Developing an

Operation, Maintenance and Surveillance Manual

for Tailings and Water Management Facilities

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The Mining Association of Canada

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Foreword

It is with pleasure that I present, on behalf of the members of The Mining Association of Canada (MAC), *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities*. This guide is the result of many months of deliberation by a 22-member team of mining industry specialists and practitioners. We are extremely grateful to the team members and their corporate sponsors for their generosity, skill and dedication in responding to this difficult challenge.

In keeping with MAC's commitment to continual improvement and sustainable development, the guide reflects the principles embodied in the association's Environmental Policy and Towards Sustainable Mining draft Guiding Principles, and complements its forerunner, *A Guide to the Management of Tailings Facilities*. Like the management guide, it encourages mining companies to practise safe and environmentally responsible management of tailings and water management facilities; however, this guide does so by focusing on the need for a site-specific operation, maintenance and surveillance (OMS) manual as an integral component of an overall tailings management system. Such a document can help companies comply with government regulation and corporate policy, demonstrate voluntary self-regulation and due diligence, practise continual improvement, and protect employees, the environment and the public.

The guide reflects principles and practices from a variety of sources. It addresses site-specific issues in a practical manner, reflecting the priorities of owners, managers and practitioners whose job it is to continually improve the performance of the mining industry in Canada and abroad.

Pierre Gratton
President & CEO
The Mining Association of Canada

Preface

In 1998, The Mining Association of Canada (MAC) published *A Guide to the Management of Tailings Facilities*. Developed collaboratively by Canadian mining industry practitioners and experts, its purpose was three-fold: to provide information on safe and environmentally responsible management of tailings facilities; to help companies develop tailings management systems that include environmental and safety criteria; and to improve the consistency of application of sound engineering and management principles to tailings facilities through their full life cycle. The *Guide* also introduced a framework for continual improvement in the management of health, safety and environmental risks associated with tailings facilities, to be applied from site selection and design, through construction and operation, to eventual decommissioning and closure. The tailings management framework presented in the *Guide* has found broad acceptance and application within Canada and abroad.

By February 2000, it was becoming apparent that while mining companies were making significant progress toward implementing and documenting tailings management systems, and integrating them with overall environmental management systems, further effort was warranted in their application at the operational level. In particular, a need was identified for further guidance in preparing manuals that outline procedures for the safe operation, maintenance and surveillance (OMS) of tailings and water management facilities.

Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities was prepared in response to this expressed need through a further collaborative effort by mining industry specialists. It recommends rationale, organization and contents for an OMS manual, and describes procedures that should be addressed.

This guide reflects sound industry practices and procedures. It adopts approaches from sources that include mining company policies and manuals, the MAC *Environmental Policy and Towards Sustainable Mining draft Guiding Principles, A Guide to the Management of Tailings Facilities*, the Canadian Dam Association (CDA) Dam Safety Guidelines, International Commission on Large Dams (ICOLD) Bulletins, and other guidelines and standards.

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Chapter 1 – Introduction

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Tailings and water management facilities are integral components of mine and mill operations. They must be managed for the long term to ensure that safe and environmentally responsible stewardship is achieved. Toward this end, in 1998, The Mining Association of Canada (MAC) published *A Guide to the Management of Tailings Facilities*, which recommended the implementation of a tailings management framework (Figure 1) to integrate environmental and safety considerations into each stage of the life cycle of a tailings facility, from initial site selection and design, through construction and operation, to eventual decommissioning and closure. Actions should be planned within the context of policies and commitments, implemented in accordance with plans, checked and corrected, and subjected to management review.

Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities has been compiled to provide additional guidance for preparing manuals that outline procedures for the safe operation, maintenance and surveillance (OMS) of tailings and water management facilities.

An OMS manual will provide the planning context for its application through the facility's life cycle (Figure 2). It should be in place upon commissioning, and maintained thereafter until closure, providing a clear, documented framework for actions. It will also provide a sound basis for measuring performance and demonstrating due diligence.

The level of detail of an OMS manual should reflect site requirements. It must be kept current and should be revised periodically with a view to continual improvement. Need for revision may be triggered, for example, by changes in dam classification, operational performance, personnel or organizational structure, regulatory or social considerations, or following changes in life cycle and/or design philosophy.

Figure 1: Elements of the Tailings Management Framework

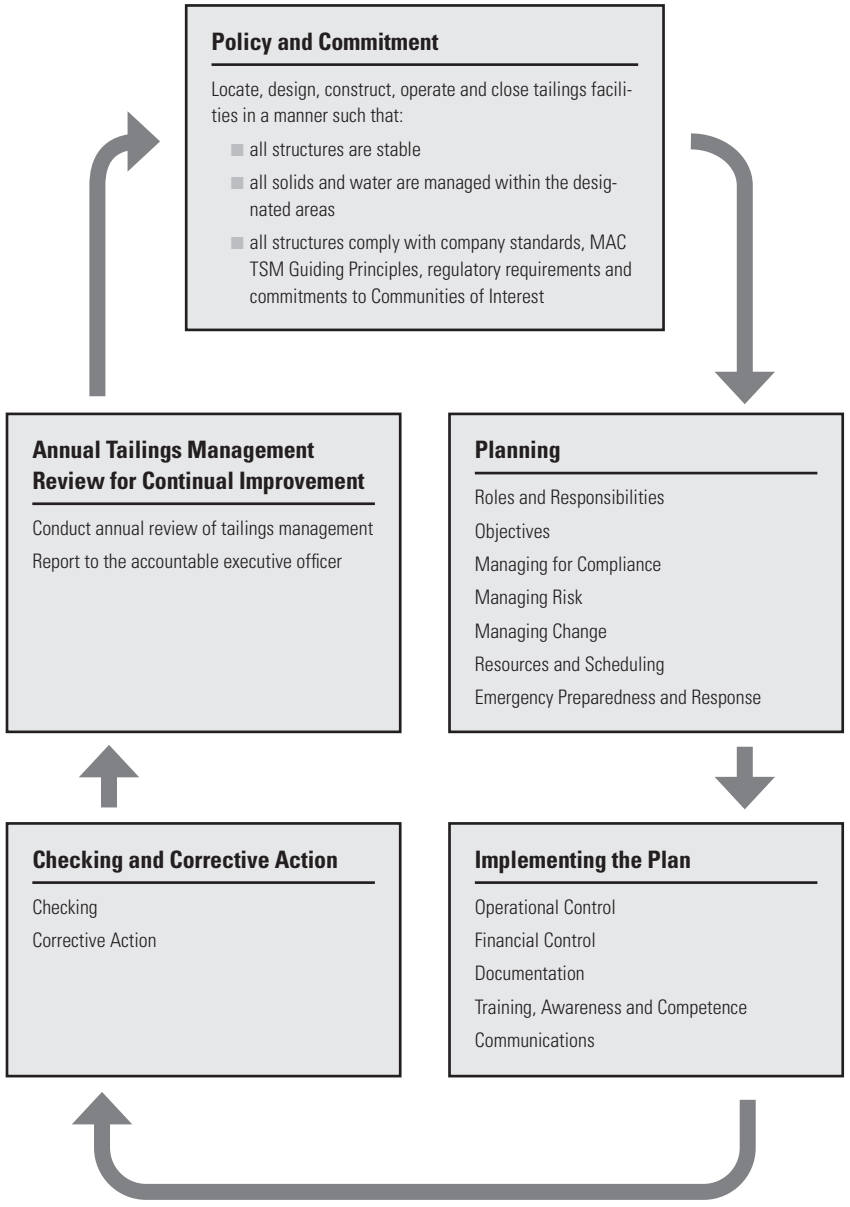
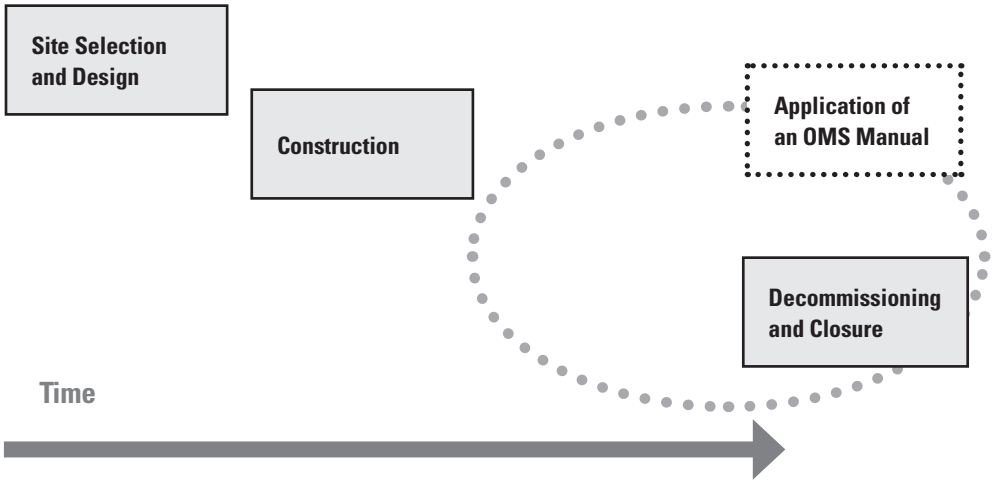


Figure 2: Application of an OMS manual through the life cycle of a tailings or water management facility



This document serves as a guide to the preparation of an OMS manual as a component of an overall site management framework. It recommends rationale, organization and contents for an OMS manual, and describes procedures that should be addressed. Tailings and water management facility owners are encouraged to use this guide to prepare their own site-specific OMS manual.

This guide does not replace professional expertise. Professional advice should be obtained in order to be sure that site and operational requirements are addressed and all regulatory requirements are met.

Regulatory requirements establish minimum standards for safety and environmental performance of tailings and water management facilities. An OMS manual should include reference to all relevant regulatory requirements and, to facilitate due diligence, delineate the performance measures that will demonstrate these requirements are being met.

An OMS manual should incorporate the principles outlined in *A Guide to the Management of Tailings Facilities*, which require tailings facilities to be located, designed, constructed, operated and closed in a manner such that:

- all structures are stable;
- all solids and water are managed within the designated areas intended in the design; and
- all structures are in compliance with company standards, the MAC Environmental Policy, regulatory requirements and commitments to stakeholders.

Chapter 2 – Preparing an OMS Manual

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The preparation of an OMS manual requires:

- setting up a team to develop an OMS manual;
- establishing objectives, a realistic budget and schedule to develop the manual;
- compiling information from many sources, within the company and beyond;
- establishing procedures for implementing, controlling and updating the OMS manual; and
- assuring that operational, engineering, corporate and regulatory issues are addressed.

OMS Manual Development Team

One individual should be assigned prime responsibility for the preparation of an OMS manual. This person should be assisted actively by a broader team with representation from the facility designers, site operations personnel, management and others having a direct interest in the performance and management of the facility.

Objective of an OMS Manual

The objective of an OMS manual is to define and describe:

- roles and responsibilities of personnel assigned to the facility;
- procedures and processes for managing change;
- the key components of the facility;
- procedures required to operate, monitor the performance of, and maintain a facility to ensure that it functions in accordance with its design, meets regulatory and corporate policy obligations, and links to emergency planning and response; and
- requirements for analysis and documentation of the performance of the facility.

2 Preparing an OMS Manual

An OMS manual should present information in a clear, logical and user-friendly manner. Any supporting documentation should be clearly referenced. The reader should be able to identify easily what is required and how to access the information needed.

The manual should enable the performance of a facility to be compared to expectations, design criteria and operating intent, particularly in the event of significant incidents.

Resources and Scheduling

A realistic budget and an achievable schedule should be established for preparation of an OMS manual, as well as for its maintenance, continual improvement, periodic review and update.

OMS Manual Control and Update

An OMS manual should be a controlled document, with specified procedures for:

- distributing and filing the manual and supporting documents;
- reviewing and updating the manual; and
- removing and archiving out-of-date materials.

OMS procedures and requirements should be reviewed and the manual updated regularly, consistent with continual improvement, and particularly after significant incidents.

Annual tailings and water management system reviews should include evaluation of OMS manuals.

Chapter 3 – Roles and Responsibilities

3

Organization, Structure, Individual Responsibilities

Organization, Structure, Individual Responsibilities

Describe the site management structure. Identify individuals having responsibilities for operation, maintenance, surveillance or emergency preparedness and response of the facility. List all (including external advisors and service providers) by name, position within the organization, roles, responsibilities and contact information.

Provide organization charts showing reporting links within the organization and communication links to external organizations.

Typical Designated Personnel for OMS	Operation	Maintenance	Surveillance	Emergency Preparedness
Mine/mill general manager				
Tailings area supervisors				
Tailings engineers and technicians				
Environmental engineers and coordinators				
Personnel responsible for facility inspections				
Personnel responsible for dam raising				
Tailings area operators and foremen				
Water management/treatment area operators and foremen				
Mill foremen (attending tailings discharge and recycle water requirements)				
Tailings backfill plant operators				
Site emergency/security personnel				
External advisors/consultants				
Mechanical/electrical foremen				
Electricians				
Mechanics				
Heavy equipment operators				
Scientists				
Administration support				
External liaison/public affairs personnel				
Legal and regulatory affairs personnel				
Engineer(s) of record				

▶ *It is essential for the integrity of operations that the facility management structure and individual roles, responsibilities and required competencies of personnel be clearly defined.*

Personnel need to understand the factors that constitute sound performance of a tailings or water management facility, how deviations from expected performance may indicate developing problems, and their individual roles in facility OMS. A new member of the team should be able to comprehend readily the facility management, organization and reporting structures, and be able to contact the appropriate management personnel using the information provided.

3 Roles and Responsibilities

Competency and Training

Set minimum knowledge and competency requirements for each position with defined responsibilities.

Define procedures to ensure that appropriate training is provided to all personnel working at the facility, including contractors and suppliers, and that all personnel have an appropriate understanding of the OMS manual and their respective roles and responsibilities. Highlight the responsibility of all site personnel to be continually aware of visual indications of facility performance.

Managing Change

Define procedures for making changes to design or operating plans, such as where conditions encountered in the field differ from design. Ensure that the process of changing design includes obtaining authorization of the changes.

▶ *Tailings and water management facilities change. Revisions to design during operations should follow a defined review and approval process, appropriately involving company management, site personnel and regulators.*

Identify responsibility for reviewing, updating and improving the OMS manual, to respond to:

- evolution of design through capacity changes, operational efficiencies, closure requirements, performance feedback and life-cycle changes;
- incorporation of as-built records of construction;
- variation of performance from design;
- changes in site management organization, facility description, roles and responsibilities, and operating and reporting procedures;
- suggestions for improvement;
- succession planning/training; and
- regulatory change.

Chapter 4 – Facility Description

4

Facility Overview

Essential information about the facility should be provided – site conditions and facility components, regulatory requirements, basis of design and design criteria, construction history, and location of all relevant documentation. The facility description may be presented in summary format with reference to more detailed information in supporting documents and reports.

Facility Overview

Provide an overview of the facility, setting the context of its surroundings, related operations and its history.

Typical Facility Overview

Ownership – current and historic

Location

Site layout plan, showing the major components and appurtenances of the tailings or water management facility, mine, mill, drainage features and access roads

The broader site context, including:

- mine, mill, smelter and/or refinery operations and process
- ore type
- tailings output
- history – changes to ore type, mining, milling and processing

Features within the site area, such as topography, creeks, streams, rivers, lakes, roadways, ditches, pipeline corridors and utility corridors, which are not part of the actual facility

History of design, construction and operation, key milestones and significant changes

Site Conditions

Describe the physical site conditions that provide the basis for design and operation of the facility. Extensive information may be available on site conditions, the essential elements of which should be summarized, with reference to supporting documents for additional detail.

Typical Site Conditions
Climate – temperature, wind, precipitation, evaporation, seasonal and extreme events, precipitation and runoff, air quality
Water ◆ hydrology – regional creeks, streams, rivers, ponds and lakes, marine conditions, catchment area, downstream areas that may be affected, and water flow, volume, chemistry/quality, and biology ◆ hydrogeology – aquifers, and water flow, volume, direction and chemistry/quality
Land forms – topography, including muskeg, peat or talus slopes
Geology and geochemistry – surficial deposits and bedrock characteristics (moisture content, gradation, mineralogy, geochemistry, shear strength, compressibility, permeability and index tests), stratigraphy, geomorphology, mineral and petroleum resources, background elemental content
Natural hazards – landslides, avalanches and debris torrents, seismicity, flood potential, frost action, wind, ice movement, frazil ice
Surrounding land and water tenure and use
Biological – ecosystem identification, flora and fauna

Provide location, and essential supporting field and analytical program data related to the site.

Typical Site Reference Data
Grid system and contour maps
Datum, location of survey benchmarks
Test hole logs and locations, drill holes, penetration holes, core holes, auger holes, geophysical tests, test pits, etc.
Instrumentation type and location: piezometers, inclinometers, settlement gauges, flow gauges, etc.
Geophysical surveys
Tailings/soil/rock conditions or characteristics – moisture content, gradation, mineralogy, geochemistry, shear strength, compressibility, permeability and index tests
Groundwater and surface water sampling points
Regulatory compliance points
Water characteristics, naturally occurring background
Weather

Facility Components

Provide a listing of significant equipment and structures that comprise the facility, including those associated with tailings delivery and tailings or water management.

Typical Components of a Facility		
Tailings/Water Management		
Dams, dykes and containment structures	Ditches	Water
Tailings beaches	Culverts	Seepage reclaim pumping and ditch systems
Perimeter containment slopes	Drains	Decant structures
Dam crest	Drop structures	Spillways
Starter dykes, berms	Liners	Siphons
Impoundment area	Control structures	Reclaim barge
Appurtenances	Tailings and water pipelines	Creek diversions
Vegetation	Pumps and pump houses	Ditch diversion
Dust control systems	Pipeline bridges	Water treatment plant
Infrastructure		
Utility corridors	Power supply, main and backup	Enclosures
Gas lines	Telecommunications	Signage
Product lines	Transmission lines	Gates
Roads, ramps, railroads	Switches	Fences
Buildings		
Instrumentation		
Piezometers	Inclinometers	Slurry density gauges
Groundwater wells	Surface movement monuments	Water-level gauges
Weirs	Computerized controls	

4 Facility Description

Facility Components

Regulatory Requirements

Include relevant supporting data and references for components of the facility in a summary table, including appurtenances and instrumentation types.

Typical Component Details
Important component dimensions
Pipeline diameter, thickness and composition
Type of dam, method of construction, failure consequence classification
Plans, maps, photographs and drawings which show the location of fixed equipment and structures, above ground and buried
Tailings and construction material characteristics and capacity
Date of construction/installation
Where to find:
■ design/construction documents, manuals and drawings
■ basis of design/design criteria
■ as-built documents – manuals, drawings and specifications

Regulatory Requirements

List all regulatory approvals. Describe their purpose, compliance and reporting requirements, and respective periods of applicability. Include reference to the personnel responsible for ensuring compliance, permit tracking procedures, and the locations of all regulatory documentation.

Typical Regulatory Compliance Issues	
Financial assurance	Vegetation, wildlife and fish impacts
Environmental assessment	Progressive reclamation
Water import and usage	Decommissioning and closure
Receiving water and effluent criteria (surface and groundwater)	Dust, steam and fugitive emissions
Water recycling	Noise and odour tolerance
Dam safety	Hazardous materials and designated substances
Land use and disturbance	Regulatory reporting
Waste management	Community outreach

Basis of Design and Design Criteria

Basis of Design and Design Criteria

Describe the basis of design and design criteria of the facility:

- **basis of design** addresses conditions imposed by the site, requirements of the project, and regulations; and
- **design criteria** are standards set by engineering practice and/or regulation, in accordance with the basis of design.

Document modifications to the design along with associated risk assessments and management authorization for such changes.

Provide sufficient information to:

- convey the capacity and the design basis of the tailings or water management facility;
- ensure that the current design criteria are always available to enable comparison of performance of the facility with design intent; and
- guide review of the design as necessary to assess the need for changes in design or OMS procedures.

Provide references to supporting documents, including initial and subsequent design and engineering reports which describe the basis of design and details of changes.

▶ *Initial design of a tailings or water management facility may be carried out when there are only limited data available on the site conditions, tailings characteristics and the longer term operational and closure requirements of the site. Assumptions are made. As additional data is generated during the construction and operation phases of the facility, these assumptions can be verified or adjusted, which may lead to changes in design.*

Changes to the documented design may have significant impact on facility risk, and should therefore be implemented only after due consideration, management approval and regulatory authorization.

Basis of Design and Design Criteria

Basis of Design

Site conditions and requirements or limitations of the project

Site Characteristics

- Basin capacity, footprint, hydrology, operational life
- Siting constraints, natural hazards
- Climatic considerations
- Elevation change and distance from mill
- Foundation conditions
- Surficial and bedrock geology

Operating Requirements

- Ore reserve, life of mine, annual through-put
- Tailings pulp density in delivery pipeline
- Tailings production and basin filling rates, impoundment raising schedule
- Tailings characteristics, including gradation, chemistry, mineralogy, dry settled density
- Tailings deposition procedures – cycloning, spigotting, cell construction, end discharge
- Slurry water chemistry
- Dam crest width
- Tailings beach width and slope
- Water quality standards for surface and groundwater
- Water balance, mill reclaim water rate, treatment plant capacity
- Water management (including diversion works, outlet structures and freeboard requirements)
- Pond freeboard, settlement and consolidation
- Regulations
- Acid-generating potential
- Pond retention time, pond chemistry
- Pond seepage control measures, perimeter surface and groundwater chemistry requirements
- Catchment area runoff diversion requirements
- Decommissioning, closure and reclamation

▶ *Closure requirements also influence the operating design of a facility. Therefore, the design basis and criteria for closure, including decommissioning and reclamation, should be included in the manual. Closure plans often evolve through the operation stage of the facility. Changes need to be tracked in the manual.*

Design Criteria

Standards set by engineering practice and/or regulation

- Maximum height and slopes of dam and tailings
- Dam construction materials
- Dam construction methods
- Seismic design criteria
- Development stages, seepage and deformation limits
- Liquefaction and compaction
- Influent flood storage and routing criteria
- Factor of safety for perimeter slopes for operation and closure
- Impoundment failure consequence classification
- Acceptable risk

Construction History

Provide a summary of the construction history of a facility, including, as available, reference to any problems or unique circumstances encountered, and a description of the construction procedures. Ongoing inspection and review should expand the documented record over time.

Typical Construction History Data
Dates of construction
General description of the construction
Engineer of record, construction contractor
Size, scale, complexity and ease (or difficulty) of construction of each stage
Summary of the key elements of the facility that were constructed
Type and source of construction materials
Summary of problems or unique circumstances encountered, including natural (ground conditions, weather, etc.) or human-made (changes from approved design, construction methods differing from standard, etc.) conditions
List of supporting documentation providing more specific details relating to the construction ◆ investigations, designs, specifications, as-built records, photographs, etc. ◆ list of key individuals supervising and documenting the construction ◆ stage construction linkages to tailings and water management, etc.

Document Control

Define procedures for the management and retention of information, data, design and performance documents, both hard copy and electronic, including the revision or version number, location, circulation, archiving and backup practices. Include the basis and schedule for retention of essential information, and removal and archiving of non-essential information, during the life of the facility.

Delineate the availability and access controls for key documents, to ensure both continued accessibility and integrity of the data record, and to avoid files being lost, removed or misplaced. Describe the method for retrieving information from electronic databases.

Provide up-to-date listings of pertinent supporting documents and reports, together with the locations of the documents and reports not bound into the manual.

Typical Reference Documents and Reports	
Site investigation, geological and environmental baseline reports	Dam inspection and dam safety review reports
Environmental assessment	Environmental control and monitoring
Laboratory and field testing results	Instrumentation, surveillance and monitoring manuals and reports
Design reports	Risk assessments and reports
Construction reports	Serious incident reports
Hydrological and meteorological reports	Emergency preparedness, response and contingency plans
Vendor manuals and drawings	Decommissioning and closure plan
Tailings deposition and water management plans	

▶ *The impact of decisions made in designing and managing tailings and water management facilities accrue over long periods of time. Resulting impacts may not be evident until some future date. It is, therefore, important that essential information be passed on to future operators so that operating methodologies and past intentions are not lost with time.*

▶ *Documentation provides the means to rely less on a person's memory, and more on a formalized system from which knowledge can be transferred.*

Chapter 5 – Operation

5

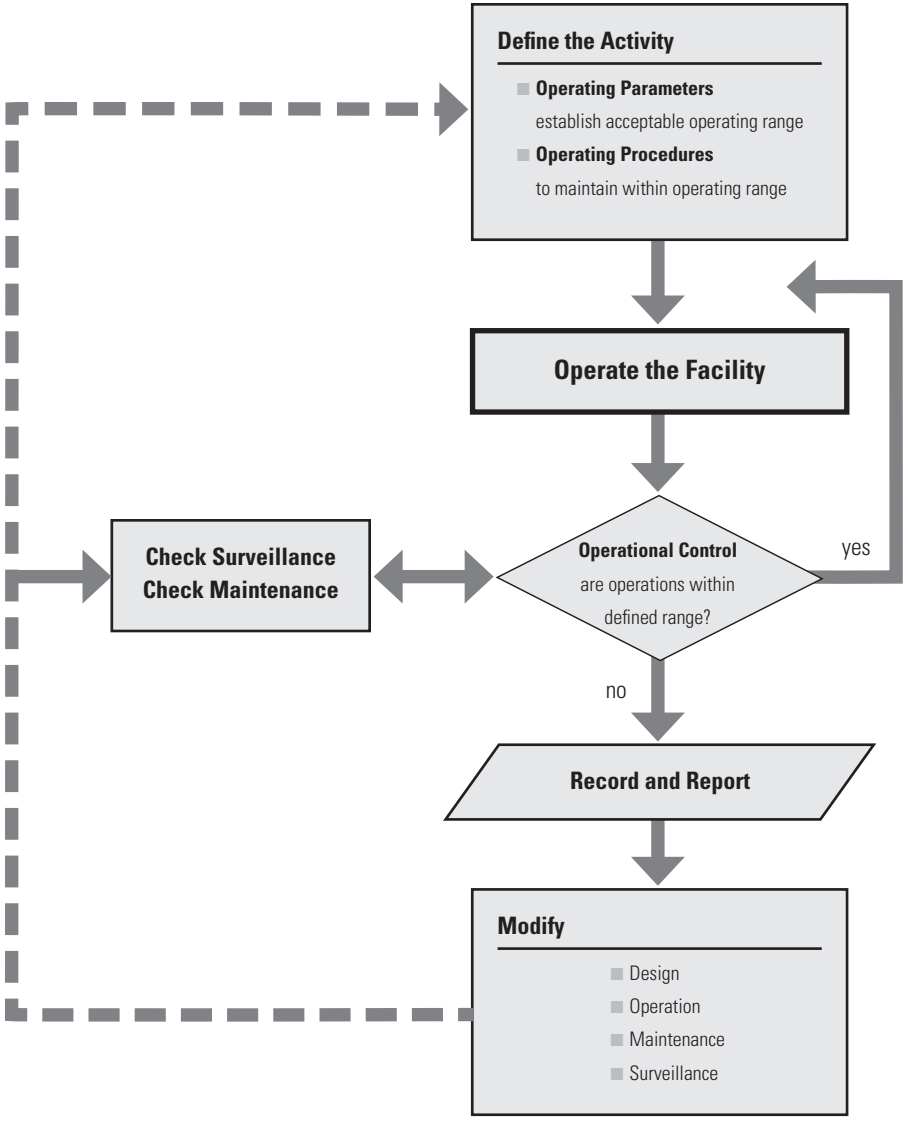
The operation plan for a tailings or water management facility addresses the transport and containment of tailings, process water, effluents and residues, and the recycle of process water.

Objective

Objective

Define operating standards and procedures in accordance with design criteria, regulatory requirements, company policies and sound operating practices, encompassing all significant aspects of, and activities for, the economical, safe and environmentally responsible disposal and storage of tailings and management of water.

Figure 3: Operation flowchart



Tailings Transport and Deposition

Describe the deposition plan. Provide a summary of the full life-cycle deposition plan, together with detailed, current-year annual plans identifying discharge locations, discharge schedule and planned construction, with reference to supporting reports and plans.

Identify key operating parameters and procedures, and a schedule for periodic review against design.

Typical Tailings Transport and Deposition Parameters
Tailings slurry quantity and flow rate projections
Pumping and pipeline operating pressures
Slurry density and other physical and chemical properties, temperature
Tailings gradation, mineralogy, specific gravity, density, angularity, clay content and plasticity, acid-generating and metal-leaching potential
Tailings deposition technique and compaction
Tailings beach and underwater slopes
Maximum beach crest elevation
Maximum and minimum beach width
Chemical properties of tailings pore water and decant water

Tailings Transport and Deposition

▶ *During operation of a facility, the tailings might vary in physical, chemical and mineralogical characteristics. Representative samples of tailings should be collected periodically for analysis. These analyses will be useful to verify any change in the physical, chemical and mineralogical characteristics of the tailings that could impact the deposition plan (a modification in the tailings specific gravity can affect the deposition slope of the material), tailings deposit density, the final effluent water quality or the rehabilitation strategy.*

Tailings Transport and Deposition

Typical Tailings Transport and Deposition Procedures

Tailings deposition

- dam safety
- staging of dam lifts
- solids storage capacity
- water recycling
- water treatment requirements
- cell construction, spigotting, contained beaching
- compaction

Operating instructions for pipes, pumps, etc.

- tailings line relocation
- line pressure
- pulp density
- pipe rotation
- valve openings
- vacuum breaks
- measures to prevent line or pump sanding or freezing
- measures to flush or thaw lines

Response to deviations in physical, chemical or mineralogical properties from the design

Response to unusual operating conditions, such as severe winter conditions, periods of high rainfall, drought, and high winds

Mechanical functions, such as line rotation, line relocation and valve openings

Dam and Basin Raising

Identify requirements and plans for staged dam construction over the life of the facility, to maintain adequate solids storage capacity and allow adequate polishing of supernatant during operation, including:

- methods of dam construction – spigotting, cell construction, upstream, downstream, etc.;
- tailings deposition procedures, taking into consideration dam safety – staging of dam lifts, solid storage capacity, water recycling and water treatment requirements; and
- quality control measures to ensure that the construction is completed properly.

Typical Dam and Basin Raising Parameters	
Maximum and minimum height	Phreatic surface and porewater pressures
Dam-raising schedule	Beach width
Construction material sources	Foundation and dam building material characteristics
Placed material density	Slurry density
Perimeter slopes	Tailings delivery volume
Progressive reclamation	

Typical Dam and Basin Raising Procedures	
Erosion control	Site preparation, vegetation/overburden removal, earth and rock fill
Compaction	Filter construction
Material placement, spigotting, cell construction, single point discharge	Instrumentation installation and/or extension

Water Management

Describe procedures for management of water flow through a facility under normal operating practice, as well as under special circumstances such as spring runoff, severe rainfall events or drought. Describe water balance, including identification of all inputs, inventory of pond and interstitial water, and outflows.

Identify key operating parameters and define operating procedures related to water balance and water management for the facility, including spillways, decant systems, siphons, ditches, swales and drop structures. Provide reference to supporting reports and plans.

Typical Water Management Operating Parameters
Minimum freeboard
Stage storage curves
Maximum and minimum operating water levels and beach widths (seasonal considerations, wind, flood and drought events, and the treatment schedule)
Tables of target pond levels
Water discharge, volume and quality (normal operating conditions and special circumstances)

Typical Water Management Operating Procedures
Control of inflows and outflows
Flood routing
Seepage water return
Reclaim water

Environmental Protection

Define parameters and procedures to protect the environment by controlling tailings and water through treatment and management. Document regulatory reporting requirements.

Typical Environmental Protection Parameters
Water/effluent discharge quality and flow rate
Chemical properties of tailings porewater, groundwater, seepage and decant water
Dust/particulate loading, quantity and quality
Fog or steam emission criteria
Basin footprint
Biomass/biodiversity, wildlife, aquatic life, livestock and habitat

Typical Environmental Protection Procedures

Treatment plant
- unit operations
- reagent addition
- instrumentation and process control

Surface water, groundwater and seepage collection, treatment and transport, including pump back

Dust abatement

Fog or steam abatement

Wildlife, aquatic life and livestock protection

Handling of hazardous materials and designated substances

Reclamation and revegetation

Progressive rehabilitation

5 Operation

Safety and Security

Define parameters and procedures to control site access, to assure both facility integrity and safety of site personnel and the general public. Address hazards or safety restrictions related to human contact with tailings or decant materials, including risk to personnel walking or operating equipment at the facility.

Typical Safety and Security Parameters	Typical Safety and Security Procedures
Site access and egress limitations	Signage, fencing and gates
Workplace hazards	Security patrols
Personal protective equipment	Workplace safe operating procedures

Documentation

Define information to be collected and recorded as part of the facility's operation. Checklists and report forms might be included or referenced.

Typical Operation Documentation
Quality control records and statistical summaries
Instrumentation records, daily diary entries
Communications and activity records
Photographic summaries and/or videos
Schedules
Change orders, memos, reports
As-constructed drawings and reports, especially of dam raising

Reporting

Define operating performance information to be reported.

Specify procedures for reporting of:

- operational conditions requiring maintenance; and
- observations which may identify significant change in conditions at the facility.

Chapter 6 – Maintenance

6

The maintenance program for a tailings or water management facility addresses identification and description of critical parts, routine, predictive and event-driven maintenance, and operating and surveillance observations for all civil, mechanical, electrical and instrumentation components of a facility.

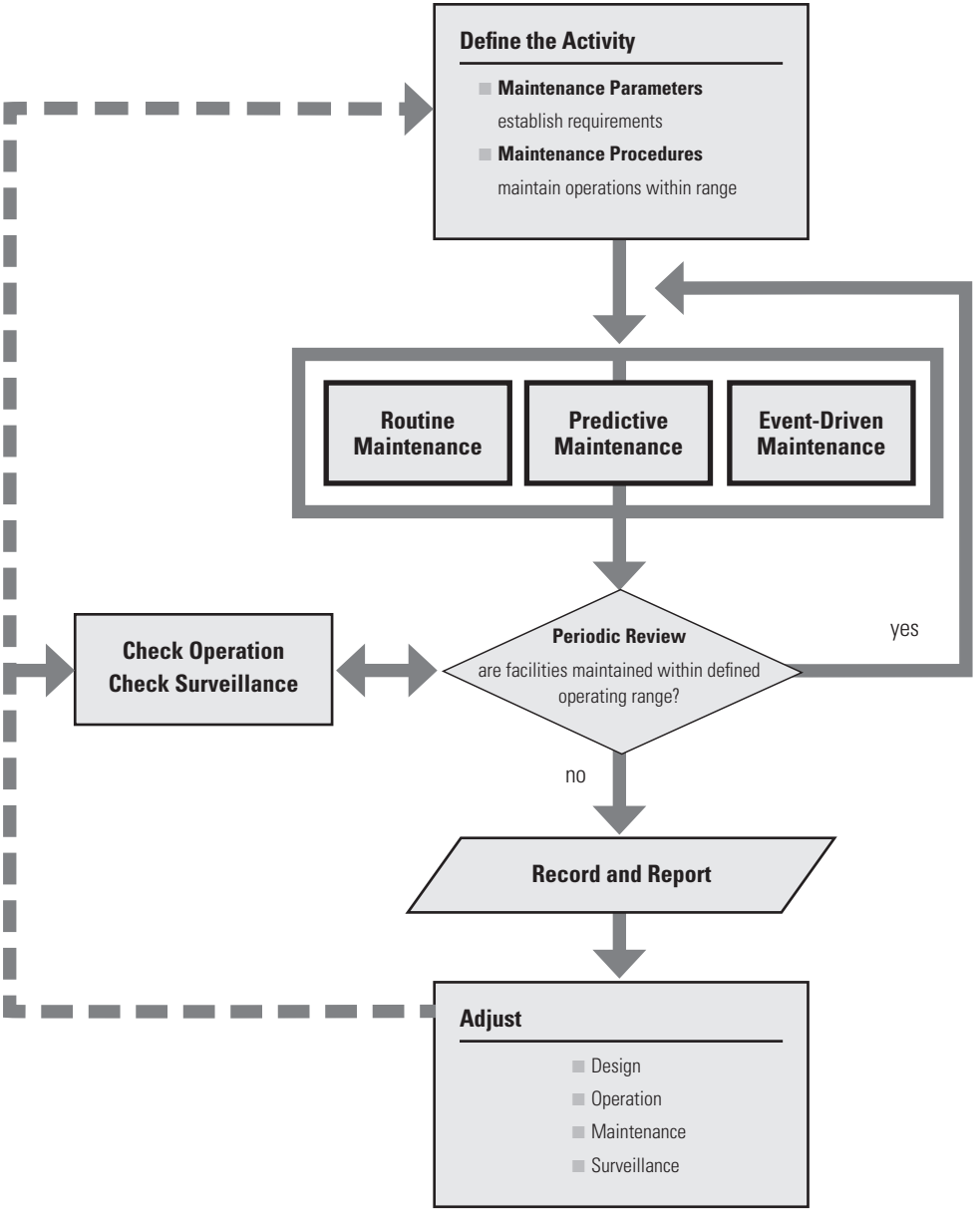
Objective

Identify key maintenance parameters and procedures to ensure that the individual components of a facility are maintained in accordance with performance criteria, company standards, legislative requirements and sound operating practices. Maintenance plans should be tailored to unique facility characteristics and site conditions.

Typical Contents of a Maintenance Plan

- Statement of objective
- Overall responsibility for maintenance
  - maintenance organization chart
    - position, name and contact information
  - required qualifications and familiarity with the OMS manual
- Inventory of components subject to maintenance, and for each component
  - where it is located
  - when it should be maintained
    - if routine or predictive maintenance, what frequency
    - if event-driven maintenance, what trigger
  - reference standards
    - design or performance standards
    - equipment operating and maintenance manuals
- Schedule for checking emergency equipment and critical spare parts list
- What is to be documented
  - component condition
  - maintenance action undertaken, standard met
  - recommendation for next action
- Reporting
  - to whom
  - when
  - how, and in what form

Figure 4: Maintenance flowchart



Maintenance Parameters

Define maintenance parameters that address civil, mechanical, electrical and instrumentation requirements.

Typical Maintenance Parameters	
Site access	Process and surveillance instrumentation controls
Ditch, spillway and drop structure capacity	Switches, interlocks and meters
Support structure integrity	Erosion
Equipment availability and reliability	Vegetation
Pipeline wear and thickness criteria	Design economic life
Minimal tailings line thickness, and associated requirements	

Routine and Predictive Maintenance

Outline routine and predictive maintenance procedures for all identified components of the facility, specifying:

- prioritization, based on risks and consequences;
- material and equipment availability;
- maintenance action plans, including repairs and replacement as required; and
- documentation of maintenance undertaken.

Event-Driven Maintenance

Provide procedures to address conditions or incidents requiring maintenance, which may arise from observations from other OMS activities, and result in planned or unplanned maintenance actions, specifying:

- prioritization, based on risks and consequences;
- maintenance team "call-out" procedures;
- material and equipment availability;
- maintenance action plans, including repairs and replacement as required;
- lock-out and safety procedures/concerns;
- return to normal operation; and
- documentation of maintenance undertaken.

▶ *Predictive maintenance utilizes feedback from*

- *equipment operating history*
- *maintenance effort (costs)*
- *site conditions*

to assist in the identification of on-time servicing needs to avoid costly, lengthy or untimely breakdowns.

▶ *A key component of maintenance planning is preparedness to respond to breakdowns, incidents or conditions requiring maintenance. It is important, however, to distinguish between requirements for maintenance and emergency response; maintenance actions do not address emergency situations, which should be covered in the emergency preparedness plan and/or emergency response plan.*

6 Maintenance

Documentation

Define information to be collected and recorded as part of the facility's maintenance. Checklists and report forms might be included or referenced.

Typical Maintenance Documentation	
Up-to-date equipment logs	Photographic summaries and/or videos
Work history	Inventory of spares, materials, tools and equipment
Frequency and cause of problems	Critical spares list
Component reliability	Schedules
Quality control records	Change orders
Daily diary entries	Memos
Communications and activity records	Reports

Reporting

Define maintenance information to be reported.

Specify procedures for:

- reporting operational conditions requiring maintenance; and
- reporting significant observations from maintenance activities, including greater than expected maintenance requirements and excess event-driven maintenance.

Such reporting may be instrumental in identifying and dealing with changed conditions at the facility.

Chapter 7 – Surveillance

7

Surveillance involves inspection and monitoring of the operation, structural integrity and safety of a facility. It consists of both qualitative and quantitative comparison of actual to expected behaviour. It must be a designed program, fully integrated with operation and maintenance activities, consistent with life cycle and regulatory requirements.

Regular review of surveillance information can provide an early indication of performance trends that, although within specification, warrant further evaluation or action.

All personnel working at a tailings or water management facility should be involved in surveillance as a routine part of daily activities, maintaining visual awareness of the facility in the course of their regular and/or routine duties, in addition to surveillance-specific site engineering, instrument monitoring, analysis, inspection, periodic review and oversight.

Objective

Objective

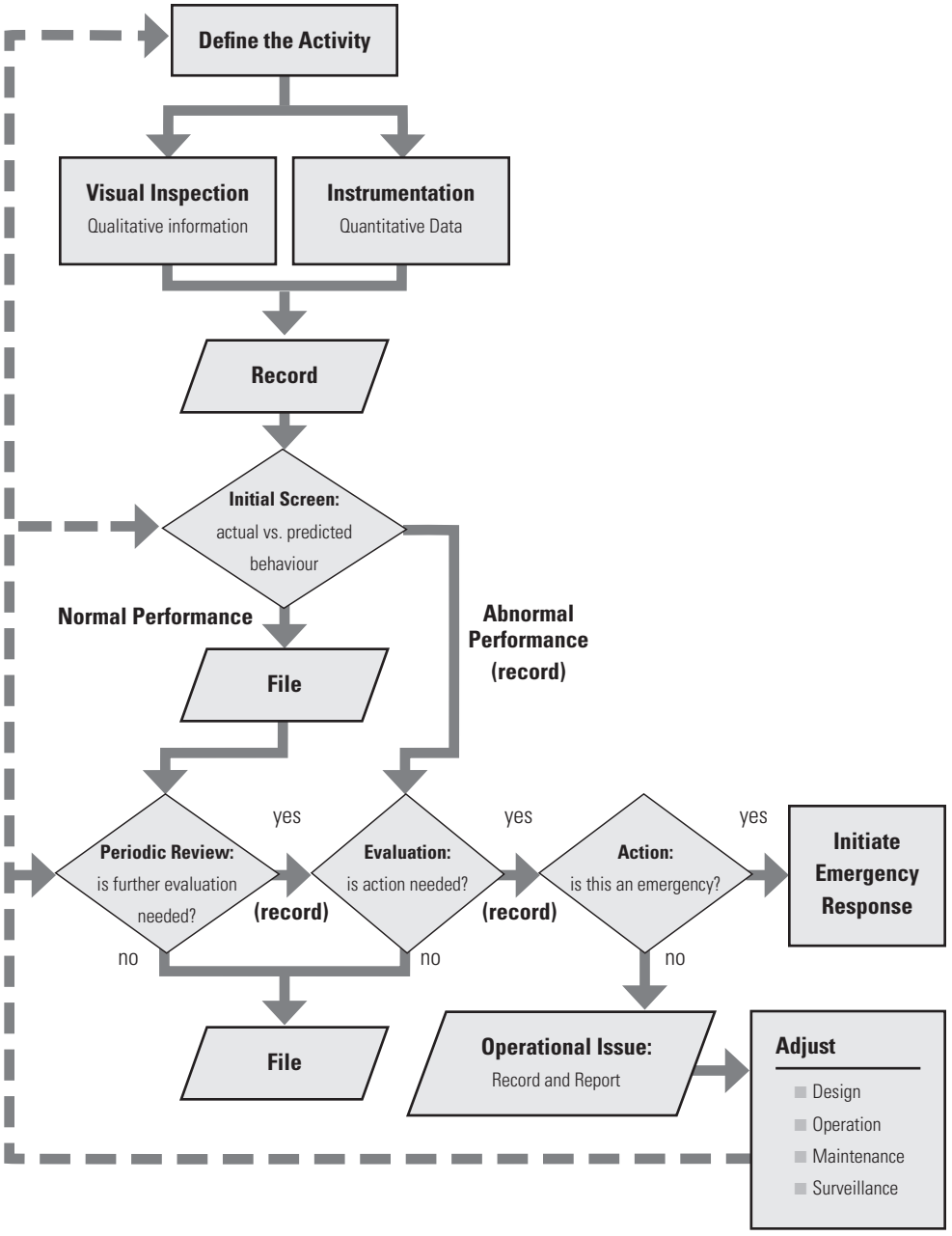
Identify key surveillance parameters and procedures for:

- monitoring the operation, safety and environmental performance of tailings and water management facilities;
- promptly identifying and evaluating deviations from expected behaviour that affect operational safety, structural integrity and environmental performance of the facility; and
- reporting significant observations for response.

Ensure that personnel are aware of the need to report and act on observed departures from expected behaviour.

▶ *Surveillance is not a substitute for design; it is a necessary component of good design practice which, to be effective, must be implemented through a designed program.*

Figure 5: Surveillance Flowchart



Surveillance Parameters

Identify and describe potential failure modes for assessment and inclusion in a surveillance program. Define the key parameters of surveillance to support the operation of the facility, building on the identified modes of failure.

Typical Surveillance Parameters
Explanation and illustration of how failure could develop, together with probable triggers, visual and instrumentation effects
Visual observations
Surface – cracking, bulging, depressions, sink holes, vegetation
Slope erosion
Water levels
Seepage – new seepage areas, changes in seepage area
Beach slopes
Classification of possible observations which would be consistent with expected behaviour, and which would not
Instrumentation
Slope displacement – survey monuments, slope inclinometers
Pore pressure monitoring – standpipes, pneumatics
Seismic monitoring
Water quality monitoring – surface, borehole, turbidity
Biological monitoring
Dust sampling
Weather
Communications
Power supply
Pipeline flow and pressure
Water levels

▶ *There are key performance parameters for which expected behaviour can be monitored – freeboard, seepage rate, containment structure displacements, pore pressures, and chemistry of the seepage and the surrounding surface water.*

Surveillance Procedures

Surveillance provides a backstop to design and operation. It provides the trigger to change operations and/or maintenance, or to initiate emergency response. It consists of a series of procedures that must be clearly defined and followed. Preparation of a surveillance program is an essential part of facility design.

Surveillance consists of both routine and event-driven procedures. Visual inspections and instrument reading which are integral to, and done as part of, routine surveillance may also be essential within the context of event-driven surveillance.

Typical Surveillance Procedures
Visual monitoring and Inspection
Routine visual monitoring by site personnel
Periodic inspections by engineering and/or specialist personnel
Instrument measurement
Surveying
Instrument reading
Material testing
Data collation and analysis
Initial screening of visual inspection observations and field data as collected to determine that operations are within performance criteria
Periodic follow-up screening of collated observations and data to determine trends as related to performance criteria
Periodic inspection and review
Of collected observations from visual inspection and instrument readings
Of total facility performance
Of continuing validity of facility design and performance criteria, including for surveillance
Documentation
Reporting

Visual Monitoring

Outline the types of visual indicators of which site personnel should be routinely aware. For example, appearance of, or changes to cracks, slumps, seepage and/or anomalous vegetation within the tailings or water management area or its immediate vicinity could provide a trigger for specific site inspection.

Specify the frequency of visual inspections.

Specify the mode of recording visual inspections, preferably on standard forms or checklists, which encourage quantification of observations where appropriate, such as width of cracks, seepage area, volume, colour and clarity, etc.

Specify criteria for initial screening and reporting of observations.

Specify the frequency, mode of reporting and documentation standards for routine visual inspection of the entire facility by engineering and/or specialist personnel. Identify conditions, such as suspension of operation or closure of the facility, during which the frequency of routine inspections may be changed.

Specify procedures for required action in the event of any sudden change in behaviour, such as abnormal water levels, increased seepage, crest drops, slumping and cracking, which may require specific incident reporting, and which would normally trigger some action.

Define the criteria which trigger special event-driven inspections, along with the required documentation and follow-up. Such events typically include first filling, earthquake, extreme precipitation, flood or operational upsets. Facility performance through these events is especially important as it defines the capacity to cope with extreme events.

▶ *Visual monitoring is not just a specialist activity – all site personnel should be trained to observe and document the performance of the facility, providing at least qualitative awareness of departures from normal performance of the tailings or water management facility, or from performance criteria.*

Instrument Measurement

Typical Instrument Measurement and Monitoring

Surveying of
- beach profile, pond level and bathymetry
- ice and snow cover
- dam profile
- settlement and displacement
- wildlife and aquatics
- vegetation

Sampling and testing
- tailings characteristics and properties
- tailings mineralogy, in situ density and gradation
- water chemistry

Flow measurements

Piezometers

Slope inclinometers

Settlement gauges

Thermistors

Meteorological stations

▶ *Instrument measurement and monitoring quantifies facility behaviour in comparison to performance criteria, and extends operational observation to beneath the surface, beyond the range of visual inspection.*

Provide a complete listing of all instrumentation, with:

- instrument identification;
- location identified on a site plan;
- record of installation, date installed, surveyed position, test hole depth, elevation of top of hole, diameter, backfill details, instrument type, depth, serial number;
- data collection and validation procedures;
- frequency of monitoring;
- data reduction and interpretation procedures;
- calibration issues; and
- data management and storage.

Specify data collection, instrument reading and monitoring frequencies with regard to design, operating requirements and site conditions.

Specify criteria for initial screening of instrumentation readings in the field at the time of collection, and identify the basis for rechecking of anomalous readings (which should remain on record).

Collation and Analysis of Data

Specify procedures for initial screening, data documentation and collation from visual inspection and instrument measurement.

Establish data reduction and analysis parameters.

Specify criteria for analysis of visual observation and inspection reports and instrument measurements against performance criteria. Identify parameter ranges representing:

- (acceptable) normal performance, normal follow-up;
- abnormal performance, additional surveillance or evaluation to be initiated;
- abnormal performance, change in operation, maintenance and/or facility design to be initiated; and
- abnormal performance, emergency alert and actions to be taken.

Establish a schedule for periodic review of collated visual observation and inspection reports and instrument measurements, to analyze data and facility performance trends.

Specify documentation and reporting procedures for analysis of visual observation and inspection reports and instrument measurements.

Periodic Inspection and Review

Identify the periodic basis for facility inspection and review, considering site and operating characteristics, jurisdiction and consequence classification.

Establish a schedule for regular periodic inspection of the tailings or water management facility and audit of the surveillance program results by a qualified engineer who is familiar with the tailings facility.

Establish criteria for independent checks of the facility and the surveillance program to be done after significant events such as earthquakes, floods and significant operational upsets.

Establish a schedule and criteria for comprehensive review of the facility – typically, every five to ten years as per failure consequence classification or by regulation. This comprehensive review should provide independent verification of the safety and environmental performance of the facility, the adequacy of the surveillance program, and the adequacy of delivery of OMS within the management framework, plus review and analysis of the facility design with respect to current standards and possible failure modes.

▶ *Data are not collected just to fill log books – they are collected to be used, and will help future operation, maintenance and surveillance to operate more efficiently and effectively, while managing risk and change.*

It is not sufficient to simply collect data. The data should be screened in the field to identify both false data and critical situations. This should be followed by collation of data collected from various points around a facility and analysis against overall performance criteria.

Documentation

Establish documentation standards for surveillance, including for recording of:

- observations from routine visual observation (departures from or exceptions to normal conditions);
- instrumentation monitoring and testing;
- evaluations;
- inspections; and
- reviews.

Provide, where practicable, standard forms and checklists.

Establish a hard copy (paper) and electronic filing system for all inspection reports, photographic and video records, incident reports, instrumentation readings, instrumentation plots, annual inspections and third-party reviews, so that they can be quickly retrieved for review and in the case of an emergency.

Reporting

Specify procedures for initiating emergency response alerts, reporting operational performance that meets expectations, and reporting conditions requiring adjustment to design, operation, maintenance or surveillance.

Specify reporting procedures and schedule for regulatory requirements.

▶ *The surveillance program must include clear identification of trigger points or changes for mandatory communication between those who monitor performance and those who control the means to improve performance. The surveillance program must be linked to the emergency response plan so that action is initiated if the performance of the facility falls below design standard.*

Chapter 8 – Emergency Planning and Response

8

Define emergency preparedness and response (EPR) plans to identify the potential for accidents, to respond in emergency situations, and to prevent and mitigate the environmental and safety impacts, both on- and off-site, associated with emergency situations.

List (and classify) warning signs with reference to potential tailings and water management facility failure modes or emergencies – both from a structural failure and failure due to environmental impacts. Examples include:

- equipment failure;
- slope or foundation failure;
- overtopping;
- power line failure;
- seepage or piping;
- loss of process control; and
- flooding.

Warning signs and potential emergencies are site-specific. For each one listed and classified, identify the appropriate actions and responses.

Specify and initiate a "call-out" process as appropriate, in the event of an incident. Specify lines of communication within the site (involving, for example, management, operations, engineers, consultants) and include names, positions, telephone numbers (work and home) and e-mail addresses. Include relevant off-site contacts, such as contractors or equipment suppliers.

Specify the process for notifying affected external stakeholders – municipalities, government agencies, local organizations, first aid, fire department, ambulance, other individuals, etc. – and include telephone numbers and e-mail addresses.

Establish verification and follow-up procedures to ensure that appropriate parties have been contacted, and that the call-out process is kept up to date.

▶ *Tailings and water management facilities pose a risk that must be managed. Despite best efforts to ensure that facilities are designed, operated and closed safely and responsibly, it is important to have emergency preparedness and response plans and procedures in place in the event of an incident. A site's overall emergency preparedness and response plans should include plans and procedures for the tailings and water management facility specifically and these, in turn, should be part of the OMS manual.*

8 Emergency Planning and Response

Develop and maintain contingency plans as part of EPR plans. Test the plans for effectiveness, review them regularly and update them as appropriate.

Widely distribute contingency and EPR plans to appropriate personnel within the organization, as well as to potentially affected external stakeholders.

Typical Contents of Emergency Preparedness and Response Plans
Identification of failure modes
Identification of roles and responsibilities
Identification of requirements of legislation, codes of practice, notification and reporting obligations
Identification of available resources
Mutual aid agreements
Public relations plans
Telephone lists
Establishment of communication system for notifications and for post-notification purposes
Risk analysis for on-site and off-site effects
Inundation study, maps and tables for both physical and environmental releases (including dam break)
Basis for activation of emergency response plan and emergency decision making
Training of personnel
Investigation and evaluation of incidents and accidents
Contingency plans
Restoration of safe operating conditions
Validation drills, test of the system

▶ *The emergency preparedness and response plans should identify the actions to be taken by the owner/operator and responsibilities assigned to appropriate individuals at the site, as well as those of other agencies and affected parties.*

Annexe 1 – Towards Sustainable Mining Guiding Principles

A1

As members of the Mining Association of Canada, our role is to responsibly meet society's needs for minerals, metals and energy products. To achieve this we engage in the exploration, discovery, development, production, distribution and recycling of these products. We believe that our opportunities to contribute to and thrive in the economies in which we operate must be earned through a demonstrated commitment to sustainable development.*

Accordingly, our actions must demonstrate a responsible approach to social, economic and environmental performance that is aligned with the evolving priorities of our communities of interest.** Our actions must reflect a broad spectrum of values that we share with our employees and communities of interest, including honesty, transparency and integrity. And they must underscore our ongoing efforts to protect our employees, communities, customers and the natural environment.

We will demonstrate leadership worldwide by:

- Involving communities of interest in the design and implementation of our Towards Sustainable Mining initiative;
- Proactively seeking, engaging and supporting dialogue regarding our operations;
- Fostering leadership throughout our companies to achieve sustainable resource stewardship wherever we operate;
- Conducting all facets of our business with excellence, transparency and accountability;
- Protecting the health and safety of our employees, contractors and communities;
- Contributing to global initiatives to promote the production, use and recycling of metals and minerals in a safe and environmentally responsible manner;
- Seeking to minimize the impact of our operations on the environment and biodiversity, through all stages of development, from exploration to closure;

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* MAC draws on the 1987 Brundtland Commission definition of Sustainable Development: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

** We use the term Communities of Interest to include all of the individuals and groups who have or believe they have an interest in the management of decisions about our operations that may affect them. This includes: employees, contractors, Aboriginal or indigenous peoples, mining community members, suppliers, customers, environmental organizations, governments, the financial community, and shareholders.

- Working with our communities of interest to address legacy issues, such as orphaned and abandoned mines;
- Practicing continuous improvement through the application of new technology, innovation and best practices in all facets of our operations.

In all aspects of our business and operations, we will:

- Respect human rights and treat those with whom we deal fairly and with dignity.
- Respect the cultures, customs and values of people with whom our operations interact.
- Recognize and respect the unique role, contribution and concerns of Aboriginal peoples (First Nations, Inuit and Métis) and indigenous peoples worldwide.
- Obtain and maintain business through ethical conduct.
- Comply with all laws and regulations in each country where we operate and apply the standards reflecting our adherence to these Guiding Principles and our adherence to best international practices.
- Support the capability of communities to participate in opportunities provided by new mining projects and existing operations.
- Be responsive to community priorities, needs and interests through all stages of mining exploration, development, operations and closure.
- Provide lasting benefits to local communities through self-sustaining programs to enhance the economic, environmental, social, educational and health care standards they enjoy.

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