BC MINING LAW REFORM

SkeenaWild CONSERVATION TRUST

Protecting Communities and Watersheds:

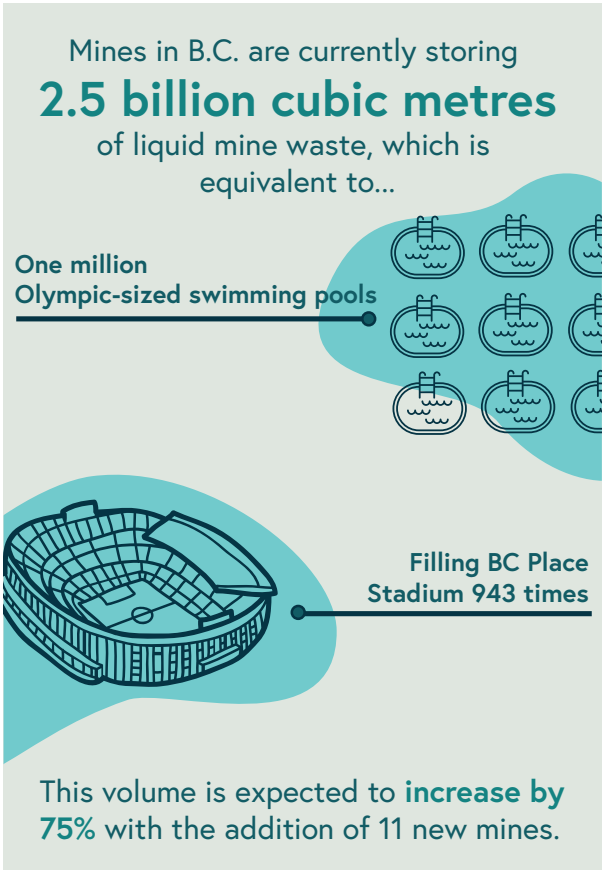
Risks of Tailings Dam Failures in the Face of Climate Change

July 2022

ABOVE: COPPER MOUNTAIN / PHOTO: ANDREW ROBERTS

A new expert analysis evaluating current and proposed mines in British Columbia shows the growing cumulative impacts of the province's mining boom at a time of increasingly extreme weather events driven by climate change. The analysis, *The Risk of Tailings Dam Failure in British Columbia: An Analysis of the British Columbia Existing and Future Tailings Storage Database*, looks at the risks of a failure at the 172 dams holding back mine processing waste, called tailings.[1] [2] The analysis also looks at the total volume of tailings currently being stored at B.C. mines, conservatively estimated to be 2.5 billion cubic metres, based on government and mining industry data. This amount of tailings is equivalent to one million Olympic-sized swimming pools and would fill B.C. Place stadium 943 times. With the addition of 11 proposed new mines, this volume is expected to increase by 75%.

According to the expert analysis, the height and volume of tailings storage facilities (TSFs) in B.C. have been increasing exponentially over time, meaning they are getting increasingly riskier. In fact, B.C. is contemplating new mines that would include TSFs among the tallest in the world. As tailings facilities have grown in height and volume, there has been a corresponding increase in the potential severity of consequences of tailings dams' failures, including the potential for loss of human life. Nearly half of B.C.'s existing mine sites with TSFs are officially rated as likely to have High, Very High, or Extreme consequences in the event of a tailings dam failure. Finally, the analysis found that one in four mine sites with tailings dams use a riskier construction type, upstream dam construction, which has twice as many stability issues than downstream constructed tailings dams. Upstream dams are banned in other jurisdictions but still permitted in B.C.



British Columbia is already at high risk for some of the primary drivers of tailings dam failures globally —earthquake risks and high precipitation, which cause flooding. Climate change will compound risks of flooding, bringing in more frequent, severe rainstorms, like the atmospheric rivers already experienced in B.C. in 2021.

Mine Tailings Storage and New Risks from Climate Change

Tailings, which can include trace heavy metals, selenium, and other toxins such as arsenic and cyanide, are typically stored permanently in aboveground facilities that are retained by dams. If these dams fail, as happened with the Mount Polley mine waste disaster in 2014, large volumes of tailings can be released to the surrounding environment. The potential risks associated with even a single tailings storage facility (TSF) failure are serious, including loss of human life, catastrophic damage to roads and infrastructure, and total losses to ecosystems, including salmon watersheds. Dozens of communities and thousands of people across B.C. live downstream of mines with tailings dams.[3] Today, there are 75 mine sites in B.C. that contain at least one TSF. At these mine sites there are at least 172 dams holding back tailings mine waste.[4]

Meanwhile, British Columbians find themselves on the front lines of climate change, facing more extreme weather. In the fall of 2021, the province experienced 'atmospheric rivers' that caused severe flooding, loss of homes and infrastructure, and billions of dollars of damage.

Climate change is rapidly compounding precipitation risks, and British Columbia is experiencing more severe and frequent storms as a result. Extreme rainfall driven by climate change adds stress to the structures holding mine tailings. Even tailings facilities designed for today's most extreme weather events may not be able to withstand future extremes under the influence of climate change, or multiple events such as heat domes, atmospheric rivers, and recurring flooding.

The Fraser River Basin, where atmospheric river events are predicted to increase in strength and frequency due to climate change,[5] is home to 27 current and future mine sites hosting at least one tailings storage facility—over one-third of the total number of mine sites across B.C.[6]

The B.C. government has stated an urgent need for action to prepare and adapt to the changing climate, including a critical need for climate-ready infrastructure.[7] The mining industry and mining experts acknowledge the growing risks of climate change, especially in light of a growing volume of tailings globally. [8]

A Current Assessment of B.C. Mines with Current or Future Tailings

Following the Mount Polley tailings disaster in 2014, the Mount Polley Independent Expert Engineering Investigation and Review Panel found that to get on a path to zero failures, the province needed to reduce its tailings facility inventory by half and use Best Available Technology (BAT) for the remaining facilities.[9] As a follow up to this recommendation, the BC Mining Law Reform network and SkeenaWild Conservation Trust created a database of mines with TSFs across the province. The database comprises 86 mine sites that currently, or are proposed to, contain at least one TSF, and informed the creation of a publicly available online British Columbia Mine Tailings Map as well as an expert report.[10] The expert report, *The Risk of Tailings Dam Failure in British Columbia: An Analysis of the British Columbia Existing and Future Tailings Storage Database*, authored by Dr. Steven Emerman, evaluates this database and the risks of a tailings dam failure (based on assessing the combination of the probability of failure and consequence of failure).[11] Dr. Emerman is an internationally recognized expert who has evaluated proposed and existing TSFs in North America, South America, Europe, Africa, Asia, and Oceania.[12]

Key Findings from the Expert Report

B.C.'s Mining Growth Will Create Some of the Largest Tailings Facilities in the World

The height and storage capacity of tailings facilities in B.C. have been increasing exponentially over time, meaning they are getting increasingly riskier. In fact, B.C. is contemplating new mines that would include tailings storage facilities among the tallest in the world.

Tailings dam height and tailings storage volume are risk factors that can increase the economic, environmental, or human consequences in the event of a tailings dam failure. According to the expert report, operating TSFs are on average nearly twice as high as facilities in closed and care and maintenance status and proposed facilities on average would be again twice as high as operating facilities. Operating facilities hold on average five times more tailings than facilities in closed and care and maintenance status and proposed facilities would hold on average three times more than operating facilities.[13] In fact, B.C. is pursuing mines with tailings dams among the tallest in the world, including one taller than Vancouver's tallest building, the Shangri-la tower.[14]

Dam Failure Consequences are also Increasing

As B.C.'s tailings facilities have grown in height and volume, there has been a corresponding increase in the potential severity of consequences of tailings dams' failures, including the potential for loss of human life. Nearly half of B.C.'s existing mine sites with tailings storage facilities are officially rated as likely to have High, Very High, or Extreme consequences to humans and the environment in the event of a tailings dam failure.[15]

Tailings dams are rated under a system established by the Canadian Dam Association, where ratings are based on the consequences of failure, including loss of human life, loss of critical fish or wildlife habitat, and economic losses to infrastructure, public transportation, or commercial facilities. A review of these ratings in B.C. suggests consequences are increasingly severe at newer tailings facilities. While the potential for loss of human life or significant to major economic or environmental damage exists at 46% of older sites (closed or under care and maintenance), that potential jumps to 83% for mines that are currently in operation. At proposed sites where consequence ratings have been established, nearly all (5 out of 6) would result in Very High or even Extreme consequences, including anywhere from 10 to over 100 human lives lost or irreparable loss of critical fish or wildlife habitats.[16] Failure consequence ratings at existing and proposed sites suggest thousands of lives could be at risk across B.C. from tailings dam failure.[17]

Figure 1: Percentage of mine sites with tailings storage facilities (TSFs) according to status and dam failure consequence classification

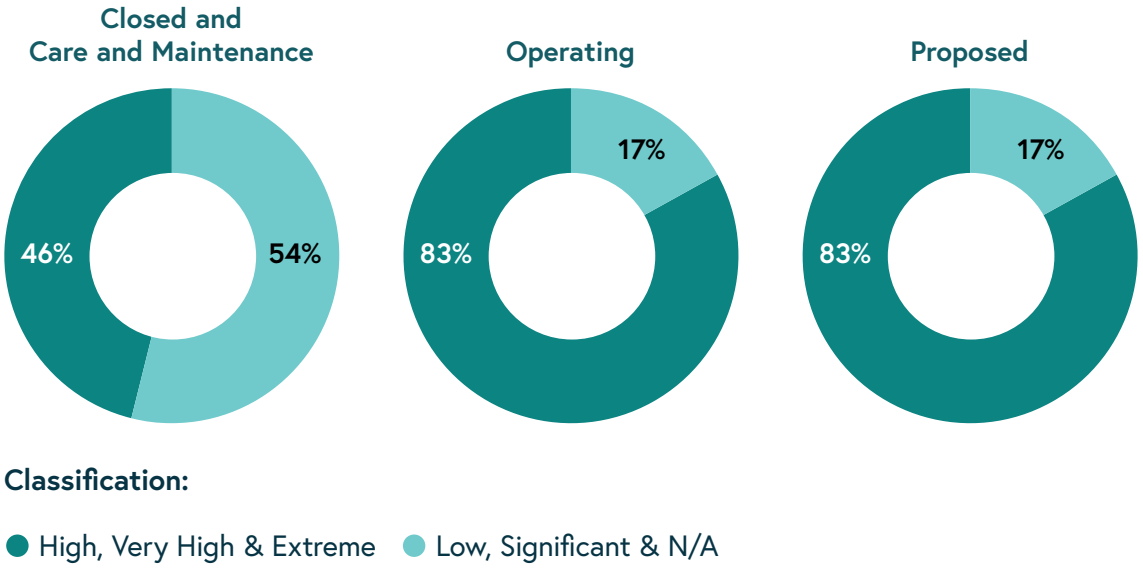


Table 1: B.C. mine sites with tailings storage facilities (TSFs) according to dam failure consequence classification

Dam Failure Consequence Classification*	Failure Consequence Description**	Percent & Number of Sites	
Low	• No loss of life • Minimal/short-term loss of environmental or cultural values • Minimal economic losses	**19%**	14
Significant	• Low potential for multiple losses of life • No significant loss of environmental/cultural values • Low economic losses	**18%**	13
High	• Loss of fewer than 10 lives • Significant loss of environmental/cultural values, where restoration is possible • High economic losses	**22%**	16
Very High	• Loss of fewer than 100 lives • Significant loss of environmental/cultural values, where restoration is impractical • Very high economic losses	**26%**	19
Extreme	• Loss of greater than 100 lives • Major loss of environmental/cultural values, where restoration is impossible • Extremely high economic losses	**10%**	7
N/A	No dam failure consequence assigned because TSF does not have dams	**4%**	3

* Dam Consequence Classifications are based on B.C. Dam Safety Regulations, which are adopted from Canadian Dam Association Guidelines.

** Consequence descriptions are adapted from the B.C. Ministry of Forests, Lands and Natural Resources "Downstream Consequence of Failure Classification Interpretation Guideline", Appendix A. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/dam-safety/con_class_guidelines_for_owners-2017.pdf

Note: There are also 14 sites with TSFs where Dam Consequence Classification is not publicly available (9 Closed or under Care and Maintenance, and 5 Proposed). These sites have been excluded from Table 1 and Figure 1.

Note: Percentages have been rounded to the nearest whole number.

Nearly two-thirds of the sites in B.C. with tailings facilities—54 out of 86—are located in salmon habitat. A major tailings failure at any of these facilities could significantly harm salmon and salmon habitat.

Seismic and Climate Factors Add to the Risk of Failures

British Columbia is at high risk for some of the primary drivers of tailings dams failure globally—earthquake risks and high precipitation. Climate change will compound the risks of flooding, bringing in more frequent and severe rainstorms, like the atmospheric rivers already experienced in B.C. in 2021.

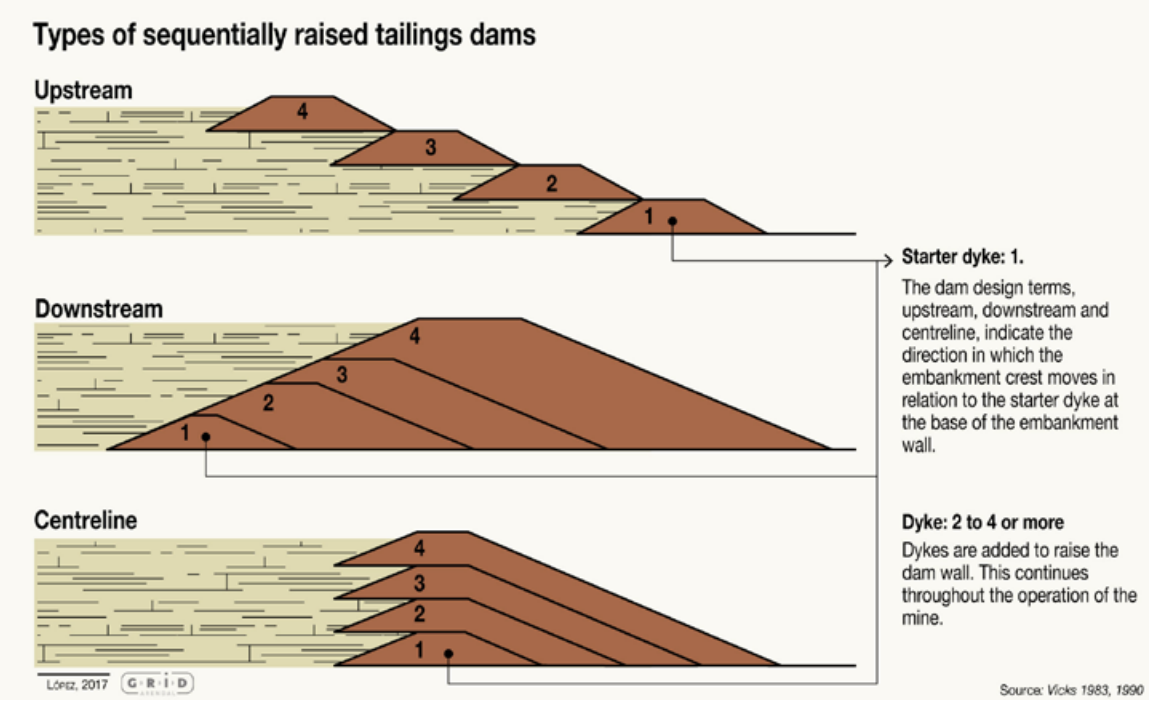
Two of the primary drivers of tailings dams failure globally are earthquakes and overtopping by floods, both of which are major risks in British Columbia. The province's western coast is on a major earthquake fault line and experts believe the province has a one in five chance of going through a major earthquake in the next 50 years, increasing the risk of a tailings dam failure. Portions of B.C. also receive extensive rainfall and flooding, which contribute to an increased risk of tailings facility dam failure.[18] Tailings facilities designed for today's most extreme weather events may not be able to withstand future extremes that will occur under the influence of climate change.

B.C. Allows Risky Construction Types

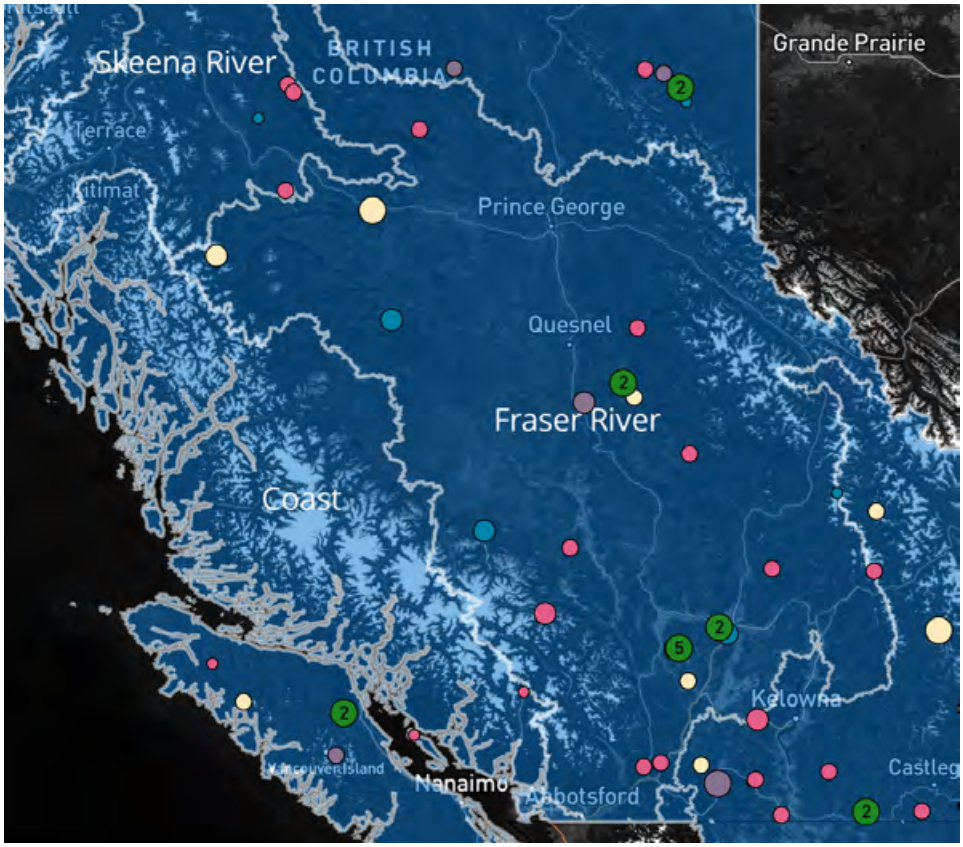
One in four B.C. mine sites with tailings dams use a riskier construction type—upstream dam construction—which has twice as many stability issues than downstream constructed tailings dams. Upstream dams are banned in other jurisdictions but still permitted in B.C.

One quarter of the currently existing mine sites with TSFs in the province—19 of them—have tailings dams constructed using the upstream method, which has a greater rate of instability issues compared to other dam construction methods.[19] Upstream construction involves progressively raising the dam on top of the existing tailings in the facility.
The expert analysis notes the risk of tailings dam failure is likely underestimated in B.C. because of the way mining companies often classify their dams.[20] Increasingly, dams are classified as 'modified centreline' construction instead of 'upstream.' Modified centreline is a lesser known construction type that also involves building on top of uncompacted tailings, giving these dams similar risks of stability as upstream dams.[21]

Figure 2: Types of sequentially raised tailings dams



The expert review indicated that certain communities in the Fraser River watershed would be more vulnerable. The watershed contains 27 existing and proposed mine sites with TSFs. One of those mine sites is the Highland Valley Copper mine, which stores 1.2 billion cubic metres of tailings at one of its storage facilities, or the equivalent to 480,000 Olympic-sized swimming pools. In the event of a complete facility failure, these tailings could be released into the lower Fraser River, potentially impacting communities downstream such as Abbotsford, Burnaby, Coquitlam, Delta, Richmond, Surrey, and Vancouver.[22]



SCREENSHOT FROM THE INTERACTIVE ONLINE MAP SHOWING THE NUMBER OF MINE SITES IN THE FRASER RIVER WATERSHED WITH AT LEAST ONE TSF.

57 Closed Mines with 'Legacy' Tailings Facilities Require Ongoing Attention

Mines that are currently closed or in care and maintenance may present higher risks if they do not receive ongoing inspection, monitoring, and maintenance. There are currently 57 sites with tailings storage facilities in B.C. that are closed or in care and maintenance.

According to the expert report, mines that are closed or in care and maintenance may not be receiving the sufficient and ongoing inspection, monitoring, and maintenance that are critical to preventing tailings failure. Tailings facilities are often expected to remain on the landscape forever. The only ways of avoiding facility failure over this timeframe are a) eliminating all possible failure modes (i.e., via decommissioning and reclamation) or b) perpetual monitoring, inspection, and maintenance.[23]

Nearly two-thirds of the sites in B.C. with tailings facilities—54 out of 86—are located in salmon habitat. A major tailings failure at any of these facilities could significantly harm salmon and salmon habitat.

Multiple Risk Factors to Mitigate as Tailings Increase by 75%

The expert report reveals that there are a number of overlapping risk factors at TSFs in British Columbia, including dam construction method, status, dam height, storage volume, and dam consequence rating. Over time, the growth and location of TSFs is cumulatively increasing the risk of tailings dam failure by increasing the consequences from a failure. Experts, including the Mount Polley Independent Expert Engineering Investigation and Review Panel, have observed that the sheer number of active tailings sites on the landscape increases risk by increasing the probability that any one of them will fail.[24]

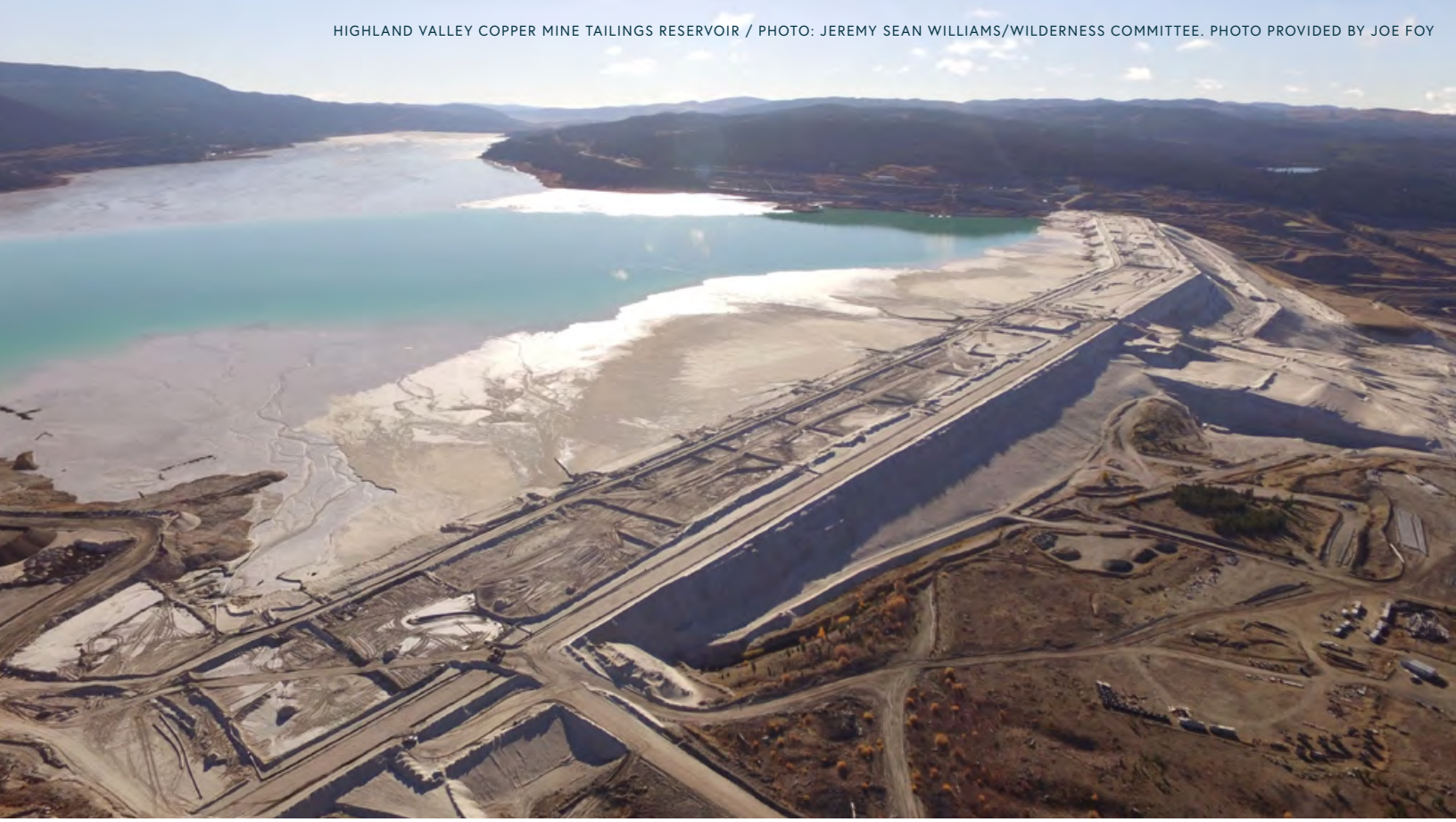
As new, larger mines are built, introducing a substantial increase in the number of TSFs and overall volume of tailings on the B.C. landscape, these new mines, in combination with the legacy of tailings already present, will increase the overall cumulative risk.

Building on progress made and continuous improvement

MOUNT POLLEY DAM BREACH / PHOTO: PHILIP N. OWENS

The B.C. government has taken steps to evaluate the regulatory framework at mines with individual TSFs. In June 2021, the government released its first audit from the new Mine Audits & Effectiveness Unit of B.C. entitled *Audit of Code Requirements for Tailings Storage Facilities*. This audit looked at the regulatory framework governing health, safety, and reclamation of mines in B.C. and made a number of recommendations calling on the government to update its regulatory framework to reflect best standards, practices, and regulations. An additional analysis of B.C.'s tailings standards and the audit was completed by the BC Mining Law Reform network and MiningWatch Canada in January 2022.[25] B.C.'s Auditor General also recently released a progress audit showing some improvements to policies, procedures, and plans for monitoring and compliance at mine sites since the Mount Polley disaster.[26]

While it is important that B.C. continues to make progress on its regulatory oversight at individual tailing storage facilities (see box: Building on progress made and continuous improvement), it is equally important that B.C. understand and evaluate the cumulative risk presented by the 75 mines with TSFs and the potential addition of 11 new mines with TSFs. This is especially imperative as B.C. faces more extreme weather events due to climate change.



HIGHLAND VALLEY COPPER MINE TAILINGS RESERVOIR / PHOTO: JEREMY SEAN WILLIAMS/WILDERNESS COMMITTEE. PHOTO PROVIDED BY JOE FOY

Recommendations

As B.C. pursues the growth of its mining sector, there are concrete steps that the government should take to reduce the likelihood and consequence of tailings dam failures, thereby preventing serious human, economic, and ecological impacts. Any one of these steps would act to lessen the cumulative risk of a tailings dam failure. Together, taking multiple actions would have an additive effect to confront new risks, including those presented by climate change.

Existing Mines

#1: Commit to a plan to reclaim or otherwise seek safe closure of tailings storage facilities in B.C.

As mentioned, the presence of more TSFs on the landscape increases risk. B.C. should address this by committing to a plan to implement a nearly decade old recommendation outlined in the 2015 Mount Polley Expert Panel report to reduce B.C.'s tailings storage facilities by half, and require Best Available Technology and Practices for the remaining TSFs.[27] According to *Safety First: Guidelines for Responsible Mine Tailings Management*, "A tailings facility is safely closed when deposition of tailings has ceased and all closure activities have been completed so that the facility requires only routine monitoring, inspection and maintenance in perpetuity or until there are no credible failure modes."[28]

#2: Clarify treatment of tailings storage facilities in 'care and maintenance' and provide clear guidance for management of facilities in this status

The expert report identifies 23 mines with TSFs in care and maintenance which may present higher risks if they do not receive ongoing inspection, monitoring, and maintenance.[29] By clearly defining the stages of mine life where a 'care and maintenance' status is permitted, long delays to closure and reclamation of tailings facilities could be avoided, thereby ensuring all credible failure modes are eliminated at TSFs that are no longer operational, so they can be removed from B.C.'s inventory.[30]

Future Mines

#3: Align with international best practices and implement a ban on risky upstream tailings dam construction methods

Globally, there is a trend away from upstream tailings dam construction. Banning upstream dam construction would put B.C. in line with best practices. This also aligns with industry trends—none of the proposed dams evaluated in the expert report contemplate use of the 'upstream' construction type. Any new provincial policy should include banning what are referred to as 'modified centreline' dams, which are still constructed on top of uncompacted tailings in the manner of an upstream dam.[31]

#4: Reverse the trend of more severe consequence ratings at new tailings storage facilities

The expert analysis reveals that tailings facilities are increasingly being designed with failure consequences in the High, Very High, and Extreme categories. Experts suggest that over hundreds of years, the required oversight to prevent failure at tailings facilities is not realistic, and facility failure should be considered a 100% likelihood. Reducing the consequences of failure at all new tailings facilities or, alternatively, denying permitting for those that cannot be more safely designed and/or located, puts safety as a top priority. This is especially important for mines located upstream from communities, and those in high seismic and/or high precipitation zones where climate change risks may make failure an even greater and more pressing likelihood.

Existing and Future Mines

#5: Factor in seismic and climate change risks at all tailings facilities, especially when evaluating proposed mines

B.C. should update its guidelines to require that all tailings dams be built to withstand the most extreme flooding and earthquake events.[32] For proposed tailings facilities, the B.C. government should factor local seismic risk and the risks of future climate impacts, such as more extreme and/or frequent precipitation events, into all environmental impact

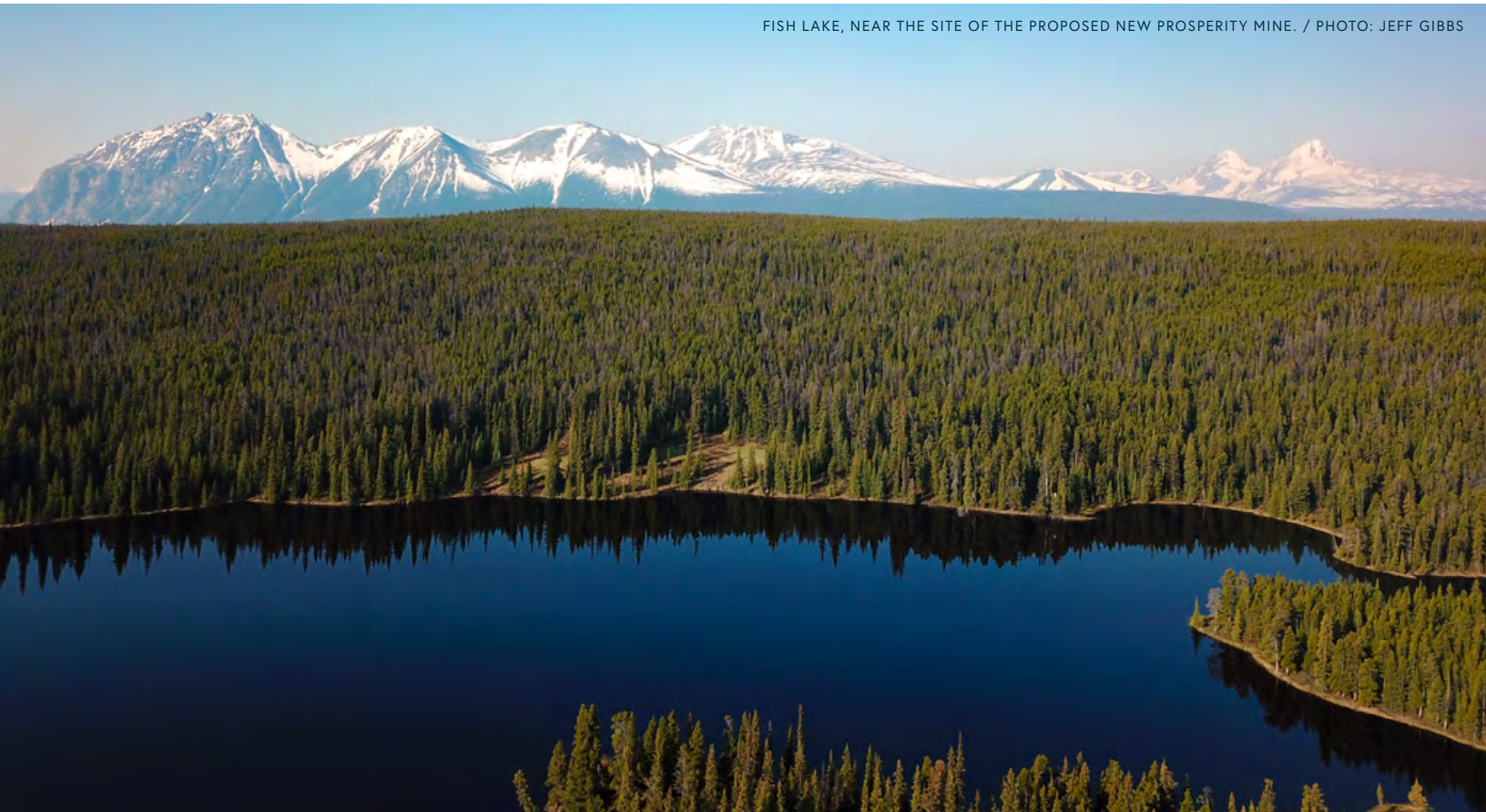
assessments. With respect to existing tailings facilities, climate change considerations should be incorporated into the regulatory oversight of all facilities to inform emergency preparedness and implement more resilient design modifications wherever possible.

#6: Pursue strategies to reduce the volume of tailings, especially at new mines

The total volume of tailings on the provincial landscape is growing. B.C. should investigate and then implement technologies and more stringent policies and requirements for dewatered tailings. Technologies to investigate would include filtered tailings as well as paste or thickened tailings, and dry closure methods (as opposed to permanent water covers). Adopting these strategies at proposed sites is particularly critical, given the greater opportunity to incorporate safer technology into the design for facilities that have not yet been built.[33]

#7: Improve accessibility and transparency of information on risk factors for all tailings facilities

Most of the risk factors identified by the expert report (e.g., storage volume, dam heights) are not required by B.C. to be publicly reported in a consistent manner. For example, current tailings storage volumes are missing for one third of all sites and tailings dam heights are not reported for about 10% of sites. The province's incomplete record of health and environmental risk at tailings dams points to the need for more transparency and disclosure in relation to all sites—past, present, and future.[34]



FISH LAKE, NEAR THE SITE OF THE PROPOSED NEW PROSPERITY MINE. / PHOTO: JEFF GIBBS

Endnotes

1 Emerman, Steven, *The Risk of Tailings Dam Failure in British Columbia: An Analysis of the British Columbia Existing and Future Tailings Storage Database*, July 2022. https://reformbcmining.ca/wp-content/uploads/2022/06/BC_TSF_Database_Analysis_Emerman_Revised2.pdf
(hereinafter "Emerman, Risk of Tailings Dam Failure"). This expert report is based on a database created by the BC Mining Law Reform network and SkeenaWild Conservation Trust, sourcing B.C. government and industry data.

2 Tailings are only one type of mine processing waste. Tailings are the wet and crushed rock particles that remain after the commodity of value has been removed from the ore body.

3 See, for example, BC First Nations Energy and Mining Council, *Uncertainty Upstream: Potential Threats from Tailings Facility Failure in Northern British Columbia*, 2015. https://fnemc.ca/wp-content/uploads/2015/07/Uncertainty-Upstream-2015-compressed.pdf

4 TSFs in the province are typically constructed using dams, often multiple dams. As of June 4, 2022, the database on which the expert report is based identified a total of at least 172 dams currently retaining tailings across B.C., and another at least 21 tailings dams proposed. This is a minimum number, as the number of tailings dams was not publicly reported for all sites.

5 Government of Canada, *Canada in a Changing Climate: Regional Perspectives Report, British Columbia*, 2022, Section 5.3, p. 24. https://changingclimate.ca/site/assets/uploads/sites/4/2020/11/British-Columbia-Regional-Perspective-Report-.pdf

6 Emerman, Risk of Tailings Dam Failure, p. 31–32.

7 Government of British Columbia and Clean BC, *Climate Preparedness and Adaptation Strategy for 2022–2025*, June 2022. https://www2.gov.bc.ca/assets/gov/environment/climate-change/adaptation/cpas.pdf

8 Global Tailings Review, *Towards Zero Harm: A Compendium of Papers Prepared for the Global Tailings Review*, August 2020. https://globaltailingsreview.org/wp-content/uploads/2020/08/towards-zero-harm.pdf (which identified climate change as a key factor influencing tailings failure outcomes throughout the report)

9 For example, the review panel stated: "Reducing the number of active dams can also be considered as a means for meeting the same safety goals. …Reducing the current inventory of active tailings dams can be brought about from attrition by eliminating surface water at closure. Restricting future growth of the inventory can be achieved through tailings technologies that avoid water storage in the first place." Mount Polley Independent Expert Engineering Investigation and Review Panel, *Report on Mountain Polley Tailings Storage Facility Breach*, January 30, 2015. https://www.mountpolleyreviewpanel.ca/sites/default/files/report/AppendixI_BCTDFFrequencyandPortfolioRisk.pdf (hereinafter, "Mount Polley Independent Expert Engineering Investigation and Review Panel Report"). Appendix I, Section 5.3, p. 10–12.

10 As of June 4, 2022, the database includes 86 sites in total: 75 mine sites in British Columbia currently containing at least one TSF holding tailings mine waste, and 11 future mine sites, many of which are advanced in the regulatory process, that would contain a TSF and create at least 19 additional tailings dams if built. Many of these sites contain more than one TSF. The database and map do not list every single TSF, nor do they provide a count on the total number of TSFs across B.C. The database and map highlight the tallest tailings dam at each site, the design storage capacity for the largest TSF on site, the current tailings storage volume across all TSFs on site, and the highest consequence classification assigned to any tailings dam on site.

11 See generally Emerman, Risk of Tailings Dam Failure. While the expert report did not look singularly at the risk of a tailings dam failure of any one mine site, it looked at multiple risk factors that can collectively increase the probability and/or consequence of failure of a tailings facility across the province. These risk factors include: high runoff (high precipitation), high seismicity, the use of upstream dam construction method, the status of sites (such as closed or in care and maintenance), dam height, and storage volume.

12 Dr. Emerman has testified before the U.S. Congress, the European Parliament, the UN Permanent Forum on Indigenous Issues, and the UN Environment Assembly. He is Chair of the Body of Knowledge Subcommittee for the U.S. Society on Dams and a co-author of *Safety First: Guidelines for Responsible Mine Tailings Management*.

13 Based on the tallest tailings dams at each site, operating TSFs on average (65.5 m) are nearly twice as high (or 1.8 times higher) as closed and care and maintenance facilities (36.8 m), and proposed facilities on average (123.9 m) will be again twice as high (or 1.9 times higher) as operating facilities. Based on current tailings storage at existing sites and design capacity at proposed sites, operating facilities hold on average (121.5 million m3) five times more than closed and care and maintenance sites (22.7 million m3), and proposed facilities would hold on average (362.3 million m3) three times more than operating facilities. See Emerman, Risk of Tailings Dam Failure, p. 15.

14 A comparison with the Global Tailings Portal (an international tailings database built from direct mine company disclosures) indicates that if built, the future KSM mine would have the seventh tallest tailings dam in the world at 239 m, which would be far taller than Vancouver's tallest building, the Shangri-la tower (201 m). See Klohn Crippen Berger's report to Seabridge Gold Inc., *2012 Engineering Design Update of Tailing Management Facility*, p. 33. https://projects.eao.gov.bc.ca/api/public/document/5887de449b566a12e7f69c83/download/Appendix%204C%20Appendix%20H8%20%20TMF%20Engineering%20Design%202012%2010f6.pdf. Additionally, B.C. currently has at least six dams, and at least two more proposed (KSM and Galore Creek) in the top 30 dam heights in the world according to the Global Tailings Portal. To be one of the top 30, based on the tallest tailings dam at each mine site, the dam would need to be greater than 126 m.

15 See Emerman, Risk of Tailings Dam Failure, p. 19. 37 out of 75 existing mine sites with tailings facilities have dam consequence ratings of High, Very High, or Extreme, which mean dam failure would likely involve loss of life and/or serious damage to environmental and cultural values.

16 There are another five proposed sites where consequence ratings have not yet been established.

17 The expert report calculates potential loss of life based on the dam consequence classification rating system established by the Canadian Dam Association. Based on a review of the official consequence ratings, the expert report found that 42 sites, including proposed sites, had dam failure consequence ratings of High (1–10 lives), Very High (11–100), and Extreme (more than 100 lives). Assuming 10 lives, 100 lives, and 101 lives lost at sites rated High, Very High, and Extreme, respectively, the potential loss of life could be as much as 2,767 lives at these 42 sites. This estimate, however, may be several orders of magnitude too low because there are sites for which the dam failure consequence is unknown, where there is more than one dam or TSF, or where the loss of life would exceed 101 lives. See Emerman, Risk of Tailings Dam Failure, p. 30.

18 According to the expert report, 12 mine sites located within areas with high seismic risk and/or areas with high annual runoff already also have other high risk factors for tailings dam failure. These sites, primarily along B.C.'s coastal region, are of significant concern.

19 Upstream dams are considered to be more risky because they have a nearly 20% greater incidence of stability issues as other types of tailings dams, including having 200% more (or twice as many) stability issues than downstream-constructed tailings dams. See Franks, D., et al. *Tailings facility disclosures reveal stability risks*, March 2021. https://www.nature.com/articles/s41598-021-84897-0. The 19 sites with upstream dams in B.C. include: Copper Mountain, Elkview-West Fork, Endako, Gibraltar, and Mount Polley mines, among others. In two cases, at Copper Mountain and Gibraltar, the TSF with the upstream dam also has an Extreme failure consequence rating (potential loss of >100 lives), which is a disturbing combination of unacceptable probability of failure and unacceptable consequences of failure.

20 See Emerman, Risk of Tailings Failure, p. 34.

21 To stay consistent with public reporting on B.C. tailings dams, the database on which the expert report is based did not treat modified centreline dams as upstream dams. See Emerman, Risk of Tailings Failure, p. 34–35 and 81–84.

22 See Emerman, Risk of Tailings Failure, p. 31–32.

23 See Emerman, Risk of Tailings Failure, p. 9–11.

24 Mount Polley Independent Expert Engineering Investigation and Review Panel Report, Appendix I.

25 Emerman, Steven, *Bridging the Gap: Toward the Best International Standards on Mine Waste Safety in British Columbia*, January 2022, https://miningwatch.ca/sites/default/files/bcmlr-bridging-the-gap-report_0.pdf (produced by BC Mining Law Reform and MiningWatch Canada; hereinafter referred to as "Emerman, Bridging the Gap").

26 Office of the Auditor General of British Columbia, *Oversight of Major Mines: Policies and Procedures to Address Environmental Risks*, June 2022. https://www.bcauditor.com/sites/default/files/publications/reports/BCOAG-Oversight-Major-Mines-Report-June-2022.pdf

27 See Mount Polley Independent Engineering Investigation and Review Panel Report, Section 9.3 and Appendix I. Section 9.3.4 states that BAT principles would apply "to the closure of active impoundments so that they are progressively removed from the inventory by attrition."

28 Morrill, J., Chambers, D., Emerman, S., Harkinson, R., Kneen, J., Lapointe, U., Maest, A., Milanez, B., Personius, P., Sampat, P., and Turgeon, R., *Safety First: Guidelines for Responsible Mine Tailings Management*, Earthworks, MiningWatch Canada and London Mining Network, 2022. https://earthworks.org/wp-content/uploads/2022/05/Safety-First-Safe-Tailings-Management-V2.0-final.pdf, Guideline 11, p. 32.

29 See Emerman, Risk of Tailings Failure, p. 12.

30 While many mines in B.C. are reported to be in 'care and maintenance,' this term is not defined anywhere in B.C.'s mining regulations or guidance documents. It often applies to mines that are not operational, but are not moving towards closure and reclamation either. While putting a mine into care and maintenance may make sense for short term reasons, any delay in moving a TSF towards safe closure prolongs the risk of tailings facility failure, so these delays must be transparent and well regulated.

31 While none of the 11 new sites with tailings facilities currently proposed by B.C. mining companies are identified as using upstream dams, the province must determine whether any of them have been labeled 'modified centreline' and regulate them as upstream dams if they are, given they use similar construction methods and pose similar risks as upstream dams. See Emerman, Risk of Tailings Failure, p. 34–35, 39 and 81–84.

32 Emerman, Bridging the Gap, p. 14.

33 All new mines that create tailings must begin with an analysis of the Best Available Technology (BAT) for tailings disposal. BAT and practices in tailings management will continue to change, but tailings BAT was specified by the Mount Polley Independent Expert Engineering Investigation and Review Panel. According to Morrill et al., "The goal of BAT 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: 1. Eliminate surface water from the impoundment. 2. Promote unsaturated conditions in the tailings with drainage provisions. 3. Achieve dilatant conditions throughout the tailings deposit by compaction." (p. 25)

34 Specific actions the province could take include: 1) Require standardized reporting by mining companies of the information highlighted in the database and map on which the expert report is based, including tailings dam construction methods, dam heights (current and planned), current storage volumes, and design storage volumes; and 2) Monitor and accelerate the B.C. Code Review Committee's progress on implementation of the 2021 TSF audit recommendations, that included providing clarity, consistency, and guidance on TSF data systems, reports, and inspections.