

## **THE ROLE OF THE ENGINEER OF RECORD IN AN INTEGRATED DAM SAFETY MANAGEMENT SYSTEM FOR TAILINGS DAMS: RECENT PERSPECTIVES FROM THE ALBERTA DAM SAFETY COMMUNITY**

Jeremy Boswell, P.Eng., Thurber Engineering, Calgary, AB, Canada  
Scott Martens, P.Eng., Canadian Natural Resources, Calgary, AB, Canada

### **ABSTRACT**

The concept of the Engineer of Record (EOR) has recently been applied to mining dams in various regulatory jurisdictions in Canada, the USA and elsewhere. The formal appointment of an EOR is a risk management tool that has gained importance as industry and regulators seek ways to improve the safety record of mine tailings dams, which have come under increased scrutiny following recent tailings dam failures in British Columbia and Brazil. The appointment of an EOR with clearly defined responsibilities for this role forms one essential component of a dam safety management system, which must have a defined chain of accountability and responsibility that includes the corporate leadership, operations management, and technical professionals.

A robust dam safety program is founded on accountability for dam safety that rests at the Owner's senior executive and board of directors' levels, and clearly defined responsibilities for managers and technical professionals. There is a list of key accountabilities and responsibilities that must be fulfilled in order to safely and effectively manage the design, construction, operation and closure/decommissioning of dams. Organizations may use different titles, and combine or split roles as necessary to fit the organizational size, scope and technical capability. However, an organization with a robust dam safety program will have all of these roles addressed in some manner within their organizational structure, or delegated to external consultants/contractors.

### **RÉSUMÉ**

Le concept d'ingénieur désigné (Engineer of Record, EOR) a récemment été appliqué aux barrages miniers au sein de divers champs de compétence réglementaire au Canada, aux États-Unis et ailleurs. La nomination formelle d'un EOR est un outil de gestion du risque qui gagne en importance puisque l'industrie et les organismes de réglementation cherchent de nouvelles façons d'améliorer le bilan en matière de sécurité de leurs digues à résidus miniers. Ces derniers ont fait l'objet d'une attention accrue depuis les récentes ruptures de digues à résidus en Colombie-Britannique et au Brésil. La nomination d'un EOR et une claire définition de ses responsabilités forment une composante essentielle du système de gestion de sécurité des digues. Ce système doit comporter une chaîne de responsabilités et d'imputabilités définie et doit inclure le support de la direction, la gestion des opérations, ainsi que les professionnels techniques.

Un programme de sécurité solide est basé sur les responsabilités que détiennent les cadres supérieurs et le conseil d'administration et sur une claire définition des responsabilités des gestionnaires et des professionnels techniques. Une liste de responsabilités et d'imputabilité clés doit être satisfaite pour assurer une gestion sécuritaire et efficace de la conception, de la construction, de l'opération et de la fermeture/démantèlement des digues. Les titres de ces responsables peuvent varier d'une organisation à une autre ou peuvent être combinés ou séparés selon la taille, la portée et les capacités techniques de l'organisation. Toutefois, une organisation avec un programme de sécurité des digues solide s'assurera que tous ces rôles seront comblés d'une manière ou d'une autre au sein de la structure organisationnelle ou délégués à des consultants ou entrepreneurs externes.

## **1 INTRODUCTION**

Shortly after the Mount Polley Tailings Breach on August 4, 2014, a group of dam safety engineers convened to consider current and emerging issues related to the responsible operation of resource sector dams in Alberta. A workshop was convened in November 2014 by the Alberta Chamber of Resources, which led to the formation of the Alberta Dam Integrity Advisory Committee (DIAC), of which both of the authors of this paper are members. One of the earliest requirements to emerge for action was the definition of roles and responsibilities for an Engineer of Record (EOR).

Other industry and professional organizations involved in the design and management of mine tailings dams have convened separate committees to define the EOR and related roles in tailings dam safety. These include the Mining Dams Committee of the Canadian Dam Association (CDA), the Tailings Working Group of the Mining Association of Canada (MAC), and the Tailings Engineer-of-Record Task Force of the Geoprofessional Business Association, which determined that assistance should be provided to their members to address the liability posed as EORs. Communication between these groups has facilitated an emerging consensus on the key elements of the EOR definition, and importantly, the role and limitations of the EOR role within a dam owner's organizational structure.

This paper summarizes the work that has been done to date in Alberta towards providing greater clarity on the role of the EOR and related dam safety roles for organizations and dam owners. The sheer number of dams currently operated within the Alberta oil sands mining industry has influenced quite strongly the thinking and direction applied to the EOR in Alberta. Much of the information below was tabled in a white paper prepared by the EOR subcommittee of DIAC in June 2017 (Alberta Chamber of Resources, 2017).

This paper outlines the basic roles and responsibilities necessary for the safe management of dams in Alberta. It is intended to be a flexible framework, adaptable to the size and structure of an organization.

The purpose of this publication was to raise awareness of the work that has been done in Alberta regarding the EOR and related dam safety topics, and to invite collaboration, technical critique and input from other jurisdictions, organizations and specialists in the dam safety field.

## **2 BACKGROUND TO THE REQUIREMENT FOR AN ENGINEER OF RECORD**

Dam owners, regulators and industry organizations have increasingly sought clarity on the roles and responsibilities needed for the safe design, construction and operation of dams within the mining, hydroelectric, water supply, flood control and irrigation industries.

The Owner of a dam is ultimately accountable for the safety of the dam. To fulfill this accountability, the Owner requires a design prepared by a qualified and experienced design team, led by an individual with overall responsibility for the design. The Owner requires further technical support to verify that the dam is being constructed in accordance with the design specifications, is operated within the design limitations, is performing as expected, and to define remediation requirements if the dam performance does not meet the requirements. The individual engineer with the single point of responsibility for the design and technical support roles has been designated as the Engineer of Record.

The scope of the EOR role encompasses the whole design life of a dam, from design through to closure. In some instances it is more practical to separate the design responsibility from the ongoing technical support during the construction and operation phases. In these cases, the Design Engineer (DE) who leads the design

team, can be defined separately from the EOR who provides the technical support to construction and operations.

### **3 ROLES AND RESPONSIBILITIES FOR DAM SAFETY**

A robust dam safety program is founded on accountability for dam safety that rests at the Owner's senior executive and board of directors' levels, and clearly defined responsibilities for managers and technical professionals. The dam safety roles from the operations staff up to the Accountable Executive should be formally declared and the responsibility acknowledged by the individuals in those roles.

The roles listed below must be fulfilled in order to safely and effectively manage the design, construction, operation and closure/decommissioning of dams. Organizations may use different titles, and combine or split roles as necessary to fit the organizational size, scope and technical capability. However, an organization with a robust dam safety program will have all of these roles addressed in some manner within their organizational structure, or delegated to external consultants/contractors.

In some cases, alternative titles may be used based on the operational phase of the dam (construction vs. operation) or the organizational structure. Some alternative titles are listed in parentheses. The roles and functions should be documented within an Owner's Dam Safety Management System or Policy document. Each party must formally acknowledge their role and accountability/responsibility. Each role must be fulfilled by an individual, not a company or department.

#### **Accountable Executive**

- Designated by the Board of Directors.
- Has overall financial control, and assigns budgetary authority and responsibility for dam safety management.
- Accountable for the management structure and ultimately the dam safety.

#### **Operations Manager (Construction Manager/Project Manager)**

- Has overall responsibility, budget and resource control for the safe operation of the dams.
- Delegated authority to execute construction and maintenance in accordance with the design specifications, and for safe operation of the dams.
- Implements the components of the Operations, Maintenance and Surveillance (OMS) program that relate to the Operations group.
- Communicates with the DSRE where technical input to the dam OMS is required.

#### **Dam Safety Responsible Engineer (DSRE) – (Chief Dam Safety Engineer)**

- Coordinates and provides oversight of the design, construction quality assurance, and overall management of the dam safety system.
- Given authority and resources to protect dam safety by the Accountable Executive, Operations and/or Mine Manager.
- Reports to the Accountable Executive regarding the status and performance of the dam(s).
- Identifies the scope and budget requirements for dam safety work.
- Verifies implementation of the OMS.
- Maintains the succession plan for the EOR.
- Implements and manages an Independent Review Board, where required by regulation or the Owner's policy.
- Determines appropriate risk mitigation strategies as part of the overall dam safety management program.

### Engineer of Record (EOR)

- On behalf of the Owner, provides technical direction for the safety of one or more dams.
- Assesses the dam conformance with design, construction specifications, operational plans, regulations and standards.
- Confirms that maintenance of the dam is carried out as per design requirements and OMS procedures.
- Implements the surveillance program. Assesses the performance against the Quantifiable Performance Objectives (QPOs), reviews and interprets construction and instrumentation performance data, and recommends changes to the design or operation to maintain the safety of the dam and compliance with regulations, guidelines and standards.
- Reports any deficiencies to the DSRE.
- Assesses risk associated with dam safety and communicates risk to the DSRE and DE. Provides recommendations to and supports the DSRE and DE in development of risk mitigation strategies.
- Maintains and submits construction quality, performance and dam safety documentation.
- Typically reports to the DSRE.

### Design Engineer (DE)

- Engineer responsible for the most recent overall design of the dam.
- Prepares design reports and construction drawings.
- Sets QPOs for the dam. Supports the EOR and DSRE to assess performance data and verify that the dam is functioning consistent with the design intent.
- Must be sufficiently familiar with previous designs, and operational and performance history so that the current design meets the regulations and safety standards.

An example organizational structure with these roles is shown in the figure below. Ideally, the DSRE reports on the safety of the dams directly to the Accountable Executive, and the DSRE coordinates the work of the DE and EOR. The Operations Manager is responsible for the construction and safe operation, and also reports to the Accountable Executive.

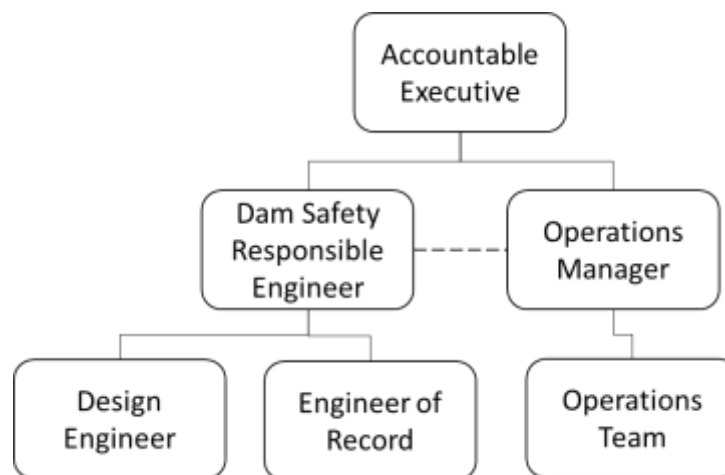


Figure 1: Dam Safety Accountabilities and Example Organizational Structure

#### **4 CONSIDERATIONS FOR PRACTICAL IMPLEMENTATION**

The Owner of the dam, as represented by the Accountable Executive, is accountable for the safety of the dam. Responsibility for the dam safety management is delegated to the DSRE, and responsibility for the construction, maintenance and operation of the dam in accordance with the design and operating limitations is delegated to the Operations Manager. The Accountable Executive position must be clearly identified within the Owner's organization. The Operations Manager and DSRE roles are typically within the Owner's organization, but may be delegated to a consultant/contractor for small organizations. The EOR and DE roles may be consultants or employees of the Owner.

It is important that the Operations Manager and DSRE have the authority and resources to protect dam safety. The EOR does not, in most organizations, have direct control over the construction and operation of the dam; that rests with the Operations Manager who has organizational and budgetary control. Close coordination is required between the Operations Manager and DSRE/EOR, so that the operations and technical groups are each fully informed and work collaboratively to manage the risks.

The qualifications of the DE and EOR must be commensurate with the risk and complexity of the dam. A typical minimum requirement is a relevant professional undergraduate and/or graduate degree, and 10 years of relevant experience in the design, construction, performance evaluation and/or operation of dams. Additional experience is needed in order to take responsibility for high risk or complex structures. Significant engineering judgment and discretion is required in these roles. They require detailed knowledge of regulations and industry standards, and the application of both direct experience and knowledge from a study of case histories. The DSRE, EOR and DE must be registered Professional Engineers in the jurisdiction in which they work - in the case of the context of the work described in this paper, this is the province of Alberta.

The roles of DE and EOR may be combined into the same person, or may be separate individuals. Where these are separate, the responsibilities and limitations of each role should be specified in writing and accepted by each. The DE and EOR may be employed by the dam owner if the owner company has sufficient internal expertise and technical resources, or contracted to an external consulting company. There are successful examples within the Alberta oil sands industry of tailings dams where both the EOR and DE are consultants, where the DE is a consultant and the EOR is an employee of the owner, and where both roles are employees of the owner. Provided that the individuals meet the experience and expertise requirements, and the roles are clearly defined, all of these models can be made to work successfully.

Particular attention needs to be paid to transfer of responsibility from a DE/EOR at the design and construction phase to the EOR during the operational phase, or between EORs during any phase of the life of the dam, to ensure that the new EOR has sufficient information to understand the design and be able to assess the safety of the structure. The accountability to coordinate between the DE and EOR, and for transfer of EOR responsibilities, rests with the DSRE.

## 5 DELINEATION OF DAM SAFETY RESPONSIBILITIES AND ACCOUNTABILITIES

Definitions of the roles used to define the dam safety responsibilities are listed in Table 1.

Table 1: Dam Safety Roles

Abbreviation	Role	Description
R	Responsible	Person doing the work to achieve the task. Others may be delegated to assist.
A	Accountable	Person ultimately answerable for the correct and thorough completion of the task, and the one who delegates the work to those responsible.
S	Support	Allocates resources to the responsible person. Helps the responsible person complete the task.
C	Consult	Those whose options are sought, typically subject matter experts; two-way communication with the responsible person.
I	Inform	Informed of the progress, status and when task is complete; one-way communication.

Table 2 shows an example of how the RASCI framework from Table 1 could be applied to a large organization with significant internal management and technical resources, such as is typical of the Alberta oil sands mining operations.

Table 3 shows an example of how this framework could be applied to a smaller organization that does not have dam design, construction and safety management expertise internally, and operates a limited number of smaller dams. In this example, several of the roles are combined, and the technical responsibility would be delegated to an external consultant.

The RASCI table follows the principle that only one person can be Accountable for a task. In some cases there is more than one person shown with Responsibility, where each person has responsibility for their area of the organization. For example, both the Operations Manager and DSRE may have responsibility for ensuring that qualified people undertake work, within their respective areas of authority.

Table 2: Example RASCI Framework for Dam Safety Management: Large Organization, Multiple Dams, Sophisticated Internal Resources

	Organizational Group				
	Organizational Accountability	Operational Control	Technical Responsibility		
	Example Roles				
	Accountable Executive (Corporate Owner)	Operations Manager	Dam Safety Responsible Engineer (DSRE)	Engineer of Record (EOR)	Design Engineer (DE)
<b>Organizational</b>					
Set dam safety policy	A	I	R	C	I
Develop and maintain the dam safety management system	A	I	R	C	I
Implement the dam safety management system	A	S	R	S	
Coordinate departments with dam safety roles	A		R	S	
Ensure qualified people undertake work	A	R	R	S	S
Provide technical oversight to manage dam safety risks			A	R	
Commission and implement an Independent Review Board	A	S	R	S	
<b>Investigation and Design</b>					
Site investigation using qualified people and appropriate methods		I	A	C	R
Prepare design report and construction drawings		I	A	S	R
Document design basis, QPOs and expected performance		C	A	C	R
<b>Construction</b>					
Provide resources to construct in accordance with design using appropriate materials and methods	A	R	C	C	I
Verify construction conformance with design		A	I	R	S
Maintain construction and performance records		R	A	R	S
<b>Operations and Maintenance</b>					
Develop and maintain operations procedures and limits		C	A	C	R
Operate and maintain dam safely in accordance with specifications, regulation and license, to meet QPOs	A	R	S	S	
<b>Surveillance and Reporting</b>					
Develop and maintain surveillance procedures		I	A	C	R
Conduct surveillance and assess dam performance including monitoring QPOs		S	A	R	C
Report on Dam Safety Inspections		S	A	R	I
Prepare and submit regulatory compliance reports	A	I	R	S	I

	Organizational Group				
	Organizational Accountability	Operational Control	Technical Responsibility		
	Example Roles				
	Accountable Executive (Corporate Owner)	Operations Manager	Dam Safety Responsible Engineer (DSRE)	Engineer of Record (EOR)	Design Engineer (DE)
Report dam safety occurrences to Regulator	A	S	R	S	
Respond to occurrences, investigate and correct issues		A	C	R	C
<b>Emergency Preparedness and Response</b>					
Assess and control public safety and access risks	A	R	S	S	
Prepare dam breach and inundation maps			A	R	S
Prepare, distribute and maintain Emergency Preparedness Plans (EPPs)		A	S	R	
Prepare and test Emergency Response Plans (ERPs) with stakeholders	A	R	S	S	
<b>Decommissioning and Closure</b>					
Prepare decommissioning and closure plan	A	R	C	C	S
Obtain regulatory approval for decommissioning and closure plan	A	R	S	S	
<b>Risk, Documentation and Review</b>					
Perform dam safety risks analysis	A	S	C	R	
Maintain design, construction, operations, maintenance and surveillance records	A	S	C	R	
Conduct Dam Safety Reviews (DSRs)	A	S	C	R	
Address DSR and Review Board recommendations	A	S	C	R	



Table 3: Example RASCI Framework for Dam Safety Management: Small Organization, Few Dams, Limited Internal Resources

	Organizational Group		
	Organizational Accountability	Operational Control	Technical Responsibility
	Example Roles		
	Accountable Executive (Corporate Owner)	Operations Manager	Engineer of Record (EOR)
<b>Organizational</b>			
Set dam safety policy	A		R
Develop and maintain the dam safety management system	A	S	R
Implement the dam safety management system	A	R	C
Coordinate departments with dam safety roles	R		I
Ensure qualified people undertake work	R		I
Provide technical oversight to manage dam safety risks	A		R
Commission and implement an Independent Review Board	A	S	R
<b>Investigation and Design</b>			
Site investigation using qualified people and appropriate methods	A		R
Prepare design report and construction drawings	A		R
Document design basis, QPOs and expected performance	A	C	R
<b>Construction</b>			
Provide resources to construct in accordance with design using appropriate materials and methods	A		R
Verify construction conformance with design	A		R
Maintain construction and performance records	R		
<b>Operations and Maintenance</b>			
Develop and maintain operations procedures and limits	A	C	R
Operate and maintain dam safely in accordance with specifications, regulation and license, to meet QPOs	A	R	C
<b>Surveillance and Reporting</b>			
Develop and maintain surveillance procedures	A		R
Conduct surveillance and assess dam performance including monitoring QPOs	A	S	R
Report on Dam Safety Inspections	A	S	R
Prepare and submit regulatory compliance reports	A	I	R
Report dam safety occurrences to Regulator	R		I
Respond to occurrences, investigate and correct issues	A	S	R

	<b>Organizational Group</b>		
	<b>Organizational Accountability</b>	<b>Operational Control</b>	<b>Technical Responsibility</b>
	<b>Example Roles</b>		
	<b>Accountable Executive (Corporate Owner)</b>	<b>Operations Manager</b>	<b>Engineer of Record (EOR)</b>
<b>Emergency Preparedness and Response</b>			
Assess and control public safety and access risks	A	S	R
Prepare dam breach and inundation maps	A		R
Prepare, distribute and maintain Emergency Preparedness Plans (EPPs)	A	R	C
Prepare and test Emergency Response Plans (ERPs) with stakeholders	A	R	C
<b>Decommissioning and Closure</b>			
Prepare decommissioning and closure plan	A	S	R
Obtain regulatory approval for decommissioning and closure plan	A	R	C
<b>Risk, Documentation and Review</b>			
Perform dam safety risks analysis	A	S	R
Maintain design, construction, operations, maintenance and surveillance records	A	R	C
Conduct Dam Safety Reviews (DSRs)	A	R	C
Act on DSR (and Review Board, if present) recommendations	A	R	C

## 6 CONCLUSION

There is a list of key roles and responsibilities for dam safety which must be clearly defined and assigned to individuals, from an accountable executive in the dam owner's organization, to the operations manager and responsible technical professionals. The role of the EOR is central to the safe management of resource dams, but is only one component of a wider team with responsibilities and accountabilities for dam safety. The detailed and team-based nature of these responsibilities illustrates the integrated and sustained effort required in order to provide the assurance of dam safety in the long term. This is particularly true for tailings dams, in which the risk profile generally rises as the facility is constructed and operated to full height and capacity.

## 7 ACKNOWLEDGEMENTS

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