CMPA

Slimes Management Guideline

Issue 1

August 2020

Acknowledgements

The CMPA would like to acknowledge those who contributed to the development of this Slimes Management Guideline.

Writer: David McKelvie – Safe Mix

Contributions by:

- Andrew Evans - Local Mix Quarries
- Cameron Black – BCA Consulting
- Bruce Totton - Geofabrics Australasia
- Peter Godwin - Lincom Group
- Tony Ferrazza – Quarry Wise

The CMPA would also like to acknowledge the Earth Resources Regulators (ERR) branch of the Department of Economic Development, Jobs, Transport and Resource (DEDJTR) for the provision of information used in developing this guideline extracted from their document titled “Technical Guideline Design and Management of Tailings Storage Facilities 2017”.

Disclaimer

This Slimes Management Guideline has been prepared by the Construction Material Processors Association (CMPA).

The guidelines here may not apply in all circumstances and should not replace a quarry manager’s considered assessment of a particular situation before them.

All information and each representation, statement, opinion and advice expressed or implied in this document is made in good faith, but on the basis that CMPA, its officers, workers, agents and contractors are not liable for any damages, costs or loss whatsoever which any person may either directly or indirectly suffer, sustain or incur as a result of reliance upon anything contained expressly or by implication in this document.

Copyright

Contents

Introduction to this Guideline

1. Overview

The objective of this Slimes Management Guideline is to assist CMPA members in ensuring that all health, safety and environmental risks associated with the generation and controls of slimes and the operation and rehabilitation of a slimes dam are reduced so far as is reasonably practicable.

This Guideline:

- Provides contemporary information specific to the management of slimes and the safe and environmental operation of slimes dams;
- Outlines processes that can be adopted to establish and implement slimes management procedures and practices;
- Offers a Slimes Management Plan (SMP) template to assist in meeting the requirements of your Work Plan as required under Mineral Resources (Sustainable Development) Act 1990.

2. Relevant Legislation

- Victorian Occupational Health and Safety (OHS) Act 2004;
- Victorian OHS Regulations 2017;
- Mineral Resources (Sustainable Development) Act 1990;
- Mineral Resources (Sustainable Development) (Extractive Industries) Regulations 2019;
- Environmental Protection Act 2017;
- Planning and Environment Amendment (General) Act 2013.

3. References and Guidance Materials

The CMPA acknowledges the publication and provision of the following documents that have provided relevant information and guidance when establishing this Slimes Management Guideline.

- Preparation of Work Plans and Work Plan Variations, Guideline for Extractive Industry Projects December 2018. Earth Resources Regulation;
- Guide NSW Resources Regulator Health and Safety at Quarries September 2018;
- Code of Practice for Small Quarries, Department of Primary Industries, Earth Resources Regulation May 2010;
- Health and Safety at Opencast Mines, Alluvial Mines and Quarries, November 2015, Work Safe New Zealand;
- Technical Guideline Design and Management of Tailings Storage Facilities 2017;
- Environmental Guidelines for Management of Small Tailings Storage Facilities 2006;
- Earth Resources Regulator - Slimes Management Workshop Presentation Titled Design, Construction, Operation and Rehabilitation, a Regulatory Perspective. 2018;
- Tailings Management, Leading Practice Sustainable Development Program for the Mining Industry. Australian Government September 2016;
- Your Dam - Your Responsibility, Victoria Government, Department of Environment, Land, Water and Planning 2018.

4. Attachments to this Document

- (A) Slimes Dam Inspection Checklist;
- (B) Emergency Response Procedure Template;
- (C) Trigger Action Response Plan (TARP) Template;
- (D) Slimes Management Plan Template.

Note - All attachments are available in electronic format from the CMPA

5. Definition of Terms

Term	Definition
Abutment	The natural ground formation between the base of the dam and its crest. The natural material below the excavation surface and in the immediate surrounding formation above the normal river level or flood plain against which the ends of the dam are placed.
Base of Dam	The area of the lowest part of the dam resting on the foundation excluding the abutments. It excludes isolated pockets of excavation which are not representative of the base extending from upstream heel to downstream toe.
Beaching Rock or Riprap Rock	Rock placed to dissipate the erosive force of waves on banks. The term can mean dumped or hand-placed rock, usually located on a prepared bed of gravel size material.
Breach	An opening or a breakthrough of a dam sometimes caused by rapid erosion of a section of earth embankment by water.
Catchment	The area of land drained by the landform, streams or waterways down to the point at which the dam is located.
Crest of Dam	The top level of a dam wall or embankment (not the spillway level). The uppermost surface of the dam.
Conduit	A closed channel to convey the discharge through or under a dam. Usually pipes constructed of concrete or steel.
Core	A zone of material of low permeability in an embankment dam, hence the terms central core, inclined core, puddle clay core, and rolled clay core.
Cut-Off	An impervious barrier of material to prevent seepage flows through or beneath a dam. It is also used to prevent seepage flow along structures such as pipelines or spillways. An impervious construction by means of which seepage is reduced or prevented from passing through foundation material.
Decommissioned Dam	A dam that is no longer used but has been made safe so that there is no requirement for operation or maintenance, and it does not have a detrimental effect on the environment.
Design Flood	The maximum flood for which the dam is designed, considering the consequences of failure and likely rainfall.
Dissolved Oxygen (DO)	A measure of how much oxygen is dissolved in the water - the amount of oxygen available to living aquatic organisms.
Embankment	An earth structure built across a waterway to either protect adjacent land from inundation by flooding or to store water. It also applies to earth structures built to contain water off a waterway.
Electrical Conductivity (EC)	EC or Electrical Conductivity of water is its ability to conduct an electric current.
Extreme Event	An event such as flood, storm or earthquake that has a low probability of occurring but is possible. Its potential forces are used for the design of dam components. It is usually expressed as Annual Exceedance Probability (AEP), being the chance of the event occurring in any one year.
Impervious	Describes a relatively waterproof soil such as clay through which water percolates very slowly making it suitable as a water barrier.

Term	Definition
Flocculants	A substance which promotes the clumping of particles, especially one used in treating wastewater.
Foundation	The material of the floor and abutments on which the dam is constructed.
Freeboard	The vertical distance between the spillway crest level and the top of the dam (crest) at its lowest point.
Full Supply Level	The maximum normal operating level of a reservoir, as distinct from flood surcharge. This is also the level of the spillway crest when water is just about to pass through the spillway.
Height of Dam/Embankment	The difference in level between the embankment crest and the downstream toe of the dam at the point of maximum height.
Potential Hydrogen (pH)	A measure of acidity or alkalinity of water soluble substances (pH stands for 'potential of Hydrogen'). A pH value is a number from 1 to 14, with 7 as the middle (neutral) point. Values below 7 indicate acidity which increases as the number decreases, 1 being the most acidic.
Permeability	Property of a soil that allows the movement of water through its connecting pore spaces.
Pervious Zone	A part of the cross section of an embankment constructed from material of high permeability.
Plasticity Index (PI)	The plasticity index (PI) is a measure of the plasticity of a soil. The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL). When referring to sand the plasticity index depends only on the amount of clay present. It indicates the fineness of the soil and its capacity to change shape without altering its volume. A high PI indicates an excess of clay or colloids in the soil. Its value is zero whenever the PL is greater or equal to the LL.
Rheology	Rheology is the study of the flow of liquids which do not flow easily**.**
Seepage	The exit of dam water by percolation through, under or around the dam.
Spillway	An open channel, weir, conduit, tunnel or other structure designed to allow discharges from the dam when water levels rise above the Full Supply Level directing flow downstream of the dam. The spillway is principally to discharge flood flows safely past a dam without overtopping the dam wall.
Spillway Chute	An inclined open channel through which water flow is directed below the toe of the dam. Surface may be grass, concrete or beached.
Spillway Crest	Usually the highest section floor in the spillway cut, which sets the level of the storage.
Seepage	The exit of dam water by percolation through, under or around the dam.
Toe of Dam	The junction of the downstream face of a dam with the natural ground surface.
Turbidity	Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air.

Introduction to Slimes

Clean fine aggregates (sands) are required in the construction materials market to manufacture concrete, asphalt, masonry and other products.

To ensure fine aggregates are fit for purpose and meet the required specifications of users, construction materials processors (Quarry Operators) must remove clays, silts and other deleterious materials such as wood, coal or general organic matter.

Quarry Operators generally wash sand to meet this objective. There are different processes utilised to wash sand and they all produce what is currently classified as a waste material, the majority of which is a fine, clay slurry known as slimes.

Other mechanical processes produce a waste material in a drier form known as cakes.

Typically, slimes are transported by pipe (pumped) or open drain (gravity fed) to a slimes dam referred to by the regulator and within minerals sector as a Tailings Storage Facility (TSF).

Slimes are also generated through washing course and fine aggregates. Water recovered from washing these aggregates is often added to crushed rock or used to suppress dust from becoming airborne; alternately it is drained to a catchment pit.

General sediment from quarry surfaces such as floors, benches and haul road become another source of slimes that must be captured and controlled.

The purpose of a slimes dam is to safely contain slimes and water so as to achieve solid sedimentation and consolidation whilst facilitating water recovery or water removal without impacting the environment or workplace safety.

Slimes dams have the potential to create risks to the community, the environment and to the workplace inclusive of:

- Uncontrolled release of water contaminated with slimes due to heavy rainfall;
- Collapse of structures, e.g. dam walls resulting in engulfment of and damage to property, flora, fauna or waterways; and
- Submerging of persons, fauna or mobile equipment/road trucks or other vehicles that have lost control.

The ongoing use of slimes dams as a means of containing a waste product, unless effectively and sustainably controlled, has the potential to create ongoing risk to the community, the environment and an ongoing reputational and financial liability to quarry operator and the overall construction materials industry.

Existing slimes dams must be managed throughout the operation of the site and be rehabilitated in a sustainably safe and environmentally responsible manner.

The CMPA recognises that there are two long term challenges in regard to management that the extractive industry must address:

- The containment of slimes in a dam may in the future not be regarded as a sustainable solution due to its potential impact on the environment and the community;
- The waste materials that are not used for re-blending or rehabilitation are a natural resource that become redundant

Consideration should be given to alternate methods of dealing with the issue of slimes management that focus on the mechanical dewatering of the waste material so that it is more easily used in the rehabilitation of the quarry or utilised as a recoverable product.

It is envisaged that this guideline shall encourage and facilitate conversation leading to initiatives that assist members and the industry in general, to address the challenges as listed above.

6. Waste Minimisation

Prior to proposing a new Slimes Dam or a variation to an existing Slimes Dam, the Quarry Operator should consider all alternatives to generating the tailings in both aspect of form and volume.

Opportunities for minimising the volume of slimes and reusing the slimes should be assessed. Slimes maybe directed to other uses such as packing sand or backfill. Opportunities for water conservation and reuse should also be explored. Continuous review of opportunities for waste minimisation over the life cycle of the extractive site will contribute to the best possible outcomes for the Quarry Operator. Earth Resources Regulation (ERR), Department of Jobs, Precincts and Regions, may request further analysis where it is considered necessary to protect the environment, nearby land, property or infrastructure or reduce risks to the community.

Currently alternate uses of slimes/cakes within the construction materials industry appears to be limited to back fill and rehabilitation materials.

Prior to committing to the traditional methods of extracting and containing slimes within a slimes dam, alternative technologies should be considered that may reduce the risk associated with the containment of slimes within a dam and potentially identify other uses of slimes/cakes as a recoverable product, e.g. a sellable construction material.

Alternative technologies include:

- Thickeners
- Belt Presses
- Centrifuge – Solid Bowl
- Filter Presses - Overhead Beam or Side Bar
- Buffer Tanks
- Geotextile Tubes
- Any combination of the above.

Sand Classifier Tank at Local Mix's Moriac Quarry

7. Alternative Technologies

Alternative technologies should be considered that may reduce the risk associated with the containment of slimes within a dam and potentially identify other uses of slimes/cakes as a recoverable product, e.g. a sellable construction material.

Slimes Management at Local Mix - Moriac Quarry

Thickeners

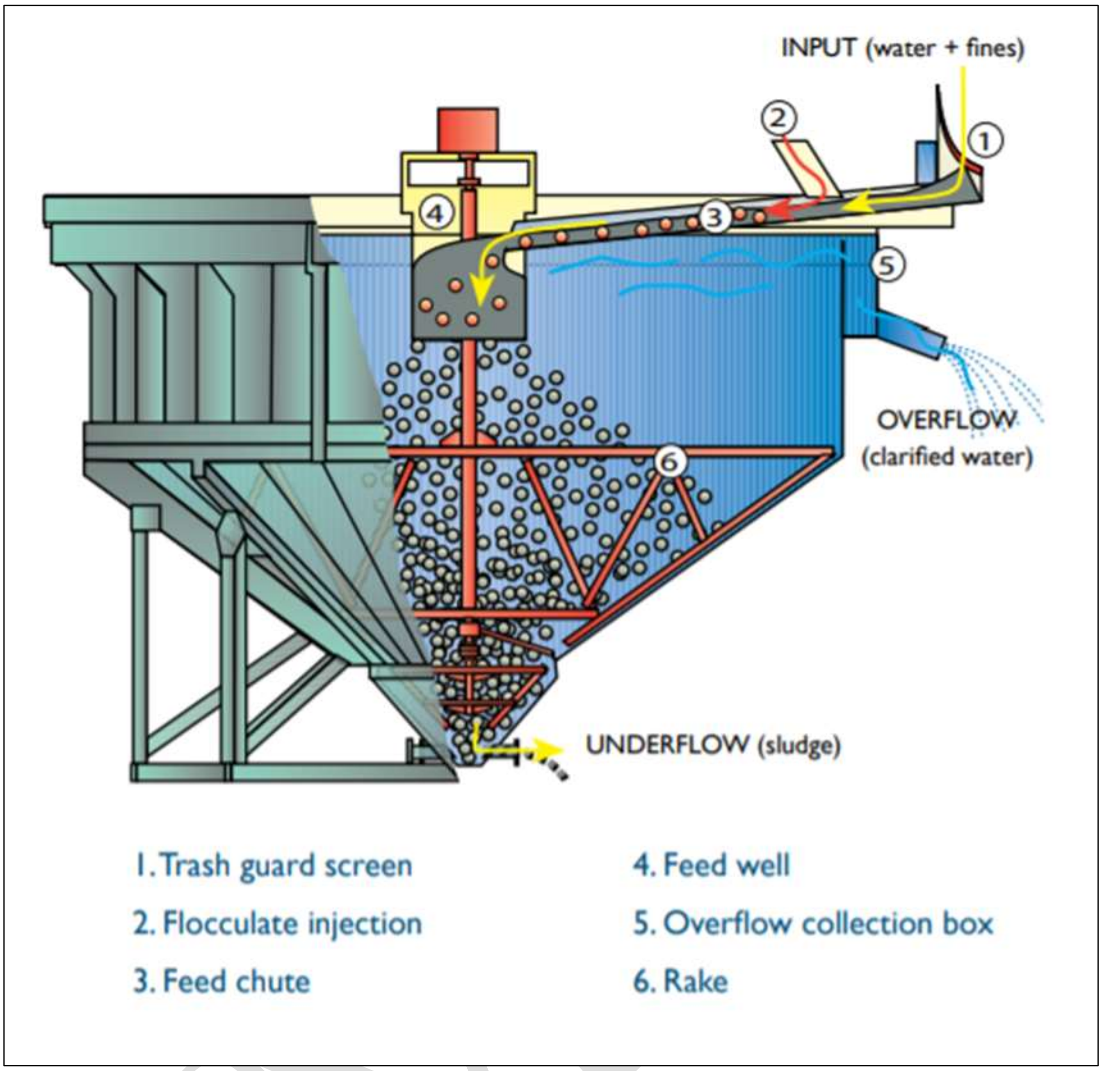
Thickeners and clarifiers are similar in operation with both used to separate solids and liquids.

While thickeners focus on the settled solids and underflow density, clarifiers are more focussed on achieving clear overflow liquor.

The early methods of thickening employed plain, flat-bottomed tanks into which the slimes and water is fed until the tank is full. Gravity thickening uses the natural tendency of higher-density solids to settle out of liquid to concentrate the solids. The solids settle to the bottom of the tank by gravity, and the scrapers or rakes slowly move the settled, thickened solids to a discharge pipe at the bottom of the tank.

Key Points

- Thickeners are usually the first step in all the dewatering processes;
- The slurry feed particle size is 75µm;
- Thickeners can be a single solution in itself with thickened underflow going to a tailings dam, or slimes cell, while the clarified overflow is returned as process water;
- Several variations of raked and non-raked thickeners e.g. high rate, high density or deep cone thickeners are available and may be designed as on ground or elevated configurations;
- The output product is wet and pumpable;
- Requires flocculent dosing for efficient settling;
- Low energy usage;
- Recovers clarified water;
- Settles thickened solids;
- This is a continuous process.



Thickener Operation:

Effluent is pumped from the sump to the top of the cone. A polymer flocculant is added (2) which causes fine particles to bind together and settle rapidly. Clear water overflows from the top of the cone (5) into a storage tank. The sludge at the bottom of the cone (which usually contains 25 - 35% solids) is pumped to a conditioning tank, where this is kept in suspension, to be pumped later to the dewatering equipment e.g. filter press, belt press.

Belt Presses

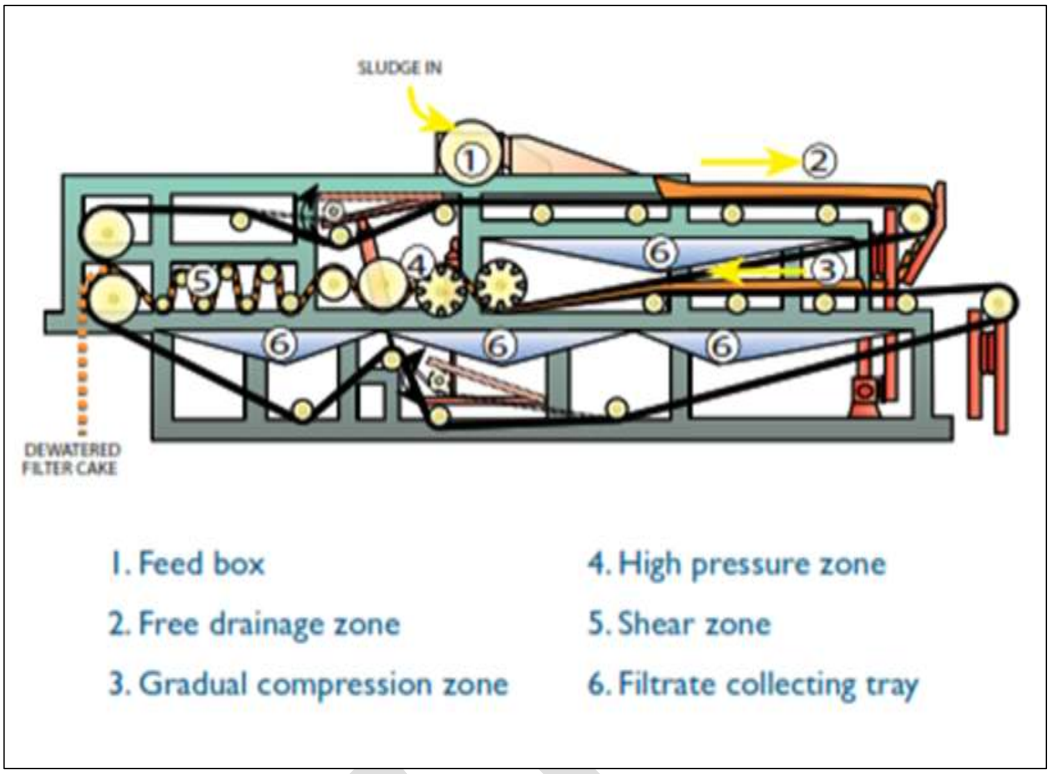
Belt Presses are used for solid/liquid separation processes, particularly the dewatering of sludge in the mining, quarry and water treatment industries. The process of filtration is primarily obtained by passing a pair of filtering cloths and belts through a system of rollers. The system takes a sludge or slurry as a feed and separates it into a filtrate (a liquid which has passed through a filter) and a solid cake.

The Belt Press is composed of two upper and lower tensioned filter belts, which is bent in an “s” shape from a series of regularly arranged roller cylinders, and is pressed against the sludge layer by the tension of filter belt itself to form the shear force to squeeze the capillary water in the sludge layer to obtain a mud cake with high solid content, thereby achieving sludge dewatering.

The Belt Press has a high requirement for flocculation effect and uses a dosing mixer to achieve the best flocculation.

Key Points

- Relatively small footprint compared to filter press;
- Requires thickener upstream;
- Slurry feed particle size -75µm
- Additional floc injected prior to dewatering;
- Variable dewatering results dependent upon consistency of the feed;
- This is a continuous process.



Belt Press Operation:

The sludge is conditioned with polymer after thickening and just prior to feeding onto the belt press. Conditioned sludge is spread evenly across the width of the belt, and then squeezed between two filter belts to remove the liquid through squeezing in compression zones.

Belt presses can be run continuously with automated or manual polymer, belt tracking or pressure adjustments made on the run.

De Watering from Belt Press

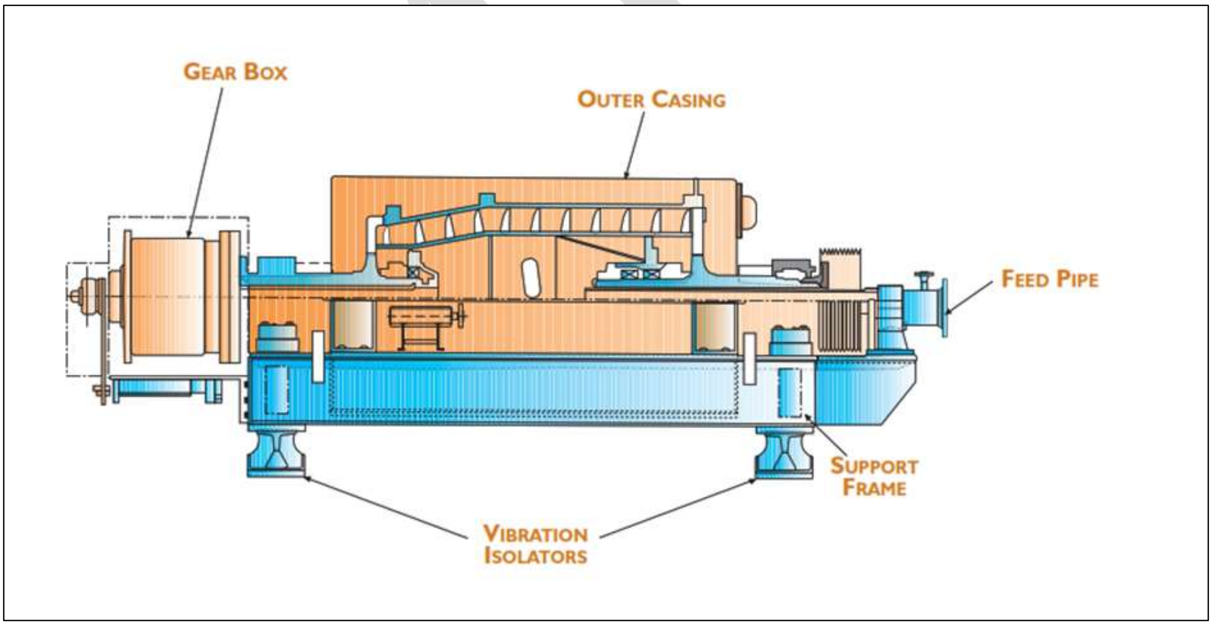
Centrifuge – Solid Bowl

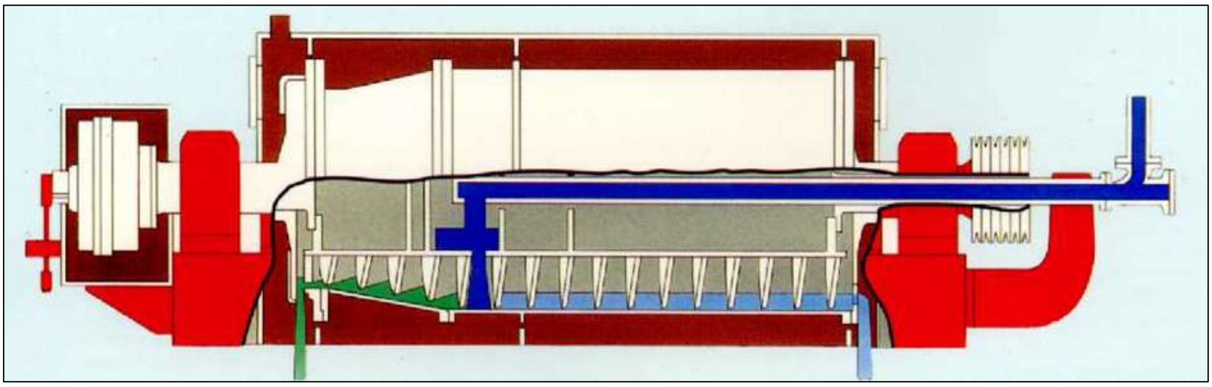
A solid bowl decanter centrifuge uses the principle of sedimentation for high speed settling. A centrifuge carries out solid/liquid separation by density, using the centrifugal force resulting from continuous high-speed rotation.

These machines allow efficient dewatering and water clarification in a continuous process without an operator in attendance. By changing the weir heights, there can be effective control over the balance between the cake solids and the water (centrate) clarity by the adjustment of its pool depth.

Key Points

- Typically requires thickening upstream (usually > 5% solids);
- Slurry feed particle size typically -75µm but may be larger;
- Relatively small footprint;
- Quick setup and relocatable;
- Requires flocculent dosing in feed;
- Higher energy consumption than other dewatering equipment;
- Can run unattended;
- This is a continuous process.





Centrifuge Operation:

Feed slurry is introduced into the bowl through the centre of the conveyor where the solids settle through the liquor pool formed in the bowl.

The gearbox produces a slight differential speed between the rotation of the bowl and that of the screw conveyor which conveys the solids along the bowl wall, out of the liquor pool, and up the conical section of the bowl to the solids discharge ports.

The clarified liquor (centrate) discharges continuously from the opposite end of the bowl over adjustable weir ports.

Filter Presses - Overhead Beam or Side Bar

Filter presses may incorporate either recessed chamber, or membrane type plates, and are widely used for solid/liquid separation across a wide range of applications. Dewatering occurs when slurry material is pumped into the cavities created between the filter plates when the filter plate pack is in the closed position.

Overhead beam filter presses typically are used in heavier duty applications. Filter plates are mounted from I-beams above the filter press, giving very good access to the filter plates and filter cloths. This orientation generally has wider plate opening distances between the plates to assist with cake discharge.

Side bar filter presses typically are used in lighter duty applications. The filter plates slide on top of the beams located on each side of the filter plates. Filter cakes discharge from the press by gravity when the filter plates are separated and often have a plate shaking device to assist the discharging.

Key Points

- Requires thickener upstream;
- Slurry feed particle size -75µm;
- Large footprint;
- No additional flocculent requirements;
- Low energy consumption;
- Cake moisture can be varied by manipulation of cycle time;
- Cake can be dry stacked;
- Cake is transportable without liquefying;
- Highest level of water recovery;
- This is a batch process.

Overhead Beam Filter Press

Side Bar Filter Press

Filter Press Operation:

Thickened slurry is pumped into a series of cloth lined filter chambers which are formed when the plate pack is closed. The solids progressively build up on the filter cloth, while the liquid (filtrate) drains away after it has passed through the filter cloth.

Through the continuous feeding of slurry into the chambers, a consistent filter cake is formed. The built solid layer acts as a filter media and solid/liquid separation is achieved.

When the filter cakes are fully formed, the plate pack is opened, and the filter cake is discharged by gravity.

Buffer Tanks

Dewatering slimes is a vital component of any wash plant and should be critically considered in the initial design, and not as an afterthought. All dewatering process work most efficiently with a consistent / homogenous feed, and whilst some dewatering items have a buffer tank built into them, some do not. Regardless, careful consideration should be given to a mud buffer tank when designing your dewatering process.

A mud buffer tank is not a complex piece of engineering; simplistically it is a large tank with some type of gentle agitation device.

The mud buffer tank serves two equally important functions. Sitting between the thickener and the dewatering process, the mud buffer tank:

- Homogenizes the thickened mud, and,
- Acts as a temporary storage

The relative importance you, as a designer/operator, place of the sand washing versus dewatering processes will determine the size of the mud buffer tank, but remember any size tank will homogenize the feed, but a larger tank will give you greater flexibility.

If homogenized feed is your prime goal, then a relatively small tank is all that is required but be mindful that variation in the washing process creates variations in the thickener which will also lead to variations in the small buffer tank.

It is recommended to go with the largest mud buffer tank you can afford. This will more economically allow the sand washing process to be independent of the dewatering process. This independence allows for variation or stoppages in the sand washing process and/or the dewatering process, i.e. breakdowns, interruption in raw feed, etc. being absorbed by the mud buffer tank. It can also allow the dewatering process to operate after the sand washing process has stopped. It is not uncommon to design a dewatering system with sufficient "*mud capacity*" to operate 6-8hrs after shutdown, allowing for smaller/few dewatering units and lower capital outlays.

Photo supplied by Local Mix – Moriac Quarry

Geotextile Tubes

A cost-effective solution for the dewatering of sludge or removing fine sediments from site run-off is to make use of geo synthetic dewatering systems.

Dewatering of waste water and sludge is commonly achieved by pumping the slurry into permeable geotextile tubes, treating with flocculants and allowing the moisture to either evaporate through the geotextile or drain through the geotextile pores under significant pressure.

There are no moving parts, therefore no maintenance issues such as with mechanical systems.

The run-off from the dewatering process can be reused or treated and returned to native waterways while the sediment or waste can be re-processed or detained.

The geotextile tubes can be placed as required and could serve secondary purposes such as the establishment of bunds, edge protection berms, embankments, retaining walls and so forth.
The material is Polypropylene which is not biodegradable but is potentially recyclable.

Photo supplied by Geofabrics Australasia

8. Regulatory Requirements specific to Management of Slimes Dams

Overview

Regulatory requirements for the management of slimes dams are set out in the Environmental Guidelines for Management of Small Tailings Storage Facilities 2006 or the Design and Management of Tailings Storage Facilities 2017.

Both documents are published by ERR and are available online from the ERR website (www.earthresources.vic.gov.au)

Common requirements to all sites are to:

- Continuously minimise waste;
- Identify and assess safety and environmental risks presented by slimes dams;
- Manage these risks appropriately to ensure that slimes dams are safe, both during operation and after closure, and that environmental impacts are minimised;
- Design new slimes dams to reduce risks to acceptable limits; and
- Ensure that slimes dams are appropriately rehabilitated after closure to minimise long term risks to the environment, social impacts, future land use and visual amenity.

To obtain a Work Authority and comply with regulatory requirements operators of slimes dams must provide ERR with the required documentation.

Required documentation includes a Work Plan accurately describing all the aspects of the operation, risks, controls and performance criteria.

The requirements for having a Work Plan approved; one of many steps in gaining a Work Authority are outlined in the Mineral Resources (Sustainable Development) Act 1990:

- Division 2 - Work Plans and Extractive Industry Work Authorities
- Section 77G - Work Plan
- Section 77I - Extractive Industry Work Authorities

Work Plan Requirements

The Work Plan is the primary document describing the permitted activities to be undertaken on a Work Authority. It is intended to provide guidance to operations staff at the quarry as well as informing other readers such as council or government officers in order to facilitate decisions, approvals, compliance, and enforcement functions.

Information in regards to the preparation of Work Plans is provided in the document titled "Preparation of Work Plans and Work Plan Variations, Guideline for Extractive Industry Projects, December 2018".

The Work Plan must be clear, concise and contain sufficient detail to enable a reader to understand the activities proposed to be undertaken at the site, their potential risks and impacts, and the control or management actions required.

Requirements specific to Slimes Dams are listed in the following table.

MRSD (EI) Regulations, Schedule 1 – Part 1		
	Summary of Required Items	**Guidance (Specific to Slimes Dams)**
R 8(c)	**Geological Information**	A general description of geological information pertaining to the proposed work and past land uses which may impact the proposed design such as contaminated land, old slimes and underground voids.
R 8(d)	**Stone Processing Methods and Facilities**	A general description of processing methods, including plant and equipment and storage of clean water, process water and slimes.
R 8(e)	**Site Map**	Drawn at an appropriate scale, showing the general layout of the quarry and associated facilities and infrastructure inclusive of water dams, in-pit sumps, slimes dams and pipelines.
R 9	**Identification of Hazards and Risks**	Details of quarrying hazards that may arise from work under the work plan inclusive of set up or construction, operations or production, details of rehabilitation hazards, how the identified hazards may harm or damage the sensitive receptors and an assessment of the risks that the identified hazards may pose to sensitive receptors.
R 10	**Risk Management Plan**	Details of controls to eliminate or minimise the risks inclusive of performance standards, management systems, practices and procedures that are to be applied to monitor and manage risks and an outline of the roles and responsibilities of personnel accountable for the implementation, management and review of the plan.
R 11	**Rehabilitation Plan**	Detail concepts for the end utilisation of the proposed quarry site inclusive of proposals for the final rehabilitation and closure of the site inclusive of the rehabilitation and security of waste dumps, stockpiles, water storages and slimes dam taking into account any potential long-term degradation of the environment.

The ERR Code of Practice for Small Quarries lists requirements with respect to slimes dams.

The objective of these requirements is to manage the disposal and rehabilitation of slimes to minimise the risk to public safety and the environment.

Requirements (R)

- R23 - The Work Authority holder must prevent contaminated runoff from entering receiving waterways
- R25 - The Work Authority holder must take all reasonable measures to minimise the generation of slimes material
- R26 - The Work Authority holder must ensure that the location, design, construction, operation and safe management of slimes dams within the Work Authority area are undertaken in a way that prevents the release of slimes to the environment
- R27 - The Work Authority holder must ensure that slimes dams on site are not accessible to the public

The code recommends the following practices to meet these requirements:

- Plan for and ensure a site has adequate storage capacity for all slimes produced
- Design slimes disposal areas to promote, where possible, rapid drying and consolidation
- Minimise storage of slimes in dams wherever possible
- Monitor the stability of slimes dams
- Control dust from dried slimes
- Ensure that slimes are securely fenced, and appropriate signs are in place to warn of potential hazards
- Properly cover and rehabilitate slimes dams as quickly as practicable after filling
- Use dried slimes in rehabilitation works where practicable

Slimes Management Plan (SMP)

The CMPA recommends the establishment and implementation of a SMP to ensure all of the requirements are met.

The SMP provides the basis for ensuring that the Work Plan objectives are converted into appropriate on-site actions and that all workers are informed of standard procedures, processes and performance measures that form part of their roles and responsibilities.

The SMP may be an attachment to the existing or proposed Work Plan or Work Plan variation and would be inclusive of but not limited to the following content:

- Objective and scope;
- Management and worker roles and responsibilities;
- Hazard Identification and control;
- Description of methods for slimes conveyance, e.g. pipelines, open drains;
- Description of slimes treatment, e.g. dam structures and process, alternative technologies;
- General Procedures for:
  - Management of native flora and fauna;
  - General Security inclusive of authorised/unauthorised access;
  - General inspection / audit regime;
  - Structural integrity monitoring, e.g. cracking, slumping, seepage;
  - Maintenance;
  - Slimes dam water levels;
  - Removal and placement of slimes/cakes;
- Emergency response plan;
- Incident reporting and management;
- Rehabilitation plan.

The SMP should be a live document that can be amended as required without triggering a Work Plan variation.

If the risks are increased as a result of changes to site actions, procedures, process etc. then a work Plan Variation will be required. If this situation arises the CMPA recommends seeking advice from the ERR.

This Guideline provides a template for CMPA Members to establish a SMP:

Refer attachment D) Slimes Management Plan Template

Slimes Storage Dams Classifications

Waste storages are classified according to either small storages or large storages.

Small storage slimes dams are classified as:

- Embankment heights of < 5 metres (m) and storage capacities of up to 50 mega litres (ML);
- Embankment heights of < 10 m and storage capacities of up to 20 ML;
- Solids or predicted concentrations classified as benign or low-level contamination as defined by EPA.

Small storages dams must be managed to meet the requirements of the guideline titled Management of Small Tailings Storage Facilities, 2006.

Note:

- The definition of the 50 ML of Small Storage Slimes Dams is the total capacity of all slimes dams on site, not each dam;
- The height of the dam wall is set as being the maximum height above natural ground level that theoretically means if the slimes dam is situated in the excavation e.g. the pit, the top of the slimes dams are below natural ground level, potentially allowing the exceedance of the 50 ML constraint. The potential risks associated with these types of facilities and determination of which guideline should be adopted would need to be assessed on a case by case basis;
- An ERR Compliance Officer can overrule any of the above if in their opinion there is a hazard/s and associated risks not being effectively controlled.
- Although requirements for slimes dams are administered by ERR, any discharges outside a quarry site boundary are also subject to the Environment Protection Act 2017, administered by the Environment Protection Authority
- The majority of large storage dams are within the mining sector and accordingly the focus of this Guideline is on Small Storage (Slimes) Dams

Large Storages Slimes Dams are classified as:

- Embankment heights of > 5 m and storage capacities of up to 50 ML or more;
- Embankment heights > 10 m and storage capacities of up to 20 ML or more;
- Embankment heights> 15 m, regardless of storage capacity;
- The combined storage capacity of all storage dams on the site is 50 ML or more;
- The tailings contain, or are predicted to contain, concentrations of contaminants exceeding those levels outlined in Section 6.4* regardless of capacity or size.

** Large storages dams must be managed to meet the requirements of the guideline titled Design and Management of Tailings Storage Facilities, 2017*

9. Slimes Dam Design

Location

The site for a slimes dam should be selected to minimise the potential impact of the facility on people, public infrastructure and the environment.

A key aspect of reducing the risk associated with slimes dam failure is to ensure it is located and designed to have the smallest practicable catchment and to hold the minimum amount of water possible.

Minimal factors that should be considered throughout the design process include:

- Topography including modified landforms, e.g. site excavations;
- Site geology, foundation conditions;
- Hydrogeology, e.g. depth to groundwater, groundwater quality and beneficial use;
- Hydrology, e.g. natural surface water flow and management requirements, the area and nature of the catchment;
- Location of public or private infrastructure and environmental elements which may be impacted by a flood/seepage event from the slimes dam;
- The distance from sensitive receptors including waterways;
- Neighbouring property owners, land and water users;
- Proximity to the Work Authority boundary;
- Adjacent quarry infrastructure;
- Effects of works on downstream flow regimes, including both flooding and dry weather flows;
- Current and final land use including planned rehabilitation outcomes for the site.

The proposed selection of location may need to be supported by a conceptual geotechnical and hydrogeological model as the basis for a comparative opportunity and risk analysis to support the final choice of slimes dam location.

Design Overview

The design of a slimes dam may need to be prepared by a suitably qualified person/s with appropriate qualifications and experience such as a Geotechnical or Civil Engineer.

The objectives for the design of a Slimes Dam include the:

- Safe and stable containment of slimes;
- Safe management of decant water and rainfall runoff;
- Management of seepage;
- Ability to achieve long term effective closure, potential removal and rehabilitation without unacceptable environmental legacy.

The design should take into account the following:

- Be suitable for the proposed use,
- Identification and control of the potential risks associated with:
  - The site
  - Flooding potential, depth to groundwater
  - Critical operational areas and public/private infrastructure
  - The nature of the materials used in the containment structure(s)
  - Water management including decant and rainfall run-off
  - Seepage minimisation and containment
  - Sized to contain wastes (solids & water) as well as rainwater and a minimum one metre freeboard
  - The nature, quantity and treatment of the slimes
  - The construction process
  - Operation of the Slimes Dam
  - Decommissioning and closure
  - Capping materials
  - Rehabilitation process and materials

Design Report

A design report may be required by ERR as part of the work plan approval process.

The design report describes the basis of the design, including the design concept and all design parameters such as geotechnical properties of the slimes and construction materials used to contain the slimes, the meteorological conditions and the key performance criteria required to measure the performance of the slimes dam.

The design report shall list the safety and environmental controls, operating procedures and maintenance programs that need to be implemented for the safe construction, operation rehabilitation and closure of the slimes dam.

Where required the Design Report shall include the following information:

- Assessment of the design against identified risks and outline how this assessment was used to develop the design;
- Outlines the required construction supervision and control;
- Outlines the monitoring and surveillance criteria to be used in operation;
- Outlines the proposed closure and rehabilitation plans.

10. Slimes Dam Construction

The following information relates to dam wall construction generally but is mostly applicable to Small Storage Slimes Dams.

A dam construction report may be required by ERR as part of the approved Work Plan conditions

Materials

During the stripping of overburden suitable material should be sourced and separated for dam wall construction.

Medium Plasticity Index (PI) clays being within the range of PI 15 to 25 are generally regarded as the most suitable material as they are easier to condition and do not shrink or crack as higher PI rated materials under dry conditions.

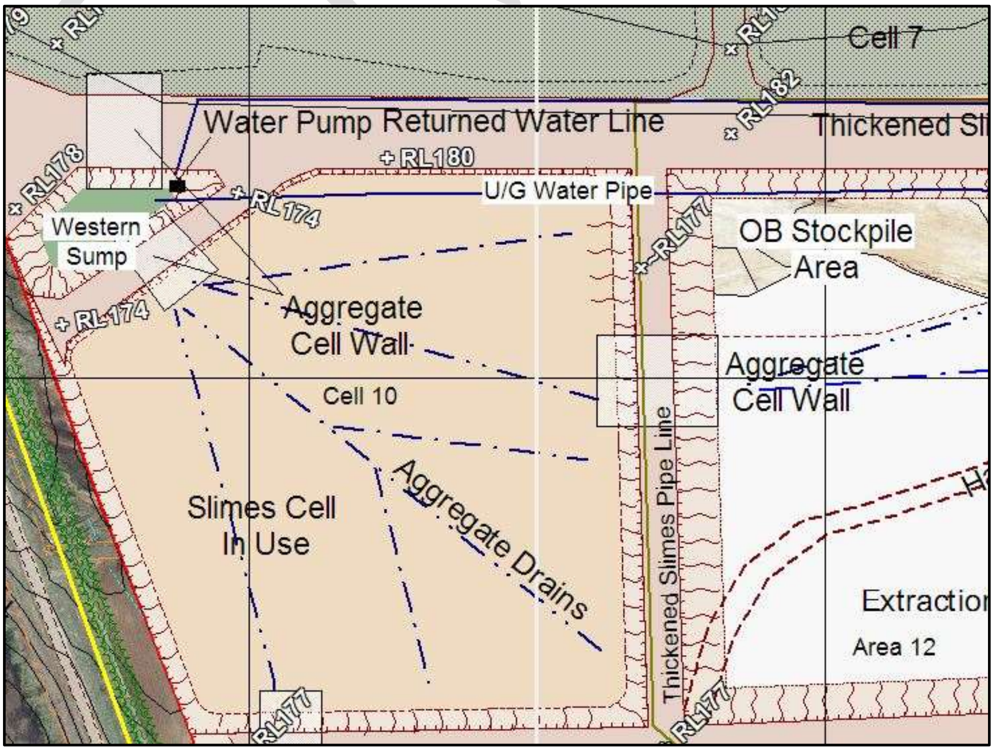
Avoid using granular material and non-plastic clays as these will not compact effectively and create weaknesses in the wall. Avoid high (>25) to very high (>35) PI clays for the core of the wall as these are too hard to condition and place and may experience excessive cracking when drying out.

Location

Where able locate slimes dams inside the excavation, as high as possible taking advantage of terminal faces and gravity to decant/drain excess water. When locating decant points, decant walls, or sumps take advantage of the excavated floor topography.

The floor should be levelled accordingly and shallow aggregate drains (approx. 0.5 m deep lined with wash plant oversize) should be established to avoid localised ponding and to assist in any water migration through the slimes, particularly if establishing a decant section in the dam wall.

If there is room and or available material plan the dam walls as thorough fairs or haul roads which will be beneficial when it is time to cap the dams.



Example of Slimes Dam Plan View

Decantation Wall

Decantation walls are sections of the constructed dam wall that are excavated at strategic locations after the wall has been completed and backfilled with aggregates, typically sourced from the wash plant oversize.

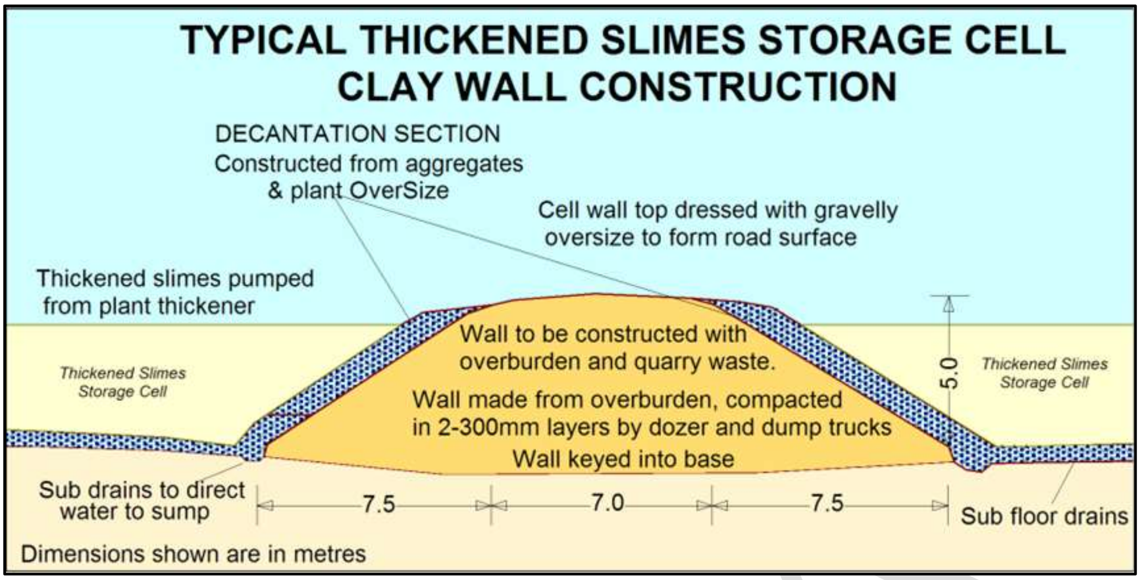
The purpose of these decantation areas is to allow free water liberated from the slimes to migrate through the dam wall and collect in a sump on the downstream side of the wall, where it can be removed, ideally via gravity or if, necessary, a sump pump.

It is imperative that the sump is located so that it will not impact the stability of the upstream dam. A layer of 200-300 mm of wash plant oversize can also be used to line the upstream face of the dam wall to assist in the migration of free water through the dam.

Dam Wall Construction

It is essential for long-term integrity that the foundation of the dam wall is prepared correctly by utilising the techniques and procedures:

- Remove all organic, loose, friable and granular material ensuring clean and solid base;
- Grade or profile the foundation area to be self-draining, i.e. no ponding;
- Check the foundation footprint for soft areas (track roll a few times) and remove soft materials if identified;
- Identify the design footprint width and mark out;
- Cut a trench in the footprint to "*key in*" the dam wall and lightly scour the remaining foundation;
- Inspect the dam wall material and add water if required to achieve close to optimum moisture content;
- Use the "*hand test*" i.e. take a handful of material and squeeze it in your hands; suitable material should be wet enough so that it binds together with no more than slight crumbling when you open your hands, and not so wet that it is at all plastic or slippery;
- Deliver material to the dam wall and spread with dozer in thin (200-300 mm) layers;
- If the wall construction process is to be left idle for several days, or if there is any chance of rain overnight, seal the crest and batters as best as possible to avoid any water ponding, and lightly scour the surface (50 – 100 mm) before construction begins again;
- Continue the operation until the desired wall height is achieved, then profile and "*seal*" the crest and downstream surfaces to avoid water pooling;
- Top dress the dam crest with crushed rock/road gravel and spread soil over downstream batter or otherwise actively encourage grasses to establish to manage erosion.



Note:

Do not use rubber tyred vehicles, e.g. dump trucks, scrapers and wheel loaders to compact the material. Whilst rubber tyred vehicles can achieve compaction, by their very nature they create a smooth surface between layers, exaggerating the laminar construction technique resulting in poor conformity, allowing moisture migration between the layers and potential instability in the dam wall.

Generally, end tipped and pushed material will rill to a natural angle of repose of 1:1.6 -2V, whilst dozer pushed and compacted material in layers up to 300 mm comes in at angle of repose of 1V:2H

Liners

The two general types of liners used to control flow through or seepage from slimes dams are geo-fabric synthetic material or constructed liners made of local clays.

Liners are generally not used beneath slimes dams where there is no risk of impact from seepage into the foundation or contamination of an underlying groundwater resource or impact to a groundwater dependent ecosystem.

In some cases, a liner over part of the slimes dams footprint may be considered to limit seepage, such as against the upstream face of the containment wall or beneath areas of high head or a fixed decant pond. The installation of a synthetic liner can lead to the long-term build-up of excess stored water on the slimes dam which can create challenges during closure and rehabilitation.

In some specific situations a quarry operator, when applying for or amending a Work Authority, may have to prove through a risk assessment process that a liner is not required to control seepage or flow from the slimes dam.

11. Common Failures of Slimes Dams

Common causes of failures of slimes dam are inclusive of:

- Surface erosion from overtopping;
- Internal erosion, i.e. piping or seepage;
- Embankment slumping;
- Embankment erosion or general structural damage through human interference, invasive flora and fauna, planting of trees
- Undercutting or erosion;
- Rotational failure or landslide;
- Lack of control of the water/slimes balance;
- Inadequate design including foundations;
- Inadequate preparation of foundations;
- Inadequate adherence to design;
- Lack of control of construction practices;
- Lack of understanding, inspection and maintenance of the controls that maintain dam integrity.

Overtopping occurs when the dam water around the overflow either grows so large that it reaches and overtops the embankment wall, or the dam water moves away from the overflow due to uneven distribution of the slimes around the dam.

If this happens, the water cannot be decanted and if the problem is not noticed and corrected, the dam water may overtop the embankment wall.

The usual cause of overtopping is holding too much water on the top of the storage, resulting in an insufficient height margin or freeboard to contain water suddenly deposited by a large rainstorm.

Overtopping usually results in the eroding of a breach in the dam outer wall, possibly causing the contents of the storage dam to liquefy and flow out of the breach.

12. Inspections and Audits of Slimes Dams

ERR Audit Program

An ERR audit program of slimes dam management and control identified the following areas for improvement.

- Emergency Response Plans (especially emergency spill response) - areas of potential inundation, environmental impact, response procedures and actions, responsibilities and periodic plan review;
- Dam design and construction records – details of constructed records, major upgrade or earthworks records;
- Spillway and operational procedures for freeboard management – spillway design, maintaining sufficient freeboard for storm events;
- Maintenance of embankment slopes – erosion, vegetation growth;
- Dam inspection procedures and record keeping procedures; and
- Documented evidence of dam inspections and maintenance works.

General Inspections

Once a slimes dam has been constructed and commissioned, regular monitoring including routine visual inspections should be carried out to minimise the risk of the dam failing and to ensure it maintains compliance with its design parameters and other site-specific requirements.

Quarry operators should ensure safe systems of work are established, implemented and maintained for workers who need access to potentially hazardous areas for the purpose of carrying out inspections of slimes dams. The safe systems may be documented in either a Safe Work Procedure (SWP) or a Safe Work Method Statement (SWMS). The worker conducting the inspection must be competent to do so and should have demonstrated their ability to carry out the inspection in compliance with the safe work system.

Inspections should be conducted:

- Before the start of each working shift and at suitable times during the shift;
- Prior to, during and after any significant rainfall or seismic event.

Inspections should be documented, and photographs should be taken to record any observations that must be acted upon. The inspection checklist should include any recommended control actions and details of how they were or are to be addressed or implemented and who is responsible.

If damage or other unusual characteristics are identified, immediate action should be taken to ensure safety of the workplace and the environment and a geotechnical engineer consulted to assist in identifying and establishing suitable controls.

Slimes Dam Inspection Checklist

The following table presents a scope of the inspection activity and is formatted into an inspection checklist.

Refer Attachment A) Slimes Dam Inspection Checklist

The checklist is available in a word document that can be amended to suit your site-specific requirements.

Slimes Dam Scope of General Inspection	
Upstream slope • Protection • Uniformity • Displacements, bulges, depressions, beaching or slumping • Vegetation • Erosion	**Seepage** • Location • Extent of area • Characteristics of area (i.e. soft, boggy, firm) • Quantity and colour • Transported or deposited material • Spring activity or boils • Piping and tunnel erosion
Crest • Cracking • Low spots • Sinkholes • Vegetation • Erosion • Shape • Freeboard	**Outlet** • Changes in vegetation • Outlet pipe and valve condition • Operation • Leakage • Downstream erosion • Gate valve operation, condition and leakage
Downstream slope • Signs of instability and non-uniformity • Erosion • Stock activity • Animal activity • Obscuring/vegetation growth • Wetness • Changes in condition	**Spillway** • Condition of crest, chute and floor protection • Spillway obstructions • Erosion or back cutting in spillway

When conducting a general inspection, the following information should be considered and taken into account.

Upstream and Downstream Slopes

- Be aware that flooding or a rapid reduction of water may cause displacements, bulges, depressions, beaching or slumping;
- Protect the upstream slope from water movement with suitably sized and placed rip rap rock;
- Ensure upstream slope is free from vegetation, particularly deep root vegetation or vegetation that conceals cracks or erosion;
- Monitor (photograph) and control any erosion on the upstream slope, divert course of water causing erosion and ensure effective drainage;
- If required fence area inclusive of upstream slope to protect from livestock;
- Ensure control program for invasive flora and fauna is implemented and effective
- Monitor and where able control potential habitats of native fauna;

Crests

- Monitor (photograph) surface level variations that may indicate abnormal settlement (vertical downward movement) or possibly an underlying void or zone of super-saturation potentially leading to failure of the dam wall structure;
- Monitor free board capacity, e.g. check the vertical distance between the spillway crest level and the top of the dam (crest) at its lowest point to ensure it meets design criteria;

Seepage

Visually identify and assess seepage when the water is at or close to its highest level.

Areas where seepage has occurred or has travelled to, i.e. the lowest area may be either partially damp or saturated depending on the volume of seepage. These areas are often identified through growth of tussock (a small area of grass that is thicker or longer than the grass growing around it) and other grasses or weeds.

Where seepage is potentially hazardous to the structure a geotechnical engineer should be consulted to ascertain whether or not a piezometer/s should be used to detect and monitor the seepage. A piezometer is a device used to measure liquid pressure in a system by measuring the height to which a column of the liquid rises against gravity, or a device which measures the pressure (more precisely, the piezo metric head) of groundwater at a specific point.

Low volumes of consistent seepage are not always hazardous but should be investigated to assess their potential of becoming high levels and hazardous. Low volumes of consistent seepage should still be controlled through effective drainage so as not to create ponding.

If seepage suddenly occurs, stops or significantly increases or decreases an immediate investigation should be undertaken and geo technical advice may be required.

Outlets, Spillways and Dewatering Channels

Outlets or Spillways should be inspected prior to heavy rainfall to ensure rip rap or armour rock is not blocked with weeds or other obstructions that may hinder water flow.

After high rainfall, outlets and spillways should be checked for erosion or washout.

The installation of pipes may be utilised to control erosion where the embankment level has lowered over time and water is overflowing in an uncontrolled manner.

Dewatering channels should be checked for weed growth, edge collapses, silt or other material build-up that may cause blockages. Prior to accessing dewatering channels walls after heavy rainfall workers should carefully inspect the channel to identify undermined edges.

Workers must be aware of the risks associated with clearing blockages (in particular, intake pipes) as a sudden release of water may draw in, engulf or entrap the worker. Intake pit or pipe blockages should be cleared with machinery so that workers remain at a safe distance from the hazard.

Structural Integrity Monitoring

Monitoring systems to measure embankment movement may be required at some sites where the consequences of embankment failures could be significant.

A monitoring system should also be established when routine inspections identify cracking, slumping, seepage etc.

For monitoring of seepage refer to section titled ***General Inspections/Seepage***

Monitoring for structural integrity can include:

- Monitoring pins/markers attached to the embankments;
- Bore hole extensometers;
- Photography;
- Electronic distance meters.

External Inspection and Audit

A more formal, externally conducted and comprehensive inspection and audit should be scheduled at an interval specific to your site requirements and conditions, e.g. the age, structure and general integrity of the slimes dam.

This inspection/audit should be undertaken by a competent person, e.g. a geotechnical engineer and would be inclusive of the following activities:

- A physical inspection of the slimes dam and associated structures to assess the general integrity of these structures and their capacity to be fit for purpose whilst validating the ongoing use of the slimes dam;
- An audit
  - Of the on-site internal inspection process to assess frequency and quality of inspections whilst making suggestions for improvement,
  - To assess compliance with the quarry operator’s work plan and slimes management plan,
  - To assess compliance with regulatory requirements and relevant engineering codes,
  - To confirm that all incidents related to the slimes dams and its structures have been managed as required,
  - To confirm that actions resulting from previous audits have been implemented and reviewed to ensure their effectiveness above.

The inspection/audit will result in a report that comments on the current status of the listed activities, directs immediate recommendations and makes suggestions for improvement.

13. Maintenance of Slimes Dams

A maintenance schedule should be established and implemented for slimes dams and associated infrastructure.

The maintenance schedule should be inclusive of all activity relating to the:

- Slimes dam;
- Decant system;
- Run off pond;
- Pipelines;
- Pumps.

All records related to maintenance work should be kept onsite and made available for periodic audit and review of the slimes dam performance.

14. Water Discharge

Routine and scheduled monitoring of water discharged from the surface of a slimes dam must be undertaken.

Records of the monitoring results should be maintained for the life of the Slimes Dam.

The monitoring results will determine the treatment requirements of the water prior to discharge.

Discharge criteria are generally based on the following:

- Dissolved Oxygen;
- Turbidity;
- Electrical Conductivity (EC);
- Potential Hydrogen (pH).

15. Removing Slimes from Slimes Dams

Removing slimes from slimes dams is usually undertaken using a long reach excavator although alternative methods may include dredges with suction pumps or vacuum pumps or onshore pumping processes.

Quarry operators must ensure safe systems of work are established, implemented and maintained for the excavation or removal of slimes from a slimes dam.

In some circumstances an observer/spotter may be utilised to direct traffic movements, observe the activity and enact an emergency response if required.

The excavator must be fit for purpose and positioned on a hardstand able to carry the weight of the excavator and with a surface are large enough to cater for any potential movements. The hard stand must also be able to carry any required load and haul or service trucks.

Hazardous work practices associated with removing slimes are inclusive of:

- Undercutting the embankment so it is unstable causing the excavators to topple into to slimes dam;
- Working parallel to the bank of the slimes dam so there is no effective escape route if the embankment was to collapse;
- Excavators or other mobile equipment driving onto soft ground that cannot support the weight of the mobile equipment;
- Excavators positioned on uneven ground threatening the stability of the excavator in particular when the bucket is full, and the excavator boom is fully extended.

The general responsibilities of quarry managers and excavator operators as listed below may assist in developing a SWP or a SWMS for this activity.

16. General Responsibilities – Quarry Manager

The quarry manager must ensure that:

- Access onto the slimes dam is prohibited unless the slimes dam has been dewatered capped and stabilised and a geotechnical engineer has conducted compaction and stability tests to ensure the material is capable of supporting the designated mobile equipment;
- A SWMS is established and implemented to identify and direct a safe means of extracting the slimes from the slimes dam;
- The edge/wall of the slimes dam is clearly visible so that the excavator operator knows the boundaries or limits of excavation. Where not visible the use of painted pegs may support this responsibility;
- The edge/wall of the slimes dam is bunded with an edge protection berm so as to prevent inadvertent movement by the excavator into the slimes dam;
- If instability is reported during slimes removal immediate control actions are implemented to protect the environment, workplace and workers; once stabilised/controlled a geotechnical engineer is consulted to provide advice on more permanent controls;
- The excavator intended to be used for slimes excavation is fit for purpose so as the operator is not inclined to over-reach to conduct this activity.

17. General Responsibilities – Excavator Operator

Excavator operators must ensure that:

- The excavator is fitted with a UHF radio that remains turned on to assist in enacting an emergency response;
- That excavator's doors and windows are fully functional and closed at all times during the activity;
- The excavator always operates perpendicular to the edge of the Slimes Dam;
- The excavator is positioned as far away from the edge as possible and maintains a clear and uninhibited escape route directly behind the excavator;
- The excavator is positioned at least 1.5 times the height of the Slimes Dam face/internal wall so as not to overload the edge embankment;
- Only remove slimes as per the working plan and do not excavate the slimes dam structure, e.g. its foundation, wall or any other part of the structure;
- The excavated slimes is not placed anywhere near the crest where it could potentially overload the crest and cause embankment failure;
- The excavated slimes are not placed in a location that may hinder or even block an intended escape route;
- Continually and diligently monitor the crest of the slimes dam and the general embankment for signs of instability including cracking or slumping;
- If instability is suspected or observed the excavator is removed from the area and parked at a safe distance;
- Once safe to do so instability is immediately reported to the quarry manager and the potentially unsafe area is secured.

18. Securing Slimes Dams against Unauthorised Access

Slimes Dams, particularly during warmer weather, form a solid crust on the surface that to the inexperienced eye may be perceived as stable and able to be walked over or crossed over on a bicycle, motor bike, quad bike or other vehicle.

Generally, the crust is only a few centimetres thick and is basically floating on top of a slurry type liquid (being the slimes) which could quickly engulf the person and the equipment being used in the crossover.

Quarry operators should determine the probability of unauthorised persons entering the quarry and being able to access the slimes dam area. Consideration should where practical be given to native fauna being able to access the slimes dam area.

Factors to take into account when determining this probability are inclusive of the following:

- Location of the quarry being either urban, industrial, rural, within forest/bush;
- Neighbouring properties and their populace;
- Activities undertaken in the quarry surrounds such as dirt bike or mountain bike riding, bushwalking;
- Coverage and integrity of boundary fencing;
- Previous trespass incidents;
- Interference with or damage to boundary fencing;
- Any evidence of trespass, e.g. tyre tracks, vandalism, dumped rubbish;
- Any evidence of native fauna movements, paw/pad tracks, excessive grazing, excrement/droppings, general sightings.

Controls inclusive of the following examples should be considered and established to reduce the probability of access to the slimes dams:

- Signage should be placed on any fencing installed, whether boundary or immediate area fencing;
- Boundary fencing signage should warn against trespassing into a hazardous area but not necessarily specific to the slimes dam hazard;
- Immediate area fencing signage should clearly articulate the hazard beyond the fence
- Fencing should be inspected on a regular basis with records of inspection being maintained;
- Any interference with fencing should be immediately repaired and recorded but also reported to the police;
- Ongoing interference may result in the installation of closed-circuit television cameras (CCTV camera) to provide evidence that may result in changes to fencing, security or assist police in their investigations.

19. Decommission and Capping of Slimes Dams

Capping slimes dams has been a long-practiced tradition with many examples in and around the Clayton - Heatherton area of south east Melbourne. A typical end use of a capped slimes dam is open space, i.e. sports fields, parks gardens etc.

With advances in slimes dewatering such as the alternative technology listed in this guideline the need for capping dams into the future will be greatly reduced, although there are still legacy sites where capping of dams will still be required.

When planning the capping of dams, a geotechnical engineer is generally engaged to design a capping system. The capping system would inclusive of testing the ability of the capping material (permeability, PI, conditioning), a study of the dam wall integrity and an investigation of the bearing capacity of the dried slimes.

The following key points in capping slimes dams have been drawn from industry experience.

Prepare the Slimes Dam for Capping.

It is imperative that the dam to be capped is removed from the slimes stream, i.e. it needs to be decommissioned and it needs time to consolidate. Depending upon the resource, the dewatering features built into the slimes dam, weather, rheology of the clays and flocculants (if any) and finally weather shall determine the time to dry and consolidate. This can range from one year, up to 5 – 7 years.

Decommission the Slimes Dam:

- Remove the dam from the slimes stream;
- Maintain adequate free board;
- Actively manage the free water, i.e. continually decant/remove any free water to encourage natural drying either via weirs and gravity or, if necessary, dig a low point and pump out the water;
- When the slimes are at a spadeable consistency, cut a trench around the perimeter to draw out any extra water;
- Continually monitor slimes consistency and free water liberation.

Capping the Slimes Dam

The basic process is to deposit overburden on the dam wall at several locations, then gradually push this material out over the consolidated slimes in an inverted fan shape.

There will be some movement of the slimes and capping material, and some settlement which is expected. Stop when the slimes capping does not support the weight of the dozer. By repeating this process, the slimes are trained to the required location, which might be a natural wall, a previously rehabilitated area, or simply the centre of the dam.

Plant oversize/reject is good capping material because it generally has a high clay content, but also because it is typically supplied at a slow rate, stockpiled then pushed out over the slimes. A common mistake here though is the operator usually concentrates on the closest location, which is not always the best option when trying to train the slimes.

When pushing out the capping, it is common to have a bow wave of thickened slimes in front of the capping. A general principle is to keep the wave no higher than the depth of capping.

When the capping process is left idle for several days or weeks, or if there is a high probability of rain overnight, seal the fresh capping and profile as best as possible to avoid any water ponding.

Generally, once the capping is over 50% completed, the surface can be rehabilitated to its end use, which could be hardstand, stockpile areas, or back to natural vegetation.

There will be some movement, settlement and cracking in the capping. It is important to reprofile, regrade, lightly scour, revegetate, or simply repair any crack or surface undulations to keep the surface free draining. This should be done at least annually or on a required basis.

Notes on Equipment:

- Capping is best done with a small to medium sized dozer, potentially fitted with swamp tracks, which can be advantageous if you want to cap the slimes dam a little earlier;
- When using haul trucks to supply the overburden, prepare a solid level tip site, have a spotter or construct suitably sized edge protection berm, restricting the trucks to a distance 10 metres from the edge;
- Always assume the edge will be unstable.

Safe Work Practices

As there are significant WHS risks associated with capping slimes dams it is imperative that a SWMS is established in consultation with the dozer operator to direct the activity in a safe manner.

The SWMS should focus on all aspects of the capping operations, particularly controls to reduce the risk of the dozer being engulfed and controls to restrict the movement and proximity to the dam of haul trucks.

20. Rehabilitation of Slimes Dams

A key requirement of a work plan is to ensure that slimes dams are appropriately rehabilitated after closure to minimise long term risks to the environment, social impacts, future land use and visual amenity.

Refer to section titled *Regulation Specific to Work Plans* for detail of regulatory requirements for the rehabilitation of slimes dams.

The following extract from "Environmental Guidelines for Management of Small Tailings Storage Facilities October 2006" present an overview of the requirements for the decommissioning and rehabilitation of Slimes Dams.

Extract:

Slimes material must be securely stored for an indefinite period and present no hazard to public health, safety or the environment. Closure and rehabilitation works must be inherently stable as well as resisting degradation. The design should minimise maintenance requirements from commissioning through closure. Plans for closure must be included in the initial Work Plan and appropriate to the nature of the slimes content, final landform plus landowner expectations.

Final landform design must be compatible with the:

1. Surrounding landscape;
2. Form of containment or encapsulation used;
3. Nature of the embankment materials;
4. Needs of the landowner and the community;
5. Any legal requirements;
6. Local climate/topography; and
7. Level of management available after reclamation.

The content of the slimes, the process by which they were deposited and the design for water recovery can significantly influence the costs and risks associated with closure.

Cake used to establish final rehabilitation at Local Mix - Moriac Quarry

21. Emergency Response Procedure

An Emergency Response Procedure (ERP) is required for the operation of a slimes dam.

The ERP should be prepared based on a worst-case scenario relative to the size of the slimes dam, the nature of its contents and its surrounding environment.

The ERP shall be inclusive of the following content:

- Emergency response contacts;
- Structural failure;
- Earthquake (where applicable based on location and probability);
- High rainfall or storm event;
- Pipeline failure.

The ERP should be kept in a prominent location, known and accessible to all quarry management, workers and emergency services personnel as applicable.

Quarry management shall ensure as far as is reasonably practicable that they are aware of potential emergencies by regularly reviewing weather forecasts and ensuring the slimes dam inspection regime is conducted as scheduled.

Quarry management and workers shall have a comprehensive understanding of how to implement the ERP as and when required.

A copy of the ERP should be forward to each of the emergency services agencies likely to attend the site.

Refer attachment B) Emergency Response Procedure Template

22. Trigger Action Response Plan (TARP)

A TARP is a tool used to monitor and direct the control or risk associated with specific physical hazards on a quarry site. The purpose of a TARP is to focus on risk prevention and control through early detection and intervention

TARPs list the normal operational conditions associated with the hazard (in this case, a slimes dam) as well as the triggers that signal that the risk arising from the hazard may potentially escalate (due to a specific event) if actions to control that risk are not taken.

A TARP must be established and implemented to ensure the ongoing safe operation of a slimes dam.

The TARP shall detail what actions and responses are required based on 3 trigger levels being:

- Level 1 - Normal Event;
- Level 2 - Medium Risk Event;
- Level 3 - High Risk Event.

The first step when establishing a TARP is to define what is the normal, safe and stable operational condition.

The second step is to identify what potential events such as high rainfall or wall/pump failure may cause an event/s that risks those operational conditions.

These events are then classified as either medium or high-level risk events and shall trigger an action to control that risk. The response is the result of that action.

To ensure a timely response can be taken at each trigger level previously undertaken preparatory work may be required to enable immediate implementation of the TARP.

The roles and responsibilities of those who are to implement the TARP should be documented, either in the TARP itself or through the site's general responsibility statements or individual manager/worker position descriptions or work instructions.

Designated managers or workers to who are responsible for implementing the TARP should be provided with adequate training and resources.

Where medium to high risk weather events are forecasted quarry management should ensure designated workers are available to initiate the TARP whether in or outside of normal working hours.

After any event where the TARP is implemented, a review of the implementation and its effectiveness in controlling the risk should be undertaken and documented.

Refer Attachment C) Trigger Action Response Plan (TARP) Template

23. Reporting of Incidents and Events

Reportable events are events which occur at a site and result in, or have the potential to result in, significant impacts to public safety, the environment, public infrastructure or assets external to the site.

They encompass actual or potential risks to the safe and stable conditions within, or external to, the site.

For sites with a slimes dam event or incidents requiring reporting include but are not limited to:

- Uncontrolled release of slimes or slimes dam water;
- Seepage causing discernible impact on vegetation, soil contamination, groundwater levels;
- Defects in the structure of the slimes dam e.g. cracking, slumping or significant erosion of the wall, faults in the decant system;
- Exceeding the monitoring trigger levels related to surface water or groundwater quality;
- Injury or death of native fauna on or near the slimes dam.

For further information refer to the Mineral Resources (Sustainable Development) (Extractive Industries) Regulations 2019 Part 4— Regulation 20 Information relating to Reportable Events at Quarries.

EPA notification may also be required where there is a potential or actual impact on the community or the environment.

24. Risk Management

Slimes dams can potentially without effective control have negative impacts on the environment, e.g. the failure of a dam wall or any other inadvertent release of slimes may result in damage to waterways or loss of flora and fauna.

In some circumstances, ERR may require a formal risk assessment process for either a proposed or pre-existing slimes dam.

MRSDA states that quarry operators should use a risk management approach in the development of their work plans. Work plans should demonstrate that risks associated with the operation of a slimes dam have been eliminated or reduced as far as is reasonably practicable through design, ongoing inspection and maintenance as required.

Further information on the risk assessment process is provided in "Preparation of Work Plans and Work Plan Variations, Guideline for Extractive Industry Projects, December 2018".

25. Units of Competency - Slimes Dams

Training.gov.au is the National Register on Vocational Education and Training (VET) in Australia. Training.gov.au is the authoritative source of:

- Nationally Recognised Training (NRT) which consists of:
  - Training Packages;
  - Qualifications;
  - Units of competency;
  - Accredited courses;
  - Skill sets.
- Registered Training Organisations (RTOs) who have the approved scope to deliver Nationally Recognised Training, as required by national and jurisdictional legislation within Australia.

The units of Competency pertaining to slimes dams are as follows:

- RIIWBP202D - Distribute tailings
- RIIWBP203D - Monitor tailings dam environment
- RIIWBP401D - Apply and monitor site waste and by-products management plan
- RIIWBP501D - Implement site waste and by-product management plan
- RIIWBP601D - Establish and maintain waste and by-product management system

Attachments

Attachment A) Slimes Dam Inspection Checklist

Inspected By	**Dam ID**
Date:	**Location**

	Items to inspect/address	**Observations/change from last inspection**
Upstream slope	Protection	
	Uniformity	
	Displacements, bulges, depressions, beaching or slumping	
	Vegetation	
	Erosion	
Crest	Cracking	
	Low spots	
	Sinkholes	
	Vegetation	
	Erosion	
	Shape	
Downstream slope	Signs of instability and non-uniformity	
	Erosion	
	Stock activity	
	Animal activity	
	Obscuring/vegetation growth	
	Wetness	
	Changes in condition	

	Items to inspect/address	Observations/change from last inspection
Seepage	Location	
	Extent of area	
	Characteristics of area (i.e. soft, boggy, firm)	
	Quantity and colour	
	Transported or deposited material	
	Spring activity or boils	
	Piping and tunnel erosion	
Outlet	Changes in vegetation	
	Outlet pipe and valve condition	
	Operation	
	Leakage	
	Downstream erosion	
	Gate valve operation, condition and leakage	
	Changes in vegetation	
Spillway	Condition of crest, chute and floor protection	
	Spillway obstructions	
	Erosion or back cutting in spillway	
Open Drains	Erosion or back cutting	
	Weed infestation	
	Blockages and or build-up of slimes	

	Items to inspect/address	Observations/change from last inspection
Pipelines	Leaks Integrity of bend, elbows and joints	
Other		

Photo	Actions and Notes

Photo	Actions and Notes

Photo	Actions and Notes

Photo	Actions and Notes

Photo	Actions and Notes

Photo	Actions and Notes

Slimes Dam Event

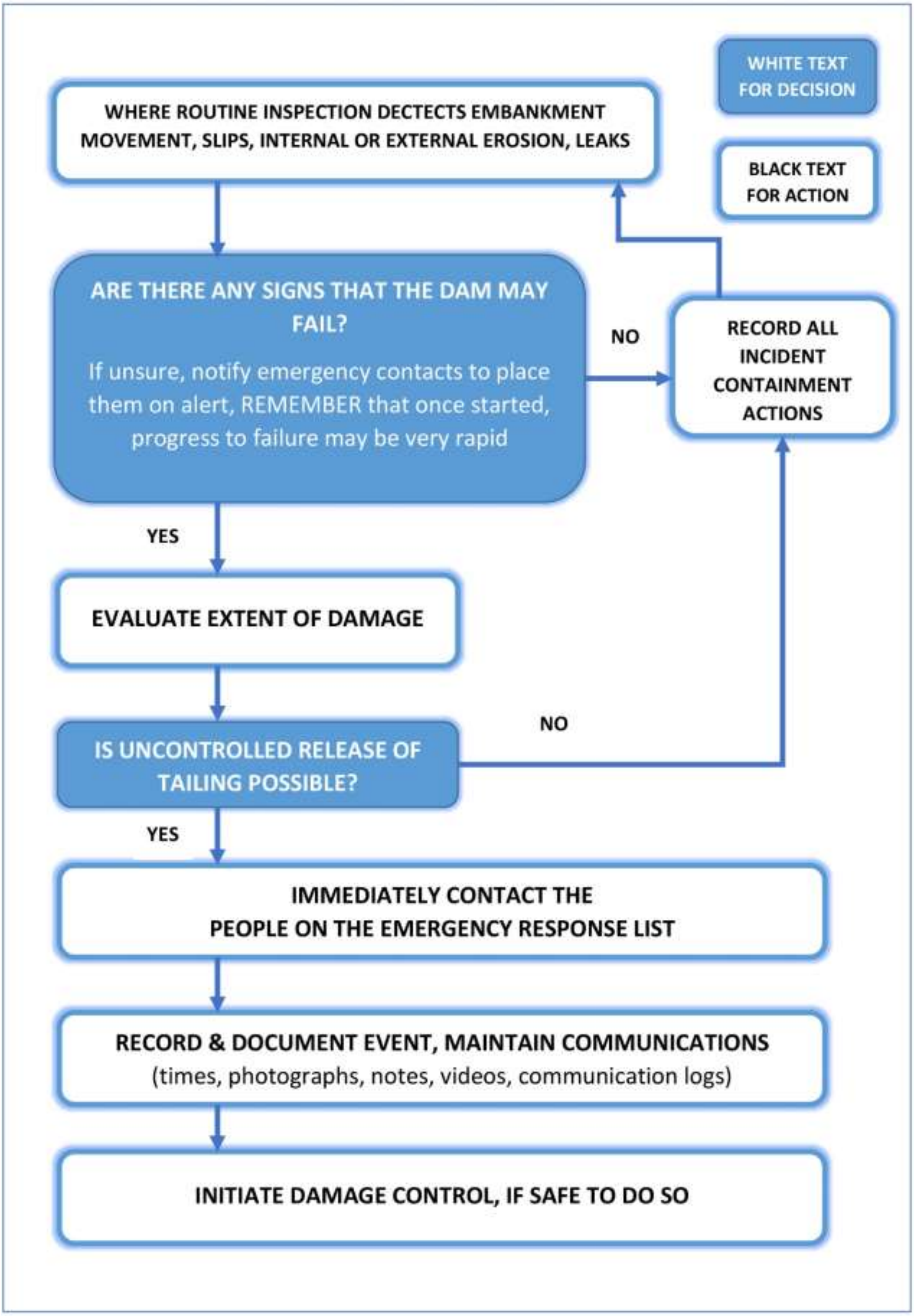
Emergency Response Contacts Listing

Site Details	
Quarry Name	
Managers Name	
Work Authority Number	
Site Address	

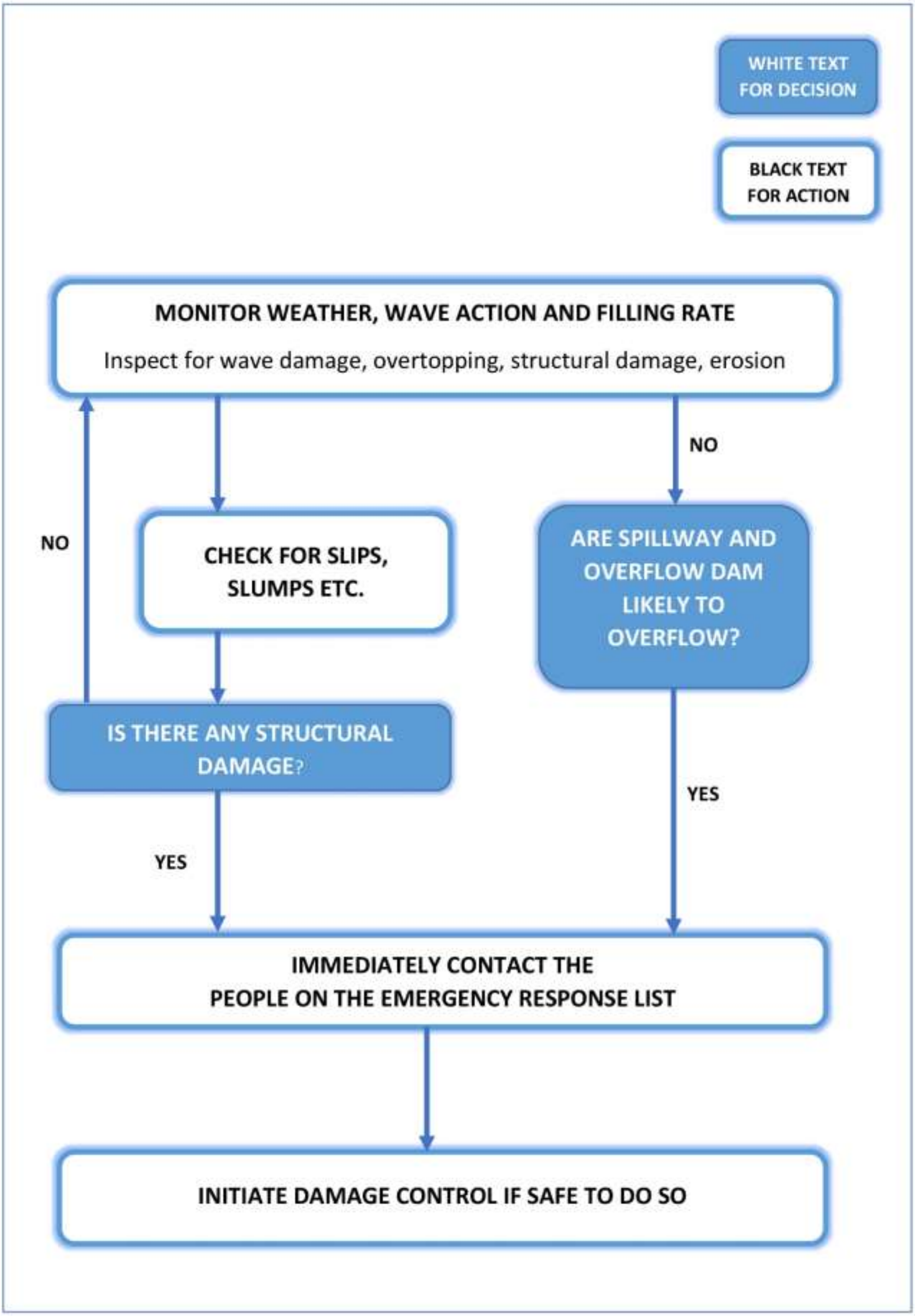
Contact	Phone Numbers
Police	
State Emergency Service	
Country Fire Authority	
ERR / DEDJTR	
Council / Shire	
Bureau of Meteorology	
Water Authority	
Electrical Authority	
Other	

Sensitive Receptors	
Name	**Phone Number**

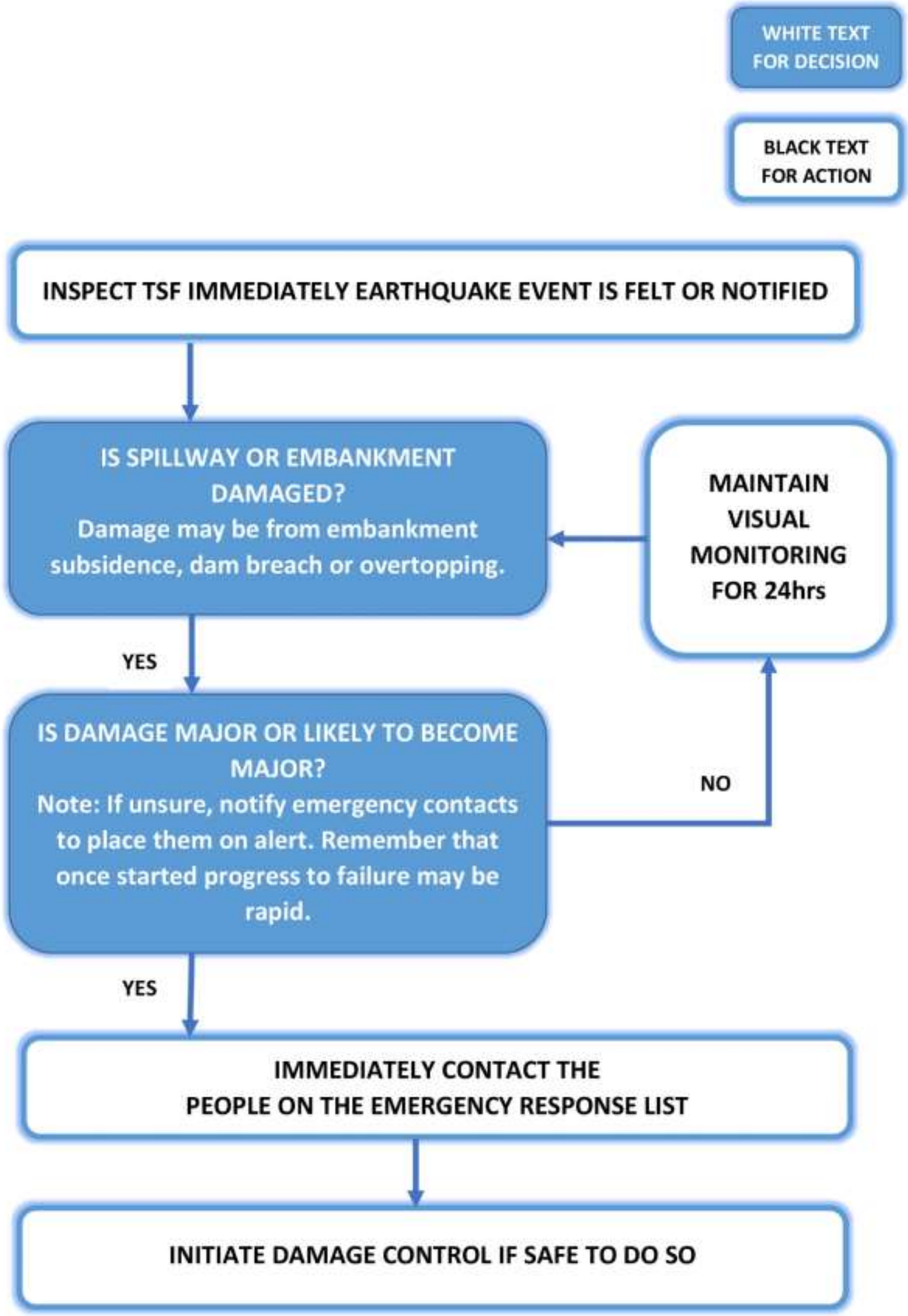
STRUCTURAL FAILURE



HIGH RAINFALL OR STORM EVENT

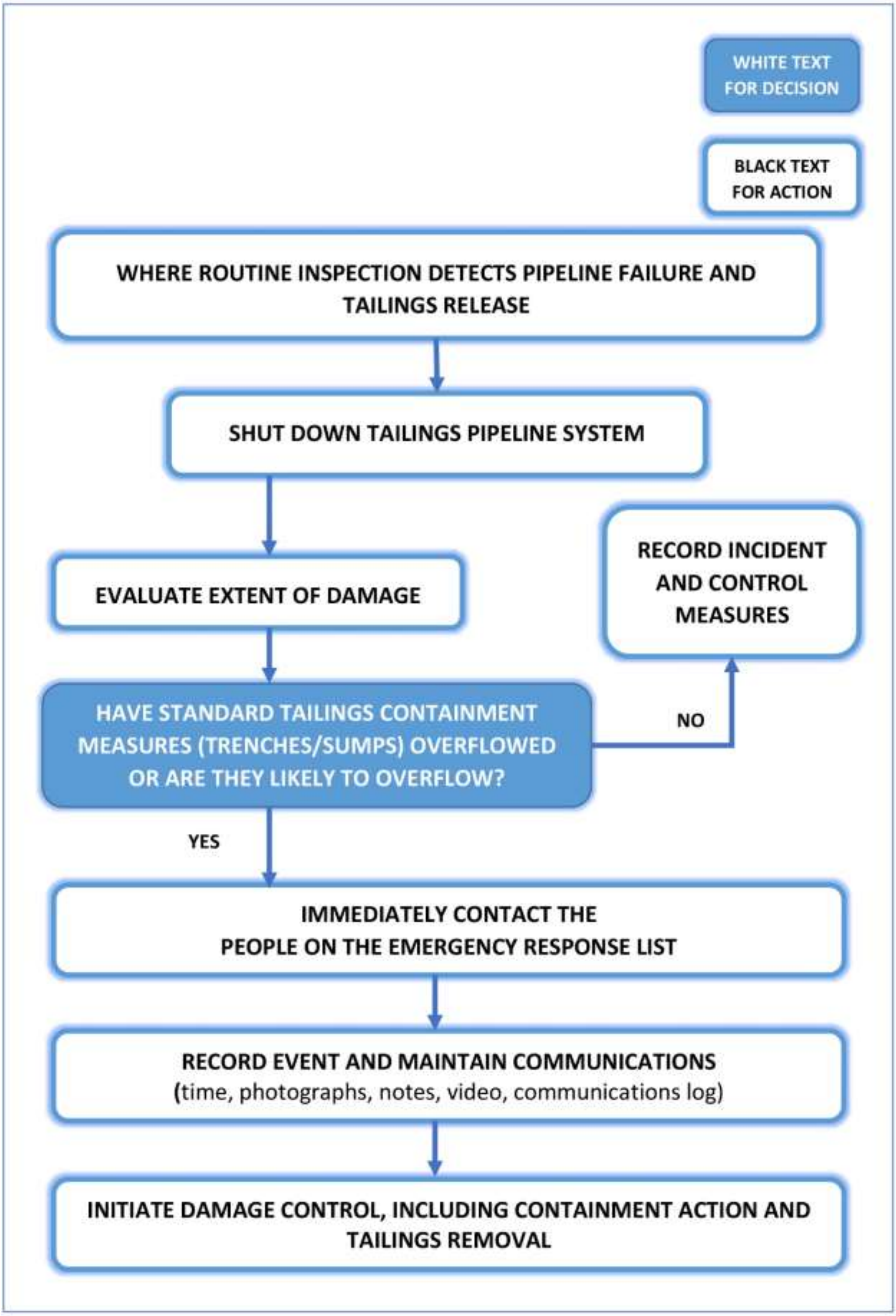


EARTHQUAKE EVENT



Note: If the initial inspection was at night follow-up inspections should be carried out in daylight.

PIPELINE FAILURE



Attachment C) Trigger Action Response Plan (TARP) Template

Quarry Name	Slimes Dam (Name or ID)	TARP Issue Date

Level 1 **Normal Event**	**Trigger**	**Action**	**Response**
	List details of conditions normally expected. *e.g. Dam water level minimum 1 metre below spillway invert*	List actions under normal conditions. *e.g. Daily observations*	List response to monitoring result *e.g. Water level at greater than 1metre – continue current operation*
Level 2 **Medium Risk Event**	**Trigger**	**Action**	**Response**
	List details of conditions that require additional monitoring and action to return to normal conditions. *e.g. Dam water level 0.75 to 1 metre below spillway invert.*	List actions to return to normal conditions. *e.g. Increase monitoring of dam and inflows/outflows.* *Cease inflows or increase outflows.*	List expected monitoring results/outcomes of actions. *e.g. Dam water level returned to 1 metre minimum within XXX timeframe.*
Level 3 **High Risk Event**	**Trigger**	**Action**	**Response**
	List details of conditions that require immediate action and may result in an emergency response. *e.g. Dam water level lees than 0.5 m from spillway invert.*	List actions to return to normal conditions. *e.g. Increase monitoring of dams and inflows/outlaws.* *Cease inflows and increase outflows. Enact Emergency Response Procedure.*	List expected monitoring results/outcomes of actions. *e.g. Dam water level returned to 1 m minimum within XXX timeframe.*

Authorised By	TARP Reviewer	Review Date

Attachment D) Example Risk Assessment Table Slimes Dam

Attachment E) Slime Management Plan (SMP) Template

Attached as separate files