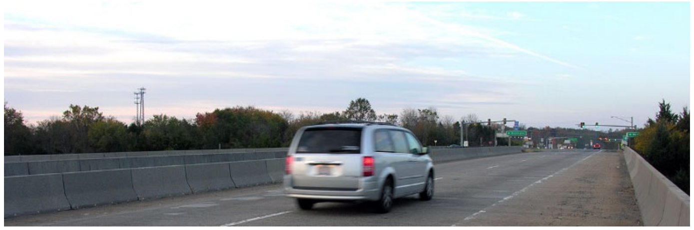
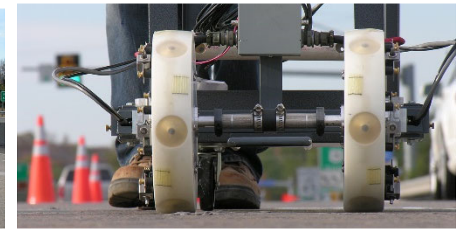


SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Nondestructive Testing Technologies for Concrete Bridge Decks (R06A)

Dennis Sack, Olson Engineering SME
Randy Strain, Indiana Department of Transportation
Corey Withroe, Oregon Department of Transportation
Kathy Crowell, New Mexico Department of Transportation

Webinar
April 30, 2019

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

R06A Webinar Agenda

- AASHTO Introduction
- FHWA Introduction
- NDT of Bridge Decks moving forward
  -Hoda Azari (FHWA)
- R06A NDT background on GPR, Impact Echo
  and Infrared Cameras – Dennis Sack - SME
- State Experiences - Indiana DOT
- State Experiences - Oregon DOT
- State Experiences – New Mexico DOT
- Questions & Answers

Focus Areas

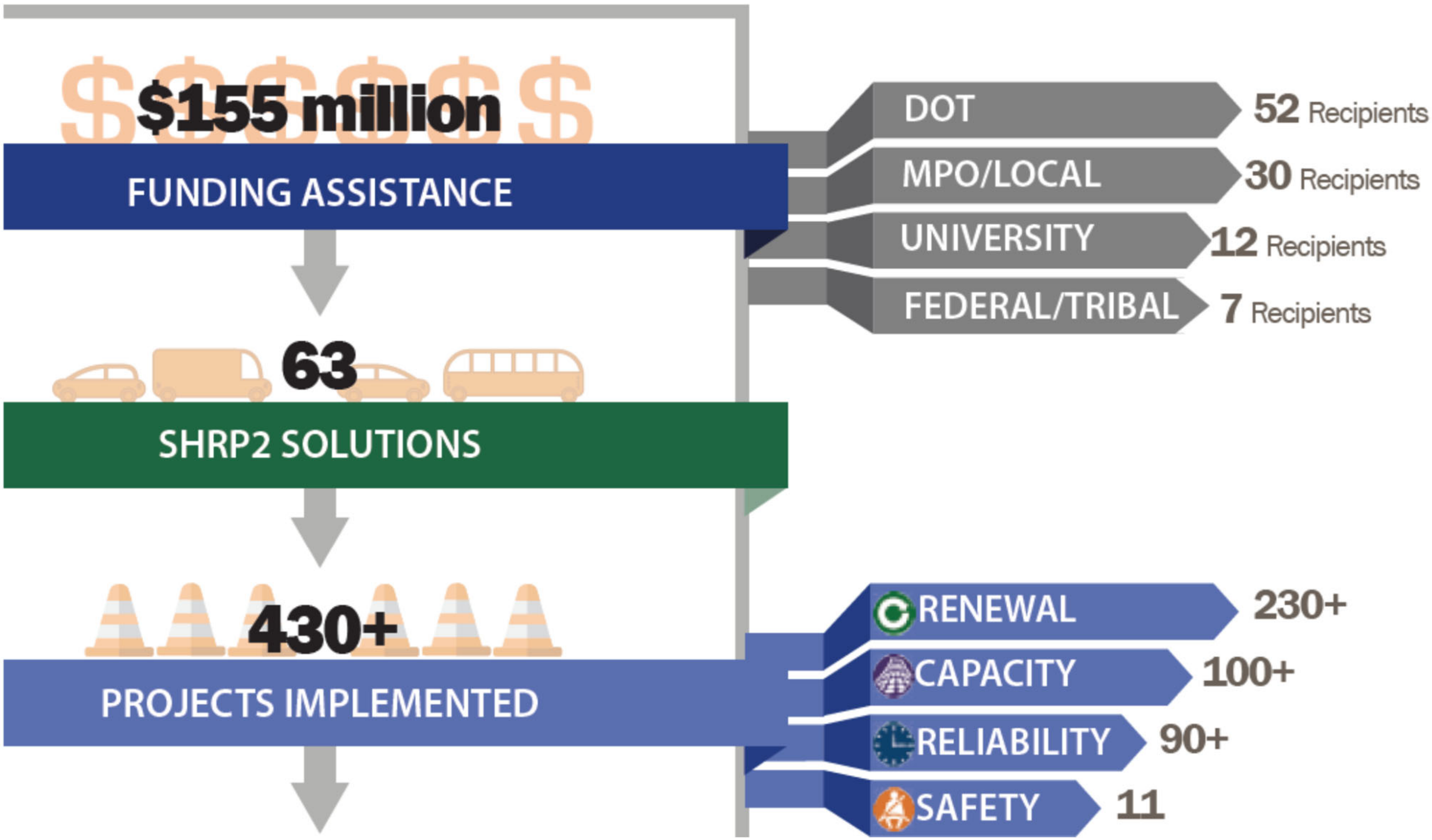
Safety: fostering safer driving through analysis of driver, roadway, and vehicle factors in crashes, near crashes, and ordinary driving

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

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

Hoda Azari, Ph.D.
NDE Research Program Manager
Infrastructure Management Team
Federal Highway Administration
Turner-Fairbank Highway Research Center

SHRP2 R06A
FHWA NDE Program Update

U.S. Department of Transportation
Federal Highway Administration

FAST NDE

SHRP2 R06A Renewal Research

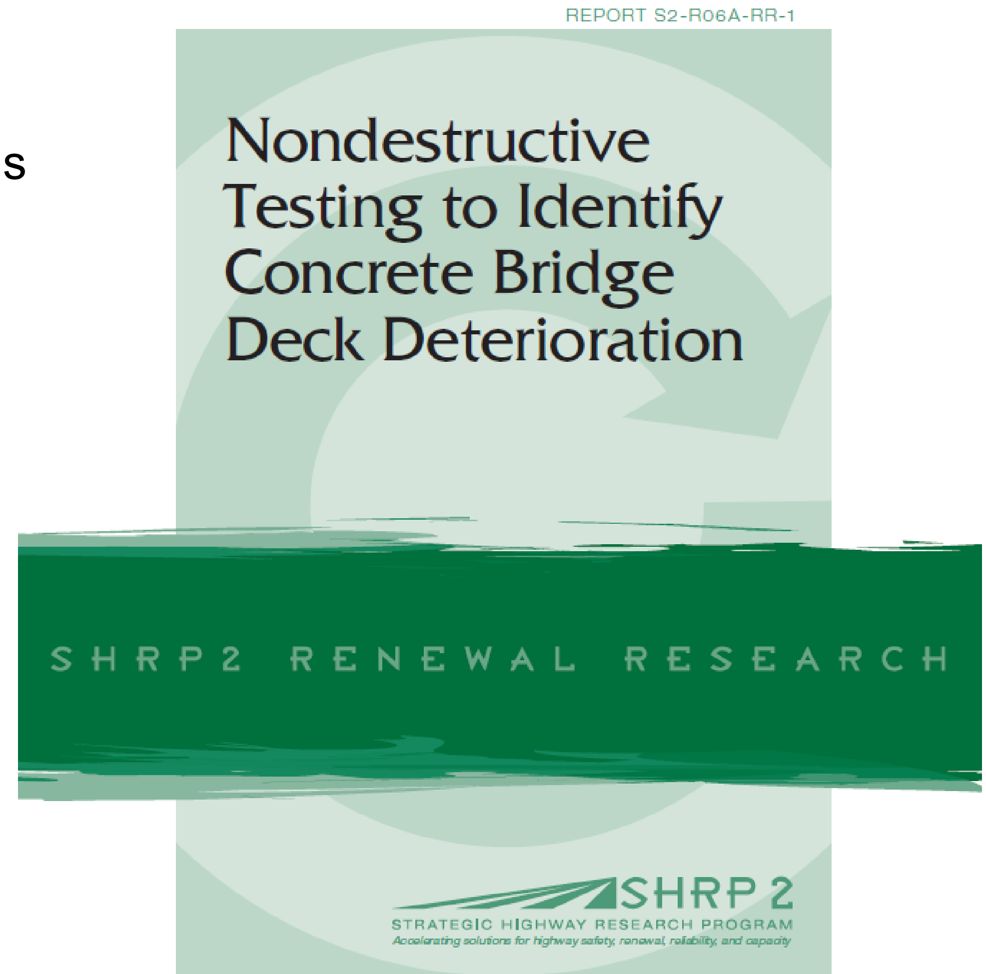
Challenge

- To find non-destructive ways to analysis bridge and tunnel deteriation

Solution

Using technologies such as:

- Ground Penetrating Radar
- Infrared Thermography
- Surface Waves
- Impact Echo



SHRP2 R06A Implementation

Round 4 had 8 State DOT awards and Round 7 had 14 State DOT awards. The support consisted of:

- Technical Assistance

for Rounds 4 and 7

- Field visits and training

for State DOT's

- Peer Exchange workshop in

Portland Oregon Jan. 30, 2019

R06A Round 4 for Bridges

- Round 4 states for R06A began in 2014.
  - Louisiana
  - Virginia
  - Indiana
  - Iowa
  - Florida
  - Pennsylvania
  - Oregon
  - Missouri

R06A Round 7 for Bridges

- 14 states completed their Round 7 testing, validating, and purchasing of various NDT technologies like Infrared Cameras and GPR.
  - Alabama
  - Arkansas
  - Delaware
  - Georgia
  - Hawaii
  - Iowa
  - Kentucky
  - North Carolina
  - California
  - North Dakota
  - Nebraska
  - New Mexico
  - New York
  - Oregon

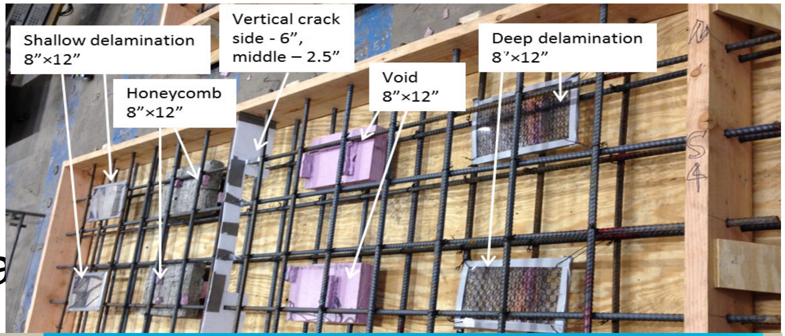
Ongoing Projects

- Technology Evaluation:

NDE techniques on bridge decks with overlay

Conventional and Phased-array UT for Steel a

Unmanned Arial System (UAS)



- Technology Development/Enhancement:

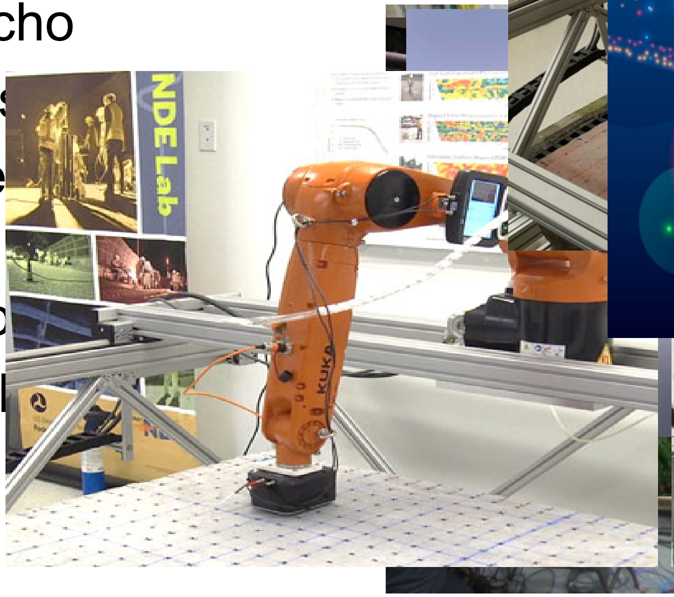
Non-contact impact echo

Magnetic NDE for pres

Magnetic NDE for inte

Use of high resolution damage detection of b

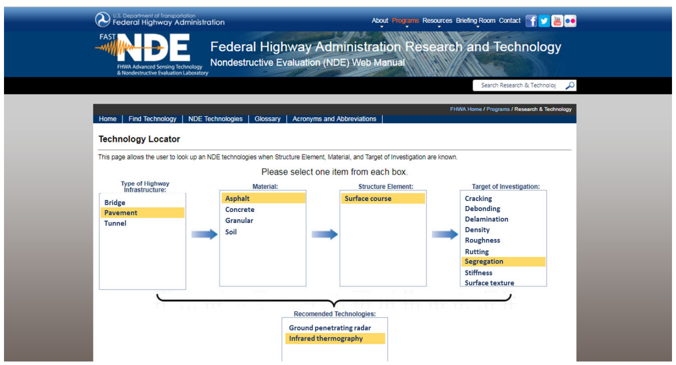
Data fusion and visual

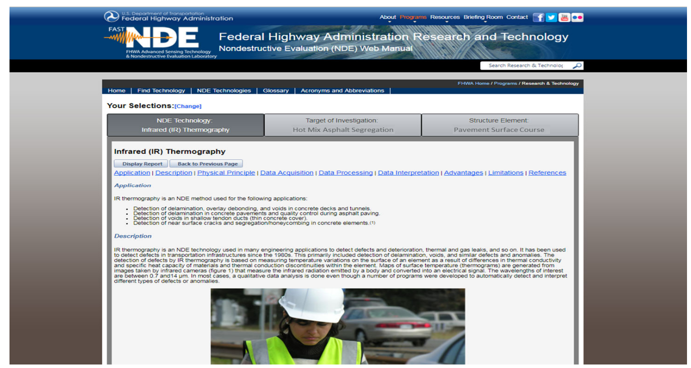


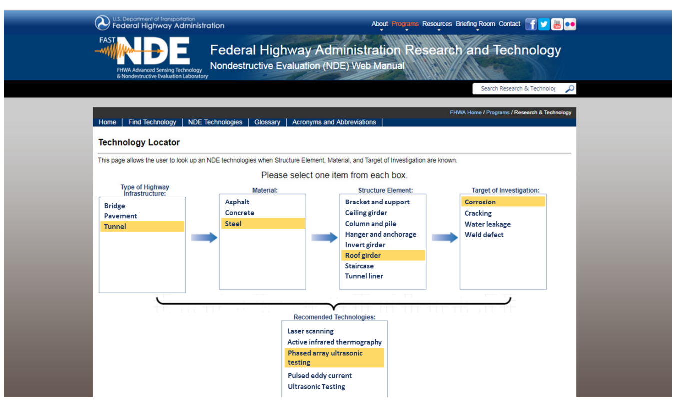
FHWA Resources to States

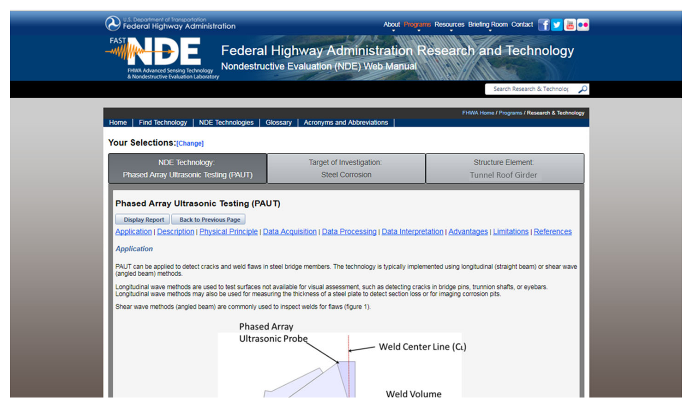
NDE Web Manual

- Provide concise and unbiased guidance to help practitioners identify the NDE technologies that can serve their specific need.
- URL: https://fhwaapps.fhwa.dot.gov/ndep/



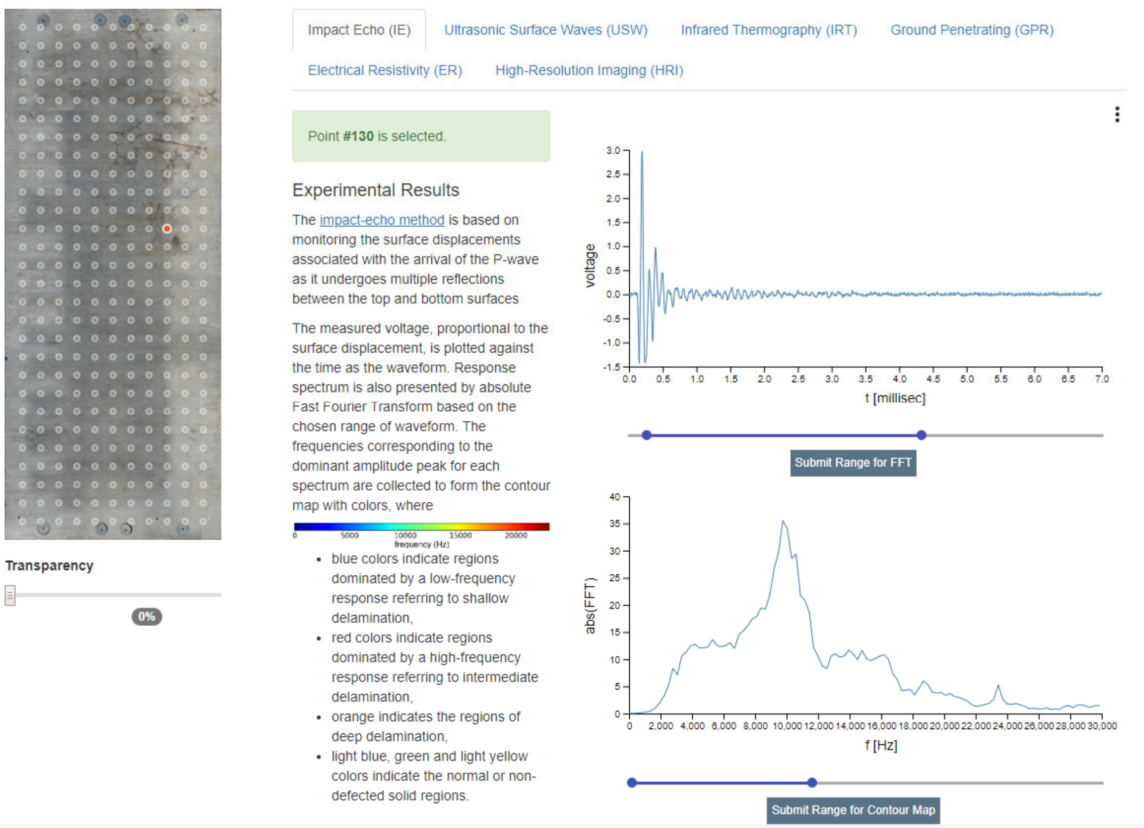




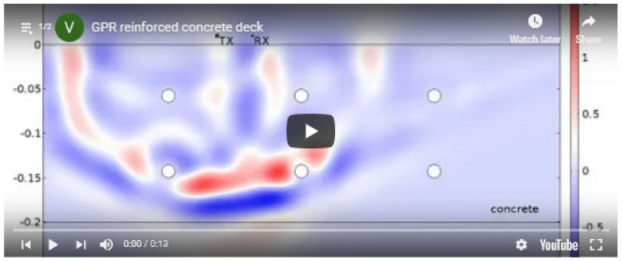


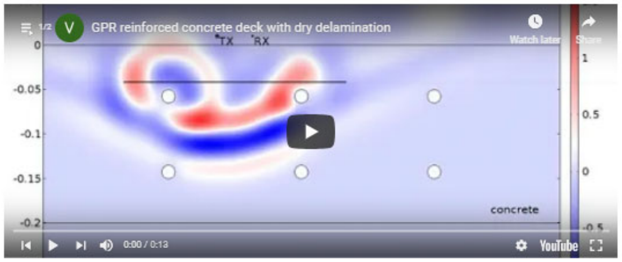
Virtual NDE Lab

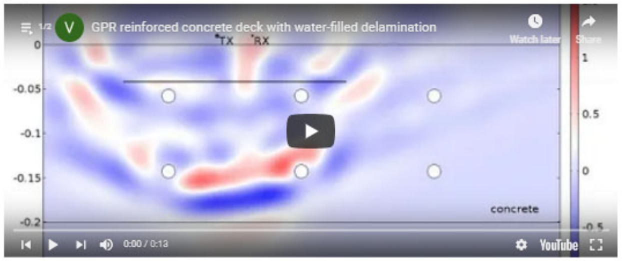
Interactive Data Portals



Simulation Portals

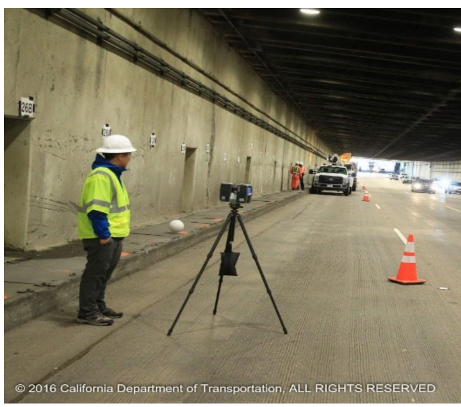


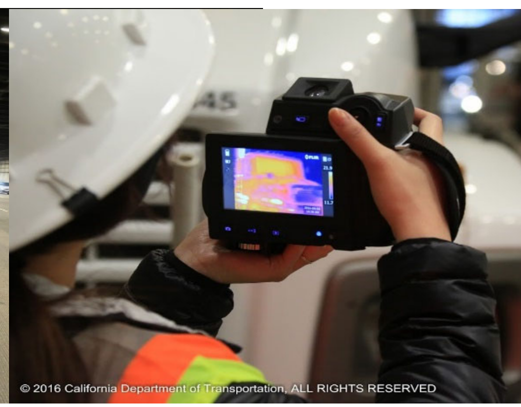




Technical Assistance

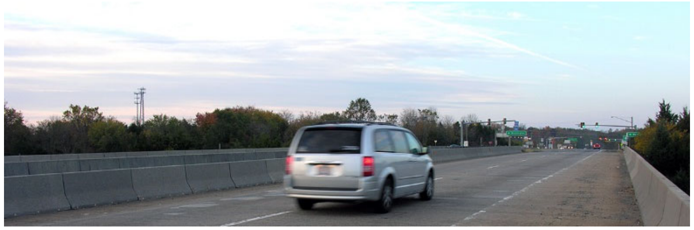
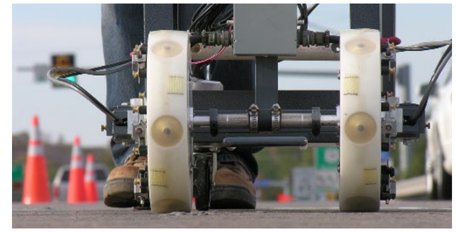
- Piece of concrete falls off Bay Bridge tunnel in Feb 2016
- Request From Caltrans for independent validation of sounding results





Moving Forward

- Potential pooled fund projects:
  - Integrating NDE Technologies into condition rating and asset management
  - Documenting NDE best practices and owner-defined return on investment
  - Further advancing and improving the NDE technologies
  - Developing AASHTO specification on data collection and analysis of NDE technologies
  - Developing training and education material for NDE technologies

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

NDT Methods for Bridge Decks Summary and Discussion

Dennis A. Sack, P.E.
Larry D. Olson, P.E.
Olson Engineering

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Challenge: Evaluating the Full Range of Deterioration Types

Deterioration of Interest

- Delamination
- Corrosion
- Vertical cracking
- Degradation

NDT Technologies of SHRP2 R06A

NDT Technique	Mode of Deterioration Detected	System	Resolution	Lane Closure
IE	1) Deeper cracks - top and bottom rebar mat 2) Shallow delaminination 3) Concrete degradation - ASR/DEF - Freeze thaw	1) Scanning 2) Point by Point	High Grid size	Yes Yes
GPR	1) Corrosion 2) Cracks (if filled with deicing salt) 3) Concrete degradation	1) Air coupled 2) Ground coupled	Lower High	No Yes
IR	Shallow delamination - Top and bottom	1) Truck mounted 2) Handheld	High High	No Yes
Resistivity	Corrosion	Point by Point	Grid size	Yes
Half Cell/GP	Corrosion	Point by Point	Grid size	Yes
Slab IR	Cracks	Point by Point	Grid size	Yes
SASW	1) Vertical cracks 2) Concrete degradation	1) Scanning 2) Point by point	High Grid size	Yes Yes

Vs.

Sounding	Only shallow delamination	Manual		Yes

Most Commonly Used NDT Methods Based on SHRP2 Work

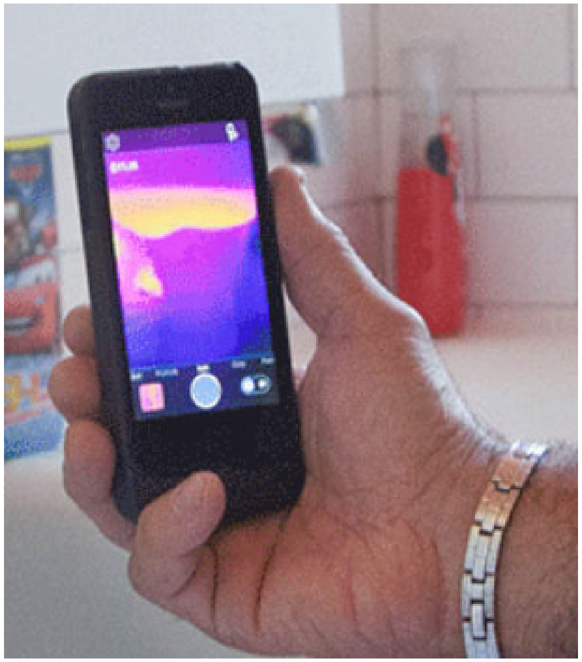
- Ground Penetrating Radar (GPR)
- Infrared Thermography (IR)
- Impact Echo and Impact Echo Scanning (IE and IES)
- Scanning Spectral Analysis of Surface Waves (SASW)
  - **(for asphalt overlaid concrete)**

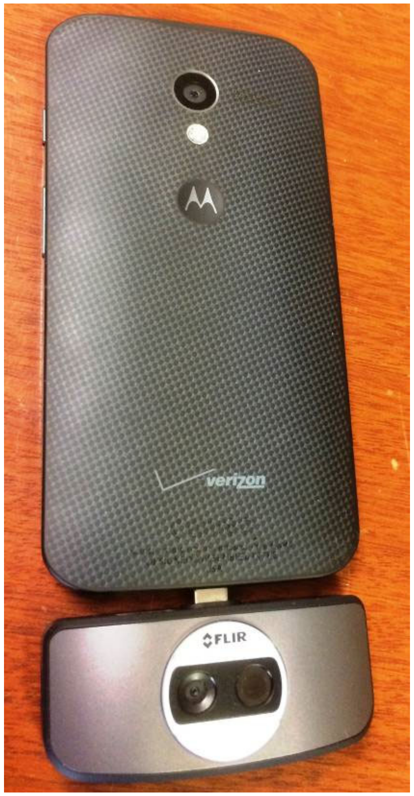
Infrared Thermography Testing

- Most commonly performed on concrete and concrete overlaid bridge decks
- Can detect delaminations at only the top rebar mat (unless done from the deck bottom)
- Cannot "see" through debonded overlays
- Not sensitive to rebar or chlorides in concrete (results will often NOT match GPR results)
- Results will generally show larger areas of delamination and incipient delamination compared to chain dragging
- Requires correct thermal environment to be effective (results affected by shading, weather, time of day, etc.)

IR Testing Performed on a Bridge Deck

Infrared Imaging with Low-Cost Hand-held IR Camera

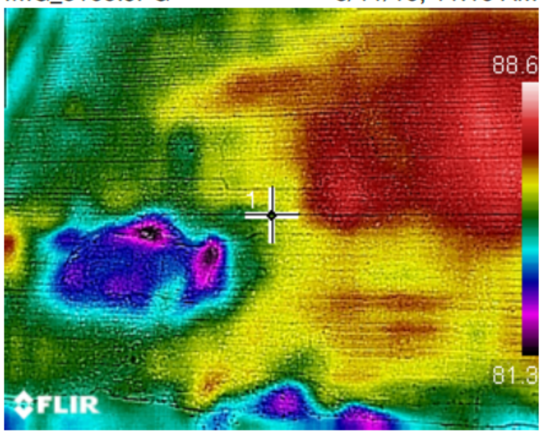




- FLIR-1 Hand-Held IR Cameras

Hand-Held IR Examples

IMG_3105.JPG 8/11/16, 11:16 AM



IMG_3105.JPG 8/11/16, 11:16 AM

MEASUREMENTS (°F)

Spot	85.6

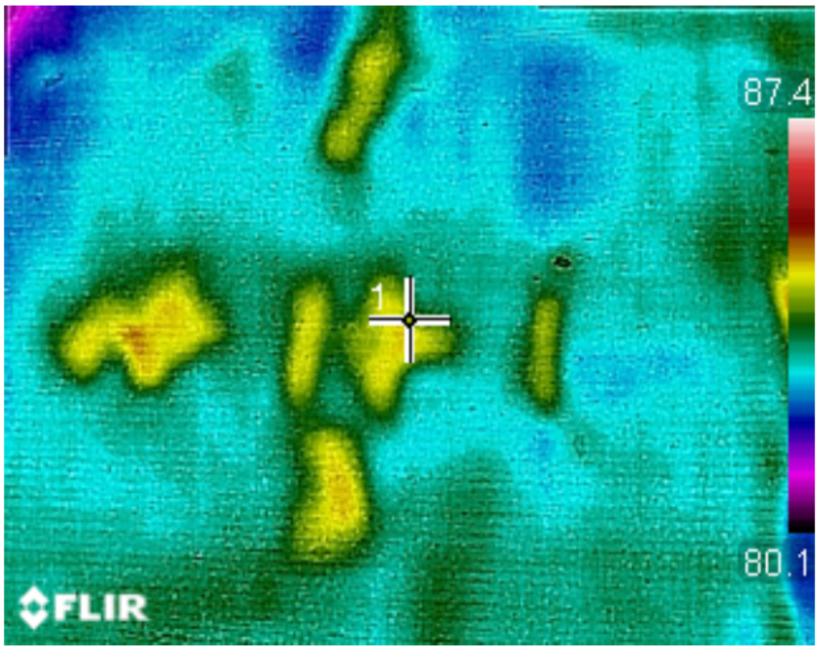
PARAMETERS

Emissivity	0.95
Refl. temp.	68.0 °F
Distance	3.28 ft
Relative humidity	50 %
Atmospheric temperature	68.0 °F
Transmission	0.94
Lat.	N 41° 49.72'
Long.	W 93° 34.73'

- Deck Spall and Nearby Delamination

Hand-Held IR Examples

IMG_3103.JPG 8/11/16, 11:05 AM



IMG_3103.JPG 8/11/16, 11:05 AM

- Deck Paint Marks PLUS Nearby Small Delaminations (above and below paint)

IR Bridge Inspection Planner Web Tool

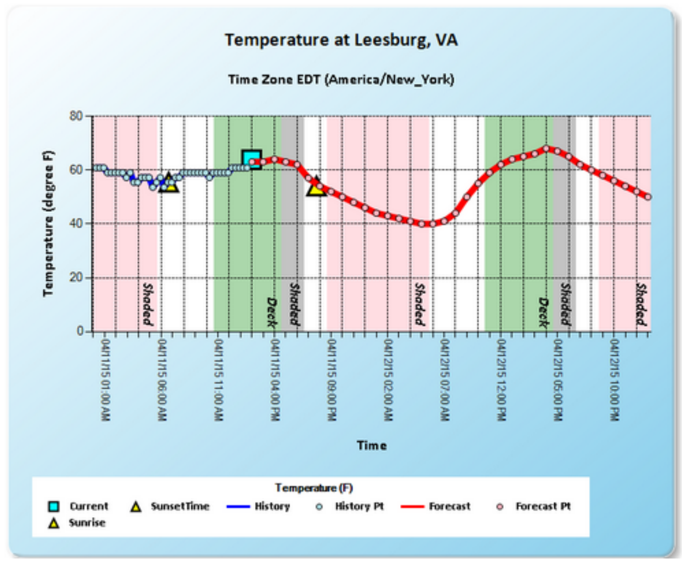
TPF-5(247) Thermography Project Phase II

IR Bridge Inspection Planner (IR BIP)

Auto Locate

Current Location: Leesburg, VA

Current Conditions	Deck Daytime	Shaded Daytime	Shaded Nighttime
			
Inspection Window	4/11/2015 10:39:00 AM to 4/11/2015 4:39:00 PM	4/11/2015 10:39:00 AM to 4/11/2015 6:39:00 PM	4/11/2015 8:43:00 PM to 4/12/2015 5:43:00 AM
Time until Inspection (hh:mm)	03:20	03:20	06:44
Time left to Inspect (hh:mm)	02:40	04:40	09:00
Temperature Increase/Decrease 6 Hr After/Before Sunrise/Sunset(Degree F)	N/A	+5.4	-9.0
Past 3hr Temperature Change (degree F/Hr)	+0.8	+0.8	+0.8
Temperature Change Maximum (degree F)	N/A	10.4	-24
3 Hr Windspeed Average (mph)	+15.3	N/A	N/A



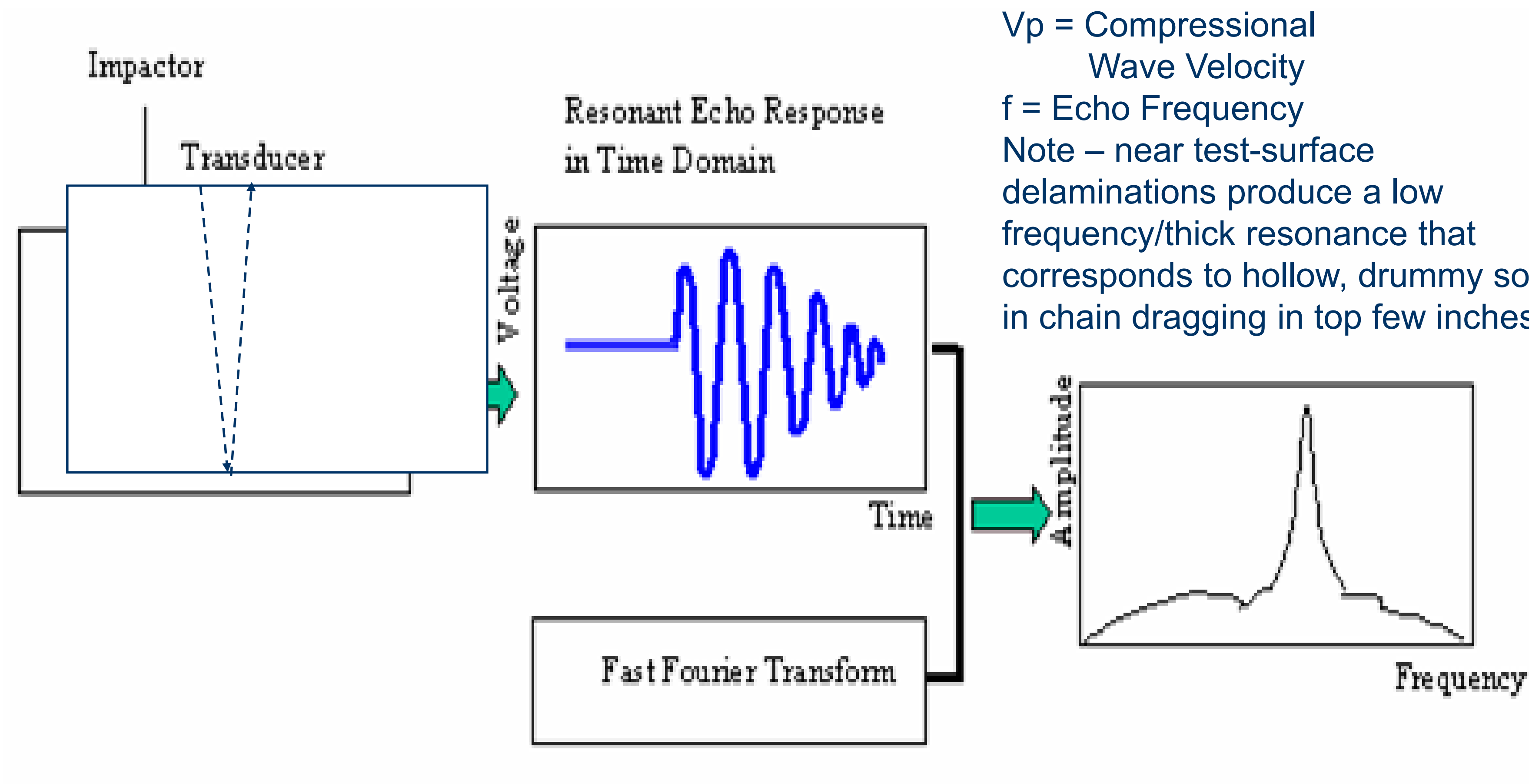
http://www.fuchsconsultinginc.com/FCIWeatherChecker1.aspx

Impact Echo Testing

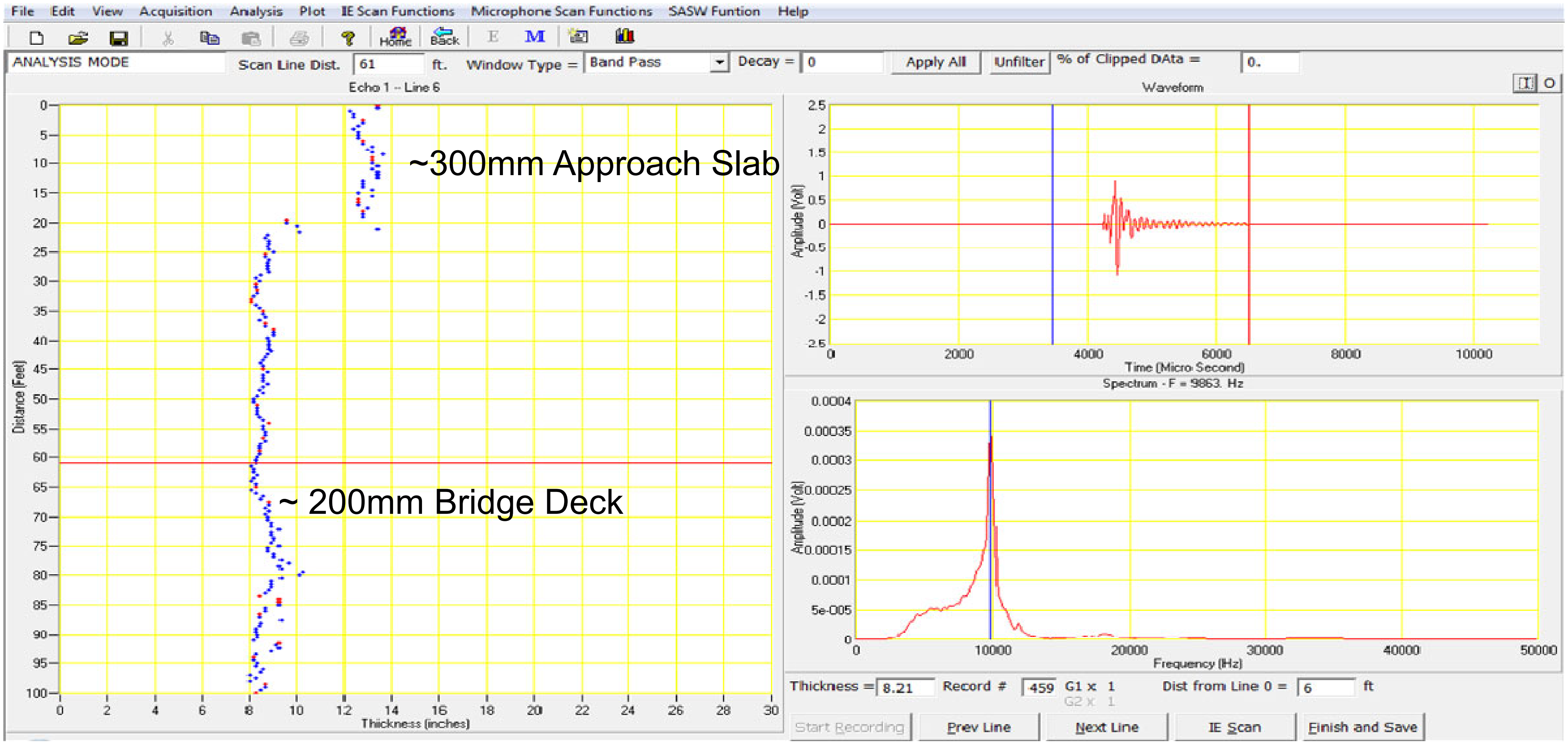
- Most commonly performed on concrete and concrete overlaid bridge decks
- Can detect delaminations at BOTH the top and bottom rebar mats when testing from the top
- Cannot “see” through debonded overlays
- Not sensitive to rebar or chlorides in concrete (results will often NOT match GPR results)
- Results will generally show larger areas of delamination and incipient delamination compared to chain dragging

Impact Echo Test for Delamination/ Cracking/Thickness of Decks

D = bVp/(2*f)
b= Shape Factor (0.96 for slab)
D = Thickness
Vp = Compressional
Wave Velocity
f = Echo Frequency
Note – near test-surface delaminations produce a low frequency/thick resonance that corresponds to hollow, drummy sound in chain dragging in top few inches



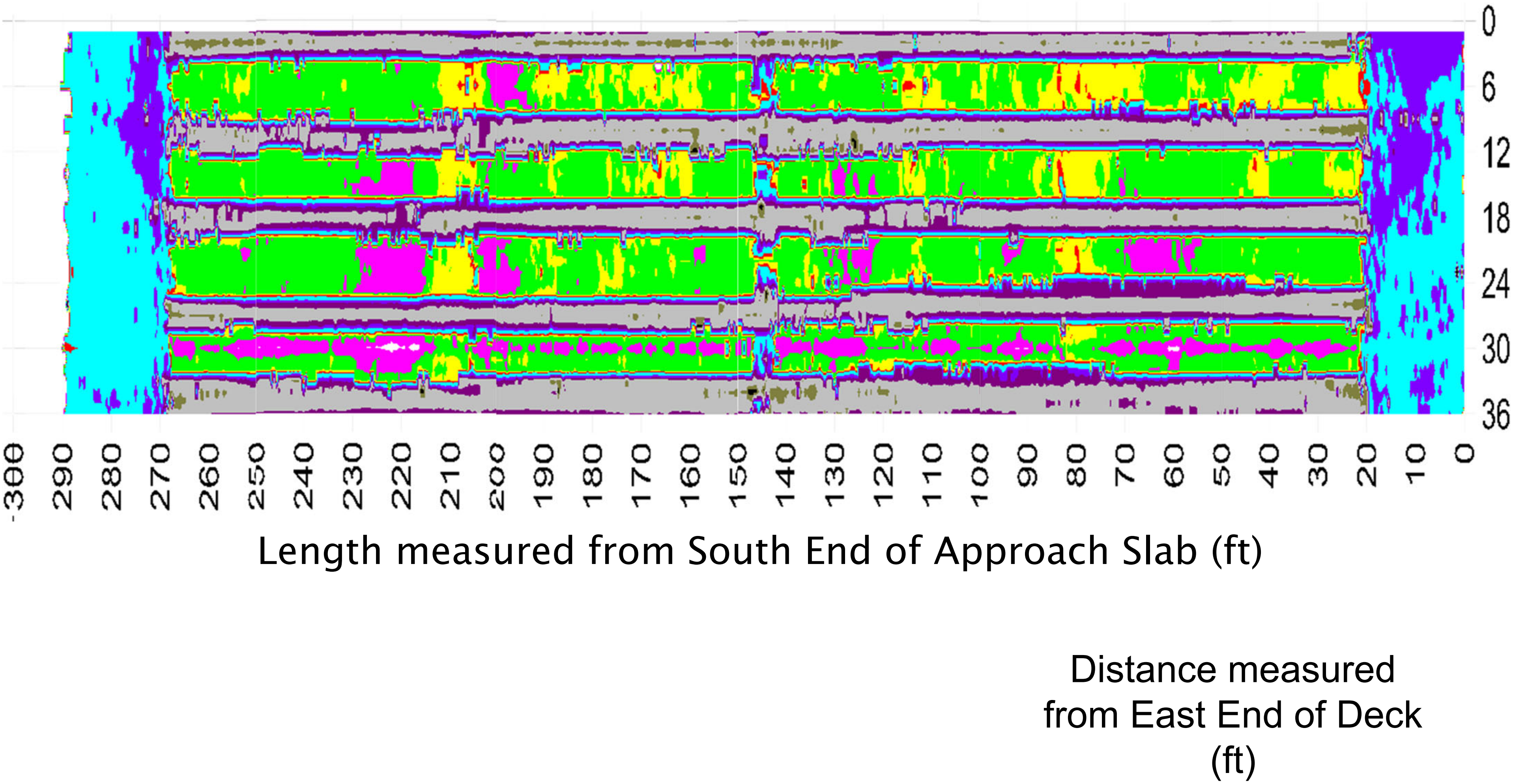
Sample Single IE Scanning Line Result



IE Thickness Plot vs. 100 ft Distance for a scan line on a bridge deck

Time Domain IE Signal at left cursor (Top Plot) and Frequency Domain Echo Depth Resonance=8.3 inches (Bottom Plot)

Overall IE Scanning Result Map from a Bridge Deck – Showing Beams and Deck Areas

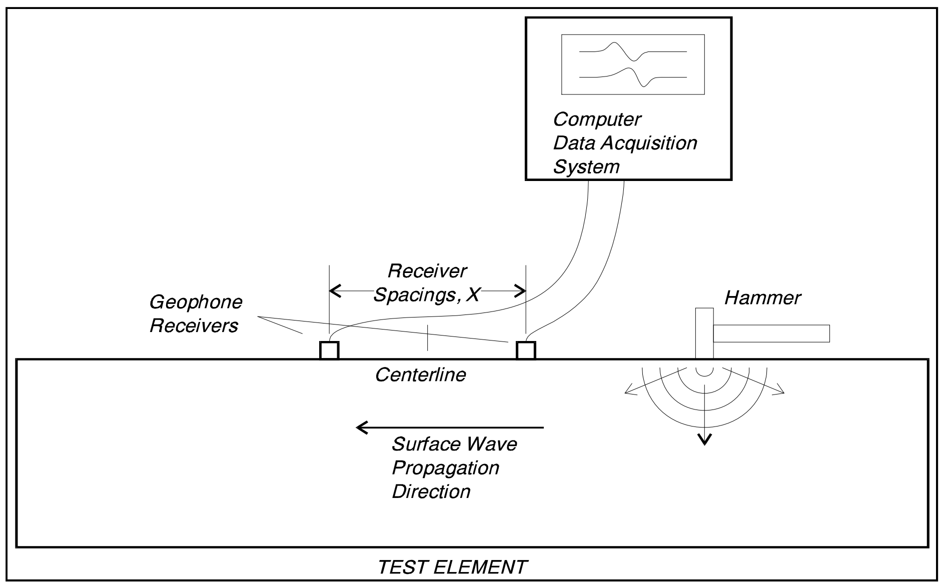


SASW Testing

- Most commonly performed on asphalt-overlaid bridge decks
- Can detect delaminations in concrete under asphalt
- Requires accurate asphalt thickness information for best results

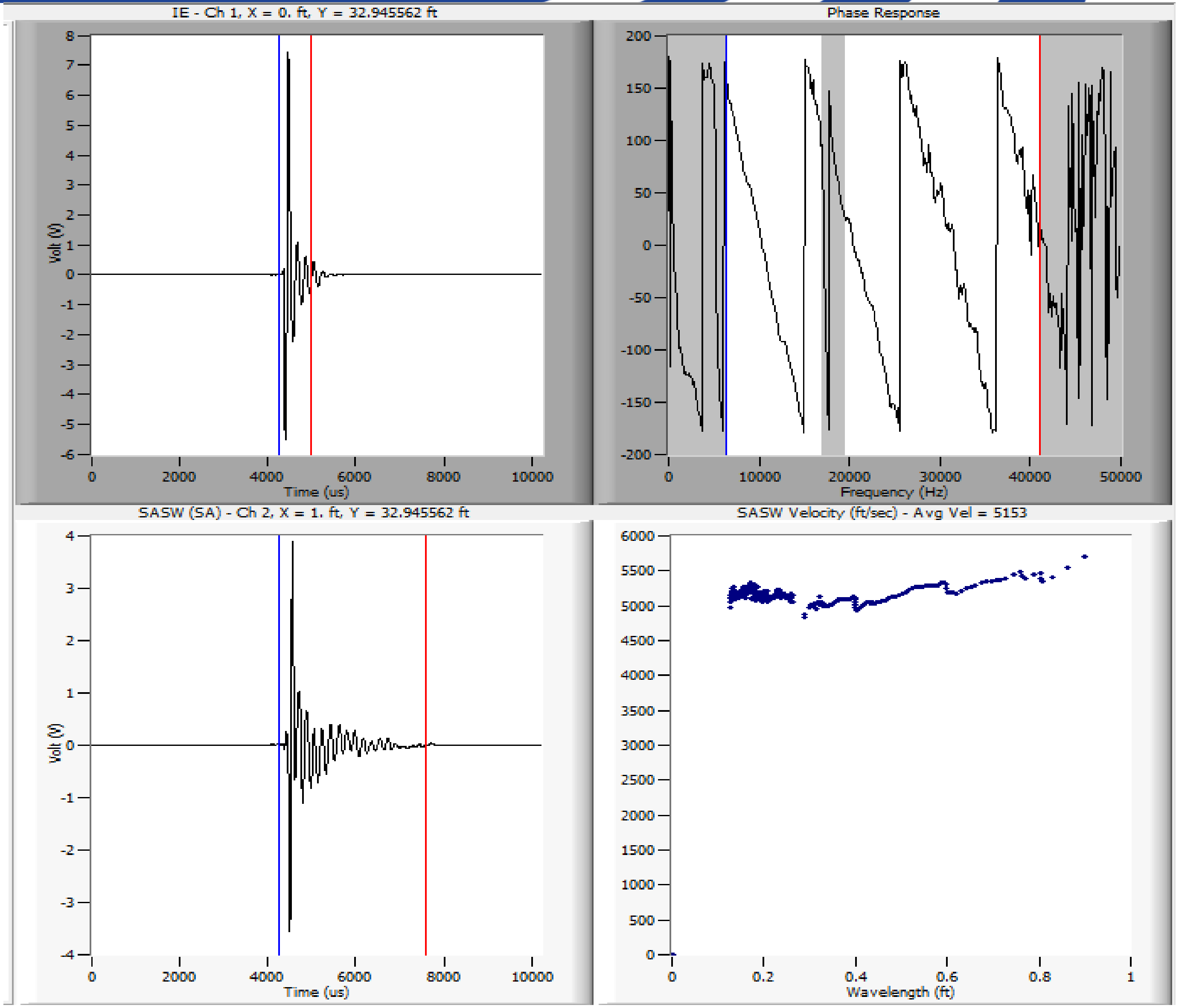
Spectral Analysis of Surface Waves Method (SASW)

- **Acoustic method – measures the propagation speed of surface waves with various wavelengths**
- **Short wavelength waves sample shallow, longer wavelengths sample deeper**
- **Allows the measurement of the velocity profile versus depth into the structure, which can be related to the strength and condition of the concrete versus depth**

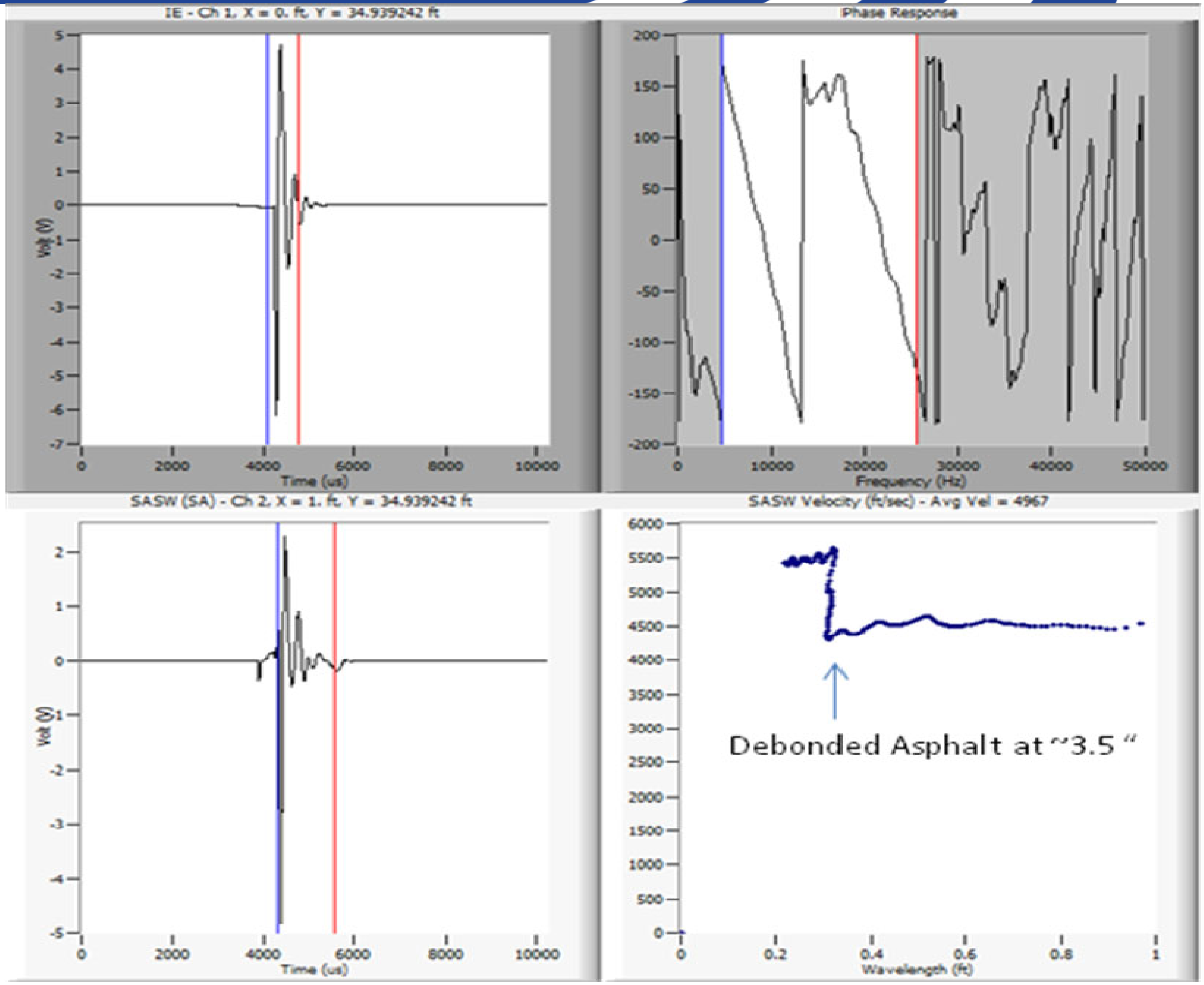


Bridge Deck Scanner with IE/SASW on Cart on Virginia Asphalt Overlaid Deck

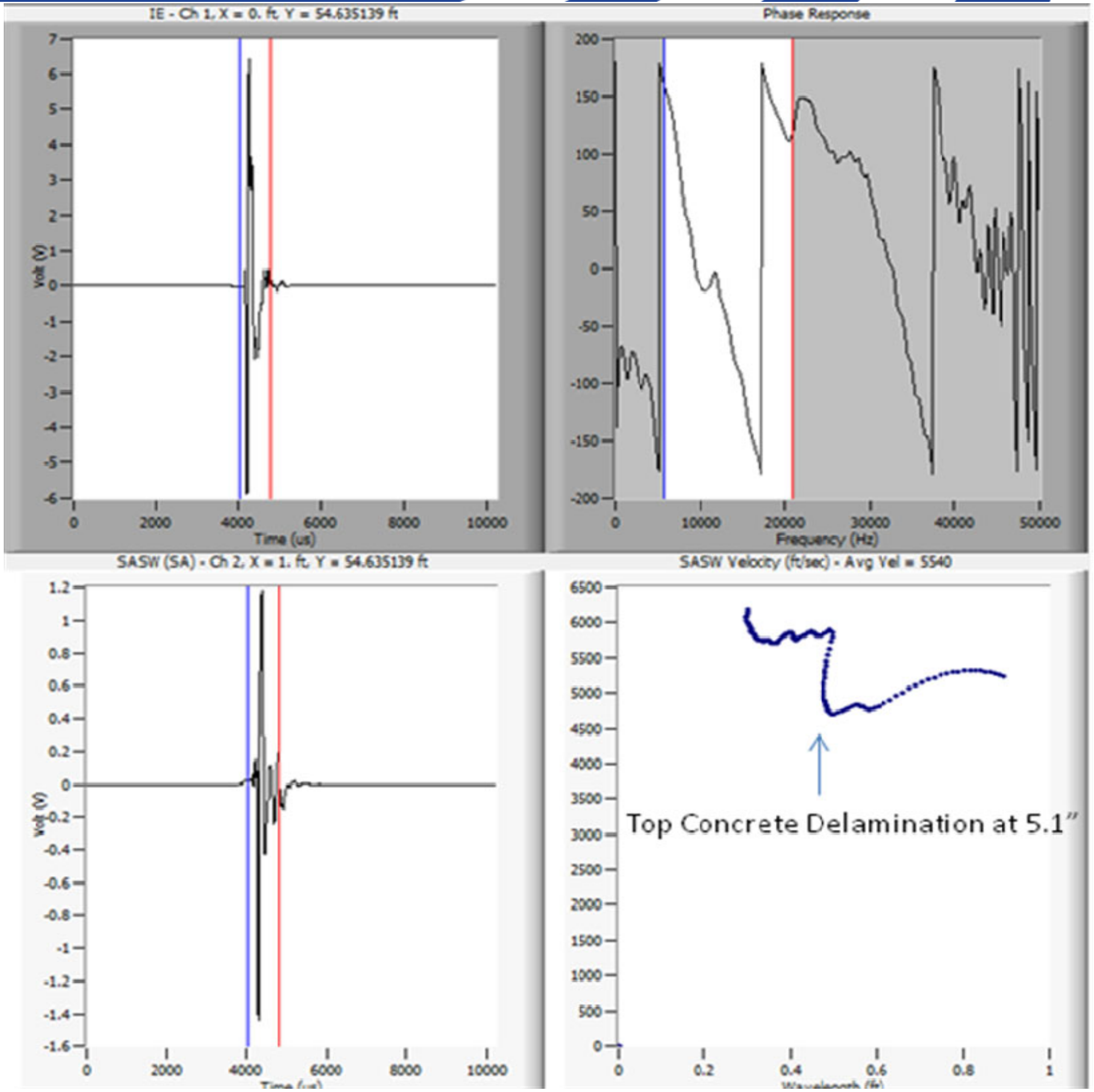
Findings – Bonded Asphalt on Sound Concrete



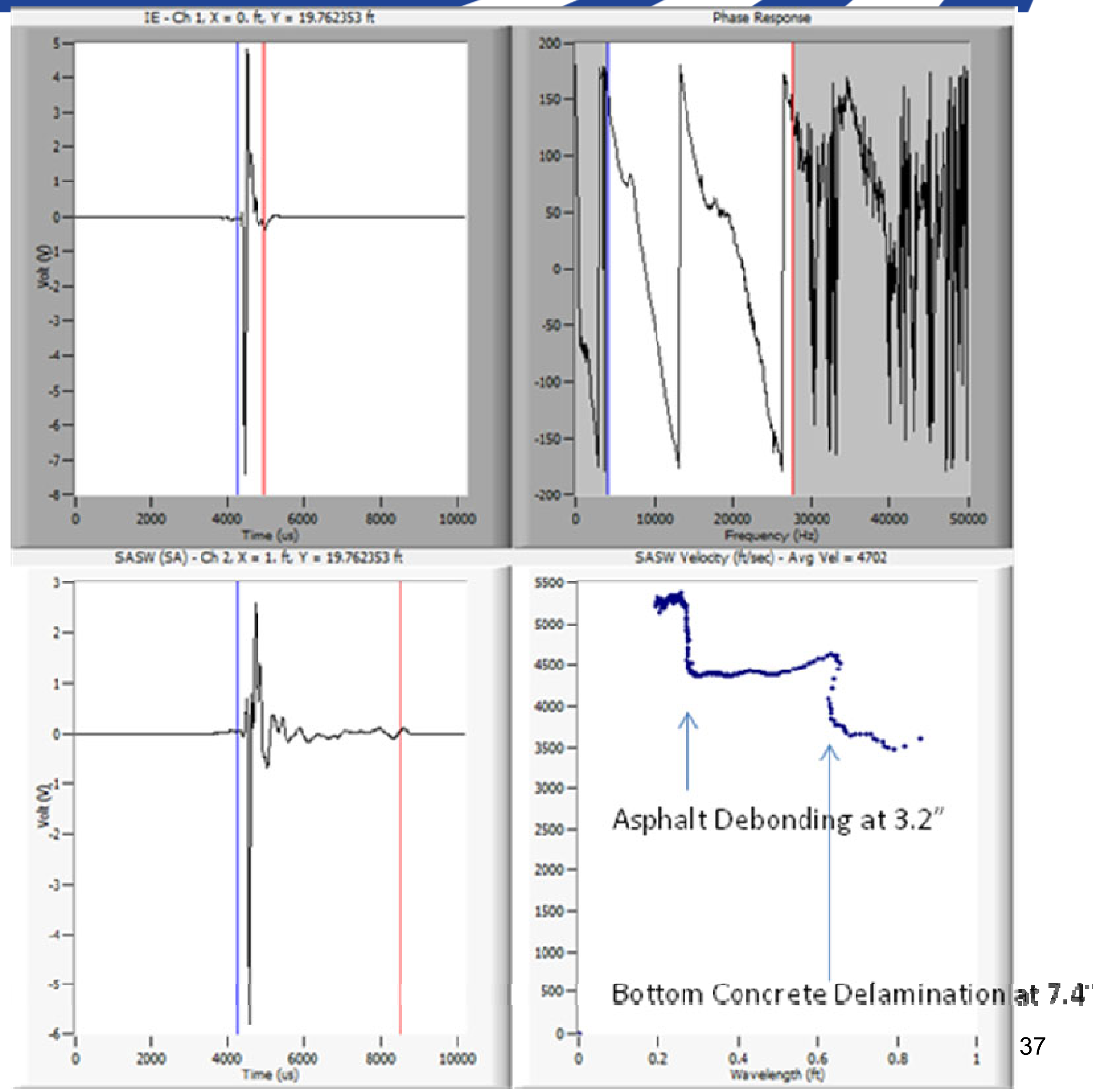
Sound Concrete with Asphalt Debonding



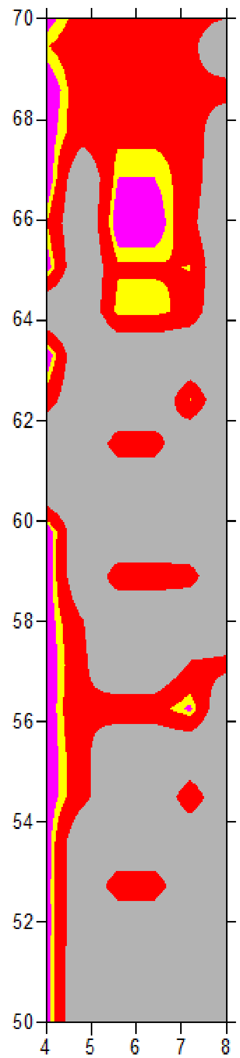
Bonded Asphalt on Concrete with Top Delamination

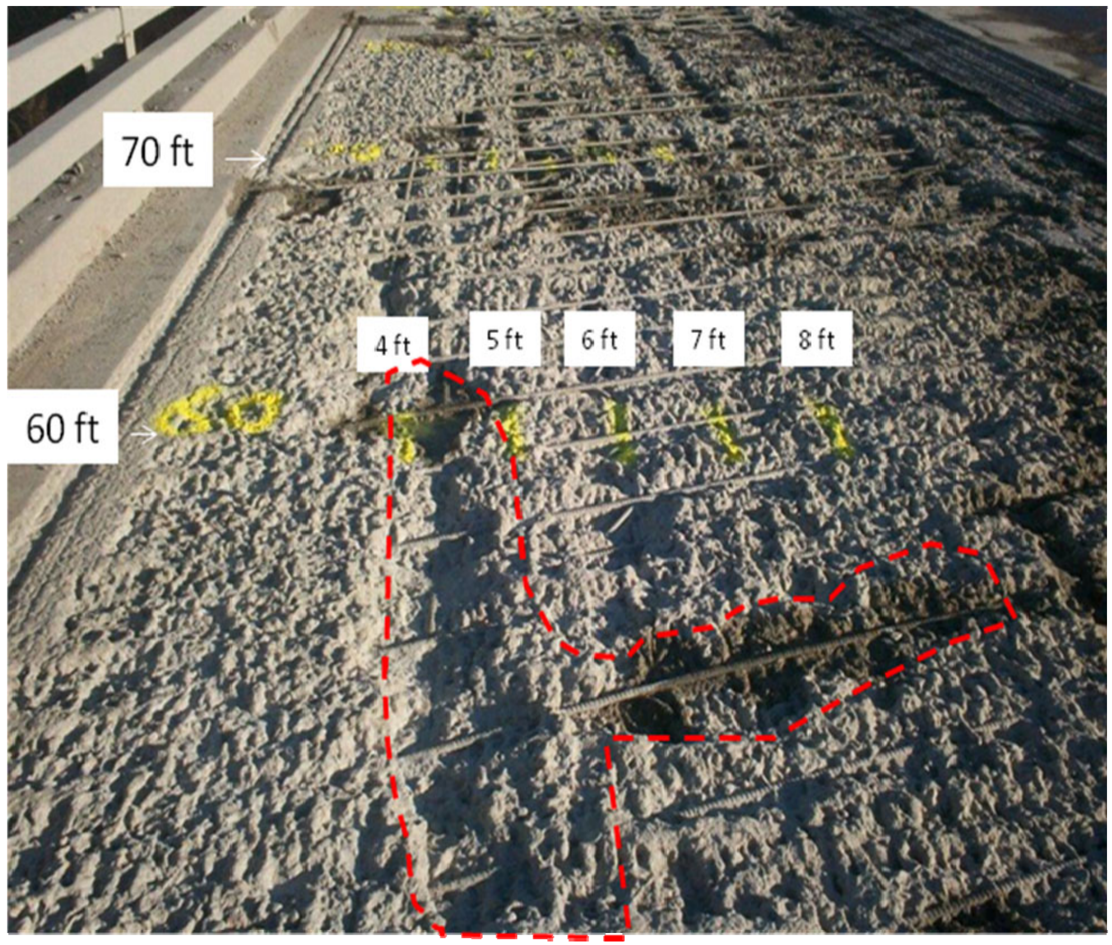


Debonded Asphalt / Concrete with Bottom Delamination



Ground Truthing - Hydrodemolition to Reveal Delaminations





GPR Testing

- Most commonly performed on concrete and concrete overlaid bridge decks
- Can detect chlorides and areas of likely future corrosion and subsequent delamination
- NOT always sensitive to current cracking and delaminations unless the cracks or delaminations have salts, corrosion products, or other GPR-reflective material present (results will often NOT match IE, IR or Sounding results)
- Can also map out rebar depth and geometry

Description of the GPR Method

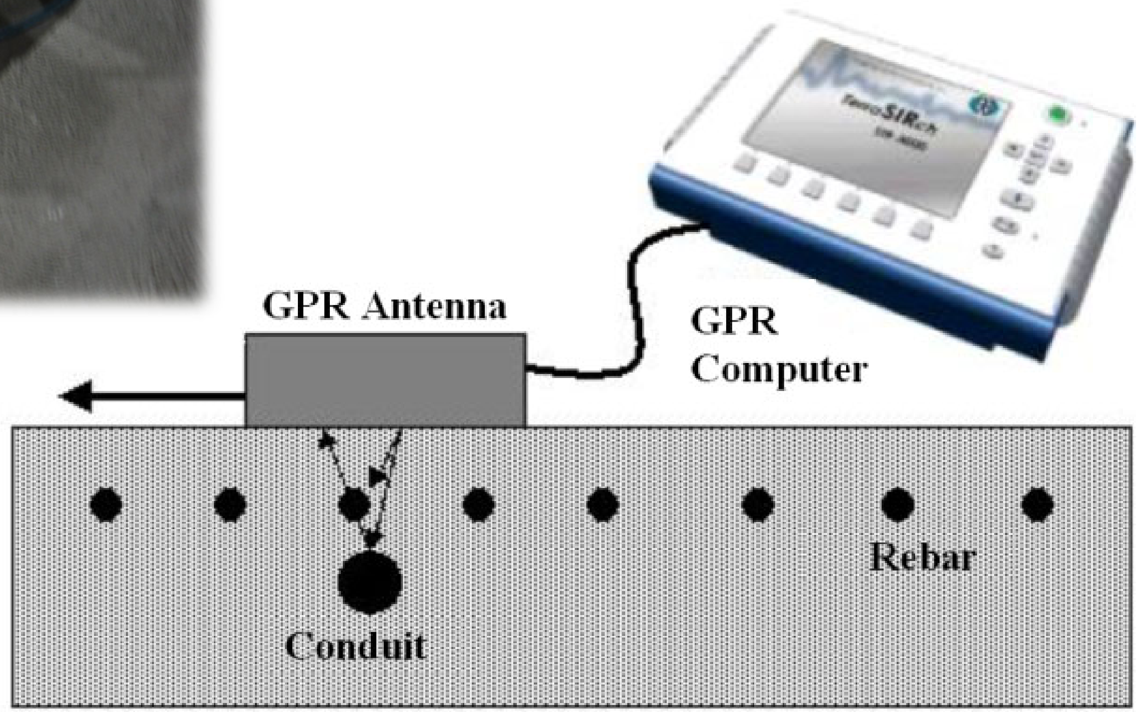
Reflection test

- Using electromagnetic waves
- Sending tiny pulse of energy through its antenna
- Reflecting back from different material or anomalies.

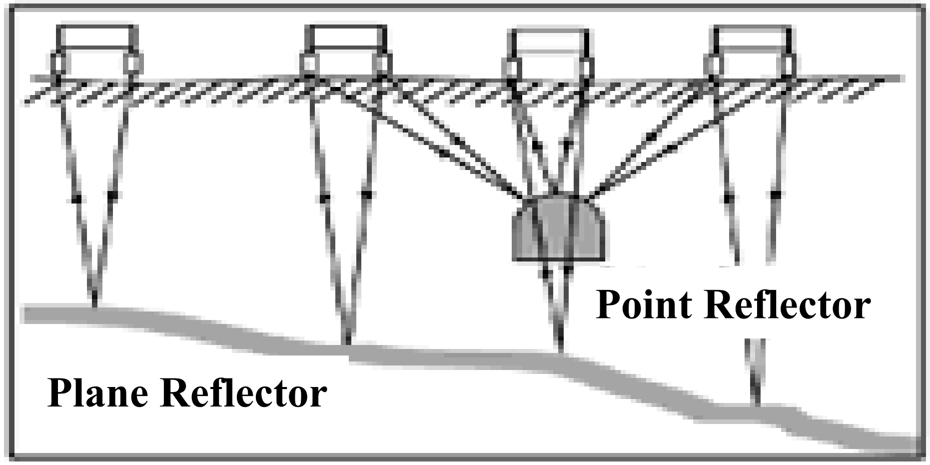
A rapid nondestructive testing method

- Ground Contact (single antenna and multiple antennas)
- Air Horn (multiple antennas)

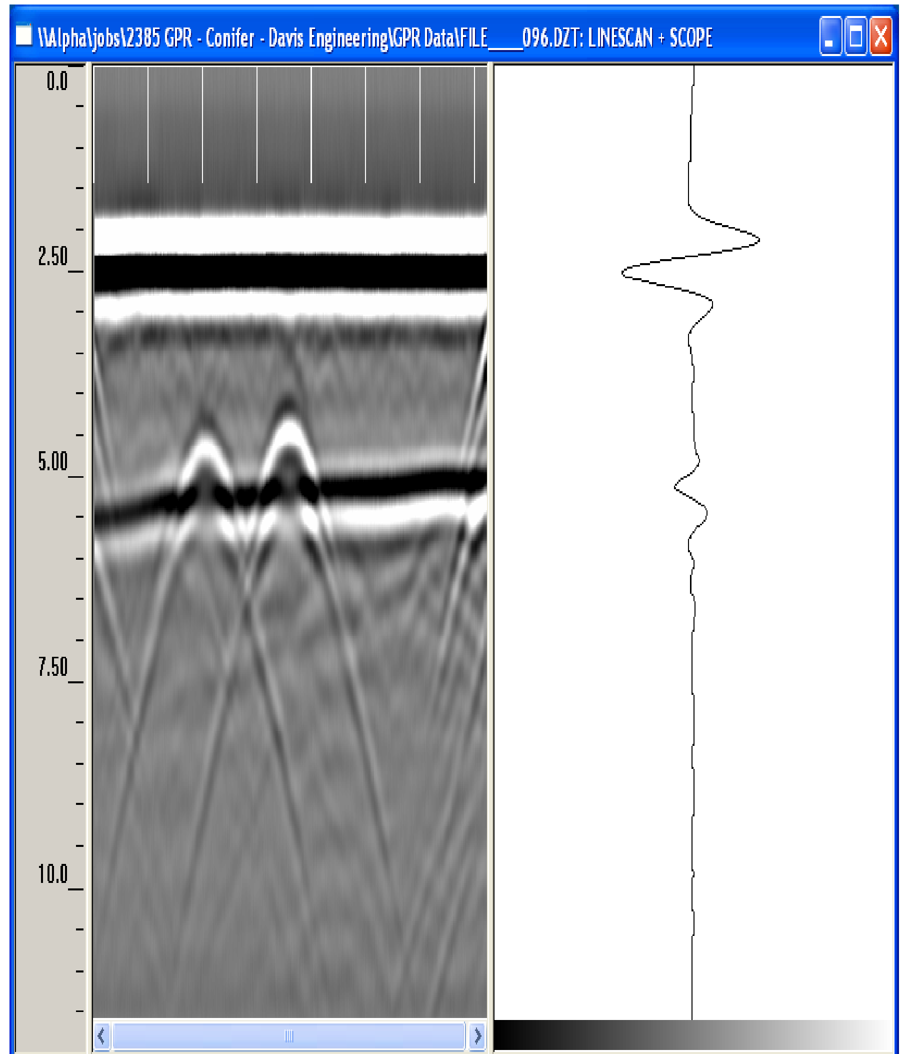
Physical Principle



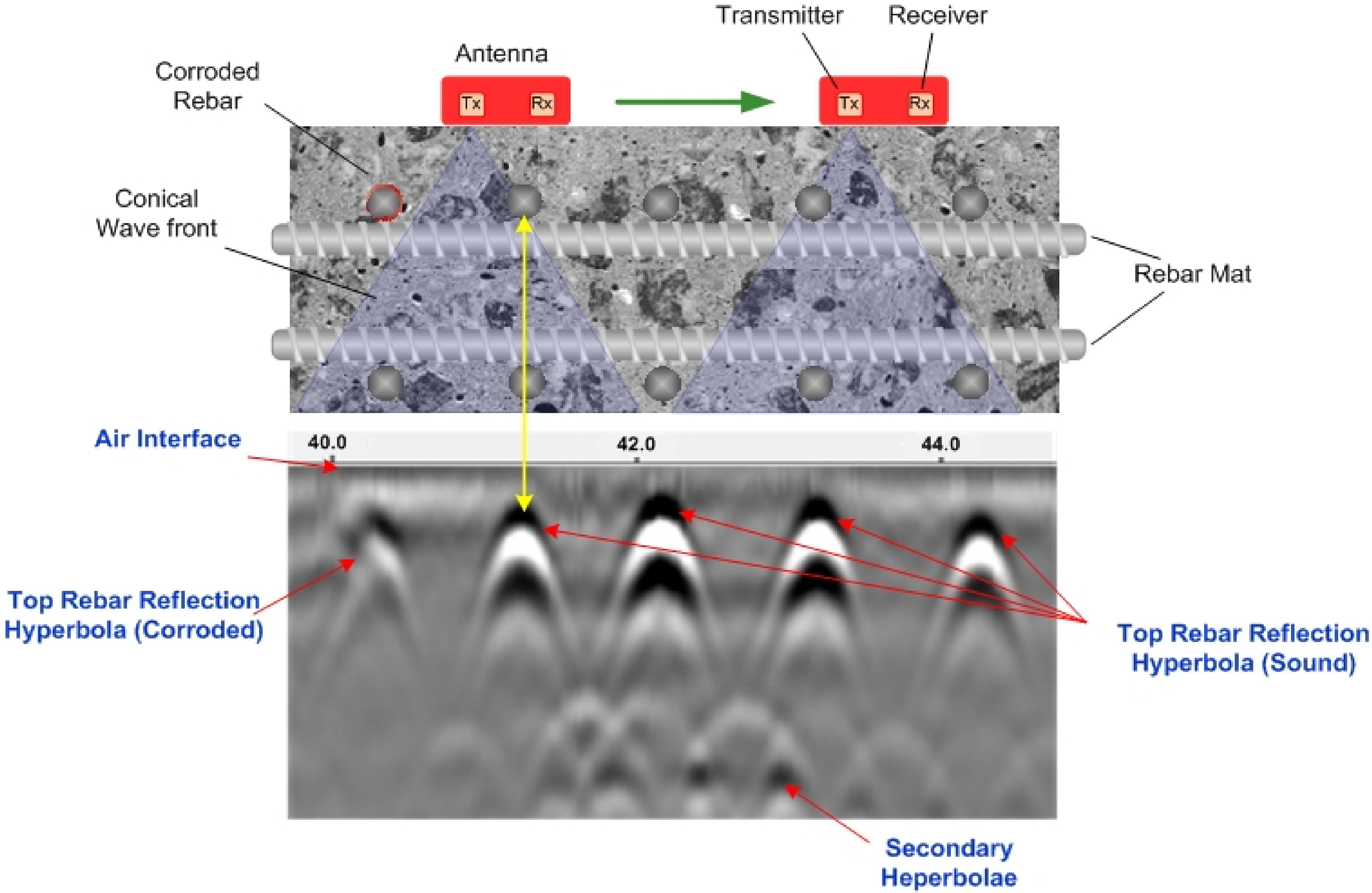
Physical Principle *(continued)*



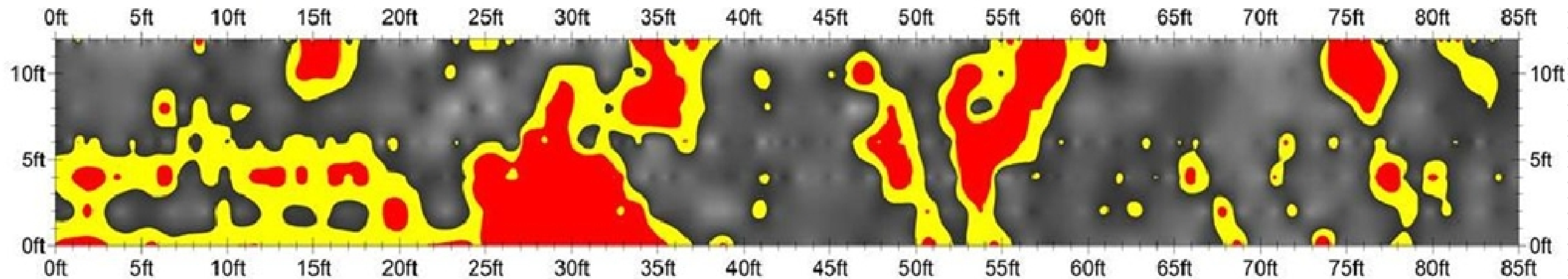
Reflection Concept



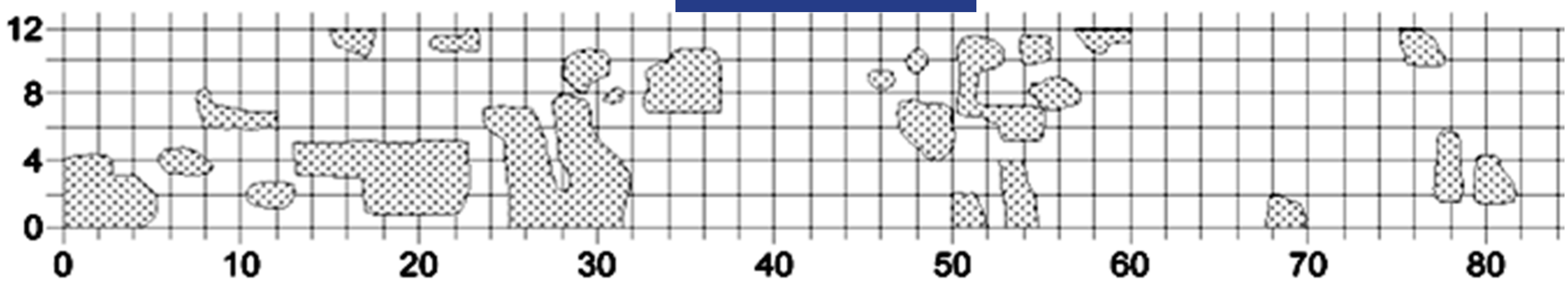
Physical Principle *(continued)*



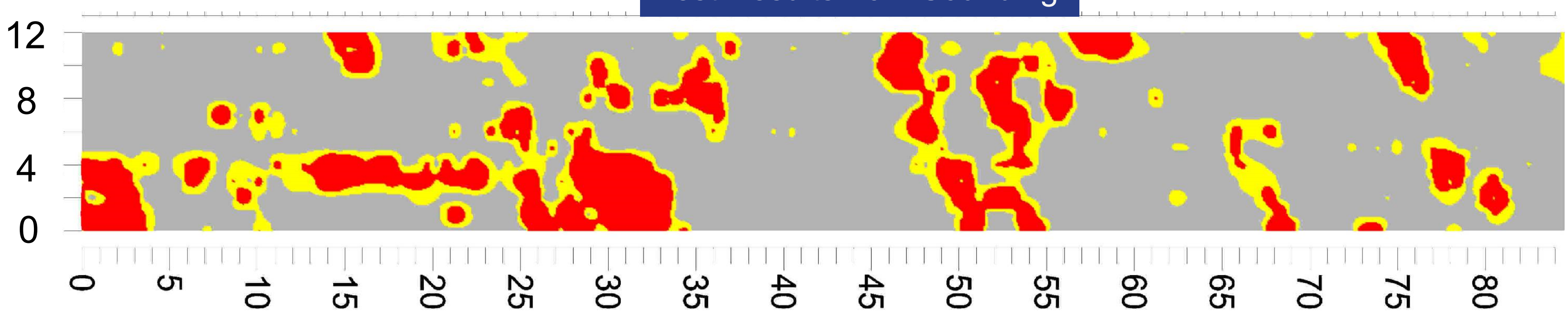
GPR, Chain Drag and IE Test Results Comparison



GPR Test Results



Test Results from Sounding

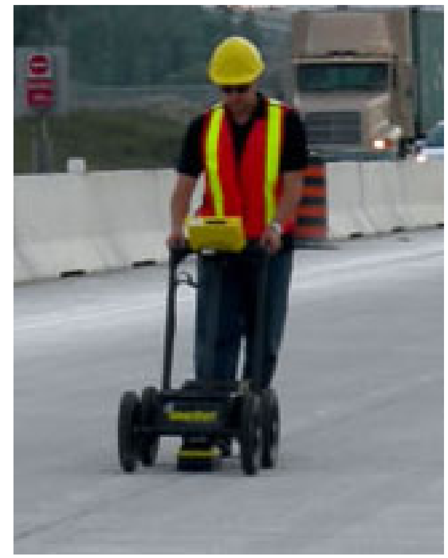


IE (Scanning Test Results

Example Equipment (Ground Contact Antennas)

3D Radar

GSSI



Sensors and Software

MALA

IDS

Example Equipment (Air Horn Antennas)

3D Radar

GSSI

IDS Georadar

Deterioration Modes Detected By GPR Testing

- Locations with a dielectric contrast between the two materials (indicative of material property changes)
- Large concrete cracks/voids (air filled)
- Smaller gaps/voids filled with salty water – larger dialectic contrast
- Corrosion, high chlorides, or rust byproducts indicated by lower amplitude reinforcement reflections due to diffraction by rust byproducts as well as attenuation by chlorides

Performances of GPR Test on Concrete Bridge Decks

- **Speed** of data collection - Rapid and reliable
- **Analysis** - Takes more time and requires a high level of expertise
- **Ease of Use** - Requires significant expertise and training
- **Cost** – Moderate-to-expensive system
- **Repeatability** - Repeatable test
- **Accuracy** – Good (better with ground-coupled antennas)

Limitation of GPR Testing on Bridge Decks

- Detect delaminations **only when** they are epoxy-impregnated and/or filled with water/salt in decks
- **De-icing salts** can limit the depth of signal penetration (but this attenuation is used to map high-chloride areas)
- **Limited test results** – cannot provide any information about the mechanical properties of the concrete (strength, modulus, etc.).
- **FCC restrictions**
- Need **validations** from other NDE methods or ground truth

Limitations (continued)

- **Cannot "see"** through dense rebar
- **Does not directly detect cracks** – need "conductive" cracking (water-filled)
- **Depth of air voids** can not usually be estimated
- **Depth of the penetration** depends on the antenna frequency
  - 2600 MHz – 12-15 inch max penetration in concrete
  - 1500 MHz – 18 inch max penetration in concrete
  - 400 MHz – 6 – 10 foot penetration in concrete

Thank you, and please contact us if you have specific questions about any of these test methods

Indiana Department of Transportation

Ground Penetrating Radar Bridge Deck Testing

Randy Strain

NextLevel INDIANA

INDOT NDT

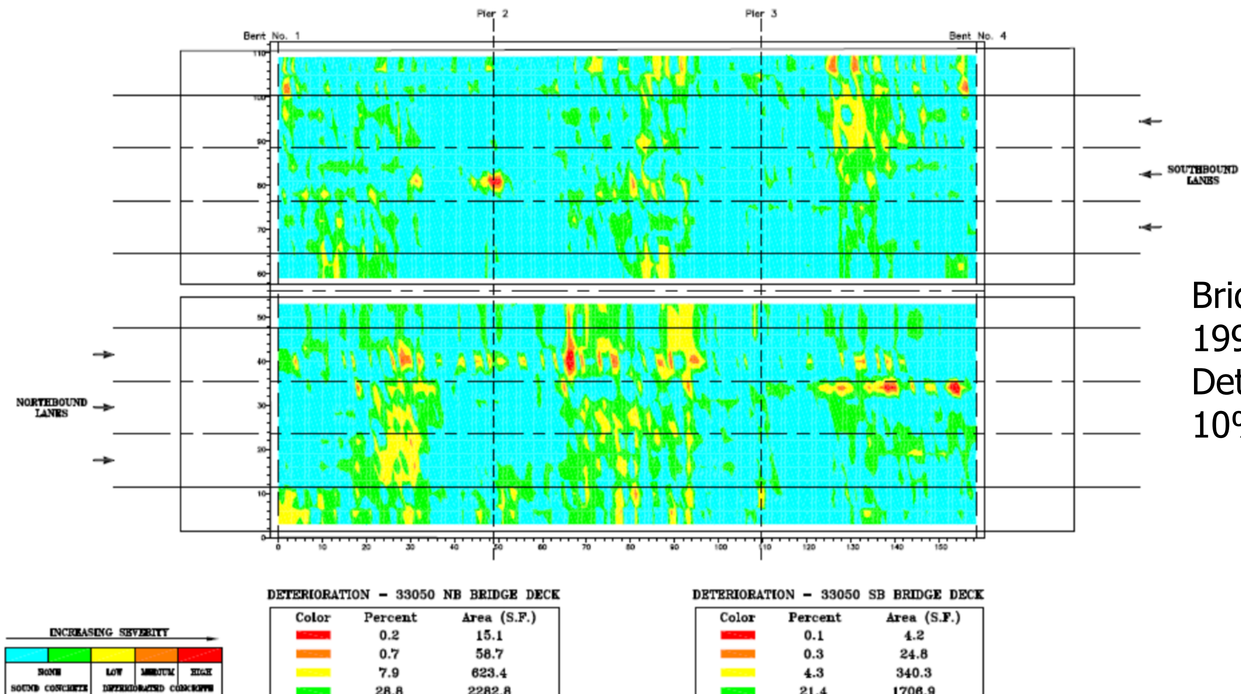
- Resource International, Inc. is in the process of completing our first contract of non-destructive bridge deck testing using ground penetrating radar.

- The contract included testing for 230 bridge decks.

- The bridges were selected by the INDOT Bridge Asset Engineers and Bridge Inspection Supervisors.

INDOT NDT

DETERIORATION MAP
(12)912-45-02353 B (NBI #33050)
SR 912 OVER N&S RR
LAKE COUNTY
STATE OF INDIANA



DETERIORATION – 33050 NB BRIDGE DECK

Color	Percent	Area (S.F.)
red	0.2	15.1
orange	0.7	58.7
yellow	7.9	623.4
green	28.8	2282.8
cyan	62.4	4944.9

DETERIORATION – 33050 SB BRIDGE DECK

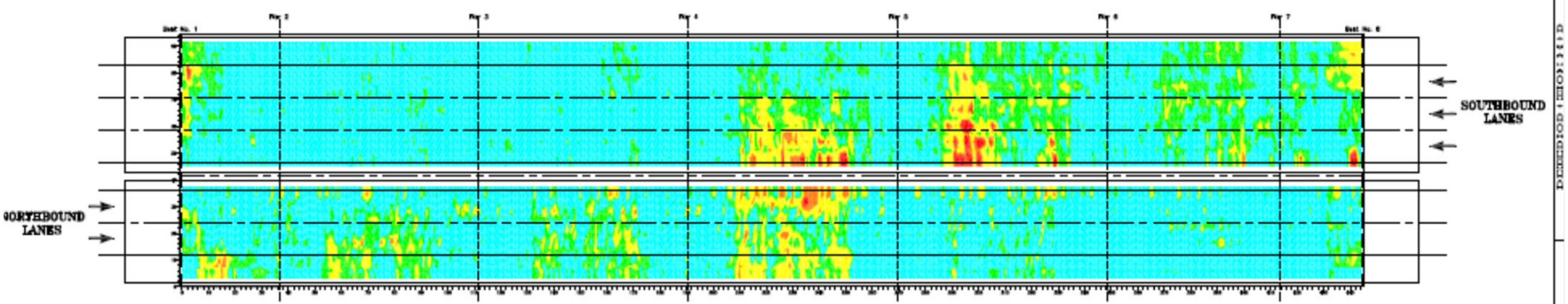
Color	Percent	Area (S.F.)
red	0.1	4.2
orange	0.3	24.8
yellow	4.3	340.3
green	21.4	1706.9
cyan	73.9	5896.3

Figure 1

2

Bridge Deck constructed in 1994 25 year old deck Deterioration less than 10%

INDOT NDT



DETERIORATION – 33090 NB BRIDGE DECK

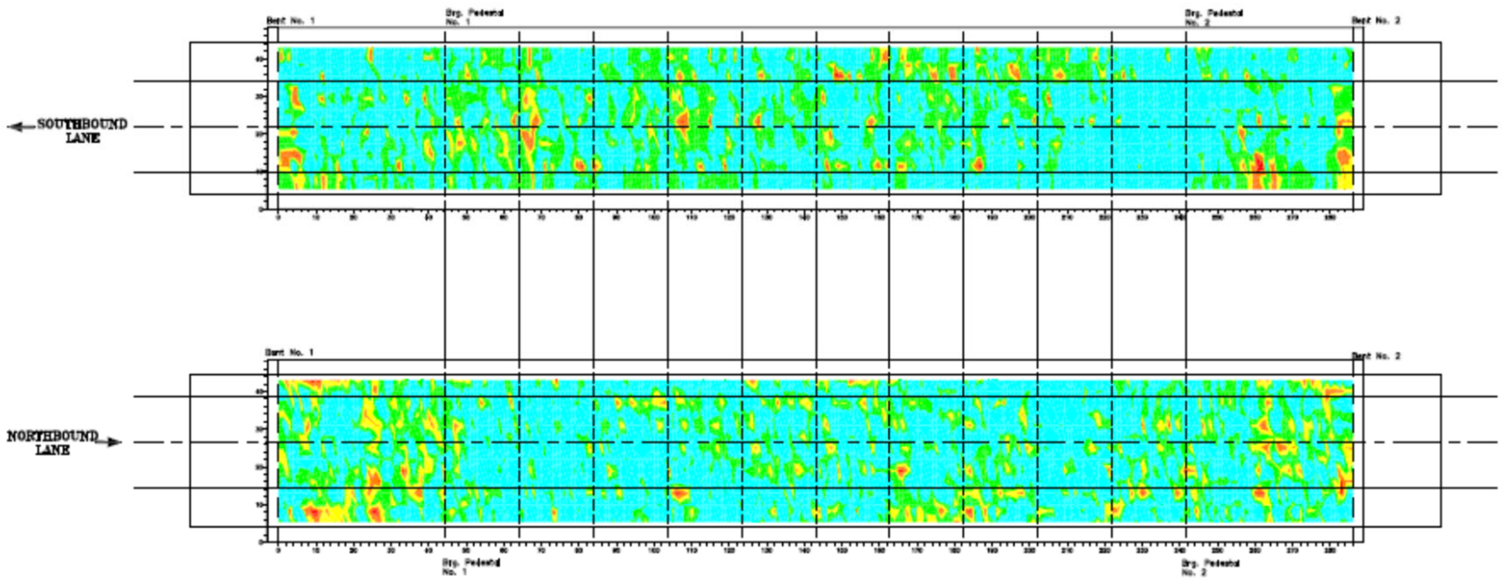
Color	Percent	Area (S.F.)
Red	0.1	7.5
Orange	1.1	171.9
Yellow	10.5	1611.6
Green	19.3	2951.9
Cyan	69.0	10585.5

DETERIORATION – 33090 SB BRIDGE DECK

Color	Percent	Area (S.F.)
Red	0.7	147.4
Orange	0.9	196.9
Yellow	7.6	1563.6
Green	21.5	4441.4
Cyan	69.3	14310.6

Bridge deck constructed in 1994 – 25 year old bridge deck
Deterioration just over 10%

INDOT NDT



DETERIORATION – 35520 NB BRIDGE DECK

Color	Percent	Area (S.F.)
Red	0.1	12.8
Orange	1.6	167.8
Yellow	9.1	985.7
Green	28.5	3065.4
Cyan	60.7	6541.0

DETERIORATION – 35520 SB BRIDGE DECK

Color	Percent	Area (S.F.)
Red	0.1	13.7
Orange	2.3	247.3
Yellow	5.0	542.2
Green	32.0	3441.8
Cyan	60.6	6527.6

I65-68-7910 Bartholomew County Complex Bridge built with a latex overlay

The deterioration is just over 10%

The structure is 20 years old.

INDOT NDT

- In order to obtain a 28 day yield strength of 4000 psi 658 pounds of cement is used in the mix design.

- Indiana is known for its’ Indiana Limestone, also know as Bedford Limestone.

- Bedford Indiana has been noted to have the highest quality quarried limestone in the United States.

- Wonderful product for building products.

- Not a great stone for obtaining a high strength concrete.

INDOT NDT

- It appears that building a bridge deck with an overlay may not provide additional protection to the deck. The shrinkage cracks from the deck seem to extend into the overlay.

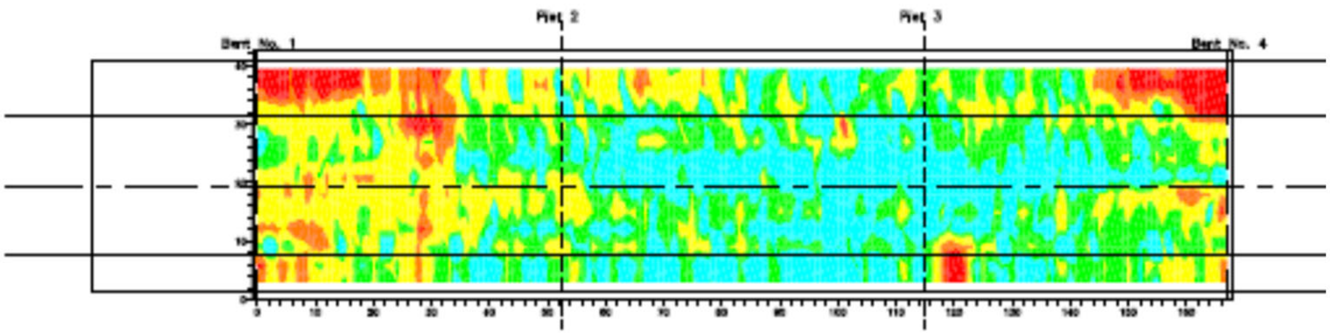
- Our best protection with our current mix design is to allow the shrinkage cracks to form and the provide protection with a polymeric concrete bridge deck overlay.

- Designing a concrete mix to overcome the shrinkage cracks increases the cost of the concrete by about four and a half times.

NextLevel INDIANA

INDOT NDT

- 41-42-5935 BSBL



DETERIORATION – 14790 SB BRIDGE DECK

Color	Percent	Area (S.F.)
Red	3.7	226.3
Orange	6.0	363.2
Yellow	28.5	1735.7
Green	32.1	1957.8
Cyan	29.7	1812.5

- 9.7% highly deteriorated
- 38.2% total deterioration
- 48 year old deck
- 24 year old 2nd overlay
- Structure is programmed to be rehabilitated in 2020. The inspector rated the deck a low 6 by notation and recommend the deck be replaced.

NextLevel INDIANA

INDOT NDT

Preliminary statistical findings

- Bridges with approximately 10% deterioration should be considered to be in fair condition.

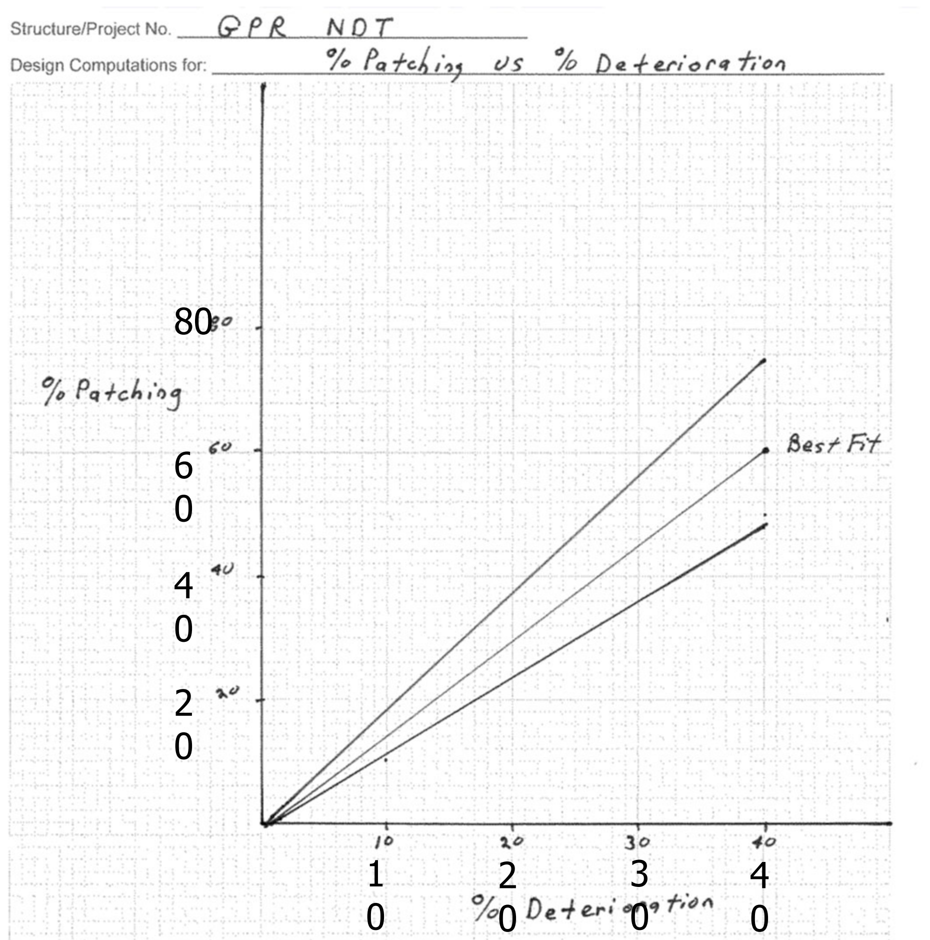
- Bridges with approximately 10% – 20% deterioration may require further testing.

- Bridges with grater than 20% deterioration should be considered in poor condition.

INDOT NDT

The relation between percent deterioration and percent patching is not a one to one correlation.

This graph is an approximation of the relationship.



INDOT NDT

When and how often should testing be done?

- The deterioration appears to be minor in bridge decks less than twenty years old
- The deterioration in latex overlays appears to follow very closely to the same time line.
- The bridge inspectors can not accurately determine the condition of the bridge decks by visual inspection. A large amount of the deterioration is simply not visible.
- Using NDT at the appropriate time line can assist in the proper evaluation of the bridge deck.

INDOT NDT

- INDOT Bridge Inspectors can use the NDT results to more accurately rate bridge decks.

- Percentage of deterioration does not directly correlate to bridge deck patching.

- Ground penetrating radar is a valuable tool for screening bridge decks.

- The correlation of deterioration percentage to patching has not been accurately determined.

INDOT NDT

- In 2019 we would like to use different methods of NDT and perform quality assurance on the bridge desks tested.

- Perhaps in order to minimize traffic disruption, the touch based NDT might be performed on the bridge deck shoulder then the traffic lanes can be tested at highway speeds.

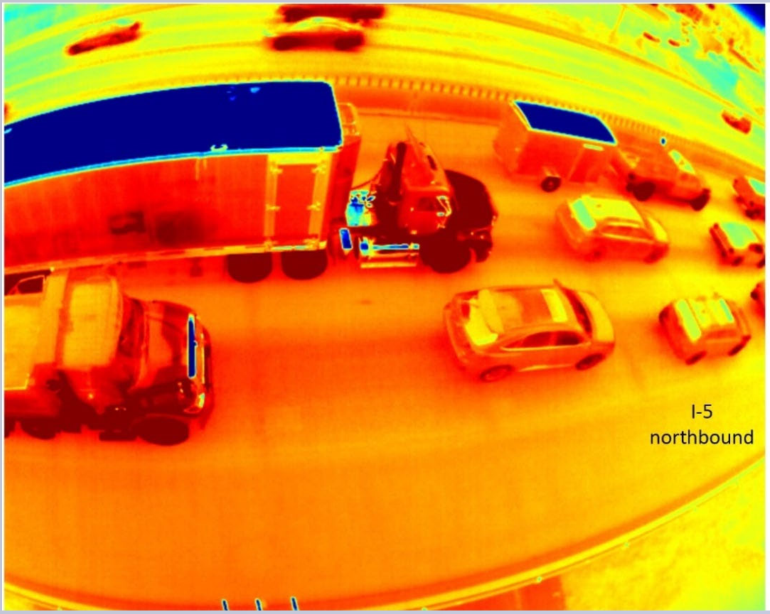
- Several bridge decks will be followed through the construction contract in order to obtain the correlation between percentage deterioration to bridge deck patching.

- The upper limit of deterioration needs to be identified.

NextLevel INDIANA

Oregon Department of Transportation

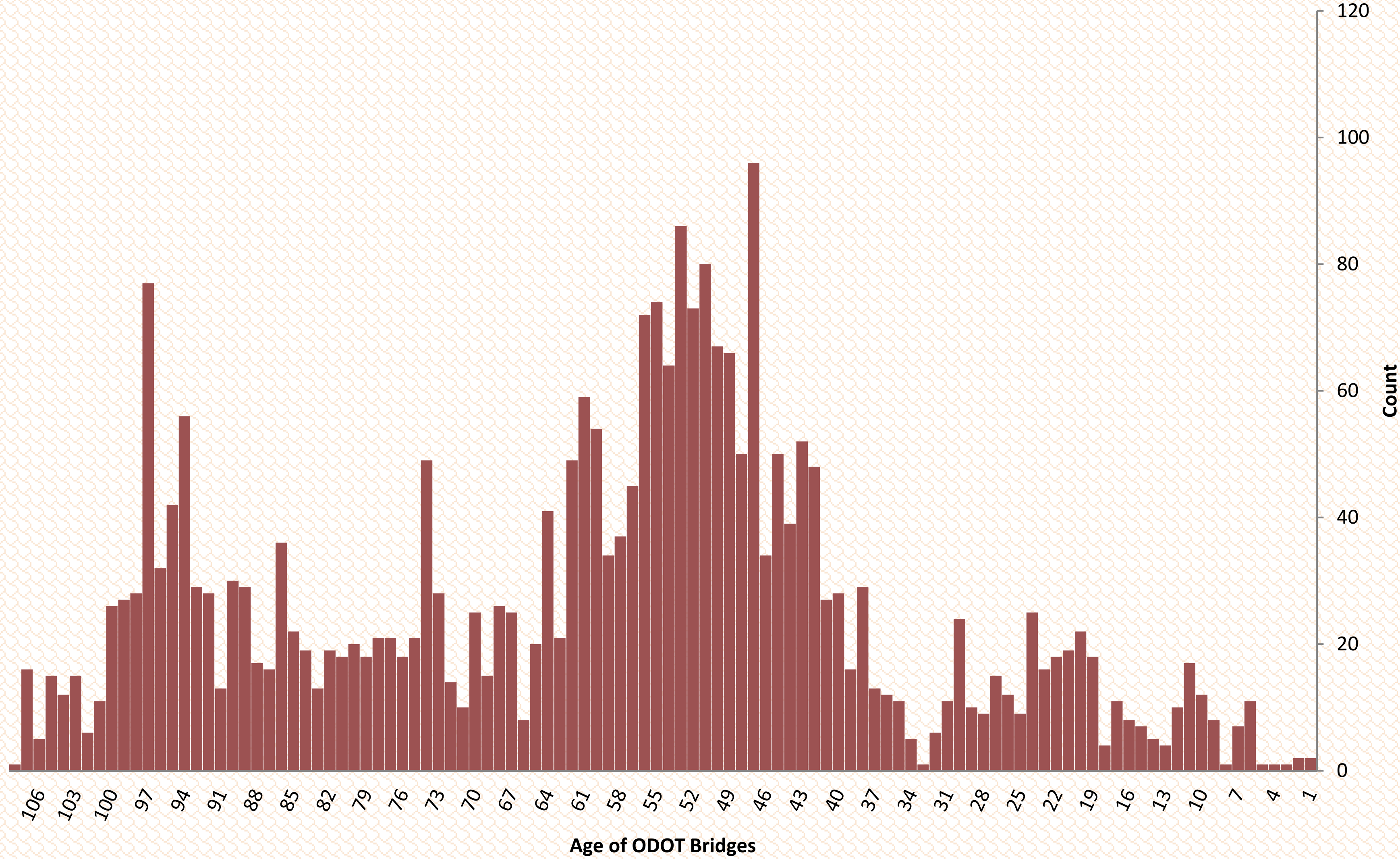
OREGON DOT's PILOT PROJECTS USING NONDESTRUCTIVE TESTING TECHNIQUES for BRIDGE DECK INSPECTION



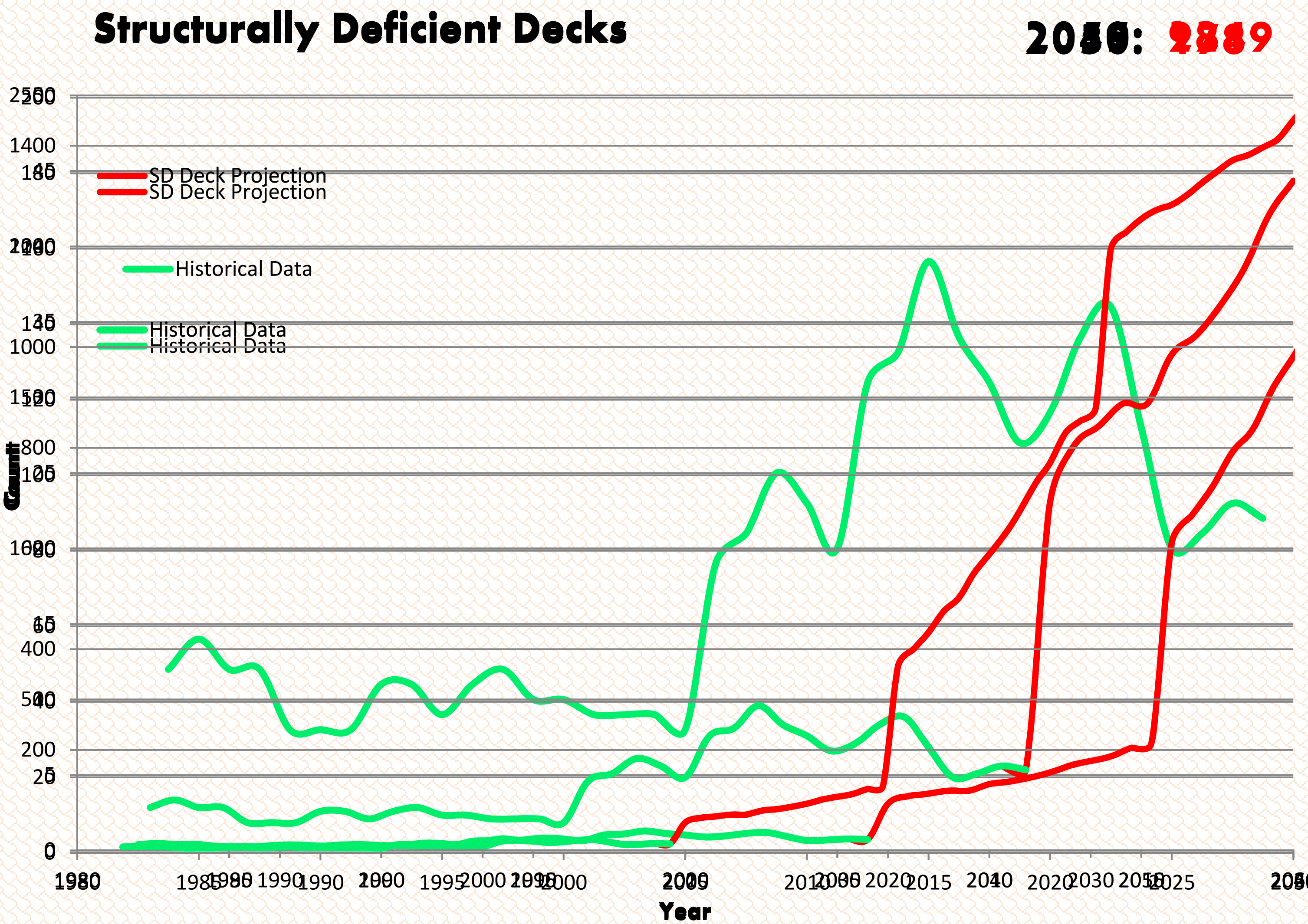
Corey Withroe
503 986 3339
corey.r.withroe@odot.state.or.us

Inventory

Median age: 52 years



Inventory



Structurally Deficient Decks
SD Deck Projection
Historical Data
Year

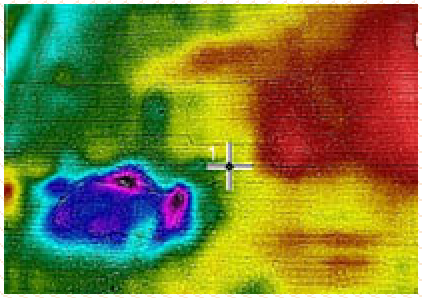
Oregon – 2 Grants

1. Can we find things the trained eye can't see?
   - Corrosion, delaminations, debonding
2. Can we distinguish bridges that need immediate attention from those that can wait 5-10 years?
3. Can we reduce costs—deck inspections/ surveys especially?
4. Are certain types of bridges responding differently?
   - Thin decks/ overlays/ mag chloride

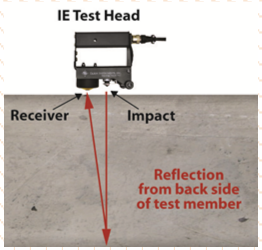
Prevailing NDE techniques for concrete bridge decks

- Ground Penetrating Radar (GPR)

- Infrared Thermography (IR)

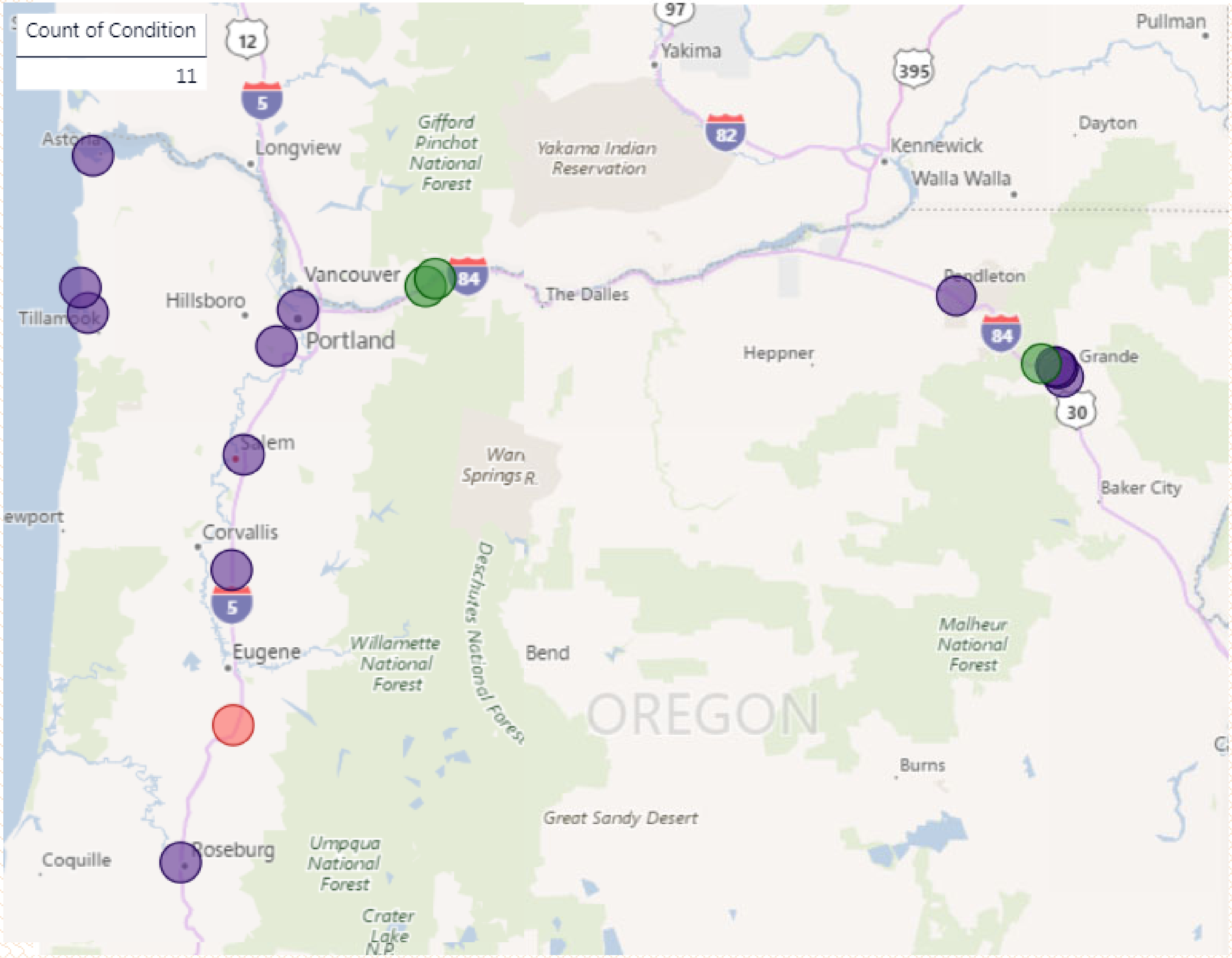


- Impact Echo (IE)

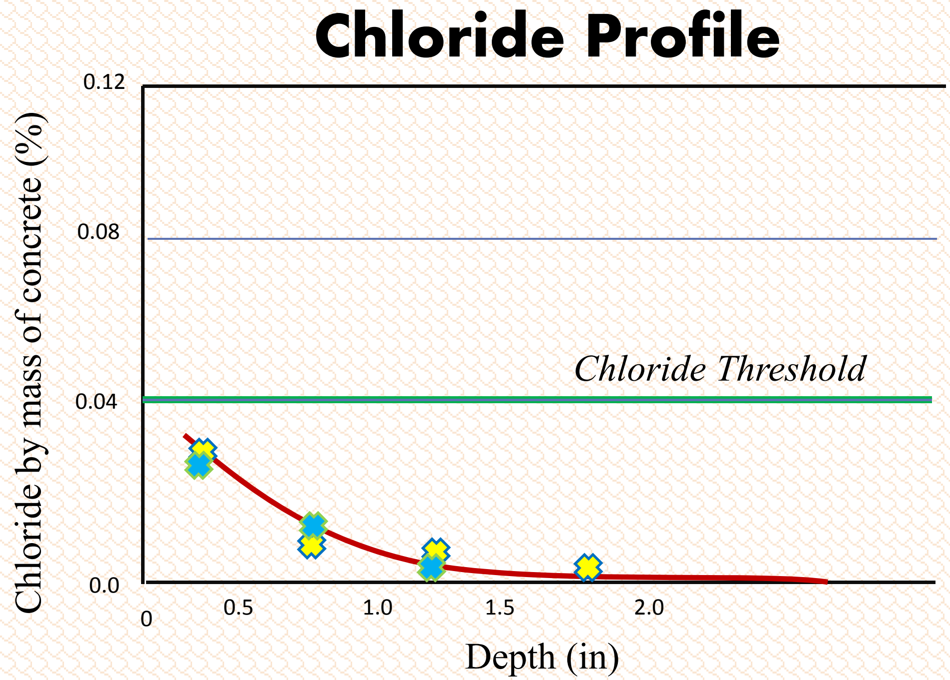


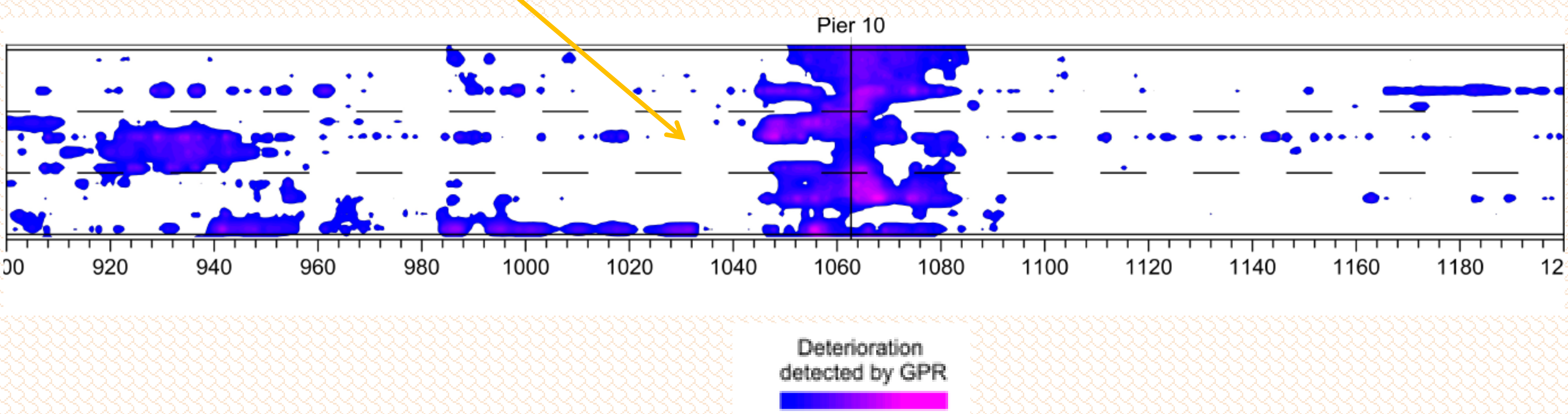
- Chain Drag

Phase 1 – High Speed



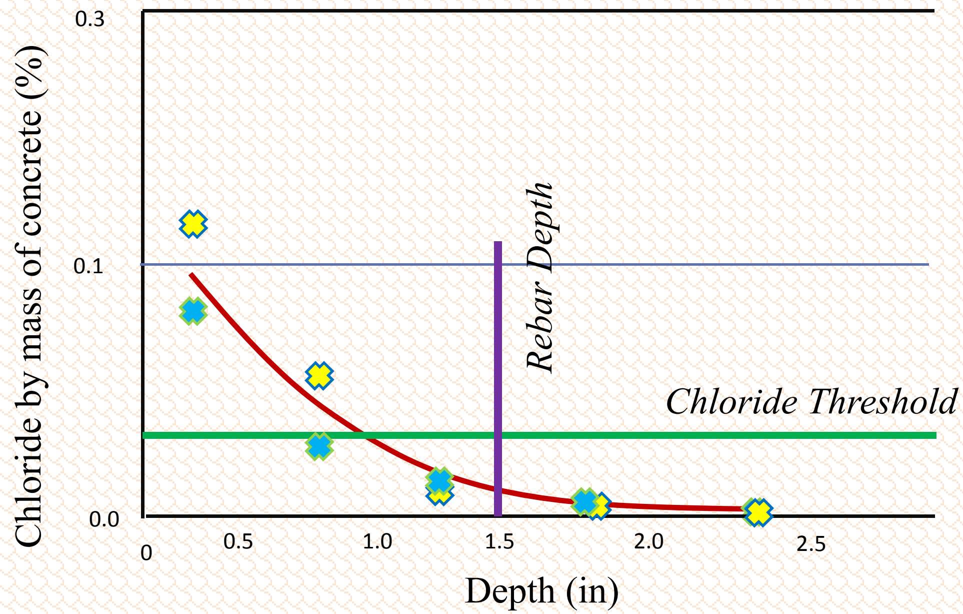
Results – Interstate Bridge

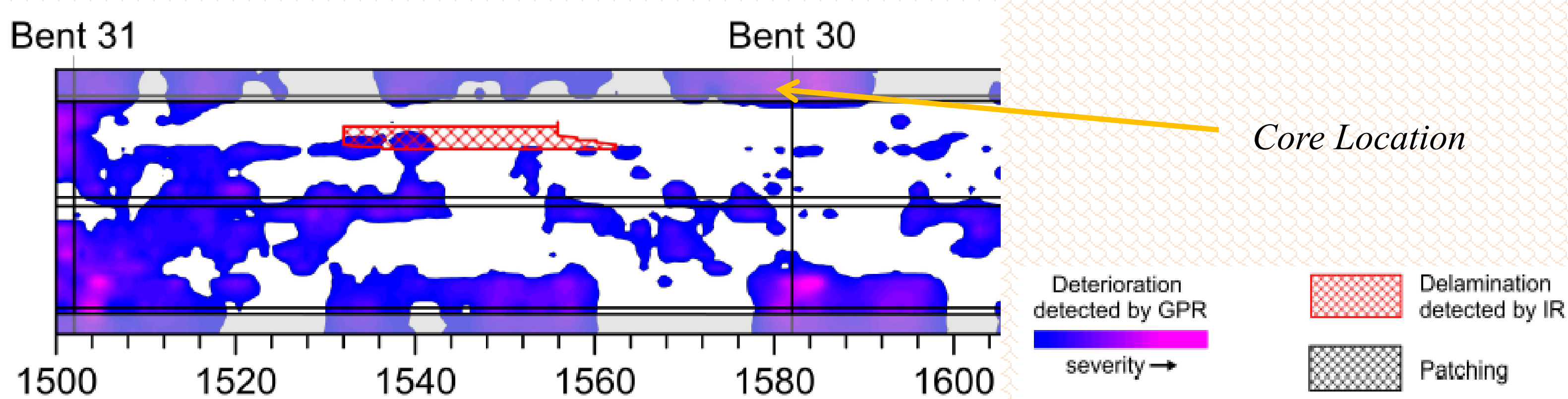




New Youngs Bay

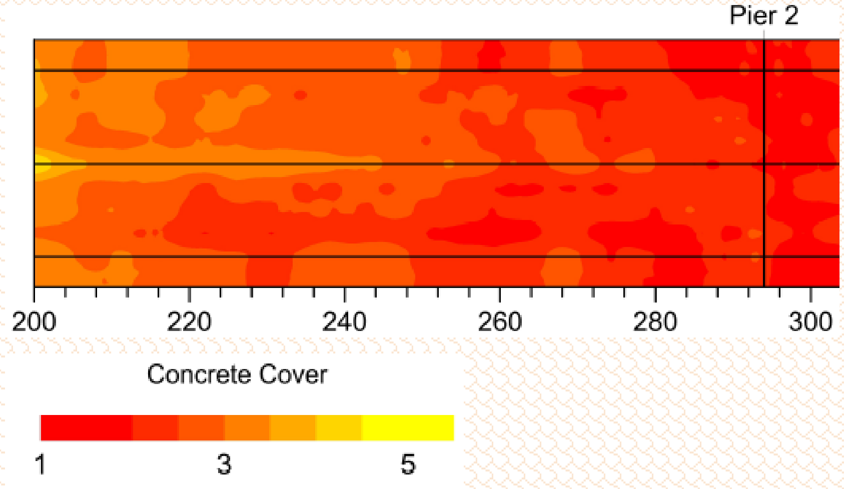
Chloride Profile

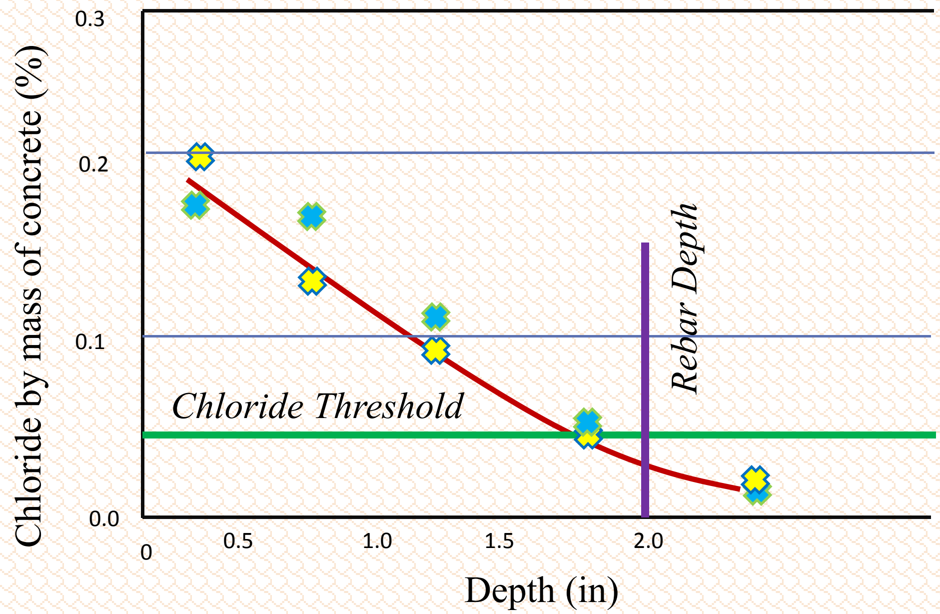


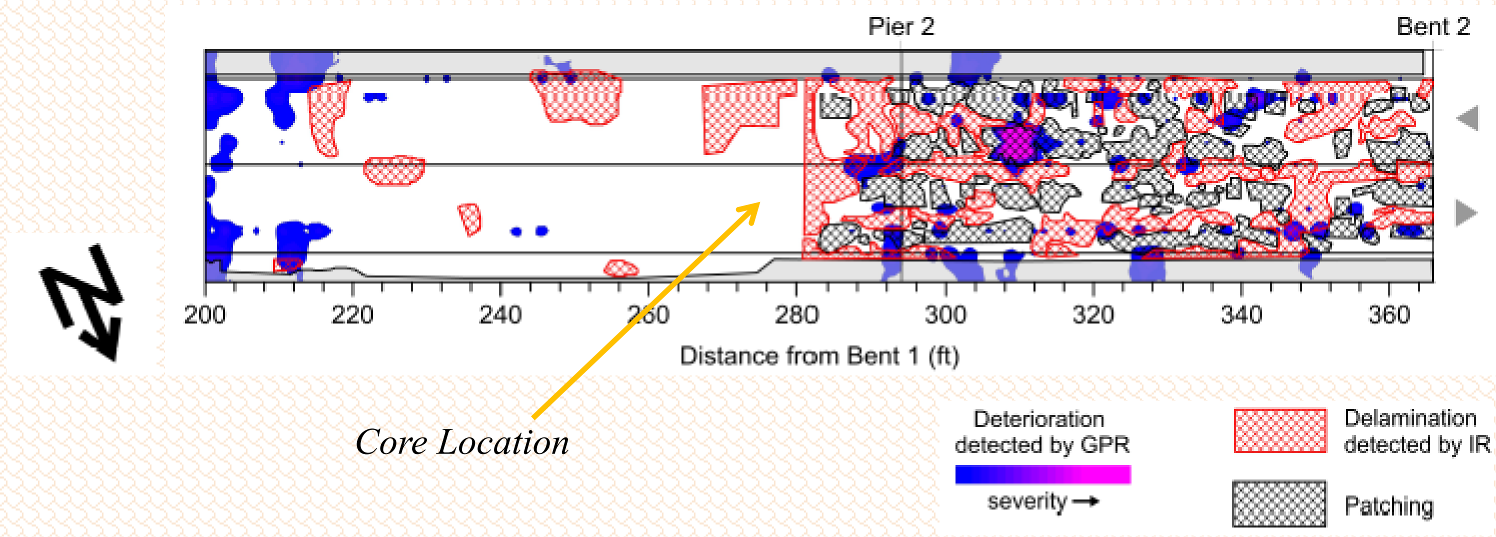


OR58, Salt Creek

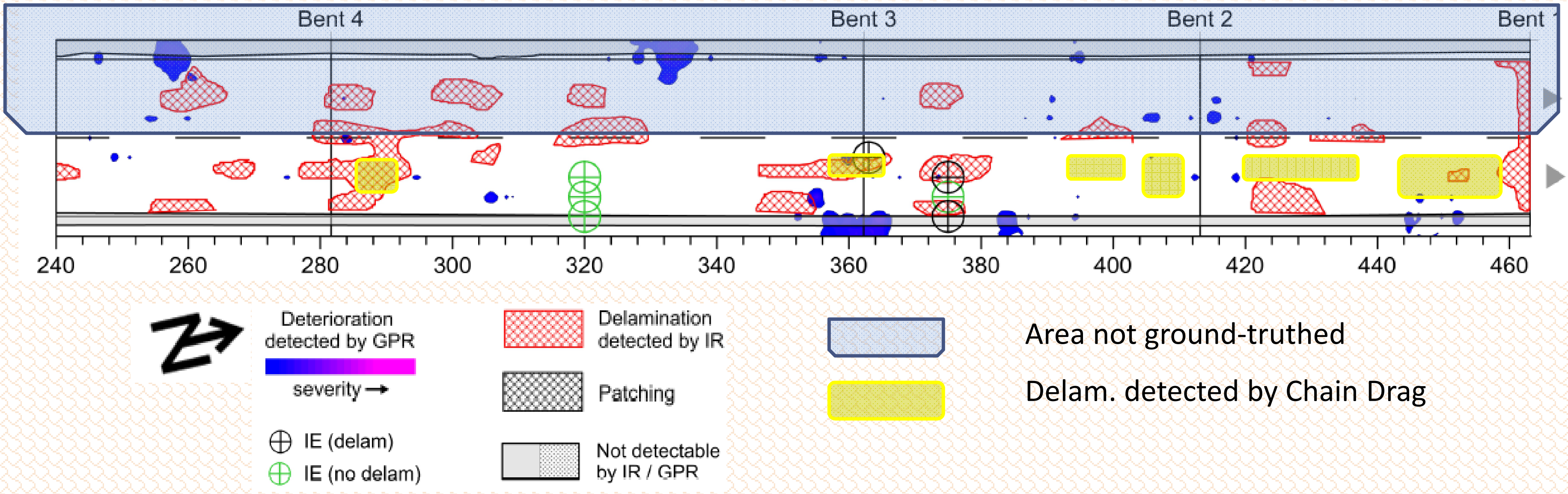
Chloride Profile

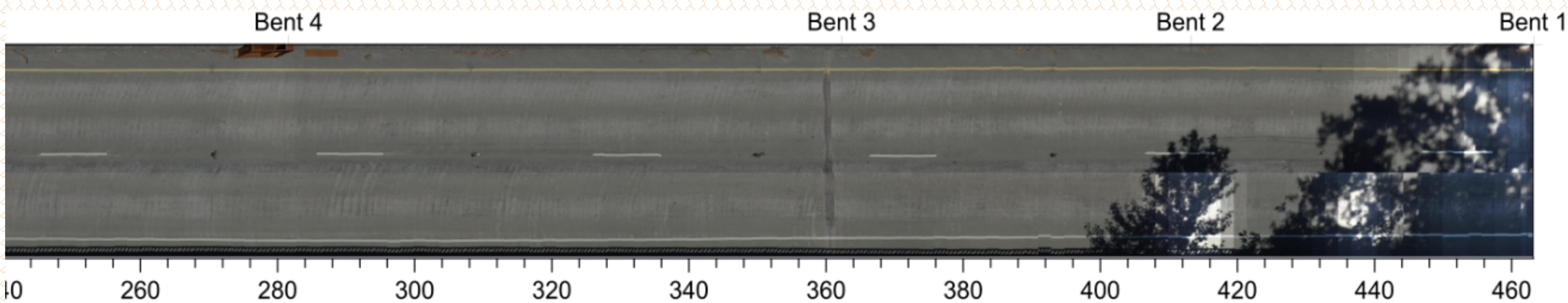




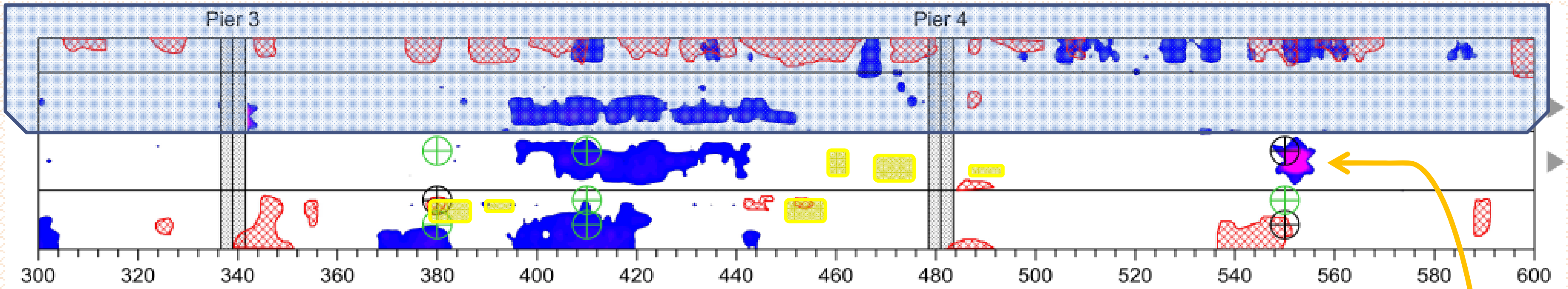


OR99, Tualatin River





I-5, Umpqua River



Deterioration detected by GPR
severity →

Delamination detected by IR

Patching

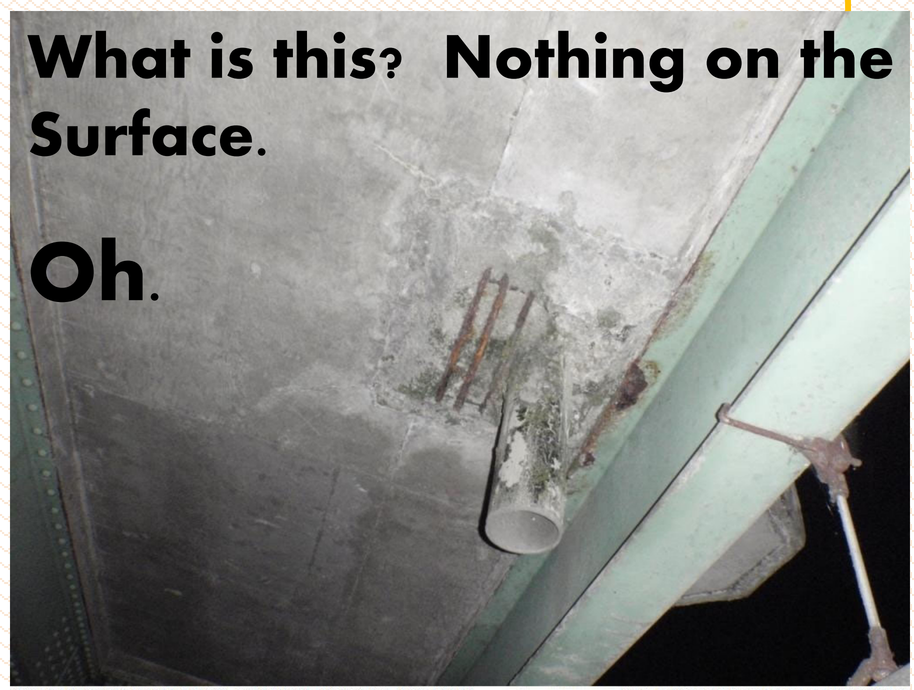
IE (delam)

IE (no delam)

Not detectable by IR / GPR

Area not ground-truthed

Delam. detected by Chain Drag



SOUTH UMPQUA RIVER (VETS) - BR# 07404 - HWY 1 SB - MP: 124.54 TYP. EXPOSED REBAR AT DECK DRAINS

I-5, Umpqua River

Chain Drag: 0.5% delam.

High Speed Infrared: 4.5% delam.

Final Class 2 Repair: 1.5%

I-84, Snake River

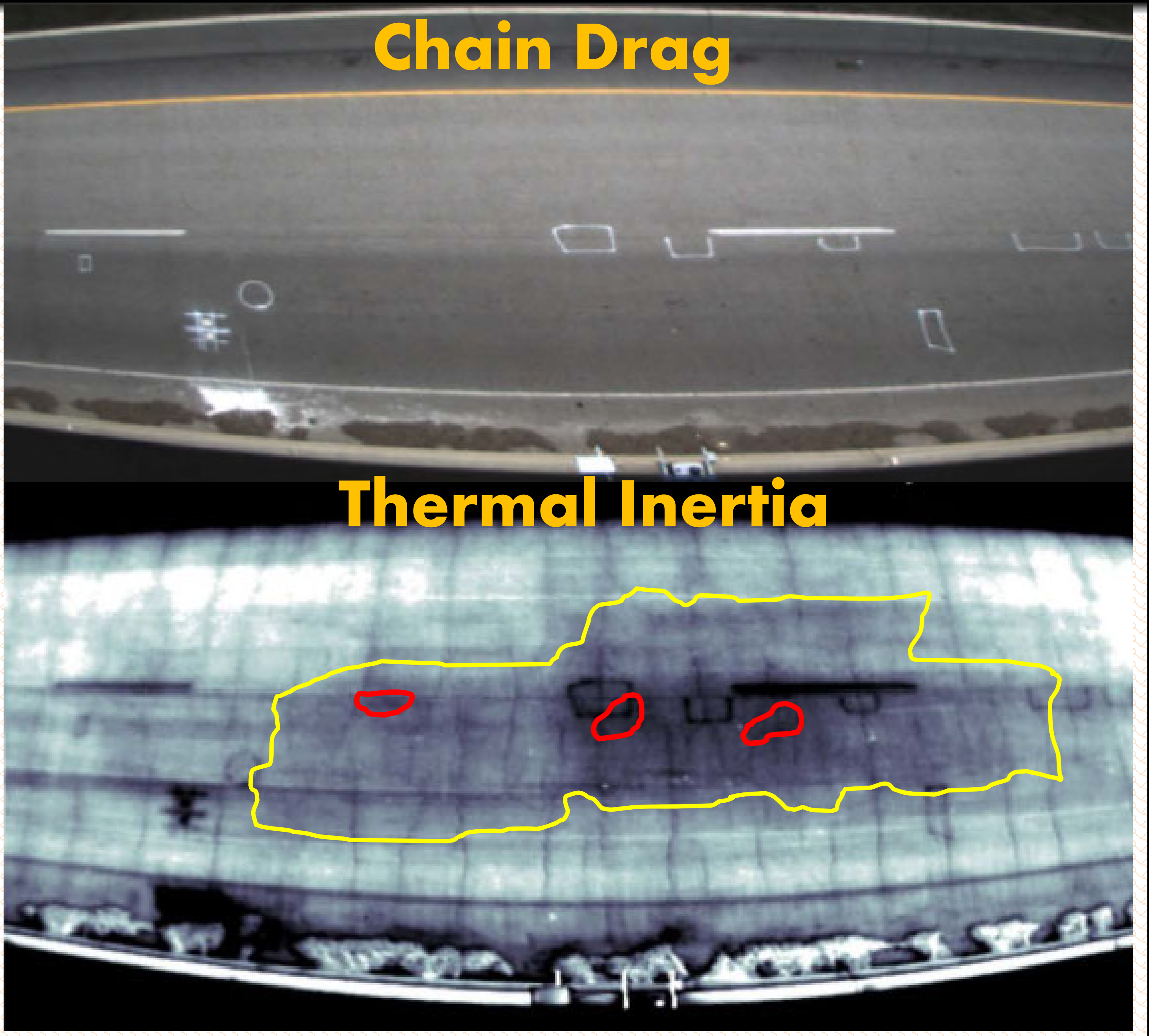
28K ft^2

4.2%

delam.

10.0%

delam.

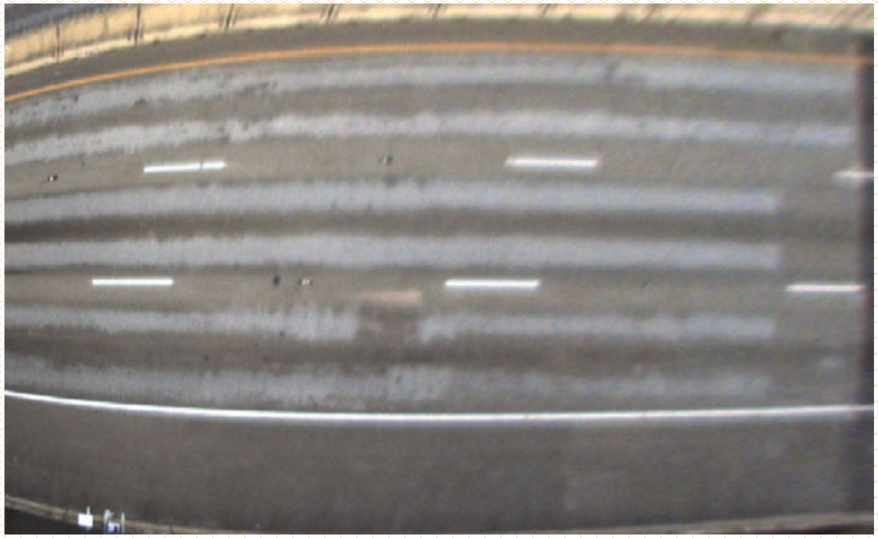


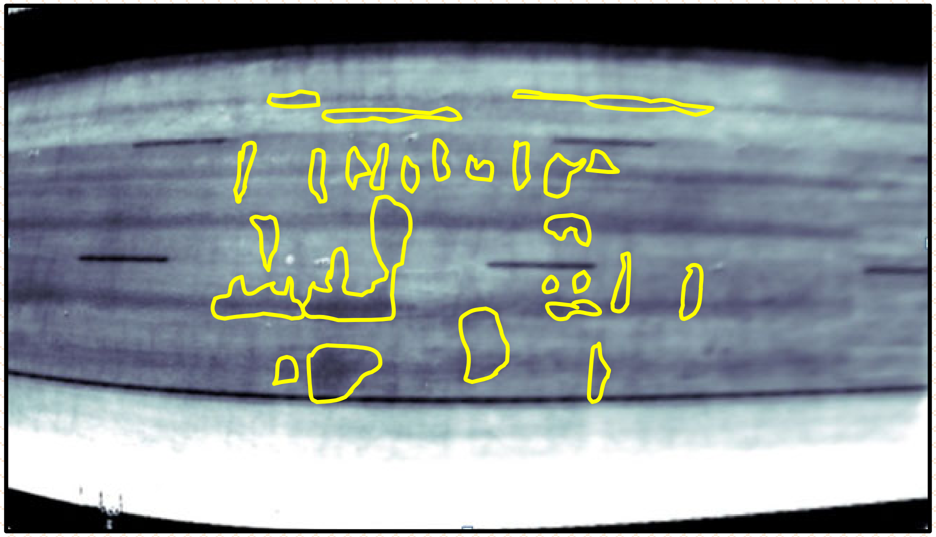
I-5 over 26th Avenue

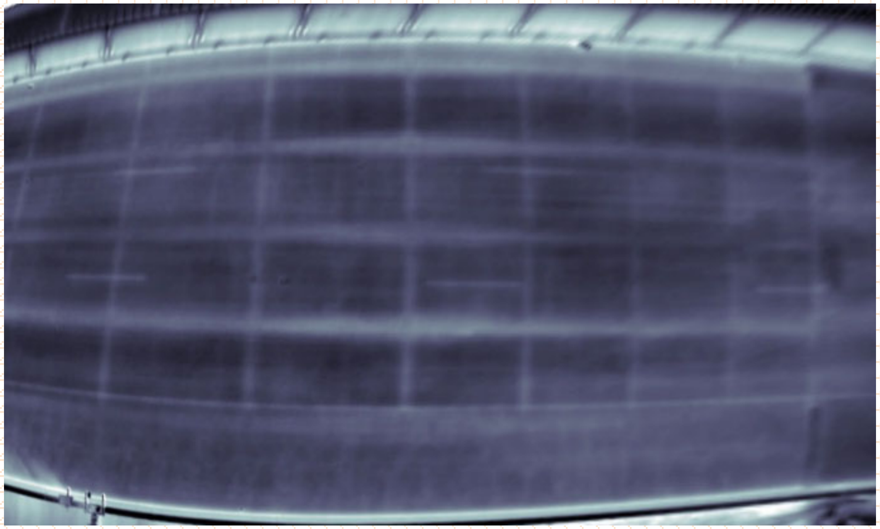
Replace Deck?

Replace Overlay?

Replace Bridge?

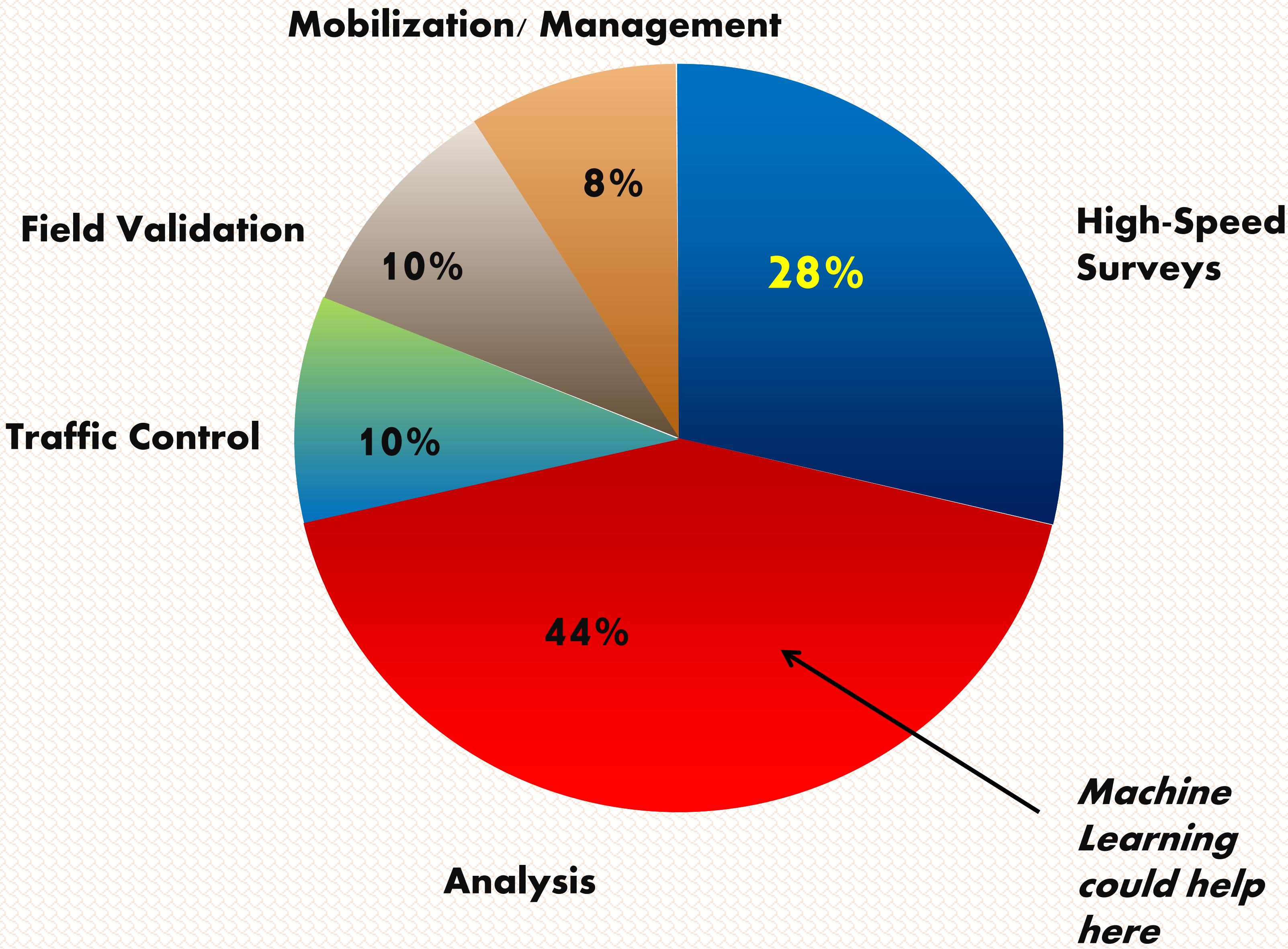






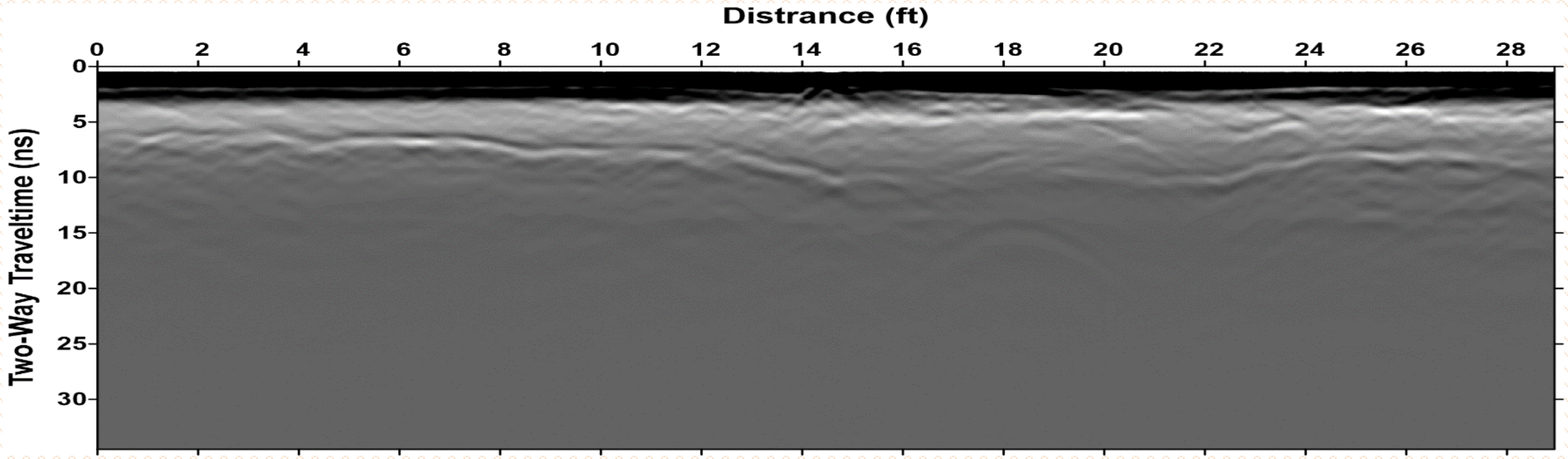
~50x$ high-speed

Costs



Mobilization/ Management
8%
High-Speed Surveys
28%
Field Validation
10%
Traffic Control
10%
44%
Analysis
Machine Learning could help here

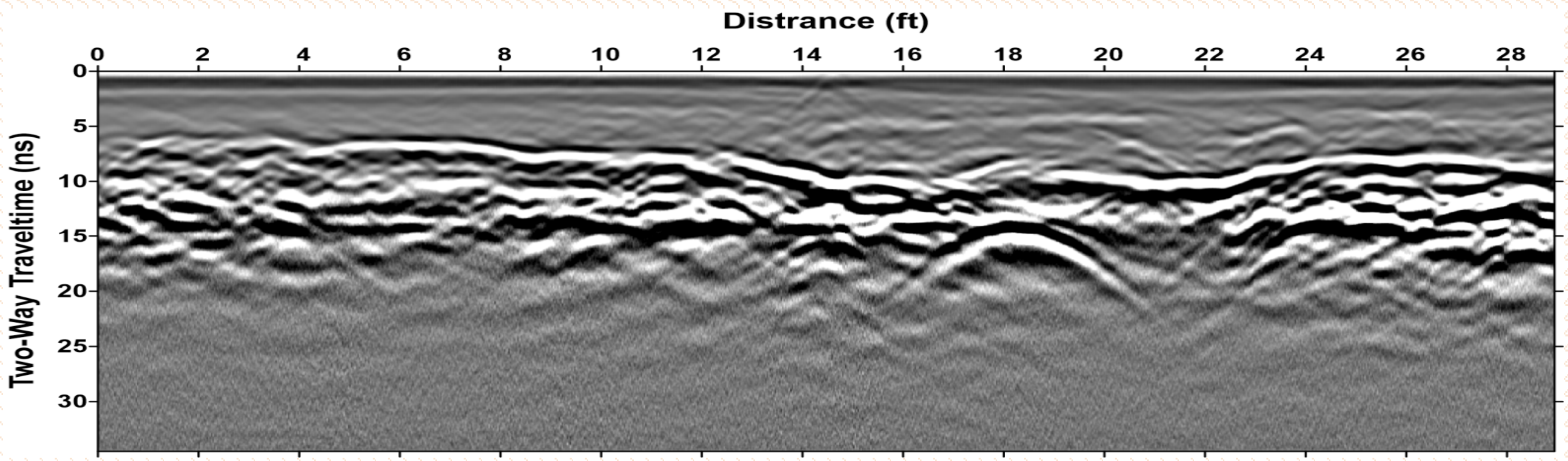
Ground-Penetrating Radar



unfiltered

Time (ns)

Depth (in)



Filtered/Enhanced

Original Questions

1. Can we find things the trained eye can't see?
   - Corrosion, delaminations, debonding

1a. Yes, but not accurate enough– or cost-effective on a network level. More calibration is needed.

Can show you rebar depths, and where to investigate further.

2. Can we distinguish bridges that need immediate attention from those that can wait 5-10 years?

2a. Yes, and that will be our focus going forward. Less useful in other situations.

Original Questions

3. Can reduce costs—deck surveys especially?

3a. Won't replace inventory surveys or destructive testing yet—but can give better repair quantities—and save money by limiting change orders.

High-speed techniques may be useful if you absolutely can not close a lane.

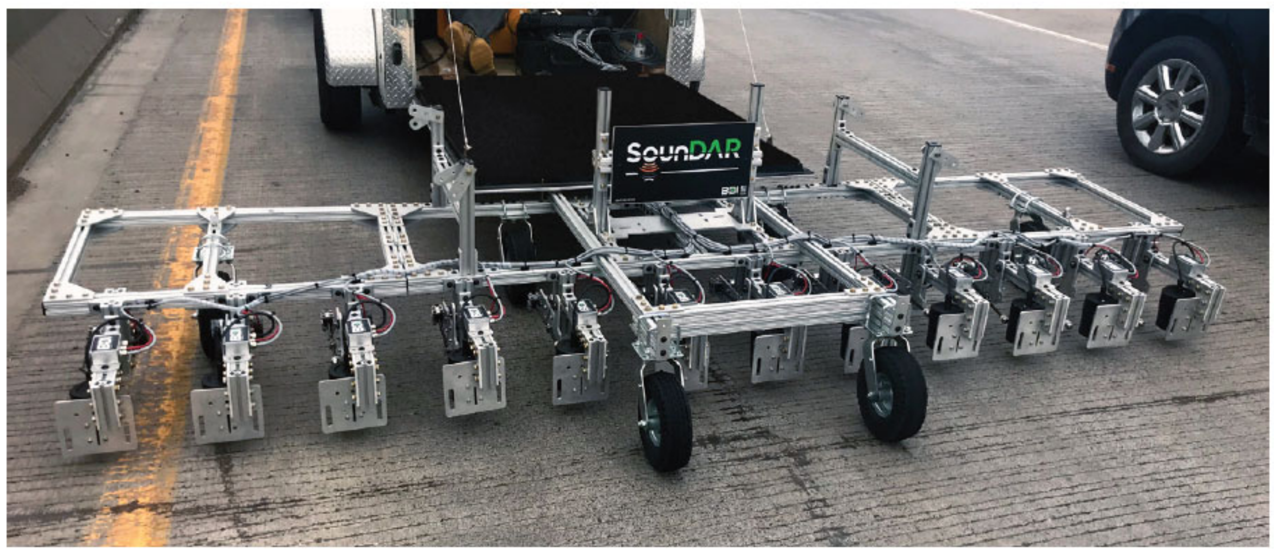
4. Are certain types of bridges responding differently over time?

- Thin decks/ overlays/ mag chloride

4a. Inconclusive, defects correlate between CS2 & CS3

Less of a focus for us, we'll continue to look at bridges on project basis.

The Future



SHRP2 R06A NDT Bridge Decks = primarily GRP

Kathy Crowell, NMDOT
Dr. Brad Weldon, NMSU
Daniel Diaz, NMSU

special thanks to:
Shane Kuhlman, NMDOT State Bridge Engineer
Dr. Manuel Celaya, Advanced Infrastructure Design

NMDOT

Agenda

- Introduction
- Start with the end in mind
- Things of interest
- Details / Pretty Pictures
- Conclusions

Why NMSU

Ground Penetrating Radar (GPR) for Concrete Bridge Deck Evaluation

Daniel E. Diaz
Dr. Brad D. Weldon

NM STATE UNIVERSITY

Department of Civil Engineering, New Mexico State University

STRUCTURAL SYSTEMS LABORATORY

NEW MEXICO STATE UNIVERSITY

Why GPR

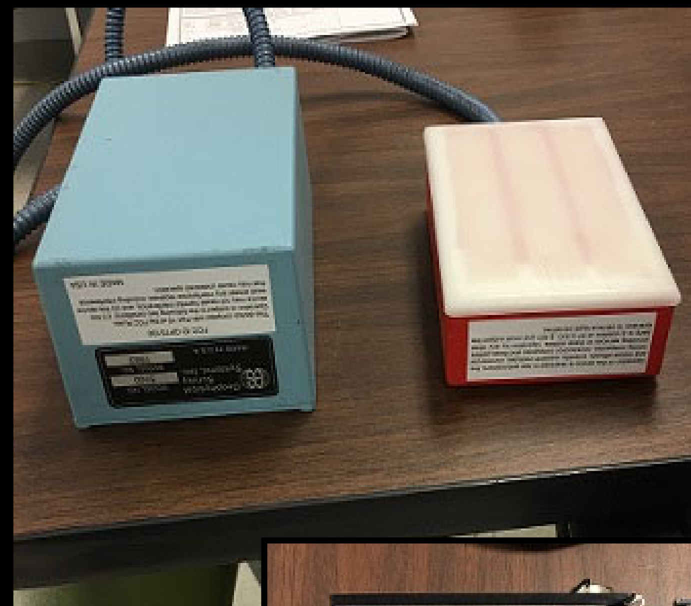
Existing Equipment

Air Coupled (2 Antenna's) 2Ghz Frequency

Ground Coupled (4 Antenna's, 2/freq.) 400Mhz and 900Mhz Frequency

NMDOT CURRENT EQUIPMENT- SIR 30

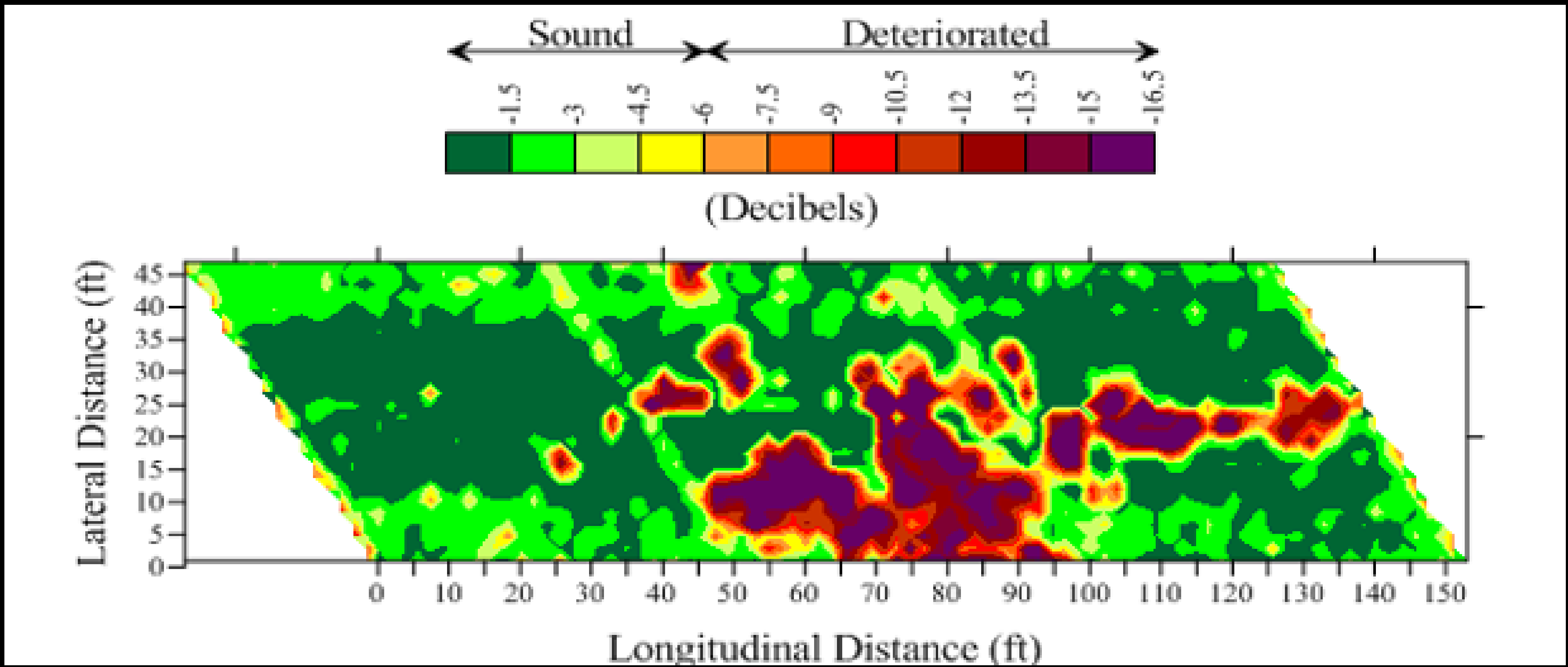
Existing Equipment



start with the end in mind

- At the end of the day, we intended to create a capability that we did not previous have.
- The capability needed to be readily accessible through our bridge inspection contract with NMSU.
- AND:

pretty pictures are required



Things of Interest

- NMDOT does use chlorides (deicing salts) – but not in the whole state
- Unique and variable deterioration models
- Various and often unintentional overlays

Things of Interest

- $14M in bridge preservation funds controlled by the State Bridge Engineer
- NMDOT is moving towards condition based prioritization using BrM

- Estimating quantities is not very scientific – we pay by actual quantity
- Difficulties in correlating preservation scope and budget

Nine Bridges

6134

6840 (bad deck)

6932

6939 (slab)

7032 (latex overlay + UHPC)

7113

7299

8845 (base)

8852

GPR Evaluation Results: Bridge 8845
NMDOT Typical Prestressed Girder

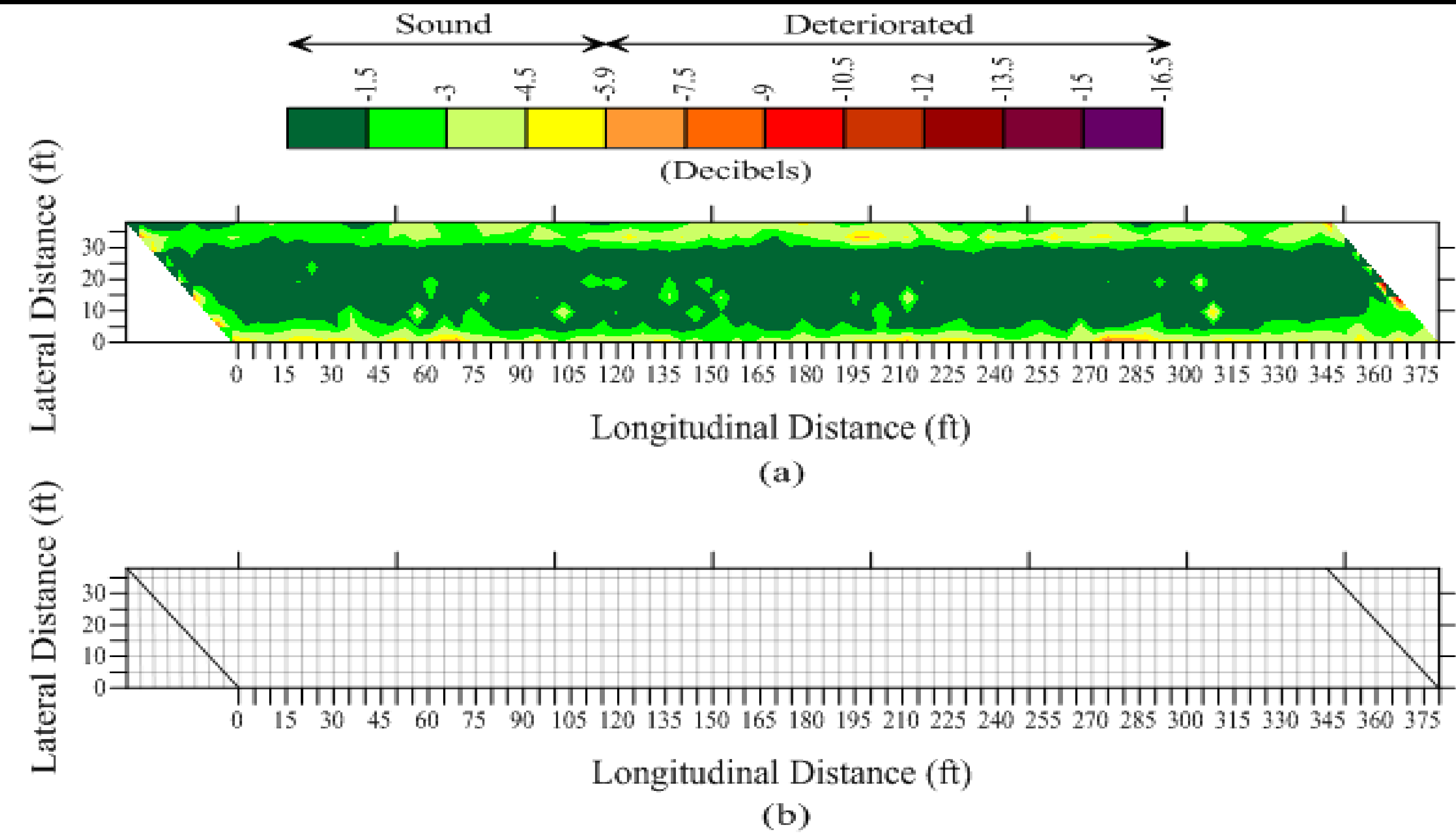
GPR Evaluation Results: Bridge 8845

- AASHTO Prestressed Girder

- From most current inspection report:
  - Deck: 7
  - Superstructure: 7
  - Substructure: 7

- Deck inspection reports:
  - Isolated transverse and longitudinal cracks up to 1/32″ with light leaching (Underside)
  - Transverse and vertical cracks up to 1/16″ with light leaching (Deck edges)

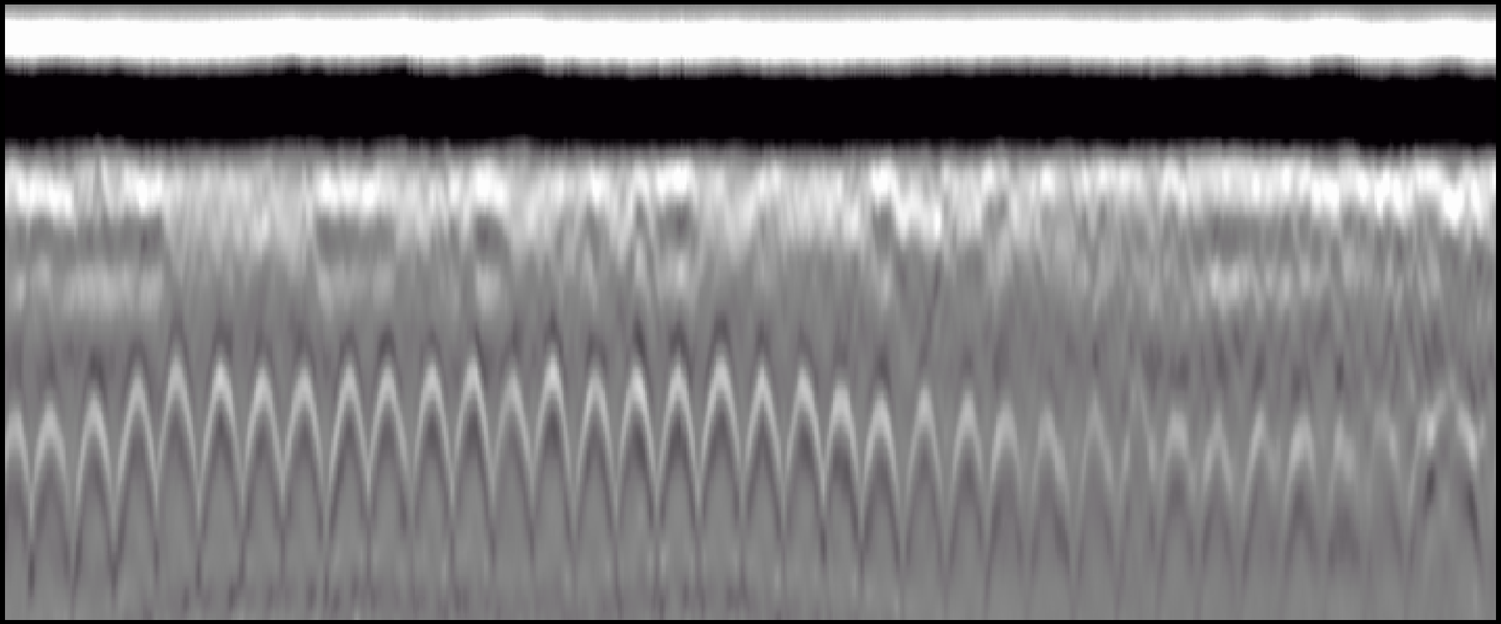
GPR Evaluation Results: Bridge 8845



GPR Evaluation Results: Bridge 6840

- AASHTO Prestressed Girder
- From most current inspection report:
  - Deck: 4
  - Superstructure: 5
  - Substructure: 6
- Deck inspection reports:
  - Transverse and longitudinal cracks up to 1/8" with heavy leaching (deck edges); transverse and longitudinal cracks up to 1/16" with heavy leaching and rust stains near joints

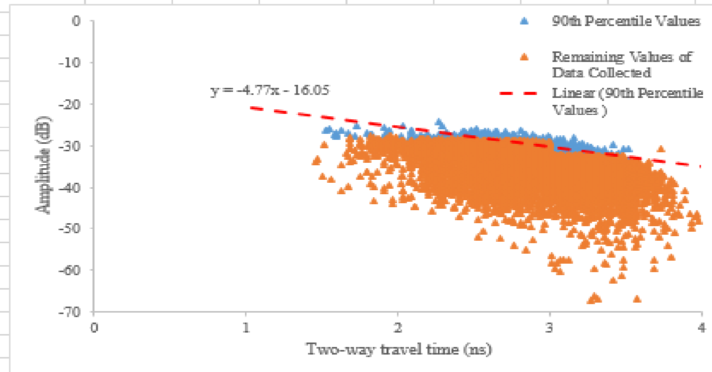
GPR Evaluation Results: Typical B Scan from Bridge 6840

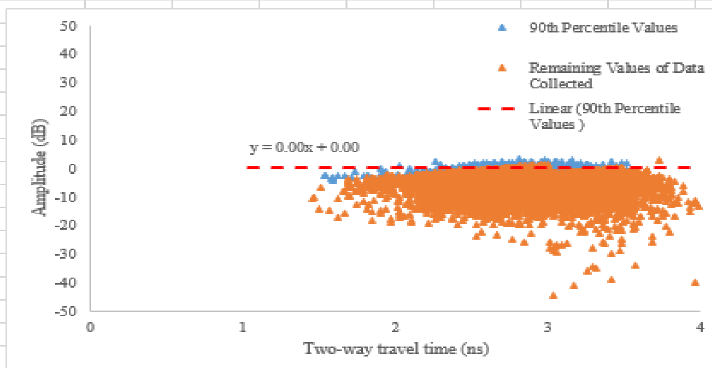


– Reflection amplitudes picks, X and Y location coordinates, and two-way travel time are obtained using Radan 7

GPR Evaluation Results: Excel Processing Bridge 6840

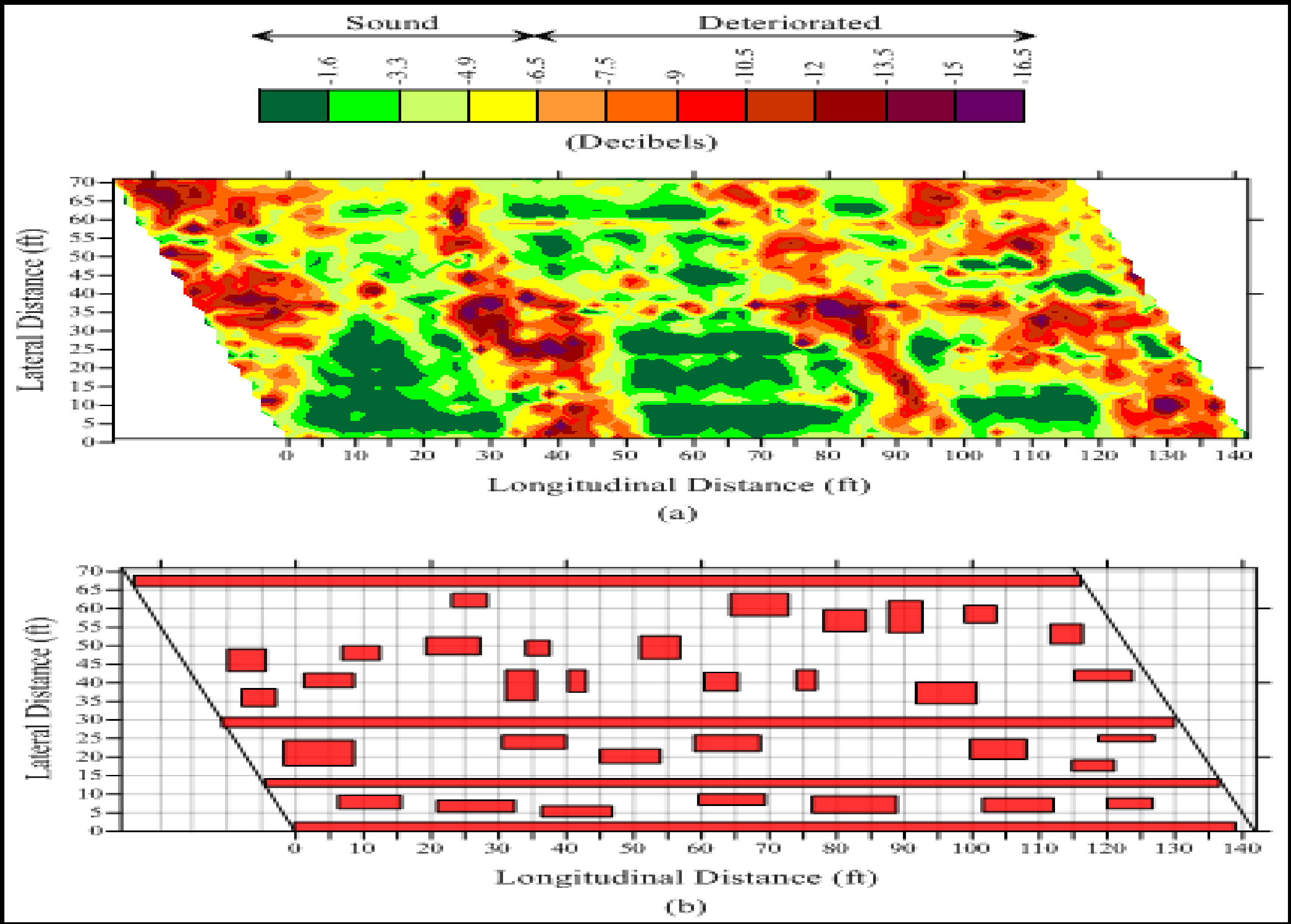
	A	B	C	D	E	F	G	H	I
1	Remaining Values					90th Percentile Values			
2	-23.261	67	-33.8	1.453		loc x	loc y	amp	twtt
3	-22.969	67	-33.13	1.469		52.9327	71	-27.54	1.594
4	111.469	71	-37.36	1.5		33.1322	71	-27.48	1.906
5	20.6257	71	-29.87	1.516		53.8454	71	-27.47	1.719
6	-22.51	67	-38.22	1.563		103.305	71	-27.42	1.578
7	-20.218	67	-40.88	1.625		37.5611	71	-27.31	1.813
8	96.4439	71	-34.45	1.625		21.0602	71	-27.17	1.594
9	105.041	71	-31.9	1.656		46.8062	3	-27.16	1.828
10	112.982	69	-39.63	1.672		46.7175	1	-27.02	1.797
11	104.173	71	-32.36	1.672		36.6495	71	-27.02	1.922
12	106.648	71	-33.79	1.688		51.196	71	-26.89	1.594
13	103.261	71	-30.75	1.688		48.6778	71	-26.85	1.672
14	110.99	71	-30.33	1.688		140.908	3	-26.3	1.938
15	100.699	71	-29.23	1.688		49.5029	71	-26.26	1.625
16	99.831	71	-28.49	1.688		50.3708	71	-26.1	1.531
17	102.479	71	-28.43	1.688		52.0649	71	-25.91	1.547
18	47.1052	1	-27.94	1.688		-24.386	67	-25.47	1.906
19	108.386	71	-33.62	1.703		116.158	71	-25.29	1.734
20	95.575	71	-30.99	1.719		104.837	5	-28.33	2.313
21	105.867	71	-30.99	1.719		85.1171	3	-28.33	2.375
22	111.772	71	-32.27	1.734		68.9948	69	-28.31	2.094
23	112.635	69	-37.24	1.75		73.177	3	-28.29	2.297
24	99.0496	71	-32.42	1.75		-4.27	17	-28.29	2.297
25	4.99363	71	-29.59	1.75		67.9803	3	-28.29	2.328
26	5.90526	71	-29.5	1.75		3.46754	5	-28.28	2.484
27	101.612	71	-29.5	1.75		130.148	23	-28.28	2.5
28	47.8526	71	-28.24	1.75		77.8223	5	-28.27	2.234
29	114.335	71	-31.76	1.766		111.328	7	-28.27	2.484
30	112.641	71	-31.62	1.766		18.0107	5	-28.27	2.5
31	97.2253	71	-29.9	1.766		11.4285	31	-28.27	2.5
32	140.092	3	-32.17	1.781		74.0364	3	-28.23	2.266
33	107.561	71	-32.16	1.781		69.2948	1	-28.22	2.328
34	-20.843	67	-36.26	1.797		67.1642	3	-28.21	2.375
35	139.792	3	-36.21	1.797		64.1239	1	-28.2	2.109





– Information obtained from Radan 7 exported to Excel for further processing

GPR Evaluation Results: Bridge 6840



GPR Evaluation Results: Bridge 6939 (slab)

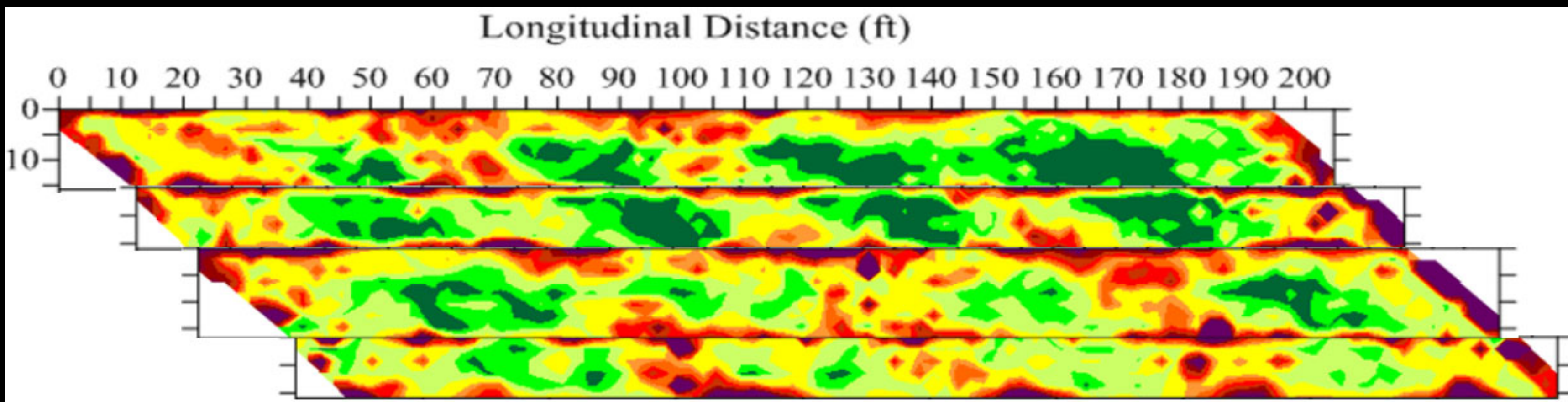
GPR Evaluation Results: Bridge 6939

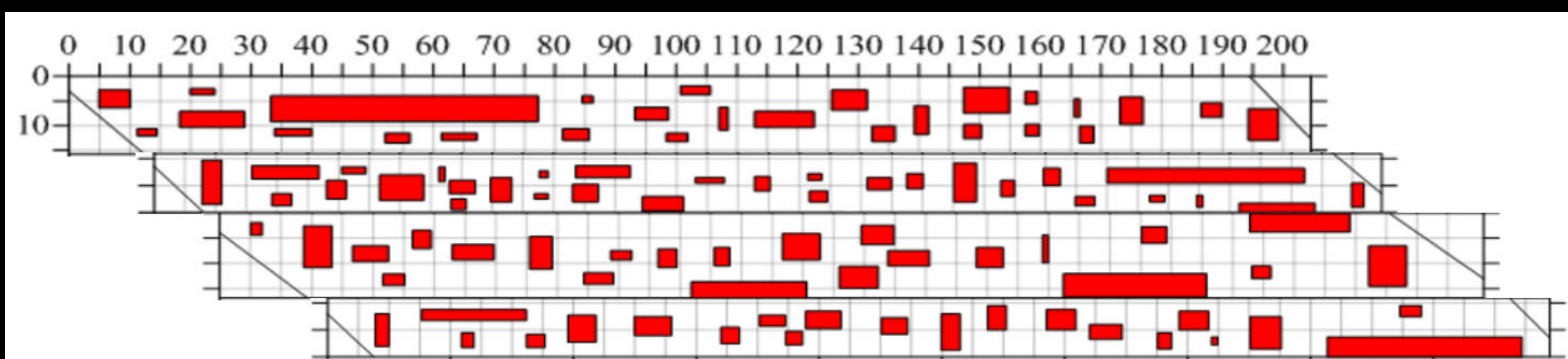
- Concrete Slab Bridge – Asphalt Overlay

- From most current inspection report:
  - Deck: 5
  - Superstructure: 5
  - Substructure: 6

- Deck inspection reports:
  - Vertical, horizontal, transverse and map cracks up to 1/4" (deck edges); transverse and map cracks up to 1/16", areas of moderate leaching, and spalls up to 6" by 5" (Underside)

GPR Evaluation Results: Bridge 6939





“Normal Deck”

- It works to help determine whether a deck is a preservation candidate verses replacement.

"Slab Deck"

- Good as first pass
- Second pass (more detailed) really necessary as DEPTH of the areas of concern is critical to decision / quantity

Overlay

- Seems to work in “seeing through” asphalt
- Seems to work with “seeing through” epoxy overlay (by extension, will likely work with polyester overlay)

- Does NOT seem to work with latex modified overlay

Successful Project

- We learned a lot
- We developed a capability that we did not previous have (implementation)
- Research value, published research, and developed engineering talent

Executive Summary

GPR is not the magic bullet

But it has value when applied appropriately

Decision must be project specific (bridge type, data need)

New Mexico DOT

Kathy Crowell

Bridge Design Manager

Kathy.crowell@state.nm.us

505-470-5663

Presenter Contacts

Hoda Azari, Ph.D.
Federal Highway Administration
hoda.azari@dot.gov
202-493-3064

Dennis Sack
Olson Engineering
dennis.sack@olsonengineering.com
303-423-1212

Randy Strain
Indiana DOT
rstrain@att.net

Corey Withroe
Oregon DOT
corey.r.withroe@odot.state.or.us
503-986-3339

Kathy Crowell
New Mexico DOT
Kathy.crowell@state.nm.us
505-470-5663