activities.

- Regional Study Area (RSA) is defined based on the Cumulative Effects Assessment Practitioners Guide (CEA Agency 1999): "the spatial area within which cumulative effects are assessed (i.e., extending a distance from the Project footprint in which both direct and indirect effects are anticipated to occur)."

The RSA and LSA were defined accordingly, and descriptions of the study areas are found in Sections 2.2.1 and 2.2.2 of Appendix 6.6-A.

Memo 0131_SSN 360 Evaluation Report_FINAL suggests that more appropriate spatial boundaries would have included the Thompson River. As outlined in Section 2.4.1 of Appendix 6.6-D, Kamloops Lake/Thompson River defines the northern boundary of the RSA. The interaction between the Thompson River and the underlying groundwater was simulated using the MODFLOW river package, which calculates water fluxes to/from the river cells based on the hydraulic head difference between the assigned water elevation at the boundary and the simulated hydraulic head within the grid block modified by a specified conductance. The Thompson River was therefore adequately included in the spatial boundaries utilized by the Proponent.

<u>Temporal Boundaries:</u>

The temporal boundaries utilized by the Proponent were also defined based on the AIR's outlined in the Table of Concordance submitted with the Application/EIS, and are conceptually segregated between existing (baseline) conditions, Construction, Operation, Decommissioning and Closure, and Post Closure.

The baseline condition for the study area was defined based on Project specific data collected between 2007 and 2014, along with historical data from Klohn Leonoff (1988), the City of Kamloops, the New Afton Site and the online Water Resources of BC Atlas. This process was conducted in accordance with AIR0377, which states that the baseline water quality in the Project area will be characterized through a Project-specific monitoring program and any regional and historical data, where available.

Memo 0313_SSN 360 Evaluation Report_FINAL suggests that a more appropriate base case would involve pre-industrial or pre-contact conditions.

The Proponent completed a review of the hard files in the Kamloops MOE office (i.e., Afton Operating Corporation, 1989; Klohn Leonoff, 1988) to look for groundwater data that predates the Teck Ajax project. Water quality data were available for the period from 1986 to 1989 but:

- Detection limits in the analysis of the water quality data available were such that the data were of limited value; and
- Groundwater level data were not available.

A detailed assessment of this data will be presented in the Ajax Project Historical Data Assessment Report, currently being prepared by others (See supplementary response memorandum "0706_KAM_Historic Water Quality Data").

It should also be noted that exploration and production in the Project area began in the 1880's and continued intermittently until the 1980s (see Section 2.2.3 of the Application/EIS). Groundwater quality and quantity data do not exist for the time period prior to this; therefore characterizing the pre-industrial or pre-contact groundwater conditions is not possible with the available information.

The groundwater simulations considered for the Construction, Operation, Decommissioning and Closure, and Post Closure phases of the Project also adhere to the AIRs (i.e. AIR0321, AIR0445 and AUR0488). These AIRs were addressed throughout the Application/EIS, including in Sections 5 through 10, Appendix 3-B and Appendix 6.6-D.

<u>Climate Change:</u>

As outlined in Section 17.5.7.1 of the Application/EIS, there is currently no specific legislation applicable to adapting Project components to climate change risk. With regards to the effect of the environment on the Project in relation to climate change, the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (CEA Agency 2003) recommends that:

*Potential [climate change] risks to the project, providing they do not affect the public, public resources, the environment, other businesses or individuals, may be borne by the project proponent and are not generally a concern for jurisdictions.*

It is believed that climate change in the Project area will not increase risks to the public, public resources, the environment, other businesses or individuals; however, the likely effects of climate change on the Project are discussed in Section 17.5.7 of the Application/EIS. Overall, the climate of the Project Area is expected to become warmer and experience more precipitation.

In addition to the information contained in Section 17.5 of the Application/EIS, climate change was also addressed in Appendix 6.4-C. The projected increases in maximum, minimum and average temperatures due to climate change for the year 2085 were compared to the climate normals (1981 to 2010) for the region, (Figure 8-8, Appendix 6.4-C), and the potential changes in hydrological conditions are discussed in Section 8.6, Appendix 6.4-C. Projected changes in temperature (Figure 8-8, Appendix 6.4-C) and precipitation (Table 8-10, Appendix 6.4-C) were applied to the site-wide water balance and were found to affect the rates and timing of snowmelt and potential evaporation.

Finally, sensitivity studies with the groundwater model considered increases in groundwater recharge of 10 times the calibrated values for:

- the full groundwater model domain, and
- specifically within areas over the mine rock storage facilities (MRSFs).

Increases in recharge of this magnitude could occur in response to greater precipitation due to climate change. However, projections for the Project area indicate that annual precipitation may decrease while evapotranspiration losses increase as the climate warms (Appendix 6.4-C, EA/EIS Application); although there is considerable uncertainty associated with the projections.

The extent of Project effects to groundwater while also considering these increases in recharge are shown on Drawings E-1 through E-13 in Appendix E of the Numerical groundwater flow model (i.e., within Appendix 6.6-D of the Application/IEIS). As shown on these maps, the effects of increased recharge do not extend significantly beyond the area of effect prediction for best estimate base case simulations nor do they extend into public areas (i.e., Aberdeen).

For additional information regarding the anticipated impacts of climate change on the Project, the reader is referred to Memos BGC-011 and BGC-013.

## 2.9. Information Requirement Issue ID # SSN-813

*Water quality- issues are outstanding on the water balance model and other effects assessment regarding surface and ground water- these must be resolved and updates must be provided in order to allow the SSN Review Panel to make informed decisions and recommendations regarding the proposed project.*

Response

The commenter is correct in stating that updates to the climate data set (i.e., precipitation and evapotranspiration) used in the water balance model (WBM) calibration may result in changes to water quality source terms that would need to be carried forward in water quality assessments. However, the Proponent advocates that, with the exception of nitrogen species, the most conservative cases were assessed as part of the Application/EIS, and therefore are adequate for the purposes of an environmental assessment. Updates to the WBM and water quality models are planned for the Permitting stage of the Project. It is proposed that the accompanying updated assessments on issues pertaining to water quality become a Condition on the Environmental Assessment Certificate to be addressed as part of Permitting.

## 2.10. Information Requirement Issue ID SSN-889

*Can KGHM guarantee that there will be no seepage from the open pit and tailings facility? How?*

Response

Thank you for the question; the concern is noted and appreciated. KAM does not guarantee that there will be no seepage from the Project facilities to groundwater. However, with regards to the open pit, mining will result in a lowering of groundwater levels in the pit vicinity compared to current conditions. This change in local hydraulic gradients would cause surrounding groundwater to flow towards the open pit and not vice versa; as such, there should be no seepage from the open pit to the surrounding groundwater system.

As discussed in Section 6.6 of the Application/EIS, some seepage from the Tailings Storage Facility (TSF) to groundwater is predicted by the assessments. Potential seepage flow paths from the TSF can be referenced in Drawing 18 and Appendix E Drawing E-12 (sensitivity simulation results) of Appendix 6.6 D. As discussed in Section 6.6-D of the Application/EIS, the majority of the seepage contributions from the TSF to groundwater are expected to travel along groundwater flow pathways that discharge to the Open Pit. However, seepage monitoring and mitigation measures as result of mining have been considered as part of the Application/EIS, and are documented in the Water Management Plan (WMP) and Surface Water and Groundwater Monitoring and Management Plan (SWGMMP) in Chapter 11 of the Application/EIS.

The SWGMMP and WMP are being updated as part of the *Mines Act and Environmental Management Act* (MA/EMA) permitting process and will be designed based around predictions made for the Effects Assessments for the Project, input from Aboriginal groups (including the Stk'emlupsemc te Secwepemc Nation (SSN)), stakeholders and regulators. Actual mitigation measures to minimize potential seepage from the mine site into groundwater flow system will vary by infrastructure type (i.e. water management ponds will have different measures than MRSFs, which may have different measures than the TSF) have been designed with current best practices in mind and will be updated in accordance with the conditions encountered during detailed site investigation, construction and mining. The SWGMMP and WMP will be reviewed and revised as needed to apply the appropriate management and mitigations deemed necessary to protect the health of both the immediate and downstream aquatic environment.

## 2.11. Information Requirement Issue ID SSN-891

*How will KGHM guarantee no seepage into or drainage of Jacko Lake?*

Response

Thank you for the question. KAM does not guarantee that there will be no seepage into, or drainage from Jacko Lake as a result of the Project. Potential groundwater seepage due to the Project was assessed using the numerical groundwater flow model in Appendix 6.6-D of the Application/EIS. Please also refer to supplementary response memorandum "0530_KAM_Jacko_Model_BGC-006" for further detail on seepage modelling in the western sector of the Ajax pit near Jacko Lake.

As discussed in Chapter 3 (Section 3.5) of the Application/EIS, the development of the open pit will occur progressively over multiple phases, i.e.:

- Mining year -2 to 2 (3-4 years)
- Up to mining year 5 (3-4 years)
- Up to mining year 10 (5-6 years)
- Up to mining year 23 (13-14 years)

As the pit is developed over time, passive depressurization methods (i.e., pumping from sumps in the pit and through installation of horizontal drains) will be used to depressurize the pit walls. There is contingency to install up to 30 ex-pit dewatering wells if necessary. Surface water and groundwater (levels and quality) will also be monitored throughout the mining process in order to assess gradual changes as they occur.

Under the currently proposed Surface Water and Groundwater Monitoring and Management Plan (SWGMMP), groundwater levels and quality will be monitored during all phases of mining (construction, operations, closure and decommissioning and post closure) near the western sector of the Ajax pit at KAX-14-107, -108, -114 and -128 (Table 11.24-1, Application/EIS). Manual groundwater levels are currently collected at these locations two times per year. The frequency of manual water level measurements will increase to quarterly during the construction, operation and closure phases. Following closure, manual water level measurements will be collected biannually, with the frequency of monitoring anticipated to decrease as water levels attain steady state conditions and groundwater quality targets are achieved. Surface water levels and quality will also be monitored throughout mining, at locations PC08, PC10 and JACL-D/M/S (Table 11.23-1, Application/EIS). Surface water monitoring events generally occur monthly, with lake samples collected twice through ice in the winter, and only when conditions are safe. The sampling schedule is anticipated to be maintained through Construction, Operation, and Decommissioning and Closure, and to be reduced over time in Post Closure as receiving water targets are achieved and as dictated by the permits.

If seepage from the mine site into Jacko Lake and/or significant flow from the lake into the pit is observed during mining, then an appropriate mitigation strategy will be developed. This strategy will involve monitoring at a minimum, in accordance with the SWGMMP, as mentioned above. Adaptive management is also included in the SWGMMP, allowing sampling locations and frequency to be altered, if necessary, to suit conditions encountered at any stage of mining.

Appropriate mitigations will be developed based on actual conditions encountered. If measures are needed to mitigate the seepage of water from the mine site to Jacko Lake and/or from Jacko Lake to the pit, conventional mitigation strategies that might be considered include:

- Permeable reactive barriers to passively treat seepage underground.
- Installation of seepage interception wells.
- Implementation of bentonite, cement-bentonite or soil-cement-bentonite slurry cutoff walls or sheet pile cutoff walls.
- Lining portions of Jacko Lake and/or interception wells to control shallow seepage in unconsolidated materials. Grouting or installation of horizontal drains or interception wells within the rock mass can also be considered.

From a water quantity perspective, the predicted reduction in groundwater discharge to Jacko Lake and increase in seepage loss to the open pit will be mitigated by implementation of the Water Management Plan.

### 2.12. Information Requirement Issue ID SSN-896

*How many fault lake test should be done? Should they be done at different times of the year?*

Response

Thank you for the question. By "*fault lake test*", it is assumed that the commentator is referring to pumping tests to characterize hydraulic properties in the Project area. KAM advocates that the pumping tests conducted for the Project adequately characterize hydraulic conductivity and storage properties of materials in key areas of the mine site (i.e. between Jacko Lake and the open Pit and in the Peterson Creek Aquifer) for the purposes of evaluating the potential Project effects on groundwater for the Application/EIS.

KAM may consider completing additional investigations, including pumping tests, at future stages of the Project (i.e., during or in support of permitting at the detailed design stage and post-permitting as part of Project construction). The purpose of the pumping tests, if deemed necessary, would be to support future monitoring and mitigations for the Project. Additional pumping tests that might be considered:

- One pumping test to investigate the Edith Lake Fault Zone (ELFZ) downgradient of the proposed West Mine Rock Storage Facility (WMRSF) and TSF, but upgradient from Jacko Lake. The purpose of this test would be to help inform the design of the Surface Water and Groundwater Monitoring and Management Plan (SWGMMP) which is being updated as part of Project permitting. Specifically, this work would be to further assess the continuity of the potentially higher hydraulic conductivity identified in one borehole, and if necessary, to inform design of seepage monitoring, mitigation or interception systems. This testing would be conducted only if the results of additional groundwater flow modeling, water balance modeling and water quality modeling discussed in the sub-working group meeting held in Kamloops on April 6, 2016 indicate that Jacko Lake water quality may be impacted by seepage along the ELFZ. It is proposed that, if necessary, this work would be a condition on the Application/EIS and would be completed in time to inform monitoring and management planning at the Project permitting stage (see supplementary response memorandum "0706_KAM_ELFZ_BGC-002" for detail).
- Two pumping tests around Jacko Lake (i.e., one adjacent to the Southeast arm and near the ultimate pit extent another adjacent to the Northwest arm and near the ultimate pit extent), as suggested by Dr. Gilles Wendling during the SSN Panel meeting. The purpose of these tests would be to further characterize surface water groundwater interactions in the vicinity of Jacko Lake, to increase confidence in the large scale characterization of the rockmass between the open pit and Jacko Lake and to provide additional information for the design of monitoring and mitigation strategies between Jacko Lake and the pit. This density of pumping testing would be considered detailed design focused and would only be considered if deemed necessary based on observations and monitoring results in the open pit near these locations made during construction and during mining. The Proponent acknowledges that drilling within the lake arms is not supported by SSN; any details of this work would therefore be established through direct consultation with, and with consent from SSN.

With regards to time of year, pumping tests should be conducted when convenient and least disruptive for the surrounding environment. As indicated in Appendix 6.6-A of the Application/EIS, annual variations in groundwater elevations are minimal (i.e., from less than 0.1 m to approximately 4 m, annually in the Project area and 1 to 4 m in wells installed near Jacko Lake) indicating that seasonal stressors have little impact on the groundwater flow regime. As such, timing of the test during the year would not impact interpretations of results significantly.

## 2.13. Information Requirement Issue ID SSN-898

*How can you ensure that underground water maps are accurate? Can you provide a map?*

Response

Thank you for the question. As discussed in Appendix 6.6-A of the Application/EIS, the spatial interpretation of groundwater levels to generate piezometric maps (i.e., underground water maps) was based on a total of 445 locations in the Regional Study Area (RSA). This incorporates data collected from the Ajax mine site, as well as data from additional locations within the RSA. The full groundwater level database was used for characterization of average annual conditions (i.e., interpretation of piezometric maps and groundwater flow directions).

The groundwater level database used to generate piezometric maps for the Ajax Project includes:

- Historic measurements from 242 locations reported by the British Columbia Ministry of Environment (BC MoE) in the Water Resources of BC (WRBC) database both in the RSA and on the Project site [BC MOE, 2014].
- Historic measurements at 20 groundwater monitoring locations reported by Piteau Associates [2006], and located near the New Afton Mine to the west of the Project site.
- Historic measurements from 42 monitoring locations compiled from digital data provided by the City [2012], and located in the Aberdeen subdivision area to the north of the Project site.
- Manual and automatic measurements collected between 2010 and 2014 from more than 141 monitoring locations on the Project site.

The groundwater level database was filtered to exclude data that were collected during known disturbance events (i.e. slug tests, well purging, pumping and drilling) so that the values in this assessment were considered to be representative of ‘annual average’ baseline conditions at the site.

The monitoring locations from which groundwater level data were available may be referenced in Section 3.1.4 of Appendix 6.6-A of the Application/EIS. The piezometric maps that were generated based on these data may be found in Figures 14 and 15 of Appendix 6.6-A of the Application/EIS.

As can be seen from the discussions above and from Drawings 02 and 03 in Appendix 6.6-A of the Application/EIS, the water level observation dataset is substantial in terms of the number of data points considered, its regional extent and for the time period over which data were collected. For these reasons, the piezometric maps that were generated for the Project are considered to be representative of groundwater flow in the Project area and the RSA.

## 3.0 CLOSURE

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Yours sincerely,

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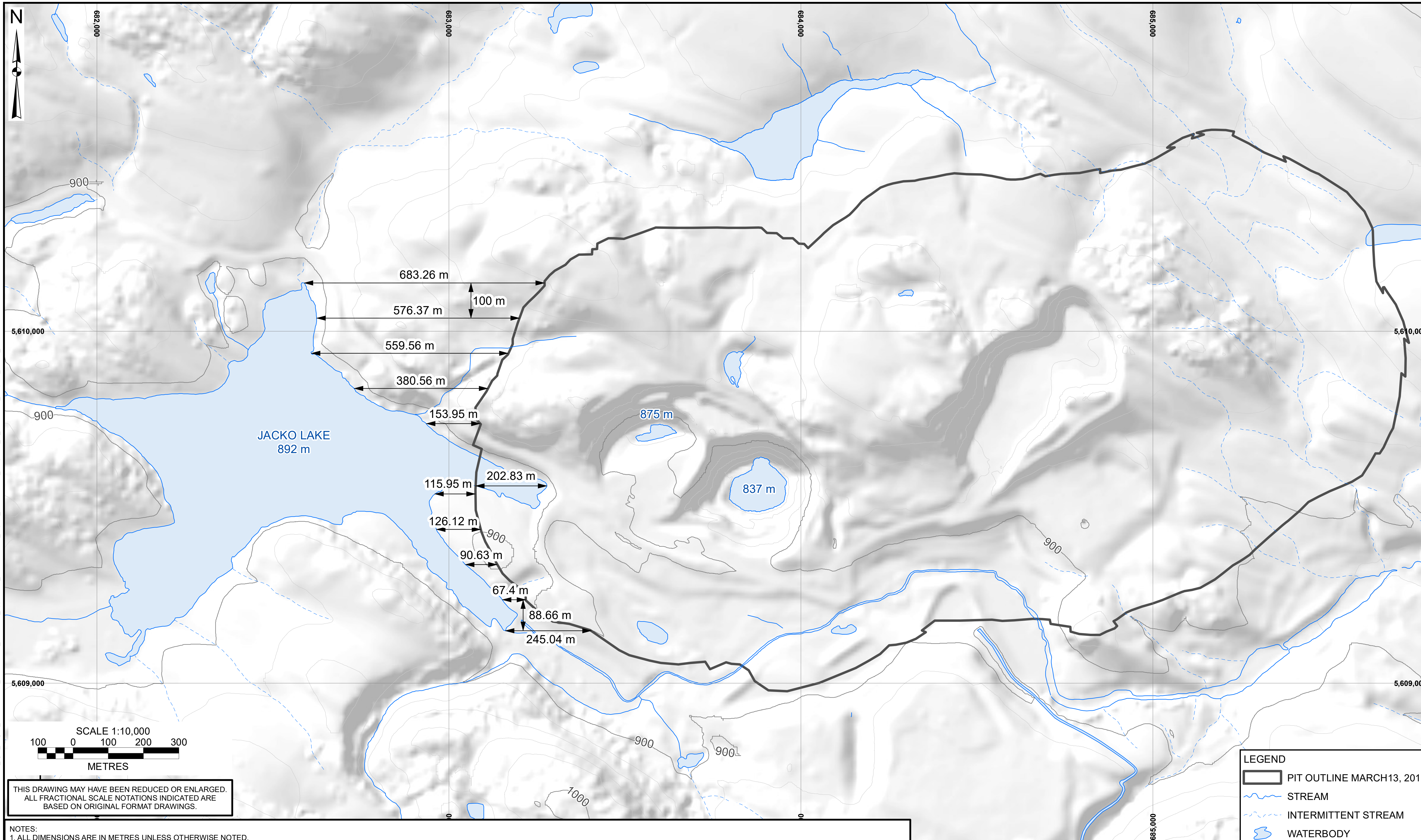
Klohn Leonoff, 1988. Ajax Mine: Water Management Plan. Report prepared for Afton Operating Corporation. Dated May 11, 1988.

# DRAWING 01




THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "AJAX PROJECT EA/EIS – RESPONSES TO INFORMATION REQUESTS CEAA-047, COK-SLR569, COK-SLR570, ECCC-020, ECCC-085, FLNRO-208, SSN-683, SSN-691 AND SSN-813." AND DATED JUNE 2016.
3. BASE TOPOGRAPHIC DATA FROM KAM, CITY OF KAMLOOPS, AND GEOBASE INFORMATION. CONTOUR INTERVAL IS 20 m.
4. WATER COMPILED FROM KAM, CITY OF KAMLOOPS, AND NATIONAL HYDRO NETWORK.
5. POND ELEVATIONS ESTIMATED BASED ON LIDAR PROVIDED BY KAM ON JUNE 4, 2013.
6. PIT OUTLINE "Pit_Outline_2015MAR13" PROVIDED BY KAM ON APRIL 15, 2015.
7. DISTANCE LINES IN 100 m INTERVAL FROM NORTHERN MOST LINE, WITH THE EXCEPTION OF THE LAST LINE.THIS INTERVAL IS NOTED ON THE DRAWING.
8. PROJECTION IS NAD 1983 UTM ZONE 10N.
9. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

DRAFT

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|---|---|
| SCALE: | 1:10,000 |
| DATE: | JUN 2016 |
| DRAWN: | JDC, MIB |
| CHECKED: | JW |
| APPROVED: | TWC |

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT:
KGHM AJAX MINING INC.

PROJECT:
AJAX PROJECT EA/EIS
RESPONSES TO INFORMATION REQUESTS

TITLE:
RESPONSE TO INFORMATION REQUEST ECCC-085

PROJECT No.: 1125011-10-04
DWG No: 01

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