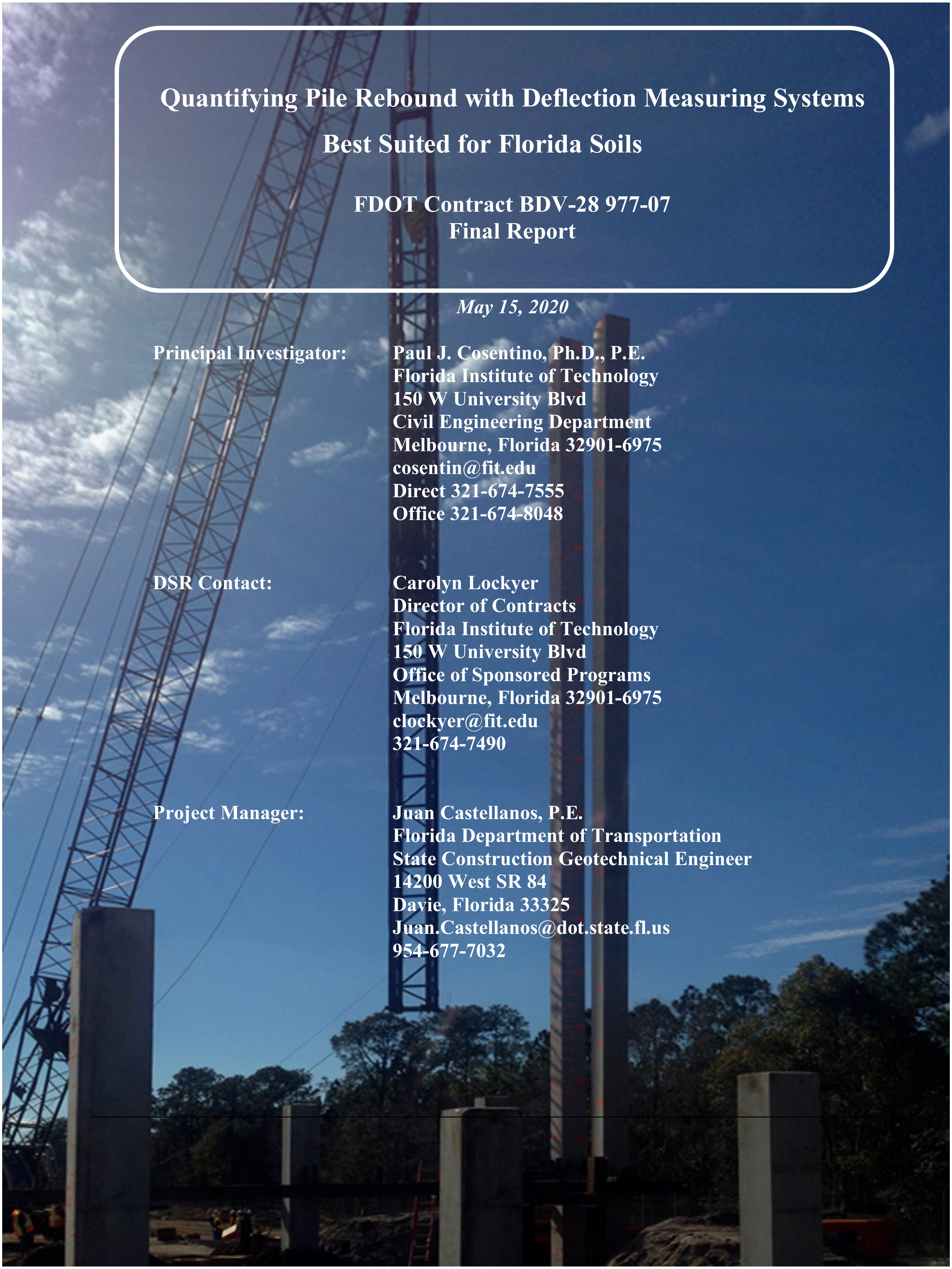

# Quantifying Pile Rebound with Deflection Measuring Systems Best Suited for Florida Soils

**FDOT Contract BDV-28 977-07**
**Final Report**

*May 15, 2020*


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# Disclaimer

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the State of Florida Department of Transportation.

# Metric Conversion Table

| Symbol | | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| LENGTH | | | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| AREA | | | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.836 | square meters | $m^2$ |
| VOLUME | | | | |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| MASS | | | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2,000 lb) | 0.907 | megagrams ("metric ton") | Mg (or "t") |
| UNIT WEIGHT | | | | |
| pcf | $lbf/ft^3$ | 16.02 | kilograms/ cubic meter | $kg/m^3$ |
| TEMPERATURE (exact degrees) | | | | |
| °F | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | °C |
| FORCE and PRESSURE or STRESS | | | | |
| lbf | pound force | 4.45 | newtons | N |
| kip | 1,000 lbf | 4.45 | kilonewtons | kN |
| ton | 2,000 lbf | 8.90 | kilonewtons | kN |
| $lbf/in^2$ | pound force/ square inch | 6.89 | kilopascals | kPa |
| ksi | kips/square inch | 6.89 | megapascals | MPa |
| tsf | tons/square foot | 95.76 | kilopascals | kPa |

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16. Abstract

Certain blends of very fine sands, silts, and clays are producing pile rebound during driving. Two major high rebound items were evaluated during this research: the possibility of using new pile movement techniques during driving to validate or check pile driving analyzer (PDA) deflections and the evaluation of cyclic triaxial test data to determine the effects of damping on rebound.

Pile and standard penetration rod movements were monitored with the Inopiles Pile Driving Monitoring (PDM) system and a Florida Tech camera monitoring system (CMS) at six sites throughout Florida. Movements were compared with PDA deflections. Both devices produced deflections with accuracies well below 0.04 inch (1 mm), which compared well to PDA deflections. CMS data recorded at 60 Hz, which currently requires post signal processing, was obtained in all locations, while PDM data were not. Both systems have potential for use as checks on PDA deflections. PDM measurements were most successfully obtained during SPT rod movement evaluations. Both CMS and PDM SPT rod movement evaluations showed time-dependent rod movements when driven through the blends of high rebound fine sands with silts and clays.

Using 40 existing cyclic triaxial tests from six sites in Central and Northern Florida, a damping coefficient sensitivity analysis of Florida high rebound soils was completed. Two analytical approaches were used, one based on the change in stress over time and a second based on the viscous energy absorbed per cycle. Over 70% of the damping coefficients obtained from the stress-over-time approach ranges from 0 to 10 $s \cdot lb/in^2$. These viscous results were not dimensionless and therefore could not be compared to the Case Western Reserve (CASE) 1974 dimensionless published coefficients. From the viscous approach, the results ranged from 0.18 to 0.59, which are similar to the CASE expected values and are also dimensionless. Therefore, the viscous energy approach is shown to be a better option for analysis.

Twelve test piles from five sites in Central and Northern Florida were analyzed with the Case Pile Wave Analysis Program (CAPWAP®). The results showed that both Smith's shaft and toe damping coefficients were acceptable based on the expected range. Smith's toe coefficient, however, was shown to be more consistent than the Smith shaft damping coefficients. A linear relationship was found between Smith's shaft and toe damping and rebound, with a stronger shaft versus rebound correlation.


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# Executive Summary

The complex phenomenon of high pile rebound or bouncing has been occurring when large diameter (i.e., high displacement) prestressed concrete piles are driven into relatively thick layers of very fine sands with silts and clays in certain percentages. Pile rebound is believed to cause a significant decrease in the pile's end bearing capacity, and therefore, it is important that geotechnical practitioners can clearly measure it. During this research, two major areas were studied. One was measuring pile movements using three devices: (a) conventional pile driving analyzer (PDA) sensors, (b) Inopiles pile driving monitor (PDM) measuring system, and (c) the camera monitoring system (CMS) developed at Florida Tech. The second was the soil damping associated with the soils as they were subjected to cyclic triaxial testing.

Pile and standard penetration rod movements were monitored with both the PDM and Florida Tech CMS systems at six sites throughout Florida. Movements were compared with PDA deflections. Both devices produced deflections with accuracies within 0.04 inch (1 mm), which compared well to PDA deflections. CMS data, which currently requires post signal processing, were able to be obtained in all locations while PDM data were not. The CMS system provides a complete log of the pile driving record in both a visual as well as a time series signal. Both systems have potential for use as checks on PDA deflections. PDM measurements were most successfully obtained during SPT rod movement evaluations. Both CMS and PDM SPT rod movement evaluations showed time-dependent rod movements when driven through the blends of high rebound fine sands with silts and clays.

The PDM system is designed to record pile movements from a static start, which makes it difficult to use for continuous pile driving monitoring. For this reason, it produced more consistent results for sets from SPT data. PDM sets were within 8% of the CMS sets for both pile driving and SPT testing. PDM rebounds were within 26% of the CMS rebounds for pile driving only. When compared to the PDA inspector set and rebound movements, the PDM was shown to produce values for set and rebound that were within 68% for pile driving.

The soil damping evaluation included studying the time-dependent response of over 600,000 load-unload cycles from 40 cyclic triaxial tests conducted on undisturbed samples obtained from six sites in Central and Northern Florida. Smith (1960) and the Case Western Reserve (CASE) 1974 studies have established damping values. Testing was conducted in two

steps. Step one was to perform a consolidated undrained triaxial test to establish a complete stress-strain response plus the failure stress level at the desired confining stress. Step two was to conduct cyclic triaxial tests with 1,000 cycles performed at 10, 20, 40, 60, and 80 percent of the established failure stress from step one. Cycles were the standard 0.1-second loading followed by 0.9 seconds of rest or unloading.

Specialized Python™ computer coding was developed that allowed the load versus time data for each CT stress level to be evaluated. For each cycle, an elastic modulus ($E_i$) was determined from the loading data, while the damping coefficient ($\eta_i$) was determined from the unloading data using the Kelvin-Voigt spring-dashpot model. The elastic moduli were evaluated to determine the quality of the data and eliminate outliers. Over 70 percent of the damping coefficients obtained from the stress-time approach ranged from 0 to 10 s·lb/in$^2$.

The damping factors, with units of stress-time, were compared to the Case Western Reserve 1974 (CASE) published unitless damping factors ($J_c$). To make this comparison, the average $\eta_i$ values for each stress level were normalized using the soil impedance and then adjusted to account for the differences in wave speeds between the concrete piles and soil. These adjustments produced normalized average $\eta_i$ values about two to five times higher than published $J_c$ values. Another comparison was developed using the Tedesco and McDougal (1999) hysteresis-loop strain energy approach. These coefficients typically were higher for the initial 1,000 cycles and, in some cases, increased over the last 1,000 or 2,000 cycles. This method produced damping coefficients from 0.18 to 0.59, which are similar to the CASE $J_c$ values. The area under the strain-time plots was used to rank the rebound level based on a relative average. This approach indicated that high rebound sites may produce larger areas than non-rebound sites.

## Table of Contents

## List of Figures

## List of Tables

# 1 Introduction

## 1.1 Research Background

High pile rebound (HPR) is a complex pile-soil interaction problem. It is a function of many variables such as pile type, shape (i.e., open versus closed end) and length, hammer type, and soil types and densities. The accuracy of the deflection measurements used to quantify HPR can be uncertain. Findings from two FDOT research projects (BDK81-977-01 and BDV-28 977-01) indicate that relatively thick layers of fine sands with silts and clays in certain percentages may cause HPR for high displacement piles. BDV-28 977-01 findings produced an HPR decision tree to guide geotechnical engineers though several levels of testing to determine the HPR level of concern. Some engineers term HPR as bounce (Cosentino et al., 2010: Murrell et al., 2008).

To date, about a dozen sites throughout central and northern Florida have been evaluated, some with and some without HPR (Table 1-1). Field testing included (a) standard penetration tests (SPT) and (b) cone penetrometer tests with pore pressure measurements (CPTu), while lab testing on both disturbed and undisturbed samples included (a) basic index and shear strength testing and (b) cyclic triaxial tests.

The cyclic behavior indicated that rebound soils are much more resilient than non-rebound soils, which therefore warrants further understanding. Figure 1-1 shows that the fine sands with silts and clays, identified as rebound soils (shown in red), required many more cycles to reach the 2.5, 5, 10, and 15 percent strain levels than the non-rebound soils (shown in blue). HPR also was found to occur in fine sands with silts and clays within a certain range. The resiliency of these soils correlates to the additional hammer blows contractors need to penetrate these soils. These resilient soils behave in a viscoelastic manner, and the cyclic data used during the BDV-28 977-01 research may have enough data to evaluate the loading-unloading movements.

Table 1-1 Summary of High Pile Rebound Testing and Test Sites

| | | | | |
|---|---|---|---|---|
| 1 | I-4 / US-192 Interchange / Osceola County / Florida. | ✔ | ✔ | ✔ |
| 2 | State Road 417 International Parkway / Osceola County / Florida. | ✔ | ✔ | ✔ |
| 3 | I-4 / Osceola Parkway / Osceola County / Florida. | | | ✔ |
| 4 | State Road 50 and State Road 436 / Orange County / Florida. | ✔ | ✔ | |
| 5 | I-4 / State Road 408 Ramp B / Orange County / Florida. | ✔ | ✔ | |
| 6 | Anderson Street Overpass at I-4/SR-408 / Orange County / Florida. | ✔ | ✔ | |
| 7 | I-4 John Young Parkway/ Orange County / Florida | ✔ | | |
| 8 | I-4 Widening Daytona / Volusia County / Florida. | ✔ | ✔ | |
| 9 | SR 528 over Indiam River, Brevard County / Florida | ✔ | | |
| 10 | Saint Johns Heritage Parkway, Brevard County / Florida | ✔ | ✔ | ✔ |
| 11 | I-10 Chaffee Road, Duval County / Florida | ✔ | | ✔ |
| 12 | State Road 83 over Ramsey Branch Bridge / Walton County / Florida. | ✔ | ✔ | ✔ |

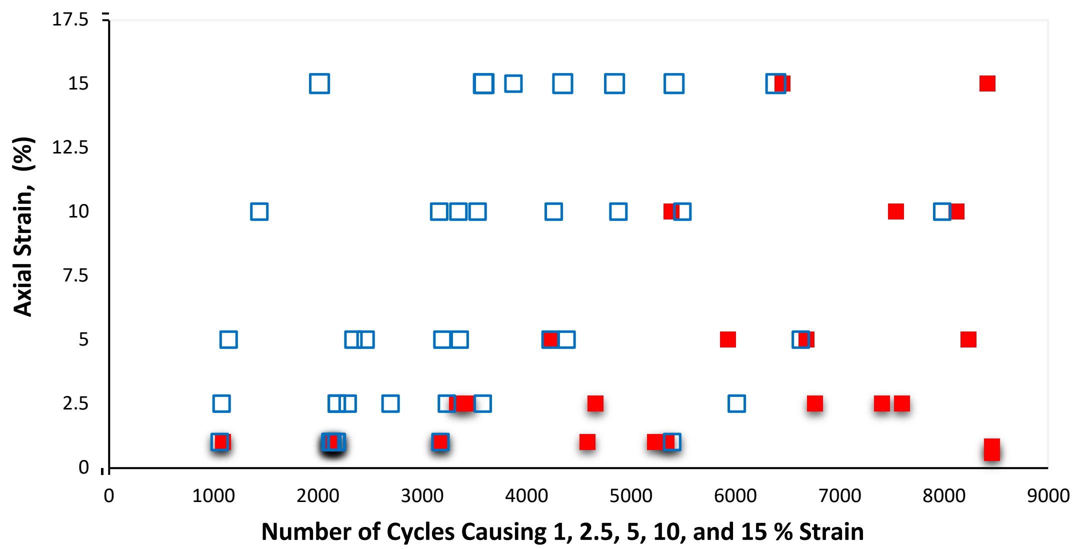



Figure 1-1: Number of Cycles Required to Produce 1, 2.5, 5, 10, and 15 Percent Axial Strain for High (Solid Red) and No Rebound (open blue) Cohesionless Soils versus Axial Strain

Although correlations have been developed between rebound and the CPTu, SPT N values fines, silt and clay and sand contents, they are based on rebound that is averaged over one-foot intervals from inspector visual information and not high-fidelity sensor measured movements.

Pile driving analyzer (PDA) data has historically been a useful tool for determining pile rebound (See Figure 1-2). Figure 1-3 depicts typical PDA displacement versus time data with the maximum displacement (DMX), digital set (SET) and corresponding pile rebound displayed over about a 205-millisecond time period. However, using PDA accelerometer data to predict deflections may not always be reliable. One common problem is that the double numerical integration used to predict displacements with time can produce results, which can deviate significantly from the accurate field measurements, simply because the pile movement has not stopped during the time period or stamp (TS) that the data acquisition records data

Other than PDA evaluations, most of the systems currently available to help geotechnical engineers accurately measure pile movement and any resulting rebound are cumbersome. For example, hand measurements are dangerous since the inspector is next to the pile during driving and relatively inaccurate since the surrounding pile and soil movements must be recorded by hand on paper or tape. Video systems with special measuring tapes placed on the piles have been used, but require significant analysis time after testing to produce results. Improvements in data acquisition systems and instrumentation should make deflection data more possible and reliable. Only one direct measuring system is currently available and has the potential to improve these complex measurements. Inopiles International PTE LTD, a company based in Australia, has developed a LASER (light amplification by stimulated emission of radiation) measuring system, called the Pile Driving Monitoring (PDM) system, sold commercially for approximately $22K. They report that it has the capability of measuring pile movements and SPT movements per hammer blow. It measures these movements using a LASER system focused on a reflective tape attached to the pile or SPT rods. The system is sold in the U.S. through Pile Dynamics in Cleveland Ohio. Data from this relatively new system will be evaluated in the Florida soils producing HPR.

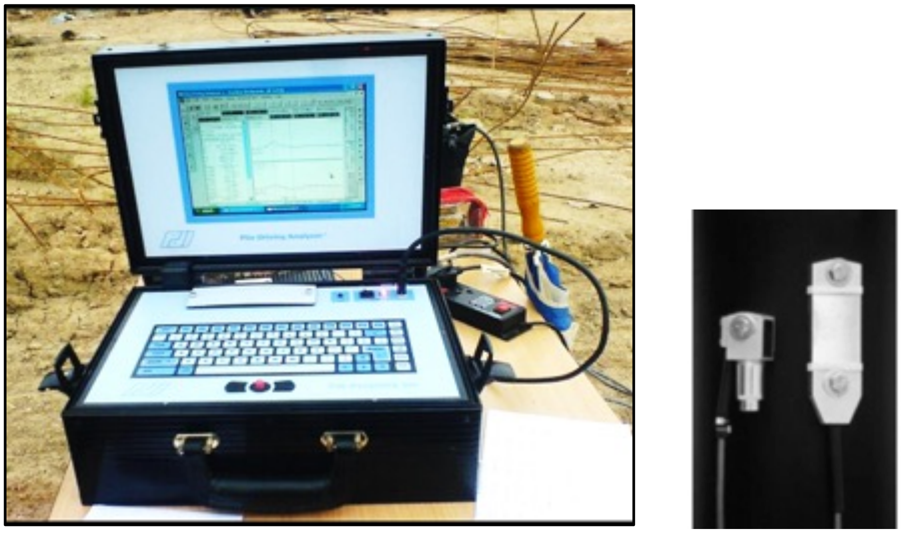


Figure 1-2 PDA Electronics and Sensors (courtesy of GRL Engineers, Inc.)

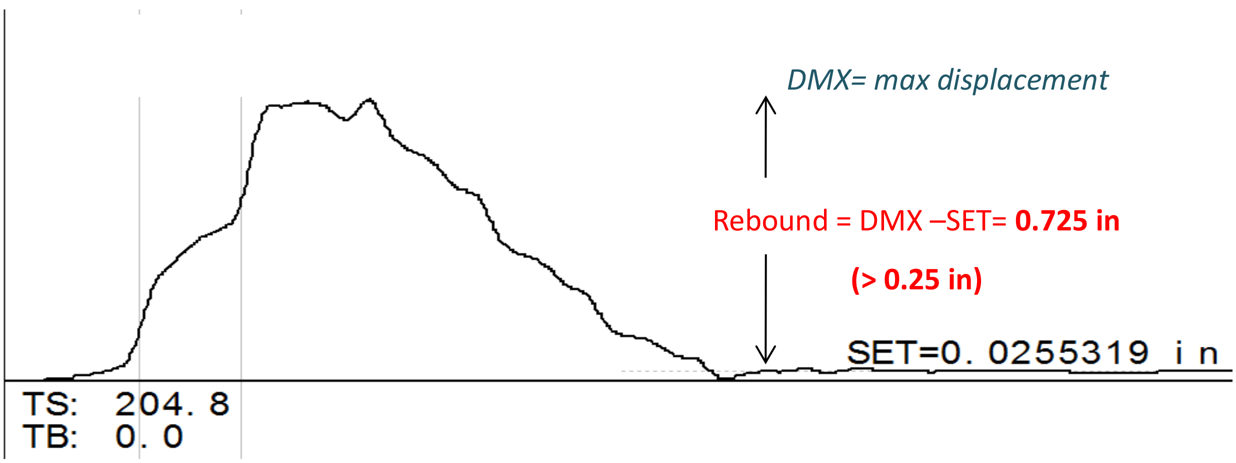



Figure 1-3 Typical PDA Accelerometer Displacement (inches) versus Time (milliseconds) (adapted from GRL Associates, Inc.)

FDOT has limited expereince with the Inopiles PDM LASER systems; therefore, the LASER system should be evaluated such that its results are understood and known to be reliable. Measurements with the Inopiles PDM can be compared to deflections from PDA instrumented test piles and further checked using relatively high-speed cameras set up to video movements during driving.

Using a LASER system to measure pile movements is also much safer than hand measurements and may be much simpler than video measurements. Clear knowledge of the pile deflections will help engineers understand the pile capacities and produce more economical designs.

FDOT's specification 455-5.10.3 defines excessive rebound in terms of 0.25 inches; however, this value was chosen somewhat arbitrarily and is difficult for inspectors to consistently and accurately determine. Pile movement is recorded digitally using PDA deflections on test piles, but are estimated visually by inspectors on production piles. BDV-28 977-01 findings produced promising correlations; however, they were based on 0.5 inches of rebound since lower rebound (i.e. below ½-inch) was difficult to analyze as well as its resolution was uncertain due to field measurements being collected visually. Ideally, the decrease in pile capacity during rebound should be documented using test piles so that engineers can make a knowledgeable decision about the pile quality. The sensitivity of the pile capacity determined using wave equation software should be evaluated. This process should focus on the damping factor that could account for the viscoelastic movement

## 1.2 Project Objectives

The objective of this work was twofold. One objective was to evaluate soil damping in the viscoelastic fine Florida sands with silts and clays using existing cyclic triaxial data, while the second objective was to evaluate how closely pile movements compares in these same soils from three independent devices. The devices are; a) the Inopiles PDM deflection-measuring system, b) Florida Tech's camera measuring system (CMS) and c) PDA accelerometer-based deflections.

## 1.3 Supporting Tasks

This research was accomplished through the completion of the following tasks.

### 1.3.1 Task 1 Literature on Pile Driving Deflection Measuring Systems and Soil Damping

To complete the literature review two main areas were evaluated; 1) the existing pile movement measuring systems and 2) the recommended literature soil damping factors used in wave equation analyses.

### 1.3.2 Task 2 Viscoelastic Analysis of Existing Cyclic Triaxial Load versus Time Data

As the pile is driven, the hammers impact wave travels down then back up the pile, producing elastic and plastic pile movements. The plastic movements are typically permanent; however, Florida's viscoelastic fine sands with silts and clays produce rebound during the plastic phase, while the cyclic triaxial results showed this soil to be more resilient.

During BDV-28-977-01, 30 sets of cyclic triaxial tests were conducted with 1000 cycles at eight stress levels ranging from 10% to 80% of the static failure stress. The following figures depict cyclic results. Both Figure 1-4 and Figure 1-5 show deflection versus time data while Figure 1-6 shows load verses time data that corresponds to both deflection-time plots. The data in Figure 1-4 is from a site with excessive rebound and the data in Figure 1-5 is from a site without rebound. Note that the Figure 1-4 rebound data shows an increase in deflection as the load is applied, followed by a decrease that does not return to near the original value. For the non-rebound site (Figure 1-5), the deflections increase as the load is applied then decrease to nearly the original deflection. The small, or more properly slow, decrease in deflection following loading for the rebound (i.e., viscoelastic) Florida soil corresponded to rebounds in excess of ¾-inch, while the large or faster decrease in deflection corresponds to minimal rebound.

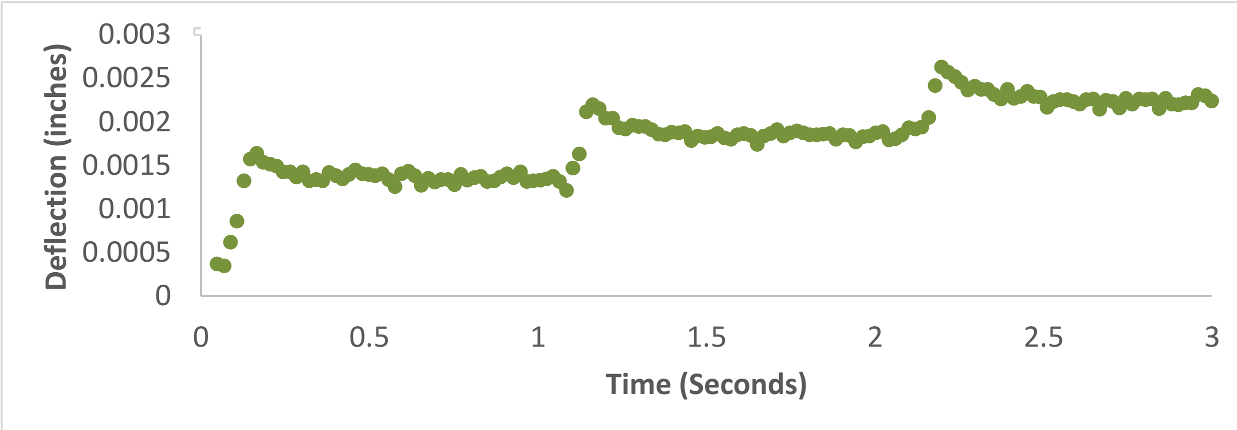



Figure 1-4 Three Deflection versus Time Cycles: Ramsey Branch at 63 feet

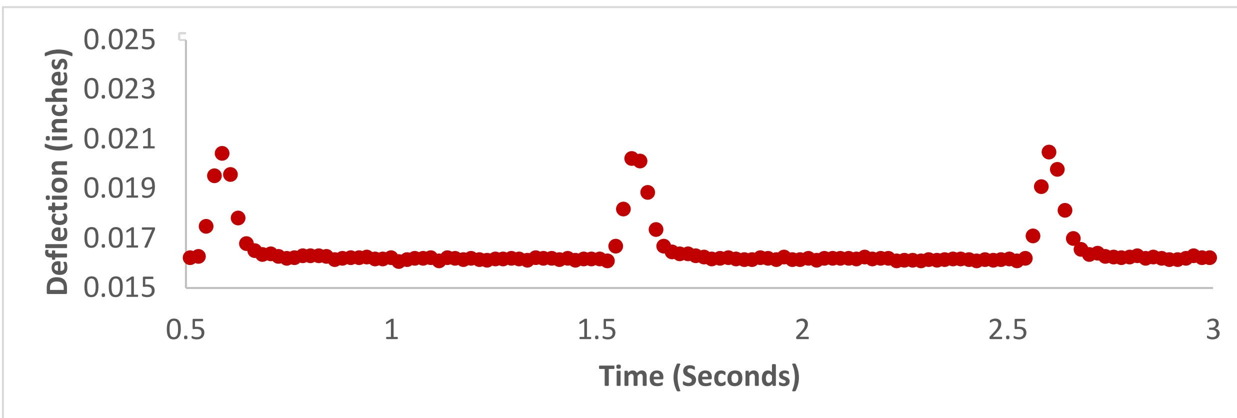



Figure 1-5 Three Deflection versus Time Cycles: Heritage Parkway at 57 feet

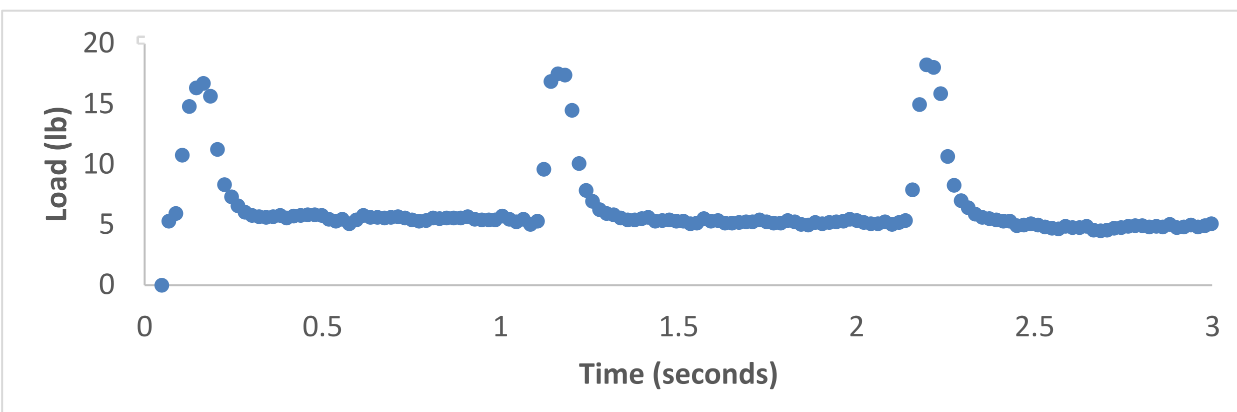



Figure 1-6 Three Load versus Time Cycles Corresponding to the data above

Using the existing (BDV-28 977-01) results from the cyclic triaxial testing, the unloading deflection versus time responses were analyzed. The differences between the responses from the HPR and nonHPR soils were evaluated. The analyses included determining the variations in the area under the deflection versus time curves, plus careful evaluations of the actual shapes of these responses. There are 34 sets of triaxial tests, from 6 of the sites. Each test has 1000 cycles from 5 stress levels that can be analyzed.

### 1.3.3 Task 3 Wave Equation Software Damping Factor Sensitivity Analyses

Viscoelastic movements are modeled as damping or time dependent movements (like car shock absorbers). There are three soil damping factors associated with pile driving; a) the Smith (1960) damping factors (Js) with units of 1/velocity, b) the CASE damping factor (Jc) which is normalized by using the pile impedance and therefore unitless and c) the viscous soil damping factor (Jv) with units of force/velocity. Note that impedance also has units of force/velocity to produce a unitless, Jc.

Based on the findings from Task 2, the wave equation software available from GRL, Inc. will be used with various damping factors to perform a sensitivity analyses on how the damping factors affect pile capacity. Test pile PDA data from each site HPR and nonHPR site will be evaluated. Following this process, the deflections from the field data PDA results will be used in a signal matching process with the CAPWAP® software to further clarify the effect of damping factors on the pile movement.

### 1.3.4 Task 4 High Speed Camera Validations for Inopiles PDM LASER Measuring System

High-speed high-definition camera videos were evaluated for use to video the movements during pile driving of FDOT test piles. Along with these videos, the Inopiles LASER measuring PDM and PDA equipment will be used to produce deflection data. These cameras were set-up to produce video along sections of the pile with a measuring strip mounted to it. The video output was analyzed to produce deflections versus time data. A similar set-up and associated deflection evaluation were performed by Olivera el al (2013) as shown in Figure 1-7.

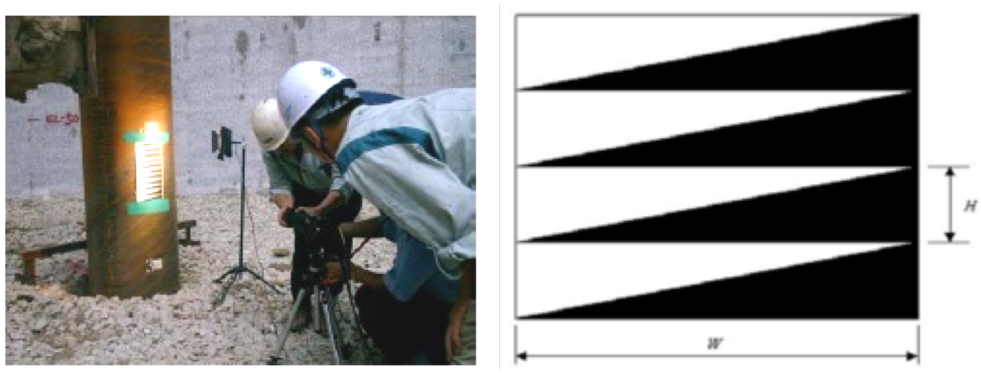



Figure 1-7 Marking Paper and Line Scan Camera Setup During Pile Driving (Oliveira et al., 2013)

The camera measuring system (CMS) was evaluated to provide guidance for the following conditions.

1. Where should the camera be located to avoid vibrations during driving?
2. What type of lens or focusing would be necessary to properly evaluate the deflections?
3. What type of measuring strip if any should be placed on the pile?
4. How should the measuring tape be applied to the pile?
    a. Does a worker climb up into the pile leads to attach the tape such that measurements are taken in the rebound zone?
    b. Should pile rebound be encountered then the driving temporarily halted while the tape is applied so that rebound measurements can be made?
    c. Should the tape be placed on the pile before it is lifted into the leads?
5. How can the camera video be synchronized with the PDA and PDM equipment so that blow counts can be matched?
6. How can the video information be processed quickly to validate the PDM and PDA deflections?

To control costs, options such as renting versus buying or using on campus expertise were considered. The solution was to use cameras on campus. Dr. Charles Bostater an Oceanography faculty member is an expert in remote sensing and possesses several high-speed cameras plus the ability to process the images accurately to determine movements.

### 1.3.5 Task 5 Determine SPT and PDA Test Piles Field Testing Locations

This task was separated into two subtasks since they are closely related. Task 5a was the identification of the SPT field-testing locations and Task 5b was the identification of PDA test piles locations. This separation allowed simpler progress tracking and reporting. From each site geotechnical, pile type and PDM/CMS system logistics information will be collected as shown in Table 1-2

<u>Task 5a SPT Field Testing Locations:</u> Based on the results from the cyclic triaxial testing conducted during BDV-28 977-01 it was concluded that the high rebound soils have a significantly higher "resiliency" than the non-rebound soils. This finding means that the rebound soils move less after each impact from the same repetitive or cyclic loading than the non-rebound soils. Since more resilient behavior may also relate to the rate that the movements occur, it may be possible to evaluate the movement per blow during SPT testing in various soils (both HPR and NonHPR soils) and document a different moving rate per blow for rebound soils than non-rebound soils. Therefore, SPT tests monitored with the various measuring systems were conducted to evaluate any changes in rate of movement between the rebound and non-rebound soils.

To allow FDOT to prepare for using the PDA, plus Inopiles PDM and CMS together it was proposed that five sites be identified where SPT borings could be completed. SPT borings were conducted about 50 feet from the test piles. The research team selected HPR sites based on a combination of locations from previous work (See Table 1-1) and the HPR decision tree. FDOT SMO personnel assisted in determining these sites, supplying both an instrumented SPT calibration rod and drilling equipment. PDM and CMS equipment plus FDOT's specially designed PDA instrumented SPT rod, were used during this testing. This task required thorough coordination between the research team and FDOT State Materials Office (SMO) personnel.

Task 5b PDA Test Pile Field Testing Locations: FDOT SMO purchased the Inopiles PDM LASER system, thereby allowing them to use the system on PDA instrumented test piles throughout Florida. They (FDOT SMO Personnel) assisted in identifying five rebound sites for using this new system as a check on the PDA data. The CMS system was used to further validate this testing. The test piles were instrumented with; a) PDA sensors; b) Inopiles LASER system and movement was videoed during driving. Pile deflections per hammer blow were recorded with all three devices simultaneously for further analysis.

Table 1-2 Summary List of Required Research Information for Tasks 5 and 6.

1. Basic Soil Sample Information: Site, Depth, Size of Sample, etc.
2. Basic Soil Properties: Type, Color, Grain Size Distribution, Unit Weight, Moisture Content, Atterberg Limits, etc.
3. SPT Type, Rod Dimensions, Depths, Hole Diameter, PDA Sensors, etc.
4. PDA Sensors Location on Pile and/or SPT Drill Rods and Model or Software Version
5. Elevation of Ground Surface, Driving Template and Ground Water Table
6. Pile Driving Hammer Type, Drop Height, Efficiency: Cushion Type and Size
7. Length, Diameter and Type of Pile
8. Offset Distance of PDM system and Active Measuring Zone Height
9. Offset Distance of High-Speed Camera, Frames Per Second, Focal Distances, etc.

### 1.3.6 Task 6 Measuring System Evaluations

Work during this task was focused on simultaneous evaluations of the deflections recorded during all field-testing. To help with the reporting and progress tracking this task is also separated into two subtasks; Task 6a will be the SPT measuring evaluations and Task 6b will be the test piles measuring evaluations.

Task 6a SPT Measuring System Evaluations:

SPT data from the instrumented SPT rod, PMD and video camera from the five FDOT sites was used to evaluate the rod movement versus time during SPT testing. The movements from all devices were analyzed and compared. Correlations between all the device movements were made such that the appropriate conclusions and recommendations could be formulated.

Task 6b Test Pile Measuring System Evaluations:

PDA deflections from the test piles, PMD and CMS systems from the chosen FDOT sites were used to evaluate the movement versus time per pile. Correlations between all the device movements were made and the results such that the appropriate conclusions and recommendations could be formulated.

### 1.3.7 Task 7 Draft Final Report

The draft final report will contain well a written summary of the findings from Tasks 1 through 6 plus pertinent conclusions and recommendations. The draft final and final reports follow the Guidelines for University Presentation and Publication of Research available at http://www.fdot.gov/research/docs/T2/University.Guidelines.2016.pdf

### 1.3.8 Task 8 Final Report

Upon review of the draft final report, all required changes were implemented to produce the final project BDV-28 977-07 final report.

# 2 Literature Search

## 2.1 Pile Rebound in Soils

Rebound occurs when large displacement piles are driven relatively into thick layers of fine sands with certain percentages of silts and clays. These soils typically have unified soils classification system (USCS) symbols of SP, SP-SM, SP-SC or SC (Cosentino et al., 2016).

During pile driving in rebound soils, an upward pile moment (i.e., rebound) occurs following hammer blows. Rebound is typically found using two different approaches. One approach is for the pile driving inspector to visually observe it, while the second is to numerically double integrate the signal from accelerometers used for PDA (Pile Driving Analyzer) testing. The visual method has limitations based on human error, while the digital signals are inconsistent, especially when the pile movement from a hammer blow has not stopped prior to the subsequent impact.

A displacement versus time signal from a PDA test pile experiencing rebound is shown in Figure 2-1. Rebound is obtained by subtracting the set from the maximum pile top displacement (DMX), as illustrated in Figure 2-1 (Cosentino et al., 2010). Note that the initial slope, which is when the hammer contacts the pile, shows a relatively fast displacement-time movement, which from an engineering viewpoint would be considered elastic. However, the displacement-time slope after impact is slower, indicating a more time-dependent or visco-elastic response.

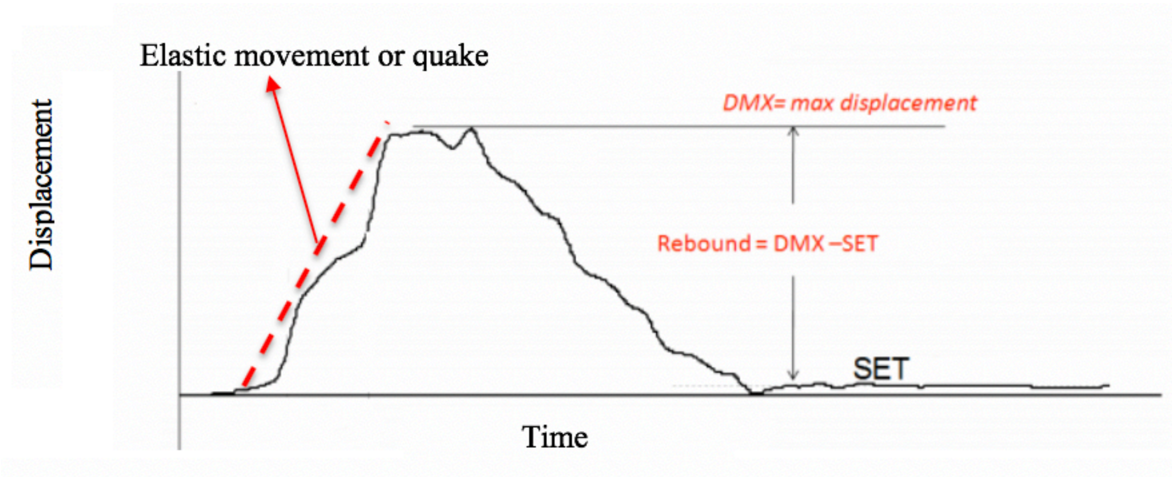



Figure 2-1 Pile Rebound from PDA Displacement-Time Data (Cosentino et al., 2010; Courtesy of GRL Engineers, Inc., adapted)

## 2.2 Overview of Florida's Pile Rebound

To date about a dozen sites throughout central and northern Florida have been evaluated, some with and some without HPR (). Field testing included: a) standard penetration tests (SPT) and b) cone penetrometer tests with pore pressure measurements (CPTu), while lab testing on both disturbed and undisturbed samples included: a) basic index and shear strength testing and b) cyclic triaxial tests.

The cyclic behavior indicated that, rebound soils are much more resilient than non-rebound soils and it therefore, warrants further understanding. Figure 1-1 shows that the fine sands with silts and clays, identified as rebound soils (shown in red), required many more cycles to reach the 2.5, 5, 10 and 15 percent strain levels than the non-rebound soils (shown in blue). HPR also was found to occur in fine sands with silts and clays within a certain range. The resiliency of these soils correlates to the additional hammer blows contractors need to penetrate these soils. These resilient soils behave in a viscoelastic manner and the cyclic data used during the BDV-28 977-01 research may have enough data to evaluate the loading-unloading movements.

Table 2-1 Summary of High Pile Rebound Testing and Test Sites

| Number | Description | Testing | | |
|---|---|---|---|---|
| | | SPT | CPTu | Undisturbed |
| 1 | I-4 / US-192 Interchange / Osceola County / Florida. | ✔ | ✔ | ✔ |
| 2 | State Road 417 International Parkway / Osceola County / Florida. | ✔ | ✔ | ✔ |
| 3 | I-4 / Osceola Parkway / Osceola County / Florida. | | | ✔ |
| 4 | State Road 50 and State Road 436 / Orange County / Florida. | ✔ | ✔ | |
| 5 | I-4 / State Road 408 Ramp B / Orange County / Florida. | ✔ | ✔ | |
| 6 | Anderson Street Overpass at I-4/SR-408 / Orange County / Florida. | ✔ | ✔ | |
| 7 | I-4 John Young Parkway/ Orange County / Florida | ✔ | | |
| 8 | I-4 Widening Daytona / Volusia County / Florida. | ✔ | ✔ | |
| 9 | SR 528 over Indiam River, Brevard County / Florida | ✔ | | |
| 10 | Saint Johns Heritage Parkway, Brevard County / Florida | ✔ | ✔ | ✔ |
| 11 | I-10 Chaffee Road, Duval County / Florida | ✔ | | ✔ |
| 12 | State Road 83 over Ramsey Branch Bridge / Walton County / Florida. | ✔ | ✔ | ✔ |

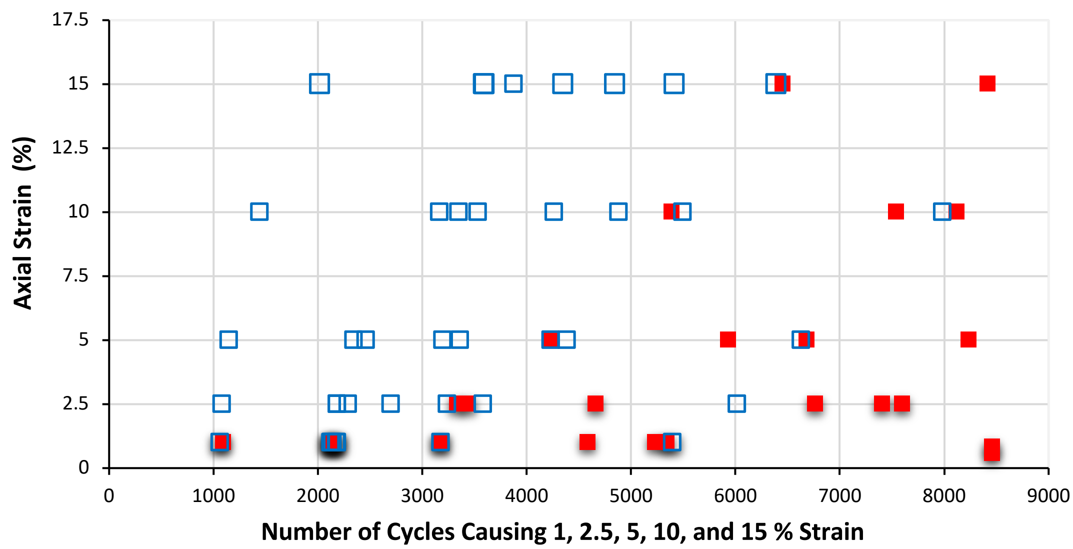



Figure 2-2: Number of Cycles Required to Produce 1, 2.5, 5, 10, and 15 Percent Axial Strain for High (Solid Red) and No Rebound (Open Blue) Cohesionless Soils versus Axial Strain

Although correlations have been developed between rebound and the CPTu, SPT N values fines, silt and clay and sand contents, they are based on rebound that is averaged over one-foot intervals from inspector visual information and not high-fidelity sensor measured movements.

## 2.3 Definition of High Pile Rebound

Smith (1960) defined quake as the immediate or elastic movement of the pile during a hammer impact. A typical plot of static soil resistance versus pile movement is shown in

Figure 2-3. There is an assumed elastic response, which overlays the actual nonlinear response. It shows typical quake values of 0.1 to 0.35 inches plus the quake typically used in dynamic analyses.

Due to the magnitude of the hammer force and the elastic properties of the pile and surrounding soils, some elastic rebound is always expected. Rebound is not a problem as long as the permanent set (downward penetration) is sufficiently high and the pile driving is not at refusal (20 blows/inch). Occasionally during the installation of large-diameter displacement piles, the pile movement is almost entirely elastic resulting in a small or negligible permanent set. FDOT considers the rebound to be excessive if it exceeds ¼ inch (FDOT Road and Bridge Construction Specifications, 455-5.10.3). Hussein et al., (2006) use the term “high-rebound,” to describe this condition while others (Murrell, et al., 2008) use the term “bounce”. During this research, excessive rebound will be termed “high pile rebound” or HPR. Authier and Fellenius (1980) related HPR to “large” quake or “high” quake (i.e., greater than 0.35 inches).

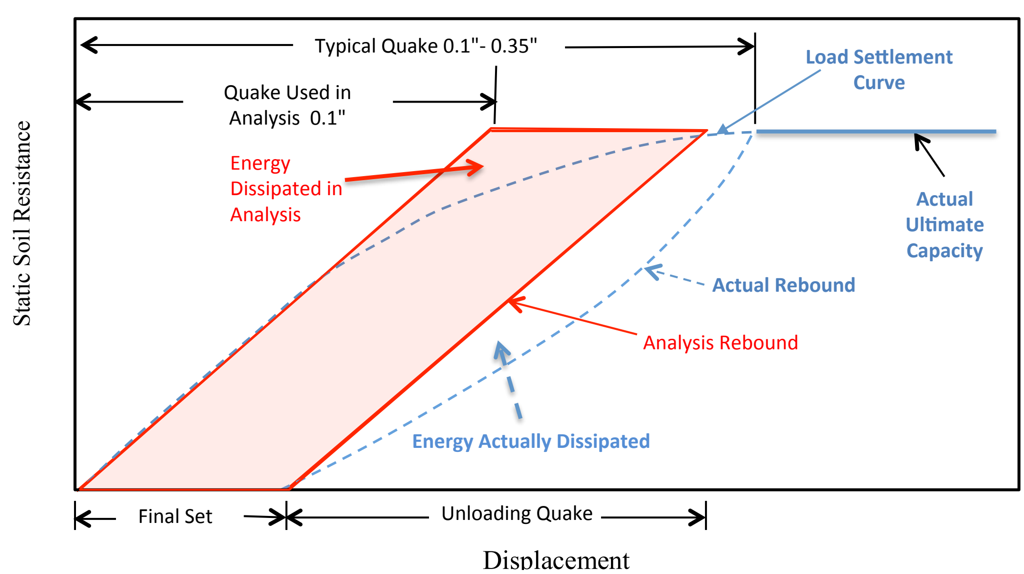



Figure 2-3: Resistance versus Penetration with Quake for One Hammer Blow (Smith, 1960)

## 2.4 Factors Affecting Pile Driving in HPR Soils

There are numerous variables associated with pile driving. Table 2-2 contains a list of 19 variables grouped into categories for piles, hammers, soils and sites. Variables related to the piles include material type, dimensions, shape and unsupported length during driving. Variables related to the hammers include type, stroke height and efficiency. The soil variables include basic index properties such as grain size and shape, density, pore water pressures during lab and field testing and pile driving, strength deformation behavior under constant strain and cyclic loading, and permeability. Site related variables include geologic stratification, pile installation order and HPR zone confining stresses. The variables being evaluated during this research are noted with a check mark. The soil related variables are being evaluated with either field tests such as the SPT, CPT or DMT or with lab tests on disturbed and thin walled tube samples.

Table 2-2: Pile Driving Variables

| Variable | | HPR |
|---|---|---|
| **Category** | **Description** | **Phase II** |
| Piles | Material Type | |
| | Diameter | |
| | Length | |
| | Unsupported Length | |
| | Shape | |
| Hammers | Type | |
| | Stroke Height | |
| | Efficiency | |
| Soils | Grain Size Distribution | ✔ |
| | Density | ✔ |
| | Pore Water Pressure | ✔ |
| | Particle Shape | ✔ |
| | Consolidation Behavior | ✔ |
| | Permeability | ✔ |
| | Static Shear Behavior | ✔ |
| | Cyclic Shear Behavior | ✔ |
| Site | Geologic Stratification | ✔ |
| | Confining Stresses | ✔ |
| | Installation Order | |

✔ = variables evaluated during this research

## 2.5 Methods for Measuring Rebound

### 2.5.1 Manual Method

The manual method of measuring pile displacement and rebound consists of taping paper onto the pile near a reference board or beam. As the pile is driven, a pencil moved horizontally across the edge of the reference board records the pile's movement as illustrated in Figure 2-4. The resulting graphs show each hammer-blow's maximum displacement and rebound. While the method is simple, it requires a high degree of dexterity and lacks the precision needed for complex engineering investigations. In addition, there is also a risk of injury to the operators.

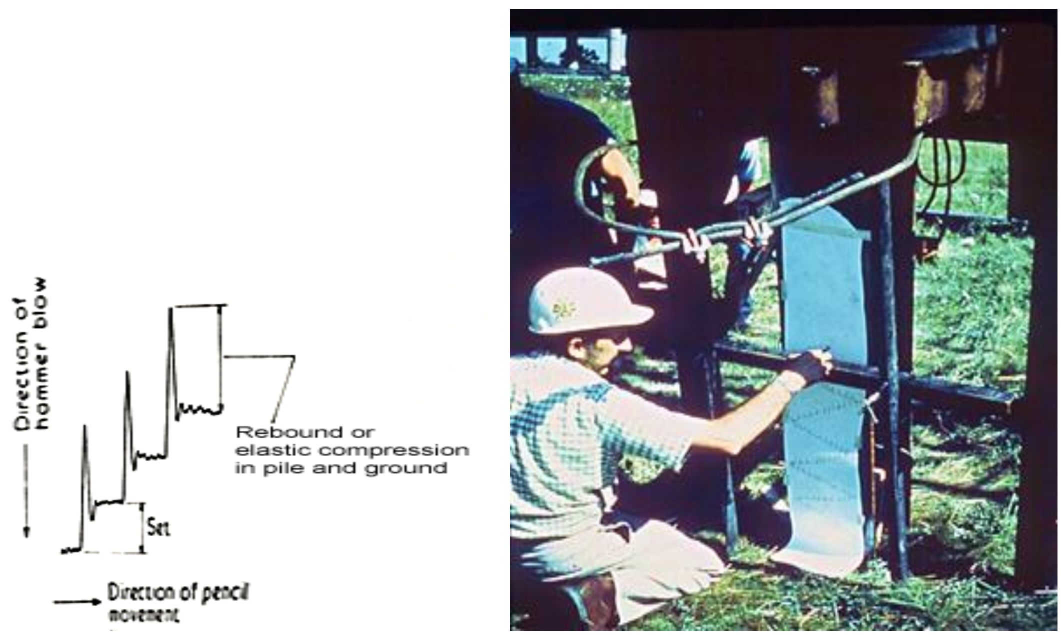



Figure 2-4: Pile Displacement and Rebound Recorded by the Manual Method (from Hattori and Nishiwaki 1974, Courtesy of GRL Engineers, Inc.)

### 2.5.2 High-speed Visual Measurement Systems of Pile Penetration and Rebound

#### 2.5.2.1 High Speed Line Camera System

Bum-Jae et al. (2002) patented an approach for measuring pile movement during installation by using a high-speed camera. The measurement system, portrayed in Figure 2-5, consists of special marking paper, a high-speed line scan camera equipped with a zoom lens and a personal computer. Line scan cameras use a single line of pixels to scan images and, therefore, require less processing than conventional digital cameras. Fax machines are an example of line scan cameras. The method is based on two-dimensional motion achieved by stacking alternating white and black right-angled triangles on paper as shown in Figure 2-5. As the pile is driven, the line-scan camera produces a line image by scanning from the top to the bottom of the attached marking paper. The height (H) of each triangle is 1.5-inch (40 mm) and the width (W) is 4-inches (200 mm). The line-scanned image is used to determine a location along the pile. This methodology shows promise in measuring pile movement and rebound during driving; however, as shown in the figure the equipment is mounted very close to the pile. Therefore, it causes not only safety concerns but also concerns about the camera stability.

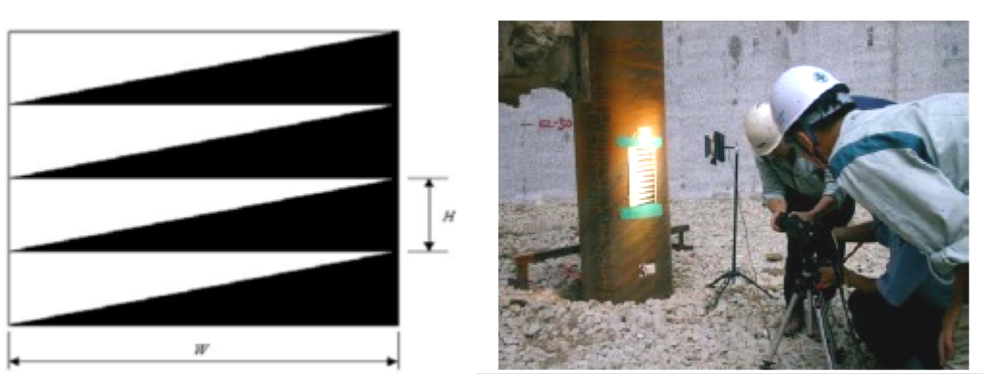



Figure 2-5: Marking Paper and Line Scan Camera Setup During Pile Driving (Oliveira et al., 2013)

### 2.5.2.2 Digital Image Processing System

Oliveira et al., (2011) developed a fast tool to measure the rebound and the final set for driven prestressed concrete piles with diameters varying from 23.6 to 31.5-inches (60 to 80 cm) and lengths varying from 65 to 165 feet (20 to 50 m). Three coastal locations in Brazil were used, one in Rio de Janeiro, another in Sepetiba and the third in Itajai. All three test locations had known soil profiles and NSPT values. Measurements were performed using digital image processing techniques. An A4-size sheet laminated with a printed pattern was fixed to the pile, and then a standard video camera (30 Hz sampling rate) was used to capture the images. An optical rebound analyzer (termed PDR by the authors) consisting of both a charged couple device (CCD) camera, mounted on a tripod, and a computer, was placed so that it faced towards the pile at a distance of approximately 15 to 30 ft (5 to 10 m). This spacing ensured that there was no significant effect from driving vibrations on the results.

A comparison between rebound values obtained by the PDR and the manual method is exhibited in Figure 2-6. These results indicated good agreement between the two methods. The manual method produced slightly higher rebound predictions at values over 0.4-inches (10 mm) than the PDR method (Figure 2-6). The authors termed this rebound “elastic”.

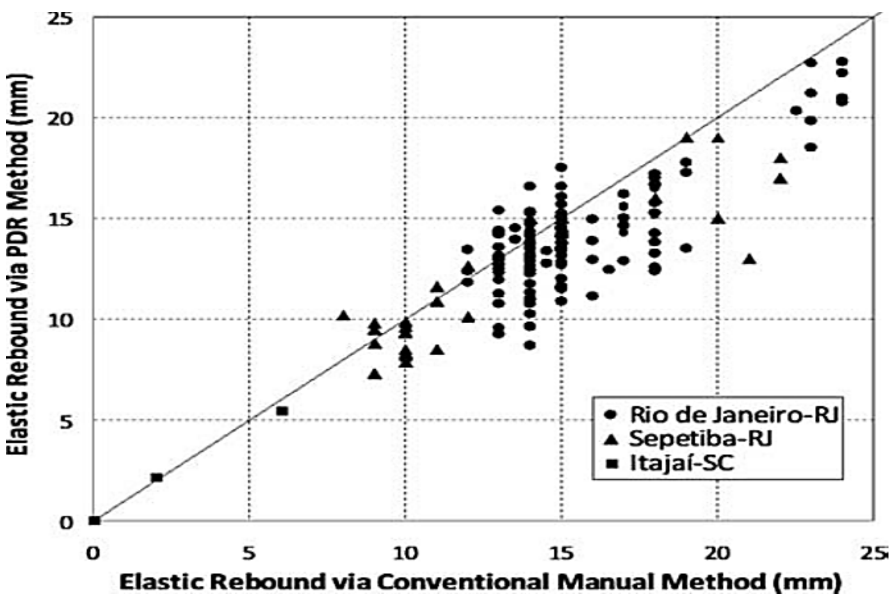



Figure 2-6: Comparison Between Elastic Rebound Results Obtained with Conventional Manual Method and the PDR System (Oliveira et al., 2013)

### 2.5.3 He-Cd Laser Beam Measuring System

Another method to physically measure pile displacements and rebound was proposed by Hattori (1974). A helium-cadmium (He-Cd) laser beam, used in conjunction with photosensitive oscillograph paper attached to the pile, produces traces of the pile movement. The laser beam has a high energy density and the proper convergence characteristics that allow it to transmit and focus the beam onto a point at a distance of 32 to 64 ft (10 to 20 m). During a field trial, the laser beam produced visual traces of pile movement including rebound after only a few minutes.

### 2.5.4 Inopile PDM

The Inopile Pile Driving Monitor (PDM) uses LED opto-electronic technology to measure pile set and temporary compression as well as calculate peak pile velocity (Look et. al 2015a). PDM measurements involve placing a reflector on the pile (Look et. al 2015b). The PDM is recommended for placement about 30 to 45 feet (10-15 m) from the pile. It allows for a greater degree of safety than other methods as operators can conduct measurements from a safe distance away from the pile driving hammer that avoids the risk of being hit by falling parts, broken cushions or spalling concrete above (Look and Seidel, 2015). The PDM has a vertical field of view of 1.5 ft (0.45 m) at 32 ft (10 m) range. This field of view varies marginally with range as illustrated in Figure 2-7 (Look et. al, 2015a). PDM sampling at 240Hz (Look et. al 2015b) yields an accuracy of 0.004-inch (0.1mm) at 32 ft (10m) (Look and Seidel, 2015).

| Offset Distance (m) | Active Zone Height (m) |
|---|---|
| 5.5 | 0.25 |
| 10 | 0.45 |
| 11 | 0.50 |
| 16.5 | 0.75 |
| 25 | 1.13 |

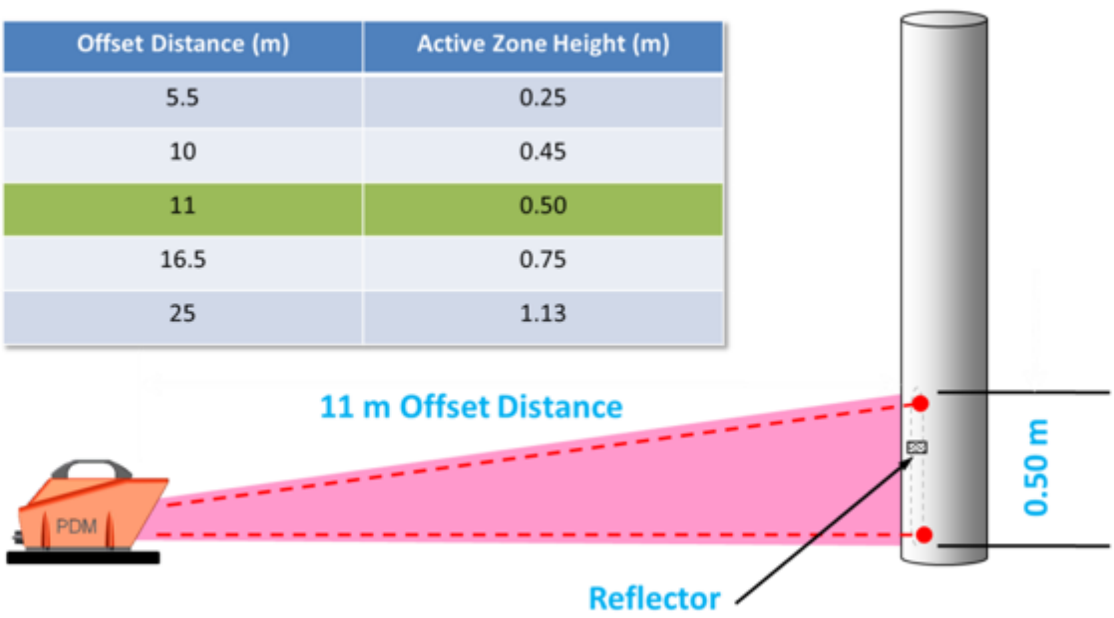



Figure 2-7: Illustration of the relationship between offset distance and active zone height for PDM (reprinted from Look et. al, 2015a)

### 2.5.5 Noncontact Laser Displacement System

The principle of non-contact laser sensors is largely divided into three types; eddy-current, optical, and ultrasonic waves. The eddy-current technique has a short measurement range and is therefore not suitable for this application. The ultrasonic wave style has a long measurement range and can measure all objects; however, it is greatly affected by environmental factors, such as wind and temperature. Thus, when outside use is intended, the optical laser displacement sensor (LDS) technique is the most appropriate option (Park et al., 2013b).

LDS with wireless data acquisition and transmission have been used in applications such as structural health monitoring (Park et al., 2013a), measuring the deflection of structural members in an irregular building (Park et al., 2013b), and measuring the displacement of medium and short span bridges (Tian et al., 2014). In these applications, the LDS is measuring a displacement that is parallel to the laser beam while the reflecting surface used is perpendicular to the laser beam. A similar setup could be used to measure pile displacement. It could be accomplished in two ways. The first would be fastening the laser and the wireless sensor to the pile with the laser pointed down at a stationary reflector at the base of the pile. This set-up means that the delicate laser would be subjected to the dynamic impacts associated with driving. The second option would be to have the laser and the wireless sensor stationary near the base of the pile with the laser pointing up at the reflector fastened to the pile. Of the two setups, the second is the more practical as mounting a reflector plate to the pile is simpler than mounting both the laser and wireless sensor. The advantage to this setup is that it allows to operator to take measurements from a safe distance away from the pile. The disadvantage to the setup is that it leaves valuable equipment dangerously close to the pile.

Islam et al., (2016) developed a novel method for measuring inter-story drift that allows for LDS equipment to measure a displacement that is perpendicular to the laser beam by using an angled reflector plate illustrated in Figure 2-8. This alteration could also be used to measure pile displacement, which would allow the LDS to be placed away from the pile with the laser pointed at an angled reflector plate fastened to the pile. The advantage to this setup is that it allows to both the operator and the LDS to take measurements at a safe distance from the pile. The disadvantage to this setup is that the range of displacement measured would be limited to the vertical length of the reflector plate.

LDS equipment used by Park et al., 2013a and Park et al., 2013b was the LLD-0100 model (JENOPTIK AG, Jena, Germany) with a measurement range from 0.6 to 115 feet (0.2 to 35 m) an accuracy to 0.007-inch (0.2 mm) at a sampling rate of 50 Hz.

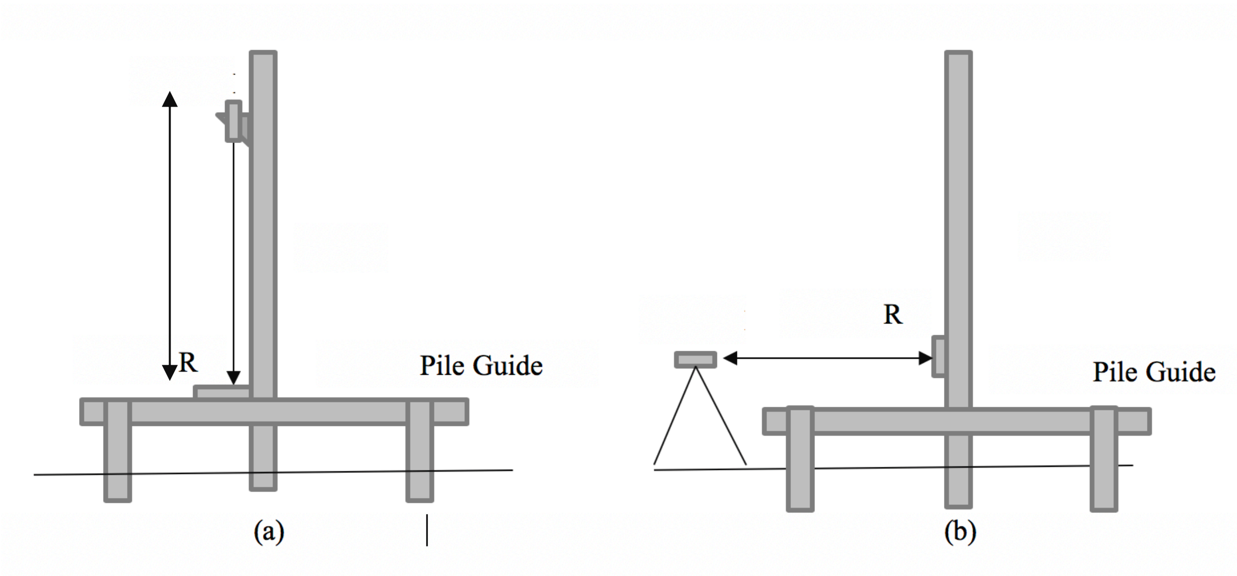



Figure 2-8: Laser-based Reflector (R) Displacement Measurement: (a) Laser Mounted on Pile; (b) Reflector Mounted on Pile (Islam et al., 2016)

### 2.5.6 FIT Camera Measurement System

Bostater and Yang (2014) developed a camera measurement system (CMS) based on video images. The researchers have tracked vertical displacements of waves and recently updated the original system (Bostater et al., 2017). This system involves the following processes. A video is taken of the desired moving object(s). Individual frames are then created using special decoding software that results in converting the video sequence into images or frames. This process is accomplished by decoding the header information in the video file. The binary header contains embedded binary descriptors. The light intensity in each image or frame is then read and analyzed using a specially coded software program. Thus, for each image, variations in light intensity at a line or edge interface is obtained. Motion can be determined by tracking the color intensity differences at the line or interface that moves as a function of the pixel number. Thus, interfaces such as the edge of a paint line or a reflective line target within a series of images can be spatially tracked using a custom edge detection algorithm.

Initial camera video imaging was performed at the Saint John's Heritage Parkway I-95 Micco Interchange. A camera was set up near a pile in the shoulder of the southbound lanes of I-95 during installation. Images were taken for short durations and analyzed. Camera images taken at 30 frames per second produce 30 times 60 or 1800 frames per minute. Figure 2-9 shows highly simplified data from 4 separate images taken during driving of the 24-inch square prestressed concrete production pile. Data is shown in terms of intensity (y-axis) versus pixel number (x-axis). Higher intensity numbers being light portions of the images (gray concrete color) and lower numbers near zero as the black one-foot line marker on the pile. The blue lines are all images as the pile is moving down, with the solid line being the first image, the darker dashed blue line the second image and the lighter dashed blue line the third image. The red line is the fourth image in the sequence and shows the pile rebounding. If the pile rebound movement is to be estimated it is easiest to choose an intensity line of for example 40 and then project from the third series (light dashed blue downward portion) line to the x-axis or pixel number (approximately pixel 215 at Intensity 40). Repeating this process at the 40-intensity line for the red line downward portion line and the approximate pixel number is 200. Each pixel is about ¼ mm thick therefore the rebound is 15 times ¼ mm or 3.75 mm or about 1/6th inch.

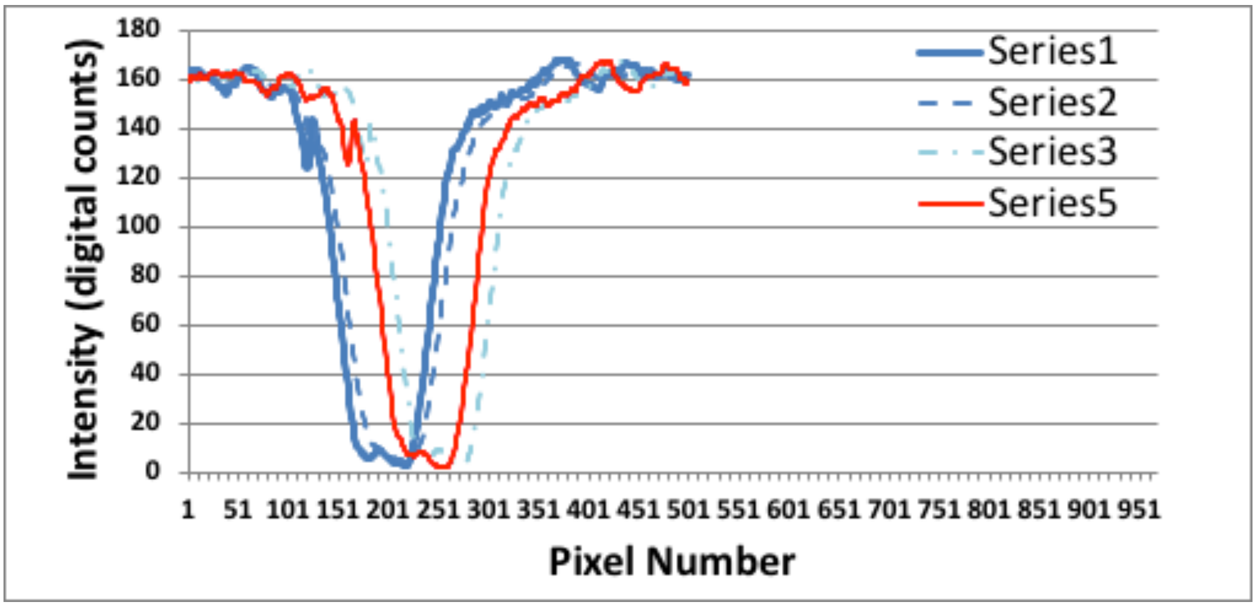



Figure 2-9 Micco Road I-95 Overpass Pile Driving Reduced Camera Data with blue lines for downward pile movement and red line upward movement

## 2.6 Summary of Pile Measurement Systems

A summary of the relative complexity, safety and costs are shown in Table 2-3. These levels and numbers are based on the literature findings and general engineering experience. Other than the manual method all the systems evaluated are relatively complex. The complex systems all involve specialized cameras/lasers and software. As shown the safety of all systems is a concern; however, the highest safety concern is associated with the manual and high-speed line camera due to their location relative to the pile driving. All other systems reviewed are considered as a safety concern since they are typically about 32 ft (10 m) from the pile during driving.

Table 2-3 Summary of the Relative Complexity, Safety, and Costs

| Method | Relative Complexity | Relative Safety | Estimated Cost |
|---|---|---|---|
| Manual | Low | Very Poor | Very Low |
| High Speed Line Camera | High | Very Poor | > $10,000 |
| Digital Image Processing | High | Poor | > $10,000 |
| He-Cd Laser | High | Poor | > $10,000 |
| Inopiles PDM | High | Poor | > $10,000 |
| LDS | High | Poor | > $10,000 |
| FIT Camera | High | Poor | > $10,000 |

## 2.7 Pile Movement during Driving

Soils are often exposed to different forms and therefore durations of cyclic loading from either natural forces or construction activities as shown in Figure 2-10. The static loads occur over a low number of cycles; however, the various dynamic loads occur over a large number of cycles. Pile driving waves are similar in duration to those found from earthquake, traffic and machine foundations.

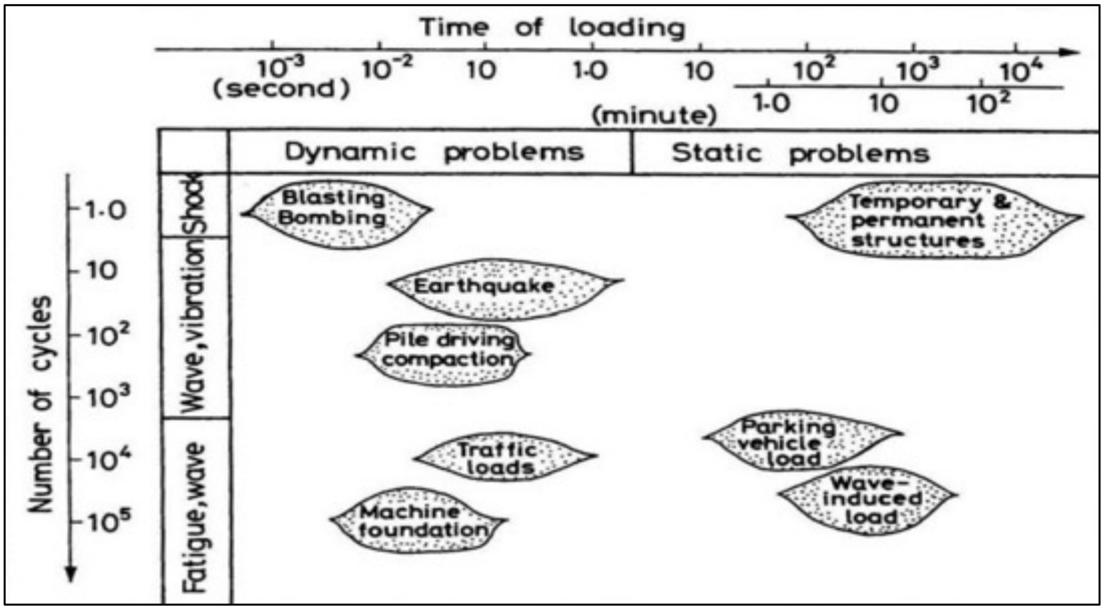



Figure 2-10: Classification of dynamic problems (after Ishihara, 1996)

### 2.7.1 Dynamic Approach: Pile-Soil Model from the Wave Equation

Soils loaded quickly, offer more resistance than soils loaded slowly. Pile driving is one of the extreme cases of fast loadings. Smith (1960) developed a discretized spring and dashpot model of a pile being driven into soils as shown in Figure 2-11. The pile driving system consists of a hammer and anvil ram, cushion material for the hammer and pile (if concrete), a pile cap, the pile, and the surrounding soils. Springs are used to represent elastic materials, while spring and dashpot combinations are used to represent elasto-plastic materials, such as soils.

Smith (1960) used a hybrid linear elastic-plastic model to depict pile load-displacement movement from a single hammer blow. Figure 2-3 shows the actual and modeled energy rebound during a single hammer cycle. The elastic compression of the soil or rock below the pile point results in an upward displacement (i.e., rebound) of the pile after the hammer blow. Rebound is typically associated with the reaction of the soil as opposed to the pile. Quake is the modeling parameter describing the soil's initial elastic movement (i.e., similar to earthquake movements) from the dynamic energy resulting from a single hammer blow (Smith, 1960). Stated another way, quake is the pile displacement when the soil behavior changes from elastic to plastic (Murrell et al., 2008).

The soil damping ($\eta$) and the wave speed (v(t)) are proportional to the force or pile resistance ($R(t) = \eta * v(t)$). In this format, $\eta$ has units of force per velocity. Historically, two damping coefficients have been defined for the dynamic pile soil model. Smith's damping coefficient (Js) has units of 1/velocity and the resulting pile resistance is found by including the maximum soil resistance per blow (Rsmax) as follows: ($R(t) = Js * Rsmax*v(t)$). The damping coefficient (Jc) as defined from the Case Western Reserve (CASE) study, (NCHRP Synthesis 253, 1997) is dimensionless, since pile impedance (Z) is included ($R(t) = Jc * Z*v(t)$). The impedance is found from Young's Modulus multiplied by the pile cross-sectional area and then divided by the wave speed, resulting in units of force/velocity ($EA/v(t)$).

Data from cyclic triaxial testing on HPR and non-HPR soils may be able to produce values for Js. Data is available from 30 cyclic triaxial tests. Each test has 6,000 or more cycles at various stress levels. This data is currently being evaluated. A sample of the results from this analysis has been written and included as Appendix F. This data is preliminary and is provided to show the current process being used to produce damping coefficients.

Dynamic testing is performed only during pile driving when real-time measurements are required. The dynamic testing system as presented in Figure 2-12, consists of: a) field testing utilizing specialized equipment such as strain gauges and accelerometers and b) pile wave signal matching software such as the CAse Pile Wave Analysis Program (CAPWAP®).

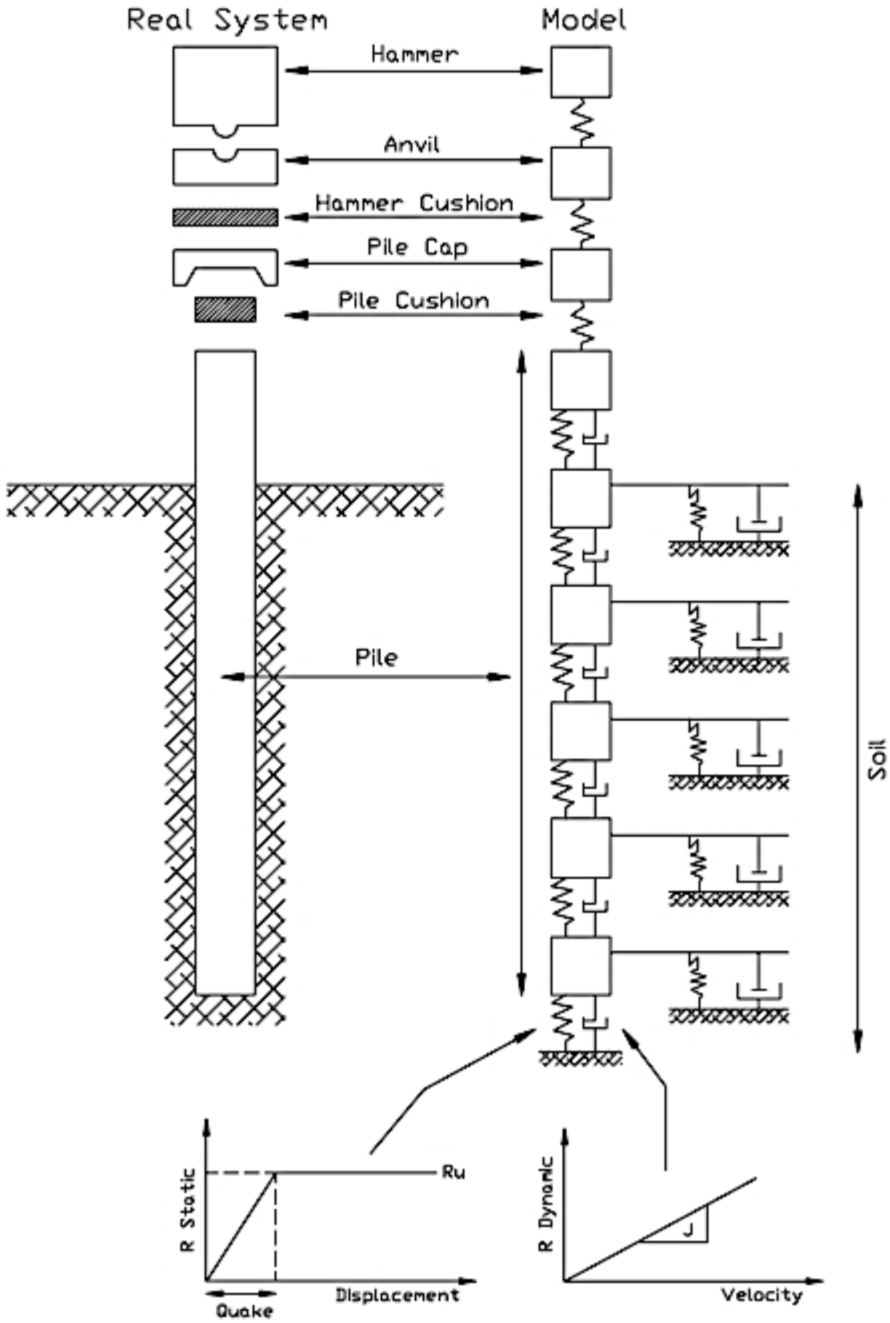
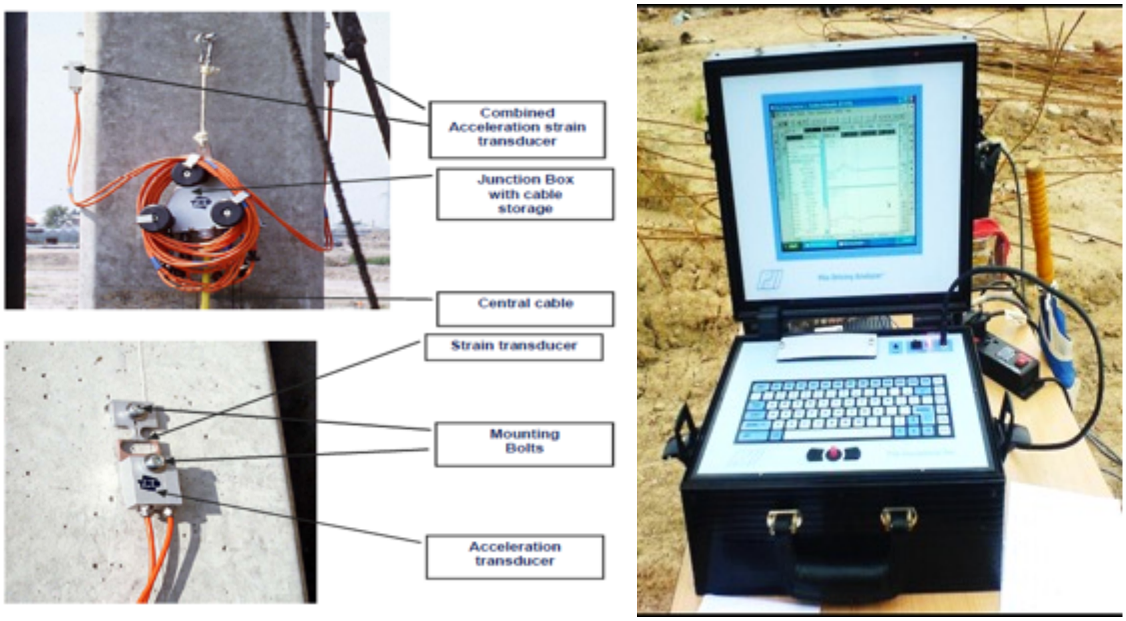



Figure 2-11: Pile-Soil Model for Wave Equation Analysis (Smith, 1960)




(a) (b)

Figure 2-12: Strain Gauge and Accelerometers Mounted on Pile and (b) PDA Equipment with CAPWAP® (Courtesy GRL Engineers, Inc.)

The signals from the accelerometers and strain gauges, placed within 2 diameters of the pile head, are used with data acquisition in a package called the Pile Driving Analyzer® System PDA Software. Accelerations are integrated once to produce velocity traces versus time and a second time to produce deflections versus time. The strains are used along with the known pile properties (area and elastic modulus) to produce the force in the pile versus time at the gauge location. Based on Hooke's Law ($E=\sigma/\varepsilon$), the strain ($\varepsilon$) and elastic modulus (E) are used to determine the stress ($\sigma$), and then the area of the pile is used to determine the force. PDA force and velocity versus time data from a hammer blow is depicted in Figure 2-14.

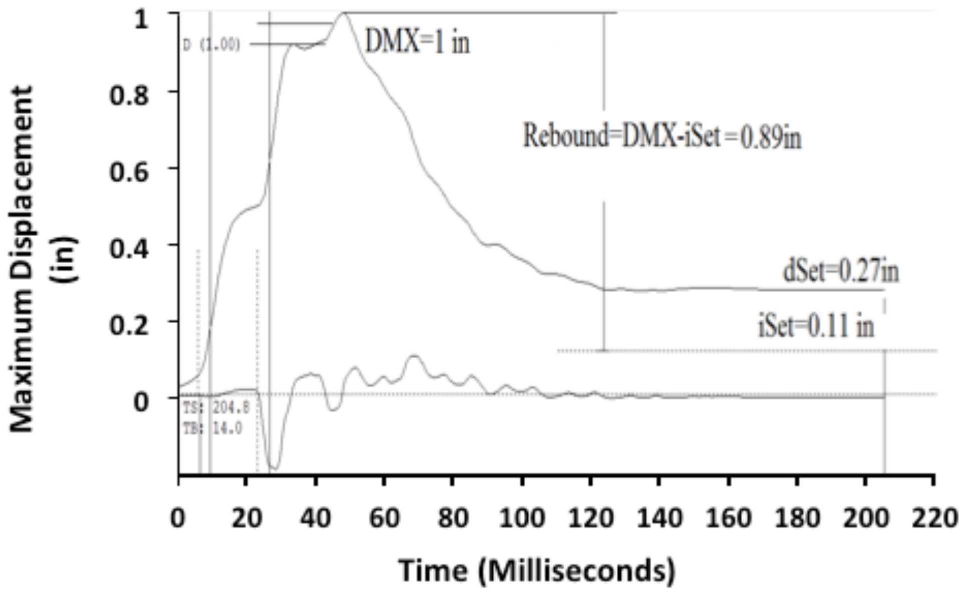



Figure 2-13: Typical PDA Pile Top Displacement versus Time Diagram from One Hammer Blow for a FDOT HPR Site (from Cosentino et al., 2010)

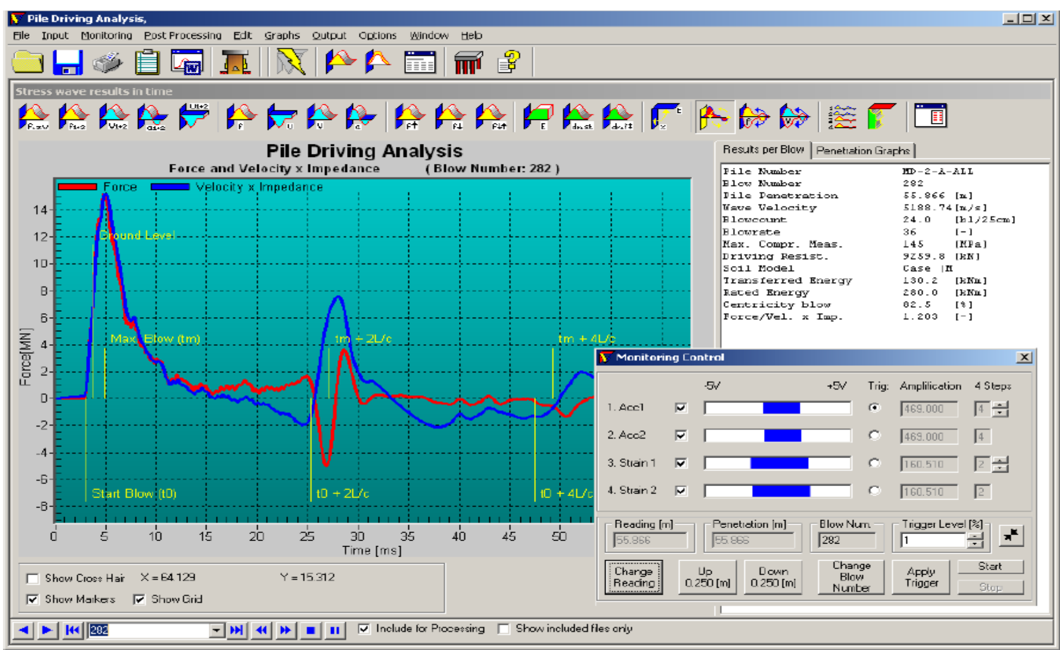



Figure 2-14: PDA Measured Force and Velocity versus Time from One Hammer Blow (Courtesy GRL Engineers, Inc.)

CAPWAP® is a software package with a signal matching procedure which primarily uses ultimate resistance values, soil damping factors and quakes in a series of equations to match computed with measured PDA force and velocity signals. The CAPWAP® program has six operator adjustable variables in the computation of its force versus time curve: side quake, toe quake, side damping, toe damping, static resistance along the pile shaft, and static resistance at the pile toe.

The operator adjusts these variables to produce a match between the actual force trace and the computed force curve (Authier and Fellenius, 1980). After the measured force has been obtained for each hammer blow (Figure 2-14), engineers use the CAPWAP® signal matching process along with these forces to predict force versus time curves. This predicted curve can be compared to the actual force trace generated during pile driving. Figure 2-15 demonstrates five iterations of this matching process. Damping was added after the first iteration, then the capacity was increased, and finally the quakes were adjusted. This process produced a good match by iteration 5.

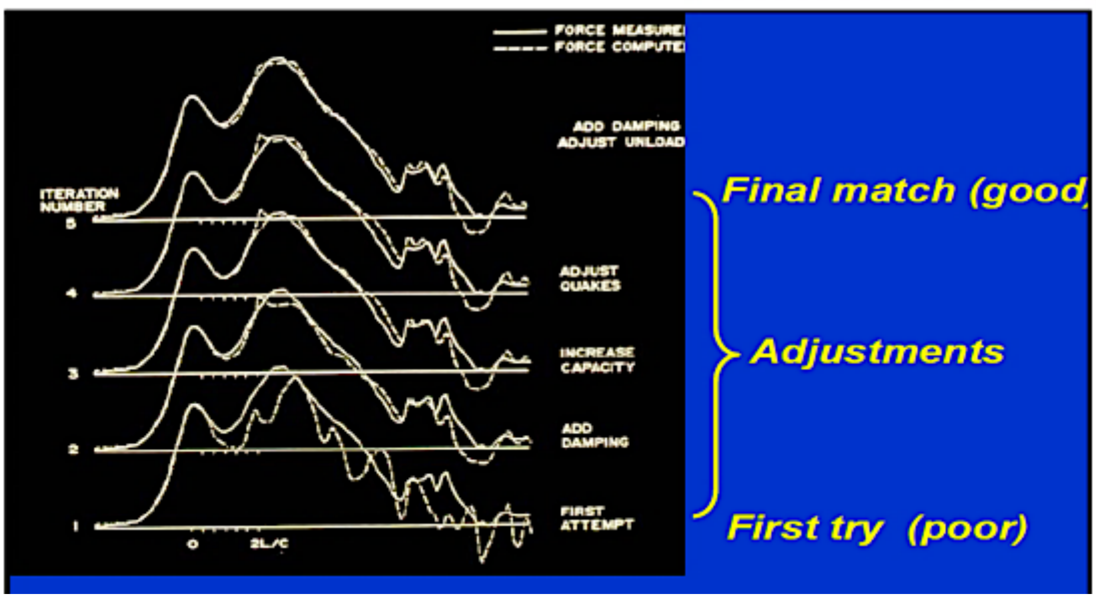



Figure 2-15: CAPWAP® Iterative Process (Courtesy GRL Engineers, Inc.)

Figure 2-13 presents typical HPR PDA data at a FDOT site. The plot, with displacement recorded in inches on the vertical axis and time recorded in milliseconds on the horizontal axis, shows a maximum displacement (DMX) of 1 inch, a digital set (dSet) of 0.27 inches, and an inspector permanent-set (iSet) of 0.11 inches. The digital set from the PDA output (DFN or dSet) is recorded over 200 milliseconds, with approximately 1.5 seconds occurring between hammer blows for typical diesel hammers. The final pile set occurs after the digital signal has ended. This discrepancy between the dSet and iSet has caused most engineers to assume the inspector set as more reliable. Assuming that the inspector set is reliable, yields a rebound of 0.89 inches. The rebound based on dSet would be 0.73 inches.

### 2.7.2 Viscoelastic Behavior of Soils

Rheology is the study of the flow of substances subjected to loads or pressures. The rheological stress-strain behavior changes with time and it is dependent upon the loading and stress history. Rheological processes are time dependent responses of the soil due to long-term load application. Vyalow (1986) describes three different forms for rheological properties manifestation: creep, relaxation and deterioration of strength. Creep is characterized as a soil deformation with time due to an applied constant load. A deterioration of soil strength occurs during creep while the soil is transitioning into the stage of failure. Relaxation is the lessening of stresses that occurs when a load is applied and reduced after a given time in order to maintain a constant deformation (Vyalow, 1986). These properties can only be observed if an adequate interval of time is given, which vary for each material.

The deformation of soils after a load is applied depends on their elasticity, plasticity and viscosity properties, which are related to the interaction forces within the atoms.

Elasticity is the capability of the soil to rebound to its initial form after the forces are removed. If a body is capable of completely returning to its initial shape and volume, the deformation is called reversible and the body is referred as a Hookean solid (i.e., perfectly elastic body). The rheological equation of state for a Hookean body with perfectly elastic behavior is given by the expression below:

$$\sigma_i = E \times \varepsilon_i$$

where $\sigma_i$ is the normal stress, $E$ is Young's modulus and ε the vertical strain.

Plasticity, on the other hand, is the capability of soils to deform permanently without failing. The plastic state of a body is achieved when the maximum stress occurs ($\sigma_{max}$), called the yield point.

The third property mentioned, viscosity, is related to fluid and gas behavior. It is described by Vyalow (1986) as the resistance of motion within the body's particles, and therefore comes into play when there is movement between layers. The rheological equation of state for a Newtonian liquid (i.e., a perfect viscous liquid) defines the tangential stress ($\sigma_i$) as function of a viscous factor ($\eta$) and the derivative of strain over time ($\dot{\varepsilon}_i$):

$$\sigma_i = \eta \times \dot{\varepsilon}_i$$

The behavior of the soils due to these properties are shown on both stress versus strain and derivative of strain versus time curves. For an elastic body, the deformation recovers instantly if unloaded and do not change in time, while for viscous bodies the deformation increases with time and does not recover after the load is removed.

The combination of elastic and viscous properties of the soils is called viscoelasticity, and it introduces a time-dependent response in addition to the elastic deformation to the soil behavior. There are numerous combinations of elastic and viscous components used to model rheological materials such as soils, and asphalt concrete. The mechanical models used to describe them use elastic springs, characterized by the Young's modulus ($E$), combined with viscous dashpots, characterized by a viscous factor ($\eta$), in series or parallel.

The Maxwell model uses a spring and a dashpot placed in series. When a constant strain is applied to a material the corresponding stress decreases or releases with time (Vyaloy, 1986). In this model, the system representing the pile being driven consists of a spring and a dashpot connected in series as shown in Figure 2-16:

Figure 2-16 Maxwell Model

The Kelvin-Voigt model, used when a material, i.e., the pile, experiences the same elastic and viscous moment during load and the strain changes with time. Smith (1960) used the Kelvin-Voigt model in his wave equations analysis of piles. In this model, the system representing the pile being driven consists of a spring and a dashpot connected in parallel as shown in Figure 2-17:

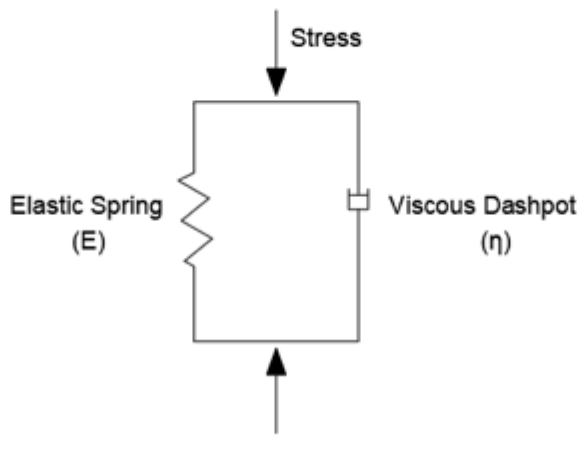



Figure 2-17 Kelvin-Voigt Model

The rheological equation of state for the Kelvin-Voigt model is given by:

$$\sigma = E \times \varepsilon + \eta \times \dot{\varepsilon}$$

where E is the elastic modulus, $\varepsilon$ is the strain, $\eta$ is the viscous factor, with units of stress-time, and $\dot{\varepsilon}$ the derivative of strain with respect to time.

### 2.7.3 Damping

Damping is related to the loss of energy during cyclic loading. It is represented by a dashpot with a damping coefficient. There are a variety of models in the literature referring to damping factors with different units of measure. Two in particular will be described in detail due to their use by the software CAPWAP®: CASE's and Smith's damping factors.

CASE's damping factor ($J_c$) relates the load applied ($R(t)$) by the hammer blow, the pile impedance (Z) and the wave velocity (c) in the pile. During cyclic triaxial tests, the load applied lasts a tenth of a second and then goes to zero, therefore, the load to be used in this analysis will be the maximum load (Rmax) applied during the cycle time. The equation developed by CASE is:

$$J_c = \frac{R(t)}{Z \times c}$$

Impedance (Z) is defined as the proportionality constant between the applied force due to the hammer impact and the particle velocity (c) at any point throughout the pile. Z is related to the pile's area, length, material and density. When Z increases the pile particle velocity decreases.  Pile impedance is calculated through the following equation:

$$Z = \frac{EA}{c} \quad \left(lb.\frac{s}{in}\right)$$

$J_c$ is dimensionless, as shown by the following dimensional analysis:

$$[J_c] = \frac{\mathrm{lb}}{\left(\frac{\mathrm{lb}}{\mathrm{in}^2} \times \frac{\mathrm{in}^2}{\frac{\mathrm{in}}{\mathrm{s}}}\right) \times \left(\frac{\mathrm{in}}{\mathrm{s}}\right)} = \text{dimensionless}$$

A range of values related to the soil type is presented in the Pile Driving Contractors Association (PDCA) Manual (Hannigan et al., 1998) reproduced in

Table 2-4. These dimensionless damping coefficients range from 0.05 to 0.7, depending upon the soil type. Florida sites generally have silty fine sands with clays, and therefore would produce CASE damping factor between 0.15 and 0.25.

Table 2-4 CASE Damping Coefficient (after Hannigan et al., 1998)

| Soil Type at Pile Toe | Original CASE Damping Correlation Range, 1975 | Updated CASE Damping Correlation Range, 1996 |
|---|---|---|
| Clean Sand | 0.05 to 0.20 | 0.10 to 0.15 |
| Silty Sand, Sand Silt | 0.15 to 0.30 | 0.15 to 0.25 |
| Silt | 0.20 to 0.45 | 0.25 to 0.40 |
| Silty Clay, Clay Silt | 0.40 to 0.70 | 0.40 to 0.70 |
| Clay | 0.60 to 1.10 | 0.70 or higher |

Smith's damping factor ($J_s$) is defined as the ratio between the load applied over time ($R(t)$) to the product of the maximum load applied ($R_{smax}$) and the wave velocity ($c$) due to the hammer blow:

$$J_s = \frac{R(t)}{R_{smax} \times c}$$

$J_s$ has units of time over displacement, as shown:

$$[J_s] = \frac{lb}{lb \times (\frac{in}{s})} = s/in$$

Both damping factors can be related to each other through the following relationship:

$$J_s \times R_{smax} = J_c \times \frac{E \times A}{c}$$

$$J_c = \frac{J_s \times R_{smax} \times v(t)}{E \times A}$$

### 2.7.4 Pile Driver Analyzer

The Pile Driver Analyzer (PDA) method was developed at Case Western Reserve University in the 1960s (Hussein and Goble, 2012). The main purpose of instrumenting a pile with PDA sensors is to use the force and impact wave recorded during driving to determine the static resistance of the pile.

In order to determine the pile capacity, sets of strain gauges and accelerometers are mounted near the top of the pile. During hammer impact, the strains are used to determine force (F) at the sensor location. The force is found knowing the pile elastic modulus (E), and cross-sectional area (A), which are input into Hooke's law (i.e., E=σ/ε, σ= F/A therefore, F= σ x A). During hammer impact, the accelerometer signal is numerically integrated to obtain the particle velocity at the location of the sensor. A second numerical integration of the acceleration produces pile movement at the sensor. These signals are recorded continuously throughout the driving process.

Typical PDA-CASE method pile force and velocity versus time data for one hammer blow is shown in Figure 2-18. Since the wave travels in two directions it changes from positive to negative as shown. Knowing the pile elastic modulus and mass density, the stress wave speed (c) can be calculated as (E/ρ) 1/2. The wave speed (c) traveling up and down the pile is a constant, but it may also be estimated using the known pile length (L) and the time (t) required for the stress wave to travel down and up the pile (i.e. a distance of 2L). In summary, the wave speed can be calculated or estimated as follows:

$$c = \left(\frac{E}{g}\right)^{1/2} \cong \frac{2L}{t}$$

PDA-CASE method software also calculates the pile's dynamic modulus (Ed) and the wave speed, based on the pile characteristics (area, length, material and density), and the data collected by the sensors. The data from PDA can be exported to other software in order to be analyzed. Figure 2-19 shows the typical export data from PDA.

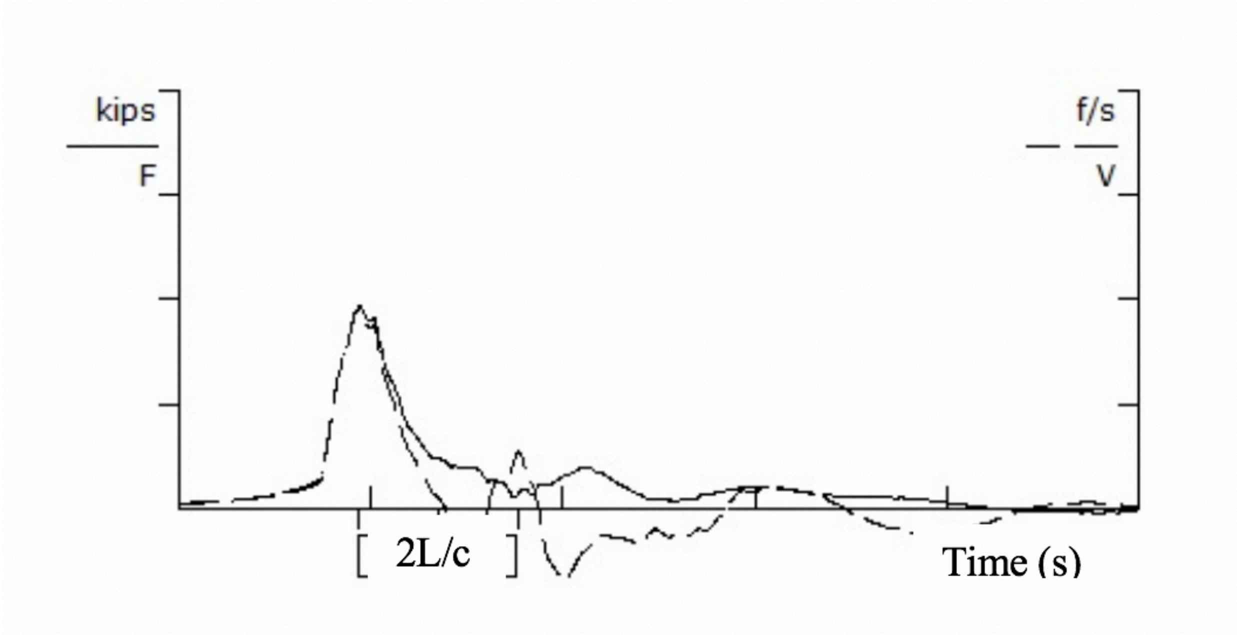



Figure 2-18 Typical PDA Pile Force (Solid Line) and Velocity (Dashed Line) versus time, including 2L/c time along pile (Rectangular shape)

| Date | Time | LP | EL | BN | EL | BPM |
|---|---|---|---|---|---|---|
| | | feet | feet | | feet | blows/minute |
| 12/21/12 | 13:12:14 | 31 | -10.58 | 1 | -10.58 | 1.9 |
| 12/21/12 | 13:12:44 | 32 | -11.58 | 2 | -11.58 | 1.9 |
| 12/21/12 | 13:12:46 | 32.5 | -11.58 | 3 | -12.08 | 42.6 |
| 12/21/12 | 13:12:47 | 33 | -12.58 | 4 | -12.58 | 52 |

| FMX | VMX | EMX | FVP | DMX |
|---|---|---|---|---|
| kips | feet/second | kip-feet | | inches |
| 286 | 10.3 | 19.5 | 1 | 12.01 |
| 376 | 8.5 | 29.2 | 0.9 | 12.01 |
| 454 | 5.7 | 21.6 | 1 | 6 |
| 416 | 5.5 | 14.7 | 0.9 | 6 |

| SET | DFN | CSX | CSI | TSX | AMX | SFT | EBR | jc |
|---|---|---|---|---|---|---|---|---|
| inches | inches | ksi | ksi | ksi | g's | kips | kips | |
| 12 | 12.01 | 0.9 | 1 | 0.2 | 12 | 0 | -1 | 0.5 |
| 12 | 12.01 | 1.2 | 1.3 | 0.3 | 29 | 0 | 0 | 0.5 |
| 6 | 6 | 1.4 | 1.6 | 0.7 | 51 | 0 | 0 | 0.5 |
| 6 | 6 | 1.3 | 1.3 | 0.7 | 28 | 0 | 0 | 0.5 |

Figure 2-19 Data exported from PDA

## 2.8 CAPWAP® Software

The Case Pile Wave Analysis Program (CAPWAP®) is a software developed to estimate the soil parameters through an iterative signal matching or reverse analysis procedure.

PDA data collected by the sensors can be used to characterize the force and velocity near the top of the pile, but the dynamic and static resistance below the pile head are unknown (Pile Dynamics, Inc., CAPWAP Background Report).

If the pile capacity is limited to the end bearing (i.e., if the pile is on a fixed support condition at its toe), the forces can be easily calculated. However, when friction occurs, it is not simple to define the capacity throughout the pile shaft and toe. CAPWAP® analysis produces an estimate of the friction distribution and the end bearing based on the matching process.

Usually, it takes a relatively large pile displacement to completely mobilize the toe bearing resistance and a relatively small displacement to mobilize the side friction. During pile rebound, any upward movement would significantly decrease the pile toe bearing capacity.

CAPWAP® uses the force and velocity measurements to estimate the wave speed up the pile and capacity. The matching quality percentage (MQ) represents the difference between the wave up calculated and the wave up measured by PDA.

The CAPWAP® soil model is composed of elasto-plastic and linear viscous components. The three main unknowns of the model are the ultimate static resistance, the elastic soil deformation or quake, and the damping coefficient, which are related to multiple parameters. An analysis is complete when all three unknowns are estimated for a certain number of points along the pile shaft and the pile toe.

### 2.8.1 Key CAPWAP® Parameters

CAPWAP® uses different parameters to describe the pile and soil behavior during the loading and unloading process. The parameters critical to this analysis will be described here, the complete nomenclature and definitions can be found in the CAPWAP® Report (Pile Dynamics, Inc., CAPWAP® Background Report, 2006).

The first key CAPWAP® parameter is the shaft unloading level multiplier (UN). It is related to the resistance of the soil around the shaft when the pile rebounds or is unloaded. UN ranges between 0 and 1, and is set as zero if there is no downward shaft resistance and one if the upward shaft resistance is the same as the downward resistance. UN does not apply to the pile toe, because the toe cannot have any downward resistance when the pile is moving up, because the soil loses contact with the pile. During rebound, UN can still vary from 0 to 1 on the pile shaft, according to the soil resistance during the upward movement.

Two additional key parameters are the skin or toe unloading quake multipliers (CS and CT respectively). The slope of the resistance versus displacement curve, which represents the stiffness of the soil, can be different for the loading and unloading phases. CS and CT are multipliers used to relate the unloading stiffness to the loading stiffness. If CS or CT are equal to one, the soil stiffness around the shaft or the toe is the same during the loading and unloading processes.

### 2.8.2 The Pile Model

CAPWAP® divides the pile into Np uniform segments. Initially Np is set as 3.3 ft (1 m) segments; however, it can be changed if needed. The results presented in this report were based on 6.6 ft (2 m) shaft segments. For the constant cross section prestressed concrete piles analyzed, the wave travel times for all pile segments are equal, and the shaft resistance is divided among the segments. Each pile segment (i) has a specific area (Ai), density (ρi), elastic modulus (Ei), wave speed (ci), impedance (Zi) and stiffness (ki).

The force-wave generated by the hammer impact produces a force wave (Fd) traveling down the pile and a reflective force (Fu) traveling up the pile. These forces can be determined using the pile impedance (Z) and the velocity of the downward traveling wave ($\dot{u}_d$) and the upward traveling wave ($\dot{u}_u$) as:

$$F_d = Z\dot{u}_d$$

$$F_u = Z\dot{u}_u$$

The total force (F) at any point throughout the pile can be determined by the superposition of the upward and downward forces:

$$F = F_d + F_u$$

Internal pile damping is defined by CAPWAP® as a fraction of the total force up and down the pile, called Pi. It depends on the pile material, and it is preset as 1% for steel piles and 2% for concrete piles. Pi is the same for all pile segments (i, j) and it can be changed within the

CAPWAP® configurations. The dampened wave forces for segment i, j (Fi,j*) values can be calculated as follows:

$$F^*{}_{u_{i,j}} = F_{u_{i,j}} - P_i(F_{u_{i,j}} - F_{u_{i,j+1}})$$

$$F^*{}_{d_{i,j}} = F_{d_{i,j}} - P_i(F_{d_{i,j}} - F_{d_{i,j-1}})$$

### 2.8.3 Soil Damping

The soil damping is directly related to the velocity in which the pile is being driven. According to Smith's wave equation, the viscous or dynamic force for each soil segment (Rdk) depends upon the segment velocity ($\dot{u}_i$), the temporary static resistance (Rsk) and Smith's dimensional damping factor Jsk, which has units of 1/velocity according to:

$$R_{dk} = J_{sk}\dot{u}_i R_{sk}$$

However, for signal matching, a linear coefficient is more convenient, because the viscous force does not depend on the segments' static resistance. Therefore, Smith's damping is replaced by a viscous factor Jvk, with units of force/velocity, as shown in the following equation:

$$R_{dk} = J_{vk}\dot{u}_i$$

By default, CAPWAP® calculates the damping forces according to the linear viscous approach. However, it is possible to manually change the settings in order to use Smith's approach or a mix of both linear and Smith's.

Once the viscous factor (Jvk) is determined, Smith's (1960) damping can be computed by setting the temporary static segment resistance (Rsk) equal to the ultimate soil resistance (Ruk) using the Smith-viscous approach:

$$J_{sk} = \frac{J_{vk}}{R_{uk}} \qquad (units: \frac{1}{velocity})$$

CASE's Method (1974) uses the pile impedance (Z) to define a non-dimensional damping coefficient, called the CASE damping factor. CAPWAP® calculates separate damping factors for shaft and toe (Jc and Jc,toe), and produces an overall CASE's Damping Factor to be used in the CASE's Method. Case's damping factor is defined as the summation of either the

Smith (1960) shaft damping factors per segment ($\sum J_{vk}$) or Smith (1960) toe damping factor divided by the pile impedance:

$$J_c = \frac{\sum J_{vk}}{Z} \qquad (dimensionless)$$

$$J_{c,toe} = \frac{J_{vk}}{Z} \qquad (dimensionless)$$

# 3 Site Descriptions

Two groups of test sites were used for this research. One group was used for the comparisons between PDA, PDM and CMS equipment, while the second group was used for the visco-elastic damping coefficient comparisons. The description of each group was separated and are presented within this chapter.

## 3.1 PDM CMS PDA Site Descriptions

The sites chosen for the comparisons between PDM, CMS and PDA equipment along with pertinent site information is presented. The task objective was to locate a minimum of 5 sites for the comparisons.

The sites were a mixture of high rebound and no rebound sites in Central and Northeast Florida. Six sites where 24-inch square prestressed concrete piles were installed were selected for the PDM evaluation. Testing included evaluations with both the PDM and camera monitoring system (CMS) equipment. The focus was to use sites that had large diameter prestressed concrete piles driven with open ended diesel hammers at sites with and without pile rebound. CMS evaluations were performed on piles at all six sites. In addition, two sites included Standard Penetration Testing (SPT) with both PDM and CMS equipment. The sites are:

- Berth 8 Port Canaveral North Cargo in Brevard County (*Port Canaveral*)
- Baldwin Bypass over CSX Railroad Crossing in Duval County (*Baldwin Bypass*)
- SR 15 (US 17) over Dunns Creek in Putnam County (*Dunns Creek*)
- Floridian Place extension in Orange County (*Reedy Creek*)
- Ellis Road Interchange over I-95 in Brevard County (*Ellis Overpass*)
- Wekiva Parkway in Lake County (*Wekiva Parkway*)

The descriptions of the work performed at each site include; a site location map, test pile locations, test boring profiles and types of research testing conducted. Table 3-1 is a summary of the PDA, CMS and PDA testing for both the pile and SPT testing. Two locations within the

Wekiva Parkway site were used for SPT PDM and CMS evaluations. One location within Dunns Creek was used for the SPT, PDM and CMS evaluations and a second location was used for the test pile PDM and CMS evaluations. Due to FDOT statewide travel restrictions after Hurricane Michael, which were in effect from late October 2018 until February 2019 SPT testing was limited to three borings at two sites. Port Canaveral was chosen as the initial PDM evaluation site and therefore, no CMS or PDA data was produced. There were no test piles installed at the Port Canaveral site. Reedy Creek was chosen as a non FDOT site due to its close proximity to campus and the fact that this site was not a high rebound site even though it is located in Central Florida. Dunns Creek and the Baldwin Bypass were both high rebound sites while the Ellis Road site was a non-rebound site.

Table 3-1 Summary of PDM-CMS-PDA Testing

| Project Name | Rebound | Pile or SPT | PDM Data | Camera Data | PDA Data |
|---|---|---|---|---|---|
| Port Canaveral | No | Pile | Yes | N/A | N/A |
| Baldwin Bypass | Yes | Pile | No | Yes | Yes |
| Dunns Creek | Yes | Pile | Yes | Yes | Yes |
| Dunns Creek | Yes | SPT | Yes | Yes | N/A |
| Reedy Creek | No | Pile | Yes | Yes | Yes |
| Ellis Overpass | No | Pile | Yes | Yes | Yes |
| Wekiva Parkway | Yes | SPT | Yes | Yes | N/A |

### 3.1.1 Port Canaveral

Several piles were evaluated with the Inopiles PDM equipment during the installation of the piles at North Cargo Berth 8 at Port Canaveral. These tests were preliminary tests with the PDM equipment that allowed the research team to work through the start-up logistics of properly using this equipment. The CMS equipment was not used at this site. A general site location map is shown in Figure 3-1. There were no test piles installed for North Cargo Berth 8, therefore, no PDA data is available.

Over 400 piles were installed at North Cargo Berth 8. A foundation layout plan is shown in Figure 3-2. The piles tested by our research team were in the first two rows closest to the water. Boring TH-FFB4 in Figure 3-3, shows the soils encountered to a depth of about 114 feet (Elevation -114). The picture in Figure 3-4, shows a typical location for these preliminary PDM tests.


Figure 3-1 Google Earth Pro® Map of North Cargo Berth 8, Port Canaveral, Florida

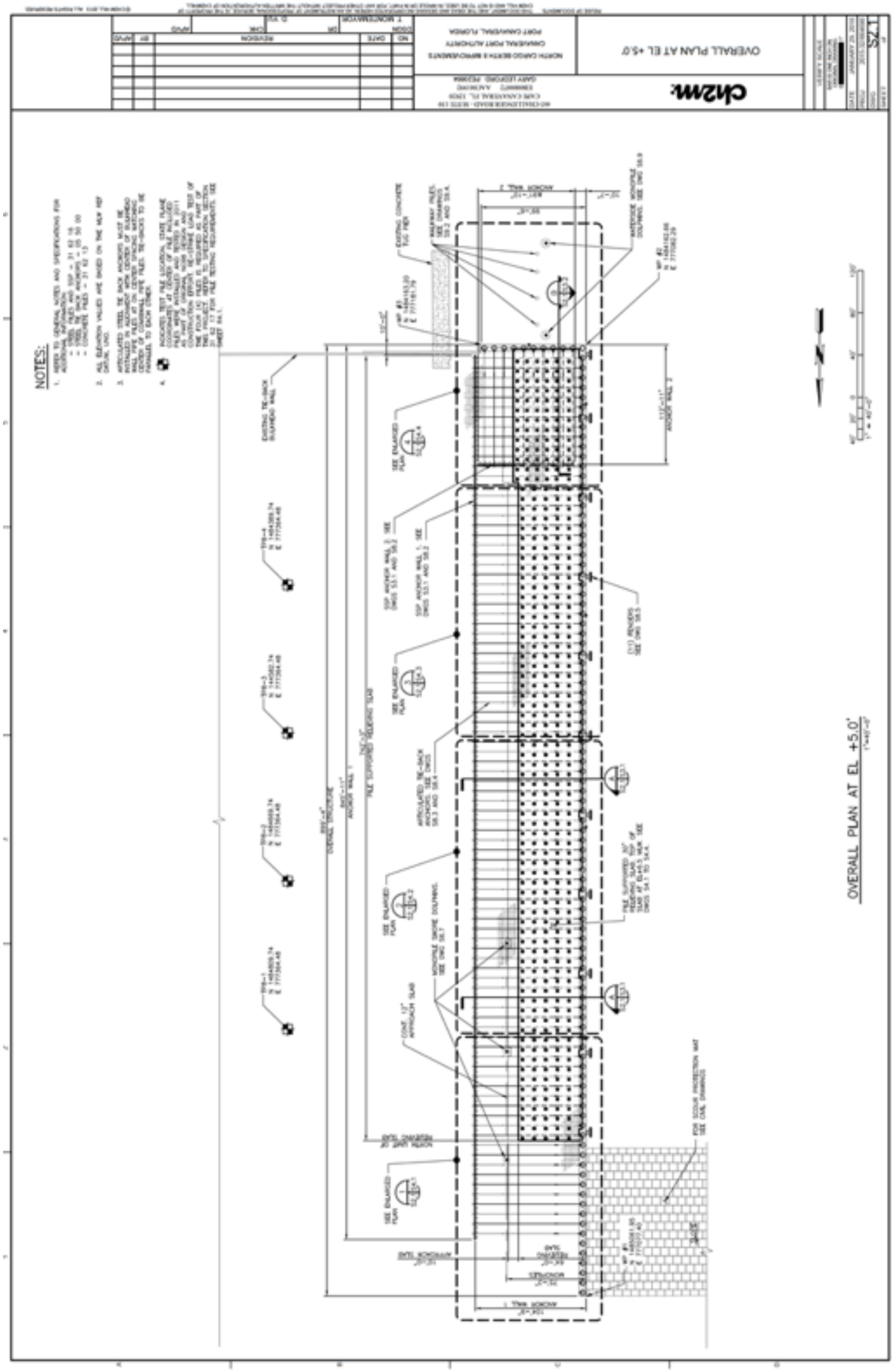


Figure 3-2 Plan View of Pile Installation for North Cargo Berth 8

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# BORING LOG

**BORING NO:** TH-FFB4
**TOTAL DEPTH:** 114.3 ft.
**SHEET** 1 OF 4

**PROJECT** Proposed NCB5 and NCB8 Borings
**FILE NO.** 10-13-0228
**CLIENT** Canaveral Port Authority
**ELEVATION** 0.0 feet (MLW)
**BORING LOCATION** N 1,484,468; E 777,034
**BORING TYPE**
**COUNTY** Brevard **STATE** Florida
**CASING TYPE**
**DATE STARTED** 10/28/10 **COMPLETED** 10/29/10
**DRILLER/RIG** Tindall, Donnie / Barge/CME 45
**WATER TABLE ATD:** -- **DATE** -- **TIME** --
**WATER TABLE AD:** -- **DATE** -- **TIME** --
**REMARKS**

| Elevation | Depth (ft) | Standard Penetration Test ASTM D-1586: Blows/ 6 in | N Value | Sample Number | Lab Data: NM (%) | -200 (%) | LL (%) | PI (%) | Dry Den. (pcf) | Su (UU) (psf) | Soils Descriptions and Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | WATER |
| -5.0 | 5 | 2-2-2 | 4 | 1 | 42.2 | 34.6 | | | | | Greenish gray silty fine sand (SM) |
| | | 1-2-1 | 3 | 2 | | | | | | | Greenish gray silty fine sand (SM) with few shell |
| | | 1-1-2 | 3 | 3 | | | | | | | Greenish gray clayey fine sand (SC) with few shell |
| -10.0 | 10 | 2-2-2 | 4 | 4 | 48.6 | 39.4 | 36 | 16 | | | Greenish gray clayey fine sand (SC) |
| | | 1-0-1 | 1 | 5 | | | | | | | |
| | | 1-2-3 | 5 | 6 | | | | | | | Greenish gray silty clayey fine sand (SM/SC) with few shell |
| | | 3-2-3 | 5 | 7 | | | | | | | |
| -15.0 | 15 | | | | | | | | | | |
| | | 4-3-1 | 4 | 8 | 41.3 | 5.1 | | | | | Greenish gray fine sand with silt (SP-SM) |
| -20.0 | 20 | | | | | | | | | | |
| | | 2-3-7 | 10 | 9 | | | | | | | Brown silty fine sand (SM) with some shell |
| -25.0 | 25 | | | | | | | | | | |
| | | 7-12-14 | 26 | 10 | | | | | | | Greenish gray silty fine sand (SM) with trace shell |
| -30.0 | 30 | | | | | | | | | | |
| | | 6-5-3 | 8 | 11 | 51.0 | 46.6 | | | | | Greenish gray silty fine sand (SM) |
| -35.0 | 35 | | | | | | | | | | |

Figure 3-3 Test Boring TH-FFB4 at North Cargo Berth 8

**Ardaman & Associates, Inc.**

# BORING LOG

**BORING NO:** TH-FFB4
**TOTAL DEPTH:** 114.3 ft.
**SHEET** 2 OF 4

**PROJECT** Proposed NCB5 and NCB8 Borings
**CLIENT** Canaveral Port Authority
**BORING LOCATION** N 1,484,468; E 777,034
**FILE NO.** 10-13-0228
**ELEVATION** 0.0 feet (MLW)
**BORING TYPE**

| Elevation | Depth (ft) | Standard Penetration Test ASTM D-1586: Blows/ 6 in | N Value | Sample Number | Lab Data: NM (%) | -200 (%) | LL (%) | PI (%) | Dry Den. (pcf) | Su (UU) (psf) | Soils Descriptions and Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Greenish gray silty fine sand (SM) *(continued)* |
| | | 2-4-1 | 5 | 12 | | | | | | | |
| -40.0 | 40 | | | | | | | | | | Mostly Shell |
| | | 1-0-1 | 1 | 13 | | | | | | | |
| -45.0 | 45 | | | | | | | | | | |
| | | 6-9-4 | 13 | 14 | 36.4 | 38.5 | | | | | Greenish gray clayey fine sand (SC) with trace shell |
| -50.0 | 50 | | | | | | | | | | |
| | | 5-6-7 | 13 | 15 | | | | | | | |
| -55.0 | 55 | | | | | | | | | | |
| | | 4-5-5 | 10 | 16 | | | | | | | |
| -60.0 | 60 | | | | | | | | | | Mostly Shell |
| | | 3-5-4 | 9 | 17 | | | | | | | |
| -65.0 | 65 | | | | | | | | | | |
| | | 3-4-4 | 8 | 18 | | | | | | | |
| -70.0 | 70 | | | | | | | | | | Light greenish gray clayey fine sand (SC) with little shell |

Figure 3-3 (cont.) Test Boring TH-FFB4 at North Cargo Berth 8 Page 2 of 4

**Ardaman & Associates, Inc.**

# BORING LOG

**BORING NO:** TH-FFB4
**TOTAL DEPTH:** 114.3 ft.
**SHEET** 3 OF 4

**PROJECT** Proposed NCB5 and NCB8 Borings
**CLIENT** Canaveral Port Authority
**BORING LOCATION** N 1,484,468; E 777,034
**FILE NO.** 10-13-0228
**ELEVATION** 0.0 feet (MLW)
**BORING TYPE**

| Elevation | Depth (ft) | Standard Penetration Test ASTM D-1586: Blows/ 6 in | N Value | Sample Number | Lab Data: NM (%) | -200 (%) | LL (%) | PI (%) | Dry Den. (pcf) | Su (UU) (psf) | Soils Descriptions and Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4-5-4 | 9 | 19 | 36.2 | 40.1 | | | | | |
| -75.0 | 75 | | | | | | | | | | Light greenish gray clayey fine sand (SC) with little shell *(continued)* |
| | | 13-9-17 | 26 | 20 | | | | | | | |
| -80.0 | 80 | | | | | | | | | | Greenish gray clayey fine sand (SC) with little shell |
| | | 7-9-13 | 22 | 21 | | | | | | | |
| -85.0 | 85 | | | | | | | | | | |
| | | 12-17-7 | 24 | 22 | | | | | | | |
| -90.0 | 90 | | | | | | | | | | Gray cemented sand and shell fragments to 1-inch size, calcareous, phosphatic |
| | | 6-7-9 | 16 | 23 | | | | | | | |
| -95.0 | 95 | | | | | | | | | | |
| | | 4-5-6 | 11 | 24 | 27.2 | 36.4 | | | | | |
| -100.0 | 100 | | | | | | | | | | Greenish gray clayey fine sand (SC) |
| | | 4-4-6 | 10 | 25 | | | | | | | |
| -105.0 | 105 | | | | | | | | | | |
| | | 13-29-16 | 45 | 26 | | | | | | | Gray cemented sand and shell fragments to 1/2-inch size, calcareous, phosphatic |
| -110.0 | 110 | | | | | | | | | | |

Figure 3-3 (cont.) Test Boring TH-FFB4 at North Cargo Berth 8 Page 3 of 4

**Ardaman & Associates, Inc.**

# BORING LOG

**BORING NO:** TH-FFB4
**TOTAL DEPTH:** 114.3 ft.
**SHEET** 4 OF 4

**PROJECT** Proposed NCB5 and NCB8 Borings
**CLIENT** Canaveral Port Authority
**BORING LOCATION** N 1,484,468; E 777,034
**FILE NO.** 10-13-0228
**ELEVATION** 0.0 feet (MLW)
**BORING TYPE**

| Elevation | Depth (ft) | Standard Penetration Test ASTM D-1586: Blows/ 6 in | N Value | Sample Number | Lab Data: NM (%) | -200 (%) | LL (%) | PI (%) | Dry Den. (pcf) | Su (UU) (psf) | Soils Descriptions and Remarks | Depth (ft) | Graphic Log |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15-22-27 | 49 | 27 | | | | | | | Gray cemented sand and shell fragments to 1/2-inch size, calcareous, phosphatic *(continued)* | | |
| | | | | | | | | | | | BORING TERMINATED AT 114.3 FEET BELOW GROUND SURFACE. | | |

Figure 3-3 (cont.) Test Boring TH-FFB4 at North Cargo Berth 8 Page 4 of 4

Figure 3-4 North Cargo Berth 8 Pile Driving and Preliminary PDM Testing

### 3.1.2 Baldwin Bypass

The Google Earth Pro image shown in Figure 3-5 depicts an overview of the Baldwin Bypass. At this site all the prestressed concrete piles were PDA instrumented and tested. Our research team used the Inopiles PDM and CMS equipment to monitor Pile 1 at End Bent 4 northbound during extremely poor weather conditions. Figure 3-6 shows Baldwin Bypass End Bent 4 North and South Bound Pile Installation Plan while Figure 3-7 is a photo of the PDA/PDM/CMS testing. Rebound occurred during driving from approximately 40 to 48 feet. Note that the PDM equipment failed to produce data at this site and that the weather conditions were extremely poor with heavy rains all during testing. Figure 3-8 is the associated test boring (21A) near the test pile.

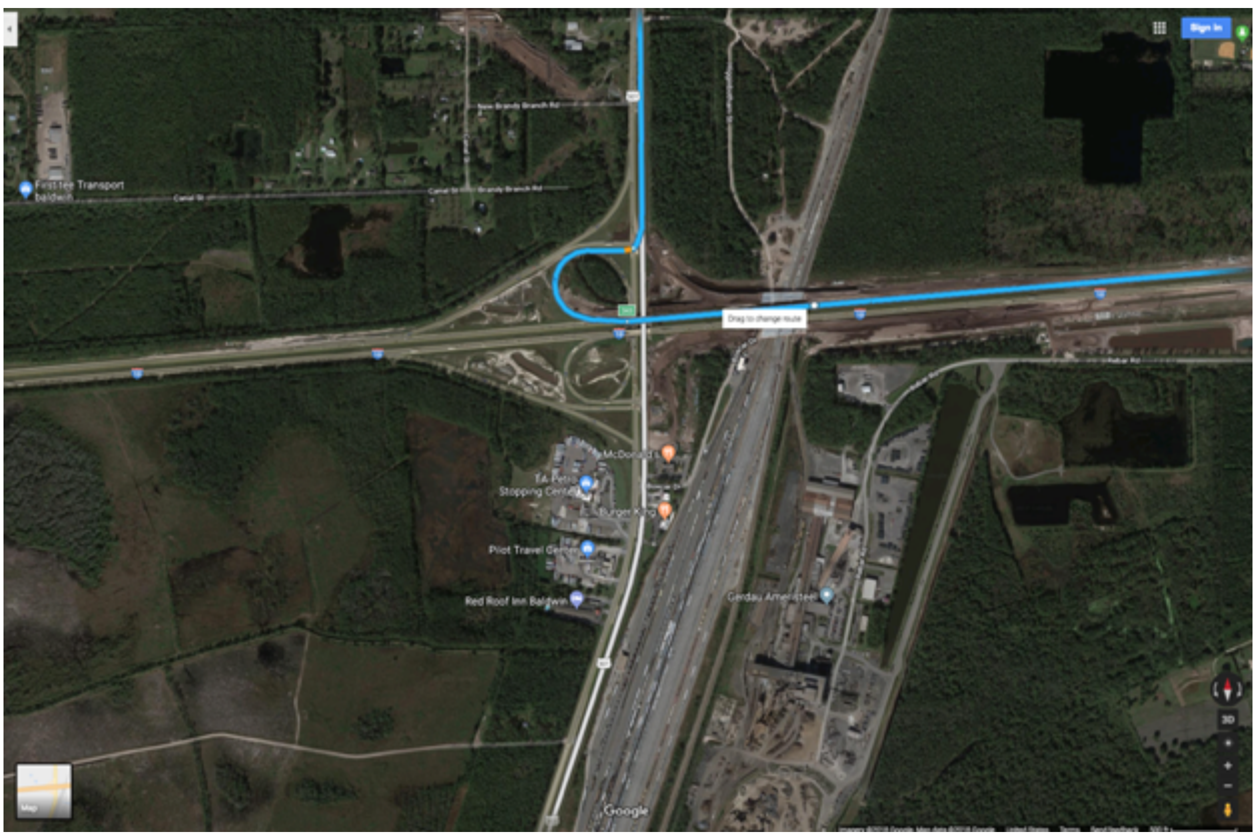



Figure 3-5 Google Earth Pro® Image of Baldwin Bypass over the CSX North-South Railroad and I-10

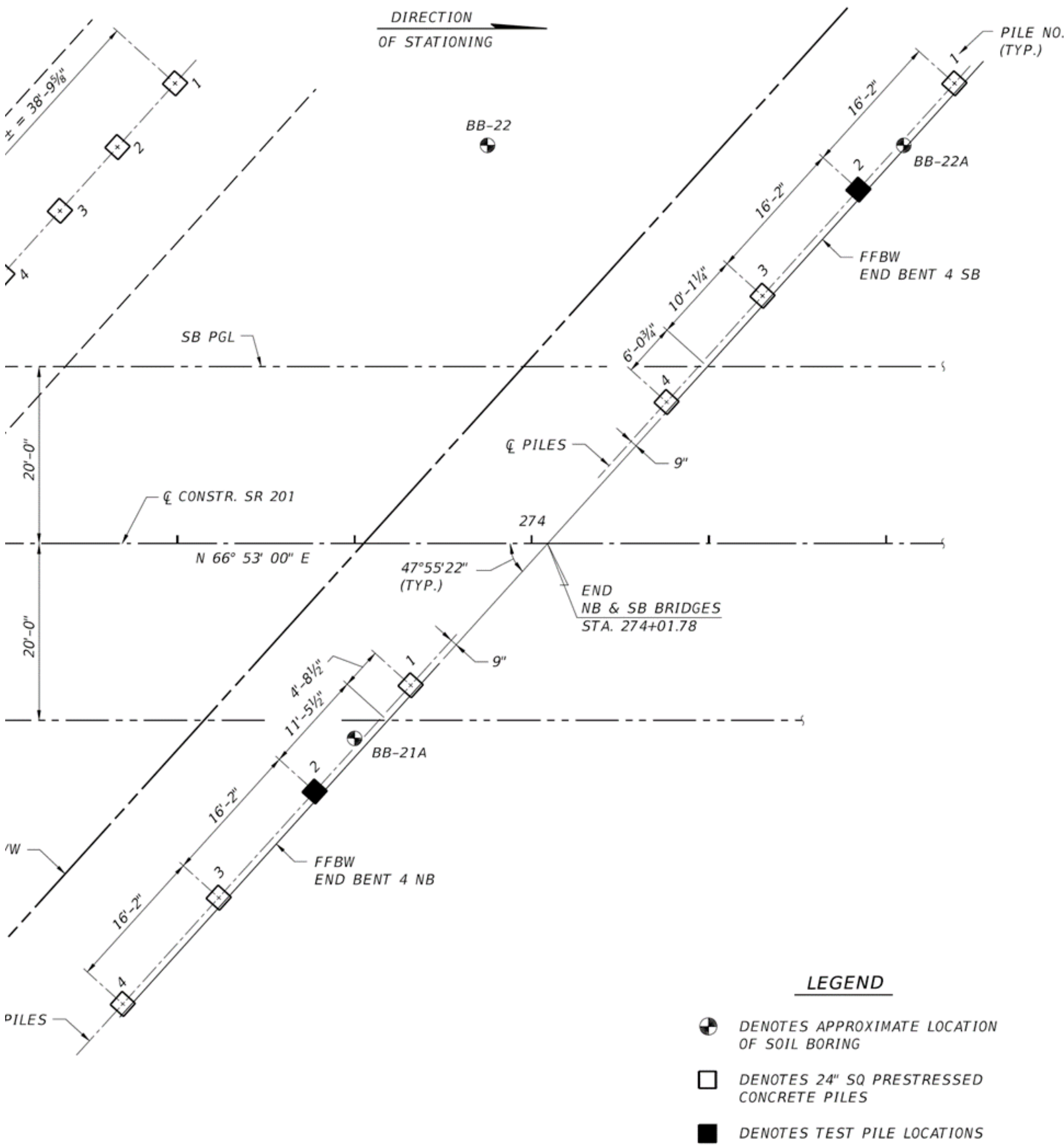



Figure 3-6 Baldwin Bypass End Bent 4 North and South Bound Pile Installation Plan, Note All Piles PDA Dynamic Testing Piles

Figure 3-7 Photo of Baldwin Bypass North Bound End Bent 4 Pile 1

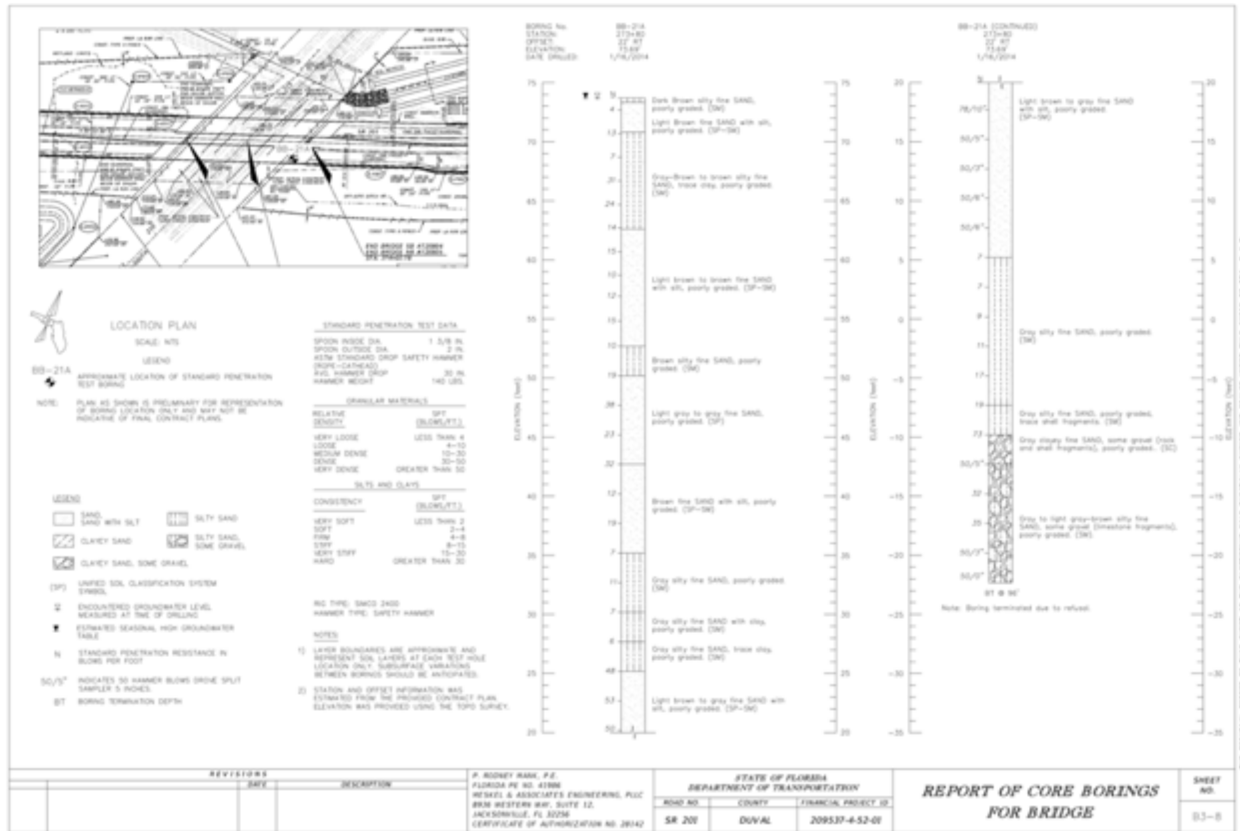



Figure 3-8 Baldwin Bypass Test Boring 21A near Pile 1 End Bent 4

### 3.1.3 Dunns Creek

One test pile and one SPT test were monitored at Duns Creek with both PDM and CMS equipment. Pile 10 at Pier 4 was the monitored test pile, while the SPT that was monitored was placed about 50 feet from its location. Figure 3-9 is a Google Earth Pro image of the Dunns Creek testing region. Figure 3-10 is a foundation plan near station 436+37, while Figure 3-11 is the test boring (BR-3) associated with the test pile. Pile rebound in the 1 to 1.5-inch range occurred throughout Dunns Creek at depths between about 65 and 80 feet.


Figure 3-9 Google Earth Pro® Image of SR-15 (US-17) Over Dunns Creek Testing Region

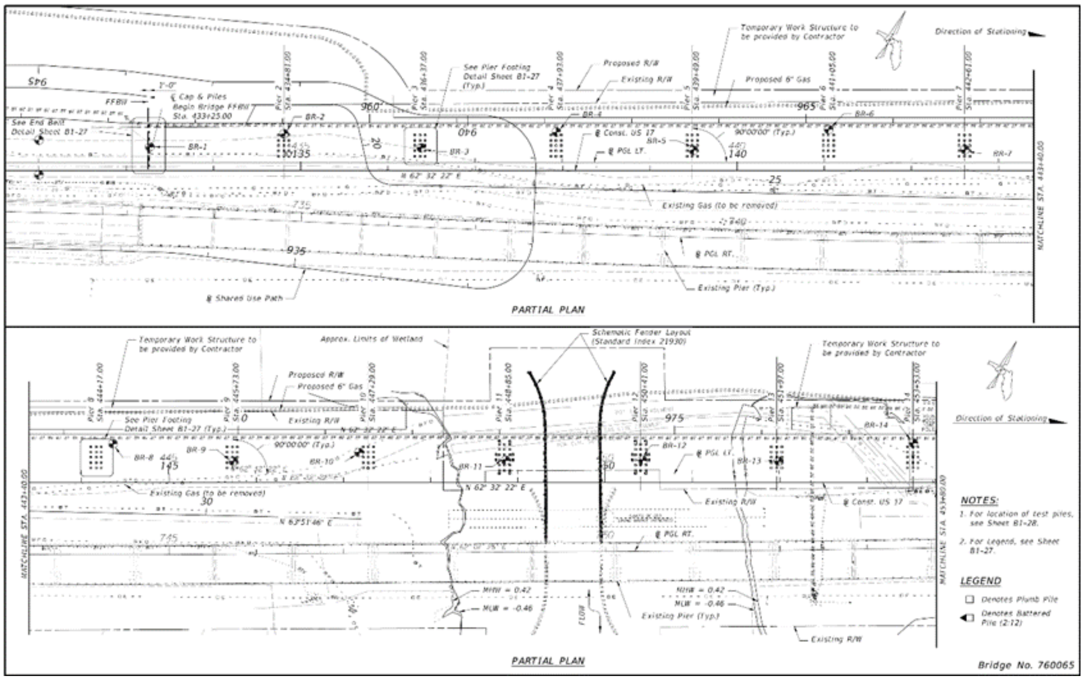


Figure 3-10 Dunns Creek Testing Region near Station 436+37

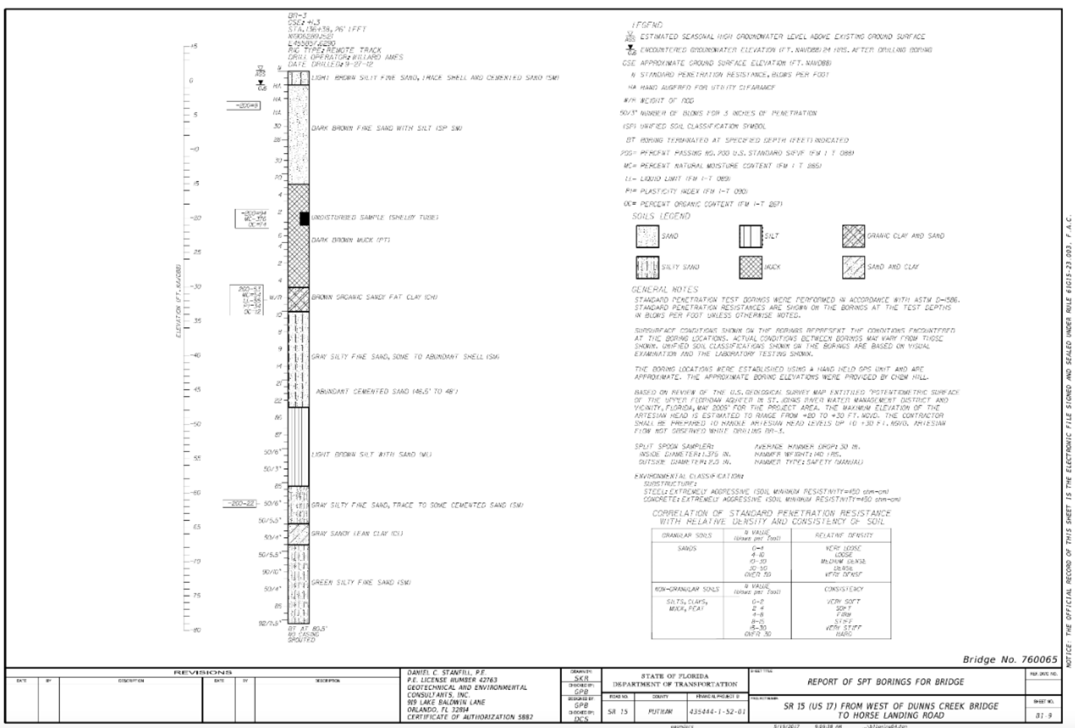


Figure 3-11 Dunns Creek SPT BR-3 Test Boring Station 136+38

### 3.1.4 Reedy Creek

At Reedy Creek Floridian Place Extension in the Reedy Creek Improvement District (RCID) one Test Pile was monitored with both PDM and CMS equipment. The test pile was at end bent 1 pile number 12 near soil boring 6. Information from DRMP Job No. 15-0260.001 and Professional Services Industries (PSI) Inc. Project No. 07571393 was used to complete this section (PSI, 2016). No rebound was encountered during pile driving. The general site location along with the approximate bridge location are shown in Figure 3-12 and Figure 3-13. The foundation plus boring location plan is shown in Figure 3-14 , while the soil profile is depicted in Figure 3-15.

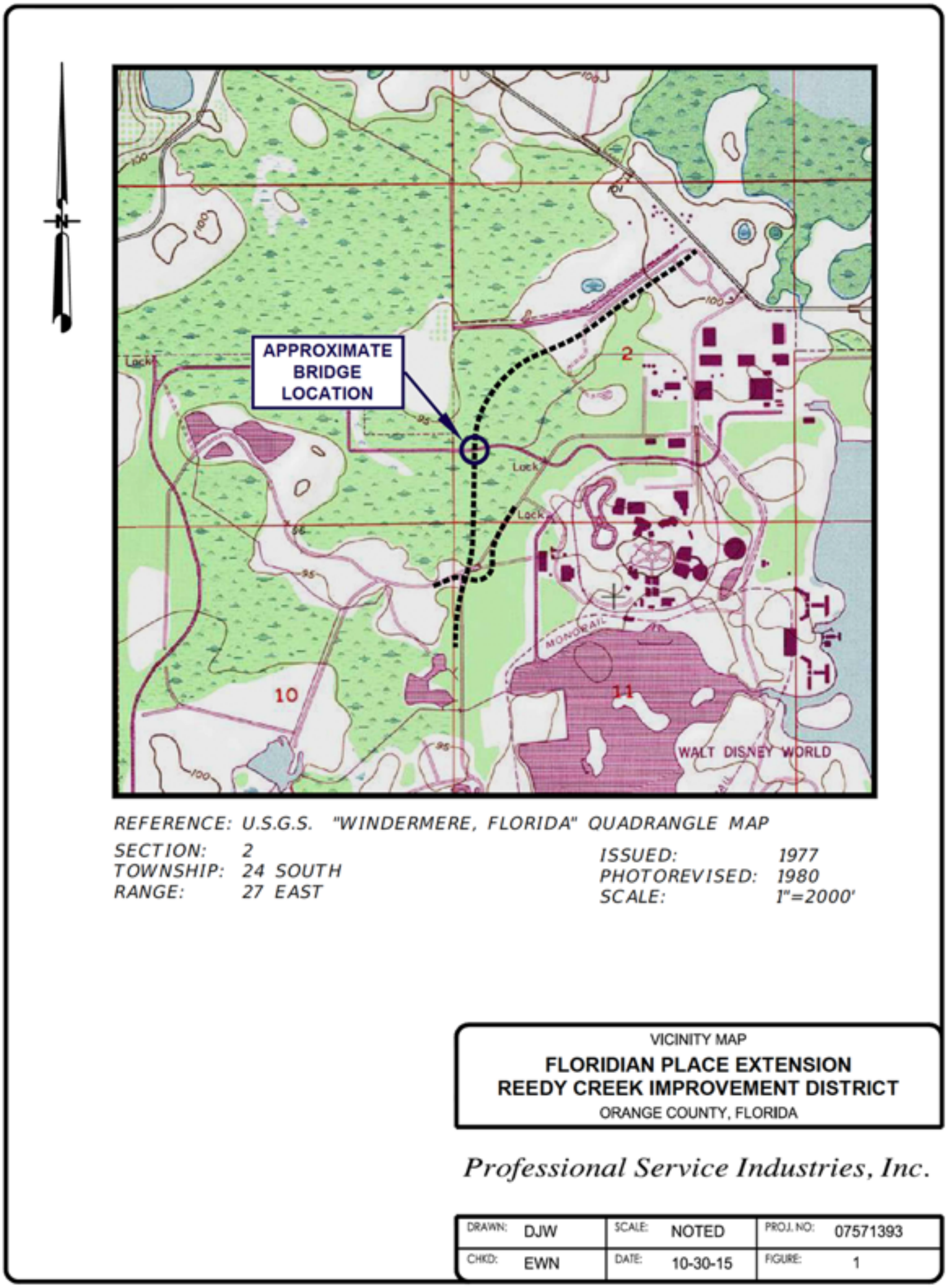



Figure 3-12 Floridian Place Extension RCID General Site Location (PSI, 2016)

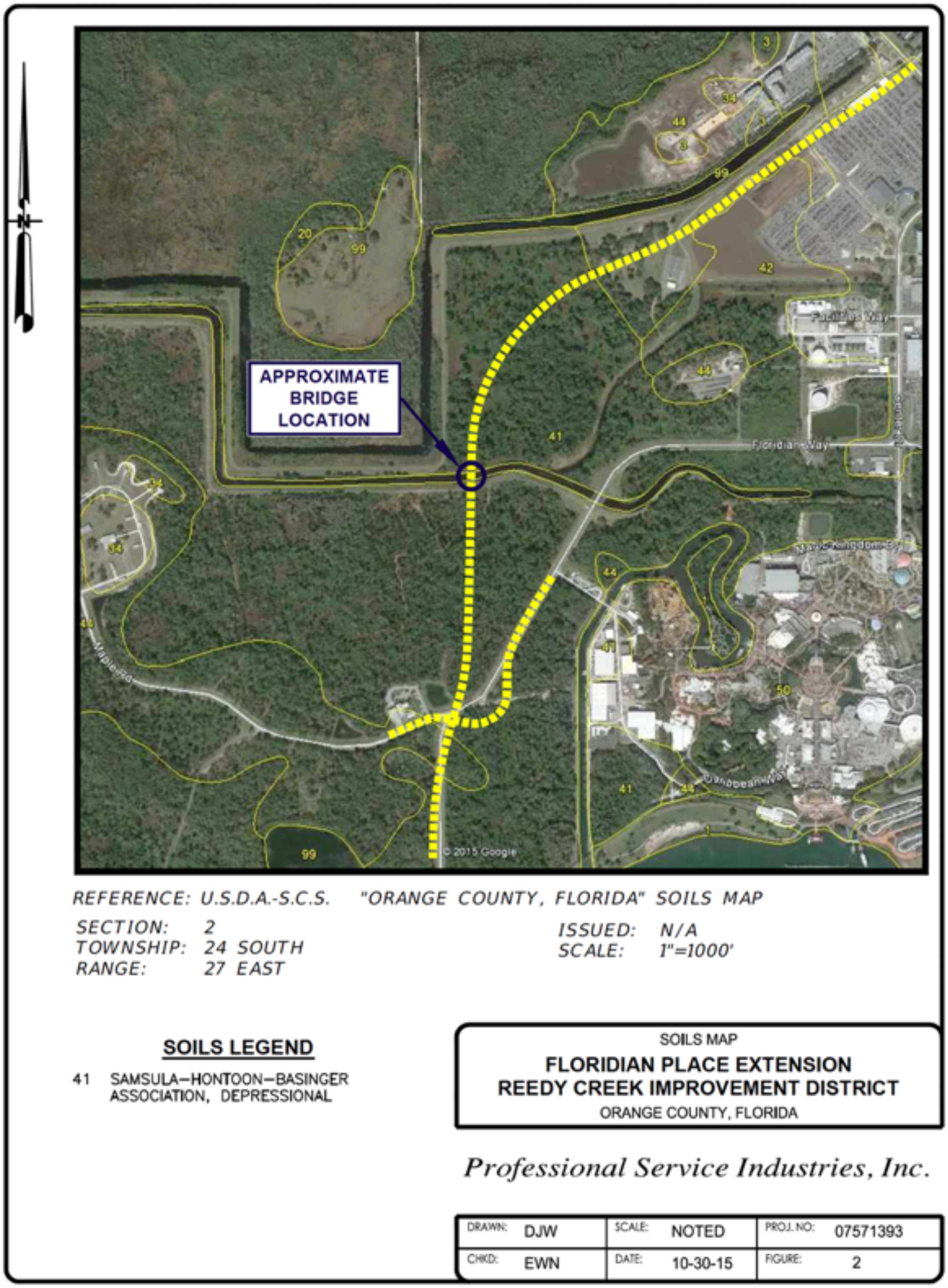



Figure 3-13 Floridian Place Extension RCID Approximate Bridge Location (PSI, 2016)

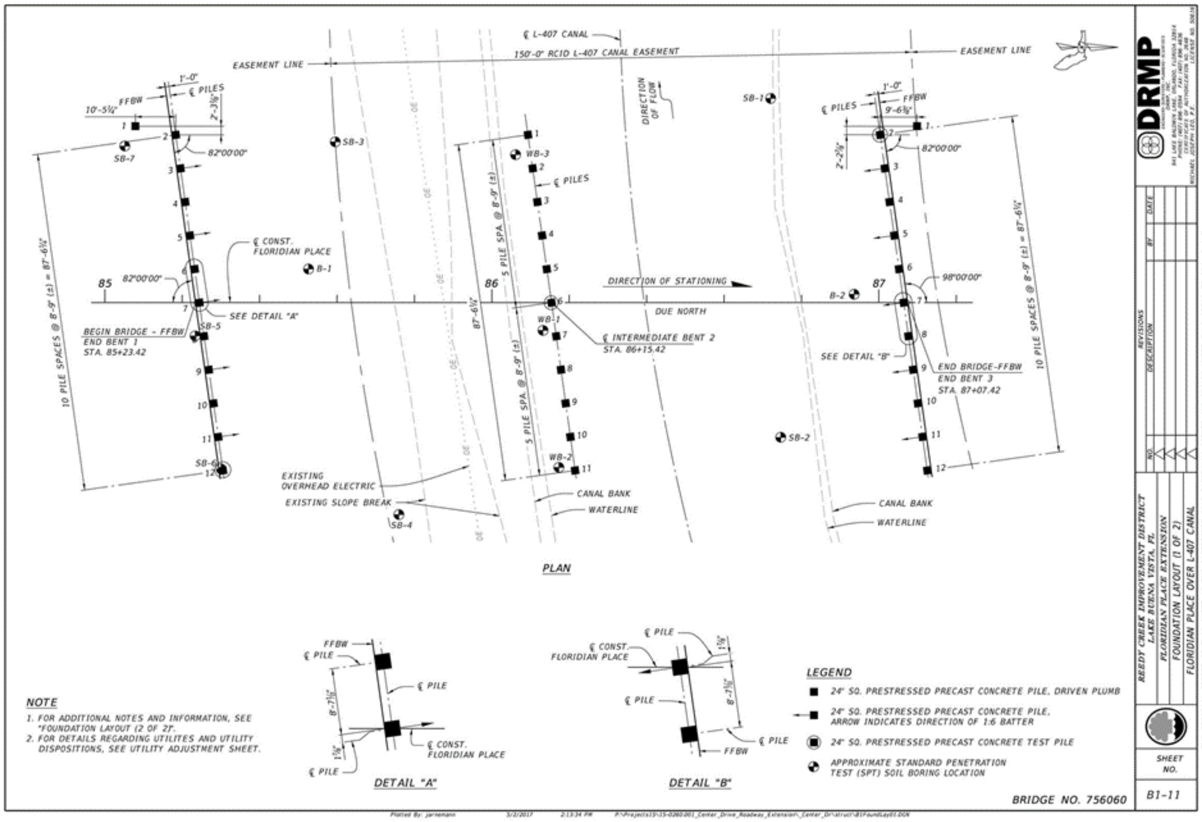



Figure 3-14 Reedy Creek Foundation and Soil Boring Location Plan

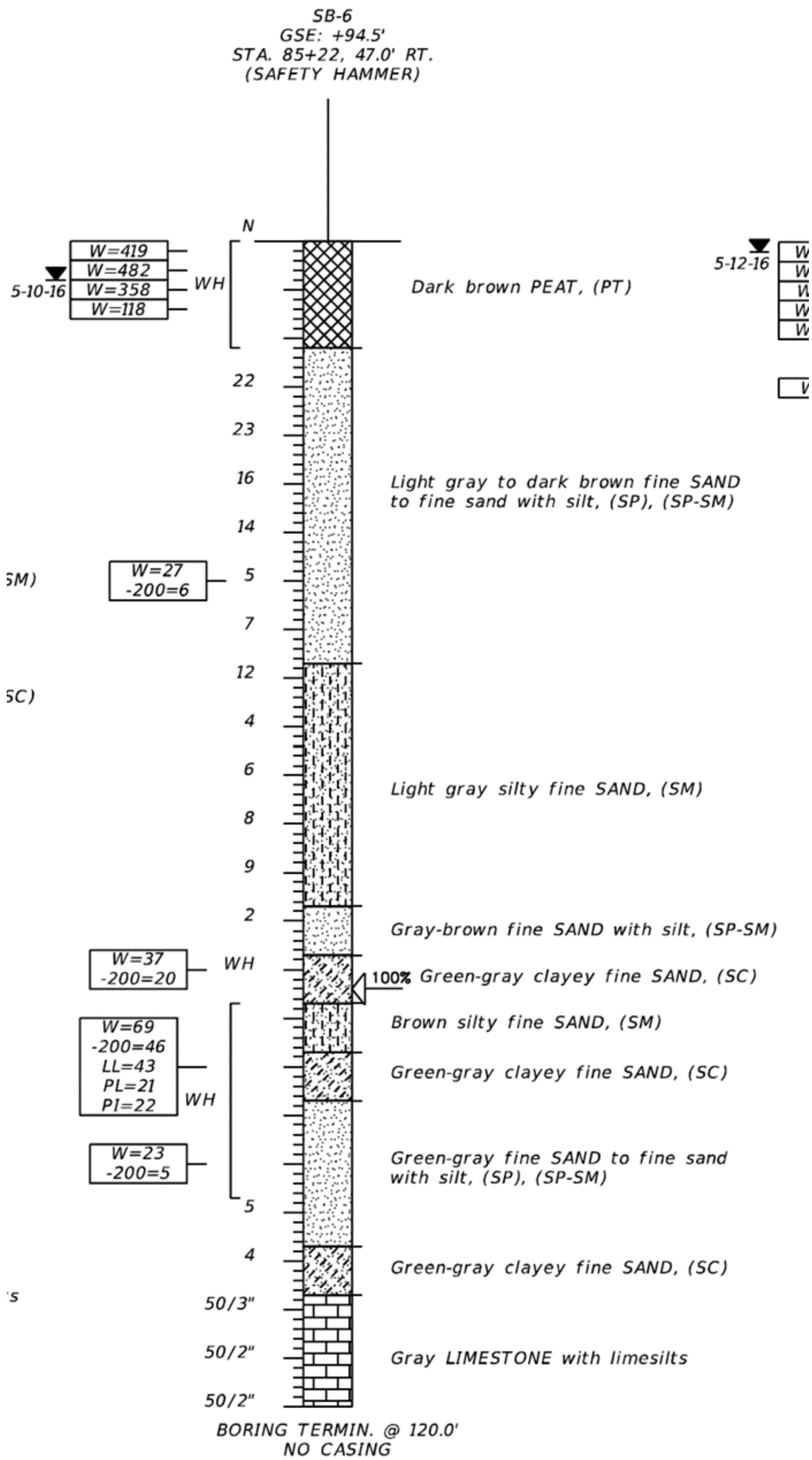


Figure 3-15 Reedy Creek Soil Boring 6 Profile

### 3.1.5 Ellis Road

Test pile 8 at bent 1 along the Ellis Road I-95 Overpass along Bridge number 700239 was monitored with both the PDM and CMS equipment. It was located at station 77+14.90 along the centerline of the roadway. There was minimal rebound in excess of 0.25 inches from approximately 25 to 32 feet, although the PDA DMX, set information indicated about 0.20 inches throughout driving. A Google Earth Pro image of the Ellis Road Overpass is shown in Figure 3-16, while the foundation plan at bents 1 through 3 is shown in Figure 3-17.


Figure 3-16 Google Earth Pro Image of Ellis Road Overpass

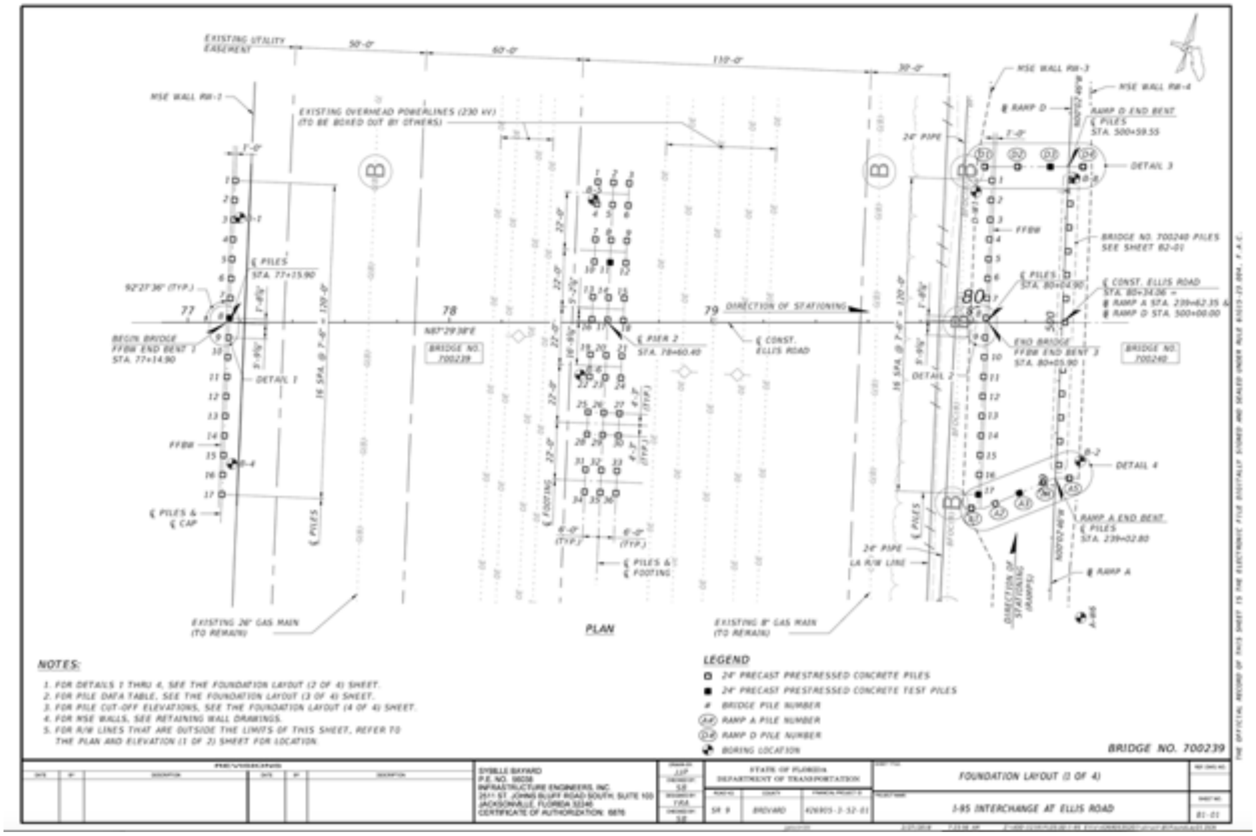



Figure 3-17 Ellis Road Overpass Bridge 700239 Foundation Plan at Bents 1 through 3

Two nearby test borings (B-1 & B-4) are shown in the vicinity of pile 8 in Figure 3-18 and Figure 3-19. Figure 3-20 shows a photograph of the test pile.

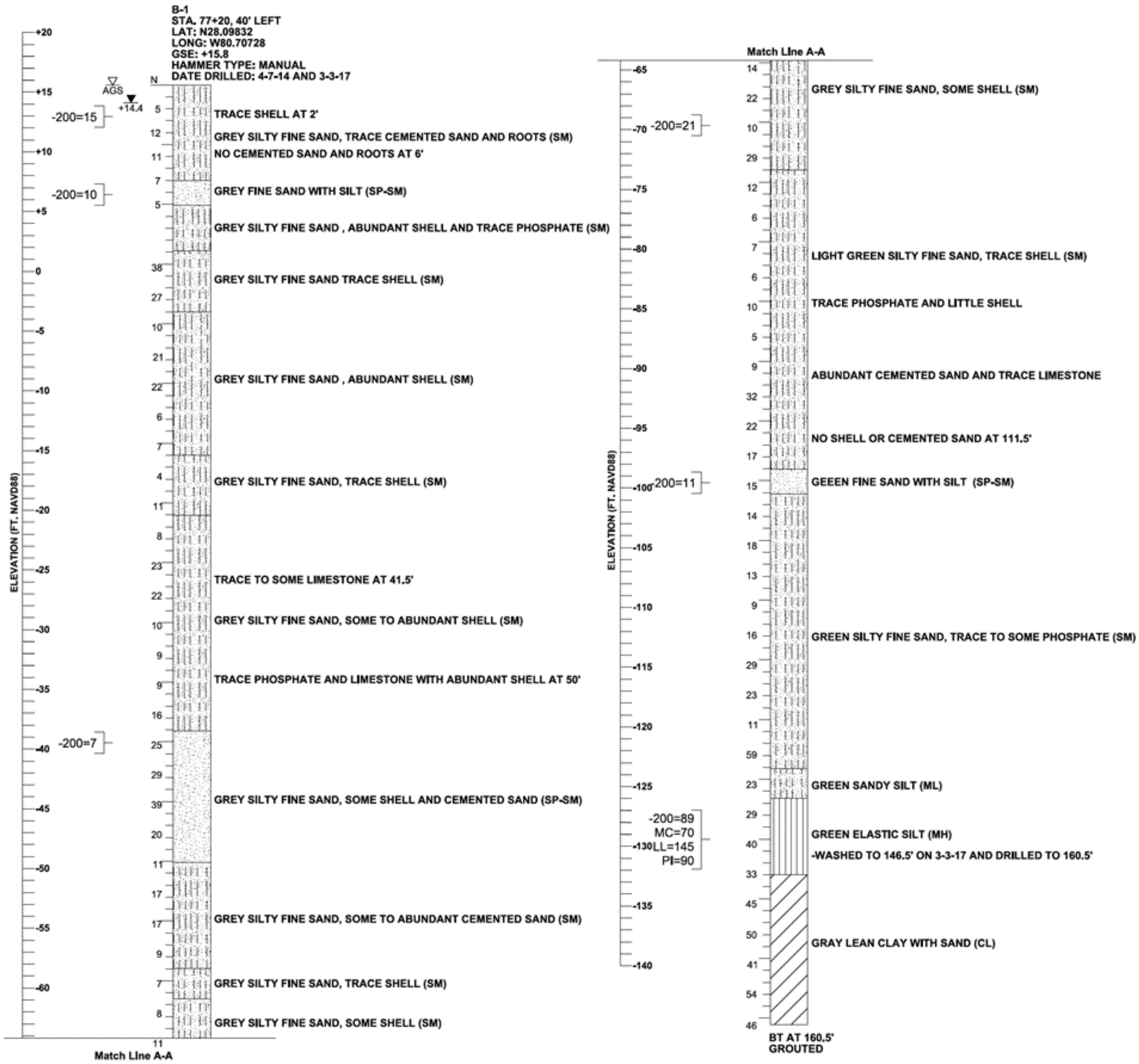



Figure 3-18 Ellis Road Overpass Boring B-1 40 feet left of Test Pile 8

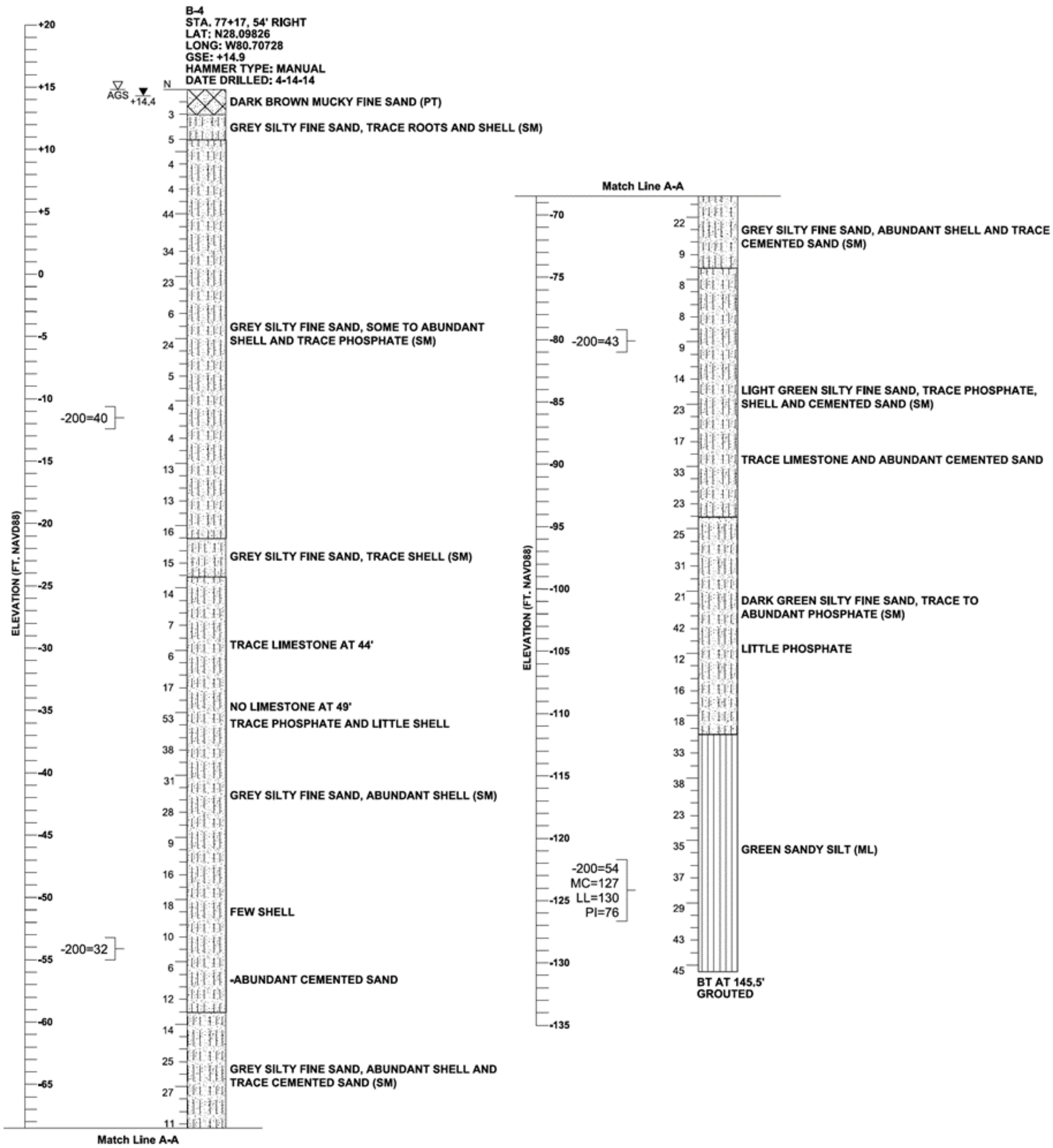



Figure 3-19 Ellis Road Overpass Boring B-4 54 feet right of Test Pile 8

Figure 3-20 Photo of Ellis Road Overpass Test Pile 8 at Bent 1

### 3.1.6 Wekiva Parkway

Three different locations were tested at Wekiva Parkway. A significant amount of rebound occurred during installation of the test piles. A Google Earth Pro image of the site which also depict the testing locations is shown in Figure 3-21.Two locations had SPT Borings videoed and monitored with the PDM plus CMS while the third had the CMS videoed on a test pile. A Google Earth Pro image of the CMS test plie location is shown in Figure 3-22. The test pile was located at bridge 110118 pier 8 PDA test pile 1 at station 919+95.19 (See Figure 3-23). The two SPT locations were at WLC 2 Station 833+33.1 near test pile 3 at bent 37 and WLC 3 Bridge 110113 near station 1239+20.05 at end bent 2.

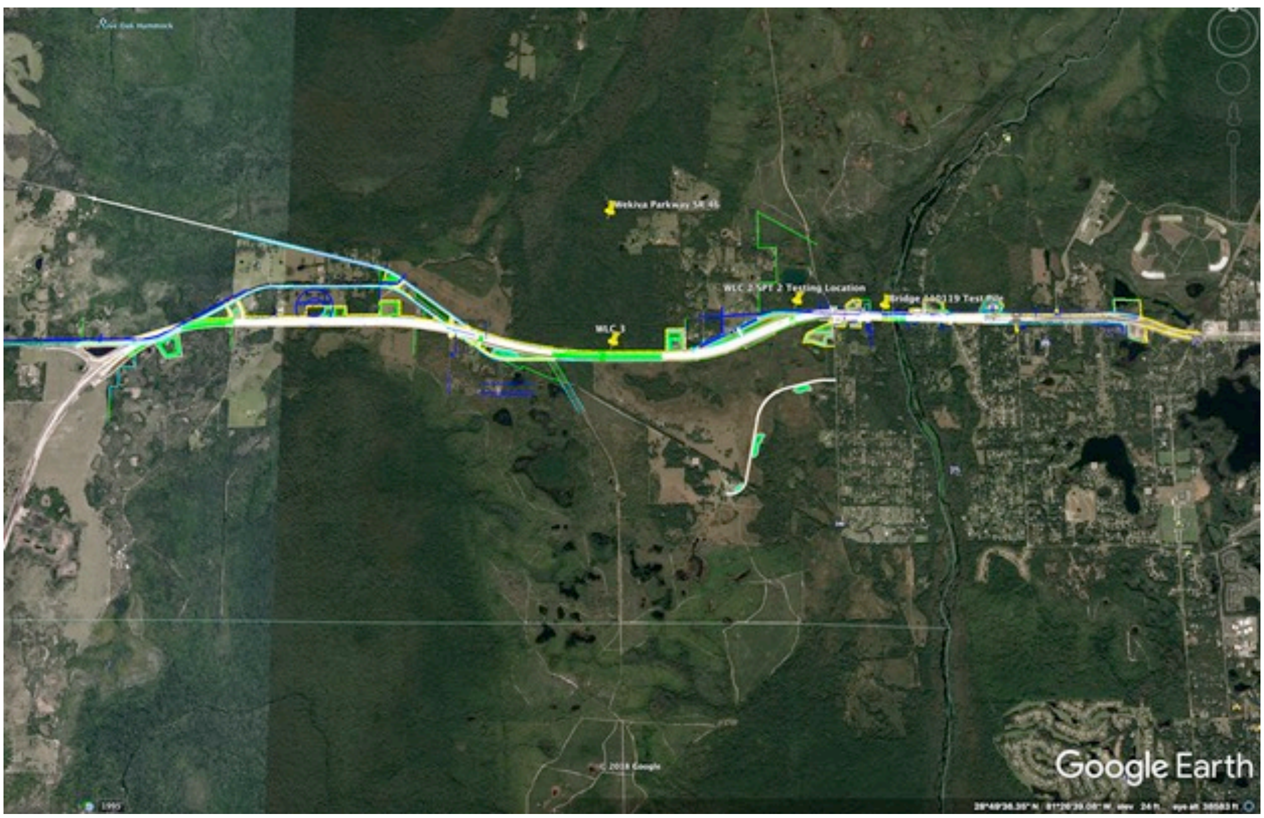



Figure 3-21 Google Earth Pro® Image of Wekiva Parkway SR-46 Improvement

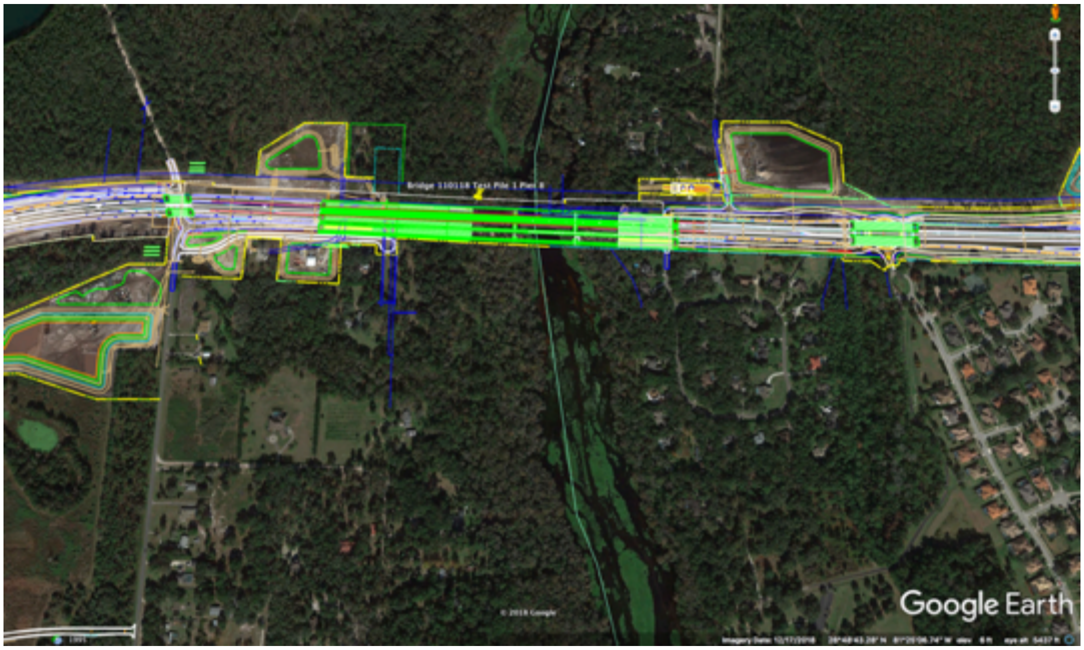



Figure 3-22 Google Earth Pro® Image of Wekiva Bridge 110118 Pier 8 Pile 1Testing Region used for CMS Evaluation

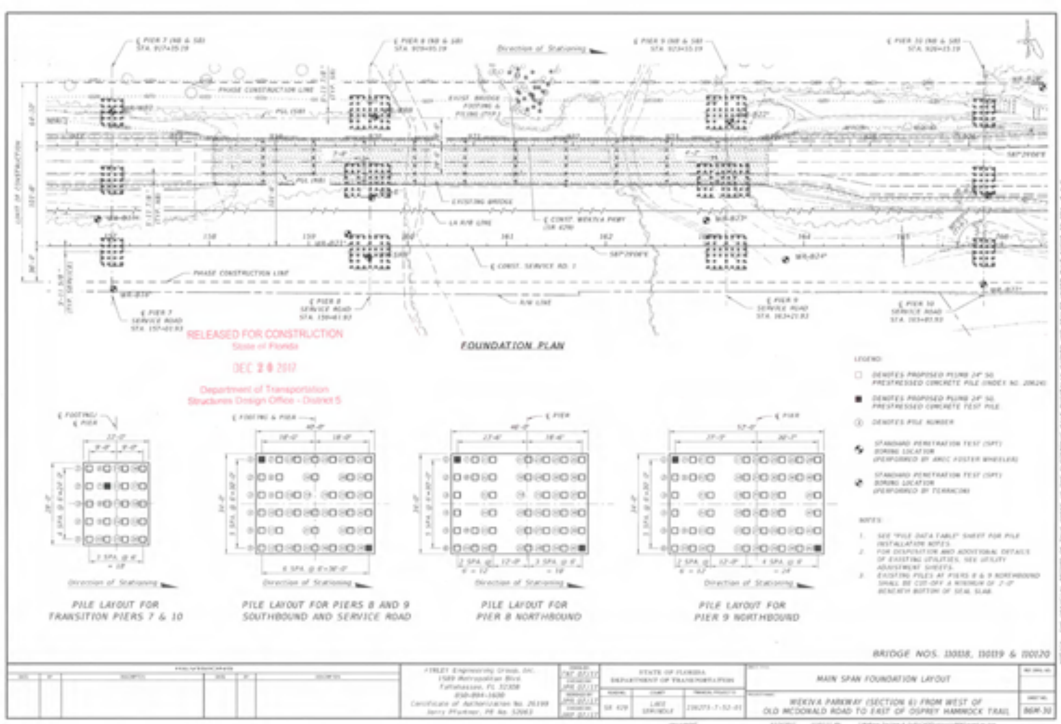



Figure 3-23 Wekiva Bridge 110118 Detailing Pier 8 PDA Test Pile 1 Layout at Station 919+95.19


Figure 3-24 Wekiva Bridge 110118 Test Boring WR-WB8 at Station 919+95.19

Figure 3-25 Photo of Wekiva Bridge 110118 Pier 8, Test Pile 1 with black paint for CMS Evaluation

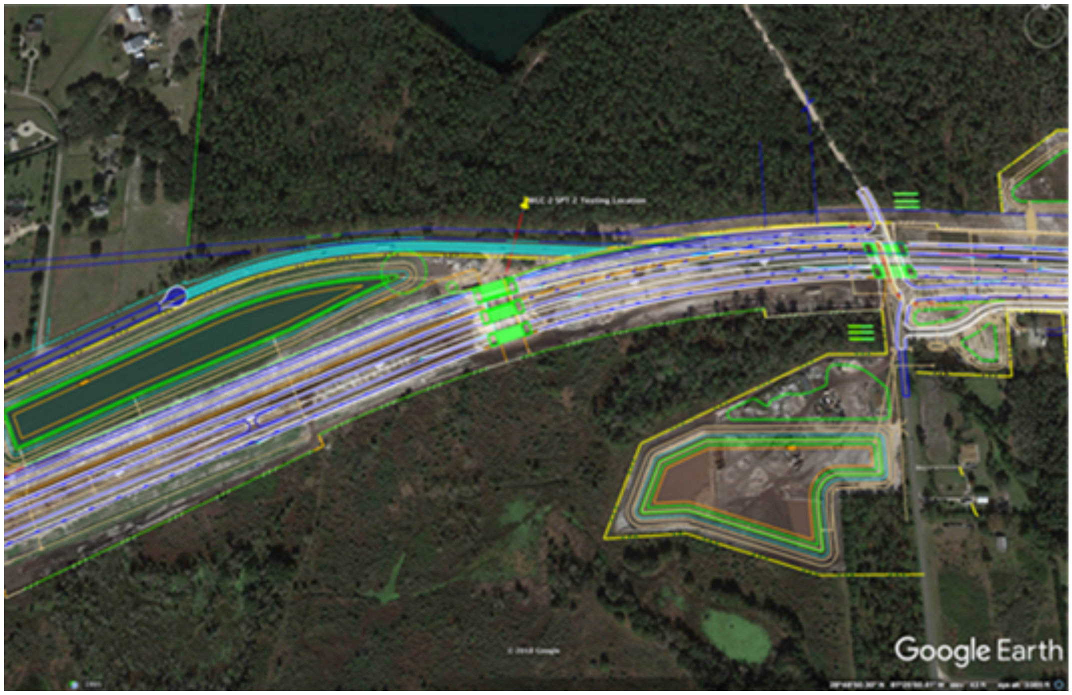



Figure 3-26 Google Earth Pro® Image of Wekiva Parkway WLC 2 SPT/PDM/CMS Testing Region

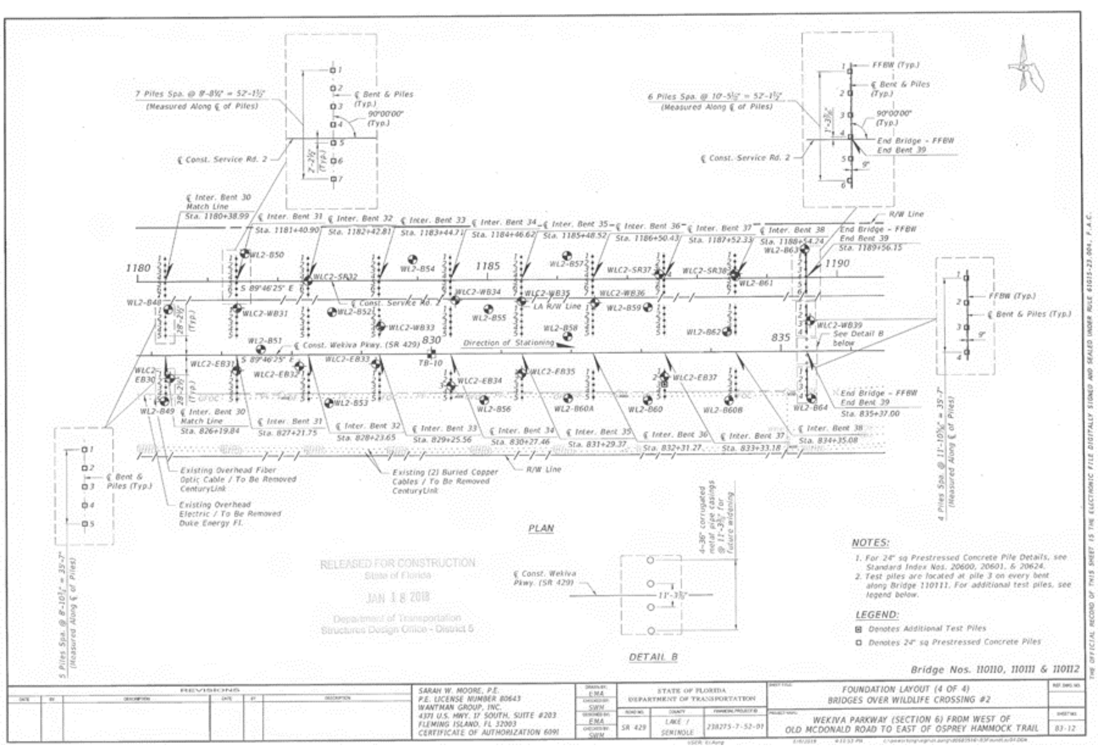



Figure 3-27 Wekiva Parkway Pile and SPT/PDM/CMS Test Boring Plan at WLC 2

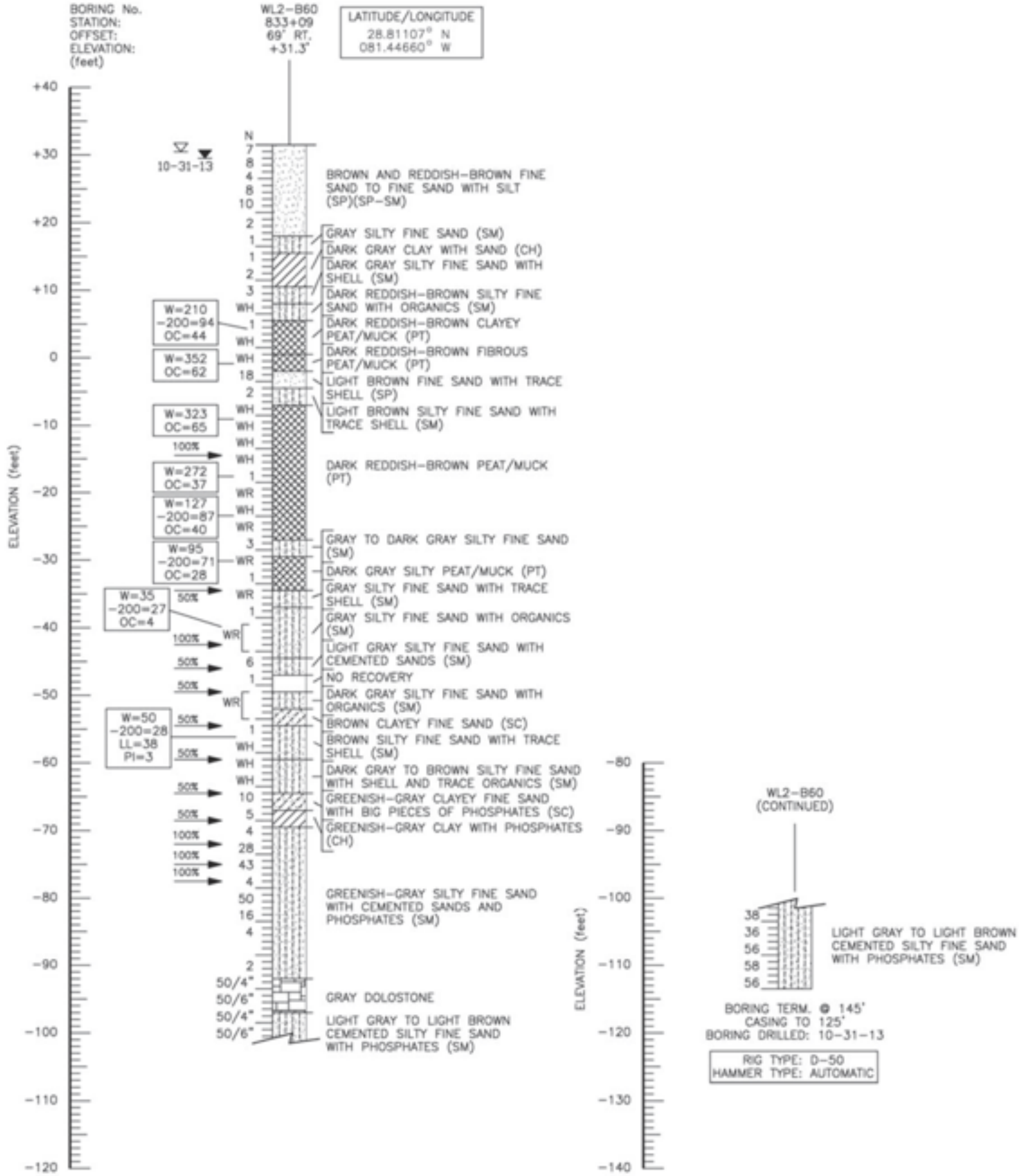



Figure 3-28 Wekiva Parkway WLC 2 Test Boring SPT/PDM/CMS WL2-B60 Station 833+09

Figure 3-29 Photo of FDOT SMO Drill Rig used for SPT/PDM/CMS WLC 2 near Station 833+09 testing

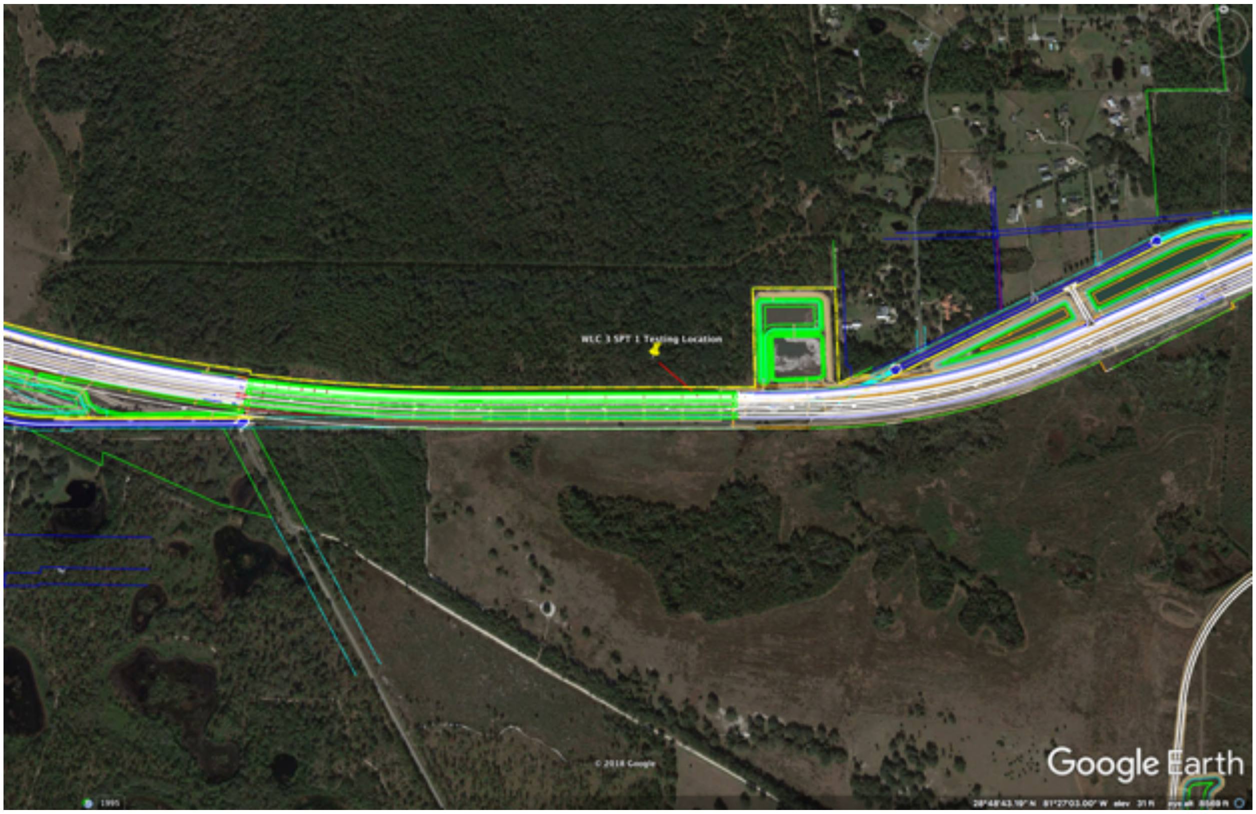



Figure 3-30 Google Earth Pro® Image of Wekiva Parkway WLC 3 SPT/PDM/CMS Testing Region near Station 1239+20

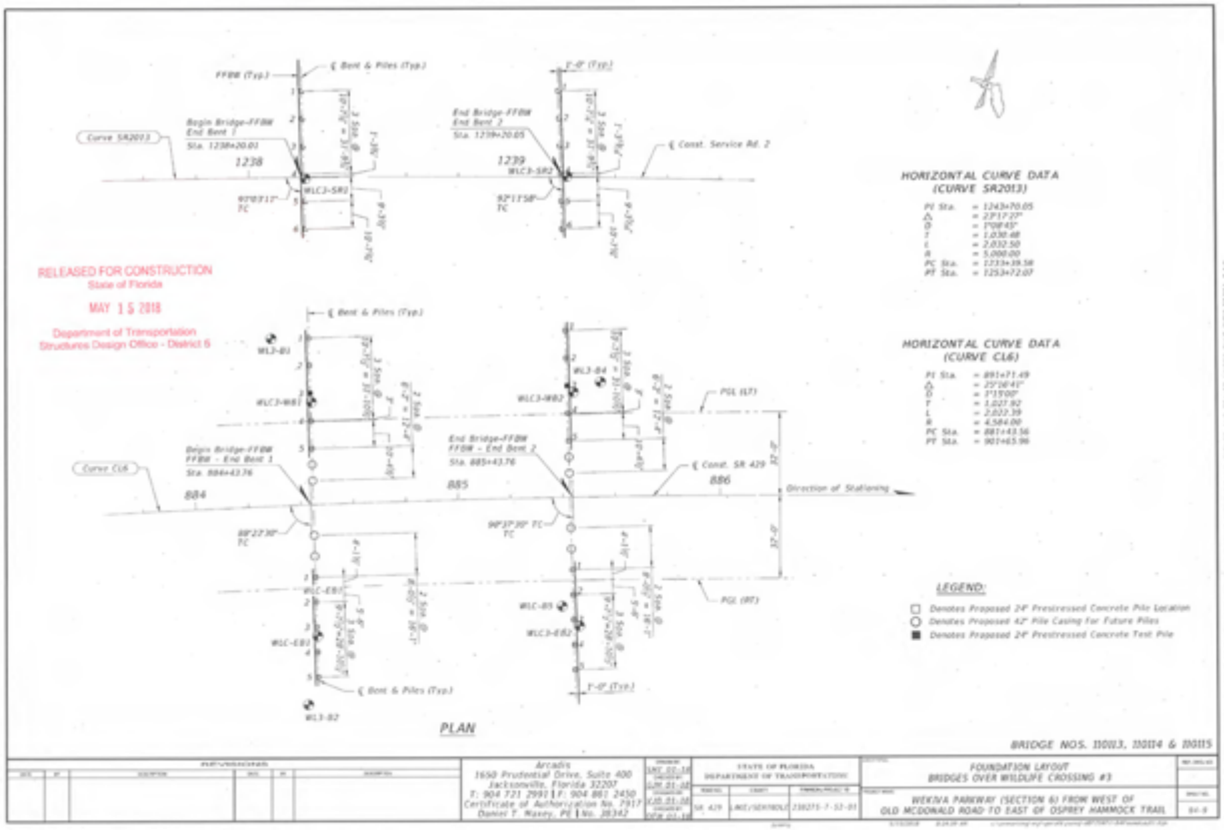


Figure 3-31 Wekiva Parkway WLC 3 SPT/PDM/CMS Testing Region near Station 1239+20

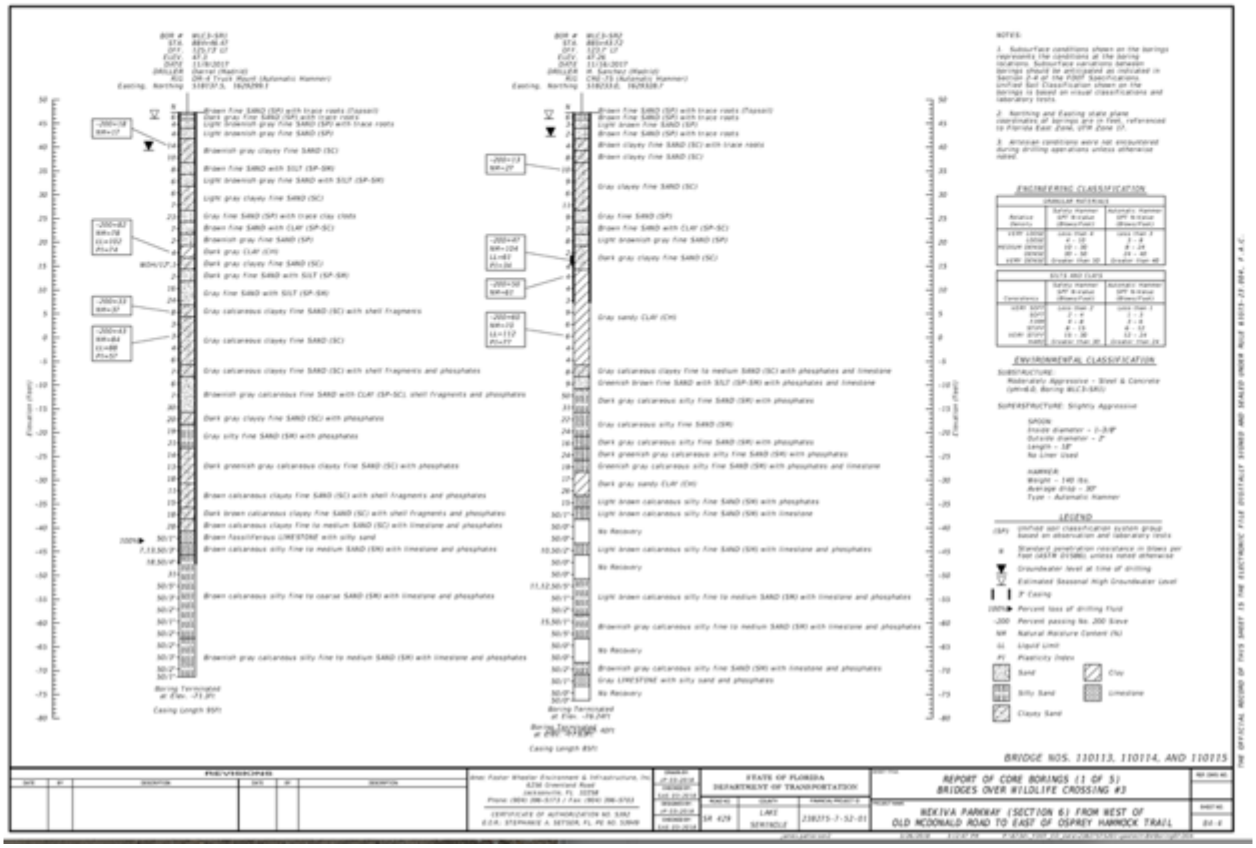


Figure 3-32 Wekiva Parkway WLC 3 SPT/PDM/CMS Test Boring WLC3-SR 2 near Station 1239+20

Figure 3-33 Photo of FDOT SMO Drill Rig used for SPT WLC 3 near Station 1239+20 testing

### 3.1.7 Summary

In summary, the research team with cooperation from Patrick Hammond Project Manager of the Canaveral Port Authority, was able to conduct preliminary PDM tests on two PCP piles at North Cargo Berth 8, in Port Canaveral. This preliminary work allowed the team to subsequently conduct tests at four FDOT projects (Baldwin Bypass, Dunns Creek, Wekiva Parkway, and Ellis Road Overpass) along with the Reedy Creek site, which we coordinated through Herb Raybourn the Manager of Disney's Environmental Permitting Department. Not only were PDA instrumented test piles evaluated, but SPT drill rods were also evaluated at three locations within two of the sites (Dunns' Creek and Wekiva Parkway). The research team was also able to collect the required site information from all six locations.

GRL Engineers, Inc., PDA data was collected at the Baldwin Bypass, Dunns Creek, Ellis Road Overpass, and Reedy Creek sites, while Smart Pile PDA data was obtained from the Wekiva Parkway site. PDM data collection were attempted on all sites; however, equipment problems prevented successful collection at Baldwin Bypass. CMS data were successfully collected at all sites when it was deployed.

## 3.2 Visco-elastic Evaluation Sites

Five sites in Florida were evaluated using Pile Driving Analyzer (PDA), Standard Penetration Tests (SPT), and CT Tests. Figure 3-34 shows the site location. One site (Osceola Parkway) was evaluated only using CT Tests due to the lack of data. The sites include:

- SR-417 & International Parkway (417 & International), located in Seminole County;
- Saint John's Heritage Parkway (Heritage Pkwy) in Brevard County;
- I-10 & Chaffee Road (Chaffee Rd) in Duval County;
- Osceola Parkway (Osceola) in Osceola County;
- I-4 & US-192 (I-4 & 192) in Osceola County and
- Ramsey Branch in Walton County.


Figure 3-34 Site locations

The list of tests performed at each location is presented in Table 3-2. It indicates that CT tests were conducted at all six sites, while PDA and SPT data were obtained from four of those sites.

Table 3-2 Test Sites Evaluated

| Site | PDA Test | SPT Test | CT Test |
|---|---|---|---|
| SR 417 & International Parkway | | | ✓ |
| Saint John's Heritage Parkway | ✓ | ✓ | ✓ |
| I10 & Chaffee Road | ✓ | ✓ | ✓ |
| I4 - US192 | ✓ | ✓ | ✓ |
| Ramsey Branch | ✓ | ✓ | ✓ |
| I-4 Osceola Parkway | | | ✓ |

An overview of SPT borings ground surface or beginning and end elevations is given in Table 3-3.Thirteen test borings were completed for five of the six sites.

Table 3-3 SPT Borings Description

| Site | SPT Boring Designation | Ground Surface Elevation (ft) | Boring Termination Elevation (ft) |
|---|---|---|---|
| 417 & International | B-1 | 72.3 | -22.7 |
| 417 & International | B-2 | 72.3 | -17.7 |
| 417 & International | PD&EB1 | 75.5 | -19.5 |
| 417 & International | PD&EB2 | 76 | -19 |
| Heritage Parkway | TH5 | 25 | -124.5 |
| Heritage Parkway | TH6 | 20 | -104.5 |
| I10 & Chaffee | B-2 | 63.08 | -36.42 |
| I4 - 192 | B-27 | 90.12 | -109.88 |
| I4 - 192 | B-39 | 109.6 | -70.4 |
| I4 - 192 | B-40 | 108.6 | -76.4 |
| I4 - 192 | B-41 | 90.2 | -89.8 |
| Ramsey Branch | B-1 | 3 | -116 |
| Ramsey Branch | B-3 | 1 | -128.5 |

Table 3-4 shows the PDA data overview, with the test pile designation plus the ground surface and ending PDA collection elevations. Seventeen PDA test piles were evaluated. All PDA test piles presented were used for CT evaluation, while only the ones marked with * were used for CAPWAP® evaluation. Appendix E contains plots describing the six sites.

Table 3-4 PDA Test Piles Description

| Site | Test Pile | Beginning Elevation of Ending PDA collection (ft) | Ending Elevation of PDA collection (ft) |
|---|---|---|---|
| 417 & International | EB1P14* | 66.7 | 0.8 |
| 417 & International | EB2P5* | 51.28 | 0.1 |
| Heritage Parkway | EB1P1* | 2.06 | -89.9 |
| Heritage Parkway | EB5P1* | -1.04 | -81.0 |
| Heritage Parkway | IB2P10 | -18.96 | -82.8 |
| Heritage Parkway | IB3P1* | -9.25 | -91.3 |
| Heritage Parkway | IB4P10* | -10.58 | -91.8 |
| I10 & Chaffee | PR2PL9* | 31.89 | -16.0 |
| I4 - 192 | BD EB1P3 | 70.69 | -1.2 |
| I4 - 192 | P6P16 | 63.13 | -4.8 |
| I4 - 192 | P7P10 | 65.55 | -6.5 |
| I4 - 192 | P8P4* | 70.11 | -1.9 |
| Ramsey Branch | EB1P1* | -46.63 | -80.5 |
| Ramsey Branch | EB1P2 | -31.12 | -70.6 |
| Ramsey Branch | EB1P3* | -51.73 | -71.6 |
| Ramsey Branch | EB4P5* | -23.07 | -104.8 |
| Ramsey Branch | EB5P2* | -21.72 | -78.6 |

*Used for CAPWAP® evaluation

# 4 Chapter 4 CMS, PDM, and CT Testing and Evaluation Procedures

The basic equipment, set-up procedures and initial evaluations for the Inopiles Pile Driving Monitor (PDM) and the Florida Tech camera measuring system (CMS) systems are presented, followed by the evaluation procedures used for the visco-elastic analysis from CT results. Appendix D, details the CMS testing procedures, while Appendix H supplements the PDM information below with additional recommendations to help during testing.

## 4.1 PDM Initial Evaluation and Setup

### 4.1.1 Equipment

Inopiles supplies a schematic for the PDM set up which includes a table of active (or measuring) zone heights versus offset distance from object (i.e., typically a pile). The measuring zone is a vertical distance up from a horizontal line projected onto the object up at an angle of 2.6 degrees as shown in Figure 4-1. The PDM should be placed from about 20 to 80 feet (5.5 to 25 m) from the pile to produce active testing zones between approximately ¾ to 3.75 feet (0.25 and 1.13 m) They show the PDM being placed on a flat surface and a sand filled black leather bag, which is designed to keep the PDM level during use.

| Offset Distance (m) | Active Zone Height (m) |
|---|---|
| 5.5 | 0.25 |
| 10 | 0.45 |
| 11 | 0.50 |
| 16.5 | 0.75 |
| 25 | 1.13 |



Figure 4-1 Schematic of Inopiles Operation within Active Zone

The Inopiles PDM in the case, leveling bag and the accompanying Surface Pro tablet are shown in Figure 4-2. Note that the power requirements for the PDM included an Australian plug, while the Surface Pro® required a European plug.  These differences required special purchases for charging and operation in the US. The PDM data acquisition and reduction software, which runs on the Surface Pro® and can be configured for a laptop, allows for the creation of reports for each set of tests within an active zone.  Metric or English units may be selected by the user.

Figure 4-2 Inopiles PDM in Case, Leveling Bag, and Surface Pro®

### 4.1.2 Preliminary Testing

A group of PDM tests were performed in several locations on and near the Florida Tech campus to allow for the research team to fully understand its operation. Several of these locations are shown in Figure 4-3.This testing was followed by field testing at six sites in the central and northeast regions of Florida.

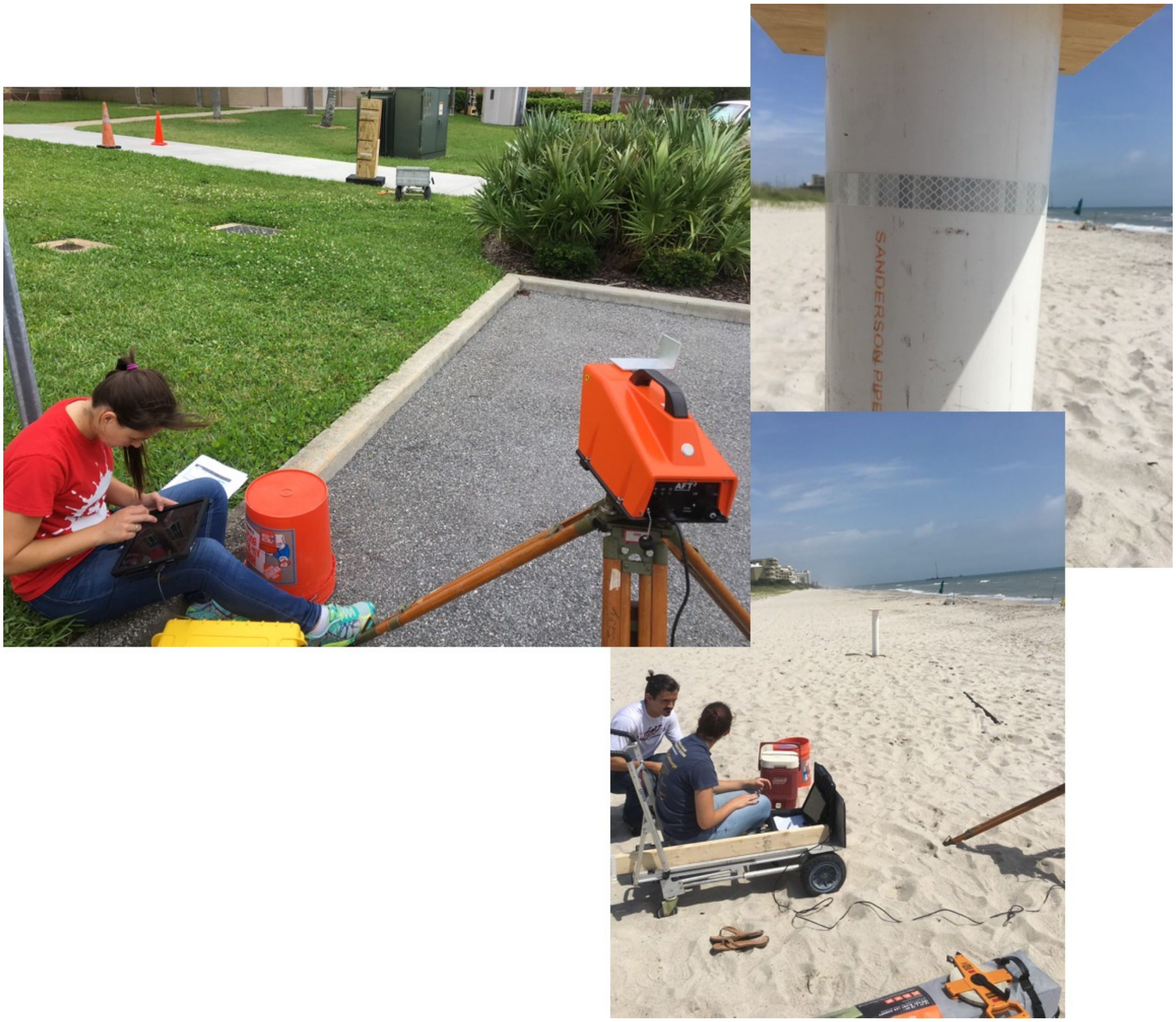


Figure 4-3 Various PDM Preliminary Testing Locations

### 4.1.3 PDM Lab Tests

#### 4.1.3.1 Learning the PDM

To initially understand the PDM operation, a series of lab tests were conducted. The first test consisted of driving a 36-inch metal ruler into loose sand that was placed in a 5-gallon bucket. A 2-pound sledge hammer was used to simulate hammer blows and the ruler was lightly tapped with the hammer to simulate driving. PDM was placed 17.32 feet from the ruler. This horizontal distance produced an active zone height of 0.79 feet. Deflection data was recorded as eight hammer blows were conducted. An arbitrary value of 50 feet for testing depth, shown as penetration, was set within the software during this trial. The metal ruler was able to be driven for seven of the eight blows, before it hit the bottom of the bucket during blow number 8.

The data for one of the lab tests in the bucket of sand are shown as a three page report generated by the PDM software as Figure 4-4, Figure 4-5, and Figure 4-6. Note several trials were conducted and are included in Appendix A. The three-page report shown includes two plots (Pages 1 and 3) and a table (page 2). Figure 4-4 shows the deflection versus blow number for the selected blows. The maximum displacement (DMX) is shown at the top of the blow and permanent SET shown at the base of a blow (See Figure 4-4). An examination of the data for blow number 1 shows a SET of 0.35 inches. The tabulated data, with set, rebound (i.e. DMX-SET), velocity (of the pile or rod being driven) and penetration (of the pile or rod per blow), for the selected blows are shown on page 2 (See Figure 4-5). It also includes averages for Set, Rebound, VMX and DMX in the Numerical Data section near the top 1/3$^{rd}$ of the table. Sets ranged from 0.35 to 0.70 inches for the six blows shown. On page 3 a plot of penetration versus time is displayed. An examination of this pages (See Appendix A) for the various tests, indicates the signal noise level. Figure 4-6 shows minimal noise until the last or seventh blow. Therefore, only six blows are shown since they produced the most useful data.

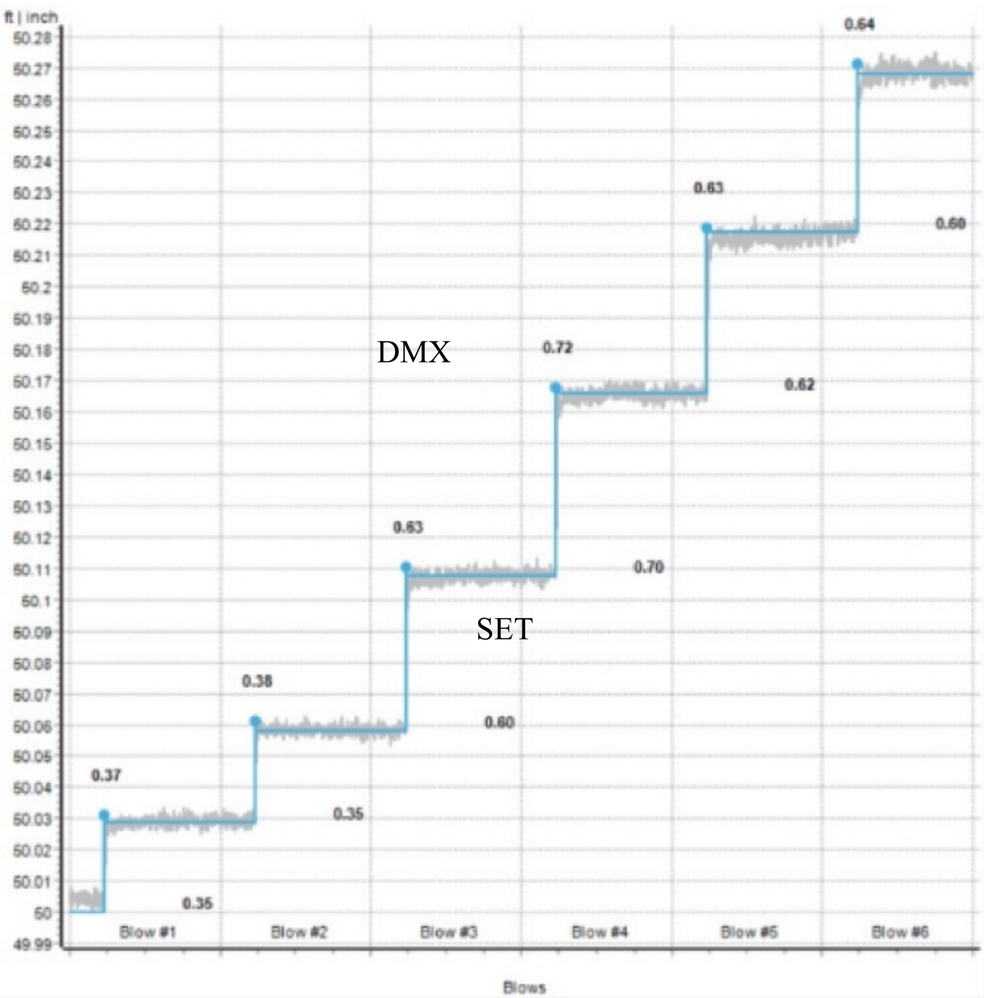
Tabulated data includes pile set, pile rebound, pile maximum velocity (VMX) and pile penetration. The software allows an Excel file to be exported that includes all of the recorded data. Table 4-1 shows the resulting summary of data for the lab test. It includes the average value for set, blows per inch, and rebound. The maximum displacement per blow (i.e., DMX) can also be output from the Inopiles software.

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 16/2/2019 |
| Client Name | | Report Time | 3:33:56 AM |
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Test Time | 12:57:30 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD | PDM Pile Offset (ft) | 29.500 |
| Pile Type | | Final Penetration at Blow 6 (ft) | 50.268 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

Figure 4-4 Preliminary PDM Lab Deflection Versus Blow -- Blows 1 through 6 -- Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 2-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.54 | VMX (ft/s) | 10.319 |
| Rebound (inch) | 0.03 | DMX (inch) | 0.56 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 6 | 0.60 | 0.04 | 11.14 | 50.268 |
| 5 | 0.62 | 0.01 | 10.67 | 50.218 |
| 4 | 0.70 | 0.02 | 11.18 | 50.166 |
| 3 | 0.60 | 0.03 | 11.26 | 50.108 |
| 2 | 0.35 | 0.04 | 8.69 | 50.058 |
| 1 | 0.35 | 0.02 | 8.97 | 50.029 |

| | | |
|---|---|---|
| Average | 0.54 inch | 0.03 inch |
| Max Variation | 0.35 inch | 0.03 inch |

Page 2 of 3

Figure 4-5 Preliminary PDM Lab Tabulated Data -- Blows 1 through 6 -- Page 2 of 3

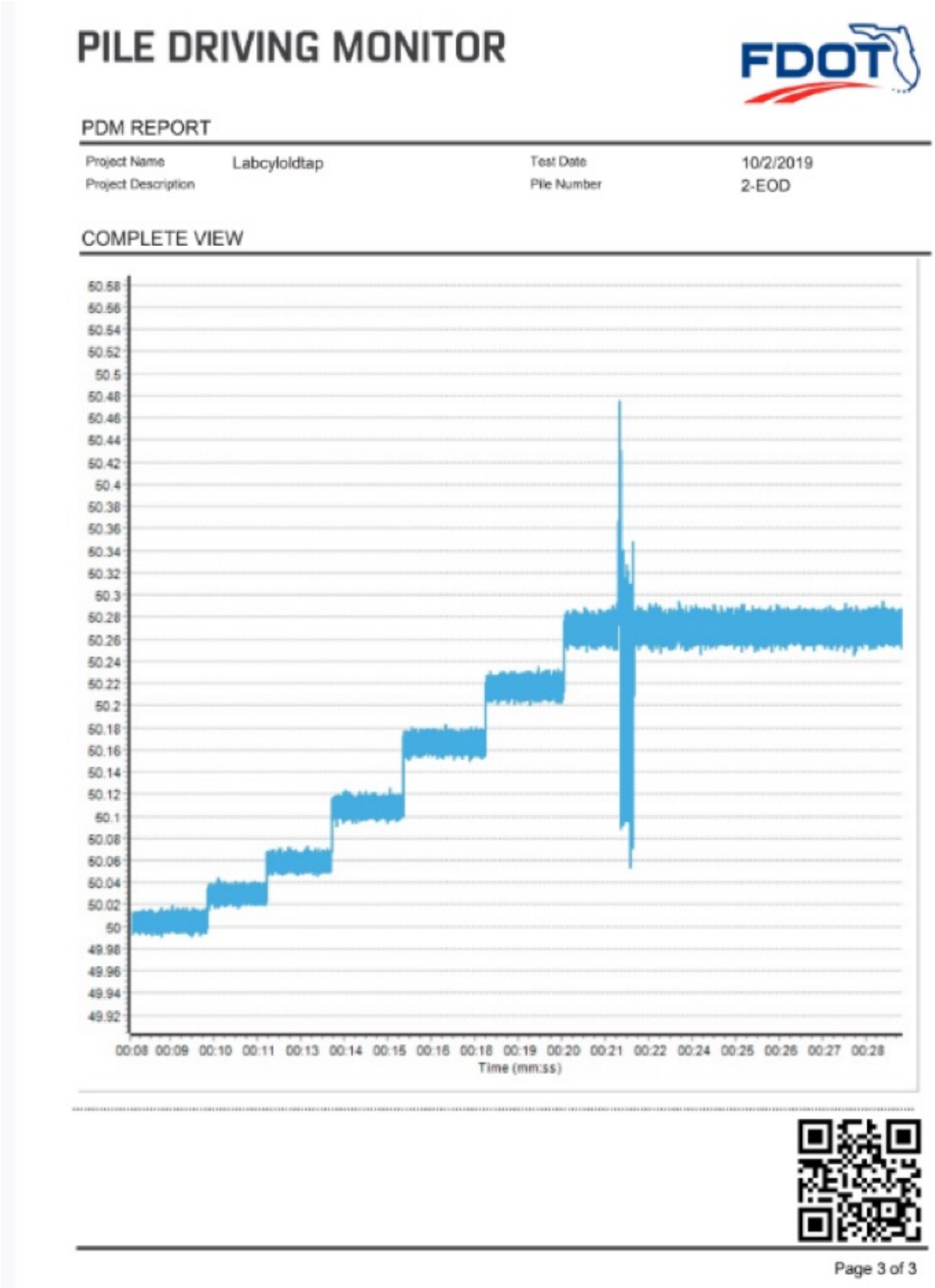



Figure 4-6 Preliminary PDM Lab Deflection versus Time -- Blows 1 through 6 -- Page 3 of 3

Table 4-1 Average PDM Data for Preliminary Ruler in Sand Lab Test

| % of active zone | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|
| | Min | Average | Max | Min | Average | Max |
| 22 | 0.04 | 0.45 | 0.76 | 0.02 | 0.05 | 0.11 |

### 4.1.3.2 PDM Data Quality

Figure 4-4 shows a good match between the digital PDM signal, shown in light gray, and the software interpretation of the ruler movement, shown in light blue.  There does seem to be some discrepancy between the initial digital signal for blow number 1 and the corresponding software interpretation.  At the end of the linear portion of the blue line the software produces a solid blue dot as the maximum displacement per blow. The software penetration was arbitrarily set at 50 feet, which corresponds to the light blue line, while the digital signal is slightly above this depth. Figure 4-7 is a second example of what is considered as high quality PDM data as both the digital and software interpreted data overlap.

Figure 4-8 shows inconsistencies at Blows's 3 and 5. This problem may have resulted from the simultaneous horizontal and vertical movements of the rod in the lab, but the exact reason was not determined. Figure 4-9 shows how the software interprets movements that a smaller than typically encountered. For example, during blow number 1 the maximum movement digitally estimated was 0.12 inches and the minimum digitally estimated movement was 0.05 inches. These small movements seemed to cause the software to show DMX and SET values that are offset from the actual values by a constant amount.  Note that 0.01 feet corresponds to 0.12 inches

### 4.1.3.3 Reflective Tape Evaluations

Three different reflective tapes were utilized during the lab and field testing. The first tape was that supplied by Inopiles, a 3M Diamond Grade tape, hereafter be referred to as the *Original tape*. The supply of the *Original tape* was limited, thus it needed replaced twice during the research. Inopiles was contacted concerning replacement tapes and suggested any white reflective tape would be acceptable.

A second tape was purchased to replace the *Original tape*. It was ordered on June 5, 2018 from Amazon. The product name is 3M 3430 White Prismatic Sheeting Reflective Tape 3" x 6" and will hereafter be referred to as *3M tape*.

The third tape was purchased to replace the second. It was ordered on January 28, 2019 from ULINE. The product name is Outdoor Reflective Tape – 2" x 50', WHITE and will hereafter be referred to as *Outdoor tape*.

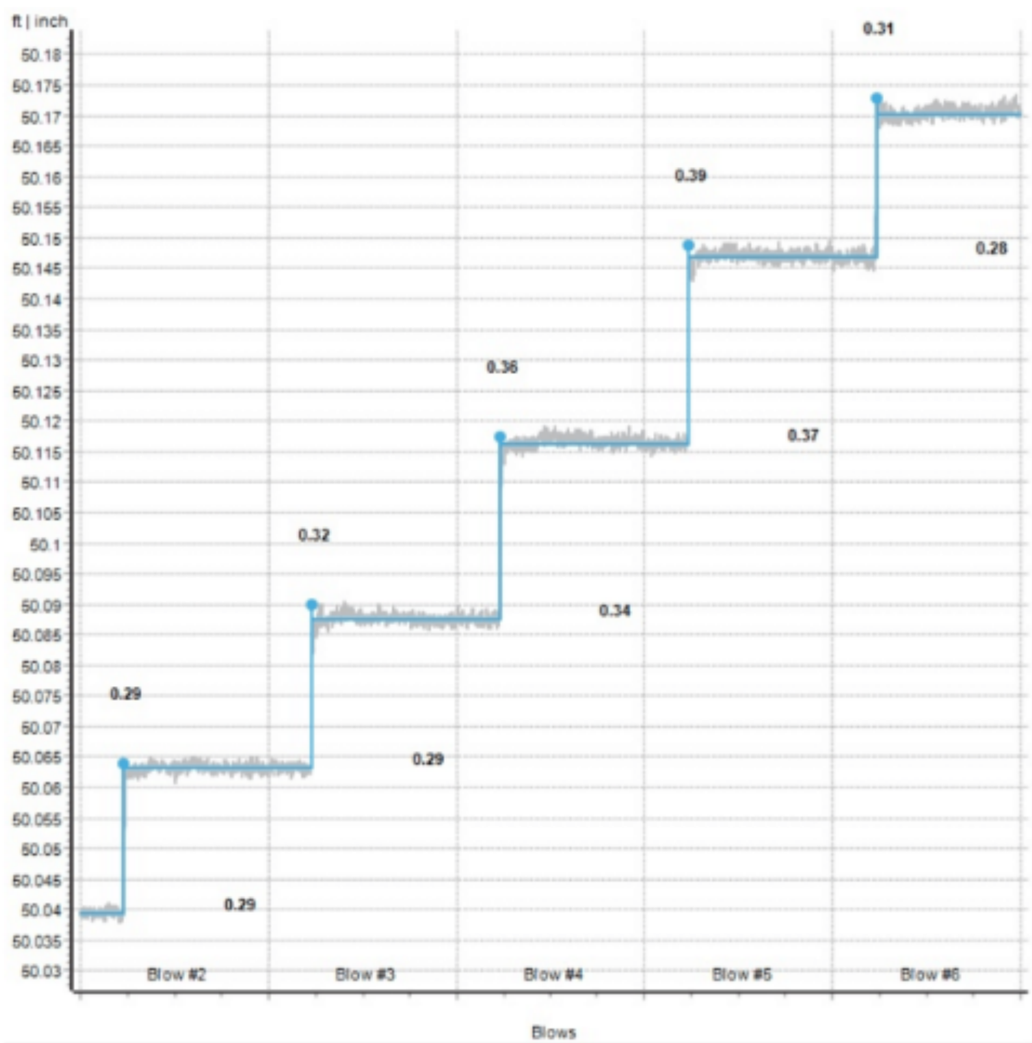



Figure 4-7 Example of High-quality PDM Data

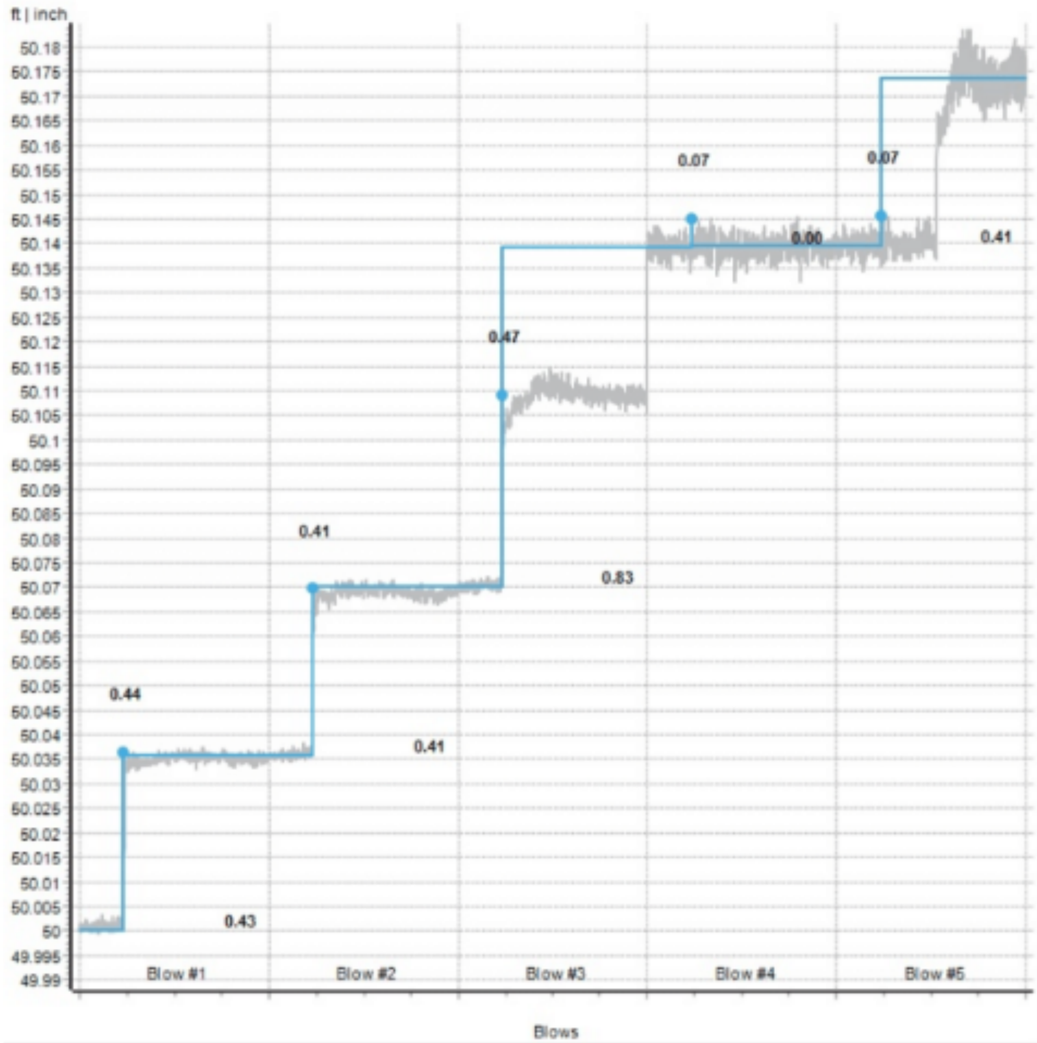



Figure 4-8 Example of PDM Data with Error after Blow 2

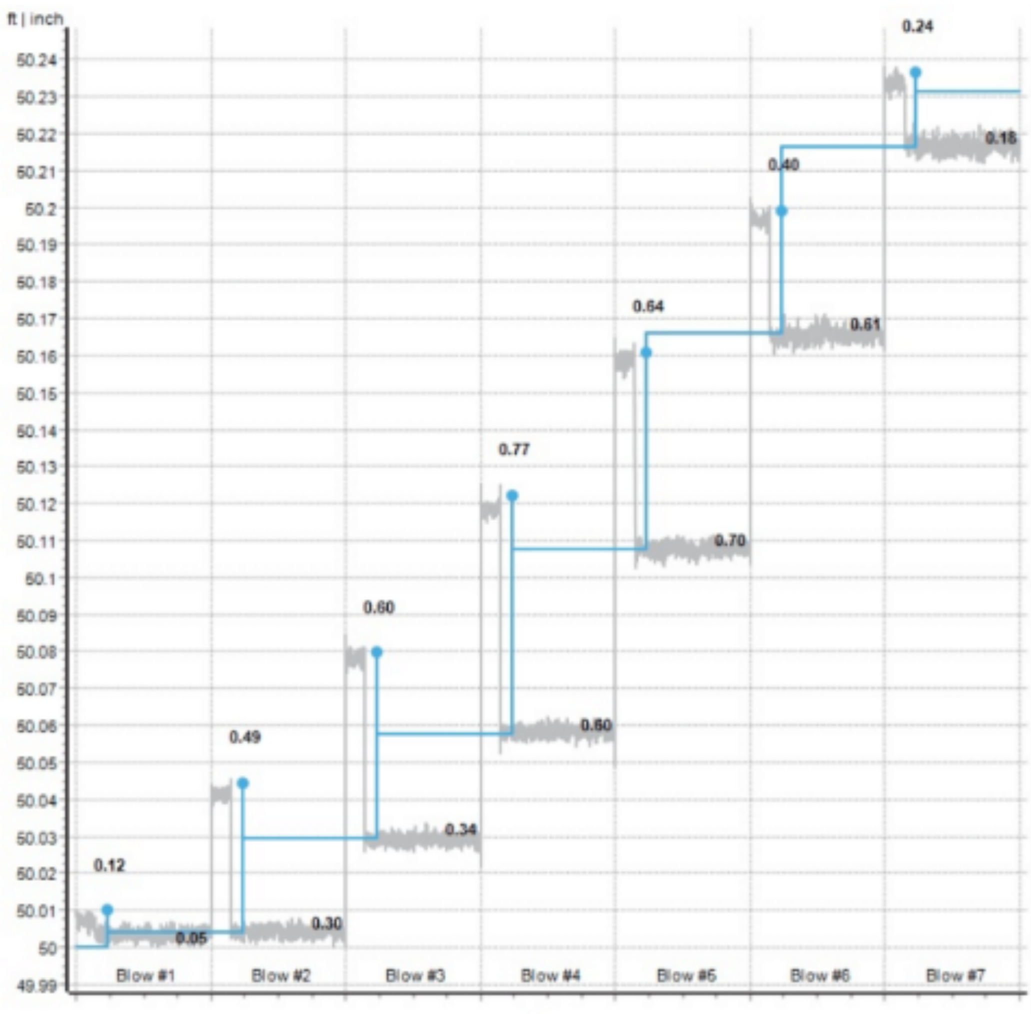



Figure 4-9 Example of Consistent Error with PDM Data

Once the *Original tape* had been completely used the research team decided to conduct lab tests to evaluate the signal quality obtained from the other reflective tapes. The tests consisted of driving a sampling rod into loose sand in a 5-gallon bucket. To drive the rod into the sand a one-foot square ½ inch thick plywood cushion was placed on top of the rod and was hit with a small sledge hammer. This combination was used to simulate pile driving of concrete piles. Each tape was tested 3 times.

The first two tests for both tapes produced no concerns, while the third test for both tapes showed errors in recording blows. Both types of tape produced errors; however, there may be more signal noise from the 3M tape than the Outdoor tape. This concern needs further investigation. Figure 4-7 shows high quality PDM data. There are 5 blows and movements shown. For each blow the light gray data points are overlain by a solid blue line.

### 4.1.4 Required PDM Equipment

The equipment required to perform testing includes:

1) PDM Unit*
2) PDM power cable*
3) PDM data cable *
4) PDM mounting piece*
5) Tripod
6) Reflective tape*
7) Laser distance finder*
8) Measuring tape
9) Laptop with PDM software
10) Laptop charging cable
11) Tablet with PDM software*
12) Tablet charging cable*
13) Power adapter (Europe – USA)
14) Power adapter (Australia – USA)
15) PDM manual*
16) Driving log notes
17) Extension cables
18) Tent
19) Rags

*The equipment supplied with the PDM are denoted with an *.*

The manufacturer recommends that the PDM, laptop and tablet be completely charged before arriving at the job site. Additionally, all cables must be transported to the site in case additional charging is required. During testing at the six sites, the PDM battery lasted throughout the work days. However, both the tablet and the laptop batteries required charging after several hours of use.

### 4.1.5 Data Collection for Piles

#### 4.1.5.1 PDM Pile Setup

Use of the manufacturers recommended leveling sand bag was not successful during deployment at the initial site. The research team therefore, recommends that the PDM be placed on a tripod using the mounting piece and located between 5 and 20 meters from the pile. It should then be connected to either the laptop or tablet using the appropriate data cable. When the computers are connected properly to the PDM and its software the red guide lasers will turn on. Operators should be able to see these on the pile or rods prior to testing, etc., therefore, the PDM should be placed directly in line and perpendicular to the pile. The distance from the PDM to the pile also affects the width of the reflective tape. The research team determined that a minimum of 4 inch by thick 6 inches wide tape should be placed on the piles. The exact distance, to within 2 inches, should be determined by using either the laser distance finder or the measuring tape. The tripod should be adjusted so that the PDM is level with an unobstructed field of view. The field of view can be seen by where the guide lasers that the PDM outputs lie on the pile (note that these lasers turn off during testing). It is recommended that the equipment be setup under a tent or other shaded area so that neither the laptop nor tablet overheat, and the associated screen is easier to read.

#### 4.1.5.2 Pile Preparation

Prior to placing reflective tape on piles, determine the depth of predrilling and or jetting. When piles are pre-drilled, it is not necessary to put tape on the first section of pile as it will drive too fast for data to be collected. Piles are marked in one-foot increments with labels every five feet. The research team recommends that reflective tape be placed on the pile every five feet. This spacing will allow the software operator to input and prepare for the subsequent set of data collection as the pile is being continuously driven.

#### 4.1.5.3 Data Collection

The PDM software and data acquisition system records data via an express job setting in the PDM software. The method allows the user to input the least amount of information between testing intervals and therefore was used to collect data every 5 feet during continuous pile driving. The instructions for running an express job are in the PDM manual. While the pile is being driven the reflective tape passes through the active zone (denoted by the red laser guides). Before each data acquisition the following parameters must be input into the software:

- Project Name – used to denote both the site and pile number being tested.
- Pile Number - used to denote subsequent data collections on the same pile.
- Penetration - depth of pile below ground or mudline level at the start of a given test.
- Reflector LE - length of pile from the reflector position to the pile toe, inclusive of pile shoes.
- OFFset Distance - measured distance from the PDM unit to the reflector position.

It is important that the parameters be entered for a data collection before the tape enters the active zone. The parameters should be entered with values that represent what the tape and piles position will be upon the tape entering the active zone. Once the tape enters the active zone the signal test must be completed as quickly as possible, which is done by pressing Test Signal and pressing Next once the signal screen turns green. Then press Start Testing. The PDM will begin recording blows and display a live displacement versus time graph on the screen. The test should be stopped just before the tape exists the field of view to prevent the software from producing errors at the end. This procedure must be repeated for each subsequent reflector.

### 4.1.6 SPT Data Collection Process

The method for collecting PDM data for SPT testing is similar to that of pile driving with several important differences. This section will cover how the testing procedure was adapted for SPT testing.

#### 4.1.6.1 PDM SPT Setup

The PDM should be placed on the tripod using the mounting piece and connected to either the laptop or tablet via using the data cable. Upon connecting to the PDM software the red guide lasers will turn on. The PDM should be angled directly at the SPT rod so that the guide lasers can be seen reflecting off of it. The distance the PDM should be from the rod is a function of how wide the reflective tape is. The distance should be determined by using measuring tape. The tripod should be adjusted so that the PDM is level with an unobstructed field of view that lies on the rod just above the trough. The field of view can be seen by where the guide lasers that the PDM outputs lie on the pile (note that these lasers turn off during testing). It is preferable to have the setup under a tent or other shade so that the laptop or tablet stays cooler and the screen is easier to read.

#### 4.1.6.2 SPT Rod Preparation

A new piece of tape needs to be applied before driving begins on a new rod segment. Reflective tape should be placed on the rod near the top of the active zone. To ensure the tape adheres properly it is helpful to wipe off the rod with a rag.

#### 4.1.6.3 Data Collection

The PDM will record data via the same express job routine within the PDM software as used during pile driving. The method was adapted to account for SPT testing. The instructions for running an express job can be found in the PDM manual. After tape has been applied to the rod within the SPT testing zone, the parameters can be entered for data collection. Note, one 4-inch-wide by 6-inch-long piece of tape was secured around the SPT rod within the 18-inch testing zone and such that it did not interfere with the drillers blow counting process. Before each data acquisition the following parameters must be inputted into the software:

- Project Name – used to denote both the site and SPT test boring number.
- Pile Number – used to denote subsequent data collections on the same SPT test.
- Penetration – depth of SPT rod below ground or seabed level at the start of a given test.
- Reflector LE – length of SPT rod from the reflector position to the SPT rod toe.
- Offset Distance – measured distance from the PDM unit to the reflector position.

Next a signal test is completed by pressing Test Signal and pressing Next once the signal screen turns green. Then press Start Testing. At this time the drillers should begin driving the SPT rods. The PDM will begin recording blows and display a live displacement over time graph on the screen. The test should be stopped just before the tape exists the field of view to prevent the data from producing an error message for the last blow. This procedure should be repeated for subsequent reflector rod section to be driven.

## 4.2 CMS Testing Process

### 4.2.1 Equipment

The Florida Tech CMS system consists of several digital cameras, lens, and associated tripods. The equipment must be carefully transported to the site and placed in a relatively clean environment and protected from severe weather. A tent is recommended to be placed over all electronics. Figure 4-10 is a photo from the Baldwin Bypass testing site near Jacksonville Florida. The testing was performed during severe rain and thunderstorms. The CMS system was carefully transported from the truck to the testing location and produced useable deflection data, while the PDM Surface Pro® malfunctioned and prevented any data from being collected. Figure 4-11 is a photo from the Reedy Creek testing, which was performed during a warm sunny Florida day. No tent was used mainly due to difficulties with the pile driving and placement, as a result one of the cameras overheated and shut down during testing.


Figure 4-10 CMS and PDM Field Testing in Heavy Rain

Figure 4-11 CMS and PDM Testing in Partially Sunny Weather

### 4.2.2 Marking the Piles or Rods

Prior to any testing, the piles or SPT rods were marked with either dark-colored paint, black or white electrical tape, or permanent markers. The recommended marking techniques are being evaluated during this research. The camera video automatically shows the pile depth markings, and therefore, no additional information was required as input prior to testing. Since each setup used different focal lengths from the piles to the cameras and lenses being used, a camera magnifying loupe was used to measure the known tape size (width in inches) of the tape placed on the test pile. This information was then used in software to calculate the number of pixels of the tape being imaged. This procedure allowed the direct calibration of the pixel size in a video sequence given the camera, lens, and focal-length from the camera to the pile being tested.

### 4.2.3 Field Testing on Piles or SPT Rods

Once the pile or SPT rods are properly marked, the camera(s) were placed perpendicular to the rods at a convenient distance of typically 15 to 50 feet. As driving commenced the cameras were turned on and focused to record movements. Currently, there are no digital signals displayed during data acquisition and testing, therefore the equipment was transported to the Florida Tech Marine Environment and Optics Lab in Melbourne, Florida.

### 4.2.4 Data Reduction

CMS data requires post image processing. Once the digital videos are downloaded to computers in the lab, special image processing software was used to convert the video imagery and associated markings to pile movements. The movement of individual pixels are tracked using the software to produce pile or SPT rod movements per hammer blow. Figure 4-12 shows the reduced data from the Baldwin Bypass video as pile movements versus pixel number. The data indicate an average of about 0.68-inch (17 mm) of displacement per blow and an average of 0.276-inch (7 mm) of rebound. Figure 4-13 shows the pile movements for testing at Dunn Creek in Palatka, Florida. SPT tests were also conducted in the soils that produced pile rebound and the image shows a time-dependent movement between hammer blows. This video was from testing at Dunns Creek, September 19$^{th}$, 2018 at depths from 75 and 75.12 feet. It represents a 20-blow recording sequence recorded over 28 seconds with the displacements in inches. The downwards trend in both figures equates to the downward driving displacement of the pile, which is opposite of the plots obtained from the PDM software.

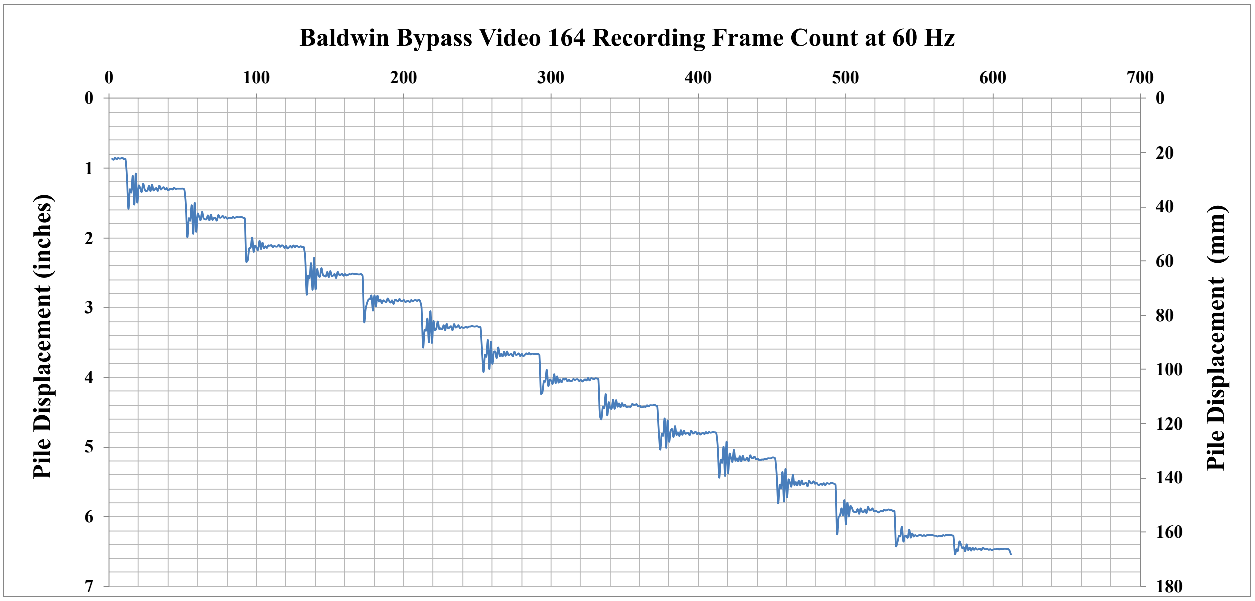



Figure 4-12 Pile Movement versus 60-Hz Frame Number for Baldwin Bypass Test Pile: Black Spray Paint Line

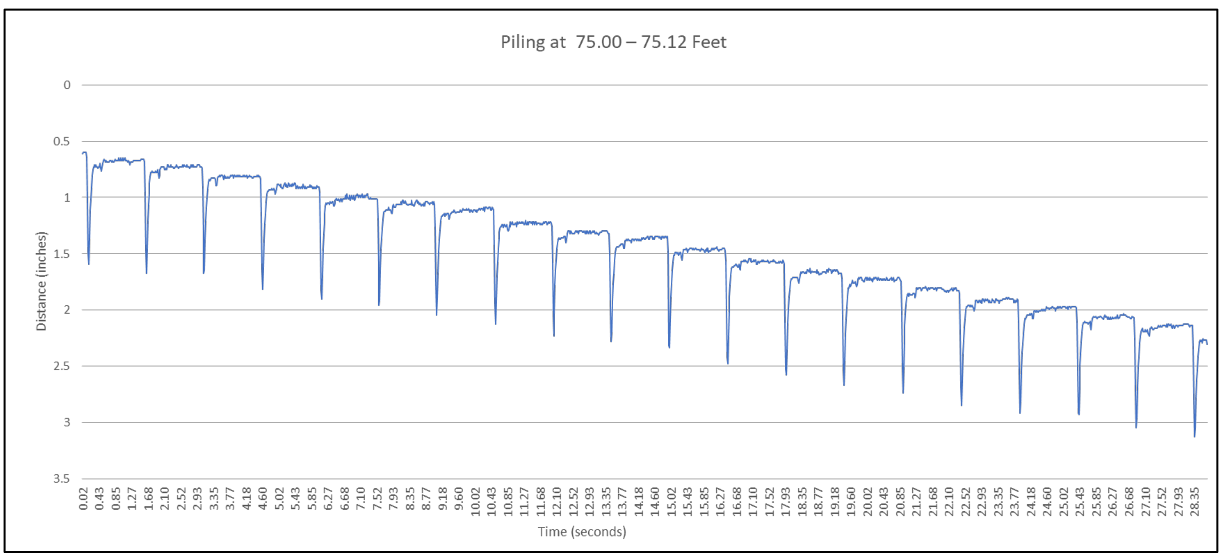



Figure 4-13 60-Hz Video Recording Software Plot from Dunns Creek SPT Rod Movements

## 4.3 Overview of CT Testing Procedures

The behavior of rebound and non-rebound soils can be analyzed and compared directly through in situ measurements during a pile driving procedure, or indirectly via lab tests simulating the same behavior.

The cyclic loading of a soil sample during a cyclic triaxial test is similar to a cyclic loading of the pile and the soil around it during a pile driving procedure. Although the scale differs when comparing the size of a soil sample and the area of soil affected around the driven pile, there are similarities such as the loading and unloading components, the application of a cyclic load and the possibility of rebound during the soil displacement.

Triaxial tests data evaluated was provided by Florida Department of Transportation (FDOT) under BDV-28 977-0,1 with the objective of determining the damping coefficient of both rebound and non-rebound soils.

## 4.4 CT Tests Performed

Table 4-2 presents an overview of the cyclic triaxial performed, with the thin walled tube sample depths for each CT boring at each site. Data from 40 CT test samples were obtained from the six sites listed.

Table 4-2 CT Testing Descriptions

| Site | Location | Sample Depth (ft) |
|---|---|---|
| Chaffee | EB3 | 52-55 |
| Chaffee | North of I-10 | 47-49 |
| Chaffee | North of I-10 | 60-62 |
| I4&192 | Pier 6 | 50-52 |
| I4&192 | Pier 6 | 60-62 |
| I4&192 | Pier 6 | 75-77 |
| I4&192 | Pier 6 | 80-82 |
| I4&192 | Pier 7 | 60-62 |
| I4&192 | Pier 7 | 70-72 |
| I4&192 | Pier 7 | 85-87 |
| I4&192 | Pier 8 | 45-47 |
| I4&192 | Pier 8 | 55-57 |
| I4&192 | Pier 8 | 65-66 |
| I4&192 | Pier 8 | 70-72 |
| I4&192 | B6 EB1 | 50-52 |
| I4&192 | B6 EB1 | 58-59 |
| I4&192 | B6 EB1 | 70-72 |
| I4&192 | B6 EB1 | 80-82 |
| I4&192 | B6 EB1 | 91-93 |
| I4&192 | B7 EB1 | 46-47 |
| I4&192 | B7 EB1 | 70-72 |
| I4&192 | B7 EB1 | 75-77 |
| I4&417 | EB1 | 20-22 |
| I4&417 | EB1 | 29-31 |
| I4&417 | EB1 | 58-61 |
| I4&417 | EB2 | 23-25 |
| I4&417 | EB2 | 55-57 |
| I4&Osceola | Pier 2 | 75-77 |
| I4&Osceola | Pier 2 | 80-81 |
| I4&Osceola | Pier 2 | 85-87 |
| I4&Osceola | Pier 3 | 75-76 |
| I4&Osceola | Pier 3 | 80-82 |
| I4&Osceola | Pier 4 | 60-61 |
| Heritage | P1 | 62-64 |
| Heritage | EB5 | 57-59 |
| Heritage | EB5 | 65-67 |
| Heritage | P10 | 55-57 |
| Heritage | P10 | 62-64 |
| Ramsey Branch | B2 | 31-33.5 |
| Ramsey Branch | B2 | 41-43.5 |
| Ramsey Branch | B3 | 48.5-51 |
| Ramsey Branch | B3 | 63.5-66 |

## 4.5 Existing Rebound Data

According to the current FDOT specification (455-5.10.3), rebound values that are equal to or greater than 0.25 inches are considered high. BVD 28 977-01 findings indicated that using ½ or even 1" for a high rebound threshold might produce clearer engineering information. Based on the PDA data for the five PDA sites tested, the percentage of depths in which the rebound is equal or greater than 0.25, 0.50 and 1.00 inch is presented in Table 4-3.

Table 4-3 Percentage of Depths with Rebound ≥ 0.25, 0.50, and 1.00 inch

| Site | % Depths with Rebound Equal or Greater than | | |
|---|---|---|---|
| | 0.25 in | 0.50 in | 1.00 in |
| Ramsey Branch | 95% | 67% | 29% |
| I10 & Chaffee | 89% | 35% | 18% |
| I4 - 192 | 80% | 37% | 0% |
| Heritage Parkway | 52% | 8% | 0% |
| I4 & 417 | 45% | 1% | 0% |

Based on Table 4-3, the following trends are shown.

- Ramsey Branch, I10 & Chaffee and I-4 & 192 data have at least 80% of the depths with rebound greater than ¼ inch.
- Ramsey Branch, I10 & Chaffee and I-4 & 192 data have at least 35% of the depths with rebound greater than ½ inch.
- Ramsey Branch and I10 & Chaffee data have at least 18% of the depths with rebound greater than ½ inch.

According to the results shown in Table 4-3, if the criteria for high rebound increases from 0.25 inches to ½ inch, fewer sites will be considered high-rebound. Even fewer sites will meet the criteria if 1 inch is considered critical, which might eliminate problematic sites.

## 4.6 CT Test Procedures

Both triaxial and CT tests were performed by FDOT at the State Materials Office (SMO). The equipment used included a Durham Geo Slope Indicator 5-500 panel and a MTS DuraGlide

244-21 Hydraulic Actuator which is part of a Servo Hydraulic Dynamic Triaxial Testing System. The cyclic loading is generated by the action of a servo valve, which used a closed-loop electrical signal control. Figure 4-14 depicts the Durham Geo Slope Indicator 5-500 panel and Figure 4-15 shows the MTS DuraGlide 244-21 hydraulic actuator and loading frame system.

Figure 4-14 Durham Geo Slope Indicator 5-500 Panel


Figure 4-15 MTS DuraGlide 244-21 Hydraulic Actuator and Loading Frame

Both cyclic and regular triaxial tests were performed on soil samples obtained from Thin Walled Tube Samples (i.e., Shelby tubes), following D1587/D1587M – 15 ASTM standards. Cyclic stress-strain behavior changes based on the stress applied during each cycle. Therefore, the deflection versus time was needed for each stress level for the analysis. In order to establish the stress levels to be used during CT testing, a consolidated undrained (CU) triaxial test was performed on the first sample extruded from the tube. The stress-strain data from this test was assumed to be representative of the second sample used in the subsequent CT test. Therefore, the failure stress from the CU test was used to establish proposed CT stress levels of 10, 20, 40, 60 and 80 percent of the CU failure stress. The stress levels for each sample are shown in Appendix

F. Due to inherent testing and sample variability, several CT samples were subjected to stress levels that exceeded the CU failure stress level. This phenomenon produced CT stress levels over 100% of the CU failure stress level. For example, at Chaffee, EB3, 52-55 ft, stress levels reached almost 170% of the failure stress. At each of these stress levels, 1000 loading and unloading cycles were performed. Each sample had its diameter, height, mass properties determined prior to the test run. After each test, moisture content was determined.

During CT tests, the sampling frequency set was 50 Hz, producing 50 data points each second or cycle. Data were collected using a data acquisition time stamp recorded in seconds. Each time stamp has a corresponding load applied (lb) and displacement (inches).

During one cycle, the servo valve responsible for applying cyclic loading on the sample is opened for 1/10 of a second. However, the soil response lags behind the loading, and due to viscous behavior, it doesn't necessarily have the same duration as the valve's cycle.

With the data collected during the test, it is possible to correlate load versus time, deflection versus time and stress versus strain. Figure 4-16, Figure 4-17 and Figure 4-18 show an example of each for 10 cycles. Inspection of Figure 4-16 shows small variations in maximum applied load near the 20-pound level. Figure 4-17 shows deflections for 10 cycles and that the accumulated deflections increase slightly after each loading. Figure 4-18 shows the stress-strain responses during the 10 cycles form a hysteresis loop, which is typical of soils, which are not purely elastic materials. Figure 4-19 shows a typical stress versus strain plot for a 14-stress-level test. At each of the 14 stress levels, which vary from about 3 psi to near 30 psi, 1000 load-unload cycles were performed. This particular plot shows several unusual responses. First, there are very limited strains for stress levels up to 20 psi, indicating that the soil is below its critical stress level (CSL), the level below which it behaves most elastically. Secondly, once the strains become excessive (i.e., past 0.30 or 30 %), the unloading stresses decrease to values below zero. This response is most likely due to the sample drastically changing shape and therefore contact area. If the contact area actually increases at this point, the unloaded stress calculated based on the initial sample diameter would be incorrect.

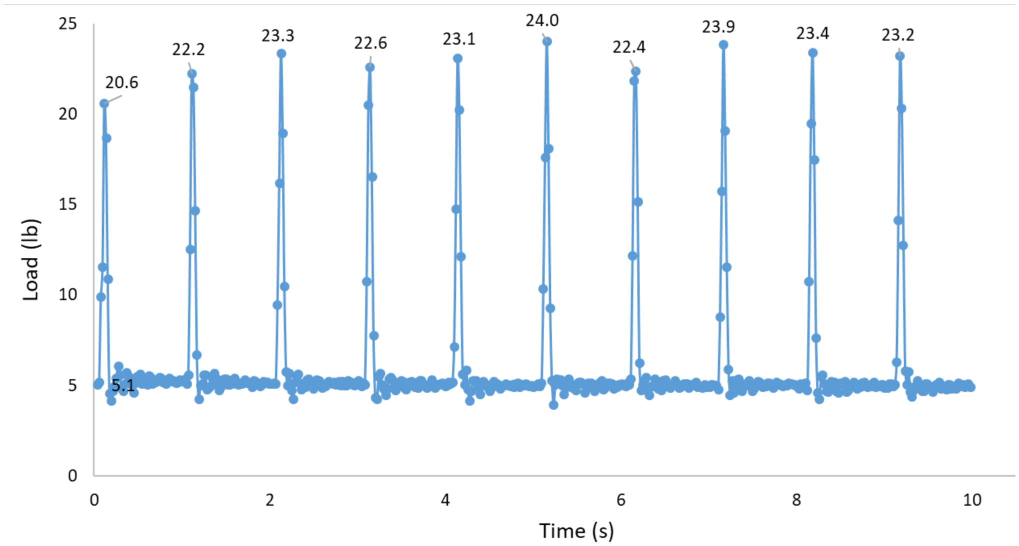



Figure 4-16 Typical Load versus Time for 10 Cycles

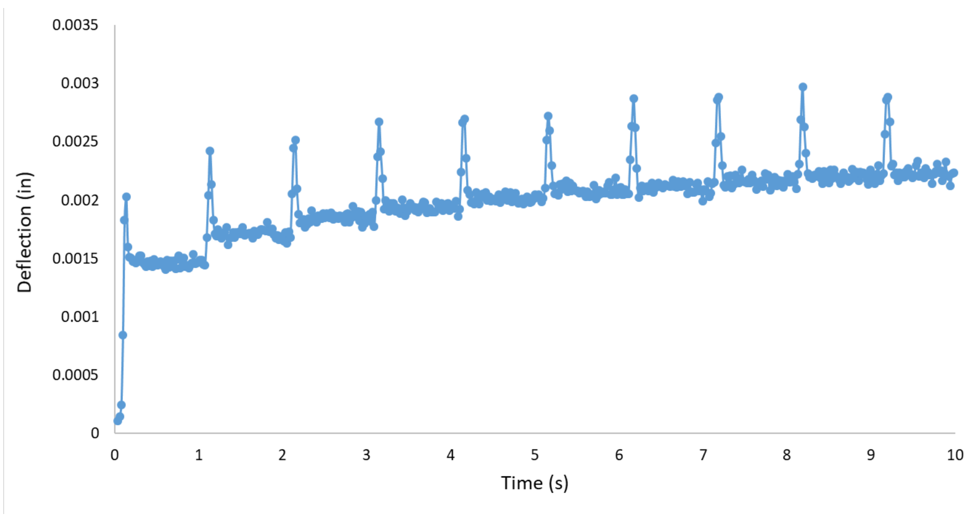



Figure 4-17 Typical Deflection versus Time for 10 Cycles

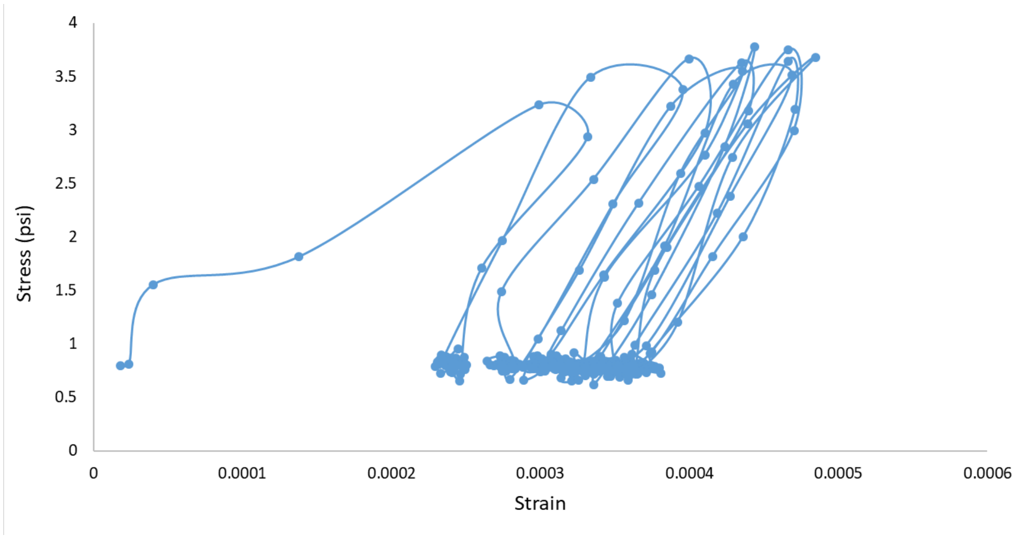



Figure 4-18 Typical Stress versus Strain for 10 Cycles

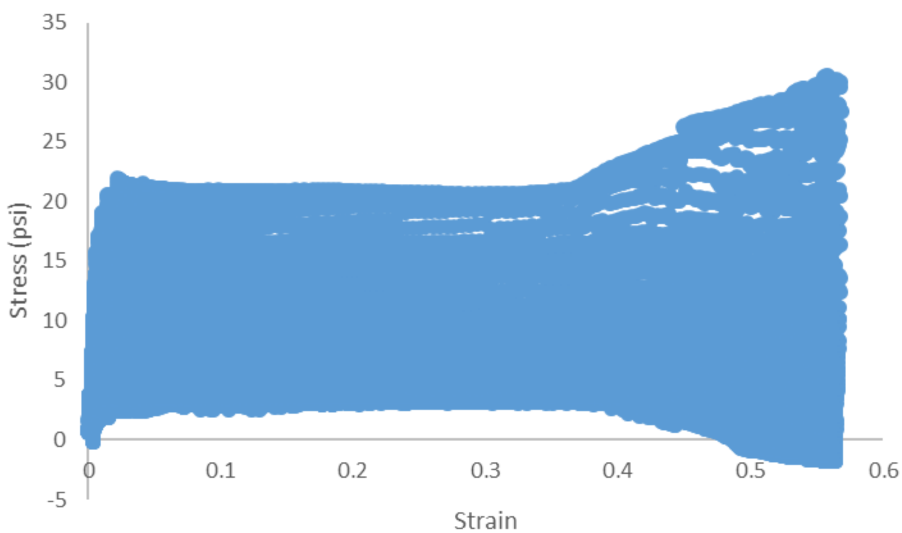



Figure 4-19 Typical Stress versus Strain for a Complete CT Cest with 14 Stress Levels

# 5 Cyclic Triaxial Results and Analysis

## 5.1 Triaxial Tests Results

Table 5-1 summarizes the results from the 42 CU triaxial tests performed prior to the corresponding CT tests for each site, boring and depth specified.

The samples were tested based on effective stresses that matched their tests depths. According to the results shown, the failure strains range from 2.75 to 30.1%, while the failure stresses range from 13.94 to 328.51 psi.

## 5.2 CT Tests Results

Plots relating strain with stress and strain with time were generated for each CT test. The strain for each data point was calculated by dividing the displacement by the original specimen height. The stress was calculated by dividing the applied load by the original area of the specimen. Strain versus time graphs are included in Appendix F.

The percentage of the failure stress that the samples were subjected at each stress level (i.e., normalized stress level) are also presented in Appendix F. The results are presented in Appendix F as well.

Table 5-1 CU Triaxial Tests Results

| Site | Location | Sample Depth (ft) | Confining Stress (σ3) | Failure Stress (psi) | Failure Strain (%) |
|---|---|---|---|---|---|
| Chaffee | EB3 | 52-55 | 17.00 | 17.99 | 3.12 |
| Chaffee | North of I-10 | 47-49 | 15.00 | 13.94 | 3.09 |
| Chaffee | North of I-10 | 60-62 | 21.00 | 62.81 | 26.46 |
| I4&192 | Pier 6 | 50-52 | 20.00 | 34.90 | 21.62 |
| I4&192 | Pier 6 | 60-62 | 24.00 | 52.96 | 25.80 |
| I4&192 | Pier 6 | 75-77 | 32.00 | 65.69 | 10.42 |
| I4&192 | Pier 6 | 80-82 | 32.00 | 65.69 | 10.42 |
| I4&192 | Pier 7 | 60-62 | 27.00 | 83.23 | 12.34 |
| I4&192 | Pier 7 | 70-72 | 30.00 | 47.93 | 18.29 |
| I4&192 | Pier 7 | 85-87 | 35.00 | 36.45 | 28.11 |
| I4&192 | Pier 8 | 45-47 | 18.00 | 21.14 | 21.50 |
| I4&192 | Pier 8 | 55-57 | 21.00 | 43.02 | 12.86 |
| I4&192 | Pier 8 | 65-66 | 24.00 | 72.34 | 30.10 |
| I4&192 | Pier 8 | 70-72 | 24.00 | 60.24 | 2.75 |
| I4&192 | B6 EB1 | 50-52 | 20.00 | 53.36 | 24.63 |
| I4&192 | B6 EB1 | 58-59 | 20.00 | 53.36 | 24.63 |
| I4&192 | B6 EB1 | 70-72 | 25.00 | 50.79 | 5.75 |
| I4&192 | B6 EB1 | 80-82 | 27.00 | 59.72 | 3.92 |
| I4&192 | B6 EB1 | 91-93 | 34.00 | 52.16 | 10.83 |
| I4&192 | B7 EB1 | 46-47 | 18.00 | 58.73 | 15.60 |
| I4&192 | B7 EB1 | 70-72 | 25.00 | 53.92 | 18.34 |
| I4&192 | B7 EB1 | 75-77 | 27.00 | 69.02 | 12.31 |
| I4&417 | EB1 | 20-22 | 10.00 | 328.51 | 6.16 |
| I4&417 | EB1 | 29-31 | 10.00 | 328.51 | 6.16 |
| I4&417 | EB1 | 58-61 | 24.00 | 214.61 | 18.44 |
| I4&417 | EB2 | 23-25 | 12.00 | 20.56 | 21.90 |
| I4&417 | EB2 | 55-57 | 24.00 | 54.57 | 14.97 |
| I4&Osceola | Pier 2 | 75-76 | 30.00 | 31.65 | 17.36 |
| I4&Osceola | Pier 2 | 80-81 | 32.00 | 58.89 | 16.12 |
| I4&Osceola | Pier 2 | 85-87 | 34.00 | 250.43 | 7.93 |
| I4&Osceola | Pier 3 | 75-76 | 27.00 | 35.84 | 4.08 |
| I4&Osceola | Pier 3 | 80-82 | 30.00 | 51.98 | 18.77 |
| I4&Osceola | Pier 4 | 60-61 | 20.00 | 28.31 | 17.39 |
| Heritage | P1 | 62-64 | 25.00 | 38.31 | 14.89 |
| Heritage | EB5 | 57-59 | 24.00 | 29.85 | 16.26 |
| Heritage | EB5 | 65-67 | 24.00 | 29.85 | 16.26 |
| Heritage | P10 | 55-57 | 23.00 | 23.35 | 14.13 |
| Heritage | P10 | 62-64 | 25.00 | 31.45 | 16.91 |
| Ramsey Branch | B2 | 31-33.5 | 17.00 | 55.61 | 4.24 |
| Ramsey Branch | B2 | 41-43.5 | 20.00 | 52.93 | 9.36 |
| Ramsey Branch | B3 | 48.5-51 | 29.00 | 50.62 | 9.97 |
| Ramsey Branch | B3 | 63.5-66 | 29.00 | 50.62 | 9.97 |

## 5.3 CT Data Analysis

CT data contain over 600,000 rows of data per test performed, which makes the analysis very difficult and lengthy if executed using Excel. For that reason, Python™, a high-level programming language, was chosen instead. Specifically, the Python™ tool Jupyter Notebook 5.4.0 was used for all test analyses. It is an online tool and therefore easily accessible. The flow chart shown in Figure 5-1 summarizes the step by step process used during the Python™ analyses. Appendix D contains the code used to generate the results. In general, the following steps were completed:

1. Importing the CT data from excel into Python™,
2. Initial calculations to determine:
    - the starting point for each cycle
    - the stress level (i.e. maximum load divided by initial sample area) for each cycle
    - the loading and unloading portions of each cycle
3. Second level calculations to determine:
    - applied stress and resulting strains per cycle,
    - the maximum displacement and its corresponding time per cycle
    - determining the loading versus time and unloading versus time math functions
4. Third level calculations to determine:
    - elastic moduli per cycle
    - outliers from the moduli
5. Fourth level analyses of data to
    - calculate a damping coefficient for each unloading cycle
    - calculate the area under the displacement-time curve for each cycle

Once these steps were completed the data was evaluated to determine possible correlations between the damping coefficients and/or the areas to rebound.

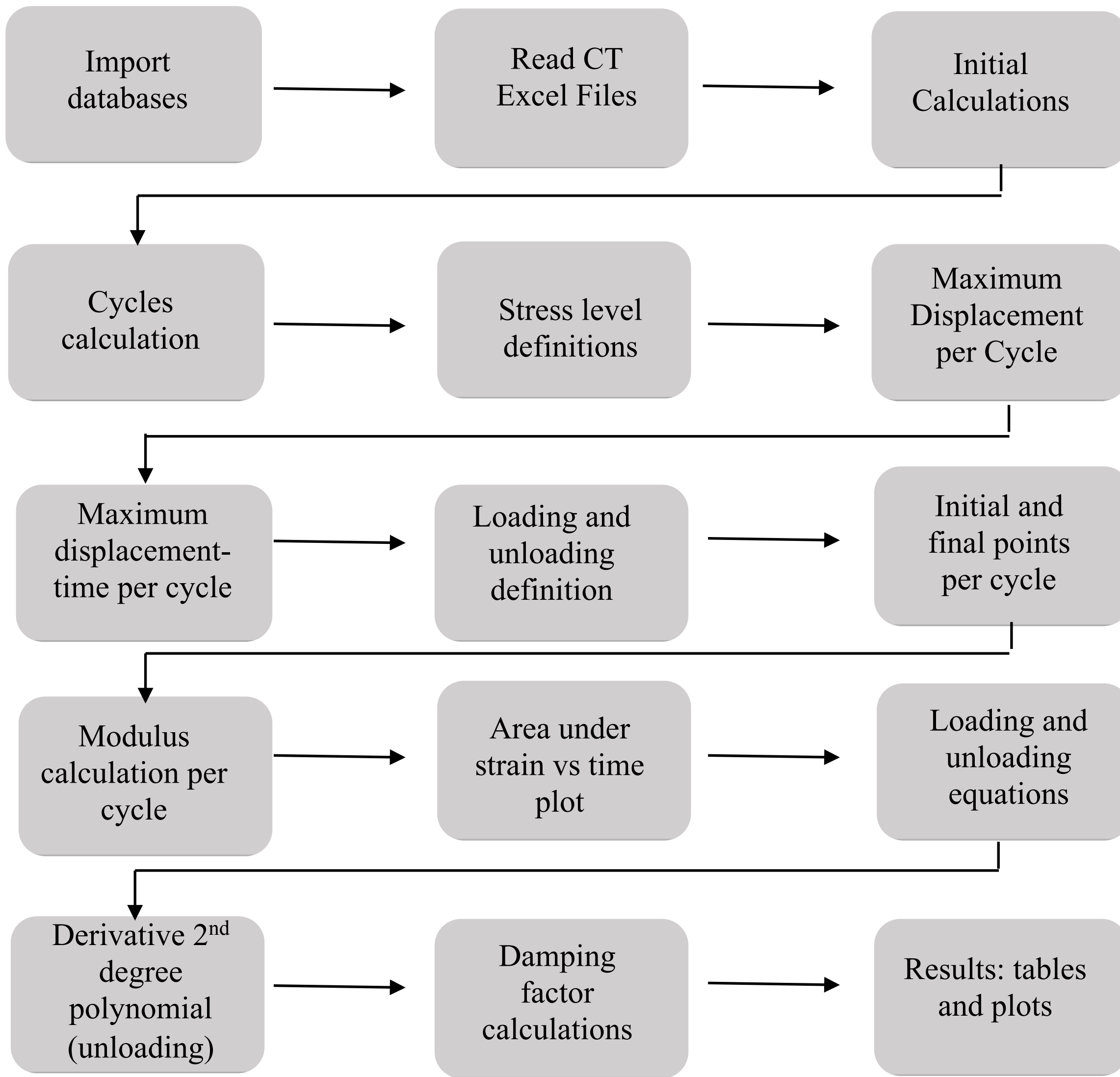



Figure 5-1 Python™ CT Data Analysis Programming Flow Chart

The assumption made for the cyclic analysis was that the soil produces elastic behavior during loading, and viscoelastic behavior during unloading. During each one second cycle, loads were applied over 0.1 seconds, followed by 0.9 seconds of no load.

Figure 5-2 shows a typical strain versus time cycle for a rebound soil. It shows that the loading portion has a linear strain-time behavior, while the unloading portion is closer to a second-degree polynomial. Therefore, a linear equation and a second-degree polynomial equation were used in Python™ to describe the strain-time behavior of the soil.

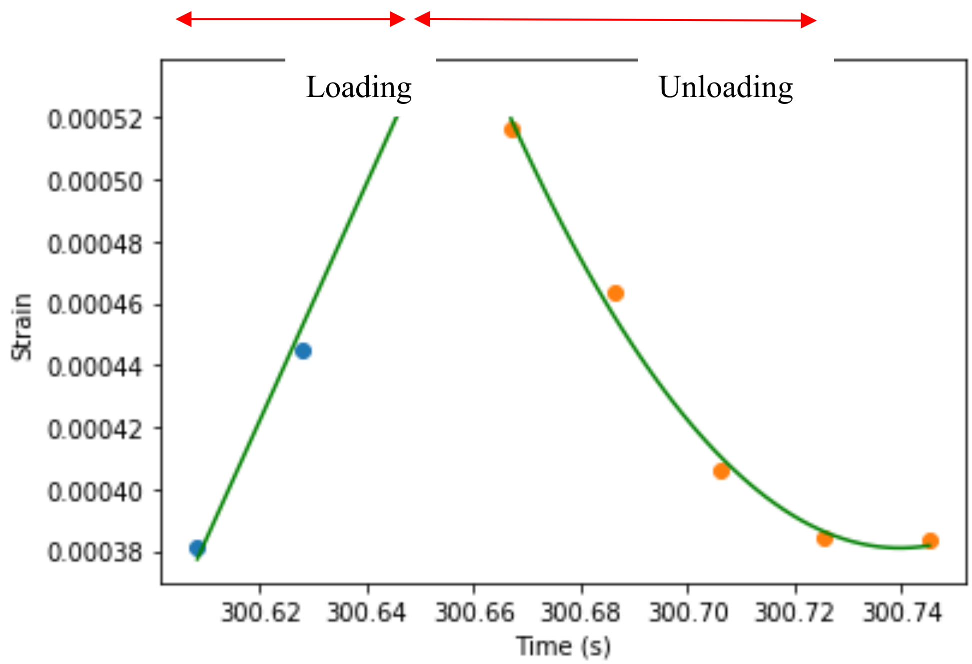



Figure 5-2 Typical Cyclic Strain versus Time Behavior

### 5.3.1 Initial Calculations

Table 5-2 shows the average triaxial and CT sample dimensions for each site. The dimensions for each sample tested are shown in Appendix F. The first calculations consisted of determining stress and strain. The stress was calculated by dividing the applied load by the initial specimen's area, and the strain is the ratio of the displacement by the specimen's initial height.

Table 5-2 Average Specimen Dimensions for both CU and CT Data

| Site | Average Area (si) | Average Height (in) | Average Mass (lb) | Average Density (pcf) |
|---|---|---|---|---|
| Chafee | 6.370 | 6.131 | 2.424 | 107.3 |
| I4&192 | 6.497 | 5.585 | 2.344 | 112.0 |
| I4&417 | 6.386 | 6.100 | 2.645 | 110.7 |
| I4&Osceola | 6.399 | 5.679 | 2.451 | 109.6 |
| Heritage | 6.223 | 6.077 | 2.369 | 109.6 |
| Ramsey Branch | 6.429 | 6.147 | 2.691 | 117.8 |

### 5.3.2 Digitally Numbering the Cycles

The second step consisted of dividing the digital data into cycles, which were determined by rounding the time down to the whole number integer as shown in Table 5-3. Although the first cycle number is 0, it is actually the first cycle read by the software, and therefore named cycle 1. For programming purposes, this manipulation does not affect the results and is an internal programming counter.

Table 5-3 Examples of Python$^{TM}$ Numbering

| Time stamp (s) | Integer | Cycle number |
|---|---|---|
| 0.220 | 0.0 | 0 |
| 0.500 | 0.0 | 0 |
| 1.250 | 1.0 | 1 |
| 1.890 | 1.0 | 1 |
| 5.890 | 5.0 | 5 |
| 6.230 | 6.0 | 6 |
| 10.790 | 10.0 | 10 |

### 5.3.3 Digitally Determining Stress Levels

The stress levels were digitally determined by dividing the cycles into groups of 1,000. Therefore, cycles 0 – 1,000 were assigned to stress level 1; cycles 1,000 – 2,000 were assigned to stress level 2 and so on.

### 5.3.4 Digitally Determining Loading and Unloading Portions

Another critical programming step was defining the load and the unload parts of each cycle. The loading portion ranges from the first point of the cycle to its maximum displacement. Unloading, on the other hand, was set as the range between the maximum displacement and the last point of the cycle.

The 600,000 data points per CT test include data between each load applications (i.e., data between the unloading of cycle I and loading of cycle i+1). Figure 5-3 shows data prior to and immediately after a cyclic loading. Since the data between cycles did not need to be analyzed, those data were removed from the analysis. In order to do so, time increments (Δ) before and after the peak load were evaluated. Therefore, assuming that the time for maximum displacement for cycle I is tmax, then the range considered goes from (tmax – 0.05) seconds to (tmax + 0.1) seconds. The unloading part was assumed to last longer due to the viscoelastic behavior.

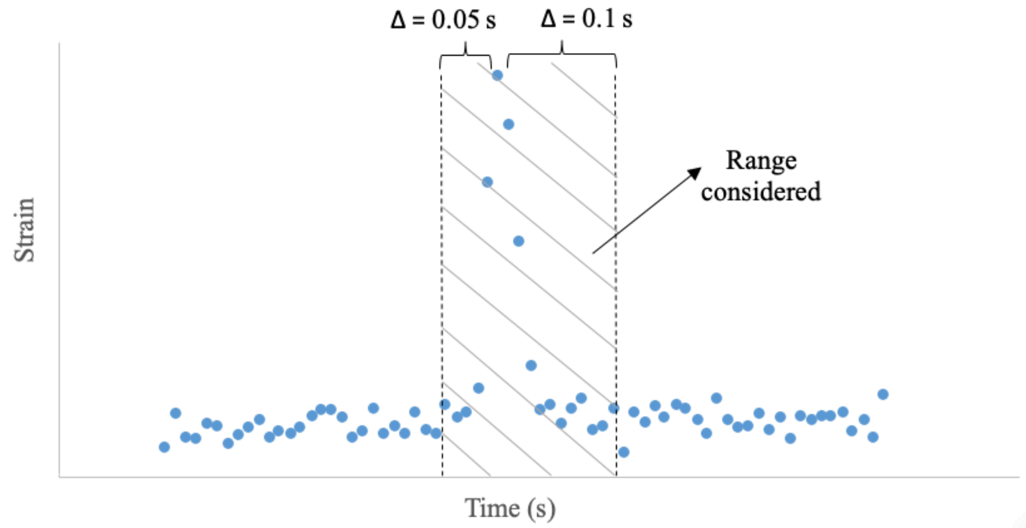



Figure 5-3 Range of Data Points Considered for Each Cycle

### 5.3.5 Engineering Properties

Once the cycles were defined and the data points to be evaluated were separated from the whole data, the soil's engineering properties were calculated. For the loading portion of each cycle, the elastic coefficient (Young's Modulus) E was calculated based on maximum deviatory stress ($\sigma_{d,max}$), maximum strain ($\varepsilon_{max}$) and initial strain ($\varepsilon_0$) of each cycle:

$$E = \frac{\sigma_{d,max}}{\varepsilon_{max} - \varepsilon_0}$$

Outliers were found when calculating E. Some results for E were infinite and were removed from the analysis. Infinity results from $\varepsilon_{max}$ being equal to $\varepsilon_0$. Possible explanations, can be either because the loading frequency is not consistent, which causes the cycle dividing method to fail, or because the data points for the loading portion were cut off when defining the range of data being analyzed (Δ). Once the moduli were determined per stress level, the data were analyzed to determine any possible engineering trends. Figure 5-4 shows E versus cycle number and depicts moduli above the average, which for this example is 250,000 psi. Figure 5-4 also shows that certain values of E were much higher than the majority of the results, and therefore were considered outliers. That most likely was caused by a lack of data points being recorded within the loading part. Outliers were removed based on engineering judgement of realistic moduli and subsequent visual analysis of plots as shown in Figure 5-4.

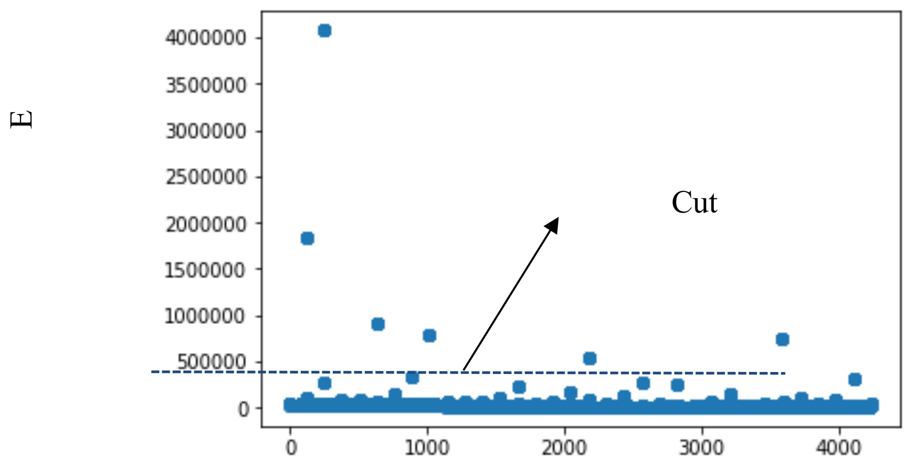



Figure 5-4 Typical E versus Cycle Number

Once the infinite values and outliers were removed from a data set, the average E value per site was determined. The average E per stress level is presented in Appendix F. Table 5-4 shows the average percentage of E values considered as outliers for each site. This testing produced about 2% outliers, which was considered acceptable.

Table 5-4 Average Number of Excluded E Outlier Values

| Site | Average of % Infinite E | Average of % Total outliers E |
|---|---|---|
| Chaffee | 2 | 3 |
| Heritage | 2 | 2 |
| I4&192 | 2 | 2 |
| I4&417 | 2 | 2 |
| I4&Osceola | 2 | 2 |
| Ramsey Branch | 2 | 3 |

In order to estimate the damping coefficient, the Python™ polyfit function was used to determine the best second-degree polynomial that fits the strain versus time data points for each cycle. Figure 5-5 shows an example of the Python™ polyfit data fitting.

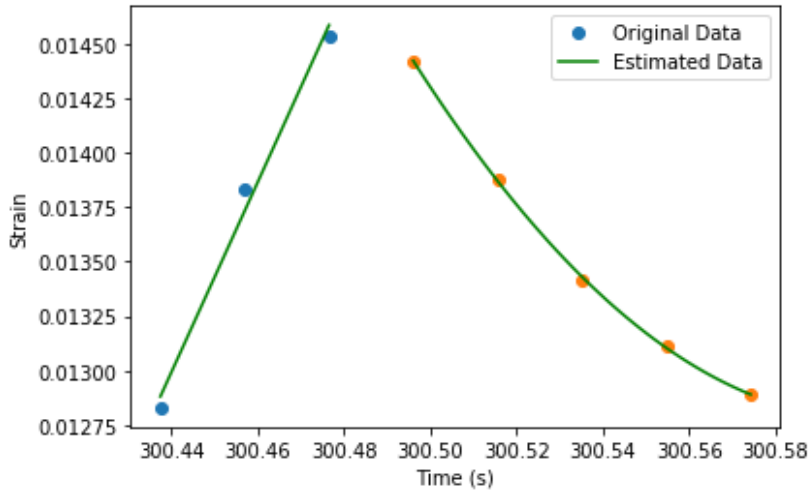



Figure 5-5 Python™ Polyfit Fitting Function Example

Once the polynomial equation was defined, its derivative ($\dot{\varepsilon}$) was calculated according to:

$$\varepsilon : At^2 + Bt + C$$

$$\dot{\varepsilon} = 2At + B$$

The damping factor was then determined based on a Kelvin-Voigt model, using $\sigma_{d,max}$, $\dot{\varepsilon}$ and E from the loading porting of the same cycle:

$$\eta = \frac{\sigma_{max} - E \times \varepsilon}{\dot{\varepsilon}}$$

An average of $\eta$ was determine per stress level.

## 5.4 CT Analysis of Results

### 5.4.1 Correlation to CASE Damping Factor

The CT damping factor has stress × time units as shown:

$$\sigma = E \times \varepsilon + \eta \times \dot{\varepsilon} \rightarrow \frac{lb}{in^2} = \frac{lb}{in^2} + [\eta]\frac{1}{s}$$

$$\frac{lb}{in^2} = [\eta]\frac{1}{s} \rightarrow [\eta] = \frac{s.lb}{in^2}$$

Figure 5-6 shows the distribution of η versus normalized stress ($\sigma_{d_{max}}/\sigma_{f_{CU}}$) for each stress level. The failure stress from the corresponding CU triaxial test was used for normalization. In several instances, the CU failure stress was much less than the corresponding CT stress level, thereby producing normalized values of well over 100 %.

Damping coefficients determined from CT tests ranged from near zero to over 100,000 psi-s, with the majority of η values below 10. To help clarify this information, a frequency table was developed, with each range corresponding to one order of magnitude (Table 5-5). Although this information could also be presented using a histogram, it is believed that the table is sufficient to clarify the results.

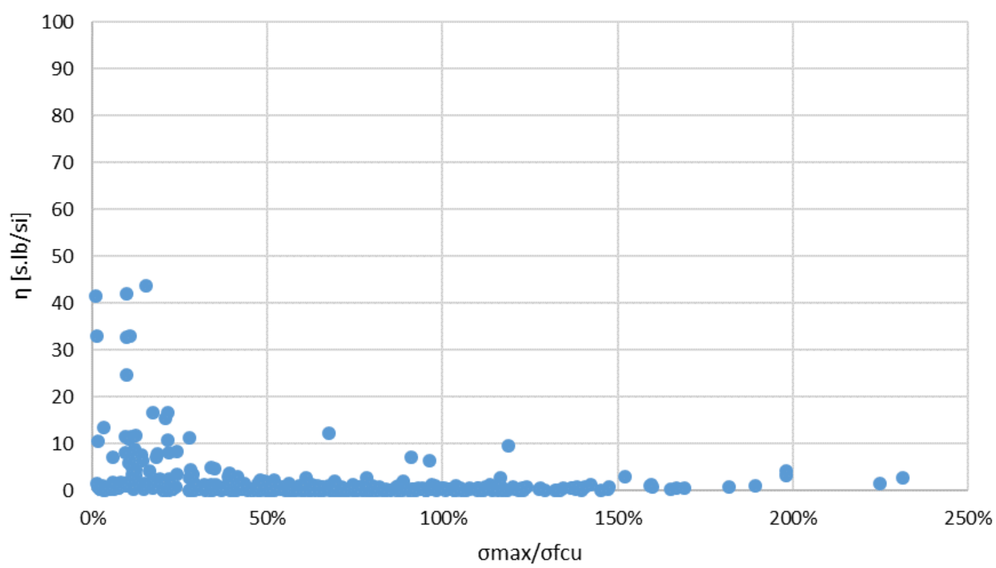



Figure 5-6 η versus Normalized Stress Level Based on CU Triaxial Failure Stress

Table 5-5 shows the data points obtained for η within each range, depicted by order of magnitude. According to the results, 80% of the η values obtained are between 0 and 10 s-lb/in$^2$.

Table 5-5 Range of η [s·lb/in$^2$] for all CT data

| Range | Data Points | % Total | % Cumulative |
|---|---|---|---|
| 0.001 - 0.01 | 5 | 1.1% | 1.1% |
| 0.01 - 0.1 | 106 | 23.6% | 24.7% |
| 0.1 - 1 | 214 | 47.6% | 72.2% |
| 1 - 10 | 84 | 18.7% | 90.9% |
| 10 - 100 | 19 | 4.2% | 95.1% |
| 100 - 1,000 | 13 | 2.9% | 98.0% |
| 1,000 - 10,000 | 3 | 0.7% | 98.7% |
| 10,000 - 100,000 | 4 | 0.9% | 99.6% |
| 100,000 - 1,000,000 | 1 | 0.2% | 99.8% |
| 1,000,000 - 10,000,000 | 0 | 0.0% | 99.8% |
| 10,000,000 - 100,000,000 | 1 | 0.2% | 100.0% |
| Total | 450 | 100% | |

Frequency tables were also developed for each of the five sites. Ramsey Branch, Chaffee Road and I4, and 192 have the highest reported PDA rebound of the five sites analyzed. Two of those three sites show over 60 % of the damping coefficients between 0.1 and 1. The Chaffee Road data shows about 60% have damping coefficients below 0.1. Heritage Parkway, which had limited rebound greater than ¼ inch showed over 50% of the coefficients between 0.01 and 0.1. In summary, there seems to be a slight relationship between the CT damping coefficients and rebound, but the sampling process and number of sites must be increased to make substantial conclusions.

Table 5-6 Range of η [s·lb/in$^2$] for Ramsey Branch

| Range | Data Points | % Total | % Cumulative |
|---|---|---|---|
| 0 – 0.01 | 0 | 0.0% | 0.0% |
| 0.01 – 0.1 | 0 | 0.0% | 0.0% |
| 0.1 – 1 | 31 | 70.5% | 70.5% |
| 1 – 10 | 10 | 22.7% | 93.2% |
| 10 – 100 | 0 | 0.0% | 93.2% |
| 100 – 1,000 | 2 | 4.5% | 97.7% |
| 1,000 – 10,000 | 1 | 2.3% | 100.0% |
| 10,000 – 100,000 | 0 | 0.0% | 100.0% |
| 100,000 – 1,000,000 | 0 | 0.0% | 100.0% |
| 1,000,000 – 10,000,000 | 0 | 0.0% | 100.0% |
| 10,000,000 – 100,000,000 | 0 | 0.0% | 100.0% |
| Total | 44 | 100% | |

Table 5-7 Range of η [s·lb/in$^2$] for Chaffee

| Range | Data Points | % Total | % Cumulative |
|---|---|---|---|
| 0 – 0.01 | 2 | 3.0% | 3.0% |
| 0.01 – 0.1 | 40 | 59.7% | 62.7% |
| 0.1 – 1 | 12 | 17.9% | 80.6% |
| 1 – 10 | 9 | 13.4% | 94.0% |
| 10 – 100 | 3 | 4.5% | 98.5% |
| 100 – 1,000 | 1 | 1.5% | 100.0% |
| 1,000 – 10,000 | 0 | 0.0% | 100.0% |
| 10,000 – 100,000 | 0 | 0.0% | 100.0% |
| 100,000 – 1,000,000 | 0 | 0.0% | 100.0% |
| 1,000,000 – 10,000,000 | 0 | 0.0% | 100.0% |
| 10,000,000 – 100,000,000 | 0 | 0.0% | 100.0% |
| Total | 67 | 100% | |

Table 5-8 Range of η [s·lb/in$^2$] for I-4 & SR-192

| Range | Data Points | % Total | % Cumulative |
|---|---|---|---|
| 0 – 0.01 | 0 | 0.0% | 0.0% |
| 0.01 – 0.1 | 14 | 11.9% | 11.9% |
| 0.1 – 1 | 74 | 62.7% | 74.6% |
| 1 – 10 | 20 | 16.9% | 91.5% |
| 10 – 100 | 5 | 4.2% | 95.8% |
| 100 – 1,000 | 4 | 3.4% | 99.2% |
| 1,000 – 10,000 | 0 | 0.0% | 99.2% |
| 10,000 – 100,000 | 1 | 0.8% | 100.0% |
| 100,000 – 1,000,000 | 0 | 0.0% | 100.0% |
| 1,000,000 – 10,000,000 | 0 | 0.0% | 100.0% |
| 10,000,000 – 100,000,000 | 0 | 0.0% | 100.0% |
| Total | 118 | 100% | |

Table 5-9 Range of η [s·lb/in$^2$] for I-4 & SR-417

| Range | Data Points | % Total | % Cumulative |
|---|---|---|---|
| 0 – 0.01 | 0 | 0.0% | 0.0% |
| 0.01 – 0.1 | 2 | 3.8% | 3.8% |
| 0.1 – 1 | 23 | 44.2% | 48.1% |
| 1 – 10 | 20 | 38.5% | 86.5% |
| 10 – 100 | 5 | 9.6% | 96.2% |
| 100 – 1,000 | 0 | 0.0% | 96.2% |
| 1,000 – 10,000 | 0 | 0.0% | 96.2% |
| 10,000 – 100,000 | 1 | 1.9% | 98.1% |
| 100,000 – 1,000,000 | 1 | 1.9% | 100.0% |
| 1,000,000 – 10,000,000 | 0 | 0.0% | 100.0% |
| 10,000,000 – 100,000,000 | 0 | 0.0% | 100.0% |
| Total | 52 | 100% | |

Table 5-10 Range of η [s·lb/in$^2$] for I-4 & Osceola

| Range | Data Points | % Total | % Cumulative |
|---|---|---|---|
| 0 – 0.01 | 0 | 0.0% | 0.0% |
| 0.01 – 0.1 | 7 | 8.0% | 8.0% |
| 0.1 – 1 | 52 | 59.8% | 67.8% |
| 1 – 10 | 17 | 19.5% | 87.4% |
| 10 – 100 | 4 | 4.6% | 92.0% |
| 100 – 1,000 | 4 | 4.6% | 96.6% |
| 1,000 – 10,000 | 2 | 2.3% | 98.9% |
| 10,000 – 100,000 | 1 | 1.1% | 100.0% |
| 100,000 – 1,000,000 | 0 | 0.0% | 100.0% |
| 1,000,000 – 10,000,000 | 0 | 0.0% | 100.0% |
| 10,000,000 – 100,000,000 | 0 | 0.0% | 100.0% |
| Total | 87 | 100% | |

Table 5-11 Range of η [s·lb/in²] for Heritage

| Range | Data Points | % Total | % Cumulative |
|---|---|---|---|
| 0 – 0.01 | 3 | 3.7% | 3.7% |
| 0.01 – 0.1 | 43 | 52.4% | 56.1% |
| 0.1 – 1 | 22 | 26.8% | 82.9% |
| 1 – 10 | 8 | 9.8% | 92.7% |
| 10 – 100 | 2 | 2.4% | 95.1% |
| 100 – 1,000 | 2 | 2.4% | 97.6% |
| 1,000 – 10,000 | 0 | 0.0% | 97.6% |
| 10,000 – 100,000 | 1 | 1.2% | 98.8% |
| 100,000 – 1,000,000 | 0 | 0.0% | 98.8% |
| 1,000,000 – 10,000,000 | 0 | 0.0% | 98.8% |
| 10,000,000 – 100,000,000 | 1 | 1.2% | 100.0% |
| Total | 82 | 100% | |

In order to be compared to Jc, η has to be normalized by an impedance (Im). The properties chosen to compose Im were based on their units, and they are the cross-sectional area of the specimen (A), the soil's density (ρ) and the shear wave velocity traveling through the soil sample ($c_{sample}$). The relation among the properties is the following:

$$I_m = \frac{A \times \rho}{c_{sample}}$$

Dividing the damping factor by the impedance, the result becomes dimensionless:

$$\frac{s.lb}{in^2} \div \frac{in^2\, {lb}/{in^3}}{in/s} = \frac{s.lb}{in^2} \times \frac{in/s}{in^2\, {lb}/{in^3}} = \frac{s.lb}{in^2} \times \frac{in^4}{in^2 lb.s} = \text{dimensionless}$$

However, the wave velocity traveling through the pile during the pile driving process is not the same as the wave traveling through the soil sample during the cyclic triaxial test. For that reason, when comparing CASE damping factor to the damping factor calculated from the cyclic triaxial data (η), a factor of cpile/csample has to be used in order to fairly compare them.

According to the U.S. Department of Transportation (2017), the compression wave velocity traveling through the triaxial soil sample relates to Young's modulus as follows:

$$\mathrm{E} = c_{sample}^{2}\rho$$

Huang et al. (2017) presents an estimate for the wave traveling during pile driving (cpile) of 320 m/s (12598 in/s) for silty sands. Therefore, η resultant from the triaxial test was multiplied by a ratio of 12598/csample and then by the impedance Im in order to be compared to Jc. Table 5-12 shows the range of results obtained.

Table 5-12 Range of Results for Normalized Damping Factor

| Range | Data Points | % Total | % Cumulative |
|---|---|---|---|
| 10E2 - 10E3 | 51 | 11.3% | 11.3% |
| 10E3 - 10E4 | 179 | 39.8% | 51.1% |
| 10E4 - 10E5 | 156 | 34.7% | 85.8% |
| 10E5 - 10E6 | 39 | 8.7% | 94.4% |
| 10E6 - 10E7 | 11 | 2.4% | 96.9% |
| 10E7 - 10E8 | 7 | 1.6% | 98.4% |
| 10E8 - 10E9 | 4 | 0.9% | 99.3% |
| 10E9 - 10E10 | 2 | 0.4% | 99.8% |
| 10E10 - 10E11 | 0 | 0.0% | 99.8% |
| 10E11 - 10E12 | 1 | 0.2% | 100.0% |
| Total | 450 | 100% | |

According to Table 5-12, 80% of the normalized damping factor results fall within the range between $10^2$ and $10^5$. Therefore, when normalized, η varies from two to five orders of magnitude higher than CASE damping factor.

### 5.4.2 Strain versus Time Area

The area under the curve strain versus time curves was also analyzed in order to differentiate rebound from non-rebound soils. The average areas (i.e. total areas from all tests per site divided by number of CT tests per site) for each site are shown in Figure 5-7. Ramsey Branch produced the most rebound (i.e. over 1 inch for well over 10 feet) and the CT data indicates that it has the largest area under the strain-time curves. Heritage Parkway showed minimal rebound (1/4 inch for about 10 feet) and produced the smallest area under the strain-time curves. I4 & 417 had over ½ inch for about 25 feet, while Chaffee Road at I-10 had about 1 inch of rebound over about 15 feet.

Based on Table 4-3, and the ½ inch rebound level, Ramsey Branch, Chaffee and I4&192 had the largest percentage of depths with rebound greater or equal to ½ inch. With the exception of I4&192, area under the strain-time curves does produce an indication of rebound. Therefore, the rebound soils are more likely to have higher average area per cycle under the strain versus time curves.

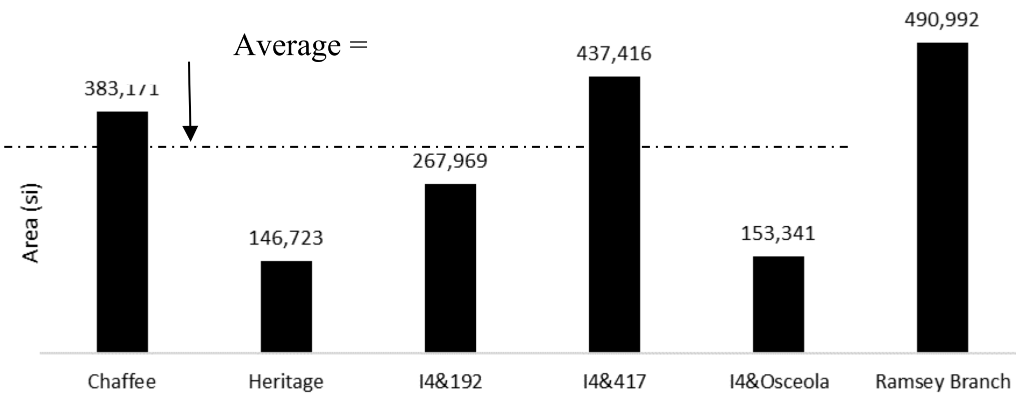



Figure 5-7 Average Strain versus Time Curve Area per Site

### 5.4.3 Hysteresis Loop Equivalent Viscous Damping

Another approach used to define the damping coefficient of soils is defined based on a hysteresis loop method. Tedesco and McDougal (1999) defined the unitless viscous damping coefficient of a material which produces a hysteresis loop using the relationship between the energy loss per cycle (ΔW) and the maximum strain energy (W) of the given cycle as shown in Figure 5-8.

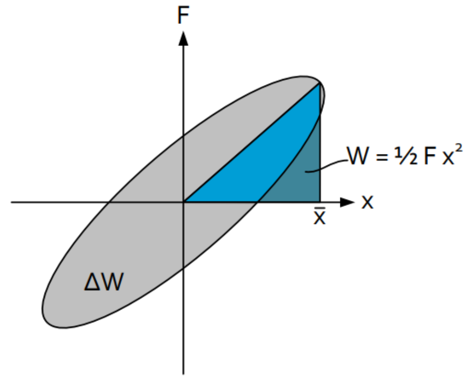



Figure 5-8 Hysteresis Curve

The energy loss per cycle is defined by the area of the hysteresis loop, which represents the difference between the energy absorbed by the system during loading minus the amount of energy dissipated during unloading. The triangle highlighted in Figure 5-8 represents the maximum energy stored in the system.

According to Tedesco and McDougal (1999), the energy loss per cycle (ΔW) can be defined by relating a linear spring constant (k1), the equivalent viscous friction or damping (ζeq) and the maximum displacement (xm) of a hysteretic system according to the following equation.

$$\Delta W = 2\pi k_1 \zeta_{eq} {x_m}^2$$

The maximum strain energy for a linear system (W) can be calculated by:

$$W = \frac{1}{2} k_1 {x_m}^2$$

By combining the two equations, the dimensionless equivalent viscous damping coefficient can be defined by the following expression:

$$\zeta_{eq} = \frac{\Delta W}{4\pi W}$$

Using the equivalent viscous damping hysteresis loop approach, the damping coefficients were obtained from the different sites using Python software coding. The results for each of the sites are shown in Figure 5-9 through Figure 5-14 . Coefficients are shown for each 1000 cycles or stress level, since stress levels were increased after each set of 1000 cycles. The coefficients typically were higher for the initial 1000 cycles and in some cases increased over the last 1000 or 2000 cycles (See Chaffee Rd, Heritage Pkwy, and Ramsey Branch).

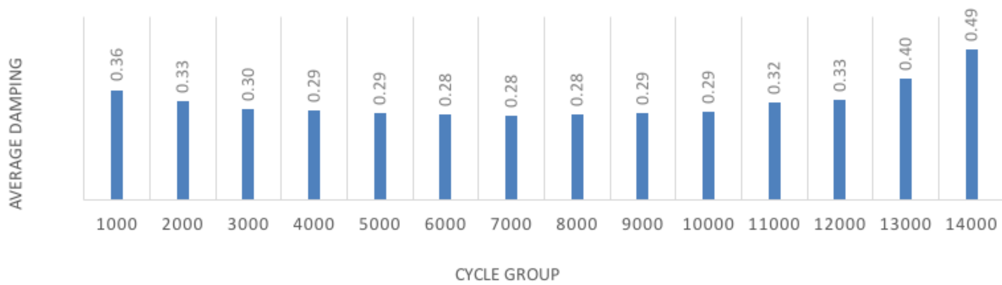



Figure 5-9 Chaffee Rd Equivalent Viscous Damping Coefficients

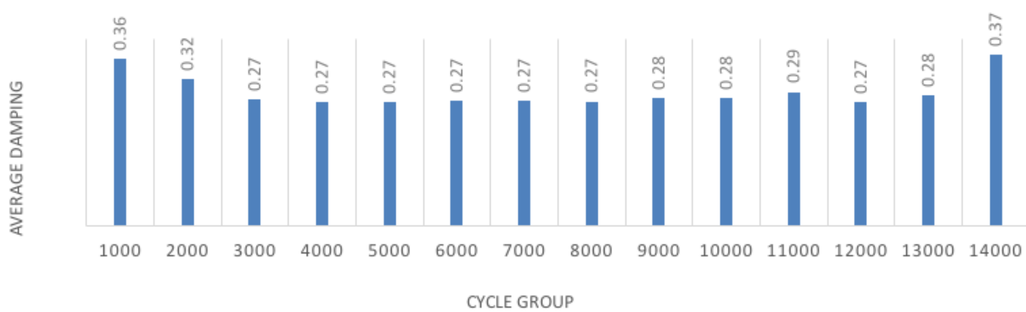



Figure 5-10 Heritage Pkwy Equivalent Viscous Damping Coefficients

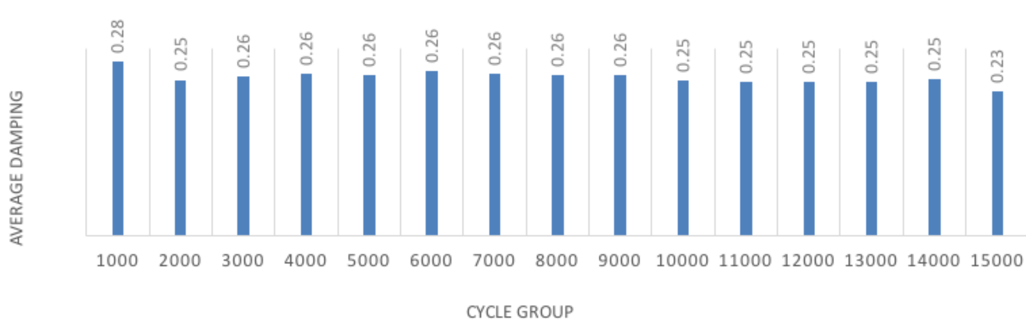


Figure 5-11 I-4 & SR-192 Equivalent Viscous Damping Coefficients

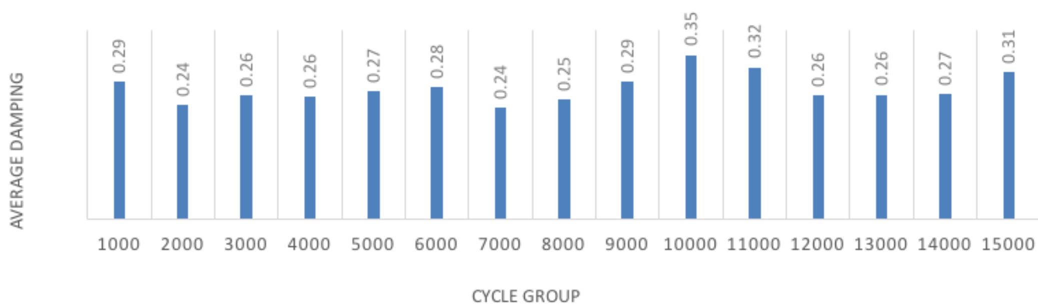



Figure 5-12 – I-4 & SR-417 Equivalent Viscous Damping Coefficients

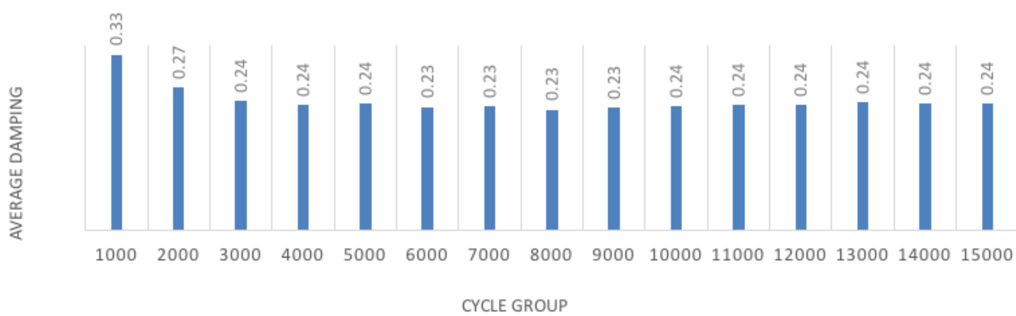



Figure 5-13 I-4 & Osceola Equivalent Viscous Damping Coefficients

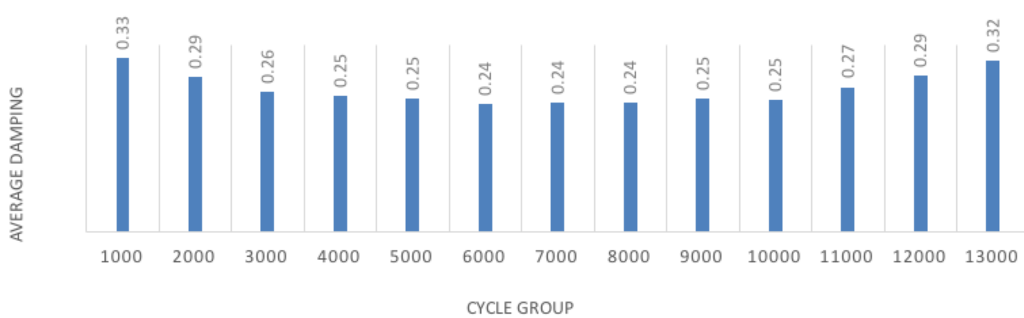



Figure 5-14 Ramsey Branch Equivalent Viscous Damping Coefficients

Figure 5-15 shows the average equivalent viscous damping coefficients for each site and Table 5-13 presents the range of results obtained. The damping coefficients presented in Table 5-13 are similar to the Case values (shown in Table 1). The Case values range from 0.15 to 0.70 for sand silt mixes, while these values range from 0.18 to 0.59. These damping coefficients are dimensionless like the Case values and are based on equivalent energy from the hysteresis response obtained during cyclic triaxial testing with 1-second cycles and load durations of 0.1 seconds.

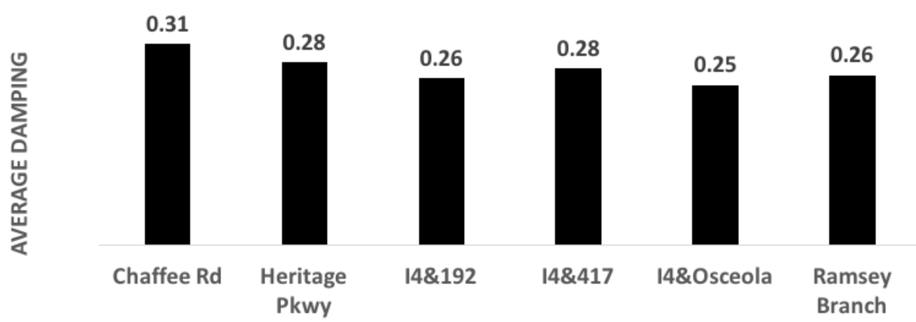



Figure 5-15 Average Equivalent Viscous Damping Coefficients for All sites

Table 5-13 – Range of Equivalent Viscous Damping Coefficients

| Site | Maximum Damping | Minimum Damping |
|---|---|---|
| Chaffee Rd | 0.59 | 0.24 |
| Heritage Pkwy | 0.48 | 0.22 |
| I4&192 | 0.37 | 0.20 |
| I4&417 | 0.54 | 0.21 |
| I4&Osceola | 0.49 | 0.18 |
| Ramsey Branch | 0.43 | 0.22 |

### 5.4.4 Findings

Viscous damping factors were successfully calculated from 40 CT tests on thin tube walled samples obtained from sites in central and north Florida. Due to the complexity of CT testing and data acquisition about 2% of the data produced unrealistic results and were eliminated from analyses.

Two approaches were used to predict damping coefficients and compare them to the reported Case damping coefficients. One approach was based on stress-time units and produced similar values for a certain percentage of the data; however, there was still a significant percentage of values well outside the ranges for the Case factors. A second, viscous energy-based approach produced unitless damping coefficients, which were very similar to the Case values. These coefficients typically were higher for the initial 1000 cycles and in some cases increased over the last 1000 or 2000 cycles.

## 5.5 CAPWAP® Analysis and Results

### 5.5.1 Overview

The direct analysis of pile driving can be done through the use of PDA data and the CAPWAP® software. The damping coefficient used for analysis in CAPWAP® and its effect on the soil's bearing capacity is not well understood. Therefore, comparing the CAPWAP® damping coefficients of different rebound and non-rebound soils may produce a better understanding of its effect on pile rebound.

### 5.5.2 Sites Evaluated

As presented previously, five sites were evaluated using Pile Driving Analyzer (PDA) and Test Piles. The sites include 417 & International, Heritage Pkwy, Chaffee Rd, I-4 & 192 and Ramsey Branch. Table 5-14 shows the site name and the test piles description for the sites evaluated:

Table 5-14 Test Piles Description

| Site | Test Pile description | Acronym |
|---|---|---|
| Chaffee Rd | Pier 2 – Pile 9 | PR2PL9 |
| Heritage Pkwy | End Bent 1 – Pile 1 | EB1P1 |
| Heritage Pkwy | End Bent 5 – Pile 1 | EB5P1 |
| Heritage Pkwy | Interior Bent 3 – Pile 1 | IB3P1 |
| Heritage Pkwy | Interior Bent 4 – Pile 1 | IB4P10 |
| I-4 & 192 | Pier 8 – Pile 4 | P8P4 |
| 417 & International | End Bent 1 – Pile 14 | EB1P14 |
| 417 & International | End Bent 2 – Pile 5 | EB2P5 |
| Ramsey Branch | End Bent 1 – Pile 1 | EB1P1 |
| Ramsey Branch | End Bent 1 – Pile 3 | EB1P3 |
| Ramsey Branch | End Bent 4 – Pile 5 | EB4P5 |
| Ramsey Branch | End Bent 5 – Pile 2 | EB5P2 |

An overview of the test borings and PDA test piles is presented in Table 5-15 ,with test pile designation, ground surface, beginning and ending PDA collection elevations. Twelve PDA test piles were evaluated.

Table 5-15 PDA Test Piles Description

| Site | Test Pile | Beginning Elevation of PDA collection (ft) | Ending Elevation of PDA collection (ft) |
|---|---|---|---|
| Chaffee Rd | PR2PL9 | 31.9 | -16 |
| Heritage Pkwy | EB1P1 | 2.1 | -89.9 |
| | EB5P1 | -1 | -81 |
| | IB3P1 | -9.3 | -91.3 |
| | IB4P10 | -10.6 | -91.8 |
| I4 & 192 | P8P4 | 70.1 | -1.9 |
| 417 & International | EB1P14 | 66.7 | 0.8 |
| | EB2P5 | 51.3 | 0.1 |
| Ramsey Branch | EB1P1 | -46.6 | -80.5 |
| | EB1P3 | -51.7 | -71.6 |
| | EB4P5 | -23.1 | -104.8 |
| | EB5P2 | -21.7 | -78.6 |

### 5.5.3 Evaluation Criteria

In order to perform the analysis three criteria needed to be established. They were, the number of hammer-blows per foot, the rebound level, and the side friction from the PDA data.

During pile driving, an average of 120 blows/ft, it means that the pile will have an average final set (net penetration) of 0.1 inches per blow. This behavior, for example, could be due to the high resistance of the soil, which means that the pile achieves its resistance goal, or due to high rebound, in which the final set is relatively small compared to the pile's maximum displacement. According to the current FDOT specification (455-5.10.3), rebound values that are equal to or greater than 0.25 inches are considered high.

In order to analyze the rebound, 12 different blows from 12 test piles at five sites, were evaluated. The criteria used to choose the critical blows were related to blow counts, rebound level and side friction.

Although 120 blows/ft would be considered a high blow count, most of the test piles analyzed did not reach this level. Therefore, based on engineering judgement, a minimum of 60 blows/ft was chosen to be the high blow count criteria.

BDV-28 977-01 results indicated that rebound greater than 0.50 inches may produce better engineering information, plus be easier for the inspector to identify, than 0.25 inches. Again, based on the available and engineering judgement in terms of the rebound, a minimum of 0.45 inches of rebound was considered in the selection of the blows. Note that eleven of the 12 blows chosen met this criterion, with one exception having rebound of 0.41 inches.

Finally, low side friction allows rebound. Although a low side friction-rebound threshold is difficult to define, after evaluating the PDA data, engineering judgement was used and values lower than 110 kips were considered low side friction (SFT-side friction total). A friction-bearing ratio was also calculated by dividing SFT by the PDA estimated total end bearing (EB0-end bearing total). These totals include both the static and dynamic components.

### 5.5.4 Blow Number Selections

The following plots show the blow count, rebound and side friction for all test piles evaluated. The rebound was calculated by subtracting the inspector set from the maximum displacement (DMX). A red dot, shown on each plot, represents the blow selected for the CAPWAP® analysis based on 60 blows/foot, 0.45 inches of rebound and SFT of 110 kips or less.

### 5.5.4.1 SR-417 & International

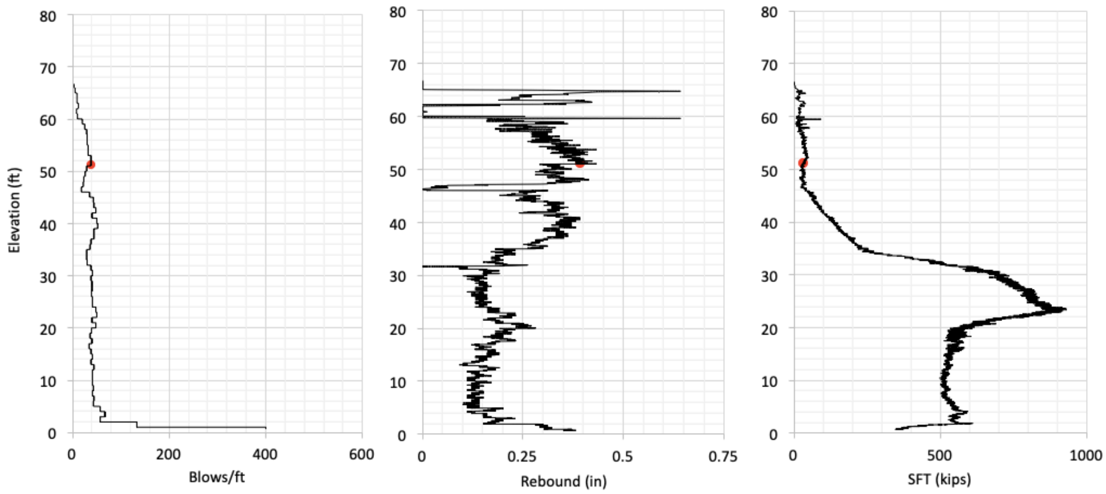



Figure 5-16 End Bent 1 Pile 14

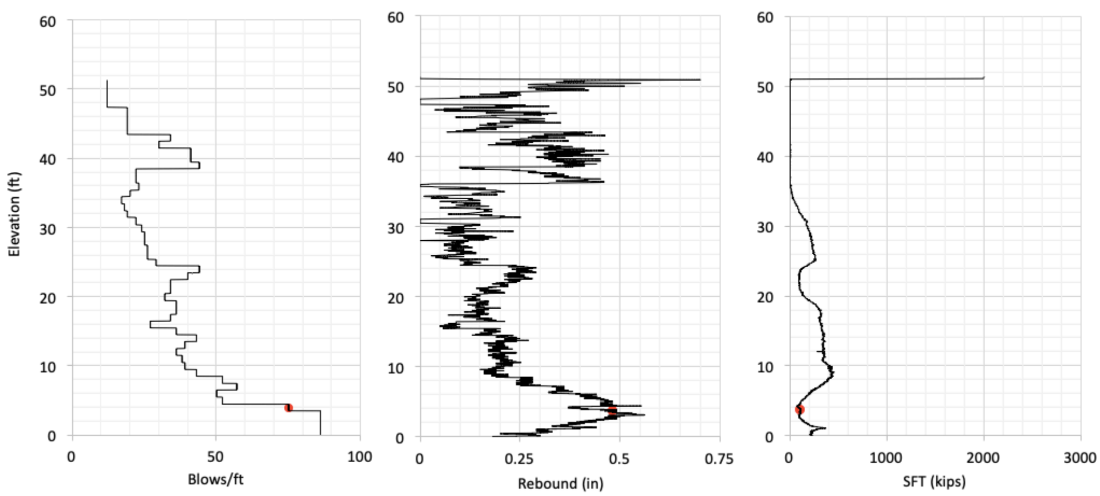



Figure 5-17 End Bent 2 Pile 5

## 5.5.4.2 Heritage Parkway

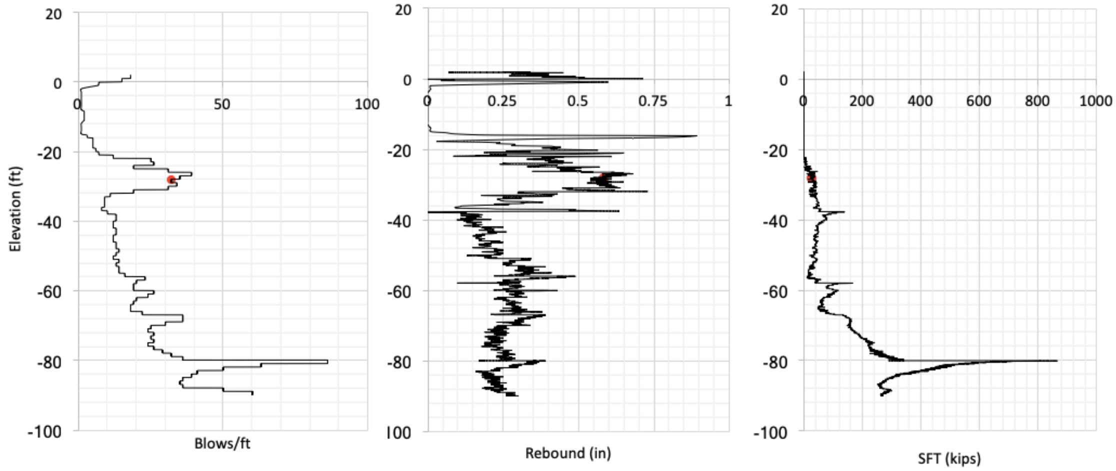



Figure 5-18 End Bent 1 Pile 1

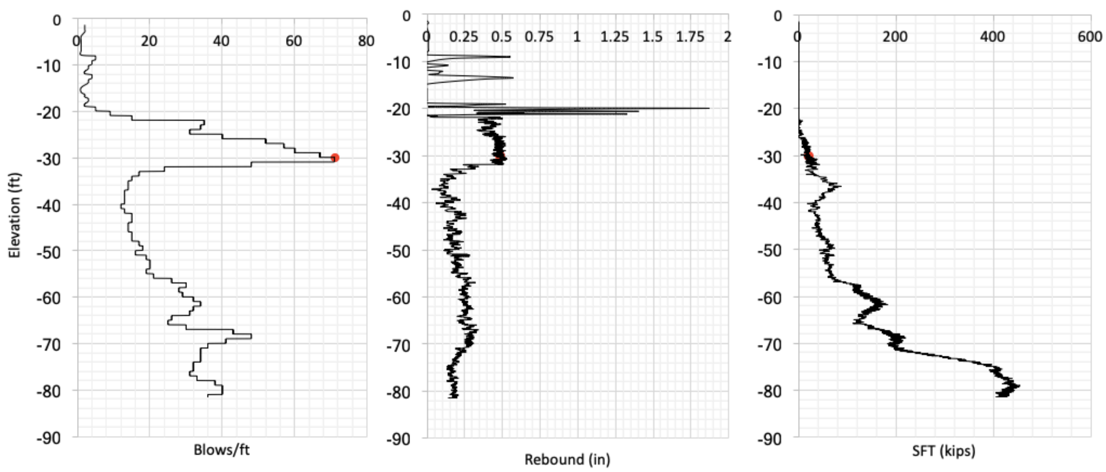



Figure 5-19 End Bent 5 Pile 1

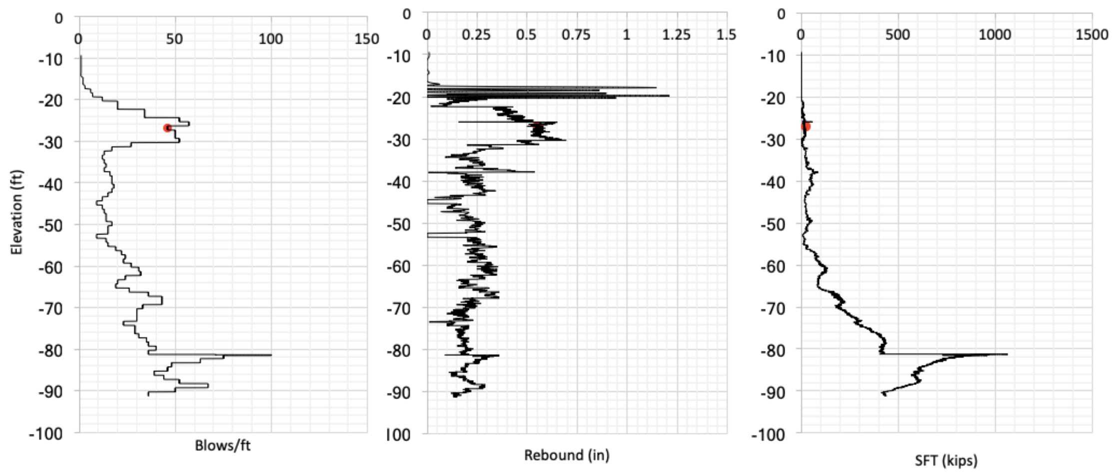



Figure 5-20 Intermediate Bent 3 Pile 1

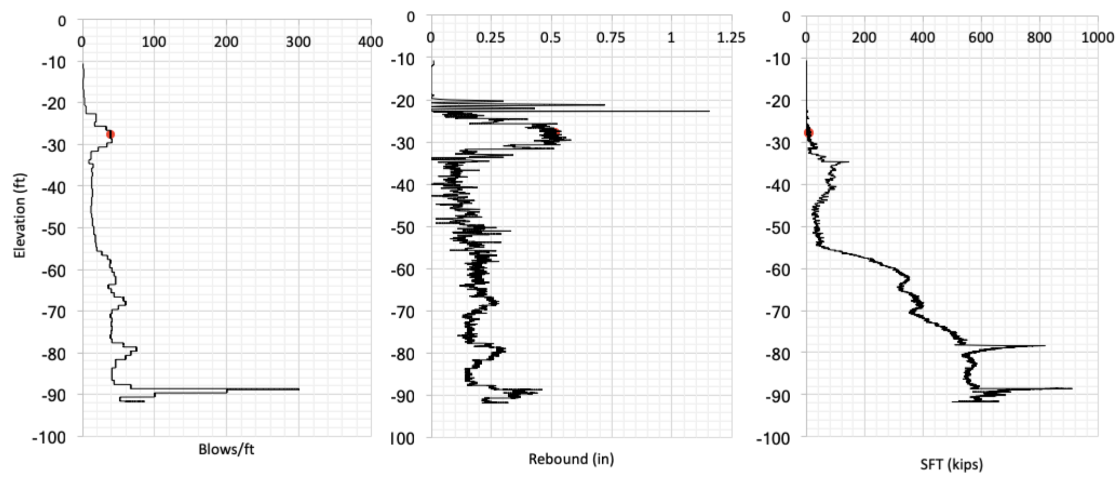



Figure 5-21 Intermediate Bent 4 Pile 10

### 5.5.4.3 Chaffee Rd

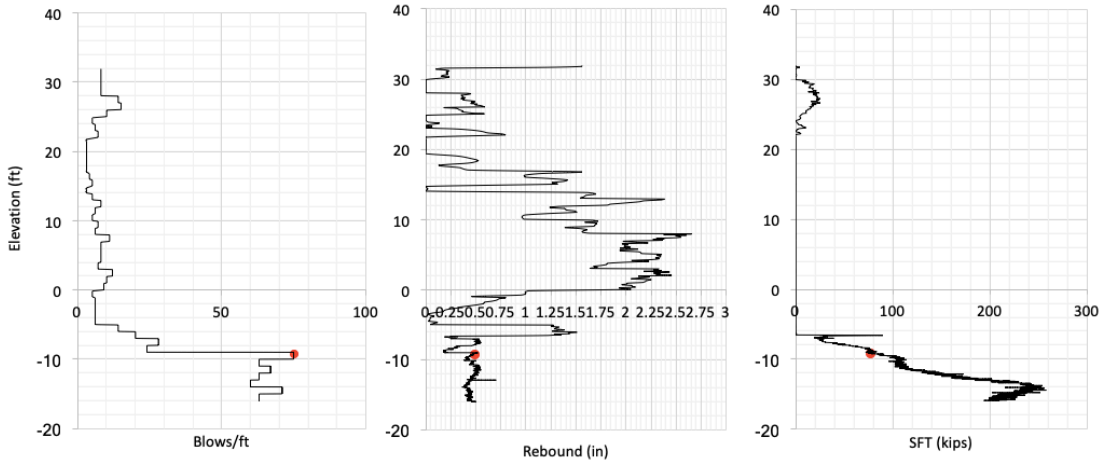



Figure 5-22 Pier 2 Pile 9

### 5.5.4.4 I-4 & SR-192

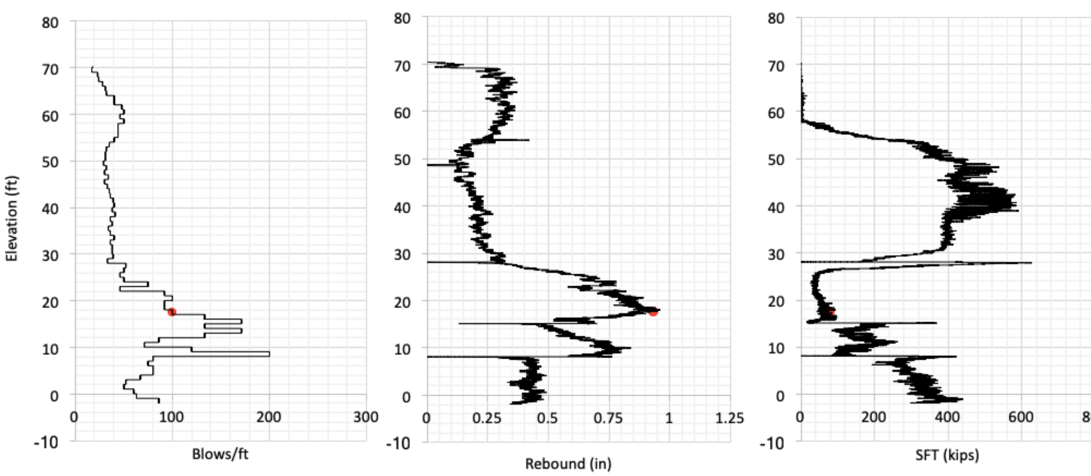



Figure 5-23 Pier 8 Pile 4

### 5.5.4.5 Ramsey Branch

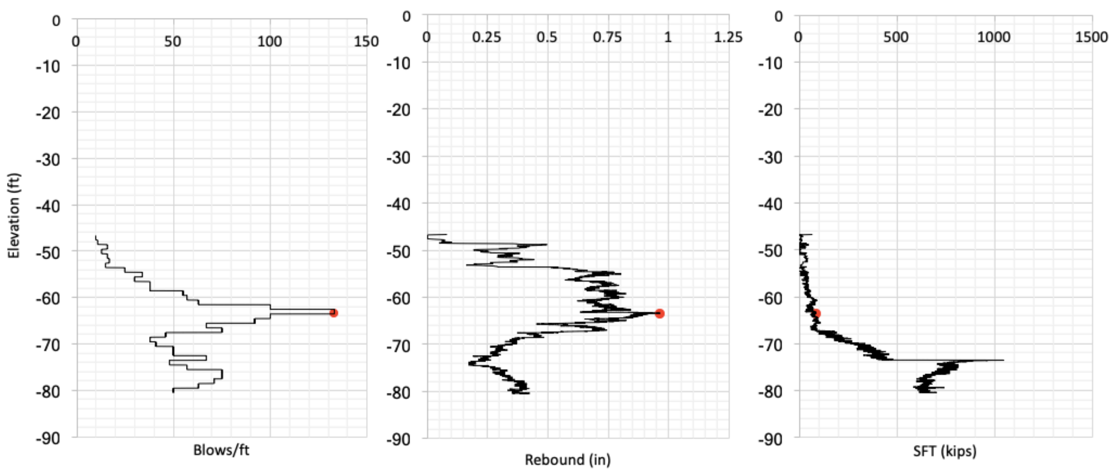



Figure 5-24 End Bent 1 Pile 1

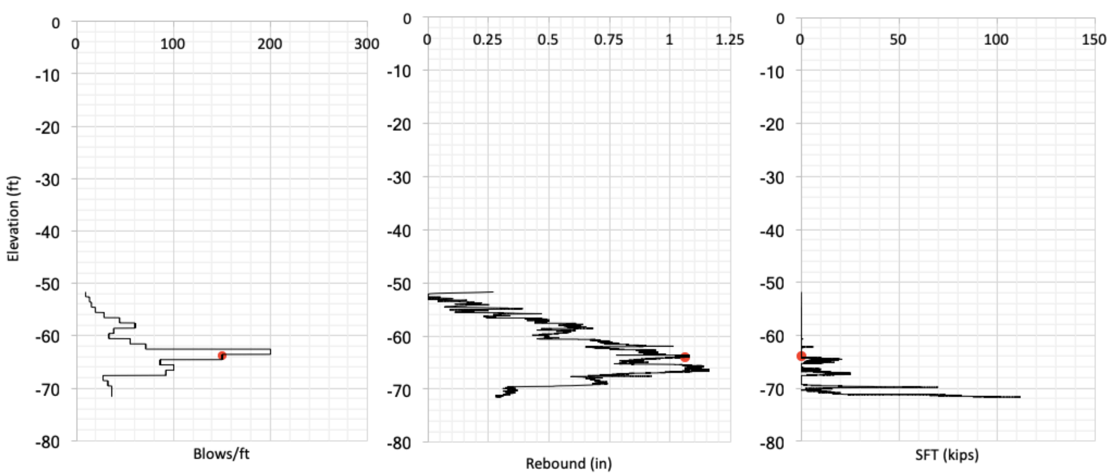



Figure 5-25 End Bent 1 Pile 3

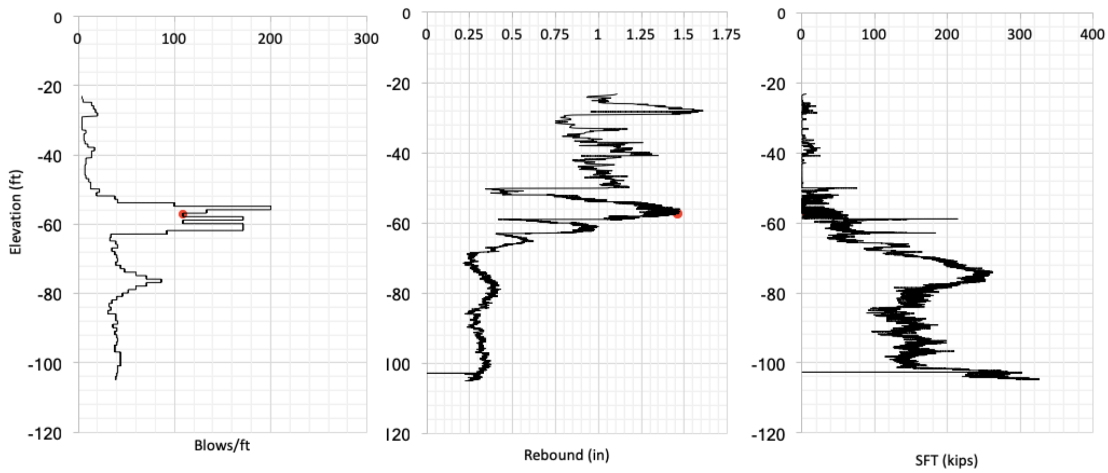



Figure 5-26 End Bent 4 Pile 5

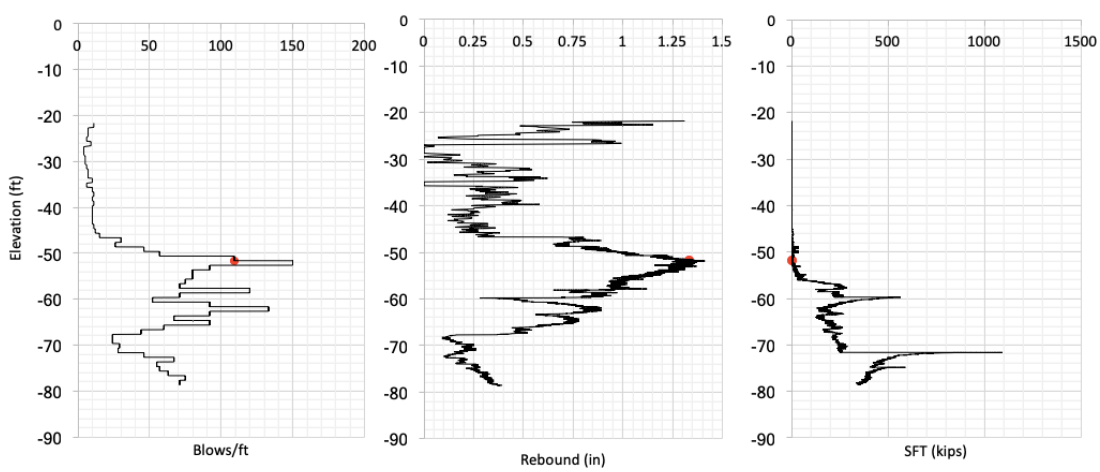



Figure 5-27 End Bent 5 Pile 2

Table 5-16 is a summary of the chosen CAPWAP® analysis blow, elevation, hammer blows per foot, rebound, side friction (SFT), end bearing (EB0) and percent SFT to EB0 selected from the plots. Both SFT and EB0 are total forces and therefore include the static and dynamic loads. Note that the SFT/EB0 percentage in all twelve cases was below 30%. The averages show, that about 87 blows per foot, with 0.73 inches of rebound, at SFT values of 41 kips and SFT/EB0 percentages of 8 %. Note that the limited number of data points results in fairly high standard deviations for these parameters.

Table 5-16 CAPWAP® Analysis Blows Selected

| Site | Test Pile | BN | Elevation (ft) | Blows/ft | Rebound (in) | SFT (kips) | EB0 (kips) | SFT/EB0 |
|---|---|---|---|---|---|---|---|---|
| Chaffee Rd | PR2PL9 | 354 | -9.15 | 75 | 0.48 | 77 | 389 | 20% |
| Heritage Pkwy | EB1P1 | 279 | -28.01 | 32 | 0.58 | 24 | 519 | 5% |
| | EB5P1 | 450 | -29.95 | 71 | 0.48 | 19 | 498 | 4% |
| | IB3P1 | 280 | -26.82 | 46 | 0.55 | 17 | 540 | 3% |
| | IB4P10 | 158 | -27.63 | 39 | 0.51 | 7 | 455 | 2% |
| I4 & 192 | P8P4 | 2260 | 17.71 | 100 | 0.93 | 76 | 485 | 16% |
| 417 & International | EB1P14 | 322 | 51.22 | 38 | 0.41 | 29 | 537 | 5% |
| | EB2P5 | 1479 | 3.85 | 75 | 0.48 | 104 | 643 | 16% |
| Ramsey Branch | EB1P1 | 654 | -63.37 | 133 | 0.96 | 82 | 580 | 14% |
| | EB1P3 | 600 | -63.81 | 150 | 1.06 | 0 | 376 | 0% |
| | EB4P5 | 1322 | -60.61 | 171 | 0.95 | 51 | 366 | 14% |
| | EB5P2 | 480 | -51.61 | 109 | 1.33 | 0 | 339 | 0% |
| **Average** | | | | 87 | 0.73 | 41 | 477 | 8% |
| **Standard Deviation** | | | | 44 | 0.29 | 34 | 90 | 7% |

Notes: PR or P = Pier, EB = End Bent, IB = Intermediate Bent PL or P = Pile,

## 5.6 CAPWAP® Damping Coefficient Sensitivity Analysis

The CAPWAP® analysis consists of multiple trials using the CAPWAP® automated resources to produce the best match, which has the lowest Match Quality (MQ) number. For this report, the MQ considered was the one related to the wave match, instead of the force or velocity.

Numerous trials were conducted in order to achieve the lowest value of MQ, for all test piles analyzed. The final MQ does not necessarily have to match a certain minimum value, but it has to be as low as possible once all the resources from CAPWAP® were used.

CAPWAP® has many auto procedures to improve the match quality, after first manually improving certain parameters. In order to manually improve the match, the toe resistance was initially set as 10% of the ultimate resistance (Ru), based on engineering judgement and experience. The shaft resistances, through the shaft elements, were changed based on the visual analysis of the measured wave speed versus the calculated wave speed.

After completing the manual adjustments, the auto procedures were used; such as Auto CAPWAP® (AC), Auto Friction (AF), Auto Toe (AT), Auto Quantity Improvement on Standard Parameters (AQ STD).

AC is an auto procedure in which the software will automatically adjust capacity, resistance distribution, toe resistance, damping factors and quakes. AF will make the software adjust the resistance distribution of the toe and the shaft elements. AT will change the main toe parameters such as quake for loading and unloading, gap, damping factors and ultimate resistance and AQ STD will vary the soil parameters within the lower and upper limits specified by CAPWAP.

The CAPWAP® final reports tables for the test piles analyzed are included in Appendix C. CAPWAP® analysis outputs Smith's damping factors for pile shaft and for the pile's toe (SS and ST, respectively). In the CAPWAP® final reports, the table entitled "CAPWAP® Summary Results" shows the average shaft and toe Smith Damping Factor in units of seconds/ft. It also shows a table entitled "CASE Method", in which it is possible to estimate CASE's damping coefficient based on the total resistance and Smith's damping coefficient. Therefore, two different damping factor (Smith's 1960 and CASE's 1974) can be defined for the soil around the pile shaft (average) and pile's toe. However, Case's damping is not going to be considered for analysis, due to the uncertainty on how CAPWAP® defines the damping factor.

## 5.7 Results and Correlations

The CAPWAP® results based on the (a) threshold blow counts, (b) rebound and (c) SFT are summarized below. Rebound was compared to damping factors; then to side friction and finally, to UN.

### 5.7.1 Rebound versus Damping Factors

Smith's damping factors were determined for all 12 blows analyzed using CAPWAP®. Table 5-17 shows the damping factors and the side friction based on the analysis criteria chosen.

Table 5-17 CAPWAP® Based Smith's Damping Factors

| Site | Test Pile | Side Friction (kips) | STF/EB0 | Rebound (in) | Smith's Shaft Damping (s/ft) | Smith's Toe Damping (s/ft) |
|---|---|---|---|---|---|---|
| Ramsey Branch | EB1P3 | 0 | 0% | 1.06 | 0.069 | 0.133 |
| Ramsey Branch | EB5P2 | 0 | 0% | 1.33 | 0.169 | 0.063 |
| Heritage Pkwy | IB4P10 | 7 | 2% | 0.51 | 0.051 | 0.088 |
| Heritage Pkwy | IB3P1 | 17 | 3% | 0.55 | 0.358 | 0.052 |
| Heritage Pkwy | EB5P1 | 19 | 4% | 0.48 | 0.088 | 0.189 |
| Heritage Pkwy | EB1P1 | 24 | 5% | 0.58 | 0.194 | 0.111 |
| 417 & International | EB1P14 | 29 | 5% | 0.41 | 0.171 | 0.17 |
| Ramsey Branch | EB4P5 | 51 | 14% | 0.95 | 0.15 | 0.024 |
| I4 & 192 | P8P4 | 76 | 16% | 0.93 | 0.211 | 0.028 |
| Chaffee Rd | PR2PL9 | 77 | 20% | 0.48 | 0.027 | 0.074 |
| Ramsey Branch | EB1P1 | 82 | 14% | 0.96 | 0.945 | 0.163 |
| 417 & International | EB2P5 | 104 | 16% | 0.48 | 0.182 | 0.103 |
| **Average** | | 41 | 8% | 0.73 | 0.22 | 0.10 |
| **Standard Deviation** | | 34 | 7% | 0.29 | 0.24 | 0.05 |

Based on an extensive study on damping and quake for prestressed concrete piles in Florida, McVay and Kuo, (1999), recommended Smith end of driving (EOD) damping factors from approximately 0.05 to slightly greater than 0.40 for Florida sand blends. The majority of the EOD damping factors shown in this work were between 0.05 and 0.3.

An examination of the results in Table 5-17 indicates that Smith's shaft damping factors range from 0.051 to 0.945 and average 0.22, while Smith's toe damping factors range from 0.028 to 0.189 while averaging 0.10. The standard deviations for each indicate that the toe damping factors also have much less deviation from the average. The majority of the shaft and toe damping average factors fall within the recommended range; however, the toe damping factors are much more consistent. Only one CAPWAP® analysis, Ramsey Branch EB1P1, produced a damping coefficient above the McVay and Kuo (1999) range. While three analyses produced values below the authors range; Ramsey Branch EB4P5, I4 & 192 P8P4 and Chaffee Rd PR2PL9.

Ten of the 12 Smith shaft damping coefficients fall within the recommended range, and ten of the 12 Smith toe damping coefficients fall within range. When the SFT/EB0 ratio is compared to the acceptable damping range, there seems to be a trend showing that for higher SFT/EB0 values (i.e. between 14 and 20%) the damping coefficients fall outside the recommended range. Although more data must be analyzed, an initial finding is that SFT less than about 30 kips or SFT/EB0 ratios below 15 percent should be the focus of future analyses.

To help describe trends from the results presented in Table 5-17, Figure 5-28 and Figure 5-29 were compiled. They relate the average damping factors to rebound for each site. Figure 5-28 and Figure 5-29 show average Smith's shaft and toe damping factors per site, respectively. Figure 5-28 results show that these average Smith's shaft damping coefficients are higher with higher rebound, which is the opposite of what was expected to produce high rebound. Figure 5-29 shows the average Smith's toe damping coefficient per site is higher for lower rebounds. These findings are based on a very limited number of sites. Therefore, it may not be possible to make conclusions when the data from each site is averaged unless a larger number of sites and PDA test piles were analyzed.

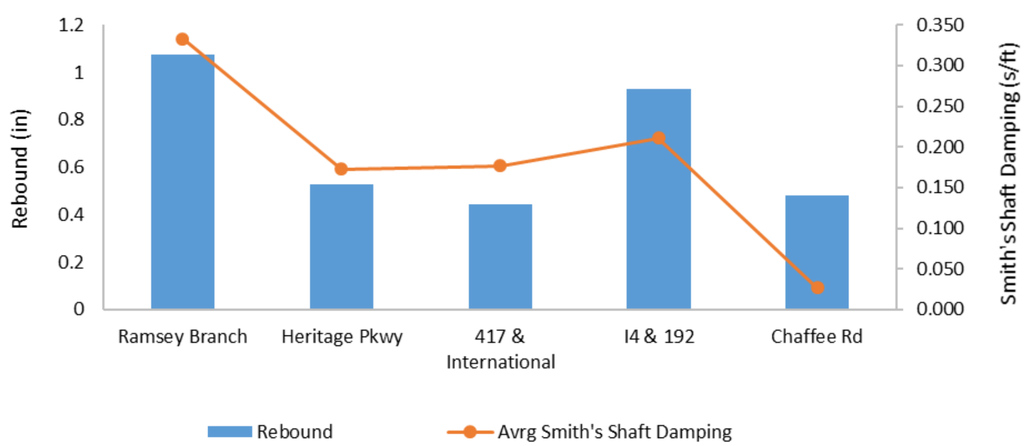



Figure 5-28 Average Rebound and Smith's Shaft Damping Factor per Site

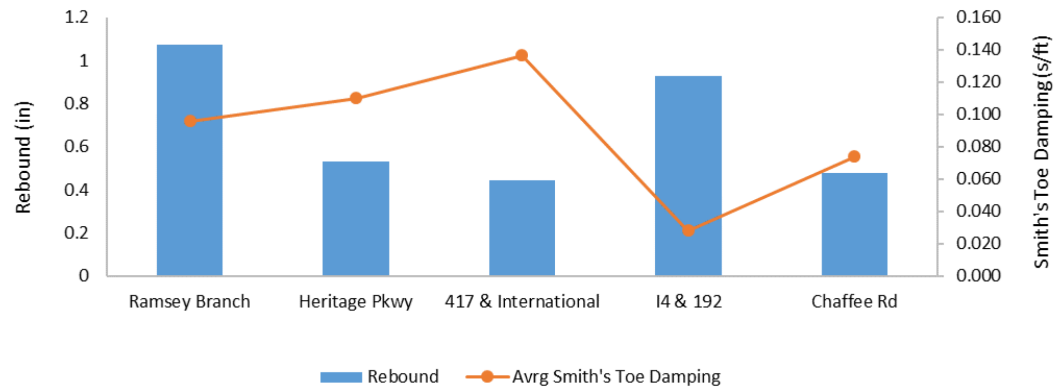



Figure 5-29 Average Rebound and Smith's Toe Damping Factor per Site

### 5.7.2 Rebound versus CAPWAP® Resistance

The CAPWAP® ultimate toe and shaft resistances from all 12 sets of data were compared to rebound. Figure 5-30 shows rebound versus ultimate toe resistance (Ru). A relatively weak linear trend was shown as rebound decreases with increasing toe resistance. This trend may occur since the higher toe resistances prevent movement.

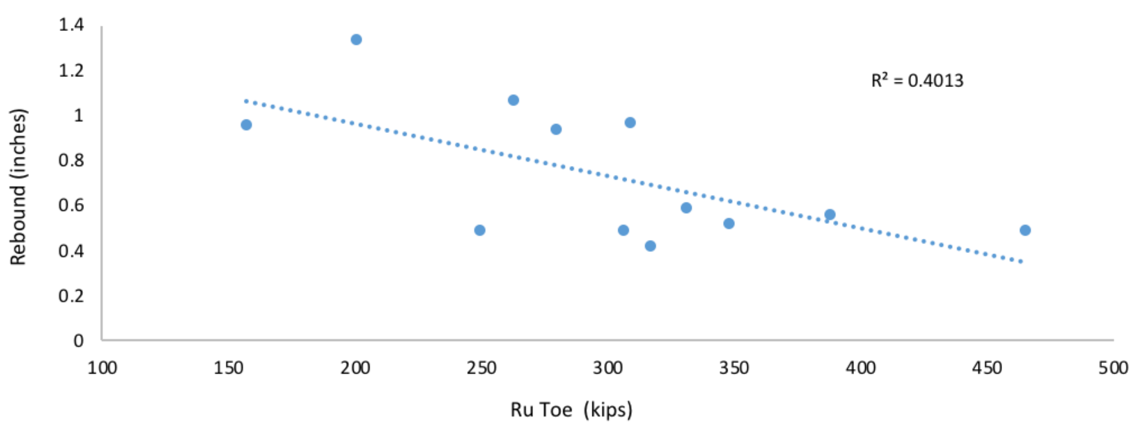



Figure 5-30 Rebound versus CAPWAP® Ultimate Toe Resistance

Figure 5-31 shows a linear trend with a slightly higher regression coefficient exists between CAPWAP® ultimate shaft resistance and rebound. This trend was anticipated since increased shaft resistance should prevent or decrease rebound.

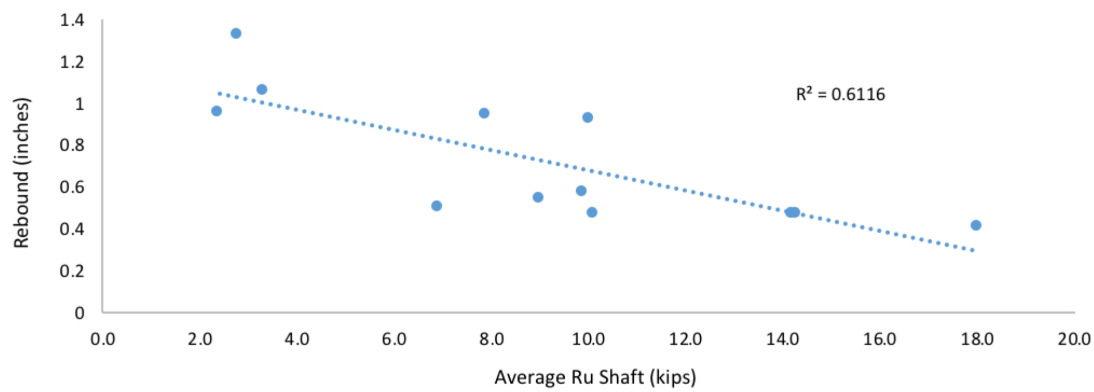



Figure 5-31 Rebound versus CAPWAP® Ultimate Shaft Resistance

In summary, the CAPWAP® ultimate toe and shaft resistances did relate to rebound, with the shaft resistance showing a promising linear relationship.

### 5.7.3 Rebound versus PDA Side Friction

A second set of plots were developed with all 12 sets of data. Figure 5-32 and Figure 5-33 show how the rebound varies with side friction and side friction normalized by the end bearing resistance (EB0) for each test pile, respectively.

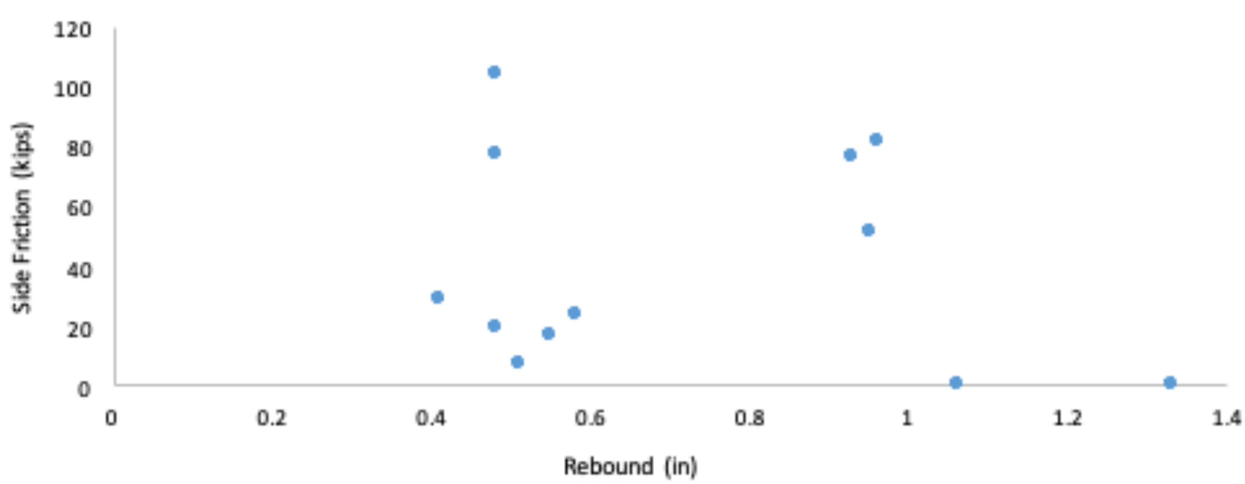



Figure 5-32 Rebound versus PDA SFT side friction

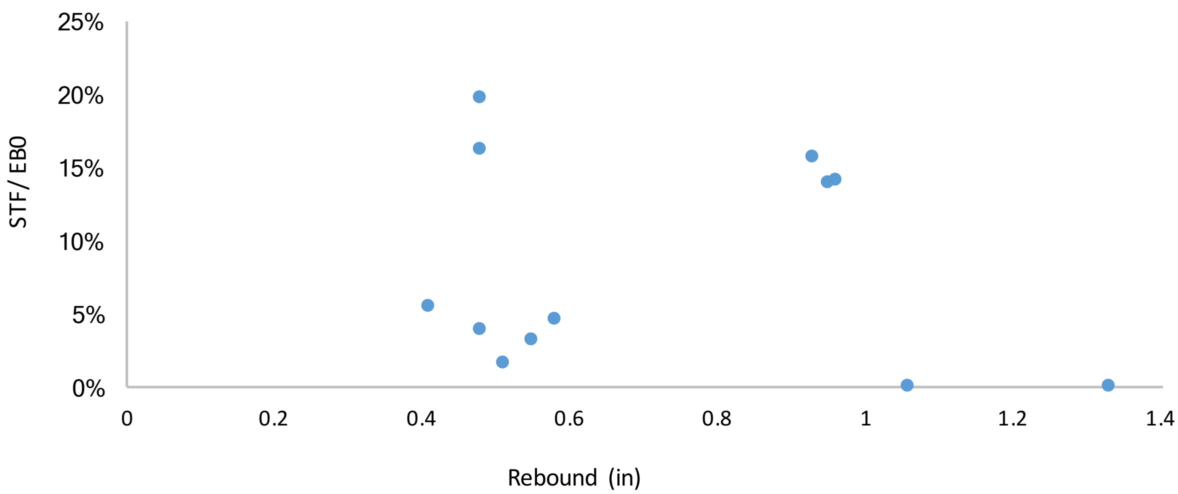



Figure 5-33 Rebound versus PDA normalized side friction

Note that both plots are similar but show no clear trends. The main finding is that damping in terms of PDA total side friction less than 30 percent of the total pile capacity does not clearly correlate with rebound.

### 5.7.4 Rebound versus UN

The UN parameters determined by CAPWAP® during the signal matching process were plotted versus rebound, to produce the graph shown in Figure 5-34.

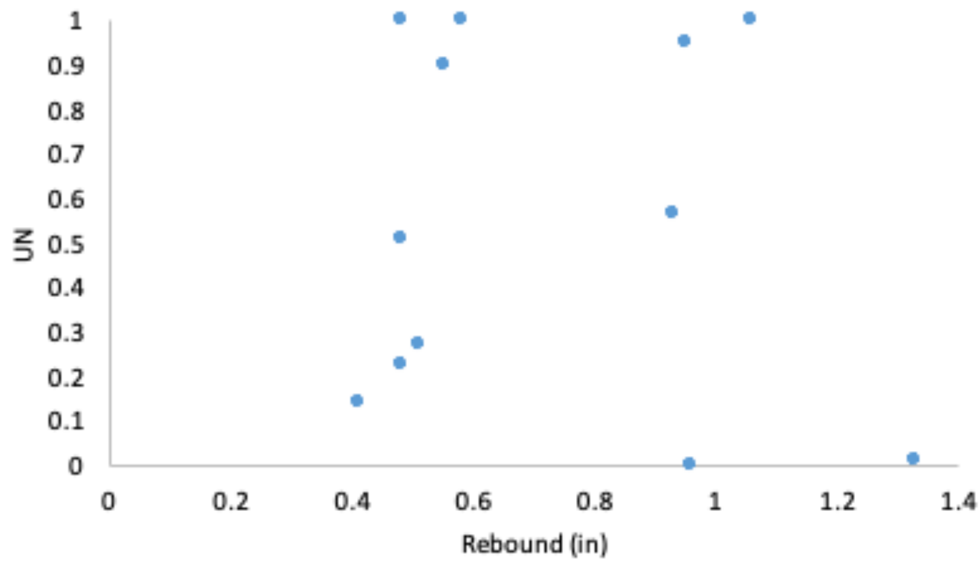



Figure 5-34 Rebound versus UN

Again, no clear trends were shown. However, the limited number of blows analyzed was not sufficient to formulate a conclusion at this point.

### 5.7.5 Findings

Of the three main CAPWAP® unknowns: ultimate static resistance, quake and damping, only damping was analyzed to produce these findings.

Smith's toe damping coefficients were more consistent than the Smith shaft damping coefficients, although 10 of the 12 CAPWAP® blows analyzed produced acceptable coefficients for both shaft and toe resistances.

The CAPWAP® based damping factors did show relationships to rebound, with the shaft damping coefficients showing a more promising relationship than toe damping.

The PDA SFT and SFT/EB0 analyses produced poor comparisons to rebound indicating that they should be avoided when attempting to understand how rebound relates to pile capacities.

For the piles analyzed, rebound seemed to occur only when the side friction was less than 30 % of the total pile capacity determine from PDA data.

When SFT is less than about 30 kips or the SFT/EB0 percentage is below about 20% reasonable damping coefficients were produced with CAPWAP®.

# 6 PDM, CMS, and PDA Measuring System Evaluations

Six sites in Central and Northeastern Florida were tested. Instrumented test piles were evaluated at all sites except Port Canaveral. Table 6-1 show the site names the types of tests performed and Figure 6-1shows their locations. PDM and CMS testing was attempted at all sites, with the exception of Port Canaveral. No camera testing was performed at Port Canaveral because it was a preliminary PDM evaluation site for the research team to learn how to use the equipment. Severe rain and thunderstorms along with equipment problems prevented PDM testing to be completed at Baldwin Bypass near Jacksonville Florida.

Table 6-1 PDA, PDM and CMS Testing Summary

| Testing Description | Site Name | Pile Location | Length of Pile (ft) | Successful PDA Testing | Successful PDM Testing | Successful CMS Testing |
|---|---|---|---|---|---|---|
| Pile | Port Canaveral | N Cargo Berth 10 | **92** | | ✓ | |
| | Baldwin Bypass | EB 4 Pile 1 | 82 | | | ✓ |
| | Reedy Creek | EB 1 Pile 1 | 120 | ✓ | ✓ | ✓ |
| | Dunns Creek | Pier 4 Pile 10 | 110 | ✓ | ✓ | ✓ |
| | Ellis Road | EB 1 Pile 8 | 140 | ✓ | ✓ | ✓ |
| SPT | Wekiva Parkway | WLC 2 and WLC 3 | | | ✓ | ✓ |
| | Dunns Creek | Near Peir 4 Pile 10 | | | ✓ | ✓ |

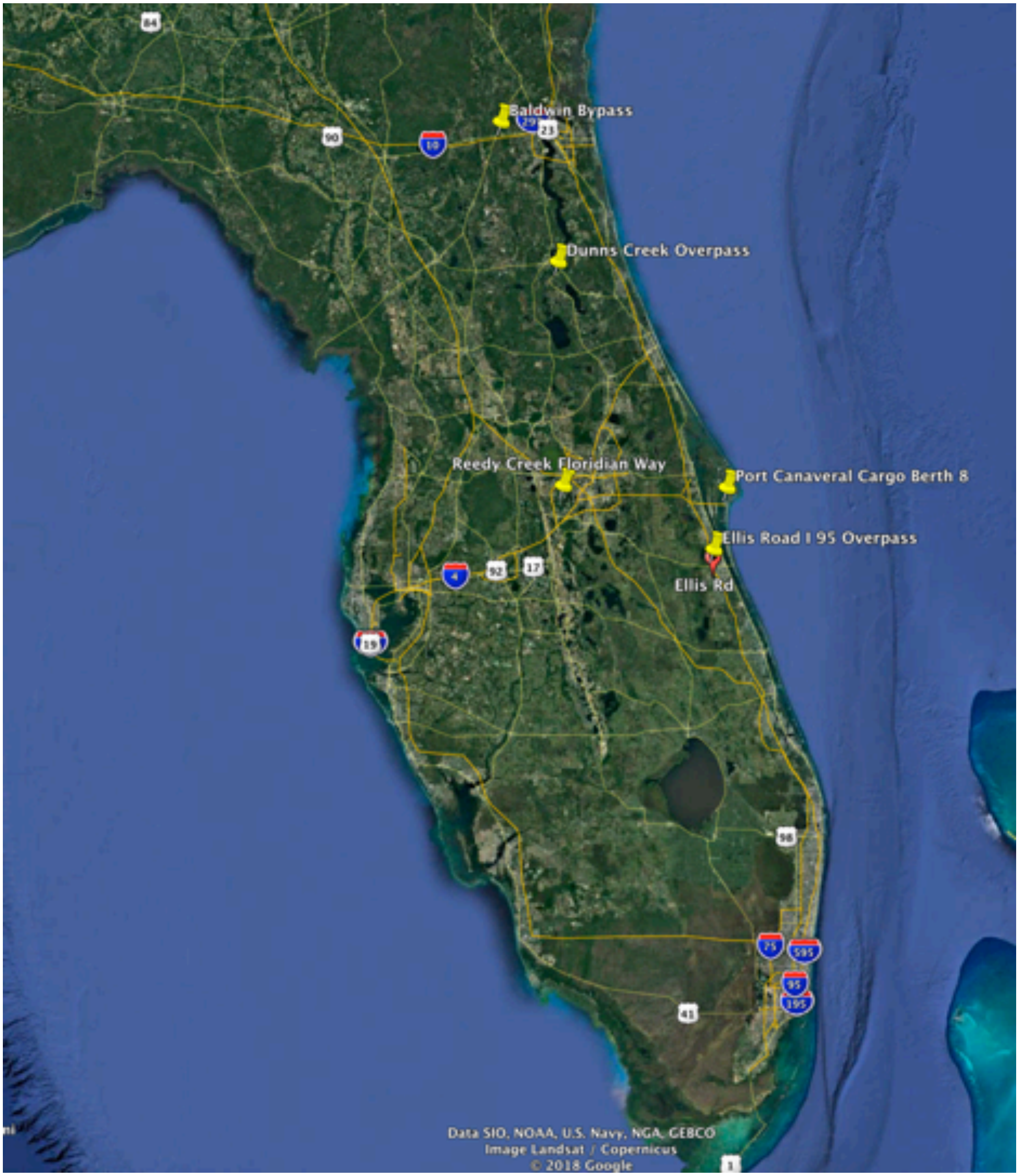



Figure 6-1 Google Maps® test site locations

## 6.1 PDM Test Pile Results

### 6.1.1 Port Canaveral North Cargo Berth 8 PDM Testing

This site was chosen to allow the research team to gain experience with the Inopiles PDM equipment, therefore, no camera evaluations were conducted. Over 400, 24-inch square prestressed concrete piles were being driven for the North Cargo Berth 8 construction. The research team received permission to work on site for several weeks during the pile installation process.

#### 6.1.1.1 Day 1 – 6/3/2018 PDM Setup and Testing Process

The setup was mostly executed as specified in the methods described in Chapter 4. The tape used was the Original tape supplied by Inopiles. The tape was placed at 2 feet increments for the first 30 feet of the pile and switched to 4 feet increments for the remaining 60 feet. These smaller distances between reflective tapes were used to try and collect more data than possible with 5 feet increments, also to see if it was possible for the operator to enter the parameters and get set for the next test given the smaller window of time. The PDM was placed on a tripod so that its field of view was above the pile driving template. The PDM offset distance was 29.95 feet from the pile, determined by the laser distance finder. This offset results in an active zone length of 1.36 feet. A tent was set up to provide shade for the equipment. The tablet was used for data collection.

This testing was the first successful instance of gathering PDM test data from pile driving. The 2-foot increments were spaced too closely to allow the computer operator time to prepare the input for the subsequent PDM tests. The 4-foot increments produced the same problem, therefore the research team collected PDM data at 8-foot increments (i.e., for every other tape location on the pile). The 8-foot testing resulted in only 3 tests for the 92-foot-long pile. It was then determined that a standard of 5-foot increment would be reasonable as long as the next test was set up quickly. As a result of the testing at Por Canaveral tape was placed at 5-foot increments on the piles at the remaining sites.

Figure 6-2 Images of Pile and PDM Setup for Port Canaveral Day 1 (Photos by Dr. Cosentino)

### 6.1.1.2 PDM Data

Table 6-2 is a summary from the three successful PDM tests. No results were obtained for the first 30 feet of driving where 2-foot increments were used between the reflective tapes. Three sets of data were obtained for the remaining 60 feet of driving that used 4 feet increments between the reflective tapes. The data is approximately 8 feet apart as it only captured every other reflective tape. The complete set of PDM data will be presented in the final report Appendices.

Table 6-2 PDM Data for Port Canaveral-Day 1

| PDM Testing Range (ft) | Useable Data (in) | % of Active Zone | # of Blows | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Avg | Max | Min | Avg | Max |
| 37.131-38.099 | 11.62 | 71 | 13 | 0.34 | 0.41 | 0.51 | 0.23 | 0.29 | 0.33 |
| 69.426-70.223 | 9.56 | 59 | 10 | 0.73 | 0.8 | 0.89 | 0.08 | 0.12 | 0.14 |
| 76.003-76.262 | 3.12 | 19 | 10 | 0.36 | 0.47 | 0.59 | 0.13 | 0.16 | 0.19 |

### 6.1.1.3 Day 2 – 6/4/2018 PDM Setup and Testing Process

The setup was mostly executed as specified in the methods described in Chapter 4. The tape used was again the Original tape supplied by Inopiles. The PDM was placed on a tripod so that its field of view was above the template. The PDM offset distance was 30.48 feet from the pile, determined by the laser distance finder. This distance resulted in an active zone length of 1.38 feet. A tent was set up to provide shade for the equipment. The tablet was used for data collection. Of the 14 tests attempted 12 yielded useful data.

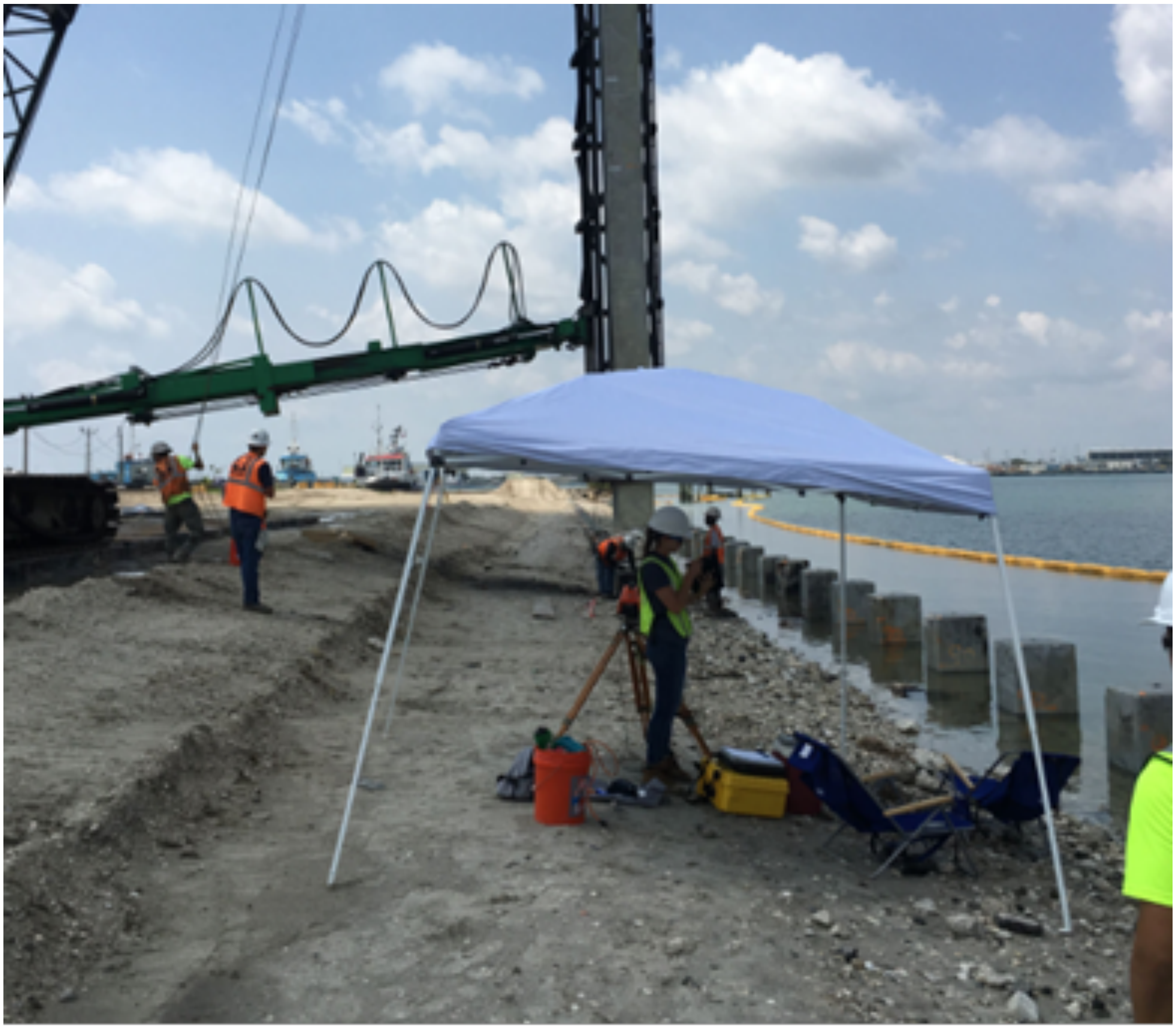


Figure 6-3 Images of Pile and PDM Setup for Port Canaveral Day 2 (Photo by Dr. Cosentino)

### 6.1.1.4 PDM Data

Table 6-3 is a summary from the twelve successful PDM tests. It shows the amount of useable data within the active testing zone for each depth the percentage of the active zone within which results were able to be obtained, the number of hammer-blows within the active testing zone and the minimum, maximum and averages for set and rebound. Note as the set increases (i.e., movement per blow) the number of blows decreases. The complete set of PDM data will be presented in the final report Appendices.

Table 6-3 PDM Data for Port Canaveral-Day 2

| PDM Testing Range (ft) | Useable Data (in) | % of Active Zone | # of Blows | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Avg | Max | Min | Avg | Max |
| 15.157-16.392 | 14.82 | 59 | 23 | 0.56 | 0.69 | 0.83 | 0.23 | 0.28 | 0.31 |
| 26.632-27.276 | 7.73 | 47 | 27 | 0.26 | 0.3 | 0.32 | 0.41 | 0.42 | 0.43 |
| 30.303-31.347 | 12.53 | 76 | 57 | 0.2 | 0.23 | 0.28 | 0.46 | 0.47 | 0.48 |
| 36.165-37.204 | 12.47 | 75 | 19 | 0.62 | 0.67 | 0.75 | 0.09 | 0.17 | 0.19 |
| 41.384-42.060 | 8.12 | 49 | 11 | 0.75 | 0.81 | 0.89 | 0.11 | 0.13 | 0.14 |
| 46.463-47.345 | 10.58 | 64 | 12 | 0.89 | 0.96 | 1 | 0.13 | 0.14 | 0.15 |
| 51.19-51.826 | 7.63 | 46 | 11 | 0.68 | 0.76 | 0.83 | 0.1 | 0.12 | 0.14 |
| 56.195-56.810 | 7.38 | 45 | 10 | 0.8 | 0.88 | 0.09 | 0.07 | 0.11 | 0.11 |
| 61.600-62.254 | 7.85 | 47 | 10 | 0.59 | 0.87 | 0.92 | 0.13 | 0.15 | 0.17 |
| 66.541-67.209 | 8.02 | 78 | 9 | 0.78 | 1.01 | 1.06 | 0.16 | 0.18 | 0.21 |
| 71.402-72.260 | 10.3 | 62 | 10 | 0.96 | 1.15 | 1.22 | 0.13 | 0.16 | 0.18 |
| 76.404-77.204 | 9.6 | 58 | 9 | 0.89 | 1.2 | 0.32 | 0.12 | 0.13 | 0.14 |

## 6.1.2 Baldwin Bypass End Bent 4, Production Pile 1: PDM Testing 5/14/18

### 6.1.2.1 PDM Setup and Testing Process

The setup was mostly executed as specified in the methods described in Chapter 4. The reflective tape placed on the pile was the Original tape provided by Inopiles. It was spaced at 5-foot intervals that matched the 5-foot markings on the pile (Figure 6-4).


Figure 6-4 Baldwin Bypass PDM and CMS 5-foot spacing pile markings

The PDM was not placed on a tripod, but it was stacked on a box covered by a thick layer of foam. The intention of the foam was to dampen vibrations and therefore mitigate signal noise to the PDM and cameras from ground vibrations. A tent was set up to protect the equipment from the environment; which for this site meant keeping it out of the rain.  The tablet provided by Inopiles to operate the PDM, malfunctioned and would not power on, despite having a full charge. Numerous attempts were made to remedy this problem; however, none were successful.

They included turning the Microsoft Surface Pro tablet on and off, logging out and logging in to the tablet, using a 110 Volt power supply instead of the battery. Therefore, no PDM data was obtained during driving.

Figure 6-5 Images of Pile and PDM setup for Baldwin Bypass (Photos by Cosentino)

### 6.1.2.2 PDM Lesson Learned

There were lessons learned/observations made from attempting PDM testing at the site. It was the researchers first experience with instrumented pile driving using RADISE equipment. The heavy rains forced the team to improve our setup procedures.

Placing the PMD on the padding proved difficult, therefore it was decided to it would be placed on a tripod for future testing. This option allows the users to vary the PDM height to produce the optimum viewing angle for the equipment.

The PDM’s laser distance finder was difficult to use in the heavy rains. The red dot reflected off of rain drops before it could be seen on the pile.  Therefore, a tape measure would be used in addition to the laser finder on subsequent sites.

The problem with the tablet was remedied by taking it to the Florida Tech IT department where diagnostic tests were run to fix the issue. Once returned the tablet worked properly. In order to reduce the chance of tablet problems, the PDM software was added to a Florida Tech laptop. Both the tablet and the laptop were transported to subsequent sites.

### 6.1.3 Reedy Creek End Bent 1, Pile 12: PDM Testing 7/19/18

#### 6.1.3.1 PDM Setup and Testing Process

The setup was mostly executed as specified in the methods described in Chapter 4. The test pile evaluated was at End Bent 1, Pile 12 as shown in Figure 6-6.The reflective tape used was the 3M tape purchased by the research team. The PDM was placed on a tripod set low to the ground with its field of view unobstructed. The PDM offset distance was 26.90 feet from the pile. This distance resulted in an active zone length of 1.22 feet. A tent was set up to provide shade for the equipment. The laptop was used for data collection. Of the 11 tests attempted 3 yielded useful data.


Figure 6-6 Images of End Bent 1, Pile 12 and PDM Setup for Reedy Creek (Photo by Dr. Cosentino)

#### 6.1.3.2 PDM Data

Table 6-4 is a summary from the three successful PDM tests. Successful testing was accomplished at 65, 98 and 109 pile depths. Of the approximately 15 inch (i.e., 1.22 ft) active measuring zone only the 65-foot testing produced results for more than 50% of this zone. The 98- and 109-foot testing produced results for 3 and 7 blows, respectfully. In summary, PDM testing was successful; however, it produced limited data for analysis. This site did not produce pile rebound. The sets were slightly less than 0.9 inches. PDA sets for these pile depths, based on the inspectors input ranged from 0.86 to 1 inch, with 1 inch reported for the 65-foot depth. The complete set of PDM data are in Appendix A

Table 6-4 PDM Data for Reedy Creek – 3M Tape

| PDM Testing Range (ft) | Useable Data (in) | % of Active Zone | # of Blows | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Avg | Max | Min | Avg | Max |
| 64.623-65.591 | 11.62 | 79 | 16 | 0.47 | 0.86 | 1.46 | -0.06 | 0 | 0.04 |
| 98.910-99.049 | 1.67 | 11 | 3 | 0.81 | 0.85 | 0.89 | 0.06 | 0.06 | 0.06 |
| 109.364-109.767 | 4.84 | 33 | 7 | 0.77 | 0.81 | 0.88 | 0.04 | 0.06 | 0.07 |

### 6.1.4 Dunns Creek PDM Pile 10 at Pier 4 Testing

#### 6.1.4.1 Test Pile Monitoring 9/19/18

Pile 10 at Pier 4 at Station 436 +37 was monitored using both PDM and CMS systems. Testing began on September 19th at about 7 AM with temperatures in the mid 70's and continued until problems installing the test pile persisted around 11:00 AM with temperatures in the mid 90's. Figure 6-7 shows the test pile being lifted into the template.

Figure 6-7 Dunns Creek Pile 10 at Pier 4 Installation

### 6.1.4.2 PDM Setup and Testing Process

The setup was executed mostly as specified in the methods described in Chapter 4. The tape used was the 3M tape. The PDM was placed on a tripod set so the field of view was unobstructed by the frame. The PDM rod was offset 30.02 feet from the pile. This distance resulted in an active zone length of 1.36 feet. A tent was set up to provide shade for the data processing but not for the PDM itself due to restrictions caused by nearby equipment. The laptop was used for data collection. Of the 2 tests attempted 1 yielded useful data.

Figure 6-8 Images of Pile and PDM Setup for Dunns Creek (Photo by Dr. Bostater)

#### 6.1.4.3 PDM Data

Table 6-5 is a summary from a zone of successful PDM testing from Dunns Creek. All driving observed at depths greater than 50 feet produced high rebound. With visual rebound observations in the 1 inch range. Just over 13 inches of PDM data was useable, or 82% of the data within the PDM active recording (16 inch) zone. One-hundred and thirty hammer blows were recorded producing an average set of 0.09 inches and an average rebound of 1.01 inches. Note that the PDM measurements confirmed the visual observations.

Table 6-5 PDM Data for Dunns Creek Test Pile-3M Tape

| PDM Testing Range (ft) | Useable Data (in) | % of Active Zone | # of Blows | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Avg | Max | Min | Avg | Max |
| 67.592-68.701 | 13.31 | 82 | 130 | 0.07 | 0.09 | 0.12 | 0.75 | 1.01 | 1.24 |

### 6.1.5 Ellis Overpass PDM Test Pile 8 at Bent 1 Testing 11/30/18

Test pile 8 at bent 1 at station 77+14.90 along the centerline of the roadway for the Ellis Road I-95 Overpass for Bridge number 700239 was monitored using PDM and CMS equipment on November 30, 2018. Mostly sunny skies with temperatures in the mid 70 were encountered. Testing began about 8 AM and continued until about 1 PM.

#### 6.1.5.1 PDM Setup and Testing Process

The setup was mostly executed as specified in the methods described in Chapter 4. The tape used was the 3M tape. The PDM was placed on a tripod set so the field of view was unobstructed. The PDM offset distance was 26.25 feet from the pile. This distance resulted in an active zone length of 1.19 feet. A tent was set up to provide shade for the equipment. The laptop was used for data collection.

Figure 6-9 Images of Pile and PDM Setup for Ellis Overpass (Photo by Dr. Cosentino)

### 6.1.5.2 PDM Data

Of the eight tests attempted, with 185 possible data points, two depths yielded useful data. Of the 90 data points or hammer blows recorded with the PDM within these two depths 30 were useful.

The PDM depths greater than 95 feet had to be adjusted due to software limitations. The depths listed as 16, 22 and 28 feet were increased by 95 feet to produce the actual depths. The values below represent the actual depth of the pile. Table 6-6 is a summary from the two successful PDM tests. They indicate that both the set and rebound was about 0.2 inches. The PDA data indicates an average set of 0.17 inches with an average rebound of 0.32 inches. The complete set of PDM data are in Appendix A

Table 6-6 PDM Data from Ellis Overpass Test Pile- 3M Tape

| PDM Testing Range (ft) | Useable Data (in) | % of Active Zone | # of Blows | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Avg | Max | Min | Avg | Max |
| 111.496-111.913 | 5 | 35 | 25 | 0.17 | 0.2 | 0.21 | 0.21 | 0.24 | 0.24 |
| 117.001-117.060 | 0.71 | 5 | 5 | 0.17 | 0.19 | 0.2 | 0.15 | 0.17 | 0.19 |

## 6.2 PDM SPT Results

### 6.2.1 Dunns Creek SPT Tests 3/14/19

#### 6.2.1.1 PDM Setup and Testing Process

The setup was mostly executed as specified in the method for SPT testing in Chapter 4. The tape used was the Outdoor tape purchased by the research team. The PDM was placed on an adjacent footing as it provided the perfect distance from the SPT rod as well as the correct height for the field of view to be unobstructed. The PDM offset distance was 26.90 feet from the rod. This distance resulted in an active zone length of 1.22 feet or approximately 15 inches. A tent was used to shade the equipment. The laptop was used for data collection. All 5 attempts yielded useful data.

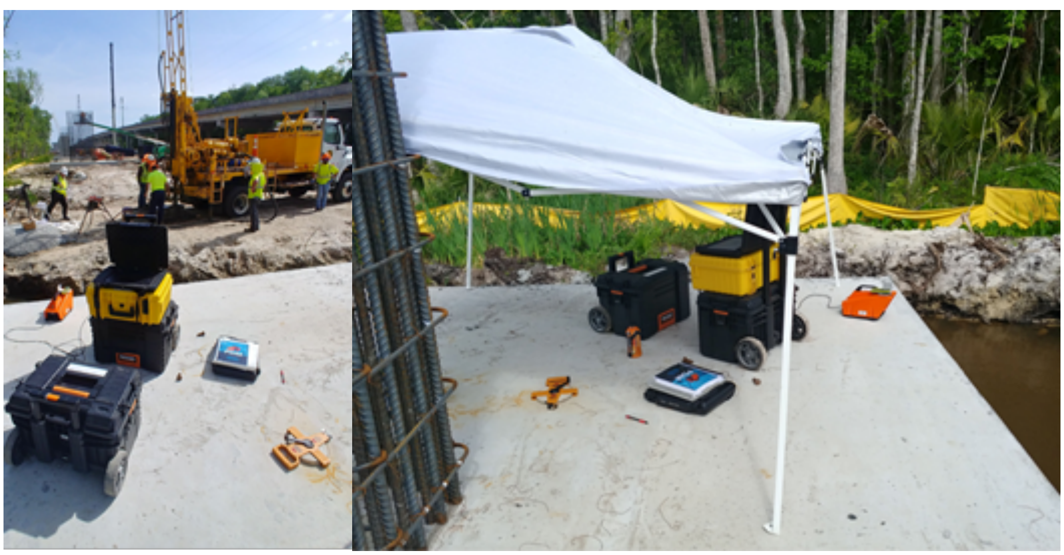


Figure 6-10 Images of SPT and PDM Setup for Dunns Creek
(Photos by Robert Rogulski)

### 6.2.1.2 Dunns Creek PDM data

Table 6-7 is summary from the five successful PDM tests. Data was recorded from approximately 46 to 60 feet as shown. The PDM testing range is shown as useable data in inches in column 2. Between about 6 and 12 inches were able to be evaluated with the PDM. The percentage of this data that was useable is shown in Column 3, it ranged from about 40 to 80 %. The corresponding number of SPT automatic hammer blows for the useable data is shown in Column 4. Minimum, average and maximum sets and rebounds are shown in the last two columns. Data from all five depths produced "negative" rebound according to the PDM software, which results when the PDM software interprets the rod movements as shown in Figure 6-11. The blue line is the software's interpreted movements and the light gray line is the actual recorded movements. The figure shows that the end of the PDM linear rod movement is denoted with a blue dot within the straight blue line; however, the light gray line shows a different displacement versus time response as the actual rod movements. The gray line increases nonlinearly after the blue dot and the software interprets that continual movement as rebound. Because it is not in the opposite direction as the downward movement it becomes negative. From a practical standpoint there is no rebound, but rather nonlinear time-dependent movements that have also been observed during cyclic triaxial testing of rebound soils. In summary, this additional downward rod movement may be the indication that the soils are the rebound soils as they display time-dependent movements along the light gray line. The negative values for rebound show that the PDM software improperly interprets rebound. The complete set of PDM data are in Appendix A

Table 6-7 PDM Data for Dunns Creek SPT

| PDM Testing Range (ft) | Useable Data (in) | % of Active Zone | # of Blows | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Avg | Max | Min | Avg | Max |
| 35.659-36.142 | 5.8 | 40 | 2 | 5.81 | 6.69 | 7.57 | -4.02 | -2.76 | -1.5 |
| 39.859-40.696 | 10.04 | 69 | 5 | 1.46 | 2.19 | 3.09 | -0.43 | -0.15 | -0.02 |
| 49.698-50.650 | 11.42 | 78 | 6 | 1.46 | 1.97 | 2.75 | -0.41 | -0.19 | -0.08 |
| 54.761-55.653 | 10.7 | 73 | 6 | 1.25 | 2.3 | 3.07 | -0.45 | -0.3 | -0.11 |
| 59.698-60.646 | 11.38 | 78 | 9 | 0.84 | 1.37 | 2.35 | -0.18 | -0.04 | 0.03 |

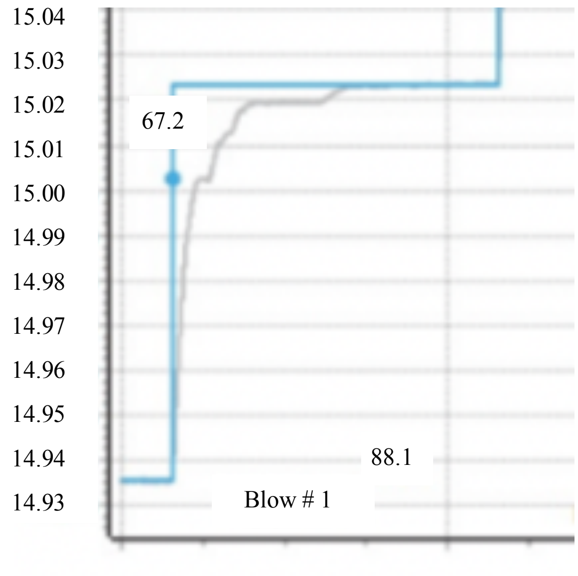



Figure 6-11 Wekiva Parkway 49.228-49.852 ft PDM blow 1 Indicating Negative Rebound

### 6.2.2 Wekiva Parkway Wildlife Crossings 2 and 3 Testing

PDM and CMS evaluations were performed on two test borings with SPT, at two wildlife crossings along the Wekiva Parkway (i.e. WLC 2 and WLC3). Testing was conducted on consecutive days. Weather conditions for both days was similar, with mostly sunny skies and temperatures ranging from the low 70's to upper 80's.

#### 6.2.2.1 Day 1 5/7/19 WLC 2 – PDM Setup and Testing Process

The setup was executed mostly as specified in the methods for SPT testing in Chapter 4. The tape used to mark the SPT rods was the Outdoor tape. The PDM was placed on a tripod set so the field of view was unobstructed. The PDM offset distance was 26.25 feet from the rod. This distance resulted in an active zone length of 1.19 feet. The equipment was kept under shade by the nearby wall and bridge abutment. The laptop was used for data collection. Of the 6 PDM tests attempts; 5 yielded useful data. During the 6th test the SPT rods did not penetration into the ground.

Figure 6-12 Images of SPT and PDM Setup for Wekiva Parkway Day 1 (Photos by Dr. Cosentino)

### 6.2.2.2 Day 1 5/7/19 WLC 2 – PDM Data

Table 6-8 is a summary from the five successful PDM tests. Data was recorded from 49 to 70 feet as shown. The PDM testing range is shown as useable data in inches in column 2. Between 6 and 12 inches were able to be evaluated with the PDM. The percentage of this data that was useable is shown in Column 3, it ranged from about 50 to 80 %. The corresponding number of SPT automatic hammer blows for the useable data is shown in Column 4. Minimum, average and maximum sets and rebounds are shown in the last two columns. Data from the first two depths again produced negative rebound, as shown in Figure 6-11. As stated previously, this additional downward rod movement is not rebound, but may be the indication that the soils are rebound soils as they display nonlinear time-dependent movements. The complete set of PDM data are in Appendix A.

Table 6-8 PDM Data for Wekiva Parkway-Day 1 WLC 2

| PDM Testing Range (ft) | Useable Data (in) | % of Active Zone | # of Blows | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Avg | Max | Min | Avg | Max |
| 49.288-49.852 | 6.77 | 47 | 4 | 1.1 | 2.56 | 3.47 | -0.83 | -0.41 | 0 |
| 55.089-55.843 | 9.05 | 63 | 8 | 0.96 | 1.13 | 1.32 | -0.02 | 0 | 0.02 |
| 59.104-59.941 | 10.04 | 70 | 12 | 0.61 | 0.85 | 1.19 | 0.02 | 0.03 | 0.04 |
| 64.088-64.967 | 10.55 | 74 | 17 | 0.42 | 0.66 | 1.09 | 0.02 | 0.04 | 0.07 |
| 69.029-69.964 | 11.22 | 79 | 26 | 0.24 | 0.47 | 0.66 | 0.02 | 0.09 | 0.15 |

### 6.2.2.3 Day 2 5/8/19 WLC 3 – PDM Setup and Testing Process

The setup was mostly executed as specified in the methods for SPT testing in Chapter 4. The tape used to mark the SPT rods was the Outdoor tape. The PDM was placed on a tripod set so the field of view was unobstructed. The PDM offset distance was 27.92 feet from the rod. This distance resulted in an active zone length of 1.27 feet. The equipment was kept under shade provided by construction work on a nearby bridge. The laptop was used for data collection. Of the 6 tests attempts 5 yielded useful data. During the 6$^{th}$ attempt the SPT rod could not be driven and therefore no movements were recorded.

Figure 6-13 Images of SPT and PDM Setup for Wekiva Parkway WLC 3 Day 2 (Photos by Dr. Cosentino)

#### 6.2.2.4 Day 2 5/8/19 WLC 3 – PDM Data

The complete set of data are presented in Appendix A. Table 6-9 is a summary from the five successful PDM tests. The PDM testing range is shown as useable data in inches in column 2. Between about 9 and 12 inches were able to be evaluated with the PDM. The percentage of this data that was useable is shown in Column 3, it ranged from about 60 to 75 %. The corresponding number of SPT automatic hammer blows for the useable data is shown in Column 4. Minimum, average and maximum sets and rebounds are shown in the last two columns. Data from three of the depths once again produced negative rebound. Negative PDM rebound from SPT testing is consistently occurring in possible rebound soils. The complete set of PDM data are in Appendix A

Table 6-9 PDM Data for Wekiva Parkway-WLC 3 Day 2

| PDM Testing Range (ft) | Useable Data (in) | % of Active Zone | # of Blows | Set (in) | | | Rebound (in) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Avg | Max | Min | Avg | Max |
| 58.632-59.402 | 9.24 | 61 | 5 | 1.6 | 1.87 | 2 | -0.19 | -0.16 | -0.12 |
| 64.085-65.000 | 10.98 | 72 | 15 | 0.61 | 0.76 | 1.06 | 0 | 0.03 | 0.05 |
| 69.091-70.043 | 11.42 | 75 | 14 | 0.65 | 0.89 | 1.11 | -0.1 | 0.02 | 0.03 |
| 74.065-75.023 | 11.5 | 75 | 25 | 0.18 | 0.51 | 0.82 | 0.02 | 0.11 | 0.23 |
| 79.094-80.000 | 10.87 | 71 | 15 | 0.6 | 0.79 | 1.17 | -0.06 | 0.01 | 0.06 |

## 6.3 PDM, CMS, and PDA Comparisons for Test Piles

As shown in Table 6-1, PDM, PDA and CMS data were obtained at three of the six sites, Reedy Creek, Dunns Creek and Ellis Road Overpass. The PDM—PDA comparisons are presented in this section.

### 6.3.1 Reedy Creek PDM – PDA Comparisons

PDA data produces two values for set. The first is DFN which is the set calculated from the double integration of the accelerometers. The second is SET which represents inspector set, determined as 1 over the inspectors blow counts blows for each foot. Therefore, SET is just one value for an entire foot. Rebound is calculated using both DFN and SET. In this instance DFN and SET were exactly the same. The average for the nearest foot of PDA data was used to be compared to the PDM data.

Table 6-10 shows comparisons between PDM and PDA for three testing depths, one in the 64-foot range, one in the 99-foot range and the third in the 109-foot range. The 64-foot data consists of 16 blows, the 99-foot data consists of three and the 109-foot data consists of eight blows. In all cases the PDA digital information matched the inspector-based information, therefore there are no differences between the data from both at any of the depths. The largest variation occurred at the 64-foot range, while the other two depths produced nearly identical data between PDM and PDA testing.

In summary, the PDM produced acceptable data for all three depths at the Reedy Creek site. Note there is a very limited amount of comparable data at this time (27 total blows);

therefore, more testing and evaluations are needed to verify these preliminary findings. The complete set of PDM data are in Appendix A

Table 6-10 PDM versus PDA for Reedy Creek

| Method | PDM Testing Range (ft) | Average Set (in) | Difference from PDM (in) | Average Rebound (in) | Difference from PDM (in) |
|---|---|---|---|---|---|
| **PDM** | **64.623-65.591** | **0.86** | **---** | **0** | **---** |
| PDA DFN | 64.64-65.92 | 1.03 | 0.17 | 0.08 | 0.08 |
| PDA SET | 64.64-65.92 | 1.03 | 0.17 | 0.08 | 0.08 |
| **PDM** | **98.910-99.049** | **0.85** | **---** | **0.06** | **---** |
| PDA DFN | 98.60-99.00 | 0.86 | 0.01 | 0.01 | -0.05 |
| PDA SET | 98.60-99.00 | 0.86 | 0.01 | 0.01 | -0.05 |
| **PDM** | **109.364-109.767** | **0.81** | **---** | **0.06** | **---** |
| PDA DFN | 109.3-109.8 | 0.80 | -0.01 | 0.06 | 0.00 |
| PDA SET | 109.3-109.8 | 0.80 | -0.01 | 0.06 | 0.00 |

### 6.3.2 Dunns Creek PDM – CMS – PDA Comparisons

A visual signal matching approach was used to compare PDM and CMS Dunns Creek data sets. Both PDM and CMS data were inspected for similar inconstancies or anomalies in a set within a known region or depth. Once an anomaly was detected within the CMS data zone a similar anomaly was searched for within the PDM data. This process allowed the PDM anomalies to be directly related to a specific hammer blow during driving. Knowing a PDM blow, the corresponding CMS blow was then determined. Subsequent data was then matched to produce reliable set and rebound comparisons.

#### 6.3.2.1 PDM versus CMS

In this case it was possible to match blows for PDM and CMS data. Within both data sets there was an anomalous blow that produced a set nearly 4 times greater than average. It was therefore assumed that this blow is a matching blow from which all others may be compared.

Table 6-11 is the comparison of 20 data points between 67.661 and 67.828 feet. Average PDM and CMS sets were very similar as were the standard deviations. PDM and CMS rebounds were similar; however, the PDM rebounds are slightly higher than the CMS rebounds. Figure 6-14 shows a plot of PDM and CMS sets. This plot shows one set of data at about 0.40 inches and the remaining set data in the 0.05 to 0.1 inch range. A line of equality was included to show how the two sets of data relate. In general, they are scattered both above and below this line. Figure 6-15 shows a comparison between the rebound for the PDM and CMS. The trend line visually represents the weak relationship. A line of equality was again included to show how the two sets of data relate. In general, they are scattered below this line, indicating that the PDM rebound exceeds the CMS rebound. The PDM data are in Appendix A and the CMS data are in Appendix B.

Table 6-11 PDM versus CMS for within 67-foot range at Dunns Creek Test Pile

| Depth (ft) | PDM set (in) | PDM Rebound (in) | CMS set (in) | CMS Rebound (in) |
|---|---|---|---|---|
| 67.661 | 0.12 | 1.36 | 0.08 | 0.91 |
| 67.697 | 0.43 | 1.01 | 0.39 | 0.94 |
| 67.7 | 0.06 | 1.04 | 0.09 | 0.83 |
| 67.707 | 0.06 | 1.05 | 0.09 | 0.91 |
| 67.713 | 0.09 | 1.09 | 0.1 | 0.9 |
| 67.72 | 0.07 | 1.11 | 0.05 | 0.86 |
| 67.726 | 0.08 | 1.12 | 0.06 | 0.93 |
| 67.733 | 0.09 | 1.15 | 0.12 | 0.89 |
| 67.74 | 0.08 | 1.17 | 0.08 | 0.91 |
| 67.749 | 0.09 | 1.17 | 0.06 | 0.91 |
| 67.756 | 0.08 | 1.19 | 0.1 | 0.84 |
| 67.762 | 0.09 | 1.19 | 0.1 | 0.9 |
| 67.772 | 0.12 | 1.21 | 0.09 | 0.91 |
| 67.782 | 0.12 | 1.21 | 0.06 | 0.39 |
| 67.792 | 0.09 | 1.22 | 0.09 | 0.92 |
| 67.799 | 0.08 | 1.21 | 0.1 | 0.93 |
| 67.805 | 0.08 | 1.21 | 0.07 | 0.92 |
| 67.808 | 0.07 | 1.21 | 0.08 | 0.85 |
| 67.818 | 0.09 | 1.21 | 0.08 | 0.9 |
| 67.828 | 0.13 | 1.22 | 0.08 | 0.9 |
| **Average** | **0.11** | **1.17** | **0.1** | **0.87** |
| **Std Dev** | **0.08** | **0.08** | **0.07** | **0.12** |
| Difference from PDM | | | **-7.00%** | **-25.25%** |

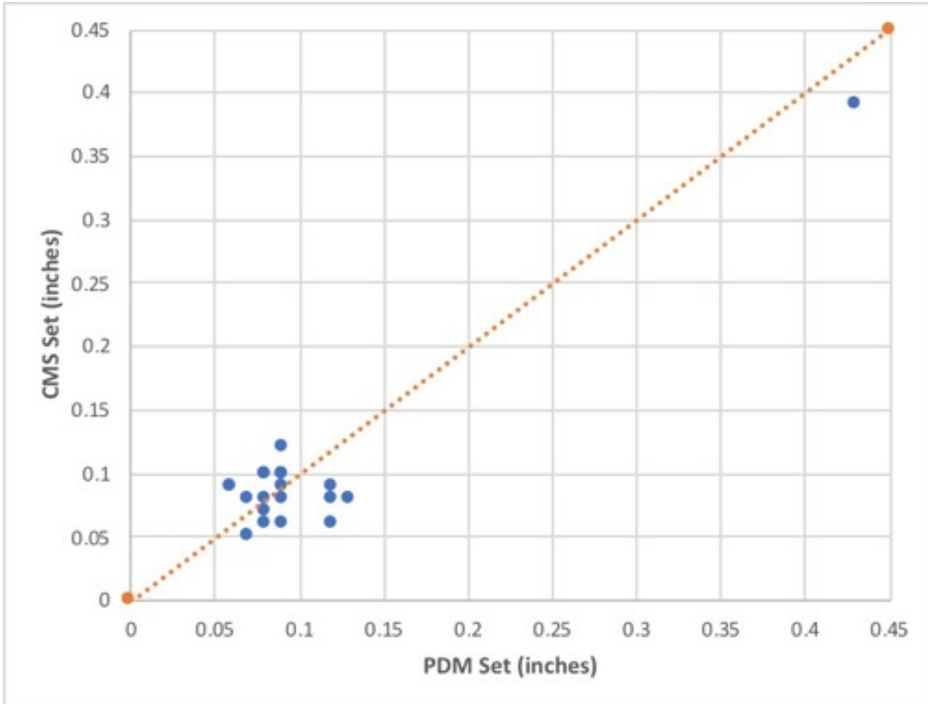


Figure 6-14 PDM set versus CMS set for Dunns Creek Pile

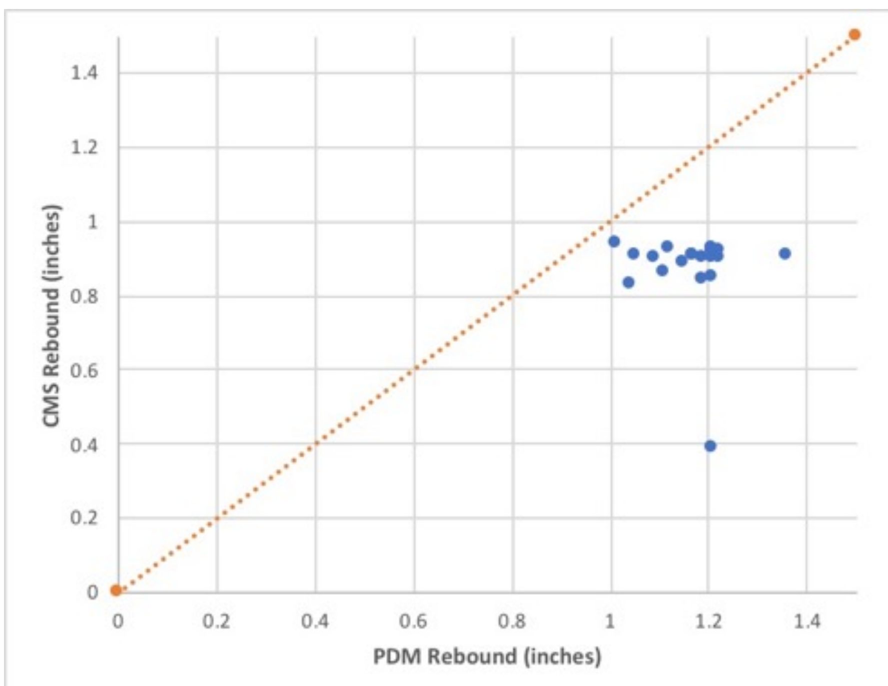


Figure 6-15 PDM Rebound versus CMS Rebound for Dunns Creek Pile

### 6.3.2.2 Dunns Creek Test Pile PDM versus PDA

The Dunns Creek test pile PDM and PDA data movements from 67.59 to 68.70 feet were compared as shown in Table 6-12. Average sets and rebounds were determined from 25 hammer blows. PDA data produced larger DFN values (i.e. called digital sets or dSET) than the inspector-based sets or iSET. The rebound based on DFN was therefore an order of magnitude smaller than rebound based on inspectors set. Again, there was visual evidence of rebound in the 1 inch range at these depths, indicating that the DFN may not be reliable in this instance.

Table 6-12 PDM versus PDA for Dunns Creek Test Pile

| Method | Testing Range (ft) | Average Set (in) | Average Rebound (in) | Difference from PDM (in) |
|---|---|---|---|---|
| **PDM** | **67.592-68.701** | **0.09** | **1.01** | **---** |
| PDA dRebound | 67.59-68.70 | --- | 0.12 | -0.89 |
| PDA iRebound | 67.59-68.70 | --- | 1.29 | 0.28 |
| PDA dSET | 67.59-68.70 | 1.37 | --- | 1.28 |
| PDA iSET | 67.59-68.70 | 0.22 | --- | 0.13 |

### 6.3.3 Ellis Road PDM – PDA Comparisons

PDA DFN and SET's were compared to the PDA DFN and SET's at two depths. Note that the raw PDM depths were recorded at 16 and 22 feet, however a 95-foot adjustment had to be included in order for these depths to be correct.

At the upper level (111 feet) the average PDM set was slightly higher (0.04 inches) than the inspector-based set and 0.15 inches higher than the digitally based set DFN. The rebound based on the inspector's data was nearly identical to the PDM rebound (0.01 inch), while the digital rebound was 0.11 inches higher than the PDM rebound. In summary, the PDM data matched the PDA inspector-based data better than the PDA digitally based data.

At the lower level (117 feet) the average PDM set was very similar to than the inspector-based set (0.01 inches) and 0.04 inches higher than the digitally based set DFN. The rebound based on the inspector's data was 0.10 inches higher than the PDM rebound, while the digital rebound was 0.13 inches higher than the PDM rebound. In summary, the PDM data again matched the PDA inspector-based data better than the PDA digitally based data.

In this instance DFN was smaller than SET which also led to larger values for rebound. The average for the nearest foot of PDA data was used to be compared to the PDM data in Table 6-13. The full PDA data will be presented in the final report Appendices.

Table 6-13 PDM versus PDA from Ellis Overpass Test Pile

| Method | PDM Testing Range (ft) | Average Set (in) | Difference from PDM (in) | Average Rebound (in) | Difference from PDM (in) |
|---|---|---|---|---|---|
| **PDM** | **111.496-111.913** | **0.20** | **---** | **0.24** | **---** |
| PDA DFN | 111.49-111.9 | 0.05 | -0.15 | 0.35 | 0.11 |
| PDA SET | 111.49-111.9 | 0.16 | -0.04 | 0.25 | 0.01 |
| **PDM** | **117.001-117.060** | **0.19** | **---** | **0.17** | **---** |
| PDA DFN | 117.0-117.06 | 0.15 | -0.04 | 0.30 | 0.13 |
| PDA SET | 117.0-117.06 | 0.18 | -0.01 | 0.27 | 0.10 |

## 6.4 PDM and CMS Comparisons for SPT

Using the data from the 39.859 to 40.696 SPT testing at Dunns Creek, it was possible to match PDM and CMS data. Table 6-14 presents the PDM sets and rebounds that correspond to the CMS sets and rebound. Since each new section of rod represents a separate test, matching data required listening to the audio of the CMS videos to determine which set of PDM data could be matched. Matching the blows was achieved by comparing the trends seen in the set for both methods. It was assumed that these trends matched such that matching blows could be established for the comparisons. PDM and CMS sets were similar, however, the CMS sets were about 15 % higher. Note that using a percentage to make a comparison may be misleading as the values are all in the 2 inch range. PDM and CMS rebounds although similar, are opposite in sign because the PDM software interprets the SPT rod movements as shown in Table 6-7. The complete set of CMS data is presented in the Appendices.

Table 6-14 PDM versus CMS for Dunns Creek SPT-1

| Depth (ft) | PDM set (in) | PDM Rebound (in) | CMS set (in) | CMS Rebound (in) |
|---|---|---|---|---|
| 39.859 | 1.46 | -0.02 | 1.6 | 0.01 |
| 39.98 | 1.52 | -0.02 | 1.6 | 0.03 |
| 40.105 | 1.8 | -0.13 | 2 | 0.11 |
| 40.256 | 3.02 | -0.43 | 3.21 | 0.11 |
| 40.509 | 2.26 | -0.09 | 3.14 | 0.04 |
| **Average** | **2.01** | **-0.14** | **2.31** | **0.06** |
| **Std Dev** | **0.66** | **0.18** | **0.81** | **0.04** |
| **Difference from PDM** | | | **14.87%** | **-144.78%** |

Figure 6-16 shows the data PDM and CMS sets from the 39.859 to 40.696 SPT testing. The line of equality was added and shows that the CMS sets are slightly larger than the PDM sets. Visually the plot indicates a promising relationship based on 5 data points. Additional testing is required to substantiate this finding.

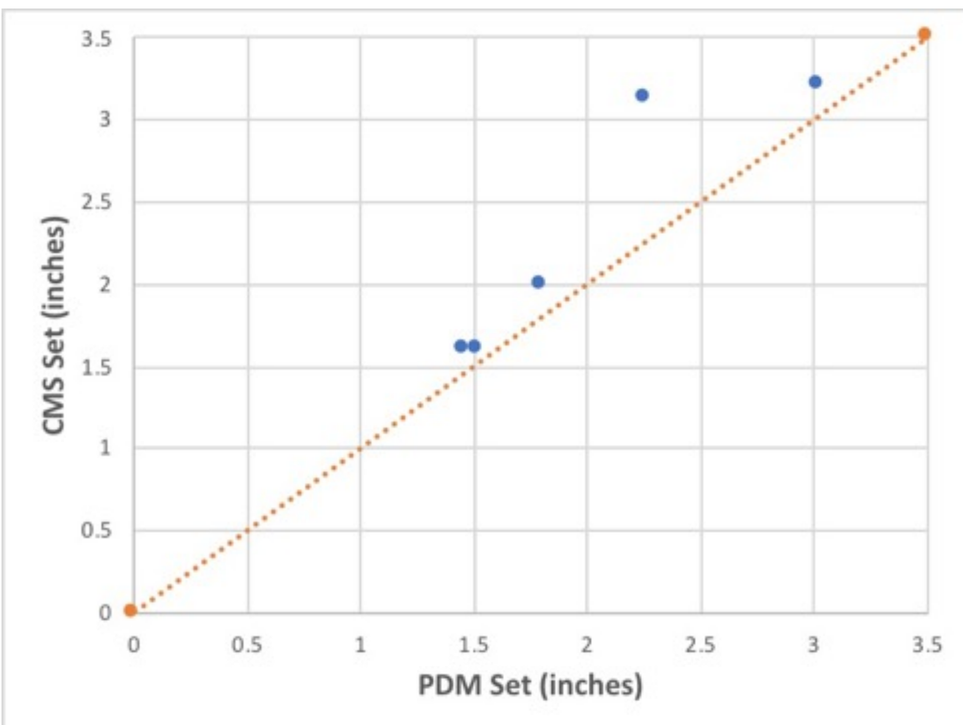



Figure 6-16 PDM Set versus CMS Set from 39.859 to 40.696 feet at Dunns Creek SPT-1

Figure 6-17 shows the Dunns Creek 39.859 to 40.696 feet PDM SPT data. The upper numbers along the graph are maximum displacements (DMX) and the lower numbers are SET, therefore, rebound is DMS-SET. There is a blue dot at the maximum displacement where the PDM software interprets as the end of the linear response range from the rods. There is a continual movement downward of the rods after this point. This continued downward movement is interpreted as negative rebound by the PDM software and therefore, its absolute value was used in the analyses. Figure 6-18 is an enlargement of the last three blows, which more clearly show the continued movement following the blue dot or end of the linear range.

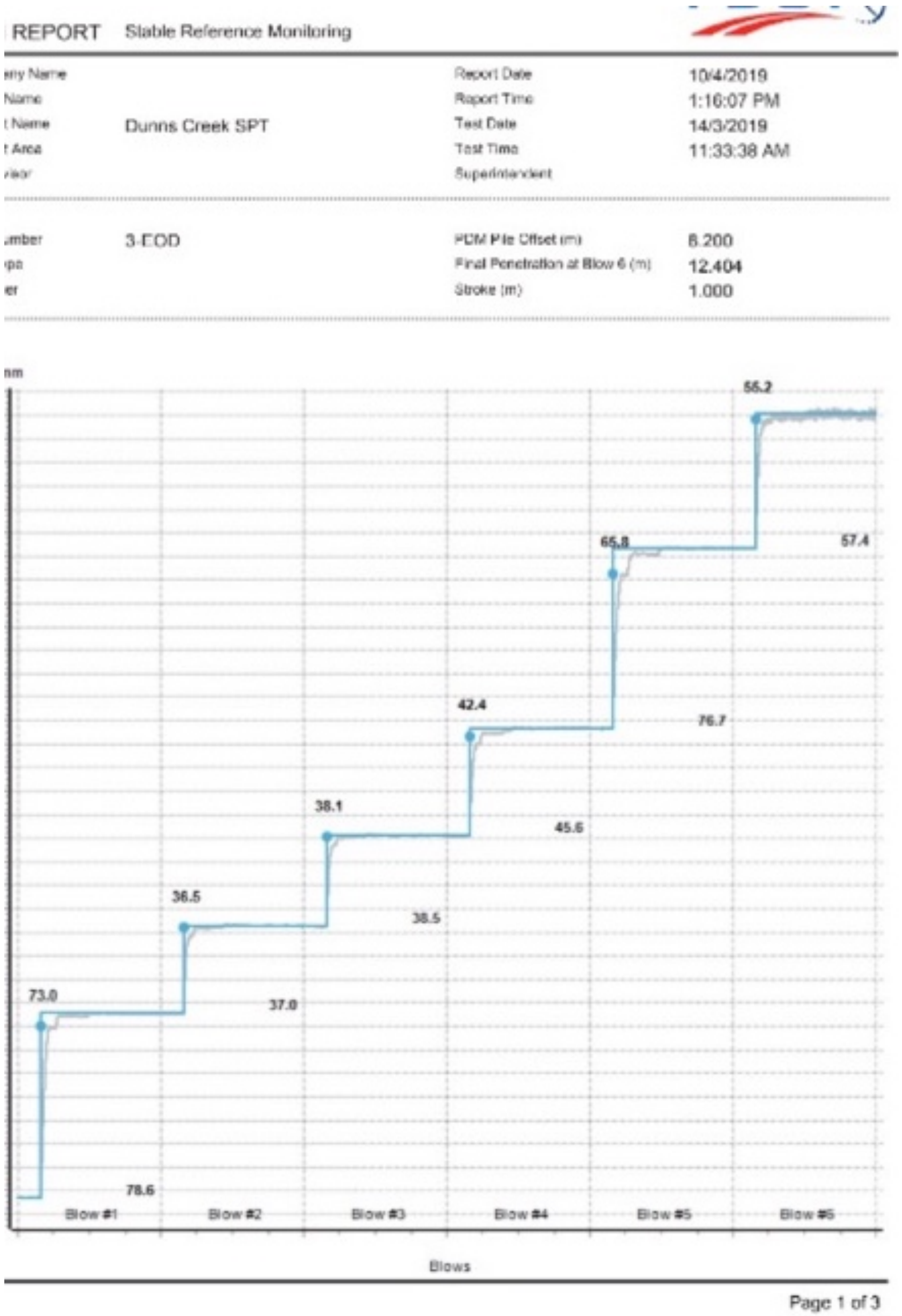



Figure 6-17 Dunns Creek PDM SPT Results

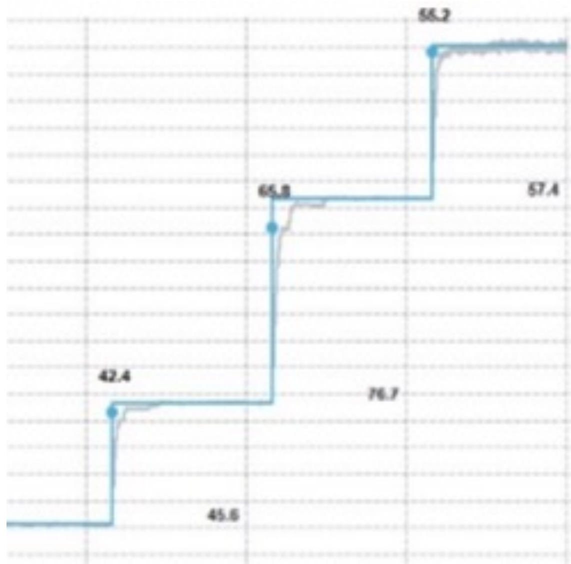



Figure 6-18 Dunns Creek PDM SPT Call-out showing Time-Dependent Movements

Figure 6-19 shows a PDM and CMS comparison between the rebound from 39.859 to 40.696 feet. The negative PDM rebounds are converted to absolute values for this plot. There is a possible relationship between the CMS and absolute values of the PDM rebound, however, there is limited data and one data point is clearly showing differences between the two techniques.

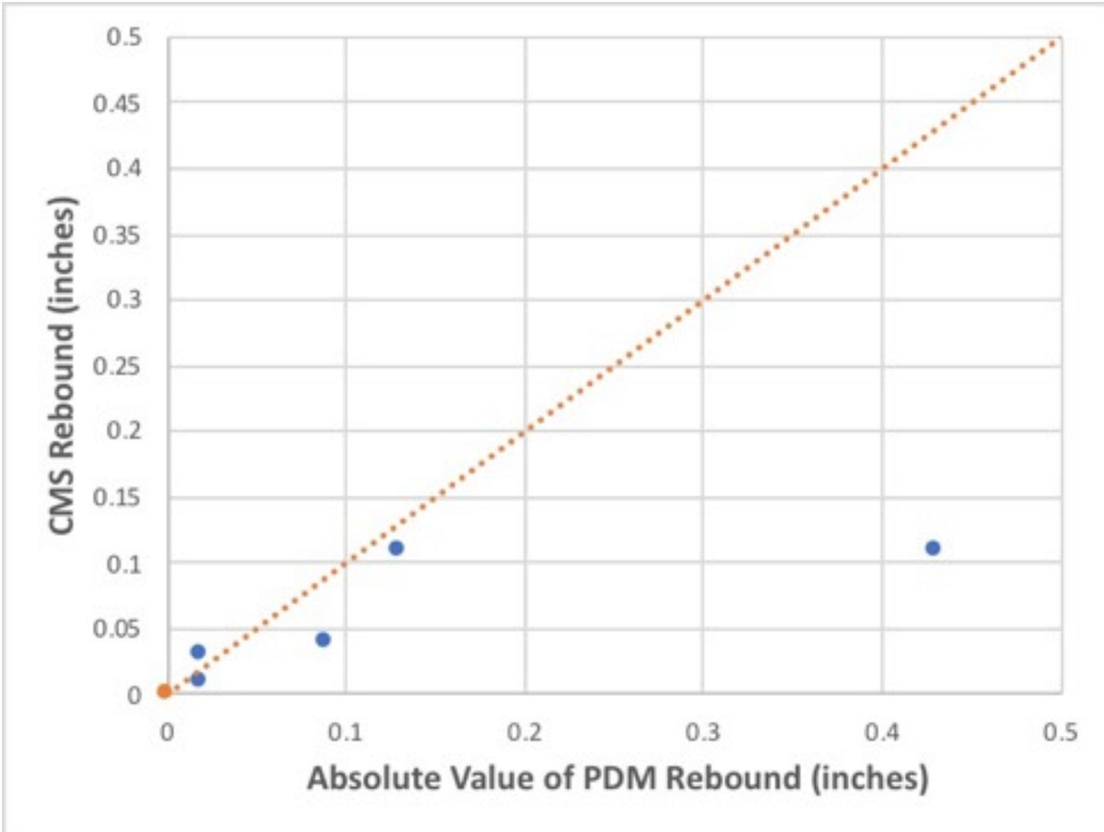



Figure 6-19 PDM Rebound versus CMS Rebound from 39.859 to 40.696 feet at Dunns Creek SPT-1

For the 59.698 to 60.646 SPT PDM data it was again possible to match PDM and CMS blows. Data from the last three blows within this region was used for this comparison. Because each new section of rod represents a separate test it required listening to the audio of the CMS videos to determine which set of PDM data they matched. Matching the blows was achieved by comparing the trends seen in the set for both methods. It was assumed that these trends corresponded such that matching blows could be established for the comparisons. Table 6-15 is a summary of PDM and CMS data at a depth of about 60.5 feet. PDM set and rebounds were compared to CMS sets and rebounds. The three sets from both devices are very similar, while the three rebounds are not.

Table 6-15 PDM versus CMS for Dunns Creek 60-foot Depth SPT-2

| Depth (ft) | PDM set (in) | PDM Rebound (in) | CMS set (in) | CMS Rebound (in) |
|---|---|---|---|---|
| 60.482 | 1.13 | 1.13 | 1.15 | 0.03 |
| 60.574 | 1.13 | 1.13 | 1.14 | 0.03 |
| 60.646 | 0.84 | 0.87 | 0.96 | 0 |
| **Average** | **1.04** | **1.04** | **1.08** | **0.02** |
| **Std Dev** | **0.14** | **0.12** | **0.09** | **0.01** |
| **Difference from PDM** | | | **4.41%** | **-98.08%** |

Figure 6-20 shows a comparison between the set for the PDM and CMS. The trend line visually represents the promising relationship, because the three sets of data are near the line of equality. Additional testing is needed to validate this finding.

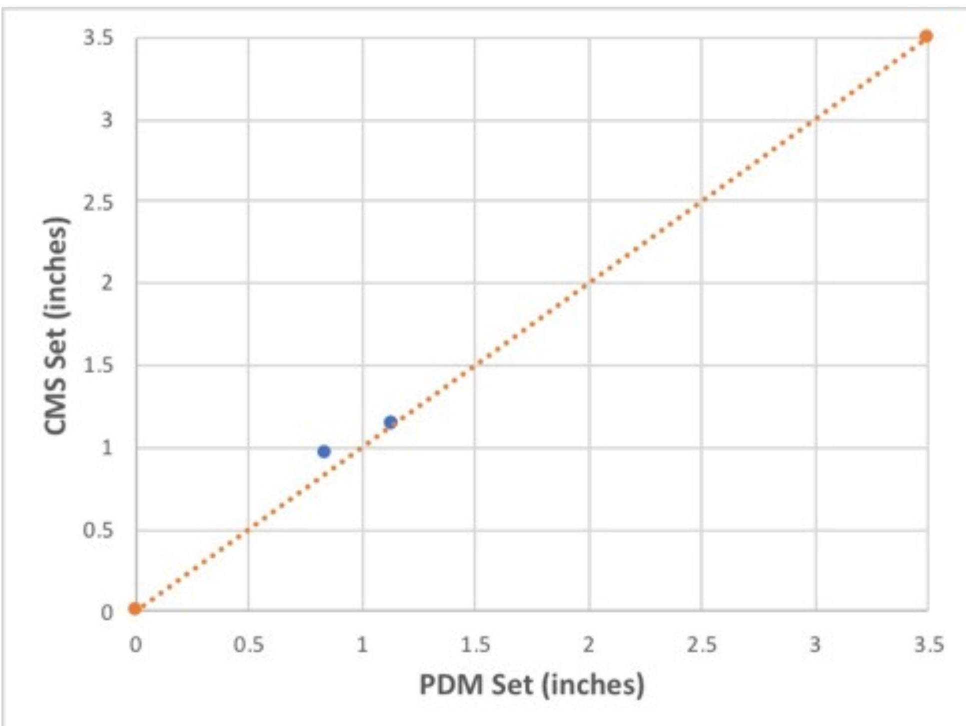



Figure 6-20 PDM set versus CMS set for Dunns Creek SPT-2

Figure 6-21 shows a comparison between the rebound for the PDM and CMS. The relationship carries no values as the values for CMS rebound are incorrect.

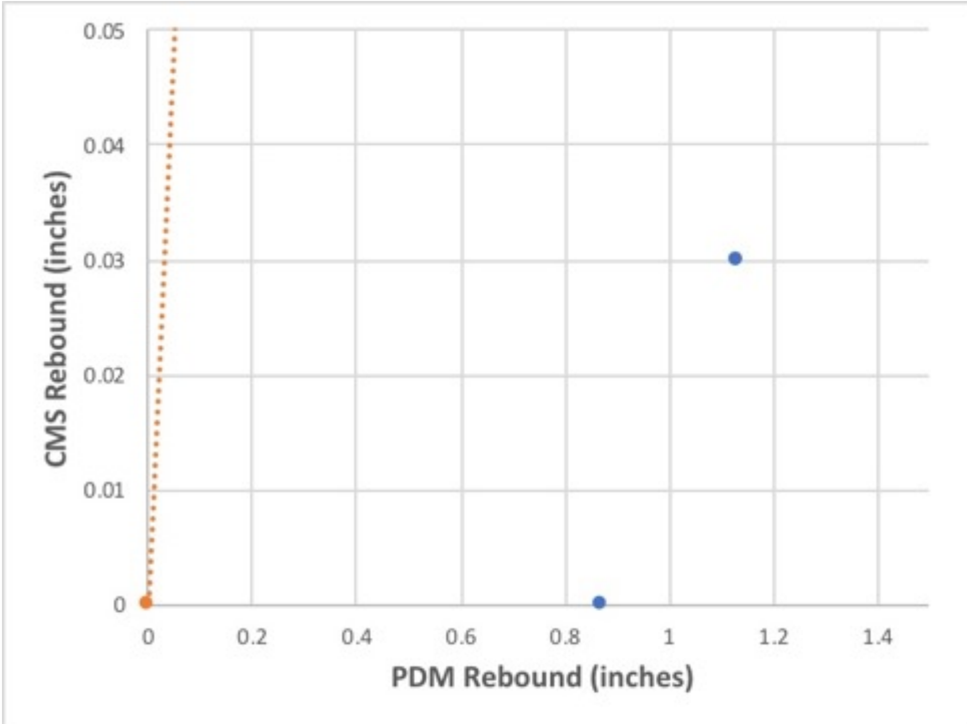



Figure 6-21 PDM Rebound versus CMS Rebound for Dunns Creek SPT-2

## 6.5 PDM Summaries

Table 6-16 displays the summary of the PDM data from pile and SPT testing. Of all the attempted tests on piles 55% yielded useable results. Of the useable results, an average 52% of the data within the active zone was acceptable. Of all the tests attempted on SPT rods 88% yielded useable results. Of those results an average 68% of the data within the active zone was acceptable.

This information indicates that using the PDM on SPT rods was more successful than using it on piles as they were driven. The reason for this is that the PDM software requires the user to input data for each test location along the pile and this task is often not completed before the reflective tape enters the active measuring zone during pile driving. However, there is sufficient time to complete it during the time intervals between SPT tests.

Table 6-16 Summary of PDM data for Piles

| Tests | % Of Useable Test Data | Average % Of Active Zone | Standard Deviation | Average Set (in) | Standard Deviation | Average Rebound (in) | Standard Deviation |
|---|---|---|---|---|---|---|---|
| PDM-Pile | 55 | 52 | 22 | 0.68 | 0.33 | 0.22 | 0.21 |
| PDM-SPT | 88 | 68 | 11 | 1.67 | 1.55 | -0.24 | 0.71 |

### 6.5.1 Summary of PDM-CMS Comparisons

Table 6-17 displays the summary of the CMS-PDM comparisons from both pile and SPT testing. The CMS-PDM comparisons are much better for set than for rebound. On average the sets were within 7% for piles and 6.16% for SPT. This data indicates a promising relationship between the two methods ability to measure set. The relationship for rebound was less significant at 25.25% for piles and at 121.33% for SPT. The differences between CMS and PDM pile rebound may be from the non-standardized method used to determine pile rebound with the CMS system. The large differences between SPT data for rebound with the SPT testing may be due to a combination of things. The PDM software produced inaccurate DMX values during this testing which was attributed to either multiple hammer hits on the rods or time-dependent movements of the rods in the high rebound soils. These options need further evaluations using SPT testing in both rebound and non-rebound soils at several sites.

Table 6-17 Summary of CMS - PDM Comparisons

| Average % Difference In Set From PDM For Piles | Average % Difference In Rebound From PDM For Piles | Average % Difference In Set From PDM For SPT | Average % Difference In Rebound From PDM For SPT |
|---|---|---|---|
| -7 | -25.25 | 6.16 | -121.33 |

### 6.5.2 Summary of PDM-SET-DFN Comparison

Table 6-18 displays the summary of the PDA-PDM comparisons for both DFN and SET. The average differences in set were higher than the average differences in rebound for both SET and DFN data. The DFN-PDM set comparisons produced a large difference of over 255%., while the PDA-SET versus PDM-SET showed produced a moderately large discrepancy of at 55.08%. SET showed some relationship on average to PDM set at 18.49% and a smaller relationship on average to rebound at 33.26%. DFN proves an imprecise value for set within the PDA data. SET (Inspector set) is far more relatively precise.

Table 6-18 Summary of PDA-PDM Comparisons

| Average % Difference In Set From PDM Using DFN | Average % Difference In Rebound From PDM Using DFN | Average % Difference In Set From PDM Using SET | Average % Difference In Rebound From PDM Using SET |
|---|---|---|---|
| 255.71 | 18.49 | 55.08 | 33.26 |

## 6.6 CMS Testing

Using various digital video cameras mounted on tripods, video images were extracted and evaluated to yield pile and SPT rods movements. The equipment was placed about 20 to 50 feet from the piles or SPT rods to help minimize job hazards. Once the videos were recorded the equipment was transported to the Florida Tech Marine Environmental Optics Lab for data analysis and reduction. A detailed description of the CMS testing process is presented in Appendix D.

### 6.6.1 CMS Results

CMS data is presented for four pile driving sites, Baldwin Bypass, Dunns Creek, Reedy Creek and Ellis Overpass, while a comparison between CMS, PDM and PDA data is presented for Dunns Creek. SPT data is presented from Dunns Creek and Wekiva Parkway. Table 6-19 is an overview of the testing performed.

Table 6-19 PDA, PDM, CMS Testing Overview

| Testing Description | Site Name | Pile Location | Length of Pile (ft) | Successful PDA Testing | Successful PDM Testing | Successful CMS Testing |
|---|---|---|---|---|---|---|
| Pile | Baldwin Bypass | EB 4 Pile 1 | 82 | | | ✓ |
| | Reedy Creek | EB 1 Pile 1 | 120 | ✓ | ✓ | ✓ |
| | Dunns Creek | Pier 4 Pile 10 | 110 | ✓ | ✓ | ✓ |
| | Ellis Road | EB 1 Pile 8 | 140 | ✓ | ✓ | ✓ |
| SPT | Wekiva Parkway | WLC 2 and WLC 3 | | | ✓ | ✓ |
| | Dunns Creek | Near Peir 4 Pile 10 | | | ✓ | ✓ |

CMS data was reduced to movements, and rebound as follows. A cumulative set was determined for each blow using an average movement following the rebound portion. These data are shown as a and b in Figure 6-22. The displacement (equivalent to the PDA maximum displacement or DMX), was calculated using the maximum distance (point 1) minus the previous average distance (a). The rebound per blow was calculated using the point 1 distance minus the subsequent average displacement (b). The cumulative displacements were determined for each blow as a, b, etc., therefore the set per blow is the difference between subsequent cumulative displacement values.

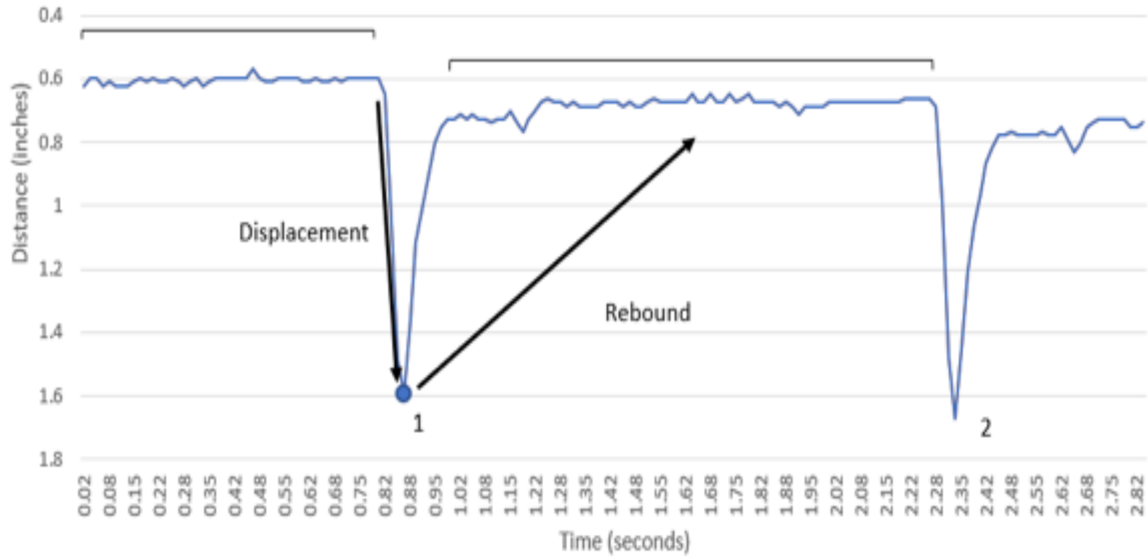



Figure 6-22 CMS Output of Displacement and Rebound for a Typical Hammer Blow

### 6.6.2 CMS Test Pile Results

#### 6.6.2.1 Baldwin Bypass Test Pile Results

Figure 6-23 shows the pile displacement during 15 sequential hammer blows from FDOT's Baldwin Overpass near Jacksonville Florida. End Bent 4 production pile 1 (EB4 PP1) was evaluated by the research team. This video was 1 minute and 24 seconds long and was taken as the pile was being driven at the 30 to 35 feet level though the template. Extremely poor weather conditions along with several unanticipated logistic problems prevented any PDM data from being obtained. The dynamic pile capacities were determined by RADISE International however, their analysis only produced deflections for each blow, making it difficult to match depths during driving. Therefore, to match CMS data to the corresponding RADISE results time stamps from each device were used. The RADISE and CMS data were recorded at 2:45 PM. Table 6-20 is a summary from blow numbers 940 to 960, which were matched to the CMS data based on the recording times. It shows approximately 0.62 inches or 16 mm of maximum displacement occurs and 0.25 inches or 6 mm of rebound occurs during this portion of driving.

Table 6-20 End Bent 4 Production Pile 1 CMS movements

| Blow | Date | Time | Max Pile Top Displacement (inches) | Pile Top Set (inches) | Pile Top Rebound (inches) |
|---|---|---|---|---|---|
| 940 | 5/14/18 | 2:45:06 PM | 0.5944 | 0.3424 | 0.2520 |
| 941 | 5/14/18 | 2:45:08 PM | 0.7364 | 0.5993 | 0.1371 |
| 942 | 5/14/18 | 2:45:09 PM | 0.6368 | 0.3905 | 0.2463 |
| 943 | 5/14/18 | 2:45:11 PM | 0.6004 | 0.3712 | 0.2292 |
| 944 | 5/14/18 | 2:45:12 PM | 0.5917 | 0.3528 | 0.2389 |
| 945 | 5/14/18 | 2:45:13 PM | 0.5740 | 0.2664 | 0.3075 |
| 946 | 5/14/18 | 2:45:15 PM | 0.5895 | 0.3003 | 0.2892 |
| 947 | 5/14/18 | 2:45:16 PM | 0.6041 | 0.3202 | 0.2839 |
| 948 | 5/14/18 | 2:45:18 PM | 0.5380 | 0.2523 | 0.2857 |
| 949 | 5/14/18 | 2:45:19 PM | 0.5961 | 0.3398 | 0.2563 |
| 950 | 5/14/18 | 2:45:21 PM | 0.6306 | 0.4111 | 0.2194 |
| 951 | 5/14/18 | 2:45:22 PM | 0.6376 | 0.4468 | 0.1908 |
| 952 | 5/14/18 | 2:45:23 PM | 0.7232 | 0.5694 | 0.1538 |
| 953 | 5/14/18 | 2:45:25 PM | 0.6215 | 0.4063 | 0.2152 |
| 954 | 5/14/18 | 2:45:26 PM | 0.6416 | 0.4174 | 0.2242 |
| 955 | 5/14/18 | 2:45:28 PM | 0.6356 | 0.4102 | 0.2254 |
| 956 | 5/14/18 | 2:45:29 PM | 0.6324 | 0.4479 | 0.1844 |
| 957 | 5/14/18 | 2:45:30 PM | 0.6141 | 0.3162 | 0.2979 |
| 958 | 5/14/18 | 2:45:32 PM | 0.6702 | 0.4604 | 0.2098 |
| 959 | 5/14/18 | 2:45:33 PM | 0.6438 | 0.3353 | 0.3085 |
| 960 | 5/14/18 | 2:45:35 PM | 0.6077 | 0.3136 | 0.2942 |
| | | **Average** | **0.6247** | **0.3843** | **0.2405** |
| | | **Stand Dev** | **0.0453** | **0.0885** | **0.0492** |
| | | **Std Error** | **0.0099** | **0.0193** | **0.0107** |

During the camera monitoring sequence, the interface being tracked was a black paint line. Data in terms of vertical displacement versus frame number indicate that over 600 frames at 60 Hz or approximately 10 seconds (i.e., 600 frames divided by 60 frames per second) a total displacement of 3 inches occurred or 150 mm (i.e., 168 – 22 mm). The signals show initial downward displacements followed by the upward rebound for each blow. About 0.79 inch (20 mm) of downward movement followed by about ¼-inch (6 mm) of rebound occurred for the first 13 blows. About ½ to ¼-inch (12 mm and 6 mm) of downward movement occurred followed by about 0.16 to 0.08 inch (4 and 2 mm) of rebound for the last two blows. Mean rebound displacement for the first 12 hammer blows was 0.3 inch with 0.037 inch (7.37 mm with 0.94

mm) standard error of the mean1. Mean maximum displacement for all 15 blows was 0.67 inch and 0.05 inch (17.11 mm and 1.25 mm) standard error of the mean.

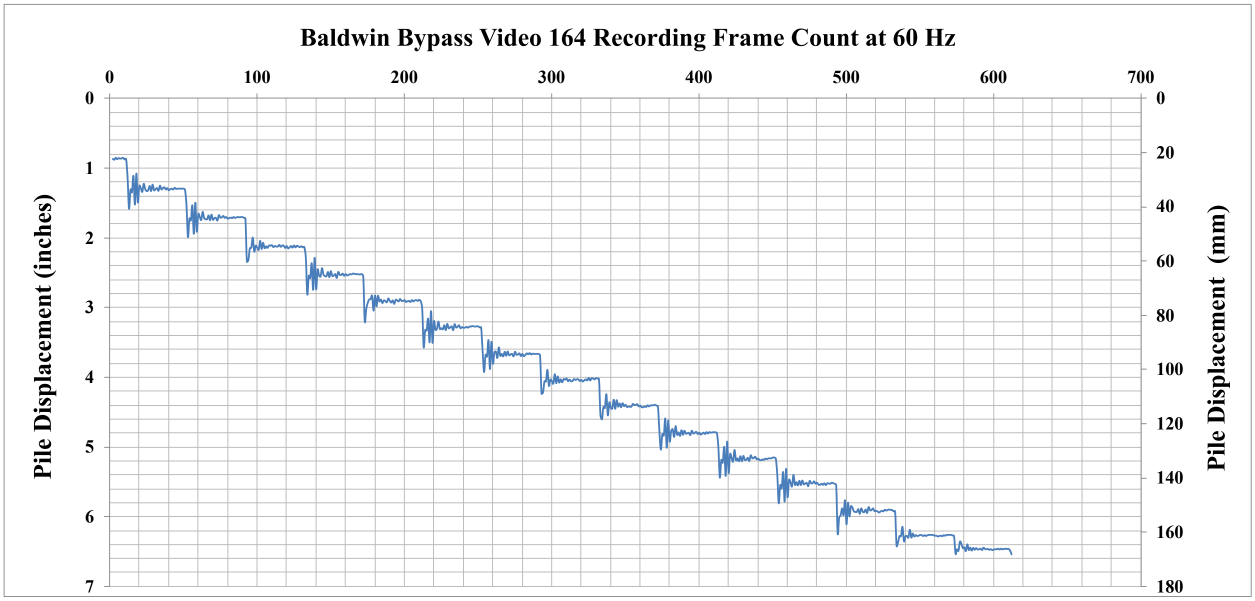



Figure 6-23 CMS Vertical Displacement from 15 pile Hammer Blows at Baldwin Bypass, Jacksonville Florida

Figure 6-24 shows the first two hammer blows over about 100 frames (about 2 seconds) from the Baldwin Bypass CMS data. Both the pile set and rebound are shown. A pile set of 0.45-inch (11 mm) results for the first blow after a rebound of 0.28-inch (7 mm) occurs. The camera signal also shows several bouncing movements which damp out prior to the subsequent blow. These bouncing movements would produce larger bouncing rebounds. For example, during blow 2 the bouncing rebound would be ½-inch (12 mm) instead of ¼ inch or 6 mm. In conclusion, the 60 Hz camera video produced a clear trace of the pile movement and accurate measurements of displacement when combined with black tape on the light gray concrete pile even though the

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1 Standard Error of the mean is equal to the standard deviation divided by the square root of the number of samples and is a precision estimate of either mean displacements or rebounds.

weather conditions were extremely poor, which however, prevented any data from being obtained with the PDM.

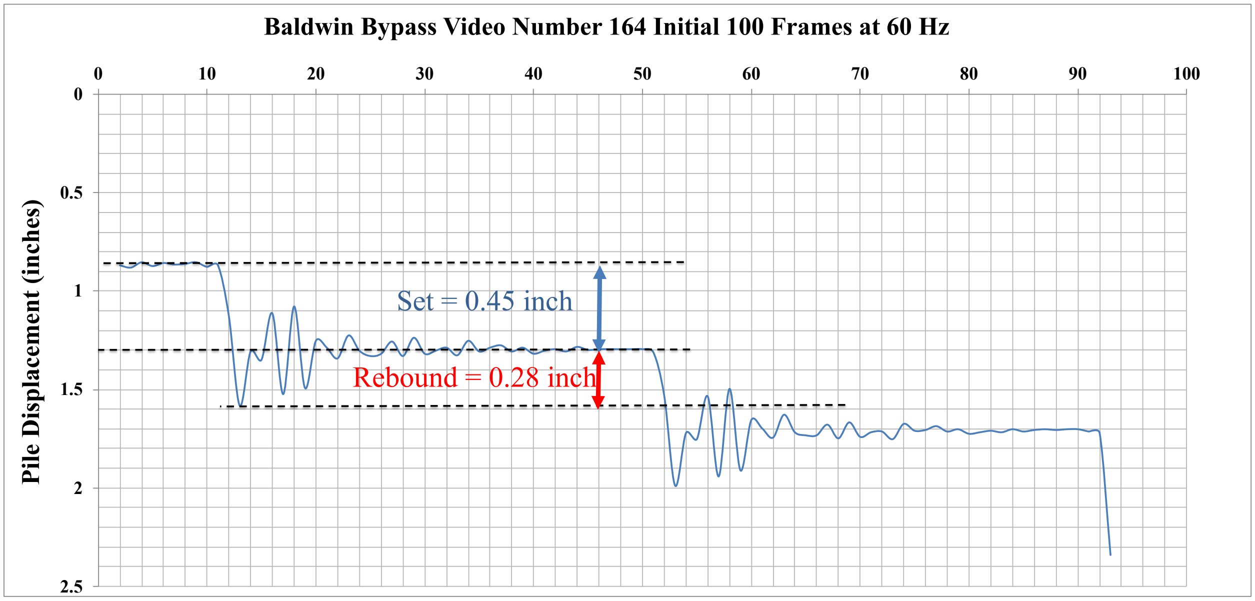


Figure 6-24 CMS 60-Hz Displacement at Baldwin Bypass showing Pile Set and Rebound

### 6.6.2.2 Reedy Creek Test Pile Results

CMS testing was performed throughout the pile driving process for the 120-foot-long test pile at Reedy Creek. Figure 6-25 is the video image and calibration information for the Reedy Creek test pile. It shows that the black electrical tape used to mark the pile was 23 pixels wide and measured to be 0.6 inch (15 mm). The calibration produced pixels that measured 0.025 inch (0.652 mm) in width.

Figure 6-26 is the CMS signal measured during 12 hammer blows recorded during the CMS test pile evaluation at the Reedy Creek sight. These signals were measured with a camera, recording at 60 Hz at the 90-foot location using black tape on the pile (Figure 6-25). During the 12 blows a total of about 8.8 inches (220 mm) of vertical movement occurred with minimal rebound. These values produce a maximum displacement of about 0.7 inch (18 mm) per blow. The set per blow for the first nine blows was about ¾ inch or 20 mm, while the set of the 10th through 12th blows decreased. The rebound standard error of the mean was approximately 0.02 inch (0.5 mm). In conclusion, the 60 Hz camera video produced a clear trace of the pile movement when combined with black tape on the light gray concrete pile.

PDA data from approximately this same depth also showed no rebound. Table 6-21 shows the PDA data from approximately the same location on the pile. The rebound averaged 0.14 inches based on either the inspectors or digital information. The maximum displacement per blow was 0.94 inches or 23 mm.

In summary, both the CMS and PDA data match at the 90-foot mark for the Reedy Creek site. End Bent 1; Pile 12 was tested.

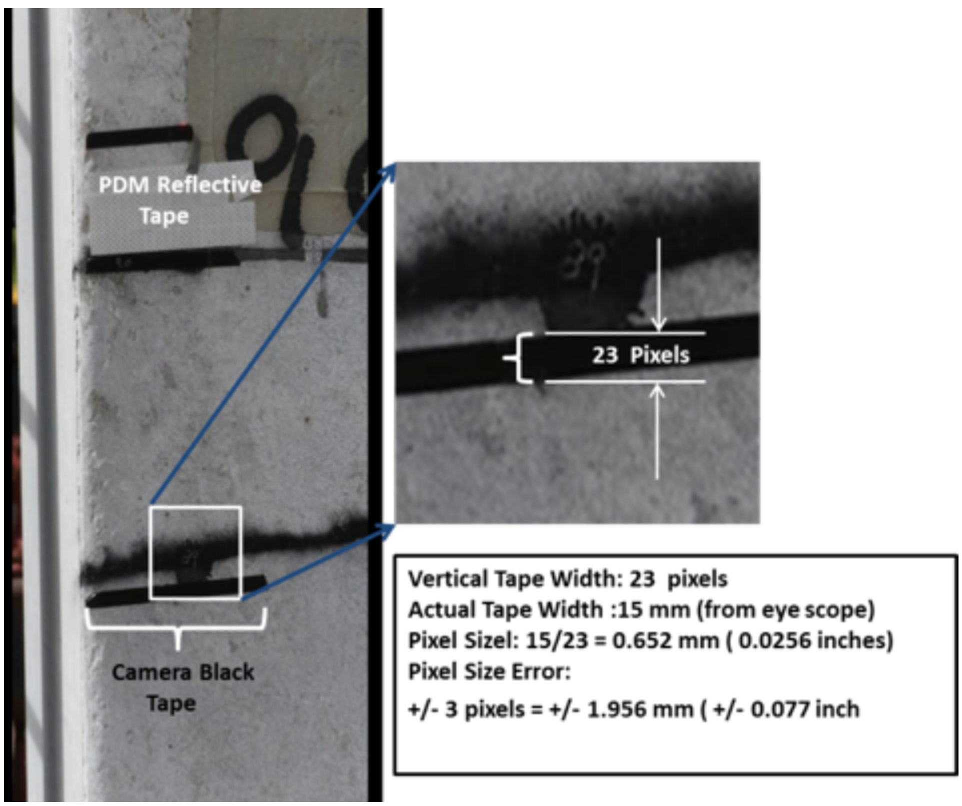


Figure 6-25 CMS Video Calibration for Reedy Creek, Orlando, Florida

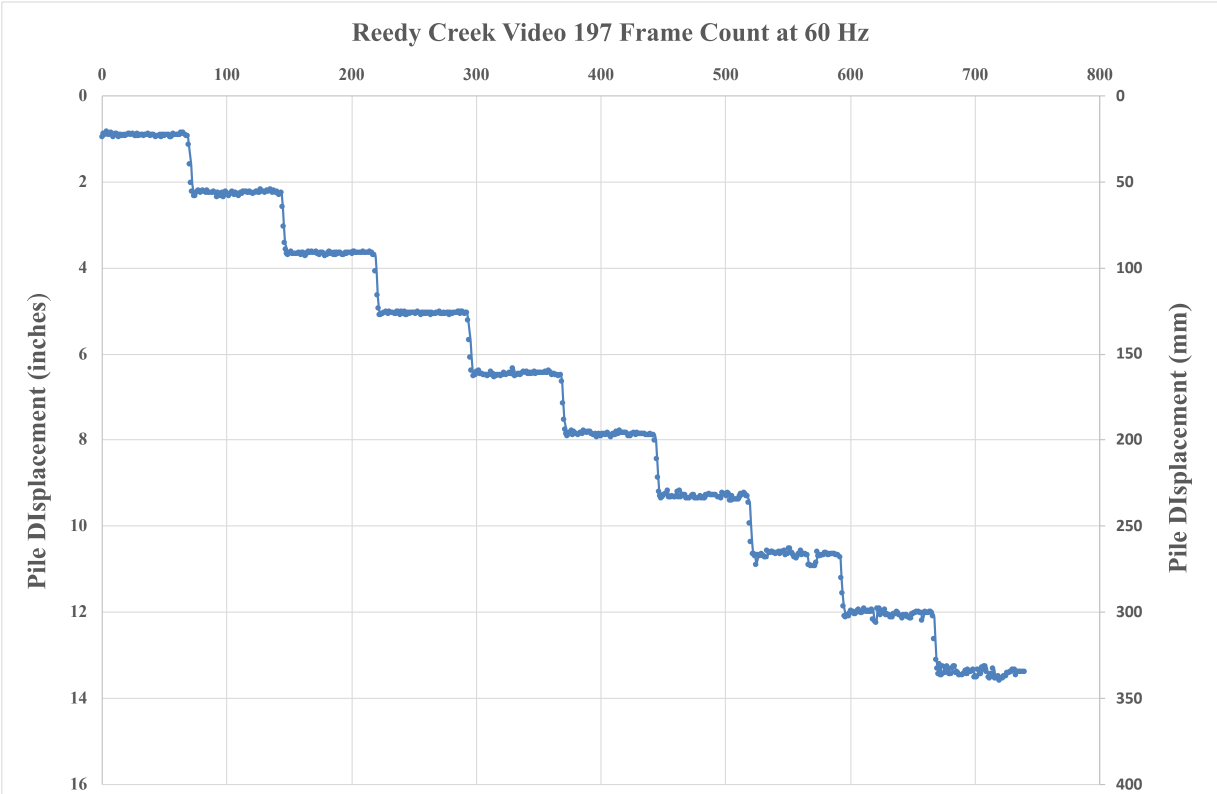


Figure 6-26 Reedy Creek CMS Signals for 12 Hammer Blows

Table 6-21 PDA Reedy Creek Data Summary from 90 feet

| Blow | Date | Time | LP | DMX | DFN | SET | iRebound | dRebound |
|---|---|---|---|---|---|---|---|---|
| | | | feet | inches | inches | inches | inches | inches |
| 1 | 7/19/18 | 14:53:38 | 90.07 | 0.91 | 0.8 | 0.8 | 0.11 | 0.11 |
| 2 | 7/19/18 | 14:53:39 | 90.13 | 0.92 | 0.8 | 0.8 | 0.12 | 0.12 |
| 3 | 7/19/18 | 14:53:40 | 90.2 | 0.94 | 0.8 | 0.8 | 0.14 | 0.14 |
| 4 | 7/19/18 | 14:53:41 | 90.27 | 0.92 | 0.8 | 0.8 | 0.12 | 0.12 |
| 5 | 7/19/18 | 14:53:42 | 90.33 | 0.92 | 0.8 | 0.8 | 0.12 | 0.12 |
| 6 | 7/19/18 | 14:53:44 | 90.4 | 0.94 | 0.79 | 0.8 | 0.14 | 0.15 |
| 7 | 7/19/18 | 14:53:45 | 90.47 | 0.96 | 0.8 | 0.8 | 0.16 | 0.16 |
| 8 | 7/19/18 | 14:53:46 | 90.53 | 0.94 | 0.8 | 0.8 | 0.14 | 0.14 |
| 9 | 7/19/18 | 14:53:47 | 90.6 | 0.95 | 0.8 | 0.8 | 0.15 | 0.15 |
| 10 | 7/19/18 | 14:53:49 | 90.67 | 0.95 | 0.8 | 0.8 | 0.15 | 0.15 |
| 11 | 7/19/18 | 14:53:50 | 90.73 | 0.95 | 0.8 | 0.8 | 0.15 | 0.15 |
| 12 | 7/19/18 | 14:53:51 | 90.8 | 0.96 | 0.8 | 0.8 | 0.16 | 0.16 |
| | | | Mean | 0.94 | 0.80 | 0.80 | 0.14 | 0.14 |
| | | | Std Dev | 0.02 | 0.00 | 0.00 | 0.02 | 0.02 |
| | | | Std Error | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

### 6.6.2.3 Dunns Creek Test Pile Results

Four sets of videos between 61 and 75 feet were analyzed. There was a wooden reference beam surveyed within the template at an elevation of 44 feet. A typical video image, from the 75 to 77-foot pile marking zone is shown in Figure 6-27. It includes the reference beam, plus pile markings and black paint used for CMS analyses.


Figure 6-27 CMS Video Image from Dunns Creek Test Pile 10 at Pier 4 at 75- to 77-foot Pile Markings

Each video was cropped to about 10 to 20 hammer blows to calculate its statistical significance. A region of interest (ROI) was determined to obtain a region of pixels passing through a black painted line on pile. A different ROI was used for each video in order to track movements of the black painted line.

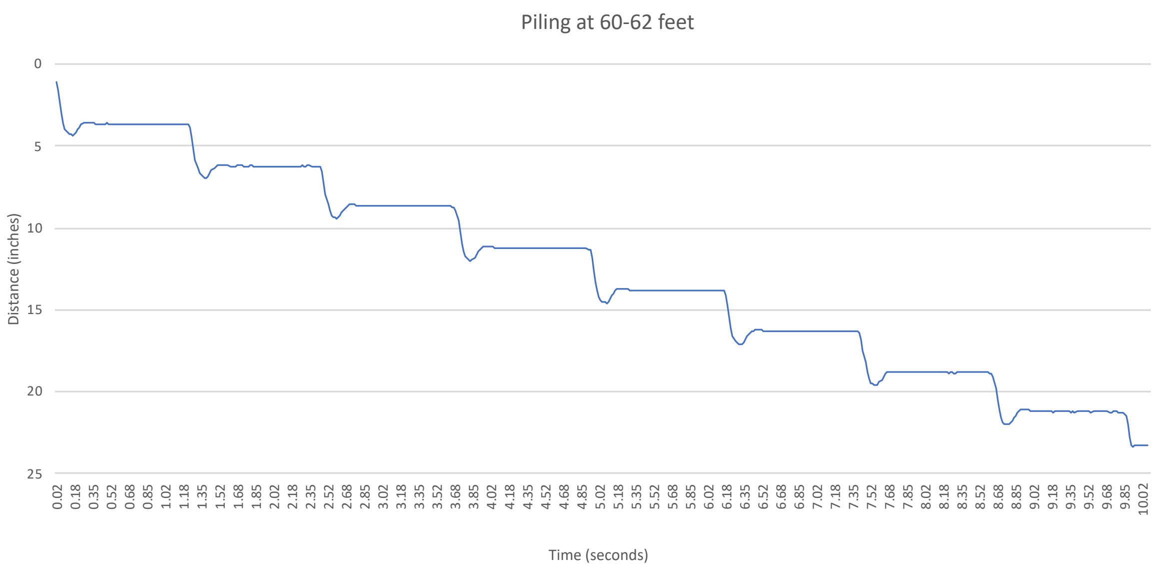


Figure 6-28 Nine CMS Hammer Blows from Dunns Creek from 60- to 62-feet

Figure 6-28 shows the camera video analysis for recordings nine hammer blows between the 60 to 62-foot pile length location. The average final cumulative displacements in inches for the first three blows are shown. Each blow also shows rebound on the order of 3/4 inch. Table 6-22 is a summary of the displacements, rebound and sets for the 9 blows from Dunns Creek's 60 to 62-foot video recording. The research team visually noted about 3/4 inch of rebound and the CMS data confirmed it.

Table 6-23 is the corresponding PDA data for 11 blows from the 60 to 62 foot range from Dunns Creek. Both the rebound based on the inspectors blows per foot (iRebound) and the digital movements (dRebound) are shown. The set based on the inspectors blow counts is calculated as 12 inches divided by the number of blows per foot. Therefore, the iRebound is maximum displacement (DMX) – Set. Although the PDA sets are similar to the CMS sets, the values for DMX and final displacement (DFN) are much lower than the sets and consequently the rebound (iRebound) become negative. Sets of 2.4 inches per blow correspond to approximately 5 blows per foot, which is a very low blow count. These negative PDA rebound values are most likely the result of the pile moving after the PDA time stamp is completed. This continual movement could be expected at the low blow counts encountered. In summary, the CMS data matches the visual information, while the PDA data may have an error due to the pile's continual movement at the low blow counts.

Table 6-22 CMS Dunns Creek Data Summary from 60- to 62-feet

| Blows | Cumulative Displacement (inches) | Max Displacement (inches) | Rebound (inches) | Set (inches) |
|---|---|---|---|---|
| 1 | N/A | N/A | 0.7288 | N/A |
| 2 | 3.6400 | 3.3100 | 0.7288 | 2.5800 |
| 3 | 6.2200 | 3.2000 | 0.7542 | 2.4500 |
| 4 | 8.6700 | 3.3200 | 0.7592 | 2.5600 |
| 5 | 11.2300 | 3.3500 | 0.7881 | 2.5600 |
| 6 | 13.7900 | 3.3300 | 0.8080 | 2.5200 |
| 7 | 16.3100 | 3.3100 | 0.7826 | 2.5300 |
| 8 | 18.8400 | 3.1300 | 0.7485 | 2.3800 |
| 9 | 21.2200 | 2.1500 | N/A | N/A |
| Mean | 12.4900 | 3.1375 | 0.7623 | 2.5114 |
| Std Dev | 5.7731 | 0.3798 | 0.0266 | 0.0664 |
| Std Error | 2.0411 | 0.1343 | 0.0094 | 0.0251 |

Table 6-24 is a summary of CMS data from 20 hammer blows from Dunns Creek recorded at the 71-foot pile depth. It shows that the rebound increased from the 61-foot data, for the majority of the blows to about 1-inch, with minimal sets in 0.1-inch range. Note two outlier points occurred at blows 16 and 17. Note if the sets are summed, from blows 2 to 19, a total of 1.66-inches of pile movement occurs during these 20 blows.

Table 6-23 PDA Dunns Creek Data Summary from 60- to 62-feet

| Blows | Date | Time | LP | DMX | DFN | SET | iRebound | dRebound |
|---|---|---|---|---|---|---|---|---|
| | | | feet | inches | inches | inches | inches | inches |
| 1 | 9/19/18 | 9:32:57 | 60 | 1.69 | 1.62 | 3 | -1.31 | 0.07 |
| 2 | 9/19/18 | 9:32:59 | 60.2 | 1.67 | 1.58 | 2.4 | -0.73 | 0.09 |
| 3 | 9/19/18 | 9:33:00 | 60.4 | 1.7 | 1.62 | 2.4 | -0.7 | 0.08 |
| 4 | 9/19/18 | 9:33:01 | 60.6 | 1.82 | 1.74 | 2.4 | -0.58 | 0.08 |
| 5 | 9/19/18 | 9:33:02 | 60.8 | 1.69 | 1.62 | 2.4 | -0.71 | 0.07 |
| 6 | 9/19/18 | 9:33:04 | 61 | 1.54 | 1.4 | 2.4 | -0.86 | 0.14 |
| 7 | 9/19/18 | 9:33:05 | 61.2 | 1.67 | 1.6 | 2.4 | -0.73 | 0.07 |
| 8 | 9/19/18 | 9:33:06 | 61.4 | 1.74 | 1.66 | 2.4 | -0.66 | 0.08 |
| 9 | 9/19/18 | 9:33:07 | 61.6 | 1.72 | 1.65 | 2.4 | -0.68 | 0.07 |
| 10 | 9/19/18 | 9:33:08 | 61.8 | 1.47 | 1.34 | 2.4 | -0.93 | 0.13 |
| 11 | 9/19/18 | 9:33:10 | 62 | 1.75 | 1.68 | 2.4 | -0.65 | 0.07 |
| | | | Mean | 1.678 | 1.592 | 2.455 | -0.776 | 0.086 |
| | | | Std Dev | 0.097 | 0.119 | 0.181 | 0.202 | 0.025 |
| | | | Std Error | 0.029 | 0.036 | 0.055 | 0.061 | 0.008 |

Table 6-25 and Table 6-26 are a summaries of PDA data from hammer blows recorded at the 71 to 72-foot pile depth. Table 6-25 with 20 blows, is a summary similar to the 61-foot PDA summary. If the set from these 20 blows is summed, 2.09 inch of pile movement occurs. Table 6-26 is the mean, standard deviation and standard error of the mean averages if all 121 hammer blows are considered. The averages, standard deviations and standard errors are similar for both tables. Both PDA tables indicate that the rebound based on the inspectors blow counts (iRebound) increased to over 1.5 inches, while the digital rebound (dRebound) was 0.11 inches, which was much less than was visually observed. Digital rebound and sets were very similar; however, set is based solely on the inspectors blow counts. If the PDA sets are summed over the proper interval, a total of 12 inches of pile movement occurs during the corresponding 120 blows.

Table 6-24 CMS Dunns Creek Data Summary from 71-foot depth

| Blows | Cumulative Displacement (inches) | Max Displacement (inches) | Rebound (inches) | Set (inches) |
|---|---|---|---|---|
| 1 | N/A | N/A | 1.04 | N/A |
| 2 | 1.57 | 1.03 | 0.93 | 0.1 |
| 3 | 1.67 | 1.1 | 1.1 | 0 |
| 4 | 1.67 | 1.11 | 1.02 | 0.1 |
| 5 | 1.77 | 1.17 | 1.09 | 0.08 |
| 6 | 1.85 | 1.22 | 1.1 | 0.12 |
| 7 | 1.97 | 1.09 | 0.98 | 0.1 |
| 8 | 2.07 | 1.18 | 1.09 | 0.1 |
| 9 | 2.17 | 1.03 | 0.94 | 0.09 |
| 10 | 2.26 | 1.13 | 1.04 | 0.1 |
| 11 | 2.36 | 1.15 | 1.05 | 0.1 |
| 12 | 2.46 | 1.14 | 1.03 | 0.11 |
| 13 | 2.57 | 1.17 | 1.11 | 0.06 |
| 14 | 2.63 | 1.15 | 1.04 | 0.11 |
| 15 | 2.74 | 1.17 | 1.07 | 0.1 |
| 16 | 2.84 | 0 | 0.11 | 0.11 |
| 17 | 2.95 | 0.1 | 0.2 | 0.1 |
| 18 | 3.05 | 1.19 | 1.09 | 0.09 |
| 19 | 3.14 | 1.14 | 1.06 | 0.09 |
| 20 | 3.23 | 1.22 | N/A | N/A |
| Mean | 2.3668 | 1.0258 | 0.9521 | 0.0922 |
| Std Dev | 0.5210 | 0.3389 | 0.2782 | 0.0257 |
| Std Error | 0.1195 | 0.0778 | 0.0638 | 0.0061 |

Table 6-25 PDA Dunns Creek Summary from the Initial 20 Hammer Blows Between 71- And 72-Feet

| Blows | Date | Time | LP | DMX | DFN | SET | iRebound | dRebound |
|---|---|---|---|---|---|---|---|---|
| | | | feet | inches | inches | inches | inches | inches |
| 1 | 9/19/18 | 9:44:05 | 71 | 1.63 | 1.52 | 0.12 | 1.51 | 0.11 |
| 2 | 9/19/18 | 9:44:06 | 71.01 | 1.62 | 1.51 | 0.11 | 1.51 | 0.11 |
| 3 | 9/19/18 | 9:44:08 | 71.02 | 1.63 | 1.52 | 0.11 | 1.52 | 0.11 |
| 4 | 9/19/18 | 9:44:09 | 71.03 | 1.59 | 1.47 | 0.11 | 1.48 | 0.12 |
| 5 | 9/19/18 | 9:44:10 | 71.04 | 1.58 | 1.46 | 0.11 | 1.47 | 0.12 |
| 6 | 9/19/18 | 9:44:12 | 71.05 | 1.63 | 1.51 | 0.11 | 1.52 | 0.12 |
| 7 | 9/19/18 | 9:44:13 | 71.05 | 1.53 | 1.42 | 0.11 | 1.42 | 0.11 |
| 8 | 9/19/18 | 9:44:15 | 71.06 | 1.62 | 1.5 | 0.11 | 1.51 | 0.12 |
| 9 | 9/19/18 | 9:44:16 | 71.07 | 1.62 | 1.5 | 0.11 | 1.51 | 0.12 |
| 10 | 9/19/18 | 9:44:18 | 71.08 | 1.52 | 1.41 | 0.11 | 1.41 | 0.11 |
| 11 | 9/19/18 | 9:44:19 | 71.09 | 1.58 | 1.46 | 0.11 | 1.47 | 0.12 |
| 12 | 9/19/18 | 9:44:20 | 71.1 | 1.63 | 1.51 | 0.11 | 1.52 | 0.12 |
| 13 | 9/19/18 | 9:44:22 | 71.11 | 1.55 | 1.44 | 0.11 | 1.44 | 0.11 |
| 14 | 9/19/18 | 9:44:23 | 71.12 | 1.6 | 1.49 | 0.11 | 1.49 | 0.11 |
| 15 | 9/19/18 | 9:44:25 | 71.13 | 1.57 | 1.45 | 0.11 | 1.46 | 0.12 |
| 16 | 9/19/18 | 9:44:26 | 71.14 | 1.54 | 1.43 | 0.11 | 1.43 | 0.11 |
| 17 | 9/19/18 | 9:44:27 | 71.14 | 1.55 | 1.44 | 0.11 | 1.44 | 0.11 |
| 18 | 9/19/18 | 9:44:29 | 71.15 | 1.57 | 1.45 | 0.11 | 1.46 | 0.12 |
| 19 | 9/19/18 | 9:44:30 | 71.16 | 1.61 | 1.49 | 0.11 | 1.5 | 0.12 |
| 20 | 9/19/18 | 9:44:32 | 71.17 | 1.53 | 1.42 | 0.11 | 1.42 | 0.11 |
| | | | Mean | 1.5850 | 1.4700 | 0.1105 | 1.4745 | 0.1150 |
| | | | Std Dev | 0.0373 | 0.0356 | 0.0022 | 0.0368 | 0.0050 |
| | | | Std Error | 0.0084 | 0.0080 | 0.0005 | 0.0082 | 0.0011 |

Table 6-26 PDA Statistical Data Summary from all 121 Hammer Blows between 71- and 72-feet

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | 1.5636 | 1.4428 | 0.1101 | 1.4535 | 0.1208 |
| | | | Std Dev | 0.0426 | 0.0423 | 0.0009 | 0.0425 | 0.0063 |
| | | | Std Error | 0.0040 | 0.0040 | 0.0001 | 0.0040 | 0.0006 |

Table 6-25 and Table 6-26 indicate that high rebound occurs. CMS data indicates approximately 1 inch or rebound occurs, but PDA data indicates about 1.5 inch of rebound occurs. Sets from both devices are similar at about 0.1 inches. Rebounds between ¾ and 1 inch were visually noted by the research team. The inspectors log only notes high rebound experienced between ¼ and ½ inch and that it continued throughout driving until refusal.

One variable that is not included in this comparison is the actual distance between pile markings, which may not be precisely 12 inches. Sets of 0.11 inches corresponds to 9 blows per foot, which is relatively low. If the markings are off or the size of the paint dot or line varies lower or higher blows could result. However, with DMX values of 1.5 to 1.6 inches, the blow count would have had to be 2 per foot to match the CMS rebounds. This value is much too low and therefore, the paint marking error could not have been the sole reason for the discrepancies. A second possible reason is that the pile was moving longer than the PDA software data collection time (i.e. timestamp). If this occurs DFN would be too high and produce smaller dRebound (digital based rebounds). These discrepancies need further analyses using PDA and CMS data from FDOT test piles.

Table 6-28 and Table 6-28 are the CMS and PDA summaries for the 74-ft-depth. Table 6-29 is the statistical mean, standard deviation and standard errors when all 124 blows are considered. These data are similar to those presented at the 71-ft-depth. They also show larger PDA rebounds (1.5 inches) than CMS rebounds (1.0 inches).

Table 6-30 and Table 6-31 are the CMS and PDA summaries for the 75-ft-depth. Table 6-31 is the data from the first 20 blows at this depth and allow a direct comparison between CMS and PDA results. Table 6-32 the statistical mean, standard deviation and standard errors when all 169 blows are considered. These data are similar to those presented at the 71-ft depth. They also show larger PDA rebounds (1.5 inches) than CMS rebounds (1.0 inches).

Table 6-27 CMS Dunns Creek Data Summary from 74-foot depth

| Blows | Cumulative Displacement (inches) | Max Displacement (inches) | Rebound (inches) | Set (inches) |
|---|---|---|---|---|
| 1 | N/A | N/A | 1.12 | N/A |
| 2 | 1.06 | 1.16 | 1.07 | 0.08 |
| 3 | 1.14 | 1.02 | 0.86 | 0.16 |
| 4 | 1.3 | 0.95 | 0.98 | -0.03 |
| 5 | 1.27 | 1.22 | 1.06 | 0.16 |
| 6 | 1.43 | 1.15 | 1.05 | 0.1 |
| 7 | 1.53 | 1.16 | 1.04 | 0.12 |
| 8 | 1.65 | 1.24 | 1.1 | 0.14 |
| 9 | 1.79 | 1.21 | 1.1 | 0.11 |
| 10 | 1.9 | 1.13 | 1.04 | 0.09 |
| 11 | 1.99 | 1.11 | 0.98 | 0.12 |
| 12 | 2.11 | 1.15 | 1.02 | 0.13 |
| 13 | 2.24 | 1.23 | 1.14 | 0.1 |
| 14 | 2.34 | 1.26 | 1.13 | 0.13 |
| 15 | 2.47 | 1.24 | 1.15 | 0.09 |
| 16 | 2.56 | 1.26 | 1.1 | 0.16 |
| 17 | 2.72 | 1.12 | 1.06 | 0.06 |
| 18 | 2.78 | 1.2 | 1.06 | 0.14 |
| 19 | 2.92 | 1.2 | N/A | N/A |
| Mean | 1.9556 | 1.1672 | 1.0589 | 0.1094 |
| Std Dev | 0.5786 | 0.0799 | 0.0680 | 0.0449 |
| Std Error | 0.1364 | 0.0188 | 0.0160 | 0.0109 |

Table 6-28 PDA Dunns Creek Summary from the Initial 20 Hammer Blows between 74- and 75-feet

| Blows | Date | Time | LP | DMX | DFN | SET | iRebound | dRebound |
|---|---|---|---|---|---|---|---|---|
| | | | feet | inches | inches | inches | inches | inches |
| 1 | 9/19/18 | 10:20:02 | 74 | 1.51 | 1.37 | 0.06 | 1.45 | 0.14 |
| 2 | 9/19/18 | 10:20:03 | 74.01 | 1.54 | 1.42 | 0.1 | 1.44 | 0.12 |
| 3 | 9/19/18 | 10:20:04 | 74.02 | 1.51 | 1.38 | 0.1 | 1.41 | 0.13 |
| 4 | 9/19/18 | 10:20:06 | 74.02 | 1.52 | 1.4 | 0.1 | 1.42 | 0.12 |
| 5 | 9/19/18 | 10:20:07 | 74.03 | 1.58 | 1.46 | 0.1 | 1.48 | 0.12 |
| 6 | 9/19/18 | 10:20:09 | 74.04 | 1.56 | 1.46 | 0.1 | 1.46 | 0.1 |
| 7 | 9/19/18 | 10:20:10 | 74.05 | 1.56 | 1.44 | 0.1 | 1.46 | 0.12 |
| 8 | 9/19/18 | 10:20:12 | 74.06 | 1.56 | 1.43 | 0.1 | 1.46 | 0.13 |
| 9 | 9/19/18 | 10:20:13 | 74.07 | 1.59 | 1.45 | 0.1 | 1.49 | 0.14 |
| 10 | 9/19/18 | 10:20:15 | 74.07 | 1.56 | 1.43 | 0.1 | 1.46 | 0.13 |
| 11 | 9/19/18 | 10:20:16 | 74.08 | 1.52 | 1.41 | 0.1 | 1.42 | 0.11 |
| 12 | 9/19/18 | 10:20:18 | 74.09 | 1.53 | 1.41 | 0.1 | 1.43 | 0.12 |
| 13 | 9/19/18 | 10:20:19 | 74.1 | 1.54 | 1.41 | 0.1 | 1.44 | 0.13 |
| 14 | 9/19/18 | 10:20:21 | 74.11 | 1.56 | 1.45 | 0.1 | 1.46 | 0.11 |
| 15 | 9/19/18 | 10:20:22 | 74.11 | 1.56 | 1.42 | 0.1 | 1.46 | 0.14 |
| 16 | 9/19/18 | 10:20:24 | 74.12 | 1.55 | 1.42 | 0.1 | 1.45 | 0.13 |
| 17 | 9/19/18 | 10:20:25 | 74.13 | 1.51 | 1.36 | 0.1 | 1.41 | 0.15 |
| 18 | 9/19/18 | 10:20:27 | 74.14 | 1.56 | 1.42 | 0.1 | 1.46 | 0.14 |
| 19 | 9/19/18 | 10:20:28 | 74.15 | 1.53 | 1.42 | 0.1 | 1.43 | 0.11 |
| 20 | 9/19/18 | 10:20:30 | 74.15 | 1.54 | 1.41 | 0.1 | 1.44 | 0.13 |
| | | | Mean | 1.5445 | 1.4185 | 0.0980 | 1.4465 | 0.1260 |
| | | | Std Dev | 0.0227 | 0.0265 | 0.0087 | 0.0213 | 0.0124 |
| | | | Std Error | 0.0051 | 0.0059 | 0.0019 | 0.0048 | 0.0028 |

Table 6-29 PDA Statistical Summary from all 124 Hammer Blows Between 74- and 75-feet

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | 1.5415 | 1.4147 | 0.0997 | 1.4419 | 0.1269 |
| | | | Std Dev | 0.0258 | 0.0280 | 0.0036 | 0.0256 | 0.0125 |
| | | | Std Error | 0.0023 | 0.0025 | 0.0003 | 0.0023 | 0.0011 |

Table 6-30 CMS Dunns Creek Data Summary from 75-foot depth

| Blows | Cumulative Displacement (inches) | Max Displacement (inches) | Rebound (inches) | Set (inches) |
|---|---|---|---|---|
| 1 | N/A | N/A | 0.91 | N/A |
| 2 | 0.68 | 0.99 | 0.94 | 0.05 |
| 3 | 0.73 | 0.94 | 0.85 | 0.09 |
| 4 | 0.82 | 1 | 0.91 | 0.08 |
| 5 | 0.9 | 1 | 0.9 | 0.1 |
| 6 | 1 | 0.95 | 0.9 | 0.06 |
| 7 | 1.06 | 0.99 | 0.93 | 0.06 |
| 8 | 1.12 | 1.01 | 0.89 | 0.11 |
| 9 | 1.23 | 1 | 0.92 | 0.08 |
| 10 | 1.31 | 0.97 | 0.91 | 0.06 |
| 11 | 1.37 | 0.96 | 0.87 | 0.1 |
| 12 | 1.47 | 1.01 | 0.9 | 0.1 |
| 13 | 1.57 | 1.01 | 0.92 | 0.09 |
| 14 | 1.66 | 1.01 | 0.94 | 0.07 |
| 15 | 1.73 | 1.01 | 0.92 | 0.08 |
| 16 | 1.81 | 1.04 | 0.93 | 0.11 |
| 17 | 1.92 | 0.99 | 0.93 | 0.07 |
| 18 | 1.99 | 0.94 | 0.86 | 0.08 |
| 19 | 2.07 | 0.98 | 0.9 | 0.08 |
| 20 | 2.15 | 0.98 | N/A | N/A |
| Mean | 1.3578 | 0.9889 | 0.9068 | 0.0817 |
| Std Dev | 0.4320 | 0.0266 | 0.0247 | 0.0174 |
| Std Error | 0.1018 | 0.0063 | 0.0057 | 0.0041 |

Table 6-31 PDA Dunns Creek Summary from the Initial 20 Hammer Blows between 75- and 76-feet

| Blows | Date | Time | LP | DMX | DFN | SET | iRebound | dRebound |
|---|---|---|---|---|---|---|---|---|
| | | | feet | inches | inches | inches | inches | inches |
| 1 | 9/19/18 | 10:23:03 | 75 | 1.53 | 1.39 | 0.1 | 1.43 | 0.14 |
| 2 | 9/19/18 | 10:23:05 | 75.01 | 1.54 | 1.41 | 0.07 | 1.47 | 0.13 |
| 3 | 9/19/18 | 10:23:06 | 75.01 | 1.54 | 1.41 | 0.07 | 1.47 | 0.13 |
| 4 | 9/19/18 | 10:23:08 | 75.02 | 1.53 | 1.41 | 0.07 | 1.46 | 0.12 |
| 5 | 9/19/18 | 10:23:09 | 75.02 | 1.55 | 1.42 | 0.07 | 1.48 | 0.13 |
| 6 | 9/19/18 | 10:23:11 | 75.03 | 1.55 | 1.42 | 0.07 | 1.48 | 0.13 |
| 7 | 9/19/18 | 10:23:12 | 75.04 | 1.56 | 1.45 | 0.07 | 1.49 | 0.11 |
| 8 | 9/19/18 | 10:23:14 | 75.04 | 1.53 | 1.43 | 0.07 | 1.46 | 0.1 |
| 9 | 9/19/18 | 10:23:15 | 75.05 | 1.55 | 1.42 | 0.07 | 1.48 | 0.13 |
| 10 | 9/19/18 | 10:23:17 | 75.05 | 1.52 | 1.42 | 0.07 | 1.45 | 0.1 |
| 11 | 9/19/18 | 10:23:18 | 75.06 | 1.59 | 1.46 | 0.07 | 1.52 | 0.13 |
| 12 | 9/19/18 | 10:23:20 | 75.07 | 1.54 | 1.41 | 0.07 | 1.47 | 0.13 |
| 13 | 9/19/18 | 10:23:21 | 75.07 | 1.55 | 1.42 | 0.07 | 1.48 | 0.13 |
| 14 | 9/19/18 | 10:23:23 | 75.08 | 1.61 | 1.48 | 0.07 | 1.54 | 0.13 |
| 15 | 9/19/18 | 10:23:24 | 75.08 | 1.62 | 1.49 | 0.07 | 1.55 | 0.13 |
| 16 | 9/19/18 | 10:23:26 | 75.09 | 1.56 | 1.44 | 0.07 | 1.49 | 0.12 |
| 17 | 9/19/18 | 10:23:27 | 75.1 | 1.56 | 1.45 | 0.07 | 1.49 | 0.11 |
| 18 | 9/19/18 | 10:23:29 | 75.1 | 1.52 | 1.39 | 0.07 | 1.45 | 0.13 |
| 19 | 9/19/18 | 10:23:30 | 75.11 | 1.55 | 1.42 | 0.07 | 1.48 | 0.13 |
| 20 | 9/19/18 | 10:23:32 | 75.11 | 1.55 | 1.44 | 0.07 | 1.48 | 0.11 |
| | | | Mean | 1.5525 | 1.4290 | 0.0715 | 1.4810 | 0.1235 |
| | | | Std Dev | 0.0261 | 0.0259 | 0.0065 | 0.0281 | 0.0111 |
| | | | Std Error | 0.0058 | 0.0058 | 0.0015 | 0.0063 | 0.0025 |

Table 6-32 PDA Statistical Summary from All 169 Hammer Blows Between 75- and 76-feet

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | 1.5267 | 1.4424 | 0.0702 | 1.4565 | 0.0843 |
| | | | Std Dev | 0.0618 | 0.0683 | 0.0023 | 0.0619 | 0.0281 |
| | | | Std Error | 0.0048 | 0.0053 | 0.0002 | 0.0048 | 0.0022 |

This set of PDA data also produces higher rebounds than the corresponding CMS data. As previously noted, the pile markings and the timestamp may be contributing factors. Sets of 0.07 inches corresponds to 14 blows per foot, which is still somewhat low.

In summary, all three sets of CMS-PDA comparisons at Dunns Creek were successful. DMX values were very similar, while CMS rebounds matched visual observations from the research team in all cases. PDA rebounds based on the inspector's sets were inconsistent, producing negative rebounds for very low blow counts (i.e. 5) and rebounds about ½-inch higher per blow than CMS rebounds and low blow counts (9-14). Additional testing must be competed to validate this work. Improvements in the pile marking process is also required to improve the results.

### 6.6.2.4 Ellis Road Test Pile Results

Figure 6-30 shows the video signal from 37 hammer blows recorded during the test pile installation at the Ellis Road site in Melbourne Florida. The pile tested was a production pile that was not instrumented to allow displacements to be determined. The camera video analysis is for recordings made at the 127-foot pile location. The pile was painted with orange paint and black tape was applied by the research team for CMS tracking. During the last 36 blows, 1.076 inches of pile penetration occurred or an average of 0.030-inches per blow. During the last few blows minimal set occurred. Driving stopped soon after this pile driving sequence. The cameras indicated higher ground vibrations than at the other sites. The prolonged vibrations can be seen as the continued up and down movements associated with each blow, which are not evident in the previous plots.

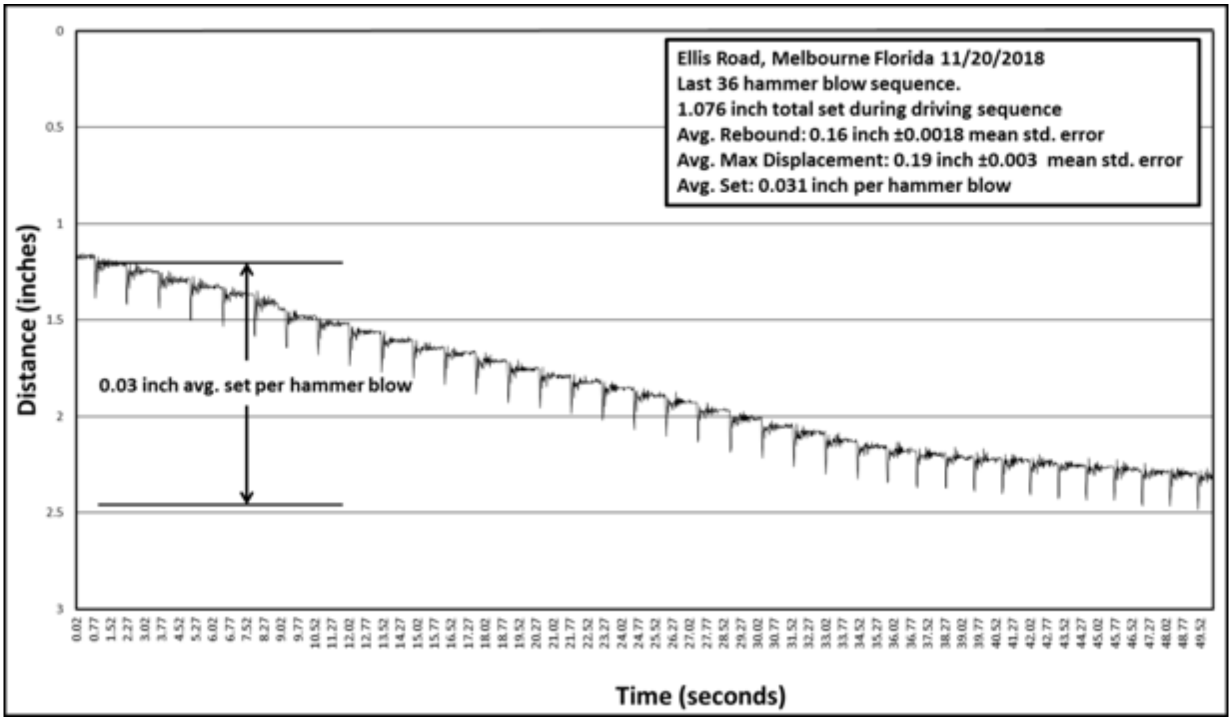

Figure 6-29 CMS results from Ellis Road, Melbourne Florida

### 6.6.2.5 SPT Rod Movement Evaluations

The research team investigated whether any trends from SPT rod movements may indicate that pile rebound would occur. Two high rebound sites (i.e. Dunns Creek and Wekiva Parkway) were investigated using FDOT's SMO drill rig and crew. SPT tests were conducted within the rebound soils at these sites using an automatic hammer.

### 6.6.2.6 Dunns Creek SPT Rod Movement Evaluation

SPT rod displacement time series data was obtained using a 60 Hz camera, from SPT testing between 65 and 67 feet at the Dunn Creek site. Figure 6-30 shows the vertical displacements from 20 SPT hammer blows each producing very large rebound during a total of 1.6 inches of rod penetration. This movement produces an average rod set per blow of 0.08 inches. Examination of the movements indicates that there is significant immediate rebound followed by a smaller time-dependent rebound occurring after each blow.

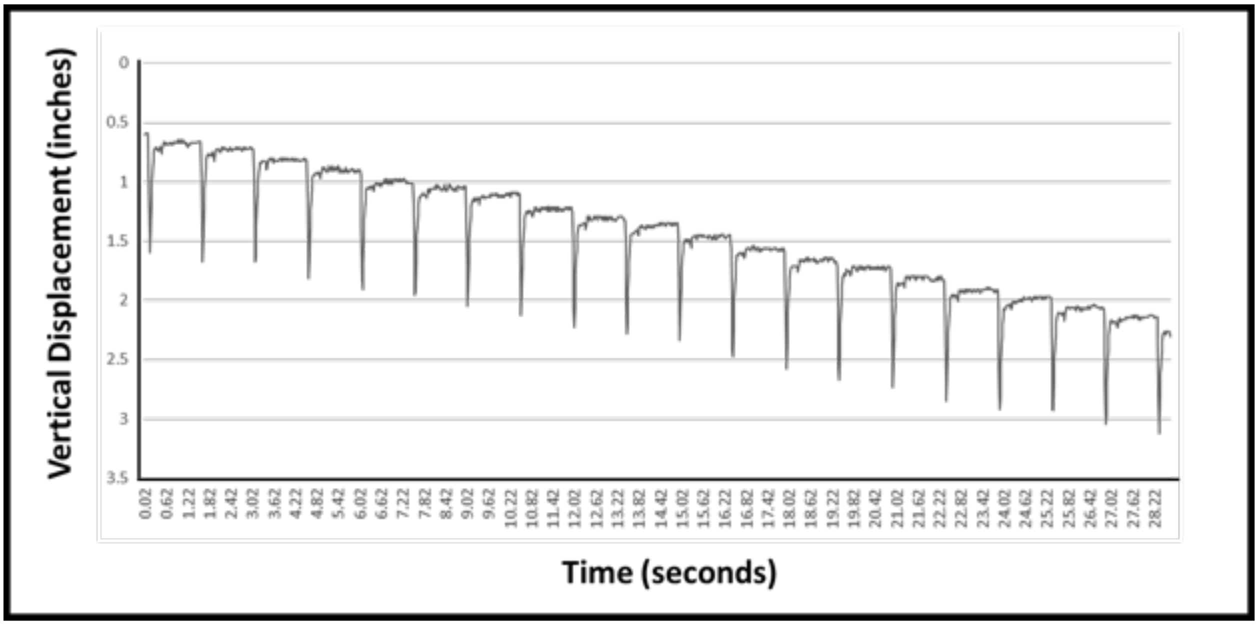


Figure 6-30 SPT Rod Movements from Dunns Creek

Figure 6-31 is an expanded view of six SPT hammer blows. During all six blows approximately 1 inch of rebound occurs followed by the upward time-dependent movements. A small circle was overlain on the first cycle, to highlight the time-dependent movement portion that followed the immediate rebound. During blow number three, 0.1 inches of time-dependent movement occurred after the immediate rebound of 0.85 inches. These SPT results clearly show the soil to have rebound characteristics. It was visually classified as a very fine silty sand with clay and shell fragments.

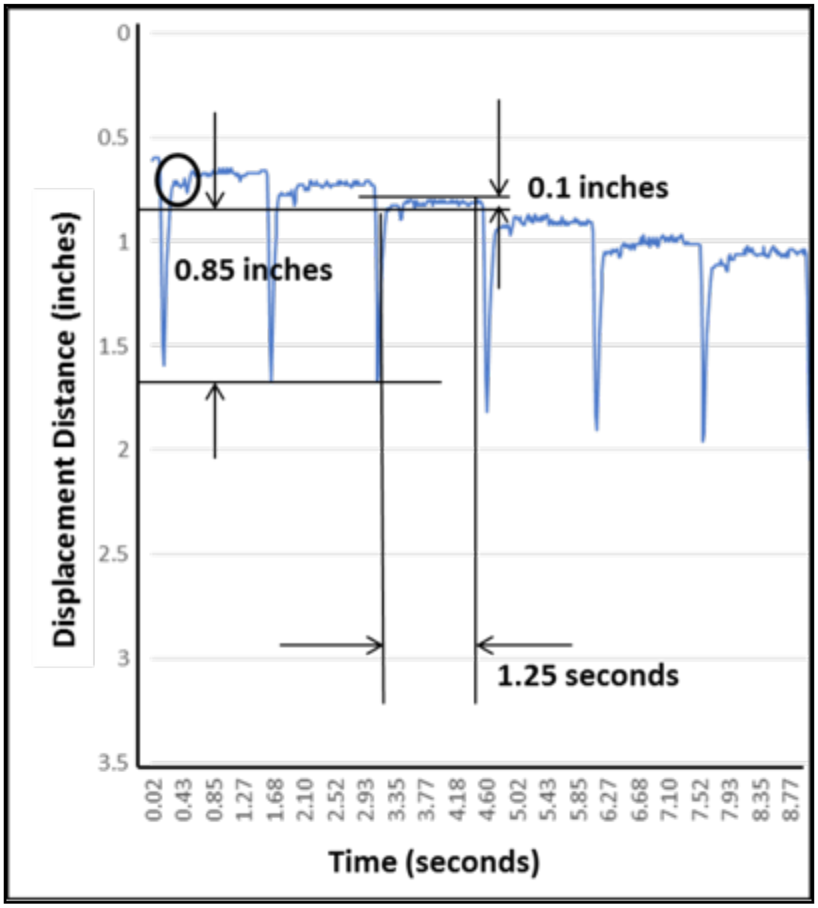


Figure 6-31 Expanded View of 6 Hammer Blows Showing SPT Time-Dependent Movements at Dunns Creek

### 6.6.3 CMS Rod Color and Tape Color Analysis

At both sites the SPT testing was performed in the soil near the concrete test pile driving locations in the spring of 2019. CMS testing was simultaneously conducted at both sites. These were the first attempts at using CMS for monitoring SPT rods. The SPT rods are typically quite dark compared to a concrete pile and some experimentation was necessary to help determine how to best monitor the rod driving process. As will be shown, the color of the rods is somewhat dependent upon the color of the drilling muds used.

Based upon the success of using back tape or a black paint line on the light gray concrete piles it was wrapped around the SPT rods at 6-inch intervals. As show in Figure 6-32, the black CMS tape and white PDM reflective tape were placed on the SPT rod at the Dunns Creek site.

Figure 6-32 Dunns Creek SPT Rods with White PDM Reflective Tape and Black CMS Tape

The rod driving process was monitored and it was determined that the contrast between the black tape and the dark SPT rod did not provide optimal contrast to be used in the future. The reflective tape was also used to track the rod movement; however, the PDM reflective tape was extremely difficult to use in the CMS system because the rod movements causes reflectivity changes due to scattering characteristics of the tape. In essence the tapes color changes when viewed by the camera due to the complexity of the reflective tape signal. The result was that the edge signal at the rod/tape interface was blurred because of the scattering characteristics of the reflective tape as shown in Figure 6-33. The detection of the edge of the tape is poor due to multiple scattering effects of the PDM tape, making the video imaging of this tape a poor choice when using the CMS. It was also determined that if black tape was used in the future, that it would be best to have just one black tape in a rod section and to have the black reflective tape and white tape overlapped as shown in a mockup in Figure 6-34.

Figure 6-33 Poor CMS Video Frame Zoomed Image of Reflective Tape

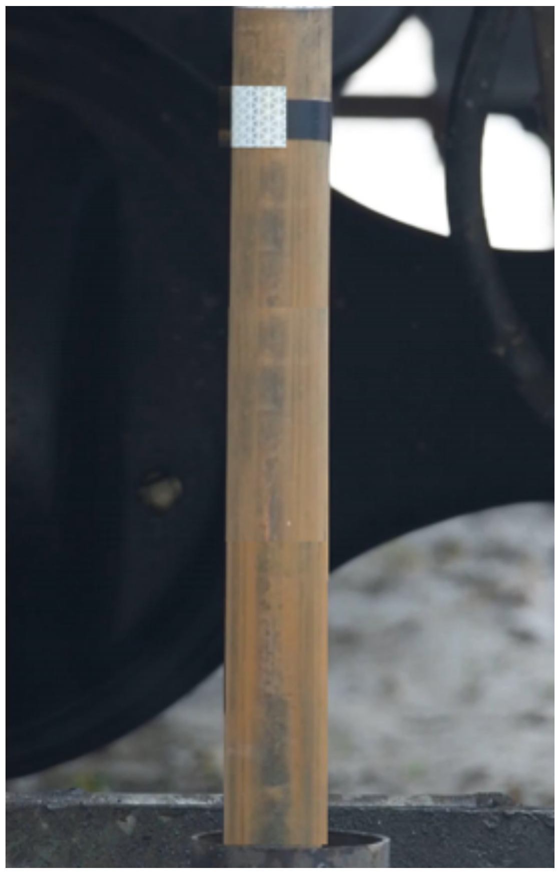

Figure 6-34 Proposed Reflective Tape and Black Tape Marking Layout for CMS and PDM Systems on SPT Rods

The method for marking the SPT rod as shown in Figure 6-34 may still be limited due to the low contrast between the black tape and the rod. However, the CMS system would allow monitoring of all blows during the 24-inch displacement sequence, whereas the PDM would only record the hits during the period the reflective tape passes between the two laser points (the PDM active area). Without the above approach, each black line can only be monitored using the CMS using a 6-inch region above the rod casing.

The monitoring of the SPT rod was also conducted at the Wekiva test site during the spring of 2019. In this CMS test, SPT rod video rebound measurements were made using the white PDM reflective tape and white chalk lines. Figure 6-35 shows the rod tape and white chalk markings for the PDM and CMS systems. From this testing it was found that the white reflective tape edge detection was still poor due to the multiple scattering behavior of the reflective tape similar to that shown in . However, the white chalk line or white electrical tape could provide excellent edge detection or contrast. The CMS system would produce excellent results, in future testing, if of only one chalk line or one standard white tape were placed into the region of interest as shown in Figure 6-36.

Figure 6-35 CMS and PDM Markings Used for Rod Displacement Monitoring at the Wekiva test site

Figure 6-36 Proposed SPT Rod Chalk Line and PDM Tape Placement (Left) or White Electrical Tape and PDM Reflective Tape Layout (Right)

Results from this testing suggests that the optimal marking of the SPT rod for CMS monitoring would be the use of one white chalk line or white electrical tape being placed alone or next to the PDM reflective tape as shown in Figure 6-36. The white tape layout as shown below (right) or the white tape and a simple chalk mark would allow optimal SPT rebound testing in future analyses.

At the Wekiva SPT test site the image processing of the video sequences were confounded by the presence of “flying debris” as shown by the white streaked lines in the video frame capture (see Figure 6-37). In essence, when the SPT blow occurred, dried drilling mud particles were broken loose and crossed the rod from one frame to another. These effective “white streaks” crossed the region of interest during the processing of the video frames and caused errors in the displacement calculations during a 24-inch rod driving sequence. These dried mud particles are observed in the snapshot shown in Figure 6-37. In order to deal with this problem will require further testing of the SPT displacement monitoring using the video camera system. One solution may be to use darker colored drilling muds.

Figure 6-37 Video Frame with White Streaks from Drilling Mud, from Wekiva CMS Tests

### 6.6.4 CMS Summary

An image processing approach, that incorporates full frame video frame rate recording images, was used to track the vertical displacements of both test piles and SPT rods during the installation process. The technique essentially tracks vertical movement of paint or tape interfaces placed on the piles or rods. Movements are automatically detected and traced using recording frequencies between 30 and 120 Hz and producing vertical movements to within a fraction of a mm. The image processing technique utilizes a unique automated feature detection solution technique, and requires no contact with the pile or structure being monitored. This technique allows the use of a static sensor (i.e., camera mounting) platform such as a tripod. The technique originally developed for detecting high resolution motion of small water surface gravity and capillary waves, has now been shown as useful for determining pile driving movements on various FDOT projects. The techniques and results have potential to be routinely used by construction safety inspectors and related personnel in need of pile driving displacement monitoring.

# 7 Conclusions and Recommendations

## 7.1 Conclusions

### 7.1.1 PDM Conclusions

At present, the PDM is producing erratic data when being used during continuous pile driving monitoring. The PDM is best suited to be used for short durations, such as pile capacity set checks, which allow the operator sufficient time to properly input the required information and check equipment operation before any testing can commence. If improved to adapt to continuous testing the PDM could serve as a useful tool for monitoring throughout the driving process. It is producing data for all SPT applications; however, the hammer impact and displacements are possibly affected by hammer bounce or time-dependent soil response.

PDM testing produced useful set and rebound results during continuous pile driving monitoring. However, due to the complex data required for input between PDM testing intervals and the continual tape movements during production driving, much of the testing resulted in unusable data. Of the 38 attempts at data acquisition, only 21 were successful at processing the blows recorded. When the data was useable, the results produced precise values for set and rebound that matched PDA and CMS results.

PDM testing produced useful results for SPT rod movements during driving for set and rebound. The data produced for rebound was unreliable as it more often than not showed negative values for rebound, which is not possible by definition. This error is likely due to the unique driving of the rods. The rods appear to have a distinct point where the displacement slows but then speeds back up. The PDM software was unsuccessful at processing this phenomenon.

Hammer blow to blow comparisons were complex since the PDM system does not provide information on the pile position during the laser PDM recording or analysis.

The PDM is designed to record measurements from a static start, making it difficult to use for continuous pile driving monitoring. For this reason, it produced more consistent movements from SPT test than piles. This limitation does not occur with CMS equipment.

PDM sets were within 8% of the CMS sets for both pile-driving and SPT testing. PDM rebounds were within 26% of the CMS rebounds for pile driving only. No comparisons were obtained between SPT PDM and CMS data because PDM rebounds were often negative.

When compared to the PDA the PDM was shown to produce values for set and rebound that were within 68% for pile driving. This data is only considering using the set and rebound calculated using inspector set. The values for DFN were inconsistent.

The lab tape tests indicated that the *Outdoor* tape produced the best results. The *Original* Inopiles tape produced the second-best results. The *3M* tape produced charts that improperly tracked blows. All three tapes worked similarly during field testing.

### 7.1.2 CMS Conclusions

The existing CMS equipment produced highly accurate displacement data at a 60 Hz sampling rate for all tests. It functioned during extreme conditions, including severe rain, and high temperatures (i.e. > 90º F) yielding displacements with accuracies to at least 0.004-inch (0.1 mm). The main limitations with this system are (1) it is not commercially available, (2) the data had to be processed in the lab after testing, (3) cameras can overheat on hot days and (4) video storage can be a concern if long videos are obtained during continuous driving. As with the PDM, CMS cameras must be set up such that the test pile markings are visible, however, it is not critical to set the lens directly in line (i.e. perpendicular to) with the pile. The cameras are reliable, and reasonably priced, especially considering that 60 Hz signals were used. Adding a rugged laptop with upgraded software will result in a reliable cost-effective system that will give personnel confidence in the data.

The high-speed camera methods worked best with either a black line sprayed on the concrete pile or a black tape. The tape occasionally fell off the pile during driving. CMS data was reduced to accurate pile or SPT rod movements in all situations.

When the hammer blows from CMS and PDM systems were compared, the displacements were similar. CMS videos always yielded pile movements.

The camera system provides a complete log of the pile driving record in both a visual as well as a time series signal. The PDM system relies upon a reflective tape being applied to the pile frequently falls off of the pile. The same problem can also occur when the camera system uses black tape applied to a pile.

Using white tape on the SPT rods produced erroneous CMS readings due to the scattering effects of the tape, which produces poor discrimination of the tape edge.

### 7.1.3 Cyclic Triaxial and Damping Coefficient Conclusions

For cyclic triaxial analysis, the viscous damping factors were successfully calculated from 40 CT tests from sites located in central and north Florida. The Python™ tool Jupyter Notebook Version 5.4.0 was crucial for the analysis of the 600,000 rows of data per test.

Due to a difference in units, the damping factors originally obtained from the stress-time analysis were not comparable to CASE's published data. When normalized, the resultant damping factors were two to five orders of magnitude higher than CASE's range.

The second approach, based on the viscous energy theory, produced damping coefficients were very similar to the CASE expected values and it is also dimensionless. Therefore, because of the similar range of results and units, the viscous energy approach is shown to be a better option of analysis, when compared to the stress-time relation.

CAPWAP® analyses produced reasonable shaft and toe damping coefficients. The toe coefficient, however, was more consistent than the shaft damping coefficient.

## 7.2 Recommendations

### 7.2.1 PDM Recommendations

The PDM needs to be further evaluated by FDOT SMO personnel using a group of pile driving projects throughout Florida. The following is a list of concerns.

- For effective monitoring, the placement and amount the reflective tape must be clarified, so that, (1) the proper width of the strips can be used, and (2) proper spacing of the strips relative to the PDM location are chosen.
- The required accuracy of the measured distance from the PDM to the pile must be evaluated to see if it affects the test data.

- PDM use in poor weather conditions needs evaluated since only one poor weather site was evaluated.  Heavy rainfall may prevent the infrared or active zone marking from being properly seen and detected by the system.
- The cause for poor data during good weather conditions also needs to be documented. Ellis Road had PDM testing from 50 to 122 feet with only 1-foot of useable data being produced.
- Extreme care must be taken to ensure that only 1 set of tape strips is within the PDM active zone.
- Monitoring blow numbers using PDM results is not clearly understood and causes concerns when comparing data to other measurement devices.
- The required input information must be checked to determine if information, such as stroke height, is critical to ensure the device works properly.

There are a number of improvements that would make the PDM more suitable for measuring pile movements during continuous pile driving monitoring. The biggest limitation is that the PDM does not produce results during continual driving. A recommended solution would be for the software to include an additional testing mode designed specifically for continuous monitoring. This upgrade should require the user to enter the elevations of the PDM active zones, the length of the pile, the as well as the locations of every reflective tape placed on the pile. Those inputs would allow the software to be programmed so that it can track exactly where the pile is in relation to the ground as each successive piece of tape enters the active zone. As a new piece of tape enters the active zone the software would automatically perform a signal test and begin data acquisition. As the tape leaves the active zone the software would stop acquisition and wait for the subsequent tape thus completely removes the need for the user to have to enter in the info for the upcoming test.

Using the PDM with SPT testing needs further study since negative rebound was interpreted with the PDM software in the soils tested. All the soils tested had produced pile rebound and the raw digital versus time signals may show a response that could be related to rebound or a second hammer bounce.

Other issues resulted from the PDM not being a device tailored for American use. The PDM software requires the devices date and time to be changed from *mm/dd/yyyy* to *dd/mm/yyyy* in order to review any of the data. The software could be modified to accommodate the US standard. A less impactful issue is that the PDM and the tablet sent with it have charging cables set up for European and Australian outlets respectively. This difference required the use of adapters to use them in American outlets. Charging cables could be changed to accommodate American outlets.

Another limitation is in the hardware used in to run the PDM software. The tablet lacked the power to review data quickly and can take minutes to open just one test for review. During testing the tablet and the laptop lacked the power to seamlessly refresh the chart that showed live displacement over time or the blow count. Both devices were subject to getting hot while on site even when under shade. Both devices had screens that were to dim to be used comfortably in the field, even on max brightness. Both devices had trouble maintain battery life thought the course of a day in the field and often would need to be charged before the day was over. The best solution would be to use a ruggedized laptop to run the PDM software that has a more powerful CPU, a brighter screen, and a better resistance to heat, and a larger battery life.

### 7.2.2 CMS Recommendations

It is recommended that the CMS software collection process be upgraded and simplified. The upgrade should include a rugged field laptop with a high visibility screen, connected directly to the camera. This upgrade will allow instant storage of the videos. To simplify the processing, short duration videos should be recorded during critical pile driving portions. This step allows smaller files to be used and thereby will significantly speed up the image light intensity processing. The videos should be limited to about 30 seconds, so that the attached computer can quickly process the data to produce near real-time pile displacement information.

It is recommended that a black line sprayed on concrete piles or a black ½ or ¾ inch wide tape be used during CMS analysis of pile driving displacement, rebound and set.

It is recommended that a white electrical tape or white chalk be placed on the SPT rods during CMS analysis of driving displacement, rebound and set.

It is recommended that hammer blow numbers plus camera lens elevations be reported to enable comparisons between CMS and PDA results.

### 7.2.3 Signal Comparison Recommendations

To properly compare CMS and PDA data, hammer blow numbers must be matched to both devices. PDA data is recorded at the sensor locations and matched to template elevations, while CMS data is currently recorded at the tripod elevation, with visual confirmations of pile location based on pile foot markings. If hammer blow numbers are used for both devices data can be more readily compared.

A second recommendation is to require that the pile markings be standardized and if possible marked at the factory. A proposed mark-shape is shown below. The triangular point would help the inspector determine where to focus while recording the number of blows.

Figure 7-1 Proposed Standardized Pile Marking

To properly match PDM and PDA data it is recommended that set-checks be used. These 10 blow driving sequences allow time for the complex input needed for PDM testing to be completed prior to driving.

### 7.2.4 Cyclic Triaxial and Damping Coefficient Recommendations

Additional CAPWAP® data should be evaluated to see if more reliable trends can be developed. A minimum of 30 new blows should be added to the current 12 analyzed.

PDA parameters such as UN, SFT and SFT/EB0 did not relate to rebound and therefore should be avoided when attempting to understand how rebound relates to pile capacities.

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# Appendix List of Figures

# Appendix List of Tables

# Appendix A. PDM Data

## A.1. PDM Lab Testing Data

### A.1.1 Lab Testing - Ruler Driven into Loose Sand in 5-Gallon Bucket

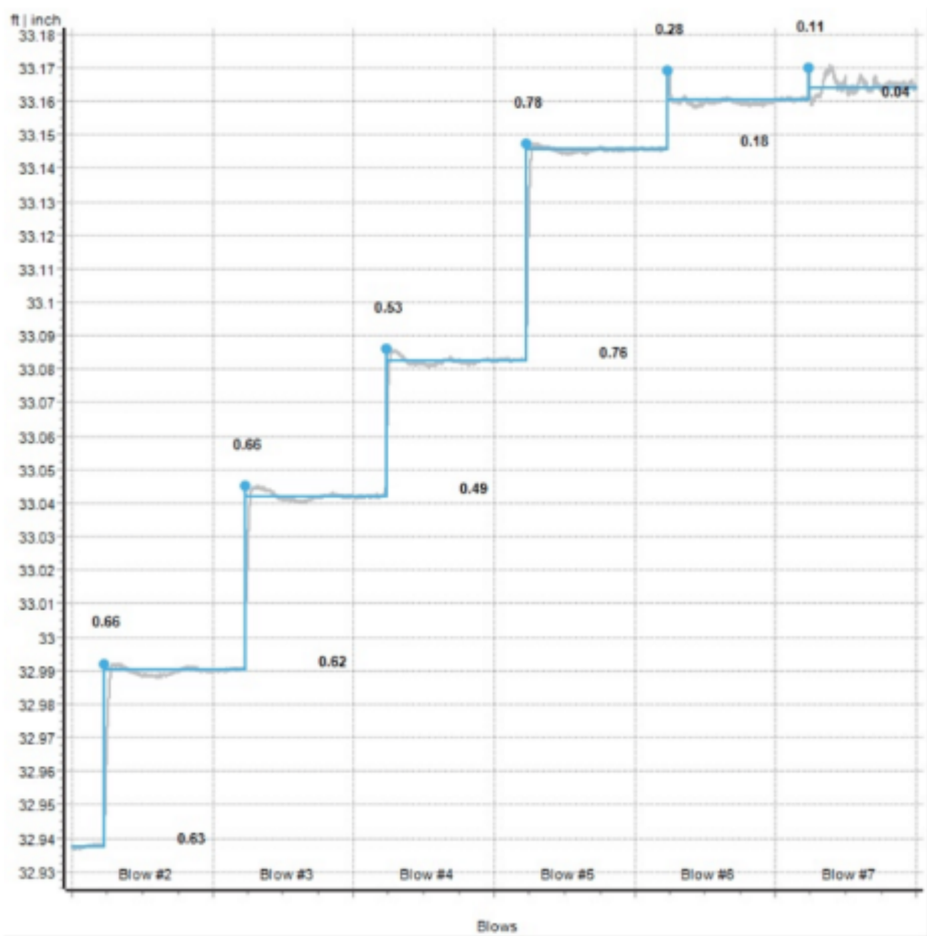
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 20:07:10 | 10.04 | 39.3 | 0.47 | 1.455 | 39.77 |
| 2 | 20:07:11 | 10.06 | 16.1 | 0.57 | 1.32 | 16.68 |
| 3 | 20:07:12 | 10.07 | 15.77 | 1 | 1.655 | 16.77 |
| 4 | 20:07:13 | 10.08 | 12.43 | 1 | 1.413 | 13.43 |
| 5 | 20:07:14 | 10.1 | 19.19 | 0.52 | 2.254 | 19.7 |
| 6 | 20:07:15 | 10.11 | 4.52 | 2.67 | 2.04 | 7.19 |
| 7 | 20:07:16 | 10.11 | 1.12 | 1.75 | 1.198 | 2.87 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 16/2/2019 |
| Client Name | | Report Time | 3:27:28 AM |
| Project Name | Test | Test Date | 9/8/2017 |
| Project Description | | Test Time | 8:06:59 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD | PDM Pile Offset (ft) | 17.323 |
| Pile Type | | Final Penetration at Blow 7 (ft) | 33.164 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Test | Test Date | 9/8/2017 |
| Project Description | | Pile Number | 2-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.45 | VMX (ft/s) | 5.403 |
| Rebound (inch) | 0.05 | DMX (inch) | 0.50 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 7 | 0.04 | 0.07 | 3.93 | 33.164 |
| 6 | 0.18 | 0.11 | 6.69 | 33.160 |
| 5 | 0.76 | 0.02 | 7.40 | 33.146 |
| 4 | 0.49 | 0.04 | 4.63 | 33.083 |
| 3 | 0.62 | 0.04 | 5.43 | 33.042 |
| 2 | 0.63 | 0.02 | 4.33 | 32.990 |

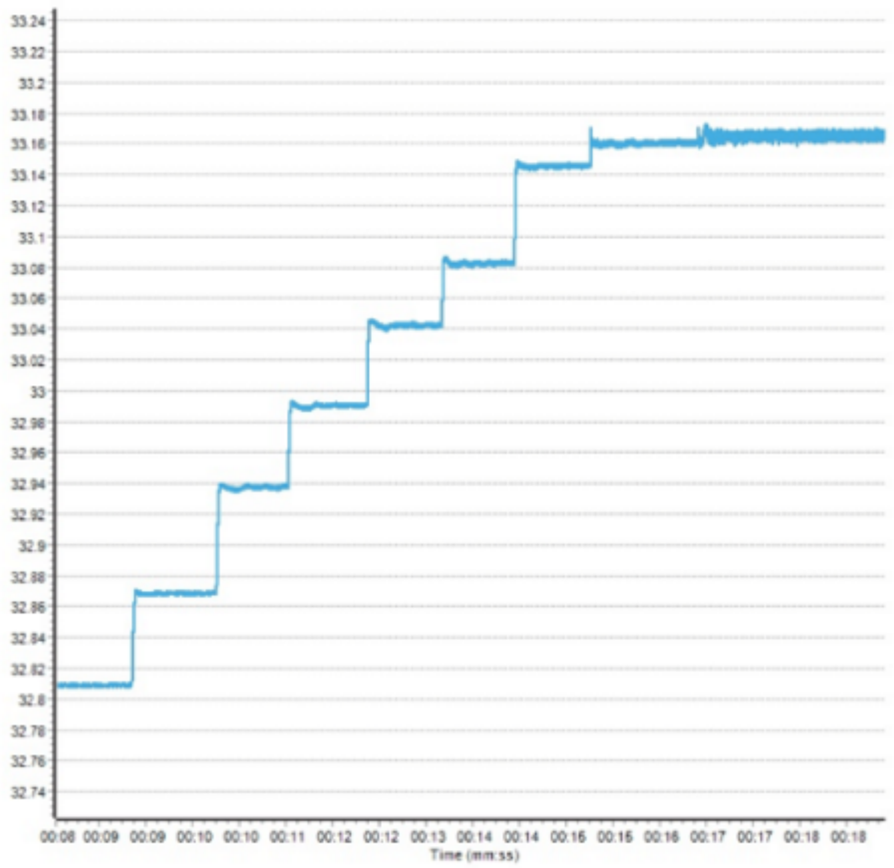
| | | |
|---|---|---|
| Average | 0.45 inch | 0.05 inch |
| Max Variation | 0.71 inch | 0.08 inch |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Test | Test Date | 9/8/2017 |
| Project Description | | Pile Number | 2-EOD |

## COMPLETE VIEW




Zoom out

Page 3 of 3

## A.1.2 3M and Outdoor Reflective Tape Testing

### A.1.2.1 3M Tape Results: Three Tests

**Trial 1 of 3**

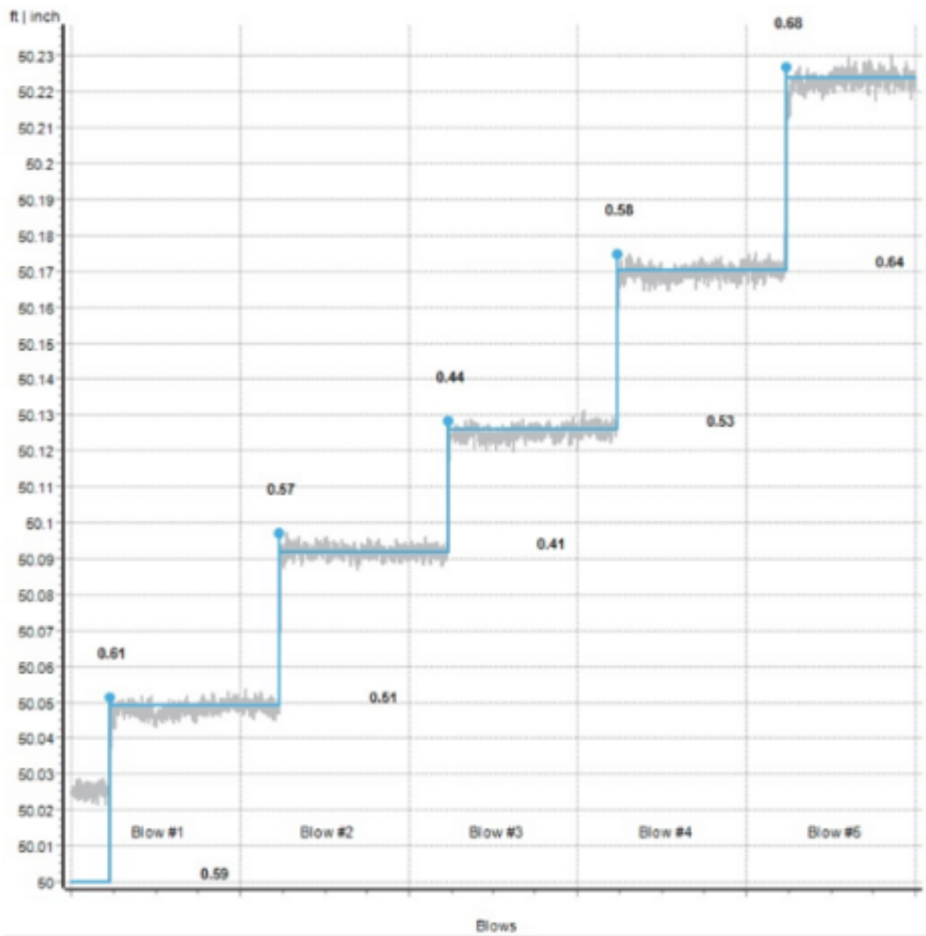
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 12:52:45 | 15.25 | 14.98 | 0.62 | 2.987 | 15.6 |
| 2 | 12:52:46 | 15.27 | 12.99 | 1.57 | 2.698 | 14.56 |
| 3 | 12:52:48 | 15.28 | 10.46 | 0.66 | 2.878 | 11.11 |
| 4 | 12:52:50 | 15.29 | 13.53 | 1.29 | 3.493 | 14.82 |
| 5 | 12:52:55 | 15.31 | 16.25 | 0.94 | 3.191 | 17.18 |
| 6 | 12:52:55 | 15.31 | 0.06 | 1.62 | 2.553 | 1.68 |
| 7 | 12:52:56 | 15.31 | -0.13 | 1.49 | 4.01 | 1.36 |
| 8 | 12:52:59 | 15.31 | -0.02 | 1.69 | 3.384 | 1.67 |
| 9 | 12:53:00 | 15.31 | 0.09 | 1.18 | 2.698 | 1.27 |
| 10 | 12:53:01 | 15.31 | -0.11 | 1.24 | 2.613 | 1.13 |
| 11 | 12:53:02 | 15.31 | 0.19 | 2.01 | 3.24 | 2.21 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 16/2/2019 |
| Client Name | | Report Time | 3:36:46 AM |
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Test Time | 12:52:31 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD | PDM Pile Offset (ft) | 29.500 |
| Pile Type | | Final Penetration at Blow 5 (ft) | 50.224 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcyloidtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 1-EOD |

NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.54 | VMX (ft/s) | 10.004 |
| Rebound (inch) | 0.04 | DMX (inch) | 0.58 |
| Capacity (kip) | - | | |

TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 5 | 0.64 | 0.04 | 10.47 | 50.224 |
| 4 | 0.53 | 0.05 | 11.46 | 50.170 |
| 3 | 0.41 | 0.03 | 9.44 | 50.126 |
| 2 | 0.51 | 0.06 | 8.85 | 50.092 |
| 1 | 0.59 | 0.02 | 9.80 | 50.049 |

| | | |
|---|---|---|
| Average | 0.54 inch | 0.04 inch |
| Max Variation | 0.23 inch | 0.04 inch |

Page 2 of 3

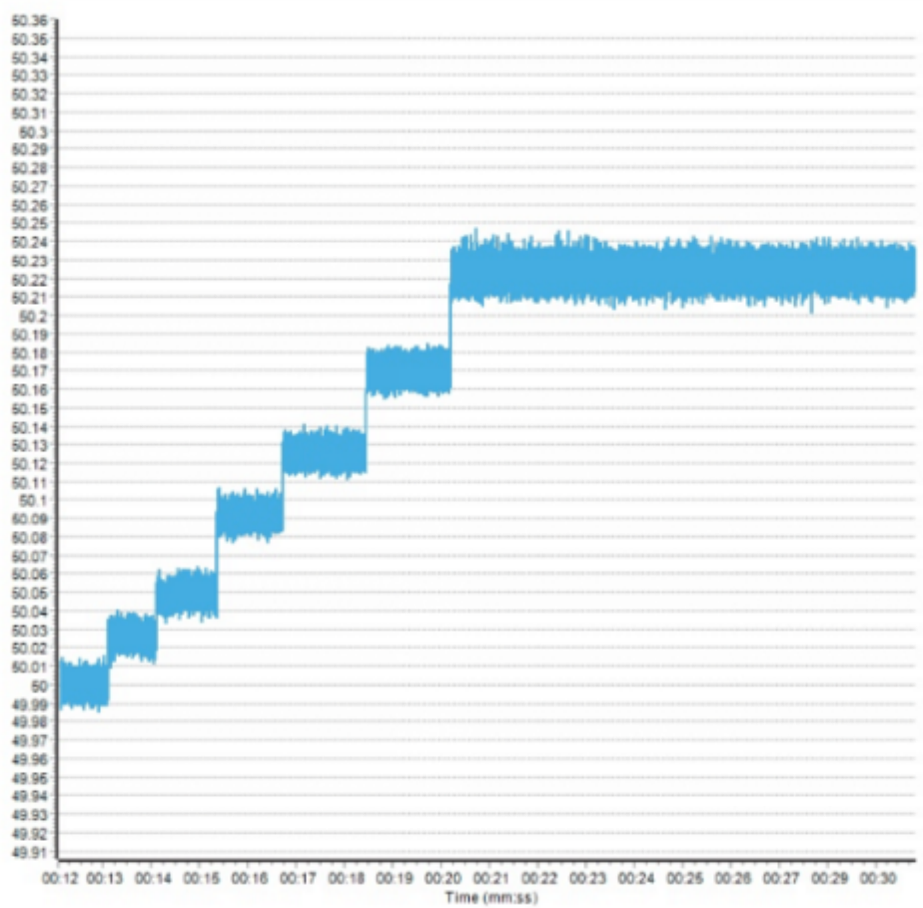
# PILE DRIVING MONITOR

FDOT

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 1-EOD |

COMPLETE VIEW




Page 3 of 3

**Trial 2 of 3**

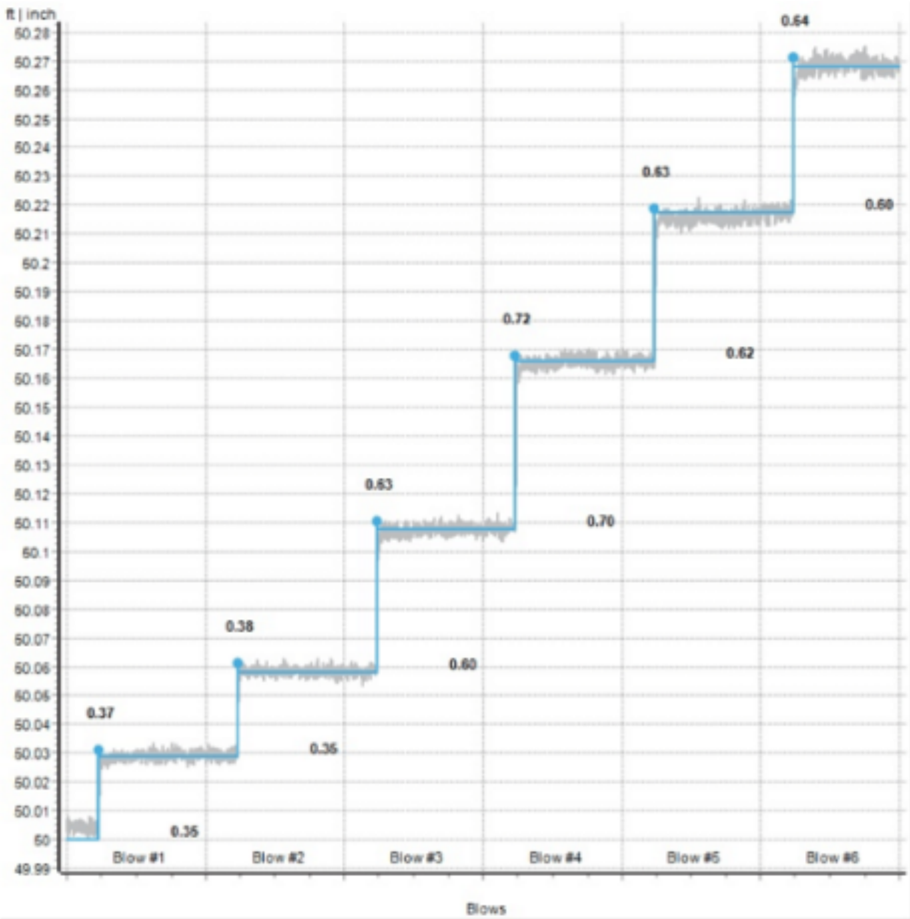
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 12:57:41 | 15.25 | 8.84 | 0.59 | 2.734 | 9.43 |
| 2 | 12:57:43 | 15.26 | 8.82 | 0.94 | 2.649 | 9.76 |
| 3 | 12:57:44 | 15.27 | 15.18 | 0.84 | 3.432 | 16.03 |
| 4 | 12:57:46 | 15.29 | 17.79 | 0.52 | 3.408 | 18.3 |
| 5 | 12:57:49 | 15.31 | 15.72 | 0.36 | 3.252 | 16.08 |
| 6 | 12:57:54 | 15.32 | 15.32 | 1.01 | 3.396 | 16.33 |
| 7 | 12:57:55 | 15.32 | 0.6 | 1.47 | 3.107 | 2.07 |
| 8 | 12:57:55 | 15.3 | -17.71 | 19.08 | 2.806 | 1.37 |
| 9 | 12:57:55 | 15.32 | 17.74 | -8.5 | 23.436 | 9.24 |
| 10 | 12:57:56 | 15.32 | -0.08 | 2.15 | 3.673 | 2.07 |
| 11 | 12:57:56 | 15.32 | -0.04 | 2.07 | 3.252 | 2.03 |
| 12 | 12:57:58 | 15.32 | 0.15 | 1.76 | 4.287 | 1.91 |
| 13 | 12:58:00 | 15.32 | -0.32 | 1.79 | 4.793 | 1.48 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 16/2/2019 |
| Client Name | | Report Time | 3:33:56 AM |
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Test Time | 12:57:30 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD | PDM Pile Offset (ft) | 29.500 |
| Pile Type | | Final Penetration at Blow 6 (ft) | 50.268 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 2-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.54 | VMX (ft/s) | 10.319 |
| Rebound (inch) | 0.03 | DMX (inch) | 0.56 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 6 | 0.60 | 0.04 | 11.14 | 50.268 |
| 5 | 0.62 | 0.01 | 10.67 | 50.218 |
| 4 | 0.70 | 0.02 | 11.18 | 50.166 |
| 3 | 0.60 | 0.03 | 11.26 | 50.108 |
| 2 | 0.35 | 0.04 | 8.69 | 50.058 |
| 1 | 0.35 | 0.02 | 8.97 | 50.029 |

| | | |
|---|---|---|
| Average | 0.54 inch | 0.03 inch |
| Max Variation | 0.35 inch | 0.03 inch |

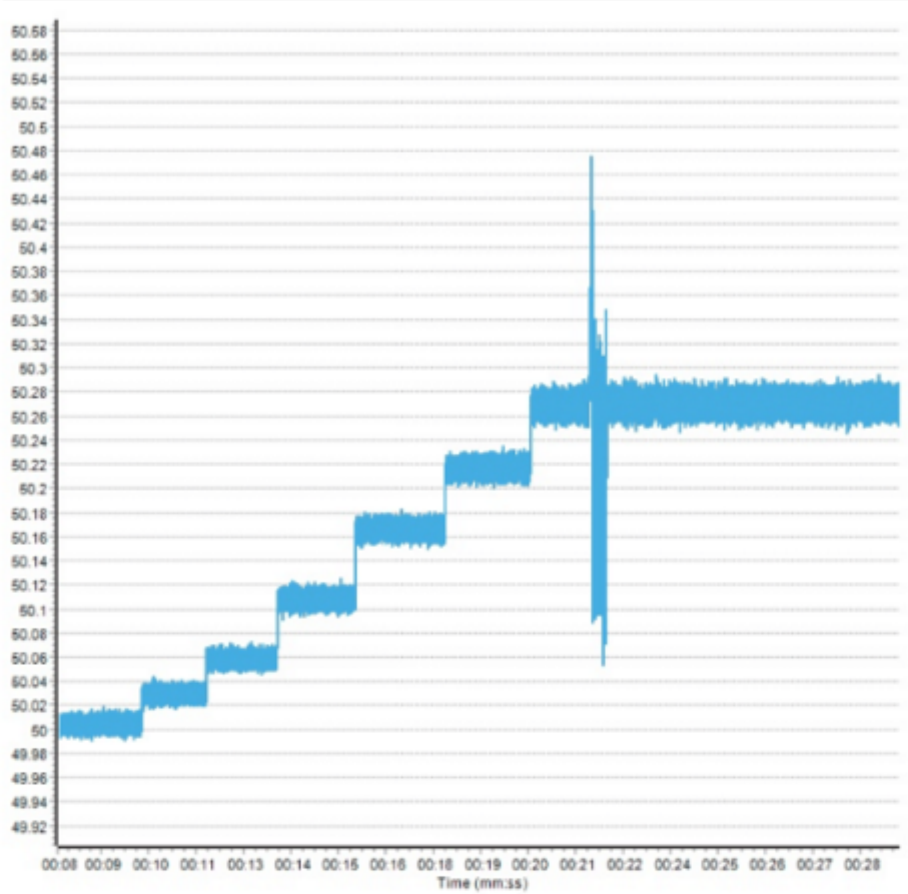
Page 2 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 2-EOD |

## COMPLETE VIEW




Page 3 of 3

**Trial 3 of 3**

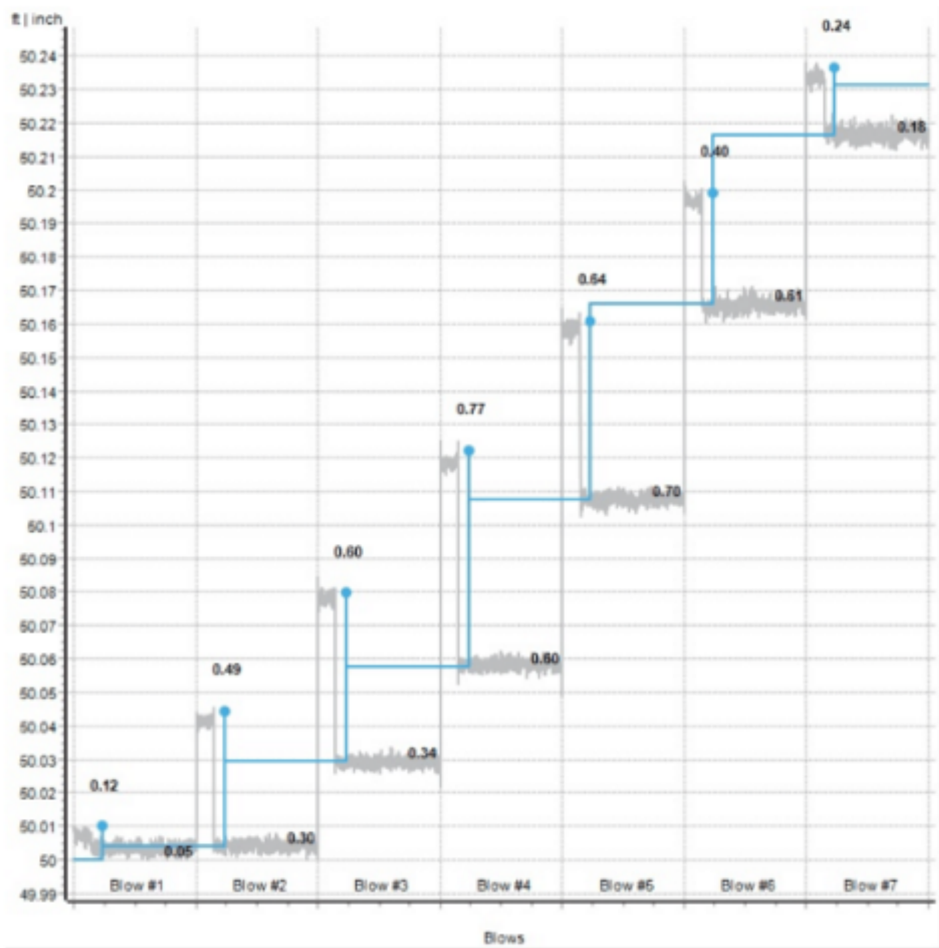
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:00:50 | 15.24 | 1.21 | 1.8 | 2.505 | 3.01 |
| 2 | 13:00:51 | 15.25 | 7.73 | 4.62 | 2.445 | 12.35 |
| 3 | 13:00:53 | 15.26 | 8.66 | 6.65 | 2.71 | 15.31 |
| 4 | 13:00:55 | 15.27 | 15.17 | 4.43 | 2.999 | 19.6 |
| 5 | 13:00:57 | 15.29 | 17.77 | -1.54 | 2.541 | 16.23 |
| 6 | 13:00:59 | 15.31 | 15.42 | -5.28 | 3.035 | 10.13 |
| 7 | 13:01:01 | 15.31 | 4.55 | 1.6 | 2.926 | 6.15 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 16/2/2019 |
| Client Name | | Report Time | 3:31:32 AM |
| Project Name | Labcyloidtap | Test Date | 10/2/2019 |
| Project Description | | Test Time | 1:00:42 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 3-EOD | PDM Pile Offset (ft) | 29.500 |
| Pile Type | | Final Penetration at Blow 7 (ft) | 50.231 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 3-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.40 | VMX (ft/s) | 8.980 |
| Rebound (inch) | 0.07 | DMX (inch) | 0.47 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 7 | 0.18 | 0.06 | 9.60 | 50.231 |
| 6 | 0.61 | -0.21 | 9.96 | 50.216 |
| 5 | 0.70 | -0.06 | 8.34 | 50.166 |
| 4 | 0.60 | 0.17 | 9.84 | 50.108 |
| 3 | 0.34 | 0.26 | 8.89 | 50.058 |
| 2 | 0.30 | 0.18 | 8.02 | 50.029 |
| 1 | 0.05 | 0.07 | 8.22 | 50.004 |

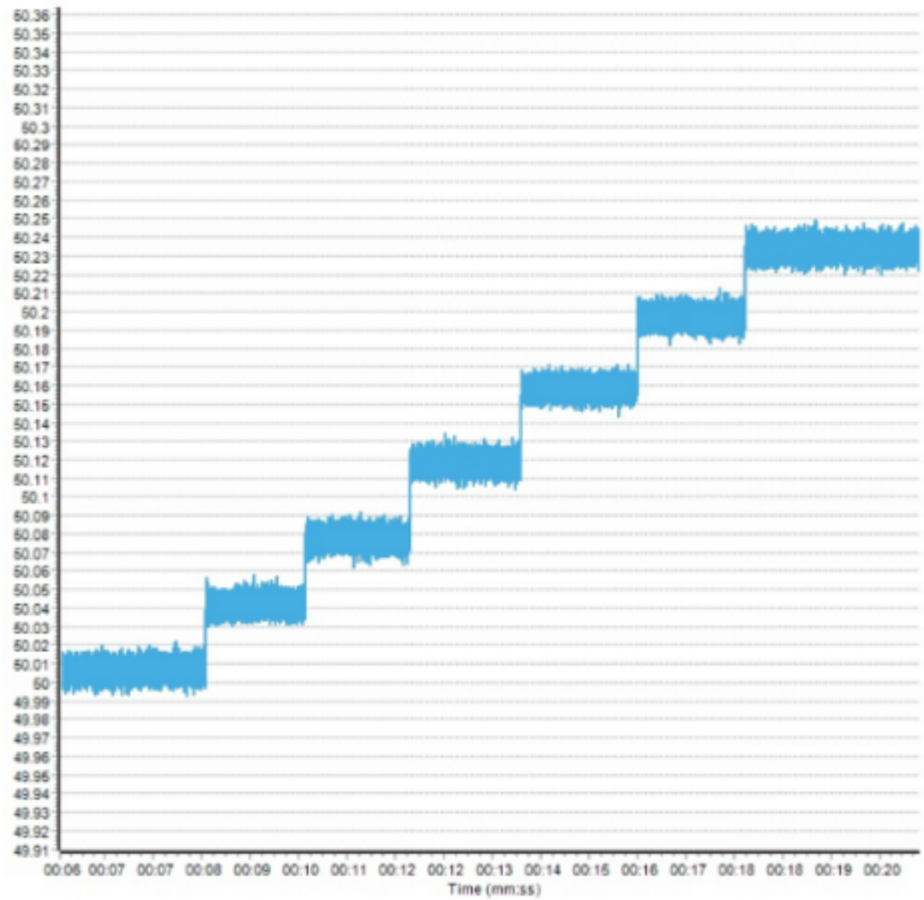
| | | |
|---|---|---|
| Average | 0.40 inch | 0.07 inch |
| Max Variation | 0.65 inch | 0.47 inch |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcyloldtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 3-EOD |

## COMPLETE VIEW



### A.1.2.2 Outdoor Tape Results: Three Tests

**Trial 1 of 3**

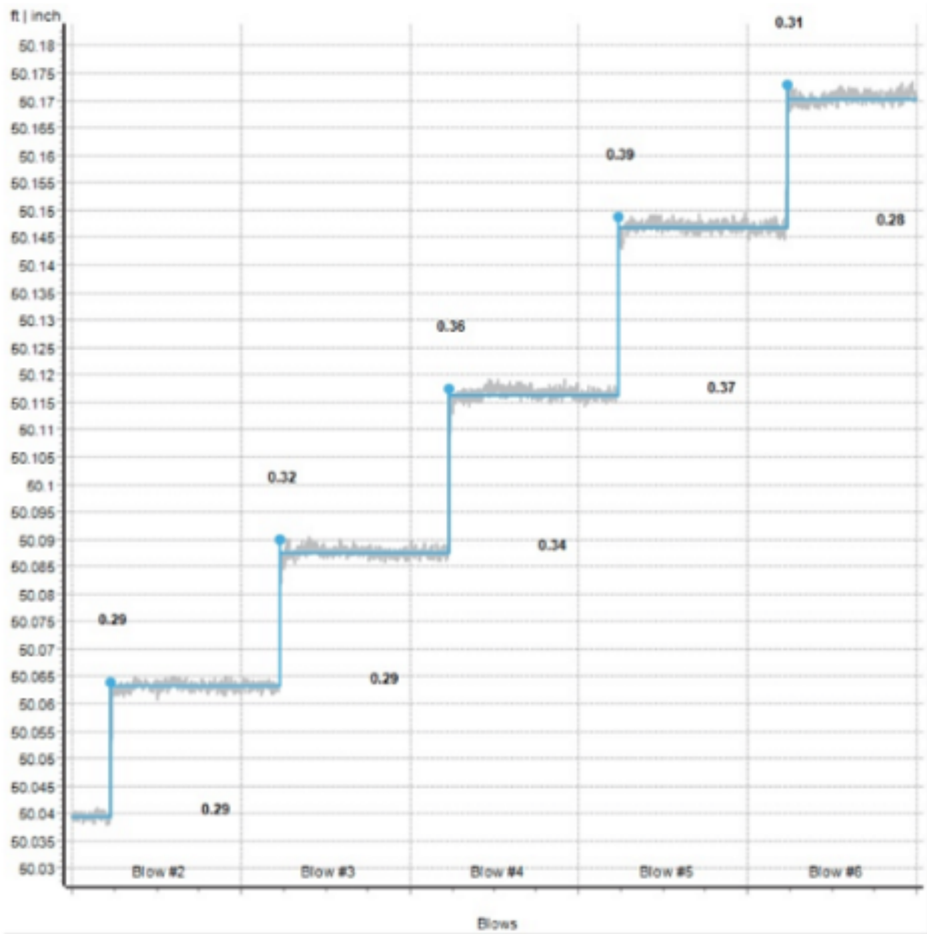
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 12:42:17 | 15.25 | 12.02 | 0.56 | 1.638 | 12.58 |
| 2 | 12:42:17 | 15.26 | 7.25 | 0.22 | 1.879 | 7.47 |
| 3 | 12:42:18 | 15.27 | 7.41 | 0.74 | 1.65 | 8.15 |
| 4 | 12:42:20 | 15.28 | 8.72 | 0.35 | 1.794 | 9.07 |
| 5 | 12:42:22 | 15.28 | 9.32 | 0.6 | 2.3 | 9.92 |
| 6 | 12:42:24 | 15.29 | 7.11 | 0.83 | 1.999 | 7.94 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 16/2/2019 |
| Client Name | | Report Time | 3:40:10 AM |
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Test Time | 12:41:53 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD | PDM Pile Offset (ft) | 29.500 |
| Pile Type | | Final Penetration at Blow 6 (ft) | 50.170 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 1-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.31 | VMX (ft/s) | 6.314 |
| Rebound (inch) | 0.02 | DMX (inch) | 0.34 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 6 | 0.28 | 0.03 | 6.56 | 50.170 |
| 5 | 0.37 | 0.02 | 7.55 | 50.147 |
| 4 | 0.34 | 0.01 | 5.89 | 50.116 |
| 3 | 0.29 | 0.03 | 5.41 | 50.088 |
| 2 | 0.29 | 0.01 | 6.16 | 50.063 |

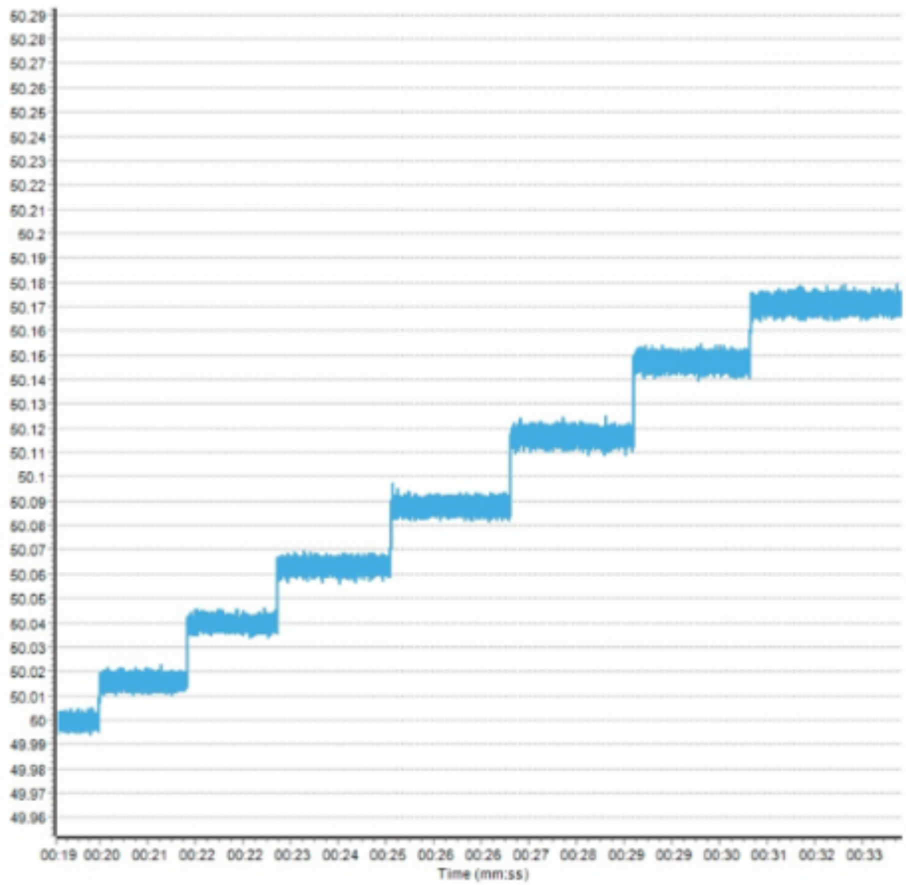
| | | |
|---|---|---|
| Average | 0.31 inch | 0.02 inch |
| Max Variation | 0.09 inch | 0.02 inch |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 1-EOD |

## COMPLETE VIEW



**Trial 2 of 3**

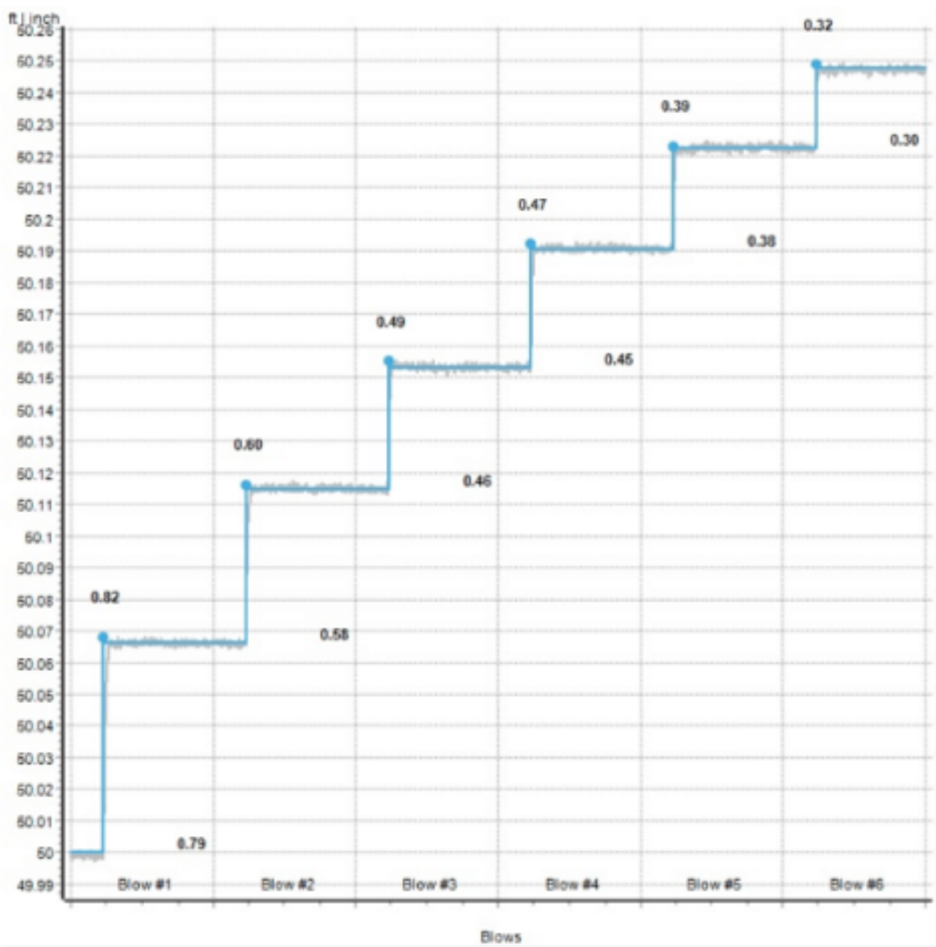
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:03:45 | 15.26 | 20.14 | 0.58 | 2.132 | 20.71 |
| 2 | 13:03:46 | 15.27 | 14.8 | 0.45 | 2.24 | 15.25 |
| 3 | 13:03:48 | 15.29 | 11.72 | 0.6 | 1.975 | 12.33 |
| 4 | 13:03:49 | 15.3 | 11.42 | 0.5 | 2.529 | 11.92 |
| 5 | 13:03:51 | 15.31 | 9.71 | 0.21 | 2.3 | 9.91 |
| 6 | 13:03:53 | 15.32 | 7.63 | 0.39 | 1.999 | 8.02 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 16/2/2019 |
| Client Name | | Report Time | 3:41:21 AM |
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Test Time | 1:03:36 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD | PDM Pile Offset (ft) | 29.500 |
| Pile Type | | Final Penetration at Blow 6 (ft) | 50.247 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 2-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.49 | VMX (ft/s) | 7.204 |
| Rebound (inch) | 0.02 | DMX (inch) | 0.51 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 6 | 0.30 | 0.02 | 6.56 | 50.247 |
| 5 | 0.38 | 0.01 | 7.55 | 50.222 |
| 4 | 0.45 | 0.02 | 8.30 | 50.191 |
| 3 | 0.46 | 0.02 | 6.48 | 50.153 |
| 2 | 0.58 | 0.02 | 7.35 | 50.115 |
| 1 | 0.79 | 0.02 | 6.99 | 50.066 |

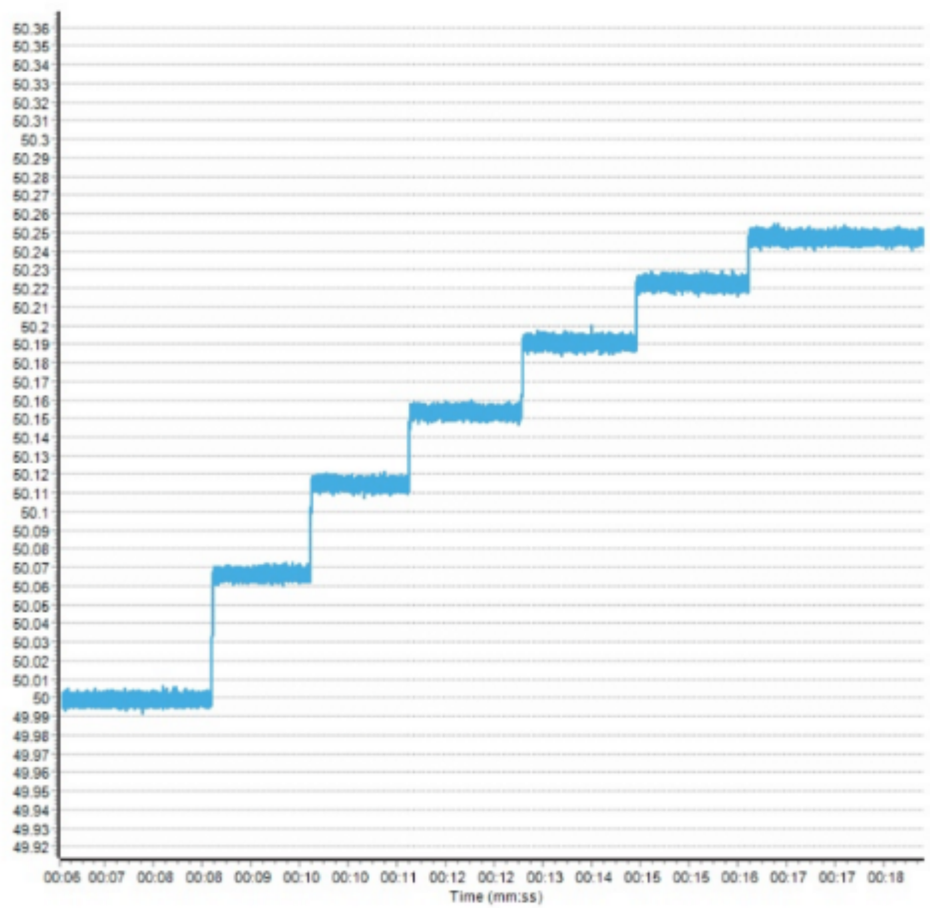
| | | |
|---|---|---|
| Average | 0.49 inch | 0.02 inch |
| Max Variation | 0.49 inch | 0.02 inch |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 2-EOD |

## COMPLETE VIEW




Page 3 of 3

**Trial 3 of 3**

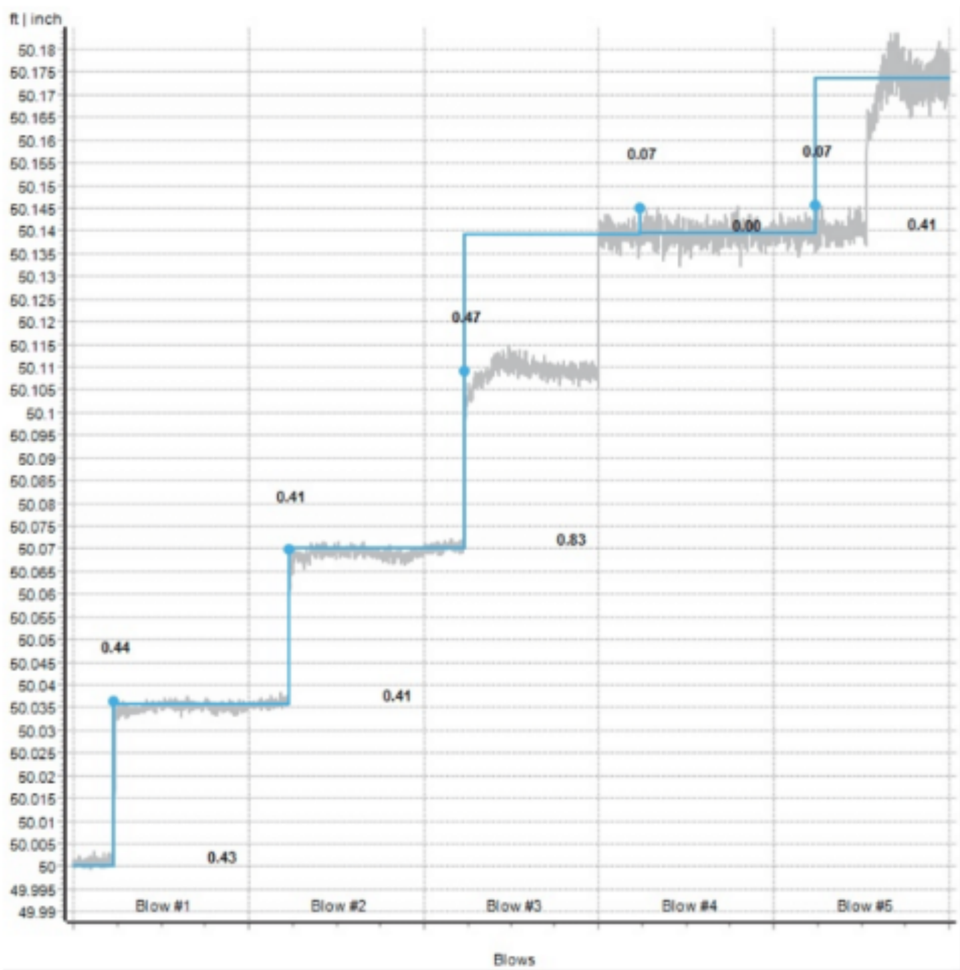
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:07:09 | 15.25 | 10.87 | 0.18 | 2.373 | 11.05 |
| 2 | 13:07:11 | 15.26 | 10.52 | -0.15 | 2.071 | 10.37 |
| 3 | 13:07:12 | 15.28 | 21.09 | -9.21 | 2.589 | 11.88 |
| 4 | 13:07:14 | 15.28 | 0.02 | 1.68 | 2.541 | 1.7 |
| 5 | 13:07:15 | 15.29 | 10.38 | -8.52 | 2.854 | 1.86 |
| 6 | 13:07:16 | 15.29 | -0.37 | 2.43 | 5.203 | 2.06 |
| 7 | 13:07:16 | 15.29 | 0.12 | 2.74 | 4.661 | 2.86 |
| 8 | 13:07:17 | 15.3 | 11.79 | 6.05 | 10.14 | 17.85 |
| 9 | 13:07:17 | 15.3 | 0.07 | 4.63 | 8.334 | 4.69 |
| 10 | 13:07:18 | 15.3 | 0.33 | 3.79 | 9.141 | 4.12 |
| 11 | 13:07:18 | 15.3 | -0.35 | 6.1 | 15.801 | 5.76 |
| 12 | 13:07:19 | 15.3 | 0.04 | 6.13 | 10.55 | 6.17 |
| 13 | 13:07:20 | 15.31 | 0.63 | 4.96 | 9.695 | 5.59 |
| 14 | 13:07:24 | 15.3 | -1.91 | 6.67 | 8.984 | 4.76 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 16/2/2019 |
| Client Name | | Report Time | 3:43:46 AM |
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Test Time | 1:07:00 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 3-EOD | PDM Pile Offset (ft) | 29.500 |
| Pile Type | | Final Penetration at Blow 5 (ft) | 50.173 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 3-EOD |

NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.42 | VMX (ft/s) | 8.155 |
| Rebound (inch) | -0.13 | DMX (inch) | 0.29 |
| Capacity (kip) | - | | |

TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 5 | 0.41 | -0.34 | 9.36 | 50.173 |
| 4 | 0.00 | 0.07 | 8.34 | 50.139 |
| 3 | 0.83 | -0.36 | 8.50 | 50.139 |
| 2 | 0.41 | -0.01 | 6.80 | 50.070 |
| 1 | 0.43 | 0.01 | 7.78 | 50.036 |

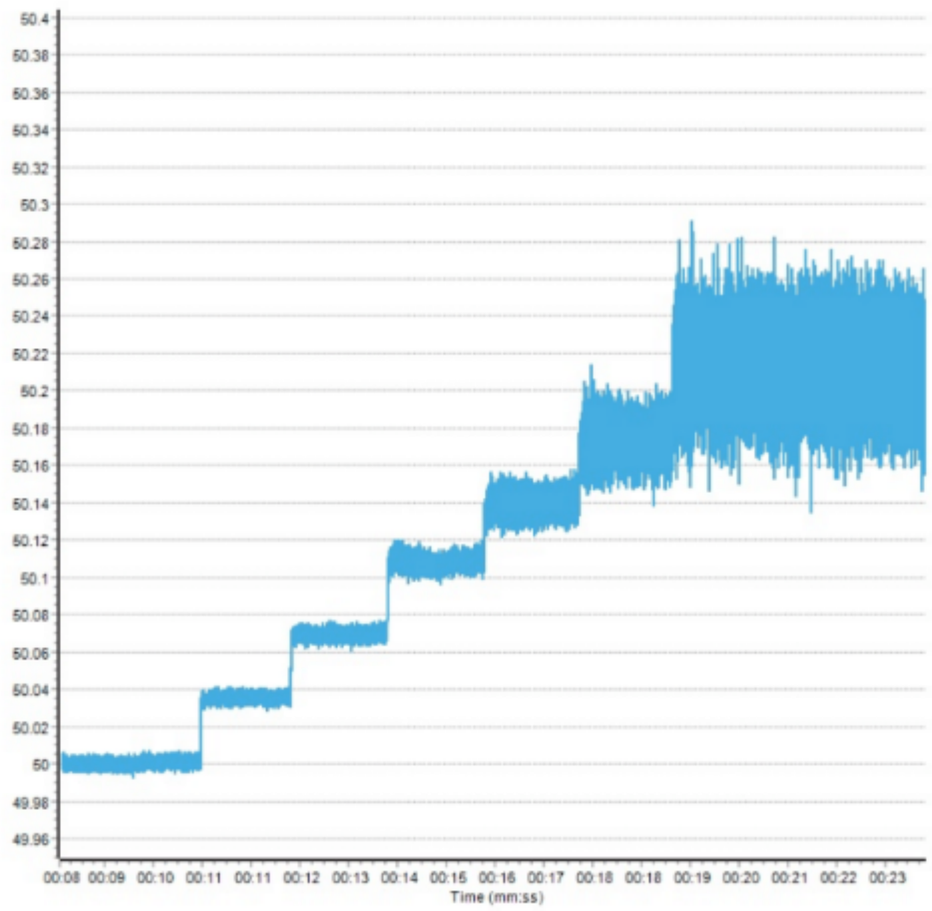
| | | |
|---|---|---|
| Average | 0.42 inch | -0.13 inch |
| Max Variation | 0.83 inch | 0.43 inch |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Labcylnewtap | Test Date | 10/2/2019 |
| Project Description | | Pile Number | 3-EOD |

COMPLETE VIEW



# A.2 PDM Site Data

## A.2.1 Port Canaveral North Cargo Berth 8

### A.2.1.1 Day 1, 6/3/2018: Three Tests

**Test 1 of 3**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 05:41:58 | 11.31 | 31.33 | 8.09 | 1.498 | 39.42 |
| 2 | 05:41:59 | 11.32 | 8.55 | 8.4 | 1.559 | 16.95 |
| 3 | 05:42:01 | 11.33 | 8.94 | 8.05 | 1.406 | 17 |
| 4 | 05:42:02 | 11.34 | 8.77 | 8.44 | 1.406 | 17.21 |
| 5 | 05:42:04 | 11.34 | 9.02 | 7.94 | 1.589 | 16.96 |
| 6 | 05:42:05 | 11.35 | 10.48 | 6.88 | 1.498 | 17.36 |
| 7 | 05:42:06 | 11.36 | 7.2 | 8.43 | 1.436 | 15.63 |
| 8 | 05:42:08 | 11.37 | 9.35 | 8.18 | 1.62 | 17.53 |
| 9 | 05:42:09 | 11.38 | 9.33 | 7.82 | 1.793 | 17.16 |
| 10 | 05:42:11 | 11.4 | 17.64 | -1.23 | 1.345 | 16.41 |
| 11 | 05:42:13 | 11.41 | 9.49 | 7.44 | 1.589 | 16.94 |
| 12 | 05:42:15 | 11.42 | 8.98 | 7.5 | 1.752 | 16.47 |
| 13 | 05:42:16 | 11.43 | 8.94 | 7.16 | 1.589 | 16.1 |
| 14 | 05:42:18 | 11.43 | 8.68 | 7.5 | 1.345 | 16.18 |
| 15 | 05:42:23 | 11.44 | 10.23 | 7.55 | 1.671 | 17.79 |
| 16 | 05:42:24 | 11.46 | 20.33 | -2.64 | 1.711 | 17.69 |
| 17 | 05:42:24 | 11.48 | 10.16 | 7.62 | 1.63 | 17.78 |
| 18 | 05:42:25 | 11.49 | 10.12 | 6.7 | 1.375 | 16.82 |
| 19 | 05:42:26 | 11.5 | 10.61 | 8.07 | 1.436 | 18.68 |
| 20 | 05:42:27 | 11.51 | 11.5 | 7.44 | 1.589 | 18.94 |
| 21 | 05:42:29 | 11.53 | 21.84 | -3.96 | 1.589 | 17.88 |
| 22 | 05:42:32 | 11.54 | 10.83 | 5.97 | 1.498 | 16.8 |
| 23 | 05:42:33 | 11.55 | 12.95 | 6.41 | 5.073 | 19.36 |
| 24 | 05:42:34 | 11.56 | 11.23 | 6.61 | 1.508 | 17.84 |
| 25 | 05:42:36 | 11.58 | 12.02 | 7.3 | 1.508 | 19.32 |
| 26 | 05:42:37 | 11.59 | 12.14 | 5.91 | 1.508 | 18.05 |
| 27 | 05:42:44 | 11.6 | 11.26 | 6.71 | 1.426 | 17.97 |
| 28 | 05:42:44 | 11.61 | 12.95 | 6.46 | 1.63 | 19.41 |
| 29 | 05:42:44 | 11.68 | 66.55 | -48.52 | 1.548 | 18.03 |
| 30 | 05:42:50 | 11.68 | 0.62 | 1.46 | 10.513 | 2.08 |
| 31 | 05:42:52 | 11.69 | 6.46 | 3.65 | 8.398 | 10.1 |
| 32 | 05:42:52 | 11.69 | -0.3 | 3.32 | 6.076 | 3.02 |
| 33 | 05:42:53 | 11.66 | -21.65 | 26.52 | 6.968 | 4.87 |
| 34 | 05:42:53 | 11.66 | -0.6 | 7.42 | 17.763 | 6.83 |
| 35 | 05:42:54 | 11.63 | -34.43 | 41.61 | 15.073 | 7.19 |
| 36 | 05:42:55 | 11.51 | -120 | 12.23 | 28.068 | -107.77 |
| 37 | 05:42:55 | 11.51 | 0.82 | 12.84 | 17.775 | 13.66 |
| 38 | 05:42:56 | 11.5 | -7.39 | 21.5 | 20.061 | 14.11 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 39 | 05:42:56 | 11.5 | -0.7 | 15.9 | 29.804 | 15.2 |
| 40 | 05:42:57 | 11.5 | -0.27 | 10.37 | 23.52 | 10.1 |
| 41 | 05:42:57 | 11.5 | 0.54 | 9.63 | 26.784 | 10.16 |
| 42 | 05:43:03 | 11.5 | 0.02 | 10.67 | 19.865 | 10.69 |
| 43 | 05:43:03 | 11.5 | -1.57 | 7.42 | 20.733 | 5.85 |
| 44 | 05:43:03 | 11.5 | 0.54 | 17.37 | 23.753 | 17.91 |
| 45 | 05:43:04 | 11.5 | -0.5 | 13.37 | 24.193 | 12.87 |
| 46 | 05:43:04 | 11.5 | 0.59 | 9.28 | 18.667 | 9.87 |
| 47 | 05:43:04 | 11.5 | 0.4 | 12.92 | 26.173 | 13.32 |
| 48 | 05:43:05 | 11.5 | 0.07 | 10.06 | 18.508 | 10.13 |
| 49 | 05:43:05 | 11.5 | -0.35 | 9.84 | 18.508 | 9.49 |
| 50 | 05:43:05 | 11.5 | 0.47 | 10.26 | 18.252 | 10.73 |
| 51 | 05:43:06 | 11.5 | -0.07 | 8.93 | 18.716 | 8.86 |
| 52 | 05:43:06 | 11.5 | -0.02 | 9.61 | 24.682 | 9.59 |
| 53 | 05:43:06 | 11.5 | 1.04 | 13.59 | 17.848 | 14.63 |
| 54 | 05:43:06 | 11.5 | -1.4 | 9.73 | 20.269 | 8.33 |
| 55 | 05:43:07 | 11.5 | -0.34 | 12.1 | 17.787 | 11.76 |
| 56 | 05:43:07 | 11.5 | -0.05 | 9.61 | 24.608 | 9.56 |
| 57 | 05:43:07 | 11.5 | 0.77 | 13.55 | 24.926 | 14.32 |
| 58 | 05:43:08 | 11.5 | 0.03 | 7.54 | 15.807 | 7.57 |
| 59 | 05:43:08 | 11.5 | -1.65 | 11.76 | 17.811 | 10.1 |
| 60 | 05:43:08 | 11.5 | 0.59 | 13.08 | 20.953 | 13.67 |
| 61 | 05:43:09 | 11.5 | 1.24 | 8.94 | 21.039 | 10.18 |
| 62 | 05:43:09 | 11.5 | -0.9 | 15.41 | 23.325 | 14.51 |
| 63 | 05:43:09 | 11.5 | 0.59 | 12.85 | 21.809 | 13.44 |
| 64 | 05:43:10 | 11.5 | -0.65 | 7.12 | 20.599 | 6.47 |
| 65 | 05:43:10 | 11.5 | -0.02 | 10.38 | 22.714 | 10.37 |
| 66 | 05:43:11 | 11.5 | -1.43 | 12.03 | 22.445 | 10.61 |
| 67 | 05:43:11 | 11.5 | 1.43 | 8.87 | 22.616 | 10.3 |
| 68 | 05:43:12 | 11.5 | 1.44 | 9.95 | 22.689 | 11.39 |
| 69 | 05:43:13 | 11.5 | -0.95 | 13 | 24.572 | 12.04 |
| 70 | 05:43:13 | 11.5 | -0.79 | 11.47 | 21.027 | 10.68 |
| 71 | 05:43:14 | 11.5 | 1.05 | 9.22 | 18.899 | 10.27 |
| 72 | 05:43:14 | 11.5 | 0.41 | 8.9 | 27.506 | 9.31 |
| 73 | 05:43:15 | 11.5 | 0 | 10.58 | 28.887 | 10.58 |
| 74 | 05:43:16 | 11.5 | -3.59 | 10.69 | 20.489 | 7.1 |
| 75 | 05:43:16 | 11.5 | 2.93 | 10.47 | 21.271 | 13.39 |
| 76 | 05:43:17 | 11.5 | -0.08 | 9.84 | 26.54 | 9.76 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 77 | 05:43:17 | 11.5 | 0.03 | 12.46 | 23.716 | 12.48 |
| 78 | 05:43:23 | 11.5 | -0.37 | 10.02 | 22.286 | 9.64 |
| 79 | 05:43:23 | 11.5 | 2.73 | 8.53 | 18.007 | 11.26 |
| 80 | 05:43:24 | 11.5 | -3.4 | 15.82 | 22.127 | 12.42 |
| 81 | 05:43:24 | 11.5 | 0.53 | 10.27 | 23.728 | 10.8 |
| 82 | 05:43:24 | 11.5 | 1 | 12.28 | 26.736 | 13.28 |
| 83 | 05:43:25 | 11.5 | -0.07 | 10.25 | 18.154 | 10.18 |
| 84 | 05:43:25 | 11.5 | -0.67 | 12.04 | 19.694 | 11.37 |
| 85 | 05:43:25 | 11.5 | 0.25 | 9.72 | 23.716 | 9.97 |
| 86 | 05:43:26 | 11.5 | -0.15 | 8.96 | 18.985 | 8.82 |
| 87 | 05:43:26 | 11.5 | 0.83 | 9.16 | 28.765 | 9.99 |
| 88 | 05:43:26 | 11.5 | -0.65 | 16.74 | 21.43 | 16.09 |
| 89 | 05:43:27 | 11.5 | -1.06 | 12.51 | 29.437 | 11.45 |
| 90 | 05:43:27 | 11.5 | 0.95 | 9.61 | 23.924 | 10.57 |
| 91 | 05:43:27 | 11.5 | 0.38 | 14.55 | 26.112 | 14.94 |
| 92 | 05:43:28 | 11.5 | -0.04 | 11.11 | 24.119 | 11.06 |
| 93 | 05:43:28 | 11.5 | -0.28 | 12.4 | 20.269 | 12.12 |
| 94 | 05:43:28 | 11.5 | -0.72 | 14.17 | 23.924 | 13.45 |
| 95 | 05:43:28 | 11.5 | 0.33 | 14.33 | 19.67 | 14.67 |
| 96 | 05:43:29 | 11.5 | 0.97 | 13.23 | 23.606 | 14.2 |
| 97 | 05:43:29 | 11.5 | -1.24 | 10.13 | 27.542 | 8.89 |
| 98 | 05:43:29 | 11.5 | 2.57 | 9.89 | 22.677 | 12.45 |
| 99 | 05:43:30 | 11.5 | -3.35 | 11.5 | 18.887 | 8.15 |
| 100 | 05:43:30 | 11.5 | 1.64 | 11.21 | 24.193 | 12.85 |
| 101 | 05:43:31 | 11.5 | 0.24 | 10.88 | 16.259 | 11.12 |
| 102 | 05:43:31 | 11.5 | 0.31 | 6.44 | 22.286 | 6.75 |
| 103 | 05:43:32 | 11.5 | -0.62 | 10.05 | 27.322 | 9.44 |
| 104 | 05:43:33 | 11.5 | 0.63 | 10.92 | 18.985 | 11.56 |
| 105 | 05:43:33 | 11.5 | 0.81 | 12.45 | 20.489 | 13.26 |
| 106 | 05:43:34 | 11.5 | -1.15 | 7.9 | 23.471 | 6.75 |
| 107 | 05:43:34 | 11.5 | 0.86 | 10.09 | 21.381 | 10.95 |
| 108 | 05:43:35 | 11.5 | -1.21 | 14.75 | 22.75 | 13.54 |
| 109 | 05:43:35 | 11.5 | 0.15 | 11.33 | 19.144 | 11.48 |
| 110 | 05:43:36 | 11.5 | 0.11 | 11.34 | 21.784 | 11.45 |
| 111 | 05:43:36 | 11.5 | -0.37 | 9.76 | 21.833 | 9.39 |
| 112 | 05:43:37 | 11.5 | -1.11 | 12.31 | 18.154 | 11.2 |
| 113 | 05:43:37 | 11.5 | 1.54 | 9.12 | 21.564 | 10.66 |
| 114 | 05:43:43 | 11.5 | -0.17 | 9.08 | 23.912 | 8.91 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 115 | 05:43:43 | 11.5 | -0.96 | 9.26 | 21.772 | 8.3 |
| 116 | 05:43:44 | 11.55 | 47.8 | -39.09 | 25.623 | 8.7 |
| 117 | 05:43:44 | 11.54 | -7.61 | -50.31 | 33.581 | -57.92 |
| 118 | 05:43:44 | 11.49 | -48.5 | 44.66 | 21.528 | -3.84 |
| 119 | 05:43:45 | 11.26 | -233.3 | 243.2 | 25.55 | 9.9 |
| 120 | 05:43:45 | 11.26 | 0.08 | 18.08 | 31.381 | 18.16 |
| 121 | 05:43:45 | 11.26 | -2.23 | 17.67 | 31.198 | 15.44 |
| 122 | 05:43:45 | 11.23 | -31.07 | 39.7 | 29.266 | 8.64 |
| 123 | 05:43:46 | 11.23 | 0.14 | 4.98 | 10.098 | 5.12 |
| 124 | 05:43:46 | 11.21 | -14.39 | 18.3 | 9.156 | 3.91 |
| 125 | 05:43:46 | 11.27 | 60.2 | -57.56 | 4.755 | 2.64 |
| 126 | 05:43:55 | 11.29 | 13.3 | 3.49 | 7.017 | 16.79 |
| 127 | 05:43:56 | 11.3 | 13.49 | 3.11 | 1.528 | 16.6 |
| 128 | 05:44:03 | 11.31 | 12.84 | 3.27 | 1.284 | 16.11 |
| 129 | 05:44:03 | 11.32 | 13.42 | 3.25 | 1.559 | 16.67 |
| 130 | 05:44:03 | 11.34 | 14.17 | 3.41 | 1.375 | 17.57 |
| 131 | 05:44:04 | 11.35 | 13.7 | 3.42 | 1.467 | 17.13 |
| 132 | 05:44:04 | 11.38 | 26.44 | -9.4 | 2.598 | 17.04 |
| 133 | 05:44:06 | 11.39 | 12.54 | 2.7 | 1.559 | 15.24 |
| 134 | 05:44:08 | 11.4 | 13 | 3.24 | 1.406 | 16.23 |
| 135 | 05:44:09 | 11.42 | 13.84 | 2.8 | 1.589 | 16.65 |
| 136 | 05:44:11 | 11.43 | 13.31 | 3 | 1.63 | 16.31 |
| 137 | 05:44:12 | 11.44 | 13.04 | 3.45 | 1.589 | 16.5 |
| 138 | 05:44:13 | 11.46 | 13.87 | 3.54 | 1.63 | 17.42 |
| 139 | 05:44:15 | 11.48 | 26.12 | -9.43 | 1.436 | 16.7 |
| 140 | 05:44:18 | 11.5 | 12.97 | 3.24 | 1.508 | 16.21 |
| 141 | 05:44:23 | 11.51 | 13.35 | 2.73 | 1.589 | 16.09 |
| 142 | 05:44:23 | 11.52 | 12.13 | 3.36 | 1.375 | 15.49 |
| 143 | 05:44:24 | 11.54 | 12.91 | 2.72 | 1.436 | 15.63 |
| 144 | 05:44:24 | 11.55 | 10.8 | 2.89 | 1.131 | 13.69 |
| 145 | 05:44:25 | 11.56 | 15.85 | 2.76 | 5.599 | 18.61 |
| 146 | 05:44:26 | 11.58 | 12.94 | 3.16 | 1.834 | 16.1 |
| 147 | 05:44:28 | 11.59 | 12.66 | 2.97 | 1.426 | 15.63 |
| 148 | 05:44:29 | 11.61 | 24.24 | -9.07 | 1.345 | 15.17 |
| 149 | 05:44:32 | 11.62 | 11.96 | 2.85 | 1.793 | 14.81 |
| 150 | 05:44:33 | 11.68 | 51.32 | -36.26 | 1.508 | 15.06 |
| 151 | 05:44:43 | 11.68 | 8.18 | -6.25 | 7.854 | 1.93 |
| 152 | 05:44:44 | 11.68 | 0.07 | 1.96 | 4.181 | 2.04 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 153 | 05:44:44 | 11.68 | -2.72 | 3.91 | 9.499 | 1.19 |
| 154 | 05:44:44 | 11.68 | 0.12 | 4.81 | 11.76 | 4.93 |
| 155 | 05:44:45 | 11.64 | -40.31 | 46.52 | 8.57 | 6.2 |
| 156 | 05:44:45 | 11.64 | 2.5 | 16.71 | 28.312 | 19.21 |
| 157 | 05:44:46 | 11.64 | -1.12 | 11.28 | 29.217 | 10.16 |
| 158 | 05:44:46 | 11.51 | -136.81 | 146.9 | 27.42 | 10.09 |
| 159 | 05:44:47 | 11.51 | -0.71 | 8.92 | 20.22 | 8.21 |
| 160 | 05:44:47 | 11.5 | -2.92 | 13.98 | 20.049 | 11.06 |
| 161 | 05:44:48 | 11.5 | -0.45 | 11.19 | 25.097 | 10.74 |
| 162 | 05:44:49 | 11.5 | 0.67 | 10.35 | 19.425 | 11.02 |
| 163 | 05:44:49 | 11.5 | -0.57 | 9.55 | 24.132 | 8.98 |
| 164 | 05:44:50 | 11.5 | 0.43 | 9.63 | 18.985 | 10.06 |
| 165 | 05:44:50 | 11.5 | -0.97 | 12.96 | 19.694 | 11.99 |
| 166 | 05:44:51 | 11.5 | -0.23 | 11.68 | 18.716 | 11.45 |
| 167 | 05:44:51 | 11.5 | -0.54 | 10.33 | 24.89 | 9.79 |
| 168 | 05:44:52 | 11.5 | 0.59 | 10.29 | 22.775 | 10.89 |
| 169 | 05:44:52 | 11.5 | 0.44 | 9.16 | 25.159 | 9.6 |
| 170 | 05:44:53 | 11.5 | -0.73 | 8.09 | 26.234 | 7.36 |
| 171 | 05:44:54 | 11.5 | 1.07 | 11.08 | 23.288 | 12.15 |
| 172 | 05:44:54 | 11.5 | -0.74 | 13.08 | 19.266 | 12.34 |
| 173 | 05:44:55 | 11.5 | -0.07 | 11.28 | 17.86 | 11.21 |
| 174 | 05:44:55 | 11.5 | 0.85 | 7.87 | 18.899 | 8.73 |
| 175 | 05:44:56 | 11.5 | -0.13 | 12.42 | 18.716 | 12.29 |
| 176 | 05:44:56 | 11.5 | -0.11 | 9.48 | 20.745 | 9.37 |
| 177 | 05:44:57 | 11.5 | 0.59 | 6.75 | 23.41 | 7.34 |
| 178 | 05:44:57 | 11.5 | -1.21 | 14.18 | 22.127 | 12.97 |
| 179 | 05:45:03 | 11.5 | 0.25 | 16.54 | 24.278 | 16.79 |
| 180 | 05:45:03 | 11.5 | -0.83 | 10.74 | 28.679 | 9.91 |
| 181 | 05:45:03 | 11.5 | 1.39 | 11.16 | 19.914 | 12.55 |
| 182 | 05:45:04 | 11.5 | 0.02 | 10.43 | 27.75 | 10.45 |
| 183 | 05:45:04 | 11.5 | -0.9 | 16.57 | 22.408 | 15.67 |
| 184 | 05:45:04 | 11.5 | 0.57 | 13.06 | 22.445 | 13.62 |
| 185 | 05:45:05 | 11.5 | -0.84 | 11.6 | 21.271 | 10.77 |
| 186 | 05:45:05 | 11.5 | 0.69 | 8.55 | 24.89 | 9.24 |
| 187 | 05:45:05 | 11.5 | -1.48 | 13.49 | 19.266 | 12.01 |
| 188 | 05:45:06 | 11.5 | 0.05 | 9.22 | 23.264 | 9.27 |
| 189 | 05:45:06 | 11.5 | 0.75 | 12.64 | 19.841 | 13.39 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 190 | 05:45:06 | 11.5 | -0.62 | 14.46 | 17.457 | 13.84 |
| 191 | 05:45:07 | 11.5 | 0.18 | 13.43 | 17.811 | 13.61 |
| 192 | 05:45:07 | 11.5 | 1.56 | 10.93 | 19.914 | 12.5 |
| 193 | 05:45:07 | 11.5 | -0.62 | 8.99 | 23.924 | 8.37 |
| 194 | 05:45:08 | 11.5 | -0.14 | 9.8 | 19.694 | 9.66 |
| 195 | 05:45:08 | 11.5 | 0.69 | 12.77 | 26.54 | 13.47 |
| 196 | 05:45:08 | 11.5 | -0.9 | 11.81 | 20.428 | 10.91 |
| 197 | 05:45:09 | 11.5 | 1 | 10.7 | 21.784 | 11.7 |
| 198 | 05:45:09 | 11.5 | -0.96 | 10.95 | 19.621 | 10 |
| 199 | 05:45:09 | 11.5 | -0.66 | 11.91 | 21.43 | 11.25 |
| 200 | 05:45:10 | 11.5 | 0.89 | 13.73 | 19.425 | 14.62 |
| 201 | 05:45:10 | 11.5 | -0.76 | 12.53 | 25.489 | 11.77 |
| 202 | 05:45:11 | 11.5 | 0.23 | 10.75 | 23.276 | 10.98 |
| 203 | 05:45:11 | 11.5 | 0.9 | 9.08 | 20.843 | 9.98 |
| 204 | 05:45:12 | 11.5 | -1.12 | 13.28 | 20.073 | 12.16 |
| 205 | 05:45:12 | 11.5 | -0.06 | 11.27 | 23.19 | 11.21 |
| 206 | 05:45:13 | 11.5 | -0.24 | 14.82 | 21.43 | 14.58 |
| 207 | 05:45:14 | 11.5 | 1.09 | 11.37 | 23.288 | 12.46 |
| 208 | 05:45:14 | 11.5 | 1.26 | 12.63 | 22.445 | 13.89 |
| 209 | 05:45:15 | 11.5 | -2.31 | 8.41 | 24.474 | 6.1 |
| 210 | 05:45:15 | 11.5 | 1.34 | 12.87 | 26.075 | 14.21 |
| 211 | 05:45:16 | 11.5 | -1.1 | 11.6 | 23.41 | 10.49 |
| 212 | 05:45:16 | 11.5 | 0.03 | 9.52 | 22.127 | 9.55 |
| 213 | 05:45:17 | 11.5 | 1.27 | 10.08 | 17.127 | 11.35 |
| 214 | 05:45:17 | 11.5 | -0.3 | 13.56 | 23.019 | 13.26 |
| 215 | 05:45:23 | 11.5 | 0.04 | 9.09 | 19.511 | 9.13 |
| 216 | 05:45:23 | 11.5 | 0.28 | 8.93 | 20.88 | 9.22 |
| 217 | 05:45:24 | 11.5 | -0.19 | 8.7 | 22.445 | 8.51 |
| 218 | 05:45:24 | 11.5 | -0.52 | 7.79 | 22.75 | 7.27 |
| 219 | 05:45:24 | 11.5 | -0.23 | 11.03 | 24.89 | 10.79 |
| 220 | 05:45:25 | 11.5 | 0.87 | 14.06 | 22.383 | 14.93 |
| 221 | 05:45:25 | 11.5 | -0.15 | 13.26 | 21.271 | 13.11 |
| 222 | 05:45:25 | 11.5 | -0.7 | 13.44 | 25.097 | 12.74 |
| 223 | 05:45:25 | 11.5 | -0.83 | 15.14 | 22.286 | 14.31 |
| 224 | 05:45:26 | 11.5 | 1.27 | 12.21 | 21.406 | 13.48 |
| 225 | 05:45:26 | 11.5 | -0.77 | 11.33 | 20.99 | 10.56 |
| 226 | 05:45:26 | 11.5 | -0.18 | 12.07 | 31.271 | 11.89 |
| 227 | 05:45:27 | 11.5 | 0.32 | 10.74 | 25.916 | 11.05 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 228 | 05:45:27 | 11.5 | 0.09 | 10.31 | 29.18 | 10.4 |
| 229 | 05:45:27 | 11.5 | -0.66 | 10.23 | 22.714 | 9.57 |
| 230 | 05:45:28 | 11.5 | 0.38 | 13.35 | 21.479 | 13.73 |
| 231 | 05:45:28 | 11.5 | 0.16 | 13.23 | 22.872 | 13.39 |
| 232 | 05:45:28 | 11.5 | 0.71 | 11.37 | 28.52 | 12.08 |
| 233 | 05:45:29 | 11.5 | 0.44 | 11.42 | 17.958 | 11.86 |
| 234 | 05:45:29 | 11.5 | -1.31 | 13.19 | 20.599 | 11.89 |
| 235 | 05:45:29 | 11.5 | 1.44 | 8.75 | 21.479 | 10.18 |
| 236 | 05:45:30 | 11.5 | -1.21 | 9.05 | 23.325 | 7.84 |
| 237 | 05:45:30 | 11.5 | 0.12 | 10.22 | 20.146 | 10.34 |
| 238 | 05:45:31 | 11.5 | 0.69 | 11.44 | 25.097 | 12.13 |
| 239 | 05:45:32 | 11.5 | -1.24 | 12.11 | 24.242 | 10.87 |
| 240 | 05:45:32 | 11.5 | -1.72 | 14.45 | 24.572 | 12.73 |
| 241 | 05:45:33 | 11.5 | 3.47 | 10.03 | 27.396 | 13.5 |
| 242 | 05:45:34 | 11.5 | -1.45 | 10.22 | 20.843 | 8.76 |
| 243 | 05:45:34 | 11.5 | -5.43 | 8.51 | 16.858 | 3.08 |
| 244 | 05:45:35 | 11.5 | 1.62 | 9.21 | 23.985 | 10.83 |
| 245 | 05:45:35 | 11.44 | -55.84 | 65.41 | 23.423 | 9.57 |
| 246 | 05:45:36 | 11.44 | -4.96 | 33.04 | 31.687 | 28.08 |
| 247 | 05:45:36 | 11.26 | -<br>176.22 | 208.59 | 32.665 | 32.37 |
| 248 | 05:45:37 | 11.24 | -24.45 | 9.09 | 21.858 | -15.36 |
| 249 | 05:45:38 | 11.24 | 0.43 | 6.7 | 19.767 | 7.13 |
| 250 | 05:45:44 | 11.21 | -23.44 | 28.55 | 19.095 | 5.11 |
| 251 | 05:45:44 | 11.21 | 0.15 | 3.34 | 7.53 | 3.49 |
| 252 | 05:45:44 | 11.21 | 1.6 | 2.54 | 8.447 | 4.15 |
| 253 | 05:45:45 | 11.28 | 70.85 | -69.38 | 3.362 | 1.47 |
| 254 | 05:45:51 | 11.33 | 41.98 | -24.91 | 1.748 | 17.07 |
| 255 | 05:45:55 | 11.34 | 14.43 | 2.35 | 1.375 | 16.78 |
| 256 | 05:45:56 | 11.39 | 44.42 | -28.13 | 1.559 | 16.29 |
| 257 | 05:46:03 | 11.42 | 31.17 | -12.03 | 1.467 | 19.13 |
| 258 | 05:46:04 | 11.43 | 14.93 | 2.29 | 1.467 | 17.22 |
| 259 | 05:46:05 | 11.45 | 14.02 | 2.4 | 1.385 | 16.42 |
| 260 | 05:46:06 | 11.46 | 15.05 | 2.44 | 2.363 | 17.49 |
| 261 | 05:46:07 | 11.48 | 14.54 | 2.33 | 1.548 | 16.88 |
| 262 | 05:46:09 | 11.49 | 15.14 | 2.21 | 1.589 | 17.34 |
| 263 | 05:46:10 | 11.51 | 14.92 | 2.26 | 1.314 | 17.18 |
| 264 | 05:46:12 | 11.52 | 15.47 | 2.45 | 1.284 | 17.93 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 265 | 05:46:13 | 11.55 | 29.52 | -11.33 | 1.345 | 18.18 |
| 266 | 05:46:16 | 11.6 | 52.83 | -29.16 | 6.021 | 23.67 |
| 267 | 05:46:23 | 11.64 | 31.73 | -12.93 | 1.467 | 18.8 |
| 268 | 05:46:24 | 11.68 | 41.78 | -25.92 | 1.671 | 15.85 |
| 269 | 05:46:28 | 11.68 | 0.06 | 1.6 | 6.455 | 1.66 |
| 270 | 05:46:29 | 11.68 | 7.77 | 2.7 | 6.785 | 10.46 |
| 271 | 05:46:29 | 11.68 | -0.11 | 3.3 | 6.76 | 3.19 |
| 272 | 05:46:30 | 11.65 | -34.46 | 35.45 | 21.87 | 0.99 |
| 273 | 05:46:31 | 11.65 | -0.4 | 10.06 | 27.591 | 9.66 |
| 274 | 05:46:31 | 11.33 | -323.44 | 184.82 | 25.305 | -138.63 |
| 275 | 05:47:22 | 11.36 | 34.88 | -15.31 | 1.314 | 19.57 |
| 276 | 05:47:24 | 11.38 | 17.07 | 2.79 | 1.589 | 19.86 |
| 277 | 05:47:26 | 11.39 | 15.95 | 2.67 | 1.284 | 18.62 |
| 278 | 05:47:27 | 11.43 | 33.9 | -14.72 | 1.589 | 19.18 |
| 279 | 05:47:30 | 11.45 | 17.41 | 2.78 | 1.63 | 20.19 |
| 280 | 05:47:31 | 11.46 | 17.48 | 2.86 | 2.078 | 20.34 |
| 281 | 05:47:33 | 11.48 | 16.75 | 2.58 | 1.375 | 19.33 |
| 282 | 05:47:34 | 11.5 | 16.39 | 2.53 | 1.284 | 18.92 |
| 283 | 05:47:36 | 11.53 | 32.24 | -13.79 | 1.284 | 18.45 |
| 284 | 05:47:38 | 11.54 | 15.1 | 1.81 | 1.314 | 16.91 |
| 285 | 05:47:40 | 11.58 | 37.17 | -15.04 | 4.89 | 22.13 |
| 286 | 05:47:46 | 11.68 | 95.65 | -75.66 | 1.528 | 20 |
| 287 | 05:47:51 | 11.68 | -0.02 | 3.22 | 10.065 | 3.2 |
| 288 | 05:47:52 | 11.68 | 8.77 | 2.73 | 6.724 | 11.5 |
| 289 | 05:47:53 | 11.69 | 0.06 | 3.5 | 5.379 | 3.56 |
| 290 | 05:47:54 | 11.64 | -42.67 | 46.06 | 7.408 | 3.38 |
| 291 | 05:48:47 | 11.28 | -360.96 | 385.4 | 20 | 24.44 |
| 292 | 05:48:49 | 11.3 | 14.74 | 2.17 | 1.65 | 16.91 |
| 293 | 05:48:50 | 11.31 | 15.03 | 2.46 | 1.528 | 17.49 |
| 294 | 05:48:52 | 11.33 | 14.26 | 2.11 | 1.528 | 16.36 |
| 295 | 05:48:53 | 11.34 | 14.11 | 1.95 | 1.375 | 16.06 |
| 296 | 05:48:55 | 11.35 | 13.93 | 2.21 | 1.62 | 16.14 |
| 297 | 05:48:56 | 11.37 | 14.6 | 2.76 | 2.659 | 17.36 |
| 298 | 05:48:57 | 11.38 | 13.4 | 2.52 | 1.589 | 15.92 |
| 299 | 05:48:59 | 11.39 | 13 | 2.21 | 1.345 | 15.2 |
| 300 | 05:49:00 | 11.41 | 13.98 | 2.06 | 1.406 | 16.04 |
| 301 | 05:49:02 | 11.42 | 13.78 | 2.07 | 1.498 | 15.84 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 302 | 05:49:03 | 11.44 | 13.46 | 2.32 | 1.467 | 15.78 |
| 303 | 05:49:04 | 11.45 | 13.19 | 2.37 | 1.375 | 15.55 |
| 304 | 05:49:06 | 11.46 | 15.29 | 2.28 | 2.048 | 17.58 |
| 305 | 05:49:13 | 11.48 | 13.83 | 2.3 | 1.436 | 16.13 |
| 306 | 05:49:13 | 11.49 | 14.77 | 2.45 | 1.345 | 17.22 |
| 307 | 05:49:13 | 11.51 | 14.25 | 2.55 | 1.375 | 16.8 |
| 308 | 05:49:13 | 11.52 | 14.81 | 2.36 | 1.375 | 17.17 |
| 309 | 05:49:13 | 11.25 | -268.11 | 283.85 | 1.314 | 15.74 |
| 310 | 05:50:19 | 11.27 | 18.66 | 2.21 | 2.152 | 20.86 |
| 311 | 05:50:21 | 11.31 | 39.76 | -17.13 | 1.284 | 22.64 |
| 312 | 05:50:24 | 11.35 | 38.08 | -16.59 | 1.467 | 21.49 |
| 313 | 05:50:26 | 11.37 | 20.55 | 2.28 | 2.078 | 22.83 |
| 314 | 05:50:28 | 11.39 | 18.83 | 2.69 | 1.406 | 21.53 |
| 315 | 05:50:29 | 11.41 | 19.18 | 2.12 | 1.345 | 21.3 |
| 316 | 05:50:31 | 11.43 | 18.48 | 2.76 | 1.508 | 21.24 |
| 317 | 05:50:32 | 11.45 | 17.89 | 2.04 | 1.426 | 19.93 |
| 318 | 05:50:33 | 11.48 | 38.42 | -17.19 | 2.078 | 21.23 |
| 319 | 05:50:39 | 11.5 | 18.58 | 2.41 | 1.345 | 20.99 |
| 320 | 05:50:39 | 11.52 | 19.52 | 2.4 | 1.589 | 21.92 |
| 321 | 05:50:39 | 11.54 | 18.89 | 2.24 | 1.345 | 21.13 |
| 322 | 05:50:40 | 11.56 | 20.81 | 2.16 | 4.865 | 22.97 |
| 323 | 05:50:42 | 11.58 | 19.23 | 2.76 | 1.548 | 22 |
| 324 | 05:50:43 | 11.6 | 18.31 | 2.56 | 1.63 | 20.88 |
| 325 | 05:50:44 | 11.62 | 19.47 | 2.31 | 1.304 | 21.78 |
| 326 | 05:50:46 | 11.67 | 55.86 | -35.02 | 1.467 | 20.83 |
| 327 | 05:50:51 | 11.68 | 10.32 | -9.24 | 7.518 | 1.08 |
| 328 | 05:50:52 | 11.69 | 0.76 | 2.41 | 7.543 | 3.17 |
| 329 | 05:50:53 | 11.64 | -44.94 | 48.69 | 5.623 | 3.75 |
| 330 | 05:50:53 | 11.64 | -1.19 | 31.84 | 31.283 | 30.65 |
| 331 | 05:51:29 | 11.57 | -66.53 | 76.5 | 27.701 | 9.97 |
| 332 | 05:51:29 | 11.5 | -71.13 | 11.49 | 19.425 | -59.64 |
| 333 | 05:51:30 | 11.5 | -1.38 | 13 | 23.716 | 11.62 |
| 334 | 05:51:30 | 11.26 | -245.14 | 255.91 | 20.953 | 10.76 |
| 335 | 05:51:34 | 11.29 | 33.26 | -14.59 | 1.528 | 18.68 |
| 336 | 05:51:36 | 11.31 | 17.64 | 2.71 | 1.528 | 20.35 |
| 337 | 05:51:38 | 11.32 | 16.55 | 2.84 | 1.467 | 19.39 |
| 338 | 05:51:39 | 11.34 | 18.17 | 2.04 | 1.467 | 20.21 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 339 | 05:51:41 | 11.36 | 17.81 | 2.34 | 1.559 | 20.16 |
| 340 | 05:51:42 | 11.39 | 33.27 | -14.03 | 1.498 | 19.23 |
| 341 | 05:51:45 | 11.41 | 16.76 | 2.21 | 1.467 | 18.98 |
| 342 | 05:51:46 | 11.42 | 16.02 | 2.58 | 1.63 | 18.6 |
| 343 | 05:51:48 | 11.46 | 32.43 | -13.58 | 1.548 | 18.85 |
| 344 | 05:51:55 | 11.47 | 16.61 | 1.97 | 1.915 | 18.59 |
| 345 | 05:51:55 | 11.49 | 15.86 | 3.11 | 1.528 | 18.97 |
| 346 | 05:51:55 | 11.52 | 32.36 | -13.31 | 1.467 | 19.05 |
| 347 | 05:51:56 | 11.55 | 29.48 | -10.83 | 1.375 | 18.64 |
| 348 | 05:51:59 | 11.59 | 35.41 | -12.89 | 6.418 | 22.52 |
| 349 | 05:52:02 | 11.6 | 15.8 | 2.59 | 1.508 | 18.39 |
| 350 | 05:52:03 | 11.62 | 15.36 | 2.25 | 1.711 | 17.61 |
| 351 | 05:52:05 | 11.63 | 15.07 | 2.51 | 1.589 | 17.57 |
| 352 | 05:52:06 | 11.67 | 40.4 | -25.31 | 1.375 | 15.09 |
| 353 | 05:52:14 | 11.68 | 9.53 | 3.13 | 7.359 | 12.65 |
| 354 | 05:52:15 | 11.68 | -5.91 | 8.11 | 3.557 | 2.2 |
| 355 | 05:52:15 | 11.68 | -1.22 | 9.74 | 13.679 | 8.52 |
| 356 | 05:52:15 | 11.67 | -1.03 | 4.96 | 13.252 | 3.93 |
| 357 | 05:52:15 | 11.6 | -75.87 | 83.6 | 13.019 | 7.73 |
| 358 | 05:52:16 | 11.6 | -0.3 | 11.31 | 20.244 | 11.02 |
| 359 | 05:52:16 | 11.54 | -61.07 | 71.39 | 18.203 | 10.33 |
| 360 | 05:52:16 | 11.5 | -35.98 | 11.12 | 26.833 | -24.86 |
| 361 | 05:52:17 | 11.5 | -1.6 | 16.01 | 25.562 | 14.4 |
| 362 | 05:52:18 | 11.5 | 0.34 | 11.78 | 22.127 | 12.13 |
| 363 | 05:52:18 | 11.5 | 0.8 | 7.53 | 22.127 | 8.34 |
| 364 | 05:52:19 | 11.5 | -0.45 | 14.84 | 21.43 | 14.39 |
| 365 | 05:52:20 | 11.5 | -0.35 | 16.81 | 21.344 | 16.45 |
| 366 | 05:52:20 | 11.5 | 0.34 | 10.42 | 22.848 | 10.76 |
| 367 | 05:52:21 | 11.5 | 0.45 | 10.69 | 22.408 | 11.13 |
| 368 | 05:52:21 | 11.5 | -1.53 | 16.01 | 18.716 | 14.48 |
| 369 | 05:52:22 | 11.5 | 1.97 | 7.77 | 20.146 | 9.74 |
| 370 | 05:52:22 | 11.5 | -0.46 | 14.05 | 26.882 | 13.59 |
| 371 | 05:52:23 | 11.5 | -1.42 | 12.13 | 23.288 | 10.71 |
| 372 | 05:52:23 | 11.5 | 0.79 | 15.05 | 20.88 | 15.84 |
| 373 | 05:52:24 | 11.5 | -0.34 | 14.13 | 20.146 | 13.79 |
| 374 | 05:52:24 | 11.5 | 1.12 | 10.34 | 24.278 | 11.46 |
| 375 | 05:52:25 | 11.5 | 0.08 | 10.64 | 21.271 | 10.73 |
| 376 | 05:52:26 | 11.5 | -0.07 | 11.35 | 21.601 | 11.28 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 377 | 05:52:26 | 11.5 | -1.18 | 16 | 23.753 | 14.82 |
| 378 | 05:52:27 | 11.5 | 0.93 | 11.13 | 24.217 | 12.06 |
| 379 | 05:52:27 | 11.5 | -0.07 | 10.82 | 24.572 | 10.75 |
| 380 | 05:52:28 | 11.5 | 0.63 | 13.68 | 17.811 | 14.31 |
| 381 | 05:52:28 | 11.5 | -0.66 | 10.39 | 18.985 | 9.73 |
| 382 | 05:52:34 | 11.5 | 0.3 | 15.63 | 23.997 | 15.94 |
| 383 | 05:52:34 | 11.5 | -1.36 | 13.03 | 26.894 | 11.68 |
| 384 | 05:52:35 | 11.5 | 1.03 | 10.31 | 20.22 | 11.34 |
| 385 | 05:52:35 | 11.5 | 0.69 | 12.18 | 25.599 | 12.87 |
| 386 | 05:52:35 | 11.5 | -1.76 | 9.95 | 20.146 | 8.18 |
| 387 | 05:52:36 | 11.5 | 0.75 | 13.99 | 20.061 | 14.75 |
| 388 | 05:52:36 | 11.5 | -0.65 | 12.38 | 30.342 | 11.73 |
| 389 | 05:52:36 | 11.5 | 1.04 | 14.32 | 22.151 | 15.36 |
| 390 | 05:52:37 | 11.5 | 0.14 | 11.09 | 18.508 | 11.23 |
| 391 | 05:52:37 | 11.5 | -0.79 | 13.17 | 20.073 | 12.39 |
| 392 | 05:52:37 | 11.5 | -0.37 | 14.49 | 20.061 | 14.11 |
| 393 | 05:52:38 | 11.5 | 0.31 | 12.72 | 27.934 | 13.03 |
| 394 | 05:52:38 | 11.5 | 1.02 | 13.14 | 21.772 | 14.16 |
| 395 | 05:52:38 | 11.5 | 0.5 | 7.63 | 15.917 | 8.13 |
| 396 | 05:52:39 | 11.5 | -0.74 | 15.31 | 23.85 | 14.58 |
| 397 | 05:52:39 | 11.5 | -0.63 | 10.95 | 17.811 | 10.32 |
| 398 | 05:52:39 | 11.5 | -0.38 | 8.42 | 22.445 | 8.04 |
| 399 | 05:52:39 | 11.5 | 0.43 | 11.73 | 15.721 | 12.16 |
| 400 | 05:52:40 | 11.5 | -0.35 | 9.55 | 26.454 | 9.2 |
| 401 | 05:52:40 | 11.5 | 0.04 | 8.68 | 22.261 | 8.71 |
| 402 | 05:52:40 | 11.5 | 0.34 | 9.52 | 21.931 | 9.85 |
| 403 | 05:52:41 | 11.5 | -0.81 | 14.54 | 27.946 | 13.73 |
| 404 | 05:52:41 | 11.5 | 1.45 | 12.84 | 19.67 | 14.29 |
| 405 | 05:52:42 | 11.5 | -0.24 | 9.25 | 19.743 | 9.01 |
| 406 | 05:52:42 | 11.5 | -0.47 | 9.35 | 19.278 | 8.88 |
| 407 | 05:52:43 | 11.5 | 0.29 | 9.51 | 21.564 | 9.81 |
| 408 | 05:52:43 | 11.5 | 1.09 | 7.73 | 24.657 | 8.82 |
| 409 | 05:52:44 | 11.5 | -0.82 | 10.56 | 20.22 | 9.74 |
| 410 | 05:52:44 | 11.5 | -0.89 | 14.84 | 22.286 | 13.95 |
| 411 | 05:52:45 | 11.5 | -0.43 | 14.25 | 19.657 | 13.81 |
| 412 | 05:52:45 | 11.5 | 1.05 | 10.12 | 28.312 | 11.17 |
| 413 | 05:52:46 | 11.5 | 0.06 | 13.04 | 23.899 | 13.11 |
| 414 | 05:52:47 | 11.5 | -0.14 | 12.87 | 21.772 | 12.72 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 415 | 05:52:47 | 11.5 | -1.03 | 15.19 | 25.916 | 14.16 |
| 416 | 05:52:48 | 11.5 | 2.07 | 9.67 | 23.63 | 11.74 |
| 417 | 05:52:48 | 11.5 | -1.53 | 12.41 | 26.894 | 10.87 |
| 418 | 05:52:49 | 11.5 | 1.45 | 8.36 | 25.501 | 9.81 |
| 419 | 05:52:54 | 11.5 | -0.3 | 11.25 | 20.22 | 10.95 |
| 420 | 05:52:54 | 11.5 | -0.31 | 10.74 | 20.599 | 10.43 |
| 421 | 05:52:55 | 11.5 | -1.23 | 13.99 | 21.43 | 12.77 |
| 422 | 05:52:55 | 11.5 | 0.2 | 11.89 | 23.288 | 12.09 |
| 423 | 05:52:55 | 11.5 | 0.2 | 15.35 | 20.745 | 15.55 |
| 424 | 05:52:56 | 11.5 | 0.04 | 9.15 | 18.508 | 9.18 |
| 425 | 05:52:56 | 11.5 | 0.83 | 12.15 | 22.066 | 12.98 |
| 426 | 05:52:56 | 11.5 | -0.41 | 9.05 | 21.895 | 8.64 |
| 427 | 05:52:57 | 11.5 | -2.05 | 13.31 | 27.09 | 11.26 |
| 428 | 05:52:57 | 11.48 | -19.56 | 32.72 | 23.264 | 13.15 |
| 429 | 05:52:57 | 11.48 | -0.54 | 13.11 | 19.156 | 12.57 |
| 430 | 05:52:58 | 11.48 | 0.87 | 14.11 | 22.445 | 14.98 |
| 431 | 05:52:58 | 11.24 | -<br>241.19 | 251.83 | 28.52 | 10.64 |
| 432 | 05:52:58 | 11.24 | -0.03 | 7.21 | 25.464 | 7.18 |
| 433 | 05:52:59 | 11.21 | -27.13 | 34.03 | 23.96 | 6.9 |
| 434 | 05:52:59 | 11.21 | -0.06 | 3.21 | 6.748 | 3.15 |
| 435 | 05:52:59 | 11.25 | 37.81 | -35.25 | 6.736 | 2.56 |
| 436 | 05:53:04 | 11.28 | 33.96 | -15.52 | 2.702 | 18.43 |
| 437 | 05:53:07 | 11.32 | 36.33 | -14.4 | 1.589 | 21.93 |
| 438 | 05:53:14 | 11.34 | 18.37 | 2.51 | 1.671 | 20.88 |
| 439 | 05:53:14 | 11.36 | 19.92 | 2.72 | 1.752 | 22.64 |
| 440 | 05:53:14 | 11.38 | 18.28 | 3.14 | 1.406 | 21.42 |
| 441 | 05:53:14 | 11.39 | 19.04 | 2.49 | 1.589 | 21.52 |
| 442 | 05:53:15 | 11.41 | 19.17 | 3.48 | 1.548 | 22.65 |
| 443 | 05:53:17 | 11.43 | 18.27 | 3.2 | 1.63 | 21.48 |
| 444 | 05:53:18 | 11.45 | 19.65 | 2.73 | 1.467 | 22.38 |
| 445 | 05:53:20 | 11.47 | 20.27 | 2.55 | 2.241 | 22.82 |
| 446 | 05:53:21 | 11.49 | 19.49 | 2.73 | 1.467 | 22.22 |
| 447 | 05:53:22 | 11.51 | 18.82 | 2.96 | 1.752 | 21.78 |
| 448 | 05:53:24 | 11.53 | 17.91 | 2.97 | 1.436 | 20.87 |
| 449 | 05:53:25 | 11.55 | 18.3 | 2.39 | 1.559 | 20.7 |
| 450 | 05:53:27 | 11.57 | 22.26 | 3.05 | 6.143 | 25.31 |
| 451 | 05:53:28 | 11.59 | 20.05 | 3.03 | 1.508 | 23.09 |

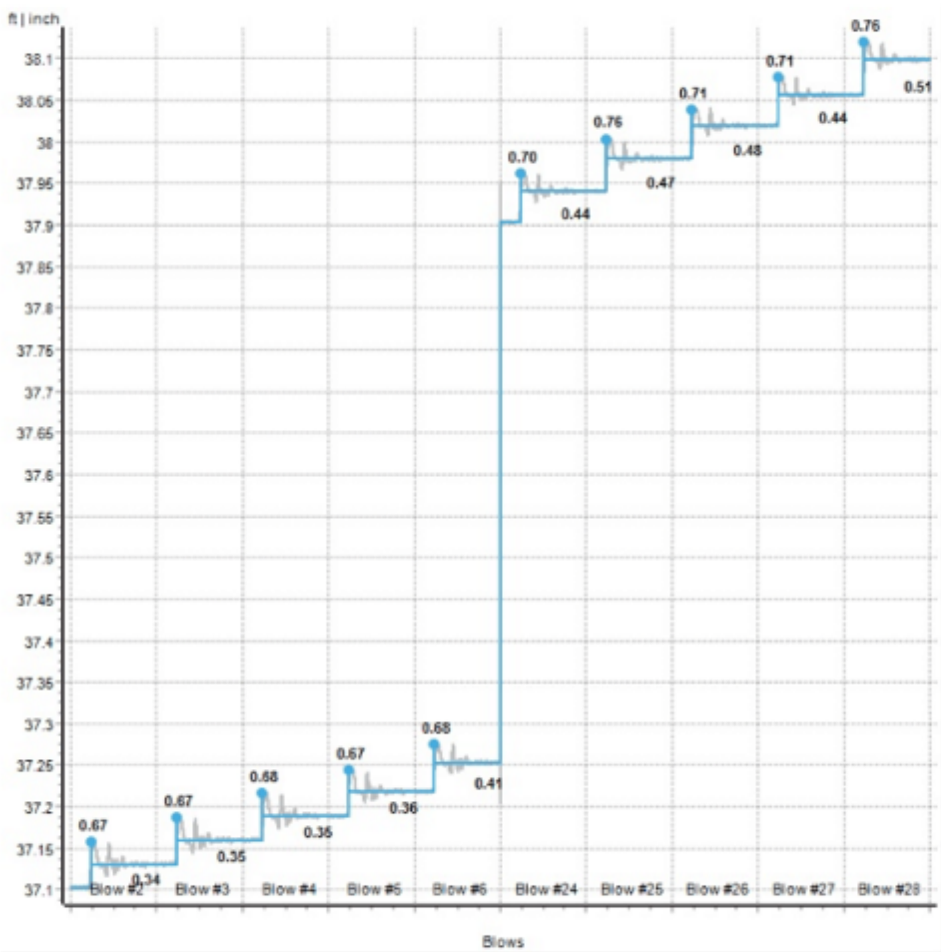
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 452 | 05:53:34 | 11.61 | 20.09 | 2.79 | 1.711 | 22.88 |
| 453 | 05:53:34 | 11.63 | 19.07 | 3.06 | 1.589 | 22.12 |
| 454 | 05:53:34 | 11.68 | 49.28 | -28.53 | 1.63 | 20.75 |
| 455 | 05:53:37 | 11.68 | 6.1 | 4.25 | 8.466 | 10.35 |
| 456 | 05:53:37 | 11.68 | 0 | 1.74 | 3.02 | 1.75 |
| 457 | 05:53:38 | 11.67 | -13.08 | 18.36 | 11.381 | 5.28 |
| 458 | 05:53:39 | 11.67 | -0.35 | 6.78 | 15.183 | 6.43 |
| 459 | 05:53:39 | 11.5 | -165.5 | 172.46 | 12.799 | 6.96 |
| 460 | 05:53:40 | 11.5 | -0.75 | 11.5 | 20.073 | 10.75 |
| 461 | 05:53:40 | 11.5 | -0.07 | 12.28 | 24.193 | 12.21 |
| 462 | 05:53:41 | 11.5 | -3.03 | 13.3 | 18.716 | 10.26 |
| 463 | 05:53:41 | 11.5 | -0.06 | 11.26 | 22.848 | 11.19 |
| 464 | 05:53:42 | 11.5 | -0.06 | 12.27 | 21.87 | 12.21 |
| 465 | 05:53:42 | 11.5 | 0.04 | 9.83 | 25.562 | 9.86 |
| 466 | 05:53:43 | 11.5 | -0.52 | 11.16 | 23.997 | 10.65 |
| 467 | 05:53:44 | 11.5 | 0.23 | 15.29 | 26.259 | 15.52 |
| 468 | 05:53:44 | 11.5 | 0.62 | 12.77 | 23.276 | 13.39 |
| 469 | 05:53:45 | 11.5 | 0.67 | 11.77 | 19.266 | 12.43 |
| 470 | 05:53:45 | 11.5 | -1.74 | 11.18 | 22.408 | 9.44 |
| 471 | 05:53:46 | 11.5 | 0.82 | 11.57 | 28.679 | 12.38 |
| 472 | 05:53:46 | 11.5 | 0.5 | 11.46 | 25.721 | 11.96 |
| 473 | 05:53:47 | 11.5 | 0.33 | 12.18 | 19.498 | 12.51 |
| 474 | 05:53:48 | 11.5 | -0.2 | 7.44 | 15.721 | 7.25 |
| 475 | 05:53:48 | 11.5 | -2.01 | 9.38 | 26.124 | 7.37 |
| 476 | 05:53:49 | 11.5 | -2.17 | 14.84 | 19.266 | 12.66 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 17/2/2019 |
| Client Name | | Report Time | 12:47:26 AM |
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Test Time | 5:41:58 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD | PDM Pile Offset (ft) | 29.950 |
| Pile Type | | Final Penetration at Blow 28 (ft) | 38.099 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Pile Number | 1-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.41 | VMX (ft/s) | 4.933 |
| Rebound (inch) | 0.29 | DMX (inch) | 0.70 |
| Capacity (kip) | - | | |

## TABLE VIEW

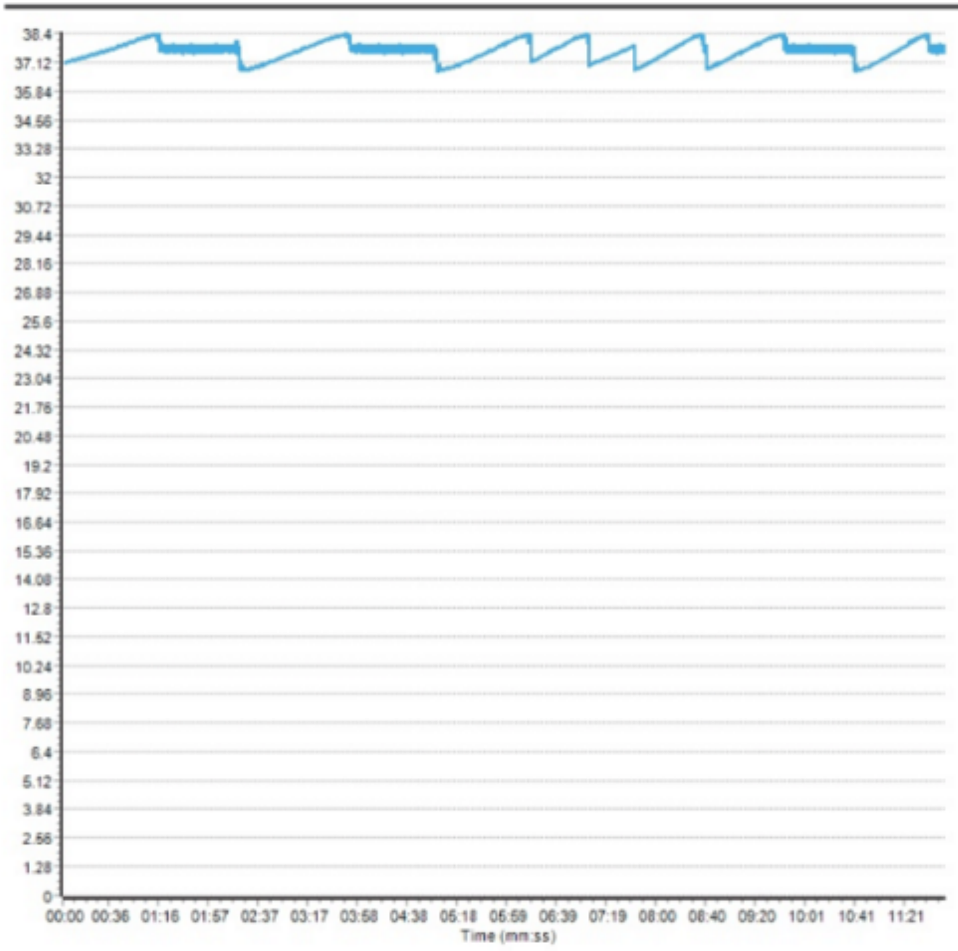
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 28 | 0.51 | 0.25 | 5.35 | 38.099 |
| 27 | 0.44 | 0.26 | 4.68 | 38.056 |
| 26 | 0.48 | 0.23 | 4.95 | 38.019 |
| 25 | 0.47 | 0.29 | 4.95 | 37.979 |
| 24 | 0.44 | 0.26 | 4.95 | 37.940 |
| 6 | 0.41 | 0.27 | 4.91 | 37.253 |
| 5 | 0.36 | 0.31 | 5.21 | 37.219 |
| 4 | 0.35 | 0.33 | 4.61 | 37.189 |
| 3 | 0.35 | 0.32 | 4.61 | 37.160 |
| 2 | 0.34 | 0.33 | 5.11 | 37.131 |
| Average | 0.41 inch | 0.29 inch | | |
| Max Variation | 0.17 inch | 0.10 inch | | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Pile Number | 1-EOD |

## COMPLETE VIEW



**Test 2 of 3**

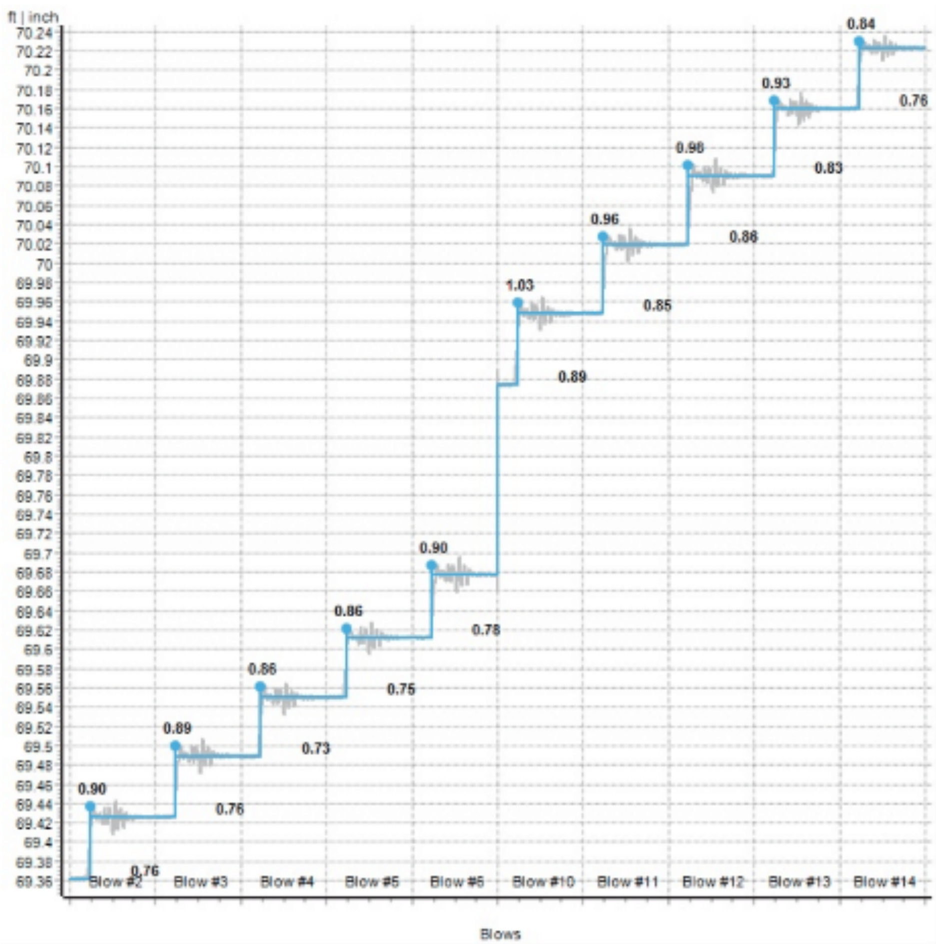
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 05:57:08 | 21.14 | 110.33 | 2.59 | 1.773 | 112.93 |
| 2 | 05:57:09 | 21.16 | 19.41 | 3.36 | 1.834 | 22.77 |
| 3 | 05:57:10 | 21.18 | 19.25 | 3.4 | 1.752 | 22.65 |
| 4 | 05:57:11 | 21.2 | 18.53 | 3.37 | 1.834 | 21.9 |
| 5 | 05:57:13 | 21.22 | 19.03 | 2.86 | 2.608 | 21.9 |
| 6 | 05:57:14 | 21.24 | 19.71 | 3.02 | 2.017 | 22.73 |
| 7 | 05:57:16 | 21.26 | 20.02 | 2.88 | 1.711 | 22.9 |
| 8 | 05:57:17 | 21.28 | 19.56 | 3.01 | 1.62 | 22.57 |
| 9 | 05:57:18 | 21.3 | 20.5 | 2.72 | 2.017 | 23.23 |
| 10 | 05:57:20 | 21.32 | 22.57 | 3.47 | 5.33 | 26.04 |
| 11 | 05:57:21 | 21.34 | 21.7 | 2.59 | 1.681 | 24.29 |
| 12 | 05:57:23 | 21.36 | 21.76 | 3.25 | 1.793 | 25.01 |
| 13 | 05:57:24 | 21.38 | 21.19 | 2.54 | 1.915 | 23.72 |
| 14 | 05:57:25 | 21.4 | 19.34 | 1.93 | 1.711 | 21.27 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 17/2/2019 |
| Client Name | | Report Time | 12:50:26 AM |
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Test Time | 5:57:07 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-2 | PDM Pile Offset (ft) | 29.950 |
| Pile Type | | Final Penetration at Blow 14 (ft) | 70.223 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Pile Number | 1-EOD-2 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.80 | VMX (ft/s) | 7.374 |
| Rebound (inch) | 0.12 | DMX (inch) | 0.91 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 14 | 0.76 | 0.08 | 5.62 | 70.223 |
| 13 | 0.83 | 0.10 | 6.28 | 70.160 |
| 12 | 0.86 | 0.13 | 5.88 | 70.090 |
| 11 | 0.85 | 0.10 | 5.51 | 70.019 |
| 10 | 0.89 | 0.14 | 17.49 | 69.948 |
| 6 | 0.78 | 0.12 | 6.62 | 69.677 |
| 5 | 0.75 | 0.11 | 8.56 | 69.612 |
| 4 | 0.73 | 0.13 | 6.02 | 69.550 |
| 3 | 0.76 | 0.13 | 5.75 | 69.489 |
| 2 | 0.76 | 0.13 | 6.02 | 69.426 |
| Average | 0.80 inch | 0.12 inch | | |
| Max Variation | 0.16 inch | 0.06 inch | | |

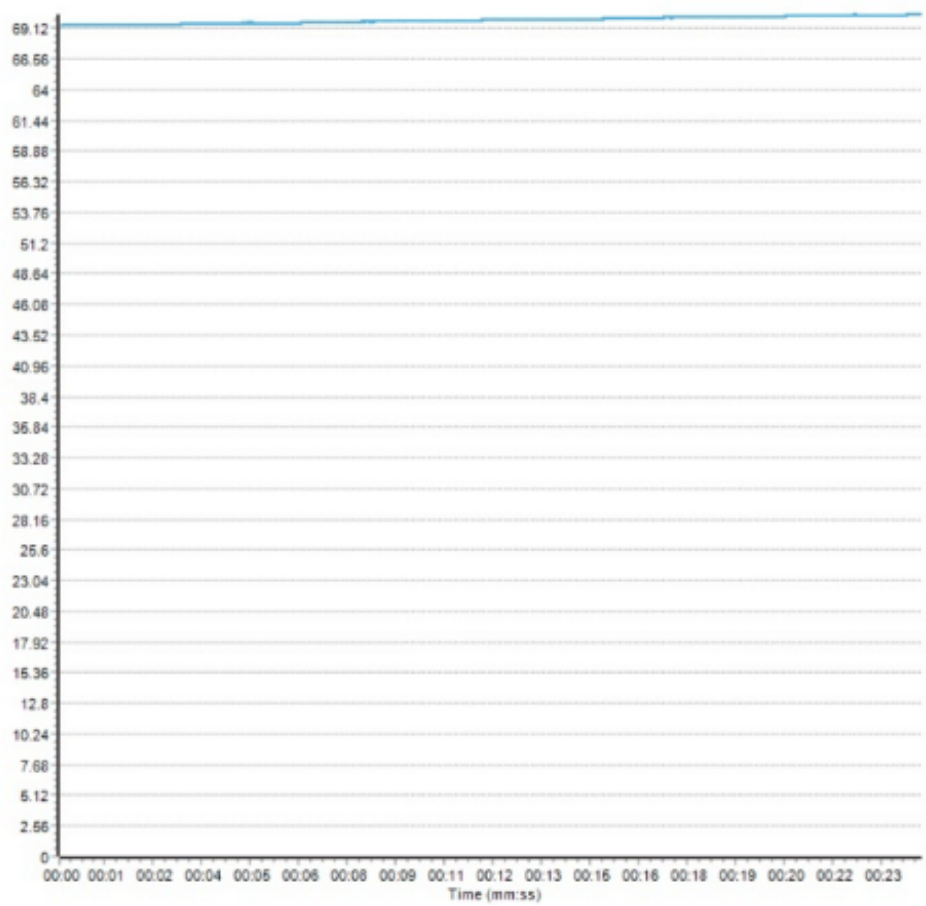
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Pile Number | 1-EOD-2 |

## COMPLETE VIEW



**Test 3 of 3**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 05:58:32 | 23.6 | 430.76 | 3.34 | 9.156 | 434.1 |
| 2 | 05:58:32 | 23.59 | -0.59 | 4.16 | 8.239 | 3.57 |
| 3 | 05:58:32 | 23.5 | -97.64 | 102.33 | 8.398 | 4.69 |
| 4 | 05:58:33 | 23.51 | 16.85 | 13.96 | 17.31 | 30.82 |
| 5 | 05:58:34 | 23.52 | 0.92 | 9.19 | 18.325 | 10.1 |
| 6 | 05:58:34 | 23.41 | -102.12 | 112.61 | 18.154 | 10.49 |
| 7 | 05:58:35 | 23.41 | -0.03 | 13.91 | 26.259 | 13.88 |
| 8 | 05:58:35 | 23.41 | -0.49 | 13.83 | 22.408 | 13.34 |
| 9 | 05:58:36 | 23.41 | 0.23 | 13.14 | 31.271 | 13.37 |
| 10 | 05:58:36 | 23.41 | 0.03 | 10.85 | 23.924 | 10.88 |
| 11 | 05:58:37 | 23.41 | 0.76 | 8.81 | 18.826 | 9.58 |
| 12 | 05:58:38 | 23.41 | -0.89 | 10.72 | 26.54 | 9.83 |
| 13 | 05:58:38 | 23.41 | 1.6 | 12.11 | 22.97 | 13.71 |
| 14 | 05:58:39 | 23.41 | -0.63 | 9.98 | 22.445 | 9.35 |
| 15 | 05:58:39 | 23.41 | -1.7 | 10.28 | 23.606 | 8.58 |
| 16 | 05:58:40 | 23.41 | 0.77 | 13.46 | 20.061 | 14.23 |
| 17 | 05:58:41 | 23.41 | 1.03 | 12.77 | 21.271 | 13.8 |
| 18 | 05:58:41 | 23.41 | -0.7 | 9.75 | 18.166 | 9.06 |
| 19 | 05:58:42 | 23.42 | 2.14 | 11.91 | 23.63 | 14.05 |
| 20 | 05:58:42 | 23.41 | -4.23 | 12.87 | 22.75 | 8.64 |
| 21 | 05:58:43 | 23.41 | 3.05 | 8.36 | 22.445 | 11.41 |
| 22 | 05:58:43 | 23.41 | -0.41 | 12.11 | 21.564 | 11.7 |
| 23 | 05:58:44 | 23.41 | -0.05 | 15.41 | 24.657 | 15.36 |
| 24 | 05:58:44 | 23.41 | -0.72 | 13.66 | 24.89 | 12.94 |
| 25 | 05:58:45 | 23.41 | 0 | 9.65 | 20.489 | 9.65 |
| 26 | 05:58:45 | 23.41 | -0.25 | 11.97 | 20.953 | 11.71 |
| 27 | 05:58:46 | 23.41 | 0.64 | 9.28 | 21.87 | 9.92 |
| 28 | 05:58:47 | 23.41 | 0.11 | 10.57 | 20.953 | 10.68 |
| 29 | 05:58:47 | 23.41 | -0.93 | 15.67 | 21.271 | 14.74 |
| 30 | 05:58:48 | 23.41 | 1.01 | 14.48 | 22.714 | 15.49 |
| 31 | 05:58:48 | 23.41 | -0.18 | 9.95 | 19.67 | 9.78 |
| 32 | 05:58:49 | 23.41 | -0.67 | 12.38 | 23.716 | 11.71 |
| 33 | 05:58:49 | 23.41 | -1.77 | 11.37 | 22.286 | 9.61 |
| 34 | 05:58:50 | 23.41 | 1.76 | 11.71 | 20.232 | 13.47 |
| 35 | 05:58:50 | 23.41 | 0.77 | 13.17 | 20.831 | 13.94 |
| 36 | 05:58:51 | 23.41 | -0.66 | 8.85 | 18.508 | 8.19 |
| 37 | 05:58:56 | 23.41 | 0.9 | 13.56 | 19.67 | 14.46 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 38 | 05:58:56 | 23.41 | -1.68 | 10.71 | 18.508 | 9.03 |
| 39 | 05:58:56 | 23.41 | 2.35 | 7.66 | 20.953 | 10.01 |
| 40 | 05:58:57 | 23.41 | -1.46 | 12.98 | 25.916 | 11.52 |
| 41 | 05:58:57 | 23.41 | 0.85 | 9.14 | 20.097 | 9.99 |
| 42 | 05:58:57 | 23.41 | -0.68 | 11.23 | 25.55 | 10.55 |
| 43 | 05:58:58 | 23.41 | 0.67 | 8.68 | 23.716 | 9.36 |
| 44 | 05:58:58 | 23.41 | -1.01 | 9.47 | 27.75 | 8.45 |
| 45 | 05:58:58 | 23.41 | 0.76 | 9.05 | 24.156 | 9.8 |
| 46 | 05:58:59 | 23.41 | -1.89 | 10.72 | 26.259 | 8.84 |
| 47 | 05:58:59 | 23.41 | 2.66 | 10.62 | 23.484 | 13.29 |
| 48 | 05:58:59 | 23.41 | 0.08 | 8.15 | 20.953 | 8.23 |
| 49 | 05:58:59 | 23.41 | -1.38 | 10.52 | 22.775 | 9.14 |
| 50 | 05:59:00 | 23.41 | 0.32 | 8.21 | 23.056 | 8.52 |
| 51 | 05:59:00 | 23.41 | -0.64 | 10.19 | 22.714 | 9.55 |
| 52 | 05:59:00 | 23.41 | 0.15 | 14.69 | 21.784 | 14.84 |
| 53 | 05:59:01 | 23.4 | -13.61 | 24.93 | 24.608 | 11.31 |
| 54 | 05:59:01 | 23.4 | -0.07 | 13.38 | 20.318 | 13.31 |
| 55 | 05:59:02 | 23.15 | -244.21 | 255.67 | 23.423 | 11.46 |
| 56 | 05:59:02 | 23.15 | -2.82 | 19.43 | 29.743 | 16.61 |
| 57 | 05:59:03 | 23.15 | -3.27 | 12.15 | 27.2 | 8.88 |
| 58 | 05:59:04 | 23.13 | -20.86 | 2.62 | 23.826 | -18.24 |
| 59 | 05:59:04 | 23.13 | 0.25 | 2.13 | 4.927 | 2.38 |
| 60 | 05:59:05 | 23.15 | 25.46 | -16.67 | 5.367 | 8.78 |
| 61 | 05:59:09 | 23.17 | 12.42 | 3.2 | 2.653 | 15.62 |
| 62 | 05:59:11 | 23.18 | 14.61 | 3.87 | 1.626 | 18.48 |
| 63 | 05:59:16 | 23.2 | 15.01 | 3.76 | 1.62 | 18.76 |
| 64 | 05:59:17 | 23.21 | 14.75 | 3.87 | 1.694 | 18.62 |
| 65 | 05:59:17 | 23.23 | 14.98 | 3.7 | 1.729 | 18.68 |
| 66 | 05:59:17 | 23.24 | 14.05 | 3.87 | 1.554 | 17.91 |
| 67 | 05:59:18 | 23.25 | 14.08 | 3.82 | 1.589 | 17.9 |
| 68 | 05:59:19 | 23.27 | 13.4 | 3.36 | 1.502 | 16.75 |
| 69 | 05:59:21 | 23.28 | 13.57 | 3.33 | 2.008 | 16.9 |
| 70 | 05:59:22 | 23.29 | 12.15 | 3.7 | 1.484 | 15.86 |
| 71 | 05:59:23 | 23.3 | 12.17 | 3.99 | 1.45 | 16.15 |
| 72 | 05:59:25 | 23.32 | 11.89 | 3.95 | 1.554 | 15.84 |
| 73 | 05:59:26 | 23.33 | 11.64 | 3.86 | 1.426 | 15.5 |
| 74 | 05:59:28 | 23.34 | 11.53 | 3.82 | 1.554 | 15.35 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 75 | 05:59:29 | 23.35 | 11.27 | 3.8 | 1.65 | 15.07 |
| 76 | 05:59:31 | 23.36 | 11.02 | 3.91 | 1.487 | 14.92 |
| 77 | 05:59:36 | 23.37 | 12.17 | 3.71 | 1.467 | 15.88 |
| 78 | 05:59:36 | 23.39 | 11 | 4.39 | 1.327 | 15.39 |
| 79 | 05:59:37 | 23.4 | 10.88 | 3.99 | 1.624 | 14.87 |
| 80 | 05:59:37 | 23.41 | 10.19 | 4.25 | 1.45 | 14.43 |
| 81 | 05:59:38 | 23.42 | 10.49 | 4.29 | 1.345 | 14.78 |
| 82 | 05:59:39 | 23.43 | 10.82 | 4.16 | 1.513 | 14.97 |
| 83 | 05:59:41 | 23.44 | 10.14 | 4.18 | 1.635 | 14.33 |
| 84 | 05:59:42 | 23.45 | 9.83 | 4.2 | 1.375 | 14.03 |
| 85 | 05:59:43 | 23.46 | 9.96 | 3.79 | 1.391 | 13.75 |
| 86 | 05:59:45 | 23.47 | 12.94 | 4.35 | 3.166 | 17.29 |
| 87 | 05:59:46 | 23.48 | 10.25 | 4.36 | 1.659 | 14.61 |
| 88 | 05:59:48 | 23.49 | 10.06 | 4.57 | 1.345 | 14.63 |
| 89 | 05:59:49 | 23.5 | 10.09 | 3.94 | 1.484 | 14.04 |
| 90 | 05:59:51 | 23.51 | 9.2 | 4.13 | 1.554 | 13.33 |
| 91 | 05:59:56 | 23.52 | 10.12 | 4.24 | 1.773 | 14.36 |
| 92 | 05:59:56 | 23.53 | 10.03 | 4.87 | 1.447 | 14.9 |
| 93 | 05:59:56 | 23.54 | 10.1 | 4.01 | 1.554 | 14.11 |
| 94 | 05:59:57 | 23.55 | 9.23 | 4.5 | 1.45 | 13.73 |
| 95 | 05:59:58 | 23.57 | 20.44 | -8.59 | 1.397 | 11.85 |
| 96 | 06:00:02 | 23.59 | 20.64 | -10.76 | 1.864 | 9.87 |
| 97 | 06:00:07 | 23.59 | 0.37 | 3.44 | 4.205 | 3.8 |
| 98 | 06:00:08 | 23.59 | 3.47 | 5.29 | 6.027 | 8.76 |
| 99 | 06:00:09 | 23.59 | 0.49 | 3.27 | 5.269 | 3.76 |
| 100 | 06:00:09 | 23.59 | -8.24 | 12.05 | 7.812 | 3.81 |
| 101 | 06:00:10 | 23.59 | 0.17 | 5.26 | 14.327 | 5.43 |
| 102 | 06:00:11 | 23.56 | -29.83 | 36.29 | 12.75 | 6.46 |
| 103 | 06:00:16 | 23.56 | 3.29 | 14.57 | 33.007 | 17.86 |
| 104 | 06:00:16 | 23.5 | -61.86 | 70.45 | 27.775 | 8.59 |
| 105 | 06:00:17 | 23.5 | -0.81 | 9.89 | 17.212 | 9.07 |
| 106 | 06:00:17 | 23.5 | -0.45 | 11.7 | 25.403 | 11.25 |
| 107 | 06:00:17 | 23.42 | -81.72 | 92.3 | 17.811 | 10.57 |
| 108 | 06:00:17 | 23.42 | 0.16 | 11.64 | 25.097 | 11.8 |
| 109 | 06:00:18 | 23.41 | -2.58 | 19.28 | 24.547 | 16.7 |
| 110 | 06:00:18 | 23.41 | 0.4 | 10.93 | 18.496 | 11.33 |
| 111 | 06:00:18 | 23.41 | -0.56 | 8.87 | 24.608 | 8.31 |
| 112 | 06:00:19 | 23.41 | 0.8 | 11.26 | 21.43 | 12.05 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 113 | 06:00:19 | 23.41 | -1.42 | 14.23 | 23.264 | 12.81 |
| 114 | 06:00:19 | 23.41 | 0.01 | 9.53 | 23.288 | 9.53 |
| 115 | 06:00:20 | 23.41 | 2.36 | 11.62 | 25.293 | 13.99 |
| 116 | 06:00:20 | 23.41 | -0.02 | 9.08 | 22.445 | 9.06 |
| 117 | 06:00:20 | 23.41 | -2.6 | 14.47 | 24.792 | 11.87 |
| 118 | 06:00:20 | 23.41 | 0.4 | 14.69 | 19.841 | 15.09 |
| 119 | 06:00:21 | 23.41 | 0.81 | 8.91 | 22.775 | 9.72 |
| 120 | 06:00:21 | 23.41 | -0.36 | 11.57 | 20.733 | 11.21 |
| 121 | 06:00:22 | 23.41 | -0.12 | 11.03 | 22.127 | 10.91 |
| 122 | 06:00:22 | 23.41 | 0.1 | 10.91 | 19.67 | 11.01 |
| 123 | 06:00:23 | 23.41 | 1.57 | 9.21 | 22.738 | 10.78 |
| 124 | 06:01:30 | 23.41 | -1.6 | 13.75 | 23.019 | 12.15 |
| 125 | 06:01:30 | 23.41 | 0.98 | 12.95 | 20.953 | 13.93 |
| 126 | 06:01:31 | 23.41 | -0.85 | 12.08 | 24.89 | 11.23 |
| 127 | 06:01:32 | 23.41 | -0.28 | 11.9 | 24.217 | 11.62 |
| 128 | 06:01:32 | 23.41 | -0.12 | 10.15 | 21.674 | 10.03 |
| 129 | 06:01:33 | 23.41 | 0.57 | 10.11 | 20.611 | 10.68 |
| 130 | 06:01:34 | 23.41 | 0.25 | 11.43 | 19.425 | 11.69 |
| 131 | 06:01:34 | 23.41 | 0.61 | 10.56 | 20.061 | 11.17 |
| 132 | 06:01:35 | 23.41 | -0.74 | 10.38 | 19.266 | 9.64 |
| 133 | 06:01:35 | 23.41 | -1.37 | 15.14 | 21.87 | 13.77 |
| 134 | 06:01:36 | 23.41 | 1.11 | 11.38 | 18.508 | 12.49 |
| 135 | 06:01:36 | 23.41 | -0.21 | 12.92 | 21.43 | 12.71 |
| 136 | 06:01:37 | 23.41 | 0.7 | 10.22 | 18.985 | 10.92 |
| 137 | 06:01:38 | 23.41 | -0.53 | 10.39 | 17.555 | 9.86 |
| 138 | 06:01:38 | 23.41 | -0.55 | 13.71 | 31.687 | 13.15 |
| 139 | 06:01:39 | 23.41 | 1.24 | 10.2 | 25.501 | 11.44 |
| 140 | 06:01:39 | 23.41 | 0.41 | 9.32 | 25.916 | 9.73 |
| 141 | 06:01:40 | 23.41 | -0.71 | 9.56 | 20.599 | 8.85 |
| 142 | 06:01:41 | 23.41 | -2.29 | 11.63 | 24.584 | 9.33 |
| 143 | 06:01:41 | 23.41 | 1.94 | 12.09 | 22.934 | 14.03 |
| 144 | 06:01:42 | 23.42 | 2.2 | 5.29 | 18.252 | 7.49 |
| 145 | 06:01:42 | 23.41 | -3.32 | 12.94 | 19.657 | 9.62 |
| 146 | 06:01:43 | 23.41 | 1.11 | 11.96 | 18.716 | 13.07 |
| 147 | 06:01:43 | 23.41 | -3.34 | 9.9 | 23.264 | 6.56 |
| 148 | 06:01:44 | 23.41 | 2.7 | 7.65 | 19.951 | 10.35 |
| 149 | 06:01:44 | 23.41 | -4.2 | 13.81 | 20.953 | 9.62 |
| 150 | 06:01:45 | 23.41 | 0.95 | 9.5 | 24.278 | 10.45 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 151 | 06:01:45 | 23.41 | -1.45 | 15.75 | 19.144 | 14.29 |
| 152 | 06:01:46 | 23.4 | -5.28 | 18.38 | 24.376 | 13.1 |
| 153 | 06:01:46 | 23.4 | -0.05 | 8.35 | 23.643 | 8.3 |
| 154 | 06:01:47 | 23.4 | 0.37 | 14.59 | 27.897 | 14.96 |
| 155 | 06:01:48 | 23.39 | -10.91 | 12.43 | 23.924 | 1.52 |
| 156 | 06:01:48 | 23.39 | -0.6 | 16.33 | 22.481 | 15.73 |
| 157 | 06:01:49 | 23.35 | -38.51 | 52.02 | 24.706 | 13.51 |
| 158 | 06:01:49 | 23.36 | 6.42 | 37.75 | 30.171 | 44.17 |
| 159 | 06:01:54 | 23.36 | 5.38 | 20.61 | 27.726 | 25.99 |
| 160 | 06:01:55 | 23.32 | -47.55 | 68.95 | 31.014 | 21.39 |
| 161 | 06:01:55 | 23.31 | -3.97 | 13.82 | 25.733 | 9.85 |
| 162 | 06:01:55 | 23.31 | -0.94 | 11 | 23.386 | 10.06 |
| 163 | 06:01:56 | 23.15 | -157 | 166.92 | 22.934 | 9.92 |
| 164 | 06:01:56 | 23.15 | -0.37 | 7.08 | 23.802 | 6.71 |
| 165 | 06:01:56 | 23.15 | -9.49 | 16.87 | 26.014 | 7.37 |
| 166 | 06:01:57 | 23.14 | -1.25 | 6.03 | 10.672 | 4.78 |
| 167 | 06:01:57 | 23.14 | -4.73 | 9.79 | 11.662 | 5.06 |
| 168 | 06:01:57 | 23.14 | -3.88 | 6.21 | 13.973 | 2.33 |
| 169 | 06:01:57 | 23.13 | -2.32 | 5.2 | 9.156 | 2.88 |
| 170 | 06:01:58 | 23.13 | -0.82 | 3.41 | 10.819 | 2.58 |
| 171 | 06:01:58 | 23.13 | -0.04 | 3.12 | 5.464 | 3.08 |
| 172 | 06:01:58 | 23.14 | 3.83 | -0.98 | 6.748 | 2.86 |
| 173 | 06:02:02 | 23.14 | 2.92 | 3.94 | 5.049 | 6.86 |
| 174 | 06:02:04 | 23.17 | 34.09 | -25.93 | 2.457 | 8.16 |
| 175 | 06:02:17 | 23.18 | 5 | 5.23 | 2.995 | 10.23 |
| 176 | 06:02:18 | 23.18 | 5.16 | 5.77 | 1.394 | 10.93 |
| 177 | 06:02:20 | 23.19 | 5.23 | 5.91 | 1.369 | 11.14 |
| 178 | 06:02:21 | 23.19 | 5.29 | 5.93 | 1.724 | 11.22 |
| 179 | 06:02:23 | 23.2 | 5.24 | 5.82 | 1.663 | 11.06 |
| 180 | 06:02:24 | 23.2 | 5.18 | 6.04 | 1.296 | 11.22 |
| 181 | 06:02:25 | 23.21 | 10.33 | 0.99 | 1.455 | 11.32 |
| 182 | 06:02:28 | 23.22 | 5.59 | 6.16 | 1.369 | 11.75 |
| 183 | 06:02:34 | 23.23 | 5.23 | 5.54 | 1.491 | 10.77 |
| 184 | 06:02:34 | 23.23 | 5.17 | 5.37 | 1.345 | 10.53 |
| 185 | 06:02:35 | 23.24 | 4.88 | 5.87 | 1.332 | 10.75 |
| 186 | 06:02:35 | 23.24 | 4.82 | 5.59 | 1.271 | 10.41 |
| 187 | 06:02:36 | 23.25 | 5.05 | 5.64 | 1.332 | 10.69 |
| 188 | 06:02:37 | 23.25 | 5.4 | 5.48 | 1.235 | 10.88 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 189 | 06:02:39 | 23.26 | 5.24 | 5.34 | 1.394 | 10.58 |
| 190 | 06:02:40 | 23.26 | 4.94 | 5.62 | 1.467 | 10.56 |
| 191 | 06:02:41 | 23.27 | 6.31 | 5.83 | 1.455 | 12.14 |
| 192 | 06:02:43 | 23.27 | 4.75 | 5.66 | 1.394 | 10.41 |
| 193 | 06:02:44 | 23.28 | 4.54 | 5.77 | 1.198 | 10.31 |
| 194 | 06:02:46 | 23.28 | 4.79 | 6.05 | 1.32 | 10.85 |
| 195 | 06:02:47 | 23.29 | 4.88 | 5.36 | 1.32 | 10.23 |
| 196 | 06:02:49 | 23.3 | 16.55 | -6.76 | 1.381 | 9.78 |
| 197 | 06:02:55 | 23.31 | 4.61 | 6.17 | 1.369 | 10.77 |
| 198 | 06:02:56 | 23.31 | 4.75 | 5.81 | 1.528 | 10.56 |
| 199 | 06:02:57 | 23.32 | 4.89 | 5.41 | 1.43 | 10.3 |
| 200 | 06:02:59 | 23.32 | 4.74 | 5.87 | 1.308 | 10.61 |
| 201 | 06:03:00 | 23.33 | 8.72 | 1.33 | 1.32 | 10.05 |
| 202 | 06:03:03 | 23.33 | 4.25 | 5.08 | 1.369 | 9.33 |
| 203 | 06:03:04 | 23.35 | 13.23 | -3.45 | 1.284 | 9.78 |
| 204 | 06:03:09 | 23.35 | 4.49 | 5.74 | 1.418 | 10.23 |
| 205 | 06:03:14 | 23.36 | 4.47 | 5.32 | 1.308 | 9.79 |
| 206 | 06:03:15 | 23.37 | 9.64 | 0.9 | 1.161 | 10.53 |
| 207 | 06:03:15 | 23.37 | 4.34 | 5.38 | 1.369 | 9.72 |
| 208 | 06:03:16 | 23.37 | 4.46 | 5.84 | 1.112 | 10.3 |
| 209 | 06:03:17 | 23.38 | 8.91 | 1.57 | 1.308 | 10.48 |
| 210 | 06:03:20 | 23.39 | 4.51 | 5.8 | 1.235 | 10.31 |
| 211 | 06:03:22 | 23.39 | 4.45 | 5.4 | 1.418 | 9.85 |
| 212 | 06:03:23 | 23.4 | 4.39 | 5.94 | 1.271 | 10.33 |
| 213 | 06:03:24 | 23.4 | 4.5 | 6.35 | 1.394 | 10.86 |
| 214 | 06:03:26 | 23.41 | 4.7 | 6.2 | 1.332 | 10.91 |
| 215 | 06:03:27 | 23.41 | 5.14 | 5.67 | 1.479 | 10.81 |
| 216 | 06:03:29 | 23.42 | 4.82 | 5.53 | 1.271 | 10.35 |
| 217 | 06:03:34 | 23.42 | 4.67 | 5.44 | 1.186 | 10.11 |
| 218 | 06:03:35 | 23.43 | 4.49 | 5.34 | 1.406 | 9.82 |
| 219 | 06:03:35 | 23.43 | 4.15 | 6.1 | 1.43 | 10.25 |
| 220 | 06:03:35 | 23.43 | 4.74 | 5.94 | 1.406 | 10.67 |
| 221 | 06:03:36 | 23.44 | 6 | 4.98 | 1.247 | 10.98 |
| 222 | 06:03:38 | 23.45 | 7.93 | 2.33 | 1.21 | 10.26 |
| 223 | 06:03:40 | 23.46 | 11.41 | -1.8 | 4.56 | 9.61 |
| 224 | 06:03:45 | 23.47 | 14.86 | -1.8 | 2.653 | 13.06 |
| 225 | 06:03:47 | 23.48 | 0.41 | 14.84 | 17.029 | 15.24 |
| 226 | 06:03:49 | 23.48 | 4.06 | 6.17 | 4.34 | 10.23 |

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 227 | 06:03:55 | 23.49 | 8.42 | 2.02 | 1.687 | 10.43 |
| 228 | 06:03:55 | 23.49 | 4.31 | 5.78 | 1.43 | 10.09 |
| 229 | 06:03:56 | 23.5 | 4.27 | 5.3 | 1.443 | 9.57 |
| 230 | 06:03:56 | 23.5 | 8.8 | 1.59 | 1.259 | 10.39 |
| 231 | 06:03:59 | 23.51 | 4.47 | 5.71 | 1.308 | 10.18 |
| 232 | 06:04:01 | 23.51 | 4.4 | 5.53 | 1.259 | 9.93 |
| 233 | 06:04:02 | 23.52 | 4.62 | 5.78 | 1.504 | 10.41 |
| 234 | 06:04:03 | 23.52 | 4.64 | 6.1 | 1.345 | 10.74 |
| 235 | 06:04:05 | 23.53 | 4.6 | 5.67 | 1.308 | 10.28 |
| 236 | 06:04:06 | 23.54 | 8.71 | 1.64 | 1.222 | 10.35 |
| 237 | 06:04:09 | 23.54 | 4.27 | 5.23 | 1.357 | 9.5 |
| 238 | 06:04:15 | 23.58 | 42.39 | -32.81 | 1.308 | 9.58 |
| 239 | 06:04:28 | 23.58 | 0.22 | 1.03 | 3.142 | 1.25 |
| 240 | 06:04:34 | 23.59 | 5.12 | 2.3 | 3.423 | 7.43 |
| 241 | 06:04:35 | 23.59 | 1.07 | 1.03 | 4.975 | 2.09 |
| 242 | 06:04:35 | 23.59 | 0.71 | 2.92 | 8.594 | 3.63 |
| 243 | 06:04:36 | 23.59 | 0.16 | 2.13 | 6.516 | 2.28 |
| 244 | 06:04:36 | 23.59 | 0.62 | 3.1 | 10.636 | 3.72 |
| 245 | 06:04:36 | 23.59 | -0.36 | 4.81 | 7.176 | 4.45 |
| 246 | 06:04:37 | 23.59 | -2.01 | 5.77 | 6.491 | 3.76 |
| 247 | 06:04:37 | 23.59 | -0.52 | 4.97 | 10.953 | 4.45 |
| 248 | 06:04:38 | 23.58 | -9.79 | 15.12 | 12.812 | 5.33 |
| 249 | 06:04:39 | 23.58 | 2.67 | 9.19 | 15.391 | 11.86 |
| 250 | 06:04:39 | 23.58 | -0.16 | 7.6 | 14.144 | 7.44 |
| 251 | 06:04:40 | 23.57 | -12.12 | 18.11 | 13.851 | 5.99 |
| 252 | 06:04:41 | 23.55 | -14.9 | 24.3 | 28.202 | 9.4 |
| 253 | 06:04:41 | 23.55 | 0.4 | 21.46 | 24.841 | 21.87 |
| 254 | 06:04:42 | 23.55 | 0.34 | 9 | 28.215 | 9.33 |
| 255 | 06:04:43 | 23.53 | -24.33 | 31.42 | 29.559 | 7.09 |
| 256 | 06:04:43 | 23.53 | 2.17 | 10.11 | 19.168 | 12.28 |
| 257 | 06:04:44 | 23.42 | -112.37 | 125.3 | 18.569 | 12.92 |
| 258 | 06:04:44 | 23.42 | 0.71 | 19.79 | 22.261 | 20.5 |
| 259 | 06:04:45 | 23.42 | 0.44 | 9.98 | 22.591 | 10.42 |
| 260 | 06:04:45 | 23.42 | -5.41 | 16.64 | 20.88 | 11.23 |
| 261 | 06:04:46 | 23.42 | 1.11 | 11.15 | 19.841 | 12.25 |
| 262 | 06:04:47 | 23.41 | -1.89 | 12.76 | 21.87 | 10.87 |
| 263 | 06:04:47 | 23.42 | 0.66 | 14.57 | 21.895 | 15.23 |

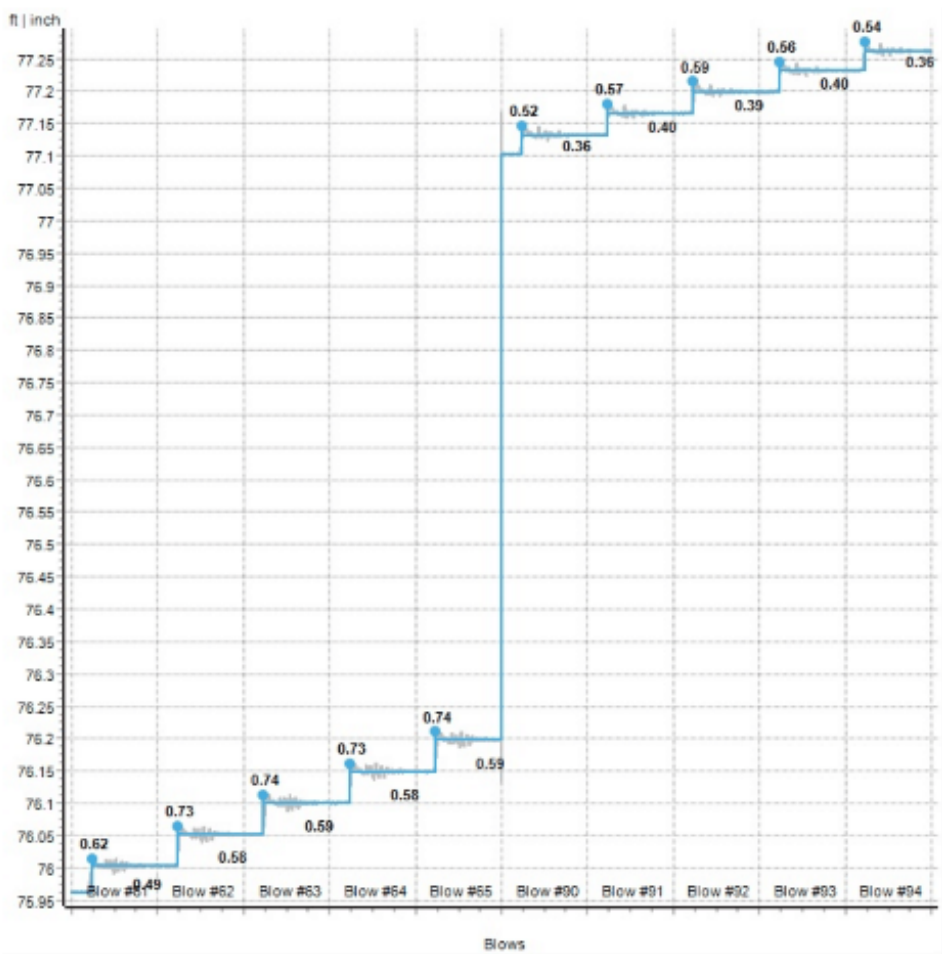
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 264 | 06:04:48 | 23.41 | -1.38 | 11.36 | 21.406 | 9.98 |
| 265 | 06:04:48 | 23.41 | -0.79 | 15.26 | 22.97 | 14.47 |
| 266 | 06:04:49 | 23.42 | 2.17 | 9.99 | 18.447 | 12.17 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 17/2/2019 |
| Client Name | | Report Time | 12:57:49 AM |
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Test Time | 5:58:31 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-3 | PDM Pile Offset (ft) | 29.950 |
| Pile Type | | Final Penetration at Blow 94 (ft) | 77.262 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Pile Number | 1-EOD-3 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.47 | VMX (ft/s) | 5.610 |
| Rebound (inch) | 0.16 | DMX (inch) | 0.63 |
| Capacity (kip) | - | | |

## TABLE VIEW

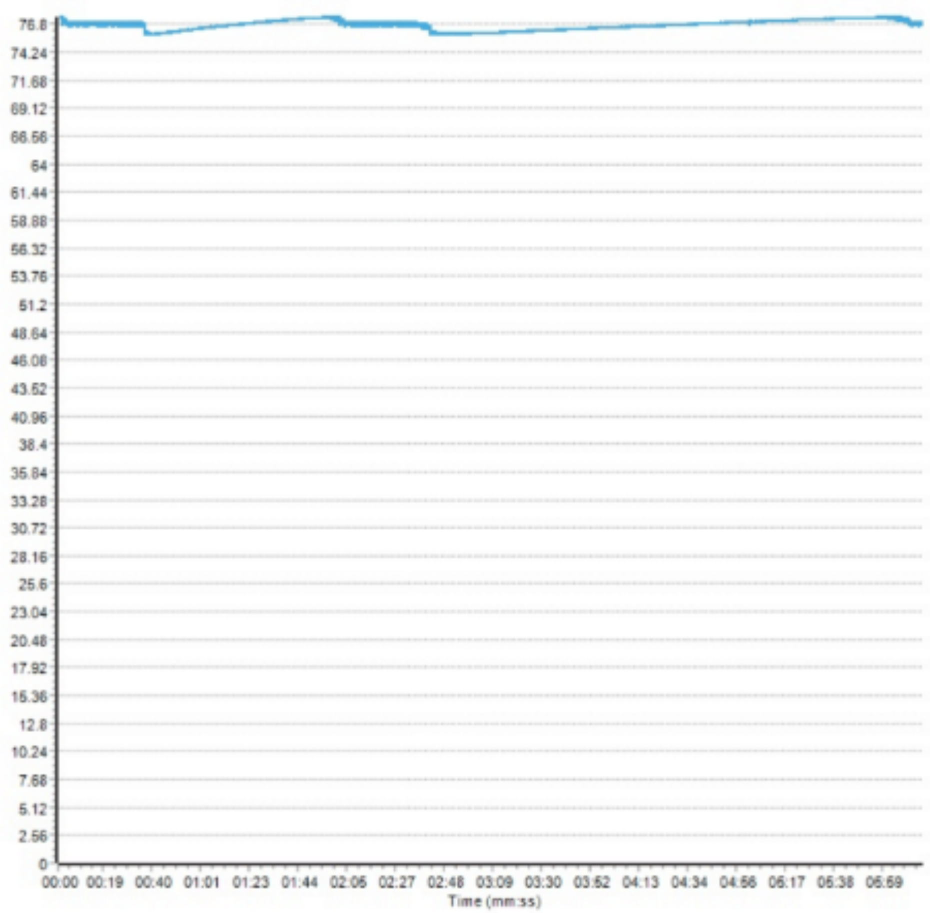
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 94 | 0.36 | 0.18 | 4.76 | 77.262 |
| 93 | 0.40 | 0.16 | 5.10 | 77.232 |
| 92 | 0.39 | 0.19 | 4.75 | 77.199 |
| 91 | 0.40 | 0.17 | 5.82 | 77.166 |
| 90 | 0.36 | 0.16 | 5.10 | 77.132 |
| 65 | 0.59 | 0.15 | 5.67 | 76.198 |
| 64 | 0.58 | 0.15 | 5.56 | 76.149 |
| 63 | 0.59 | 0.15 | 5.31 | 76.101 |
| 62 | 0.58 | 0.15 | 5.33 | 76.051 |
| 61 | 0.49 | 0.13 | 8.70 | 76.003 |
| Average | 0.47 inch | 0.16 inch | | |
| Max Variation | 0.23 inch | 0.07 inch | | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Port | Test Date | 3/6/2018 |
| Project Description | | Pile Number | 1-EOD-3 |

COMPLETE VIEW



### A.2.1.2 Day 2, 6/4/2018: Fourteen Tests

**Test 1 of 14**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 05:56:17 | 4.85 | -22.54 | 15.01 | 19.765 | -7.53 |
| 2 | 05:56:18 | 4.86 | 1.08 | 9.97 | 24.442 | 11.05 |
| 3 | 05:56:18 | 4.85 | -0.65 | 11.61 | 22.837 | 10.95 |
| 4 | 05:56:19 | 4.85 | -0.56 | 12.04 | 24.168 | 11.48 |
| 5 | 05:56:19 | 4.85 | -0.41 | 14.98 | 22.837 | 14.57 |
| 6 | 05:56:20 | 4.85 | 1.07 | 10.36 | 26.718 | 11.43 |
| 7 | 05:56:21 | 4.85 | -1.13 | 10.37 | 19.155 | 9.24 |
| 8 | 05:56:21 | 4.85 | -0.65 | 12.6 | 23.671 | 11.95 |
| 9 | 05:56:22 | 4.85 | 0.65 | 12.24 | 21.32 | 12.89 |
| 10 | 05:56:22 | 4.85 | 0.55 | 16.48 | 19.69 | 17.03 |
| 11 | 05:56:23 | 4.86 | 0.79 | 12.14 | 27.004 | 12.92 |
| 12 | 05:56:23 | 4.85 | -0.52 | 12.97 | 24.342 | 12.45 |
| 13 | 05:56:24 | 4.85 | -0.58 | 17.07 | 27.651 | 16.49 |
| 14 | 05:56:24 | 4.85 | -0.46 | 15.25 | 21.32 | 14.79 |
| 15 | 05:56:25 | 4.86 | 2.01 | 13.21 | 26.432 | 15.22 |
| 16 | 05:56:26 | 4.85 | -0.56 | 10.81 | 22.962 | 10.25 |
| 17 | 05:56:26 | 4.86 | 0.36 | 12.98 | 23.011 | 13.34 |
| 18 | 05:56:27 | 4.85 | -0.93 | 10.94 | 27.875 | 10 |
| 19 | 05:56:27 | 4.85 | -0.36 | 10.92 | 20.424 | 10.56 |
| 20 | 05:56:28 | 4.86 | 1.54 | 10.99 | 26.171 | 12.53 |
| 21 | 05:56:28 | 4.85 | -1.43 | 12.62 | 29.952 | 11.19 |
| 22 | 05:56:29 | 4.85 | -0.92 | 12.03 | 23.335 | 11.11 |
| 23 | 05:56:29 | 4.85 | 0.76 | 10.1 | 19.703 | 10.86 |
| 24 | 05:56:30 | 4.85 | 0.29 | 14.37 | 20.785 | 14.66 |
| 25 | 05:56:31 | 4.86 | 1.36 | 15.56 | 24.977 | 16.92 |
| 26 | 05:56:31 | 4.85 | -0.6 | 13.15 | 20.947 | 12.56 |
| 27 | 05:56:32 | 4.86 | 0.13 | 12.59 | 26.693 | 12.72 |
| 28 | 05:56:32 | 4.85 | -0.9 | 10.14 | 23.136 | 9.23 |
| 29 | 05:56:33 | 4.85 | 0.58 | 12.33 | 23.111 | 12.91 |
| 30 | 05:56:33 | 4.85 | -1.26 | 12.58 | 18.832 | 11.33 |
| 31 | 05:56:34 | 4.85 | 0.49 | 9.97 | 23.136 | 10.46 |
| 32 | 05:56:35 | 4.85 | 0.83 | 10.86 | 21.855 | 11.7 |
| 33 | 05:56:35 | 4.83 | -25.29 | 13.28 | 24.28 | -12.01 |
| 34 | 05:56:36 | 4.83 | 0.3 | 13.97 | 26.444 | 14.28 |
| 35 | 05:56:36 | 4.57 | -263.53 | 272.34 | 23.409 | 8.81 |
| 36 | 05:56:41 | 4.57 | -0.4 | 4.9 | 10.573 | 4.5 |
| 37 | 05:56:41 | 4.59 | 19.86 | -13.77 | 8.968 | 6.09 |

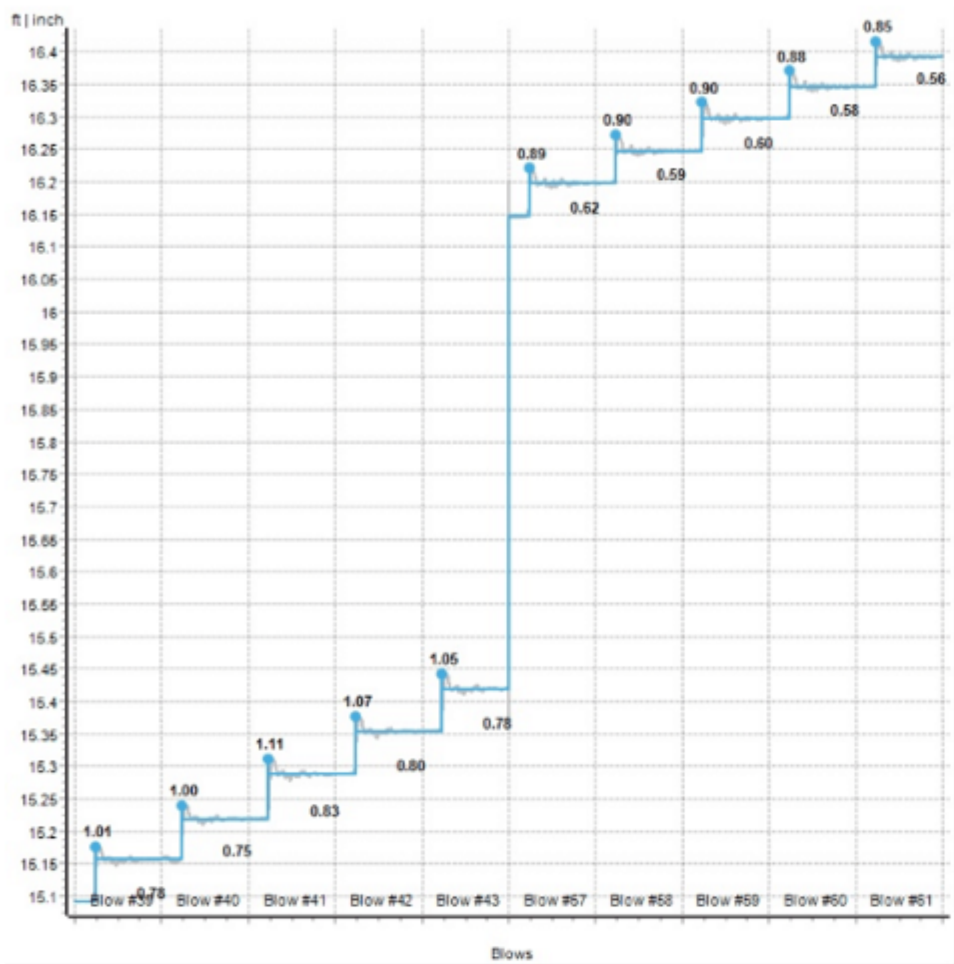
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 38 | 05:56:41 | 4.6 | 14.25 | 5.59 | 3.309 | 19.84 |
| 39 | 05:56:43 | 4.62 | 19.85 | 5.83 | 1.94 | 25.68 |
| 40 | 05:56:44 | 4.64 | 18.96 | 6.35 | 1.965 | 25.31 |
| 41 | 05:56:45 | 4.66 | 20.98 | 7.26 | 2.021 | 28.23 |
| 42 | 05:56:47 | 4.68 | 20.22 | 6.9 | 1.959 | 27.12 |
| 43 | 05:56:48 | 4.7 | 19.84 | 6.8 | 1.928 | 26.64 |
| 44 | 05:56:49 | 4.72 | 19.5 | 6.85 | 2.27 | 26.35 |
| 45 | 05:56:51 | 4.74 | 18.51 | 7.57 | 1.866 | 26.08 |
| 46 | 05:56:52 | 4.76 | 18.26 | 7.06 | 1.99 | 25.33 |
| 47 | 05:56:53 | 4.77 | 17.32 | 7.32 | 1.928 | 24.63 |
| 48 | 05:56:55 | 4.79 | 17.02 | 6.74 | 2.083 | 23.76 |
| 49 | 05:56:56 | 4.81 | 18.74 | 6.51 | 1.928 | 25.25 |
| 50 | 05:57:01 | 4.83 | 16.19 | 7.1 | 1.679 | 23.29 |
| 51 | 05:57:01 | 4.84 | 15.8 | 7 | 1.959 | 22.8 |
| 52 | 05:57:01 | 4.86 | 16.05 | 6.83 | 1.897 | 22.89 |
| 53 | 05:57:02 | 4.87 | 15.68 | 7.37 | 1.741 | 23.05 |
| 54 | 05:57:03 | 4.89 | 15.7 | 7.57 | 2.015 | 23.27 |
| 55 | 05:57:04 | 4.91 | 16.34 | 7.11 | 2.189 | 23.46 |
| 56 | 05:57:06 | 4.92 | 16.39 | 7.75 | 1.94 | 24.14 |
| 57 | 05:57:07 | 4.94 | 15.68 | 6.91 | 1.897 | 22.59 |
| 58 | 05:57:08 | 4.95 | 14.98 | 7.8 | 1.835 | 22.77 |
| 59 | 05:57:10 | 4.97 | 15.33 | 7.48 | 2.021 | 22.81 |
| 60 | 05:57:11 | 4.98 | 14.74 | 7.6 | 1.866 | 22.34 |
| 61 | 05:57:13 | 5 | 14.14 | 7.33 | 1.772 | 21.47 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:49:59 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 5:56:17 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 61 (ft) | 16.392 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.69 | VMX (ft/s) | 6.301 |
| Rebound (inch) | 0.28 | DMX (inch) | 0.96 |
| Capacity (kip) | - | | |

## TABLE VIEW

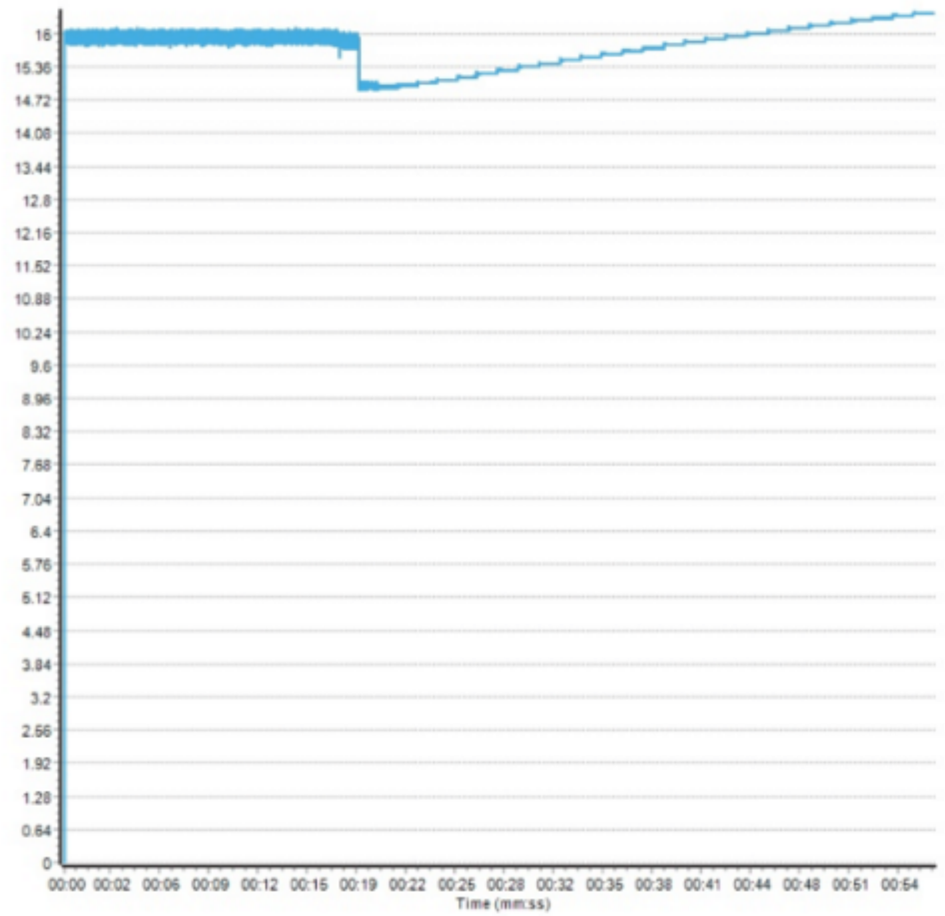
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 61 | 0.56 | 0.29 | 5.82 | 16.392 |
| 60 | 0.58 | 0.30 | 6.12 | 16.346 |
| 59 | 0.60 | 0.29 | 6.63 | 16.297 |
| 58 | 0.59 | 0.31 | 6.02 | 16.247 |
| 57 | 0.62 | 0.27 | 6.22 | 16.198 |
| 43 | 0.78 | 0.27 | 6.33 | 15.420 |
| 42 | 0.80 | 0.27 | 6.43 | 15.354 |
| 41 | 0.83 | 0.29 | 6.63 | 15.288 |
| 40 | 0.75 | 0.25 | 6.45 | 15.219 |
| 39 | 0.78 | 0.23 | 6.37 | 15.157 |
| Average | 0.69 inch | 0.28 inch | | |
| Max Variation | 0.27 inch | 0.08 inch | | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD |

## COMPLETE VIEW



**Test 2 of 14**

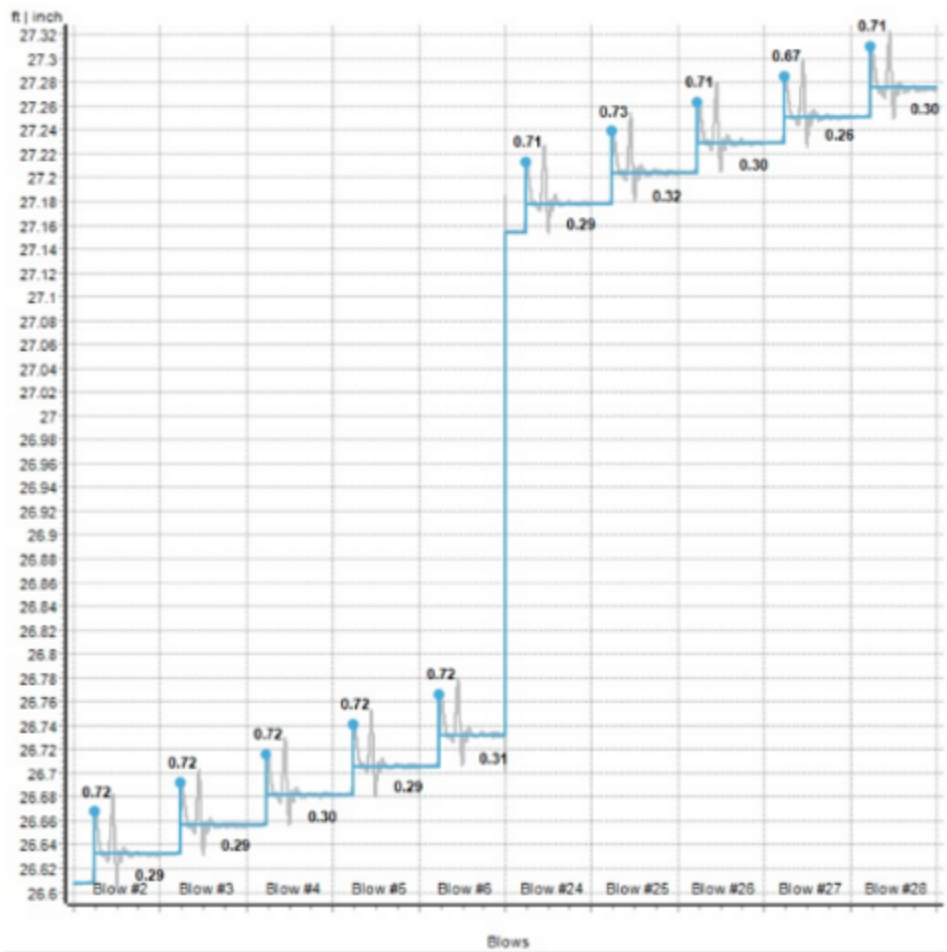
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:00:25 | 8.11 | 185.15 | 10.32 | 1.99 | 195.46 |
| 2 | 06:00:26 | 8.12 | 7.49 | 10.81 | 1.99 | 18.3 |
| 3 | 06:00:28 | 8.12 | 7.39 | 10.78 | 1.804 | 18.17 |
| 4 | 06:00:29 | 8.13 | 7.66 | 10.54 | 1.959 | 18.2 |
| 5 | 06:00:31 | 8.14 | 7.49 | 10.67 | 2.021 | 18.16 |
| 6 | 06:00:32 | 8.15 | 7.93 | 10.44 | 1.866 | 18.38 |
| 7 | 06:00:33 | 8.16 | 8.39 | 10.56 | 2.208 | 18.95 |
| 8 | 06:00:35 | 8.16 | 8.24 | 10.33 | 1.928 | 18.57 |
| 9 | 06:00:36 | 8.17 | 7.44 | 10.82 | 2.021 | 18.25 |
| 10 | 06:00:38 | 8.18 | 6.9 | 11.32 | 2.27 | 18.22 |
| 11 | 06:00:39 | 8.19 | 6.87 | 11.39 | 2.301 | 18.26 |
| 12 | 06:00:40 | 8.19 | 7.76 | 10.73 | 2.208 | 18.49 |
| 13 | 06:00:42 | 8.2 | 7.71 | 10.08 | 2.239 | 17.79 |
| 14 | 06:00:43 | 8.21 | 7.48 | 9.73 | 2.27 | 17.21 |
| 15 | 06:00:45 | 8.22 | 7.46 | 11.23 | 1.959 | 18.69 |
| 16 | 06:00:49 | 8.22 | 7.34 | 11.3 | 2.189 | 18.64 |
| 17 | 06:00:49 | 8.23 | 7.12 | 10.97 | 1.94 | 18.08 |
| 18 | 06:00:50 | 8.24 | 7.85 | 10.36 | 2.065 | 18.21 |
| 19 | 06:00:51 | 8.25 | 7.67 | 9.72 | 1.791 | 17.38 |
| 20 | 06:00:52 | 8.25 | 8.29 | 8.27 | 1.791 | 16.55 |
| 21 | 06:00:53 | 8.26 | 7.65 | 10.32 | 1.667 | 17.97 |
| 22 | 06:00:55 | 8.27 | 7.08 | 10.74 | 1.741 | 17.82 |
| 23 | 06:00:56 | 8.28 | 7.37 | 11.05 | 1.99 | 18.42 |
| 24 | 06:00:58 | 8.28 | 7.36 | 10.78 | 2.083 | 18.14 |
| 25 | 06:00:59 | 8.29 | 8.03 | 10.51 | 1.804 | 18.54 |
| 26 | 06:01:01 | 8.3 | 7.52 | 10.45 | 1.99 | 17.97 |
| 27 | 06:01:02 | 8.31 | 6.57 | 10.52 | 1.648 | 17.09 |
| 28 | 06:01:03 | 8.31 | 7.61 | 10.41 | 1.866 | 18.02 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:47:24 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:00:25 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-2 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 28 (ft) | 27.276 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-2 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.30 | VMX (ft/s) | 6.244 |
| Rebound (inch) | 0.42 | DMX (inch) | 0.71 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 28 | 0.30 | 0.41 | 6.12 | 27.276 |
| 27 | 0.26 | 0.41 | 5.41 | 27.251 |
| 26 | 0.30 | 0.41 | 6.53 | 27.229 |
| 25 | 0.32 | 0.41 | 5.92 | 27.204 |
| 24 | 0.29 | 0.42 | 6.84 | 27.178 |
| 6 | 0.31 | 0.41 | 6.12 | 26.732 |
| 5 | 0.29 | 0.42 | 6.63 | 26.706 |
| 4 | 0.30 | 0.41 | 6.43 | 26.681 |
| 3 | 0.29 | 0.42 | 5.92 | 26.656 |
| 2 | 0.29 | 0.43 | 6.53 | 26.632 |
| Average | 0.30 inch | 0.42 inch | | |
| Max Variation | 0.06 inch | 0.02 inch | | |

Page 2 of 3

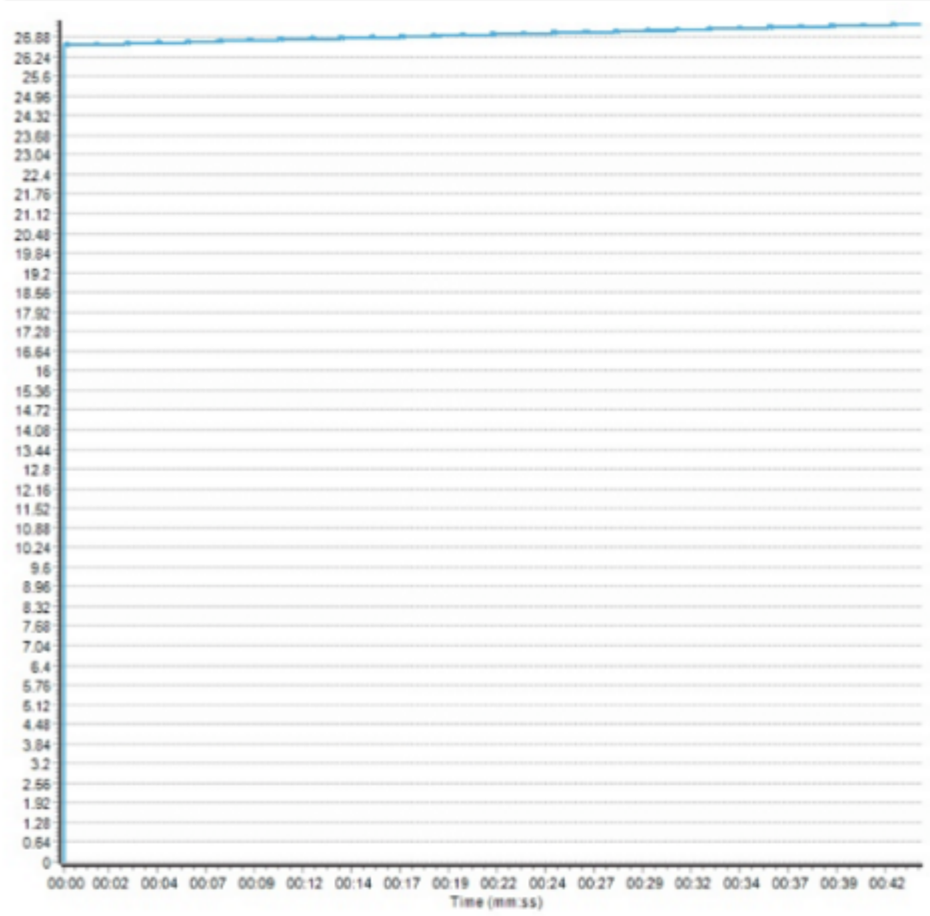
# PILE DRIVING MONITOR

FDOT

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-2 |

COMPLETE VIEW



**Test 3 of 14**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:06:34 | 9.23 | -217.87 | 11.9 | 1.791 | -205.96 |
| 2 | 06:06:35 | 9.24 | 5.35 | 12 | 1.866 | 17.35 |
| 3 | 06:06:36 | 9.24 | 5.09 | 12.3 | 1.692 | 17.39 |
| 4 | 06:06:38 | 9.25 | 5.43 | 12.18 | 1.891 | 17.61 |
| 5 | 06:06:39 | 9.25 | 5.69 | 12.05 | 1.94 | 17.74 |
| 6 | 06:06:41 | 9.26 | 5.5 | 11.89 | 1.741 | 17.39 |
| 7 | 06:06:42 | 9.26 | 5.25 | 11.87 | 1.667 | 17.12 |
| 8 | 06:06:44 | 9.27 | 4.92 | 12.13 | 1.791 | 17.05 |
| 9 | 06:06:45 | 9.27 | 4.63 | 12.06 | 1.741 | 16.69 |
| 10 | 06:06:47 | 9.28 | 5.09 | 11.97 | 1.741 | 17.06 |
| 11 | 06:06:48 | 9.28 | 5.76 | 12.02 | 1.692 | 17.78 |
| 12 | 06:06:50 | 9.29 | 5.07 | 11.88 | 1.592 | 16.95 |
| 13 | 06:06:51 | 9.29 | 4.84 | 11.98 | 1.617 | 16.82 |
| 14 | 06:06:52 | 9.3 | 6.41 | 11.6 | 1.717 | 18.01 |
| 15 | 06:06:57 | 9.31 | 5.41 | 11.62 | 1.7 | 17.03 |
| 16 | 06:06:57 | 9.31 | 4.86 | 11.74 | 1.741 | 16.6 |
| 17 | 06:06:58 | 9.32 | 5.06 | 11.84 | 1.679 | 16.91 |
| 18 | 06:06:58 | 9.32 | 5.79 | 11.7 | 1.596 | 17.49 |
| 19 | 06:07:00 | 9.33 | 5.45 | 11.83 | 1.791 | 17.28 |
| 20 | 06:07:01 | 9.33 | 5.26 | 12.13 | 1.841 | 17.39 |
| 21 | 06:07:03 | 9.34 | 5.74 | 12.22 | 1.717 | 17.96 |
| 22 | 06:07:04 | 9.34 | 5.69 | 12.18 | 1.766 | 17.86 |
| 23 | 06:07:06 | 9.35 | 5.61 | 12.39 | 1.866 | 18 |
| 24 | 06:07:07 | 9.35 | 5.92 | 12.15 | 1.791 | 18.07 |
| 25 | 06:07:08 | 9.36 | 5.58 | 11.82 | 1.816 | 17.39 |
| 26 | 06:07:10 | 9.37 | 5.45 | 11.56 | 1.692 | 17.02 |
| 27 | 06:07:11 | 9.37 | 4.88 | 11.95 | 1.692 | 16.83 |
| 28 | 06:07:13 | 9.38 | 5.59 | 12.03 | 1.766 | 17.62 |
| 29 | 06:07:17 | 9.38 | 5.35 | 12.07 | 1.928 | 17.42 |
| 30 | 06:07:17 | 9.39 | 5.74 | 11.73 | 1.692 | 17.47 |

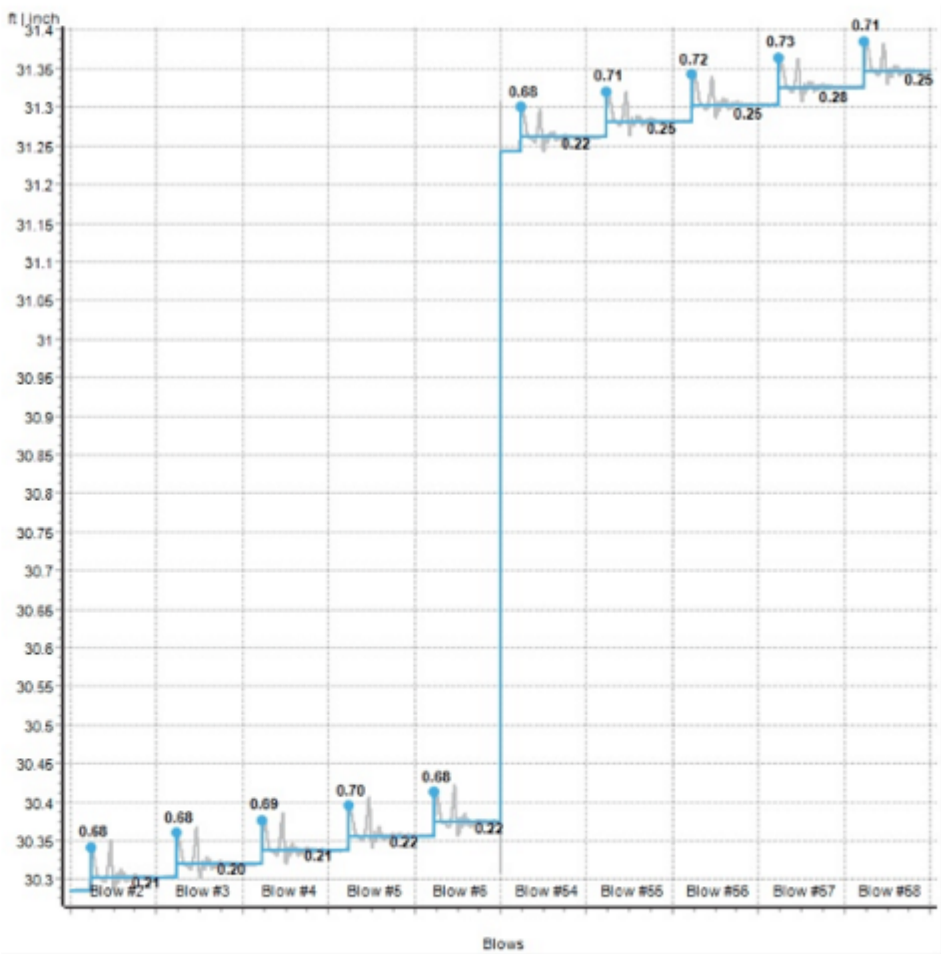
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 31 | 06:07:17 | 9.39 | 5.77 | 11.45 | 1.617 | 17.22 |
| 32 | 06:07:19 | 9.4 | 5.99 | 12.08 | 1.692 | 18.06 |
| 33 | 06:07:20 | 9.4 | 5.85 | 12.28 | 1.791 | 18.13 |
| 34 | 06:07:21 | 9.41 | 5.96 | 11.94 | 2.065 | 17.89 |
| 35 | 06:07:23 | 9.42 | 5.39 | 11.85 | 1.816 | 17.24 |
| 36 | 06:07:24 | 9.42 | 5.93 | 12.31 | 1.804 | 18.24 |
| 37 | 06:07:26 | 9.43 | 5.61 | 12.02 | 1.721 | 17.64 |
| 38 | 06:07:27 | 9.43 | 5.36 | 11.66 | 1.596 | 17.02 |
| 39 | 06:07:29 | 9.44 | 5.68 | 11.76 | 1.596 | 17.44 |
| 40 | 06:07:30 | 9.44 | 5.86 | 12.3 | 1.7 | 18.16 |
| 41 | 06:07:32 | 9.45 | 5.65 | 12.28 | 1.783 | 17.92 |
| 42 | 06:07:37 | 9.46 | 6.37 | 11.96 | 1.721 | 18.32 |
| 43 | 06:07:37 | 9.46 | 5.44 | 11.84 | 1.534 | 17.28 |
| 44 | 06:07:37 | 9.47 | 5.73 | 11.69 | 1.555 | 17.42 |
| 45 | 06:07:38 | 9.47 | 5.51 | 11.8 | 1.721 | 17.31 |
| 46 | 06:07:39 | 9.48 | 5.81 | 12 | 1.741 | 17.81 |
| 47 | 06:07:40 | 9.49 | 6.42 | 11.73 | 1.928 | 18.16 |
| 48 | 06:07:42 | 9.49 | 6.09 | 11.5 | 1.741 | 17.59 |
| 49 | 06:07:43 | 9.5 | 5.7 | 10.93 | 1.581 | 16.63 |
| 50 | 06:07:45 | 9.51 | 7.99 | 11.65 | 2.505 | 19.65 |
| 51 | 06:07:46 | 9.51 | 5.68 | 11.79 | 1.7 | 17.47 |
| 52 | 06:07:47 | 9.52 | 6.38 | 11.51 | 1.7 | 17.89 |
| 53 | 06:07:49 | 9.52 | 5.39 | 11.54 | 1.667 | 16.94 |
| 54 | 06:07:50 | 9.53 | 5.5 | 11.71 | 1.667 | 17.22 |
| 55 | 06:07:52 | 9.53 | 6.26 | 11.76 | 1.816 | 18.02 |
| 56 | 06:07:57 | 9.54 | 6.48 | 11.91 | 1.841 | 18.38 |
| 57 | 06:07:57 | 9.55 | 7.02 | 11.59 | 1.965 | 18.62 |
| 58 | 06:07:57 | 9.55 | 6.35 | 11.79 | 1.717 | 18.14 |
| 59 | 06:07:58 | 9.55 | -0.09 | 18.52 | 1.766 | 18.43 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:45:37 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:06:33 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-3 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 58 (ft) | 31.347 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-3 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.23 | VMX (ft/s) | 5.950 |
| Rebound (inch) | 0.47 | DMX (inch) | 0.70 |
| Capacity (kip) | - | | |

## TABLE VIEW

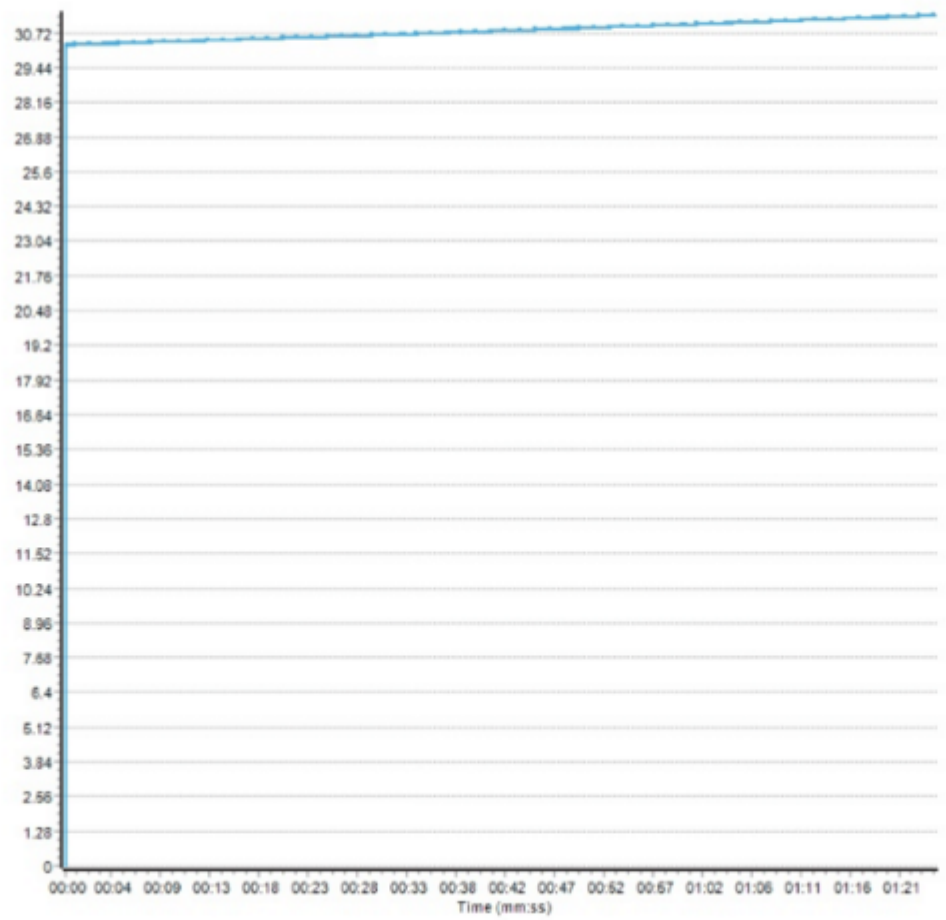
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 58 | 0.25 | 0.46 | 5.63 | 31.347 |
| 57 | 0.28 | 0.46 | 6.45 | 31.326 |
| 56 | 0.25 | 0.47 | 6.04 | 31.303 |
| 55 | 0.25 | 0.46 | 5.96 | 31.282 |
| 54 | 0.22 | 0.46 | 5.47 | 31.261 |
| 6 | 0.22 | 0.47 | 5.71 | 30.374 |
| 5 | 0.22 | 0.47 | 6.37 | 30.356 |
| 4 | 0.21 | 0.48 | 6.20 | 30.337 |
| 3 | 0.20 | 0.48 | 5.55 | 30.319 |
| 2 | 0.21 | 0.47 | 6.12 | 30.303 |
| Average | 0.23 inch | 0.47 inch | | |
| Max Variation | 0.08 inch | 0.03 inch | | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-3 |

COMPLETE VIEW



**Test 4 of 14**

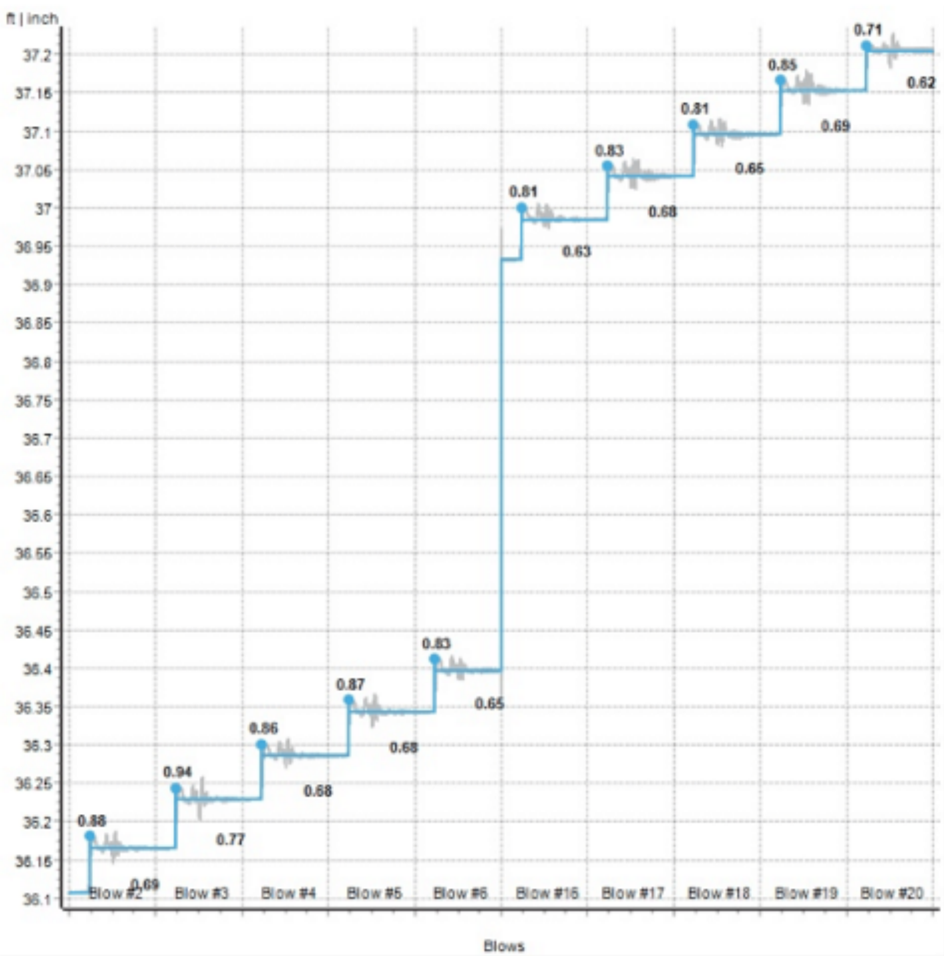
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:10:21 | 11.01 | 32.6 | 4.95 | 1.617 | 37.55 |
| 2 | 06:10:23 | 11.02 | 17.63 | 4.84 | 1.824 | 22.47 |
| 3 | 06:10:24 | 11.04 | 19.58 | 4.34 | 1.783 | 23.91 |
| 4 | 06:10:26 | 11.06 | 17.24 | 4.69 | 1.524 | 21.93 |
| 5 | 06:10:27 | 11.08 | 17.32 | 4.8 | 1.907 | 22.13 |
| 6 | 06:10:29 | 11.09 | 16.43 | 4.75 | 1.658 | 21.17 |
| 7 | 06:10:30 | 11.11 | 17.81 | 4.35 | 1.783 | 22.16 |
| 8 | 06:10:31 | 11.13 | 17.17 | 4.17 | 1.576 | 21.34 |
| 9 | 06:10:33 | 11.15 | 17.61 | 4.55 | 2.488 | 22.17 |
| 10 | 06:10:34 | 11.16 | 18.35 | 4.44 | 1.617 | 22.8 |
| 11 | 06:10:36 | 11.18 | 18.11 | 4.36 | 1.824 | 22.48 |
| 12 | 06:10:37 | 11.2 | 18.68 | 4.29 | 1.866 | 22.97 |
| 13 | 06:10:38 | 11.22 | 18.27 | 3.92 | 1.835 | 22.19 |
| 14 | 06:10:40 | 11.24 | 18.42 | 4.26 | 2.488 | 22.68 |
| 15 | 06:10:45 | 11.26 | 18.81 | 3.62 | 1.71 | 22.43 |
| 16 | 06:10:45 | 11.27 | 16.09 | 4.6 | 1.534 | 20.69 |
| 17 | 06:10:45 | 11.29 | 17.18 | 4.02 | 1.7 | 21.21 |
| 18 | 06:10:45 | 11.31 | 16.45 | 4.02 | 1.576 | 20.47 |
| 19 | 06:10:47 | 11.32 | 17.64 | 4.03 | 1.741 | 21.66 |
| 20 | 06:10:48 | 11.34 | 15.66 | 2.35 | 4.146 | 18 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:42:58 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:10:20 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-4 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 20 (ft) | 37.204 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-4 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.67 | VMX (ft/s) | 6.363 |
| Rebound (inch) | 0.17 | DMX (inch) | 0.84 |
| Capacity (kip) | - | | |

## TABLE VIEW

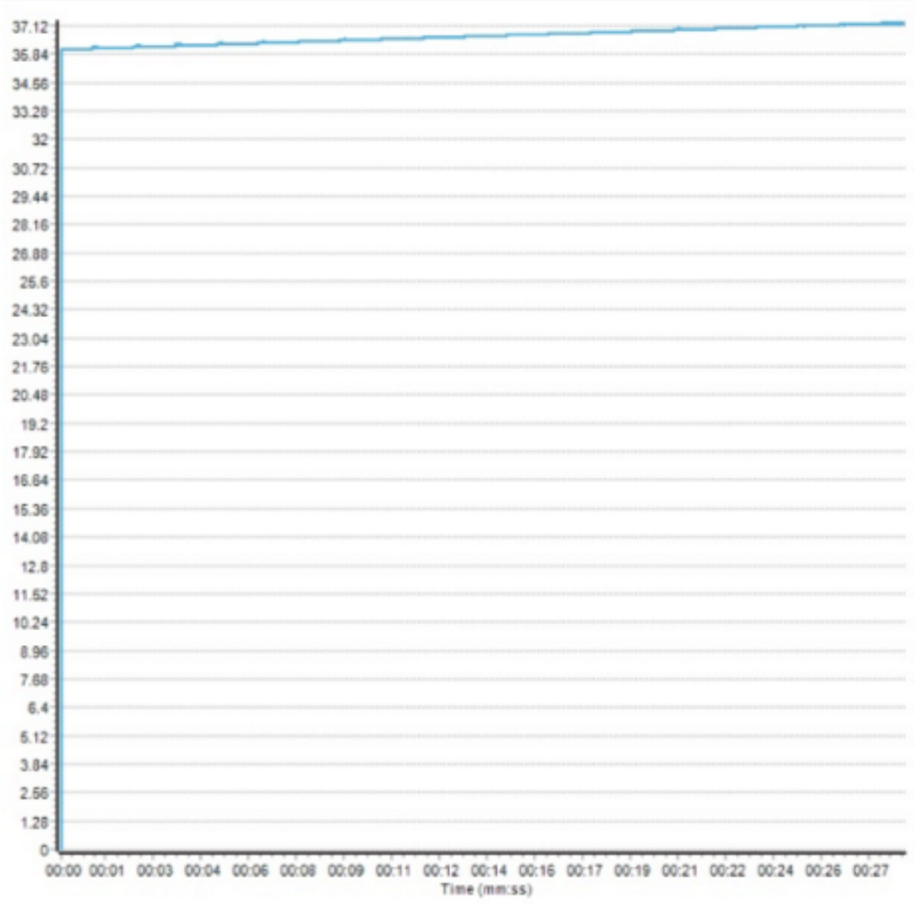
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 20 | 0.62 | 0.09 | 13.60 | 37.204 |
| 19 | 0.69 | 0.16 | 5.71 | 37.153 |
| 18 | 0.65 | 0.16 | 5.17 | 37.095 |
| 17 | 0.68 | 0.16 | 5.58 | 37.041 |
| 16 | 0.63 | 0.18 | 5.03 | 36.985 |
| 6 | 0.65 | 0.19 | 5.44 | 36.396 |
| 5 | 0.68 | 0.19 | 6.26 | 36.342 |
| 4 | 0.68 | 0.18 | 5.00 | 36.286 |
| 3 | 0.77 | 0.17 | 5.85 | 36.229 |
| 2 | 0.69 | 0.19 | 5.99 | 36.165 |
| Average | 0.67 inch | 0.17 inch | | |
| Max Variation | 0.15 inch | 0.10 inch | | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-4 |

## COMPLETE VIEW



**Test 5 of 14**

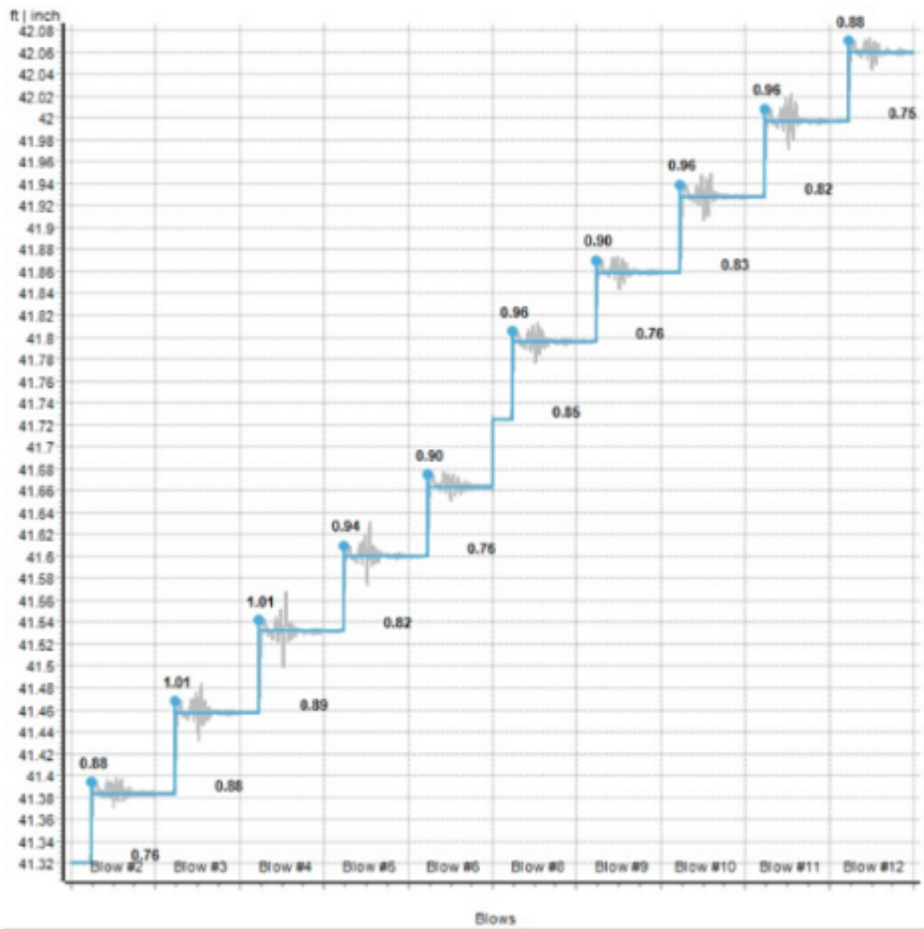
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:12:29 | 12.59 | 97.64 | 5.38 | 1.202 | 103.02 |
| 2 | 06:12:30 | 12.61 | 19.34 | 3.11 | 1.493 | 22.44 |
| 3 | 06:12:31 | 12.64 | 22.43 | 3.16 | 1.592 | 25.6 |
| 4 | 06:12:33 | 12.66 | 22.58 | 3.1 | 1.576 | 25.68 |
| 5 | 06:12:34 | 12.68 | 20.84 | 3.05 | 1.513 | 23.88 |
| 6 | 06:12:36 | 12.7 | 19.33 | 3.49 | 1.472 | 22.83 |
| 7 | 06:12:37 | 12.72 | 18.81 | 2.78 | 1.389 | 21.58 |
| 8 | 06:12:38 | 12.74 | 21.54 | 2.86 | 2.052 | 24.39 |
| 9 | 06:12:40 | 12.76 | 19.35 | 3.39 | 1.617 | 22.74 |
| 10 | 06:12:41 | 12.78 | 21.06 | 3.27 | 1.959 | 24.33 |
| 11 | 06:12:43 | 12.8 | 20.91 | 3.39 | 1.741 | 24.31 |
| 12 | 06:12:44 | 12.82 | 19.14 | 3.23 | 1.648 | 22.37 |
| 13 | 06:12:46 | 12.84 | 17.38 | 2.23 | 3.079 | 19.6 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:40:31 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:12:29 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-5 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 12 (ft) | 42.060 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-5 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.81 | VMX (ft/s) | 5.467 |
| Rebound (inch) | 0.13 | DMX (inch) | 0.94 |
| Capacity (kip) | - | | |

## TABLE VIEW

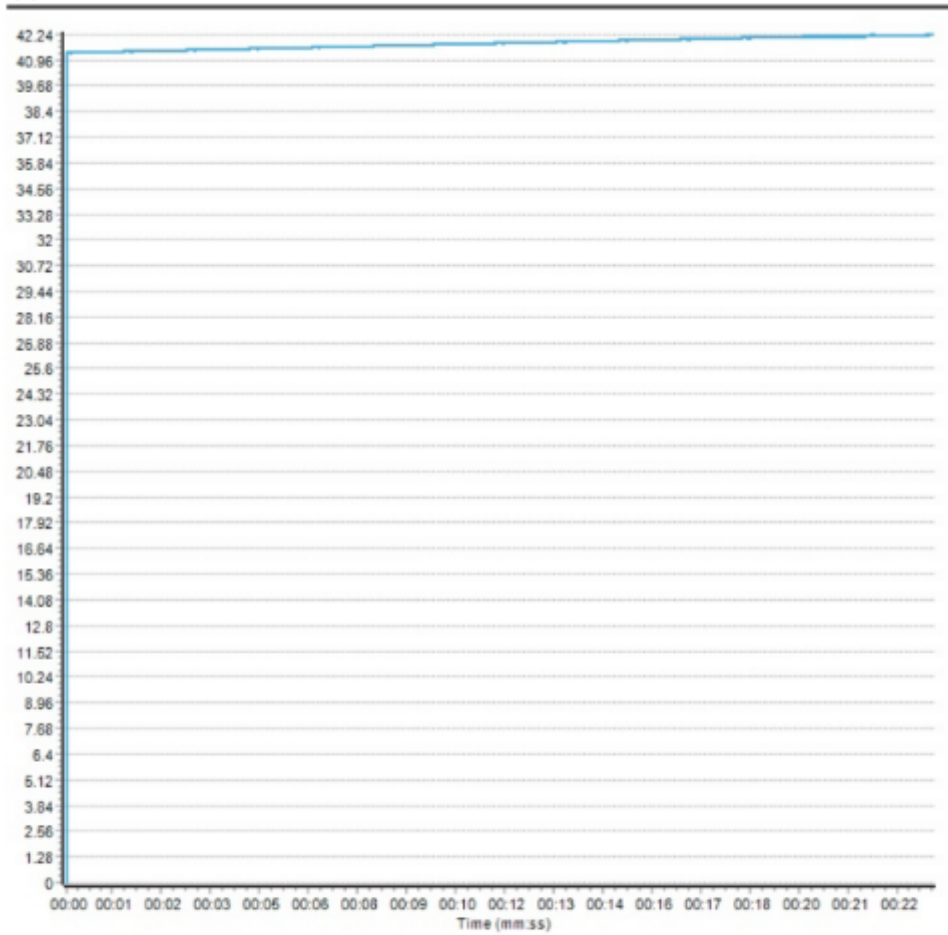
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 12 | 0.75 | 0.13 | 5.41 | 42.060 |
| 11 | 0.82 | 0.13 | 5.71 | 41.997 |
| 10 | 0.83 | 0.13 | 6.43 | 41.928 |
| 9 | 0.76 | 0.13 | 5.31 | 41.859 |
| 8 | 0.85 | 0.11 | 6.73 | 41.796 |
| 6 | 0.76 | 0.14 | 4.83 | 41.663 |
| 5 | 0.82 | 0.12 | 4.97 | 41.600 |
| 4 | 0.89 | 0.12 | 5.17 | 41.531 |
| 3 | 0.88 | 0.12 | 5.22 | 41.457 |
| 2 | 0.76 | 0.12 | 4.90 | 41.384 |
| Average | 0.81 inch | 0.13 inch | | |
| Max Variation | 0.14 inch | 0.03 inch | | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-5 |

## COMPLETE VIEW




Page 3 of 3

**Test 6 of 14**

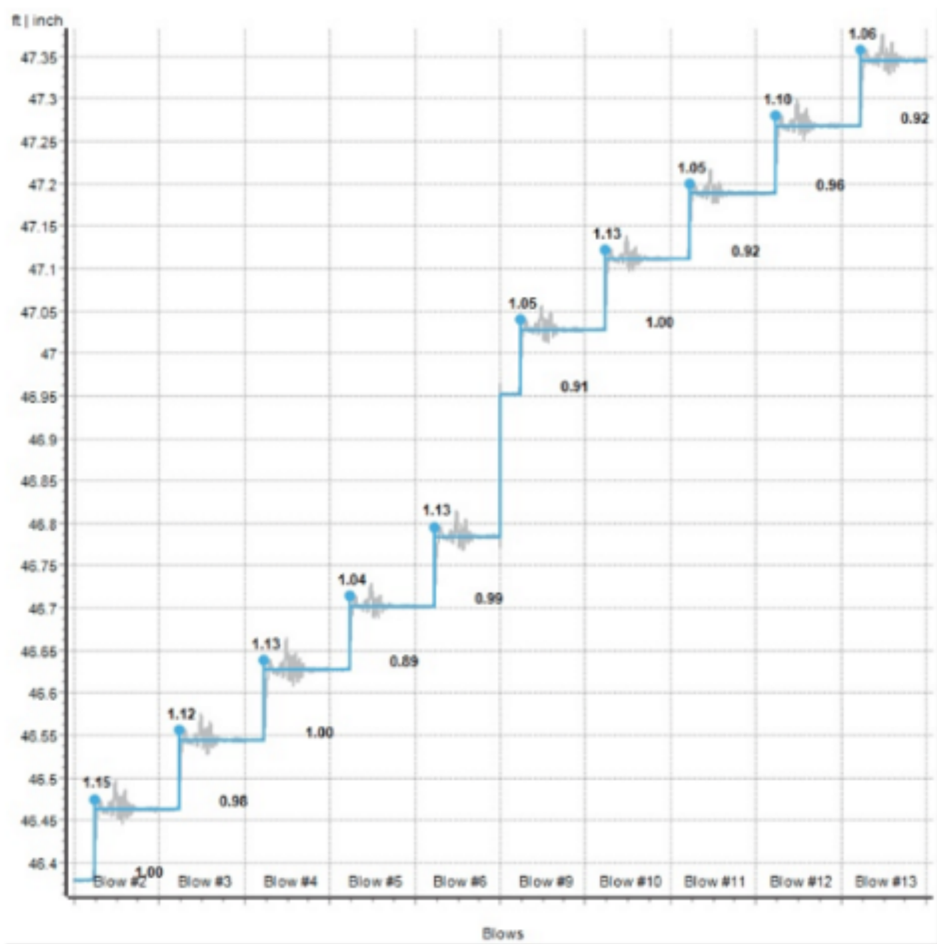
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:13:58 | 14.14 | 115.57 | 3.91 | 1.617 | 119.48 |
| 2 | 06:13:59 | 14.16 | 25.49 | 3.64 | 1.824 | 29.13 |
| 3 | 06:14:01 | 14.19 | 24.77 | 3.56 | 1.783 | 28.33 |
| 4 | 06:14:02 | 14.21 | 25.37 | 3.45 | 1.617 | 28.82 |
| 5 | 06:14:04 | 14.23 | 22.54 | 3.83 | 1.451 | 26.37 |
| 6 | 06:14:05 | 14.26 | 25.22 | 3.47 | 1.617 | 28.68 |
| 7 | 06:14:06 | 14.29 | 26.13 | 3.26 | 1.658 | 29.39 |
| 8 | 06:14:08 | 14.31 | 25 | 3.42 | 1.7 | 28.41 |
| 9 | 06:14:09 | 14.33 | 23.17 | 3.56 | 1.462 | 26.72 |
| 10 | 06:14:11 | 14.36 | 25.47 | 3.28 | 3.016 | 28.75 |
| 11 | 06:14:12 | 14.38 | 23.41 | 3.38 | 1.866 | 26.79 |
| 12 | 06:14:13 | 14.41 | 24.36 | 3.48 | 2.073 | 27.85 |
| 13 | 06:14:15 | 14.43 | 23.44 | 3.6 | 1.617 | 27.05 |
| 14 | 06:14:16 | 14.43 | -0.01 | 22.22 | 3.897 | 22.21 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:38:47 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:13:57 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-6 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 13 (ft) | 47.345 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-6 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.96 | VMX (ft/s) | 6.013 |
| Rebound (inch) | 0.14 | DMX (inch) | 1.10 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 13 | 0.92 | 0.14 | 5.31 | 47.345 |
| 12 | 0.96 | 0.14 | 6.80 | 47.268 |
| 11 | 0.92 | 0.13 | 6.12 | 47.188 |
| 10 | 1.00 | 0.13 | 9.90 | 47.111 |
| 9 | 0.91 | 0.14 | 4.80 | 47.028 |
| 6 | 0.99 | 0.14 | 5.31 | 46.784 |
| 5 | 0.89 | 0.15 | 4.76 | 46.701 |
| 4 | 1.00 | 0.14 | 5.31 | 46.627 |
| 3 | 0.98 | 0.14 | 5.85 | 46.544 |
| 2 | 1.00 | 0.14 | 5.99 | 46.463 |
| Average | 0.96 inch | 0.14 inch | | |
| Max Variation | 0.12 inch | 0.02 inch | | |

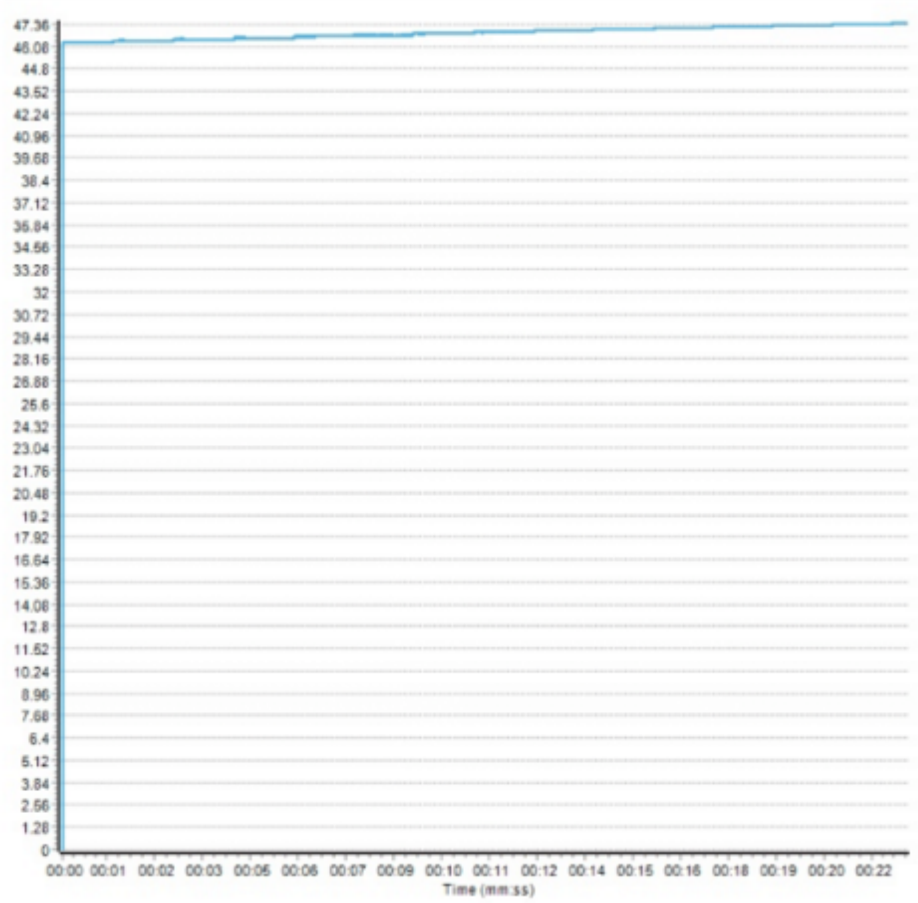
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-6 |

## COMPLETE VIEW



**Test 7 of 14**

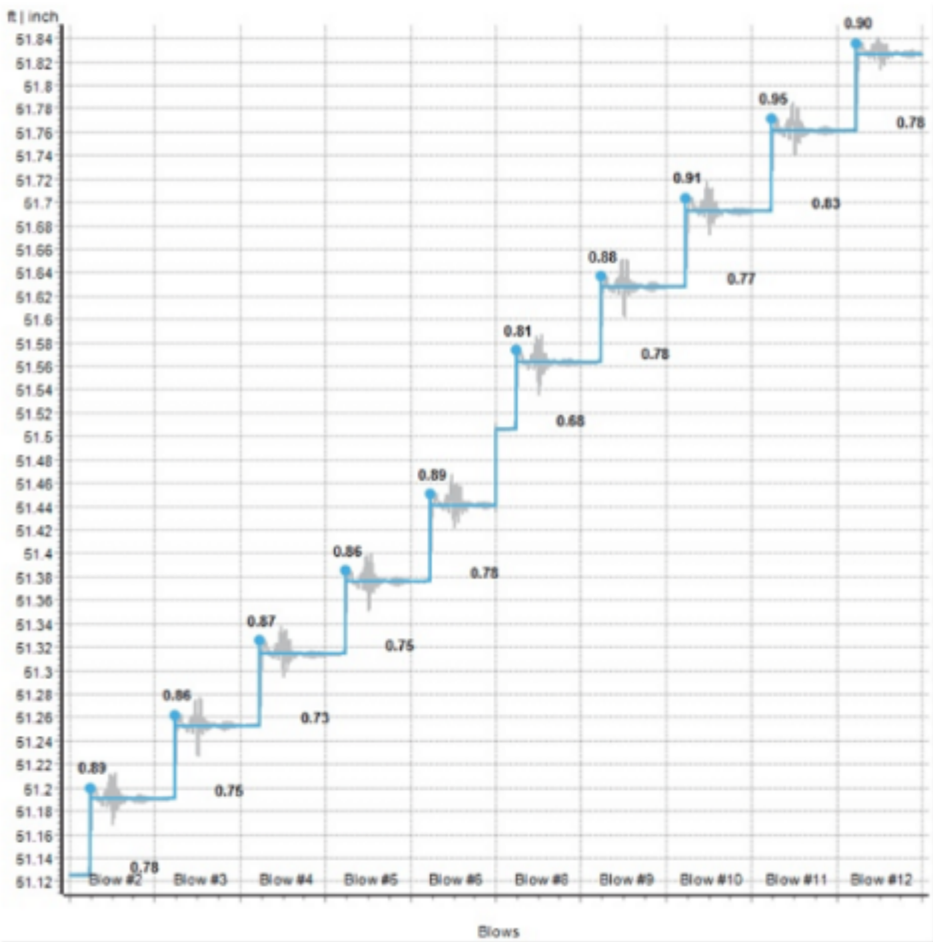
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:16:09 | 15.58 | 38.23 | 3.19 | 1.53 | 41.42 |
| 2 | 06:16:11 | 15.6 | 19.77 | 2.82 | 1.654 | 22.59 |
| 3 | 06:16:12 | 15.62 | 19.11 | 2.8 | 1.48 | 21.91 |
| 4 | 06:16:14 | 15.64 | 18.6 | 3.51 | 1.555 | 22.11 |
| 5 | 06:16:15 | 15.66 | 18.97 | 2.78 | 1.368 | 21.74 |
| 6 | 06:16:17 | 15.68 | 19.79 | 2.94 | 1.53 | 22.72 |
| 7 | 06:16:18 | 15.7 | 19.75 | 2.74 | 1.406 | 22.49 |
| 8 | 06:16:19 | 15.72 | 17.4 | 3.2 | 1.599 | 20.6 |
| 9 | 06:16:21 | 15.74 | 19.81 | 2.61 | 1.493 | 22.42 |
| 10 | 06:16:22 | 15.76 | 19.56 | 3.6 | 1.555 | 23.16 |
| 11 | 06:16:24 | 15.78 | 21.04 | 3.16 | 1.804 | 24.2 |
| 12 | 06:16:25 | 15.8 | 19.84 | 2.93 | 1.617 | 22.77 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:37:02 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:16:09 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-7 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 12 (ft) | 51.826 |
| Hammer | | Stroke (ft) | |



# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-7 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.76 | VMX (ft/s) | 5.136 |
| Rebound (inch) | 0.12 | DMX (inch) | 0.88 |
| Capacity (kip) | - | | |

## TABLE VIEW

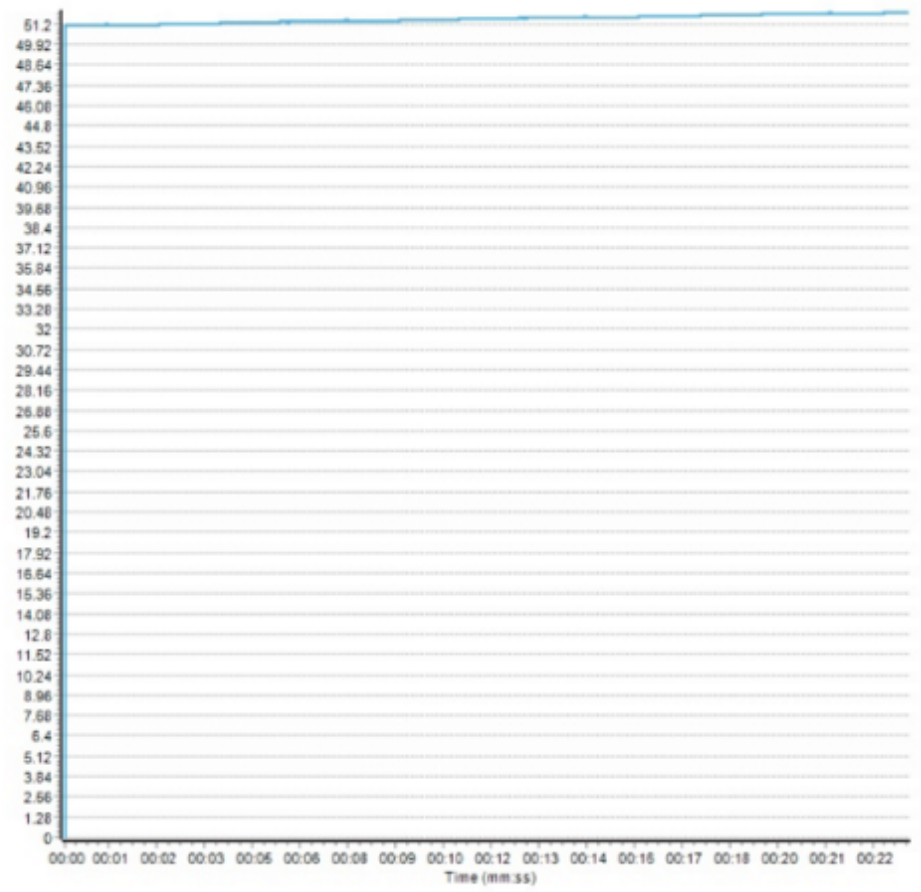
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 12 | 0.78 | 0.12 | 5.31 | 51.826 |
| 11 | 0.83 | 0.12 | 5.92 | 51.761 |
| 10 | 0.77 | 0.14 | 5.10 | 51.692 |
| 9 | 0.78 | 0.10 | 4.90 | 51.628 |
| 8 | 0.68 | 0.13 | 5.25 | 51.563 |
| 6 | 0.78 | 0.12 | 5.02 | 51.441 |
| 5 | 0.75 | 0.11 | 4.49 | 51.376 |
| 4 | 0.73 | 0.14 | 5.10 | 51.314 |
| 3 | 0.75 | 0.11 | 4.86 | 51.253 |
| 2 | 0.78 | 0.11 | 5.43 | 51.190 |
| Average | 0.76 inch | 0.12 inch | | |
| Max Variation | 0.14 inch | 0.04 inch | | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-7 |

## COMPLETE VIEW



**Test 8 of 14**

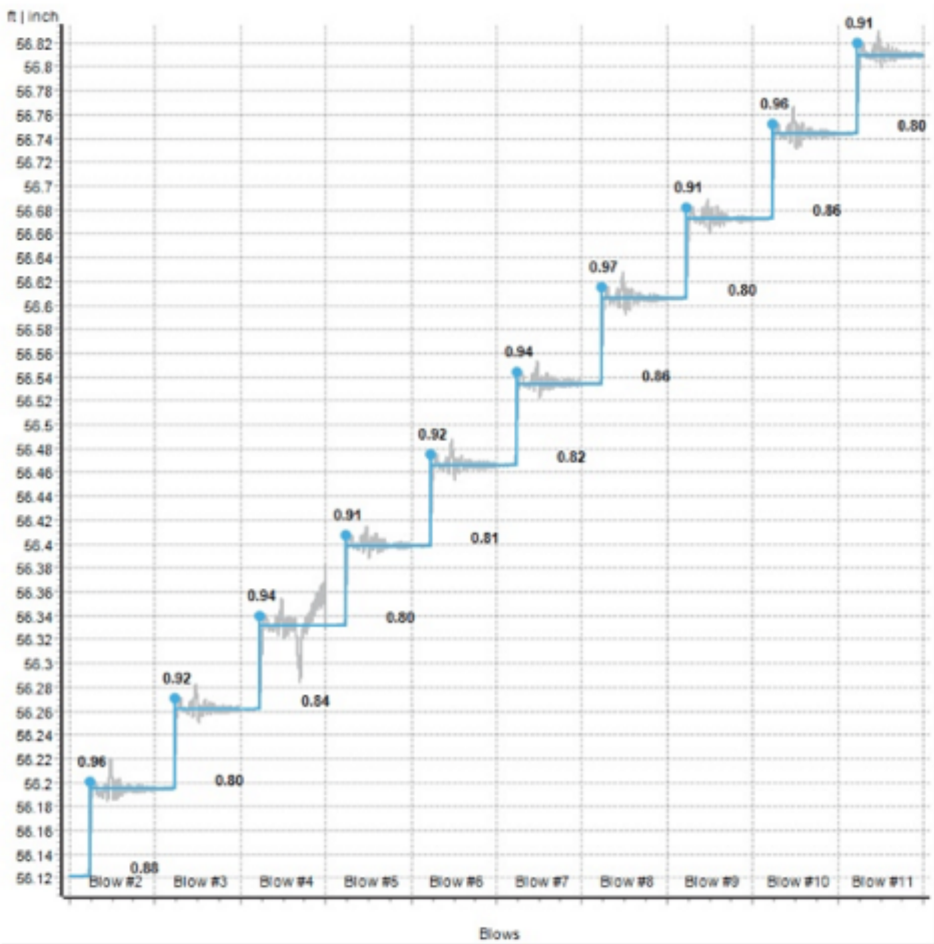
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:17:41 | 17.11 | 36.92 | 2.75 | 1.555 | 39.67 |
| 2 | 06:17:42 | 17.13 | 22.43 | 1.88 | 1.679 | 24.32 |
| 3 | 06:17:43 | 17.15 | 20.36 | 2.89 | 1.741 | 23.25 |
| 4 | 06:17:45 | 17.17 | 21.45 | 2.54 | 1.617 | 23.99 |
| 5 | 06:17:46 | 17.19 | 20.37 | 2.82 | 2.749 | 23.19 |
| 6 | 06:17:48 | 17.21 | 20.56 | 2.82 | 1.741 | 23.38 |
| 7 | 06:17:49 | 17.23 | 20.83 | 2.92 | 2.032 | 23.75 |
| 8 | 06:17:51 | 17.25 | 21.75 | 3 | 1.679 | 24.75 |
| 9 | 06:17:52 | 17.27 | 20.27 | 2.93 | 1.617 | 23.2 |
| 10 | 06:17:53 | 17.3 | 21.78 | 2.61 | 1.804 | 24.39 |
| 11 | 06:17:55 | 17.32 | 20.19 | 2.98 | 1.648 | 23.18 |
| 12 | 06:17:56 | 17.01 | -306.5 | 330.47 | 3.184 | 23.98 |
| 13 | 06:17:57 | 17.36 | 347.69 | -347.71 | 72.424 | -0.02 |
| 14 | 06:17:59 | 17.38 | 19.25 | 2.67 | 1.567 | 21.93 |
| 15 | 06:18:04 | 17.42 | 38.94 | -16.75 | 1.741 | 22.19 |
| 16 | 06:18:04 | 17.4 | -19.72 | 38.19 | 151.253 | 18.47 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:35:04 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:17:39 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-8 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 11 (ft) | 56.810 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-8 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.83 | VMX (ft/s) | 6.006 |
| Rebound (inch) | 0.11 | DMX (inch) | 0.93 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 11 | 0.80 | 0.12 | 5.41 | 56.810 |
| 10 | 0.86 | 0.10 | 5.92 | 56.744 |
| 9 | 0.80 | 0.12 | 5.31 | 56.672 |
| 8 | 0.86 | 0.12 | 5.51 | 56.606 |
| 7 | 0.82 | 0.12 | 6.67 | 56.535 |
| 6 | 0.81 | 0.11 | 5.71 | 56.466 |
| 5 | 0.80 | 0.11 | 9.02 | 56.399 |
| 4 | 0.84 | 0.10 | 5.31 | 56.332 |
| 3 | 0.80 | 0.11 | 5.71 | 56.262 |
| 2 | 0.88 | 0.07 | 5.51 | 56.195 |
| Average | 0.83 inch | 0.11 inch | | |
| Max Variation | 0.09 inch | 0.04 inch | | |

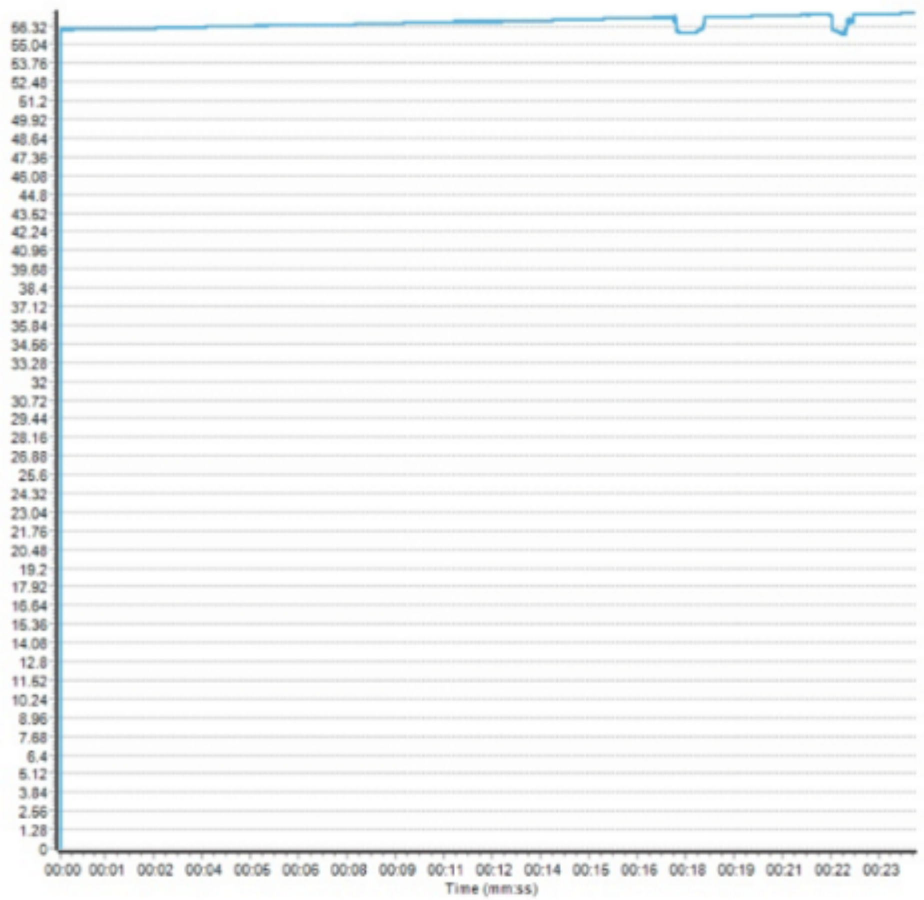
# PILE DRIVING MONITOR

FDOT

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-8 |

COMPLETE VIEW




Page 3 of 3

**Test 9 of 14**

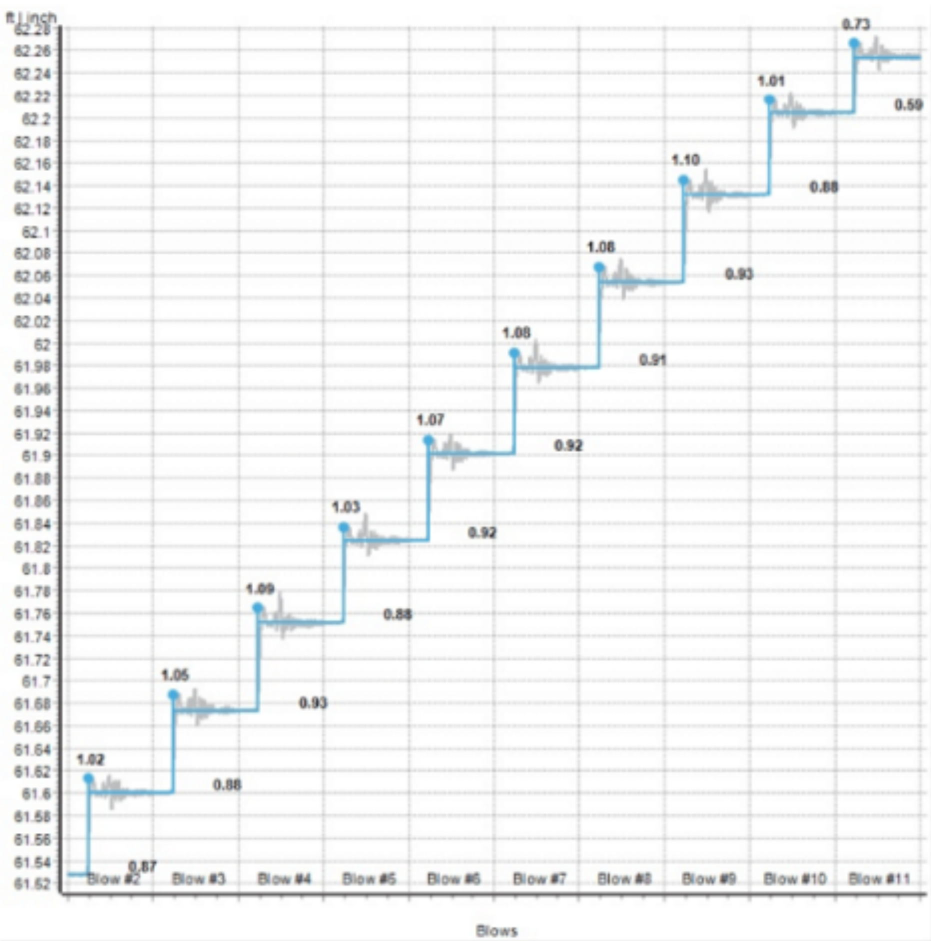
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:19:49 | 18.75 | 160.87 | 3.96 | 1.617 | 164.83 |
| 2 | 06:19:51 | 18.78 | 22.03 | 3.89 | 1.772 | 25.93 |
| 3 | 06:19:52 | 18.8 | 22.39 | 4.27 | 1.866 | 26.66 |
| 4 | 06:19:54 | 18.82 | 23.64 | 3.99 | 1.94 | 27.64 |
| 5 | 06:19:55 | 18.84 | 22.43 | 3.69 | 1.576 | 26.12 |
| 6 | 06:19:56 | 18.87 | 23.37 | 3.93 | 2.612 | 27.3 |
| 7 | 06:19:58 | 18.89 | 23.44 | 4.1 | 1.866 | 27.54 |
| 8 | 06:19:59 | 18.91 | 23.05 | 4.27 | 1.679 | 27.32 |
| 9 | 06:20:01 | 18.94 | 23.69 | 4.13 | 1.71 | 27.82 |
| 10 | 06:20:02 | 18.96 | 22.31 | 3.34 | 1.648 | 25.64 |
| 11 | 06:20:04 | 18.97 | 14.95 | 3.68 | 1.845 | 18.63 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:33:02 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:19:48 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-9 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 11 (ft) | 62.254 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-9 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 0.87 | VMX (ft/s) | 6.074 |
| Rebound (inch) | 0.15 | DMX (inch) | 1.03 |
| Capacity (kip) | - | | |

## TABLE VIEW

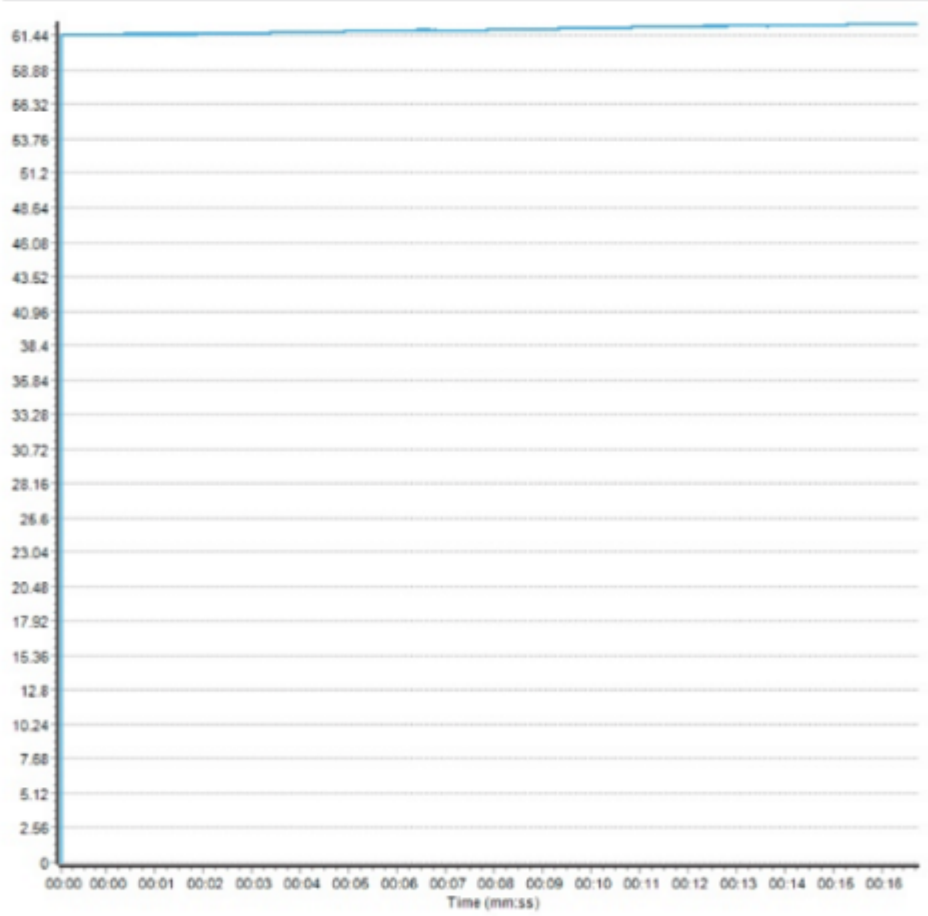
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 11 | 0.59 | 0.14 | 6.05 | 62.254 |
| 10 | 0.88 | 0.13 | 5.41 | 62.205 |
| 9 | 0.93 | 0.16 | 5.61 | 62.132 |
| 8 | 0.91 | 0.17 | 5.51 | 62.054 |
| 7 | 0.92 | 0.16 | 6.12 | 61.978 |
| 6 | 0.92 | 0.15 | 8.57 | 61.901 |
| 5 | 0.88 | 0.15 | 5.17 | 61.825 |
| 4 | 0.93 | 0.16 | 6.37 | 61.751 |
| 3 | 0.88 | 0.17 | 6.12 | 61.674 |
| 2 | 0.87 | 0.15 | 5.82 | 61.600 |
| Average | 0.87 inch | 0.15 inch | | |
| Max Variation | 0.34 inch | 0.04 inch | | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-9 |

COMPLETE VIEW



**Test 10 of 14**

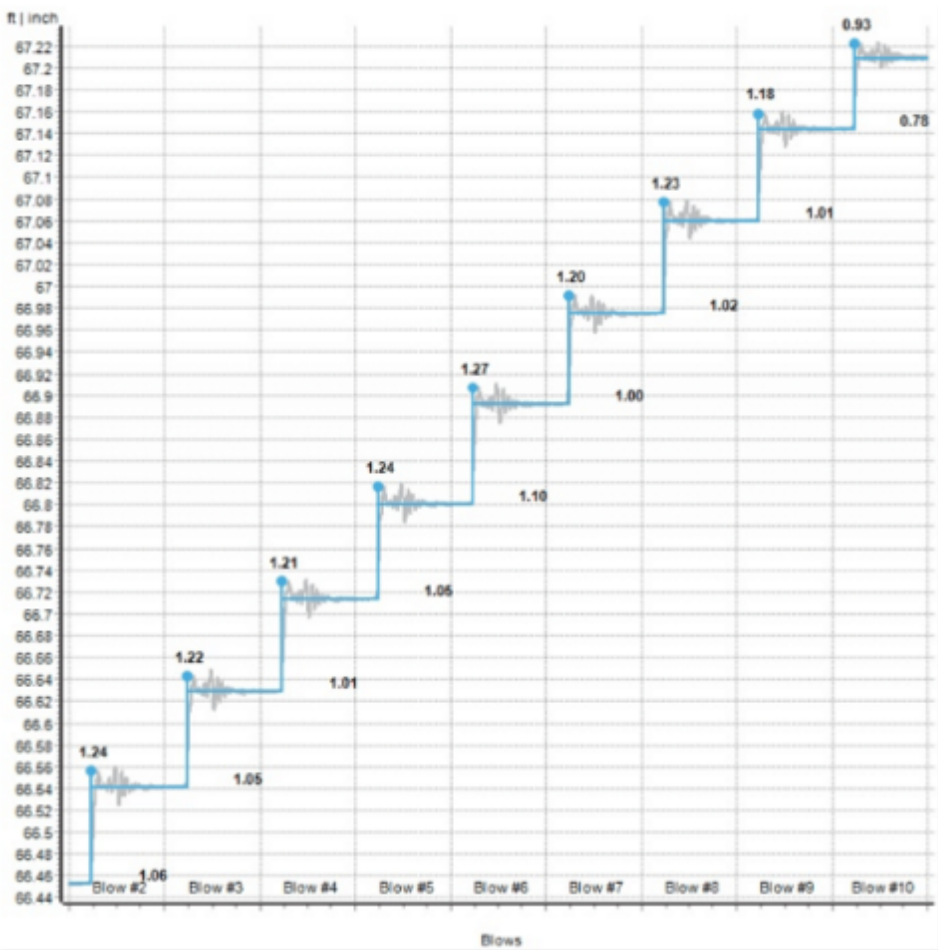
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:21:11 | 20.25 | 137.98 | 4.33 | 2.146 | 142.31 |
| 2 | 06:21:13 | 20.28 | 27.04 | 4.49 | 2.083 | 31.53 |
| 3 | 06:21:14 | 20.31 | 26.62 | 4.45 | 2.015 | 31.07 |
| 4 | 06:21:15 | 20.33 | 25.75 | 5.03 | 2.115 | 30.78 |
| 5 | 06:21:17 | 20.36 | 26.64 | 4.87 | 2.115 | 31.51 |
| 6 | 06:21:18 | 20.39 | 27.82 | 4.52 | 2.882 | 32.33 |
| 7 | 06:21:20 | 20.41 | 25.28 | 5.16 | 1.99 | 30.44 |
| 8 | 06:21:21 | 20.44 | 25.93 | 5.31 | 2.27 | 31.24 |
| 9 | 06:21:22 | 20.47 | 25.69 | 4.28 | 2.27 | 29.97 |
| 10 | 06:21:24 | 20.49 | 19.7 | 4.05 | 3.135 | 23.75 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:31:35 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:21:10 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-10 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 10 (ft) | 67.209 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-10 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 1.01 | VMX (ft/s) | 7.609 |
| Rebound (inch) | 0.18 | DMX (inch) | 1.19 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 10 | 0.78 | 0.16 | 10.28 | 67.209 |
| 9 | 1.01 | 0.17 | 7.45 | 67.144 |
| 8 | 1.02 | 0.21 | 7.45 | 67.060 |
| 7 | 1.00 | 0.20 | 6.53 | 66.975 |
| 6 | 1.10 | 0.18 | 9.45 | 66.892 |
| 5 | 1.05 | 0.19 | 6.94 | 66.801 |
| 4 | 1.01 | 0.20 | 6.94 | 66.713 |
| 3 | 1.05 | 0.18 | 6.61 | 66.629 |
| 2 | 1.06 | 0.18 | 6.84 | 66.541 |

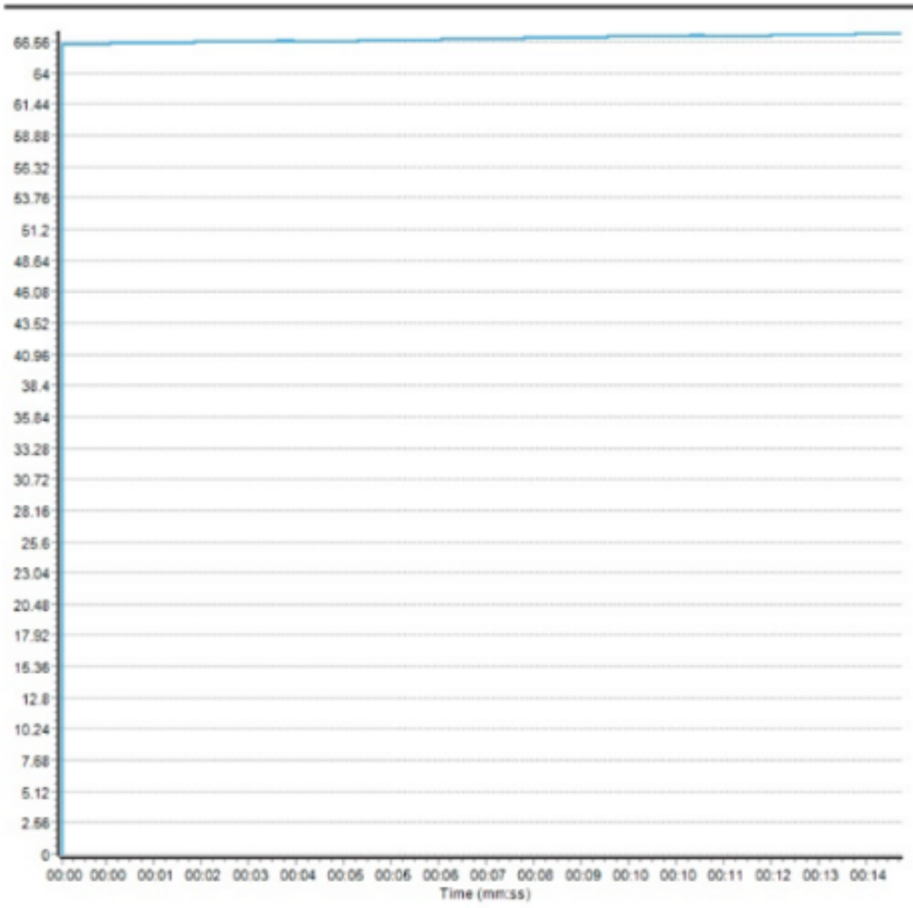
| | | |
|---|---|---|
| Average | 1.01 inch | 0.18 inch |
| Max Variation | 0.32 inch | 0.05 inch |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-10 |

## COMPLETE VIEW




Page 3 of 3

**Test 11 of 14**

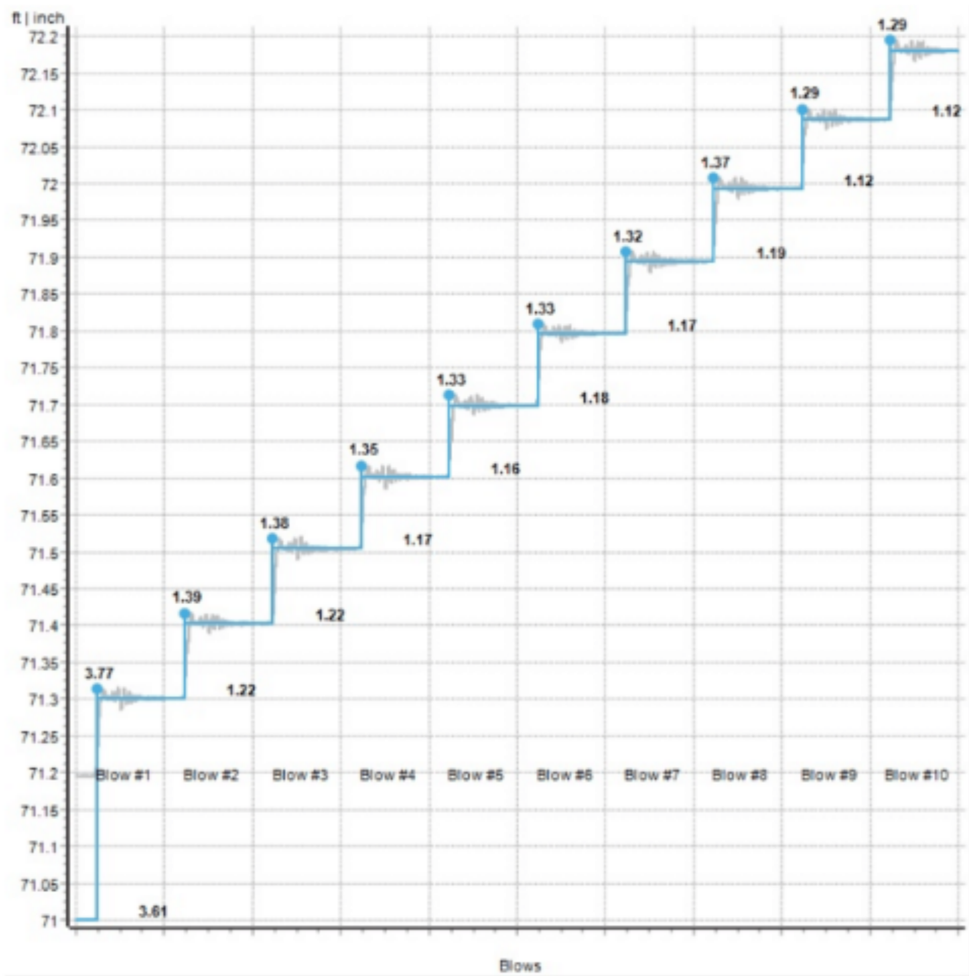
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:22:26 | 21.73 | 91.65 | 4.12 | 2.073 | 95.77 |
| 2 | 06:22:27 | 21.76 | 30.96 | 4.43 | 2.27 | 35.39 |
| 3 | 06:22:29 | 21.79 | 30.96 | 4.17 | 2.322 | 35.13 |
| 4 | 06:22:30 | 21.82 | 29.73 | 4.67 | 1.99 | 34.4 |
| 5 | 06:22:31 | 21.85 | 29.57 | 4.16 | 2.115 | 33.73 |
| 6 | 06:22:33 | 21.88 | 29.91 | 3.94 | 2.208 | 33.85 |
| 7 | 06:22:34 | 21.91 | 29.6 | 4.01 | 2.146 | 33.61 |
| 8 | 06:22:35 | 21.94 | 30.32 | 4.48 | 2.643 | 34.8 |
| 9 | 06:22:37 | 21.97 | 28.54 | 4.27 | 2.197 | 32.81 |
| 10 | 06:22:38 | 22 | 28.53 | 4.23 | 2.197 | 32.77 |
| 11 | 06:22:40 | 22.02 | 24.31 | 3.35 | 3.732 | 27.66 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:30:18 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:22:25 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-11 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 10 (ft) | 72.180 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-11 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 1.15 | VMX (ft/s) | 7.815 |
| Rebound (inch) | 0.16 | DMX (inch) | 1.32 |
| Capacity (kip) | - | | |

## TABLE VIEW

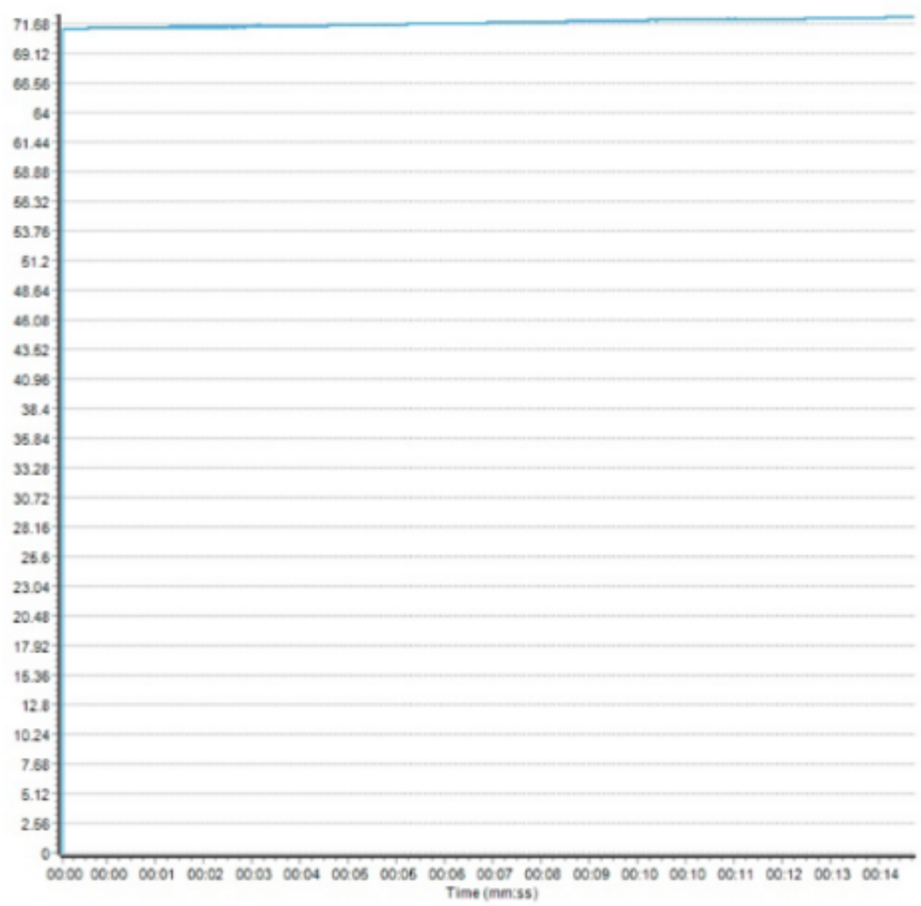
| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 11 | 0.96 | 0.13 | 12.24 | 72.260 |
| 10 | 1.12 | 0.17 | 7.21 | 72.180 |
| 9 | 1.12 | 0.17 | 7.21 | 72.087 |
| 8 | 1.19 | 0.18 | 8.67 | 71.993 |
| 7 | 1.17 | 0.16 | 7.04 | 71.894 |
| 6 | 1.18 | 0.16 | 7.24 | 71.797 |
| 5 | 1.16 | 0.16 | 6.94 | 71.698 |
| 4 | 1.17 | 0.18 | 6.53 | 71.601 |
| 3 | 1.22 | 0.16 | 7.62 | 71.504 |
| 2 | 1.22 | 0.17 | 7.45 | 71.402 |
| Average | 1.15 inch | 0.16 inch | | |
| Max Variation | 0.26 inch | 0.05 inch | | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-11 |

COMPLETE VIEW



**Test 12 of 14**

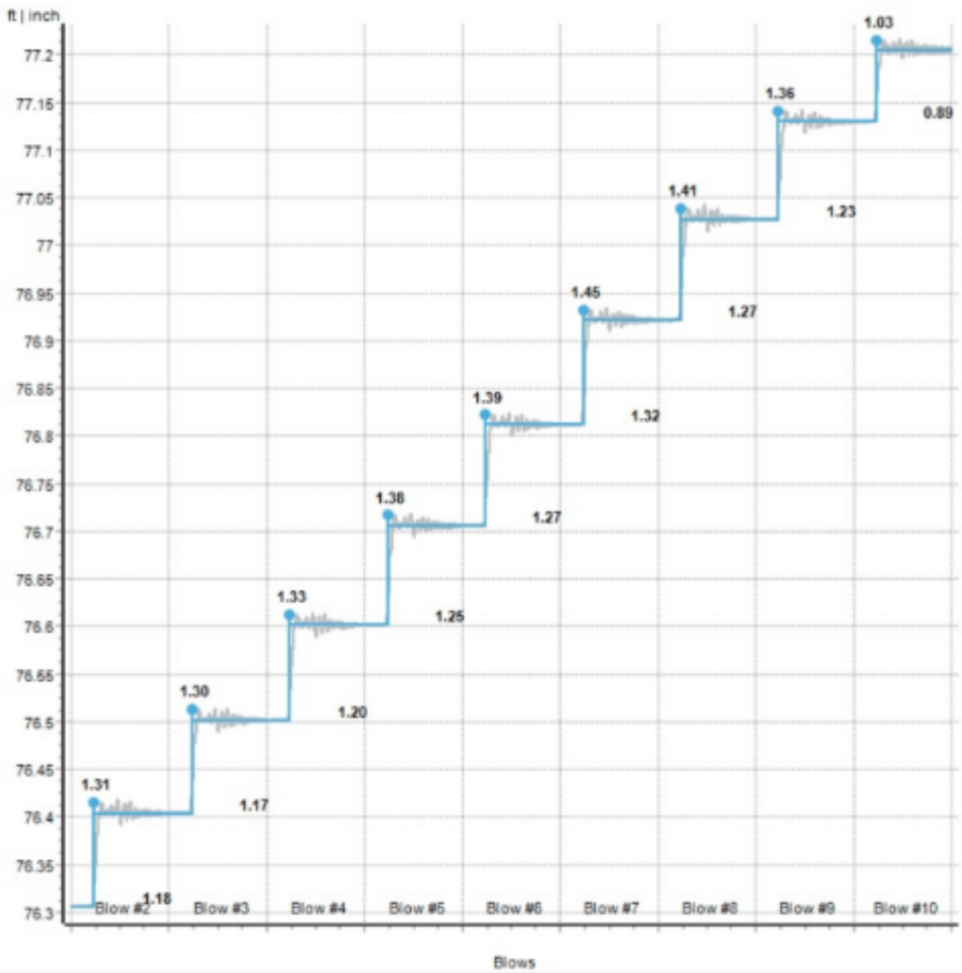
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:23:44 | 23.26 | 93.31 | 3.24 | 2.146 | 96.55 |
| 2 | 06:23:45 | 23.29 | 29.9 | 3.43 | 2.239 | 33.33 |
| 3 | 06:23:47 | 23.32 | 29.65 | 3.42 | 2.446 | 33.07 |
| 4 | 06:23:48 | 23.35 | 30.46 | 3.42 | 2.778 | 33.88 |
| 5 | 06:23:49 | 23.38 | 31.86 | 3.28 | 2.612 | 35.13 |
| 6 | 06:23:51 | 23.41 | 32.18 | 3.12 | 2.457 | 35.3 |
| 7 | 06:23:52 | 23.45 | 33.47 | 3.3 | 3.7 | 36.77 |
| 8 | 06:23:54 | 23.48 | 32.32 | 3.45 | 2.197 | 35.76 |
| 9 | 06:23:55 | 23.51 | 31.23 | 3.3 | 2.571 | 34.53 |
| 10 | 06:23:56 | 23.53 | 22.68 | 3.36 | 6.136 | 26.04 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:25:58 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:23:43 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-12 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 10 (ft) | 77.204 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-12 |

NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 1.20 | VMX (ft/s) | 9.892 |
| Rebound (inch) | 0.13 | DMX (inch) | 1.33 |
| Capacity (kip) | - | | |

TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 10 | 0.89 | 0.13 | 20.13 | 77.204 |
| 9 | 1.23 | 0.13 | 8.43 | 77.130 |
| 8 | 1.27 | 0.14 | 7.21 | 77.027 |
| 7 | 1.32 | 0.13 | 12.14 | 76.921 |
| 6 | 1.27 | 0.12 | 8.06 | 76.812 |
| 5 | 1.25 | 0.13 | 8.57 | 76.706 |
| 4 | 1.20 | 0.13 | 9.11 | 76.601 |
| 3 | 1.17 | 0.13 | 8.03 | 76.502 |
| 2 | 1.18 | 0.13 | 7.35 | 76.404 |

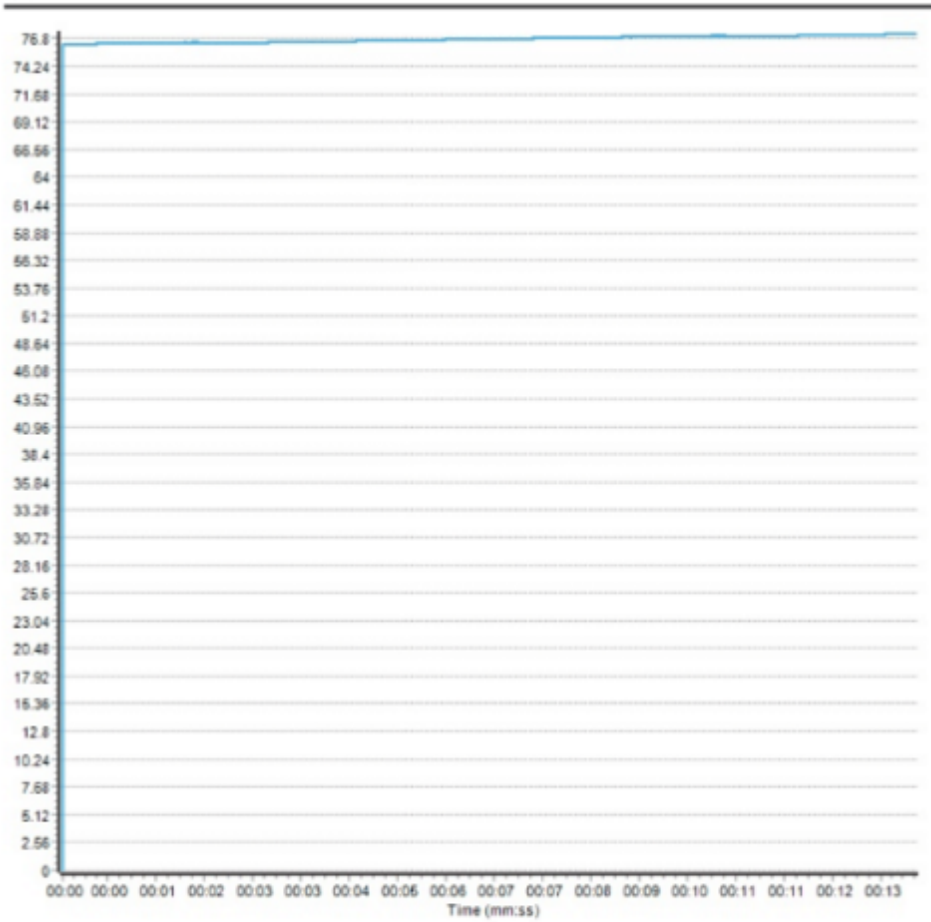
| | | |
|---|---|---|
| Average | 1.20 inch | 0.13 inch |
| Max Variation | 0.42 inch | 0.01 inch |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-12 |

## COMPLETE VIEW



**Test 13 of 14**

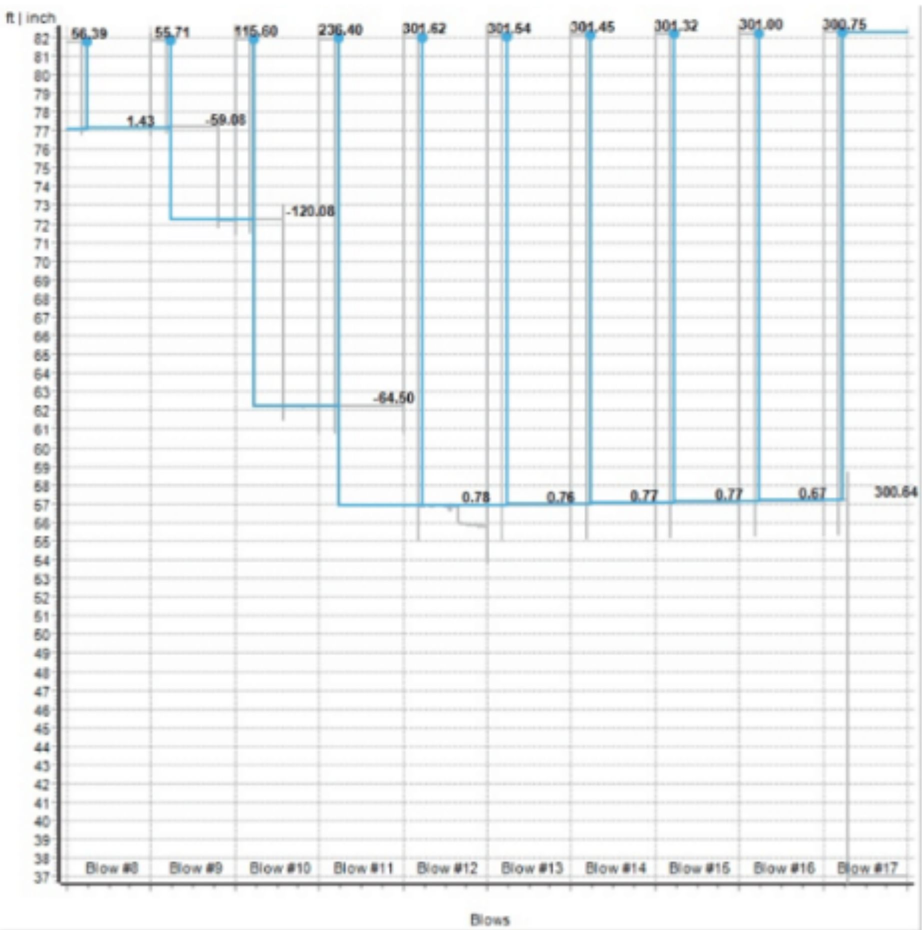
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:24:54 | 23.29 | -1400.78 | 1482.39 | 2.052 | 81.61 |
| 2 | 06:24:55 | 23.32 | 29.68 | 1475.55 | 2.208 | 1505.23 |
| 3 | 06:24:56 | 23.35 | 30.54 | 1466.49 | 2.177 | 1497.02 |
| 4 | 06:24:58 | 23.38 | 31.81 | 1456.26 | 2.073 | 1488.08 |
| 5 | 06:24:59 | 23.41 | 32.4 | 1445.08 | 2.654 | 1477.48 |
| 6 | 06:25:01 | 23.45 | 37.18 | 1430.27 | 2.27 | 1467.45 |
| 7 | 06:25:02 | 23.49 | 40.08 | 1411.74 | 2.27 | 1451.82 |
| 8 | 06:25:04 | 23.53 | 36.32 | 1395.91 | 2.27 | 1432.23 |
| 9 | 06:25:05 | 22.03 | -1500.76 | 2915.75 | 2.457 | 1414.99 |
| 10 | 06:25:06 | 18.98 | -3050.07 | 5986.43 | 3.955 | 2936.36 |
| 11 | 06:25:08 | 17.34 | -1638.21 | 7642.85 | 2.083 | 6004.64 |
| 12 | 06:25:09 | 17.36 | 19.89 | 7641.2 | 2.052 | 7661.09 |
| 13 | 06:25:11 | 17.38 | 19.3 | 7639.77 | 2.239 | 7659.07 |
| 14 | 06:25:16 | 17.4 | 19.46 | 7637.34 | 2.021 | 7656.8 |
| 15 | 06:25:16 | 17.42 | 19.54 | 7633.91 | 1.897 | 7653.45 |
| 16 | 06:25:16 | 17.43 | 17.03 | 7628.3 | 3.358 | 7645.32 |
| 17 | 06:25:16 | 25.07 | 7636.36 | 2.6 | 3.023 | 7638.96 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:24:02 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:24:52 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-13 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 17 (ft) | 82.246 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-13 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 6.22 | VMX (ft/s) | 8.319 |
| Rebound (inch) | 220.96 | DMX (inch) | 227.18 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 17 | 300.64 | 0.10 | 9.92 | 82.246 |
| 16 | 0.67 | 300.33 | 11.02 | 57.192 |
| 15 | 0.77 | 300.55 | 6.22 | 57.136 |
| 14 | 0.77 | 300.68 | 6.63 | 57.072 |
| 13 | 0.76 | 300.78 | 7.35 | 57.008 |
| 12 | 0.78 | 300.83 | 6.73 | 56.945 |
| 11 | -64.50 | 300.90 | 6.84 | 56.880 |
| 10 | -120.08 | 235.69 | 12.98 | 62.255 |
| 9 | -59.08 | 114.79 | 8.06 | 72.261 |
| 8 | 1.43 | 54.96 | 7.45 | 77.185 |
| Average | 6.22 inch | 220.96 inch | | |
| Max Variation | 420.73 inch | 300.80 inch | | |

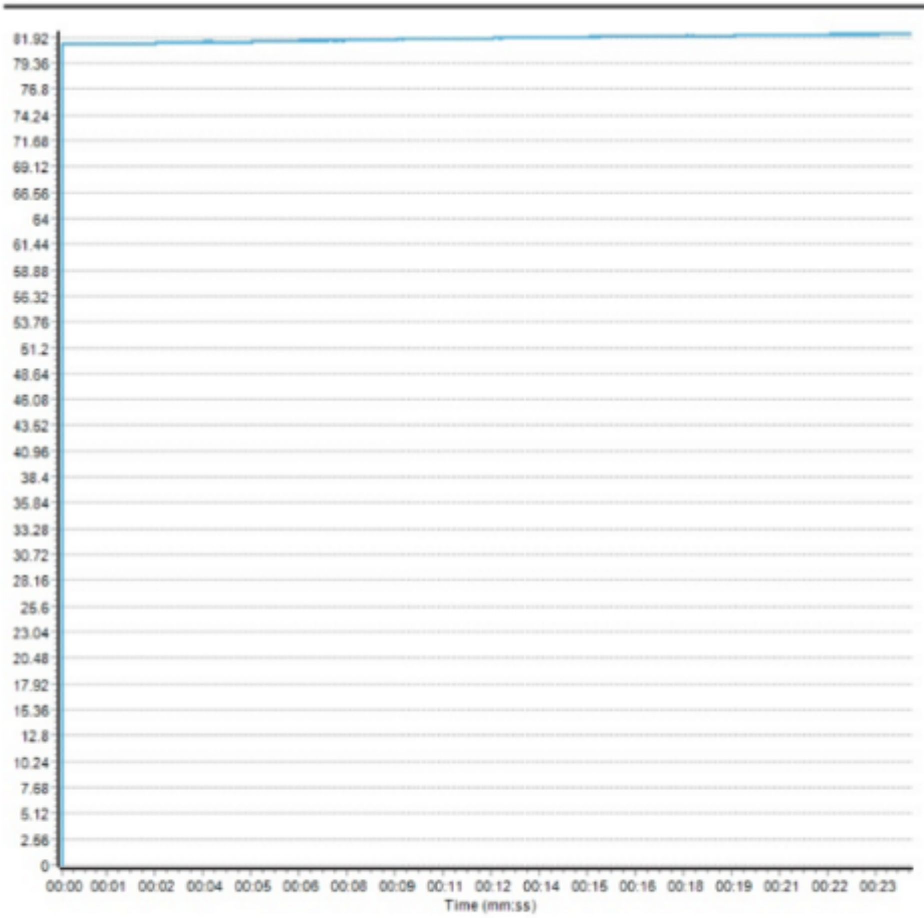
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-13 |

## COMPLETE VIEW




Page 3 of 3

Test 14 of 14

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 06:27:31 | 24.79 | -1424.56 | 1457.74 | 1.891 | 33.17 |
| 2 | 06:27:32 | 24.81 | 21.52 | 1444.69 | 1.638 | 1466.21 |
| 3 | 06:27:34 | 24.83 | 21.7 | 1431.31 | 1.99 | 1453.01 |
| 4 | 06:27:35 | 24.85 | 21.21 | 1418.05 | 1.717 | 1439.26 |
| 5 | 06:27:37 | 24.87 | 21.92 | 1405.09 | 1.845 | 1427.02 |
| 6 | 06:27:38 | 24.9 | 21.73 | 1391.62 | 1.783 | 1413.35 |
| 7 | 06:27:40 | 24.92 | 20.53 | 1379.2 | 1.658 | 1399.73 |
| 8 | 06:27:41 | 24.94 | 19.19 | 1368.5 | 1.721 | 1387.68 |
| 9 | 06:27:43 | 24.96 | 20 | 1356.4 | 1.804 | 1376.4 |
| 10 | 06:27:44 | 24.97 | 18.3 | 1345.46 | 1.638 | 1363.76 |
| 11 | 06:27:45 | 24.99 | 18.17 | 1334.32 | 1.534 | 1352.49 |
| 12 | 06:27:47 | 25.01 | 17.5 | 1324.37 | 1.692 | 1341.87 |
| 13 | 06:27:48 | 25.03 | 17.58 | 1314.94 | 1.741 | 1332.52 |
| 14 | 06:27:53 | 25.04 | 16.63 | 1306.31 | 1.791 | 1322.94 |
| 15 | 06:27:53 | 25.06 | 11.35 | 1302.7 | 2.015 | 1314.05 |
| 16 | 06:27:54 | 11.3 | -13756.72 | 15066.91 | 1.866 | 1310.19 |
| 17 | 06:27:54 | 11.32 | 22.87 | 15051.71 | 1.567 | 15074.58 |
| 18 | 06:27:56 | 11.34 | 18.46 | 15040.81 | 1.717 | 15059.26 |
| 19 | 06:27:57 | 9.33 | -2008.37 | 17056.89 | 1.642 | 15048.52 |
| 20 | 06:27:59 | 9.34 | 5.77 | 17058.24 | 1.916 | 17064 |
| 21 | 06:28:00 | 9.34 | 5.67 | 17061.22 | 2.363 | 17066.88 |
| 22 | 06:28:02 | 9.35 | 5.59 | 17063 | 2.09 | 17068.59 |
| 23 | 06:28:03 | 9.35 | 5.92 | 17065.08 | 1.887 | 17071 |
| 24 | 06:28:05 | 9.36 | 5.6 | 17066.99 | 1.721 | 17072.59 |
| 25 | 06:28:06 | 9.37 | 5.42 | 17069.38 | 1.887 | 17074.8 |
| 26 | 06:28:07 | 9.37 | 4.89 | 17072.3 | 1.721 | 17077.19 |
| 27 | 06:28:09 | 9.38 | 5.61 | 17073.71 | 1.741 | 17079.32 |
| 28 | 06:28:13 | 9.38 | 5.34 | 17075.22 | 1.658 | 17080.56 |
| 29 | 06:28:14 | 9.39 | 5.75 | 17077.23 | 1.824 | 17082.98 |
| 30 | 06:28:14 | 9.39 | 5.74 | 17078.51 | 1.688 | 17084.25 |

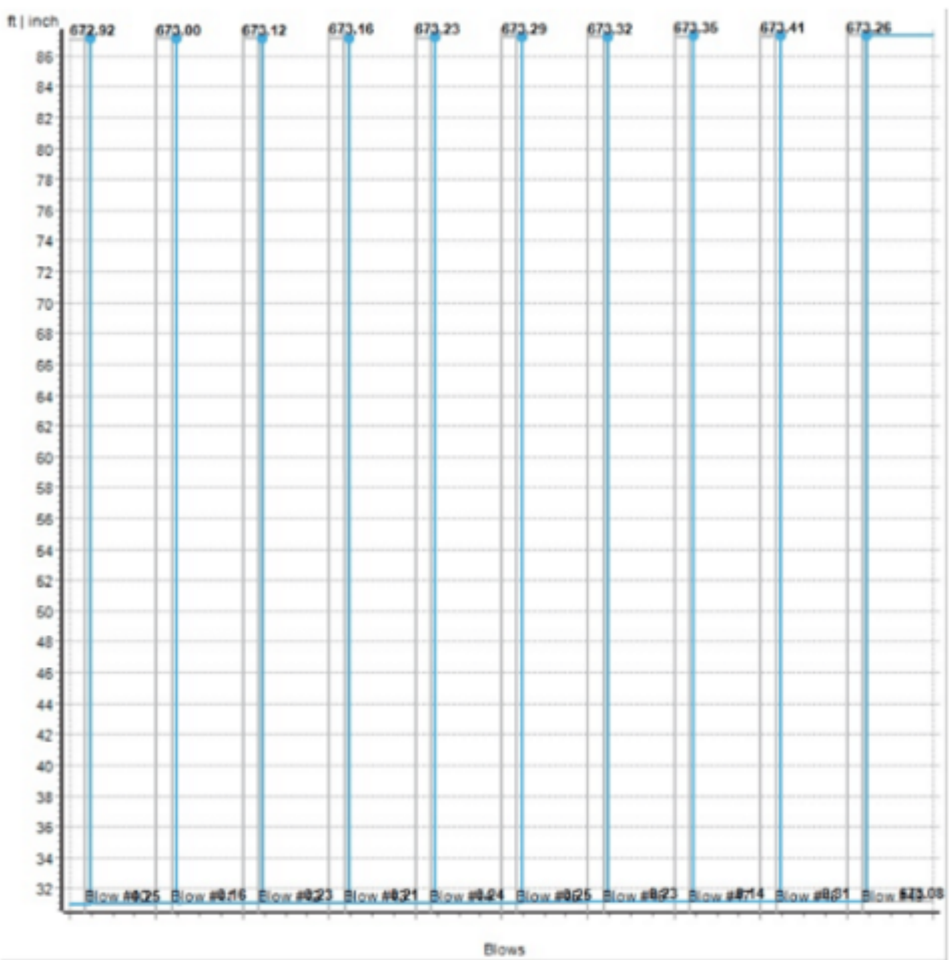
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 31 | 06:28:15 | 9.4 | 6 | 17080.18 | 1.724 | 17086.18 |
| 32 | 06:28:16 | 9.4 | 5.83 | 17081.96 | 1.795 | 17087.79 |
| 33 | 06:28:18 | 9.41 | 5.97 | 17082.44 | 1.67 | 17088.41 |
| 34 | 06:28:19 | 9.42 | 5.4 | 17083.06 | 1.475 | 17088.46 |
| 35 | 06:28:21 | 9.42 | 5.97 | 17087.49 | 2.457 | 17093.46 |
| 36 | 06:28:22 | 9.43 | 7.62 | 17087.37 | 1.783 | 17094.99 |
| 37 | 06:28:24 | 9.44 | 9.03 | 17085.11 | 1.721 | 17094.14 |
| 38 | 06:28:25 | 9.45 | 7.31 | 17085.4 | 1.824 | 17092.71 |
| 39 | 06:28:26 | 9.45 | 7.27 | 17085.27 | 1.617 | 17092.54 |
| 40 | 06:28:28 | 9.46 | 6.25 | 17085.98 | 1.741 | 17092.23 |
| 41 | 06:28:33 | 9.46 | 4.08 | 17090.19 | 1.791 | 17094.27 |
| 42 | 06:28:34 | 9.47 | 5.83 | 17091.53 | 2.04 | 17097.35 |
| 43 | 06:28:34 | 9.47 | 5.34 | 17092.93 | 1.762 | 17098.26 |
| 44 | 06:28:34 | 9.48 | 6.2 | 17093.96 | 1.638 | 17100.17 |
| 45 | 06:28:35 | 9.49 | 6.37 | 17095.31 | 1.928 | 17101.68 |
| 46 | 06:28:37 | 9.49 | 5.76 | 17096.54 | 1.762 | 17102.31 |
| 47 | 06:28:38 | 9.5 | 3.67 | 17099.51 | 1.824 | 17103.18 |
| 48 | 06:28:40 | 9.5 | 8 | 17096.7 | 1.635 | 17104.7 |
| 49 | 06:28:41 | 26.6 | 17096.12 | 4.81 | 2.026 | 17100.93 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 11/2/2019 |
| Client Name | | Report Time | 7:22:14 PM |
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Test Time | 6:27:29 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD-14 | PDM Pile Offset (ft) | 30.480 |
| Pile Type | | Final Penetration at Blow 49 (ft) | 87.274 |
| Hammer | | Stroke (ft) | |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-14 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (inch) | 67.51 | VMX (ft/s) | 5.954 |
| Rebound (inch) | 605.70 | DMX (inch) | 673.21 |
| Capacity (kip) | - | | |

## TABLE VIEW

| Blow | Set (inch) | Rebound (inch) | VMX (ft/s) | Penetration (ft) |
|---|---|---|---|---|
| 49 | 673.08 | 0.19 | 6.65 | 87.274 |
| 48 | 0.31 | 673.10 | 5.36 | 31.184 |
| 47 | 0.14 | 673.21 | 5.99 | 31.158 |
| 46 | 0.23 | 673.09 | 5.78 | 31.146 |
| 45 | 0.25 | 673.04 | 6.33 | 31.127 |
| 44 | 0.24 | 672.99 | 5.37 | 31.106 |
| 43 | 0.21 | 672.95 | 5.78 | 31.086 |
| 42 | 0.23 | 672.89 | 6.69 | 31.068 |
| 41 | 0.16 | 672.84 | 5.88 | 31.049 |
| 40 | 0.25 | 672.68 | 5.71 | 31.036 |
| Average | 67.51 inch | 605.70 inch | | |
| Max Variation | 672.93 inch | 673.02 inch | | |

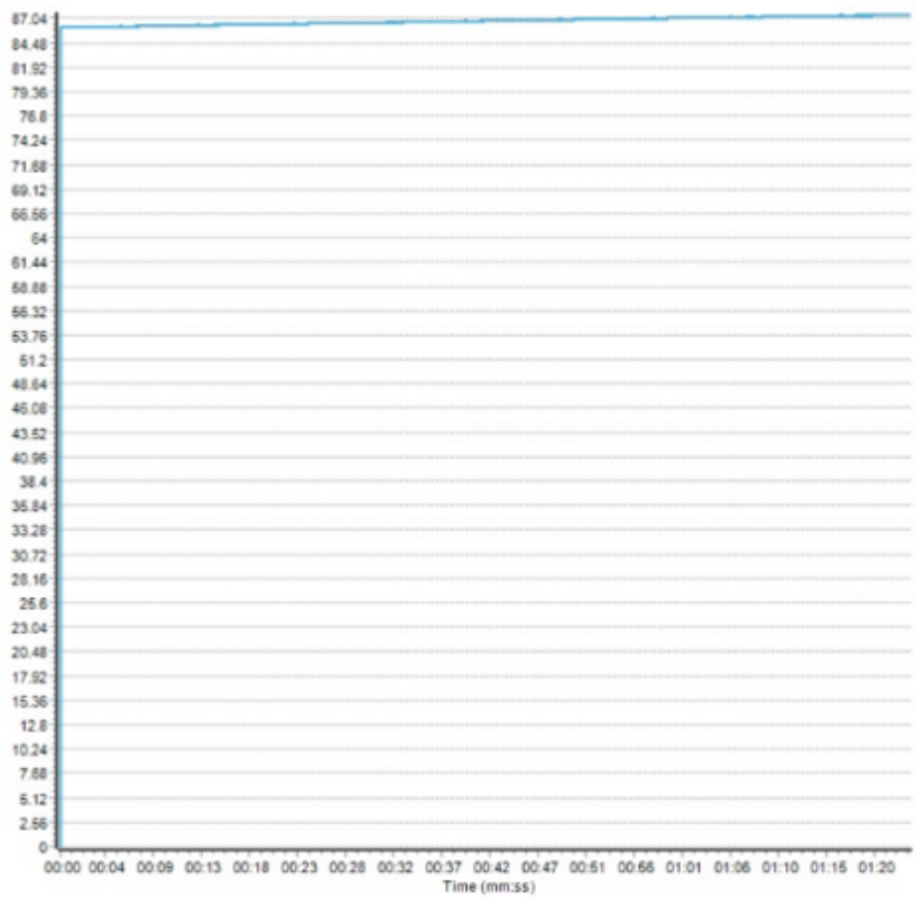
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Canaveral Day 2 | Test Date | 4/6/2018 |
| Project Description | | Pile Number | 1-EOD-14 |

## COMPLETE VIEW




Page 3 of 3

## A.2.2 Reedy Creek, 7/19/2018, Floridian Place Extension: Ten Tests

**Test 1 of 10**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:23:37 | 19.697 | 37.1 | -1.4 | 3.062 | 35.7 |
| 2 | 13:23:38 | 19.731 | 34.2 | -1 | 3.095 | 33.3 |
| 3 | 13:23:39 | 19.759 | 27.8 | -0.3 | 2.854 | 27.5 |
| 4 | 13:23:40 | 19.786 | 26.4 | -0.1 | 2.876 | 26.3 |
| 5 | 13:23:42 | 19.811 | 25.7 | 0.1 | 2.894 | 25.8 |
| 6 | 13:23:45 | 19.834 | 23.1 | 0.6 | 2.883 | 23.7 |
| 7 | 13:23:45 | 19.854 | 19.8 | 0.6 | 2.795 | 20.4 |
| 8 | 13:23:45 | 19.873 | 18.4 | 0.8 | 2.656 | 19.2 |
| 9 | 13:23:47 | 19.89 | 17.7 | 0.8 | 2.546 | 18.5 |
| 10 | 13:23:48 | 19.908 | 18.1 | 0.7 | 2.594 | 18.8 |
| 11 | 13:23:49 | 19.924 | 15.3 | 0.8 | 2.598 | 16 |
| 12 | 13:23:50 | 19.939 | 14.9 | 0.7 | 2.631 | 15.6 |
| 13 | 13:23:52 | 19.953 | 14.2 | 0.9 | 2.488 | 15.1 |
| 14 | 13:23:53 | 19.966 | 13.6 | 0.8 | 2.448 | 14.5 |
| 15 | 13:23:54 | 19.98 | 13.4 | 1 | 2.385 | 14.4 |
| 16 | 13:23:55 | 19.992 | 12 | 0.6 | 2.301 | 12.6 |
| 17 | 13:23:56 | 20.011 | 19.4 | -10 | 2.279 | 9.3 |
| 18 | 13:24:00 | 20.015 | 3.9 | -1.9 | 2.524 | 2 |
| 19 | 13:24:01 | 20.015 | 0.4 | 3 | 3.739 | 3.5 |
| 20 | 13:24:01 | 20.014 | -1.2 | 4.3 | 4.581 | 3.1 |
| 21 | 13:24:02 | 20.001 | -12.9 | 15.3 | 8.25 | 2.4 |
| 22 | 13:24:02 | 20 | -1.6 | 3.3 | 11.452 | 1.7 |
| 23 | 13:24:05 | 19.963 | -36.4 | 43.2 | 14.218 | 6.9 |

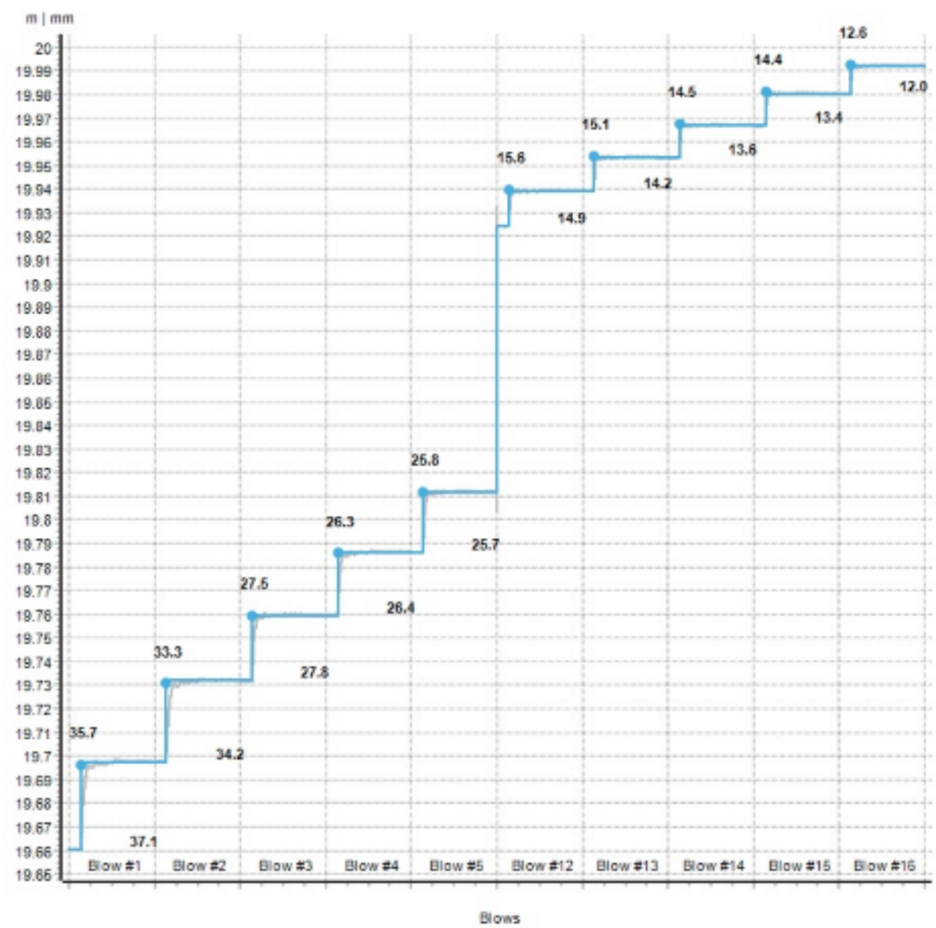
# PILE DRIVING MONITOR

FDOT

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 3:56:22 PM |
| Project Name | Disney | Test Date | 14/3/2019 |
| Project Area | A1 | Test Time | 1:23:22 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 7-EOD | PDM Pile Offset (m) | 8.200 |
| Pile Type | | Final Penetration at Blow 16 (m) | 19.992 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 14/3/2019 |
| Project Area | A1 | Pile Number | 7-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 21.9 | VMX (m/s) | 2.52 |
| Rebound (mm) | 0.1 | DMX (mm) | 22.1 |

## TABLE VIEW

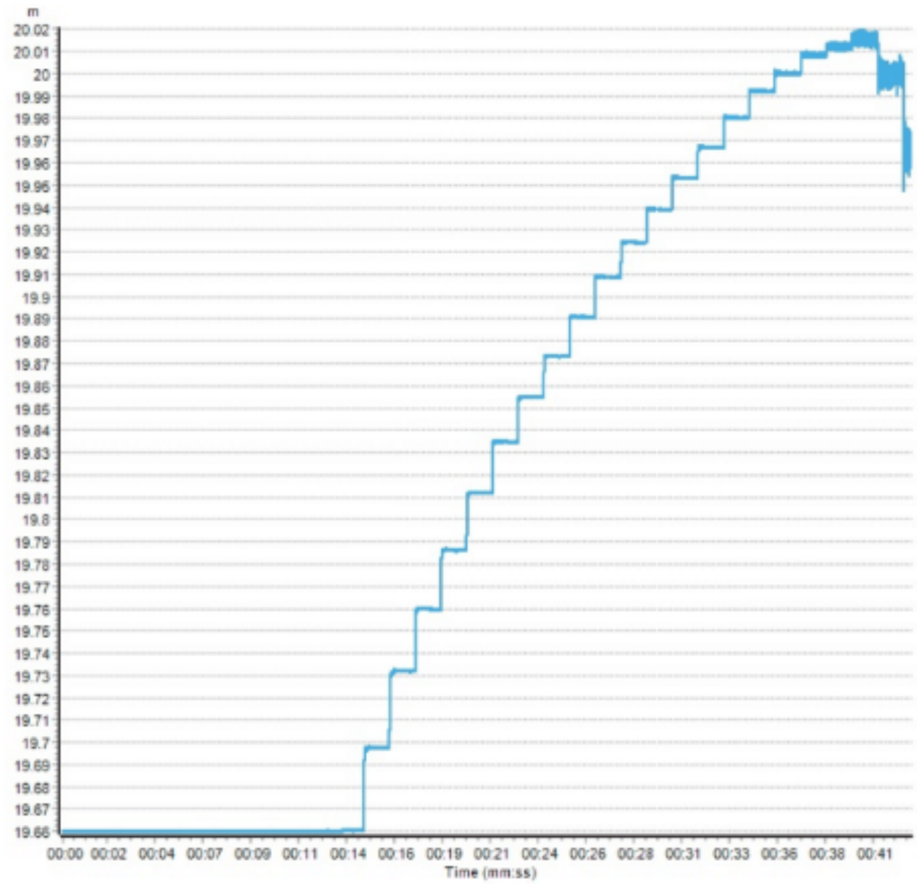
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 16 | 12.0 | 0.6 | 2.30 | 19.992 |
| 15 | 13.4 | 1.0 | 2.39 | 19.980 |
| 14 | 13.6 | 0.8 | 2.45 | 19.966 |
| 13 | 14.2 | 0.9 | 2.49 | 19.953 |
| 12 | 14.9 | 0.7 | 2.63 | 19.939 |
| 5 | 25.7 | 0.1 | 2.89 | 19.811 |
| 4 | 26.4 | -0.1 | - | 19.786 |
| 3 | 27.8 | -0.3 | - | 19.759 |
| 2 | 34.2 | -1.0 | - | 19.731 |
| 1 | 37.1 | -1.4 | - | 19.697 |
| **Average** | 21.9 | 0.1 | 2.52 | |
| **Max Variation** | 25.1 | 2.4 | 0.59 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 14/3/2019 |
| Project Description | A1 | Pile Number | 7-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

Page 3 of 3

**Test 2 of 10**

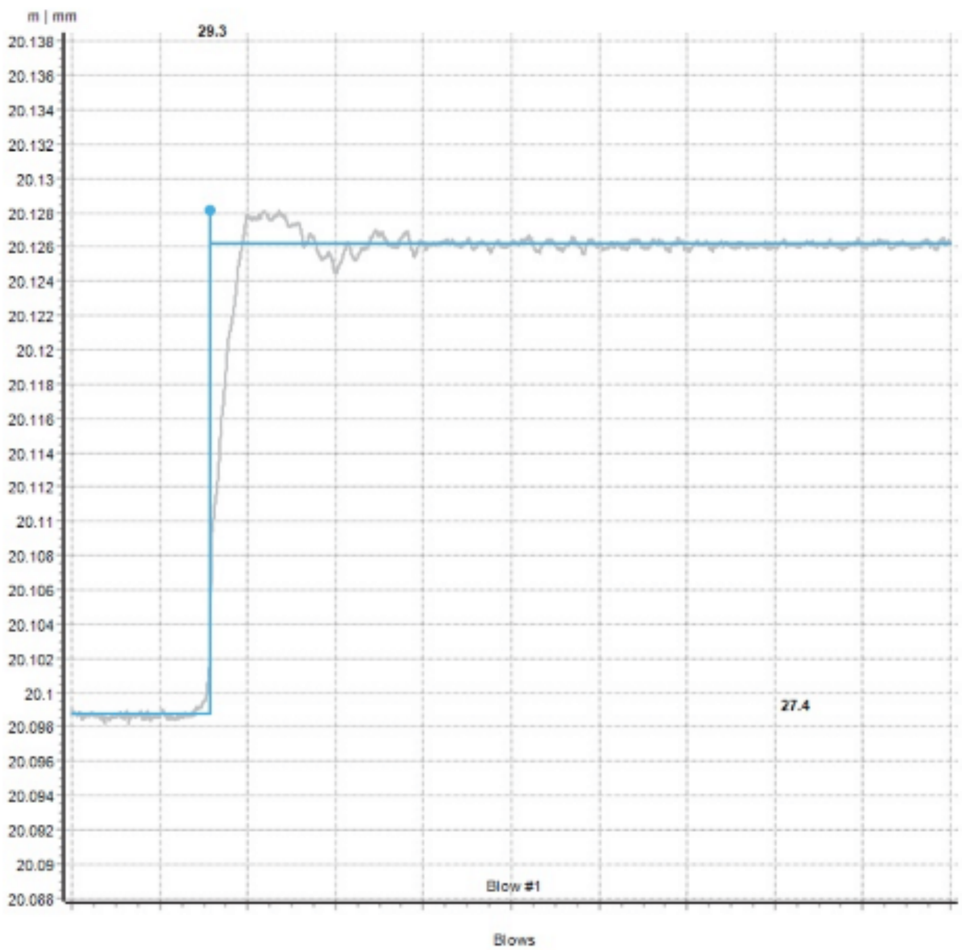
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:36:49 | 20.027 | 27.4 | 1.9 | 3.896 | 29.3 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:14:13 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:36:43 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 1 (m) | 20.027 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 27.4 | VMX (m/s) | 0.00 |
| Rebound (mm) | 1.9 | DMX (mm) | 29.3 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 1 | 27.4 | 1.9 | - | 20.027 |

| | | | | |
|---|---|---|---|---|
| **Average** | 27.4 | 1.9 | 0.00 | |
| **Max Variation** | 0.0 | 0.0 | -1998.00 | |

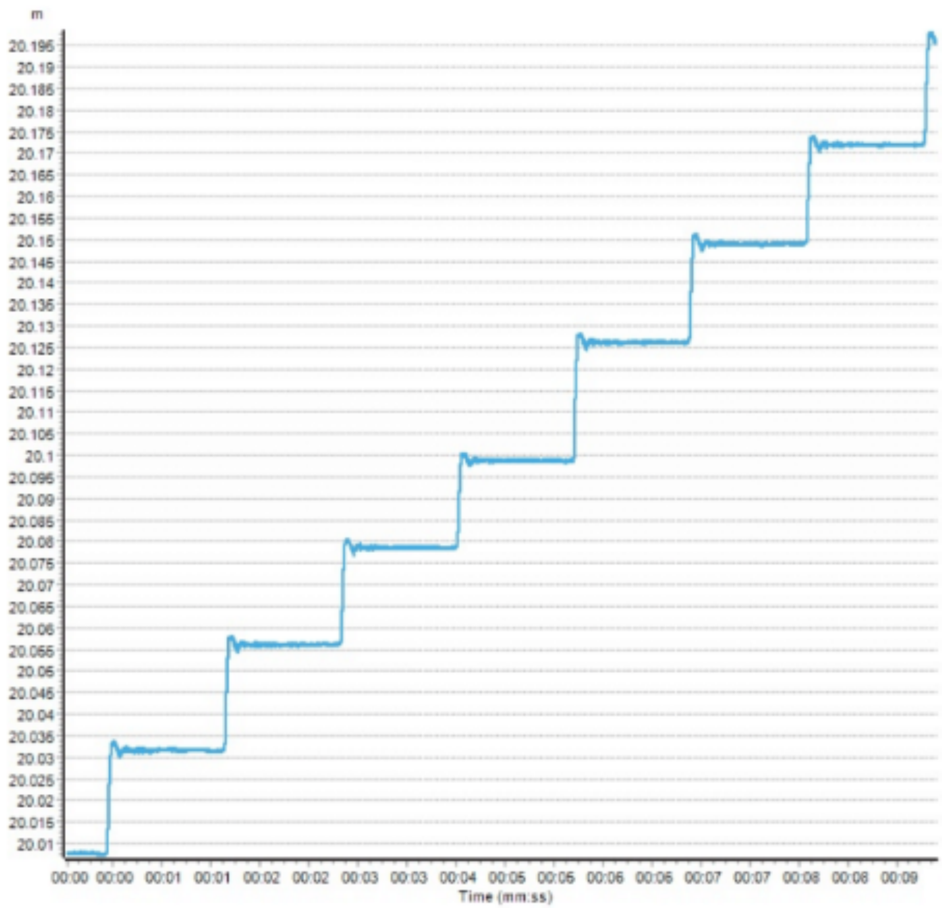
# PILE DRIVING MONITOR

FDOT

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD |

COMPLETE VIEW




PDM Serial Number: PG2024174

Test 3 of 10

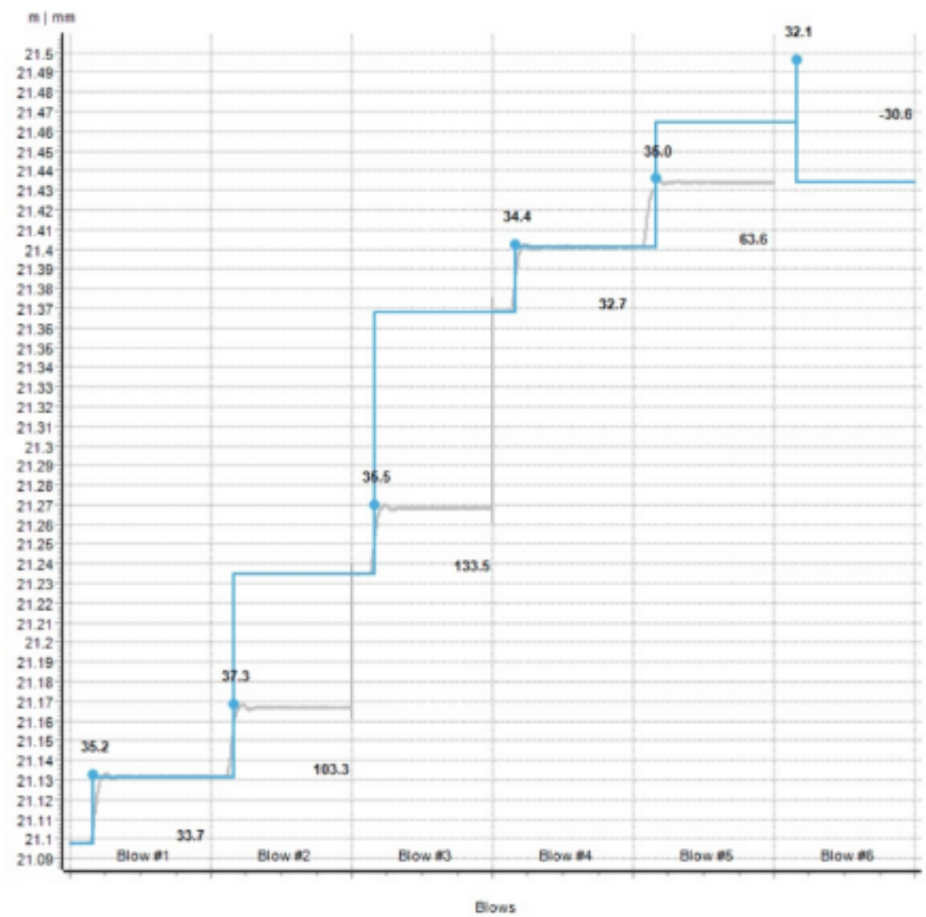
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:39:01 | 21.034 | 33.7 | 1.4 | 1.19 | 35.2 |
| 2 | 15:39:02 | 21.137 | 103.3 | -66 | 1.667 | 37.3 |
| 3 | 15:39:06 | 21.271 | 133.5 | -98.1 | 1.177 | 35.5 |
| 4 | 15:39:11 | 21.303 | 32.7 | 1.7 | 1.342 | 34.4 |
| 5 | 15:39:13 | 21.367 | 63.6 | -28.6 | 1.579 | 35 |
| 6 | 15:39:15 | 21.336 | -30.6 | 62.6 | 1.619 | 32.1 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:13:20 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:39:00 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD-2 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 6 (m) | 21.336 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-2 |

NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 56.0 | VMX (m/s) | 1.60 |
| Rebound (mm) | -21.1 | DMX (mm) | 34.9 |
| Capacity (kN) | - | EMX (kJ) | - |

TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 6 | -30.6 | 62.6 | 1.62 | 21.336 |
| 5 | 63.6 | -28.6 | 1.58 | 21.367 |
| 4 | 32.7 | 1.7 | - | 21.303 |
| 3 | 133.5 | -98.1 | - | 21.271 |
| 2 | 103.3 | -66.0 | - | 21.137 |
| 1 | 33.7 | 1.4 | - | 21.034 |

| | | | |
|---|---|---|---|
| **Average** | 56.0 | -21.1 | 1.60 |
| **Max Variation** | 164.1 | 160.7 | 0.04 |

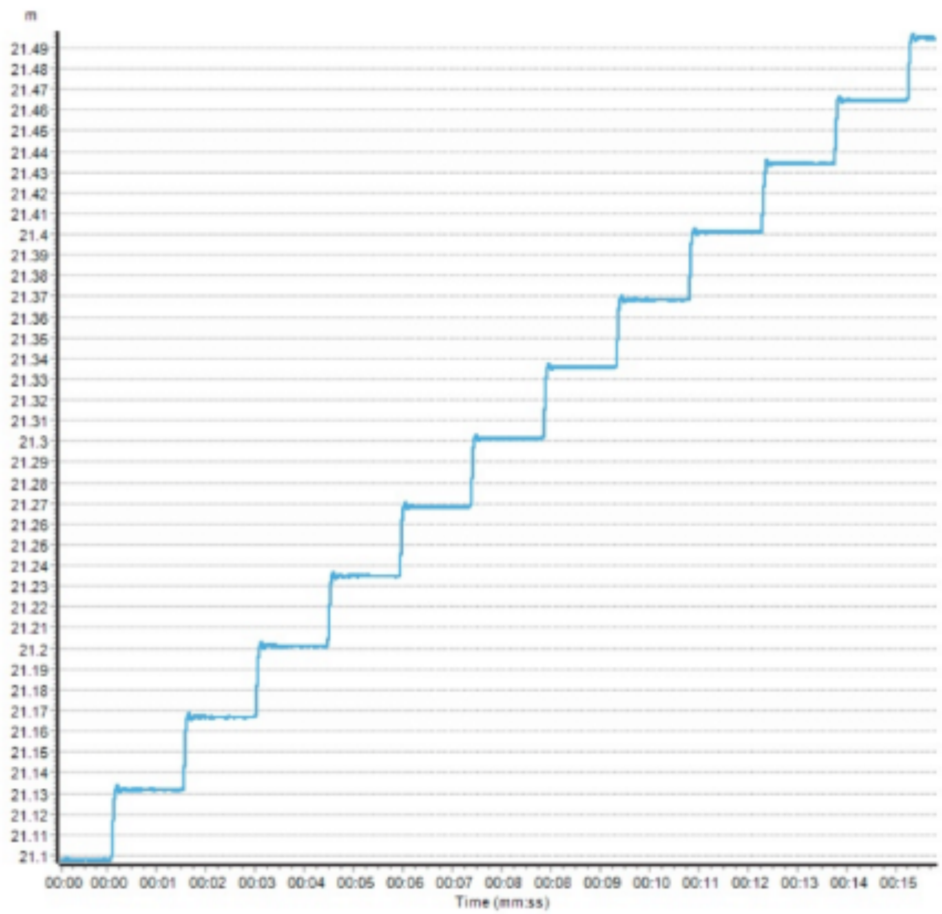
# PILE DRIVING MONITOR

FDOT

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-2 |

COMPLETE VIEW




PDM Serial Number: PG2024174

Page 3 of 3

**Test 4 of 10**

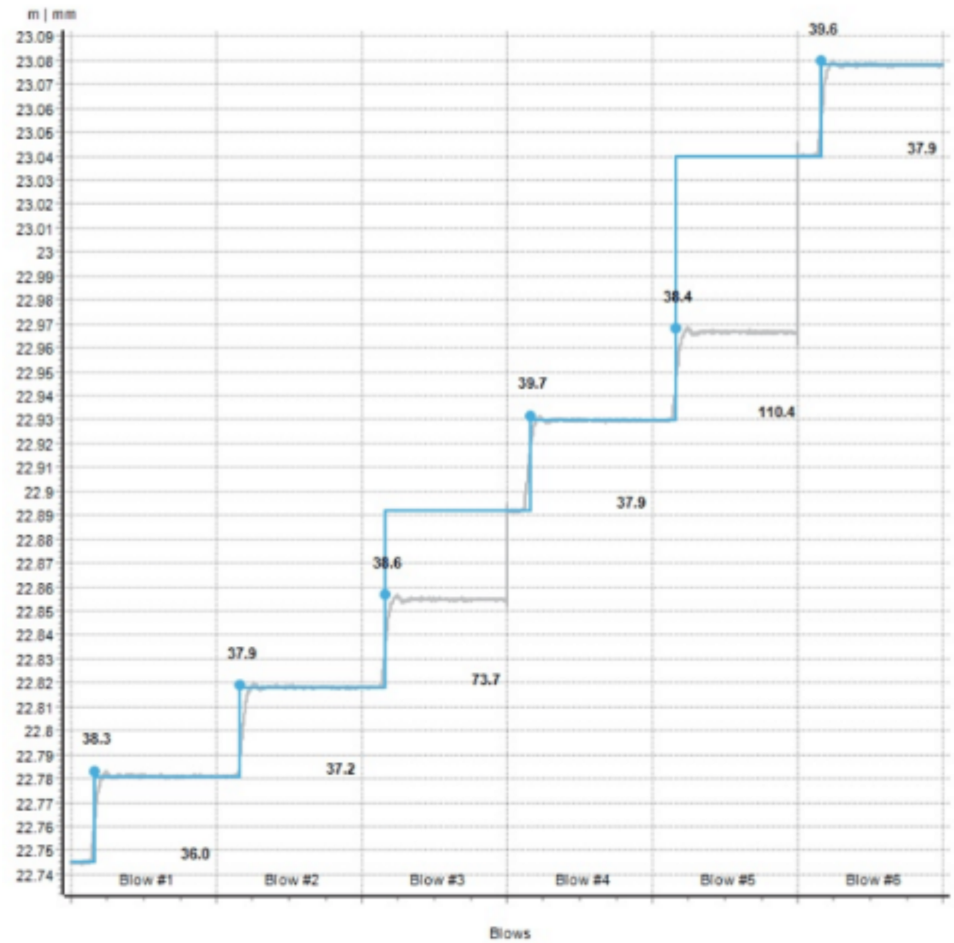
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:40:02 | 23.036 | 36 | 2.2 | 1.489 | 38.3 |
| 2 | 15:40:03 | 23.073 | 37.2 | 0.7 | 1.991 | 37.9 |
| 3 | 15:40:05 | 23.147 | 73.7 | -35.1 | 1.697 | 38.6 |
| 4 | 15:40:07 | 23.185 | 37.9 | 1.8 | 1.835 | 39.7 |
| 5 | 15:40:09 | 23.295 | 110.4 | -71.9 | 1.714 | 38.4 |
| 6 | 15:40:13 | 23.333 | 37.9 | 1.7 | 1.974 | 39.6 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:12:13 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:40:01 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD-3 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 6 (m) | 23.333 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-3 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 55.5 | VMX (m/s) | 1.84 |
| Rebound (mm) | -16.8 | DMX (mm) | 38.8 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 6 | 37.9 | 1.7 | 1.97 | 23.333 |
| 5 | 110.4 | -71.9 | 1.71 | 23.295 |
| 4 | 37.9 | 1.8 | - | 23.185 |
| 3 | 73.7 | -35.1 | - | 23.147 |
| 2 | 37.2 | 0.7 | - | 23.073 |
| 1 | 36.0 | 2.2 | - | 23.036 |

| | | | |
|---|---|---|---|
| **Average** | 55.5 | -16.8 | 1.84 |
| **Max Variation** | 74.3 | 74.1 | 0.26 |

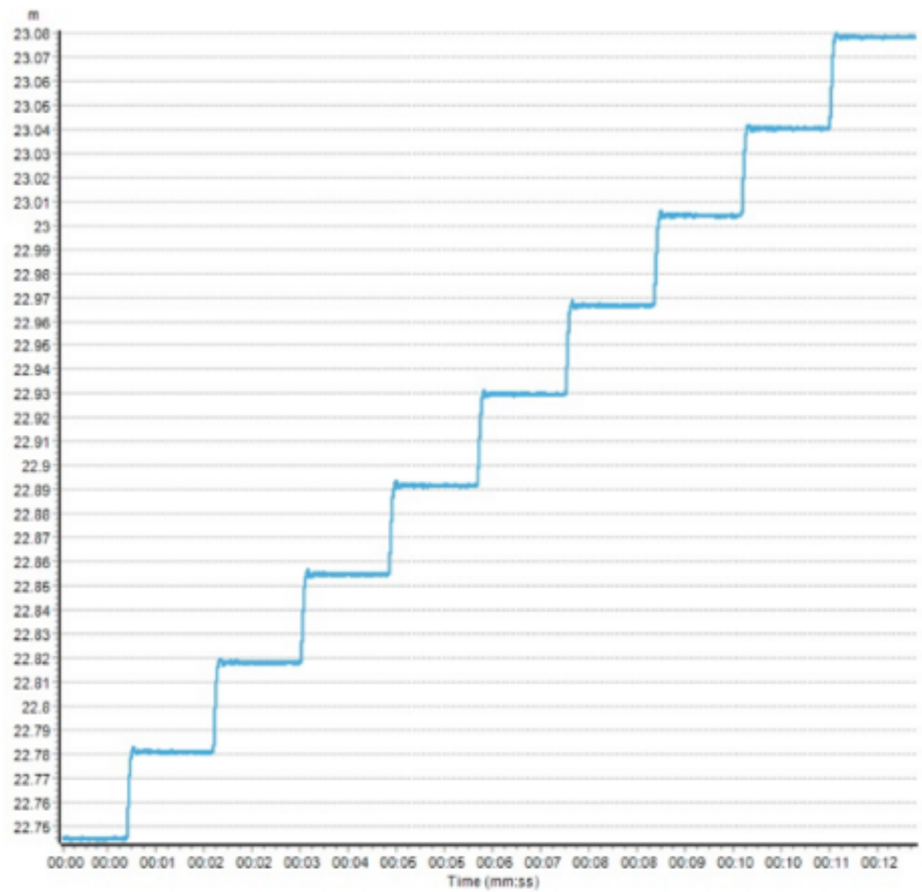
Page 2 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-3 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 5 of 10**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:51:10 | 23.631 | -368.8 | 2.1 | 6.407 | -366.7 |
| 2 | 15:51:11 | 23.642 | 11.1 | -8.4 | 4.987 | 2.7 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:11:19 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:51:10 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-FOD-4 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 2 (m) | 23.642 |
| Hammer | | Stroke (m) | 1.000 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-4 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | -178.9 | VMX (m/s) | 0.00 |
| Rebound (mm) | -3.2 | DMX (mm) | -182.0 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 2 | 11.1 | -8.4 | - | 23.642 |
| 1 | -368.8 | 2.1 | - | 23.631 |

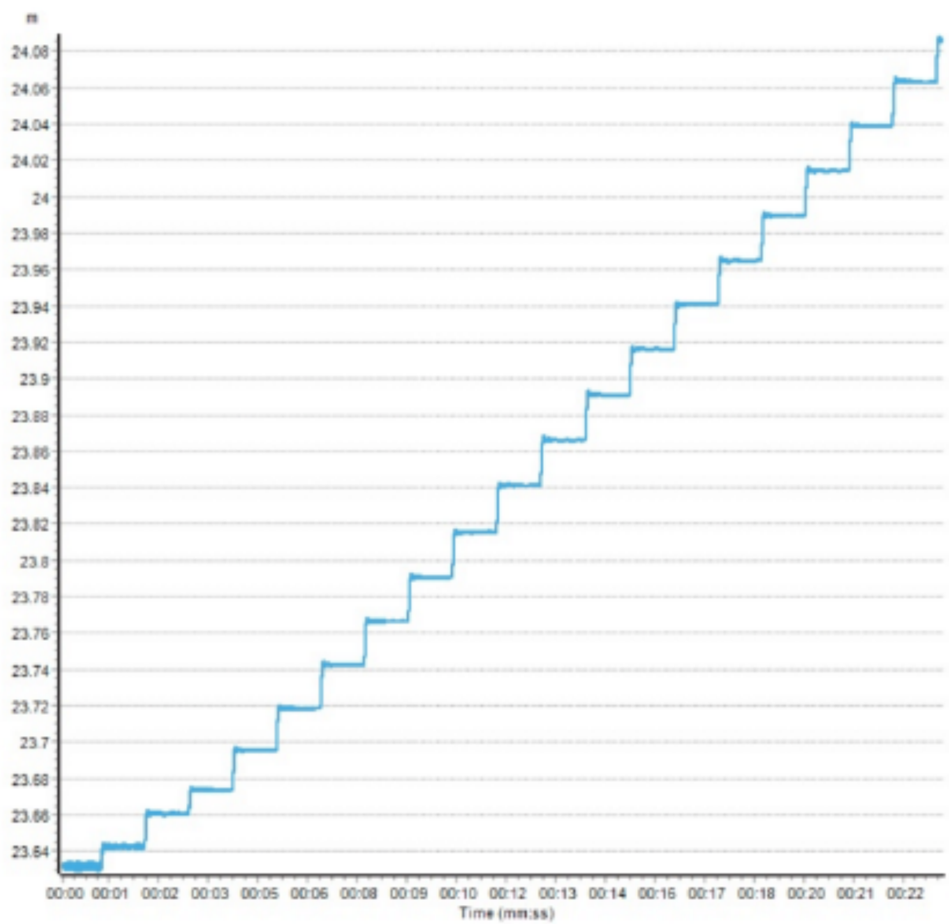
| | | | | |
|---|---|---|---|---|
| **Average** | -178.9 | -3.2 | 0.00 | |
| **Max Variation** | 379.9 | 10.4 | -1998.00 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-4 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 6 of 10**

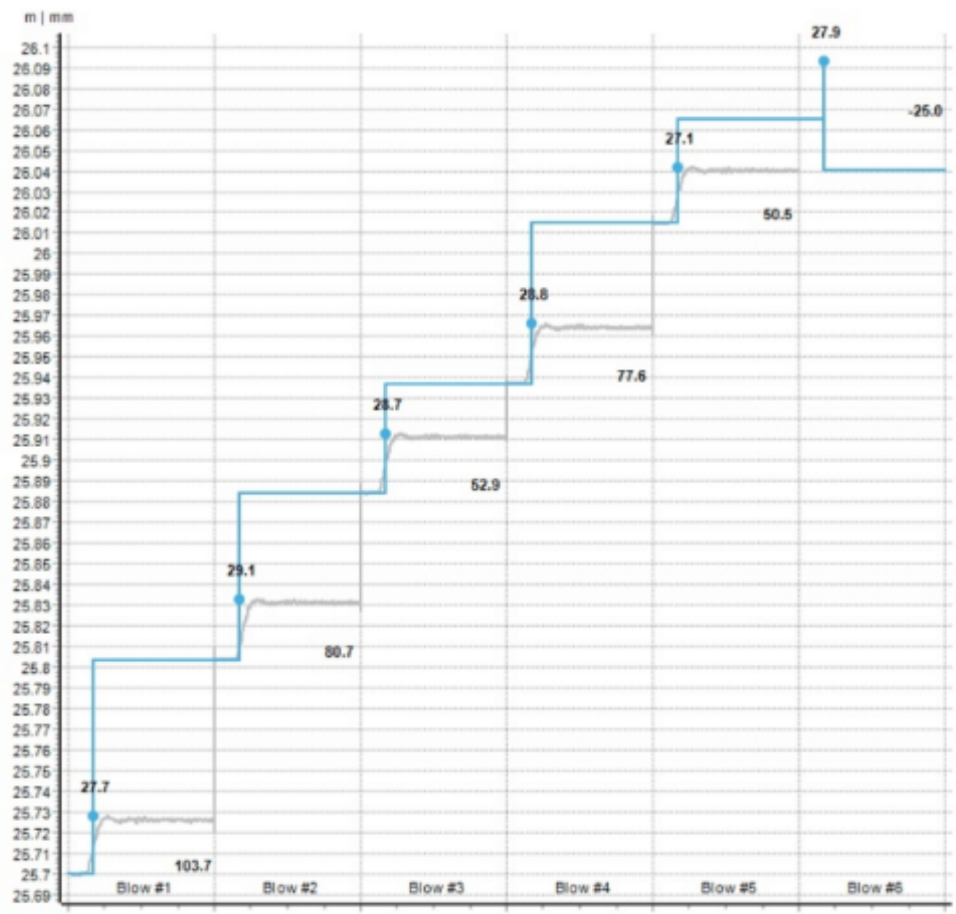
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:52:40 | 26.104 | 103.7 | -76 | 1.645 | 27.7 |
| 2 | 15:52:45 | 26.184 | 80.7 | -51.6 | 1.87 | 29.1 |
| 3 | 15:52:48 | 26.237 | 52.9 | -24.3 | 1.593 | 28.7 |
| 4 | 15:52:51 | 26.315 | 77.6 | -48.8 | 2.078 | 28.8 |
| 5 | 15:52:55 | 26.365 | 50.5 | -23.4 | 1.789 | 27.1 |
| 6 | 15:52:57 | 26.34 | -25 | 52.9 | 2.061 | 27.9 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:08:44 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:52:39 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD-5 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 6 (m) | 26.340 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-5 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 56.7 | VMX (m/s) | 1.92 |
| Rebound (mm) | -28.5 | DMX (mm) | 28.2 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 6 | -25.0 | 52.9 | 2.06 | 26.340 |
| 5 | 50.5 | -23.4 | 1.79 | 26.365 |
| 4 | 77.6 | -48.8 | - | 26.315 |
| 3 | 52.9 | -24.3 | - | 26.237 |
| 2 | 80.7 | -51.6 | - | 26.184 |
| 1 | 103.7 | -76.0 | - | 26.104 |

| | | | |
|---|---|---|---|
| **Average** | 56.7 | -28.5 | 1.92 |
| **Max Variation** | 128.7 | 128.9 | 0.27 |

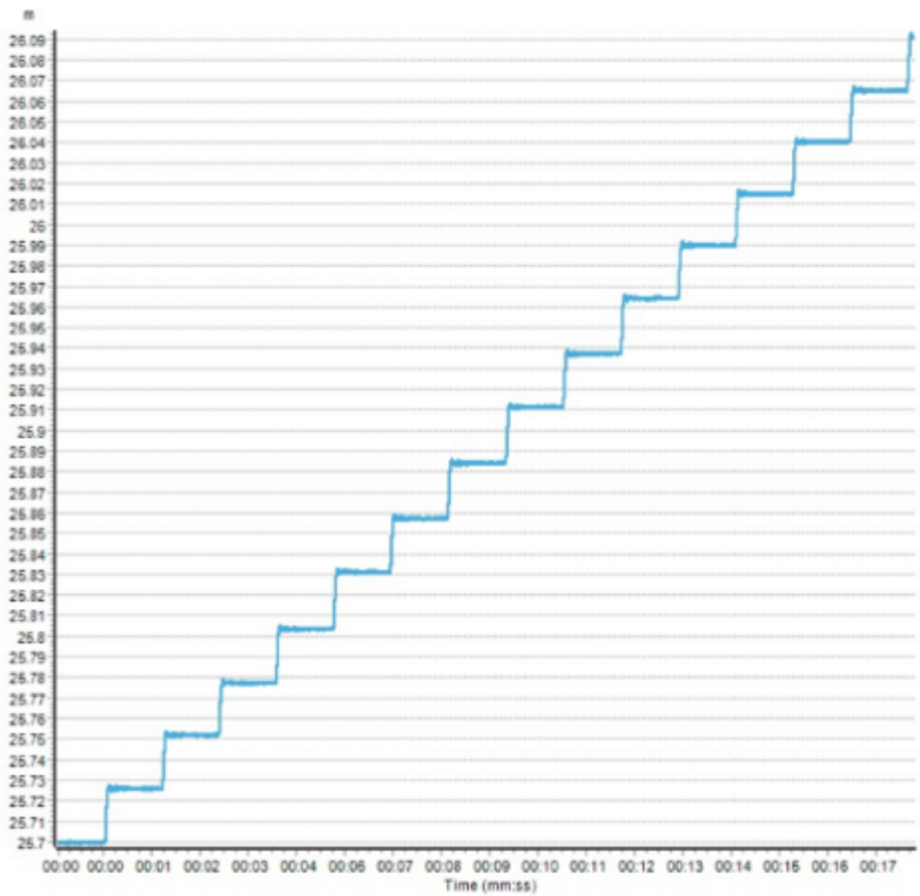
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-5 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 7 of 10**

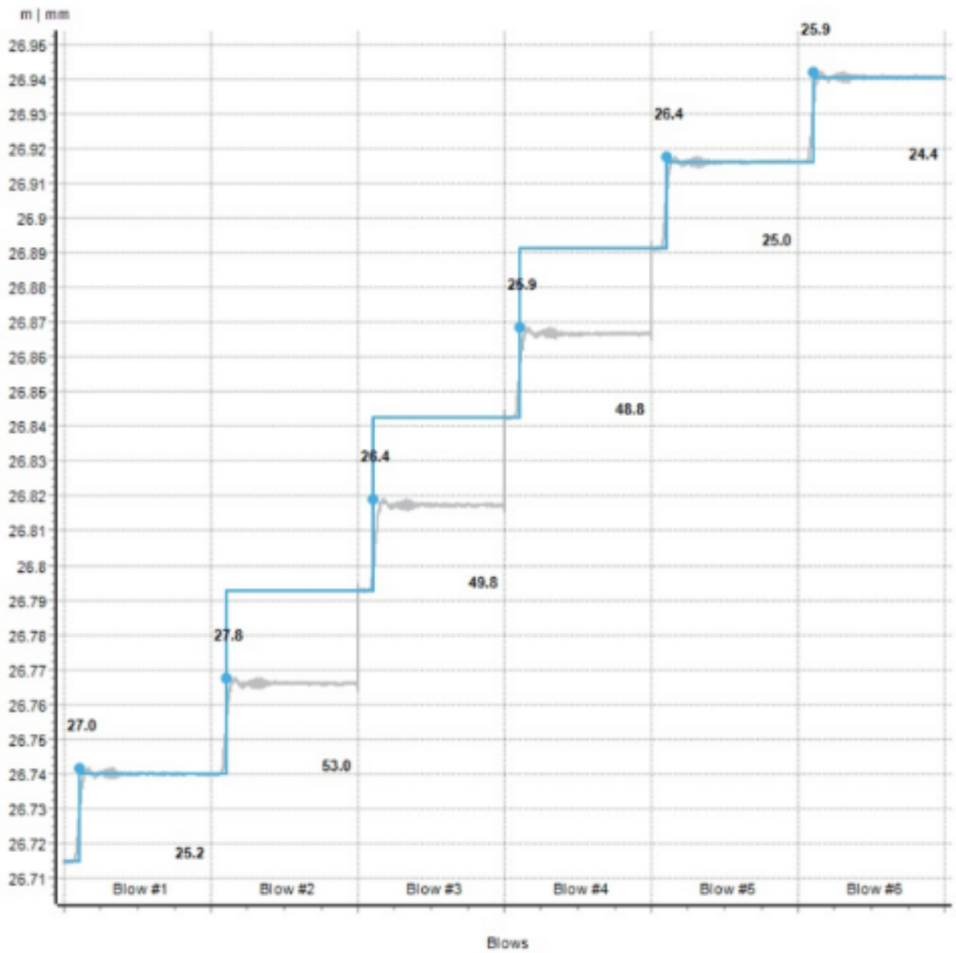
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:53:56 | 27.025 | 25.2 | 1.8 | 1.212 | 27 |
| 2 | 15:53:57 | 27.078 | 53 | -25.3 | 1.472 | 27.8 |
| 3 | 15:54:00 | 27.128 | 49.8 | -23.4 | 1.299 | 26.4 |
| 4 | 15:54:02 | 27.177 | 48.8 | -22.9 | 1.342 | 25.9 |
| 5 | 15:54:05 | 27.202 | 25 | 1.3 | 1.299 | 26.4 |
| 6 | 15:54:06 | 27.226 | 24.4 | 1.4 | 1.393 | 25.9 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:07:40 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:53:53 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD-6 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 6 (m) | 27.226 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-6 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 37.7 | VMX (m/s) | 1.35 |
| Rebound (mm) | -11.2 | DMX (mm) | 26.6 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 6 | 24.4 | 1.4 | 1.39 | 27.226 |
| 5 | 25.0 | 1.3 | 1.30 | 27.202 |
| 4 | 48.8 | -22.9 | - | 27.177 |
| 3 | 49.8 | -23.4 | - | 27.128 |
| 2 | 53.0 | -25.3 | - | 27.078 |
| 1 | 25.2 | 1.8 | - | 27.025 |

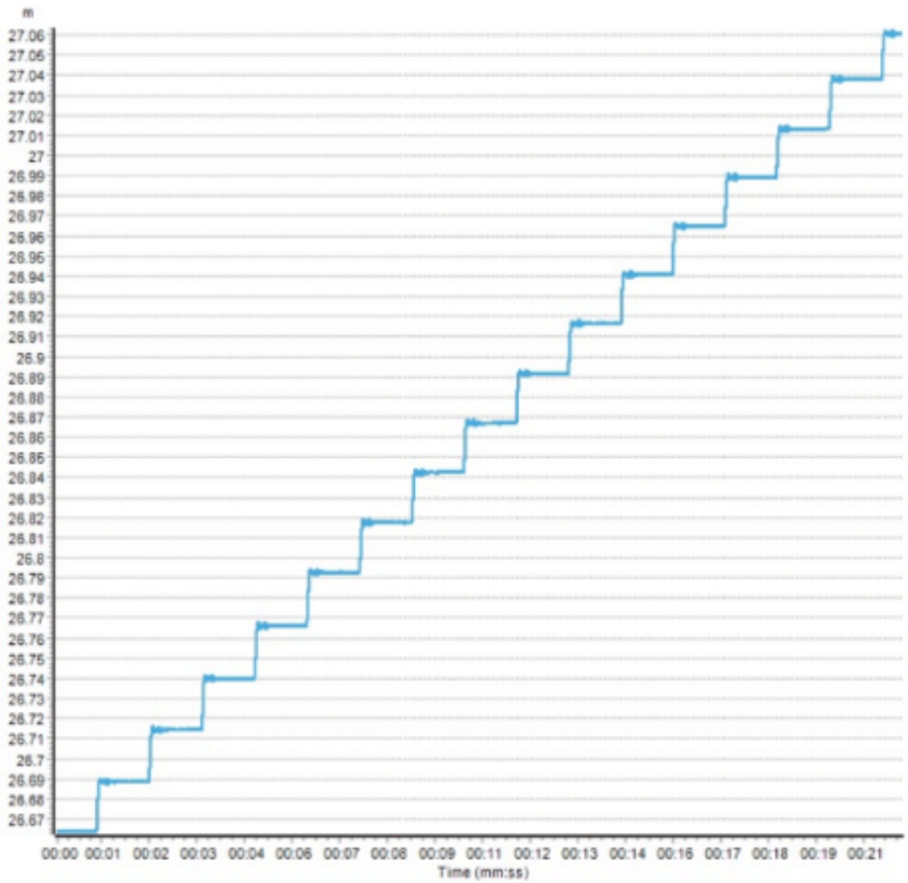
| | | | | |
|---|---|---|---|---|
| **Average** | 37.7 | -11.2 | 1.35 | |
| **Max Variation** | 28.6 | 27.1 | 0.09 | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-6 |

COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 8 of 10**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:55:15 | 29.043 | 43.5 | -19.7 | 2.078 | 23.8 |
| 2 | 15:55:18 | 29.128 | 84.5 | -60.8 | 1.645 | 23.8 |
| 3 | 15:55:23 | 29.169 | 41.1 | -18.3 | 1.697 | 22.8 |
| 4 | 15:55:25 | 29.209 | 39.6 | -17.4 | 2.182 | 22.3 |
| 5 | 15:55:28 | 29.292 | 82.8 | -58.8 | 1.87 | 24 |
| 6 | 15:55:33 | 29.35 | 58.6 | -36.1 | 1.887 | 22.4 |
| 7 | 15:55:36 | 29.37 | 20.3 | 2.4 | 1.997 | 22.7 |
| 8 | 15:55:38 | 29.391 | 20.6 | 2.2 | 2.13 | 22.8 |

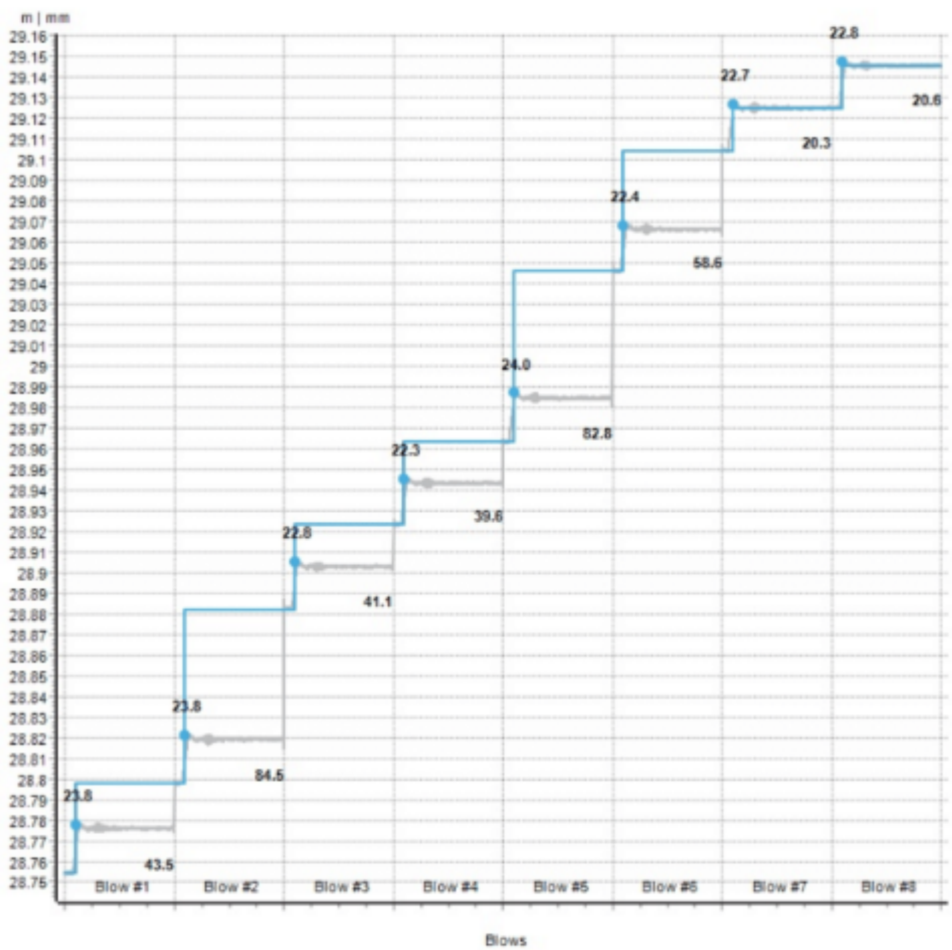
# PILE DRIVING MONITOR

FDOT

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:06:34 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:55:13 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD-7 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 8 (m) | 29.391 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-7 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 48.9 | VMX (m/s) | 1.97 |
| Rebound (mm) | -25.8 | DMX (mm) | 23.1 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 8 | 20.6 | 2.2 | 2.13 | 29.391 |
| 7 | 20.3 | 2.4 | 2.00 | 29.370 |
| 6 | 58.6 | -36.1 | 1.89 | 29.350 |
| 5 | 82.8 | -58.8 | 1.87 | 29.292 |
| 4 | 39.6 | -17.4 | - | 29.209 |
| 3 | 41.1 | -18.3 | - | 29.169 |
| 2 | 84.5 | -60.8 | - | 29.128 |
| 1 | 43.5 | -19.7 | - | 29.043 |

| | | | |
|---|---|---|---|
| **Average** | 48.9 | -25.8 | 1.97 |
| **Max Variation** | 64.2 | 63.2 | 0.26 |

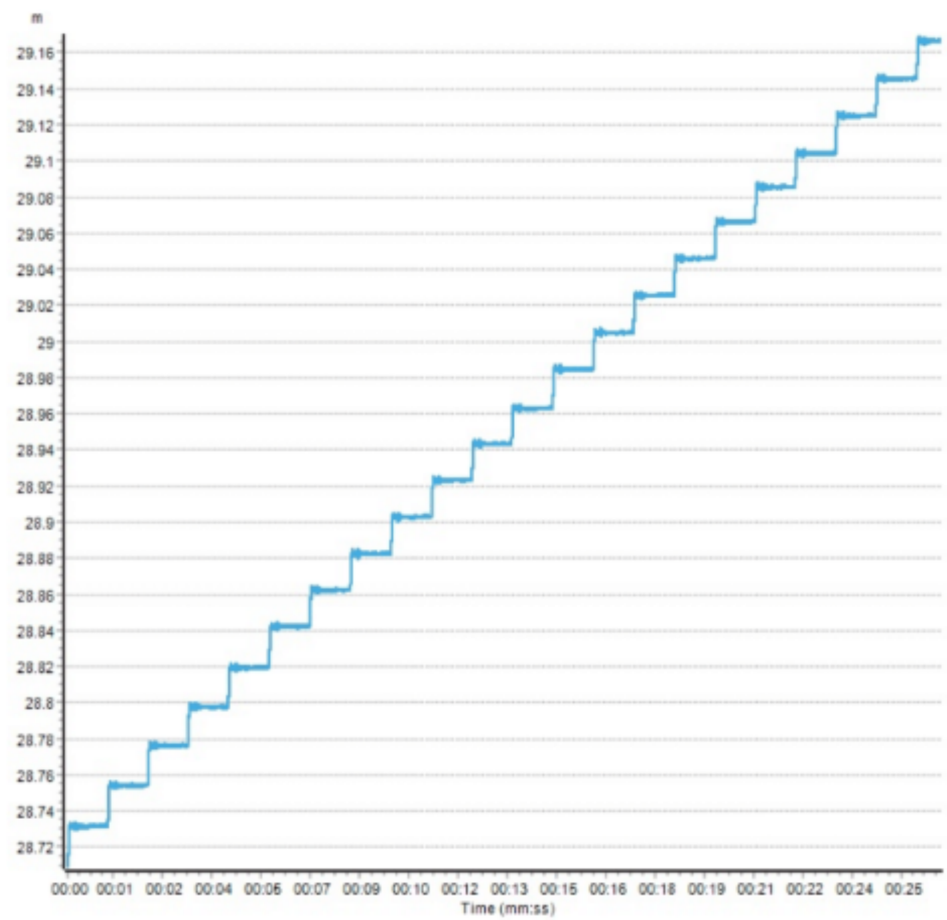
Page 2 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-7 |

COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 9 of 10**

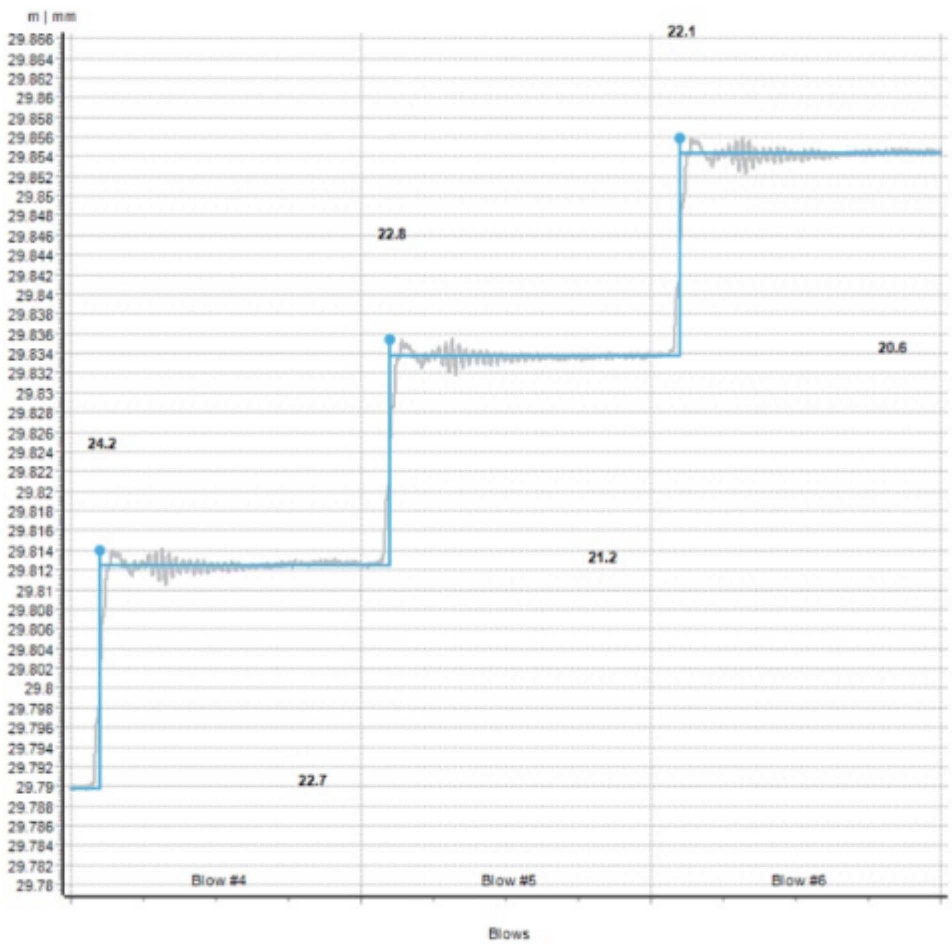
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:56:43 | 30.02 | 20.3 | 1.8 | 1.143 | 22.1 |
| 2 | 15:56:44 | 30.063 | 42.4 | -19.8 | 1.385 | 22.6 |
| 3 | 15:56:46 | 30.125 | 62.6 | -40.5 | 1.515 | 22.1 |
| 4 | 15:56:50 | 30.148 | 22.7 | 1.5 | 1.537 | 24.2 |
| 5 | 15:56:51 | 30.169 | 21.2 | 1.6 | 1.456 | 22.8 |
| 6 | 15:56:52 | 30.19 | 20.6 | 1.6 | 1.449 | 22.1 |
| 7 | 15:56:54 | 30.231 | 41.7 | -19.2 | 1.427 | 22.4 |
| 8 | 15:56:56 | 30.272 | 40.8 | -18.8 | 1.414 | 22 |
| 9 | 15:56:59 | 30.294 | 21.6 | 1.8 | 1.378 | 23.4 |
| 10 | 15:57:00 | 30.356 | 62.3 | -39.7 | 1.349 | 22.5 |
| 11 | 15:57:04 | 30.397 | 40.7 | -18.6 | 1.4 | 22.1 |
| 12 | 15:57:06 | 30.415 | 18.2 | 1.3 | 1.4 | 19.4 |
| 13 | 15:57:07 | 30.441 | 26 | 1.6 | 1.913 | 27.6 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:05:00 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:56:42 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD-8 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 6 (m) | 30.190 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-8 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 21.5 | VMX (m/s) | 1.45 |
| Rebound (mm) | 1.6 | DMX (mm) | 23.1 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 6 | 20.6 | 1.6 | 1.45 | 30.190 |
| 5 | 21.2 | 1.6 | 1.46 | 30.169 |
| 4 | 22.7 | 1.5 | - | 30.148 |

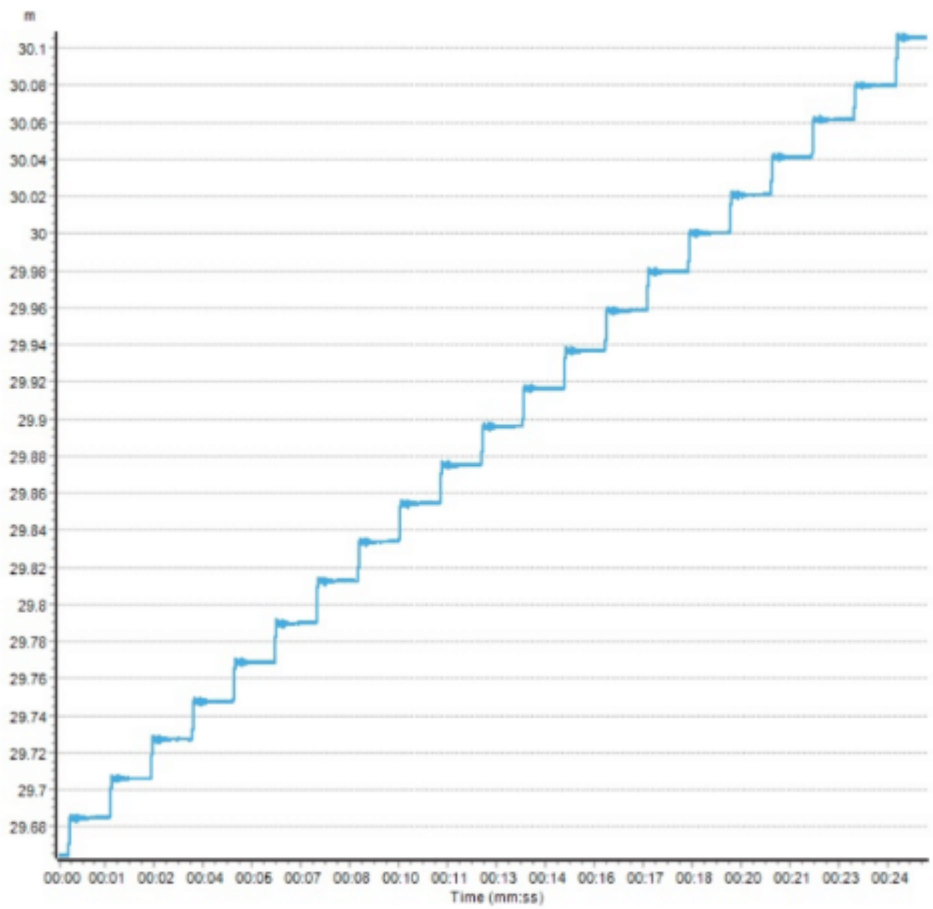
| | | | | |
|---|---|---|---|---|
| **Average** | 21.5 | 1.6 | 1.45 | |
| **Max Variation** | 2.1 | 0.1 | 0.01 | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-8 |

COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 10 of 10**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:58:17 | 32.02 | 20 | 1.6 | 1.576 | 21.6 |
| 2 | 15:58:18 | 32.04 | 20.2 | 2 | 1.68 | 22.3 |
| 3 | 15:58:19 | 32.161 | 120.6 | -98.1 | 1.714 | 22.5 |
| 4 | 15:58:27 | 32.2 | 38.9 | -17.4 | 1.853 | 21.5 |
| 5 | 15:58:29 | 32.274 | 73.8 | -52.8 | 1.772 | 21 |
| 6 | 15:58:34 | 32.37 | 96.7 | -75 | 1.657 | 21.7 |
| 7 | 15:58:41 | 32.407 | 36.8 | -16.7 | 1.685 | 20.2 |
| 8 | 15:58:43 | 32.428 | 21.3 | 1.7 | 1.807 | 23 |

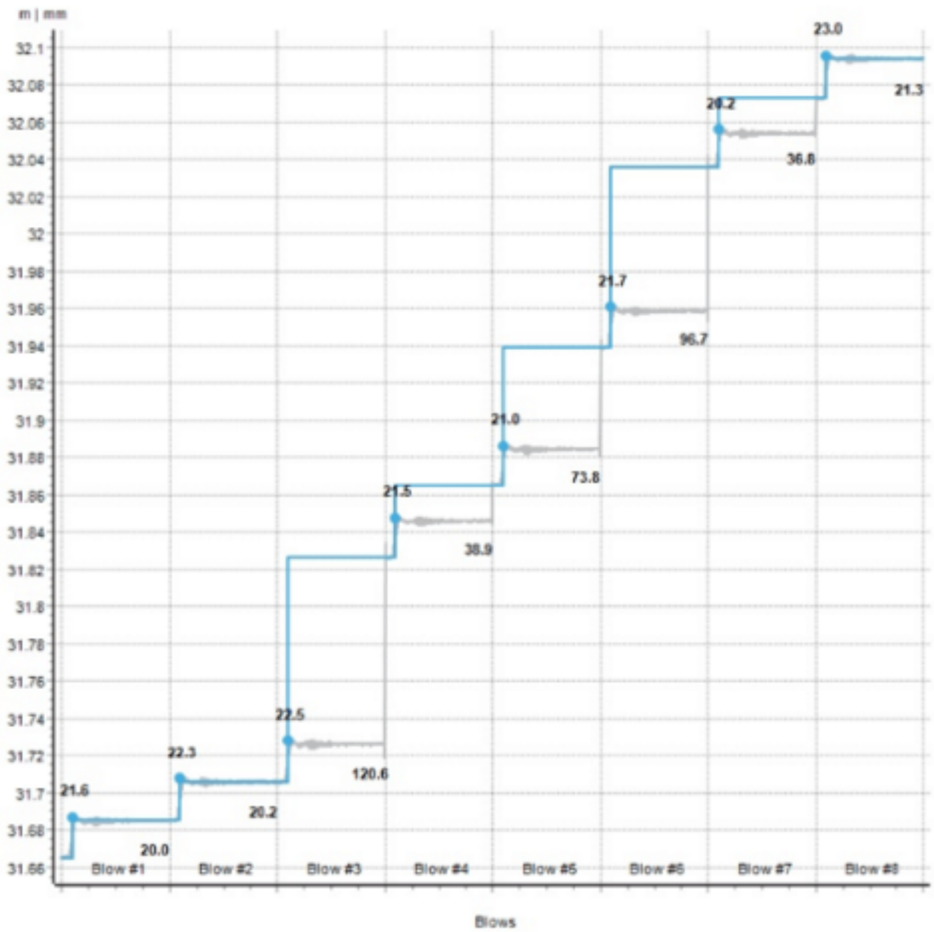
# PILE DRIVING MONITOR

FDOT

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:02:45 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:58:16 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD-9 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 8 (m) | 32.428 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-9 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 53.6 | VMX (m/s) | 1.73 |
| Rebound (mm) | -31.8 | DMX (mm) | 21.7 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 8 | 21.3 | 1.7 | 1.81 | 32.428 |
| 7 | 36.8 | -16.7 | 1.69 | 32.407 |
| 6 | 96.7 | -75.0 | 1.66 | 32.370 |
| 5 | 73.8 | -52.8 | 1.77 | 32.274 |
| 4 | 38.9 | -17.4 | - | 32.200 |
| 3 | 120.6 | -98.1 | - | 32.161 |
| 2 | 20.2 | 2.0 | - | 32.040 |
| 1 | 20.0 | 1.6 | - | 32.020 |

| | | | |
|---|---|---|---|
| **Average** | 53.6 | -31.8 | 1.73 |
| **Max Variation** | 100.6 | 100.2 | 0.15 |

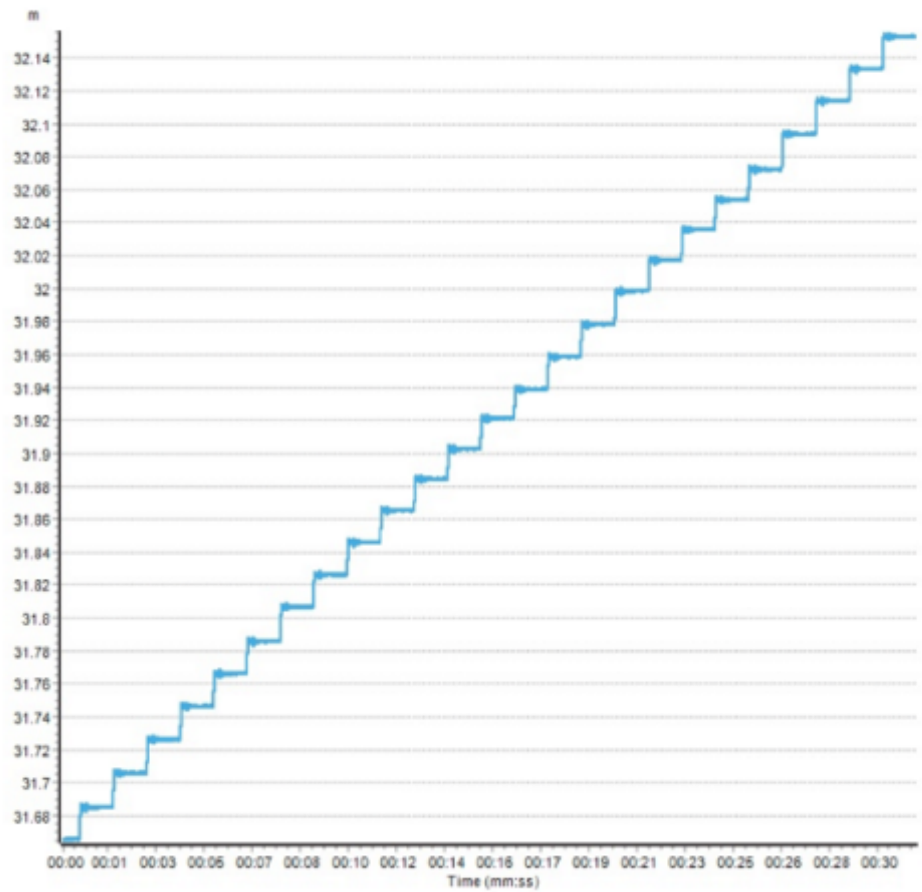
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-9 |

## COMPLETE VIEW



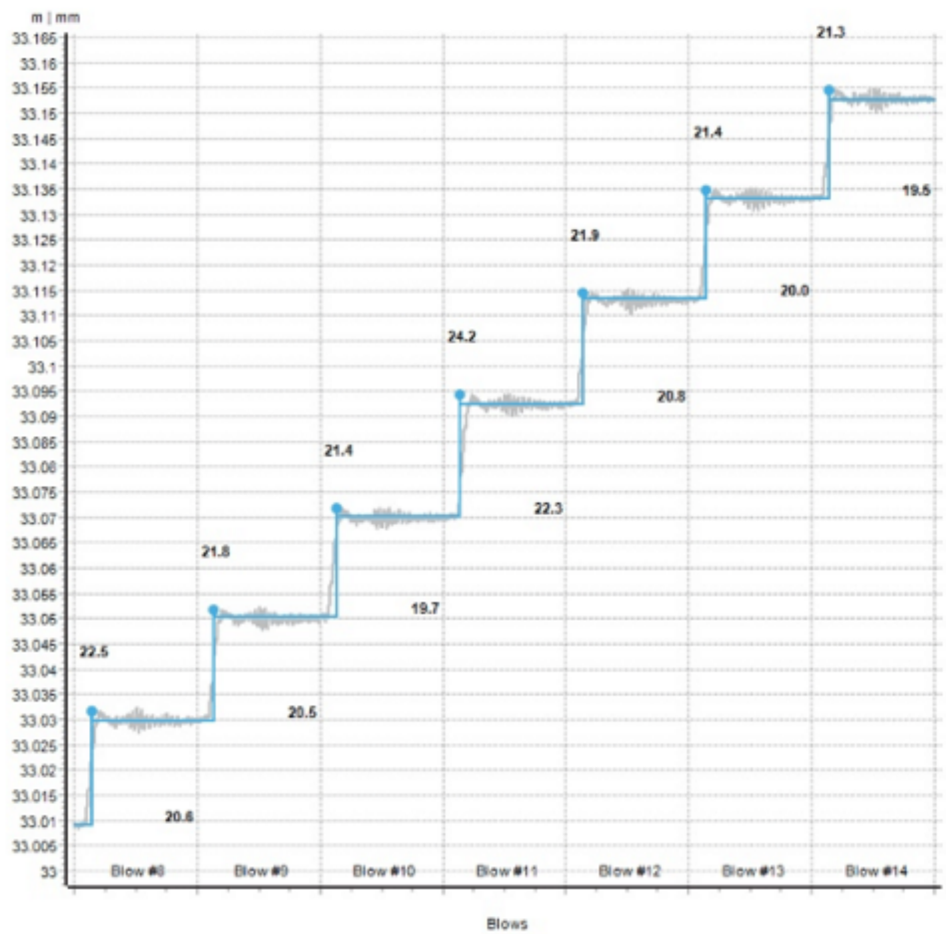

PDM Serial Number: PG2024174

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 4:00:16 PM |
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Test Time | 3:59:55 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | P1-EOD-10 | PDM Pile Offset (m) | 13.000 |
| Pile Type | | Final Penetration at Blow 14 (m) | 33.457 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Area | A1 | Pile Number | P1-EOD-10 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 20.5 | VMX (m/s) | 1.62 |
| Rebound (mm) | 1.6 | DMX (mm) | 22.1 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 14 | 19.5 | 1.8 | 1.55 | 33.457 |
| 13 | 20.0 | 1.5 | 1.68 | 33.437 |
| 12 | 20.8 | 1.1 | 1.51 | 33.417 |
| 11 | 22.3 | 1.9 | 1.65 | 33.396 |
| 10 | 19.7 | 1.6 | 1.58 | 33.374 |
| 9 | 20.5 | 1.3 | 1.64 | 33.354 |
| 8 | 20.6 | 1.9 | 1.73 | 33.334 |

| | | | | |
|---|---|---|---|---|
| **Average** | 20.5 | 1.6 | 1.62 | |
| **Max Variation** | 2.8 | 0.8 | 0.23 | |

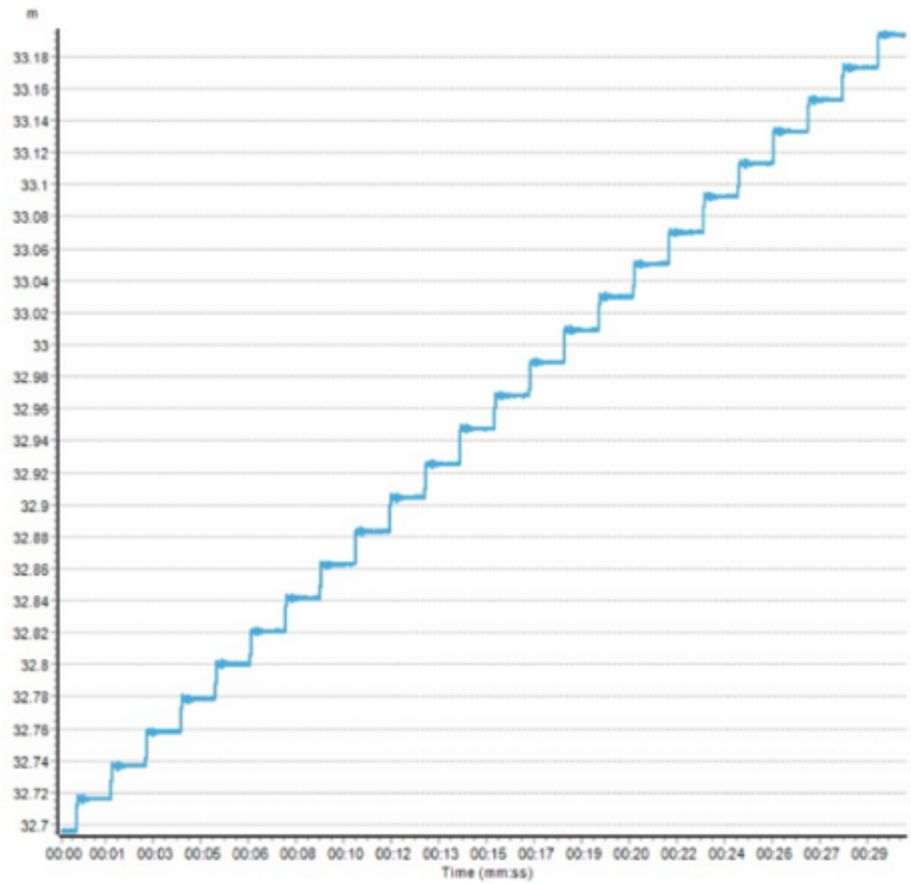
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Disney | Test Date | 19/7/2018 |
| Project Description | A1 | Pile Number | P1-EOD-10 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

### A.2.3 Ellis Road I-95 Overpass, 11/30/2018: Eight Tests

**Test 1 of 8**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 10:36:20 | 5.023 | 22.5 | -8.8 | 2.544 | 13.8 |
| 2 | 10:36:29 | 5.028 | 5.3 | 6.3 | 1.178 | 11.6 |
| 3 | 10:36:30 | 5.033 | 5.1 | 6.1 | 0.985 | 11.2 |
| 4 | 10:36:30 | 5.038 | 4.9 | 6.2 | 0.943 | 11.2 |
| 5 | 10:36:30 | 5.043 | 4.9 | 6 | 0.975 | 11 |
| 6 | 10:36:31 | 5.048 | 5.1 | 6.4 | 0.978 | 11.5 |
| 7 | 10:36:31 | 5.053 | 5.4 | 6.2 | 1.007 | 11.6 |
| 8 | 10:36:32 | 5.059 | 5.2 | 6.2 | 1.046 | 11.4 |
| 9 | 10:36:32 | 5.064 | 5.3 | 5.9 | 1.071 | 11.2 |
| 10 | 10:36:32 | 5.069 | 5.1 | 5.8 | 1.035 | 10.8 |
| 11 | 10:36:34 | 5.074 | 4.8 | 5.5 | 1.01 | 10.3 |
| 12 | 10:36:35 | 5.078 | 4.5 | 5.1 | 0.964 | 9.6 |
| 13 | 10:36:36 | 5.082 | 4.3 | 4.9 | 0.96 | 9.2 |
| 14 | 10:36:38 | 5.087 | 4.6 | 4.6 | 0.957 | 9.1 |
| 15 | 10:36:39 | 5.097 | 10.4 | 5.8 | 1.728 | 16.1 |
| 16 | 10:36:41 | 5.102 | 5.1 | 5.7 | 1.757 | 10.8 |
| 17 | 10:36:42 | 5.108 | 5.2 | 5.8 | 1.775 | 10.9 |
| 18 | 10:36:45 | 5.113 | 5.2 | 5.8 | 1.036 | 10.9 |
| 19 | 10:36:45 | 5.118 | 5.2 | 5.9 | 1.039 | 11.1 |
| 20 | 10:36:46 | 5.123 | 5.5 | 5.9 | 1.044 | 11.4 |
| 21 | 10:36:47 | 5.129 | 5.4 | 6 | 1.049 | 11.4 |
| 22 | 10:36:49 | 5.134 | 5.3 | 5.9 | 1.067 | 11.2 |
| 23 | 10:36:50 | 5.139 | 5.3 | 6 | 1.062 | 11.3 |
| 24 | 10:36:52 | 5.145 | 5.4 | 5.8 | 1.067 | 11.2 |
| 25 | 10:36:53 | 5.149 | 4.5 | 5.5 | 1.009 | 10 |
| 26 | 10:36:54 | 5.155 | 5.2 | 5.8 | 0.976 | 11 |
| Average (mm) | | | 5.3 | 5.8 | 1.1 | 11.1 |
| Standard Dev (mm) | | | 1.1 | 0.4 | 0.2 | 1.3 |
| Average (in) | | | 0.21 | 0.23 | 0.04 | 0.44 |
| Standard Dev (in) | | | 0.04 | 0.02 | 0.01 | 0.05 |

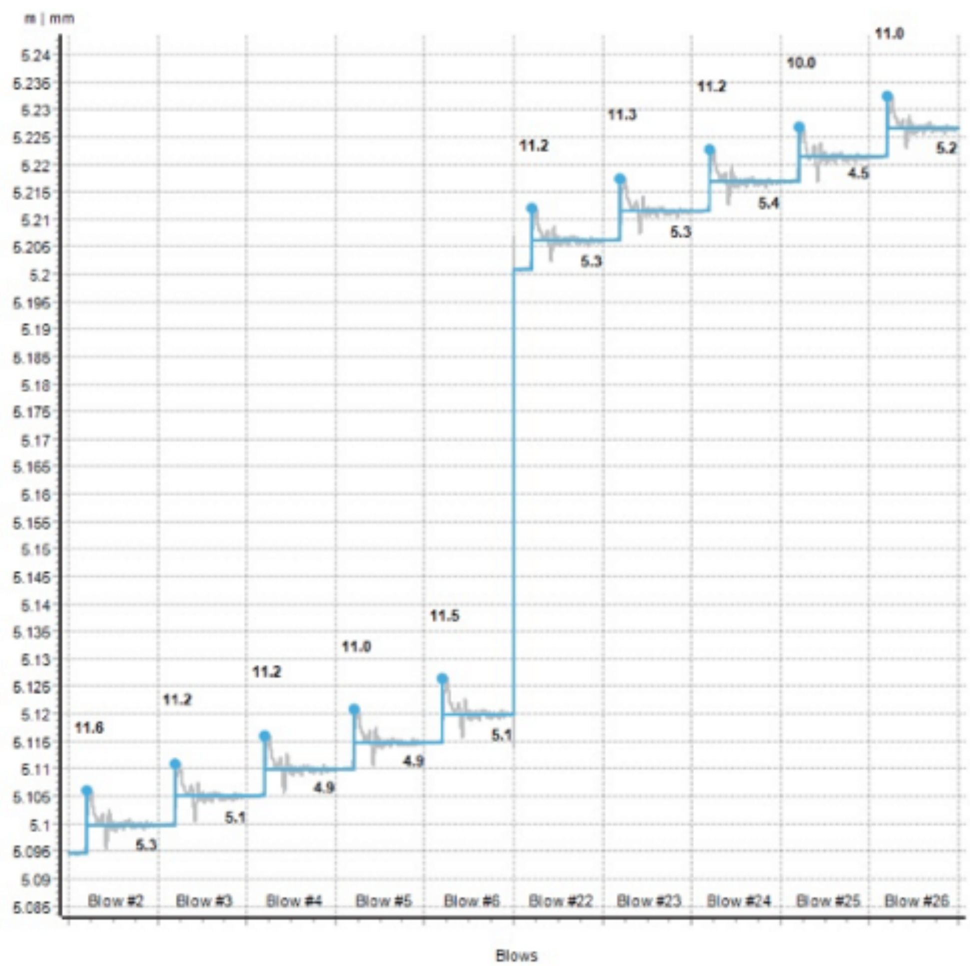
Note: Blow 1 excluded

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 4:02:23 PM |
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Test Time | 10:36:02 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 3-EOD-2 | PDM Pile Offset (m) | 8.000 |
| Pile Type | | Final Penetration at Blow 26 (m) | 5.155 |
| Hammer | | Stroke (m) | 1.000 |



# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Pile Number | 3-EOD-2 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 5.1 | VMX (m/s) | 1.02 |
| Rebound (mm) | 6.0 | DMX (mm) | 11.1 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

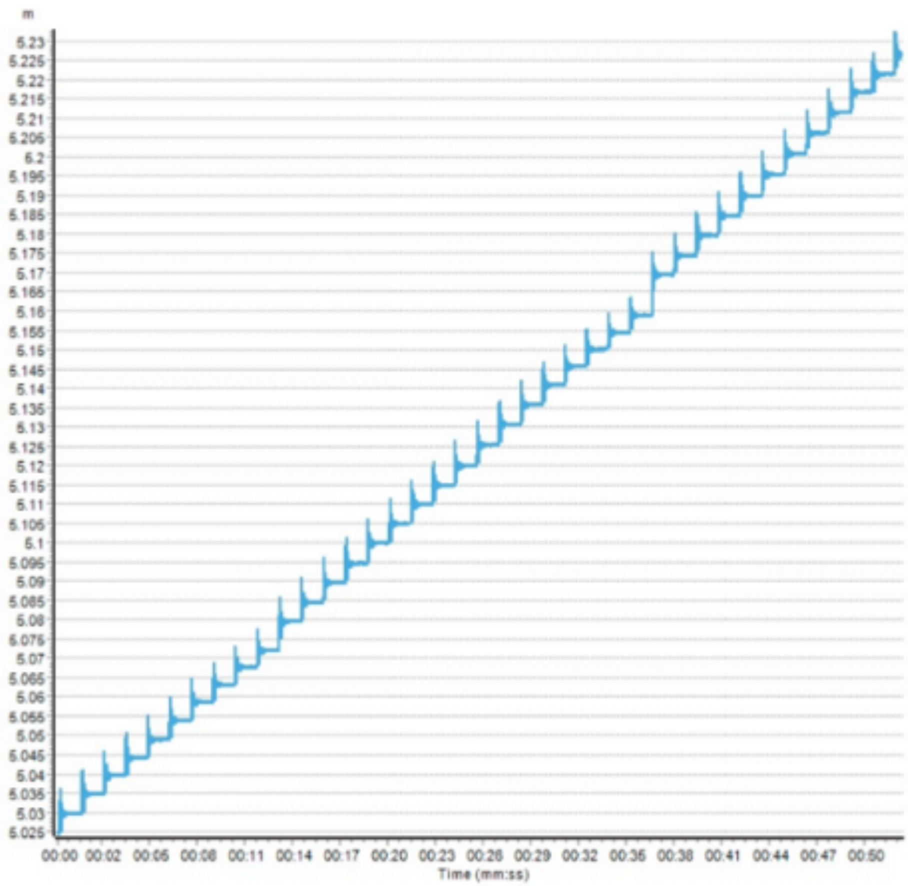
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 26 | 5.2 | 5.8 | 0.98 | 5.155 |
| 25 | 4.5 | 5.5 | 1.01 | 5.149 |
| 24 | 5.4 | 5.8 | 1.07 | 5.145 |
| 23 | 5.3 | 6.0 | 1.06 | 5.139 |
| 22 | 5.3 | 5.9 | 1.07 | 5.134 |
| 6 | 5.1 | 6.4 | 0.98 | 5.048 |
| 5 | 4.9 | 6.0 | 0.97 | 5.043 |
| 4 | 4.9 | 6.2 | - | 5.038 |
| 3 | 5.1 | 6.1 | - | 5.033 |
| 2 | 5.3 | 6.3 | - | 5.028 |
| **Average** | 5.1 | 6.0 | 1.02 | |
| **Max Variation** | 1.0 | 0.8 | 0.09 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Description | 192 | Pile Number | 3-EOD-2 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 2 of 8**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 10:42:11 | 6.606 | 5.7 | 4.9 | 1.35 | 10.7 |
| 2 | 10:42:12 | 6.606 | -0.2 | 0.7 | 1.185 | 0.4 |
| 3 | 10:42:12 | 6.611 | 5.8 | 5 | 1.515 | 10.8 |
| 4 | 10:42:13 | 6.611 | -0.2 | 0.6 | 1.339 | 0.4 |
| 5 | 10:42:14 | 6.616 | 5.2 | 5.5 | 1.416 | 10.7 |
| 6 | 10:42:14 | 6.616 | 0 | 0.9 | 1.255 | 0.9 |
| 7 | 10:42:15 | 6.621 | 5 | 5 | 1.368 | 9.9 |
| 8 | 10:42:16 | 6.626 | 4.6 | 4.9 | 1.281 | 9.4 |
| 9 | 10:42:17 | 6.626 | 0 | 0.9 | 1.416 | 0.8 |
| 10 | 10:42:18 | 6.631 | 5.3 | 4.3 | 1.292 | 9.6 |
| 11 | 10:42:18 | 6.631 | -0.3 | 0.7 | 1.372 | 0.4 |
| 12 | 10:42:19 | 6.631 | 0 | 0.6 | 1.237 | 0.6 |
| 13 | 10:42:19 | 6.635 | 4.4 | 4.6 | 1.244 | 9 |
| 14 | 10:42:20 | 6.639 | 3.6 | -2.9 | 1.2 | 0.7 |
| 15 | 10:42:21 | 6.639 | 0.5 | 1 | 1.277 | 1.6 |
| 16 | 10:42:21 | 6.654 | 14.1 | 4.8 | 2.462 | 18.9 |
| 17 | 10:42:30 | 6.658 | 4.8 | 4.8 | 2.535 | 9.6 |
| 18 | 10:42:30 | 6.667 | 8.3 | -7.4 | 2.495 | 0.9 |
| 19 | 10:42:30 | 6.663 | -3.6 | 2.2 | 1.31 | -1.4 |
| 20 | 10:42:31 | 6.668 | 4.8 | 5.2 | 1.35 | 10 |
| 21 | 10:42:33 | 6.673 | 5 | 5.5 | 1.485 | 10.5 |
| 22 | 10:42:33 | 6.678 | 5 | 5 | 1.778 | 10 |
| 23 | 10:42:33 | 6.687 | 9.5 | 0.3 | 1.712 | 9.8 |
| 24 | 10:42:34 | 6.706 | 18.4 | -8.4 | 1.742 | 10 |
| 25 | 10:42:34 | 6.701 | -4.5 | 2.6 | 1.551 | -1.9 |
| 26 | 10:42:35 | 6.706 | 5.2 | 4.7 | 1.529 | 9.9 |
| 27 | 10:42:36 | 6.711 | 5 | 4.7 | 1.606 | 9.7 |
| 28 | 10:42:38 | 6.716 | 4.6 | 4.5 | 1.573 | 9.1 |
| 29 | 10:42:39 | 6.72 | 4.3 | 3.9 | 1.643 | 8.1 |
| 30 | 10:42:40 | 6.724 | 4.2 | 4.1 | 1.559 | 8.3 |
| 31 | 10:42:41 | 6.744 | 19.4 | -3.9 | 2.195 | 15.5 |
| 32 | 10:42:43 | 6.74 | -3.7 | 2.8 | 2.14 | -0.9 |
| 33 | 10:42:44 | 6.745 | 4.9 | 5.8 | 2.137 | 10.7 |
| 34 | 10:42:45 | 6.75 | 5.4 | 5.5 | 1.482 | 10.9 |
| 35 | 10:42:47 | 6.756 | 5.4 | 5.1 | 1.555 | 10.5 |
| 36 | 10:42:48 | 6.772 | 16 | -4.5 | 1.665 | 11.6 |
| 37 | 10:42:54 | 6.776 | 4.5 | 5.3 | 1.763 | 9.8 |
| 38 | 10:42:54 | 6.786 | 10 | 0.5 | 1.763 | 10.5 |

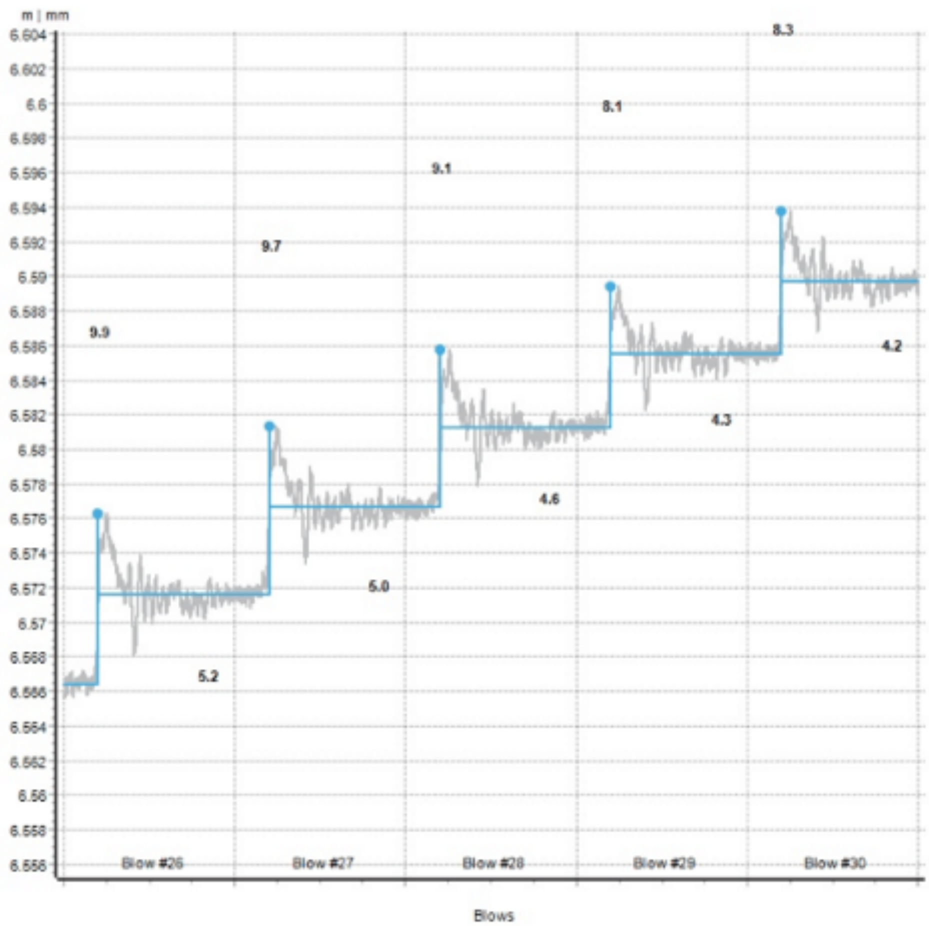
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 39 | 10:42:55 | 6.791 | 4.6 | -3.6 | 1.588 | 1 |
| 40 | 10:42:57 | 6.796 | 5.2 | 4.8 | 1.712 | 10 |
| 41 | 10:42:58 | 6.805 | 9.2 | 0.1 | 1.679 | 9.3 |
| 42 | 10:43:00 | 6.81 | 4.3 | 4.1 | 1.742 | 8.4 |
| 43 | 10:43:02 | 6.814 | 4.4 | 3.7 | 1.57 | 8.1 |
| 44 | 10:43:03 | 6.826 | 11.9 | 4.3 | 2.59 | 16.2 |
| 45 | 10:43:04 | 6.83 | 4.5 | -3.6 | 2.528 | 0.9 |
| 46 | 10:43:05 | 6.835 | 4.6 | 4.9 | 2.554 | 9.5 |
| 47 | 10:43:06 | 6.843 | 8.3 | -7.4 | 1.54 | 0.8 |
| 48 | 10:43:07 | 6.84 | -3.1 | 2.5 | 1.617 | -0.6 |
| 49 | 10:43:08 | 6.845 | 4.8 | 5.8 | 1.599 | 10.6 |
| 50 | 10:43:09 | 6.86 | 15.1 | -4.9 | 1.551 | 10.2 |
| 51 | 10:43:13 | 6.86 | 0.5 | -2.4 | 1.434 | -1.9 |
| 52 | 10:43:14 | 6.865 | 4.6 | 5.4 | 1.361 | 10 |
| 53 | 10:43:14 | 6.87 | 5.2 | 5.2 | 1.467 | 10.5 |
| 54 | 10:43:23 | 6.875 | 4.7 | 5 | 1.632 | 9.7 |
| 55 | 10:43:24 | 6.886 | 11.4 | -10.3 | 1.701 | 1.1 |
| 56 | 10:43:24 | 6.882 | -4.7 | 2.5 | 1.668 | -2.1 |
| 57 | 10:43:24 | 6.895 | 13.2 | -3.2 | 1.785 | 10 |
| 58 | 10:43:25 | 6.901 | 6.6 | -5.4 | 1.987 | 1.1 |
| 59 | 10:43:25 | 6.903 | 1.8 | -2.5 | 1.998 | -0.7 |
| 60 | 10:43:25 | 6.903 | -0.4 | 1 | 1.906 | 0.6 |
| 61 | 10:43:26 | 6.906 | 3.2 | 3.7 | 1.844 | 6.9 |
| 62 | 10:43:26 | 6.91 | 3.8 | -2.7 | 2.228 | 1.1 |
| 63 | 10:43:27 | 6.91 | 0.1 | 1.3 | 3.168 | 1.4 |
| 64 | 10:43:28 | 6.909 | -0.7 | 2 | 3.45 | 1.3 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 3:59:25 PM |
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Test Time | 10:42:11 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 3-EOD-3 | PDM Pile Offset (m) | 8.200 |
| Pile Type | | Final Penetration at Blow 30 (m) | 6.724 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Pile Number | 3-EOD-3 |

NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 4.7 | VMX (m/s) | 1.58 |
| Rebound (mm) | 4.4 | DMX (mm) | 9.0 |
| Capacity (kN) | - | EMX (kJ) | - |

TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 30 | 4.2 | 4.1 | 1.56 | 6.724 |
| 29 | 4.3 | 3.9 | 1.64 | 6.720 |
| 28 | 4.6 | 4.5 | 1.57 | 6.716 |
| 27 | 5.0 | 4.7 | 1.61 | 6.711 |
| 26 | 5.2 | 4.7 | 1.53 | 6.706 |

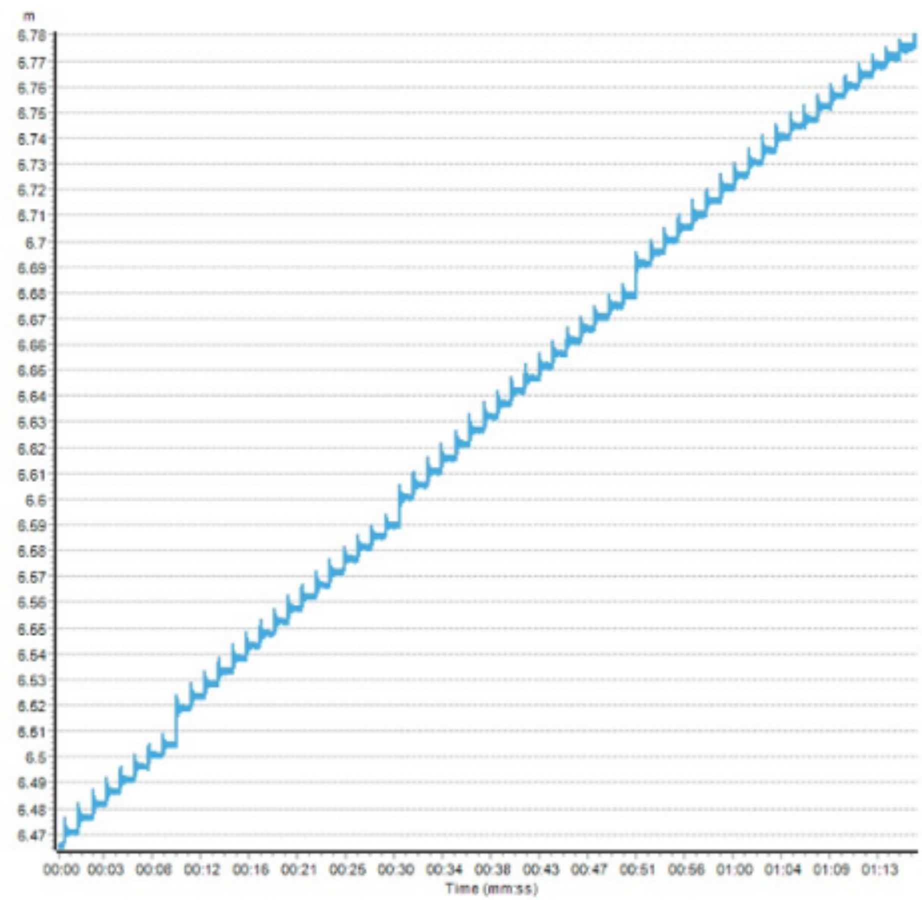
| | | | | |
|---|---|---|---|---|
| **Average** | 4.7 | 4.4 | 1.58 | |
| **Max Variation** | 1.0 | 0.8 | 0.11 | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Description | 192 | Pile Number | 3-EOD-3 |

COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 3 of 8**

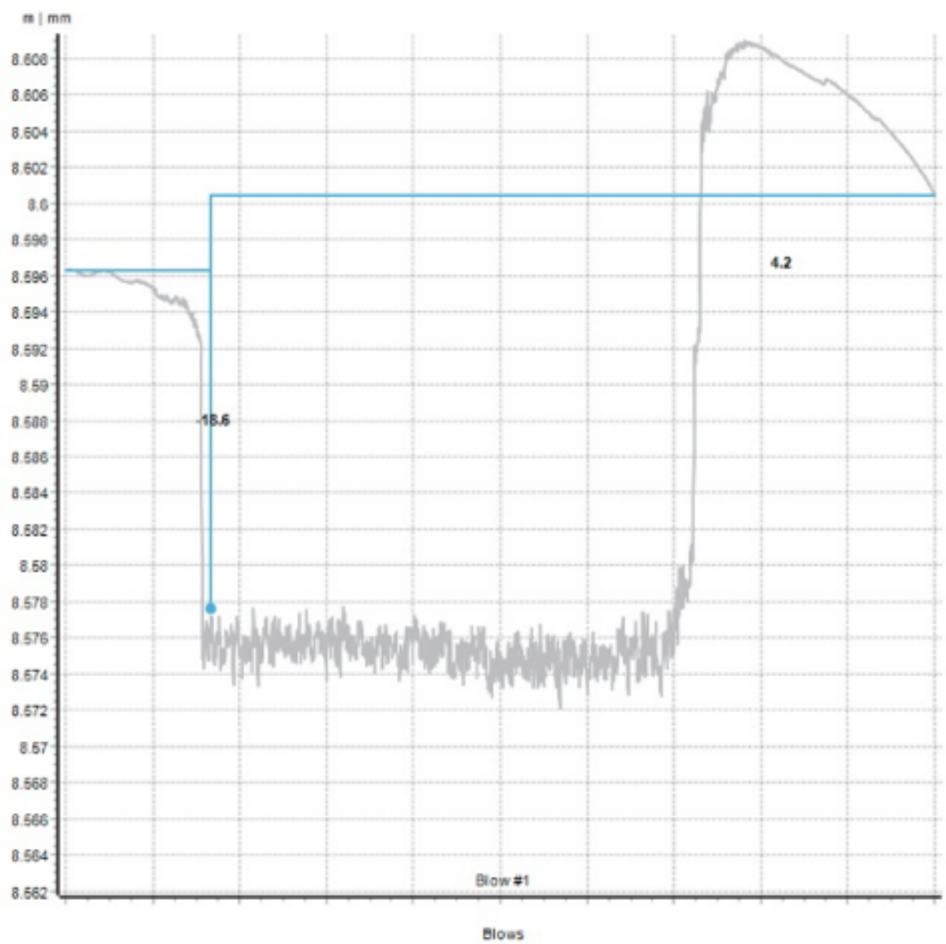
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:16:23 | 8.604 | 4.2 | -22.8 | 5.5 | -18.6 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 3:49:48 PM |
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Test Time | 1:15:56 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 4-EOD-2 | PDM Pile Offset (m) | -1.000 |
| Pile Type | | Final Penetration at Blow 1 (m) | 8.604 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Pile Number | 4-EOD-2 |

NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 4.2 | VMX (m/s) | 0.00 |
| Rebound (mm) | -22.8 | DMX (mm) | -18.6 |
| Capacity (kN) | - | EMX (kJ) | - |

TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 1 | 4.2 | -22.8 | - | 8.604 |
| **Average** | 4.2 | -22.8 | 0.00 | |
| **Max Variation** | 0.0 | 0.0 | -1998.00 | |

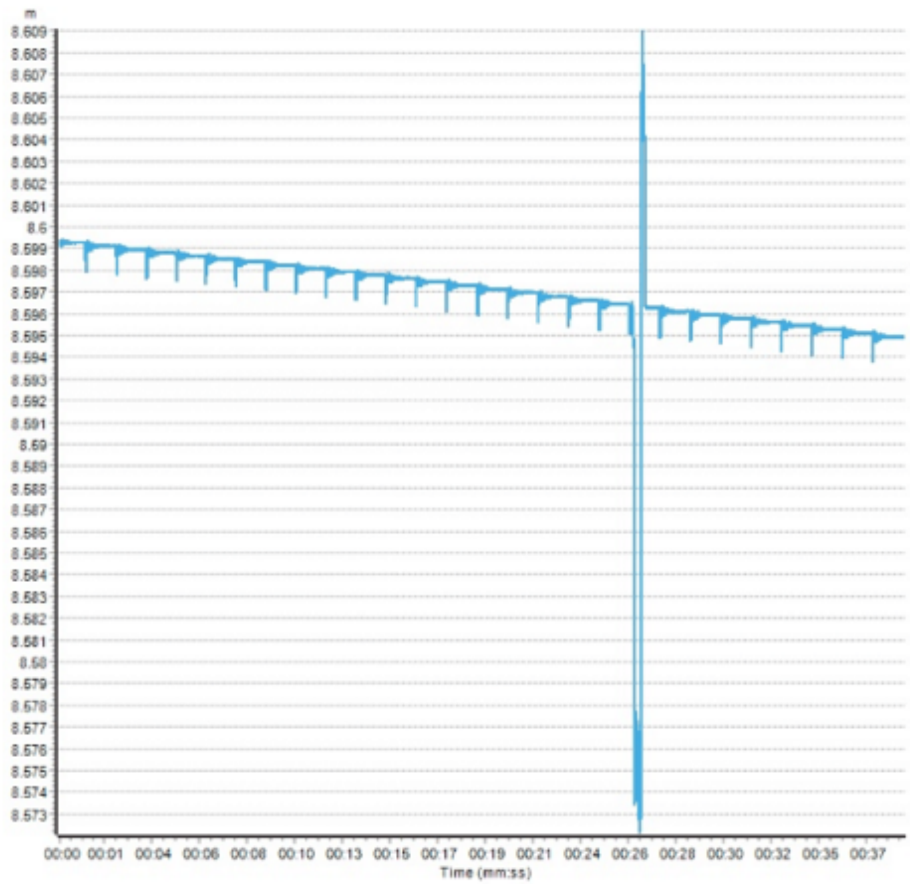
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Description | 192 | Pile Number | 4-EOD-2 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

Page 3 of 3

Test 4 of 8

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 08:06:23 | 22.102 | 2.4 | 3.7 | 6.78 | 6.1 |
| 2 | 08:06:24 | 22.112 | 9.2 | 8.2 | 2.836 | 17.4 |
| 3 | 08:06:24 | 22.112 | 0.7 | 6 | 4.78 | 6.7 |
| 4 | 08:06:24 | 22.118 | 5.3 | 2.6 | 3.153 | 7.9 |
| 5 | 08:06:25 | 22.119 | 1 | 1.3 | 3.44 | 2.3 |
| 6 | 08:06:25 | 22.114 | -4.3 | 6.3 | 2.977 | 2 |
| 7 | 08:06:25 | 22.118 | 3.6 | 2 | 2.659 | 5.6 |
| 8 | 08:06:26 | 22.119 | 0.6 | 1.4 | 2.793 | 2.1 |
| 9 | 08:06:26 | 22.118 | -0.5 | 1.6 | 2.473 | 1.1 |
| 10 | 08:06:26 | 22.119 | 0.7 | 1.3 | 2.38 | 2 |
| 11 | 08:06:26 | 22.119 | 0.3 | 0.5 | 2.304 | 0.8 |
| 12 | 08:06:27 | 22.119 | -0.4 | 0.9 | 2.423 | 0.5 |
| 13 | 08:06:27 | 22.119 | -0.1 | 1 | 2.677 | 0.9 |
| 14 | 08:06:27 | 22.119 | 0 | 1.1 | 2.762 | 1.1 |
| 15 | 08:06:28 | 22.119 | 0 | 0.9 | 2.6 | 0.9 |
| 16 | 08:06:28 | 22.119 | 0.1 | 1.6 | 2.728 | 1.7 |
| 17 | 08:06:28 | 22.118 | -0.4 | 1.5 | 2.59 | 1.1 |
| 18 | 08:06:29 | 22.119 | 0.4 | 0.9 | 2.654 | 1.3 |
| 19 | 08:06:29 | 22.119 | 0 | 1 | 2.705 | 1 |
| 20 | 08:06:29 | 22.118 | -0.2 | 1.2 | 3.118 | 1 |
| 21 | 08:06:30 | 22.118 | 0 | 1.2 | 3.343 | 1.2 |
| 22 | 08:06:30 | 22.119 | 0.2 | 1.4 | 3.13 | 1.6 |
| 23 | 08:06:30 | 22.119 | -0.1 | 1.3 | 2.709 | 1.2 |
| 24 | 08:06:31 | 22.119 | 0.1 | 1.1 | 2.47 | 1.2 |
| 25 | 08:06:31 | 22.119 | -0.1 | 0.9 | 2.423 | 0.8 |
| 26 | 08:06:31 | 22.119 | 0.1 | 1.6 | 2.415 | 1.7 |
| 27 | 08:06:32 | 22.118 | -0.6 | 1.9 | 2.669 | 1.3 |
| 28 | 08:06:32 | 22.118 | 0.2 | 1.4 | 2.68 | 1.5 |
| 29 | 08:06:32 | 22.119 | 0.3 | 1.5 | 2.673 | 1.8 |
| 30 | 08:06:33 | 22.118 | -0.3 | 1.7 | 2.567 | 1.4 |
| 31 | 08:06:33 | 22.119 | 0.5 | 0.8 | 2.966 | 1.3 |
| 32 | 08:06:33 | 22.118 | -0.4 | 1.3 | 3.328 | 1 |
| 33 | 08:06:34 | 22.119 | 0.1 | 1.3 | 3.1 | 1.3 |
| 34 | 08:06:39 | 22.119 | 0 | 1.5 | 3.061 | 1.5 |
| 35 | 08:06:39 | 22.118 | -0.1 | 1.4 | 2.773 | 1.3 |
| 36 | 08:06:40 | 22.119 | 0.4 | 0.8 | 2.956 | 1.2 |
| 37 | 08:06:40 | 22.118 | -0.6 | 1.4 | 2.679 | 0.8 |
| 38 | 08:06:40 | 22.119 | 0.9 | 0.7 | 2.673 | 1.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 39 | 08:06:41 | 22.119 | -0.5 | 1.6 | 2.744 | 1.1 |
| 40 | 08:06:41 | 22.119 | 0.2 | 0.8 | 2.96 | 1 |
| 41 | 08:06:41 | 22.118 | -0.4 | 2.1 | 3.115 | 1.7 |
| 42 | 08:06:42 | 22.119 | 0.9 | 0.2 | 3.306 | 1.1 |
| 43 | 08:06:42 | 22.119 | -0.2 | 0.6 | 3.078 | 0.4 |
| 44 | 08:06:42 | 22.118 | -1.5 | 2 | 2.837 | 0.5 |

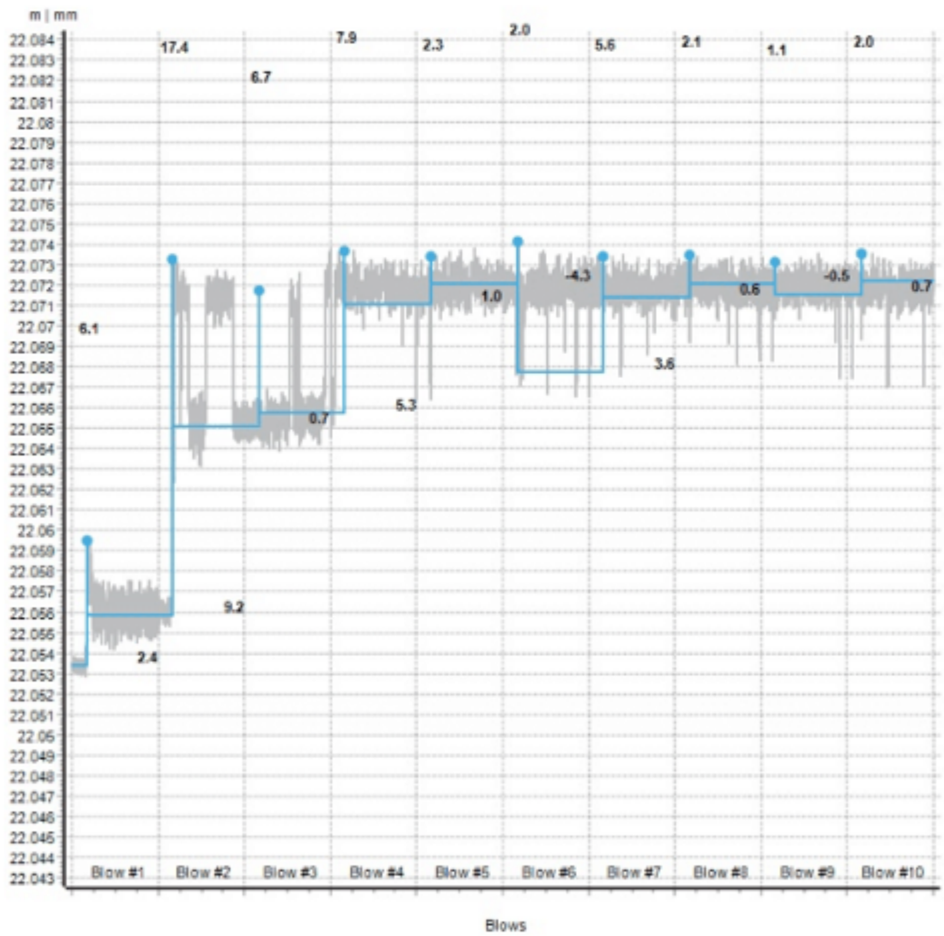
# PILE DRIVING MONITOR

FDOT

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 4:13:09 PM |
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Test Time | 8:05:29 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD | PDM Pile Offset (m) | -1.000 |
| Pile Type | | Final Penetration at Blow 10 (m) | 22.119 |
| Hammer | | Stroke (m) | 0.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Pile Number | 1-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 1.9 | VMX (m/s) | 2.79 |
| Rebound (mm) | 3.4 | DMX (mm) | 5.3 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

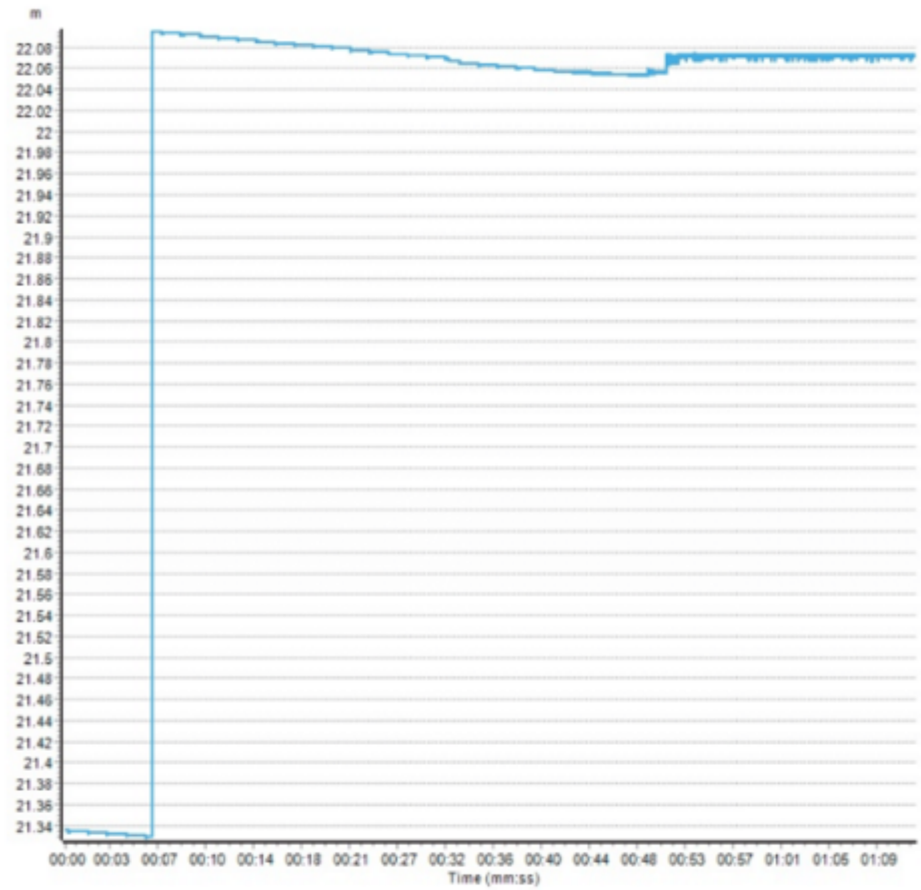
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 10 | 0.7 | 1.3 | 2.38 | 22.119 |
| 9 | -0.5 | 1.6 | 2.47 | 22.118 |
| 8 | 0.6 | 1.4 | 2.79 | 22.119 |
| 7 | 3.6 | 2.0 | 2.66 | 22.118 |
| 6 | -4.3 | 6.3 | 2.98 | 22.114 |
| 5 | 1.0 | 1.3 | 3.44 | 22.119 |
| 4 | 5.3 | 2.6 | - | 22.118 |
| 3 | 0.7 | 6.0 | - | 22.112 |
| 2 | 9.2 | 8.2 | - | 22.112 |
| 1 | 2.4 | 3.7 | - | 22.102 |
| **Average** | 1.9 | 3.4 | 2.79 | |
| **Max Variation** | 13.6 | 6.9 | 1.06 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Description | 192 | Pile Number | 1-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 5 of 8**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 08:20:36 | 23.587 | -12.5 | 1 | 2.413 | -11.6 |
| 2 | 08:20:37 | 23.587 | -0.3 | 2 | 2.385 | 1.7 |
| 3 | 08:20:38 | 23.587 | -0.2 | 1.6 | 2.54 | 1.4 |
| 4 | 08:20:39 | 23.587 | -0.3 | 2.3 | 2.588 | 2 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 4:11:02 PM |
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Test Time | 8:20:36 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD | PDM Pile Offset (m) | -1.000 |
| Pile Type | | Final Penetration at Blow 4 (m) | 23.587 |
| Hammer | | Stroke (m) | 1.000 |


Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Pile Number | 2-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | -3.3 | VMX (m/s) | 0.00 |
| Rebound (mm) | 1.7 | DMX (mm) | -1.6 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 4 | -0.3 | 2.3 | - | 23.587 |
| 3 | -0.2 | 1.6 | - | 23.587 |
| 2 | -0.3 | 2.0 | - | 23.587 |
| 1 | -12.5 | 1.0 | - | 23.587 |

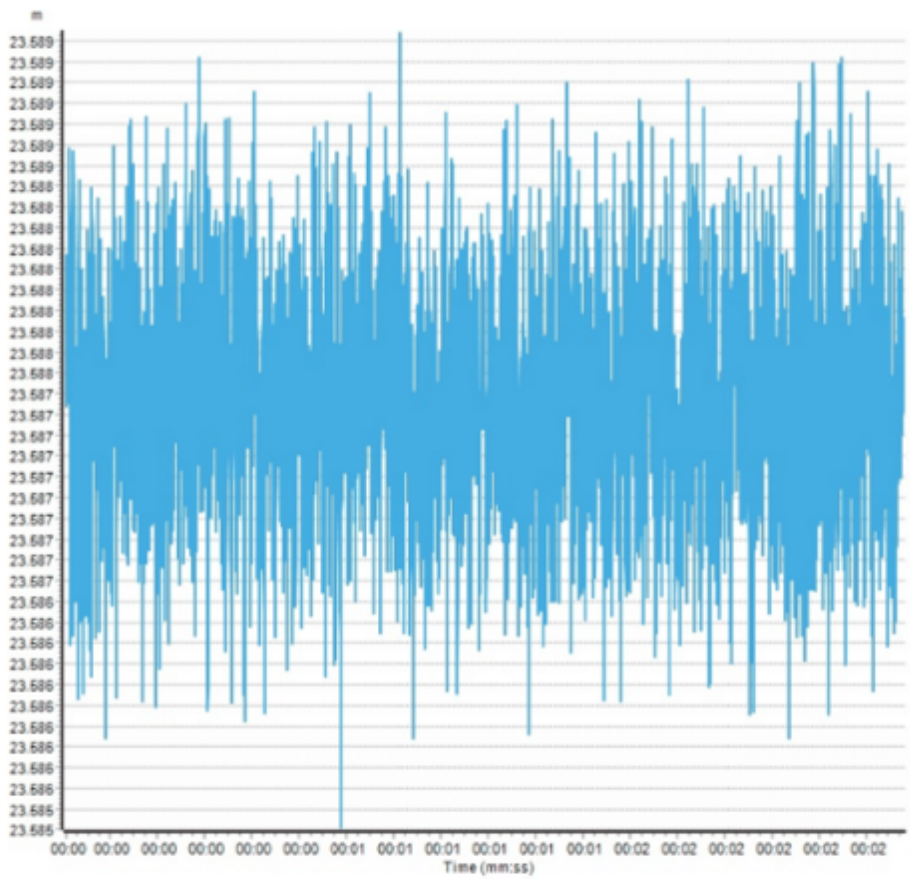
| | | | | |
|---|---|---|---|---|
| **Average** | -3.3 | 1.7 | 0.00 | |
| **Max Variation** | 12.4 | 1.4 | -1998.00 | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Description | 192 | Pile Number | 2-EOD |

COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 6 of 8**

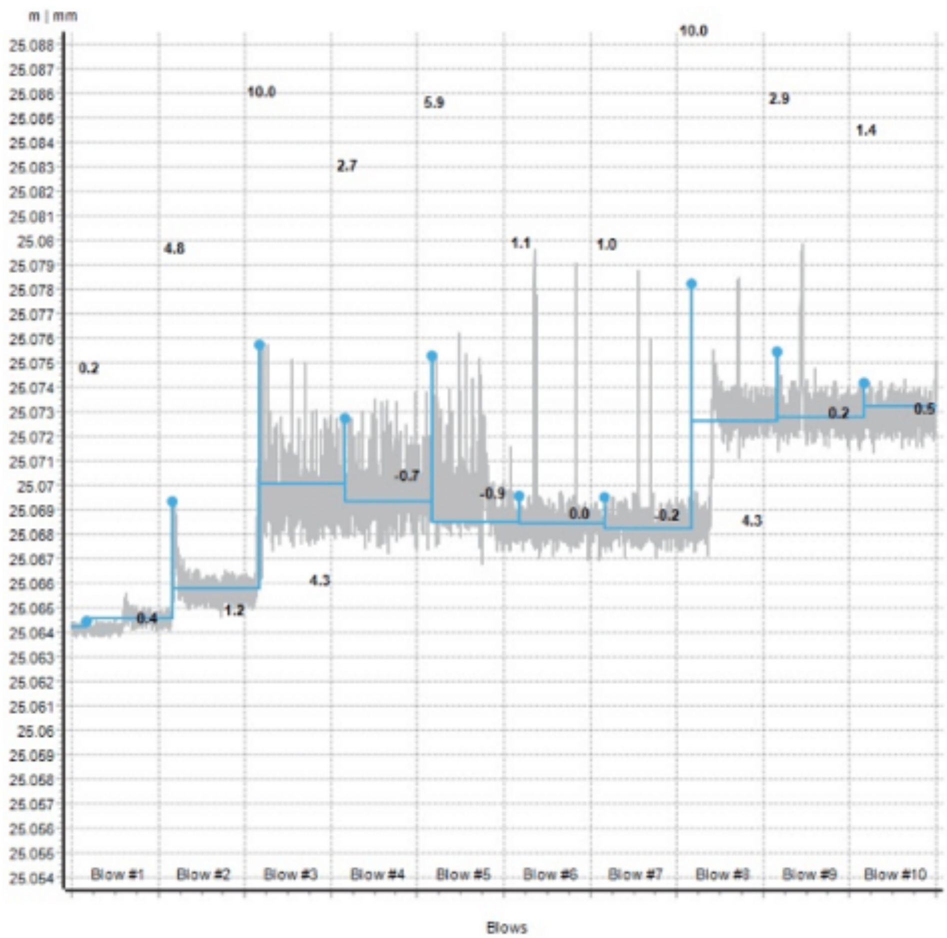
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 08:23:28 | 25.1 | 0.4 | -0.1 | 0.633 | 0.2 |
| 2 | 08:23:28 | 25.102 | 1.2 | 3.6 | 4.588 | 4.8 |
| 3 | 08:23:28 | 25.106 | 4.3 | 5.7 | 7.947 | 10 |
| 4 | 08:23:29 | 25.105 | -0.7 | 3.4 | 5.78 | 2.7 |
| 5 | 08:23:29 | 25.104 | -0.9 | 6.8 | 6.927 | 5.9 |
| 6 | 08:23:29 | 25.104 | 0 | 1.1 | 4.916 | 1.1 |
| 7 | 08:23:30 | 25.104 | -0.2 | 1.3 | 3.711 | 1 |
| 8 | 08:23:30 | 25.108 | 4.3 | 5.6 | 3.61 | 10 |
| 9 | 08:23:30 | 25.109 | 0.2 | 2.7 | 3.825 | 2.9 |
| 10 | 08:23:31 | 25.109 | 0.5 | 1 | 3.913 | 1.4 |
| 11 | 08:23:31 | 25.116 | 6.5 | 0.6 | 2.776 | 7.1 |
| 12 | 08:23:31 | 25.111 | -4.9 | 5.1 | 2.965 | 0.2 |
| 13 | 08:23:32 | 25.114 | 3.4 | 2.3 | 3.225 | 5.7 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 4:09:59 PM |
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Test Time | 8:22:45 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD-2 | PDM Pile Offset (m) | -1.000 |
| Pile Type | | Final Penetration at Blow 10 (m) | 25.109 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Pile Number | 2-EOD-2 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 0.9 | VMX (m/s) | 4.48 |
| Rebound (mm) | 3.1 | DMX (mm) | 4.0 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

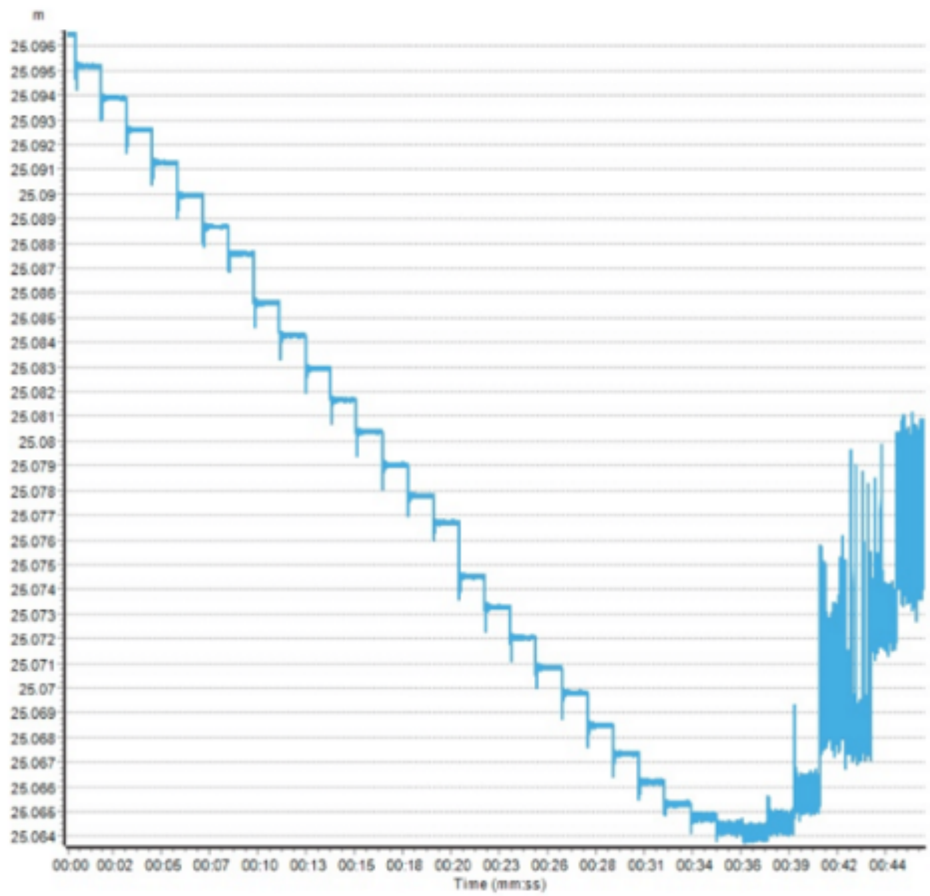
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 10 | 0.5 | 1.0 | 3.91 | 25.109 |
| 9 | 0.2 | 2.7 | 3.83 | 25.109 |
| 8 | 4.3 | 5.6 | 3.61 | 25.108 |
| 7 | -0.2 | 1.3 | 3.71 | 25.104 |
| 6 | 0.0 | 1.1 | 4.92 | 25.104 |
| 5 | -0.9 | 6.8 | 6.93 | 25.104 |
| 4 | -0.7 | 3.4 | - | 25.105 |
| 3 | 4.3 | 5.7 | - | 25.106 |
| 2 | 1.2 | 3.6 | - | 25.102 |
| 1 | 0.4 | -0.1 | - | 25.100 |
| **Average** | 0.9 | 3.1 | 4.48 | |
| **Max Variation** | 5.2 | 6.9 | 3.32 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Description | 192 | Pile Number | 2-EOD-2 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 7 of 8**

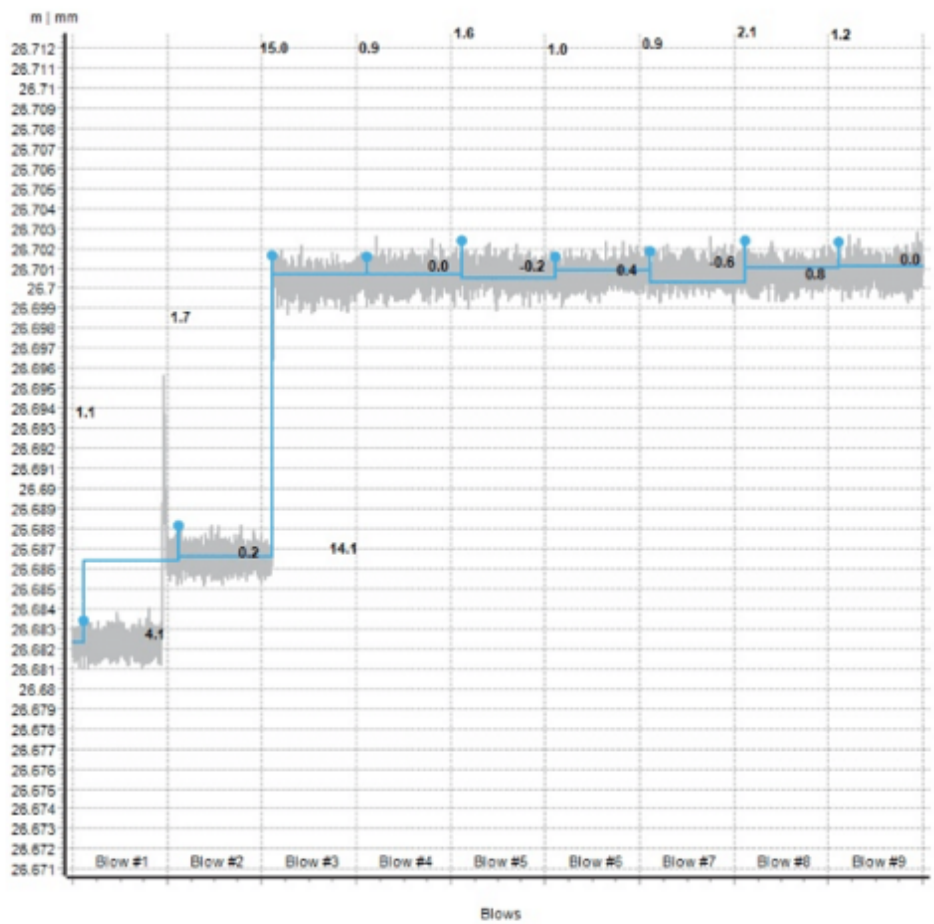
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 08:27:59 | 26.704 | 4.1 | -3 | 4.423 | 1.1 |
| 2 | 08:28:00 | 26.704 | 0.2 | 1.5 | 4.629 | 1.7 |
| 3 | 08:28:03 | 26.718 | 14.1 | 0.9 | 3.571 | 15 |
| 4 | 08:28:04 | 26.718 | 0 | 0.9 | 1.972 | 0.9 |
| 5 | 08:28:05 | 26.718 | -0.2 | 1.8 | 2.72 | 1.6 |
| 6 | 08:28:07 | 26.719 | 0.4 | 0.7 | 2.335 | 1 |
| 7 | 08:28:08 | 26.718 | -0.6 | 1.5 | 2.373 | 0.9 |
| 8 | 08:28:09 | 26.719 | 0.8 | 1.3 | 2.266 | 2.1 |
| 9 | 08:28:11 | 26.719 | 0 | 1.2 | 2.24 | 1.2 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 4:06:51 PM |
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Test Time | 8:27:00 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD-3 | PDM Pile Offset (m) | -1.000 |
| Pile Type | | Final Penetration at Blow 9 (m) | 26.719 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Pile Number | 2-EOD-3 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 2.1 | VMX (m/s) | 2.39 |
| Rebound (mm) | 0.8 | DMX (mm) | 2.8 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 9 | 0.0 | 1.2 | 2.24 | 26.719 |
| 8 | 0.8 | 1.3 | 2.27 | 26.719 |
| 7 | -0.6 | 1.5 | 2.37 | 26.718 |
| 6 | 0.4 | 0.7 | 2.33 | 26.719 |
| 5 | -0.2 | 1.8 | 2.72 | 26.718 |
| 4 | 0.0 | 0.9 | - | 26.718 |
| 3 | 14.1 | 0.9 | - | 26.718 |
| 2 | 0.2 | 1.5 | - | 26.704 |
| 1 | 4.1 | -3.0 | - | 26.704 |

| | | | | |
|---|---|---|---|---|
| **Average** | 2.1 | 0.8 | 2.39 | |
| **Max Variation** | 14.7 | 4.8 | 0.48 | |

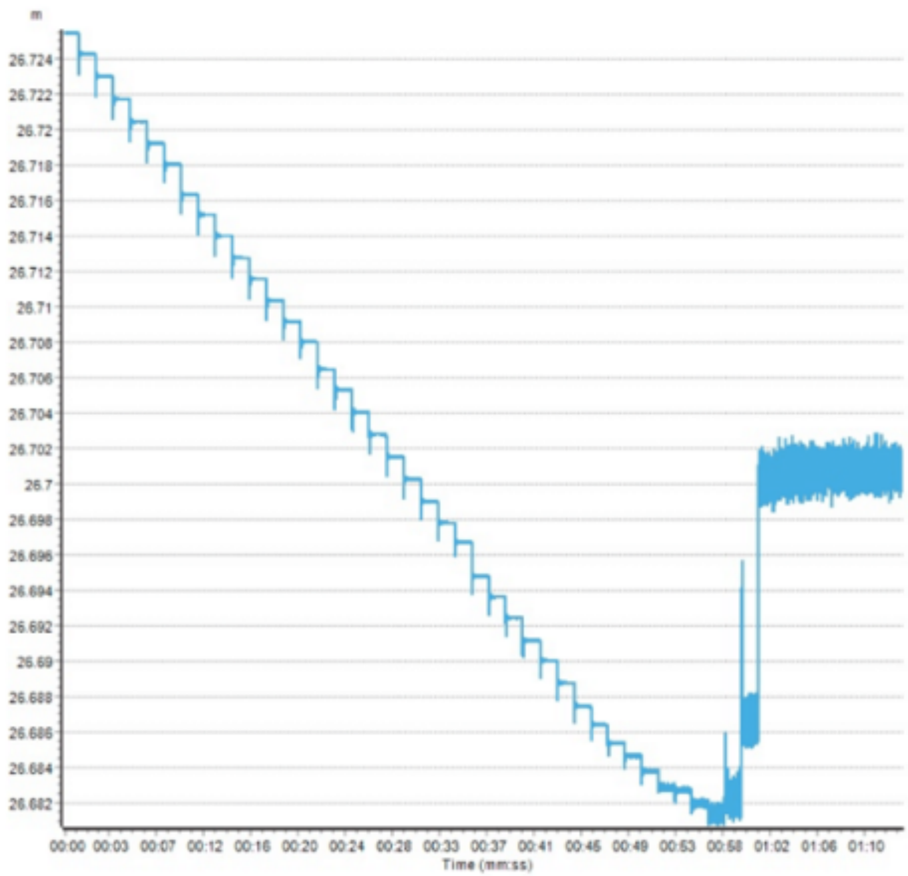
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Description | 192 | Pile Number | 2-EOD-3 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 8 of 8**

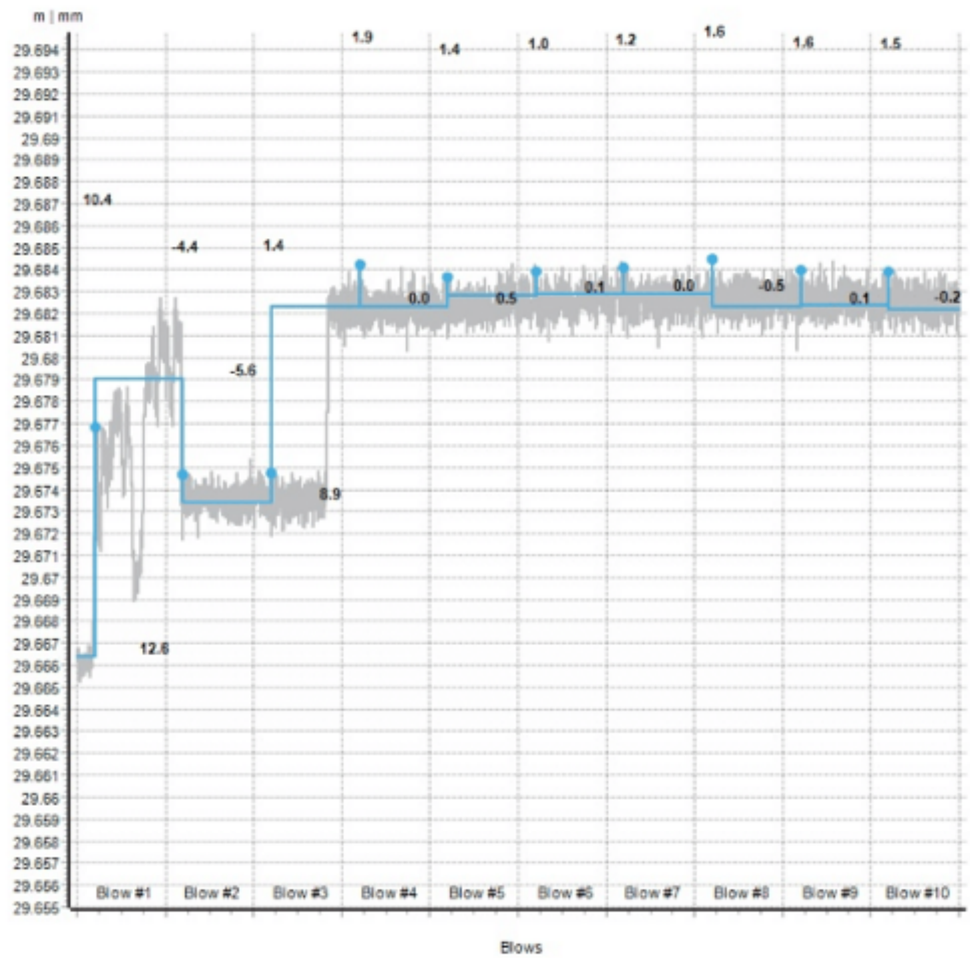
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 08:35:50 | 29.713 | 12.6 | -2.2 | 8.983 | 10.4 |
| 2 | 08:35:50 | 29.707 | -5.6 | 1.3 | 2.305 | -4.4 |
| 3 | 08:35:51 | 29.716 | 8.9 | -7.6 | 2.188 | 1.4 |
| 4 | 08:35:51 | 29.716 | 0 | 1.9 | 2.961 | 1.9 |
| 5 | 08:35:51 | 29.716 | 0.5 | 0.8 | 2.581 | 1.4 |
| 6 | 08:35:52 | 29.716 | 0.1 | 1 | 2.685 | 1 |
| 7 | 08:35:52 | 29.716 | 0 | 1.2 | 2.483 | 1.2 |
| 8 | 08:35:52 | 29.716 | -0.5 | 2.1 | 2.35 | 1.6 |
| 9 | 08:35:53 | 29.716 | 0.1 | 1.5 | 2.238 | 1.6 |
| 10 | 08:35:53 | 29.716 | -0.2 | 1.7 | 2.283 | 1.5 |
| 11 | 08:35:53 | 29.716 | 0.1 | 1.3 | 2.444 | 1.4 |
| 12 | 08:35:54 | 29.716 | -0.2 | 1.5 | 2.526 | 1.3 |
| 13 | 08:35:54 | 29.716 | -0.1 | 1.5 | 2.596 | 1.4 |
| 14 | 08:35:54 | 29.716 | -0.1 | 2.6 | 2.474 | 2.6 |
| 15 | 08:35:55 | 29.716 | 0.2 | 1.8 | 2.596 | 2 |
| 16 | 08:35:55 | 29.716 | -0.1 | 1.2 | 2.382 | 1.2 |
| 17 | 08:35:56 | 29.715 | -0.3 | 1.8 | 2.516 | 1.5 |
| 18 | 08:35:57 | 29.716 | 0.4 | 1.4 | 2.322 | 1.8 |
| 19 | 08:36:03 | 29.716 | 0 | 1.5 | 2.383 | 1.5 |
| 20 | 08:36:03 | 29.716 | -0.1 | 1.6 | 2.365 | 1.4 |
| 21 | 08:36:03 | 29.716 | 0.6 | 1.2 | 2.436 | 1.9 |
| 22 | 08:36:04 | 29.716 | -0.4 | 1.2 | 2.568 | 0.8 |
| 23 | 08:36:04 | 29.717 | 0.7 | 0.8 | 2.429 | 1.5 |
| 24 | 08:36:04 | 29.716 | -1 | 2.1 | 2.44 | 1.2 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 4:05:10 PM |
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Test Time | 8:35:24 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD-5 | PDM Pile Offset (m) | -1.000 |
| Pile Type | | Final Penetration at Blow 10 (m) | 29.716 |
| Hammer | | Stroke (m) | 1.000 |



# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Area | 192 | Pile Number | 2-EOD-5 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 1.6 | VMX (m/s) | 2.44 |
| Rebound (mm) | 0.2 | DMX (mm) | 1.8 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

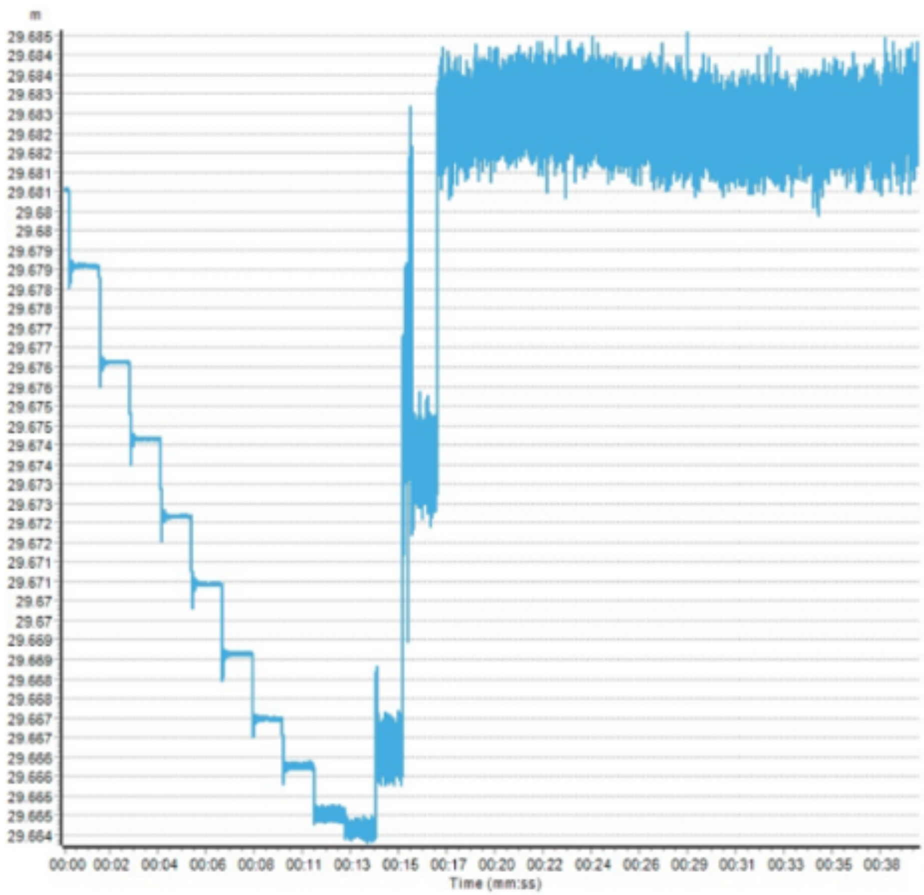
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 10 | -0.2 | 1.7 | 2.28 | 29.716 |
| 9 | 0.1 | 1.5 | 2.24 | 29.716 |
| 8 | -0.5 | 2.1 | 2.35 | 29.716 |
| 7 | 0.0 | 1.2 | 2.48 | 29.716 |
| 6 | 0.1 | 1.0 | 2.69 | 29.716 |
| 5 | 0.5 | 0.8 | 2.58 | 29.716 |
| 4 | 0.0 | 1.9 | - | 29.716 |
| 3 | 8.9 | -7.6 | - | 29.716 |
| 2 | -5.6 | 1.3 | - | 29.707 |
| 1 | 12.6 | -2.2 | - | 29.713 |
| **Average** | 1.6 | 0.2 | 2.44 | |
| **Max Variation** | 18.3 | 9.7 | 0.45 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | 12 | Test Date | 30/11/2018 |
| Project Description | 192 | Pile Number | 2-EOD-5 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

## A.2.4 **Dunns Creek Two Tests**

### A.2.4.1 **Pile 10, Pier 4, near Station 436+37**

Test 1 of 2

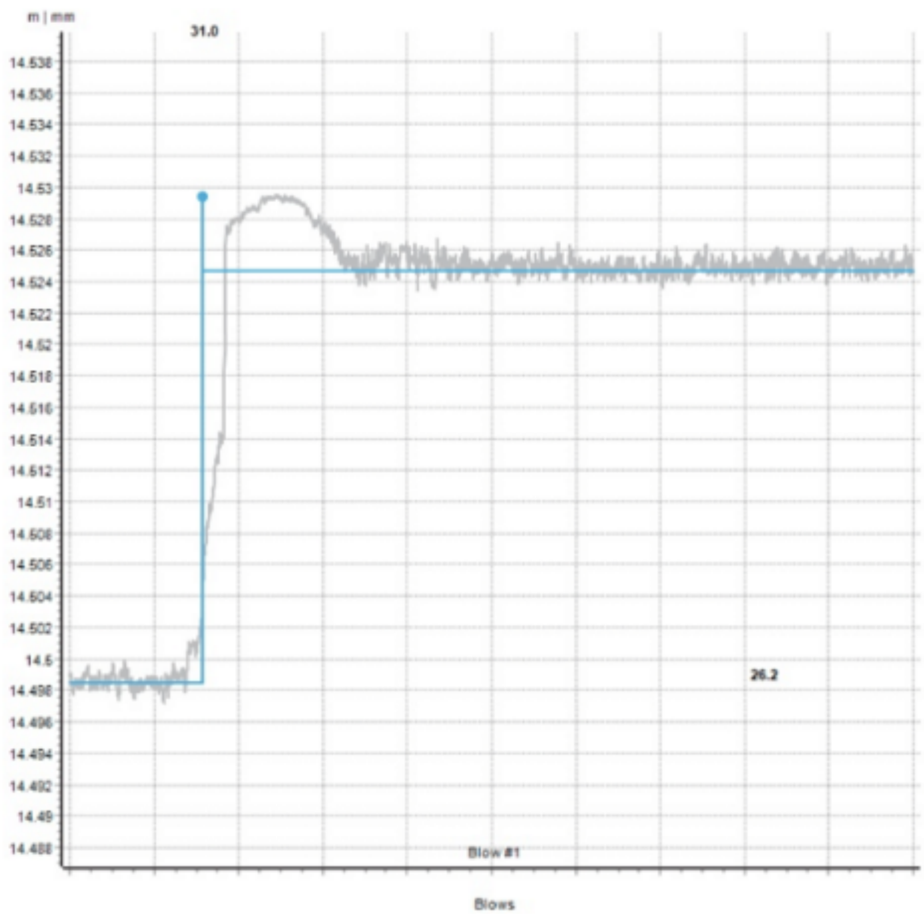
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 09:16:22 | 14.526 | 26.2 | 4.8 | 6.727 | 31 |

# PILE DRIVING MONITOR

PDM REPORT  Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 4:25:19 PM |
| Project Name | Jacksonville | Test Date | 19/9/2018 |
| Project Area | A1 | Test Time | 9:16:21 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD | PDM Pile Offset (m) | -1.000 |
| Pile Type | | Final Penetration at Blow 1 (m) | 14.526 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Jacksonville | Test Date | 19/9/2018 |
| Project Area | A1 | Pile Number | 1-EOD |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 26.2 | VMX (m/s) | 0.00 |
| Rebound (mm) | 4.8 | DMX (mm) | 31.0 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 1 | 26.2 | 4.8 | - | 14.526 |

| | | | | |
|---|---|---|---|---|
| **Average** | 26.2 | 4.8 | 0.00 | |
| **Max Variation** | 0.0 | 0.0 | -1998.00 | |

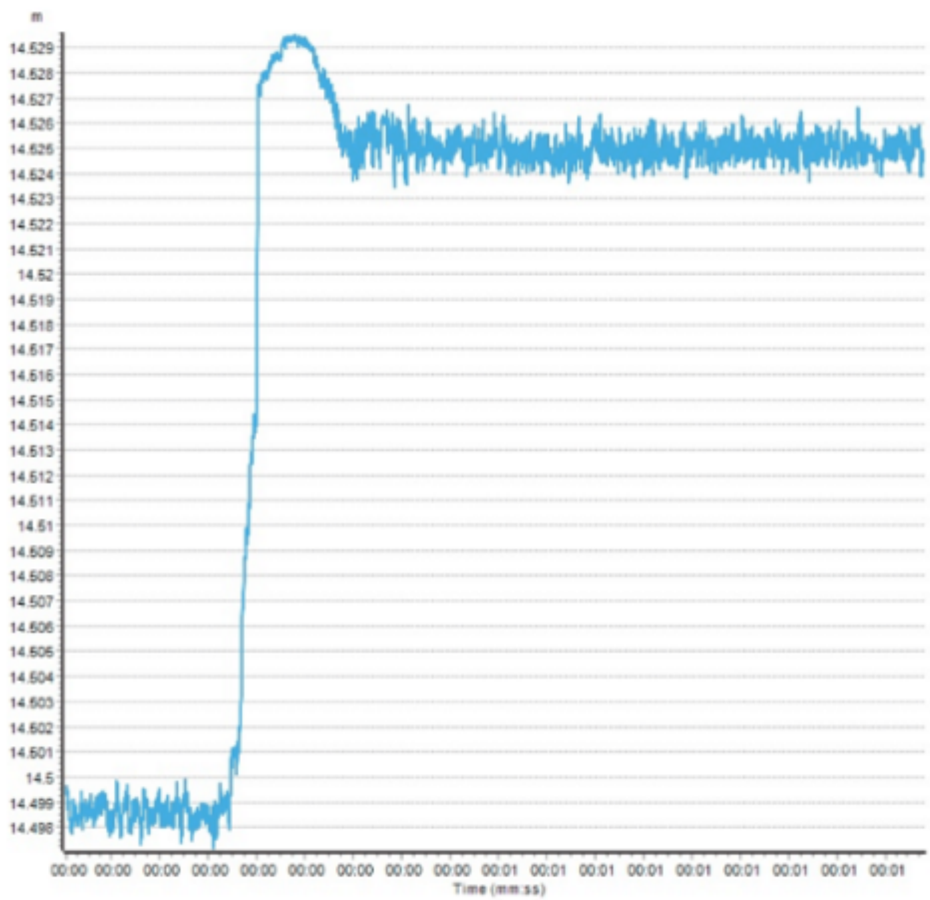
Page 2 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Jacksonville | Test Date | 19/9/2018 |
| Project Description | A1 | Pile Number | 1-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

**Test 2 of 2**

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 10:02:53 | 20.602 | 2.5 | 31.6 | 1.712 | 34.1 |
| 2 | 10:02:54 | 20.604 | 1.9 | 31.4 | 1.758 | 33.3 |
| 3 | 10:02:56 | 20.607 | 2.5 | 31.4 | 1.667 | 33.9 |
| 4 | 10:02:57 | 20.609 | 2.5 | 31.5 | 1.789 | 34 |
| 5 | 10:02:59 | 20.612 | 3.1 | 31.6 | 1.738 | 34.6 |
| 6 | 10:03:00 | 20.615 | 2.5 | 31.2 | 1.804 | 33.8 |
| 7 | 10:03:02 | 20.617 | 2.3 | 31.3 | 1.779 | 33.6 |
| 8 | 10:03:03 | 20.62 | 2.6 | 30.9 | 1.774 | 33.6 |
| 9 | 10:03:05 | 20.623 | 3.1 | 34.5 | 2.033 | 37.5 |
| 10 | 10:03:06 | 20.634 | 10.9 | 25.7 | 2.365 | 36.7 |
| 11 | 10:03:08 | 20.635 | 1.6 | 26.3 | 2.257 | 27.9 |
| 12 | 10:03:09 | 20.637 | 1.5 | 26.7 | 1.864 | 28.3 |
| 13 | 10:03:11 | 20.639 | 2.3 | 27.7 | 1.464 | 30 |
| 14 | 10:03:14 | 20.641 | 1.8 | 28.2 | 1.492 | 30 |
| 15 | 10:03:15 | 20.643 | 2 | 28.4 | 1.5 | 30.4 |
| 16 | 10:03:15 | 20.645 | 2.2 | 29.2 | 1.537 | 31.5 |
| 17 | 10:03:16 | 20.647 | 2 | 29.7 | 1.57 | 31.7 |
| 18 | 10:03:18 | 20.65 | 2.4 | 29.8 | 1.594 | 32.2 |
| 19 | 10:03:19 | 20.652 | 2 | 30.1 | 1.59 | 32.2 |
| 20 | 10:03:21 | 20.654 | 2.3 | 30.3 | 1.611 | 32.5 |
| 21 | 10:03:22 | 20.657 | 3 | 30.6 | 1.625 | 33.6 |
| 22 | 10:03:24 | 20.66 | 3.1 | 30.6 | 1.672 | 33.7 |
| 23 | 10:03:25 | 20.663 | 2.2 | 30.9 | 1.692 | 33.1 |
| 24 | 10:03:27 | 20.665 | 2 | 30.6 | 1.733 | 32.7 |
| 25 | 10:03:28 | 20.667 | 2 | 30.7 | 1.682 | 32.8 |
| 26 | 10:03:30 | 20.668 | 1.7 | 30.7 | 1.646 | 32.4 |
| 27 | 10:03:31 | 20.671 | 2.2 | 30.8 | 1.616 | 33 |
| 28 | 10:03:35 | 20.674 | 3.3 | 31 | 1.677 | 34.3 |
| 29 | 10:03:35 | 20.676 | 2.6 | 31.2 | 1.707 | 33.8 |
| 30 | 10:03:36 | 20.679 | 2.7 | 31.1 | 1.75 | 33.8 |
| 31 | 10:03:37 | 20.682 | 2.7 | 31.1 | 1.718 | 33.7 |
| 32 | 10:03:39 | 20.685 | 2.9 | 30.9 | 1.718 | 33.9 |
| 33 | 10:03:40 | 20.687 | 2.6 | 30.8 | 1.73 | 33.4 |
| 34 | 10:03:41 | 20.69 | 2.7 | 31.1 | 1.724 | 33.8 |
| 35 | 10:03:43 | 20.692 | 2.3 | 30.9 | 1.73 | 33.2 |
| 36 | 10:03:44 | 20.695 | 2.4 | 31 | 1.724 | 33.4 |
| 37 | 10:03:46 | 20.698 | 3.3 | 30.9 | 1.776 | 34.1 |
| 38 | 10:03:47 | 20.701 | 3.3 | 30.9 | 1.806 | 34.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 39 | 10:03:49 | 20.703 | 2.1 | 30.7 | 1.776 | 32.8 |
| 40 | 10:03:50 | 20.706 | 2.4 | 30.6 | 1.724 | 32.9 |
| 41 | 10:03:52 | 20.708 | 2.1 | 30.2 | 1.666 | 32.3 |
| 42 | 10:03:55 | 20.711 | 2.7 | 30.3 | 1.672 | 33 |
| 43 | 10:03:55 | 20.713 | 2.7 | 30.1 | 1.695 | 32.8 |
| 44 | 10:03:56 | 20.716 | 2.5 | 29.5 | 1.695 | 32 |
| 45 | 10:03:58 | 20.719 | 3.5 | 29 | 1.683 | 32.5 |
| 46 | 10:03:59 | 20.722 | 3 | 32.4 | 1.881 | 35.4 |
| 47 | 10:04:01 | 20.725 | 3.3 | 32.2 | 2.371 | 35.4 |
| 48 | 10:04:02 | 20.728 | 2.2 | 32.1 | 2.604 | 34.3 |
| 49 | 10:04:04 | 20.733 | 5.6 | 29.2 | 2.901 | 34.8 |
| 50 | 10:04:05 | 20.736 | 2.5 | 29.7 | 2.424 | 32.2 |
| 51 | 10:04:07 | 20.738 | 2.4 | 30.9 | 2.183 | 33.3 |
| 52 | 10:04:08 | 20.741 | 3.2 | 30.9 | 1.687 | 34 |
| 53 | 10:04:10 | 20.744 | 3 | 30.9 | 1.733 | 33.9 |
| 54 | 10:04:11 | 20.747 | 2.9 | 31.2 | 1.738 | 34.1 |
| 55 | 10:04:15 | 20.75 | 2.8 | 31.3 | 1.712 | 34.1 |
| 56 | 10:04:15 | 20.753 | 2.7 | 31 | 1.677 | 33.7 |
| 57 | 10:04:16 | 20.755 | 2.4 | 31.4 | 1.697 | 33.8 |
| 58 | 10:04:17 | 20.758 | 2.8 | 31.5 | 1.717 | 34.3 |
| 59 | 10:04:19 | 20.76 | 2.5 | 31.2 | 1.682 | 33.7 |
| 60 | 10:04:20 | 20.763 | 2.2 | 31.3 | 1.631 | 33.5 |
| 61 | 10:04:22 | 20.765 | 2.8 | 31.3 | 1.641 | 34.1 |
| 62 | 10:04:23 | 20.768 | 2.6 | 31.3 | 1.702 | 33.9 |
| 63 | 10:04:24 | 20.77 | 2.5 | 31.1 | 1.763 | 33.5 |
| 64 | 10:04:26 | 20.774 | 3.2 | 31.4 | 1.784 | 34.6 |
| 65 | 10:04:27 | 20.776 | 2.2 | 30.9 | 1.779 | 33.2 |
| 66 | 10:04:29 | 20.778 | 2.1 | 31.4 | 1.774 | 33.6 |
| 67 | 10:04:30 | 20.78 | 2.1 | 30.8 | 1.712 | 32.9 |
| 68 | 10:04:32 | 20.782 | 2.1 | 30.8 | 1.707 | 32.8 |
| 69 | 10:04:35 | 20.785 | 2.6 | 31.2 | 1.692 | 33.8 |
| 70 | 10:04:35 | 20.787 | 2.6 | 31 | 1.712 | 33.5 |
| 71 | 10:04:36 | 20.789 | 2.2 | 30.9 | 1.733 | 33 |
| 72 | 10:04:38 | 20.792 | 2.9 | 31.1 | 1.743 | 34.1 |
| 73 | 10:04:39 | 20.795 | 2.7 | 30.9 | 1.728 | 33.6 |
| 74 | 10:04:41 | 20.798 | 2.6 | 30.7 | 1.682 | 33.3 |
| 75 | 10:04:42 | 20.8 | 2.1 | 30.6 | 1.682 | 32.7 |
| 76 | 10:04:44 | 20.802 | 2 | 30.2 | 1.677 | 32.2 |
| 77 | 10:04:45 | 20.804 | 2.5 | 29.8 | 1.687 | 32.3 |
| 78 | 10:04:47 | 20.807 | 2.7 | 29.8 | 1.672 | 32.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 79 | 10:04:48 | 20.809 | 2.3 | 29.4 | 1.728 | 31.7 |
| 80 | 10:04:50 | 20.811 | 2.1 | 28.8 | 1.728 | 30.9 |
| 81 | 10:04:51 | 20.814 | 2.4 | 28.6 | 1.774 | 31 |
| 82 | 10:04:54 | 20.816 | 2.3 | 28.1 | 1.733 | 30.4 |
| 83 | 10:04:55 | 20.818 | 2.3 | 27.4 | 1.717 | 29.7 |
| 84 | 10:04:55 | 20.821 | 2.6 | 26.5 | 1.667 | 29.1 |
| 85 | 10:04:57 | 20.83 | 8.9 | 27.9 | 2.655 | 36.8 |
| 86 | 10:04:58 | 20.832 | 2.4 | 28.1 | 2.589 | 30.5 |
| 87 | 10:05:00 | 20.835 | 2.4 | 28.5 | 2.547 | 30.9 |
| 88 | 10:05:01 | 20.836 | 1.2 | 28.7 | 1.488 | 30 |
| 89 | 10:05:03 | 20.837 | 1.4 | 28.9 | 1.513 | 30.3 |
| 90 | 10:05:04 | 20.839 | 1.7 | 29 | 1.5 | 30.7 |
| 91 | 10:05:06 | 20.841 | 2.5 | 29.3 | 1.5 | 31.8 |
| 92 | 10:05:07 | 20.844 | 2.8 | 29.7 | 1.537 | 32.5 |
| 93 | 10:05:09 | 20.847 | 3 | 29.9 | 1.601 | 32.9 |
| 94 | 10:05:10 | 20.849 | 2.1 | 29.9 | 1.651 | 32.1 |
| 95 | 10:05:12 | 20.851 | 2 | 30.2 | 1.667 | 32.2 |
| 96 | 10:05:15 | 20.854 | 2.8 | 30.5 | 1.656 | 33.3 |
| 97 | 10:05:15 | 20.858 | 3.4 | 30.6 | 1.675 | 34 |
| 98 | 10:05:16 | 20.86 | 2.5 | 30.7 | 1.668 | 33.1 |
| 99 | 10:05:18 | 20.862 | 2.3 | 30.7 | 1.654 | 32.9 |
| 100 | 10:05:19 | 20.865 | 2.4 | 30.4 | 1.648 | 32.7 |
| 101 | 10:05:21 | 20.867 | 2.1 | 30.6 | 1.637 | 32.7 |
| 102 | 10:05:22 | 20.869 | 2.1 | 30.6 | 1.625 | 32.6 |
| 103 | 10:05:23 | 20.871 | 2 | 30.5 | 1.637 | 32.5 |
| 104 | 10:05:25 | 20.873 | 2.5 | 30.7 | 1.672 | 33.2 |
| 105 | 10:05:26 | 20.876 | 2.6 | 30.6 | 1.736 | 33.2 |
| 106 | 10:05:28 | 20.879 | 3.3 | 30.6 | 1.759 | 33.9 |
| 107 | 10:05:29 | 20.882 | 2.4 | 30.9 | 1.712 | 33.2 |
| 108 | 10:05:31 | 20.884 | 2.7 | 30.7 | 1.712 | 33.4 |
| 109 | 10:05:34 | 20.886 | 1.9 | 30.4 | 1.736 | 32.3 |
| 110 | 10:05:35 | 20.889 | 2.5 | 30.6 | 1.8 | 33.1 |
| 111 | 10:05:35 | 20.892 | 3.1 | 30.4 | 1.782 | 33.5 |
| 112 | 10:05:37 | 20.894 | 2.4 | 30.3 | 1.788 | 32.6 |
| 113 | 10:05:38 | 20.897 | 2.7 | 30.4 | 1.765 | 33.1 |
| 114 | 10:05:40 | 20.9 | 2.9 | 30 | 1.771 | 32.9 |
| 115 | 10:05:41 | 20.902 | 2.3 | 29.8 | 1.742 | 32.1 |
| 116 | 10:05:43 | 20.905 | 2.7 | 29.4 | 1.771 | 32.1 |
| 117 | 10:05:44 | 20.907 | 2.7 | 29.2 | 1.788 | 31.9 |
| 118 | 10:05:46 | 20.91 | 2.5 | 28.4 | 1.8 | 30.9 |

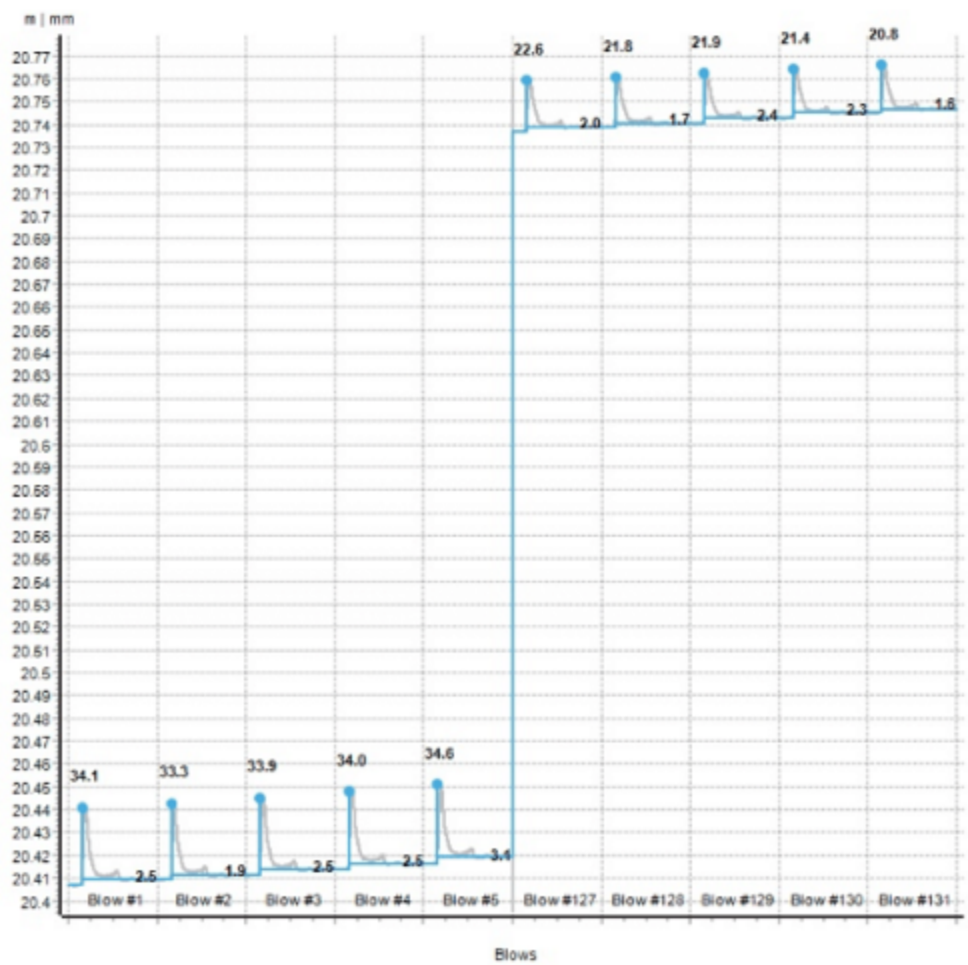
| | | | | | | |
|---|---|---|---|---|---|---|
| 119 | 10:05:47 | 20.913 | 2.9 | 27.5 | 1.782 | 30.4 |
| 120 | 10:05:49 | 20.915 | 2.6 | 27.1 | 1.771 | 29.6 |
| 121 | 10:05:50 | 20.918 | 2.6 | 26.4 | 1.736 | 29 |
| 122 | 10:05:52 | 20.92 | 2.3 | 25.6 | 1.689 | 27.8 |
| 123 | 10:05:55 | 20.923 | 2.7 | 25 | 1.596 | 27.7 |
| 124 | 10:05:55 | 20.925 | 2.5 | 23.6 | 1.578 | 26.1 |
| 125 | 10:05:56 | 20.927 | 1.8 | 22.4 | 1.625 | 24.3 |
| 126 | 10:05:58 | 20.93 | 2.4 | 21 | 1.718 | 23.4 |
| 127 | 10:05:59 | 20.932 | 2 | 20.6 | 1.681 | 22.6 |
| 128 | 10:06:00 | 20.933 | 1.7 | 20.1 | 1.552 | 21.8 |
| 129 | 10:06:02 | 20.936 | 2.4 | 19.5 | 1.498 | 21.9 |
| 130 | 10:06:03 | 20.938 | 2.3 | 19.1 | 1.468 | 21.4 |
| 131 | 10:06:05 | 20.94 | 1.6 | 19.3 | 1.568 | 20.8 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 25/4/2019 |
| Client Name | | Report Time | 4:24:04 PM |
| Project Name | Jacksonville | Test Date | 19/9/2018 |
| Project Area | A1 | Test Time | 10:02:52 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD-2 | PDM Pile Offset (m) | 9.150 |
| Pile Type | | Final Penetration at Blow 131 (m) | 20.940 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Jacksonville | Test Date | 19/9/2018 |
| Project Area | A1 | Pile Number | 2-EOD-2 |

## NUMERICAL DATA

Capacity Method: (None)

| | | | |
|---|---|---|---|
| Set (mm) | 2.2 | VMX (m/s) | 1.58 |
| Rebound (mm) | 25.6 | DMX (mm) | 27.8 |
| Capacity (kN) | - | EMX (kJ) | - |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 131 | 1.6 | 19.3 | 1.57 | 20.940 |
| 130 | 2.3 | 19.1 | 1.47 | 20.938 |
| 129 | 2.4 | 19.5 | 1.50 | 20.936 |
| 128 | 1.7 | 20.1 | 1.55 | 20.933 |
| 127 | 2.0 | 20.6 | 1.68 | 20.932 |
| 5 | 3.1 | 31.6 | 1.74 | 20.612 |
| 4 | 2.5 | 31.5 | - | 20.609 |
| 3 | 2.5 | 31.4 | - | 20.607 |
| 2 | 1.9 | 31.4 | - | 20.604 |
| 1 | 2.5 | 31.6 | - | 20.602 |
| **Average** | 2.2 | 25.6 | 1.58 | |
| **Max Variation** | 1.5 | 12.5 | 0.27 | |

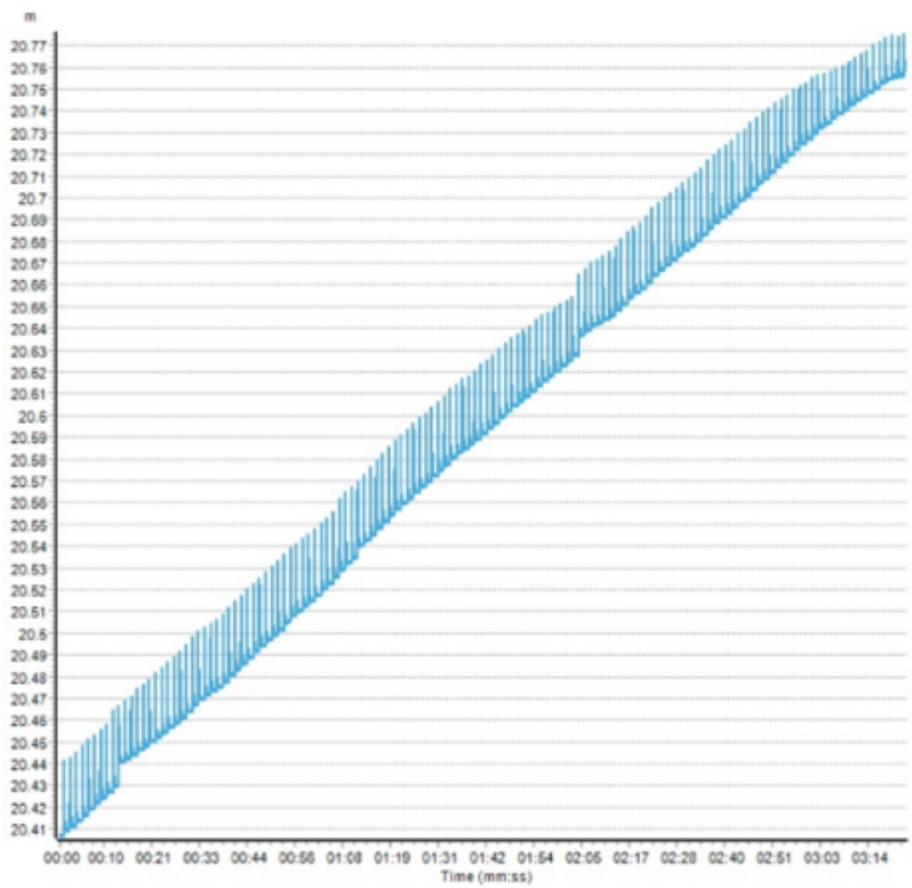
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Jacksonville | Test Date | 19/9/2018 |
| Project Description | A1 | Pile Number | 2-EOD-2 |

## COMPLETE VIEW




PDM Serial Number: PG2024174

Page 3 of 3

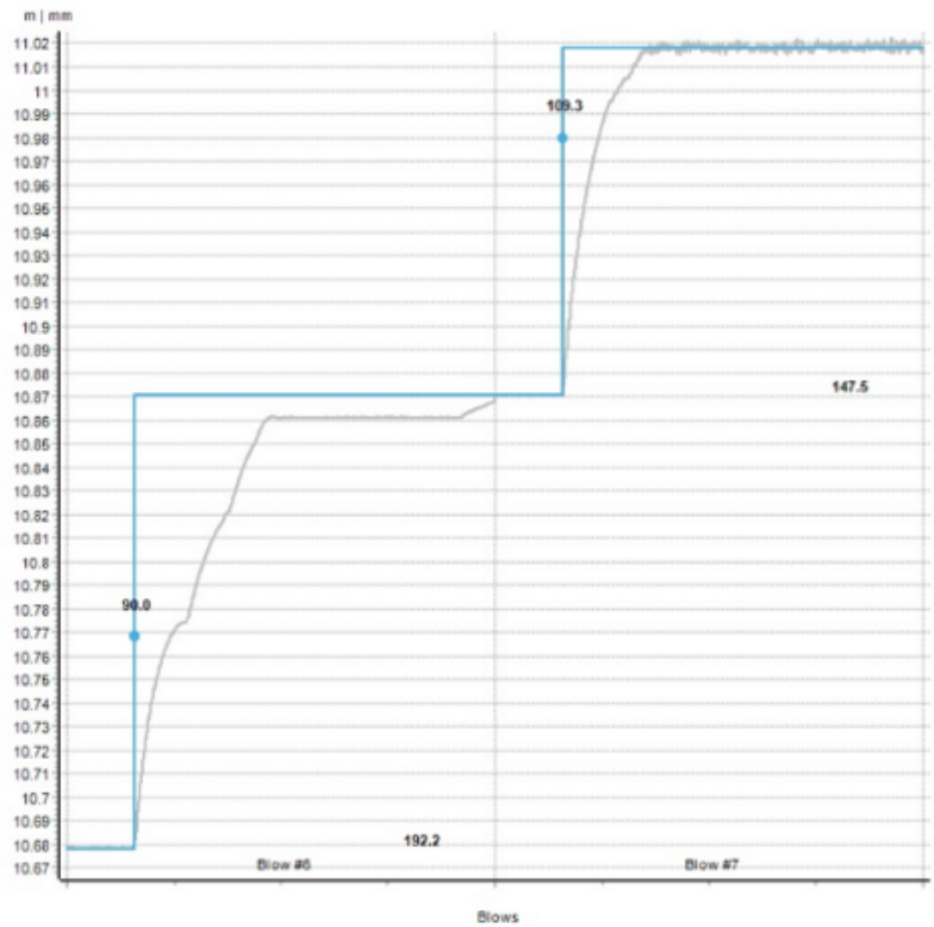
### A.1.5.1. SPT near Station 136+38

## PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 18/4/2019 |
| Client Name | | Report Time | 3:48:04 PM |
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Test Time | 11:02:37 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD | PDM Pile Offset (m) | 8.200 |
| Pile Type | | Final Penetration at Blow 7 (m) | 11.016 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Pile Number | 2-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 169.9 | VMX (m/s) | 23.58 |
| Rebound (mm) | -70.2 | DMX (mm) | 99.7 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 7 | 147.5 | -38.2 | 23.23 | 11.016 |
| 6 | 192.2 | -102.2 | 23.94 | 10.869 |

| | | | | |
|---|---|---|---|---|
| **Average** | 169.9 | -70.2 | 23.58 | |
| **Max Variation** | 44.7 | 64.0 | 0.72 | |

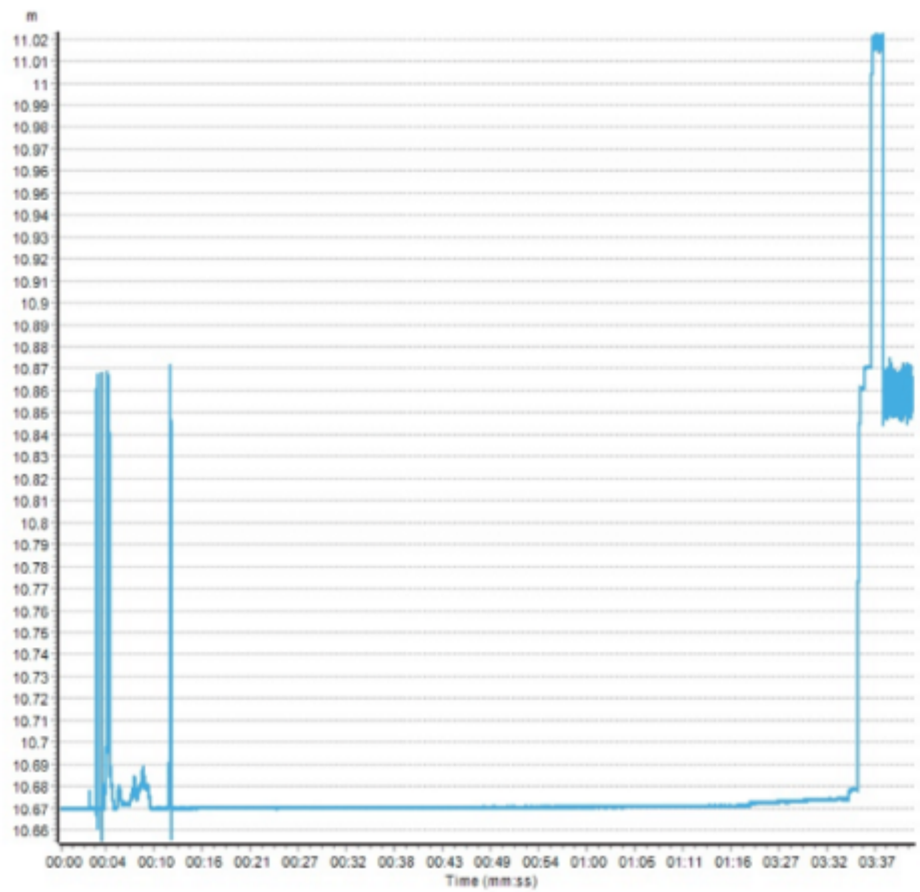
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Description | | Pile Number | 2-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

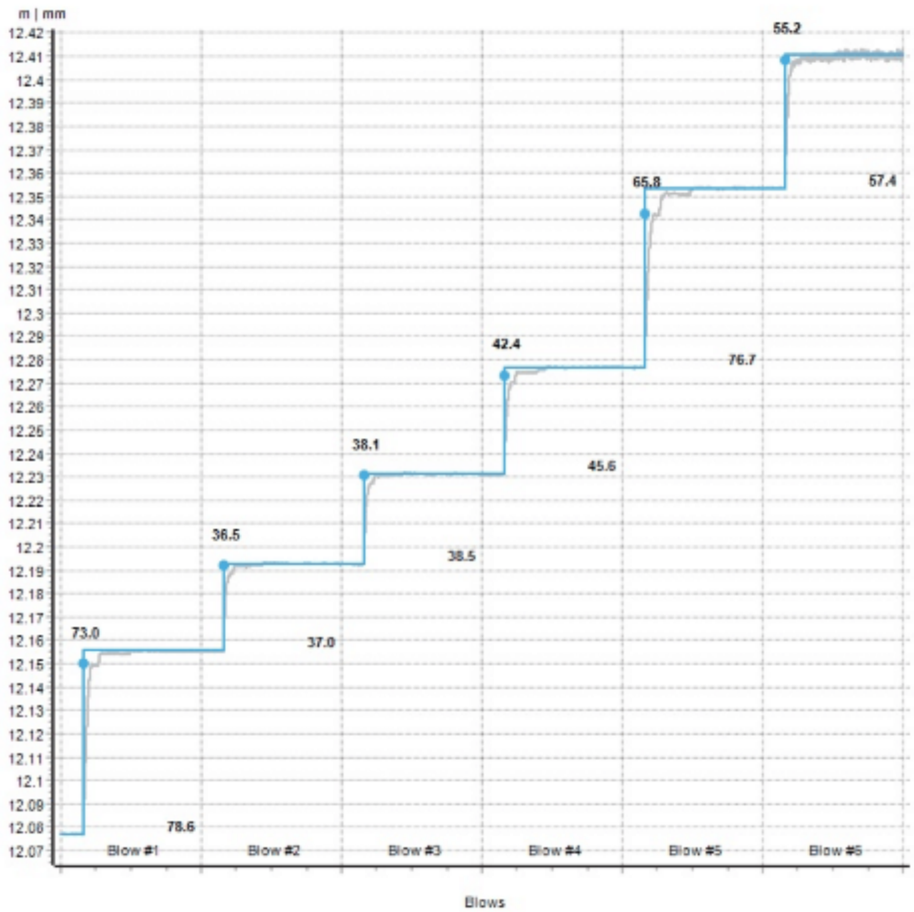
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 11:02:40 | 10.668 | -0.1 | 8.1 | 2.327 | 8 |
| 2 | 11:02:42 | 10.676 | 8.1 | 189.8 | 75.328 | 197.9 |
| 3 | 11:02:42 | 10.679 | 2.6 | 186.3 | 63.035 | 188.9 |
| 4 | 11:02:47 | 10.668 | -10.2 | 18.4 | 5.466 | 8.3 |
| 5 | 11:02:50 | 10.677 | 8.2 | 189.7 | 43.798 | 198 |
| 6 | 11:06:13 | 10.869 | 192.2 | -102.2 | 23.942 | 90 |
| 7 | 11:06:15 | 11.016 | 147.5 | -38.2 | 23.225 | 109.3 |
| 8 | 11:06:16 | 10.858 | -158.8 | 162 | 4.299 | 3.2 |
| 9 | 11:06:17 | 10.858 | 0.1 | 7.2 | 10.091 | 7.3 |
| 10 | 11:06:18 | 10.856 | -1.6 | 9.7 | 15.505 | 8.2 |
| 11 | 11:06:18 | 10.855 | -0.9 | 11.1 | 20.221 | 10.2 |
| 12 | 11:06:19 | 10.852 | -2.8 | 12.1 | 20.338 | 9.3 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 10/4/2019 |
| Client Name | | Report Time | 1:16:07 PM |
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Test Time | 11:33:38 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 3-EOD | PDM Pile Offset (m) | 8.200 |
| Pile Type | | Final Penetration at Blow 6 (m) | 12.404 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Pile Number | 3-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 55.7 | VMX (m/s) | 3.14 |
| Rebound (mm) | -3.8 | DMX (mm) | 51.8 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 6 | 57.4 | -2.2 | 3.21 | 12.404 |
| 5 | 76.7 | -10.9 | 3.07 | 12.347 |
| 4 | 45.6 | -3.2 | - | 12.270 |
| 3 | 38.5 | -0.5 | - | 12.224 |
| 2 | 37.0 | -0.6 | - | 12.186 |
| 1 | 78.6 | -5.6 | - | 12.149 |

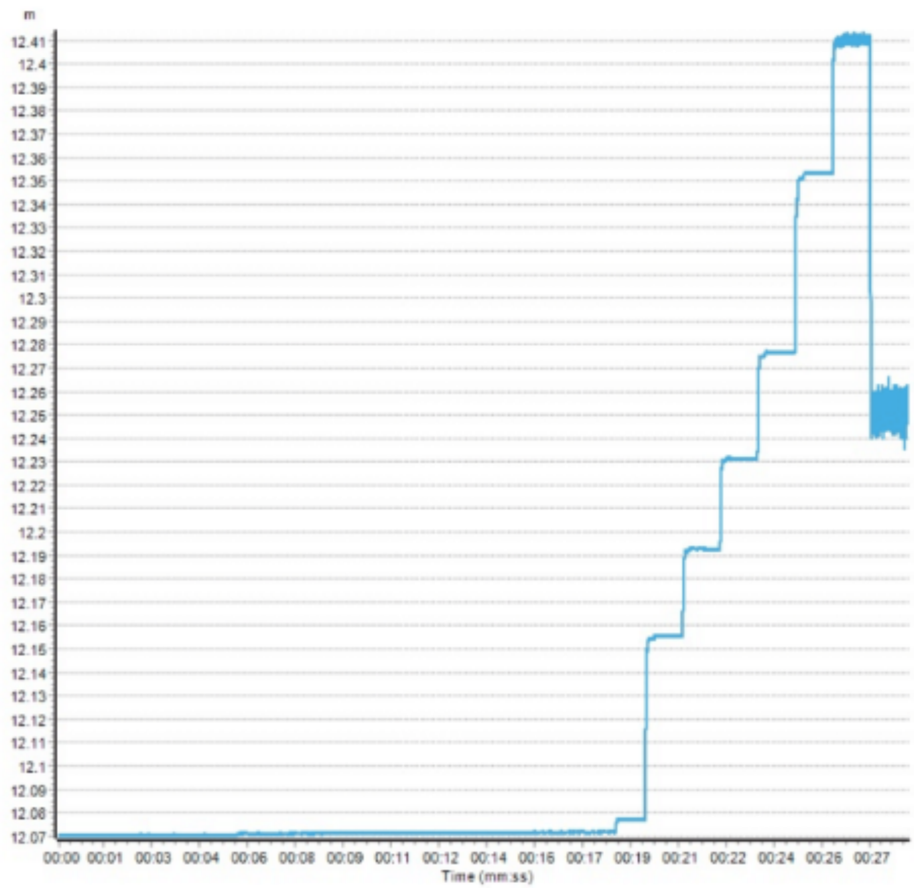
| | | | | |
|---|---|---|---|---|
| **Average** | 55.7 | -3.8 | 3.14 | |
| **Max Variation** | 41.6 | 10.5 | 0.14 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Description | | Pile Number | 3-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

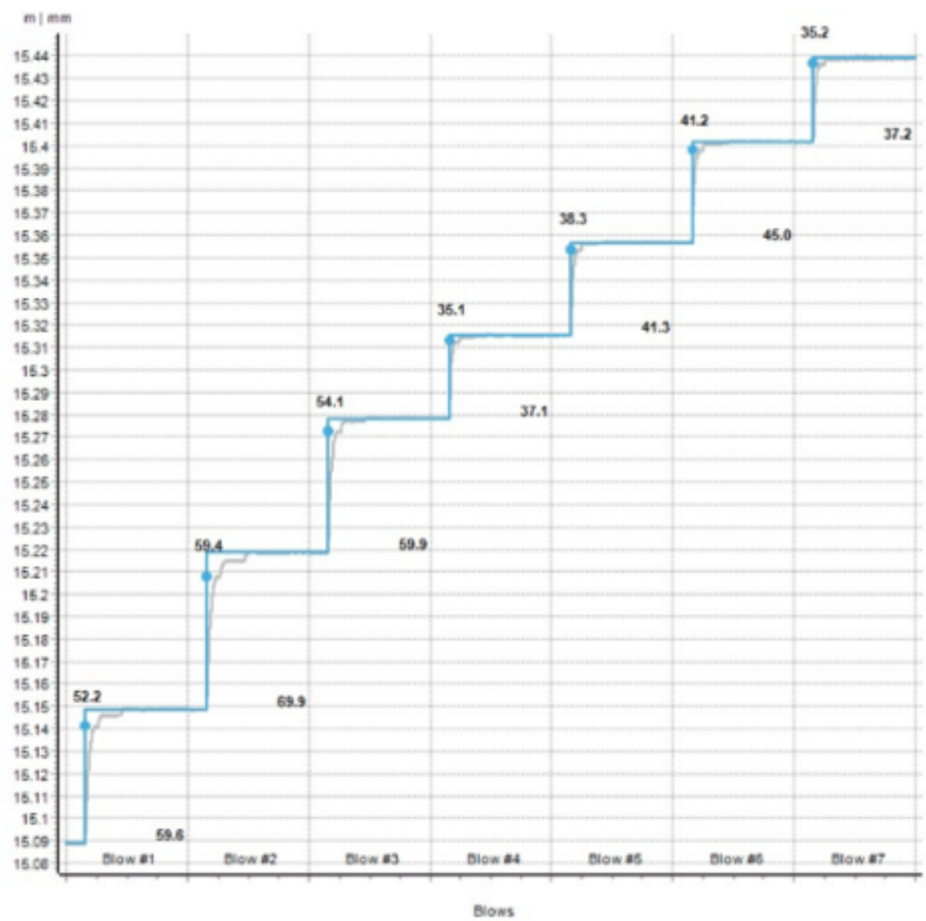
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 11:34:00 | 12.149 | 78.6 | -5.6 | 3.677 | 73 |
| 2 | 11:34:01 | 12.186 | 37 | -0.6 | 3.117 | 36.5 |
| 3 | 11:34:01 | 12.224 | 38.5 | -0.5 | 2.854 | 38.1 |
| 4 | 11:34:02 | 12.27 | 45.6 | -3.2 | 3.084 | 42.4 |
| 5 | 11:34:03 | 12.347 | 76.7 | -10.9 | 3.073 | 65.8 |
| 6 | 11:34:05 | 12.404 | 57.4 | -2.2 | 3.209 | 55.2 |
| 7 | 11:34:06 | 12.243 | -160.6 | 162 | 3.6 | 1.4 |
| 8 | 11:34:07 | 12.246 | 2.6 | 8.7 | 9.666 | 11.3 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 10/4/2019 |
| Client Name | | Report Time | 1:24:28 PM |
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Test Time | 12:05:10 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 4-EOD | PDM Pile Offset (m) | 8.200 |
| Pile Type | | Final Penetration at Blow 7 (m) | 15.438 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Pile Number | 4-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 50.0 | VMX (m/s) | 3.13 |
| Rebound (mm) | -4.9 | DMX (mm) | 45.1 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 7 | 37.2 | -2.0 | 3.12 | 15.438 |
| 6 | 45.0 | -3.8 | 3.12 | 15.401 |
| 5 | 41.3 | -3.0 | 3.14 | 15.356 |
| 4 | 37.1 | -2.1 | - | 15.315 |
| 3 | 59.9 | -5.7 | - | 15.277 |
| 2 | 69.9 | -10.5 | - | 15.218 |
| 1 | 59.6 | -7.4 | - | 15.148 |

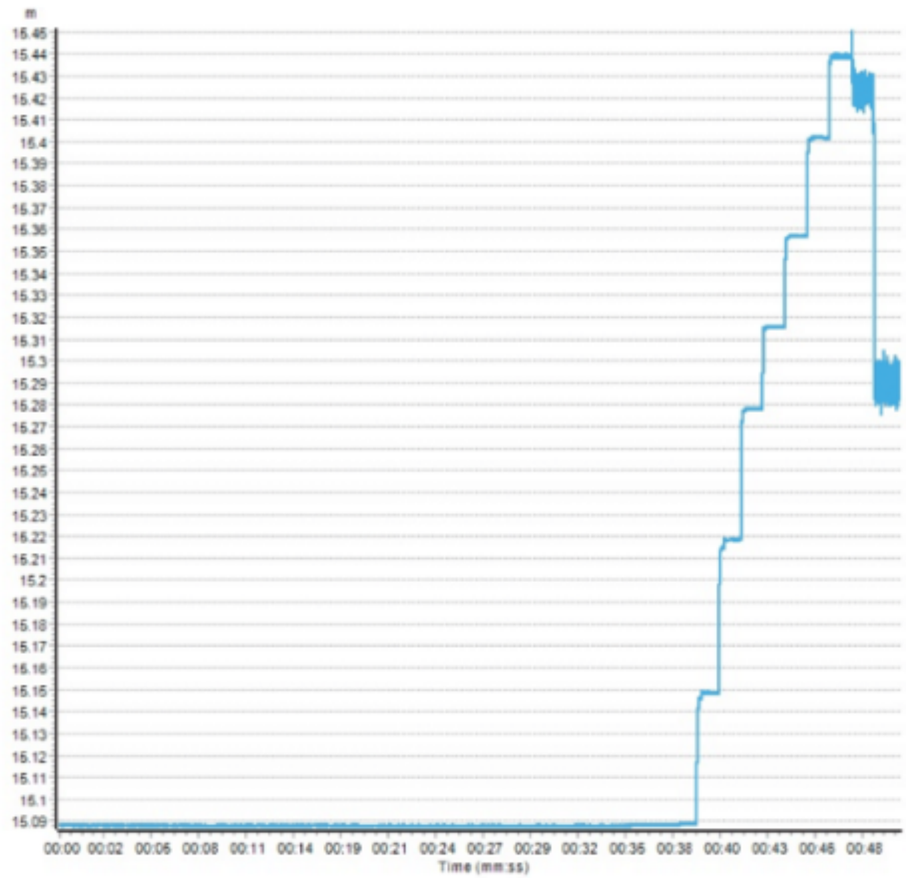
| | | | |
|---|---|---|---|
| **Average** | 50.0 | -4.9 | 3.13 |
| **Max Variation** | 32.8 | 8.6 | 0.02 |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Description | | Pile Number | 4-EOD |

COMPLETE VIEW




PDM Serial Number: PG2024174

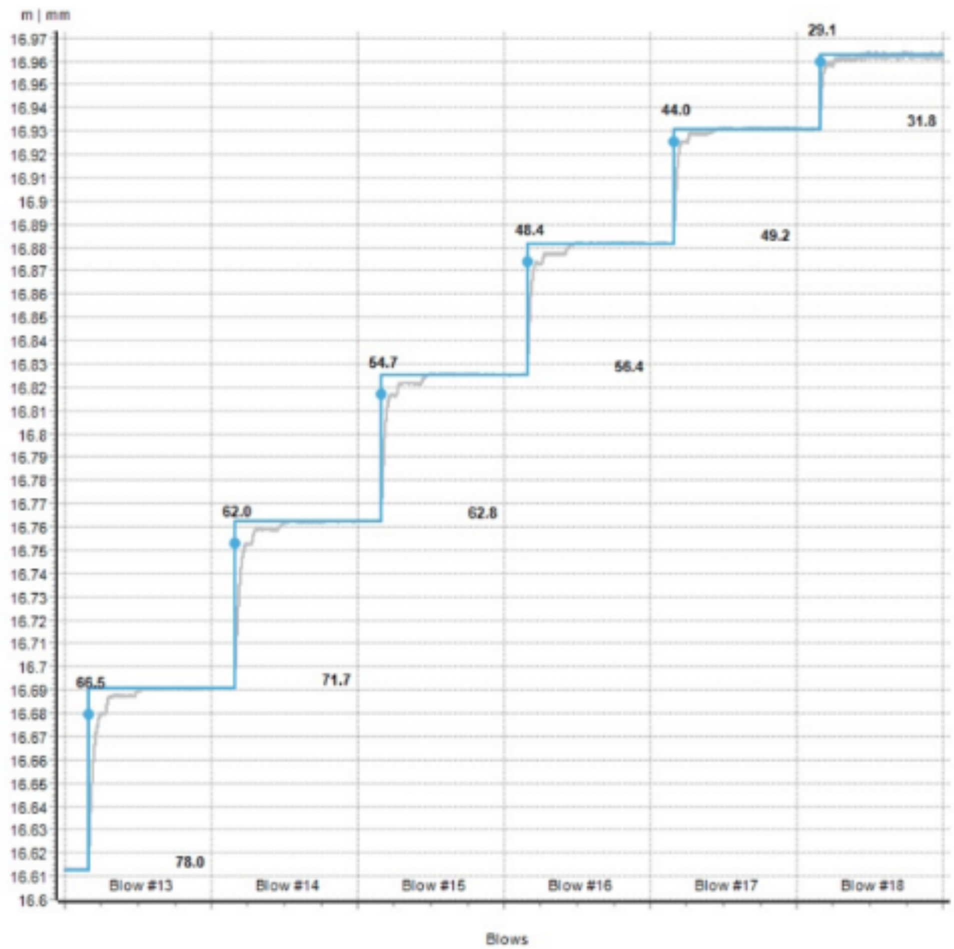
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 12:05:49 | 15.148 | 59.6 | -7.4 | 3.084 | 52.2 |
| 2 | 12:05:51 | 15.218 | 69.9 | -10.5 | 3.589 | 59.4 |
| 3 | 12:05:52 | 15.277 | 59.9 | -5.7 | 3.172 | 54.1 |
| 4 | 12:05:52 | 15.315 | 37.1 | -2.1 | 3.128 | 35.1 |
| 5 | 12:05:54 | 15.356 | 41.3 | -3 | 3.143 | 38.3 |
| 6 | 12:05:55 | 15.401 | 45 | -3.8 | 3.121 | 41.2 |
| 7 | 12:05:56 | 15.438 | 37.2 | -2 | 3.121 | 35.2 |
| 8 | 12:05:58 | 15.423 | -15.6 | 27.1 | 10.599 | 11.6 |
| 9 | 12:05:59 | 15.29 | -132.1 | 137.7 | 17.06 | 5.6 |
| 10 | 12:06:00 | 15.286 | -4.2 | 9.6 | 22.717 | 5.4 |
| 11 | 12:06:01 | 15.288 | 1.9 | 13 | 19.384 | 14.9 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 10/4/2019 |
| Client Name | | Report Time | 1:33:39 PM |
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Test Time | 12:36:14 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 5-EOD | PDM Pile Offset (m) | 8.200 |
| Pile Type | | Final Penetration at Blow 18 (m) | 16.963 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Pile Number | 5-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 58.3 | VMX (m/s) | 5.84 |
| Rebound (mm) | -7.5 | DMX (mm) | 50.8 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 18 | 31.8 | -2.7 | 2.97 | 16.963 |
| 17 | 49.2 | -5.2 | 3.16 | 16.931 |
| 16 | 56.4 | -7.9 | 3.23 | 16.882 |
| 15 | 62.8 | -8.1 | 3.22 | 16.825 |
| 14 | 71.7 | -9.6 | 9.07 | 16.762 |
| 13 | 78.0 | -11.5 | 13.41 | 16.691 |

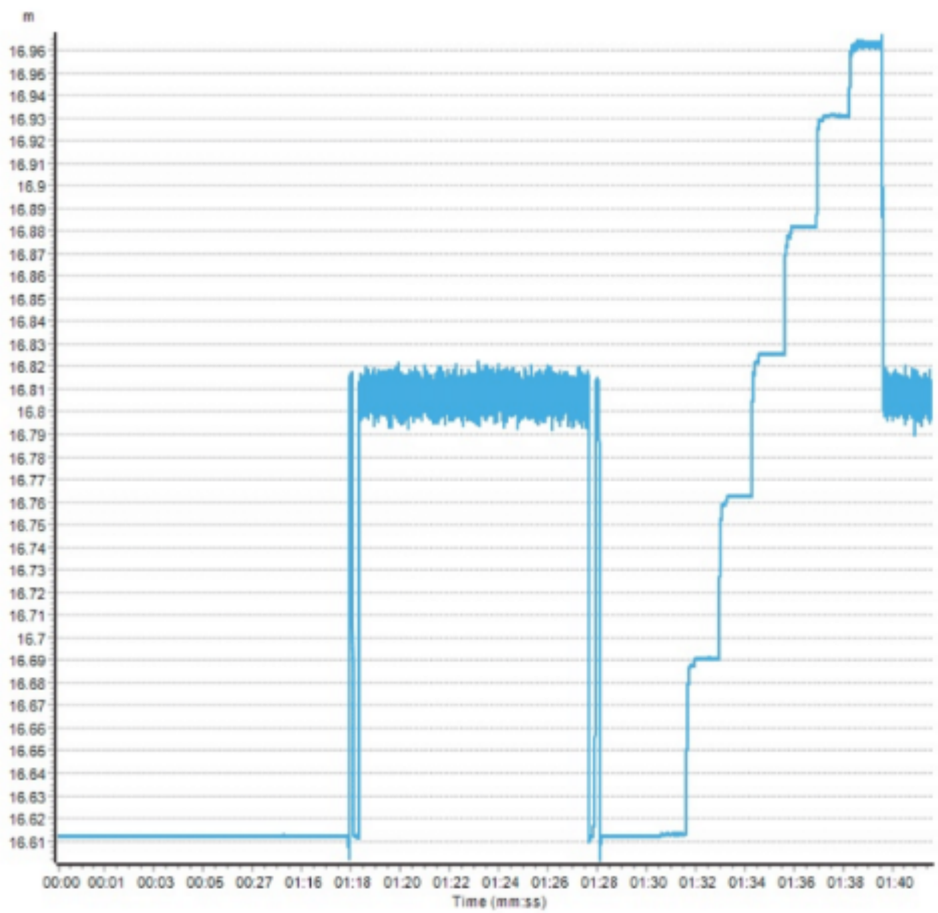
| | | | | |
|---|---|---|---|---|
| **Average** | 58.3 | -7.5 | 5.84 | |
| **Max Variation** | 46.2 | 8.7 | 10.45 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Description | | Pile Number | 5-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

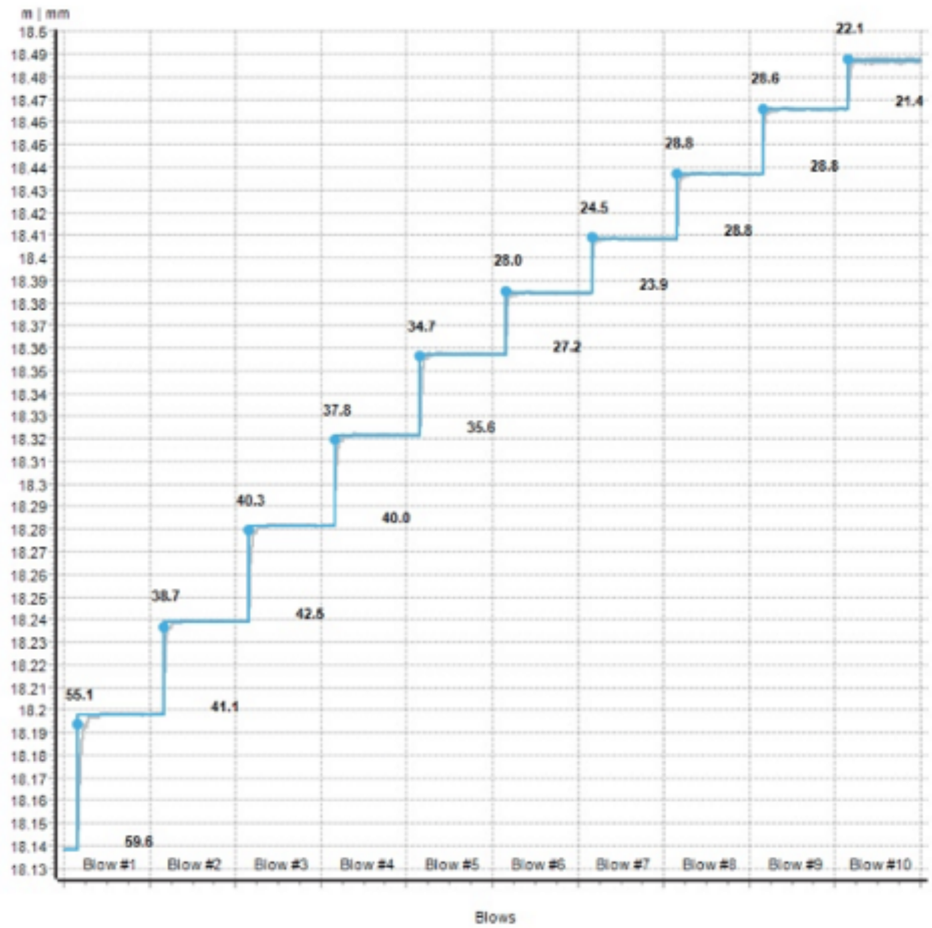
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 12:37:33 | 16.81 | 197.6 | 7 | 63.145 | 204.6 |
| 2 | 12:37:34 | 16.807 | -2.8 | 12.2 | 19.834 | 9.3 |
| 3 | 12:37:35 | 16.81 | 3.5 | 9.2 | 24.432 | 12.7 |
| 4 | 12:37:36 | 16.805 | -5.5 | 12.9 | 18.088 | 7.4 |
| 5 | 12:37:36 | 16.805 | 0.2 | 12.5 | 20.737 | 12.6 |
| 6 | 12:37:37 | 16.807 | 2.1 | 8.1 | 18.707 | 10.2 |
| 7 | 12:37:38 | 16.807 | -0.3 | 13 | 18.948 | 12.7 |
| 8 | 12:37:39 | 16.809 | 2.1 | 9.3 | 18.996 | 11.4 |
| 9 | 12:37:40 | 16.808 | -0.8 | 5.4 | 18.824 | 4.6 |
| 10 | 12:37:40 | 16.809 | 1.2 | 6.7 | 19.259 | 7.9 |
| 11 | 12:37:41 | 16.806 | -3.5 | 11.3 | 18.081 | 7.8 |
| 12 | 12:37:42 | 16.613 | -193 | 205.2 | 19.029 | 12.3 |
| 13 | 12:37:46 | 16.691 | 78 | -11.5 | 13.413 | 66.5 |
| 14 | 12:37:47 | 16.762 | 71.7 | -9.6 | 9.066 | 62 |
| 15 | 12:37:48 | 16.825 | 62.8 | -8.1 | 3.223 | 54.7 |
| 16 | 12:37:52 | 16.882 | 56.4 | -7.9 | 3.227 | 48.4 |
| 17 | 12:37:52 | 16.931 | 49.2 | -5.2 | 3.165 | 44 |
| 18 | 12:37:52 | 16.963 | 31.8 | -2.7 | 2.967 | 29.1 |
| 19 | 12:37:54 | 16.805 | -157.2 | 124.5 | 7.815 | -32.7 |
| 20 | 12:37:55 | 16.806 | 0.3 | 9.9 | 12.728 | 10.2 |
| 21 | 12:37:56 | 16.803 | -2.5 | 13.4 | 18.988 | 11 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 10/4/2019 |
| Client Name | | Report Time | 1:30:48 PM |
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Test Time | 1:00:24 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 6-EOD | PDM Pile Offset (m) | 8.200 |
| Pile Type | | Final Penetration at Blow 10 (m) | 18.485 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Area | | Pile Number | 6-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 34.9 | VMX (m/s) | 2.84 |
| Rebound (mm) | -1.0 | DMX (mm) | 33.9 |

## TABLE VIEW

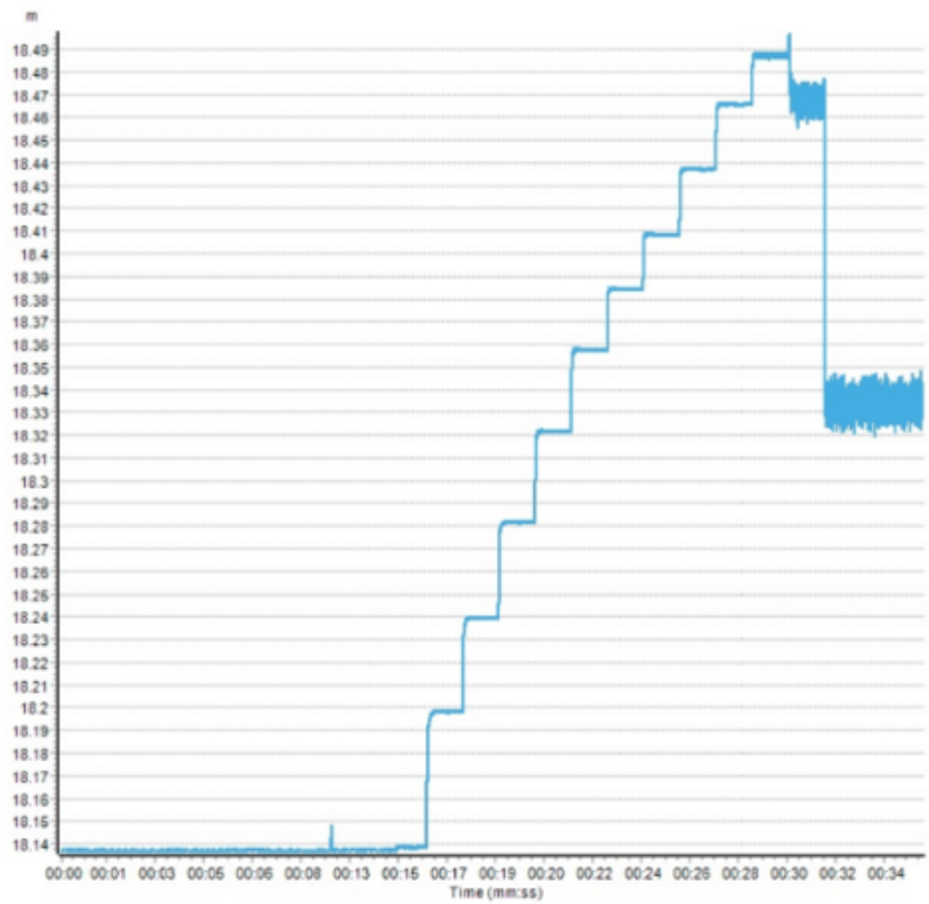
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 10 | 21.4 | 0.7 | 2.82 | 18.485 |
| 9 | 28.8 | -0.2 | 2.79 | 18.463 |
| 8 | 28.8 | 0.0 | 2.73 | 18.435 |
| 7 | 23.9 | 0.6 | 2.70 | 18.406 |
| 6 | 27.2 | 0.8 | 2.92 | 18.382 |
| 5 | 35.6 | -0.9 | 3.08 | 18.355 |
| 4 | 40.0 | -2.2 | - | 18.319 |
| 3 | 42.5 | -2.2 | - | 18.279 |
| 2 | 41.1 | -2.4 | - | 18.237 |
| 1 | 59.6 | -4.5 | - | 18.196 |
| **Average** | 34.9 | -1.0 | 2.84 | |
| **Max Variation** | 38.2 | 5.3 | 0.38 | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Dunns Creek SPT | Test Date | 14/3/2019 |
| Project Description | | Pile Number | 6-EOD |

COMPLETE VIEW




PDM Serial Number: PG2024174

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:00:40 | 18.196 | 59.6 | -4.5 | 3.238 | 55.1 |
| 2 | 13:00:42 | 18.237 | 41.1 | -2.4 | 3.666 | 38.7 |
| 3 | 13:00:43 | 18.279 | 42.5 | -2.2 | 3.194 | 40.3 |
| 4 | 13:00:44 | 18.319 | 40 | -2.2 | 3.271 | 37.8 |
| 5 | 13:00:45 | 18.355 | 35.6 | -0.9 | 3.084 | 34.7 |
| 6 | 13:00:46 | 18.382 | 27.2 | 0.8 | 2.923 | 28 |
| 7 | 13:00:48 | 18.406 | 23.9 | 0.6 | 2.704 | 24.5 |
| 8 | 13:00:49 | 18.435 | 28.8 | 0 | 2.733 | 28.8 |
| 9 | 13:00:50 | 18.463 | 28.8 | -0.2 | 2.788 | 28.6 |
| 10 | 13:00:51 | 18.485 | 21.4 | 0.7 | 2.821 | 22.1 |
| 11 | 13:00:53 | 18.464 | -20.7 | 9.5 | 11.587 | -11.2 |
| 12 | 13:00:54 | 18.331 | -132.8 | 9.8 | 16.958 | -123.1 |
| 13 | 13:00:55 | 18.334 | 2.6 | 4.9 | 20.957 | 7.5 |
| 14 | 13:00:56 | 18.331 | -2.6 | 13.1 | 17.854 | 10.5 |
| 15 | 13:00:57 | 18.333 | 1.9 | 9.5 | 17.979 | 11.5 |

### A.2.5 Wekiva Parkway Wildlife Crossings 2 and 3

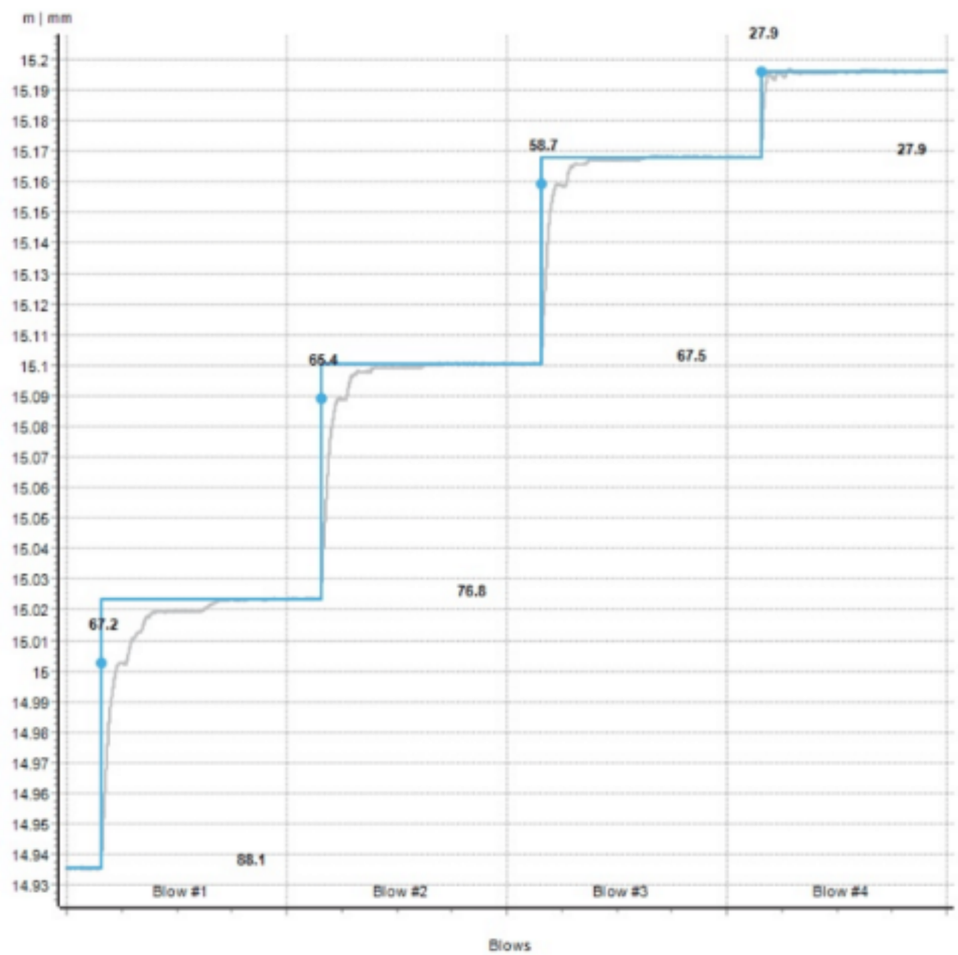
A.2.5.1 Day 1, 5/7/2019, WLC 2

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 4:53:13 PM |
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Test Time | 1:18:31 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD | PDM Pile Offset (m) | 8.000 |
| Pile Type | | Final Penetration at Blow 4 (m) | 15.195 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Pile Number | 1-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 65.1 | VMX (m/s) | 0.00 |
| Rebound (mm) | -10.3 | DMX (mm) | 54.8 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 4 | 27.9 | 0.1 | - | 15.195 |
| 3 | 67.5 | -8.9 | - | 15.168 |
| 2 | 76.8 | -11.4 | - | 15.100 |
| 1 | 88.1 | -21.0 | - | 15.023 |

| | | | | |
|---|---|---|---|---|
| **Average** | 65.1 | -10.3 | 0.00 | |
| **Max Variation** | 60.3 | 21.0 | -1998.00 | |

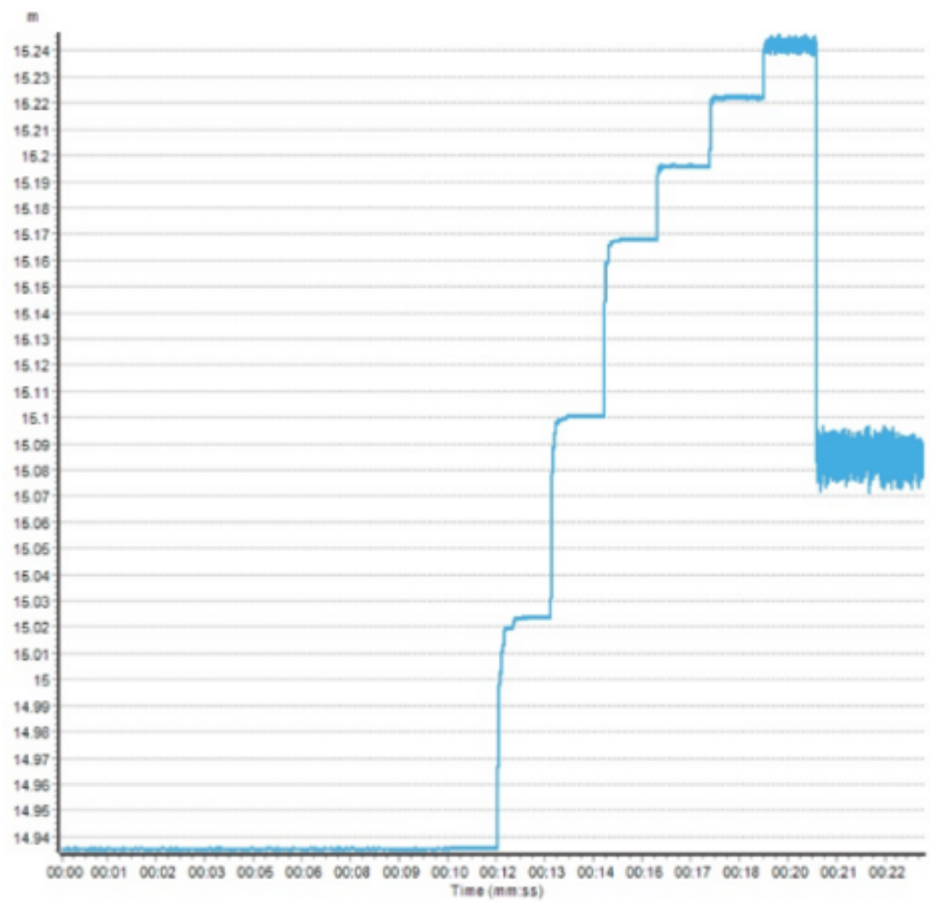
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Description | | Pile Number | 1-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

Page 3 of 3

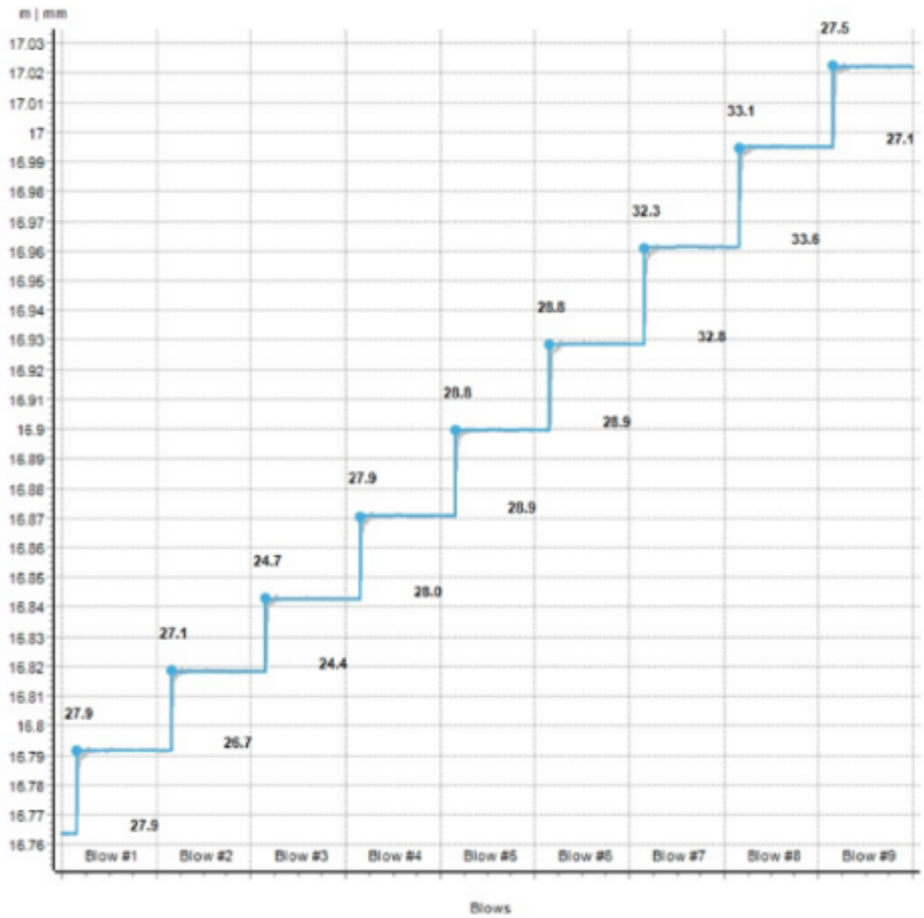
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:18:43 | 15.023 | 88.1 | -21 | 3.331 | 67.2 |
| 2 | 13:18:45 | 15.1 | 76.8 | -11.4 | 3.203 | 65.4 |
| 3 | 13:18:46 | 15.168 | 67.5 | -8.9 | 3.256 | 58.7 |
| 4 | 13:18:48 | 15.195 | 27.9 | 0.1 | 3.053 | 27.9 |
| 5 | 13:18:49 | 15.241 | 45.8 | -19.9 | 2.992 | 25.9 |
| 6 | 13:18:53 | 15.243 | 1.6 | 2.3 | 3.66 | 3.8 |
| 7 | 13:18:53 | 15.085 | -158 | 159.9 | 4.638 | 1.9 |
| 8 | 13:18:54 | 15.084 | -0.4 | 9.2 | 8.991 | 8.9 |
| 9 | 13:18:54 | 15.087 | 2.5 | 6.6 | 12.983 | 9.1 |
| 10 | 13:18:55 | 15.082 | -5.1 | 13.2 | 15.807 | 8.1 |
| 11 | 13:18:55 | 15.084 | 2.5 | -15076.5 | 15.807 | -15074 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 4:57:11 PM |
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Test Time | 1:40:11 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-RST | PDM Pile Offset (m) | 8.000 |
| Pile Type | | Final Penetration at Blow 9 (m) | 17.021 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Pile Number | 2-RST |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 28.7 | VMX (m/s) | 3.13 |
| Rebound (mm) | 0.0 | DMX (mm) | 28.7 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 9 | 27.1 | 0.3 | 3.31 | 17.021 |
| 8 | 33.6 | -0.5 | 3.27 | 16.994 |
| 7 | 32.8 | -0.5 | 3.10 | 16.961 |
| 6 | 28.9 | -0.1 | 3.00 | 16.928 |
| 5 | 28.9 | -0.1 | 2.96 | 16.899 |
| 4 | 28.0 | -0.1 | - | 16.870 |
| 3 | 24.4 | 0.3 | - | 16.842 |
| 2 | 26.7 | 0.4 | - | 16.818 |
| 1 | 27.9 | 0.0 | - | 16.791 |

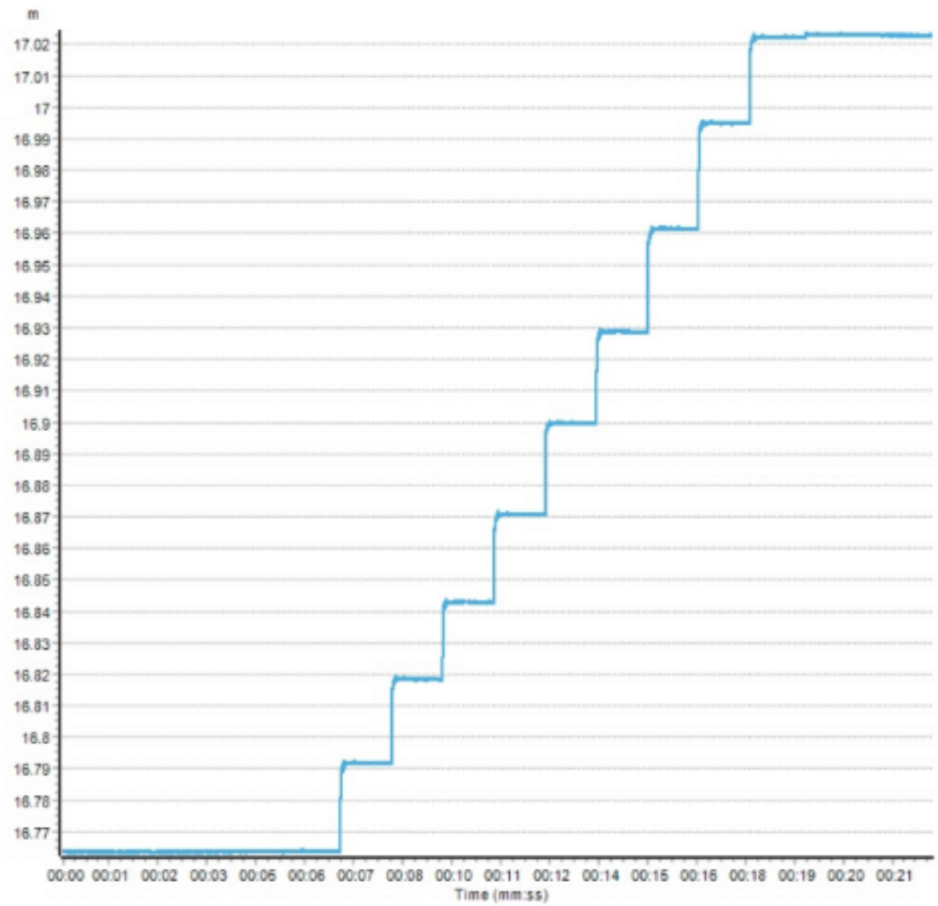
| | | | |
|---|---|---|---|
| **Average** | 28.7 | 0.0 | 3.13 |
| **Max Variation** | 9.2 | 0.9 | 0.35 |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Description | | Pile Number | 2-RST |

## COMPLETE VIEW




PDM Serial Number: PG2024174

Page 3 of 3

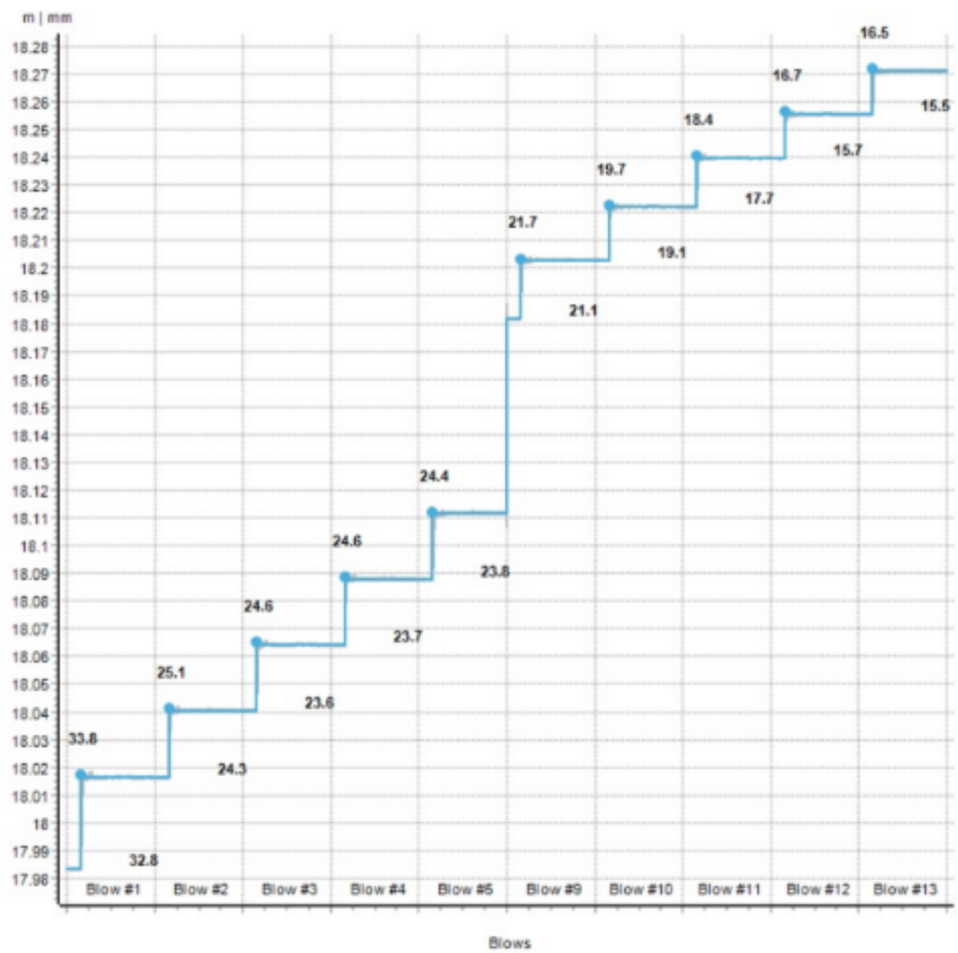
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:40:18 | 16.791 | 27.9 | 0 | 2.903 | 27.9 |
| 2 | 13:40:19 | 16.818 | 26.7 | 0.4 | 3.021 | 27.1 |
| 3 | 13:40:21 | 16.842 | 24.4 | 0.3 | 2.785 | 24.7 |
| 4 | 13:40:22 | 16.87 | 28 | -0.1 | 2.935 | 27.9 |
| 5 | 13:40:24 | 16.899 | 28.9 | -0.1 | 2.964 | 28.8 |
| 6 | 13:40:25 | 16.928 | 28.9 | -0.1 | 2.999 | 28.8 |
| 7 | 13:40:26 | 16.961 | 32.8 | -0.5 | 3.096 | 32.3 |
| 8 | 13:40:28 | 16.994 | 33.6 | -0.5 | 3.267 | 33.1 |
| 9 | 13:40:29 | 17.021 | 27.1 | 0.3 | 3.31 | 27.5 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 4:59:29 PM |
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Test Time | 2:02:45 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 3-EOD | PDM Pile Offset (m) | 8.000 |
| Pile Type | | Final Penetration at Blow 13 (m) | 18.270 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Pile Number | 3-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 21.7 | VMX (m/s) | 2.56 |
| Rebound (mm) | 0.8 | DMX (mm) | 22.6 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 13 | 15.5 | 1.0 | 2.36 | 18.270 |
| 12 | 15.7 | 1.0 | 2.41 | 18.254 |
| 11 | 17.7 | 0.7 | 2.54 | 18.238 |
| 10 | 19.1 | 0.6 | 2.62 | 18.221 |
| 9 | 21.1 | 0.6 | 2.64 | 18.201 |
| 5 | 23.8 | 0.6 | 2.82 | 18.110 |
| 4 | 23.7 | 0.9 | - | 18.086 |
| 3 | 23.6 | 1.0 | - | 18.063 |
| 2 | 24.3 | 0.8 | - | 18.039 |
| 1 | 32.8 | 1.0 | - | 18.015 |
| **Average** | 21.7 | 0.8 | 2.56 | |
| **Max Variation** | 17.3 | 0.4 | 0.46 | |

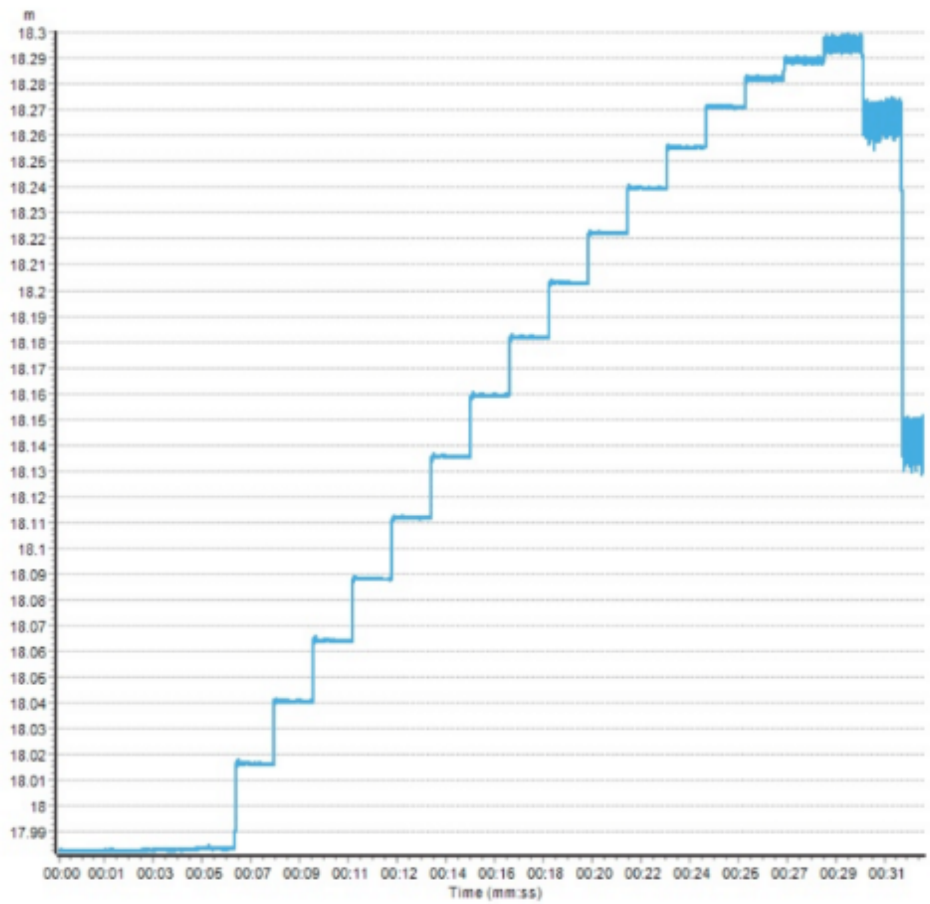
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Description | | Pile Number | 3-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

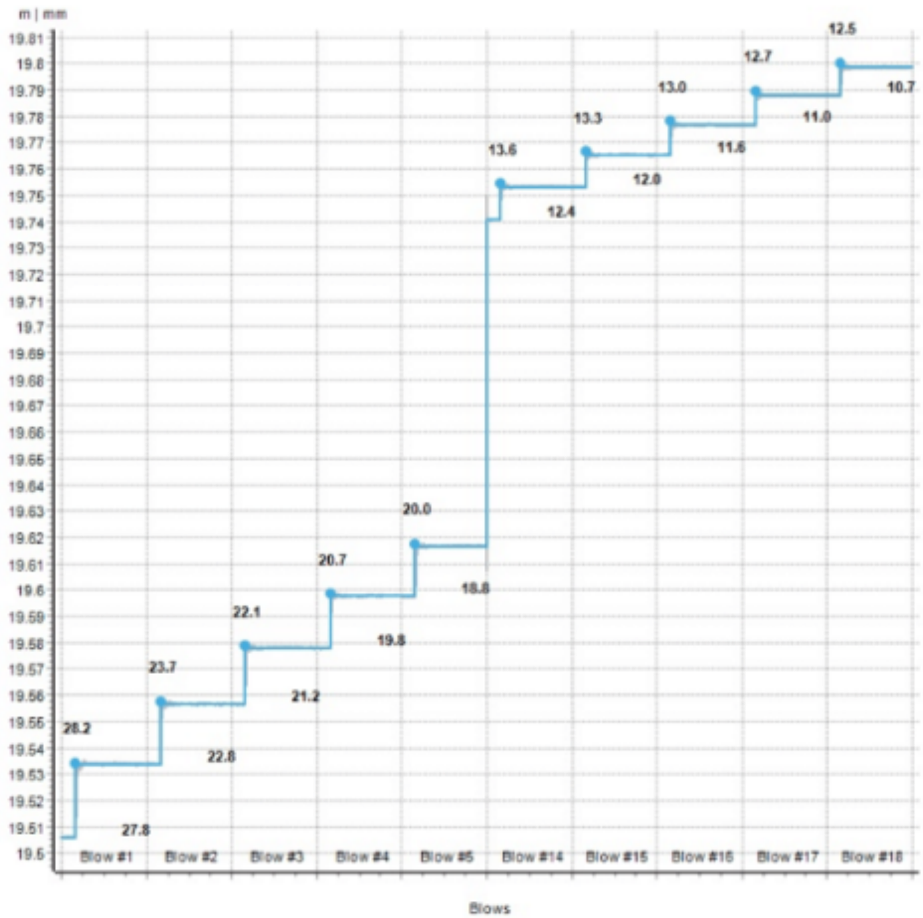
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 14:02:51 | 18.015 | 32.8 | 1 | 3.117 | 33.8 |
| 2 | 14:02:53 | 18.039 | 24.3 | 0.8 | 2.699 | 25.1 |
| 3 | 14:02:54 | 18.063 | 23.6 | 1 | 2.881 | 24.6 |
| 4 | 14:02:56 | 18.086 | 23.7 | 0.9 | 2.764 | 24.6 |
| 5 | 14:02:57 | 18.11 | 23.8 | 0.6 | 2.821 | 24.4 |
| 6 | 14:02:59 | 18.134 | 23.9 | 0.3 | 2.789 | 24.1 |
| 7 | 14:03:00 | 18.158 | 23.8 | 0.2 | 2.742 | 24 |
| 8 | 14:03:02 | 18.18 | 22.5 | 0.3 | 2.681 | 22.8 |
| 9 | 14:03:03 | 18.201 | 21.1 | 0.6 | 2.635 | 21.7 |
| 10 | 14:03:07 | 18.221 | 19.1 | 0.6 | 2.617 | 19.7 |
| 11 | 14:03:07 | 18.238 | 17.7 | 0.7 | 2.539 | 18.4 |
| 12 | 14:03:08 | 18.254 | 15.7 | 1 | 2.407 | 16.7 |
| 13 | 14:03:09 | 18.27 | 15.5 | 1 | 2.357 | 16.5 |
| 14 | 14:03:11 | 18.288 | 18.3 | -6.2 | 2.228 | 12.1 |
| 15 | 14:03:14 | 18.294 | 5.9 | 2.6 | 3.87 | 8.5 |
| 16 | 14:03:15 | 18.265 | -29 | 32.4 | 4.902 | 3.5 |
| 17 | 14:03:16 | 18.265 | -0.2 | 7 | 11.883 | 6.7 |
| 18 | 14:03:17 | 18.14 | -124.5 | 8.4 | 15.036 | -116.1 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:01:17 PM |
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Test Time | 2:27:15 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 4-EOD | PDM Pile Offset (m) | 8.000 |
| Pile Type | | Final Penetration at Blow 18 (m) | 19.799 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Pile Number | 4-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 16.8 | VMX (m/s) | 2.28 |
| Rebound (mm) | 1.1 | DMX (mm) | 18.0 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 18 | 10.7 | 1.8 | 2.16 | 19.799 |
| 17 | 11.0 | 1.7 | 2.15 | 19.788 |
| 16 | 11.6 | 1.4 | 2.26 | 19.777 |
| 15 | 12.0 | 1.3 | 2.25 | 19.765 |
| 14 | 12.4 | 1.2 | 2.25 | 19.753 |
| 5 | 18.8 | 1.2 | 2.62 | 19.616 |
| 4 | 19.8 | 0.8 | - | 19.598 |
| 3 | 21.2 | 0.9 | - | 19.578 |
| 2 | 22.8 | 0.9 | - | 19.557 |
| 1 | 27.8 | 0.4 | - | 19.534 |
| **Average** | 16.8 | 1.1 | 2.28 | |
| **Max Variation** | 17.0 | 1.3 | 0.47 | |

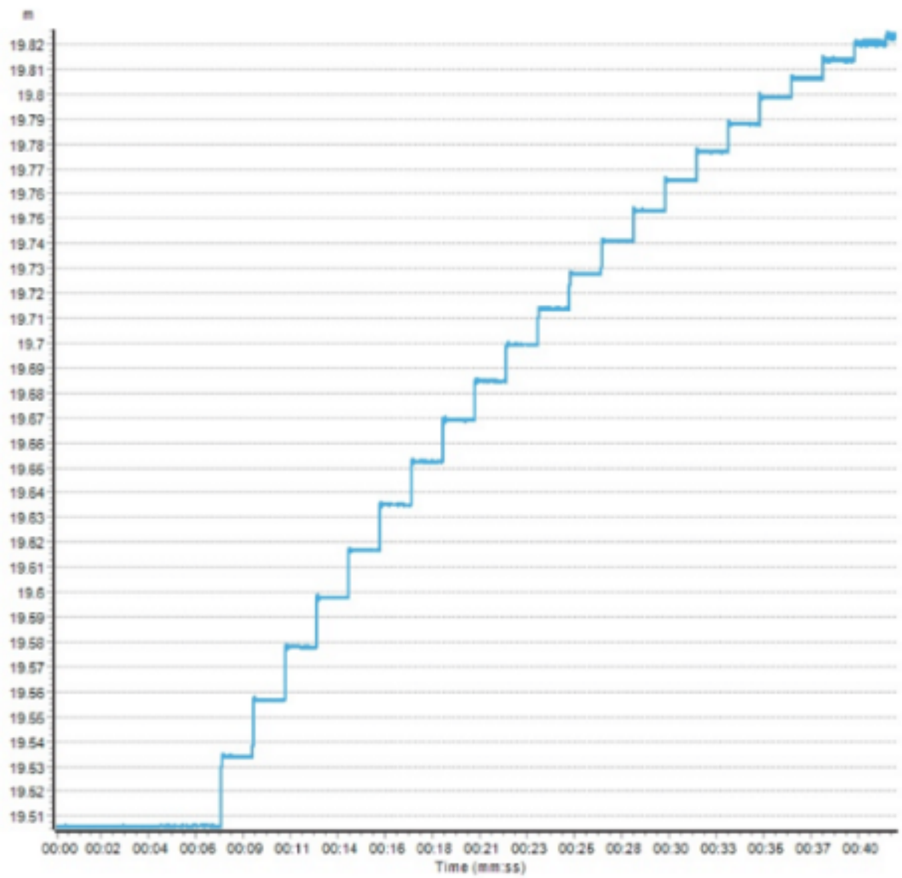
# PILE DRIVING MONITOR

FDOT

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Description | | Pile Number | 4-EOD |

COMPLETE VIEW




PDM Serial Number: PG2024174

Page 3 of 3

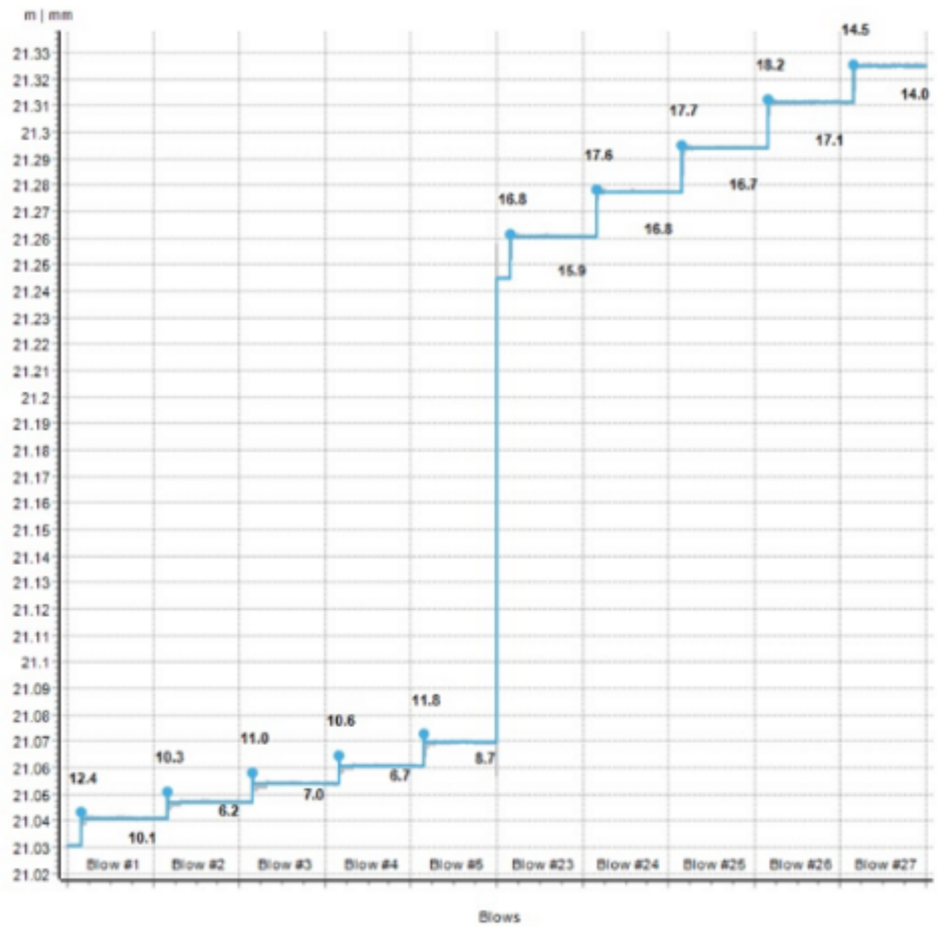
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 14:27:23 | 19.534 | 27.8 | 0.4 | 2.785 | 28.2 |
| 2 | 14:27:24 | 19.557 | 22.8 | 0.9 | 2.839 | 23.7 |
| 3 | 14:27:26 | 19.578 | 21.2 | 0.9 | 2.806 | 22.1 |
| 4 | 14:27:27 | 19.598 | 19.8 | 0.8 | 2.464 | 20.7 |
| 5 | 14:27:29 | 19.616 | 18.8 | 1.2 | 2.624 | 20 |
| 6 | 14:27:30 | 19.635 | 18.5 | 0.8 | 2.457 | 19.3 |
| 7 | 14:27:32 | 19.652 | 17.5 | 0.5 | 2.424 | 18 |
| 8 | 14:27:33 | 19.669 | 16.4 | 0.7 | 2.303 | 17.2 |
| 9 | 14:27:35 | 19.685 | 15.7 | 0.7 | 2.314 | 16.4 |
| 10 | 14:27:37 | 19.699 | 14.6 | 1 | 2.36 | 15.7 |
| 11 | 14:27:38 | 19.714 | 14.5 | 0.8 | 2.424 | 15.2 |
| 12 | 14:27:39 | 19.728 | 14.1 | 0.9 | 2.417 | 15 |
| 13 | 14:27:41 | 19.741 | 12.9 | 0.9 | 2.303 | 13.8 |
| 14 | 14:27:42 | 19.753 | 12.4 | 1.2 | 2.253 | 13.6 |
| 15 | 14:27:44 | 19.765 | 12 | 1.3 | 2.249 | 13.3 |
| 16 | 14:27:45 | 19.777 | 11.6 | 1.4 | 2.264 | 13 |
| 17 | 14:27:47 | 19.788 | 11 | 1.7 | 2.153 | 12.7 |
| 18 | 14:27:48 | 19.799 | 10.7 | 1.8 | 2.157 | 12.5 |
| 19 | 14:27:50 | 19.813 | 14.6 | -5.7 | 2.06 | 8.9 |
| 20 | 14:27:53 | 19.821 | 7.6 | 0.6 | 2.328 | 8.2 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:03:35 PM |
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Test Time | 2:55:53 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 5-EOD | PDM Pile Offset (m) | 8.000 |
| Pile Type | | Final Penetration at Blow 27 (m) | 21.325 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Pile Number | 5-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 11.9 | VMX (m/s) | 2.28 |
| Rebound (mm) | 2.2 | DMX (mm) | 14.1 |

## TABLE VIEW

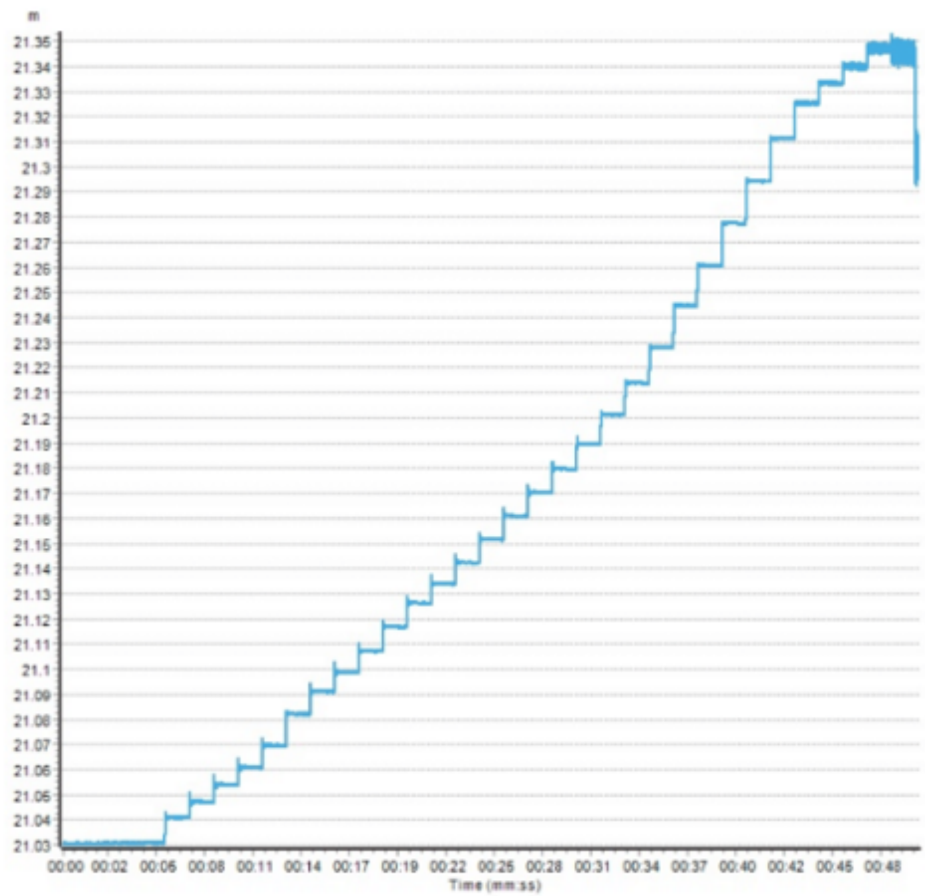
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 27 | 14.0 | 0.5 | 2.25 | 21.325 |
| 26 | 17.1 | 1.1 | 2.27 | 21.311 |
| 25 | 16.7 | 1.0 | 2.31 | 21.293 |
| 24 | 16.8 | 0.8 | 2.47 | 21.277 |
| 23 | 15.9 | 0.9 | 2.40 | 21.260 |
| 5 | 8.7 | 3.1 | 1.99 | 21.069 |
| 4 | 6.7 | 3.8 | - | 21.060 |
| 3 | 7.0 | 4.1 | - | 21.053 |
| 2 | 6.2 | 4.0 | - | 21.046 |
| 1 | 10.1 | 2.3 | - | 21.040 |
| **Average** | 11.9 | 2.2 | 2.28 | |
| **Max Variation** | 10.9 | 3.6 | 0.47 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Description | | Pile Number | 5-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 14:55:59 | 21.04 | 10.1 | 2.3 | 1.939 | 12.4 |
| 2 | 14:56:00 | 21.046 | 6.2 | 4 | 2.089 | 10.3 |
| 3 | 14:56:02 | 21.053 | 7 | 4.1 | 2.078 | 11 |
| 4 | 14:56:03 | 21.06 | 6.7 | 3.8 | 1.992 | 10.6 |
| 5 | 14:56:05 | 21.069 | 8.7 | 3.1 | 1.992 | 11.8 |
| 6 | 14:56:06 | 21.081 | 12.4 | 1 | 1.989 | 13.5 |
| 7 | 14:56:08 | 21.09 | 9.1 | 3.1 | 1.975 | 12.3 |
| 8 | 14:56:09 | 21.098 | 7.6 | 3.9 | 2 | 11.5 |
| 9 | 14:56:10 | 21.106 | 8.4 | 3.4 | 2.007 | 11.8 |
| 10 | 14:56:12 | 21.116 | 9.8 | 2.5 | 2.032 | 12.3 |
| 11 | 14:56:15 | 21.125 | 9.3 | 2.8 | 2.035 | 12 |
| 12 | 14:56:15 | 21.133 | 7.8 | 3.8 | 1.964 | 11.6 |
| 13 | 14:56:16 | 21.142 | 8.4 | 3.2 | 1.9 | 11.6 |
| 14 | 14:56:18 | 21.151 | 9.2 | 2.8 | 1.942 | 12 |
| 15 | 14:56:19 | 21.16 | 9.5 | 3 | 1.971 | 12.5 |
| 16 | 14:56:21 | 21.17 | 9.4 | 2.9 | 1.989 | 12.4 |
| 17 | 14:56:22 | 21.179 | 9.1 | 3 | 1.975 | 12.1 |
| 18 | 14:56:24 | 21.189 | 10 | 2.9 | 2.049 | 13 |
| 19 | 14:56:25 | 21.201 | 11.7 | 1.3 | 2.153 | 13.1 |
| 20 | 14:56:27 | 21.213 | 12.6 | 1.1 | 2.167 | 13.7 |
| 21 | 14:56:28 | 21.227 | 14.1 | 0.9 | 2.142 | 15 |
| 22 | 14:56:30 | 21.244 | 16.8 | 0.9 | 2.332 | 17.7 |
| 23 | 14:56:31 | 21.26 | 15.9 | 0.9 | 2.396 | 16.8 |
| 24 | 14:56:33 | 21.277 | 16.8 | 0.8 | 2.467 | 17.6 |
| 25 | 14:56:35 | 21.293 | 16.7 | 1 | 2.307 | 17.7 |
| 26 | 14:56:35 | 21.311 | 17.1 | 1.1 | 2.267 | 18.2 |
| 27 | 14:56:37 | 21.325 | 14 | 0.5 | 2.253 | 14.5 |
| 28 | 14:56:38 | 21.339 | 14.6 | -5.5 | 2.149 | 9.1 |

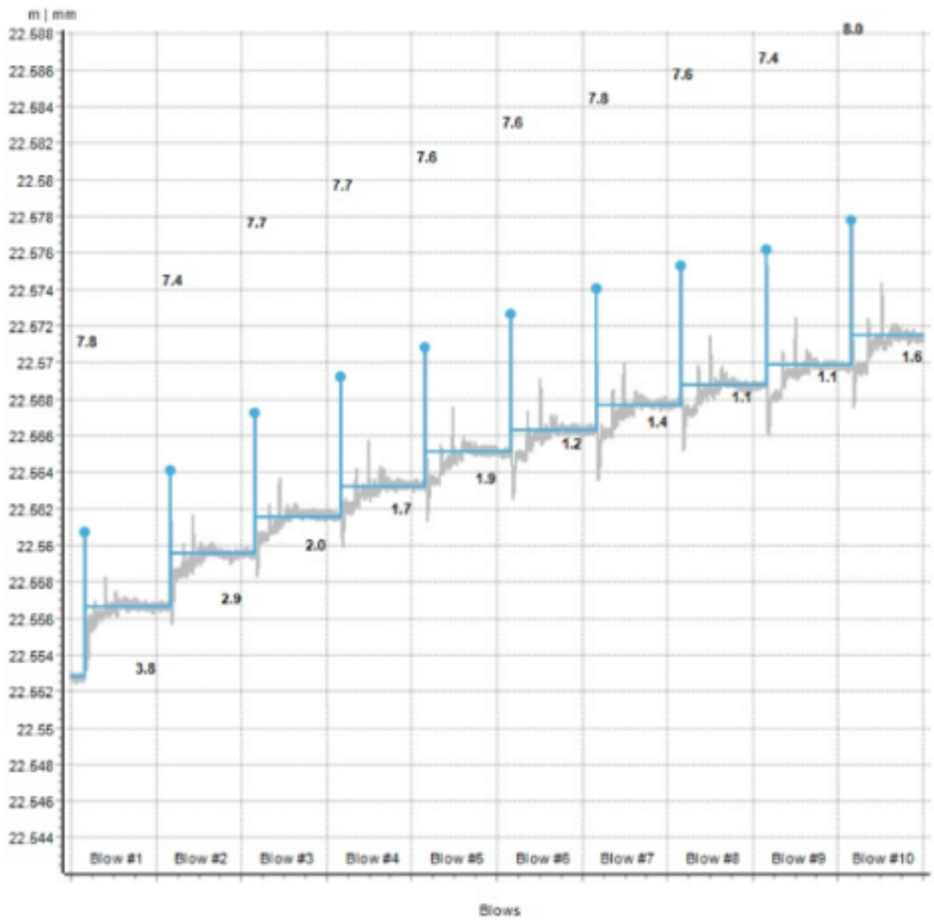
| | | | | | | |
|---|---|---|---|---|---|---|
| 29 | 14:56:41 | 21.347 | 7.6 | 1.5 | 2.721 | 9.1 |
| 30 | 14:56:43 | 21.346 | -1.2 | 6.5 | 4.817 | 5.3 |
| 31 | 14:56:44 | 21.345 | -0.9 | 4 | 6.927 | 3.2 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:06:44 PM |
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Test Time | 3:43:02 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 6-EOD | PDM Pile Offset (m) | 8.000 |
| Pile Type | | Final Penetration at Blow 10 (m) | 22.573 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Area | | Pile Number | 6-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 1.9 | VMX (m/s) | 2.14 |
| Rebound (mm) | 5.8 | DMX (mm) | 7.7 |

## TABLE VIEW

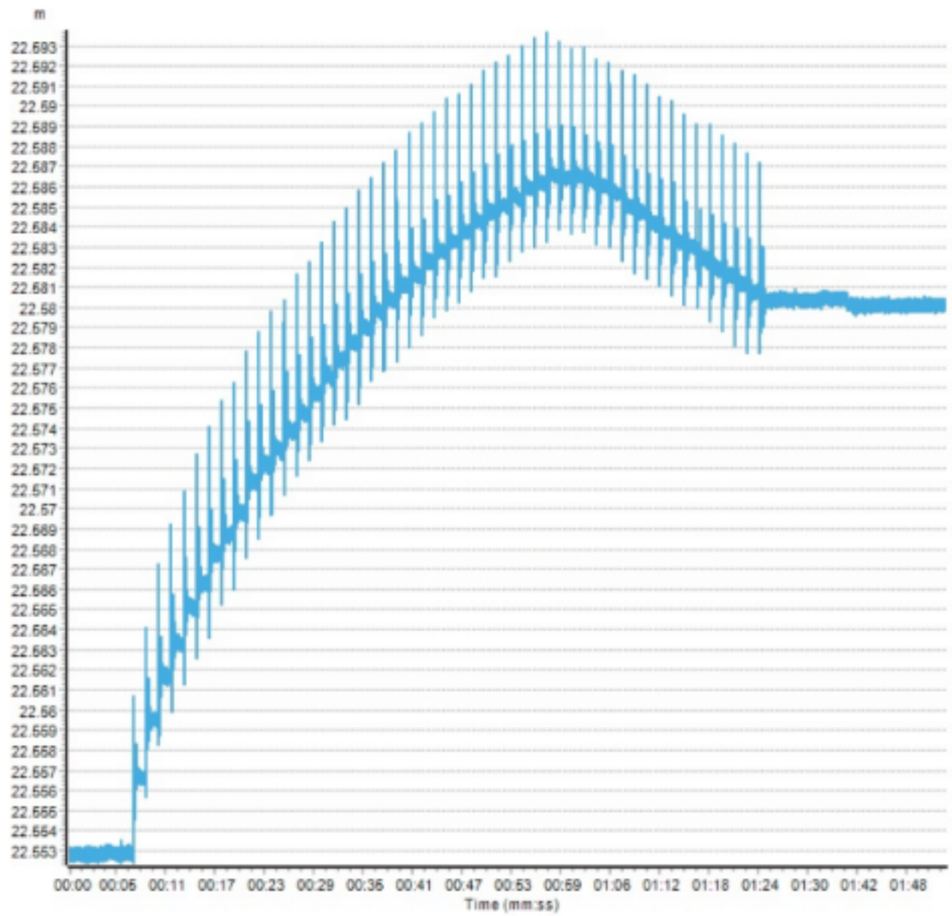
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 10 | 1.6 | 6.3 | 2.10 | 22.573 |
| 9 | 1.1 | 6.4 | 2.19 | 22.571 |
| 8 | 1.1 | 6.5 | 2.14 | 22.570 |
| 7 | 1.4 | 6.3 | 2.12 | 22.569 |
| 6 | 1.2 | 6.4 | 2.19 | 22.567 |
| 5 | 1.9 | 5.7 | 2.13 | 22.566 |
| 4 | 1.7 | 6.0 | - | 22.564 |
| 3 | 2.0 | 5.7 | - | 22.563 |
| 2 | 2.9 | 4.5 | - | 22.561 |
| 1 | 3.8 | 4.0 | - | 22.558 |
| **Average** | 1.9 | 5.8 | 2.14 | |
| **Max Variation** | 2.7 | 2.5 | 0.10 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva | Test Date | 7/5/2019 |
| Project Description | | Pile Number | 6-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 15:43:10 | 22.558 | 3.8 | 4 | 1.917 | 7.8 |
| 2 | 15:43:11 | 22.561 | 2.9 | 4.5 | 2.153 | 7.4 |
| 3 | 15:43:13 | 22.563 | 2 | 5.7 | 1.885 | 7.7 |
| 4 | 15:43:14 | 22.564 | 1.7 | 6 | 2.346 | 7.7 |
| 5 | 15:43:16 | 22.566 | 1.9 | 5.7 | 2.128 | 7.6 |
| 6 | 15:43:17 | 22.567 | 1.2 | 6.4 | 2.189 | 7.6 |
| 7 | 15:43:19 | 22.569 | 1.4 | 6.3 | 2.121 | 7.8 |
| 8 | 15:43:20 | 22.57 | 1.1 | 6.5 | 2.139 | 7.6 |
| 9 | 15:43:24 | 22.571 | 1.1 | 6.4 | 2.192 | 7.4 |
| 10 | 15:43:24 | 22.573 | 1.6 | 6.3 | 2.096 | 8 |
| 11 | 15:43:25 | 22.573 | 0.7 | 6.6 | 2 | 7.3 |
| 12 | 15:43:27 | 22.574 | 0.8 | 6.9 | 1.971 | 7.6 |
| 13 | 15:43:28 | 22.575 | 0.9 | 6.4 | 2.021 | 7.4 |
| 14 | 15:43:30 | 22.576 | 0.8 | 6.9 | 2.082 | 7.7 |
| 15 | 15:43:31 | 22.577 | 1 | 6.5 | 2.039 | 7.6 |
| 16 | 15:43:33 | 22.578 | 0.7 | 6.8 | 2.01 | 7.5 |
| 17 | 15:43:34 | 22.579 | 1 | 6.8 | 2.049 | 7.8 |
| 18 | 15:43:36 | 22.579 | 0.7 | 6.7 | 2.017 | 7.4 |
| 19 | 15:43:37 | 22.58 | 0.8 | 6.8 | 2.071 | 7.6 |
| 20 | 15:43:39 | 22.581 | 0.7 | 6.7 | 1.971 | 7.4 |
| 21 | 15:43:40 | 22.581 | 0.7 | 6.8 | 1.946 | 7.5 |
| 22 | 15:43:42 | 22.582 | 0.8 | 6.7 | 1.935 | 7.5 |
| 23 | 15:43:44 | 22.583 | 0.3 | 7.3 | 1.996 | 7.5 |
| 24 | 15:43:45 | 22.583 | 0.9 | 6.9 | 2.042 | 7.7 |
| 25 | 15:43:46 | 22.584 | 0.5 | 6.9 | 1.935 | 7.4 |
| 26 | 15:43:48 | 22.584 | 0.5 | 7.1 | 1.878 | 7.6 |
| 27 | 15:43:49 | 22.585 | 0.6 | 6.8 | 1.925 | 7.4 |
| 28 | 15:43:51 | 22.585 | 0.5 | 6.8 | 2.074 | 7.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 29 | 15:43:53 | 22.586 | 0.4 | 7.1 | 2.092 | 7.5 |
| 30 | 15:43:54 | 22.586 | 0.4 | 7.1 | 2.003 | 7.5 |
| 31 | 15:43:56 | 22.587 | 0.4 | 7.1 | 2.071 | 7.4 |
| 32 | 15:43:57 | 22.587 | 0.6 | 7 | 2.228 | 7.5 |
| 33 | 15:43:59 | 22.587 | 0.1 | 7.3 | 2.21 | 7.4 |
| 34 | 15:44:00 | 22.588 | 0.4 | 7.2 | 2.035 | 7.6 |
| 35 | 15:44:02 | 22.587 | -0.2 | 6.9 | 1.896 | 6.7 |
| 36 | 15:44:04 | 22.588 | 0.3 | 6.2 | 1.832 | 6.6 |
| 37 | 15:44:05 | 22.587 | -0.4 | 6.8 | 1.832 | 6.3 |
| 38 | 15:44:06 | 22.587 | -0.3 | 6.5 | 1.732 | 6.1 |
| 39 | 15:44:08 | 22.587 | -0.3 | 6.6 | 1.735 | 6.3 |
| 40 | 15:44:09 | 22.586 | -0.5 | 6.7 | 1.696 | 6.2 |
| 41 | 15:44:11 | 22.586 | -0.5 | 6.9 | 1.721 | 6.4 |
| 42 | 15:44:13 | 22.585 | -0.6 | 7 | 1.803 | 6.4 |
| 43 | 15:44:14 | 22.585 | -0.3 | 6.7 | 1.789 | 6.4 |
| 44 | 15:44:16 | 22.584 | -0.5 | 6.9 | 1.742 | 6.4 |
| 45 | 15:44:17 | 22.584 | -0.4 | 6.7 | 1.685 | 6.3 |
| 46 | 15:44:19 | 22.584 | -0.5 | 6.7 | 1.675 | 6.1 |
| 47 | 15:44:20 | 22.583 | -0.5 | 7.1 | 1.689 | 6.7 |
| 48 | 15:44:22 | 22.583 | -0.3 | 6.9 | 1.707 | 6.6 |
| 49 | 15:44:24 | 22.582 | -0.5 | 7 | 1.696 | 6.4 |
| 50 | 15:44:25 | 22.582 | -0.3 | 6.8 | 1.703 | 6.5 |
| 51 | 15:44:26 | 22.582 | -0.4 | 6.8 | 1.621 | 6.3 |

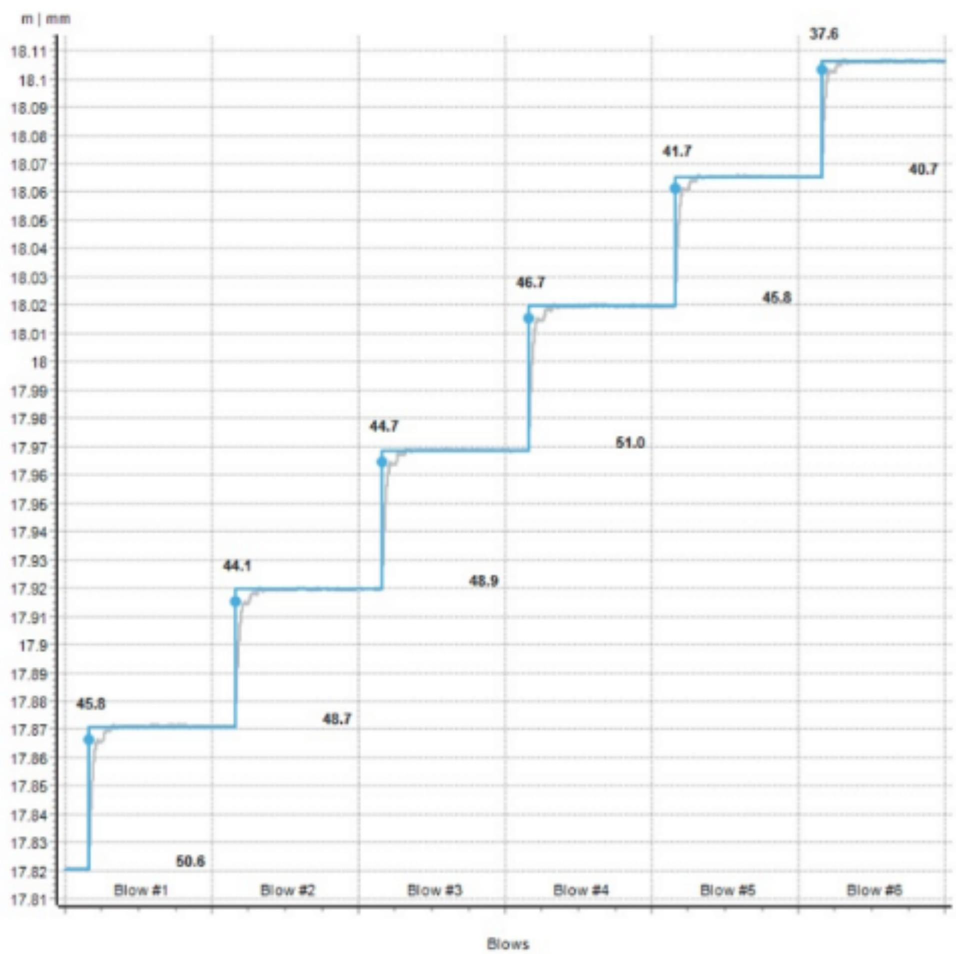
### A.5.2.2 Day 2, 5/8/2019, WLC 3

## PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:07:54 PM |
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Test Time | 11:07:24 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 1-EOD | PDM Pile Offset (m) | 8.510 |
| Pile Type | | Final Penetration at Blow 6 (m) | 18.106 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Pile Number | 1-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 47.6 | VMX (m/s) | 2.98 |
| Rebound (mm) | -4.1 | DMX (mm) | 43.5 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 6 | 40.7 | -3.0 | 3.00 | 18.106 |
| 5 | 45.8 | -4.1 | 2.96 | 18.065 |
| 4 | 51.0 | -4.3 | - | 18.019 |
| 3 | 48.9 | -4.2 | - | 17.968 |
| 2 | 48.7 | -4.5 | - | 17.919 |
| 1 | 50.6 | -4.7 | - | 17.871 |

| | | | | |
|---|---|---|---|---|
| **Average** | 47.6 | -4.1 | 2.98 | |
| **Max Variation** | 10.4 | 1.7 | 0.04 | |

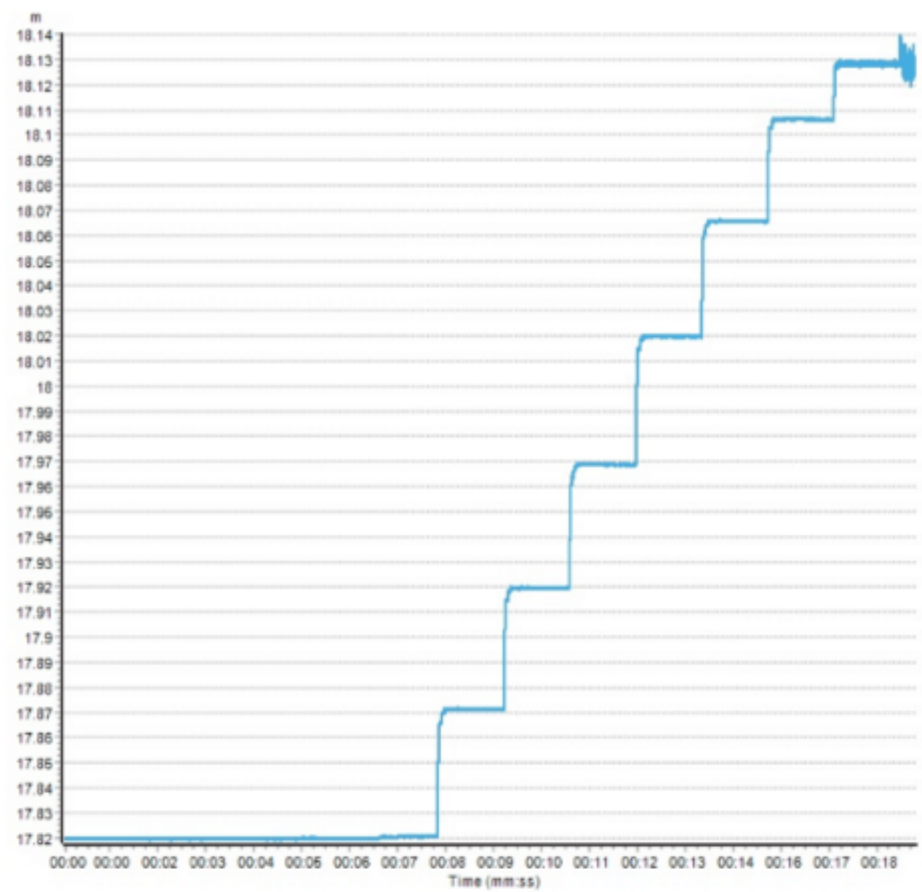
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Description | | Pile Number | 1-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

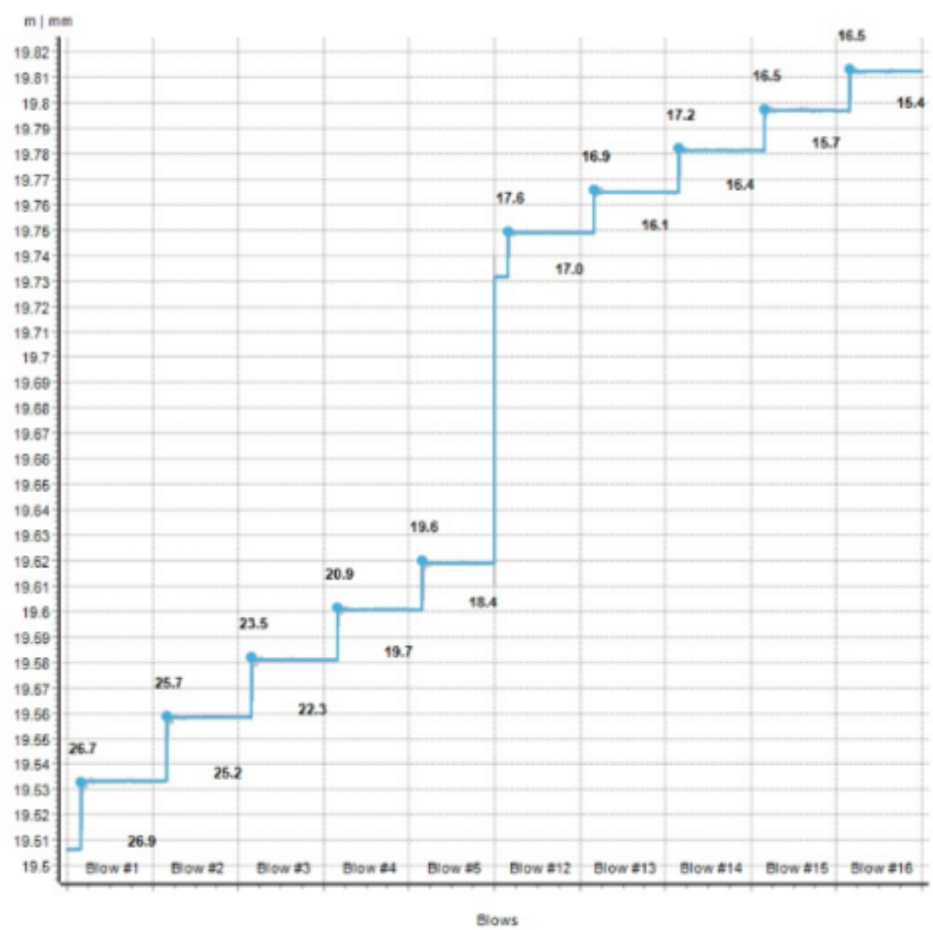
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 11:07:32 | 17.871 | 50.6 | -4.7 | 2.972 | 45.8 |
| 2 | 11:07:34 | 17.919 | 48.7 | -4.5 | 2.824 | 44.1 |
| 3 | 11:07:35 | 17.968 | 48.9 | -4.2 | 2.881 | 44.7 |
| 4 | 11:07:37 | 18.019 | 51 | -4.3 | 2.926 | 46.7 |
| 5 | 11:07:38 | 18.065 | 45.8 | -4.1 | 2.96 | 41.7 |
| 6 | 11:07:40 | 18.106 | 40.7 | -3 | 3.002 | 37.6 |
| 7 | 11:07:41 | 18.132 | 26.2 | -3.7 | 2.915 | 22.5 |
| 8 | 11:07:43 | 18.128 | -4.4 | 6.1 | 6.919 | 1.7 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:10:00 PM |
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Test Time | 11:30:02 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 2-EOD | PDM Pile Offset (m) | 8.510 |
| Pile Type | | Final Penetration at Blow 16 (m) | 19.812 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Pile Number | 2-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 19.3 | VMX (m/s) | 2.49 |
| Rebound (mm) | 0.8 | DMX (mm) | 20.1 |

## TABLE VIEW

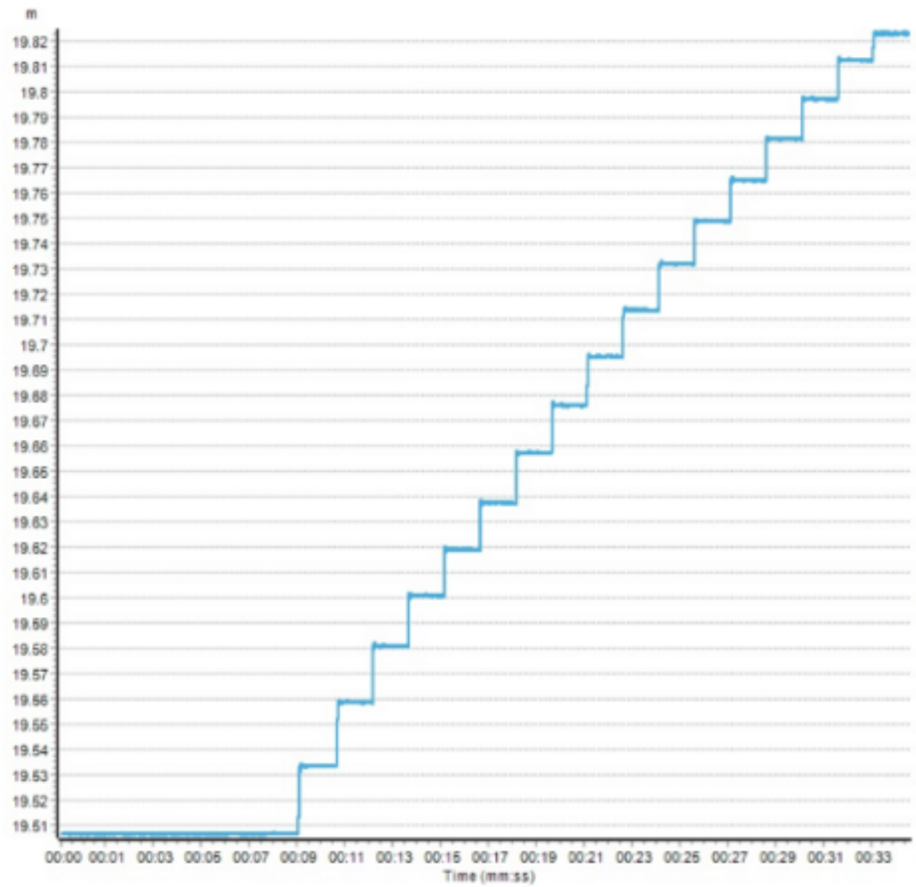
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 16 | 15.4 | 1.1 | 2.49 | 19.812 |
| 15 | 15.7 | 0.8 | 2.45 | 19.796 |
| 14 | 16.4 | 0.8 | 2.36 | 19.781 |
| 13 | 16.1 | 0.8 | 2.43 | 19.764 |
| 12 | 17.0 | 0.7 | 2.43 | 19.748 |
| 5 | 18.4 | 1.2 | 2.79 | 19.618 |
| 4 | 19.7 | 1.2 | - | 19.600 |
| 3 | 22.3 | 1.2 | - | 19.580 |
| 2 | 25.2 | 0.5 | - | 19.558 |
| 1 | 26.9 | -0.1 | - | 19.533 |
| **Average** | 19.3 | 0.8 | 2.49 | |
| **Max Variation** | 11.5 | 1.4 | 0.42 | |

# PILE DRIVING MONITOR

PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Description | | Pile Number | 2-EOD |

COMPLETE VIEW




PDM Serial Number: PG2024174

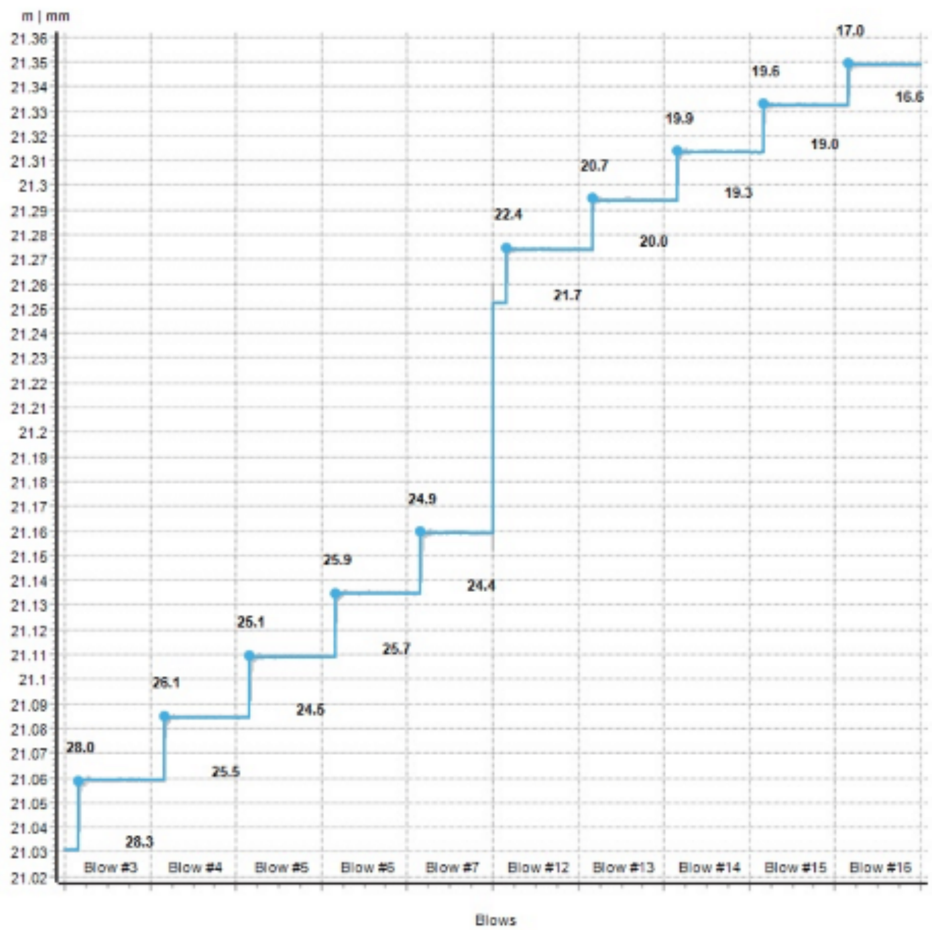
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 11:30:11 | 19.533 | 26.9 | -0.1 | 2.733 | 26.7 |
| 2 | 11:30:13 | 19.558 | 25.2 | 0.5 | 2.71 | 25.7 |
| 3 | 11:30:14 | 19.58 | 22.3 | 1.2 | 2.71 | 23.5 |
| 4 | 11:30:16 | 19.6 | 19.7 | 1.2 | 3.029 | 20.9 |
| 5 | 11:30:17 | 19.618 | 18.4 | 1.2 | 2.786 | 19.6 |
| 6 | 11:30:19 | 19.637 | 18.5 | 0.8 | 2.695 | 19.3 |
| 7 | 11:30:20 | 19.657 | 19.9 | 0.6 | 2.558 | 20.5 |
| 8 | 11:30:24 | 19.675 | 18.6 | 1.5 | 2.452 | 20.1 |
| 9 | 11:30:24 | 19.695 | 19.2 | 0.8 | 2.509 | 20 |
| 10 | 11:30:25 | 19.713 | 18.5 | 0.8 | 2.463 | 19.3 |
| 11 | 11:30:26 | 19.731 | 18.1 | 0.6 | 2.52 | 18.7 |
| 12 | 11:30:28 | 19.748 | 17 | 0.7 | 2.425 | 17.6 |
| 13 | 11:30:29 | 19.764 | 16.1 | 0.8 | 2.425 | 16.9 |
| 14 | 11:30:31 | 19.781 | 16.4 | 0.8 | 2.364 | 17.2 |
| 15 | 11:30:32 | 19.796 | 15.7 | 0.8 | 2.452 | 16.5 |
| 16 | 11:30:34 | 19.812 | 15.4 | 1.1 | 2.49 | 16.5 |
| 17 | 11:30:35 | 19.822 | 10.5 | 0.8 | 2.49 | 11.3 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:11:47 PM |
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Test Time | 11:57:20 AM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 3-EOD | PDM Pile Offset (m) | 6.510 |
| Pile Type | | Final Penetration at Blow 16 (m) | 21.349 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Pile Number | 3-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 22.5 | VMX (m/s) | 2.52 |
| Rebound (mm) | 0.5 | DMX (mm) | 23.0 |

## TABLE VIEW

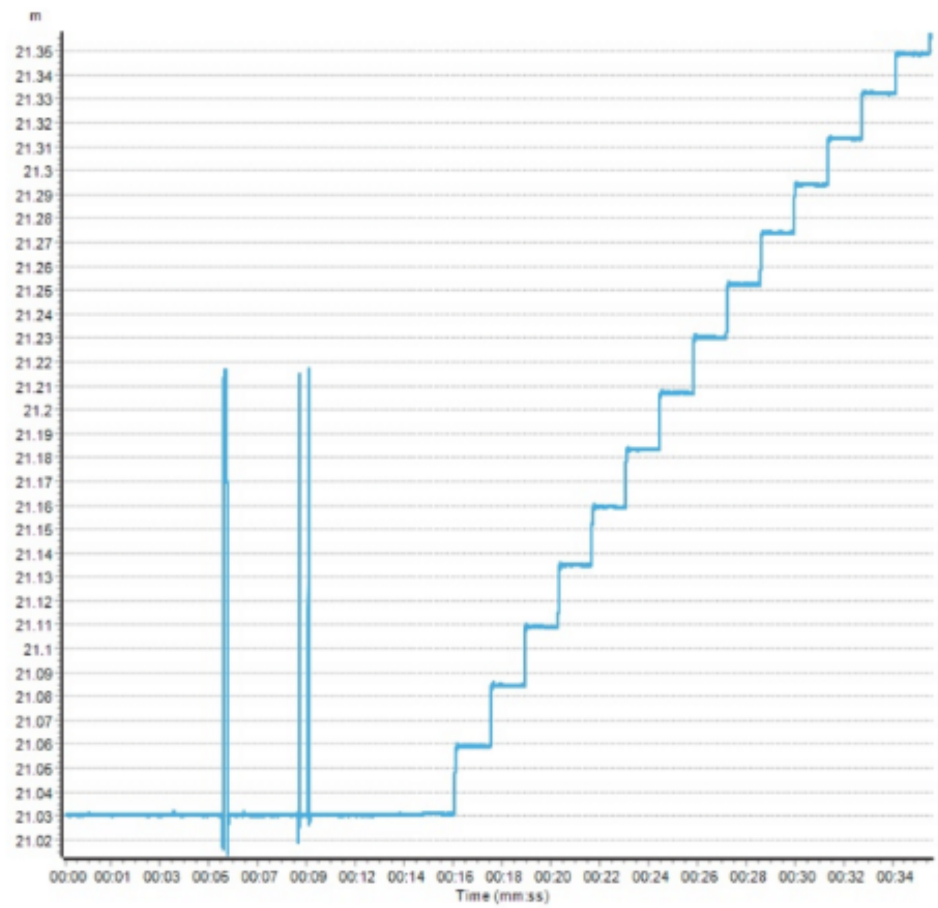
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 16 | 16.6 | 0.4 | 2.49 | 21.349 |
| 15 | 19.0 | 0.6 | 2.36 | 21.332 |
| 14 | 19.3 | 0.6 | 2.33 | 21.313 |
| 13 | 20.0 | 0.7 | 2.51 | 21.294 |
| 12 | 21.7 | 0.7 | 2.71 | 21.274 |
| 7 | 24.4 | 0.5 | 2.60 | 21.159 |
| 6 | 25.7 | 0.2 | 2.55 | 21.134 |
| 5 | 24.5 | 0.7 | 2.61 | 21.109 |
| 4 | 25.5 | 0.6 | - | 21.084 |
| 3 | 28.3 | -0.3 | - | 21.059 |
| **Average** | 22.5 | 0.5 | 2.52 | |
| **Max Variation** | 11.7 | 1.0 | 0.38 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Description | | Pile Number | 3-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

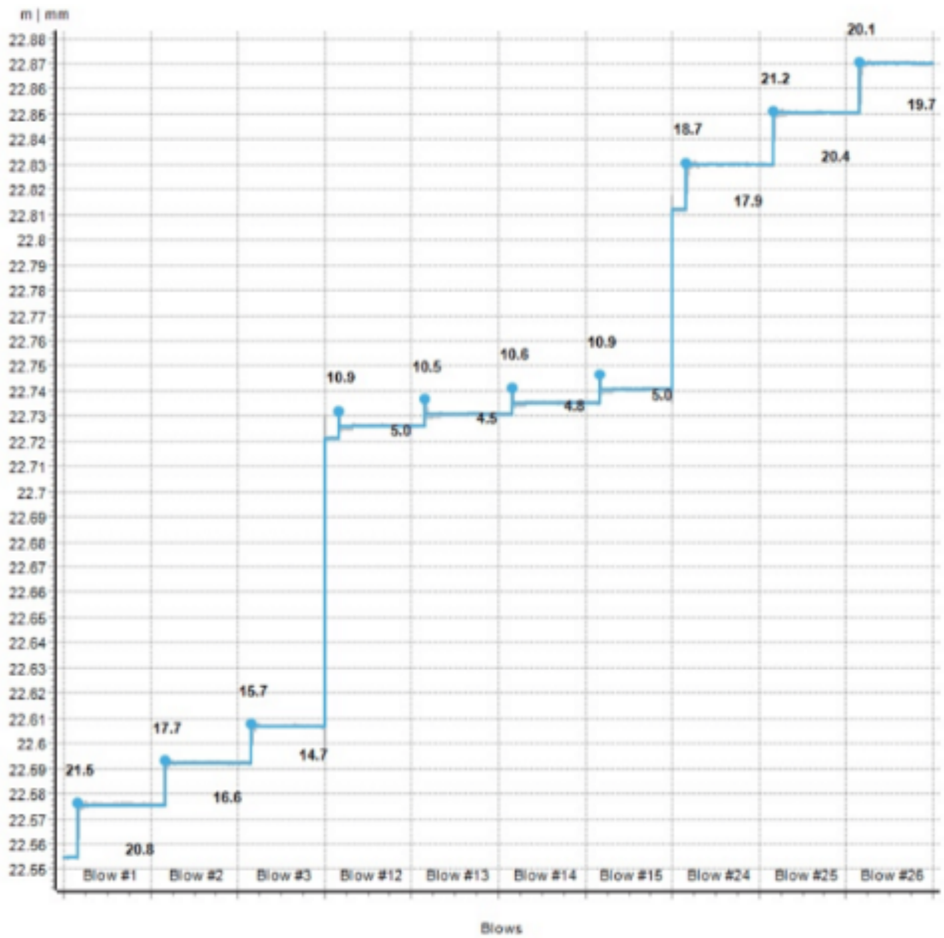
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 11:57:26 | 21.03 | 0 | 186.3 | 72.561 | 186.3 |
| 2 | 11:57:30 | 21.031 | 0.6 | 184.2 | 78.413 | 184.7 |
| 3 | 11:57:36 | 21.059 | 28.3 | -0.3 | 2.744 | 28 |
| 4 | 11:57:38 | 21.084 | 25.5 | 0.6 | 2.596 | 26.1 |
| 5 | 11:57:39 | 21.109 | 24.5 | 0.7 | 2.615 | 25.1 |
| 6 | 11:57:42 | 21.134 | 25.7 | 0.2 | 2.554 | 25.9 |
| 7 | 11:57:43 | 21.159 | 24.4 | 0.5 | 2.604 | 24.9 |
| 8 | 11:57:43 | 21.183 | 24.4 | 0.2 | 2.683 | 24.5 |
| 9 | 11:57:45 | 21.207 | 23.5 | 0.6 | 2.66 | 24.1 |
| 10 | 11:57:46 | 21.23 | 23.3 | 0.4 | 2.717 | 23.7 |
| 11 | 11:57:48 | 21.252 | 22.1 | 0.6 | 2.748 | 22.7 |
| 12 | 11:57:49 | 21.274 | 21.7 | 0.7 | 2.706 | 22.4 |
| 13 | 11:57:51 | 21.294 | 20 | 0.7 | 2.509 | 20.7 |
| 14 | 11:57:52 | 21.313 | 19.3 | 0.6 | 2.33 | 19.9 |
| 15 | 11:57:53 | 21.332 | 19 | 0.6 | 2.364 | 19.6 |
| 16 | 11:57:55 | 21.349 | 16.6 | 0.4 | 2.493 | 17 |
| 17 | 11:57:56 | 21.348 | -0.2 | -21331.6 | 2.493 | -21331.8 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:14:11 PM |
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Test Time | 12:30:16 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 4-EOD | PDM Pile Offset (m) | 8.510 |
| Pile Type | | Final Penetration at Blow 26 (m) | 22.869 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Pile Number | 4-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 13.0 | VMX (m/s) | 2.25 |
| Rebound (mm) | 2.8 | DMX (mm) | 15.8 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 26 | 19.7 | 0.4 | 2.49 | 22.869 |
| 25 | 20.4 | 0.7 | 2.50 | 22.850 |
| 24 | 17.9 | 0.8 | 2.41 | 22.829 |
| 15 | 5.0 | 5.8 | 2.04 | 22.740 |
| 14 | 4.8 | 5.9 | 2.16 | 22.735 |
| 13 | 4.5 | 5.9 | 2.06 | 22.730 |
| 12 | 5.0 | 5.9 | 2.07 | 22.725 |
| 3 | 14.7 | 1.0 | - | 22.606 |
| 2 | 16.6 | 1.0 | - | 22.591 |
| 1 | 20.8 | 0.7 | - | 22.575 |
| **Average** | 13.0 | 2.8 | 2.25 | |
| **Max Variation** | 16.2 | 5.6 | 0.46 | |

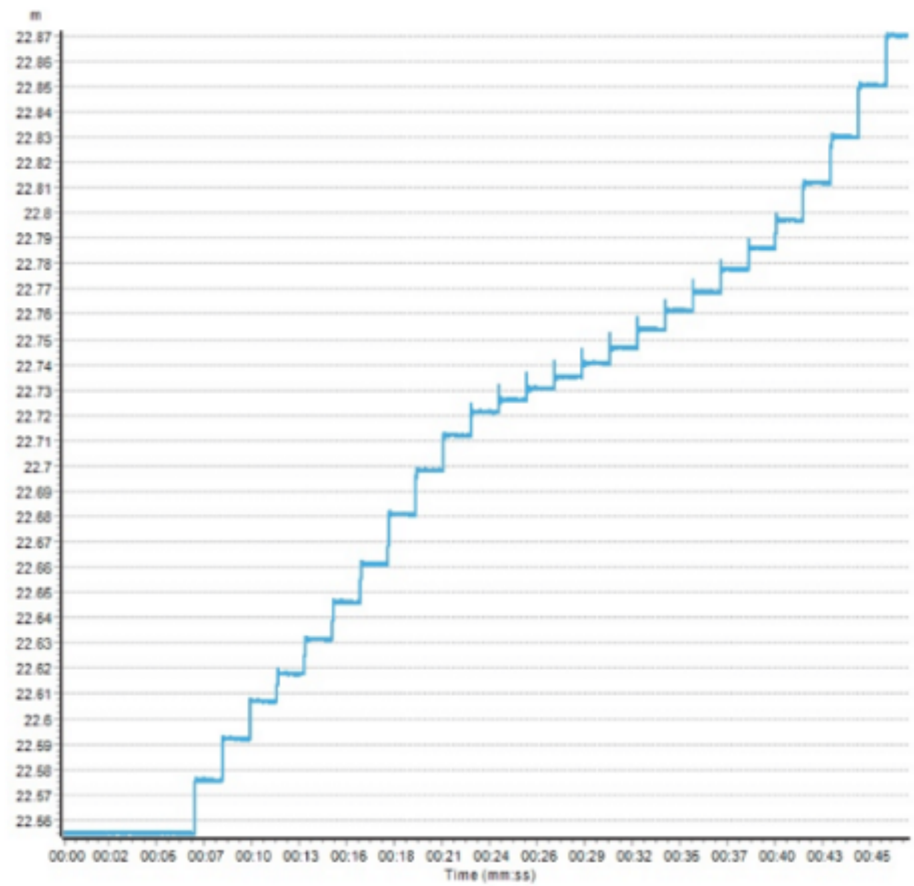
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Description | | Pile Number | 4-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

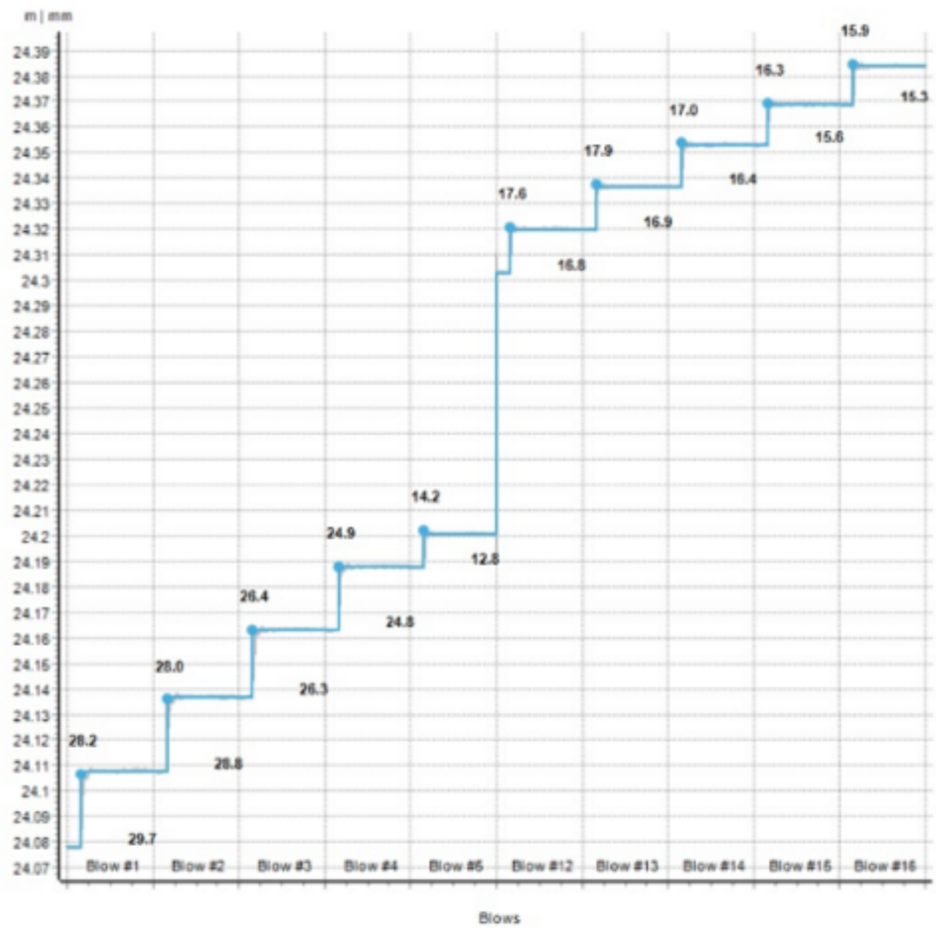
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 12:30:23 | 22.575 | 20.8 | 0.7 | 2.755 | 21.5 |
| 2 | 12:30:25 | 22.591 | 16.6 | 1 | 2.414 | 17.7 |
| 3 | 12:30:26 | 22.606 | 14.7 | 1 | 2.129 | 15.7 |
| 4 | 12:30:28 | 22.617 | 11 | 2.1 | 2.084 | 13 |
| 5 | 12:30:29 | 22.631 | 13.8 | 0.9 | 2.175 | 14.6 |
| 6 | 12:30:31 | 22.645 | 14.3 | 1.2 | 2.315 | 15.4 |
| 7 | 12:30:33 | 22.661 | 15.4 | 1 | 2.463 | 16.4 |
| 8 | 12:30:34 | 22.68 | 19.3 | 0.9 | 2.592 | 20.2 |
| 9 | 12:30:36 | 22.698 | 17.7 | 0.7 | 2.588 | 18.4 |
| 10 | 12:30:38 | 22.711 | 13.9 | 0.9 | 2.395 | 14.8 |
| 11 | 12:30:39 | 22.72 | 8.9 | 3.5 | 2.141 | 12.4 |
| 12 | 12:30:40 | 22.725 | 5 | 5.9 | 2.068 | 10.9 |
| 13 | 12:30:42 | 22.73 | 4.5 | 5.9 | 2.065 | 10.5 |
| 14 | 12:30:44 | 22.735 | 4.8 | 5.9 | 2.163 | 10.6 |
| 15 | 12:30:45 | 22.74 | 5 | 5.8 | 2.042 | 10.9 |
| 16 | 12:30:47 | 22.746 | 6.2 | 5.7 | 2.167 | 11.8 |
| 17 | 12:30:48 | 22.753 | 7.2 | 4.9 | 2.106 | 12.1 |
| 18 | 12:30:50 | 22.761 | 7.5 | 4.4 | 2.076 | 12 |
| 19 | 12:30:52 | 22.768 | 7.2 | 4.8 | 2.042 | 12.1 |
| 20 | 12:30:53 | 22.777 | 9.1 | 3.9 | 2.19 | 13 |
| 21 | 12:30:55 | 22.785 | 8.4 | 3.5 | 2.213 | 11.9 |
| 22 | 12:30:58 | 22.796 | 11 | 2.5 | 2.216 | 13.5 |
| 23 | 12:30:58 | 22.811 | 15 | 0.8 | 2.209 | 15.8 |
| 24 | 12:30:59 | 22.829 | 17.9 | 0.8 | 2.406 | 18.7 |
| 25 | 12:31:01 | 22.85 | 20.4 | 0.7 | 2.501 | 21.2 |
| 26 | 12:31:03 | 22.869 | 19.7 | 0.4 | 2.486 | 20.1 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:15:27 PM |
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Test Time | 1:08:15 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 5-EOD | PDM Pile Offset (m) | 8.510 |
| Pile Type | | Final Penetration at Blow 16 (m) | 24.384 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Pile Number | 5-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 20.3 | VMX (m/s) | 2.46 |
| Rebound (mm) | 0.3 | DMX (mm) | 20.6 |

## TABLE VIEW

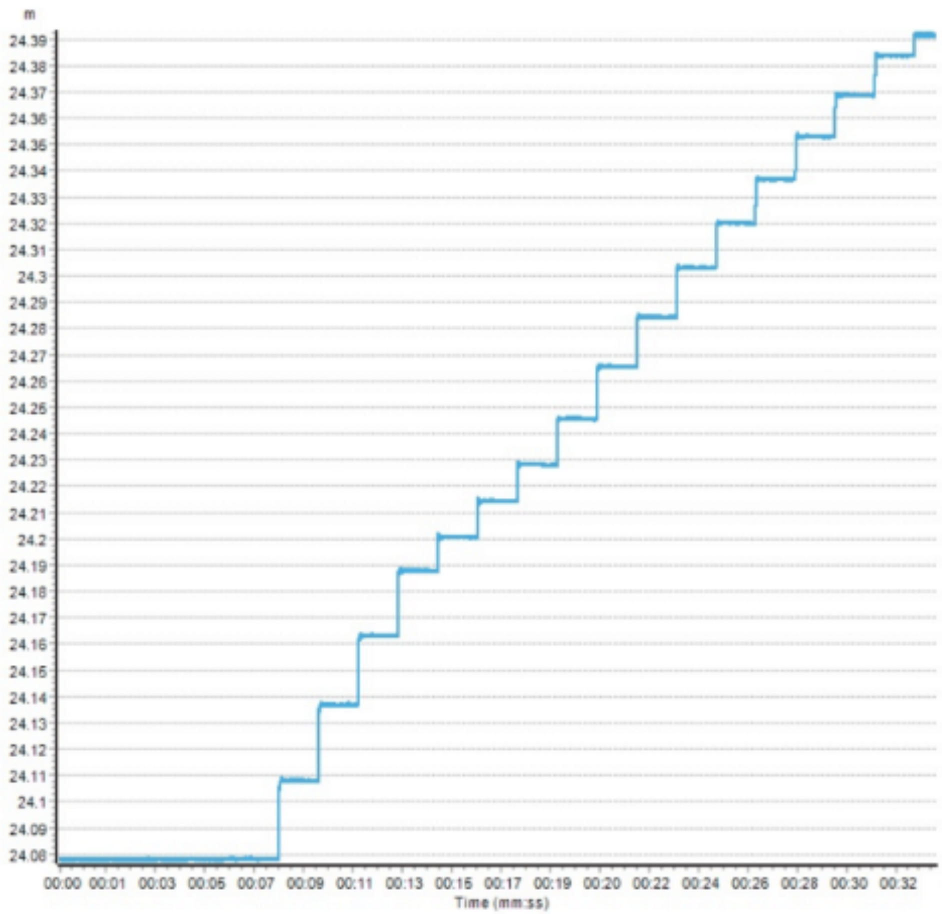
| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 16 | 15.3 | 0.6 | 2.35 | 24.384 |
| 15 | 15.6 | 0.7 | 2.41 | 24.368 |
| 14 | 16.4 | 0.6 | 2.47 | 24.353 |
| 13 | 16.9 | 1.0 | 2.50 | 24.337 |
| 12 | 16.8 | 0.8 | 2.50 | 24.320 |
| 5 | 12.8 | 1.4 | 2.51 | 24.200 |
| 4 | 24.8 | 0.1 | - | 24.188 |
| 3 | 26.3 | 0.0 | - | 24.163 |
| 2 | 28.8 | -0.7 | - | 24.136 |
| 1 | 29.7 | -1.5 | - | 24.108 |
| **Average** | 20.3 | 0.3 | 2.46 | |
| **Max Variation** | 16.9 | 2.9 | 0.16 | |

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Description | | Pile Number | 5-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

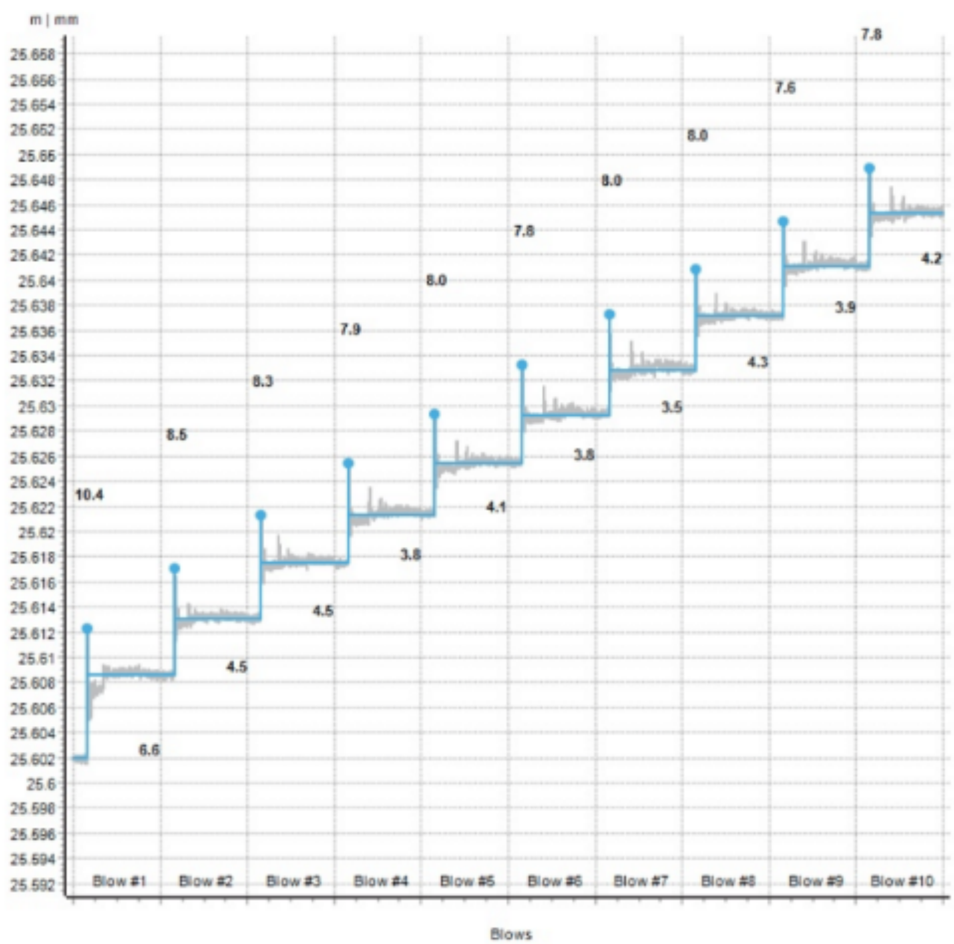
| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:08:23 | 24.108 | 29.7 | -1.5 | 2.607 | 28.2 |
| 2 | 13:08:25 | 24.136 | 28.8 | -0.7 | 2.903 | 28 |
| 3 | 13:08:26 | 24.163 | 26.3 | 0 | 2.676 | 26.4 |
| 4 | 13:08:28 | 24.188 | 24.8 | 0.1 | 2.425 | 24.9 |
| 5 | 13:08:29 | 24.2 | 12.8 | 1.4 | 2.509 | 14.2 |
| 6 | 13:08:31 | 24.214 | 13.8 | 1.1 | 2.33 | 14.9 |
| 7 | 13:08:33 | 24.228 | 13.7 | 1.3 | 2.361 | 15 |
| 8 | 13:08:34 | 24.245 | 17.4 | 0.9 | 2.349 | 18.3 |
| 9 | 13:08:37 | 24.265 | 19.9 | 0.6 | 2.44 | 20.4 |
| 10 | 13:08:37 | 24.284 | 19.1 | 0.7 | 2.418 | 19.9 |
| 11 | 13:08:39 | 24.303 | 18.5 | 0.8 | 2.437 | 19.3 |
| 12 | 13:08:40 | 24.32 | 16.8 | 0.8 | 2.505 | 17.6 |
| 13 | 13:08:42 | 24.337 | 16.9 | 1 | 2.505 | 17.9 |
| 14 | 13:08:43 | 24.353 | 16.4 | 0.6 | 2.471 | 17 |
| 15 | 13:08:45 | 24.368 | 15.6 | 0.7 | 2.414 | 16.3 |
| 16 | 13:08:47 | 24.384 | 15.3 | 0.6 | 2.353 | 15.9 |
| 17 | 13:08:48 | 24.391 | 7.6 | 0.8 | 2.353 | 8.4 |

# PILE DRIVING MONITOR

PDM REPORT Stable Reference Monitoring

| | | | |
|---|---|---|---|
| Company Name | | Report Date | 13/5/2019 |
| Client Name | | Report Time | 5:18:02 PM |
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Test Time | 1:41:37 PM |
| Supervisor | | Superintendent | |

| | | | |
|---|---|---|---|
| Pile Number | 6-EOD | PDM Pile Offset (m) | 8.510 |
| Pile Type | | Final Penetration at Blow 10 (m) | 25.645 |
| Hammer | | Stroke (m) | 1.000 |




Page 1 of 3

# PILE DRIVING MONITOR

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Area | | Pile Number | 6-EOD |

## NUMERICAL DATA

| | | | |
|---|---|---|---|
| Set (mm) | 4.3 | VMX (m/s) | 2.10 |
| Rebound (mm) | 3.9 | DMX (mm) | 8.2 |

## TABLE VIEW

| Blow | Set (mm) | Rebound (mm) | VMX (m/s) | Penetration (m) |
|---|---|---|---|---|
| 10 | 4.2 | 3.6 | 2.00 | 25.645 |
| 9 | 3.9 | 3.6 | 2.02 | 25.641 |
| 8 | 4.3 | 3.7 | 2.13 | 25.637 |
| 7 | 3.5 | 4.5 | 2.18 | 25.633 |
| 6 | 3.8 | 4.0 | 2.12 | 25.629 |
| 5 | 4.1 | 3.9 | 2.14 | 25.625 |
| 4 | 3.8 | 4.1 | - | 25.621 |
| 3 | 4.5 | 3.8 | - | 25.618 |
| 2 | 4.5 | 4.0 | - | 25.613 |
| 1 | 6.6 | 3.8 | - | 25.609 |
| **Average** | 4.3 | 3.9 | 2.10 | |
| **Max Variation** | 3.1 | 0.9 | 0.18 | |

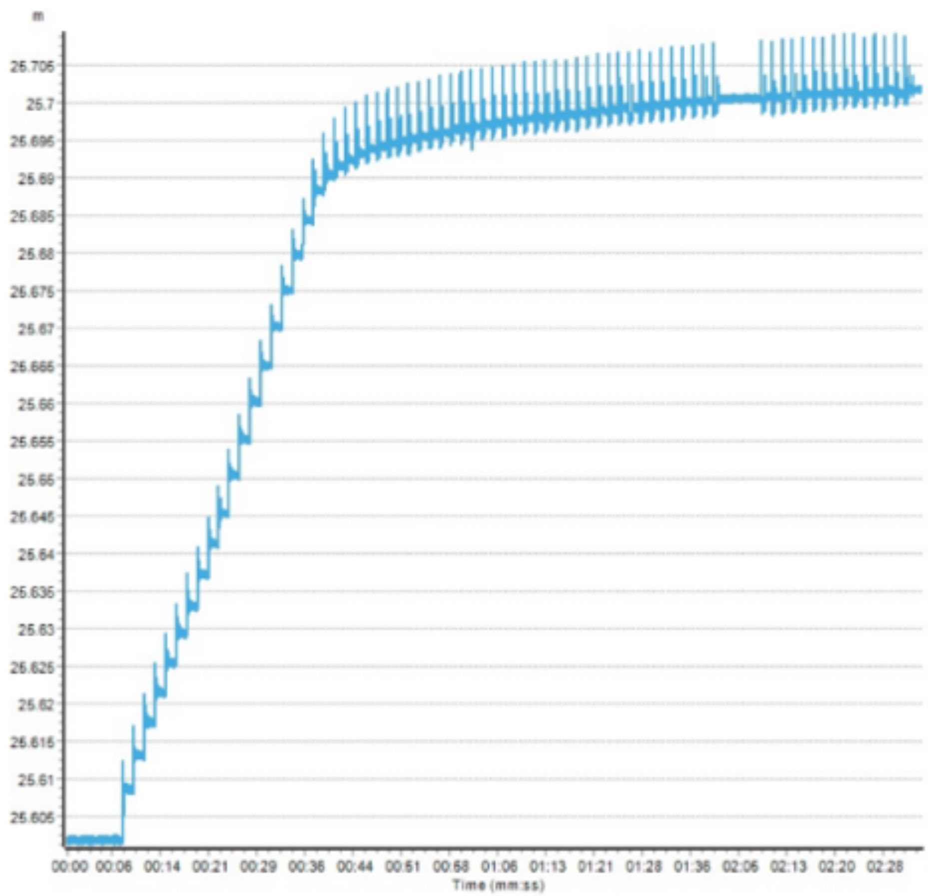
# PILE DRIVING MONITOR

FDOT

## PDM REPORT

| | | | |
|---|---|---|---|
| Project Name | Wekiva 2 | Test Date | 8/5/2019 |
| Project Description | | Pile Number | 6-EOD |

## COMPLETE VIEW




PDM Serial Number: PG2024174

| Blow | StartTime | Penetration (m) | Set (mm) | Rebound (mm) | Velocity (m/s) | DMX (mm) |
|---|---|---|---|---|---|---|
| 1 | 13:41:46 | 25.609 | 6.6 | 3.8 | 1.867 | 10.4 |
| 2 | 13:41:47 | 25.613 | 4.5 | 4 | 2.038 | 8.5 |
| 3 | 13:41:49 | 25.618 | 4.5 | 3.8 | 2.254 | 8.3 |
| 4 | 13:41:51 | 25.621 | 3.8 | 4.1 | 1.97 | 7.9 |
| 5 | 13:41:52 | 25.625 | 4.1 | 3.9 | 2.144 | 8 |
| 6 | 13:41:54 | 25.629 | 3.8 | 4 | 2.118 | 7.8 |
| 7 | 13:41:56 | 25.633 | 3.5 | 4.5 | 2.182 | 8 |
| 8 | 13:41:57 | 25.637 | 4.3 | 3.7 | 2.129 | 8 |
| 9 | 13:42:01 | 25.641 | 3.9 | 3.6 | 2.015 | 7.6 |
| 10 | 13:42:01 | 25.645 | 4.2 | 3.6 | 2.004 | 7.8 |
| 11 | 13:42:02 | 25.65 | 5 | 3.5 | 2.114 | 8.5 |
| 12 | 13:42:04 | 25.655 | 4.9 | 3.2 | 2.319 | 8.1 |
| 13 | 13:42:05 | 25.66 | 4.8 | 3.3 | 2.338 | 8.1 |
| 14 | 13:42:07 | 25.665 | 5.2 | 3.1 | 2.273 | 8.2 |
| 15 | 13:42:09 | 25.67 | 4.8 | 3.1 | 2.141 | 7.9 |
| 16 | 13:42:10 | 25.675 | 5.1 | 3.2 | 2.057 | 8.3 |
| 17 | 13:42:12 | 25.68 | 4.5 | 3.4 | 1.905 | 7.9 |
| 18 | 13:42:14 | 25.684 | 4.8 | 2.8 | 1.879 | 7.6 |
| 19 | 13:42:15 | 25.688 | 4 | 4 | 1.951 | 8 |
| 20 | 13:42:17 | 25.69 | 1.9 | 5.7 | 2.167 | 7.6 |
| 21 | 13:42:20 | 25.692 | 1.3 | 6.3 | 2.224 | 7.6 |
| 22 | 13:42:20 | 25.693 | 0.9 | 6.8 | 2.281 | 7.8 |
| 23 | 13:42:22 | 25.693 | 0.7 | 6.8 | 2.175 | 7.5 |
| 24 | 13:42:23 | 25.694 | 0.5 | 7.2 | 2.175 | 7.7 |
| 25 | 13:42:25 | 25.694 | 0.4 | 7.1 | 2.068 | 7.6 |
| 26 | 13:42:27 | 25.695 | 0.4 | 7.3 | 2.148 | 7.7 |
| 27 | 13:42:28 | 25.695 | 0.4 | 7.1 | 2.099 | 7.4 |
| 28 | 13:42:30 | 25.695 | 0.3 | 7.4 | 2.171 | 7.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 29 | 13:42:32 | 25.696 | 0.4 | 7.2 | 2.099 | 7.6 |
| 30 | 13:42:33 | 25.696 | 0.3 | 7.2 | 2.175 | 7.5 |
| 31 | 13:42:35 | 25.696 | 0.2 | 7.6 | 2.167 | 7.8 |
| 32 | 13:42:36 | 25.696 | 0.2 | 7.5 | 2.163 | 7.7 |
| 33 | 13:42:40 | 25.697 | 0.3 | 7.6 | 2.141 | 7.8 |
| 34 | 13:42:40 | 25.697 | 0.3 | 7.4 | 2.099 | 7.8 |
| 35 | 13:42:41 | 25.697 | 0.2 | 7.3 | 2.042 | 7.6 |
| 36 | 13:42:43 | 25.697 | 0.1 | 7.5 | 2.053 | 7.7 |
| 37 | 13:42:45 | 25.697 | 0.1 | 7.6 | 2.076 | 7.7 |
| 38 | 13:42:46 | 25.698 | 0.3 | 7.5 | 2.091 | 7.7 |
| 39 | 13:42:48 | 25.698 | 0.3 | 7.5 | 2.034 | 7.8 |
| 40 | 13:42:49 | 25.698 | -0.1 | 7.5 | 1.909 | 7.5 |
| 41 | 13:42:51 | 25.698 | 0.1 | 7.7 | 2.023 | 7.8 |
| 42 | 13:42:53 | 25.698 | 0.1 | 7.6 | 2.057 | 7.7 |
| 43 | 13:42:54 | 25.699 | 0.5 | 7 | 2.133 | 7.6 |
| 44 | 13:42:56 | 25.698 | -0.3 | 7.6 | 2.118 | 7.3 |
| 45 | 13:43:00 | 25.699 | 0.4 | 7.3 | 2.129 | 7.7 |
| 46 | 13:43:00 | 25.699 | 0.1 | 7.6 | 2.057 | 7.7 |
| 47 | 13:43:01 | 25.699 | 0 | 7.8 | 2.023 | 7.7 |
| 48 | 13:43:03 | 25.699 | 0.6 | 7.2 | 2.091 | 7.9 |
| 49 | 13:43:04 | 25.699 | -0.1 | 7.2 | 2.182 | 7.2 |
| 50 | 13:43:06 | 25.7 | 0.2 | 7.4 | 2.118 | 7.6 |
| 51 | 13:43:07 | 25.7 | 0.1 | 7 | 2.038 | 7.1 |
| 52 | 13:43:09 | 25.7 | 0.1 | 7.4 | 2.034 | 7.5 |
| 53 | 13:43:11 | 25.7 | 0.1 | 7.5 | 2.106 | 7.6 |
| 54 | 13:43:12 | 25.7 | 0.2 | 7.4 | 2.008 | 7.5 |
| 55 | 13:43:14 | 25.7 | 0 | 7.4 | 2.084 | 7.5 |
| 56 | 13:43:16 | 25.7 | 0.3 | 7.5 | 2.023 | 7.8 |
| 57 | 13:43:17 | 25.701 | 0.1 | 7.4 | 2.042 | 7.5 |
| 58 | 13:43:47 | 25.701 | 0.3 | 7.4 | 1.939 | 7.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 59 | 13:43:48 | 25.701 | -0.3 | 7.6 | 1.951 | 7.4 |
| 60 | 13:43:50 | 25.701 | 0.3 | 7.5 | 1.981 | 7.8 |
| 61 | 13:43:52 | 25.701 | 0.2 | 7.4 | 2.087 | 7.6 |
| 62 | 13:43:53 | 25.701 | 0 | 7.5 | 2.163 | 7.5 |
| 63 | 13:43:55 | 25.701 | -0.1 | 7.8 | 2.228 | 7.6 |
| 64 | 13:43:56 | 25.701 | 0.2 | 7.4 | 2.057 | 7.7 |
| 65 | 13:43:58 | 25.701 | 0.1 | 7.8 | 1.996 | 7.9 |
| 66 | 13:44:00 | 25.701 | 0.1 | 7.7 | 2.084 | 7.8 |
| 67 | 13:44:01 | 25.701 | -0.4 | 8.1 | 2.167 | 7.7 |
| 68 | 13:44:05 | 25.702 | 0.5 | 7.2 | 2.167 | 7.7 |
| 69 | 13:44:05 | 25.701 | -0.3 | 8 | 2.099 | 7.6 |
| 70 | 13:44:06 | 25.702 | 0.3 | 7.4 | 2.114 | 7.6 |
| 71 | 13:44:07 | 25.701 | -0.3 | 8 | 2.122 | 7.7 |
| 72 | 13:44:09 | 25.702 | 0.3 | 7.3 | 2.038 | 7.6 |

# Appendix B. CMS Data

## B.1 **Dunns Creek**

### B.1.1 **Pile10, Pier 4**

Dunn's Creek September 19, 2018
Pile at 75 feet Number of hits: 20

| Hits | Average of Tops (inches) | Max Displacement (inches) | Rebound (inches) | Change in height (inches) |
|---|---|---|---|---|
| 1 | N/A | N/A | 0.91 | N/A |
| 2 | 0.68 | 0.99 | 0.94 | 0.05 |
| 3 | 0.73 | 0.94 | 0.85 | 0.09 |
| 4 | 0.82 | 1.00 | 0.91 | 0.08 |
| 5 | 0.90 | 1.00 | 0.90 | 0.10 |
| 6 | 1.00 | 0.95 | 0.90 | 0.05 |
| 7 | 1.06 | 0.99 | 0.93 | 0.06 |
| 8 | 1.12 | 1.01 | 0.89 | 0.12 |
| 9 | 1.23 | 1.00 | 0.92 | 0.08 |
| 10 | 1.31 | 0.97 | 0.91 | 0.06 |
| 11 | 1.37 | 0.96 | 0.87 | 0.09 |
| 12 | 1.47 | 1.01 | 0.90 | 0.11 |
| 13 | 1.57 | 1.01 | 0.92 | 0.09 |
| 14 | 1.66 | 1.01 | 0.94 | 0.07 |
| 15 | 1.73 | 1.01 | 0.92 | 0.08 |
| 16 | 1.81 | 1.04 | 0.93 | 0.11 |
| 17 | 1.92 | 0.99 | 0.93 | 0.07 |
| 18 | 1.99 | 0.94 | 0.86 | 0.08 |
| 19 | 2.07 | 0.98 | 0.90 | 0.08 |
| 20 | 2.15 | 0.98 | N/A | N/A |

| | Max Displacement (inches) | Rebound (inches) | Change in height (inches) |
|---|---|---|---|
| Mean | 0.99 | 0.91 | 0.08 |
| STD Deviation | 0.02551 | 0.024219391 | N/A |
| STD Error | 0.006013 | 0.005556309 | N/A |

| Total Pile Distance (inches) | Total Pile Distance (feet) |
|---|---|
| 1.47 | 0.122220795 |

### **B.1.2 SPT near Station 136+38**

Dunn's Creek Metal Pipe
March 2019
Camera: Z7
DSC_0292_white_tape

Z7 Camera 120 FPS 1920x1080 40-42 ft

| Hits | Top Averages (inches) | Displacement (inches) | Rebound (inches) | Change in Height (inches) | Average Displacement (inches) | Average Rebound (inches) |
|---|---|---|---|---|---|---|
| 0 | N/A | N/A | N/A | N/A | N/A | N/A |
| 1 | 3.01856087 | 1.5852 | 0.01206087 | 1.59726087 | 2.260679834 | 0.061950261 |
| 2 | 4.620491429 | 1.63683913 | 0.034908571 | 1.601930559 | 2.260679834 | 0.061950261 |
| 3 | 6.617454412 | 1.887408571 | 0.109554412 | 1.996962983 | 2.260679834 | 0.061950261 |
| 4 | 9.825494118 | 3.094445588 | 0.113594118 | 3.208039706 | 2.260679834 | 0.061950261 |
| 5 | 12.96463333 | 3.099505882 | 0.039633333 | 3.139139216 | 2.260679834 | 0.061950261 |

# Dunn’s Creek Metal Pipe

March 2019
Camera: J5
DSC_0290_white_tape 60-62

| Number of Hits | Top Avg (inches) | Displacement from hits (inches) | Rebound from hits (inches) | Change in Height (inches) | Average Displacement (inches) | Average Rebound (inches) |
|---|---|---|---|---|---|---|
| 0 | N/A | N/A | N/A | N/A | N/A | N/A |
| 1 | 2.336359701 | 1.150359701 | 0.023359701 | 1.150359701 | 0.771693582 | 0.034841931 |
| 2 | 3.474082353 | 1.141382353 | 0.030482353 | 1.137722651 | 0.771693582 | 0.034841931 |
| 3 | 4.432384848 | 0.825084848 | 0.003215152 | 0.958302496 | 0.771693582 | 0.034841931 |
| 4 | 5.283722388 | 0.843822388 | 0.031277612 | 0.85133754 | 0.771693582 | 0.034841931 |
| 5 | 6.052701408 | 0.793501408 | 0.039798592 | 0.76897902 | 0.771693582 | 0.034841931 |
| 6 | 6.799988235 | 0.652888235 | 0.110611765 | 0.747286827 | 0.771693582 | 0.034841931 |
| 7 | 7.250784722 | 0.493984722 | 0.022815278 | 0.450796487 | 0.771693582 | 0.034841931 |
| 8 | 7.638425 | 0.272525 | 0.017175 | 0.387640278 | 0.771693582 | 0.034841931 |
| 9 | N/A | N/A | N/A | N/A | N/A | N/A |

| | Displacement | Rebound |
|---|---|---|
| Mean | 0.771693582 | 0.034841931 |
| STD Deviation | 0.078624098 | 0.000923275 |
| STD Error | 0.027797816 | 0.000326427 |

# Appendix C. PDA Data

## C.1 Reedy Creek – 7/19/2018 – Floridian Place Extension

| | | |
|---|---|---|
| 576 | inches^2 | Area |
| 121 | feet | Length |
| 0.15 | kips/feet^3 | Specific Weight Density |
| 14000 | feet/second | Wave Speed |
| 6345.69 | ksi | Elastic Modulus |
| | | |
| F3 | F404 | 93.3 |
| F4 | D632 | 94.3 |
| | | |
| | | |
| 8 | feet | Pile Circumference |
| 576 | inches^2 | Bottom Area |
| | | |
| PJ | FLORIDIAN PLACE OVER L407 CANAL | |
| PN | 7-19-18 END BENT 1 PILE 12 ID | |
| PD | TEST PILE | |

| | | | | | | |
|---|---|---|---|---|---|---|
| OP | FGE-JJW | | Average | 0.95 | 0.88 | 0.88 |
| | | | Std Dev | 0.12 | 0.08 | 0.08 |
| Date | Time | LP | BN | DMX | DFN | SET |
| | | feet | | inches | inches | inches |
| 7/19/18 | 14:37:36 | 65.08 | 268 | 1.07 | 1 | 1 |
| 7/19/18 | 14:37:37 | 65.17 | 269 | 1.09 | 1 | 1 |
| 7/19/18 | 14:37:39 | 65.25 | 270 | 1.09 | 1 | 1 |
| 7/19/18 | 14:37:40 | 65.33 | 271 | 1.11 | 1 | 1 |

| Date | Time | LP | BN | DMX | DFN | SET |
|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches |
| 7/19/18 | 14:37:41 | 65.42 | 272 | 1.13 | 1 | 1 |
| 7/19/18 | 14:37:43 | 65.5 | 273 | 1.12 | 1 | 1 |
| 7/19/18 | 14:37:44 | 65.58 | 274 | 1.13 | 1 | 1 |
| 7/19/18 | 14:37:45 | 65.67 | 275 | 1.14 | 1 | 1 |
| 7/19/18 | 14:37:46 | 65.75 | 276 | 1.11 | 1 | 1 |
| 7/19/18 | 14:37:48 | 65.83 | 277 | 1.16 | 1 | 1 |
| 7/19/18 | 14:37:49 | 65.92 | 278 | 1.17 | 1 | 1 |
| 7/19/18 | 14:37:51 | 66 | 279 | 1.17 | 1 | 1 |
| 7/19/18 | 14:55:54 | 98.07 | 660 | 0.87 | 0.86 | 0.86 |
| 7/19/18 | 14:55:55 | 98.14 | 661 | 0.86 | 0.86 | 0.86 |
| 7/19/18 | 14:55:56 | 98.21 | 662 | 0.89 | 0.86 | 0.86 |
| 7/19/18 | 14:55:58 | 98.29 | 663 | 0.86 | 0.86 | 0.86 |
| 7/19/18 | 14:55:59 | 98.36 | 664 | 0.89 | 0.86 | 0.86 |
| 7/19/18 | 14:56:00 | 98.43 | 665 | 0.92 | 0.86 | 0.86 |
| 7/19/18 | 14:56:01 | 98.5 | 666 | 0.89 | 0.86 | 0.86 |
| 7/19/18 | 14:56:03 | 98.57 | 667 | 0.9 | 0.86 | 0.86 |
| 7/19/18 | 14:56:04 | 98.64 | 668 | 0.88 | 0.86 | 0.86 |
| 7/19/18 | 14:56:05 | 98.71 | 669 | 0.88 | 0.86 | 0.86 |
| 7/19/18 | 14:56:06 | 98.79 | 670 | 0.87 | 0.86 | 0.86 |
| 7/19/18 | 14:56:08 | 98.86 | 671 | 0.87 | 0.86 | 0.86 |
| 7/19/18 | 14:56:09 | 98.93 | 672 | 0.86 | 0.86 | 0.86 |
| 7/19/18 | 14:56:10 | 99 | 673 | 0.87 | 0.86 | 0.86 |
| 7/19/18 | 14:59:21 | 109.07 | 825 | 0.87 | 0.8 | 0.8 |
| 7/19/18 | 14:59:23 | 109.13 | 826 | 0.87 | 0.8 | 0.8 |
| 7/19/18 | 14:59:24 | 109.2 | 827 | 0.86 | 0.8 | 0.8 |
| 7/19/18 | 14:59:25 | 109.27 | 828 | 0.86 | 0.8 | 0.8 |
| 7/19/18 | 14:59:26 | 109.33 | 829 | 0.86 | 0.8 | 0.8 |
| 7/19/18 | 14:59:28 | 109.4 | 830 | 0.87 | 0.8 | 0.8 |
| 7/19/18 | 14:59:29 | 109.47 | 831 | 0.87 | 0.8 | 0.8 |
| 7/19/18 | 14:59:30 | 109.53 | 832 | 0.89 | 0.8 | 0.8 |
| 7/19/18 | 14:59:32 | 109.6 | 833 | 0.85 | 0.8 | 0.8 |
| 7/19/18 | 14:59:33 | 109.67 | 834 | 0.86 | 0.8 | 0.8 |

| Date | Time | LP | BN | DMX | DFN | SET |
|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches |
| 7/19/18 | 14:59:34 | 109.73 | 835 | 0.86 | 0.8 | 0.8 |
| 7/19/18 | 14:59:35 | 109.8 | 836 | 0.86 | 0.8 | 0.8 |
| 7/19/18 | 14:59:37 | 109.87 | 837 | 0.87 | 0.8 | 0.8 |
| 7/19/18 | 14:59:38 | 109.93 | 838 | 0.87 | 0.8 | 0.8 |
| 7/19/18 | 14:59:39 | 110 | 839 | 0.87 | 0.8 | 0.8 |

## C.2. **Ellis Road I-95 Overpass – 11/30/2018**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 576 | inches^2 | Area | | | | | |
| 151 | feet | Length | | | | | |
| 0.15 | kips/feet^3 | Specific Weight Density | | | | | |
| 14550 | feet/second | Wave Speed | | | | | |
| 6854.08 | ksi | Elastic Modulus | | | | | |
| | | | | | | | |
| F3 | L624 | 147.8 | | | | | |
| F4 | L619 | 147.6 | | | | | |
| | | | | | | | |
| | | | | | | | |
| 8 | feet | Pile Circumference | | | | | |
| 576 | inches^2 | Bottom Area | | | | | |
| | | | | | | | |
| PJ | I-95 INTERCHANGE AT ELLIS ROAD | | | | | | |
| PN | 700239 EB1 P8 TOP | | | | | | |
| PD | RE 21.24 GE 18.63 CE 34.9 | | | | | | |
| OP | MAF | | Average | 0.42 | 0.11 | 0.17 | 0.32 |
| | | | Std Dev | 0.03 | 0.05 | 0.01 | 0.04 |
| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
| | | feet | | inches | inches | inches | inches |
| 11/30/18 | 10:29:38 | 111.01 | 202 | 0.41 | 0.21 | 0.16 | 0.2 |
| 11/30/18 | 10:29:39 | 111.03 | 203 | 0.4 | 0.2 | 0.16 | 0.2 |
| 11/30/18 | 10:29:41 | 111.04 | 204 | 0.39 | 0.18 | 0.16 | 0.21 |
| 11/30/18 | 10:29:42 | 111.05 | 205 | 0.39 | 0.16 | 0.16 | 0.23 |
| 11/30/18 | 10:29:44 | 111.07 | 206 | 0.39 | 0.18 | 0.16 | 0.21 |
| 11/30/18 | 10:29:45 | 111.08 | 207 | 0.38 | 0.16 | 0.16 | 0.22 |

| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
|---|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches | inches |
| 11/30/18 | 10:29:46 | 111.1 | 208 | 0.38 | 0.17 | 0.16 | 0.21 |
| 11/30/18 | 10:29:48 | 111.11 | 209 | 0.44 | 0.2 | 0.16 | 0.24 |
| 11/30/18 | 10:29:49 | 111.12 | 210 | 0.38 | 0.15 | 0.16 | 0.23 |
| 11/30/18 | 10:29:50 | 111.14 | 211 | 0.38 | 0.14 | 0.16 | 0.24 |
| 11/30/18 | 10:29:52 | 111.15 | 212 | 0.38 | 0.13 | 0.16 | 0.25 |
| 11/30/18 | 10:29:53 | 111.16 | 213 | 0.42 | 0.15 | 0.16 | 0.27 |
| 11/30/18 | 10:29:54 | 111.18 | 214 | 0.38 | 0.12 | 0.16 | 0.26 |
| 11/30/18 | 10:29:56 | 111.19 | 215 | 0.35 | 0.07 | 0.16 | 0.28 |
| 11/30/18 | 10:29:57 | 111.21 | 216 | 0.38 | 0.11 | 0.16 | 0.27 |
| 11/30/18 | 10:29:58 | 111.22 | 217 | 0.38 | 0.11 | 0.16 | 0.27 |
| 11/30/18 | 10:30:00 | 111.23 | 218 | 0.38 | 0.1 | 0.16 | 0.28 |
| 11/30/18 | 10:30:01 | 111.25 | 219 | 0.41 | 0.13 | 0.16 | 0.28 |
| 11/30/18 | 10:30:02 | 111.26 | 220 | 0.39 | 0.12 | 0.16 | 0.27 |
| 11/30/18 | 10:30:04 | 111.27 | 221 | 0.39 | 0.11 | 0.16 | 0.28 |
| 11/30/18 | 10:30:05 | 111.29 | 222 | 0.38 | 0.1 | 0.16 | 0.28 |
| 11/30/18 | 10:30:06 | 111.3 | 223 | 0.42 | 0.11 | 0.16 | 0.31 |
| 11/30/18 | 10:30:08 | 111.32 | 224 | 0.41 | 0.14 | 0.16 | 0.27 |
| 11/30/18 | 10:30:09 | 111.33 | 225 | 0.39 | 0.09 | 0.16 | 0.3 |
| 11/30/18 | 10:30:10 | 111.34 | 226 | 0.39 | 0.11 | 0.16 | 0.28 |
| 11/30/18 | 10:30:12 | 111.36 | 227 | 0.38 | 0.08 | 0.16 | 0.3 |
| 11/30/18 | 10:30:13 | 111.37 | 228 | 0.41 | 0.1 | 0.16 | 0.31 |
| 11/30/18 | 10:30:14 | 111.38 | 229 | 0.4 | 0.08 | 0.16 | 0.32 |
| 11/30/18 | 10:30:16 | 111.4 | 230 | 0.43 | 0.13 | 0.16 | 0.3 |
| 11/30/18 | 10:30:17 | 111.41 | 231 | 0.37 | 0.06 | 0.16 | 0.31 |
| 11/30/18 | 10:30:18 | 111.42 | 232 | 0.36 | 0.05 | 0.16 | 0.31 |
| 11/30/18 | 10:30:20 | 111.44 | 233 | 0.44 | 0.11 | 0.16 | 0.33 |
| 11/30/18 | 10:30:21 | 111.45 | 234 | 0.37 | 0.07 | 0.16 | 0.3 |
| 11/30/18 | 10:30:22 | 111.47 | 235 | 0.38 | 0.07 | 0.16 | 0.31 |
| 11/30/18 | 10:30:24 | 111.48 | 236 | 0.4 | 0.08 | 0.16 | 0.32 |
| 11/30/18 | 10:30:25 | 111.49 | 237 | 0.42 | 0.06 | 0.16 | 0.36 |
| 11/30/18 | 10:30:26 | 111.51 | 238 | 0.39 | 0.06 | 0.16 | 0.33 |
| 11/30/18 | 10:30:28 | 111.52 | 239 | 0.42 | 0.09 | 0.16 | 0.33 |

| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
|---|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches | inches |
| 11/30/18 | 10:30:29 | 111.53 | 240 | 0.4 | 0.08 | 0.16 | 0.32 |
| 11/30/18 | 10:30:31 | 111.55 | 241 | 0.39 | 0.07 | 0.16 | 0.32 |
| 11/30/18 | 10:30:32 | 111.56 | 242 | 0.42 | 0.09 | 0.16 | 0.33 |
| 11/30/18 | 10:30:33 | 111.58 | 243 | 0.41 | 0.06 | 0.16 | 0.35 |
| 11/30/18 | 10:30:35 | 111.59 | 244 | 0.43 | 0.1 | 0.16 | 0.33 |
| 11/30/18 | 10:30:36 | 111.6 | 245 | 0.44 | 0.08 | 0.16 | 0.36 |
| 11/30/18 | 10:30:37 | 111.62 | 246 | 0.41 | 0.08 | 0.16 | 0.33 |
| 11/30/18 | 10:30:39 | 111.63 | 247 | 0.38 | 0.03 | 0.16 | 0.35 |
| 11/30/18 | 10:30:40 | 111.64 | 248 | 0.44 | 0.08 | 0.16 | 0.36 |
| 11/30/18 | 10:30:42 | 111.66 | 249 | 0.42 | 0.06 | 0.16 | 0.36 |
| 11/30/18 | 10:30:43 | 111.67 | 250 | 0.41 | 0.05 | 0.16 | 0.36 |
| 11/30/18 | 10:30:44 | 111.68 | 251 | 0.41 | 0.06 | 0.16 | 0.35 |
| 11/30/18 | 10:30:46 | 111.7 | 252 | 0.38 | 0.04 | 0.16 | 0.34 |
| 11/30/18 | 10:30:47 | 111.71 | 253 | 0.41 | 0.07 | 0.16 | 0.34 |
| 11/30/18 | 10:30:48 | 111.73 | 254 | 0.39 | 0.04 | 0.16 | 0.35 |
| 11/30/18 | 10:30:50 | 111.74 | 255 | 0.37 | 0 | 0.16 | 0.37 |
| 11/30/18 | 10:30:51 | 111.75 | 256 | 0.41 | 0.05 | 0.16 | 0.36 |
| 11/30/18 | 10:30:52 | 111.77 | 257 | 0.41 | 0.06 | 0.16 | 0.35 |
| 11/30/18 | 10:30:54 | 111.78 | 258 | 0.39 | 0.03 | 0.16 | 0.36 |
| 11/30/18 | 10:30:55 | 111.79 | 259 | 0.41 | 0.06 | 0.16 | 0.35 |
| 11/30/18 | 10:30:57 | 111.81 | 260 | 0.37 | 0.01 | 0.16 | 0.36 |
| 11/30/18 | 10:30:58 | 111.82 | 261 | 0.43 | 0.04 | 0.16 | 0.39 |
| 11/30/18 | 10:30:59 | 111.84 | 262 | 0.45 | 0.09 | 0.16 | 0.36 |
| 11/30/18 | 10:31:01 | 111.85 | 263 | 0.38 | 0 | 0.16 | 0.38 |
| 11/30/18 | 10:31:02 | 111.86 | 264 | 0.39 | 0.01 | 0.16 | 0.38 |
| 11/30/18 | 10:31:03 | 111.88 | 265 | 0.39 | 0.02 | 0.16 | 0.37 |
| 11/30/18 | 10:31:05 | 111.89 | 266 | 0.41 | 0.04 | 0.16 | 0.37 |
| 11/30/18 | 10:31:06 | 111.9 | 267 | 0.44 | 0.07 | 0.16 | 0.37 |
| 11/30/18 | 10:31:07 | 111.92 | 268 | 0.4 | 0.01 | 0.16 | 0.39 |
| 11/30/18 | 10:31:09 | 111.93 | 269 | 0.42 | 0.05 | 0.16 | 0.37 |
| 11/30/18 | 10:31:10 | 111.95 | 270 | 0.36 | -0.03 | 0.16 | 0.39 |
| 11/30/18 | 10:31:12 | 111.96 | 271 | 0.43 | 0.06 | 0.16 | 0.37 |

| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
|---|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches | inches |
| 11/30/18 | 10:31:13 | 111.97 | 272 | 0.42 | 0.04 | 0.16 | 0.38 |
| 11/30/18 | 10:31:14 | 111.99 | 273 | 0.38 | -0.01 | 0.16 | 0.39 |
| 11/30/18 | 10:31:16 | 112 | 274 | 0.39 | 0 | 0.16 | 0.39 |
| 11/30/18 | 10:39:48 | 117.01 | 652 | 0.42 | 0.12 | 0.18 | 0.3 |
| 11/30/18 | 10:39:49 | 117.03 | 653 | 0.42 | 0.13 | 0.18 | 0.29 |
| 11/30/18 | 10:39:51 | 117.04 | 654 | 0.46 | 0.17 | 0.18 | 0.29 |
| 11/30/18 | 10:39:52 | 117.06 | 655 | 0.46 | 0.16 | 0.18 | 0.3 |
| 11/30/18 | 10:39:53 | 117.07 | 656 | 0.43 | 0.13 | 0.18 | 0.3 |
| 11/30/18 | 10:39:55 | 117.09 | 657 | 0.47 | 0.15 | 0.18 | 0.32 |
| 11/30/18 | 10:39:56 | 117.1 | 658 | 0.43 | 0.13 | 0.18 | 0.3 |
| 11/30/18 | 10:39:57 | 117.12 | 659 | 0.46 | 0.15 | 0.18 | 0.31 |
| 11/30/18 | 10:39:59 | 117.13 | 660 | 0.45 | 0.14 | 0.18 | 0.31 |
| 11/30/18 | 10:40:00 | 117.15 | 661 | 0.45 | 0.15 | 0.18 | 0.3 |
| 11/30/18 | 10:40:02 | 117.16 | 662 | 0.44 | 0.15 | 0.18 | 0.29 |
| 11/30/18 | 10:40:03 | 117.18 | 663 | 0.46 | 0.14 | 0.18 | 0.32 |
| 11/30/18 | 10:40:04 | 117.19 | 664 | 0.47 | 0.14 | 0.18 | 0.33 |
| 11/30/18 | 10:40:06 | 117.21 | 665 | 0.42 | 0.11 | 0.18 | 0.31 |
| 11/30/18 | 10:40:07 | 117.22 | 666 | 0.46 | 0.14 | 0.18 | 0.32 |
| 11/30/18 | 10:40:08 | 117.24 | 667 | 0.42 | 0.12 | 0.18 | 0.3 |
| 11/30/18 | 10:40:10 | 117.25 | 668 | 0.45 | 0.14 | 0.18 | 0.31 |
| 11/30/18 | 10:40:11 | 117.27 | 669 | 0.45 | 0.13 | 0.18 | 0.32 |
| 11/30/18 | 10:40:12 | 117.28 | 670 | 0.42 | 0.12 | 0.18 | 0.3 |
| 11/30/18 | 10:40:14 | 117.3 | 671 | 0.42 | 0.1 | 0.18 | 0.32 |
| 11/30/18 | 10:40:15 | 117.31 | 672 | 0.43 | 0.12 | 0.18 | 0.31 |
| 11/30/18 | 10:40:16 | 117.33 | 673 | 0.42 | 0.1 | 0.18 | 0.32 |
| 11/30/18 | 10:40:18 | 117.34 | 674 | 0.43 | 0.11 | 0.18 | 0.32 |
| 11/30/18 | 10:40:19 | 117.36 | 675 | 0.43 | 0.12 | 0.18 | 0.31 |
| 11/30/18 | 10:40:21 | 117.37 | 676 | 0.44 | 0.12 | 0.18 | 0.32 |
| 11/30/18 | 10:40:22 | 117.39 | 677 | 0.46 | 0.12 | 0.18 | 0.34 |
| 11/30/18 | 10:40:23 | 117.4 | 678 | 0.43 | 0.12 | 0.18 | 0.31 |
| 11/30/18 | 10:40:25 | 117.42 | 679 | 0.5 | 0.16 | 0.18 | 0.34 |
| 11/30/18 | 10:40:26 | 117.43 | 680 | 0.45 | 0.12 | 0.18 | 0.33 |

| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
|---|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches | inches |
| 11/30/18 | 10:40:27 | 117.45 | 681 | 0.45 | 0.13 | 0.18 | 0.32 |
| 11/30/18 | 10:40:29 | 117.46 | 682 | 0.45 | 0.1 | 0.18 | 0.35 |
| 11/30/18 | 10:40:30 | 117.48 | 683 | 0.47 | 0.14 | 0.18 | 0.33 |
| 11/30/18 | 10:40:31 | 117.49 | 684 | 0.46 | 0.15 | 0.18 | 0.31 |
| 11/30/18 | 10:40:33 | 117.51 | 685 | 0.44 | 0.13 | 0.18 | 0.31 |
| 11/30/18 | 10:40:34 | 117.52 | 686 | 0.44 | 0.11 | 0.18 | 0.33 |
| 11/30/18 | 10:40:36 | 117.54 | 687 | 0.41 | 0.09 | 0.18 | 0.32 |
| 11/30/18 | 10:40:37 | 117.55 | 688 | 0.46 | 0.14 | 0.18 | 0.32 |
| 11/30/18 | 10:40:38 | 117.57 | 689 | 0.41 | 0.09 | 0.18 | 0.32 |
| 11/30/18 | 10:40:40 | 117.58 | 690 | 0.45 | 0.11 | 0.18 | 0.34 |
| 11/30/18 | 10:40:41 | 117.6 | 691 | 0.43 | 0.11 | 0.18 | 0.32 |
| 11/30/18 | 10:40:42 | 117.61 | 692 | 0.44 | 0.12 | 0.18 | 0.32 |
| 11/30/18 | 10:40:44 | 117.63 | 693 | 0.45 | 0.14 | 0.18 | 0.31 |
| 11/30/18 | 10:40:45 | 117.64 | 694 | 0.41 | 0.1 | 0.18 | 0.31 |
| 11/30/18 | 10:40:46 | 117.66 | 695 | 0.41 | 0.11 | 0.18 | 0.3 |
| 11/30/18 | 10:40:48 | 117.67 | 696 | 0.44 | 0.11 | 0.18 | 0.33 |
| 11/30/18 | 10:40:49 | 117.69 | 697 | 0.46 | 0.15 | 0.18 | 0.31 |
| 11/30/18 | 10:40:51 | 117.7 | 698 | 0.43 | 0.12 | 0.18 | 0.31 |
| 11/30/18 | 10:40:52 | 117.72 | 699 | 0.44 | 0.11 | 0.18 | 0.33 |
| 11/30/18 | 10:40:53 | 117.73 | 700 | 0.49 | 0.14 | 0.18 | 0.35 |
| 11/30/18 | 10:40:55 | 117.75 | 701 | 0.44 | 0.12 | 0.18 | 0.32 |
| 11/30/18 | 10:40:56 | 117.76 | 702 | 0.46 | 0.14 | 0.18 | 0.32 |
| 11/30/18 | 10:40:57 | 117.78 | 703 | 0.45 | 0.13 | 0.18 | 0.32 |
| 11/30/18 | 10:40:59 | 117.79 | 704 | 0.41 | 0.1 | 0.18 | 0.31 |
| 11/30/18 | 10:41:00 | 117.81 | 705 | 0.42 | 0.09 | 0.18 | 0.33 |
| 11/30/18 | 10:41:01 | 117.82 | 706 | 0.47 | 0.16 | 0.18 | 0.31 |
| 11/30/18 | 10:41:03 | 117.84 | 707 | 0.45 | 0.15 | 0.18 | 0.3 |
| 11/30/18 | 10:41:04 | 117.85 | 708 | 0.43 | 0.12 | 0.18 | 0.31 |
| 11/30/18 | 10:41:06 | 117.87 | 709 | 0.45 | 0.12 | 0.18 | 0.33 |
| 11/30/18 | 10:41:07 | 117.88 | 710 | 0.47 | 0.16 | 0.18 | 0.31 |
| 11/30/18 | 10:41:08 | 117.9 | 711 | 0.44 | 0.13 | 0.18 | 0.31 |
| 11/30/18 | 10:41:10 | 117.91 | 712 | 0.42 | 0.12 | 0.18 | 0.3 |

| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
|---|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches | inches |
| 11/30/18 | 10:41:11 | 117.93 | 713 | 0.45 | 0.14 | 0.18 | 0.31 |
| 11/30/18 | 10:41:12 | 117.94 | 714 | 0.5 | 0.18 | 0.18 | 0.32 |
| 11/30/18 | 10:41:14 | 117.96 | 715 | 0.43 | 0.13 | 0.18 | 0.3 |
| 11/30/18 | 10:41:15 | 117.97 | 716 | 0.44 | 0.14 | 0.18 | 0.3 |
| 11/30/18 | 10:41:16 | 117.99 | 717 | 0.44 | 0.13 | 0.18 | 0.31 |
| 11/30/18 | 10:41:18 | 118 | 718 | 0.47 | 0.16 | 0.18 | 0.31 |

## C.3. **Dunns Creek Pile 10, Pier 4, near Station 436+37**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 576 | inches^2 | Area | | | | | |
| 106 | feet | Length | | | | | |
| 0.15 | kips/feet^3 | Specific Weight Density | | | | | |
| 13150 | feet/second | Wave Speed | | | | | |
| 5598.54 | ksi | Elastic Modulus | | | | | |
| | | | | | | | |
| F3 | N430 | 147.9 | | | | | |
| F4 | K193 | 90.4 | | | | | |
| | | | | | | | |
| | | | | | | | |
| 8 | feet | Pile Circumference | | | | | |
| 576 | inches^2 | Bottom Area | | | | | |
| | | | | | | | |
| PJ | US 17 at Dunns Creek | | | | | | |
| PN | PIER 4, PILE 10 | | | | | | |
| PD | INITIAL DRIVE, NBR 746 KIPS | | | | | | |
| OP | GRL-JP | | Average | 1.494 | 1.377 | 0.150 | 0.117 |
| | | | Std Dev | 0.040 | 0.038 | 0.000 | 0.006 |
| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
| | | feet | | inches | inches | inches | inches |
| 9/19/18 | 9:37:06 | 68.01 | 248 | 1.53 | 1.4 | 0.15 | 0.13 |
| 9/19/18 | 9:37:08 | 68.03 | 249 | 1.5 | 1.38 | 0.15 | 0.12 |
| 9/19/18 | 9:37:09 | 68.04 | 250 | 1.52 | 1.4 | 0.15 | 0.12 |
| 9/19/18 | 9:37:10 | 68.05 | 251 | 1.53 | 1.41 | 0.15 | 0.12 |
| 9/19/18 | 9:37:12 | 68.06 | 252 | 1.51 | 1.38 | 0.15 | 0.13 |
| 9/19/18 | 9:37:13 | 68.08 | 253 | 1.48 | 1.36 | 0.15 | 0.12 |
| 9/19/18 | 9:37:14 | 68.09 | 254 | 1.48 | 1.37 | 0.15 | 0.11 |
| 9/19/18 | 9:37:16 | 68.1 | 255 | 1.5 | 1.38 | 0.15 | 0.12 |
| 9/19/18 | 9:37:17 | 68.11 | 256 | 1.57 | 1.45 | 0.15 | 0.12 |
| 9/19/18 | 9:37:18 | 68.13 | 257 | 1.51 | 1.39 | 0.15 | 0.12 |

| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
|---|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches | inches |
| 9/19/18 | 9:37:20 | 68.14 | 258 | 1.5 | 1.37 | 0.15 | 0.13 |
| 9/19/18 | 9:37:21 | 68.15 | 259 | 1.46 | 1.35 | 0.15 | 0.11 |
| 9/19/18 | 9:37:22 | 68.16 | 260 | 1.47 | 1.36 | 0.15 | 0.11 |
| 9/19/18 | 9:37:24 | 68.18 | 261 | 1.47 | 1.35 | 0.15 | 0.12 |
| 9/19/18 | 9:37:25 | 68.19 | 262 | 1.53 | 1.41 | 0.15 | 0.12 |
| 9/19/18 | 9:37:26 | 68.2 | 263 | 1.5 | 1.37 | 0.15 | 0.13 |
| 9/19/18 | 9:37:28 | 68.22 | 264 | 1.49 | 1.37 | 0.15 | 0.12 |
| 9/19/18 | 9:37:29 | 68.23 | 265 | 1.48 | 1.36 | 0.15 | 0.12 |
| 9/19/18 | 9:37:30 | 68.24 | 266 | 1.44 | 1.32 | 0.15 | 0.12 |
| 9/19/18 | 9:37:32 | 68.25 | 267 | 1.52 | 1.39 | 0.15 | 0.13 |
| 9/19/18 | 9:37:33 | 68.27 | 268 | 1.49 | 1.37 | 0.15 | 0.12 |
| 9/19/18 | 9:37:34 | 68.28 | 269 | 1.46 | 1.34 | 0.15 | 0.12 |
| 9/19/18 | 9:37:36 | 68.29 | 270 | 1.46 | 1.34 | 0.15 | 0.12 |
| 9/19/18 | 9:37:37 | 68.3 | 271 | 1.53 | 1.41 | 0.15 | 0.12 |
| 9/19/18 | 9:37:39 | 68.32 | 272 | 1.47 | 1.35 | 0.15 | 0.12 |
| 9/19/18 | 9:37:40 | 68.33 | 273 | 1.44 | 1.33 | 0.15 | 0.11 |
| 9/19/18 | 9:37:41 | 68.34 | 274 | 1.45 | 1.34 | 0.15 | 0.11 |
| 9/19/18 | 9:37:43 | 68.35 | 275 | 1.48 | 1.36 | 0.15 | 0.12 |
| 9/19/18 | 9:37:44 | 68.37 | 276 | 1.51 | 1.39 | 0.15 | 0.12 |
| 9/19/18 | 9:37:45 | 68.38 | 277 | 1.46 | 1.34 | 0.15 | 0.12 |
| 9/19/18 | 9:37:47 | 68.39 | 278 | 1.46 | 1.35 | 0.15 | 0.11 |
| 9/19/18 | 9:37:48 | 68.41 | 279 | 1.46 | 1.34 | 0.15 | 0.12 |
| 9/19/18 | 9:37:49 | 68.42 | 280 | 1.5 | 1.38 | 0.15 | 0.12 |
| 9/19/18 | 9:37:51 | 68.43 | 281 | 1.53 | 1.42 | 0.15 | 0.11 |
| 9/19/18 | 9:37:52 | 68.44 | 282 | 1.55 | 1.43 | 0.15 | 0.12 |
| 9/19/18 | 9:37:53 | 68.46 | 283 | 1.49 | 1.37 | 0.15 | 0.12 |
| 9/19/18 | 9:37:55 | 68.47 | 284 | 1.47 | 1.35 | 0.15 | 0.12 |
| 9/19/18 | 9:37:56 | 68.48 | 285 | 1.47 | 1.36 | 0.15 | 0.11 |
| 9/19/18 | 9:37:58 | 68.49 | 286 | 1.49 | 1.37 | 0.15 | 0.12 |
| 9/19/18 | 9:37:59 | 68.51 | 287 | 1.57 | 1.45 | 0.15 | 0.12 |
| 9/19/18 | 9:38:00 | 68.52 | 288 | 1.49 | 1.37 | 0.15 | 0.12 |
| 9/19/18 | 9:38:02 | 68.53 | 289 | 1.5 | 1.38 | 0.15 | 0.12 |

| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
|---|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches | inches |
| 9/19/18 | 9:38:03 | 68.54 | 290 | 1.44 | 1.32 | 0.15 | 0.12 |
| 9/19/18 | 9:38:04 | 68.56 | 291 | 1.54 | 1.42 | 0.15 | 0.12 |
| 9/19/18 | 9:38:06 | 68.57 | 292 | 1.52 | 1.4 | 0.15 | 0.12 |
| 9/19/18 | 9:38:07 | 68.58 | 293 | 1.51 | 1.4 | 0.15 | 0.11 |
| 9/19/18 | 9:38:08 | 68.59 | 294 | 1.46 | 1.34 | 0.15 | 0.12 |
| 9/19/18 | 9:38:10 | 68.61 | 295 | 1.45 | 1.34 | 0.15 | 0.11 |
| 9/19/18 | 9:38:11 | 68.62 | 296 | 1.51 | 1.39 | 0.15 | 0.12 |
| 9/19/18 | 9:38:12 | 68.63 | 297 | 1.45 | 1.34 | 0.15 | 0.11 |
| 9/19/18 | 9:38:14 | 68.65 | 298 | 1.5 | 1.38 | 0.15 | 0.12 |
| 9/19/18 | 9:38:15 | 68.66 | 299 | 1.51 | 1.39 | 0.15 | 0.12 |
| 9/19/18 | 9:38:17 | 68.67 | 300 | 1.45 | 1.33 | 0.15 | 0.12 |
| 9/19/18 | 9:38:18 | 68.68 | 301 | 1.48 | 1.36 | 0.15 | 0.12 |
| 9/19/18 | 9:38:19 | 68.7 | 302 | 1.56 | 1.44 | 0.15 | 0.12 |
| 9/19/18 | 9:38:21 | 68.71 | 303 | 1.52 | 1.4 | 0.15 | 0.12 |
| 9/19/18 | 9:38:22 | 68.72 | 304 | 1.48 | 1.37 | 0.15 | 0.11 |
| 9/19/18 | 9:38:23 | 68.73 | 305 | 1.49 | 1.38 | 0.15 | 0.11 |
| 9/19/18 | 9:38:25 | 68.75 | 306 | 1.47 | 1.36 | 0.15 | 0.11 |
| 9/19/18 | 9:38:26 | 68.76 | 307 | 1.51 | 1.39 | 0.15 | 0.12 |
| 9/19/18 | 9:38:27 | 68.77 | 308 | 1.5 | 1.39 | 0.15 | 0.11 |
| 9/19/18 | 9:38:29 | 68.78 | 309 | 1.45 | 1.34 | 0.15 | 0.11 |
| 9/19/18 | 9:38:30 | 68.8 | 310 | 1.53 | 1.42 | 0.15 | 0.11 |
| 9/19/18 | 9:38:31 | 68.81 | 311 | 1.57 | 1.45 | 0.15 | 0.12 |
| 9/19/18 | 9:38:33 | 68.82 | 312 | 1.54 | 1.43 | 0.15 | 0.11 |
| 9/19/18 | 9:38:34 | 68.84 | 313 | 1.53 | 1.41 | 0.15 | 0.12 |
| 9/19/18 | 9:38:36 | 68.85 | 314 | 1.43 | 1.32 | 0.15 | 0.11 |
| 9/19/18 | 9:38:37 | 68.86 | 315 | 1.43 | 1.32 | 0.15 | 0.11 |
| 9/19/18 | 9:38:38 | 68.87 | 316 | 1.52 | 1.4 | 0.15 | 0.12 |
| 9/19/18 | 9:38:40 | 68.89 | 317 | 1.51 | 1.4 | 0.15 | 0.11 |
| 9/19/18 | 9:38:41 | 68.9 | 318 | 1.5 | 1.38 | 0.15 | 0.12 |
| 9/19/18 | 9:38:42 | 68.91 | 319 | 1.43 | 1.33 | 0.15 | 0.1 |
| 9/19/18 | 9:38:44 | 68.92 | 320 | 1.43 | 1.31 | 0.15 | 0.12 |
| 9/19/18 | 9:38:45 | 68.94 | 321 | 1.46 | 1.35 | 0.15 | 0.11 |

| Date | Time | LP | BN | DMX | DFN | SET | Rebound |
|---|---|---|---|---|---|---|---|
| | | feet | | inches | inches | inches | inches |
| 9/19/18 | 9:38:46 | 68.95 | 322 | 1.48 | 1.37 | 0.15 | 0.11 |
| 9/19/18 | 9:38:48 | 68.96 | 323 | 1.4 | 1.3 | 0.15 | 0.1 |
| 9/19/18 | 9:38:49 | 68.97 | 324 | 1.54 | 1.43 | 0.15 | 0.11 |
| 9/19/18 | 9:38:50 | 68.99 | 325 | 1.59 | 1.48 | 0.15 | 0.11 |
| 9/19/18 | 9:38:52 | 69 | 326 | 1.59 | 1.47 | 0.15 | 0.12 |

# Appendix D. CMS Testing Procedures

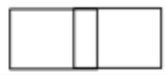
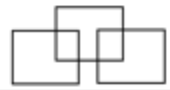
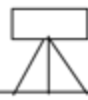
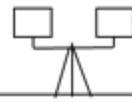
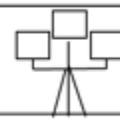
## D.1 Choosing a Camera

A mono camera with or without multispectral capability using staff gauge type target or laser line target is proposed in this study (Bostater, et al. 2014). The cameras used for this research are relatively inexpensive in terms of high-end camera. With the specialty lens, tripod, and miscellaneous equipment they are approximately $2000 in 2020. Figure D-1 shows a typical CMS camera.

Figure D-1 Typical Camera for Field Testing

The options available for this type of work are outlined in Table D-1. Either one, two r or three cameras can be deployed. Various types of targets can be deployed and various number of cameras can be used for each option. The trinocular system relies on three cameras and would be the most expensive. The field of vision (FOV) increases with each option. The methods used to obtain a target as either motion or functions of a Cartesian coordinate system (i.e. x, y, z). Mono cameras can be easily used while the coverage area increases with both multispectral and trinocular cameras. All three options require the same gauge or targets on the device that is monitored.

Table D-1 Advantages and Disadvantages of Cameras for Detecting Movements

| | Mono | Multispectral | Trinocular |
|---|---|---|---|
| Camera number | 1 | 1 or 2 | 3 |
| Viewing Target | Staff Gauge Type | Laser Line Image | to be determine |
| Determine FOV |  |  |  |
| Deployment of camera(s) |  |  |  |
| Method used to obtain target height | read surface level motion changes against staff gauge or laser target | $\begin{bmatrix} x_1 \\ y_1 \\ x_2 \\ y_2 \end{bmatrix} f(\alpha,\theta,\tau) = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$ | $\begin{bmatrix} x_1 \\ y_1 \\ x_2 \\ y_2 \\ x_3 \\ y_3 \end{bmatrix} f(\alpha,\theta,\tau) = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$ |
| Virtues | easy to achieve | larger coverage | larger coverage more accuracy |
| Shortcomings | staff gauge(s) or other targets needed for height extraction | staff gauge(s) or other equipment needed for validation | staff gauge(s) or other equipment needed for validation |
| Reference | Bostater et al., 2014 | Benetazzo et al., 2012 | Wanek et al., 2005 |

## D.2 Camera in Field Location

Setup of the cameras varied at each site. Vibrations were more of a concern during pile driving than SPT testing. In general, the goal was to safely record as close as possible and reduce the effects of vibrations. Placing the camera close enough minimizes the need of extreme lens zooming. At locations where the testing area was relatively level, the CMS cameras were placed on the flat surface and the viewing was relatively level.  However, if the site location on the pile is below the camera grade, as was the case at Reedy Creek (Figure D-2) the cameras were angled to record the videos.

At the first few pile driving sites, foam was placed under the camera tripod to reduce vibration effects (Figure D-2). However, this did not always work since the camera and tripod actually become less stable on the vibrating cushion.  If this approach is to be used a heavier tripod may help stabilize the equipment. In general, it was found that ground vibration effects *were* reduced by use a vibration reduction lens.

Figure D-2 Typical Camera Setups

## D.3 Marking the Pile or SPT Rods

Piles and SPT rods were marked using several techniques. At all sites, the piles were marked before being placed into the hammer leads. Either black spray paint or electrical tape (white or black ½ or ¾ inches wide) were used on piles (See Figure D-3), while white chalk plus the tape was used on the SPT rods.  Note that the black spray paint lines did not need to be perfectly straight in order for the CMS video imaging to be processed. Pile markings were typically placed at one-foot intervals. To aid during video processing, a silver permanent marking pen was also used to write the foot number next to or on the tape.  These silver footmarks allowed were then viewed within the images. SPT markings were placed at 6-inch intervals to match with the blow counts recorded by the drillers.


Figure D-3 Typical Pile plus PDM Markings

Figure D-4 Typical CMS and PDM SPT Rod Markings

Analysis of the images indicated that black spray-painted lines worked just as well as tape lines on the concrete piles. The horizontal sprayed lines were typically ¾ to just over 1 inch in width. The painted lines with the viewable foot mark written within the line worked the best, since the electrical tape tended to fall off the pile during driving.

SPT video recordings proved difficult because of the dark metal rods. Black tape did not provide high quality contrast for automated detection of vertical displacements. White reflector tape similar to the PDM tape was tested and also produced poor displacement analyses results, due to the changing reflectivity within the PDM tape. White electrical tape worked as well as the white chalk used by the drillers to determine the SPT 6-inch blows. The disadvantage of the white tape was that it tended to fall off of the SPT rods. Therefore, a horizontal white chalk line drawn across half the diameter of the rod is the preferred method for marking SPT rods. These markings would allow a complete 24-inch SPT displacement monitoring record to be produced.

## D.4. Synchronizing CMS, PDM, and PDA Data

Camera clocks as well as the PDM were synchronized to approximately the nearest second. Blow counts were easily recorded by using the sound recording feature of the video recordings. In addition, voice comments made during the recording proved useful. Timings with the PDM are also assisted since the laser dots that specify the active PDM testing region were viewable in the video before the PDM measurements became active.

## D.5. Smart Image Processing

The “automated” or smart image analysis procedure automatically records the displacement, rebound and set as will be shown in the results. This analysis takes very little time to process and produces the *staircase graphical output* of displacement versus time.

The cameras selected for evaluation, produced imagery with digital resolutions of 8 to 14 bits. Thus, the effective radiance intensity in terms of digital counts for the camera systems range from 0-255 for 8-bit to 0-16384 digital counts or intensity values for 14-bit recordings. The Nikon cameras all produce >8-bit videos which helps eliminate the need for higher frame rates. The JVC camera records at 8-bits and frame rates as high as 600 Hz. Analyses of the videos images indicates that the higher frame rates did not produce as reliable results because the required integration time was much shorter therefore, requiring higher light levels to enable the automated edge contrast detection algorithms to work properly. Vibrations detected during driving needed to be removed.

The use of vibration reduction lenses and zoom capabilities also allows the user to produce high quality displacement results. A stable image sequence with high zoom allows the user to calibrate (i.e. measure) small pixel sizes. The small pixel sizes are determined by knowing any known size of a feature on a pile or SPT rod. In practice we used a piece of tape placed anywhere on the pile near the beginning of the pile driving. Any change in zoom level and or change in the distance of the camera from the pile or rod requires a recalibration of the pixel size, which is accomplished using a piece of tape. Once the pixel size is known, using the number of pixels in a specified tape width, the width or dimensions of a pixel is calculated. This measurement allows one to calculate the number of pixels per inch. The process is enhanced using a magnifying camera film loupe. This magnification loupe allows precise measurement of the tape or other features on a pile or SPT rod.

Figure D-6 is a photo extracted from within the video recorded at 60 frames per second at the 75-foot mark of the concrete test pile at Dunns Creek in Palatka Florida. Black electrical tape and white reflective tape were both visible within the frame. Calibration of the black tape indicted the video frame pixels were 0.658 mm in height. The black tape was tracked as the pile was driven into the soil. The white reflective tape was used by the PDM system to produce movements per hammer blow for validating the camera monitoring system.

## D.6. **Essential Video Imagery Processing Steps**

Figure D-5 is a flow chart describing the five critical image and signal processing steps used to process the high-speed camera video recordings. Keep in mind that image calibration is performed once for a pile or rod being driven, unless the position of the camera is changed, or the lens zoom level is changed. The key steps include the following steps.

(1) Obtaining images then converting each video frame to an image.

(2) Determining a region of interest (ROI) for the signal detection and analysis.

(3) Analyzing each ROI to detect a paint line or tape and determine displacements in terms of mm or inches to produce the position change of the marking on the pile or rod.

(4) Modifying steps 1 thru 3 to optimize the signals such that plots of displacement versus time are produced.

(5) Safely acquiring additional data for subsequent piles or SPT rods.

The raw data are used to calculate the displacement statistics, including rebound and set for a sequence of hammer blows plus standard error of the mean displacement.

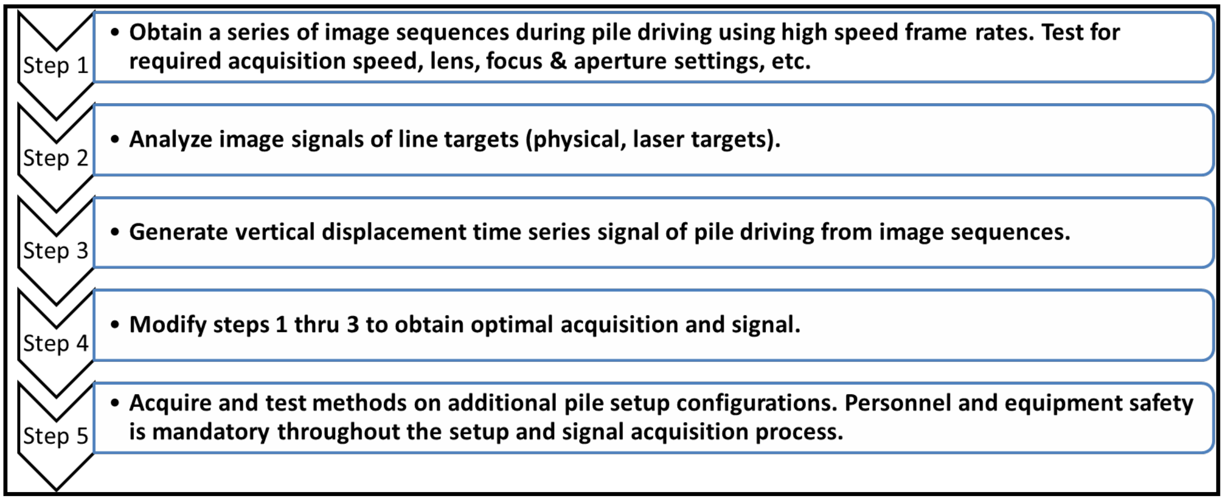



Figure D-5 Five Steps for Processing Video Imagery

Figure D-6 Dunns Creek Concrete Test Pile Photo at 75-Foot Location from 9/19/2018 Video Frame Recorded At 60-Hz

## D.7. **Laboratory Pixel Size Calibration**

For this research the pixel size calibration procedure was developed using a wooden box built to simulate a pile as shown in the standard photo in Figure D-7. The calibration procedure requires the use of eye or loupe scopes (Figure D-8) with a reticule[1]. Bullet crosshair targets were placed on the wooden pile for pixel size calibrations. During calibration, the test pile was placed on foam and a sledgehammer was used to simulate a pile driving hammer strike. The vertical displacement was tracked using the white or black tape and paint lines. The corresponding video image was then used to develop the calibrations as shown in Figure D-8.

[1] Reticule: a series of fine lines in a scope often found in telescopes, cameras and rifles; also a women's small handbag with meshing☺.

Figure D-7 Laboratory wooden simulated pile with PDM and CMS markings

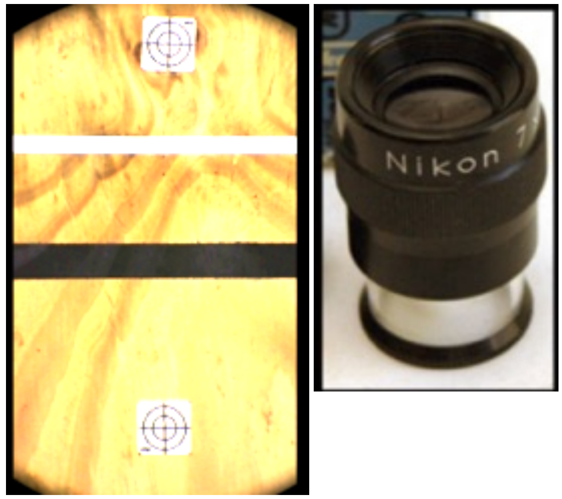



Figure D-8 Video Image of the Wooden Laboratory Test Pile and Markings Plus Photo of Eye or Loupe Scope

## D.8. **Pile Driving Movement Evaluation Procedure**

Once the lab camera pixel calibration was completed, the target can be placed on the pile or SPT rods and used to determine movements. The corresponding field video analysis procedure produces a pixel size in terms of mm or inches as shown in Figure D-9.

Figure D-9 includes two images, the left most image includes a region of interest (ROI) established for the analysis. The vertical distance shown is approximately 1-foot and includes 966 pixels. The right most image shows that 61 pixels are within the black tape, which was measured with the loupe scope as 12 mm, producing a pixel width of 0.197 mm or 0.00774 inches. Figure D-9 was acquired at the Baldwin Bypass site near Jacksonville, Florida.

The procedure for calibration of videos for *each site* requires the determination of the vertical size of a pixel within a video image. This measurement is accomplished by using the known width of a piece of tape. Knowledge of tape width is determined using a loupe or eye scope with a reticule as shown in the image. This allows one to determine the pixel size in mm or inches. Once known, any pixel, tape or paint line can be tracked by analysis of the region of interest from one video image to another in a temporal sequence as described below.

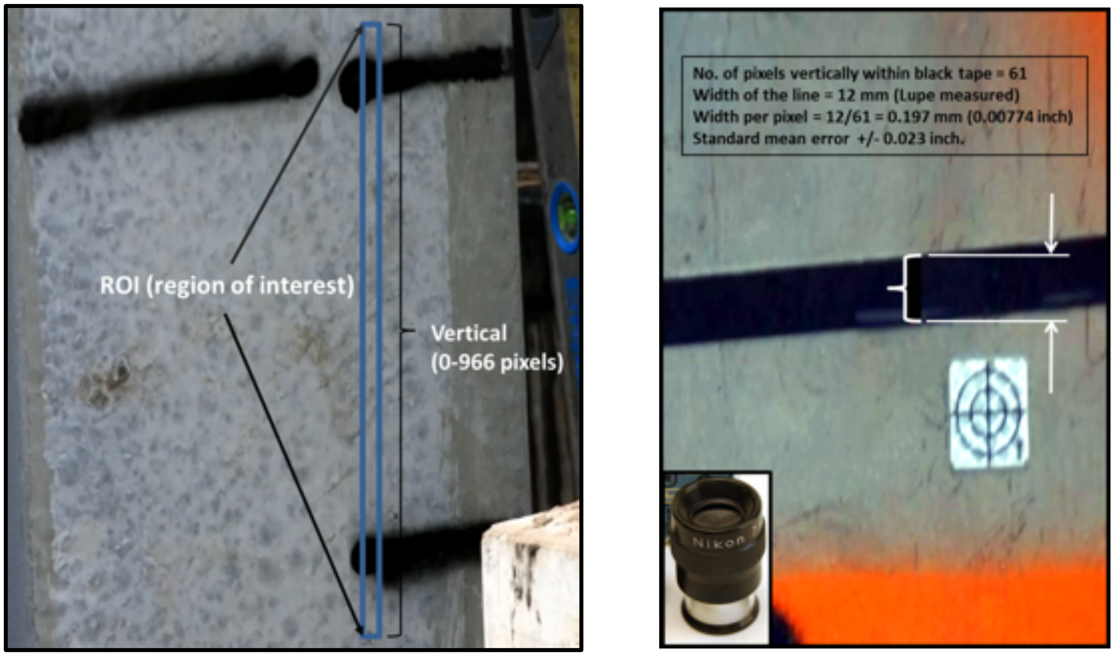



Figure D-9 Video Images Showing Pile Markings and Analysis of ROI to Produce Pile Driving Movements

## D.9. **Video Processing**

All videos sequences are recorded in standard *mpeg* or *mov* format using the Nikon cameras. The JVC video camera recordings are converted to *mov* or *jpeg* format. Video sequences are cropped with respect to time. Cropping reduces the video sequence lengths and corresponding file size. Videos are cropped to seconds based upon the chosen pile driving hits to be analyzed. For the concrete piles cropping was chosen as the length of time required to drive a pile at least one foot. During this time interval the number of hammer blows can be counted using the sound recording in the selected video to be analyzed. Next, each frame in the video is converted to a jpeg image file format. Then a ROI within the jpeg images is selected and a reduced image (cropped in size) can be used to automatically track the displaced tape or paint line vertical position as the pile driving occurs. The paint line or tape is found in each ROI image. Figure D-10 shows a typical set of CMS video imaging results. These data are then reduced to deflections per blow similar to Figure D-11.

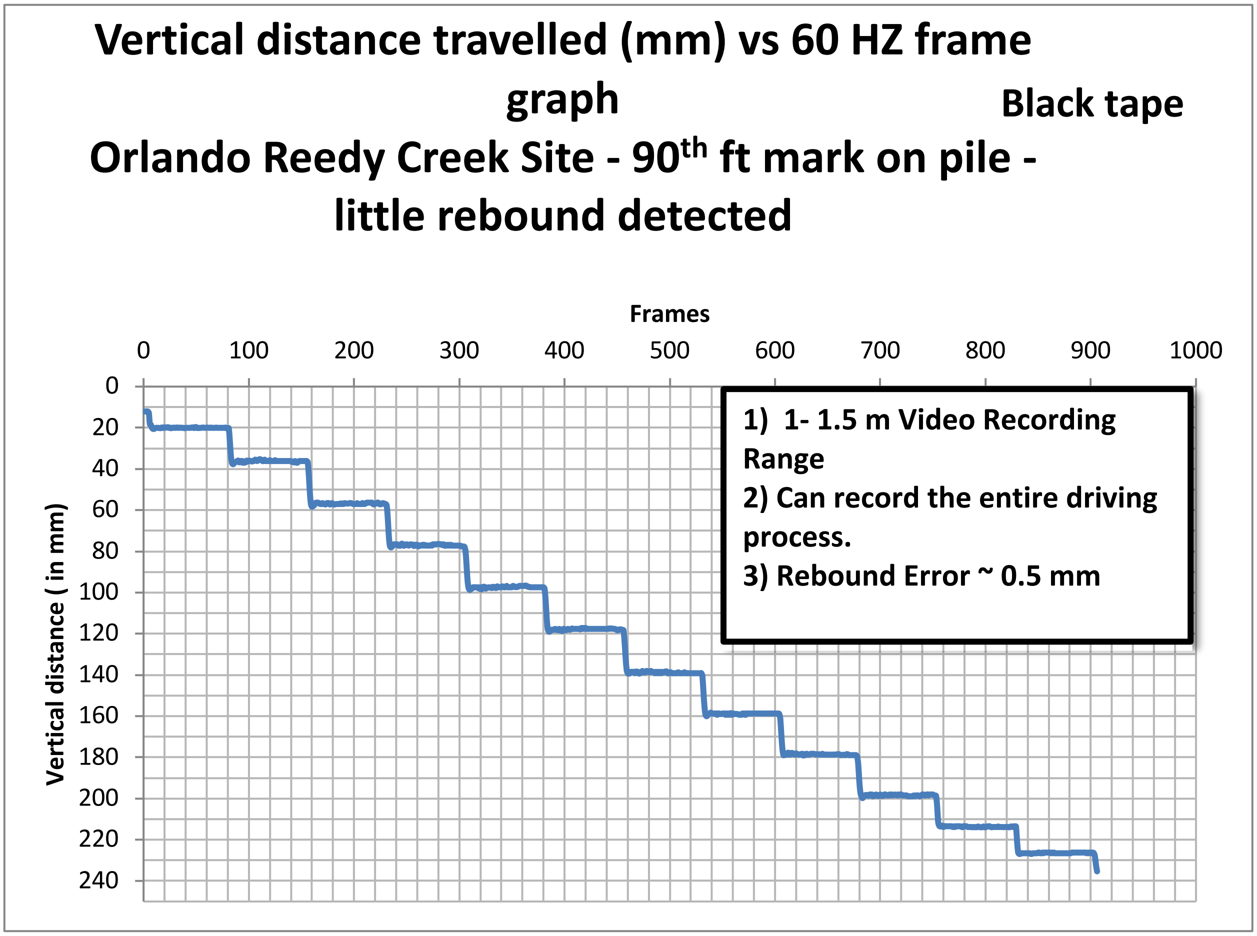



Figure D-10 Typical Image Processing of Vertical Deflection versus Frame Number

| Blow | Date | Time | Max Pile Top Displacement (Inches) | Pile Top Set (Inches) | Pile Top Rebound (inches) |
|---|---|---|---|---|---|
| 940 | 5/14/18 | 2:45:06 PM | 0.5944 | 0.3424 | 0.2520 |
| 941 | 5/14/18 | 2:45:08 PM | 0.7364 | 0.5993 | 0.1371 |
| 942 | 5/14/18 | 2:45:09 PM | 0.6368 | 0.3905 | 0.2463 |
| 943 | 5/14/18 | 2:45:11 PM | 0.6004 | 0.3712 | 0.2292 |
| 944 | 5/14/18 | 2:45:12 PM | 0.5917 | 0.3528 | 0.2389 |
| 945 | 5/14/18 | 2:45:13 PM | 0.5740 | 0.2664 | 0.3075 |
| 946 | 5/14/18 | 2:45:15 PM | 0.5895 | 0.3003 | 0.2892 |
| 947 | 5/14/18 | 2:45:16 PM | 0.6041 | 0.3202 | 0.2839 |
| 948 | 5/14/18 | 2:45:18 PM | 0.5380 | 0.2523 | 0.2857 |
| 949 | 5/14/18 | 2:45:19 PM | 0.5961 | 0.3398 | 0.2563 |
| 950 | 5/14/18 | 2:45:21 PM | 0.6306 | 0.4111 | 0.2194 |
| 951 | 5/14/18 | 2:45:22 PM | 0.6376 | 0.4468 | 0.1908 |
| 952 | 5/14/18 | 2:45:23 PM | 0.7232 | 0.5694 | 0.1538 |
| 953 | 5/14/18 | 2:45:25 PM | 0.6215 | 0.4063 | 0.2152 |
| 954 | 5/14/18 | 2:45:26 PM | 0.6416 | 0.4174 | 0.2242 |
| 955 | 5/14/18 | 2:45:28 PM | 0.6356 | 0.4102 | 0.2254 |
| 956 | 5/14/18 | 2:45:29 PM | 0.6324 | 0.4479 | 0.1844 |
| 957 | 5/14/18 | 2:45:30 PM | 0.6141 | 0.3162 | 0.2979 |
| 958 | 5/14/18 | 2:45:32 PM | 0.6702 | 0.4604 | 0.2098 |
| 959 | 5/14/18 | 2:45:33 PM | 0.6438 | 0.3353 | 0.3085 |
| 960 | 5/14/18 | 2:45:35 PM | 0.6077 | 0.3136 | 0.2942 |
| | | **Average** | **0.6247** | **0.3843** | **0.2405** |
| | | **Stand Dev** | **0.0453** | **0.0885** | **0.0492** |
| | | **Std Error** | **0.0099** | **0.0193** | **0.0107** |

Figure D-11 Typical Reduced CMS Measurement Data

The automatic detection of a paint line or tape is performed by selecting a digital count or effective radiance that allows discrimination of the line or tape from the pile background light intensity. The pixels selected are then vertically averaged and horizontally averaged. The averaging process results in one point in each image that changes only in its vertical position as a function of frame number. Knowledge of the frame rate allows time in seconds to be estimated and the pixel size allows the estimation of vertical displacement in inches or mm versus time. A plot of position versus time for each point within an image is saved and the time series is created.

The CMS equipment and data reduction is currently under development. Upgrades to the system will produce near real time results on a robust camera/computer system.

# Appendix E. Soil Profiles and PDA Plots

## E.1 SPT Plots

The SPT plots for each site include boring name, soil descriptions with USCS symbols, elevations, followed by plots with $N_{SPT}$ values versus boring elevation.

## E.1.1 I-4 & SR-417

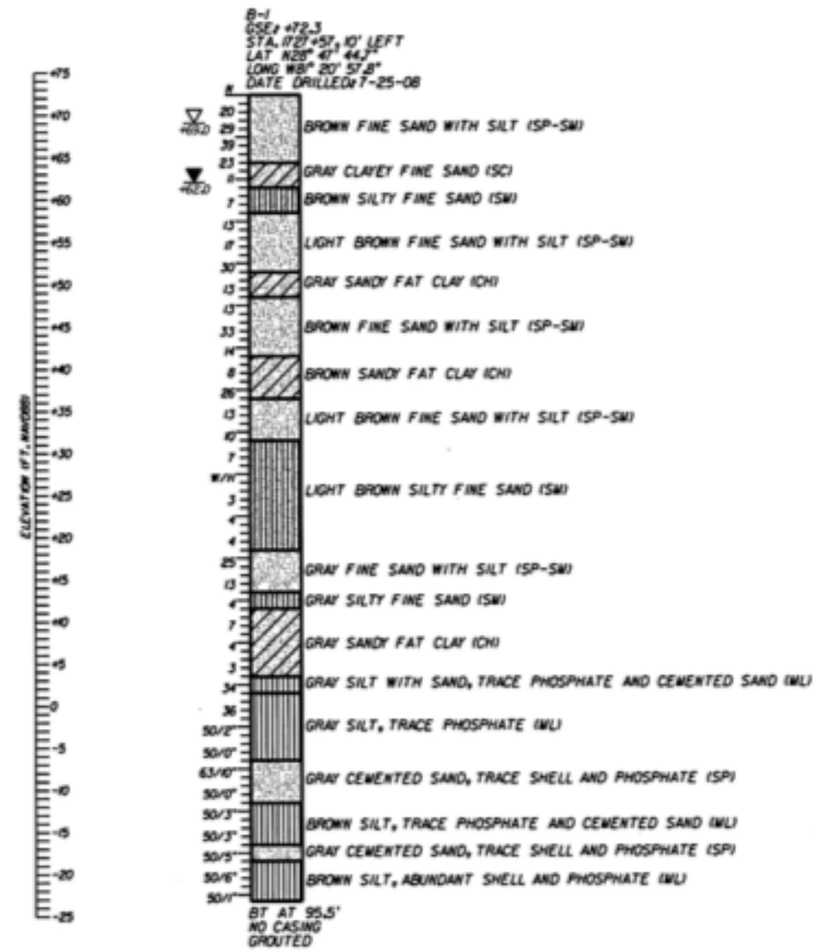



Figure E-1 – I-4 & SR-417 Soil profile for Soil Boring B-1

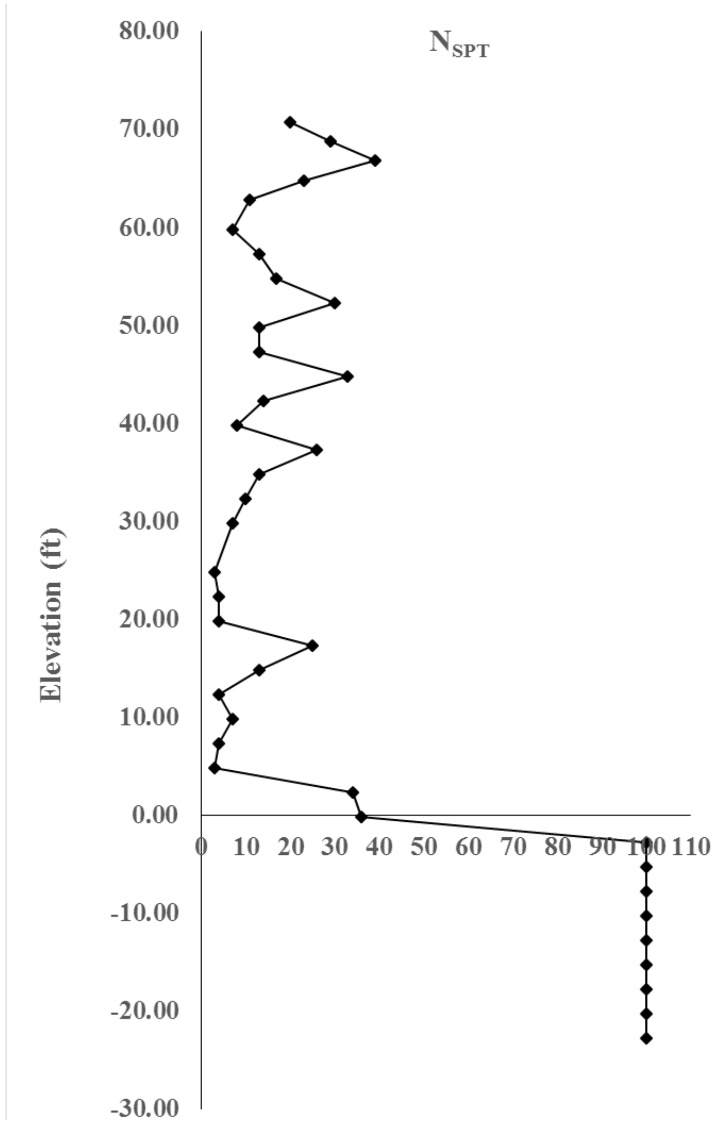



Figure E-2 – I-4 & SR-417 $N_{SPT}$ values for Soil Boring B-1

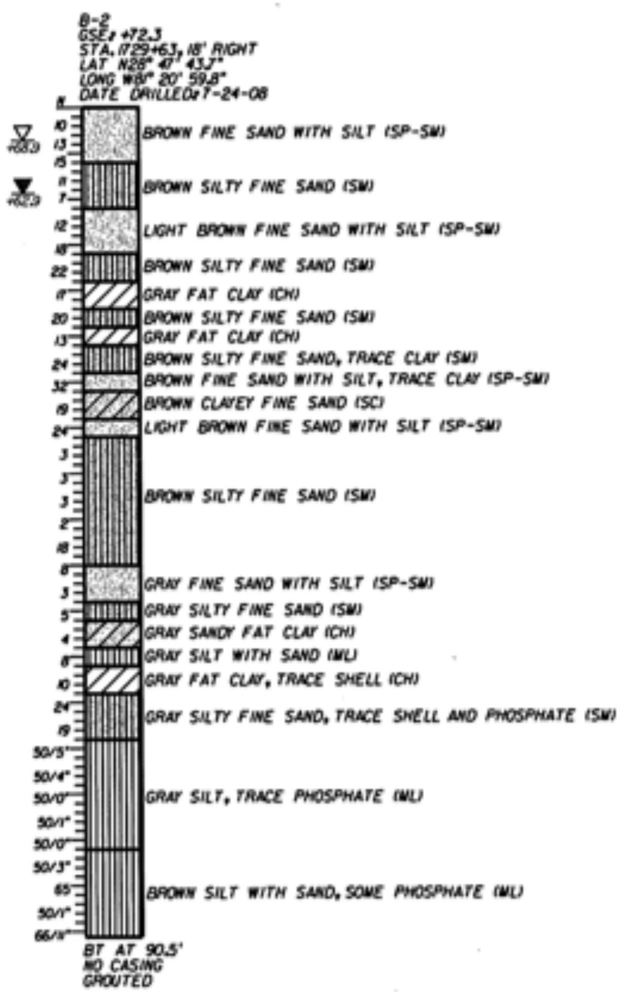



Figure E-3 – I-4 & SR-417 Soil for Soil Boring B-2

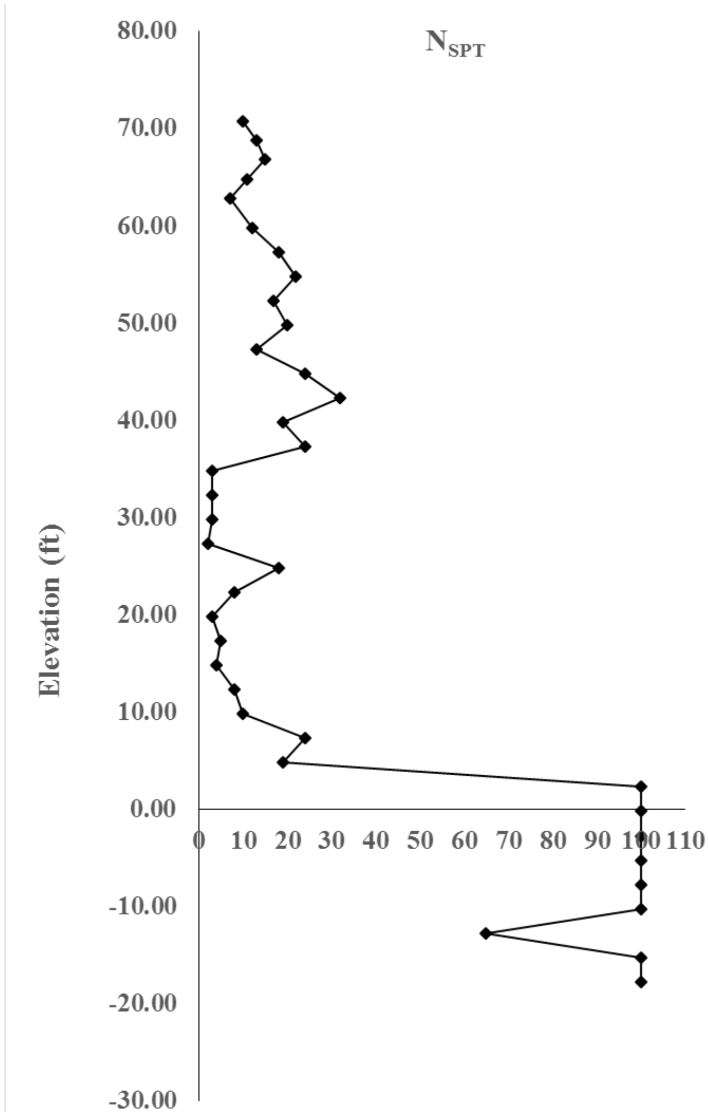



Figure E-4 – I-4 & SR-417 $N_{SPT}$ values for Soil Boring B-2

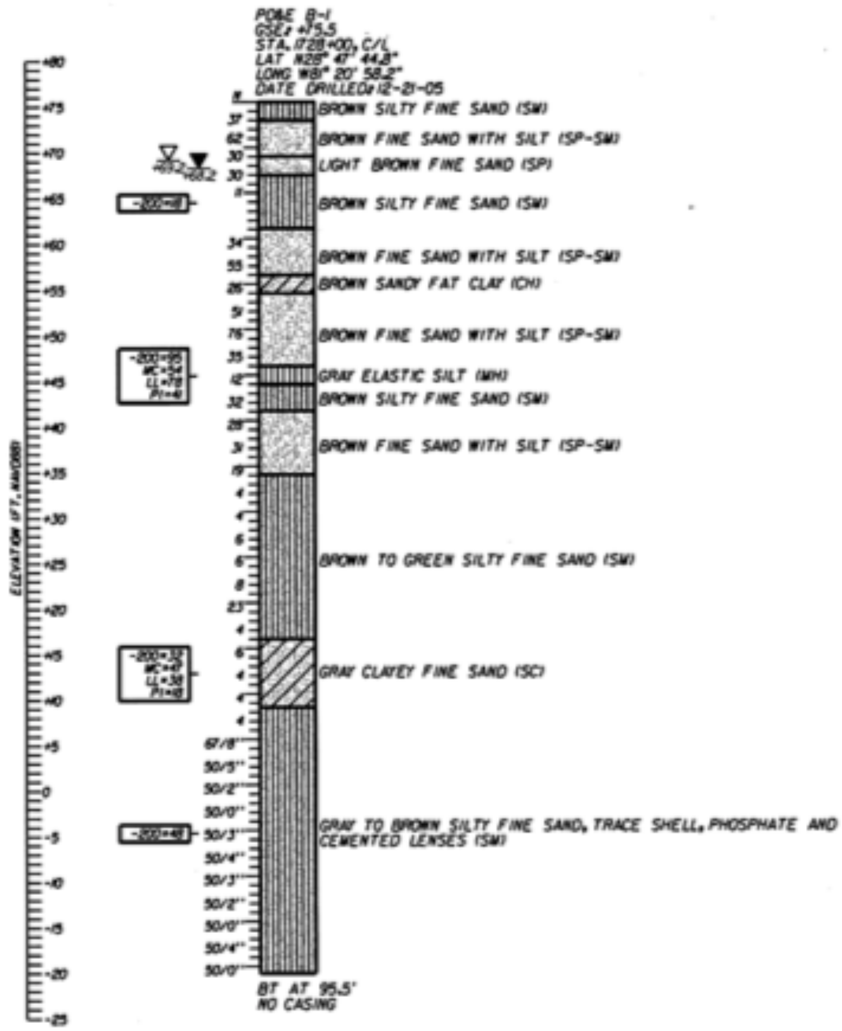



Figure E-5 – I-4 & SR-417 Soil profile PD&E Soil Boring B-1

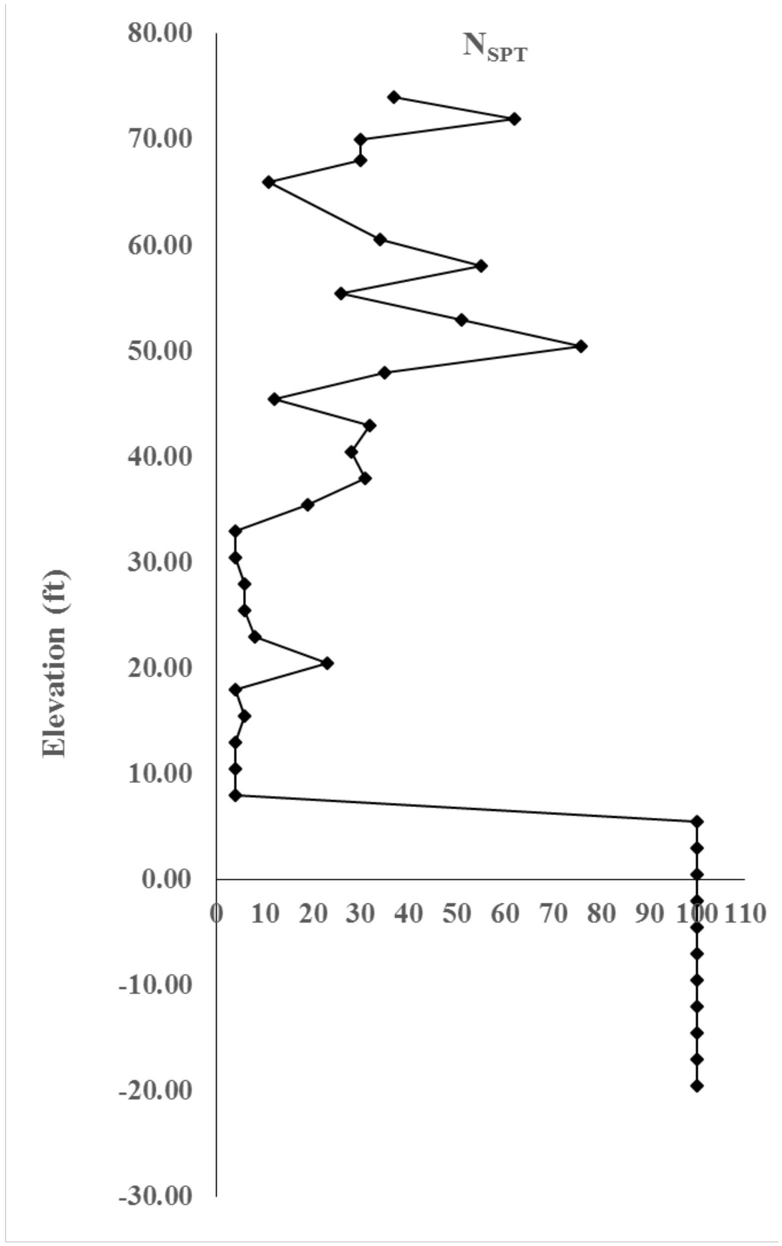



Figure E-6 – I-4 & SR-417 $N_{SPT}$ values for PD&E Soil Boring B-1

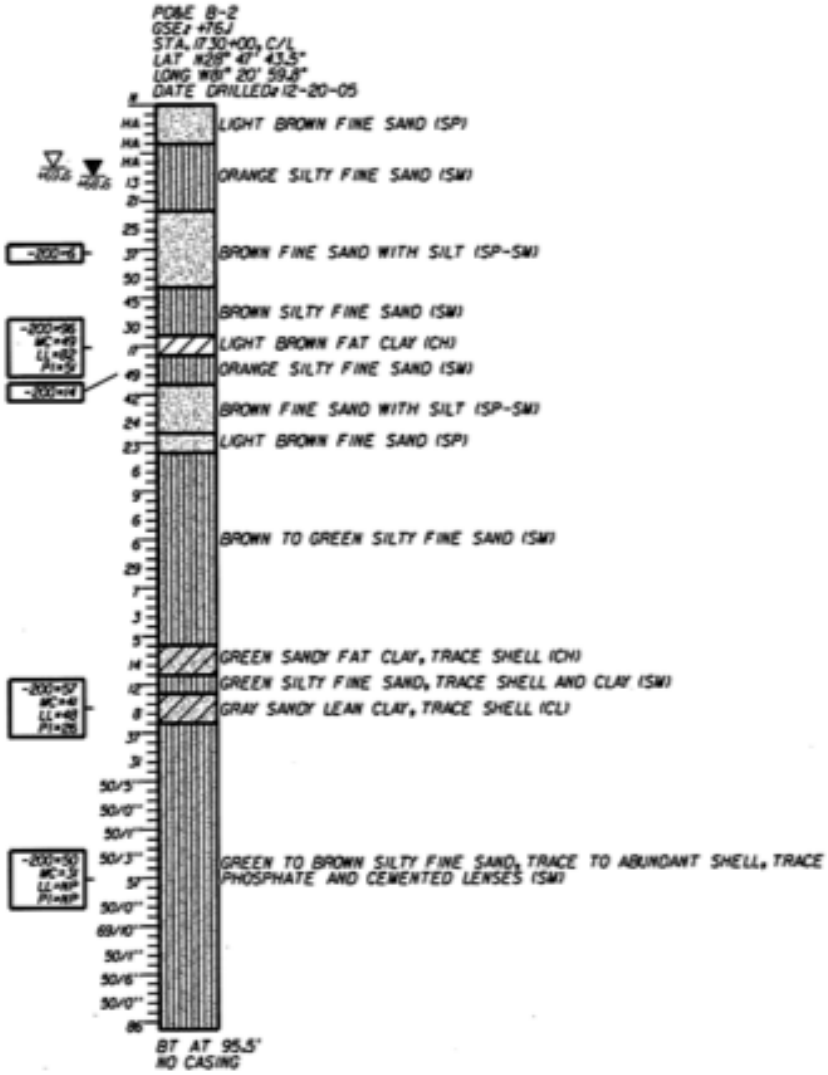



Figure E-7 I-4 & SR-417 Soil profile for PD&E Soil Boring B-2

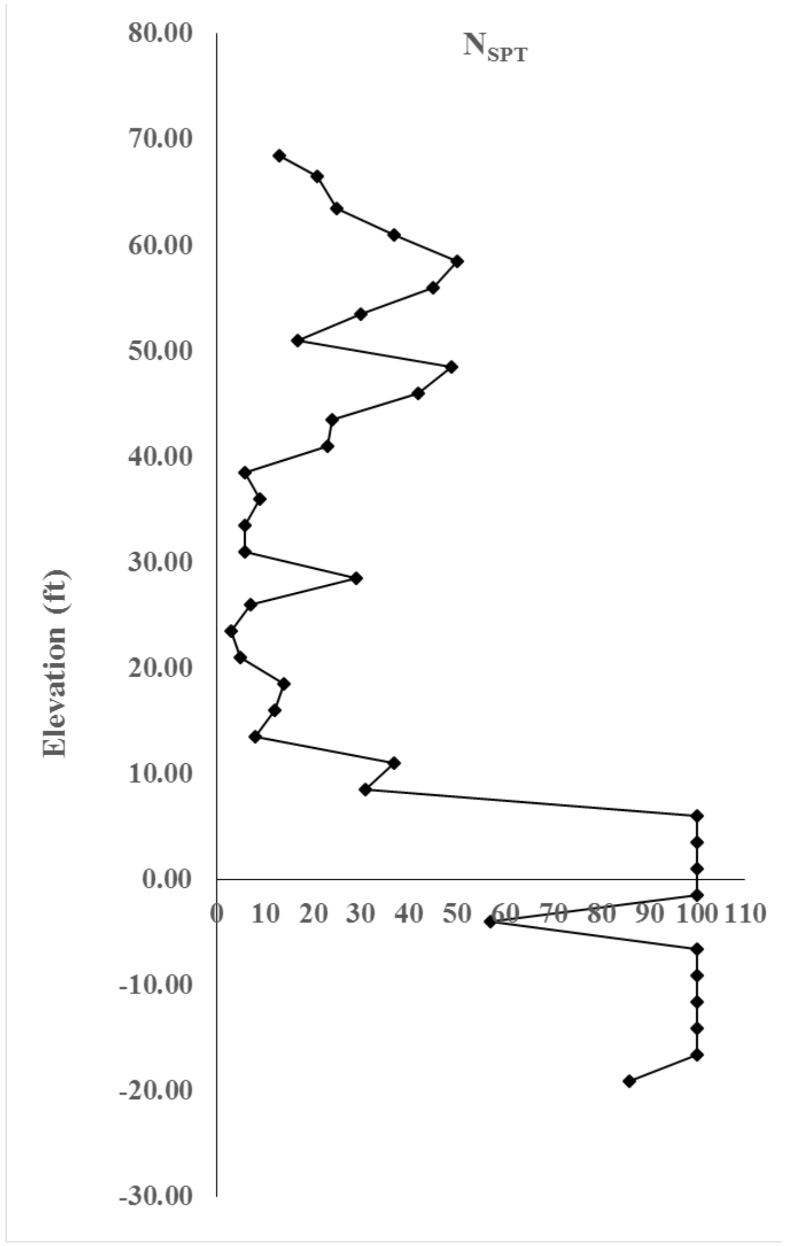



Figure E-8 I-4 & SR-417 $N_{SPT}$ values for PD&E Soil Boring B-2

## E.1.2 Heritage Parkway

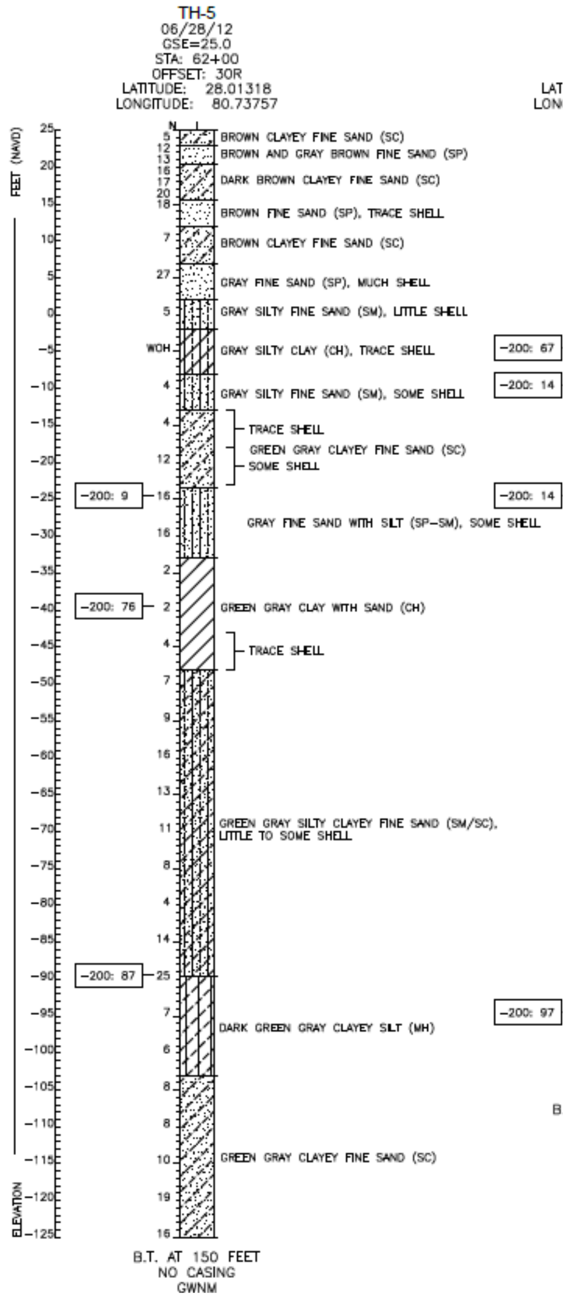



Figure E-9 – Heritage Soil profile for Soil Boring TH-5

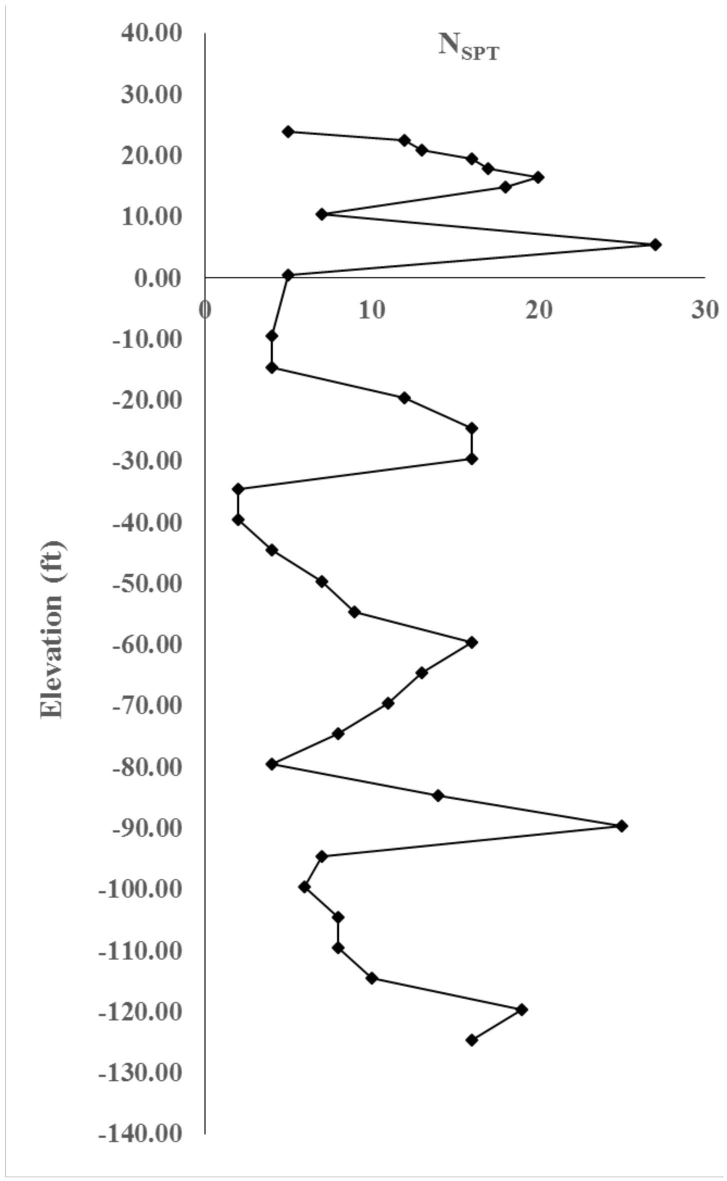



Figure E-10 – Heritage $N_{SPT}$ values for Soil Boring TH-5

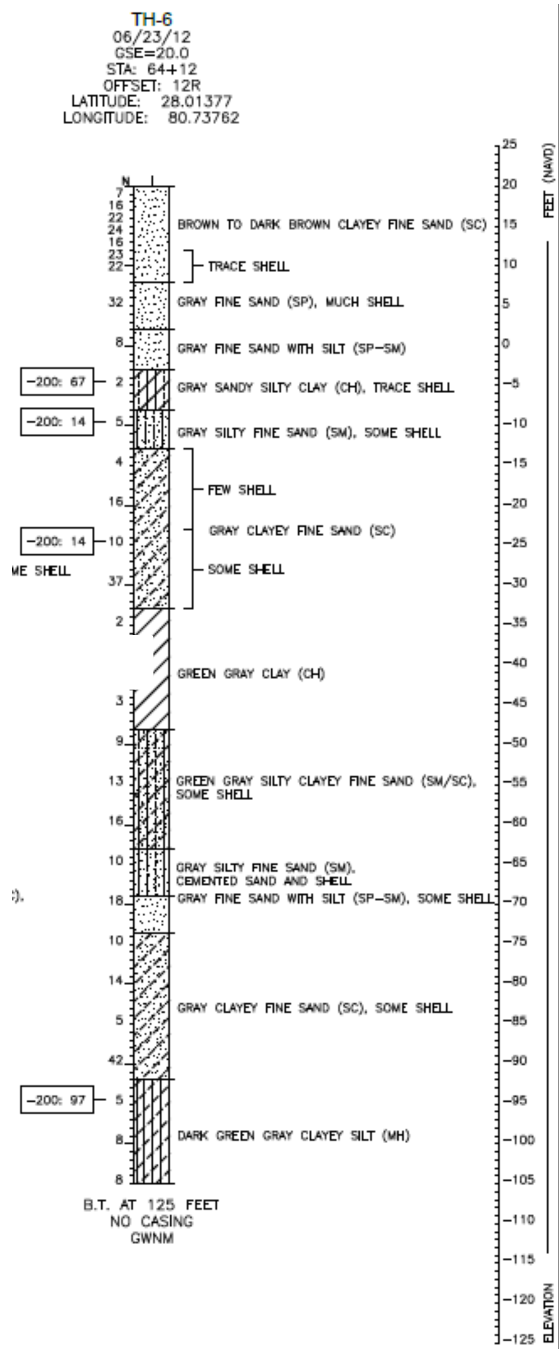



Figure E-11 - Heritage Soil profile for Soil Boring TH-6

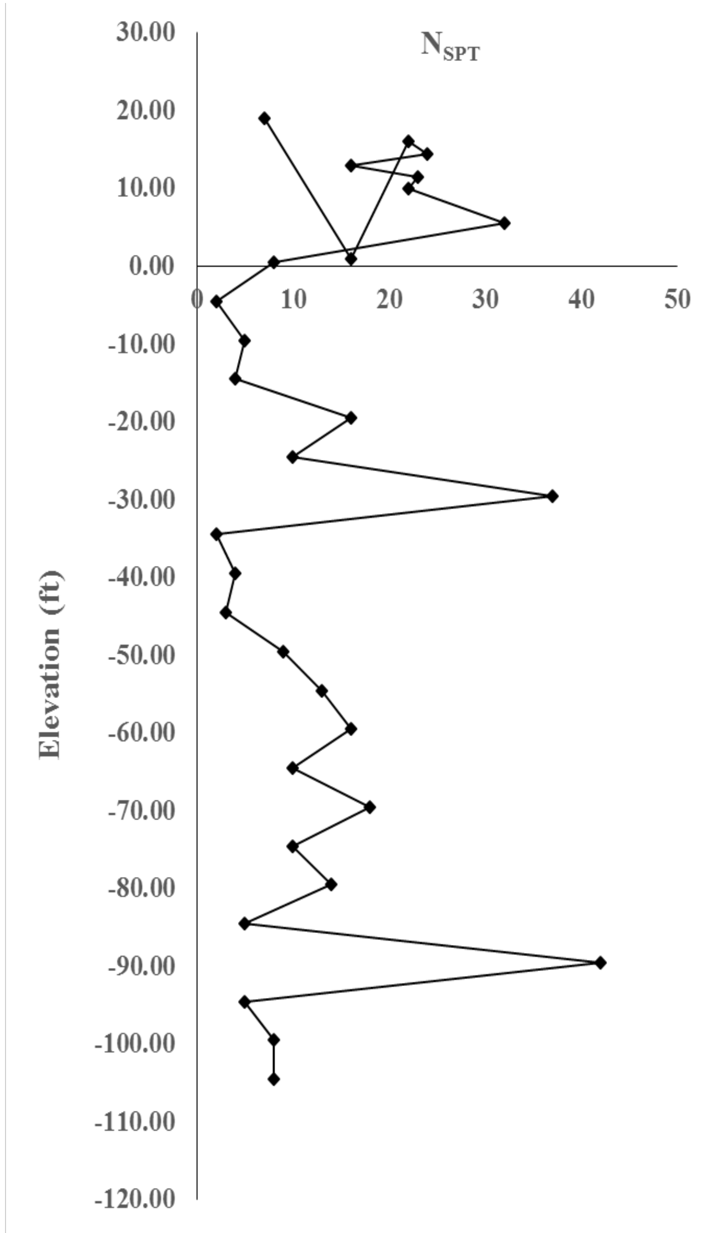



Figure E-12 – Heritage $N_{SPT}$ values for Soil Boring TH-6

## E.1.3 I-10 & Chaffee

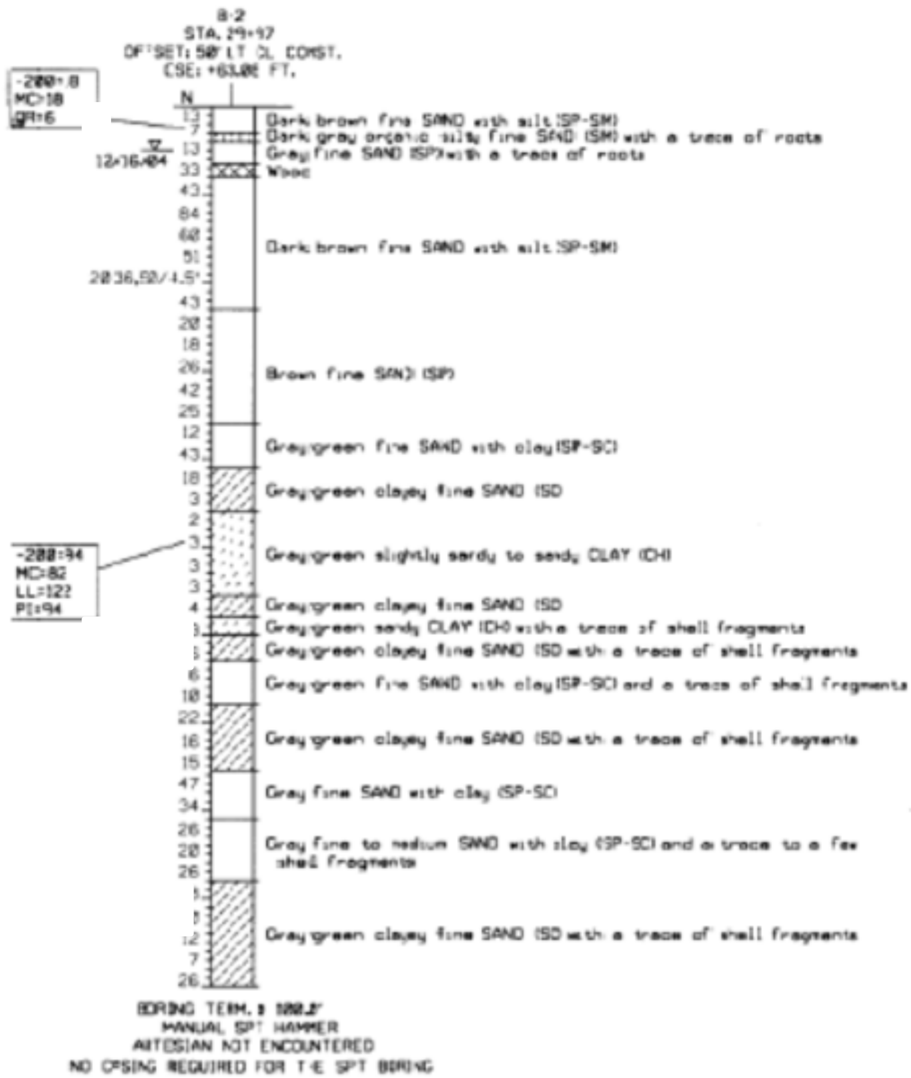



Figure E-13 – I-10 & Chaffee Soil Profile for Soil Boring B-2

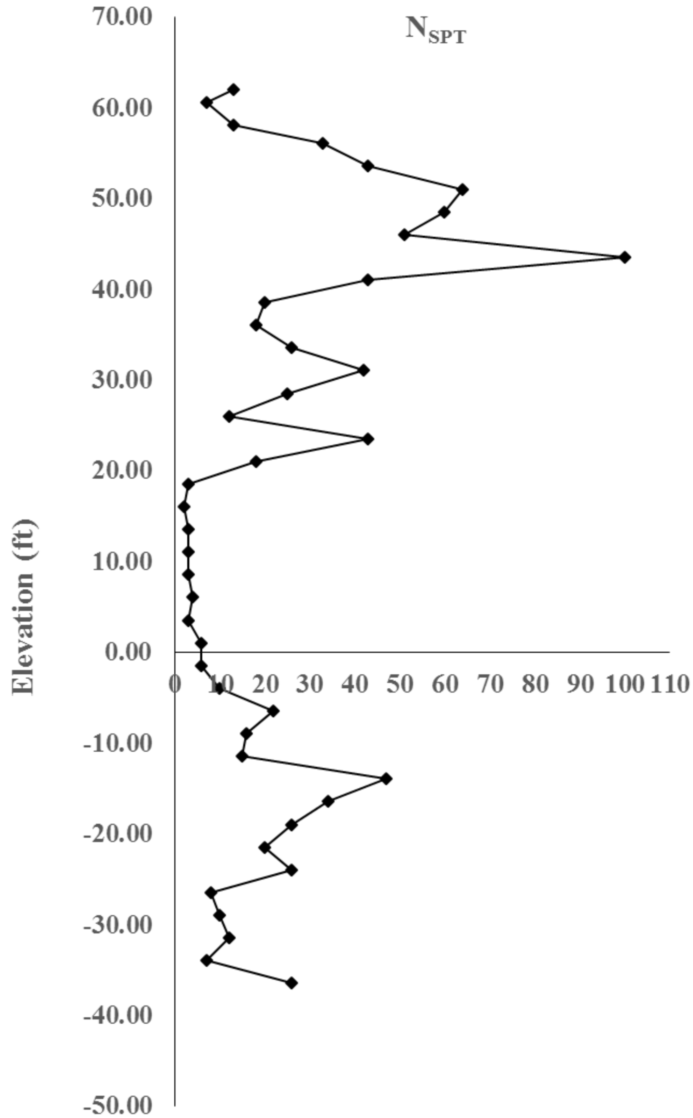



Figure E-14 – I-10 & Chaffee $N_{SPT}$ Values for Soil Boring B-2

E.1.1 I4 – 192

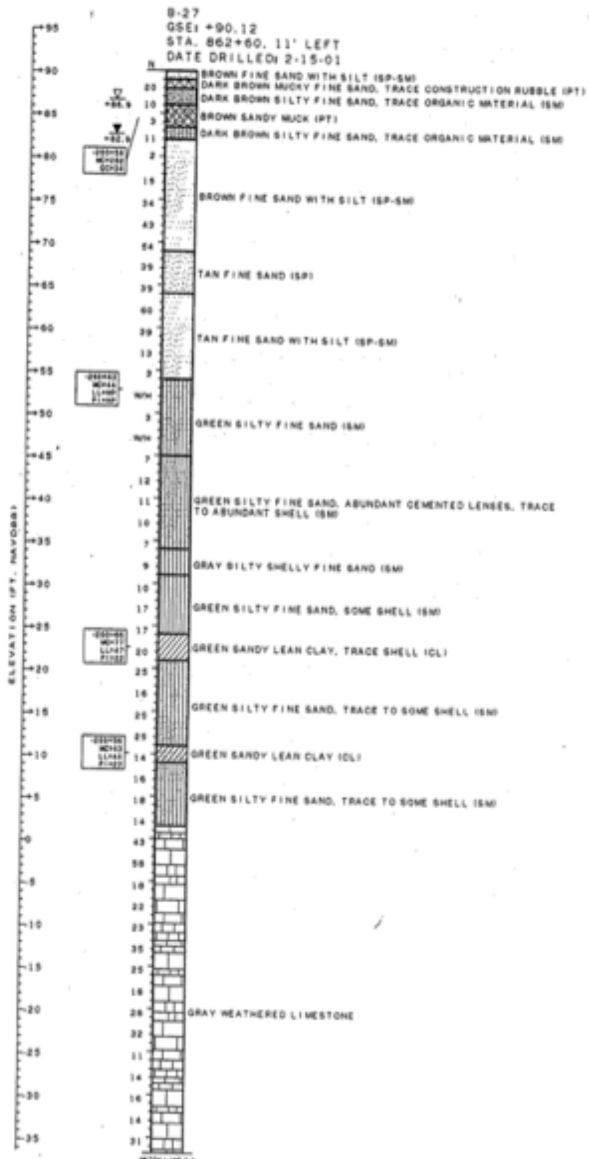



Figure E-15 – I-4 & SR-192 Soil Profile for Soil Boring B-27

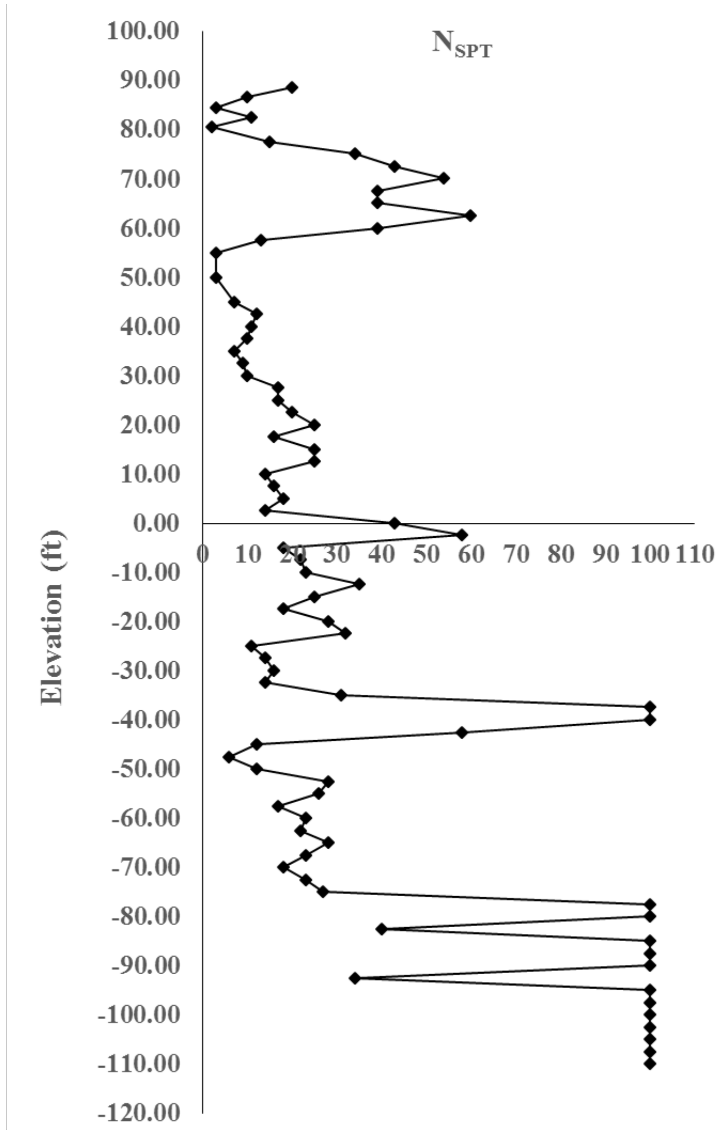



Figure E-16 – I-4 & SR-192 $N_{SPT}$ Values for Soil Boring B-27

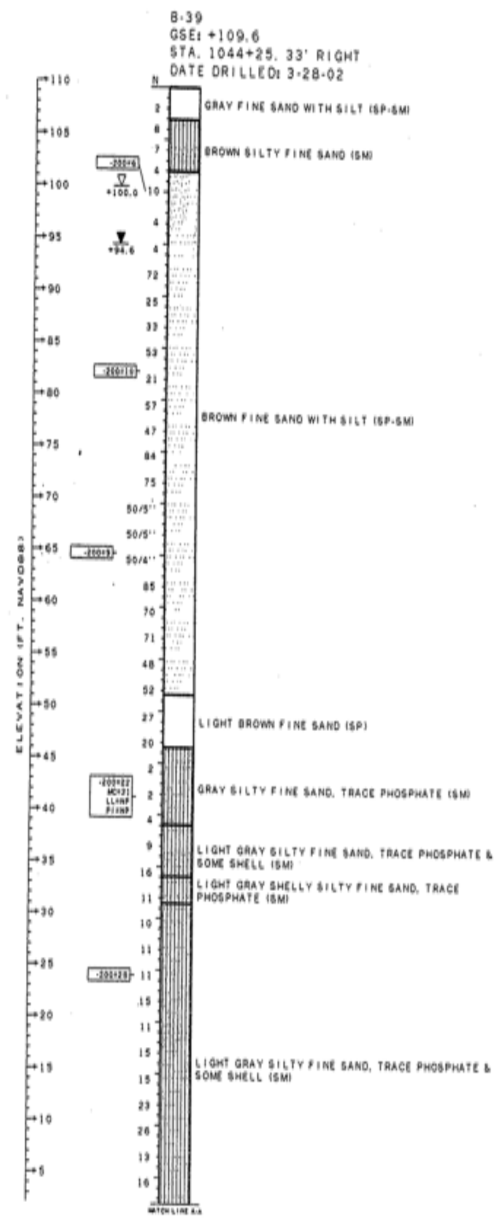



Figure E-17 – I-4 & SR-192 Soil Profile for Soil Boring B-39

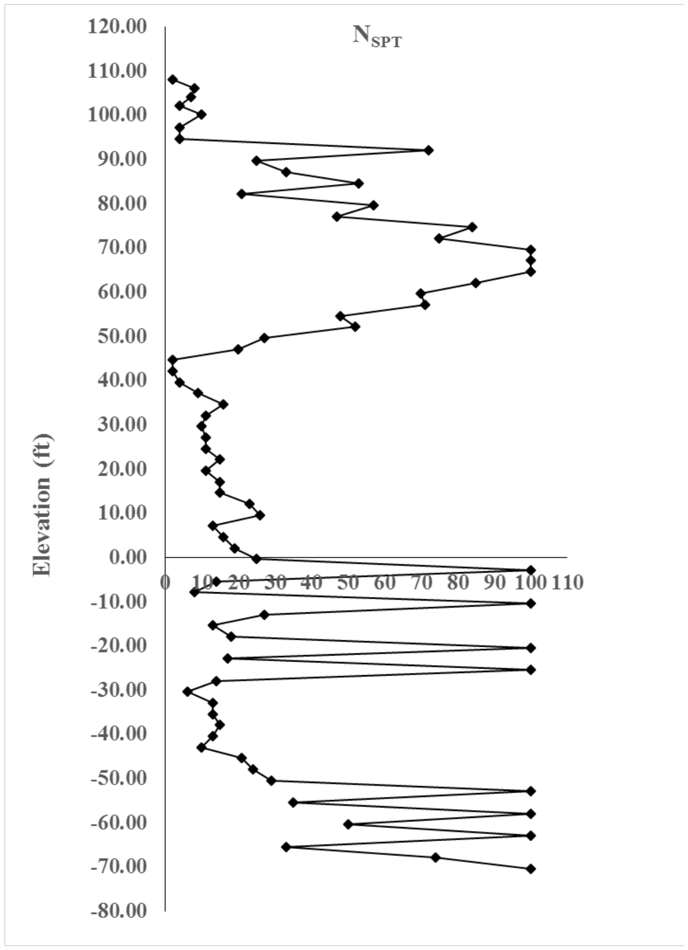



Figure E-18 – I-4 & SR-192 $N_{SPT}$ values for Soil Boring B-39

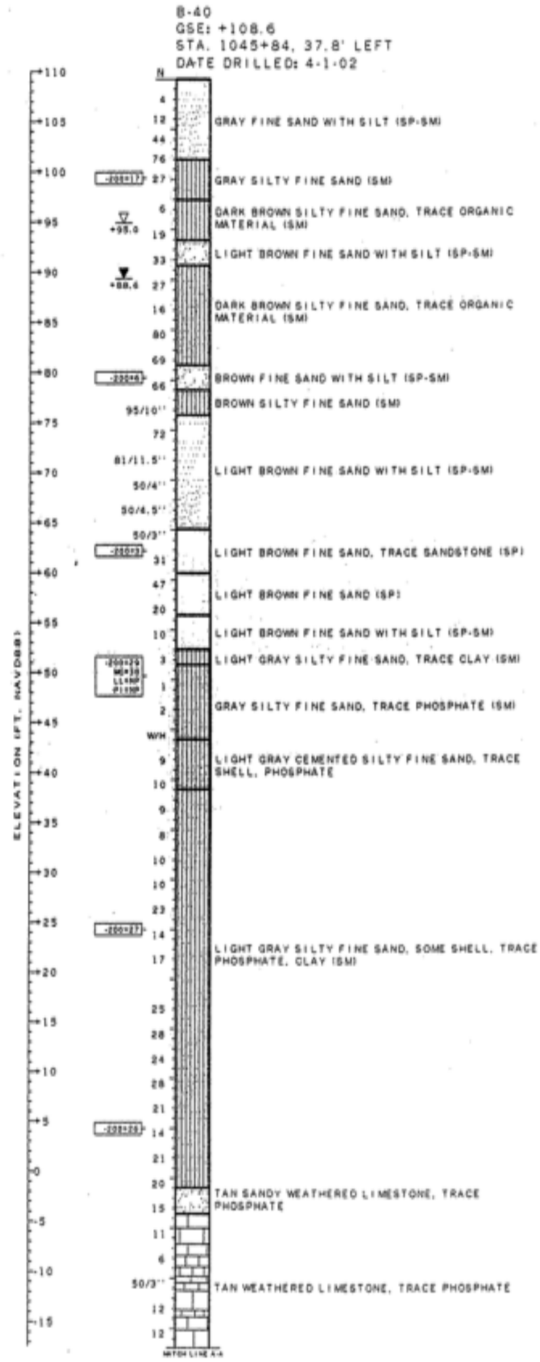


Figure E-19 – I-4 & SR-192 Soil Profile for Soil Boring B-40

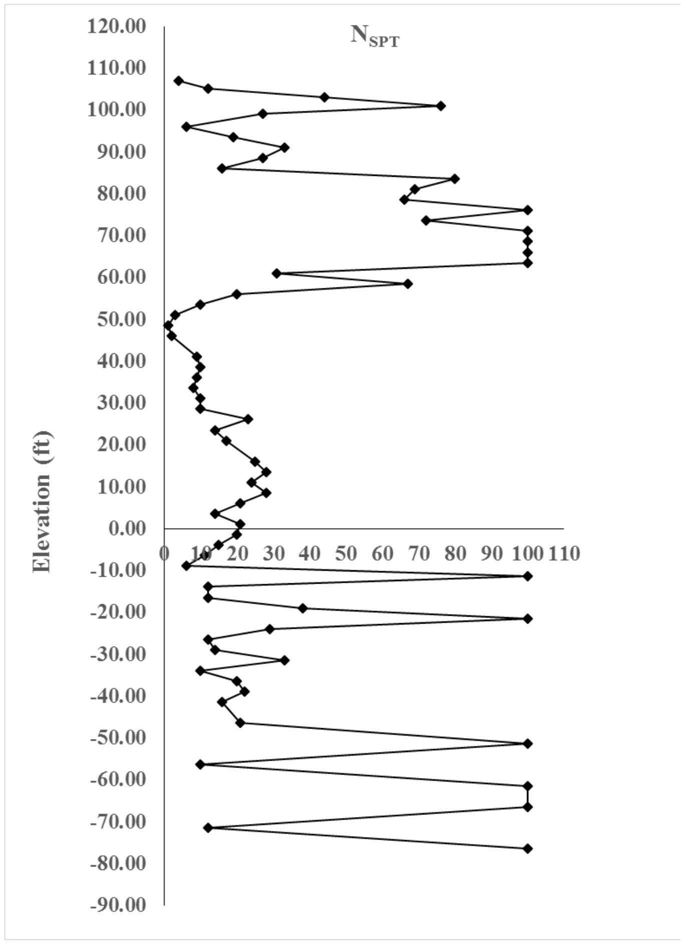



Figure E-20 – I-4 & SR-192 $N_{SPT}$ Values for Soil Boring B-40

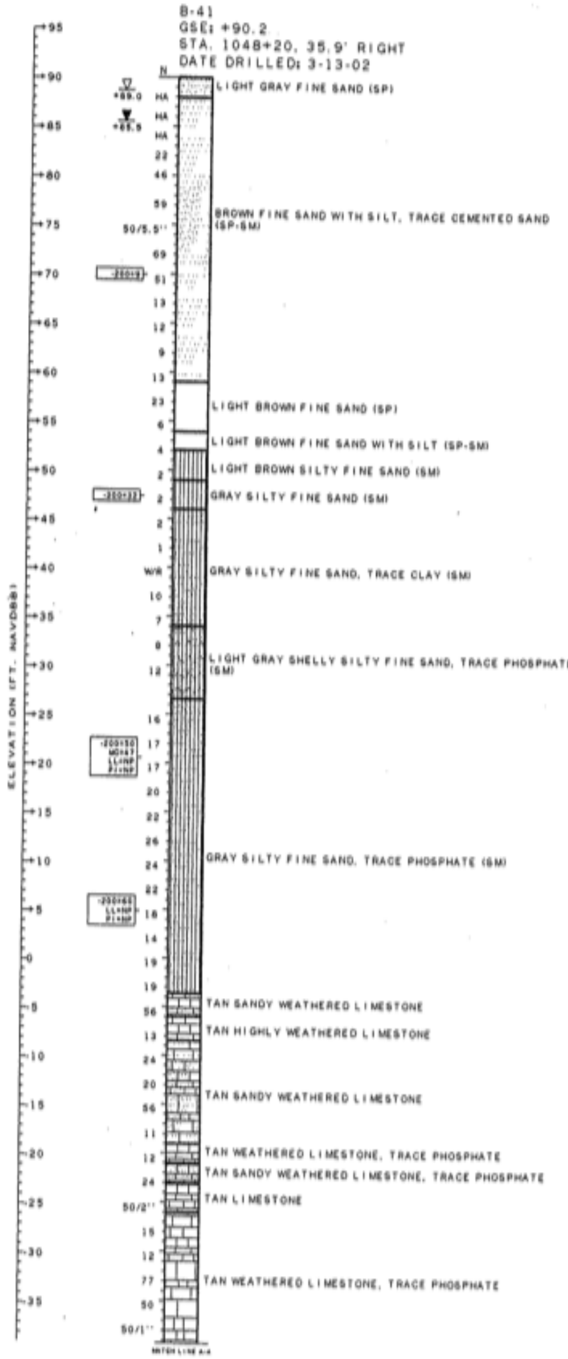


Figure E-21 – I-4 & SR-192 Soil Profile for Soil Boring B-41

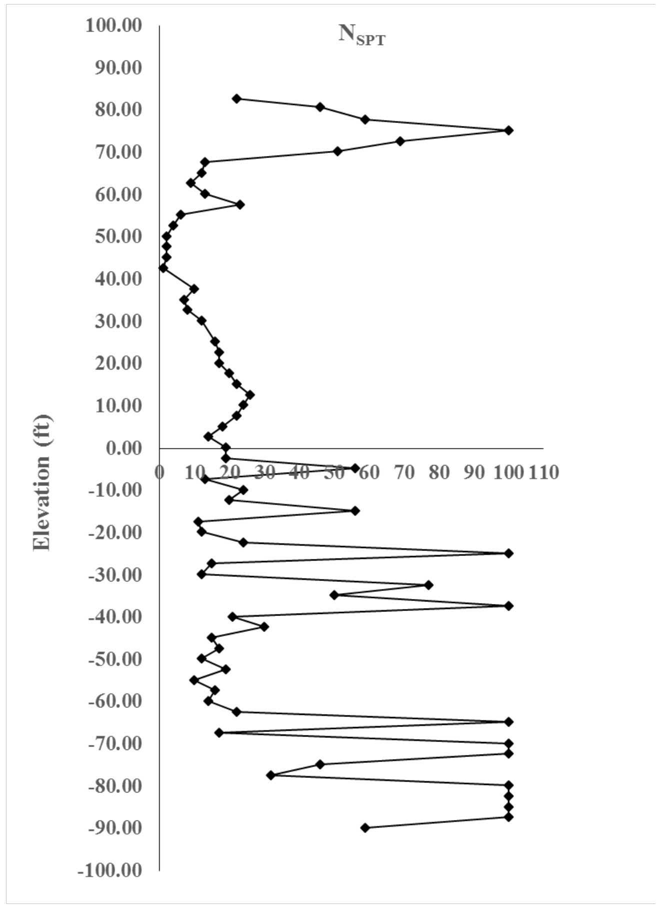



Figure E-22 – I-4 & SR-192 $N_{SPT}$ Values for Soil Boring B-41

## E.1.4 Ramsey Branch

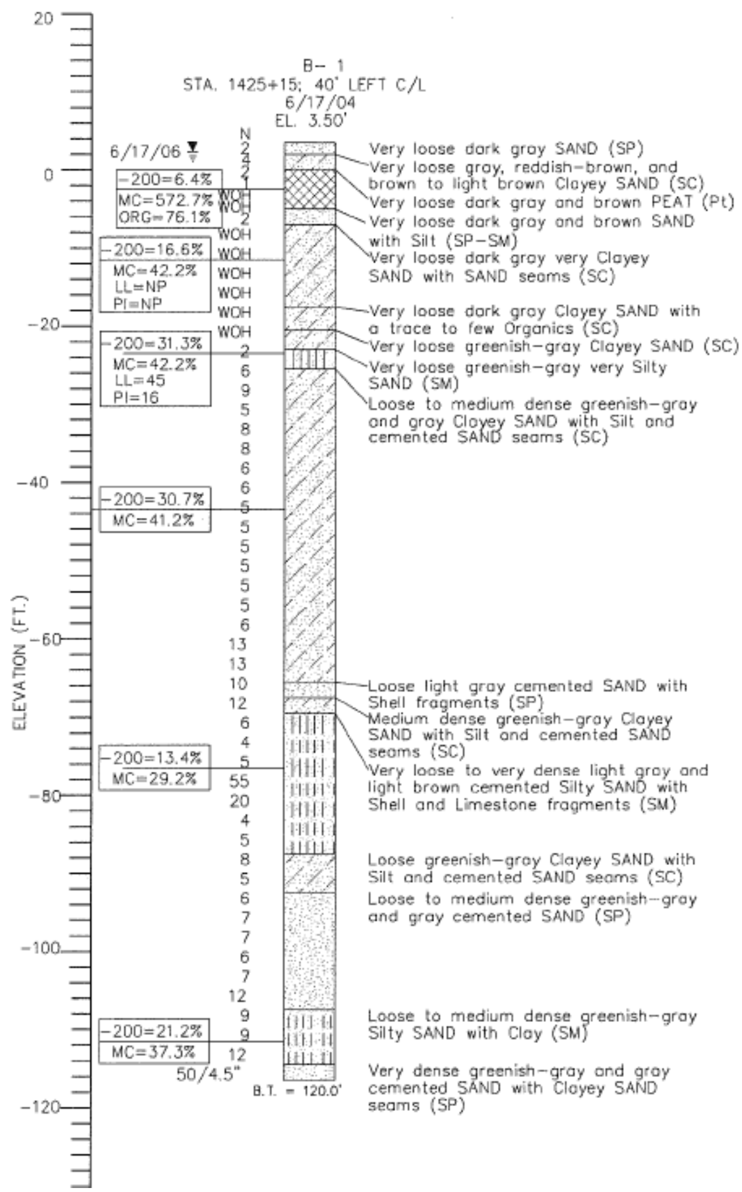



Figure E-23 – Ramsey Branch Soil Profile for Soil Boring B-1

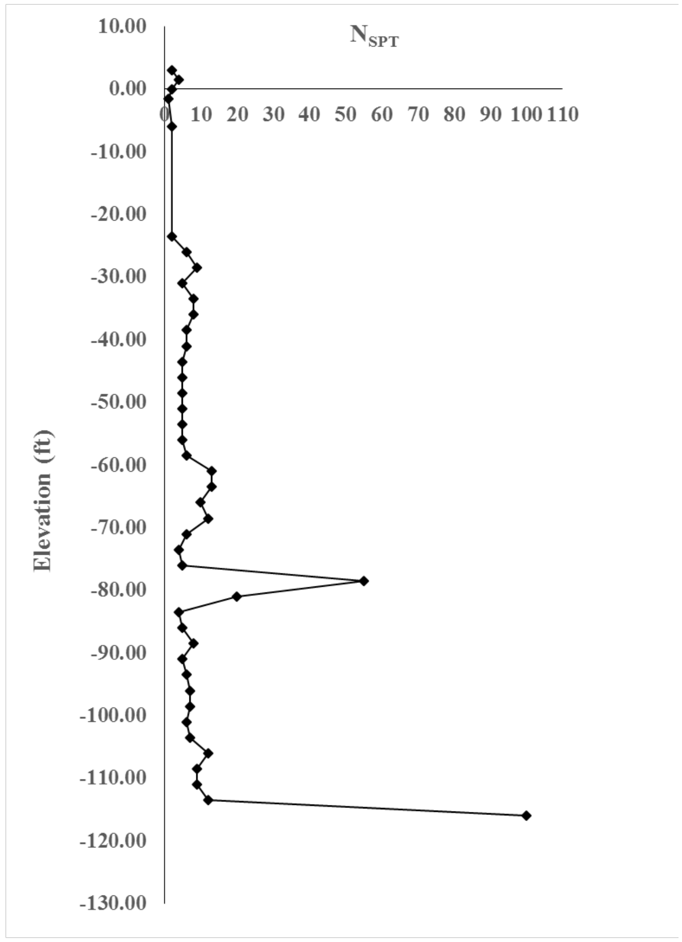



Figure E-24 – Ramsey Branch $N_{SPT}$ Values for Soil Boring B-1

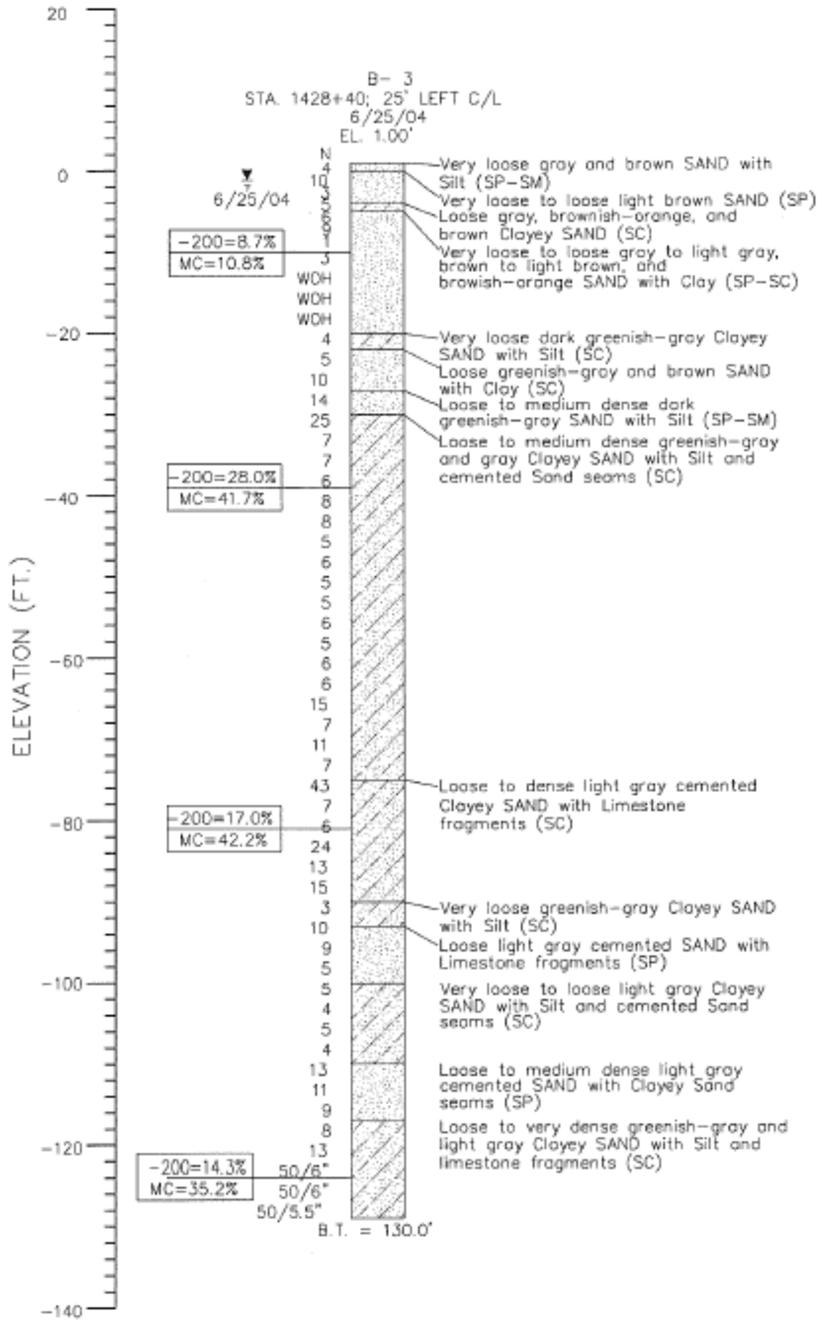



Figure E-25 - Ramsey Branch Soil Profile for Soil Boring B-3

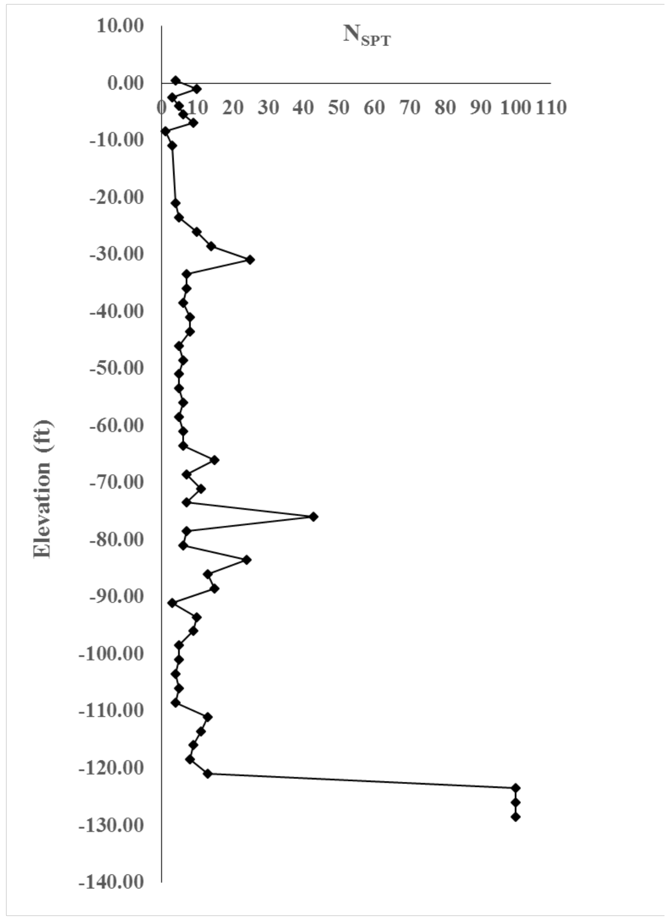



Figure E-26 – Ramsey Branch $N_{SPT}$ Values for Soil Boring B-3

## E.2 PDA Rebound Plots

The following plots show the PDA Maximum Displacement (DMX), Set and Rebound for all 5 sites evaluated. Elevations were calculated by subtracting the depth of the pile driven into the ground from the Ground Soil Elevation (GSE). Some elevation values are negative, meaning that it is below the sea level (elevation = 0).

For some tests, the rebound values were negative, which should not occur. The most likely cause for this would be an error from the Set.

*Notes for figure titles: EB = end bent, IB = Intermediate Bent, PR= production pile, P= pier or pile, PL = pile*

## E.2.1 I-4 & SR-417

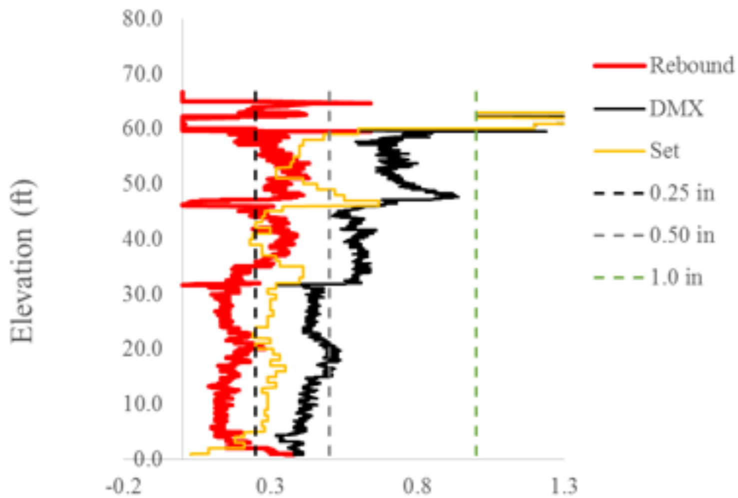



Figure E-27 – I-4 & SR-417 EB1P14

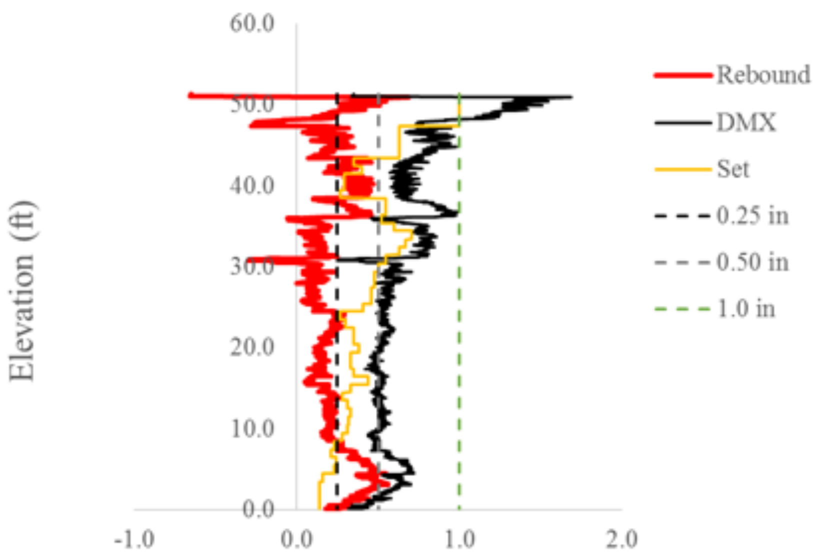



Figure E-28 – I-4 & SR-417 EB2P5

## E.2.2 Heritage Parkway

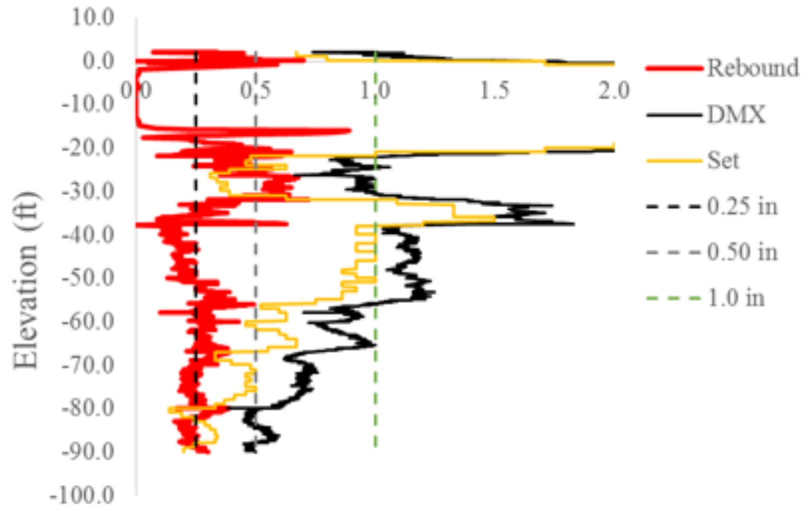



Figure E-29 – Heritage EB1P1

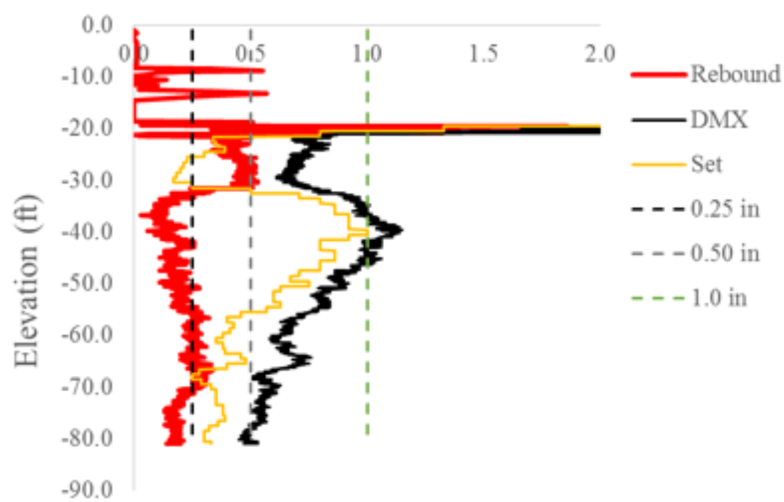



Figure E-30 – Heritage EB5P1

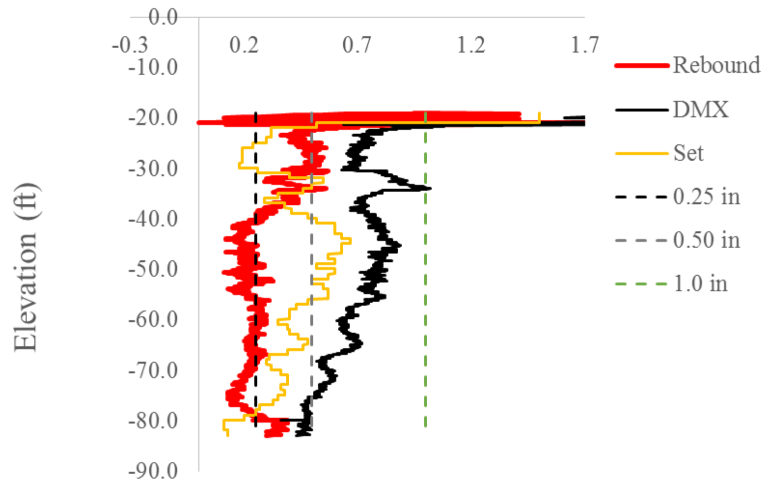



Figure E-31 – Heritage IB2P10

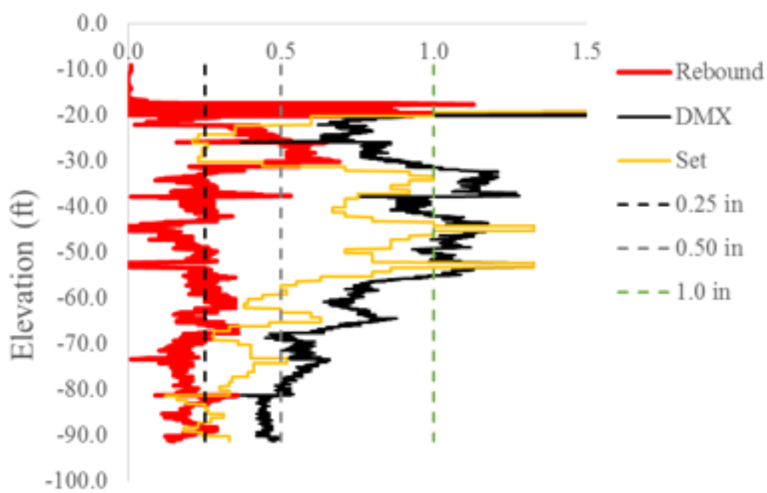



Figure E-32 – Heritage IB3P1

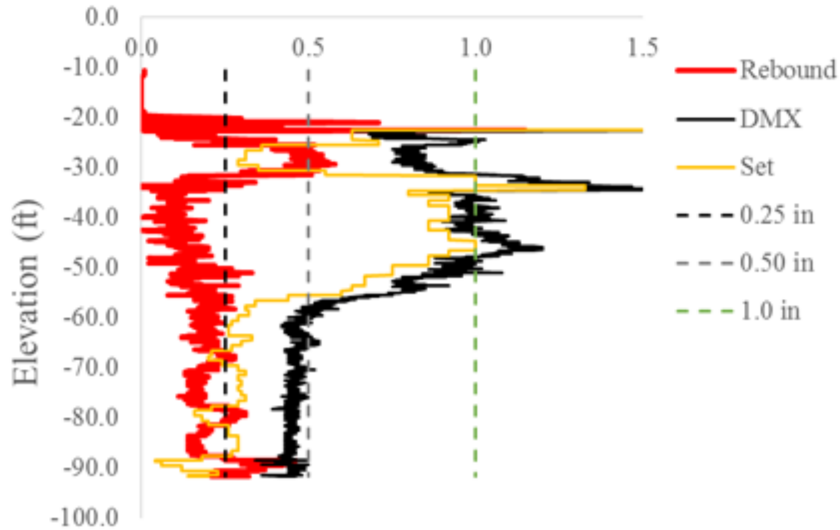



Figure E-33 – Heritage IB4P10

### E.2.3 I-10 & Chaffee

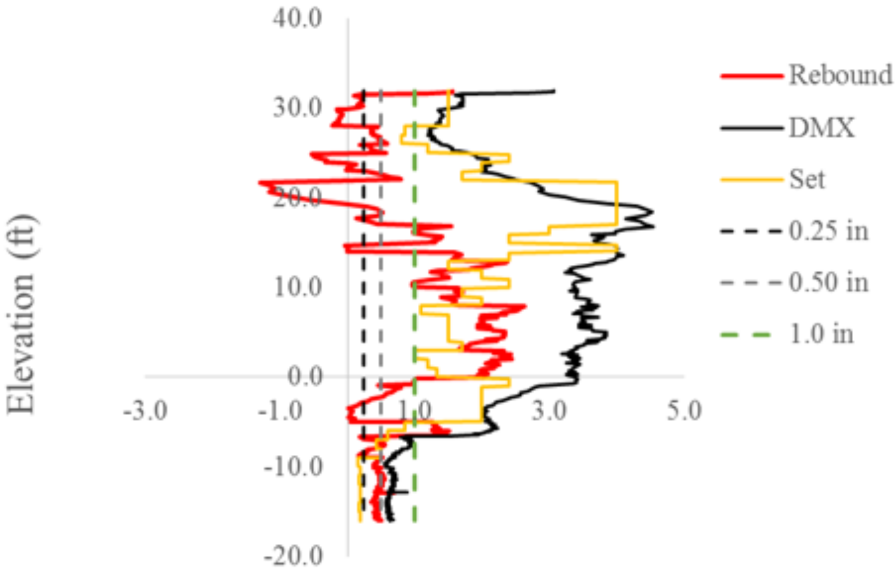



Figure E-34 – I-10 & Chaffee PR2PL9

**E.2.4 I-4 & SR-192**

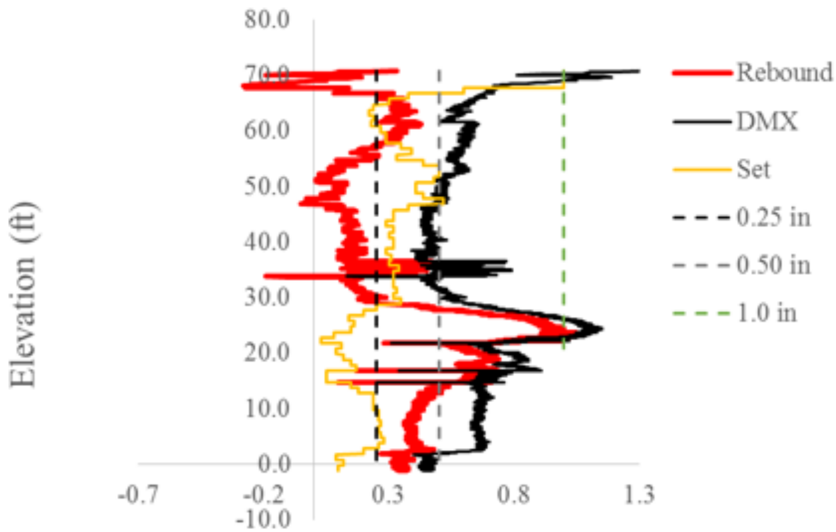



Figure E-35 – I-4 & SR-192 BD EB1P3

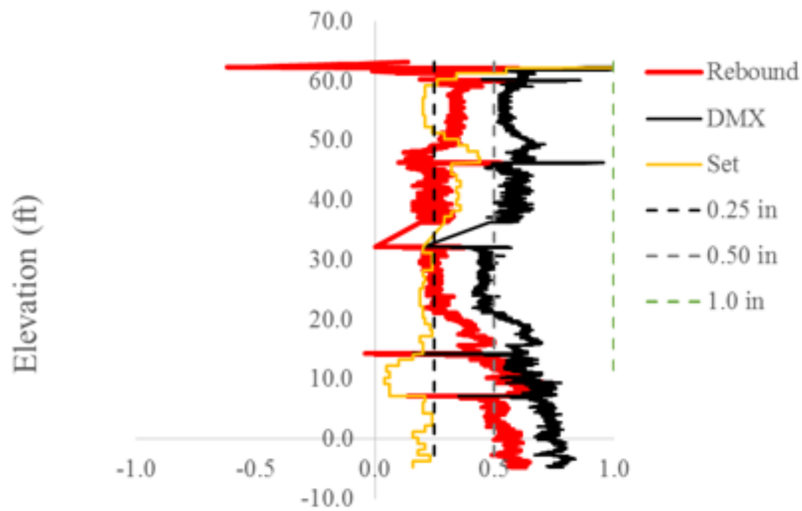



Figure E-36 – I-4 & SR-192 P6P16

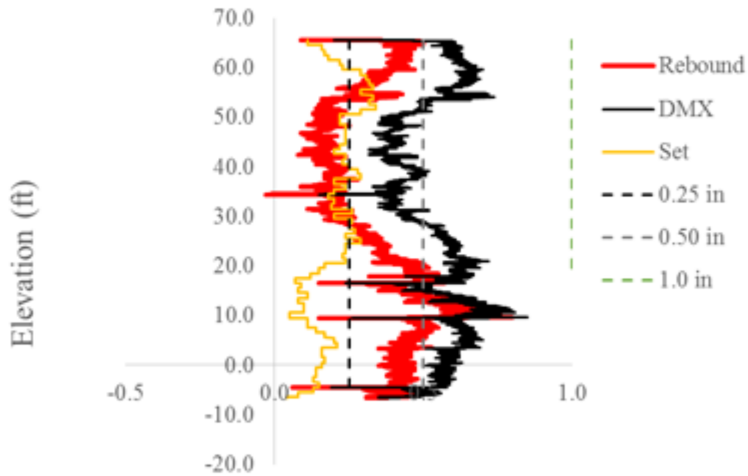



Figure E-37 – I-4 & SR-192 P7P10

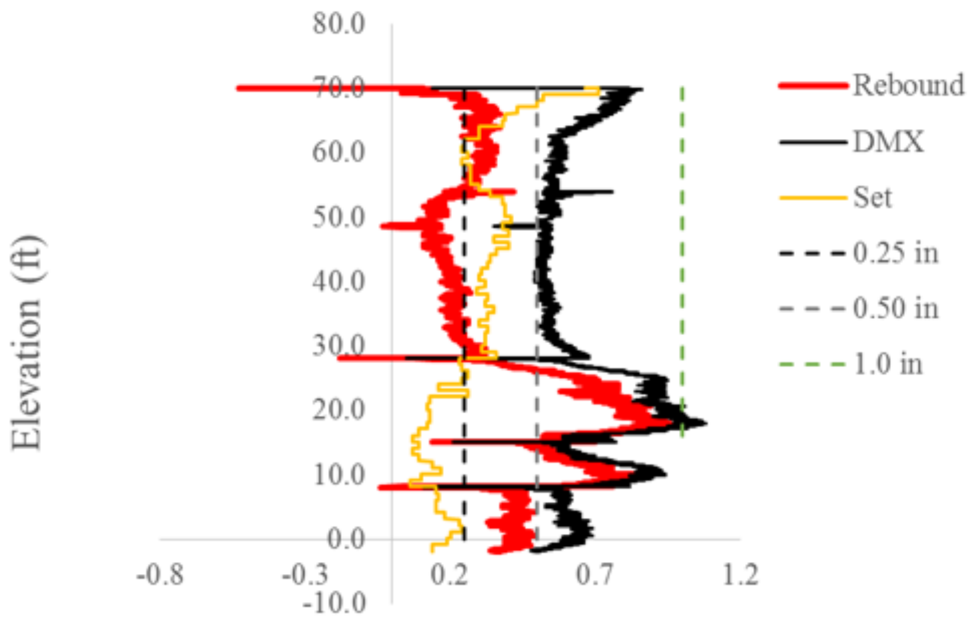



Figure E-38 – I-4 & SR-192 P8P4

### E.2.5 Ramsey Branch

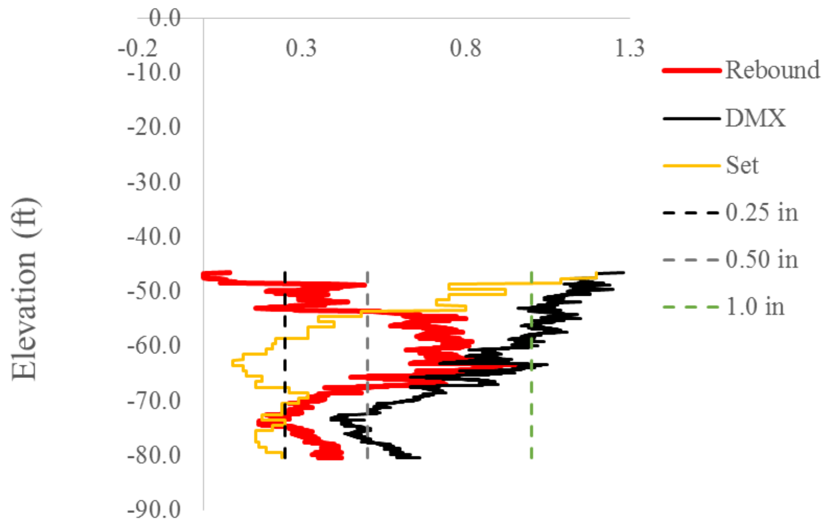



Figure E-39 – Ramsey Branch EB1P1

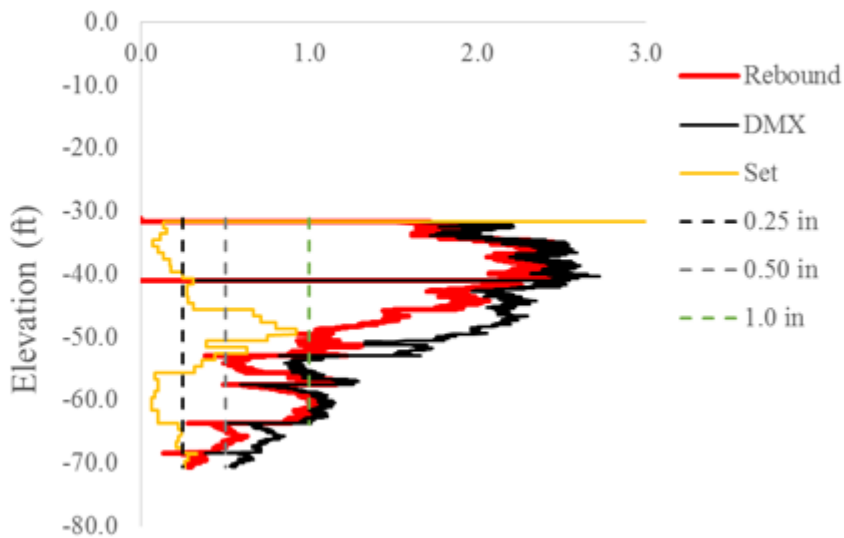



Figure E-40 – Ramsey Branch EB1P2

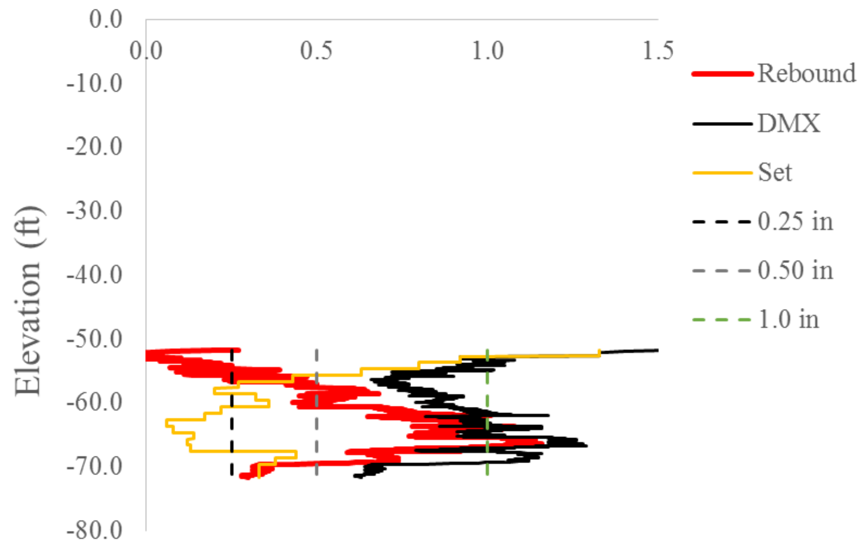



Figure E-41 – Ramsey Branch E1P3

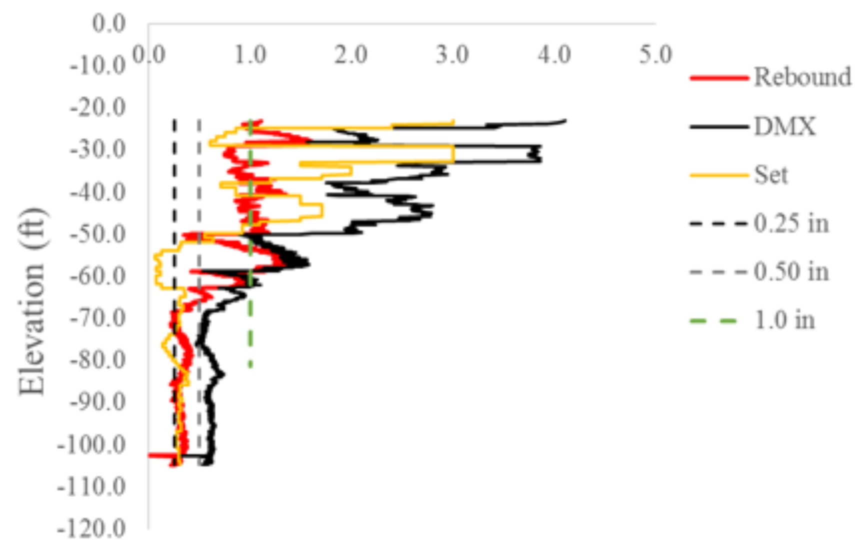



Figure E-42 – Ramsey Branch EB4P5

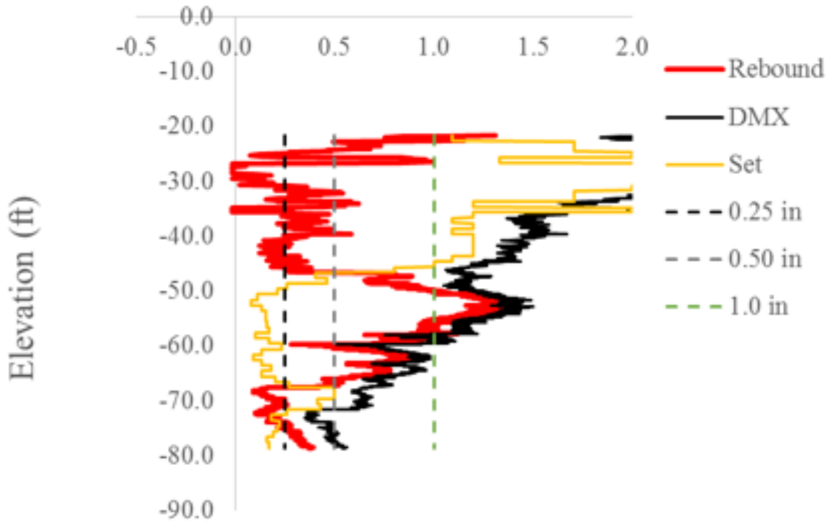



Figure E-43 – Ramsey Branch EB5P2

# Appendix F. CT Damping Analysis

## F.1 CU Triaxial Data and Results

## Table F-1 Sample Dimensions and Mass

| Site | Boring | Depth | Area (si) | Height (in) | Mass (lb) |
|---|---|---|---|---|---|
| Chaffee | EB3 | 52-55 | 6.3734 | 6.13381 | 2.2106 |
| Chaffee | North of I-10 | 47-49 | 6.4316 | 6.1964 | 2.4022 |
| Chaffee | North of I-10 | 60-62 | 6.3043 | 6.0631 | 2.6583 |
| Average | | | 6.3698 | 6.1311 | 2.4237 |
| I4&192 | Pier 6 | 50-52 | 6.5881 | 5.5690 | 2.3785 |
| I4&192 | Pier 6 | 60-62 | 6.5348 | 5.5535 | 2.3258 |
| I4&192 | Pier 6 | 75-77 | 6.5620 | 5.6171 | 2.3377 |
| I4&192 | Pier 6 | 80-82 | 6.4512 | 5.5910 | 2.2870 |
| I4&192 | Pier 7 | 60-62 | 6.5054 | 5.5918 | 2.4804 |
| I4&192 | Pier 7 | 70-72 | 6.4074 | 5.6054 | 1.9506 |
| I4&192 | Pier 7 | 85-87 | 6.5654 | 5.5934 | 2.4438 |
| I4&192 | Pier 8 | 45-47 | 6.5269 | 5.5673 | 2.4118 |
| I4&192 | Pier 8 | 55-57 | 6.5359 | 5.5601 | 2.5185 |
| I4&192 | Pier 8 | 65-66 | 6.3727 | 5.6263 | 2.2690 |
| I4&192 | Pier 8 | 70-72 | 6.4291 | 5.6064 | 2.1788 |
| I4&192 | B6 EB1 | 50-52 | 6.5813 | 5.5471 | 2.4292 |
| I4&192 | B6 EB1 | 58-59 | 6.5382 | 5.5093 | 2.5022 |
| I4&192 | B6 EB1 | 70-72 | 6.4647 | 5.6000 | 2.2348 |
| I4&192 | B6 EB1 | 80-82 | 6.4963 | 5.5773 | 2.2914 |
| I4&192 | B6 EB1 | 91-93 | 6.4816 | 5.6038 | 2.3940 |
| I4&192 | B7 EB1 | 46-47 | 6.4805 | 5.5840 | 2.4700 |
| I4&192 | B7 EB1 | 70-72 | 6.4692 | 5.6223 | 2.4019 |
| I4&192 | B7 EB1 | 75-77 | 6.4557 | 5.5958 | 2.2399 |
| Average | | | 6.4972 | 5.5853 | 2.3445 |
| I4&417 | EB1 | 20-22 | 6.4293 | 5.8698 | 2.8257 |
| I4&417 | EB1 | 29-31 | 6.4466 | 6.2021 | 2.5137 |
| I4&417 | EB1 | 58-61 | 6.4124 | 6.1199 | 2.7359 |
| I4&417 | EB2 | 23-25 | 6.5359 | 6.2022 | 2.7322 |
| I4&417 | EB2 | 55-57 | 6.1049 | 6.1084 | 2.4180 |
| Average | | | 6.3858 | 6.1005 | 2.6451 |
| I4&Osceola | Pier 2 | 75-76 | 6.5506 | 5.6029 | 2.3362 |
| I4&Osceola | Pier 2 | 80-81 | 6.2146 | 5.5434 | 2.2626 |
| I4&Osceola | Pier 2 | 85-87 | 6.1713 | 5.4360 | 2.4820 |
| I4&Osceola | Pier 3 | 75-76 | 6.4873 | 5.6124 | 2.2339 |
| I4&Osceola | Pier 3 | 80-82 | 6.5370 | 6.1173 | 2.6927 |
| I4&Osceola | Pier 4 | 60-61 | 6.4312 | 5.7649 | 2.6976 |
| Average | | | 6.3987 | 5.6795 | 2.4508 |
| Heritage | P1 | 62-64 | | | |
| Heritage | EB5 | 57-59 | 6.0306 | 5.9075 | 2.1870 |
| Heritage | EB5 | 65-67 | 6.3947 | 6.0419 | 2.5574 |
| Heritage | P10 | 55-57 | 6.2192 | 6.1925 | 2.3000 |
| Heritage | P10 | 62-64 | 6.2479 | 6.1642 | 2.4330 |
| Average | | | 6.2231 | 6.0765 | 2.3693 |
| Ramsey Branch | B2 | 31-33.5 | 6.4766 | 6.2048 | 2.8609 |
| Ramsey Branch | B2 | 41-43.5 | 6.4725 | 6.1719 | 2.6422 |
| Ramsey Branch | B3 | 48.5-51 | 6.4023 | 6.1059 | 2.6090 |
| Ramsey Branch | B3 | 63.5-66 | 6.3639 | 6.1051 | 2.6533 |
| Average | | | 6.4288 | 6.1469 | 2.6913 |

Table F-2 CU Triaxial Results

| Site | Location | Sample Depth (ft) | Confining Stress (σ3) | Failure Stress (psi) | Failure Strain (%) |
|---|---|---|---|---|---|
| Chaffee | EB3 | 52-55 | 17.00 | 17.99 | 3.12 |
| Chaffee | North of I-10 | 47-49 | 15.00 | 13.94 | 3.09 |
| Chaffee | North of I-10 | 60-62 | 21.00 | 62.81 | 26.46 |
| I4&192 | Pier 6 | 50-52 | 20.00 | 34.90 | 21.62 |
| I4&192 | Pier 6 | 60-62 | 24.00 | 52.96 | 25.80 |
| I4&192 | Pier 6 | 75-77 | 32.00 | 65.69 | 10.42 |
| I4&192 | Pier 6 | 80-82 | 32.00 | 65.69 | 10.42 |
| I4&192 | Pier 7 | 60-62 | 27.00 | 83.23 | 12.34 |
| I4&192 | Pier 7 | 70-72 | 30.00 | 47.93 | 18.29 |
| I4&192 | Pier 7 | 85-87 | 35.00 | 36.45 | 28.11 |
| I4&192 | Pier 8 | 45-47 | 18.00 | 21.14 | 21.50 |
| I4&192 | Pier 8 | 55-57 | 21.00 | 43.02 | 12.86 |
| I4&192 | Pier 8 | 65-66 | 24.00 | 72.34 | 30.10 |
| I4&192 | Pier 8 | 70-72 | 24.00 | 60.24 | 2.75 |
| I4&192 | B6 EB1 | 50-52 | 20.00 | 53.36 | 24.63 |
| I4&192 | B6 EB1 | 58-59 | 20.00 | 53.36 | 24.63 |
| I4&192 | B6 EB1 | 70-72 | 25.00 | 50.79 | 5.75 |
| I4&192 | B6 EB1 | 80-82 | 27.00 | 59.72 | 3.92 |
| I4&192 | B6 EB1 | 91-93 | 34.00 | 52.16 | 10.83 |
| I4&192 | B7 EB1 | 46-47 | 18.00 | 58.73 | 15.60 |
| I4&192 | B7 EB1 | 70-72 | 25.00 | 53.92 | 18.34 |
| I4&192 | B7 EB1 | 75-77 | 27.00 | 69.02 | 12.31 |
| I4&417 | EB1 | 20-22 | 10.00 | 328.51 | 6.16 |
| I4&417 | EB1 | 29-31 | 10.00 | 328.51 | 6.16 |
| I4&417 | EB1 | 58-61 | 24.00 | 214.61 | 18.44 |
| I4&417 | EB2 | 23-25 | 12.00 | 20.56 | 21.90 |
| I4&417 | EB2 | 55-57 | 24.00 | 54.57 | 14.97 |
| I4&Osceola | Pier 2 | 75-76 | 30.00 | 31.65 | 17.36 |
| I4&Osceola | Pier 2 | 80-81 | 32.00 | 58.89 | 16.12 |
| I4&Osceola | Pier 2 | 85-87 | 34.00 | 250.43 | 7.93 |
| I4&Osceola | Pier 3 | 75-76 | 27.00 | 35.84 | 4.08 |
| I4&Osceola | Pier 3 | 80-82 | 30.00 | 51.98 | 18.77 |
| I4&Osceola | Pier 4 | 60-61 | 20.00 | 28.31 | 17.39 |
| Heritage | P1 | 62-64 | 25.00 | 38.31 | 14.89 |
| Heritage | EB5 | 57-59 | 24.00 | 29.85 | 16.26 |
| Heritage | EB5 | 65-67 | 24.00 | 29.85 | 16.26 |
| Heritage | P10 | 55-57 | 23.00 | 23.35 | 14.13 |
| Heritage | P10 | 62-64 | 25.00 | 31.45 | 16.91 |
| Ramsey Branch | B2 | 31-33.5 | 17.00 | 55.61 | 4.24 |
| Ramsey Branch | B2 | 41-43.5 | 20.00 | 52.93 | 9.36 |
| Ramsey Branch | B3 | 48.5-51 | 29.00 | 50.62 | 9.97 |
| Ramsey Branch | B3 | 63.5-66 | 29.00 | 50.62 | 9.97 |

# F.2 Python™ CT Results output

Table F-3 CT Results output Python™

| Site | Location | Depth (ft) | Total Number of Cycles | Stress Level (psi) | Displacement vs Time Area (si) | Average of E (psi) | Average of η (s.lb/si) | % Infinite E | % Outliers E | E cut off value (psi) | Failure Stress (psi) | Normalized Stress |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I-10 & Chaffee | B1 | 50-52 | 1000 | 2.83 | 62944.95 | 22364.44 | 1.16 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 16% |
| I-10 & Chaffee | B1 | 50-52 | 2000 | 5.14 | 62233.25 | 19054.01 | 0.11 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 29% |
| I-10 & Chaffee | B1 | 50-52 | 3000 | 10.30 | 62219.56 | 13977.61 | 0.04 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 57% |
| I-10 & Chaffee | B1 | 50-52 | 4000 | 12.40 | 62342.74 | 11148.71 | 0.02 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 69% |
| I-10 & Chaffee | B1 | 50-52 | 5000 | 14.54 | 62329.05 | 9333.78 | 0.01 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 81% |
| I-10 & Chaffee | B1 | 50-52 | 6000 | 17.15 | 62684.90 | 7365.98 | 0.01 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 95% |
| I-10 & Chaffee | B1 | 50-52 | 7000 | 18.94 | 63122.88 | 6541.79 | 0.01 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 105% |
| I-10 & Chaffee | B1 | 50-52 | 8000 | 20.87 | 62493.29 | 6021.86 | 0.02 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 116% |
| I-10 & Chaffee | B1 | 50-52 | 9000 | 23.80 | 27551.25 | 6207.60 | 0.06 | 2.39 | 2.57 | 1.8E+05 | 17.99 | 132% |
| I-10 & Chaffee | EB3 | 52-55 | 1000 | 3.88 | 320500.93 | 39926.09 | 10.76 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 22% |
| I-10 & Chaffee | EB3 | 52-55 | 2000 | 6.48 | 318125.30 | 16441.82 | 0.33 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 36% |
| I-10 & Chaffee | EB3 | 52-55 | 3000 | 8.00 | 317426.58 | 13150.13 | 0.08 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 44% |
| I-10 & Chaffee | EB3 | 52-55 | 4000 | 10.19 | 317706.07 | 13057.23 | 0.05 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 57% |
| I-10 & Chaffee | EB3 | 52-55 | 5000 | 11.68 | 319592.60 | 12083.08 | 0.03 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 65% |
| I-10 & Chaffee | EB3 | 52-55 | 6000 | 13.12 | 318055.43 | 10818.99 | 0.02 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 73% |
| I-10 & Chaffee | EB3 | 52-55 | 7000 | 13.91 | 319522.73 | 9162.76 | 0.02 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 77% |
| I-10 & Chaffee | EB3 | 52-55 | 8000 | 15.15 | 317775.94 | 8545.95 | 0.01 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 84% |
| I-10 & Chaffee | EB3 | 52-55 | 9000 | 17.16 | 317775.94 | 7823.72 | 0.01 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 95% |
| I-10 & Chaffee | EB3 | 52-55 | 10000 | 19.06 | 317845.81 | 6545.66 | 0.01 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 106% |
| I-10 & Chaffee | EB3 | 52-55 | 11000 | 20.57 | 317566.33 | 6028.03 | 0.01 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 114% |
| I-10 & Chaffee | EB3 | 52-55 | 12000 | 21.91 | 322666.95 | 5657.48 | 0.01 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 122% |
| I-10 & Chaffee | EB3 | 52-55 | 13000 | 29.71 | 318474.66 | 7248.78 | 0.23 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 165% |
| I-10 & Chaffee | EB3 | 52-55 | 14000 | 30.42 | 43739.61 | 9524.14 | 0.56 | 2.44 | 2.67 | 1.8E+05 | 17.99 | 169% |
| I-10 & Chaffee | North of I-10 | 54-56 | 1000 | 2.79 | 74208.43 | 81351.13 | 135.83 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 4% |
| I-10 & Chaffee | North of I-10 | 54-56 | 2000 | 3.72 | 73383.53 | 53886.22 | 7.14 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 6% |
| I-10 & Chaffee | North of I-10 | 54-56 | 3000 | 5.98 | 73512.92 | 30170.16 | 1.00 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 10% |
| I-10 & Chaffee | North of I-10 | 54-56 | 4000 | 7.36 | 73755.54 | 24046.66 | 0.25 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 12% |
| I-10 & Chaffee | North of I-10 | 54-56 | 5000 | 9.09 | 74418.69 | 22164.84 | 0.14 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 14% |
| I-10 & Chaffee | North of I-10 | 54-56 | 6000 | 12.73 | 74208.43 | 17888.70 | 0.06 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 20% |
| I-10 & Chaffee | North of I-10 | 54-56 | 7000 | 13.63 | 73739.37 | 15702.60 | 0.04 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 22% |
| I-10 & Chaffee | North of I-10 | 54-56 | 8000 | 18.20 | 73884.94 | 14239.19 | 0.03 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 29% |
| I-10 & Chaffee | North of I-10 | 54-56 | 9000 | 17.27 | 74176.08 | 11692.75 | 0.02 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 28% |
| I-10 & Chaffee | North of I-10 | 54-56 | 10000 | 20.23 | 73868.76 | 10770.29 | 0.02 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 32% |
| I-10 & Chaffee | North of I-10 | 54-56 | 11000 | 21.06 | 73836.41 | 8243.16 | 0.02 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 34% |
| I-10 & Chaffee | North of I-10 | 54-56 | 12000 | 25.36 | 56125.38 | 7344.33 | 0.04 | 2.41 | 2.55 | 8.0E+05 | 62.81 | 40% |
| I-10 & Chaffee | EB3 | 60-63 | 1000 | 3.87 | 1148837.00 | 25061.89 | 16.60 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 22% |
| I-10 & Chaffee | EB3 | 60-63 | 2000 | 7.04 | 1151366.00 | 14908.07 | 0.13 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 39% |
| I-10 & Chaffee | EB3 | 60-63 | 3000 | 8.48 | 1165021.00 | 12250.43 | 0.07 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 47% |
| I-10 & Chaffee | EB3 | 60-63 | 4000 | 13.58 | 1138469.00 | 11456.16 | 0.05 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 76% |
| I-10 & Chaffee | EB3 | 60-63 | 5000 | 11.65 | 1166033.00 | 9018.35 | 0.04 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 65% |
| I-10 & Chaffee | EB3 | 60-63 | 6000 | 12.63 | 1152883.00 | 7341.65 | 0.03 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 70% |
| I-10 & Chaffee | EB3 | 60-63 | 7000 | 13.56 | 1151619.00 | 6485.34 | 0.03 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 75% |
| I-10 & Chaffee | EB3 | 60-63 | 8000 | 14.06 | 1152377.00 | 5829.52 | 0.03 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 78% |
| I-10 & Chaffee | EB3 | 60-63 | 9000 | 15.93 | 1151366.00 | 5056.96 | 0.03 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 89% |
| I-10 & Chaffee | EB3 | 60-63 | 10000 | 19.99 | 1166539.00 | 4583.10 | 0.08 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 111% |
| I-10 & Chaffee | EB3 | 60-63 | 11000 | 34.05 | 1152377.00 | 12763.36 | 0.89 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 189% |
| I-10 & Chaffee | EB3 | 60-63 | 12000 | 40.45 | 1149343.00 | 19675.22 | 1.51 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 225% |
| I-10 & Chaffee | EB3 | 60-63 | 13000 | 41.63 | 237202.10 | 26606.03 | 2.60 | 2.33 | 2.53 | 2.5E+05 | 17.99 | 231% |
| I-10 & Chaffee | North of I-10 | 47-49 | 1000 | 3.91 | 334310.94 | 30478.46 | 4.28 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 28% |
| I-10 & Chaffee | North of I-10 | 47-49 | 2000 | 5.93 | 335190.12 | 19162.87 | 0.16 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 43% |
| I-10 & Chaffee | North of I-10 | 47-49 | 3000 | 6.99 | 338267.28 | 16738.65 | 0.07 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 50% |
| I-10 & Chaffee | North of I-10 | 47-49 | 4000 | 8.06 | 334017.87 | 15381.07 | 0.05 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 58% |
| I-10 & Chaffee | North of I-10 | 47-49 | 5000 | 9.17 | 334384.20 | 14380.52 | 0.03 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 66% |
| I-10 & Chaffee | North of I-10 | 47-49 | 6000 | 10.45 | 334457.47 | 14252.48 | 0.03 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 75% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I-10 & Chaffee | North of I-10 | 47-49 | 7000 | 11.54 | 338267.28 | 12951.04 | 0.02 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 83% |
| I-10 & Chaffee | North of I-10 | 47-49 | 8000 | 12.60 | 334457.47 | 14491.32 | 0.02 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 90% |
| I-10 & Chaffee | North of I-10 | 47-49 | 9000 | 14.48 | 334384.20 | 11431.45 | 0.02 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 104% |
| I-10 & Chaffee | North of I-10 | 47-49 | 10000 | 16.36 | 334091.14 | 9962.52 | 0.02 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 117% |
| I-10 & Chaffee | North of I-10 | 47-49 | 11000 | 17.15 | 334091.14 | 9803.76 | 0.02 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 123% |
| I-10 & Chaffee | North of I-10 | 47-49 | 12000 | 18.01 | 337534.62 | 8047.98 | 0.03 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 129% |
| I-10 & Chaffee | North of I-10 | 47-49 | 13000 | 18.63 | 334384.20 | 7849.31 | 0.12 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 134% |
| I-10 & Chaffee | North of I-10 | 47-49 | 14000 | 25.36 | 252912.85 | 11511.14 | 0.74 | 2.32 | 2.35 | 2.0E+06 | 13.94 | 182% |
| I-10 & Chaffee | North of I-10 | 60-62 | 1000 | 6.91 | 331729.21 | 27031.99 | 11.51 | 2.38 | 2.64 | 2.5E+05 | 62.81 | 11% |
| I-10 & Chaffee | North of I-10 | 60-62 | 2000 | 13.14 | 328697.08 | 17723.97 | 0.68 | 2.38 | 2.64 | 2.5E+05 | 62.81 | 21% |
| I-10 & Chaffee | North of I-10 | 60-62 | 3000 | 24.13 | 328119.53 | 12121.04 | 1.11 | 2.38 | 2.64 | 2.5E+05 | 62.81 | 38% |
| I-10 & Chaffee | North of I-10 | 60-62 | 4000 | 32.56 | 328841.47 | 15149.37 | 2.10 | 2.38 | 2.64 | 2.5E+05 | 62.81 | 52% |
| I-10 & Chaffee | North of I-10 | 60-62 | 5000 | 38.35 | 77102.68 | 16471.12 | 2.60 | 2.38 | 2.64 | 2.5E+05 | 62.81 | 61% |
| I-4 & 192 | Pier 2 | 85-87 | 1000 | 4.18 | 379041.60 | 66269.85 | 392.84 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 11% |
| I-4 & 192 | Pier 2 | 85-87 | 2000 | 8.71 | 385742.89 | 60501.20 | 8.25 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 24% |
| I-4 & 192 | Pier 2 | 85-87 | 3000 | 17.24 | 381638.35 | 45771.33 | 1.54 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 47% |
| I-4 & 192 | Pier 2 | 85-87 | 4000 | 21.89 | 381889.65 | 49860.65 | 0.97 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 60% |
| I-4 & 192 | Pier 2 | 85-87 | 5000 | 24.05 | 382140.95 | 45369.64 | 0.68 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 66% |
| I-4 & 192 | Pier 2 | 85-87 | 6000 | 27.03 | 386915.62 | 46537.99 | 0.71 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 74% |
| I-4 & 192 | Pier 2 | 85-87 | 7000 | 29.53 | 381889.65 | 35584.85 | 0.51 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 81% |
| I-4 & 192 | Pier 2 | 85-87 | 8000 | 31.88 | 381638.35 | 30910.03 | 0.48 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 87% |
| I-4 & 192 | Pier 2 | 85-87 | 9000 | 36.66 | 381889.65 | 31983.02 | 0.52 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 101% |
| I-4 & 192 | Pier 2 | 85-87 | 10000 | 40.08 | 381554.59 | 32275.85 | 0.55 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 110% |
| I-4 & 192 | Pier 2 | 85-87 | 11000 | 45.19 | 381889.65 | 35988.20 | 0.64 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 124% |
| I-4 & 192 | Pier 2 | 85-87 | 12000 | 51.33 | 382140.95 | 36420.69 | 0.69 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 141% |
| I-4 & 192 | Pier 2 | 85-87 | 13000 | 53.77 | 381889.65 | 36698.91 | 0.75 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 148% |
| I-4 & 192 | Pier 2 | 85-87 | 14000 | 58.12 | 382559.78 | 40449.82 | 0.88 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 159% |
| I-4 & 192 | Pier 2 | 85-87 | 15000 | 58.30 | 20941.52 | 34696.22 | 0.79 | 2.43 | 2.44 | 1.0E+07 | 36.45 | 160% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 1000 | 8.00 | 264482.56 | 45007.89 | 42.07 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 10% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 2000 | 14.25 | 264424.51 | 40597.43 | 2.41 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 17% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 3000 | 29.70 | 264888.93 | 32667.32 | 0.56 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 36% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 4000 | 36.95 | 260477.01 | 29400.85 | 0.26 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 44% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 5000 | 44.67 | 267036.83 | 27510.31 | 0.19 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 54% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 6000 | 51.03 | 263960.10 | 23718.58 | 0.21 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 61% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 7000 | 57.17 | 265759.70 | 23273.51 | 0.38 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 69% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 8000 | 63.36 | 265005.03 | 25157.50 | 0.65 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 76% |
| I-4 & 192 | Pier 7 (2) | 60-62 | 9000 | 63.78 | 122662.79 | 25608.18 | 0.84 | 2.49 | 2.60 | 1.0E+06 | 83.23 | 77% |
| I-4 & 192 | Pier 7 | 70-72 | 1000 | 4.75 | 62497.88 | 23545.09 | 446.44 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 10% |
| I-4 & 192 | Pier 7 | 70-72 | 2000 | 10.83 | 61409.06 | 23468.00 | 0.38 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 23% |
| I-4 & 192 | Pier 7 | 70-72 | 3000 | 14.42 | 62715.64 | 22723.71 | 0.16 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 30% |
| I-4 & 192 | Pier 7 | 70-72 | 4000 | 24.23 | 61722.10 | 18326.65 | 0.08 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 51% |
| I-4 & 192 | Pier 7 | 70-72 | 5000 | 28.70 | 61735.71 | 14503.16 | 0.05 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 60% |
| I-4 & 192 | Pier 7 | 70-72 | 6000 | 33.15 | 62103.18 | 13694.72 | 0.04 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 69% |
| I-4 & 192 | Pier 7 | 70-72 | 7000 | 38.18 | 62565.93 | 11988.14 | 0.03 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 80% |
| I-4 & 192 | Pier 7 | 70-72 | 8000 | 38.77 | 62144.01 | 10976.10 | 0.03 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 81% |
| I-4 & 192 | Pier 7 | 70-72 | 9000 | 37.93 | 29561.28 | 11387.46 | 0.22 | 2.43 | 2.48 | 1.0E+06 | 47.93 | 79% |
| I-4 & 192 | Pier 7 | 85-87 | 1000 | 4.64 | 134506.91 | 55241.54 | 251.33 | 2.40 | 2.42 | 1.0E+07 | 36.45 | 13% |
| I-4 & 192 | Pier 7 | 85-87 | 2000 | 7.57 | 133164.46 | 52358.56 | 15.45 | 2.40 | 2.42 | 1.0E+07 | 36.45 | 21% |
| I-4 & 192 | Pier 7 | 85-87 | 3000 | 14.28 | 133193.65 | 45880.46 | 3.71 | 2.40 | 2.42 | 1.0E+07 | 36.45 | 39% |
| I-4 & 192 | Pier 7 | 85-87 | 4000 | 17.88 | 133573.03 | 49531.77 | 1.99 | 2.40 | 2.42 | 1.0E+07 | 36.45 | 49% |
| I-4 & 192 | Pier 7 | 85-87 | 5000 | 21.53 | 134477.72 | 42453.17 | 1.06 | 2.40 | 2.42 | 1.0E+07 | 36.45 | 59% |
| I-4 & 192 | Pier 7 | 85-87 | 6000 | 24.58 | 132755.89 | 40551.46 | 1.09 | 2.40 | 2.42 | 1.0E+07 | 36.45 | 67% |
| I-4 & 192 | Pier 7 | 85-87 | 7000 | 28.00 | 134039.97 | 35278.36 | 0.44 | 2.40 | 2.42 | 1.0E+07 | 36.45 | 77% |
| I-4 & 192 | Pier 7 | 85-87 | 8000 | 27.78 | 54077.09 | 57584.77 | 0.60 | 2.40 | 2.42 | 1.0E+07 | 36.45 | 76% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I-4 & 192 | P6 | 75-77 | 1000 | 7.42 | 149467.93 | 50386.84 | 10944.66 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 11% |
| I-4 & 192 | P6 | 75-77 | 2000 | 15.11 | 147263.68 | 42667.59 | 1.05 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 23% |
| I-4 & 192 | P6 | 75-77 | 3000 | 31.21 | 149630.01 | 29401.00 | 0.24 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 48% |
| I-4 & 192 | P6 | 75-77 | 4000 | 41.41 | 147069.19 | 24547.80 | 0.16 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 63% |
| I-4 & 192 | P6 | 75-77 | 5000 | 45.21 | 148527.88 | 19191.60 | 0.10 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 69% |
| I-4 & 192 | P6 | 75-77 | 6000 | 52.65 | 147847.16 | 17780.33 | 0.11 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 80% |
| I-4 & 192 | P6 | 75-77 | 7000 | 60.22 | 146485.71 | 18719.00 | 0.12 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 92% |
| I-4 & 192 | P6 | 75-77 | 8000 | 67.30 | 150278.32 | 21500.90 | 0.16 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 102% |
| I-4 & 192 | P6 | 75-77 | 9000 | 67.51 | 68850.55 | 21232.91 | 0.21 | 2.47 | 2.48 | 2.5E+06 | 65.69 | 103% |
| I-4 & 192 | Pier 8 | 55-57 | 1000 | 4.63 | 411386.45 | 40000.74 | 32.96 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 11% |
| I-4 & 192 | Pier 8 | 55-57 | 2000 | 8.41 | 411837.53 | 32765.30 | 1.00 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 20% |
| I-4 & 192 | Pier 8 | 55-57 | 3000 | 16.90 | 412469.04 | 27332.70 | 0.30 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 39% |
| I-4 & 192 | Pier 8 | 55-57 | 4000 | 20.51 | 416167.91 | 23529.62 | 0.20 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 48% |
| I-4 & 192 | Pier 8 | 55-57 | 5000 | 25.21 | 412378.83 | 18198.69 | 0.19 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 59% |
| I-4 & 192 | Pier 8 | 55-57 | 6000 | 30.43 | 411837.53 | 17491.61 | 0.26 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 71% |
| I-4 & 192 | Pier 8 | 55-57 | 7000 | 35.17 | 411296.23 | 18184.45 | 0.36 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 82% |
| I-4 & 192 | Pier 8 | 55-57 | 8000 | 40.03 | 415536.40 | 19587.68 | 0.50 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 93% |
| I-4 & 192 | Pier 8 | 55-57 | 9000 | 44.82 | 411206.01 | 21047.27 | 0.66 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 104% |
| I-4 & 192 | Pier 8 | 55-57 | 10000 | 48.28 | 217872.43 | 21664.99 | 0.80 | 2.35 | 2.46 | 5.0E+05 | 43.02 | 112% |
| I-4 & 192 | Pier 6 | 60-62 | 1000 | 5.48 | 193349.51 | 33380.30 | 11.03 | 2.33 | 2.42 | 1.0E+06 | 52.96 | 10% |
| I-4 & 192 | Pier 6 | 60-62 | 2000 | 10.95 | 194274.43 | 30920.07 | 0.72 | 2.33 | 2.42 | 1.0E+06 | 52.96 | 21% |
| I-4 & 192 | Pier 6 | 60-62 | 3000 | 23.82 | 191709.89 | 18691.98 | 0.35 | 2.33 | 2.42 | 1.0E+06 | 52.96 | 45% |
| I-4 & 192 | Pier 6 | 60-62 | 4000 | 27.18 | 191247.43 | 15047.31 | 0.39 | 2.33 | 2.42 | 1.0E+06 | 52.96 | 51% |
| I-4 & 192 | Pier 6 | 60-62 | 5000 | 34.56 | 193896.05 | 17092.55 | 0.75 | 2.33 | 2.42 | 1.0E+06 | 52.96 | 65% |
| I-4 & 192 | Pier 6 | 60-62 | 6000 | 37.69 | 87068.24 | 14909.24 | 0.65 | 2.33 | 2.42 | 1.0E+06 | 52.96 | 71% |
| 417 & | EB2 | 55-57 | 1000 | 5.06 | 221221.63 | 32353.81 | 11.45 | 2.34 | 2.37 | 1.0E+06 | 54.57 | 9% |
| 417 & | EB2 | 55-57 | 2000 | 9.43 | 224526.35 | 21656.13 | 0.45 | 2.34 | 2.37 | 1.0E+06 | 54.57 | 17% |
| 417 & | EB2 | 55-57 | 3000 | 17.79 | 221707.62 | 15423.20 | 0.17 | 2.34 | 2.37 | 1.0E+06 | 54.57 | 33% |
| 417 & | EB2 | 55-57 | 4000 | 21.60 | 221513.22 | 11618.29 | 0.12 | 2.34 | 2.37 | 1.0E+06 | 54.57 | 40% |
| 417 & | EB2 | 55-57 | 5000 | 24.36 | 221416.03 | 9210.32 | 0.20 | 2.34 | 2.37 | 1.0E+06 | 54.57 | 45% |
| 417 & | EB2 | 55-57 | 6000 | 29.97 | 135541.99 | 9262.72 | 0.78 | 2.34 | 2.37 | 1.0E+06 | 54.57 | 55% |
| 417 & | EB1 | 29-31 | 1000 | 3.75 | 354344.25 | 31233.10 | 32.94 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 1% |
| 417 & | EB1 | 29-31 | 2000 | 7.38 | 352949.20 | 22756.31 | 0.24 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 2% |
| 417 & | EB1 | 29-31 | 3000 | 9.96 | 356436.84 | 20385.73 | 0.09 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 3% |
| 417 & | EB1 | 29-31 | 4000 | 11.67 | 352484.18 | 19626.60 | 0.09 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 4% |
| 417 & | EB1 | 29-31 | 5000 | 13.45 | 352406.68 | 19387.90 | 0.16 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 4% |
| 417 & | EB1 | 29-31 | 6000 | 15.41 | 353336.71 | 18597.24 | 0.23 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 5% |
| 417 & | EB1 | 29-31 | 7000 | 17.07 | 352561.68 | 18310.31 | 0.27 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 5% |
| 417 & | EB1 | 29-31 | 8000 | 19.56 | 356591.84 | 19595.71 | 0.35 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 6% |
| 417 & | EB1 | 29-31 | 9000 | 23.86 | 352639.18 | 22415.89 | 0.53 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 7% |
| 417 & | EB1 | 29-31 | 10000 | 27.38 | 352484.18 | 27391.23 | 1.03 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 8% |
| 417 & | EB1 | 29-31 | 11000 | 35.19 | 283816.42 | 34948.47 | 1.82 | 2.39 | 2.67 | 2.0E+05 | 328.51 | 11% |
| 417 & | EB1 | 23-25 | 1000 | 2.30 | 228004.66 | 141731.60 | 41.58 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 1% |
| 417 & | EB1 | 23-25 | 2000 | 3.92 | 226221.82 | 51735.81 | 1.54 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 1% |
| 417 & | EB1 | 23-25 | 3000 | 4.83 | 226221.82 | 47076.78 | 0.73 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 1% |
| 417 & | EB1 | 23-25 | 4000 | 5.77 | 226568.49 | 47972.75 | 0.38 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 2% |
| 417 & | EB1 | 23-25 | 5000 | 6.96 | 226667.53 | 44776.30 | 0.28 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 2% |
| 417 & | EB1 | 23-25 | 6000 | 7.91 | 227014.19 | 39805.75 | 0.22 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 2% |
| 417 & | EB1 | 23-25 | 7000 | 8.63 | 225875.16 | 38865.35 | 0.20 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 3% |
| 417 & | EB1 | 23-25 | 8000 | 9.46 | 225924.68 | 38152.95 | 0.16 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 3% |
| 417 & | EB1 | 23-25 | 9000 | 11.42 | 225776.11 | 41067.88 | 0.18 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 3% |
| 417 & | EB1 | 23-25 | 10000 | 13.06 | 228499.89 | 31946.38 | 0.19 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 4% |
| 417 & | EB1 | 23-25 | 11000 | 14.77 | 225974.21 | 36766.81 | 0.37 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 4% |
| 417 & | EB1 | 23-25 | 12000 | 23.32 | 225875.16 | 28128.09 | 0.54 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 7% |
| 417 & | EB1 | 23-25 | 13000 | 22.56 | 225578.02 | 31295.33 | 0.83 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 7% |
| 417 & | EB1 | 23-25 | 14000 | 37.17 | 226172.30 | 28056.17 | 0.86 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 11% |
| 417 & | EB1 | 23-25 | 15000 | 39.91 | 183186.19 | 35820.92 | 1.21 | 2.27 | 2.28 | 1.0E+07 | 328.51 | 12% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 417 & | EB1 | 58-61 | 1000 | 6.50 | 323490.69 | 48058.29 | 13.31 | 1.96 | 2.06 | 2.5E+06 | 214.61 | 3% |
| 417 & | EB1 | 58-61 | 2000 | 12.64 | 319914.27 | 40893.30 | 1.09 | 1.96 | 2.06 | 2.5E+06 | 214.61 | 6% |
| 417 & | EB1 | 58-61 | 3000 | 21.85 | 319633.77 | 33220.06 | 5.77 | 1.96 | 2.06 | 2.5E+06 | 214.61 | 10% |
| 417 & | EB1 | 58-61 | 4000 | 30.05 | 322368.68 | 35444.07 | 7.49 | 1.96 | 2.06 | 2.5E+06 | 214.61 | 14% |
| 417 & | EB1 | 58-61 | 5000 | 39.12 | 319142.89 | 34852.64 | 7.09 | 1.96 | 2.06 | 2.5E+06 | 214.61 | 18% |
| 417 & | EB1 | 58-61 | 6000 | 39.52 | 19284.62 | 69827.10 | 7.69 | 1.96 | 2.06 | 2.5E+06 | 214.61 | 18% |
| 417 & | EB1 | 20-22 | 1000 | 4.91 | 935680.16 | 57376.04 | 10.59 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 1% |
| 417 & | EB1 | 20-22 | 2000 | 9.68 | 925739.06 | 49190.70 | 1.05 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 3% |
| 417 & | EB1 | 20-22 | 3000 | 19.33 | 926550.58 | 44857.13 | 1.79 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 6% |
| 417 & | EB1 | 20-22 | 4000 | 26.33 | 926550.58 | 40478.13 | 1.63 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 8% |
| 417 & | EB1 | 20-22 | 5000 | 32.93 | 925333.30 | 47676.42 | 1.74 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 10% |
| 417 & | EB1 | 20-22 | 6000 | 40.05 | 933245.60 | 99778.91 | 3.23 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 12% |
| 417 & | EB1 | 20-22 | 7000 | 47.61 | 928173.62 | 45129.98 | 1.36 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 14% |
| 417 & | EB1 | 20-22 | 8000 | 55.10 | 924927.55 | 63364.11 | 1.86 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 17% |
| 417 & | EB1 | 20-22 | 9000 | 82.33 | 910928.86 | 4032286.00 | 136794.71 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 25% |
| 417 & | EB1 | 20-22 | 10000 | 92.79 | 927564.98 | 4627515.00 | 18055.41 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 28% |
| 417 & | EB1 | 20-22 | 11000 | 93.78 | 928579.38 | 66021.52 | 2.07 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 29% |
| 417 & | EB1 | 20-22 | 12000 | 110.84 | 932636.97 | 147419.40 | 4.82 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 34% |
| 417 & | EB1 | 20-22 | 13000 | 127.76 | 925941.94 | 83489.48 | 2.87 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 39% |
| 417 & | EB1 | 20-22 | 14000 | 129.61 | 650431.61 | 77693.97 | 2.66 | 2.25 | 2.34 | 1.0E+08 | 328.51 | 39% |
| I4&Osceola | Pier 2 | 80-81 | 1000 | 39.78 | 207998.71 | 30918.52 | 12.24 | 2.41 | 2.64 | 5.0E+05 | 58.89 | 68% |
| I4&Osceola | Pier 2 | 80-81 | 2000 | 43.76 | 206054.79 | 30809.08 | 1.29 | 2.41 | 2.64 | 5.0E+05 | 58.89 | 74% |
| I4&Osceola | Pier 2 | 80-81 | 3000 | 47.04 | 205602.72 | 32130.58 | 0.98 | 2.41 | 2.64 | 5.0E+05 | 58.89 | 80% |
| I4&Osceola | Pier 2 | 80-81 | 4000 | 51.42 | 205873.97 | 32354.46 | 0.92 | 2.41 | 2.64 | 5.0E+05 | 58.89 | 87% |
| I4&Osceola | Pier 2 | 80-81 | 5000 | 57.61 | 205738.34 | 32216.84 | 0.96 | 2.41 | 2.64 | 5.0E+05 | 58.89 | 98% |
| I4&Osceola | Pier 2 | 80-81 | 6000 | 61.02 | 207908.29 | 32458.78 | 1.09 | 2.41 | 2.64 | 5.0E+05 | 58.89 | 104% |
| I4&Osceola | Pier 2 | 80-81 | 7000 | 66.83 | 105920.66 | 34441.42 | 1.31 | 2.41 | 2.64 | 5.0E+05 | 58.89 | 113% |
| I4&Osceola | Pier 2 | 75-76 | 1000 | 3.11 | 26625.40 | 75989.60 | 544.29 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 10% |
| I4&Osceola | Pier 2 | 75-76 | 2000 | 6.18 | 26289.69 | 38653.99 | 0.90 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 20% |
| I4&Osceola | Pier 2 | 75-76 | 3000 | 12.19 | 26197.08 | 35335.22 | 0.21 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 39% |
| I4&Osceola | Pier 2 | 75-76 | 4000 | 14.01 | 26590.67 | 35744.60 | 0.13 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 44% |
| I4&Osceola | Pier 2 | 75-76 | 5000 | 16.12 | 26370.72 | 33774.96 | 0.09 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 51% |
| I4&Osceola | Pier 2 | 75-76 | 6000 | 19.02 | 26353.36 | 31462.77 | 0.06 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 60% |
| I4&Osceola | Pier 2 | 75-76 | 7000 | 22.22 | 26376.51 | 30292.13 | 0.05 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 70% |
| I4&Osceola | Pier 2 | 75-76 | 8000 | 24.82 | 26353.36 | 26228.47 | 0.04 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 78% |
| I4&Osceola | Pier 2 | 75-76 | 9000 | 27.83 | 26382.30 | 24145.53 | 0.04 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 88% |
| I4&Osceola | Pier 2 | 75-76 | 10000 | 32.68 | 26440.18 | 21012.81 | 0.03 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 103% |
| I4&Osceola | Pier 2 | 75-76 | 11000 | 33.72 | 15292.24 | 18082.69 | 0.03 | 2.50 | 2.62 | 1.0E+06 | 31.65 | 107% |
| I4&Osceola | Pier 3 | 75-76 | 1000 | 2.11 | 121419.00 | 89706.27 | 1019.11 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 6% |
| I4&Osceola | Pier 3 | 75-76 | 2000 | 3.46 | 121073.68 | 39297.83 | 32.81 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 10% |
| I4&Osceola | Pier 3 | 75-76 | 3000 | 9.91 | 122189.32 | 35616.28 | 2.71 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 28% |
| I4&Osceola | Pier 3 | 75-76 | 4000 | 11.47 | 120940.86 | 35261.50 | 1.12 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 32% |
| I4&Osceola | Pier 3 | 75-76 | 5000 | 15.11 | 121073.68 | 39528.49 | 0.79 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 42% |
| I4&Osceola | Pier 3 | 75-76 | 6000 | 17.98 | 121073.68 | 38442.31 | 0.55 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 50% |
| I4&Osceola | Pier 3 | 75-76 | 7000 | 20.85 | 121020.55 | 40315.73 | 0.43 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 58% |
| I4&Osceola | Pier 3 | 75-76 | 8000 | 23.48 | 122083.07 | 39020.03 | 0.36 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 66% |
| I4&Osceola | Pier 3 | 75-76 | 9000 | 26.50 | 121365.87 | 39036.94 | 0.27 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 74% |
| I4&Osceola | Pier 3 | 75-76 | 10000 | 31.39 | 121020.55 | 38837.07 | 0.22 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 88% |
| I4&Osceola | Pier 3 | 75-76 | 11000 | 36.19 | 121073.68 | 35338.58 | 0.18 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 101% |
| I4&Osceola | Pier 3 | 75-76 | 12000 | 41.45 | 121286.18 | 36624.89 | 0.17 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 116% |
| I4&Osceola | Pier 3 | 75-76 | 13000 | 45.68 | 121179.93 | 34386.92 | 0.16 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 127% |
| I4&Osceola | Pier 3 | 75-76 | 14000 | 49.93 | 122454.95 | 36437.02 | 0.18 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 139% |
| I4&Osceola | Pier 3 | 75-76 | 15000 | 49.44 | 98149.90 | 35632.76 | 0.19 | 2.39 | 2.44 | 2.5E+06 | 35.84 | 138% |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I4&Osceola | Pier 3 | 80-82 | 1000 | 4.02 | 83569.01 | 82769.57 | 407.38 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 8% |
| I4&Osceola | Pier 3 | 80-82 | 2000 | 7.49 | 82952.26 | 65951.07 | 6.42 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 14% |
| I4&Osceola | Pier 3 | 80-82 | 3000 | 15.28 | 82643.89 | 50932.88 | 1.27 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 29% |
| I4&Osceola | Pier 3 | 80-82 | 4000 | 18.68 | 82698.31 | 49927.01 | 0.69 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 36% |
| I4&Osceola | Pier 3 | 80-82 | 5000 | 22.55 | 82607.61 | 45493.46 | 0.45 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 43% |
| I4&Osceola | Pier 3 | 80-82 | 6000 | 25.51 | 83478.31 | 42998.07 | 0.32 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 49% |
| I4&Osceola | Pier 3 | 80-82 | 7000 | 30.31 | 82643.89 | 42040.74 | 0.26 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 58% |
| I4&Osceola | Pier 3 | 80-82 | 8000 | 31.73 | 82625.75 | 40865.98 | 0.23 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 61% |
| I4&Osceola | Pier 3 | 80-82 | 9000 | 38.13 | 82680.17 | 41724.77 | 0.21 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 73% |
| I4&Osceola | Pier 3 | 80-82 | 10000 | 41.07 | 83097.38 | 37534.00 | 0.18 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 79% |
| I4&Osceola | Pier 3 | 80-82 | 11000 | 47.27 | 83278.77 | 35635.16 | 0.20 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 91% |
| I4&Osceola | Pier 3 | 80-82 | 12000 | 58.19 | 82680.17 | 38173.86 | 0.26 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 112% |
| I4&Osceola | Pier 3 | 80-82 | 13000 | 54.69 | 8670.72 | 38820.73 | 0.31 | 2.35 | 2.43 | 2.0E+06 | 51.98 | 105% |
| I4&Osceola | Pier 3 | 80-82 | 1000 | 3.90 | 425224.73 | 99325.49 | 22042.92 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 8% |
| I4&Osceola | Pier 3 | 80-82 | 2000 | 7.32 | 441761.78 | 60328.25 | 1987.22 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 14% |
| I4&Osceola | Pier 3 | 80-82 | 3000 | 14.32 | 441665.07 | 59853.46 | 11.15 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 28% |
| I4&Osceola | Pier 3 | 80-82 | 4000 | 18.13 | 440988.12 | 48795.35 | 4.59 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 35% |
| I4&Osceola | Pier 3 | 80-82 | 5000 | 21.44 | 443986.06 | 47656.77 | 2.88 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 41% |
| I4&Osceola | Pier 3 | 80-82 | 6000 | 24.82 | 444372.90 | 52597.06 | 2.28 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 48% |
| I4&Osceola | Pier 3 | 80-82 | 7000 | 29.07 | 440988.12 | 44543.94 | 1.39 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 56% |
| I4&Osceola | Pier 3 | 80-82 | 8000 | 33.47 | 440891.41 | 44785.88 | 1.09 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 64% |
| I4&Osceola | Pier 3 | 80-82 | 9000 | 35.73 | 440794.70 | 44832.17 | 0.87 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 69% |
| I4&Osceola | Pier 3 | 80-82 | 10000 | 42.58 | 446210.35 | 38689.59 | 0.62 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 82% |
| I4&Osceola | Pier 3 | 80-82 | 11000 | 51.84 | 439924.33 | 37210.31 | 0.46 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 100% |
| I4&Osceola | Pier 3 | 80-82 | 12000 | 57.30 | 440601.29 | 37964.99 | 0.39 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 110% |
| I4&Osceola | Pier 3 | 80-82 | 13000 | 63.87 | 441471.66 | 43134.75 | 0.38 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 123% |
| I4&Osceola | Pier 3 | 80-82 | 14000 | 86.67 | 443309.11 | 39102.58 | 0.37 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 167% |
| I4&Osceola | Pier 3 | 80-82 | 15000 | 71.24 | 362461.29 | 39659.28 | 0.49 | 2.25 | 2.33 | 5.0E+06 | 51.98 | 137% |
| I4&Osceola | Pier 2 | 80-81 | 1000 | 4.95 | 51338.31 | 71941.10 | 105.30 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 8% |
| I4&Osceola | Pier 2 | 80-81 | 2000 | 9.62 | 50549.00 | 54520.26 | 4.20 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 16% |
| I4&Osceola | Pier 2 | 80-81 | 3000 | 19.85 | 50637.94 | 59014.24 | 1.18 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 34% |
| I4&Osceola | Pier 2 | 80-81 | 4000 | 24.88 | 50671.29 | 62253.14 | 0.66 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 42% |
| I4&Osceola | Pier 2 | 80-81 | 5000 | 30.26 | 51115.97 | 64430.64 | 0.47 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 51% |
| I4&Osceola | Pier 2 | 80-81 | 6000 | 34.87 | 50982.56 | 60032.50 | 0.33 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 59% |
| I4&Osceola | Pier 2 | 80-81 | 7000 | 39.92 | 50749.11 | 64505.89 | 0.28 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 68% |
| I4&Osceola | Pier 2 | 80-81 | 8000 | 43.57 | 50649.05 | 54410.01 | 0.20 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 74% |
| I4&Osceola | Pier 2 | 80-81 | 9000 | 47.87 | 50671.29 | 62802.49 | 0.19 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 81% |
| I4&Osceola | Pier 2 | 80-81 | 10000 | 54.47 | 51271.61 | 54659.30 | 0.15 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 93% |
| I4&Osceola | Pier 2 | 80-81 | 11000 | 52.25 | 29371.11 | 56034.62 | 1.92 | 2.42 | 2.43 | 1.0E+07 | 58.89 | 89% |
| I4&Osceola | Pier 4 | 60-61 | 1000 | 2.83 | 125260.27 | 304452.63 | 346.52 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 10% |
| I4&Osceola | Pier 4 | 60-61 | 2000 | 4.34 | 124390.40 | 103180.36 | 43.77 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 15% |
| I4&Osceola | Pier 4 | 60-61 | 3000 | 8.08 | 123710.82 | 58327.17 | 3.36 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 29% |
| I4&Osceola | Pier 4 | 60-61 | 4000 | 9.91 | 124037.02 | 59881.18 | 1.20 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 35% |
| I4&Osceola | Pier 4 | 60-61 | 5000 | 12.07 | 124852.52 | 51442.60 | 0.62 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 43% |
| I4&Osceola | Pier 4 | 60-61 | 6000 | 14.29 | 124118.57 | 47987.04 | 0.43 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 50% |
| I4&Osceola | Pier 4 | 60-61 | 7000 | 16.10 | 124009.84 | 47251.81 | 0.34 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 57% |
| I4&Osceola | Pier 4 | 60-61 | 8000 | 17.47 | 124009.84 | 62583.21 | 0.38 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 62% |
| I4&Osceola | Pier 4 | 60-61 | 9000 | 19.13 | 123846.74 | 44213.08 | 0.24 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 68% |
| I4&Osceola | Pier 4 | 60-61 | 10000 | 22.44 | 125287.45 | 37637.01 | 0.20 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 79% |
| I4&Osceola | Pier 4 | 60-61 | 11000 | 25.44 | 123982.66 | 40680.84 | 0.26 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 90% |
| I4&Osceola | Pier 4 | 60-61 | 12000 | 28.67 | 124037.02 | 40479.66 | 0.34 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 101% |
| I4&Osceola | Pier 4 | 60-61 | 13000 | 33.13 | 123873.92 | 34106.05 | 0.37 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 117% |
| I4&Osceola | Pier 4 | 60-61 | 14000 | 38.02 | 124037.02 | 37507.66 | 0.51 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 134% |
| I4&Osceola | Pier 4 | 60-61 | 15000 | 39.16 | 103187.49 | 45663.93 | 0.75 | 2.28 | 2.30 | 2.5E+07 | 28.31 | 138% |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heritage | P1 | 62-64 | 1000 | 4.74 | 200088.43 | 39567.03 | 11.62 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 12% |
| Heritage | P1 | 62-64 | 2000 | 9.06 | 197831.96 | 40609.10 | 0.80 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 24% |
| Heritage | P1 | 62-64 | 3000 | 17.84 | 197875.35 | 35013.40 | 0.22 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 47% |
| Heritage | P1 | 62-64 | 4000 | 21.96 | 197614.99 | 29326.18 | 0.11 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 57% |
| Heritage | P1 | 62-64 | 5000 | 25.97 | 198005.54 | 23451.29 | 0.08 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 68% |
| Heritage | P1 | 62-64 | 6000 | 29.76 | 197918.75 | 18929.84 | 0.06 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 78% |
| Heritage | P1 | 62-64 | 7000 | 33.52 | 199697.89 | 15236.36 | 0.06 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 87% |
| Heritage | P1 | 62-64 | 8000 | 40.30 | 197831.96 | 15035.06 | 0.50 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 105% |
| Heritage | P1 | 62-64 | 9000 | 40.08 | 198092.32 | 13693.20 | 0.18 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 105% |
| Heritage | P1 | 62-64 | 10000 | 44.69 | 106705.15 | 14328.46 | 2.75 | 2.39 | 2.47 | 1.0E+06 | 38.31 | 117% |
| Heritage | P10 | 62-64 | 1000 | 3.54 | 132747.05 | 24848.61 | 3.36 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 11% |
| Heritage | P10 | 62-64 | 2000 | 7.03 | 134116.47 | 23728.36 | 0.16 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 22% |
| Heritage | P10 | 62-64 | 3000 | 14.19 | 132834.46 | 22567.79 | 0.08 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 45% |
| Heritage | P10 | 62-64 | 4000 | 17.59 | 132688.77 | 21969.34 | 0.05 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 56% |
| Heritage | P10 | 62-64 | 5000 | 20.59 | 132659.64 | 20721.06 | 0.04 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 65% |
| Heritage | P10 | 62-64 | 6000 | 24.54 | 132455.68 | 18824.11 | 0.03 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 78% |
| Heritage | P10 | 62-64 | 7000 | 26.15 | 133533.74 | 16428.36 | 0.03 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 83% |
| Heritage | P10 | 62-64 | 8000 | 28.70 | 133446.33 | 14400.11 | 0.02 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 91% |
| Heritage | P10 | 62-64 | 9000 | 30.86 | 132688.77 | 12515.87 | 0.02 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 98% |
| Heritage | P10 | 62-64 | 10000 | 34.60 | 132980.14 | 10359.47 | 0.03 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 110% |
| Heritage | P10 | 62-64 | 11000 | 38.01 | 112089.09 | 8329.23 | 0.14 | 2.36 | 2.49 | 2.5E+05 | 31.45 | 121% |
| Heritage | P1 | 57-59 | 1000 | 3.71 | 185676.35 | 69315.66 | 24.67 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 10% |
| Heritage | P1 | 57-59 | 2000 | 5.94 | 185108.66 | 39704.44 | 1.38 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 16% |
| Heritage | P1 | 57-59 | 3000 | 11.44 | 184784.26 | 24364.18 | 0.20 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 30% |
| Heritage | P1 | 57-59 | 4000 | 14.12 | 184824.81 | 20958.01 | 0.09 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 37% |
| Heritage | P1 | 57-59 | 5000 | 19.75 | 184865.36 | 18884.51 | 0.06 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 52% |
| Heritage | P1 | 57-59 | 6000 | 18.41 | 185270.86 | 16336.12 | 0.04 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 48% |
| Heritage | P1 | 57-59 | 7000 | 21.12 | 187014.49 | 12847.41 | 0.03 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 55% |
| Heritage | P1 | 57-59 | 8000 | 22.80 | 185108.66 | 11741.84 | 0.03 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 60% |
| Heritage | P1 | 57-59 | 9000 | 24.39 | 185108.66 | 9642.32 | 0.04 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 64% |
| Heritage | P1 | 57-59 | 10000 | 28.54 | 184622.06 | 7701.95 | 0.05 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 74% |
| Heritage | P1 | 57-59 | 11000 | 33.09 | 157372.77 | 7943.54 | 0.15 | 2.42 | 2.47 | 1.0E+06 | 38.31 | 86% |
| Heritage | P1 | 65-67 | 1000 | 3.12 | 88058.79 | 79541.73 | 150.29 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 8% |
| Heritage | P1 | 65-67 | 2000 | 6.55 | 88829.38 | 41379.63 | 1.65 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 17% |
| Heritage | P1 | 65-67 | 3000 | 13.64 | 87943.21 | 39263.46 | 0.33 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 36% |
| Heritage | P1 | 65-67 | 4000 | 17.08 | 87923.94 | 42760.65 | 0.18 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 45% |
| Heritage | P1 | 65-67 | 5000 | 20.26 | 88309.23 | 41669.02 | 0.14 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 53% |
| Heritage | P1 | 65-67 | 6000 | 23.79 | 87943.21 | 41806.19 | 0.09 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 62% |
| Heritage | P1 | 65-67 | 7000 | 27.06 | 87808.35 | 38667.04 | 0.07 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 71% |
| Heritage | P1 | 65-67 | 8000 | 30.23 | 88867.91 | 36349.97 | 0.05 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 79% |
| Heritage | P1 | 65-67 | 9000 | 33.56 | 87750.56 | 33920.87 | 0.04 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 88% |
| Heritage | P1 | 65-67 | 10000 | 39.61 | 87962.47 | 32747.35 | 0.04 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 103% |
| Heritage | P1 | 65-67 | 11000 | 45.42 | 88001.00 | 41683.13 | 0.03 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 119% |
| Heritage | P1 | 65-67 | 12000 | 50.73 | 87866.15 | 29458.61 | 0.02 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 132% |
| Heritage | P1 | 65-67 | 13000 | 55.60 | 88964.23 | 15724.09 | 0.02 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 145% |
| Heritage | P1 | 65-67 | 14000 | 53.56 | 48874.46 | 16691.05 | 0.12 | 2.50 | 2.51 | 2.0E+07 | 38.31 | 140% |
| Heritage | P10 | 55-57 | 1000 | 2.45 | 150061.92 | 42322.56 | 6.39 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 11% |
| Heritage | P10 | 55-57 | 2000 | 4.68 | 151678.32 | 31870.22 | 0.58 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 20% |
| Heritage | P10 | 55-57 | 3000 | 9.19 | 150754.66 | 27139.19 | 0.18 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 39% |
| Heritage | P10 | 55-57 | 4000 | 12.11 | 150688.69 | 23986.06 | 0.09 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 52% |
| Heritage | P10 | 55-57 | 5000 | 14.11 | 150490.76 | 20738.69 | 0.05 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 60% |
| Heritage | P10 | 55-57 | 6000 | 16.16 | 150325.82 | 20221.16 | 0.04 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 69% |
| Heritage | P10 | 55-57 | 7000 | 18.13 | 152272.11 | 17924.39 | 0.03 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 78% |
| Heritage | P10 | 55-57 | 8000 | 19.91 | 150358.81 | 15736.76 | 0.02 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 85% |
| Heritage | P10 | 55-57 | 9000 | 21.53 | 150358.81 | 14177.53 | 0.02 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 92% |
| Heritage | P10 | 55-57 | 10000 | 24.84 | 150424.78 | 12807.12 | 0.02 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 106% |
| Heritage | P10 | 55-57 | 11000 | 27.33 | 151975.22 | 11171.21 | 0.02 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 117% |
| Heritage | P10 | 55-57 | 12000 | 28.60 | 150853.63 | 9058.08 | 0.04 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 122% |
| Heritage | P10 | 55-57 | 13000 | 34.37 | 106221.01 | 8272.34 | 0.17 | 2.44 | 2.45 | 2.0E+07 | 23.35 | 147% |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heritage | P1 | 60-62 | 1000 | 5.15 | 358944.38 | 46440.10 | 129.87 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 13% |
| Heritage | P1 | 60-62 | 2000 | 8.34 | 354666.60 | 41571.52 | 8.01 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 22% |
| Heritage | P1 | 60-62 | 3000 | 16.60 | 354277.71 | 34018.45 | 1.45 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 43% |
| Heritage | P1 | 60-62 | 4000 | 20.66 | 354666.60 | 32946.20 | 0.61 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 54% |
| Heritage | P1 | 60-62 | 5000 | 24.46 | 357155.49 | 26366.67 | 0.31 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 64% |
| Heritage | P1 | 60-62 | 6000 | 28.62 | 356377.71 | 22125.61 | 0.18 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 75% |
| Heritage | P1 | 60-62 | 7000 | 31.37 | 354977.71 | 17570.04 | 0.12 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 82% |
| Heritage | P1 | 60-62 | 8000 | 33.43 | 355133.27 | 12728.87 | 0.12 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 87% |
| Heritage | P1 | 60-62 | 9000 | 35.54 | 354588.82 | 11386.14 | 0.27 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 93% |
| Heritage | P1 | 60-62 | 10000 | 36.94 | 153066.64 | 12932.63 | 6.40 | 2.41 | 2.46 | 2.0E+06 | 38.31 | 96% |
| Heritage | EB5 | 54-56 | 1000 | 2.83 | 18441.31 | 212124.21 | 25496430.00 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 9% |
| Heritage | EB5 | 54-56 | 2000 | 4.35 | 18253.13 | 49117.61 | 77542.16 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 15% |
| Heritage | EB5 | 54-56 | 3000 | 8.28 | 18265.14 | 42872.92 | 0.04 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 28% |
| Heritage | EB5 | 54-56 | 4000 | 10.19 | 18261.14 | 26127.26 | 0.02 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 34% |
| Heritage | EB5 | 54-56 | 5000 | 11.90 | 18377.25 | 32160.61 | 0.02 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 40% |
| Heritage | EB5 | 54-56 | 6000 | 13.73 | 18405.27 | 33551.75 | 0.04 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 46% |
| Heritage | EB5 | 54-56 | 7000 | 15.41 | 18281.16 | 30849.40 | 0.02 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 52% |
| Heritage | EB5 | 54-56 | 8000 | 17.36 | 18261.14 | 16607.64 | 0.01 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 58% |
| Heritage | EB5 | 54-56 | 9000 | 18.55 | 18253.13 | 17098.32 | 0.01 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 62% |
| Heritage | EB5 | 54-56 | 10000 | 21.30 | 18481.34 | 12789.92 | 0.01 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 71% |
| Heritage | EB5 | 54-56 | 11000 | 24.02 | 18281.16 | 12305.45 | 0.01 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 80% |
| Heritage | EB5 | 54-56 | 12000 | 26.05 | 18277.15 | 9474.45 | 0.01 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 87% |
| Heritage | EB5 | 54-56 | 13000 | 24.84 | 2386.24 | 9664.53 | 0.01 | 2.43 | 2.44 | 2.0E+07 | 29.85 | 83% |
| Ramsey Branch | 0 | 63.5-66 | 1000 | 5.32 | 491761.99 | 75724.30 | 168.91 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 11% |
| Ramsey Branch | 0 | 63.5-66 | 2000 | 10.84 | 491225.72 | 50484.55 | 1.41 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 21% |
| Ramsey Branch | 0 | 63.5-66 | 3000 | 20.88 | 489724.16 | 38654.19 | 0.33 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 41% |
| Ramsey Branch | 0 | 63.5-66 | 4000 | 25.89 | 488866.12 | 29691.39 | 0.19 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 51% |
| Ramsey Branch | 0 | 63.5-66 | 5000 | 29.73 | 488651.61 | 25823.70 | 0.19 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 59% |
| Ramsey Branch | 0 | 63.5-66 | 6000 | 35.13 | 489187.89 | 23994.61 | 0.20 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 69% |
| Ramsey Branch | 0 | 63.5-66 | 7000 | 40.97 | 495301.39 | 24793.34 | 0.23 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 81% |
| Ramsey Branch | 0 | 63.5-66 | 8000 | 46.80 | 489080.63 | 26482.16 | 0.27 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 92% |
| Ramsey Branch | 0 | 63.5-66 | 9000 | 52.77 | 488758.87 | 29367.18 | 0.36 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 104% |
| Ramsey Branch | 0 | 63.5-66 | 10000 | 62.39 | 488866.12 | 29787.88 | 0.52 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 123% |
| Ramsey Branch | 0 | 63.5-66 | 11000 | 72.10 | 494550.61 | 30890.74 | 1.12 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 142% |
| Ramsey Branch | 0 | 63.5-66 | 12000 | 76.93 | 242716.99 | 39855.12 | 2.91 | 2.45 | 2.48 | 2.0E+06 | 50.62 | 152% |
| Ramsey Branch | B2 | 31-33.5 | 1000 | 6.58 | 271531.25 | 51730.00 | 9905.98 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 12% |
| Ramsey Branch | B2 | 31-33.5 | 2000 | 13.36 | 268178.29 | 47785.03 | 3.36 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 24% |
| Ramsey Branch | B2 | 31-33.5 | 3000 | 26.14 | 268472.41 | 36223.28 | 0.72 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 47% |
| Ramsey Branch | B2 | 31-33.5 | 4000 | 33.11 | 268354.76 | 22515.20 | 0.31 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 60% |
| Ramsey Branch | B2 | 31-33.5 | 5000 | 41.24 | 268119.46 | 22755.43 | 0.25 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 74% |
| Ramsey Branch | B2 | 31-33.5 | 6000 | 46.68 | 271295.95 | 23083.28 | 0.25 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 84% |
| Ramsey Branch | B2 | 31-33.5 | 7000 | 53.86 | 268119.46 | 27408.79 | 0.34 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 97% |
| Ramsey Branch | B2 | 31-33.5 | 8000 | 59.92 | 268001.81 | 28009.90 | 0.44 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 108% |
| Ramsey Branch | B2 | 31-33.5 | 9000 | 66.07 | 141530.37 | 33349.79 | 9.52 | 2.55 | 2.57 | 5.0E+07 | 55.61 | 119% |
| Ramsey Branch | B2 | 41-43.5 | 1000 | 5.95 | 341244.81 | 42384.66 | 115.76 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 11% |
| Ramsey Branch | B2 | 41-43.5 | 2000 | 11.46 | 337618.49 | 30361.05 | 2.45 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 22% |
| Ramsey Branch | B2 | 41-43.5 | 3000 | 22.89 | 337470.47 | 17482.87 | 0.53 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 43% |
| Ramsey Branch | B2 | 41-43.5 | 4000 | 29.70 | 337026.43 | 16052.18 | 0.37 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 56% |
| Ramsey Branch | B2 | 41-43.5 | 5000 | 36.44 | 338506.57 | 17458.61 | 0.30 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 69% |
| Ramsey Branch | B2 | 41-43.5 | 6000 | 43.01 | 339764.68 | 17660.49 | 0.26 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 81% |
| Ramsey Branch | B2 | 41-43.5 | 7000 | 48.30 | 337766.50 | 18801.29 | 0.24 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 91% |
| Ramsey Branch | B2 | 41-43.5 | 8000 | 54.39 | 336730.41 | 19217.54 | 0.24 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 103% |
| Ramsey Branch | B2 | 41-43.5 | 9000 | 60.39 | 337544.48 | 21264.75 | 0.33 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 114% |
| Ramsey Branch | B2 | 41-43.5 | 10000 | 67.67 | 182056.44 | 22910.34 | 0.57 | 2.46 | 2.55 | 5.0E+05 | 52.93 | 128% |
| Ramsey Branch | B3 | 48.5-51 | 1000 | 6.07 | 876487.79 | 32694.12 | 2.15 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 12% |
| Ramsey Branch | B3 | 48.5-51 | 2000 | 11.50 | 866223.13 | 32636.66 | 0.17 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 23% |
| Ramsey Branch | B3 | 48.5-51 | 3000 | 21.62 | 865842.96 | 17892.99 | 0.19 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 43% |
| Ramsey Branch | B3 | 48.5-51 | 4000 | 28.31 | 865462.79 | 17079.75 | 0.23 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 56% |
| Ramsey Branch | B3 | 48.5-51 | 5000 | 35.29 | 866603.31 | 18762.38 | 0.26 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 70% |
| Ramsey Branch | B3 | 48.5-51 | 6000 | 40.66 | 877058.05 | 19889.23 | 0.26 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 80% |
| Ramsey Branch | B3 | 48.5-51 | 7000 | 47.35 | 865652.87 | 21212.63 | 0.26 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 94% |
| Ramsey Branch | B3 | 48.5-51 | 8000 | 54.58 | 865842.96 | 22887.62 | 0.30 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 108% |
| Ramsey Branch | B3 | 48.5-51 | 9000 | 60.82 | 866223.13 | 26189.34 | 0.61 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 120% |
| Ramsey Branch | B3 | 48.5-51 | 10000 | 69.18 | 866983.48 | 27405.86 | 0.54 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 137% |
| Ramsey Branch | B3 | 48.5-51 | 11000 | 80.86 | 874396.84 | 32789.97 | 1.29 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 160% |
| Ramsey Branch | B3 | 48.5-51 | 12000 | 100.32 | 865082.62 | 48089.52 | 3.29 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 198% |
| Ramsey Branch | B3 | 48.5-51 | 13000 | 100.38 | 23760.78 | 53798.88 | 4.10 | 2.43 | 2.52 | 5.0E+05 | 50.62 | 198% |

# F.3 Cyclic Triaxial Strain versus Time Plots from Python™

## F.3.1 I-4 & SR-417

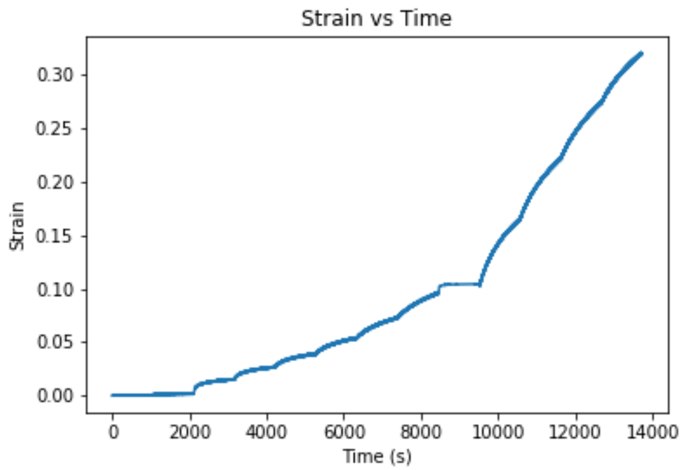


Figure F-1 – I-4 & SR-417: Sample Depth 20-22 ft

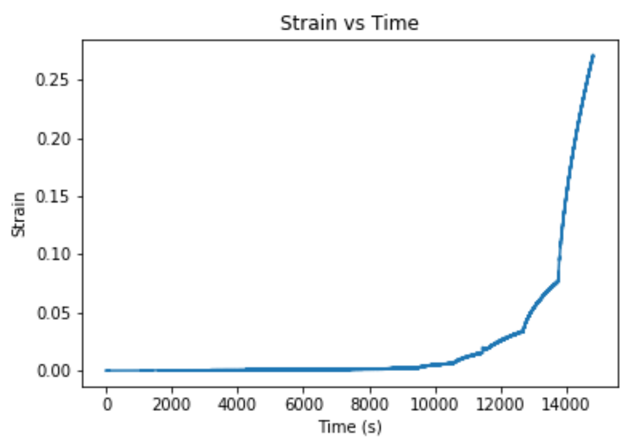


Figure F-2 I-4 & SR-417: Sample Depth 23-25 ft

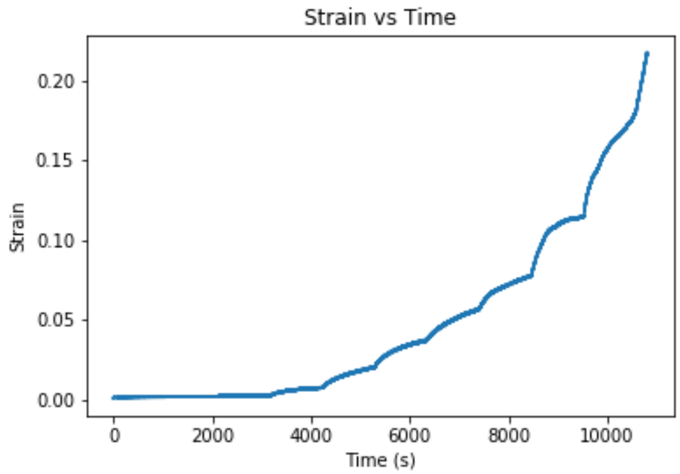


Figure F-3 I-4 & SR-417: Sample Depth 29-31 ft

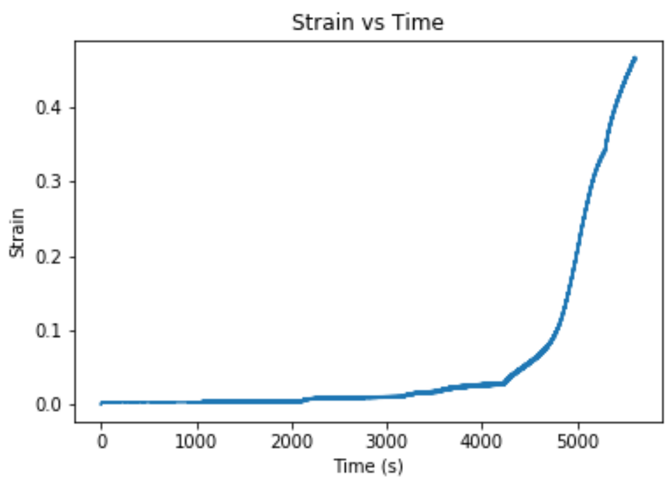


Figure F-4 I-4 & SR-417: Sample Depth 55-57 ft

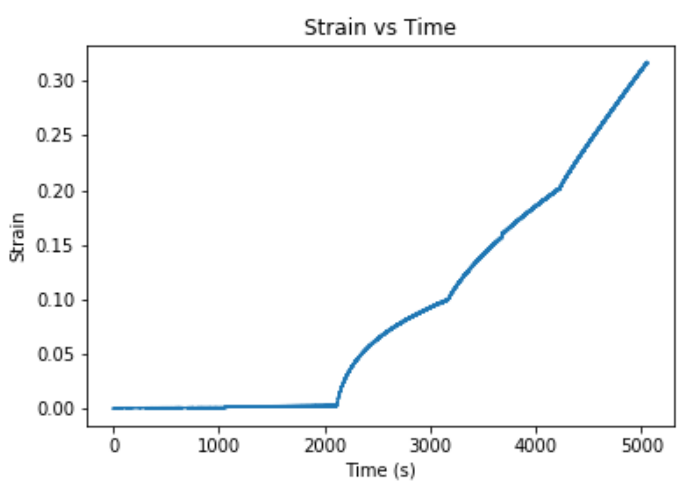


Figure F-5 I-4 & SR-417: Sample Depth 58-61 ft

## F.3.2 Heritage Parkway

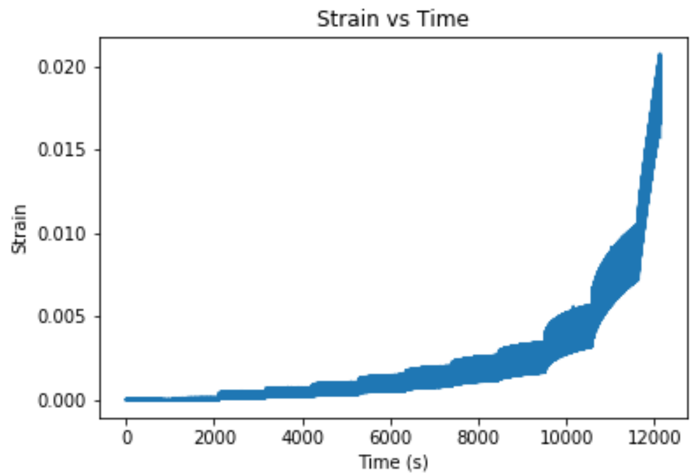


Figure F-6 - Heritage: Sample Depth 54-56 ft

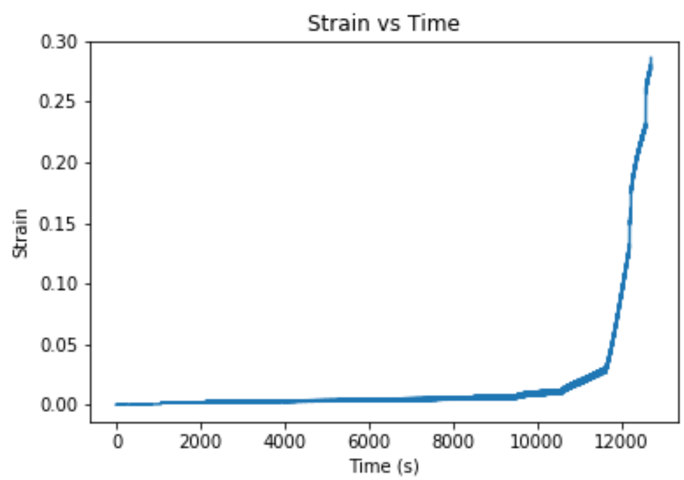


Figure F-7 - Heritage: Sample Depth 55-57 ft

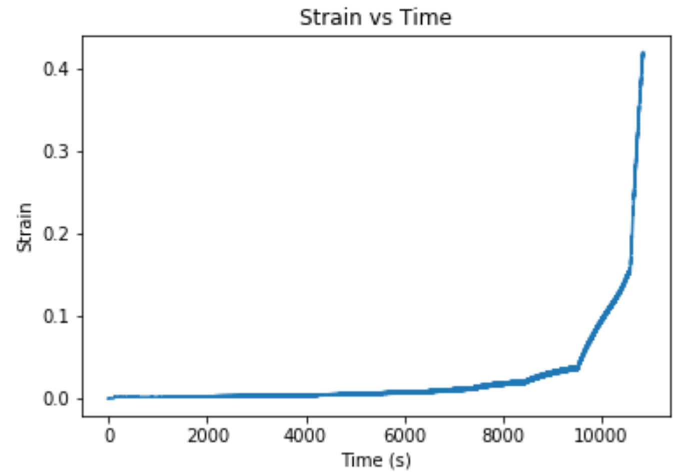

Figure F-8 Heritage: Sample Depth 57-59 ft

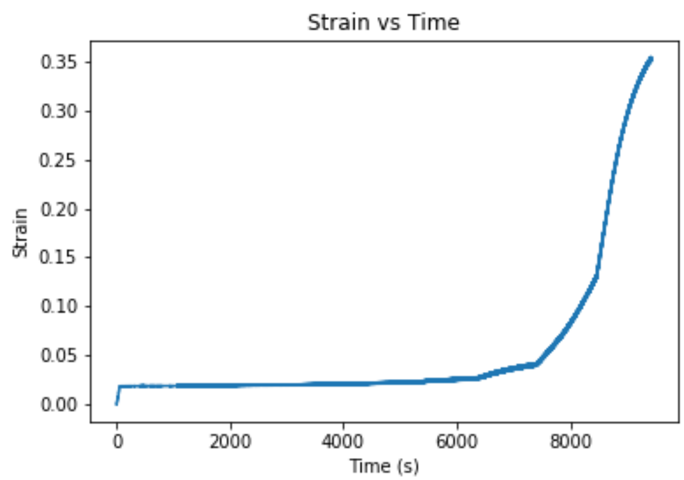

Figure F-9 Heritage: Sample Depth 60-62 ft

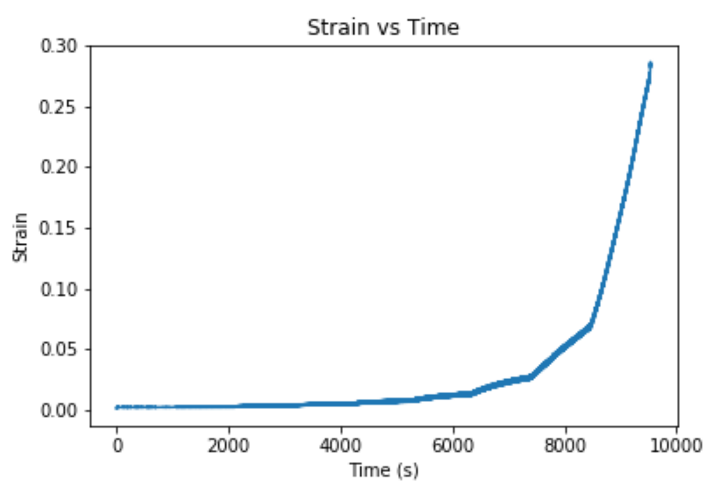

Figure F-10 Heritage: Sample Depth 62-64 ft

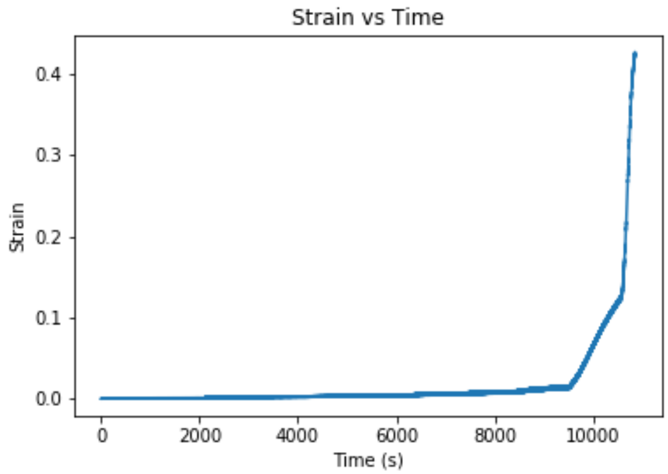

Figure F-11 Heritage: Sample Depth 62-64 (Test 2) ft

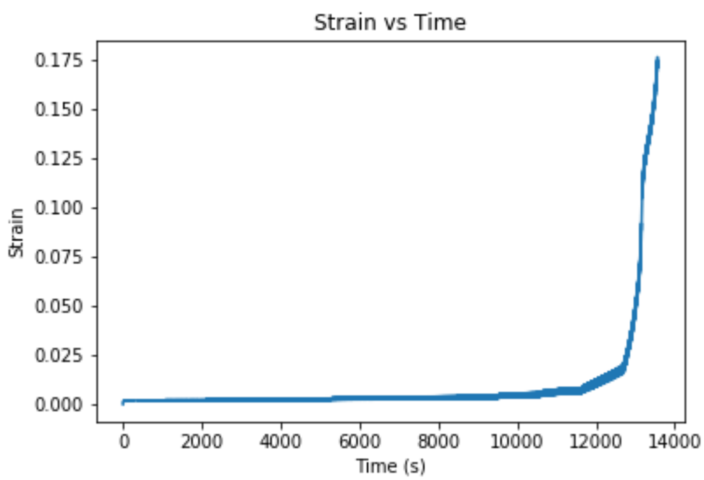

Figure F-12 Heritage: Sample Depth 65-67 ft

### F.3.3 I-10 & Chaffee

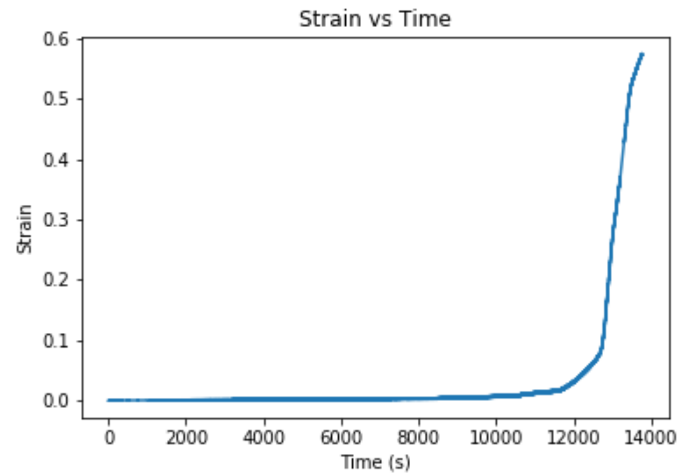


Figure F-13 I10 & Chaffee: Sample Depth 47-49 ft

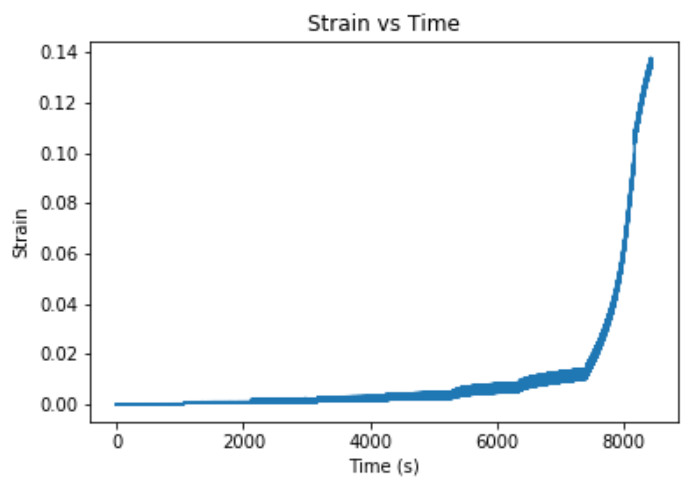


Figure F-14 I10 & Chaffee: Sample Depth 50-52 ft

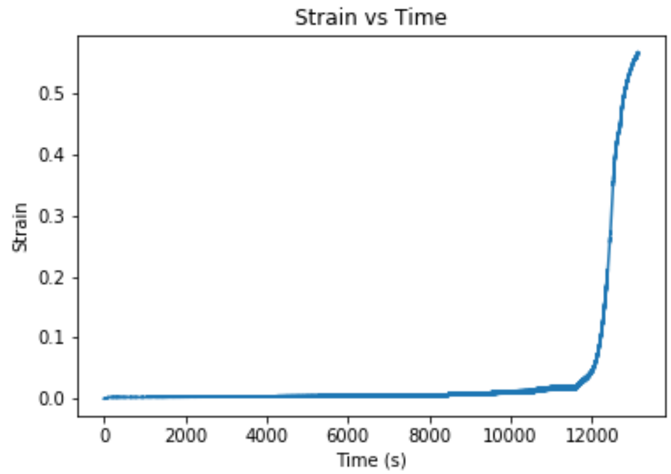


Figure F-15 I10 & Chaffee: Sample Depth 52-55 ft

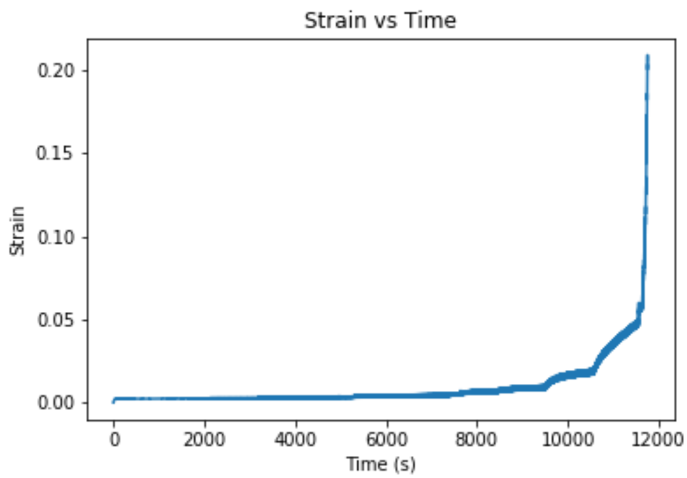


Figure F-16 I10 & Chaffee: Sample Depth 54-56 ft

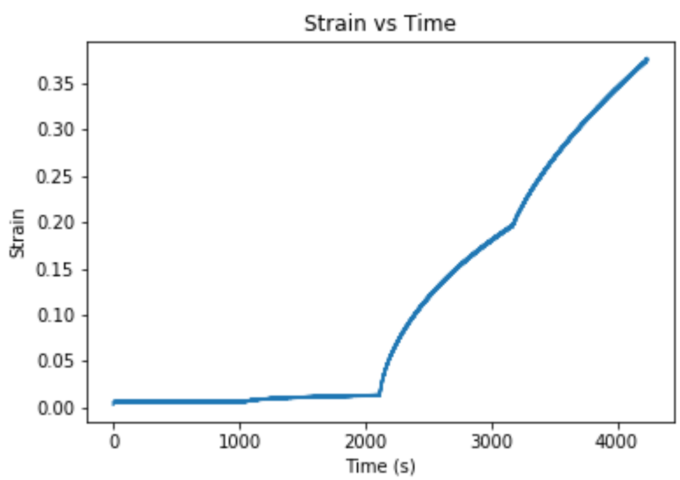


Figure F-17 I10 & Chaffee: Sample Depth 60-62 ft

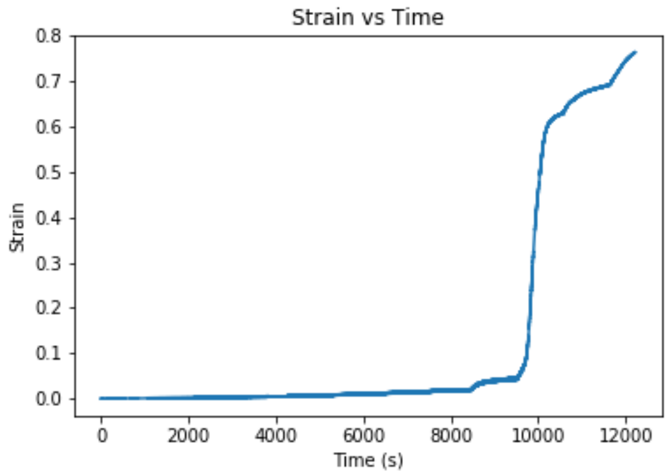

Figure F-18 I10 & Chaffee: Sample Depth 60-63 ft

### F.3.4 I-4 – SR-192

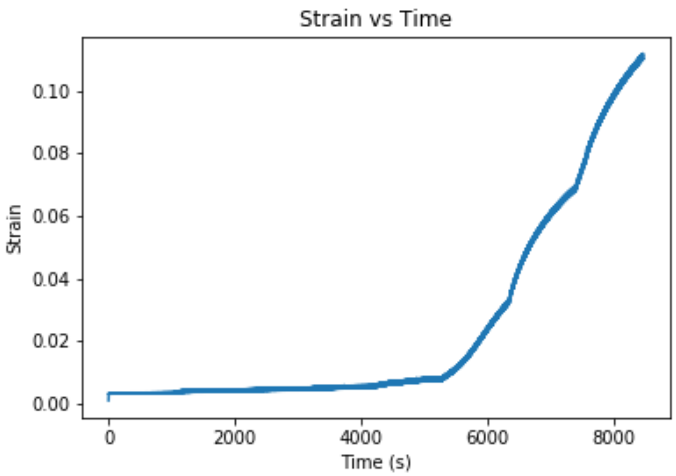


Figure F-19 I4 & 192: Sample Depth 45-47 ft

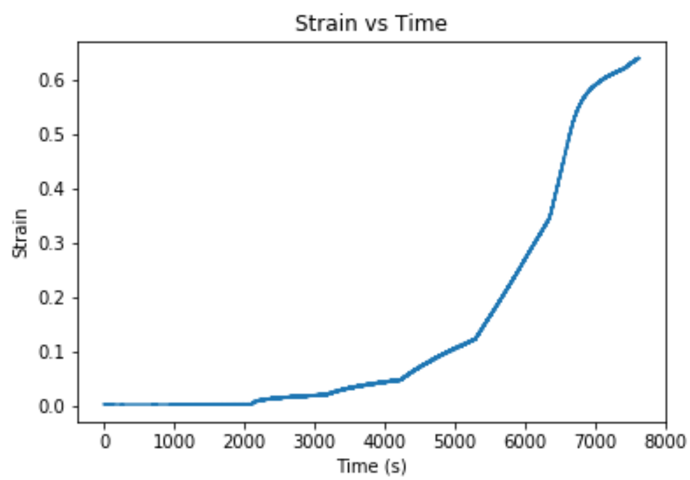


Figure F-20 I4 & 192: Sample Depth 46-47 ft

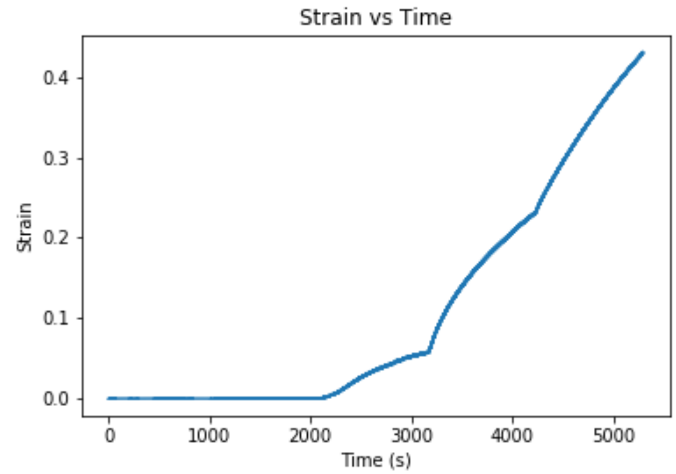


Figure F-21 I-4 & SR-192: Sample Depth 50-52 ft

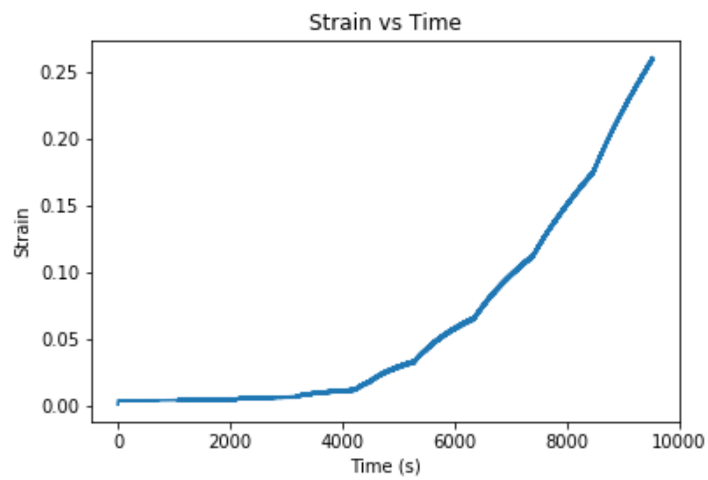


Figure F-22 I-4 & SR-192: Sample Depth 55-57 ft

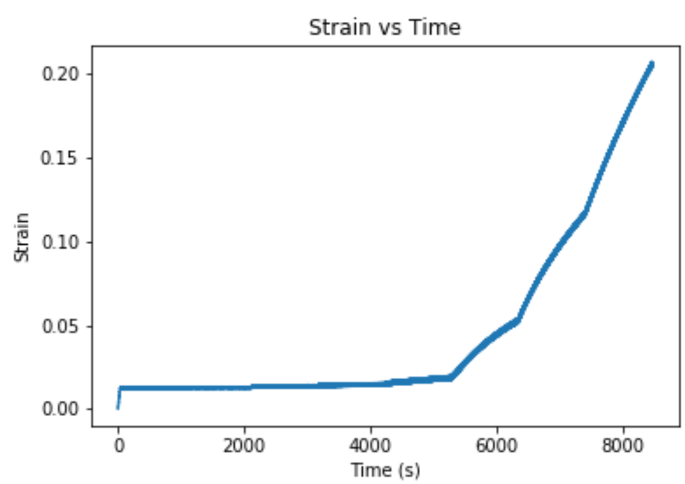


Figure F-23 I-4 & SR-192: Sample Depth 60-62 ft

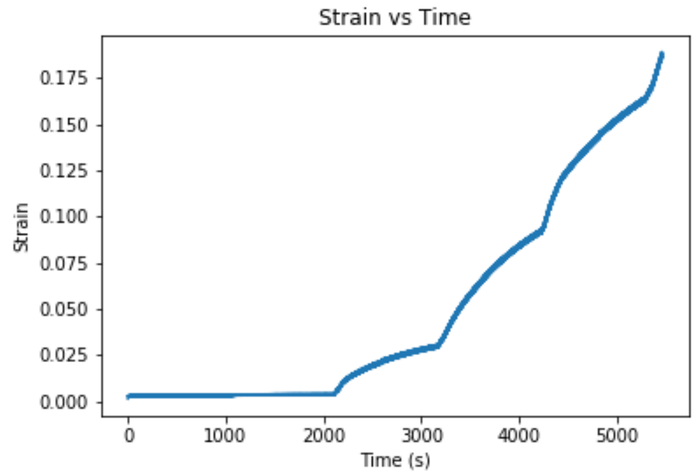


Figure F-24 I-4 & SR-192: Sample Depth 60-62 ft (Test 3)

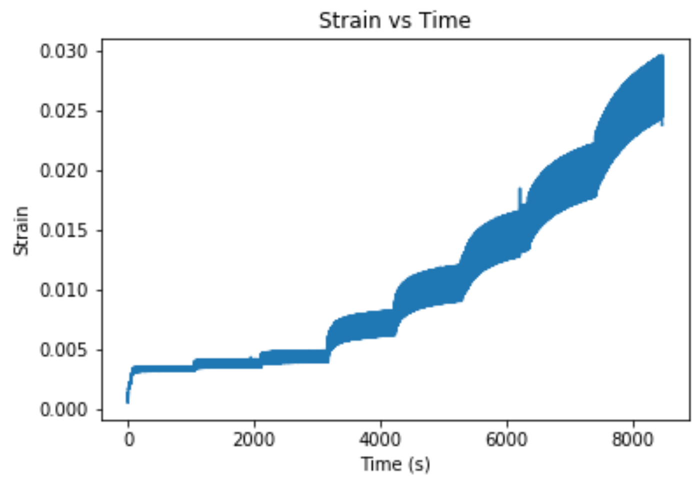


Figure F-25 I-4 & SR-192: Sample Depth 70-72 ft

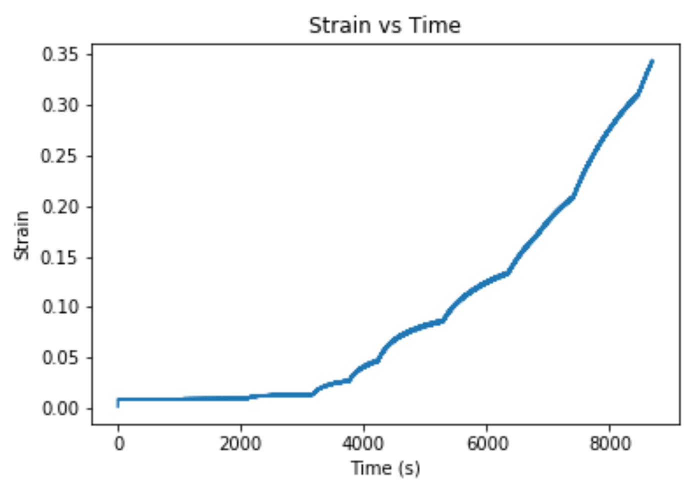


Figure F-26 I-4 & SR-192: Sample Depth 70-72 ft (Test 2)

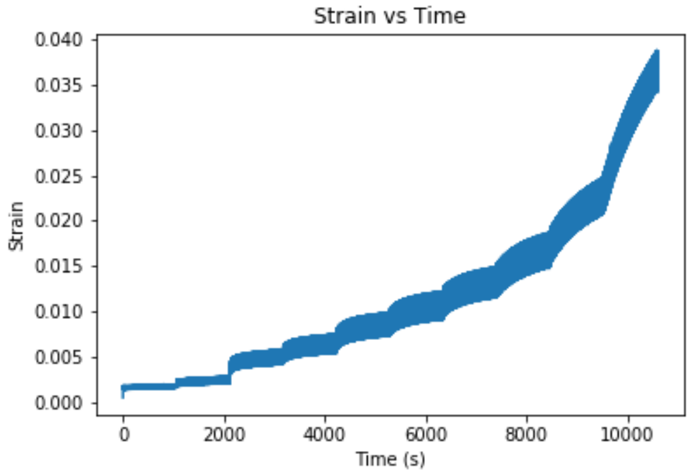


Figure F-27 I-4 & SR-192: Sample Depth 75-77 ft

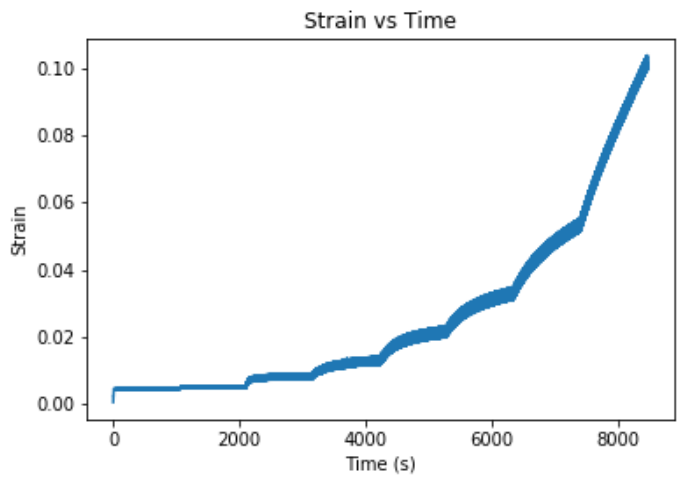


Figure F-28 I-4 & SR-192: Sample Depth 75-77 ft (Test 2)

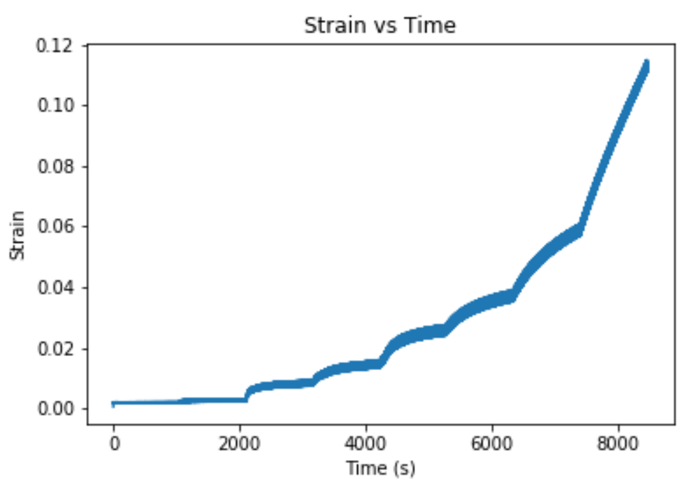


Figure F-29 I-4 & SR-192: Sample Depth 80-82 ft

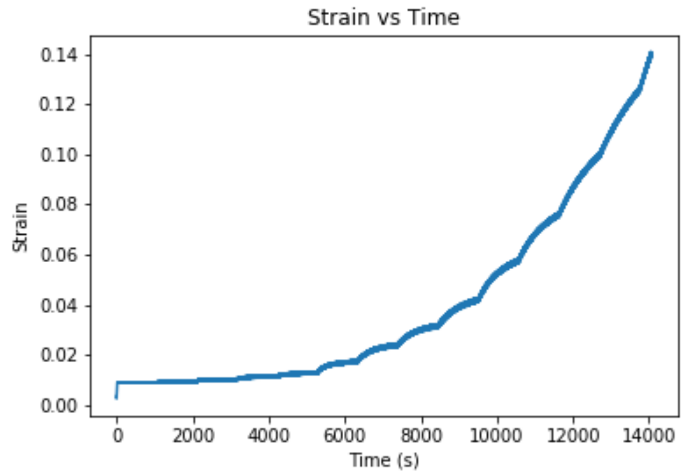


Figure F-30 I-4 & SR-192: Sample Depth 85-87 ft

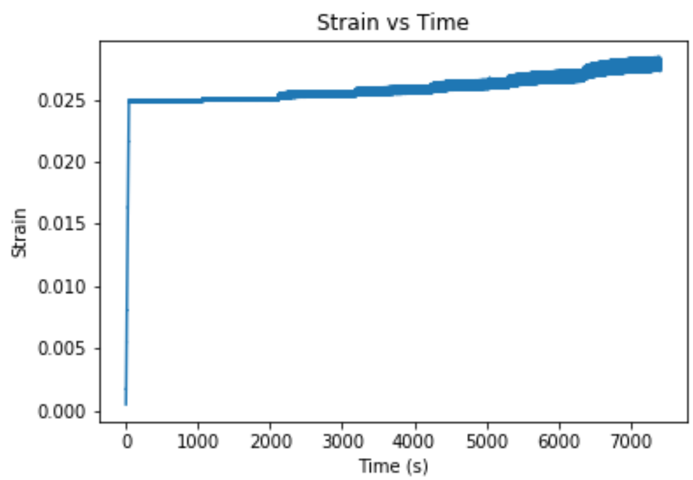


Figure F-31 I-4 & SR-192: Sample Depth 85-87 ft (Test 2)

## F.3.5 Ramsey Branch

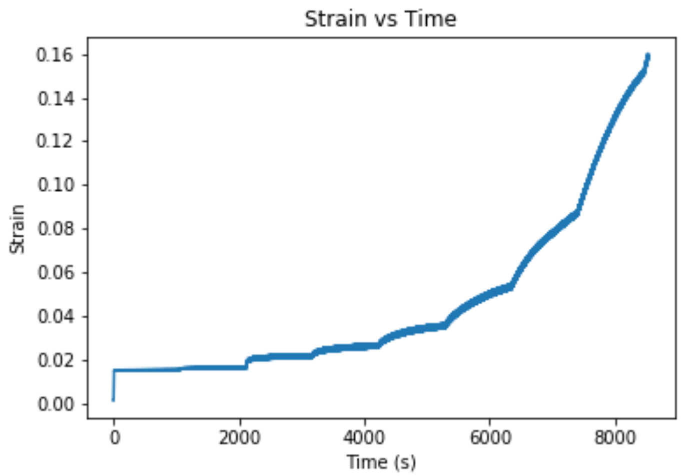


Figure F-32 Ramsey Branch: Sample Depth 31-33.5 ft

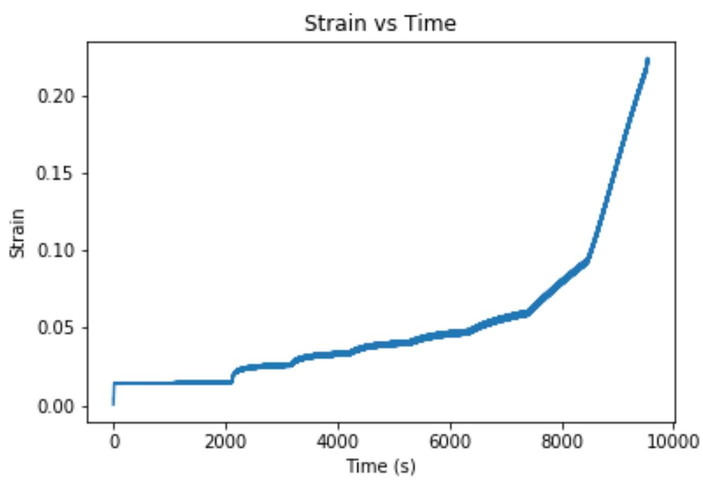


Figure F-33 Ramsey Branch: Sample Depth 41-43.5ft

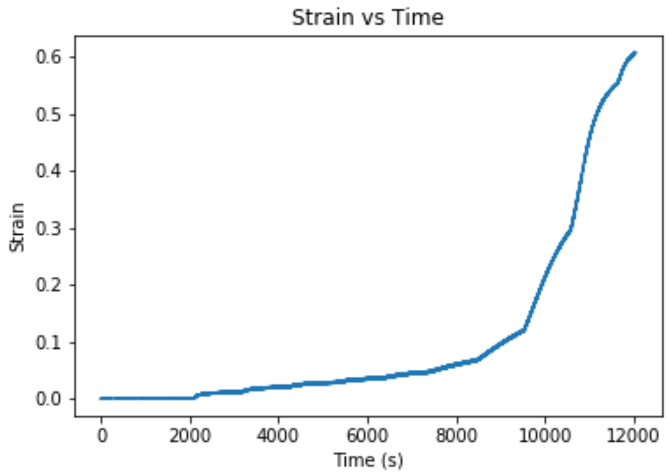

Figure F-34 Ramsey Branch: Sample Depth 48.5-51 ft

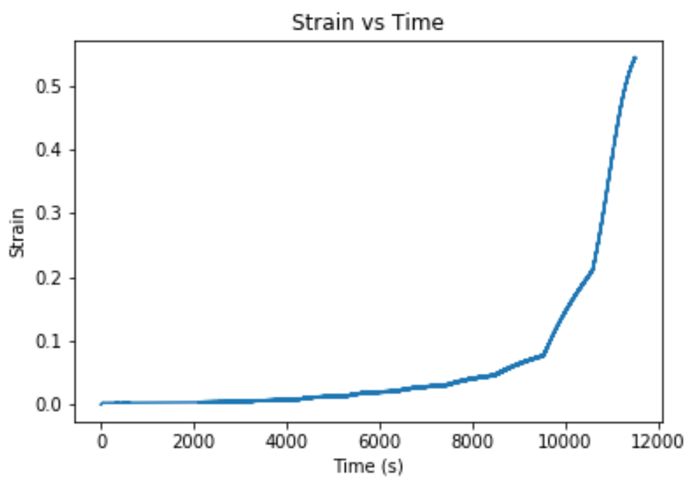

Figure F-35 Ramsey Branch: Sample Depth 63.5-66 ft

### F.3.6 I-4 and Osceola Parkway

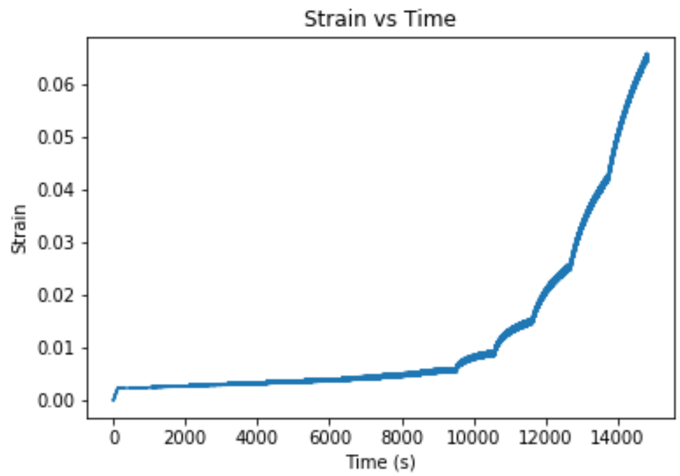


Figure F-36 Osceola: Sample Depth 60-61 ft

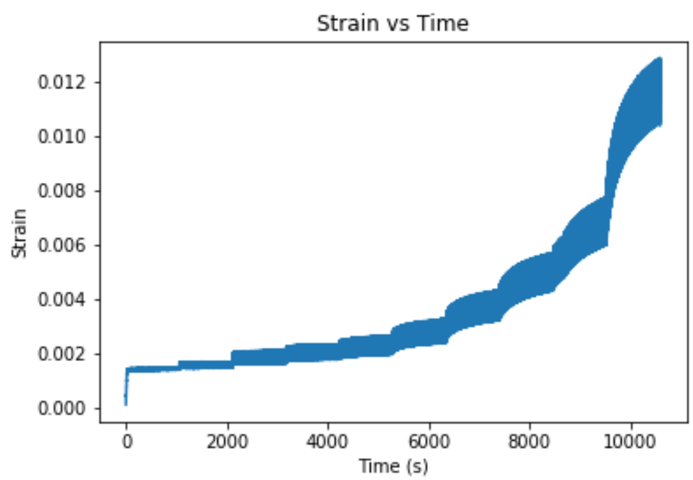


Figure F-37 Osceola: Sample Depth 75-76 ft

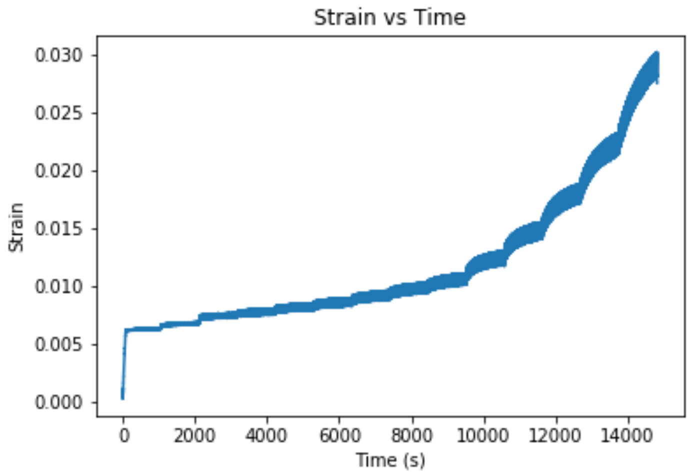

Figure F-38 Osceola: Sample Depth 75-76 ft (Test 2)

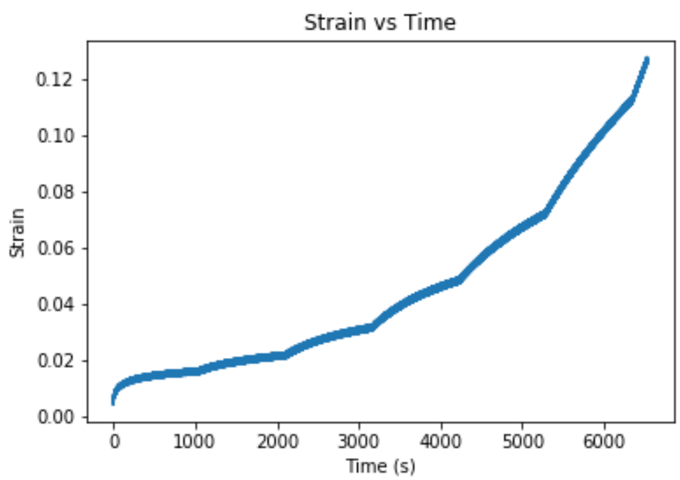

Figure F-39 Osceola: Sample Depth 80-81 ft

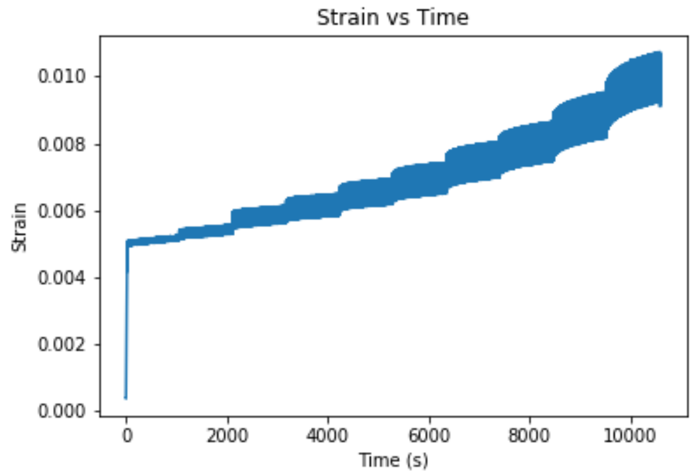


Figure F-40 Osceola: Sample Depth 80-81 ft (Test 2)

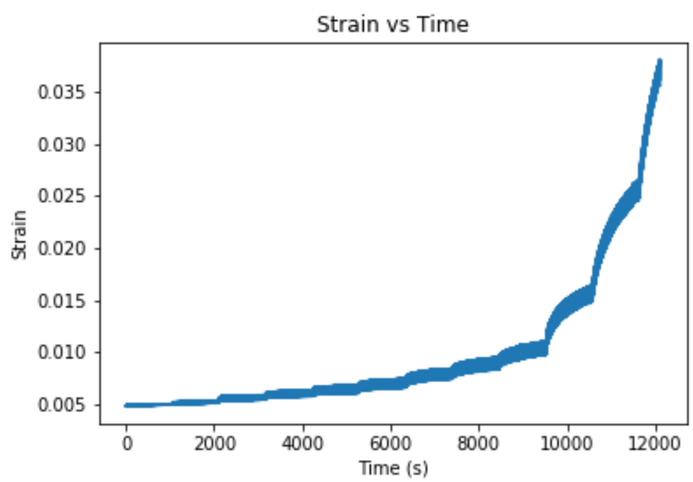


Figure F-41 Osceola: Sample Depth 80-82 ft

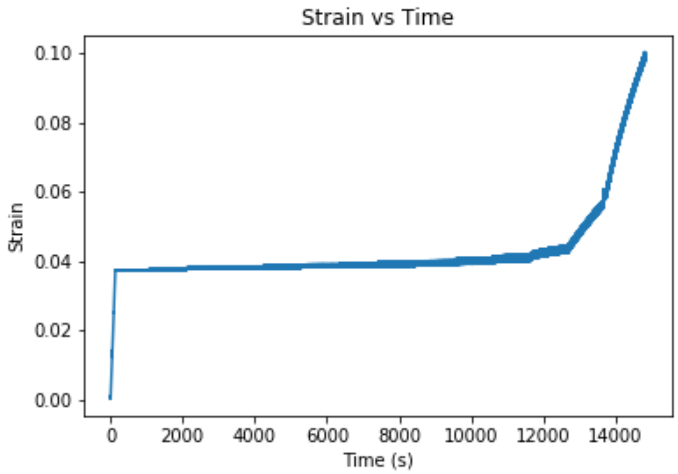

Figure F-42 Osceola: Sample Depth 80-82 ft (Test 2)

# Appendix G. CAPWAP Output Tables Results

## G.1 Chaffee Rd

CHAFFEE RD OVER I-10; Pile: PIER 2 PILE 9 Test: 15-Jun-2009 13:59:
PILECO D36-32; Blow: 354 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL-CH

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 421.1; along Shaft 171.1; at Toe 250.0 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 421.1 | | | | |
| 1 | 13.2 | 4.4 | 18.2 | 402.9 | 18.2 | 4.13 | 0.69 | 0.027 |
| 2 | 19.8 | 11.0 | 18.8 | 384.1 | 37.0 | 2.84 | 0.47 | 0.027 |
| 3 | 26.5 | 17.6 | 19.3 | 364.8 | 56.3 | 2.92 | 0.49 | 0.027 |
| 4 | 33.1 | 24.3 | 17.4 | 347.4 | 73.7 | 2.63 | 0.44 | 0.027 |
| 5 | 39.7 | 30.9 | 9.9 | 337.5 | 83.6 | 1.50 | 0.25 | 0.027 |
| 6 | 46.3 | 37.5 | 1.6 | 335.9 | 85.2 | 0.24 | 0.04 | 0.027 |
| 7 | 52.9 | 44.1 | 0.9 | 335.0 | 86.1 | 0.14 | 0.02 | 0.027 |
| 8 | 59.5 | 50.7 | 9.1 | 325.9 | 95.2 | 1.38 | 0.23 | 0.027 |
| 9 | 66.2 | 57.3 | 17.7 | 308.2 | 112.9 | 2.68 | 0.45 | 0.027 |
| 10 | 72.8 | 63.9 | 20.2 | 288.0 | 133.1 | 3.05 | 0.51 | 0.027 |
| 11 | 79.4 | 70.6 | 19.2 | 268.8 | 152.3 | 2.90 | 0.48 | 0.027 |
| 12 | 86.0 | 77.2 | 18.8 | 250.0 | 171.1 | 2.84 | 0.47 | 0.027 |
| Avg. Shaft | | | 14.3 | | | 2.22 | 0.37 | 0.027 |
| Toe | | | 250.0 | | | | 111.11 | 0.074 |

Figure G-1 - PR2PL9 – BN 354

## G.2 Heritage Parkway

PALM BAY PK OVER C1 CANAL; Pile: End Bent 1 Pile 1 — Test: 17-Dec-2012 12:25:
APE 36-32; Blow: 279 — CAPWAP(R) 2006-3
Florida Institute of Technology — OP: GRL

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 420.4; along Shaft 89.4; at Toe 331.0 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 420.4 | | | | |
| 1 | 64.1 | 7.2 | 0.0 | 420.4 | 0.0 | 0.00 | 0.00 | 0.000 |
| 2 | 70.8 | 13.9 | 0.0 | 420.4 | 0.0 | 0.00 | 0.00 | 0.000 |
| 3 | 77.5 | 20.7 | 0.0 | 420.4 | 0.0 | 0.00 | 0.00 | 0.000 |
| 4 | 84.3 | 27.4 | 0.0 | 420.4 | 0.0 | 0.00 | 0.00 | 0.000 |
| 5 | 91.0 | 34.2 | 0.0 | 420.4 | 0.0 | 0.00 | 0.00 | 0.000 |
| 6 | 97.8 | 40.9 | 0.0 | 420.4 | 0.0 | 0.00 | 0.00 | 0.000 |
| 7 | 104.5 | 47.6 | 0.0 | 420.4 | 0.0 | 0.00 | 0.00 | 0.000 |
| 8 | 111.3 | 54.4 | 30.9 | 389.5 | 30.9 | 4.58 | 0.76 | 0.194 |
| 9 | 118.0 | 61.1 | 58.5 | 331.0 | 89.4 | 8.68 | 1.45 | 0.194 |
| Avg. Shaft | | | 9.9 | | | 1.46 | 0.24 | 0.194 |
| Toe | | | 331.0 | | | | 147.11 | 0.111 |

Figure G-2 – EB1P1 – BN 279

Palm Bay Pk over C1 Canal; Pile: End Bent 5 Pile 1 — Test: 20-Dec-2012 16:31:
APE D36-32; Blow: 450 — CAPWAP(R) 2006-3
Florida Institute of Technology — OP: GRL-RMG

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 419.9; along Shaft 113.8; at Toe 306.1 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 419.9 | | | | |
| 1 | 70.8 | 4.9 | 6.1 | 413.8 | 6.1 | 1.26 | 0.21 | 0.088 |
| 2 | 77.5 | 11.6 | 4.3 | 409.5 | 10.4 | 0.64 | 0.11 | 0.088 |
| 3 | 84.3 | 18.3 | 1.1 | 408.4 | 11.5 | 0.16 | 0.03 | 0.088 |
| 4 | 91.0 | 25.1 | 0.0 | 408.4 | 11.5 | 0.00 | 0.00 | 0.000 |
| 5 | 97.8 | 31.8 | 2.2 | 406.2 | 13.7 | 0.33 | 0.05 | 0.088 |
| 6 | 104.5 | 38.6 | 16.6 | 389.6 | 30.3 | 2.46 | 0.41 | 0.088 |
| 7 | 111.3 | 45.3 | 35.4 | 354.2 | 65.7 | 5.25 | 0.87 | 0.088 |
| 8 | 118.0 | 52.1 | 48.1 | 306.1 | 113.8 | 7.13 | 1.19 | 0.088 |
| Avg. Shaft | | | 14.2 | | | 2.19 | 0.36 | 0.088 |
| Toe | | | 306.1 | | | | 136.04 | 0.189 |

Figure G-3 – EB5P1 – BN 450

Palm Bay Pk over C1 Canal; Pile: Int Bent 3 Pile 1 Test: 20-Dec-2012 14:14:
APE D36-32; Blow: 280 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL-RMG

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 450.8; along Shaft 63.1; at Toe 387.7 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 450.8 | | | | |
| 1 | 77.5 | 8.1 | 0.1 | 450.7 | 0.1 | 0.01 | 0.00 | 0.358 |
| 2 | 84.3 | 14.9 | 0.1 | 450.6 | 0.2 | 0.01 | 0.00 | 0.358 |
| 3 | 91.0 | 21.6 | 0.2 | 450.4 | 0.4 | 0.03 | 0.00 | 0.358 |
| 4 | 97.8 | 28.3 | 0.1 | 450.3 | 0.5 | 0.01 | 0.00 | 0.358 |
| 5 | 104.5 | 35.1 | 0.0 | 450.3 | 0.5 | 0.00 | 0.00 | 0.000 |
| 6 | 111.3 | 41.8 | 15.6 | 434.7 | 16.1 | 2.31 | 0.39 | 0.358 |
| 7 | 118.0 | 48.6 | 47.0 | 387.7 | 63.1 | 6.97 | 1.16 | 0.358 |
| Avg. Shaft | | | 9.0 | | | 1.30 | 0.22 | 0.358 |
| Toe | | | 387.7 | | | | 172.31 | 0.052 |

Figure G-4 - IB3P1 – BN 280

Palm Bay Pk over C1 Canal; Pile: Int Bent 4 Pile 10 Test: 21-Dec-2012 13:19:
APE D36-32; Blow: 158 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL-RMG

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 396.4; along Shaft 48.0; at Toe 348.4 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 396.4 | | | | |
| 1 | 77.5 | 7.6 | 0.1 | 396.3 | 0.1 | 0.01 | 0.00 | 0.051 |
| 2 | 84.3 | 14.3 | 0.1 | 396.2 | 0.2 | 0.01 | 0.00 | 0.051 |
| 3 | 91.0 | 21.1 | 0.0 | 396.2 | 0.2 | 0.00 | 0.00 | 0.000 |
| 4 | 97.8 | 27.8 | 0.3 | 395.9 | 0.5 | 0.04 | 0.01 | 0.051 |
| 5 | 104.5 | 34.6 | 5.4 | 390.5 | 5.9 | 0.80 | 0.13 | 0.051 |
| 6 | 111.3 | 41.3 | 16.1 | 374.4 | 22.0 | 2.39 | 0.40 | 0.051 |
| 7 | 118.0 | 48.1 | 26.0 | 348.4 | 48.0 | 3.86 | 0.64 | 0.051 |
| Avg. Shaft | | | 6.9 | | | 1.00 | 0.17 | 0.051 |
| Toe | | | 348.4 | | | | 154.84 | 0.088 |

Figure G-5 – IB4P10 – BN 158

## G.3 I-4 & SR-192

RAMP CA FLYOVER; Pile: PIER 8 PILE 4 Test: 19-Aug-2005 16:05:
ICE 120-S; Blow: 2260 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL/MH

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 389.5; along Shaft 110.1; at Toe 279.4 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 389.5 | | | | |
| 1 | 26.3 | 4.7 | 32.9 | 356.6 | 32.9 | 7.02 | 0.88 | 0.211 |
| 2 | 32.9 | 11.3 | 22.0 | 334.6 | 54.9 | 3.35 | 0.42 | 0.211 |
| 3 | 39.4 | 17.8 | 9.5 | 325.1 | 64.4 | 1.45 | 0.18 | 0.211 |
| 4 | 46.0 | 24.4 | 4.6 | 320.5 | 69.0 | 0.70 | 0.09 | 0.211 |
| 5 | 52.6 | 31.0 | 9.4 | 311.1 | 78.4 | 1.43 | 0.18 | 0.211 |
| 6 | 59.1 | 37.5 | 19.5 | 291.6 | 97.9 | 2.97 | 0.37 | 0.211 |
| 7 | 65.7 | 44.1 | 5.9 | 285.7 | 103.8 | 0.90 | 0.11 | 0.211 |
| 8 | 72.3 | 50.7 | 6.3 | 279.4 | 110.1 | 0.96 | 0.12 | 0.211 |
| 9 | 78.9 | 57.3 | 0.0 | 279.4 | 110.1 | 0.00 | 0.00 | 0.000 |
| 10 | 85.4 | 63.8 | 0.0 | 279.4 | 110.1 | 0.00 | 0.00 | 0.000 |
| 11 | 92.0 | 70.4 | 0.0 | 279.4 | 110.1 | 0.00 | 0.00 | 0.000 |
| Avg. Shaft | | | 10.0 | | | 1.56 | 0.20 | 0.211 |
| Toe | | | 279.4 | | | | 69.85 | 0.028 |

Figure G-6 - P8P4 – BN 2260

# G.4 SR-417 & International

SR 417 INTL PKWY RAMP; Pile: END BENT 1 PILE 14 Test: 14-Mar-2011 11:39:
APE D46-42 HAMMER; Blow: 322 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL-MH

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 407.3; along Shaft 90.1; at Toe 317.2 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 407.3 | | | | |
| 1 | 72.6 | 3.4 | 0.0 | 407.3 | 0.0 | 0.00 | 0.00 | 0.000 |
| 2 | 79.2 | 10.0 | 0.0 | 407.3 | 0.0 | 0.00 | 0.00 | 0.000 |
| 3 | 85.8 | 16.6 | 0.4 | 406.9 | 0.4 | 0.06 | 0.01 | 0.171 |
| 4 | 92.4 | 23.2 | 33.3 | 373.6 | 33.7 | 5.05 | 0.63 | 0.171 |
| 5 | 99.0 | 29.8 | 56.4 | 317.2 | 90.1 | 8.55 | 1.07 | 0.171 |
| Avg. Shaft | | | 18.0 | | | 3.02 | 0.38 | 0.171 |
| Toe | | | 317.2 | | | | 79.30 | 0.170 |

Figure G-7 – EB1P14 – BN 322

SR 417 INTL PKWY RAMP; Pile: END BENT 2 PILE 5 Test: 16-Mar-2011 15:16:
APE D46-42 HAMMER; Blow: 1479 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 577.2; along Shaft 111.6; at Toe 465.6 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 577.2 | | | | |
| 1 | 33.0 | 7.0 | 0.5 | 576.7 | 0.5 | 0.07 | 0.01 | 0.182 |
| 2 | 39.6 | 13.6 | 2.8 | 573.9 | 3.3 | 0.42 | 0.05 | 0.182 |
| 3 | 46.2 | 20.2 | 6.2 | 567.7 | 9.5 | 0.94 | 0.12 | 0.182 |
| 4 | 52.8 | 26.8 | 7.9 | 559.8 | 17.4 | 1.20 | 0.15 | 0.182 |
| 5 | 59.4 | 33.4 | 7.3 | 552.5 | 24.7 | 1.11 | 0.14 | 0.182 |
| 6 | 66.0 | 40.0 | 6.4 | 546.1 | 31.1 | 0.97 | 0.12 | 0.182 |
| 7 | 72.6 | 46.6 | 6.7 | 539.4 | 37.8 | 1.02 | 0.13 | 0.182 |
| 8 | 79.2 | 53.2 | 7.2 | 532.2 | 45.0 | 1.09 | 0.14 | 0.182 |
| 9 | 85.8 | 59.8 | 9.6 | 522.6 | 54.6 | 1.45 | 0.18 | 0.182 |
| 10 | 92.4 | 66.4 | 21.0 | 501.6 | 75.6 | 3.18 | 0.40 | 0.182 |
| 11 | 99.0 | 73.0 | 36.0 | 465.6 | 111.6 | 5.45 | 0.68 | 0.182 |
| Avg. Shaft | | | 10.1 | | | 1.53 | 0.19 | 0.182 |
| Toe | | | 465.6 | | | | 116.40 | 0.103 |

Figure G-8 - EB2P5 – BN 1479

## G.5 Ramsey Branch

SR 83 OVER RAMSEY BRANCH; Pile: END BENT 1 PILE 1 Test: 11-Jul-2014 15:04:
APE D50-42; Blow: 654 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL-DP

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 336.4; along Shaft 26.9; at Toe 309.5 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 336.4 | | | | |
| 1 | 33.7 | 5.5 | 19.6 | 316.8 | 19.6 | 3.56 | 0.44 | 0.945 |
| 2 | 40.4 | 12.2 | 6.6 | 310.2 | 26.2 | 0.98 | 0.12 | 0.945 |
| 3 | 47.1 | 19.0 | 0.2 | 310.0 | 26.4 | 0.03 | 0.00 | 0.945 |
| 4 | 53.9 | 25.7 | 0.0 | 310.0 | 26.4 | 0.00 | 0.00 | 0.000 |
| 5 | 60.6 | 32.4 | 0.0 | 310.0 | 26.4 | 0.00 | 0.00 | 0.000 |
| 6 | 67.3 | 39.2 | 0.0 | 310.0 | 26.4 | 0.00 | 0.00 | 0.000 |
| 7 | 74.1 | 45.9 | 0.0 | 310.0 | 26.4 | 0.00 | 0.00 | 0.000 |
| 8 | 80.8 | 52.6 | 0.0 | 310.0 | 26.4 | 0.00 | 0.00 | 0.000 |
| 9 | 87.5 | 59.4 | 0.1 | 309.9 | 26.5 | 0.01 | 0.00 | 0.945 |
| 10 | 94.3 | 66.1 | 0.4 | 309.5 | 26.9 | 0.06 | 0.01 | 0.945 |
| 11 | 101.0 | 72.8 | 0.0 | 309.5 | 26.9 | 0.00 | 0.00 | 0.000 |
| Avg. Shaft | | | 2.4 | | | 0.37 | 0.05 | 0.945 |
| Toe | | | 309.5 | | | | 77.37 | 0.163 |

Figure G-9 - EB1P1 – BN 654

SR 83 OVER RAMSEY BRANCH; Pile: END BENT 1 PILE 3 Test: 07-Aug-2014 09:50:
APE D50-42; Blow: 600 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL-DP

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 299.7; along Shaft 36.5; at Toe 263.2 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 299.7 | | | | |
| 1 | 9.9 | 6.1 | 9.0 | 290.7 | 9.0 | 1.48 | 0.18 | 0.069 |
| 2 | 16.5 | 12.7 | 6.2 | 284.5 | 15.2 | 0.94 | 0.12 | 0.069 |
| 3 | 23.1 | 19.3 | 3.0 | 281.5 | 18.2 | 0.45 | 0.06 | 0.069 |
| 4 | 29.7 | 25.9 | 1.3 | 280.2 | 19.5 | 0.20 | 0.02 | 0.069 |
| 5 | 36.3 | 32.5 | 1.5 | 278.7 | 21.0 | 0.23 | 0.03 | 0.069 |
| 6 | 43.0 | 39.1 | 3.3 | 275.4 | 24.3 | 0.50 | 0.06 | 0.069 |
| 7 | 49.6 | 45.8 | 5.2 | 270.2 | 29.5 | 0.79 | 0.10 | 0.069 |
| 8 | 56.2 | 52.4 | 5.0 | 265.2 | 34.5 | 0.76 | 0.09 | 0.069 |
| 9 | 62.8 | 59.0 | 2.0 | 263.2 | 36.5 | 0.30 | 0.04 | 0.069 |
| 10 | 69.4 | 65.6 | 0.0 | 263.2 | 36.5 | 0.00 | 0.00 | 0.000 |
| 11 | 76.0 | 72.2 | 0.0 | 263.2 | 36.5 | 0.00 | 0.00 | 0.000 |
| Avg. Shaft | | | 3.3 | | | 0.51 | 0.06 | 0.069 |
| Toe | | | 263.2 | | | | 65.80 | 0.133 |

Figure G-10 – EB1P3 – BN 600

US331 OVER RAMSEY BRANCH; Pile: BENT 4 PILE 5 Test: 07-Oct-2013 18:39:
APE D50-42; Blow: 1322 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL-DP

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 244.0; along Shaft 86.9; at Toe 157.1 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 244.0 | | | | |
| 1 | 49.7 | 4.5 | 16.6 | 227.4 | 16.6 | 3.69 | 0.46 | 0.024 |
| 2 | 56.3 | 11.1 | 8.5 | 218.9 | 25.1 | 1.28 | 0.16 | 0.024 |
| 3 | 63.0 | 17.8 | 0.0 | 218.9 | 25.1 | 0.00 | 0.00 | 0.000 |
| 4 | 69.6 | 24.4 | 0.0 | 218.9 | 25.1 | 0.00 | 0.00 | 0.000 |
| 5 | 76.2 | 31.0 | 0.0 | 218.9 | 25.1 | 0.00 | 0.00 | 0.000 |
| 6 | 82.9 | 37.6 | 8.6 | 210.3 | 33.7 | 1.30 | 0.16 | 0.024 |
| 7 | 89.5 | 44.3 | 17.2 | 193.1 | 50.9 | 2.59 | 0.32 | 0.024 |
| 8 | 96.1 | 50.9 | 21.0 | 172.1 | 71.9 | 3.17 | 0.40 | 0.024 |
| 9 | 102.7 | 57.5 | 11.9 | 160.2 | 83.8 | 1.80 | 0.22 | 0.024 |
| 10 | 109.4 | 64.2 | 3.1 | 157.1 | 86.9 | 0.47 | 0.06 | 0.024 |
| 11 | 116.0 | 70.8 | 0.0 | 157.1 | 86.9 | 0.00 | 0.00 | 0.000 |
| Avg. Shaft | | | 7.9 | | | 1.23 | 0.15 | 0.024 |
| Toe | | | 157.1 | | | | 39.27 | 0.207 |

Figure G-11 - EB4P5 – BN 1322

US331 OVER RAMSEY BRANCH; Pile: END BENT 5 PILE 2 Test: 02-Oct-2013 10:22:
APE D50-42; Blow: 480 CAPWAP(R) 2006-3
Florida Institute of Technology OP: GRL-DP

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 229.2; along Shaft 28.0; at Toe 201.2 kips

| Soil Sgmnt No. | Dist. Below Gages ft | Depth Below Grade ft | Ru kips | Force in Pile kips | Sum of Ru kips | Unit Resist. (Depth) kips/ft | Unit Resist. (Area) ksf | Smith Damping Factor s/ft |
|---|---|---|---|---|---|---|---|---|
| | | | | 229.2 | | | | |
| 1 | 30.3 | 2.3 | 1.1 | 228.1 | 1.1 | 0.48 | 0.06 | 0.169 |
| 2 | 37.1 | 9.1 | 0.0 | 228.1 | 1.1 | 0.00 | 0.00 | 0.000 |
| 3 | 43.8 | 15.8 | 0.0 | 228.1 | 1.1 | 0.00 | 0.00 | 0.000 |
| 4 | 50.6 | 22.5 | 0.0 | 228.1 | 1.1 | 0.00 | 0.00 | 0.000 |
| 5 | 57.3 | 29.3 | 0.0 | 228.1 | 1.1 | 0.00 | 0.00 | 0.000 |
| 6 | 64.0 | 36.0 | 0.0 | 228.1 | 1.1 | 0.00 | 0.00 | 0.000 |
| 7 | 70.8 | 42.8 | 0.0 | 228.1 | 1.1 | 0.00 | 0.00 | 0.000 |
| 8 | 77.5 | 49.5 | 1.0 | 227.1 | 2.1 | 0.15 | 0.02 | 0.169 |
| 9 | 84.3 | 56.2 | 8.6 | 218.5 | 10.7 | 1.28 | 0.16 | 0.169 |
| 10 | 91.0 | 63.0 | 17.3 | 201.2 | 28.0 | 2.57 | 0.32 | 0.169 |
| Avg. Shaft | | | 2.8 | | | 0.44 | 0.06 | 0.169 |
| Toe | | | 201.2 | | | | 50.30 | 0.063 |

Figure G-12 - EB5P2 – BN 480

# Appendix H. Lessons Learned from PDM Field Usage

The basic equipment, set-up procedures for the Inopiles Pile Driving Monitor (PDM) are outlined. *For more detailed information please see the PDM User's Manual supplied with the equipment and Chapter 4 of this report. At the time of this report an internet search indicates that the equipment is available in the US from AFT.*

## H.1 PDM Initial Equipment Evaluation and Setup

Inopiles supplies a schematic for the PDM set up which includes a table of active (or measuring) zone heights versus offset distance from object (i.e., typically a pile). The measuring zone is a vertical distance up from a horizontal line projected onto the object up at an angle of 2.6 degrees as shown in Figure H-1. They show the PDM being placed on a flat surface and a sand filled black leather bag, which is designed to keep the PDM level during use.

*Note that the measuring zone is about 18-inches maximum. It can be viewed by the operator as the distance between the two red dots shown in the schematic. Note however, these dots are only visible prior to testing. Once the software begins to collect data they are no longer shown. We recommend that the operator marks the pile/rods with colored chalk or possibly a set of string lines attached to the pile leads prior to each testing sequence. This additional step may not be possible during pile driving unless the installation is stopped.*

| Offset Distance (m) | Active Zone Height (m) |
|---|---|
| 5.5 | 0.25 |
| 10 | 0.45 |
| 11 | 0.50 |
| 16.5 | 0.75 |
| 25 | 1.13 |


Figure H-1 Schematic of Inopiles Operation within Active Zone

The Inopiles PDM in the case, leveling bag and the accompanying Surface Pro tablet are shown in Figure H-2 Note that the power requirements for the PDM included an Australian plug, while the Surface Pro® required a European plug. These differences required special purchases for charging and operation in the US. The PDM data acquisition and reduction software, which runs on the Surface Pro® and can be configured for a laptop, allows for the creation of reports for each set of tests within an active zone. Metric or English units may be selected by the user.

*Please bring a tent for shade and to prevent rainfall onto the PDM. Avoid carrying the PDM from the vehicle to the test location in heavy rain. Rain droplets could obscure the infrared light and the lasers used to denote the active zone.*

*Our experience indicates that the Surface Pro® battery life and operation may not be completely reliable, therefore we asked Inopiles for permission to place their software on a Laptop PC, which was granted. We recommend that any field laptop be equipped with a special screen to allows the operator to view data properly. Standard screens are difficult to read due to glare.*

Figure H-2 Inopiles PDM in Case, leveling bag and Surface Pro®

*Please ensure that all the charging cables are US compatible. The cables shipped with the unit are not. We found the cables at a local computer store.*

## H.2 Reflective Tape Evaluations

Three different reflective tapes were utilized during the lab and field testing. The first tape was that supplied by Inopiles, a 3M Diamond Grade tape. A second tape was purchased to replace the 3M Diamond Grade tape. It was 3M 3430 White Prismatic Sheeting Reflective Tape 3” x 6”. The third tape was purchased from ULINE with a product name of Outdoor Reflective Tape – 2" x 50’, WHITE. This third tape worked the best based on our work, however, all three tapes functioned well during field testing.

*Our experience with all tapes was that they had to be placed such that they were 2-inchs (50 mm) wide on the surface. If they were less than this thickness, they did not reflect the signal from the PDM well enough for data to be recorded.*

## H.3 PDM Field Testing Equipment

The equipment required to perform testing includes:

1) PDM Unit*
2) PDM power cable*
3) PDM data cable *
4) PDM mounting piece*
5) Surveying Tripod
6) Reflective tape*
7) Ryobi Laser distance finder*
8) 100-foot Surveying Measuring tape
9) Laptop PC with PDM software
10) Laptop charging cable
11) Tablet with PDM software*
12) Tablet charging cable*
13) Power adapter (Europe – USA)
14) Power adapter (Australia – USA)
15) PDM manual*
16) Driving log notes
17) Extension cables
18) Tent
19) Rags
20) *Miscellaneous Tools*

*The equipment supplied with the PDM are denoted with an *.*

*The manufacturer recommends that the PDM, laptop and tablet be completely charged before arriving at the job site. We recommend that equipment be carefully charged several days before use. Additionally, all cables must be transported to the site in case additional charging is* *required. During testing at the six sites, the PDM battery lasted throughout the workdays. However, both the tablet and the laptop batteries required charging after several hours of use. Also, be careful not to leave the Laptop PC on during travel time to the site as this extra duration will drain the battery.*

## H.4 PDM Data Collection for Piles

### H.4.1 PDM Pile Setup

Use of the manufacturers recommended leveling sandbag was not successful during deployment at the initial site. The research team, therefore, recommends that the PDM be placed on a tripod using the mounting piece and located between 5 and 20 meters from the pile. It should then be connected to either the laptop or tablet using the appropriate data cable. When the computers are connected properly to the PDM and its software the red guide lasers will turn on. Operators should be able to see these on the pile or rods prior to testing, etc., therefore, the PDM should be placed directly in line and perpendicular to the pile. The distance from the PDM to the pile also affects the width of the reflective tape. The research team determined that a minimum of 4-inch by thick 6-inches wide tape should be placed on the piles. The exact distance, to within 2-inches, should be determined by using either the laser distance finder or the measuring tape. The tripod should be adjusted so that the PDM is level with an unobstructed field of view. The field of view can be seen by where the guide lasers that the PDM outputs lie on the pile (note that these lasers turn off during testing). It is recommended that the equipment be setup under a tent or other shaded area so that either the laptop or tablet do not overheat, and the associated screen is easier to read.

*Our final recommendations are to have the surveying crew determine the elevation of the center of the PDM once it is mounted and leveled on the tripod. This elevation should be compared to the template elevation (i.e. beam) and the PDM operator should be made aware of whether the top of the template beam is being used. Use the 100- foot tape to confirm the distance from the PDM to the pile or rods being tested.*

### H.4.2 Pile Preparation and Data Collection

Prior to placing reflective tape on piles, determine the depth of predrilling and or jetting. When piles are pre-drilled, it is not necessary to put tape on the first section of pile as it will drive too fast for data to be collected. Piles are marked in one-foot increments with labels every five feet. The research team recommends that reflective tape be placed on the pile every five feet. This spacing will allow the software operator to input and prepare for the subsequent set of data collection as the pile is being continuously driven.

*This spacing of 5 feet did not produce enough data during the research and needs further evaluations. It might be better to check movement every 10 or 20 feet and compare them to the PDA movement. It might also be better to place tape on the piles when driving has to be stopped for such things as replacing the wooden cushions, adjustments in stroke height etc.*

Our experience with this data entry was that it was difficult to complete all the required step for input when the tape spacing was 5 feet apart.