



# Rockfall Hazard Rating System for Railroads

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# Rockfall Hazards

- Fouled and Damaged Track





# Rockfall Hazards

- Fouled Track





# Rockfall Hazards

- Equipment Damage





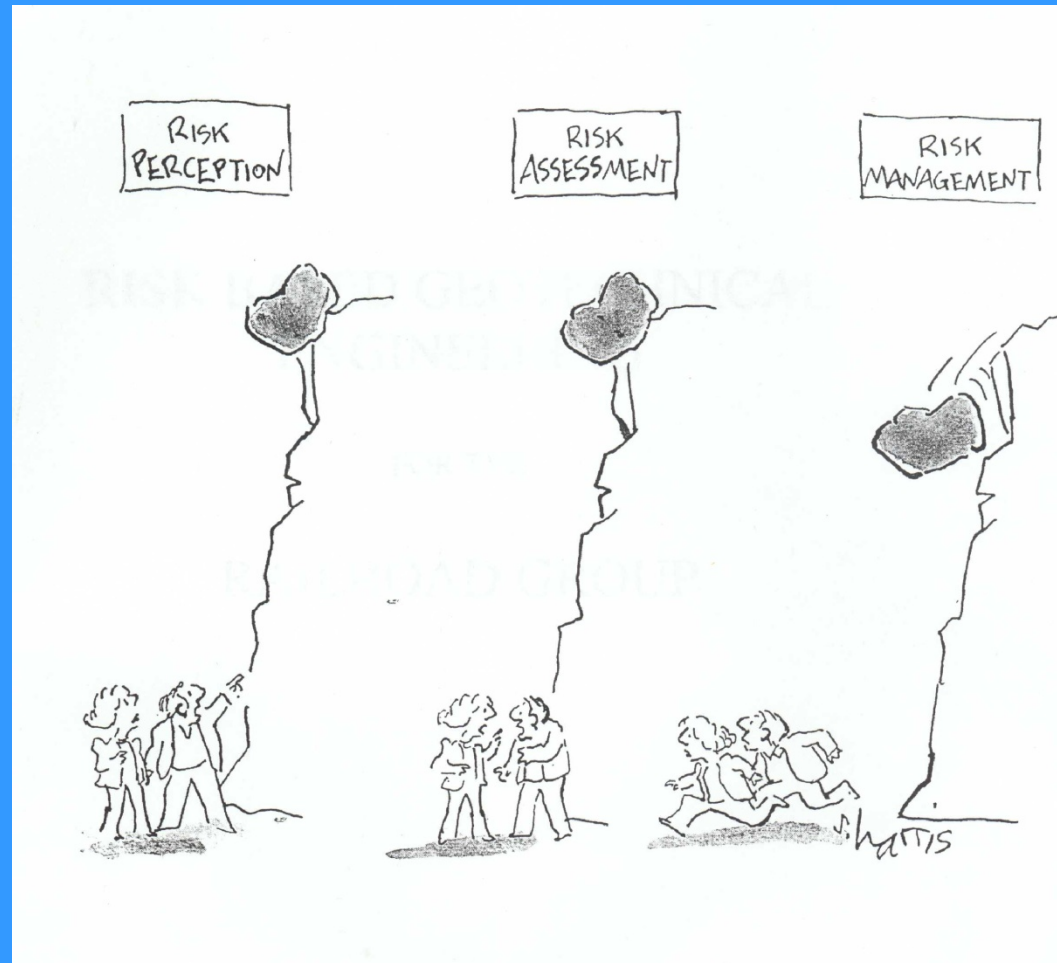
# Rockfall Hazards

- Derailments





# Managing Rockfall Hazard Risks





# Objectives for Managing Rockfall Hazard Risk

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- Identify Risks due to Rockfall
  - Allocate Resources Efficiently
  - Provide Documentation for Hazard Assessment and Reduction
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# Procedure for Rockfall Hazard Evaluation and Mitigation

- Conduct hi-rail trip with MOW personnel
  - a) Interview MOW Personnel about site history
  - b) Site Specific Evaluations (Rockfall Hazard Rating)
  - c) Take Photographs
- Compile ratings and photographs in a spreadsheet
- Select sites for mitigation and design
- Construct mitigation measures





# Rockfall Hazard Rating System (RHRS)

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A Rockfall Hazard Rating System is a semi-quantitative system for ranking rockfall hazard along long segments of track



# Rockfall Hazard Rating Systems

- Highways
  - Oregon Department of Transportation (1990)
  - Colorado Department of Transportation (1992)
- Railroads
  - Brawner and Wyllie (1975)
  - Canadian National Railway (1995)



# Elements of Rockfall Hazard Rating System

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- Slope Profile
  - Geologic Characteristics
  - Climate and Presence of Water
  - Rockfall History
  - Catchment Area
  - Adjustments for Operating Practices
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# Rockfall Hazard Rating System Scoring System

- Basic Score
  - physical conditions
  - rockfall history
- Basic Rating
  - score ranges from 30 to 810
  - higher scores implies more risk

Rockfall Hazard Rating System						
FACTOR		RANK				
		3 Points	9 Points	27 Points	81 Points	
SLOPE PROFILE	Slope Height (feet)	25 to 50	50 to 75	75 to 100	>100	
	Slope Inclination (degrees)	35 to 45	45 to 55	55 to 65	>65	
	Launching Features	Possible	Minor	Many	Major	
GEOLOGIC CHARACTERISTICS	Rock Diameter or Quantity of Rockfall Event	< 1 ft or < 1 cu yd.	1 to 2 ft or 1 to 3 cu yds	2 to 5 ft or 3 to 10 cu yds	>5 ft or >10 cu yds	
	CASE 1	Structural Condition	Discontinuous fractures, favorable orientation	Discontinuous fractures, random orientation	Discontinuous fractures, adverse orientation	Continuous fractures, adverse orientation
		Rock Friction	Rough Irregular	Undulating, smooth	Planar	Clay, gouge infilling, or slickensided
	CASE 2	Structural Condition	Few differential erosion features	Occasional erosion features	Many erosion features	Major erosion feature
		Difference in Erosion	Small difference	Moderate difference	Large difference	Extreme difference
	Climate and Presence of Water on Slope		Low to moderate precipitation; no freezing periods; no water on slope	Moderate precipitation or short freezing periods, or intermittent water on slopes	High precipitation or long freezing periods or continual water on slope	High precipitation and long freezing periods, or continual water on slope and long freezing periods
Rockfall History (From Ride Through)		Few falls (< 2/yr.)	Occasional falls (< 2 to 12/yr.)	Many falls (>1/month but <1/week)	Constant falls (> 1/week)	
Catchment Area		Excellent	Fair to Good	Poor	None	



# Adjustments applied to Basic Rating

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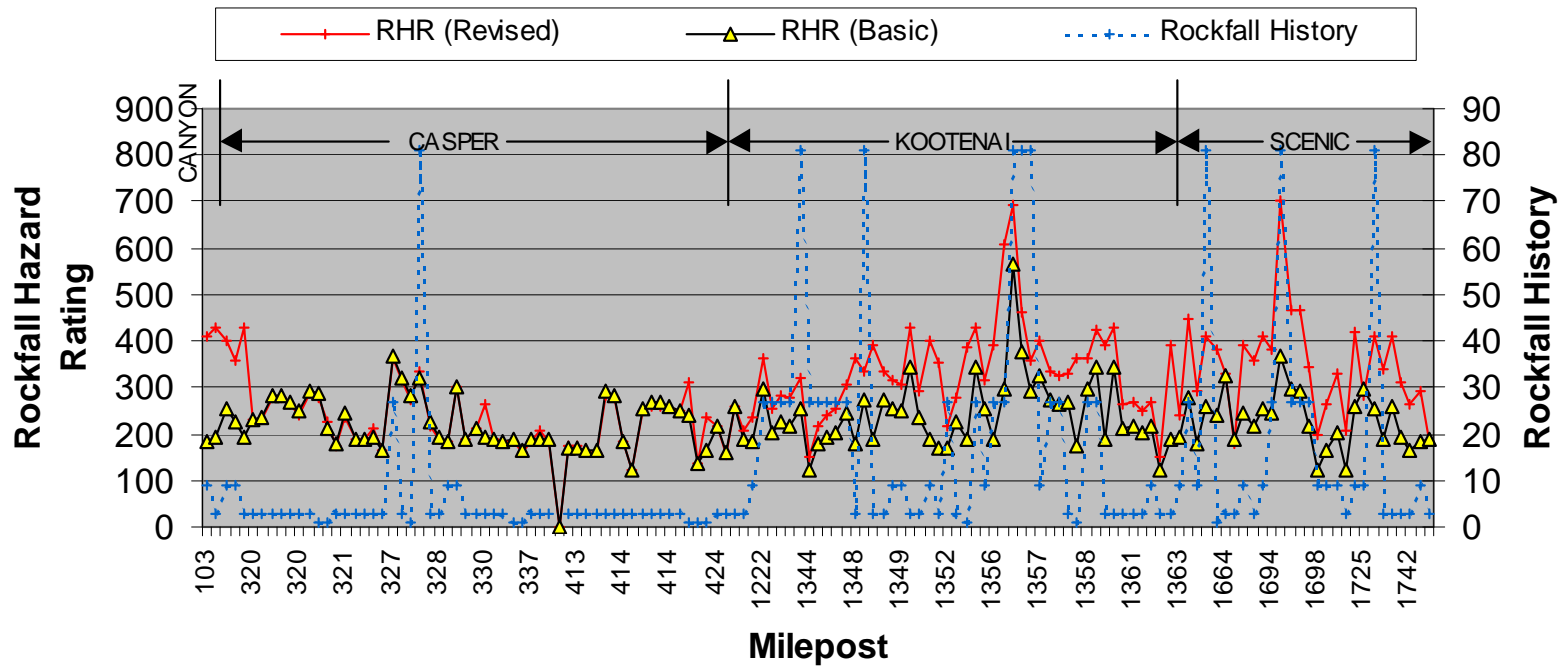
- Existing Warning Systems (slide fence tied into signal system)
  - Passenger Trains
  - Hazardous Material
  - Number of Trains
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# RHR by Subdivision

**Figure 1: Rockfall Hazard Rating  
Selected Sites, Washington, Idaho, Montana, and Wyoming**





# Rockfall Hazard Identification

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- Planar Failures
  - Wedge Failures
  - Toppling Failures
  - Ravelling Failures
  - Key Block Failures
  - Erosion
-





# Rockfall Hazard Identification

- Planar Failure





# Rockfall Hazard Identification

- Planar Failure





# Rockfall Hazard Identification

- Wedge Failure





# Rockfall Hazard Identification

- Toppling Failure





# Rockfall Hazard Identification

- Ravelling Failure





# Rockfall Hazard Identification

- Ravelling Failure





# Rockfall Hazard Identification

- Key Block Failure





# Rockfall Hazard Identification

- Erosion







# Rockfall Hazard Identification

- Erosion





# Rockfall Mitigation Methods

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- Stabilization (Removal, Rock Bolts, Shotcrete, etc.)
  - Protection (Barriers, avoidance, increased catchment)
  - Warning Systems
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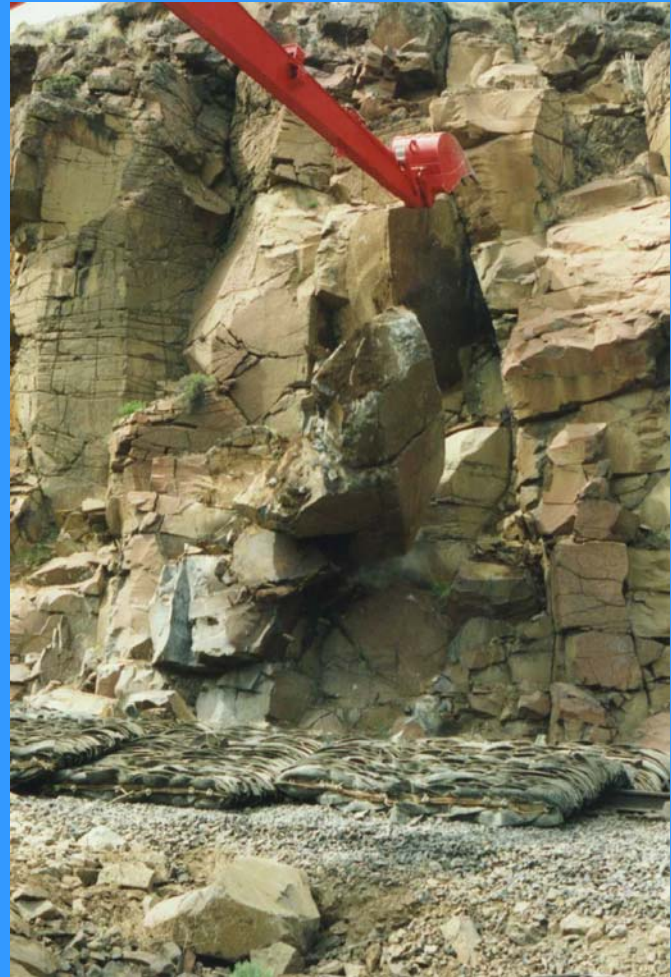
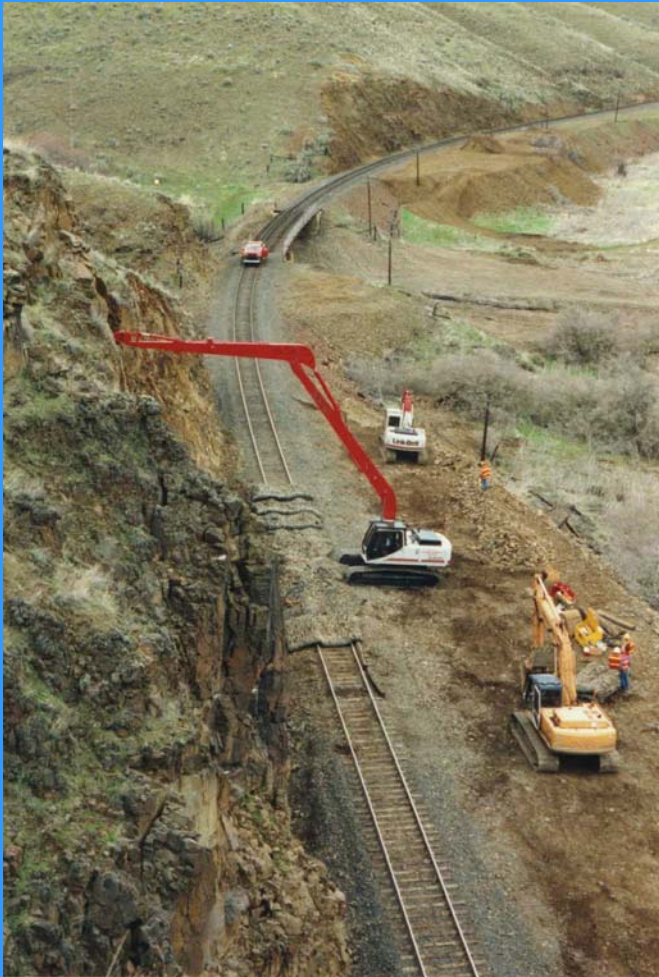


# Hand Scaling





# Mechanical Scaling





# Blast Scaling





# Rock Bolting from Crane





# Shotcrete





# Rockfall Catchment Ditch

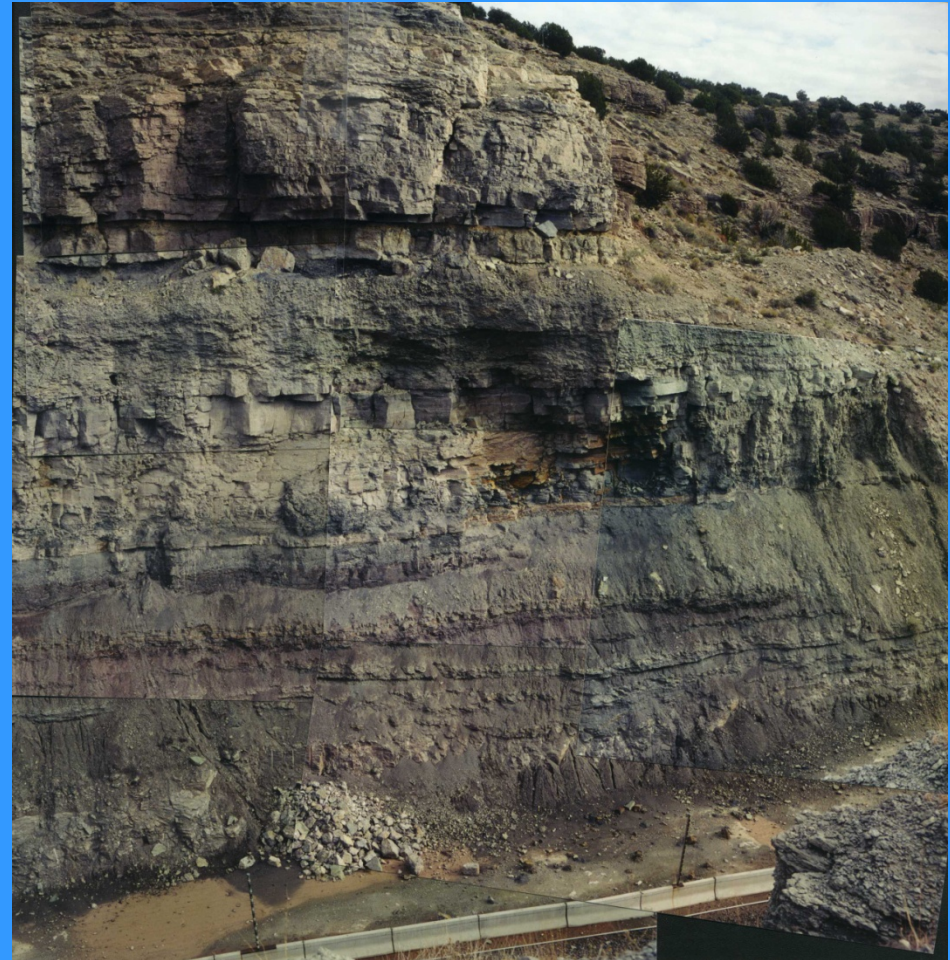






# Rockfall Catchment Ditch

- Jersey Barrier at toe of slope can improve catchment.





# Ditch Improvement

Before

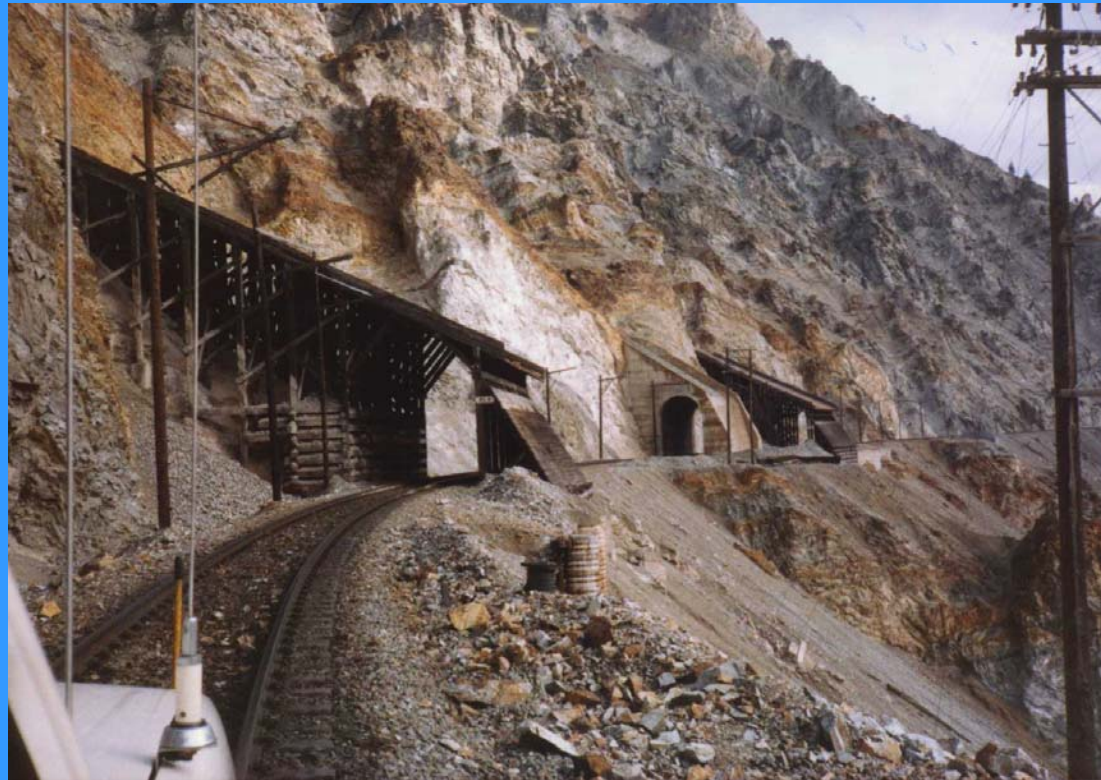


After





# Rock Sheds





# Rock Sheds





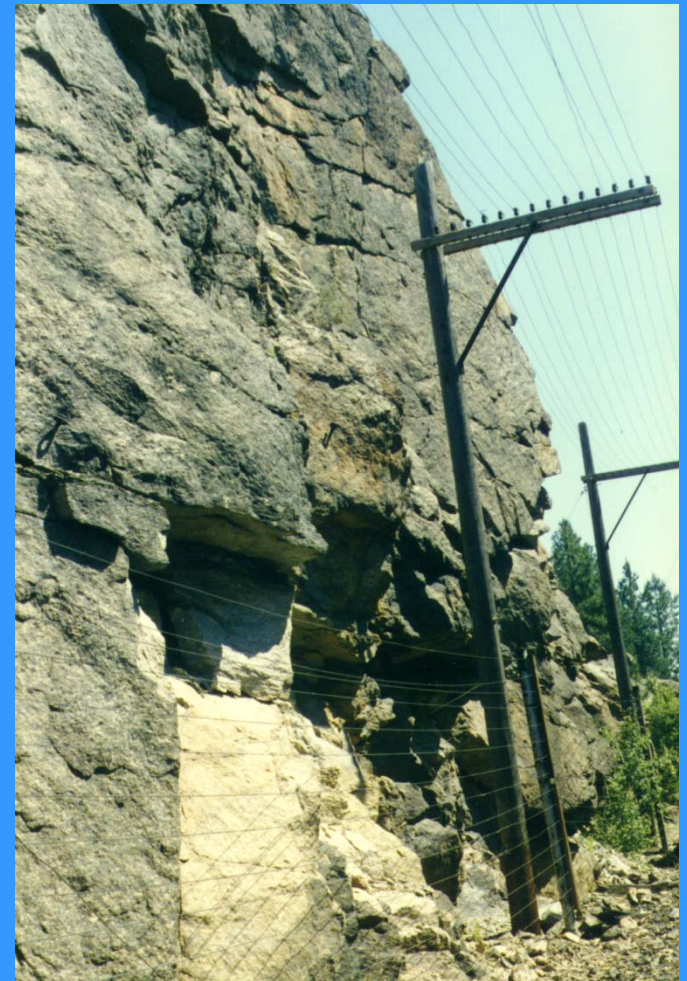
# Rockfall Barrier Fence





# Slide Detection Fences

- Detect rocks and debris moving toward the track structure from above
- Maintenance of Slide Detection Fence should be considered.
- Difficult or impossible to remove once installed.





# Shannon & Wilson, Inc.

