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"Technical Support for Grassroots Public Interest Groups"

August 15, 2022

To: Jay Gilden
What Matters In Our Valley
Telkwa, British Columbia

Re: **BC EAO EAC Tenas Project Application – Comments on Management Pond Dams**

General comments

Historic coal mining took place in this area from 1918 to 1985, producing 400,000 tons of coal. The Tenas Project is proposing to produce 800,000 tons per year, so this project will match the total historic coal production in just six months.

The Tenas Coal Project is noteworthy because of the significant amount of potentially acid generating and neutral drainage waste material that will be produced as a result of mining. In order to minimize the amount of contamination released from this waste, the waste will be kept submerged under water during mine operation, and at closure this material will be buried under cover material. This is designed to deep the potentially acid generating mine waste permanently saturated. Permanent saturation raises several potential long-term concerns. First, if the mine waste is not kept permanently saturated, and the groundwater level in the management ponds moves up and down, dramatically increased rates of contaminants would be produced. Second, the saturated waste below the surface of the management pond means that the waste material can be readily mobilized, so the dam must provide containment in perpetuity. If released from the management pond as the result of a catastrophic dam failure, the waste would likely flow a great distance. Even though a catastrophic dam failure is a low probability event, the consequences would be high, and any people in the potentially affected zone must be ready to evacuate on short notice – again in perpetuity. Because of this risk, the dams need to be designed to be as safe as possible, but the management pond dams, as proposed, are not being designed to the seismic standard recommended by the Canadian Dam Association.

The mine waste in the management ponds is being placed on a bentonite-augmented earth liner in order to restrict the flow of contaminants from the waste into groundwater. Groundwater below the management ponds has a direct connection to surface water in the surrounding streams, and is projected to be the primary source of contamination to these streams in the long-term. The liner being proposed does not adequately restrict the flow of contaminants from the management ponds to the nearby streams, as evidenced by the significant increases in contamination in those streams, especially after mine closure.

No water treatment is being proposed for this project, again a very unusual situation, especially with so much water contamination being produced by the waste at this mine. SRK is recommending that exceptions be granted to the B.C. water quality guidelines, and that zones of initial dilution that exceed the length recommended by regulatory guidance be allowed.

British Columbia is already experiencing serious impacts to fisheries from coalmine contamination in the Elk Valley, and these impacts appear that they will persist in the Elk Valley for some time. Although the Tenas Project is not as large as most of the mines in the Elk Valley, on a per-ton basis the potential for contamination from the Tenas Project is more prolific than that at the Elk Valley mines. Toxic discharges from the Tenas Project, as presently proposed, could lead to long-term serious contamination in a drainage that that has not seen the type of severity of contamination in the Elk Valley.

Management Pond Dam Classification and Design Requirements

There are three Management Ponds proposed for the Tenas Project (Figure 1-2). These ponds will contain potentially acid generating waste rock, as well as the fine processing waste from cleaning the coal. During mine operation the Management Ponds will have a water cover to minimize the production of contaminants from the waste material. The East Management Pond dam, at 40 meters in height, is the same height as the failed Mount Polley tailings dam. The West Management Pond dam is 37 meters in height. During mine operation there is also the Tenas Management Pond, used for water management, which will be decommissioned after mine closure.

A fundamental design flaw for these dams is that they are in a cascading configuration (Figure 1-2). That is, the East and West Dams are located directly above the North Dam, and these three dams are located above the Tenas Dam. The failure of an upper dam, especially the West Dam, could also lead to the failure of a lower dam, making the results of the failure much more severe. During its participation in the development of the Global Industry Standard on Tailings Management, the United Nations Environmental Program strongly discouraged the use of cascading dams (UNEP 2020). A cascading dam failure at Stave, Italy, in 1985, led the one of the largest loss of life incidents caused by a tailings dam failure. Cascading failures were not modelled as a part of the Dam Breach Assessment.

<u>Design Seismic Earthquake</u>

The dams for the Management Ponds are of downstream-type construction. Downstream-type dam construction is the safest of the dam construction types, but this does not affect the hazard classification of the dam. The factor having the most influence on the dam hazard classification of the Tenas Project dams is the number of people at risk should the dam fail catastrophically.

The choice of the design earthquake for a dam is very important because it essentially determines the minimum strength the dam and its foundation materials must achieve in order to resist the shaking of an earthquake that could lead to a catastrophic dam failure. When all of the available information on past earthquakes and known fault locations is assessed, the largest earthquake that is thought possible to occur at a given location is called the maximum credible earthquake, or the 1-in-10,000-year earthquake.[1]

The Canadian Dam Association recommends a hazard rating of "Extreme" for dam failures that place greater than 100 people at risk (CDA 2019, Table 3-1, attached). SRK has recommended that the Tenas Project Management Dams be classified as “Very High” risk, which is one classification lower than Canadian Dam Association’s “Extreme” risk classification (SRK 2021a). There is no explanation as to why SRK does not use the hazard classification recommended by the Canadian Dam Association.

However, in either case, the Canadian Dam Association dam hazard classification of either a Very High or Extreme rating must utilize "*Annual Exceedance Probability (AEP) of the 1 in 10,000-year Natural Hazard*" for both earthquake and flood events (CDA 2019, Table 4-2, attached).

The dams have been designed for the 1 in 2,475-year earthquake, which equates to a CDA hazard classification rating of “Significant”, the next to the lowest CDA dam hazard rating (CDA 2019, Table 4-2, attached).

The dams need to be reclassified and redesigned to meet the correct requirements of the Canadian Dam Association, the 1 in 10,000-year earthquake.

[1] 10,000-years is something of an arbitrary number, but the rationale for using this number is that 10,000 years is the limit of both historical human recordings of events (in this case earthquakes), as well as the limit as to what is thought to be faults that are still geologically active.

In addition to the seismic redesign, there are also a number of significant technical design issues noted by SRK that must be resolved before even the conceptual design of the dam can be considered final. These include

- Inclusion of a 2-to-3 m thick draining layer at the toe of the buttress in the design to prevent the development of pore pressures which may induce localized instabilities within the buttresses;
- Inclusion of a chimney drain in all embankments;
- Additional geotechnical boreholes to determine the presence, extension, depth and thickness of the two potentially weak layers under the East and West Management Ponds noted in the SRK (2021b) report; and,
- Oedometric consolidation tests in selected samples to: (i) determine the pre-consolidation stress and (ii) define if undrained conditions are expected or not.

SRK also listed conflicting comments on the presence of groundwater under the Management Ponds. The presence of shallow groundwater complicates the long-term stability analysis. While it is noted by SRK that, "*Piezometric information and water table estimates were based on a review of monitoring well reading data. Most of the recorded groundwater levels were between 20 m and 40 m, and the shallowest level were approximately 14 m.*" (SRK 2021b)

This is immediately followed by the statement, "*Groundwater inflow was observed in four test pits during 2018 and in one test pit during 2019.*" (SRK 2021b). According to this same report, these test pits had a maximum depth of 4.6 meters (SRK 2021b). Therefore, the shallow groundwater depth level measured in the piezometers conflicts with the shallow groundwater levels observed in the test pits.

The need for reassessment for seismic design, additional testing to assess whether the foundation and dam construction materials are of sufficient strength to use and support the construction of a dam, and the use of a dangerous cascading dam configuration, all suggest that the fundamental redesign of these waste disposal facilities is warranted.

Dam Breach Assessment

In its dam breach assessment report, SRK notes that if the East, North, or Tenas dams would catastrophically fail 150 people could be affected (i.e. would be potential fatalities), and failure of the West dam 200 people could at risk (SRK 2021a).

The SRK dam breach assessment (2021a) also contains the unusual assumption that if a dam failure occurs, only water and no mine waste would be released. SRK offered the following explanation for this assumption:

> *"Given the design heights of waste rock within the Management Ponds, the relatively flat ground beneath the ponds themselves, and the containment within an earthen dam, the liquefaction of neither the rock stored in the ponds nor the rock used in the dam fill is likely to occur."* (SRK 2021a)

This assumption is not supported by experience. Historical dam failures have always included a release of solid material, the only question being how much solid waste would be released with the intraining water. The waste in the Management Ponds will remain saturated, and potentially mobile, even after mine closure.

The most recent estimate of the average amount of solid waste released by a dam failure is 35% (Quelopana 2019). All of the 35 data samples cited in the research have some release of solid waste. If corrected to match normal assumptions for a dam breach assessment, that 25% - 35% of the waste would be released, this would make the potential impacts of the dam breach even worse, especially from an environmental risk standpoint.

It is less expensive to use Newtonian flow models (i.e. water only) than non-Newtonian flow (i.e water plus solids), which may explain the "no release of solids" assumption used for the dam breach assessment. In addition, just the volume of water released would result in at least 150 potential casualties, so an additional release of solid material would not change the hazard rating for the dams.

Management Pond Liner Design

A soil-bentonite liner is proposed for the bottom of the East and North Management Ponds, and part of the West Management Pond (SRK 2020). The Tenas Management Pond would not have a soil-bentonite liner (Figure 4). The purpose of this liner is to limit the migration of contaminants from the waste leaching into groundwater, since the Ponds will have direct hydraulic connections to adjacent streams.

The recommended liner design is a 0.30 m low permeability soil-bentonite liner that will be constructed in two 0.15 m lifts. The bentonite is added to the soil by disking the bentonite into the surficial soil as the lifts are constructed. This liner system is designed to allow a maximum seepage rate of 2,800 m3/day. SRK based this seepage rate on the contamination effects resulting from this seepage on nearby streams during the 10 Year Dry scenario (SRK 2021b).

Even with the proposed soil-bentonite liner, SRK is asking for Site Performance Objectives for aluminum, selenium, cadmium, cobalt, thallium, and nitrite (SRK 2022, Table 2-2). Site Performance Objectives allow water quality guidelines to be exceeded, based on site-specific considerations. However, at least in the case of selenium, the rationale being used by SRK to justify the Site Performance Objective is not site-specific, but reflects a fundamental difference with the British Columbia water quality guideline for selenium itself (SRK 2022). Asking for a Site Performance Objective does not appear to be the appropriate place to make these arguments. That should have been considered when the water quality guideline itself was established, or reviewed.

In addition, SRK is proposing an Initial Dilution Zone for the contaminants for which it has requested Site Performance Objectives, and additionally an Initial Dilution Zone for copper, iron, manganese, zinc, and sulfate (SRK 2022, Table 3-3).

The takeaway from these requests for variances from water quality guidelines is that selected seepage rate of 2,800 m3/day is too large, because it is allowing so much contamination that significant variances from water quality guidelines are needed. A seepage rate much lower than the planned 2,800 m3/day must be achieved in order to protect water quality.

To achieve the proposed design criteria the soil-bentonite liner system will require a hydraulic conductivity of 1E-10 m/s (SRK 2021b). This requires a permeability that is two orders of magnitude lower than that most clay liner systems typically achieve. A typical bentonite-soil liner would have a hydraulic conductivity of 1E-8 m/s. The proposed hydraulic conductivity of 1E-10 m/s is achievable, but is approaching the limit of what is possible for this liner design. Additionally, achieving a hydraulic conductivity of 1E-10 m/s would be accomplished by disking bentonite into two 0.15 thick layers of soil placed at the bottom of the Management Ponds. The care in construction of these layers, and the quality control required to insure the required hydraulic conductivity is uniformly achieved, will be challenging.

A fundamentally sound approach liner design would be to use a double liner with a leak detection layer, and with at least the upper liner constructed of synthetic material. This approach could reduce the seepage rate to approximately $1/10^{th}$ or less that of the proposed 2,800 m3/day. After mine closure, the seepage collected in the seepage collection layer could be passively treated in a wetland system constructed in the abandoned Tenas Management Pond.

SRK (2021b) also notes that the success of the liner in preventing seepage is important to dam safety. This is another reason the requirements for, and the design of, the liner need to be very conservative. A clay liner with a permeability requirement of 1E-10 m/s is too risky. A double liner system, with leak detection/collection, is warranted.

Background of the reviewer

David Chambers has 45+ years of experience in mineral exploration and development – 15 years of technical and management experience in the mineral exploration industry, and for the past 30+ years he has served as an advisor on the environmental effects of mining projects both nationally and internationally. He has Professional Engineering Degree in physics from the Colorado School of Mines, a Master of Science Degree in geophysics from the University of California at Berkeley, and is a registered professional geophysicist in California (# GP 972). Dr. Chambers received his Ph.D. in environmental planning from Berkeley. His recent research focuses on tailings dam failures, and the intersection of science and technology with public policy and natural resource management.

Sincerely;

David M. Chambers, Ph.D., P. Geop

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SRK 2021a, Tenas Project Dam Breach Analysis, SRK Consulting (Canada) Inc, April 15, 2021

SRK 2021b. Tenas Project – Management and Control Ponds Stability Assessment, SRK Consulting (Canada) Inc, April 22, 2021

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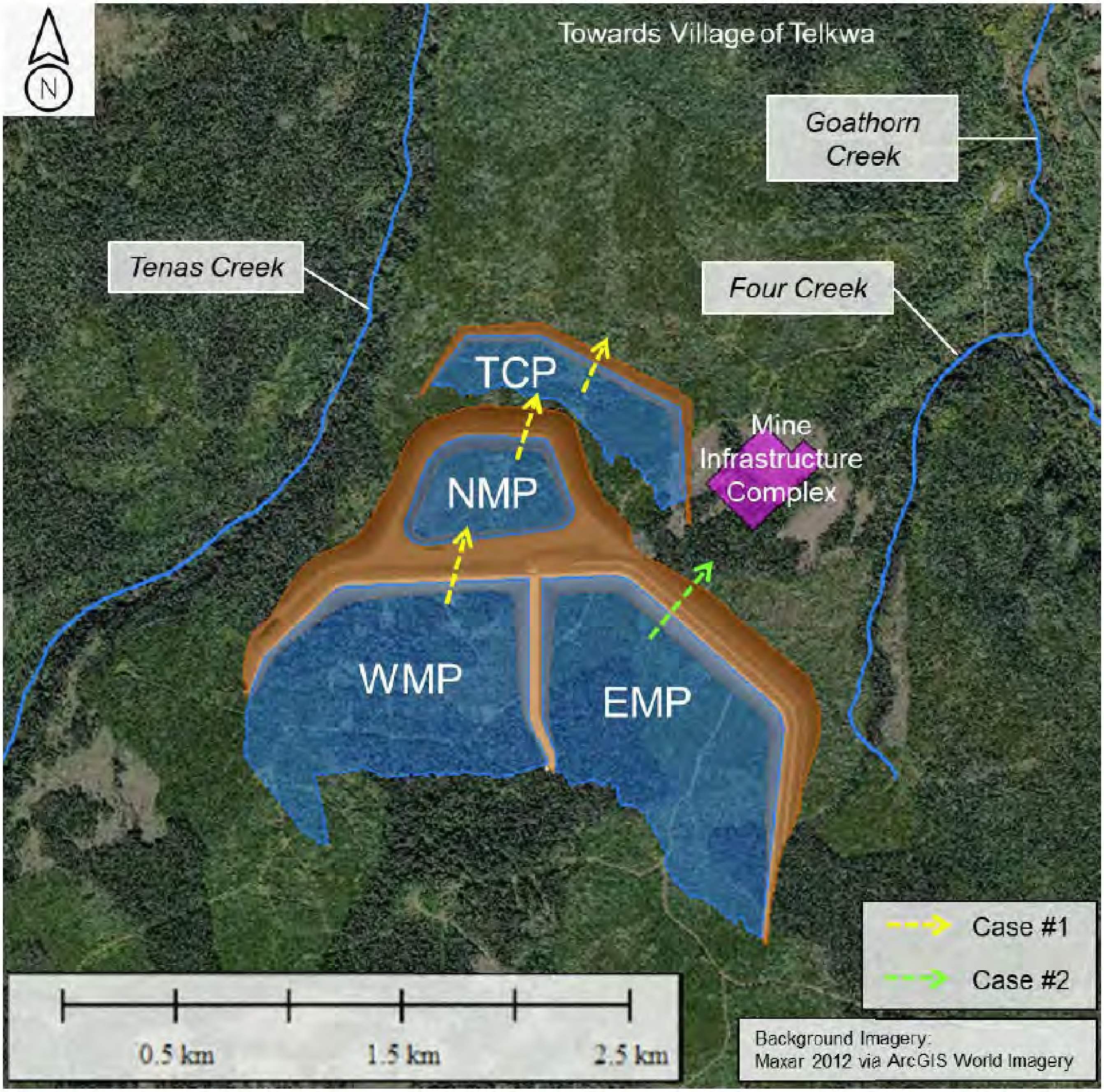
Quelopana 2019. Released Volume Estimation for Dam Break Analysis, Hugo Quelopana, Tailings 2019, 6th International Seminar on Tailings Management

UNEP 2020. United Nations Environment Assembly Resolution on Mineral Resource Governance, Elisa Tonda, Daniel M. Franks, and Angela Kariuki, Chapter VIII, Towards Zero Harm – A Compendium of Papers Prepared for the Global Tailings Review, Oberle, B., Brereton, D., Mihaylova, A. (eds.), 2020

Figure 1-2: Management and Control Pond Site Plan



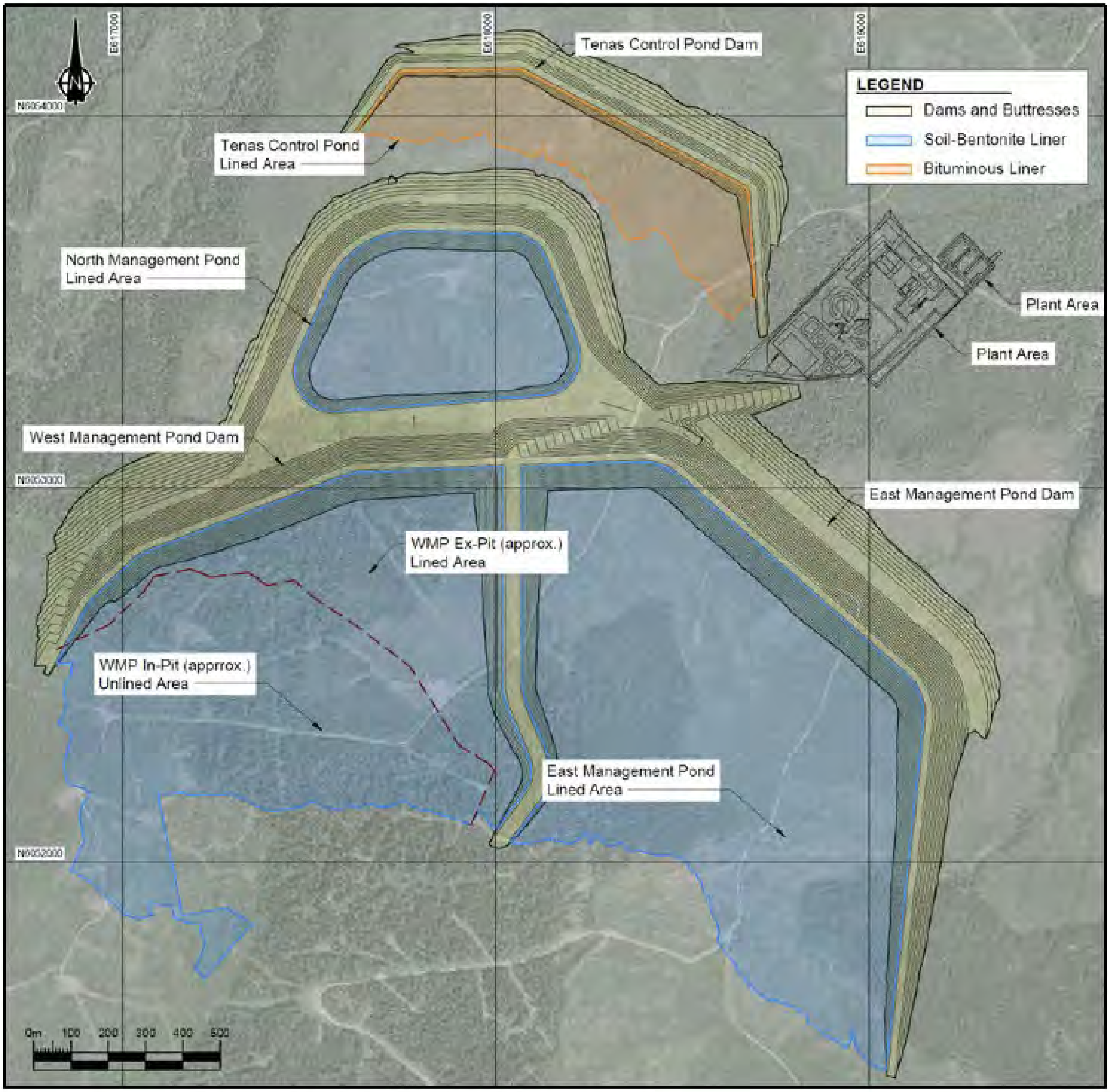


Figure 4: **Plan view of the lined surface areas of the Tenas Control Pond and PAG management ponds at the Tenas Project**

Table 3-1. Dam Classification

Source: Table 2-1 of CDA 2013

Dam class	Population at risk [note 1]	Incremental losses		
		Loss of life [note 2]	Environmental and cultural values	Infrastructure and economics
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definitions for population at risk:

None—There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary—People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent—The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

Note 2. Implications for loss of life:

Unspecified—The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Table 4-1. Target Levels for Flood Hazards, Standards-Based Assessments, Closure – Passive Care Phase

(Initial Consideration and Consultation Between Owner and Regulator)

Dam Classification	Annual Exceedance Probability – Floods (note 1)
Low	1/1,000
Significant	1/3 Between 1/1,000 and PMF (note 2)
High	2/3 Between 1/1,000 and PMF (note 2)
Very High	PMF (note 2)
Extreme	PMF (note 2)

Notes:

Acronyms: PMF, Probable Maximum Flood; AEP, annual exceedance probability

1. Simple extrapolation of flood statistics beyond 10[illegible] AEP is not acceptable.
2. PMF has no associated AEP.

Table 4-2. Target Levels for Earthquake Hazards, Standards-Based Assessments for Closure – Passive Care Phase

(Initial Consideration and Consultation Between Owner and Regulator)

Dam Classification	Annual Exceedance Probability – Earthquakes (note 1)
Low	1/1,000
Significant	1/2,475 (note 2)
High	1/2 Between 1/2,475 (note 2) and 1/10,000 AEP or MCE (note 3)
Very High	1/10,000 AEP or MCE (note 3)
Extreme	1/10,000 AEP or MCE (note 3)

Acronyms: MCE, Maximum Credible Earthquake; AEP, annual exceedance probability

Notes:

1. Mean values of the estimated range in AEP levels for earthquakes should be used. The earthquake(s) with the AEP as defined above is (are) then input as the contributory earthquake(s) to develop Earthquake Design Ground Motion (EDGM) parameters as described in Section 6.5 of *Dam Safety Guidelines* (CDA, 2013).
2. This level has been selected for consistency with seismic design levels given in the National Building Code of Canada.
3. MCE has no associated AEP.