TAILINGS AND MINE WASTE 2026

CIVIL AND ENVIRONMENTAL ENGINEERING
COLORADO STATE UNIVERSITY

SHORT COURSE

TRIGGER ACTION RESPONSE PLAN (TARP) DEVELOPMENT INCORPERATING RISK-INFORMED DECISION MAKING AND PERFORMANCE BASED DESIGN

Date: November 8, 2026
Duration: Full-Day

Information provided here is subject to change.

Objective:

TARPs are an invaluable risk management tool that outlines monitoring and response procedures to support safe operations of tailings storage facilities (TSFs) based on risk controls. TARPs describe actions to be taken if pre-defined trigger levels are exceeded, indicating performance outside of the normal range. The trigger levels are developed based on the performance objectives and risk management plan for a TSF typically using a traffic light assessment method. This short course will provide practical applications on development of TARP, incorporating risk-informed decision making and performance-based design through.

Course Summary

This full-day workshop introduces Trigger Action Response Plans (TARPs) as essential tools for managing TSF performance using Risk-Informed Decision Making and Performance-Based Design principles. The precautionary design approach includes design factors of safety, monitoring, and the observational method where instrument threshold levels are set based on minimum factors of safety. The Performance-Based Design approach also includes monitoring and the observational method, but the key updates are the incorporation of real-time response modelling to match observations in field instrumentation and the evaluation of reserve resistance(s) versus factors of safety. TSFs are built over many years and change constantly over their operational life, Performance-Based Design attempts to predict performance over the full life of the facility and identify thresholds for implementing actions and responses prior more substantial performance issues develop. Performance-Based Design goes beyond conventional precautionary design (factor of safety) as the sole design criteria and instead focuses on the accurate prediction of performance, based on characterization of geotechnical conditions and loading conditions recognizing the uncertainties.

Participants learn what TARPs are, why they are needed, and how they are developed—from identifying credible failure modes to establishing trigger levels and defining response actions. The course emphasizes reliable monitoring, technical justification of triggers, and practical Incorporating Risk-Informed Decision Making and Performance-Based Design. Case studies and industry perspectives illustrate how TARPs support proactive, defensible risk management throughout a facility's lifecycle.

Detailed Course Description:

This full-day workshop provides a comprehensive and practical introduction to Trigger Action Response Plans (TARPs) for Tailings Storage Facilities (TSFs) Incorporating Risk-Informed Decision Making and Performance-Based Design. TARPs are a critical component of TSF risk management, defining how monitoring data, field observations, and technical analyses translate into clear, actionable responses to ensure safe and stable operations.

Participants will learn what a TARP is, why TARPs are essential for TSF management, what information they contain, and how they are developed though Performance-Based Design. The course emphasizes the connection between monitoring systems, engineering analyses, operational decision-making, and emergency preparedness.

Throughout the workshop, participants will explore:

- The role of TARPs within risk management, the observational method, performance-based design and global standards such as GISTM and ICOLD guidance.
- How to identify credible failure modes, determine meaningful indicators, and select appropriate monitoring tools and frequencies.
- The technical basis for establishing tiered trigger levels, including performance criteria, modeling outputs, and analysis of brittle or sensitive behaviors.
- How to develop and implement effective, practical response actions using a traffic-light system that supports proactive decision-making.
- The human factors that influence TARP performance, including communication, alarm fatigue, and integration with site governance systems.

Real-world case studies—from major mining operations to closure contexts—illustrate how TARPs function in practice and highlight lessons learned across the industry. Perspectives from regulators and industry bodies further reinforce expectations, trends, and best practices.

By the end of the course, participants will have a clear understanding of how TARPs are structured, how they support safe TSF operations, and how to apply TARP principles to their own facilities.

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Workshop Agenda:

Course Introduction
Purpose of the workshop

- Overview of workshop objectives and outcomes
- Why TARPs exist as a component of TSF risk management
- Performance-Based Design overview
- How TARPs fit within the broader governance framework (OMS, EoR)

Participant expectations

- Interactive learning, discussions, and exercises
- Case-based application throughout the day

TARP Background
What is a TARP?

- Definition and fundamental concept
- Relationship to risk controls and performance objectives
- Role within the TSF management system

Why TARPs are needed

- Connection to catastrophic failure prevention
- Support for early detection of abnormal performance
- Regulatory expectations and global standards (GISTM, ICMM principles)

AM Introduction to Performance-Based Design (PBD)

- Overview of PBD principles
- Importance of PBD in TSF construction
- Regulatory frameworks and industry standards
- PBD benefits and limitations in design

Definitions
Key terminology supporting TARP development and use

- Trigger levels (green/yellow/orange/red)
- Lagging vs leading indicators
- Thresholds vs. limits
- Alert vs alarm conditions
- Monitoring vs surveillance

Importance of consistent definition usage across organizations

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Identification
How TARPs are developed — Step 1: Identifying what matters

- Types of failure modes applicable to TSFs
    - Geotechnical, hydraulic, structural, operational
- Roles & responsibilities
    - Operators, engineers, EoR, third-party reviewers

Risk-based evaluation / Identifying credible failure modes

- Physically possible vs. probable scenarios
- Using failure mode analyses

Understanding operational impacts

- Distinguishing operational constraints from failure modes
- Incorporating operational risk lenses without diluting technical focus

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Surveillance

How TARPs are developed — Step 2: Determining what to monitor

- Instrumentation overview
    - Piezometers, radar, prisms, inclinometers, cameras, drones
- Inspections and observational data
- Surveillance plans
    - Data collection, frequency, responsibilities

Data evaluation

- Data quality, validation, and redundancy
- Recognizing data drift, noise, and errors
- Benchmarking vs baseline performance

Other technologies

- Remote sensing, machine learning tools, real-time dashboards
- Use of historical datasets to guide trigger thresholds

Basis

How TARPs are developed — Step 3: Establishing technical basis for trigger levels

- Performance-based design principles
- Material characterization and model inputs
- Limit equilibrium and numerical modeling
    - How analysis results relate to trigger setting

Establishing triggers

- Normal range vs. concern thresholds
- Tiered levels of escalation (traffic light system)
- How brittle behaviors influence trigger selection
    - Recognizing precursor indicators
    - Sensitivity to rapid change

Frequency of updates

- When and why TARPs require revision
- Incorporating design changes, new data, or operational changes

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Implementation

How TARPs are developed — Step 4: Building the response framework

- Traffic-light systems: green/yellow/orange/red
- Developing actionable response plans
    - Proactive vs. reactive actions
    - Balancing false alarms vs missed alerts

Response planning exercises

- Scenario-based group work
- Identifying appropriate responses for each trigger level

Setting appropriate trigger thresholds

- Avoiding overly restrictive or vague ranges

Notification and escalation

- Where notifications reside (TARP vs EAP vs OMS)
- Relationship to emergency response planning
- Integrating TARP communication with established governance

Human element

- Alarm fatigue and complacency
- Practical considerations in TARP implementation
- Decision-making under uncertainty

Case Studies

Applying learning to real and hypothetical examples

- New generation of TARPs: design evolution
- CASE history 1
- CASE History 2
- Closure-focused case study
- Group discussion: What would you improve about each TARP?

Regulator / MSHA / ICMM Perspective

- Expectations from major governing bodies
- How TARPs support compliance with global standards (e.g., GISTM)
- Trends in TARP requirements across industry

Closure Perspective

- TARPs for legacy and closed facilities
- Adjusting triggers and monitoring strategies for closure stages
- Long-term risk management considerations

Workshop Closing

- Summary of key takeaways
- Final Q&A

Presenters:

Jason Hilgers

Jason Hilgers, P.E. is a registered professional engineer in AECOM's Water Business Unit in Denver, Colorado. He received his BS degree in geological engineering at the Colorado School of Mines and his MS degree in civil engineering with geotechnical focus from the University of Colorado. Mr.

Hilgers has over 22 years of experience specializing in the design, evaluation, inspection, monitoring, and operation of mine tailing storage facilities. He currently serves as the Engineer of Record and has been responsible for the design and operation of some of the largest tailings storage facilities in North America.

Masood Kafash

Dr. Masood Kafash is a registered professional engineer, technical practice lead and deputy EOR in AECOM's DCS Mining Business Unit with more than 15 years of experience in geotechnical engineering consulting and research. His experience is focused on tailings and embankment dams and levees, with demonstrated expertise in leading the design and analysis of existing and new tailings storage facilities and dams, developing investigation and laboratory program, material characterization, and numerical analysis. He has been responsible for the design of some of the largest tailings storage facilities in North America. Dr. Kafash has authored several technical papers on these topics and has been an instructor for several short courses including T&M 2025 "Performance-based design", T&M2024 "Lesson learned from Brazil Technical, Environmental and Social Auditing", USSD 2022 "Static Liquefaction in Water dams" workshops and The Tailings Center's "Fundamentals of Tailings Management" series.

Lisa Yenne

Lisa Yenne is a registered professional engineer with over 31 years of diversified civil and geotechnical engineering experience in the mining industry. Ms. Yenne has experience specifically focused in the evaluation, design, construction, operation and closure of tailings facilities worldwide. Her technical expertise includes world-class tailing storage facilities. She has been responsible for geotechnical investigations, tailings dam sitings and design, mine closure planning, mine reclamation, Dam Safety Reviews (DSRs), heap leach facilities, construction oversight services, and evaluation of civil engineering and environmental projects. Ms. Yenne also serves as Engineer of Record for multiple active and inactive tailings storage facilities along with advising clients as a review board member or as a SME. Ms. Yenne also is the AECOM Division Manager for the Mining Engineering Team in the AECOM West Water Business Region managing a team of mining multi-discipline engineering specialists including EoRs focused on tailings dams, heap leach facilities, water storage facilities, and supporting infrastructure for these facilities.

Richard R. Davidson

Mr. Davidson is an internationally recognized Senior Principal Geotechnical & Dams Consulting Engineer with more than 40 years of global expertise in mine waste geotechnics, tailings storage facilities (TSFs), and dam safety. Operating as an independent principal consultant and former Vice President / Senior Principal at AECOM (formerly URS), he directs and advises multidisciplinary teams on the engineering, construction, and closure of critical mining infrastructure.

Throughout his career, Mr. Davidson has pioneered risk-informed approaches and advanced cyclone construction techniques (centerline and downstream) for some of the world's largest and highest tailings facilities—including impoundments exceeding 2.5 billion tonnes, processing rates over 290,000 tonnes per day, and dam heights reaching 210 meters in extreme seismic environments. His global project footprint spans North and South America, Australasia, Asia, and Europe (including Chile, Peru, New Zealand, Mongolia, Australia, the Philippines, and the United States).

Kevin Ritter

Mr. Ritter has over 16 years of experience in geotechnical engineering and mine waste facilities. Mr. Ritter's experience has focused on managing the evaluation, inspection, design, construction, and closure of water reservoirs and mine waste facilities. He has served as Engineer-of-Record for multiple active and inactive tailings storage facilities and water storage reservoirs has been responsible for geotechnical investigations, dam siting and design studies, mine waste closure planning, dam safety inspections, construction oversight services, and evaluation of mining and dams related civil engineering projects.

James Alcorn

James Alcorn is a Geotechnical Dam Engineer with over 17 years of experience with AECOM designing, investigating, and constructing water storage dams in Australia and tailings storage facilities in U.S.A. Mr. Alcorn is a Civil Manager and Engineer of Record based in Denver, Colorado who is passionate about providing solutions for new and existing dams. James believes the safe design, construction, and operation of dams can be fundamentally achieved with a risk-informed approach, particularly with the use of quantitative risk assessments. Mr. Alcorn has extensive experience facilitating multiple accounts analyses, and quantitative risk assessment workshops for dam owners worldwide.

Braden Error

Braden Error is a registered professional engineer and geotechnical manager with a decade of geotechnical experience in AECOM's US West Mining Department. He received his BS and MS degrees in civil engineering with a geotechnical focus from Brigham Young University with research focused on evaluations of performance-based seismic liquefaction hazard. Braden currently serves as deputy Engineer of Record for an active upstream raise tailings storage facility for one of his clients. Braden also has experience in subsurface investigations, geotechnical instrumentation installation and

monitoring, as well as project delivery working with large multidisciplinary design teams on some of the largest tailings storage facilities throughout North America.

Workshop Target Audience:

Geotechnical engineers, tailings dam designers, project managers, regulators, and industry professionals involved in the design, construction, and safety management of tailings dams.