# Tailings Dams: When We Start Worrying

Clara Balasko, MSc, PE

Dave Bentel

SME Society for Mining, Metallurgy & Exploration

srk consulting

# Operational Monitoring

- Why operational monitoring is important
  - Indication that this is an issue before incident occurs
- What to monitor
  - Embankments and berms
  - Decant structures
  - Tailings deposition systems
  - Piezometers
  - Downstream sediment control
- What can happen when operational monitoring is not perform or if the results are ignored

# Key to Safety: Operational Monitoring

- More than 2 Major Failures per year with fatalities
- Typically more than one negative condition contributes to failures
- Water is the key element in the majority of failures
- Free Water amplifies extent of damage
- Tailings dams safety relies on proper operation of the facility

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# What to Monitor

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Downstream Sediment Control

# Embankments and Berms

In order to:

- Prevent unnecessary formation of cracks and holes
- Provide indication of degree of consolidation of outer walls
- Prevent outer wall overtopping
- Ensure compliance with legal freeboard requirements
- Prevent outer wall erosion from leaks in piping

# Embankments and Berms

- Monitoring Activities
  - Embankment drainage

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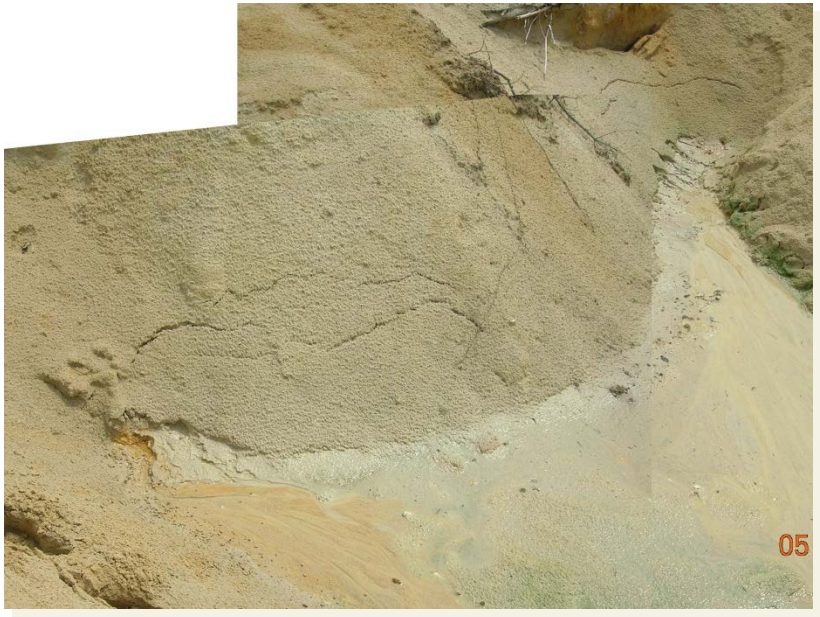
  - Moisture conditions



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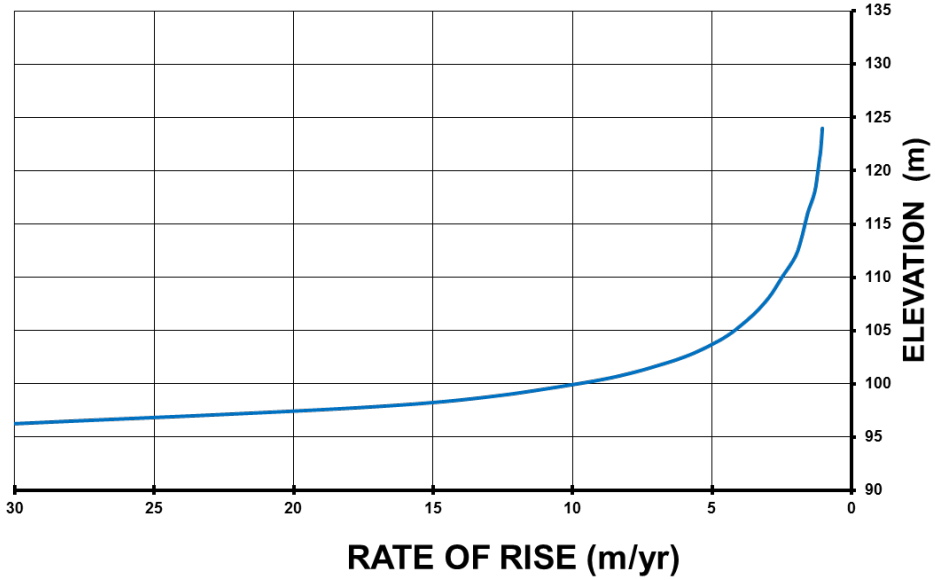
# Embankments and Berms

- Monitoring Activities
  - Embankment drainage
  - Moisture conditions
  - Slope geometry
  - Vertical freeboard
  - Quality of embankment
  - Rate of rise
  - Tailings deposition program



# Piezometers

- In order to
  - Provide early warning of significant increases in phreatic surface elevation and potential stability problems
  - Evaluate remedial measure to improve stability
- Monitoring Activities
  - Evaluation of variation in piezometer elevation
  - Sufficient operable monitoring locations

# What to Monitor

# Decant Structures

In order to:

- Ensure safe operating procedures
- Eliminate unnecessary storage of water on dam surface
- Determine pool control effectiveness
- Ensure decant operating per design
- Determine required to decant stormwater

# Decant Structures

- Monitoring Activities
  - Pool control
  - Decant discharge

Condición de Agua Alta

Condición de Agua Baja

# Decant Structures

- Actividades de Monitoreo
  - Pool control
  - Decant discharge
  - Sinkhole development

# Decant Structures

- Monitoring Activities
  - Pool control
  - Decant discharge
  - Sinkhole development
  - Access safety
  - Quality of decant structure

# What to Monitor

# Tailings Delivery System

- In order to
  - Eliminate unequal distribution of tailings
  - Determine future deposition point requirements
  - Determine deposition extension requirements
  - Determine maintenance requirements
  - Prevent of unnecessary spillage from burst pipes and valves

# Tailings Delivery System

- Monitoring Activities
  - Operation and control of deposition points
  - Beaching characteristics from deposition point
  - Condition of deposition piping
  - Effectiveness of deposition system with respect to embankments and pool control

# What to Monitor

Downstream Sediment Control

# Downstream Sediment Control

- In order to
  - Warn of required wall raising or sediment removal
  - Prevent unnecessary build-up of moisture at dam toe
  - Detect of potential stability problems

# Downstream Sediment Control

- Monitoring Activities
  - Available capacity
  - Efficient drainage
  - Degree of saturation

# Control Operativo

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# Free State Saaiplaas (1993)

- No overtopping
- Higher rate-of-rise than design lead to higher phreatic surface
- Insufficient piezometers to monitor

# Merriespruit (1994)

- Poor pool control (i.e. supernatant water not at the decant) due to single point deposition

# Fundão Dam (2015)

- Liquefaction of the sand embankment because of insufficient drainage
- Two year period of pool encroachment on the embankment
- High rate-of-rise

Funão Tailings Dam Review Panel (2016), Google Earth, July 2016