Application of 3D Radar for Pavement Evaluation

By

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FDOT

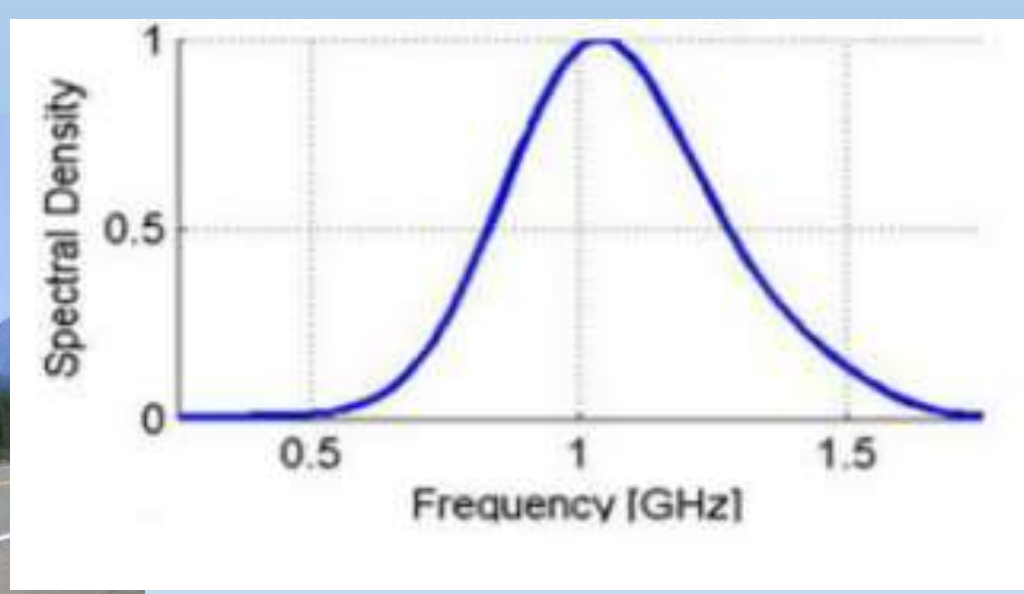
SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

INFRASENSE

Conventional GPR Systems

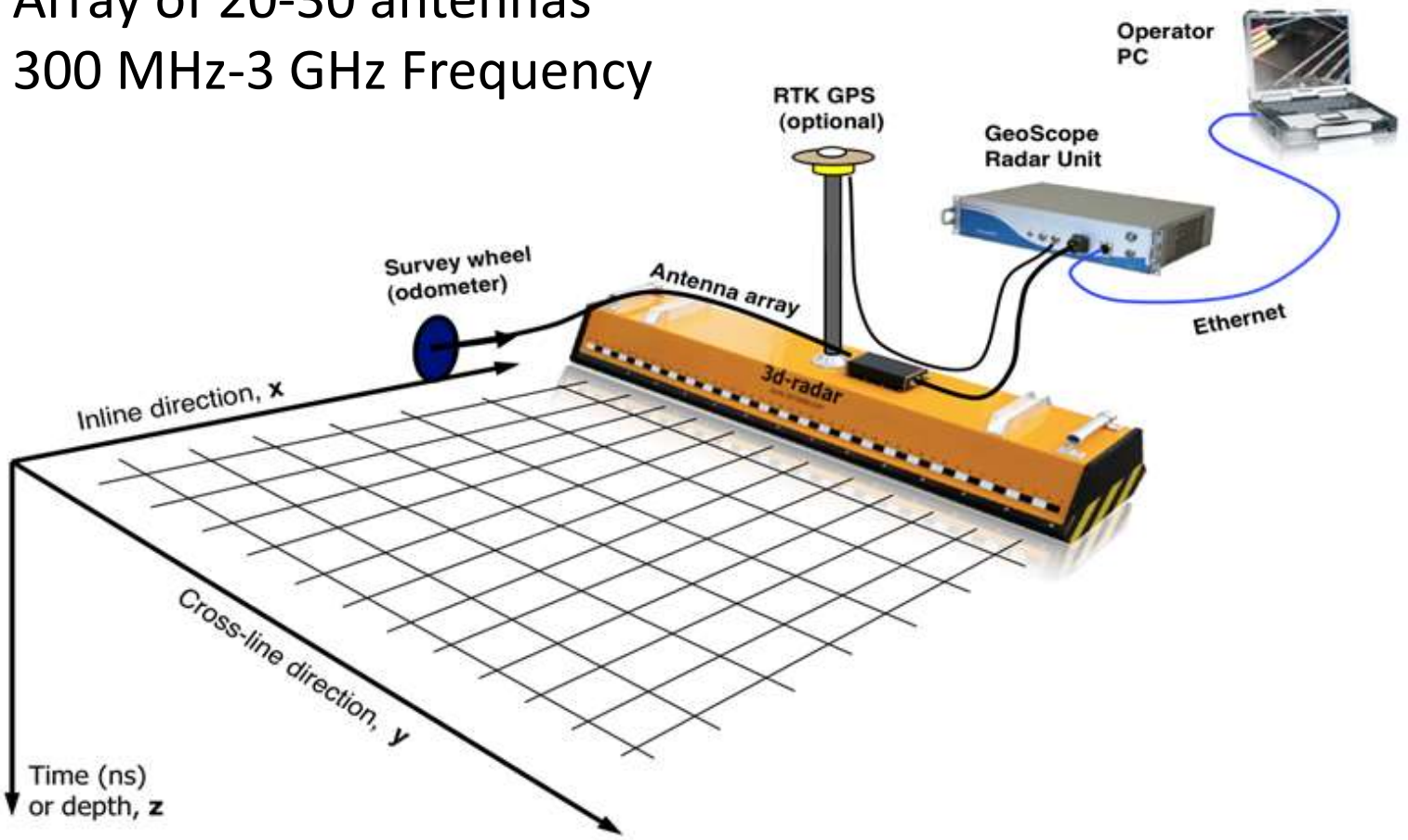
- Time Domain Impulse Radar
- Broadband Pulse with Specified Center Frequency and Associated Antenna
  - 2 GHz antenna
  - 1 GHz antenna
  - 400 MHz antenna
- Single antenna or array up to 4 antennas

Typical Impulse GPR Highway Systems

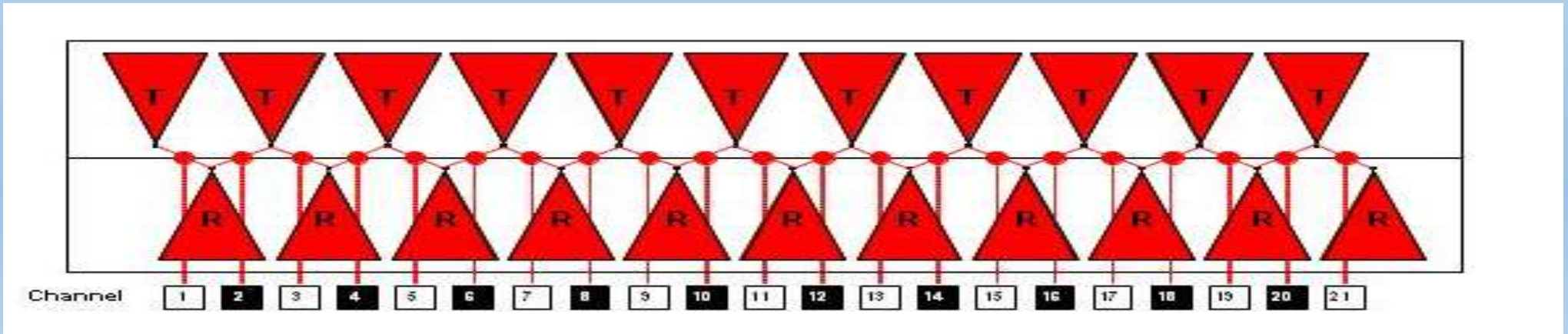


About 3D-Radar

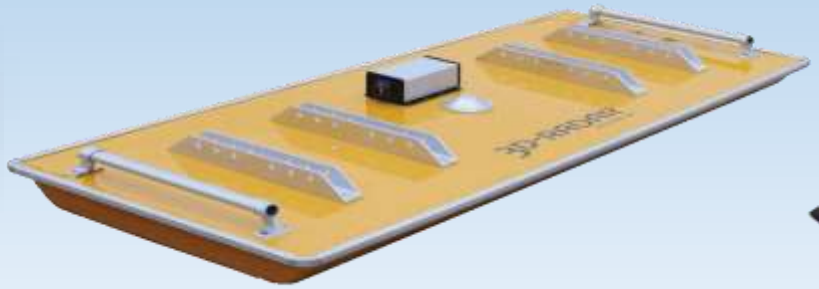
Array of 20-30 antennas
300 MHz-3 GHz Frequency



3D RADAR

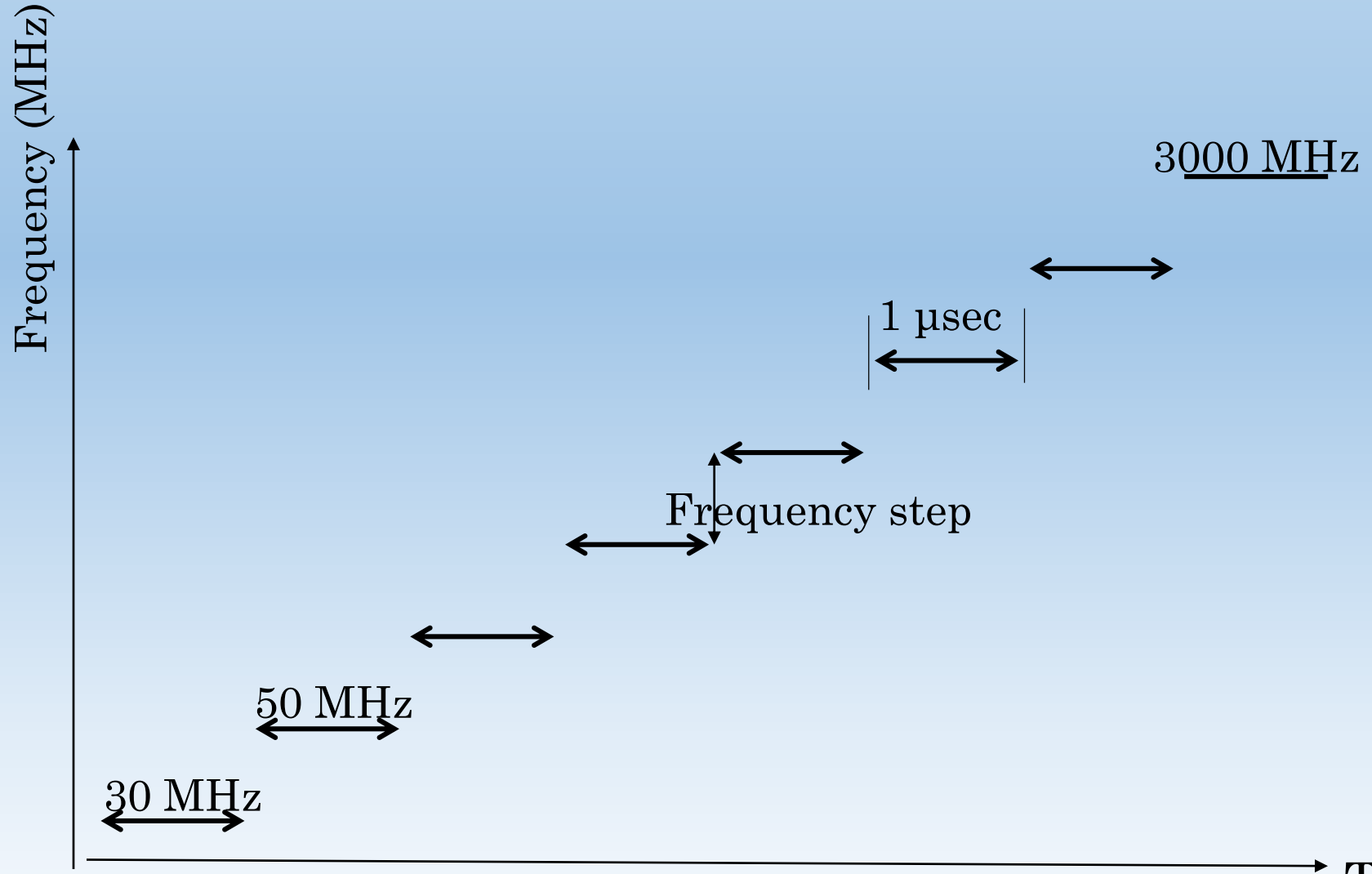


3D GPR Geoscope MKIV

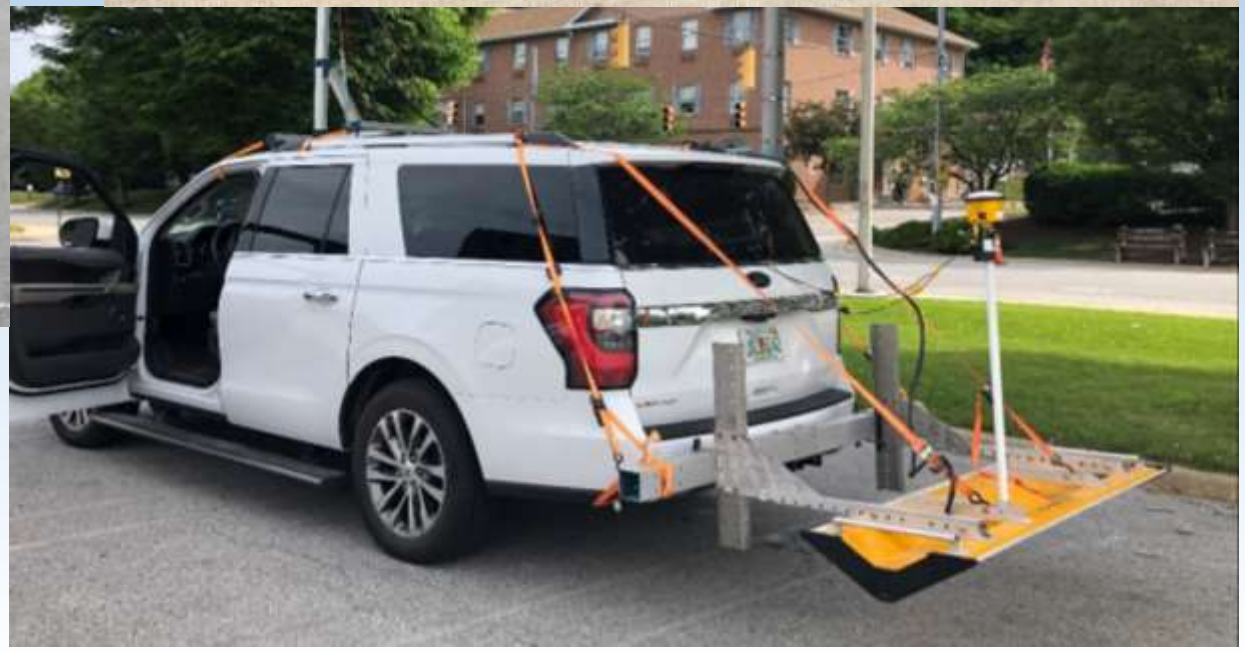


DXG-1820 Ground Coupled Antenna

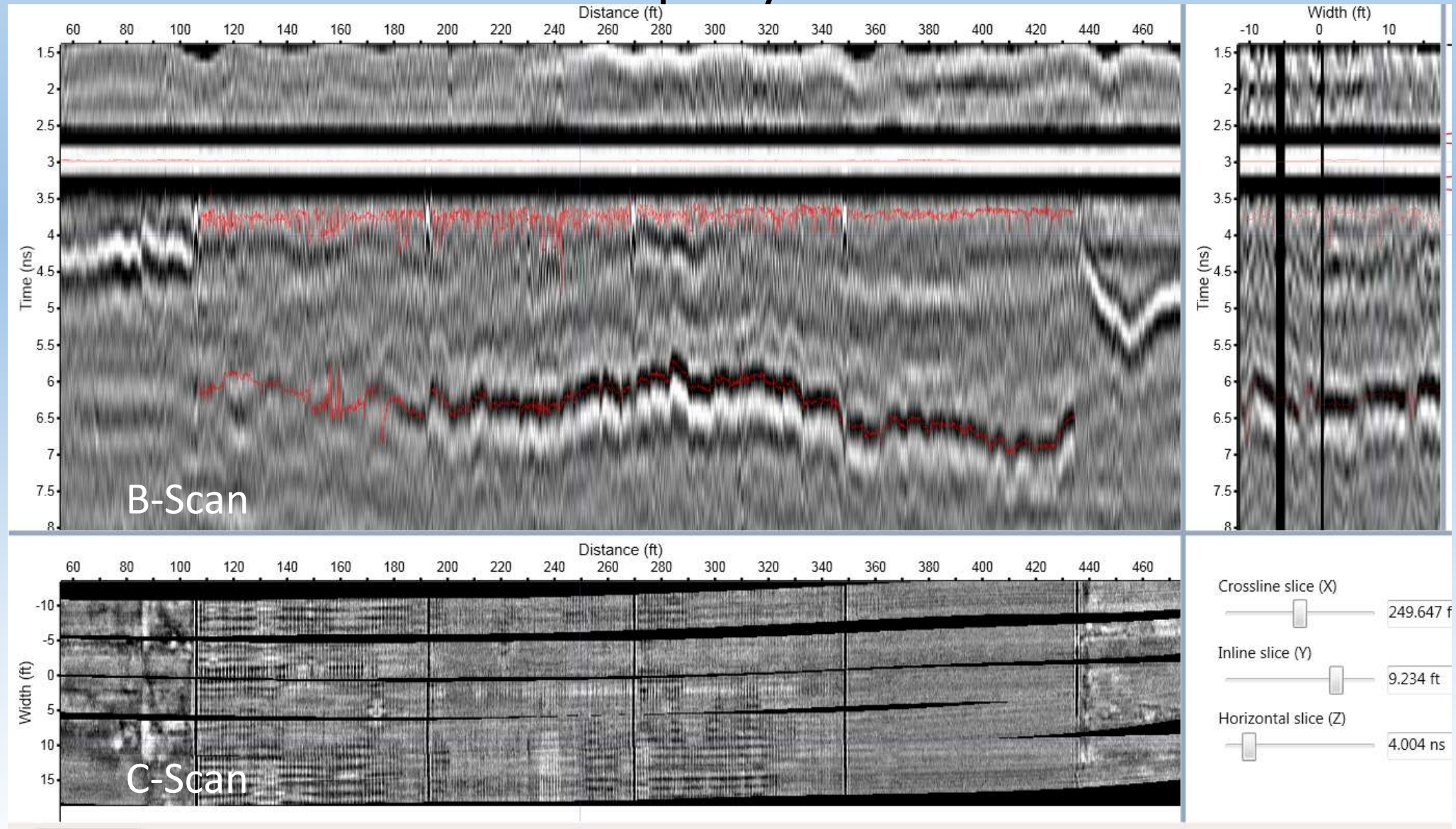
Step-frequency waveform



Vehicle Mounting



3D Radar Data Display



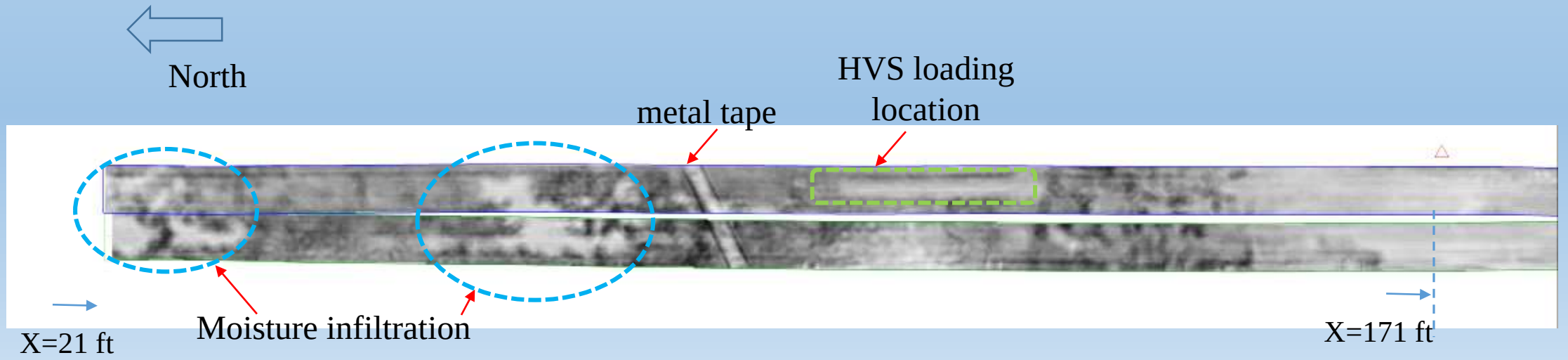
3D Radar Data Spatial Display

Key Applications of 3-D Radar

- Detection of features that have two dimensionality
  - Damage
    - Stripping,
    - Debonding
    - densification
  - Reinforcing
  - Pipes and Utilities

Asphalt Delamination, Density, and Segregation

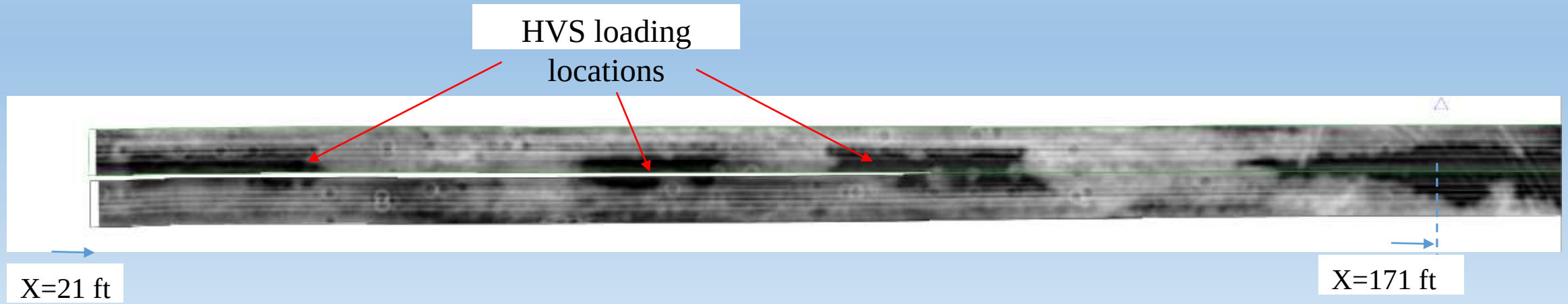
Lane 3 - Debonding between Asphalt Layers



This section - Sand interface area (unbonded) – 1.4”

Lane 4 - Density

Lane 4 - depth slice at 0.8”

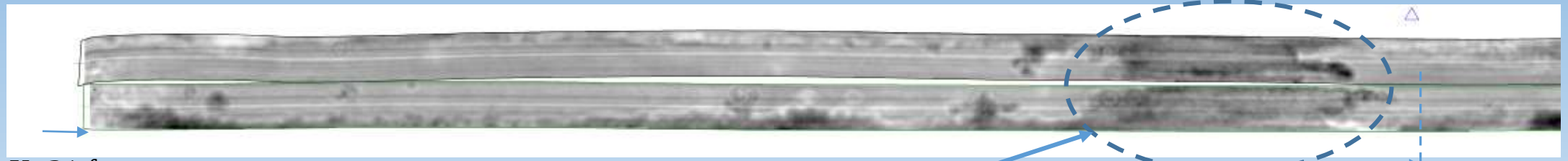


Loading Area	Core location (feet)*	Ave. Core Density
Left (AL)	15	90.4
Right (CR)	65	91.4
Left (EL)	250	92.7
Left (HL)	345	93.5

*Cores measured from approximately 20ft. from the start as the reference location

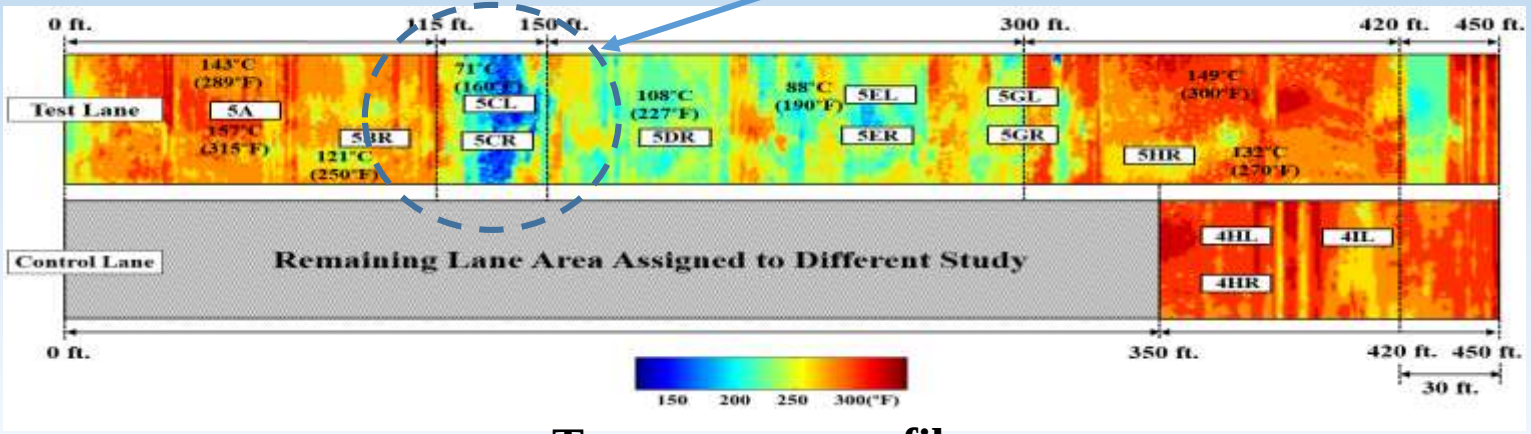
Lane 5 - Segregation

Lane 5 - depth slice at 1.5”



X=21 ft

X=171 ft



Temperature profile map

Detection of “Stripping” in Asphalt Pavement

NCAT Test Track – Embedded Defects

Stripping at 2” depth

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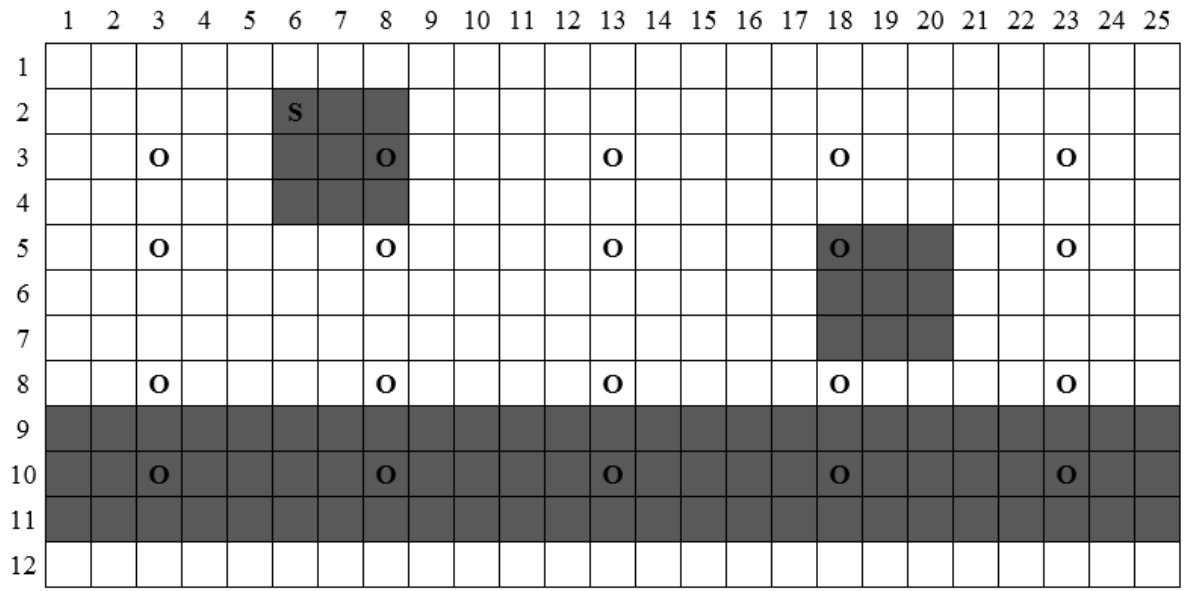
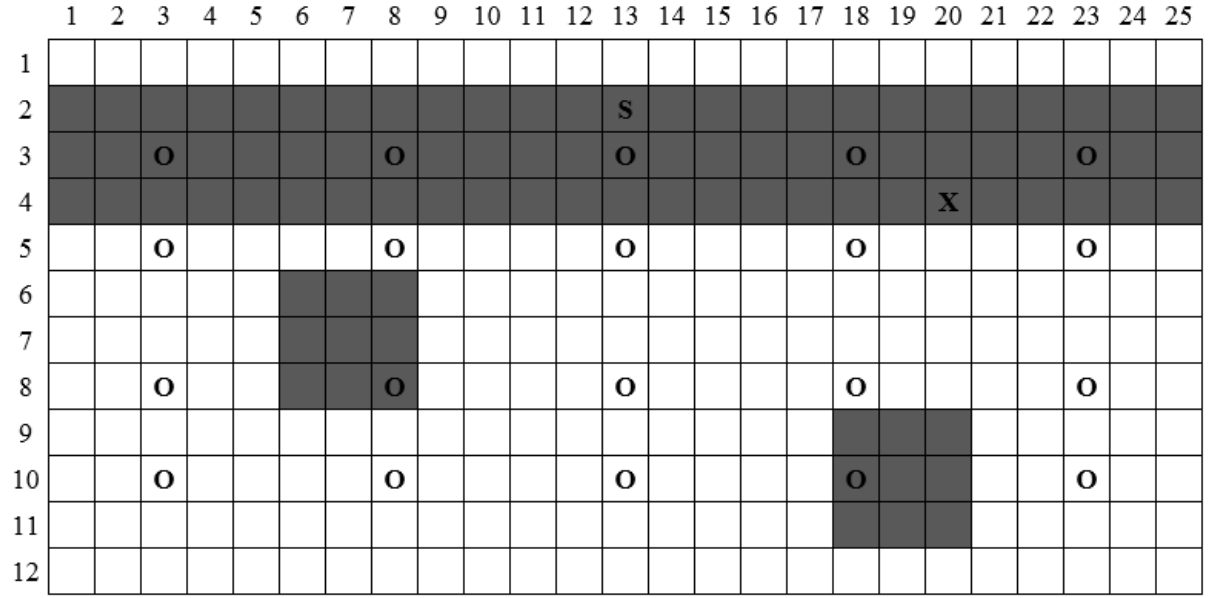
Stripping at 2” depth



Dark gray = RAP; bottom of delamination = ~ 2 in.; RAP thickness = ~ 0.75 in.; O = locations where point-load methods were conducted; S = standpipe.

FIGURE 16 Section 6: HMA Pavement, Partial Stripping (STA 1+40 to 1+65).

Stripping at 5” depth

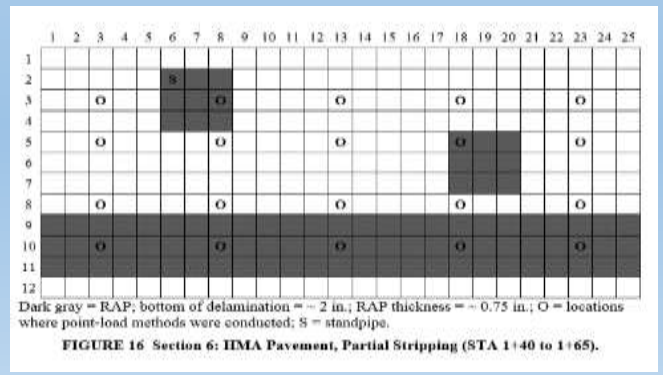


Dark gray = RAP; bottom of delamination = ~ 5 in.; RAP thickness = ~ 0.75 inches; O = locations where point-load methods were conducted; X = verification core; S = standpipe.

FIGURE 18 Section 8: HMA Pavement, Partial Stripping (STA 1+90 to 2+15).

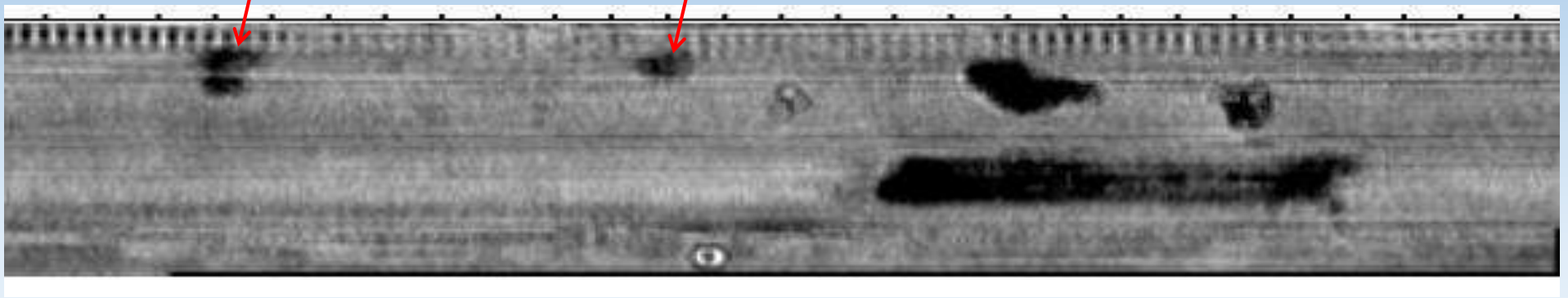
3D Radar Depth Slice at 2”

Section 6 RAP placed at 2" depth

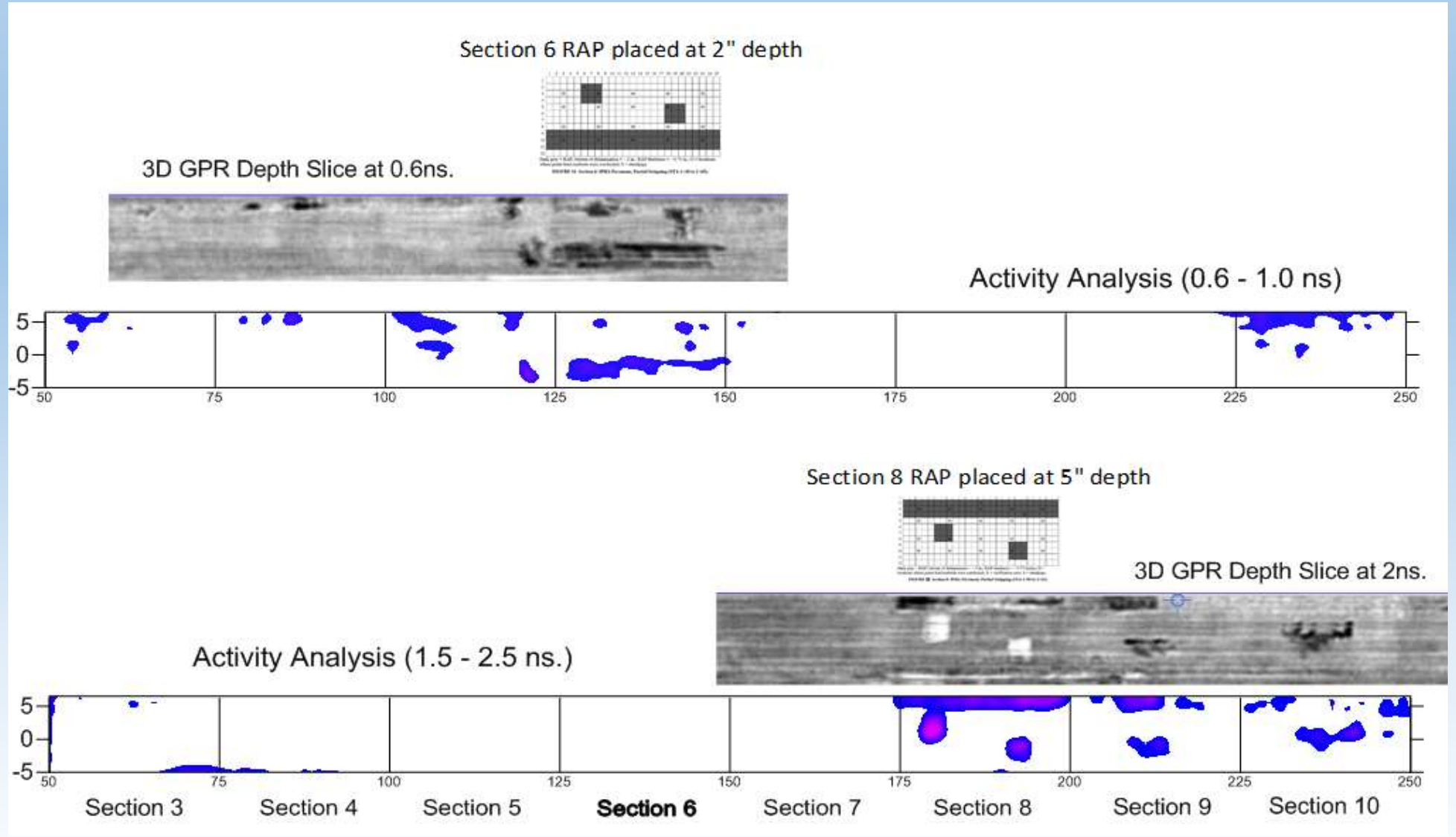


Section 5 – Debond placed at 2" depth

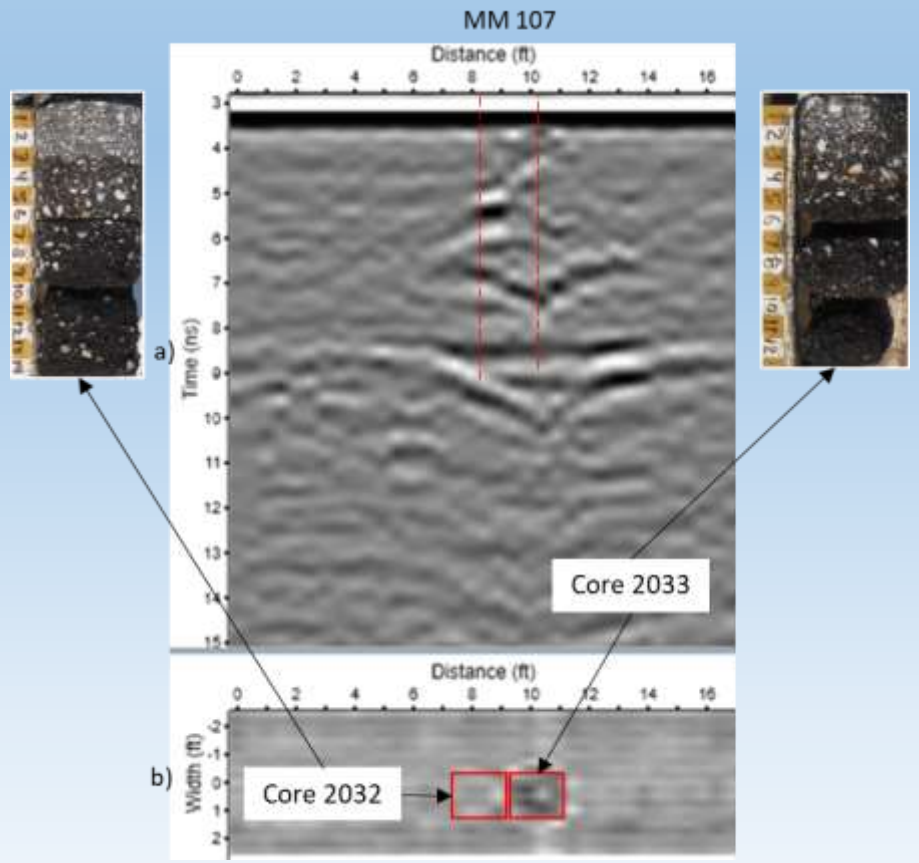
water introduced

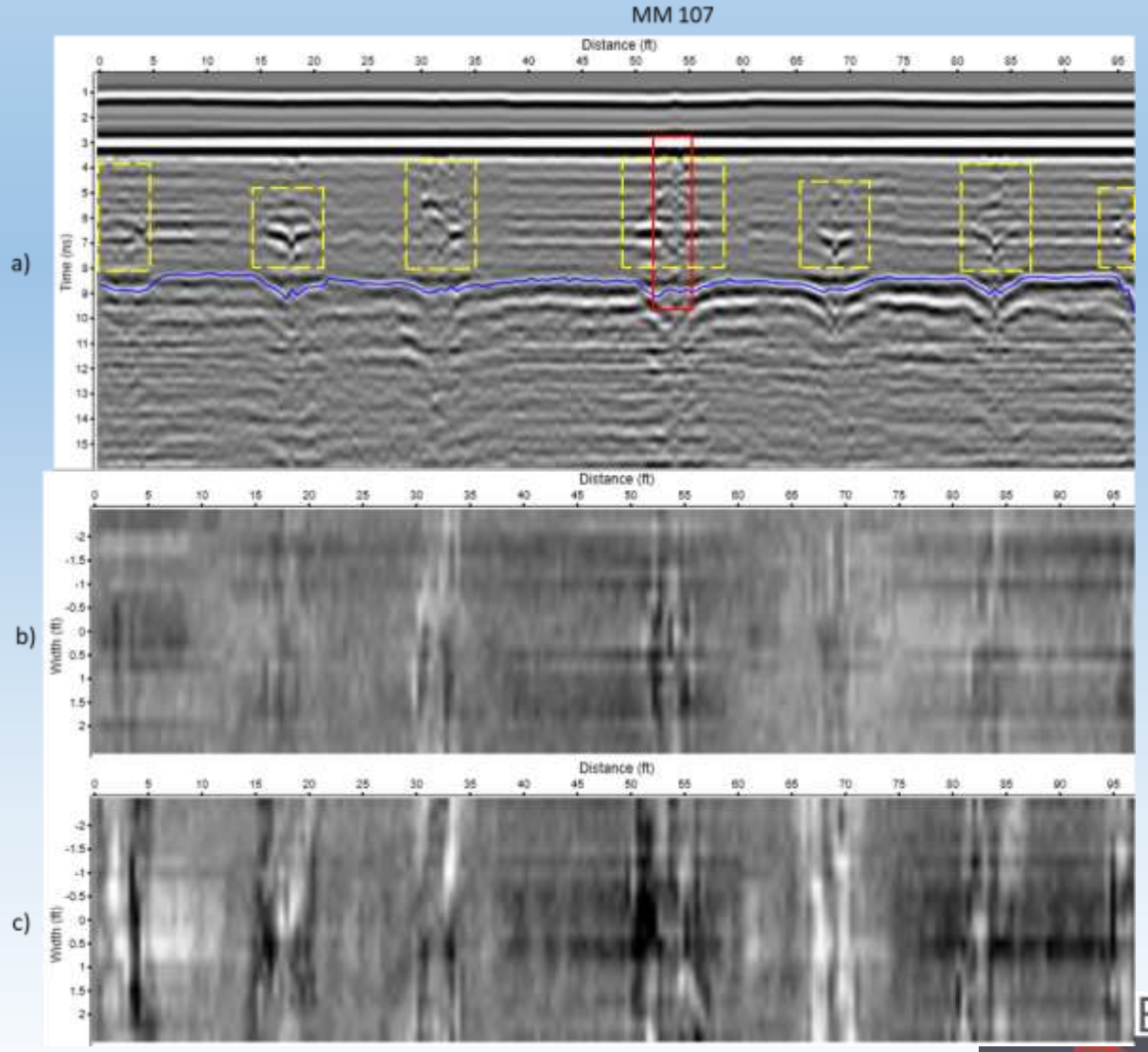


Depth Slice and Activity Analysis



Mn TH-7 16-Mile Section – Asphalt Stripping GPR at Core Locations

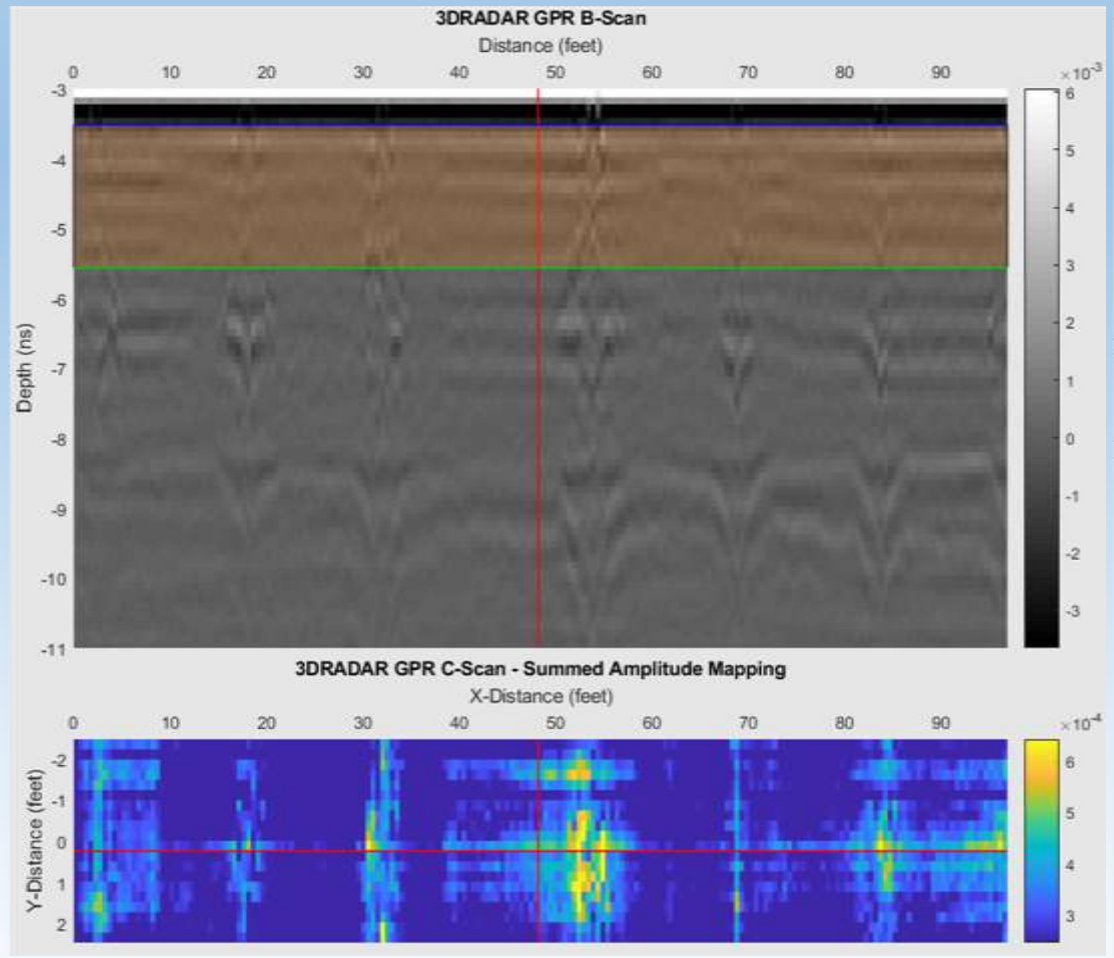


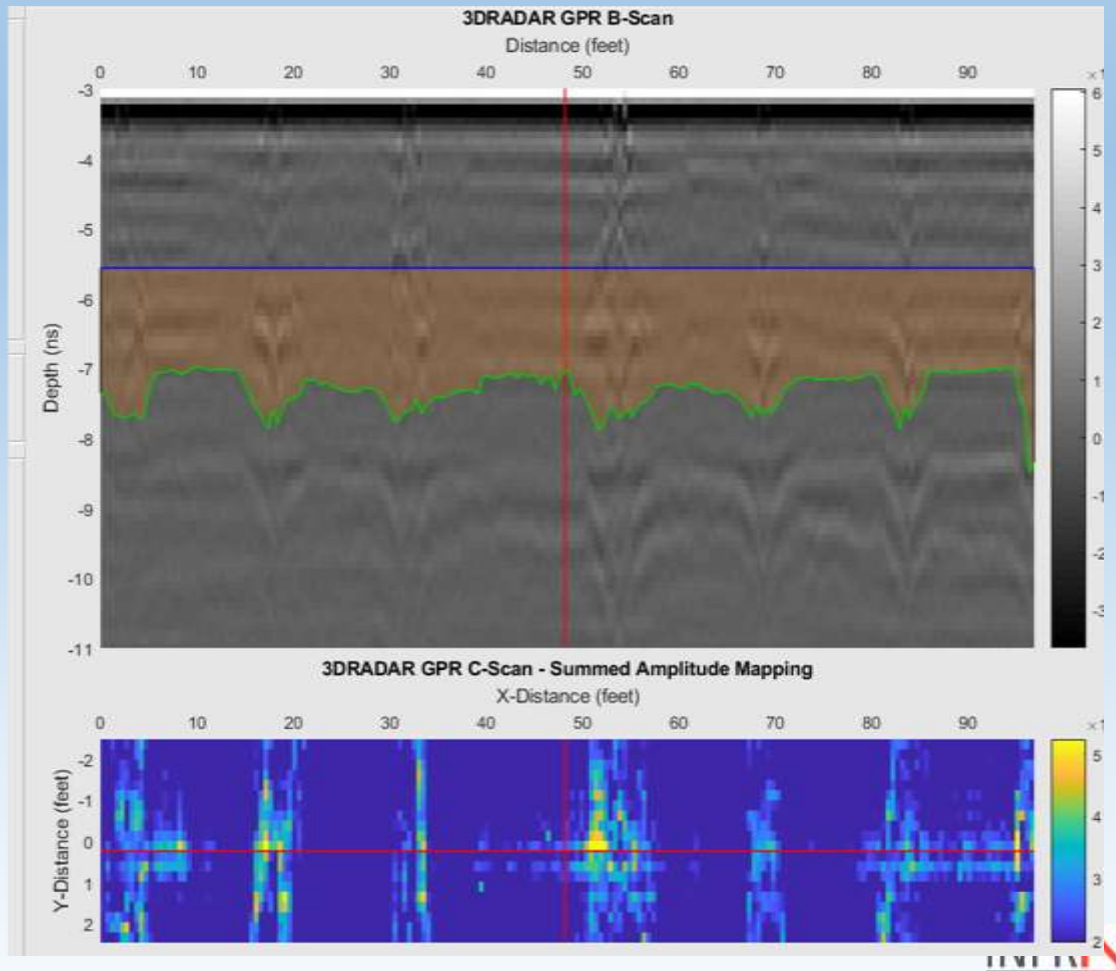


Activity Analysis at 2 Levels

a)

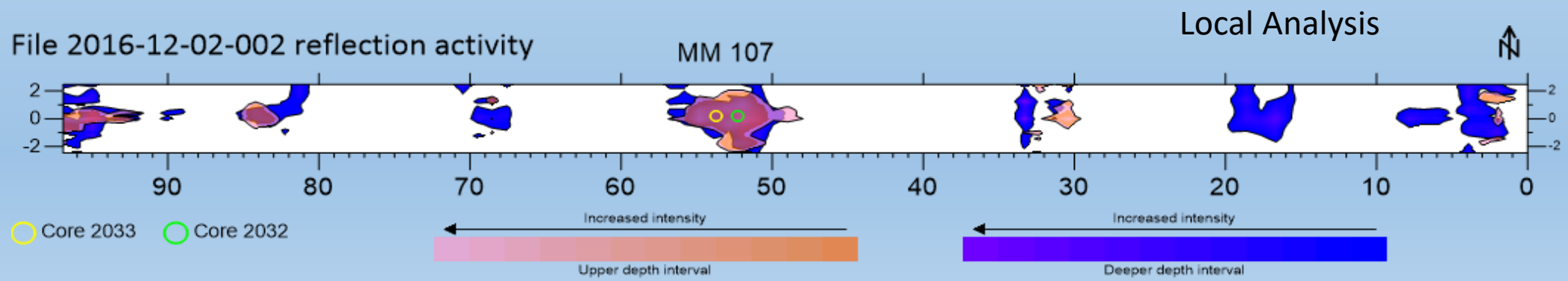
b)



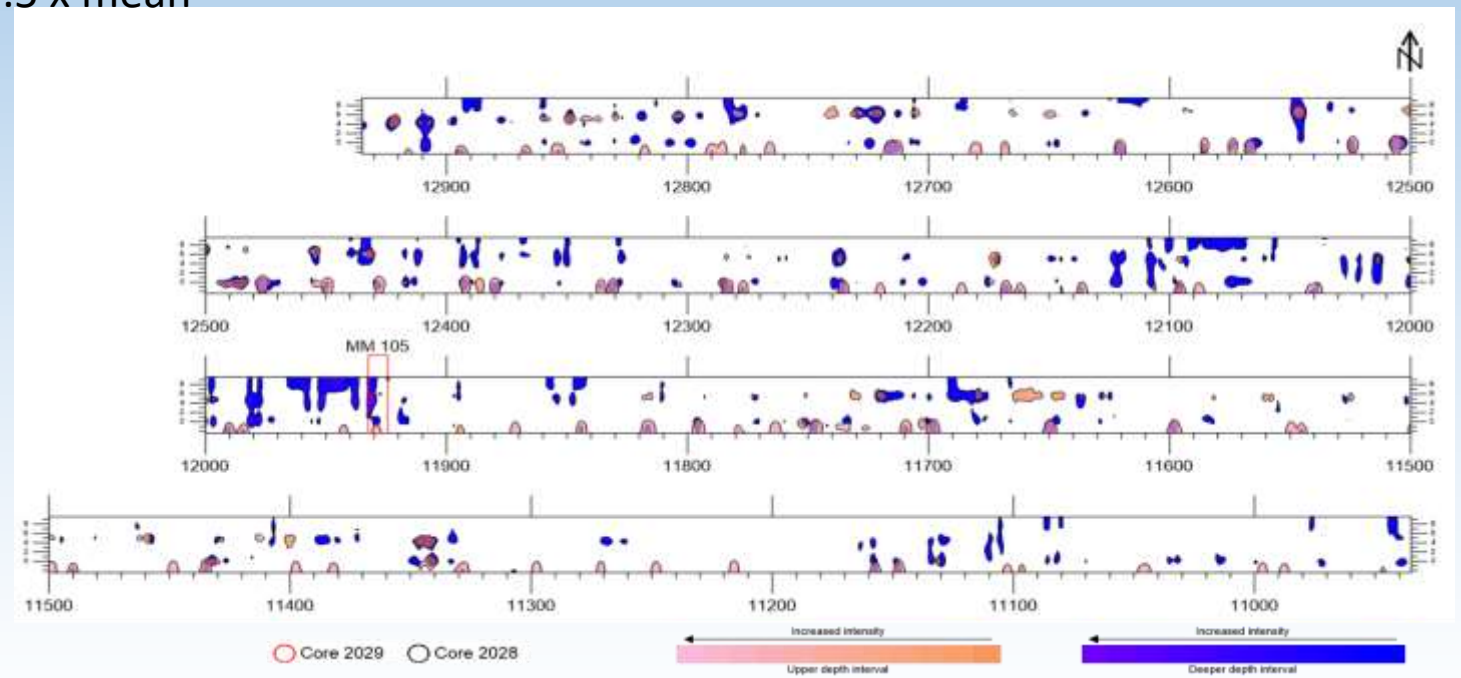


Analysis Results

Local Analysis

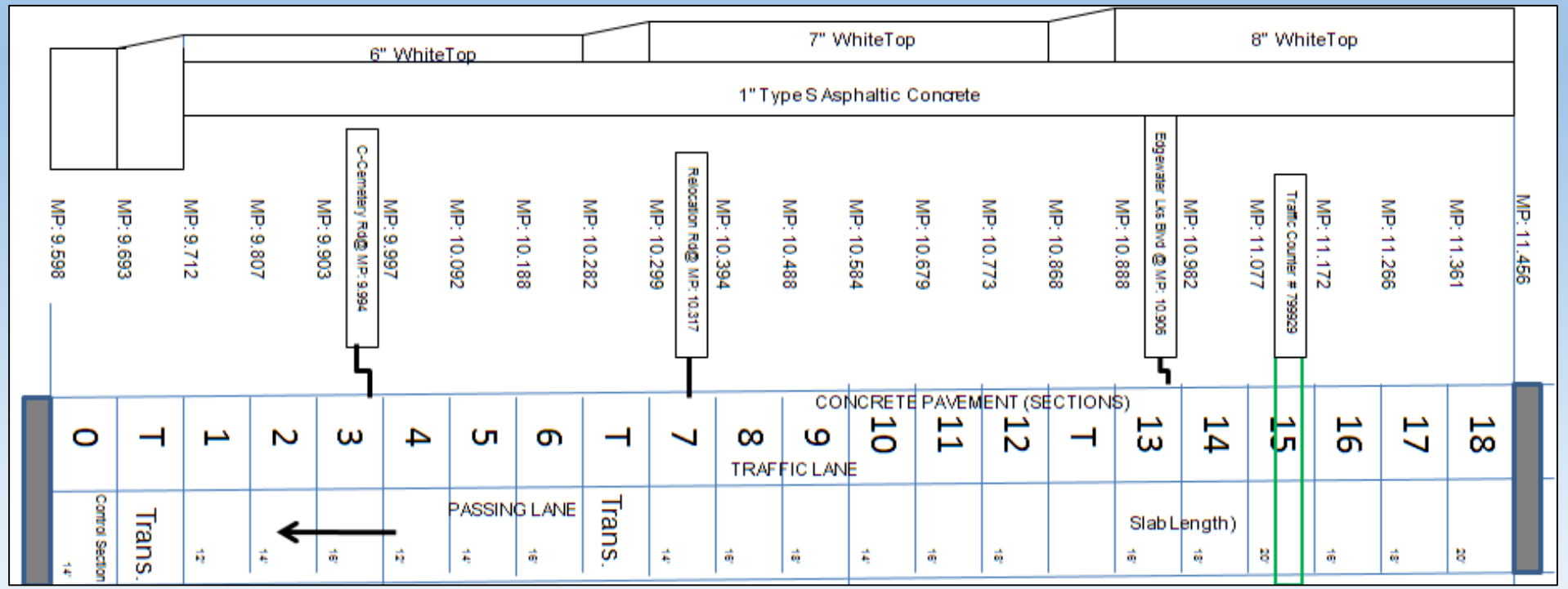


Threshold = 1.5 x mean



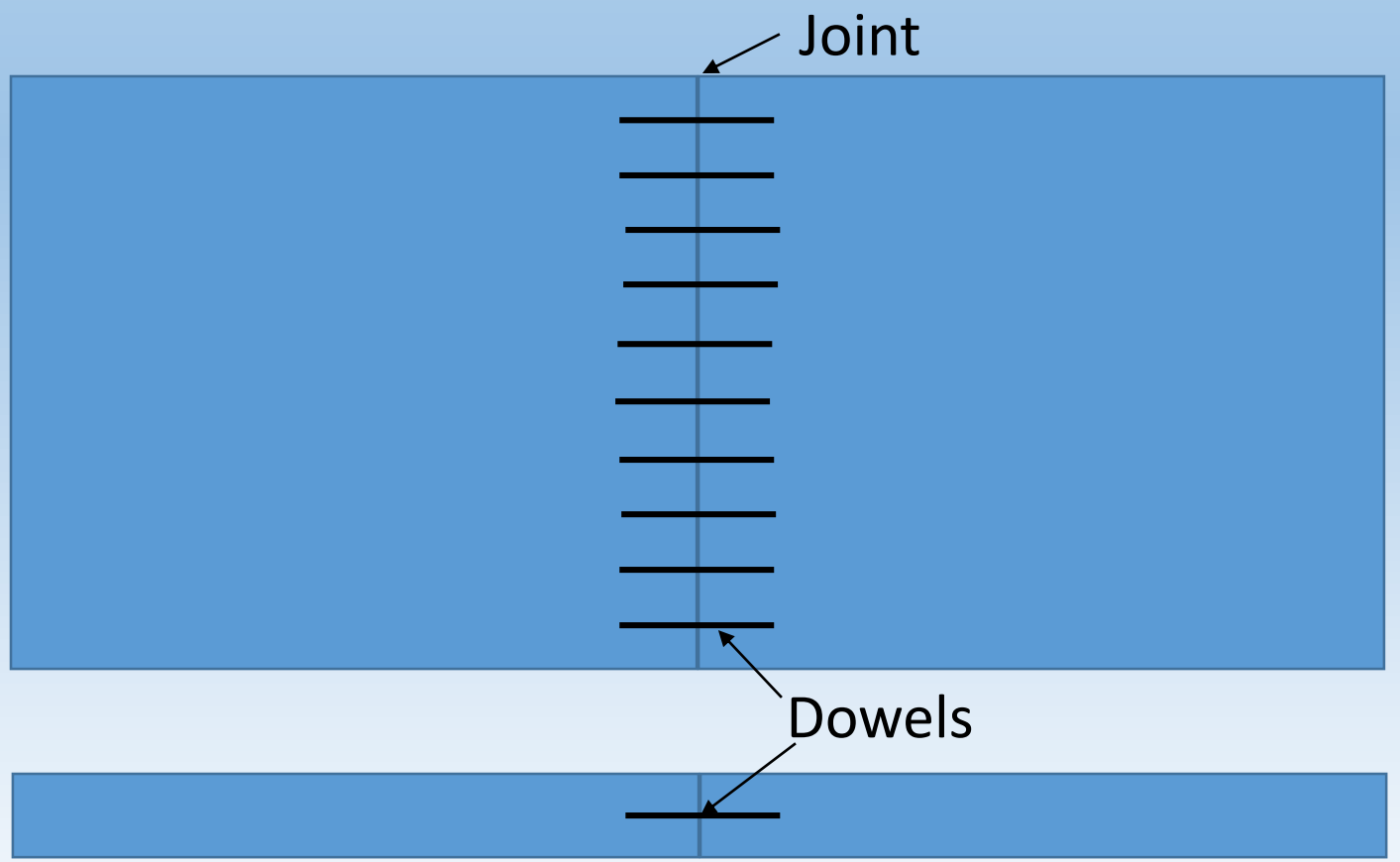
Larger Scale Analysis

FL SR-5
dowel bar detection and alignment

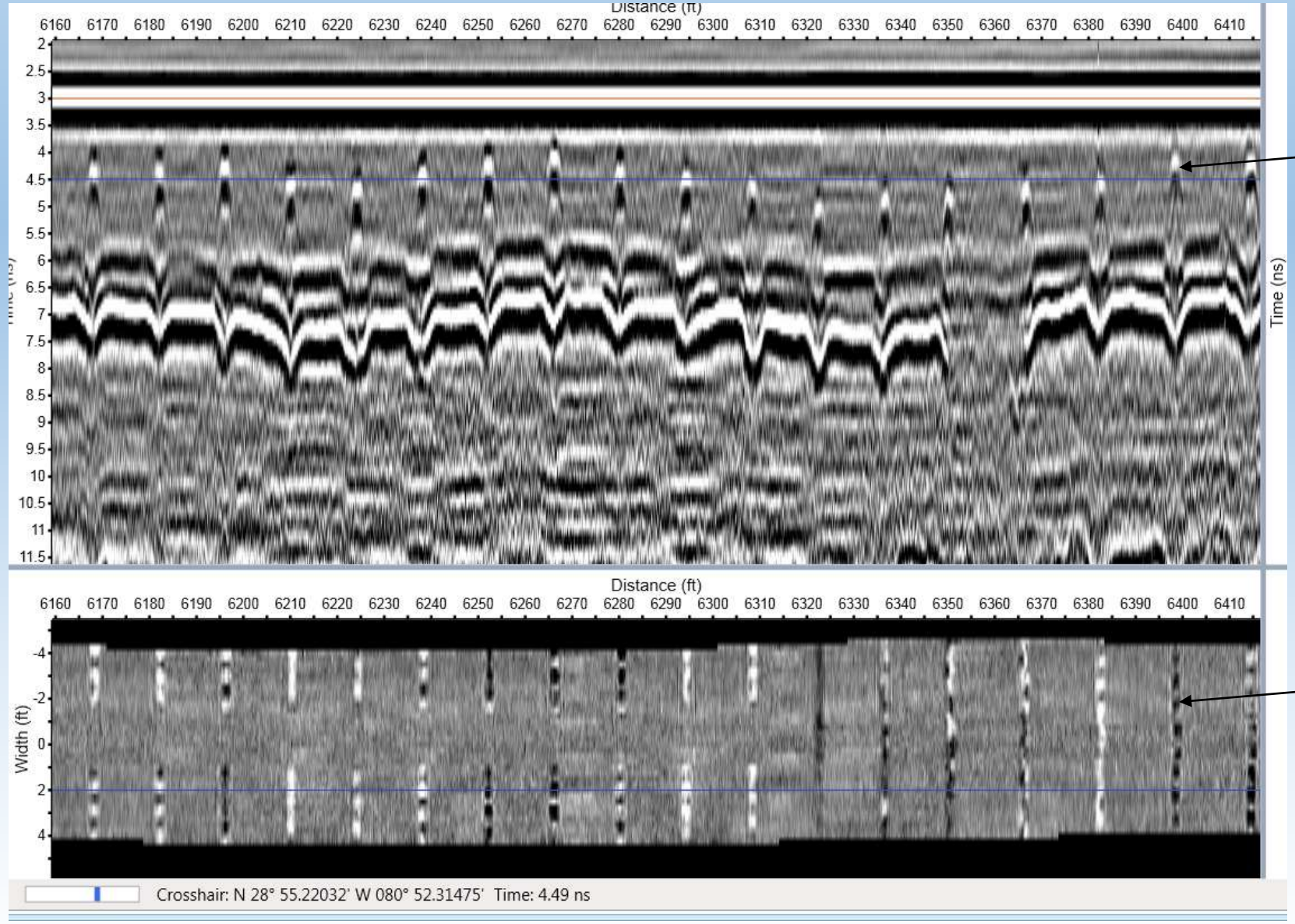


Schematic drawing of test section design

Dowel Bars in Concrete Pavement



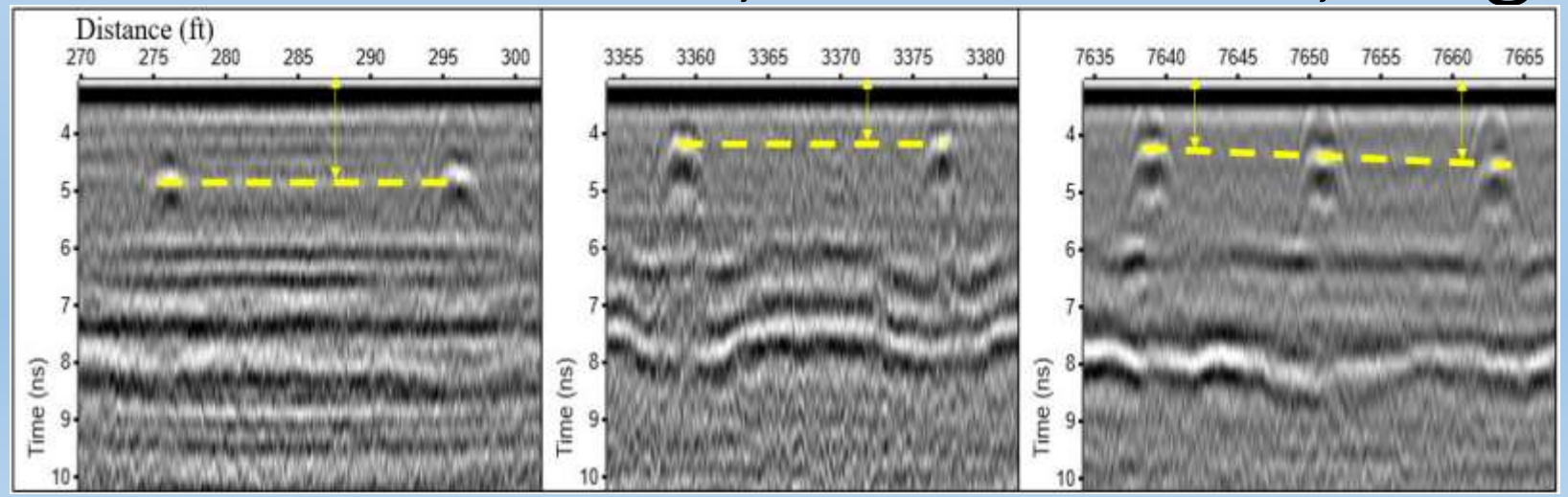
Dowel Bars in GPR

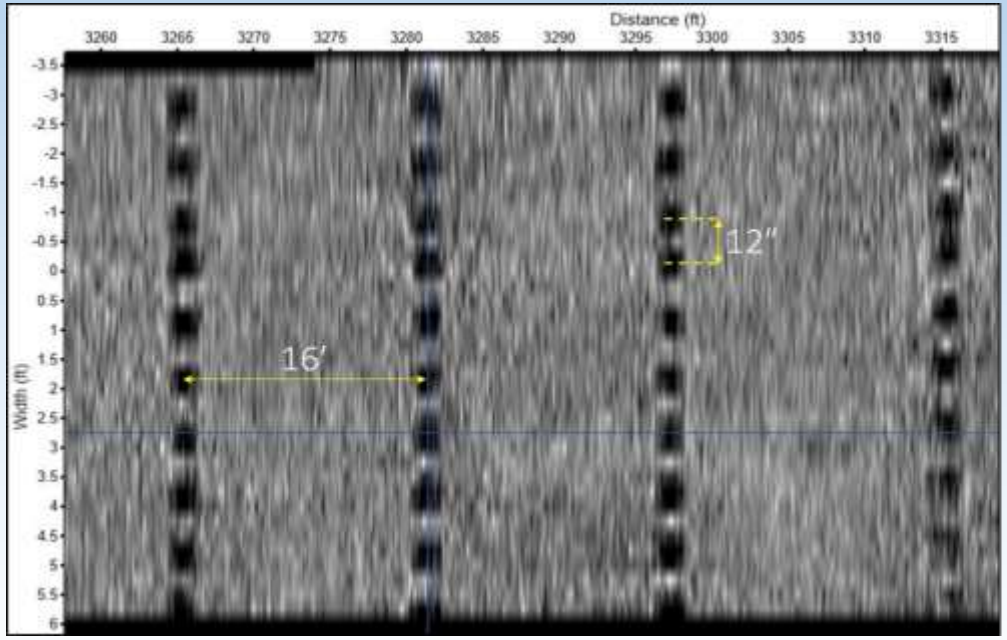


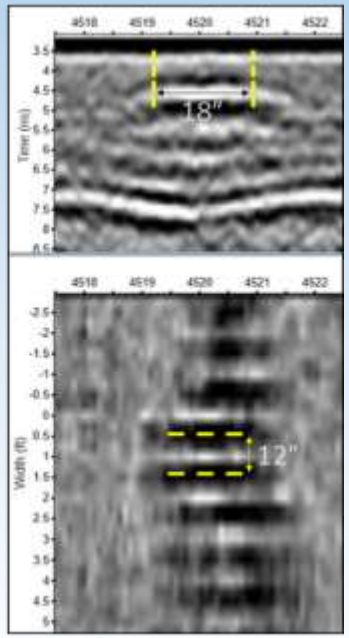
Dowels

Dowels

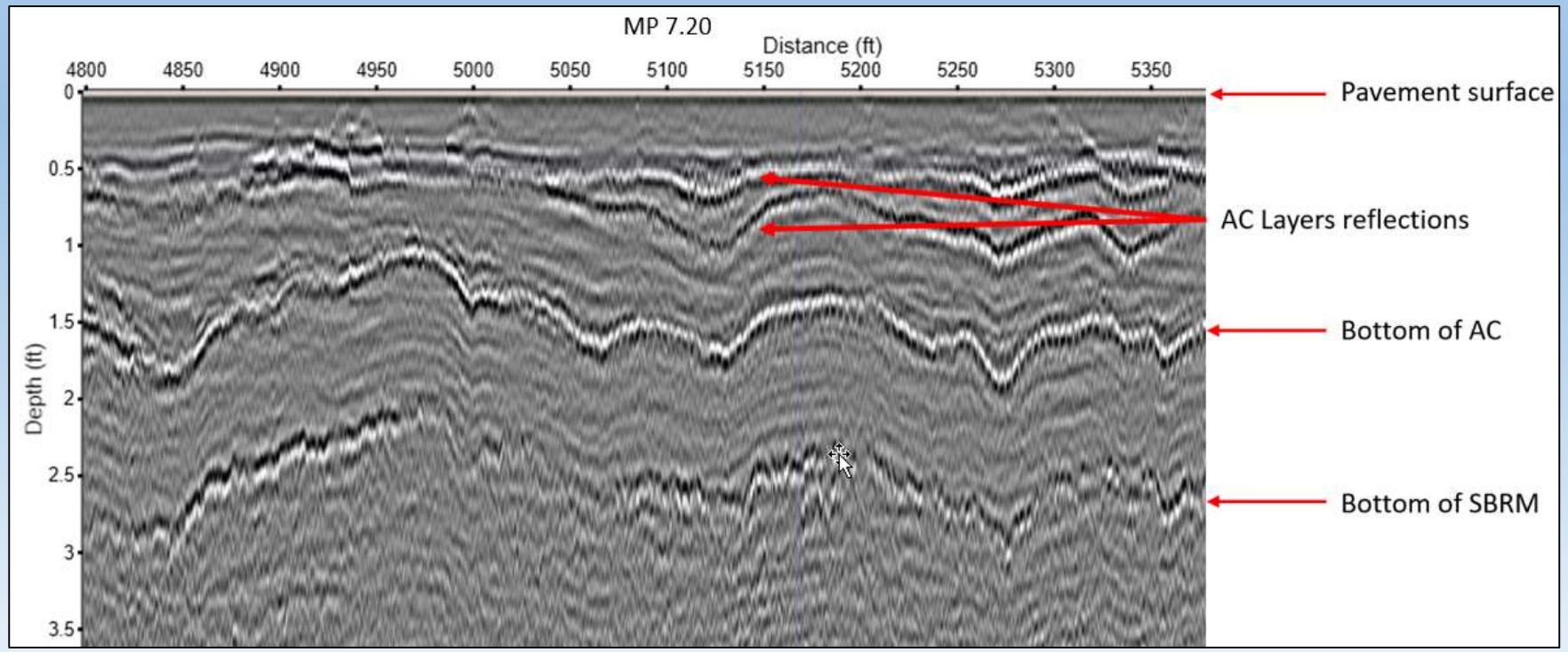
Dowel Bars – Position, Dimensions, Alignment





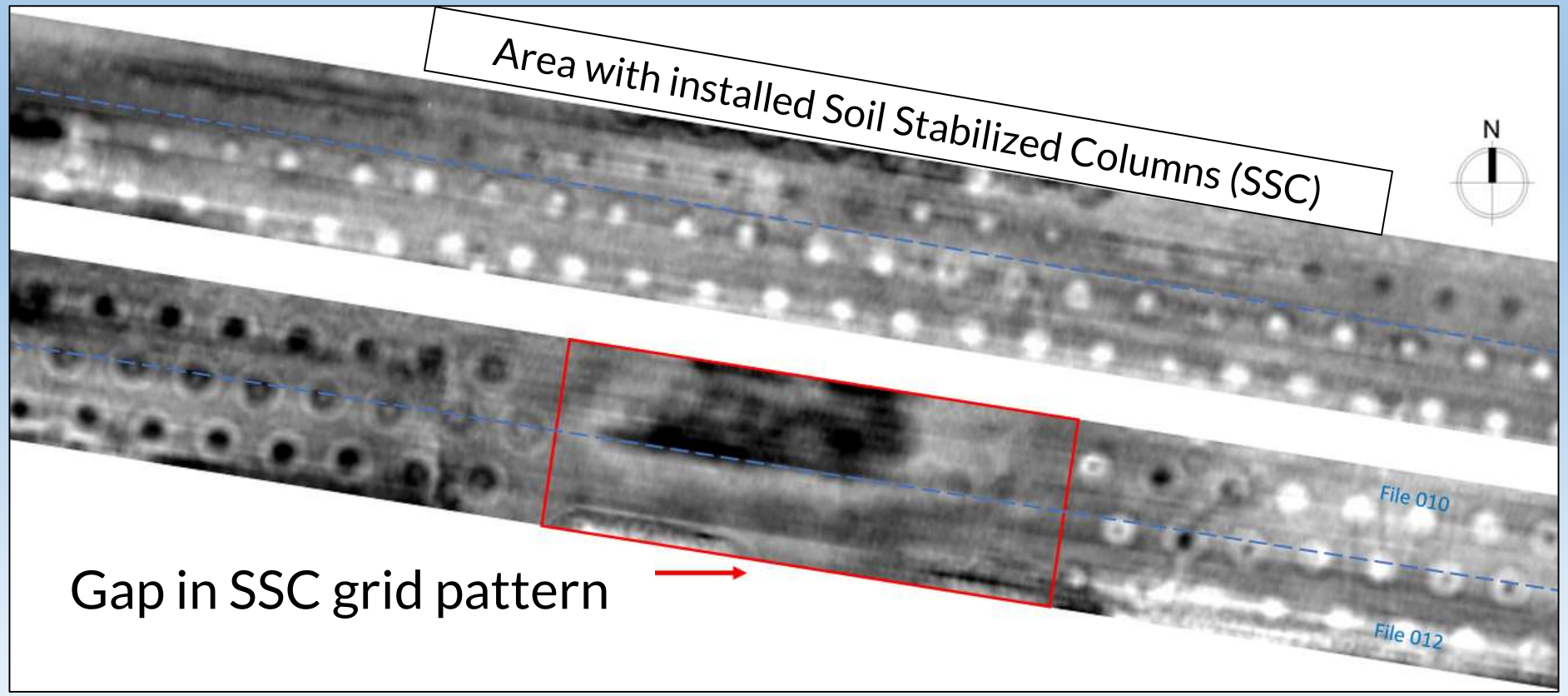


FL SR-100 - Detection of Subsurface Soil Stabilized Columns (SSC)



3D-Radar cross-section through the area with observed signs of possible settlement development

Case study 5 - Detection of Subsurface Soil Stabilized Columns (SSC)



3D-Radar data slice showing the reflections at the top of the area with installed SSC grid

3D Radar Summary

- Step frequency allows greater depth range for a given antenna array
- Data can be collected at highway speed
- Antenna array useful for detecting subsurface conditions with 2-D spatial characteristics.
- Demonstrated ability to detect:
  - Stripping in Asphalt Pavement
  - Dowels in Concrete Pavement
  - Deterioration in Bridge Decks