Suite 500 - 980 Howe Street, Vancouver, BC Canada V6Z 0C8
Telephone (604) 684-5900 Fax (604) 684-5909

Project Memorandum

To:	**KGHM Ajax Mining Inc.**	**Doc. No.:**	**BGC-026**
Attention:	**Nettie Ore**	**cc:**	
From:	**C. Koenig**	**Date:**	**January 23, 2017**
Subject:	**Ajax Project EA/EIS - Responses to Round 2 Information Requests from ECCC**		
Project No.:	**1125011**		

1.0 INTRODUCTION

An *Application for an Environmental Assessment Certificate / Environmental Impact Statement for a Comprehensive Study* (the Application/EIS) was submitted in January 2016 (KAM, 2016) for the Ajax Project (the Project). The Application/EIS is currently in the review phase, during which the BC Environmental Assessment Office (EAO) reviews all available information and seeks input from Aboriginal groups, all levels of government and the public to identify potential environmental impacts of the Project.

BGC Engineering Inc. (BGC) and Knight Piesold Limited (KP) are supporting KAM in responding to groundwater quantity and quality related information requirements (IRs), respectively, during the Application/EIS review phase. This memorandum was prepared to respond in part to IR # 47 (ECCC-098.1) submitted to KAM by the Canadian Environmental Assessment Agency (CEAA) in a letter dated December 5, 2016 (CEAA, 2016).

2.0 COMMENTER INFORMATION REQUIREMENT RESPONSE

Information requirement ECCC-098.1 is copied below and is followed by the response. The initial comment (i.e., ECCC-098) is not reproduced herein but may be reviewed in 0706_KAM_ELFZ_Model_BGC-002 and in the Environmental Assessment (EA) review comment tracking sheet for the Ajax Project. Comments and responses will be posted together with all project documentation on the BC EAO Project Information Center (e-PIC) website[1].

2.1. Comment #ECCC-098.1

See complete comment in Memo; 2016.12.05 Agency Letter Re Ajax Response Adequacy & Technical Comments

KGHM's analysis of particle tracking simulations with four different transmissivities of the ELFZ, as presented in Figure 8 to 11 of memo 0706_KAM_ELFZ_Model_BGC-002, suggests that the impact on Jacko Lake water quality is not substantial. KGHM's analysis indicates that while a

[1] http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_home.html

large number of particles reach the ELFZ, even on the northern side of Jacko Lake for the two scenarios with the most transmissive ELFZ, very few of them enter Jacko Lake….

To allow the Agency to determine whether additional information and/or investigation relating to the conductivity of the ELFZ is required, provide the following information:

- *Cross-sections, similar to Figure 2 from memo 0706_KAM_ELFZ_Model_BGC-002, showing particle paths for each of the scenarios depicted in Figures 8 to 11 from the memo;*
- *Conservative estimates of the proportion of particles entering Jacko Lake (top of the lake bed) versus all particles leaving the mining facility; and*
- *As assessment of the impacts of the ELFZ on Jacko Lake water quality by using these proportions as proxies, as well as the travel time through the lake bed, to conservatively estimate the impact on water quality (including a discussion on the limitations of the approach and possible need for a more complex transport model and/or investigation.)*

Response

BGC's response within this memorandum is limited to the first two bullet points in the above-noted IR. The reader is referred to KP(2017) for a response to the third bullet point (0123_KAM_KP Response to CEAA Round 2 Water Quality).

Conceptual cross-sections similar to Figure 2 of 0706_KAM_ELFZ_Model_BGC-002 showing particle paths are provided in Figure 1 (Figure 2 of 0706_KAM_ELFZ_Model_BGC-002 is reproduced as Figure 2 below for reference). The cross-sections provided are limited to the tailings storage facility (TSF) and west mine rock storage facility (WMRSF), where particle tracking analyses indicated the potential for seepage to flow towards Jacko Lake (see 0706_KAM_ELFZ_Model_BGC-002 Figures 8 and 9). Figure 1A depicts predicted groundwater flow paths for locations outside of the fault zone and for Edith Lake Fault Zone (ELFZ) hydraulic conductivity scenarios (i.e., <$5x10^{-7}$ m/s). For these scenarios, groundwater simulated to originate from the footprints of the TSF and WMRSF was generally predicted to discharge near the toe of the dam/WMRSF (where it would evaporate or drain to the water collection ponds) or remain in the subsurface and flow towards the proposed open pit, with no discharge from the facilities predicted to reach Jacko Lake within the simulated 200-year timeframe.

Figure 1B depicts predicted groundwater flow paths for ELFZ simulated with hydraulic conductivity >$5x10^{-7}$ m/s along the trace of the fault. For these scenarios, groundwater flowing along the fault trace that originated from the footprints of the TSF and WMRSF was predicted to follow three potential flow paths, including:

- A shallow groundwater flow path with discharge near the toe of the dam/WMRSF,
- An intermediate groundwater flow path with eventual discharge to Jacko Lake, and
- A deeper groundwater flow path that flows beneath and beyond Jacko Lake.

As detailed in 0706_KAM_ELFZ_Model_BGC-002, the Project MODFLOW-SURFACT (Hydrogeologic 1996) groundwater flow model was used in conjunction with MODPATH (Pollock 1994) particle tracking simulations to delineate post-closure groundwater flow paths from the proposed TSF and WMRSF for several ELFZ sensitivity scenarios. For each scenario, particles were released at the water table, with one particle specified within each vertical column of cells located within the footprint of the respective facilities. Results of these simulations indicated that seepage-affected water could reach Jacko Lake for higher ELFZ hydraulic conductivity scenarios (i.e., >$5x10^{-7}$ m/s).

The results of these particle tracking simulations were used to determine the total proportion of particles originating from the WMRSF and TSF predicted to reach Jacko Lake over the simulated period (Table 1) as requested in Comment #ECCC-098.1. The total flow of water from the WMRSF and TSF was also conservatively estimated by assuming that, in Jacko Lake model cells where particles were predicted to discharge, all groundwater discharge was composed of seepage-affected water, with the proportion from each facility determined by weighting the respective inflows (Table 1) from particle tracking results from total predicted inflows to Jacko Lake at Closure (Table 2). Results of this analysis indicated:

- 0% of particles originating from both the WMRSF and TSF for the base case and lower hydraulic conductivity ELFZ scenarios (i.e., <$5x10^{-7}$ m/s) were predicted to reach Jacko Lake, resulting in seepage-affected water accounting for 0% of total groundwater discharge to the lake. Therefore, no seepage-affected water is predicted to reach Jacko Lake for scenarios with an ELFZ K <$5x10^{-7}$ m/s.
- 0.4% (WMRSF) and 0.2% (TSF) of particles released were predicted to reach Jacko Lake for the scenario with ELFZ hydraulic conductivity of $5x10^{-7}$ m/s. As a result, approximately 13.16 m^3/day (0.16 m^3/day from the WMRSF and 13 m^3/day from the TSF) of seepage-affected water was predicted to discharge to Jacko Lake in this scenario (Table 1). This accounts for 40% of total groundwater predicted to discharge to Jacko Lake at Closure (i.e., total discharge at Closure is estimated to be 33 m^3/day for an ELFZ hydraulic conductivity of $5x10^{-7}$ m/s, Table 2).
- 8% (WMRSF) and 3% (TSF) of particles released were predicted to reach Jacko Lake for the scenario with ELFZ hydraulic conductivity of $5x10^{-6}$ m/s. Therefore, approximately 159.4 m^3/day (1.4 m^3/day from the WMRSF and 158 m^3/day from the TSF) of seepage-affected water was predicted to discharge to Jacko Lake in this scenario (Table 1). This accounts for 90% of total groundwater predicted to discharge to Jacko Lake at Closure (i.e., total discharge at Closure is estimated to be 178 m^3/day for an ELFZ hydraulic conductivity of $5x10^{-6}$ m/s, Table 2).

For the higher ELFZ hydraulic conductivity scenarios (i.e., $\geq 5x10^{-7}$ m/s) where seepage-affected water was predicted to reach Jacko Lake, simulated travel times ranged from 18 years (9 to 72 years range for ELFZ K = $5x10^{-6}$ to $5x10^{-7}$ m/s) and 121 years (16 to >200 years range for ELFZ K = $5x10^{-6}$ m/s to $5x10^{-7}$ m/s) from the WMRSF and TSF, respectively (see 0706_KAM_ELFZ_Model_BGC-002).

As discussed in 0706_KAM_ELFZ_Model_BGC-002, the analysis completed with the numerical groundwater flow model included several layers of conservatism, including the following:

- The ELFZ was simulated in the numerical groundwater model as a zone a minimum of 50 m wide and up to 250 m wide, and present through the full vertical and lateral extents of the model used to represent bedrock units. The maximum interpreted thickness of the fault from field investigations was 60 m (see Appendix 6.2-B of the Application/EIS).
- The model assumes that the supernatant pond within the TSF remains at its highest operational level (i.e., 1057.8 masl) into perpetuity. As discussed in Appendix 6.6-D of the Application/EIS, this assumption would likely overestimate potential groundwater inflows from the TSF at Closure, since the TSF supernatant pond will be decommissioned (i.e., water pumped to the Open Pit), and the area will be progressively capped with crushed Non Potentially Acid Generating (NPAG) mine rock and soil during the Closure/Decommissioning phases of mining.
- No mitigation measures have been implemented in the model. The model does not consider reclamation covers that will be implemented as part of mine closure nor does it consider specific seepage mitigation measures (e.g., grouting, interception wells, etc.) that would be implemented if monitoring results indicated the potential to affect Jacko Lake water quality.

The analysis also considered a sensitivity case where fault cells within the model were assigned a K value of $5x10^{-6}$ m/s (i.e., slightly greater than estimated maximum from field testing) to capture the uncertainty associated with this value (0706_KAM_ELFZ_Model_BGC-002). Therefore, the above results of the numerical simulations should be considered preliminary and conservative at this stage.

It should be noted that the simulated groundwater discharge to Jacko Lake for existing conditions in the high ELFZ K scenarios was higher than what is currently predicted with the base case calibrated model (Table 2). That is, for existing conditions:

- The total simulated discharge to Jacko Lake from groundwater sources was 14 m^3/day for the base case, calibrated model.
- The total simulated discharge to Jacko Lake from groundwater sources was 26 m^3/day for the case where a K of $5x10^{-7}$ m/s was assigned to the ELFZ.
- The total simulated discharge to Jacko Lake from groundwater sources was 64 m^3/day for the case where a K of $5x10^{-6}$ m/s was assigned to the ELFZ.

The current baseline understanding of water quality for Jacko Lake does not support the increased contribution of groundwater discharge that would need to occur in scenarios where K of the ELFZ $\geq 5x10^{-7}$ m/s. This is demonstrated in the baseline concentrations of some conservative tracers (e.g., sulphate) that suggest the water quality of Jacko Lake is more similar to surface water inflow chemistry than groundwater chemistry. Increasing the loading from groundwater to the lake would result in higher concentrations of sulphate that are inconsistent with observed conditions for the site (Knight Piesold, 2017). Therefore, the simulated increases in groundwater discharge to Jacko Lake associated with scenarios where K of the ELFZ $\geq 5 \times 10^{-7}$ m/s do not reflect existing conditions, suggesting that these scenarios may not be realistic.

Further investigation at future stages of the Project will be used to improve the characterization of the ELFZ and refine proposed monitoring and mitigation plans. Additional investigations have been proposed for the ELFZ at future stages of the Project and prior to the commencement of mining activity. Further detail on these investigations is provided in Supplementary Memorandum 1213_KAM_BGC-022_FLNRO. As guided by the KGHM International Environmental Policy, KAM believes that protection of the natural environment is fundamental to the success of its operations and projects. Emphasizing its core value of “Zero Harm”, KAM will use environmental and natural resource management tools and practices to minimize environmental risk during the evaluation, exploration, planning, design, construction, operation and closure phases of the Project. KAM is committed to the environment and continuous improvement in environmental performance through the Environmental Management System, which uses the Plan, Do, Check, and Act cycle to proactively identify and manage environmental effects, evaluates effectiveness of control, and adapts to monitoring results or changing conditions. In cases where monitoring indicates that mitigation measures are not performing adequately, adaptive management measures will be taken to ensure that the operation remains in compliance with regulatory requirements and with commitments made. Continuous improvements approaches look for trends in data, so that measures can be implemented <u>before</u> the operation exceeds standards, regulatory requirements, or commitments (See Chapter 11 of the Application/EIS, Environmental Management System).

3.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of KGHM Ajax Mining Inc. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

As a mutual protection to our client, the public, and ourselves all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending BGC's written approval. A record copy of this document is on file at BGC. That copy takes precedence over any other copy or reproduction of this document.

Yours sincerely,

BGC ENGINEERING INC.
per:

Craig Thompson, M.Sc., GIT.
Hydrogeologist

Cassandra Koenig, M.Sc., P.Geo.
Senior Hydrogeologist

Reviewed by:

Trevor Crozier, M.Eng., P.Eng.
Principal Hydrogeological Engineer

REFERENCES

CEAA. 2016. KGHM Ajax Mining Inc.'s responses to the Information Requests relating to the Environmental Impact Statement for the Ajax Mine Project. Letter addressed to KGHM Ajax Mining Inc., from Canadian Environmental Assessment Agency, dated December 5, 2016.

Hydrogeologic Inc., 1996. MODFLOW-SURFACT Software (Version 3.0) Overview: Installation, Registration and Running Procedures. Herndon, Virginia, 548 p.

KAM. 2016. Ajax Project: Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study. Assembled for KGHM Ajax Mining Inc. by ERM Consultants Canada Ltd.: Vancouver, British Columbia.

Knight Piesold. 2017. Responses to Follow-up Water Quality Comments Provided in the Canadian Environmental Assessment Agency Letter (December 5, 2016) Re: KGHM Ajax Mining Inc.'s responses to the Information Requests relating to the Environmental Impact Statement for the Ajax Mine – Water Quality. Memorandum prepared by Knight Piesold Ltd for KGHM Ajax Mining Inc., dated January 23, 2017.

Knight Piesold. 2017. Personal communication re: Jacko Lake Water Balance. 2017/01/24.

Pollock, D.W., 1994. User's Guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model. U.S. Geological Survey Open-File Report 94-464, 249 p.

Table 1. Predicted Jacko Lake Discharge from Mining Facilities for Base Cases and ELFZ Sensitivity Scenarios

Facility	ELFZ Hydraulic Conductivity (m/s)	Discharge to Jacko Lake (Closure)		
		% of Particles Released	% of Total Groundwater Flow	m^3/d
WMRSF	Base Case	0	0	0
	$3x10^{-8}$	0	0	0
	$1x10^{-7}$	0	0	0
	$5x10^{-7}$	0.4	0.48	0.16
	$5x10^{-6}$	8	0.79	1.4
TSF	Base Case	0	0	0
	$3x10^{-8}$	0	0	0
	$1x10^{-7}$	0	0	0
	$5x10^{-7}$	0.2	39	13
	$5x10^{-6}$	3	89	158

Table 2. Predicted ELFZ influence on Jacko Lake – groundwater exchange (from 0706_KAM_ELFZ_Model_BGC-002).

Scenario	Jacko Lake - Groundwater Exchange [a,d]	Base Case [b]	ELFZ Sensitivity Cases (K in m/s) [c]			
			$3x10^{-8}$ [b]	$1x10^{-7}$	$5x10^{-7}$	$5x10^{-6}$
Pre-mining	Seepage (m^3/d)	13	12	12	11	12
	Discharge (m^3/d)	14	15	17	26	64
Closure	Seepage (m^3/d)	138	137	136	136	139
	Discharge (m^3/d)	7	8	12	33	178

Notes:

a) Preliminary estimates subject to refinement.

b) As summarized in Appendix 6.6-D (Application/EIS).

c) K = hydraulic conductivity.

d) Seepage = flow from lake to groundwater system; discharge = flow from groundwater system to lake.

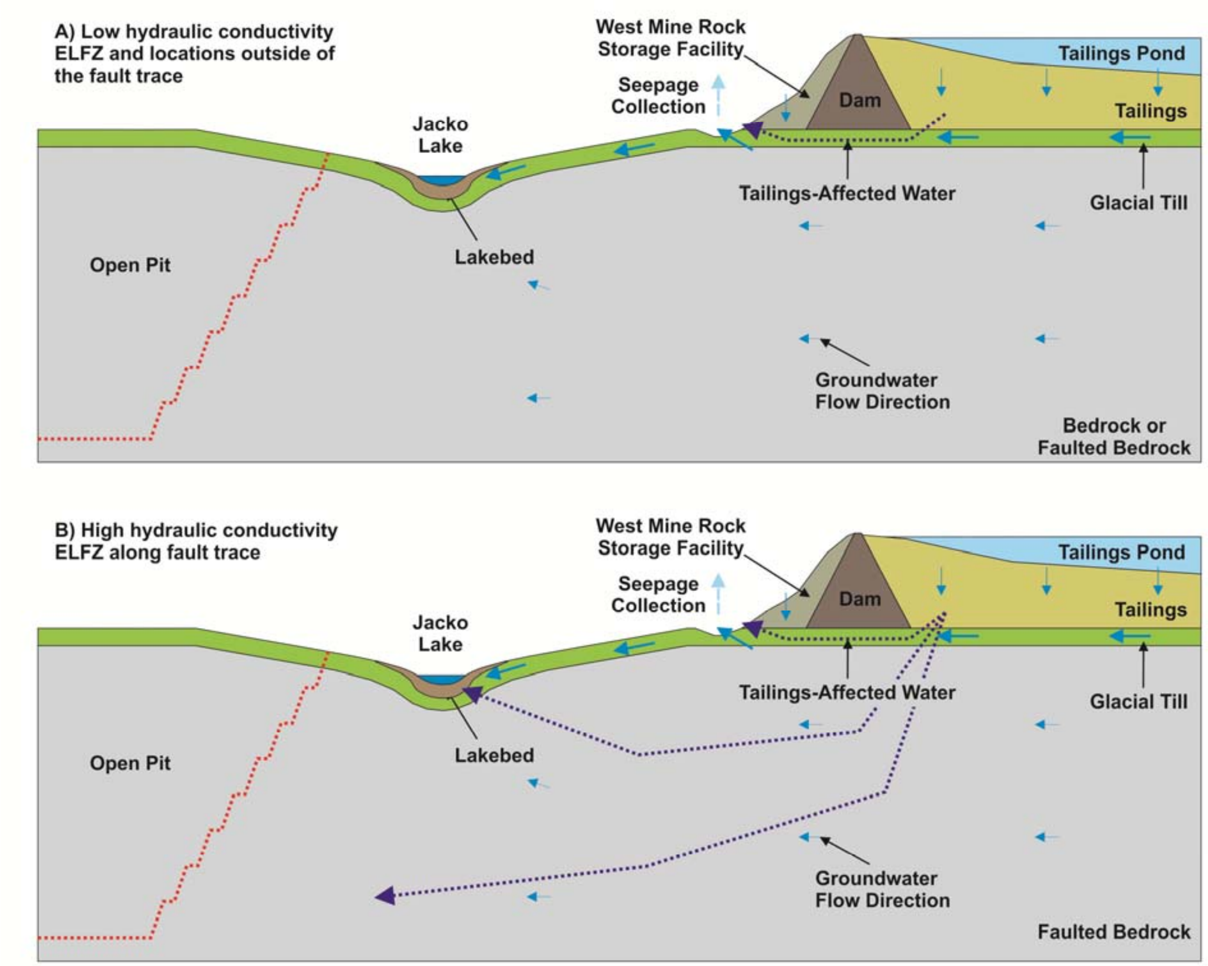

Figure 1. Conceptual cross-section along the fault trace from TSF to Jacko Lake for A) low hydraulic conductivity (i.e., <5x10^{-7} m/s) ELFZ and locations outside of the fault trace and B) high hydraulic conductivity (i.e., >5x10^{-7} m/s) ELFZ relative to the adjacent host rock (hydraulic conductivity of 5x10^{-10} to 6x10^{-8} m/s). Note that groundwater flow paths are shown only from the TSF; flow paths originating from the WMRSF are predicted to follow a similar trajectory. Conceptual diagram not to scale.

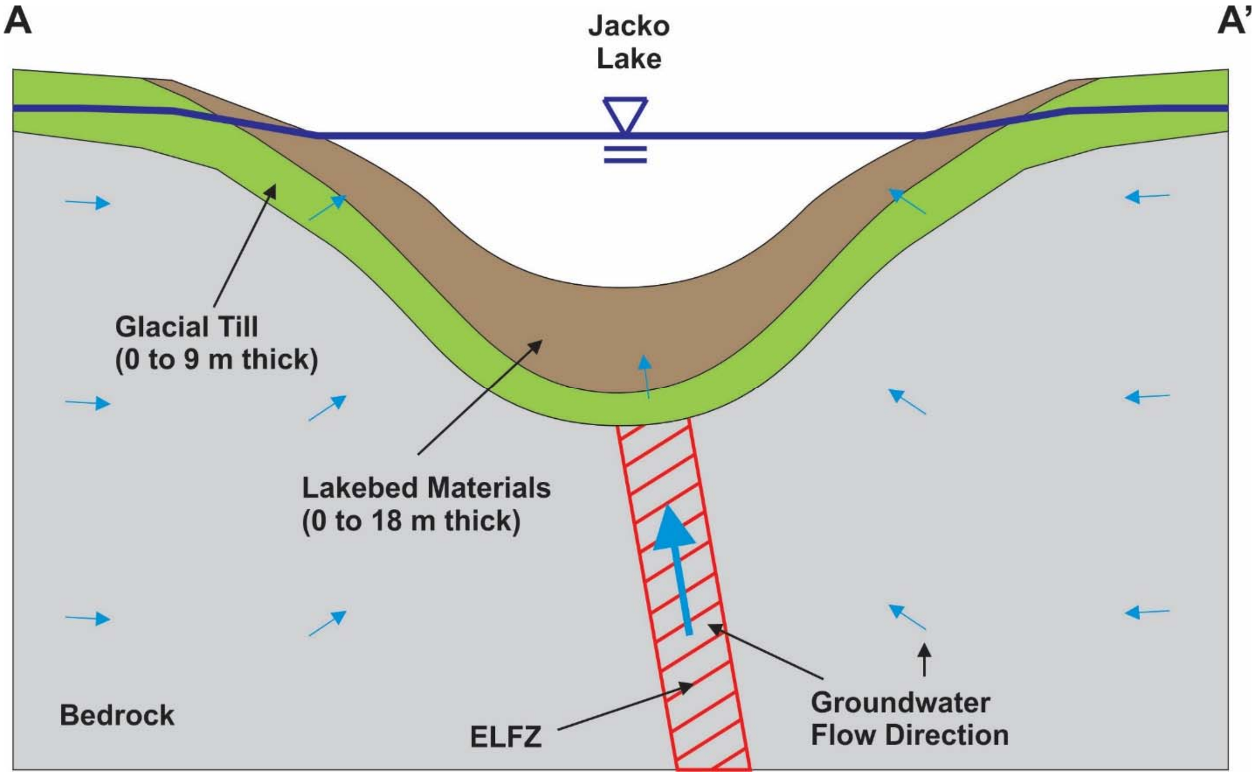

Figure 2. Sketch showing the potential influence of the ELFZ on lake-groundwater interactions at Jacko Lake referenced in Comment #ECCC-098.1 (reproduced from 0706_KAM_ELFZ_Model_BGC-002). Arrows indicate groundwater flow directions sized by relative magnitude.