Post-Mount Polley Tailings Dam Safety in Transboundary British Columbia

March 2016

On behalf of Earthworks, Rivers Without Borders, MiningWatch Canada Southeast Alaska Conservation Council, Inland Passage Waterkeepers, Friends of the Stikine Society, David Suzuki Foundation, Sierra Club BC, Pacific Wild, Skeena Wild, Watershed Watch Salmon Society, Canadian Parks and Wilderness Society, Clayoquot Action, and the Wilderness Commitee

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Background

Alaskans, like their British Columbia neighbors, were shaken by the failure of the tailings dam at the Mount Polley mine on August 4, 2014. The dam collapse sent 24 million cubic meters of mining waste into a stream below the operation, virtually bulldozing the stream from 5 meters to 100 meters in width, and depositing most of the waste into Quesnel Lake, a large salmon spawning glacial lake in the watershed below the tailings dam.

Mount Polley tailings dam failure.

This was a dam that shouldn't have failed. This was a modern dam engineered and supervised by reputable engineering companies, operated by a respected mining company, and regulated by an experienced, developed-country regulatory agency. In fact, some said (prior to Mount Polley) that a dam with these characteristics could not fail.

The tailings dam failure is the largest mine waste spill in Canadian history.[1] Alaskans are concerned that a similar failure might occur at a similar mine in the transboundary region.

Transboundary watersheds are those that originate in British Columbia, but terminate in coastal Alaska. The concern for Alaskans is that such a failure in a transboundary watershed could physically destroy, and chemically impact, spawning and rearing habitat in both BC and Alaska that is critical to commercial, recreational, sport, and subsistence fishing. Billions of dollars in fisheries, cultural heritage, and a way of life in Southeast Alaska literally depend on the fish that come from these watersheds.[2]

> "It is my goal that BC's regulatory regime for health and safety on mine sites is the best in the world and we will get there by implementing all of the recommendations of the Independent expert panel and the chief inspector of mines."
>
> — Bill Bennett, BC Mines Minister, February 2016.

This area of western British Columbia is called the Golden Triangle because of the all of the gold and copper mineralization that has been discovered. Within the Golden Triangle transboundary area there have been/are gold mines, lead-zinc-gold-silver mines, and now large copper porphyry mines. These large, low-grade, mines create a tremendous amount of waste, typically billions of tons, largely because of the low grades of minerals involved.

The concern for future tailings dam failures is warranted. On a global level, recent research has determined that the rate and severity of serious tailings dam failures has increased.[3] It predicts additional failures generated by the use of larger and higher tailings dams to accommodate the waste generated by mining increasingly lower grade deposits. Thus, the increase in tailings dam failures is propelled by modern mining practices.

The Mount Polley expert panel, created by the B.C. government to investigate the Mount Polley tailings dam failure, predicted that an estimated 2 additional tailings dam failures could occur every 10 years in British Columbia alone -- if mine waste disposal practices continue as usual (Expert Panel, 2015, p. 118). The panel of experts issued a series of recommendations to the BC government to reduce the risk of catastrophic failure. BC Mines Minister, Bill Bennett, has pledged that he will implement all recommendations from the Expert Panel: "It is my goal that BC's regulatory regime for health and safety on mine sites is the best in the world and we will get there by implementing all of the recommendations of the independent expert panel and the chief inspector of mines."[4] To date, a core recommendation of the Mount Polley expert panel, which urges a policy shift from wet tailings to dry tailings after mine closure, has not been adopted.
This report assesses the tailings dam designs at four mines in B.C. in light of the recommendations of the Mount Polley Expert Panel to examine whether regulatory agencies are applying best available technology to reduce the risk of catastrophic tailings dam failures, and where they aren't, if changes could be made to do so.

Mount Polley Expert Panel Recommendations for Tailings Storage Facilities

A major advancement that came out of the Mount Polley disaster was the analysis and recommendations of the Mount Polley Expert Panel (Expert Panel, 2015). Following the breach of the tailings storage facility at Mount Polley, the British Columbia Ministry of Energy and Mines, the Williams Lake Indian Band, and the Soda Creek Indian Band, established an independent expert investigation and review panel (the Expert Panel) to investigate and report on that breach. Among the charges to the Expert Panel was to identify any changes that could be considered to reduce the potential for future such occurrences.

In its recommendations the Expert Panel said:

> "The goal of BAT ***(Best Available Technology)*** for tailings management is to assure physical stability of the tailings deposit. This is achieved by preventing release of impoundment contents, ***independent of the integrity of any containment structures***. In accomplishing this objective, BAT has three components that derive from first principles of soil mechanics:
>
> - Eliminate surface water from the impoundment.
> - Promote unsaturated conditions in the tailings with drainage provisions.
> - Achieve dilatant conditions[5] throughout the tailings deposit by compaction." (Expert Panel, 2015, p. 121)

In terms of how to apply BAT, the Panel made the following recommendations:

> "Implementation of BAT is best carried out using a phased approach that applies differently to tailings impoundments in various stages of their life cycle.
>
> - For existing tailings impoundments: Constructing filtered tailings facilities on existing conventional impoundments poses several technical hurdles. Chief among them is undrained shear failure in the underlying saturated tailings, similar to what caused the Mount Polley incident. Attempting to retrofit existing conventional tailings impoundments is therefore not recommended, with reliance instead on best practices during their remaining active life.[6]
> - For new tailings facilities: BAT should be actively encouraged for new tailings facilities at existing and proposed mines. Safety attributes should be evaluated separately from economic considerations, and cost should not be the determining factor.
> - For closure: BAT principles should be applied to closure of active impoundments so that they are progressively removed from the inventory by attrition. Where applicable, alternatives to water covers should be aggressively pursued." (Expert Panel, 2015, p. 125)

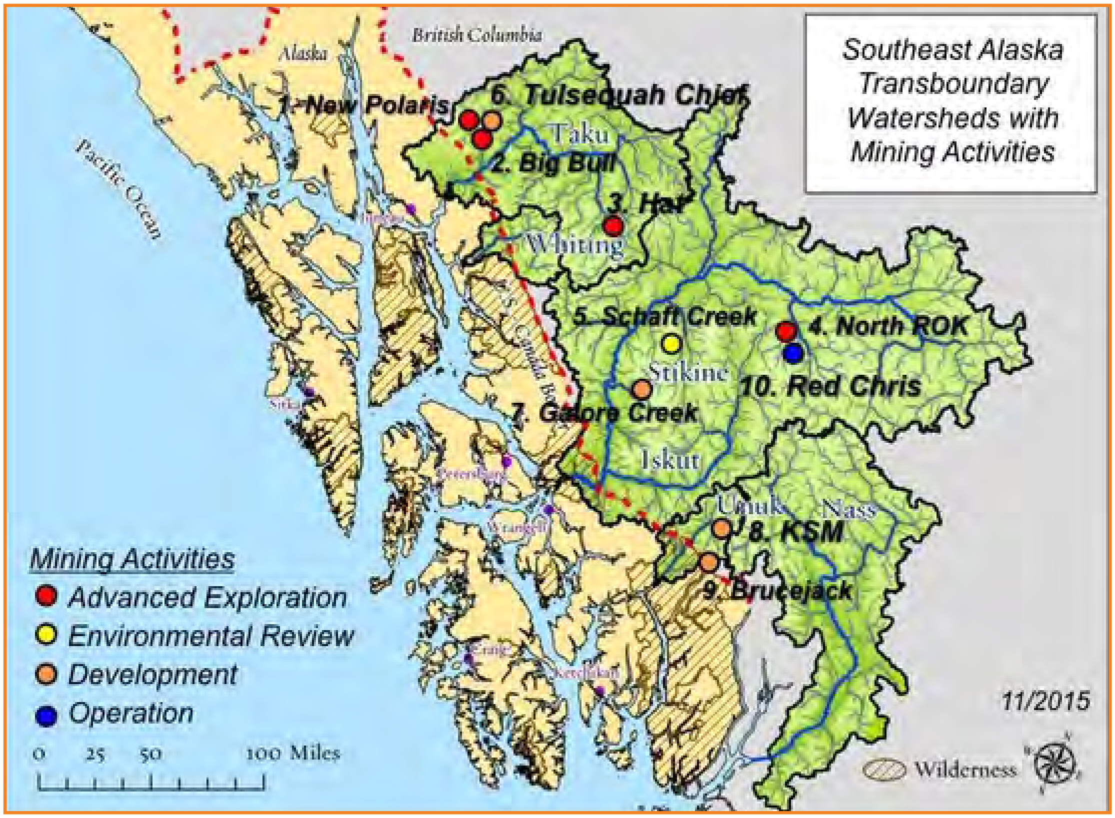

Figure 1. Transboundary Mine Locations

Transboundary Copper Porphyry Mines

In late 2014 the Red Chris copper-gold mine became the first porphyry mine to operate in the transboundary region. In addition to Red Chris, there are already three large copper-gold projects being proposed that are very similar to Mount Polley, including the planned tailings dam design. The projects, Red Chris, Schaft Creek, KSM, and Galore Creek, are all larger than Mount Polley in terms of production and the amount of waste that would be generated. Unlike Mount Polley, much of the waste in these transboundary projects will be potentially acid generating. This would make the waste from these projects much more toxic than that released at Mount Polley, so a Mount Polley-type failure could have more severe short and long-term effects.

	Mine Ore Production Rate (tpd)	Tailings Dam Type	Tallest Tailings Dam Height (meters)	Primary Construction Material	Closure	Total TSF Storage Volume (Mm3)	Closure Earthquake Event (one-in yr)	Closure Hydrology Event	Closure Spillway
Transboundary Mines									
KSM	130,000	CL	239	cycloned sand	Wet	1,213	1/10,000	PMF	yes
Galore Creek	95,000	CL	165	cycloned sand	Wet	424	1/10,000	PMF	yes
Red Chris	30,000	CL	105	cycloned sand	Wet	305	1/10,000	PMF	yes
Schaft Creek	130,000	CL	140	mine rock	Wet	588	1/5,000	PMF	yes
Related BC Mines									
Mt Polley	20,000	CL	40	mine rock	Wet	44	50% of MCE	PMF	yes

CL= Centerline-type dam construction (safer than upstream-type but not as safe as downstream-type)
DS = Downstream-type dam construction (safest type)
MCE = Maximum Credible Earthquake = 1/10,000 year event
PMF = Probable Maximum Flood

Table 1 – Transboundary and Related BC Copper Porphyry Mine TSF Summary

The basic characteristics of the Tailings Storage Facilities (TSFs) for the 4 large transboundary mining projects are summarized in Table 1. The critical factors, from the perspective of potential for catastrophic failure at some point between the operation stage and 10,000 years[7] in the future, are:

- Dam height – the higher the dam the larger the potential for tailings release during a failure;
- TSF capacity – like dam height, the larger the TSF capacity, the greater the potential for tailings release during a failure;
- TSF construction design – there are three types of dam construction design: (1) upstream, the least safe; (2) downstream, the safest; and, (3) centerline, safer than upstream, but not as safe as downstream (see Figure 2 for illustrations of these construction methods);
- TSF design criteria – has the dam been designed to survive the largest earthquake or flood it could experience during its design life; and,
- TSF closure design – will the tailings be saturated or drained after closure? The Expert Panel recommends drained tailings. TSFs with lakes on top after closure pose the greatest risk for catastrophic damage if a dam failure were to occur.

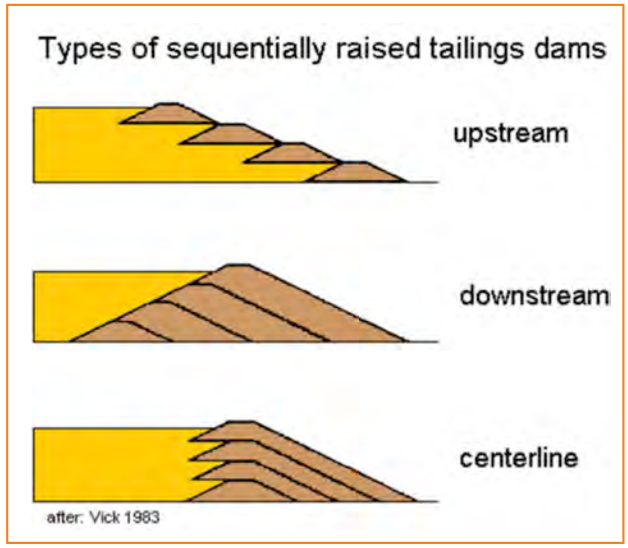

Figure 2 – Tailings Dam Construction Types: (a) Upstream, (b) Downstream, (c) Centerline

KSM (Kerr-Sulphurets-Mitchell)

KSM is large copper-gold porphyry, and if developed would probably be the largest mine in British Columbia. KSM contains mineral reserves that are planned for both open pit and underground mining.

The tailings impoundment would require two large dams, the tallest would be 6 times as high as the failed Mount Polley dam, and would contain 28 times the amount of tailings (see Figure 3). In the middle of the main impoundment would be a smaller, lined repository for the high-sulfide tailings from the final concentrator circuit (see Figure 4). The TSF is planned for a wet closure (saturated tailings) to inhibit acid generation (see Figure 5).

An Environmental Assessment Application was submitted to the provincial and federal regulatory authorities in early 2013 and received final approval from the Canadian Federal Government in December, 2014, after having received approval from the Province of British Columbia in July, 2014. However, construction has not been started, nor has a start date been identified. Financing is still needed for this project. The proposed tailings dams are centerline-type construction, like that at Mount Polley, and a wet closure is planned for the potentially acid generating tailings (KSM, 2013).

Does this design meet the recommendations of the Expert Panel? No. The primary problem is that this design incorporates a wet closure, with active ponding of water on top of the tailings that will keep them permanently saturated. Permanent saturation, while providing the best approach for the prevention of acid mine drainage, also means that the tailings are vulnerable to mobilization if there is a dam failure.

Can this design be altered to meet the recommendation of the Expert Panel? Yes. The BAT Expert Panel recommendation can be met if the North and South impoundments of non-acid generating tailings were drained to provide long-term stability, even if the central sulfide residue cell were left permanently saturated in order to inhibit acid generation, the

North and South drained impoundments would provide sufficient long-term protection for the saturated residue impoundment to meet the requirements of the Expert Panel.

Construction on this mine is still in the indefinite future. There is still time for design changes to the TSF that could incorporate drainage for the non-acid generating impoundments that would be very easy from a technical and cost perspective. However, at present there have been no public discussions about this possibility.

Red Chris

This is the first project issued a permit by British Columbia to operate post-Mount Polley.[8] The ore body is a copper porphyry, and the operating company is the same company that owns the Mount Polley mine. The tailings dam is the same design as that at Mount Polley (Imperial Metals, 2012).

The TSF is centerline-type dam (see Figure 6), like Mount Polley, but at 105 meters (BGC, 2014) will be approximately 3 times as tall, impounding 7 times the tailings. The TSF is planned for a wet closure, with an active pond of water on top (see Figure 7).

Does this design meet the recommendations of the Expert Panel? No. The large dam with undrained tailings does not meet the recommendation of the Expert Panel.

Can this design be altered to meet the recommendation of the Expert Panel? No. This mine was allowed to start operation even though it was clear that this dam was of the same design and operated by the same company as the dam that failed at Mount Polley. The Province could have delayed the start of mine operation until a thorough review of the dam design and Expert Panel recommendations could be implemented, but this delay would probably have bankrupted the company. This was clearly a case of economic considerations, instead of safety consideration, driving a policy decision.

If safety were the primary consideration (another recommendation of the Expert Panel), a drain system could have been retrofitted for the impoundment. If the mine and operating company were of significant importance to the province, which the decision to issue the operating permit strongly suggests, then the province could have provided enough funding, perhaps through loans, to keep the company solvent while the necessary changes to provide long-term safety were implemented. The decision to issue the operating permit for Red Chris was clearly a case of economic considerations prevailing over safety consideration in driving a policy decision.

Schaft Creek

Schaft Creek is a copper/gold/molybdenum/silver porphyry mining project. Located in the upper regions of Schaft Creek, it ultimately drains into the Stikine River, on the eastern edge of the Boundary Range of the Coast Mountains in northwestern BC. The mining rate would nominally be 130,000 tons/day, making it one of the largest mines in BC, roughly the same as KSM, but with smaller mineral reserves. This project is still undergoing advanced exploration, although a formal feasibility study, which is generally the last step before an EIS review, has been published (Copper Fox, 2013).

The tailings dam would, like the others in the transboundary region, be a centerline-type dam, with a height of 140 meters. The tailings impoundment is planned for a wet closure (see Figure 8).

Does this design meet the recommendations of the Expert Panel? No. The dam with undrained tailings does not meet the recommendation of the Expert Panel. And, unlike the other projects reviewed, the dam is not designed to withstand the maximum credible earthquake (1/10,000-year seismic event), but only the 1/5,000-year event.

Can this design be altered to meet the recommendation of the Expert Panel? Yes. This project is still in the design stage. The plan for a wet closure can be changed to incorporate drains that would allow a dry closure. The dam design can also easily be upgraded to withstand the maximum credible earthquake.

Galore Creek

The proposed Galore Creek copper-gold-silver mining project lies in a remote and rugged area of the Coast Range Mountains in northwestern British Columbia, Canada. According to the current plan, the site is located within Tahltan Traditional Territory and near the communities of Dease Lake, Iskut and Telegraph Creek. A NovaGold-Tahltan Participation Agreement was ratified by the Tahltan Nation and signed on February 10, 2006 (NovaGold, 2006).

The Galore Creek Project received its Environmental Assessment (EA) approval in February 2007. The Project's first permits were obtained in May 2007 and in June 2007, and the project received final Federal approval for the Project as envisaged in the 2007 EA (NovaGold, 2011).

The Project is currently not accessible by road. An access road is planned to the proposed mine site, but will require the drilling of twin access tunnels for the road of 13.6 km each in length. Road construction had begun in mid-2007, but the project ran into significant timing and cost overruns and was terminated in late 2007.

The tailings impoundment at the Galore Creek project would require a large centerline-type dam, 165 meters in height. This impoundment would hold 424 million cubic meters of tailings, almost 10 times that in the Mount Polley impoundment (see Figure 9). Like the other large mines proposed for the transboundary area, the tailings impoundment is planned for a wet closure, in large part related to acid generating material it would contain.

Does this design meet the recommendations of the Expert Panel? No. The dam with undrained tailings does not meet the recommendation of the Expert Panel.

Can this design be altered to meet the recommendation of the Expert Panel? Yes. The plan for a wet closure can be changed to incorporate drains that would allow a dry closure.

Comparisons

The proposed mines, unsurprisingly, are larger than most of the existing mines in BC. The trend for new mines that exploit low grade ore bodies will always be toward larger mines. Larger mines mean larger waste storage facilities, and the tailings dams associated with the newer mines require larger tailings dams.

None of the four mines analyzed in the report fully meet the recommendations of the expert panel, particularly the mines in the transboundary region between BC and Alaska. All four of the transboundary mines propose to use wet tailings, rather than dry tailings at closure (see Table 2). And, all four of these mines propose to use the centerline style tailings dam design used at the Mount Polley dam, rather than the safer downstream tailings dam design.

	KSM	Red Chris	Schaft Creek	Galore Creek
Does this design meet the recommendations of the Expert Panel?	No - wet closure	No - wet closure	No - wet closure & earthquake safety	No - wet closure
Can this design be altered to meet the recommendation of the Expert Panel?	Yes	No	Yes	Yes

Table 2 – Transboundary and Related BC Copper Porphyry Mine TSF Summary

For the three large mines in the transboundary region that are still unconstructed there is still ample opportunity to conduct such an analysis, and to implement best practices. However, it is not clear that this will happen voluntarily, or that regulators will require such an analysis. And, given the example of the rapid mine approval for the Red Chris Project after the Mount Polley accident, it is not clear that the regulatory agencies in BC will require best practices of these and any future mine proposals[9] in the transboundary region.

None of the five mines analyzed in the report fully meet the recommendations of the expert panel, particularly the mines in the transboundary region between BC and Alaska.

Most of the tailings dams are designed to withstand the Maximum Credible Earthquake (MCE). The Mount Polley dam was designed for approximately ½ the MCE, as would the Schaft Creek dam. Not requiring use of the MCE as the design criteria is clearly not utilizing Best Available Technology.

All of the dams are designed to withstand the probable maximum flood (although the Mount Polley dam was also designed to hold this event, but the impoundment was full of water at the time it failed). All of the dams will have a spillway to permit water to pass over the closed impoundment.

Conclusion

A comparison of the tailings dam facilities at four BC mines with the Mount Polley expert panel recommendations, demonstrates that:

- All four of these tailings dams involve substantially taller tailings dams (2-6 times the height) storing significantly greater volumes of mine waste tailings (6-27 times the volume) than the Mount Polley tailings dam that failed.
- None of these four mines meet the recommendations of the Mount Polley expert panel to reduce the risk of tailings dam failure and prioritize public safety.
- All four mines plan to use same technologies that failed at Mount Polley: wet tailings at closure, rather than the dry tailings at closure recommended by the panel, and the centerline tailings dam design, rather than the safer downstream design.
- With the exception of the Red Chris Mine, which is already operating, there is still ample time to make changes at all four of the others mines to conform to best practices to better protect public safety and downstream resources.

Recommendations

The one existing and three proposed porphyry copper mines in the transboundary region are all of similar design to the Mount Polley dam that failed, but all are much larger and each will impound many times more tailings than Mount Polley. Unlike the Mount Polley Mine, these transboundary mines are largely acid-generating, so the ecological consequences are significantly greater. These projects as currently designed are not employing best available technology for their proposed tailings impoundments as it is understood after the Mount Polley failure. While there is still ample time to change these mine proposals to conform to best practices, it is not clear that will happen. Meanwhile, downstream stakeholders in BC and Alaska bear considerable long-term risk. To better protect public safety and downstream stakeholders, the following measures should be implemented:

- The recommendations of the Mount Polley expert panel should be formally adopted by BC regulators and implemented at the four mines that are not operational - KSM, Galore Creek, and Schaft Creek, and all future mines that are proposed for the transboundary region.
- For existing tailings dams, safety should be enhanced by requiring strict adherence to best practices.
- Prioritizing safety in all aspects of dam site assessment, design and construction should be the primary focus of government regulators. The economic considerations of abiding by safety-first standards should not be a part of the project approval process.

Figures

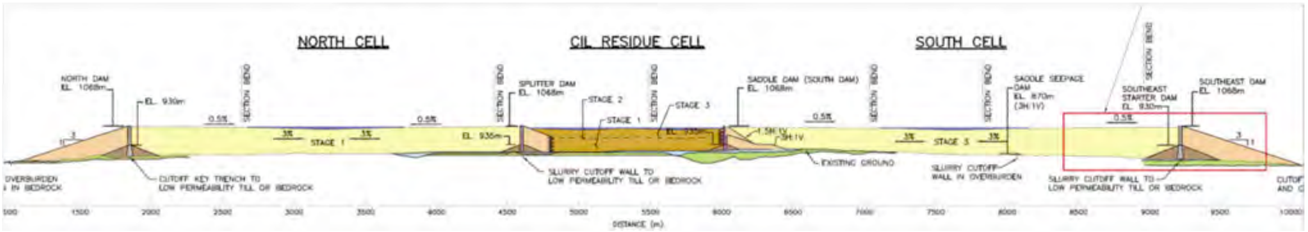

Figure 3 — KSM Tailings Impoundment Longitudinal Cross Section

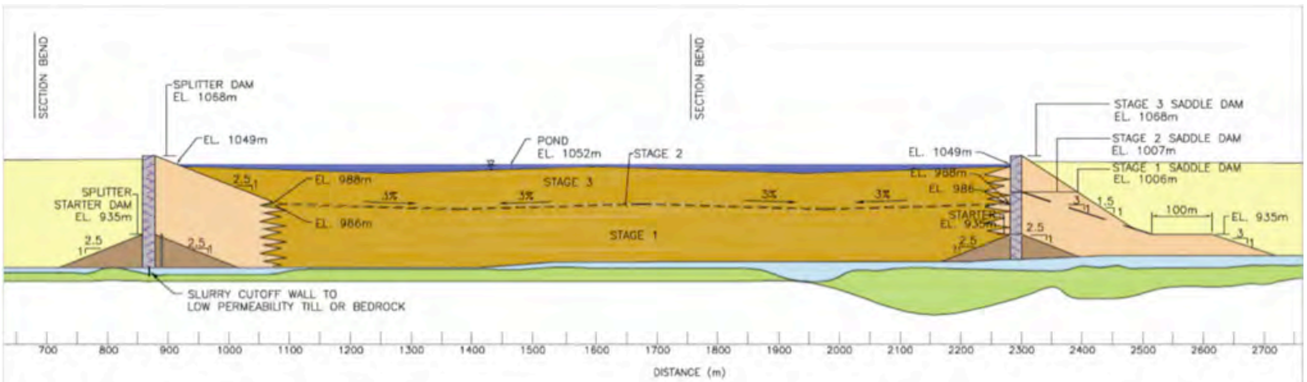

Figure 4 — KSM Lined Sulfide Residue Cell Cross Section

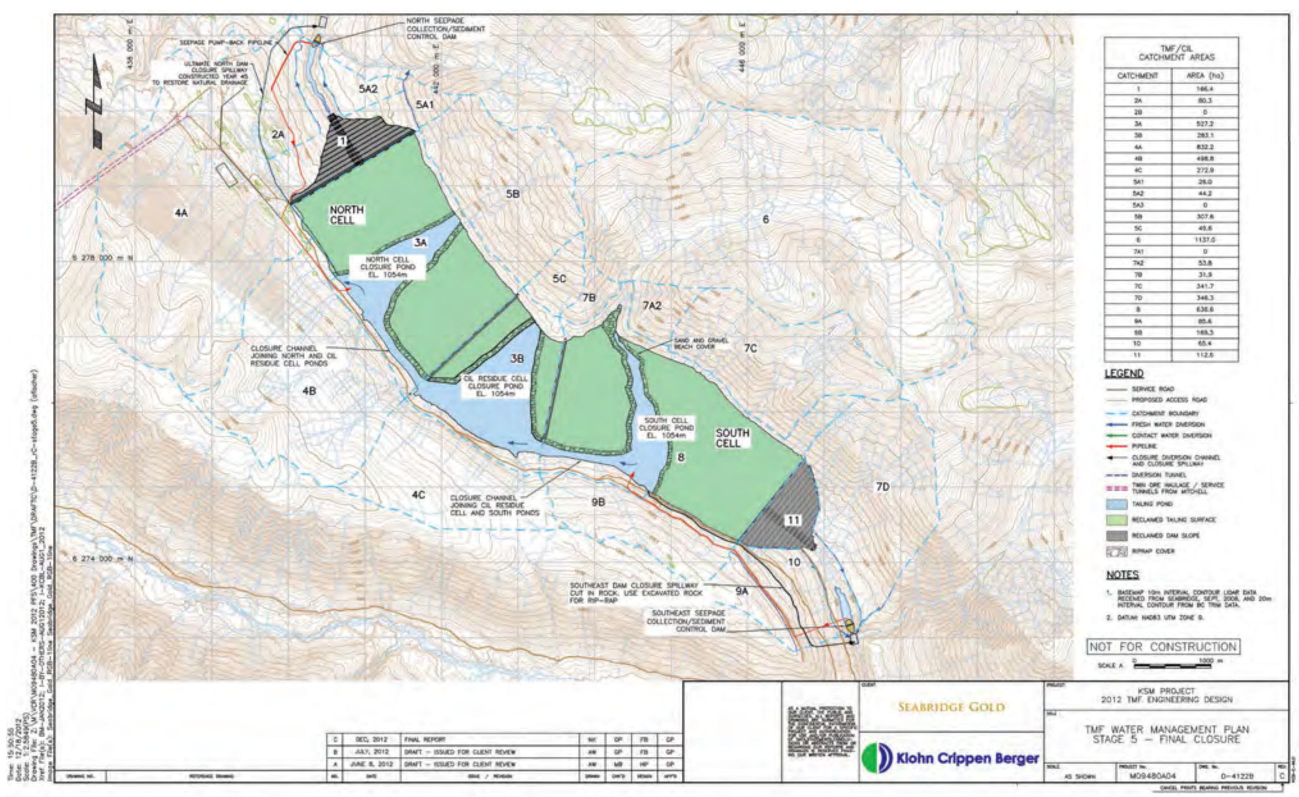

Figure 5 — KSM Final Closure Configuration

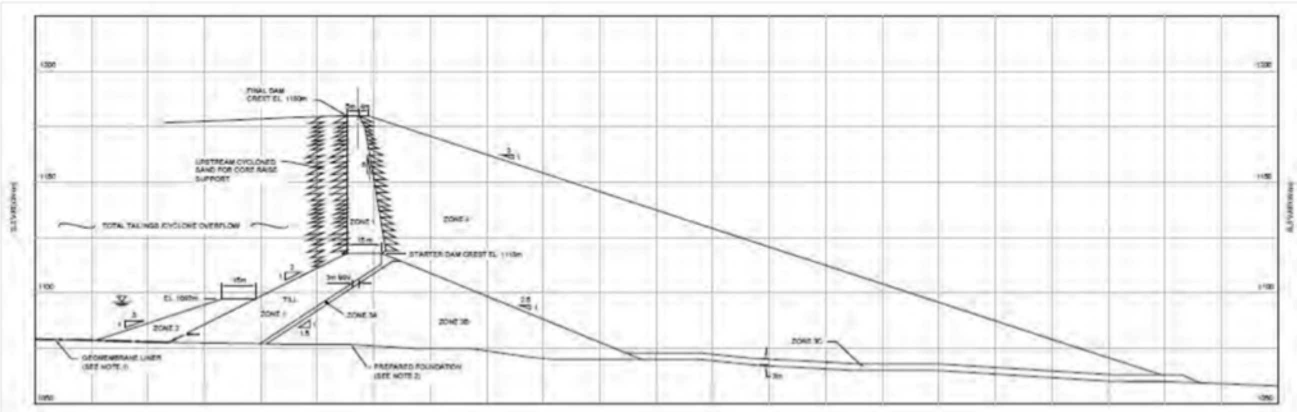

Figure 6 — Red Chris Centerline Tailings Dam Cross Section

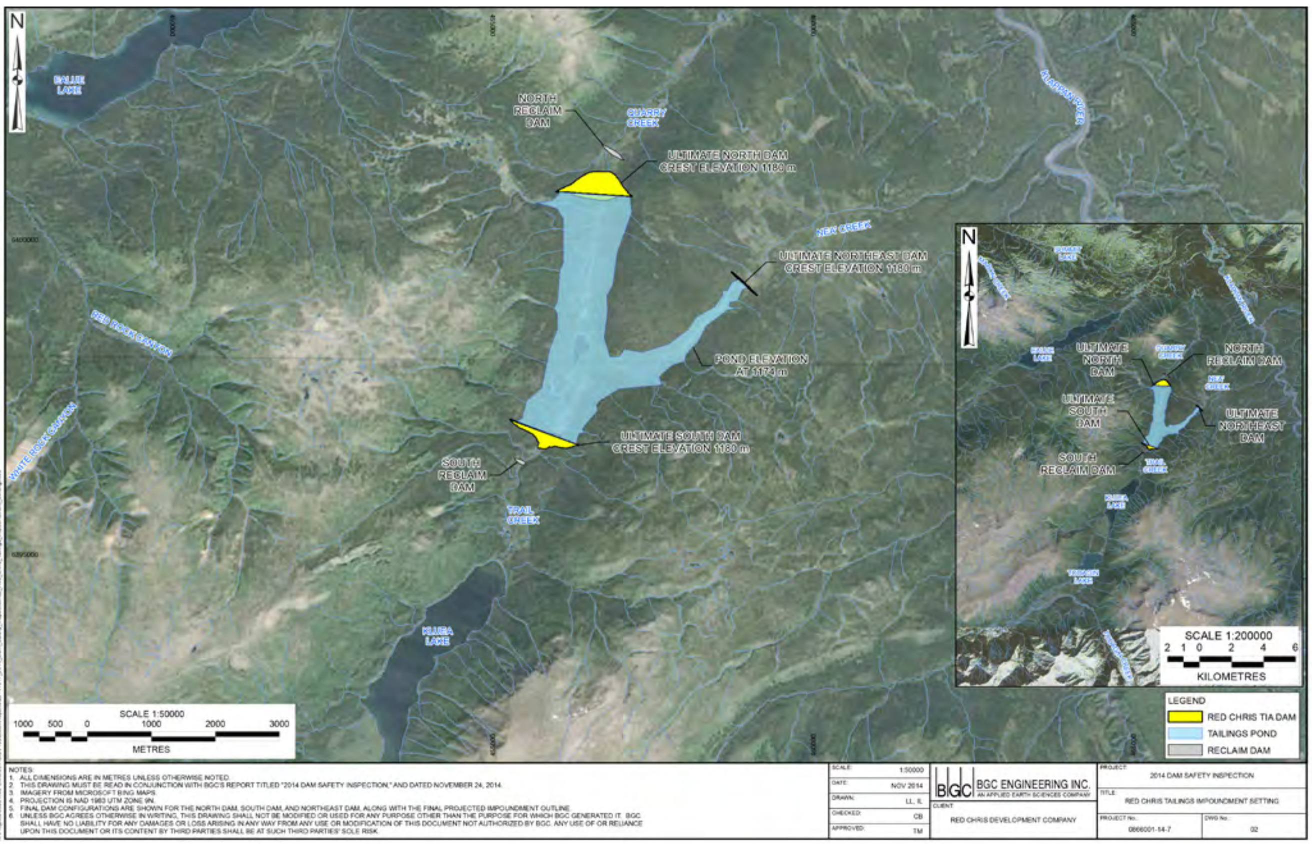

Figure 7 — Red Chris Tailings Storage Facility

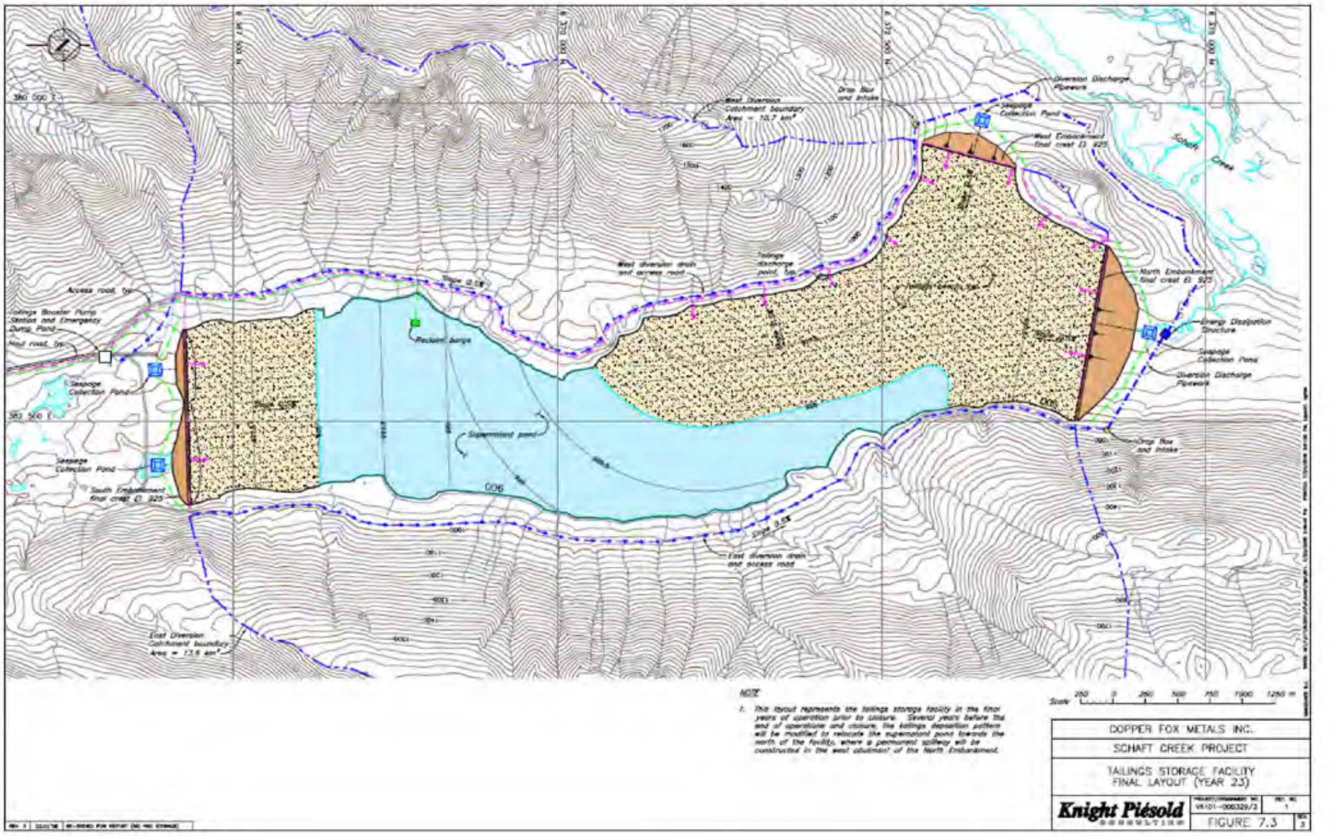

Figure 8 — Shaft Creek TSF at Closure

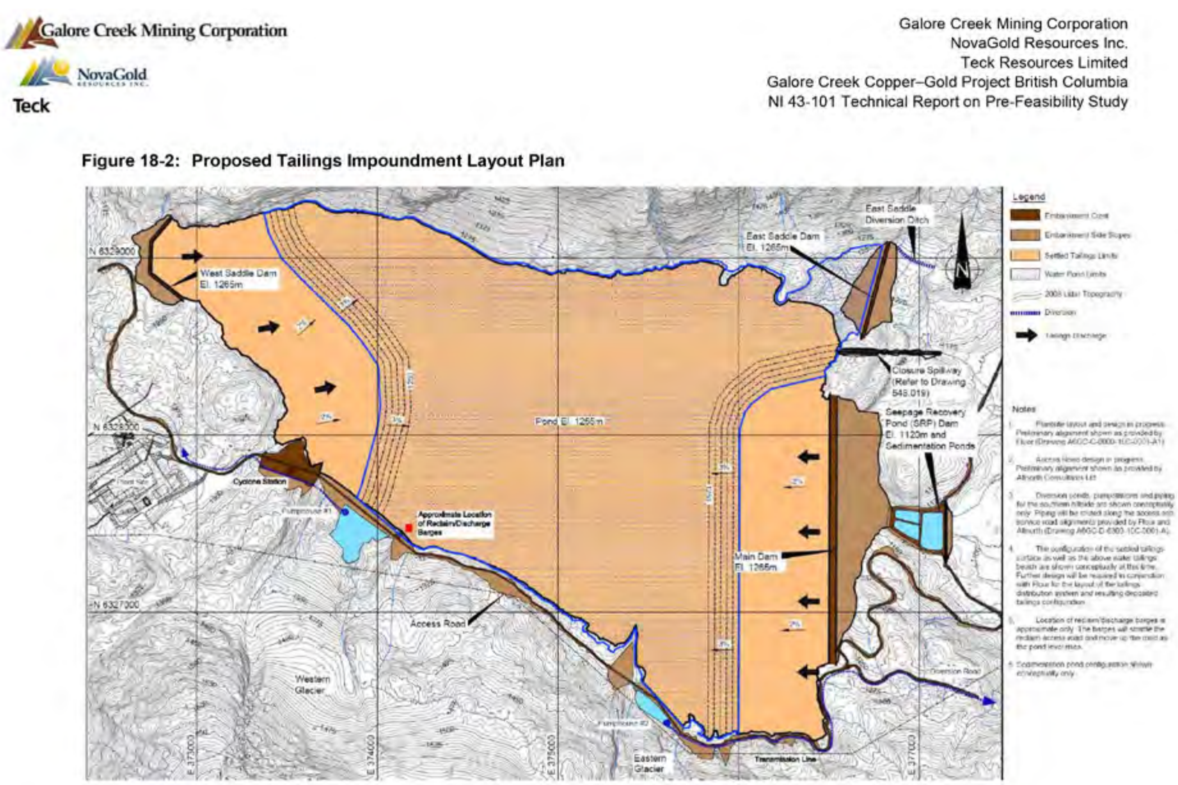

Figure 9 — Galore Creek Proposed Tailings Impoundment Layout

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ENDNOTES

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3 Bowker, Lindsey Newland and Chambers David M., "The Risk, Public Liability and Economics of Storage Tailings Facility Failures, July 21, 2015. http://csp2.org/files/reports/Bowker%20%26%20Chambers%20-%20Risk-Public%20Liability-Economics%20of%20Tailings%20Storage%20Facility%20Failures%20%E2%80%93%2023Jul15.pdf

4 Mining Technology, "British Columbia Introduces New Mining Laws," February 26, 2016. http://www.mining-technology.com/news/newsbritish-columbia-introduces-new-mining-laws-4822535

5 A dilatant (also termed shear thickening) material is one in which the resistance to gradual deformation increases with increasing external stresses. With earth-materials this is achieved by mechanically compacting that material.

6 The Expert Panel also notes the danger in using tailings ponds for the storage of excess-water storage (usually stormwater) during mine operation. (Expert Panel, 2015, p. 121)

7 Tailings dams must last forever. Tailings deposited by water do not have enough inherent stability to be self-supporting. For the analysis of the largest earthquake or largest flood a tailings dam might possibly experience during its design life, a period of 10,000 years is most often assumed because, based on recorded history for those events, that is longest time period for which reasonable assumptions can be made.

8 Although KSM received its final permits in December, 2014, the permits required from British Columbia were issued in July, 2014, about a month before the Mount Polley dam failure.

9 There are two additional large porphyry mine projects in the advanced exploration stage – the Bronson Slope and Hat Projects.

MiningWatch Canada

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Rivers Without Borders Transboundary Watershed Conservation

Southeast Alaska Conservation Council

SkeenaWild Conservation Trust

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David Suzuki Foundation Solutions are in our nature

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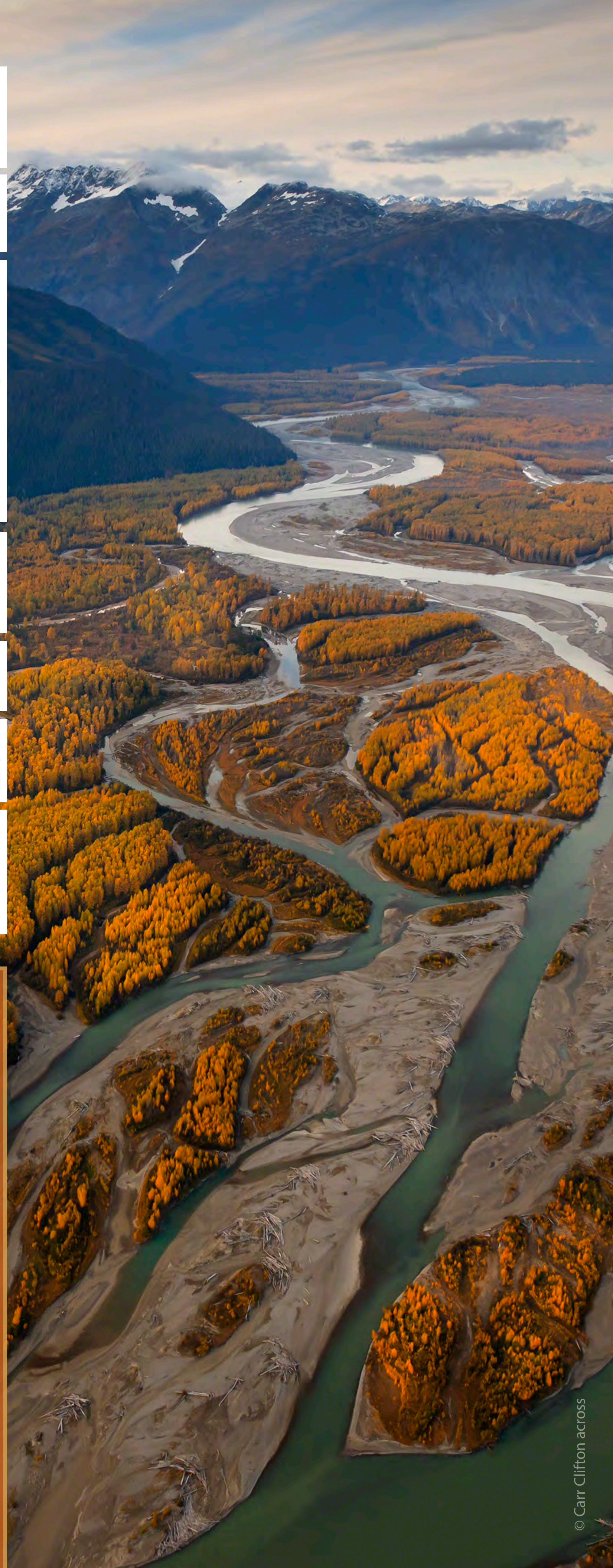

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