PROFESSIONAL PRACTICE GUIDELINES



CIVIL AND TRANSPORTATION INFRASTRUCTURE

LEGISLATED DAM SAFETY REVIEWS IN BC

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PREFACE

These *Professional Practice Guidelines – Legislated Dam Safety Reviews in BC* were originally developed by Engineers and Geoscientists British Columbia to guide professional practice related to legislated Dam Safety Reviews in British Columbia (BC).

In 2013, Engineers and Geoscientists BC initially collaborated with the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (now the Ministry of Forests; FOR) to develop and publish *Professional Practice Guidelines - Legislated Dam Safety Reviews in BC*, Version 1.0. The original guidelines were written with the intention of guiding professional practice for legislated Dam Safety Reviews of water reservoir Dams pursuant to the *Dam Safety Regulation*. The BC Ministry of Energy, Mines, and Low Carbon Innovation (EMLI) provided assistance and support in applying the guideline content to mining Dams.

This current revision (2023) is intended to capture changes that have occurred with the introduction of the *Professional Governance Act* and the corresponding revised *Engineers and Geoscientists Regulation* and Bylaws of Engineers and Geoscientists BC, as well as updates to other applicable legislation and guidance documents. Changes in professional practice that have occurred since the last revision of these guidelines in 2016 are also addressed herein, with a focus on adequate documentation and reporting requirements. The objective of these guidelines is to provide clear expectations and obligations for professional Registrants when carrying out legislated Dam Safety Reviews, by introducing consistency and increased quality to Dam Safety Reviews and establishing roles and responsibilities for various parties involved. These guidelines also outline various methodologies for Dam safety analysis, address how to appropriately state findings and professional opinions, provide guidance on quality management processes, and cover the education, skillsets, training, and experience required to conduct Dam Safety Reviews.

In an ongoing effort to promote high standards in Dam Safety Reviews, FOR and EMLI have established a leadership role in working with Engineers and Geoscientists BC to revise these guidelines and have provided funding towards this current revision project.

These guidelines describe the expectations and obligations of professional practice in relation to the specific professional activity of legislated Dam Safety Reviews in BC to be followed at the time they were prepared. However, this is a living document that is to be revised and updated as required in the future, to reflect the developing state of practice.

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ABBREVIATIONS

ABBREVIATION	TERM
ALARP	As Low As Reasonably Practicable
BC	British Columbia
BCOGC	British Columbia Oil and Gas Commission
CDA	Canadian Dam Association
DEP	Dam Emergency Plan
EMLI	Ministry of Energy, Mines, and Low Carbon Innovation
EOR	Engineer of Record
ENV	Ministry of Environment and Climate Change Strategy
FOR	Ministry of Forests
GISTM	Global Industry Standard on Tailings Management
HSRC	Health Safety and Reclamation Code for Mines in British Columbia
ICMM	International Council on Mining and Metals
ICOLD	International Commission on Large Dams
IDF	Inflow Design Flood
ITRB	Independent Tailings Review Board
MAC	Mining Association of Canada
OMS	Operation, Maintenance, and Surveillance
TSF	Tailings storage facility
us	United States
WSA	Water Sustainability Act

DEFINED TERMS

The following definitions are specific to these guidelines. These words and terms are capitalized throughout the document.

TERM	DEFINITION
Bylaws	The <i>Bylaws</i> of Engineers and Geoscientists BC made under the <i>Professional Governance Act</i> .
CDA Dam Safety Guidelines	The Dam Safety Guidelines published by the Canadian Dam Association in 2007 and revised in 2013 and associated technical bulletins referenced in these guidelines.
Consequence Classification	The failure Consequence Classification of a Dam as determined by Schedule 1 of the <i>Dam Safety Regulation</i> (for water reservoir Dams), or the HSRC Guidance Document (for mining Dams under the <i>Mines Act</i>).
Dam	A barrier constructed for the purposes of enabling the storage or diversion of water, water containing other substances, fluid waste, or tailings, including all works which are incidental to or necessary for the barrier, as defined in the CDA <i>Dam Safety Guidelines</i> . See Section 1.4 for more information on applicability of this term.
Dam Owner	 The individual or company who is responsible for the safety of the Dam and engages a Qualified Professional Engineer to conduct a Dam Safety Review (usage within these Guidelines). In the <i>Dam Safety Regulation</i>, "Dam Owner" is a defined term and is used in a similar manner to its usage within these guidelines. In the <i>Mines Act</i>, "Owner" is a defined term. An Owner is a Dam Owner for mining Dams on a Mine. In the HSRC, the responsibility for DSR submittal is assigned to the Owner, agent, or manager.
Dam Safety Regulation	British Columbia Regulation B.C. Reg. 32/2023; o.c. 114/2016
Dam Safety Review	 A comprehensive, formal review of the safety assessment of a Dam. Within these guidelines, this defined term is used when this scope is legislated by a Regulatory Authority. For water reservoir Dams, a Dam Safety Review is legislated for Dams that have a Consequence Classification of high, very high, or extreme, as defined by the <i>Dam Safety Regulation</i>, in accordance with the requirements of Section 20 or Section 36 (4) of the <i>Dam Safety Regulation</i>. For mining Dams, Dam Safety Reviews are required in accordance with the HSRC.
Dam Safety Review Assurance Statement	The statement for submission, along with the Dam Safety Review report, to the Regulatory Authority, to fulfill the Dam Owner's obligations in accordance with Section 20 or Section 36 (4) of the <i>Dam Safety Regulation</i> (for water reservoir Dams), or the HSRC (for mining Dams). Two such assurance statements are attached as Appendices C1 and C2 to these guidelines.

TERM	DEFINITION
Dam Safety Review Report	A report prepared by the Qualified Professional Engineer for the Dam Owner, for submission to the Regulatory Authority in accordance with Section 20 or Section 36 (4) of the <i>Dam Safety Regulation</i> and Section 10.5.4. of the HSRC.
Deficiency	An actual or potential unacceptable Dam performance condition that has been confirmed, based on an assessment by reference to the BC <i>Dam Safety Regulation</i> , CDA <i>Dam Safety Guidelines</i> , HSRC, or other specified safety standard.
Engineering/Geoscience Professional(s)	Professional engineers, professional geoscientists, professional licensees engineering, professional licensees geoscience, and any other individuals registered or licensed by Engineers and Geoscientists BC as a "Professional Registrant" as defined in Part 1 of the Bylaws.
Engineer of Record	Means the same as defined in the Health, Safety, and Reclamation Code for Mines in British Columbia (2022) and associated guidance documents.
Engineers and Geoscientists BC	The Association of Professional Engineers and Geoscientists of the Province of British Columbia, also operating as Engineers and Geoscientists BC.
Established Good Practice	The current practices or understanding with respect to Dam safety governance, design, construction, operation, closure and/or management, expressed in the form of industry-accepted guidelines or technical standards, or as documented lessons learned from recent engineering failures or successful strategies which may not yet be incorporated into codes and standards.
Independent Tailings Review Board	Means the same as defined in the Health, Safety, and Reclamation Code for Mines in British Columbia (2022) and associated guidance documents.
Mine	As defined in the <i>Mines Act.</i>
Mine Manager	Means the same as defined in the <i>Mines Act</i> , Health, Safety, and Reclamation Code for Mines in British Columbia (2022) and associated guidance documents.
Mines Act	Mines Act R.S.B.C., 1996 c. 293 (Updated to 2020).
Non-Conformance	An identified situation where established procedures, systems and instructions are not being followed, or they are missing, inadequate, or inappropriate, and should be revised. These situations can be related to operational, maintenance, procedural, or surveillance aspects of Dam safety or relate to the information required to assess these as well as information regarding the design basis of the Dam when constructed in relation with Established Good Practice.
Professional Governance Act	Professional Governance Act [SBC 2018], Chapter 47.
Qualified Professional Engineer	An Engineering Professional responsible for carrying out the Dam Safety Review scope of work defined in these guidelines. A Qualified Professional Engineer must be a Registrant in good standing with Engineers and Geoscientists BC, and meet the requirements set out in Section 1.0.

TERM	DEFINITION
Reasonably Safe	Term used within these guidelines as a means to achieve the intent of the <i>Dam Safety Regulation</i> with respect to determining that a Dam is "safe". Determination that a Dam is Reasonably Safe is intended to mean a clear and independently verifiable demonstration that reasonable care has been taken in all aspects of the stewardship of the Dam with due consideration of the following:
	 the design, construction, surveillance, maintenance, operation and, where applicable, the removal from service or the closure of the Dam are carried out in accordance with Established Good Practice and, if not, whether the vulnerabilities associated with not meeting Established Good Practice are acceptably managed;
	 the assumptions made for analysis are well reasoned, supported by data and fully documented, and the risks associated with the key uncertainties in those assumptions are accounted for and mitigated;
	3. the condition and performance of the Dam are such that the Dam is expected to perform its function as intended in the design or as updated, including having the capacity to withstand the external loads commensurate with the Consequence Classification of the Dam;
	4. the surveillance and instrumentation monitoring program is sufficient to provide ongoing validation of design assumptions and expected performance predictions, or to detect potential deviations so as to prompt design modifications and/or mitigation measures as required;
	5. the Dam Owner has implemented all governance processes and Dam safety management measures that conform to established principles and approaches to safety management that are considered by the Regulatory Authority and the Qualified Professional Engineer to reflect Established Good Practice; and
	6. all applicable regulatory requirements related to Dam safety are met.
Registrant	Means the same as defined in Schedule 1, section 5 of the <i>Professional Governance Act</i> .
Regulatory Authority	The department within the British Columbia Ministry of Forests (FOR; for water reservoir Dams) or the British Columbia Ministry of Energy Mines and Low Carbon Innovation (EMLI; for mining Dams), depending upon the nature of the Dam involved, that is tasked with managing the regulatory requirements of Dam safety as established by statutes and regulations of British Columbia.
TSF Qualified Person	Means the same as defined in the Health, Safety, and Reclamation Code for Mines in British Columbia (2022) and associated guidance documents.

VERSION HISTORY

VERSION NUMBER	PUBLISHED DATE	DESCRIPTION OF CHANGES
4.0	September 18, 2023	Major revisions to address changes under the <i>Professional Governance Act</i> , associated Regulations and Bylaws, as well as changes intended to improve quality and consistency of Dam Safety Reviews, and updated mining Dam applications.
3.0	October 2016	Minor revision.
2.0	March 2014	Major revision to include amendments to the <i>Dam Safety Regulation</i> , and to address Dam Safety Reviews required by permit conditions under the <i>Mines Act</i> (mining Dams).
1.0	July 2013	Initial version.

1.0 INTRODUCTION

Engineers and Geoscientists BC is the regulatory and licensing body for the engineering and geoscience professions in British Columbia (BC). To protect the public, Engineers and Geoscientists BC establishes, monitors, and enforces standards for the qualification and practice of its Registrants.

Engineers and Geoscientists BC provides various practice resources to its Registrants to assist them in meeting their professional and ethical obligations under the *Professional Governance Act* and the Bylaws of Engineers and Geoscientists BC (Bylaws). The practice resources include professional practice guidelines, which are produced under the authority of Section 7.3.1 of the Bylaws and are aligned with Principle 4 of the Code of Ethics.

Engineers and Geoscientists BC publishes professional practice guidelines on specific professional activities where additional guidance is deemed necessary. They are written by subject matter experts and reviewed by stakeholders before publication. Each professional practice guideline establishes the expectations and obligations of professional practice that all Engineering/Geoscience Professionals are expected to have regard for.

Having regard for professional practice guidelines means that Engineering/Geoscience Professionals must follow established and documented procedures to stay informed of, be knowledgeable about, and meet the intent of any professional practice guidelines related to their area of practice. By carefully considering the objectives and intent of a professional practice guideline, an Engineering/Geoscience Professional can then use their professional judgment when applying the guidance to a specific situation. Any deviation from the guidelines must be documented and a rationale provided. Where the guidelines refer to professional obligations specified under the *Professional Governance Act*, the Bylaws, and other regulations/legislation, Engineering/Geoscience Professionals must understand that such obligations are mandatory.

These *Professional Practice Guidelines – Legislated Dam Safety Reviews in BC* provide guidance on professional practice for individuals and firms who are involved in carrying out, requesting, reviewing, or receiving Dam Safety Reviews as required by legislation in BC.

Dams in BC may be owned by diverse parties including private owners, utilities, mining companies, pulp and paper companies, and various levels of government, including First Nations. Provincial legislation requires that Dam Safety Reviews be carried out by a professional engineer qualified in Dam safety analysis. The Qualified Professional Engineer (as defined within these guidelines) is required to provide a professional opinion regarding the safety status of a Dam; these guidelines provide Dam Safety Review Assurance Statements (Appendix C) to assist the Qualified Professional Engineer in providing this professional opinion.

Documents referenced throughout this guideline are:

- The Canadian Dam Association (CDA)'s *Dam* Safety Guidelines and associated Technical Bulletins
- Bulletins and guidelines issued by the International Commission on Large Dams (ICOLD)
- Bulletins and guidelines issued by the Global Industry Standard on Tailings Management (GISTM)

- Bulletins and guidelines issued by the International Council on Mining and Metals (ICMM)
- Bulletins and guidelines issued by the Mining Association of Canada (MAC)

The latest versions of these documents are resources which provide current practices for the determination of the adequacy of the design and physical performance capacity of a Dam, the management of the operational integrity of a Dam, and the closure of a Dam (where applicable).

1.1 PURPOSE OF THESE GUIDELINES

This document provides guidance on professional practice to individuals and firms who are involved in carrying out, requesting, reviewing, or receiving legislated Dam Safety Reviews in BC. The purpose of these guidelines is to provide a common approach for carrying out a range of professional activities related to this work.

Following are the specific objectives of these guidelines:

- Describe the expectations and obligations of professional practice that Engineering/Geoscience Professionals are expected to have regard for in relation to Dam Safety Reviews by:
 - specifying tasks and/or services that Engineering/Geoscience Professionals should complete when preparing Dam Safety Review Reports,
 - referring to professional obligations under the *Professional Governance Act*, the Bylaws, and other regulations/legislation, including the primary obligation to protect the safety, health, and welfare of the public and the environment; and
 - describing the established standards of practice in this area, including identifying various concepts that can be used in risk-

informed decision making, and providing guidance to promote consistency in Dam Safety Review Reports.

- Describe the roles and responsibilities of the various participants/stakeholders involved in Dam Safety Reviews.
- Define the skill sets, training, and experience required to carry out these professional activities.
- Provide guidance on the use of Dam Safety Review Assurance Statements, so the appropriate considerations have been addressed (both regulatory and technical Dam safety management practices) for the specific professional activities.
- Provide guidance on how to meet the quality management requirements under the *Professional Governance Act* and the Bylaws when carrying out the professional activities identified in these professional practice guidelines.
- Contains the Dam Safety Review Assurance Statement for water reservoir Dams and is to be submitted in conjunction with the Dam Safety Review Reports for the purposes of the *Dam Safety Regulation*.
- Contains the Dam Safety Review Assurance Statement for mining Dams and is to be submitted with the Dam Safety Review Reports as defined in the *Health, Safety, and Reclamation Code for Mines in British Columbia* (HSRC).

1.2 ROLE OF ENGINEERS AND GEOSCIENTISTS BC

Engineers and Geoscientists BC has the statutory duty to serve and protect the public interest as it relates to the practice of professional engineering and professional geoscience, including regulating the conduct of Engineering/Geoscience Professionals. Engineers and Geoscientists BC is responsible for establishing, monitoring, and enforcing the standards of practice, conduct, and competence for Engineering/Geoscience Professionals. One way that Engineers and Geoscientists BC exercises these responsibilities is by publishing and enforcing the use of professional practice guidelines, as per Section 7.3.1 of the Bylaws.

Guidelines are meant to assist Engineering/Geoscience Professionals in meeting their professional obligations. As such, Engineering/Geoscience Professionals are required to be knowledgeable of, competent in, and meet the intent of professional practice guidelines that are relevant to their area of practice. Engineering/Geoscience Professionals must exercise professional judgment when providing professional services; application of these guidelines will vary depending on the circumstances.

The writing, review, and publishing process for professional practice guidelines at Engineers and Geoscientists BC is comprehensive. These guidelines were prepared by subject matter experts, reviewed at various stages by a formal review group, and the final draft underwent a thorough consultation process with various advisory groups and divisions of Engineers and Geoscientists BC. These guidelines were then approved by Engineers and Geoscientists BC's Board and, prior to publication, underwent final editorial and legal reviews.

These guidelines may be used to assist in defining the scope and terms of reference of an agreement between a Qualified Professional Engineer and a Dam Owner. Registrants must comply with the expectations and obligations within these guidelines when delivering the referenced scopes of work, regardless of compensation or financial or technical resources.

1.3 INTRODUCTION OF TERMS

See the <u>Defined Terms</u> Section at the front of the document for a full list of definitions specific to these guidelines.

1.3.1 REASONABLY SAFE

Within these guidelines, determination that a Dam is Reasonably Safe is intended to mean that there is a clear and independently verifiable demonstration that reasonable care has been taken in all aspects of the stewardship of the Dam, with due consideration of the following:

- the design, construction, surveillance, maintenance, operation and, where applicable, the removal from service or the closure of the Dam are carried out in accordance with Established Good Practice, and, if not, whether the vulnerabilities associated with not meeting Established Good Practice are acceptably managed;
- the assumptions made for analysis are well reasoned, supported by data, and fully documented, and the risks associated with the key uncertainties in those assumptions are accounted for and mitigated;
- the condition and performance of the Dam are such that the Dam is expected to perform its function as intended in the design or as updated, including having the capacity to withstand the external loads commensurate with the Consequence Classification of the Dam;
- the surveillance and instrumentation monitoring program is sufficient to provide ongoing validation of design assumptions and expected performance predictions, or to detect potential deviations so as to prompt design modifications and/or mitigation measures as required;
- 5. the Dam Owner has implemented all governance processes and Dam safety management measures that conform to established principles and approaches to safety management that are considered by the Regulatory Authority and the Qualified Professional Engineer to reflect Established Good Practice; and
- 6. all applicable regulatory requirements related to Dam safety are met.

Additional context and details are provided in Section <u>3.1.2</u>.

1.4 SCOPE AND APPLICABILITY OF THESE GUIDELINES

These guidelines provide guidance on professional practice for Qualified Professional Engineers who carry out Dam Safety Reviews and prepare reports in response to Section 20 of the *Dam Safety Regulation*. These guidelines also apply to Dam Safety Reviews for mining Dams prepared in response to requirements outlined in the HSRC under the *Mines Act*.

A Dam is defined herein as a barrier constructed for the purposes of enabling the storage or diversion of water, water containing other substances, fluid waste, or tailings, including all works which are incidental to or necessary for the barrier, as defined in the CDA *Dam Safety Guidelines*.

- For water reservoir Dams, these professional practice guidelines apply to Dams:
 - whose size equals or exceeds the size given in Section 2 of the *Dam Safety Regulation*, and
 - have a Consequence Classification of "high", "very high", or "extreme".
- For mining Dams, these professional practice guidelines apply to Dams (as defined by the HSRC) that:
 - exist on a Mine to prevent uncontrolled release of water, slurry, or solids, and
 - may be used for tailings, contact water, sludge, or sediment storage.

Overlapping authority related to freshwater reservoir Dams on Mine sites are regulated per the Memorandum of Understanding *Regulation of Impoundments and Diversions on a Mine Site* (EMLI, FOR, and ENV 2014).

It is recognized that Dam Safety Reviews may be carried out for purposes other than in response to the

above-referenced legislation, such as when preparing for a modification of a Dam, or as a result of newly identified Dam safety concerns. Although these guidelines were not intended to address such nonlegislated Dam Safety Reviews, the information may be relevant to the preparation of such non-legislated Dam Safety Review Reports.

These professional practice guidelines may also be used as a reference document for carrying out periodic safety reviews not specifically defined as Dam Safety Reviews. These safety reviews may be carried out for facilities not referred to as Dams, or for facilities that do not have an associated Dam but may have similar requirements for a periodic safety review under various regulatory frameworks.

Regulatory Authorities may use this document as a reference when requesting these periodic safety reviews, as needed.

Similarly, some Dams and fluid-retaining structures may not be captured in the legislation discussed in Section <u>1.1</u>.

There are several other Dam-like structures in BC that are not regulated by the Ministry of Forests (FOR) nor the Ministry of Energy, Mines, and Low Carbon Innovation (EMLI). These include contaminated water facilities, stormwater facilities, wastewater storage facilities, and debris flow containment structures. However, even in the absence of other legislation or guidance, a local authority may still require that the guidance on professional practice presented in these guidelines be followed, and Engineering/Geoscience Professionals should consider these guidelines in those cases.

These guidelines are not intended to provide technical or systematic instructions for how to carry out a Dam Safety Review; rather, these guidelines outline considerations and identify certain obligations that apply when carrying out these activities. Qualified Professional Engineers must exercise professional judgment when providing professional services; application of these guidelines will vary depending on the circumstances. Dam Safety Reviews, as documented in these guidelines, are not intended to address occupational health and safety requirements in relation to Dams, although where a serious concern is identified, it must be brought to the attention of the Dam Owner.

A Qualified Professional Engineer's decision not to follow one or more aspects of these guidelines does not necessarily represent a failure to meet professional obligations. For information on how to appropriately depart from the practice guidance within these guidelines, refer to the *Quality Management Guides – Guide to the Standard for the Use of Professional Practice Guidelines* (Engineers and Geoscientists BC 2023a), Section 3.4.2.

These guidelines are influenced by current provincial legislation, current case law, advances in knowledge, and evolution of professional practice in BC, as well as the evolution of practice outside of BC. As such, they are subject to periodic updates.

1.5 ACKNOWLEDGEMENTS

Engineers and Geoscientists BC assembled a team of subject matter experts from government and the engineering community to prepare and review these guidelines. Authorship and review of these guidelines does not necessarily indicate the individuals and/or their employers endorse everything in these guidelines.

Engineers and Geoscientists BC thanks the authors and reviewers of the original document, as well as the authors and reviewers of this revision, for their time and effort in sharing their knowledge and experience.

Engineers and Geoscientists BC also thanks the Ministry of Forests, and the Ministry of Energy, Mines, and Low Carbon Innovation for their input, technical expertise, and funding support, as well as their endorsement of these guidelines.

2.0 ROLES AND RESPONSIBILITIES

2.1 REGULATORY CONTEXT

Legislation in British Columbia pertinent to Dam Safety Reviews includes:

Water Reservoir Dams:

- the *Water Sustainability Act* and *Dam Safety Regulation* (32/2023), with oversight provided by the Ministry of Forests (FOR)
 - Water storage Dams in the mining sector are regulated under this framework.
 - Water storage Dams in the oil and gas sector in BC are regulated by the BC Oil and Gas Commission (BCOGC) through a Memorandum of Understanding with FOR.

Mining Dams (including tailings Dams):

- the Mines Act and Health Safety and Reclamation Code for Mines in British Columbia (HSRC) with oversight provided by the Ministry of Energy, Mines and Low Carbon Innovation (EMLI).
 - All mining Dams on Mine sites including but not limited to tailings, contact water, sediment, and sludge storage Dams are regulated by EMLI per the HSRC.

For additional details on the regulatory framework for water reservoir Dams, refer to Appendix A. For additional details on the regulatory framework for mining and tailings Dams, refer to Appendix B.

The Ministry of Environment and Climate Change Strategy (ENV) is responsible for the protection of human health and the environment from adverse effects of Mine wastes or impoundments, the use of hazardous materials, and the management of contaminated sites. ENV is not responsible for regulating the structural safety and integrity of impoundments at Mine sites, per the Memorandum of Understanding *Regulation of Impoundments and Diversions on a Mine Site* (EMLI, FOR, and ENV 2014).

2.1.1 GUIDANCE DOCUMENTS

While the legislation listed in the previous section takes precedence in BC, the *Dam Safety Guidelines* (CDA 2013) and associated technical bulletins provide guiding principles for the safe management of Dams. The *CDA Technical Bulletin: Dam Safety Reviews* (CDA 2016) is the principal technical document in Canada that guides the conduct of Dam Safety Reviews. The *CDA Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* (CDA 2014) provides additional context related to mining Dams. These professional practice guidelines are intended to be complimentary to the other published guidance documents listed here and provide additional content to professional practice in BC.

While not a part of legislative requirements, the Professional Practice Guidelines - *Site Characterization for Dam Foundations in BC* (Engineers and Geoscientists BC 2016) and the Practice Advisory – *Determining Dam Hydrologic Loading* (Engineers and Geoscientists BC 2022) provide information specific to Dam design in BC that should be considered by a Qualified Professional Engineer performing a Dam Safety Review.

With respect to reconciliation and Indigenous knowledge, the United Nations Declaration of Rights of Indigenous People applies.

With respect to mining Dams, GISTM and ICMM guidance identify requirements for meaningful recognition and engagement of Indigenous and project-affected people throughout the tailings facility lifecycle, and in building the knowledge base and decisions that may have a bearing on public safety and the integrity of a tailings facility. MAC has similar guidance regarding indigenous engagement as part of the communities of interest.

2.2 COMMON FORMS OF PROJECT ORGANIZATION

Dam Owners (including their agents) are required to comply with legislation by having a Qualified Professional Engineer carry out periodic Dam Safety Reviews. Typically, the Dam Owner and the Qualified Professional Engineer establish an agreement for professional services between the two parties. The Qualified Professional Engineer may undertake the Dam Safety Review alone, or act as the lead Qualified Professional Engineer in a multi-disciplinary team of Engineering Professionals and/or other qualified persons.

The Dam Owner should be aware that the Qualified Professional Engineer is obligated to identify safety concerns in the Dam Safety Review Report and may conclude that the Dam is not Reasonably Safe.

2.2.1 COMMUNICATION AND COORDINATION

Dam Safety Reviews are part of a larger Dam safety management framework. Guidance provided by the CDA (in CDA Guidelines and CDA Technical Bulletins) gives an overview of the role of Dam Safety Reviews within this larger framework, and also indicates the responsibilities of each party at each stage.

Communication between the Dam Owner, their representatives, and the Qualified Professional Engineer is essential for the successful completion of the Dam Safety Review.

The various engineers within a multi-discipline team review must communicate and coordinate with each other appropriately, as well as with other specialists or qualified persons, to ensure project objectives and appropriate professional practice requirements are being met. The role of the lead Qualified Professional Engineer in a multi-discipline team review is key to ensuring effective and efficient communication and coordination is taking place on a project.

2.3 RESPONSIBILITIES

The following is a description of the project participants involved in Dam Safety Reviews and their respective responsibilities.

2.3.1 DAM OWNER

The Dam Owner is ultimately responsible for the safe management of a Dam, per section 5 of the *Dam Safety Regulation*. As per section 22 of the *Dam Safety Regulation*, there may be multiple Dam Owners for a Dam, but the division of responsibilities with respect to Dam Safety Reviews remains similar.

The Dam Owner should be aware of the legislative requirements associated with the operation and maintenance of the Dam in question, as set out in the *Dam Safety Regulation* and/or the HSRC and the associated guidance documents for each. It is the Dam Owner's responsibility to contact the appropriate Regulatory Authority to clarify any uncertainties about their legislative responsibilities.

The Dam Owner is generally responsible for:

- The overall safety and safe management of the Dam.
- Initiating a Dam Safety Review at a frequency established in the *Dam Safety Regulation*, HSRC, or other applicable regulatory framework.
- Understanding the current Consequence Classification of the Dam and requirements set out in Section 2 of the *Dam Safety Regulation* or the HSRC under the *Mines Act.* This includes understanding the required minimum frequency for undertaking a Dam Safety Review.
- Initiating the Dam Safety Review and selecting Qualified Professional Engineer(s) to conduct the appropriate type of Dam Safety Review.

- Providing the necessary background information for the Qualified Professional Engineer to conduct the Dam Safety Review, including details of the Dam safety management program that is in place and being implemented.
- Providing the required access to the Dam and all related facilities and making staff available for necessary interviews and operations, as requested, to enable the Qualified Professional Engineer to conduct the Dam Safety Review.
- Reviewing and understanding the Dam Safety Review Report including the conclusions and recommendations and discussing the findings of the Dam Safety Review Report with the Qualified Professional Engineer.
- Submitting the Dam Safety Review Report to the appropriate Regulatory Authority.
- Addressing the recommendations from the Dam Safety Review Report in a timely manner.

For mining Dams specifically, under the *Mines Act* and the HSRC, the Owner must appoint a Mine Manager to be responsible for compliance with regulatory requirements on site. As such, the Mine Manager is ultimately responsible for the safety of each Tailings Storage Facilities (TSF) and other mining Dams on the site.

If the Dam Safety Review Report concludes that the Dam is not safe or has Deficiencies that may pose a potential safety hazard, the Dam Owner must prepare a plan that sets out actions required to rectify the potential safety hazard(s). The plan must be informed by the conclusions and recommendations of the Dam Safety Review Report, should provide a timeframe for the work to be completed, and include any mitigative action necessary to reduce the risk to acceptable levels until the Deficiencies have been rectified.

2.3.2 QUALIFIED PROFESSIONAL ENGINEER

The Dam Safety Review must be carried out by a Qualified Professional Engineer, or a multidisciplinary team led by a Qualified Professional Engineer. For additional information on qualifications of the Qualified Professional Engineer, refer to Section <u>5.0</u>. The Qualified Professional Engineer is responsible for the final Dam Safety Review Report, the overall quality of the work, and completion of the Dam Safety Review Assurance Statement.

The Qualified Professional Engineer's responsibilities include:

- Making all reasonable attempts to obtain from the Dam Owner and their representatives, all relevant information related to the Dam Safety Review and, if necessary, assisting the Dam Owner in obtaining relevant information.
- Engaging with appropriate parties, such as operators, the Engineer of Record (EOR), and Tailings Storage Facility (TSF) Qualified Person, as applicable, during the Dam Safety Review.
- Conducting the Dam Safety Review in compliance with applicable legislation and following Established Good Practice, including these professional practice guidelines; the guiding principles in the CDA *Dam Safety Guidelines* and associated CDA technical bulletins; other relevant guidance that is available through International Commission on Large Dams (ICOLD), Global Industry Standard on Tailings Management (GISTM), International Council on Mining and Minerals (ICMM), Mining Association of Canada (MAC); and any other authoritative industry publications as appropriate.
- Determining whether the Dam has been safely designed, constructed, operated, and closed (if applicable), and determine if any actions are required to make the operations Reasonably Safe.
- Notifying the Dam Owner as soon as reasonably possible of any serious Deficiencies or hazardous conditions that pose an imminent or near-term threat to the safety of the Dam, and notifying the appropriate Regulatory Authority in cases where the Dam Owner is reluctant or unwilling to address these issues (refer to Section 2.3.2.1).

- Notifying the Dam Owner if specialty services or changes in scope of work are required in the near future, and of associated changes to the original agreement related to carrying out the Dam Safety Review.
- Identifying information gaps including any relevant information/materials regarding the Dam that are not available and the resulting assumptions made where there is a lack of information.
- Writing the Dam Safety Review Report in a clear, concise, logical, and complete manner (see Section <u>3.4</u>) and confirming that the preparation of the Dam Safety Review Report follows Engineers and Geoscientists BC's quality management requirements (see Section <u>4.0</u>).
- Ensuring conclusions are supported by the appropriate level of analysis and a clear rationale and evidence, and that any assumptions made are clearly stated along with their limitations and confidence limits, where appropriate.
- Ensuring summaries and data sources of all design calculations are provided in support of the technical analysis and are similarly presented in a clear and concise manner.
- Providing a statement in the Dam Safety Review Report that the conclusions and recommendations contained in the Dam Safety Review Report are valid for the current condition and life cycle of the Dam and the current overall environment of the Dam system, and include a time frame for the statement of the conclusions and recommendations (including climate change impacts, as addressed in Section <u>3.3.4</u>).
 - In the case of Mining Dams that are being continually raised (i.e., operated and constructed concurrently), the statement should also include a summary of the Qualified Professional Engineer's understanding of key operational changes that the Dam Owner expects to occur before the next Dam Safety Review (e.g., Mine plan, tailings plan, life cycle phase), and provide

recommendations for managing those operational changes as they arise (refer to Section <u>3.3.3</u>);

- Submitting a draft Dam Safety Review Report to the Dam Owner for discussion followed by an authenticated (signed, sealed, and dated) Dam Safety Review Report, including a completed Dam Safety Review Assurance Statement.
- Providing follow-up and response to questions from the Dam Owner and/or the Regulatory Authority regarding the Dam Safety Review, the Dam Safety Review Report, and/or the Dam Safety Review Assurance Statement.

2.3.2.1 Application of the Engineers and Geoscientists BC Code of Ethics in Dam Safety Reviews

Registrants are required to adhere to the Engineers and Geoscientists BC Code of Ethics, including in particular (but not limited to) the following provisions:

- Principle 1: hold paramount the safety, health, and welfare of the public, including the protection of the environment and the promotion of health and safety in the workplace;
- **Principle 7:** provide professional opinions that distinguish between facts, assumptions, and opinions;
- Principle 9: report to Engineers and Geoscientists BC and, if applicable, any other appropriate authority, if the Registrant, on reasonable and probable grounds, believes that:
 - the continued practice of a regulated practice by another Registrant or other person, including firms and employers, might pose a risk of significant harm to the environment or to the health or safety of the public or a group of people; or
 - a Registrant or another individual has made decisions or engaged in practices which may be illegal or unethical; and

 Principle 10: present clearly to employers and clients the possible consequences if professional decisions or judgments are overruled or disregarded.

All Registrants must especially be aware of their "duty to report" (Code of Ethics Principle 9 and section 58 of the *Professional Governance Act*) when participating in Dam Safety Reviews. Registrants must report to Engineers and Geoscientists BC (and, if applicable, any other appropriate authority) if there are reasonable and probable grounds to believe that circumstances or situations may pose a risk of significant harm to the environment or to the health or safety of the public or are illegal or unethical. Registrants must also understand their obligations to communicate any hazardous conditions identified during the Dam Safety Review to the Dam Owner to allow them to exercise their obligations under appropriate legislation.

With respect to the results of the Dam Safety Review, the Qualified Professional Engineer must:

- advise the Dam Owner in writing of the potential consequences of the Dam Owner's actions or inactions, and
- consider whether an unresolved situation (such as a hazardous condition) warrants notifying Engineers and Geoscientists BC, Dam operators or agents, and/or the Regulatory Authority, including communications of the Dam Owner's actions or inactions.

The Qualified Professional Engineer must first confirm that there are reasonable and probable grounds to believe the problem or hazardous condition exists and that possible consequences have been assessed (e.g., gather relevant material to support their assessment of the situation). If the Qualified Professional Engineer is unsure of whether they should report, they may seek advice from Engineers and Geoscientists BC. The Qualified Professional Engineer must discern who to inform and must promptly tell the appropriate Regulatory Authority about the problem, its consequences, and recommendations that have been provided to the Dam Owner for remedial action. The Qualified Professional Engineer must then follow-up to see that action is being taken. Additional information on duty to report can be found in the Guide to the Code of Ethics (Engineers and Geoscientists BC 2021).

2.3.2.2 Multi-discipline Team Review

The Dam Safety Review may be led by a Qualified Professional Engineer and carried out by a team of appropriately qualified Engineering/Geoscience Professionals for the various disciplines involved. The Dam Safety Review may also incorporate stand-alone analyses, studies, or reports completed by appropriately qualified Engineering/Geoscience Professionals, and/or other qualified persons.

In these situations, the lead Qualified Professional Engineer coordinates the work carried out by the other Engineering/Geoscience Professionals. It is the responsibility of the lead Qualified Professional Engineer to determine that the Dam is reviewed as an overall system, that Engineering/Geoscience Professionals with the appropriate qualifications and experience are engaged on the team, and that the Dam Safety Review is complete for its intended purpose. The lead Qualified Professional Engineer is responsible for ensuring proper coordination occurs between the various members of the multidisciplinary team.

In the case of a multi-discipline team review, the lead Qualified Professional Engineer must authenticate the Dam Safety Review Assurance Statement and take professional responsibility for the coordination aspects of the Dam Safety Review. Individual Engineering/Geoscience Professionals responsible for each discipline must authenticate the portions of the Dam Safety Review Report for their specific disciplines and qualify the extent of their responsibilities.

Stand-alone analyses, studies, or reports that are conducted to support or inform aspects of the Dam Safety Review work do not need to be completed under the direct supervision of the Qualified Professional Engineer if another appropriately qualified Engineering/Geoscience Professional is taking professional responsibility for the stand-alone work. The Qualified Professional Engineer is responsible for reviewing the work of others that inform the Dam Safety Review and for coordinating how this work is incorporated into the Dam Safety Review itself.

2.3.3 RESPONSIBLE PERSON

The following section introduces the concept of a responsible person, which is a role that is captured in the regulatory framework for mining Dams (via the Mine Manager and TSF Qualified Person) but not for water reservoir Dams.

2.3.3.1 Water Reservoir Dams

For water reservoir Dams, there is currently no definitive term or designation for a responsible person – a single role designating professional responsibility for the safe design, construction, operation and closure of a Dam. Instead, in accordance with the *Dam Safety Regulation*, the Dam Owner is the only entity responsible for the ongoing safety assurance of the Dam. Within this framework, the Dam Owner may engage a qualified person or company, or appoint one or more Engineering Professionals from within their own staff to carry out ongoing professional activities while retaining responsibility for the safety and safe management of the Dam. This qualified person or company may be tasked with:

- Preparation and maintenance of the Operation, Maintenance, and Surveillance (OMS) Manual as required by the *Dam Safety Regulation* Section 8.
- Preparation, maintenance, implementation, and improvement of the surveillance plan, with consideration of factors such as consequences, failure modes, performance indicators, regulatory requirements, and Dam Owner policies.

- Provision of continuous assessment of the performance, including timely identification of conditions which might threaten Dam safety, and reporting of hazardous conditions and provision of follow-up action as appropriate to protect public safety.
- Preparation of or participation in the development and maintenance of Dam Emergency Plans (DEP). Development of enhanced surveillance and response plans when required to manage identified risks, and carry out duties as required for emergency response to delay or to prevent dam failure.
- Preparation of any annual reports on the safety of each Dam for submission to the Regulatory Authority, as required.

It is important to note that these activities are beyond the scope of carrying out a Dam Safety Review, but will be reviewed as part of the Dam Safety Review.

2.3.3.2 Mining Dams

For mining Dams under the *Mines Act* and the HSRC, the Owner must appoint a *Mine Manager* to be responsible for compliance with regulatory requirements on site. The HSRC requires the *Mine Manager* to designate a person to fulfil the role of the *Tailings Storage Facility* (*TSF*) *Qualified Person*, ensure that each TSF has an *Engineer of Record* (EOR), and ensure that an *Independent Tailings Review Board (ITRB)* has been convened and fulfils its mandate.

The two distinct roles that are particularly relevant for Dam Safety Reviews are the EOR and the TSF Qualified Person, who are required to undertake key Dam safety related activities, as listed in Sections 2.3.3.2.1 and 2.3.3.2.2. The Qualified Professional Engineer should discuss these roles with the Dam Owner as part of their review of the following activities carried out by the EOR and the TSF Qualified Person.

2.3.3.2.1 Engineer of Record

The EOR is an integral part of risk management for mining Dams. Under the HSRC, the EOR is defined as "a qualified professional, [who] has professional responsibility for assuring that a tailings storage facility or dam has been designed and constructed in accordance with the applicable guidelines, standards and regulations". The EOR must be designated before construction of a TSF or Dam is underway.

The EOR is responsible for:

- determining the Consequence Classification for the TSF or Dam in consideration of the HSRC and associated guidance;
- determining the seismic and flood design criteria for the TSF and Dams in accordance with the HSRC;
- if the calculated static stability factor of safety is less than 1.5, submitting justification for the selected factor of safety to the Mine Manager, who will need to obtain authorization from the chief permitting officer prior to construction;
- if the overall downstream slope of the TSF is steeper than 2H:1V, submitting justification for the selected design slope to the Mine Manager, who will need to obtain authorization from the chief permitting officer prior to construction;
- determining and reviewing the quantifiable performance objectives and monitoring frequencies for the TSF and Dams, in conjunction with the TSF Qualified Person;
- reviewing the Dam OMS Manual for adequacy;
- conducting and reporting on the Annual Dam Safety Inspection;
- reporting safety issues related to the Dam in accordance with the HSRC;
- ensuring that the TSF or Dam is designed and constructed in accordance with the Established Good Practice and applicable regulations, statutes, guidelines, codes, and standards;

- providing design continuity and ongoing technical support to the Dam Owner with respect to Dam safety issues over the life of the Dam;
- participating in Dam Safety Reviews and risk assessments; and
- participating in the implementation of the EOR succession plan.

The EOR must be clearly identified by the Dam Owner and must have accepted these responsibilities. Whether the EOR is part of the Dam Owner's organization or is contracted externally, the EOR must have the authority and independence to ensure that safety assessments and measures are not compromised by operational constraints. The EOR is required to notify the Mine Manager in writing of any unresolved safety issues that compromise the integrity of a TSF (EMLI 2022).

If the EOR is a consultant, this individual should be supported by a firm that has Dam safety professionals and specialists who can provide the necessary support and oversight. The EOR cannot be a firm.

The EOR must be separate from the Qualified Professional Engineer who carries out the Dam Safety Reviews. Dam Safety Reviews should be carried out by an independent third party who has not previously been involved as the EOR for the facility and has not otherwise been involved with the design, construction, or operations of the Dam. Similarly, consecutive Dam Safety Reviews on the same facility should not be completed by the same Qualified Professional Engineer.

This requirement applies to both individuals and firms per the HSRC Guidance Document. However, the EOR must be engaged during the Dam Safety Review process and must review all Dam Safety Review Reports.

2.3.3.2.2 TSF Qualified Person

Under the HSRC, the *TSF Qualified Person* is designated by the Mine Manager for safe management of all tailings storage facilities.

The responsibilities of the TSF Qualified Person (as defined in the HSRC and associated guidance) are:

- developing and implementing the tailings and water management plans for the TSF;
- coordinating the design, construction, and overall management of the TSF on the site with the EOR as well as internal and external resources;
- developing a succession plan for the EOR in conjunction with the EOR;
- implementing training programs for tailings and water management activities;
- implementing the surveillance, inspection, monitoring, and maintenance plan, as outlined in the OMS manual;
- providing quantifiable performance objectives for operational and maintenance activities for inclusion in the OMS Manual, and
- reporting the status and performance of the tailings management system to the Mine Manager.

2.3.4 REGULATORY AUTHORITY

The Regulatory Authority is the department within the appropriate government ministry tasked with governing the regulatory requirements of Dam safety.

For water reservoir Dams, this is the Ministry of Forests (FOR), which is responsible for the status and regulations of the *Dam Safety Regulation* under the *Water Sustainability Act*. Details of the regulatory requirements for water reservoir Dams are presented in Appendix A.

For mining Dams, this is the Ministry of Energy Mines, and Low Carbon Innovation (EMLI), which is responsible for the status and regulations of the *Mines Act*. Details of the regulatory requirements for mining Dams are presented in Appendix B.

2.3.4.1 Water Reservoir Dams

Currently, only water reservoir Dams with "high", "very high", and "extreme" Consequence

Classifications require legislated Dam Safety Reviews. Water reservoir Dams with "low" and "significant" Consequence Classifications are not required by the *Dam Safety Regulation* to undergo regularly scheduled legislated Dam Safety Reviews, but Dam Owners may elect to undertake a Dam Safety Review by choice. In accordance with the *Dam Safety Regulation*, the Regulatory Authority can accept or reject a Consequence Classification proposed by the Dam Owner (refer to Section 3 of the *Dam Safety Regulation*).

The *Dam Safety Regulation* specifies the minimum frequency that Dam Safety Reviews must be completed; every 10 years for "high" and "very high" consequence Dams, and every seven years for "extreme" consequence Dams. The Regulatory Authority may also require that a Dam Safety Review be conducted earlier than the frequency specified in the *Dam Safety Regulation* to address safety concerns.

As per Section 21 (4) of the *Dam Safety Regulation*, a dam safety officer may request additional information and records deemed necessary to assess the condition or the hazard potential of the Dam and operations. If the Consequence Classification changes for any reason—such as increased downstream development—the Regulatory Authority may review and amend the Consequence Classification of the Dam.

After the Dam Safety Review, the Regulatory Authority will:

- review the Dam Safety Review Report and Dam Safety Review Assurance Statement;
- accept the Dam Safety Review Report or, if the Dam Safety Review Report does not comply with the requirements of the relevant legislation, reject the Dam Safety Review Report providing justification for the decision; and

 if necessary, discuss the conclusions and recommendations of the Dam Safety Review Report and Dam Safety Review Assurance Statement with the Dam Owner and Qualified Professional Engineer.

In some cases, FOR may request a peer review of a specific component of the Dam Safety Review, if there are unusual circumstances with respect to design, construction, or hazards related to the Dam (see Section 3.4.4.1).

2.3.4.2 Mining Dams

Dams subject to the *Mines Act* are required to have Dam Safety Reviews be carried out at the frequency specified in the HSRC. For Mining Dams, the Dam's Consequence Classification is determined by the EOR and is communicated to the Regulatory Authority by the Mine Manager (note: this differs from Dams under the *Water Sustainability Act* as set out above, where a determination of Consequence Classification can be made by the Regulatory Authority).

After the Dam Safety Review, the Regulatory Authority will:

- review the Dam Safety Review Report and Dam Safety Review Assurance Statement;
- if necessary, discuss the conclusions and recommendations of the Dam Safety Review Report and Dam Safety Review Assurance Statement with the Dam Owner, EOR, and/or Qualified Professional Engineer; and
- if necessary, request the Dam Owner to provide a plan and timeline for addressing some or all of the recommendations of the Dam Safety Review Report.

3.0 GUIDELINES FOR PROFESSIONAL PRACTICE

3.1 OVERVIEW

This section sets out the professional responsibilities of Qualified Professional Engineers who undertake legislated Dam Safety Reviews in BC.

The safety of Dams is managed through an integrated set of policies and activities involving Regulatory Authorities, Dam Owners, and Qualified Professional Engineers, who work together to achieve defined objectives for the safe performance of Dams.

It is the responsibility of the Qualified Professional Engineer who conducts the Dam Safety Review to determine if the safety management system for the Dam is current and adequate with respect to all relevant laws, regulations, current leading engineering practices, the expectations of the Regulatory Authority, and the expectations outlined within these professional practice guidelines.

The scope and applicability of these guidelines are set out in more detail in Section 1.4.

3.1.1 GENERAL CONSIDERATIONS

A Dam Safety Review involves a systematic examination and assessment of the data and information about the design, construction, maintenance, operation, processes, and systems affecting a Dam's safety, including the Dam safety management system.

It is the responsibility of the Dam Owner to provide the Qualified Professional Engineer with access to all available information about the Dam for the purpose of meeting the Dam Safety Review requirement of the *Dam Safety Regulation* or the HSRC. It is the responsibility of the Qualified Professional Engineer to have the experience and knowledge to be able to judge whether there is enough relevant information to enable completion of the appropriate type of Dam Safety Review. The Qualified Professional Engineer is expected to know the nature, completeness, and quality of the information that would normally be required to make a determination that a Dam is Reasonably Safe as intended.

For water reservoir Dams, the *Dam Safety Regulation* (Section 20 (1) a.) requires that an engineering professional who has qualifications and experience in Dam safety analysis:

- *"i. carries out a review, in accordance with the requirements of the comptroller or a water manager,*
 - a. to determine if the dam is safe, and
 - b. if it is determined that the dam is not safe, to determine what actions are required to make the dam safe, and,
- *ii.* prepares, in the form and with the content specified by the comptroller or a water manager, a report on the safety of the dam"

Within these professional practice guidelines, Section 20 (1) a.i.a is interpreted as the requirement to identify immediate actions to make the Dam Reasonably Safe in the interim pending future permanent actions by the Dam Owner.

Making a Dam safe in the interim can include actions such as reservoir drawdown, operational restrictions, enhanced surveillance, heightened emergency preparedness, and downstream evacuation. For mining Dams, the HSRC and associated guidance requires that a Dam Safety Review Report be prepared with appropriate frequency as specified. These documents reference the CDA Dam Safety Guidelines and these professional practice guidelines.

3.1.2 SAFETY AND CONTEXT

While there is a large body of knowledge concerning what might constitute "safe", there is no unified and widely agreed-upon definition. Safety is a relative concept and cannot be defined in absolute terms, nor can it be measured directly. What might be considered safe in relative terms can often be achieved in various ways, such as through structural rigidity or flexibility, or a mix of structural and operational measures. Balancing competing objectives is typically necessary to determine what constitutes "safe" in a particular context.

In light of these considerations, making a determination of whether a Dam is "safe" is not a straightforward engineering matter.

To address the complexity of determining what constitutes "safe" with respect to a Dam, these guidelines introduce the term Reasonably Safe within the Dam Safety Review Assurance Statement. The term Reasonably Safe as used within these guidelines is a means to achieve the intent of the *Dam Safety Regulation* with respect to determining that a Dam is "safe".

Determination that a Dam is Reasonably Safe in terms of these guidelines is intended to mean that:

- the design, construction, surveillance, maintenance, operation and, where applicable, closure of the Dam are carried out in accordance with Established Good Practice and, if not, whether the vulnerabilities associated with not meeting Established Good Practice are acceptably managed;
- the assumptions made for analysis are well reasoned, supported by data and fully documented, and the risks associated with the

key uncertainties in those assumptions are accounted for and mitigated;

- the condition and performance of the Dam are such that the Dam is expected to perform its function as intended in the design or as updated, including having the capacity to withstand the external loads commensurate with the Consequence Classification of the Dam;
- the surveillance and instrumentation monitoring program is sufficient to provide ongoing validation of design assumptions and expected performance predictions, or to detect potential deviations so as to prompt design modifications and/or mitigation measures as required;
- 5. the Dam Owner has implemented all governance processes and Dam safety management measures that conform to established principles and approaches to safety management that are considered by the Regulatory Authority and the Qualified Professional Engineer to reflect Established Good Practice; and
- 6. all applicable regulatory requirements related to Dam safety are met.

At a minimum, it is the responsibility of the Qualified Professional Engineer to either verify that safety can be adequately demonstrated by the Dam Owner, or to identify what would be required to provide an adequate demonstration of safety commensurate with the Dam's Consequence Classification.

Conformance to Established Good Practice is the starting point for determination that a Dam is Reasonably Safe. As such, the Qualified Professional Engineer should be aware that Established Good Practice may exceed the minimum regulatory requirements at the time of the Dam Safety Review. Where this is the case, the determination that a Dam is Reasonably Safe in terms of these guidelines is intended to be judged against the higher standards set by Established Good Practice. As an example, Established Good Practice for tailings Dams, as outlined in the GISTM and the ICMM Guidance Document, requires the EOR and the Dam Owner to design for extreme consequence loading conditions for the passive closure phase of the tailings Dam, irrespective of the Dam failure Consequence Classification. This applies to both new and existing tailings Dams, but for the latter where upgrading the existing tailings facility is not viable or cannot be retroactively applied—as determined by the EOR and reviewed by the ITRB—measures to reduce the risk to a level as low as reasonably practicable (ALARP) must be implemented.

The Qualified Professional Engineer is expected to provide a clear explanation as to why the assurance that the Dam is Reasonably Safe can be accepted by the Dam Owner and the Regulatory Authority (refer to Section <u>3.4.1</u> for details on how this is expected to be demonstrated by the Qualified Professional Engineer within the Dam Safety Review Report).

3.1.3 DAM SAFETY REVIEW PHASES

A Dam Safety Review consists of steps or phases that form the framework of the review, which should be carried out in a systematic order. A Dam Safety Review includes:

- a field review of the site conditions;
- review of all relevant documentation covering the technical, operational and governance aspects;
- interviews with site staff;
- review of incidents;
- review of operations, maintenance and surveillance protocols, and other pertinent records;
- testing of flow discharge equipment (where applicable);
- review of recent test records;
- review of emergency response and preparedness protocols;
- review of risk assessments and risk management plans; and

review of available instrumentation data.

For mining Dams that are continually being raised, the Dam Safety Review will also include review of the construction record reports, including quality control and quality assurance records, and the construction vs. design intent verification report. An important consideration for stewarding the safety of mining Dams that are continually being raised is whether efforts are made to regularly improve upon the site characterization as additional data is collected, and to improve upon performance predictions by incrementally calibrating the design models to observed behavior (refer to *Professional Practice Guidelines - Site Characterization for Dam Foundations in BC* [Engineers and Geoscientists BC 2016]).

Section 1 of the CDA Technical Bulletin on Dam Safety Reviews provides an overview of the Dam Safety Review phases (CDA 2016).

3.2 DAM SAFETY ANALYSIS

3.2.1 GENERAL

Dam safety analysis is the means of providing a snapshot of the condition of the Dam, its performance capacity, and the safety management of the Dam. It identifies and measures new threats or potential vulnerabilities, such that improvements in safety can be identified. The Dam Owner can then use the results of the Dam Safety Review to initiate development of any needed upgrades, repairs, or operational improvements.

The process for analyzing Dam safety requires experiential knowledge, insight, and a degree of foresight by the Qualified Professional Engineer, to identify the variety of mechanisms whereby an existing Dam could be reasonably expected to pose a significant hazard to people, property, and the environment, as linked to the Consequence Classification of the Dam. The Qualified Professional Engineer may then identify options to address these threats to the performance and functional integrity of the Dam and propose measures to protect the safety of the Dam, pending resolution of the safety concern by the Dam Owner. The extent to which this detailed process can be applied may depend on factors outside the scope of the Dam safety analysis process.

Dam Safety Reviews are carried out in a principlesbased approach. The principles-based approach to Dam safety analysis requires:

- an extensive understanding of the design, construction, operation, maintenance, and (if applicable) closure of Dams of the class and type under review;
- a comprehensive understanding of the various hazards that could impact the safety of the Dam over its entire life cycle;
- a comprehensive understanding of the functional modes of such Dams as systems and components, as well as an understanding of associated modes of failure and potential impacts/effects;
- an understanding of the indicators that reflect the adequacy of the performance of such Dams;
- an extensive knowledge base of the causes of failures of other Dams and the measures adopted to prevent their recurrence;
- an understanding of how people and organizations affect the safety of the Dam, including the corporate culture of the Dam Owner;
- foresight to identify potential failure modes that could arise at the Dam or with the people involved in managing safety, and opportunities for prevention, control, and mitigation;
- an up-to-date awareness and understanding of changes in regulatory requirements and Established Good Practice;
- for mining Dams that are active and are continually being raised, a comprehensive understanding of the interaction between Mine planning, production, processing, tailings

deposition, water management and closure, and a recognition of the requirement to fully integrate these aspects throughout the entire lifecycle of the Dam; and

 for mining Dams that are inactive and are closed, and will remain in place nominally in perpetuity, an understanding of the reclamation and closure plan to return the Dam to an environmentally stable condition suitable for future land uses, in accordance with the HSRC and associated guidance and requirements.

In application, features of the principles-based approach should be evident in the Dam Safety Review Report. The Dam Safety Review Report should state the extent of the understanding of the functional performance of the Dam under review under present and foreseeable future conditions gained over the course of the Dam Safety Review. The report should also state the degree to which the Dam Safety Review permitted the identification of failure modes and the analysis of their effects, and the identification of safety improvement measures.

3.2.2 IMPLEMENTATION

The implementation of this principles-based approach, as commonly adopted in Dam safety assessment in Canada, is described in the CDA *Dam Safety Guidelines* and supporting Technical Bulletins. ICOLD Bulletins 154, 175, and 191 provide a complementary set of principles that serve as a basis for the managerial aspects of the Dam Safety Review. Documents by the GISTM, ICMM, and MAC provide specific principles and guidance for mining Dams.

Dams are designed to perform certain functions, and Dam safety analysis involves three fundamentally different dimensions of the safe performance of a Dam:

 the physical capacity of the Dam to withstand applied loads associated with the hazards of the environment at the Dam's location, commensurate with the Consequence Classification of the Dam (limit of the design envelope);

- the functional capacity of the Dam to safely perform its functions (containment and conveyance) within the design envelope; and
- the reasonableness of the engineering and policy basis for performance under its intended operating conditions and for the limits of the design envelope.

The Dam safety analysis process involves consideration of the actual and potential vulnerabilities of the Dam and the various relevant engineered and operational safety control measures, including:

- prevention of loss of performance capacity or loss of functional capability;
- control of the deviations from designed performance characteristics; and
- mitigation of the effects of loss of some or all of the controls over the containment and conveyance functions.

There are many other engineering principles, engineering standards, and good practices, such as those concerning the quality of materials used in construction of Dams and their components, and those that contribute to the reliability of components in mechanical and electrical systems, as well as those that contribute to the achievement of the safety characteristics of the Dam system as a whole that should also be considered in the analysis.

Dam safety analysis is intended to reveal the extent to which engineering principles, or other suitable principles, standards, and practices have been put in place at a Dam. The important concepts to be followed in implementing this principles-based approach for carrying out Dam Safety Reviews include:

 the Dam Safety Review should be framed in the context of generally accepted Dam design principles and safety management principles. The principles that are selected for use in analysis of the safety of the Dam should be documented, and their application in the Dam safety assessment should be explained;

- the Dam Safety Review must identify the performance capacity dimensions and the functional capability dimensions of the Dam in the assessment of the vulnerability of Dams and their components;
- the Dam Safety Review must identify the degree to which preventive, control, and mitigation measures are in place at a Dam, and the analysis should determine the adequacy of these measures both individually as components and collectively as a "safety system";
- the Dam safety analysis should identify the degree to which established engineering principles have been implemented; and
- for mining Dams that are continually being raised, the Dam Safety Review must identify the degree to which Mine planning, production, processing, tailings deposition, water management, and closure could impact the safety and safe management of the Dam.

3.2.3 DAM SAFETY REVIEW TYPES

The types of Dam Safety Review can be broadly considered to cover a spectrum ranging from an *Audit-Type Dam Safety Review* (described in Section <u>3.2.3.4</u>) to a *Comprehensive Detailed Design, Construction, Operations, and Performance Dam Safety Review* (described in Section <u>3.2.3.6</u>). Between these, lies the *Targeted Dam Safety Review,* (described in Section <u>3.2.3.5</u>) which involves targeting specific aspects of Dam performance and safety management for more specific analysis.

The breadth and depth of scope and level of effort required for a Dam Safety Review should be commensurate with the complexity of the Dam system, the Consequence Classification, and the ongoing safety management of the Dam. The scope that can be delivered may be dictated by the availability of documentation and data about the Dam, its design and construction, operational history, maintenance, and functional performance.

3.2.3.1 Considerations for Water Reservoir Dams

For water reservoir Dams, the Dam Owner, in conjunction with the Regulatory Authority, are required to determine the appropriate form of Dam Safety Review within this spectrum prior to the appointment of the Qualified Professional Engineer. The minimum requirement is an *Audit-Type Dam Safety Review*, as defined below. In the case of reviews that involve some degree of targeting, the determination of the type of review includes specification of what is to be targeted and to what degree.

3.2.3.2 Considerations for Mining Dams

For mining Dams, the appropriate form of Dam Safety Review should be determined by the Qualified Professional Engineer carrying out the Dam Safety Review, based on information provided by the Dam Owner at the outset, regarding the Dam safety program and corporate governance activities and elements that are already in place. These activities and elements may include but are not restricted to:

- governance structure which establishes policies, systems, and accountabilities to support the safety and integrity of the mining Dam facilities;
- risk assessments, mitigations, and regular updates;
- regular reviews and audits of the facility's Dam Safety Management System, which ensures that Mine planning, production, processing, tailings deposition, water management, and closure are fully integrated through all operation and closure phases;
- regular review and updates of the site characterization and design as additional investigation and performance data become available;
- a comprehensive surveillance and monitoring program, including critical controls and an

effective Trigger Action Response Plan (TARP) to manage unexpected behaviour;

- annual construction record reports, Dam safety inspection reports, and annual performance reports prepared by the EOR;
- annual Tailings Stewardship reports, which audit the operational aspects of the facility by an independent qualified Engineering Professional;
- a formal change management process for unavoidable or unanticipated changes;
- emergency preparedness and response; and
- regular reviews by an ITRB.

Rigorous application of each of the above elements may be considered as fulfilling various equivalent components of a Dam Safety Review. The extent to which this equivalency is considered applicable in supporting the conclusions made as part of the Dam Safety Review and the Dam Safety Review Assurance Statement should be justified and documented by the Qualified Professional Engineer.

In addition, for active mining Dams that are continually being raised, the *Report on Mount Polley Tailings Storage Facility Breach* (Mount Polley Independent Expert Engineering Investigation and Review Panel 2015) stated:

"Tailings dams are complex systems that have evolved over the years. They are also unforgiving systems, in terms of the number of things that have to go right. Their reliability is contingent on consistently flawless execution in planning, in subsurface investigation, in analysis and design, in construction quality, in operational diligence, in monitoring, in regulatory actions, and in risk management at every level. All of these activities are subject to human error."

A comprehensive Dam Safety Review every five years alone cannot be expected to align with the pace of the activities normally associated with an actively operated/constructed mining Dam. If other key elements of a Dam safety program are already in place, then an *Audit-Type Dam Safety Review* may be considered appropriate. On the other hand, for closed facilities where the pace of activities has significantly reduced, some level of comprehensive and targeted Dam Safety Reviews may be appropriate depending on the extent to which other Dam safety program elements are implemented.

3.2.3.3 Considerations Common to Water Reservoir Dams and Mining Dams

The Dam Safety Review Report should document the rationale and justification made by the Qualified Professional Engineer in selecting the form of the Dam Safety Review.

Once retained for the Dam Safety Review, the Qualified Professional Engineer should confirm the suitable level of service within the context and constraints of the selected type of review, based on several factors:

- Current Consequence Classification of the Dam
- Age of the Dam
- Use of the Dam
- Type of design and method of construction of the Dam
- Complexity of flow control systems and presence of a debris management system
- Previous Dam safety management history
- Previous Dam Safety Reviews
- Recent and on-going performance observations and analyses of the Dam
- Significant alterations to the Dam system or changes within the watershed, including downstream within the potential breach inundation zone
- The availability and quality of historical design, construction, and monitoring documentation (including any information gaps)

The Qualified Professional Engineer must bring their concerns to the attention of the Dam Owner (with recommendations to address the concerns) if they determine that the selected type of Dam Safety Review is inadequate. In some cases, relevant information (e.g., design basis, or design records including changes during construction) may not be available for a Dam's first Dam Safety Review. In this situation, it may be necessary to conduct site investigation activities and in-depth analyses to provide the level of detail sufficient to demonstrate the safety of the Dam structure and that the Dam is being safely operated, maintained, and monitored. These requirements should be discussed prior to the Dam Safety Review work. The Dam Owner may decide to include these requirements as part of the scope of services for the first Dam Safety Review or as a separate scope of work prior to the first Dam Safety Review.

The following summarizes the most important concepts for implementing an appropriate methodology when carrying out a Dam Safety Review.

- All aspects of the Dam Safety Review should conform to the current Engineers and Geoscientists BC quality management requirements.
- A Dam Safety Review must be carried out by one or more Qualified Professional Engineer(s).
 Where a team is involved, the lead Qualified Professional Engineer will be the responsible Qualified Professional Engineer. The responsible Qualified Professional Engineer is expected to be sufficiently knowledgeable and experienced to act in this role for all aspects of a Dam Safety Review (see Section <u>5.0</u>).
- The methodology is consistent with the expectations of the Regulatory Authority and is in accordance with Established Good Practice.
- The methodology used for a Dam Safety Review should suit its intended purpose and be in accordance with the principles-based approach described in Section <u>3.2.1</u>.
- The Dam Safety Review Report should disclose the evidence produced and the line of reasoning that connects the evidence to the determination of the safety status of the Dam.

3.2.3.4 Audit-Type Dam Safety Review

The *Audit-Type Dam Safety Review* is intended to be a thorough, overarching, critical review of the currency and adequacy of the design basis, the design, construction, operation and maintenance records, and safety management system, including monitoring and surveillance in place for a Dam. In this context, the Qualified Professional Engineer must complete the following, at a minimum:

- a review of available documentation;
- site reviews and performance tests, where relevant;
- interviews with operating staff;
- confirmatory checking that all of the key Dam safety principles according to Established Good Practice are fulfilled and are being effectively implemented;
- confirmatory checking of available engineering analyses, record drawings, and performance records;
- confirmatory checking that the Dam is behaving as intended;
- confirmatory checking of available risk assessments and risk management plans, with due consideration of uncertainties and human error; and
- completion of an information gap assessment.

The Mining Association of Canada (MAC) document *A Guide to Audit and Assessment of Tailings Facility Management* (MAC 2011) provides a framework for auditing the tailings management system for mining Dams.

Currency (as used above) refers to the information used in the Dam Safety Review being current, up-todate, and collected in terms of accepted practices. From a currency perspective, an Audit-Type Dam Safety Review assesses the available data and information about the Dam, relative to up-to-date technical information and data, and Established Good Practice. Adequacy refers to the interpretation of this information as it is being applied and used at the time of the Dam Safety Review and is adequate in relation to Established Good Practice. From an adequacy perspective, an Audit-Type Dam Safety Review focuses on the extent to which the understanding and interpretation of the Dam design, and associated records and safety management system, are comprehensive and meet or exceed legislative requirements.

The Qualified Professional Engineer should not only confirm the presence of the required information, but also critically evaluate the suitability of the documented material considering the Consequence Classification of the Dam. The Qualified Professional Engineer must consider that the Consequence Classification of the Dam may have changed since the Dam was constructed and that there are ongoing advances in what is considered appropriate Dam safety information. The Qualified Professional Engineer should explain why the information is either suitable or not, in order to provide a basis for the conclusions.

There is a limit to how often an *Audit-Type Dam Safety Review* can be carried out for an individual Dam. Changes over time will render the Audit-Type basis for the review out of date or inadequate unless additional work is carried out (i.e., the design criteria, design basis, site characterization, performance evaluations, operational information, and risk assessments are being regularly reviewed and updated to reflect the changes). Adoption of an *Audit-Type Dam Safety Review* may be appropriate as an interim measure, or as a precursor to more detailed forms of Dam Safety Review at the next scheduled formal review.

3.2.3.5 Targeted Dam Safety Review

A *Targeted Dam Safety Review* comprises all the elements of an *Audit-Type of Dam Safety Review*, but with selected elements carried out in a sufficiently in-

depth way to reveal those aspects of the expected performance of the Dam that may not necessarily be confirmed in an Audit-Type Dam Safety Review. A *Targeted Dam Safety Review* is carried out by one or more Qualified Professional Engineers under the direction of the lead Qualified Professional Engineer. In this regard, the review of documentation, site reviews, interviews with operating staff, and followup performance analysis will be selectively more detailed, and may include a second verification site visit at the Dam Safety Review Report preparation stage. The engineering analysis will involve an independent verification of the appropriateness and sufficiency of calculations used in the safety assessment, with subsequent site verification where appropriate.

The Qualified Professional Engineer should explain to the Dam Owner how uncertainties in available data and information could impact the anticipated scope of work required to meet the objectives of a *Targeted Dam Safety Review*.

3.2.3.6 Comprehensive Detailed Design, Construction, and Performance Dam Safety Review

A *Comprehensive Detailed Design, Construction, and Performance Dam Safety Review* includes a detailed performance analysis of the Dam over its operating life, and analysis of expected performance under future conditions that can be reasonably anticipated in terms of the design basis and intent. A Dam Safety Review of this scale and rigor can take considerable time and be highly resource-intensive.

In many cases, essential design and performance information may be lacking, necessitating exploratory investigations and detailed sub-studies to assemble sufficient evidence and knowledge on which to base this type of Dam Safety Review. The comprehensive detailed design and performance review should be based on the latest available information including but not restricted to:

• rationale and basis for Consequence Classification;

- analysis and/or determination of impacts of:
 - water, ice, debris, and sediment;
 - uplift, stability, internal erosion/piping related to the seepage flow regime;
 - geological hazards;
 - geology and site characterization of foundation conditions, including the potential for undetected adverse foundation/abutment conditions; and
 - seismic considerations.
- review of construction record documentation, including construction defects and:
 - whether or not the constructed facility continues to meet the design intent even with the identified defects in place, or
 - whether design modifications were made to accommodate the identified defects;
- analysis of reservoir and unexpected upstream conditions, and unexpected downstream conditions;
- analysis of functional availability and reliability objectives;
- review of historical performance, and riskinformed performance expectations predictions, including surveillance and instrumentation monitoring to validate those expectations;
- review of governance aspects, including roles, responsibilities, and accountabilities, and formal processes for change management;
- review of operational aspects including completeness of the OMS and Dam Emergency Plan (DEP); and
- review of risk assessments and critical controls, including consideration of uncertainties, and human error.

This type of Dam Safety Review should conform to current generally accepted Canadian and international standards aimed at ensuring the physical stability of the Dam, and capacity of the Dam to retain the stored volume and to safely store or pass the design flood flows (e.g., Inflow Design Flood [IDF]) through and around the Dam in a controlled way.

3.3 ADDITIONAL CONSIDERATIONS

3.3.1 CONSIDERATION OF RISK AND UNCERTAINTY

The Qualified Professional Engineer has a professional responsibility to uphold the principles outlined in the Engineers and Geoscientists BC Code of Ethics (Engineers and Geoscientists BC 2021), including protection of public safety and the environment. As such, the Qualified Professional Engineer must use a documented approach to identify, assess, and mitigate risks that may impact public safety or the environment when performing a Dam Safety Review.

Other areas of risk encountered in professional practice may be quality, technical, socio-economical, socio-environmental, reputational, financial, and commercial risks.

For mining Dams that are in the active closure or passive closure phase, the challenge in risk mitigation is increased because the design life extends far beyond that normally associated with conventional engineering projects, and may extend in perpetuity. The Qualified Professional Engineer should consider risks in such areas using techniques that are appropriate to their area of practice.

It is acknowledged that there is uncertainty associated with many aspects of Dam Safety Reviews, including aleatory and epistemic uncertainties and human error. The Qualified Professional Engineer should include a statement of the uncertainties that are identified in the Dam Safety Review and identify approaches to resolve these uncertainties—or to acceptably manage the risks associated with these uncertainties—in the future. For example, the Qualified Professional Engineer must consider the reliability and suitability of the background information that is reviewed as part of the Dam Safety Review.

3.3.2 CONSIDERATIONS OF PARTICULAR IMPORTANCE IN BRITISH COLUMBIA

British Columbia's natural environment, climate, and associated natural hazards require that a Dam Safety Review pays particular attention to possible meteorological, geological, environmental, and seismological events (including both natural and induced seismicity). These are generally considered in terms of floods, landslides, and seismic events, although simple categorization masks the complexity of these hazards, which can act individually or in combination. A Dam Safety Review should take account of the nature and complexity of these hazards and explain how they have been addressed. Considerations include:

- Hydrologic Hazards Hydrological hazards include the extreme floods, sudden extreme inflow and influx of ice, and the siltation and debris that can be expected in some areas of BC. Extreme floods can be a result of an intense rainstorm, snowmelt, or a combination of the two, depending on location and other factors. The potential for debris loading cannot be accurately estimated simply by observation. Extreme events, particularly in mountainous terrain, can lead to sudden buildup or release of debris and sediment into the reservoir.
- Seismic Hazards Seismic hazards vary considerably across BC and are particularly significant where situated adjacent to destructive tectonic plate margins. In these regions and where significant earthquakes have been experienced in the past, the seismic hazard may be the governing loading condition for the structure, foundation, and slopes, upstream or downstream of the Dam. The Qualified Professional Engineer should verify the currency and adequacy of the design in context to seismic loading, commensurate with the complexity of

the Dam system and the Consequence Classification of the Dam.

The technical bulletin, *Seismic Hazard Considerations for Dam Safety* (CDA 2007), which is associated with the CDA *Dam Safety Guidelines*, provides a summary of the state of practice in Canada. Consideration should also be given to the latest state of practice for charactering seismic hazards and Dam response analysis as set out in ICOLD Bulletins and Engineers and Geoscientists BC's *Professional Practice Guidelines – Site Characterization for Dam Foundations in BC* (Engineers and Geoscientists BC 2016).

Landslides/Reservoir Rim Hazards – Landslides and reservoir rim hazards (such as forest slope debris) can be significant due to the steep terrain and other conditions. There is a history of catastrophic impacts to reservoirs and natural lakes, including landslides, rock avalanches, debris flows, and glacial lake outburst floods. Reservoir rim hazards include overtopping waves, direct impacts, and significant indirect impacts to the Dam and appurtenant structures, which may cause failure or severe damage to the Dam itself as well as upstream and downstream areas. All anticipated conditions (seismic, high infiltration, rapid drawdown, and load combinations) that could impact the safety of the Dam system should be accounted for.

3.3.3 CONSIDERATION OF CHANGED CONDITIONS

Dams are physically located in an ever-changing environment, and upstream and downstream developments may also impact the Consequence Classification of the Dam. In addition, the understanding of the natural hazards imposed on the Dam is continually evolving, and technical methodologies for Dam safety analyses are continually developing, as new knowledge is acquired in various aspects of Dam safety. Changes that potentially apply to all types of Dams include:

- changes in the state of knowledge about the dam and its natural setting;
- changes in the state of knowledge concerning natural hazards;
- changes in the operating regime of the Dam;
- changes to Established Good Practice and best available technology;
- changes to regulatory requirements; and
- changes in weather patterns or effects of climate change.

For water reservoir Dams, additional changes beyond the control of the Dam Owner can include changes in the operating regime of the Dam resulting from new demands for power, evolving societal demands, water availability or storage capacity, changes to the inflow into the reservoir resulting from changes to the operating regime of upstream Dams, and changes to the inflow into the reservoir resulting from watershed disturbances (e.g., wildfire, timber harvesting, forest health, and other causes).

For mining Dams, additional changes can include changes to the Mine plan, changes to the characteristics of the ore being mined and processed, changes to the tailings deposition plan, changes that occur as the Dam transitions from the operating phase to the active closure phase to the passive closure phase, and changes to the economic climate. Dam Owners of inactive mining Dams that are in the closure phase also face the challenge of maintaining safety of the Dam in perpetuity, unless it can be delicensed.

For both water reservoir and mining Dams, the condition of the Dam itself will change over time as the Dam ages and the Dam material and equipment deteriorate.

The Qualified Professional Engineer is not expected to forecast the impact of all potential future changing conditions on the assessment of the safe operation of the Dam for a specific Dam Safety Review.

Further, the Qualified Professional Engineer is not expected to anticipate all natural and/or operational conditions, in isolation or in combination, which could result in failure of the Dam. The Dam Safety Review should assess the Dam in its current state and environment using the current state of practice for Dam safety analysis. However, if it is clear during the review process that imminent changes are to be made or, are in the process of being made to the Dam or to the Dam's environment within the inter-review timeframe, the Qualified Professional Engineer should assess the impact of these changing conditions on the safe operation of the Dam in the immediate future and document these impacts in the Dam Safety Review Report.

3.3.4 CLIMATE CHANGE CONSIDERATIONS

One of the risk factors that must be considered is climate change implications. The Qualified Professional Engineer has a responsibility to:

- notify the Dam Owner of relevant climate-related risks (i.e., short-term climate related risks and associated uncertainties that are reasonably expected in terms of the available climate science during the period up to the next Dam Safety Review);
- identify reasonable adaptations of the Dam or its operational management to lessen the impact of those risks and uncertainties; and
- identify the potential impacts should a Dam Owner refuse to implement the recommended adaptations.

The Canadian Standards Association (CSA) publication entitled *Climate Change Adaptation for Dams* (CSA 2022) provides some considerations for climate change related vulnerabilities for Dams. While this study is primarily a literature review and stakeholder engagement exercise, the research provides many indications of key climate threats and indicates where Dam vulnerabilities lie:

- <u>Design considerations</u> such as hydrologic hazards, storage and spill capacity, and hydraulic modelling boundary conditions.
- <u>Operational considerations</u> such as shared usage of water supplies, changes in site access, cold weather operations, power outage and control systems, and effect on hydropower generation.
- <u>Dam safety and maintenance considerations</u> such as extreme hydrological events, winter and ice considerations, coastal erosion, stability relative to permafrost in northern regions, and structural integrity.

Several recommendations are provided for professionals and Dam Owners within ICOLD Bulletin 169 *Global Climate Change, Dams, Reservoirs and Related Water Resources* (ICOLD 2016). Engineers and Geoscientists BC and FOR have compiled BCspecific information related to inflow design flood estimation in a practice advisory entitled *Determining Dam Hydrologic Loading* (Engineers and Geoscientists BC 2022). Additional information can also be found in the *BC Extreme Flood Project* (FOR 2022). The Qualified Professional Engineer is responsible for being aware of and meeting the intent of any climate change requirements imposed by a Dam Owner or Regulatory Authority.

Engineers and Geoscientists BC also provides information and links to climate change adaption resources in the online Climate Change Information Portal.

3.4 DELIVERABLES AND COMMUNICATIONS

3.4.1 DAM SAFETY REVIEW REPORT

The Qualified Professional Engineer is expected to communicate the results of the Dam Safety Review to the Dam Owner (and subsequently to the Regulatory Authority) via a written report, complete with the Dam Safety Review Assurance Statement.
Report formats vary depending on the complexity and scope of the Dam Safety Review.

While the structure and composition of the report is the Qualified Professional Engineer's responsibility and is dependent on the type of Dam Safety Review completed, some documentation must be included in the Dam Safety Review Report to allow the Qualified Professional Engineer to explain how they arrived at their conclusions. A Dam Safety Review Report should include, at minimum, the following:

- an executive summary highlighting the key conclusions including the degree of safety as set out in the Dam Safety Review Assurance Statement;
- an introduction that defines the purpose and type of the Dam Safety Review and the scope of services of the Qualified Professional Engineer;
- a general description of the Dam and related structures, including the general arrangement, design and construction history, recent history of the Dam since the previous Dam Safety Review, and the assessment of the Consequence Classification of the Dam in the present environment;
- a statement regarding the appropriateness of the current Dam failure Consequence Classification and rationale for potential changes;
- a summary of the findings of the previous Dam Safety Review, if any, and any actions taken since the previous Dam Safety Review to rectify Deficiencies and Non-Conformances;
- the identification of the external and internal hazards and potential failure modes, (including descriptions of the flood, seismic, reservoir rim, and slope stability hazards) and compilation of these hazard and failure mode pairs into a hazards and failure modes matrix, with supporting rationale and justification for the results including consideration of design features and critical controls in place;
- a statement of the adequacy of all controls and their relation to the potential failure modes

including instrumentation and monitoring, surveillance, and emergency preparedness;

- a summary of the Dam Owner's compliance with the regulatory requirements;
- the details of the assessment of each component of the Dam, including the reservoir or impoundment (mining Dams). This should include a general description of the components and how they are intended to function, the monitoring and performance of the components (e.g., Dam, spillway) over the period since the previous Dam Safety Review, if any, and any Deficiencies and Non-Conformances identified during the assessment of the particular component;
- the details of the assessment of the operations, maintenance, and surveillance manual and practices at the Dam, including the assessment of the overall Dam safety management system and identification of Non-Conformances;
- the details of the review of the emergency planning, including documentation and training of personnel and testing of the emergency plans, and identification of any Non-Conformances;
- identification of key data gaps and information that was not available;
- the details of all design assumptions and their appropriateness and limitations in the current context;
- a summary of design calculations performed to support the technical analyses, including a complete data set together with a statement of their appropriateness in the current context;
- the conclusions of the Dam Safety Review, including the key findings, a list of Deficiencies and Non-Conformances, and recommended actions to be taken to correct any hazardous conditions identified during the Dam Safety Review at the Dam;
- the limitations and period of validity of the Dam Safety Review Report (see Section <u>3.4.2</u>);

- a statement of qualifications for the team including responsibilities and related experience; and
- a completed Dam Safety Review Assurance Statement (see Appendix A).

Supporting documents—such as the site visit report and minutes/results of staff interviews—can be included in appendices. Dam Safety Review Reports should be accompanied by drawings, figures, sketches, photographs, tables, and/or other support information, as required. Graphic information must be consistent with information in-text.

The Dam Safety Review Report should be clearly written, with sufficient detail to allow the Dam Owner, Regulatory Authority, and others reviewing the report to understand the methods, information used (including referenced material), and supporting rationale for conclusions, without necessarily visiting the Dam site.

The Dam Safety Review Report should clearly identify:

- whether the Dam is Reasonably Safe;
- the Deficiencies and Non-Conformances, with an explanation of the extent to which the identified concern deviates from Established Good Practice;
- the expected timeframe of applicability of the report content;
- any redundant compensating functional capacity; and
- operational risk mitigation measures that may have been established.

The Qualified Professional Engineer should use these considerations to outline their professional opinion concerning the relative importance or urgency of each identified Dam safety concern with respect to their importance to maintaining the safety of the Dam, adequate control over the stored volume, and/or adequate control over discharged flows.

In situations where the determination that a Dam is Reasonably Safe is conditional on implementation of some form of corrective action (for example, reservoir drawdown), the conditions should consider the operational constraints, and capacity of the Dam Owner to implement such a plan in each instance. If corrective actions are not practical or implementable by the Dam Owner, the determination should indicate that the Dam is not safe.

The Qualified Professional Engineer is expected to provide a clear explanation as to why an assurance that a Dam is Reasonably Safe can be accepted by the Dam Owner and the Regulatory Authority. A conclusion that a Dam is not safe must similarly be demonstrated, with evidence provided to support the conclusion.

In the case of Dams that are declared to be not safe, the Dam Safety Review Report should propose potential measures to render the Dam to be in an acceptably safe state. The Dam Safety Review Report may provide recommendations as to the priority or urgency for such measures, as determined by the Qualified Professional Engineer. Communication of the unmitigated risk of not carrying out such measures may be required, in line with Principle 10 of the Code of Ethics.

For information on technical reviews of Dam Safety Review Reports, including peer reviews and independent reviews, refer to Section <u>3.4.4</u>.

3.4.2 LIMITATIONS AND QUALIFICATIONS IN DAM SAFETY REVIEW REPORTS

Most consulting firms have standard limitation statements that are routinely included in reports. However, for Dam Safety Reviews, other limitation statements may be necessary. The original design and construction, design upgrades, and any other safety assessments done on the Dam in the past were likely done by other professionals, and the only evidence of this previous work exists in the form of reports and drawings, if at all. The Qualified Professional Engineer must review and interpret the data provided in these existing documents to form an opinion of the current safety status of the Dam. Reliance on work performed by other professionals in the past is therefore used in the Dam Safety Review, and the Qualified Professional Engineer may wish to include limitations and qualifications in the Dam Safety Review Report where they have relied on the work done previously by other professionals.

In addition, the determination of the flood, geologic interpretation, and seismic hazards can be carried out independently of the Dam Safety Review by professionals with specializations in the respective fields or disciplines. This work is highly specialized, and it is usually not possible (nor would it be appropriate) for the Qualified Professional Engineer to accept responsibility for the determination of these natural hazards. Therefore, in most cases, the Qualified Professional Engineer must rely on the work done by others to define the natural hazards that affect the Dam and should qualify the Dam Safety Review Report in this regard.

This professional opinion regarding the safety status of the Dam has a time limitation pursuant to the *Dam Safety Regulation.* As noted previously, the Dam Safety Review represents a "snapshot in time"; with a timeframe specified in the Dam Safety Review Report. With an appropriate documented rationale, the professional opinion in the Dam Safety Review Report may be valid for a shorter time than the interval between reviews in the *Dam Safety Regulation* – this should be communicated to the Dam Owner by the Qualified Professional Engineer. The HSRC does not consider this variation, and professional judgement must be applied on a case-by-case basis.

Limitations and qualifications, including those associated with background information, field reviews, data gaps, assumptions, sources of error, ranges of values, and subjective opinions, should be described clearly in the Dam Safety Review Report.

3.4.3 QUALITY MANAGEMENT PROCESSES

The quality management processes for authentication of engineering work, documented checking of engineering work, the quality assurance process, and procedures for authentication of the Dam Safety Review Report should be set out at the commencement of the professional service. These are captured in Section <u>4.1</u> of these guidelines.

3.4.4 THIRD PARTY REVIEWS OF DAM SAFETY REVIEW REPORTS

Two types of third-party technical reviews that may be required of Dam Safety Reviews include peer reviews and independent reviews. Regulatory reviews are covered in Section <u>2.3.4</u>.

3.4.4.1 Peer Review

A peer review is the evaluation of the engineering work completed by an Engineering Professional (the originating professional) by another appropriately qualified Engineering Professional (the reviewing professional), for a specific purpose defined by the party requesting the peer review. Peer reviews are part of good professional practice as they improve the quality of work and reduce the chance of mistakes being made; Engineering Professionals should be willing to give and receive honest reviews of performance and technical project aspects.

A reviewing professional may be engaged or requested by the Regulatory Authority or a Dam Owner to carry out a peer review of a Dam Safety Review Report prepared by the originating Qualified Professional Engineer. This external peer review process may be part of the Regulatory Authority's review of the Dam Safety Review Report.

Peer reviews are not the same as documented checks, or other internal or external reviews carried out as a part of the required quality management activities of the Qualified Professional Engineer prior to submitting the Dam Safety Review Report (see Section <u>4.0</u>). Documented checks are required on all professional engineering and geoscience work (Section 7.3.4 of the Bylaws), whereas peer review is not a mandatory part of professional practice in all cases. The reviewing professional takes professional responsibility for their work in undertaking the peer review; the originating Qualified Professional Engineer retains professional responsibility for the Dam Safety Review, the Dam Safety Review Assurance Statement, and the Dam Safety Review Report.

The reviewing professional's peer review report should be authenticated and include:

- the scope of the peer review;
- limitations and qualifications with regards to the peer review; and
- results and/or recommendations arising from the peer review.

The reviewing professional should respond to any questions the Regulatory Authority or Dam Owner may have regarding the peer review.

Occasionally, an independent professional is retained to provide a second opinion. This role goes beyond that of a peer review of the original Qualified Professional Engineer's work. The independent professional providing a second opinion must carry out sufficient pre-field work, field work, analysis, and comparisons, as required, to accept full responsibility for their Dam Safety Review.

Additional detail regarding Registrants' obligations in terms of peer reviews are captured in the *Guide to the Code of Ethics* (Engineers and Geoscientists BC 2021) and *Professional Practice Guidelines – Peer Review* (Engineers and Geoscientists BC 2022).

3.4.4.2 Independent Review

The Bylaws of Engineers and Geoscientists BC require documented independent review(s) of professional activity or work that has been identified by the Qualified Professional Engineer as high-risk – this may include Dam Safety Reviews. This is described in detail in the *Quality Management Guides – Guide to the Standard for Documented Independent Review of High-Risk Professional Activities or Work* (Engineers and Geoscientists BC 2023b). The Qualified Professional Engineer is required to:

- complete a documented risk assessment to determine whether the Dam Safety Review and associated professional services are deemed high-risk;
- determine the appropriate frequency for the independent review, as necessary; and
- determine if a Type I or Type II review is required, as necessary.

Dam Safety Review Reports already comprise many aspects of this quality management standard; the Dam Safety Review Report is itself a review by a Qualified Professional Engineer of other engineering and design work completed by other professionals. Similarly, the *Dam Safety Regulation* (for water reservoir Dams) and the Dam Consequence Classification described in the HSRC (for mining Dams) both contain aspects of a risk assessment that can be included in the Qualified Professional Engineer's risk assessment.

There are many considerations that will determine whether the work carried out in the Dam Safety Review is considered high-risk (and therefore requires independent review):

- The type of Dam Safety Review undertaken (see Section <u>3.2.3</u>)
- The Consequence Classification of the Dam
- The age of the Dam, type of Dam, complexity of the Dam system, and construction methods or materials used
- Whether or not previous Dam Safety Reviews have been carried out, the results of the previous Dam Safety Review Reports, and the time elapsed since the previous Dam Safety Review
- The availability of reliable and complete information on the original Dam design, design changes, and Dam operation and maintenance
- Whether or not technical review boards, expert advisors, and Dam safety management experts

have been engaged in the Dam Owner's Dam safety assurance process

- Whether or not the Dam has an EOR or responsible person overseeing its operation
- Whether or not the Dam has safety assessments carried out by experienced Engineering Professional(s) on a regular basis
- Whether another level of independent oversight already exists within the Dam safety framework (i.e., ITRB review)
- Whether or not recent changes have the potential to affect the continued safe operation of the Dam (e.g., recent hazards such as earthquakes or debris flows, recent changes to the inflow to the reservoir, recent changes to the Dam operation)
- Changes to the Established Good Practice

The Qualified Professional Engineer is required to complete a risk assessment for their professional services and the scope of work of the Dam Safety Review – this risk assessment will assist the Qualified Professional Engineer in determining if an independent review is required. The risk assessment and independent review may be discipline-specific, as would be the case in a multi-disciplinary review.

The Regulatory Authority may request a documented risk assessment be submitted to determine if the Dam Safety Review is considered a High-Risk Professional Activity or Work, as described in *Quality Management Guides – Guide to the Standard for Documented Independent Review of High-Risk Professional Activities or Work* (Engineers and Geoscientists BC 2023b). A template for risk assessment is provided in Appendix B of the same Guide. Should independent review be required, the process will follow that which is laid out in the same Guide.

4.0 QUALITY MANAGEMENT IN PROFESSIONAL PRACTICE

4.1 ENGINEERS AND GEOSCIENTISTS BC QUALITY MANAGEMENT REQUIREMENTS

Engineering Professionals must adhere to applicable quality management requirements during all phases of work, in accordance with the Engineers and Geoscientists BC Bylaws and quality management standards.

To meet the intent of the quality management requirements, Engineering Professionals must establish, maintain, and follow documented quality management policies and procedures for the following activities:

- use of relevant professional practice guidelines;
- authentication of professional documents by application of the professional seal;
- direct supervision of delegated professional engineering or professional geoscience activities;
- retention of complete project documentation;
- regular, documented checks using a written quality control process;
- documented field reviews of engineering or geoscience designs and/or recommendations during implementation or construction;
- where applicable, documented independent review of structural designs prior to construction; and

• where applicable, documented independent review of high-risk professional activities or work prior to implementation or construction.

Engineering Professionals employed by a Registrant firm are required to follow the quality management policies and procedures implemented by the Registrant firm as per the Engineers and Geoscientists BC's permit to practice program.

4.1.1 USE OF PROFESSIONAL PRACTICE GUIDELINES

Engineering Professionals are required to comply with the intent of any applicable professional practice guidelines related to the engineering work they undertake. As such, Engineering Professionals must implement and follow documented procedures to ensure they stay informed of, be knowledgeable about, and meet the intent of professional practice guidelines that are relevant to their professional activities or services. These procedures should include periodic checks of the Engineers and Geoscientists BC website to ensure that the latest version of available guidance is being used.

When carrying out Dam Safety Reviews, a Qualified Professional Engineer must have sufficient broadbased knowledge of, and experience in, these guidelines.

For more information, refer to the Quality Management Guides – *Guide to the Standard for the Use of Professional Practice Guidelines* (Engineers and Geoscientists BC 2023a), which also contains guidance for how an Engineering Professional can appropriately depart from the guidance provided in professional practice guidelines.

4.1.2 AUTHENTICATING DOCUMENTS

Engineering Professionals are required to authenticate (seal with signature and date) all professional documents, including electronic files, that they prepare or deliver in their professional capacity to others who will rely on the information contained in them. This applies to professional documents that Engineering Professionals have personally prepared and those that others have prepared under their direct supervision. In addition, any professional document that is authenticated by an individual Engineering Professional must also have a permit to practice number visibly applied. A permit to practice number is a unique number that a Registrant firm receives when they obtain a permit to practice engineering in BC.

Failure to appropriately authenticate and apply the permit to practice number to documents is a breach of the Bylaws.

The Qualified Professional Engineer must authenticate Dam Safety Review Reports prepared in their professional capacity or their direct supervision, and the Qualified Professional Engineer or the lead Qualified Professional Engineer must apply their seal to the Dam Safety Review Assurance Statement. For multi-discipline team review (i.e., where more than one engineering discipline is involved), the Qualified Professional Engineer for each discipline must authenticate the portions of the Dam Safety Review relevant to their specific disciplines and qualify the extent of their responsibilities. Where there has been input from one or more professionals (either registrants of Engineers and Geoscientists BC, or registrants of another regulatory body), each professional must also authenticate the document and qualify the extent of their responsibility or contribution.

For more information, refer to the Quality Management Guides – *Guide to the Standard for the Authentication of Documents* (Engineers and Geoscientists BC 2023c).

4.1.3 DIRECT SUPERVISION

Engineering Professionals are required to directly supervise any engineering work they delegate. When working under the direct supervision of an Engineering Professional, an individual may assist in performing engineering work, but they may not assume responsibility for it. Engineering Professionals, who are professional licensees, may only directly supervise work within the scope of their license.

When determining which aspects of the work may be appropriately delegated using the principle of direct supervision, the Engineering Professional having ultimate responsibility for that work should consider:

- the complexity of the project and the nature of the risks associated with the work;
- which aspects of the Dam safety analysis, and how much of those aspects, may be delegated;
- the training and experience of individuals to whom the work is delegated; and
- the amount of instruction, supervision, and review required.

If certain professional activities, such as aspects of the field work, are delegated by Engineering Professionals to subordinates—including nonprofessionals—such delegation of professional activities must occur under the principle of direct supervision. Careful consideration must be given to delegating field work, and the Engineering Professional should exercise judgment when relying on delegated field observations. Due to the complexities and subtleties of Dam safety analysis, direct supervision of field work is difficult, and care must be taken to see that delegated work meets the standard expected of the Engineering Professional. Direct supervision typically takes the form of specific instructions on what to observe, check, confirm, test, record, and report back to the Engineering Professional. The Engineering Professional must conduct a sufficient level of review to be satisfied with the quality and accuracy of the field observations. The Engineering Professional assumes full responsibility for all delegated work.

Stand-alone analyses, studies, or reports that are conducted to support or inform aspects of the Dam Safety Review work do not need to be completed under the direct supervision of the Qualified Professional Engineer if another appropriately qualified Engineering Professional is taking professional responsibility for the stand-alone work. The Qualified Professional Engineer is responsible for reviewing any work of others that informs the Dam Safety Review and for coordinating how this work is incorporated into the Dam Safety Review itself.

When delegating field review activities, all Engineering Professionals must document the field review instructions given to a subordinate. (See Section <u>4.1.6</u>).

For more information, refer to the *Quality Management Guides – Guide to the Standard for Direct Supervision* (Engineers and Geoscientists BC 2023d).

4.1.4 RETENTION OF PROJECT DOCUMENTATION

In accordance with Engineers and Geoscientists BC Bylaws, Engineering Professionals are required to establish and maintain documented quality management processes to retain complete project documentation for a minimum of 10 years after the completion of a project, or 10 years after an engineering document is no longer in use.

This may not be adequate for Dam safety work described in this guideline, given the elapsed time between legislated Dam Safety Reviews. Good professional practice may require document retention longer than the Engineers and Geoscientists BC requirement of 10 years – Dam safety review documentation should be retained by the Qualified Professional Engineer until two subsequent Dam Safety Reviews have been conducted.

Many Engineering Professionals are employed by firms, which ultimately own the project documentation. Engineering Professionals are considered compliant with this quality management requirement when reasonable steps are taken to confirm that: (1) a complete set of project documentation is retained by the organizations that employ them, using means and methods consistent with the Engineers and Geoscientists BC Bylaws and quality management standards; and (2) they adhere to the documented policies and procedures of their organizations while employed there.

For more information, refer to the Quality Management Guides – Guide to the Standard for Retention of Project Documentation (Engineers and Geoscientists BC 2023e).

4.1.5 DOCUMENTED CHECKS OF ENGINEERING AND GEOSCIENCE WORK

Engineering Professionals are required to perform a documented quality checking process of engineering work, appropriate to the risk associated with that work. All Engineering Professionals must meet this quality management requirement. A Dam Safety Review Report must undergo a documented checking and review process before being finalized and delivered to the Dam Owner and/or the Regulatory Authority. The Regulatory Authority may carry out a review of the Dam Safety Review Report to determine the presence or absence of information as required within the regulatory framework. The Qualified Professional Engineer may not rely on the expectation that a Dam Owner or Regulatory Authority will carry out reviews as a reason to reduce the checking that the Qualified Professional Engineer conducts.

Engineering Professionals are responsible for ensuring that the checks being performed are appropriate to the level of risk associated with the item being checked. Considerations for the level of checking should include:

- the type of item being checked;
- the complexity of the subject matter and underlying conditions related to the item;
- the quality and reliability of associated background information, field data, and elements at risk; and
- the Engineering Professional's training and experience.

As determined by the Engineering Professional, the individual doing the checking must:

- have current expertise in the discipline of the type of work being checked;
- be sufficiently experienced and have the required knowledge to identify the elements to be checked;
- be objective and diligent in recording observations; and
- understand the checking process and input requirements.

The checking process should be comprehensive and address all stages of the execution of the engineering work. This process would normally involve an internal check by another Engineering Professional within the same organization. Where an appropriate internal checker is not available, an external checker (i.e., one outside the organization) must be engaged. In some limited instances, self-checking may be appropriate (for example, smaller scopes of work that will be more comprehensively reviewed at a later stage). The Qualified Professional Engineer may use a different means of analysis at a later time to self-check their work. Before self-checking their work, the Qualified Professional Engineer must ask themselves whether self-checking alone will meet the ethical expectations and obligations of their work. Even when a check by others is performed, Registrants must self-check their

work and not rely on others to find any errors or omissions.

Where internal, external, or self-checking has been carried out, the details of the check must be documented. The documented quality checking process must include checks of all professional deliverables before being finalized and delivered.

For more information, refer to the Quality Management Guides – Guide to the Standard for Documented Checks of Engineering and Geoscience Work (Engineers and Geoscientists BC 2023f).

4.1.6 DOCUMENTED FIELD REVIEWS DURING IMPLEMENTATION OR CONSTRUCTION

Field reviews are reviews conducted at the site of the construction or implementation of the engineering work, such as intrusive investigations carried out as part of the Dam Safety Review. They are carried out by an Engineering Professional or a subordinate acting under the Engineering Professional's direct supervision (see Section <u>4.1.3</u>).

Field reviews enable the Engineering Professional to ascertain whether the construction or implementation of the work substantially complies in all material respects with the engineering concepts or intent reflected in the engineering documents prepared for the work. As the scope of work of a Dam Safety Review typically does not involve design or construction works, application of quality management requirements for Field Reviews is not anticipated unless the Dam Safety Review includes targeted invasive investigations or remedial work. Under these circumstances, both Engineers and Geoscientists BC and regulatory framework requirements must be met.

With respect to the scope of work of Dam Safety Reviews, if the Qualified Professional Engineer makes specific recommendations in the Dam Safety Review Report regarding the implementation or construction of remedial engineering works, the Qualified Professional Engineer should inform the Dam Owner (and EOR, if one is appointed) in writing, that those works must be carried out by or under the direct supervision of a professional engineer.

For more information, refer to the Quality Management Guides – Guide to the Standard for Documented Field Reviews During Implementation or Construction (Engineers and Geoscientists BC 2023g).

4.1.7 DOCUMENTED INDEPENDENT REVIEW OF HIGH-RISK PROFESSIONAL ACTIVITIES OR WORK

Engineering Professionals must perform a documented risk assessment prior to initiation of a professional activity or work, to determine if that activity or work is high risk and requires a documented independent review. If the activities or work are deemed high risk, and an independent review is required, the results of the risk assessment must be used to (1) determine the appropriate frequency of the independent review(s); and (2) determine if it is appropriate for the independent reviewer to be employed by the same firm as the Professional of Record, or if the independent reviewer should be employed by a different firm.

Additional detail on carrying out a risk assessment for the purpose of determining whether work is high-risk is captured in Section <u>3.4.4.2</u>.

The documented independent review of high-risk professional activities or work must be carried out by an Engineering Professional with appropriate experience in the type and scale of the activity or work being reviewed, who has not been involved in preparing the design. The documented independent review must occur prior to implementation; that is, before the professional activity or work is submitted to those who will be relying on it.

In independent review may be required at the discretion of an Engineering Professional (in consultation with the reviewer involved in the regular checking/review process outlined above), even in situations where work is not formally deemed high risk. Alternatively, a Regulatory Authority or the Dam Owner may request an independent external review to support report approval. An independent review may be undertaken by another Engineering Professional employed within the same firm, or an external firm. In terms of the Dam Safety Review process, the independent review process should be more formal than the checking/review process carried out under Section 7.3.4 of the Bylaws. An independent reviewer should submit a signed, sealed, and dated letter or report, to be either included with the Dam Safety Review Report or put on file, and should include the following:

- limitations and qualifications with regard to the independent review; and
- results of the independent review.

When an independent review is carried out, each professional retains responsibility for their work; the Qualified Professional Engineer is responsible for the Dam Safety Review Report, and the reviewing professional is responsible for their independent review.

For more information, refer to the Quality Management Guides – Guide to the Standard for Documented Independent Review of High-Risk Activities or Work (Engineers and Geoscientists BC 2023b).

4.2 OTHER QUALITY MANAGEMENT REQUIREMENTS

Engineering Professionals must also be aware of any additional quality management requirements from other sources that are relevant to their work, which may include but are not limited to:

- legislation and regulations at the local, regional, provincial, and federal levels;
- policies of Regulatory Authorities at the local, regional, provincial, and federal levels;
- agreements and service contracts between Dam Owners and Engineering Professionals or their firms; and/or

• standards for engineering firms, particularly those that apply to quality management system certification, such as the ISO 9000 family.

Engineering Professionals should assess any areas of overlap between the Engineers and Geoscientists BC quality management requirements and the requirements of other applicable sources. If the requirements of various sources overlap, Engineering Professionals must meet the complete intent of all requirements.

Where there are conflicts between requirements, Engineering Professionals should negotiate changes or waivers to any contractual or organizational requirements which may conflict with requirements of legislation, regulation, or the Engineers and Geoscientists BC Code of Ethics. No contractual obligation or organizational policy that may apply to an Engineering Professional will provide justification or excuse for breach of any of the Engineering Professional's obligations under any legislation, regulation, or the Engineers and Geoscientists BC Code of Ethics. Where such conflicts arise and cannot be resolved, Engineering Professionals should consider seeking legal advice from their own legal advisers on their legal rights and obligations in the circumstances of the conflict, and they may also seek practice advice from Engineers and Geoscientists BC on any related ethical dilemma that they may face in the circumstances.

4.3 PRACTICE ADVICE

Engineers and Geoscientists BC provides their Registrants and others with assistance addressing inquiries related to professional practice and ethics.

Practice advisors at Engineers and Geoscientists BC can answer questions regarding the intent or application of the professional practice or quality management aspects of these guidelines.

To contact a practice advisor, email Engineers and Geoscientists BC at <u>practiceadvisor@egbc.ca</u>.

5.0 PROFESSIONAL REGISTRATION & EDUCATION, TRAINING, AND EXPERIENCE

5.1 PROFESSIONAL REGISTRATION

Engineering Professionals must meet minimum education, experience, and character requirements for admission to their professions. However, the educational and experience requirements for professional registration do not necessarily constitute an appropriate combination of qualifications for legislated Dam Safety Reviews in BC. Professional registration alone does not automatically qualify an Engineering Professional to take professional responsibility for all types and levels of professional services in this professional activity.

The *Dam Safety Regulation* indicates that Dam Safety Reviews must be carried out by a professional engineer "with qualifications and experience in Dam safety analysis". The CDA *Dam Safety Guidelines* that form the basis for Dam Safety Reviews state that "dam safety reviews should be carried out by, or under the direction of, a registered professional engineer with a background in design, construction, performance analysis, and operation of dams" (CDA 2013).

A Qualified Professional Engineer, as described above, must be a person registered and in good standing with Engineers and Geoscientists BC as a professional engineer under the *Professional Governance Act.* The Qualified Professional Engineer is typically registered with Engineers and Geoscientists BC within the disciplines of structural, civil, geotechnical, hydrotechnical, or mining engineering. As the complexity of the Dam and site conditions increases, characterization and sound understanding of the hazard and failure mode processes become more critical, necessitating specific direct applicable experience. As a result, not all professional engineers registered in the disciplines noted above are Qualified Professional Engineers in Dam Safety Reviews.

It is the responsibility of the Qualified Professional Engineer to determine whether they are qualified by training or experience to undertake and accept responsibility for Dam Safety Reviews for proposed Dam and site conditions (*Code of Ethics* Principle 2; Engineers and Geoscientists BC 2021) and should meet the intent of the requirements discussed below.

5.2 EDUCATION, TRAINING, AND EXPERIENCE

Dam Safety Reviews, as described in these guidelines, require minimum levels of education, training, and experience in many overlapping areas of engineering and geoscience. Engineering Professionals who take responsibility for legislated Dam Safety Reviews in BC must adhere to the second principle of the Engineers and Geoscientists BC *Code of Ethics*, which is to "practice only in those fields where training and ability make the Registrant professionally competent" (Engineers and Geoscientists BC 2021) and, therefore, must evaluate their own qualifications and must possess the appropriate education, training, and experience to provide the services with the level of experience adequate for the complexity of the project.

Education, training, and experience can vary depending on a Qualified Professional Engineer's background and whether specialty sub-services are being provided. Whether a Qualified Professional Engineer is carrying out a Dam Safety Review or providing specialty sub-services, appropriate experience can only be gained by working under the direct supervision of other experienced and knowledgeable Qualified Professional Engineers.

Depending on the size and complexity of the Dam and site conditions, Dam Safety Reviews may be carried out by an individual Qualified Professional Engineer, or a multidisciplinary team of professionals led by an experienced lead Qualified Professional Engineer. Directly applicable training and experience for the type of Dam and site conditions should be highlighted in both the proposal and reporting stages of the project in a statement of qualifications such that the qualifications are transparent throughout and after the review process, as noted in Section <u>3.0</u>.

Prior to conducting a Dam Safety Review, an individual Qualified Professional Engineer or a lead Qualified Professional Engineer must have significant knowledge, understanding, experience, and appreciation of investigation, design, construction, performance analysis, and operations of Dams, as well as the system approach to Dam safety analysis required for the review. The potential cause of failures and the impacts of these should also be understood.

An individual Qualified Professional Engineer or a lead Qualified Professional Engineer must also:

- be knowledgeable about the *Dam Safety Regulation* and applicable legislation and/or be knowledgeable about the regulations applicable to the *Mines Act* and the HSRC, as applicable; and
- be knowledgeable about the various technical and governance Dam safety guidelines and

principles, specifically the CDA *Dam Safety Guidelines* and associated technical bulletins, and the GISTM, ICMM, and MAC documents.

The Qualified Professional must confirm through the statement of qualifications that they have the appropriate training and experience to conduct the Dam Safety Review associated with the particular type of Dam, the complexity of the associated overall Dam system providing containment of the reservoir, and the conveyance of the river flow past the Dam. If they don't have the appropriate training and experience within specific areas or disciplines, the Qualified Professional must demonstrate the involvement of required specialists or qualified persons to contribute or assist in the relevant areas and provide the necessary range of disciplines required for the specific Dam and site conditions.

5.2.1 INDIVIDUAL QUALIFIED PROFESSIONAL ENGINEER

Minimum qualifications for an individual Qualified Professional Engineer carrying out the Dam Safety Review will include the following:

- registration with Engineers and Geoscientists BC as a professional engineer;
- previous involvement with at least five Dam Safety Reviews with a lead role in at least two Dam Safety Reviews with similar Dam types and site characteristics which demonstrates their understanding of the Dam safety management system. Prior work related to Dams with similar Consequence Classification or complexity is also a requirement;
- at least 15 years of direct and progressive experience in design, construction, performance assessment, and/or operation of Dams of similar type, complexity and Consequence Classification, and a broad level of expertise and experience in Dam safety. Prior experience should be able to demonstrate increasing complexity of work;

- current knowledge of the Dam Safety Regulation, CDA *Dam Safety Guidelines*, and international Dam safety standards;
- in the case of mining Dams, current knowledge of the regulations applicable to the *Mines Act*, the HSRC, and the CDA *Dam Safety Guidelines*, and leading practice guides such as GISTM and publications by ICMM, ICOLD, and MAC; and
- have not participated in the design, construction, or safety management (surveillance, Deficiency investigation, capital improvement) of the specific Dam in question.
 - with respect to mining Dams, the Qualified Professional Engineer cannot be an individual previously involved as the EOR for the Dam.

5.2.2 LEAD QUALIFIED PROFESSIONAL ENGINEER FOR A MULTIDISCIPLINARY TEAM

As the complexity of the Dam and site conditions increase, so does the need for a multi-disciplinary team approach to the delivery of a Dam Safety Review. For complex Dams, it is unlikely that any given Qualified Professional Engineer has sufficiently broad education and experience to address all the required components of a Dam Safety Review. Depending on the facility's characteristics, including upstream and downstream conditions, the background of the Qualified Professional Engineer, and the skill sets of the Dam Safety Review team, specialty services may be required and may include hydrology, inundation studies, seismic hazard determination and response, concrete technology, or instrumentation.

A professional who offers specialized services may require specific education, training, and experience in addition to that discussed in Section <u>5.2</u>. The Qualified Professional Engineer who engages the professional specialist has a responsibility to confirm that the specialist has the appropriate skills and competencies required to complete the activity they are engaged to carry out. Minimum qualifications for a lead Qualified Professional Engineer coordinating a multidisciplinary team of professionals for a Dam Safety Review are as follows:

- current registration with Engineers and Geoscientists BC as a professional engineer;
- previous involvement with at least three Dam Safety Reviews with consideration given to the Dam type and site characteristics, and which demonstrates full understanding of the Dam safety management system. Prior work related to Dams with similar Consequence Classification or complexity is also a requirement. This experience should include significant involvement and direct supervision of a well-qualified and experienced Qualified Professional Engineer;
- at least 10 years of direct and progressive experience in design, construction, performance evaluation, and/or operation of Dams. Prior experience should be able to demonstrate increasing complexity of work;
- current knowledge of the *Dam Safety Regulation*, CDA *Dam Safety Guidelines*, and other international Dam safety guidelines;
- in the case of mining Dams, current knowledge of the regulations applicable to the *Mines Act*, the HSRC, and the CDA *Dam Safety Guidelines*, and leading practice guides such as GISTM and publications by ICMM, ICOLD and MAC; and
- not participated in the design, construction, or safety management (surveillance, Deficiency investigation, capital improvement) of the specific Dam in question.
 - with respect to mining Dams, the Qualified Professional Engineer cannot be an individual previously involved as the EOR for the Dam.

Under the multidisciplinary team approach, the lead Qualified Professional Engineer may rely on a team of Qualified Professional Engineers and specialists within various disciplines. However, the lead Qualified Professional Engineer is expected to have an in-depth knowledge of all facets of the work and be directly involved throughout the Dam Safety Review process.

5.2.3 QUALIFICATION INDICATORS

All Qualified Professional Engineers who carry out Dam Safety Reviews, whether as individual Qualified Professional Engineers, as lead Qualified Professional Engineers, or as specialist team members, must have the appropriate education, training, and experience that specifically encompasses the area of expertise required of them. It is the Qualified Professional Engineer's obligation to obtain and document their education, training, and experience to be able to practice and maintain their competency in their area of practice.

The academic training for the above skill sets can be acquired through formal university or college courses, or through professional development.

A Qualified Professional Engineer should remain current—through continuing professional development—with the evolving topics of Dam safety, surveillance, construction, rehabilitation, and other specialized services (refer to Engineers and Geoscientists BC Code of Ethics, Principle 5). Continuing professional development can include taking formal courses; attending conferences, workshops, seminars, and technical talks; reading new texts and periodicals; searching the web; and participating in field trips.

Certain indicators demonstrate that Engineering Professionals have received education, training, and experience that might qualify them to participate professionally in legislated Dam Safety Reviews in BC. While applicable work experience is the most important factor, other qualification indicators may include:

• An undergraduate-level degree in structural, civil, hydrotechnical, geological, geotechnical, mining, or a related engineering/geoscience field from an accredited engineering or geoscience program.

- A postgraduate-level degree in similar disciplines with specialization in aspects of Dam safety, Dam design and construction, or Dam operation.
- Participation in conferences and continuing education courses offered by professional organizations such as CDA and other recognised institutions (ICOLD, Mining Association of Canada, US Federal Emergency Management Agency, US Federal Energy Regulatory Commission, United States Army Corps of Engineering, United States Bureau of Reclamation) that focus on Dam safety issues.
- A rigorous, documented self-study program involving a structured approach that contains materials from textbooks and technical papers on Dam engineering and ongoing Dam safety monitoring.

Whether carrying out a Dam Safety Review or providing specialty services, appropriate experience can only be gained by working under the direct supervision of other experienced and knowledgeable Qualified Professional Engineers. Typical qualifications for Qualified Professional Engineers who carry out Dam Safety Reviews may include an appropriate combination of training and experience in the following areas, based on CDA Technical Guidance:

Structural/Geotechnical:

- Design and construction experience (disciplinespecific) including retention structures, hydraulic structures, and their specific foundation requirements. Refer to *Site Characterization for Dam Foundations in BC* (Engineers and Geoscientists BC 2016)
- Deficiency investigations and capital improvements (discipline-specific)
- Analysis and understanding of the applicable loads and load combinations, including applicable design flood and seismic loading in comparison to the physical capacity of structures

- Analysis and understanding of the uncertainty in:
 - material properties and subsurface conditions;
 - variable construction and operating conditions;
 - soil response (contractive/dilative) and its variation with confining stress and stress level, including the potential for brittle failure mechanisms;
 - time-dependent, deformation-dependent, and stress-path-dependent processes that may affect the critical material properties such as the operational pore pressures and shear strengths; and
 - strain-incompatibility of the different materials forming the Dam and its foundation.
- Failure modes and failure mechanisms, including visual and historical indicators
- Impacts of operations and maintenance
- Instrumentation and monitoring (key performance indicators)

Hydrotechnical:

- Dam breach and inundation analyses
- Watershed modelling and inflow analysis
- Hydraulic analyses of spillways and outlet works
- Flood operations and mitigation strategies
- Wind and wave analyses, determination of freeboard, and ice/debris issues

Seismic:

- Seismic hazard characterisation
- Seismic response analysis

Electro-Mechanical:

- Control systems
- Hydraulic gates and drives
- Power systems

Dam Safety:

- Interpretation of Dam breach inundation mapping, Dam Failure Consequence Classification considering life safety, economic impacts, environmental impacts, and potential cultural losses, as well as related emergency planning and response
- Dam safety analysis and assessment (as described in Section <u>3.0</u>)
- Surveillance including field inspections of the Dam and abutment areas, conveyance system, reservoir and downstream areas, as well as evaluation of instrumentation data. Potential impact of natural hazards within the reservoir, Dam, and downstream areas
- Flow control equipment including design, field inspection, testing, design review, and maintenance requirements
- Public safety and security including safety hazards, control measures, and warning systems

Note that these indicators are not an exhaustive list of education and experience types that are relevant to legislated Dam Safety Reviews in BC. Satisfying one or more of these indicators does not automatically imply competence in legislated Dam Safety Reviews in BC.

6.0 REFERENCES AND RELATED DOCUMENTS

Documents and legislation cited in the main guidelines appear in **Section 6.1: Legislation** and **Section 6.2: References**; documents cited in appendices appear in the reference list at the end of each corresponding appendix.

Related documents that may be of interest to users of these guidelines but are not formally cited elsewhere in this document appear in **Section 6.3: Related Documents**.

6.1 LEGISLATION

Professional Governance Act [SBC 2018], Chapter 47.

Dam Safety Regulation (32/2023).

Mines Act [RSBC 1996], c. 293.

Water Sustainability Act [SBC 2014] c. 15.

Emergency Program Act [RSBC 1996] c. 111.

Health, Safety, and Reclamation Code for Mines in British Columbia. Ministry of Energy, Mines and Low Carbon Innovation. 2022. Victoria, BC.

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6.3 RELATED DOCUMENTS

Additional guidance from International Commission on Large Dams (ICOLD) can be found at: <u>https://www.icold-cigb.org/GB/publications/publications.asp</u>

Additional guidance from International Council on Mining and Minerals (ICMM) can be found at: <u>https://www.icmm.com/en-gb/resources</u>

Additional guidance from the Mining Association of Canada (MAC) can be found at: <u>https://mining.ca/resources/</u>

Additional guidance related to the Global Industry Standard on Tailings Management (GISTM) can be found at: <u>https://globaltailingsreview.org/global-industry-standard/</u>

Additional information on the Mount Polley Independent Expert Investigation and Review Report can be found at: <u>https://www.mountpolleyreviewpanel.ca/</u>

Additional Information on the BC Ministry of Forests BC Extreme Flood Project can be found at: <u>https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/dam-safety/bc extreme flood project.pdf</u>

Additional Information on Engineers and Geoscientists BC's Climate Change Portal can be found at: https://www.egbc.ca/Practice-Resources/Programs-Resources/Climate-Sustainability/Climate-Change-Information-Portal

7.0 APPENDICES

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Appendix A: LEGISLATIVE FRAMEWORK – WATER RESERVOIR DAMS

The regulation of water reservoir Dams and issuing of water licenses in British Columbia (BC) is a provincial responsibility. The *Water Sustainability Act* and the *Dam Safety Regulation* are the statute and regulation that govern water reservoir Dam safety in BC.

The Dam Owner is responsible for carrying out Dam Safety Reviews on their Dams for certain Consequence Classifications and at the intervals provided by the *Dam Safety Regulation*.

Several rivers in BC flow across the international border with the United States. The International Joint Commission was established by the governments of Canada and the United States under the Boundary Waters Treaty, to prevent or resolve disputes involving waters in rivers common to both countries. The Columbia River Treaty was signed by Canada and the United States in 1964 and is an international agreement between the two countries to coordinate flood control and to optimize hydroelectric energy production on both sides of the border. The requirements of the treaty dictate the operation of the Mica, Keenleyside, and Duncan Dams. When starting a Dam Safety Review, the Qualified Professional Engineer should determine whether the operations of the Dam are affected by any orders issued by the International Joint Commission or whether the Dam falls within the ambit of the Columbia River Treaty.

The *Water Sustainability Act* contains little detail specifically regarding Dam safety. The *Dam Safety Regulation* more specifically addresses the responsibilities of the Dam Owner for the safe operation of a Dam and prescribes documentation requirements, such as OMS manuals and Dam Emergency Plans (DEPs) for the Dam. It also prescribes surveillance activities, Dam Safety Reviews, and operational testing of flow control equipment. The *Dam Safety Regulation* includes the determination of the Consequence Classification of Dams based on the consequences of a postulated failure of the Dam. The *Dam Safety Regulation* does not contain specific technical details pertaining to Dam safety engineering.

The Canadian Dam Association (CDA) *Dam Safety Guidelines* and associated technical bulletins provide guiding principles for the management of Dams; the technical bulletins suggest methodologies and procedures for use by professional engineers as they carry out Dam analyses and safety assessments. The CDA *Dam Safety Guidelines* were developed by CDA working groups that represented a cross section of Dam Engineering Professionals across Canada. The CDA *Dam Safety Guidelines* represent technical guidance prepared by a non-governmental organization, and the *Dam Safety Regulation* takes precedence. However, the CDA *Dam Safety Guidelines* are considered the principal technical document in Canada for conducting Dam Safety Reviews.

It is recognized that Dam Safety Reviews may be carried out for purposes other than in response to the abovereferenced legislation. Similarly, some Dams and fluid retaining structures may not be captured in the legislation above. There are several other Dam-like structures in BC that are not regulated by the Ministry of Forests (FOR) or the Ministry of Energy, Mines and Low Carbon Innovation (EMLI). These include contaminated water facilities, stormwater facilities, wastewater storage facilities, and debris flow containment structures. In the absence of other legislation or guidance, a local authority may require that the guidance on professional practice presented in these guidelines be followed, and Engineering Professionals should consider the guidance in these guidelines in those cases.

Although these guidelines are not intended to address such non-legislated Dam Safety Reviews, some of the information contained in these guidelines may be relevant to the preparation of such non-legislated Dam Safety Review reports.

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Appendix B: LEGISLATIVE FRAMEWORK AND CONSIDERATIONS IN DAM SAFETY REVIEWS – MINING DAMS

Mining Dams include structures that impound tailings, contaminated water, acid-generating waste rock, sediments, and water treatment sludge.

Currently, the Ministry of Energy, Mines, and Low Carbon Innovation (EMLI) issues permits that provide authorization under the *Mines Act* to construct and operate impoundment and associated Dams on Mine sites in BC. The permit includes conditions under which the impoundment and Dams are to be operated and managed.

The design, construction, and operation of Dams on a Mine site in BC are currently covered by regulations and requirements under the *Mines Act* and the Health, Safety and Reclamation Code for Mines in British Columbia (HSRC 2021). Dams on a Mine site that require a water license are also subject to regulations under the *Water Sustainability Act* (see Appendix A).

A *Memorandum of Understanding* (EMLI, FOR, ENV 2014) specifies the responsibilities between three provincial ministries for the regulation of impoundments and diversion structures at Mine sites. The purpose of the *Memorandum of Understanding* is to define and clarify the roles of the three provincial ministries in the siting, design, construction, operation, maintenance, abandonment, reclamation, and regulation of impoundments and diversions on a Mine site, in order to protect the public, the environment, and the users of water in the affected watershed.

The 2016 HSRC Guidance Document provides specific guidance and context to the Dam Owners on the minimum expectations from EMLI for the application of, and to assist in the understanding and complying with, the HSRC requirements. Guidance is provided with respect to the following:

- appropriate characterization of the risks to inform design and operational objectives;
- design criteria and principles for risk management;
- recognition and consideration of First Nations established and asserted rights;
- appropriate site characterization assessments for Dam foundations;
- consequence Classification of mining Dams;
- construction and Operations:
 - Annual Manager's Report
 - Annual Dam Safety Inspection Report
 - Emergency Preparedness and Response
 - Operations, Maintenance and Surveillance Manual, including surveillance and monitoring requirements
 - Maintaining a registry of all tailings and water retaining structures on site
 - Periodic Safety Reviews
 - As-Built Reports
 - Developing and implementing a tailings management system;

- retention of key documents; and
- reclamation and closure.

Tailings Dams and other mining Dams can be evolving structures. This should be considered when establishing the appropriate frequency of Dam Safety Reviews. A Dam Safety Review should also be considered when substantive change in the operation of a mining Dam occurs, if significant changes occur downstream, or if applicable regulations change. Notwithstanding these considerations, the HSRC requires a Dam Safety Review be carried out at least every five years for all water storage Dams and tailings storage Dams at the Mine site, regardless of Consequence Classification (HSRC Guidance Document).

The Canadian Dam Association (CDA) *Dam Safety Guidelines* (CDA 2013) includes a section detailing the information required for completing a formal Dam Safety Review. The CDA technical bulletin *Application of Dam Safety Guidelines to Mining Dams* (CDA 2014) explains how the requirements for a Dam Safety Review, as described in the CDA *Dam Safety Guidelines* (CDA 2013), apply to mining Dams in the operation phase. In addition, the bulletin addresses aspects of Dam Safety Reviews relevant to closure, including "Closure – Transition Phase," "Closure – Active Care Phase," and "Closure – Passive Care Phase."

Guidance on tailings Dam design, management, operations, maintenance and surveillance, and closure can also be found in guidelines developed by industry associations, such as the International Commission on Large Dams (ICOLD), the Mining Association of Canada (MAC), the International Council on Mining and Metals (ICMM), and the Global Industry Standard on Tailings Management (GISTM). The latest versions of publications by the CDA and these associations are considered to represent Established Good Practice in Dam safety management.

The CDA *Dam Safety Guidelines* (and the associated bulletin for mining Dams) focuses on the structural failure modes of a Dam (sliding, overtopping, internal erosion). However, mining Dams typically store contaminated water and/or solids that can negatively impact the quality of offsite discharges of surface water and groundwater. Consequently, the Dam Safety Review should also appropriately consider other failure modes that are non-structural in nature and are related to meeting the environmental objectives of its design.

Environmental design criteria should be clearly documented and should include the "allowable" seepage rate, the Environmental Design Flood (EDF), and the water-flow and water-quality requirements for any release of surface water. The main components to be assessed in the Dam Safety Review include, but are not limited to:

- The properties of contaminants of potential concern. These could include parameters such as pH levels, metal and metalloid concentrations, and total suspended solids. During Mine operations, the concentrations of certain parameters may increase due to recycling of water and input from leached Mine rock. Unless considered in the original design, the increase in concentrations may require additional seepage mitigation or water discharge/treatment facilities.
- The efficiency of seepage mitigation. This could include assessment of the seepage rate and efficiency of seepage mitigation works, which may include grout curtains, low hydraulic conductivity core zones or impoundment lining, geomembrane or geosynthetic clay liners, seepage-interception ditches, or seepage pumpback wells.
- Water releases and risks of water release. Water releases can occur via groundwater or direct discharge. Monitoring of groundwater wells downstream of the facility can indicate potential contaminant migration and may be used to estimate and confirm potential seepage rates. Tracking of indicator parameters (such as sulphate) provide early indication of seepage effects. Surface water releases must meet site-specific and/or

- regulatory discharge water-quality criteria, which may also include allowable assimilative capacity of the receiving environment.
- Environmental flood containment. The water balance of the impoundment should be assessed to assure adequate freeboard exists to store the EDF.
- **Requirement for dust mitigation measures.** For some facilities, dust can be generated from tailings sand Dams, creating a public health and environmental concern. Accordingly, the Dam Safety Review should assess if the dust-mitigation measures are meeting the design objectives.

Environment Canada's *Environmental Code of Practice for Metal Mines* (Environment Canada 2009) provides a series of recommended environmental practices pertinent to mining Dams throughout the life of a mining Dam. The focus of this code of practice document is on metal Mines; this document can be used to help define the objectives and criteria for mining Dams with respect to environmental protection requirements.

Dam Safety Reviews are required for both active and closed tailings Dams.

For active tailings Dams that are continually being raised, due consideration should be given to the following statement made in the *Report on Mount Polley Tailings Storage Facility Breach* (Mount Polley Independent Expert Engineering Investigation and Review Panel 2015):

"Tailings dams are complex systems that have evolved over the years. They are also unforgiving systems, in terms of the number of things that have to go right. Their reliability is contingent on consistently flawless execution in planning, in subsurface investigation, in analysis and design, in construction quality, in operational diligence, in monitoring, in regulatory actions, and in risk management at every level. All of these activities are subject to human error."

As such, conducting a Dam Safety Review every five years may not necessarily align with the pace of the activities normally associated with an actively operated/constructed tailings Dam, especially if the conditions are complex. In this case, it will be particularly important to critically evaluate the Dam safety program and corporate governance activities and elements that the Dam Owner already has in place to ensure resiliency in engineering and Dam safety management, as discussed in Section <u>3.2.3</u> of these guidelines.

For closed tailings facilities, some of the unique considerations include:

- The Consequence Classification and Dam design criteria (flood and seismic) should be appropriately updated to reflect the increased risk of the long-term closure time period. Guidance in this regard is provided in:
 - CDA Technical Bulletin Application of Dam Safety Guidelines to Mining Dams (CDA 2014)
 - *Global Industry Standard on Tailings Management* (Global Tailings Review 2020)
 - *Tailings Management: Good Practice Guide* (ICMM 2021)
 - Conformance Protocols -Global Industry Standard on Tailings Management (ICMM 2019).
- The Dam design should be amenable to closure, or design measures should be implemented during operations to reduce risks upon closure.
- The development of new settlements downstream of the Dam should be considered because this could change the Dam Consequence Classification.
- Long-term geochemical actions that could lead to exceedance of the water-quality design components should be considered.

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Appendix C1: Dam Safety Review Assurance Statement for Dams Regulated under the BC *Dam Safety Regulation*

Note: This statement is to be read and completed in conjunction with the current *Professional Practice Guidelines – Legislated Dam Safety Reviews in British Columbia* (Engineers and Geoscientists BC 2023) and is to be provided for Dam Safety Review Reports for the purposes of the *Dam Safety Regulation*, BC Reg. 32/2023 as amended. Capitalized terms are defined in the Engineers and Geoscientists BC Guidelines.

Date:	

To: The Dam Owner(s)

Name:

Address:

With reference to the Dan	Safety Regulation, B.	C. Reg. 32/2023 a	as amended.
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For the Dam:

UTM (Location):	
Located at (Description):	

Name of Dam or description: _	

Provincial Dam number:		

Dam function: _____

Owned by: _____

Current Dam Consequence Classification is:

Check one

- □ Low
- □ Significant
- □ High
- Very High
- □ Extreme

I have signed, sealed, and dated the attached Dam Safety Review Report on the Dam in accordance with the Engineers and Geoscientists BC Guidelines, and have included a statement of qualifications as an individual or multidiscipline team lead in Appendix _____ of the Dam Safety Review Report. The above-referenced report must be read in conjunction with this statement. In preparing that report I have:

Check to the left of applicable items:

1.	Collected and reviewed available and relevant background information, documentation, and data
2.	Understood the current Consequence Classification for the Dam, including performance expectations
3.	Undertaken an initial facility review
4.	Reviewed and assessed the Dam safety management obligations, systems, and procedures
5.	Inspected the physical condition of the Dam, reservoir, and relevant upstream and downstream portions of the river
6.	Interviewed operations and maintenance personnel
7.	Reviewed available maintenance records such as the Operation, Maintenance and Surveillance (OMS) Manual and the Dam Emergency Plan (DEP), assessed if suitable to this situation and made recommendations to improve if applicable
8.	Confirmed proper functioning of flow control equipment
9.	After the above, reviewed the appropriateness of the Consequence Classification, including the identification of required Dam safety criteria
10.	Carried out a Dam safety analysis based on the Consequence Classification in item 9 above
11.	Assessed facility performance
12.	Identified, characterized, and determined the severity of Deficiencies in the safe operation of the Dam and Non-Conformances in Dam safety management system
13.	Recommended actions to be taken in relation to Deficiencies and Non-Conformances if all or part of the Dam has been found to be "not safe".
14.	Prepared a Dam Safety Review Report for submittal to the Regulatory Authority by the Dam Owner and reviewed the report with the Dam Owner.
15.	Reviewed the Dam Safety Review Report in compliance with Engineers and Geoscientists BC Bylaw Section 7.3.4.

Based on my Dam Safety Review, the current Dam Consequence Classification is:

Check one

- □ Appropriate
- □ Should be reviewed and/or amended

I undertook the following type of Dam Safety Review:

Check one

- □ Audit
- □ Targeted
- Comprehensive Detailed Design, Construction, and Performance

I recommend the following type of Dam Safety Review as the subsequent review:

Check one

- □ Audit
- □ Targeted
- Comprehensive Detailed Design, Construction and Performance

Rationale:

I hereby give my assurance that, based on the attached Dam Safety Review Report, as of the date below:

Check one

- The Dam **is Reasonably Safe, as defined in Section 3.1.2,** in that the Dam Safety Review did not reveal any Deficiencies or Non-Conformances in relation to the design, construction, maintenance, and operation of the Dam as set out in the attached Dam Safety Review Report.
- The Dam is Reasonably Safe, as defined in Section 3.1.2, but the Dam Safety Review did reveal administrative Non-Conformances with the *Dam Safety Regulation* as set out in section(s)
 ______ of the attached Dam Safety Review Report.
- The Dam will be Reasonably Safe, as defined in Section 3.1.2, conditional on implementation of the additional Established Good Practice recommendations, captured within the interim safety improvement action(s) described in section(s) ______ of the attached Dam Safety Review Report, to compensate for physical Deficiencies and/or regulatory, procedural and operational Non-Conformances (OMS) that have been identified as set out in Section(s) ______ of this Dam Safety Review Report.

Name	Date		
Signature			
Address			
		(Affix Professional Seal here)	
Telephone			
Name of Firm			

Permit to Practice Number

Appendix C2: Dam Safety Review Assurance Statement for Dams Regulated under the *Mines Act*

Note: This statement is to be read and completed in conjunction with the current *Professional Practice Guidelines – Legislated Dam Safety Reviews in British Columbia* (Engineers and Geoscientists BC 2023) and is to be provided for Dam Safety Review Reports in accordance with permit conditions and the *Health, Safety and Reclamation Code for Mines in British Columbia* or the *Dam Safety Regulation*, B.C. Reg. 32/2023 as amended. Capitalized terms are defined in the Engineers and Geoscientists BC Guidelines. An assurance statement is required for each Dam that is assessed.

Date: _____

To: The Dam Owner(s)

Name

Address

With reference to the permit conditions and the *Health, Safety and Reclamation Code for Mines in British Columbia* or the *Dam Safety Regulation*, B.C. Reg. 32/2023 as amended.

For the Dam: UTM (Location): Located at (Description): _____ Name of Dam or description: _____ Dam function: _____ Owned by: _____ Current Dam Consequence Classification is: Check one Low Significant П High П Very High П Extreme П

I have signed, sealed, and dated the attached Dam Safety Review Report on the Dam in accordance with the Engineers and Geoscientists BC Guidelines, and have included a statement of qualifications as an individual or multidiscipline team lead in Appendix _ of the Dam Safety Review Report. The above-referenced report must be read in conjunction with this statement. In preparing that report I have:

Check to the left of applicable items:

1.	Collected and reviewed available and relevant background information, documentation, and data
2.	Reviewed the environmental objectives for the materials stored in the impoundment and related design requirements
3.	Understood the current Consequence Classification for the Dam, including performance expectations
4.	Undertaken an initial facility review
5.	Reviewed and assessed the Dam safety management obligations, systems, and procedures
6.	Inspected the physical condition of the Dam, impoundment area and relevant areas upstream and downstream of the facility
7.	Interviewed operations and maintenance personnel
8.	Interviewed the Engineer of Record
9.	Reviewed available maintenance and operating records, such as the Operation, Maintenance and Surveillance (OMS) Manual and the Dam Emergency Plan (DEP)
10.	Confirmed proper functioning of Mine waste and water management systems and environmental control systems
11.	After the above, reviewed the appropriateness of the Consequence Classification, including the identification of required Dam safety criteria
12.	Carried out a Dam safety analysis based on the Consequence Classification in item 11 above.
13.	Assessed facility performance and conformance with the design basis and operating criteria
14.	Identified, characterized, and determined the severity of Deficiencies in the safe operation of the Dam and Non-Conformances in the Dam safety management system
15.	Recommended actions to be taken in relation to Deficiencies and Non-Conformances if all or part of the Dam has been found to be "not safe",
16.	Prepared a Dam Safety Review Report for submittal to the Regulatory Authority by the Dam Owner and reviewed the report with the Dam Owner
17.	Reviewed the Dam Safety Review Report in compliance with Engineers and Geoscientists BC Bylaw Section 7.3.4.

Based on my Dam Safety Review, the current Dam Consequence Classification is:

Check one

- □ Appropriate
- □ Should be reviewed and/or amended

I undertook the following type of Dam Safety Review:

Check one

- □ Audit
- □ Targeted
- Comprehensive Detailed Design, Construction and Performance

I recommend the following type of Dam Safety Review as the subsequent review:

Check one

- □ Audit
- □ Targeted
- Comprehensive Detailed Design, Construction and Performance

Rationale:

Where Established Good Practice (as captured in applicable guidance documents) differs from the regulatory requirements adopted by the Regulatory Authority, I have made the following distinction:

Check one

- □ Where the regulatory requirements have not been met, I have made recommendations to achieve the regulatory requirements
- □ Where the regulatory requirements have been met, I have made recommendations to improve the level of safety to comply with Established Good Practice
I hereby give my assurance that, based on the attached Dam Safety Review Report, as of the date below:

Check one

- The Dam **is Reasonably Safe, as defined in Section 3.1.2,** in that the Dam Safety Review did not reveal any Deficiencies or Non-Conformances in relation to the design, construction, maintenance, and operation of the Dam as set out in the attached Dam Safety Review Report
- The Dam is Reasonably Safe, as defined in Section 3.1.2, but the Dam Safety Review did reveal Non-Conformances with the *Health, Safety and Reclamation Code for Mines in British Columbia* as set out in section(s) ______ of the attached Dam Safety Review Report.

Name

Date

Signature

Address

(Affix Professional Seal here)

Telephone

Name of Firm

Permit to Practice Number

Appendix D: DAM SAFETY REVIEW BACKGROUND INFORMATION

This appendix is intended to provide a general outline of the type of background information that should be considered when carrying out a Dam Safety Review, while recognizing that the specifics around background information, including what is relevant to the scope of work, will vary depending on the nature of the Dam undergoing a Dam Safety Review. The Qualified Professional Engineer must apply professional judgment to the analysis and interpretation of both primary and secondary sources of information and data. The Dam Safety Review report should state the origin of the data used in the analysis and the assumptions that have been made.

DAM OWNER AND ORGANIZATIONAL INFORMATION

- Dam safety policy/management system
- Organizational charts and responsibilities
- Applicable regulations (water license, permits, orders)
- Purpose of structure (key capabilities and as-designed performance objectives)
- Operational obligations (laws, regulations, obligations, and stakeholder agreements)

OTHER INFORMATION GENERALLY INCLUDED IN THE OMS MANUAL:

- Site location and access
- Access restrictions
- Training/safety aspect for site access (or specific areas)
- Site staff qualifications
- Site staffing schedule

DESIGN AND CONSTRUCTION RECORDS

- Design documentation
 - Pre-design/conceptual design reports
 - Location and physiography
 - Site Investigations
 - Field and laboratory testing
 - Geologic/hydrogeologic conditions
 - Hydrology
 - Water quality
 - Seismicity
 - Stability of structures
 - Design details (design sections, foundation prep, instrumentation)
 - Reservoir rim assessment

- As-built or record drawings
- Construction and quality control
- Equipment specifications
- First reservoir filling data
- Original Consequence Classification
- Functional performance relative to key capabilities and as-designed performance objectives

ANNUAL AND ROUTINE CLIENT DAM SAFETY INSPECTIONS

- Annual or semi-annual inspection documents
- Special inspection documents
- Instrumentation records and documents
- Checklists (if not included in above)
- Photographs and videos

OPERATION OF DISCHARGE FACILITIES

- Operations, Surveillance, and Maintenance Manual
- Operating parameters and procedures
 - Inflow forecasting
 - Summary of critical, maximum, and other important water levels
 - Emergency or unusual operations
 - Flow control systems
 - Testing and maintenance requirements
 - Surveillance requirements
 - Instrumentation
 - Site communications
 - Site safety and security
- Test records (annual, monthly, etc.)
- Inspection records
- Operational records
 - The OMS Manual should be reviewed as part of the Dam Safety Review. It should provide pertinent information for the site review, staff interviews, and discharge facilities testing. The instructions in the OMS Manual being followed by operations and site staff (interviews) are critical to the safety of the Dam. The OMS Manual is required under the *Dam Safety Regulation* and serves as a vital component of facility documentation. For mining Dams, the OMS Manual is required under the HSRC. It should, therefore, be critically reviewed in the office and in the field by the Qualified Professional Engineer and assessed as to whether the document is current (latest revisions, organizational charts), adequate, and understandable.

- The OMS Manual should state the Consequence Classification and complexity of the Dam and appurtenant facilities and clearly state the frequency and requirements of inspections, monitoring, and testing. It should also include a surveillance plan which considers the Dam's consequence, failure modes, and performance indicators. The OMS Manual should include:
 - Description of facility, location, access (access restrictions), and Dam history;
 - Dam Owner description organizational relationship between Dam Owner, operator, Dam safety and other departments, site staff organization, and qualifications;
 - Legal requirements government regulations, discharge requirements, downstream interests;
 - As-built or record drawings and pertinent documentation;
 - Key and critical levels and expected performance;
 - Operating requirements normal operations and operations during floods and adverse weather conditions, emergencies, discharge restrictions and reservoir evacuation, flood forecasting, ice and debris management;
 - Maintenance requirements inspections, testing and supporting documentation including operating and maintenance instructions, hydraulic and backup power information. Component requirements, such as concrete structures, outlets, access routes;
 - Surveillance requirements routine, periodic and enhanced surveillance plans together with inspection checklists, qualification of staff;
 - Instrumentation objectives, listings, drawings, calibration requirements, reservoir level redundancy, data management procedures;
 - Site communications modes, records, maintenance requirements;
 - Emergency preparedness (may be found in a separate document) response, training, materials, and equipment; and
 - Security and public safety.

DAM PERFORMANCE AND SAFETY HISTORY

- Previous Dam Safety Reviews or comprehensive inspection reports
- Updated inundation studies and mapping
- Dam Emergency Plan (DEP)
- Deficiency investigations
- Dam safety improvements, repairs, or upgrades
- Updated drawings
- Updated information (hydrological, seismic, structural, geotechnical)

OTHER INFORMATION AND DATA SOURCES

- Regional Dam Safety Officer of the Dam Safety section of the Ministry of Forests, or the geotechnical engineering section of the Ministry of Energy, Mines, and Low Carbon Innovation
- Large and small scale topographic and cadastral maps
- Maps that show existing and proposed infrastructure, such as, transportation routes, utilities, residential and commercial subdivisions (information from local approving authority)

- Air photos (historical to present) and scales; high-resolution satellite imagery, and Light Detection and Ranging (LiDAR) images that can be also used for geological and geomorphological mapping and/or topographical mapping
- Terrain maps, terrain stability maps, bedrock and surficial geology
- Flood plain mapping and alluvial fan mapping
- Previous development, including residential and non-residential, and associated infrastructure
- Seismic data, including: seismic hazard maps and reports; ground motion data, seismic site class, and modal magnitude values of the design earthquake

POTENTIAL UPDATES TO THE ORIGINAL DESIGN CRITERIA MAY INCLUDE:

- Inflow Design Flood (IDF)
- Maximum Design Earthquake (MDE)
- Water, ice, sediment
- Uplift and seepage
- Undetected adverse foundation conditions
- Construction defects
- Reservoir and Unexpected conditions
- Functional availability and reliability objectives
- Risk-informed performance expectations

ADDITIONAL CONSIDERATIONS, CHANGED CONDITIONS, OR INCREASED KNOWLEDGE MAY INCLUDE:

- Alteration to discharge capacity due to conversions of gates, settlement of embankment or changes in available free board.
 - Obstructions such as debris, ice, landslides, debris flows or rockfall.
 - Failure to operate due to power, control, or overtopping of gates.
 - Inconsistencies and incompatibilities in procedures.
- Foundation/Abutment issues Undetected geological defects, such as open fissures, erodible or soluble materials, etc., have led to some notable Dam failures including Teton Dam (1976) where core fines were transported in the foundation.
 - Excessive settlements can occur due to hydrogeological changes in the foundation or natural ground may be poorer than considered in design.
 - Potential liquefaction should also be considered.
- **Construction defects** Defects that result in conditions not considered in design include inferior materials and poor workmanship, particularly in older Dams.
 - Defective joints, inadequate foundation treatment, and defective drains have resulted in excessive uplift.
 - Construction interruptions (winter stoppages, etc.) can result in drying or freezing and creation of preferential seepage paths at different levels in the Dam.
 - Inadequate compaction at abutments, conduits, and other interfaces.
 - Instrumentation problems associated with inadequate compaction or sealed lead trenches.

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