MDT Rockfall Hazard Assessment

Rock Slope Asset Management Program

RAMP

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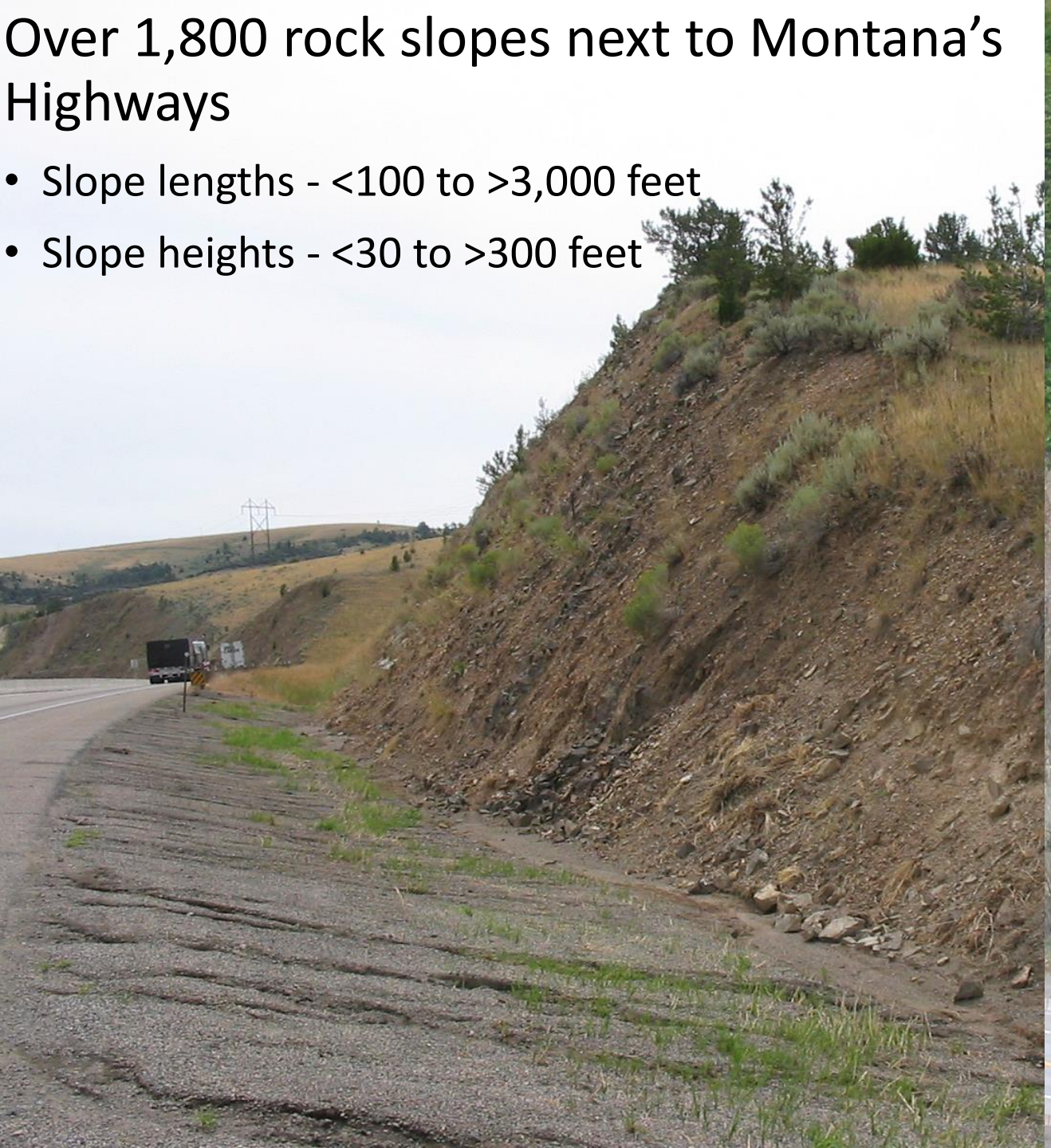
LANDSLIDE TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS

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

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

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



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. Rockfall mitigation measures, if present, are in new or like new condition.
Fair	2	80 - 60	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.
Fair	3	60 - 40	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.
Poor	4	40 – 20	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.
Poor	5	20 – 0	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.

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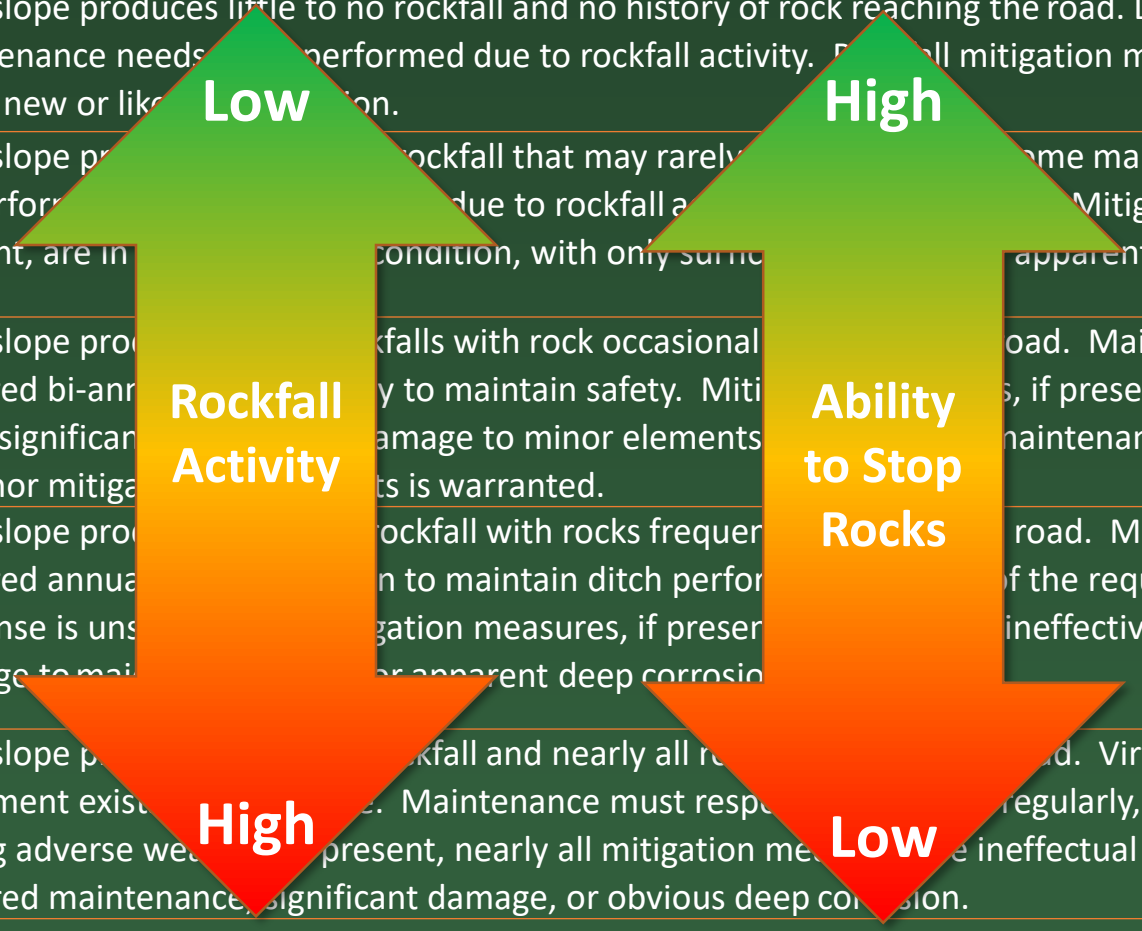
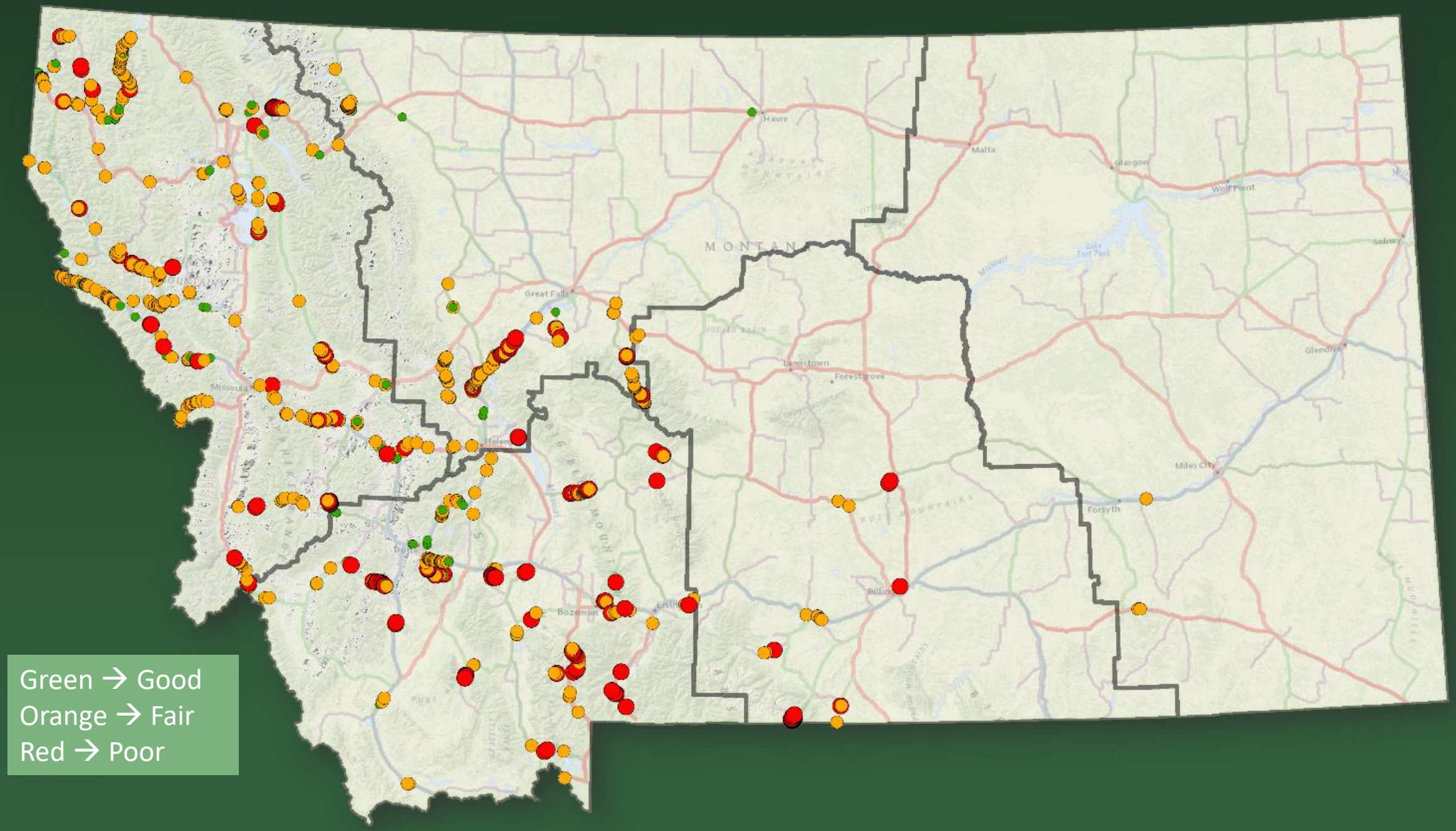
Fair	2	80 - 60	Rock slope produces rockfall that may rarely reach the road. Some maintenance needs to be performed due to rockfall activity. Mitigation measures, if present, are in condition, with only apparent damage.
Fair	3	60 - 40	Rock slope produces rockfalls with rock occasionally reaching the road. Maintenance is required bi-annually to maintain safety. Mitigation measures, if present, appear to have more significant damage to minor elements requiring maintenance or replacement of minor mitigation elements is warranted.
Poor	4	40 – 20	Rock slope produces rockfall with rocks frequently reaching the road. Maintenance is required annually to maintain ditch performance. Some of the required maintenance response is unsuccessful. Mitigation measures, if present, are ineffective due to significant damage to mitigation elements or apparent deep corrosion.
Poor	5	20 – 0	Rock slope produces rockfall and nearly all rockfall reaches the road. Virtually no rockfall catchment existence. Maintenance must respond 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.



Good (CS1)

Poor (CS5)


Havre
Malta
Glasgow
Wolf Point
Sidney
MONTANA
Great Falls
Lewistown
Forest Grove
Glendive
Miles City
Forsyth
Missoula
Bozeman
Billings
Green → Good
Orange → Fair
Red → Poor

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

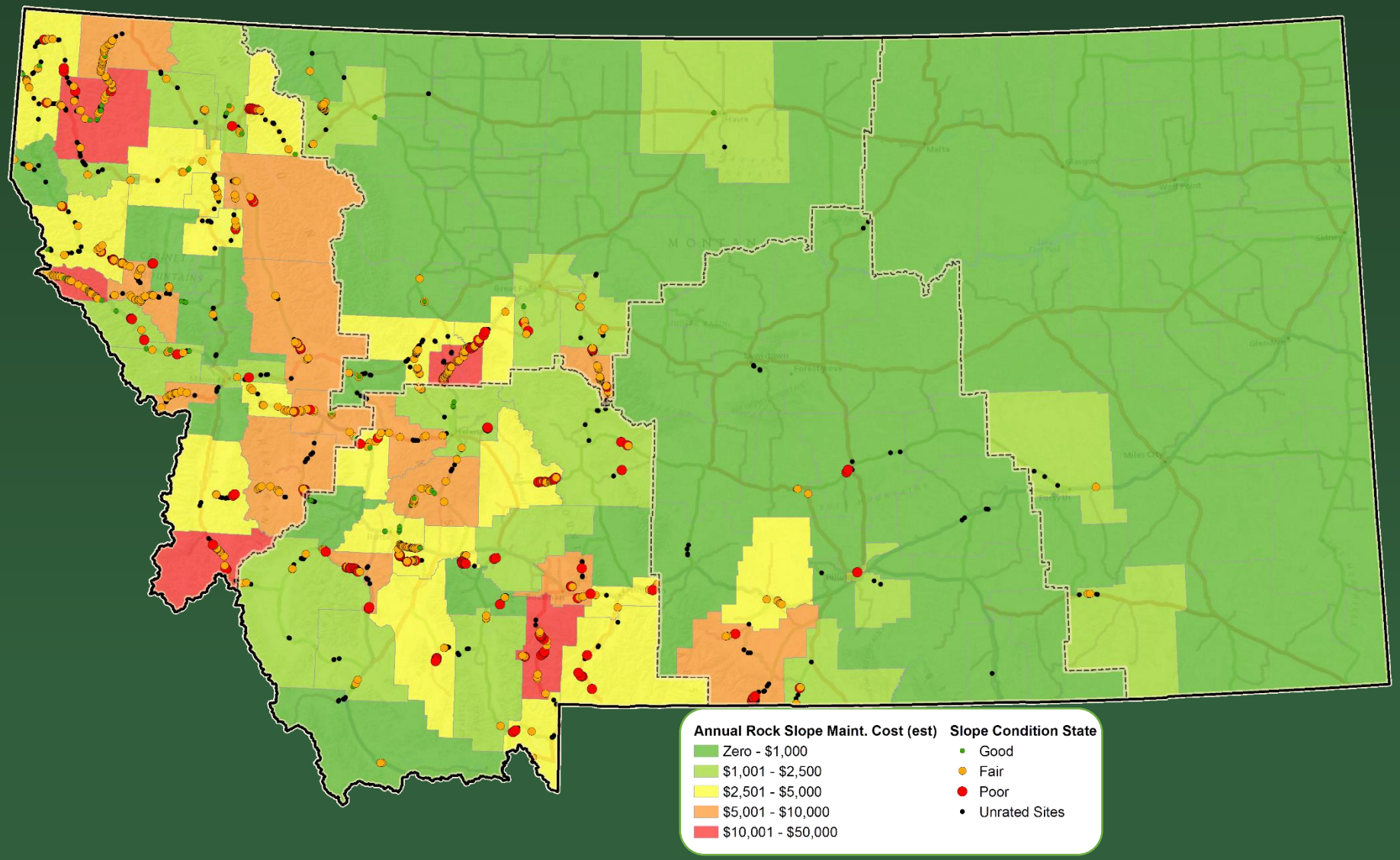
Condition State (CS)	Event Likelihood per sq ft of rock face.	Example 500 ft long by 75 ft high slope	Recurrence interval on example slope (yrs)
1	1.2E-08	0.03%	3,419
2	4.8E-08	0.12%	855
3	3.9E-07	0.95%	105
4	1.3E-06	3.17%	32
5	2.0E-06	4.88%	21

- Risk is cumulative: Multiple rock slopes along a corridor can close a road every year

- 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)

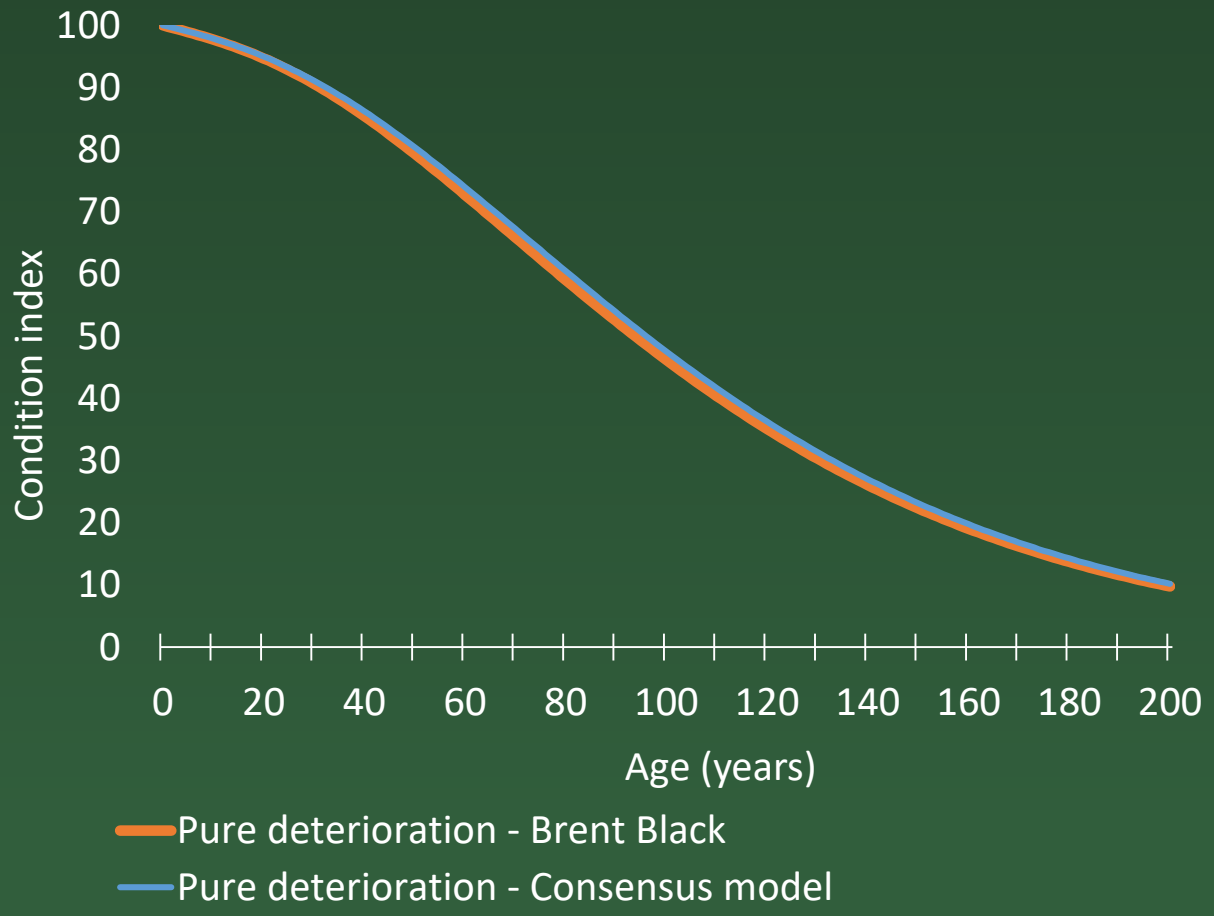
- Rockfall Debris Removal (~$120k)
- Clean Rockfall from Ditches (~$170k)
- 100% State Funds



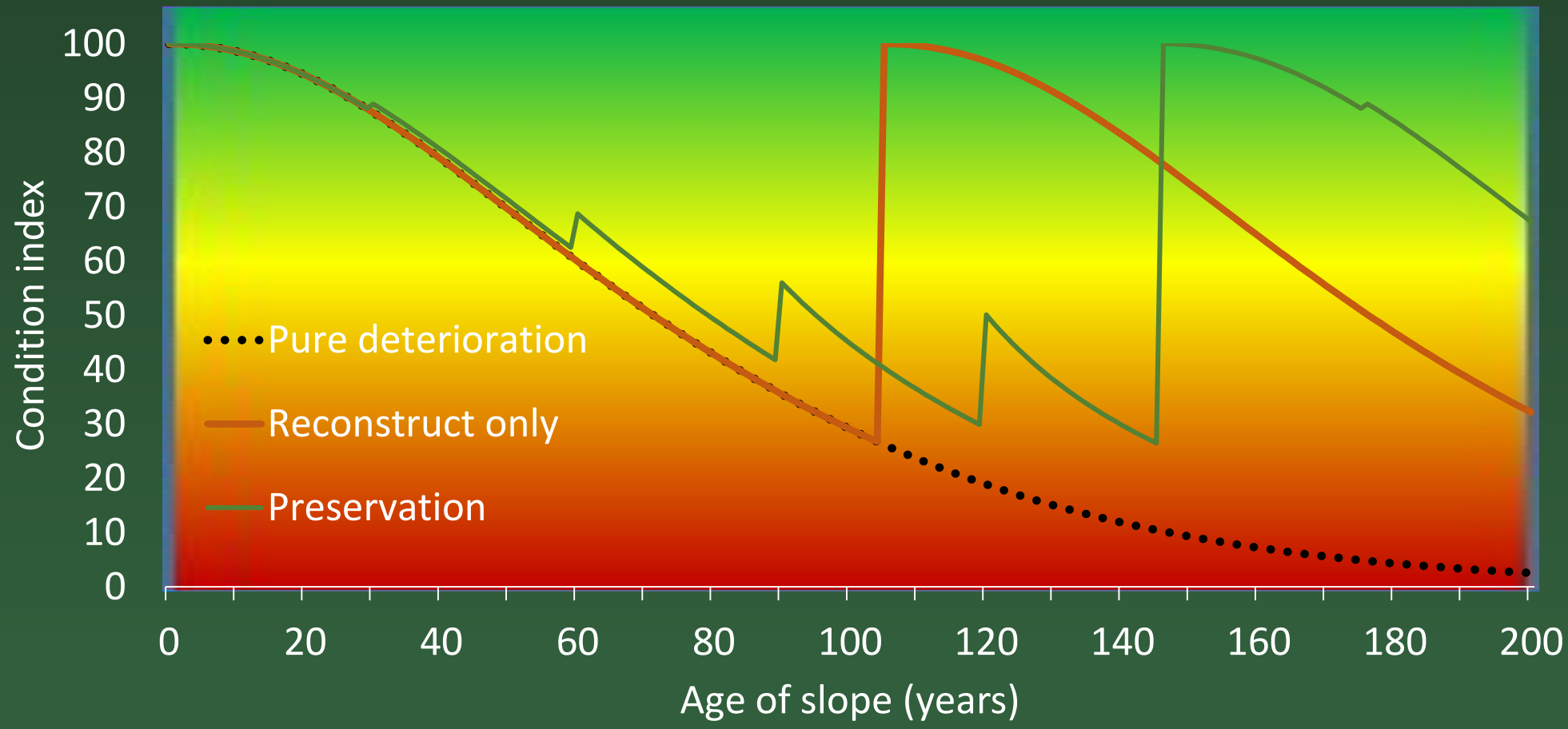
Slope Deterioration Rates

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

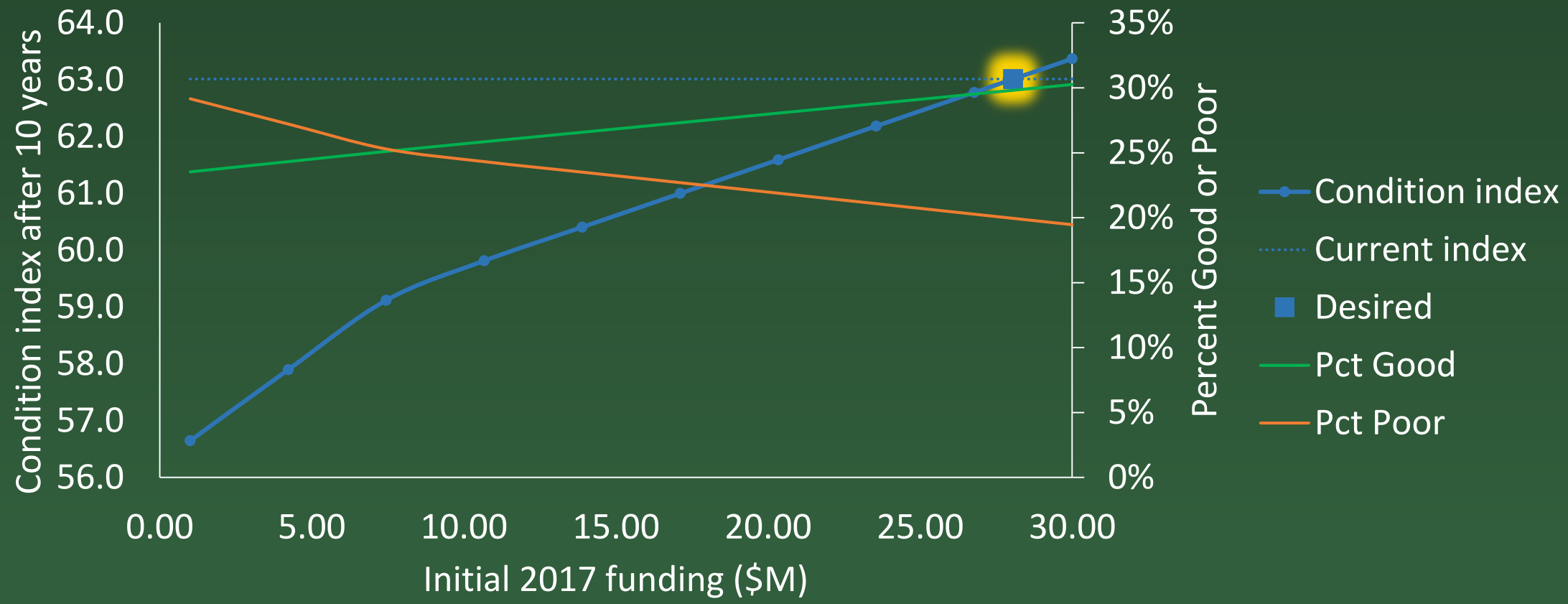
Imagine there are 100 assets in the indicated Condition State. After how many years will 50 of them have deteriorated to the next Condition State or worse, if no maintenance or corrective action is taken?



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%*

Database Use and Decision Support

- http://mdt.maps.arcgis.com/apps/MapJournal/index.html?appid=8fd7f0e0daca4c0db8f2aa2ddeb9c53f

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?
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