

# Failure Modes and Root Causes of Water Quality Impacts

Characterizing, Predicting, and Modeling Water from Mine Sites



# Failure Modes and Root Causes of Water Quality Impacts

- Identifies the underlying causes of water quality impacts at the case study mines
- Uses information gathered from the case studies and conducts a “failure modes” and “root cause” analysis
  - A failure is an outcome that is different than intended or predicted
  - A failure mode is the general type of failure that occurred or is predicted to occur (e.g., prediction failure, mitigation failure), while a root cause is the underlying, more specific, reason for the failure

# Types of Characterization Failures

- Two Primary Characterization Failure Modes Identified
  - Hydrological Characterization Failures
  - Geochemical Characterization Failures
- Inaccuracies in hydrologic and geochemical characterization can lead to a failure to recognize or predict water quality impacts

# Root Causes of Characterization Failures

## Hydrological Failures

- dilution overestimated
- lack of hydrological characterization
- amount of discharge overestimated
- size of storms underestimated
- Six of 25 mines had hydrological characterization failures

## Geochemical Failures

- lack of adequate geochemical characterization
- sample size and/or representativeness
- 11 of 25 mines had geochemical characterization failures

# Mitigation Failures

- Root Cause of Mitigation Failures
  - mitigation not identified, inadequate or not installed
  - waste rock mixing and segregation not effective
  - liner leak, embankment failure or tailings spill
  - land application discharge not effective.
- 16 of 25 mines had mitigation failures

**Table 8.2 Failure Analysis Spreadsheet – NEPA/EIS Case Studies  
Water Quality at Hardrock Mine Sites**

Failure Mode		Effects	Consequences	Examples
Hydrological Characterization	Dilution overestimated	Surface water impacted in smaller upper watershed streams	M	Greens Creek, Jerritt Canyon
	Presence of water from springs or lateral flow not recognized	Ground and surface water impacts from contact with contaminant source	H	Black Pine, Mineral Hill, Royal Mountain King
	Amount of water underestimated	Load of contamination exceeds surface water discharge standards	M	Mineral Hill
			H	Ray, Zortman and Landusky
Geochemical Characterization	Sample representation, testing methods or interpretations inadequate	potential for acid drainage and other contaminants not recognized leading to failure to identify need for or type of mitigation	M	Greens Creek, Jamestown, McLaughlin, Royal Mountain King, Thompson Creek, Jerritt Canyon
			H	Grouse Creek, Beal Mountain, Black Pine
			S	Golden Sunlight, Zortman and Landusky
Mitigation	Mitigation Not identified identified, inadequate or not installed	inadequate mitigation identified to prevent impacts to water resources	M	Greens Creek, Jamestown, Thompson Creek, Jerritt Canyon
			H	Bagdad, Grouse Creek, Beal Mountain, Black Pine, Zortman and Landusky
	Waste rock mixing and segregation not effective	leachate contains acid drainage and other contaminants	M	Greens Creek, McLaughlin, Jerritt Canyon
	Liner leak, embankment failure or tailings spill	greater than design (e.g. exceedances) impacts to water resources	L	Stillwater, Florida Canyon, Lone Tree, Rochester, Twin Creeks
			M	Jamestown, Royal Mountain King, Jerritt Canyon, Mineral Hill
			H	Bagdad
			S	Golden Sunlight

# Geochemical Characterization Failures

- Geochemical failures resulted from:
  - Assumptions made about geochemical nature of ore deposits and surrounding areas
  - Site analogs inappropriately applied to new proposal
  - Inadequate sampling
  - Failure to conduct and have results for long-term contaminant leaching and acid drainage testing procedures before mining begins.
  - Failure to conduct the proper tests, or to improperly interpret test results, or to apply the proper models

# Failure Modes Root Causes Recommendations

- A more systematic and complete effort should be undertaken when collecting data
- Recognize the importance of thorough hydrological and geochemical characterization
- Utilize information in a conservative manner to identify and utilize mitigation measures
- Consider the likelihood and consequences of mitigation failures