Substructure Foundation Investigation Report

SCDOT Asset ID: 09211

SCDOT Structure Number: 2670015400100
Road Designation: S-26-154
Feature Crossing Name: Swash
County: Horry
Location: 33.58351, -78.99818

FDH Project Number: PR-009681

Prepared By:

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Project Manager
Field Engineering

Reviewed By:

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4/12/2024

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4-12-2024

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Report Submitted to: Thomas P. Knight
SCDOT Hydraulics Design Support Office (HDSO)
955 Park Street
P.O. Box 191
Columbia, SC 29201-3959

Foundation Type: Concrete Piles

Number of Foundations tested: 3 (1 pile on Bent 2 and 2 piles on Bent 3)

Scope of Work

Non-Destructive Bending Wave Propagation Tests were conducted on Structure No. 2670015400100 for the purposes of determining the length of the in-situ piles. Refer to *Appendix A1: Methodology* for a summary of the Non-Destructive Test (NDT) methods employed. Work was commissioned under the 2018 FHWA Metric 18 PCA, and as a subconsultant to CDM Smith.

The locations of the tested piles were determined by representatives of FDH Infrastructure Services, LLC (FDH) during a field investigation of the structure's pile configuration. The selected piles are intended to be representative of the typical pile length in areas of the bridge deemed most susceptible to scour. See the pile layout *Figures 2-4* depicting locations of the tested piles in report section *Non-Destructive Testing Pile Locations & Bridge Profiles.*

Field Observations

In addition to the non-destructive testing performed on the bridge's piles, the immediate bridge surroundings were examined to identify site conditions which may impact the NDT test results and/or subsequent scour analyses. Such notable observations are listed below, and photographs are included in *Appendix B: Site Photographs* where applicable.

1. Any Scouring Noted: Yes See Photo(s): 19-25
2. Debris:
   a. Large Trees Leaning on Bank: No
   b. Debris Collection on Bents: No
3. Exposed Bedrock in Streambed: No
4. Visible Damage to Piles: No
5. Visible Modifications to Piles: No
6. Concrete Collars or Footers: No

Signal Analysis

Prepared By:

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Research and Development

Reviewed By:

Josh Scott
Research Analyst III
Research and Development

Data Analysis Results

Based upon the data collected by FDH at this site, *Table 1* below shows the computational results from the wave propagation tests.

The following are the column headings and notations used in this table.

- **Pile ID:** An identifier assigned to each pile by FDH. Location of tested piles and assigned Pile IDs are shown in the attached CAD schematic**.**
- **Pile Size/Diameter:** The measured pile size near the exposed top. This is the diameter for timber piles, and the lateral dimensions for concrete and steel piles. Pile diameter determined by measuring pile circumference.
- **Computed Overall Length:** The overall length computed from bending wave propagation test data. The length shown in this column is considered to be the distance from the top of rail to the pile tip.
- **Top of Pile to Pile Tip:** The distance, in feet, from the top of the pile to the pile tip.
- **Exposed Length:** The distance, in feet, from the mud-line to the top of pile, as measured by FDH technicians.
- **Computed Embedment:** The amount of effective pile beneath the mud line. (Top of Pile to Pile Tip) – (Exposed Length)

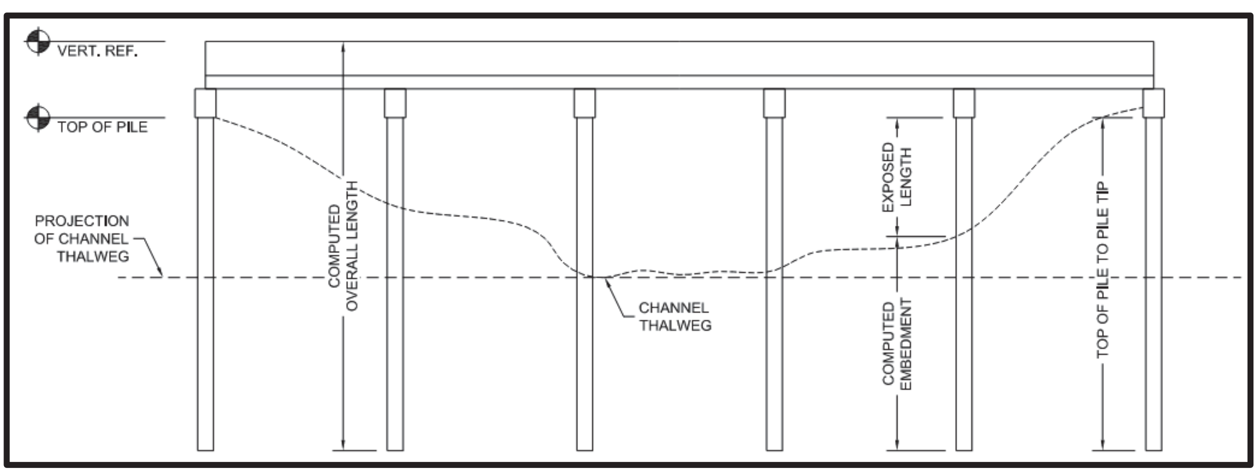


Figure 1 - Typical Bridge Section Diagram

Table 1 - Table of Bending Wave Results

Pile ID	Pile Size/Diameter (in)	Computed Overall Length (ft)	Top of Pile to Pile Tip (ft)	Exposed Length (ft)	Computed Embedment (ft)	Applicable Notes
B2P1	18.0 x 18.0	70.9	64.4	4.7	59.7	1,2,3,4,5
B3P1	18.0 x 18.0	68.7	62.2	5.6	56.6	1,2,3,4,5
B3P4	18.0 x 18.0	67.2	60.7	5.8	54.9	1,2,3,4,5

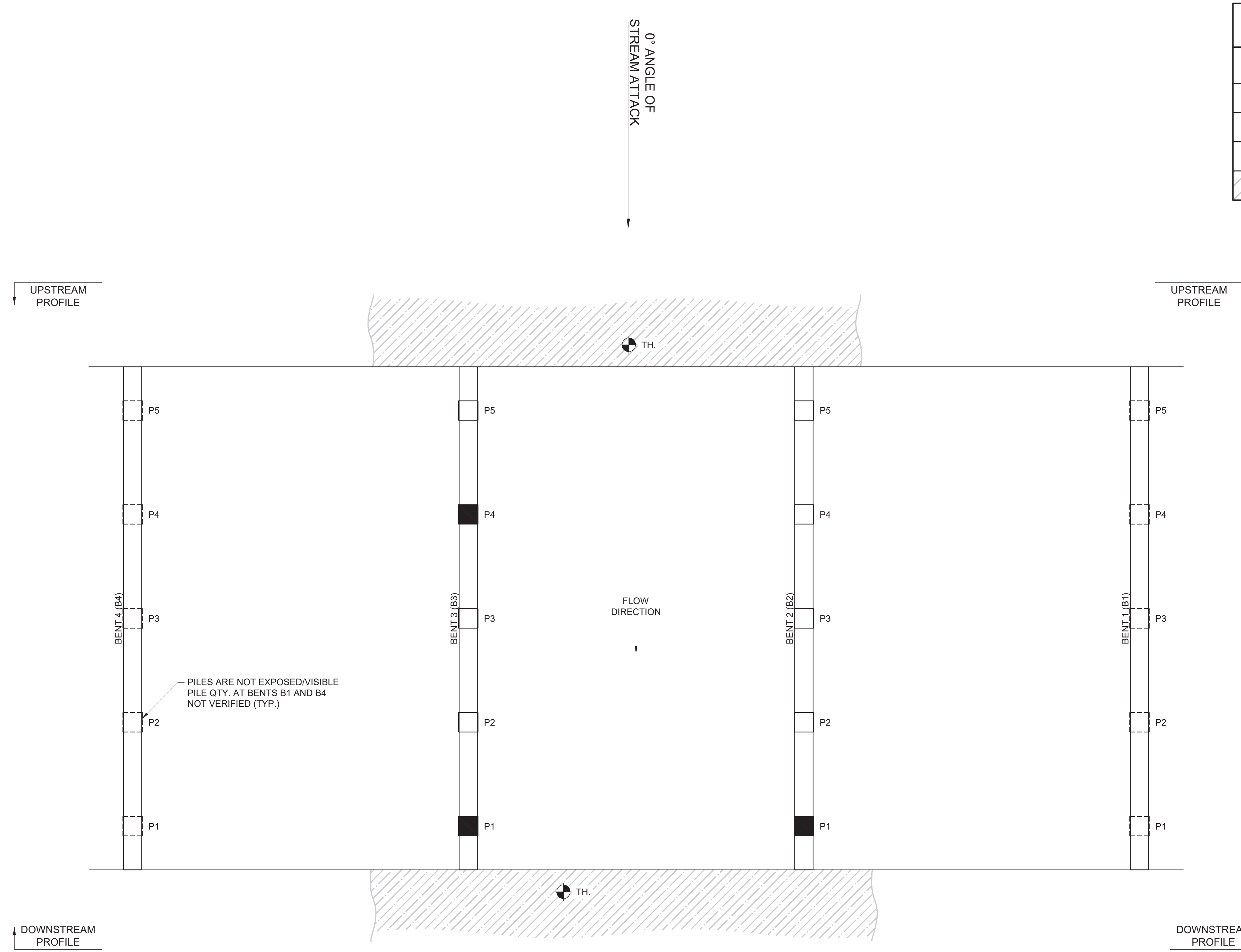
Notes:

1. Values are approximated.
2. Measured Thalweg from Top of Rail: 13.5 ft. Downstream
3. Top of Rail to Top of Pile: 6.5 ft.
4. The Computed Overall Length shown for this pile is calculated from the measured distance from top of rail to top of pile, plus the distance from the pile top, where the pile touches or enters the pile cap, to the pile tip; or it may be from the pile top to the location of a material anomaly such as a break, fracture, split, splice, area of deterioration or corrosion, etc. There is no definitive way to mathematically determine which case exists. If pile damage or other material anomalies are present, they create areas that can reflect wave energy and result in computed lengths that represent the distance from the pile top to the location of such. The Top of Pile to Pile Tip, Computed Embedment, and Embedment Below Thalweg measurements are calculated using the more conservative Computed Overall Length measurement.
5. The absence of a buried pad or pile collar was confirmed through probing below the mudline at a pile near the thalweg.

Conclusion

For the piles tested, the Bending Wave (BW) test results indicated pile lengths (top of pile to pile tip) from ~60.7 ft. - 64.4 ft and computed embedment lengths from ~54.9 ft. - 59.7 ft. These lengths correspond to the dominant features in the acquired accelerometer data. While the results of pile NDT investigations cannot be completely verified without performing direct length measurements, the consistency of Bending Wave test results at tested locations support the FDH calculated pile lengths. Available information on soil conditions, physical bridge features or tags, and/or experience with nearby bridges are considered along with the results of the testing in coming to these conclusions.

The results from this data analysis should be used as directed by the SCDOT Hydraulic Design Support Office. These results are intended to be used as a field investigative tool, or guide, in conjunction with other available information to determine the scour susceptibility of the foundation. Pile-driving records are optimal, but do not always exist and cannot reflect whether piles are damaged, broken, deteriorated, or unknowingly driven shorter or longer than intended. Where records do not exist, useful information could be total purchased pile length for a project, soils (geotechnical) information and/or borings logs, and knowledge of local foundation construction practices. See *Appendix A2: General Comments* for additional considerations pertaining to the use of this data analysis.



LEGEND

MARK	DESCRIPTION
TH.	THALWEG
○	PILE
●	TESTED PILE
(hatched)	WATER

FIGURE 2: FOUNDATION PLAN
NTS

CLIENT: SCDOT SCOUR CRITICAL ASSESSMENT & MANAGEMENT SYSTEM

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SUBMITTALS

DATE	DESCRIPTION	REV
04/12/2024	SUPPLEMENTAL	0

FDH PROJECT ID:
PR-009681

ASSET ID:
2670015400100

STRUCTURE #:
09211

COUNTY:
HORRY

ROAD DESIGNATION:
S-26-154

FEATURE CROSSING:
SWASH

COORDINATES:
33.58351° N
-78.99818° W

PILE TYPE:
CONCRETE

SHEET TITLE
NON DESTRUCTIVE TESTING PILE LOCATIONS & BRIDGE PROFILES

SHEET NUMBER
A-1

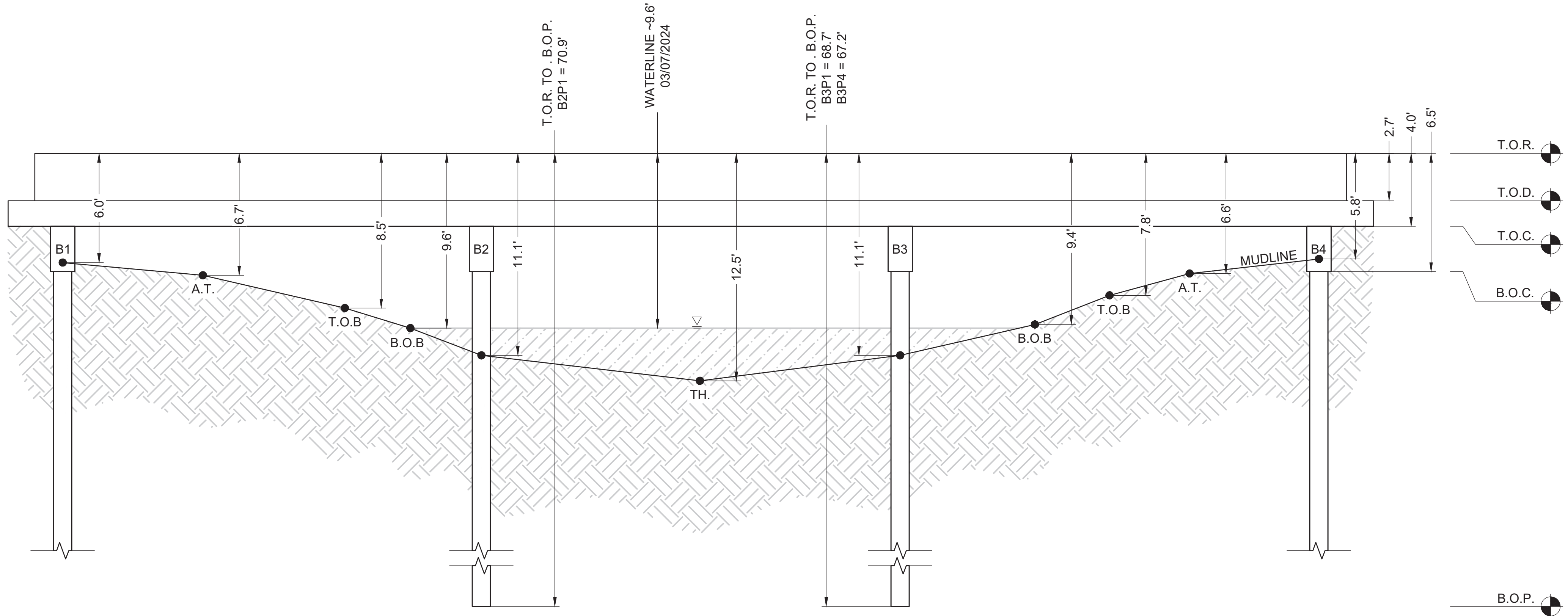

FIGURE 3: UPSTREAM PROFILE

NTS

LEGEND

MARK	DESCRIPTION
TH.	THALWEG
A.T.	ABUTMENT TOE
T.O.B	TOP OF BANK
B.O.B	BOTTOM OF BANK
T.O.R.	TOP OF RAIL (CONCRETE RAIL)
T.O.D.	TOP OF DECK
T.O.C.	TOP OF CAP
B.O.C.	BOTTOM OF CAP
B.O.P.	BOTTOM OF PILE
▽	WATERLINE
	WATER
	EARTH

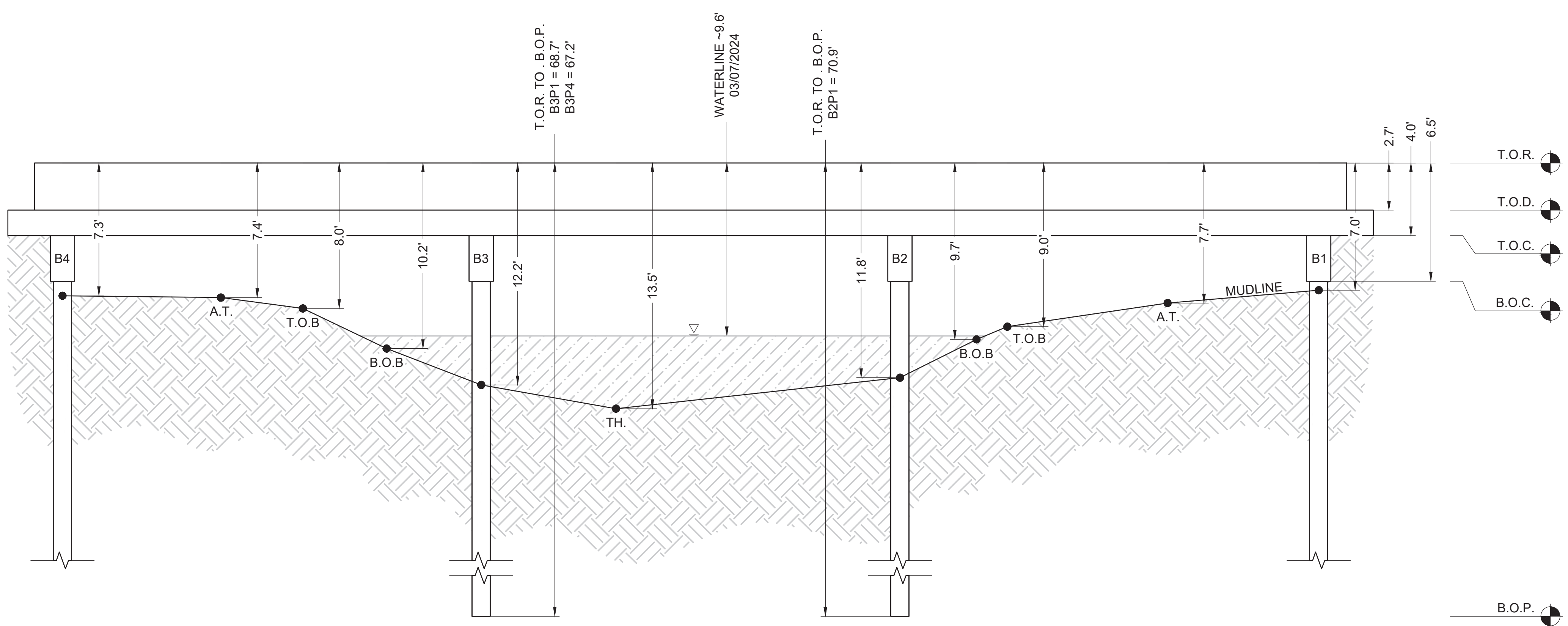

FIGURE 4: DOWNSTREAM PROFILE

NTS

CLIENT:

PREPARED BY:

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A-2

Appendix A

Appendix A1: Methodology

Tests on this structure utilized Bending Wave Propagation methods.

Bending Wave data is collected at the bridge site by affixing accelerometers to the side of each tested pile. Wave energy is induced within the pile using various mechanical impact devices that create flexural waves rich in spectral content. This wave energy is captured by the accelerometers, and a time history of the captured data is digitized and recorded with a custom data acquisition system. The recorded signal is representative of the subsequent response within the pile following impact. The saved signals from both tests are then post processed and analyzed to identify locations of significant wave energy return within the pile. This energy return, or reflection, is used to determine the in-situ length and qualitative integrity of the tested pile.

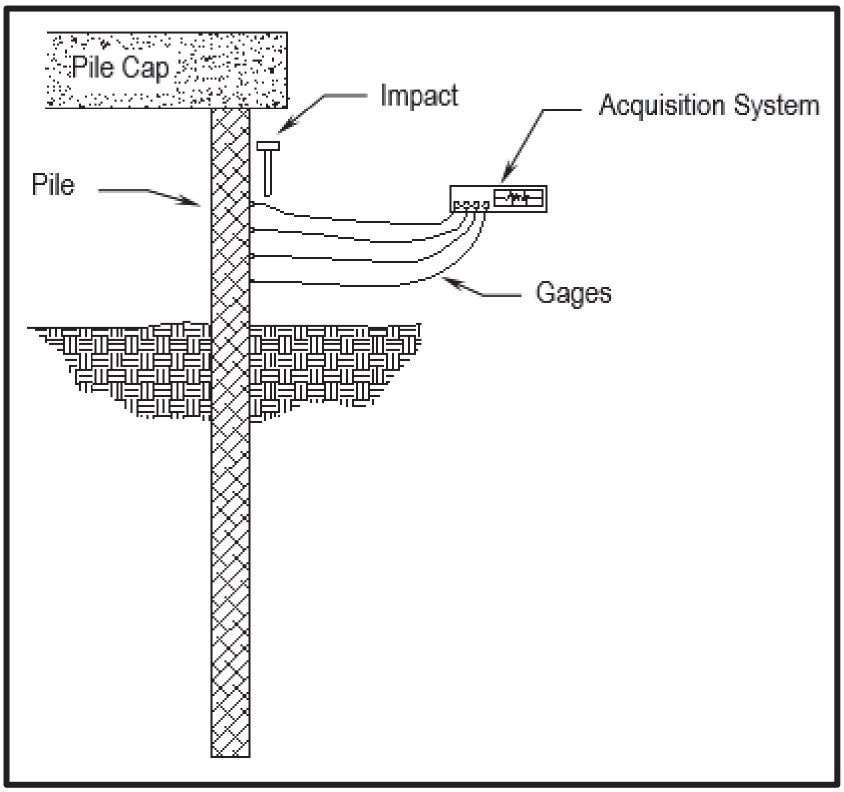

Figure 5 - Bending Wave Testing Diagram

All NDT data analyses are conducted by in-house analysts experienced in the field of wave propagation theory and signal processing. The analyses are then reviewed by the signal analysis manager, schooled through research and practice, on the theory, analysis, and interpretation of wave mechanics. The final results (pile lengths) are then reviewed by engineers with expertise in foundation design.

Appendix A2: General Comments

FDH's experience with dispersive wave testing in piles provides the opportunity to compile a wide database for comparison between computed length and actual length values from pile records and extracted piles. The percent difference between these values for this type pile is generally, but not always, within about +/- 10%.

Evaluation of foundation piles using dispersive wave propagation methods is a technology pioneered by the Founders of FDH Infrastructure Services, LLC. Due to the nature of the test procedure, several factors may affect the analysis results. The impact (strike) made by the hammer during the test creates dispersive waves that travel the length of the pile. When the waves encounter the pile tip or a material anomaly, which can include a major fracture or area of material deterioration, some of their energy is reflected and returned to the gages. Later processing of this data then allows the distance to be computed from the pile top to its tip or from the pile top to an area of damage or material anomaly from which the energy was reflected. In the latter case, the result is a computed length that is shorter than the actual pile length. For the case of steel H-piles, where splices are present and the welds do not encompass the pile's full cross section, a reflection could be found in the data at the approximate location of the splice and the computed length then representative of the distance from the pile top to the location of the splice, and not the pile tip.

In the event multiple fractures or areas of deterioration are present in a pile, the stress wave energy in the dispersive signals is dissipated rapidly. In such cases, the data may only indicate the presence of a single fracture or area of deterioration because interpretation of the data from the lower regions of the pile is difficult due to the dissipation of wave energy. A technology is presently not available for determining the exact size of any crack or fracture, deterioration, or whether any such area is transverse or parallel to the pile's longitudinal axis; these types of areas can easily reflect and dissipate wave energy. Cracks that are parallel to the pile's longitudinal axis may not totally reflect the waves and may not be detected.

Professional judgments are incorporated into this report. These are based on evaluations of field information gathered, on understanding of the characteristics of the project, and on experience and proven capabilities using dispersive wave propagation methods. Performance of this project is not guaranteed in any respect. Work and judgments rendered meet professional standards of care.

Appendix B: Site Photographs

Photo 1: SCDOT Asset Number

Photo 2: SCDOT Structure Number

Photo 3: Top of Bridge Roadway

Photo 4: Roadway Approach from Bridge (Looking Northwest)

Photo 5: Roadway Approach from Bridge (Looking Southeast)

Photo 6: Top of Rail Reference Photo (Top of Concrete)

Photo 7: View From Bridge Deck (Looking Upstream)

Photo 8: View From Bridge Deck (Looking Upstream)

Photo 9: View From Bridge Deck (Looking Upstream)

Photo 10: View From Bridge Deck (Looking Downstream)

Photo 11: View From Bridge Deck (Looking Downstream)

Photo 12: View From Bridge Deck (Looking Downstream)

Photo 13: View From Bridge Deck (Looking Downstream)

Photo 14: Bent 1 (Looking Upstream), Abutment 1

Photo 15: Bent 2 (Looking Upstream)

Photo 16: Bent 3 (Looking Upstream)

Photo 17: Bent 4 (Looking Upstream), Abutment 2

Photo 18: Substructure Bent Features Testing Probe

Photo 19: Scour Present Between Bents 3 & 4

Photo 20: Scour Present Between Bents 1 & 2

Photo 21: Erosion Present at Upstream Embankment

Photo 22: Erosion Present at Abutment 1

Photo 23: Erosion Present at Abutment 1

Photo 24: Erosion Present at Abutment 2

Photo 25: Erosion Present at Abutment 2

Photo 26: Spalling w/ Exposed Rebar Noted Throughout the Bridge Deck

Photo 27: Spalling w/ Exposed Rebar Noted Throughout the Bridge Deck

Photo 28: Spalling w/ Exposed Rebar Noted Throughout the Bridge Deck

Photo 29: Spalling w/ Exposed Rebar Noted Throughout the Bridge Deck

Photo 30: Spalling w/ Exposed Rebar Noted Throughout the Bridge Deck