Rockfall Hazard Evaluation and Prioritization: A Case Study in Northwestern New Mexico

Randy Post, PE
Senior Lead Consultant, Geological Engineer
Tucson, AZ USA

Henok Tiruneh, PhD, PE, PG
Senior Consultant, Geological Engineer
Atlanta, GA USA

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NMDOT

STGEC '24
Southeastern Transportation Geotechnical Engineering Conference

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Baton Rouge, LA

Hosted by
DOTD

Project Overview

110 Miles
Of rockfall-prone highway to evaluate

12 Corridors
Spread around Northwest New Mexico

10 Highways
Mostly rural
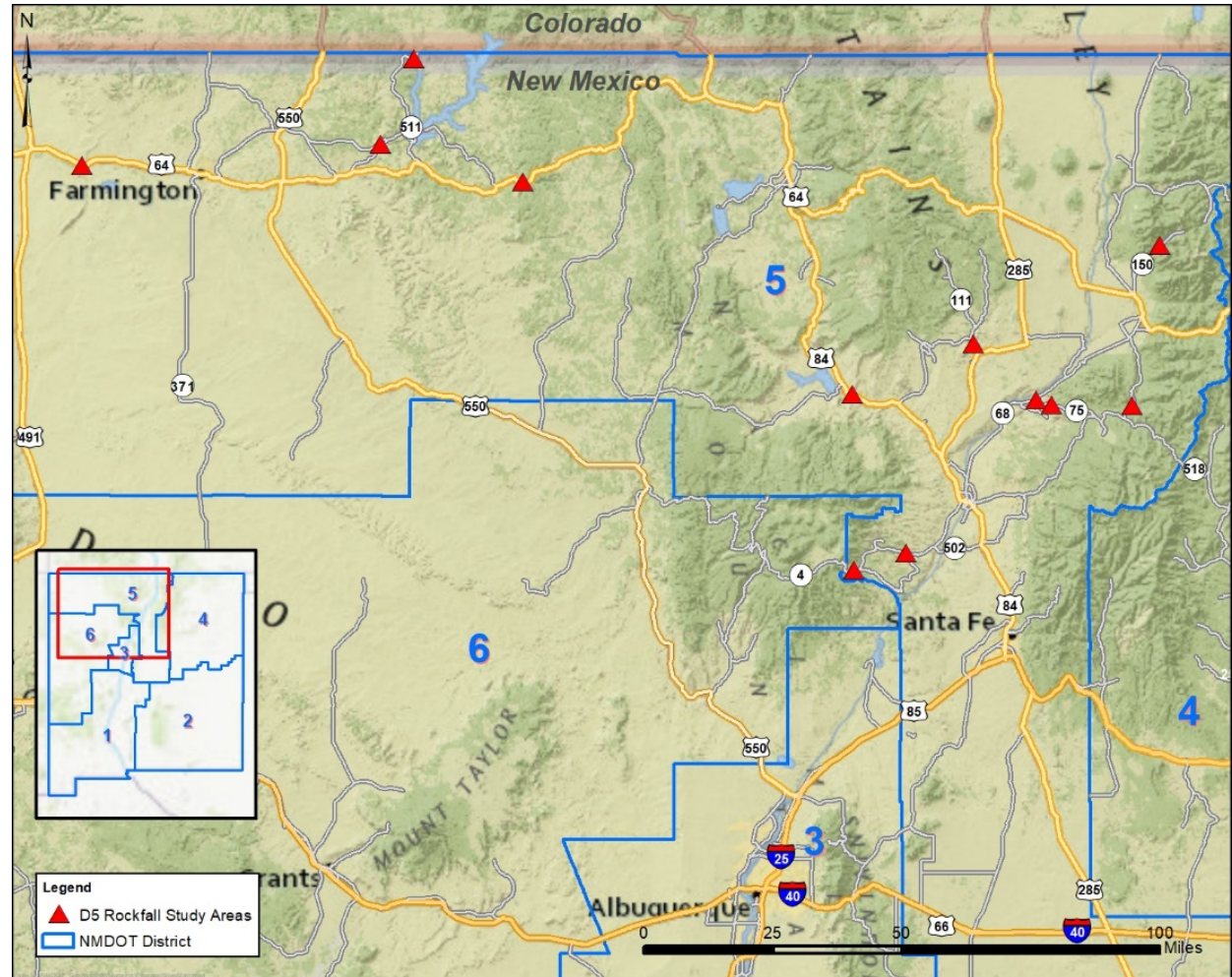
Inventory
Inventory rockfall sites

Assess
Categorize rockfall hazard

Prioritize
Conceptual mitigation design and costing

Project Overview

Methodology

1. Desktop Inventory

2. Develop Rockfall Ranking Rating System (Class 1 to 3)

3. Field Investigation and Verification

4. Develop Online ArcGIS System

5. Meeting with Maintenance Patrols

6. Develop Conceptual Mitigation Design and Cost Estimates

7. Summarize Results and Develop Power BI Dashboard

Desktop Inventory

1 Google Earth / Streetview

2 240 RHRS records

3 Crash Data

4 Environmental

5 Land Ownership / ROW

6 Populate ArcGIS Online

Project Rockfall Ranking System

Class 1

The most significant impact to safety and in some cases, maintenance and mobility. To be mitigated first.

Class 2

Intermediate sites, but still relatively high risk. Group with Class 1 sites where it makes sense.

Class 3

Judged to be low hazard and consequence of rockfall, or sites with existing mitigation.

Field Investigation

ArcGIS Survey123

Boots on the Ground

Visited ~200 sites

ArcGIS Survey 123 form

Confirm Deskop Data

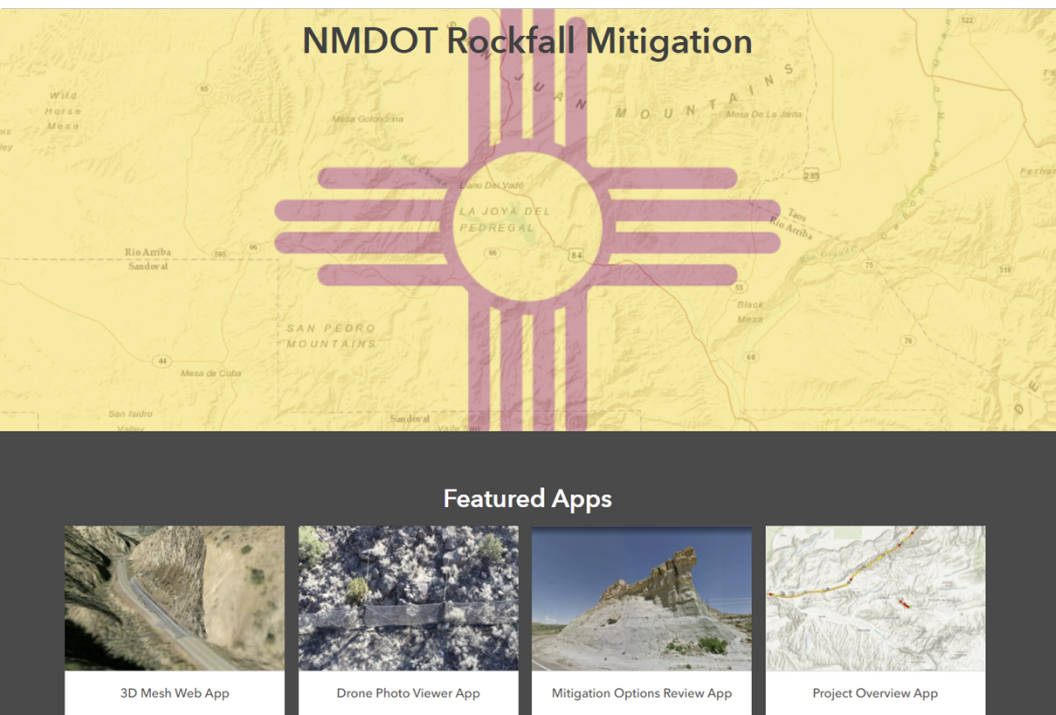Revise Site Class on AGOL

Propellers in the Air

Drone data at 10 sites

Used for existing fence inspections – Very useful for very large area

3D Models at more complex sites

7

ArcGIS Online Interface (AGOL)

Front End for Inventory

Length of slope hazard

Approximate slope height

Block sizes

Existing mitigation

Ditch configuration and condition

Rockfall hazard class
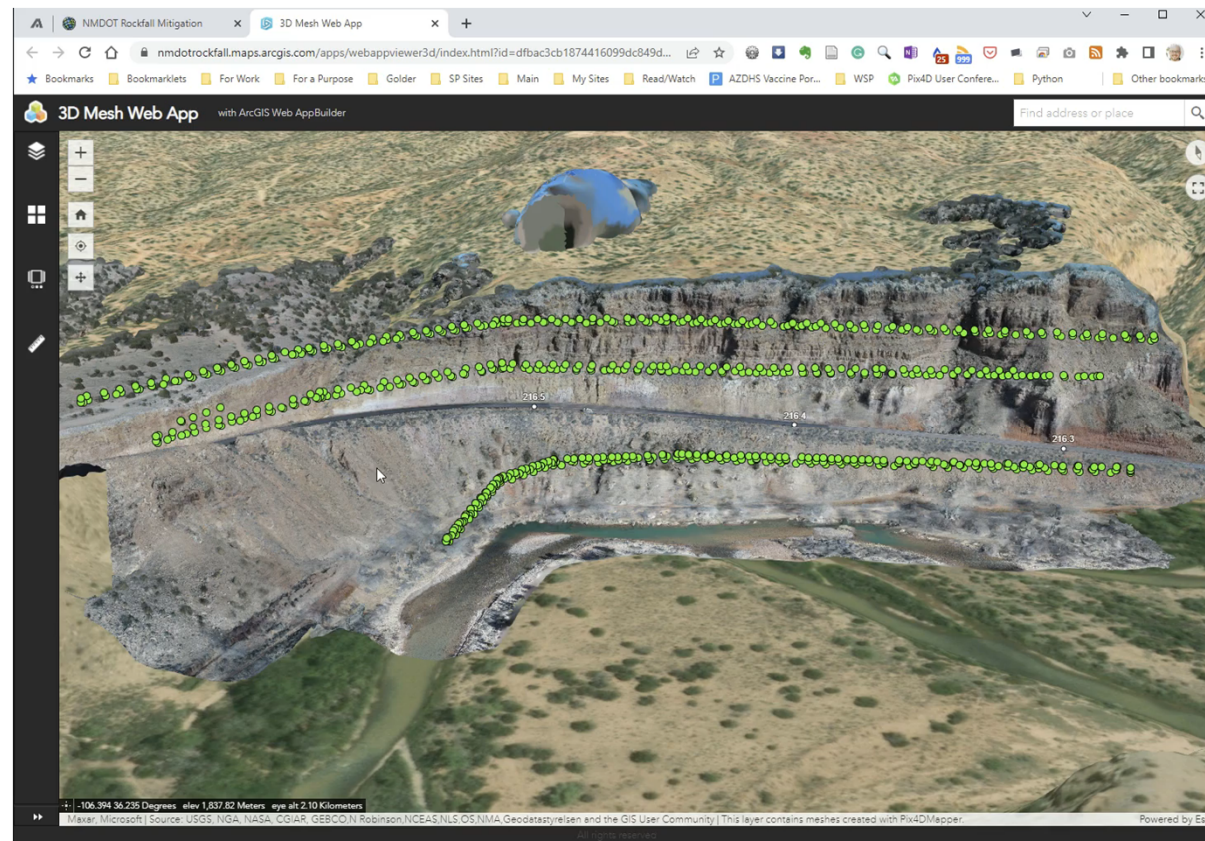
Visualization of 3d Meshes

Safely view site

Measure for quantities

Review Photos and Mitigation

Useful for Patrol meetings

AGOL For 3D Data

Environmental and Right of Way Screening Criteria

1   Land Ownership

2   Critical Habitat

3   National Wetland Inventory

4   NPS / BLM / USGS Sensitive Areas

5   Cultural Resource Boundaries

6   ROW Data Availability and Mitigation Impact

Meetings with Maintenance Patrols

Perhaps MOST Important!

Institutional / practical knowledge

9 different orgs/patrols

Help estimate frequency / severity

Preference for mitigation option

Primary Rockfall Site Database

Built from Scratch
Microsoft Access Front End

Data stored on SharePoint List Back End

Sites

Build Mitigation Estimates
Sites

- Mitigation Options (e.g. Mesh Mitigation)

   + Mitigation Elements (e.g. Scaling by the hour, Mesh by the sq. ft., ditch ex. By the lf, etc)

Cost estimates by site, and aggregated

Unit costs common throughout project

QC Tools

Conceptual Mitigation Design

Mitigation Options

Ditch cleanout

Scaling

Temporary concrete barrier

Soil or rock excavation

Draped mesh

Pinned mesh

Rockfall Fence

Soil Nail wall

MSE wall rockfall barrier

Selection Criteria

Technical

Cost (capital and maintenance)

District and maintenance preference

ROW and adjacent land ownership

Environmental and cultural

Cost Estimating

System Level Cost Estimating

Previous NMDOT and CDOT costs

Simplifying assumptions

Built using database

Simple measurements for quantities

Mitigation Items With Descriptions and Unit Costs

ItemType	Item Name	Units	Unit Cost	Description	Cost Notes
System Level	Attenuator Fence	LF	$2,000.00		Estimate from CO 133, Firehouse cut
System Level	Cable Lashing	LS	$1.00	Cable lashing with anchors, cables, turnbuckles, and mesh. Need to specify actual cost in quantities.	You need to specify actual $ in quantities. One recent cable lashing project we worked on for an approx. 11' boulder had estimates ranging from $20k to $40k.
System Level	Concrete Barrier (Temporary)	LF	$75.00		Per Roger.
System Level	Concrete Barrier (Temporary) - Reset	LF	$20.00	Moving existing temporary barrier to do something and then moving it back later.	From CDOT Bid-tabs. RMP 1/29/2021
System Level	Excavation - Rock	CY	$100.00	General rock excavation.	
System Level	Excavation - Rock for Ditch	LF	$100.00	Rock excavation to clean out ditch, assumed to be about 1CY/LF.	Assumes 1.0 CY per LF at $100/CY
System Level	Excavation - Soil for Ditch	LF	$30.00	Excavation to clean out ditch, assumed to be about 1CY/LF.	Assume 1.0 CY per LF at $30/CY
System Level	Excavation - Soil Slope	CY	$50.00	General excavation to cut back a soil slope.	
System Level	Excavation - Trim Blasting	CY	$35.00	Trim blasting for laying back a slope. Includes hauling	Based on Mike's I-40 E of Parks derivation. Applicable for larger, production oriented blasting projets. For smaller volumes, use Excavation-Rock. Includes blasting, loading, and hauling (20 mi, 6 trucks).
System Level	Mesh - Draped, Heavyweight	SF	$12.00	Heavy duty draped mesh, such as cable net with secondary mesh.	
System Level	Mesh - Draped, Midweight	SF	$4.00	Typical draped mesh.	
System Level	Mesh - Fix Existing, Lightweight	LF	$340.00		Assume 10' mesh replacement per linear foot. From US 550 study.
System Level	Mesh - Fix Existing, Midweight	LF	$330.00		Assume 10' mesh replacement per linear foot. From US 550 study.
System Level	Mesh - Pinned, Heavyweight	SF	$37.00	Pinned mesh system consisting of a heavy weight mesh (e.g. Cable Net) plus secondary mesh and rock bolts.	Adds draped mesh and pattern bolting.
System Level	Mesh - Pinned, Midweight	SF	$29.00	Pinned mesh system consisting of a mid-weight mesh (e.g. Tecco), and rock bolts.	Adds draped mesh and pattern bolting.
System Level	Retaining Wall MSE - Two-Sided	LF	$1,200.00	Assuming about 16' high, 12' wide.	From 133 Penny Hot Springs.

NMDOT D5 Rockfall Mitigation Project
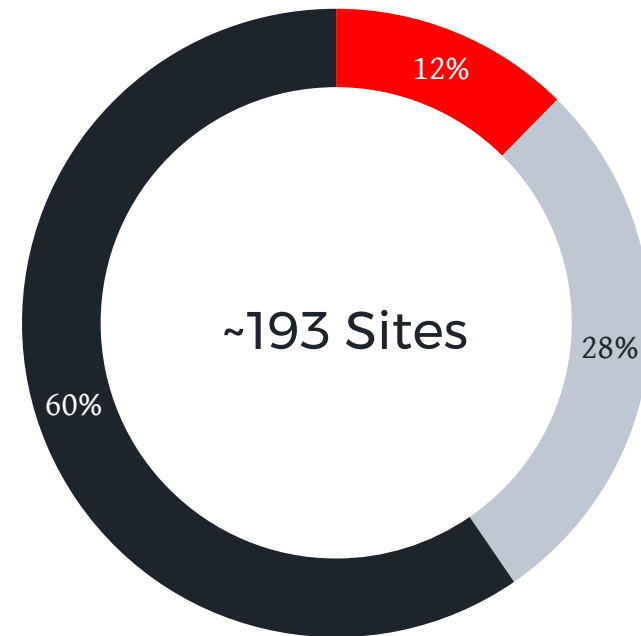5101550; Golder Project: 20142878   Page 1 of 2   Friday, June 11, 2021

Results of Inventory

Worst Sites Rose to Top

Over $25M (geohazard costs) to fix everything
for Class 1

Translates to roughly $45M total project costs

Now what?

~193 Sites

12%

28%

60%

■ Class 1   ■ Class 2   ■ Class 3

Next Step: Grouping Sites Into Projects

Possible Groupings

In-house maintenance opportunities

Scaling project or on-call

Worst first

One or two Class 1, Plus nearby Class 2
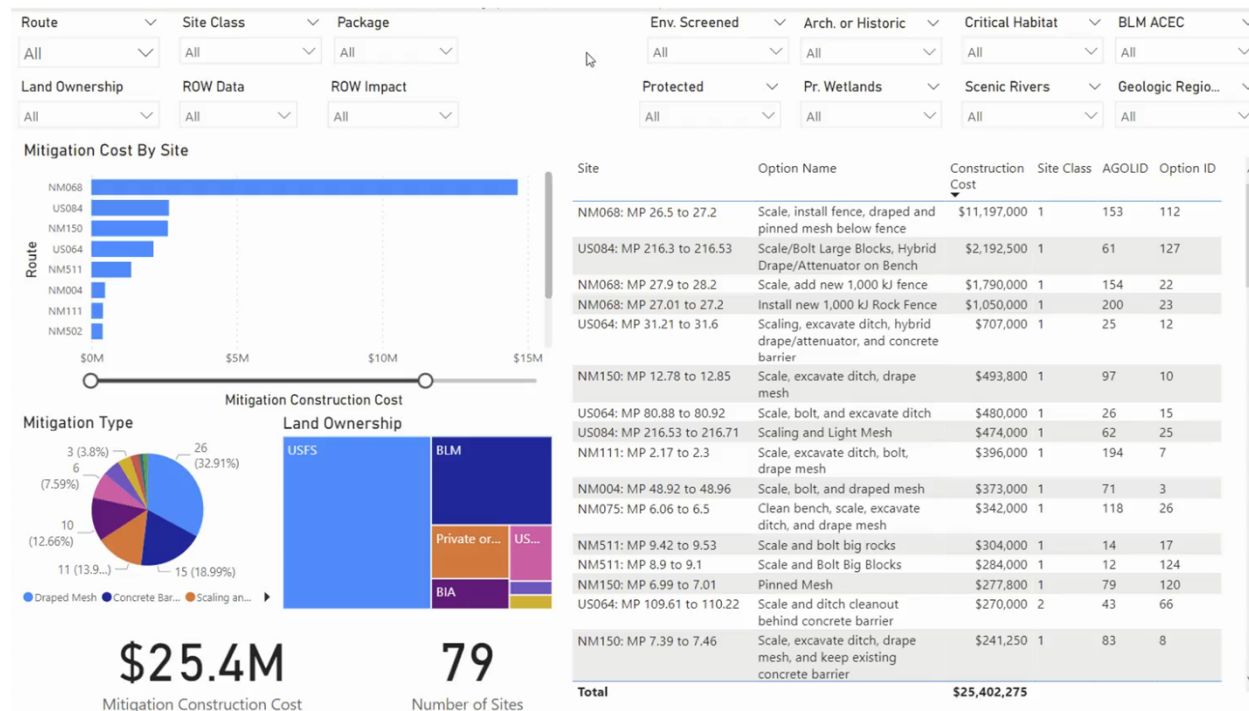
Similar environmental requirements

Key Learnings

Select more sites than you can realistically afford to construct

Try to group similar construction techniques

Keep construction cost to $4-5M max

Power BI Dashboard Interface

Best Practices and Future Improvement

Database is Key
Connection between GIS and primary database

More robust database back end

Improved usability

Room for expansion

Quick and Accurate Site Assessments
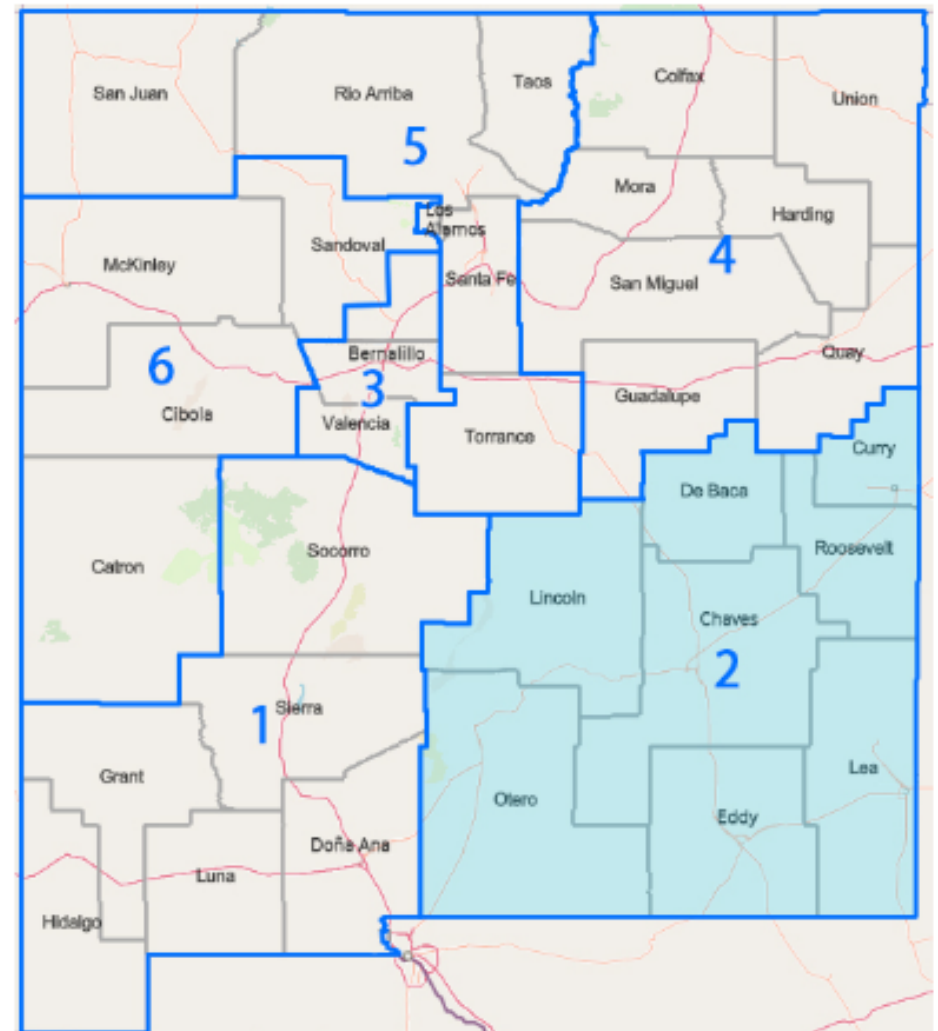No substitute for experience

High-level cost estimates are key for planning

Talk to maintenance forces!!!

Helping the Client
Help package projects (PowerBI!!)

Expand to or integrate with Geotechnical Asset Management (GAM)

Currently Ongoing D2 Rockfall Study
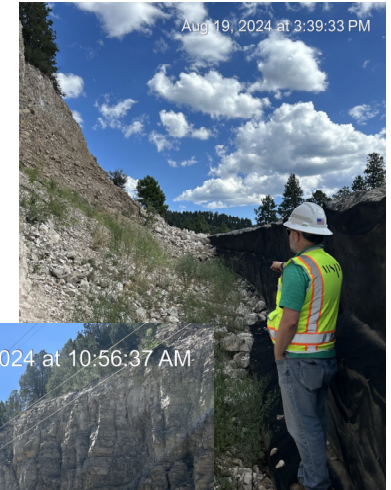
NMDOT D2 Study – US 82 AGOL Model

D2 Field Investigation

Aug 20, 2024 at 10:28:08 AM

Aug 19, 2024 at 3:39:33 PM

Aug 20, 2024 at 10:56:37 AM

Thank you

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