

## *Appendix D*

*KSM Mining Best Available Technology (BAT) Study for  
Tailing Management, Plain English Summary*

KSM PROJECT

**Application for an Extension to Environmental Assessment Certificate #M14-01**

**Best Available Technology (BAT) Study  
for Tailing Management at the KSM Project**  
*Plain Language Summary*



*This booklet contains an abbreviated, plain language summary of a report entitled Best Available Technology (BAT) Study for Tailing Management at the KSM Project prepared by Klohn Crippen Berger. This summary is designed to provide information about this study to readers who are not familiar with technical terminology. For greater detail about any of the topics covered in this document, please consult the complete technical report, which may be obtained electronically by contacting:*

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**Best Available****Technology (BAT)**

is the combination of tailing technologies and management strategies that most effectively reduce the physical, geochemical, ecological and social risks associated with tailing.

BAT also includes consideration of cultural, heritage, economic values and site-specific conditions.

BAT includes site selection considerations, technologies and design features that provide a resilient and robust tailing facility during operations and post-closure. BAT should be implemented at every stage of the tailing life cycle.

# Introduction

## *About this report*

Safe management of tailing may be the single most important way to minimize the environmental impact of a mine. Tailing facilities pose risks that must be carefully managed from a mine's initial design until long after its closure. The Mount Polley dam breach in August of 2014 significantly heightened awareness of these risks in British Columbia, Canada, and internationally. In response to the breach, the provincial government, together with the Williams Lake Indian Band and the Soda Creek Indian Band, ordered an independent review panel to conduct an engineering investigation into the event. An outcome of this investigation was the review panel's recommendation that new tailing facilities implement **Best Available Technology (BAT)** for tailing facilities. The panel highlighted a strategy known as filtered tailing as an example of BAT for tailing management, but noted that a range of technologies should be considered. Dr. Dirk van Zyl of the University of British Columbia stated that, in his personal opinion, BAT is:

*...not a single technology; its selection is based on a site-specific risk management process with the outcome of a stable and resilient tailings deposit.*

Following the panel's recommendations, the British Columbia Environmental Assessment Office required that the owners of all new proposed mines with tailing dams entering the environmental assessment review process provide a detailed BAT assessment on tailing management specific to the conditions found at each mine site. The goal of these studies is to identify the best available tailing technology for the site conditions

of each mine, taking many factors into account, including implications to safety, the environment, technical feasibility, social and economic values, and project economics.

This report summarizes the BAT tailing study conducted for the proposed KSM Project (location shown in Figure 1), which followed the methods suggested by Environment Canada’s *Guidelines for the Assessment of Alternatives for Mine Waste Disposal*, supplemented with additional analysis specific to tailing management. The KSM Project’s proponent, Seabridge Gold Inc., voluntarily initiated this study to further review the proposed tailing management strategy—as described in the Project’s 2013 *Application for an Environmental Assessment Certificate/ Environmental Impact Statement for the KSM Project (Application/EIS)*—and to confirm that the current plan is the most appropriate strategy to minimize physical, geochemical, biophysical, and social risks over the life of the tailing facility.

Figure 1. KSM Project location.



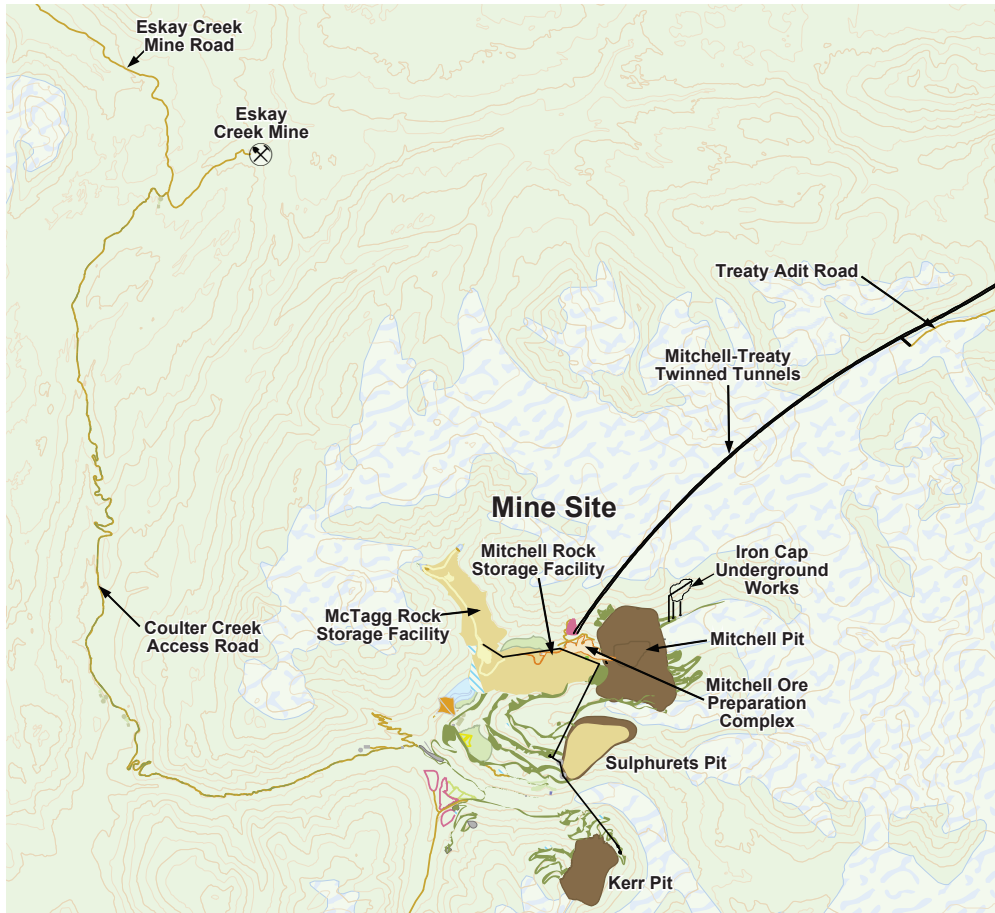


## About the KSM Project

The proposed **KSM Project (the Project)** is a gold, copper, silver, and molybdenum mine located in the coastal mountains of northwestern British Columbia, approximately 950 kilometres northwest of Vancouver, 65 kilometres northwest of Stewart, and 35 kilometres northeast of British Columbia’s border with Alaska.

As shown in Figure 2, the Project will have two main development areas: (1) the Mine Site, and (2) the Processing and Tailing Management Area. The Mine Site is located within the Mitchell Creek, McTagg Creek, and Sulphurets Creek valleys, and comprises three open pits, two underground mines, rock storage facilities, an ore crushing complex, diversion structures, a water storage dam, and a water treatment facility.

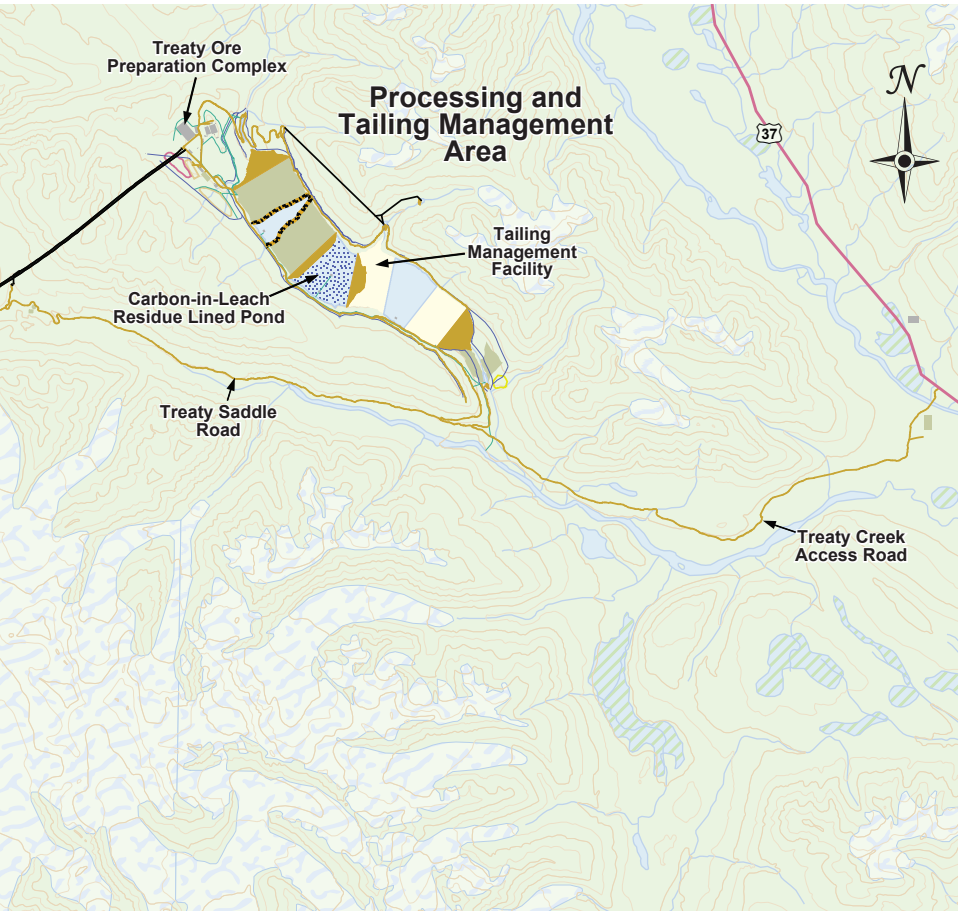
Figure 2. Proposed KSM Project layout.





The proposed location for the Processing and Tailing Management Area is the Teigen-Treaty Valley, about 23 kilometres east of the Mine Site. The Processing and Tailing Management Area includes the process plant and the **Tailing Management Facility (TMF)**.

The Project is designed to process an annual average maximum of 130,000 tonnes of ore per day for 51.5 years. Over the life of the Project, approximately 2.3 billion tonnes of tailing will be produced by the process plant, in two separate tailing streams. The first stream, comprising about 90% (or 2.1 billion tonnes) of the Project's tailing, will be the bulk rougher flotation tailing. The second stream, representing the remaining 10% (or 0.2 billion tonnes), will be a material known as **Carbon-in-Leach (CIL) residue**. CIL residue is the waste from the gold recovery







process used at the Project, in which gold is leached from ore using cyanide and activated carbon in a series of tanks. Unlike the flotation tailing, **CIL residue** is sulphide-rich and potentially acid-generating. Poor management of such materials can lead to oxidization and the production of acid rock drainage, which in turn can severely degrade water quality in lakes and streams, and is thus a major concern for surface tailing facilities. CIL residue will be sent to the fully lined centre cell of the TMF to prevent exposure to the environment.

The landscape surrounding the Project is mountainous and rugged, and receives significant annual precipitation as both snow and rain. The challenging terrain and climate limits the number of feasible sites that also have enough space for the process plant and TMF and are within a reasonable distance of the Mine Site.

For the following reasons, Seabridge Gold Inc. is confident that the design of the KSM Project, which has been approved by both the provincial and federal government's environmental assessment agencies, represents Best Available Technology:

- The selected site for the TMF has good geology and foundation conditions, with relatively few geohazards and no high value fish habitat within the footprint.
- The design features for the TMF provide long-term physical and geochemical stability.
- The TMF configuration supports the resilient and robust management of tailing after mine closure, and allows water to return to flow patterns similar to pre-mine conditions, in order to achieve the long-term environmental objectives that were identified during consultations.

Filtered tailing technology was originally considered as part of the Project's 2013 Application/EIS, which concluded that filtered

tailing for the Project was impractical due to several serious concerns, including:

- issues relating to stability and seismic liquefaction;
- the lack of a precedent for use of this technology at any mine approaching the Project's daily tailing throughput, and in particular, the practicality of construction and the necessary erosion control measures for operating a filtered tailing facility in the wet local climate; and
- the challenges involved in collecting and managing seepage water from the facility.

## *About Seabridge Gold Inc.*

**Seabridge Gold Inc. (Seabridge)** is a publicly traded company with common shares on Canada's TSX Exchange and the New York Stock Exchange. Seabridge intends the KSM Project to be a technically and economically sound and environmentally responsible operation, with measures in place to monitor, mitigate, and manage potential environmental effects while providing social and economic benefits to local communities, other British Columbians, and Canadians at large.

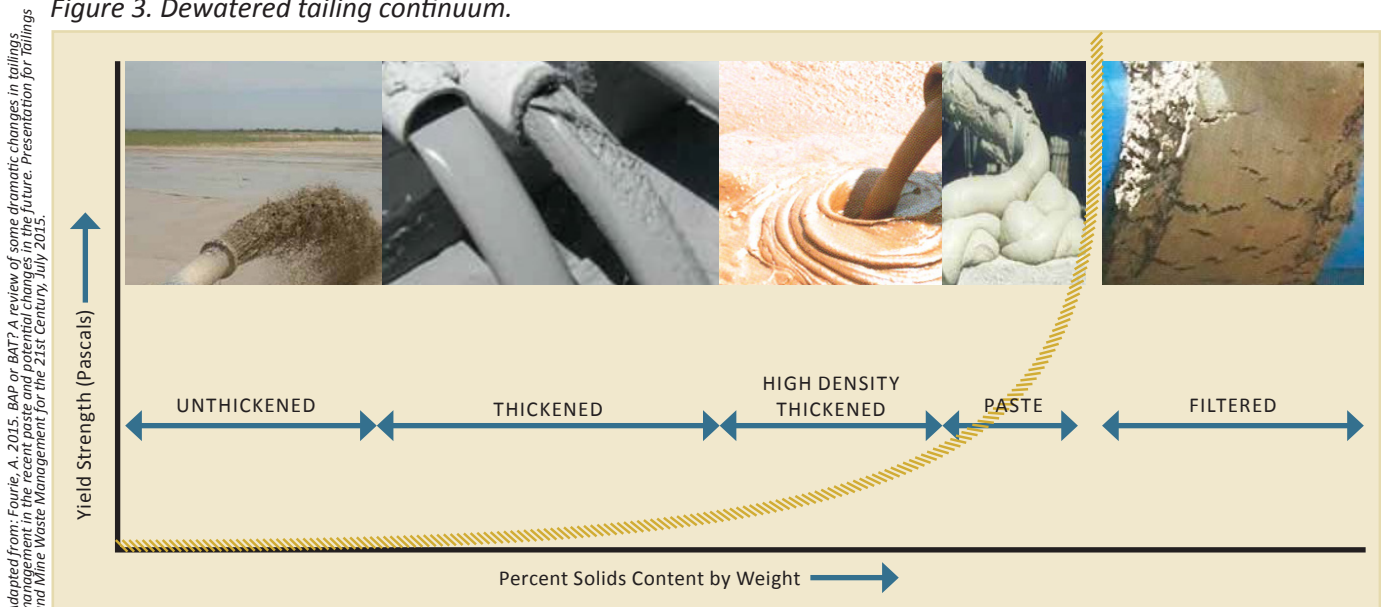


# Tailing Technologies

Water management is arguably the most essential aspect of tailing management, and is necessary to ensure physical and chemical stability throughout all phases of a mine’s life. Poor water management has been a root cause or a contributing factor to past tailing dam failures.

One way to limit the volume of water sent to (and therefore requiring management at) a tailing facility is to use thickeners and/or filters, in a process known as **dewatering**, to remove a portion of the water before transporting the tailing to the facility. Different degrees of dewatering result in different tailing states, defined by the yield stress and percentage of solids in their composition (Figure 3 and Table 1). There are also several alternatives to conventional surface storage facilities. These tailing technologies are discussed in the following sections.

Figure 3. Dewatered tailing continuum.





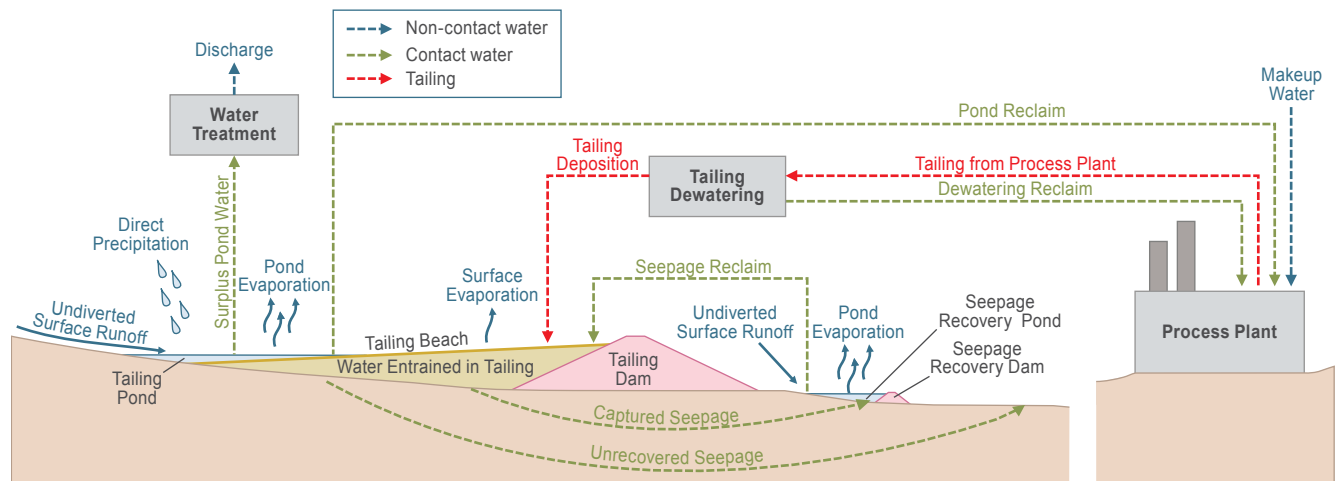
*Table 1. Properties of different tailing states.*

Tailing States	Typical Percent Solids	Equipment Required	Transportation Method
Unthickened	25 to 35%	None	Pumps and pipeline
Thickened	50 to 60%	Conventional or high rate thickeners and flocculants	Pumps and pipeline
High-density thickened	60 to 70%	High-density or high-compression thickeners and flocculants	Pumps and pipeline
Paste	70 to 78%	Deep cone thickener or combination of thickening and filtering	Positive displacement pumps and pipeline
Filtered	>78%	Vacuum or pressure filters	Trucks or conveyors

## Unthickened Tailing

**Unthickened tailing** is the output of a processing plant with no additional dewatering efforts (a typical conventional facility is depicted in Figure 4). A potential benefit of unthickened tailing in a conventional tailing facility that impounds water is that potentially acid-generating materials, such as CIL residue, can be kept underwater, preventing them from oxidizing and releasing metals and acid to the environment. On the other hand, impounding this water increases the total amount of material that must be stored in the tailing facility, and increases the consequence of potential failure.

*Figure 4. Conceptual illustration of (unthickened or thickened) conventional tailing facility.*



This form of tailing can be further treated with cycloning or sulphide flotation before deposition, as described below.

## Cyclone Sand Tailing Dams

**Cyclone sand tailing dams** use hydrocyclones (Figure 5) to separate the sand-sized particles from the tailing stream, which can then be used for dam construction. These types of dams have been built in a wide variety of climates, most often for larger copper mines that have tailing containing coarse particles. Cyclone sand tailing dams can provide robust stability, even in seismic areas with high levels of precipitation, and have been used around the world for over 50 years. There are two main advantages of cyclone sand tailing dams. Firstly, as the coarse sand recovered in the cycloning process can be further dewatered and used in dam construction, less material needs to be sourced from the surrounding area, minimizing land disturbances. Secondly, with the removal of the coarse particles, the volume of tailing requiring storage in the facility is reduced.

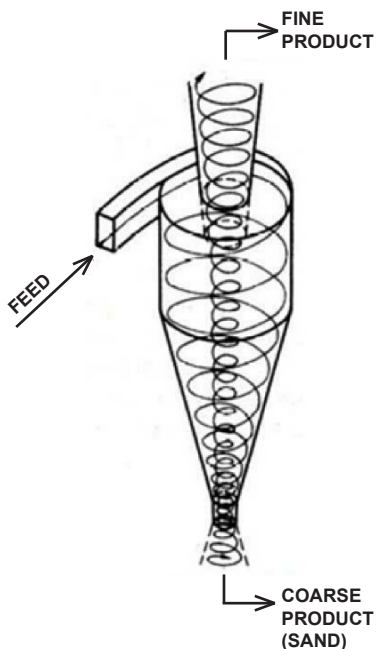


Figure 5. Schematic of cyclone particle segregation.

Source: Kujawa, Christian. 2011. Paterson & Cooke Ltd. Proceedings Tailings and Mine Waste 2011. Vancouver, BC, November 6 to 9, 2011.

## Sulphide Flotation

A technology known as **sulphide flotation** can also be used to separate tailing into multiple streams: one that contains sulphide minerals that may generate acid, and one that contains other minerals. This method minimizes the amount of tailing that requires special management, and results in better control of acid-generating material, reducing environmental risk.

## *Thickened and High Density Thickened Tailing*

**Thickened tailing** is produced by dewatering tailing using large circular thickeners. Thickening tailing is a common practice worldwide, and has been applied at mines producing over 100,000 tonnes of tailing per day. Thickened tailing can still be transported via pipeline, although this becomes less practical at higher solids contents and over longer distances.

Like unthickened tailing, thickened tailing must be stored in a conventional tailing facility (a typical facility is depicted in Figure 4), which, as noted above, may result in higher failure consequences.

## *Paste Tailing*

**Paste tailing** has an even lower moisture content than thickened tailing, and is primarily produced at smaller mines, where it is mixed with cement and used to backfill underground developments. Surface storage of paste tailing has also been attempted at small mines producing around 4,500 tonnes of tailing per day. However, we do not know of any mines that have successfully used paste tailing methods to achieve their design targets (high solids content and steep beach slopes), nor of any precedent for use of this method at larger mines.

The main advantage of a paste tailing strategy is that it reduces the amount of water requiring management at the tailing facility, while still using pumping for transportation. However, paste tailing operations often still require impoundment of water at the tailing facility, again increasing the consequences of failure, as well as presenting significant erosion and seismic stability risks. The technology is more costly than both unthickened and thickened tailing, and has no significant advantages when used for surface disposal.

*Thickener at Chilean copper mine.*



Source: Vietti Slurrytec ([http://www.viettislurrytec.com/About\\_us.html](http://www.viettislurrytec.com/About_us.html)).



*Paste thickener.*

Source: Jewell, R.J. and A.B. Fourie. 2015. *Paste and Thickened Tailings – A Guide*. 3rd ed. Perth: Australian Centre for Geomechanics



Filtered tailing facility in Chile.



Source: Anglo American/Debswana. n.d. "La Coipa, Region III, Chile, South America." <http://www.tailings.info/casestudies/lacoipa.htm>.

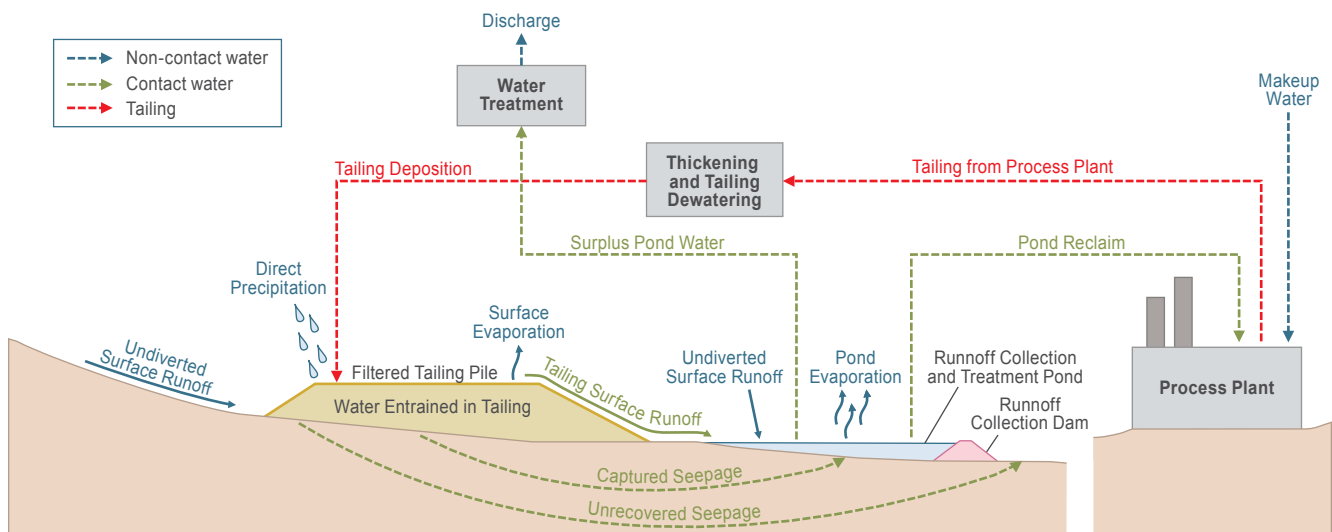
## Filtered Tailing

To produce **filtered tailing**, large-scale vacuum or pressure filter technology is used after initial thickening to remove moisture (a typical facility is depicted in Figure 6). The resulting material is down to 10 to 20% moisture by weight and acts like a solid (rather than a fluid), and thus must be transported by conveyor or truck and formed into a tailing pile.

The main advantage of a filtered tailing facility is that it does not impound water and can be compacted to a higher density and possibly placed into a smaller footprint. However, the application of filtered tailing methods in wetter climates and at larger scales can present serious challenges.

Most filtered tailing projects are in dry, arid climates where water management requirements are reduced and air-drying aids in the removal of moisture from tailing. Filtering tailing is more difficult in wet climates, as tailing piles must be protected from moisture to prevent saturation, erosion, and destabilization, as well as to minimize surface runoff and seepage. Managing high

Figure 6. Conceptual illustration of filtered tailing facility.



intensity storms at large filtered tailing facilities is challenging, as water must be prevented from flowing over and eroding the structural areas of tailing piles. While runoff from heavy rain can be directed away from these areas, it may temporarily pond on the surface, thereby increasing the risk of facility failure.

Filtered tailing has been implemented at operations producing up to 20,000 tonnes of tailing per day, and has been proposed for use at projects producing up to 75,000 tonnes of tailing per day. Few mines currently use surface filtered tailing facilities in wet climates, and these are relatively small operations producing a maximum of 4,000 tonnes of tailing per day.

## *In-pit Disposal and Backfilling*

As its name suggests, **in-pit disposal** is the process of placing tailing within mined-out open pits; the term **backfilling** is often used when tailing is pumped into underground mine works.

Advantages of these methods include stabilization of mined-out areas, reduction of above-ground disturbances, and cost savings for the mine's owner (versus those associated with building a conventional facility). However, in-pit disposal is only a viable alternative where scheduling, geological, and environmental conditions are suitable, and where mining pits have significant storage capacity with no additional resources below them.

Backfilling is not feasible at operations where cavities are mined throughout the project's life, as placing tailing over active caves creates an unacceptable health and safety risk.



## *Lake and Ocean Disposal*

**Lake and ocean disposal** strategies provide an effective way of managing acid-generating materials by submerging tailing in water to limit oxidation. Lake disposal, in particular, has been used or proposed for use at several mines in British Columbia, though this practice has recently been the subject of controversy, particularly when the proposed facilities were to be located on or near fish-bearing lakes.

## *Co-disposal*

**Co-disposal** is the practice of mixing tailing with mine rock in a single facility. The finer tailing materials fill in the void spaces between the coarser pieces of mine rock. The resulting material generally takes up less space than the two separate waste streams, and provides a relatively stable medium for the tailing. However, co-disposal may not be a feasible option in areas with topographical constraints.

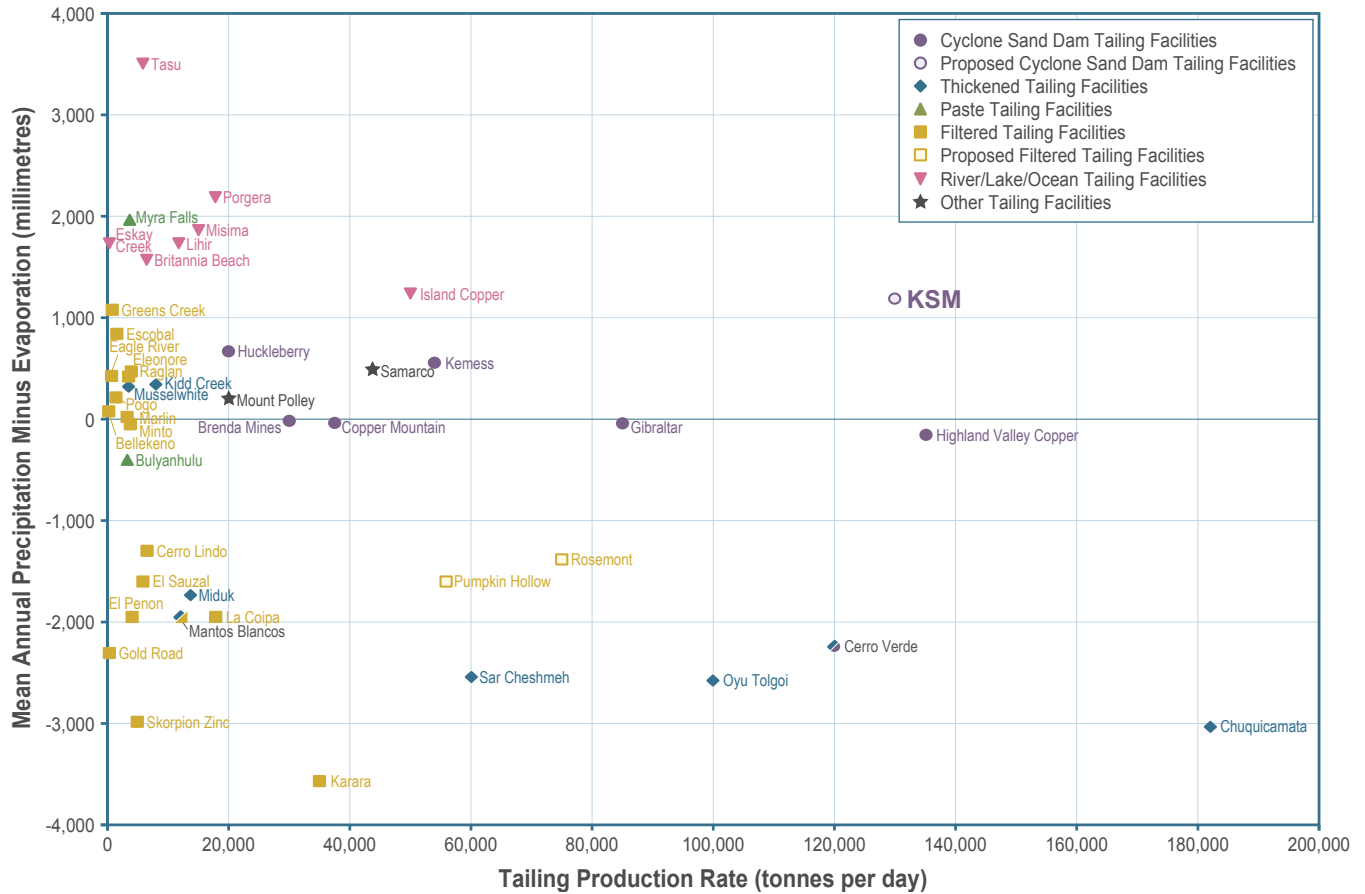
## *Tailing Technologies in Practice*

As noted in the above sections, two of the key factors in selecting suitable tailing technologies are (1) the climate in the mine's location, and (2) the tailing production rates involved. Figure 7 compares these two factors at operating and proposed mines around the world, together with the tailing strategies selected.





Figure 7. Precipitation versus tailing production at mines using different tailing technologies.



As noted previously, tailing production rates at filtered tailing projects in dry, arid climates range up to 20,000 tonnes per day. Additional filtered tailing projects in these climates have been proposed at production rates of up to 75,000 tonnes per day, but have not yet been built. A few operating facilities in wet, cold climates produce up to 4,000 tonnes per day using filtered tailing disposal methods, often with back-up storage for short periods during adverse weather conditions. No projects at the scale of the KSM Project (up to 130,000 tonnes per day) have used filtered tailing strategies in wet, cold environments.

The **Teigen-Treaty Cyclone Sand TMF** is located in a valley about 23 kilometres east of the proposed Mine Site. Surface waters in the valley drain both north- and south-ward, toward the Bell-Irving River via Teigen Creek and Treaty Creek, respectively.

Four cycloned tailing dams will be constructed roughly perpendicular to the valley sides, separating the TMF into three separate cells. The northern- and southern-most cells will hold non-acid generating material, and will flank a third, fully-lined cell holding acid-generating materials, including CIL residue. Non-acid generating tailing will be cycloned on the dam crests to produce sand to raise the dams to their ultimate elevation, and to construct long sand beaches in the two outer cells.

# Tailing Alternative Selection

Potential sites for an unthickened tailing facility using cyclone sand technology were explored in the Alternatives Study prepared as part of the Project's Application/EIS in 2013. The Teigen-Treaty Cyclone Sand TMF—described further in the sidebar and compared with other alternatives later in this section—was identified as the preferred location and tailing strategy in this study, and was approved in the provincial and federal regulatory reviews.

Sites that were highly ranked in the Alternatives Study, or had potential for tailing storage using one or more of the other technologies described previously in this summary, were revisited in the BAT study, as shown in Table 2.

Preliminary location screening of the sites found that Upper Unuk Valley, Tom Mackay Lake Terrace, South Unuk Valley, Ted Morris Creek Valley, Sulphurets Creek Valley, West Teigen Lake, and Knipple Lake were unsuitable for various reasons, including the need for deposition in a lake, insufficient capacity, and issues of accessibility.

The other six locations—Unuk Valley Terrace, McTagg Valley, Teigen-Treaty Valley, Upper Treaty Valley, Scott Creek Valley, and the KSM Rock Storage Facility—were carried forward to the critical flaw assessment.

*Table 2. TMF sites and technologies considered in 2013 Alternatives Study and current BAT study.*

Site Selection	Technology Selection									
	Cyclone Sand Tailing (Conventional Facility)	High Density Thickened Tailing	Paste Tailing	Filtered Tailing	In-pit Disposal	Backfilling	Lake Disposal	Ocean Disposal	Co-disposal	
Potential TMF Sites										
Unuk Valley	●	—	—	●	—	—	—	—	—	—
Unuk Valley Terrace	—	—	—	●	—	—	—	—	—	—
Tom Mackay Lake Terrace	—	—	—	●	—	—	—	—	—	—
South Unuk Valley	—	—	—	●	—	—	—	—	—	—
Ted Morris Valley	◇	—	—	●	—	—	—	—	—	—
McTagg Valley	◇	—	—	●	—	—	—	—	—	—
Sulphurets Creek Valley	◇	—	—	●	—	—	—	—	—	—
West Teigen Lake	●	—	—	●	—	—	—	—	—	—
Teigen-Treaty Valley	●	●	●	●	—	—	—	—	—	—
Upper Treaty Valley	●	—	—	●	—	—	—	—	—	—
Knipple Lake	◇	—	—	●	—	—	—	—	—	—
Bowser Lake	—	—	—	—	—	—	◇	—	—	—
Scott Creek Valley	●	—	—	●	—	—	—	—	—	—
Burroughs Bay	—	—	—	—	—	—	—	◇	—	—
KSM - Mitchell Pit	—	—	—	—	◇	—	—	—	—	—
KSM - Underground Mine	—	—	—	—	—	◇	—	—	—	—
KSM - Rock Storage Facilities	—	—	—	—	—	—	—	—	—	●

● Evaluated in the 2013 Alternatives Study - Preferred option.  
● Evaluated in the 2013 Alternatives Study - Feasible.  
◇ Evaluated in the 2013 Alternatives Study - Not feasible.  
● Evaluated in this BAT study.



## Critical Flaw Assessment

The potential for implementing the five remaining tailing technologies—unthickened, thickened, paste, filtered, and co-disposal—at six different locations was assessed, as shown in Table 3.

In the mountainous topography and wet climate of the Project area, thickened and paste tailing have requirements similar to conventional unthickened tailing. Therefore, sites that were





Table 3. Results of critical flaw assessment.

Site Selection	Technology Selection				
	Cyclone Sand Tailing (Conventional Facility)	High Density Thickened Tailing	Paste Tailing	Filtered Tailing	Co-disposal
Potential TMF Sites					
Unuk Valley Terrace				●	
McTagg Valley	●			●	
Teigen-Treaty Valley	●	●	◇	●	
Upper Treaty Valley				●	
Scott Creek Valley				●	
KSM - Rock Storage Facilities					◇

● Alternatives passed critical flaw assessment.  
 ◇ Alternatives did not pass critical flaw assessment.

deemed not suitable in the 2013 Alternatives Study were also considered not suitable for thickened or paste tailing methods. Alternatives were then screened for critical flaws in order to eliminate any options with identifiable deficiencies. A critical flaw was defined as “a flaw so unfavourable that it alone is sufficient to eliminate the option from further consideration in the context of the KSM Project.”

The potential for implementing paste disposal at Teigen-Treaty Valley was screened out due to the unacceptable risk of slope failure posed by the use of large paste slopes. It was also found that capacity at the Project’s Rock Storage Facilities is not sufficient to allow for co-disposal of tailing with waste rock.

## Preliminary Alternatives Screening

Following the critical flaw assessment, the remaining alternatives were screened for undesirable aspects that increase the risk of embankment failure, tailing release, environmental impact, or health and safety hazards, relative to other options. Where a site

had multiple feasible alternatives, the most favourable option was selected to advance to the next stage of analysis, provided the other alternatives did not have significant benefits over the selected option (Table 4).

*Table 4. Results of alternatives screening.*

Site Selection	Technology Selection		
	Cyclone Sand Tailing (Conventional Facility)	High Density Thickened Tailing	Filtered Tailing
Potential TMF Sites			
Unuk Valley Terrace	—	—	●
McTagg Valley	◇	—	◇
Teigen-Treaty Valley	●	◇	●
Upper Treaty Valley	—	—	●
Scott Creek Valley	—	—	●

● Potential preferred alternative.  
◇ Alternative not carried forward.

From this assessment, six preferred alternatives were identified; these alternatives are compared in Table 5, mapped in Figure 8, and summarized in the following sections.

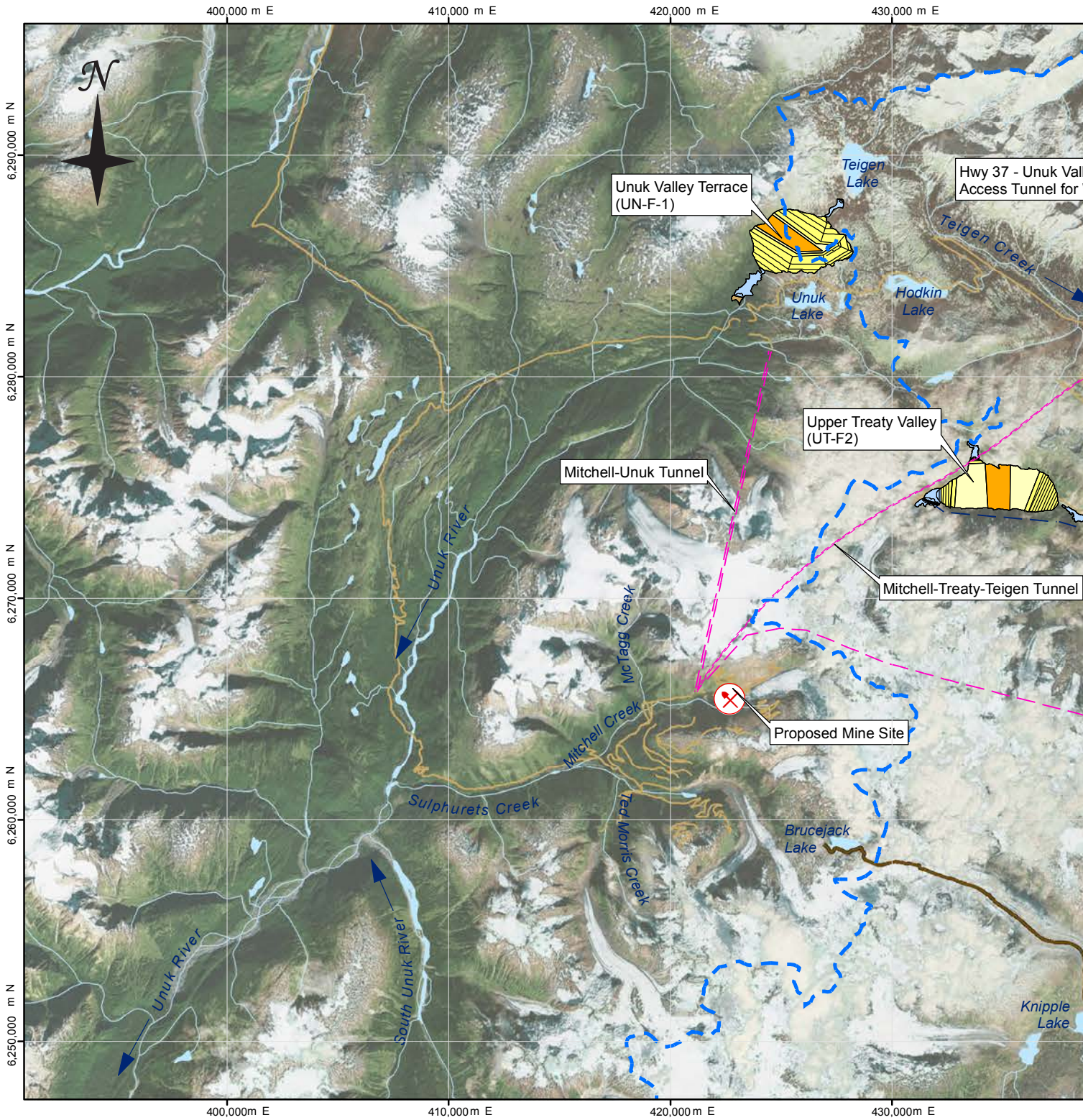
*Table 5. Comparison of TMF alternatives.*

Alternative Details	Teigen-Treaty Cyclone Sand TMF	Teigen-Treaty Filtered TMF (Options 1 and 2)	Upper Treaty Filtered TMF	Scott Creek Filtered TMF	Unuk Valley Terrace Filtered TMF
Tailing storage capacity (% of Project requirement)	100	100	100	100	100
Potential for expansion?	Yes	Yes	Yes	Yes	Yes
Embankment height (metres)	239	301	339	291	329
Floatation tailing structural fill (%)	12	32	27	27	73
Total catchment area (square kilometres)	60.7	37.9	114.8	76.9	28.6
Footprint area (square kilometres)	13.5	8.8	9.2	10.8	9.8





Figure 8. Map of tailing alternative locations and configurations.





# FINAL DRAFT

## Best Available Technology (BAT) Study for Tailing Management at the KSM Project: | 21 Plain Language Summary

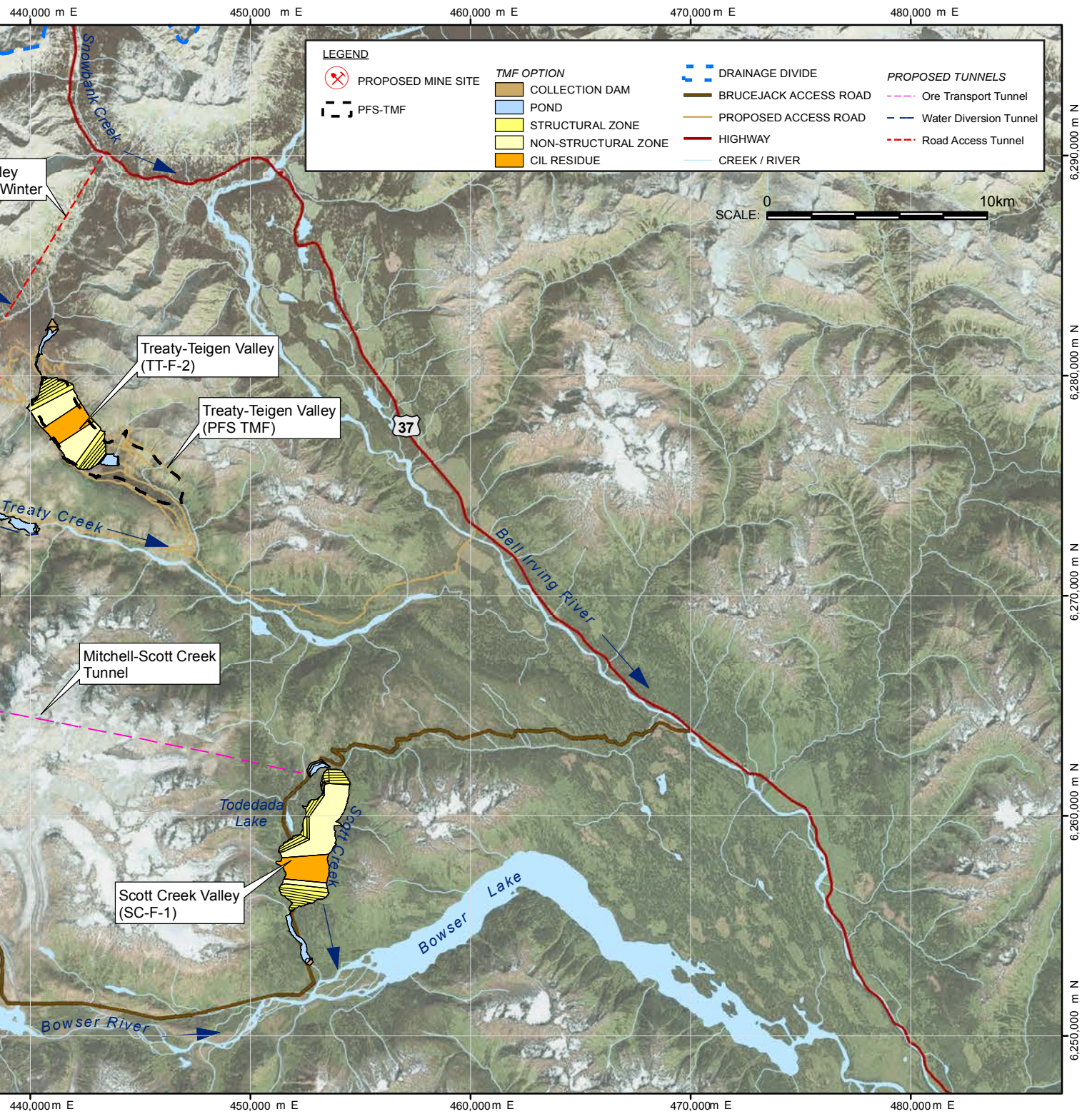
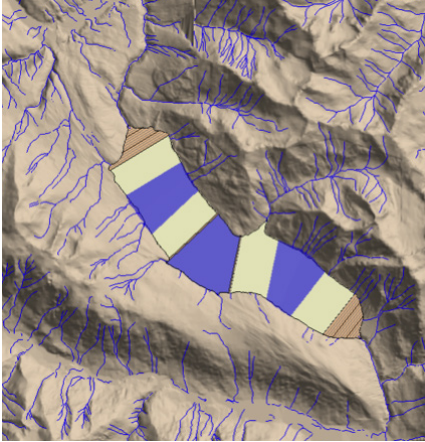




Figure 9. Teigen-Treaty Cyclone Sand TMF.



### Teigen-Treaty Cyclone Sand TMF

As mentioned previously, the Teigen-Treaty Cyclone Sand TMF (Figure 9) is the tailing design proposed and approved for the Project as part of the Application/EIS in 2013. The location for the facility is a long, wide, gently sloping valley with a small catchment, providing robust water management capabilities for managing flood flows.

The TMF design includes four till-core cyclone sand dams confining three tailing cells: a central lined cell for storing CIL residue underwater to reduce the potential for acid generation, and north and south cells for non-acid generating tailing. Flotation tailing will be cycloned on the dam crests to produce sand for dam construction. The cyclone sand dam will be compacted to meet seismic structural stability. The overflow will be deposited in the flotation cells from the dam to produce long beaches. For the first half of the mine life, the north and CIL cells will be used, with the north cell rising approximately twice as fast as the CIL cell. After the north cell reaches its design height, tailing will be deposited in the south cell. Water management will consist of perimeter diversions, a tunnel diverting the East Valley catchment north to Teigen Creek, and seepage recovery dams below the tailing dams to help recover and treat seepage water. During operations, surplus water will be discharged from the TMF on a schedule designed to mimic seasonal flows.

The TMF's stability does not rely on the structural strength of the impounded tailing; the required structural zones are limited to the cyclone sand dam fill, which are relatively free-draining and can be compacted using established techniques, even in a wet climate. A relatively small percent of the overall tailing facility is required to be structural, allowing engineering and quality control efforts to be focused in that area during good weather conditions. The design allows for CIL residue to be stored underwater in a lined impoundment to prevent acid generation

and limit seepage, both during operations and after mine closure. This TMF alternative also allows water flows downstream of the TMF to return to baseline conditions soon after closure.

Concerns associated with this alternative relate to sourcing materials to build the dam cores and the seepage and starter dams, as well as the requirement to store and seasonally release water from the TMF ponds.

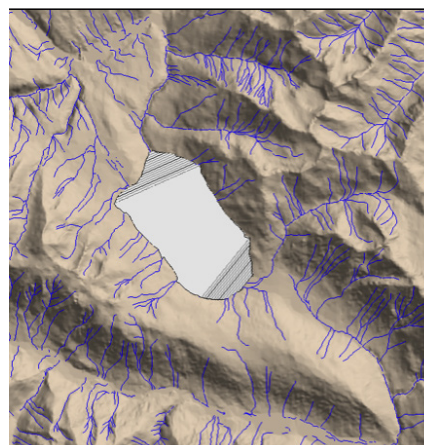
### Teigen-Treaty Filtered TMF (Options 1 and 2)

Two options for the Teigen-Treaty Filtered TMF (Figure 10) were considered; both have the same footprint and ultimate configuration. Option 1 includes filtering both the flotation tailing and the CIL residue. For Option 2, the CIL residue will be sent to the facility as thickened slurry, and the lined CIL residue cell will require a small reclaim pond with flood storage.

Advantages for the two options are similar. As mentioned above, the Teigen-Treaty location has a relatively small catchment, with no large, concentrated flows on the pile footprint. Confinement by the valley sides reduces the perimeter embankment requirements and allows for CIL residue to be contained within a central area of the pile. The valley sides in the pile footprint generally have more shallow slopes than other sites; this would permit perimeter diversions and access to be more easily established and maintained, and would also allow a liner to be installed beneath the CIL residue cell. The pile would have a regular, rectangular shape that could be deposited by conveyor using a less operationally complex and more reliable configuration than that required by other, irregularly shaped, filtered tailing options.

Significant concerns identified with this alternative relate to underdrainage requirements, stability, construction practicality, erosion of the high tailing slopes, and the large collection pond

Figure 10. Teigen-Treaty Filtered TMF (Options 1 and 2).

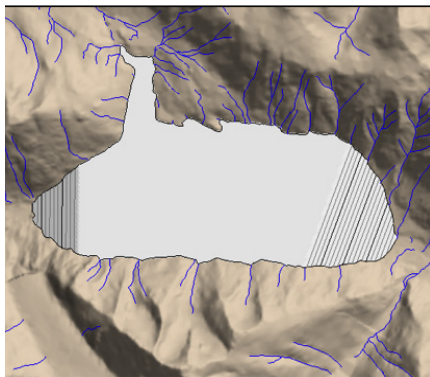




and 135 metre high collection dam that would be required to collect runoff from the pile.

### Upper Treaty Filtered TMF

Figure 11. Upper Treaty Filtered TMF.



Like the Teigen-Treaty site, the Upper Treaty Filtered TMF (Figure 11) is located in a long valley, though with much more steeply sloping sides. The proposed site drains north to Teigen Lake and Teigen Creek, and south to Treaty Creek. The large upstream glaciated catchments would be diverted through a series of tunnels, with diversions constructed on the valley sides to divert as much natural catchment as possible. Collection ditches would convey surface runoff from the TMF to the collection dams.

Provided that upstream flows could be diverted using the required nine kilometres of tunnels, the Upper Treaty Filtered TMF would also have a relatively small catchment. Confinement by the valley sides reduces the perimeter embankment requirements and would allow CIL residue to be contained within a central area of the pile. As with the previous tailing alternative, the regular, rectangular shape of the pile could be deposited using a less complex and more reliable configuration than what would be required for other, irregularly shaped, filtered tailing options. Mineralization in the area has already reduced water quality in Upper Treaty Creek, resulting in lower value aquatic habitat.

Nevertheless, this location and tailing strategy present several serious concerns in addition to those listed for the Teigen-Treaty site. Compared to the Teigen-Treaty location, the steep valley sides are more susceptible to avalanche. The valley sides would make constructing water diversion and collection channels more difficult. However, the biggest concerns relate to the diversion tunnels. Failure of the tunnels during operations would result in flooding upstream of the pile, potentially overtopping it if the

tunnels could not be repaired in time. On closure, the diversion tunnels could either be decommissioned or maintained. If the tunnels were decommissioned, a lake would form upstream of the TMF, impounding approximately 300 million cubic metres of water and potentially flooding the toe of the Treaty Glacier. The tailing pile would then essentially become a major dam, and surface runoff would flow in a channel on the tailing surface. While the tunnels could be maintained post-closure, it would not be practical to do this in perpetuity. Therefore, once water met discharge guidelines, a closure channel would be built over the tailing pile to a spillway. The tailing pile would again serve as a dam, impounding 300 million cubic metres of water in the upstream valleys below the level of the closure channel; in addition, both the channel and the spillway would require long-term maintenance. The necessity of impounding this volume of water would eliminate the benefit of adopting a filtered tailing strategy in the first place.

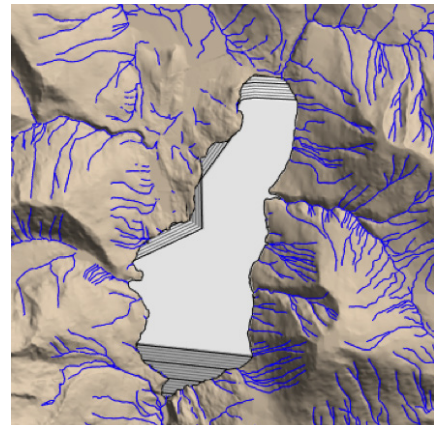
### Scott Creek Filtered TMF

The Scott Creek Filtered TMF (Figure 12) is located in another steeply sided valley, which drains primarily south to Bowser Lake via Scott Creek, but also partly north to Todedada Creek.

Access to the area is already established via the Brucejack Mine access road (although the road would require realignment). Confinement by the valley sides reduces the perimeter embankment requirements and allows for CIL residue to be contained within a central area of the pile.

However, in addition to the concerns noted for the Teigen-Treaty site, valuable aquatic habitat—including high value salmon habitat—exists both north and south of the Scott Creek site, and, like the Upper Treaty Filtered TMF, the steep valley sides are susceptible to avalanches. In addition, the irregular valley shape would make placement by conveyers challenging. A collection

Figure 12. Scott Creek Filtered TMF.

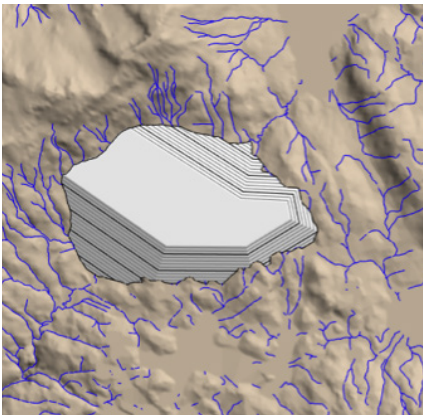


channel would be required to route runoff water from the north side of the TMF around Todedada Lake to a collection pond; failure of this channel could result in the water being released directly to the lake.

### Unuk Valley Terrace Filtered TMF

The Unuk Valley Terrace Filtered TMF (Figure 13) is located 17 kilometres north of the Mine Site, on the north side of the Unuk River. Unlike the other alternatives, the Unuk Valley Terrace Filtered TMF would be placed on a terrace rather than within a valley. As the topography is confined on only one side, larger volumes of compacted structural zones would be required on the three outer sides of the pile.

Figure 13. Unuk Valley Terrace Filtered TMF.



This site has the smallest catchment of the filtered alternatives, reducing water management requirements, and would have no large, concentrated flows into the pile footprint. Diversion channels would only be required on one side of the pile, reducing the need for closure diversion maintenance.

This alternative has several serious drawbacks, in addition to those listed for the Teigen-Treaty Filtered TMF. A high percentage of the overall tailing facility would need to be structural, necessitating much re-handling of materials and stringent maintenance during winter construction. A collection channel would be required to route runoff water from the pile to collection ponds, and failure of this channel could result in downstream releases to Unuk Lake, Hodkin Lake, and Teigen Lake. As the area's groundwater is unconfined, there would be a risk of uncontrolled seepage to the same three lakes. High precipitation in this area, relative to the Teigen-Treaty Valley site, makes water management more difficult, and has the potential to preclude the high levels of compaction required for construction of the outer embankments. Foundation conditions at the site are generally poor, leading to additional concerns about pile stability.



## *Multiple Accounts Analysis*

A **Multiple Accounts Analysis (MAA)** is a decision-making method used to identify the most suitable or advantageous alternative from a list of alternatives by weighing the relative advantages and disadvantages of each.

An MAA was completed in the 2013 Alternatives Study, and was updated as part of the BAT study to compare the five additional filtered TMF alternatives to the proposed Teigen-Treaty Cyclone Sand TMF, as well as to place greater emphasis on the risk associated with a potential TMF failure. The MAA considered factors (also called **accounts**) in five main categories: Environment, Risks and Potential Impacts, Socio-economic, Technical, and Project Economics.

The Environment Account considered each alternative's potential impacts to aquatic and terrestrial habitat, water quality and quantity, and fisheries. Alternatives with greater potential effects on these components—particularly ones with the potential to affect more pristine environments or vulnerable species—were considered less desirable.

The Risks and Potential Impacts Account compared how the consequence and likelihood of physical failures and risk of geochemical failures, as well as requirements for water storage and management, could differ between alternatives.

The Socio-economic Account gave preference to alternatives with lower potential to be in conflict with Aboriginal interests, commercial land uses, and archaeological sites, as well as greater employment benefits.

The Technical Account compared the logistics surrounding water management, containment structures, and other requirements over the various phases of the mine. Alternatives associated with





larger catchments, more complex structures, or more challenging process, transportation, and/or construction requirements were given lower rankings.

The Project Economics Account comprised the estimated cost of each alternative, giving preference to alternatives with lower overall costs.

Weightings were assigned to each account on a six-point scale, with 6 being the most significantly valued and 1 being the least. Table 6 presents the standard weighting assigned to each account.

*Table 6. Account weightings used in Multiple Accounts Analysis.*

Account	Standard Account Weighting (in descending order of significance)
Environment	6
Risks and Potential Impacts	4
Socio-economics	3
Technical	3
Project Economics	1.5

Evaluation and measurement criteria for these accounts were developed using the professional judgement of a multi-disciplinary team of relevant experts. The six alternatives were then scored according to these criteria, with the scores weighted as indicated above. The results were compared to determine the preferred TMF alternative, as shown in Table 7.

Table 7. Results of Multiple Accounts Analysis.

Account	Account Score (and Rank)					
	Teigen-Treaty Cyclone Sand TMF	Teigen-Treaty Filtered TMF Option 1	Teigen-Treaty Filtered TMF Option 2	Upper Treaty Filtered TMF	Scott Creek Filtered TMF	Unuk Valley Terrace Filtered TMF
Environment	144.6 (1)	97.5 (3)	102.4 (2)	95.7 (4)	92.6 (5)	83.7 (6)
Risks and Potential Impacts	104.4 (1)	72.9 (3)	76.9 (2)	70.9 (4)	69.2 (5)	68.4 (6)
Socio-economics	91.5 (1)	78.9 (2)	75.9 (3)	59.9 (5)	46.8 (6)	66.1 (4)
Technical	119.6 (1)	62.7 (3)	68.7 (2)	48.3 (6)	59.7 (4)	53.6 (5)
Project Economics	5.4 (1)	1.6 (3)	1.9 (2)	1.6 (3)	1.2 (5)	1.0 (6)
Account weighting	Total Score (and Rank)					
Equal account weighting	24.5 (1)	14.6 (3)	15.4 (2)	13.0 (4)	12.3 (5)	12.3 (5)
Standard account weighting	84.8 (1)	54.5 (3)	57.1 (2)	49.2 (4)	47.4 (5)	47.0 (6)
No Project Economics Account weighting	76.7 (1)	52.1 (3)	54.2 (2)	46.8 (4)	45.6 (5)	45.5 (6)
No Risks and Potential Impacts Account weighting	65.8 (1)	41.2 (3)	43.1 (2)	36.3 (4)	34.8 (5)	34.6 (6)

# Conclusions

The BAT study conducted for the KSM Project had three main conclusions, which are summarized below.

**Conclusion 1: The Teigen-Treaty site is the preferred TMF site.**

Based on the 2013 Alternatives Study and the BAT study, the Teigen-Treaty site is the most appropriate location for a tailing facility for the KSM Project. The other potential TMF locations have less desirable qualities: more geohazards, large upstream catchments, more high-value and sensitive fisheries and terrestrial habitat, less favourable storage to structural fill ratios, and less favourable foundation conditions and hydrogeological containment.





## **Conclusion 2: A filtered TMF is not practical for the KSM Project.**

The primary advantage of implementing filtered tailing technology at the Project is that water would not need to be impounded on the tailing surface. However, the climate of the Project area is not well-suited to this tailing method. In addition, the scale of the filter plant needed for a project of this size is unprecedented and would likely have major challenges achieving design targets. Any downtime at the filter plant would likely result in shutdown of mining operations. Processing, transporting, and placing the tailing (especially in winter conditions) would be very operationally difficult and impractical. The slopes of the tailing piles would have to be precisely contoured and constructed to preserve stability and assist with drainage. Protecting the tailing piles during periods of heavy rain would be difficult; water that collects and ponds during these periods would increase the risk of facility failure. A large external water storage facility would be needed to collect and manage runoff and seepage water.

A filtered TMF would prevent CIL residue from being deposited underwater, and would therefore generate acid. Surface runoff and seepage would impact water quality and require perpetual management long after mine closure.

For these reasons, all of the filtered alternatives scored well below the Teigen-Treaty Cyclone Sand TMF in the MAA's Technical and Environment Accounts.

## **Conclusion 3. The Teigen-Treaty Cyclone Sand TMF is the preferred management strategy for the KSM Project tailing.**

Based on the foregoing, the Teigen-Treaty Cyclone Sand TMF was selected as the best available technology for tailing

management at the Project. The Teigen-Treaty Cyclone Sand TMF scored the highest for every account in the MAA.

The robust and resilient design of this alternative is backed by a proven technology, minimizing potential impacts to water quality and fish habitat, failure risks, and project costs, while maximizing technical feasibility and socio-economic benefits.

The tailing technology selected provides both chemical and physical stability after Project closure, allowing the site to return to its baseline conditions. The design is also the most technically feasible to construct, operate and close in a safe manner, and has the fewest associated socio-economic concerns.

## Key BAT Features of the Selected Alternative

The Teigen-Treaty Cyclone Sand TMF alternative was selected as having the preferred combination of location and tailing technology.

The location—at the catchment divide between Teigen and Treaty Creek—minimizes the upstream catchment area. The site provides good, stable geological and foundation conditions, with relatively few geohazards. There is no high value fish habitat within the TMF footprint.

The technology of cyclone sand dams is well-understood and has more than half a century of precedent. Such dams are simpler to raise than other types of dams, minimizing the risk of human error, and are less prone to failures caused by internal seepage erosion. While impounding water increases the consequence of hypothetical failure, the design of the TMF, including the positioning of long sand beaches in the north and south cells, decreases the likelihood of a catastrophic release of water, were such a failure to occur. Potentially acid-generating materials, such as CIL residue, will be kept below water in the lined central cell to limit seepage and oxidation. On closure, the site will return to flow patterns similar to pre-mine conditions.

