

# MDT Rockfall Hazard Assessment

Rock Slope Asset Management Program  
RAMP

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# Montana's Rockfall Management History

- 2003 – 2005 Implemented the Rockfall Hazard Rating System (RHRS)
  - Standard RHRS implementation from the NHI manual, with minor alteration
  - Housed all the data in MDT's Enterprise Oracle Database, had gone unchanged for 10 years
- 2015 – Research RFP for updating their Rockfall Hazard Rating Process
  - Reassess rock slopes
  - New database
  - Evaluate TAM compatibility







WEIGH  
STATION  
1 MILE



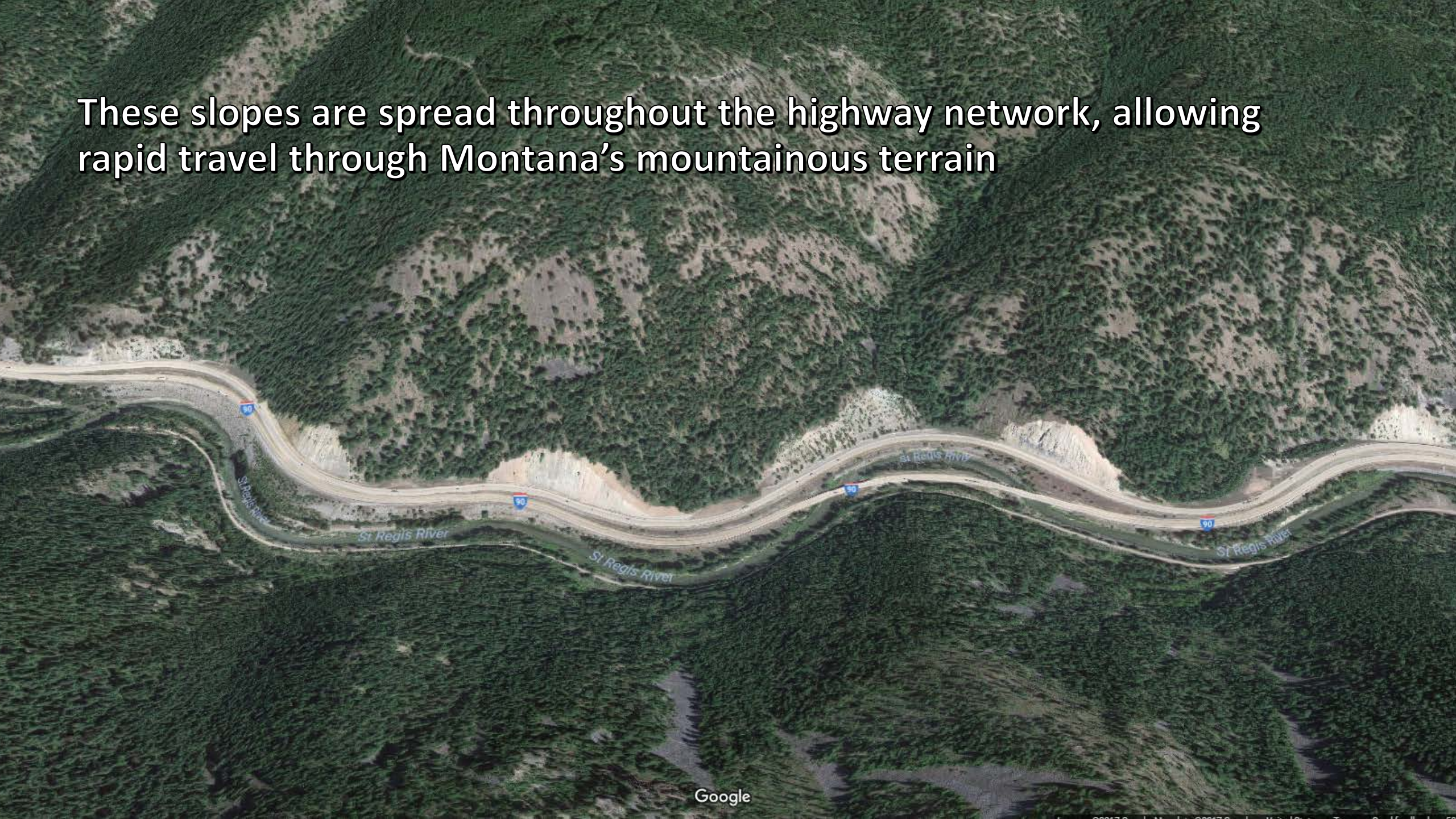
# Over 1,800 rock slopes next to Montana's Highways

- Slope lengths - <100 to >3,000 feet
- Slope heights - <30 to >300 feet





These slopes are spread throughout the highway network, allowing rapid travel through Montana's mountainous terrain





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Most of the time

Site of Feb 15, 2013 truck accident,  
interrupting traffic flow for months







Many additional rock slopes remain





# Rock Slope Condition

G/F/P Descriptor	Condition State	Cond. Index Range	Description
<b>Good</b>	<b>1</b>	<b>100 - 80</b>	Rock slope produces little to no rockfall and no history of rock reaching the road. Little to no maintenance needs to be performed due to rockfall activity. Rockfall mitigation measures, if present, are in new or like new condition.
<b>Fair</b>	<b>2</b>	<b>80 - 60</b>	Rock slope produces occasional rockfall that may rarely reach the road. Some maintenance needs to be performed on a scheduled basis due to rockfall activity to address safety. Mitigation measures, if present, are in generally good condition, with only surficial rust or minor apparent damage.
<b>Fair</b>	<b>3</b>	<b>60 - 40</b>	Rock slope produces many rockfalls with rock occasionally reaching the road. Maintenance is required bi-annually or annually to maintain safety. Mitigation measures, if present, appear to have more significant corrosion or damage to minor elements. Preventative maintenance or replacement of minor mitigation components is warranted.
<b>Poor</b>	<b>4</b>	<b>40 – 20</b>	Rock slope produces constant rockfall with rocks frequently reaching the road. Maintenance is required annually or more often to maintain ditch performance. Much of the required maintenance response is unscheduled. Mitigation measures, if present, are generally ineffective due to significant damage to major components or apparent deep corrosion.
<b>Poor</b>	<b>5</b>	<b>20 – 0</b>	Rock slope produces constant rockfall and nearly all rockfall reaches the road. Virtually no rockfall catchment exists or is effective. Maintenance must respond to rockfalls regularly, possibly daily during adverse weather. If present, nearly all mitigation measures are ineffectual either due to deferred maintenance, significant damage, or obvious deep corrosion.



# Rock Slope Condition

G/F/P Descriptor	Condition State	Cond. Index Range	Description
Good	1	100 - 80	Rock slope produces little to no rockfall and no history of rock reaching the road. Little to no maintenance needs to be performed due to rockfall activity. If all mitigation measures, if present, are in new or like condition.
Fair	2	80 - 60	Rock slope produces little to no rockfall that may rarely reach the road. Some maintenance needs to be performed due to rockfall activity. Mitigation measures, if present, are in good condition, with only surface corrosion.
Fair	3	60 - 40	Rock slope produces small rockfalls with rock occasional reaching the road. Maintenance is required bi-annually to maintain safety. Mitigation measures, if present, appear to have some effectiveness. Minor mitigation measures are warranted.
Poor	4	40 - 20	Rock slope produces small rockfall with rocks frequently reaching the road. Maintenance is required annually to maintain ditch performance. Mitigation measures, if present, are ineffective due to significant damage to mitigation measures or apparent deep corrosion.
Poor	5	20 - 0	Rock slope produces large rockfall and nearly all rock reaches the road. Virtually no rockfall catchment exists. Maintenance must respond regularly, possibly daily during adverse weather conditions. Mitigation measures, if present, are nearly all mitigation measures are ineffectual either due to deferred maintenance, significant damage, or obvious deep corrosion.

Low

High

Rockfall Activity

Ability to Stop Rocks

High

Low



# Examples – Condition State 1 (Good)





# Examples – Condition State 2 (Fair)



C000013N-60\_33 (Hwy 287)



# Examples – Condition State 3 (Fair)



C018203N-8\_88 (Looking Glass Road, East Glacier)



C000090E-237\_11 (I-90, near Homestake)



# Examples – Condition State 4 (Poor)



C000011N-13\_84 (Hwy 89, Near Gardiner)





# Examples – Condition State 5 (Poor)



C000029N-68\_49 (US 10/MT 2, west of Whitehall)



C000046E-68\_06  
MT 43, w of Divide



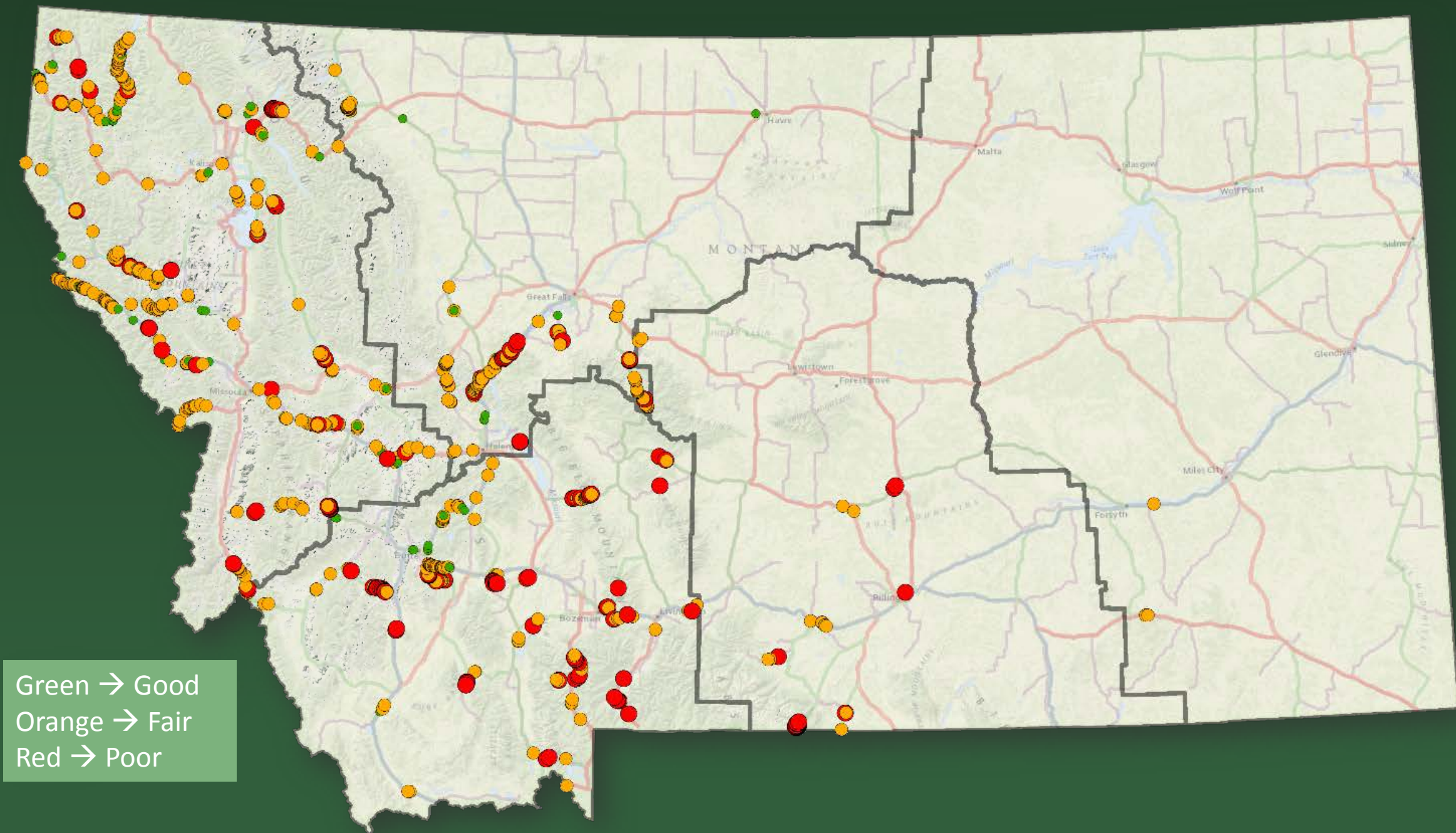
# Examples – Condition State 5 (Poor)



C022249N-5\_08 (US 10/MT 2, East of Whitehall @ L&C Canyon)









6.2 Million SF  
(13%) Good  
Condition

31.4 Million SF  
(63%) Fair  
Condition

12.1 Million SF  
(24%) Poor  
Condition



# Assessing Risk and Economic Analysis

- Monetizing Risk Estimation
- Estimation of Average Annual Maintenance Costs
- Slope Deterioration Modeling
- Life Cycle Cost Analysis
- Return on preservation investment
- Long term investment planning



# User Cost Risk Monetization

- Survey Results
- Correlate event occurrence to slope condition and size
- Applied AASHTO values to disruption and safety risks
- Risk equated to dollars, compare risk to mitigation costs
- Improvement over previous low/med/high risk assessments

Date	Hwy	MP	RAMP Section	Closure duration	Duration slowdown	Damage?	Comments
Feb. 2012	I-90	24.1	1172	Crossover, Months	Months	Yes	Design Build Project, Rockfall Mitigation W of Drexel. 14 C.Y Boulder reached driving lane. Resulting wreck of truck.
Spring 2013	I-90	6.5	1147	Crossover, Months	Months	No	Change order in rockfall mitigation W of Drexel corrected the slope back to pre fail conditions mostly
Feb. 10- 12, 2015	Hwy 12	18	1304	39 hrs	3 days	no	total 3 days includes the 39 hour closure, approximately 5000 ton rock give or take a few hundred tons.
Feb. 2015	I-90	22.4	1168	Crossover, Months	Months	Possibly	800 CY of debris filled ditch, overwhelmed truck rail with some material spilling onto roadway.



# Event Risk Results

- Reviewed Event Data
  - Most complete and location specific data from D1
- D1 data extended throughout the state
- Risk is cumulative: Multiple rock slopes along a corridor can close a road every year

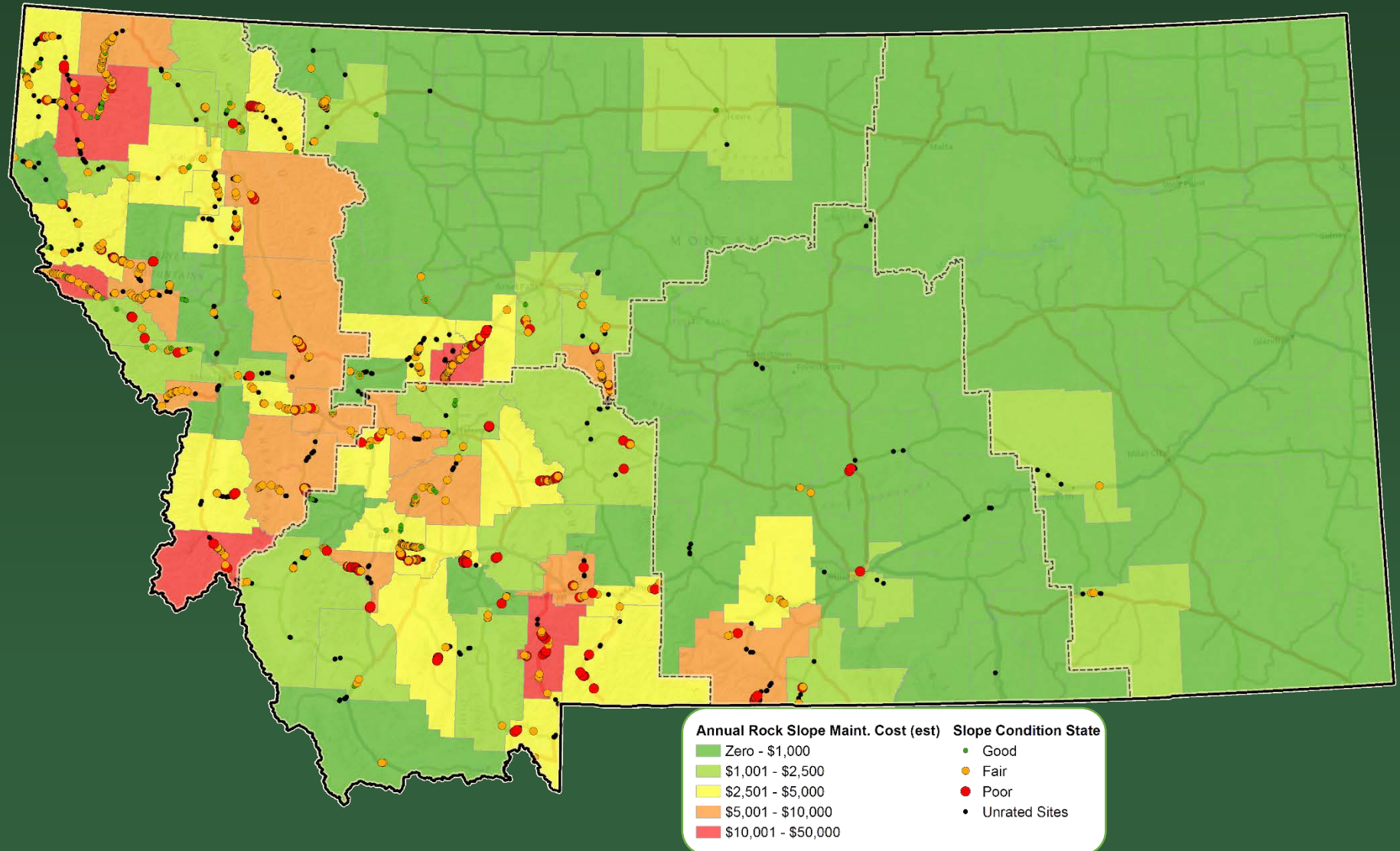
Condition State (CS)	Event Likelihood per sq ft of rock face.	Example 500 ft long by 75 ft high slope	Recurrence interval on example slope (yrs)
1	1.2E-08	0.03%	3,419
2	4.8E-08	0.12%	855
3	3.9E-07	0.95%	105
4	1.3E-06	3.17%	32
5	2.0E-06	4.88%	21

- Size Effects
  - Slope 1: 1,000' x 150' CS 2 = 0.47%
  - Slope 2: 200' x 55' CS 4 = 0.95%
  - Double the likelihood, 13x smaller



# Estimated Annual Maintenance Costs (\$290k)

- Rockfall Debris Removal (~\$120k)
- Clean Rockfall from Ditches (~\$170k)
- 100% State Funds

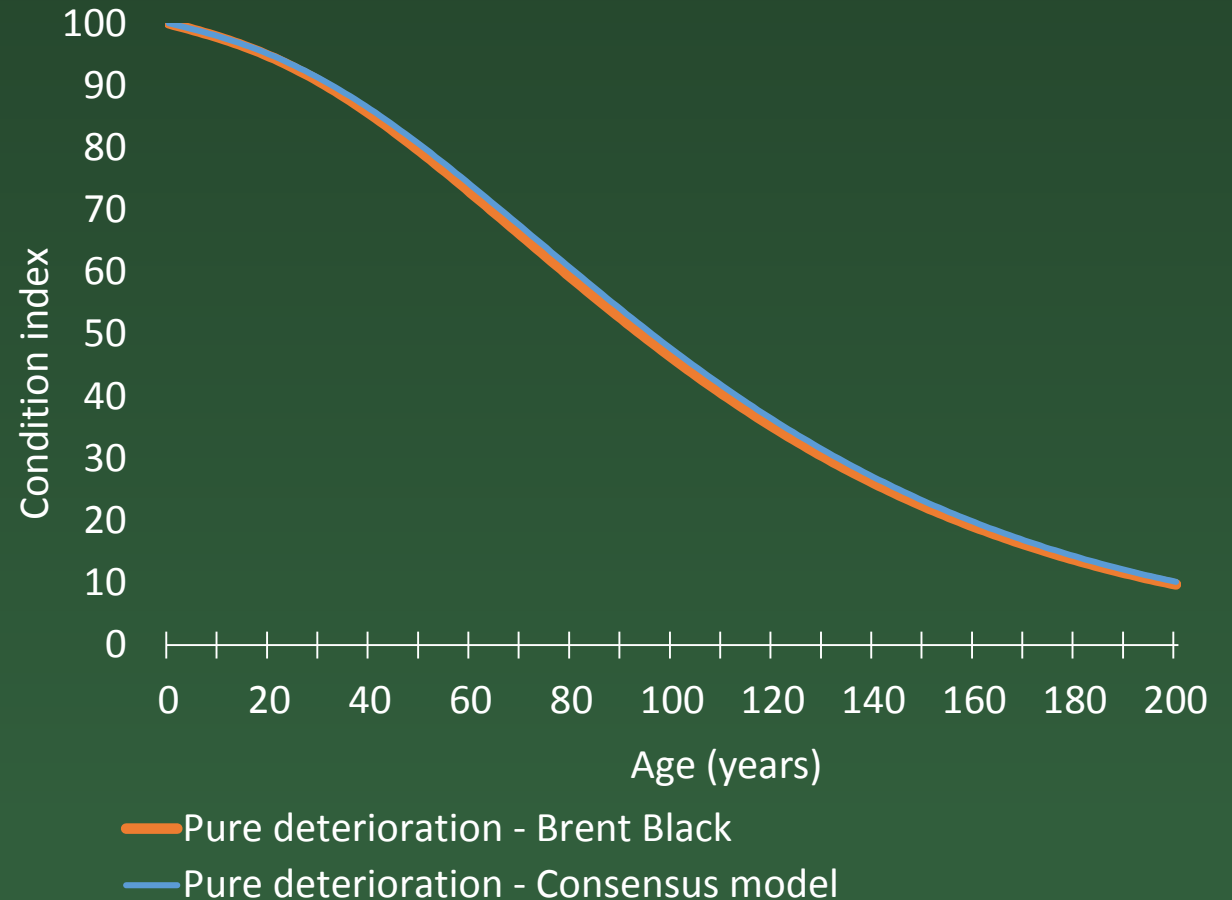




# Slope Deterioration Rates

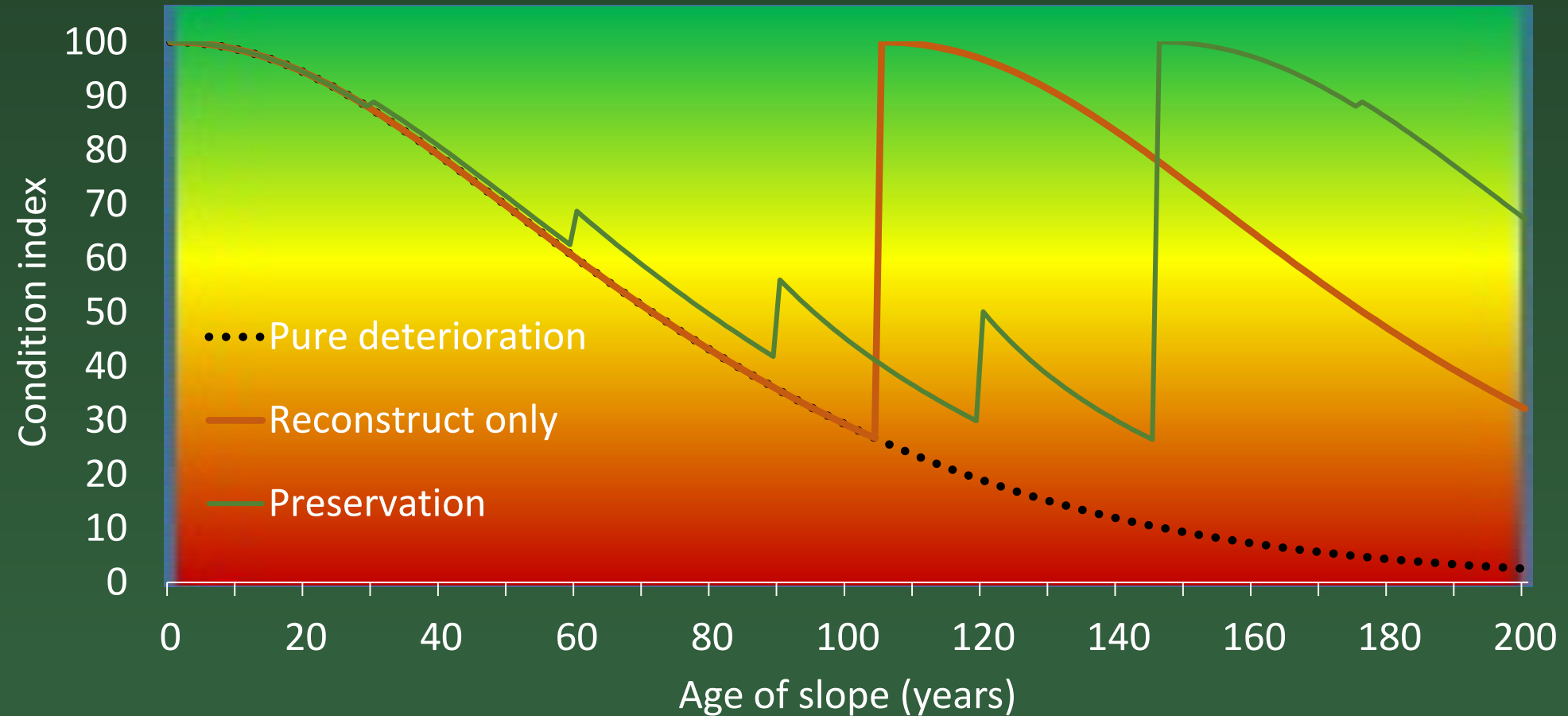
- Expert Elicitation
- Nearly all MDT Geotechnical Personnel Participated and MDT's rock slope mitigation design personnel

*Imagine there are 100 assets in the indicated Condition State. After how many years will 50 of them have deteriorated to the next Condition State or worse, if no maintenance or corrective action is taken?*



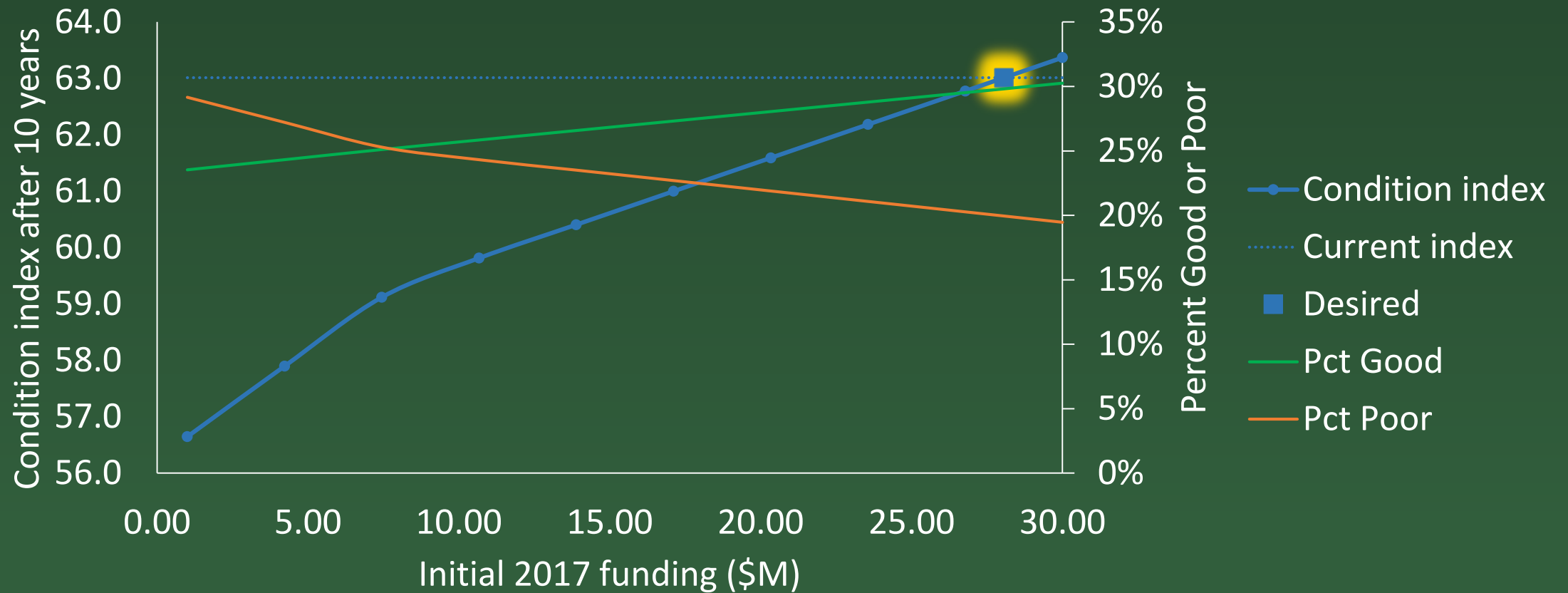


# Life Cycle Cost Analyses





# Trade Off Analysis – Seeking to Maintain Current Conditions





# Value of Slope Preservation

- Cost to build again today: \$4B...an asset worthy of preservation
- Approach to rock slope investment – Preserving current network Conditions
  - Reconstruction only, starting with the worst first - \$35M annually
  - Reconstruction and preservation activities - \$28M annually
  - Over 10 years, \$70 million in savings for same network outcome
  - Preservation Return on Investment: 114%



# Implementation Recommendations

1. Incorporate RAMP into the TAM Plan; regulations allow significant flexibility beyond pavement and bridge assets
2. Incorporate RAMP into Planning workflow; realize lower State-funded Maintenance expenditures by improving slopes with Federal funds
3. Develop STIP and HSIP line items for maintaining the RAMP and for stand-alone rock slope preservation and improvement efforts
4. Utilize Condition State concept for rock slope design goals



# Implementation Recommendations

5. Update rock slope site data regularly using RAMP geodatabase
6. Track rockfall events and related maintenance activities and costs with tools developed during this project
7. Maintain MDT software licenses for GIS services
8. Conduct large-scale assessments of rock slopes at five-year interval, similar to annual pavement surveys and bridge inspections.



# *Thank you!*

- Questions?



*Paul D. Thompson*

