SR-2 Corridor Study and PROTECT-Act Review

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Robert Jowers, P.E., TDOT

TN TDOT Department of Transportation

LANDSLIDE TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS

Background


Jasper
Parkridge West Hospital
Hales Bar Marina & Resort
Marion County Park
Guild
Nickajack Lake
Raccoon Mountain Mtb Trail
Nickajack Cave Wildlife Refuge
Running Water Church of God
TENNESSEE
GEORGIA
Wildwood
Covenant College
Lookout Mountain
LOOKOUT VALLEY
ANDREA HEIGHTS
STUART HEIGHTS/ RIVERMONT
NORTH ATTANOOGA
Tennessee Riverpark
Tennessee Aquarium
Chattanooga
Chattanooga Zoo
ORCHARD KNOB
SOUTHSIDE HISTORIC DISTRICT
HIGHLAND PARK
Ridgeside
MISSIONARY RIDGE
BRAINERD
EAST LAKE
PINEY WOODS
Rossville
Lakeview
Woodland Hills

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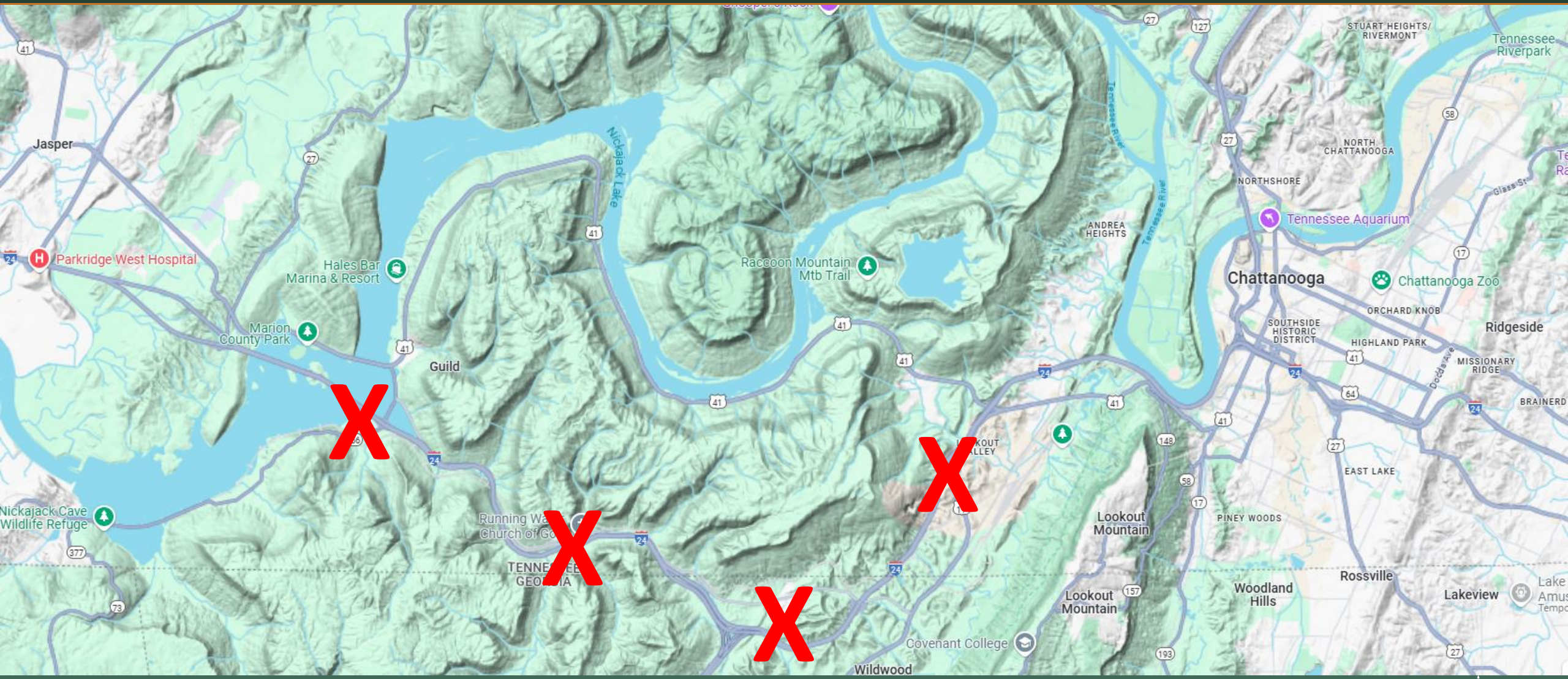
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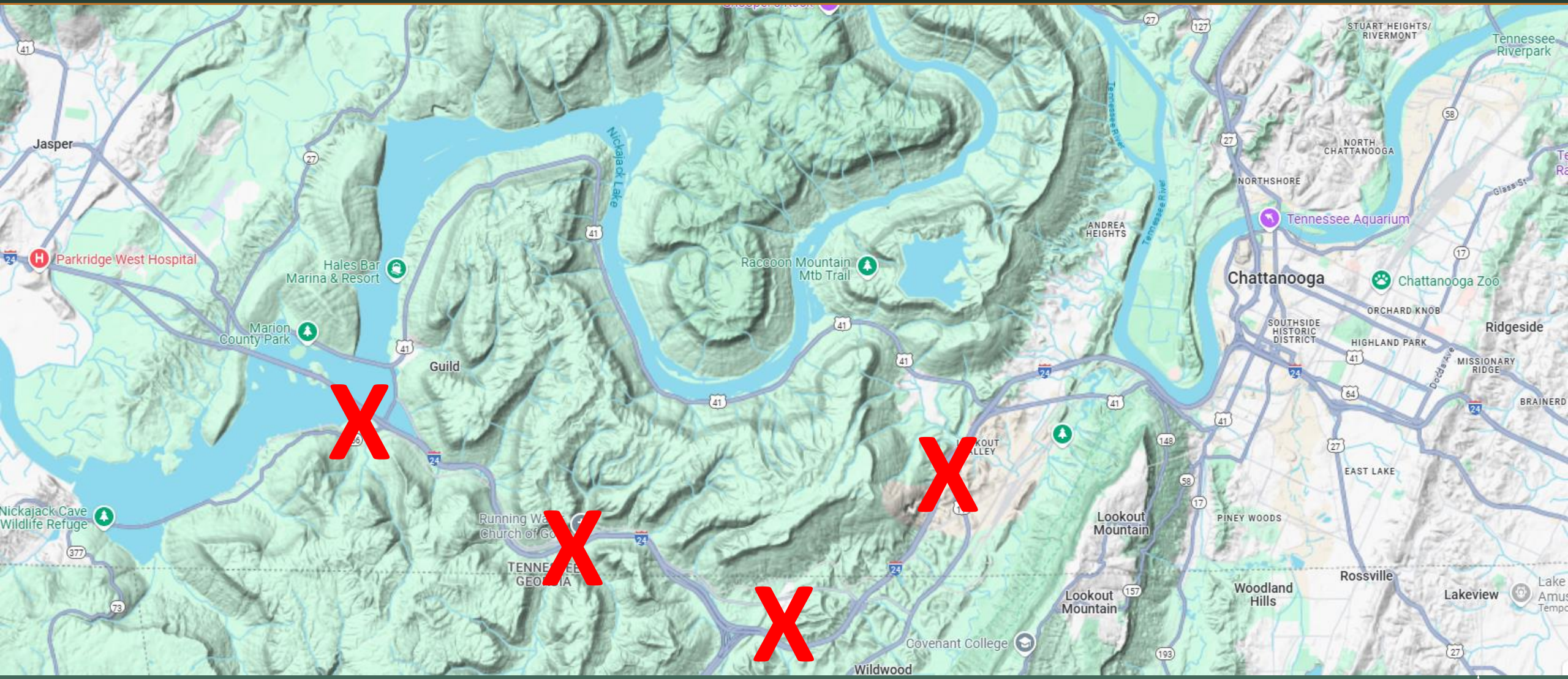
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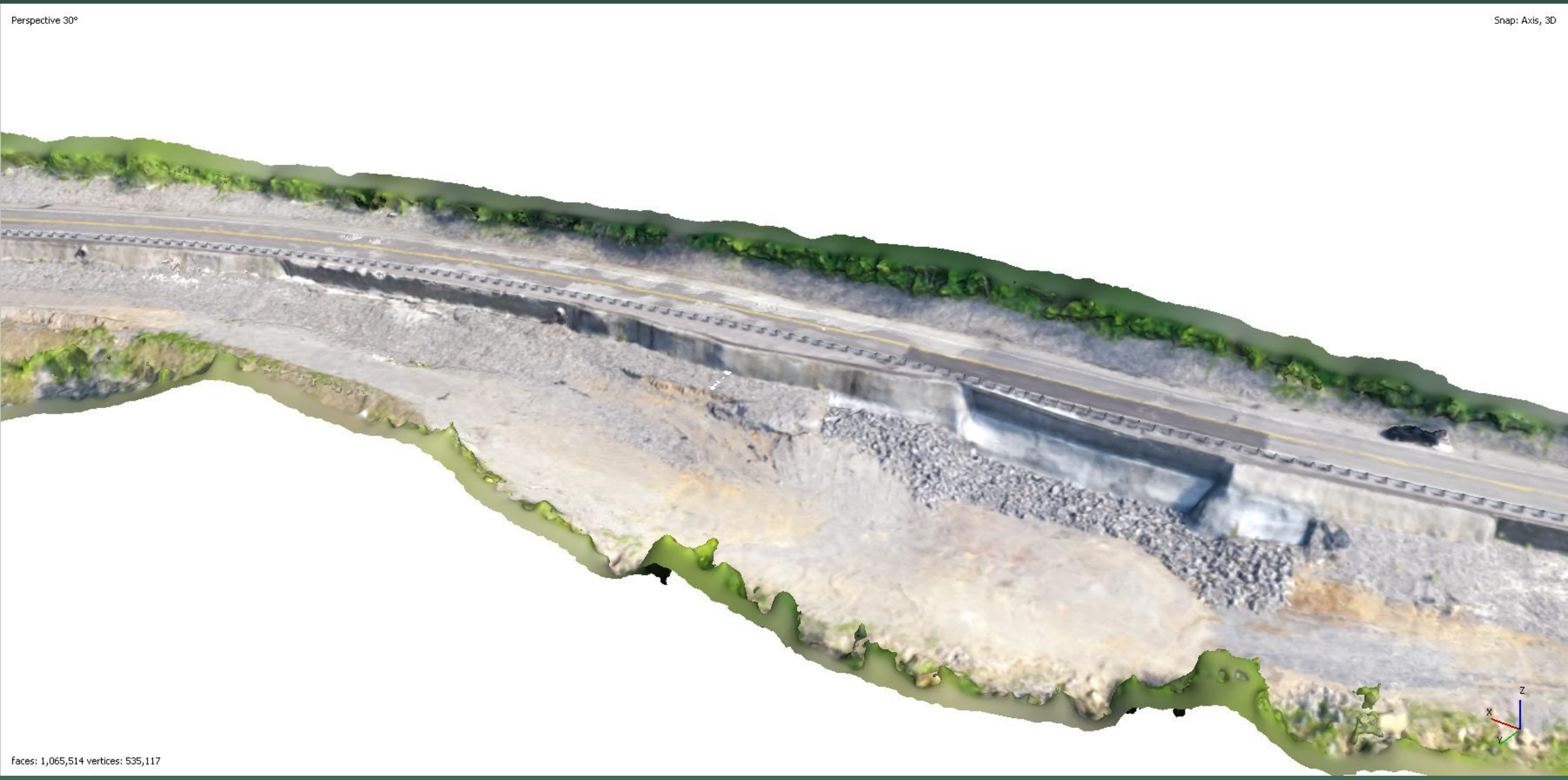
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Snap: Axis, 3D
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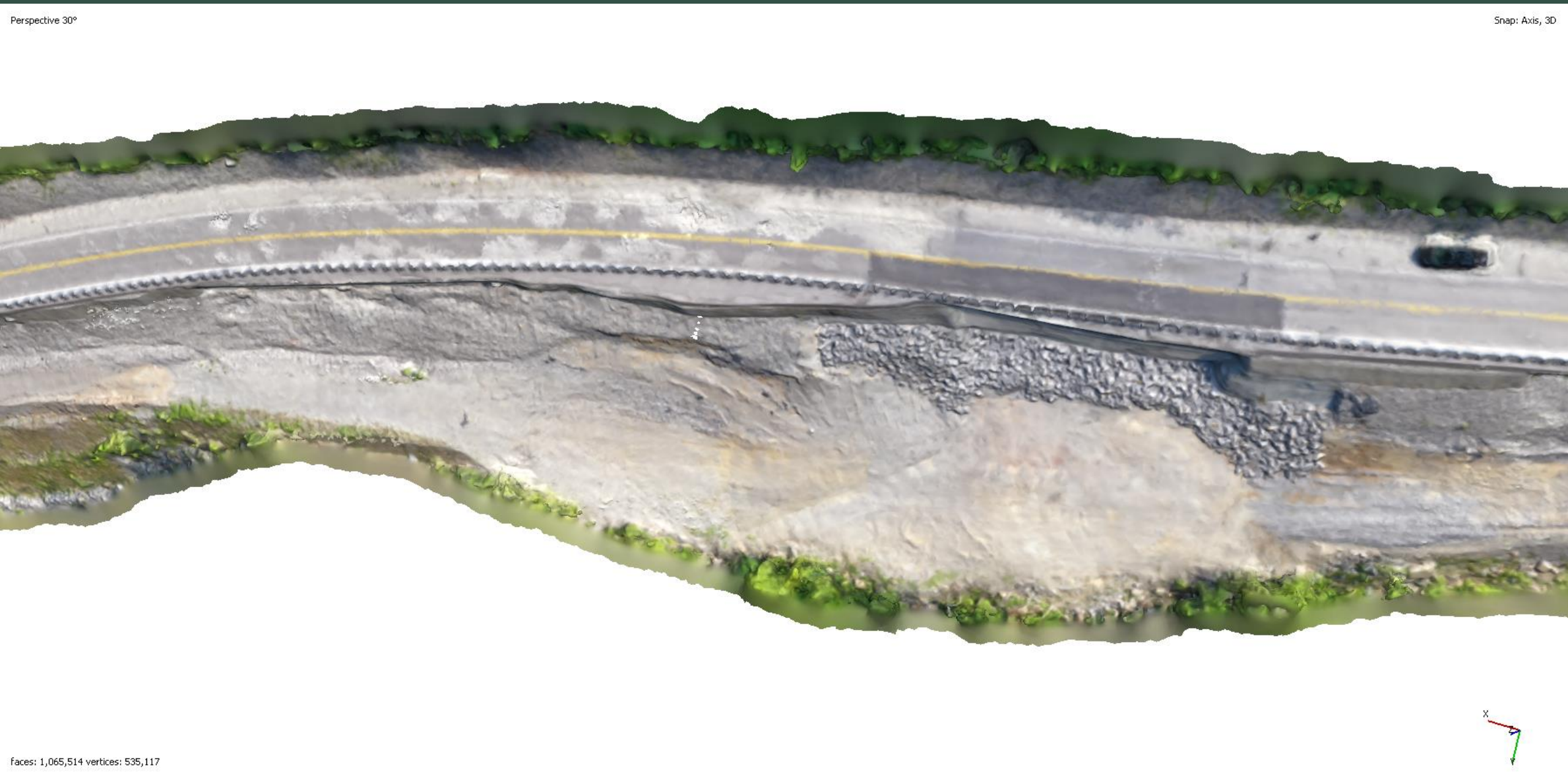
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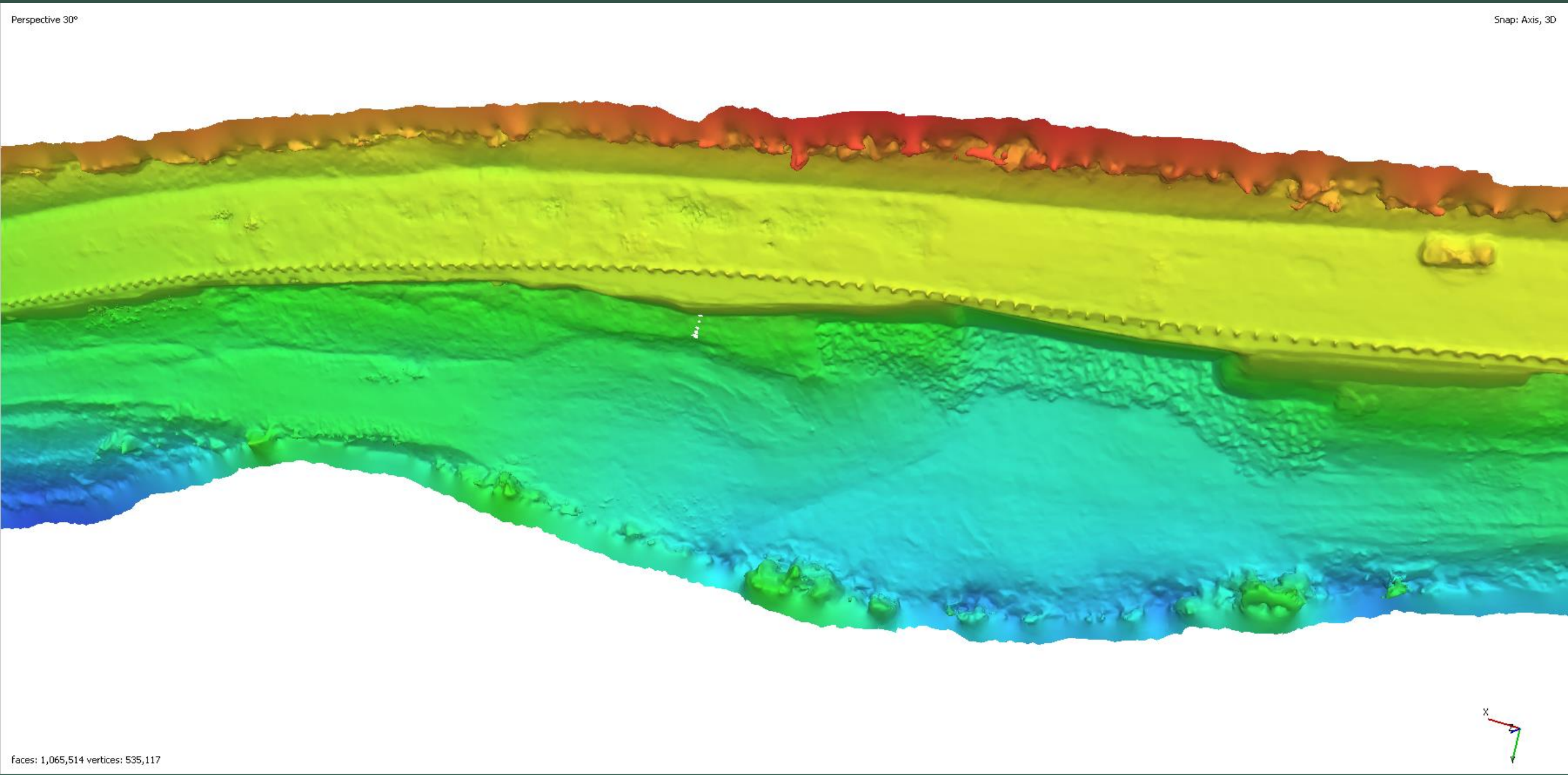
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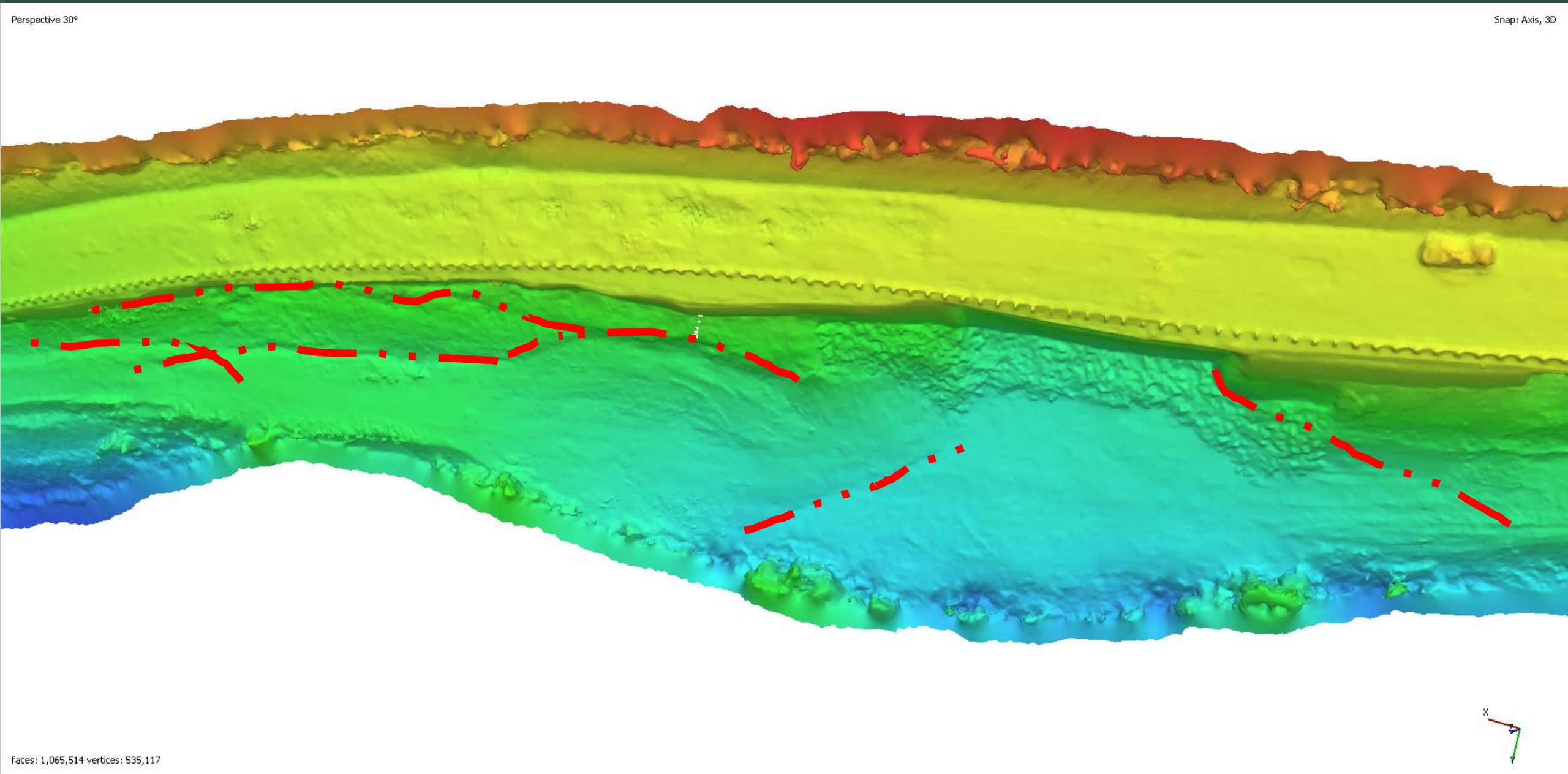
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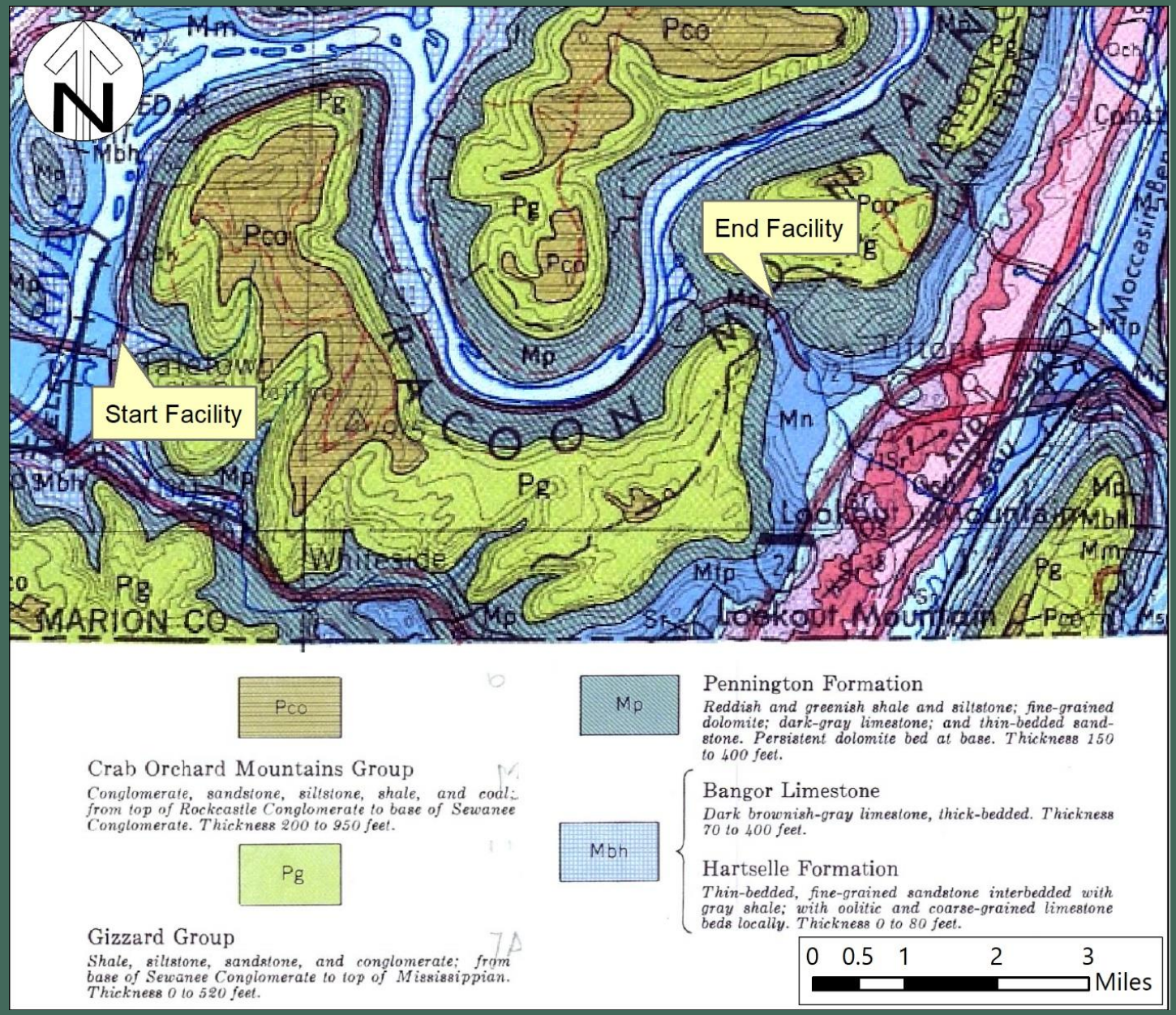
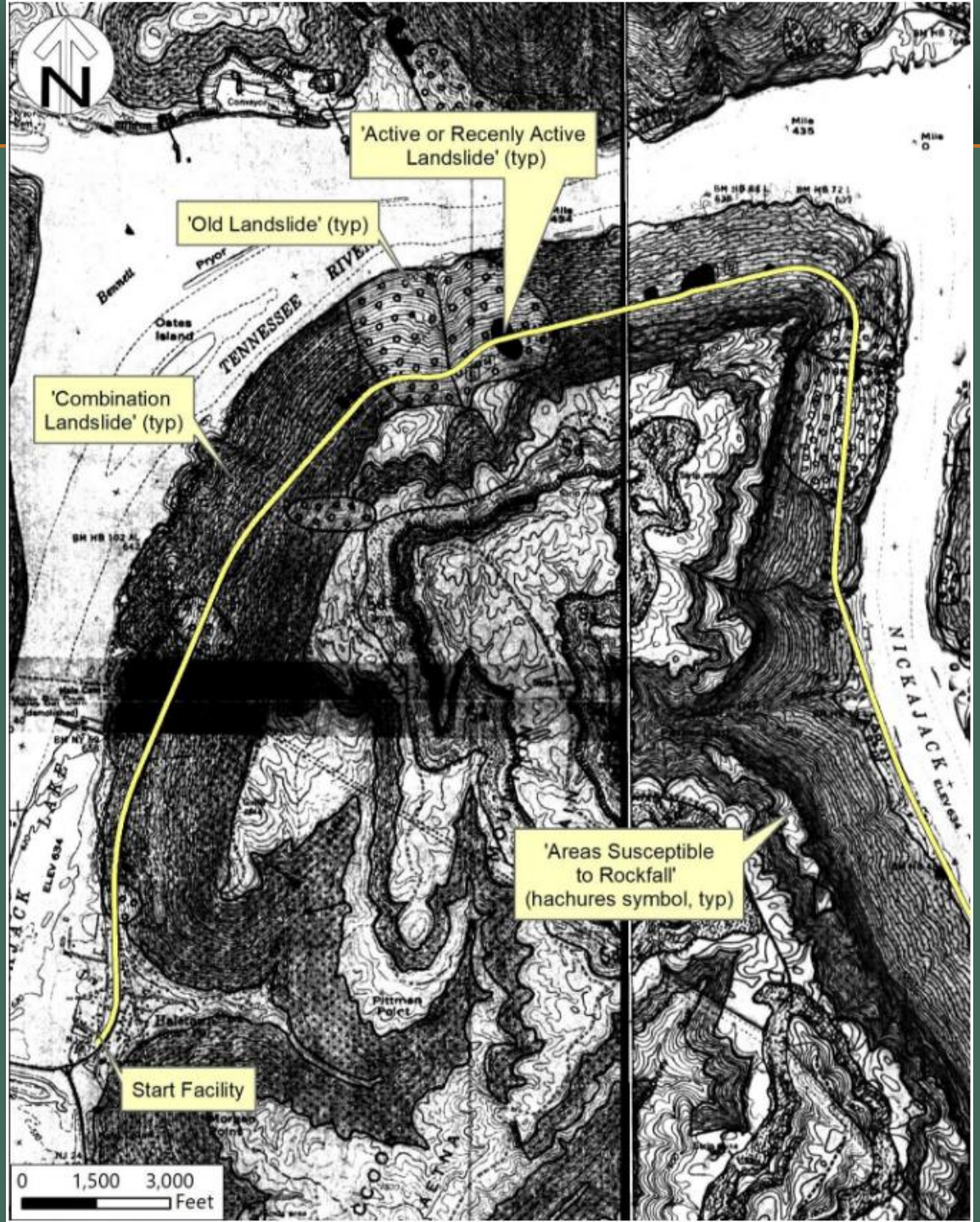
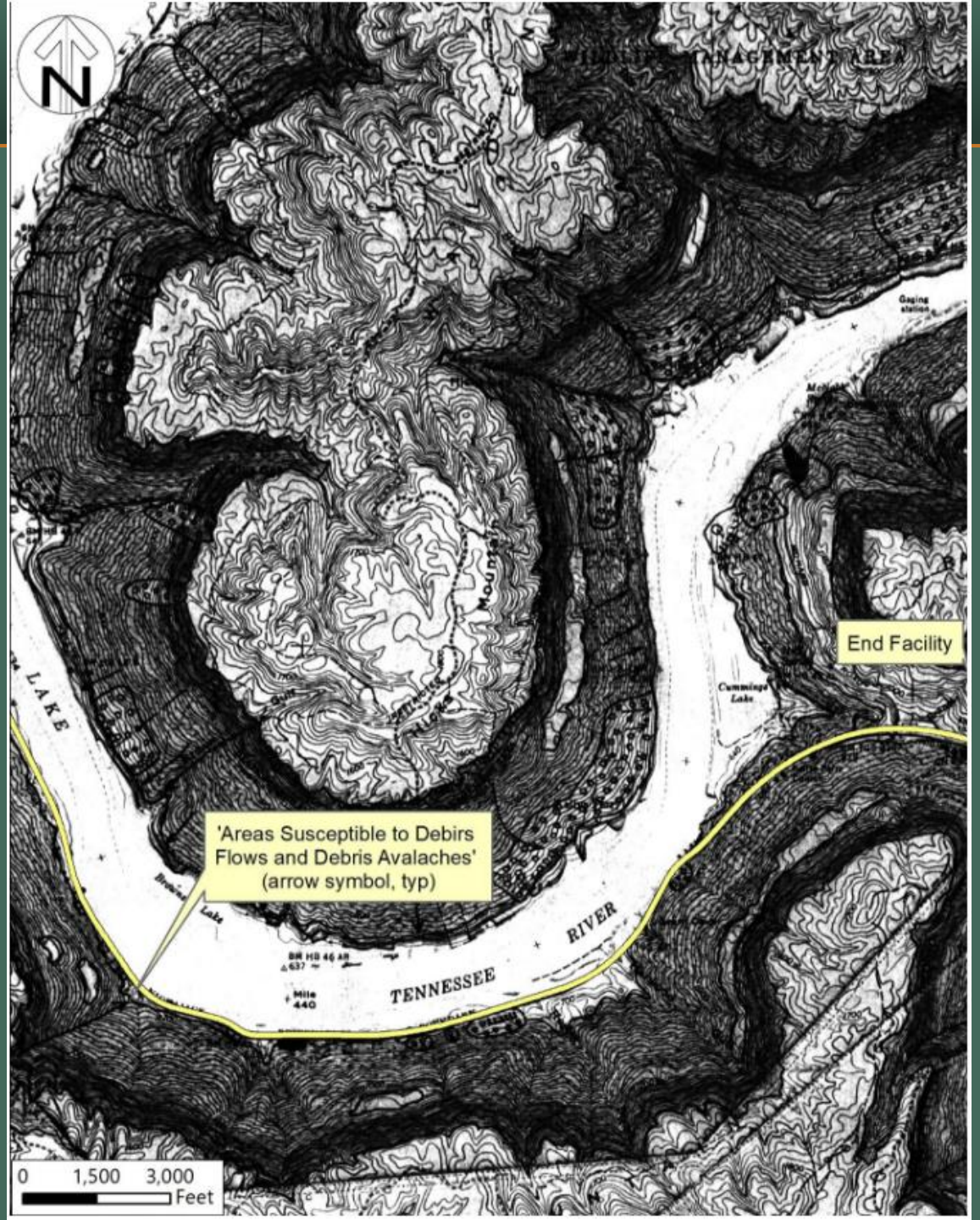
Site Engineering Geology




N
'Active or Recenly Active Landslide' (typ)
'Old Landslide' (typ)
'Combination Landslide' (typ)
'Areas Susceptible to Rockfall' (hachures symbol, typ)
Start Facility
TENNESSEE RIVER
NICKAJACK LAKE
Oates Island
Pittman Point
0 1,500 3,000 Feet


N
End Facility
'Areas Susceptible to Debirs Flows and Debris Avalaches' (arrow symbol, typ)
TENNESSEE RIVER
NICKAJACK LAKE
0 1,500 3,000 Feet

Corridor Study Scope of Work

1. Review
   - Available data, site history, and maintenance records

2. Desk Study
   - Corridor Identification & Assessment

3. Field Verification
   - Site Selection

4. Monitoring Plan
   - Layout, sensors, placement, geohazard

5. PROTECT Eligibility
   - Review and address checklist criteria

Desk Study

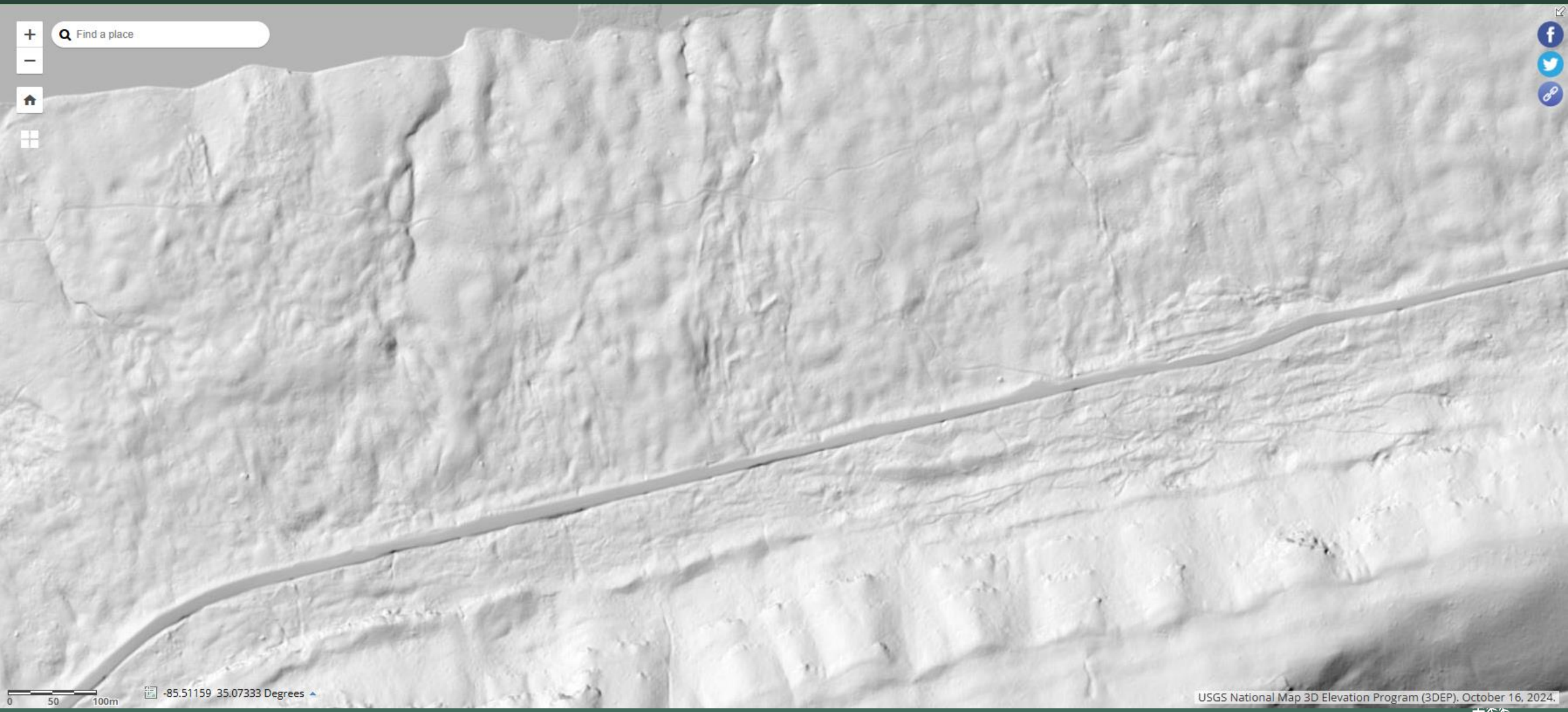
- Reviewed Applicable Monitoring Techniques
  - Site challenges: Heavy canopy and ground vegetation, LOS for satellites, variable rates of change (landslides, rockfall, debris flows)
  - Change Detection
    - LiDAR – Fair chance of seeing change from occasional, repeat surveys. Low temporal resolution (annual if fixed wing, seasonal if UAV)
    - InSAR – LOS not ideal, cannot see through vegetation. Poor reflectance on pavement. Moderate temporal resolution (~12 days)
    - Photogrammetry – UAV fly under canopy for pavement changes. Low to moderate temporal resolution (annual to seasonal)

    LIMITED APPLICABILITY FOR RAPID VELOCITY, GOOD FOR SLOW VELOCITY
  - Direct Monitoring
    - Inclinometers, piezometers, debris flow sensor arrays

    LIMITED APPLICABILITY FOR MOVEMENT EXTENT DETECTION, GOOD FOR RAPID CHANGE AT INSTALLATION POINT

Desk Study

- Interpret landslides and debris flow paths on bare earth LiDAR maps
- Conceptualize sensor types and locations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100m
-85.51159 35.07333 Degrees
USGS National Map 3D Elevation Program (3DEP). October 16, 2024.


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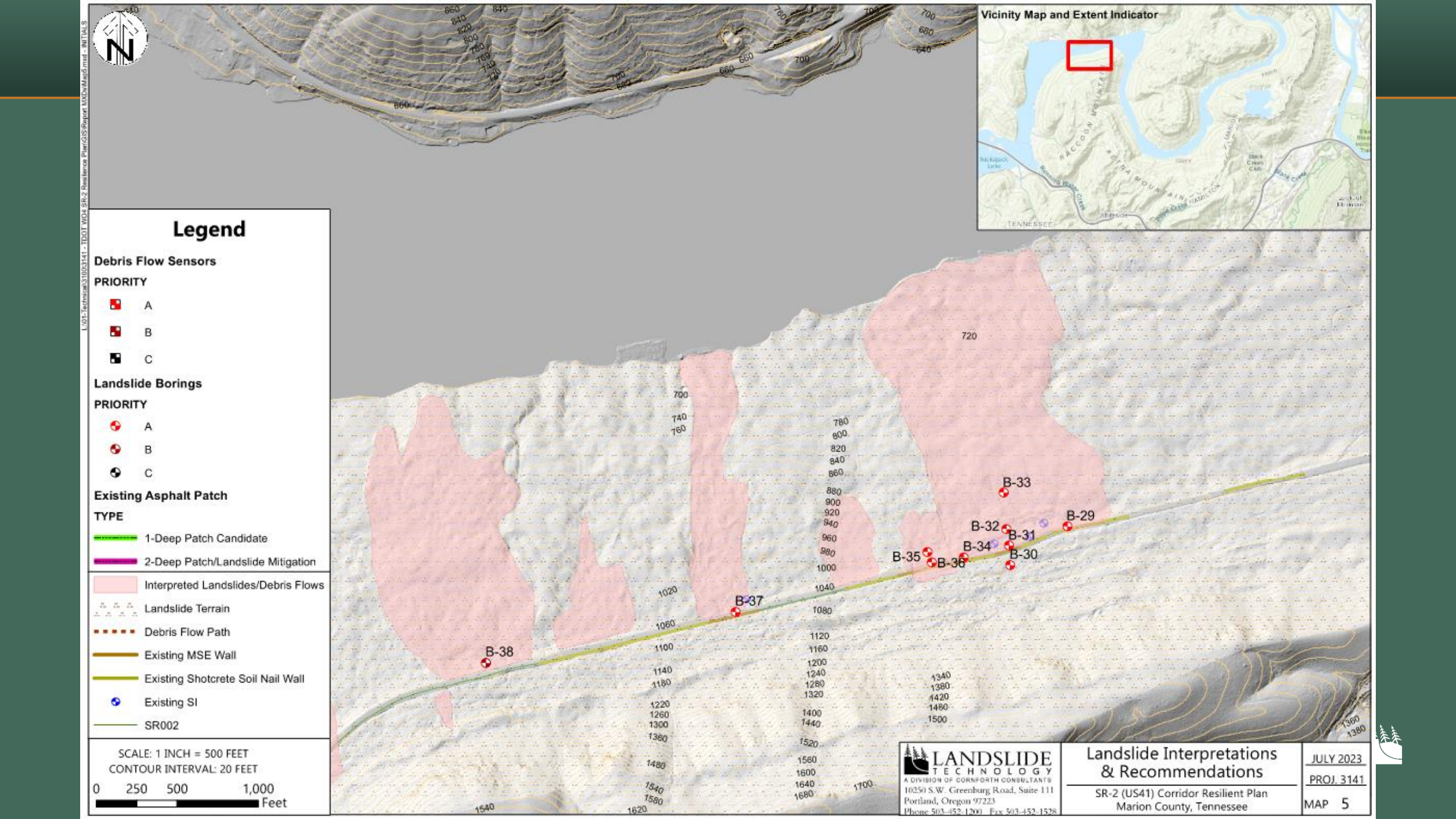

Vicinity Map and Extent Indicator
Legend
Debris Flow Sensors
PRIORITY
A
B
C
Landslide Borings
PRIORITY
A
B
C
Existing Asphalt Patch
TYPE
1-Deep Patch Candidate
2-Deep Patch/Landslide Mitigation
Interpreted Landslides/Debris Flows
Landslide Terrain
Debris Flow Path
Existing MSE Wall
Existing Shotcrete Soil Nail Wall
Existing SI
SR002
SCALE: 1 INCH = 500 FEET
CONTOUR INTERVAL: 20 FEET
0 250 500 1,000
Feet
B-38
B-37
B-35
B-36
B-34
B-32
B-33
B-31
B-30
B-29
LANDSLIDE TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS
10250 S.W. Greenburg Road, Suite 111
Portland, Oregon 97223
Phone 503-452-1200 Fax 503-452-1528
Landslide Interpretations & Recommendations
SR-2 (US41) Corridor Resilient Plan
Marion County, Tennessee
JULY 2023
PROJ. 3141
MAP 5

Stability Issues LM 25-26

- Minor distress in several locations
- 12/2018 and 1/2019 – several storms led to landslides
- Several inches of vertical displacement
- Landslide was too fast to keep road open, ER contract let
- Realignment, soil nail walls, and horizontal drains installed in summer 2019
- Distress is on going

Field Verification

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

- Summer 2023
  - Two geologists, one long week in the field
  - Visited all locations & performed cursory reconnaissance
  - Observed other infrastructure damage
  - Planned and prioritized (A, B, C) ground monitoring locations
  - Conceptualized mitigation approaches
  - Collected and verified GIS data
  - Mapped drains at LM 25-26

Other Damages – Damaged/Distressed Box Culverts

Other Damages – Damaged/Distressed Box Culverts

Other Damages – Repairs Stacked on Other Repairs

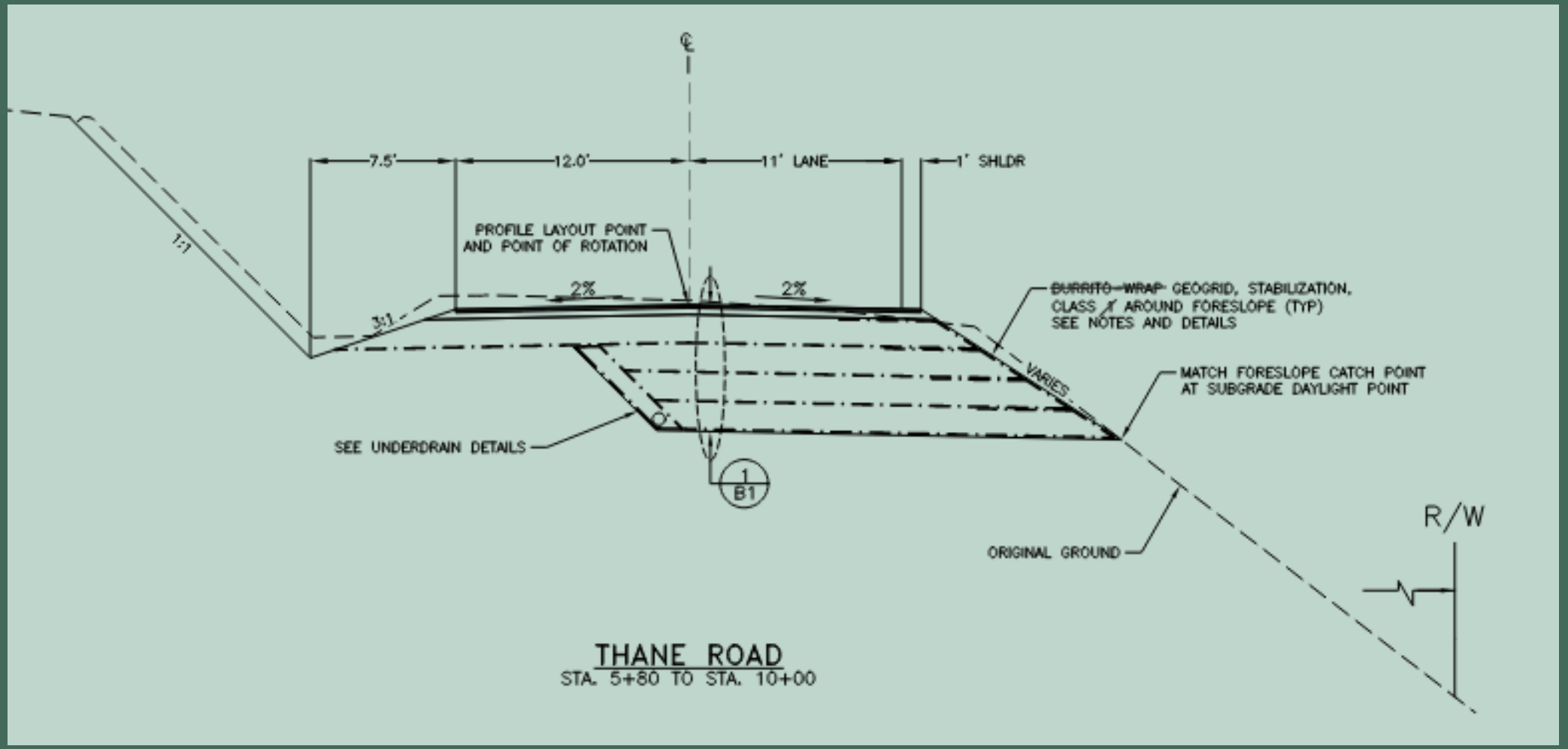
Other Damages – Shoulder/Embankment Repairs

Other Damages – Past Events

Other Damages – Past Events

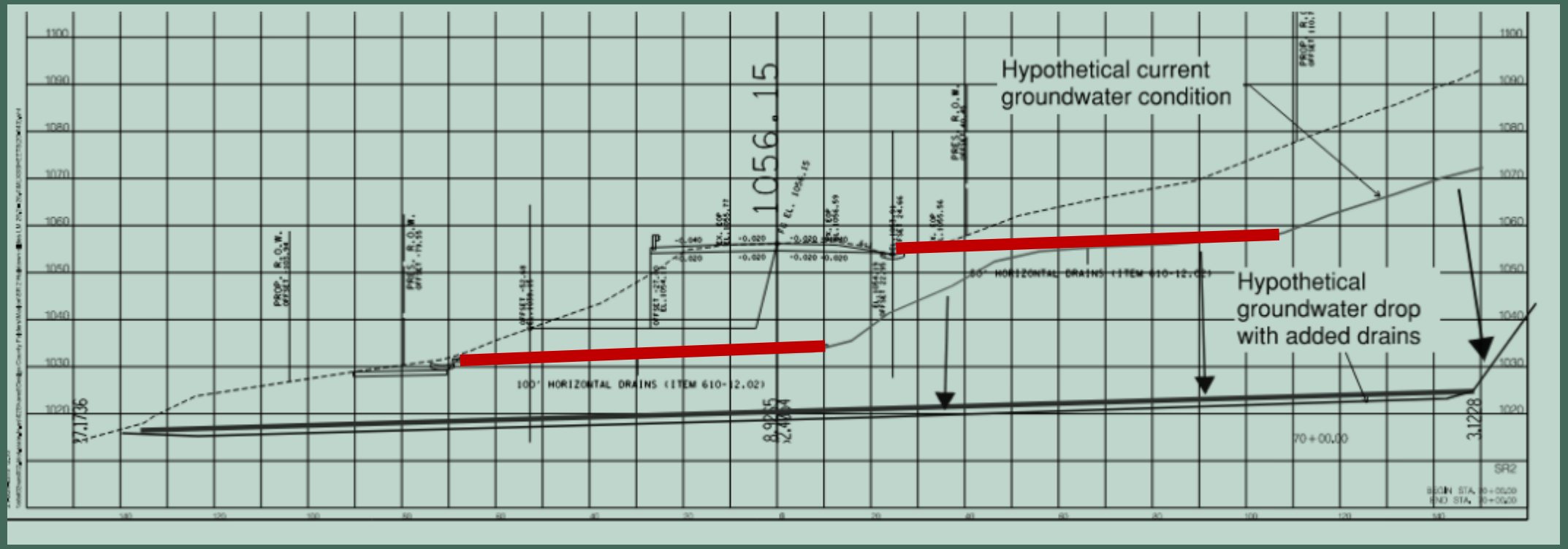
Conceptual Resiliency Improvements

- Candidate Deep Patch Locations



Conceptual Resiliency Improvements

- Possible Horizontal Drain Improvements



Conceptual Resiliency Improvements

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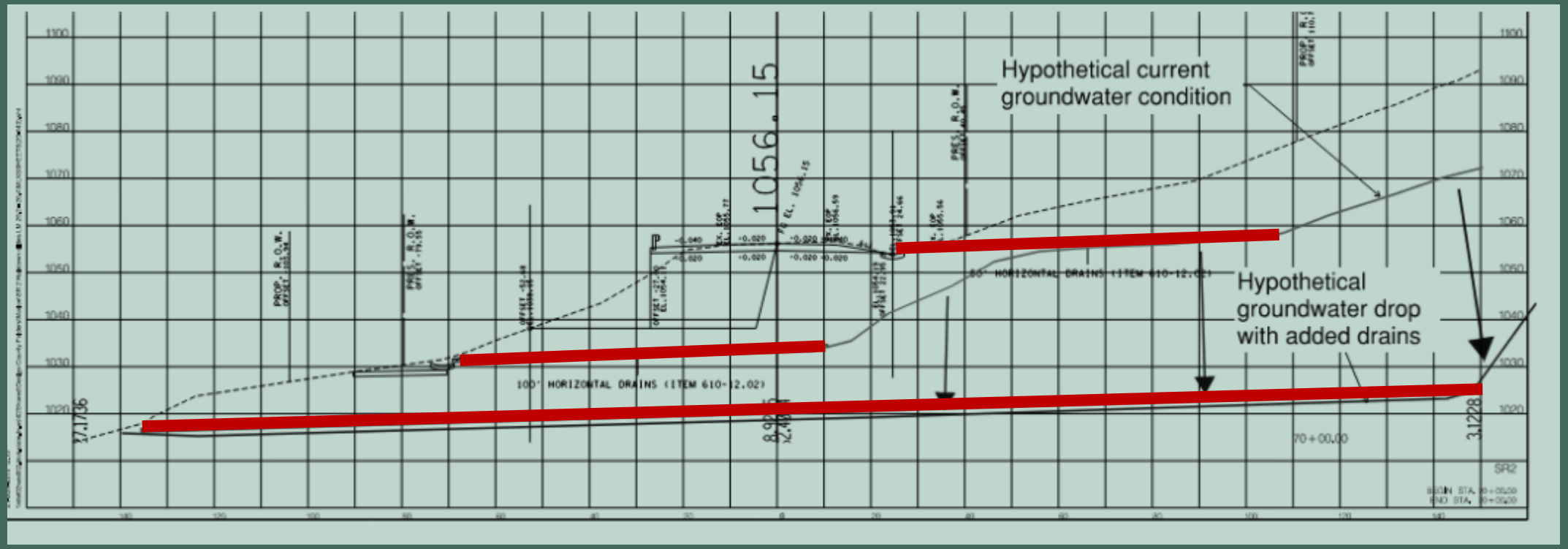


Field Verification - Results

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

- Mapped 95 Landslide Features (landslides, embankment failures, debris flows)
- Seven Rock Slopes
- 21 Debris Flow Paths
- 18 Candidate Deep Patch Locations
- 104 Wall or Horizontal Drains @ LM 25-26 area
- 45 Candidate Borings with A, B, C Prioritization
- 10 Candidate Debris Flow Sensors

Monitoring Plan

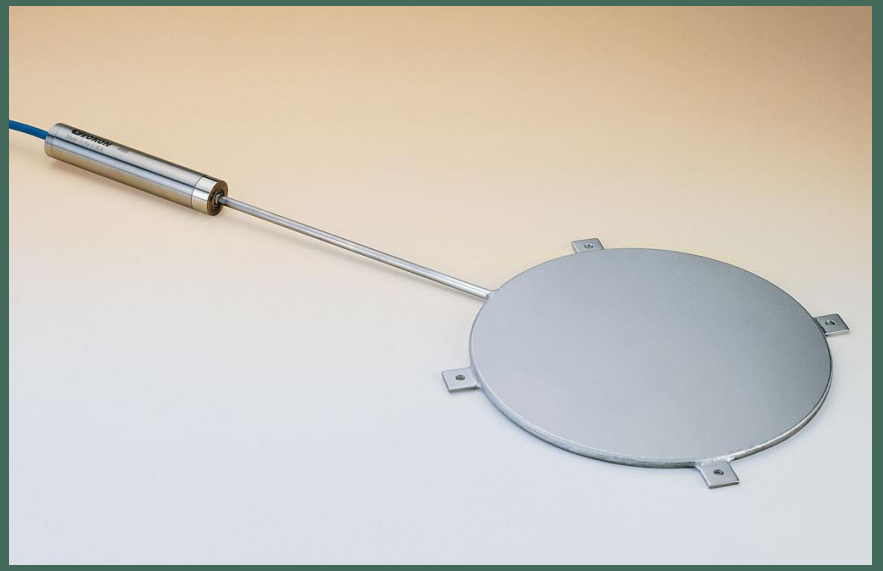
1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

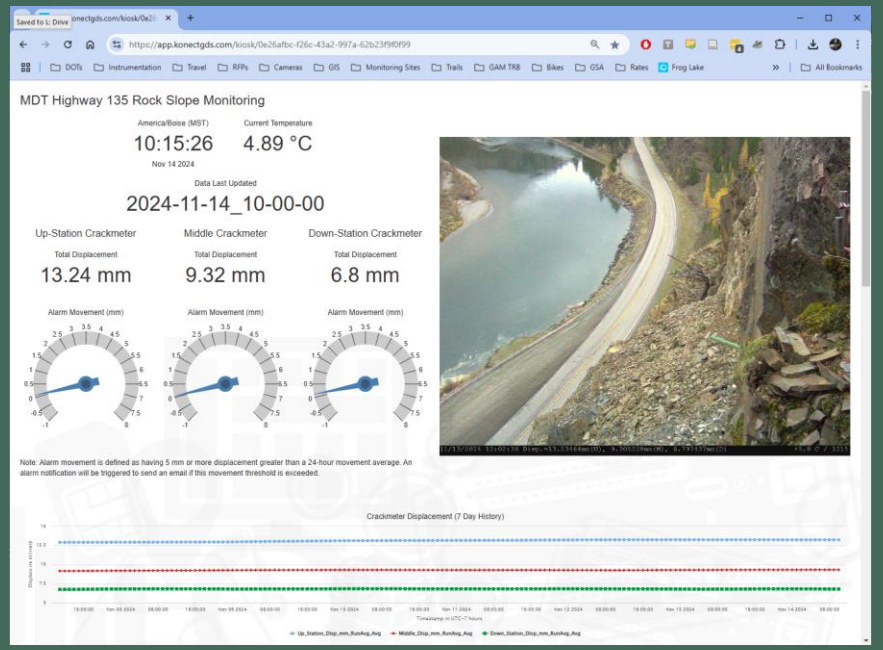
- Pilot Study for InSAR, Lidar, and SfM Photogrammetry Change Detection
- Geotechnical Borings focusing on Landslide Sensors
  - Vibrating Wire Piezometers
  - Inclinometers (discrete IPIs after movement is known)
  - Option to install ShapeAccelArrays
  - Depths and access estimated for each boring

Monitoring Plan

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

- Debris Flow Sensors
  - Earth Pressure Cells installed at Culvert Inlet (detect bedload + streamflow)
  - Piezometers (streamflow)
- Radio-telemetry capable dataloggers
- Transmitting data to a cellular modem-equipped centralized datalogger(s)
- Obtain readings at close intervals (5 to 15 minutes)
- Send data to an interactive website





Monitoring Plan - Costs

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

- Required generalization and estimation
  - Track rig: $8,500/day (materials, labor, and TC)
  - Debris Flow Installation: $7,000/day, 2 days
  - Drilling 45’ per day, including installation
  - Moves take 6 hours
  - Landslide Boring Hardware: $5,300 per combination SI & VWP, $4,500 SI only, SAA $350 per foot
  - Debris Flow Monitoring $7,200 ea
  - Geotech Inspection & Instrumentation Install $2,900/day

PLUG ALL INTO EXCEL AND PIVOT THOSE TABLES!!

Monitoring Plan - Costs

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

Location	LN	Offset (ft)	Latitude	Longitud	Boring_De	Hazard	Instrument	Drill_Access	Purpose	Duration (da	Drilling Cost (no SAA)	Sensor Instrumen t Cost	Field Time & Documentatio n	Total Approx Cost	Total w/ SAA	Priorit	Program A Priorit	Program B Priorit
B-01	32.65	7 L	35.03068432	-85.43108959	50	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 5,300	$ 5,500.00	$ 26,800	$ 44,300	B	B	
B-09	30.39	15 L	35.02106802	-85.46540337	30	Landslide	SI	Track	Landslide Geometry and Monitoring	1.4	$ 13,000.00	$ 4,500	$ 4,300.00	$ 21,800	$ 32,300	C	C	
B-10	30.31	0	35.0213394	-85.46688788	50	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 5,300	$ 5,500.00	$ 26,800	$ 44,300	B	B	
B-11	29.69	33 L	35.02804498	-85.47367268	40	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.6	$ 14,000.00	$ 5,300	$ 4,900.00	$ 24,200	$ 38,200	A	A	
B-12	29.73	25 L	35.02743552	-85.47337225	40	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.6	$ 14,000.00	$ 5,300	$ 4,900.00	$ 24,200	$ 38,200	A	A	
B-13	29.65	26 L	35.02854927	-85.47391872	40	Landslide	SI	Track	Landslide Geometry and Monitoring	1.6	$ 14,000.00	$ 4,500	$ 4,900.00	$ 23,400	$ 37,400	A	A	
B-14	28.76	36 L	35.04036161	-85.47986124	50	Landslide	SI	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 4,500	$ 5,500.00	$ 26,000	$ 43,500	C	C	
B-15	27.86	51 R	35.05247173	-85.48572615	50	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 5,300	$ 5,500.00	$ 26,800	$ 44,300	A	A	
B-16	27.79	32 L	35.05356815	-85.48584878	50	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 5,300	$ 5,500.00	$ 26,800	$ 44,300	B	B	
B-17	27.60	64 R	35.05622114	-85.48626005	30	Landslide	SI	Track	Landslide Geometry and Monitoring	1.4	$ 13,000.00	$ 4,500	$ 4,300.00	$ 21,800	$ 32,300	B	B	
B-18	27.55	69 R	35.0570294	-85.48621284	40	Landslide	SI	Track	Landslide Geometry and Monitoring	1.6	$ 14,000.00	$ 4,500	$ 4,900.00	$ 23,400	$ 37,400	B	B	
B-19	27.48	33 L	35.05803939	-85.48575394	50	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 5,300	$ 5,500.00	$ 26,800	$ 44,300	A	A	
B-20	26.90	24 L	35.06630212	-85.48481848	40	Landslide	SI	Track	Landslide Geometry and Monitoring	1.6	$ 14,000.00	$ 4,500	$ 4,900.00	$ 23,400	$ 37,400	B	B	
B-21	26.89	29 L	35.06655007	-85.48477236	60	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	2.1	$ 18,000.00	$ 5,300	$ 6,200.00	$ 29,500	$ 50,500	A	A	
B-22	26.69	15 L	35.06945003	-85.48474127	40	Landslide	SI	Track	Landslide Geometry and Monitoring	1.6	$ 14,000.00	$ 4,500	$ 4,900.00	$ 23,400	$ 37,400	A	A	
B-23	24.89	23 L	35.0656896	-85.51395786	50	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 5,300	$ 5,500.00	$ 26,800	$ 44,300	B	B	
B-26	24.52	8 L	35.06314559	-85.51946491	50	Landslide	SI	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 4,500	$ 5,500.00	$ 26,000	$ 43,500	B	B	
B-28	23.13	6 L	35.04594178	-85.53220991	50	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	1.9	$ 16,000.00	$ 5,300	$ 5,500.00	$ 26,800	$ 44,300	A	A	
B-29	26.00	16 L	35.07007049	-85.49670416	100	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	3.0	$ 26,000.00	$ 5,300	$ 8,700.00	$ 40,000	$ 75,000	A	A	
B-30	25.93	90 R	35.06974199	-85.4966775	80	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	2.5	$ 22,000.00	$ 5,300	$ 7,400.00	$ 34,700	$ 62,700	A	A	
B-31	25.93	28 L	35.07034467	-85.4967571	100	Landslide	SI and VWP	Track	Landslide Geometry and Monitoring	3.0	$ 26,000.00	$ 5,300	$ 8,700.00	$ 40,000	$ 75,000	A	A	

Monitoring Plan - Costs

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

Drill_Access	(All)						
Hazard	Program A Priority	Data Count of Hazard	Sum of Duration (days)	Sum of Total Approx Cost	Sum of Boring Dep	Sum of Total w/ SAA
Debris Flow	A	3	6	$ 81,198	$ -	
	B	7	14	$ 189,462	$ -	
Debris Flow Total		**10**	**20**	**$ 270,660**	**$ -**	
Landslide	A	25	56	$ 698,470	$ 1,660	$ 1,279,470.00
	B	15	28	$ 348,100	$ 740	$ 607,100.00
	C	5	9	$ 116,080	$ 250	$ 203,580.00
Landslide Total		**45**	**93**	**$ 1,162,650**	**$ 2,650**	**$ 2,090,150.00**
(blank)						
Grand Total		**55**	**113**	**$ 1,433,310**	**$ 2,650**	**$ 2,090,150.00**

PROTECT Eligibility

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

- PROTECT Act (Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation)
  - Competitive grant program focusing on resiliency related to natural hazards, climate change, wildfire, landslides, rockfall, debris flows, etc.

  - Four Grant Categories
    - Planning ($45M)
    - Resilience Improvements ($638M)
    - Community Resilience and Evacuation Routes ($45)
    - At-Risk Coastal Infrastructure ($120M)

Implementation (10% pre-const.)

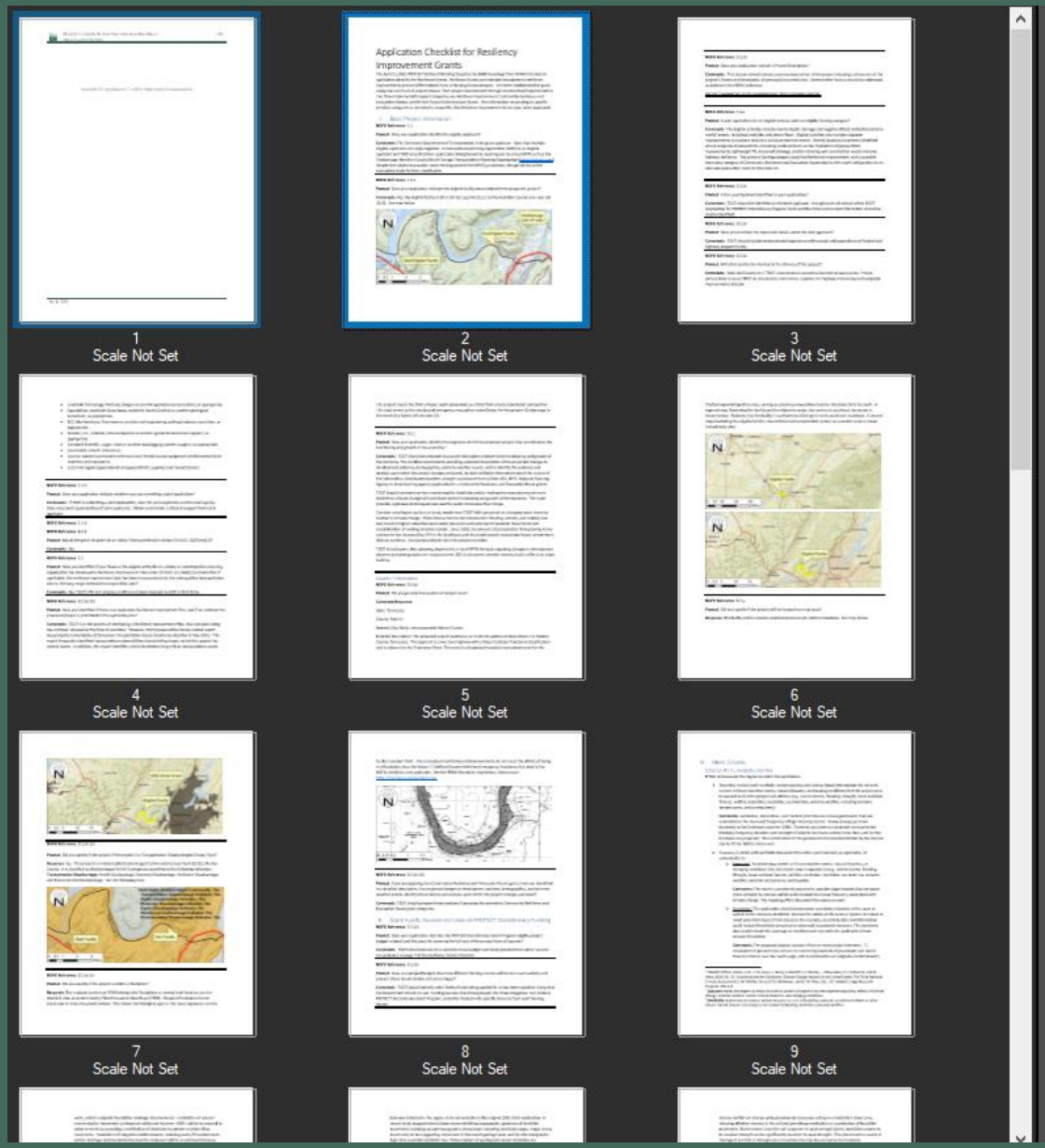
PROTECT Eligibility

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

- Grants approved on Merit, measured against 8 criteria
  1. Vulnerability and Risk
  2. Criticality to Community
  3. Design Elements
  4. Public Engagement, Partnerships, and Collaboration
  5. Equity and Justice40
  6. Climate Change and Sustainability
  7. Schedule and Budget
  8. Innovation

PROTECT Eligibility

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility



Application Checklist for Resiliency Improvement Grants

The April 21, 2023 PROTECT Notice of Funding Opportunity (NOFO) package from FHWA included an application checklist for Resilience Grants. Resilience Grants are intended to implement resilience improvements and are differentiated from a Planning Grant category. The three implementation grant categories can fund all project phases, from project development through construction/implementation. The three implementation grant categories are *Resilience Improvement*, *Community Resilience and Evacuation Routes*, and *At-Risk Coastal Infrastructure Grants*. The information responding to specific checklist categories is intended to respond to the Resilience Improvement Grant type, when applicable.

I. Basic Project Information

NOFO Reference: C.1.

Prompt: Does your application identify the eligible applicant?

Comments: The Tennessee Department of Transportation is the grant applicant. Note that multiple eligible applicants can apply together. A metropolitan planning organization (MPO) is an eligible applicant and TDOT may find their application strengthened by reaching out to a local MPO such as the Chattanooga-Hamilton County/North Georgia Transportation Planning Organization (https://chcrpa.org/) despite the subject evacuation route residing outside the MPO's jurisdiction, though serves as the evacuation route for their constituents.

NOFO Reference: C.3.c.

Prompt: Does your application indicate the eligible facility associated with the proposed project?

Comments: Yes, the eligible facility is SR-2 (US 41) Log mile 22.11 to the Hamilton County Line near LM 33.92. See map below.

PROTECT Eligibility

1. Review → 2. Desk Study → 3. Field Verification → 4. Monitoring Plan → 5. PROTECT Eligibility

- Opinion: Subject corridor and the proposed monitoring and resiliency improvements meet eligibility criteria
  - Evacuation route with a history of redundant infrastructure (I-24 and Marion Memorial Bridge both cross the TN River)
  - Vulnerable to geohazards and intensifying storm systems
  - Meets political goals of disadvantaged communities and partnerships with MPOs

Thank you!