

Case Histories

Building and Using 3D Models to Plan and Execute Site Characterizations

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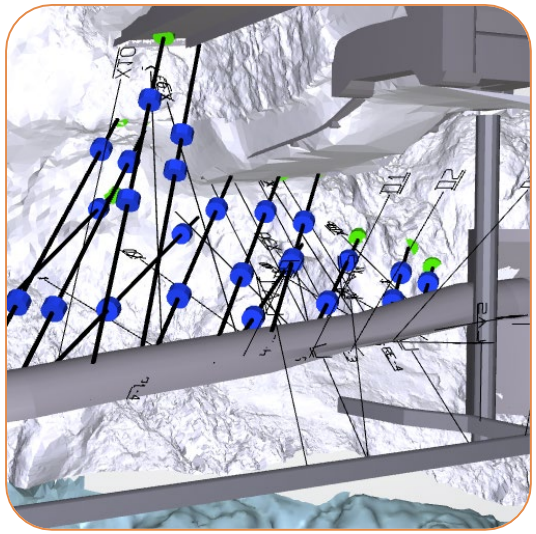
Schnabel ENGINEERING

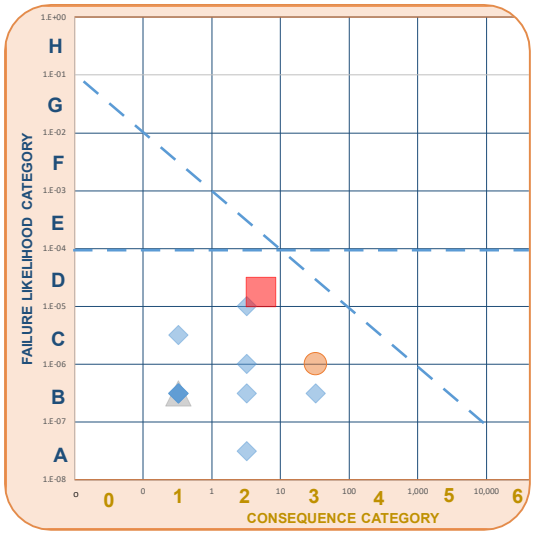
Build Better. Together.

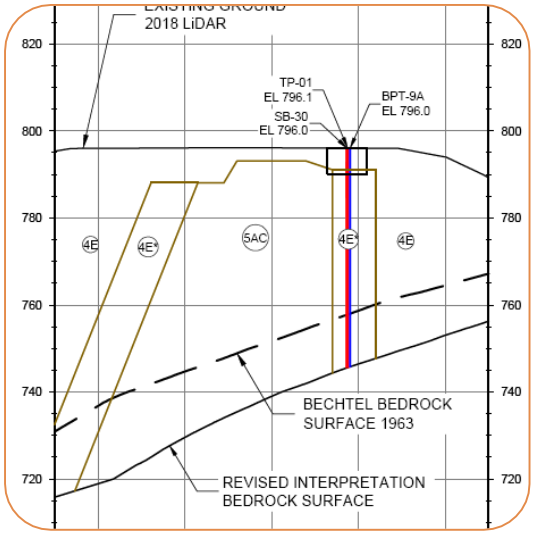
Presentation Objectives

Case Histories will show:

1. Existing projects can be totally recharacterized with existing information.
2. Creation of 3D models allows us to do a much better job of designing geotechnical investigations so that we are answering the right questions.
3. Creation of 3D model leads to project discovery

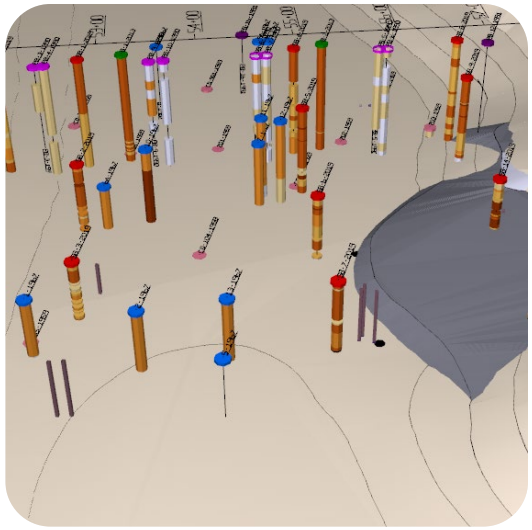


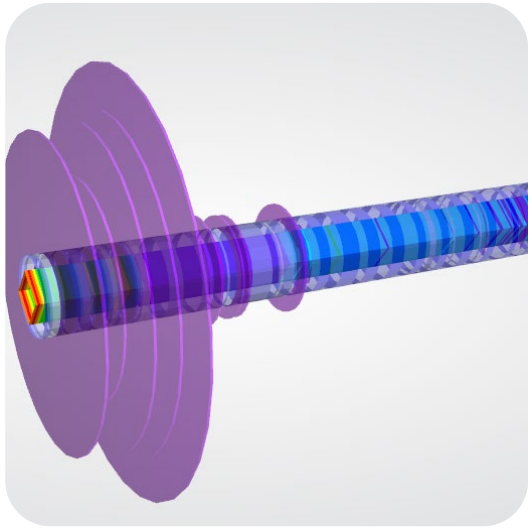




Our Approach to Site Characterization

- Start with Construction History
  - Review more than the typical plan view, section, profile, and geology descriptions
- View **ALL** available data in one space
  - Spend more resources upfront (time and money) to understanding the story
  - Data is displayed, limit interpretations
  - Sources are well documented
- Communication
  - Design Team, Owners, Stakeholders all on the same page from the beginning
  - Easily shared, user-friendly, visualization enhancing 3D PDF Models





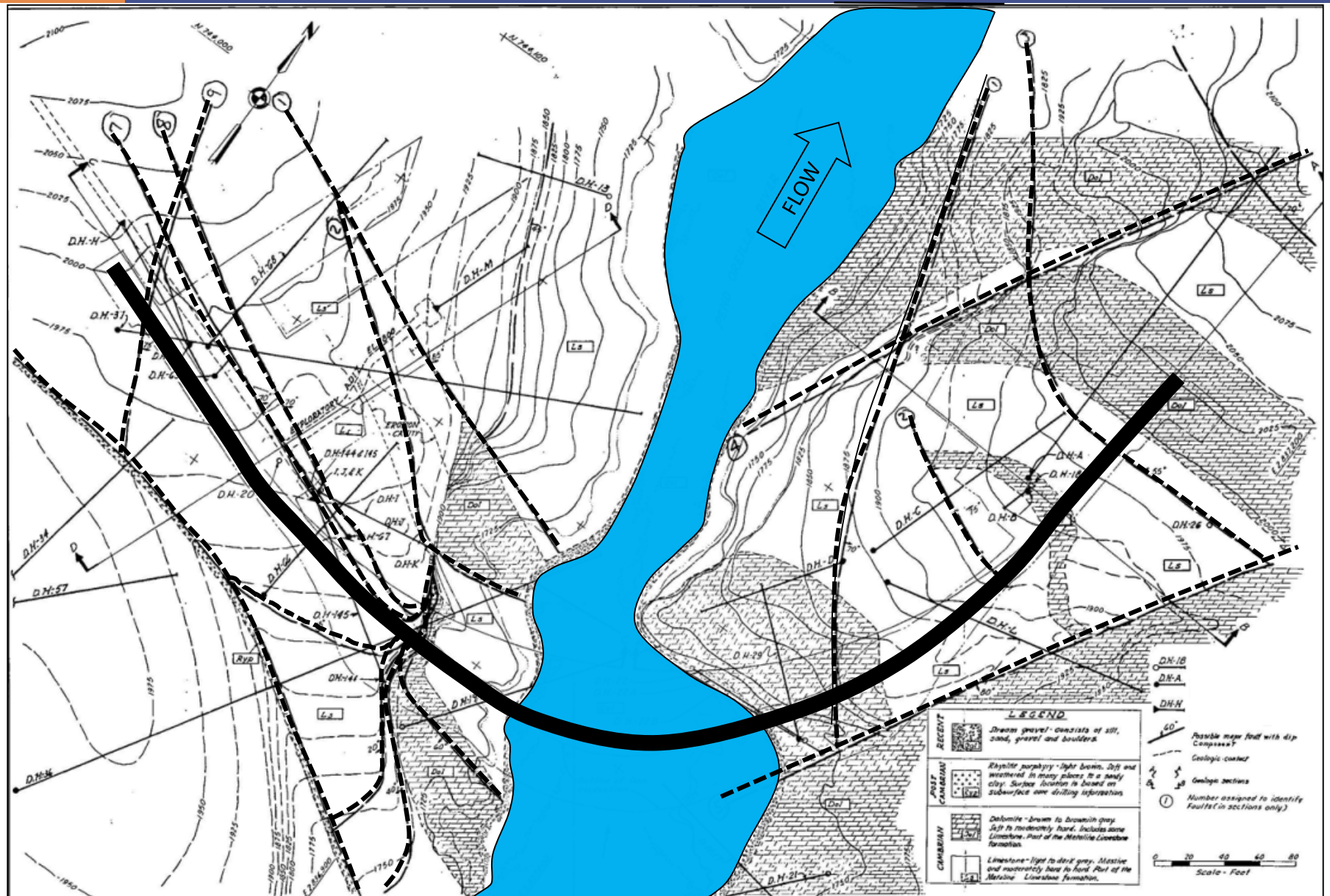
The result is a significantly higher likelihood of **confidence** in our geotechnical investigations, risk analyses, instrumentation, and remedial designs.

Case History #1

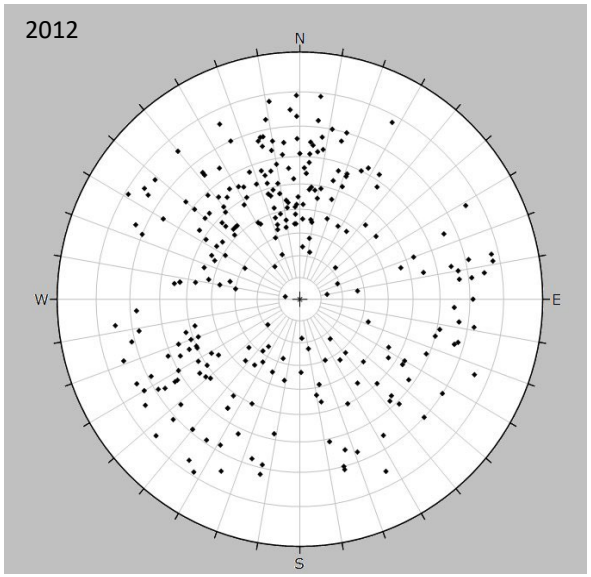
Somewhere West of the Mississippi

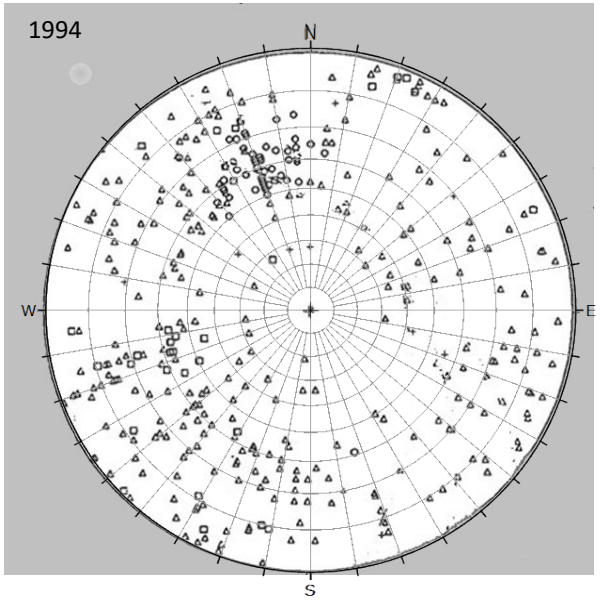
350’ High Double Curvature Thin Arch
Underground powerhouse
Online in late-1960s
Massive 500-million-year-old limestone and dolomite, cliffs 500+ ft high

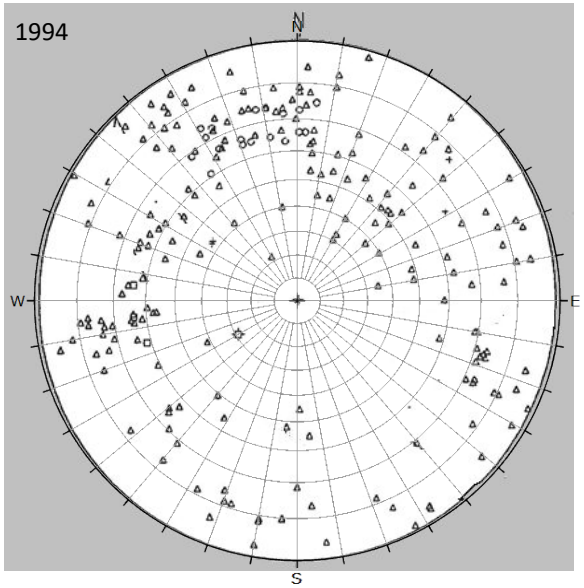
Case History #1 – Where we started…

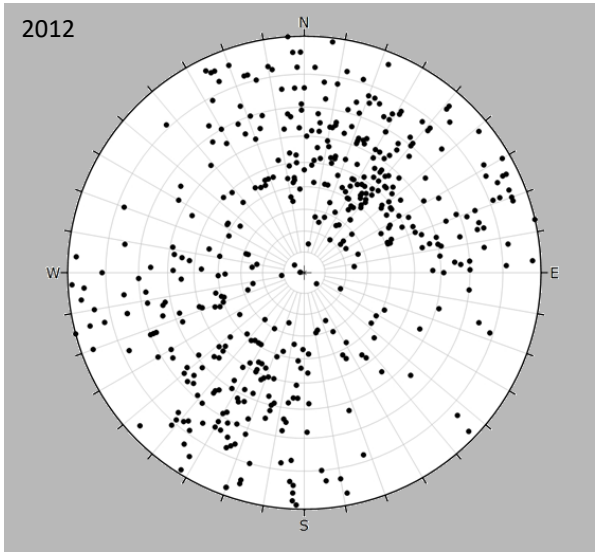


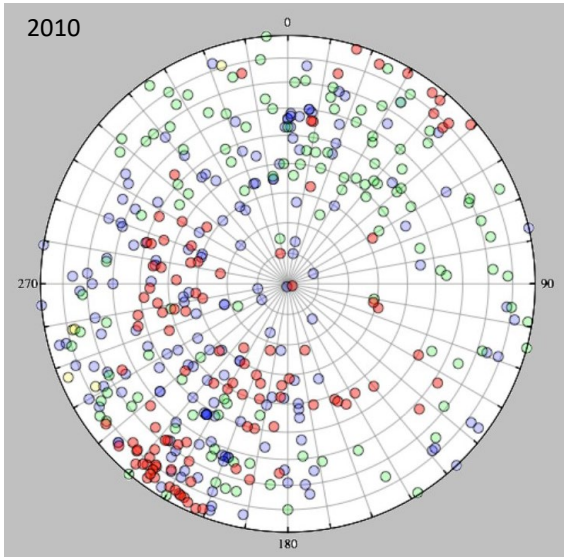
Case History #1 – Where we started…







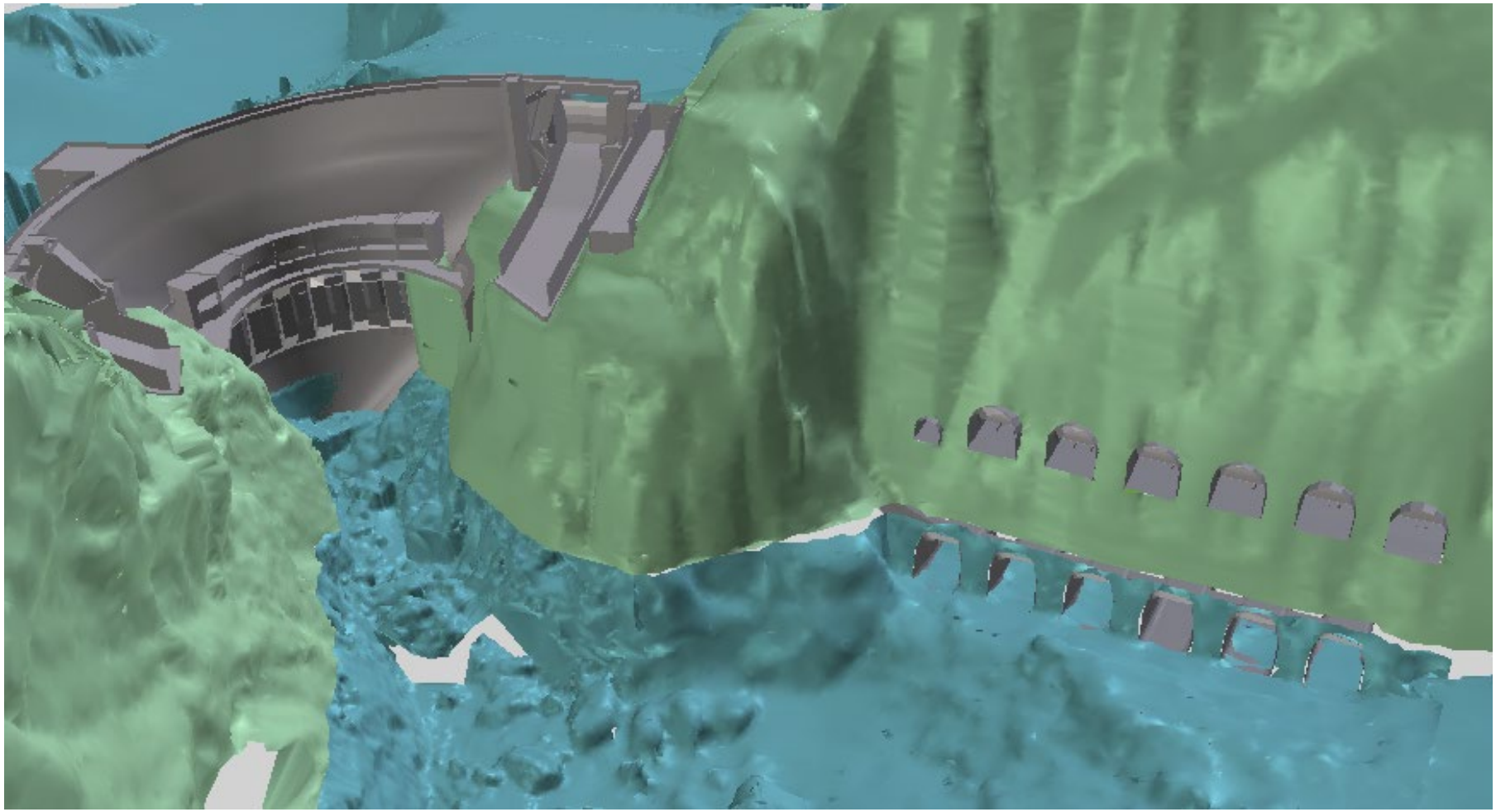




3D Model?! Where do we even begin?

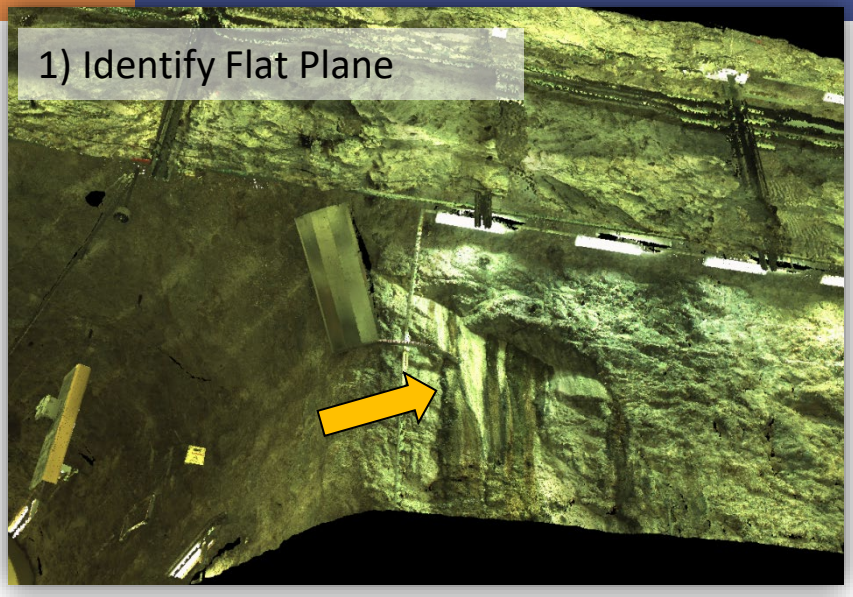
- Let the data tell the story
- Dive into construction records and compile ALL existing geotechnical data
  - Construction photos
  - Construction drawings
  - Boring logs
  - Water test results
  - Geologic maps
  - **Point cloud**
    - Site coverage

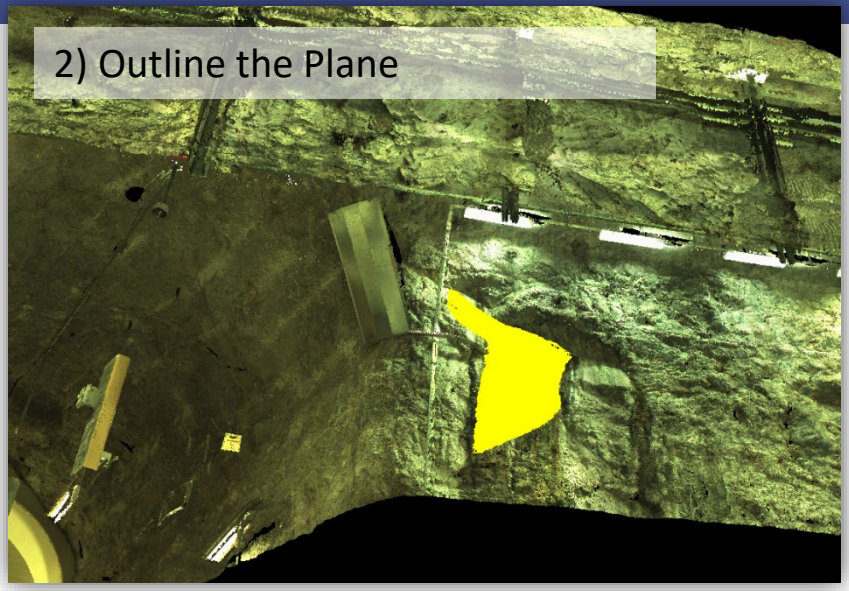
3D Model

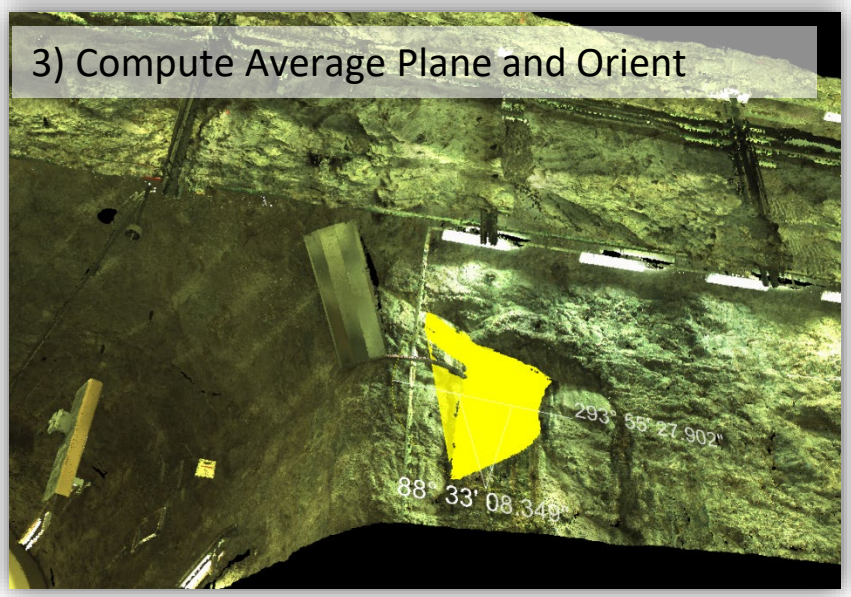


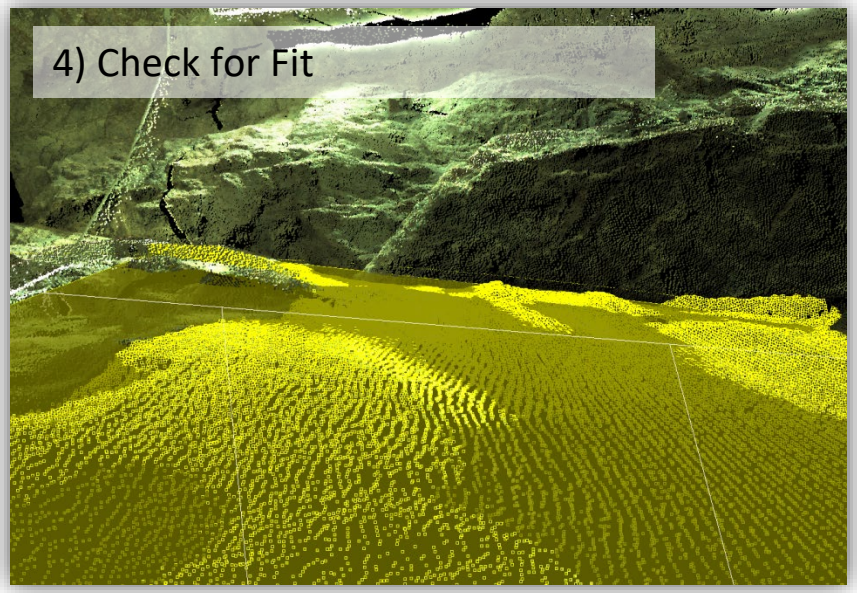
Laser Scanning to Measure Discontinuities

Mapping Discontinuities – Planes

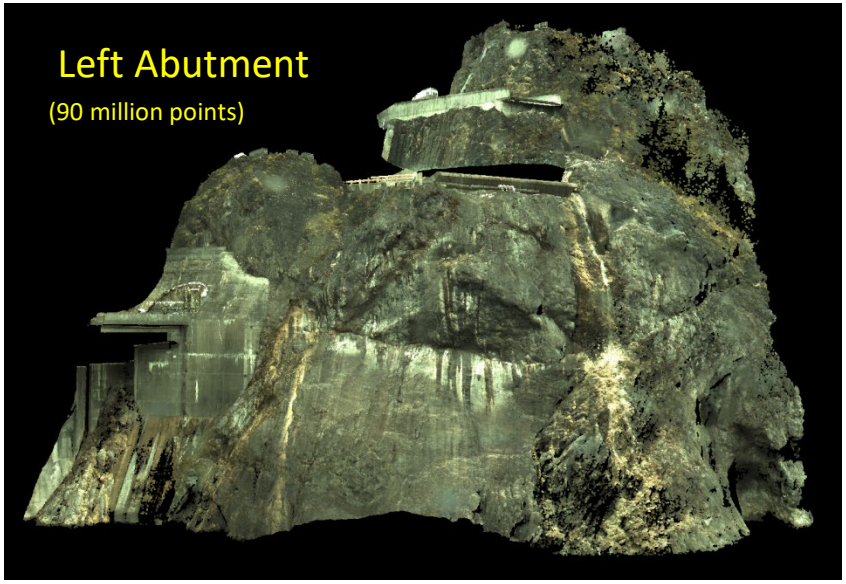


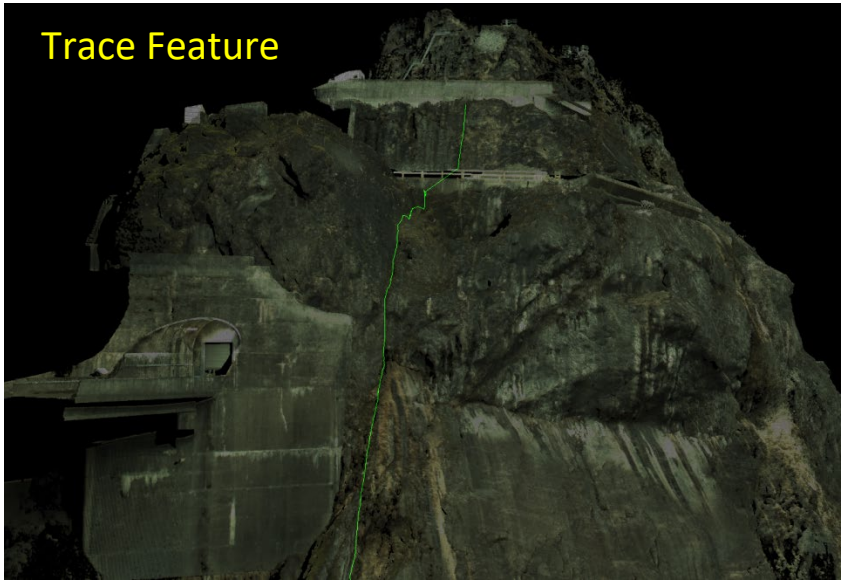


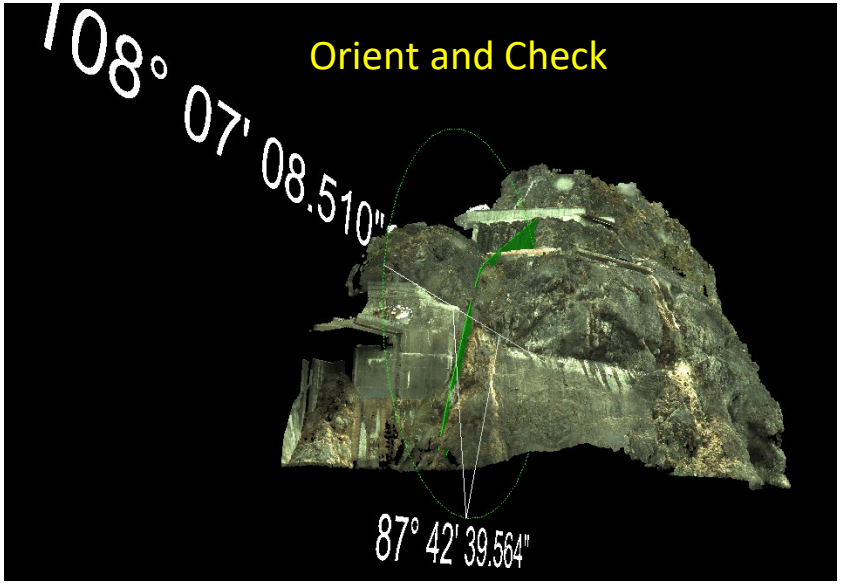




Mapping Discontinuities – Traces

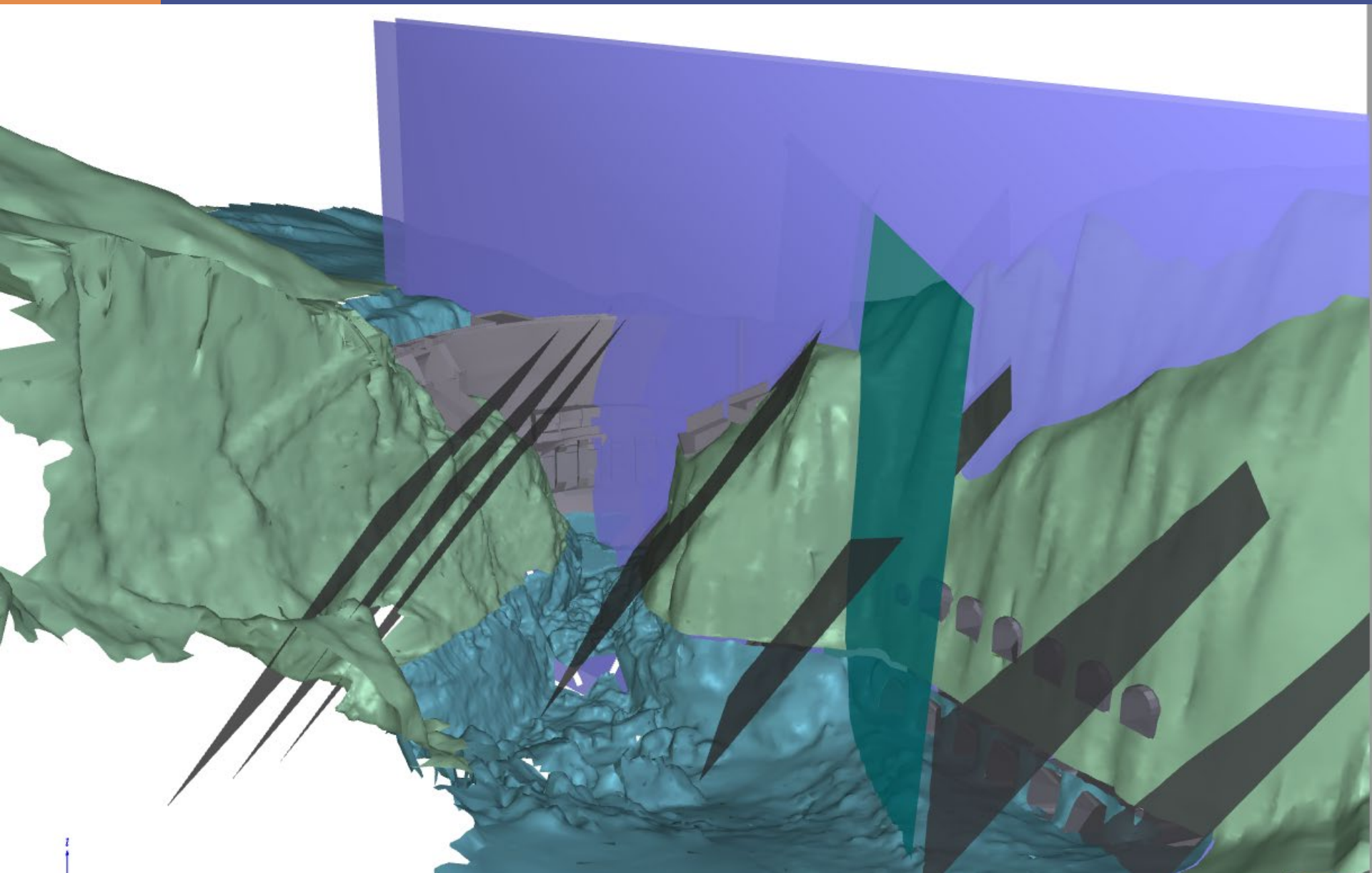




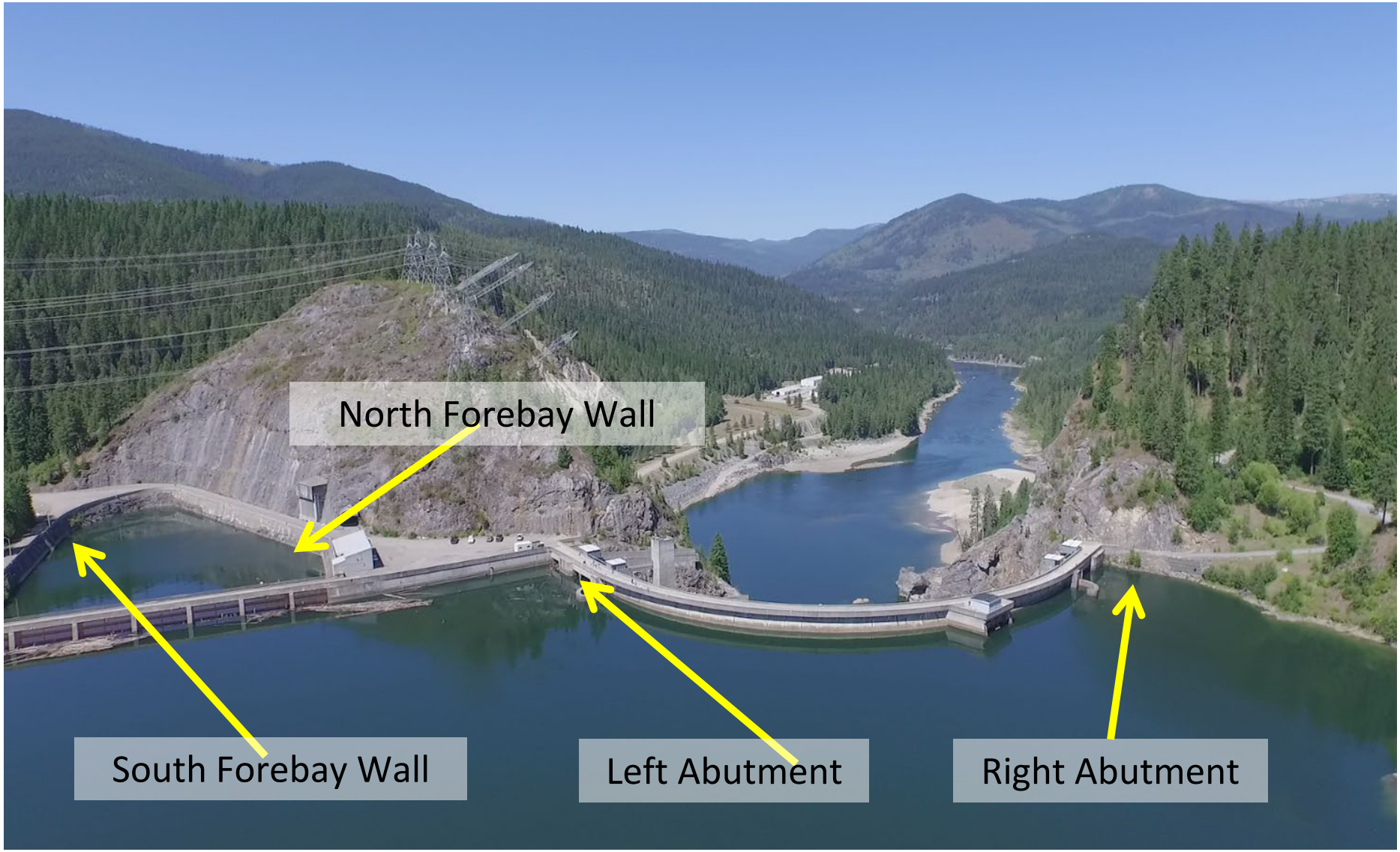


- There are many traces with no planes
- There are many planes with no traces
- Traces and planes both saved for

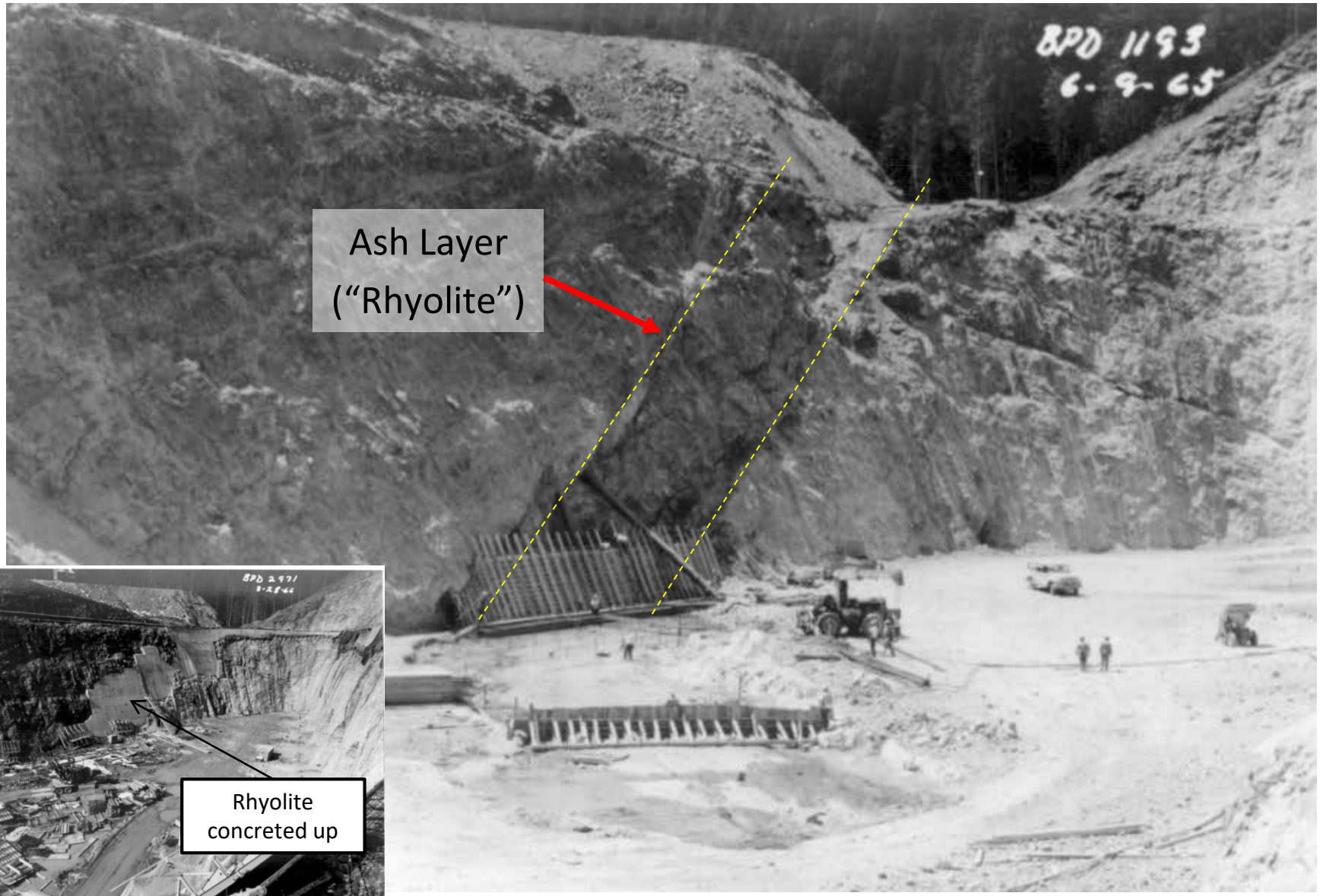
3D Model



Stratigraphic Analysis

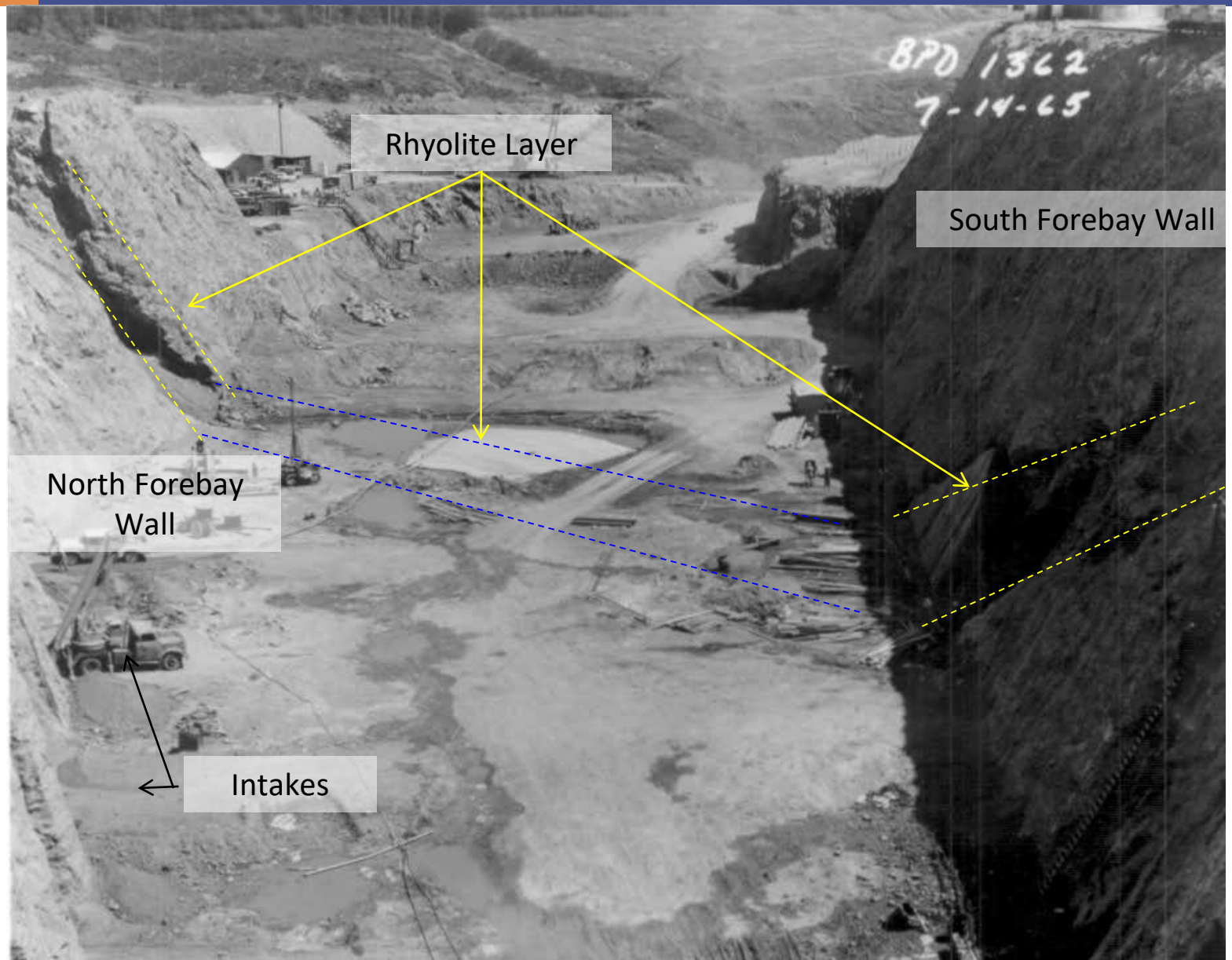


South Forebay Wall

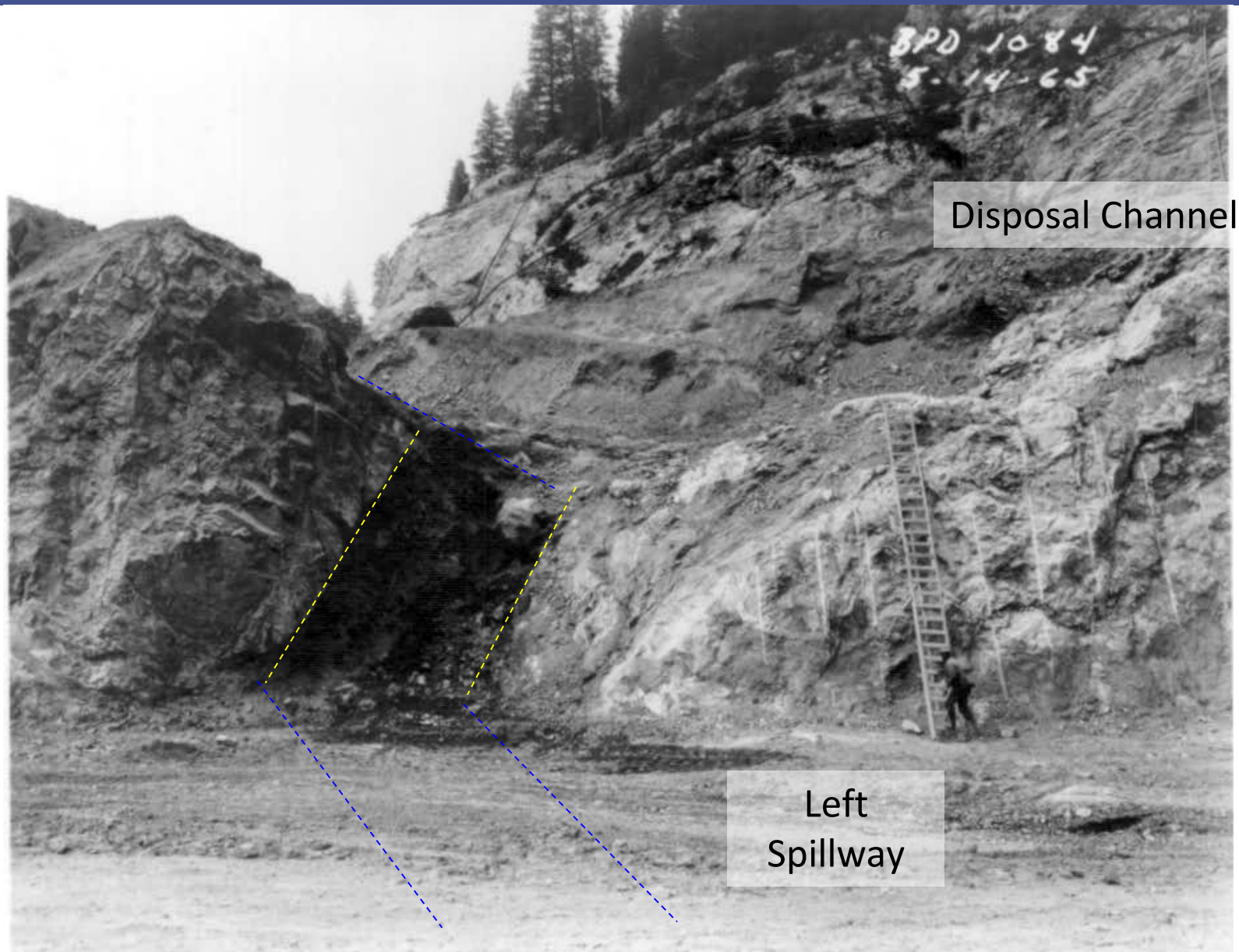


North Forebay Wall

Forebay


BPD 1362
7-14-65
Rhyolite Layer
South Forebay Wall
North Forebay Wall
Intakes

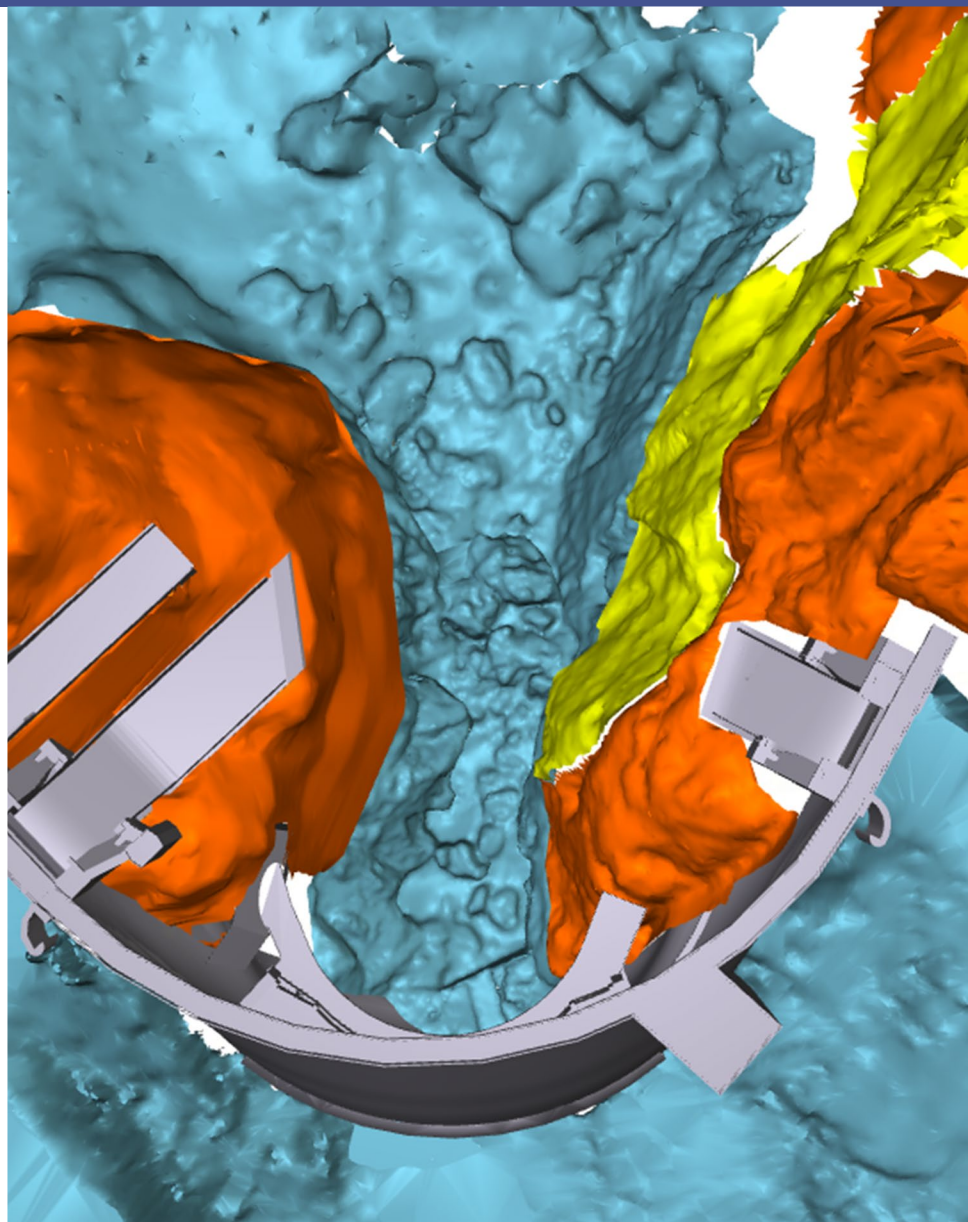
Left Spillway



Right Abutment

Case History #1 – Lessons Learned

- Site totally recharacterized based on existing data
- Complex stratigraphy and fracturing BUT the site is one contiguous block!
- “Possible Major Faults” appear to be through-going joint sets with little displacement
  - Form large potentially removable blocks
- Re-understanding of original geologic map stratigraphy
  - collapse breccia



Case History #1 – Lessons Learned

Understanding of Site Geology Changed Completely

- Resulted in analyses of potentially removable blocks on the abutments
- Emergency stabilization of bridge pier supported by a rock block with low Factor of Safety

3D Model was Used for a Variety of Tasks

- Rock block stabilization support
- Risk – address PFMs in PFMA and SQRA
  - Reclassification of PFMs
  - Increased confidence
- Targeted ground-truthing
- Reevaluation of instrumentation program

Case History #2

Down in a Valley

Embankments on either side of a central powerhouse

Maximum embankment height of about 160 ft

Output of ~800 MW

Built in late-1960s

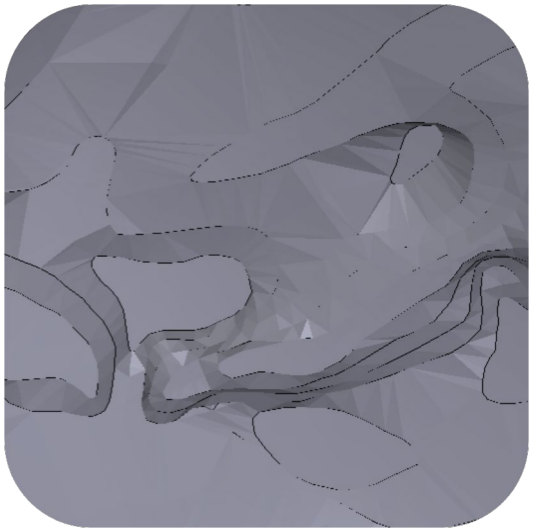
Glaciofluvial deposits on a major river

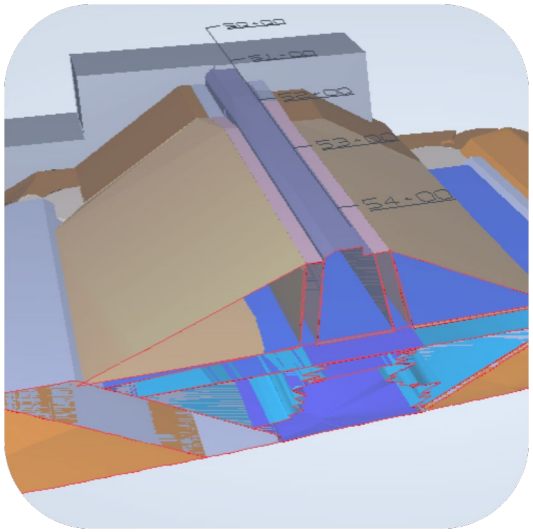
Case History #2 – It's Complicated

Periodic Risk Assessment performed, and conclusion was that there is a lot of uncertainty regarding project risk.

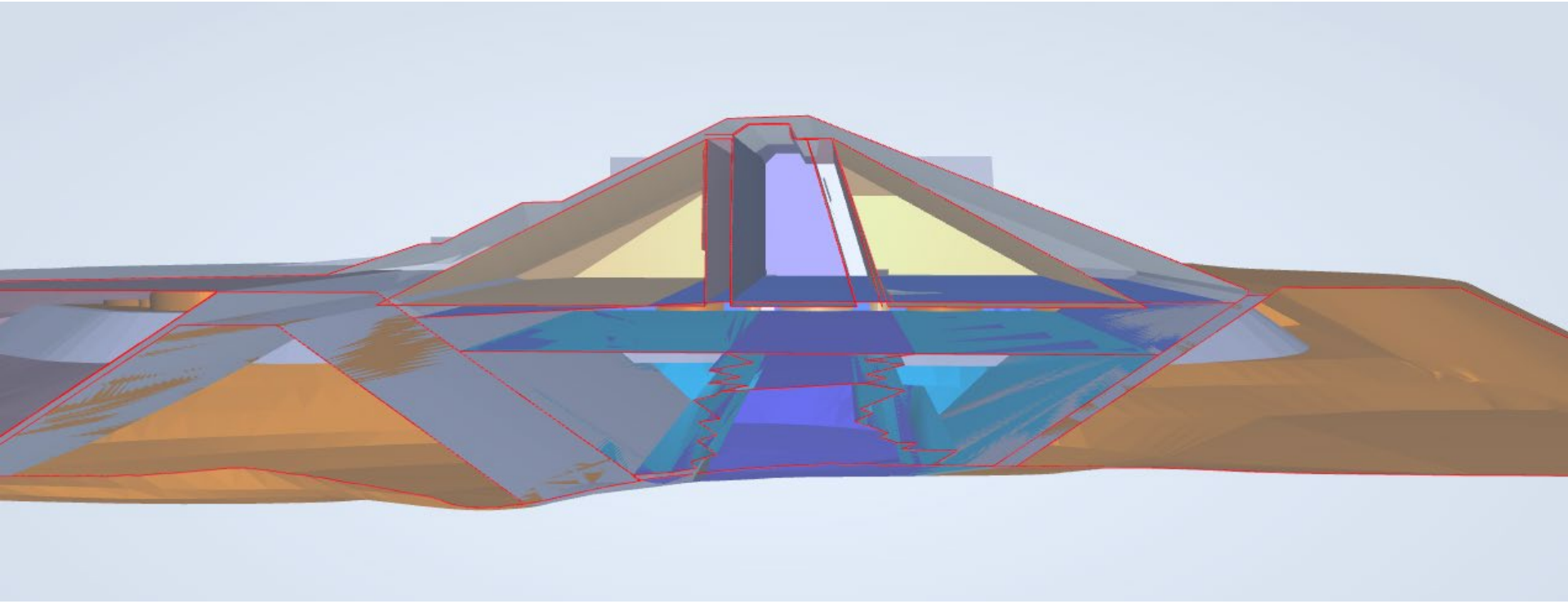
3D Modeling Objectives:

- Inform filter compatibility analysis
- Support planning of a geotechnical investigation to inform:
  - seismic stability
  - internal erosion, and
  - other risk-driving PFMs.





3D Model

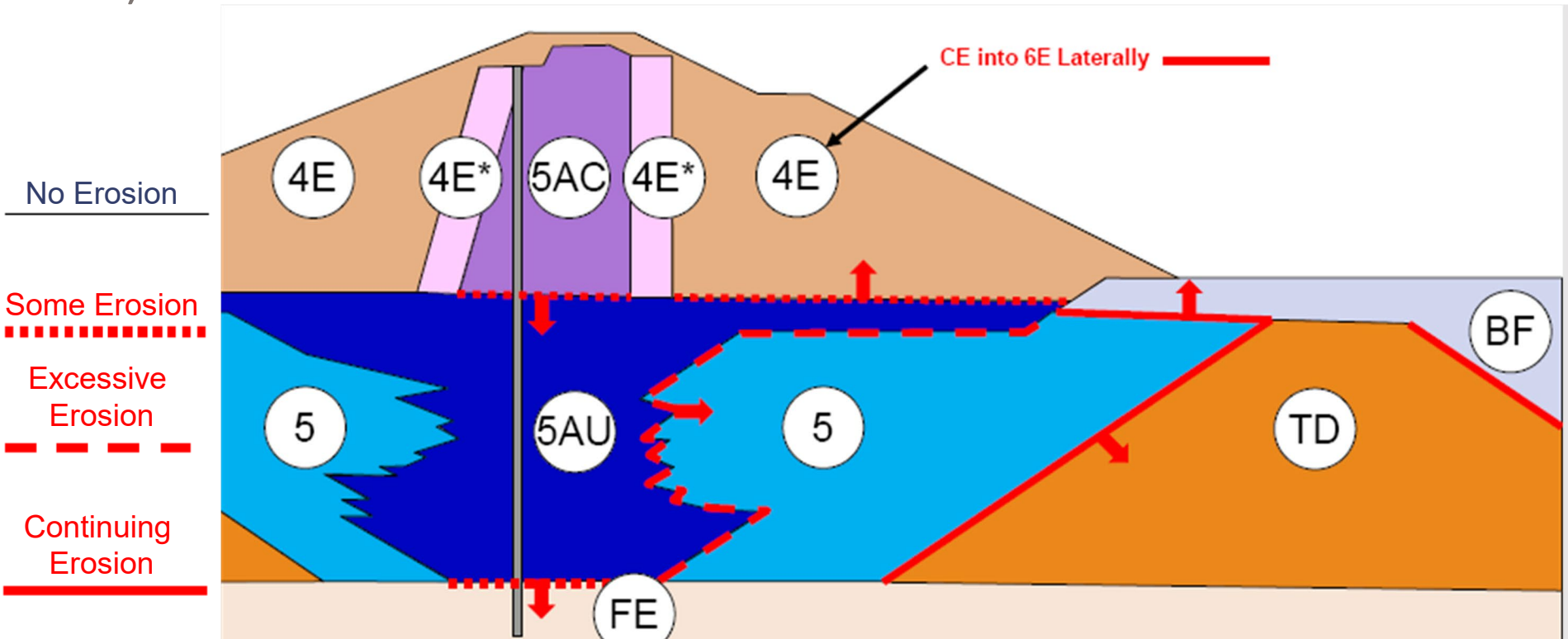


Case History #2 – Using the 3D Model as our Guide

- Does the current site understanding make sense based on available data?
- Where are our existing borings? In-situ testing?
- What is missing?
- Where is the data we need? What are the best ways to get it?
- Is there liquefiable material in the foundation? Where are those materials?

Case History #2 – Planning an Investigation to Address Uncertainty

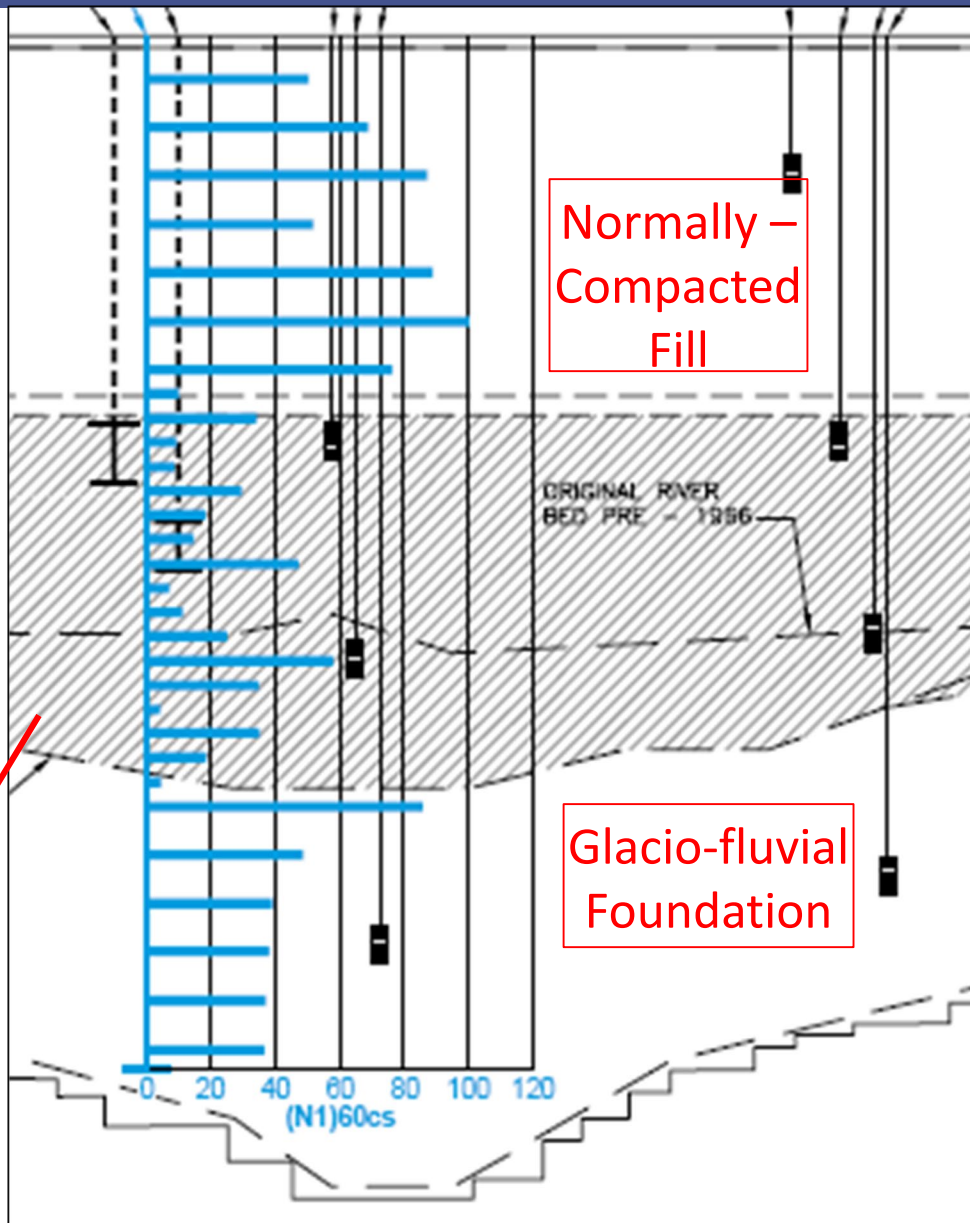
1. Internal Erosion
   a) Material properties
      a) Characterize geometry of zone contacts
   b) Changes over time
   c) Gradients



Case History #2 – Planning an Investigation to Address Uncertainty

2. Seismic Stability
   a) penetration resistance data
   b) material properties

What do you do when your materials are gravel or larger?



Case History #2 – Complex Investigation

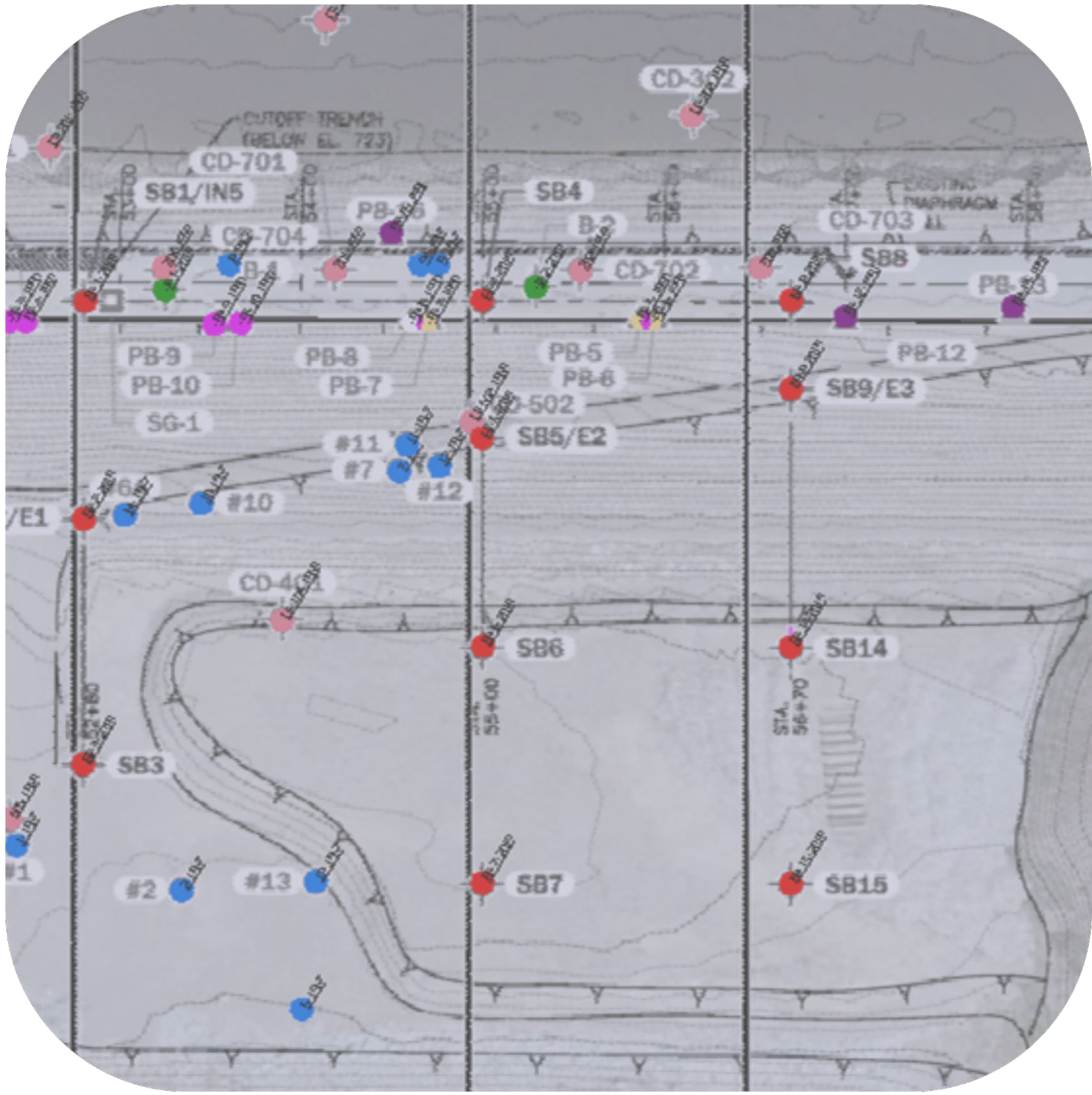
Targeted Investigation with Multiple Techniques

Drilling

- Sonic – samples for gradation testing (8-inch diameter in certain zones)
- Becker Drilling – penetration resistance
- Mud Rotary – SPT values and site-specific correlations
  - Blows per-inch
  - Shear wave velocity in embankment
- Diamond Rotary Coring – foundation shear wave velocities

Geophysics

- Suspension logging – shear wave velocity



Case History #2 – Lessons Learned

- Understanding construction methods is critical
- Past performance is key
- Data Quality Must be Assessed
- Keep the end goal in mind

CONCLUSIONS

The process of building 3D models leads to a more holistic understanding of projects.

Existing records are critical for site characterization

Good models result in higher likelihood of success

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