Ajax Project Review -
Review of Predicted Water Contamination

prepared for:

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P.Geo. Notice

This study is based on detailed technical information interpreted through standard and advanced chemical and geoscientific techniques available at this time. As with all geoscientific investigations, the findings are based on data collected at discrete points in time and location. In portions of this report, it has been necessary to infer information between and beyond the measured data points using established techniques and scientific judgement. In our opinion, this report contains the appropriate level of geoscientific information to reach the conclusions stated herein.

This study has been conducted in accordance with British Columbia provincial legislation as stated in the Engineers and Geoscientists Act.

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Summary of This Review

The Sierra Club of BC Foundation asked the Minesite Drainage Assessment Group (MDAG) to review and comment on the *Ajax Project Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study* ("Ajax EIS"). This EIS consists of many chapters and supporting appendices, submitted by KGHM Ajax Mining Inc. (KAM).

MDAG was asked to focus on predictions of water contamination that would arise on and downstream of the proposed Ajax minesite. The basic question was: Are the predictions of water contamination contained in the EIS reasonable, considering the studies in the EIS and the inevitable uncertainties that cannot be known in advance?

It is very important to understand that KAM has committed the Ajax Project to the Precautionary Principle and Zero Harm in Section 3.2 of the EIS. The strengths of these commitments can be seen in the following quotations from the EIS.

> "The Precautionary Principle stipulates that lack of certainty regarding threats of environmental harm should not be used as an excuse for not taking proactive steps to avert that threat. It also recognizes that delaying action until there is compelling evidence of harm will often mean that it is then too costly or impossible to avert the threat. The use of the Precautionary Principle promotes action to avert risks of serious or irreversible harm to the environment."
>
> "KAM integrates the application of the Precautionary Principle throughout the design of the Project and forms the basis for project design criteria, the effects assessment, the alternatives assessment and management practices. To this end, the precautionary approach has been used throughout the environmental assessment by applying conservative factors in design, assessment inputs and modelling, including: ... where there is uncertainty or some plausible risk, implementing conservative approaches, together with a dynamic process of adaptive management."
>
> "ZERO HARM - We are committed to Zero Harm for our employees, our communities and the environment. . . . KAM believes that protection of the natural environment is fundamental to the success of operations and projects. . . . [W]e will . . . [p]revent and minimize environmental impacts [and] meet or exceed all environmental laws and regulations."

While commitments to the Precautionary Principle and Zero Harm are noble and laudable, they are not easily carried out. When it comes to contamination of water around and downstream of the proposed Ajax Project, the EIS clearly fails to uphold the Precautionary Principle and Zero Harm.

The question put to us was, "Are the predictions of water contamination contained in the EIS reasonable, considering the studies in the EIS and the inevitable uncertainties that cannot be known in advance?" Our answer is, "No, the predictions are not reasonable, and they significantly underestimate the likely contamination of water on and leaving the proposed minesite".

Our answer is based on the following three-step approach for causing impacts, harm, or damage: source → pathway → receptor. For the Ajax EIS, the primary receptors are nearby humans and the surrounding environment. These receptors can be harmed by the Ajax Project if there are both a source, and a pathway from the source.

For water contamination, various pathways connect the proposed minesite to the receptors. The two largest groups of pathways are: surface waters and groundwaters.

This review looked at one pathway in particular, the Peterson Creek Aquifer generally east and downgradient of the proposed Ajax Minesite. As explained in Section 3 of this review, the contaminant plume modelling in the Ajax EIS underestimated the much larger extent and severity of contamination reasonably expected in the Peterson Creek Aquifer.

The extent and severity can reasonably be expected to be much worse than predicted for the Aquifer, not just for a few reasons, but for many reasons as compiled in Section 3. These reasons do not include problems with contaminant-source predictions, as discussed in Section 4.

Moreover, the intentional release of a contaminant plume into the Peterson Creek Aquifer fails to meet the objectives of British Columbia legislation.

Section 4 of this review looked at the proposed sources of water contamination, that is, the components of the Ajax site. These components include:

(a) waste-rock disposal dumps called "mine rock stockpile facilities";
(b) the low-grade-ore and medium-grade-ore stockpiles that will not be processed before the end of the operation and may, in effect, become additional waste-rock disposal dumps;
(c) the tailings disposal facility called the "tailings storage facility" or TSF,
(d) the waste-rock embankments of the TSF, which will contain a significant percentage of the total waste rock and thus represent additional waste-rock disposal dumps;
(e) the open pit, which will fill with water after mining;
(f) the overburden stockpile and overburden spread across the proposed site during construction and operation; and
(g) several other components that will contain mined material or receive water from the minesite, including roads and ponds.

Thus, there are many individual contaminant sources within the collective footprint of the proposed Ajax Minesite. Predictions of water contamination from many of these individual sources were developed in the EIS.

For the many reasons discussed in Section 4 of this review, the Ajax EIS significantly underestimated the severity of contaminated source water at the proposed minesite. We expect Ajax on-site waters and drainages would be much more contaminated than estimated in the EIS if mining were ever to occur.

Altogether in our review of the Ajax EIS, we have found a cumulative and substantial underestimation of the extent and severity of contamination (1) at the source, which is the proposed minesite, and (2) in one pathway reviewed here, the Peterson Creek Aquifer. This means that the likely impacts, damage, and harm to human health and environmental quality are significantly underestimated in the Ajax EIS.

To emphasize, the significant underestimation of contamination at the source in the Ajax EIS automatically underestimates the amount of contamination travelling along all pathways in the EIS, including non-aqueous pathways like windblown dust. Additionally, the transport of water contamination through the Peterson Creek Aquifer was underestimated. Therefore, the assessments of risk and residual risks in the Ajax EIS may greatly underestimate the actual risks that would occur if mining is ever approved.

1. INTRODUCTION

The Sierra Club of BC Foundation has asked the Minesite Drainage Assessment Group (MDAG) to review and comment on the *Ajax Project Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study* ("Ajax EIS"). This document consists of many chapters and supporting appendices, submitted by KGHM Ajax Mining Inc. (KAM).

MDAG was asked to focus on predictions of water contamination that would arise on and downstream of the proposed Ajax minesite. The basic question was: Are the predictions of water contamination contained in the EIS reasonable, considering the studies in the EIS and the inevitable uncertainties that cannot be known in advance?

As the following sections of this review show, the answer to the basic question is "No, they are not reasonable and significantly underestimate the likely contamination of water on and leaving the proposed minesite". Even the EIS provides this answer when it comes to how uncertainties should be carefully considered in the EIS: through the Precautionary Principle.

In Section 3.2.3 of the EIS, KAM explains,

> "The Precautionary Principle stipulates that lack of certainty regarding threats of environmental harm should not be used as an excuse for not taking proactive steps to avert that threat. It also recognizes that delaying action until there is compelling evidence of harm will often mean that it is then too costly or impossible to avert the threat. The use of the Precautionary Principle promotes action to avert risks of serious or irreversible harm to the environment."
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> "KAM integrates the application of the Precautionary Principle throughout the design of the Project and forms the basis for project design criteria, the effects assessment, the alternatives assessment and management practices. To this end, the precautionary approach has been used throughout the environmental assessment by applying conservative factors in design, assessment inputs and modelling, including: ... where there is uncertainty or some plausible risk, implementing conservative approaches, together with a dynamic process of adaptive management."

By implementing the Precautionary Principle, KAM would be proposing a proactive and safer mine plan in the face of uncertainties. Unfortunately, as the Acknowledgements in the EIS confirm, KAM did not conduct most of the technical work where the Precautionary Principle is needed. Instead, several non-KAM consulting companies did the work. As shown in this review, these other companies did not use the Precautionary Principle and, thus, the EIS fails to implement the two paragraphs quoted above from the EIS.

On the issue of water contamination on and leaving the minesite, as reviewed here, the EIS:

- does not take proactive steps;
- does not recognize that delaying action until there is compelling evidence of harm will often mean that it is then too costly or impossible to avert the threat;

- does not promote action to avert risks of serious or irreversible harm to the environment; and
- does not apply conservative factors in design, assessment inputs and modelling.

The following sections of this review confirm these observations.

Furthermore, KAM in Section 3.2 of the EIS commits to "zero harm".

> "ZERO HARM - We are committed to Zero Harm for our employees, our communities and the environment. . . . KAM believes that protection of the natural environment is fundamental to the success of operations and projects. . . . [W]e will . . . [p]revent and minimize environmental impacts [and] meet or exceed all environmental laws and regulations"

As with the Precautionary Principle, the EIS fails to offer reasonable evidence that zero harm will be done to the environment from water contamination.

2. APPROACH USED IN THIS REVIEW

The approach used in this review is based on three steps resulting in impacts, harm, or damage to the environment or nearby humans: source → pathway → receptor.

Step 1) There must be a source of contamination to start the processes. The source in this case is the Ajax site itself, specifically the minesite components that include:
- (a) waste-rock disposal dumps called "mine rock stockpile facilities";
- (b) the low-grade-ore and medium-grade-ore stockpiles that will not be processed before the end of the operation and may, in effect, become additional waste-rock disposal dumps[1];
- (c) the tailings disposal facility called the "tailings storage facility" or TSF,
- (d) the waste-rock embankments of the TSF, which will contain a significant percentage of the total waste rock and thus represent additional waste-rock disposal dumps;
- (e) the open pit, which will fill with water after mining;
- (f) the overburden stockpile and overburden spread across the proposed site during construction and operation; and
- (g) several other components that will contain mined material or receive water from the minesite, including roads and ponds.

Step 2) The contamination from Step 1 must travel along some pathway to reach receptors at Step 3. If there is no pathway, no contamination would leave the proposed Ajax site. The two groups of pathways at the proposed Ajax site that would allow contaminated water to migrate downstream are: surface water and groundwater.

Step 3) Receptors would have to be connected in some way to pathways from Step 2 carrying contamination from Step 1 to create adverse impacts, harm, or damage. The Ajax EIS recognizes two groups of receptors for contaminated water: humans (Chapter 10 addresses "potential health effects") and a collective "environment" for everything else (Chapter 6 addresses "potential environmental effects").

The Ajax EIS contains predictions of adverse impacts, harm, and damage to the two groups of receptors, with proposed mitigation and residual effects. It is important to understand that these predictions under Step 3 are only as reasonable and reliable as the predictions for (a) the contaminant sources in Step 1 and (b) the pathways in Step 2.

If the extent and/or severity of the contaminant sources in Step 1 are underestimated, then the predicted impacts, harm, and damage would be worse than discussed in the EIS. Additionally, if the contaminant pathways in Step 2 are greater or more conductive than estimated in the EIS, then the predicted impacts, harm, and damage would be worse than discussed in the EIS.

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[1] Decades-long exposure and weathering of ore, as planned for the Ajax Project, can make the economic elements (gold and copper) economically unrecoverable, and these ore stockpiles would in effect become waste-rock disposal dumps.

If both the sources and the pathways are underestimated, then the predicted impacts, harm, and damage could be much worse than discussed in the EIS. This would invalidate the predictions of residual effects, because they could be much worse. This would also violate the EIS' invocation of the Precautionary Principle discussed above in Section 1.

The previous paragraph is important, because this is actually what has occurred in the Ajax EIS, as confirmed in the following sections. Because there are so many detailed sources, pathways, and receptors in the Ajax EIS, most could not be reviewed here in detail. Instead, a specific pathway was chosen for review, with the understanding that problems with this pathway would likely signal similar problems with other pathways.

Therefore, the next section focusses on one pathway, namely groundwater in the Peterson Creek Aquifer. This particular pathway would transmit contaminated water from the Ajax site to residential water wells and/or reaches of Peterson Creek where aquatic life could be locally affected. As shown in the next section, the Ajax EIS has underestimated the extent and severity of contaminated water entering and flowing through this Aquifer.

The subsequent section of this review (Section 4) focusses on predictions of contaminant levels at the source - the minesite components themselves. As that section shows, the severity of contaminant levels at the minesite have been underestimated.

To summarize, this review has found that the Ajax EIS has underestimated:
- the severity of contaminated water originating on the minesite (Section 4), and
- has underestimated the amount and severity of this more contaminated water entering the Peterson Creek Aquifer and flowing to residential water wells and/or reaches of Peterson Creek where aquatic life resides (Section 3).

Therefore, the risks and potential damage to human health and environmental quality have been significantly underestimated in the Ajax EIS.

3. THE PETERSON CREEK AQUIFER AS A CONTAMINANT PATHWAY

3.1 Description of the Peterson Creek Aquifer

The Peterson Creek Aquifer is about 18 km^2 in lateral area along Peterson Creek (~12 km long and ~1.5 km wide according to Figure 6.6-E-3 in the Ajax EIS). Appendix 6.6-C explains it is up to 80 m thick with "sand and gravel units . . . interpreted to be glaciofluvial in origin and interbedded with glaciolacustrine silt and clay lenses". "The PC Aquifer may be recharged by both the underlying Sugarloaf Hill Bedrock Aquifer . . . and from groundwater flow in the overlying quaternary materials. Infiltration from precipitation, snowmelt and anthropogenic irrigation may also contribute to recharge of the aquifer."

The Peterson Creek Aquifer is rated by the British Columbia Ministry of Environment as "low development, high vulnerability and moderate productivity (Class IIIA)" (Appendix 6.6-C). Thus, the Peterson Creek Aquifer has a moderate productivity that is not currently taken advantage of, but is vulnerable to pollution and contamination. This contamination will happen if the Ajax Mine proceeds, as the Ajax modelling predicts but underestimates (Section 3.2)

3.2 Underestimation of Contamination of Residential Wells and Reaches of Peterson Creek in the Ajax EIS

The main source on predicted contamination of the Peterson Creek Aquifer in the Ajax EIS is Appendix 6.5-A, "Plume Migration Analyses to RES-2". RES-2 is a nearby residential water well.

Most of the problems and contradictions in Appendix 6.5-A become apparent only upon reviewing other portions of the EIS, like Chapters 3, 6, 10, and 11, and Appendices like 3-A and 6.6-D. When all these pieces of information are combined, it becomes apparent how the EIS underestimates the likely extent and severity of contamination of the Peterson Creek Aquifer. In turn, the likely impacts, damage, and harm to human health and environmental quality are underestimated in the EIS.

The following is a list of problems and contradictions.

3.2.1 Maximum source concentrations were not used as stated

Appendix 6.5-A falsely states that "maximum source concentrations" were used to predict the severity of contamination. Other EMRSF contaminant-source concentrations in the Ajax EIS are up to 4 times higher than used in this model.

Therefore, even according to the EIS, this plume study has substantially underestimated the severity of the contaminants entering the Peterson Creek Aquifer, RES-2, other wells, and reaches of the creek in the path of the groundwater plume. Moreover, even the higher contaminant concentrations elsewhere in the EIS are too low (see Section 4 of this review).

3.2.2 RES-2 is not the closest residential well

Apparently, the concept of the plume study in Appendix 6.5-A was that risk to RES-2 would be highest, because RES-2 “is the nearest residential well down-gradient from the proposed mining infrastructure” (EIS Section 6.5.4). Thus, risks to all other wells would by inference be lower. That is wrong for several reasons.

> First, EIS figures like Figure 6.5-2 show that RES-5 and RES-3 are much closer to mining infrastructure.
>
> Second, in addition to all the concerns raised here about the underestimation of risk, this plume study included a “main assumption” that “the well screen for RES-2 fully penetrates the Peterson Creek Aquifer (i.e., the well screen is installed across the full vertical thickness of the aquifer)”. In simple terms, this means that any contaminants entering this well from a plume will be diluted down to lower levels by the full thickness of the Aquifer and its clean water.
>
> Should risk to human health at RES-2 be estimated based on an “assumption”? Also, should risk to human health be estimated based on maximum assumed dilution, with no sensitivity study of a shorter well screen?
>
> Third, the sensitivity analyses of Section 2.4 in the appendix consider variations in hydraulic conductivity, effective porosity, and hydrodynamic dispersion. Notably, there were no sensitivity analyses for the variables underestimated in the modelling: the amount of contaminated water leaving the minesite, the severity of its concentrations, and the proportion of RES-2 well screen pumping water from the plume.

3.2.3 Low flow of contaminated water based on closure conditions after a fully stable cover

Based on the EIS, the volume of contaminated water flowing from the East Mine Rock Storage Facility (the “EMRSF” or east waste-rock disposal dump) into the groundwater will be at least 16 times higher than modelled in the appendix. This would drive the contamination down into and through the aquifer at much greater rates than estimated in the predictions. In turn, this means contaminant levels and volumes at RES-2 would likely be much higher than predicted in this plume study.

The low modelled volume is due to the false assumption that a fully intact dry cover will be installed on top of the rock dump when mining starts. Perhaps KAM assumed, incorrectly, that relocating overburden into stockpiles on the EMRSF during operation counts as a full intact dry cover. In reality, if the mine is built, the mine life of approximately 20 years would prevent a fully intact cover from being built for years, and perhaps for 30-40 years depending on rock-settlement rates that would periodically rupture and damage the cover.

Such damage to engineered fine-grained layers caused by rock settlement is the reason that specially sized and compacted rock is planned for the TSF embankments (see EIS Section 3.8.3). Remarkably, this sizing and compaction are not included with covers for the rock dumps and the TSF, which are assumed to be intact and remain so in perpetuity.

For the top of the EMRSF, the time before a fine-grained cover is fully installed, intact, and permanently stabilized would be about a minimum of about 10-20 years, and perhaps 30-40 years. Until then, larger contaminant inflow continues into the Aquifer. As a result, Figures 3-3 and 3-4 of the appendix show the main core of the plume would arrive at RES-2 before an intact cover would be installed. It makes no sense to use a small flow of contamination, controlled by an intact dry cover, before the cover is even installed and stabilized.

It is possible that someone assumed groundwater would not leave the EMRSF during Operation and for up to decades later as an entire intact cover was installed and stabilized. However, this is not a viable assumption, as explained in the point below on the accuracy of the Ajax groundwater modelling (Section 3.2.14).

3.2.4 Elevated baseline concentrations in the Aquifer

The Aquifer already has elevated baseline levels of some elements, like sulphate. As a result, there is no way that “breakthrough” concentrations at RES-2 could ever decrease to levels like 2% of the source (Figures 3-3 and 3-4 and Table 3-4 in Appendix 6.5-A). Instead, they would be strongly affected by the dispersive mixing of the baseline water. In technical terms, the “C/C_0” approach does not provide valid predictions in this dispersive flow system with significant baseline concentrations.

Also, KAM is apparently arguing that elevated baseline concentrations of some elements already in the Aquifer means the Aquifer is already contaminated. No matter whether one accepts this argument, the proposed Ajax site would significantly increase the contamination, including toxic metals that are not currently high in the Aquifer, rendering more of the Aquifer unfit, which is opposite of provincial legislation (Section 3.2.7).

3.2.5 Natural attenuation into elevated background levels does not persist indefinitely

It is unlikely that “natural attenuation” of contaminants would lead to the predicted 2% of source levels, with RES-2 located only 1.762 km from the “center of source”, and only about 1 km from the closest edge of the EMRSF creating the plume. Additionally, it is unlikely natural attenuation would persist for at least 200 years as shown by Figures 3-3 and 3-4 in the appendix, because the aquifer would continue to increase in concentrations as the contaminant input continued for decades and centuries.

The initial large contaminant input for the first 20-40 years would overwhelm any sorptive capacity and would widely contaminate the aquifer around the plume, so that attenuation would decrease through time. In the end, this means contaminant levels would be higher than predicted in this model, and thus the risk to the environment and humans would be higher.

3.2.6 RES-2 is not the only receptor of contaminated water

Because a single residential well will not capture all the contamination, other portions of the Peterson Creek Aquifer will experience substantial degradation of water quality and perhaps other residential wells too. Substantial degradation could also occur along reaches of the creek receiving the discharge of this groundwater plume.

At this time, there are only a few groundwater monitoring wells near the east and south side of the EMRSF (Figure 6.5-2 in the EIS). There are none farther to the east and close to RES-1, RES-2, and the discharge reaches in lower Peterson Creek. As a result, it is likely not possible with current information to determine better where and when the contaminant plume would flow and discharge near the residential wells. This uncertainty means the risk to human health and environmental quality cannot be reliably estimated with the studies to date for the Ajax Project. This is discussed further in Section 3.2.14 on the accuracy of the Ajax groundwater modelling

3.2.7 Failure to meet British Columbia's Water Sustainability Act and the Ground Water Protection Regulation

In light of British Columbia's Water Sustainability Act, this intentional contamination of the Peterson Creek Aquifer and its discharges to surface is not consistent with protecting stream health and aquatic environments, nor with conservation and efficiency of water. The Ajax contaminant groundwater plume will not "ensure that water stays healthy and secure for future generations of British Columbians".

Also, the Ground Water Protection Regulation calls for:

- ensuring activities related to well water and ground water are undertaken in an environmentally safe manner;
- securing a safe and healthy ground water resource and reducing risk of degradation of water quality and depletion of aquifers;
- increased public confidence in ground water resources;
- improved integrity and safety of wells and community drinking water supplies (consumer protection);
- a system of ground water protection that is efficient and accountable, and
- enhanced protection of aquatic ecosystems dependent on ground water.

(http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/gw_regulation/backgrounder.html)

This intentional release of a contaminant plume into the Peterson Creek Aquifer fails to meet these objectives of British Columbia legislation.

3.2.8 Declaration of the Aquifer as Contaminated, with warnings and limitations on usage

The Peterson Creek Aquifer should be declared contaminated if the proposed mining starts. This will protect other well owners currently using the Aquifer, so that they will be vigilant regarding the significant contamination that could be drawn into their wells. This will also protect drillers who may drill downward through the contaminant plume and thus be exposed to the contamination. This will also protect future well owners, so that they do not place well screens across the plume. This will not protect subsurface biota or benthic aquatic life in the plume-discharge reaches in the creek, which would violate KAM's zero-harm policy.

3.2.9 Failure of KAM to achieve "Zero Harm"

This intentional contamination of an aquifer taints "KAM core values" for the Ajax Project of "ZERO HARM - We are committed to Zero Harm for our employees, our communities and the environment. . . . KAM believes that protection of the natural environment is fundamental to the success of operations and projects. . . . [W]e will ... [p]revent and minimize environmental impacts [and] meet or exceed all environmental laws and regulations" (EIS Section 3.2). See the comment above about not meeting one regulation, the British Columbia Ground Water Protection Regulation.

3.2.10 Failure of KAM to meet its corporate Precautionary Principle

The unrealistic modelling of the contaminant plume in Appendix 6.5-A, underestimating the severity of the contamination of the Peterson Creek Aquifer, violates KAM commitments under the Precautionary Principle including:

> "where there is uncertainty or some plausible risk, implementing conservative approaches"
>
> and
>
> "that lack of certainty regarding threats of environmental harm should not be used as an excuse for not taking proactive steps to avert that threat. It also recognizes that delaying action until there is compelling evidence of harm will often mean that it is then too costly or impossible to avert the threat." (EIS Section 3.2.3)

Appendix 6.5-A does not reflect these commitments by KAM.

3.2.11 Warnings from this Reviewer to well owners

As a contaminant hydrogeologist with a Ph.D. in this field, I strongly recommend to people using water from the Peterson Creek Aquifer to have the well water tested (1) very frequently and (2) in perpetuity, now and in the future if the mine is built. Or, to be more cautious, to avoid using the aquifer water.

The reason for "very frequent" testing is that the contaminant plume could leave the minesite quickly and quickly arrive at your well in the Aquifer. Thus, even monthly sampling combined with a typical one-month time for laboratory analyses means that water from your well could be contaminated for two months before it is known and confirmed.

The reason for "in perpetuity" testing is due to the longevity of the contaminant sources at the Ajax site. The waste rock and tailings are being placed in "storage" facilities, which may give the impression of storage for only a limited time. In reality, these facilities are planned as permanent disposal areas like landfills. The rock and tailings as sources of environmental contamination will persist in perpetuity, so well testing should continue in perpetuity.

The contaminant groundwater plume description in the EIS is not sufficient to determine whether your well or any well in the Peterson Creek Aquifer would be safe, and the plume modelling actually underestimates the effect of the contamination. As a result, the estimated effects on human health ("not significant (minor)", EIS Section 10.4) and water quality (EIS Section 6.5, referring to Section 10.4) have also been underestimated.

3.2.12 Reliance by third parties on this preliminary assessment in the EIS

The engineering company that conducted this plume analysis showing no substantial additional risk (BGC Engineering Inc.) states in Appendix 6.5-A that

> "Any use which a third party [such as a hydrogeological reviewer like me or a well owner] 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."

Perhaps this is because Appendix 6.5-A on which contaminant migration and health risks are based is notably called "a preliminary assessment", which would be consistent with not placing any reliance on it. Yet, risks to human health and the environment in the Ajax EIS indeed rely on this appendix and its preliminary assessment.

Also, this appendix, through "particle tracking", suggested the plume may not even pass through RES-2 at all, but 50-150 m north of it. This raises the issue of what other wells and creek reaches might this plume reach, and what other minesite components might actually send a contaminant plume to RES-2. This is discussed further on the next page.

3.2.13 Lack of real monitoring of the Aquifer in the EIS

One may wonder why there are all these uncertainties and underestimations of contamination of an aquifer when it has likely been studied in detail for the Ajax EIS. Surprisingly, the reality is the Peterson Creek Aquifer has not been studied in detail. Table 6.5-1 of the EIS lists only five groundwater monitoring wells near the EMRSF. Of those five, only one, just one, in an aquifer 18 km^2 in lateral area and up to 80 m deep, is installed in the Peterson Creek Aquifer. This one monitor well is more than 1 km away from RES-2.

Therefore, the EIS has taken very little information on the Aquifer, and through impressive models and the many resulting detailed diagrams from the models, made it seem like the movements of contamination and groundwater from the proposed Ajax site were reasonably well known. They are not! The movements of contamination and groundwater are not reasonably well known, and there is little information on which to make reliable predictions for the proposed Ajax minesite.

3.2.14 Accuracy and reliability of EIS groundwater modelling

The accuracy of the Ajax groundwater modelling determines how accurately the groundwater flows, directions, and volumes in the Peterson Creek Aquifer can be estimated during Operation and after Closure. Section 6.6.4 of the EIS says that changes (or uncertainties) of a few meters in groundwater levels cause major changes in groundwater movement in the Aquifer.

So, are the currently existing groundwater levels at the Ajax site well matched by the model, within a few meters? They have to be for any predictions for the Aquifer to be reasonable and likely.

Appendix 6.6-D (Numerical Groundwater Flow Model) shows in Figure 14 that the value of the steady-state “absolute residual mean”, which is the average of the absolute differences between measured and modelled groundwater levels were 5.8 m locally and 11.2 m regionally. Also, Figure 17 of that Appendix shows that groundwater-model levels at the Ajax Monitoring Locations were often within 10 meters above to 10 meters below the measured levels. Also, Figure 19 showed that the observed vs. modelled water levels (drawdowns) above 1 m for the pumping-test calibration could often differ by up to meters to tens of meters.

Therefore, Ajax groundwater modelling showed that existing groundwater levels could not often be matched by the model to within a few meters. Therefore, the EIS models cannot be counted on to simulate reasonably and accurately the Peterson Creek Aquifer, which requires better accuracies.

3.2.15 Recommendation from this Reviewer

I recommend going beyond the current preliminary plume assessment in Appendix 6.5-A containing unrealistic input values that contradict the EIS. A detailed, EIS-consistent, three-dimensional plume assessment is needed to protect human health and environmental quality around the Ajax Project.

However, there are at this time only a few groundwater monitoring wells near the east and south side of the EMRSF (EIS Figure 6.5-2). None are farther to the east and close to RES-1 and RES-2 to understand better the Peterson Creek Aquifer and groundwater movement in the local area. Because insufficient information currently exists for an intensive three-dimensional plume model, this shows that the groundwater system around the Ajax Project and the Peterson Creek Aquifer are not sufficiently characterized and monitored with the current EIS studies. Much more work is needed either way.

3.2.16 Summary and understimation of risk to human health and the environment in the EIS

In summary, the contaminant plume modelling in Appendix 6.5-A underestimates the much larger extent and severity of contamination reasonably expected in the Peterson Creek Aquifer. In turn, this significantly raises the potential impacts, harm, and damage to the environment and human health higher than is written in the EIS. Moreover, this intentional release of a contaminant plume into the Peterson Creek Aquifer fails to meet these objectives of British Columbia legislation.

4. PREDICTED SOURCE CONTAMINATION AT THE PROPOSED AJAX SITE

As explained in Section 2 of this review, the source of contamination is the first step before an impact, harm, or damage can occur to the environment or human health. If the severity and/or volume of contamination are underestimated, then any risk of an impact could be underestimated.

In the Ajax EIS, the components of the proposed minesite represent the sources of water contamination. This contamination is also called "water quality", "ML-ARD" (metal leaching and acid rock drainage), and "geochemical source terms".

Section 3 of this review examined the groundwater contaminant pathway in the Peterson Creek Aquifer. The conclusion was that the extent and severity of contamination of the Aquifer had been underestimated in the EIS, and had even been underestimated in the plume-model appendix compared to other sections of the EIS. Much of this is independent of whether the source levels were reasonably predicted.

This section of the review focusses on the predicted source levels of contamination around the minesite. As with the Aquifer pathway above in Section 3, most problems with contaminant source concentrations become apparent only upon reviewing several portions of the EIS, like Chapters 3, 6, 10, and 11, and Appendices like 3-A and 3-B. When all these pieces of information are combined, it becomes apparent how the EIS underestimates the extent and severity of contaminated source water on the proposed minesite. In turn, the likely impacts, damage, and harm to human health and environmental quality are underestimated in the EIS.

For ease of reading, each of the following subsections begins with a summary. Then details follow the summary, offering further explanations and examples.

4.1 Weakness of kinetic-testing methods used in the Ajax EIS to predict geochemical source-water contamination

Summary:

A liter of rainfall passing through mined materials, such as a pile of rock or tailings or overburden, will dissolve and leach various elements and contaminants from these materials. This is well documented behaviour around the world, leading to increased aqueous concentrations in the water. Here is a simple question: would you expect a liter of rainfall to dissolve more contaminants as it passes through more and more rock or tailings or overburden? In other words, would the contaminant concentrations be higher if the liter passed through 200 m of piled rock (as proposed for Ajax) compared with passing through less than one meter (as tested in the EIS)? This situation is depicted in Figure 4-1 of this review. If your answer is "yes", that concentrations could be much higher, then the Ajax EIS disagrees with you.

Contaminant concentrations from the various dilute tests (less than 1 m high) were compared directly to provincial water-quality guidelines, and most were declared uncontaminated and low risk. They were not compared to the more stringent ("cleaner") federal CCME guidelines. Further, some tests like “shake flasks” on overburden had even more clean water added to dilute further the contaminant concentrations, leading to the decision that overburden can be used during proposed construction because it would not contaminate water. An alarming aspect is that even some of these dilute, short tests still exceeded the higher provincial guidelines, such as for arsenic and selenium! How much higher would the full-scale concentrations be? We cannot know because full-scale concentrations were grossly underestimated.

Water contamination around the proposed minesite was also predicted and underestimated using “kinetic rates”. This rate-based approach is discussed in a following subsection.

Finally, only “dissolved” concentrations were predicted for Ajax source terms, whereas water-quality guidelines are typically based on total (dissolved plus suspended) concentrations. Because by definition dissolved levels are less than total levels, comparisons of the lower predicted dissolved concentrations for Ajax to higher total government-determined guidelines can only make the Ajax Project look better than it would realistically be. Total concentrations could be predicted for Ajax, but were not, (1) because suspended-sediment levels at Ajax were not predicted (we could not find any such predictions) and (2) if realistic total-metal levels in Ajax rock were made available (the company refuses to release the assay database). The assay database is discussed in the next subsection of this review.

Details:

Before getting into the details of contaminant-source predictions, there is a very important concept to understand. This concept will be referred to several times in the following subsections.

In the EIS, Section 3.1.4 of Appendix 3-A discusses the geochemical “kinetic-test” programs, based in laboratories and on the Ajax site. In all these programs, the height of the sample is about one meter or less. One kind of test (shake flask) is even highly diluted with dilute water. All tests are said to provide valuable information on water quality. In fact, the aqueous concentrations are compared directly to British Columbia water-quality guidelines.

As a side note, the concentrations are not compared to the federal CCME water-quality guidelines which are lower, safer, and more precautionary for some parameters. This would have made the proposed water contamination at Ajax look even worse.

Do such tests reasonably reflect water quality under full-scale mining conditions, or can they severely underestimate it? A simple way to answer this question is with a diagram, as shown in Figure 4-1.

The testwork in Appendix 3-A put water through samples about 1 m in height or less (left side of Figure 4-1). At the proposed Ajax site, the waste-rock dumps would have heights of 85-270 m, and the waste-rock tailings embankments would be 10-122 m high (longer than the right side of Figure 4-1)! Would you expect concentrations in water that has passed through 100 m of rock to be higher than concentrations that passed through less than 1 m? I see they could be much, much higher.

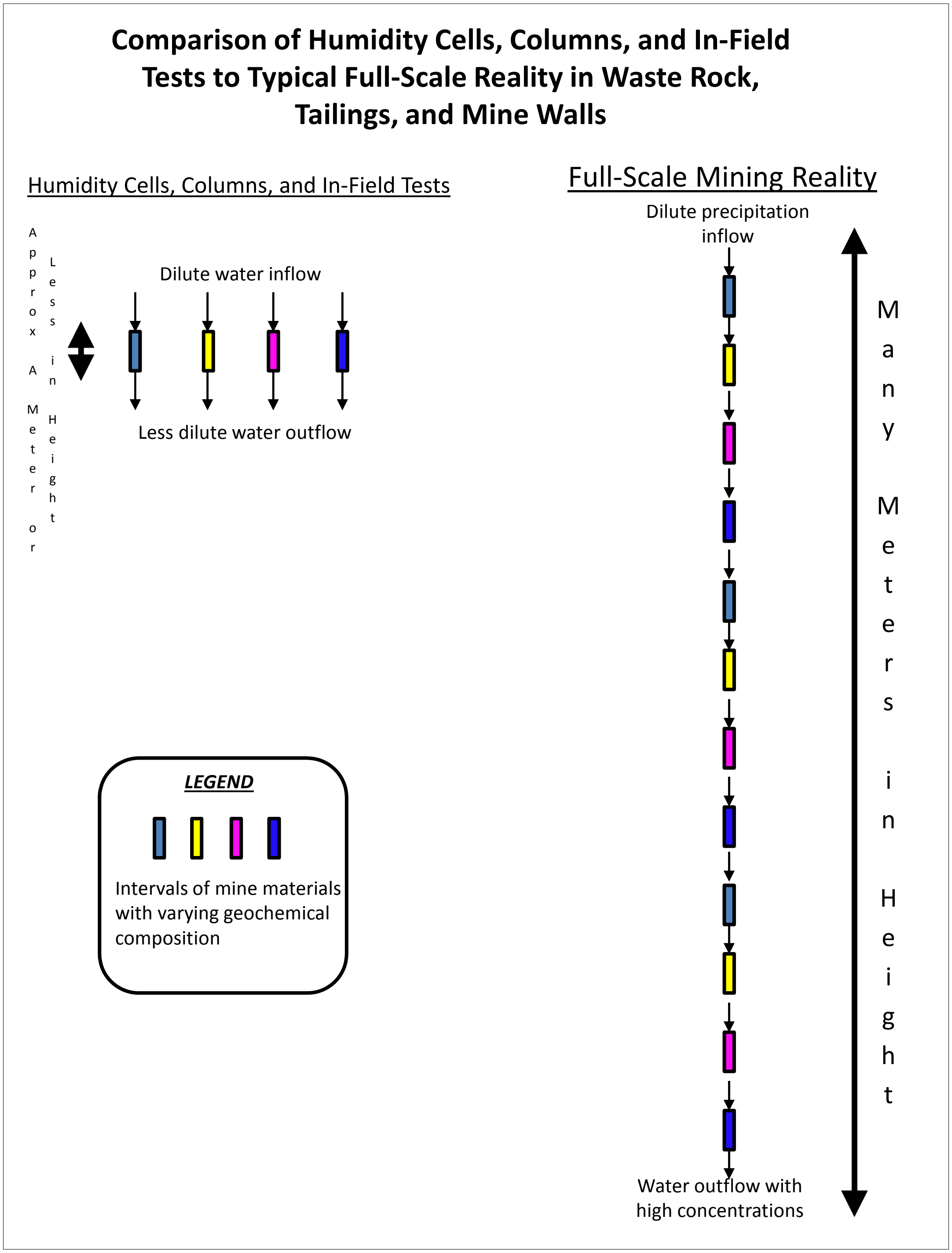

Figure 4-1. A schematic comparison of typical testwork with humidity cells, columns, and in-field tests to typical full-scale reality in waste rock, tailings, and mine walls, showing that reality at Ajax can produce much higher concentrations than typical testwork.

As a result, the many comparisons of test results in Appendix 3-A to British Columbia water-quality guidelines are meaningless, because all we can surmise is that the real on-site source concentrations could be much higher and thus more contaminated to some unknown degree. Alarmingly, some concentrations from the short-length kinetic tests even surpassed provincial water-quality guidelines, so real on-site source contaminant concentrations could be highly toxic.

This point alone shows that contaminant source concentrations have been underestimated in the Ajax EIS.

Furthermore, it is important to note that British Columbia water-quality guidelines are based on total metals (dissolved plus suspended, except aluminum and iron). However, Appendices 3-A and 3-B that define the geochemical source terms, on which all risks to the environmental and human health are based, predict only part of the total. They only predict the dissolved portion. There is no explanation in the EIS for this, but total-metal concentrations can be estimated based on:
(1) predictions of suspended solids, but such predictions could not be found in the EIS, and
(2) accurate measurements of metal levels in the solid rock particles, but KAM refuses to release these measurements (see next subsection).

Therefore, aqueous concentrations at the source (the proposed Ajax minesite) and in pathways of contaminant migration, such as in ditches and ponds and groundwater, can easily be much higher than predicted in the Ajax EIS. They could exceed water-quality guidelines even when not predicted to do so in the EIS.

4.2 What are the metal levels in rock and tailings and blowing dust at the Proposed Ajax Project?

Summary:

It is very important, for many reasons, to know accurately the levels of metals and other potentially toxic elements within Ajax rock, tailings, and overburden. For example, where pathways exist, windblown dust carries all these solid-phase elements off the minesite into the environment and into human/animal lungs. As another example, water contamination by some elements can depend on their solid-phase levels. So what are the levels of metals and other potentially toxic elements in Ajax rock, tailings, and overburden? We do not know accurately and the company will not tell us. The company claims the environmental analyses in the EIS tell us, but they are wrong.

The primary problem lies in the analytical methods for solid-phase elements. Some methods dissolve only part of a sample, and thus analyses using these methods say that levels are relatively low. Other methods dissolve most or all of a sample, and thus analyses using these methods say that levels are relatively high.

For exploration work and assay analyses at Ajax, KAM used the strong four-acid-digestion method. This makes sense, because it reports maximum levels of the economic elements like copper and gold, which makes for the best economics. On the down side, this near-complete digestion also reveals the real levels of unwanted elements like mercury and arsenic, which are then used by smelters to charge monetary penalties for unacceptably high levels. The company has refused to release the assay database, so we do not know the real, high levels of metals and other elements.

The company instead refers people to the environmental analyses in the EIS. What method was used for all the environmental samples? The weaker, partial digestion method was used, which yields only part of the real concentrations. All the environmental samples used this. All risks to humans and the environment in the EIS are based on these partial levels.

An important question would be: how much higher are the real assay levels compared to the lower environmental samples? There is no way to tell reliably, because the company will not release the assay database. Yet, there is a clue. Figure 11.5-6 in the EIS shows a graphical comparison of arsenic levels in samples analyzed both for assay and for environmental studies. It turns out the assay levels of arsenic can be higher by a factor of 10 times or more. Yet, even knowing this, all predictions of water contamination and risks for windblown dust in the EIS are based on the much lower environmental values. What would these real, much higher levels of arsenic and other elements tell us about actual risks to humans and the environment from the Ajax Project?

This approach in the EIS and its significant underestimation of effects and risks are not precautionary, may lead to non-zero harm, and are not even reasonable. Nevertheless, KAM refuses to release the assay database.

Details:

The rock and crushed-rock tailings would be the basic sources of water contamination at the proposed Ajax site, organized into various components like the TSF, TSF embankments, and mine-rock stockpiles. Therefore, the solid-phase levels of metals and other elements in rock become important as the first step in estimating water contamination. One might think these levels are easy to measure - just analyze samples of rock! The EIS contains hundreds of environmental analyses of rock and tailings.

However, it is not that easy. This is because there are many methods for analyzing rock and they do not necessarily yield similar values. It would take too many pages here to describe the differences and results of various methods, so this review will highlight one important aspect.

In order to analyze rock and tailings, many methods require the samples to be dissolved first. One common way to dissolve rock and tailings is by soaking the samples in acid. Here is where discrepancies arise. One method called “aqua regia digestion” uses a combination of two acids, which dissolves only parts of the samples. Three-acid digestion is more aggressive and dissolves more of the samples. Finally, four-acid digestion is extremely aggressive and dissolves most or all of the samples. Obviously, four-acid digestion can lead to much higher values than aqua regia when the acid solutions are analyzed.

For mining projects, assay samples are usually analyzed with four-acid digestion. This maximizes the results for economic elements like copper and gold. However, this also reveals the real levels of unwanted elements like mercury and arsenic, which are then used by smelters to charge monetary penalties for unacceptably high levels. The Ajax Project Feasibility Study Update of February 2016 (page 84) explains that four-acid digestion was used for KAM assay samples.

For non-mining contaminated-site studies, two-acid aqua regia is often used because the leachable portion of the solids is considered more important. The solid particles are considered unreactive and undissolvable. However, this does not apply to mining environmental studies.

For example, trace metals in silicate minerals are often thought to be non-dissolvable, because silicate minerals do not dissolve much in stable aquifers. However, Appendix 3-A emphasizes that silicate minerals in Ajax rock and tailings do dissolve relatively rapidly. Therefore, four-acid digestion is needed for Ajax environmental samples.

As another example, non-leachable sulphide minerals can be present in mine rock and tailings, as they are at Ajax (EIS Appendix 3-A). Sulphide minerals release their otherwise non-leachable metals only as they oxidize, as they will at Ajax. Therefore, four-acid digestions of Ajax environmental samples are required for proper characterization and predictions.

As another example, there are large concerns about dust from rock dumps and tailings blowing from the Ajax site to Kamloops and other locations. The windblown dust carries the total amount of metals and other elements, not just the more leachable portions. Again, four-acid digestion is needed for Ajax environmental samples.

Remarkably, EIS Appendix 3-A explains that only two-acid aqua regia digestion was used for all environmental samples. Therefore, we know that solid-phase levels have been underestimated for rock, tailings, and windblown dust in the EIS, and thus the human-health and environmental risk assessments in the EIS have also been underestimated. (This is due to the source-pathway-receptor connection discussed in Section 2 of this review).

A reasonable question is: how much has solid-phase contamination been underestimated by the aqua regia approach for Ajax environmental studies? This is easily answered by comparing results of the four-acid assay database to the two-acid environmental database for the same samples.

However, for the Ajax Project, this cannot be done, because KAM refuses to release the assay database. Slide 54 in the February 18, 2016, company presentation to the Community Advisory Group explains the Ajax assay database will not be released, and that "considerable environmental sampling data has been included to support the Environmental Assessments". There is no mention that the environmental analyses are not sufficient to support the Environmental Assessments properly.

However, there is a telling clue to how extreme the differences are between the high assay values and the low the environmental values. Section 11.5.3.7 explains that solid-phase arsenic can affect how much arsenic is released to water and thus how contaminated the water can become. Figure 11.5-6 (reproduced in this review for convenience as Figure 4-2) then shows that the real, assay values are often greater than 10 ppm and approach 50 ppm (along the y-axis). In remarkable contrast, the corresponding environmental "static test" samples (along the x-axis) do not exceed 10 ppm and are often less than 4 ppm. There can be a difference of a factor of 10 or more. Again, the EIS, its estimates of contamination, and estimated of risk to humans and the environment are all based on the low, partial digestion values. Thus, environmental effects and risks may be underestimated by a factor of 10 or more in the EIS!

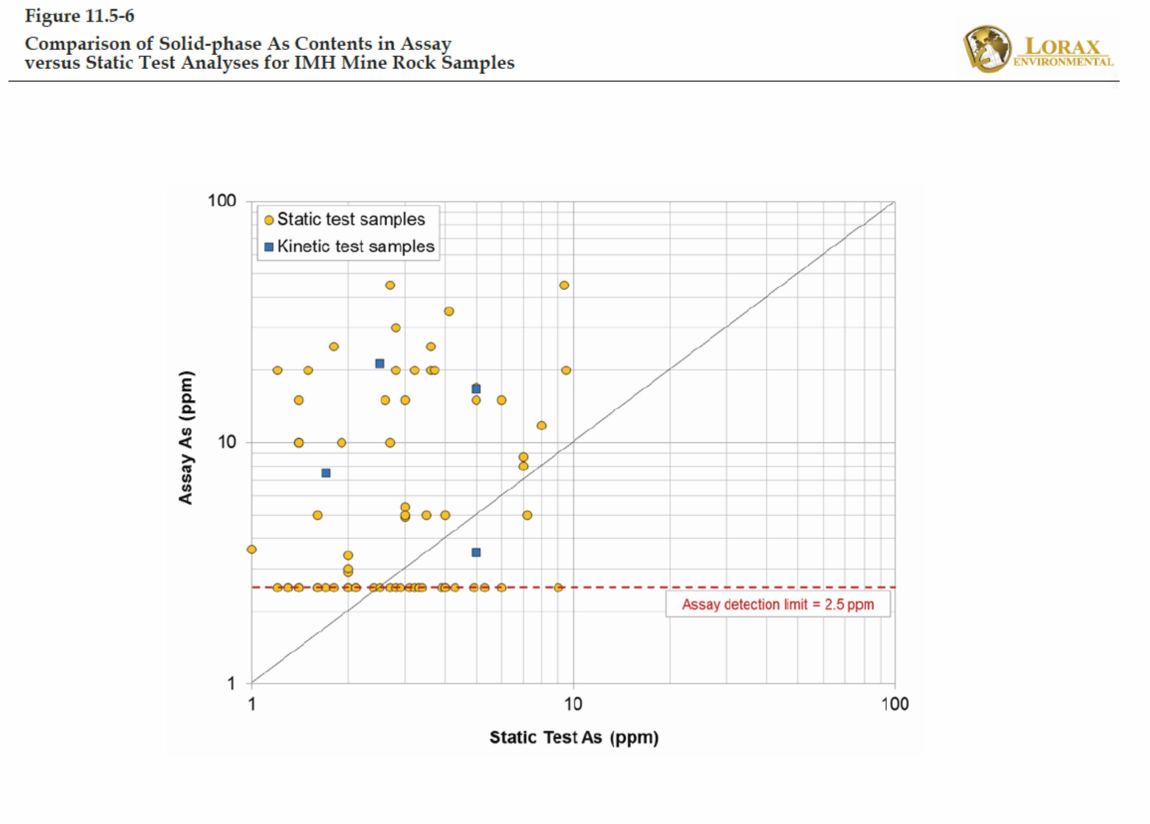
Figure 11.5-6

Comparison of Solid-phase As Contents in Assay versus Static Test Analyses for IMH Mine Rock Samples

Figure 4-2. A copy of Figure 11.5-6 from the Ajax EIS, showing that Ajax environmental "static test" analyses grossly underestimate the true total amount of arsenic measured by the Ajax assay database; KAM refuses to release the assay database, so the substantially lower environmental values were used to predict lower environmental contamination, lower effects of windblown dust, and lower risks to human health and the environment in the EIS.

This approach and its underestimation of effects and risks are not precautionary (see Section 1 of this review), may not lead to non-zero harm, and may not even be reasonable. Nevertheless, KAM refuses to release the assay database.

4.3 Lack of usage of historical geochemical data during operation at the earlier Ajax mining operation

Summary:

The Ajax site is not a “greenfields” site, pristine and without previous mining. Mining occurred there, although on a much smaller scale than is now proposed, in the 1980's and 1990's. This older operation would have kept monitoring records, showing how much higher contamination was during operation relative to decades after closure. Surprisingly, the Ajax EIS has no assessment of the past contaminant data during operation. It is not hard to find, even we could find some.

Only data long after closure, some only back to 2007 but most starting in 2011, is provided in the Ajax EIS. Despite the data coming many years after closure, it is used for predictions during proposed active mining at the proposed Ajax site, which can lead to underestimations of source contamination.

In any case, the post-closure data for the previous smaller-scale mining shows that water quality is still poor. Since the proposed operation is vastly larger, the water quality can only become much worse.

Details:

Section 3.3 of the EIS explained,

> “The Ajax property includes three areas: the Ajax West Pit, the Ajax East Pit (both pits were formerly mined in the 1980s and 1990s) and the Ajax East Extension (previously known as Monte Carlo).”

Also,

> “The Project is located on the footprint of the previous Ajax East and Ajax West open pits and associated access and haul roads and reclaimed mine rock piles.” (EIS Section 2.2.3)

Because mining took place in the 1980's and 1990's, there would be monitoring reports and databases on water contamination during active mining. There would also be old solid-phase testwork like acid-base accounts (ABAs) indicating sulphur levels and the potential for ML-ARD.

These analyses would have been made during active mining when contaminant levels would be highest due to mining activity. Such high levels are due to the ongoing day-to-day blasting, excavation, hauling, dumping, and dozer-grading which enhance the percentages of finer particles and the reaction rates of many minerals. After mine closure, contaminant levels may decrease, so monitoring data after closure is not as reliable.

Surprisingly, the Ajax EIS has no assessment of the past contaminant data during mining in the 1980's and 1990's. Only data long after closure, some only back to 2007 but most starting in 2011, is provided (Appendix 3-A of the EIS). Despite the data coming many years after closure, it is used for predictions during proposed active mining at the Ajax site, which can lead to underestimations of source contamination.

The data from the old mining operation should not be hard to find. MDAG has found a few hundred ABA from historical analyses of waste rock, low-grade ore, ore, and tailings. If we have this information, why doesn't KAM have it? Therefore, it appears the EIS intentionally ignored the operational data from the previous operation. This may account in part for the underestimation of contamination from the proposed project.

Although the water contamination during the former operation is conspicuously missing, the Ajax EIS does look at contamination more than 15 years after closure. Section 6.3 of Appendix 3-A explains that post-closure water samples were collected from a mine-rock seep, two monitoring wells (~40 m and ~18 m deep) in the backfilled East Pit (although Section 8 of the same appendix says the wells were ~28 m and ~6 m deep), and water held in small lakes on top of the backfilled West Pit.

Appendix 3-A explains, "These sites have been exposed to actual weathering conditions in the Ajax site for more than 15 years; mining activities were completed in 1997." While true, they are (1) not representative of the higher rates and concentrations expected during operation (where the old operational data has been ignored, as discussed above), and (2) not representative of the higher proposed waste piles estimated at 85-270 m high (EIS Table 3.9-1). So water contamination at the proposed Ajax Operation could be much worse, for both operation and closure.

Despite the much worse contamination expected from the proposed Ajax site, Appendix G of Appendix 3-A shows that water contamination long after closure of the previous, smaller mining operation is still bad. For example, sulphate in the pit lakes, rock porewater in the backfilled pit, and the mine-rock seep typically have sulphate concentrations above 1000 mg/L.

Furthermore, concentrations fluctuate significantly, with sulphate from the waste-rock seep (WR-SEEP) varying from 475 to 2390 mg/L (average of 1400 mg/L), based on an annual sampling frequency less than monthly. Therefore, seasonal fluctuations around the average can be significant. As another example, dissolved copper in the seep had an average of 0.02 mg/L, but reached a maximum of 0.0637 mg/L (3 times higher than average). These variations, which can produce higher concentrations that can be more toxic and persist for weeks and months, are important to note, because they are not included in Ajax predictions! This is discussed in a subsection below on contaminant variability.

Figure 6-44 of Appendix 3-A compares molybdenum concentrations in on-site waters to British Columbia water-quality guidelines. The 30-day-duration guideline is 1 mg/L, with an allowable measured maximum of 2 mg/L. This seems okay, until one considers the federal CCME guideline for protection of aquatic life is only 0.073 mg/L! Suddenly, just about every molybdenum analysis is far above the federal guideline. This shows the seriousness of the existing water contamination, decades after initial mining and at a much smaller scale than proposed now for Ajax. Obviously, the provincial guidelines give a much better impression, but even some higher provincial guidelines are exceeded.

Finally, Appendix 3-A attempts to minimize concern over water contamination in the backfilled pit.

> "It should also be noted samples from the monitoring wells were recovered from the saturated zone within the backfilled pit which could lead to an increased solubility for redox-sensitive species."

There is a failure to mention the much larger, opposite problem: the saturated conditions nearly halt the oxidative weathering reaction. As a result, the monitor wells would be showing much lower contaminant levels than expected during active mining and long after closure at the proposed Ajax site. Oxidative weathering is, in fact, the focus of most of this Appendix 3-A in the EIS, and thus the monitor wells do not show the higher, more realistic impacts.

4.4 Source leaching of metals and other elements, leading to contamination of waters in surface and subsurface pathways

Summary:

The Ajax EIS also predicted water contamination using "kinetic rates", which show the amount of contamination released by 1 kg of rock, tailings, or overburden. These rates are then scaled up ("upscaled") to the number of kg proposed for each minesite component at Ajax.

This is a monumental task, fraught with difficulties, pretending that contamination from more than 100,000,000,000 kg under on-site conditions can be derived from small tests containing mostly 1 kg under laboratory conditions. Other issues that make the usage of small-scale kinetic rates unreliable for Ajax include:

- the selection of an average rate for upscaling especially when higher rates were ignored;
- dried out on-site "field bins";
- the usage of small "scaling factors" to consistently lower contaminant predictions;
- the reduction of full-scale predictions based on maximum "caps" derived from small-scale information (left side of Figure 4-1) and unreliable databases; and
- predictions of only "average annual" concentrations despite the knowledge that higher shorter-term, potentially toxic concentrations could persist for weeks or months.

Contaminant levels for all elements were predicted in mg/L, allowing comparisons to guidelines and to other minesites, except nitrogen species (nitrate, nitrite, and ammonia). Contaminant levels of these nitrogen species were simply predicted as kilograms for most minesite components at the proposed Ajax site. These levels suggest nitrate, nitrite, and ammonia will be at very high toxic levels in Ajax waters, but there is no way to know.

Therefore, just as with the mg/L approach in Section 4.1, the kinetic-rate approach used in the Ajax EIS also significantly underestimated water contamination. Thus, the likely impacts, damage, and harm to human health and environmental quality are unrealistically low. As explained above, there are not just one or two reasons that contamination was underestimated with kinetic rates, but several reasons. This is not precautionary at all, contradicting the Ajax EIS' commitment to the Precautionary Principle and Zero Harm (see Section 1 of this review).

Details:

The previous subsections have shown that water contamination for the Ajax Project has been substantially underestimated in the Ajax EIS. The contamination can be much worse than predicted. There is even more evidence for this in the EIS, as explained in this subsection which focusses on some details of predictions for the full-scale contaminant levels, should mining ever proceed at Ajax.

For clarity, we point out that the previous subsections and this one are addressing the near-neutral water contamination predicted for most of the Ajax site. The effects of acidic conditions and the development of acid rock drainage (ARD) would be additional to this. ARD can be expected to develop at Ajax, likely within a few years, as explained in the following subsections of this review. This would add to the contamination discussed here.

Section 4.1 above explained how near-neutral contaminant concentrations from small samples at Ajax (less than 1 m high, left side of Figure 4-1) could grossly underestimate contamination under full-scale mining (right side, where proposed heights reach 270 m). Nevertheless, the EIS compared these diluted concentrations to provincial water-quality guidelines to conclude most concentrations will be acceptable. There is another way to use the results of small samples, using “kinetic rates” rather than concentrations. However, it is important to note that the dilute small-test concentrations were still used with kinetic rates, to “cap” many full-scale predictions at those dilute levels (Appendix C of Appendix 3-B). So the conclusion remains that water contamination has been substantially underestimated in the Ajax EIS.

The kinetic-rate approach uses the contaminant leaching rates from small tests (left side of Figure 4-1) on a per-kilogram basis. These rates are applied to the number of kg estimated for various minesite components like the waste-rock dump, TSF, etc. (see the list in Section 2 of this review).

While such an approach may sound reasonable, it has difficulties. Studies of full-scale minesite components have repeatedly shown that full-scale contamination cannot be reliably predicted from small samples.

Here are some reasons why the Ajax EIS grossly underestimated water contamination using kinetic rates.

- Many laboratory-based kinetic tests for Ajax weighed about 1 kg, with the larger on-site tests weighing hundreds of kg. In contrast, many minesite components will contain hundreds of billions of kg! How many people believe that such small samples could provide all the important geochemical, physical, and biological information needed to reliably predict full-scale contamination from volumes that are larger by at least 1,000,000,000 times?

- There are several kinetic rates defined for each sample, such as the first-week rate, the first-ten-week-average rate, the full-test-average rate, the last-five-week rate, the long-term-stable rate, etc. Which rate should be used for full-scale predictions? Laboratory-based kinetic tests showed that concentrations and rates were relatively high in early weeks and generally decreased in later weeks (e.g., Figures 6-15 through 6-20 of Appendix 3-A).

As explained in other subsections of this review, active mining leads to relatively high rates, and ongoing mining produces ongoing tonnages with relatively high rates. Unlike predictions of ARD based on Weeks 40-45 of testing (Section 4.5 of this review), the pH-neutral contaminant predictions for most of the Ajax EIS used rates from Weeks 109-117 to Weeks 181-189 (Table 6-5 of Appendix 3-A). This shows that the kinetic rates used to predict water contamination during proposed operation at Ajax were unrealistically low, and thus contamination can be expected to be higher than EIS predictions.

Furthermore, several kinetic tests had not reached these much later weeks, so they were simply ignored altogether. Therefore, while ARD predictions were based on 10 kinetic tests, near-neutral rates were based on only 5 tests (Table 6-5 of Appendix 3-A). This approach intentionally ignored samples with the higher rates and reactivity.

Also, the most reactive rock at Ajax is the higher sulphur rock that represents about one-quarter of the total. In Table 6-5, Col-3 containing elevated sulphide produced leaching rates that were up to 100x higher than the other samples. Therefore, metal-leaching rates under active mining conditions can be expected to be even higher for the higher-sulphur rock at Ajax ignored in the predictions. This is discussed further in Section 4.6, where it also affects the “lag time” until ARD appears at Ajax.

We could not check metal-leaching rates and estimate active-mining rates, because KAM did not provide spreadsheets with the data for our review. Also, the Ajax geochemical assay database contains many more metal analyses, using a proper analytical technique unlike the environmental studies in the Ajax EIS (see Section 4.2 of this review). However, KAM refuses to release the assay database, so we cannot estimate how much worse the water contamination at Ajax would be if mining ever started.

- Another weakness in the Ajax kinetic testing involves the on-site testwork using “field bins”. Section 3.1.4 of Appendix 3-A shows that the field weathering bins have drainage holes directly in the bottom, allowing all water to drain. In reality, full-scale minesite components like huge rock piles and tailings impoundments retain some moisture inside, sometimes there is even a water table, and this moisture moves upwards to higher levels during evaporation and then drains downward after condensing. Moisture and water cause the reaction rates of several minerals to accelerate. Two important points come from this:
  (1) The field weathering bins drained completely and due to their small size likely dried out at times, and thus they would underestimate the geochemical reactivity and water contamination from more realistic moist rock, and
  (2) In full-scale components, much of the rock surfaces is moistened and reacts frequently, leading to increased contamination, which is in contrast to the lower reactive rock surface used for the Ajax predictions of water contamination (discussed in more detail below).

This unrealistic drying was even recognized later in Appendix 3-A for the Unsaturated Columns, where the EIS states, “Such dry conditions were deemed unrealistic on a large scale where residual moisture can be expected in the majority of the MRSF volume.” If such drying was unrealistic, why are contaminant predictions based on testwork where such drying occurred? The EIS states,

> "It is precisely this type of [mineralogical] variability that suggests field bin studies be used to inform the more controlled laboratory kinetic testing."

So the unreliable field testwork was used to adjust the laboratory kinetic tests.

- The per-kg kinetic rates from the small Ajax tests are mathematically scaled upwards by factors of 1,000,000,000 times or more. This leads to predictions of massive loadings that show contamination could be quite serious. However, to make the situation less dire, "scaling factors" are used to substantially lower the upscaled contamination until it is reduced to more acceptable levels.

  There are hundreds of more physical, geochemical, and biological processes that can affect full-scale rates. The effect (individual scaling factor) of each one is multiplied by the others to obtain the single "cumulative scaling factor" (CSF). If even one individual scaling factor is missed, the resulting full-scale predictions can be very wrong.

  First, one would think the mining industry would have case studies and proofs of valid cumulative scaling factors, from comparing small-scale testwork to full-scale minesites, but this would be wrong. MDAG is one of the few that have searched the literature and found only a handful of these CSFs, and several come from MDAG studies. They lie in the range of 5% to 60% (0.05 to 0.60).

  Second, some individual scaling factors are greater than 100% and some are less than 100%. When all are multiplied together to calculate the CSF, they should lie in the range of 5% to 60% based on the few reported studies.

  The Ajax EIS only used individual scaling factors less than 100%, ignoring those above 100% that would raise the predictions of contamination. Furthermore, the low scaling factors used in the Ajax EIS, when multiplied together, resulted in low CSFs of 0.08% to 0.50% with one maximum of 1% (Table 2-3 of Appendix 3-B). The average Ajax CSF is 0.29%, with a median of 0.30% and a 90th percentile of 0.44%. These Ajax values around 0.30% are 16 times to 200 times less than the few confirmed CSFs at other minesites! Thus, based on known CSF values, full-scale water contamination at Ajax based on kinetic rates would be 16-200 times higher than predicted in the EIS! This is in addition to all the other underestimations highlighted in this review.

- As mentioned above, predicted full-scale concentrations from the minesite components at Ajax were not allowed to go above selected maximum values in mg/L ("caps", Appendix 3-B). The scaling up of per-kg kinetic rates can create large contaminant loads and, for the Ajax Project, less-than-1.0 scaling factors were used to bring them down. Still, that was not enough - caps were selected to restrict large contaminant loads.

  The Ajax contaminant caps for the full-scale components were taken from three sources.

First, most caps for the full-scale components (right side of Figure 4-1) were taken from, amazingly, the maximum concentrations measured in the small testwork (left side of Figure 4-1). So much of this review has explained the many reasons why small-scale testwork, particularly contaminant concentrations in mg/L, underestimate full-scale concentrations. Now we see the EIS uses those underestimated concentrations to cap the full-scale ones. Put simply the Ajax EIS used the left side of Figure 4-1 to cap the maximum from the right side! Thus, these caps are much too low.

Second, the mine-rock piezometers in the backfilled pit from the smaller-scale, earlier mining operations provided some maximum caps. The previous subsection (Section 4.3) explained the reasons why these would underestimate contaminant levels. Thus, these caps are too low.

Third, an ambiguous "neutral drainage database from BC porphyry copper minesites (SRK, 2004)" was used for some caps. The reference, SRK (2004), is from an EIS submitted to the British Columbia government in 2004. As with the Ajax EIS, this other EIS also used scaling factors and caps. In any case, as with any database, one would wonder whether it has been validated and confirmed, especially since it is being used for all-important caps at Ajax.

That SRK database has not been validated or confirmed, and in fact is known to be biased. For example, one British Columbia minesite in that database has over 5000 water analyses, but the SRK database for that site includes only about 70 of those 5000 analyses. Who picked the 70 from the 5000? Why were only about 1% of the analyses used? Did SRK pick the highest or lowest values from the 5000? The questions continue, but it is clear this SRK database is not reliable for caps, including caps for the Ajax Project where risks to human health and the environment can depend on them. Where is the Ajax Precautionary Principle in this? The SRK caps are unreliable at best and much too low at worst.

- As Appendix 3-B explained, the geochemical source-term predictions at Ajax are presented as "average annual" values. As explained throughout this review, these contaminant predictions drastically underestimate the much higher contamination that can be expected if full-scale mining proceeded at Ajax.

  As mentioned above, certain average rates were selected; for Ajax, low rates late in the testwork were selected to represent active mining and closure. Even if we could accept the contaminant predictions for Ajax as reasonable, and we cannot, there is yet another problem. This problem lies in the words, "average annual".

  "Average annual" means that, in a simple situation, contaminant concentrations will be higher than average for half the year and lower half the year. If the higher half is much higher than the average annual, then toxic levels can be reached and persist for up to six months. That is sufficient time to damage the environment, kill aquatic life, and degrade human health. Also, after up to six months of such degradation, a subsequent six months of below-average levels will not restore previous conditions, just in time for up to the next six months of degradation.

A simple illustration of this is in Figure 4-3 in this review. Figure 4-3 is based on real, full-scale near-neutral drainage, from waste rock, at a British Columbia copper minesite. In fact, this minesite is one of those in the special SRK database that Ajax chose for capping its maximum concentrations. This figure shows that the average annual concentration (0.0874 mg/L at the horizontal dashed line) can be exceeded for weeks or months each year, to levels that would be toxic to aquatic life. The horizontal dashed line in Figure 4-3 is how the Ajax EIS predicts high peaks in contaminant levels, whereas the solid, highly variable line shows reality with toxicity events.

- There may be arguments that contaminant concentrations at Ajax would be smoothed out to average annual levels. However, these arguments would be wrong.

  For surface drainages into ditches and ponds, there might be some smoothing, but pulses of elevated contamination above average annual would still occur. In fact, Figure 4-3 shows real, full-scale pulses in a ditch draining waste rock. Perhaps if the ponds had retention times (holding all water entering them) for an entire year with no release, then the average annual might apply. However, this is not the plan for Ajax surface drainages and ponds according to the EIS.

  For groundwater, movement along subsurface flowpaths might not smooth out peaks of contaminants fully. Thus, at the nearby residential wells and the reaches of creeks, such smoothing would not result in average annual levels. This can be seen in EIS Appendix 6.5-A (reviewed here in Section 3.2 of this review). The contaminant-plume modelling in that EIS appendix was based on tracking pulses of contamination through the Peterson Creek Aquifer. Thus, the potential for contaminant pulses has been raised at Ajax, but not incorporated into the average annual predictions for all geochemical source terms.

  Therefore, “annual average” predictions of geochemical contaminant source terms are not sufficient to estimate risks to the environment and human health near the Ajax Project.

- While many contaminant concentrations in Appendix 3-B were predicted from kinetic rates from the Ajax testwork, there is one major exception. Nitrogen species, namely nitrate, nitrite, and ammonia, can reach toxic levels from leftover residues from explosives. The contaminant levels of nitrogen species cannot be predicted in advance with rock samples, because they were not blasted during full-scale mining. This requires a rough guess based on other minesites, as explained in Section 4 of Appendix 3-B.

  The loadings of most contaminants were converted into aqueous concentrations in mg/L for most elements in Ajax drainages (Appendix D of Appendix 3-B). These can be compared to water-quality guidelines and to other minesites to identify toxicity concerns.

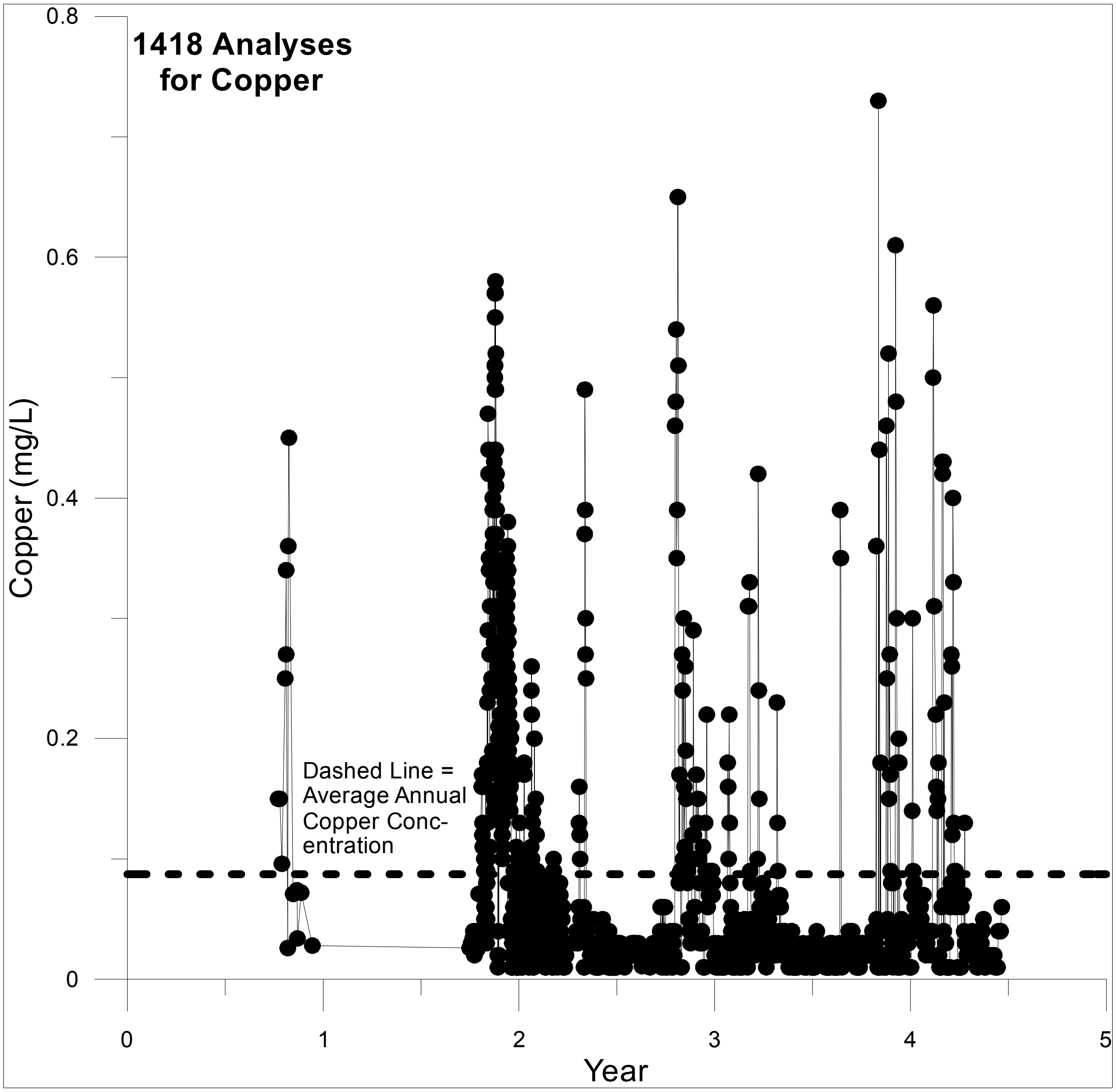

Figure 4-3. Aqueous concentrations of copper (mg/L) draining from waste rock at a copper minesite in British Columbia, showing that the average-annual value (dashed line) provides no information on toxic peaks that can persist for weeks or months; the average-annual approach was used for all source-term predictions of water contamination in the Ajax EIS.

> Prominently missing from these predictions of concentrations in Appendix D are the nitrogen species, so no one can judge whether they are of concern. Despite the missing predictions, Appendix C does include caps, but only for the TSF Pond. These unrealistically low caps were discussed above.
>
> In any case, Section 4 of Appendix 3-B includes tables of loadings for nitrogen species in kg. We cannot tell what these translate to in mg/L, but they could be at toxic levels. Surprisingly, some loadings are absolutely zero for up to 10 years of mining.
>
> Table 4-6 of Appendix 3-B is the only one that shows predictions of nitrogen species in mg/L. However, these were for post-closure pit water, and they were simply guesswork taken from other sites. Nevertheless, these pit-lake predictions show elevated concentrations of nitrogen species in dilute water long after closure, so operational levels from other minesite components will likely be highly toxic.
>
> Also, post-closure pit-lake predictions for nitrogen species are the only place we can find recognition of short-term fluctuations around the average annual. Section 4.4 simply says, "Daily levels are expected to fluctuate. . . .".

Therefore, just as with the mg/L approach in Section 4.1, the kinetic-rate approach used in the Ajax EIS also significantly underestimated water contamination, Thus, the likely impacts, damage, and harm to human health and environmental quality are also unrealistically low. As explained above, there are not just one or two reasons that contamination was underestimated with kinetic rates, but several reasons. This is not precautionary at all, contradicting the Ajax EIS' commitment to the Precautionary Principle and Zero Harm (see Section 1 of this review).

4.5 How many tonnes of proposed mine rock will be capable of releasing ARD at Ajax?

Summary:

Minesites can have contaminated drainages associated with various pH ranges. The best known is "acid rock drainage" (ARD), but the other pH ranges (near neutral and alkaline) can also be toxic and even more expensive to mitigate. Nevertheless, there is a regulatory fear of ARD in British Columbia, so portions of the EIS focus on it.

The EIS estimates percentages of waste and ore-grade rock expected to release ARD after some lag time (lag time is discussed in the following subsection). This rock is called PAG (potentially acid generating), relative to NPAG (non-PAG) rock, although virtually all rock at Ajax can in fact generate acidity.

The PAG percentages vary with the method used for analyses of Neutralization Potential (NP). The EIS in Chapter 11 finally settles on an unspecified "modified" NP method, which results in much less ARD rock than the precautionary CaNP method used in most of Appendix 3-A. In fact, the unspecified method provides about the same percentage as the "bulk NP Sobek" value for waste rock (the largest tonnage of rock at Ajax) in Chapter 11, although the Sobek method was dismissed in Appendix 3-A as significantly unreliable.

The problem with identifying PAG and NPAG rock lies in the misconception that PAG rock is "bad", so NPAG rock (in the other pH ranges) must be "good". This is wrong. Yet, the Ajax EIS discusses how NPAG as well as overburden will be used for mine construction if it "is available". First, this NPAG rock and overburden have been shown to carry high levels of potentially toxic metals and other elements, even using the partial-digestion method in the environmental studies (Section 4.2 above). Second, water did leach unacceptably high concentrations from NPAG rock and overburden even in the dilute kinetic tests used in the Ajax EIS (Sections 4.1, 4.3, and 4.4).

Details:

Water contamination at minesites is often divided into categories based on pH: ARD is acid rock drainage, NRD is near-neutral rock drainage, and LRD is alkaline rock drainage. All three pH categories can be, and often are, toxic to aquatic life. The costs to mitigate or treat the contamination is not dependent on pH. For example, mitigation costs for some NRD can exceed those for world-class ARD.

Despite these realities, impressions and non-technical priorities lead to disproportional concerns and fears over ARD relative to NRD and LRD in some jurisdictions. British Columbia is one of them. Due to this, the potential for ARD has received special attention in the Ajax EIS.

As a result, this subsection, and those following, focus on ARD-related predictions and mitigation, or lack thereof, for the proposed Ajax site. In any case, the preceding subsections have shown water contamination has been underestimated, no matter what its pH range, so these subsections are additional evidence of the lack of the Precautionary Principle and Zero Harm espoused in the EIS.

In the EIS, differing percentages of waste rock, low-grade ore, medium-grade ore, and high-grade ore are predicted to release ARD eventually (see Table 4-1 in this review). The percentages are based on the simple ratio of (1) how much acidity a sample can neutralize (the Neutralization Potential, or NP) relative to (2) the amount of acidity a sample can generate based on a sulphur value (the Acid Potential, or AP).

We could spend pages discussing only the NP methods used in the Ajax EIS, and how they affected Ajax predictions. However, we opt at this point simply to point out that the percentage of PAG rock depends significantly on the method (Table 4-1). Most of Appendix 3-A uses the CaNP method as a precautionary approach, saying the "bulk" Sobek method overestimates full-scale NP[2]. However, at the end of that appendix, the Precautionary Principle was "thrown to the wind" and higher values of NP from some unspecified "modified" method were used to reduce the PAG percentages. Notably, for waste rock, the PAG percentages using this modified NP method (8%) were close to those using the "unreliable" Sobek method (5%).

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[2] The next subsection of this review (4.6) discusses how the CaNP method misled interpretations of "carbonate-removed" samples which actually did not have carbonate removed. The more accurate bulk Sobek method confirmed mineralogical examinations that the carbonate was still present.

Table 4-1. Percentages of net-acid-generating (PAG) rock from various parts of the Ajax EIS

Based on ...	Percentage of Samples			Block Model
NP Method	CaNP[1]	"Bulk" Sobek[1]	Unsp. Modified[2]	Unsp. Modified[2]
Waste Rock[3]	21%	5%	8%	8%
Low-Grade Ore	29%	9%	22%	22%
Medium-Grade Ore[4]	32%	12%	17%	21%
High-Grade Ore	39%	17%	33%	20%

[1] From Table 5-2 of Appendix 3-A.

[2] From Table 11.5-5; many "modified" NP methods exist and each method can yield a different value, but EIS table does not specify which modification was used; for waste rock, the modified-based percentages are close to the "unreliable" Sobek values.

[3] Waste rock has the largest tonnage of all rock at Ajax.

[4] Medium-grade ore has the largest tonnage of all ore grades.

To continue, any sample with a ratio (Net Potential Ratio, or NPR = NP/AP) below 2.0 is called "PAG" (Potentially Acid Generating)in the Ajax EIS. All other samples are considered "NPAG" (Non Potentially Acid Generating). This is misleading and gives the false impression that NPAG rock cannot generate acid; the truth is the direct opposite.

Most rock, including that at Ajax contains sulphide, even when sulphide may be below the detection limit. Thus, literally all rock at Ajax is potentially acid generating. The Ajax EIS is really trying to distinguish rock that will release ARD (PAG) after some lag time (Section 4.6) from rock that is not expected to do so ever (NPAG).

It is very important to keep in mind that NPAG rock can be as reactive as, or more reactive, than PAG rock, but NPAG theoretically contains sufficient NP so that ARD is never released. Of course, Table 4-1 above and the associated discussion raise the issues of what full-scale NP actually is at the Ajax Project and what method should be used to measure it. In any case, NPAG rock can release near-neutral drainage that is still toxic and can cost more to mitigate than ARD.

So, from a water-contamination perspective, PAG rock is "bad" and NPAG is also "bad". Please note that KAM is suffering from this misconception, because it intends to use NPAG rock around the minesite for roads, etc., in the false belief that NPAG rock must be "good" because PAG rock is "bad".

Still, KAM may yet choose to use PAG rock, and cause additional ARD, if construction warrants it. EIS Section 3.1.3 says,

> "Overburden and non-potential acid generating (NPAG) mine rock from the open pit will be used as much as possible during construction where it has been determined that sufficient material is available."

This is ominous and ambiguous, so this cheaper option of using whatever type of rock is available can be expected.

Furthermore, the major IMH waste-rock unit, which has virtually no predicted PAG tonnage, has been identified for usage during construction (if it "is available"). However, even its underestimated aqua-regia two-acid metal levels (see Section 4.2 above) are problematic near and above the median range for elements like copper, chromium, and vanadium. In other words, actual levels of metals and other potentially toxic elements in 50% or more of the IMH samples are problematic. Again, such "good" rock is actually "bad" rock for construction at Ajax, but there is apparently no other choice.

Finally, the quotation above says overburden will be used around the minesite during construction if it "is available". As explained in Sections 4.1, 4.2, and 4.4 of this review, overburden can contaminate water, although highly diluted testwork was used to minimize this. Again, water contamination has been underestimated in the Ajax EIS.

4.6 How quickly will rock begin releasing ARD at Ajax (the ARD "lag time")?

Summary:

The EIS argues that lag times until ARD could arise at the Ajax site is 76 to 1849 years, which is after sulphide and associated acid generation has ceased. In effect, ARD could not appear at Ajax. However, these long lag times are based on lower-sulphur samples. The higher-sulphur samples that can consume NP faster, generate acidity longer, and have much shorter lag times were ignored in the EIS lag times, because the chosen testwork could not figure this out. The lag times are further extended in the EIS by (1) non-carbonate NP not considered in the lag-time calculations, which was erroneously based on carbonate-removed testwork that still contained carbonate and (2) two "conservative" assumptions that are wrong.

Details:

In the Ajax EIS, a certain percentage of rock is predicted to release ARD eventually, as discussed in the previous subsection of this review. An important aspect of ARD release is the estimated "lag time" until it happens. Predictions of ARD lag times in the EIS and its Appendix 3-A for PAG rock should be based on:

- the full-scale on-site rates of sulphide oxidation and acid generation;
- the amounts of full-scale on-site Neutralization Potential (NP) available to neutralize acidity.

As discussed in the preceding subsections, particularly Sections 4.1 and 4.5, (1) the full-scale rates during active mining have been underestimated, and (2) the full-scale amount of NP is ambiguous or at least variable depending on the selected NP method. Therefore, the lag times during full-scale active mining have been overestimated (are unrealistically too long) and ARD can be expected at Ajax within a few years. The rest of this subsection will examine this is more detail.

Before discussing Ajax waste rock, the proposed low-grade and medium-grade ore stockpiles require a note. These stockpiles will contain about 20% PAG material (EIS Table 11.5-5), a significantly higher percentage than waste rock, for decades or longer. Furthermore, because the Ajax EIS states the intent of Ajax is to find more ore and keep the mine running longer, these lower-grade stockpiles may be around even longer (at the Year 17, they still contain more than 50 million tonnes). Therefore, their lag times to net acidity become critical, because the copper cannot be recovered by the mill process if the ore becomes acidic and coated in secondary-mineral precipitants. If this happens, then these "ore stockpiles" will become long-term acidic waste-rock dumps. Please read Section 4.8 below to see the mitigation proposed for the ore stockpiles should ARD arise (hint: there is no proposed mitigation).

For waste rock at Ajax, Table 4-4 in Appendix 3-A shows that kinetic test HC4, with carbonate removed, still contained high amounts of carbonates: calcite at 0.50% and ankerite/dolomite at 1.0%. This means that all interpretations of non-carbonate silicate neutralization and stable pH ranges are unreliable. In turn, this invalidates all predictions of lag times to net acidity and additional NP contributions from non-carbonate minerals.

Here is a paragraph from Appendix 3-A, which can now be seen to be unreliable, yet so important to the unreliable predictions for the geochemical source terms (and thus for the pathways and receptors and risk assessments throughout the EIS):

> "This [testwork] indicates that in CaNP-depleted SLD material of median S content [which is actually not CaNP-depleted], sulphide oxidation is sufficiently slow, and/or silicate buffering sufficiently fast, to keep drainage pH neutral over extended periods of time. At higher S contents, silicate minerals are still capable of buffering drainage between 5 and 6. These are important findings that will be accounted for during source term development and PAG-NPAG classification."

It was not as if the ongoing presence of carbonate in the carbonate-removed samples was not recognized in the EIS. The next paragraph in Appendix 3-A says,

> "As expected, there is a discrepancy with respect to alkalinity release between untreated and pre-treated . . . . This [discrepancy] is consistent with residual carbonate content in the sample due to the ineffective carbonate removal by the H2SO4 pre-leach. Overall it appears as if the NaOAc-leach is the most efficient method of removing NP from the mine rock samples."

However, the implications of that remaining carbonate, and the resulting incorrect interpretations for the geochemical source terms, lag times, and risks, were dismissed.

Focussing on the numerical predictions of lag times in the Ajax EIS, Table 6-2 of Appendix 3-A says that CaNP will be depleted in 76 to 1849 years, long after sulphide is exhausted, so in effect no ARD can form. However, a closer look at the samples and data show that those very long lag times are implausible, and more reasonable lag times and precautionary-principle lag times are much shorter.

Here are the reasons why lag times are likely overestimated and ARD could arise at Ajax in a matter of a few years.

- The results show a general correlation of rates for acid generation and sulphate production with solid-phase sulphur levels. This makes sense: the greater the amount of sulphur, the greater the rate of acid generation, and in turn the greater the rate of CaNP consumption. These samples, which appear to represent about one-quarter of the waste rock, can have the shortest lag times.

  So what are the lag times of the columns with elevated non-SO4 sulphur levels, the ones which could have the shortest lag times? They were ignored! Appendix 3-A says,

  > "Note that this table [6-2] only provides information pertaining to kinetic test samples with low sulphate mineral content in order to eradicate the effect of sulphate dissolution on CMR values, and therefore, NP depletion calculations."

  It makes sense that the samples with highest total-sulphur levels would have elevated sulphate and sulphide levels. However, ignoring these all-important samples because the testwork could not differentiate between sulphate dissolution and sulphide oxidation is simply the fault of the EIS testwork. Meanwhile, the very samples of most concern for ARD with short lag times were ignored! So lag times for the onset of ARD from Ajax rock could well be much shorter than stated in the EIS.

- As explained earlier in this review, higher rates of acid generation and NP consumption can be expected, and would occur, in Ajax rock during mining, transport, and dumping. Therefore, a higher rate from early weeks should be used for calculations, leading to shorter lag times.

  How much higher were the rates in the early weeks relative to the low rates used in the EIS for lag-time estimates (Weeks 40-45)? Column 14 would be the most important here, because it had the highest non-SO4 sulphur levels of the columns that were not ignored. Table 6-2 of Appendix 3-A says its sulphate rate was 13 mg/kg/wk at Weeks 40-45. What was the rate at Weeks 1-5, for example? There is no way to know - the EIS does not present the information for this column. Figures like 6-5 do not show Col-14. Appendix D-1.2 Col 14 lists only the first 11 weeks of testing, so there is no way even to confirm the stated rate at Weeks 40-45. Again, results of the all-important high-sulphur test work for reasonable lag times is minimized or missing.

  Nevertheless, Appendix D-1.2 Col 14 shows the sulphate rate dropped by a factor of 5 over the first 11 weeks. Thus, by Weeks 40-45, the rate could have been 50-100 times lower. This means that the long lag time for Col-14 in Table 6-2 of 119 years could, in reality, during active mining be shockingly only 1 to 2 years! Also, the sulphur would not be depleted in this short time, so ARD would appear within a few years.

  Even for the columns listed in Table 6-2, much shorter precautionary lag times can be estimated. For example, Col-2 is said to have a lag time of 110 years. However, Appendix D-1.2 Col 2 shows that the sulphate rate at Week 1 dropped by a factor of 50 to Week 45, and by a factor of 10 from Week 11 to Week 45. So its active-mining lag time could realistically be 2 to 11 years, so ARD would arise during the proposed mining at Ajax.

- Various grades of ore may have a higher percentage of PAG rock (EIS Table 11.5-5), but waste rock has produced the highest measured level of sulphide and total sulphur measured in the Ajax ABA database (Figure 5-3 of Appendix 3-A). Furthermore, several waste-rock samples have the highest sulphide levels, and thus the highest acid-generating capacities. This can lead to the highest consumption rate of NP depletion and the shortest lag times, but again the high-sulphur samples were ignored because the testwork was not sufficient.

- Again, the columns with the highest acid-generating sulphur levels were ignored in the lag time, so their lag times could be even shorter than a year. The testwork in the EIS cannot tell us because it could not identify the oxidation rate, so these shorter lag times were ignored. We could not do the calculations ourselves, because KAM did not provide spreadsheets with the data for our review.

Predictions in the EIS of very long and unrealistic lag times for ARD, at 76 to 1849 years, are not done yet. The EIS argues they are even longer. Section 7.2 of Appendix 3-A discusses why ARD during mine life is even more unlikely due to “conservative assumptions” which really are not conservative at all, but simply wrong and unreliable.

- Assumption 1: “Not all material surfaces in a full-scale MRSF will be flushed on a regular basis, such that calculation based on kinetic test cells will likely overestimate the CaNP removal rate, prolonging the time to onset of acidic drainage.”

This is wrong, because the material surfaces do not have to be flushed at all. All (100%) of rock surfaces will be oxidizing and sulphides will be generating acidity, and all local NP will be neutralizing that acidity as the NP is consumed. This wrong Assumption 1 implies that, in the full-scale minesite components (right side of Figure 4-1), water flushing drives the removal of NP, not acid generation. Additionally, most surfaces are flushed periodically even if a smaller percentage is flushed annually. Processes like condensation, intense storms, rock slaking, and ongoing geotechnical settlement ensure most rock surfaces are flushed periodically. Therefore, this Assumption 1 is not conservative at all.

- Assumption 2: “PAG mine rock will be intermixed with NAG material such that any generated acidity may be neutralized by excess NP contained in the MRSF.”

This is wrong, as explained in the next subsection. There will be no “intermixing”, only layering, which does not meet the provincial ARD policy. This Assumption 2 is not conservative at all, just plain wrong.

4.7 “Blending” of net-acid-generating (“NPAG”) rock with net-acid-neutralizing rock to prevent ARD at the proposed Ajax Project

Summary:

The Ajax Project is not proposing ARD mitigation in waste rock using “mixing” and “blending” as stated, but by layering. Such layering is not reliable, can lead to rapid ARD production in the net-acid-generating layers (see Section 4.6 above), and requires onerous proof of success in advance under the provincial ML-ARD Policy.

Details:

A relatively small but ambiguous percentage of waste rock could release acid rock drainage (ARD) upon the proposed mining at Ajax (Section 4.4 of this review). Like a cancer, ARD overwhelms the neutralizing capacity of adjacent and underlying rock. Then this rock becomes acidic and releases ARD. The right side of Figure 4-1 shows how this can happen if any layer becomes acidic, which has actually happened at full-scale minesites, like Samatosum in British Columbia.

Therefore, the Ajax EIS addresses how the formation and spread of ARD would be prevented in the waste-rock dumps. The next subsection discusses ore, for which no ARD mitigation is proposed, despite its higher capacity to release ARD.

For Ajax waste rock, Section 3.4 of the EIS explains,

> "In general, NPAG [net-neutralizing] material will be used for construction over Project life and PAG [net-acid-generating] material will be placed in Mine Rock Storage Facilities (MRSFs) and mixed with NPAG such that the resultant neutralization potential ratio (NPR) is 3.0 to further reduce potential for ML/ARD."

It is very important to note the EIS uses the word, "mixed".

Thus, mixing (or blending) of "PAG" and "NPAG" rock to an NPR of 3.0 is proposed in the EIS to minimize ARD. Studies have shown that NPR of mixtures is not the criterion that determines minimization of ARD, but factors such as distances between PAG zones. This can be seen in an obvious question to the quotation above: at what volume/tonnage must the mixture have an average NPR = 3.0? Does every kg have to be mixed to an NPR of 3.0, does every tonne have to be mixed, every 1000 t?

Section 11.5.3 discusses "blending" of one truckload of rock with one or more of another. Section 11.5.4 then elaborates that each PAG load would be end dumped, followed by a dozer spreading it to a 1 m thickness, and an NPAG layer at least 1 m thick would be placed on top, until both layers reach an average NPR of 3.

This is then clarified that dumping would be on a slope ("the face") of the waste-rock dump, where a dozer would have difficulty maintaining a constant thickness.

> "The assumed standard operating procedure for end dumping mine rock at Ajax is creating 20 m-high lifts with 300 t capacity haul trucks (truck capacity may change with advancement of Project design). With these standard conditions, one truck load of mine rock would produce a thickness of 0.5 m over average width of 8.15 m on the face of the MRSF." (Section 11.5.4)

This could create a subvertical to vertical zone of PAG material that could lead to ARD forming and migrating through it and then acidifying adjacent rock.

In any case, this meters-thick layering really is not mixing or blending (it is just "layering"). Layering to prevent ARD has not been tested and verified on a large scale at the site. Thus, the Ajax

EIS fails to meet KAM Ajax' core value of Zero Harm and its commitments under the Precautionary Principle as stated in Section 3.2 of the EIS.

Moreover, the *British Columbia Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia* states,

> "Blending will only be accepted as an environment protection tool if supported by detailed design criteria, strong evidence of feasibility and effectiveness, and in the case of a segregated blend, adequate back-up or contingency measures."

The EIS meets none of these requirements in the formal government Policy.

Therefore, the proposed prevention of ARD for Ajax waste rock fails to meet government policy and has a good chance of causing ARD to arise and spread through the waste rock.

4.8 ARD mitigation for ore stockpiles

Summary:

Some ore-grade rock in the proposed Ajax low-grade and medium-grade stockpiles may not be processed for decades or ever. This rock has a higher potential to release ARD stronger and faster than waste rock. However, there is no proposed mitigation for ARD at all, unlike waste rock. Furthermore, the onset of ARD in these ore stockpiles can make copper economically unrecoverable and thus cause this "ore" to become "waste". Therefore, the proposed ore stockpiles should be viewed as additional waste-rock dumps at Ajax, with additional long-term environmental impacts and human-health risks (from blowing dust, water contamination, etc.) beyond those currently in the EIS. The provincial government should ensure this is addressed for the Ajax Project, and financial security for long-term ARD treatment is in place if the Project should ever be approved.

Details:

The preceding Section 4.7 of this review discussed the proposed, but unreliable, mitigation of layering for ARD in waste rock. However, it is important to understand that some ore may also be left behind on site after closure or after an unexpected shutdown, effectively to become "waste rock". There is no proposed mitigation for preventing ARD in the ore stockpiles, and the various grades of ore have much higher percentages of ARD-releasing rock than waste rock (EIS Table 11.5-5). Therefore, ARD is even more likely from ore stockpiles (see also Section 4.6 above), with no proposed ARD mitigation at all!

Up to 60% of ore will not be immediately processed, but stockpiled in the low-grade, medium-grade, and high-grade ore stockpiles. With low-grade and medium-grade ore representing 60% of ore, Appendix 3-A explained,

> "The higher-grade ore will be sent directly to the mill for processing while low- and medium- ore grade will be placed in the ore stockpile in years of excess ore production."

Section 3.9 says,

> "The low-grade and medium grade stockpiles will store lower grade ore until the end of mine life or to supplement ROM ore. Once the pit reserves are exhausted, all ore stockpiles will be mined with production equipment in a top-down sequence and delivered to the mill for

processing."

At the Year 17, these lower-grade stockpiles are expected still to contain more than 50 million tonnes. This rock would be the older, first-mined rock in the EIS-stated "top-down sequence" that can begin releasing ARD faster due to longer NP consumption (Section 4.6)

The hope in the EIS is that all this ore can be economically milled, up to decades after first mining. However, as experience at other minesites has shown, the economic minerals may not be recoverable after decades of weathering and secondary-mineral coatings. In effect, the remaining proposed "ore stockpiles" would become "waste-rock dumps". The Ajax low-grade and medium-grade ore would contain much higher percentages of net-acid-generating rock (up to 22%) with higher rates of acid generation and NP consumption (Section 4.6 above). Thus, the expectation of ARD is much higher and faster from this ore than from the waste rock. Yet, no prevention of ARD is mentioned in the EIS for ore as it is for waste rock.

The British Columbia Ministry of Mines has recognized that lower-grade-ore stockpiles may never be processed. As a result, that Ministry should consider the proposed Ajax ore stockpiles as waste-rock dumps, and consider the associated estimates of environmental impacts and financial security bonding. It is important that the Ministry is reminded of this.