



**2014 FHWA National Hydraulic Engineers
Conference**

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***Unknown Foundations: A Marriage in Oregon of
Geotechnical and Hydraulic Engineering***

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Scour Problems





Introduction

- After the Schoharie Creek Bridge collapse, on the NY Thruway where there were 10 fatalities in 1987, the National Bridge Scour Evaluation Program was initiated in May 1988 with an FHWA memo requesting data from bridge owners about their conduct of scour calculations – for new and existing bridges.





- Scour evaluation reporting was established in 1990 by an FHWA memo.
- Based on rating factors of Item 113 of the FHWA “Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation’s Bridges” – *Coding Guide*
 - Rating factors grouped in scour categories





- Based on Item 113 of the Coding Guide
 - Low Risk: 4, 5, 7-9
 - Susceptible: 6
 - Critical: 0-3
 - Unknown Foundations: U
 - Tidal Bridges: T





What Do We Mean By A Bridge With Unknown Foundations?

- A Bridge Lacking Information Regarding:
 - Foundation type (spread footing, piles, column) and/or,
 - Elevation (Pile tip elevation) and/or,
 - Material (steel, concrete, or timber) and/or,
 - Dimensions (width, length, or thickness) and/or,
 - Foundation condition (integrity)





Unknown Foundations Summit

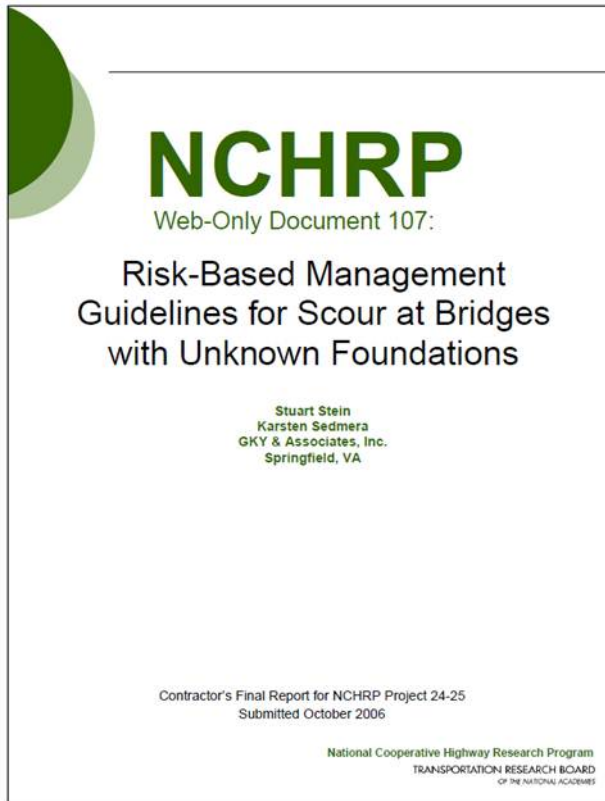
- Because of various issues throughout the country, FHWA called for an Unknown Foundations Summit in November 2005 in Lakewood, CO





NCHRP Study

Project 24-25



- Scour Risk Management Guidelines
 - Probability of Failure
 - Cost of Failure
 - Risk of Failure
- Quantifying Risk for Scour Failure
- Mitigating Actions for Scour
- Scour Management Case Studies





Oregon Bridge Facts

- State Owned
 - ~1740 State owned NBI bridges over water,
 - ~175 Unknown (includes some new bridges where we are waiting for as-constructed plans and hydraulic reports, started with ~113 to test in the field, the ADT on some will be too low to justify cost of testing).
- Local Agency
 - ~4000 Local agency bridges over water,
 - ~1640 Unknown.





ODOT Approach

- Screen all “U” bridges to check that they are correctly coded and then prioritize them,
- Conduct office research for existing information,
- Develop “inferred foundations” (if possible),
- Conduct field investigations.

Conduct a scour evaluation at each site, compare the results with the foundation depths obtained from the research and investigation work and recode Item 113 for the bridge accordingly.

This may also involve an evaluation of the stability of the bridge under scour and flood water conditions.





Screening

- Screen all bridges coded “U” to ensure that they are correctly coded as having unknown foundations. Also screened out:
 - culverts,
 - bridges to be replaced within 5 years ,
 - recently constructed bridges.
- Prioritize these bridges based on their functional classification and ADT.
 - Principal Arterial – Interstate,
 - Principal Arterial - Other Freeways or Expressways,
 - Other Principal Arterial,
 - Minor Arterial,
 - Major Collector,
 - Minor Collector.





Office Research

- Collect and document existing information for each bridge from the following resources:
 - Bridge plan sheets, (as-constructed or not),
 - Pile driving record books,
 - Bridge construction records,
 - Bridge archive records (design and construction information).

Is there sufficient as-built information to perform a scour analysis?



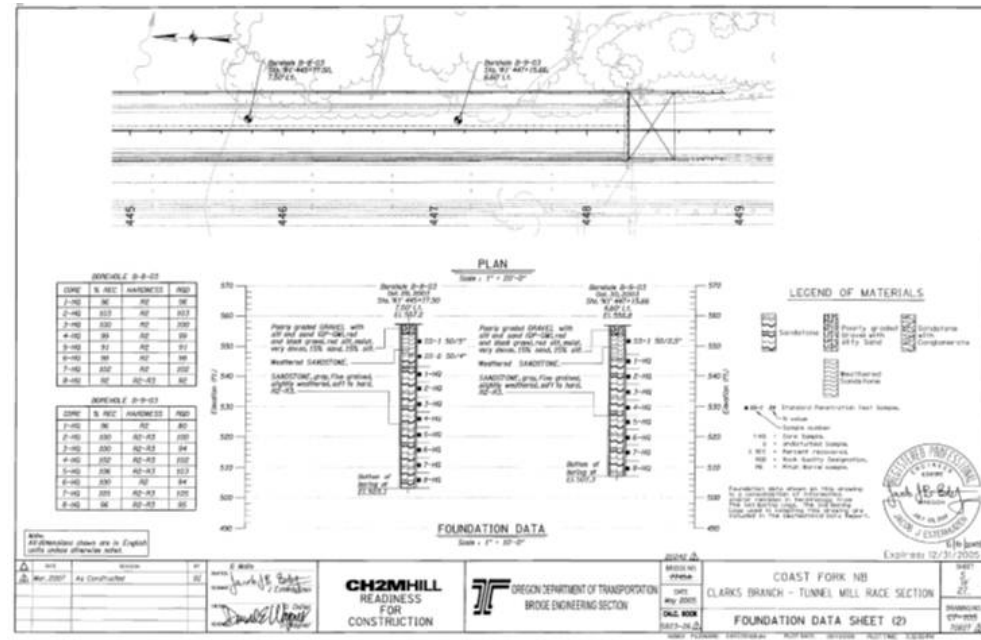


Inferred Foundations

Collect information on the geologic subsurface conditions at each site and in the general area.

If foundation type, design loading and subsurface materials are known to a sufficient extent, perform calculations to determine “inferred” foundation depths.

Able to do this for 5 bridges.





- After our review of files and archives, there were ~113 bridges that we had insufficient information to fully determine scour. This was often a case where we knew the foundation was a pile foundation, but with no pile lengths (usually timber) or an unknown depth of a spread footing





Next Steps

- We prepared an RFP for field NDT by geophysical means. We've now had a contract with FDH Engineering out of NC for several years. FDH has been involved in NDT for unknown foundations since 1994.





NDT Testing for Unknown Foundations

- Surface Nondestructive Test (NDT) Methods
 - Simple pulse echo/Sonic Echo (SE, time domain)/Impulse Response (IR, frequency domain),
 - Bending Waves/Dispersive bending or flexural wave,
 - Ultraseismic (US),
 - Seismic Wave Reflection Survey,
 - Transient Forced Vibration.





- Borehole Nondestructive Test (NDT) Methods
 - Parallel Seismic (PS),
 - Induction Field (IF),
 - Borehole logging Methods,
 - Dynamic Foundation Response,
 - Borehole Radar,
 - Borehole Sonic,
 - Cross-borehole Seismic Tomography.





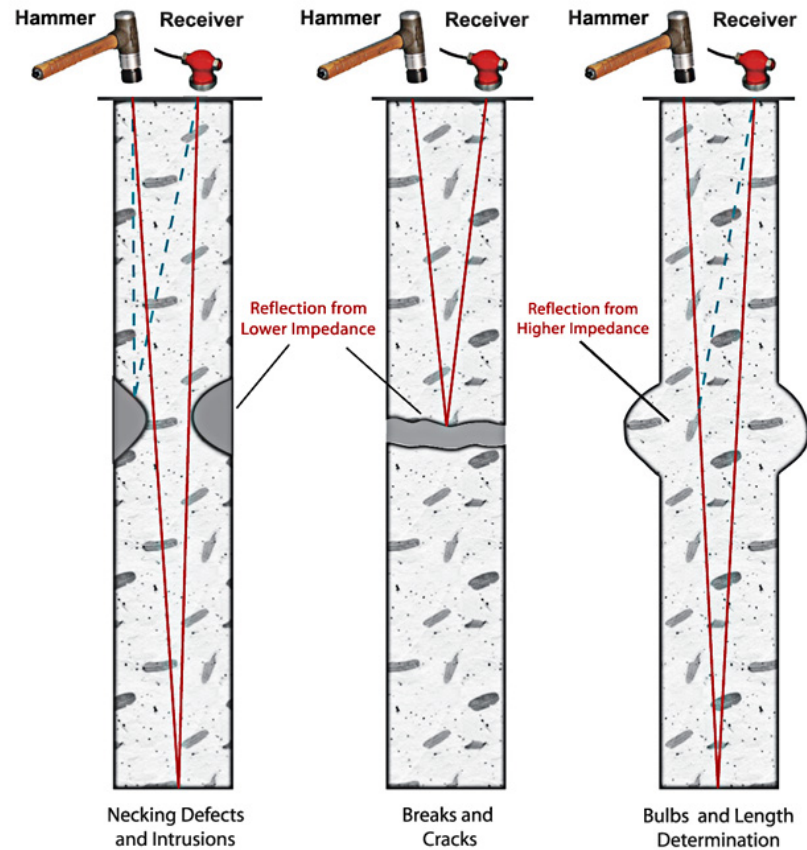
Simple Pulse Echo (SE)

- This technique is conducted by striking a pile from its top to create a stress wave (compression wave) that travels up and down the pile's length. Analyzing this wave for the location of the pile's tip is done by simply manipulating and observing the raw data as it is collected at a transducer mounted on the pile top.
- This noise results from the wave reflecting and refracting numerous times from the pile's internal boundaries, thus obscuring the identification of the pile tip.
- This method also requires access to the top of the pile, which is difficult with most modern bridges.
- Need to measure wave velocity in material tested.
- Because of these shortcomings, simple pulse echo is not often used anymore for pile depth but can be used to determine a footing thickness.



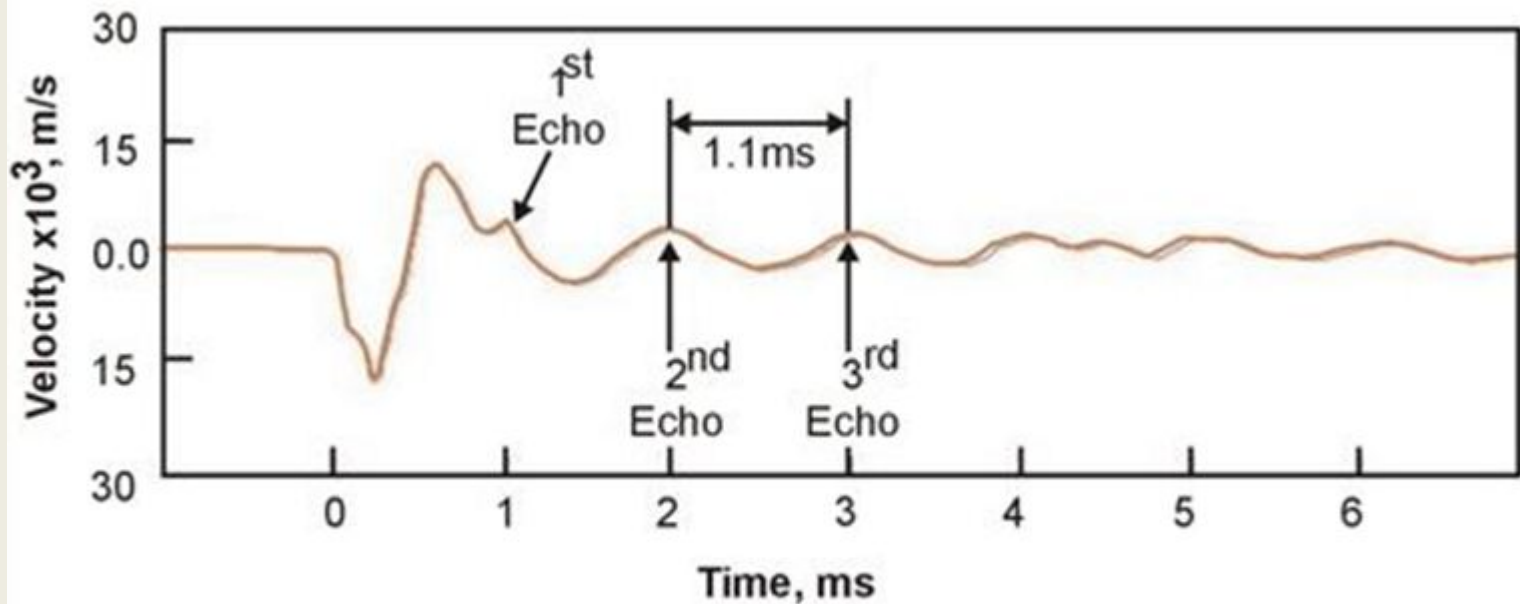


Simple Pulse Echo (SE)





Simple Pulse Echo (SE)



$$\text{Depth} = V \times \Delta t / 2 = 3,652 \times 1.1 \times 0.001 / 2 = 2.01 \text{ m}$$





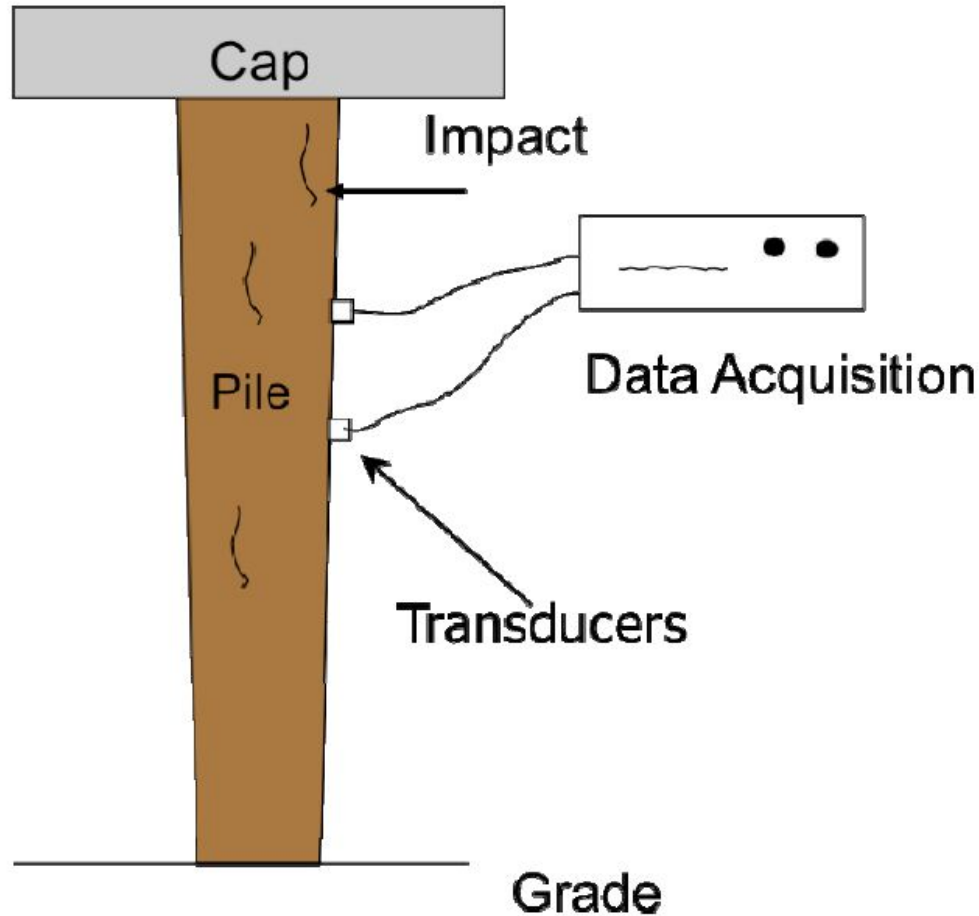
Dispersive Bending Wave

- High frequency transducers are attached to the pile's side. The pile is struck on the side of the pile to create flexural waves that travel downward along the pile's length. These waves are reflected from the pile tip or any discontinuity in the pile.
 - Useful when the top surface of the foundation is not available.





Dispersive Wave Setup



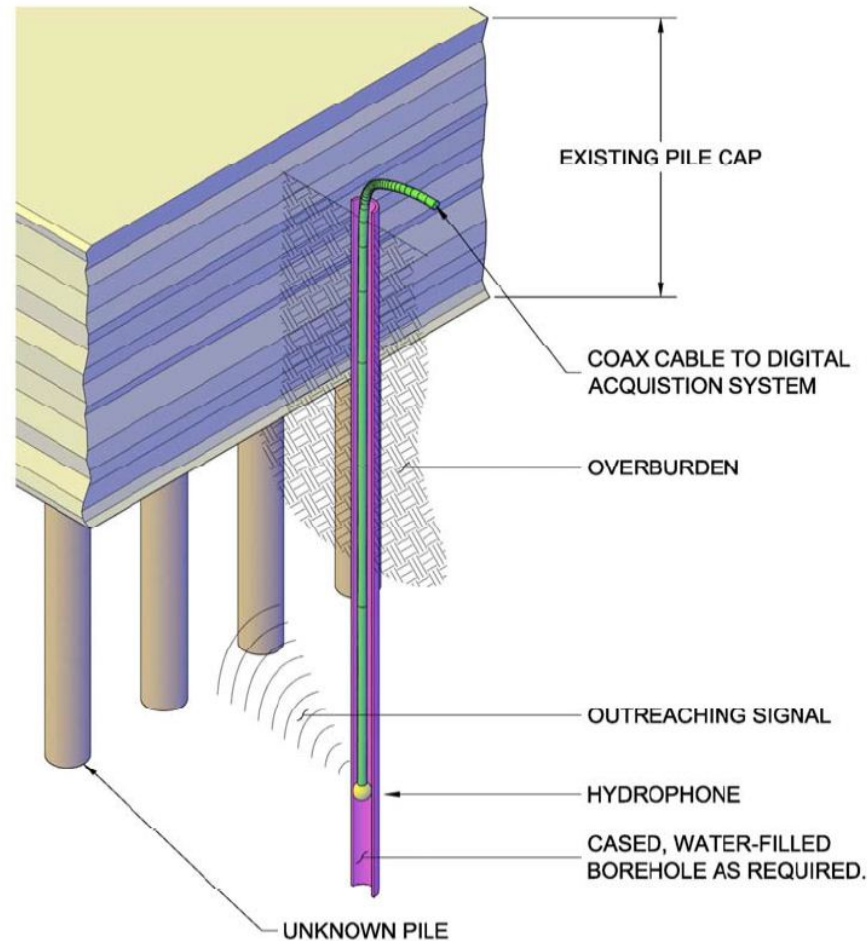


Dispersive Wave in the Field



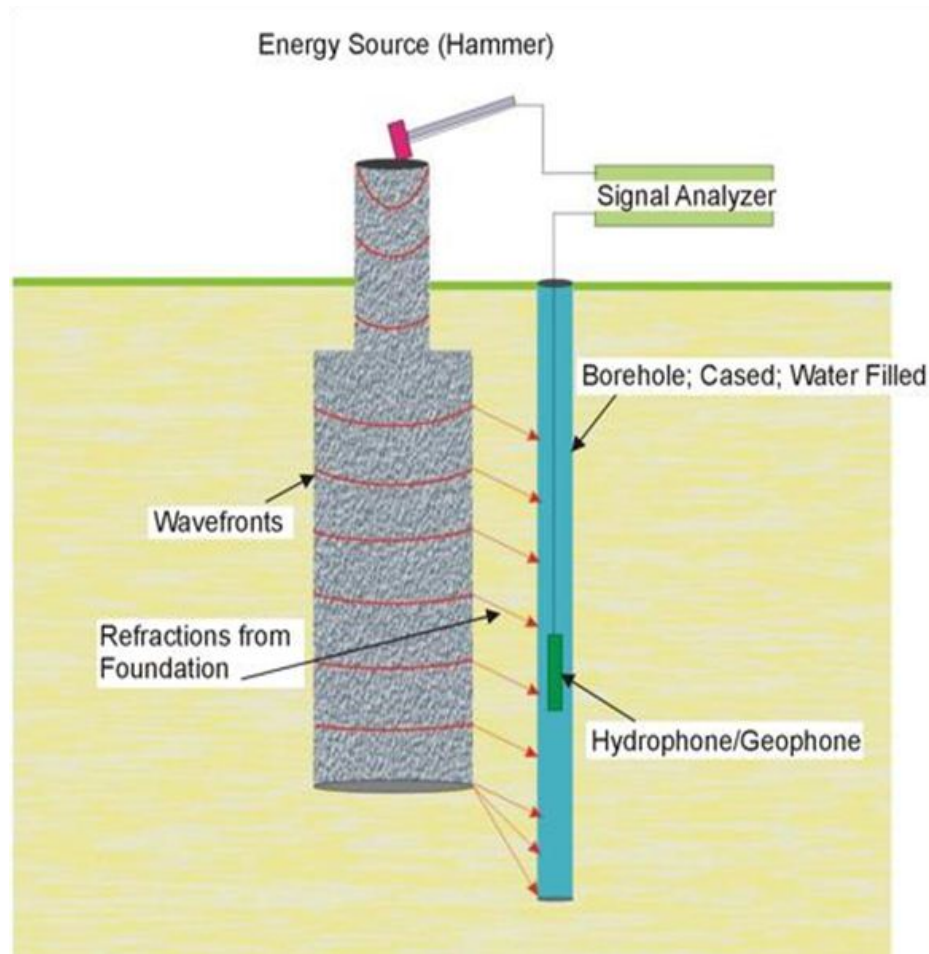


Parallel Seismic (PS)





Parallel Seismic (PS)



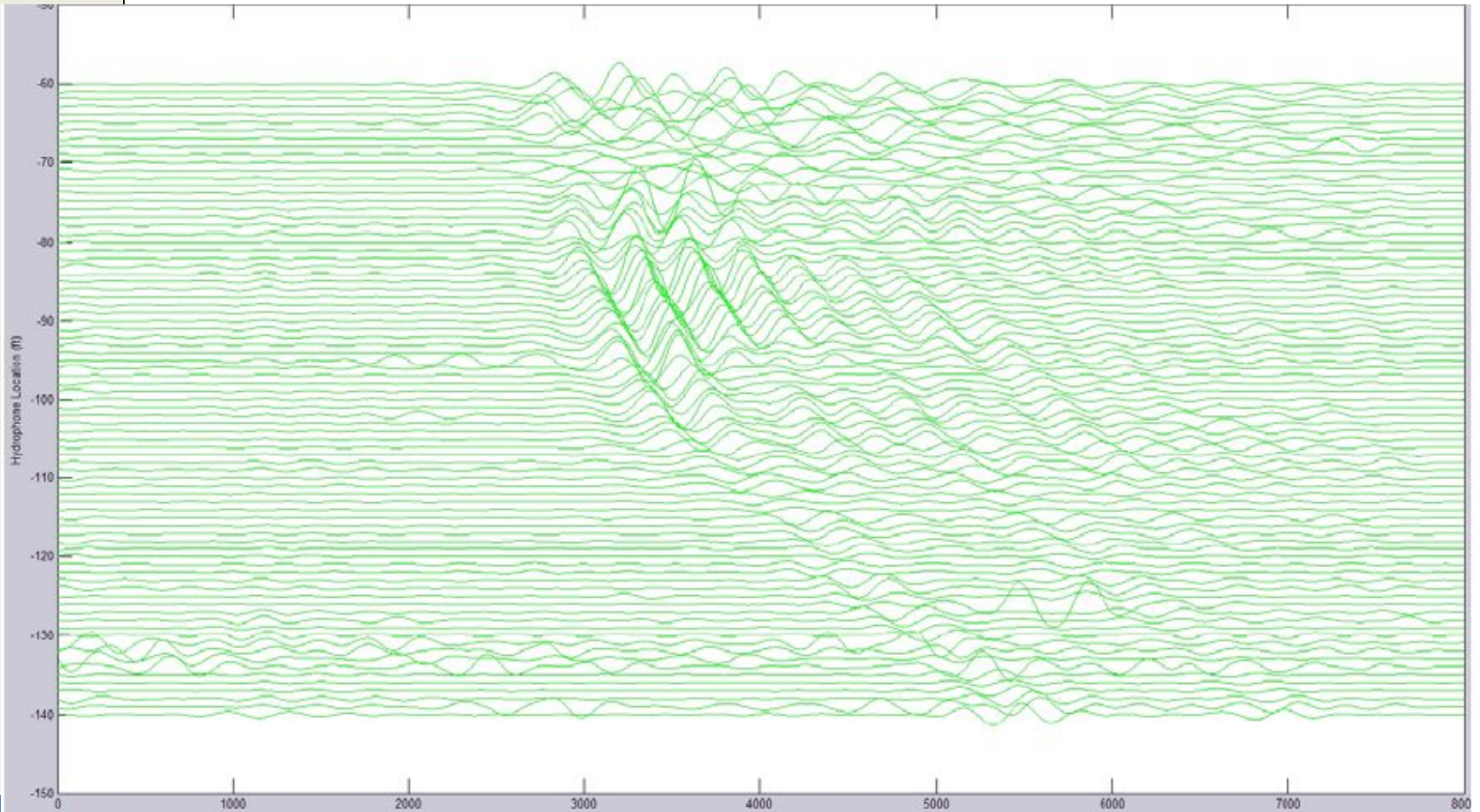


Parallel Seismic (PS)



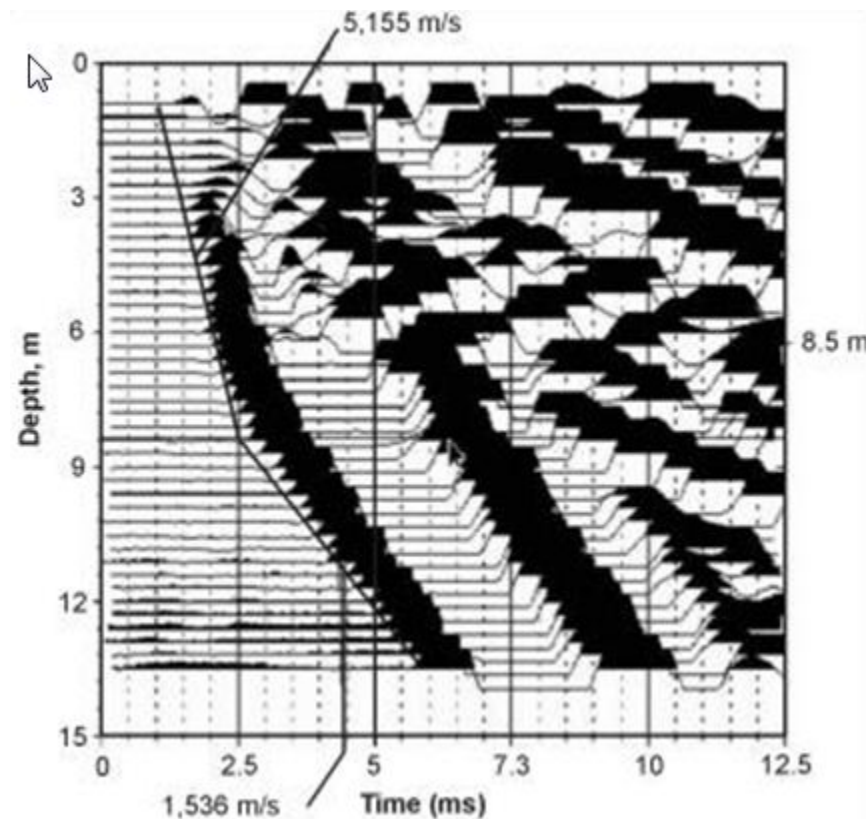


Output From Parallel Seismic Test





Output From Parallel Seismic Test





Current status of Unknown Foundations (2014)

Original Total (2007)		175
Remove culverts and replacements		16
	Revised Total	159
Completed (or inferred) with in-house records		45
	Revised Total	114
Already recoded		2
	Revised Total	112
Completed under FDH WO#1 (2011)		33
	Revised Total	79
Br 5018A, completed 1/28/2013		1
	Revised Total	78
Completed under FDH WO#2 (2013)		21
	Revised Total	57
Planned for FDH WO#3 (2014)		3
	Revised Total	54
Bridges pulled for further review and recoding		20
	Remaining after 2014	34





Where is Oregon Today?

- We have field tested 54 foundations.
 - 42 - Dispersive bending wave
 - 12 - Simple pulse echo (buried footing thickness)
- This year's contract is for 3 parallel seismic tests
 - The costs for PS are high (need a crane to set drill rig over the side of the bridge), estimated \$73,000 for the 3 bridges
- Continuing to review new bridges as they come in to our inventory

