Embedded Data Collectors

The Virginia Experience

D. Ashton Lawler, P.E.
Virginia Department of Transportation

August 13, 2014

Virginia's Highway System

Interstate – 1,118

Primary – 8,111

Secondary – 48,305

Frontage – 333

Total Mileage - 57,867

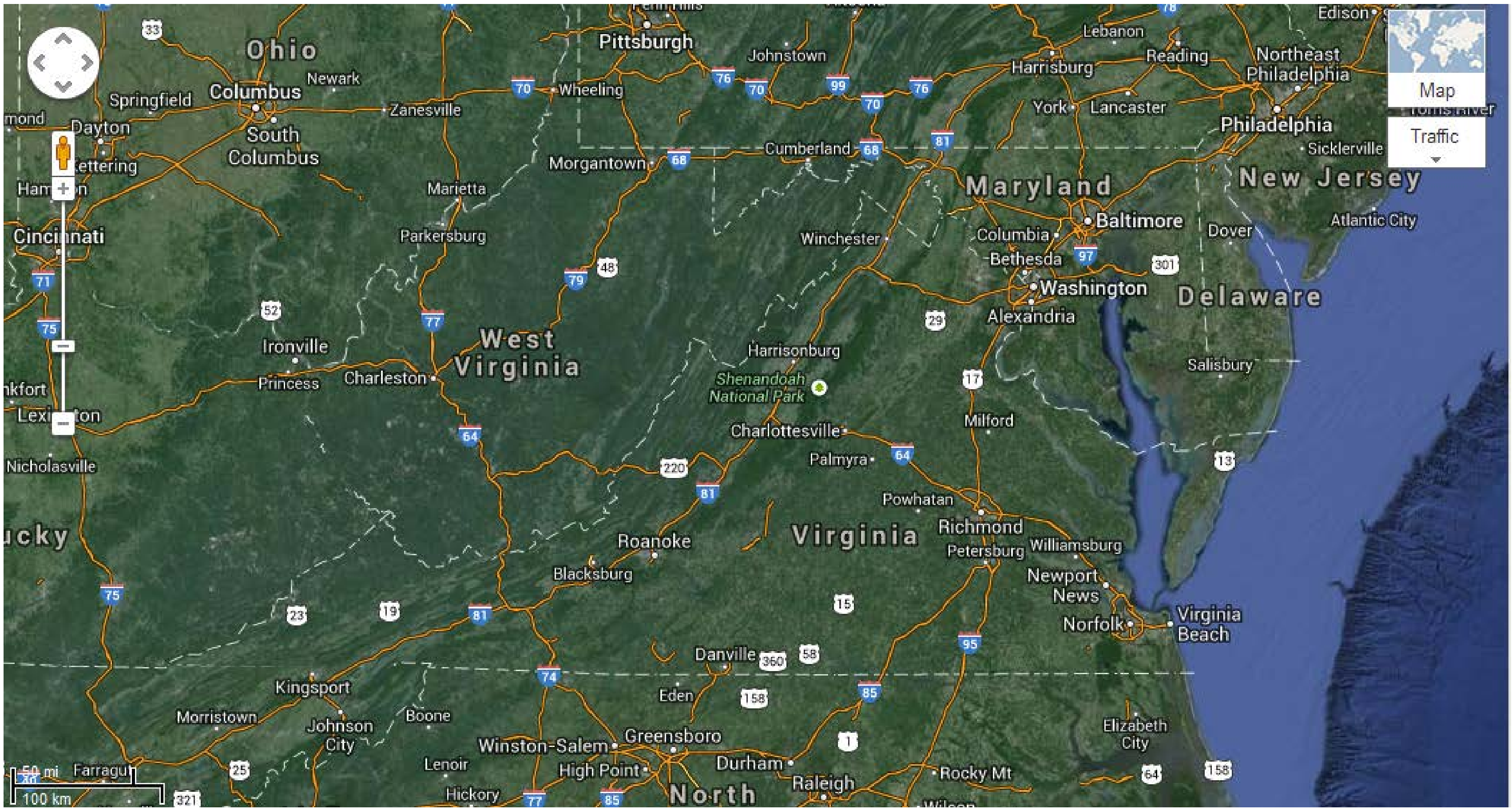
Table 1a – Total Number of Structures (Bridges and Culverts)

DISTRICT	Number of Structures (Bridges and Culverts)				
	Interstate	Primary	Secondary	Urban	Total
Bristol	216	956	2,188	83	3,443
Salem	217	807	1,943	103	3,070
Lynchburg	0	665	1,394	59	2,118
Richmond	511	801	1,146	161	2,619
Hampton Roads	458	458	515	257	1,688
Fredericksburg	79	249	474	8	810
Culpeper	122	495	1,053	23	1,693
Staunton	429	827	2,140	100	3,496
NOVA	345	446	1,181	79	2,051
Grand Total	**2,377**	**5,704**	**12,034**	**873**	**20,988**

VDOT's Annual Budget

$4.19 Billion

$1.830 Billion – Road Maintenance
$1.605 Billion – Construction
$449.7 Million – Support to other agencies, administration, tolls and other programs
$300 Million – Debt service


Ohio
Pittsburgh
Johnstown
Lebanon
Harrisburg
Reading
Northeast Philadelphia
Edison
Map
Traffic
Springfield
Columbus
Newark
Zanesville
Wheeling
York
Lancaster
Philadelphia
Sicklerville
Dayton
South Columbus
Kettering
Morgantown
Cumberland
Maryland
New Jersey
Cincinnati
Marietta
Parkersburg
Winchester
Baltimore
Columbia
Bethesda
Dover
Atlantic City
Washington
Alexandria
Delaware
Ironville
Princess
Charleston
West Virginia
Harrisonburg
Shenandoah National Park
Salisbury
Lexington
Nicholasville
Charlottesville
Palmyra
Milford
Powhatan
Richmond
Petersburg
Williamsburg
Roanoke
Blacksburg
Virginia
Newport News
Norfolk
Virginia Beach
Danville
Eden
Kingsport
Morristown
Johnson City
Boone
Winston-Salem
Greensboro
High Point
Durham
Raleigh
Rocky Mt
Lenoir
Hickory
North
Elizabeth City
Farragut
50 mi
100 km

VDOT's first project using

DYNAMIC PILE TESTING

was in the Summer 1984

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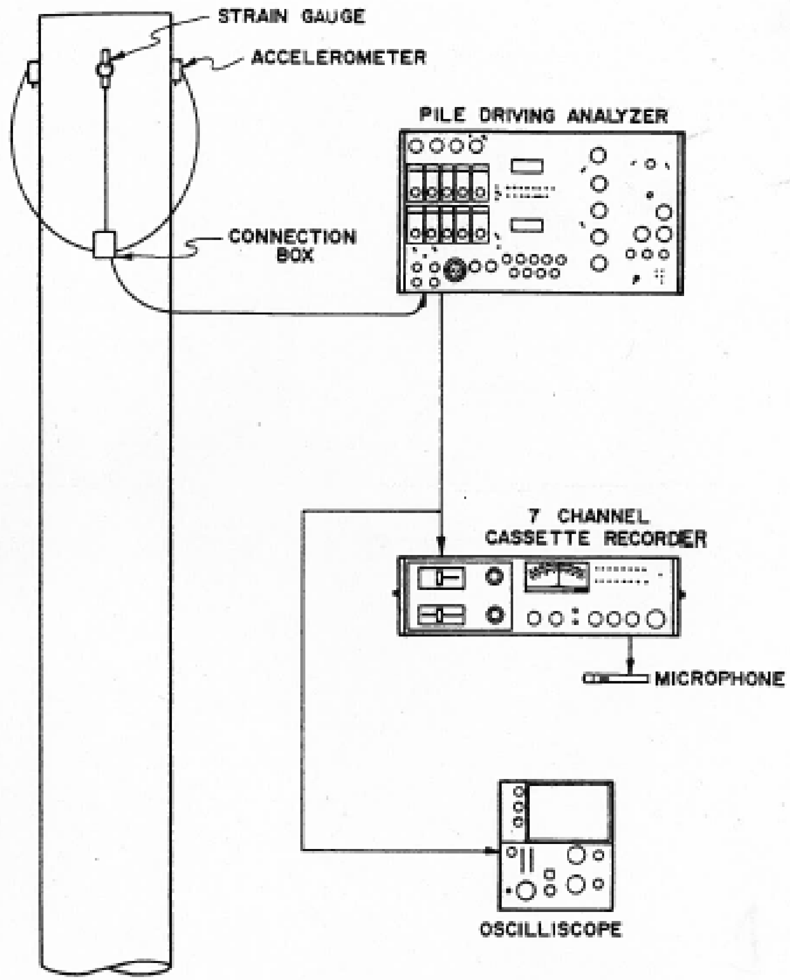

FIGURE 1. Pile Driving Analyzer Equipment Schematic

This is a sample image. Similar documentation will be posted to the TIG Embedded Data Collectors website in the near future.

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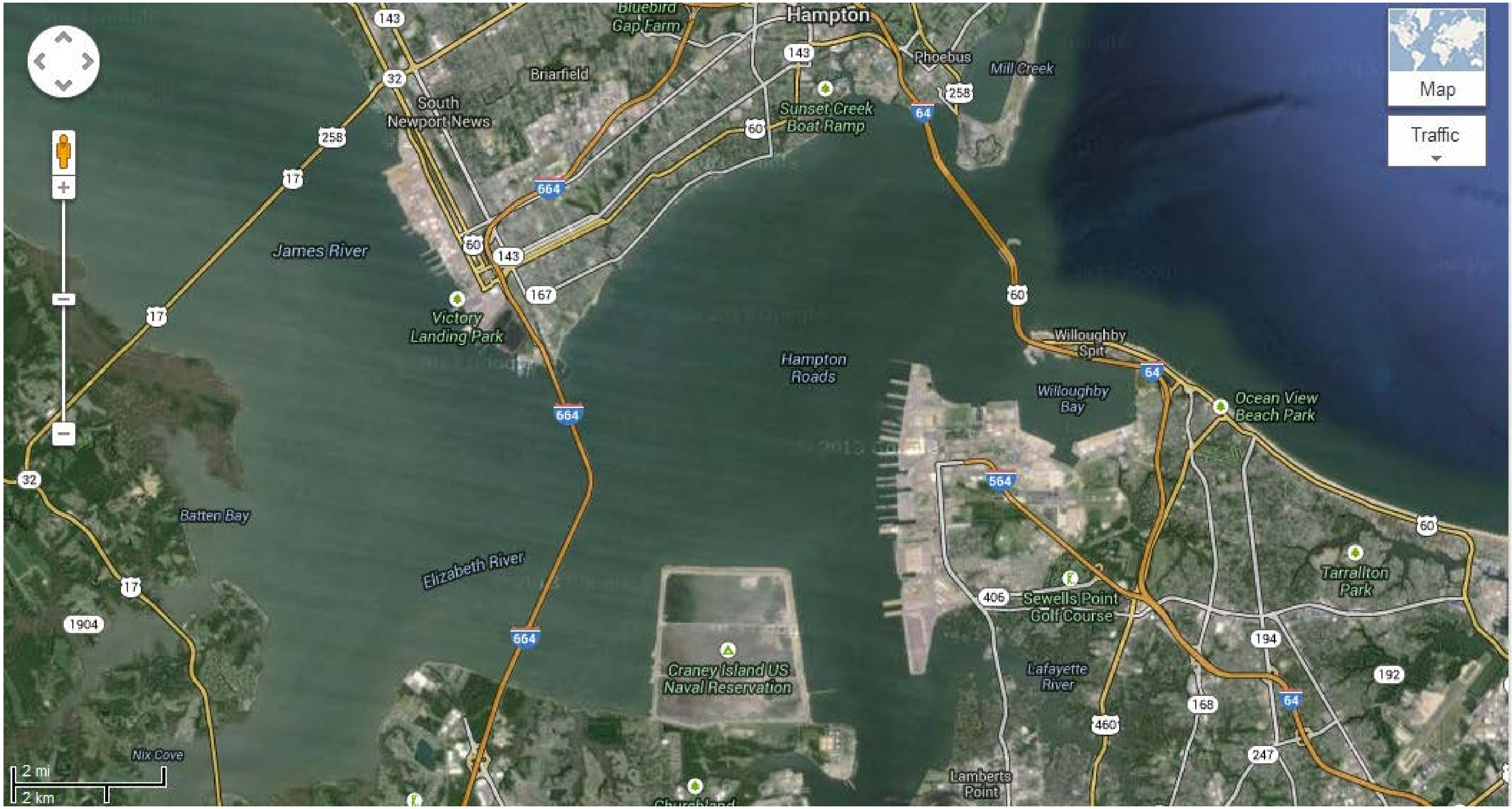
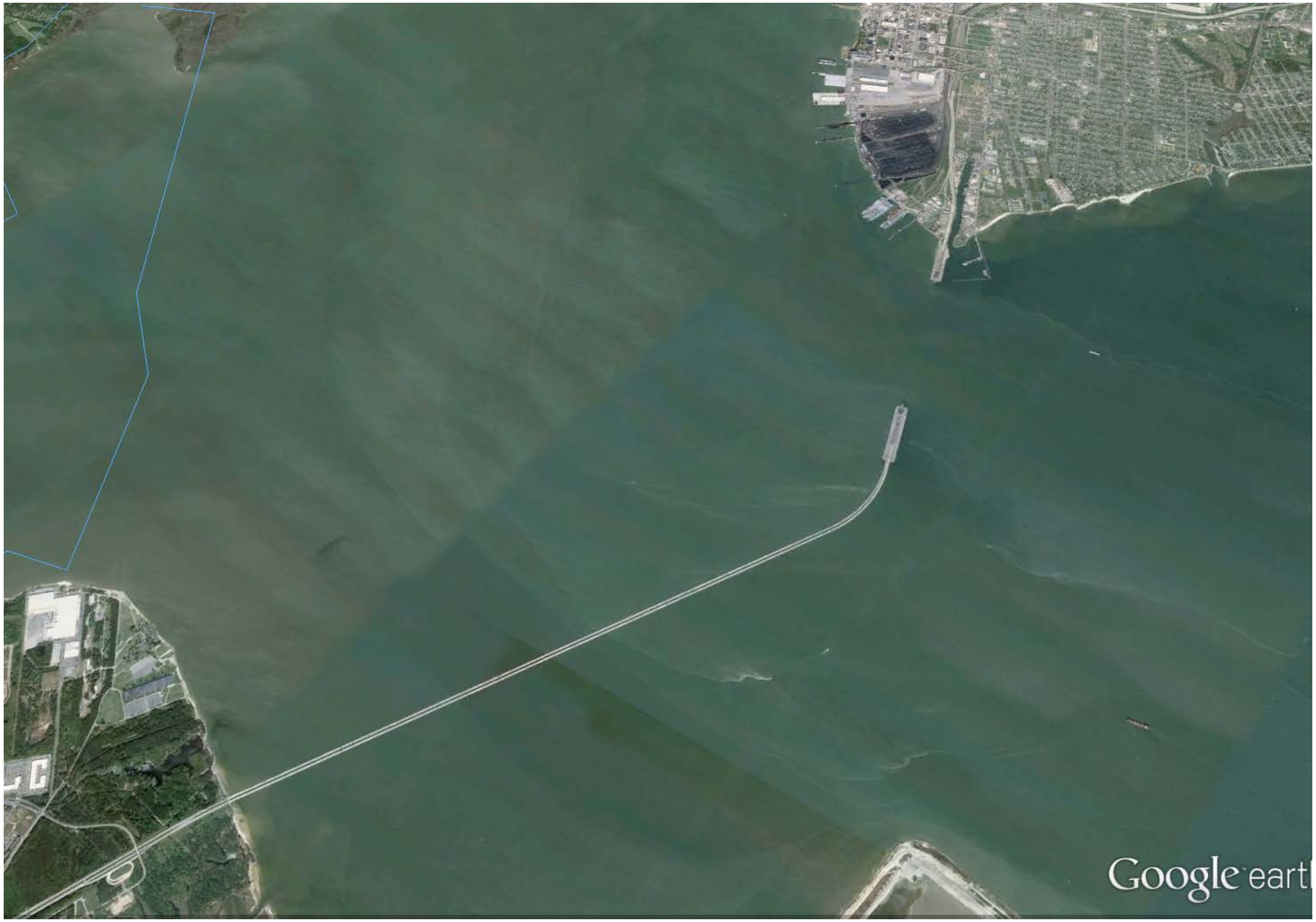

Hampton
Bluebird Gap Farm
Briarfield
South Newport News
Phoebus
Mill Creek
Sunset Creek Boat Ramp
Map
Traffic
James River
Victory Landing Park
Hampton Roads
Willoughby Spit
Willoughby Bay
Ocean View Beach Park
Batten Bay
Elizabeth River
Craney Island US Naval Reservation
Sewells Point Golf Course
Lafayette River
Tarrallton Park
Lamberts Point
Nix Cove
2 mi
2 km


Google earth

Monitor- Merrimac Memorial Bridge

Interstate Route 664 in Newport News, Virginia

Pile Driving Program

2 Pre-Construction Pile Load Test Programs ($333,000)

16 Construction Load Tests ($387,000)

45 Construction Dynamic Pile Tests ($95,000)

Monitor- Merrimac Memorial Bridge

Interstate Route 664 in Newport News, Virginia

Pile Driving Program

430,000 linear feet of pile

12” Prestressed Concrete Piles

24” Prestressed Concrete Piles

54” Prestressed Concrete Cylinder Piles

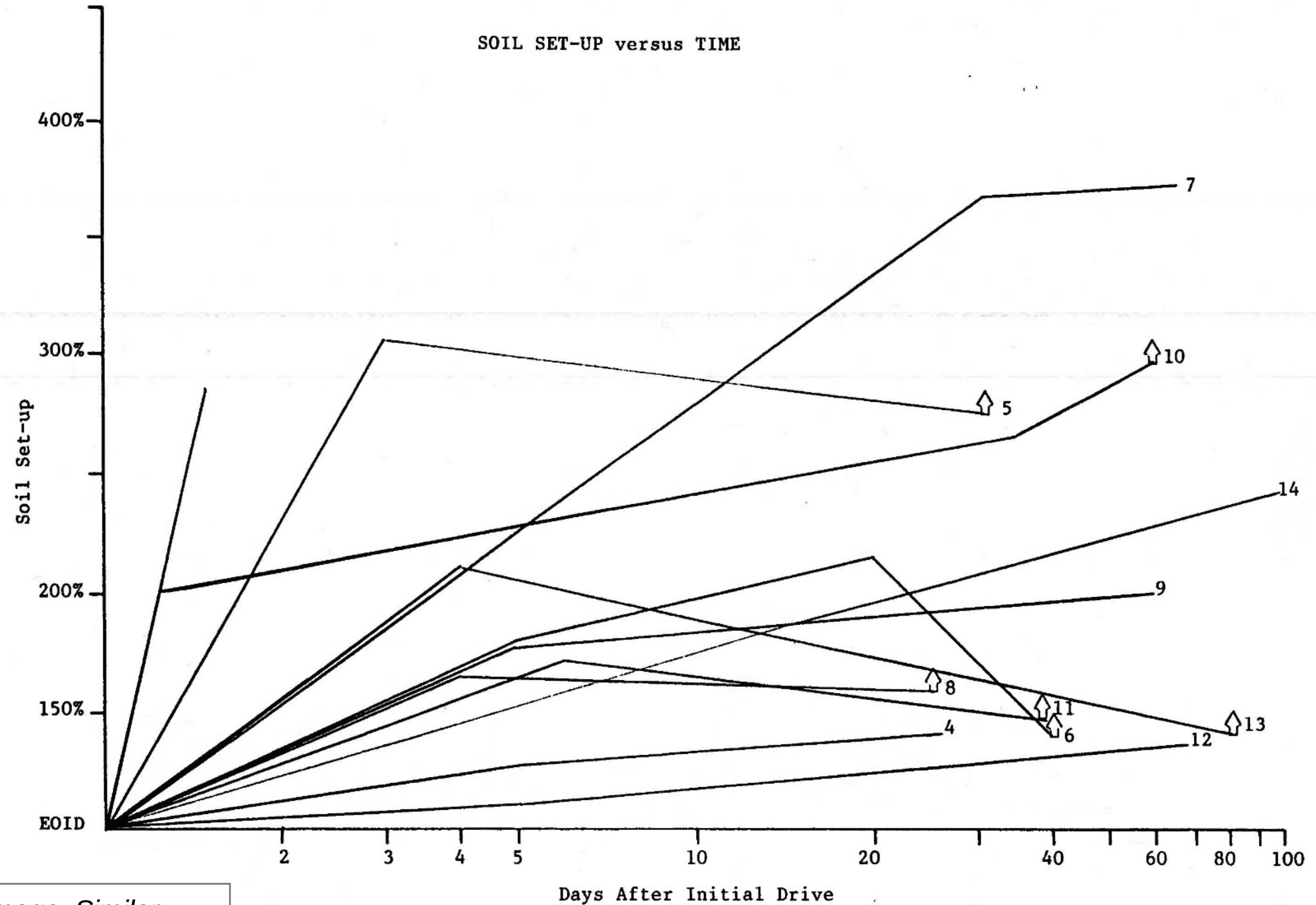
Monitor- Merrimac Memorial Bridge

Interstate Route 664 in Newport News, Virginia

Pile Testing Program Costs: $815,000

Estimated savings in Construction Cost due to increased pile capacities: $12 Million

Estimated savings in Construction Cost due to reduced pile lengths through Dynamic Testing: $2 Million



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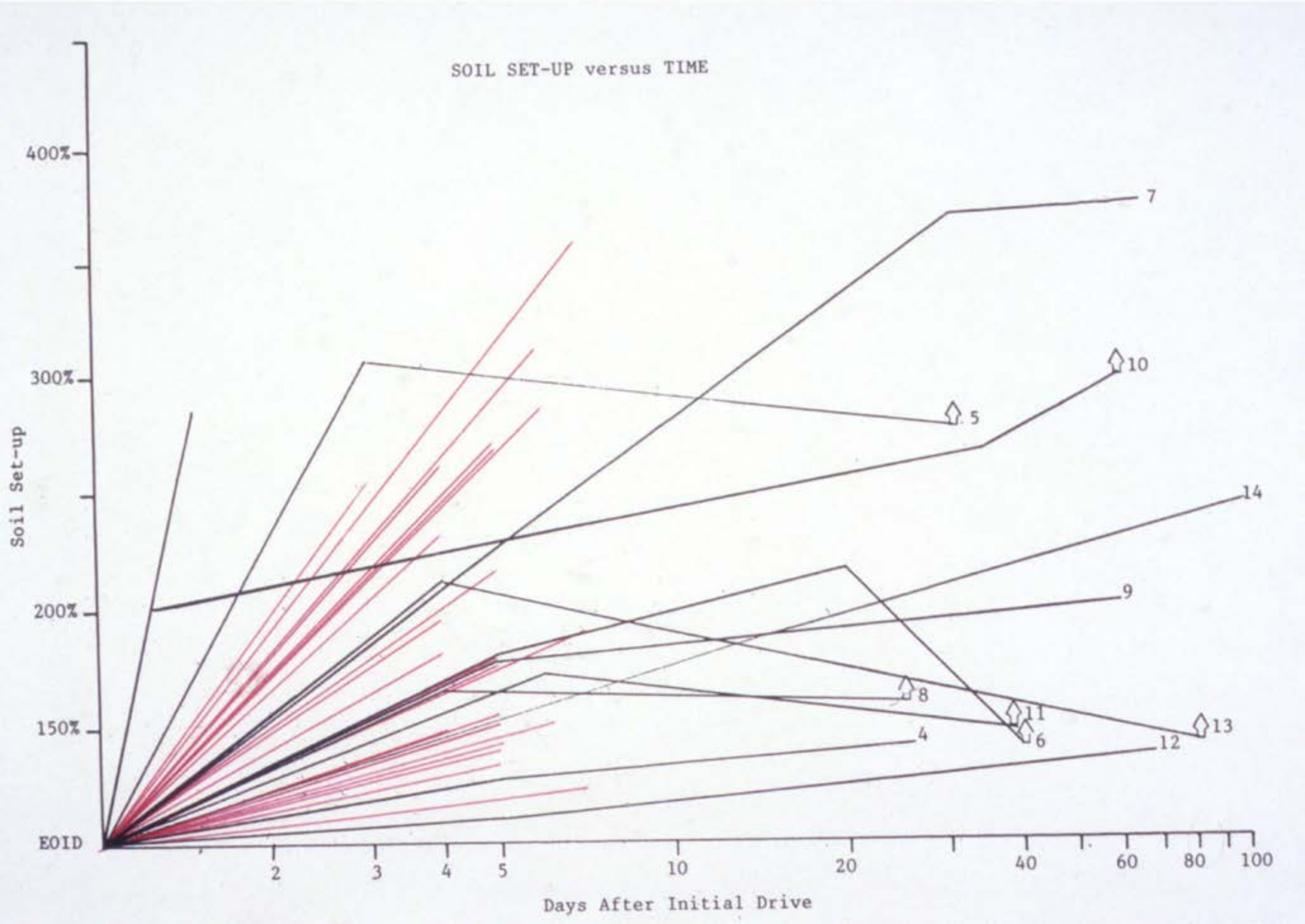

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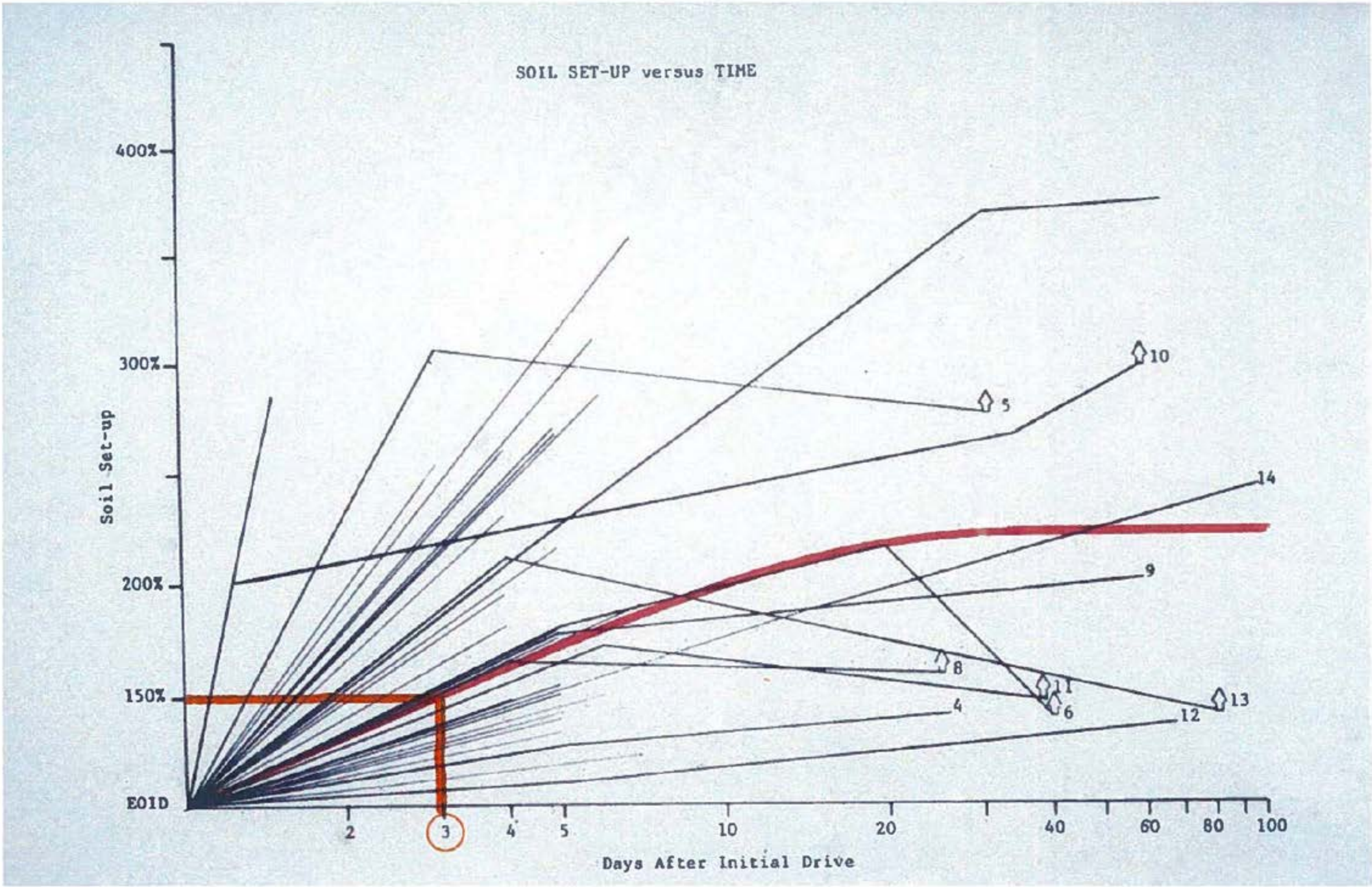

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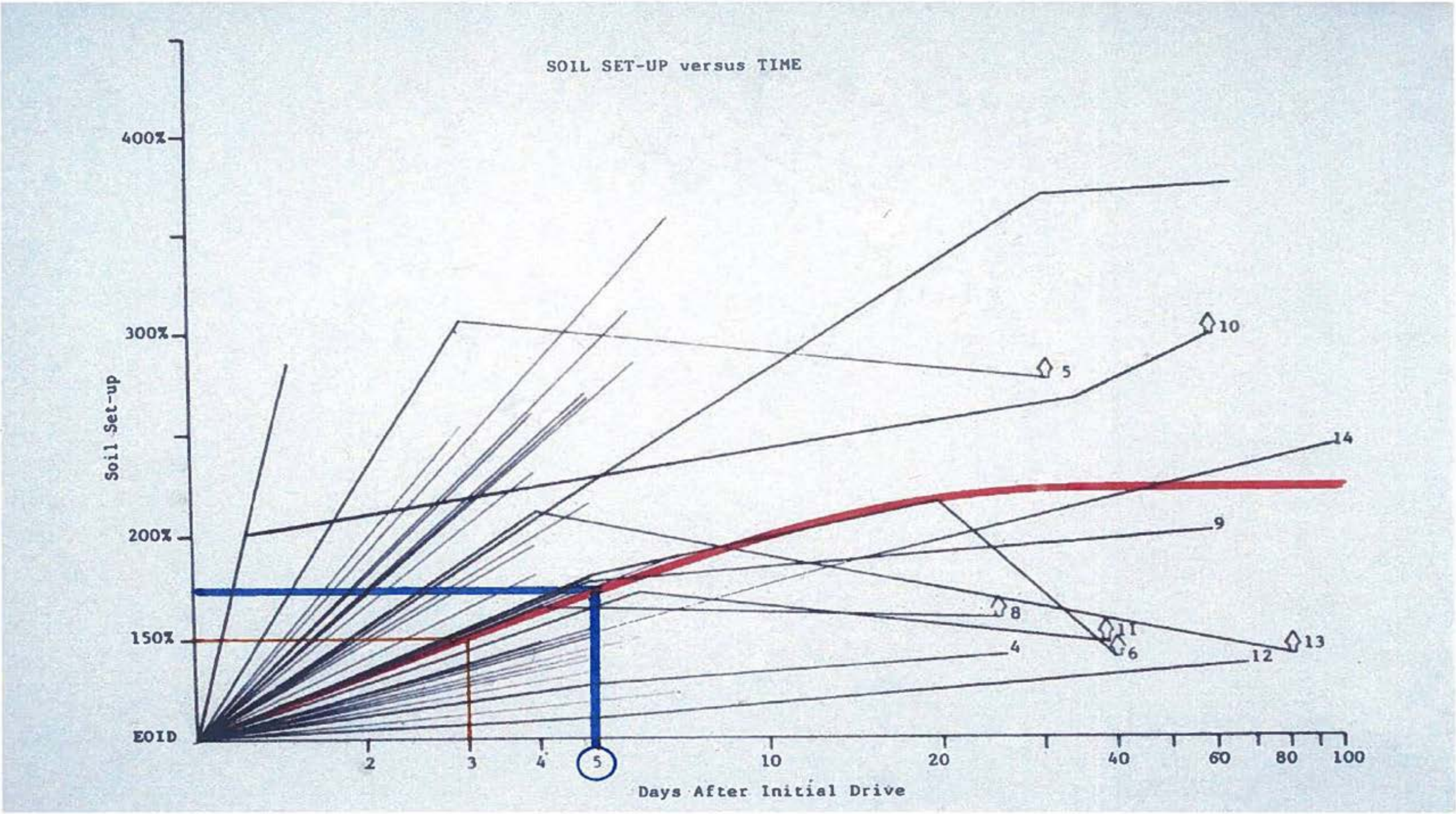

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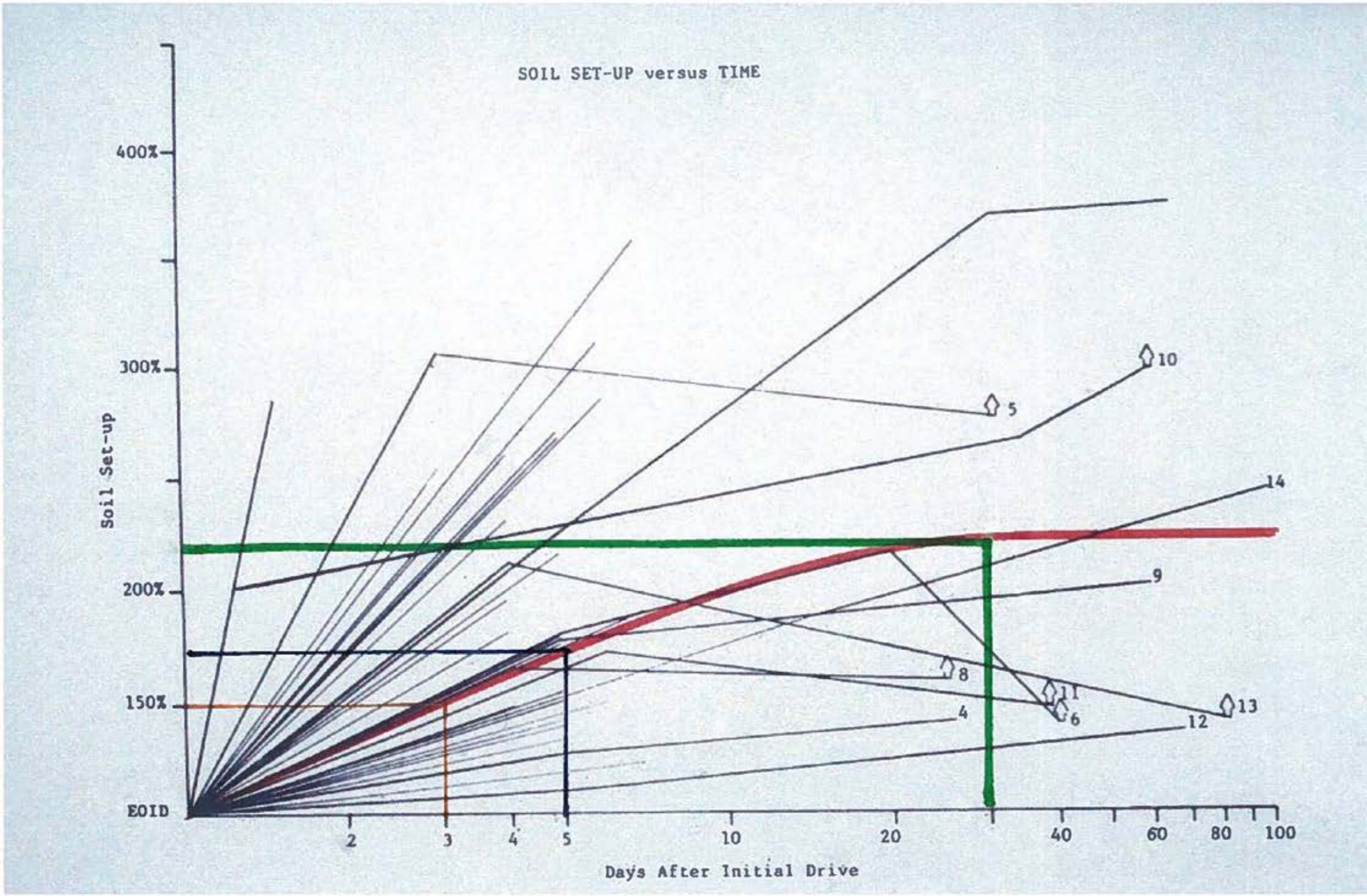

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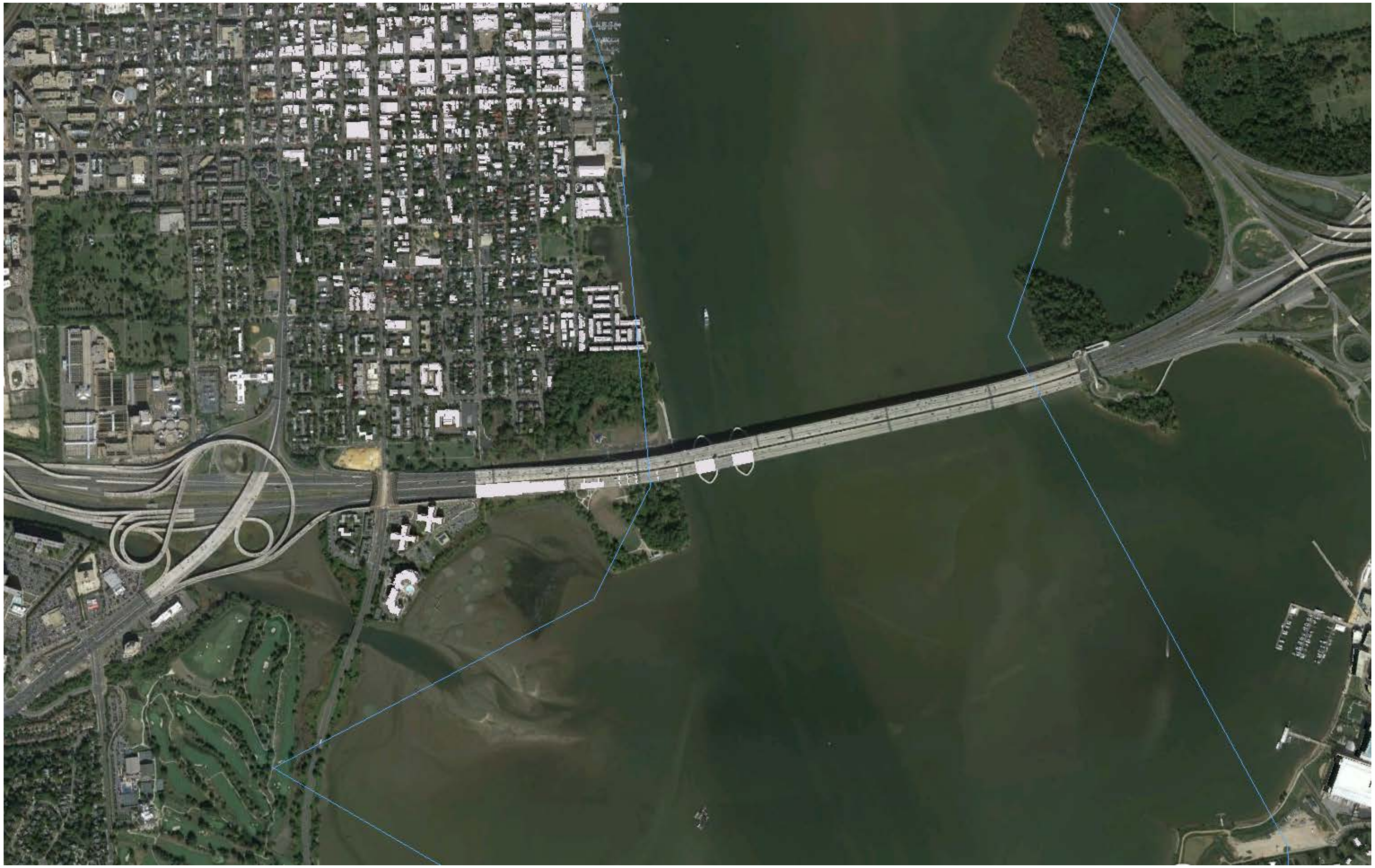
What followed was 25 Years of productive and cost effective Pile Driving using Dynamic Testing.

Virginia first experimented with Embedded Data Collectors on the Woodrow Wilson Bridge Project in Alexandria, Virginia in 2005.



Six 24” square prestressed concrete piles were cast with EDC’s in the top and at the tip.

The piles were used as Driving Test Piles.

The tests were only partly successful due to the failure of several of the sensors possibly due to the heat of hydration in the concrete.

No new Virginia projects with EDC's were developed but we followed the progress of Florida DOT's EDC research.

When the Florida research was completed and the use of EDC's was allowed in the Florida pile specification, Virginia followed suit.

In December of 2011 VDOT organized a one day new product information transfer workshop on EDC’s for our consultants and contractors.

The first project where EDC's were chosen for use by the Contractor is the new bridge on Dominion Boulevard in Chesapeake, Virginia, advertised in 2012.

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Pile Driving Program

on Dominion Boulevard

Pile Size	Driving Tests	Linear Feet of Pile
12”	2	1,668
16”	16	15,146
24”	20	36,657
	38	53,471

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AVER TECHNOLOGIES, INC.
13104 Queensdale Dr.
Woodbridge, VA 22193
Tel: (703) 580 8907
Fax: (480) 247-4839
Email: swamy@avertechnologies.com

To: Mclean Contracting Company
6700 McLean Way
Glen Burnie, MD 21060-6480
Attn: Mr. Joe Hoffman, PE

Date: 26-Mar-13
AVER Doc No.: 13-251R-VB

Subject: Dynamic Load Test and Production Pile Recommendations
RT17 over Elizabeth River, Chesapeake, VA — Project # (FO)6017-131-109
Test Pile at B609 NB Pier 12

Dear Mr. Hoffman,

The following are summary of results from our dynamic load testing services for the above referenced test pile and our recommendations for production piles at this location. General test pile information along with results are attached to this letter in tabular and graphical form.

Dynamic Load Testing Method: EDC with Top & Tip Sensors					
Pile Information			**Hammer Information**		
Bridge No.:	B609 NB		**Name:**	Delmag D46-32	
Pier #:	Pier 12		**Total Energy:**	122.435	kip-ft
Pile No.:	18		**Ram Weight:**	10.14	kips
Pile Type.:	24" PSC, SQ		**Pile Cushion:**	Plywood	
Length:	78	Feet	**Thickness:**	8	inches
Pile Cutoff:	3.5	Feet			
Refer. El.:	3.5	Feet	**Nom. Bearing Res.:**	710	kips

Summary of Dynamic Load Test Results:

	EDC			PDA		
	(Performed)			(Performed)		
Test Condition:	ID	RS	Units	ID	RS	Units
Start Depth:	0	68.5	feet	0	68.5	feet
Final Depth:	68.5	68.66	feet	68.5	68.66	feet
Pile Tip El.	-65.00	-65.16	feet	-65.00	-65.16	feet
Jc: Assumed	0.5	0.5		0.5	0.5	
Required Driving Resistance:	568	710	kips	568	710	kips
Avg. Ult. Comp. Capacity (jc):	499	1085	kips	482	1014.7	kips
Avg. Ult. Comp. Capacity (UF):	455	1143	kips			kips
Avg. Ult. Tip Capacity (UF):	168	209	kips			kips
CAPWAP (total):	NA	NA	kips	450.5	1013.8	kips
CAPWAP (Tip)):	NA	NA	kips	157.4	849.4	kips
CAPWAP (Skin):	NA	NA	kips	293	164.4	kips
Max Top Comp. Stress:	3.9	3.9	ksi	2.9	4.2	ksi
Max. Tip Comp. Stress:	1.2	1.0	ksi			
Max Tensile Stress:	1.9	1.9	ksi	2	0.4	ksi
Blow Count	44	8/1 inch		44.0	8/1 inch	
Stroke:	6.9	9.3	feet	7	8.6	feet
Energy:	23.5	34.3	kip-ft	22.3	36.8	kip-ft
Average Wave Speed:	14008.5	14028.6	ft/sec			
Average Dynamic Jc:	0.3	0.4				
Maximum Loss in Prestress Top:	85.3	93.2	µ Strain			
Maximum Loss in Prestress Tip:	27.7	18.9	µ Strain			
Pile Integrity:	Good					

Notes: Ultimate Capacity, stroke, and energy indicated for initial drive are at end of drive.
Ultimate Capacity, stroke and energy indicated for restrike are average during restrike
All stresses reported are maximum values — NA - Not Applicable

This is a sample image. Similar documentation will be posted to the TIG Embedded Data Collectors website in the near future.


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Panasonic

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MTE

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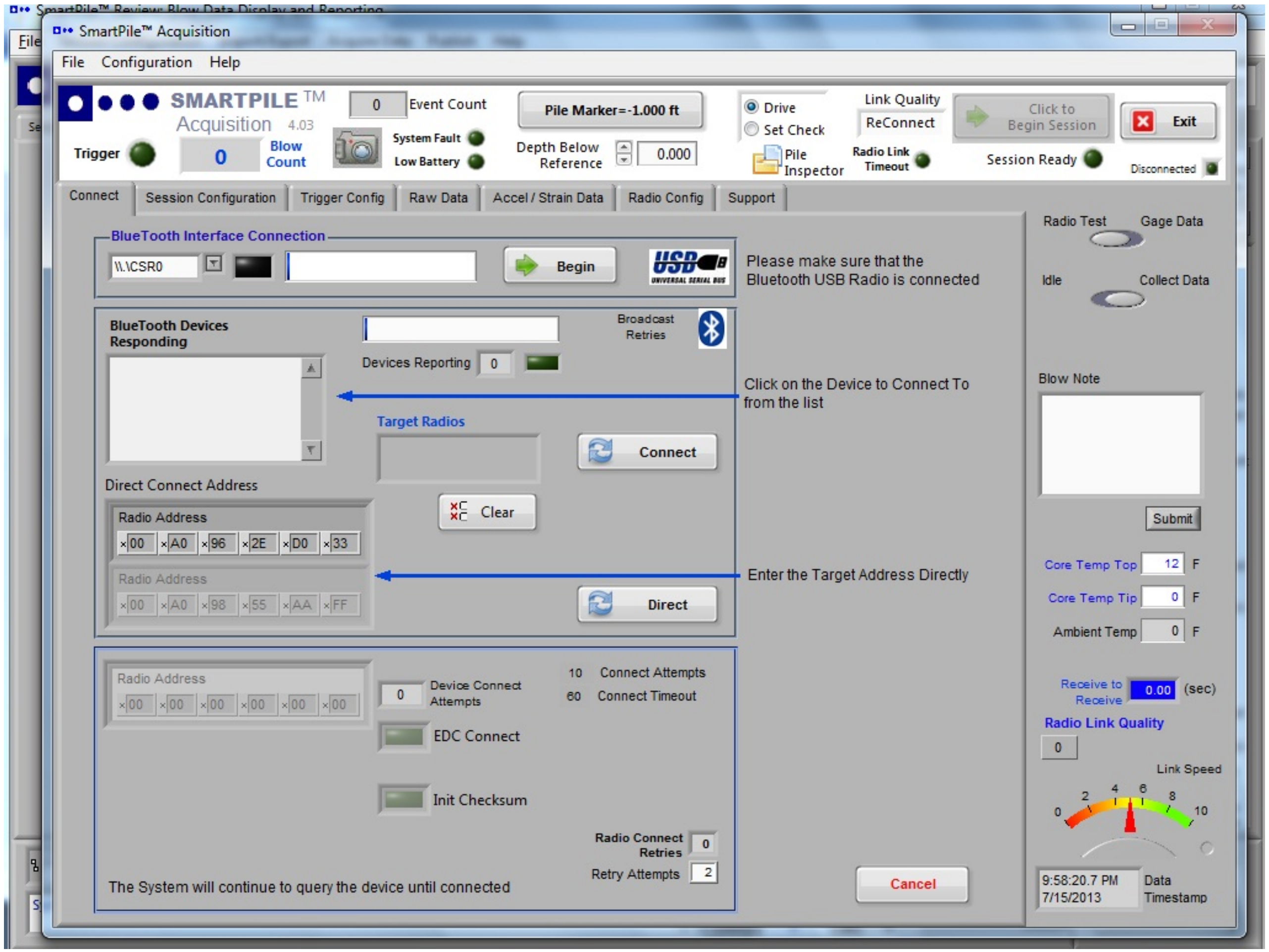

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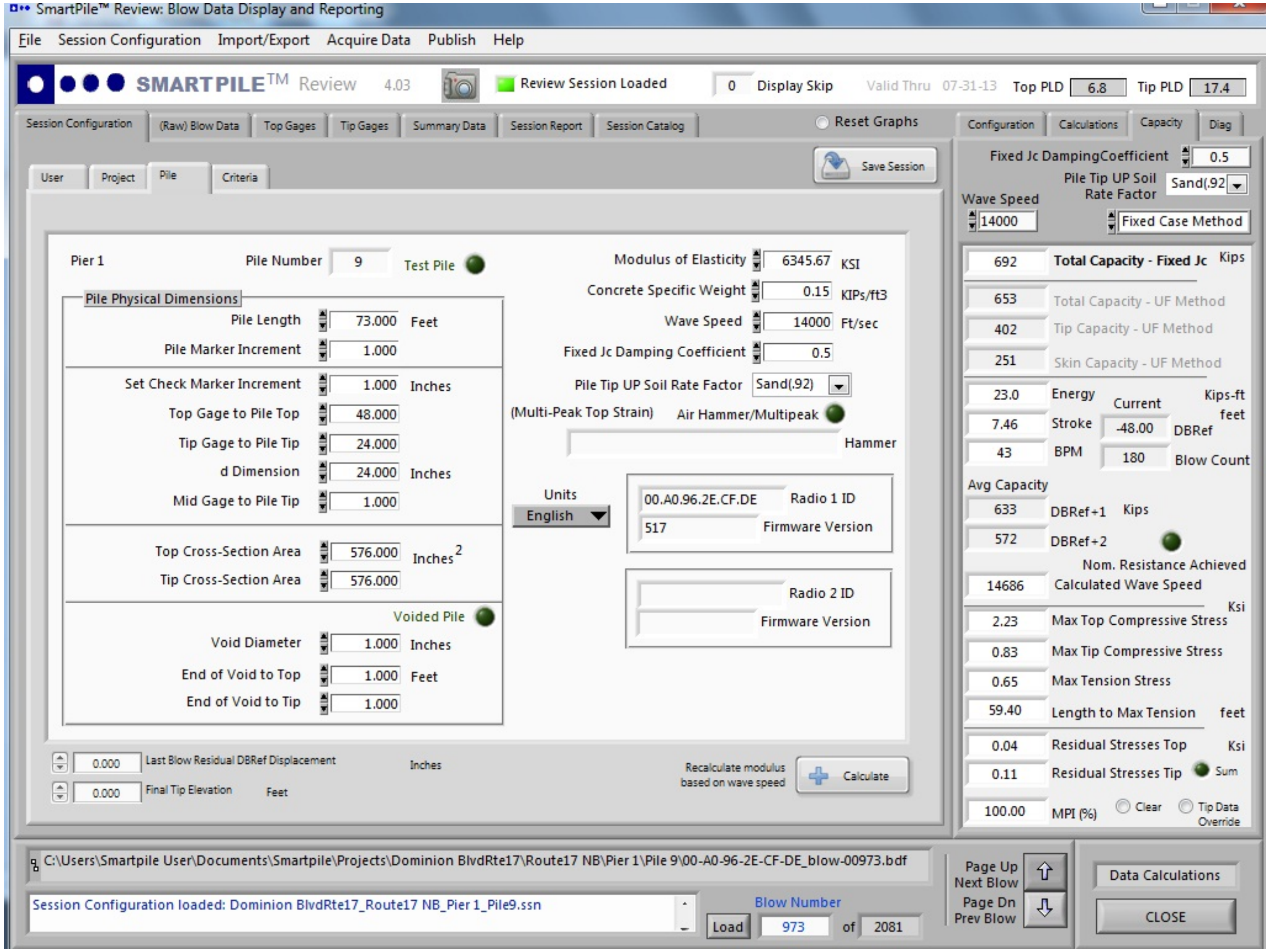

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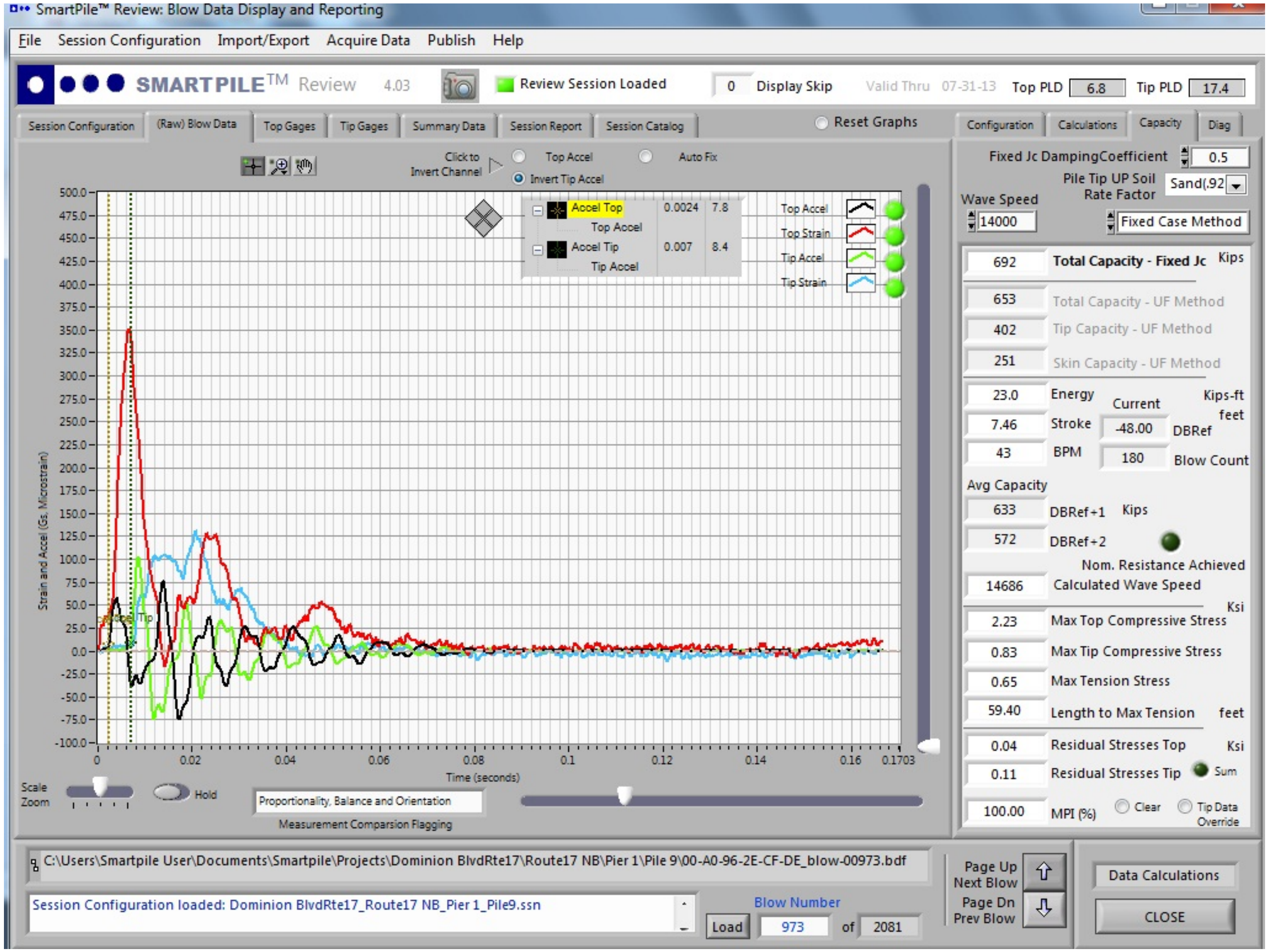

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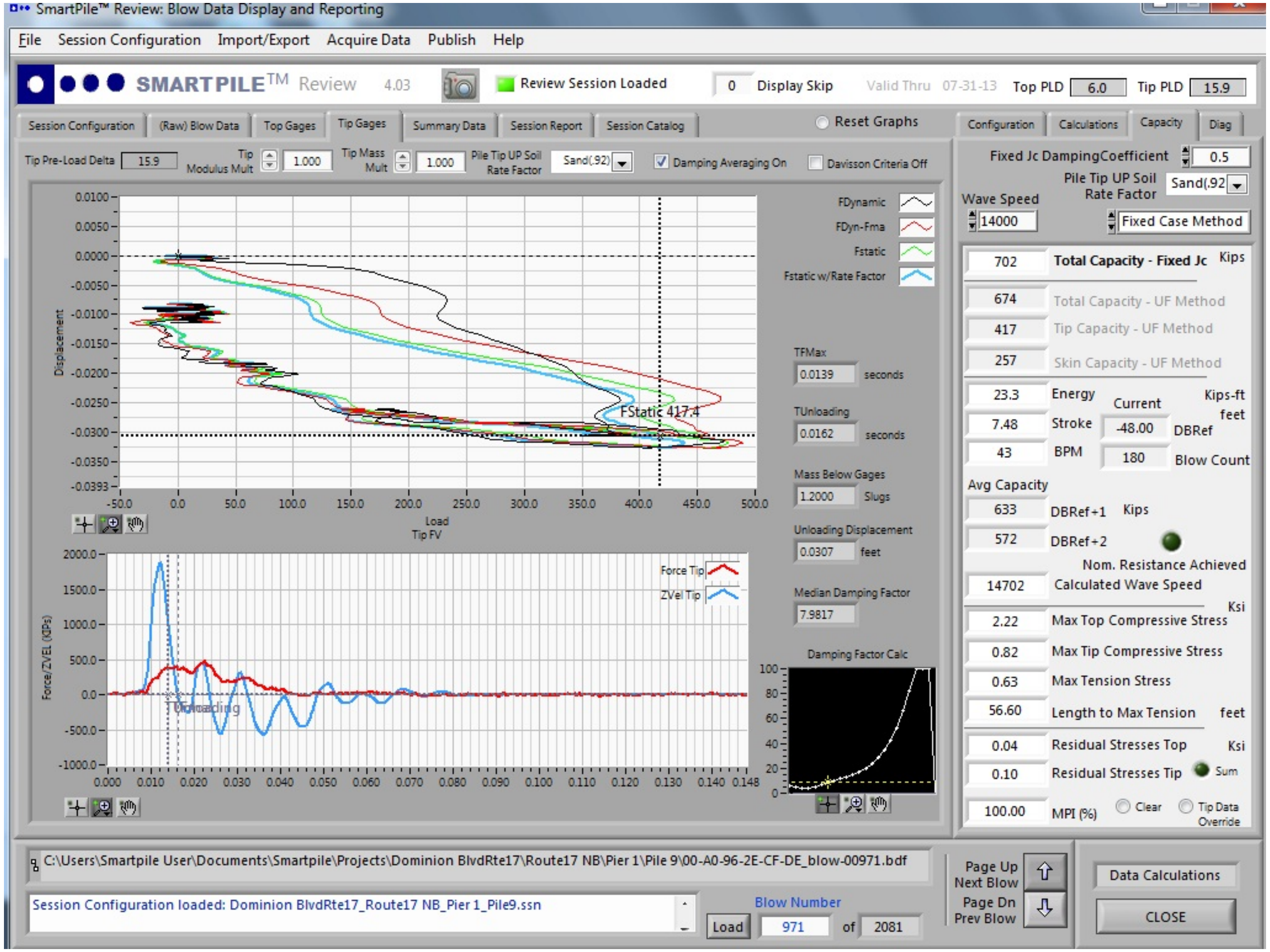

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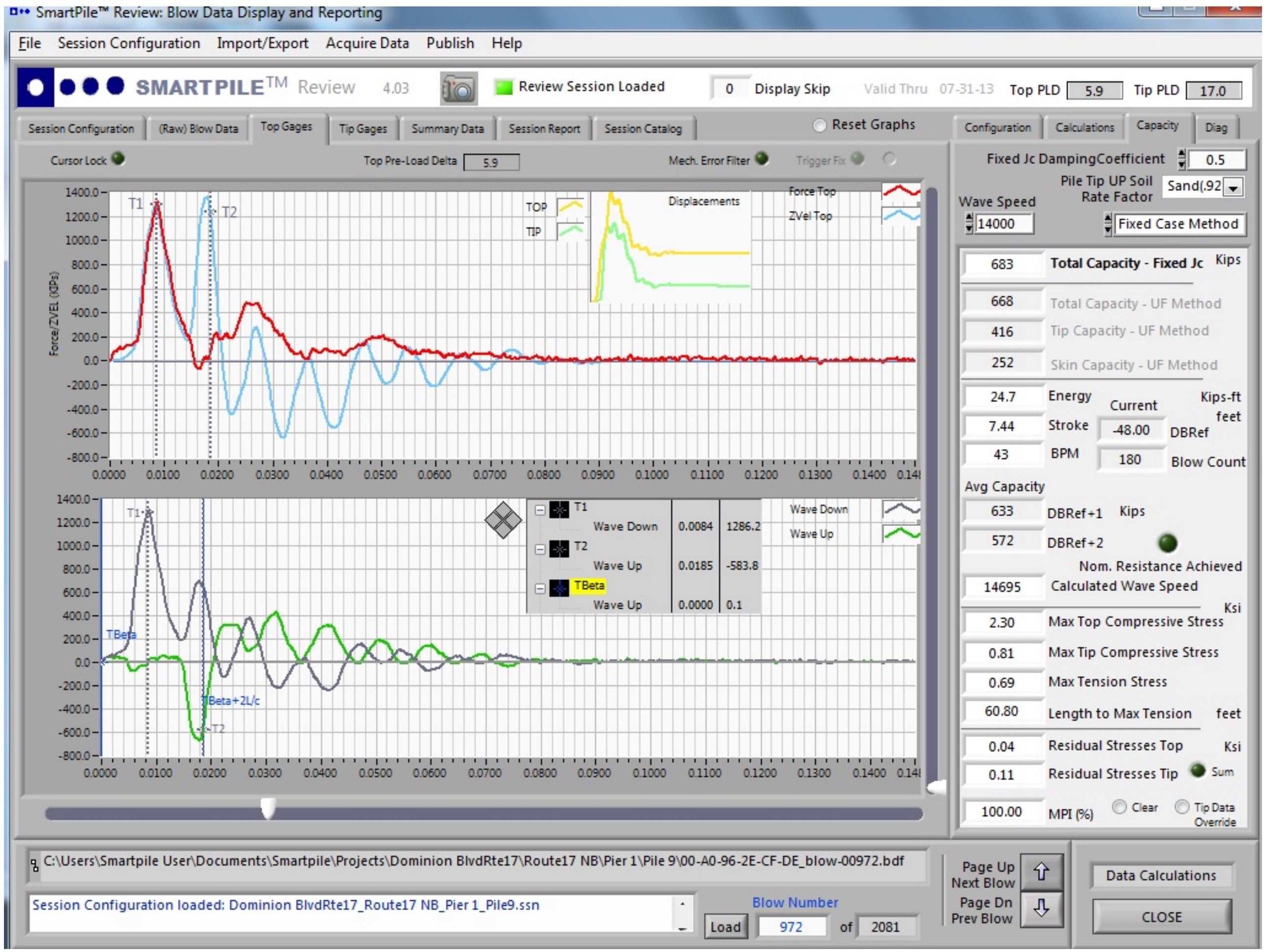

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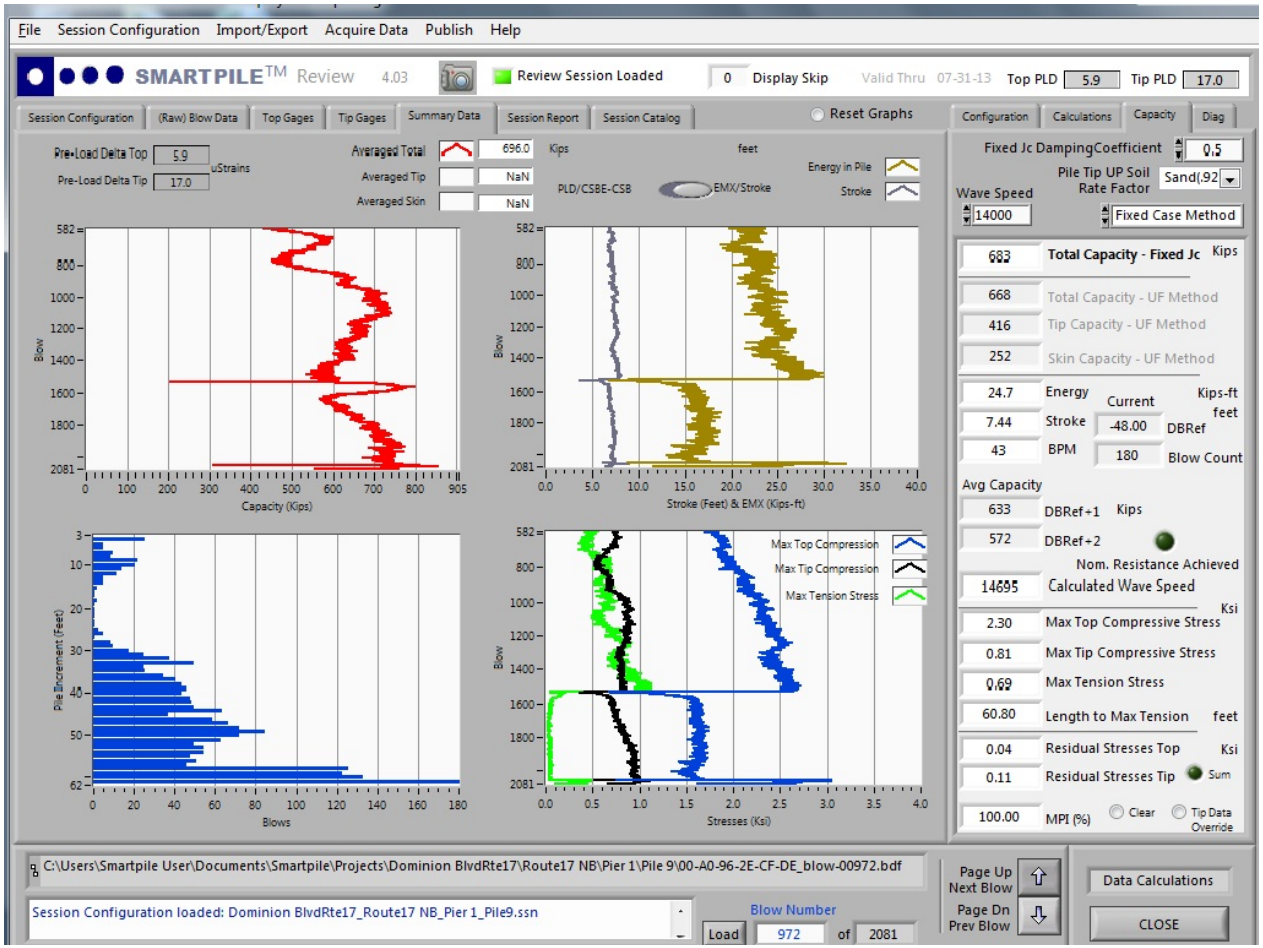

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In What Ways Does VDOT Plan To Use Embedded Data Collectors?

The new Special Provision allows Contractors the choice to use either EDC or PDA.

The new Special Provision allows Contractors to choice to use either EDC or PDA.

We may begin to require that the first Driving Test Pile have a top and bottom sensor.

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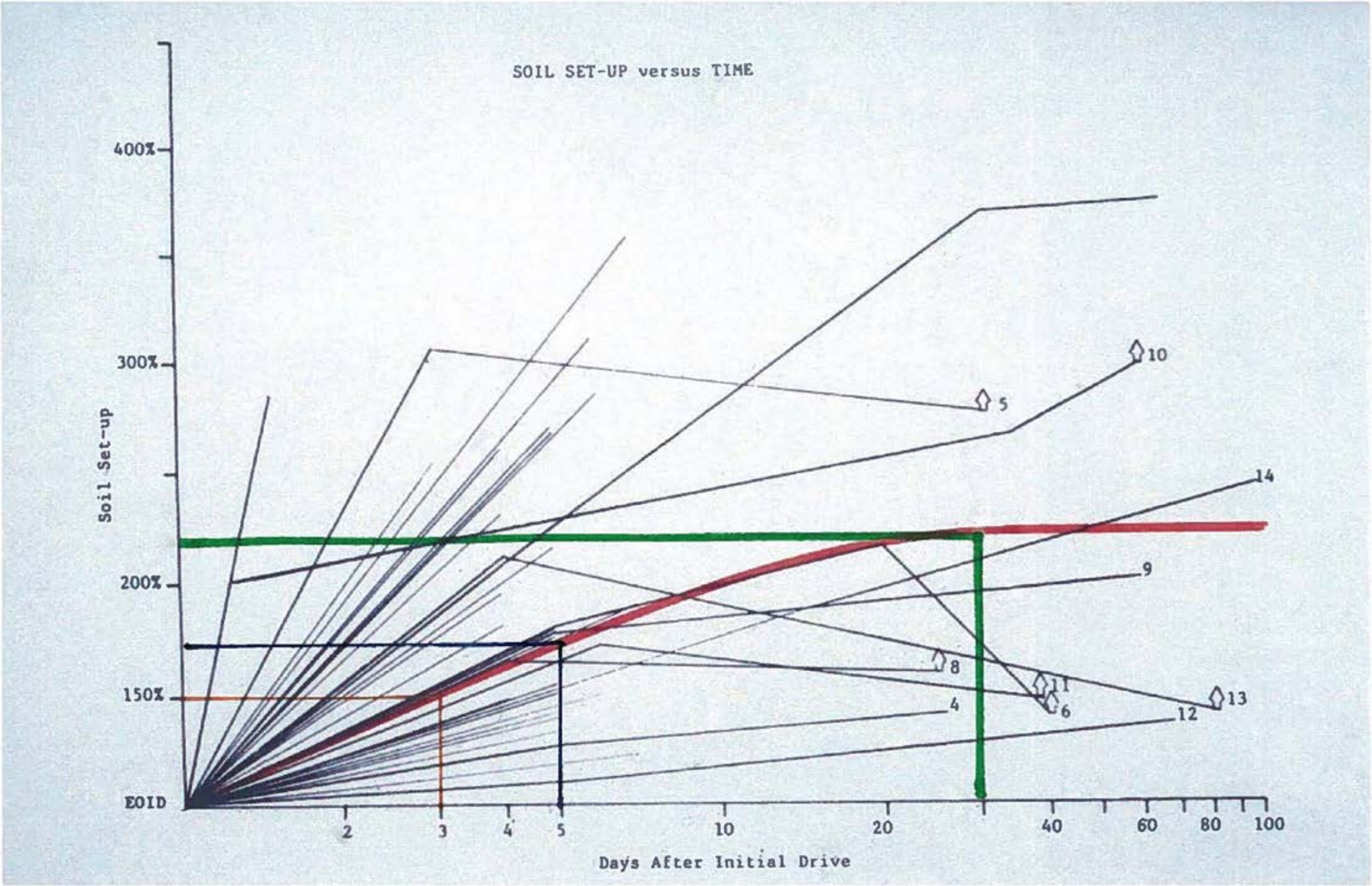
Cost Benefits – Advanced Damage Detection

(early detection saves $$)



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Driving Tests are usually done on a pile that will be incorporated into the bridge foundation.

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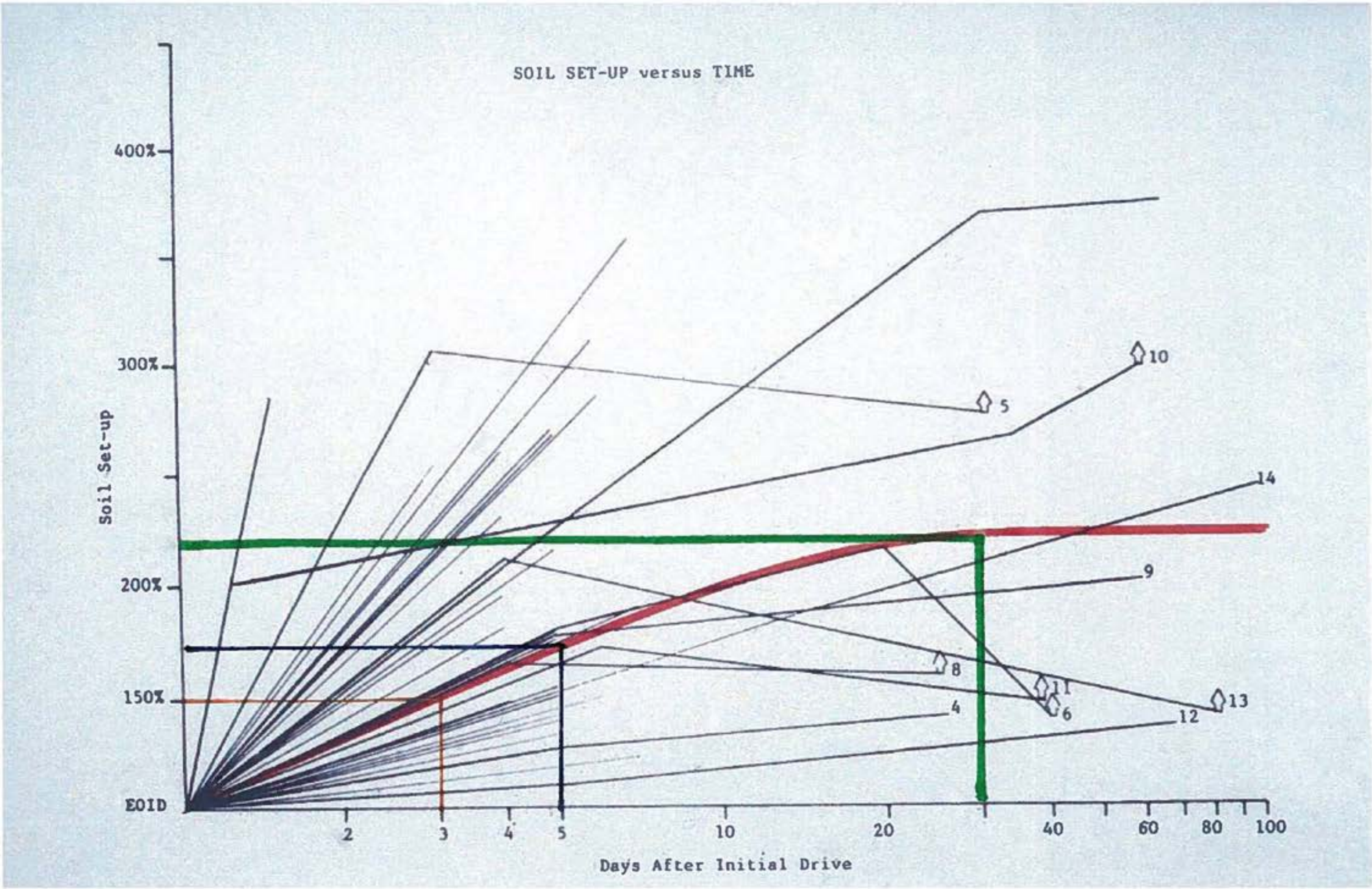
When the Contractor remobilizes to begin production pile driving, the EDC in the Driving Test Pile can easily be reactivated and a second restrike performed, giving us soil setup weeks after initial driving.



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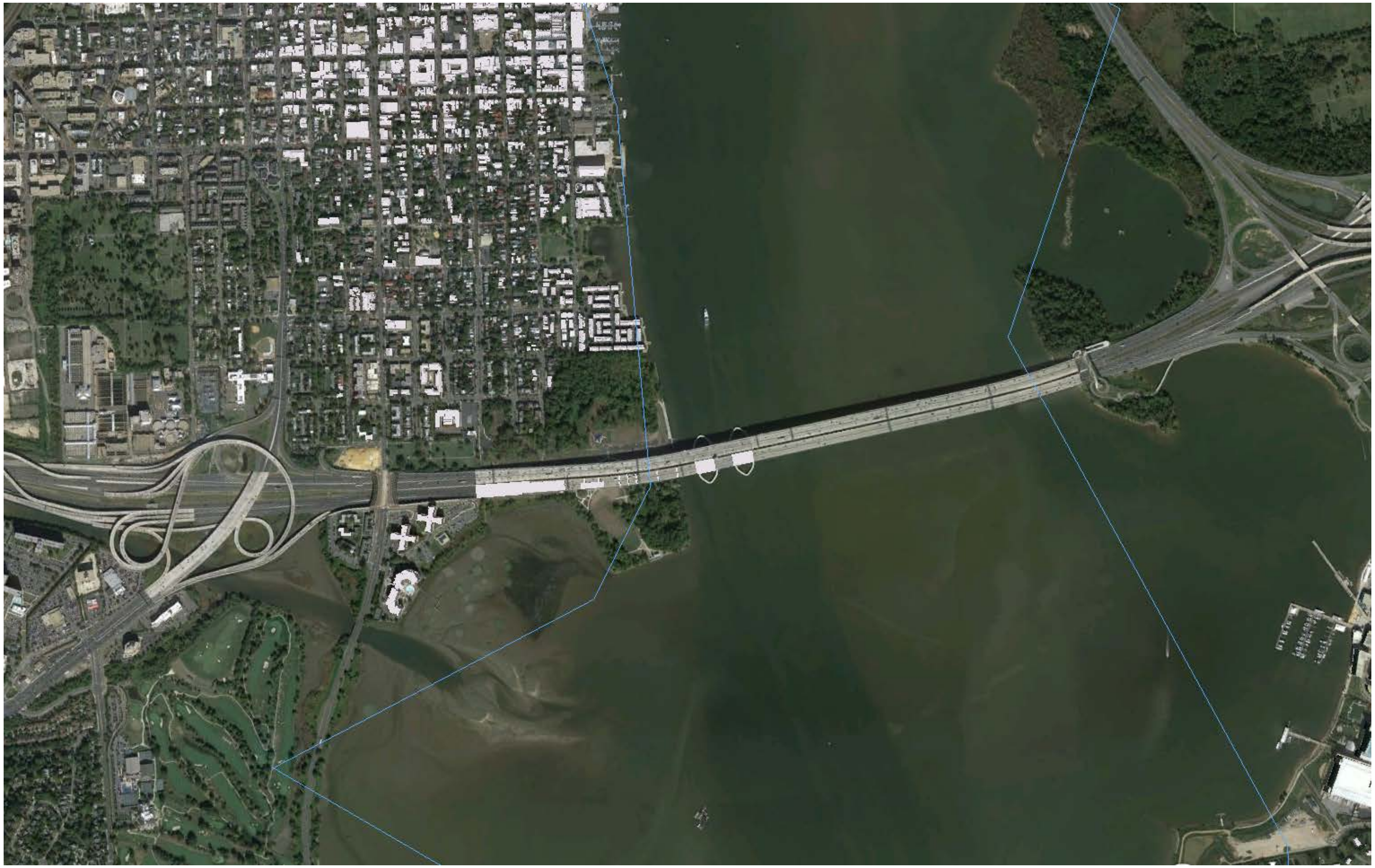
Long Term Monitoring using Embedded Data Collectors (EDC) in Bridge Structures



A pier cap with Embedded Data Collectors installed in it was built for FHWA's Turner-Fairbank Highway Research Center. It will provide data for ongoing studies into lifecycle monitoring and cost. The work is being done by Carl Ealy.

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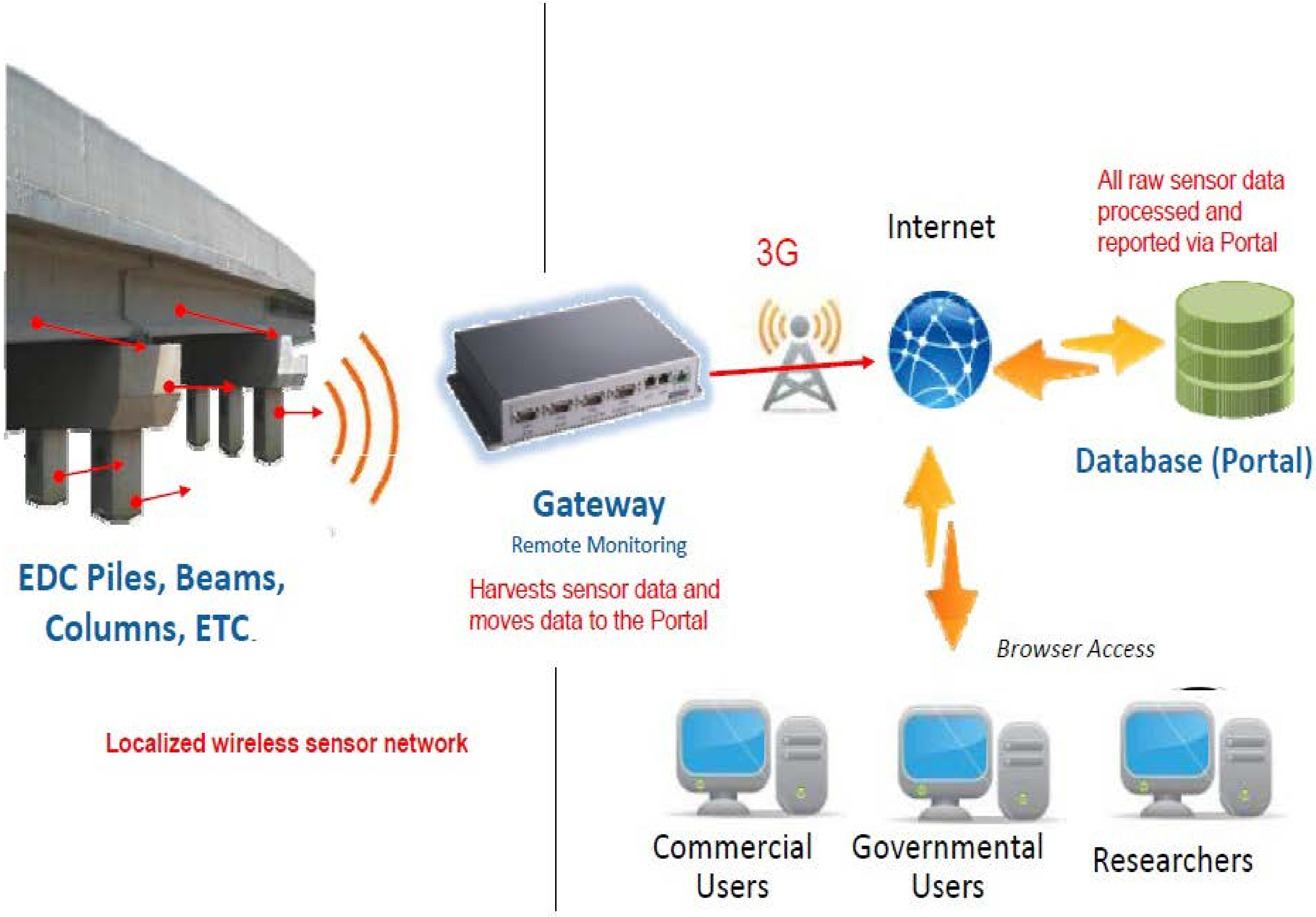
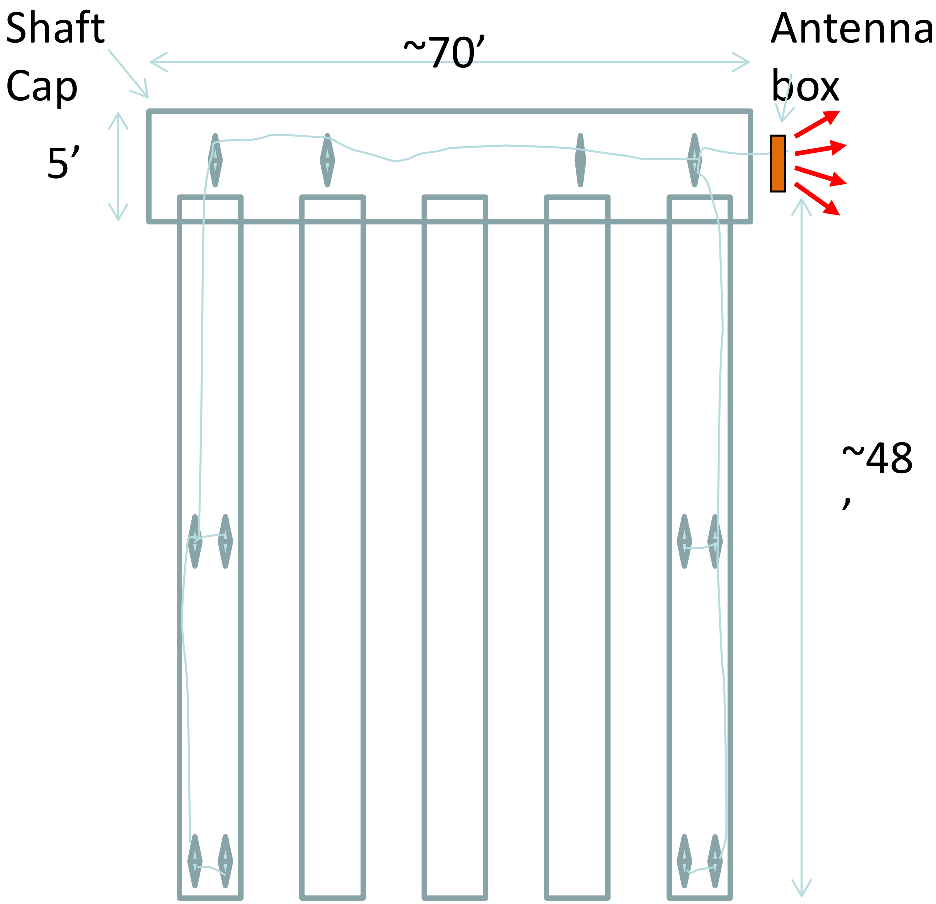
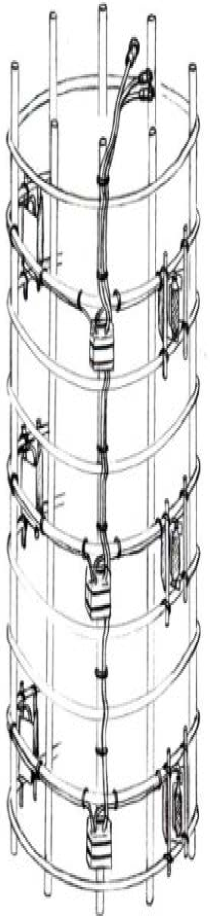
Remote Monitoring – System Elements



EDC Drilled Shaft Instrumentation Layout – Bridge B606, I-95 Hot lanes Project, Virginia, USA





Step 1

Strain transducers and temperature sensors are installed on drilled shaft rebar cage

Step 2

Preliminary data is collected from the dataport before and after concrete pour in drilled shafts

Step 3

Cables are installed for cap monitoring

Step 4

Sensors are connected through cables and are connected to data port

Step 5

Data port attached to the form work, to collect data after concrete pour

Step 6

Cap instrumentation set up before concrete pour

Concrete Pour

Data Collection Equipment

Data port cover on the back wall of abutment

Purpose of using EDC Instrumentation & Monitoring in Drilled Shaft

Purpose of Using EDC Instrumentation & Monitoring in Drilled Shafts

- Static Load measurements at various locations along the shaft and shaft cap.
- Changes in shaft strain during live load, dead load and service loads.
- Temperature of concrete at various stages of the shaft and shaft cap construction and post construction.
- Determine the load transfer along the shaft.

This information will be extremely valuable if States want to revisit and modify load and resistance factors based on their local conditions and practices.

Embedded Data Collectors

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Want more information?

Visit the Embedded Data Collectors webpage at:

tig.transportation.org