REPORT - MEETING No. 10

INDEPENDENT GEOTECHNICAL REVIEW BOARD (IGRB)
March 7 and 8, 2024

Review of Water Dam, Water Management and Tailings Management Facility, KSM Project

British Columbia, Canada

KSM MINING ULC
A SUBSIDIARY OF **SEABRIDGE GOLD** INC.

REPORT – MEETING NO. 10, INDEPENDENT GEOTECHNICAL REVIEW BOARD

REVIEW OF WATER DAM, WATER MANAGEMENT AND TAILINGS MANAGEMENT FACILITY, KSM PROJECT

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1. Introduction

1.1 BACKGROUND

The tenth meeting of the Independent Geotechnical Review Board (IGRB or Board) for the Kerr-Sulphurets-Mitchell (KSM) Project (Project) was conducted in person by KSM Mining ULC (KSM) on March 7th and 8th, 2024 at the Blakes Law Offices in Vancouver, BC. KSM is a subsidiary of Seabridge Gold Inc. (Seabridge).

The Board is comprised of Dr. Ian Hutchison (Chairman), Mr. Terry Eldridge (Vice Chairman), Mr. Anthony Rattue, Dr. Gabriel Fernandez, Mr. Jim Obermeyer, Dr. Leslie Smith, and Dr. Jean-Pierre Tournier. Dr. Gabriel Fernandez attended the meetings virtually. Dr. Leslie Smith was not able to attend the meeting but was able to view select video recordings of the meeting, review the material presented on groundwater modeling, and provide input to this report.

A list of meeting attendees is provided in Appendix A to this report. The meeting agenda is provided in Appendix B.

This meeting provided for presentations and discussion on the following topics:

- Project update generally for information purposes, including:
  - Safety Share
  - Company Update
  - Future Role of the IGRB
  - Hydrogeological Update
  - Update on the Geochemical/Block Modelling
- Water Storage Dam (WSD) site characterization work completed to date, including:
  - Stantec Team introductions and deliverables overview
  - Factual Report summary
  - Geologic Model update
  - Dam Site Characterization Report
  - Spillway Location
  - Seepage Collection Dam (SCD) and Sump
  - Seepage Collection Tunnels
  - Construction Tunnels
  - Recommendations to support Feasibility Design (Feasibility Study - FS)
  - MODFLOW Groundwater Model for dam sites.

1.2 MATERIAL PROVIDED TO THE BOARD

During the meeting Stantec provided presentations on the following topics:

- 21451930-281-PP_RevB_1200_IGRB 2024 Hydrogeology.pptx
- 21451930-282-PP-Rev1-1600-KSM Block Model 06MAR_24.pptx
- 21451930-283-PP-RevA-1300_IGRB 2024 Geochemistry Presentation_17JAN2024.pptx
- KSM_IGRB_PresentationRev0 stantec.pptx

Prior to the meetings the Board was provided with the following reports for their information and review as necessary:

- Stantec (2024a). 2023 Seabridge KSM Water Storage Dam Site Investigation – Factual Report, Revision C, 9 February 2024 (referred to as the WSD Factual Report).
- Stantec (2024b). Dam Site Characterization Report – Preliminary Report, Revision C, 9 February 2024 (Preliminary Dam Site Characterization Report).

After the meeting the Board was provided with the following additional information at its request:

- Stantec (2024c). Memorandum: KSM WSD Piezometric Cross-section Hydrogeology Commentary, 22 March 2024
- Stantec (2024d). Memorandum: KSM WSD Thermistors Cross-Section Commentary, 27 March 2024

1.3 BOARD REPORT

The Board's report deals with the following topics which are discussed below:

- Board Overview Comments and Recommendations (Section 2).
- Company Update (Section 3).
- Hydrogeologic and Geochemical Update (Section 4).
- Stantec Team and Deliverables Overview (Section 5).
- Water Storage Dam (WSD) Design Considerations (Section 6).
- Seepage Dam Design Considerations (Section 7).
- Seepage Collection Dam (SCD) Design (Section 8).
- Recommendations to Support Feasibility Design (Section 9).
- Closing Remarks (Section 10)

As for prior meetings, the Board's review is carried out at the "Discussion Level", in which the Board relies principally on information provided during meeting presentations together with some information taken from the Stantec reports and memoranda provided.

In this report, the IGRB (Board) provides observations made during the meeting, presents the outcome of the discussions, and provides recommendations for design considerations and future work for the upcoming Feasibility Study (FS). *The recommendations in the report are in italics. <u>The more significant recommendations are underlined</u>.*

In our discussions in this report the Board refers to "the Team" presenting information. The Board defines the Team as including KSM staff and the consultants working for KSM.

2. Board Overview Comments and Recommendations

The Board notes that the Stantec/WSP team that attended the meeting appears to be well-qualified for undertaking the work. They have and are executing sound field investigation and analytical programs, including the assembly of past data, and provided good overview presentations. The Board recognizes that significant effort has gone into compiling the new and historic geologic, geotechnical and hydrogeologic information. Further data interpretation is ongoing, which the Board expects will include more detailed assessment of the geo-hydrologic conditions around the WSD and SCD.

The primary issue discussed during the meetings is the assessment of how well the WSD and SCD will achieve containment of the stored fluids, partially within the impoundment basins behind the dam structures. Of particular interest was to what extent hydraulic containment would be provided along the left abutment flank upstream of the WSD, since some of the groundwater levels measured in this area appear to be low when compared to values along the right abutment. This issue is discussed further in Section 4.1.

The Board senses the site investigation and modeling programs have been focused on general site characterization, rather than on specific key design elements, such as achieving hydraulic containment in the impoundments, establishing effective grouting access tunnels and the seepage collection systems as discussed further below.

The Board therefore generally encourages increased detailed interpretation of the available information to establish characterization and parameters needed for design of the dams.

The Board also notes that intense intergroup coordination between the different dam design (Stantec) and geohydrologic and geochemistry (WSP) teams will be essential for maximizing the design information obtained from the programs discussed during the meeting.

3. Company Update

3.1 PROJECT UPDATE

Substantially Started Update

The Board was updated on the progress made with regards to achieving the Substantially Started Certification. Key milestones include:

- Progress continued with the BC Hydro Treaty Creek Switching Station through December 2023.
- On February 22, 2024, the Environmental Assessment Office (EAO) officially acknowledged KSM's submittal for a Substantial Start decision.
- EAO will now start their engagement with indigenous groups.
- KSM are following up with Tahltan Central government on their letter of support.
- KSM indicated sufficient work would be completed by the due date of January 29, 2026.

The Board commends KSM on the continued progress towards certification.

JV Partner Discussions

KSM informed the Board that a formal process of identifying a Joint Venture (JV) Partner is underway and is being managed by the Royal Bank of Canada (RBC). Five companies visited the site in late summer/early fall 2023. Discussions are ongoing and noted to be encouraging.

Alaska Transboundary Discussion

The Board was updated on the following key activities that had occurred:

- A recent media campaign was organized by Environmental Non-governmental Organizations and Alaskan Tribes against BC mining.
- Other Developments:
  - A Petition to the Inter-American Commission on Human Rights was submitted by Southeast Indigenous Transboundary Commission (SEITC) alleging Canada has failed to regulate and prevent threats from large-scale mining operations in British Columbia.
  - SEITC is also asking the BC government to recognize their legitimacy and involve them in the environmental review and approval process for mines in the transboundary rivers area under their Section 35 Rights.
- The SEITC is publicly opposing KSM's application.

The Board appreciates being updated on these developments and has no comments at this time.

Project Schedule

KSM indicated the schedule of conducting the Feasibility Study (FS) is still uncertain and could potentially start within the next 3 years and likely extend over a period of approximately 2 years.

3.2 FUTURE ROLE OF THE IGRB

The Board was informed that Seabridge is recommending the existing Board remain in place until after a JV partner is appointed. The Board supports this approach, and its members are committed to remaining on the Board at least through 2025 and until an orderly transfer can be made to any new Board members that would be appointed.

During the meetings, the need for experienced geochemical and tunneling subject matter experts on the Board was discussed. A suitable time for making such appointments would be when the future JV Partner assumes responsibility.

3.3 DAM DESIGN CONCEPTS

As background to the discussion that follows in this report, this section briefly summarizes the WSD and SCD design concepts and alternatives being considered (Figure 1).

3.3.1 Water Storage Dam

The WSD will be an asphaltic-concrete cored rockfill dam founded on a prepared foundation. The pre-feasibility design (PFD) considers an upstream face slope inclined at 2.25H:1V, a downstream face slope inclined at 1.75H:1V, and a crest length of about 650 m. The dam would have a maximum height of 165 m with the crest at elevation 716 masl. The open channel spillway sill would be at elevation 706 masl and the capacity would be selected to manage floods greater than the 200-year wet year up to the Probable Maximum Flood (PMF). The maximum storage capacity of the reservoir behind the dam will be 50 Mm^3 with the water level at 706 masl. The normal operating range of the reservoir is expected to be between 630 masl to 650 masl.

To minimize seepage losses from the dam, a grout curtain extending to depths ranging from 25 m to 150 m is proposed to be installed through a concrete plinth anchored to the bedrock foundation and from horizontal grouting galleries extending into the abutments. These grouting galleries are referred to as Seepage Interception Tunnels and are shown on Figures 1 through 3. In the bottom of the Mitchell Creek canyon, the plinth may also incorporate a concrete-encased grouting gallery. The 4 proposed Seepage Interception Tunnels within the WSD dam footprint are located near the dam axis and are intended to be used both for grouting during construction and remedial grouting when required during facility operation and to collect seepage through the dam and grouted foundation. Another key feature of the dam shown on Figure 1 is the Construction Diversion Tunnel in the right abutment and an alternative alignment for this tunnel in the left abutment.

The WSD reservoir will collect seepage and runoff from the open pit mine and waste rock dumps located upstream of the dam. The water is projected to be acidic, and provisions are to be included in the design to mitigate the impact of acid on the dam and its associated design components. The asphaltic-concrete core was selected because of its low permeability and the high resistance of bitumen to acid. Rockfill for the dams will be produced from the P8 Quarry at the Mitchell Pit. This rock is identified as intrusive and is expected to be resistant to acidic water.

The dam has been classified as an Extreme Consequence dam. The Inflow Design Flood (PMF) and Earthquake Design Ground Motion (10,000-yr return period ground motion) are consistent with this Extreme Consequence classification.

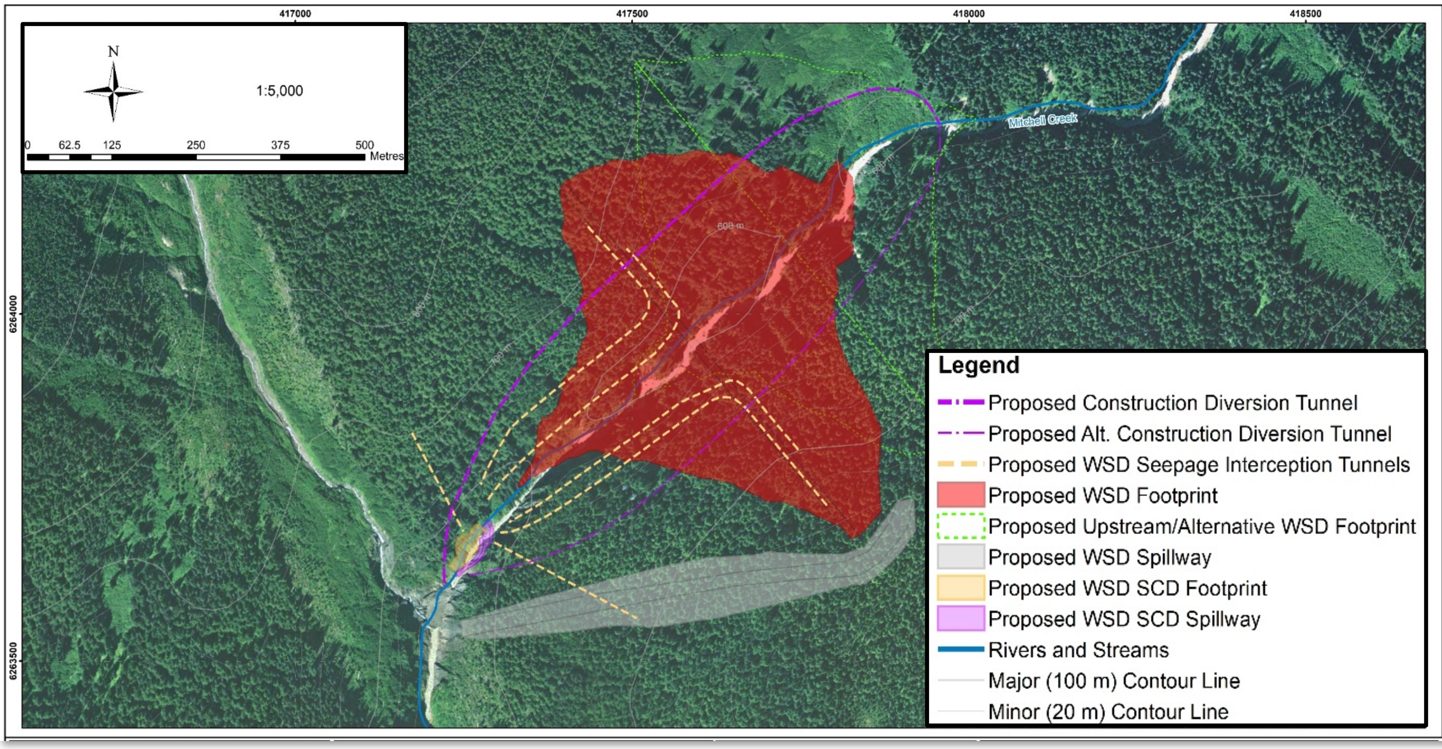

Figure 1 Dam Components

3.3.2 Seepage Collection Dam

The proposed SCD located on the Mitchell Creek downstream of the WSD, approximately 150 m from the main water storage dam's downstream toe, is intended to capture any seepage from the WSD. The proposed dam has 2.25H:1V upstream and downstream slopes and will be approximately 25 m tall with a crest at El 544 masl. This proposed dam height is intended to store runoff from the 200-year 24-hour storm. The SCD spillway is designed as a cut into the left abutment bedrock with capacity to pass the Inflow Design Flood (IDF) selected for the SCD. Stantec indicates that, based on the proposed dam location and the potential consequences in the event of a dam failure, the hazard classification of the dam is "Significant" in accordance with 2013 CDA guidelines and the BC Province guidance for mine water dams.

The SCD design incorporates an asphaltic-concrete core and a grout curtain along the dam centerline. It includes two (2) seepage collection tunnels, one at each abutment, to intercept any seepage from the WSD and direct it to the SCD sump. See Figure 1 for locations of these seepage collection tunnels. Water collected by the SCD will be conveyed to the Water Treatment Plant via an HDPE pipeline.

4. Hydrogeologic and Geochemistry Update

4.1 HYDROGEOLOGICAL FINDINGS

During the meetings there were discussions on the groundwater levels and pressures or hydraulic heads in the bedrock at the WSD and SCD. Based on the limited piezometric information presented at the meeting, the Board expressed concerns about the extent of hydrodynamic containment provided by groundwater in the left abutment of the WSD and potentially in the storage impoundment upstream from the dam. The Board is concerned about preferential groundwater seepage pathways that could extend from the left abutment either to Mitchell Creek to the Southwest and downstream of the SCD and/or to Sulphurets Creek to the South. The low piezometric head recorded by the vibrating wire piezometer VWP-TS-22-143 in the left abutment was the root of this enquiry (see area B in Figures 3 and 4).

As a follow-up, the Board has further evaluated additional piezometric data provided by Stantec after the meeting. These data sources are listed at the end of Section 1.2 above. The Board used the data provided to establish approximate piezometric head (total pressure head) contours for cross sections through the WSD (Figure 3) and through both abutments (Figures 4 and 5). The locations of these sections are shown in Figure 2.

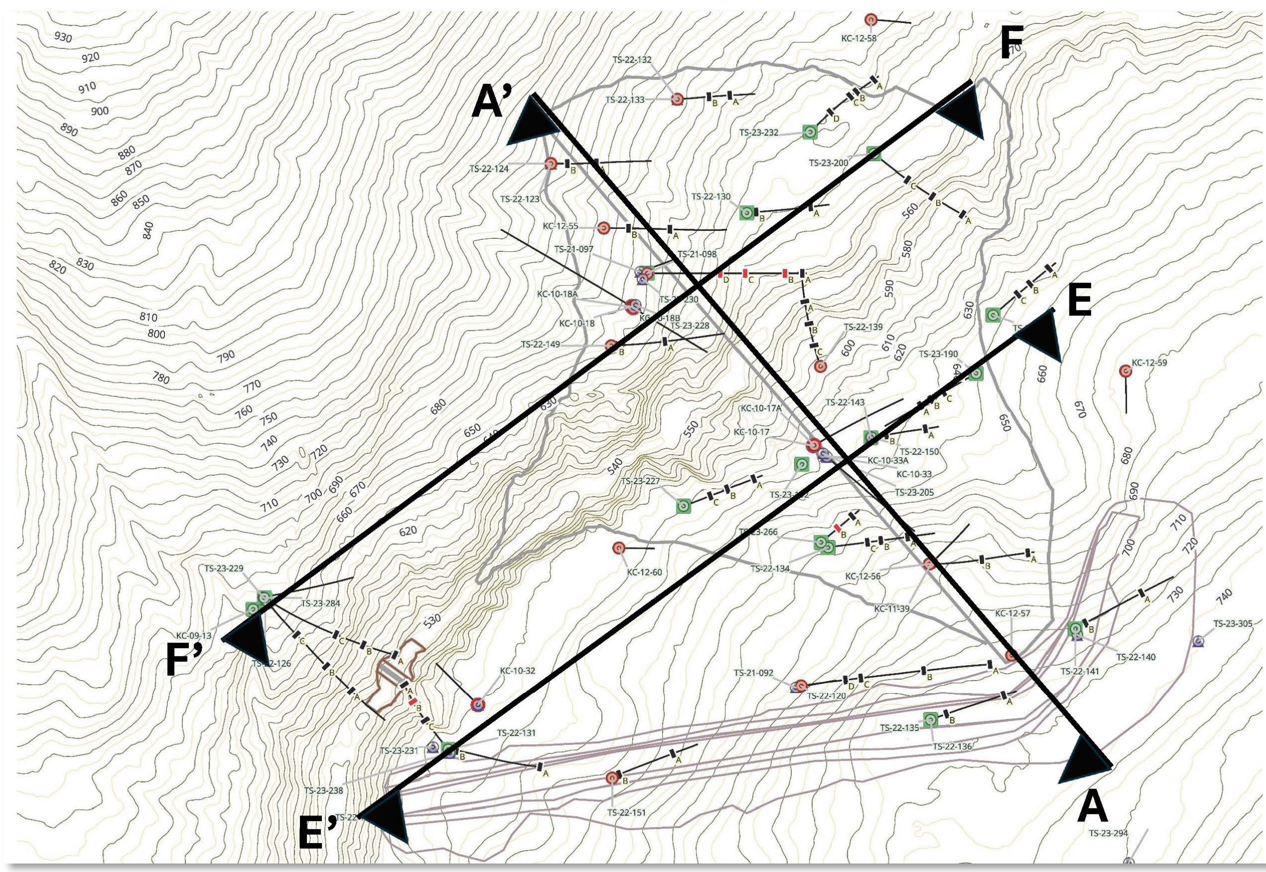

Figure 2 Plan View of WSD and SCD Showing Hydrogeologic Section Locations

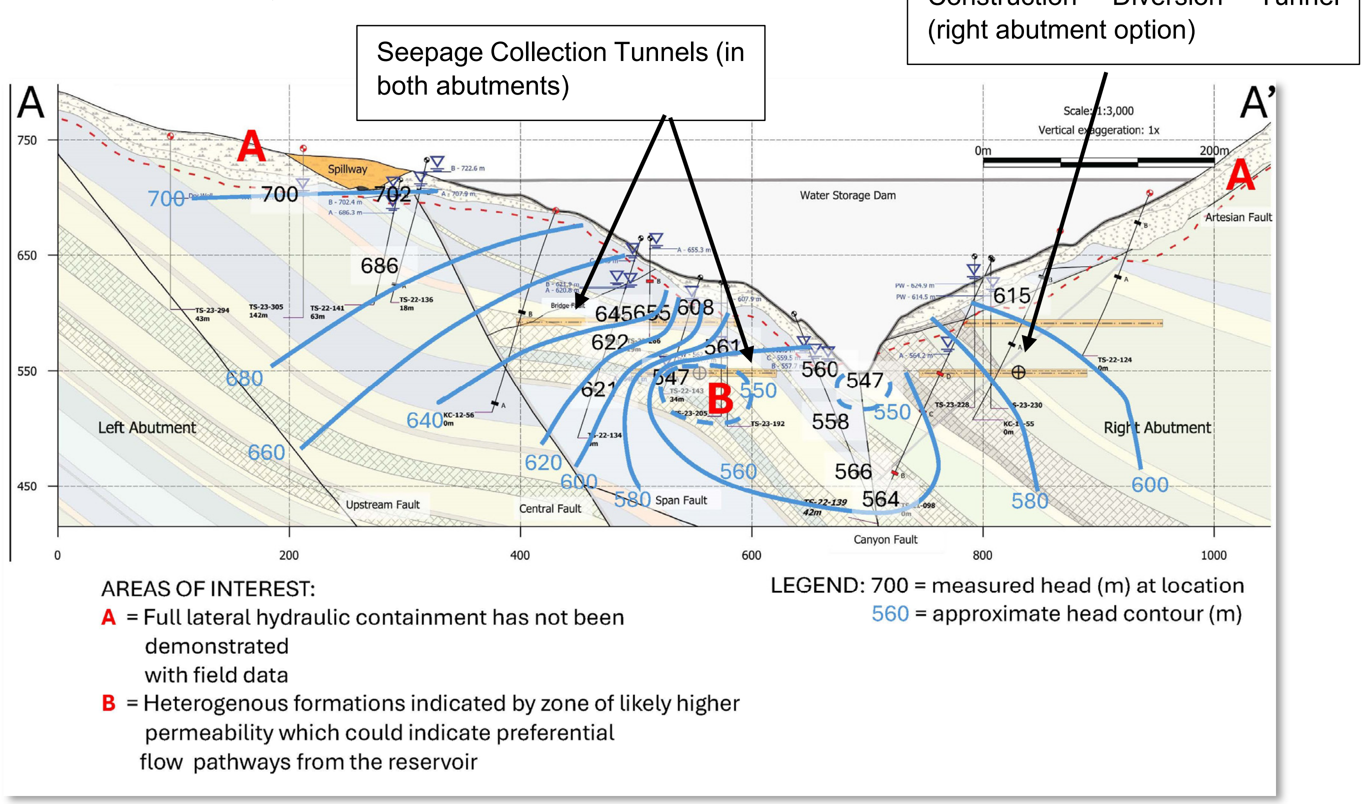

Figure 3 Hydrogeologic Section A-A' Through the WSD

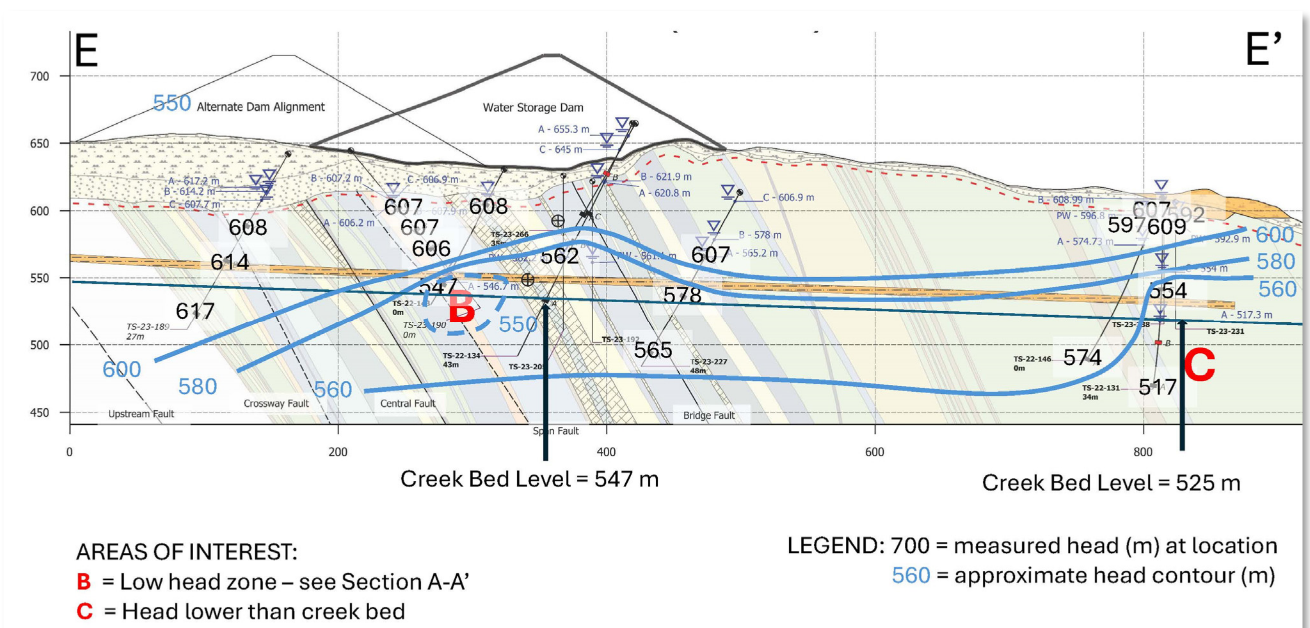

Figure 4 Hydrogeologic Section E-E' Through the Left Abutment of the WSD

As shown on the figures, the following can be observed:

- On Section A-A' through the WSD (Figure 3):

  Area A: Full lateral hydraulic containment on the upper left and right abutments has not been demonstrated. On the left abutment, the highest hydraulic head measurements are approximately 700 masl, below the spillway invert level of 706 masl. No measurements are available on the upper right abutment.

  Area B: Heterogenous formations are indicated by an apparent zone of lower head and higher permeability approximately 100 m below the surface and in the left abutment, which could indicate preferential flow pathways out the impoundment behind the dam.

- Section E-E' in the Left Abutment (Figure 4):

  Area B: The same low hydraulic head zone in Figure 2 appears on this section as well.

  Area C: Of note, is that the total pressure head in this area 150 m below the surface is lower than the creek bed indicating a higher permeability zone draining groundwater to further downstream.

- Section F-F' in the Right Abutment (Figure 5)

  Area D: In contrast to the above, this section exhibits a high total pressure head zone and upward gradient approximately 100 m below the upstream toe of the WSD. A higher conductivity zone may be connected to a higher head area upslope causing this condition.

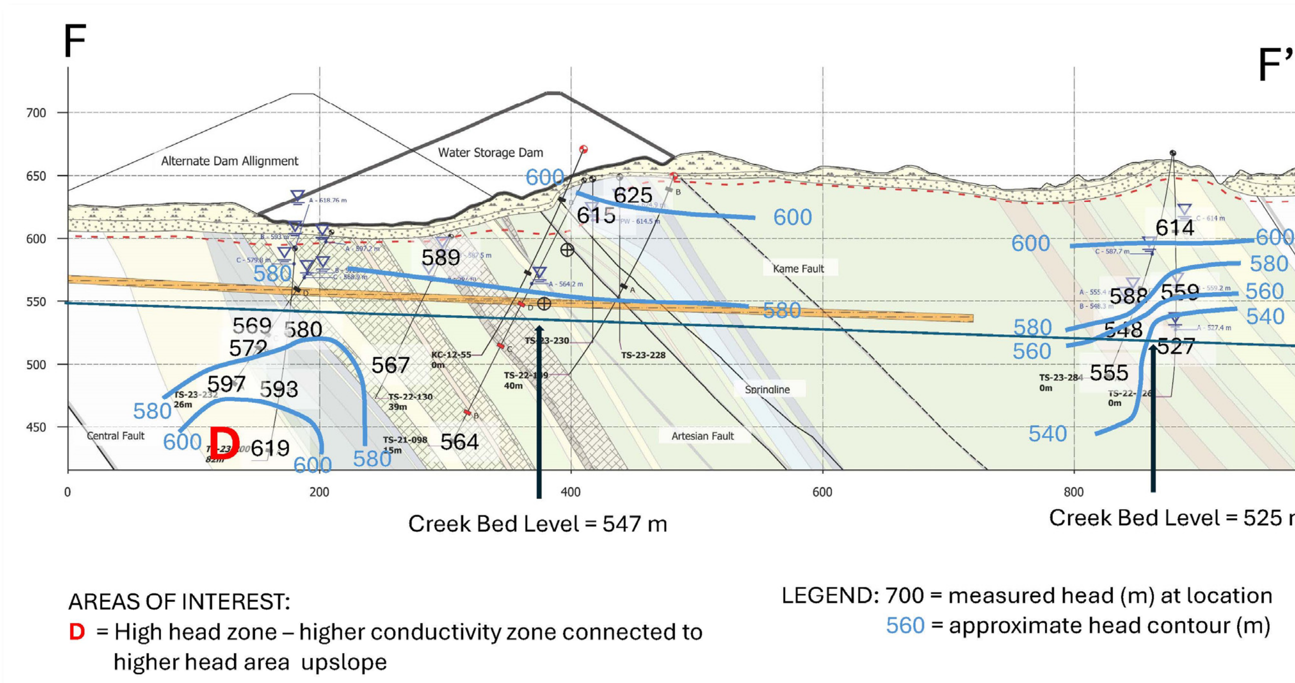

Figure 5 Hydrogeologic Section F-F' Through the Right Abutment of the WSD

<u>The geologic heterogeneity illustrated by these data, including potential zones of higher permeability bedrock, will pose challenges in achieving the necessary high degree of seepage control needed for both for the WSD itself and possibly the left side of the impoundment area upstream of the dam. Also, it is still uncertain as to whether hydrodynamic containment will be provided when the reservoir water levels are in the 700 to 706 masl range.</u>

As part of completing the current work, the complexity of the geohydrology of the WSD area (and the SCD area as well) requires further evaluation as it will influence the extent to which the WSD, the SCD and the impoundments behind the dams will contain the collected runoff and ARD.

A sound understanding of hydrogeologic conditions will also be necessary to inform the FS design of the grouting program and other design elements necessary to provide hydraulic containment under the full range of hydraulic loading conditions.

In planning future additional field investigations and testing as mentioned in Section 8 of this Report, a specific focus should be on determining the extent of natural hydraulic containment around the impoundment areas behind the dams as well as designing the elements (e.g. grout programs, drainage tunnels, etc.) necessary to achieve the high degree of containment required by the project permit.

Consideration should also be given to enhancing the grouting program for WSD if necessary, by extending the length of the galleries (which are part of the Seepage Collection Tunnels shown on Figure 1) along the dam axis in both abutments, especially on the left abutment, to enhance the efficiency of the grouting curtain and the seepage collection system.

In the event there are still concerns about providing sufficient containment along the left side of the impoundment, other measures to reduce seepage in this area may have to be considered.

4.2 GROUNDWATER MODELING UPDATE

4.2.1 Regional Groundwater Modeling

A brief overview was provided of previous work carried out for the Environmental Impact Assessment (EIA) in 2013 that established separate site-scale hydrogeologic models for the Processing and Tailings Management Area (PTMA) and the Mine Area (MA) domains. More recently an attempt was made to develop a single hydrogeological model incorporating the PTMA, MA, and the terrain through which the Mitchell Treaty Tunnel (MTT) will pass to connect both development areas. The Board was informed that such a large domain proved to be impractical, for reasons of both numerical stability and computational time for transient simulations. Therefore, the KSM project is moving ahead with two separate models, one for the PTMA and the other for the MA. An experienced team at WSP is carrying out this work.

The Board learned that only minor changes have been made in the area covered by each model domain, with the exception that the MA domain was extended to the east to encompass the region around MTT tunnel alignment and to connect with the PTMA domain, sharing a common boundary. The Board supports this revised approach as the most practical. The same representation of the elevation-dependent groundwater recharge distribution used by ERM in 2013 has been adopted by WSP. WSP has chosen to construct both regional-scale models using FEFLOW[1], with the geologic structure imported from Leapfrog. The Board supports this decision.

The models have been updated and data from wells installed in 2021 and 2022 have been included. Steady state calibration results were shown for the PTMA model, and provide an acceptable model fit to the water level data. Preliminary transient calibration results for baseflow conditions were also presented. Work on calibration of the transient PTMA model is ongoing.

[1] Finite Element subsurface FLOW system is a computer program for simulating groundwater flow, mass transfer and heat transfer in porous media and fractured media. The program uses finite element analyses.

Development of the MA hydrogeology model has not progressed as far as that for the PTMA area. The Board looks forward to a presentation of MA modeling results at our meeting in 2025.

4.2.2 Groundwater Modeling to Support Design

A local-scale more detailed 3D hydrogeological model is being developed by Stantec for the WSD area to support the dam design effort. Given the complexity of geology and the geologic structures in the area, this separate model is essential because it is not feasible to incorporate the necessary level of detail in the WSP regional models. The WSP regional models will be used to establish boundary conditions for the local-scale model. The linkage between the models is planned and is key to developing "inset" models from a regional model.

The ability to assign an anisotropic hydraulic conductivity to individual cells in the model grid will be a key feature of the local scale model. While they have experience in using both FEFLOW and MODFLOW 6, Stantec propose to use MODFLOW 6[2], which can allow an unstructured grid design, coupled with a Leapfrog geologic model.

The Board acknowledges that either the MODFLOW or FEFLOW platform could be used to develop a functional model, and that code selection is not as important as the formulation and calibration of the conceptual model on which the numerical model is built. However, there are benefits to having both the local-scale and regional models using the same code, particularly when it comes to presentation of results for permit approvals.

Considering the structural complexity in the Mitchell Valley, and the need to obtain a reliable representation of the complex water pressure distribution discussed in Section 4.1, the Board recommends re-consideration of the decision to develop the model in MODFLOW 6. The Board undertook an informal survey of similar dam-design projects encountered in their recent practice, and the FEFLOW platform was adopted more frequently than the MODFLOW platform.

Other more detailed recommendations the Board has include:

- *It is important that WSP and Stantec both adopt the same format of representing field data. For example, in plots of in situ hydraulic conductivity values versus depth, the horizontal scale of hydraulic conductivity goes from low to high in the WSP plots, while in Stantec plots, the scale is set from high to low in moving to the right.*
- *The Board advises in the first instance a focus on calibration of the local-scale model in a traditional "deterministic sense". While automated PEST (parameter estimation) calibration is well-suited to uncertainty analysis, such analyses would seem to be a better fit for subsequent work.*

4.3 GEOCHEMICAL CHARACTERIZATION AND BLOCK MODELLING

The Team provided a summary of the objectives and approaches to the geochemical characterization being performed, and the environmental block model that is being established to be able to plan for and better manage acid generating construction and mine waste material on site.

[2] The U.S. Geological Survey's modular finite-difference flow model, which is a computer code that solves the groundwater flow equation. The program is used by hydrogeologists to simulate the flow of groundwater through aquifers.

The Team provided the Permit P-245 geochemical classification criteria established for the Mine Site and the amended criteria for ongoing construction activities, as well as an update on progress with the geochemical program made during 2023.

As previously discussed, the Board is supportive of this approach provided that in practice the uncertainties associated with the predictions is factored into consideration and that it be well documented and simplified as much as possible to allow the field staff during mining operations to continually check, calibrate, and use these relatively complex models.

This geochemical block modeling is intended to provide input to mine planning and the design, construction, and operation of the RSF to optimize placement of waste material to minimize acid rock drainage formation. The Board has previously provided recommendations on the use of the block model including that initially a conservative approach be adopted in the design of the Rock Storage Facility (RSF) to allow management of all the waste rock as Potentially Acid Generating (PAG) if necessary, with possible exceptions for blocks of materials that are conclusively determined to be Non PAG, and providing for a separate management approach for the short-term acid generating (STL) PAG.

4.4 OTHER WASTE MANAGEMENT CONSIDERATIONS

KSM indicated that consideration was given to pH adjustment to waters emanating from the RSF entering the WSD as a means of increasing the robustness of the containment provided. This would include providing facilities for leachate collection and storage, lime storage and dosing, as well as potentially sludge settlement and cleanout.

The Board supports continuing to evaluate such an approach both as a short-term contingency measure to deal with surges of unexpectedly low pH conditions, and/or as a permanent measure to maintain a higher pH (lower acidity) in the water stored behind the WSD. Since such a system adds complexity to the overall site operations, care would need to be taken to clearly establish the lowest pH (highest acidity) that can be tolerated by the WSD, SCD, and the surrounding natural impoundment bedrock in the long term to ensure such pH adjustments are made when necessary.

5. Stantec Team and Deliverables

5.1 STANTEC TEAM

Stantec has been appointed as the design team for the WSD and SCD. The team includes senior geologists, engineering geologists, hydrogeologists, and Stantec's tunnel practice leader. The Board looks forward to interacting with these team members as the field investigations, studies, and designs progress.

5.2 DELIVERABLES OVERVIEW

The Board notes that the following deliverables are to be completed in March or early April in parallel with the IGRB completing this report.

- Drone Photogrammetry.
- Final Dam Site Characterization Report (Stantec 2024a).
- WSD Geologic Model (Stantec 2024b).
- Revised Factual Data Report.
- WSD MODFLOW Model.

The Board looks forward to being briefed on the finalized results and findings contained in these reports during our 2025 review meetings.

5.3 FACTUAL REPORT UPDATE

The Preliminary Dam Site Characterization Report covers the objectives, methodology and findings of the 2023 site investigation campaign and integrates data from previous field investigations. Previous site investigation work was carried out in 2008, 2009, 2010, 2011, 2021 and 2022, with the most extensive being that of 2022. In planning the 2023 activities, a thorough review of the accumulated data was carried out with a view to identifying information gaps and orienting new work to the design needs of the Water Storage Dam (WSD) and its ancillary works.

The scope of work completed in 2023 (summarized in Table 1 below) includes the following:

- Geotechnical Investigation.
- Hydrogeological Investigation.
- Geophysical Investigation.
- Historic Instrumentation Field Audit and Surface Monument Installation.

One of the major goals was to update the 3-D geological model for use in dam design and hydrogeological studies. There were apparent inconsistencies in the description of the various lithological units identified and used in borehole descriptions over the time span of the various campaigns. For the updated model, these were distilled into 18 different codes and subsequently reduced to 8 units as presented in the report. The 8 units cover the essential anticipated geotechnical and hydrogeological characteristics that may affect the performance of the WSD.

Table 1 Summary of Site Investigation Work Completed in 2023.

Site Activity Completed	Quantity
Geotechnical Boreholes (total meterage)	8 holes (1,261.3 m)
Point Load Testing	686 tests
125 mm Diameter Wells (total meterage)	6 holes (681.78 m)
Pumping Well Installations	3
Observation Well Installations	3
Single Well Pressure Response Tests (Packer Test)	36
Step Rate Pumping Test	3
Constant Rate Pumping Test	3
Soil Index Testing	36 Samples (76 Tests)
Rock Strength Testing (all methods)	102 samples
Groundwater Samples	3
Seismic Refraction Lines	7 lines (3,120 m)
Vibrating Wire Piezometers Installed	20
Thermistors Strings Installed (meterage)	3 (390 m)
Surface Monument Installed (Pelican)	6
Surface Monument Installed (Telescopic Steel)	6 monuments
Historical Instrumentation Audit - Sites	21 locations
Historical Instrumentation Audit - Instrumentation	45 instruments
Historical Instrumentation Audit – Monitoring Wells	9 wells

The units used in the geological model are as follows:

- OVBN Overburden soils
- SARG Graphitic Mudstone
- SSL Siltstone
- SSN Sandstone
- SSC Calcareous Siltstone
- SSM Mudstone
- K-series Igneous Dikes and Volcanics
- CGL Conglomerate

In addition to the above lithological units, rock is also classified according to rock mass quality expressed in terms of Rock Quality Designation (RQD) and Rock Mass Rating (RMR).

The packer tests and pump well tests also provide a means to distinguish anticipated performance though the results for most units varied essentially between $1x10^{-8}$ and $1x10^{-6}$ m/s, with a few outliers. An example of the distribution with depth is shown in Figure 6.

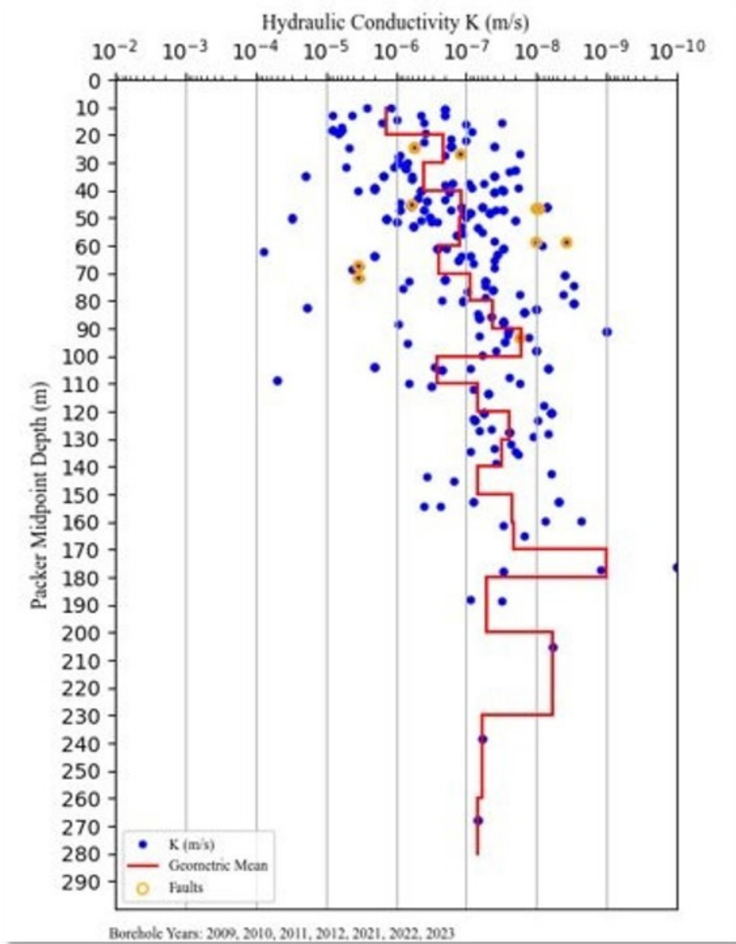

Figure 6 Packer Testing Hydraulic Conductivities.

The seismic refraction survey results were compared to the borehole results and presumably the latter were used in calibration of the former. The report mentions "anomalous" low compression wave velocity zones. *The Board suggests that the term anomalous be reserved for zones where there is an apparent discrepancy between the borehole findings and the geophysics.*

Importantly, new boreholes and the re-interpretation of existing holes that cross beneath the Mitchell Creek bed have brought to light the existence of what is currently named the Mitchell Creek Fault. The previous geological model showed calcareous siltstone and sandstone mapped crossing the Mitchell Creek as a continuous unit. This fault is now hypothesized as a possible causative feature of the valley with its strike-slip nature explaining some displacement of the beds between the left and right banks.

Thick overburden is noted primarily on the left bank and upstream of the current WSD axis. This deposit, reaching thicknesses up to 50 m, has some influence on the ultimate location of the dam axis. *Improved characterization of the overburden which appears to consist of glacial till may be required to judge its acceptability as foundation material and should be addressed by the investigations described in Section 8.*

The common bedding orientation is dipping to the SW on both the left and right banks. Joints and faults appear on the lower hemisphere Schmidt plots in two main families NNE and WNW which is also common to both abutments. The SCD site also contains weathered and fractured rock units and calcareous units with potential voids though not to the extent of warranting the term "karstic".

Highly weathered rock has been interpreted to exist on the right abutment of the WSD particularly downstream of the dam centreline.

The Seepage Collection Tunnels at the WSD and the SCD will pass through variable rock conditions with quality from very poor to excellent. The tunnels at the WSD will be required for rock grouting but use of these tunnels for seepage collection may create high hydraulic gradients that may not be desirable in areas of poor quality and/or soluble rock. No grout testing has been performed to verify the penetrability of cement, ultra-fine cement, chemical grouts, or bitumen.

The Team recognizes that refinement of the geological model with the aid of strategically focused additional boreholes and geophysics may be required for detailed design. The Board agrees with this finding. *In planning and performing the additional investigations (mentioned in Section 8)[3], the Board recommends the general conditions for the various ancillary structures should also be better defined. For example, the spillway locations include relatively thick overburden, highly weathered rock, and potentially soluble rock, all of which require better characterization.*

The Board also repeats a prior recommendation that future exploration campaigns include grout testing. The useful information obtained would include characterization of drilling rates, grout takes, grout mixes, and the types of grout materials that can be used to achieve penetration. It should be recognized that the narrow valley bottom, steep abutment slopes and access constraints at the damsite will limit the ability of such a program to be of sufficient scale to confirm that grouting can achieve an effective barrier.

For constructability of the above-mentioned Seepage Interception and Construction Diversion Tunnels additional information will be required to understand groundwater conditions, and the need for temporary and permanent ground support. If these tunnels are not used for seepage collection as discussed in Section 6.4, the need for tunnel lining to minimize the inflow of groundwater should also be considered. Furthermore, in performing the additional work described in Section 8, the Board recommends attention be given to the following aspects:

- *Geotechnical drilling, including in-situ testing and laboratory testing, at the portal locations is recommended to support the feasibility-level design and for better understanding of depth to rock, depth to competent rock, and type of rock along the alignment.*
- *Geophysical surveys using both seismic refraction and resistivity along the tunnel alignments are also recommended to support the feasibility design.*
- *Evaluation of ground support and tunnel excavation techniques is required for design of the tunnel(s) through calcareous deposits with acidic water moving through the system.*

[3] The proposed future work described in Section 8 appears to focus only on further characterization of karstic zones in the spillway footprint.

6. Water Storage Dam Design Considerations

6.1 WSD ALIGNMENT

The 2022/2023 site investigations included drilling to investigate a dam axis alignment located about 200 m upstream of the currently proposed dam axis. The objective of this alternative dam alignment was to assess if the dam could be moved away from calcareous bedrock, particularly the vuggy calcareous beds identified in previous investigations, to eliminate the potential for dissolution of the calcareous components of the bedrock within the dam foundation.

The interpreted site conditions based on the new information show that the upstream axis would not materially reduce the occurrence of calcareous bedrock upstream of the seepage control elements of the dam (core, plinth and grout curtain). Furthermore, the upstream location is interpreted to have a deeper soil profile over bedrock (up to 50 m depth of soil) requiring deeper excavations to expose bedrock at the dam axis and correspondingly larger quantities of rockfill to construct the dam.

The Board concurs that there is not a convincing argument to move the dam 200 m upstream.

In moving forward, the Board's advice is to focus further investigations and design work on the existing dam alignment with minor adjustments to the axis that would improve construction safety and overall constructability of the dam. Such adjustments could entail moving the right abutment upstream to reduce the depth soil excavation in this area. Adjustments in the location that are significant enough to trigger re-permitting should be avoided.

6.2 WSD DESIGN ISSUES

The Board provides the following brief comments on some of the WSD design requirements to be addressed in performing the FS.

6.2.1 Stability and Deformation

The WSD will be constructed on a prepared foundation. The plinth and core will be founded on bedrock. Bedrock bedding (Figure 7-left image) appears favorably oriented for dam stability. Identified faults dip steeply and appear favorably oriented for dam stability (Figure 8). The bedding/joint Set 1 (Figure 7-right image) is key to both the dam's stability and the stability of foundation preparation excavations.

The effect of the bedding/joint Set 2 on dam stability and the stability of any excavations of the dense till overlying bedrock will need to be evaluated and documented.

The dam shells will be constructed of compacted intrusive rockfill. The seismic stability of well compacted high rockfill dams constructed on bedrock foundations is well documented in technical literature. The proposed dam face slopes are at the shallower (more conservative) end of the range typically used for rockfill dams. The Team has listed the steepening of these slopes as an opportunity still to be considered when finalizing the designs.

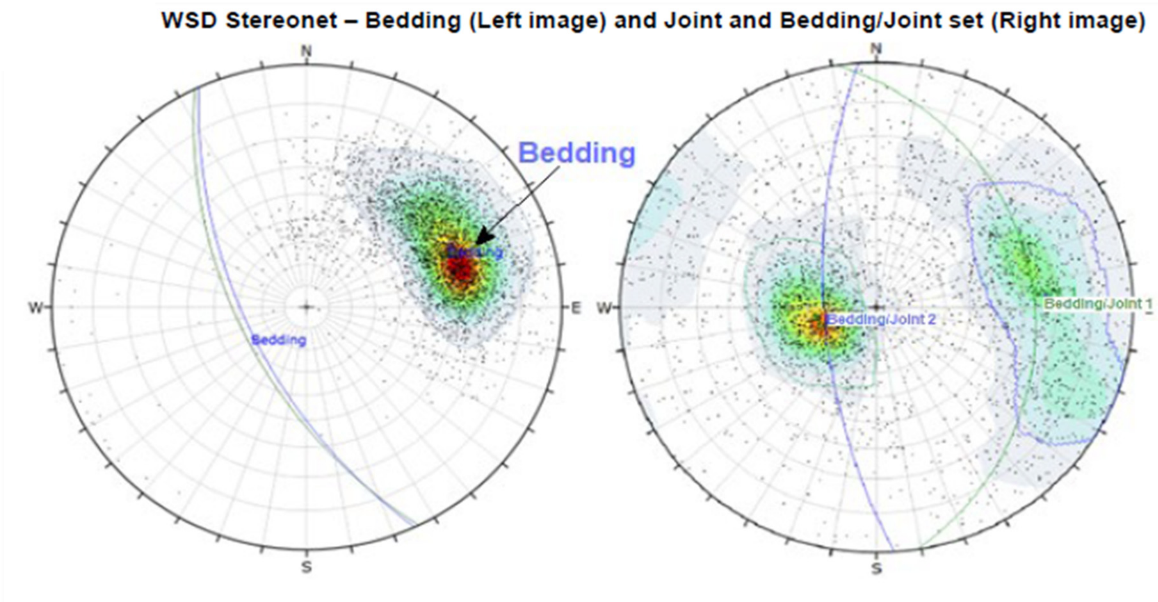

Figure 7 WSD Stereo Nets

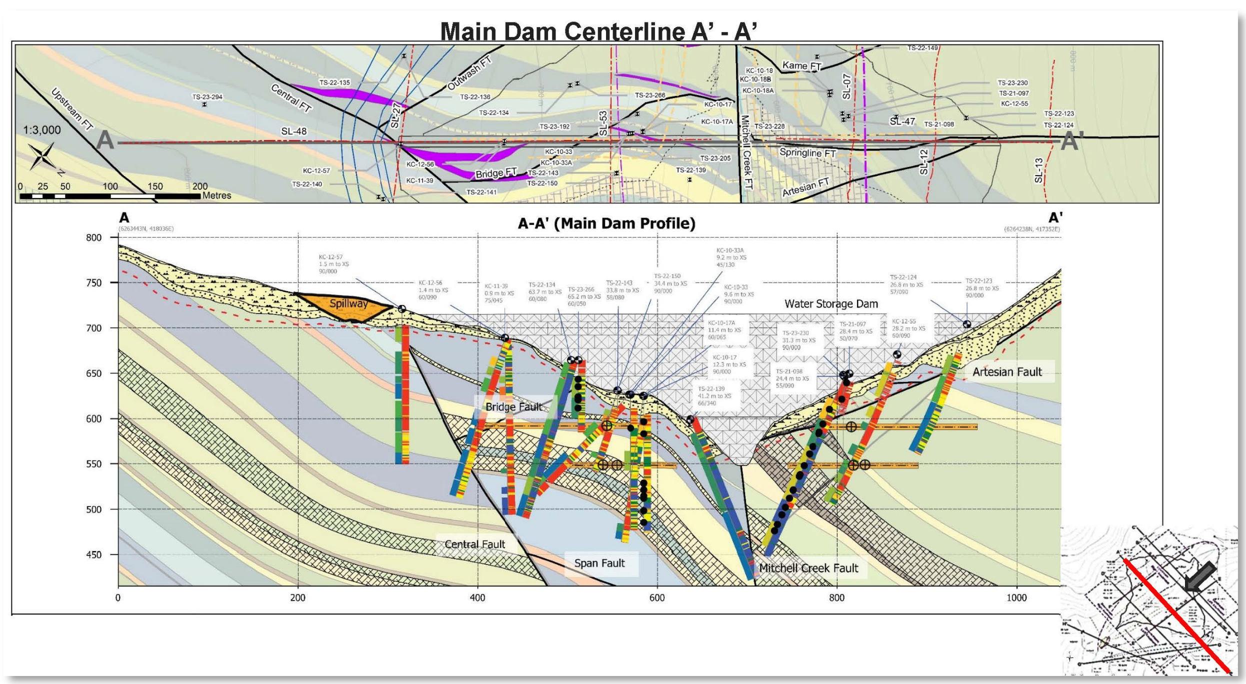

Figure 8 WSD Geology and Faults

The earthquake design ground motions (EDGM) will be based on a 10,000-year return period event. The Board expects that a properly designed and constructed asphaltic-concrete core dam will perform well during earthquakes. The Board supports the recommendation made by Stantec to update the seismic hazard study. The previous study was carried out in 2012 and there have been two updates to the Canadian seismic hazard maps since that time as well as important additions to the ground motion attenuation relationships used for these studies. The results of these updates should be included in the design criteria for the WSD, SCD, the TMF, and other site facilities.

6.2.2 Flood Management

Overtopping of the WSD is mitigated by a spillway designed to pass the Probable Maximum Flood (PMF) adjusted for climate change.

6.2.3 Internal Erosion Control

Asphaltic concrete has a documented high resistance to erosion. The material exhibits plastic deformation, creeps to relieve stress, and is self-healing if cracks do occur.

Internal stability and filter compatibility of the core support zones (filter transitioning to rockfill) will need to be addressed in the FS design. Measures to mitigate erosion of bedrock fracture fillings in high gradient areas that could lead to an increase of seepage flow will also need to be addressed.

6.2.4 General Seepage Control

The Board considers design of the seepage control measures for the WSD (and the SCD) to be the most challenging element of the design due to the heterogeneity of the geologic and hydrogeologic conditions as discussed in Section 4.1. It is understood remedial grouting of the dam foundation will be carried out as needed using the grouting galleries incorporated in the Seepage Interception Tunnels as further discussed in Section 6.4.

The WSD will retain acidic water and an assessment of the impact of this water on the dam and foundation is included in the dam design studies. *Provisions to protect the concrete plinth from acid attack should also be evaluated. Plinth protection could include completely covering all concrete surfaces with a bituminous mastic that incorporates a non-calcareous filler. Use of epoxy coated reinforcing steel should also be considered. Acid-resistant grouts, either chemical or bituminous, should also be evaluated for use in conjunction with the proposed Portland cement-based grouts.*

6.2.5 Geohazards

The need to mitigate the risk of avalanches and rockfalls during construction and then the much longer operating life of the WSD and ancillary facilities is included in the design studies.

6.3 SPILLWAY

During the discussions, Stantec provided an excavation drawing for the proposed chute spillways for the WSD and the SCD. No conceptual designs of the proposed erosion control measures (e.g., either bedrock, riprap, or concrete), the side walls, or the energy dissipation features within or at the end of the spillway, were provided. The Board considers that understanding such design details is important to assessing the field data needs along the spillway alignment to allow the FS design to be prepared.

The Board recommends that the Team review and then update the prior PFS level spillway designs as needed and use this information to determine what additional geotechnical and hydrogeologic field investigations are required for the FS.

6.4 SEEPAGE INTERCEPTION TUNNELS

The 6 Seepage Interception Tunnels (Section 3.3) were originally intended to provide access for grouting in the dam abutments, thereby removing grouting off the critical path during construction. The tunnels would also provide long-term access to the dam foundations in case additional remediation, i.e., additional grouting, might be required in the long-term and/or after disturbing events such as an earthquake. During the EA process it was decided that these tunnels should also be used to collect and monitor seepage around the dam during operations and afterwards.

During the meetings Stantec presented and discussed geologic sections along the Seepage Interception Tunnel alignments. The Board noted that the cover over the tunnels in the WSD (Figure 12) is thin and will require attention to support systems if constructed as currently laid out.

<u>The Board is not sure that both the grouting access and seepage collection objectives can be met with the tunnels as proposed. Meeting these two objectives requires different alignments, tunnel sizes, and tunnel support. Furthermore, the two objectives are not complementary. The Board believes the main objective is to maximize access for grouting to be conducted both during and after construction. Also, seepage collection tunnels are expected to generate high hydraulic gradients within weak rock surrounding the tunnels which is not conducive to satisfactory access for grouting.</u>

<u>*Therefore, the Board strongly recommends the approaches to providing grouting access and seepage collection be reevaluated. These evaluations should include, among possibly others, the following approaches:*</u>

- Identify the objectives to be achieved, i.e.,
  - For grouting – provide access during dam construction and thereafter to areas in the abutments where design and future remedial grouting may be necessary.
  - For seepage collection – at the WSD identify where seepage collection may be necessary because it would not be collected by the SCD, and at the SCD, where seepage collection is needed to prevent seepage migration to the downstream creek.
- Use the groundwater model to aid in the refinement of where the necessary types of facilities should be located, and how they should be constructed (e.g., lined or unlined tunnels, use of boreholes rather than tunnels, etc.), and how effective they might be.
  - Recognize the importance of the upper tunnels at the WSD, particularly on the left abutment, due to potential seepage concerns in that area as described in Section 4.1
  - At the WSD, consider the use of inclined drains to intersect faults and other rock mass discontinuities to improve the effectives of the grouting program.

6.5 CONSTRUCTION DIVERSION TUNNEL

The geology at the dam foundations at the right abutment is shown in Figure 5 and Figure 9 below. As indicated in these figures, the rock mass at the dam foundations consists of downstream steeply inclined bedding striking perpendicular to the river flow. Some of these beds could be highly permeable. The diversion tunnel rock cover is low to moderate at the upstream sections of the tunnel, and leakage into the tunnel can be significant along the more permeable layers. Thus, probing and grouting would be required to avoid flooding with workers inside the tunnel. Significant grouting efforts should be anticipated during tunnel construction.

The Team outlined future evaluation work to be done and expressed preference for the left abutment alignment shown on Figure 1. Tunnel construction along this alignment is considered to have lower construction workers' health and safety risks and lower cost. The Board agrees with the logic presented by the Team and their conclusions.

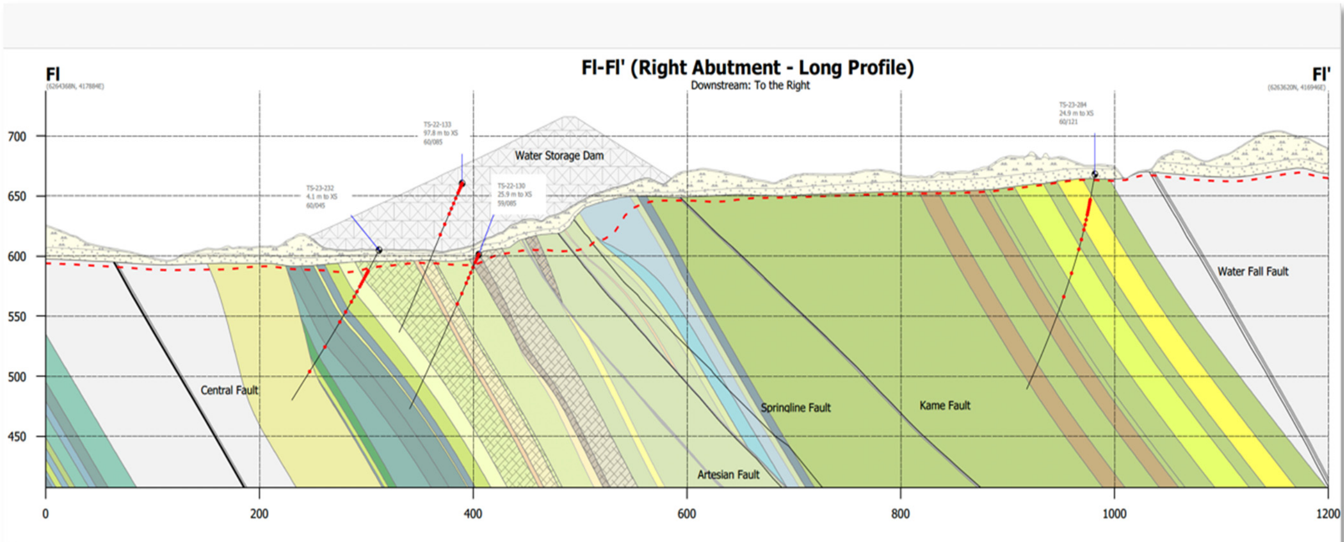

Figure 9 Geology along tunnel Alignment

6.5.1 Grouting

No details on the grouting programs were provided.

For purposes of the FS, the *designers should evaluate the grouting efforts needed and should design for access to all the identified necessary locations. In terms of construction scheduling, access should be provided in a timely manner to remove grouting from the critical path for construction of the dams.*

6.6 LOW LEVEL OUTLET

The Board notes that there is no low-level outlet proposed for either dam. Such outlets can be required by some jurisdictions to allow for draining the dams in the event of a risk of catastrophic dam failure. Such outlets can also be sued for conveying flow downstream by gravity for treatment, for example. It may also be possible to utilize the diversion tunnel for the installation of a low-level outlet for the WSD.

The Board recommends that in preparing the FS design, consideration be given to including low-level outlets at each of the dams and their functionality over the life of the dams, including the decades following mine closure.

7. Seepage Collection Dam Design Considerations

7.1 GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

The SCD and spillway lie within the footprint of the Avalanche Chute fault, a large northwest-southeast steeply dipping thrust fault. In the area of the SCD, the bedrock beds typically dip approximately 65 to 85 degrees to the southwest. The Mitchell Creek fault, a sinistral strike slip fault with potential vertical dip-slip movement, is located down the center of the valley under the SCD. The SCD and Spillway are shown on cross section H – H’ on Figure 10.

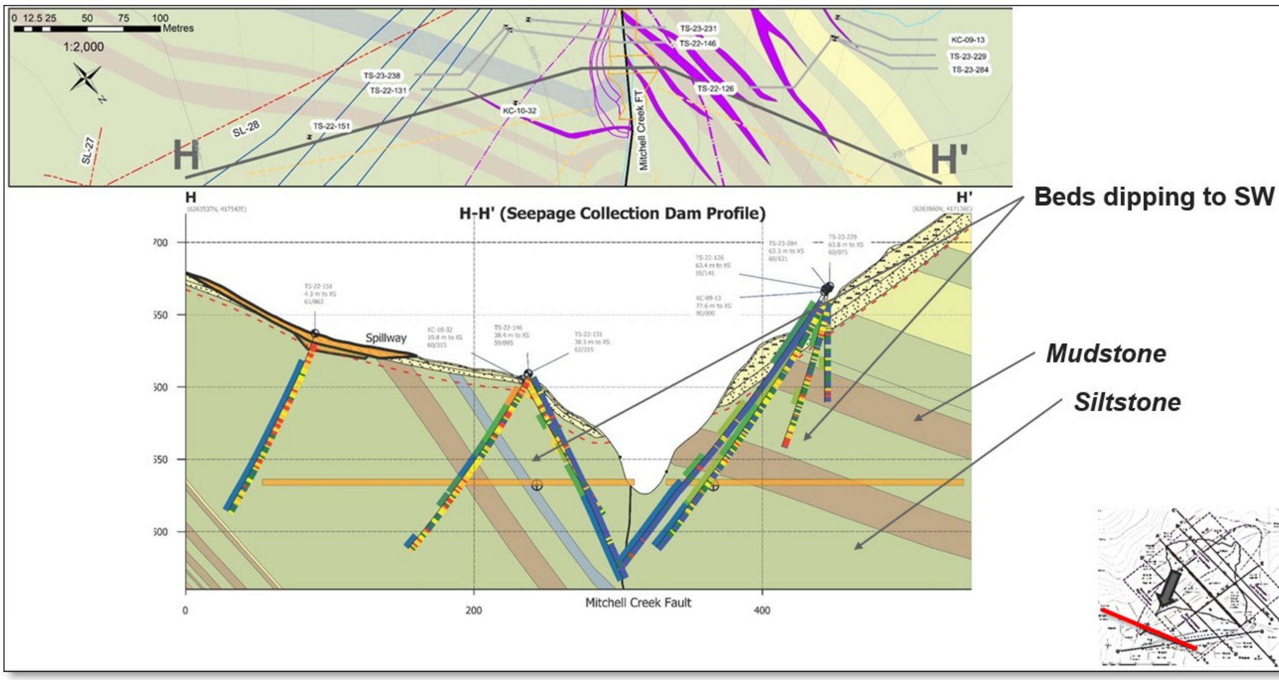

Figure 10 Geologic-Hydrogeologic Model Section of SCD Centerline.

The overburden on the left abutment is characterized by a thin layer of organics overlying varying thicknesses of sands and silts over thin basal gravel and cobble layers. The overburden thickness is 3 m to 15 m with seismic velocities of 1,100 m/s to 2,150 m/s. The overburden thickness decreases downslope with bedrock outcropping in the lower part of the slope. The left abutment bedrock is composed of siltstones with interbedded mudstone. Seismic data has indicated this area is highly weathered and/or fractured upstream of the SCD and could present rock quality issues for the spillway design. No structures were observed close to the left abutment of the dam.

Overburden on the right abutment is thicker than on the left abutment and is characterized by a thin layer of organics overlying sands and silts over a thin basal gravel and cobble till. No geophysical data is available for the right abutment, but borehole data suggests overburden depths of 6 m to 11 m above a steep break in the slope down to Mitchell Creek. The right abutment bedrock is composed of sandstones and siltstones with interbedded calcareous units and increasing mudstone closer to the Mitchell Creek fault.

One of the three pumping tests performed by Stantec during the 2023 site investigation was at the SCD left abutment. Interpretation of the pumping test data indicated a low hydraulic conductivity of bulk rock mass of 1×10^{-8} m/s. Presentations to the Board did not include in situ permeability test results for borings drilled in the vicinity of the SCD. The Board looks forward to the Team's assessment of natural hydraulic containment and the design requirements for design features that will be needed to provide hydraulic containment during operation of the facility.

Based on a geohazard assessment, the SCD may be subject to debris avalanches and snow avalanches within the canyon upstream from the dam.

7.2 SEEPAGE COLLECTION DAM DESIGN CONSIDERATIONS

Stantec summarized the following technical considerations to support Feasibility Design of the SCD and SCD Spillway.

- Potential for highly weathered and fractured bedrock.
- Fault features impact on design.
- Completely to highly weathered bedrock identified beneath the dam core, cutoff trench and filter zones, should be removed to the degree practical with heavy construction equipment and potentially a pneumatic chisel in limited areas, blasting should be avoided.
- Calcareous subunits throughout the Stuhini Group appear to have the potential for development of voids in various forms when subjected to the effects of flowing water.
- The impacts of acidic water anticipated to be impounded in the WSD reservoir on the calcareous lithologies must be considered in design.
- Future studies should be completed to better understand the hydrogeological setting in the area and include additional pump testing and monitoring of the local vibrating wire piezometer network, downhole testing, and laboratory testing to support the program.

The IGRB agrees with these technical considerations and has the following additional observations and recommendations.

- Water levels in the abutments appear to be above the proposed SCD pond level, which should be favorable for hydraulic containment.
- The project permit requirement that seepage be less than 1 L/s downstream of the SCD is very stringent and may be difficult to achieve.
- In situ permeability test results in borings drilled at the SCD were not presented to the Board, and characterization of the bedrock permeability is fundamental to design of the SCD.
- The drill holes angled toward the valley bottom were slightly too short to intersect the Mitchel Creek fault. *The next investigation campaign should include holes of sufficient length to intersect the fault.*
- *Consider long horizontal borehole drains at the SCD that could be used to supplement the proposed Seepage Interception Tunnels or as an alternative to these two tunnels (Figure 1). Open pit wall depressurization is likely to require installation of horizontal drains, and the use of the same drilling rig could be cost and schedule competitive to construction of seepage interception tunnels. In considering such boreholes, the installation and long-term maintenance or replacement requirements will need to be addressed.*

8. Recommendations to Support Feasibility Design

The recommendations outlined by Stantec in their report for future work for the FS include performing (Stantec 2024b):

- Hydrogeology:
  - Long term pumping tests.
  - Permeameter tests with pure and acidic water for rock solubility/erosion.
  - Packer tests in holes drilled parallel to the bedding. Note that many existing holes were drilled across the bedding to identify the sequences.
  - Spring and seep assessments.
- Geotechnical:
  - Update the seismic design criteria.
  - Drilling and sampling for overburden quality. This may be oriented to obtaining information for excavation slopes as well as assessing the potential for leaving in place certain foundation materials.
  - Geotechnical testing of soil and rock materials.
  - Infill core drilling.
  - Defining the overburden and rock conditions along Mitchell Creek.
  - Additional geophysical characterization.
  - Further delineation of potential karstic zones along the spillway location.
  - Targeted boreholes in the SCD footprint area.
  - Geotechnical drilling and geophysical surveys along the Seepage Collection and Construction Diversion Tunnels.
  - Designing the Seepage Collection and Construction Diversion Tunnels for acidic water flows.

No specific details on the overall program were provided, and the Board understands KSM will start working on planning these FS work scopes in April 2024.

During the meeting Stantec stated that there has been limited exploration of the creek bed because it is difficult to access. Drone surveys have provided some information that indicates that rock outcrops occur along the bed. They indicated that mapping and drilling will be needed in future for this area.

The Board concurs with the above general recommendations.

The Board is concerned about the methodology to be used for the permeameter tests with acidic water and the interpretation of the results. These tests, of necessity, are conducted under laboratory conditions over a short term, months possible years, and are then used to project behaviour out a century or more. *Therefore, the Board recommends the methods used for these tests needs be carefully considered so that meaningful results can be obtained for use in design.*

The Board wishes to add the following comments and suggestions to the Stantec recommendations:

- *Refinement of the geological model is indeed required but all future work should be carefully planned to also address specific design needs.*
- *The Board notes that boring orientations are generally parallel to the "Mitchell Creek" fault and hence the potential for parallel faulting and structures is not known. This lack of data should be considered in future field investigation programs.*

- *The available permeability data has been plotted against depth to identify statistical trends which are typically seen in most similar rock masses and are used, for example, to define the required depth of a grout curtain (Figure 6). Since the site includes a range of different stratified formations with varying degrees of tectonic and extents of weathering, the data needs to be filtered to eliminate data with poor confidence levels and should also be presented by geologic formation and structural zone to depict any differences in the permeability of these.*

  It may be informative to also include packer testing in screened open holes and consider camera survey or borehole flowmeters to identify localized groundwater inflow zones.

In addition to the above general recommendations, the Board recommends the following additional work scope be undertaken:

- *Construction access – examine how developing access could affect areas outside the immediate dam footprint.*
- *Borrow materials – examine how developing borrow areas could affect areas outside the immediate dam footprint.*
- *Stockpile locations – investigate stripped overburden stockpile areas to determine suitability for stockpile construction and access.*
- *Excavation slopes – evaluate the influence of excavations for the dam and spillway both during construction and for those that will remain exposed long-term.*
- *Dam fill(s) processing locations – investigation of the site proposed for asphaltic concrete batching, as well as for crushing and screening operations for dam zone fills.*
- *Impacts of geohazards – evaluate the influence of geohazards on construction and operation of the WSD facilities.*
- *Long term pumping tests proposed as described above, should be completed at the WSD using the existing pumping wells equipped with pumps and discharge lines to assess the hydraulic connectivity of the faults and various lithologies at the WSD site.*
- *Packer interval testing proposed should be completed in geotechnical boreholes drilled parallel to dip direction and bedding planes to obtain continuous data across the lithological units of interest.*

Regarding the design bases and approaches, the Board has the following additional recommendations that should be addressed during the FS:

- *While the proposed worst case predicted pH in WSD is 4, the Team should recognize that lower values could potentially occur, and establish remedial measures if necessary (e.g., lime addition as suggested).*
- *Plan three-way coordination on data between KSM, Stantec and WSP.*
- *Recommend the bottom of the gorge be accessed (as suggested by KSM during the meeting) to conduct seep surveys, and prepare channel bottom and abutment preparation plans, etc.*
- *The board recommends doing some form of FMEA on design, construction and operation of the dams to inform on what additional design elements and associated field investigations would be required.*

9. Closing Remarks

The Board appreciates the effort made by KSM to brief it on progress made and the ongoing Project developments. It is recognized that these meetings focused mainly on work completed and that some of the data evaluations are still underway. The Board considers the key issues that were identified during the meetings include:

- The need for further evaluation of the extent to which hydrodynamic (hydraulic) containment is provided around the WSD and its associated storage area.
- Reconsideration of the currently proposed Seepage Interception Tunnels to provide for more effective access for grouting, and to better define needs for seepage collection in key areas.
- Recognize and address potential constructability issues, such as groutability of the various rock formations.

KSM and the Board discussed scheduling future annual meetings at dates when there would be a significant amount of further data reduction, interpretation, and analyses and/or design development available for review. After the meetings the next Board review (number 11) was scheduled as a virtual meeting for the 17th and 18th of April 2025.

Appendix A

Participants List

Participants List - 2024 IGRB Review Meeting

Name		Organization
Day 1	**Day 2**	
Gabriel Fernandez	Gabriel Fernandez	IGRB Member, virtual
Jean Pierre Tournier	Jean Pierre Tournier	IGRB Member
Jim Obermeyer	Jim Obermeyer	IGRB Member
Ian Hutchison	Ian Hutchison	IGRB Member
Anthony Rattue	Anthony Rattue	IGRB Member
Terry Eldridge	Terry Eldridge	IGRB Member
Brent Murphy	Brent Murphy	Seabridge Gold
Tracey Meintjes	Tracey Meintjes	Seabridge Gold
Mike Skurski	Mike Skurski	Seabridge Gold
Peter Williams	Peter Williams	Seabridge Gold, virtual
Kamran Shaikh	Kamran Shaikh	PRA
Kristin Salzsauler	N/P	Geosyntech
Tom Meuzelaar	N/P	Life Cycle Geo LLC
Dan Hepp	Dan Hepp	Stantec
Danica Labelle	Danica Labelle	Stantec
Donald Montgomery	Donald Montgomery	Stantec
Dan Kennedy	Dan Kennedy	Stantec
Sean Ennis	Sean Ennis	Stantec
Carolyn Randolf	Carolyn Randolf	Stantec, virtual
Eric Bort	Eric Bort	Stantec, virtual?
N/P	Greg Raines	Stantec, virtual
N/P	Thomas Poitras	Stantec, virtual
Ross Hammett	Ross Hammett	WSP, part time
Jennifer Laverick	N/P	WSP

Appendix B

Agenda

Agenda
10th IGRB Meeting
March 7 and 8, 2024
Blakes Law Offices
3500-1133Melville Street
Vancouver, BC

Day 1 -Thursday, March 7:

1. Project Update – Information purposes only: 8:30 AM -10:30 AM PST

- Introductions — Brent Murphy
- Safety Share
- Company Update
  - Substantially Started Update — Brent Murphy
  - Partner Discussions — Brent Murphy
  - Alaska Transboundary Discussion — Brent Murphy
- Future role of the IGRB — Brent Murphy
- Hydrogeological Update — Jennfier Levenwick
- Geochemical/Block Modelling — Ross Hammett/Kristin Salezsauler

Coffee Break – 10:30-10:45 AM

2. Topics within IGRB Purview: Dam Site Characterization Work 10:45AM – 5:30 PM (a working lunch will be provided between 12:00-12:30 PM)

- Stantec Team Introductions and Review of Deliverables Status (10:45-11:00AM)
- Factual Report Summary Review (11:00-12:30PM)
- Geology Model Update (12:30-1:30)
- Dam Site Characterization Report (1:30-2:15PM)

Coffee Break (2:15-2:30PM)

- Water Storage Dam Review (2:30- 4:15pm)
- Spillway Review (4:15-5:00PM)

End of Day 1- 5:00 PM

Group Supper 6:00 PM
Joe Fortes Restaurant
777 Thurlow Street

Day 2 -Friday, March 8, 2024 (8:30 AM-5:00PM)

2. **Dam Site Characterization Work cont'd (a working lunch will be provided between 12:00-12:30 PM)**

    - Seepage Collection Dam and Sump Review (8:30-9:30AM)
    - Seepage Collection Tunnels (9:30-10:00AM)
    - Construction Tunnels (10:00-10:30 AM)

    Coffee Break – 10:30-10:45 AM

    - Construction Tunnels cont'd (10:45-11:00 AM)
    - Recommendations to Support Feasibility Design (11:00-11:15AM)
    - ModFlow Modeling Update (objectives, requirements, and scope) (11:15-11:30AM)

3. **Board Deliberations (11:30-5:00PM)**

End of Day 2 –5:00 PM