Subsurface Exploration for I-40 Reconstruction in the Pigeon River Gorge Post Hurricane Helene

Chris Ramsey, PE and Jason Holland, PG

STGEC 2025

September 16, 2025

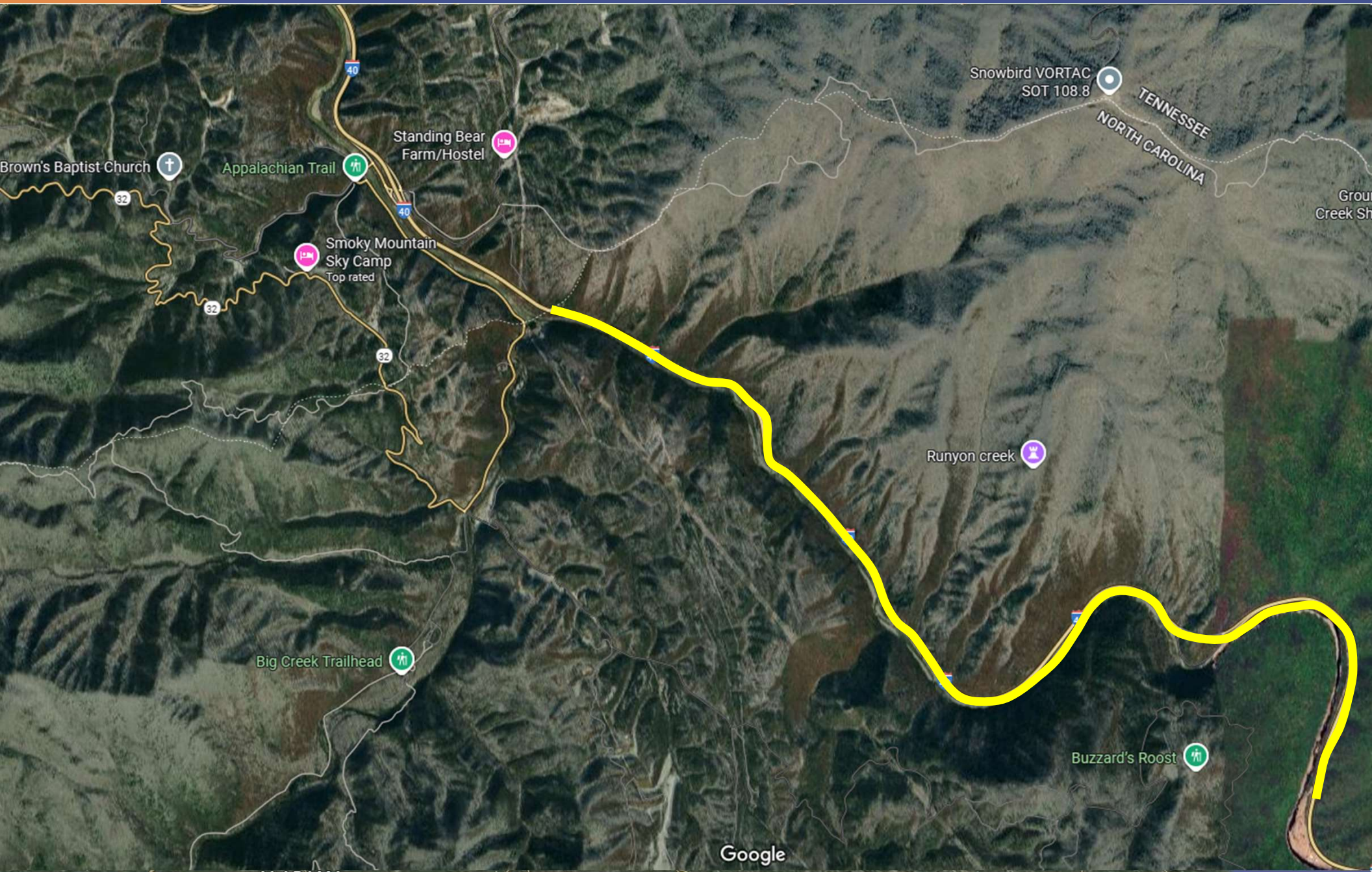
Schnabel ENGINEERING

Build Better. Together.

PRESENTATION OUTLINE

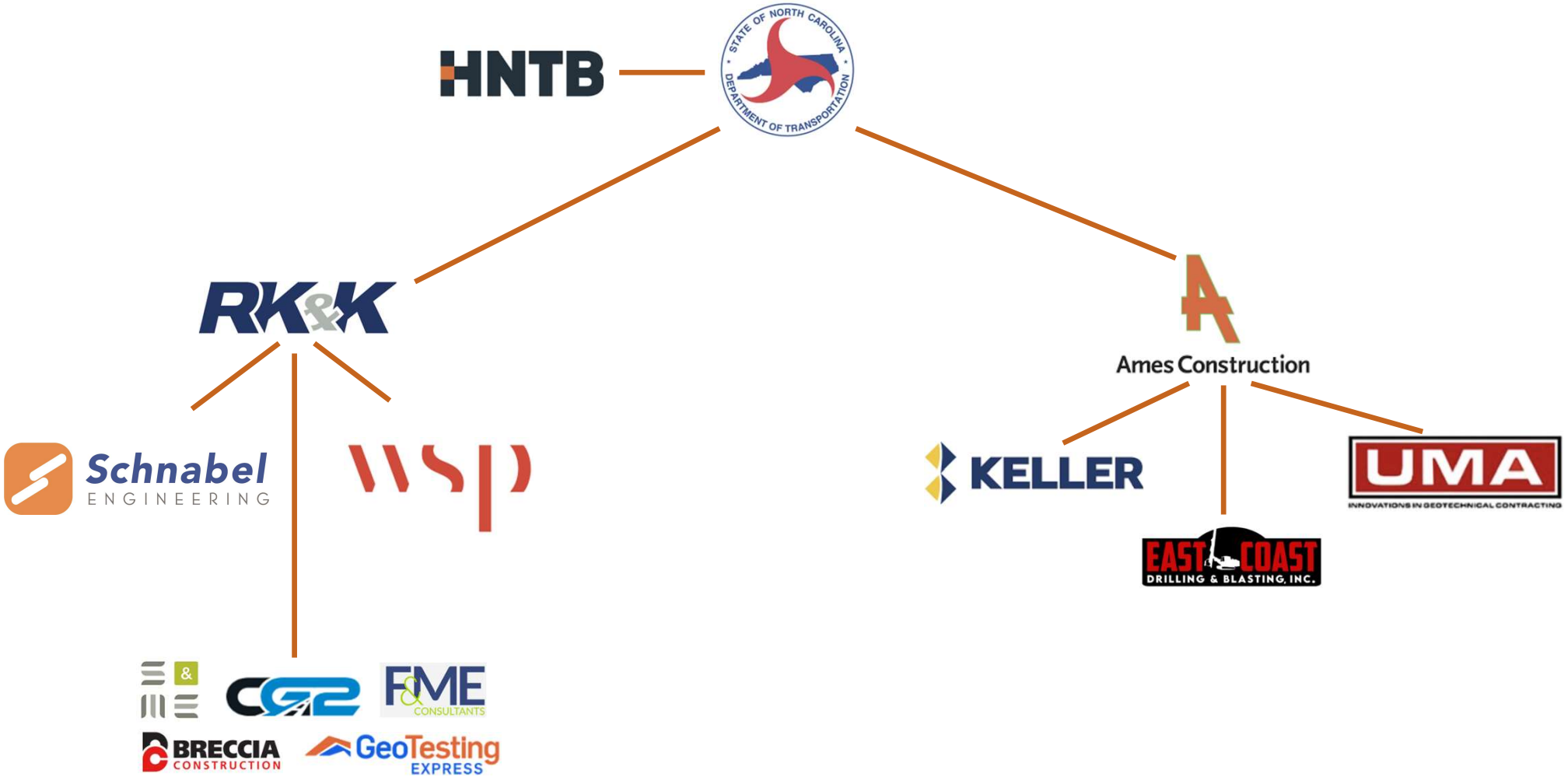
- History of I-40 through Pigeon River Gorge
- Damage from Hurricane Helene
- Geotechnical Exploration
- Data, Data, Data!

History of I-40 through Pigeon River Gorge



History of I-40 through Pigeon River Gorge

Overall Project Team – CMGC Procurement



Parallel Emergency Stabilization Efforts

WRIGHT BROTHERS

GSI
GeoStabilization International

ACCESS LIMITED

Project Goals

Per FHWA via NCDOT

- Resilient, Redundant, Reliable
- I-40 Corridor from MM 0.0 to MM 5.0 has a history of closure/repairs recurring every ~10 years
- Provide a system that will be resilient in storm events – generally withstand a storm event and not have extended road closures

- From FHWA-HIF-23-008, 2023:

Resilience	With respect to a project, "resilience" means a project with the ability to anticipate, prepare for, and/or adapt to changing conditions and/or withstand, respond to, and/or recover rapidly from disruptions, including the ability: (A) to resist hazards or withstand impacts from weather events and natural disasters, or reduce the magnitude or duration of impacts of a disruptive weather event or natural disaster on a project; and (B) to have the absorptive capacity, adaptive capacity, and recoverability to decrease project vulnerability to weather events or other natural disasters.	23 U.S.C. § 101(a)(24)[4] (See also definition in TEACR Synthesis Report)

Excerpt from: Table 2-1, "Geohazards, Extreme Weather Events, and Climate Change Resilience Manual", B. Zelenko et al, (2023)

GEOTECHNICAL INVESTIGATIONS

- What has already been used?
  - Horizontal drains
  - Mass Rip Rap Embankment
  - Soldier Pile Walls
- What type and length of structure is anticipated?
  - Tunnel?
  - Walls & Viaducts?
  - Reinforced Buttress?
  - Continuous Walls?
- Determine investigation methods

Previous Repair Methods used at I-40 & Pigeon River

GEOTECHNICAL INVESTIGATION

- 5 miles of stabilization
- Find depth to bedrock
- Overburden is very variable – silts & sands up to 20 foot boulders
  - Observation of temp. soil nails used for stabilization
  - Multichannel Analysis of Subsurface Waves (MASW) Geophysical investigation
  - Air track probes ~200 feet
  - Traditional rock coring ~500 feet
  - Include televiewer of rock cores

GEOTECHNICAL INVESTIGATION

- Over 600 investigation data points, split into 3 Phases
  - Phase I: WB Lanes while no live traffic
  - Phase II: EB Lanes
  - Phase III: At river level from causeway
- Over 15 miles of MASW
- Lab sample data (UCS, Point Load, Direct Shear, etc.)

Geotechnical Investigation
Soil Nail Installation

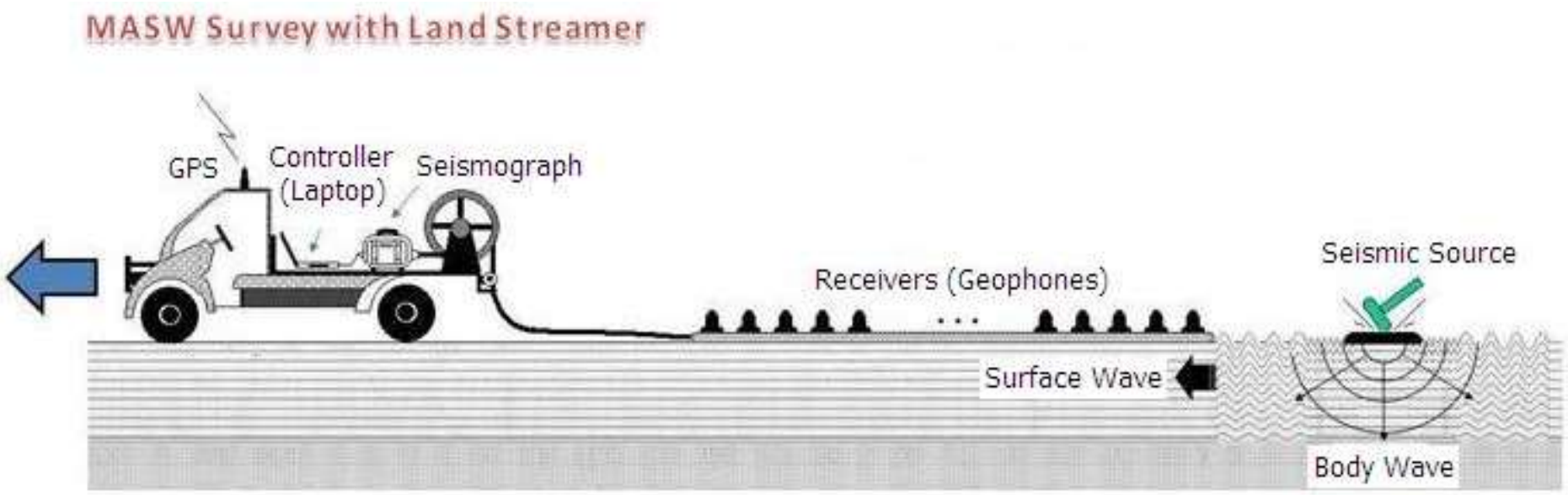
Temp. Soil Nail Drilling Observation

- Depth to rock
  - Range from 2 to 38 feet
  - Rock not encountered in ~25% of observed nails
- Penetration Rates
  - Range from 0.1 to 4.1 minutes per foot (min/ft)

Geotechnical Investigation
MASW Surveys

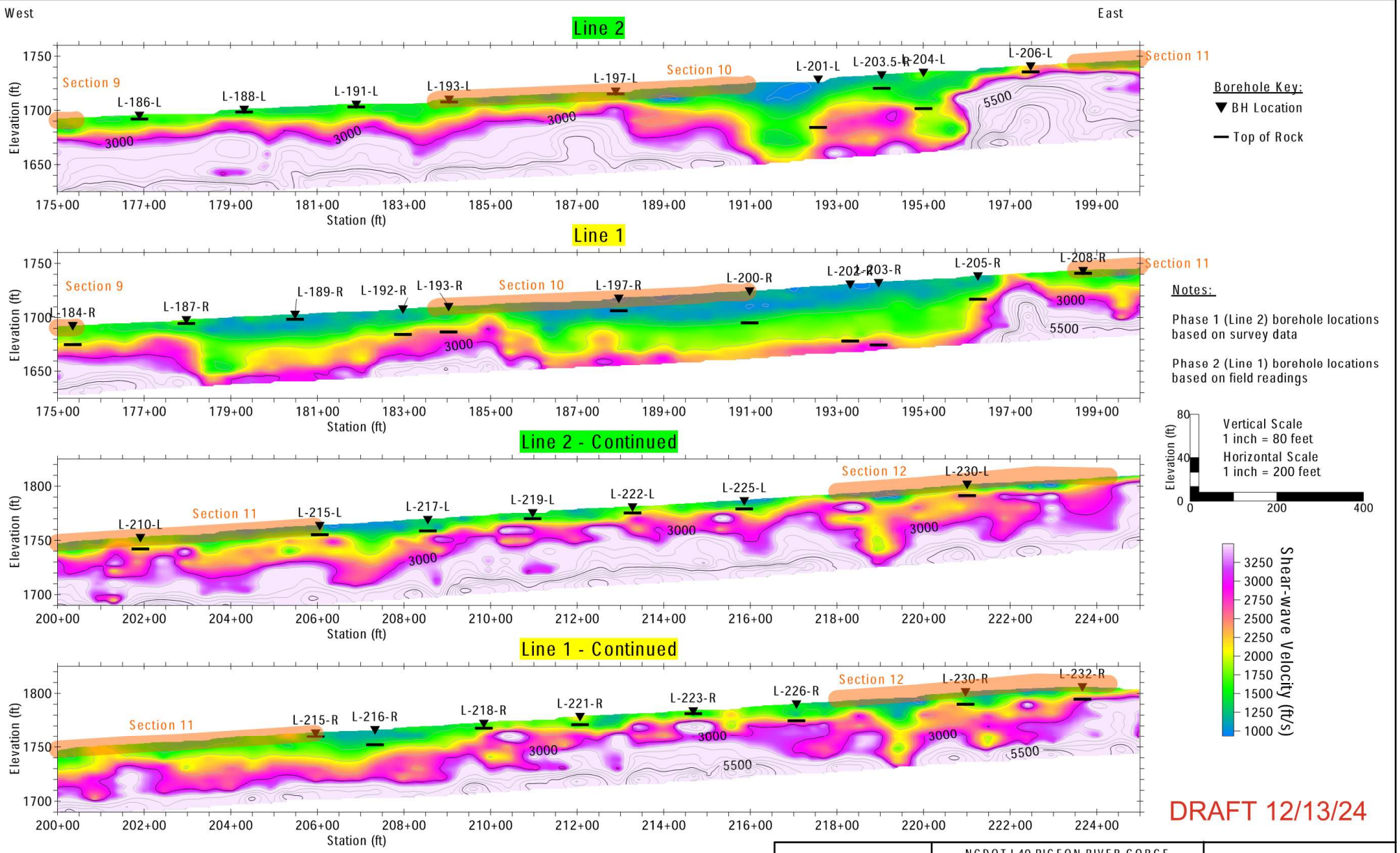
Geophysics

- 3 crews working multiple shifts
- ~15 miles of data collected



Geotechnical Investigation
Geophysics – High Resolution Imagery with MASW

Geotechnical Investigation
Geophysics – MASW Profiles



Schnabel ENGINEERING

NCDOT I-40 PIGEON RIVER GORGE
RK&K
HAYWOOD CO., NC
PROJECT NO. 24400014.000

Preliminary Results
Sta. 175 to Sta. 225

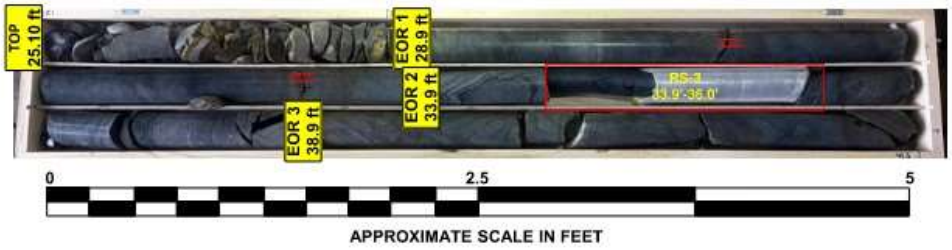
Draft B-5

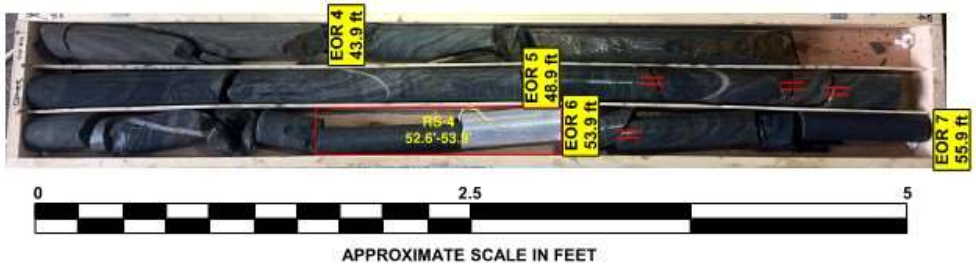
Geotechnical Investigation
Conventional Drilling Methods

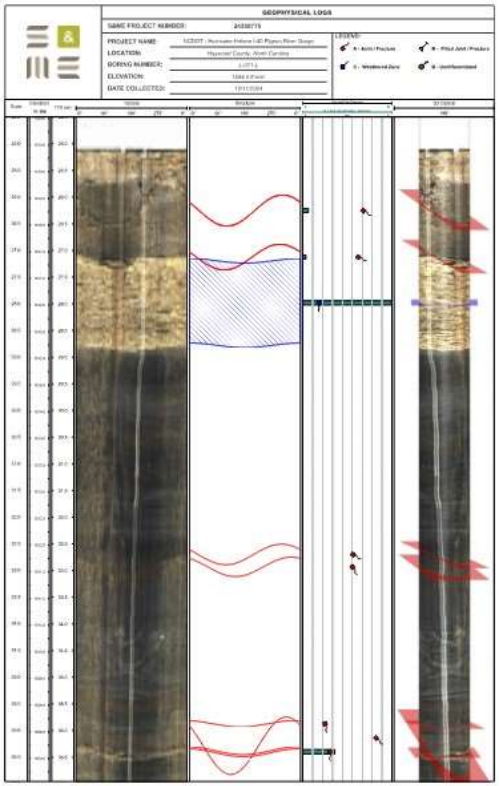
Geotechnical borings

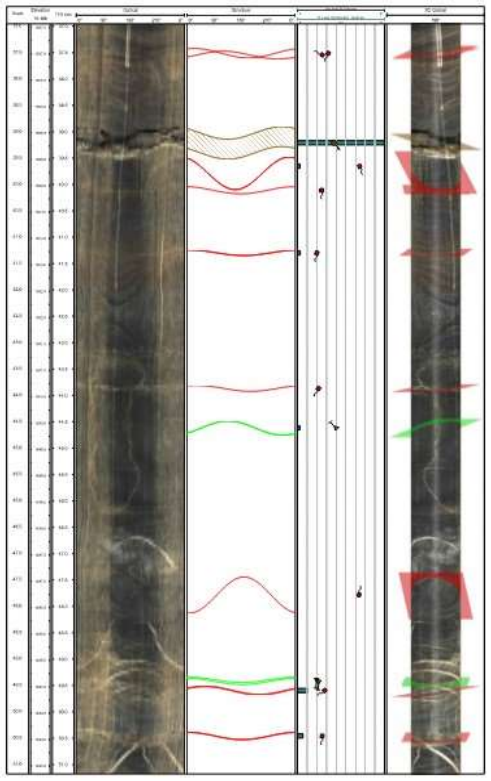
- Probe to rock
  - Casing advancer on Geotech drill
  - Micropile drill
- Core bedrock 30 feet
- Televiewer core length

Geotechnical Investigation
Rock Core & Optical Televiewer Data Comparison









Geotechnical Investigation
Air Track Methods

Air Track Probes

- Up to 3 rigs at a time
- Depth to rock
  - Range from 3 to 58 feet
  - Rock not encountered in ~7% of probes

Geotechnical Investigation
Considerations

Top of Rock

- Steep sloping bedrock surface
- Variability in rock surface elevation
- Hard rock – siltstone, sandstone, meta graywacke, quartzite

Rock Bedding / Fractures Planes

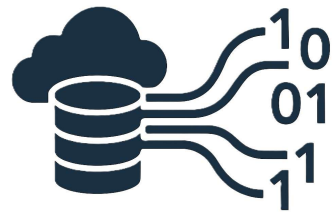
- Dip toward the river

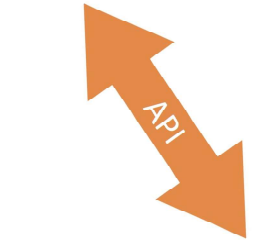
DATA MANAGEMENT WITH MORTAR

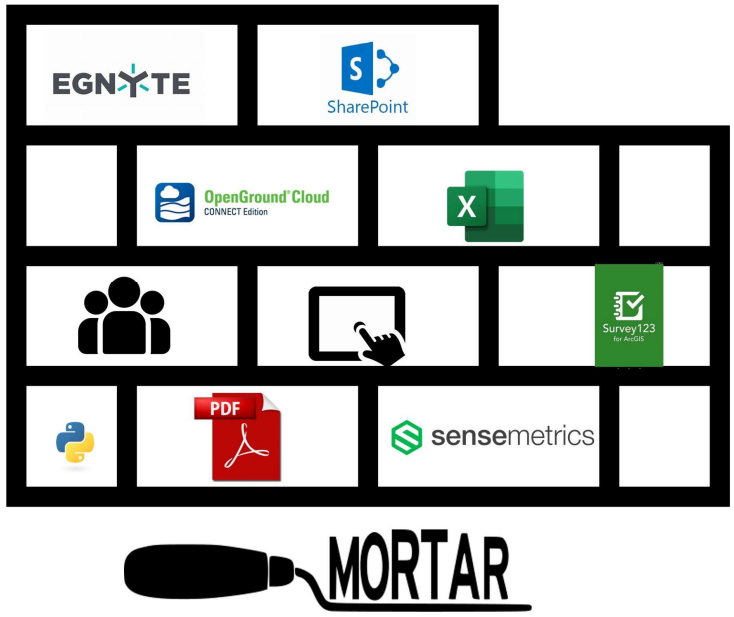
- Internally developed database system (MORTAR)
- Geo-referenced data
- Data mapping and integration
- Facilitates a more informed design process

Data Management with Mortar
Next Generation of Project Delivery

- Centralized Data Hub
- Built-in QA/QC
- Dynamic Visualization
- Linked Content
- Integration & Portals
- Advanced Outputs







MAPPING & VISUALIZATION

- Internally developed database system (MORTAR)
- Data mapping and integration
- Facilitates a more informed design process

Mapping and Visualization
Mortar Portal

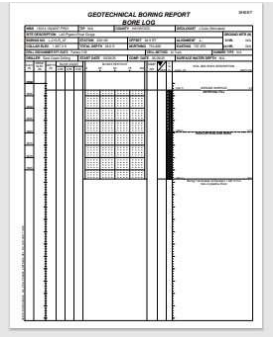
Airtrack borings

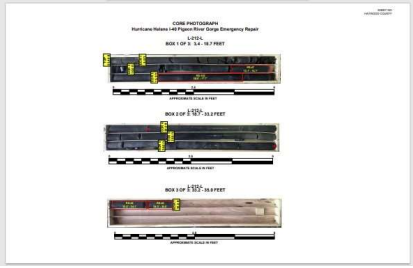
Temporary Support Soil Nails

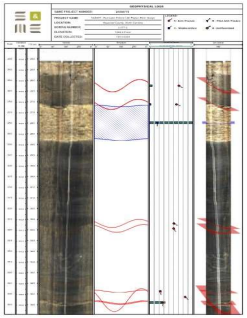
Historic NCDOT borings

Rock Core borings

Main
Geophysics
Rock_Depth ✔
Progress
Prelim_vs_Drilled
Zones
PenRate_AirTrack
PenRate_SoilNail
UAV

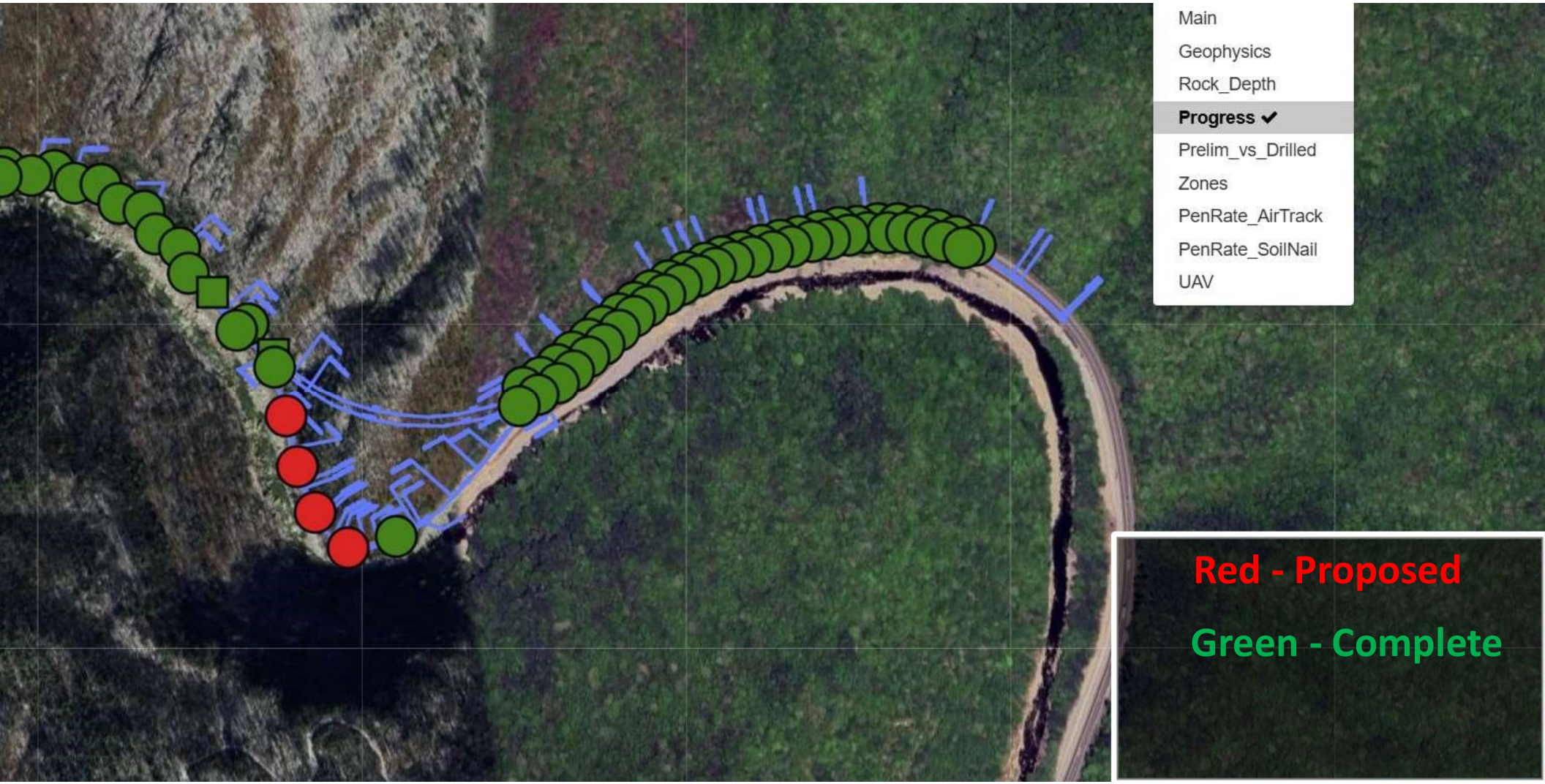






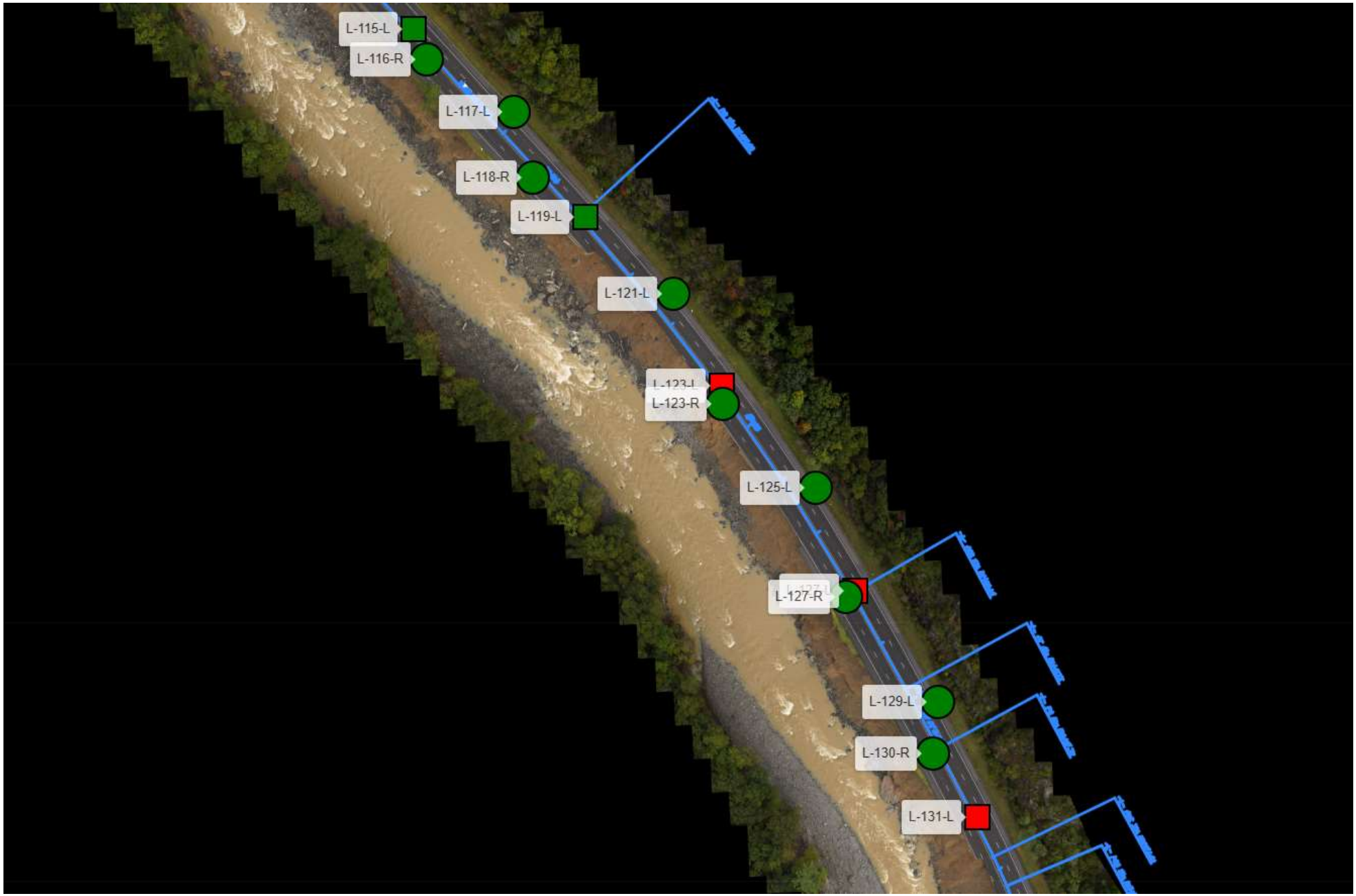
- >30 feet
- 30 feet > 20 feet
- 20 feet > 10 feet
- < 10 feet

Mapping & Visualization
Mortar Progress Example



Pre-Storm Satellite Aerial Imagery

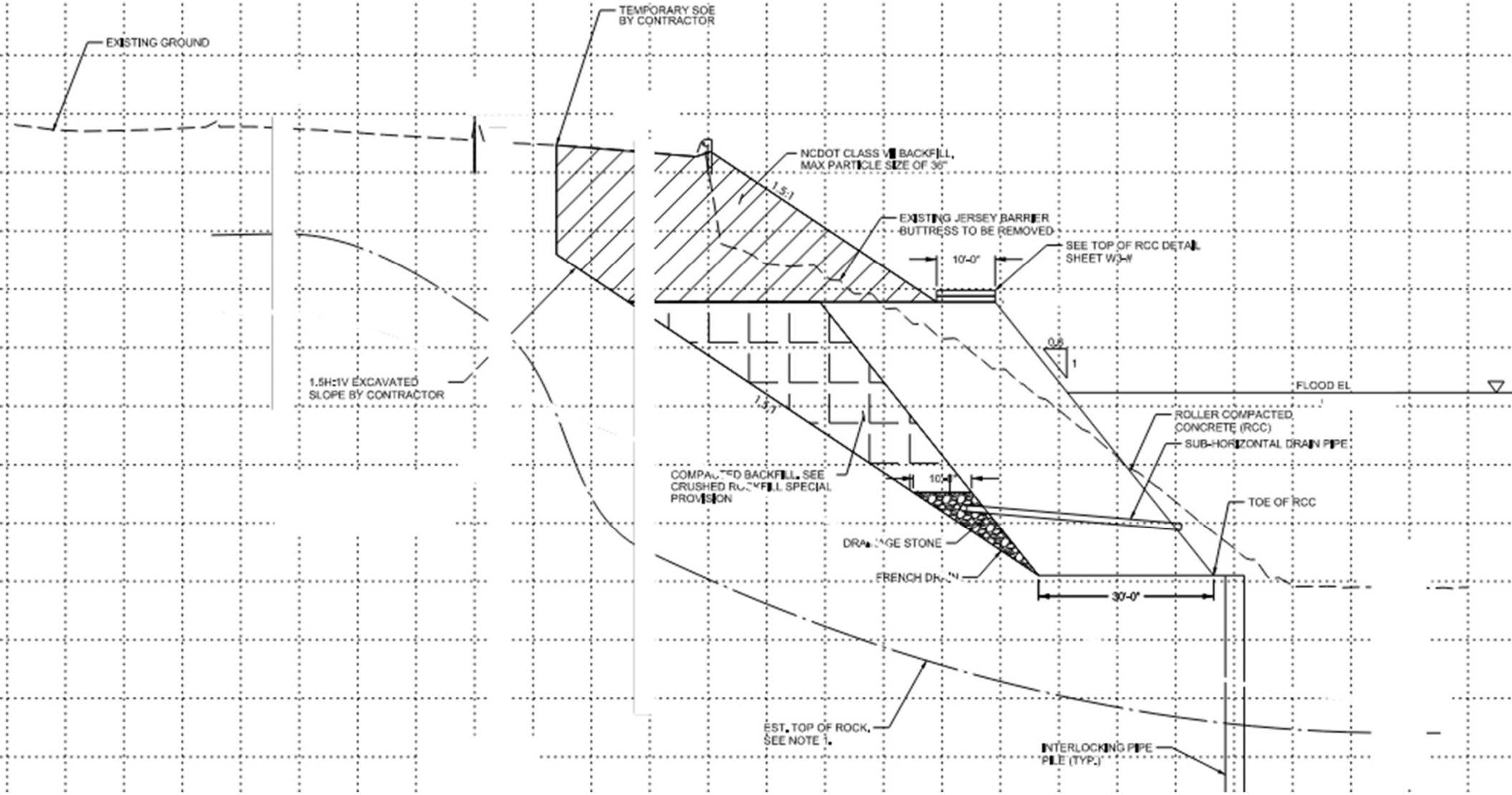
Post Storm Satellite Aerial Imagery



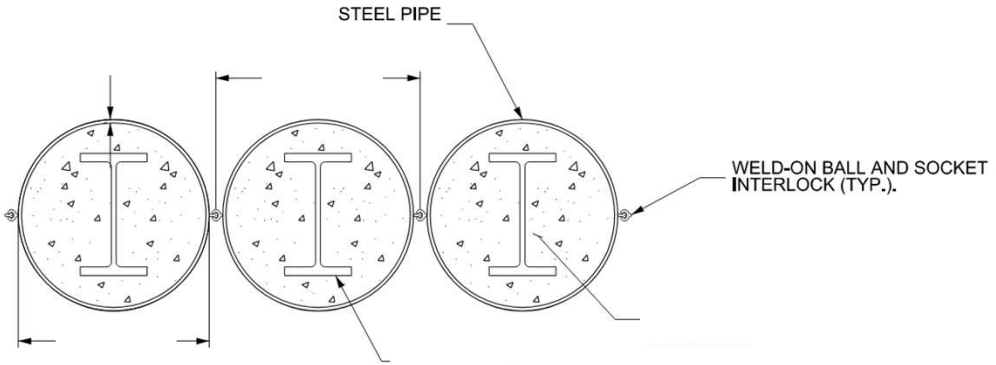
GEOSTRUCTURAL CONCEPTS

- TUNNEL (no-go)
- VIADUCT WITH WALL AT CENTERLINE (no-go)
- RCC BUTTRESS
- WALL AT SHOULDER WITH BACKFILL OPTIONS
- WALL AT TOE TO RE-ESTABLISH EMBANKMENT

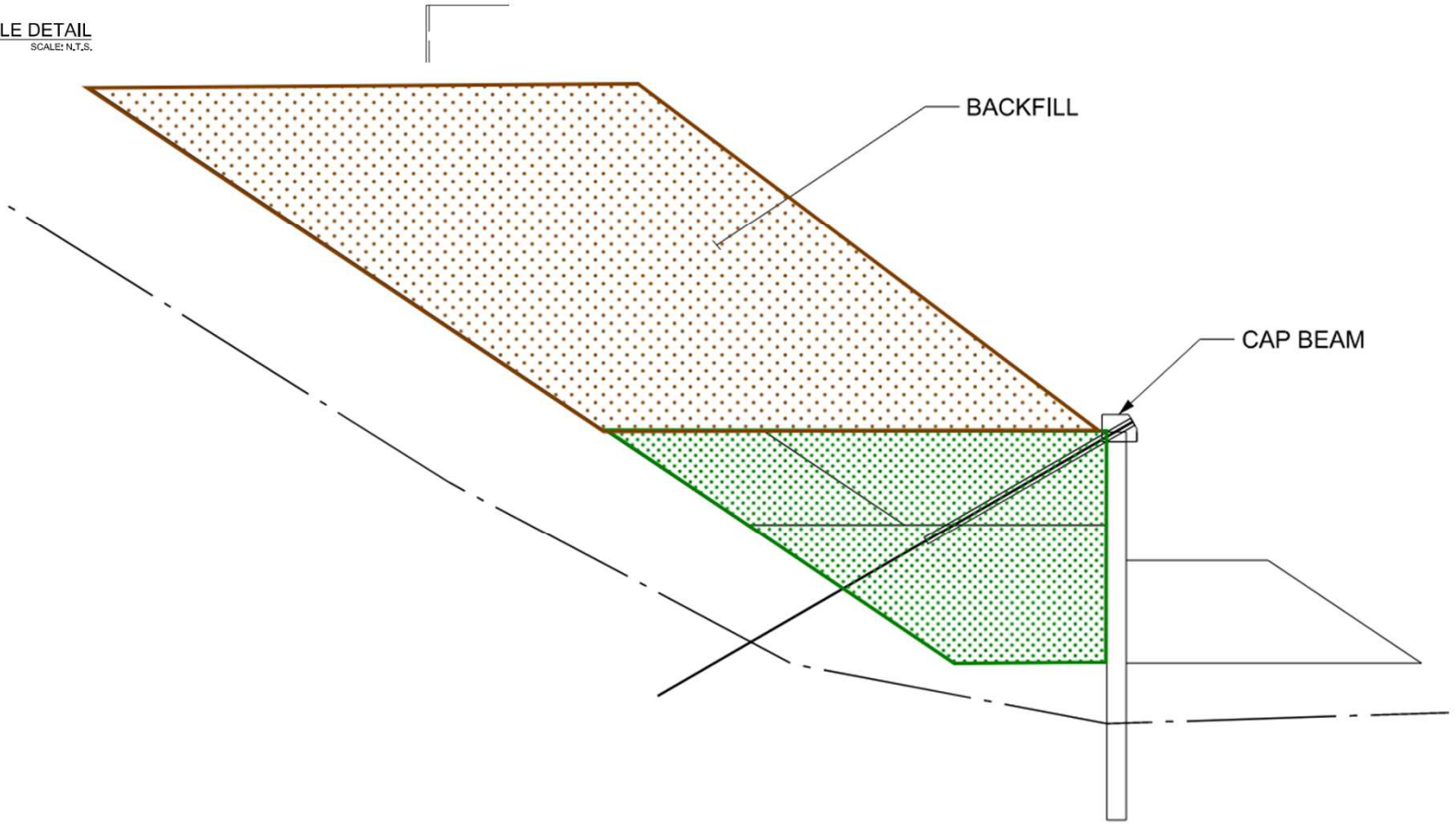
RCC Buttress Concept



Interlocking Pipe Pile Wall Concept



2 TYPICAL INTERLOCKING PIPE PILE DETAIL
SCALE: N.T.S.



LESSONS LEARNED

- Need to be adaptable to get information quickly and inform timely decisions on an emergency project
  - Ground conditions vs. design concepts
  - Air tracks vs. traditional borings
- Data management helps with large volumes of data to review/reduce

QUESTIONS?

- Chris Ramsey 615-974-0797 cramsey@schnabel-eng.com
- Jason Holland 910-512-5622 jholland@schnabel-eng.com

Schnabel ENGINEERING

schnabel-eng.com