GOLDER

# Copper Flat Mine Discharge Permit 1840

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EXHIBIT
88

# Copper Flat Mine Tailing Storage Facility (TSF) Design

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## Background and Experience

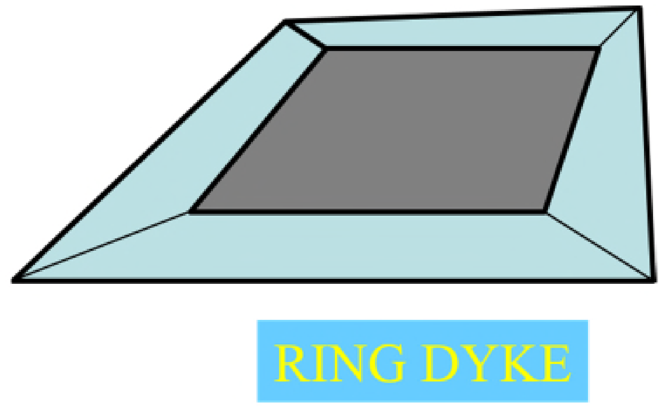
- Role on Project (Project Director/Engineer of Record on TSF Design)
- Educational Background
  - BS Civil Engineering – University of Arizona
  - MS Civil Engineering, Geotechnical emphasis – University of Arizona
- Relevant Experience
  - MSHA certified TSF inspector for Amax Coal 1980 to 1985
  - TSF and other mine waste design and construction experience continuously since 1989
  - Has worked on over 30 TSF designs since 1989
  - Questa Mine, New Mexico - Engineer of Record of TSF since 2003
  - Chino

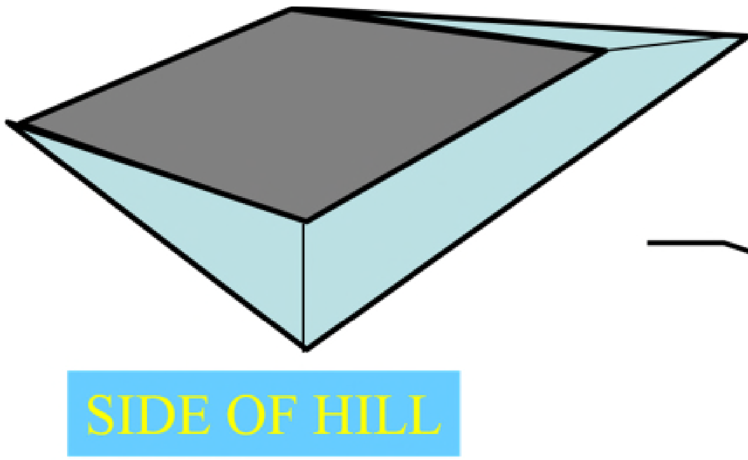
# TSFs – The Basics

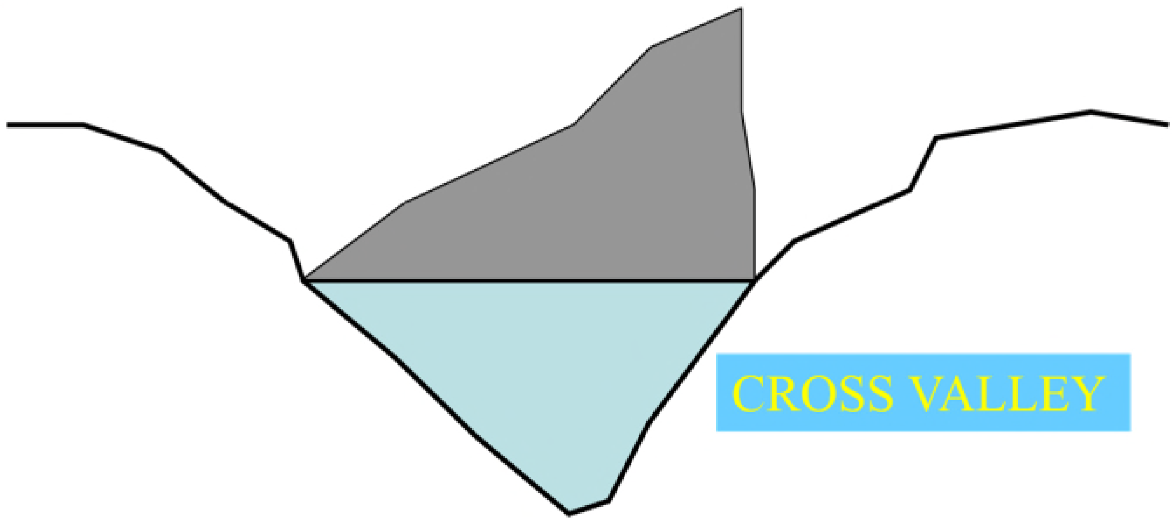
- Tailings – finely crushed and ground rock residue and associated fluids discharged from an ore milling, flotation beneficiation and concentrating process
- Tailings Storage Facility (TSF) – The collective engineered structures, components, and equipment involved in the management of tailing solids, other mine waste (if applicable), and any water managed in the tailing facility including pore fluid and ponds. The design is site, material, and consistency specific and must conform to governing regulations and industry practiced standards

# TSFs – The Basics (cont.)

Common Types of TSF



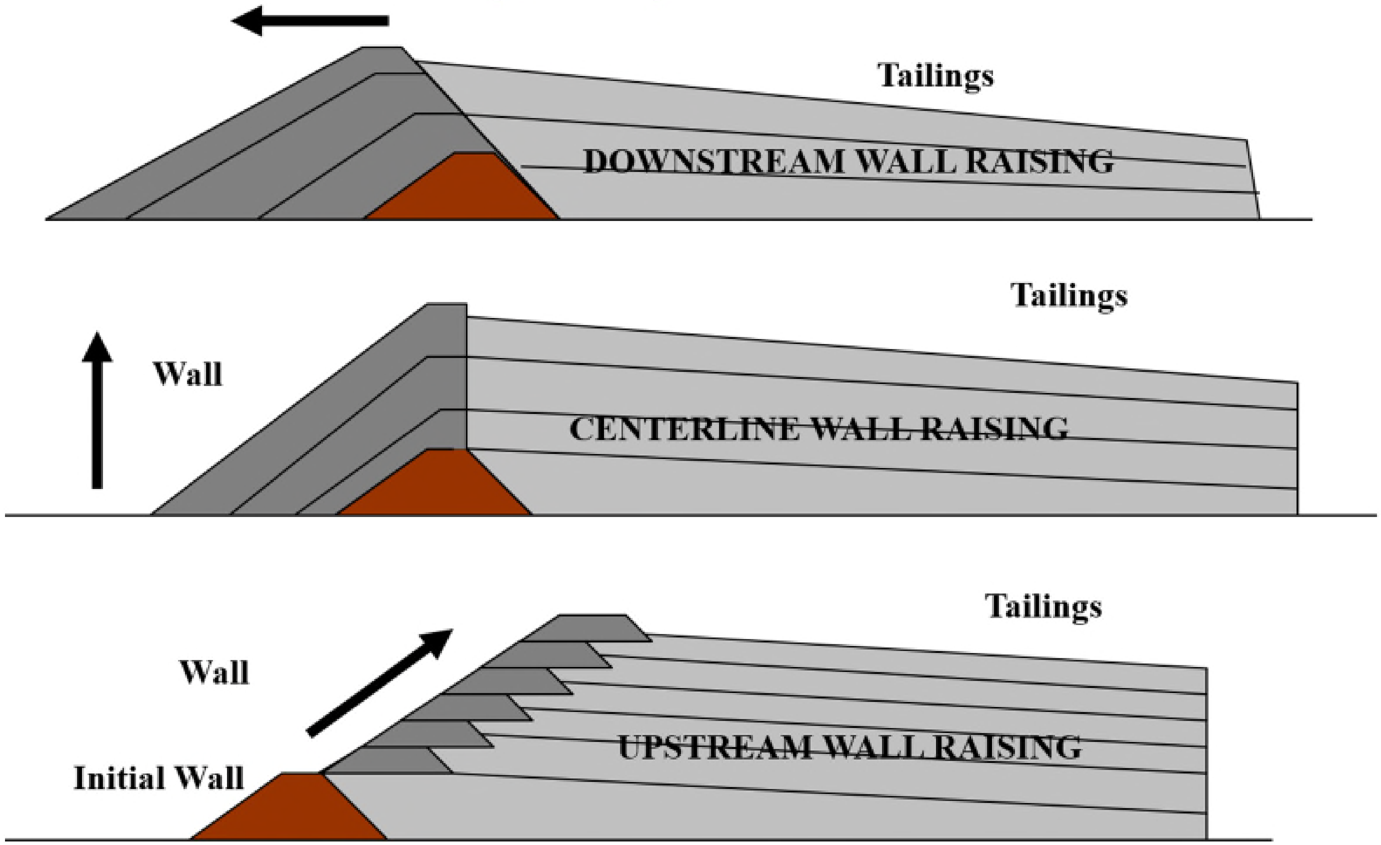
# TSFs – The Basics (cont.)

- Typical consistencies of tailings:
  - Slurry – typically 30 to 50% solids by mass (other is water)
  - Thickened – typically more than 50% solids by mass and exhibits yield stress (Rheology is the measure of the resistance of a fluid to movement, low solids content behave more like water, high solids content behave more like toothpaste and have a high resistance to flow)
  - Filtered – typically 80% or more solids by mass and requires significant equipment and power to dewater to this level. Behaves more like a very moist sand that you buy at a construction materials yard

# TSFs – The Basics (cont.)

- Unlike water dams, tailing embankments are typically raised throughout the operating life and have been designed to provide adequate capacity for the planned mill operation, supernatant (on top) water pool, temporary storage for the design storm event, and freeboard.
- Embankment raises can be configured as:
  - Downstream
  - Centerline
  - Upstream

# TSFs – The Basics (cont.)



# Copper Mine Rule, 20.6.7 NMAC – Tailing Storage Facility

- 20.6.7.17 General Engineering and Surveying Requirements
  - A. Practice of Engineering. All plans, designs, drawings, reports and specifications required by the copper mine rule require that the practice of engineering shall bear the seal and signature of a licensed New Mexico professional engineer (NMPE)
  - C. Design plans, specifications, and construction quality assurance/construction quality control (CQA/CQC) must be submitted, all signed and sealed by a NMPE
  - New Mexico Office of the State Engineer - Dam Safety Bureau (NMOSE-DSB). Applicant must submit documentation of compliance with the requirements of the DSB (Section 72-5-32 NMSA 1978).

## Copper Mine Rule, 20.6.7 NMAC – TSF (cont.)

- 20.6.7.22 Requirements for Copper Crushing, Milling, Concentrator, Smelting, and Tailing Impoundment Units:
  - (4). New Tailings Impoundments
    - (a) Stormwater run-on shall be diverted…..
    - (b) Seepage from the sides of a TSF shall be captured and contained by headwalls, etc
    - (c) Ground water impacted by the TSF in excess of applicable standards shall be captured and contained
    - (d) Applicant shall submit design plans signed and sealed by NMPE along with design report
    - (e) Department may require additional controls (e.g., environmental)

## NMOSE-Dam Safety Bureau, 19.25.12 NMAC

- Applies to all jurisdictional dams (25 ft, 15 ac-ft or 6 ft, 50 ac-ft) in NM, not just TSFs
- Dam Size Classification
  - Small – 25 to 40 ft embankment height, 50 to 1000 ac-ft
  - Medium – 40 to 100 ft embankment height, 1000 to 50,000 ac-ft
  - Large - > 100 ft embankment height, > 50,000 ac-ft

## NMOSE-Dam Safety Bureau, 19.25.12 NMAC (cont.)

- Hazard Potential Classification
  - Low – failure or misoperation results in no probable loss of life and low economic or environmental losses. Principally limited to dam owner's property
  - Significant – failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Often located in predominately rural or agricultural areas but could be in populated areas with significant infrastructure.
  - High – failure or misoperation will probably cause loss of human life.

## NMOSE-Dam Safety Bureau, 19.25.12 NMAC (cont.)

- Slope Stability Analysis (minimum factor of safety)
  - 1.5 for steady state long-term stability
  - 1.5 for operational drawdown conditions (water impounded at dam)
  - 1.3 for rapid drawdown conditions (water impounded at dam)
  - 1.3 for end of construction
- Seismic Design (high or significant hazard potential)
  - Seismological investigation to determine and justify appropriate seismic parameter to be used for design.

## NMOSE-Dam Safety Bureau, 19.25.12 NMAC (cont.)

- Seismic Design (cont.)
  - Dam and appurtenant structures capable of withstanding the operating basis earthquake (OBE) with little or no damage and without interruption of function. OBE has 50% probability of exceedance during service life but in no case can service life be less than 100 years.
  - High hazard designed for maximum credible earthquake or 1% probability of exceedance in 50 years (approx. 5,000 year return period)
  - Significant hazard designed for maximum credible earthquake or 2% probability of exceedance in 50 years (approx. 2,500 year return period)

# NMOSE-Dam Safety Bureau, 19.25.12 NMAC (cont.)

- Dam Geometry primary factors
  - Crest width at least equal to dam height in ft. divided by 5 plus 8 ft, or 10 ft min and 24 ft max
  - Longitudinal profile shall provide adequate camber based on settlement analysis (tailing embankments are continuously raised so less sensitive to settlement)
- Freeboard
  - Wave run-up from 100 mph wind with reservoir at spillway will not overtop dam
  - Wave run-up from 50 mph wind with maximum reservoir level from routed spillway design flood will not overtop dam
  - Minimum of 3 ft of freeboard remains after seismic event
  - At least 4 ft shall be provided

# NMOSE-Dam Safety Bureau, 19.25.12 NMAC (cont.)

- Dam design must include and Instrumentation Plan, Operation and Maintenance Manual, and Emergency Action Plan.
- NMOSE-DSB may perform inspections at any time during construction and operation.

# NMCC TSF Feasibility Design Basis

- 112 million tons (dry) of tailing storage
- 30,000 (nominal) tons per day
- Stormwater potential run-on diverted around TSF
- Site characterized with 82 test-pits and 75 boreholes (Golder & SHB)
- Liner system under entire TSF footprint as interceptor system (bottom to top)
  - Prepared subgrade
  - 12-inch thick liner bedding
  - 80 mil thick HDPE geomembrane liner
  - Granular drainage layer with drainage pipe network to reduce hydraulic head on liner

# NMCC TSF Feasibility Design Basis (cont.)

- Earthen starter dam built to elevation 5,250 prior to tailing deposition
  - 2.5H:1V inboard slope, 2.0H:1V outboard slope
- Continuous embankment raises using compacted cycloned sand in the centerline construction configuration
  - 3.0H:1V outboard slope
- Whole tailing and cyclone overflow deposited inboard of embankments
- Significant Hazard Potential Classification (NMOSE-DSB) due to earlier (1980s) determination and environmental risks associated with release.
- Maintain freeboard for wave run-up and 72-hour PMP (26 inches)

## NMCC TSF Feasibility Design Basis (cont.)

- Water reclaimed from supernatant water pool and underdrain collection pond for reuse in mill
- Underdrain collection pond will use two layers of geomembrane liner separated with a leak collection and recovery system (LCRS).

## NMCC TSF Feasibility Design Basis (cont.)

- Slope stability factor of safety calculations meet or exceed NMOSE-DSB requirements
- Residual strength analyses indicate embankment will remain stable if liquefaction or saturation upstream of dam occurs
- Sensitivity analysis performed using seismic loading indicate that interface shear strength values are within normally acceptable ranges to maintain embankment stability

## NMCC TSF NMOSE-DSB Design Requirements

- Dam Application Form
- Detailed Cost Estimate
- Submit Filing and Plan Review Fees
- Water Rights – Letter from OSE Water Rights District Office
- Engineering Design Report that includes:
  - Hazard Potential Classification (supporting analysis)
  - Hydrologic Analysis
  - Spillway Design (for closure)
  - Outlet Works Design

# NMCC TSF NMOSE-DSB Design (cont.)

- Engineering Design Report that includes (cont.):
  - Geological Assessment
  - Geotechnical Investigation
  - Seepage Analysis
  - Stability Analysis
  - Seismic Analysis
  - Dam Geometry
  - Erosion Protection
  - Structural Design
  - Utility Placement/Relocation

## NMCC TSF NMOSE-DSB Design (cont.)

- Construction Drawings
  - Title Sheet
  - Vicinity Map
  - Site Topography (NAVD 88)
  - Dam Plan/Profile Sheets
  - Cross-Sections/Details of Dam, Spillway, Outlet Works, etc.
  - Construction Detail of Permanent Bench Mark
- Technical Specifications
- Plat of Survey

# NMCC TSF NMOSE-DSB Design (cont.)

- Dam Site Security Plan
- Instrumentation Plan
  - Description of Monitoring Instrumentation
  - Installation Description
  - Calibration/Maintenance Manual
  - Instrument Reading Schedule/Data Interpretation

# NMCC TSF NMOSE-DSB Design (cont.)

- Operation and Maintenance Manual
  - Description of Instrumentation
  - Operating Instructions
  - Inspection Requirements
  - Maintenance Requirements
- Emergency Action Plan
  - EAP Breach Analysis and Flood Report
  - Emergency Action Plan Document

# Response to TSF Review Comments

- "No NMOSE-DSB Permit"
  - Work is in progress and must be completed for permit approval
- "TSF designed for 100-yr event and anything larger would cause failure"
  - The TSF is currently designed to store the 72-hour PMP (26 inches) which is in excess of the 100-year, 24-hour event (3.73 inches)
- "DP fails to include estimate of seepage from the TSF"
  - JSAI performed a liner leakage calculation for the TSF and incorporated that information into seepage estimates

## Response to TSF Review Comments (cont.)

- "Tailing run-off collected in unlined ditches could seep into groundwater"
  - All precipitation that falls upgradient of the TSF will either be diverted before contact with tailing or directed into the TSF for use. Precipitation in contact with the TSF outslopes will be collected on the lined surface and directed to the underdrain collection pond.
- "Geological assessment including seismic design does not meet standard of care based on industry guidance therefore NMCC should use 1-in-10,000 year return period maximum credible earthquake"

# Response to TSF Review Comments (cont.)

- Our feasibility level seismic work has been done in accordance with NMOSE-DSB criteria for a dam with a significant hazard rating (1 in 2,500 yr return period). If during advanced engineering it is determined that the hazard rating is high, then the 1 in 5,000 yr return period will be used in the design.
- Seismic criteria for other jurisdictions:
  - Arizona – *Judgement should be used to establish the actual design earthquake ranging between the MPE and the MCE. MPE is the largest earthquake with a 100 yr return period and MCE is largest possible of occurring under presently known tectonic framework.*
  - Canadian Dam Safety Guidelines to Mining Dams *2014 -*

# Response to TSF Review Comments (cont.)

- Canadian Dam Safety Guidelines to Mining Dams *2014* –

| Dam Classification | Annual Exceedance Probability – Earthquakes (note 1) |
|---|---|
| Low | 1/100 AEP |
| Significant | Between 1/100 and 1/1,000 |
| High | 1/2,475 (note 2) |
| Very High | 1/2 Between 1/2,475 (note 2) and 1/10,000 or MCE (note 3) |
| Extreme | 1/10,000 or MCE (note 3) |

**Notes:**

Acronyms: MCE, Maximum Credible Earthquake; AEP, annual exceedance probability

1. Mean values of the estimated range in AEP levels for earthquakes should be used. The earthquake(s) with the AEP as defined above is(are) then input as the contributory earthquake(s) to develop the Earthquake Design Ground Motion (EDGM) parameters as described in Section 6.5 of the *Dam Safety Guidelines* (CDA 2013).
2. This level has been selected for consistency with seismic design levels given in the National Building Code of Canada.
3. MCE has no associated AEP.

## Summary and Conclusions

- NMCC is working with NMOSE-DSB and in the process of preparing TSF design and permitting submittals in accordance with the Rules and Regulations Governing Dam Design, Construction, and Dam Safety as outlined above
- TSF design meets or exceeds requirements in the Copper Rule and is designed to provide optimal environmental protection