GEOTECH ROLES AND RESPONSIBILITIES DURING FEASIBILITY

PRESENTATION TO PCOP

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Engineering & Construction
Headquarters

February 2025

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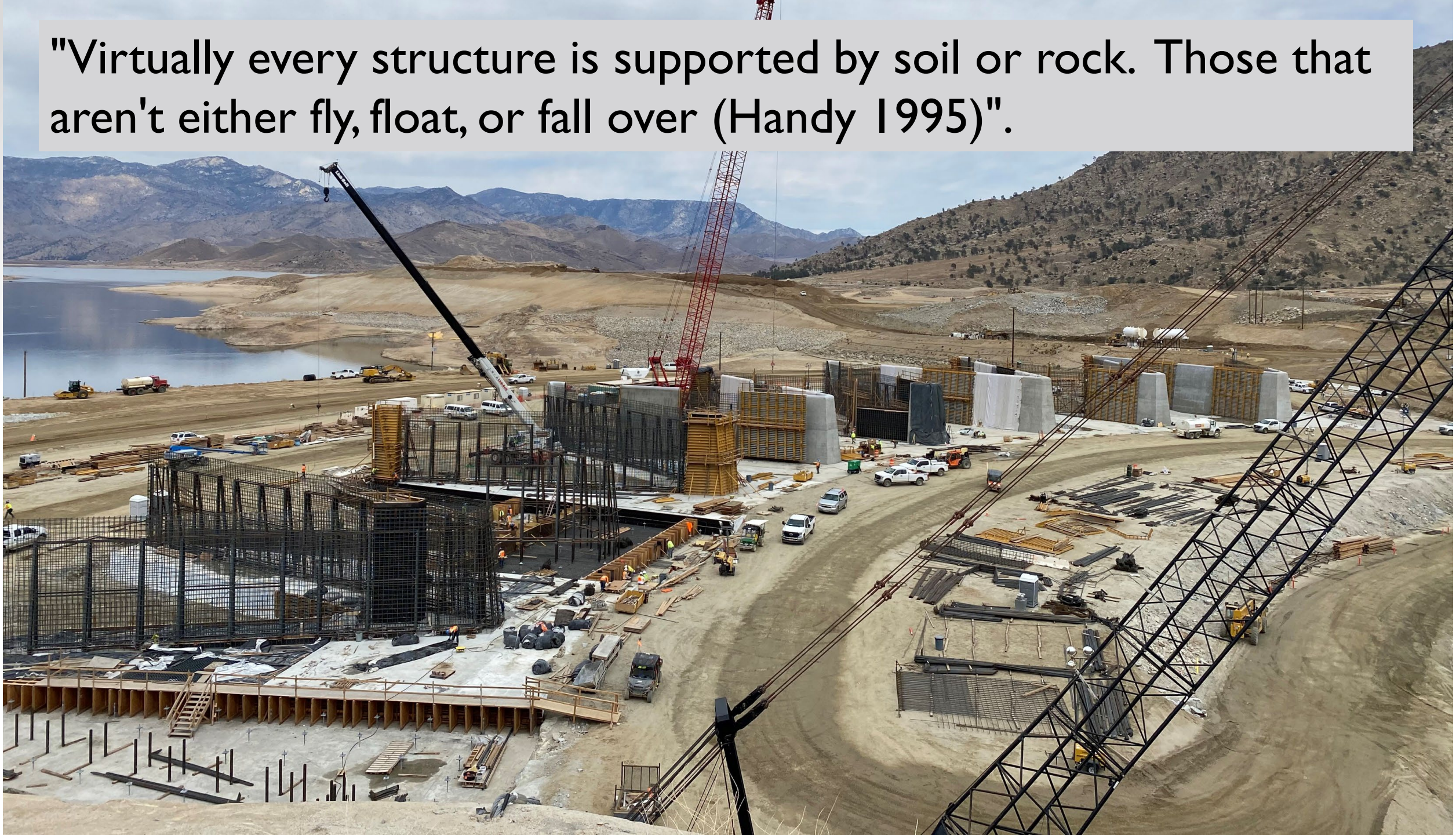
US Army Corps of Engineers

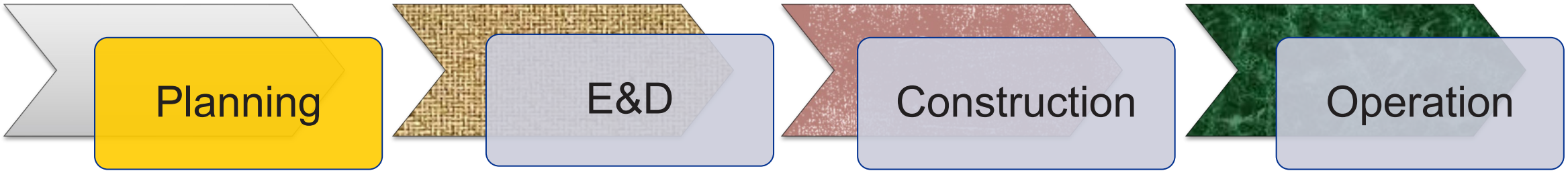
"Virtually every structure is supported by soil or rock. Those that aren't either fly, float, or fall over (Handy 1995)".



SOME EXAMPLE PROJECTS THAT ARE HEAVY GEO

- Embankments Designs (dams/levees)
- Shallow/Deep Foundation Design (buildings, bridges, structures)
- Slope Stabilization (rock anchors, soil nails, retaining walls)
- Seepage Control/Remediation (cutoff walls, grouting, dewatering)
- Tunnels and Access Shafts
- Erosion Control
- Dredge Material Management

GEO-PROFESSIONS ARE REQUIRED THROUGHOUT PROJECT LIFE



- During Planning - A geotech/geologists role is to
  - Understand and communicate the subsurface conditions
  - Identify & communicate geo-risks associated with potential project alternatives
  - Aid in selection of actions to **address risks appropriately** & provide input on budget and schedule impacts

WHAT RISKS AM I TALKING ABOUT?

Those leading to consequences…

- Project Cost Growth & Schedule Delays
- Project Design Failure
- Life Loss/Safety Implications
- Property Damage
- Public Perception/Reputation Impact

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BIGGEST ISSUE IS UNFORESEEN CONDITIONS (DIFFERING SITE CONDITIONS)

SOME EXAMPLES

- Soil encountered where rock was expected (vice/versa)
- Condition/Properties of rock/soil different than Expected (different excavation equipment needed, different foundation design needed)
- Encountered Unexpected Obstructions/Utilities
- Encountered Contaminated/Hazardous Materials identified
- Varying Groundwater elevation/pressure from expected

SUBSURFACE RELATED IMPACTS

- 80-85% of (European) building failures are related to ground problems

  -Brandl, 2004

- 50% of project delays caused by adverse ground conditions

  – Chapman & Marcetteau, 2004

- "…Despite the absence of definitive statistics, most expert would agree that the incidence of geotechnical disasters has increased over the last 20 years"

  -David E Sherwood, 2011

You want to know that features like this are here …

…Or like this here

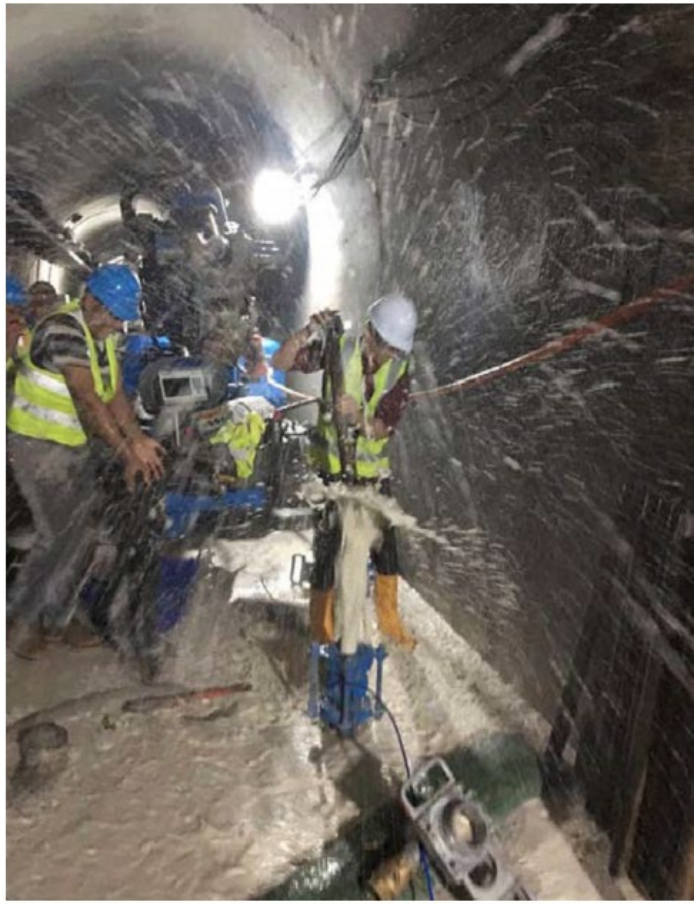
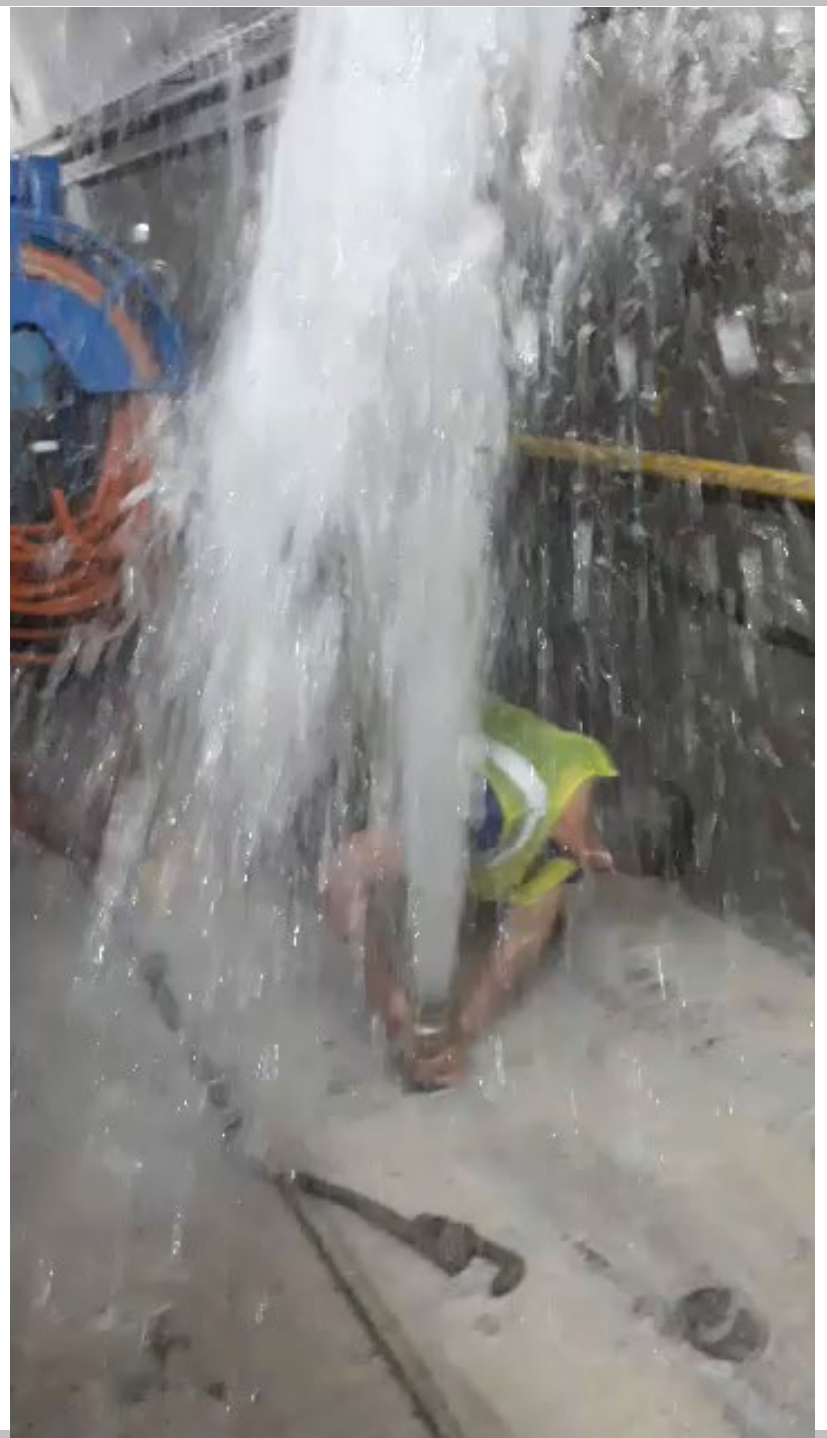


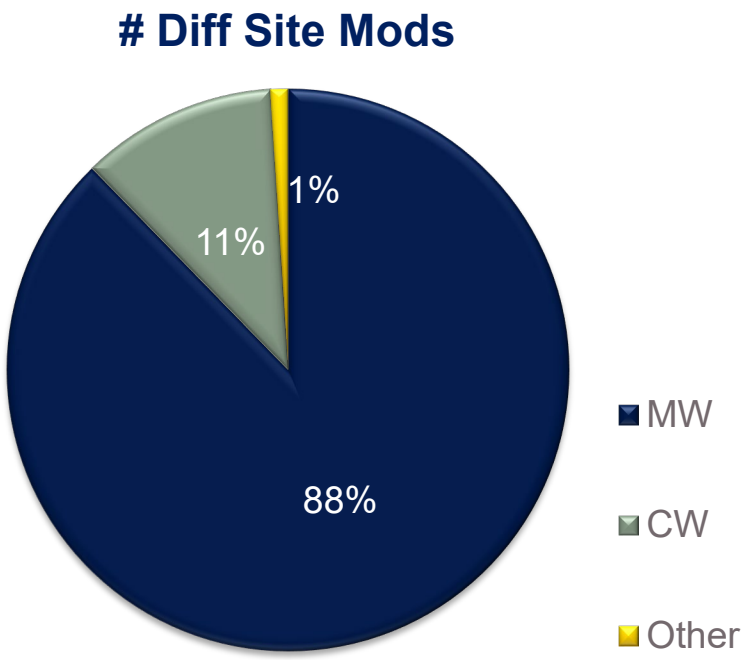
Figure 3-14. Problem Holes were Difficult to Close

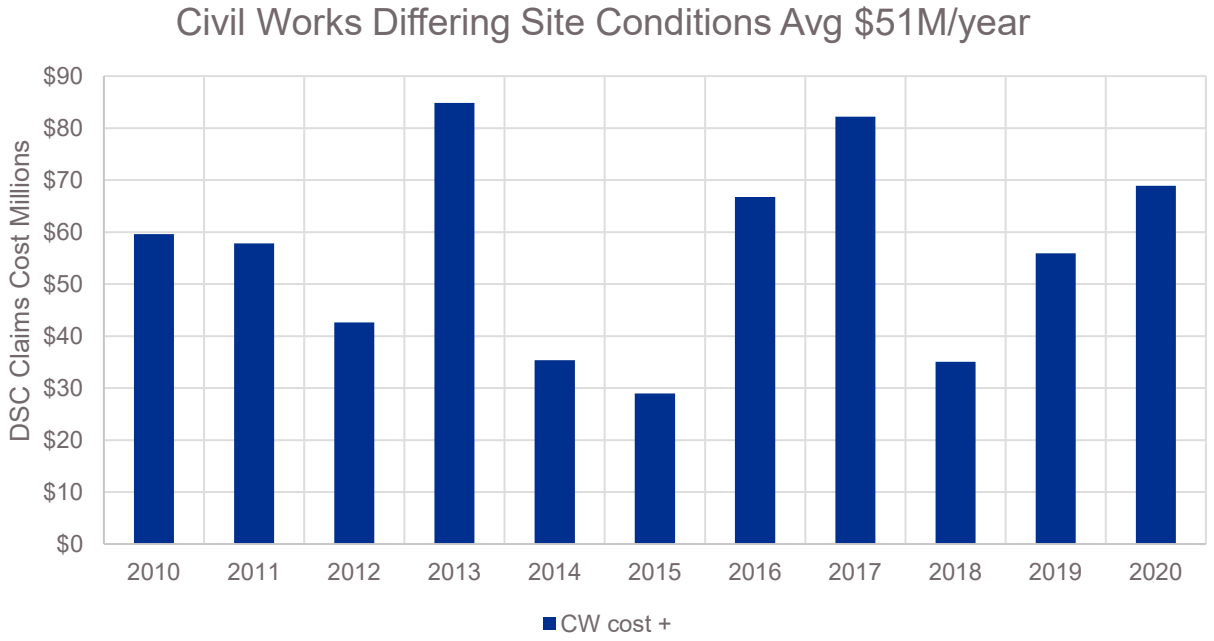


BEFORE you are forced to deal with them in construction or they impact the project long term.

What does this look like at USACE?

DIFF SITE CONDITION (DSC) OVERVIEW* (2010-2020)





LAST 18 Months ALL PROGRAMS (from Nov 2024)

- 2,922 changes (includes REAs)
- $642M (Top 10 Mods = $105M)
- 61,710 days of delay

*Does not consider data not reported in RMS ;
*Cannot Confirm mods were accurately reported
CMA2 will aid in better quantification in future

WHY DO WE HAVE GEO-RELATED PROBLEMS?

Insufficient Subsurface Information Early In Project Life Cycle

Condensed Schedules – Reduced Time for Reviews

Understaffed – Especially in Senior Level Engineers

Engineering During Construction Underfunded

Lack of Consistent Funding to Update Guidance Documents

Limited Funding to Update Trainings

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LACK OF INVESTMENT IN SUBSURFACE INVESTIGATIONS

Common Attitude of PM/PDT:

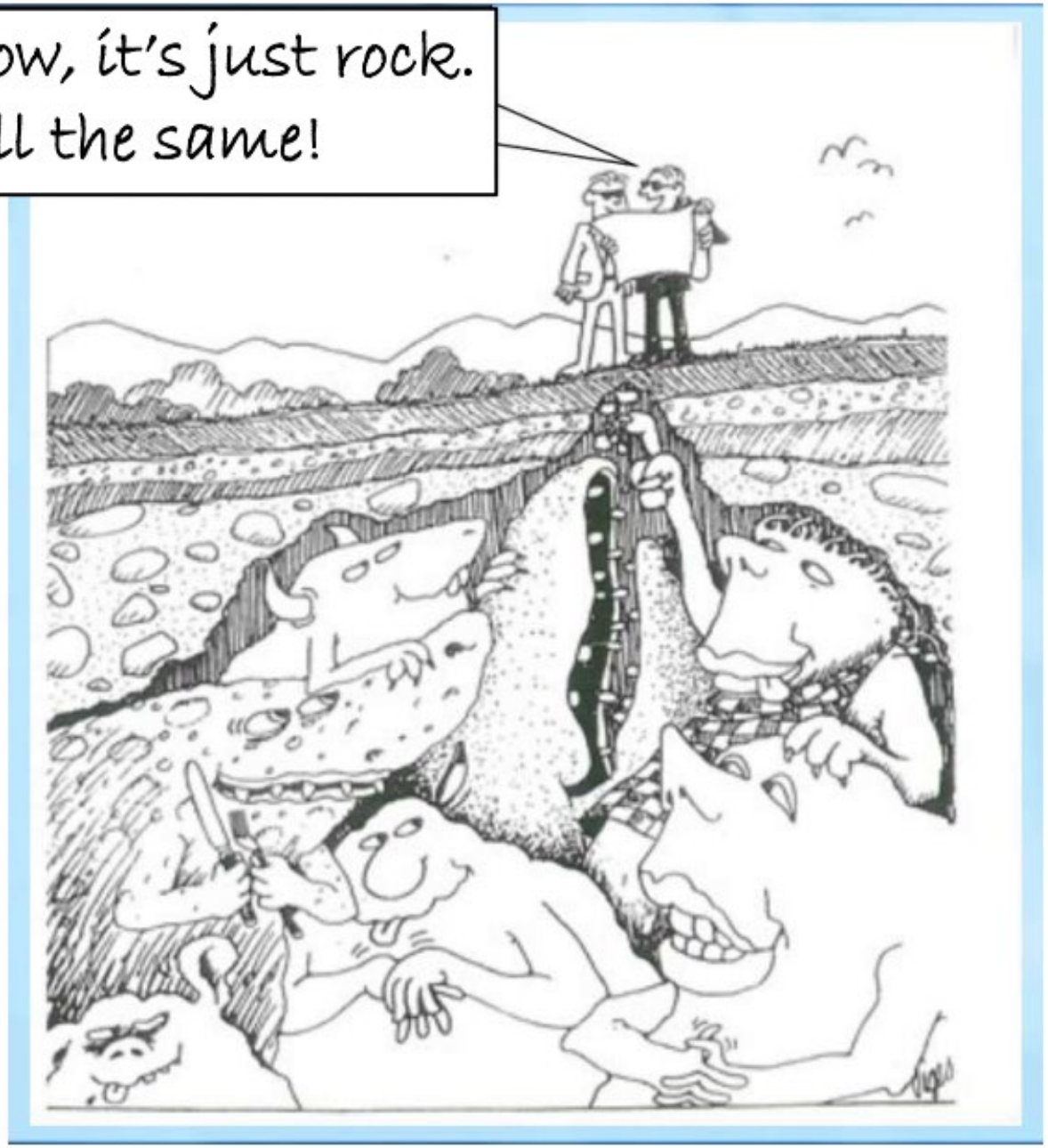
"I don't have x-ray vision."

"No one really knows what is down there"

"Differing site conditions are just cost of doing business"

"It's always a known unknown"

"We didn't have time or money to do investigation"



SASKATCHEWAN BRIDGE COLLAPSE

Bridge that collapsed six hours after opening was built without geotech investigation of riverbed: Reeve | CBC News

Bridge that collapsed six hours after opening was built without geotech investigation of riverbed

“It's being sort of penny-wise and pound-foolish by not doing the geotechnical investigation.”
Paul Gauvreau, University of Toronto Engineering Professor

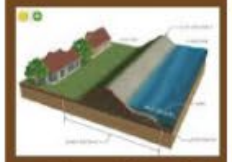
“The RM provided the instruction that no geotechnical investigation should be obtained as the RM was concerned about the additional cost and delay.” *- Scott Gullacher's and Inertia's statement of defence*

It's not an insignificant cost but the point is that's not a cost that you can shave," Gauvreau said.

HOW DO WE FIX THE PROBLEM?

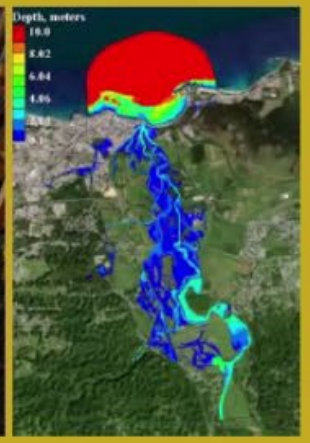
15

10%
Concept Design



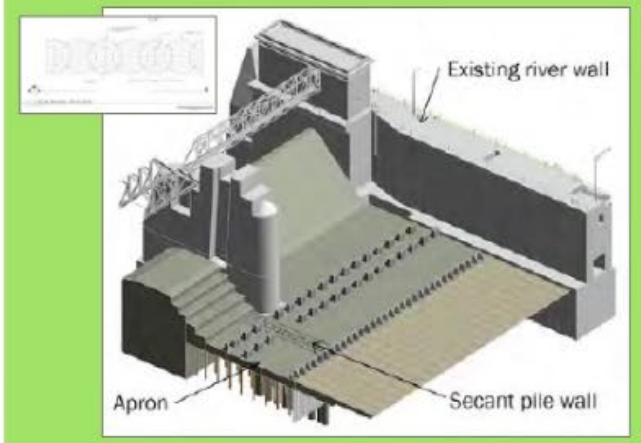
- Defined Scope

30%
Preliminary Design



- Preliminary Design Analysis Complete
- Field Investigations Complete

60%
Intermediate Design



- Design Analyses Complete
- Finalizing Engineering Details

90%
Final Design

- Complete Design, Plans, and Specs
- Ready for Final Reviews

Feasibility

PED/Design Process

FOLLOW OUR GUIDANCE… Get the data at the Right Phase – this is where Geo-Professionals come in

GEO-PROFESSIONAL ROLES & RESPONSIBILITIES

- Should be on PDT at for **ALL** Phases of the project
- Should be ACTIVELY participating in risk register development, review, & update
- Are Required for ATR & DQC
- Engineering Tech Lead in Planning should ensure the right level of experience and funding is sourced

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❑ PRIMARY GUIDANCE

- ER 1110-2-1150: Engineering and Design for Civil Works Projects
- EM 1110-1-1804: Geotechnical Investigations

13.6. Engineering studies and investigations. Engineering data and analyses in the feasibility phase shall be sufficient to develop the complete project schedule and baseline cost estimate with reasonable contingency factors for each cost item or group of cost items. Results of engineering evaluations of planning alternatives will be documented in an engineering appendix to the feasibility report.

13.6.5. Subsurface Exploration. Sufficient geologic and soils information shall be obtained, analyzed, and presented to support the site selection, type of foundations, and selection of structures. Subsurface investigations necessary to support the project design and baseline cost estimate, are to be performed. Additional foundation exploration and testing required during the PED and construction phases shall be identified. Subsurface investigations shall also include investigations of potential borrow and spoil areas.

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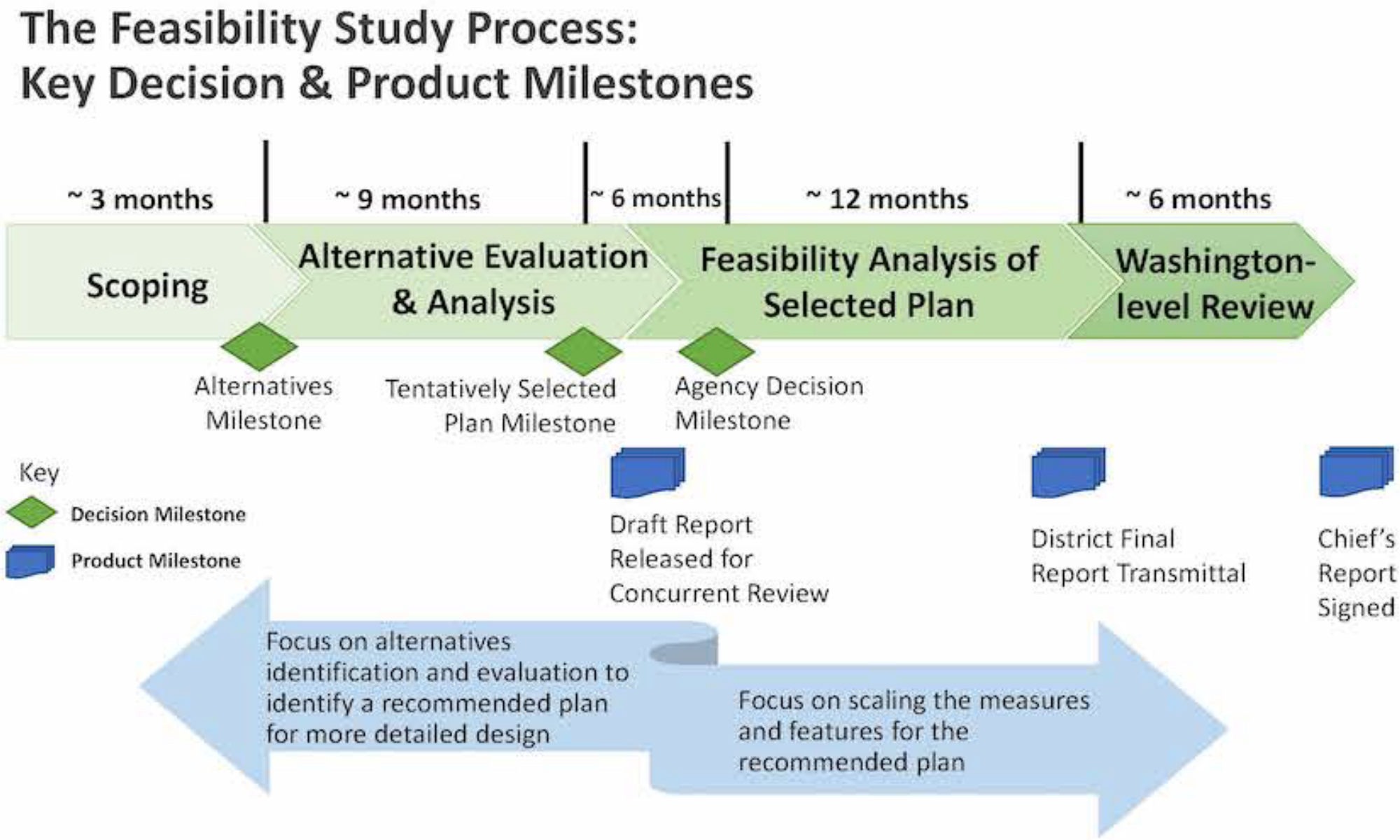
WHAT DOES THAT MEAN FOR THE FEASIBILITY PROCESS



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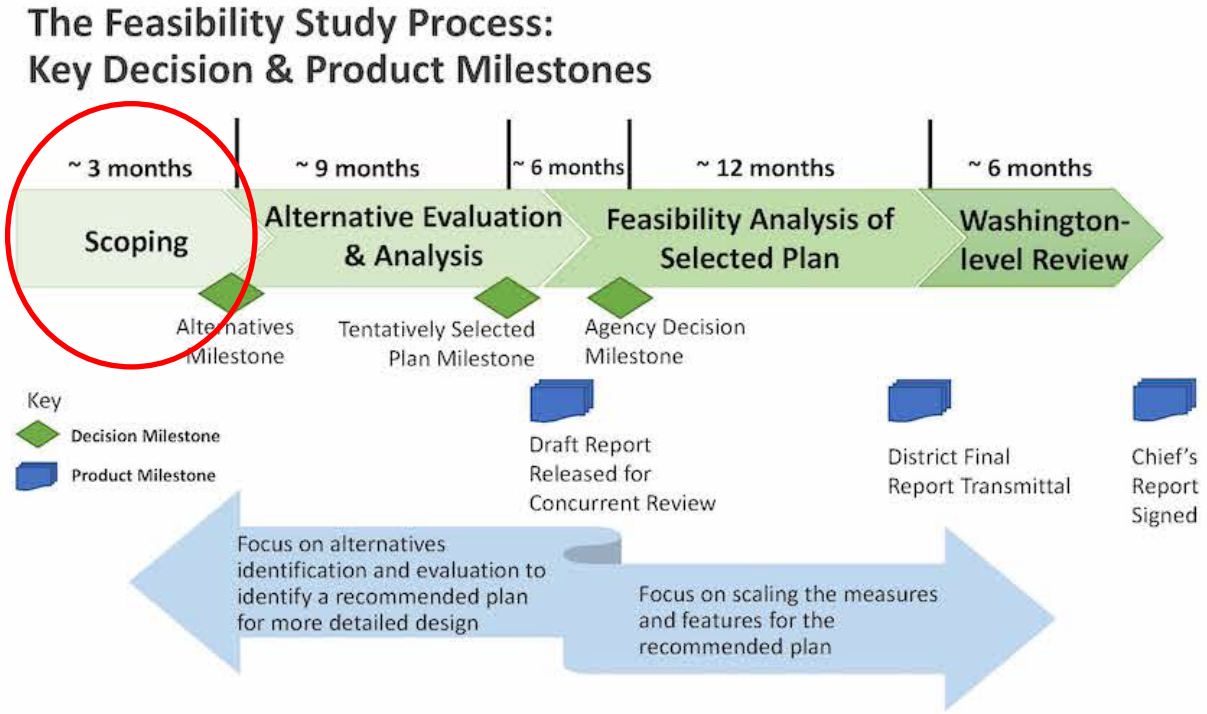
❑ SCOPING (Alternatives Milestone)

- Collect and provide basic information about site conditions
- Identify potential subsurface challenges in the risk register
- Participate in suggesting alternatives
- Develop recommendations for investigations and analyses required for next study phases



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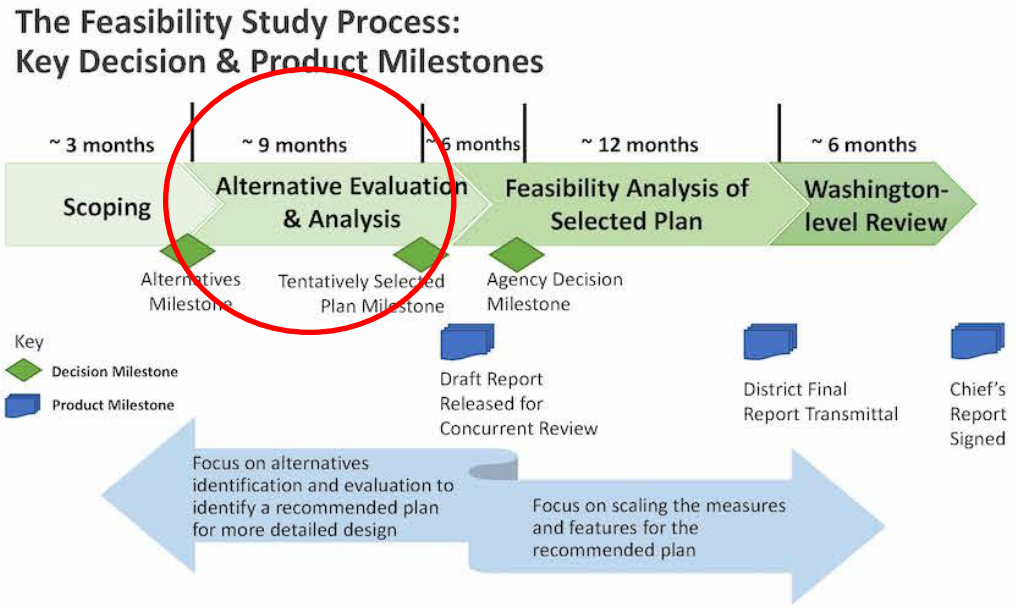
❑ ALTERNATIVE EVALUATION & ANALYSIS (TSP Milestone)

- Collect available subsurface information, identifying subsurface conditions (soils, bedrock, groundwater) and potential geo-hazards (seismic, karst, landslides, expansive soils, permafrost, etc.)
- Perform investigations and analysis as necessary to support the alternative evaluation
- Ensure relevant subsurface information and characterization is available for Risk-Informed Decisions, update risk register as needed
- Document available subsurface information about the alternatives and the critical performance risk issues for the different alternatives (DRAFT REPORT)



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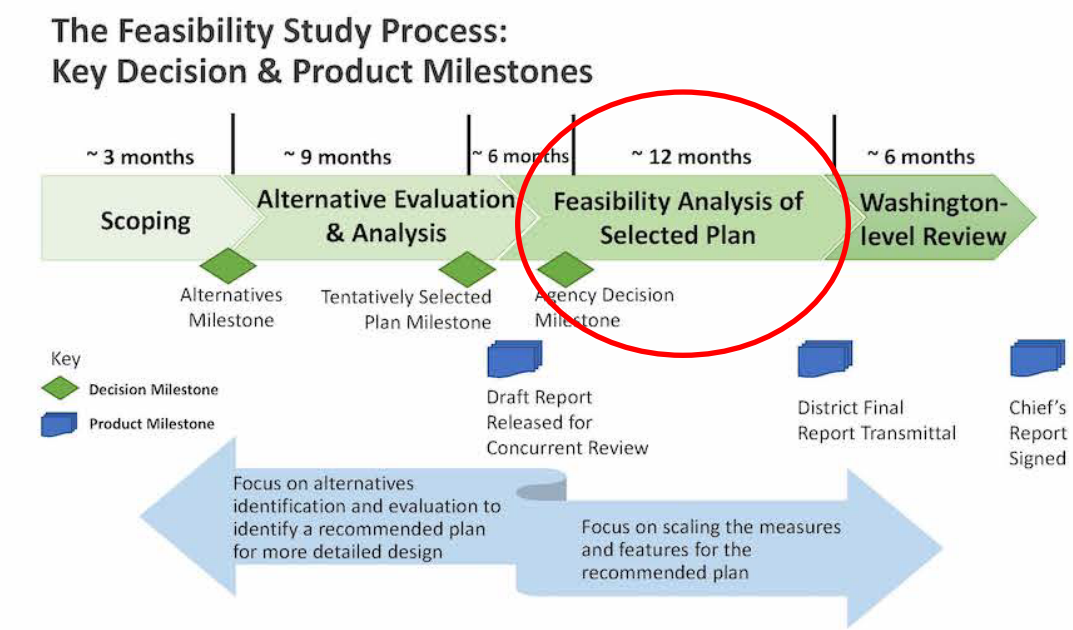
❑ FEASIBILITY ANALYSIS OF SELECTED PLAN

- Refine the project Geologic Conceptual Model
- Perform ***sufficient investigations*** to support the level of design and Class 3 cost estimate
- Perform ***sufficient analyses*** to support the level of design and Class 3 cost estimate
- **Identify critical uncertainties** related to the subsurface conditions of the selected plan
- Contribute to project **risk register** on project performance, schedule, and cost risks
- Document available subsurface data and analyses performed, characterize the subsurface conditions of the project, document the critical subsurface uncertainties, and develop recommendations for investigations and analyses required for Post-Feasibility/PED Phase (**FINAL REPORT**)



Geo-professional's role is to determine what is "sufficient"

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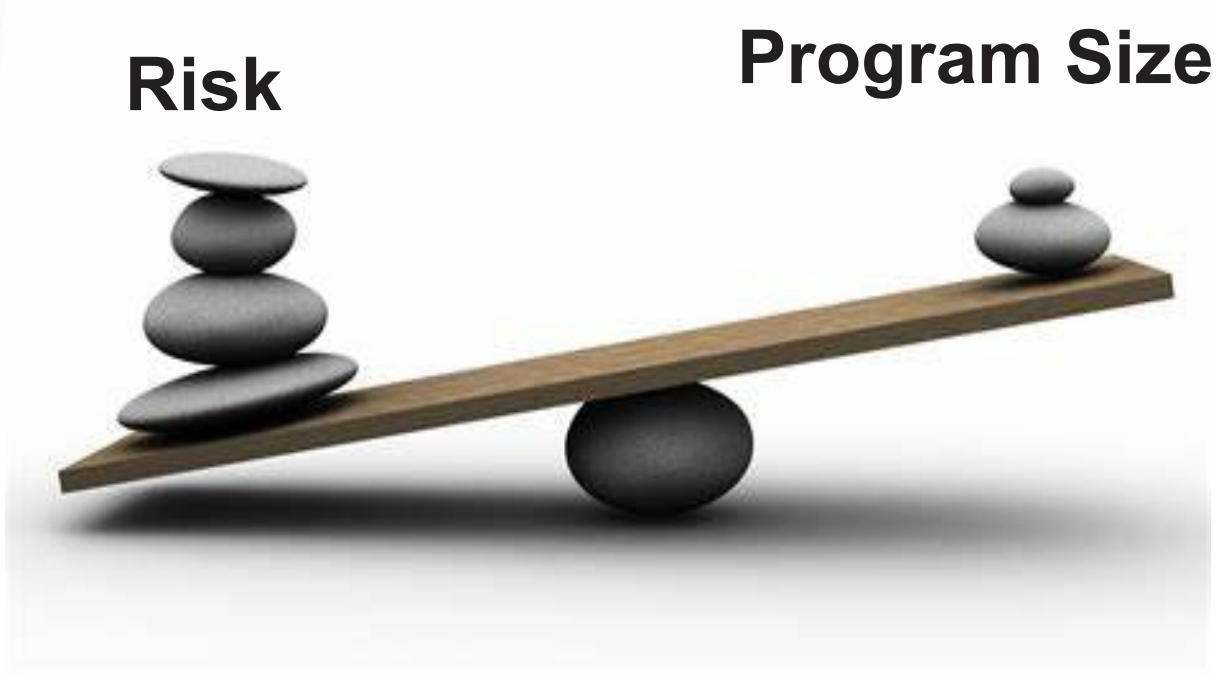
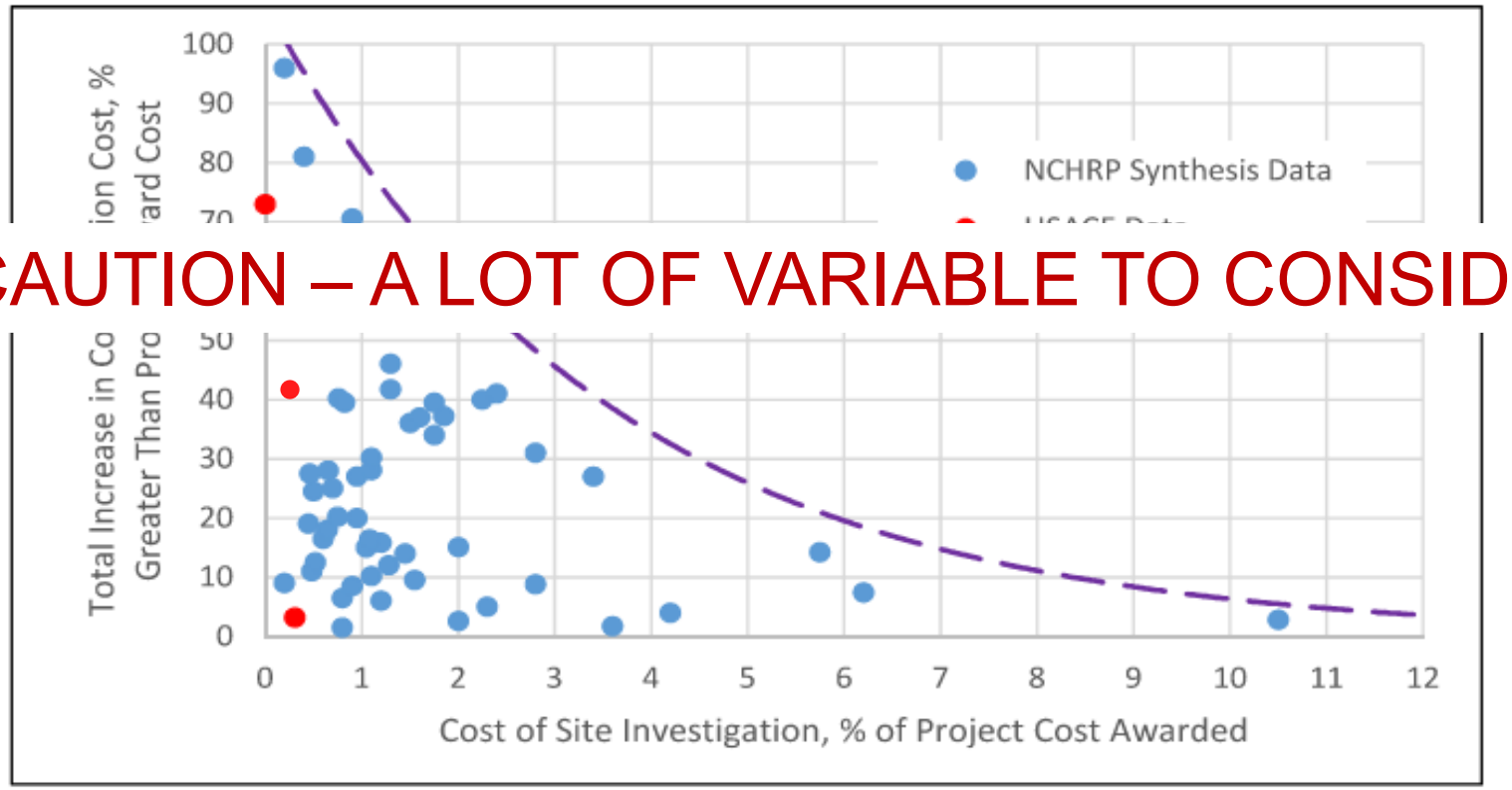
WHAT IS SUFFICIENT?

There is no "one-size fits all" or "rule of thumb"



- **Engineering Judgement is needed! Consider**
  - Phase of the Study
  - Project type and size
  - Complexity of subsurface
  - How much is already known
  - What are the Risks
  - What are the Consequences

Take a risk-informed approach! Requires GGM involvement!



CAUTION – A LOT OF VARIABLE TO CONSIDER

PAY NOW OR PAY MORE LATER!!

- Early Investment (Planning Phase) Pays Off!
- Geo Involvement Needed From the Start (Planning)
- Geo Involvement Needed in Risk Registers!!

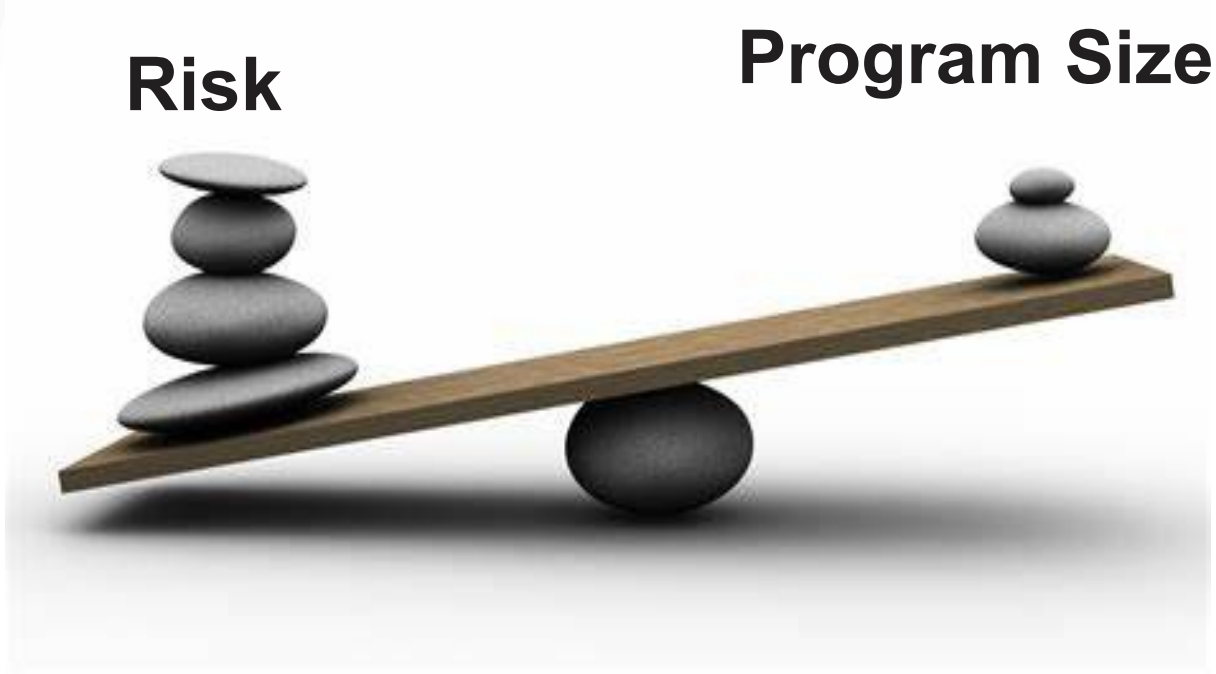
Subsurface Characterization is like a puzzle…

…THE MORE PIECES PUT TOGETHER, THE BETTER THE UNDERSTANDING

…BUT THAT COMES AT A COST

HOW MUCH $$ SHOULD I INVEST?? ISN'T MORE BETTER?

There is no "one-size fits all" or "rule of thumb"



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WHO ARE MY POCS/SMES??

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~1,200 GEOTECH, GEOLOGY, & MATERIALS PROFESSIONALS
INCLUDES ENGINEERING, CONSTRUCTION, AND R&D PERSONNEL

SubCoPs

- Geophysics
- Drilling and Subsurface Exploration
- In-Situ and Laboratory Materials Testing
- Instrumentation and Performance Monitoring

Committees

- Advanced Geotechnical Modeling
- Anchors and Tension Micropiles
- Landslides
- Technical Data Management
- Groundwater
- Blasting
- Seismic
- Materials
- Deep Foundations

Drivers for Knowledge Sharing & Advancements of State of Practice in Geotechnical, Geology, and Materials Disciplines

Strive to produce QUALITY work ON TIME and ON BUDGET

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DRILLING AND SUBSURFACE EXPLORATION SUBCOP

11 District Drill Crews

USACE Drilling Production Centers (DPC)	
Baltimore District DPC	Far East District DPC
Fort Worth District DPC	Kansas City District DPC
Mobile District DPC	New Orleans District DPC
Omaha District DPC	Savannah District DPC
Vicksburg District DPC	

Reduced risk or unforeseen condition by improving subsurface characterization

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IN-SITU AND LABORATORY MATERIALS TESTING SUBCOP

USACE Labs	
Baltimore District Lab	Bluestone Dam QA Lab
Engineering Research and Development Center Lab	Far East District Lab
Fort Worth District Lab	Herbert Hoover Dike QA Lab
Los Angeles District Lab	New Orleans District Lab
Pittsburg District Lab	Savannah District Lab
St. Louis District Lab	Vicksburg District Lab

11 District Laboratories

Rock	Asphalt
Petrography	Concrete
Soils	Cement/Pozzalons
Aggregate	…and more!

Rock Laboratory

- Rock Core Drilling and Sampling
- Preparing Rock Core Specimens and Determining Tolerances
- Point Load Index
- Rock-Mass Classification
- Rock Quality Designation (RQD)
- Compressive Strength and Elastic Moduli

Reduced risk or unforeseen condition by improving subsurface characterization

GEOPHYSICS DISTRICT CAPABILITIES ACROSS ENTERPRISE

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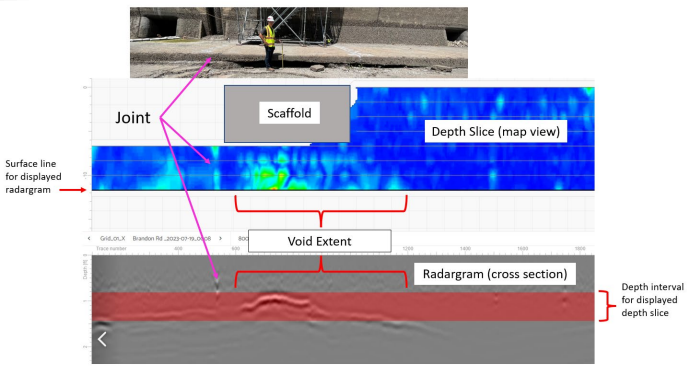
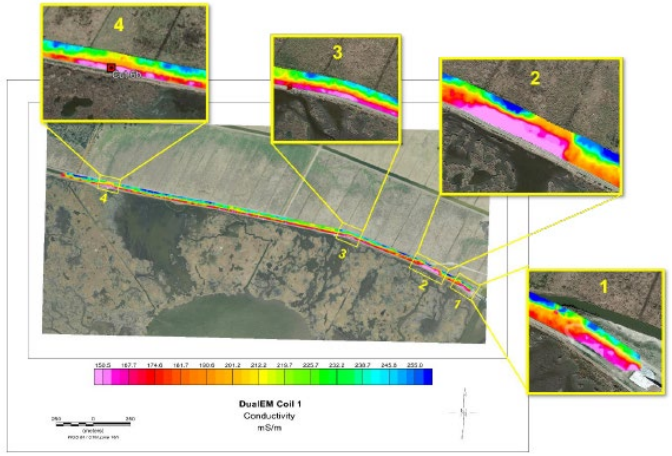
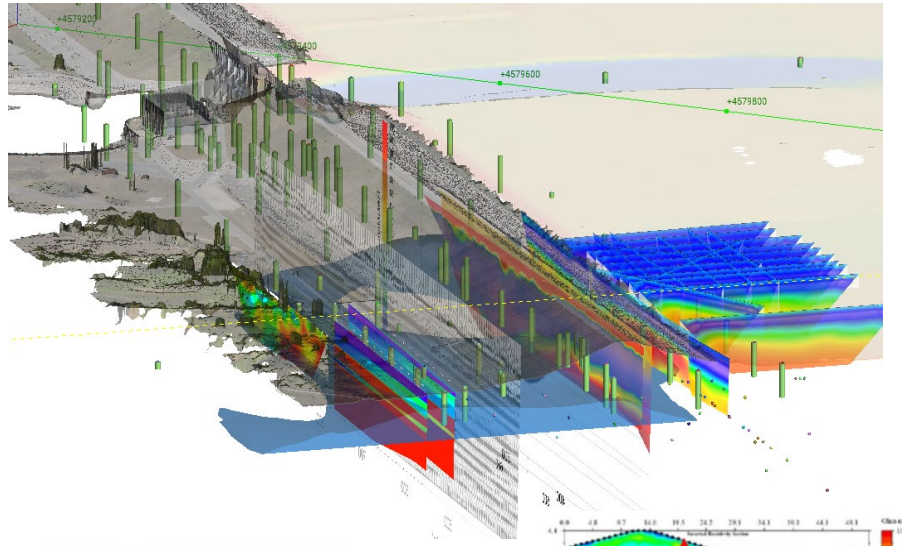
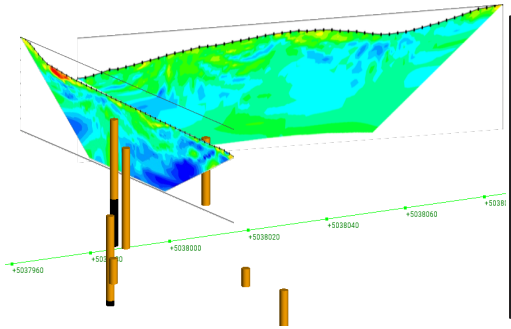
- Subsurface characterization
- Utility & void detection
- Groundwater & seepage studies

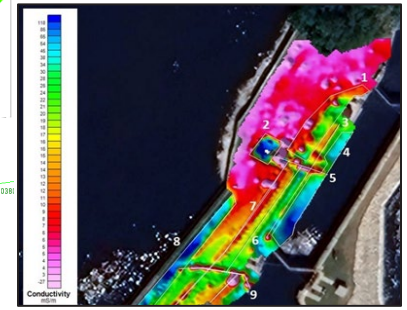
- **Reduced investigation cost** by decreasing number of borings
- **Reduced risk or unforeseen condition** by improving subsurface characterization

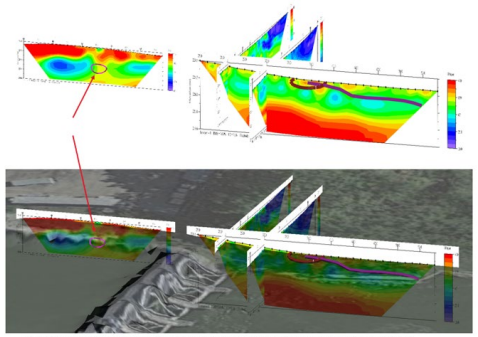




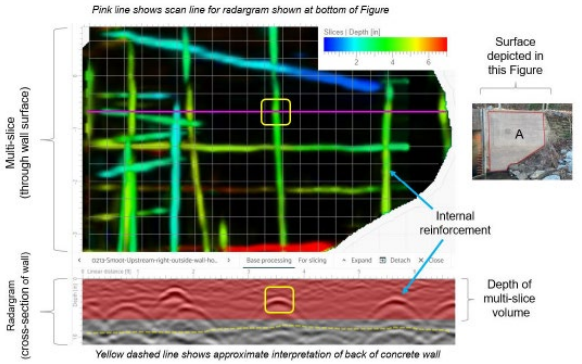


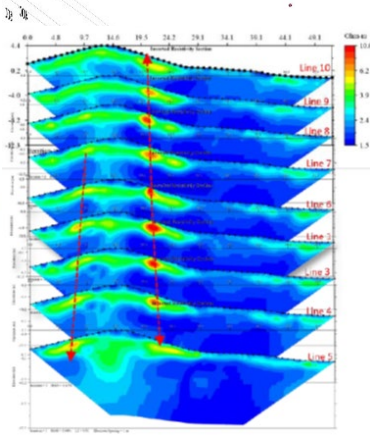






ERT Cross Sections with and without aerial photo overlay with possible seepage source identified by red arrows (also correlated via die tracer)





- Magnetics
- Electrical Magnetics
- Resistivity
- Self-Potential
- Ground Penetrating Radar
- Seismic Data Interpretation
- Seismic Refraction
- Data Processing & Interpretation

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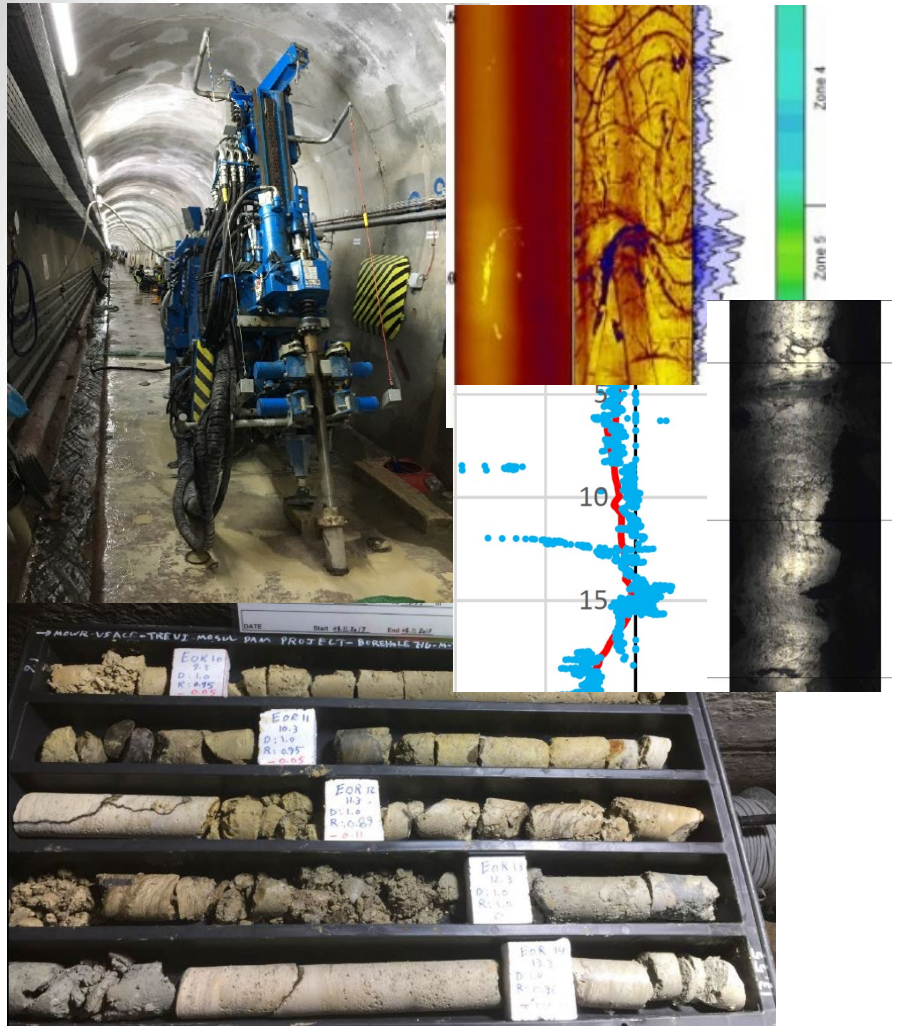
VARIETY SUBSURFACE EXPLORATION TOOLS TO GET THE JOB DONE!



Drilling and Sampling
Cone Penetrometer Tests
Optical Televiewer (OPTV)
Geophysics
Acoustic Televiewer (ATV)
Flow meter
Monitoring While Drilling (MWD)
Water Pressure Test (WPT)
Geographic Information System (GIS)

**A lot of tools in the tool box, trick is selecting the right tools to best understand the subsurface –*
This is where a Geotech/Geologist is NEEDED

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WHAT CAN WE DO TO REDUCE INVESTIGATION COSTS??

TARGET INVESTIGATIONS
ESPECIALLY WHEN LIMITED TIME AND $$

- Prioritize High Risk Areas!
- Target where there is
  - limited information
  - anomalies in the existing data
  - unexplained instrumentation/geophysics data

- Communicate need to adjust the plan over time!
  - Additional data may be needed
  - Additional tools/tests may be needed
  - Potential to descope based on initial findings

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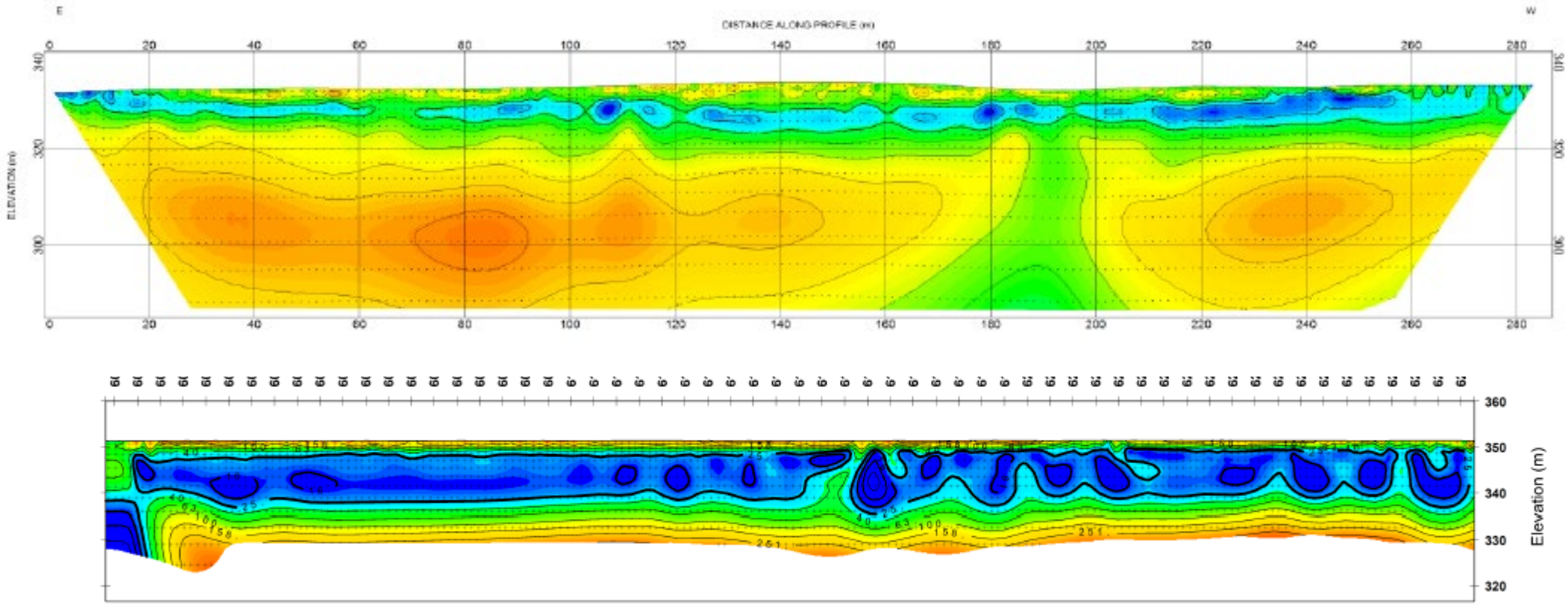
GEOPHYSICS CAN HELP TARGET INVESTIGATION AREAS



Geophysicist needed to identify the right tool for the job and aid in interpretation!

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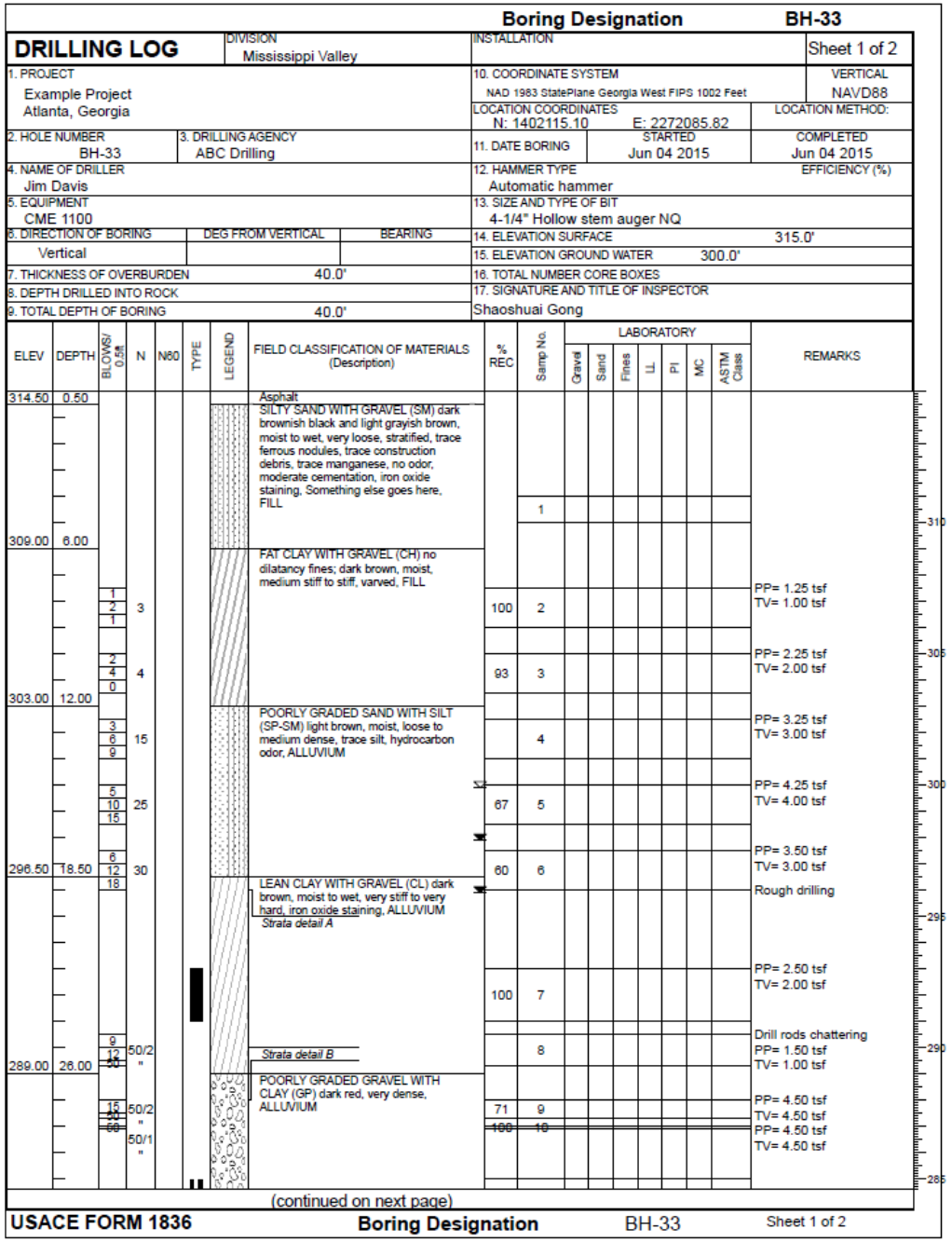
DO WE HAVE EXISTING SUBSURFACE INFORMATION WE CAN LEVERAGE?

CAN WE READILY ACCESS IT?

CAN WE MORE EFFECTIVELY USE IT?



Boring Designation BH-33

DRILLING LOG

DIVISION: Mississippi Valley

INSTALLATION:

Sheet 1 of 2

1. PROJECT: Example Project, Atlanta, Georgia
10. COORDINATE SYSTEM: NAD 1983 StatePlane Georgia West FIPS 1002 Feet
VERTICAL: NAVD88
LOCATION COORDINATES: N: 1402115.10 E: 2272085.82
LOCATION METHOD:
2. HOLE NUMBER: BH-33
3. DRILLING AGENCY: ABC Drilling
11. DATE BORING: STARTED Jun 04 2015 COMPLETED Jun 04 2015
4. NAME OF DRILLER: Jim Davis
12. HAMMER TYPE: Automatic hammer
EFFICIENCY (%)
5. EQUIPMENT: CME 1100
13. SIZE AND TYPE OF BIT: 4-1/4" Hollow stem auger NQ
6. DIRECTION OF BORING: Vertical
DEG FROM VERTICAL:
BEARING:
14. ELEVATION SURFACE: 315.0'
15. ELEVATION GROUND WATER: 300.0'
7. THICKNESS OF OVERBURDEN: 40.0'
16. TOTAL NUMBER CORE BOXES:
8. DEPTH DRILLED INTO ROCK:
17. SIGNATURE AND TITLE OF INSPECTOR: Shaoshuai Gong
9. TOTAL DEPTH OF BORING: 40.0'

ELEV	DEPTH	BLOWS/0.5ft	N	N60	TYPE	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	LABORATORY: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
314.50	0.50						Asphalt										
							SILTY SAND WITH GRAVEL (SM) dark brownish black and light grayish brown, moist to wet, very loose, stratified, trace ferrous nodules, trace construction debris, trace manganese, no odor, moderate cementation, iron oxide staining, Something else goes here, FILL		1								
309.00	6.00																
		1 2 1	3				FAT CLAY WITH GRAVEL (CH) no dilatancy fines; dark brown, moist, medium stiff to stiff, varved, FILL	100	2								PP= 1.25 tsf TV= 1.00 tsf
		2 4 0	4					93	3								PP= 2.25 tsf TV= 2.00 tsf
303.00	12.00																
		3 6 9	15				POORLY GRADED SAND WITH SILT (SP-SM) light brown, moist, loose to medium dense, trace silt, hydrocarbon odor, ALLUVIUM		4								PP= 3.25 tsf TV= 3.00 tsf
		5 10 15	25					67	5								PP= 4.25 tsf TV= 4.00 tsf
296.50	18.50	6 12 18	30					60	6								PP= 3.50 tsf TV= 3.00 tsf
							LEAN CLAY WITH GRAVEL (CL) dark brown, moist to wet, very stiff to very hard, iron oxide staining, ALLUVIUM *Strata detail A*										Rough drilling
								100	7								PP= 2.50 tsf TV= 2.00 tsf
		9 12 50	50/2"				*Strata detail B*		8								Drill rods chattering PP= 1.50 tsf TV= 1.00 tsf
289.00	26.00																
		15 50 ~~60~~	50/2" 50/1"				POORLY GRADED GRAVEL WITH CLAY (GP) dark red, very dense, ALLUVIUM	71 ~~100~~	9 ~~10~~								PP= 4.50 tsf TV= 4.50 tsf PP= 4.50 tsf TV= 4.50 tsf

(continued on next page)

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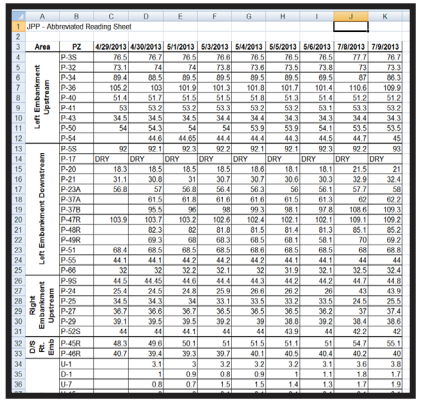
GGM Development & Implementation of Advancement in Technology

Paper Files



Excel

Local server database

Cloud server database

Leveraging Technology to Increase Efficiencies in Data Management, Data Visualization, Communication, and Data Driven Decision Making

WE ARE GETTING RID OF THIS

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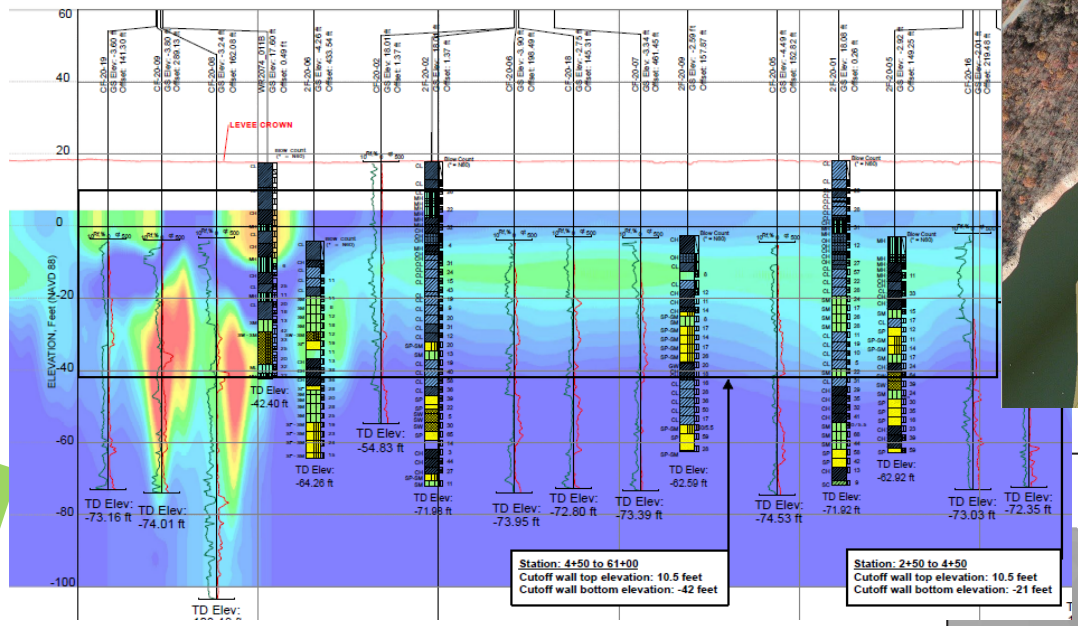
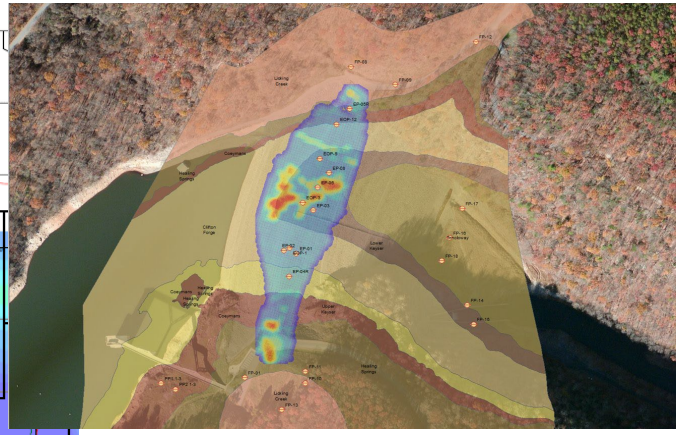
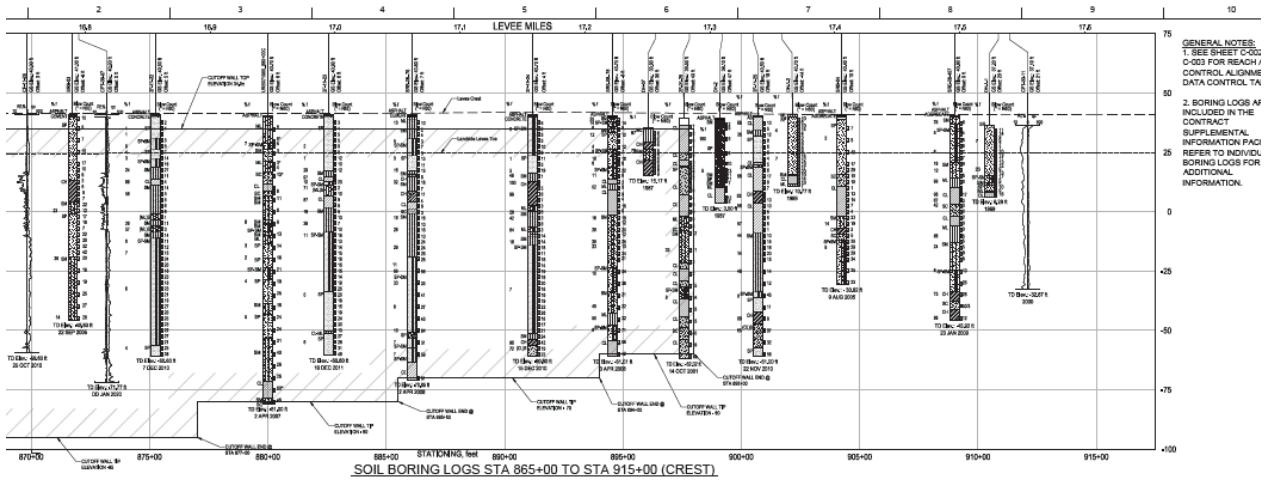
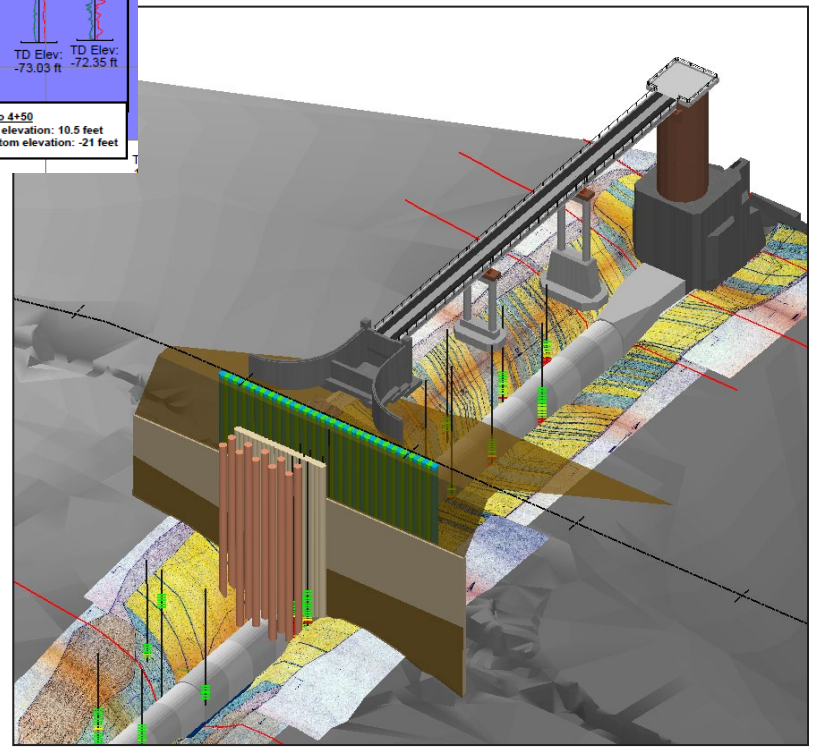
AND DOING MORE OF THIS -

Advances in data management and visualization – more efficient & improve understanding **and communication**









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OPEN GROUND CLOUD – BOREHOLE DATA MANAGEMENT

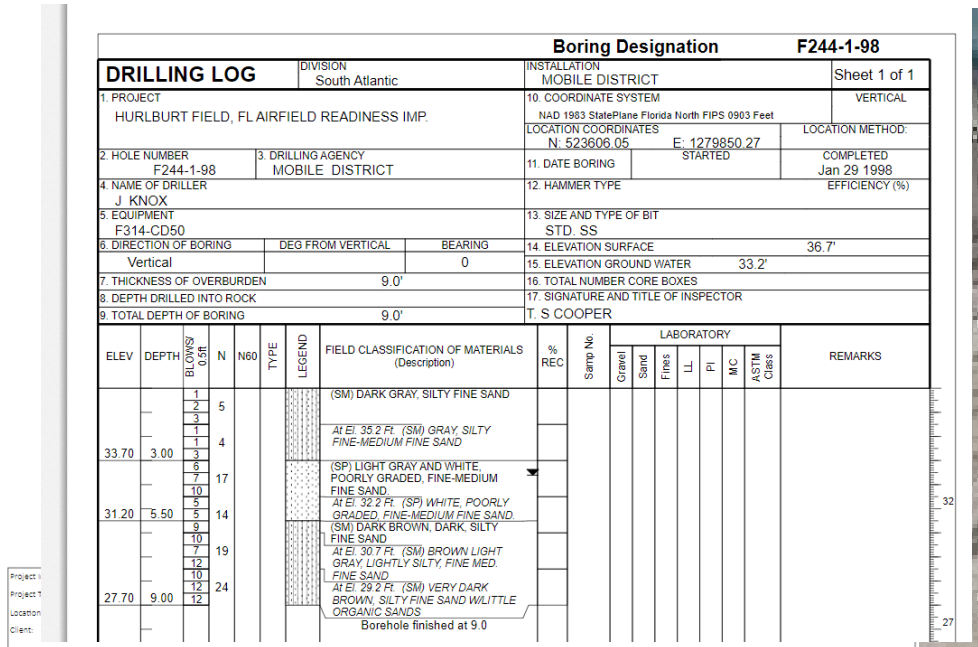
Authoritative Database

Increased Efficiency

- **Data Access**
- **Data Sharing**
- **Knowing where we do and do not have information rapidly!!**

- ~ 8 Million LF of Drilling
- ~ 8,700 projects
- ~ 200,000 boreholes
- ~ 90% Projects Converted
- ~ $600,000 of investment
- ~ $600 million worth of data

ER in HQ Review

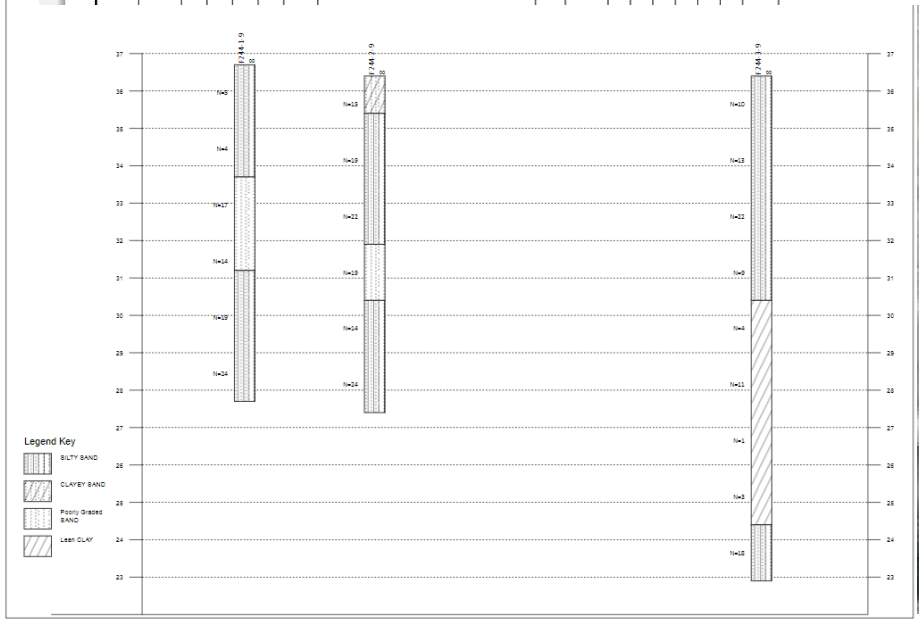


Boring Designation F244-1-98

DRILLING LOG | DIVISION South Atlantic | INSTALLATION MOBILE DISTRICT | Sheet 1 of 1

1. PROJECT: HURLBURT FIELD, FL AIRFIELD READINESS IMP.
10. COORDINATE SYSTEM: NAD 1983 StatePlane Florida North FIPS 0903 Feet | VERTICAL
LOCATION COORDINATES: N: 523606.05 E: 1279850.27 | LOCATION METHOD:
2. HOLE NUMBER: F244-1-98 | 3. DRILLING AGENCY: MOBILE DISTRICT | 11. DATE BORING STARTED | COMPLETED: Jan 29 1998
4. NAME OF DRILLER: J KNOX | 12. HAMMER TYPE | EFFICIENCY (%)
5. EQUIPMENT: F314-CD50 | 13. SIZE AND TYPE OF BIT: STD. SS
6. DIRECTION OF BORING: Vertical | DEG FROM VERTICAL | BEARING: 0 | 14. ELEVATION SURFACE: 36.7'
15. ELEVATION GROUND WATER: 33.2'
7. THICKNESS OF OVERBURDEN: 9.0' | 16. TOTAL NUMBER CORE BOXES
8. DEPTH DRILLED INTO ROCK | 17. SIGNATURE AND TITLE OF INSPECTOR: T. S COOPER
9. TOTAL DEPTH OF BORING: 9.0'

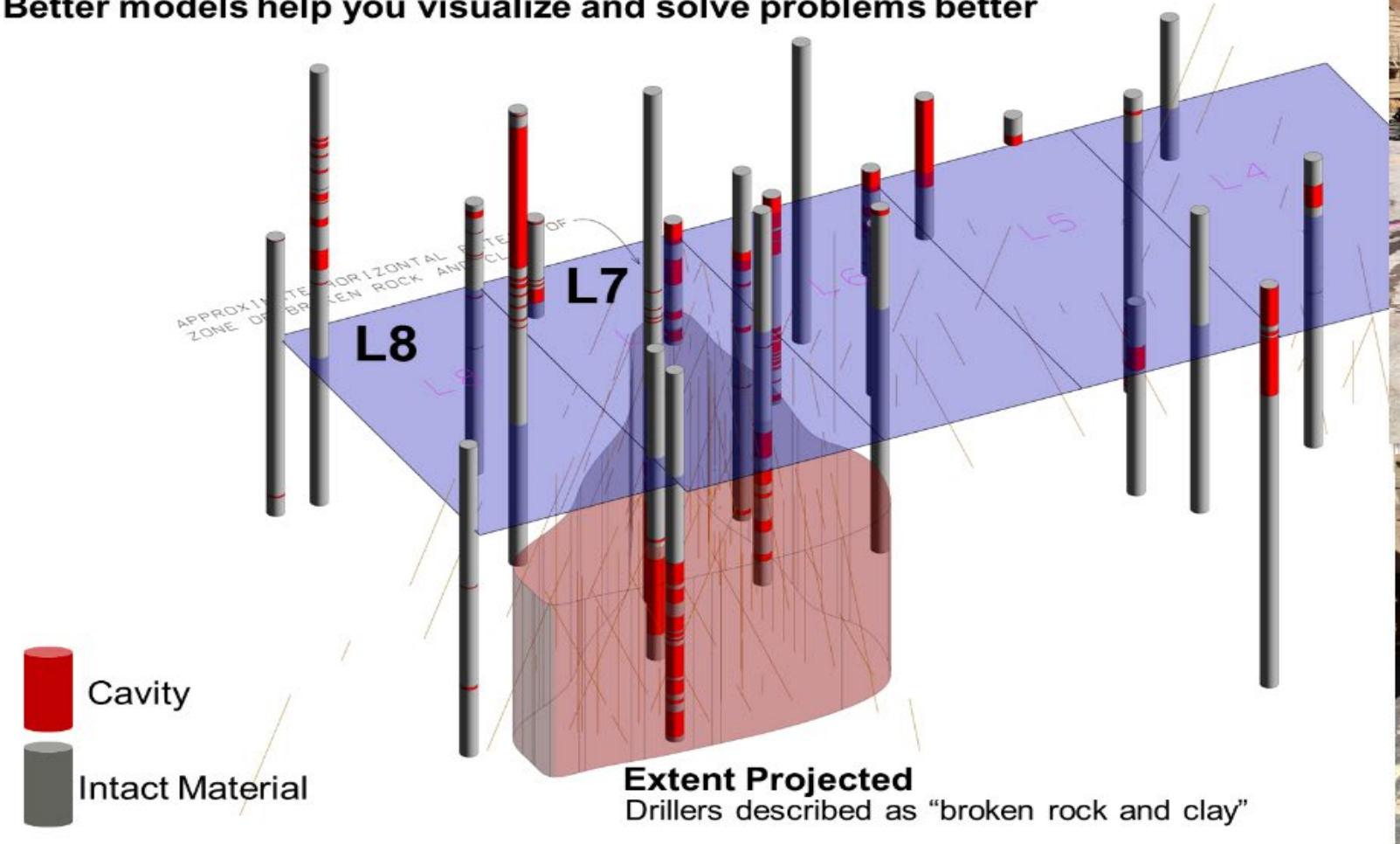
ELEV	DEPTH	BLOWS/0.5ft	N	N60	TYPE	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	LABORATORY: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		1 2 3	5				(SM) DARK GRAY, SILTY FINE SAND										
33.70	3.00	1 1 3	4				At El. 35.2 Ft. (SM) GRAY, SILTY FINE-MEDIUM FINE SAND										
		6 7 10	17				(SP) LIGHT GRAY AND WHITE, POORLY GRADED, FINE-MEDIUM FINE SAND. At El. 32.2 Ft. (SP) WHITE, POORLY GRADED, FINE-MEDIUM FINE SAND.										
31.20	5.50	5 5 9	14				(SM) DARK BROWN, DARK, SILTY FINE SAND. At El. 30.7 Ft. (SM) BROWN LIGHT GRAY, LIGHTLY SILTY, FINE MED. FINE SAND.										
		10 7 12	19				At El. 29.2 Ft. (SM) VERY DARK BROWN, SILTY FINE SAND W/LITTLE ORGANIC SANDS										
27.70	9.00	10 12 12	24				Borehole finished at 9.0										



OPENGROUND INTEGRATION CAPABILITIES

CADD / GIS / LEAPFROG / WEBAPPS

Better models help you visualize and solve problems better



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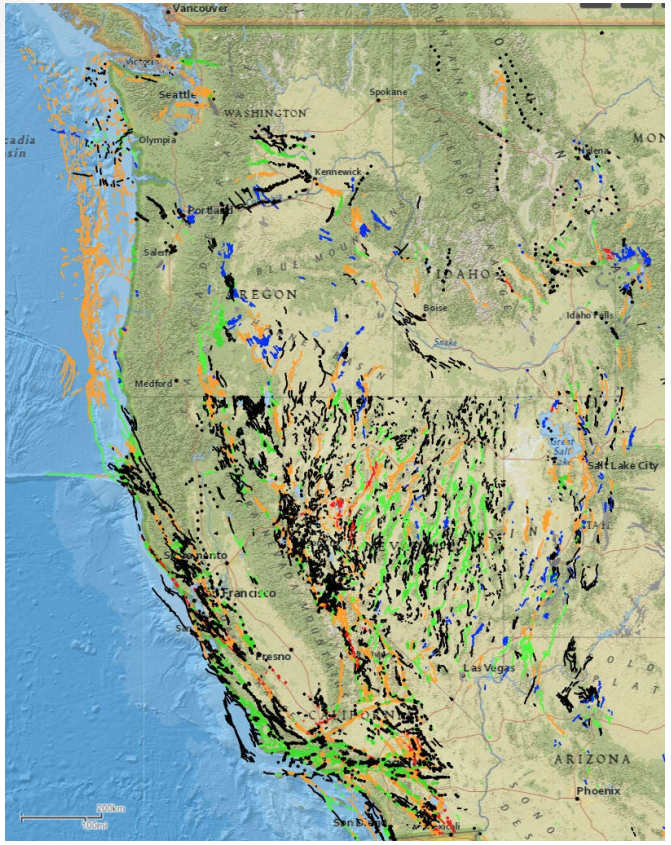
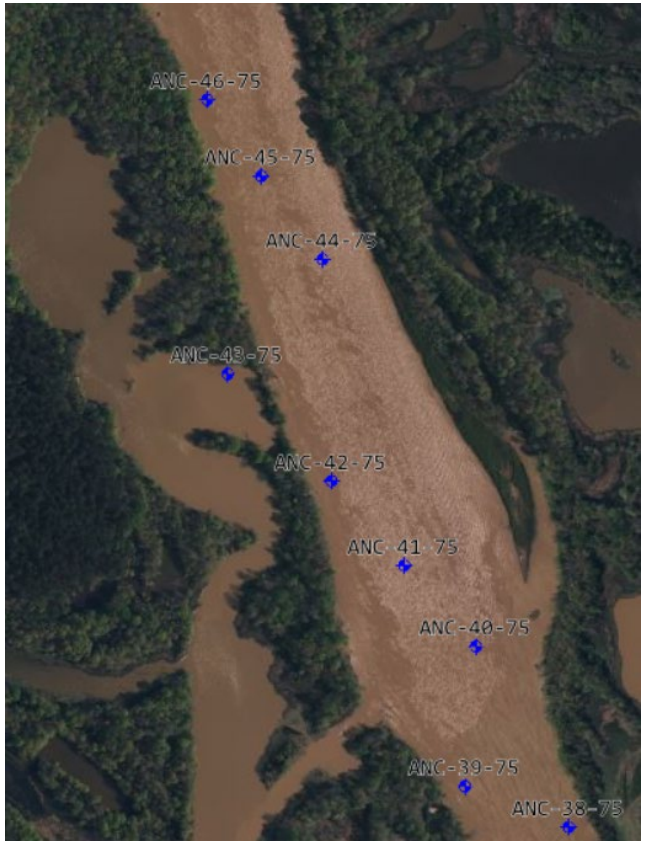
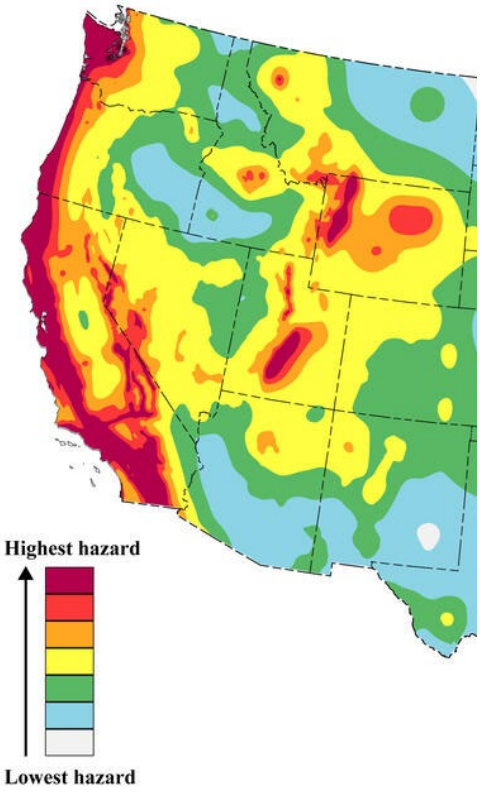
WE OFTEN NEED TO READILY RELATE A VARIETY OF AVAILABLE SUBSURFACE DATA WITH INFRASTRUCTURE LOCATIONS



USGS Quaternary Fault Mapping



Open Ground Cloud

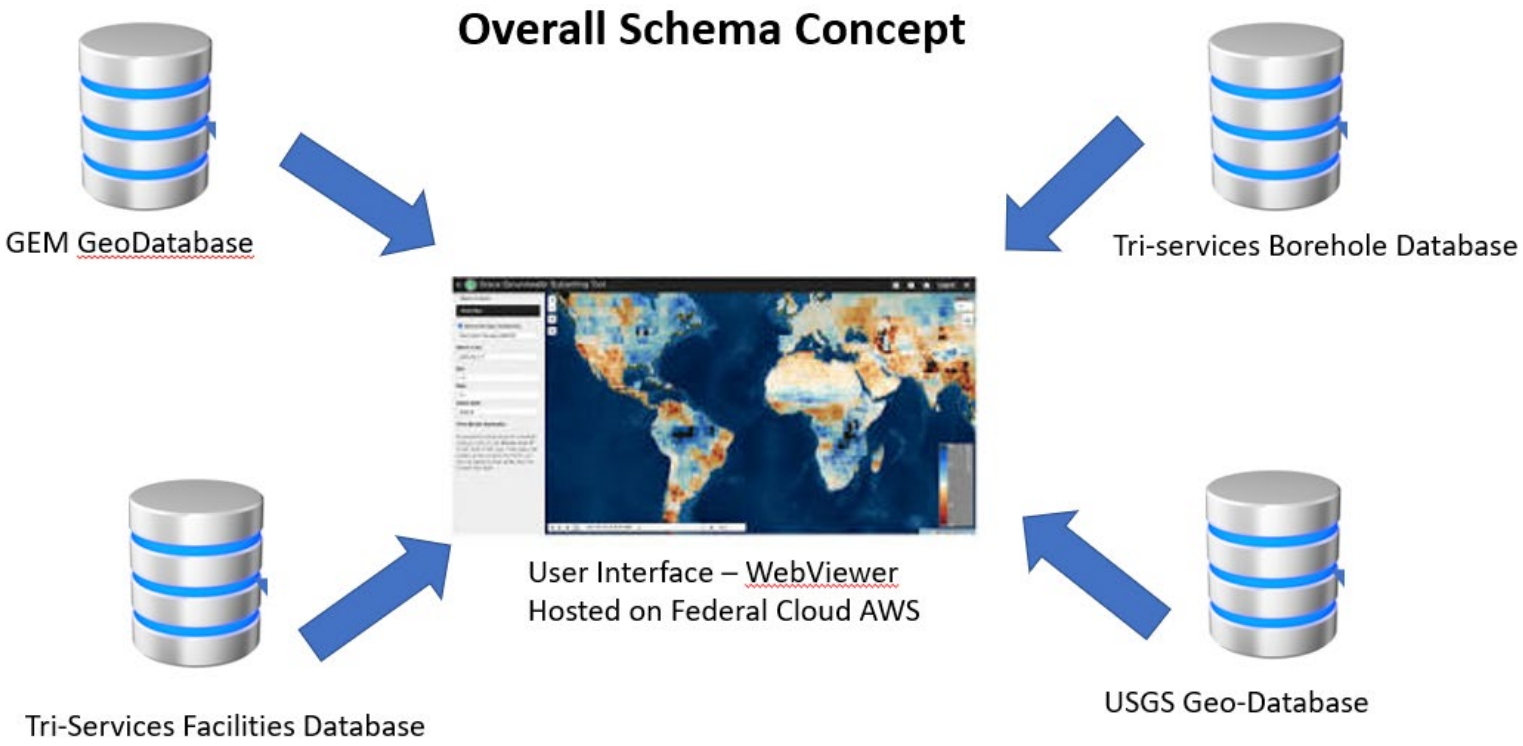


USGS National Seismic Hazard Model

GEM National Seismic Hazard Model

GeoDataOne

- Tri-Services Effort
- Interactive Web Platform
- Ease of Access to
  - Open Ground Cloud Data
  - USGS Geologic Maps
  - GEM OCONUS Seismic Maps
  - Landslide Locations
  - Military installations
- Will NOT store duplicative information



Increased Efficiency

- **Rapid access and assessment of available Geotech, Geology, & Seismic Information**

CONCEPT LEVEL DESIGN

GeoDataOne

Search for any location in the USA

Search...

Find a Tri-services Facility

Norfolk, VA_ Add

Lat Long Add

° ' " Add

Add Layer (Shp.) Add

FACILITIES LIST:

1 Norfolk, VA
2 Facility two
3 Facility three
4 Facility four
39°1'34.392"N 77°0'29.556"W

Selected Facilities: 5

Seismic Hazard Models and Data

- ☐ GEM Probabilistic Seismic Hazard Data
- ☐ ASCE Ground Shaking
- ☑ Probabilistic Seismic Hazard Curves

Subsurface and Ground Properties Data

- ☐ Borehole Geolocated Data
- ☐ USGS Cone Penetration Testing Data

Fault Mapping and Historical Data

Current Page Print Map

Analysis Parameters

Probabilistic Seismic Hazard Curves

Parameters

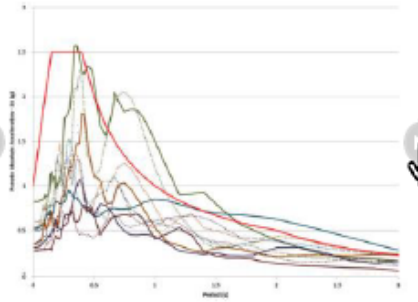
P1
P2
P3
P4
P5
P6
P7
P8

Run Tool

Analysis Results

Probabilistic Seismic Hazard Curves

Norfolk, VA
(41°24'12.2"N 2°10'26.5"E)



Print Result

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CAUTION: NOT ALL DATA CREATED EQUAL

49

- Location of borings vs Project Footprint
- Depth boreholes
- Angle of Boreholes
- Variability of conditions
- Quality of the Data
- Original Purpose of Investigation

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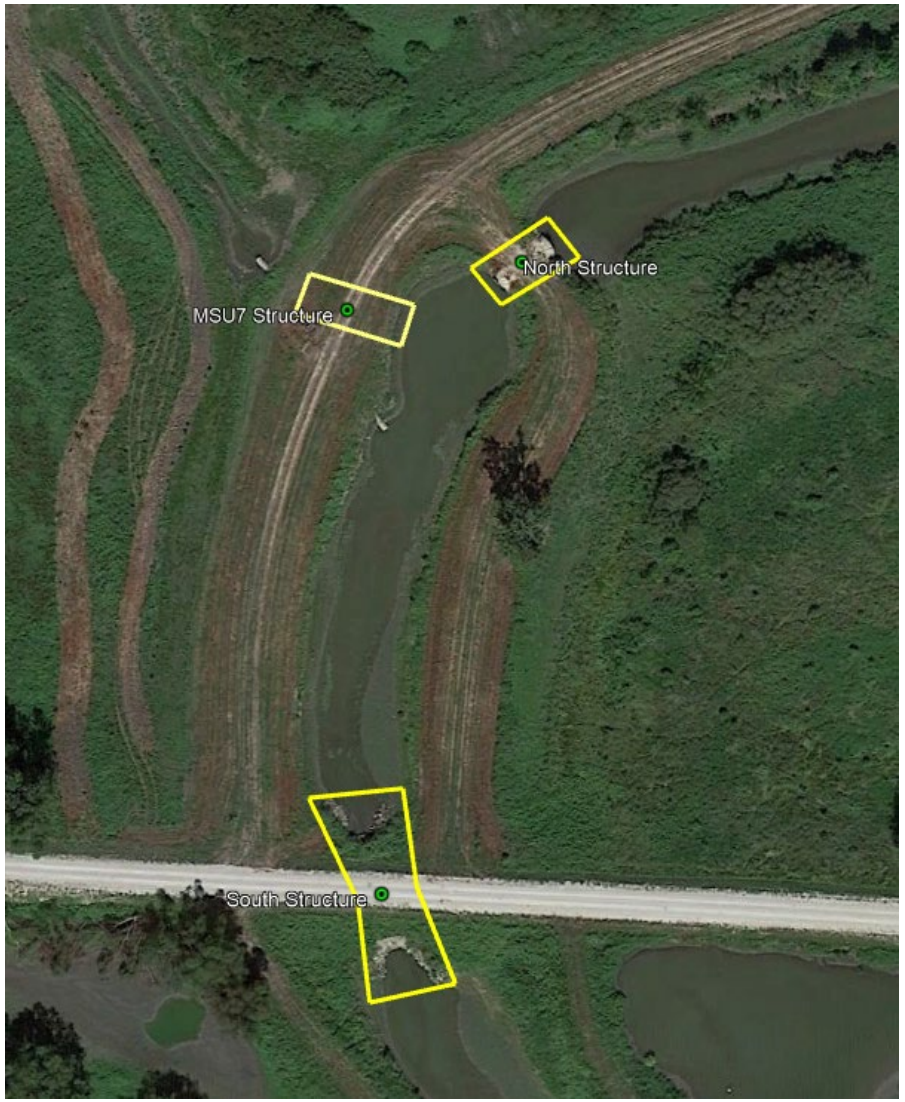
CASE STUDY – A TALE OF 2 WATER CONTROL PROJECTS

Southern Structure
Northern Structures



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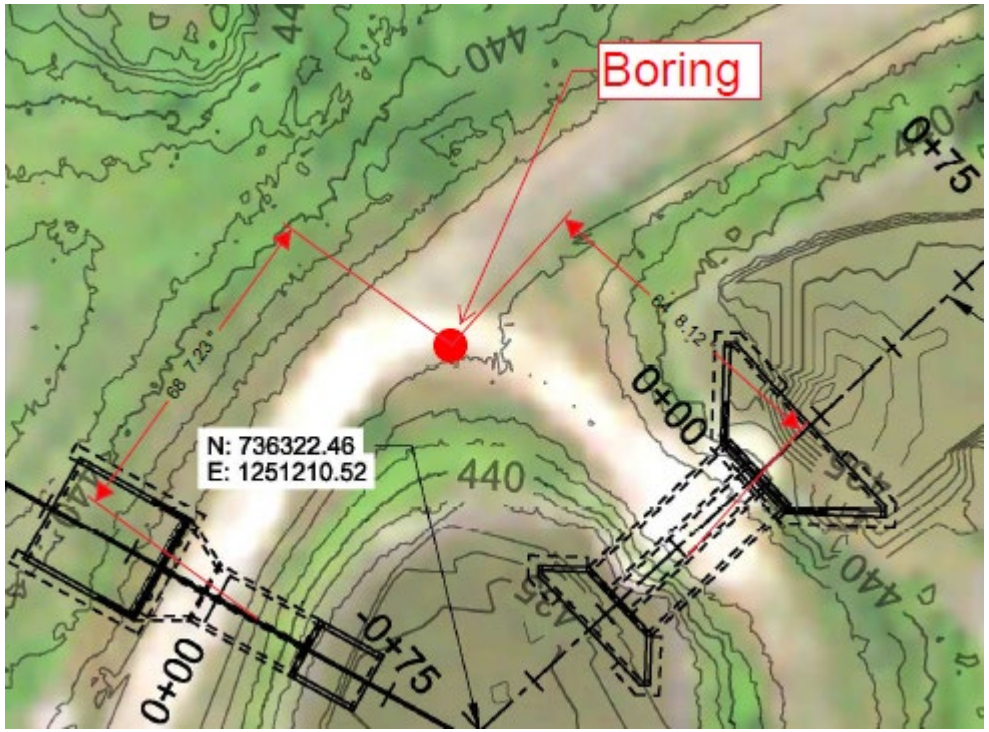
SOUTHERN STRUCTURE

Traditional Geotechnical Design and Analysis
Appropriate site specific exploration and characterization was performed
Geotechs and Structural engineers worked out foundations details
– Shallow foundation footings employed
Dewater considerations were properly taken into account
– Mill sumps and water collection trenches

Risk Mitigated w/Subsurface Investigations
Cost Growth: $0 Time Delay: 0

NORTHERN STRUCTURES

Not originally in the project scope
Risk identified by the geotechnical engineers
– Insufficient Foundation Design
– Only one boring in the vicinity
– Expected variable subsurface conditions
A time delay and cost associated with the additional investigations and analysis.



Risk Accepted

NORTHERN STRUCTURES

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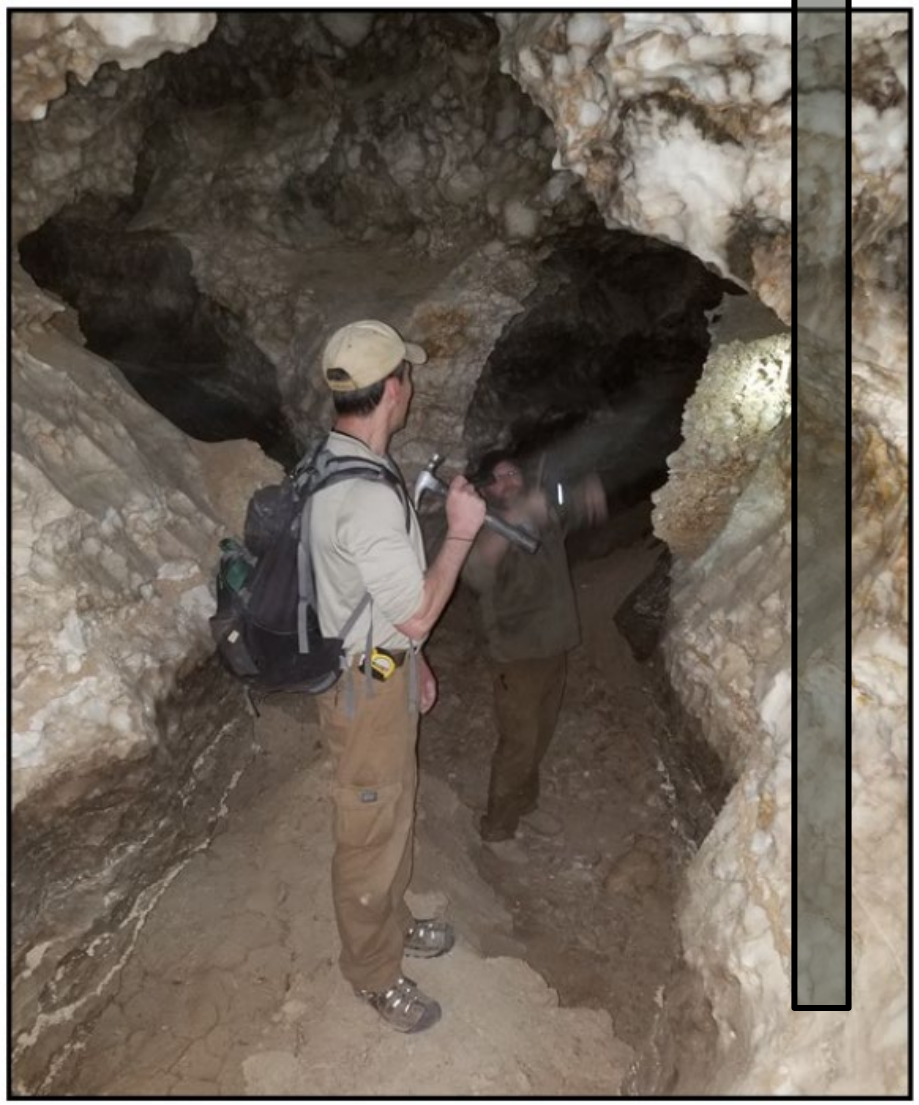
Similar design incorporated as Southern Structure
Dewatering design insufficient
– Deep wells and higher capacity pumps required
Foundation Design Inappropriate
– Subsurface materials lower strength
– Timber Pile Foundation required

Cost Growth: 55%
Time delay: 69 days

one borehole



Geologists for Scale

Large open features may be missed!

SITE VISITS ARE CRITICAL!!!

- Scale Determination
- Exposed Materials (soil/rock)
- Topography Overview
- Site Access
  - -vehicle/equipment
  - -overhead line/trees
  - -slopes/terrain
- Changes in Field Over Time
  - -Fill and Excavation Activities
  - -Utility Installations
  - -Building construction/demolition
  - -Land Use Changes

KEY TAKE-AWAYS

- Understanding of subsurface conditions is **CRITICAL** for **quality**, on-budget, and on-time project deliverables
- Subsurface Investigations at the **PLANNING** stage are **CRITICAL** – we have the team and tools to do this efficiently
- Geo-Professionals are key in developing the right size investigation program to understand and address the geo-risks
- Geo-Professionals are needed to identify and communicate the geo-risks and recommended actions
- Geo-Professionals need to re-assess the risks as additional information is acquired and understanding changes

GGM COP SITE

https://usace.dps.mil/sites/KMP-GGM

Highest Possible Classification is CUI

SharePoint

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