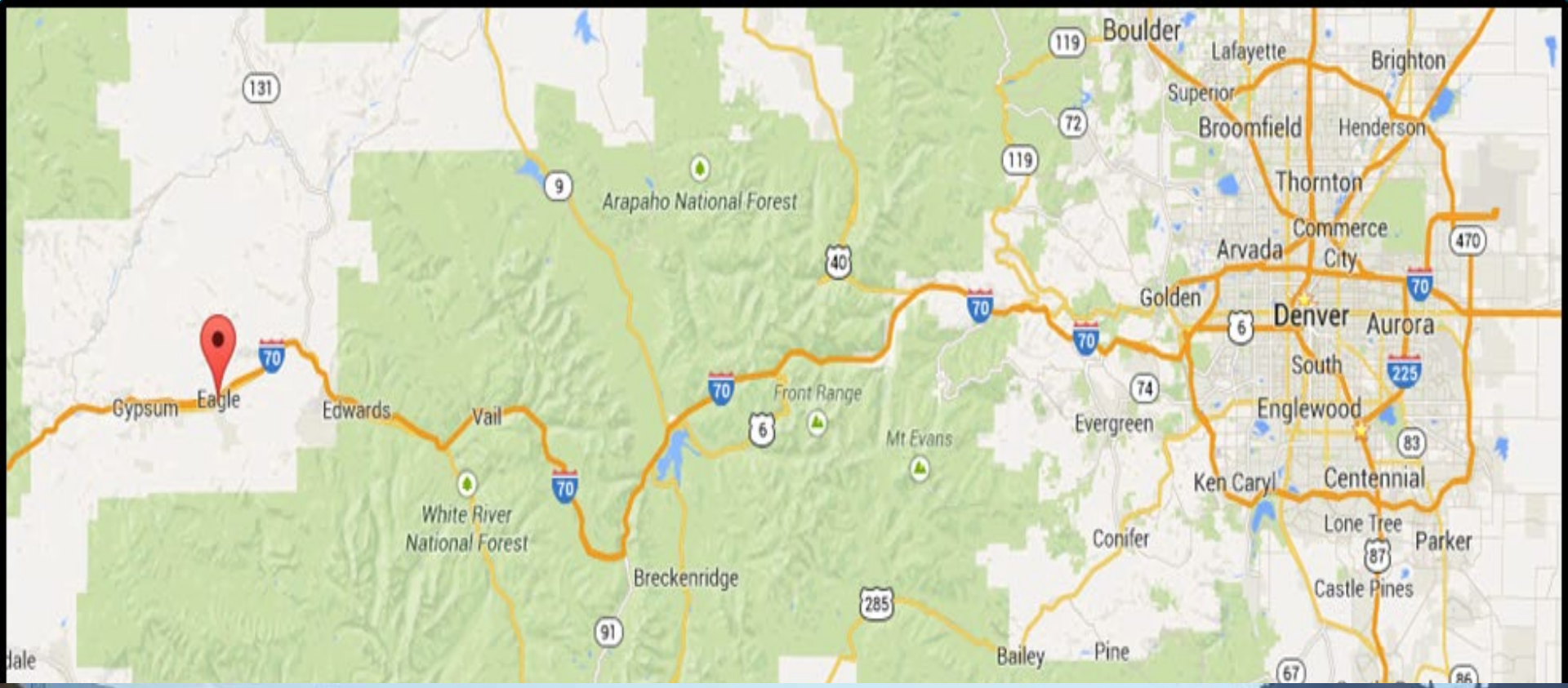
Highway Geophysical Applications

From the Rocky Mountains to the Volcano National Park

Jacob Sheehan

Collier Geophysics

Jacob@collierconsulting.com


Boulder
Lafayette
Brighton
Superior
Broomfield
Henderson
Thornton
Commerce City
Arvada
Golden
Denver
Aurora
South
Englewood
Evergreen
Ken Caryl
Centennial
Lone Tree
Parker
Castle Pines
Conifer
Bailey
Pine
Arapaho National Forest
Front Range
Mt Evans
White River National Forest
Breckenridge
Gypsum
Eagle
Edwards
Vail
131
9
119
72
40
70
6
74
225
83
87
285
91
470
67
86

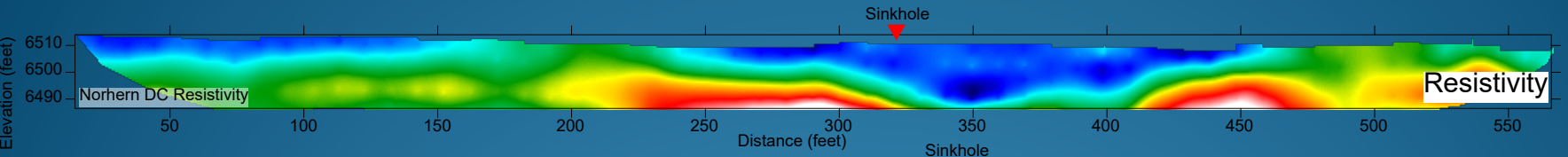
The Problem

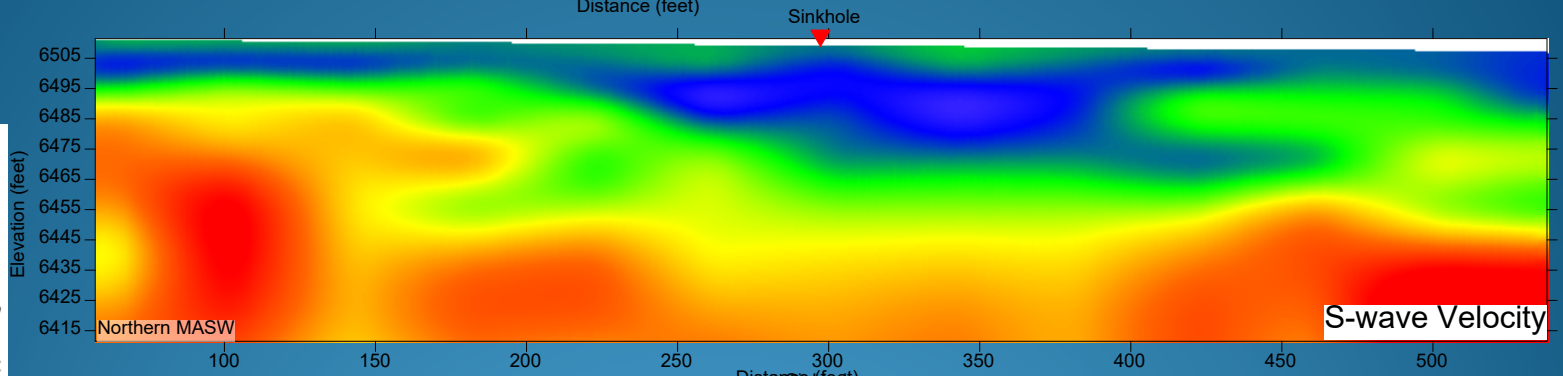
We were asked by Colorado DOT to perform a geophysical survey located along I70 west of Eagle and east of Gypsum to investigate the cause of a subsidence or erosional feature

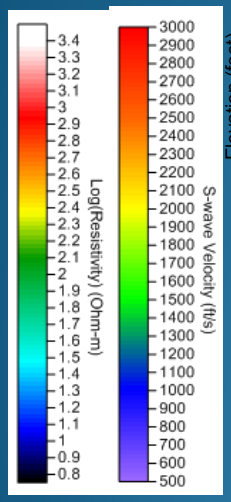
Site Conditions

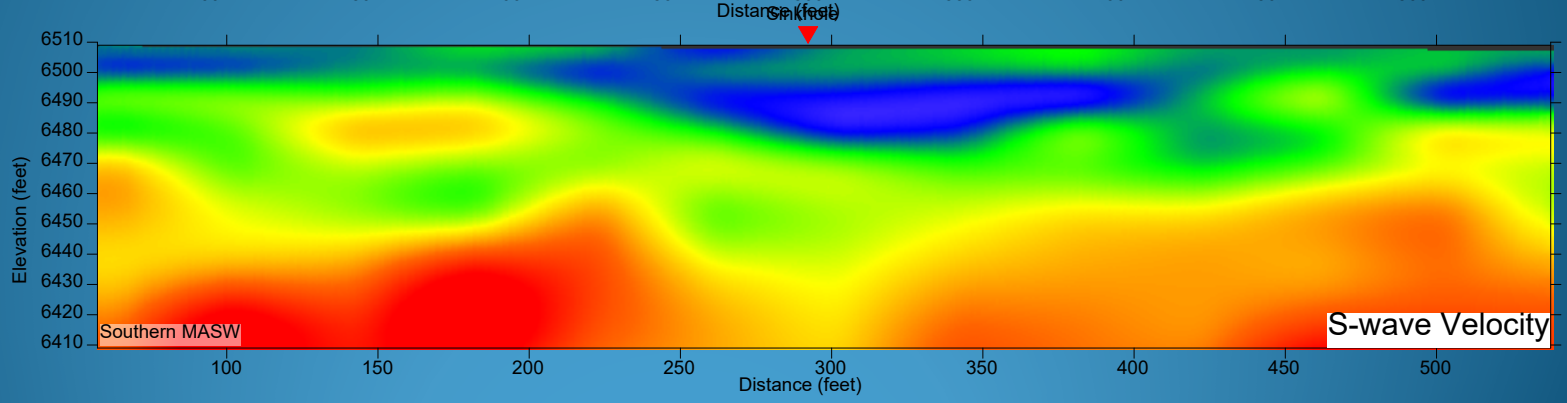
Site Overview

Results

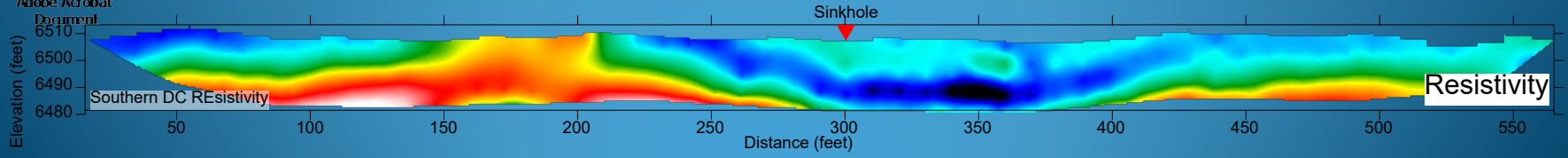

Sinkhole
Elevation (feet)
6510
6500
6490
Norhern DC Resistivity
Resistivity
50
100
150
200
250
300
350
400
450
500
550
Distance (feet)


Sinkhole
Elevation (feet)
6505
6495
6485
6475
6465
6455
6445
6435
6425
6415
Northern MASW
S-wave Velocity
100
150
200
250
300
350
400
450
500
Distance (feet)

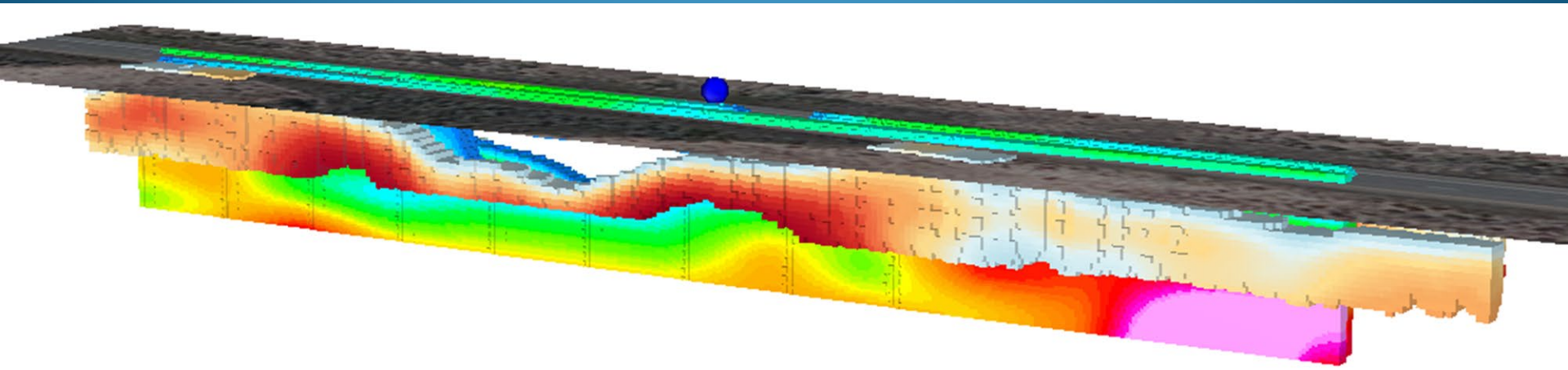

Log(Resistivity) (Ohm-m)
3.4
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
S-wave Velocity (ft/s)
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500


Sinkhole
Elevation (feet)
6510
6500
6490
6480
6470
6460
6450
6440
6430
6420
6410
Southern MASW
S-wave Velocity
100
150
200
250
300
350
400
450
500
Distance (feet)

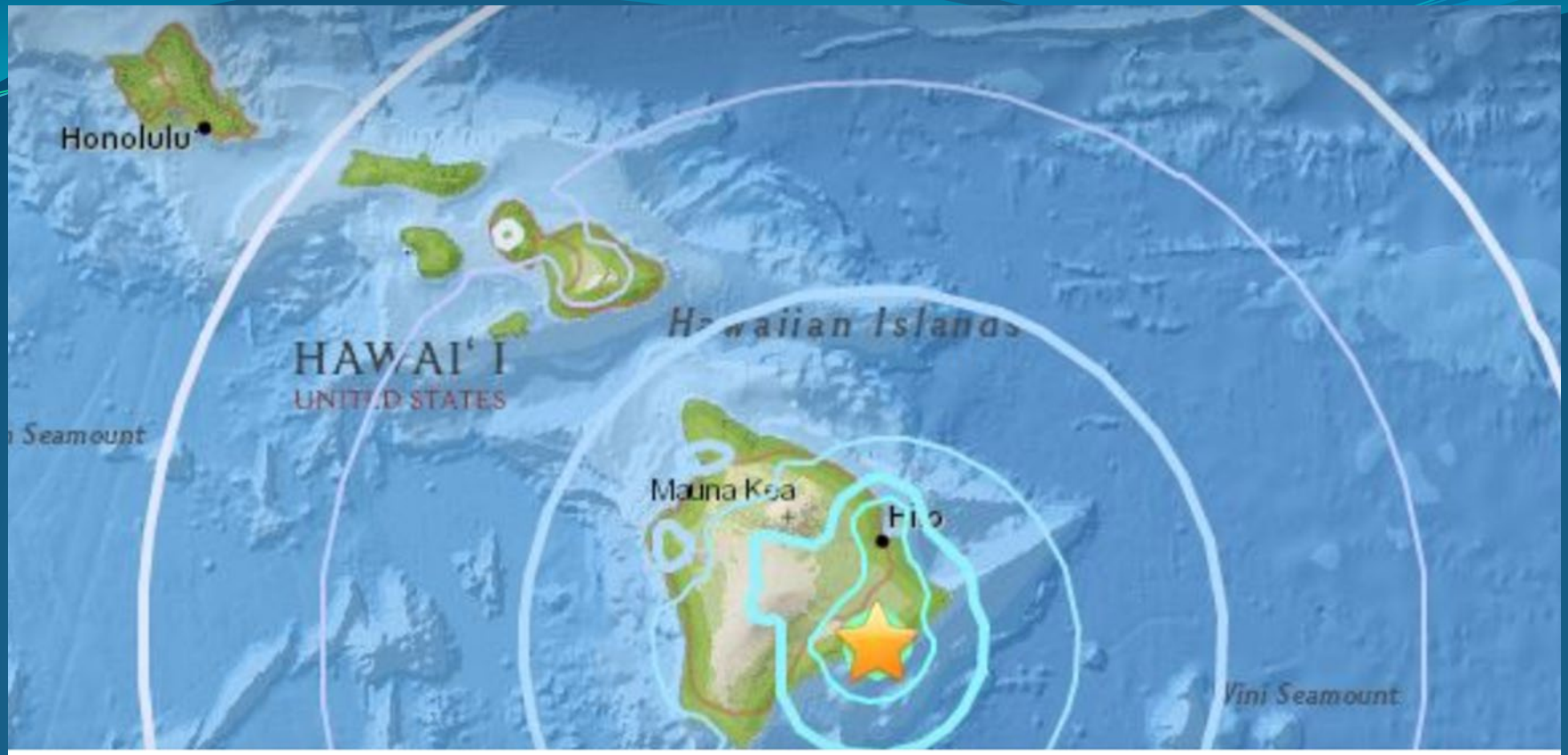

Adobe Acrobat Document


Sinkhole
Elevation (feet)
6510
6500
6490
6480
Southern DC REsistivity
Resistivity
50
100
150
200
250
300
350
400
450
500
550
Distance (feet)

- The resistivity results show a conductive zone that is centered to the east of the sinkhole feature that is 20 to 30 feet deep at the center
- The shear-wave velocity shows a low velocity zone in the same area as the conductive zone noted in the resistivity
- Combined, this suggests that there is a soft and possibly moist zone that is settling, causing the erosional/collapse feature observed.
  - We concluded that the hillside was slumping in the area of this soft moist zone, creating fissures at the edges of the slump.



- ***NPS Emergency Response Problem Statement***: pavement distress and holes/voids along Chain of Craters Road



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Geology | Earthquake, Tremor

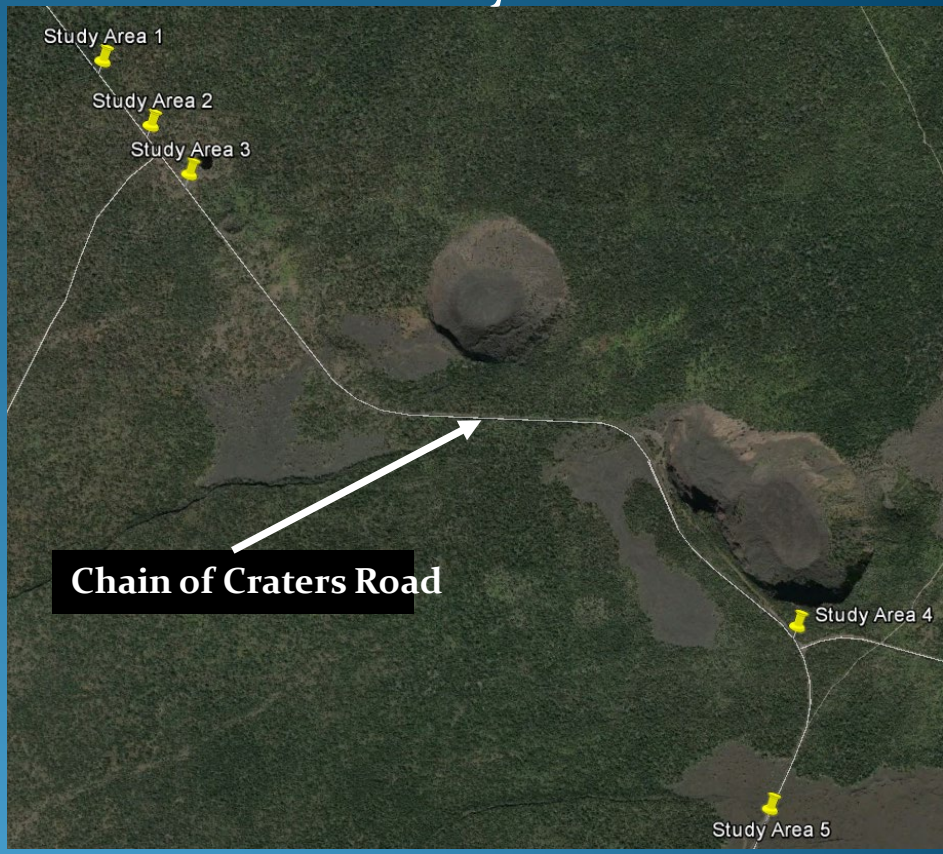
Rare M5.3 earthquake hits Big Island in Hawaii

June 8, 2017

Introduction

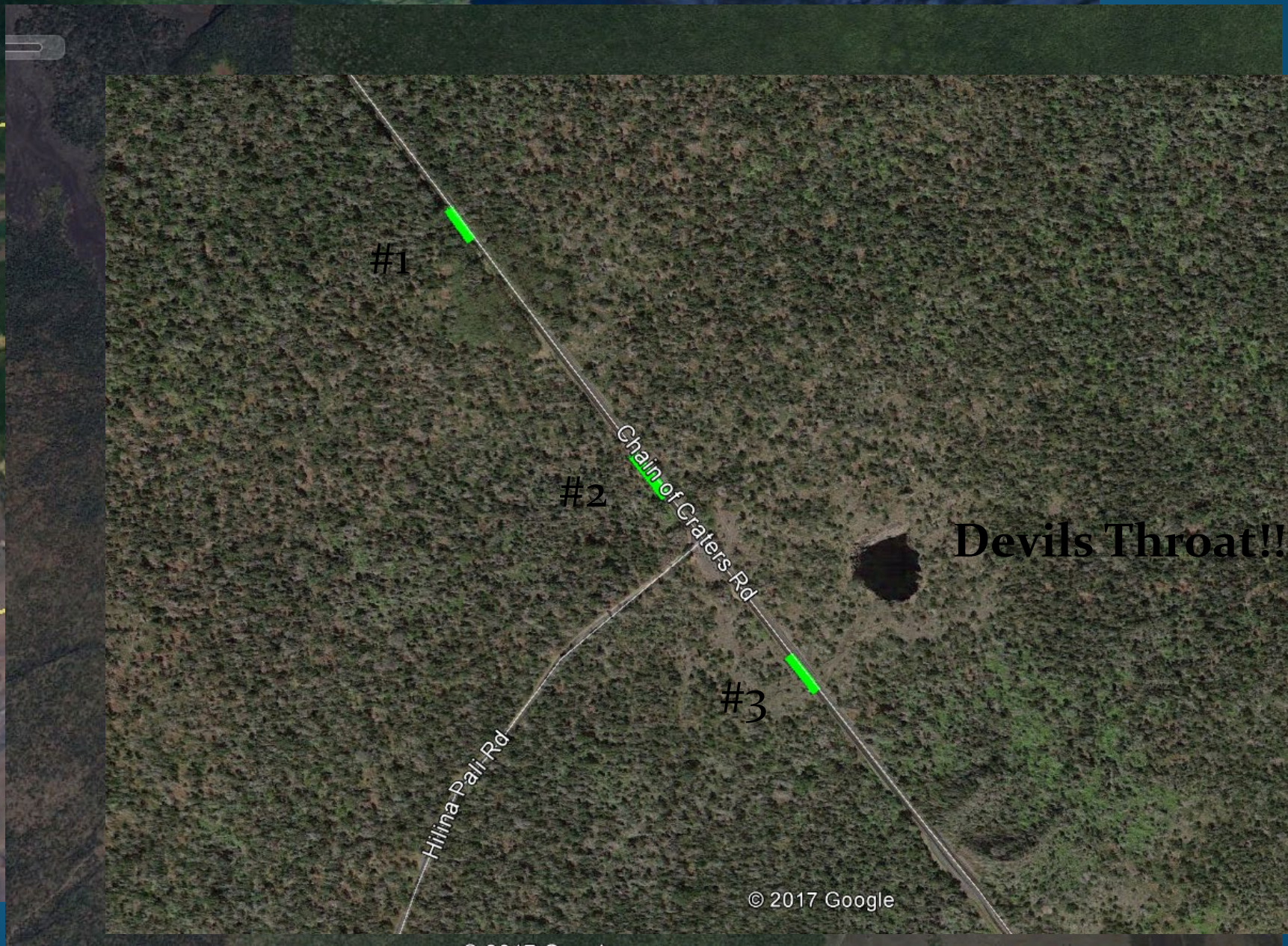
- July 27th CFL performed site assessment and based on field observations identified 5 areas displaying pavement distress - each needed to be studied by ***non-destructive methods*** *(with minimal impact to traffic!)*.
- Geophysical methods selected were: **3D Ground Penetrating Radar (GPR)** and **3D Seismic Refraction Tomography (SRT)**.
- Geophysical investigation performed August 28th and 29th, 2017.

Five Study Areas

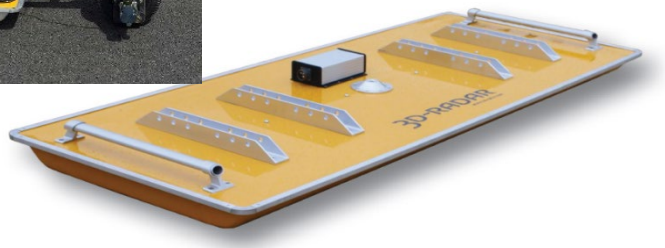


Site “Issues” - small to very

Google Earth Views -

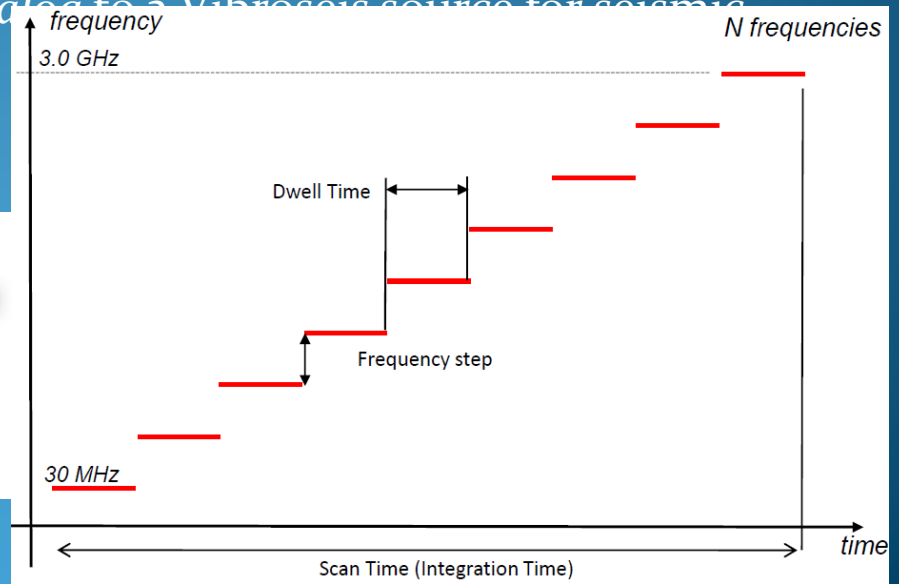


Most Appropriate Approaches:



3D GPR: The 3D RADAR DXG 0908 multichannel, step frequency array was used, with 8 antenna at ~1.5-inch spacing, and a 18-inch 'swath width'; reflector tape and GPS used for positioning. ~20-foot roadway, thus 18 line-passes to get overlap and full coverage (at 1.5"). The GeoScope MkIV was mounted on the cart with 2 12-volt batteries.

The 3D RADAR instrument covers radar frequencies between 200 and 3000MHz (3.0GHz); with 4MHz steps. This is the *analog to a Vibroseis source for seismic*



Most Appropriate Approaches:

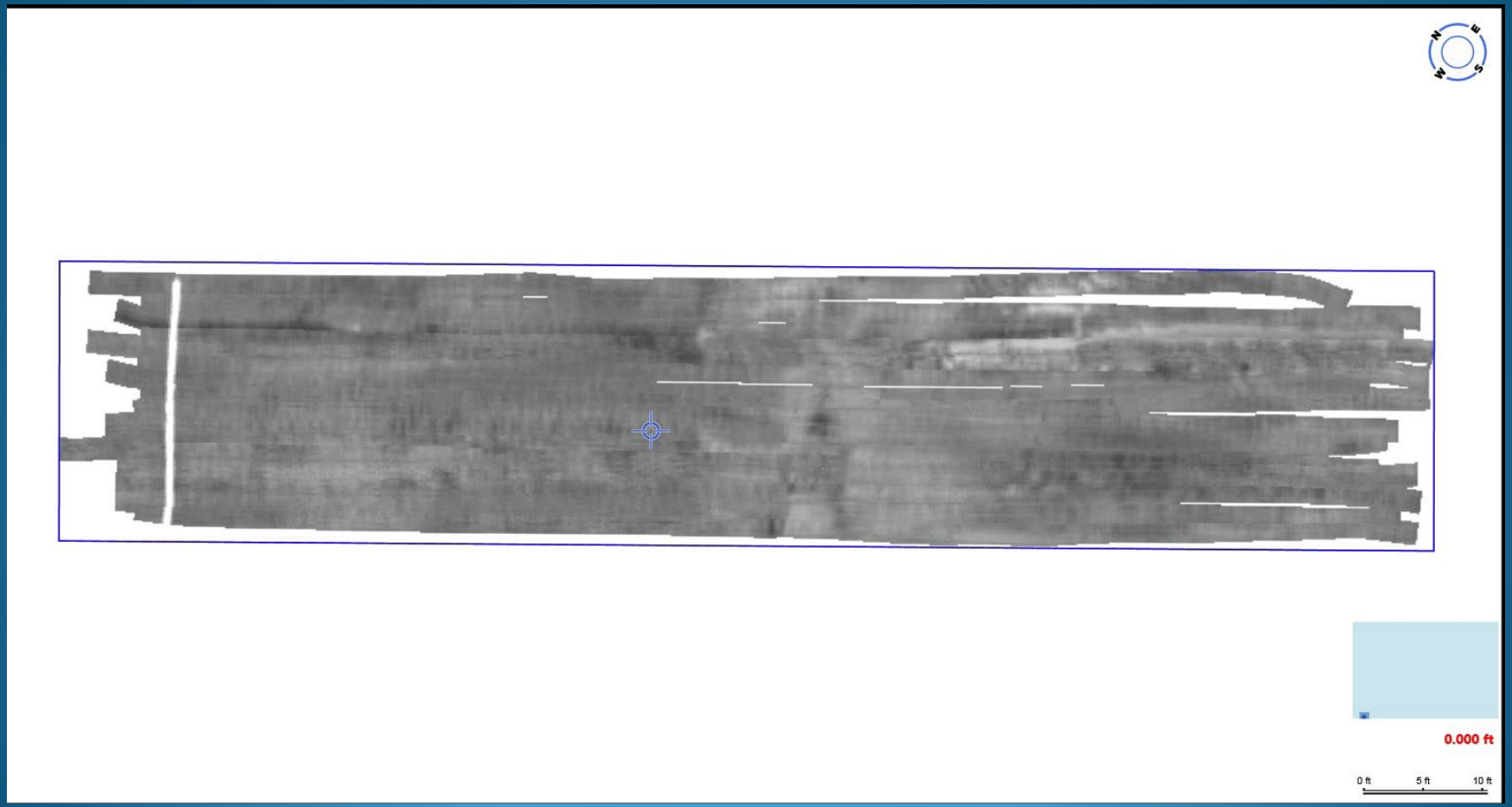
3D SRT: 1-meter spaced gimbaled 14Hz geophones, on three 24-ch landstreamer arrays for a 72-receiver 3D array (every SP and receiver position GPS'd)..

Anomalies

- *Anomaly*: Something that deviates from what is standard, normal, or expected.
- Several anomalies were detected - different number, size and character at each site.
- CFL categorized the anomalies into three severity classes based on the quality and reliability of the geophysical data, the risk of near-future distress, and public safety.
  - **Class 1 (High Severity):** Immediate remediation is a high priority.
  - **Class 2 (Medium Severity):** Immediate remediation is beneficial. Site should be visually monitored regularly.
  - **Class 3 (Low Severity):** Immediate remediation unnecessary. Occasional visual monitoring should be performed.

3D GPR - Video Result (*Study Area 2*)

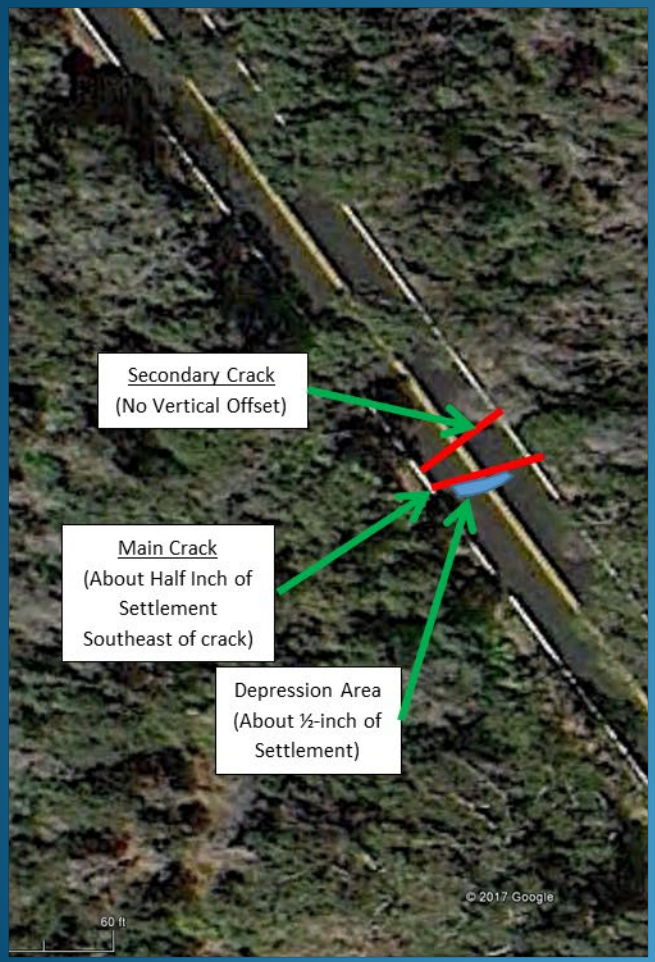
This .wmv file is a final

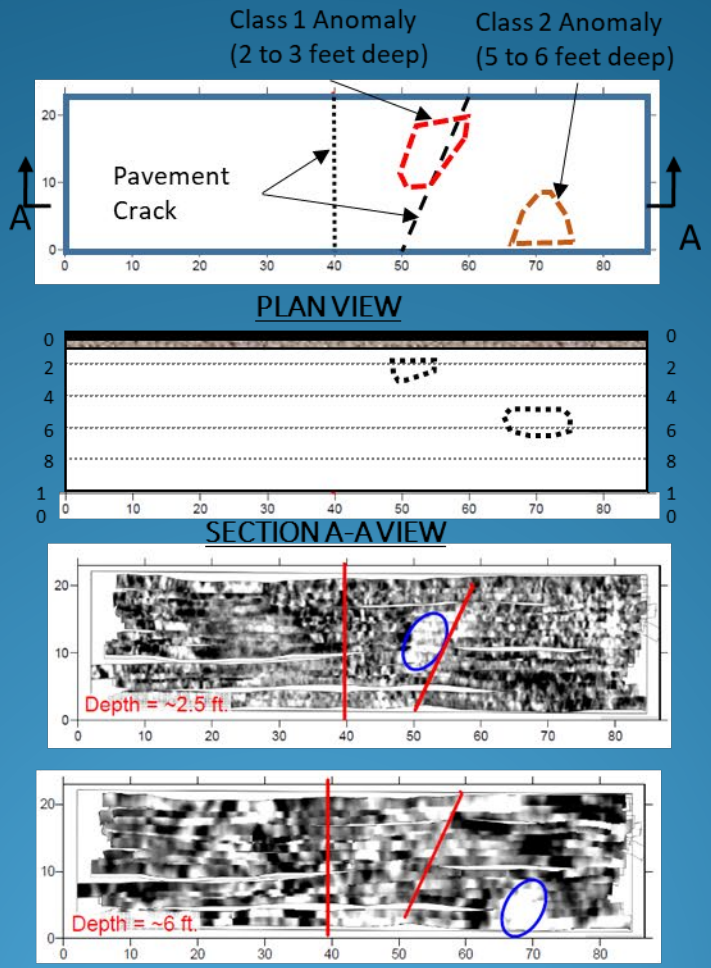

N
E
S
W
0.000 ft
0 ft
5 ft
10 ft

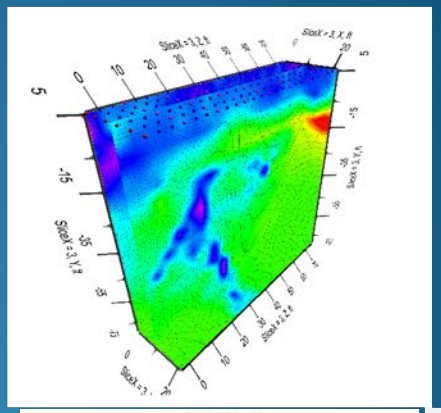
3D SRT - Video Result (*Study Area 2*)

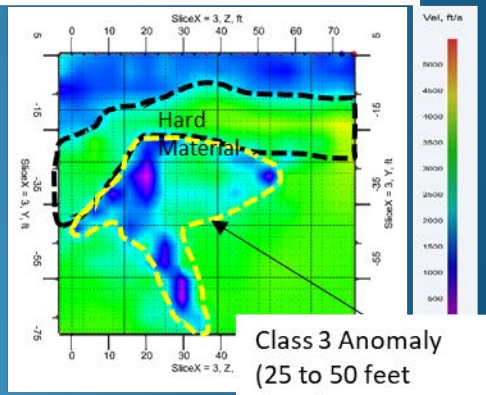
Area2EastWestVIDEO.mp4

Study Area No. 1







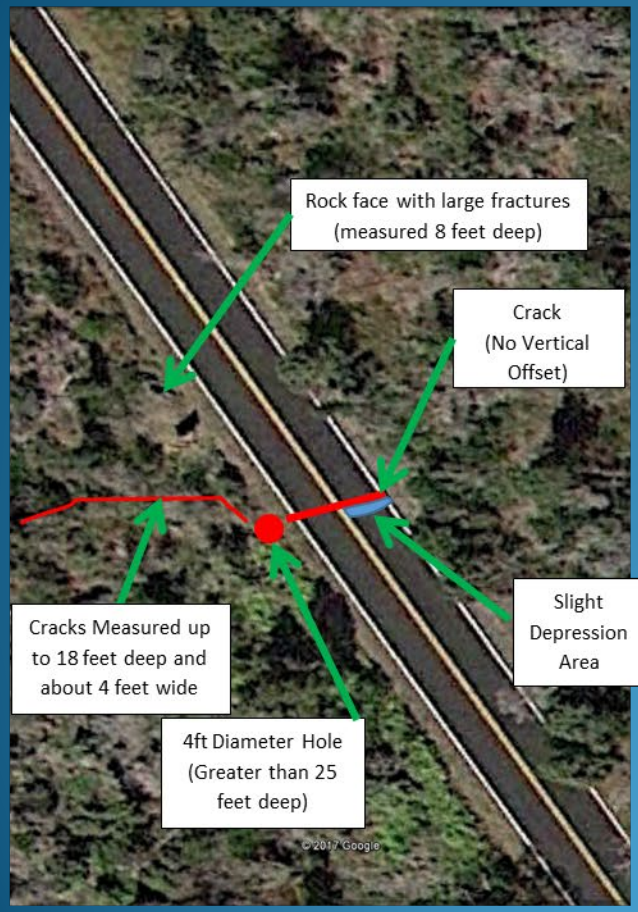


Class 3 Anomaly
(25 to 50 feet deep)

3D GPR RESULTS

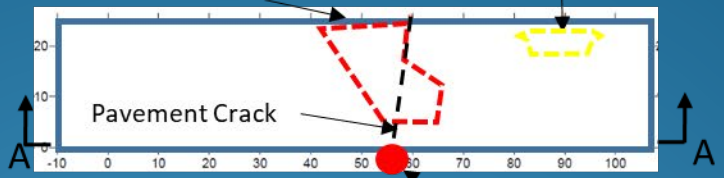
3D SRT RESULTS

Study Area No. 2

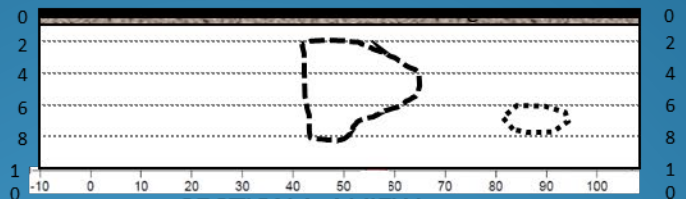


Class 1 Anomaly (2 to 8 feet deep)

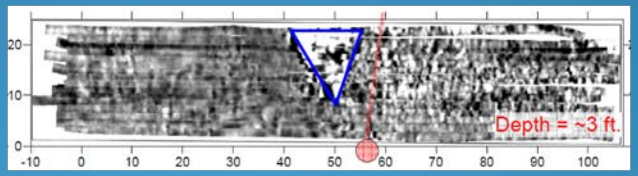
Class 3 Anomaly (6 to 7 feet deep)

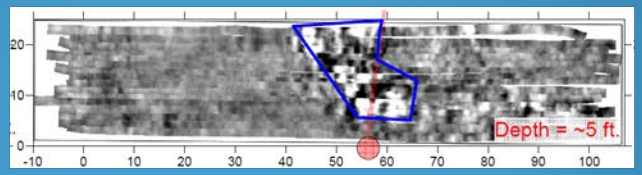


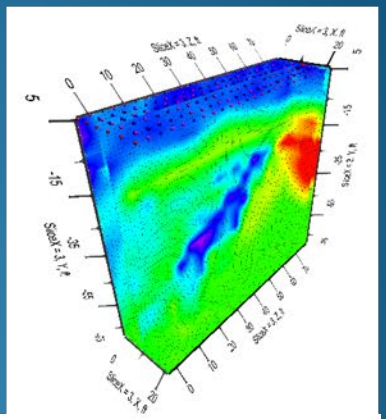
PLAN VIEW

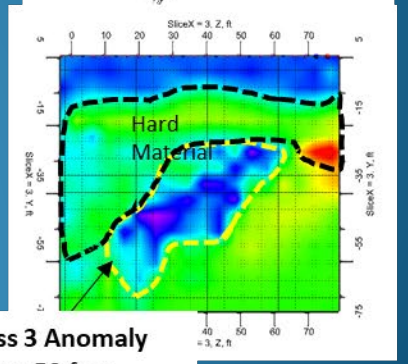


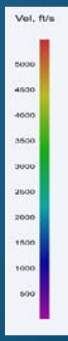
SECTION A-A VIEW











Class 3 Anomaly (30 to 50 feet deep)

Conclusions

- ***Both methods were successful for the ER and detected anomalies***.
- GPR identified narrow cracks and voids very shallow beneath the roadway and to **a minimum of 7-8' bgs**.
- SRT identified anomalies interpreted to be voids and/or soft (rock) zones, **to depths of ~50 feet**. (SRT could *not* resolve features <5 feet bgs).
- Each method showed promise for fast (ER) data acquisition, fast data processing, and delivery of ***useful results within days*** of data acquisition.

➢ **CFLHD made mitigation recommendations *without* additional geotechnical investigation (*NO DRILLING*!).**


Questions?