

Coal Impoundment Project
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Guide to the Management and Operation of West Virginia Coal Refuse Disposal Facilities

Preface

In the early hours of October 11, 2000, intense pressure within Martin County Coal Company's (MCCC's) Big Branch Refuse Impoundment near Inez, Kentucky, ruptured a barrier wall in the basin of the impoundment, opening a pathway for 306 million gallons of slurry (fine coal waste and water) to escape into the underground mine workings of MCCC's 1-C mine. (MSHA report). In the hours that followed, the dense mixture of black water and coal tailings breached two sealed areas within the 1-C Mine and ultimately exited at two drift areas into Coldwater Fork and Wolf Creek, tributaries to the Tug Fork and Big Sandy Rivers, respectively.

Within ten days, a black plume of slurry appeared in the Ohio River. Although the slurry took no human lives on its 75-mile path, the sludge obliterated wildlife, killed 1.6 million fish, destroyed property, washed away roads and bridges, and contaminated the water systems of countless people. The United States Environmental Protection Agency declared the spill the largest environmental catastrophe in the history of the southeastern United States. (Cite) In fact, the Inez disaster was almost 30 times larger than the infamous Exxon Valdez tanker spill, which dumped 11 million gallons of oil into Alaska's Prince William Sound. (Cite)

In the wake of the Inez Disaster, the United States Mine Safety and Health Administration (MSHA) began an investigation to determine the disaster's causes. In summary, MSHA's accident investigators determined that the failure of the Big Branch Refuse Impoundment and subsequent inundation of the 1-C Mine occurred as a result of MCCC's failure to follow a previously approved Impoundment Sealing Plan, dated August 8, 1994, and subsequent plan modification dated September 7, 1995. (MSHA report) Specifically, the approved plan required MCCC to reduce seepage from the impoundment into mine workings. Yet, MCCC's failure to comply with these provisions resulted in unnecessary erosion of the material between the impoundment and the mine workings. Over time, the erosion process began to

carry sand into the mine toward the mine workings. As this erosion continued, a small void began to develop in the impoundment's basin. As more material was carried into the mine workings, the void grew larger, allowing additional and larger particles to be carried into the mine. This process continued until the void developed close enough to the impoundment that the remaining plug of material failed, allowing the contents of the impoundment to discharge violently into the mine. (MSHA report).

Like many mining disasters, such as the Buffalo Creek Disaster, the Inez disaster illustrates an often learned lesson for all those involved or affected by coal mining -- that it is apparent that these unfortunate disasters can be prevented through proper design, construction and inspection of the impoundment. However, in addition to measures to prevent future disasters, the Inez Disaster should be studied for what could have happened. In the hours immediately following the breakthrough, MCCC made little or no effort to warn individuals living within the path of slurry flow, mostly because no established protocol existed for MCCC or local emergency officials to undertake such an effort.

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Introduction

Coal Impoundment Project

Guide to the Management and Operations of Coal Mines Tailing Facilities

“Tailings facilities provide a window on the mining industry. They tell a story to the public about how the industry manages its activities. They also pose a risk that must be managed for the long term. The mining industry has the technology that can be applied during the full mine life-cycle, to safely design, build, operate and decommission tailings facilities. This technology must be consistently applied for the safe and environmentally responsible management of tailings.”

Mining Association of Canada, a Guide to the Management of Tailings Facilities, September 1998,

One way to apply this technology is to establish a comprehensive tailings management system that individual companies may adopt and implement under widely ranging conditions.

Through this approach, the industry can:

- develop effective self-regulation,
- demonstrate due diligence,
- complement government regulations, and
- protect the environment and the public.

I) WHAT IS THIS DOCUMENT ABOUT?

This document is an initial trail to compose a manual guidebook for management and operators of coalmines tailing facilities in West Virginia. It is intended to assist mining community in managing their operating facilities by governing codes and standards of safety and environmental practices.

In addition, using this manual, mining companies can integrate consistent environmental and safety considerations, to improve their tailings operations.

The manual main structure was composed based on national and international literature reviews that are listed in the references section of this document.

II) WHICH GROUPS OF THE POPULATION DOES THE MANUAL TARGET?

This document is a guide for the management and operators of coal impoundment facilities. It provides basis for developing customized coal slurry management system to address specific needs of individual mining companies.

No set of generic recommendations could be fully applicable to every operation; for this reason, it is recommend that professional and/or expert advice should be obtained in order to ensure that companies' specific needs are fully addressed.

III) PURPOSE OF THE MANUAL

The manual presents a framework to handle impoundment facilities safely and in environmentally responsible manner through the full life-cycle of the impoundment including:

- 1) site selection and design,
- 2) construction and operation,

3) eventual reclamation and closure.

It is meant to be adapted to specific sites, individual company policies, and local regulatory and community requirements. Tailings facilities are site-specific and complex, involving unique environmental settings and physical characteristics. Effective management of tailings Facilities should depend on applying both managerial and technical expertise.

IV) HOW IS THE MANUAL DESIGNED

The manual is divided into two major sections related and addressed to coal impoundment facilities.

- I- Management, responsible parties and stakeholders, and
- II- Operation control and maintenance.

Management

1. MANAGEMENT SCOPE and APPLICABILITY

This Section includes:

- 1) a framework of management principles,
- 2) policies and objectives;
- 3) checklists for implementing the framework through the life-cycle of a Coal refuse Disposal Facility; and
- 4) lists of technical considerations.

The guide is built on the platform of an engineering manual framework specifically applied to tailings management. It is designed to assist companies to manage tailings facilities responsibly and safely, and to demonstrate this to the regulators and the public. It should also help companies practice due diligence.

The framework is expanded into a series of management action checklists addressing the various stages of the life-cycle. These checklists can be used at any stage, to:

- 1) develop operating procedures and manuals;
- 2) expose gaps within existing procedures;
- 3) identify training requirements;

- 4) communicate with stakeholders/public;
- 5) obtain permits;
- 6) conduct internal audits; and
- 7) assist compliance and due diligence.

In this document, there are lists of technical considerations that address environmental setting, facility design and operating aspects typically encountered through the various stages of the life-cycle of a coal refuse disposal facility. The management framework addresses these technical considerations in varying levels of detail, sometimes revisiting them at different stages in the life-cycle. The guide includes a technical section that does not contain or suggest performance criteria. It is not a comprehensive authority on tailings management, nor is it intended to replace professional expertise or regulatory requirements.

1.1. TAILING MANAGEMENT PRINCIPLES

A guiding principle of tailings management must be the continual improvement in operational, safety and environmental performance, supported by periodical inspections and audits.

This section presents the key elements of a framework to manage tailings facilities, which is the foundation for the management action checklists that follow, and which address tailings management through the full life-cycle of the facility.

The requisites of this framework are listed in the following text.

1.2. MANAGEMENT RELATED OVERVIEWS

1.2.1. Tailings' Management System and Policies.

This management philosophy is based on the following concepts:

- 1) The system must be managed through the full life-cycle and phases of the tailings facilities such that, all structures are stable, all solids and water are managed within the designated areas intended in the design and all structures should comply with the standards of the company, MSHA, DEP and EPA and the obligations to the related stakeholders.
- 2) Company policies and management systems have to facilitate proper procedures for management of the impoundment and ensure consistency between impoundment sites.
- 3) Maintain up-to-date records for the processes, equipment, and operational practices.
- 4) Development of a continual program for monitoring and continual minimization of risks associated with health, safety and environmental management.
- 5) Maintain the responsibilities of the implementation of this framework through commitments of tailing management teams.

1.2.2. Setting Plans, Objectives and Targets

Plan tailings facilities in accordance with this framework, company standards, legislative requirements, and sound engineering and environmental practices. Identify and assess significant environmental and safety aspects, and their associated risks.

Prepare and document coal refuse disposal facility plans, including descriptions of the following:

- aspects, objectives, targets and performance measures;
- permits and approvals;
- roles and responsibilities of key personnel;
- site selection and characterization criteria;
- safety, environmental and engineering
- design criteria; and as-built records
- communication procedures with senior management and external stakeholders;
- constructing, operating and decommissioning procedures and documentation requirements;
- monitoring, inspection, reporting and review requirements; and

- knowledge and skills (awareness, training and competence) requirements as well as the training records.

1.2.3. Tailings Management Team Roles, Responsibilities and Communications

Select a tailings management team with clearly defined roles, responsibilities and boundaries of authorities to implement the framework through all stages in the Coal refuse Disposal Facility life-cycle.

The team should follow the set system procedures and team members are accountable for successfully managing all operations safely, and in environmental friendly behaviors.

Establish and maintain communication procedures for all personnel who have roles and responsibilities in implementing the tailings management plan, including reporting of significant information to management.

1.2.4. Setting Initial reviews

An initial review for the Coal refuse disposal facility may be conducted and used as a benchmark. Post review activities should be planned and should undergo the necessary decision making process.

1.2.5. Implementing and Developing Necessary Controls

The ongoing need for planning the work to be completed on the facility, including specific implementation activities, checking, and reviewing. The application of the tailings management framework is presented as follows:

The management system is presented in four checklists focusing on the respective life-cycle stages of a Coal refuse disposal facility:

- site selection and design;
- construction;
- operation; and
- reclamation and abandonment.

1.3. HOW TO IMPLEMENT THIS MANUAL FRAMEWORK

The tailings management framework has been designed for application through the full life-cycle of a Coal refuse disposal Facility. This may begin at any stage. Companies are encouraged to implement the framework at the earliest chance.

In practice, the framework is implemented through the usage of checklists:

- Checklist for site selection and design
- Checklist for construction;
- Checklist for operation and
- Checklist for abandonment.

The checklists comprise six columns, addressing key elements for ensuring effective implementation of the management framework:

- Management Action - activities requiring management attention, derived from the management framework;
- Responsibility - the company official responsible and accountable for the management action;

- Performance measure - indicator of progress toward a management action target or objective, quantified where practicable, that should be set in order to track performance;
- Schedule - the time frame for completion of significant milestones for a management action, which may include specific delivery dates or times, and/or frequency of ongoing or periodic activities such as monitoring and reviews;
- Technical Considerations - reference to lists of Technical Considerations, A through E; and
- References - additional technical, managerial and regulatory information relevant to the management action.

The checklists can be adapted to suit the requirements of specific sites, company policies, and local regulatory and community requirements.

An owner of a Coal refuse disposal facility or an operator may fill out and customize the checklist, as appropriate, by:

- confirming and/or customizing the relevant management actions;
- assigning responsibility and authority for the management actions to individuals within the organization;

- determining relevant performance measures, quantified where practicable, to ensure that objectives are targeted, tracked and met;
- identifying the schedule requirements;
- referring to indicated Technical Considerations (A through E) as a basis for determining requirements, responsibilities and performance measures; and
- adding references applicable to the site and operations in the form of company standards and procedures, environmental policies, regulatory and permit requirements,
- commitments to stakeholders and selected documentation,

The checklists provide the basis for developing a customized management framework to address a company's tailings management and operating needs. Completing the checklists is essential to implementation of the tailings management framework. The process of completing the checklists will help identify gaps and/or deficiencies in existing tailings management. When fully implemented, this framework will ensure continual improvement in the safe and environmentally responsible management of tailings facilities.

1.4. MANAGEMENT MONITORING USING AUDITS, INSPECTIONS, AND FEEDBACK TOOLS

It is important to establish evaluating and monitoring measures for management to use in evaluating performance and to pinpoint associated health, environmental, and safety risks that required immediate or ongoing attention.

Periodic inspections and audits are expected to be set on schedule and an as needs basis, such as during periods of heavy rainfall, seismic activity, etc.

Monitoring objectives are to be established to examine facility implementation and conformance to plans and regulatory requirements.

Reviews of the facility design, construction, operation and closure plans and programs should be executed. Re-evaluate downstream risks (which may change during the life of the facility). Update consideration of possible failure modes, risk assessment and risk management; and identify items requiring corrective action.

Results of inspections must be communicated promptly to responsible persons and reviewed periodically with senior management. A system must be established to convey problems requiring immediate attention to persons responsible for corrective actions.

1.5. OVERALL EVALUATION

1.5.1. Ongoing Evaluations and Developments

Annual management reviews of the tailings management framework is required to be set and implemented:

- to ensure that the scope of this review is appropriate to the level of identified risk.

- to address the need for executing changes to management elements in response to monitoring reports, changing circumstances, recommendations and the commitment to continual improvement.
- to encourage ongoing environmental and safety research to effect continual improvement.

1.6. CERTIFICATIONS AND TRAINING

Management must ensure that all persons performing inspection activities have been received the proper training and MSHA certification to inspect impoundments.

Workers performing duties in the construction and maintenance of the impoundment must be trained as set in the plan requirements for those particular tasks. In addition, they should receive all required safety training for the duties and tasks they are performing.

Comprehensive and task training must be documented on MAHA form 5000-23 or equivalent approved forms and maintained at the facility office.

For those persons only requiring hazard training, a system must be in place to ensure this training is given before such employee access the property and written record must be maintained.

Section

2

Operation and Maintenance

2. OPERATION and MAINTENANCE

INTRODUCTION

This section serves as a guide for a mining company to create an overall site management framework for the technical management of a facility. It was compiled to provide guidance for preparing outline procedures for safe operation, maintenance and surveillance of tailings and water management facilities.

The objective in this section is to define the Standards Operating Procedures in accordance to the set design criteria at the impoundment. It incorporates aspects for economical, safe and environmentally responsible disposal and storage of tailings and management of water.

The level of detail in this manual should reflect site requirements. It must be maintained current and should be revised periodically with a view to continual improvement. Generally, this section should include the following:

I- FACILITY OPERATION provides details and inclusion of all operations and equipments along with how the reservoir and equipment at a facility are to be operated.

II - MAINTENANCE provides detailed information and instructions on performing periodic maintenance and upkeep at the facility.

III - INSPECTION provides information on performing regular inspections of a facility by the owner/operator.

2.1. OPERATION OBJECTIVES

Company running operations must clearly be identified, described and noted to define keys of operating parameters, procedures, and the related technical management and responsibilities. Operating details can be summarized under the following four fields, which include related checklists

2.2. THE FOUR OPERATING FIELDS

2.2.1. Tailings Transport and Description of Operations

The overall purpose of operation at the facility is to transport and deposit refuse and slurry from various processes and operations to the impoundment and recycling it back to the system if it is initially designed in this manner. This information should be compiled and updated on periodic basis, and compared to the future design stage/plans.

A description of the deposition plan for the life of the facility should be developed reviewed and updated periodically.

The following list of parameters should be considered when developing a plan for the transportation and deposition of refuse and tailings

Table 1 : Plan for the transportation and deposition of refuse and tailings

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
1. Refuse Transport and Deposition:			
1.1 Describe Deposition Plan			
1.2 Provide a Summary of the Full Life-Cycle Deposition Plan with Detailed Current-Year Annual Plans Identifying:			
1.2.1 Discharge Locations			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
1.2.2 Discharge Schedule			
1.2.3 Planned Construction			
1.2.4 Supporting Reports and Plans			
1.3 Identify Key Operating Parameters and Procedures			
1.4 Develop a Schedule for Periodic Review against Design			
1.5 Typical Refuse Transport and Deposition Parameters:			
1.5.1 Refuse Slurry Quantity and Flow Rate Procedures			
1.5.2 Pumping and Pipeline Operating Pressures			
1.5.3 Slurry:			
1.5.3.1. Density			
1.5.3.2. Temperature			
1.5.3.3. Other Physical Parameters			
1.5.3.4. Other Chemical Parameters			
1.5.4 Refuse:			
1.5.4.1. Gradation			
1.5.4.2. Mineralogy			
1.5.4.3. Specific Gravity			
1.5.4.4. Density			
1.5.4.5. Angularity			
1.5.4.6. Clay Content			
1.5.4.7. Plasticity			
1.5.4.8. Acid Generation Potential			
1.5.4.9. Metal Leaching Potential			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
1.5.5 Refuse Deposition Technique and Compaction			
1.5.6 Refuse Beach and Underwater Slopes			
1.5.7 Maximum Beach Crest Elevation			
1.5.8 Maximum and Minimum Beach Width			
1.5.9 Chemical Properties of Refuse:			
1.5.9.1. Pore Water			
1.5.9.2. Decant Water			
1.6 Typical Refuse Transport and Deposition Procedures:			
1.6.1 Refuse Deposition:			
1.6.1.1. Dam Safety			
1.6.1.2. Staging of Dam Lifts			
1.6.1.3. Solids Storage Capacity			
1.6.1.4. Water Recycling			
1.6.1.5. Water Treatment Requirements			
1.6.1.6. Cell Construction			
1.6.1.7. Spigotting			
1.6.1.8. Contained Beaching			
1.6.1.9. Compaction			
1.6.2 Operating Instructions for Pipes, Pumps, and Pipelines:			
1.6.2.1. Refuse Line Relocation			
1.6.2.2. Line Pressure			
1.6.2.3. Pulp Density			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
1.6.2.4. Pipe Rotation			
1.6.2.5. Valve Openings			
1.6.2.6. Vacuum Breaks			
1.6.2.7. Measures to Prevent Line of Pump Sanding or Freezing			
1.6.2.8. Measures to Flush or Thaw Lines			
1.6.3 Response to Deviations from the Design in Refuse:			
1.6.3.1. Physical Properties			
1.6.3.2. Chemical Properties			
1.6.3.3. Mineralogical Properties			
1.6.4 Response to Unusual Operating Conditions:			
1.6.4.1. Severe Winter Conditions			
1.6.4.2. Periods of High Rainfall			
1.6.4.3. Drought			
1.6.4.4. High Winds			
1.6.5 Mechanical Functions:			
1.6.5.1. Line Rotation			
1.6.5.2. Line Relocation			
1.6.5.3. Valve Openings			

2.2.2. Procedures

A SOP for all levels of management, should be documented and defined clearly by the planning affiliated employees. These procedures should be

updated and reviewed every time a change to the procedures or the management occurs.

All procedures should follow the health, occupational, and public safety and environmental codes of practice and all areas of operation should be addressed and assessed concerning compliance with the public safety of the surrounding communities of the facility during its life-cycle. All emergency operating procedures should be followed concerning training for employees and notification of the community to the surrounding areas.

All employees should be trained in the procedures outlined in the SOP. This should include training for new employees and annual refresher training for experienced employees

The following list of parameters should be considered when developing related details to procedures

Table 2: Details to procedures

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
2.1. Objective – Describe Operating Standards and Procedures in Accordance with:			
2.1.1 Design Criteria			
2.1.2 Regulatory Requirements			
2.1.3 Company Policies			
2.1.4 Sound Operating Practices			
2.1.5 Encompassing all Significant Aspects of, and Activities for:			
2.1.5.1 Economical Disposal and Storage of Refuse			
2.1.5.2 Safe Disposal and Storage of Refuse			
2.1.5.3 Environmentally Responsible Disposal and Storage of Refuse			

2.1.5.4 Management of Water			
2.2. Operation Flowchart – Following is a guide to developing a flowchart.			

2.2.3. Impoundment Management

Stages of dam construction should be identified and planned for over the life of the facility. All methods procedures, quality control, assurance and surveillances should be clearly defined recorded and strictly followed to ensure the safety of the facility.

The following list of parameters should be considered when developing impoundment management, dam and basin rising.

Table 3: Impoundment management, dam, and basin rising

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
3. Dam and Basin Raising:			
3.1 Objective - Identify Requirements and Plans for Staged Dam Construction over the Life of the Facility to:			
3.1.1 Maintain Adequate Solids Storage Capacity			
3.1.2 Allow Adequate Polishing of Supernatant during Operation			
3.2 Requirements of Plans:			
3.2.1 Methods of Dam Construction:			
3.2.1.1. Spigotting			
3.2.1.2. Cell Construction			
3.2.1.3. Upstream			
3.2.1.4. Downstream			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
3.2.1.5. Other Techniques			
3.2.2 Refuse Depositional Procedures:			
3.2.2.1. Staging of Dam Lifts			
3.2.2.2. Solid Storage Capacity			
3.2.2.3. Water Recycling			
3.2.2.4. Water Treatment Requirements			
3.2.2.5. Dam Safety Considerations			
3.2.3 Quality Control Measures to Ensure Proper Completion			
3.3 Typical Dam and Basin Raising Parameters:			
3.3.1 Maximum and Minimum Height			
3.3.2 Dam-Raising Schedule			
3.3.3 Construction Material Sources			
3.3.4 Placed Material Density			
3.3.5 Perimeter Slopes			
3.3.6 Progressive Reclamation			
3.3.7 Phreatic Surface and Pore water Pressures			
3.3.8 Beach Width			
3.3.9 Foundation and Dam Building Characteristics			
3.3.10 Slurry Density			
3.3.11 Refuse Delivery Volume			
3.4 Typical Dam and Basin Raising Procedures:			
3.4.1 Erosion Control			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
3.4.2 Compaction			
3.4.3 Material Placement			
3.4.4 Spigotting			
3.4.5 Cell Construction			
3.4.6 Single Point Discharge			
3.4.7 Site Preparation			
3.4.8 Vegetation and Overburden Removal			
3.4.9 Earth and Rock Fill			
3.4.10 Filter Construction			
3.4.11 Instrumentation Installation and Extension			

2.2.4. Water Management

Flow rates for inlets and discharging locations are important functions that need to be identified with all its related functional standards, monitored regularly and charted to show changes in flow, plotted against rainfall or other factors, which could effect changes to flow, not corresponding to a rainfall could indicate serious problems or potential failure.

Typical parameters to be considered and the related details to water management are as follows:

Table 4: Water management

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
4. Water Management:			
4.1 Description of Water Management Procedures:			
4.1.1 Normal Operating Procedure			
4.1.2 During Special Circumstances:			
4.1.2.1 Spring Runoff			
4.1.2.2 Severe Rainfall Events			
4.1.2.3 Drought			
4.2 Description of Water Balance:			
4.2.1 Identification of All Inputs			
4.2.2 Identification of All Outputs			
4.2.3 Inventory of Pond and Interstitial Water			
4.3 Identification of Key Operating Parameters			
4.4 Definition of Operating Procedures Related to Water Balance and Management of the Facility:			
4.4.1 Spillways			
4.4.2 Decant Systems			
4.4.3 Siphons			
4.4.4 Ditches			
4.4.5 Swales			
4.4.6 Drop Structures			
4.5 Reference to Supporting Reports and Plans for Operating Procedures			
4.6 Typical Water Management Operating Parameters:			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
4.6.1 Minimum Freeboard			
4.6.2 Stage Storage Curves			
4.6.3 Maximum and Minimum Operating Water Levels and Beach Widths:			
4.6.3.1. Seasonal Considerations			
4.6.3.2. Wind Events			
4.6.3.3. Flood Events			
4.6.3.4. Drought Events			
4.6.3.5. Treatment Schedule			
4.6.4 Tables of Target Pond Levels			
4.6.5 Water Discharge, Volume, and Quality:			
4.6.5.1. Normal Operating Conditions			
4.6.5.2. Special Circumstances			
4.7 Typical Water Management Operating Procedures:			
4.7.1 Control of Inflows and Outflows			
4.7.2 Flood Routing			
4.7.3 Seepage Water Return			
4.7.4 Reclamation of Water			

2.2.5. Environmental Protection, Safety and Security

Impounded water if not managed properly, could threaten public safety and the environment. All measures must be taken to minimize chances of human error and unpredicted ability of weather, ground stability, etc.

Typical parameters to be considered, related to facility environmental safety and security are as follows:

Table 5: Facility environmental safety and security

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
5.1. Environmental Protection:			
5.1.1 Definition of Parameters and Procedures to Protect the Environment by Controlling the Refuse and Water through Treatment and Management			
5.1.2 Documentation of the Regulatory Reporting Requirements			
5.1.3 Typical Environmental Protection Parameters:			
5.1.3.1 Water/Effluent Discharge Quality and Flow Rate			
5.1.3.2 Chemical Properties of:			
5.1.3.2.1. Refuse Pore water			
5.1.3.2.2. Groundwater			
5.1.3.2.3. Seepage			
5.1.3.2.4. Decant Water			
5.1.3.3 Dust/Particulate Loading, Quality, and Quantity			
5.1.3.4 Fog or Steam Emission Criteria			
5.1.3.5 Basin Footprint			
5.1.3.6 Biomass/Biodiversity			
5.1.3.7 Wildlife			
5.1.3.8 Aquatic Life			
5.1.3.9 Livestock			
5.1.3.10 Habitat			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
5.1.4 Typical Environmental Protection Procedures:			
5.1.4.1 Treatment Plant			
5.1.4.1.1. Unit Operations			
5.1.4.1.2. Reagent Additions			
5.1.4.1.3. Instrumentation and Process Control			
5.1.4.2 Surface Water, Groundwater, and Seepage:			
5.1.4.2.1. Collection			
5.1.4.2.2. Treatment			
5.1.4.2.3. Transport			
5.1.4.2.4. Pump Back			
5.1.4.3 Dust Abatement			
5.1.4.4 Fog or Steam Abatement			
5.1.4.5 Wildlife, Aquatic Life, and Livestock Protection			
5.1.4.6 Handling of Hazardous Materials and Dangerous Substances			
5.1.4.7 Reclamation and Re-vegetation			
5.1.4.8 Progressive Rehabilitation			
5.2. Safety and Security:			
5.2.1 Definition of Parameters and Procedures to Control Site Access:			
5.2.1.1 Facility Integrity			
5.2.1.2 Safety of Site Personnel and General Public			
5.2.2 Document Hazards or Safety Restrictions Related to Human Contact with:			
5.2.2.1 Refuse Materials			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
5.2.2.2 Decant Materials			
5.2.3 Typical Safety and Security Parameters:			
5.2.3.1 Site Access and Egress Limitations			
5.2.3.2 Workplace Hazards			
5.2.3.3 Personal Protective Equipment			
5.2.4 Typical Safety and Security Procedures:			
5.2.4.1 Signage, Fencing, and Gates			
5.2.4.2 Security Patrols			
5.2.4.3 Workplace Safe Operating Procedure			

2.2.6. Documentation

Documentation of the scheduled inspections of the facility along with work records, maintenance reports and other historical documentation are essential to determine trends, identifying problems, and correcting deficiencies.

The following records and checklists should be developed and maintained for use during the life of the facility:

Table 6: Checklist for use during the life of a typical facility

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
6. Documentation:			

6.1 Types of Information to be Routinely Collected and Recorded			
6.2 Checklists and Report Forms should be Considered or Referenced			
6.3 Typical Operation Documentation:			
6.3.1 Quality Control Records and Statistical Summaries			
6.3.2 Instrumentation Records and Daily Diary Entries			
6.3.3 Communication and Activity Records			
6.3.4 Photographic Summaries and/or Videos			
6.3.5 Schedules			
6.3.6 Change Orders, Memos, and Reports			
6.3.7 As-Constructed Drawings and Reports			
6.3.8 Dam Raising Drawings, Reports, and other Documentation			

2.2.7. Reporting

Reporting is a valuable system of feedback that is needed when setting the operating management system of a tailing facility discussed in the previous section of the manual. This reporting system depicts the faults/ flows in the designed/ set system that allows the whole system to close gaps and improve the management quality of planning and control. Reporting on periodical, eventual, and incidental basis will help the management components of the operation to understand the capabilities and the risks related to each operation/process. This will assist management in controlling risks and minimizing problems.

Typical parameters to be considered and related details to facility reporting

Table 7: Facility reporting parameters

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
7. Reporting:			
7.1 Delineation of Operating Performance Information to be Reported			
7.2 Specification of Procedures for Reporting of:			
7.2.1 Operational Conditions Requiring Maintenance			
7.2.2 Observations which may Identify Significant Change in Facility Conditions			

2.3. MAINTENANCE OBJECTIVES AND MAINTENANCE PLANS

Maintenance key parameters and procedures must clearly be identified and documented, to ensure facilities 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, and Instructions for performing periodic maintenance should be given in detail, so that new personnel can understand the tasks, and experienced personnel can verify that they have performed the work properly. All types of maintenance should be identified and listed in a maintenance plan section of the Manual

A facility maintenance program usually involves identification and description of critical parts, routine, predictive and event-driven maintenance and operating and surveillance observations for all engineering components of a facility:

- Civil Engineering
- Electric engineering

- Mechanical engineering
- Instrumentation components

Table 8: Maintenance parameters I

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
8.1. Objective:			
8.1.1 Identify Key Maintenance Parameters and Procedures to Ensure that the Individual Components of the Facility are Maintained in Accordance with:			
8.1.1.1 Performance Criteria			
8.1.1.2 Company Standards			
8.1.1.3 Legislative Requirements			
8.1.1.4 Sound Operating Practices			
8.1.2 Maintenance Plans should be Tailored to Unique:			
8.1.2.1 Facility Characteristics			
8.1.2.2 Site Conditions			
8.1.3 Typical Contents of a Management Plan:			
8.1.3.1 Statement of Objective			
8.1.3.2 Overall Responsibility for Maintenance:			
8.1.3.2.1. Maintenance Organization Chart			
8.1.3.2.2. Required Qualifications			
8.1.3.3 Inventory of Components Subject to Maintenance			
8.1.3.4 For each Inventoried Component:			
8.1.3.4.1. Location			
8.1.3.4.2. Maintenance Schedule			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
8.1.3.4.2.1. Frequency of Routine Maintenance			
8.1.3.4.2.2. Trigger for Event Driven Maintenance			
8.1.3.4.3. Reference Standards			
8.1.3.4.3.1. Design or Performance Standards			
8.1.3.4.3.2. Equipment O&M Manuals			
8.1.3.5 Schedule for Checking:			
8.1.3.5.1. Emergency Equipment			
8.1.3.5.2. Critical Spare Parts List			
8.1.3.6 What is to be Documented:			
8.1.3.6.1. Component Condition			
8.1.3.6.2. Maintenance Action Undertaken, Standard Met			
8.1.3.6.3. Recommendation for Next Action			
8.1.3.7 Reporting:			
8.1.3.7.1. to Whom			
8.1.3.7.2. When			
8.1.3.7.3. How			
4.1.3.7.4. What Form			
8.2. Maintenance Flowchart			
8.3. Maintenance Parameters:			
8.3.1 Definition of Maintenance Parameters that Address Civil, Mechanical, Electrical, and Instrumentation Requirements.			
8.3.2 Typical Maintenance Parameters:			
8.3.2.1 Site Access			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
8.3.2.2 Ditch, Spillway, and Drop Structure Capacity			
8.3.2.3 Support Structure Integrity			
8.3.2.4 Equipment Availability and Reliability			
8.3.2.5 Pipeline Wear and Thickness Criteria			
8.3.2.6 Minimal Refuse Line Thickness, and Associated Requirements			
8.3.2.7 Process and Surveillance Instrumentation Controls			
8.3.2.8 Switches, Interlocks, and Meters			
8.3.2.9 Erosion			
8.3.2.10 Vegetation			
8.3.2.11 Design Economic Life			
8.4. Routine and Predictive Maintenance – Routine and Predictive Maintenance Procedures for all Identified Components of the Facility, specifying:			
8.4.1 Prioritization, based upon Risks and Consequences			
8.4.2 Material and Equipment Availability			
8.4.3 Maintenance Action Plans, including:			
8.4.3.1 Repairs, As Needed			
8.4.3.2 Replacements, As Needed			
8.4.4 Documentation of Maintenance Undertaken			

2.3.1. Types of Maintenance

2.3.1.1. Event Driven/ Unscheduled Maintenance

An effective maintenance program has a limited tolerance for unexpected deficiencies to occur at any time, inducing the need for repairs or replacement. Unscheduled maintenance is maintenance that is performed on an as-needed basis. The need for unscheduled maintenance may be identified during the performance of preventative maintenance, because of inspections, or after an unusual event.

Although unscheduled maintenance cannot be planned for in a maintenance plan, an owner should anticipate the need for repair or rehabilitation of unexpected deficiencies. To this end, a section should be provided in the Maintenance plan, which gives instructions for dealing with unscheduled maintenance. Major repairs or improvements would necessitate review and approval by the Dam Safety Section.

Table 9: Maintenance parameters II

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
9. Event-Driven Maintenance – Procedures to Address Conditions or Incidents Requiring Maintenance, which may arise from Observations from other OM and S Activities, and Result in Planned or Unplanned Maintenance Actions, specifying:			
9.1 Prioritization, based upon Risks and Consequences			
9.2 Maintenance Team “Call-Out” Procedures			
9.3 Material and Equipment Availability			
9.4 Maintenance Action Plans, including:			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
9.4.1 Repairs, As Needed			
9.4.2 Replacements, As Needed			
9.5 Lock-out and Safety Procedures and Concerns			
9.6 Return to Normal Operation			
9.7 Documentation of Maintenance Undertaken			

2.3.1.2. Routine Scheduled Maintenance

Scheduled maintenance involves servicing, replacing, or performing regular tasks according to an established schedule.

Scheduled maintenance varies as it can be based on time (e.g. days, months, years, etc.) or amount of use (e.g. hours of operation, number of cycles, etc.). Equipment maintenance schedules are normally based on the manufacturers specifications.

2.3.1.3. Monitored /Prediction Maintenance

Monitored maintenance involves periodic surveillance and testing of equipment and making repairs or modifications as needed. A surveillance schedule is established based on predictions of the wear rates of certain types of equipment or materials. For example, inspecting trash racks weekly and clearing debris as needed, and checking gate leakage monthly and replacing seals as needed.

2.3.1.4. Preventive Maintenance

A conceptual maintenance routine that could be followed in case of high risk anticipated with the unscheduled maintenance. It is used mainly in critical high risk and complex facility systems to prevent any unexpected failures, which could cause catastrophic consequences.

A surveillance schedule is established based on set time / use pre set limits of the total lifetime / maximum use ranges beyond which potential of failure is likely to occur, usually based on predictions of the total wear rates of equipment or materials.

2.3.1.5. Maintenance Documentation and Reporting

As discussed before in the operations these two components are the main guarantee of smooth working environment for newly and experienced employees. It is a tool for having all the required data assembled and ready to be managed, ensuring the total control of the systems. Information must be periodically updated and modified when actual status is being modified.

Table 10: Maintenance documentation and reporting

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
10.1. Documentation:			
10.1.1 Information to be Collected and Recorded as Part of the Facility’s Maintenance			
10.1.2 Typical Maintenance Documentation:			
10.1.2.1 Up-to-date Equipment Logs			
10.1.2.2 Work History			
10.1.2.3 Frequency and Cause of Problems			

<i>Operation / Sub-operations</i>	<i>Required</i>	<i>Not Required</i>	<i>Optional</i>
10.1.2.4 Component Reliability			
10.1.2.5 Quality Control Records			
10.1.2.6 Daily Diary Entries			
10.1.2.7 Communication and Activity Records			
10.1.2.8 Photographic Summaries and/or Videos			
10.1.2.9 Inventory of Spares, Materials, Tools, and Equipment			
10.1.2.10 Critical Spares List			
10.1.2.11 Schedules			
10.1.2.12 Change Orders			
10.1.2.13 Memos			
10.1.2.14 Reports			
10.2. Reporting:			
10.2.1 Maintenance Information to be Reported			
10.2.2 Procedures for:			
10.2.2.1 Reporting Operational Conditions Requiring Maintenance			
10.2.2.2 Reporting Significant Observations from Maintenance Activities, including:			
10.2.2.2.1. Greater than expected Maintenance Requirements			
10.2.2.2.2. Excess Event-Driven Maintenance			

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