SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Advanced Methods to Identify Asphalt Pavement Delamination (R06D)

Spectral Analysis of Surface Waves (SASW) and Impact Echo (IE)

AASHTO & FHWA Welcome

Kate Kurgan, AASHTO
Monica Jurado, FHWA

Webinar
June 26, 2018

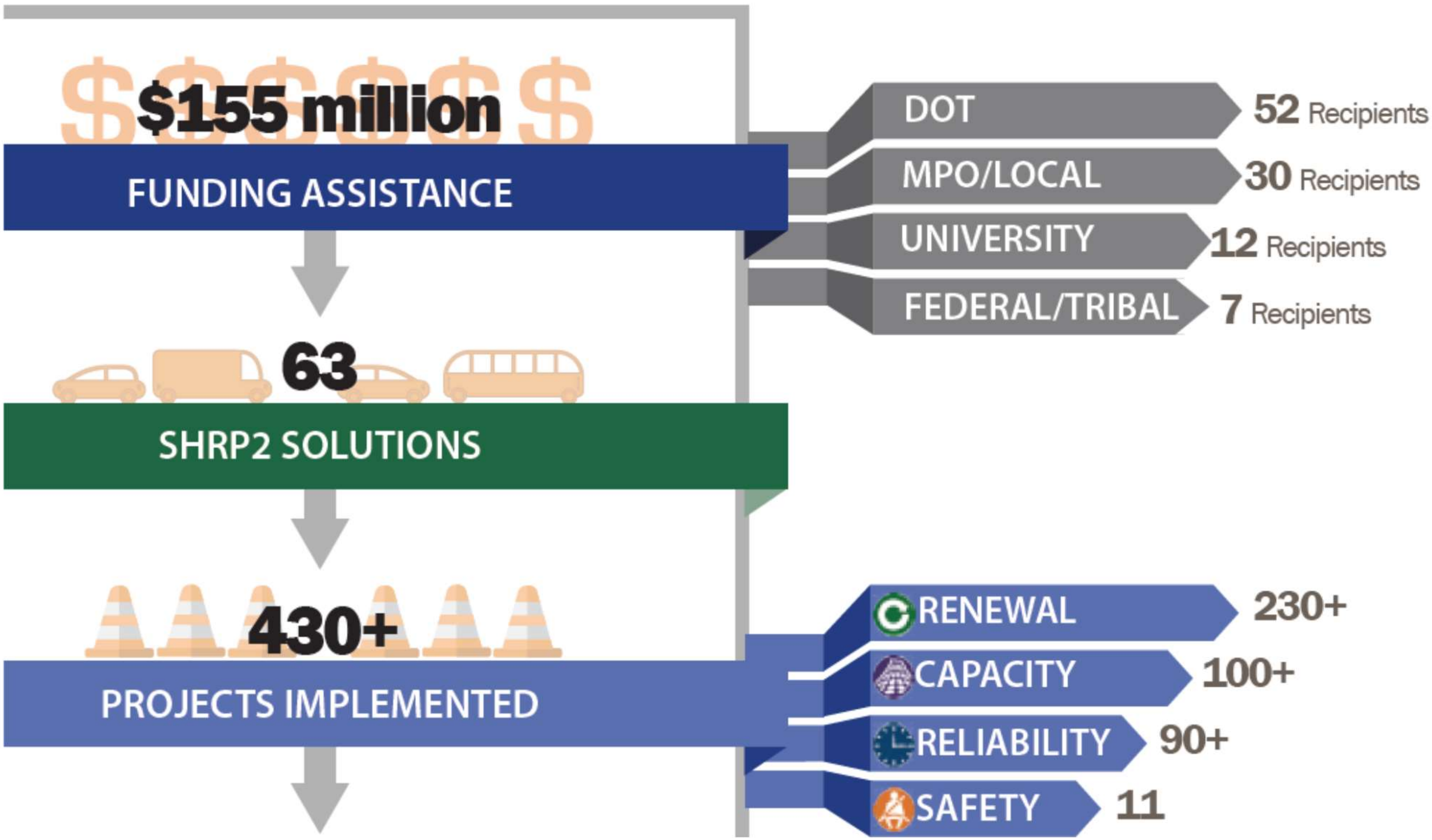
U.S. Department of Transportation
Federal Highway Administration

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AASHTO

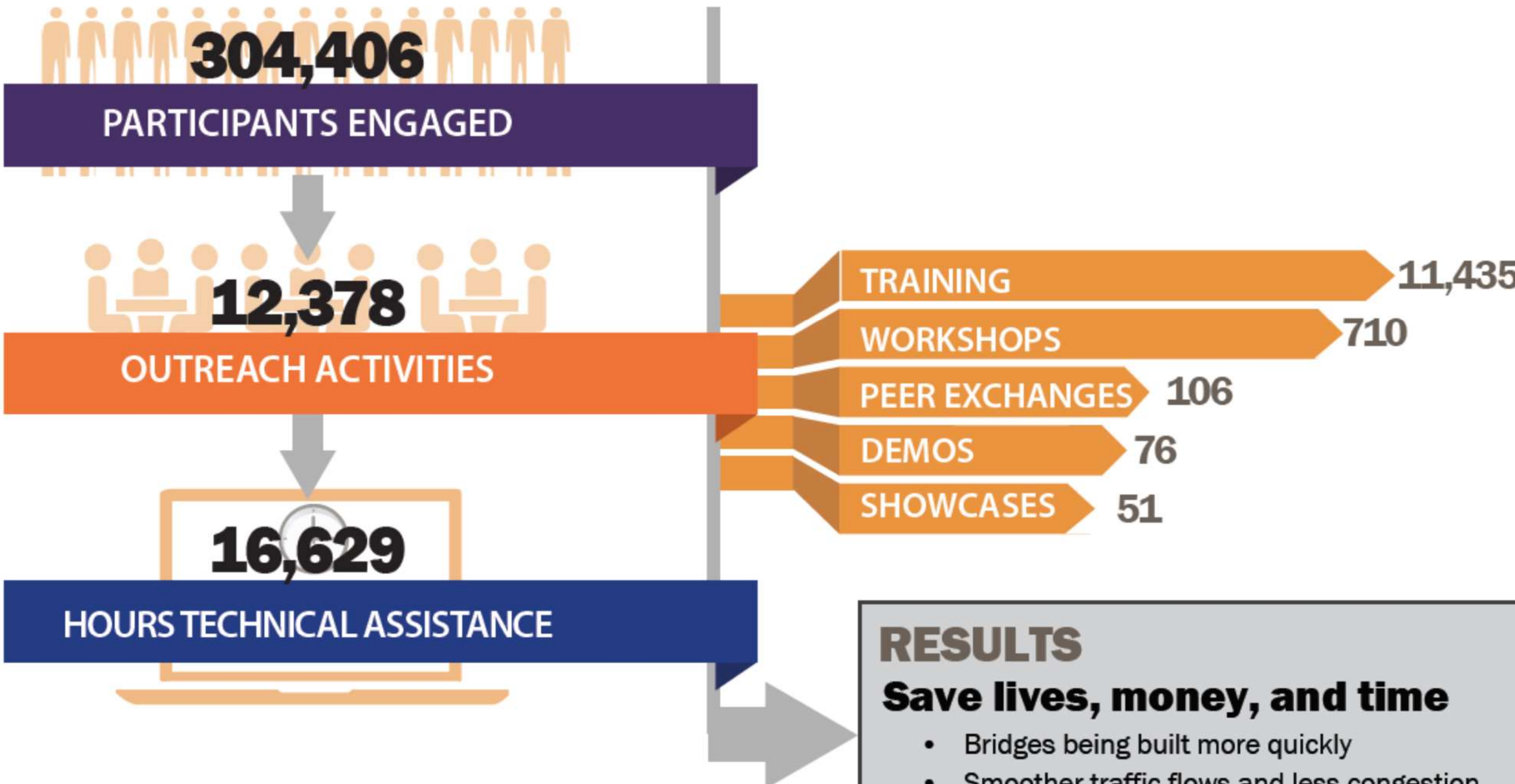
Webinar Agenda

- AASHTO & FHWA Introduction
- R06D Overview
- SASW/IE Technology Features
- Agency Evaluation – New Mexico
- Agency Evaluation – Texas
- Agency Evaluation – Kentucky
- Analysis Automation
- Questions and Answers

SHRP2 Implementation: INNOVATE – IMPLEMENT - IMPROVE



SHRP2 Implementation:
INNOVATE – IMPLEMENT - IMPROVE



RESULTS

Save lives, money, and time

- Bridges being built more quickly
- Smoother traffic flows and less congestion
- Reduced construction costs
- Safer roadways
- Smarter environmental reviews

SHRP2 Focus Areas

Safety: fostering safer driving through analysis of driver, roadway, and vehicle factors in crashes, near crashes, and ordinary driving

Reliability: reducing congestion and creating more predictable travel times through better operations

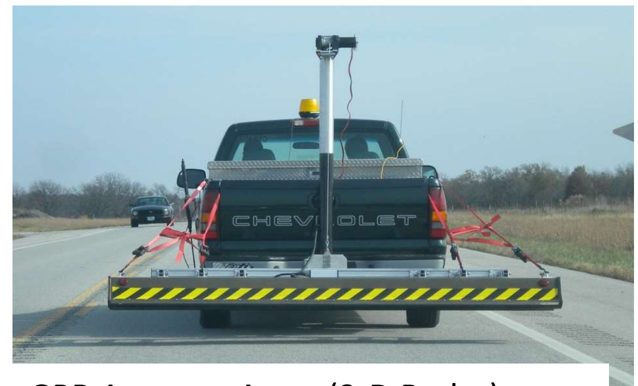
Capacity: planning and designing a highway system that offers minimum disruption and meets the environmental and economic needs of the community

Renewal: rapid maintenance and repair of the deteriorating infrastructure using already-available resources, innovations, and technologies

Advanced Methods to Identifying Pavement Delamination (R06D)

CHALLENGE:

Asphalt pavements with delamination problems experience considerable early damage. Rapid detection of the existence and extent of delamination is key for determining appropriate rehab strategies and extending pavement life.

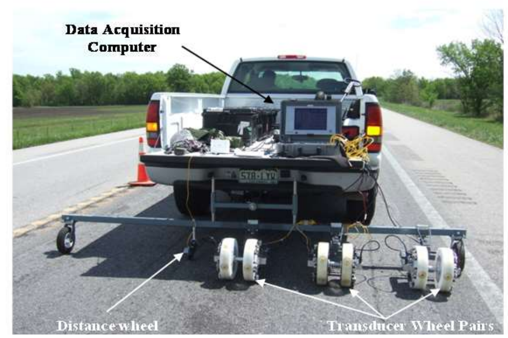


GPR Antenna Array (3-D Radar)

RESEARCH:

Identify and develop NDT technology that can:

- Detect & quantify delamination in HMA
- Operate at reasonable traveling speed
- Cover full-lane width



Impact Echo (IE) /
Spectral Analysis of Surface Waves (SASW)
Scanning System

ROUND 7 Proof-of-Concept Agencies:

- FL, TX, NM, MN, CA & KY
- Focused on field validation and assist in advancement of one or both technologies.

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STRATEGIC HIGHWAY RESEARCH PROGRAM

Advanced Methods to Identify Asphalt Pavement Delamination (R06D) SASW and IE

Overview of R06D Project

Michael Heitzman, PE, PhD
Asst. Director
NCAT

Webinar
June 26, 2018

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
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Asphalt Delamination

SHRP2 R06D Project Goal

Identify and develop NDT technology that can:

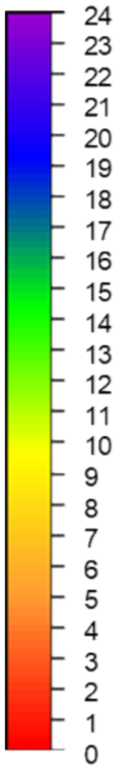
- Detect delamination in HMA
- Operate at reasonable traveling speed
- Cover full lane width

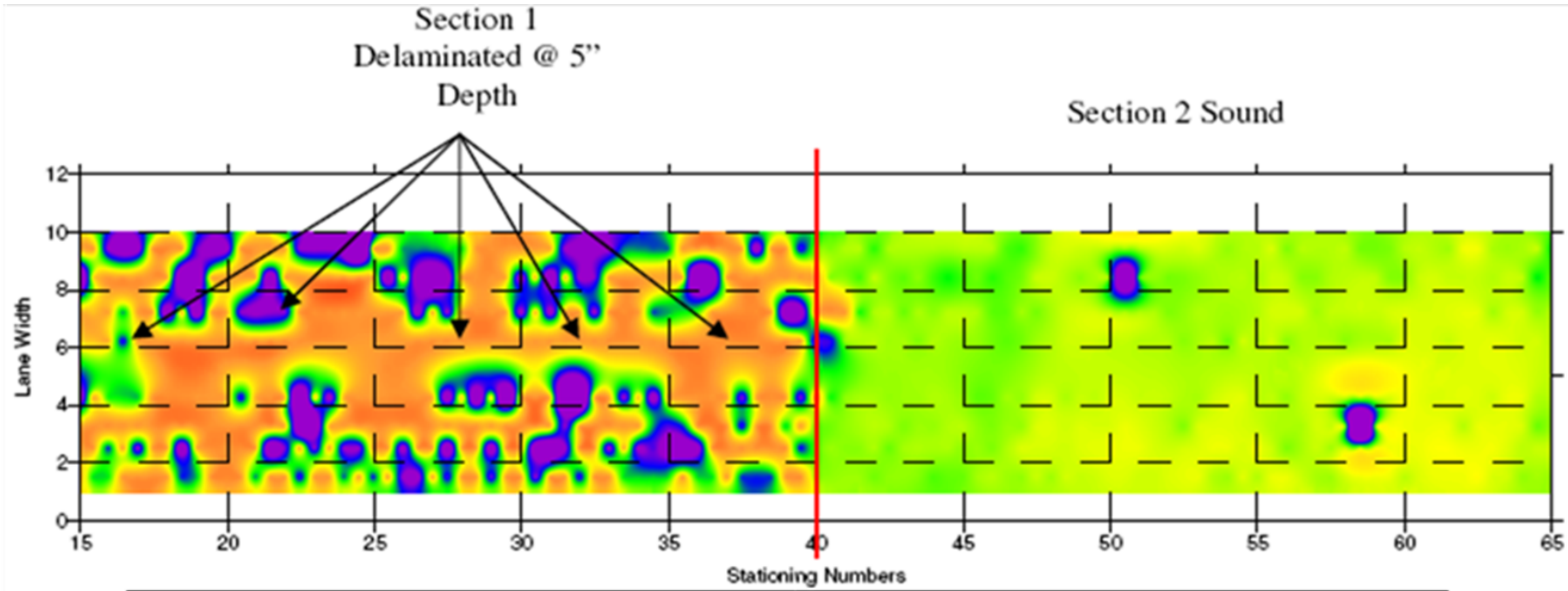
SHRP2 Project Overview

- Identify candidate NDT technologies
- Evaluate potential to meet the goals
- Select NDT technologies with high potential to achieve goals
- Promote development of hardware and software
- Validate equipment improvements
- Examine performance in field conditions
- Demonstrate NDT to interested agencies

NCAT Test Track R06D Sections

IE Data Display
(NCAT test track section)

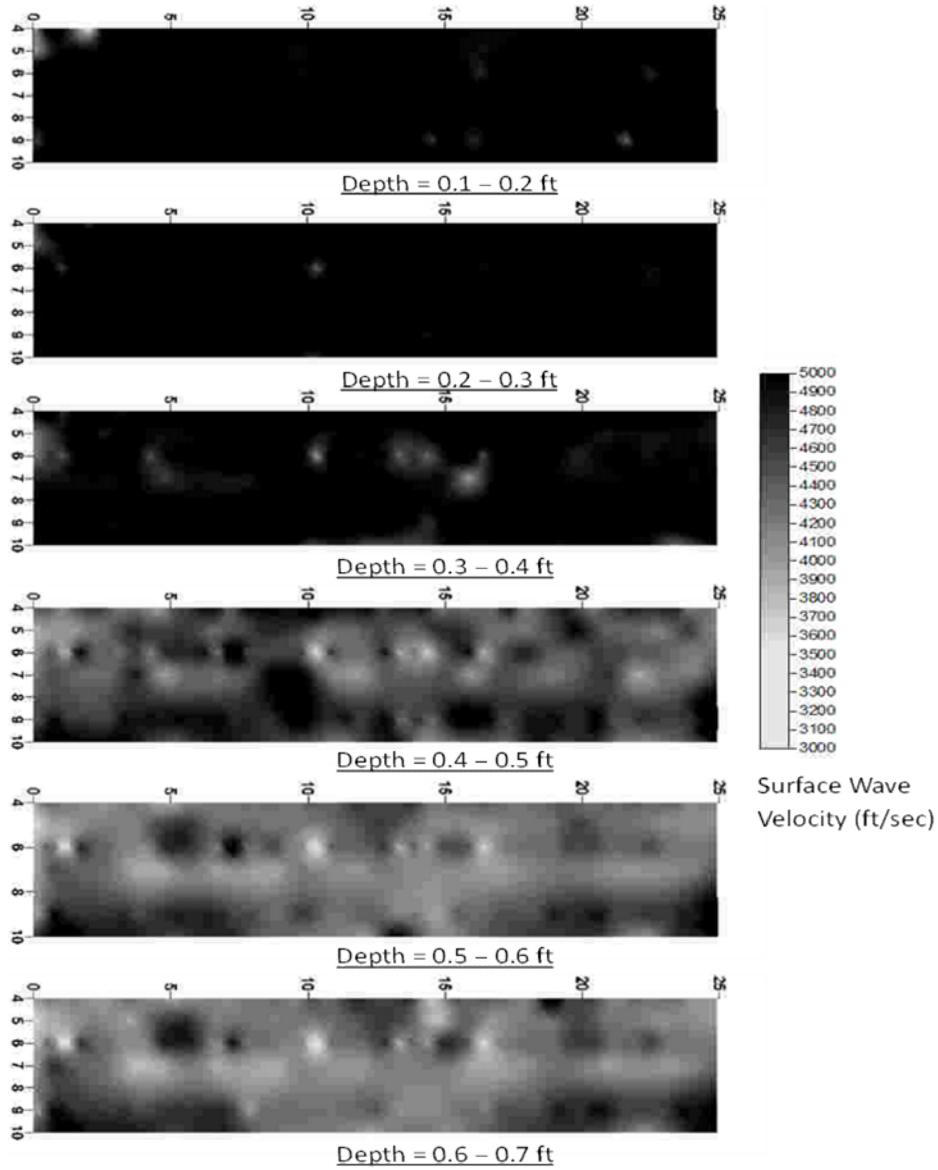




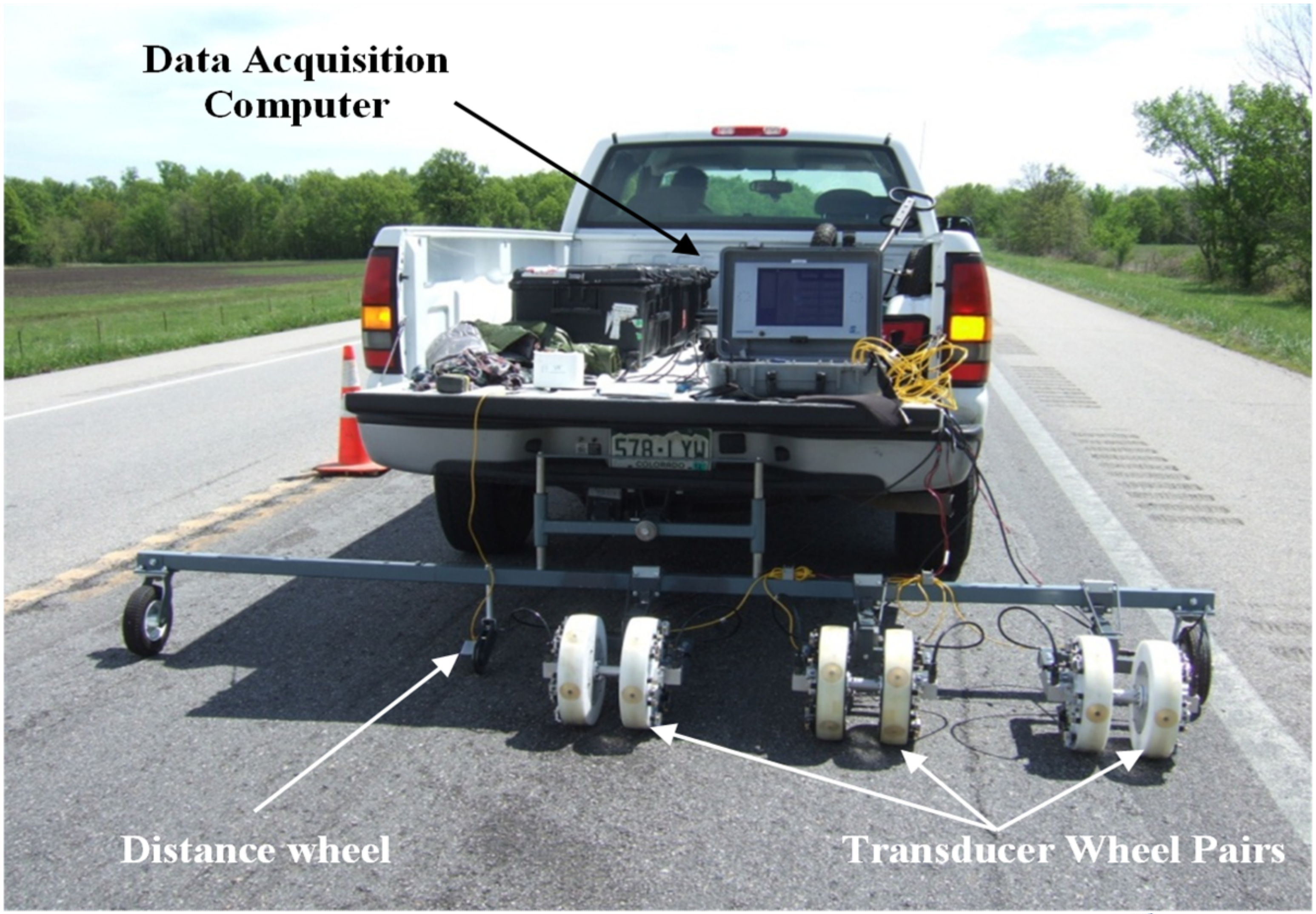
Section 1	Section 2
No bond	Full bond
5-inch depth	control

Thickness Color Scale (in)

SASW Data Display
(NCAT test track section)



SASW-IE Rolling Meter by Olson Engineering



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Advanced Methods to Identify Asphalt Pavement Delamination (R06D)

Surface Waves and Impact Echo Scanning

Larry Olson, PE
Chief Engineer
Olson Engineering/Olson Instruments

Webinar
June 26, 2018

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Sonic Surface Scanner (S^3)

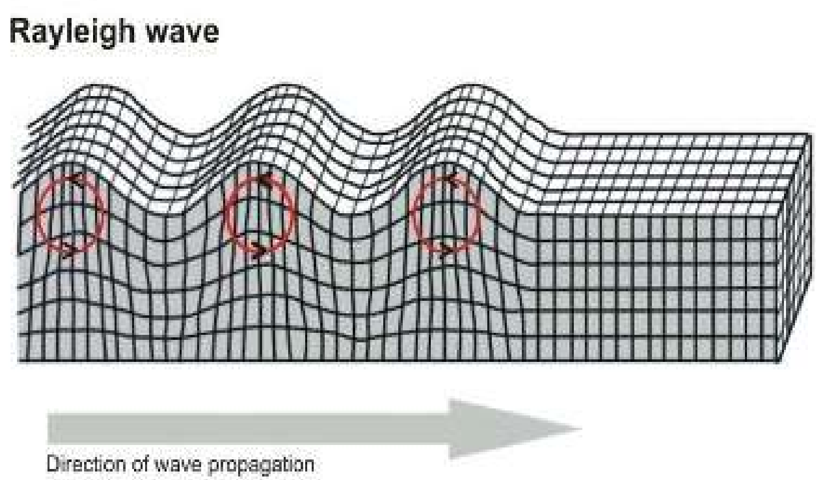
- Slow-rolling (1 mph) scanner for delamination mapping of asphalt pavements and bridge decks
- 6 Displacement transducers on two wheels lined up 6 to 9 inches apart
- Impacts surface every 6 inches for
    - Impact Echo (IE) test
    - Spectral Analyses of Surface Waves (SASW) test

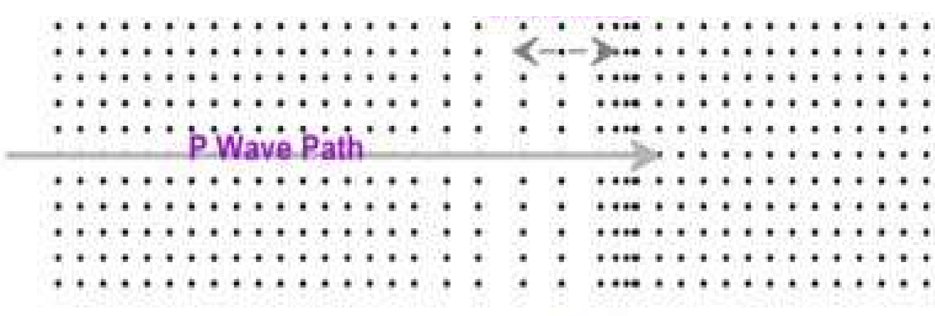
Types of stress waves

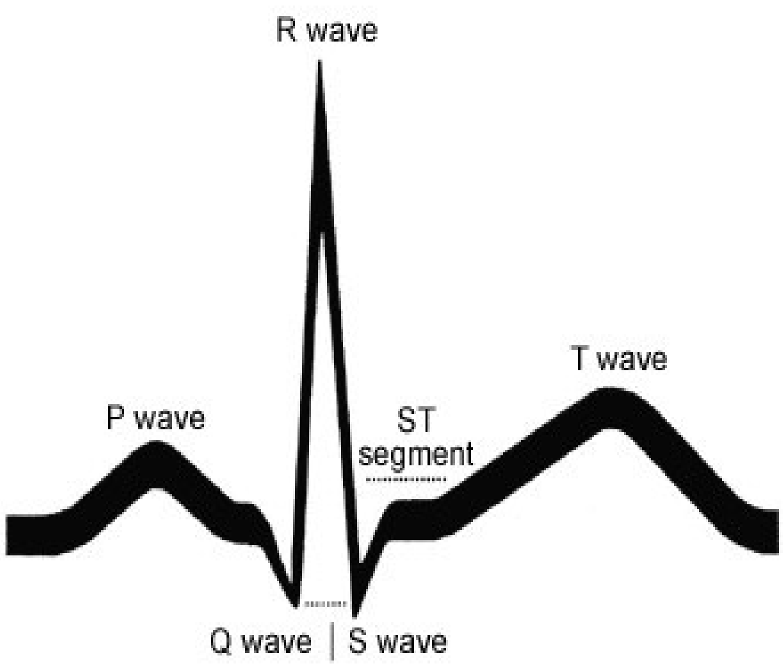
Principles of elastic wave theory

R-waves, surface waves – used by SASW to measure material stiffness

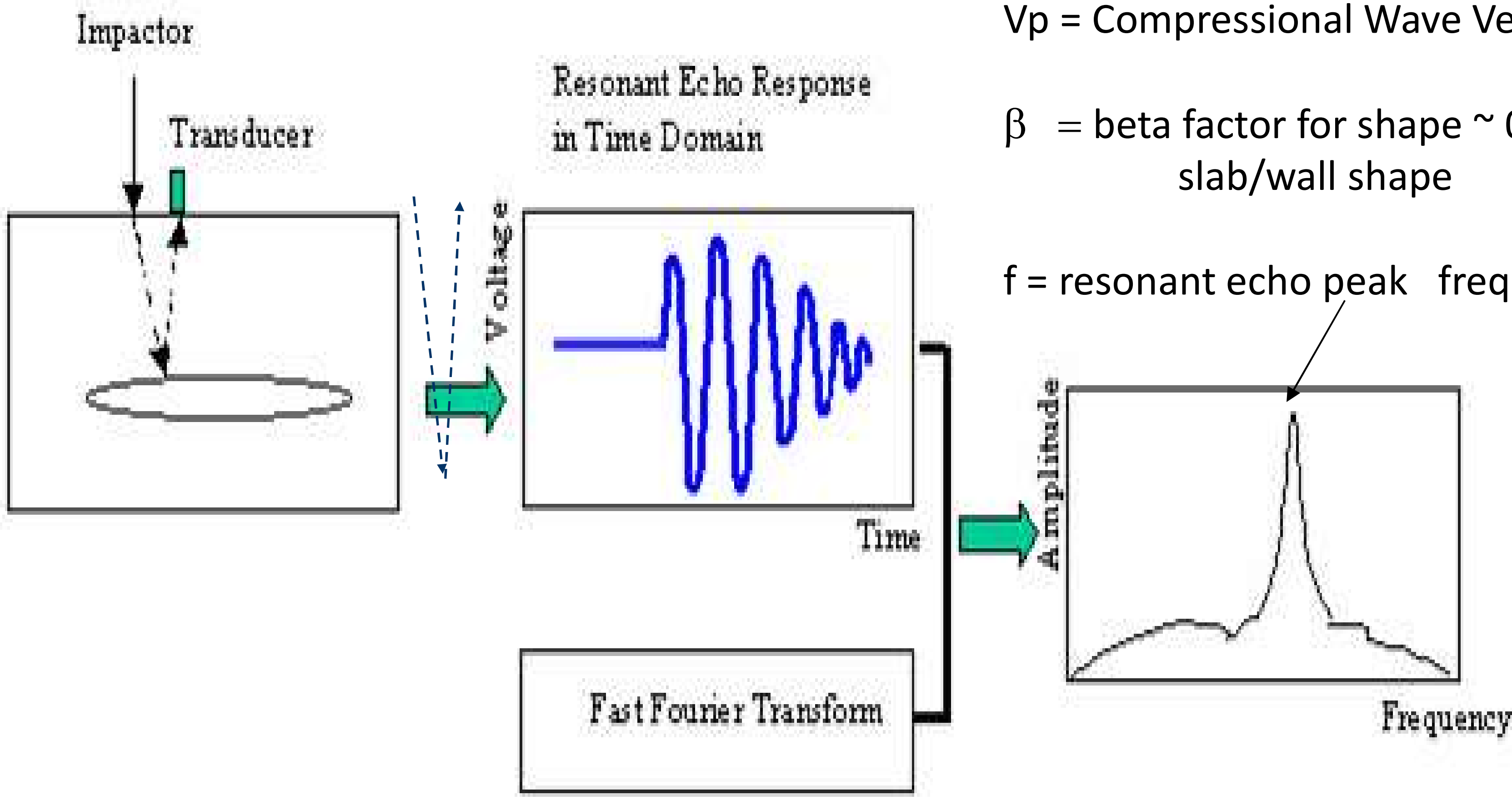
P-waves, body waves – used by Impact Echo (IE) to measure layer thickness







Impact Echo Test



D = βVp/(2*f) = Thickness echo depth

Vp = Compressional Wave Velocity

β = beta factor for shape ~ 0.96 for slab/wall shape

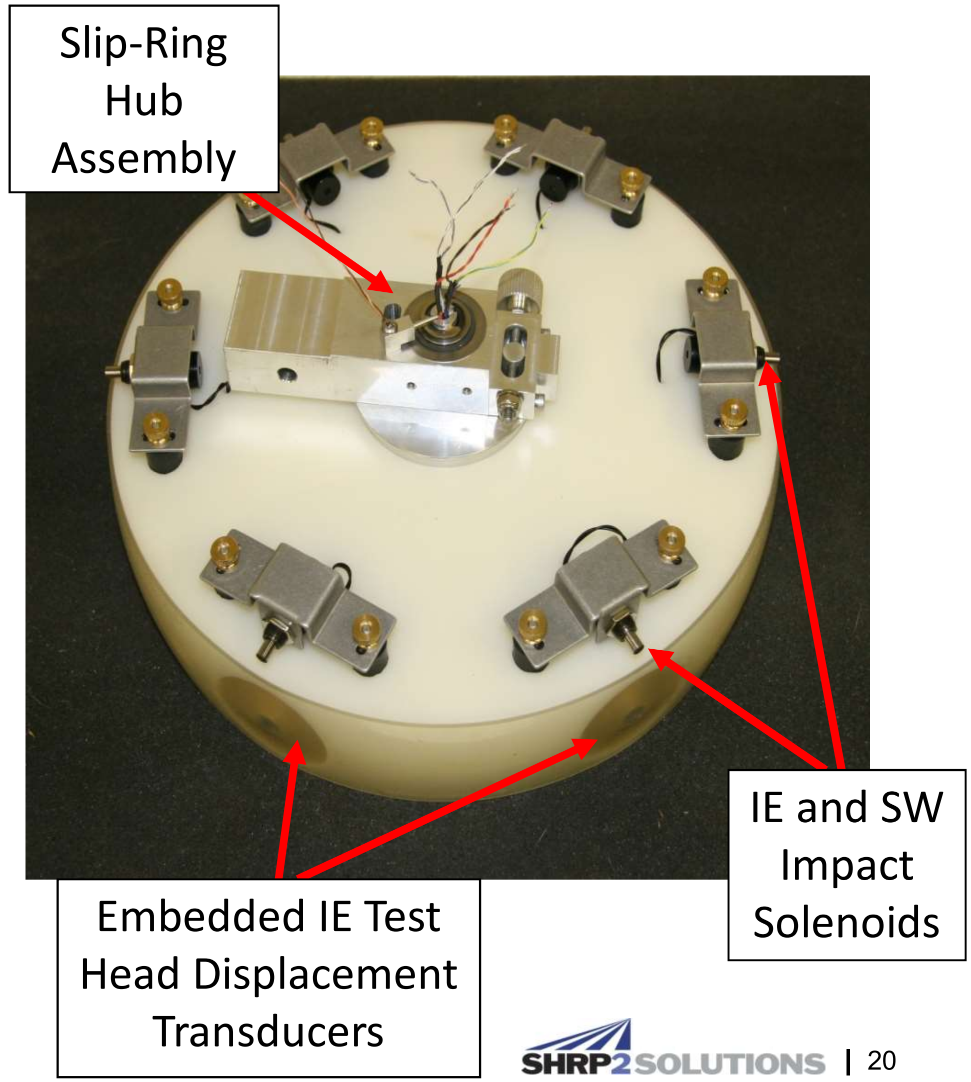
f = resonant echo peak frequency (Hz)

Sonic Surface Scanner – S3 Features

- Iowa DOT and Indiana DOT using IE on bare concrete decks for project level delamination mapping
- Dell Ruggedized Notebook with excellent sunlight viewable screen
- Shown with offset displacement transducers for IE tests on both wheels
- Rotate 30 degrees for IE test on left wheel and SASW test between wheels

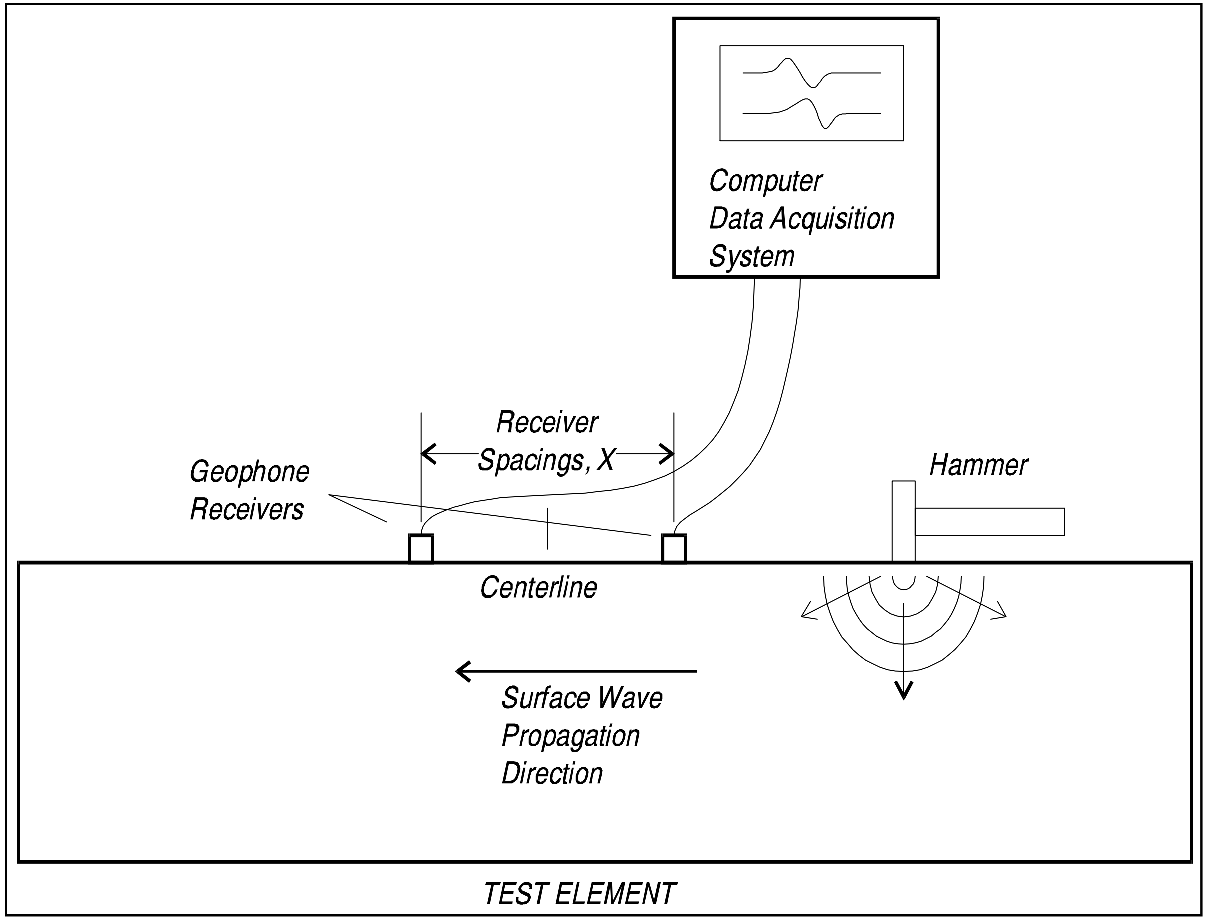
Scanning Impact Echo Testing

- Diameter of Wheel = 293 mm (11.5 inches)
- Six individual displacement transducers
- Six individual impactors
- Impacts spaced 150 mm (6 inches) apart along a scan line (around the wheel circumference)
- The 6 transducers were spring mounted with rubber isolators and captured with a thin urethane tire approximately 60 mm (2.5 inch) wide
- The thin urethane tire was added as a dust cover and to improve coupling



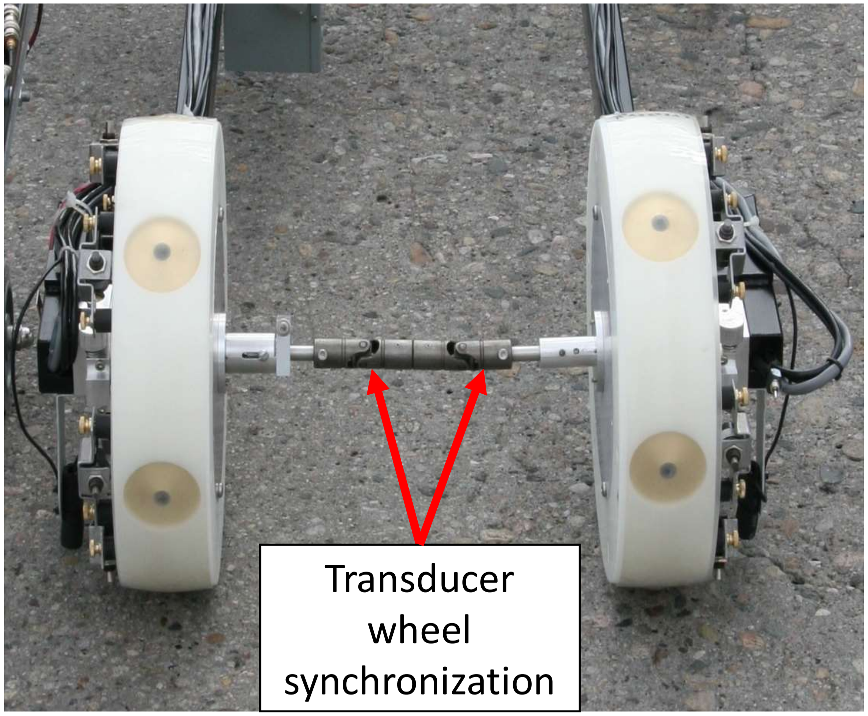
Spectral Analysis of Surface Waves Method (Stokoe and Nazarian)

- Acoustic method – Short wavelength waves sample shallow, longer wavelengths sample deeper
- Allows the measurement of the velocity profile versus depth into the pavement, which provides Young's Moduli (E) versus deptha
- Based on Velocity = Frequency x Wavelength

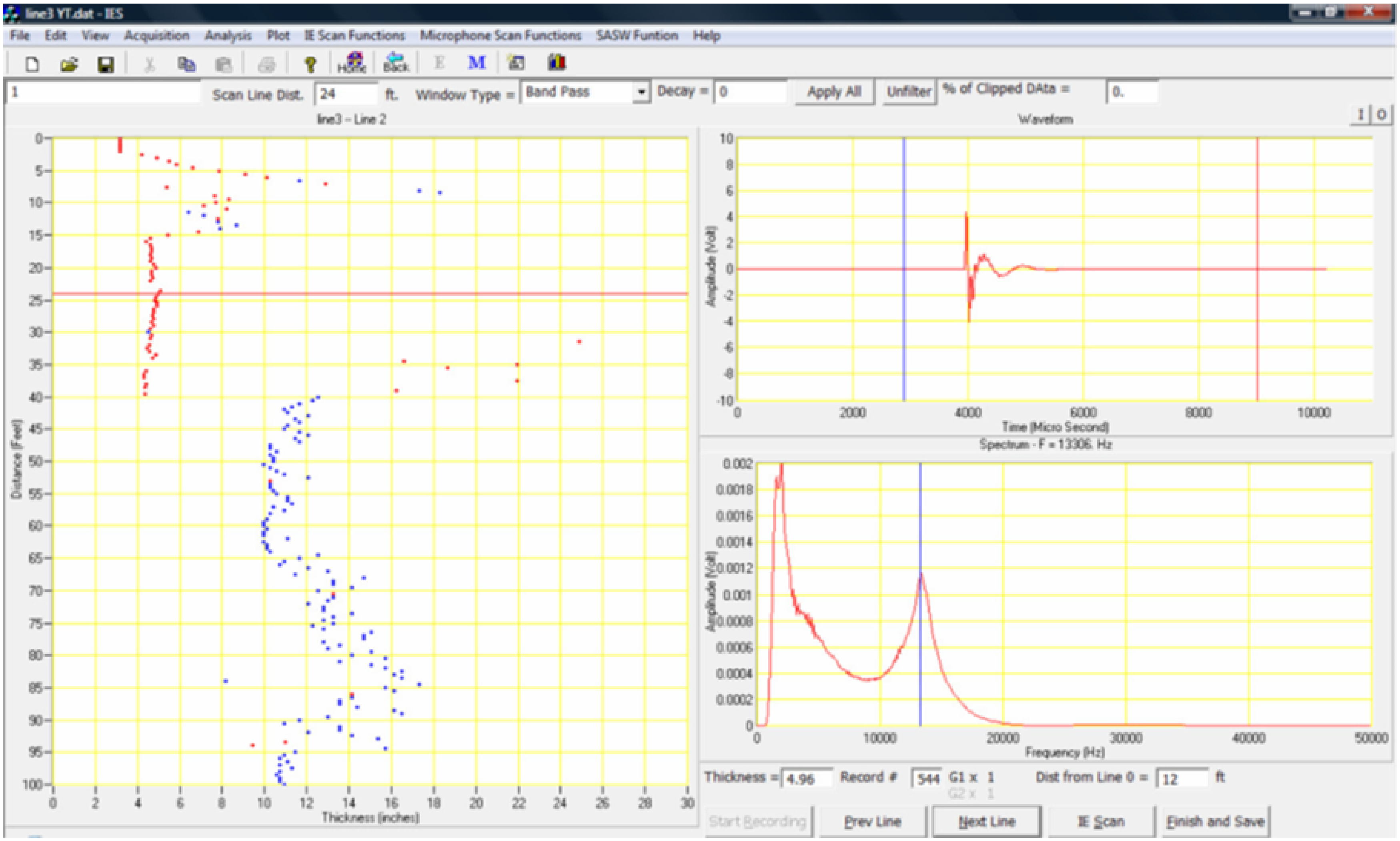


Scanning SASW

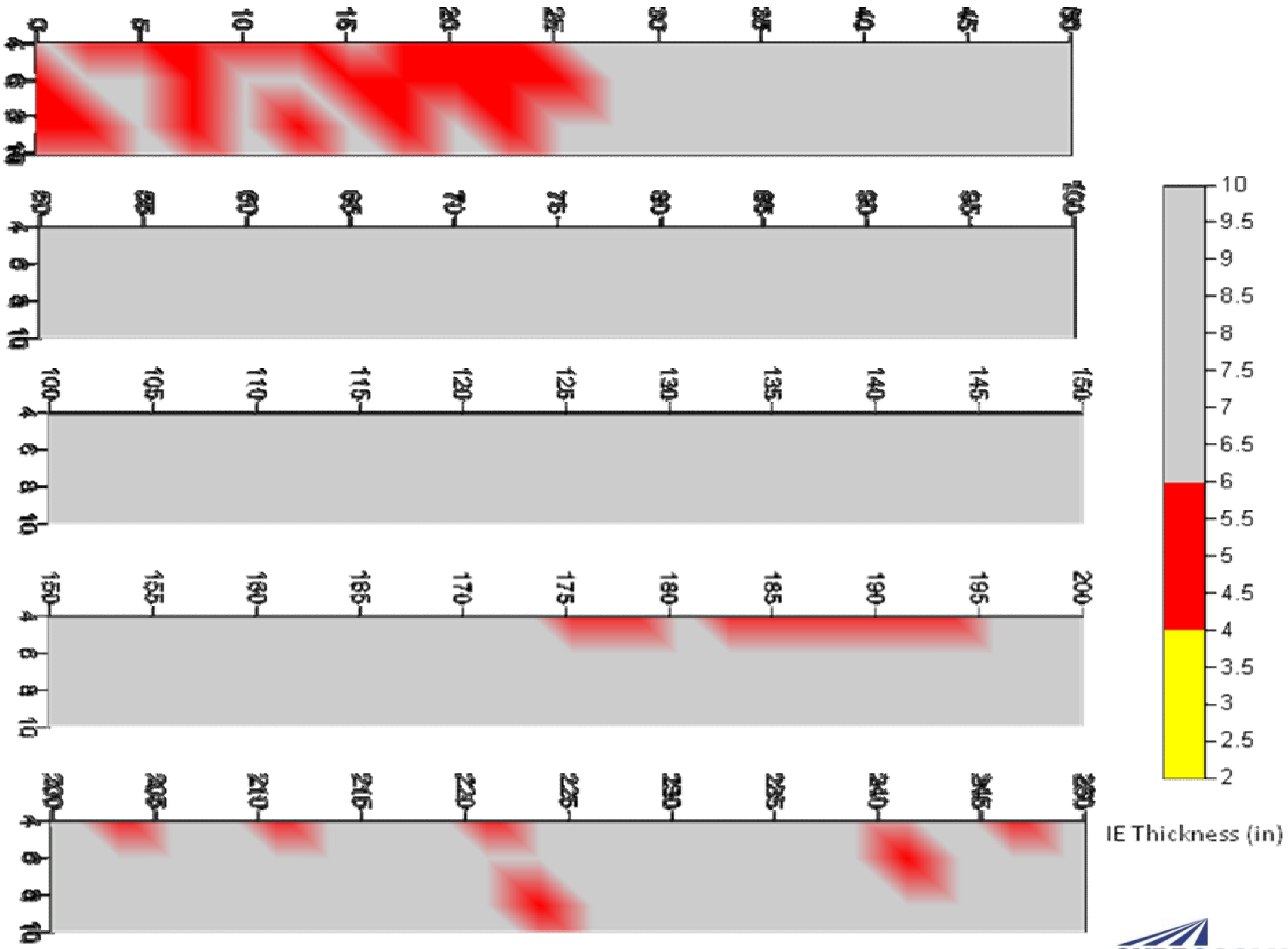
- Use 2 identical sensor/impactor wheels
- Only one wheel with the impactor turned on
- The spacing between the transducers is typically 6 or 9 inches for asphalt pavement SASW+IE and 12 or 24 inches for IE on concrete decks
- Can rotate the wheels 30 degrees out of phase to perform IE testing on both wheels simultaneously



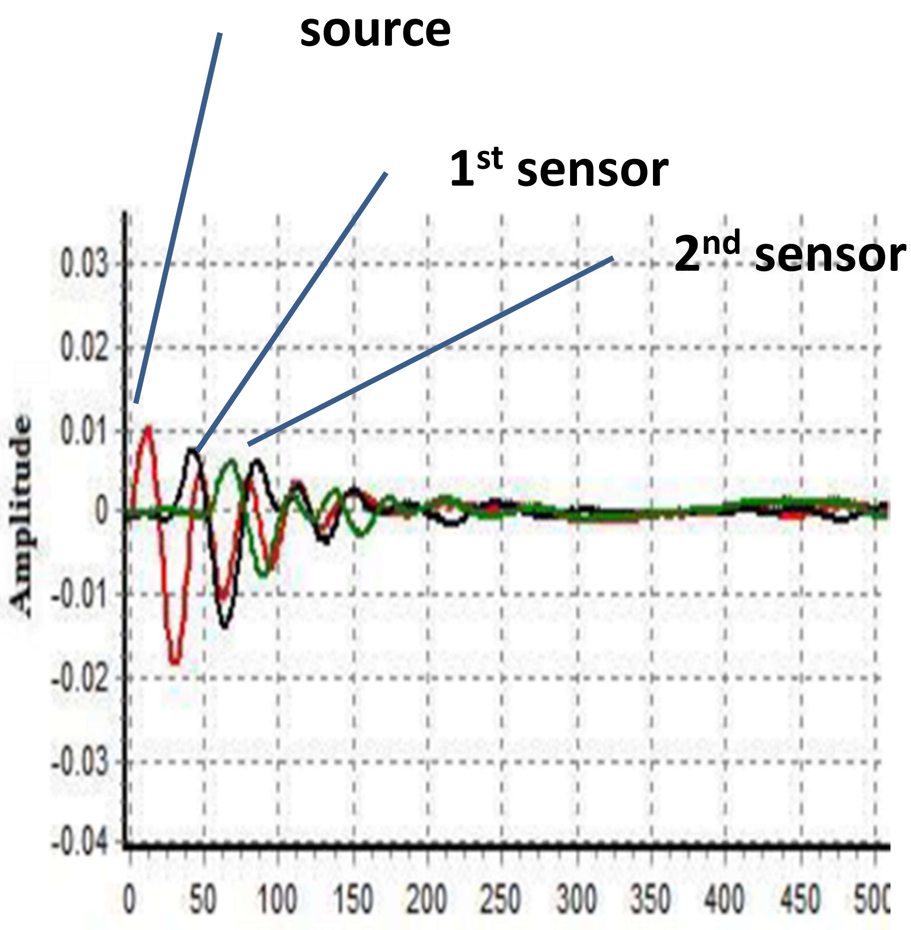
Impact Echo Scanning Results at NCAT

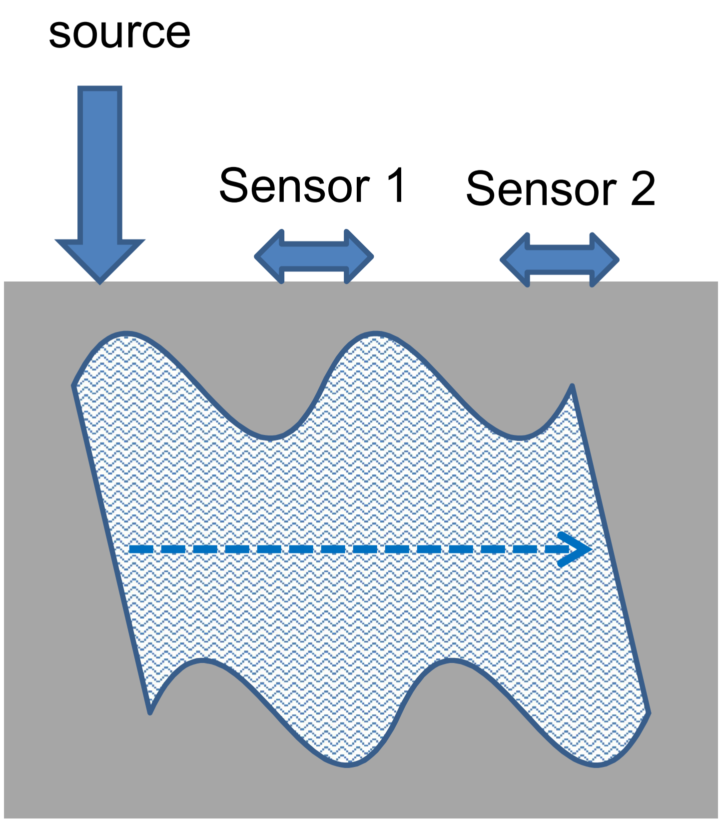


NCAT IE Delamination Echo Depths at 4-6" (RED)

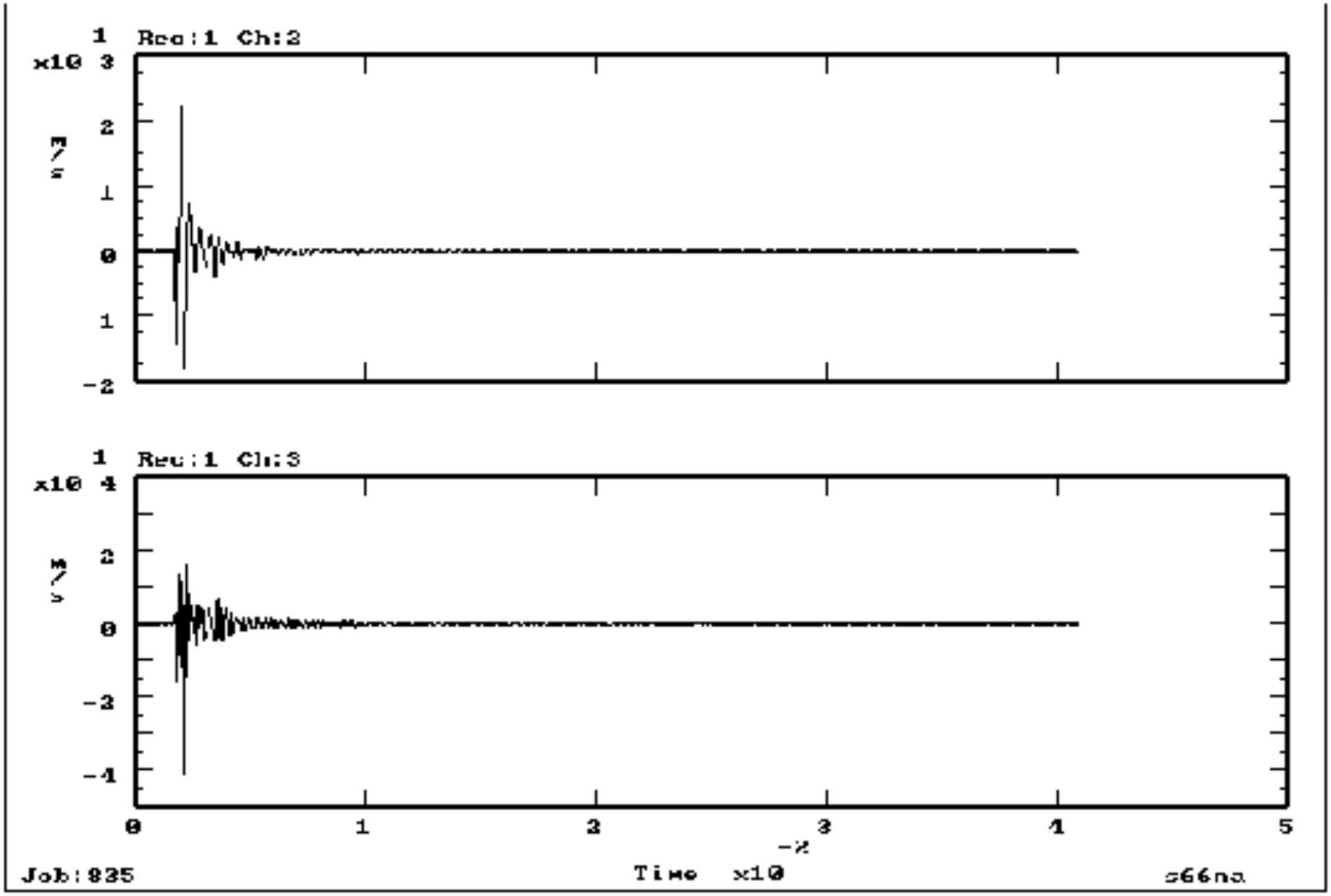


How SASW measures pavement properties

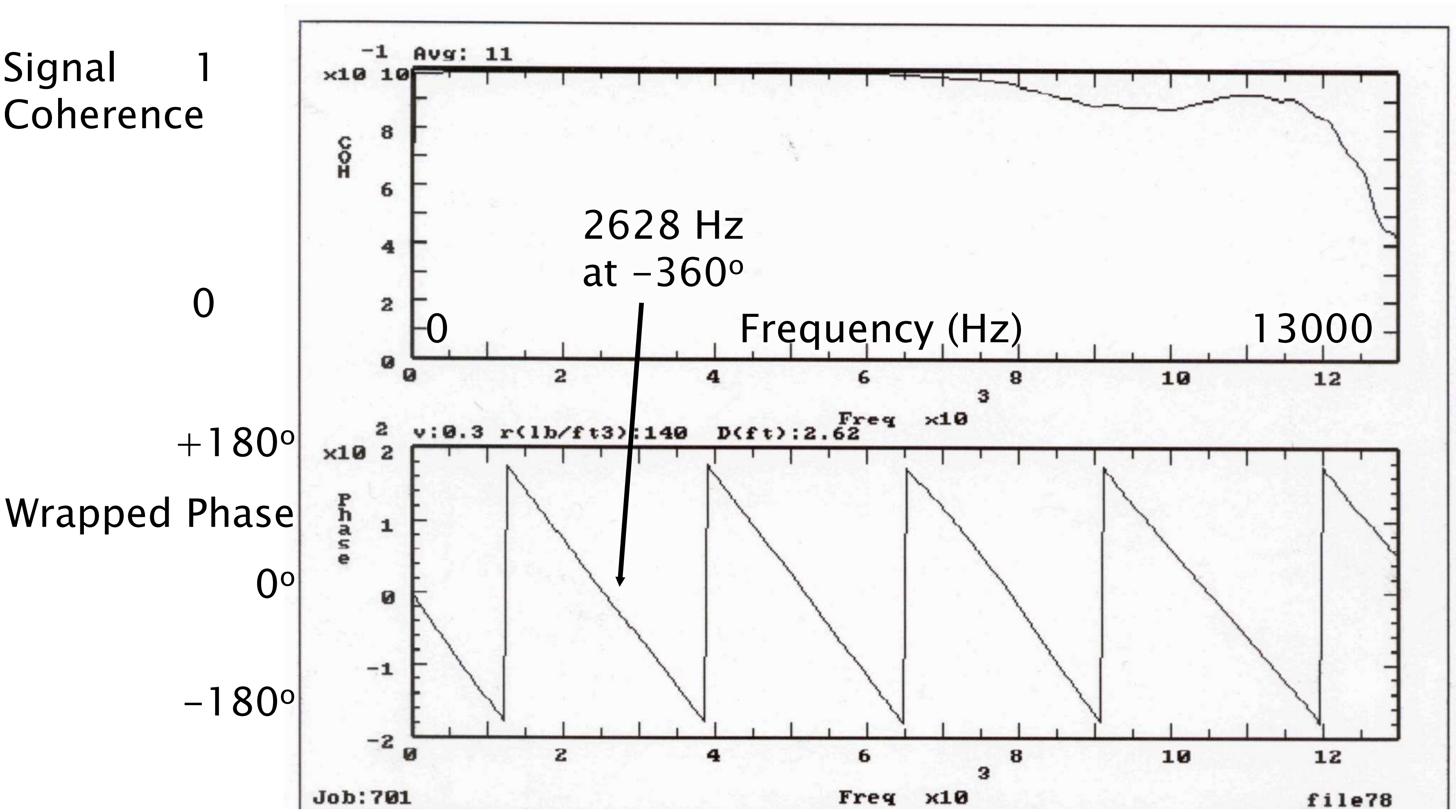




Typical Time Domain Records for Two SASW Receivers



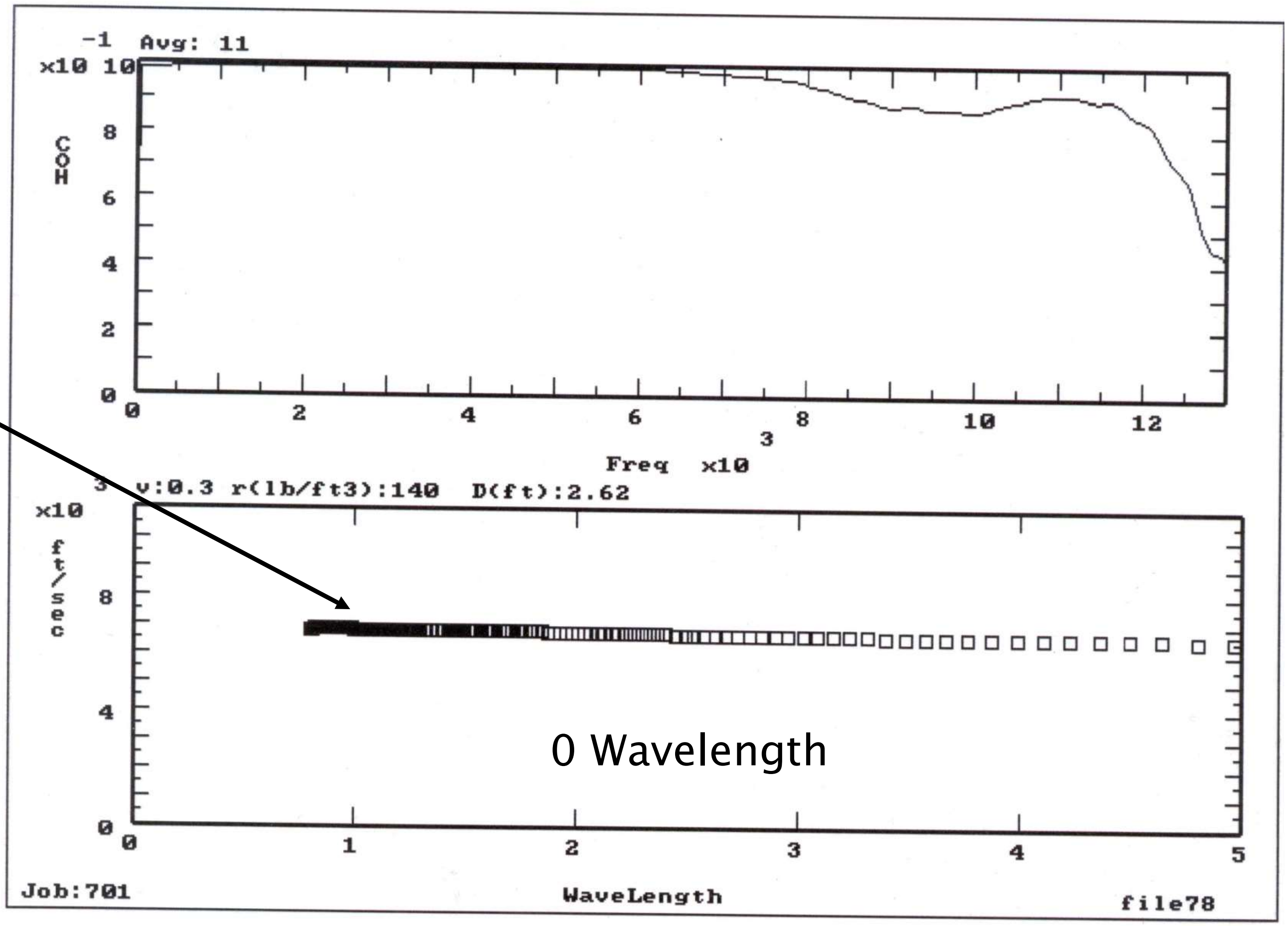
SASW Phase Plot from Sound Area (concrete)



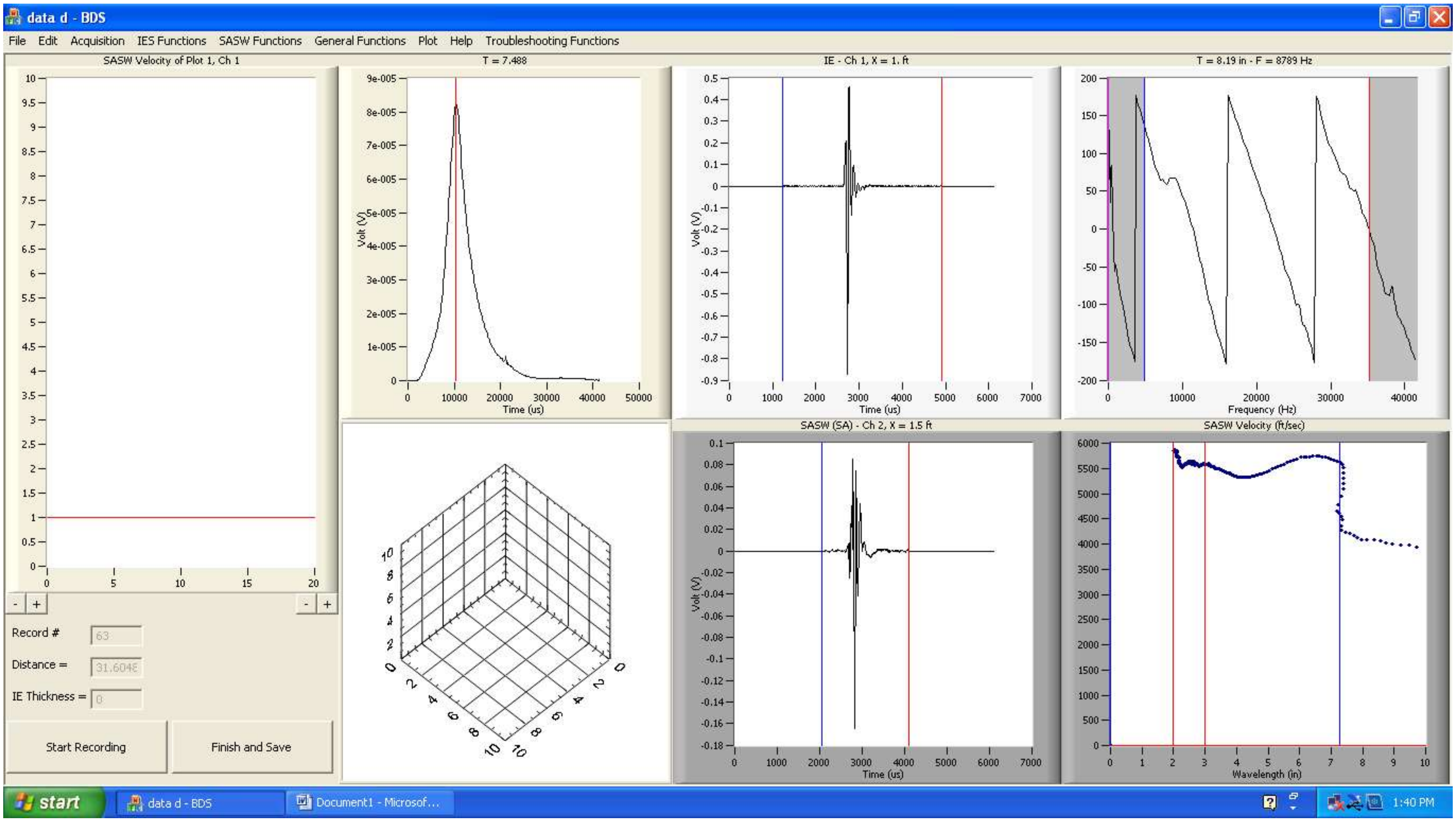
for 2.62ft SASW Bar spacing = 1 wavelength (–360° phase),
Velocity=frequency x wavelength=2.62 x 2628Hz=6900 ft/s

Surface Wave Velocity vs. Wavelength – Sound Concrete

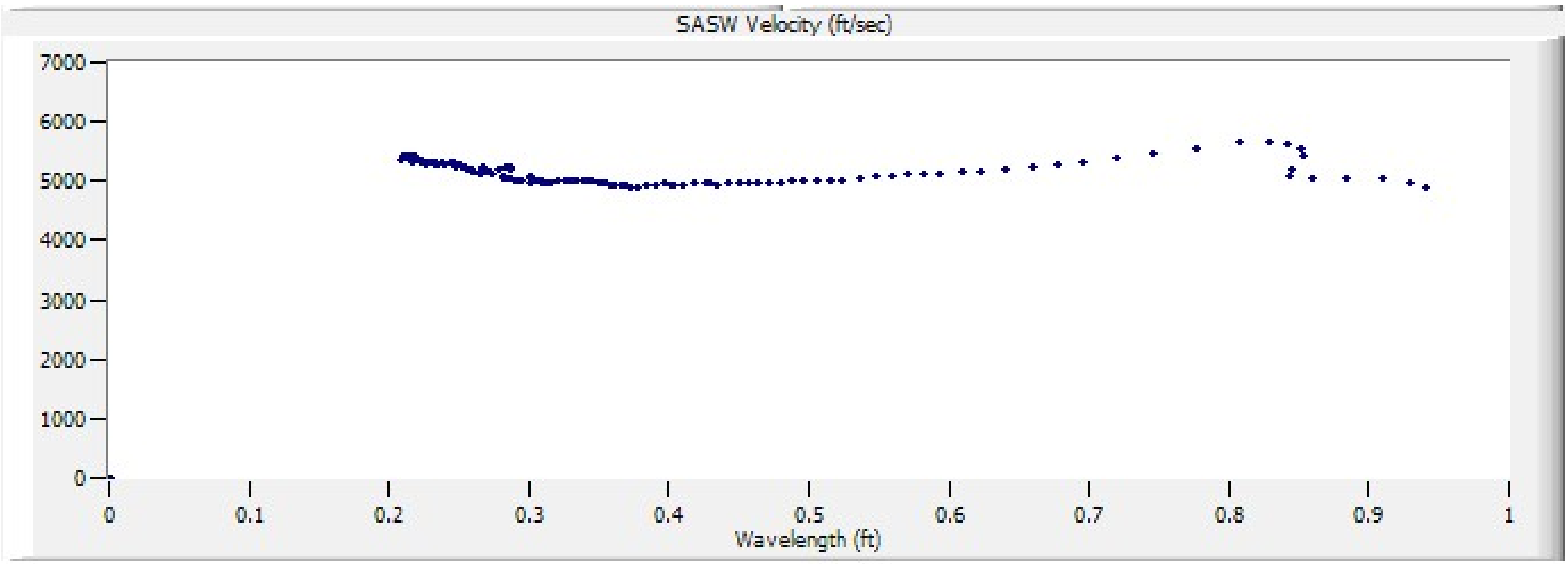
V =6900 ft/sec Surface Wave Velocity for Sound Concrete



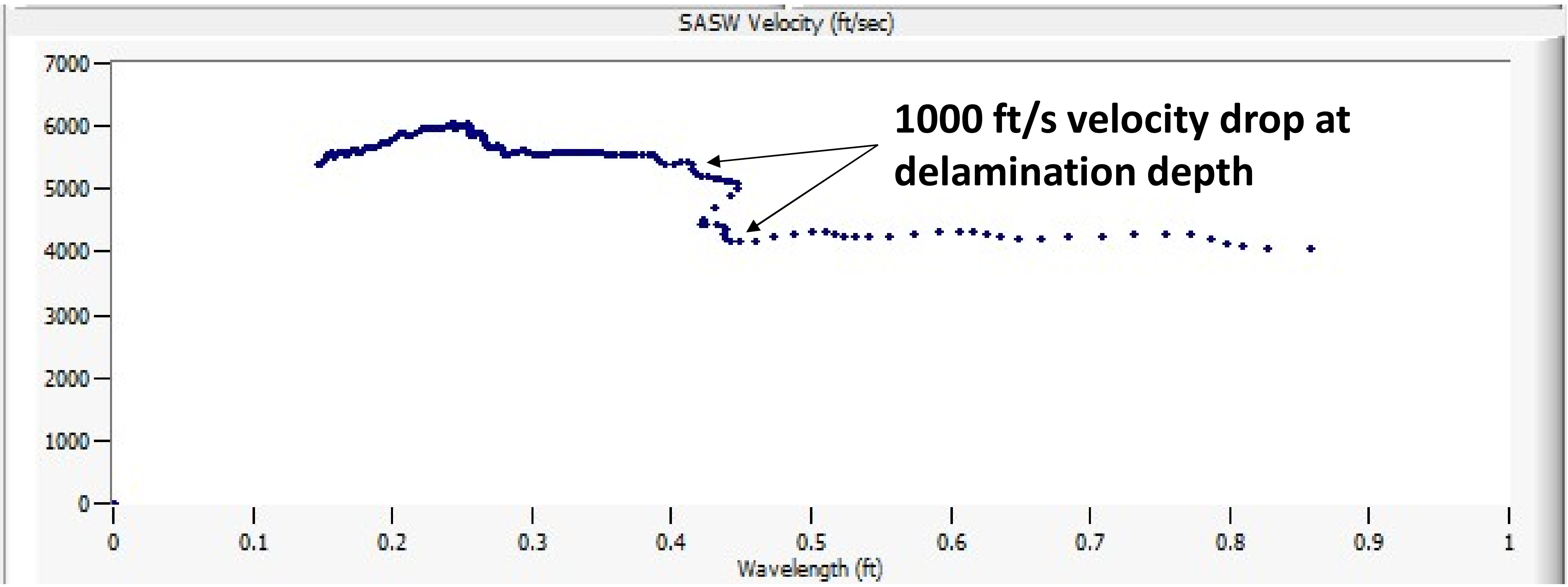
Simultaneous IE/SASW Software Display



SASW Dispersion Curve from Sound Asphalt Pavement - NCAT

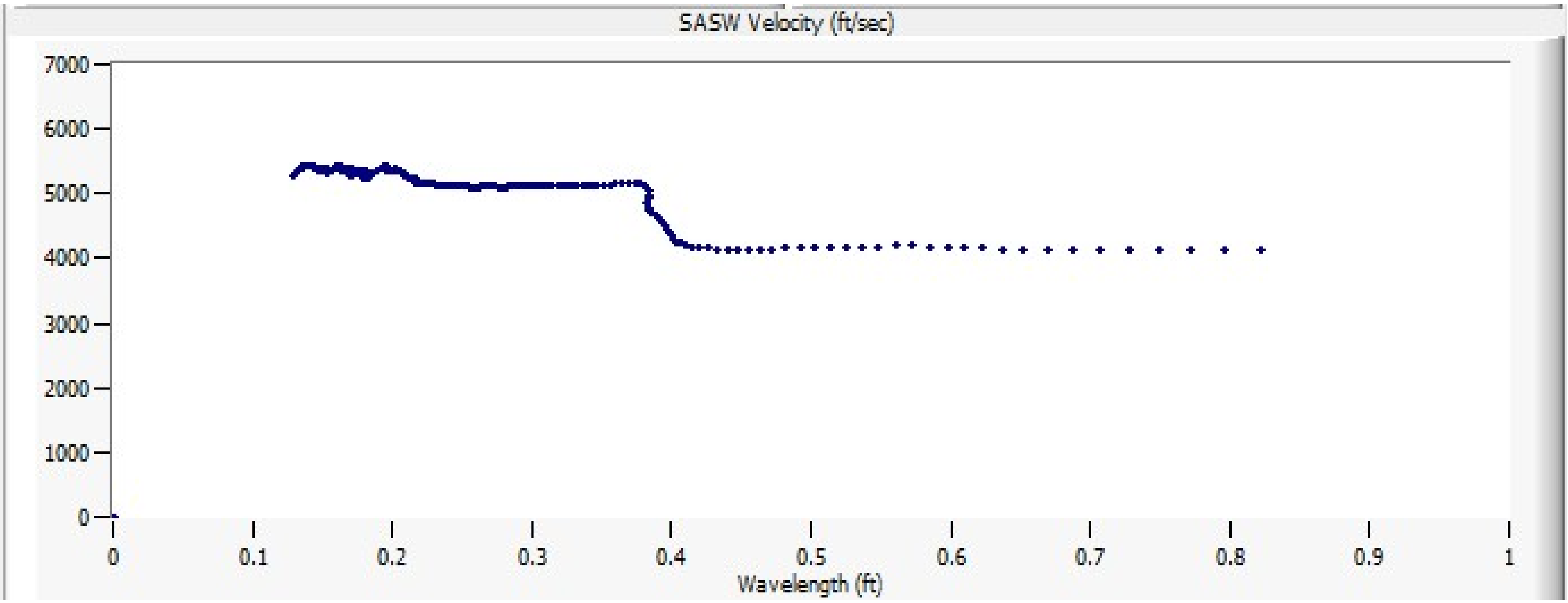


SASW Dispersion Curves from 5 Inch Deep Delamination Condition - NCAT



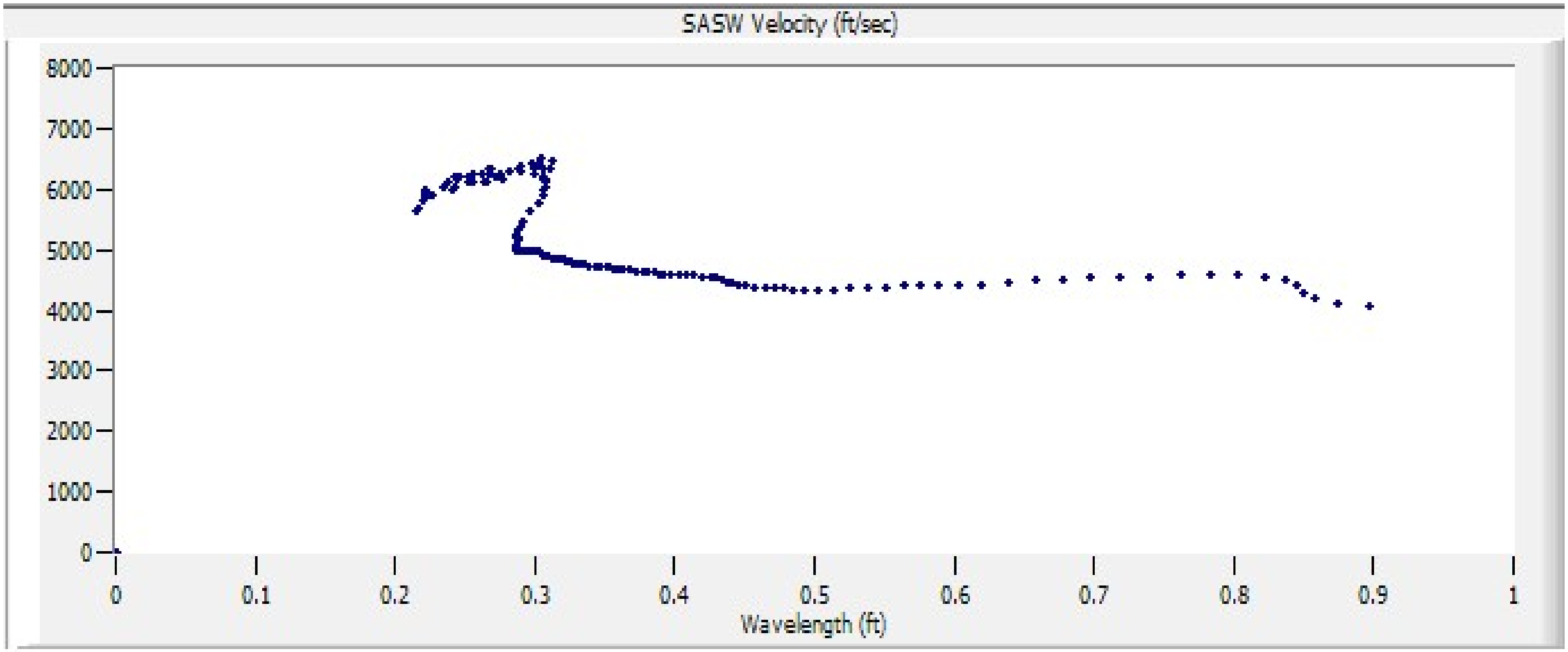
Delamination due to Thin Paper Delamination built at 12.5 cm (5 inches) deep – note surface wave velocity decrease from ~1590 m/s (~5300 ft/s on vertical scale) to ~1290 m/s (~4300 ft/s) at a wavelength of 12.5 cm (0.43 ft - ~ 5 inches)

SASW Dispersion Curve from Baghouse Dust Delamination Conditions



Delamination due to Baghouse Dust built at 12.5 cm (5 inches) deep – note surface wave velocity decrease from ~1560 m/s (5200 ft/s on vertical scale) to ~1290 m/s (4300 ft/s) at a wavelength of 12.5 cm (0.4 ft on horizontal scale ~ 5 inches)

SASW Dispersion Curve 2 Inches Deep Delamination Conditions on Asphalt

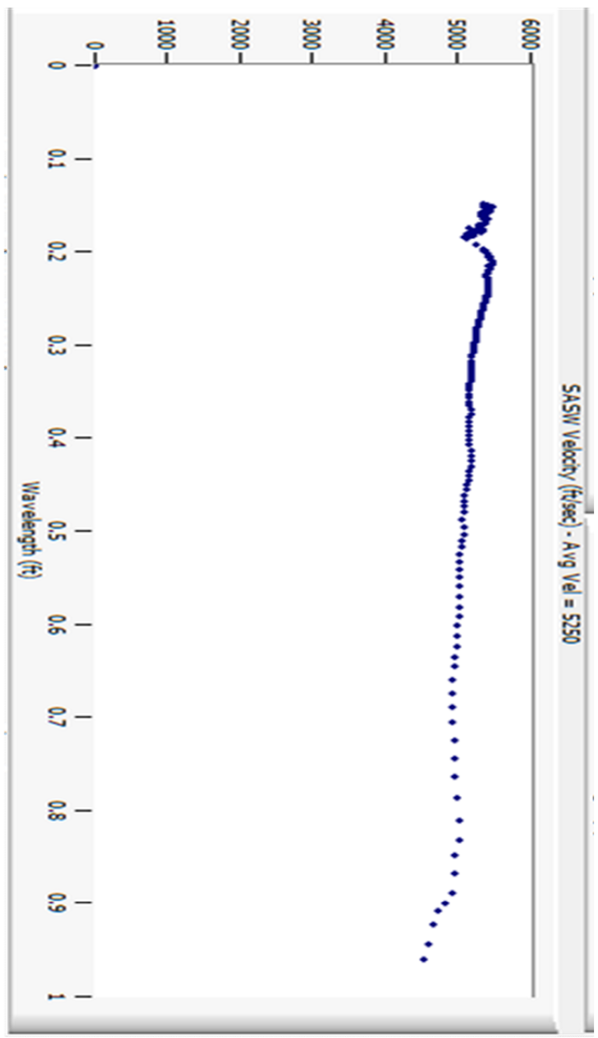


Delamination 5 cm (2 inches) deep – note surface wave velocity decrease from ~1920 m/s (6400 ft/s on vertical scale) to ~1440 m/s (4800 ft/s) at a wavelength of 5 cm (0.27 ft on horizontal scale ~ 3.2 inches)

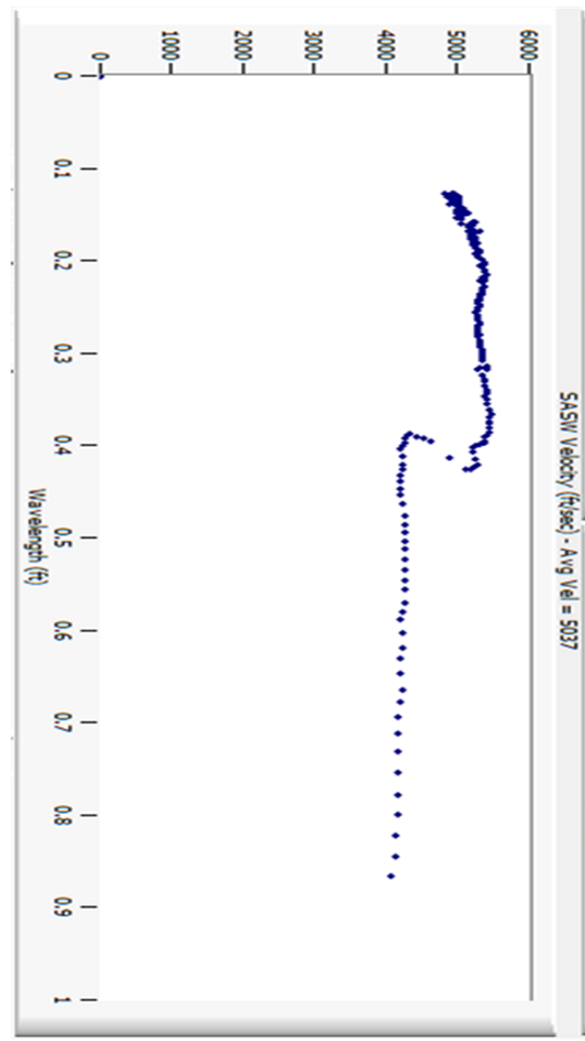
SASW Results for Sound vs. Delaminated Asphalt Pavement

Sound pavement

Surface wave velocity (ft/sec)



Surface wave velocity (ft/sec)



Delaminated Pavement – note decrease in velocity at wavelength (depth) of delamination

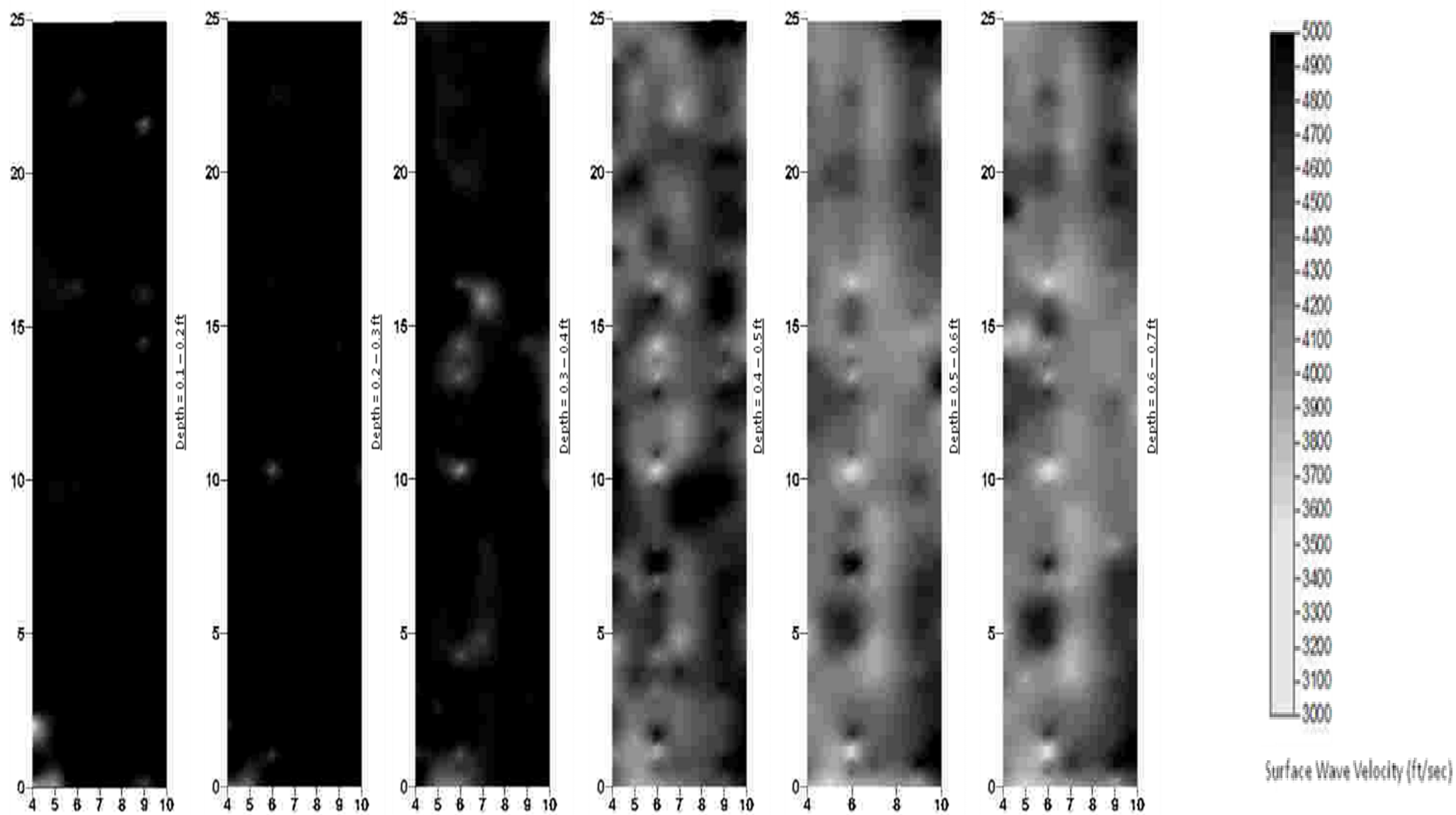
NCAT Section 1
Debonding Delamination

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1																									
2													S												
3																									
4			O					O					O					O		X			O		
5																									
6			O					O					O					O					O		
7																									
8																									
9			O					O					O					O					O		
10																									
11			O					O					O					O					O		
12																									

Gray = baghouse dust; tan = paper; delamination depth = ~ 5 in. (between PCC and HMA); O = locations where point-load methods were conducted; X = verification core; S = standpipe.

FIGURE 11 Section 1: HMA over PCC (STA 0+15 to 0+40).

SASW Delamination Plot Velocity Results NCAT Section 1 Stations 15 to 40 ft



0.1 0.2 0.3 0.4 0.5 0.6

Plots at 0.1 ft depth slices

Prototype Pavement Scanner on Kansas DOT Asphalt Pavement test site with 3 pairs of wheels - Future full lane Scanner?

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Advanced Methods to Identify Asphalt Pavement Delamination (R06D) SASW and IE

New Mexico DOT Evaluation

Naomi Gaede
Pavement Design Engineer
NM DOT

Webinar
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Introduction

New Mexico Concerns

- Temperature sensitivity
- Surface Treatment
- Delamination Detection

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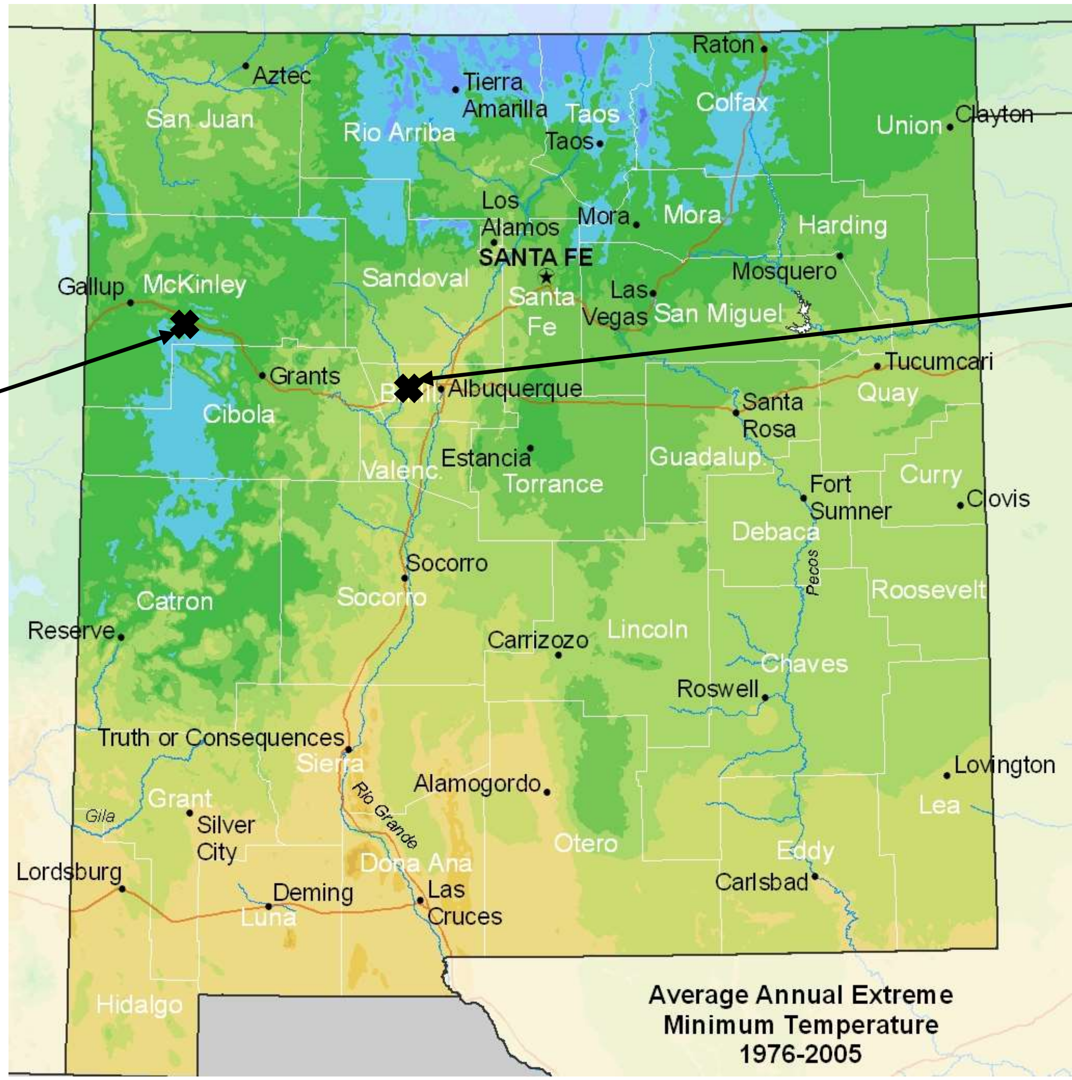
Site Locations

District 6 Site



District 3 Site

District 6 Sites

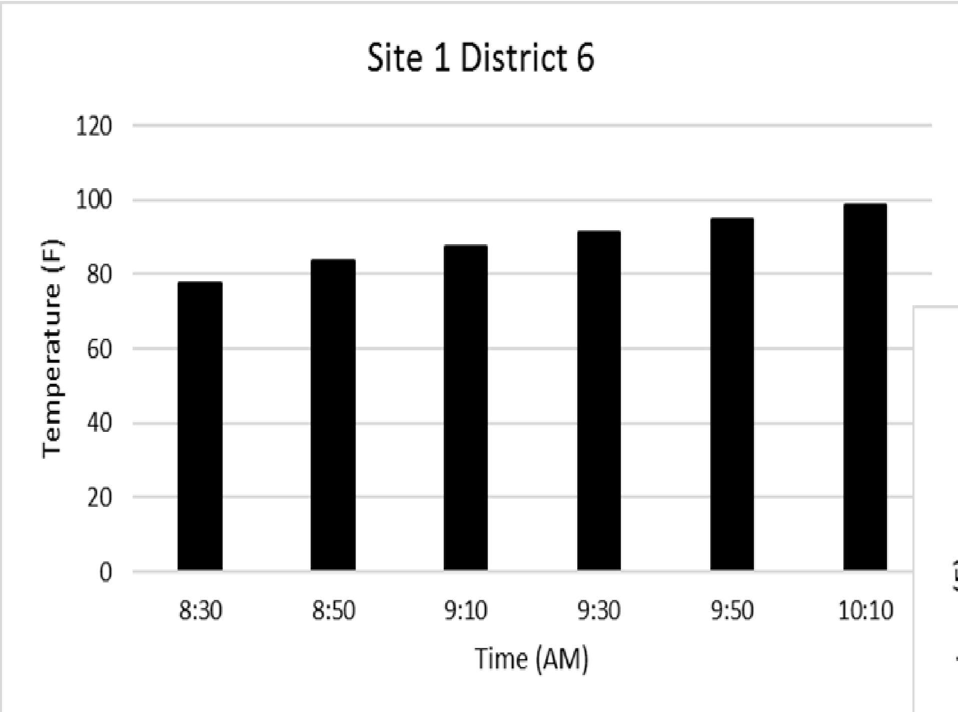
- 2 -1000ft. Sections tested
- In Mountains
- Basalt Mixes Top Mix
- Marshal Mix Bottom Mix
- Open graded friction course

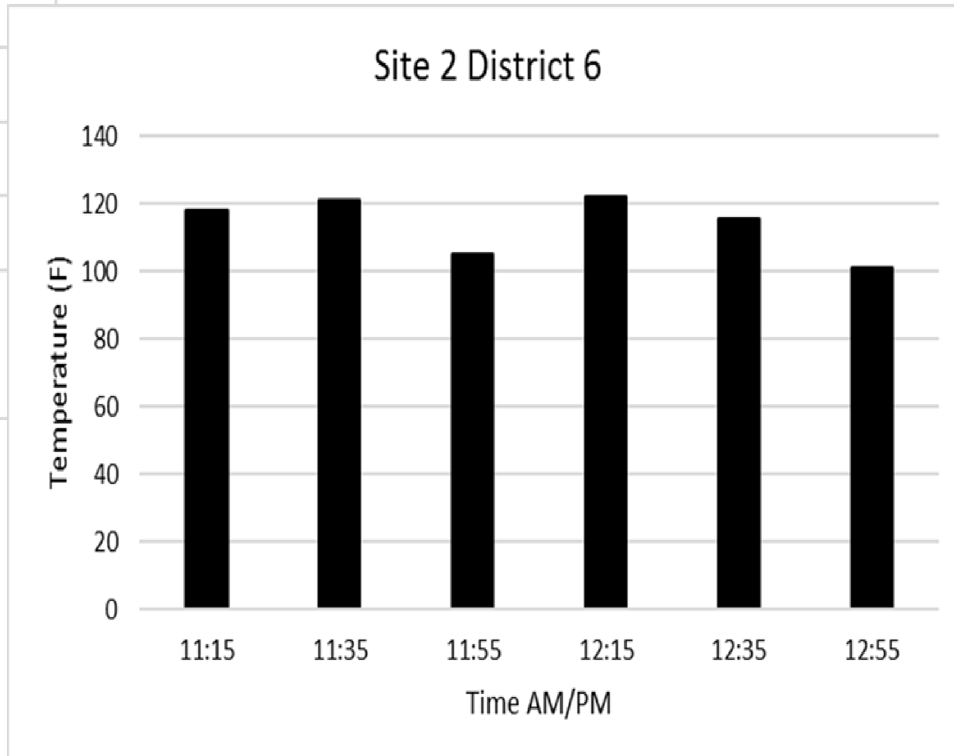
NMDOT

District 3 Site

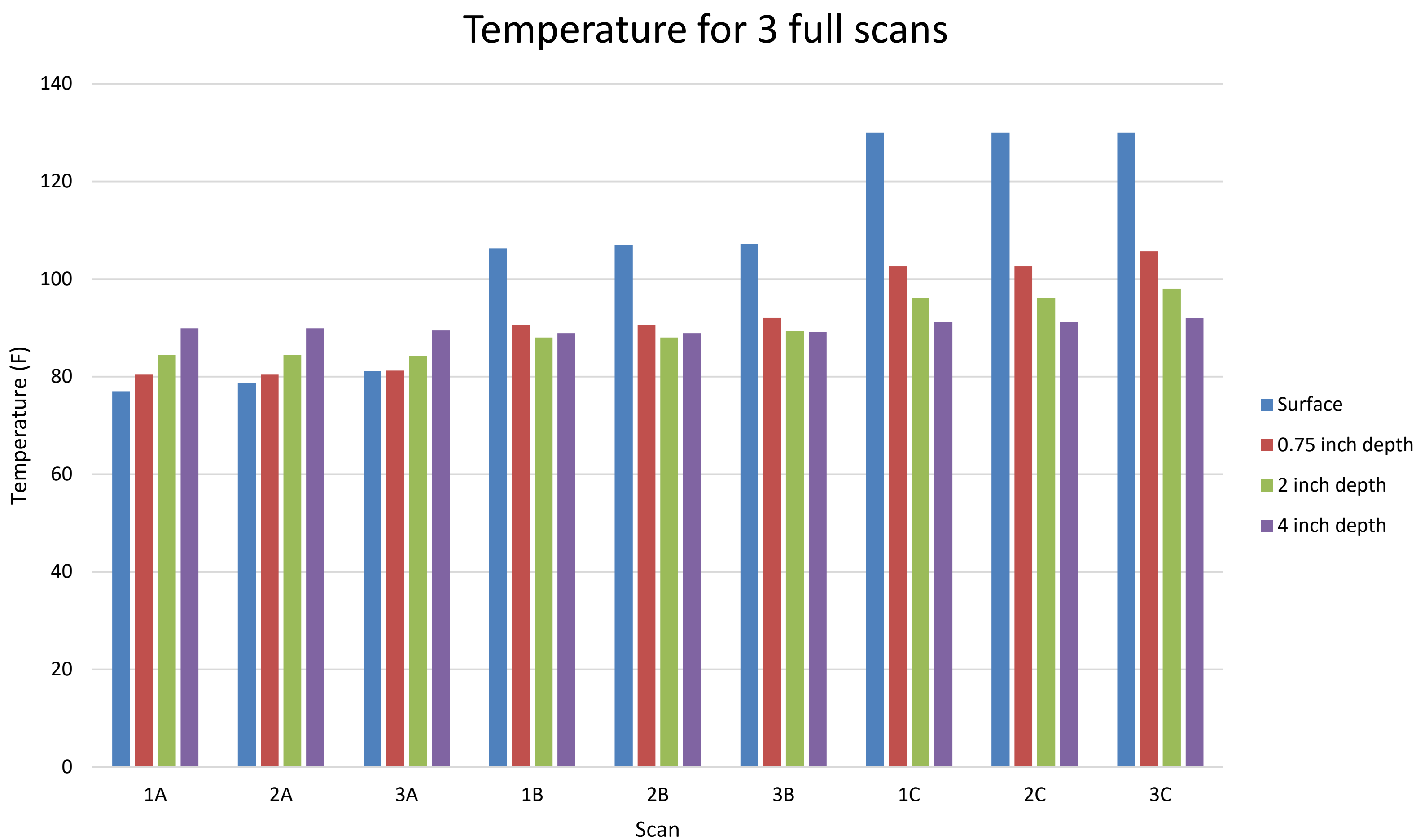
- Temperature probes
- In “flat” area
- Same SPIII mix throughout
- Open graded friction course
- 1-500 ft. section tested multiple times

District 6 Test Sites Temperature

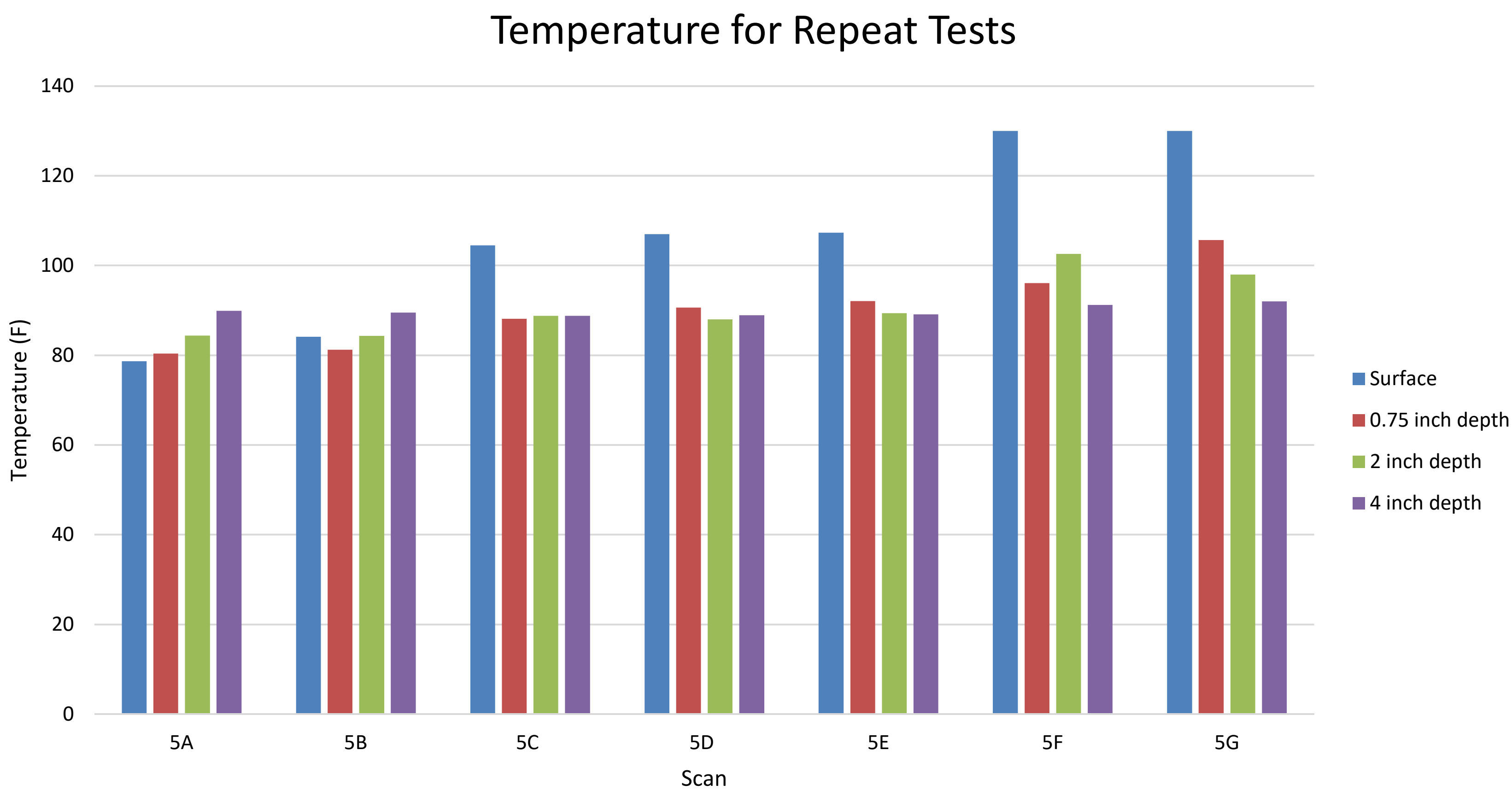




District 3 Full Scans Temperature



District 3 Repeat Scan Temperature



IE Conclusions

- Repeatability was poor even with tests with similar temperatures
- General Trends are probably okay
- This test will probably need some form of temperature correction in the future for high temperature change areas

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IE Example of Results

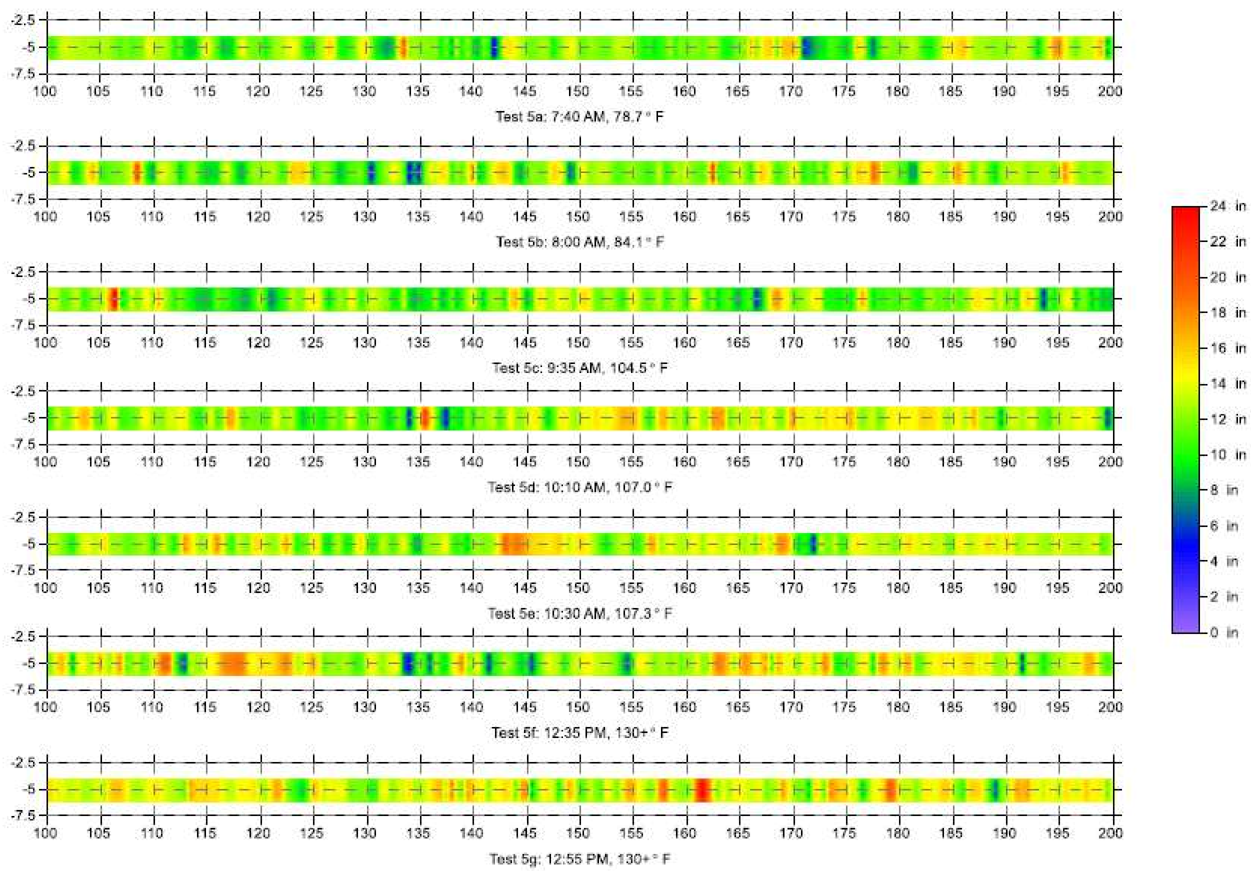

Figure B4: IE Results, 7/20/2017, Repeatability Study, 5 feet from left shoulder tested seven times (a – g). X = 0 @ start of section, Y = 0 at left shoulder. Distance 100 – 200 feet for all seven tests.

SASW Conclusions

- Good repeatability of trends were found for both similar temperatures and with different temperatures
- At high temperatures (130+ F) degradation of <2 inches existed, however, data was much better than expected
- Absolute velocity values changed with temperature, but percentage change in velocity with damage was similar

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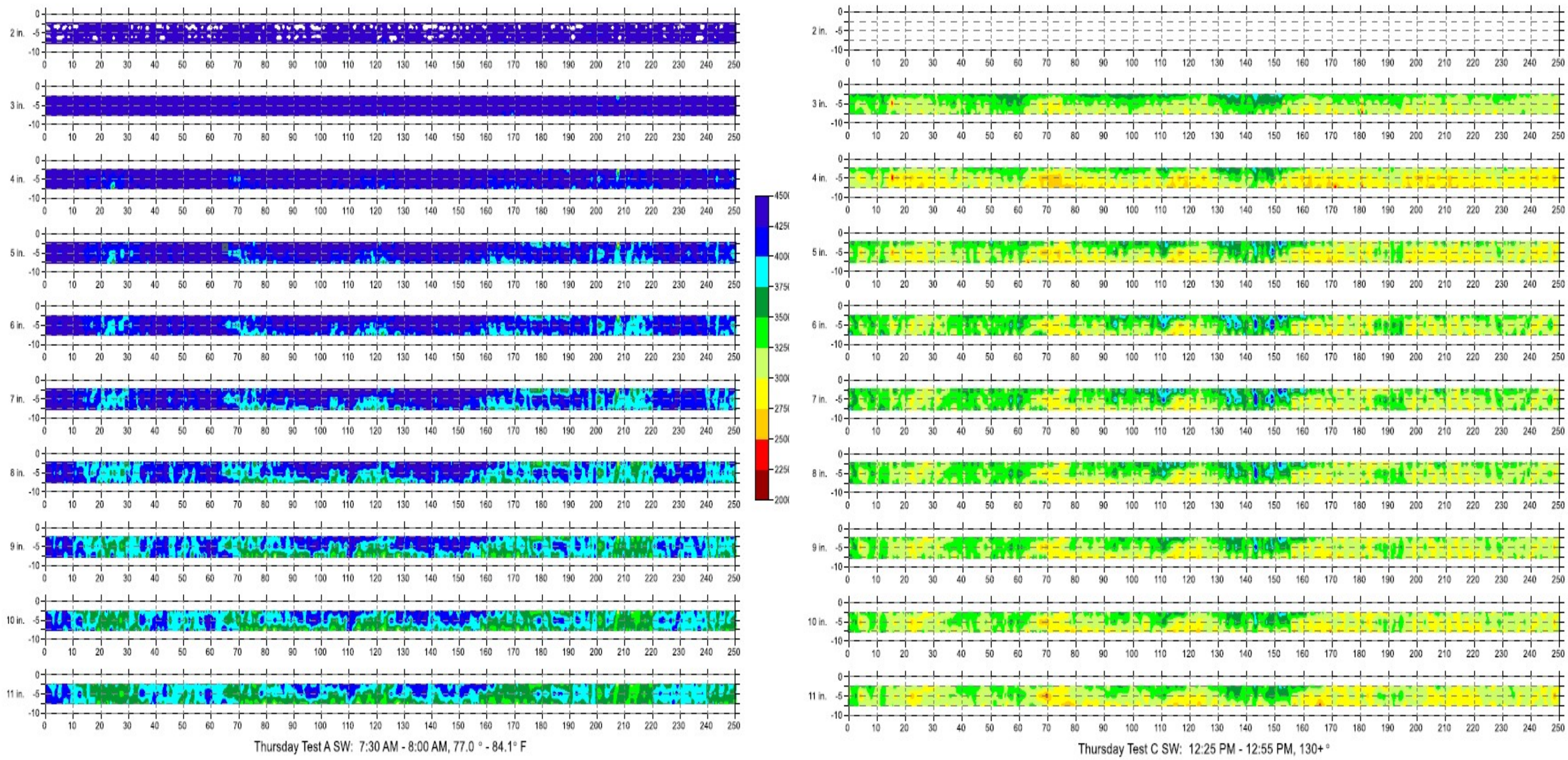
SASW Example of Results



NMDOT Experience

- 1000 ft. line ~ 20 min.
- 1000 ft. segment ~ 2 hrs.
- Still much faster than PSPA!
- Analysis software in progress…

NMDOT

Core Comparison

Core #	IE/SASW condition	Depth to Delamination	Core Condition	Depth to Delamination	Accuracy
3	Good, full depth	NA	Visible strip	6	Incorrect
4	Fair to Poor	4	Debonding	5	Correct, close
5	Good to fair	4.5	Visible strip + horizontal crack	4.5	Correct, exact
6	Good to fair	4	Debonding	5.5	Correct, close
7	Good to fair	4	Debonding	4.75	Correct, close
8	Good, full depth	NA	Visible strip	3	Incorrect

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Core Comparison District 3

Core #	IE/SASW condition	Depth to Delamination	Core Condition	Depth to Delamination	Accuracy
15	Good, full depth	NA	Debonding	8	Incorrect
16	Good, full depth	NA	Visible strip	4	Incorrect

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Core Conclusions

- All the visible stripping only cores without cracks were missed
- The deeper debonding was not picked up, otherwise all debonding was found and thicknesses reasonably close
- Did not seem to have an issues with the open graded friction course

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Advanced Methods to Identify Asphalt Pavement Delamination (R06D) SASW and IE

Texas DOT Evaluation

Darlene Goehl, PE
Research Specialist
Texas A&M Transp. Institute

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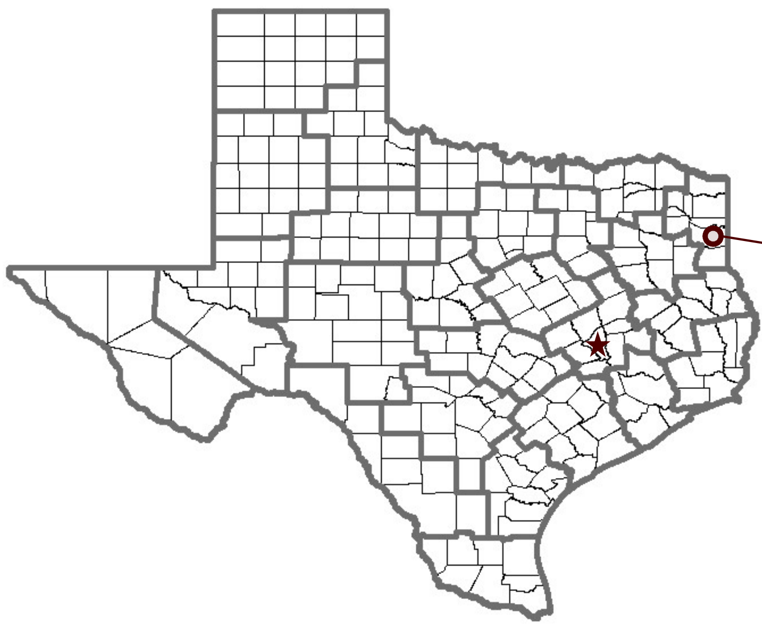
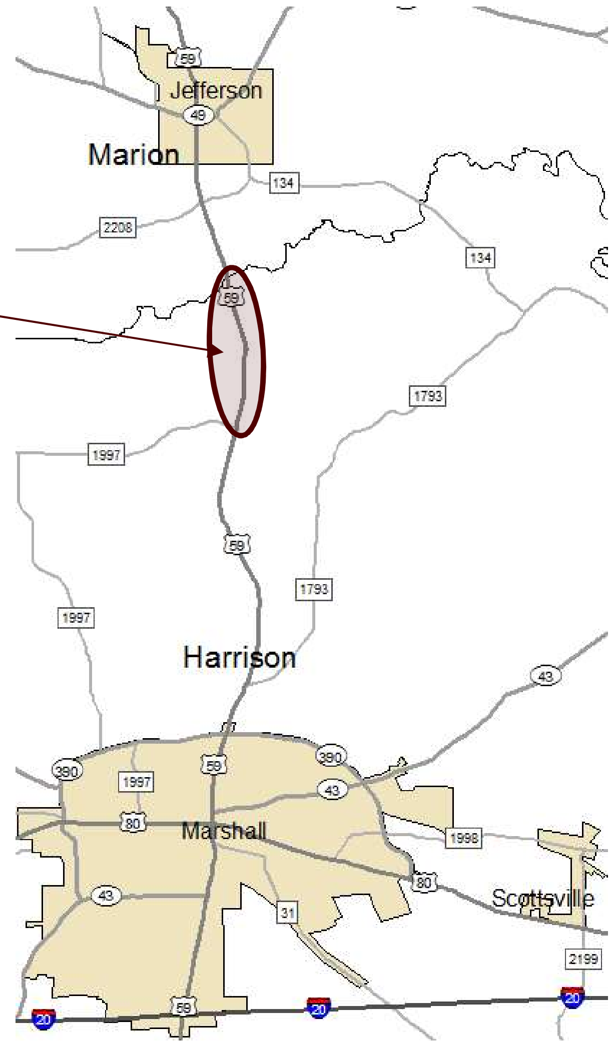
SASW/IE Test Location

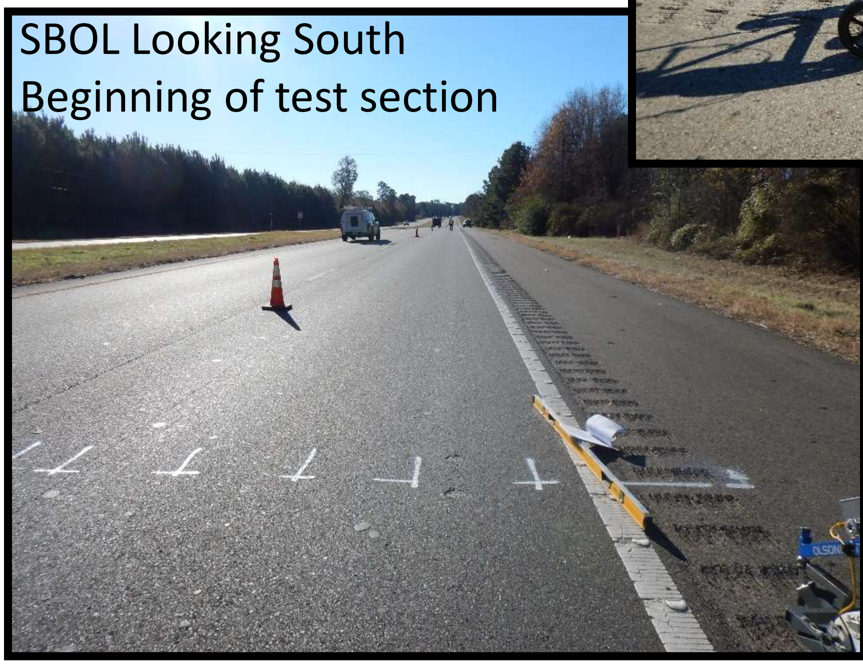




US 59

From Marion/Harrison County line to FM 1997

SASW/IE – US 59



SBOL Looking South
Beginning of test section

SBOL Looking North
~middle of test section

SASW/IE Testing US 59

- 1000’ test Section
- 6 Scan Lines
  - At 1’, 3’, 5’, 7’ 9’ and 10’ measured from white edge line.
- Testing Time was ~2 hours.
- Pavement Surface temperature ~50˚F


SASW/IE Testing US 59

Impact Echo (IE) Test Results
US 59

- Impact Echo (IE) Test Results
  - Test every 6 inches resulting in ~12,000 tests for the 6000 LF tested (1000’ test section with 6 locations)
  - IE velocity of 8,000 ft/sec used for thickness values
  - Yellow and red areas are potential deteriorated areas

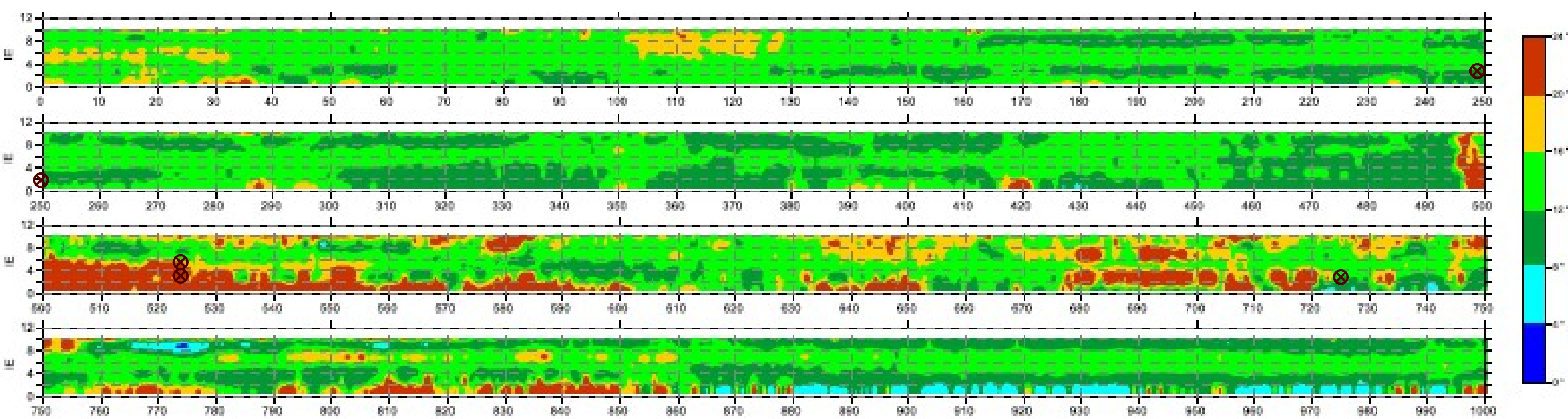


Figure A1: IE Results, Highway 59 SB Right Lane. X = 0 @ start of section, Y = 0 at right shoulder.

⊗ Core Locations

Spectral Analysis of Surface Waves (SASW) Test Results - US 59

- Test every 6 inches
  - ~12,000 tests for the 6000 LF tested
- Based on velocity profile with depth at each location.
  - Drop in velocity at depth of the degradation. Larger velocity drop indicates worse conditions.
- Velocity scale
- The SASW test results are presented 3 separate ways:
  - 1st as absolute velocity
  - 2nd as normalized velocity (percentage)
  - 3rd as changes in normalized velocity between depths.

SASW Test Results –Absolute Velocity US 59

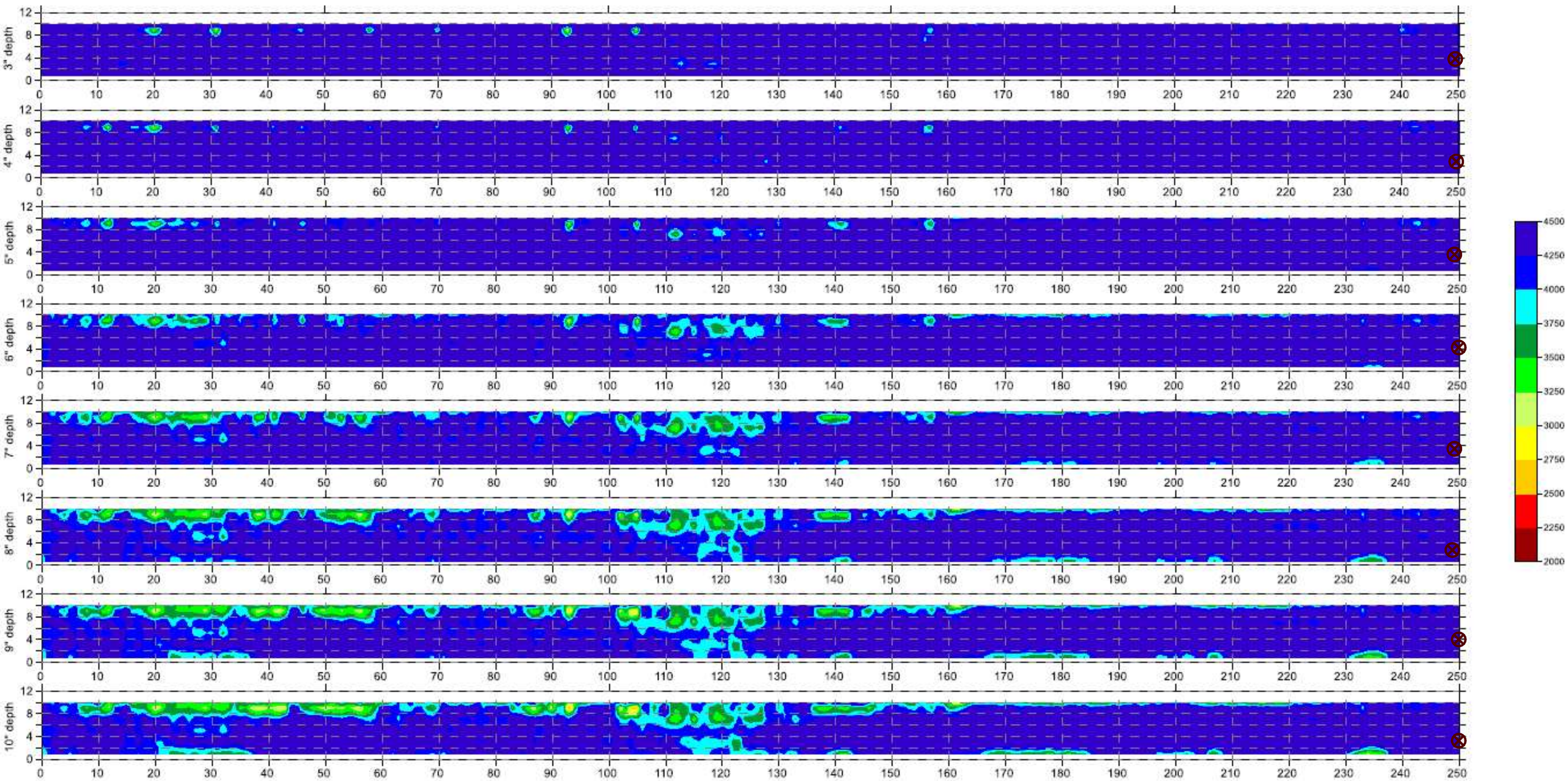


Figure B1: SASW Results, Absolute Velocity, Highway 59 SB, Right Lane. X = 0 @ start of section, Y = 0 at right shoulder. Distance 0 – 250 feet.

⊗ Core Locations

SASW Test Results –Absolute Velocity US 59

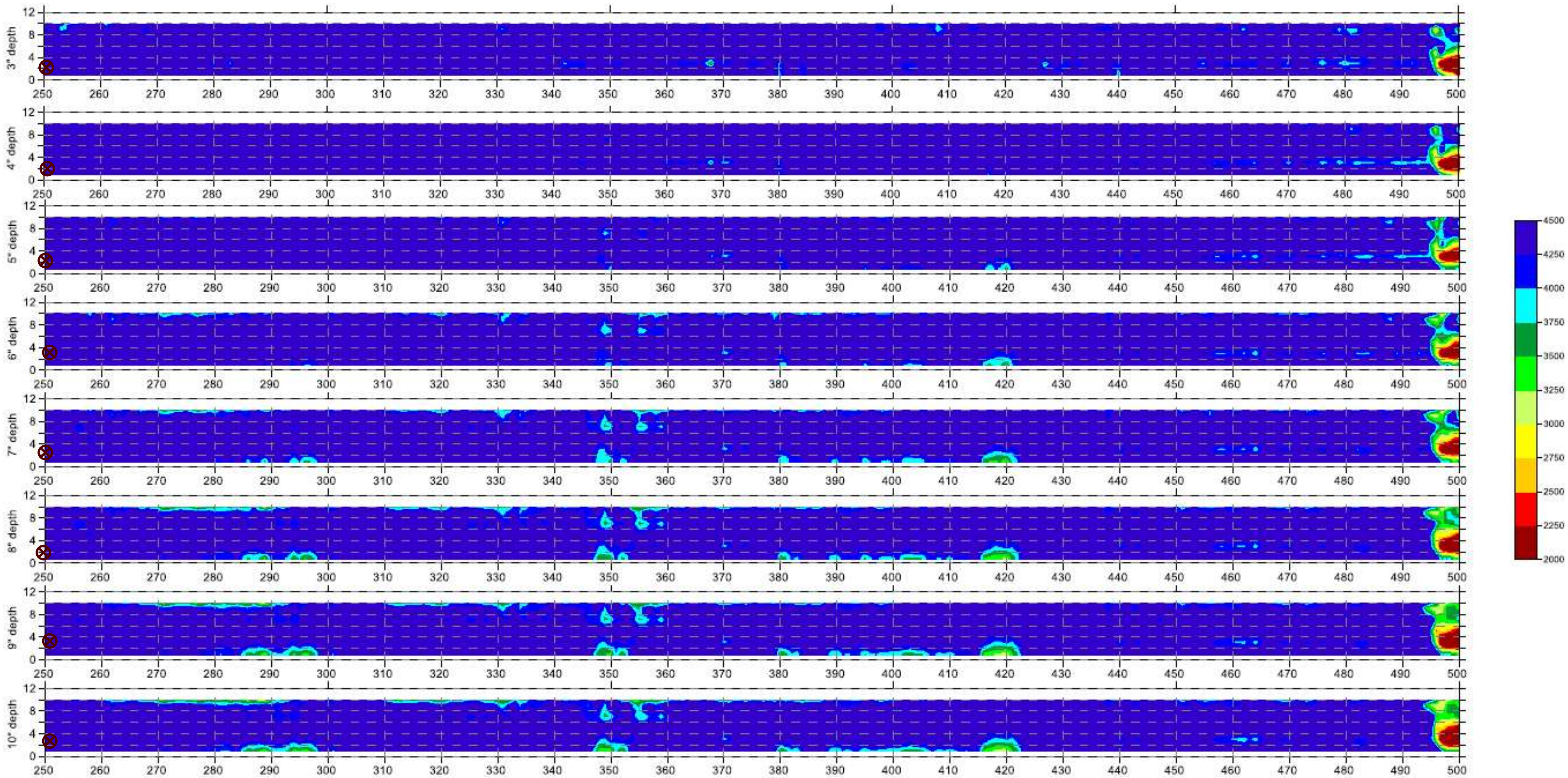


Figure B2: SASW Results, Absolute Velocity, Highway 59 SB, Right Lane. X = 0 @ start of section, Y = 0 at right shoulder. Distance 250 – 500 feet.

⊗ Core Locations

SASW Test Results –Absolute Velocity US 59

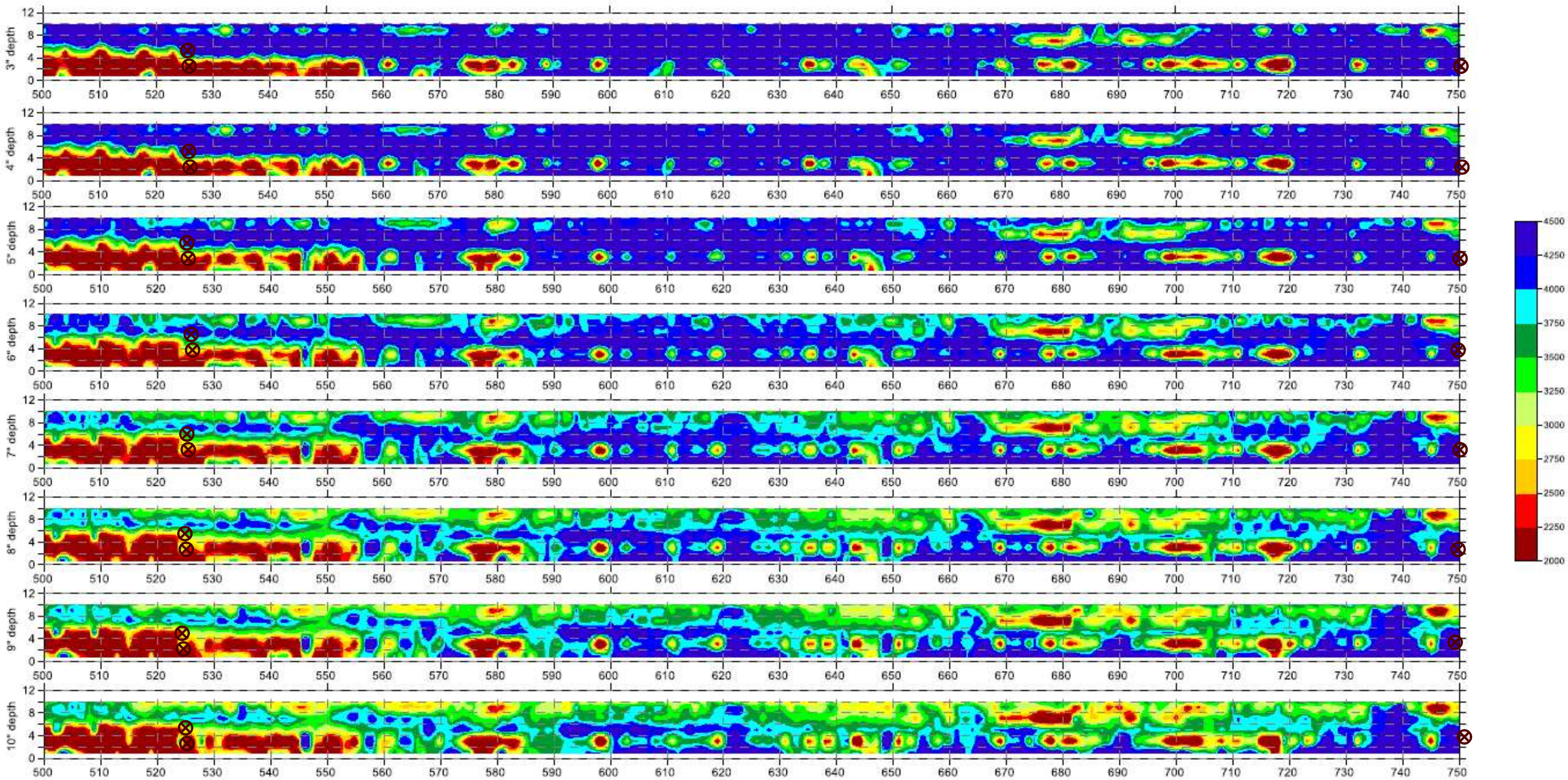


Figure B3: SASW Results, Absolute Velocity, Highway 59 SB, Right Lane. X = 0 @ start of section, Y = 0 at right shoulder. Distance 500 – 750 feet.

⊗ Core Locations

SASW Test Results –Absolute Velocity US 59

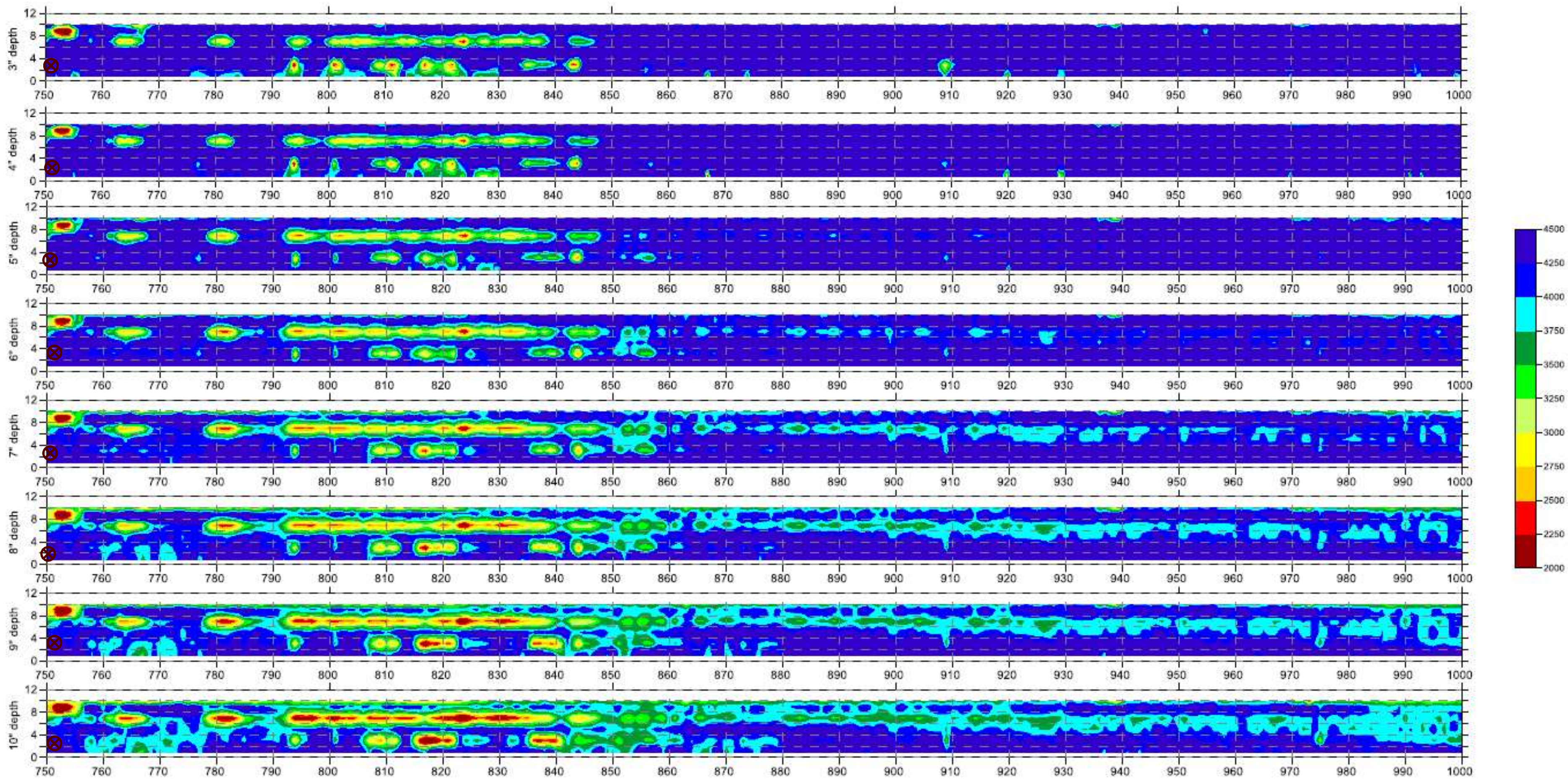
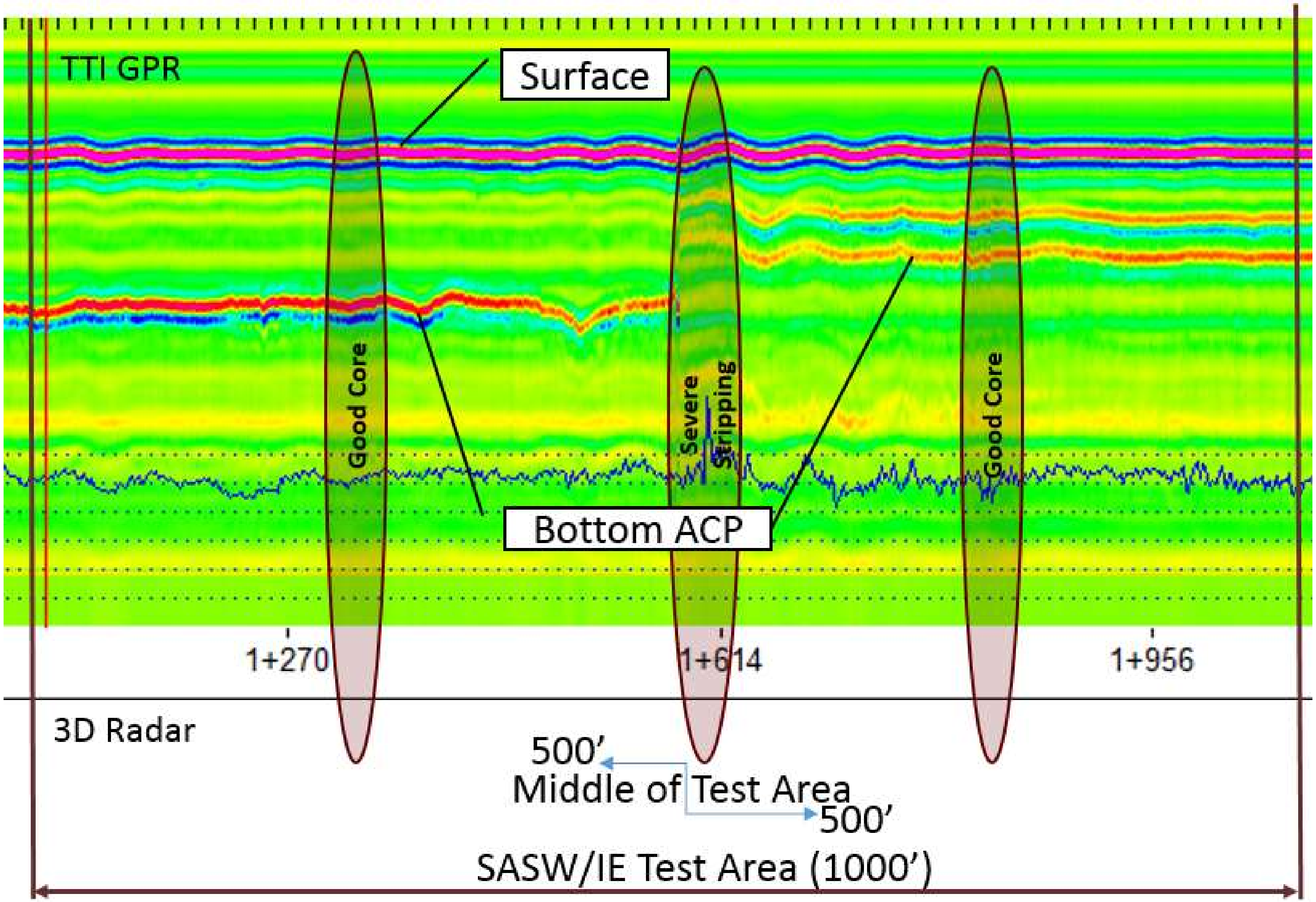


Figure B4: SASW Results, Absolute Velocity, Highway 59 SB, Right Lane. X = 0 @ start of section, Y = 0 at right shoulder. Distance 750 – 1000 feet.

⊗ Core Locations

SASW/IE – US 59 Test Area



Spectral Analysis of Surface Waves (SASW) Test Results - US 59

Distance from Start (ft)	Effected Portion of Lane	Pavement Condition	Approximate Depth of Degradation (in)	Notes
100 - 130	Full Width	Fair	6	
495 - 850	Full Width	Fair to Poor	<3 - 7	Some areas are degraded extensively near the surface (<3"), other areas have moderate degradation starting at depths of 6" - 8".
10 - 60	Left Half of Lane	Poor	7	
130 - 165	Left Half of Lane	Fair	8	
850 - 1000	Left Half of Lane	Fair	7	

Core #	Distance from Start (ft)	Expected Condition	Depth of Deterioration (inches)	Notes
1	250	Good Condition, Full Depth	NA	
2	525	Poor Condition	<3 to 7"	Core on borderline regarding depth to degradation, possibly near surface, possibly 6-7" deep
3	750	Fair Condition	7"	Core on borderline of Poor Condition near surface and Fair condition at 7" deep

SASW/IE – US 59 Test Area Cores

County: Harrison | Highway: US 59 | Date Cored: 12-12-2017
Projet: Research - SHRP2 R06D | Limits From: Marion Co. Line | Report Date:12-13-2017
Resp. Office: Marshall AO | Limits To: FM 1997 | Field Coring Personel: Gustavus | Goehl

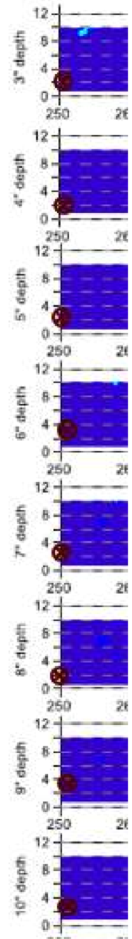
Core #	250'r	MP + offset:	272 +	mi	Direction of Travel: SB	Lane:	Outside
3D Radar File	4"	Latitude, Longitude:	32.699546		94.342567		

Existing Roadway Condition

Looking in direction of Travel

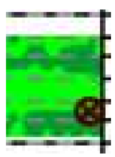
	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'
	owp		WheelPath			between wp			WheelPath		
Core Loc (x)											
Rutting (in)			3/8						3/8		

check if apply
Transverse Crk
Long Crk
Alligator Crk
Pothole
Bleeding
Raveling
Polished Aggr
Patch
Pumping



Core Description

Description of Layers & Notes:	Depth Below Surface (inches) From	To	Layer thickness
Dense Graded HMA	0	2 1/4	2 1/4
Dense Graded HMA; gravel	2 1/4	3	3/4
Dense Graded HMA; gravel	3	4	1
Dense Graded HMA; gravel	4	4 7/8	7/8
Dense Graded HMA; gravel	4 7/8	5 7/8	1
Dense Graded HMA; gravel	5 7/8	7 1/4	1 3/8
Dense Graded HMA; gravel	7 1/4	9 3/4	2 1/2
Dense Graded HMA; gravel	9 3/4	13 1/4	3 1/2



County: Harrison | Highway: US 59 | Date Cored: 12-12-2017
Projet: Research - SHRP2 R06D | Limits From: Marion Co. Line | Report Date:12-13-2017
Resp. Office: Marshall AO | Limits To: FM 1997 | Field Coring Personel: Gustavus | Goehl

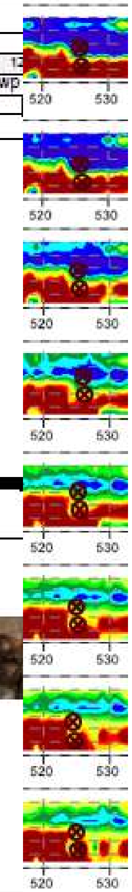
Core #	525'r	MP + offset:	272 +	0.25 mi	Direction of Travel: SB	Lane:	Outside
3D Radar File	4"	Latitude, Longitude:	32.698883		94.34235		

Existing Roadway Condition

Looking in direction of Travel

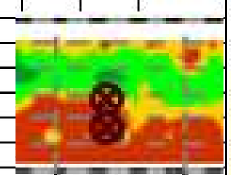
	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	12'
	owp		WheelPath			between wp			WheelPath			owp
Core Loc (x)												
Rutting (in)			1/5						3/8			

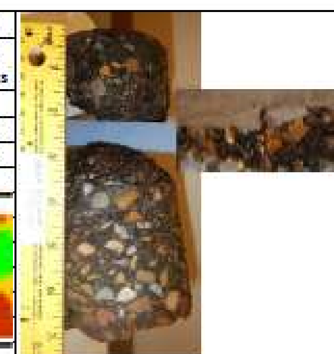
check if apply
Transverse Crk
Long Crk
Alligator Crk
Pothole
Bleeding
Raveling
Polished Aggr
Patch
Pumping



Core Description

Description of Layers & Notes:	Depth Below Surface (inches) From	To	Layer thickness
Dense Graded HMA; cracked	0	2	2
Dense Graded HMA; stripping	2	3 1/2	1 1/2
Dense graded HMA; gravel	3 1/2	7	3 1/2





SASW/IE – US 59 Test Area Cores

County: Harrison | Highway: US 59 | Date Cored: 12-12-2017
Projet: Research - SHRP2 R06D | Limits From: Marion Co. Line | Report Date:12-13-2017
Resp. Office: Marshall AO | Limits To: FM 1997 | Field Coring Personel: Gustavus | Goehl

Core #	525'b	MP + offset: 272 + 0.25 mi	Direction of Travel: SB	Lane:	Outside
3D Radar File	4"	Latitude, Longitude:	32.698883	94.34235	

Existing Roadway Condition

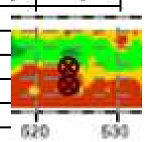
Looking in direction of Travel

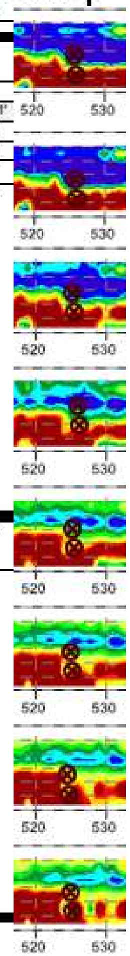
	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'
	owp		WheelPath			between wp		WheelPath			
Core Loc (x)											
Rutting (in)			1/5					3/8			

check if apply	
Transverse Crk	
Long Crk	
Alligator Crk	
Pothole	
Bleeding	
Raveling	
Polished Aggr	
Patch	
Pumping	

Core Description

Description of Layers & Notes:	Depth Below Surface (inches) From	To	Layer thickness
Dense Graded HMA	0	2	2
Dense Graded HMA; gravel	2	3 1/2	1 1/2
Dense Graded HMA; stripping	3 1/2	4 5/8	1 1/8
Dense Graded HMA; gravel	4 5/8	5 5/8	1
Dense Graded HMA; gravel	5 5/8	8 3/4	3 1/8





County: Harrison | Highway: US 59 | Date Cored: 12-12-2017
Projet: Research - SHRP2 R06D | Limits From: Marion Co. Line | Report Date:12-13-2017
Resp. Office: Marshall AO | Limits To: FM 1997 | Field Coring Personel: Gustavus | Goehl

Core #	750'r	MP + offset: 272 + 0.25 mi	Direction of Travel: SB	Lane:	Outside
3D Radar File	4"	Latitude, Longitude:	32.698223	94.342132	

Existing Roadway Condition

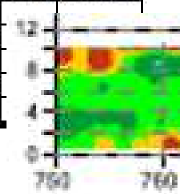
Looking in direction of Travel

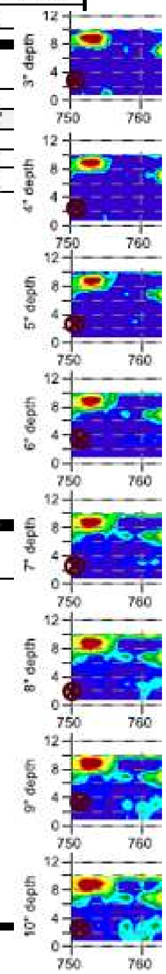
	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'
	owp		WheelPath			between wp		WheelPath			
Core Loc (x)											
Rutting (in)			1/4					1/4			

check if apply	
Transverse Crk	
Long Crk	
Alligator Crk	
Pothole	
Bleeding	
Raveling	
Polished Aggr	
Patch	
Pumping	

Core Description

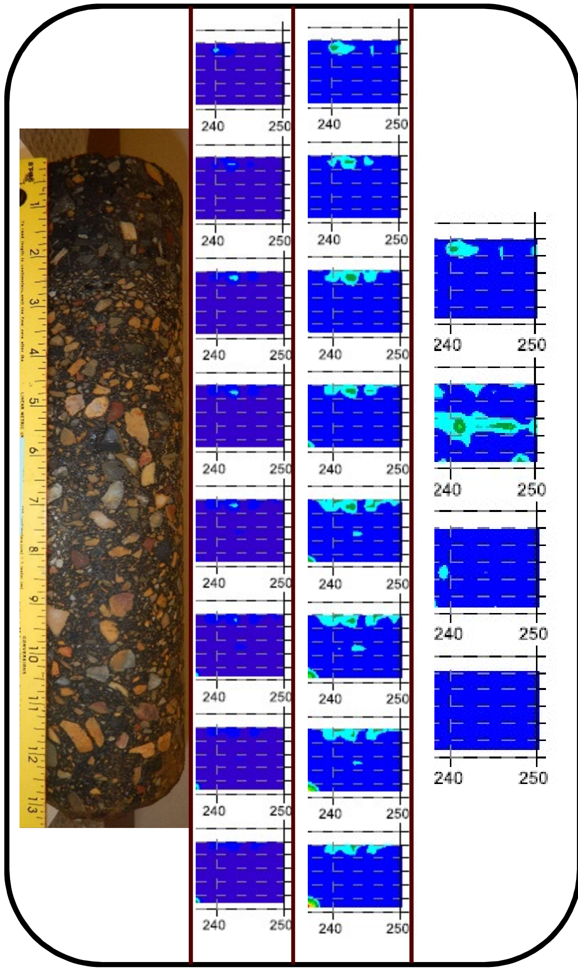
Description of Layers & Notes:	Depth Below Surface (inches) From	To	Layer thickness
Dense Graded HMA	0	2 1/2	2 1/2
Dense Graded HMA; gravel	2 1/2	4	1 1/2
Dense Graded HMA; gravel	4	5 1/4	1 1/4
Seal Coat	5 1/4	5 1/2	1/4
Dense Graded HMA; gravel	5 1/2	6 1/4	3/4
Dense Graded HMA; gravel	6 1/4	8 7/8	2 5/8

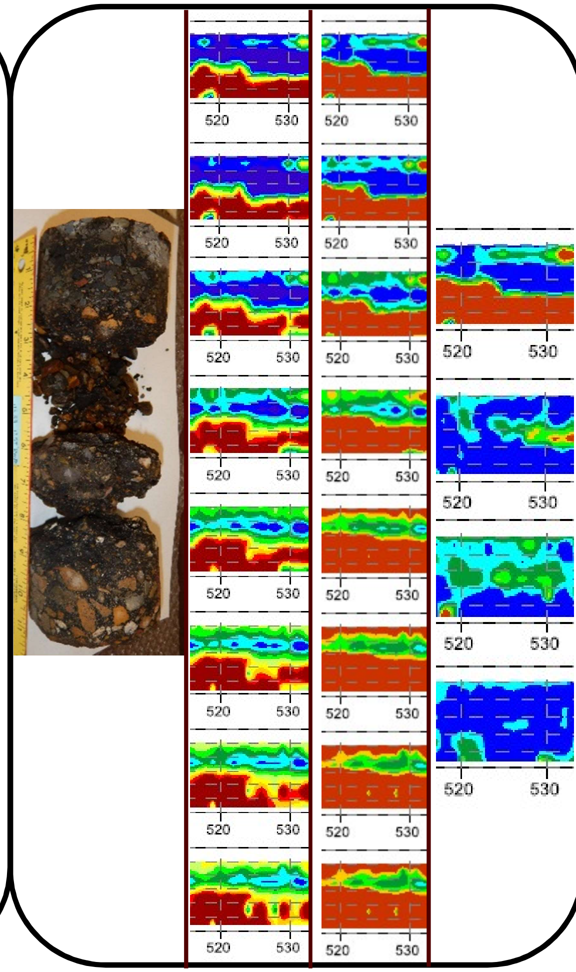


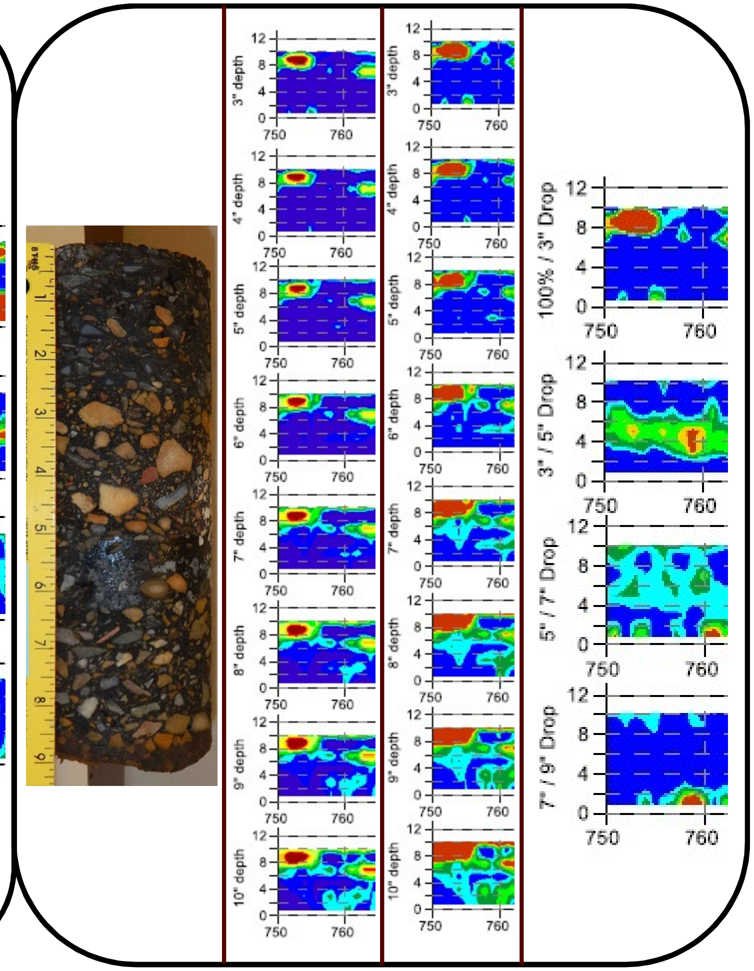


SASW Analysis at Cores
US 59

Analysis - Left is Absolute Velocity, Middle is Normalized Velocity and Right is Normalized Depth-Difference







SASW/IE Olson Engineering Report

- Information from Olson Engineering Report (IE)
  - The IE test method does not provide a measure of the level of degradation, only an indication if degradation is present or not in the form of a resonance echo outside the expected range.
    - The IE method is considered sub-optimal on asphalt surfaces due to the difficulty exciting the necessary frequency range.
  - There appears to be good correlation between the IE and SASW test results.

SASW/IE Olson Engineering Report

- Information from Olson Engineering Report (SASW)
  - There is extensive degradation of the tested area particularly between distances 495 – 850 feet.
  - All three presentation methods show the same general results.
  - It is likely that the normalized velocity method will allow users to become more comfortable with interpretation by removing the variable of temperature effects from the interpretation and allowing users to observe velocity changes on a percentage basis.
  - The difference maps help determine the depth range of deterioration.
  - Beyond the first significant poor layer (velocity drop) the SASW data becomes less definitive as the poor layer will affect the "appearance" of everything below it.

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Advanced Methods to Identify Asphalt Pavement Delamination--R06D SASW and IE

Evaluation on Kentucky Sites

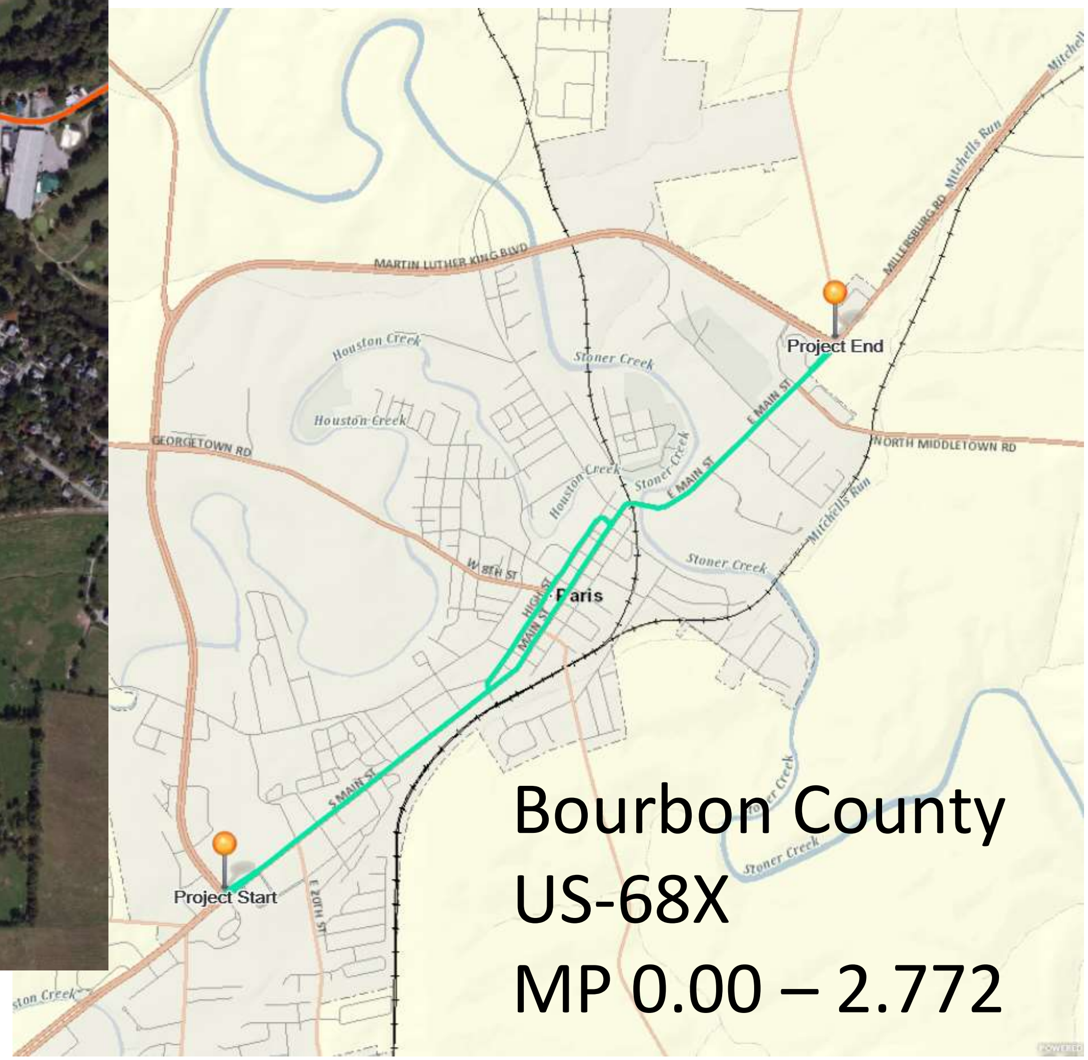
Michael Heitzman, PE, PhD
Asst. Director, NCAT

Webinar
June 26, 2018

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Project Location



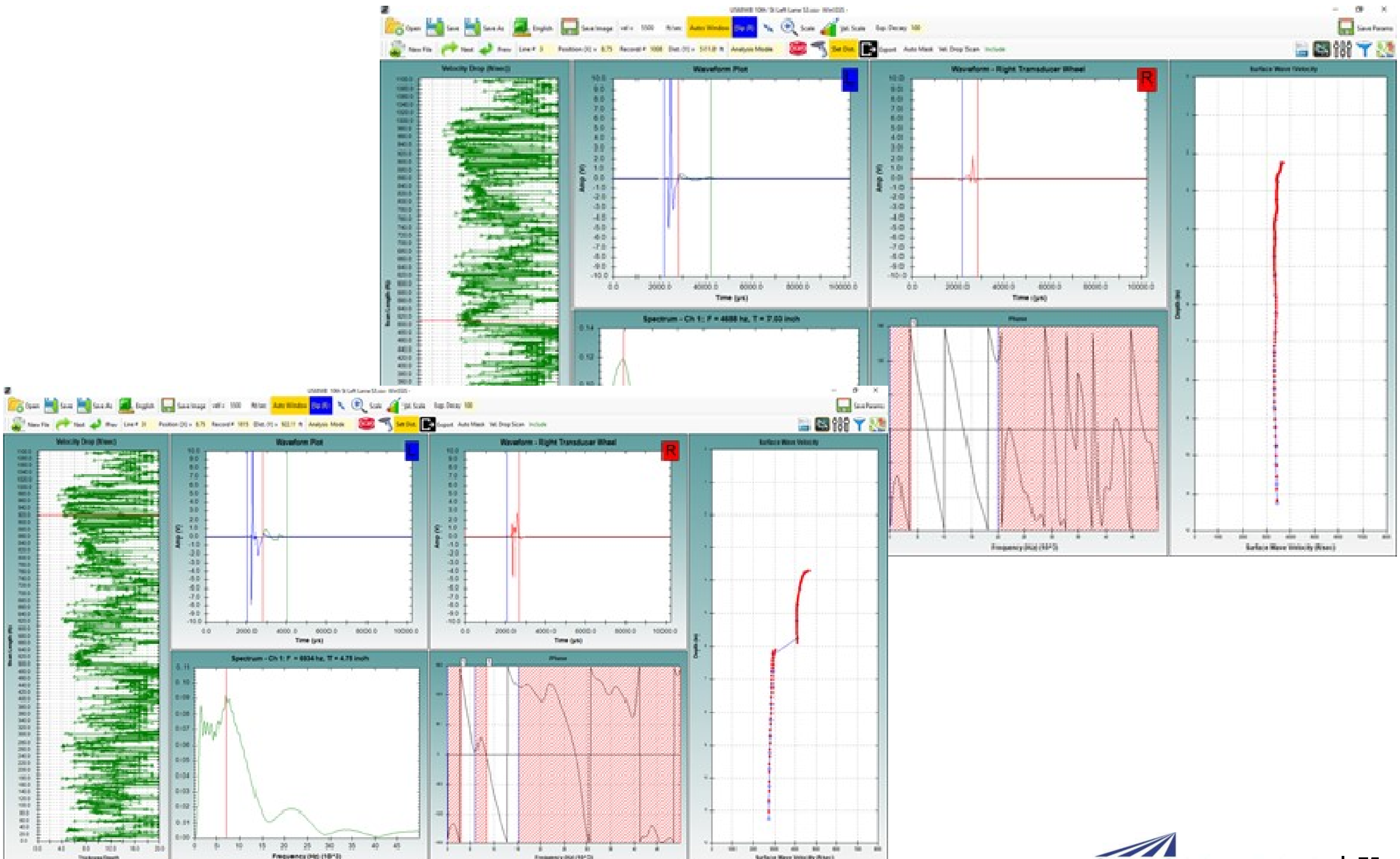
Bourbon County
US-68X
MP 0.00 – 2.772

US Highway 68 WB Left Lane
PARIS, KENTUCKY

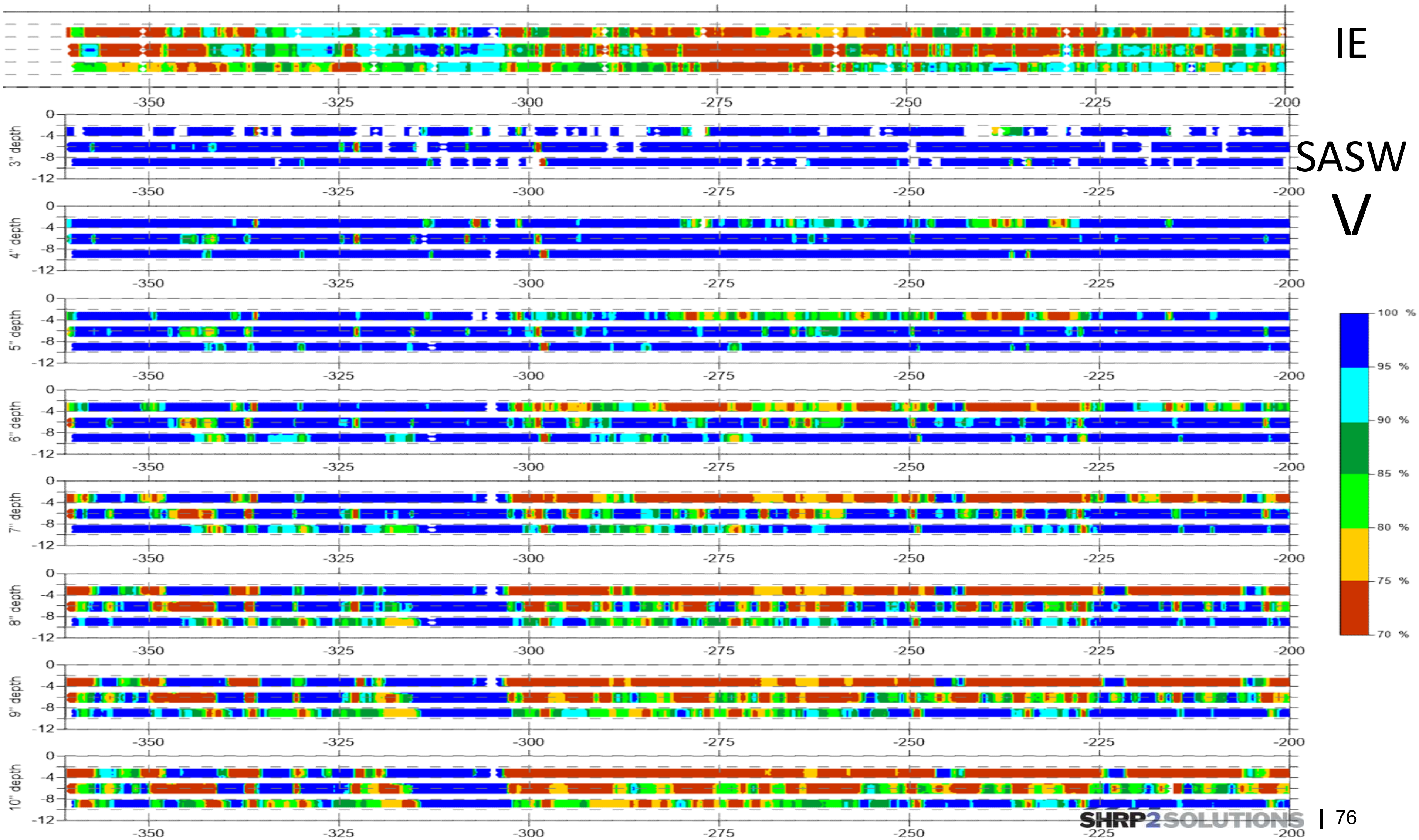
Segment	Length (ft)	# Test Lines	Linear Feet	Temperature Range Shaded Areas (F)	Temperature Range Sunny Areas (F)
1	361	3	1,083	65	80 - 90
2	537	3	1,611	72	93 - 101
3	1,105	3	3,315	75	90 - 104
		Total:	**6,009**		

SASW/IE & GPR

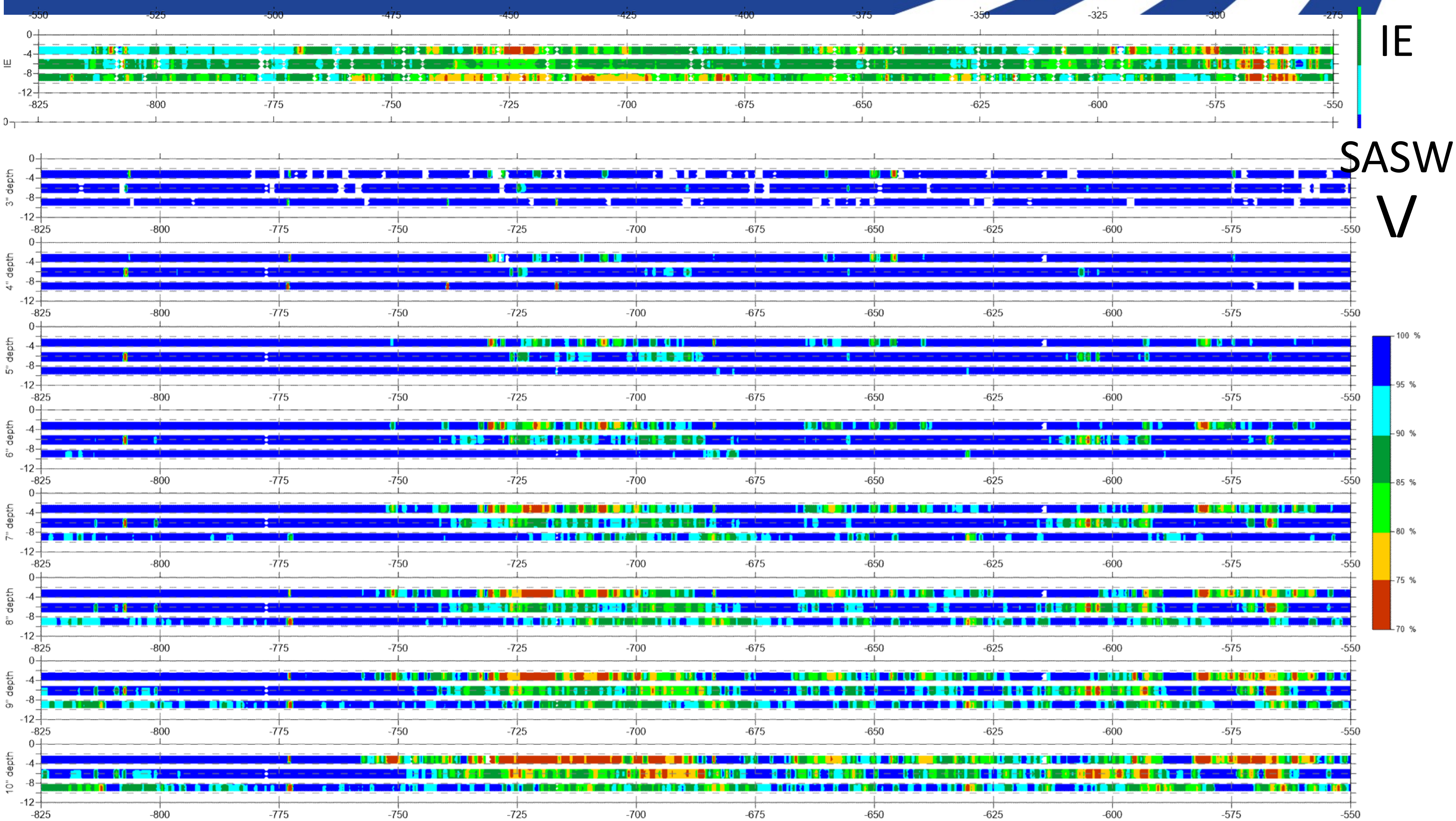
Onsite Olson Display



Section 1 (200-360 ft)

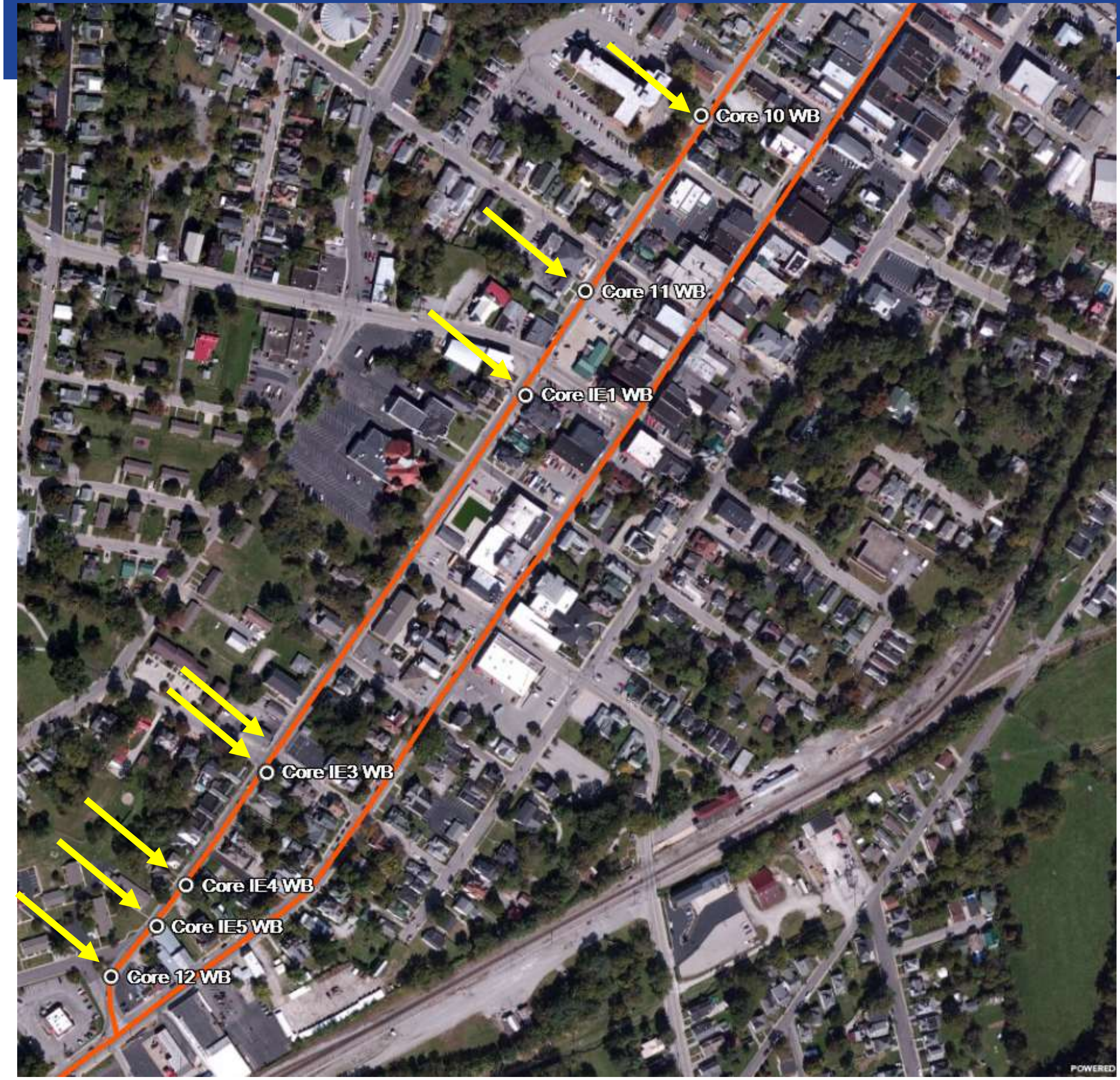


Section 3 (550-825 ft)



Segment	Distance Range (ft)	Area	Condition	Depth of Deterioration (in)	Notes
1	20 - 45	Full Lane	Poor	5-6	
1	85 - 140	LWP	Poor	6	Intermittent
1	155 - 200	RWP	Poor	5 - 6	Intermittent
1	175 - 190	LWD	Fair	8	
1	190 - 200	Center	Poor	<3	
1	200 - 305	Full Lane	Poor	5	Worst in RWP
1	335 - 360	Full Lane	Fair	6	Intermittent
2	25 - 225	Full Lane	Fair	5	Intermittent (some Poor areas)
2	260 - 270	Full Lane	Poor	5	
2	300 - 375	Full Lane	Fair	5	
2	375 - 430	RWP	Poor	4	
2	470 - 530	Center	Poor	4	
3	20 - 105	Full Lane	Poor	5	
3	135 - 245	Full Lane	Fair	5	
3	295 - 400	RWP	Poor	6	
3	555 - 585	RWP	Fair	6	
3	685 - 735	RWP	Poor	5	
3	855 - 870	Center & RWP	Poor	4	
3	1025 - 1075	Full Lane	Poor	6	
3	1075 - 1105	RWP	Poor	6	

Core Locations



Cores taken day of field testing

IE-5 IE-4 IE-3 IE-2 IE-1

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Advanced Methods to Identify Asphalt Pavement Delamination--R06D

Sonic Surface Scanner (S^3) Advances

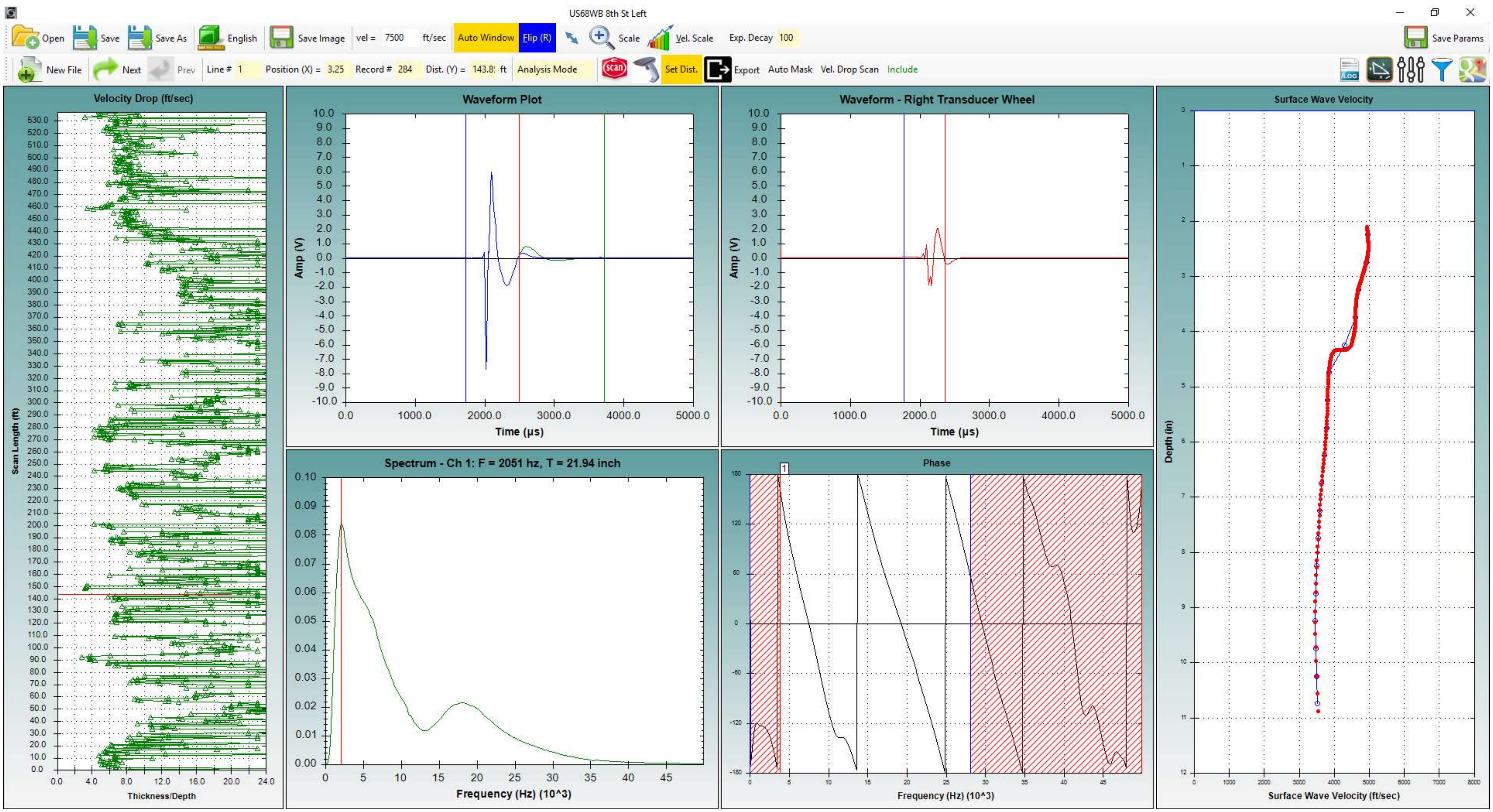
Patrick Miller, PE
Senior Engineer
Olson Engineering

Webinar
June 26, 2018

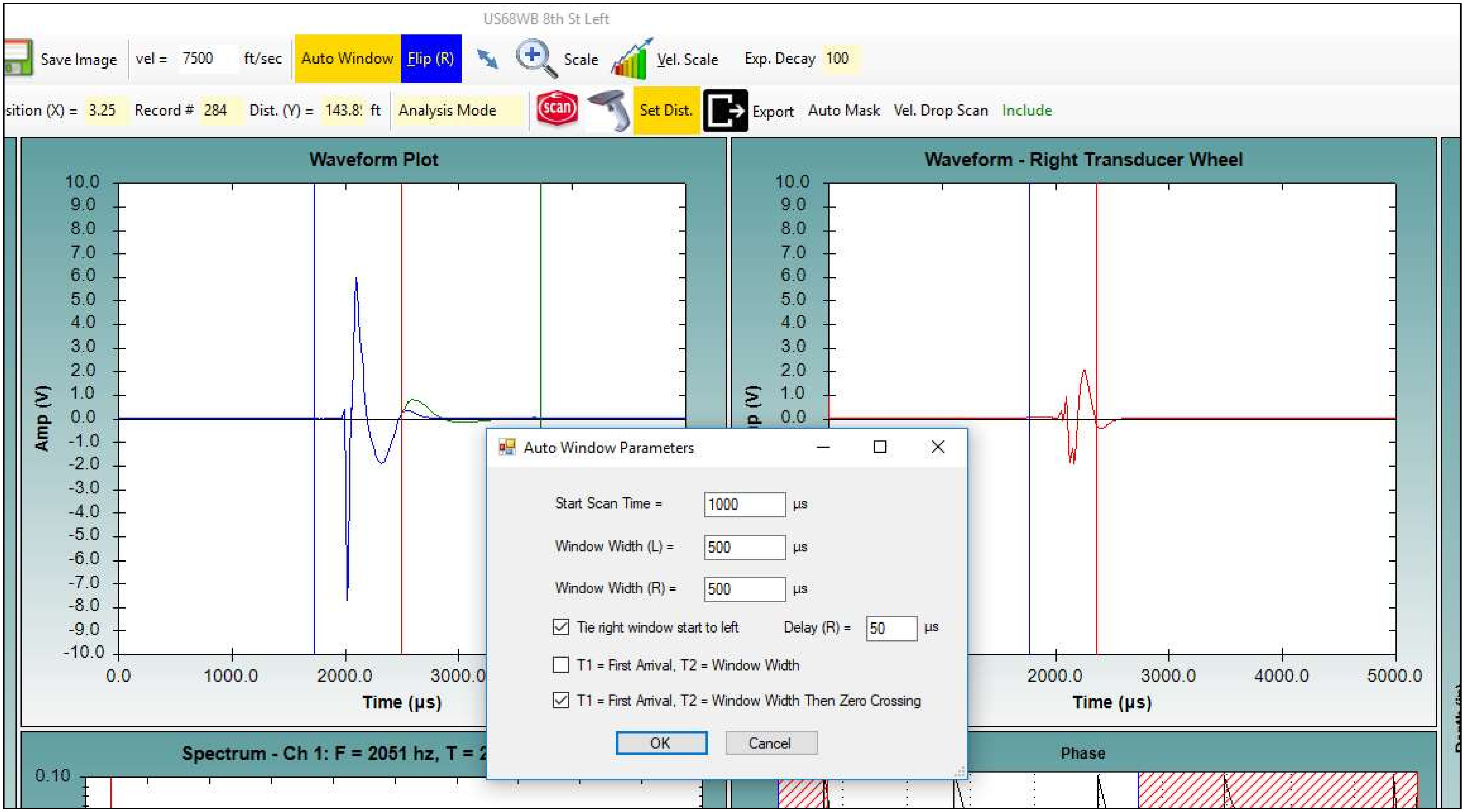
U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

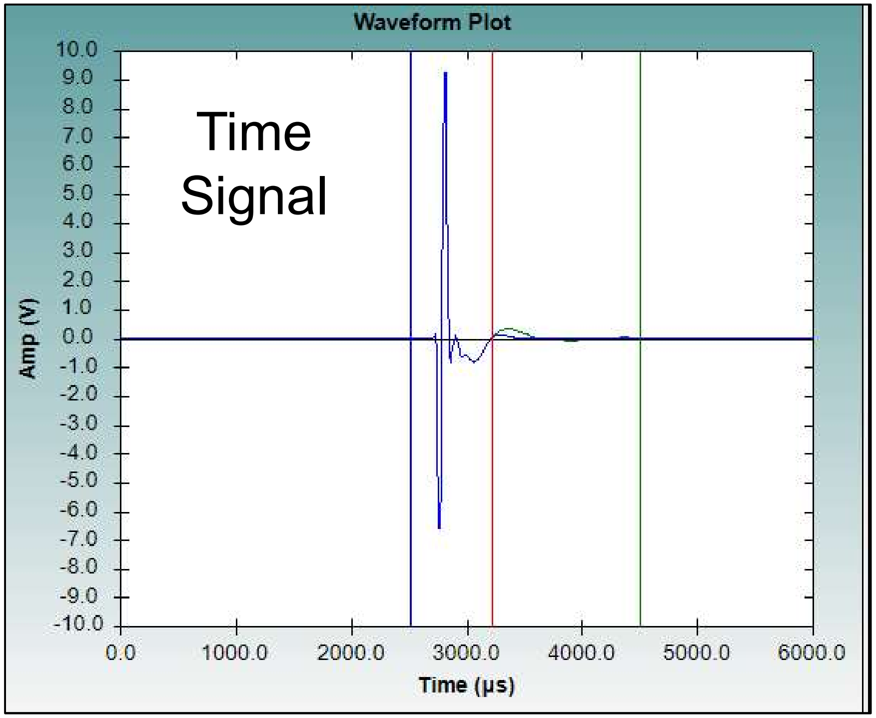
Standard S^3 Data Analysis View

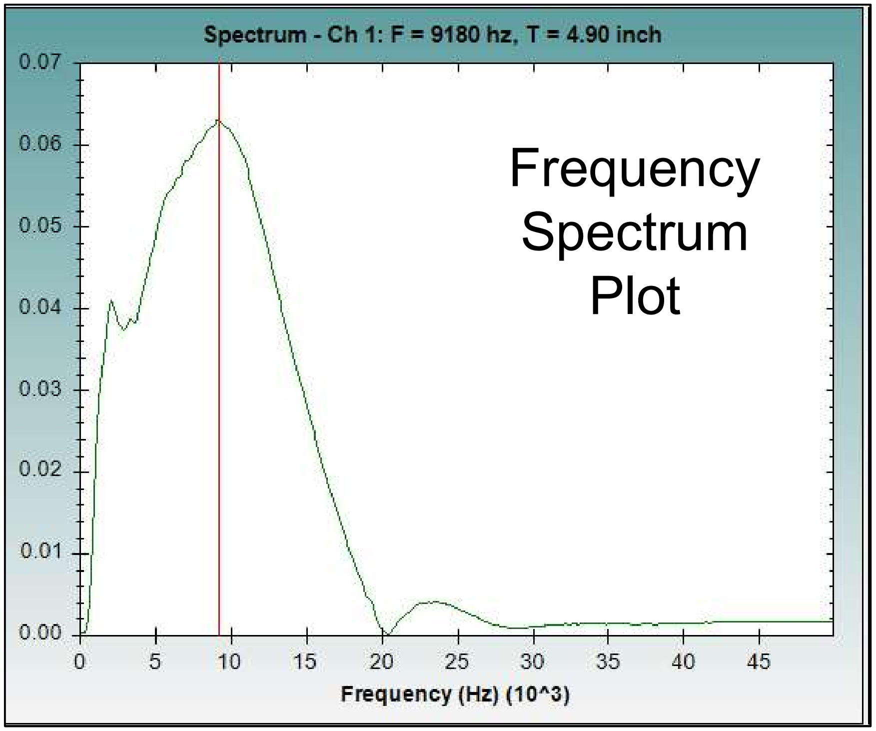


Automated Time Windowing Options

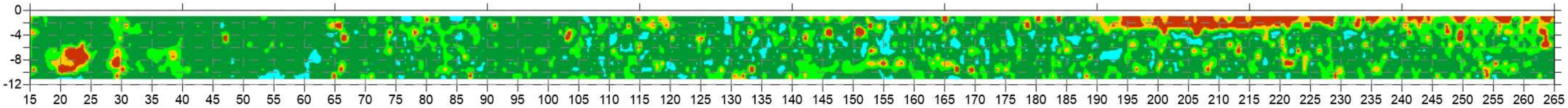


Automated IE Analysis

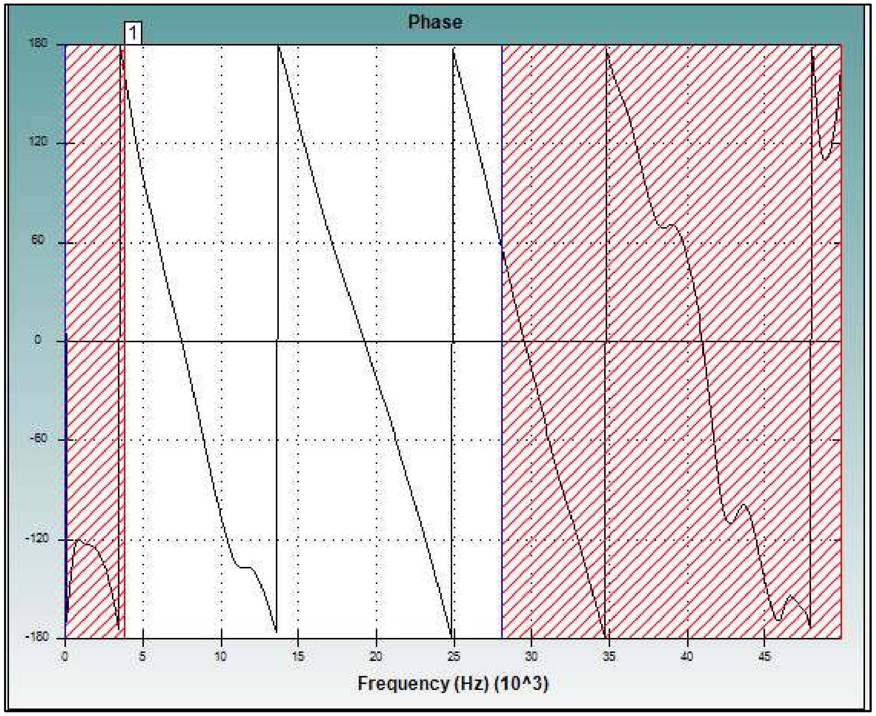




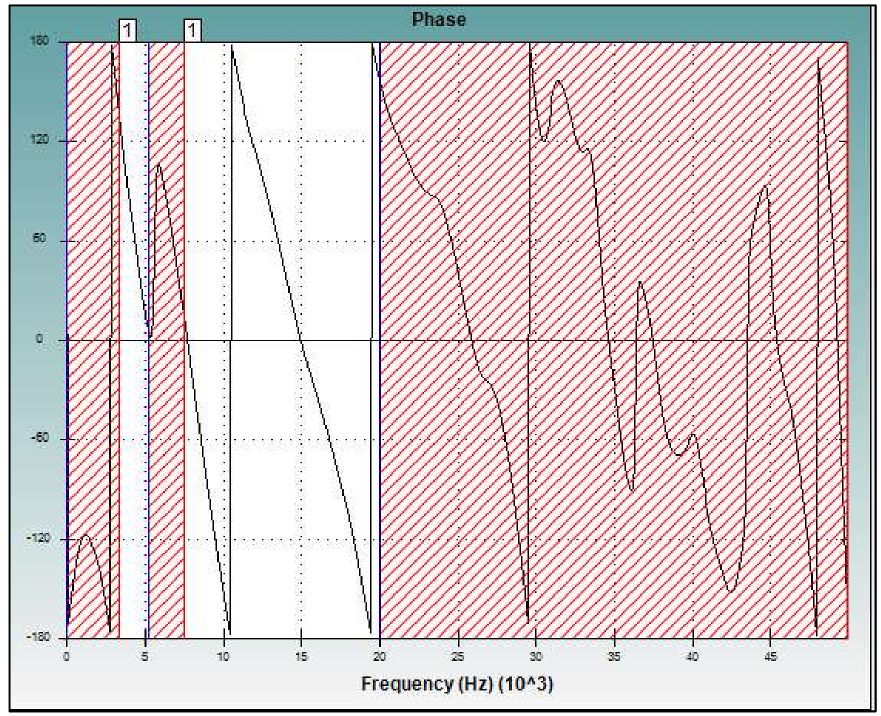
IE NCAT Results Image



Automated SASW Phase Masking



Automated Phase Analysis Works Well

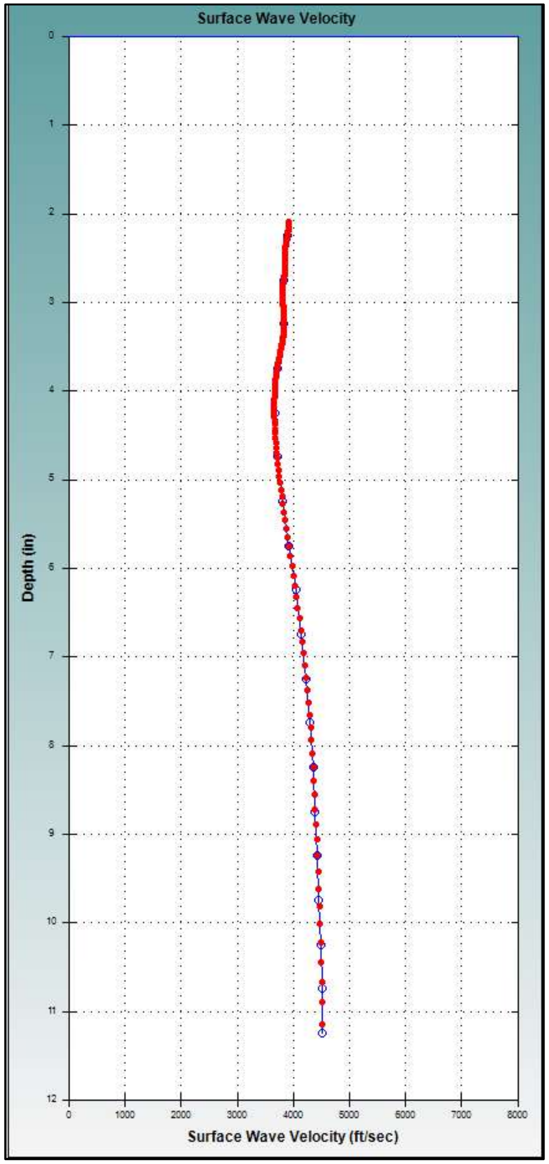


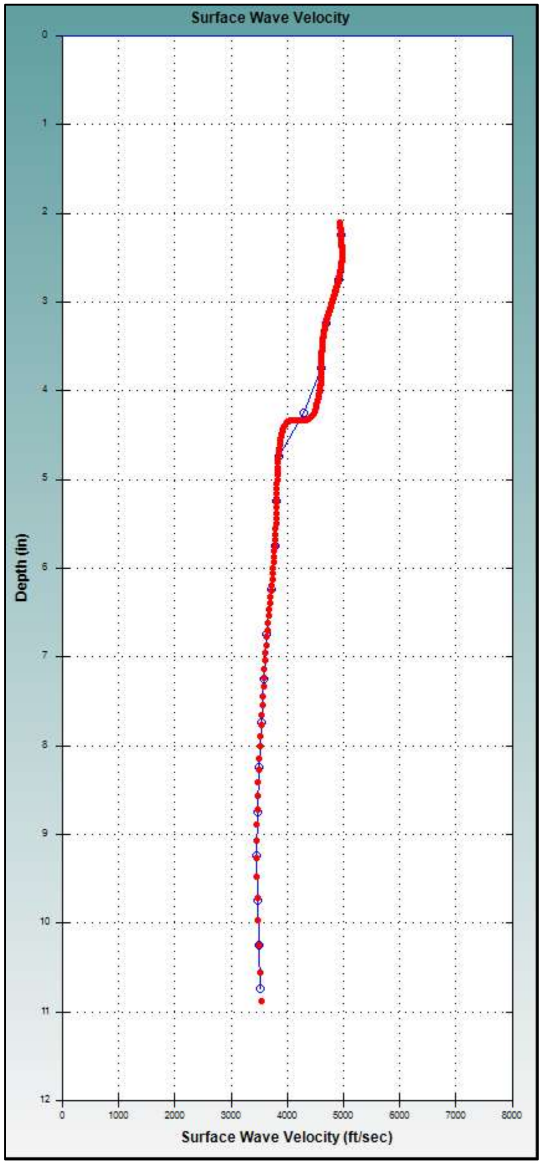
Additional Phase Mask added Manually

Dispersion Curve Interval Averaging

Good Condition

Velocity vs Depth

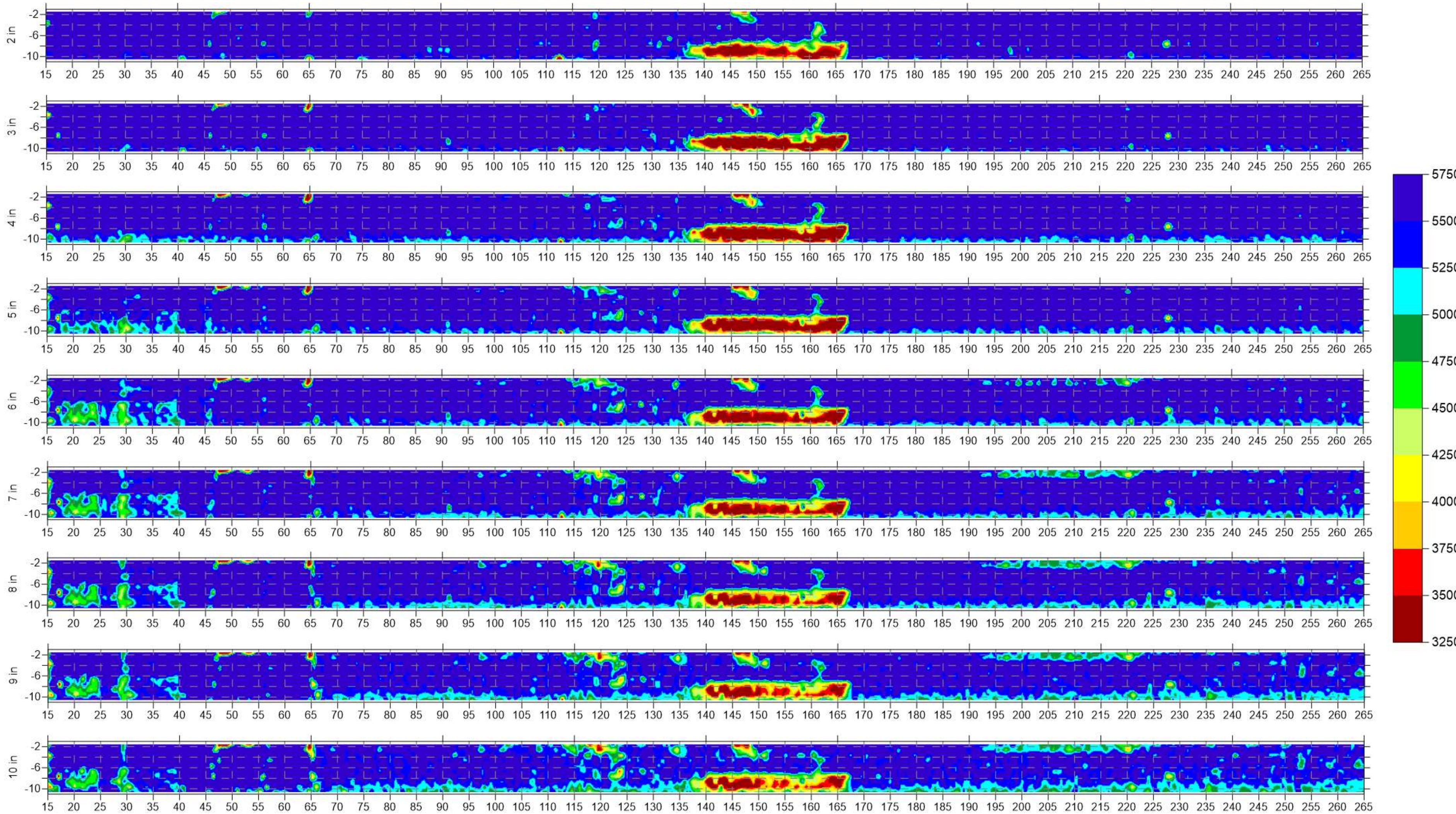




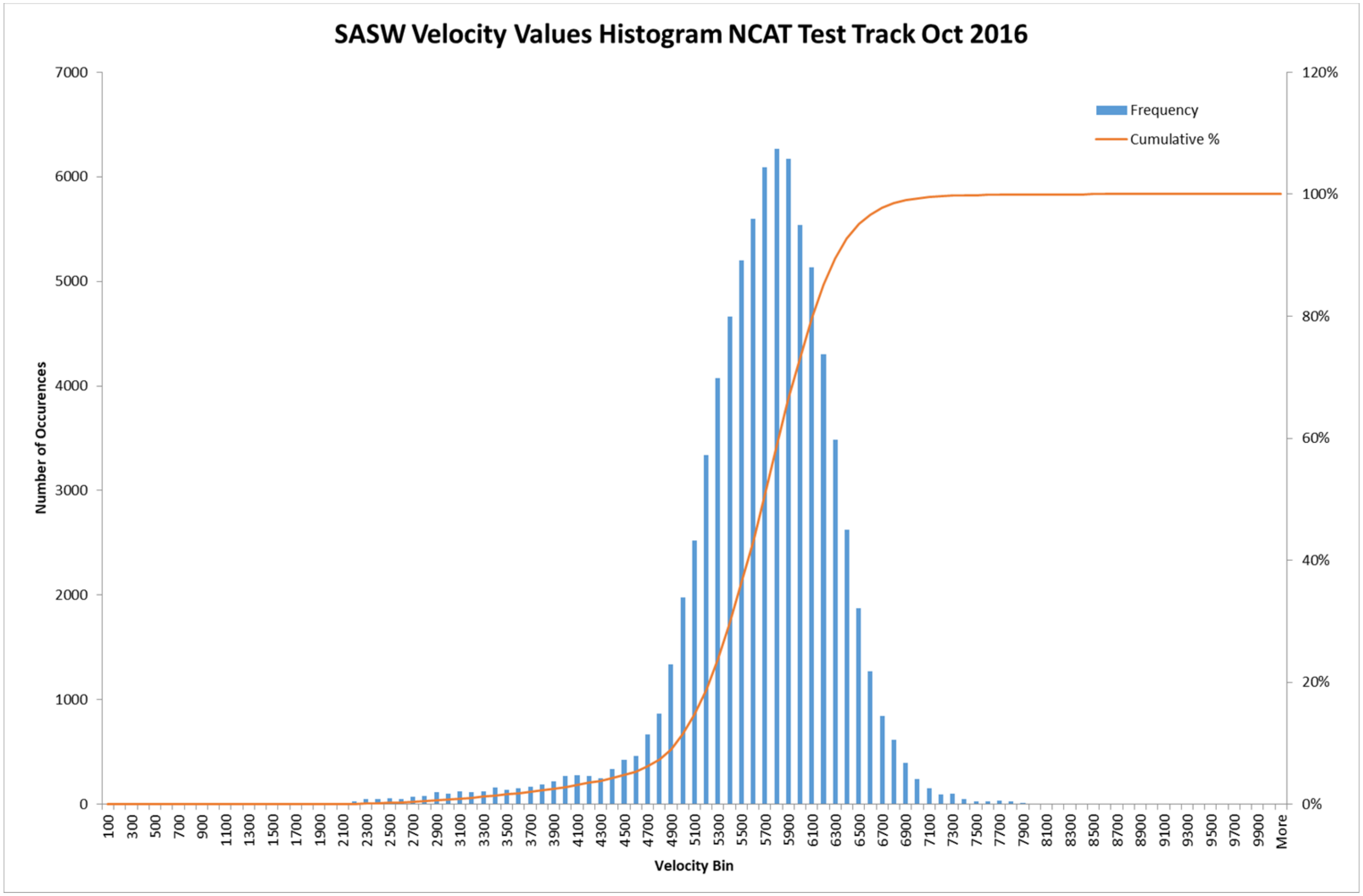
Fair Condition

Velocity Drop @4.5”

Surface Wave Velocity Slices View

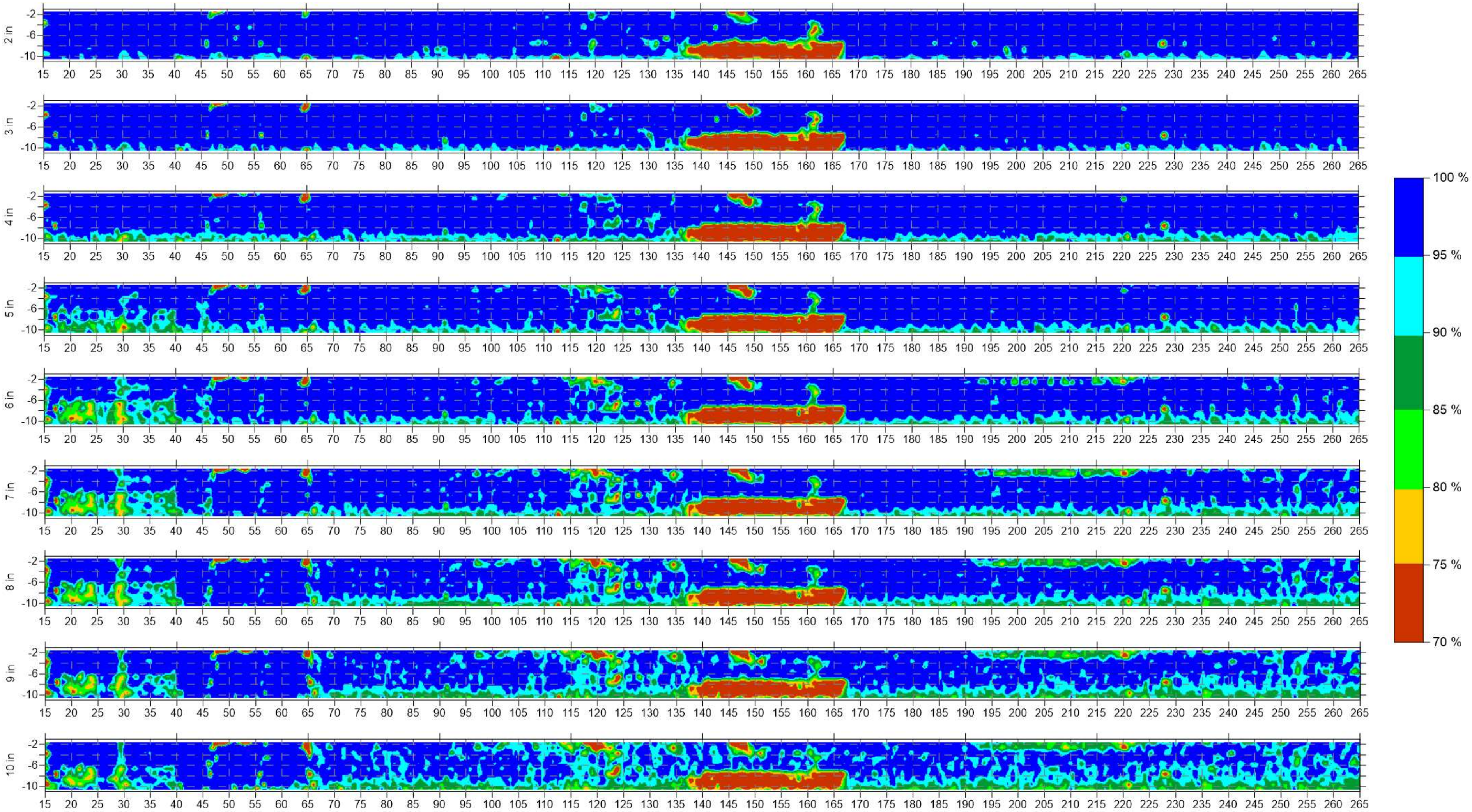


Normalized Velocity Method

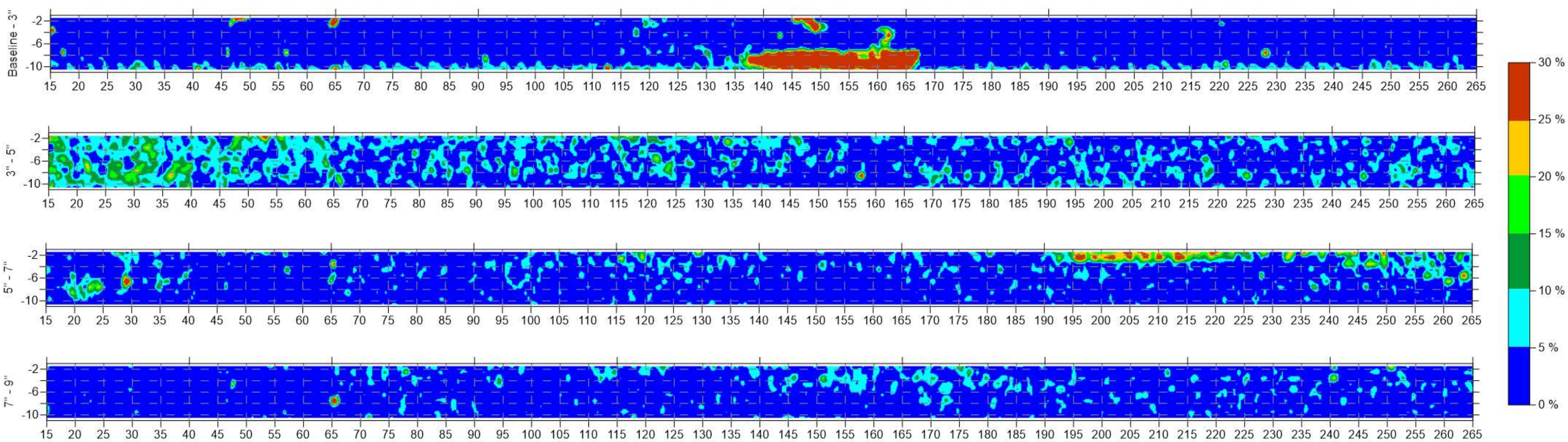


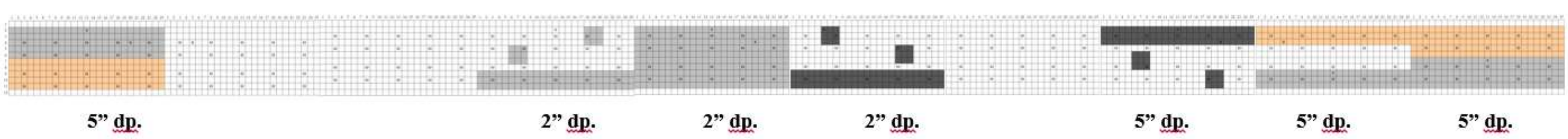
- Most common value between 5700 – 5800 ft/sec

Normalized Velocity Slices View



Depth Difference Slice View





Gray = Bag House Dust

Tan = Paper

Dark Gray = RAP

As Built Conditions

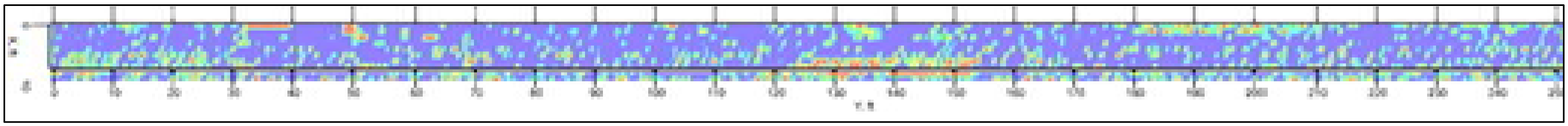
S3 Fully Automated Software In Development

- Utilizes latest high speed processors.
- Bulk data processing techniques.
- Attempting to fully automate data analysis.
  - Would make data analysis accessible to technicians.
- Hope to reduce data processing time by 10 – 100 times.
  - What took a week could be reduced to an hour or less.
  - Would reduce costs of testing.
  - Potential to provide same day test results.

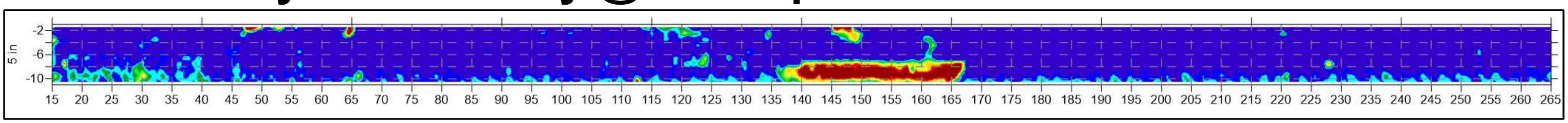
S3 Fully Automated Software In Development

- Promising Initial Results

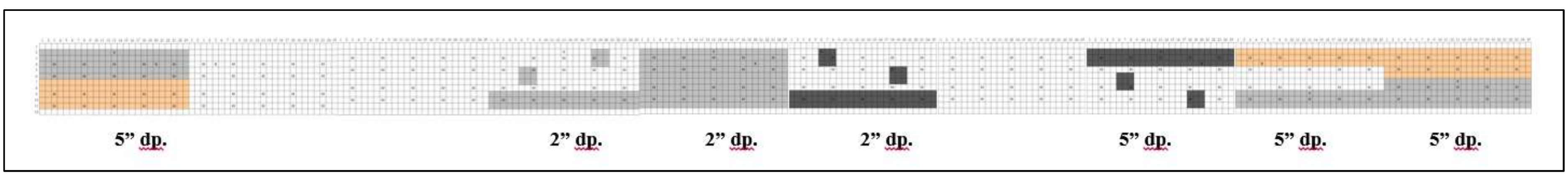
Fully Automated Analysis - Velocity @ 5" deep



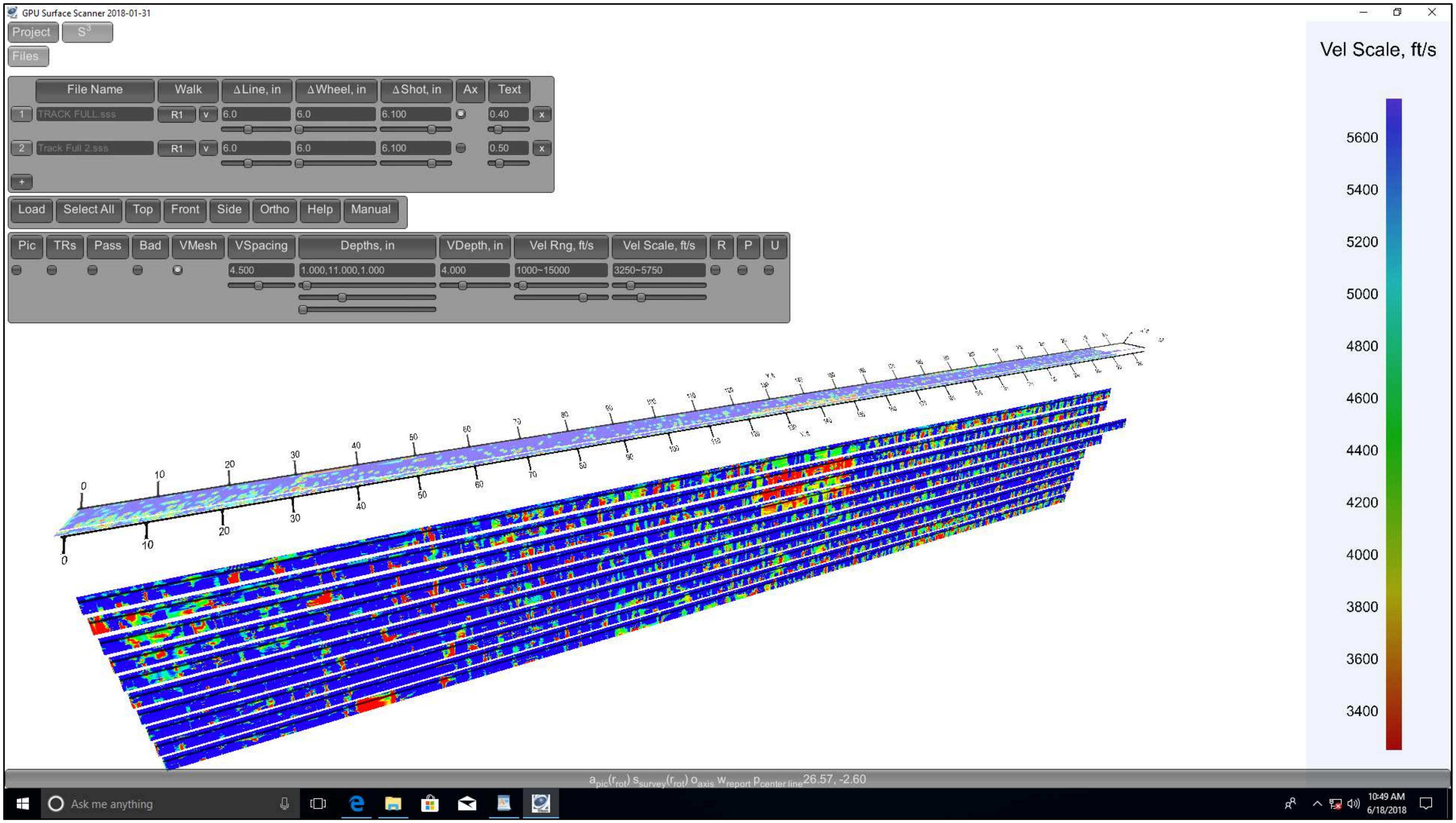
Current Analysis – Velocity @ 5" deep



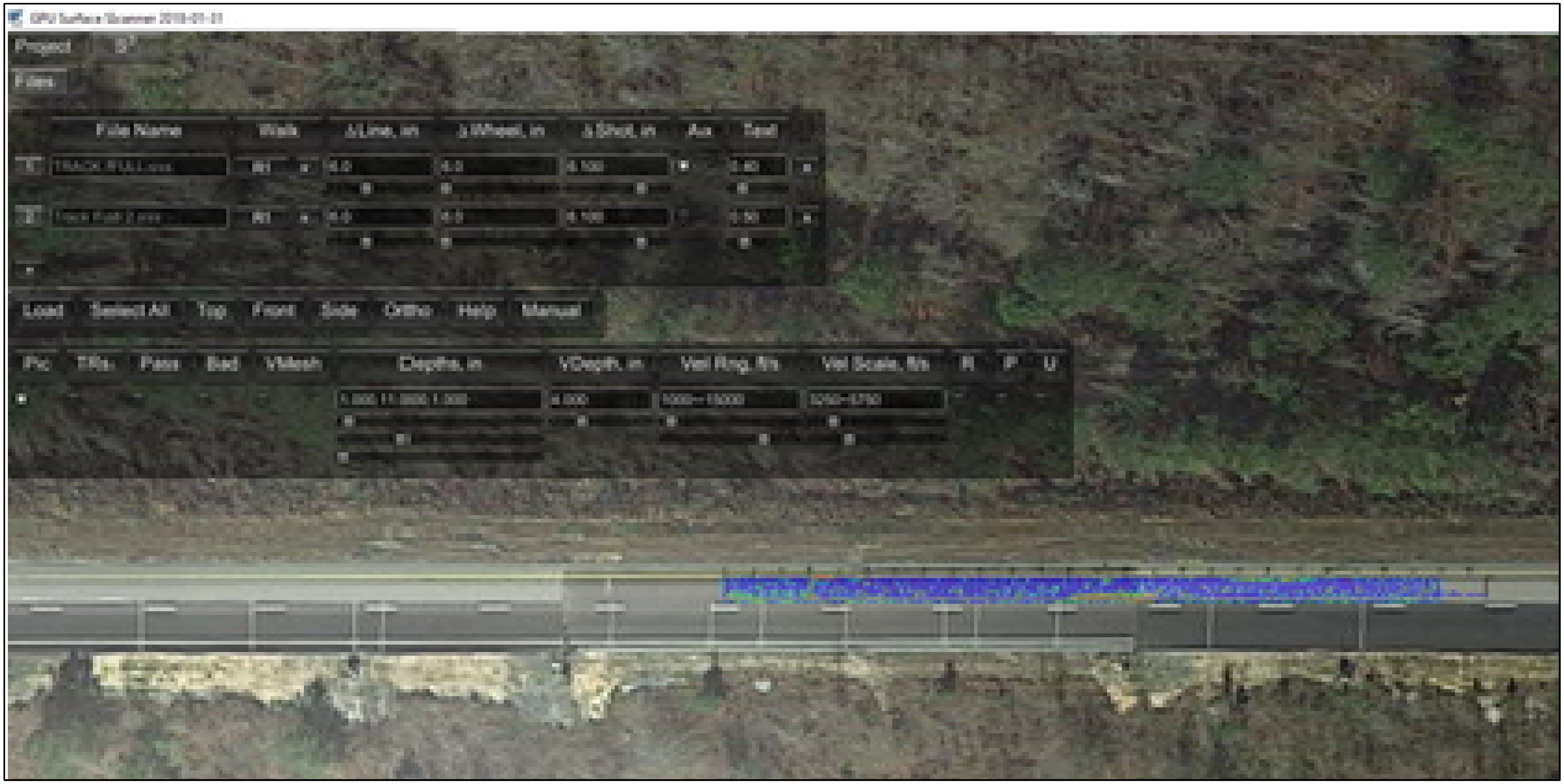
As Built Conditions



S^3 Fully Automated Software In Development



S³ Fully Automated Software In Development



SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Advanced Methods to Identify Asphalt Pavement Delamination (R06D) SASW and IE

Questions and Comments

Michael Heitzman, PE, PhD
Asst. Director
NCAT

Webinar
June 26, 2018

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

R06D Ground Penetrating Radar Webinar

WEBINAR REMINDER!

Proof of Concept: Ground Penetrating Radar

A SHRP2 R06D Webinar

Thursday, June 28, 2018
1:00–2:30pm ET

https://collaboration.fhwa.dot.gov/dot/fhwa/WC/Lists/Seminars/DispForm.aspx?ID=1687

Future R06D Events

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

SHRP2 Peer Exchange

Advanced Methods to Identify Pavement Delamination (R06D)

August 1-3, 2018

https://fs6.formsite.com/Mrussell/form198/index.html

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Photos courtesy: Geop

SHRP2 R06C Technologies to Enhance Quality Control on Asphalt Pavements: Surface Dielectric Profiling System using Ground Penetrating Radar (DPS GPR) Peer Exchange July 31-August 1

For More Information on R06D

Contacts:

Steve Cooper
FHWA Product Lead
stephen.j.cooper@dot.gov

Kate Kurgan
AASHTO Product Lead
kkurgan@aashto.org

Monica Jurado
FHWA Technical expert
monica.jurado@dot.gov

Pam Hutton
AASHTO Program Manager
phutton@aashto.org

Additional Resources:

GoSHRP2 Website:	fhwa.dot.gov/GoSHRP2
AASHTO SHRP2 Website:	http://shrp2.transportation.org
R06D Product Page	http://shrp2.transportation.org/Pages/R06D.aspx

Mike Heitzman
Subject Matter Expert
mah0016@auburn.edu