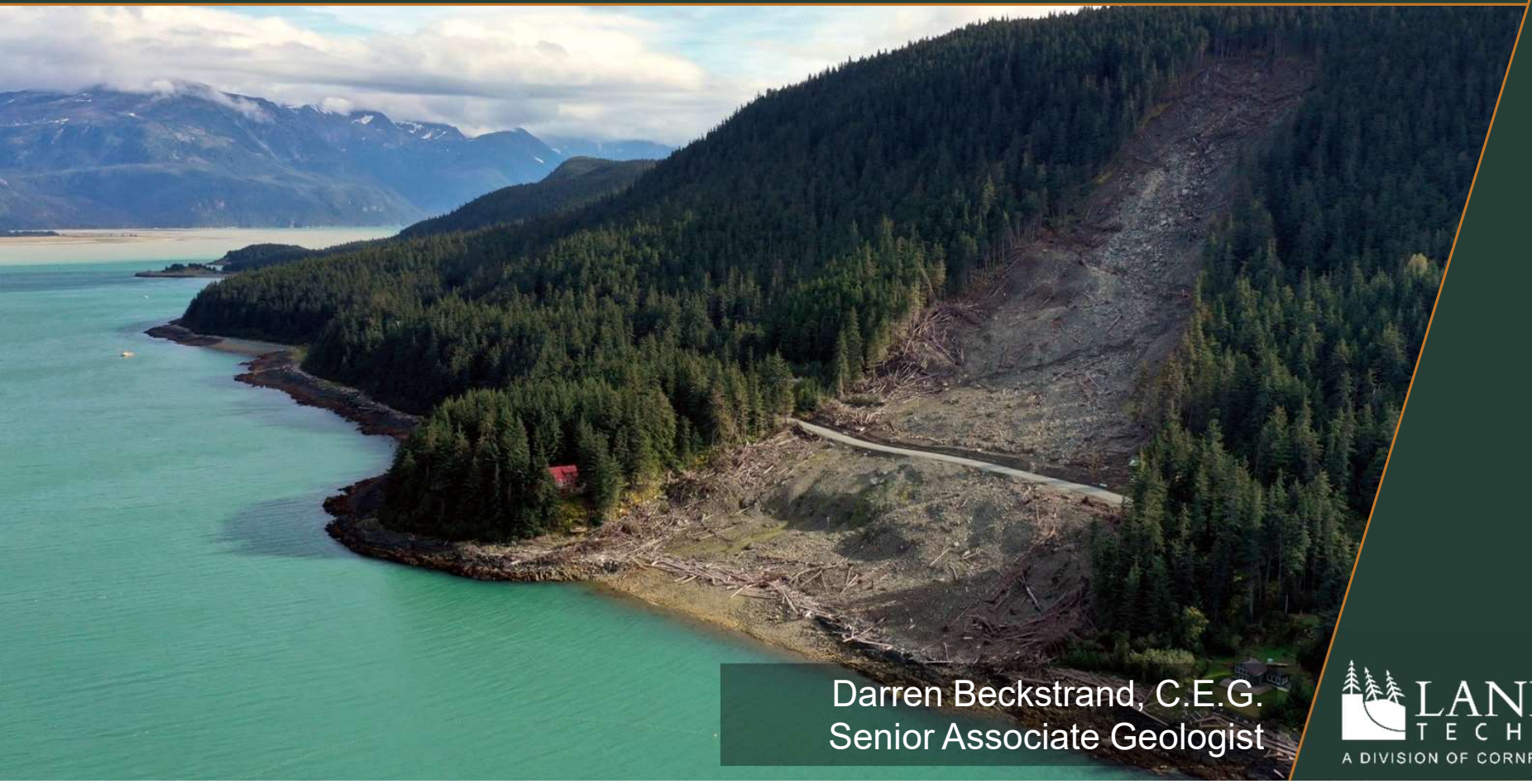
Getting Started with Geotechnical Asset Management Approaches from Various State DOTs



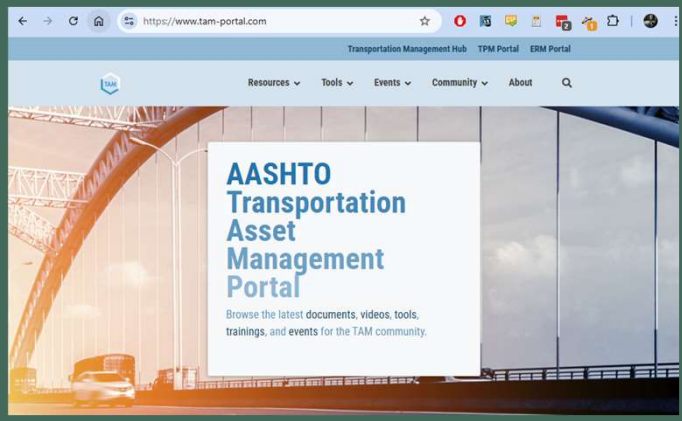
Darren Beckstrand, C.E.G.
Senior Associate Geologist

LANDSLIDE TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS

What is Transportation Asset Management?

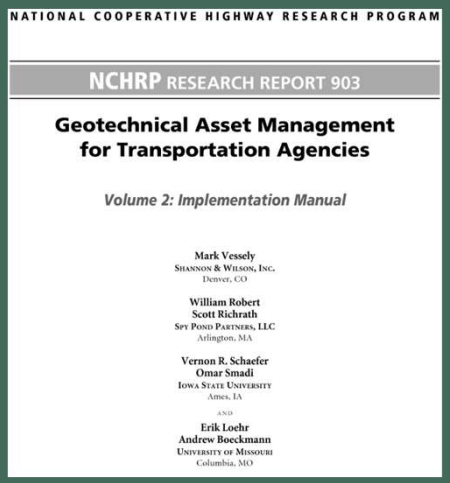
- Transportation Asset Management (TAM)

  "Strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycle" – AASHTO



- TAM for Bridges and Pavements is required and *encouraged* for ancillary assets

  What it means: No Federal directive or requirement … may be (likely?) considered optional by management


NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP RESEARCH REPORT 903

Geotechnical Asset Management for Transportation Agencies

Volume 2: Implementation Manual

Mark Vessely
Shannon & Wilson, Inc.
Denver, CO

William Robert Scott Richrath
Spy Pond Partners, LLC
Arlington, MA

Vernon R. Schaefer
Omar Smadi
Iowa State University
Ames, IA

AND

Erik Loehr
Andrew Boeckmann
University of Missouri
Columbia, MO

Application of TAM Business Models to Geotech Assets

"My Department has 5,000 geotechnical assets and 70% meet performance criteria. If we do nothing, in 10 years it will be 65% and will result in accumulated direct costs of $10,000,000 and indirect costs of $30,000,000. We're forecast to have 8 road closures per year, growing to 9.

If we invest $2,500,000 per budget cycle, we'll reduce unforeseen state expenditures by 50%, reduce forecast road closures to 7, and project that 75% meet performance criteria."

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GAM Provides:

- Inventory

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- Perf. Measures

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- Deterioration Estimates

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- Deterioration Estimates
- Costs & Consequences

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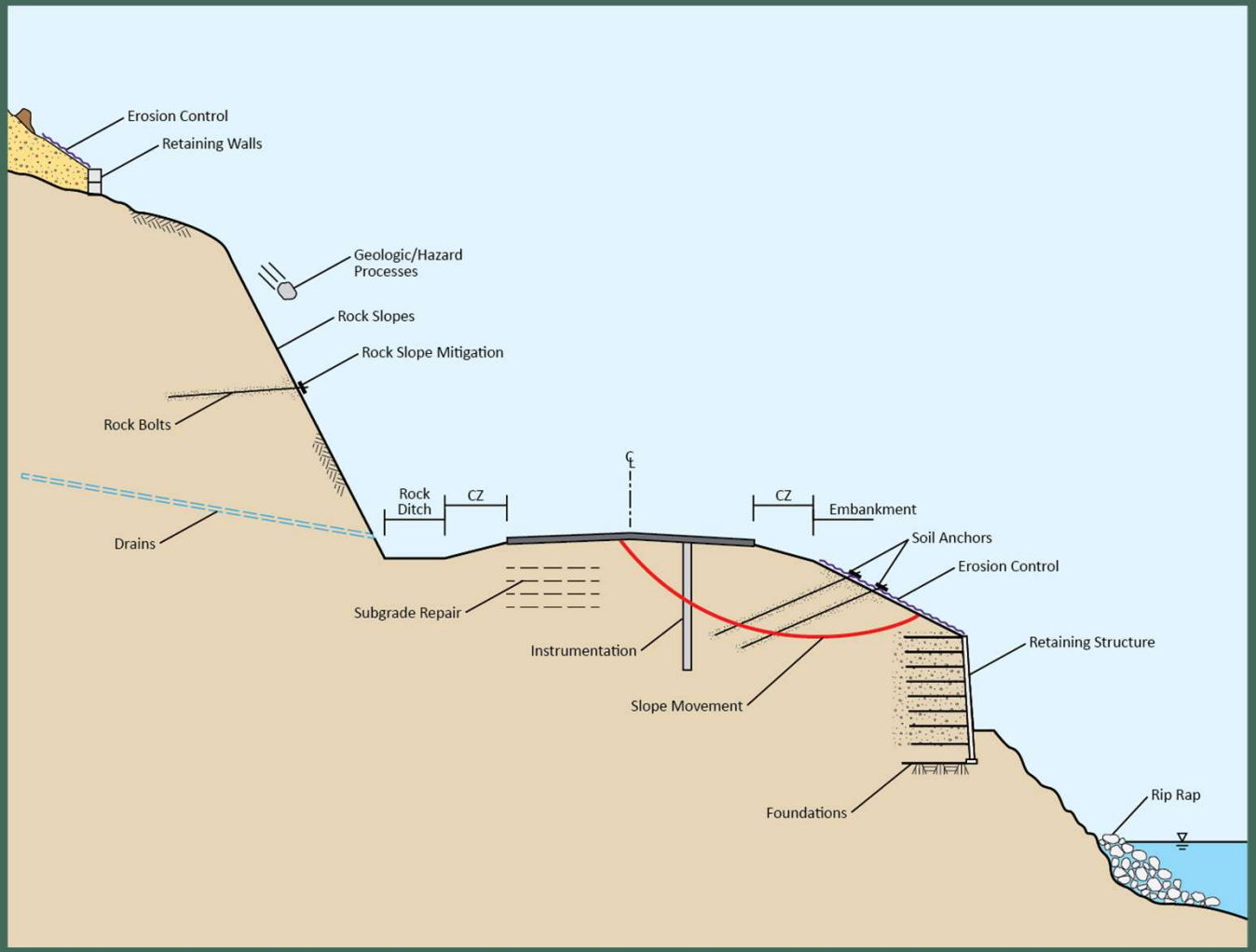
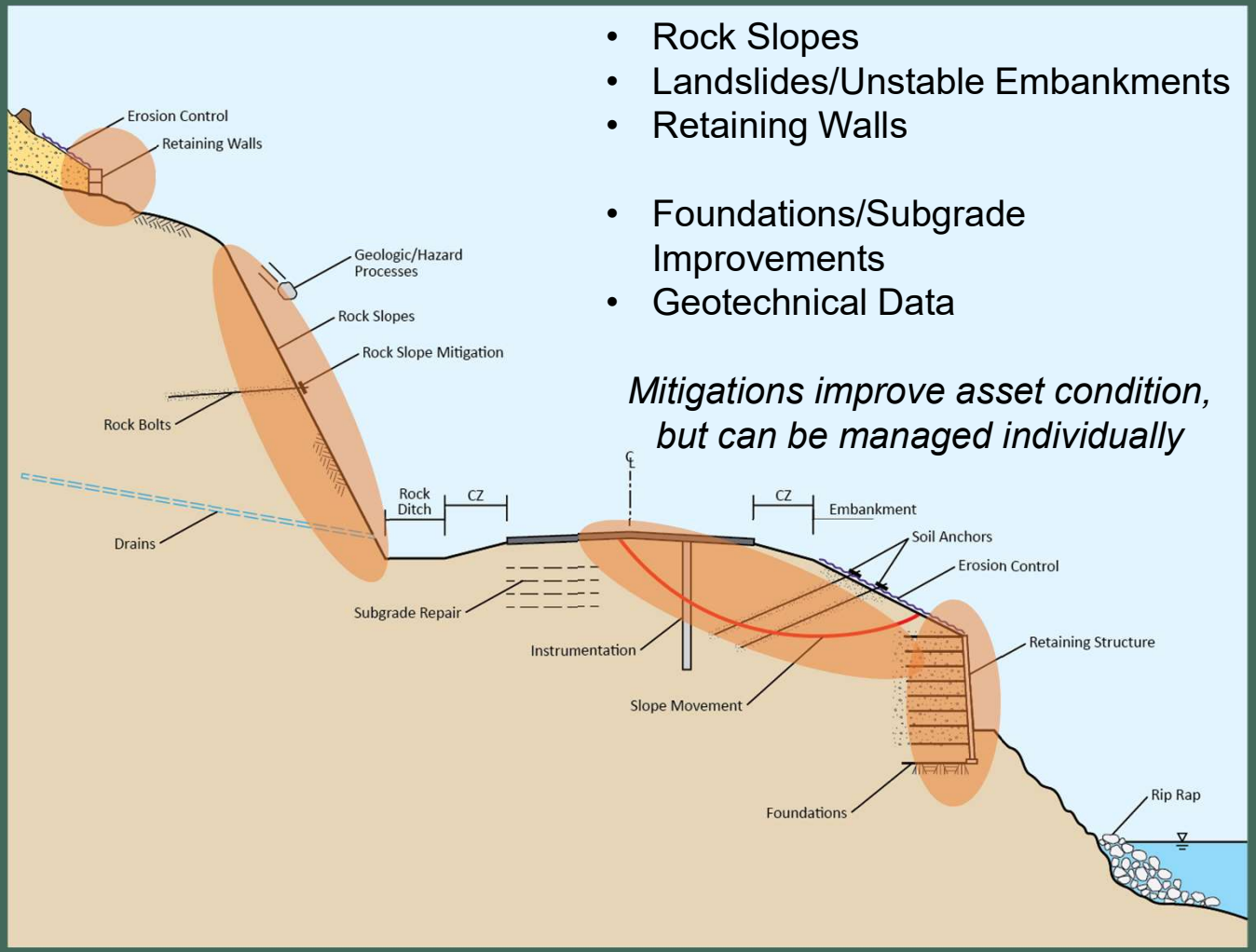
GAM Provides:

- Inventory
- Perf. Measures
- Deterioration Estimates
- Costs & Consequences
- Budgets to Achieve Set Goals

Geotechnical Asset Examples



Geotechnical Asset Examples



- Rock Slopes
- Landslides/Unstable Embankments
- Retaining Walls

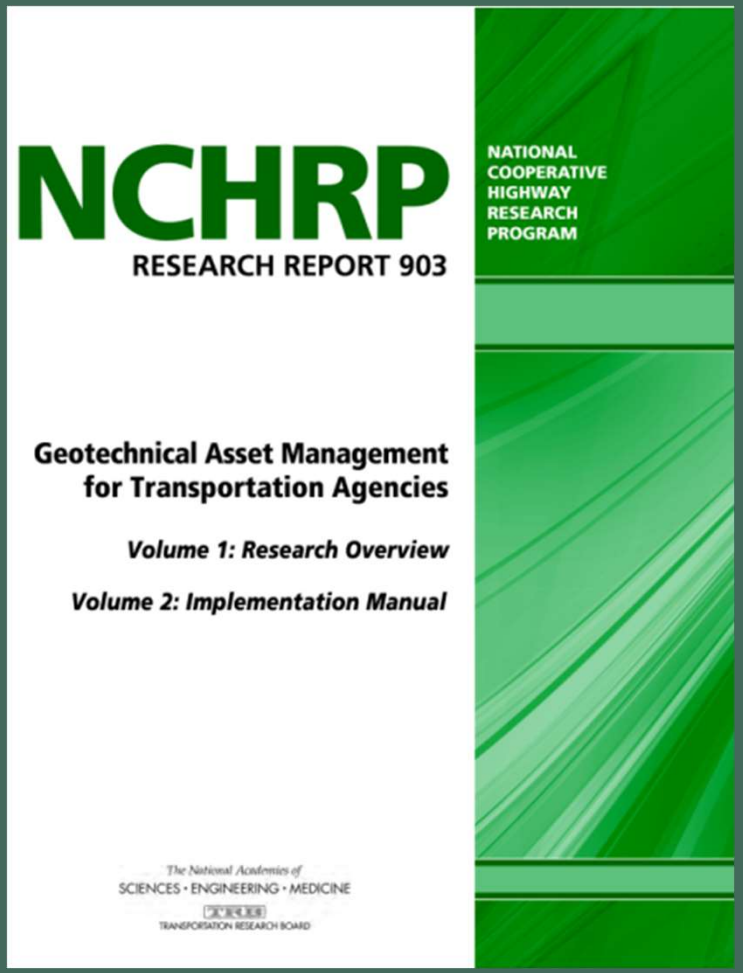
- Foundations/Subgrade Improvements
- Geotechnical Data

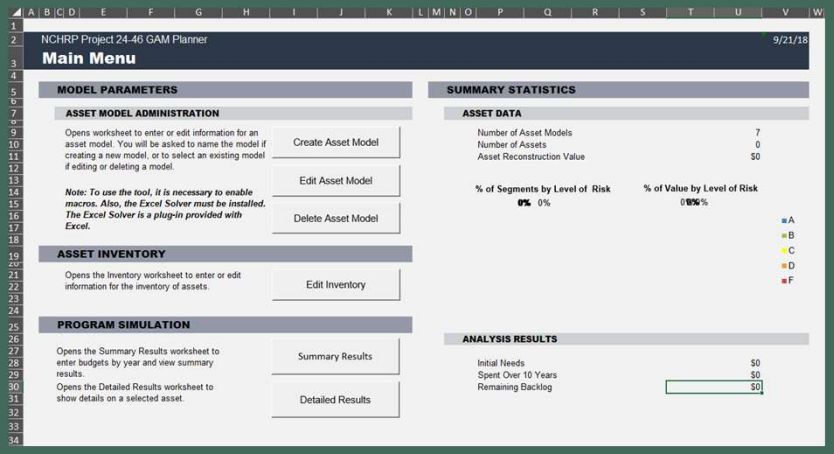
Mitigations improve asset condition, but can be managed individually

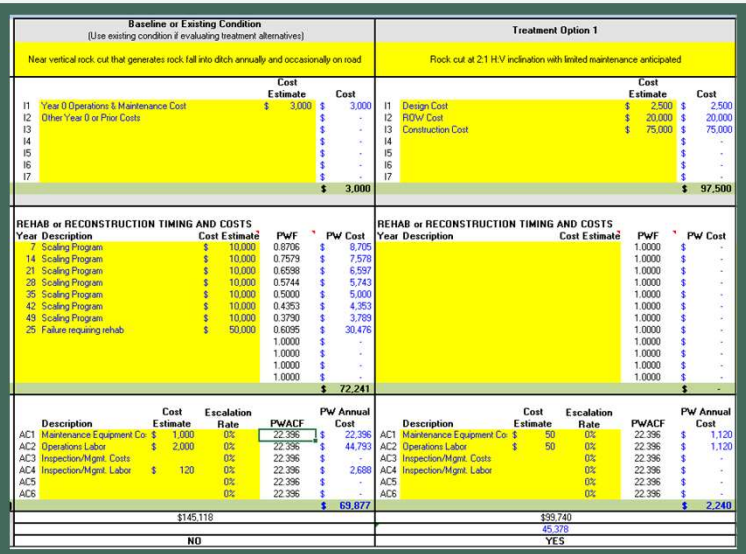
Statewide Program Scoping and Execution is Daunting

- Inventory
  - Many infrastructure owners don't know what is out there
  - Not knowing ≠ No liability ≠ No cost
    - *Doing the entire state is bananas; we are already fiscally constrained…maybe we can do it driving to and from various sites…*
- Condition assessment
  - What kind of shape is it in?
    - *Count and then estimate asset condition?!? Can maintenance personnel perform evaluations in the off-season? Interns!!*
- Risk Estimation and Evaluation Frameworks
  - How many traffic interruptions occur from geo events? Excess maintenance activities?
    - *We don't have all the crash and damage causation data. Can't invent it out of thin air.*
- Financial Planning
  - How much will costs increase by deferring maintenance? Will preservation now save replacement costs in the future?
    - *Geologists are hard enough to manage, now I need economists also?!?*

Guidance and Tools for GAM







- Guidance
- Blank Inventory and Condition Databases
- Fiscal Decision Support Tools
- Great Starting Point

NO REQUIREMENTS EXIST

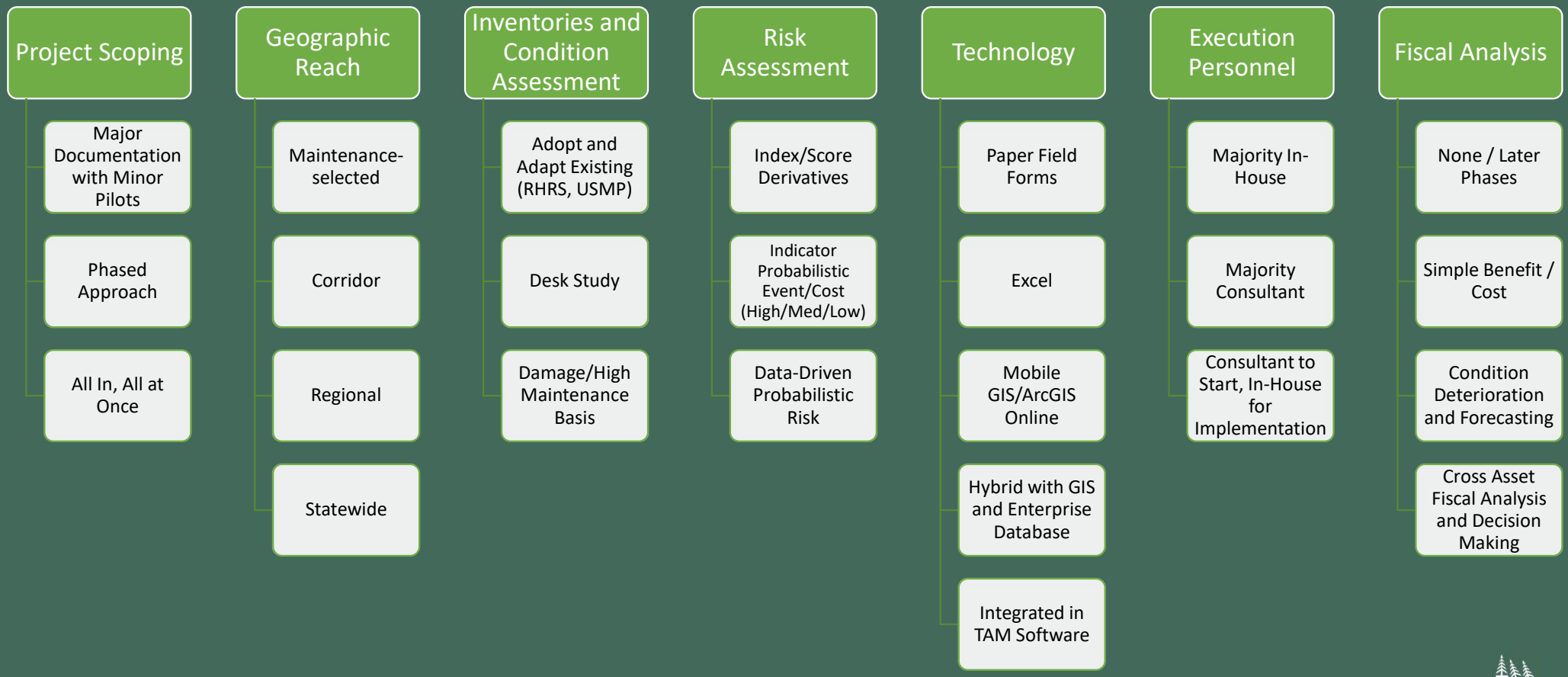
No Requirements Equate to Added Flexibility

- Scoping
  - Adopt known assessment systems with adjustments (i.e. RHRS, USMP)
  - Document with minor pilot programs
  - Scope inventory and condition, then figure out next phase
  - All in, all at once
- Inventory
  - Statewide, Regional, or Corridor
  - Desk, Field, Combo Study

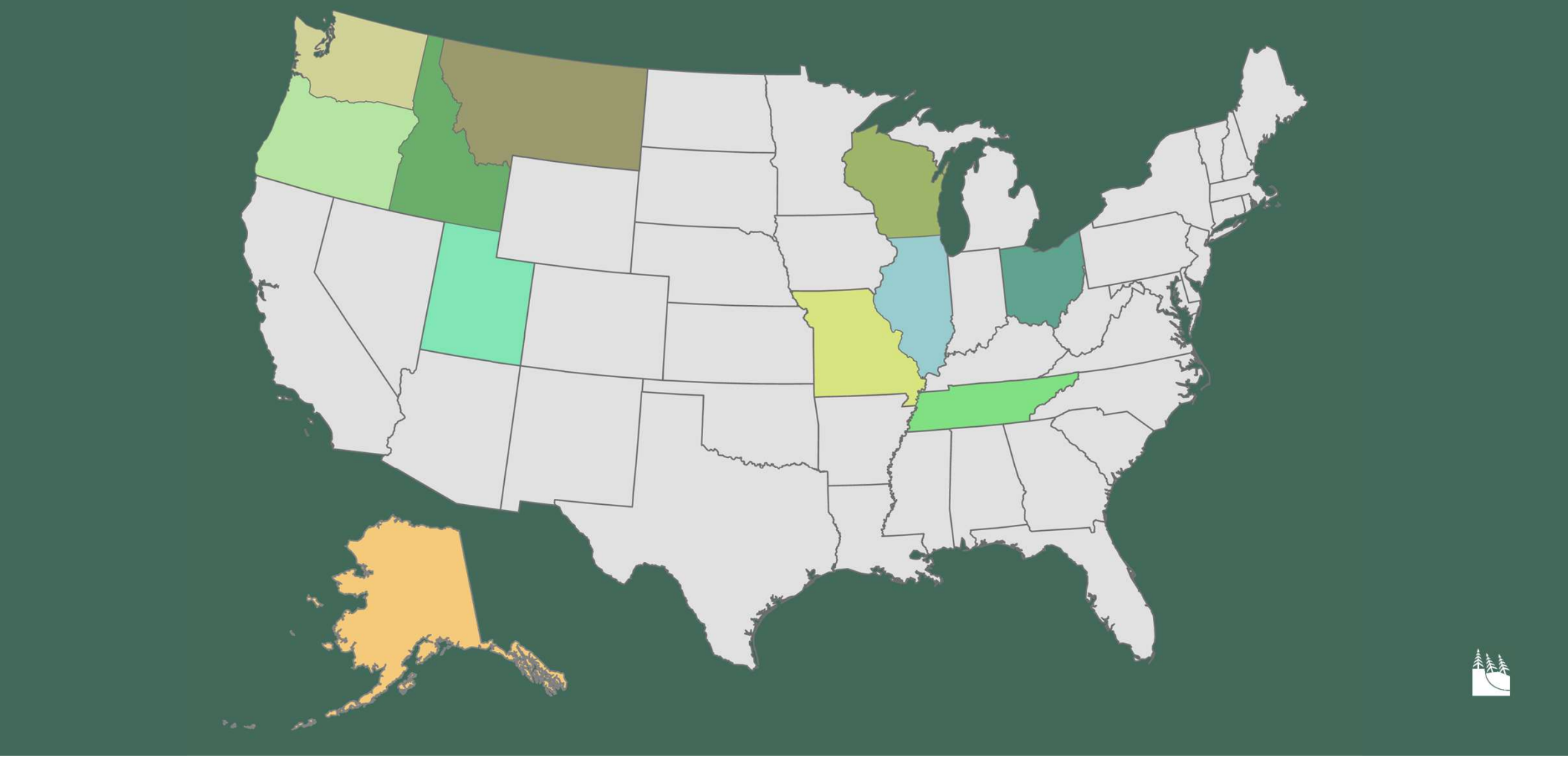
No Requirements Equate to Added Flexibility

- Project Scoping
- Geographic Reach
- Inventories and Condition Assessment
- Risk Assessment
- Technology
- Execution Personnel
- Fiscal Analysis

No Requirements Equate to Added Flexibility



No Requirements Equate to Added Flexibility



Alaska's Path (2013+/-)

Project Scoping	Geographic Reach	Inventories and Condition Assessment	Risk Assessment	Technology	Execution Personnel	Fiscal Analysis
Major Documentation with Minor Pilots	Maintenance-selected	Adopt and Adapt Existing (**RHRS**, **USMP, G/F/P**)	Index/Score Derivatives	Paper Field Forms	Majority In-House	None / Later Phases
Phased Approach	Corridor	Desk Study	Indicator Probabilistic Event/Cost (High/Med/Low)	Excel**/Access**	Majority Consultant	Simple Benefit / Cost
All In, All at Once **(Rock, Slides, Walls, Material Sources)**	Regional	Damage/High Maintenance Basis	Data-Driven Probabilistic Risk	Mobile GIS/**ArcGIS Online**	Consultant to Start, In-House for Implementation	Condition Deterioration and Forecasting
	Statewide **(NHS)**			Hybrid with GIS and Enterprise Database		Cross Asset Fiscal Analysis and Decision Making
				Integrated in TAM Software		

AKDOT&PF GAM Program Webpage

AKDOT&PF GAM Program Storymap

Development of the Unstable Slopes Management Program (USMP)

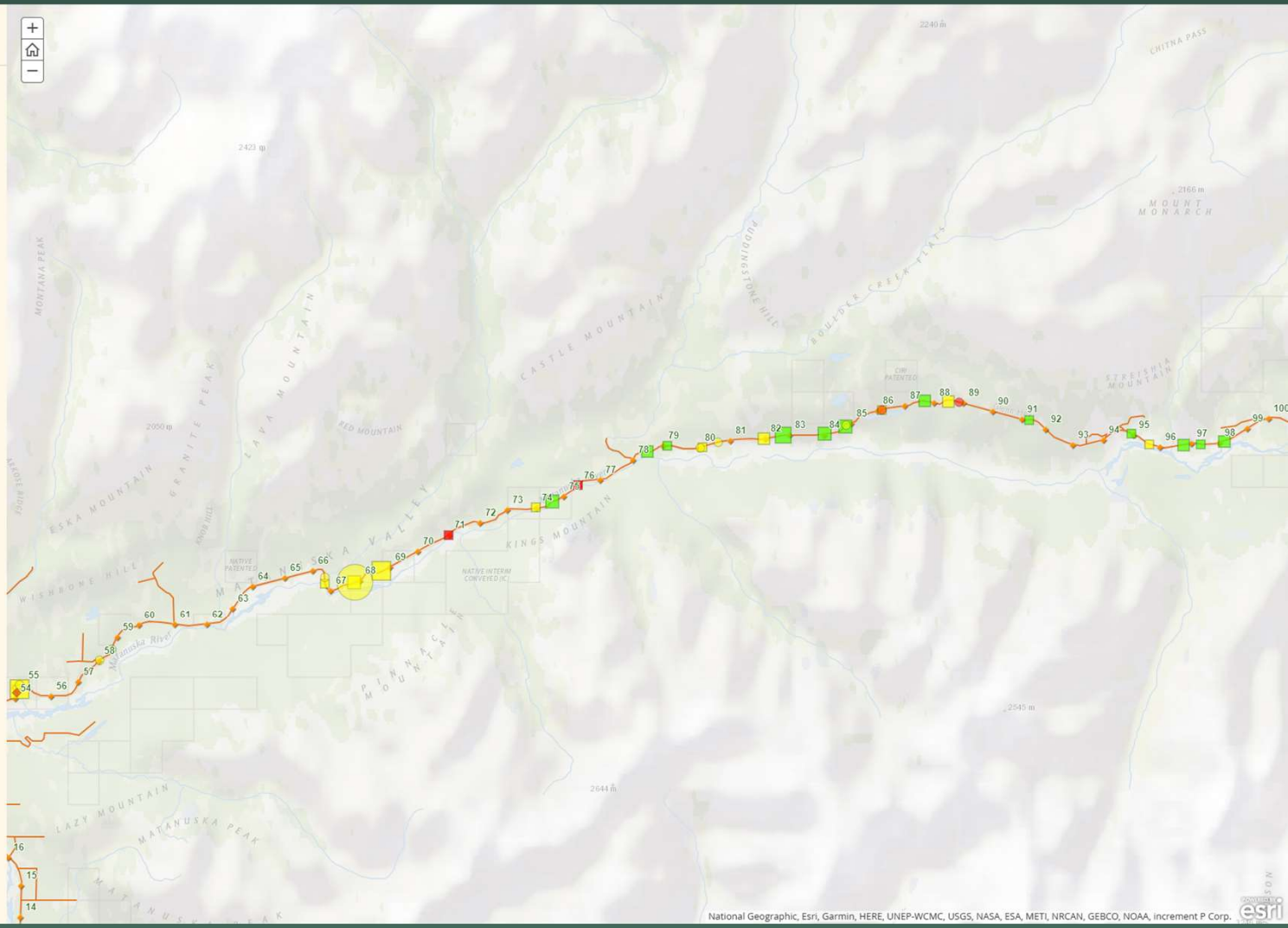
In 2010, AKDOT&PF began inventorying rock slopes and unstable soil slopes under the Unstable Slopes Management Program (USMP). Initial work focused on transportation corridor segments with a high concentration of poorly performing soil and rock slopes, like Long Lake on the Glenn Highway.

A field form was developed for geotechnical engineers or geologists to use in inventorying slopes. Raters spent 15 to 30 minutes at each site, and met with M&O personnel when possible to improve data capture of movement history or required maintenance. More detailed data capture would be part of work on a specific roadway improvement project.

The USMP rating rubric is similar to the Rockfall Hazard Rating Systems (RHRS) already used by many DOTs nationwide. Each category is scored on an exponential scale, with 100 being the worst possible category score. There are 17 final rating categories each with a maximum category score of 100, so the highest possible USMP score for a rock or soil slope was 1,700 points. In general, a higher score implied that a site was in worse condition or that a failure at this location would have a greater effect on the transportation system.

Unstable soil slope on Glenn Highway, MP 49.7. Total USMP score is 518.

Integrating Rock Slope Assets into GAM



https://akdot.maps.arcgis.com/apps/MapJournal/index.html?appid=15ca1b0297e94ad386c01cc459851ee8

Montana's Path (2004, 2017, Ongoing)

Project Scoping	Geographic Reach	Inventories and Condition Assessment	Risk Assessment	Technology	Execution Personnel	Fiscal Analysis
Major Documentation with Minor Pilots	Maintenance-selected	Adopt and Adapt Existing (**RHRS**, USMP, **G/F/P**)	Index/Score Derivatives	Paper Field Forms	Majority In-House	None / Later Phases
Phased Approach **Rock Slopes, Now Walls**	Corridor	**Desk Study**	Indicator Probabilistic Event/Cost (High/Med/Low)	Excel **Access 2004, Excel 2017**	Majority Consultant	Simple Benefit / Cost
All In, All at Once	Regional	Damage/High Maintenance Basis	Data-Driven Probabilistic Risk **Regional data -> Statewide**	Mobile GIS/ArcGIS Online **Locations, IDs Mapped**	Consultant to Start, In-House for Implementation **(GAM Manager)**	Condition Deterioration and Forecasting **(Expert Elicitation)**
	Statewide			Hybrid with GIS and Enterprise Database		Cross Asset Fiscal Analysis and Decision Making
				Integrated in TAM Software **(2004 – Oracle)**		

MDT RAMP Interface | New Tab

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

MDT's Rock Slope Asset Management Program (RAMP)

MDT RAMP Interface

RAMP site locations, classified by Good, Fair, or Poor Condition, overlaid with MDT Districts and highways sized by traffic volumes. Click and zoom to interact with the map. View the map outside this application with this link, where you can view the site data with greater ease.

RHRS Scores

I-15 North of Sieben exhibiting rock slopes above the Interstate.

RHRS Scores

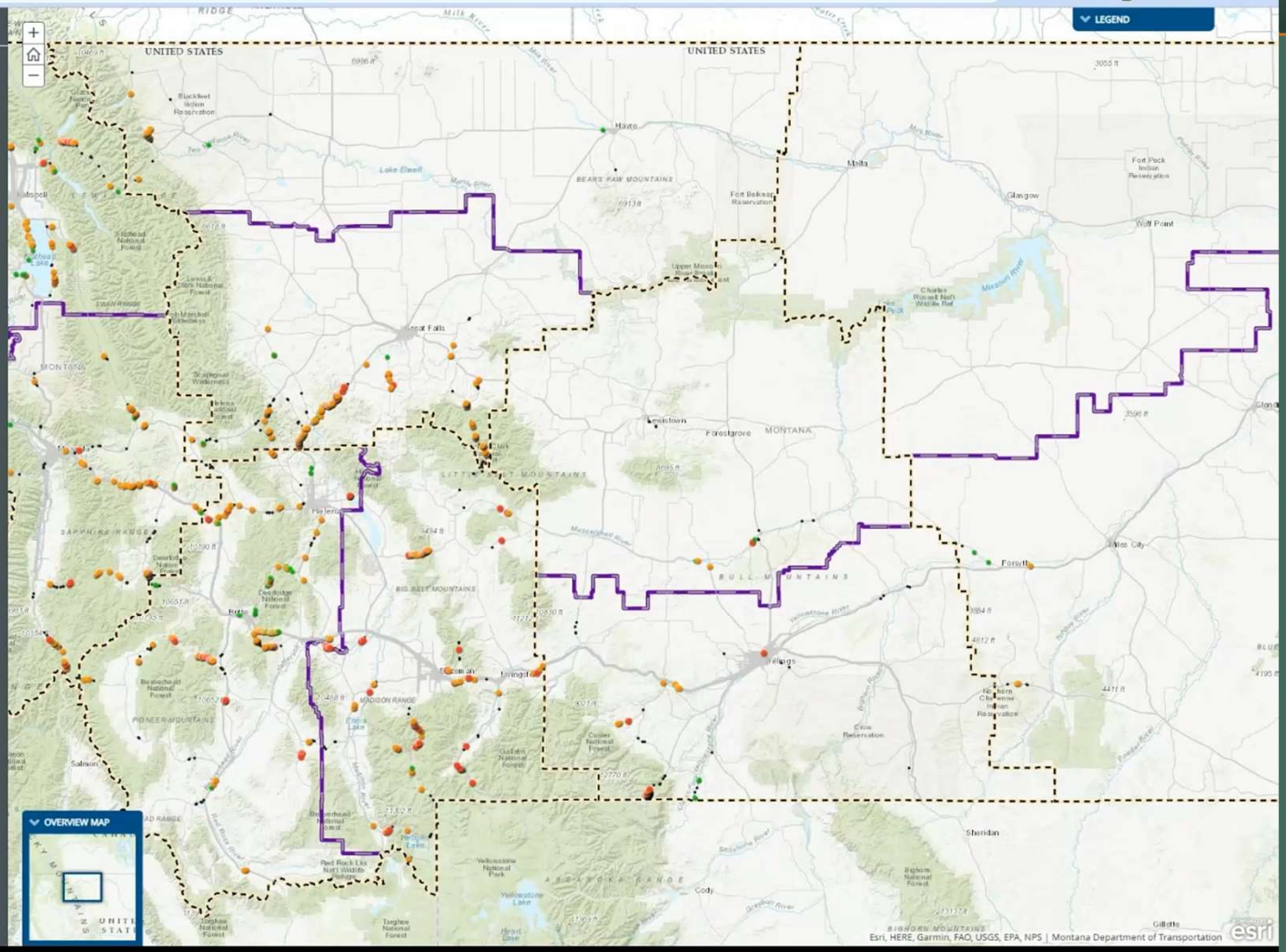
RAMP Sites Displayed as RHRS Scores. Map available at this link.

Condition Index

RAMP Sites Displayed by Condition Index. Map available here.

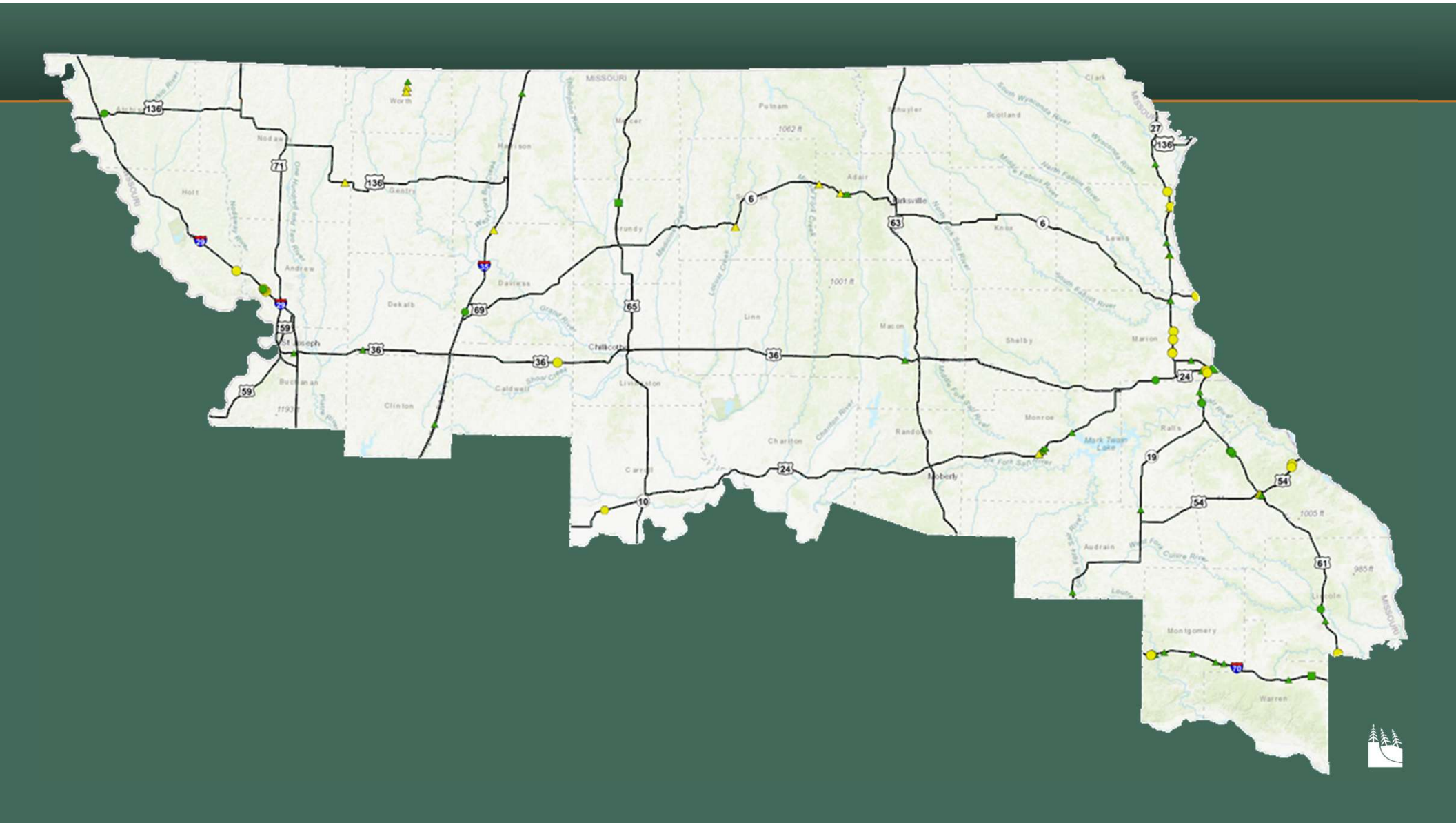
Condition State

RAMP Sites displayed by Condition State. Map available here.



Missouri's Path (2019)

Project Scoping	Geographic Reach	Inventories and Condition Assessment	Risk Assessment	Technology	Execution Personnel	Fiscal Analysis
Major Documentation with Minor Pilots	Maintenance-selected	Adopt and Adapt Existing (**RHRS, USMP, +**)	Index/Score Derivatives **(AADT)**	Paper Field Forms	Majority In-House	None / Later Phases
Phased Approach	Corridor	Desk Study **Existing Data Incorporated**	Indicator Probabilistic Event/Cost (High/Med/Low)	Excel	Majority Consultant	Simple Benefit / Cost
All In, All at Once	Regional	Damage/High Maintenance Basis	Data-Driven Probabilistic Risk	**Mobile GIS**/ArcGIS Online	Consultant to Start, In-House for Implementation	Condition Deterioration and Forecasting
	Statewide			Hybrid with GIS and Enterprise Database		Cross Asset Fiscal Analysis and Decision Making
				Integrated in TAM Software		


136
71
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69
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24
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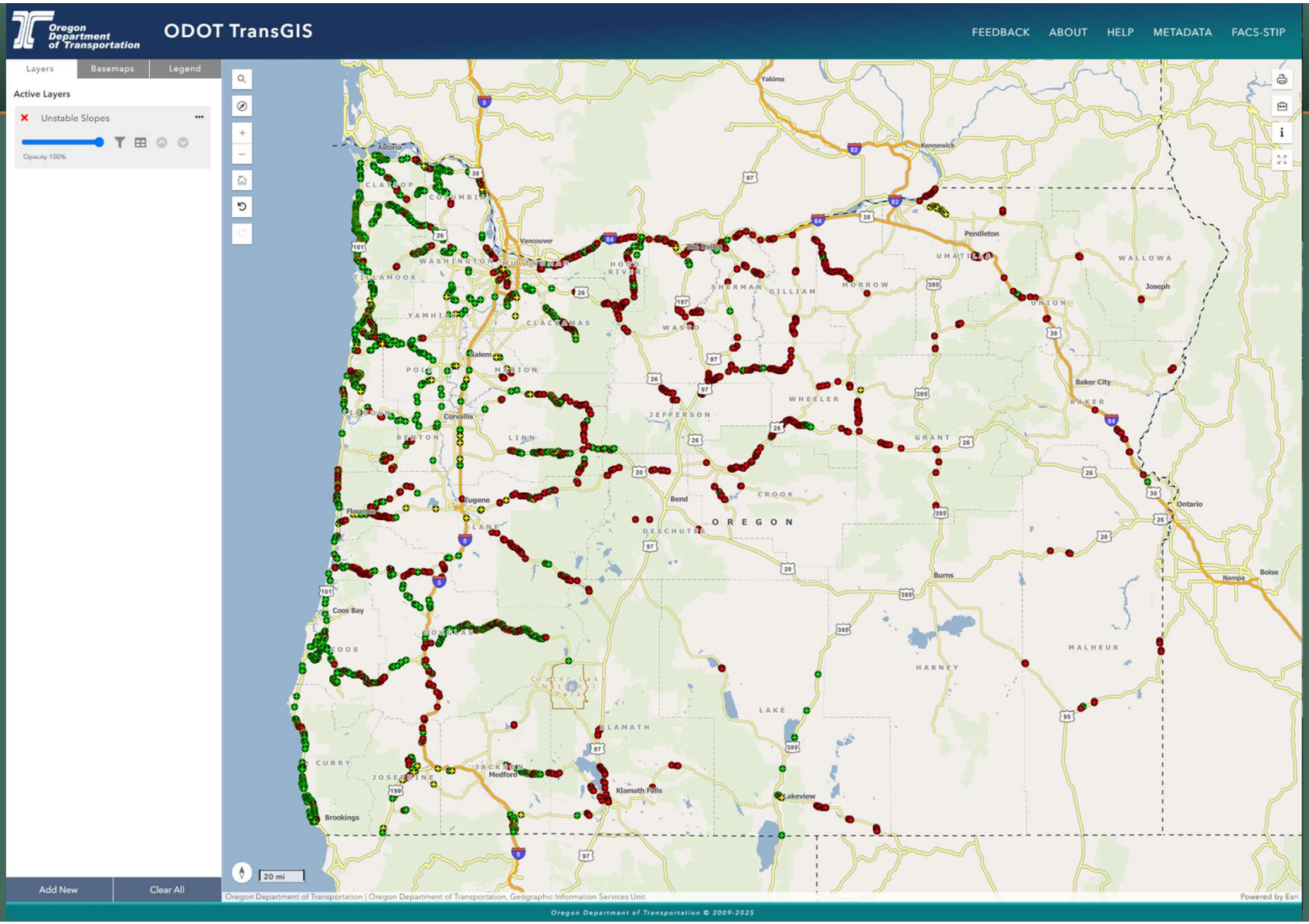
27
Worth
Nodaway
Holt
Andrew
Gentry
Harrison
Mercer
Putnam
Sullivan
Adair
Knox
Clark
Scotland
Lewis
Marion
Shelby
Macon
Linn
Chillicothe
Livingston
Caldwell
Clinton
DeKalb
Buchanan
Carroll
Charlton
Randolph
Monroe
Audrain
Ralls
Mark Twain Lake
Montgomery
Warren
Lincoln
MISSOURI

Oregon's Path (1990's onward)

Project Scoping	Geographic Reach	Inventories and Condition Assessment	Risk Assessment	Technology	Execution Personnel	Fiscal Analysis
Major Documentation with Minor Pilots	Maintenance-selected	Adopt and Adapt Existing (**RHRS**, USMP)	Index/Score Derivatives	Paper Field Forms	Majority In-House **(minor consultant)**	None / Later Phases
Phased Approach	Corridor	Desk Study	Indicator Probabilistic Event/Cost (High/Med/Low	Excel	Majority Consultant	Simple Benefit / Cost **(no economists)**
All In, All at Once	Regional	Damage/High Maintenance Basis	Data-Driven Probabilistic Risk	Mobile GIS/**ArcGIS Online**	Consultant to Start, In-House for Implementation	Condition Deterioration and Forecasting
	Statewide **(some still undone)**			Hybrid with GIS and Enterprise **(GIS)** Database		Cross Asset Fiscal Analysis and Decision Making
				Integrated in TAM Software		


Oregon Department of Transportation
ODOT TransGIS
FEEDBACK
ABOUT
HELP
METADATA
FACS-STIP
Layers
Basemaps
Legend
Active Layers
Unstable Slopes
Opacity 100%
Add New
Clear All
20 mi
Oregon Department of Transportation | Oregon Department of Transportation, Geographic Information Services Unit
Powered by Esri
Oregon Department of Transportation © 2009-2025
OREGON
Yakima
Kennewick
Pendleton
Vancouver
Portland
Salem
Eugene
Corvallis
Bend
Astoria
Coos Bay
Brookings
Medford
Klamath Falls
Lakeview
Baker City
Ontario
Boise
Nampa
Burns
Joseph

Utah's Path (2024)

Project Scoping	Geographic Reach	Inventories and Condition Assessment	Risk Assessment	Technology	Execution Personnel	Fiscal Analysis
~~Major Documentation with Minor Pilots~~	Maintenance-selected	Adopt and Adapt Existing (RHRS, USMP) **(~2004)**	Index/Score Derivatives	Paper Field Forms	Majority In-House	None / Later Phases
~~Phased Approach~~	Corridor **One select geohazards corridor**	Desk Study **(incl. LiDAR and UAVs)**	Indicator Probabilistic Event/Cost (High/Med/Low	Excel	Majority Consultant	Simple Benefit / Cost
~~All In, All at Once~~	Regional	Damage/High Maintenance Basis	Data-Driven Probabilistic Risk **(Borrowed)**	Mobile GIS/ArcGIS Online	Consultant to Start, In-House for Implementation	Condition Deterioration and Forecasting
	Statewide			Hybrid with GIS and Enterprise Database		Cross Asset Fiscal Analysis and Decision Making
				Integrated in TAM Software		

Utah's Path (2024)

UDOT Rock Slope Assessment Form

Fill in orange cells

Ver. 1.00 April 2024

Assessed By	Rachel Hunt		
Assessment Date	4/25/2024		
Hazard Type	Rockfall	Photo Range	
Slope Beginning Latitude	39.719211	39.717379 t Number	3268
lope Beginning Longitude	-110.866556	-110.868133 Slope ID	3_0006NM_MP230.42_RF

Site Information

Region	3	Highway Name	US 6	Mitigation Present?	NO
County	Utah	Milepost Start	230.42	Anchors?	
Route Name	0006	Milepost End	230.59	Shotcrete?	
Functional Classification	Other Principle Arteri	Side	Right	Fence?	
Rating Status				Mesh?	
AADT (Count)	11773	AADT (Year)	2022	Drains?	
Failure Type	Differential Erosion				

Comments

The rock slope is above a weigh station. Maintenance reported a car-sized block crushed a van parked here. This facility appears to have been vacated for a few years and is now permanently abandoned.

Character Count 139

Site Measurements

Slope Height (ft)	690	adway Width (ft)	80
Roadway Length (ft)	850		
Slope Angle (°)	40	eed Limit (mph)	55
Ditch Width (ft)	12	nual Precip. (in)	13.65
Ditch Depth (ft)	0	ht Distance (ft)	1050
Ditch Slope (°)	0	ASHTO DSD (ft)	875
Block Size (ft)	10		
Event Volume (cy)	0		

RHRS Rating — EXP

Ditch Effectiveness	Moderate	h Effectiveness Score	27
Rockfall Activity	Few	B. Rockfall Activity Score	3
Case 1 Structure		C. Geologic Character Score	54
Case 1 Joint Friction		D. Slope Height Score	100
Case 2 Struc-Features	Many differential erosional features	E. Block Size or	100
Case 2 Diff Erosion	Large difference	F. Annual Precipitation Score	4
Maintenance Frequency	Normal, scheduled maintenance	G. Roadway Width Score	1
Slope Drainage	Slope appears dry or well-drained; surface runoff well controlled	H. Average Vehicle Risk Score	100
		I. Decision Sight Distance	1
		J. Maintenance Frequency	3
		K. Slope Drainage	3
Evaluation Result Summary		Total Score:	396

Total RHRS Score	396	Condition State (G/F/P)	2 FAIR
Condition Index (A+B)	75		
Risk Index (G+H+I)	67		

Risk Analysis — Risk Result Summary

Avg. Disruption Duration	6	ual Likelihood of Disruption	1.81%
Typical Detour Add. Dist. (mi)	65.5	ikelihood of Injury Accident	0.91%
Typ. Detour Add. Time (min)	82	nnual Mobility Consequence	$ 19,971.08
Slowdown Delay (min)	10	Annual Safety Consequence	$ 516.12
Add. delay duration (days)	7	t. Annual Maintenance Cost	$ 1,041
Average disruption duration is 6 hrs; Rater may adjust duration based on judgement		nnual Risk and Maint. Cost	$ 21,528
		Est. Annual Agency Benefit	$ 73,348
		Est. Total Economic Loss (30 yrs)	$ 450,586
		Est. Cost to Improve to CS 1	$ 4,063,858.50

UDOT Landslide Assessment Form

Fill in green cells

Ver. 1.00 April 2024

Assessed By	Rachel Hunt				
Assessment Date	4/24/2024				
Hazard Type	Landslide	Photo Range			
ginning, Ending Latitude	39.77924	39.778558	Proj. No.	3268	
pe Beginning Longitude	-110.918154	-110.917383	Slope ID	3_0006NM_MP225.12_LS	

Site Information

Region	3	Highway Name	US 6	Mitigation Present?	NO
County	Utah	Milepost Start	225.12	Buttress?	
Route Name	0006	Milepost End	225.18	Rock Inlay?	
Functional Classification	Other Principle Arter	Side	Right	Soil Nails?	
Rating Status		Location	Above	inage Improvements?	
AADT (Count)	9151	AADT (Year)	2022	Drains?	
Failure Type	Debris Flow				

Comments

Debris chute

Character Count 12

Site Measurements

Axial Length of Slide (ft)	190	idway Width (ft)	47
Slope Angle (°)	30	Roadway Length Affected (ft)	326
dway Width Affected (ft)	12	eed Limit (mph)	50
		ual Precip. (in)	16.66
		ht Distance (ft)	1050
		ASHTO DSD (ft)	750

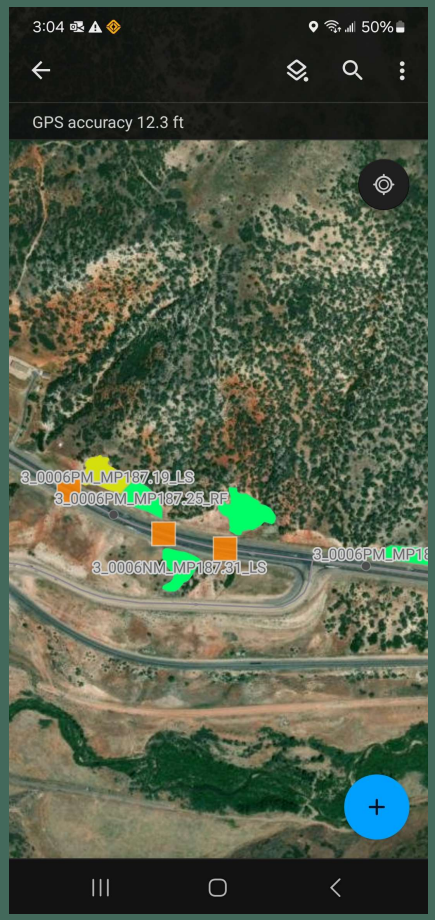
Modified USMP Rating — EXP

dway Width Affected (%)	26%	Roadway Width Affected Score	27
Displacement/Slide Deposit	1 inch offset, or 6-inch deposit of material / major erosion will affect travel in < 5 years	B. Slide/Erosion Affects Score	9
		C. Length of Roadway Axial Length of Slide	53 100
Maintenance Frequency	Every year	F. Maintenance Frequency	81
Movement History	Up to 3 inches per event, one event per yea	G. Movement History	15
Slope Drainage	Water usually on slope; poorly drained; or surface runoff poorly controlled	H. Slope Drainage Score	27
		I. Annual Precipitation Score	6
		J. Roadway Width Score	2
		K. Average Vehicle Risk Score	8
		L. Decision Sight Distance	1
Evaluation Result Summary		Total Score:	329

Total RHRS Score	329	Condition State (G/F/P)	3 FAIR
Condition Index (A+B+G)	47		
Risk Index (J+K+L)	93		

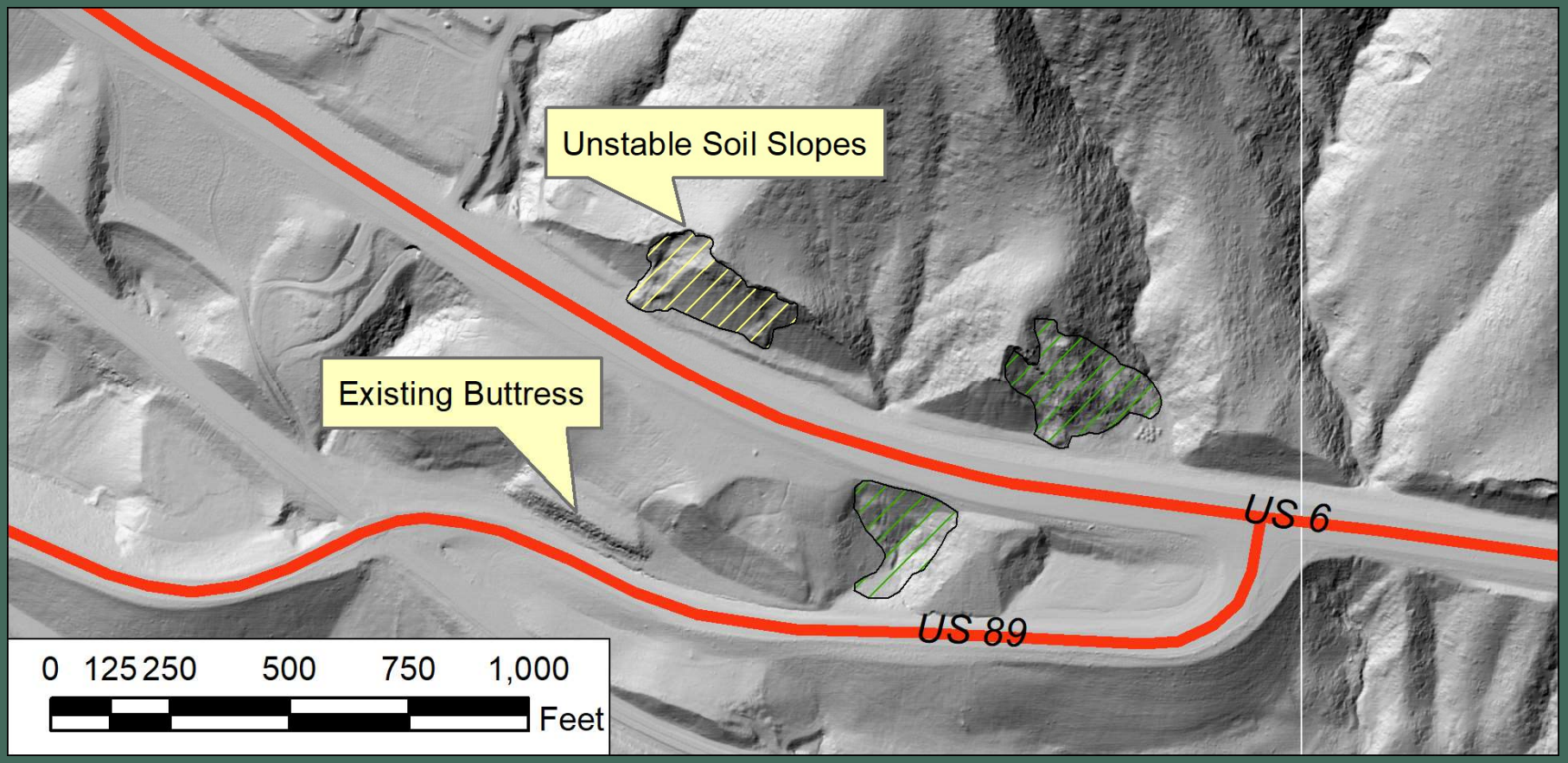
Risk Analysis — Risk Result Summary

Avg. Disruption Duration	6	Likelihood of Disruption in 10 yrs if untreated	Medium
Typical Detour Add. Dist. (mi)	65.5		
Typ. Detour Add. Time (min)	82	Est. Cost to Improve to CS 1	$ 1,194,444.57
Slowdown Delay (min)	10		
dd. delay duration (days)	7		
Average disruption duration is 6 hrs; Rater may adjust duration based on judgement			



Utah’s Path (2024)

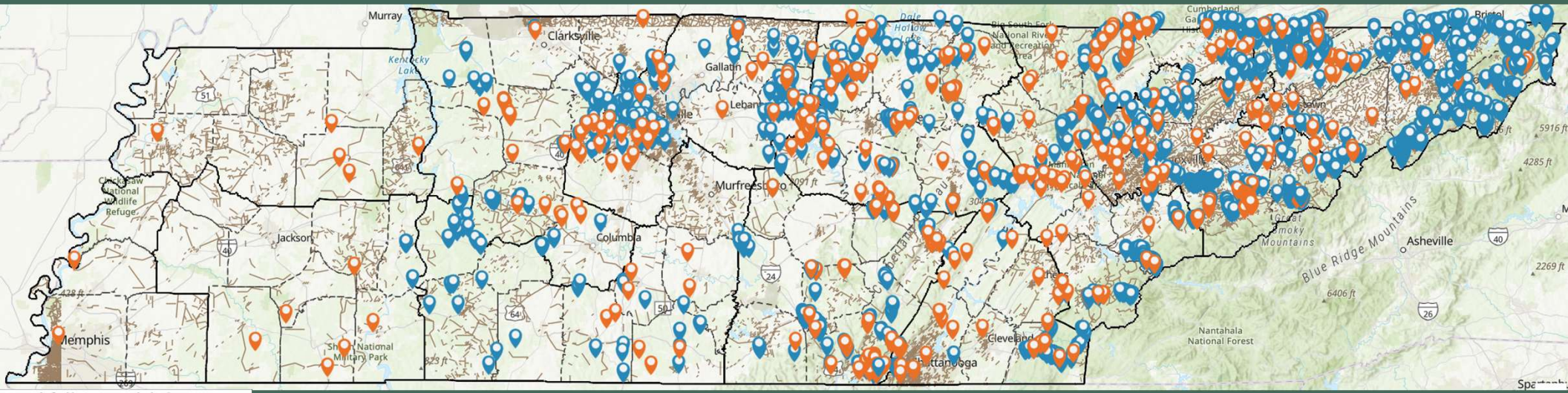
Utah's Path (2024)



Tennessee's Path (2002-2007, ~2018 onward)

Project Scoping	Geographic Reach	Inventories and Condition Assessment	Risk Assessment	Technology	Execution Personnel	Fiscal Analysis
Major Documentation with Minor Pilots	Maintenance-selected	Adopt and Adapt Existing (RHRS, USMP)	Index/Score Derivatives	Paper Field Forms	Majority In-House	None / Later Phases
Phased Approach	Corridor	Desk Study	Indicator Probabilistic Event/Cost (High/Med/Low	Excel	Majority Consultant	Simple Benefit / Cost
All In, All at Once	Regional	Damage/High Maintenance Basis	Data-Driven Probabilistic Risk	Mobile GIS/ArcGIS Online	Consultant to Start, In-House for Implementation	Condition Deterioration and Forecasting
	Statewide			Hybrid with GIS and Enterprise Database		Cross Asset Fiscal Analysis and Decision Making
				Integrated in TAM Software		

Tennessee's Path



Ohio's Path (2000's onward)

Project Scoping	Geographic Reach	Inventories and Condition Assessment	Risk Assessment	Technology	Execution Personnel	Fiscal Analysis
Major Documentation with Minor Pilots	Maintenance-selected	Adopt and Adapt Existing (RHRS, USMP)	Index/Score Derivatives	Paper Field Forms	Majority In-House	None / Later Phases
Phased Approach	Corridor	Desk Study	Indicator Probabilistic Event/Cost (High/Med/Low	Excel	Majority Consultant	Simple Benefit / Cost
All In, All at Once	Regional	Damage/High Maintenance Basis	Data-Driven Probabilistic Risk	Mobile GIS/ArcGIS Online	Consultant to Start, In-House for Implementation	Condition Deterioration and Forecasting
	Statewide			Hybrid with GIS and Enterprise Database		Cross Asset Fiscal Analysis and Decision Making
				Integrated in TAM Software		

Rock Slope Dashboard

This dashboard provides a high level view of Rock Slope Inventory data.

Dashboard Generated: 5/12/2025 6:03:58 PM

Department of Transportation
Office of Data Governance

DISTRICT: All | COUNTY: All | LATEST TIER: All | MAINTENANCE RESPONSIBILITY: All

2,431 RS INSPECTION DUE

3,718 RS TIER 1 SITES

1,072 RS TIER 2 SITES

456 RS TIER 3 SITES

12 RS TIER 4 SITES

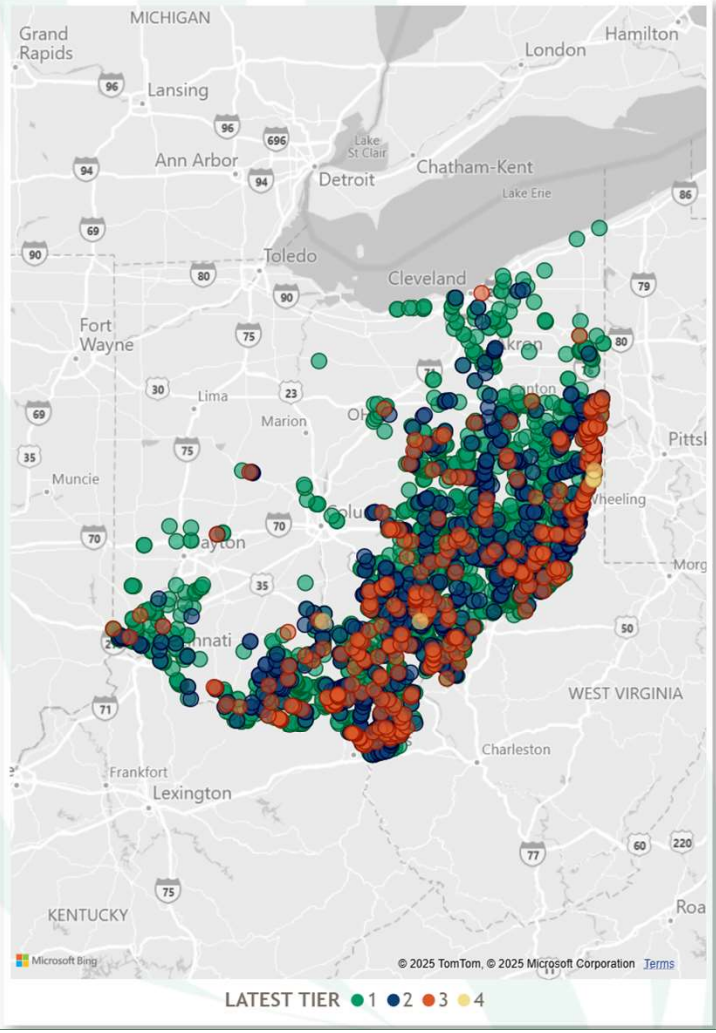
5,259 ACTIVE RS SITES

172 REMEDIATED RS SITES

15 NEW RS SITES THIS YEAR

2 PROGRESSING RS SITES

ROCK SLOPE SITE ID	DISTRICT	COUNTY	NLFID	CTL BEGIN NUMBER	CTL END NUMBER	LATEST EMGY DETER	CREATED DATE
RS00000004	10	ATHENS	SATHUS00050**N	21.481			10/30/2020 6:54:41 PM
RS00000005	10	ATHENS	SATHUS00050**N	22.766			10/30/2020 6:54:41 PM
RS00000006	10	ATHENS	SATHSR00356**C	4.093			10/30/2020 6:54:41 PM
RS00000007	10	ATHENS	SATHSR00356**C	2.109			10/30/2020 6:54:41 PM
RS00000008	10	ATHENS	SATHSR00144**C	4.821			10/30/2020 6:54:41 PM
RS00000009	10	ATHENS	TATHTR01337**C	0.931			10/30/2020 6:54:41 PM
RS00000011	10	ATHENS	SATHSR00013**C	13.612	13.710	No	10/30/2020 6:54:41 PM
RS00000012	10	ATHENS	SATHSR00013**C	6.357	6.507	No	10/30/2020 6:54:41 PM
RS00000013	10	ATHENS	SATHSR00013**C	6.350	6.460	No	10/30/2020 6:54:41 PM
RS00000015	10	ATHENS	SATHUS00050**N	23.121			10/30/2020 6:54:41 PM
RS00000016	10	ATHENS	SATHSR00329**C	16.647			10/30/2020 6:54:41 PM
RS00000017	10	ATHENS	SATHSR00078**C	4.314	4.351	No	10/30/2020 6:54:41 PM
RS00000018	10	ATHENS	SATHRA05007**C	0.162	0.050	No	10/30/2020 6:54:41 PM
RS00000019	10	ATHENS	SATHUS00033**N	14.559	14.655	No	10/30/2020 6:54:41 PM
RS00000020	10	ATHENS	SATHRA05042**C	0.552			10/30/2020 6:54:41 PM
RS00000021	10	ATHENS	PATHMR80271**C	0.123			10/30/2020 6:54:41 PM
RS00000022	10	ATHENS	SATHUS00033**C	22.509			10/30/2020 6:54:41 PM
RS00000023	10	ATHENS	SATHUS00050**N	28.325			10/30/2020 6:54:41 PM
RS00000024	10	ATHENS	SATHUS00050**N	27.476			10/30/2020 6:54:41 PM
RS00000025	10	ATHENS	SATHUS00050**N	27.089			10/30/2020 6:54:41 PM
RS00000026	10	ATHENS	SATHUS00050**N	27.001			10/30/2020 6:54:41 PM



Key Takeaways/Suggestions

- No ‘One Way’ to get started
  - Use GAM how your Department (DOT, geotech/materials division) see fit…
- Consider a regional (county/region/corridor/highway system) ‘big picture’ and gauge time and scope based on a pilot
  - Make the pilot a ‘go it alone’ approach and then see who needs to be engaged?
  - Jump in with field assessments with an existing paper form (USMP) with some tweaks (AADT, maintenance cost ranges, etc.)
- Use existing services to leverage existing IT investments
  - https://*YOUR STATE HERE*.maps.arcgis.com/
- Go Big?

TRY IT OUT AND GET STARTED!


Thank You!