COMPARISON OF BRIDGE DECK DETERIORATION FOUND BY NDT METHODS AND HYDRODEMOLITION

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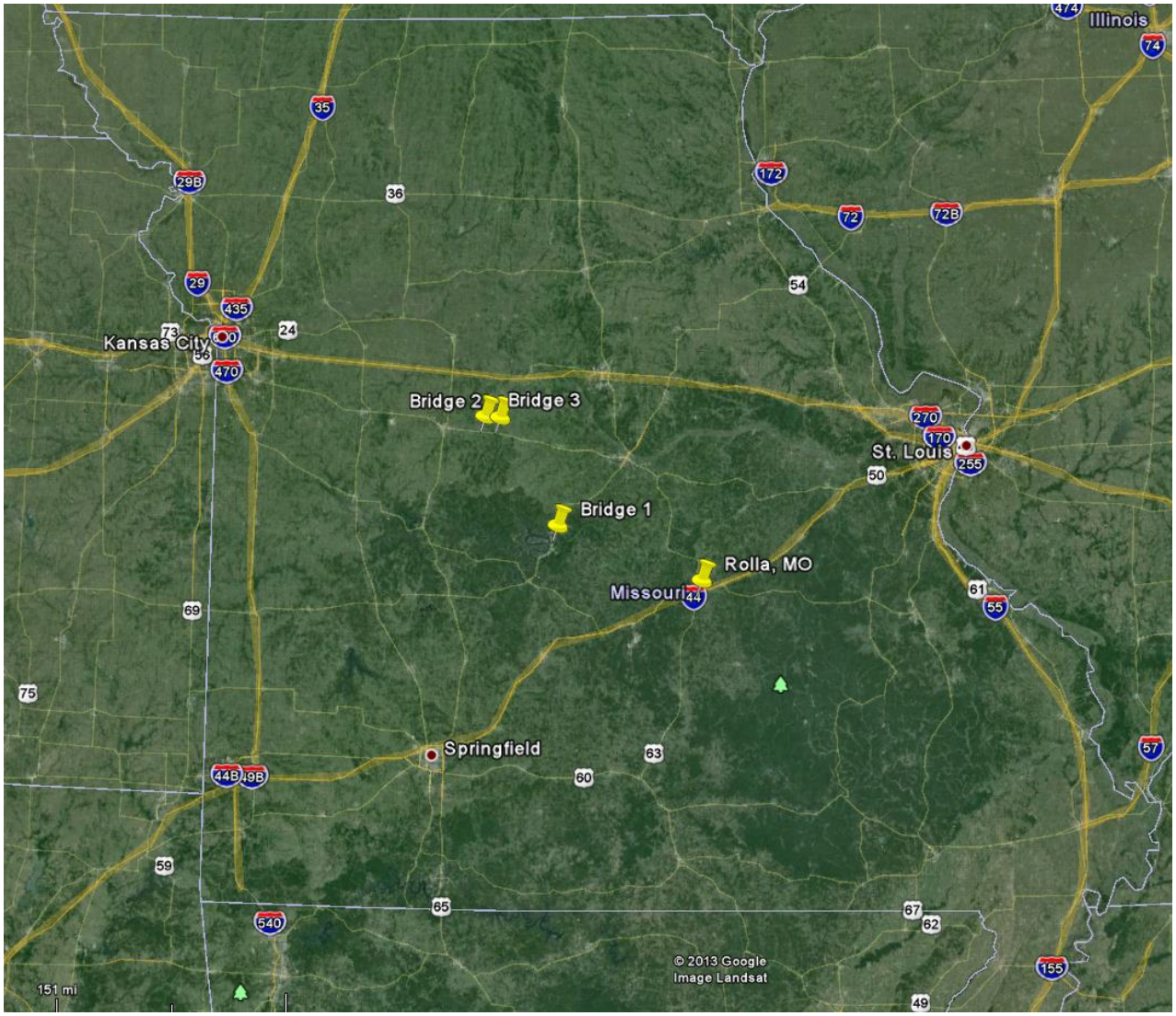
Outline

- Research Objectives
- Methods of Investigation
- Results
- Conclusions and Ongoing Work

Research Objectives

- Investigation of 12 bridge decks of similar construction type to allow more comprehensive deck examinations at a lower cost than traditional hammer sounding and chain dragging techniques
- Calibration of results using cores, visual deck inspection, and rehabilitation to enable use by DOTs for monitoring, planning, and estimating

Bridge Locations

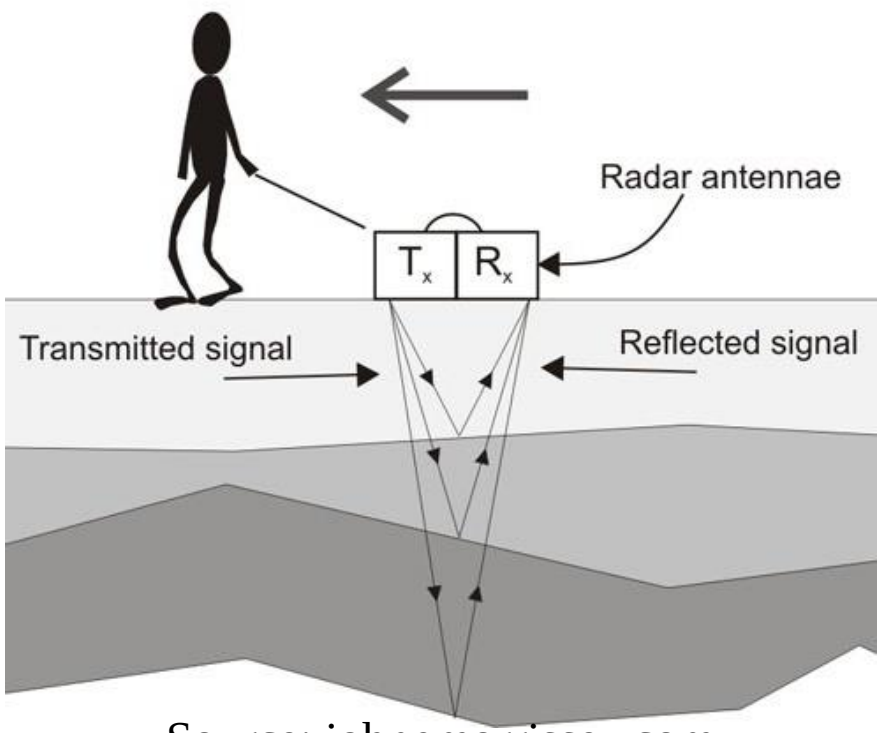


Methods of Investigation

- GPR
- Visual Deterioration Mapping
- Core Extraction
- Deck Rehabilitation

Ground Penetrating Radar (GPR)

- Electromagnetic (EM) pulses transmitted
- Changes in material cause the signal to be reflected
- Two-way travel time and amplitude of the signal is measured



Source: johnpmorrissey.com

GPR Continued

- Real-time data can be viewed on the screen
- Very versatile tool – can be used to locate buried objects, estimate concrete deterioration, determine layers in pavements and soils
- Can scan an entire bridge deck in a few hours using a ground coupled antenna as used in this project

GPR Data Acquisition

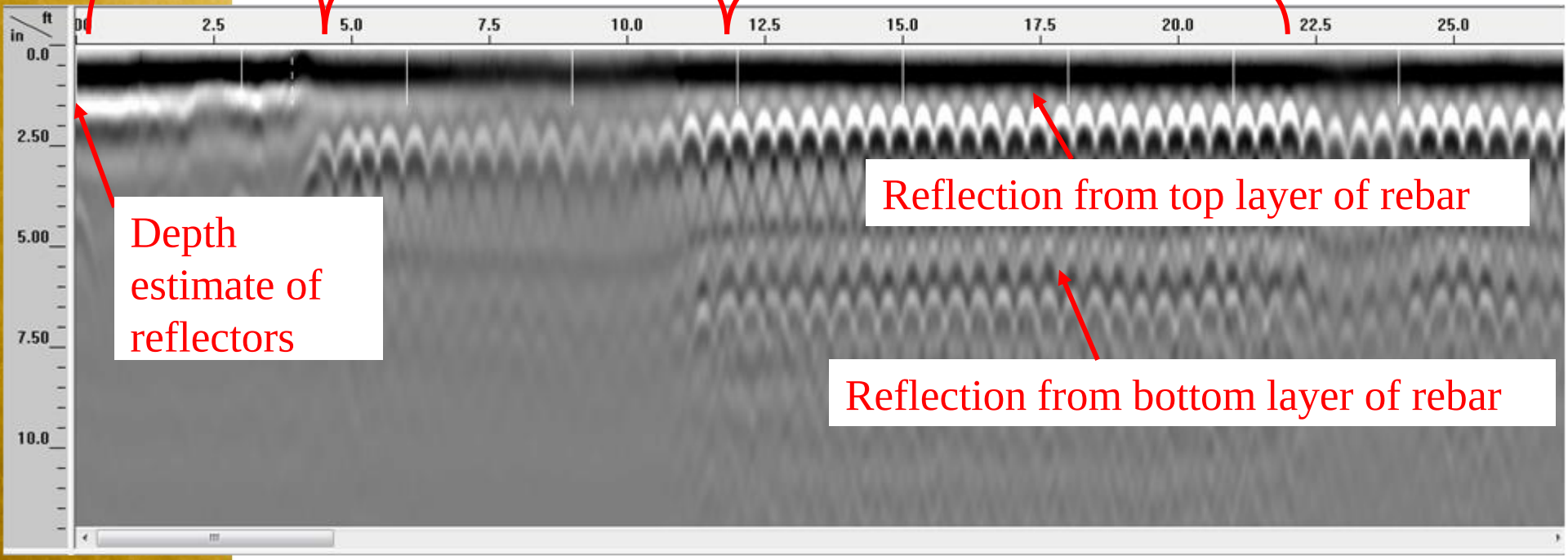
- 1.5 GHz ground coupled antenna
- Variable transverse spacing
- Acquired for all lanes

Sample GPR Results

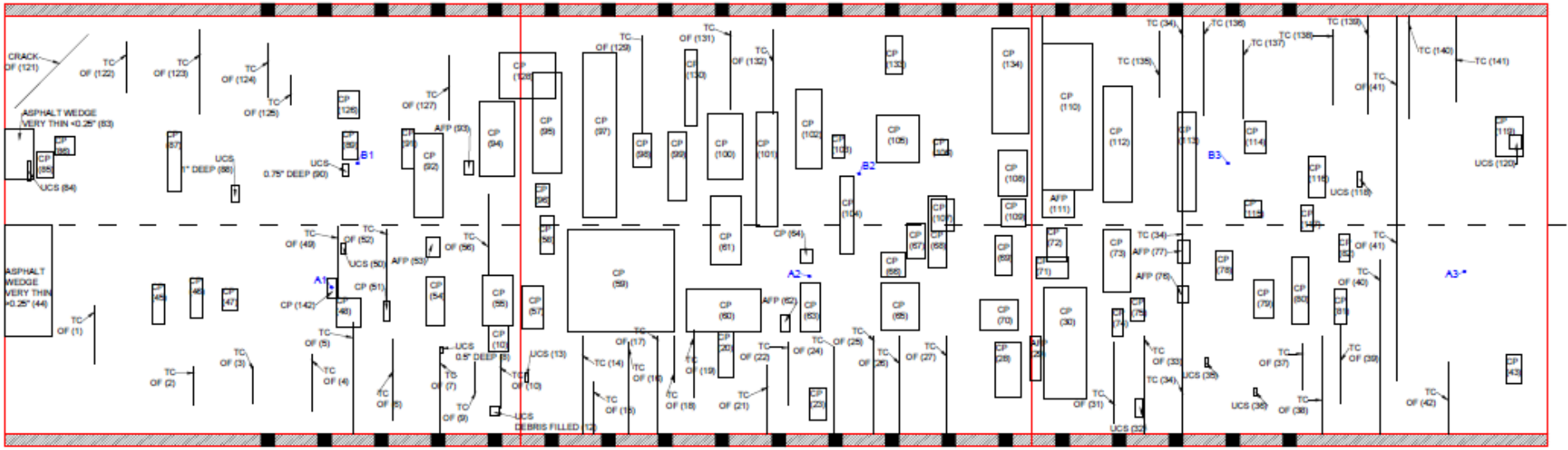
Area without rebar

Area with evidence of deterioration of concrete

Area with no evidence of deterioration of concrete



Visible Deterioration Mapping



Core Extraction

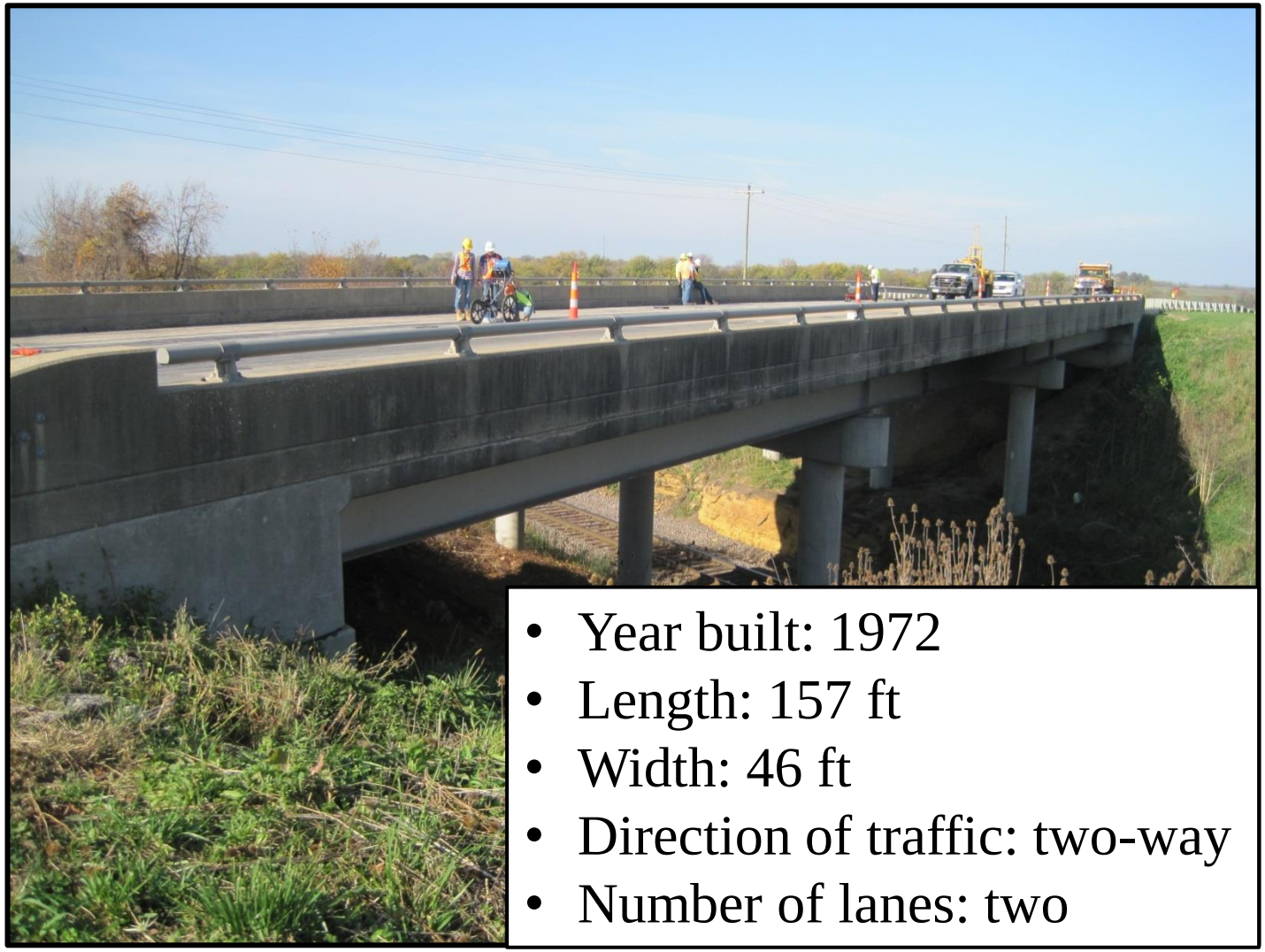
Visual Core Rating

		
Good: No delaminations or visible deterioration.	**Fair:** Some visible deterioration including delaminations, however concrete is in large sections.	**Bad:** Concrete shows a lot of deterioration and is in many pieces including several small pieces.

Deck Rehabilitation

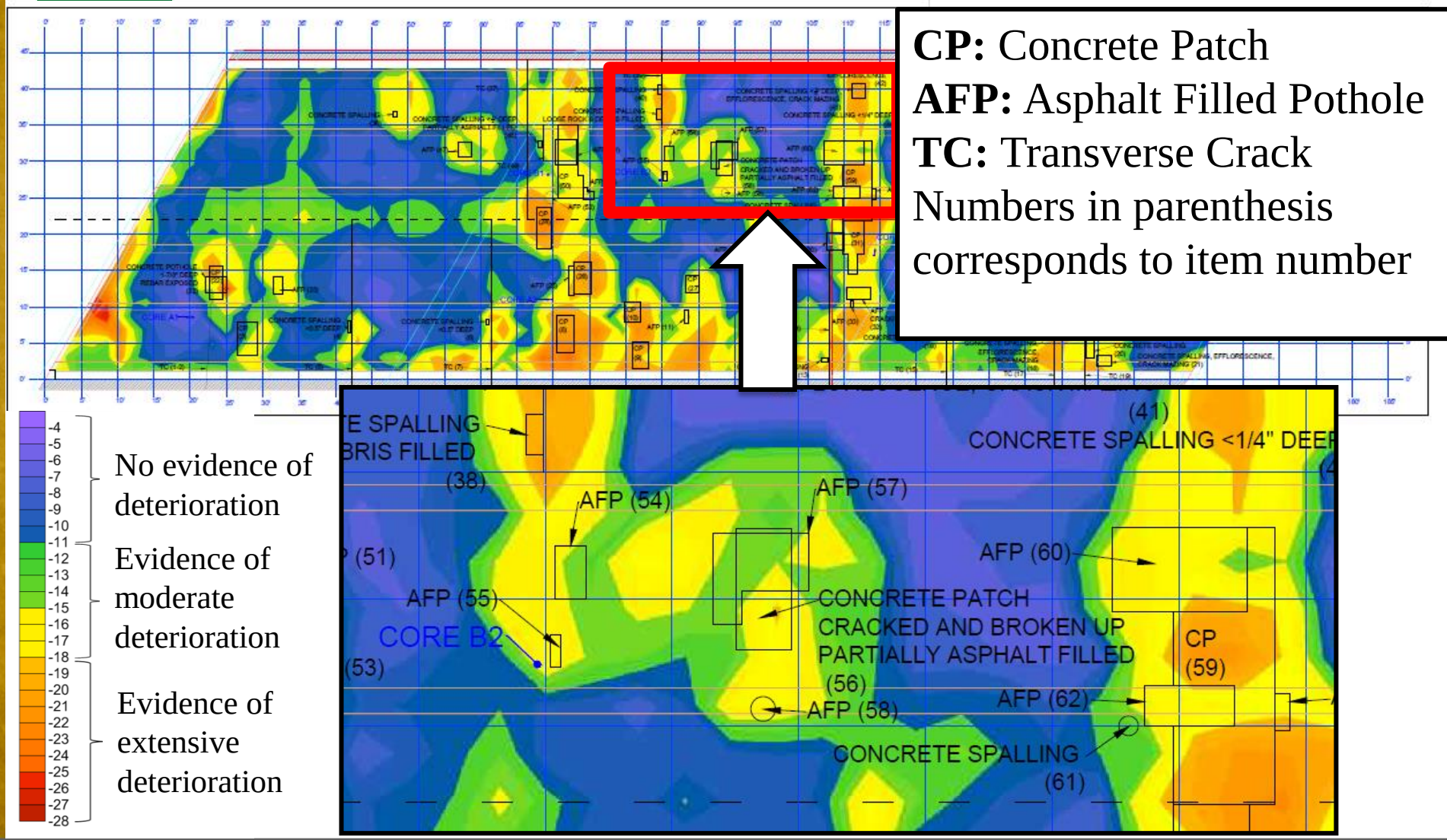
- Top 0.75 in. of deck surface removed by milling
- Hydro demolition then removed remaining loose and deteriorated concrete
- Performed on all 3 of the bridges that were investigated using GPR
- Volume and locations of concrete removal was determined using LiDAR (Light Detection and Ranging)

Bridge 3 Results



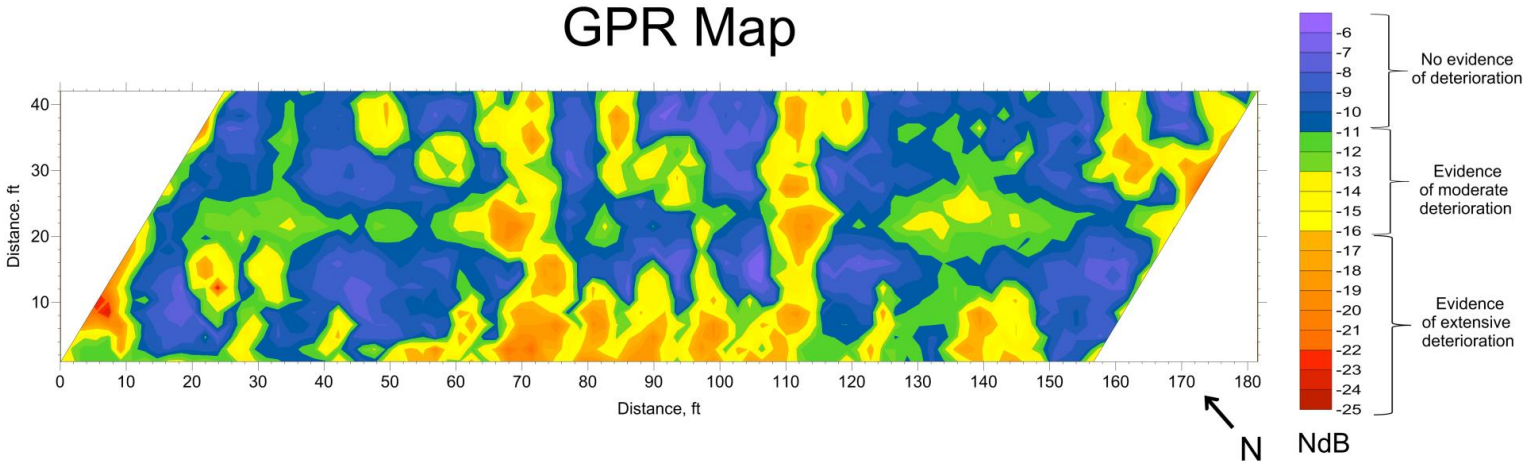
- Year built: 1972
- Length: 157 ft
- Width: 46 ft
- Direction of traffic: two-way
- Number of lanes: two

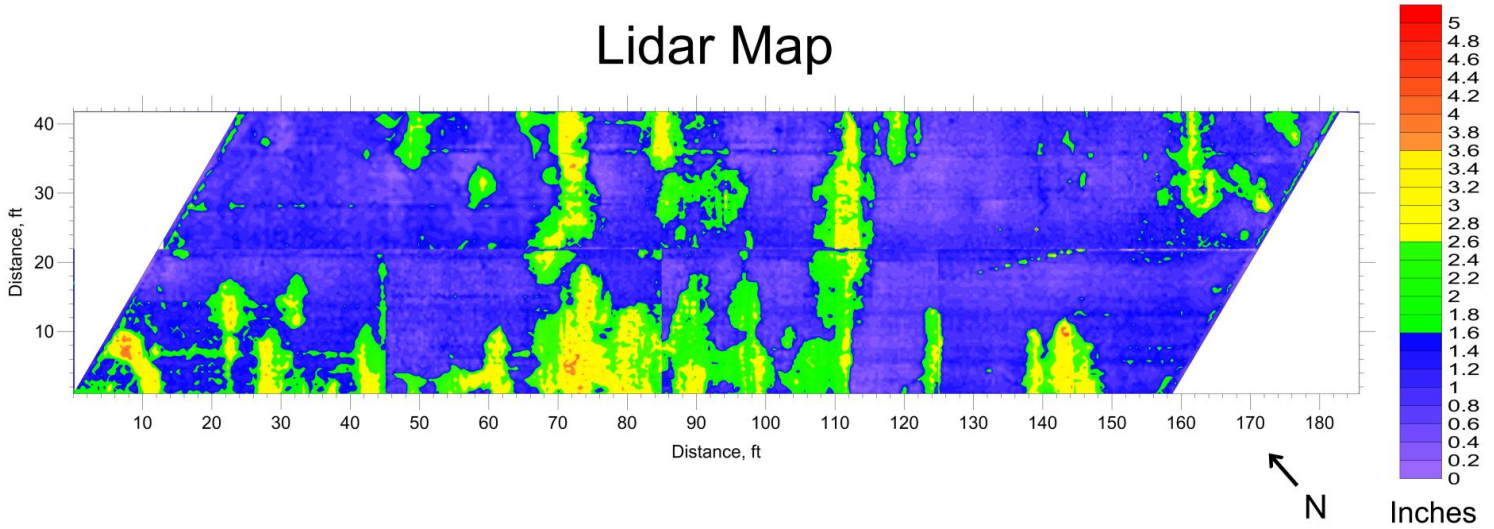
GPR and Visible Deterioration Mapping



CP: Concrete Patch
AFP: Asphalt Filled Pothole
TC: Transverse Crack
Numbers in parenthesis corresponds to item number

GPR and Hydro Demolition Correlation

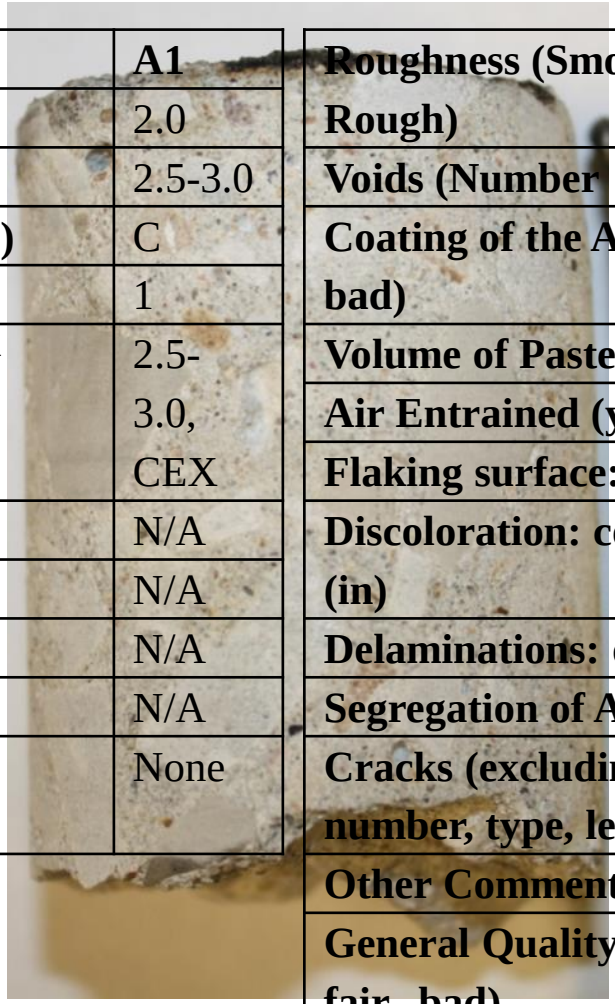




GPR vs. Hydro Demolition Video

Visual Core Inspection – Core A1

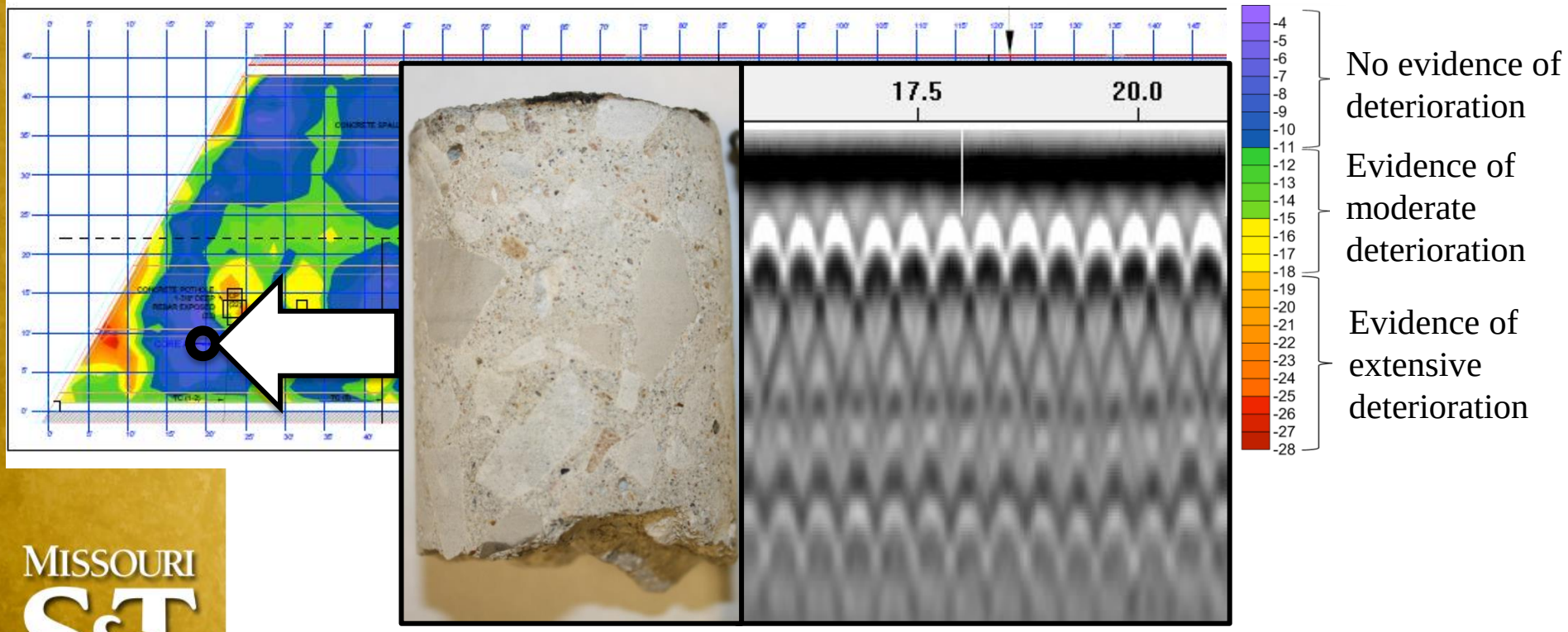
Core	A1
Diameter (in)	2.0
Length (in)	2.5-3.0
Surface (Asphalt: A, Concrete: C)	C
Number of Pieces	1
#1 Length (in) and failure mode [1]	2.5-3.0, CEX
#2 Length (in) and failure mode	N/A
#3 Length (in) and failure mode	N/A
#4 Length (in) and failure mode	N/A
#5 Length (in) and failure mode	N/A
Rebar: diameter (in), length (in), orientation [2], corrosion [2]	None



Roughness (Smooth, Average, Very Rough)	Smooth
Voids (Number >0.25 in. diameter)	1
Coating of the Aggregate (good or bad)	Good
Volume of Paste (good or bad)	Good
Air Entrained (yes or no)	Yes
Flaking surface: thickness (in)	None
Discoloration: color, maximum length (in)	None
Delaminations: depths (in)	None
Segregation of Aggregate: depths (in)	None
Cracks (excluding fracture planes): number, type, length (in)	None
Other Comments	
General Quality of Concrete[3] (good, fair, bad)	Good

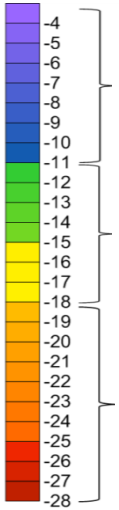
GPR and Core Correlation

Core A1
Visual Core Rating: Good



Core A1

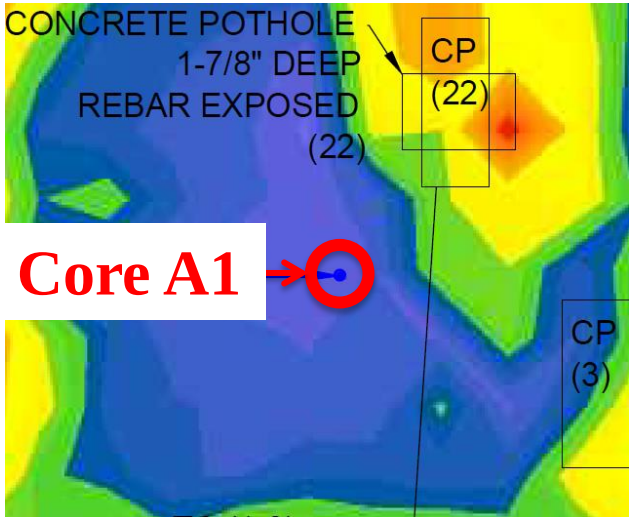
GPR

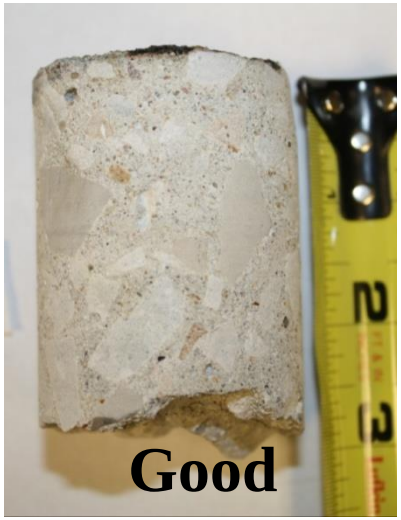


No evidence of deterioration

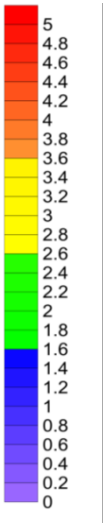
Evidence of moderate deterioration

Evidence of extensive deterioration

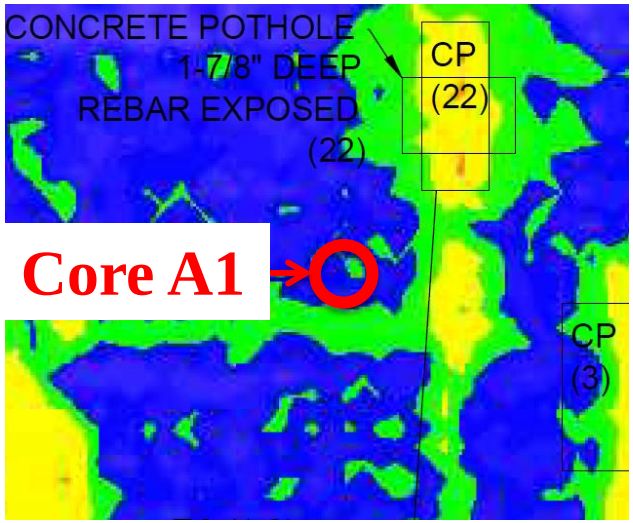


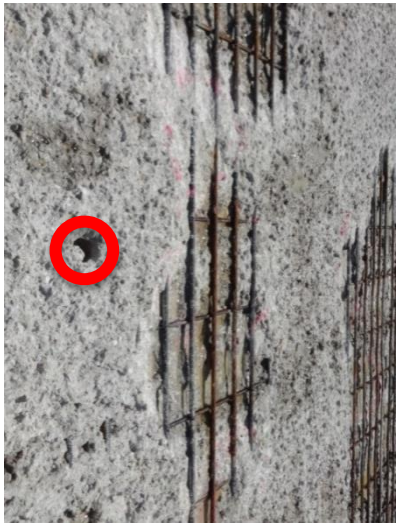


LiDAR



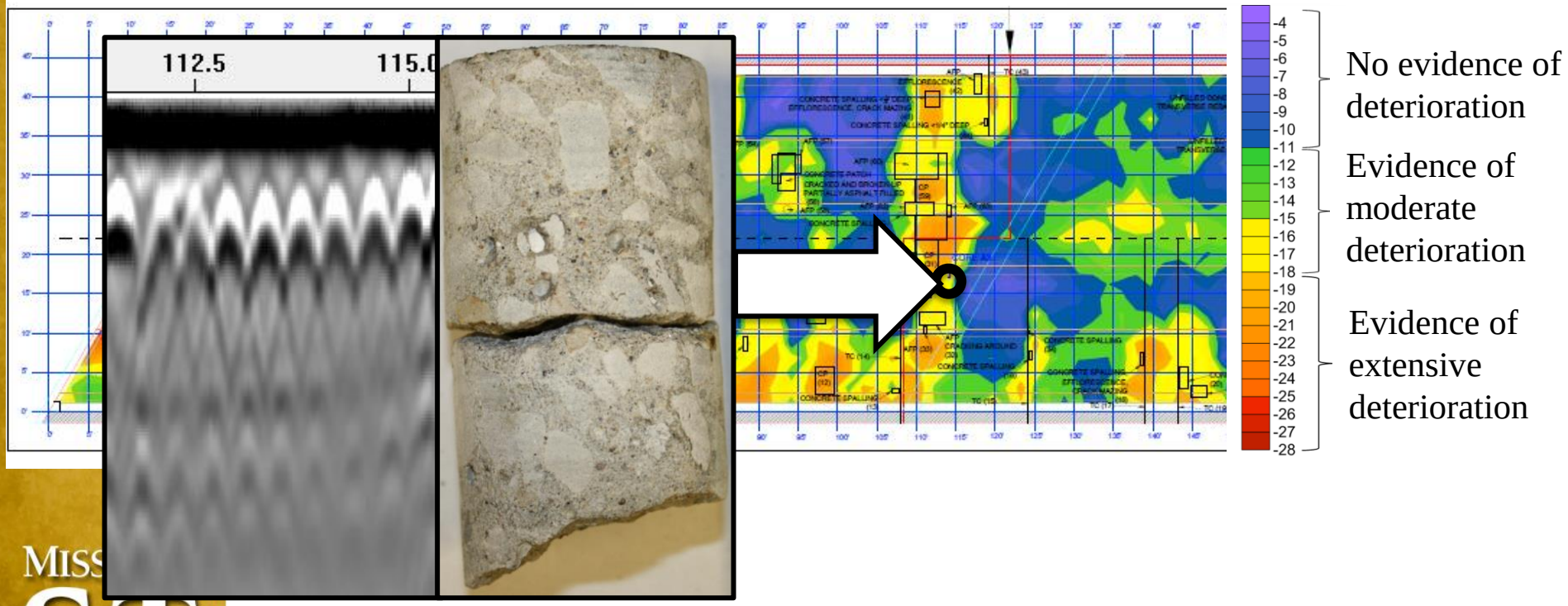
Depth of material removal (inches)





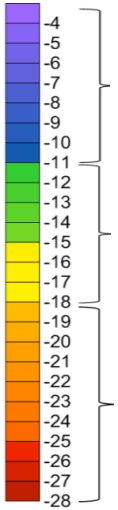
GPR and Core Correlation

Core A3
Visual Core Rating: Fair



Core A3

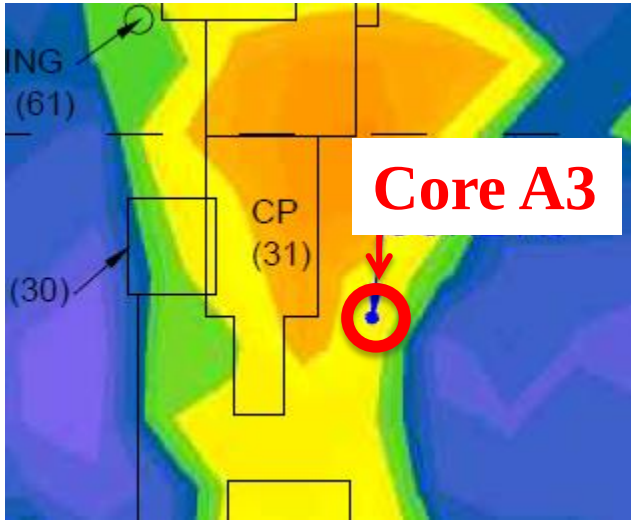
GPR



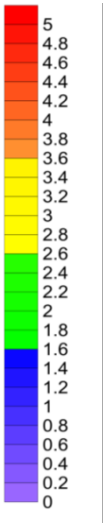
No evidence of deterioration

Evidence of moderate deterioration

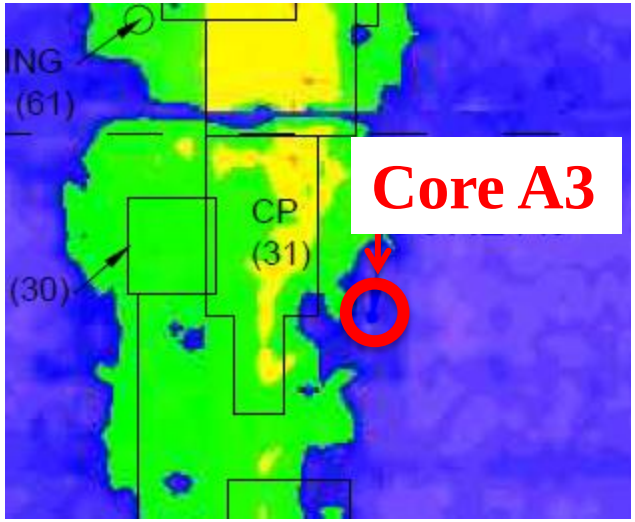
Evidence of extensive deterioration

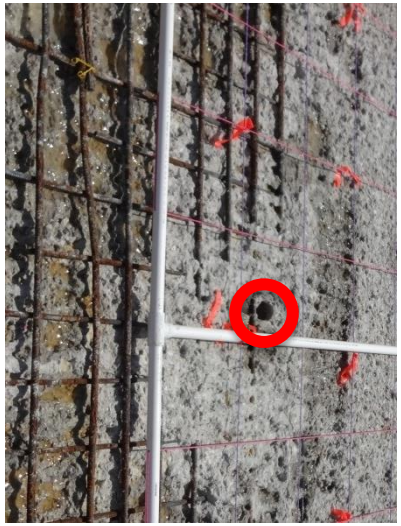


LiDAR

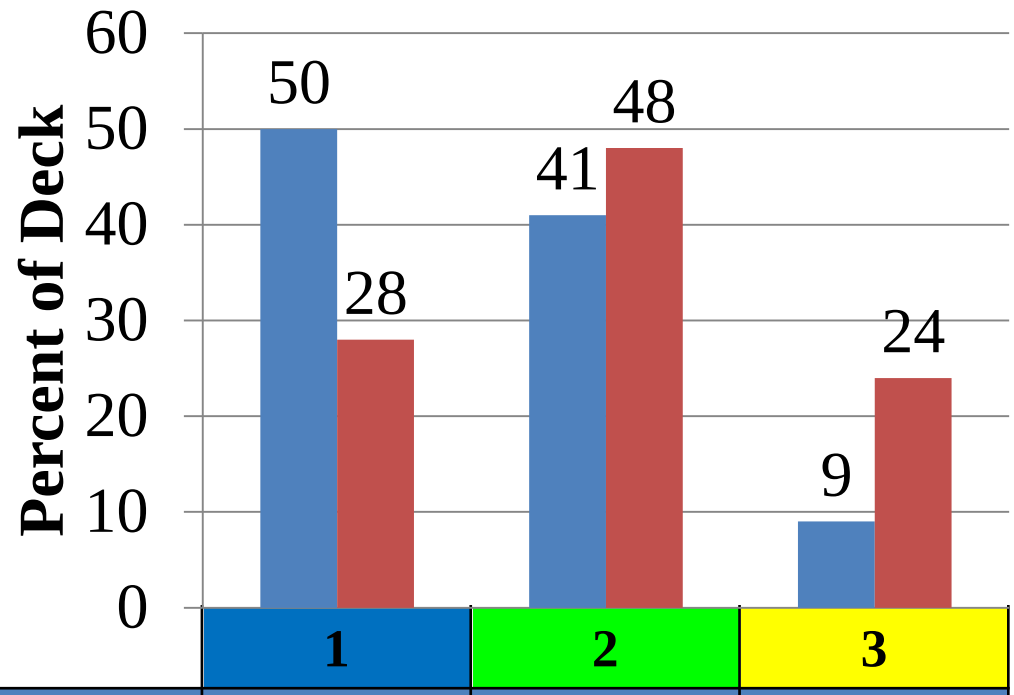


Depth of material removal (inches)





Bridge 3 Deck Condition Comparison

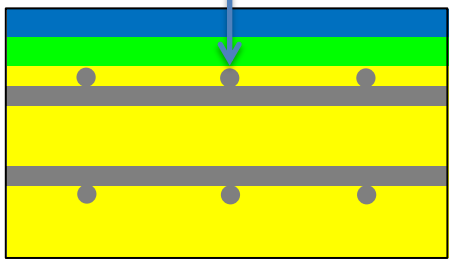


	1	2	3
GPR	No evidence of deterioration	Evidence of moderate deterioration	Evidence of extensive deterioration
Hydro Demolition	Depth < 0.75 in.	0.75 in.< Depth< Top of Rebar	Depth > Top of Rebar

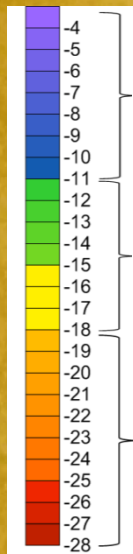
GPR Deterioration Estimate

Hydro Demolition Material Removal

Reinforcing Bar



GPR and Core Correlation



No evidence of deterioration

Evidence of moderate deterioration

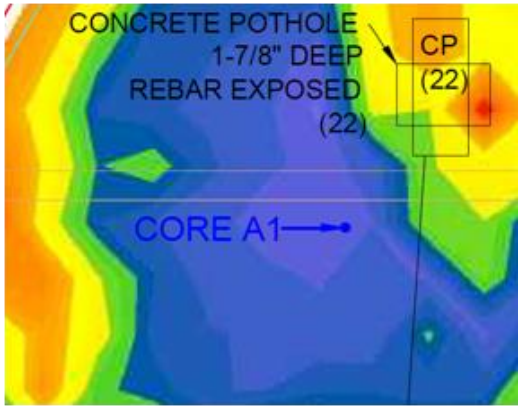
Evidence of extensive deterioration

		VISUAL CORE RATING		
		Good	**Fair**	**Bad**
GPR MAP CLASSIFICATION	**No Evidence of Deterioration**	A1		
	Moderately Deteriorated	A2, B3 (Border Line No Deterioration)	A3, B2	B1
	Extensively Deteriorated			
	% Ideal Match	**% Ideal Match with Border Line Correct**		
	50%	**67%**		

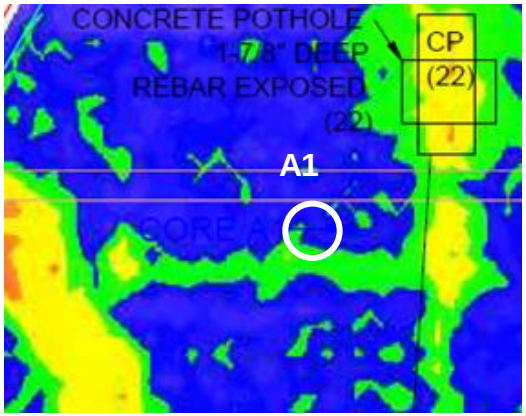
Note: GPR responds to saline moisture in concrete, and the moisture content does not necessarily coincide with visible core rating.

Cores A1 and A2 Comparison

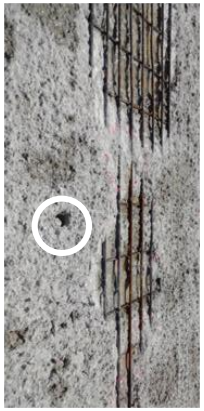
A1



GPR



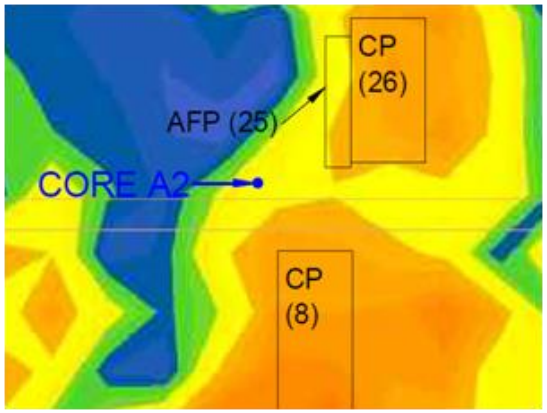
Lidar



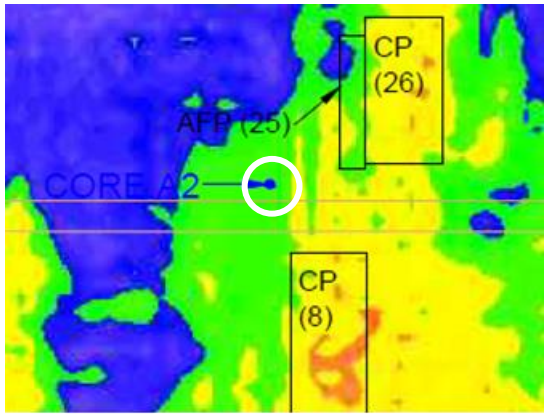
Post Hydro-demolition surface

Core

A2



GPR



Lidar

Core

Conclusions and Ongoing Work

- GPR was found effective for detecting bridge deck deterioration as proved by coring and deck surveys after hydro demolition on 3 bridges
- Calibration of GPR results to hydro demolition results is ongoing
- Additional interpretation of GPR data to estimate the through-thickness deterioration is ongoing

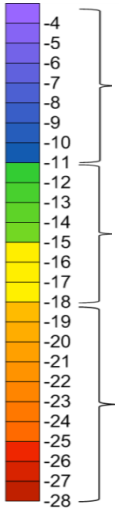
Acknowledgments

- Missouri Department of Transportation (MoDOT)
- Center for Transportation Infrastructure and Safety (CTIS) – A National University Transportation Center (NUTC) at Missouri S&T
- Dr. Norbert Maerz & Ken Boyko, Missouri S&T

Thank You!
Questions?

Core B1

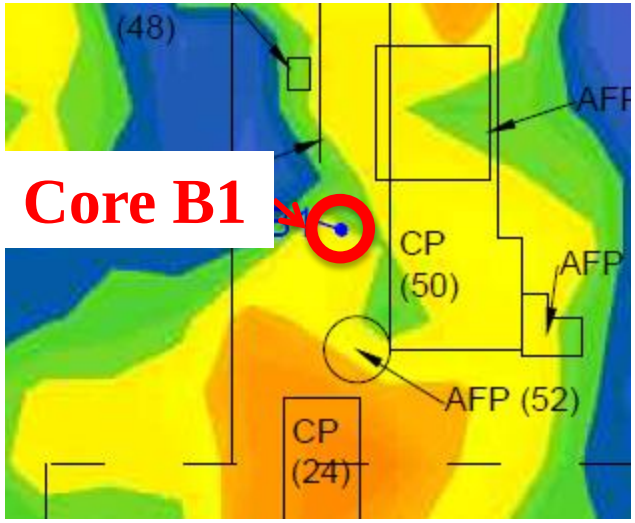
GPR



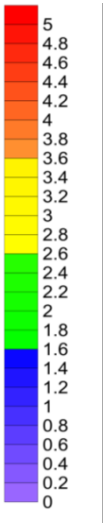
No evidence of deterioration

Evidence of moderate deterioration

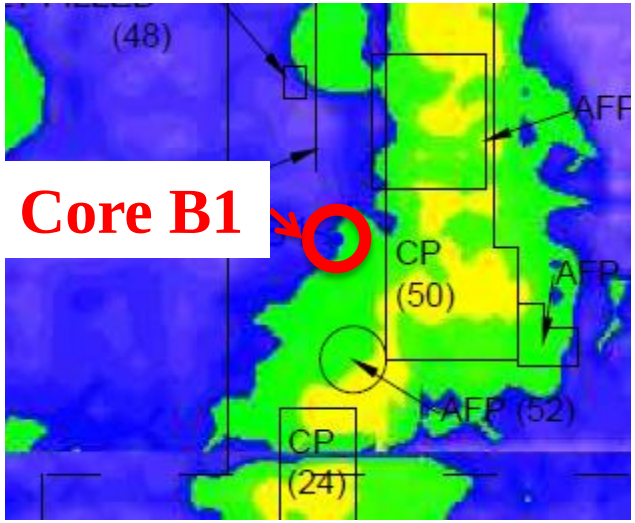
Evidence of extensive deterioration



LiDAR

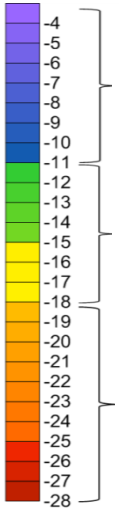


Depth of material removal (inches)



Core B3

GPR



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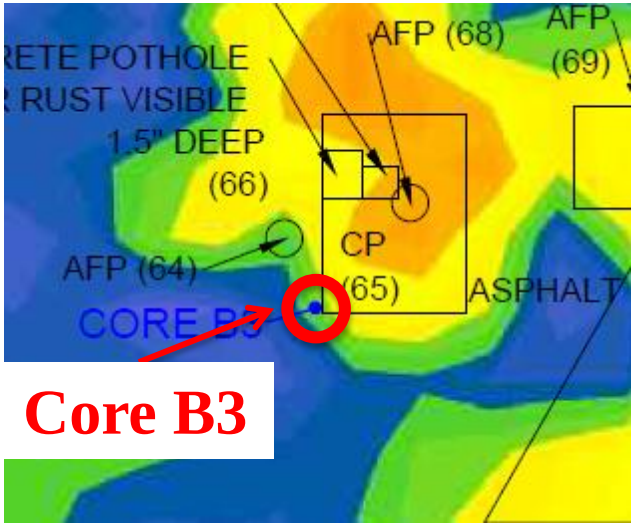
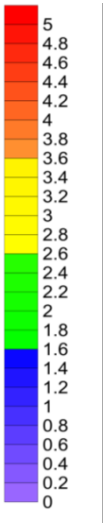
Evidence of moderate deterioration

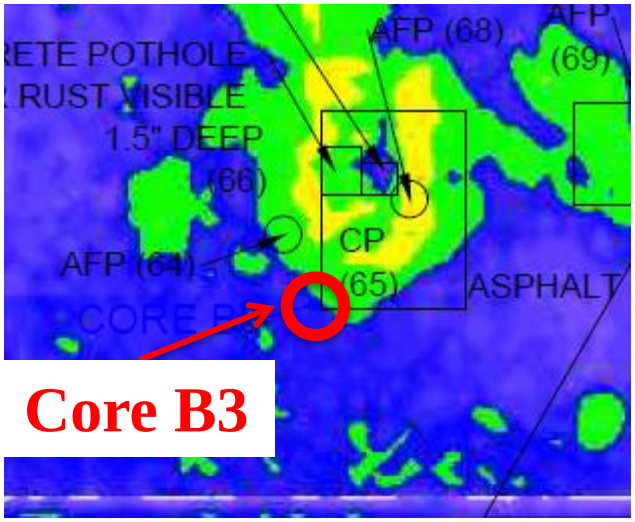
Evidence of extensive deterioration



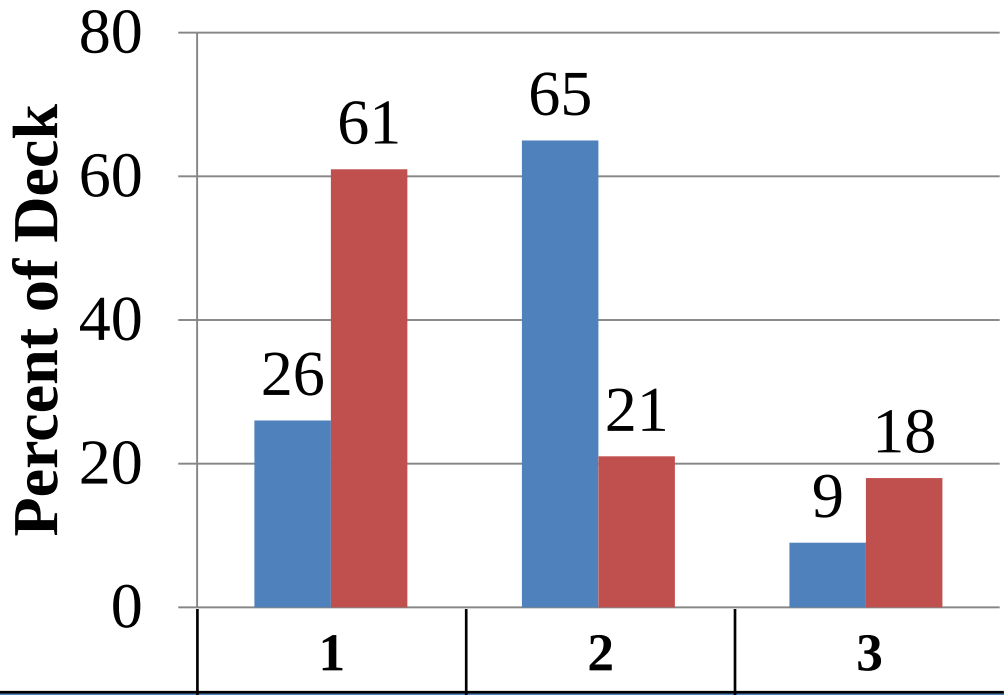
LiDAR



Depth of material removal (inches)



Bridge 1 Deck Condition Comparison



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