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Preservation of Pre-Stressed and Post-Tensioned Structures: Using Correct Tools to Save Costs

Western Bridge Preservation Partnership
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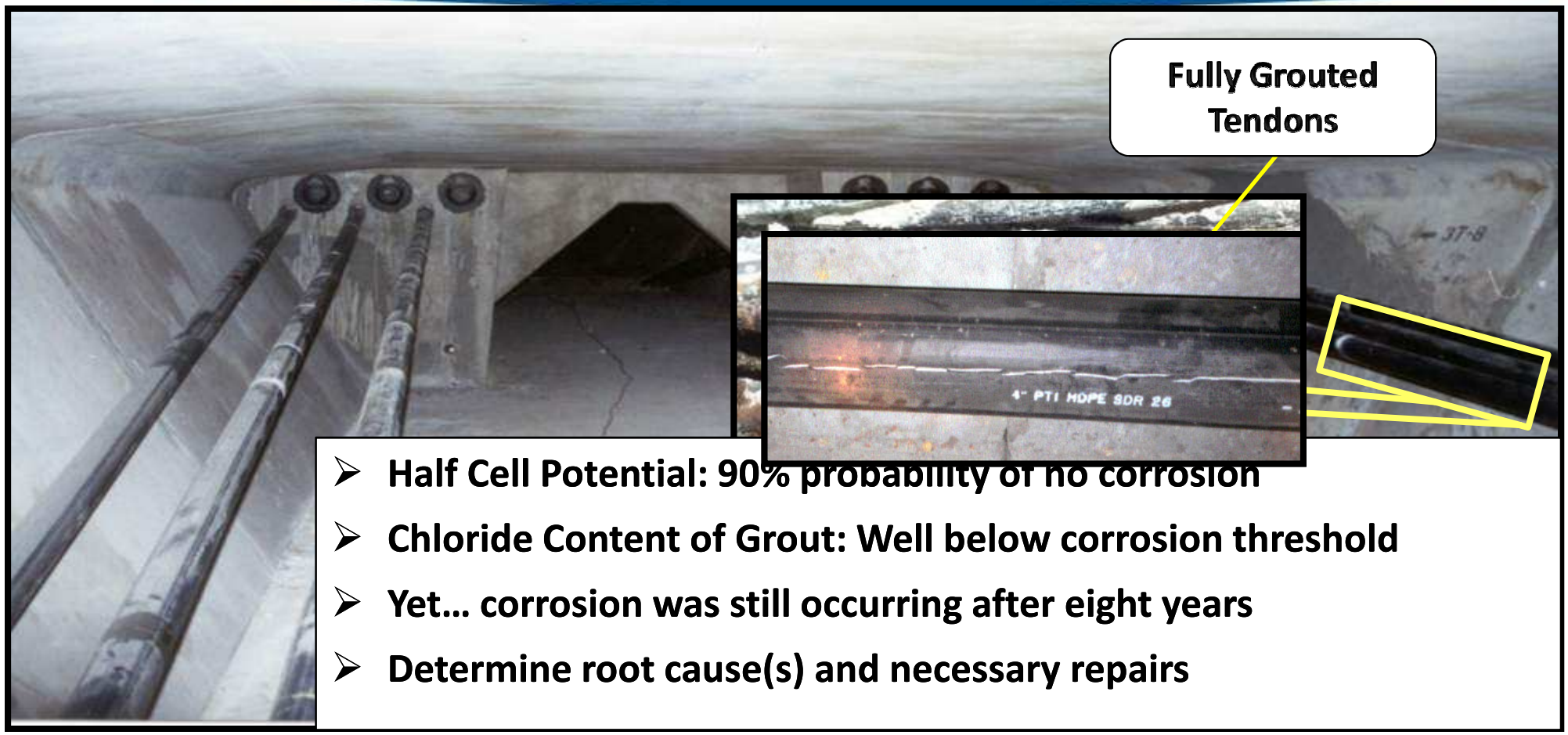
In This Presentation

- Corrosion damage can be quantified using a proper combination of NDT
- Solutions can be designed to cost effectively extend service lives of structures
- Average cost savings for owners: **75-80%** compared to replacement

Problems in PT

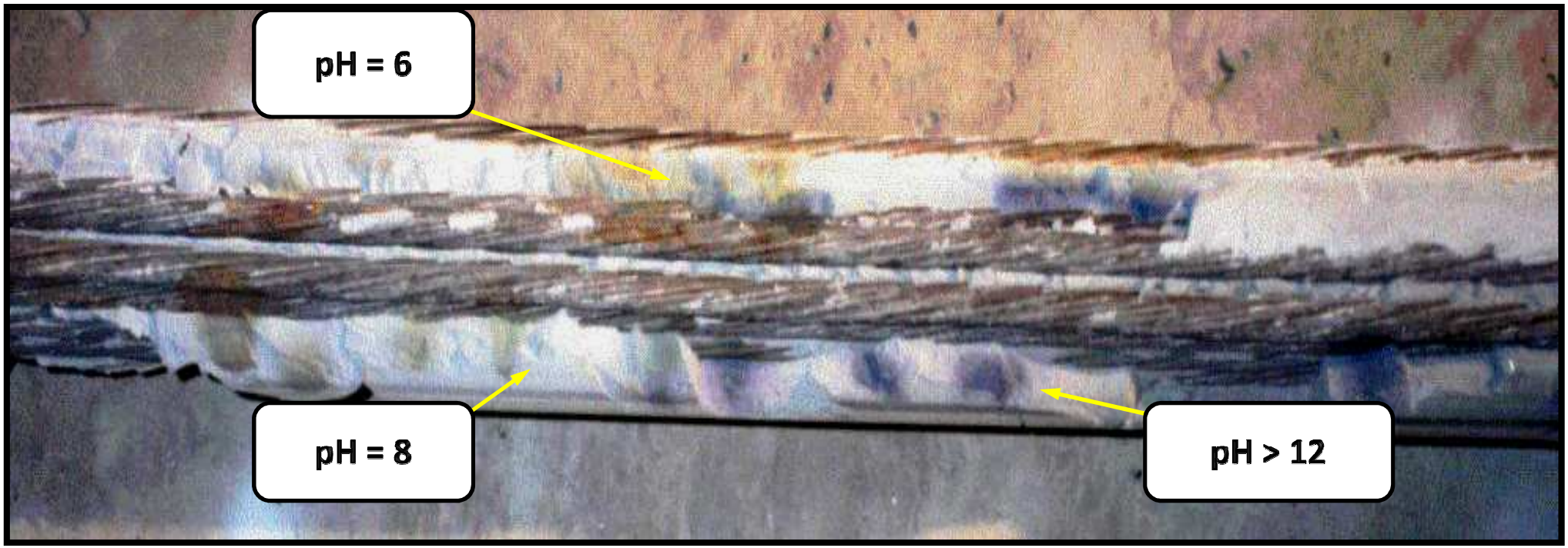
- Visual evaluation cannot quantify problems
- Low pH grout and high chloride content can increase the rate of corrosion of tendons
- Problematic voids need to be identified
- Cancerous corrosion can cause sudden failures as more wires/strands break

PT Box Girder – External Tendons



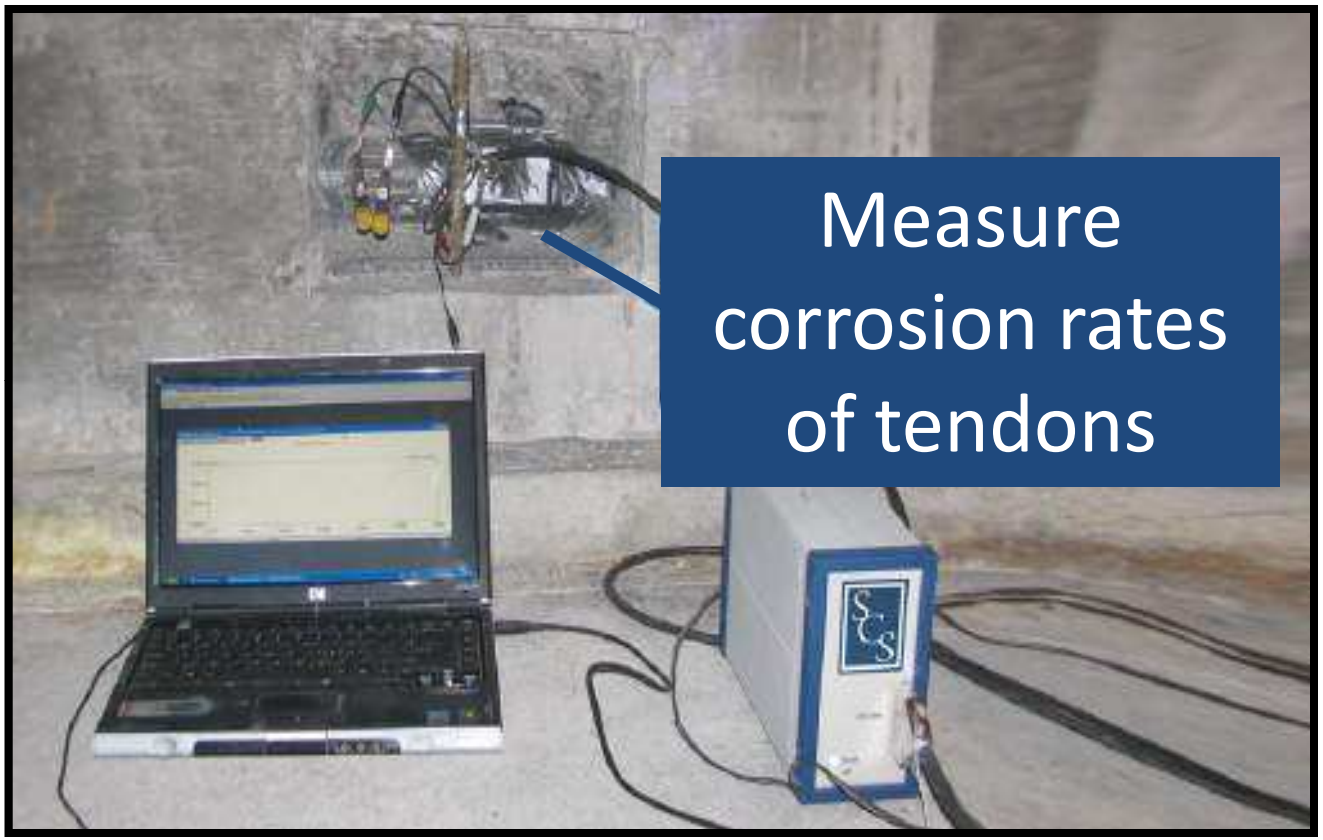
- Half Cell Potential: 90% probability of no corrosion
- Chloride Content of Grout: Well below corrosion threshold
- Yet… corrosion was still occurring after eight years
- Determine root cause(s) and necessary repairs

Grout pH Variation



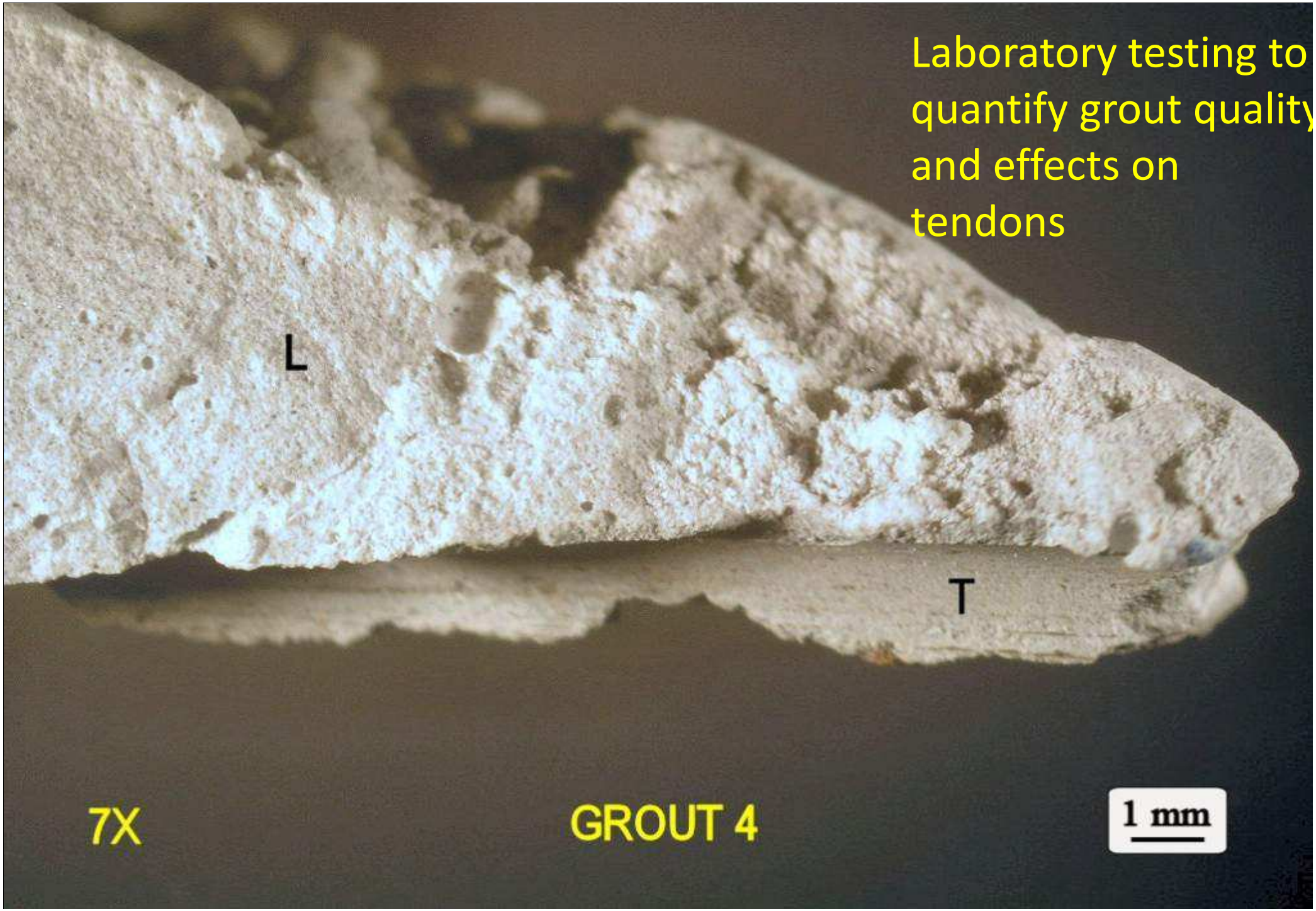
PT Box Girder – Internal Tendons

Computer-Driven Testing



Quantify:

- Section losses
- Effects of grout
- Time-to-criticality


Laboratory testing to quantify grout quality and effects on tendons
L
T
7X
GROUT 4
1 mm

Quantifying “Hidden” Corrosion

- Evaluation:
  - GPR to locate tendons
  - Computer-driven testing for corrosion rate, present/future section losses, effects of grout, and time-to-criticality
  - Laboratory testing for material quality
  - Remaining strength (collaborate with structural firm)

Quantify problems early

Cost Effective Solutions for PT

- Solutions:
  - Address ongoing corrosion
  - Corrosion protection (where applicable)
  - Targeted structural strengthening
  - Exceed service life goals

Sleep well at night

9 Bridges in Oklahoma








9 Bridges in Indiana

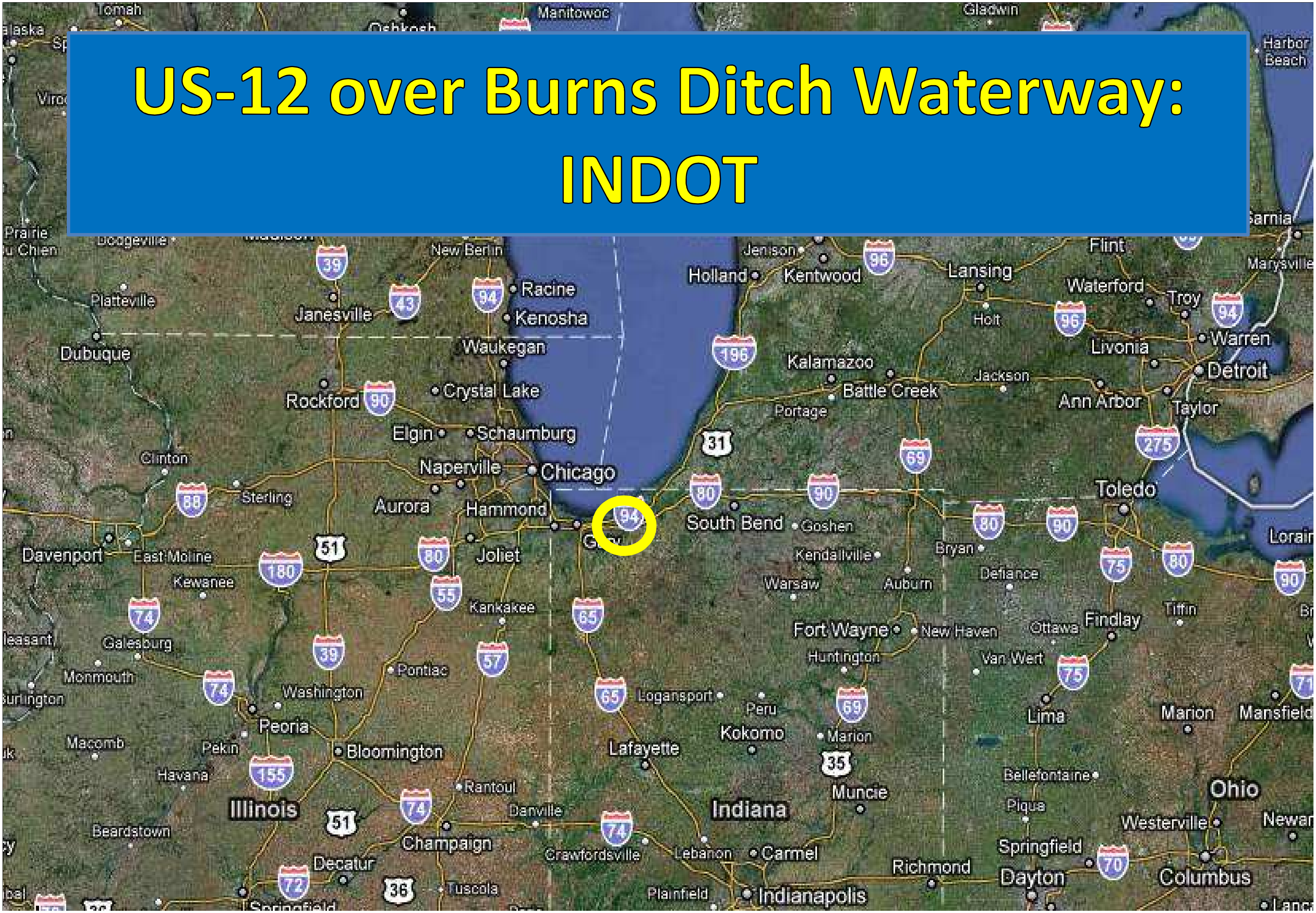




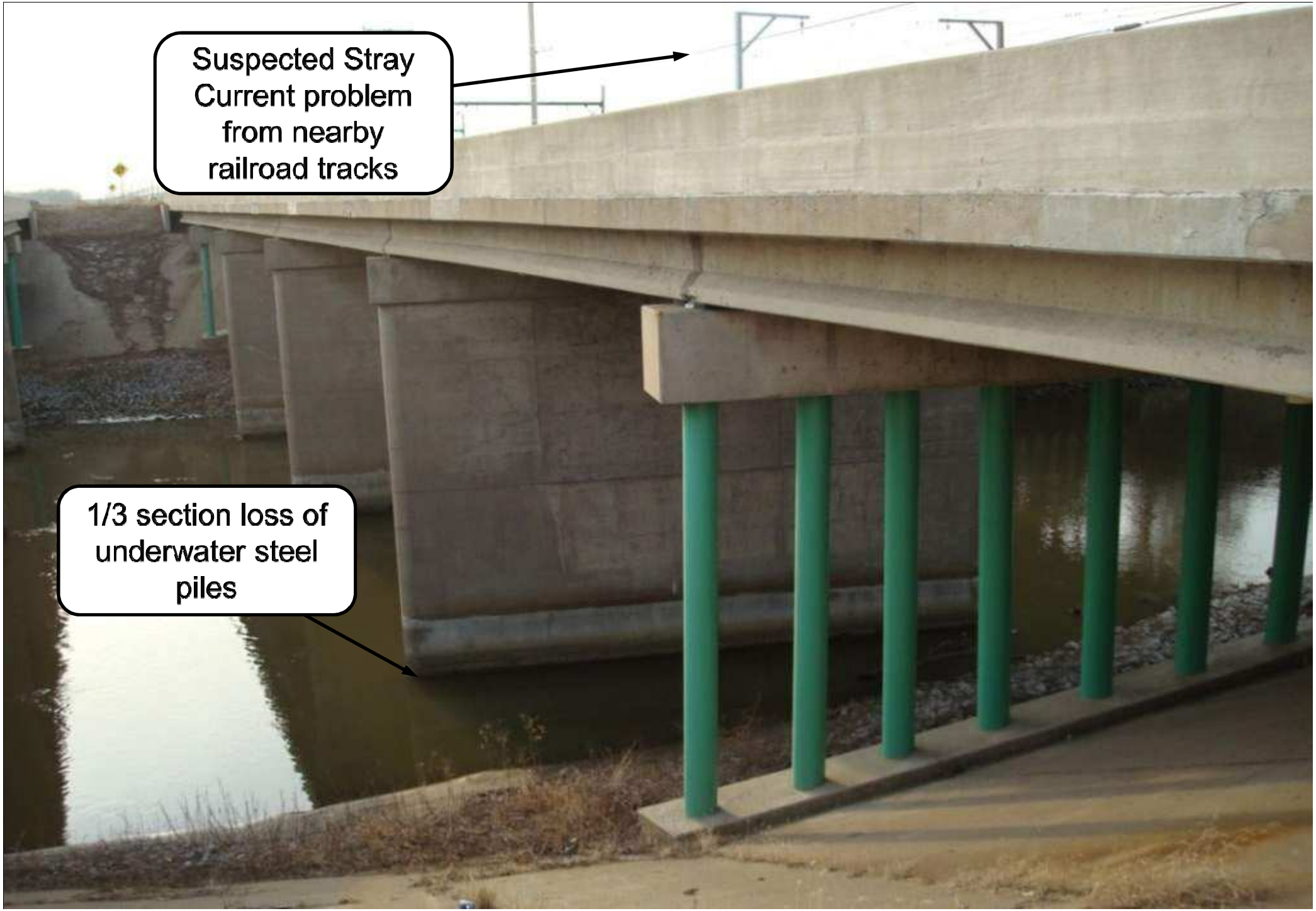




US-12 over Burns Ditch Waterway: INDOT



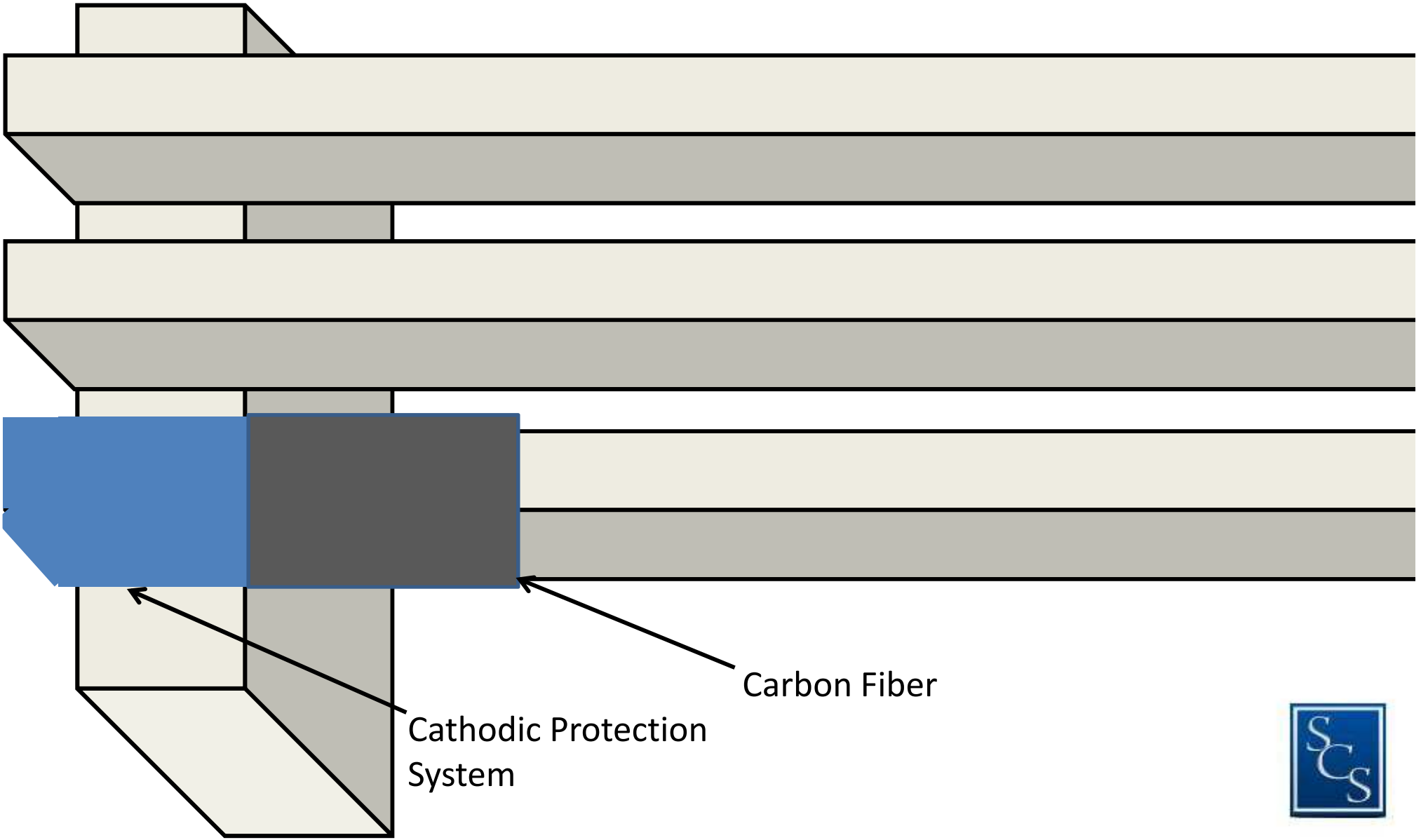

Spalled concrete &
broken wires


Suspected Stray Current problem from nearby railroad tracks
1/3 section loss of underwater steel piles

Solution

- SCS quantified the extent of deterioration at beam ends and steel piles
- We determined that the water and soil were corrosive
- We designed a corrosion mitigation system and developed plans to extend the service lives of pre-stressed beams and steel piles

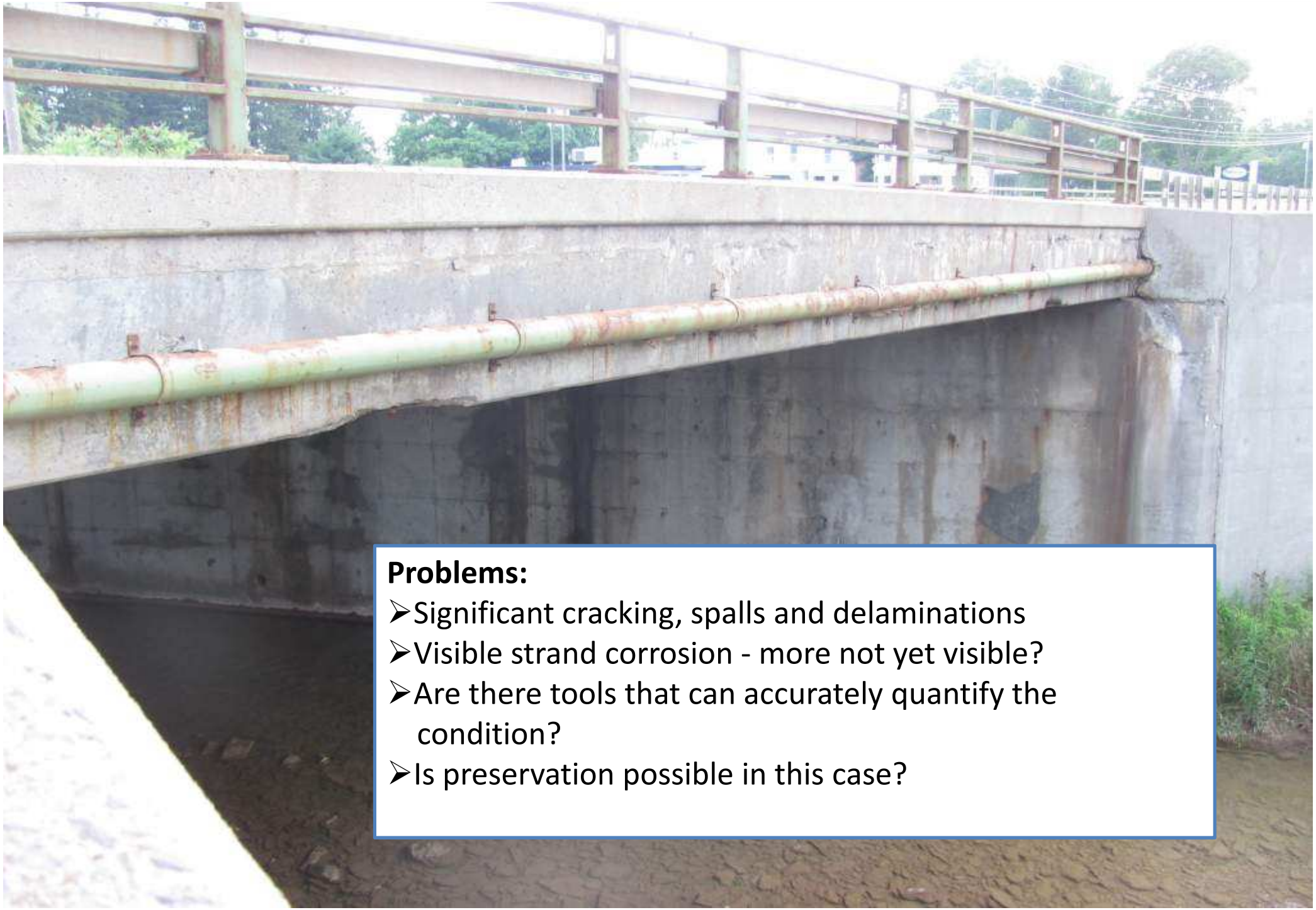
Design of Life Extension System



Benefit

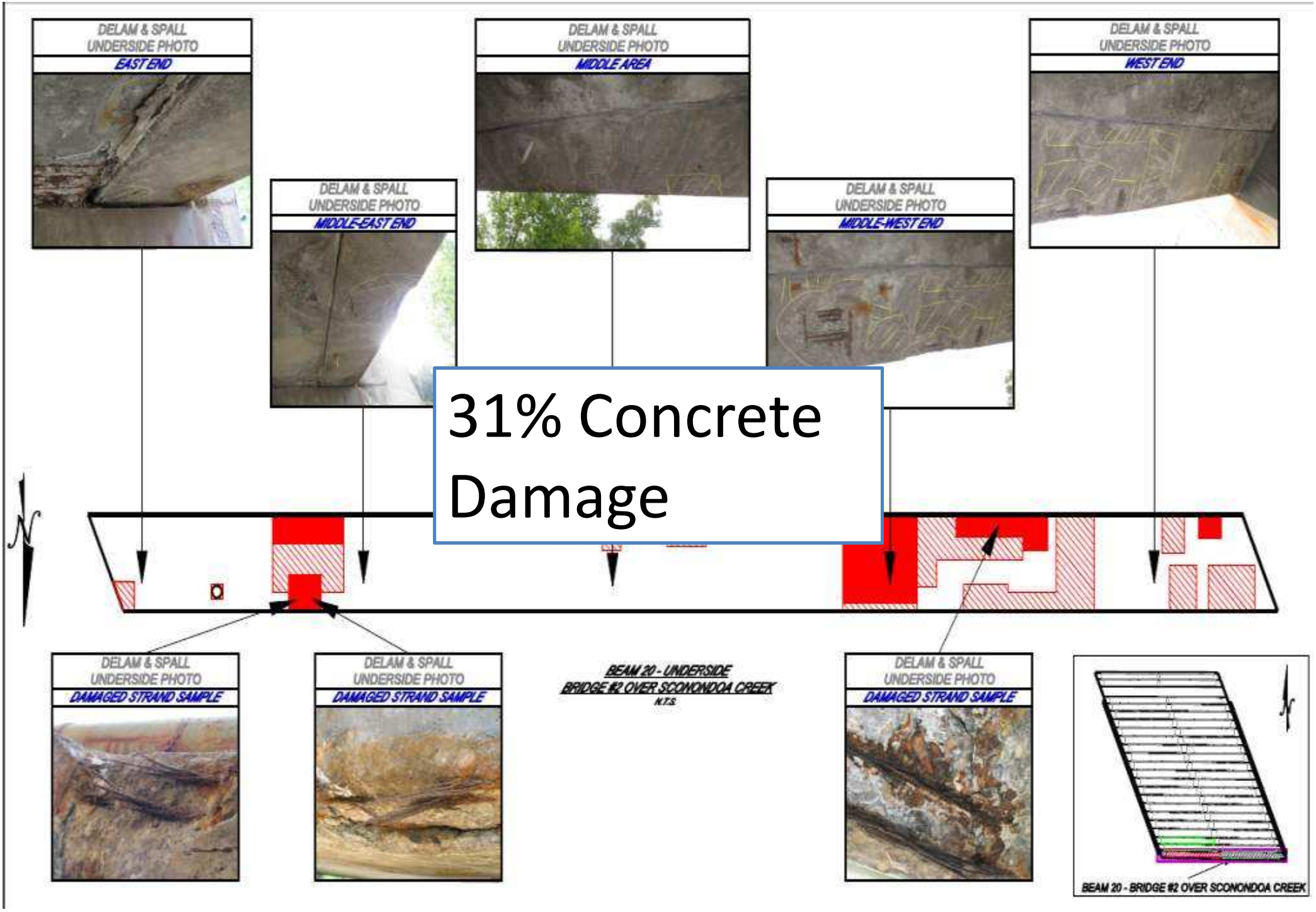
- As an independent firm, SCS selected the most suitable corrosion protection system
- The Department was able to avoid the cost of mitigating the effects of stray current
- The Department was able to save 80% of the replacement cost

Sconondoa Creek Bridge: NYSDOT



Problems:

- Significant cracking, spalls and delaminations
- Visible strand corrosion - more not yet visible?
- Are there tools that can accurately quantify the condition?
- Is preservation possible in this case?


DELAM & SPALL
UNDERSIDE PHOTO
EAST END
DELAM & SPALL
UNDERSIDE PHOTO
MIDDLE AREA
DELAM & SPALL
UNDERSIDE PHOTO
WEST END
DELAM & SPALL
UNDERSIDE PHOTO
MIDDLE-EAST END
DELAM & SPALL
UNDERSIDE PHOTO
MIDDLE-WEST END
31% Concrete Damage
DELAM & SPALL
UNDERSIDE PHOTO
DAMAGED STRAND SAMPLE
DELAM & SPALL
UNDERSIDE PHOTO
DAMAGED STRAND SAMPLE
BEAM 20 - UNDERSIDE
BRIDGE #2 OVER SCONONDOA CREEK
N.T.S.
DELAM & SPALL
UNDERSIDE PHOTO
DAMAGED STRAND SAMPLE
BEAM 20 - BRIDGE #2 OVER SCONONDOA CREEK

Strand Section Losses

No.	Test Location	Strand Size (inch)	Measurement (inch)	Difference in Diameter	Section Loss (%)	Note
Beam 20						
1	Location 1 (Strand 1)	0.50	0.45	0.05	19	Spall
2	Location 1 (Strand 2)	0.50	0.43	0.07	26	Spall
3	Location 2 (Strand 13)	0.50	0.48	0.02	8	Chipout
4	Location 2 (Strand 14)	0.50	0.48	0.02	8	Chipout
5	Location 3 (Strand 7)	0.50	0.48	0.02	8	Spall
6	Location 3 (Strand 8)	0.50	0.42	0.08	29	Spall
7	Location 4 (Strand 1)	0.50	0.00	0.50	100	Spall
8	Location 4 (Strand 1)	0.50	0.00	0.50	100	Spall
9	Rebar (Near Strand 1)	0.50	0.33	0.17	56	Spall

LEGEND:

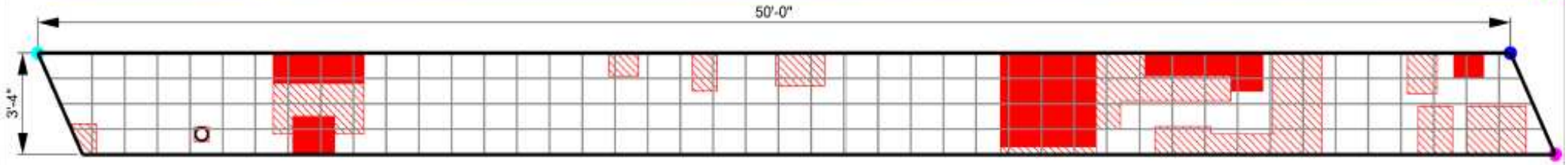
1) RED HATCHED AREA REPRESENTS DELAMINATION -

2) RED FILLED AREA REPRESENTS SPALLING -

BEAM 20 - BRIDGE #2 OVER SCONONDOA CREEK

POTENTIAL

-409	-468	-405	-472	-382	-440	-454	-545	-428	-360	-304	-423	-415	-345	-346	-362	-343	-351	-372	-364	-352	-422	-409	-348	-374	-371	-387	-398	-370	-408	-472	-338	-454	-431	-372	-374	-358	-312	-526
-404	-416	-291	-286	-320	-299	-470	-494	-358	-331	-324	-348	-337	-295	-245	-288	-315	-309	-271	-320	-243	-391	-243	-299	-269	-317	-310	-327		-436	-371	-473	-434	-368	-375	-351	-326	-337	-348	-322	-327	-352	-477
-376	-371	-330	-329	-348	-295	-392	-485	-410	-366	-361	-391	-402	-337	-308	-320	-326	-332	-273	-318	-297	-361	-319	-352	-330	-365	-352	-352		-579	-406	-367	-340	-322	-314	-334	-317	-320	-328	-327	-328	-385	-413
	-412	-384	-367	-365	-321	-390	-471	-454	-439	-424	-396	-381	-373	-390	-355	-335	-348	-354	-294	-353	-339	-402	-359	-443	-402	-388	-446	-484	-451	-472	-432	-402	-472	-374	-357	-386	-372	-371	-411	-399	-382	-421	-404



BEAM 20 - UNDERSIDE
BRIDGE #2 OVER SCONONDOA CREEK
N.T.S.

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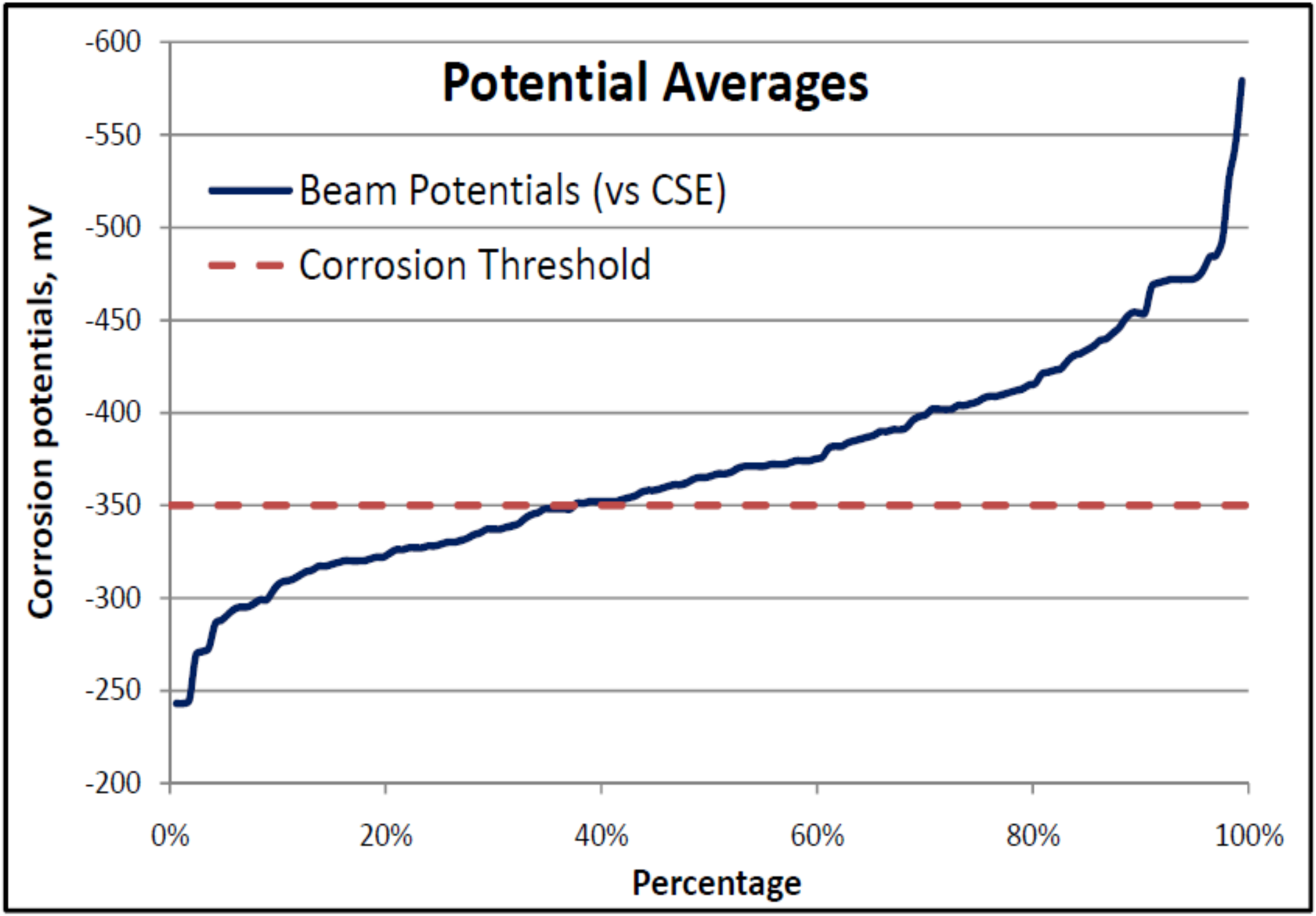
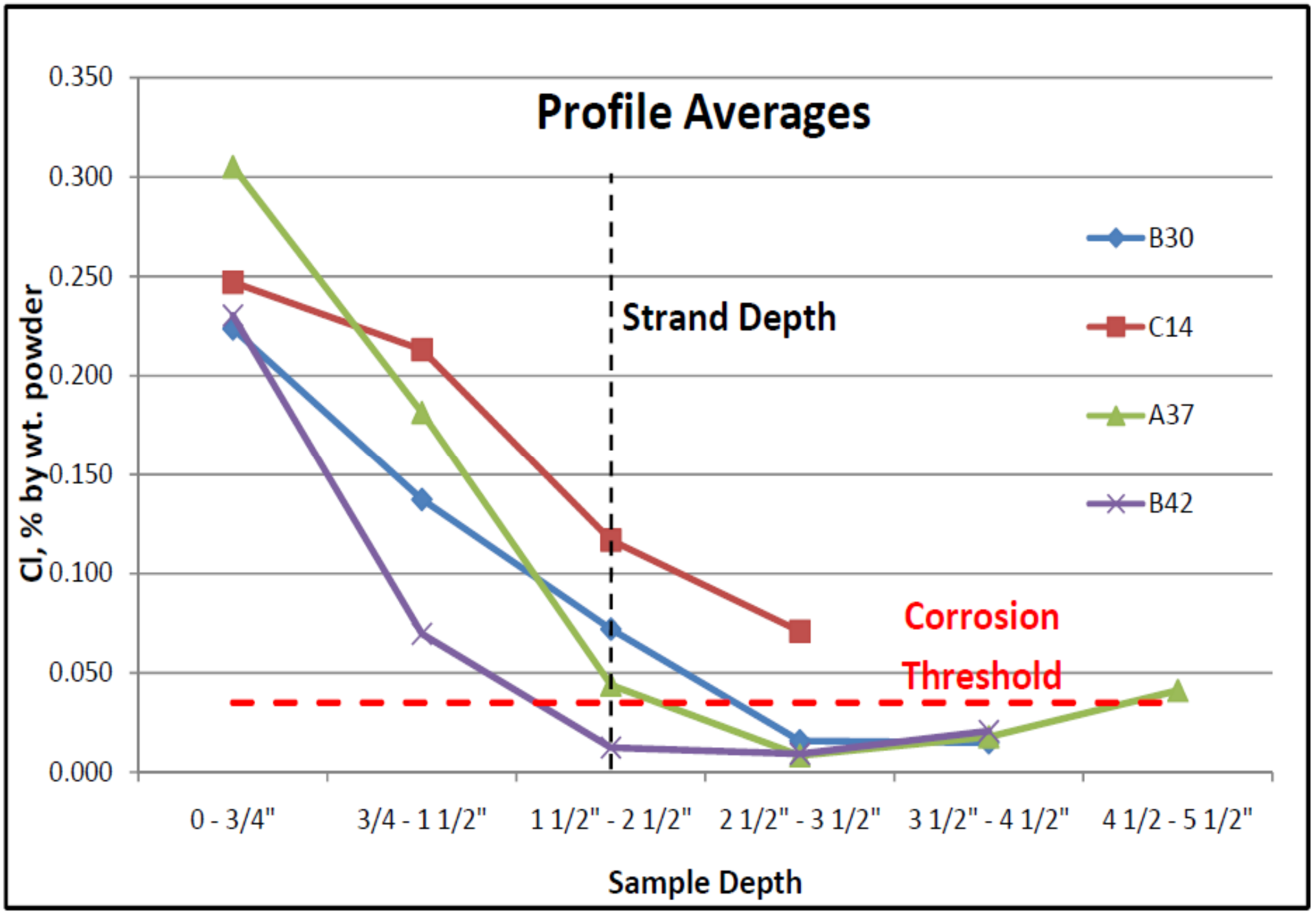
POTENTIAL READING BEAM 20	NEW YORK STATE DEPARTMENT OF TRANSPORTATION	HORIZONTAL SCALE: N.T.S. / VERTICAL SCALE: N.T.S. / DRAWING NUMBER: A-3
DESIGNED: / DRAWN: BJ / CHECKED: / CHECKED: S.V.	BRIDGE #2 OVER SCONONDOA CREEK	SURVEY BOOK: N/A / SHEETS: 1 OF 1 / DATE: SEPTEMBER 2010 / PROJECT: 1001


Potential Averages
Beam Potentials (vs CSE)
Corrosion Threshold
Corrosion potentials, mV
-600
-550
-500
-450
-400
-350
-300
-250
-200
0%
20%
40%
60%
80%
100%
Percentage

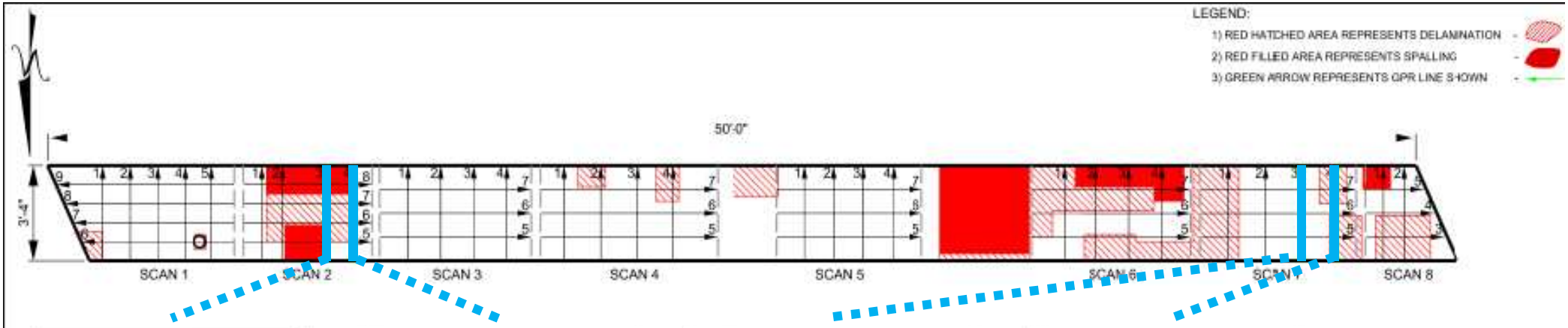

Profile Averages
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Cl, % by wt. powder
Strand Depth
B30
C14
A37
B42
Corrosion
Threshold
0 - 3/4"
3/4 - 1 1/2"
1 1/2" - 2 1/2"
2 1/2" - 3 1/2"
3 1/2" - 4 1/2"
4 1/2 - 5 1/2"
Sample Depth

Water in Beam

- Half-inch hole was drilled
- Water drained for a few hours
- Chloride concentration of the water was very high
- Resistivity of the water was low

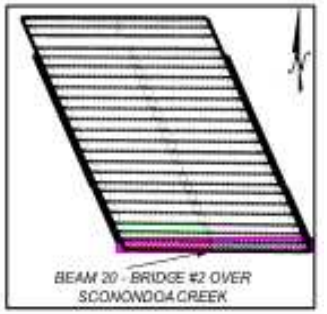
LEGEND:

1) RED HATCHED AREA REPRESENTS DELAMINATION
2) RED FILLED AREA REPRESENTS SPALLING
3) GREEN ARROW REPRESENTS GPR LINE SHOWN



BEAM 20 - UNDERSIDE
BRIDGE #2 OVER SCONONDOA CREEK
N.T.S.

NOTE: GPR LINE LOCATIONS ARE APPROXIMATE.



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GPR SCANS
BEAM 20

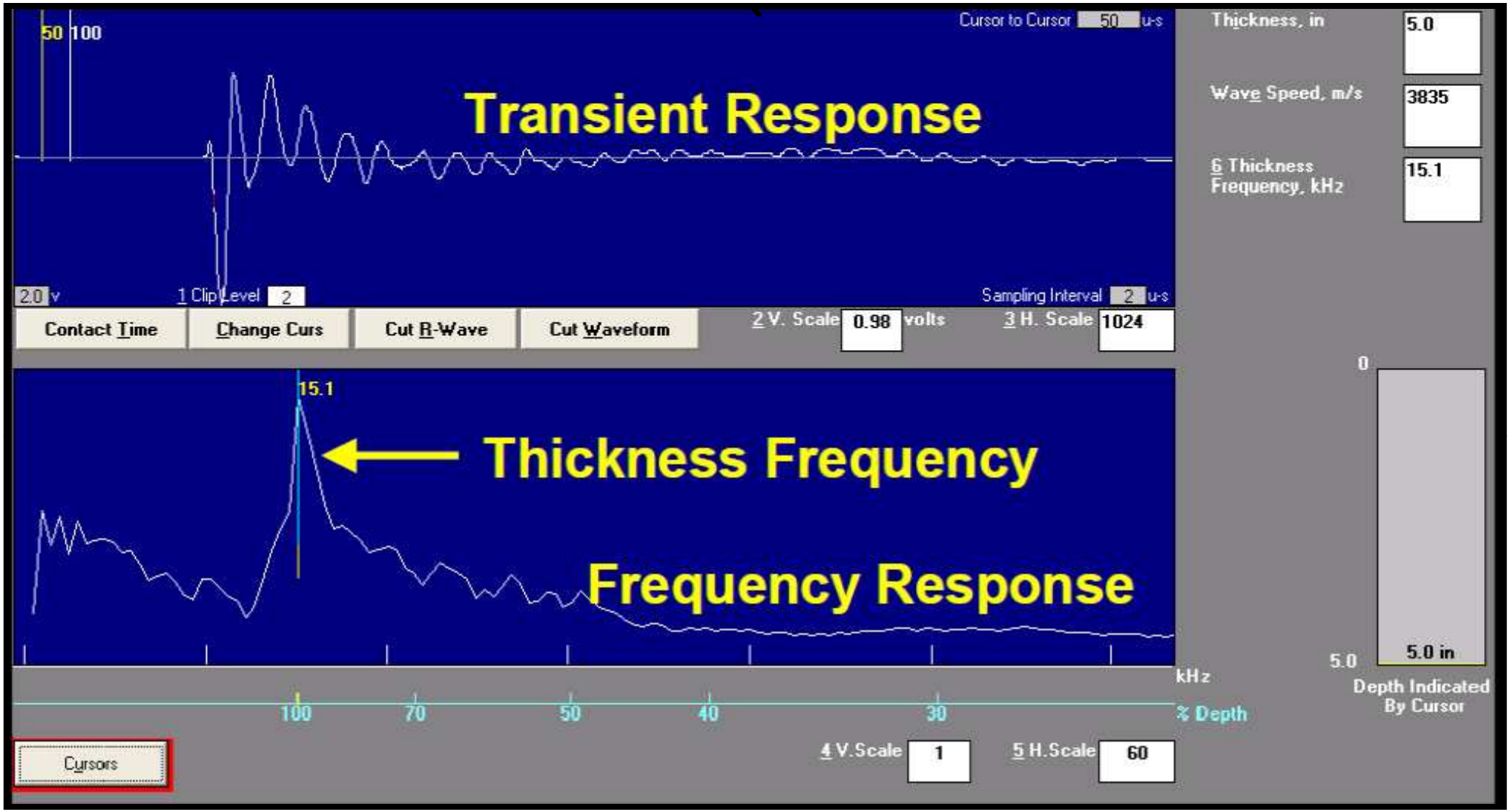
NEW YORK STATE
DEPARTMENT OF TRANSPORTATION

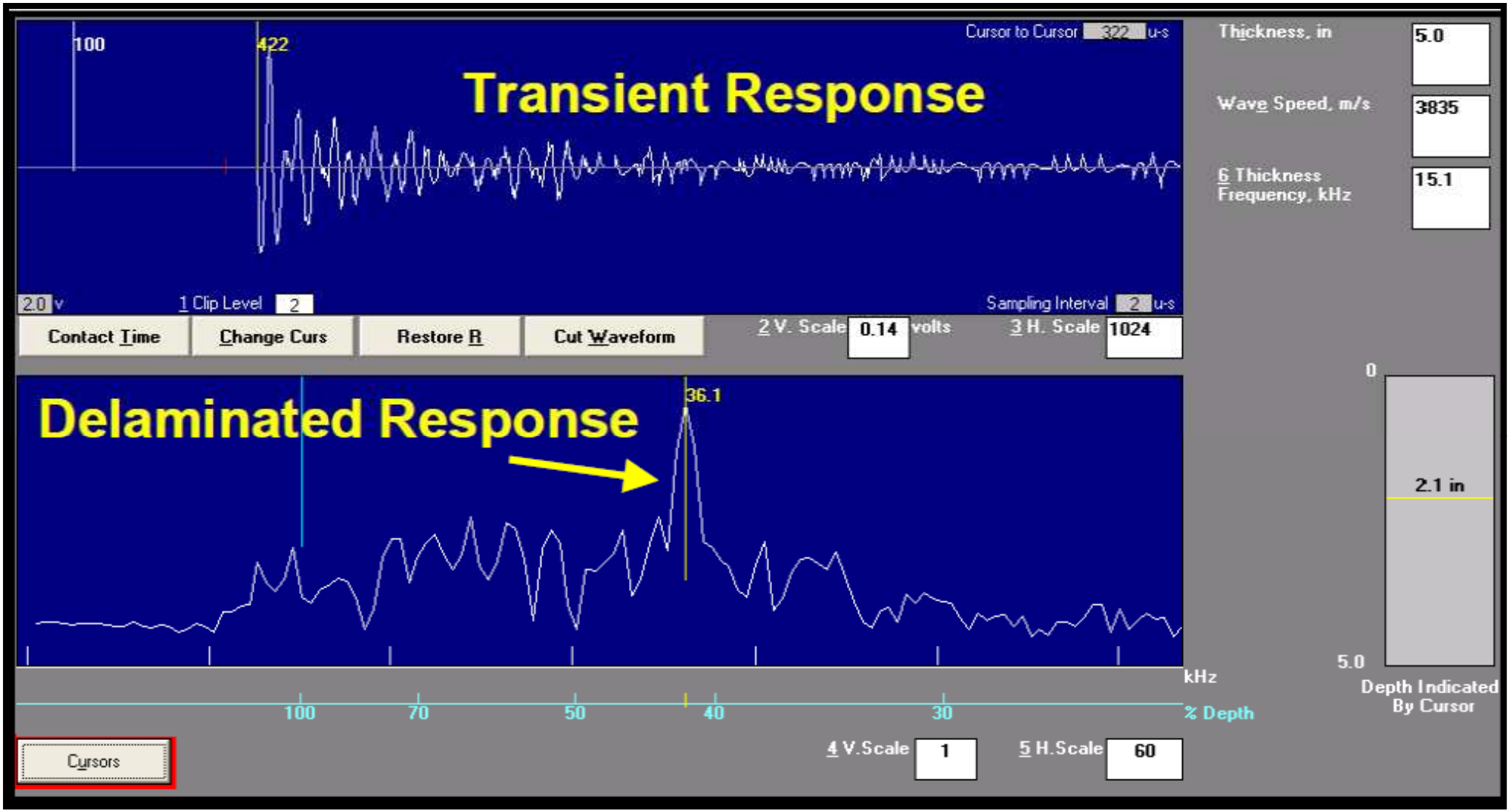
BRIDGE #2 OVER
SCONONDOA CREEK

HORIZONTAL SCALE N.T.S.	DRAWING NUMBER
VERTICAL SCALE N.T.S.	A-4
DESIGNED	DRAWN SJ
CHECKED	CHECKED S.J.
SURVEY BOOK N/A	SHEETS 1 OF 1
DATE SEPTEMBER 2010	PROJECT 1001

GPR

- Difficult to identify early stage delaminations by sounding
- GPR can rapidly identify <u>early stage delaminations</u>
- GPR can identify reinforcement location/depth and member dimensions

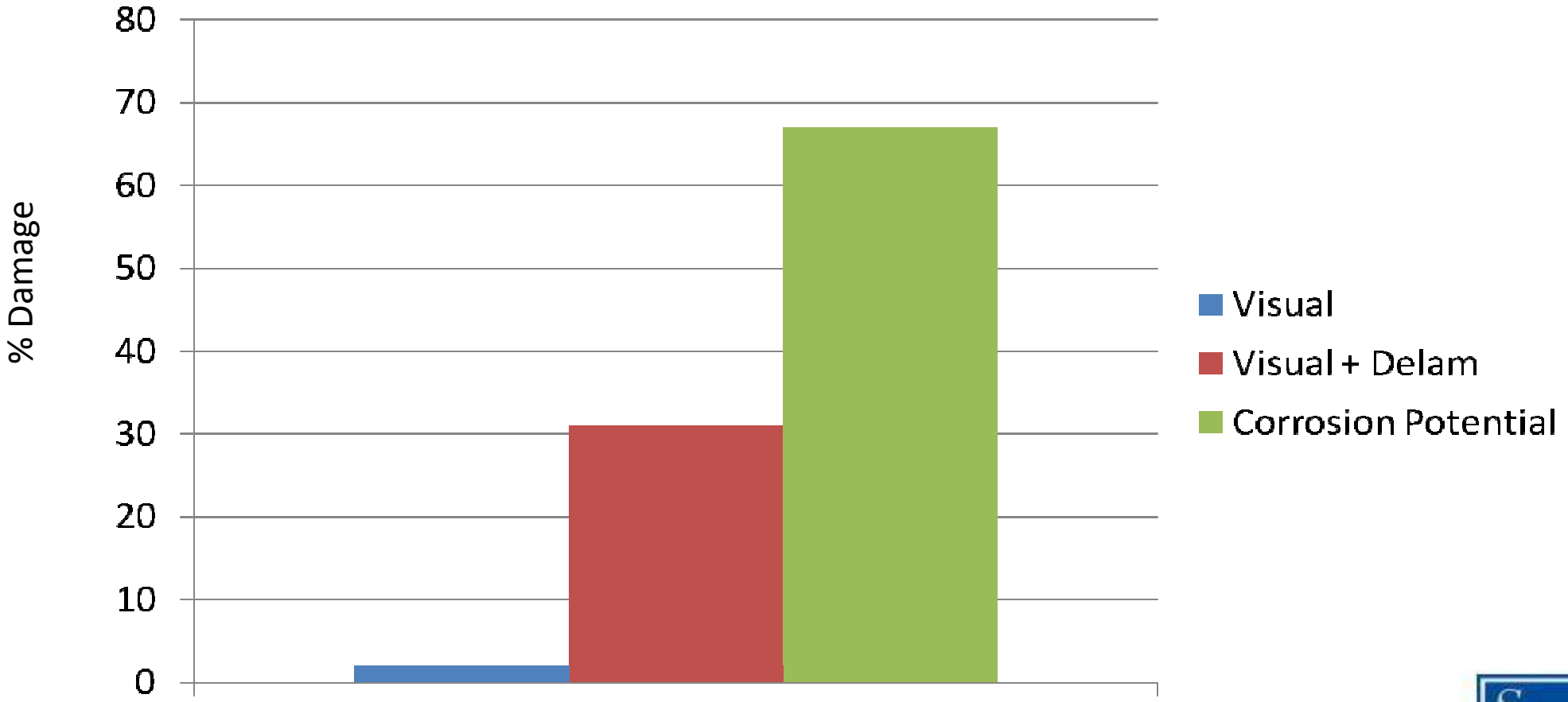

50 100
Cursor to Cursor 50 u-s
Transient Response
Thickness, in
5.0
Wave Speed, m/s
3835
6 Thickness Frequency, kHz
15.1
2.0 v
1 Clip Level 2
Sampling Interval 2 u-s
Contact Time
Change Curs
Cut R-Wave
Cut Waveform
2 V. Scale 0.98 volts
3 H. Scale 1024
15.1
Thickness Frequency
Frequency Response
0
5.0 in
5.0
Depth Indicated By Cursor
kHz
100
70
50
40
30
% Depth
Cursors
4 V.Scale 1
5 H.Scale 60


100
422
Cursor to Cursor 322 u-s
Transient Response
Thickness, in
5.0
Wave Speed, m/s
3835
6 Thickness Frequency, kHz
15.1
2.0 v
1 Clip Level 2
Sampling Interval 2 u-s
Contact Time
Change Curs
Restore R
Cut Waveform
2 V. Scale 0.14 volts
3 H. Scale 1024
Delaminated Response
36.1
0
2.1 in
5.0
Depth Indicated By Cursor
kHz
100
70
50
40
30
% Depth
Cursors
4 V.Scale 1
5 H.Scale 60

Impact Echo

- Can find flaws not detectable by GPR and provide more information about those flaws
- Well suited for flaw determination on structures with difficult access or multiple layers of materials (e.g. overlays)

Visual/Delam/Potential Data



Visual/Delam/Potential Data

- Visual data – only a small percentage of the beam corroding
- Visual & delam data – 31% of the beam corroding
- Corrosion potential data – 67% of the beam corroding
- Evaluate before visual signs of distress to achieve and exceed service life goals

Benefits

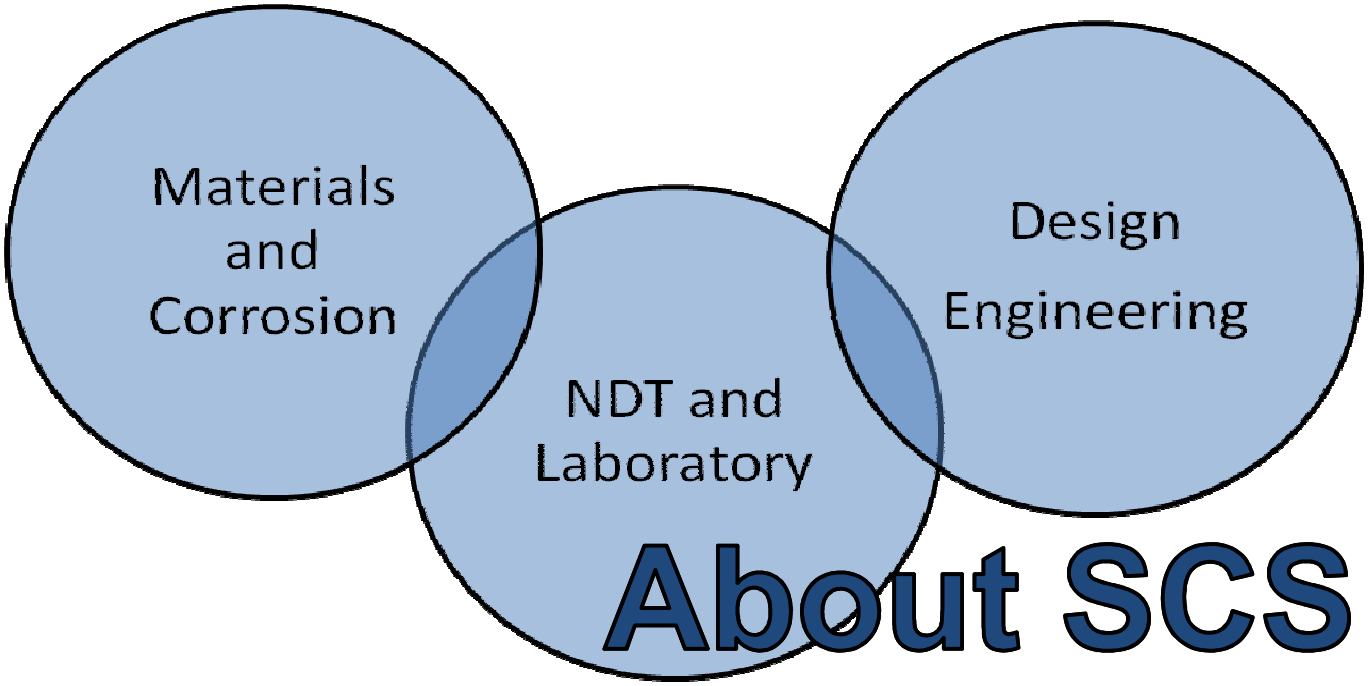
- The owner better understood proper combinations of NDT tools needed to:
  - Identify existing deterioration
  - Quantify the extent of deterioration
  - Predict future deterioration
- Plan proactive, cost effective preservation instead of expensive replacement
- Service life can be typically extended 10 to 25 years at 20-25% of the cost of replacement

Preservation is Possible

- SCS develops preservation methodology based on corrosion/NDT data
- NDT is increasingly cost effective
- Use appropriate combination of tools to evaluate and preserve

Preservation Experience

- Reinforced Concrete
  - ✓ ***11 Bridges – 25 year life extension – $18.5 M savings***
- Simple and Complex Steel Structures
- Decks
- MSE Walls
- Tunnels
- Marine Wharf Structures



About SCS

In-Depth Evaluation

Life Extension System Design

Installation Inspection

Structure Types:

- Reinforced Concr
- Steel
- Pre-Stressed
- Post-Tensioned
- Cable Stayed

An Independent Consultant

- Materials, NDT, and Corrosion Specialist
- Partner with structural firms
- Do not sell or install materials or products
- Address corrosion without financial bias towards a proprietary product

Thank You

Questions?

Siva Venugopalan
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