Rockfall Hazard Rating System for Railroads

- Neal McCulloch and Roberto Guardia
- Shannon & Wilson, Inc.
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

• Identify Risks due to Rockfall
• Allocate Resources Efficiently
• Provide Documentation for Hazard Assessment and Reduction
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
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

- Slope Profile
- Geologic Characteristics
- Climate and Presence of Water
- Rockfall History
- Catchment Area
- Adjustments for Operating Practices
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
Adjustments applied to Basic Rating

- Existing Warning Systems (slide fence tied into signal system)
- Passenger Trains
- Hazardous Material
- Number of Trains
# Rockfall Hazard Rating System Worksheet

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<thead>
<tr>
<th>CATEGORY</th>
<th>DESCRIPTION</th>
<th>SCORE</th>
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<td>Slope Inclination</td>
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<tr>
<td>Block Size/Quantity</td>
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<td>Fracture/Orientation</td>
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<td>Rock Proto</td>
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<td>Seismic Features</td>
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<td>Difference in Elevation Rate</td>
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<td>Precipitation / Seepage/Exposure</td>
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<td>Observed Rockfall History</td>
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<td>Ditch Catchment</td>
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<th>Is slide fence present? (Yes/No)</th>
<th>Factor</th>
<th>SUBTOTAL 1</th>
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<td>Factor</td>
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<td>Passenger train? (Yes/No)</td>
<td>Factor</td>
<td>SUBTOTAL 3</td>
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<tr>
<td>High Rail? (Yes/No)</td>
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Figure 1: Rockfall Hazard Rating
Selected Sites, Washington, Idaho, Montana, and Wyoming
Rockfall Hazard Identification

- 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

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