Video Imaging Methodology for Estimation of Pile Capacity

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Piles have been used for generations in areas with weak soil conditions to reinforce existing ground or to support bridges and structures. As the piling industry increased over these years it was necessary to develop prediction methods to optimize designs and provide cost savings in material and man power.

Multiple predictive methods exist, in Ontario Ministry of Transportation (MTO) Modified Hiley Formula, further referred to as Modified Hiley, is used to estimate pile capacities during an installation program and provide a level of confidence in the design that was selected. Parameters required to generate this estimate are historically obtained with a pen and paper and ruler while standing below the pile driving equipment. Being inherently unsafe due to the noise and potential for equipment failure another method was devised during this research using high speed cameras and post processing techniques.

The first phase the research consisted of field data acquisition and collection of the pen and paper plots and of high speed video. This was followed by writing of computer code to convert the high-speed video into usable and legible data plots.

The second phase of research compared manually generated plots to plots generated using the high-speed camera equipment and it was found that an excellent correlation existed. Based on this correlation, subsequent parameters that were once measured manually or calculated with a timer were instead extrapolated from a plot generated by the post processing software.

The third and final phase of research used the newly gathered data from the high-speed camera equipment to calculate a predicted pile capacity for the MTO Modified Hiley, FHWA Gates and ENR Bearing formulae. All variables that required field data were populated and predicted pile capacities were computed without issue.

Despite the introduction of the post processed high-speed videos, it was found that this method could be used as a substitute for the traditional pen and paper methods used today with further testing.

Acknowledgements

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Chapter 1
Introduction

This thesis investigates the use of video imaging methods to obtain characteristics of pile driving process to estimate pile bearing capacity. Current methods utilized by the Ontario Ministry of Transportation (MTO) require personnel to stand near or next to the pile while being installed into the ground which can be dangerous. The parameters are required to carry out a calculation for the pile bearing capacity. This thesis describes the development of a tool to measure the elastic rebound and final set without contacting the pile during driving. The solution presented herein is a low-cost solution using open-source image processing software and a standard programming language.

The physical data for this thesis were obtained during the field portion of the research carried out between September 23, 2013 and November 22, 2013. Data collected during pile driving activities included pile blow counts, generation of manual set-rebound plots, and recording high speed videos of pile penetration. Following the piling activities, the research consisted of organizing the collected data, selecting a software that would assist in extracting the required information from the videos, writing computer code to facilitate the data extraction and finally comparing manually collected data with the computer-generated outputs from the high-speed video recordings.

Field data collected for this thesis was obtained on location at the Nipigon River Bridge Twinning pile driving program along Highway 11/17 in the township of Nipigon, Ontario. In total 30 piles were observed during pile driving. A total of 1418 high-speed video clips were recorded. There was a total of 11 video clips that corresponded with a set-rebound plot generated at the same time.

This thesis is subdivided into chapters to aid in the understanding of the process used to develop this method, and to summarize the background information required to work with the developed process.

Chapter one presents background information on piling and includes a brief history on piling, various types of piles and pile composition.

Chapter two presents the pile type and provides the installation method selected for this site and summarizes the type of pile driving equipment.

Chapter three summarizes the Dynamic Pile Driving Formulae including the FHWA Modified Gates, Hiley and MTO Modified Hiley and discusses the performance of each formula.

Chapter four describes the data collection required to calculate the pile bearing capacity and summarizes the data acquisition methodology and equipment used for the data collection.

Chapter five presents the data processing software and software selection and provides the correlation between the manually and computer collected data.

Chapter six describes the pile capacity estimation methodology and estimated bearing capacities computed with the computer collected data.

Chapter seven discusses the results encountered during the field work and later the computation stages and summarizes the limitations of the methods described herein.

Chapter eight provides concluding statements and recommendations for future research.

1.1 Background

Piles are defined as vertical or near vertical components of a foundation that are installed into the earth and act as a method to aid in supporting a load present at the ground surface or transfer a load present at the ground surface to a layer of more suitable material located below the surface. Piles are a type of deep foundation; deep foundations are defined as any structure whose embedded length to width ratio is greater than five (Terzaghi and Peck, 1960). Piles are used in areas where soil layers near the ground surface are too weak to support shallow foundations, or it is not economical to excavate earth to expose a more competent soil layer. Piles are used in structures ranging from but not limited to building foundations, bridge foundations, retaining walls, sign posts and piers.

Piles were initially composed of timber. Due to load carrying and length imitations present within the timber, piles have been constructed from concrete, steel and a combination of these materials. Steel provides the most flexible installation method as the length can be increased through splicing and steel has a higher load carrying capacity than that of timber.

More advanced pile materials led to more advanced installation methods of piles. Originally piles were installed manually by man power, pulleys and weights dropped onto the head of the piles. During the industrial revolution of the early 19th century steam, powered drivers were invented, followed by diesel and then hydraulically powered machines in 1801, 1946 and the 1960s, respectively (Sowers, 1979 and Hough, 1969). Other types of piles include piles that are not installed with percussion-based methods are installed with excavation, jetting, boring, jacking, vibration and electro-osmosis.

Piles transfer the loads present at the ground surface to subsurface strata through two methods:

1. Tip or End bearing – The load from the surface is passed down to a competent soil layer, and the base of the pile supports most of the load.
2. Friction Bearing – The load from the surface is passed to the soil along the length of the pile.

Several methods exist for determining the bearing capacity of the piles. Initially, bearing capacity was based on just the type of soil that was encountered and the material the pile was made from; industry accepted methods based on existing installations were developed from this. The use of theoretical formulae was the next step taken, which utilized subsurface condition data obtained through geotechnical investigations. This also allowed for estimation of load that each pile can support prior to pile installation. The geotechnical investigation would collect data, such as in situ split probe testing (SPT) and lab analysis. Due to the heterogeneous nature of the materials encountered in geotechnical engineering, it is impossible to account for all variations in the calculations for bearing capacity estimates. Dynamic pile prediction formulae were developed to account for site specific conditions and estimate the bearing capacity from data obtained during driving of the pile.

1.2 Piles

Three types of piles exist today; wide thin piles, wide flange piles, and cylindrical shaped piles. Wide thin and flange piles are known as sheet and soldier piles, respectively (Coduto, 2001). Sheet and soldier piles are attached together to form walls and are usually used for temporary lateral supports. These supports have been used to prevent water and soil from entering excavations. Sheet piles are made from steel, reinforced concrete, wood, aluminum, fiberglass, vinyl or polyvinyl chloride where solider pile walls consist of installed steel members with horizontal wood supports between them (Coduto, 2001).

Cylindrical piles are made from steel, concrete, timber or a combination of these materials. They can be circular, square, octahedral or H-shaped in cross sectional design. Cylindrical piles are used mainly for axial compression and tensile or lateral load resistance. The focus of this thesis is on cylindrical piles, sheet and wide flange piles will not be discussed in this thesis.

1.3 Pile Classification

Piles can be installed in two possible orientations; vertically or at an angle. Piles installed at an angle are referred to as inclined piles and are also known as batter or raker piles. Batter piles are used to resist lateral loads such as those induced by wind, earthquake action, downhill slope movement, open water forces (Coduto, 2001). Vertical piles are used to resist loads in two ways. Vertical piles resist axial compressive or axial tensile loads through frictional and toe resistance; and lateral loads through bending moments and shear forces.

Piles can be classified by the method they were installed into the subsurface. These methods include percussion, vibratory methods, jacking, jetting, excavation, boring and electro-osmosis. Percussion methods can be further expanded to include hammer action from gravity, steam, diesel or hydraulic pile driving rigs. The focus of this thesis is on a diesel hammer. This method will be discussed in greater detail in Chapter 2: Pile Driving.

The focus of this thesis is on a pile type known as low displacement. Large displacement and non-displacement pile types also exist. Large displacement piles occur when timber, pre-cast concrete piles and closed end pipe or tube piles are driven into the subsurface. Low displacement pile types occur when H and open end tube piles are driven into the subsurface. Non-displacement piles include pre-drilled, augered, excavated or bored cast in place concrete piles.

1.4 Pile Composition

Most piles are composed of timber, concrete, steel or combination of these materials. The focus of this thesis is on steel H-Piles as they were the subject of study for the video imaging methodology.

Chapter 2
Pile Driving

This chapter describes the pile type and pile driving method that was utilized to obtain raw data for the video imaging method.

2.1 Pile Type

The pile profile selected for this site was an HP 360x132 steel pile protected with a Titus Steel rock injector point to reduce the potential of piles slipping on the sloping bedrock surface observed during the geotechnical investigation and tip damage. Figure 1 shows a small section of the 360x132 steel pile with the Titus Steel rock injector point welded to the pile prior to installation.

Figure 1 – Steel Pile HP 360x132 With Installed Titus Steel Rock Injector Point

2.2 Installation Method

The Contractor who won the contract for the Nipigon bridge foundation selected a diesel hammer mounted onto a crane for installing the piles. The general procedure that was followed for installing a pile consisted of steps summarized below.

1. Layout the pile locations on the ground with a Total Station.
2. Plan the installation order to avoid interference from previously installed piles.
3. Position the crane at the desired installation location.
4. Lift the pile from the ground and seat the top inside the pile Helmet and secure the pile with a gate mounted on the crane leads.
5. Begin to drive the pile. Stopping near the surface to check the desired installation angle has been achieved.
6. Continue driving the pile section until it is at the desired level, or at a level where the next section can be welded on.
7. After welding the next pile section, continue the pile driving installation procedure or cut the pile to the desired cut off length.

2.3 Pile Driving Equipment

A crane mounted diesel pile driving hammer was used to install the piles at the Nipigon River Bridge. Diesel hammers became commonly used in 1946 (Fleming et al., 1992). In single acting diesel hammers the ram is raised mechanically and allowed to fall initially due to gravity. In this case diesel fuel is injected into the bottom of the cylinder as the ram reaches its apex. As the ram falls the compressed air and heat causes an explosion to occur which forces the cylinder down onto the pile and the ram upwards, where fuel is injected again causing the cycle to repeat. In double acting diesel hammers; fuel is also injected into the top of the cylinder and ignited to cause the ram to travel down the cylinder. A disadvantage of diesel hammers is that the energy transferred to the pile depends on the driving resistance and is therefore variable. During hard driving conditions, most of the theoretical maximum produced energy impacts the pile head as the fuel and gas mixture can compress with high efficiency, conversely in easy driving conditions the hammer produces less energy per blow because it is difficult for the fuel and air mixture to combust properly.

Figure 2 shows the crane and diesel hammer on site at the Nipigon River Bridge installing a pile.

Figure 2 – Crane and Hammer

The pile driving contractor provided a 110 ton Link Belt LS 218H crawler crane equipped with Berminghammer L-18 fixed leads (including kicker) and a Delmag D46-32 diesel hammer. The D46-32 can deliver 70kJ to 145 kJ of energy per hammer blow according to the manufacturer specifications. There were four energy settings available on the hammer, and they are summarized in Table 1.

Table 1 – Hammer Energy Settings

Hammer Setting	Approximate Energy (kJ)	Observed Blows Per Minute (BPM)
4	145	37
3	120	40
2	100	44
1	75	50

Table 1 was developed during the pile driving observations. While the pile was being driven, the Blows Per Minute (BPM) were measured for each setting. BPM measurements were obtained using a Beats Per Minute application installed on a smart phone. The beats per minute application is used in the music industry by tapping the screen of the smart phone to a musical beat. Instead of a musical beat, the smart phone was tapped at the time of impact over 200 mm driving intervals. The application used an averaging function to output the average beats per minute. This average was then reset manually when the next 200 mm section of pile was being driven. The process was then repeated at 200 mm intervals until the pile driving was complete. The BPM was then compared to the manufacturer bearing capacity chart that is attached in Appendix A and correlated with the hammer energy setting to obtain the approximate energy being imparted on the pile.

Hammer energy settings were varied during the driving procedure to optimize the force of impact while the pile tip moved through varying soil stratigraphy. A low Hammer setting such as 1 or 2 was used initially to start the pile driving process through the lower density material closer to the surface. Generally, As the density of the material increased, the energy setting was also increased.

Chapter 3
Dynamic Pile Driving Formulae

Dynamic formulae are based on the principals of energy and momentum conservation and have the advantage of measuring conditions during driving. Therefore, estimating or assuming soil properties from similar locations is not required. They are also simple and straightforward, and they relate the ultimate pile capacity to easily obtainable field measurements such as, pile driver properties and blow counts.

3.1 Dynamic Formulae

Dynamic formulae are essentially energy balance equations where the energy generated by the hammer is equal to the energy imparted on the pile apart from any losses. Losses may be due to friction created by the ram weight during its fall, compression of the hammer weight, the pile, the pile cushion, and the soil during striking. Other areas of energy loss are due to hammers not performing at peak efficiencies, formulae which do not consider freeze effects, piles flexing during striking, and possible differences in pile driver properties used to calculate capacities and those used during subsequent pile driving operations (Coduto, 2001).

Several assumptions used in estimating/prediction/calculating the pile bearing capacity from dynamic methods are as follows:

- Behavior of soil and pile interaction during static pile loading is the same as dynamic loading
- The pile is a rigid rod which experiences an instantaneous compressive wave as the pile is struck
- Ram weight is significantly heavier than the pile itself

Dynamic formulae are used as a field aid in determining when the required pile capacity is achieved and when to terminate pile driving. From this determination, a blow count is correlated to a value obtained from the dynamic formulae. The blow count is then used in the field as a guide to determine when a pile is driven to a satisfactory depth or bearing capacity.

The four most commonly used dynamic formulae in North America are the Engineering News Record (ENR), Gates, FHWA Modified Gates, and the Hiley formulae. The MTO uses a customized version of the Hiley formula (hereafter referred to as the MTO modified Hiley formula). The focus of this thesis is on the MTO modified Hiley formula but the FHWA Modified Gates formula will be used for comparison purposes.

Dynamic formulae apply to driven piles only, and they do not apply to piles installed by other means such as boring, excavating, auger, vibratory, etc.)

3.1.1 FHWA Modified Gates Formula

The Gates formula (1) is named after Marvin Gates and was developed in 1957. It is based on the results from comparing 130 pile load tests to the hammer energy used and the set developed for each pile driven (Gates, 1957). The formula is given below as:

$$\boldsymbol{R = \frac{1}{7}\sqrt{E_n}(1 - \log s)} \qquad (1)$$

Where: R is the allowable bearing capacity of the pile (tons), E_n is the developed hammer energy from the Engineering News Record (ENR) (ft lb), and s is the final pile set (inches).

The ENR formula was developed in 1888 by A.M. Wellington (Coduto, 2001) for timber piles installed by drop hammer (Fragaszy et al., 1985), and it is given below as:

$$\boldsymbol{R = \frac{2E_n}{s+c}} \qquad (2)$$

Where: R is the allowable pile capacity (lb) and E_n is the hammer energy (ft lb). For drop hammers the energy is calculated as the product of the ram weight (lb) and the fall height (ft). For all other hammers, the energy is the rated energy of the pile driver and s is the final set of the pile (inches). The final set is defined as the amount of settlement the pile undergo use per one hammer blow at the end of driving. The coefficient, c represents the energy loss during the driving process in inches.

The original Gates formula was modified based on longer, heavier piles and newer and more innovative driving equipment. Government groups and private companies applied the modifications to fit their own observations found during construction.

The Federal Highway Administration (FHWA) suggests using Equation 3 since 1997, first developed by Hannigan et al. (Allen, 2005):

$$\boldsymbol{R = 1.75\sqrt{E_n}\log(10N) - 100} \tag{3}$$

Where: R is the allowable bearing capacity (kip), E_n is the energy of the hammer calculated in the same manner as in the ENR formula (ft lb), N is the inverse of the pile set (blows/in).

The FHWA modified Gates formula considers the efficiency of the type of pile driver being used to install the pile. For drop hammers the E_n term is multiplied by 0.75 and for all others it is multiplied by 0.85; this is meant to account for the losses in energy transferred from the driver to the pile. The 1.75 coefficient at the beginning of the formula is an empirical factor to link the estimated capacity to field observations.

3.1.2 Hiley Formula

The Hiley formula considers pile driver efficiency, the weight of the pile, the length of the pile and quantifies the loss of transferred energy due to the compression of the pile cap, pile and soil.

One of the most common versions of the Hiley Formula can be found in Chellis (1961) for double acting, differential acting, and diesel hammers (4).

$$\boldsymbol{R_u = \frac{12 e_f E_n}{s + \frac{1}{2}(c_1 + c_2 + c_3)} X \frac{W_r + e^2 W_p}{W_r + W_p}} \tag{4}$$

Where: R_u is the ultimate bearing capacity of the pile (lb), e_r is the efficiency factor of the pile driver (between 65 to 100 percent). W_r is the ram weight (lb), h is the fall height (in), E_n is the rated hammer energy (ft lb), s is the final set of the pile (in), W_p is the pile weight (lb), and e is the coefficient of restitution of the pile, which ranges from 0 to 0.8 depending on cap material, physical condition and pile material. C_1, C_2 and C_3 are the amount of compression of the pile cap and head, pile and soil, respectively (in). These compression values can be found in Chellis (1961).

3.1.3 MTO Modified Hiley Formula

According to Rauf (2012) and the OPSD SS103-11 MTO engineers use the following modified version of the Hiley Formula for drop and single acting steam hammers (5):

$$\boldsymbol{R_u = \frac{n e_f W_r g H}{s + {}^{C}/_{2}}} \tag{5}$$

For diesel, double acting, and differential acting steam hammers (6):

$$\boldsymbol{R_u = \frac{n e_f E_n}{s + {}^{C}/_{2}}} \tag{6}$$

Where: R_u is the ultimate pile resistance (kN), s is the measured pile penetration or set per hammer blow (mm), C is the measured rebound of the pile per hammer blow (mm), E_n is the rated hammer energy (Joules), W_r is the mass of the pile ram or piston (kg), H is the free fall height of the mass (m), g is the gravitational constant (9.81 m/s2), e_f is the hammer efficiency based on the manufacturers gross rated energy. For drop hammers e_f is set to 0.75, for steam hammers e_f is taken from 0.6 to 0.8, and for diesel hammers e_f is set to 1.0, and n is the efficiency of the hammer blow (7), given as:

$$\boldsymbol{n = \frac{W_r + W_p e^2}{W_r + W_p}} \tag{7}$$

Where: W_r is the same as defined above, W_p is the mass of the pile and anvil or helmet (kg), and e is the coefficient of restitution set to 0.25 for timber piles driven with a pile cushion, 0.32 for steel piles driven with a cushion, and 0.55 for steel piles driven without a cushion.

The MTO modified Hiley formula assumes the pile acts as a rigid rod and the compression it undergoes during striking is instantaneous throughout the entire pile length. The method of applying the MTO Modified Hiley formula can be found in Appendix B as an Ontario Standard Drawing SS103-11 Pile Driving Control.

3.2 Performance of Dynamic Formulae

Rauf (2012) compared the MTO Modified Formulae to pile load test data and concluded the most highly variable data points with respect to the values of bearing capacity were obtained from field tests. He also concluded that the Hiley formula seems better suited for predicting bearing capacity piles driven by drop hammers over those generated by diesel hammers. Figure 3 summarizes data from pile load test vs MTO Modified Formulae.

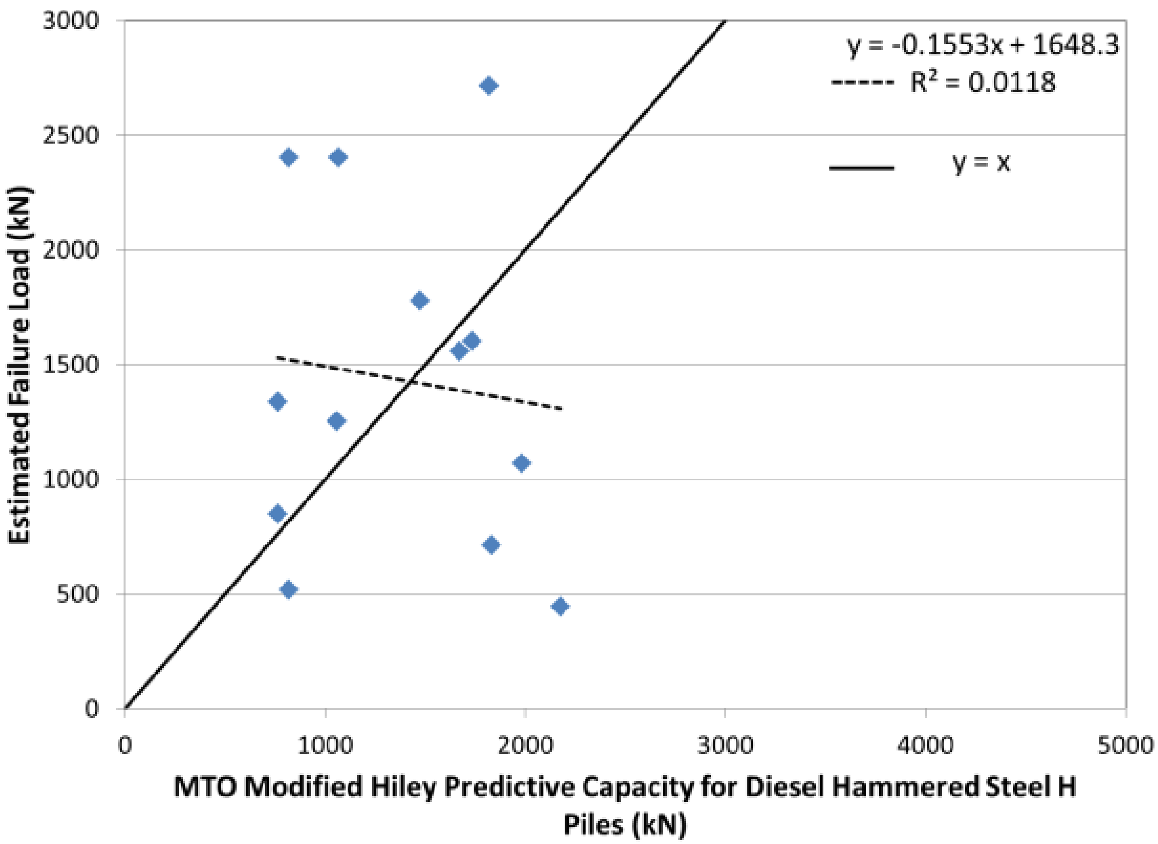

Figure 3 – MTO Modified Hiley Formula Predicted Capacity Vs. Pile Load Test Failure Loads for Diesel Hammered Steel H Piles (Rauf, 2012)

Data gathered for use in the MTO Modified formula is assumed to be accurate. However, Figure 3 shows there is low correlation between the estimated failure load of a pile load test and the MTO Modified Hiley Prediction.

Chapter 4
Data Requirements

To estimate pile capacities, one must obtain data from the pile driving activity. Some values are provided by manufacturers, others are calculated based on pile material densities and the size of pile cross sections. The more interesting and difficult to obtain values are gathered during the installation of a given pile. The merging of this unique data set allows us to utilize the equations discussed in Chapter 3 to estimate the pile capacity quickly after installation.

4.1 Data Acquisition

Current methods to obtain the elastic rebound and final set, or displacement measurements, of a pile consist of a worker standing by the pile during the measuring procedure. Typically, a piece of heavy paper is adhered to the pile being driven. While the pile is being driven, a writing instrument, such as a pencil, pen or marker, is held against a flat stationary object that is independent of the pile. During pile driving, the writing instrument is slid across the stationary object for 10 to 20 impacts, and set and rebound is recorded, this record of the set and rebound will henceforth be known as a set-rebound plot. The plot is used to calculate an average of the set and rebound values. This requires an experienced worker with a steady hand to gather the required data. Figure 4 shows a typical result from this method. Since Figure 4 is not to scale dimensionless parameters are shown to provide context for the hand generated plot on the side of a pile.

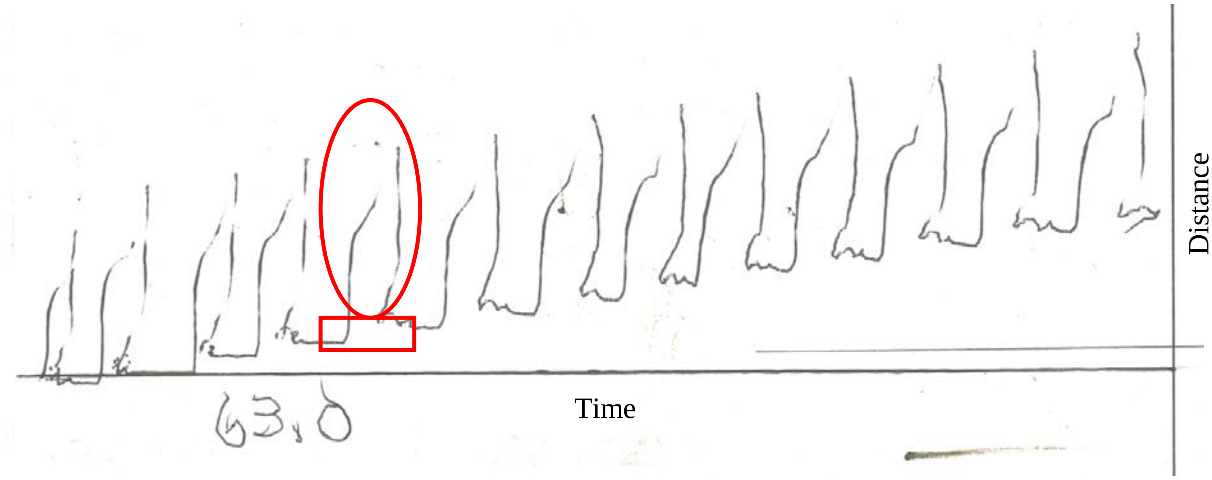

Figure 4 – Sample Set-Rebound Plot Generated by Hand While in Proximity to the Pile Being Installed

In Figure 4 the red rectangle shows the set component of the plot and the red oval shows the rebound component of the plot.

To reduce the risk to personnel on site, a test rig was constructed using metal rods and stands to keep a distance away from the equipment when the set-rebound plot was being generated. A sample image of this setup can be seen in Figure 5.

Figure 5 – Metal Test Rig Setup Utilized to Generate Set Rebound Plot

The result of a plot generated with the metal test rig is presented in Figure 6.

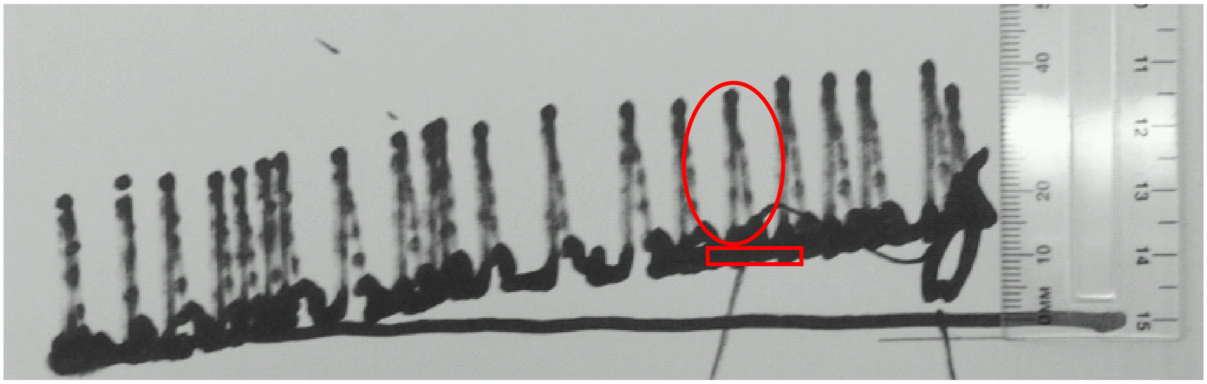

Figure 6 – Set Rebound Plot Generated Using the Metal Test Rig Setup

Figure 6 shows the set and rebound components of the plot with a red rectangle and red oval respectively. When comparing Figure 4 and Figure 6, the first change was the use of a pencil instead of a permanent marker. The thicker marker makes it more difficult to measure the set and rebound accurately, but the use of the marker also minimizes breakage of the pencil during driving and generates more consistent data plots.

Alternative methods that include mechanical distance transducers or laser beams require a long setup time or have a high acquisition cost (Oliveira et al, 2011). Oliveira (2011) proposes a method using a charge coupled device (CCD) camera and a hand computer. Oliveira utilized a printed pattern affixed to the pile being tested.

4.2 Equipment

Field equipment selected for the computer vision data collection portion was governed by a budget of approximately $1,000 CDN. Figure 7 shows an image of the testing equipment utilized for the field data acquisition.

Figure 7 – High Speed Video Equipment

The equipment consisted of a Nikon 1 J1 Two-Lens Zoom Kit and a steel tripod for added stability. The camera kit and tripod were purchased for around $750 CAD.

The Nikon 1 J1 was selected based on the price and capability. At the time, the Nikon 1 was the only camera available in the price range capable of recording at 400 frames per second (FPS) and 1200 FPS. Limitations of the high-speed video or slow-motion recording are summarized below:

- 400 fps video resolution at 640 x 240 pixels
- 1200 fps video resolution at 320 x 120 pixels
- High speed video recording limited to 5 second intervals

The 5 second interval allowed for between 3 and 5 impacts of the pile hammer, half of what is typically used in the traditional data collection methods. The recording time and resolution would improve as technology improves. Current cellphones like the Apple iPhone 8 are capable of 240 FPS recording at 1080p resolution (Apple, 2017). The Apple iPhone is just one example of how high-speed video imaging has progressed.

4.2.1 Camera Apparatus and Operation

The camera needs to be setup with a clear line of sight to the target placed on the pile. Ample lighting is also required to obtain the desired results. No calibration was carried out with the camera or system as the target was printed to scale with a high contrast black and white pattern. Figure 8 is a sample of the target adhered to the pile being tested. A full-scale copy of the target is shown in Appendix B. The target was adhered to the pile using duct tape.

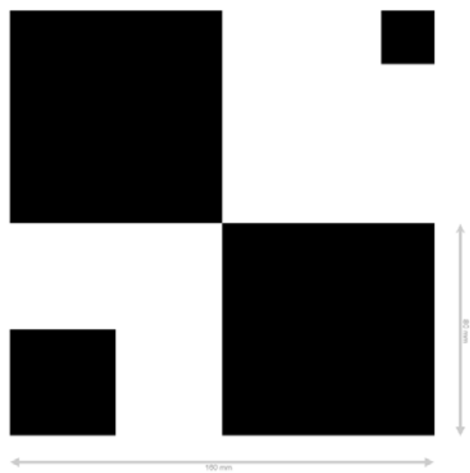

Figure 8 – Pile Target

The target was printed to scale to prevent the need to maintain a constant distance to the pile. It also was not critical to be exactly orthogonal to the pile face as post processing of the captured image would accommodate for this. A sample of the image captured can be found in Figure 9.

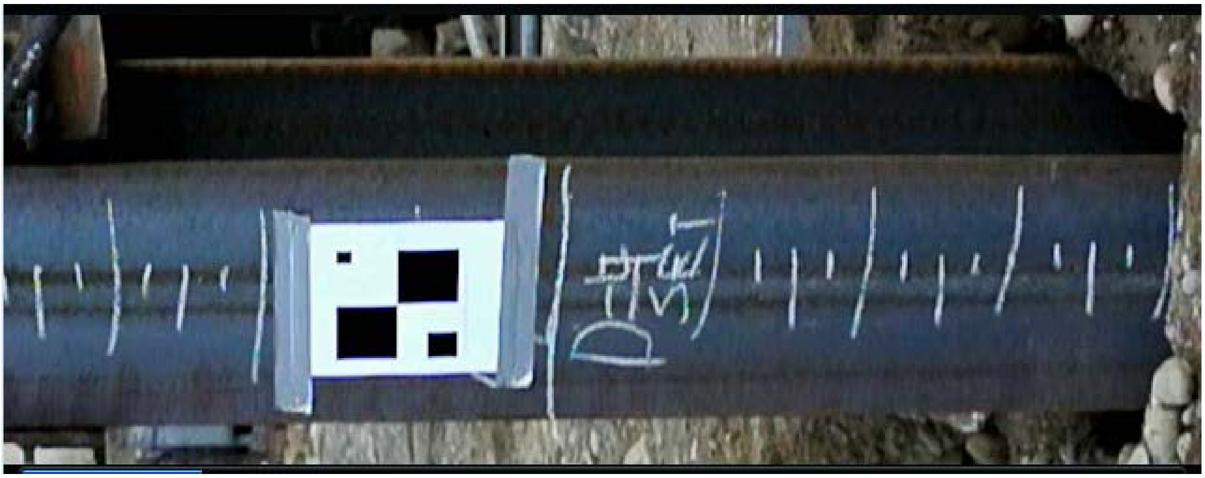

Figure 9 – Image Capture Sample

Oliveira (2011) discusses considerations on the influence of vibrations from the act of pile driving on the camera. Oliveira states the vibrations do not interfere with the elastic rebound measurements. Oliveira also describes that equipment is not affected by imaging measurements when the equipment is more than 3 m away. The videos recorded for this thesis agree with Oliveira's statement, and vibrations generated from the pile driving did not affect the videos that were recorded. In the videos, there was a clear time separation between the time the hammer impacted the pile and a "shaking" of the camera in instances where the camera was placed close enough to the pile to be exposed to the shockwave.

The camera setup serves as a data collection device to capture the imaging data. Post processing is required to make use of the images captured and will be discussed in a Chapter 4. One benefit to this method is that as camera equipment improves over time the image processing can be improved. The second benefit is that utilizing a basic tripod and moderately priced camera the required data can be captured quite easily by anyone on site and does not necessarily require a Professional Engineer to operate the camera equipment to be present on site. Current smart phone technology can capture 240 FPS video at a 720p resolution which is much greater than the video captured for this thesis.

Chapter 5
Data Processing

After gathering the digital data on site, the data needs to be processed to extract relevant information. Currently, there are no software packages exist that can translate pile movement into data points and graphical plots.

5.1 Software Selection

With the budget constraints present for this research program Microsoft Visual Studio Premium 2012 (Visual Studio) was utilized for the coding portion through Microsoft licensing program available to students. C++ was selected as the language of choice due to the flexibility it offers if the coding is to be ported to another language or operating system, or to simplify the creation of a graphical user interface (GUI) in the future.

5.1.1 OpenCV library

According to the developer website, OpenCV or Open Computer Vision Library is an open source computer vision and machine learning software library. The library has more than 2,500 optimized algorithms which includes a comprehensive set of computer vision and machine learning algorithms. The algorithms can be used to detect and recognize faces, produce 3D point clouds from stereo cameras among other image processing techniques. In addition to C++ support. OpenCV has libraries available for C, Python, Java and MATLAB and has support for Windows, Linux, Android and Mac OS.

OpenCV is open source and can be used free of charge by business and private entities alike.

5.2 Sample Output Observed

Upon running the set-rebound software a sample of the raw data being process can be seen in Figure 10.

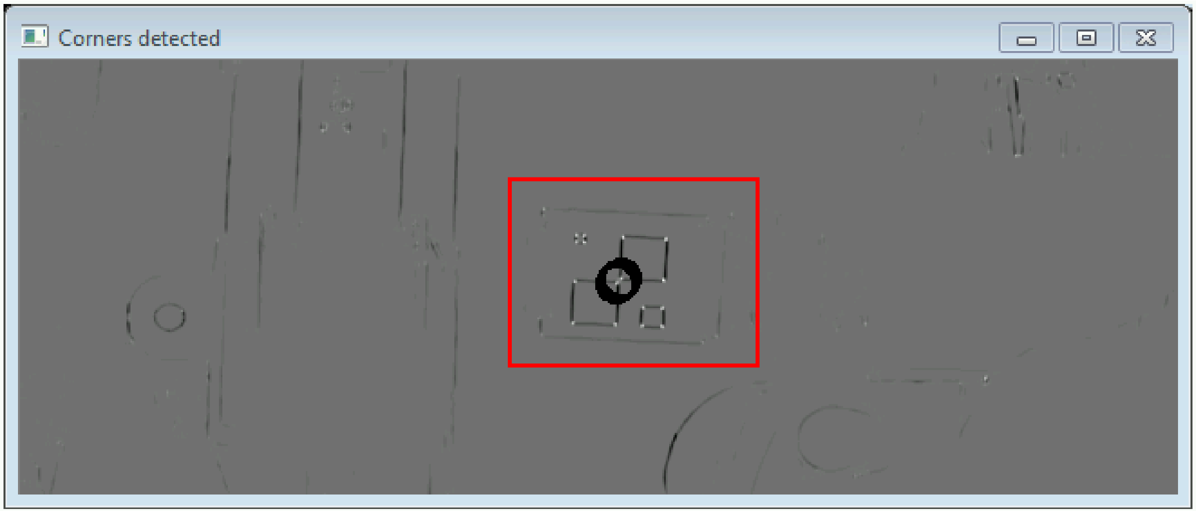

Figure 10 – Video Processing Sample

The red rectangle in Figure 9 outlines the target adhered to the pile and the corners it has detected. There are multiple black circles in the center of the target, and they represent the centroid of the collection of shapes present on the target image.

The centroid co-ordinates are recorded for each frame within the captured video. A total of approximately 2,000 frames are recorded when processing the 400 FPS video. Each frame captures 3 data points: the video time step or frame number, the X – coordinate in pixels, and the Y – coordinate in pixels. Each time step in a 400-FPS video represents 2.5 milliseconds. When post processing is complete a plot is generated with Microsoft Excel (Figure 11).

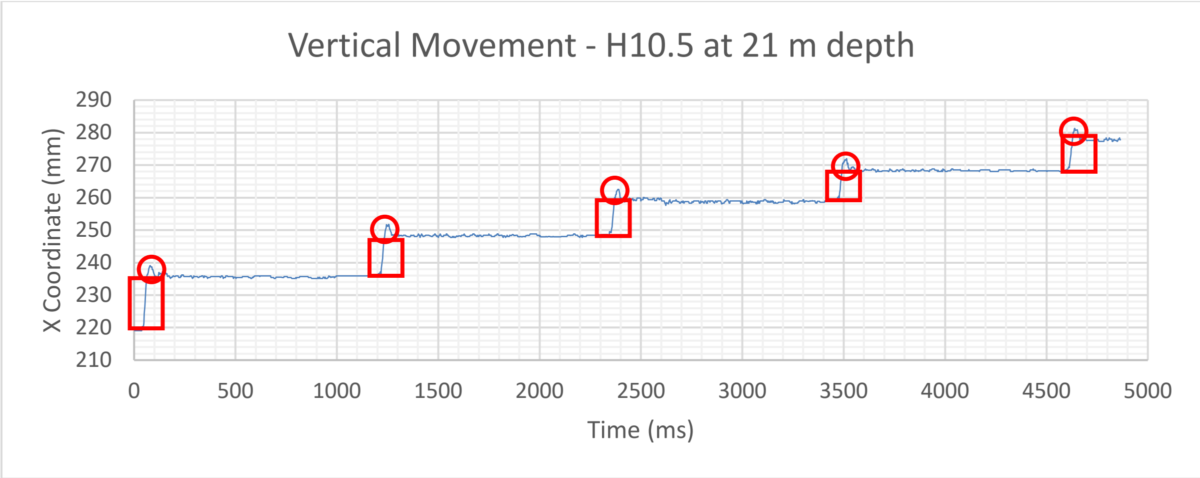

Figure 11 – Sample Plot Generated with Processing Software

In Figure 11, the sample set is approximately 17 mm as indicated by the red rectangles and a rebound of approximately 2 mm as indicated by the red circles. A total of five impacts were recorded in Figure 11 at the following time steps: 37.5 ms, 1192.5 ms, 2352.5 ms, 3467.5 ms and 4592.5 ms. The average beats per minute over the five impacts was calculated at 52.7 beats per minute (bpm).

The plots generated from the data captured by the camera will henceforth be known as Computer Vision Set Rebound) CVSR plots. Traditionally, generated plots will henceforth be referred to as (Manual Set Rebound) MSR plots.

5.3 Correlation Between CVSR and MSR Plots

During the Nipigon pile driving program, there were few opportunities to record a video and a traditionally acquired set-rebound plot. The following sub-sections present plots generated at Piles H-6.5, I-4, I-2, H-1, G-5.2, B-9.5, B.5-11, D-4 and B.5-1. More detailed pile driving information for these piles can be found in Appendix C. There is very little to no set and a very high rebound measured in these piles. The plots were generated when the piles were being installed into bedrock or have met a refusal condition. Due to time and safety restrictions on site, MSR plots were not generated in the layers above the bedrock and very hard soil layers. The plots here-in were generated as part of the contract requirements.

5.3.1 Pile H-6.5 at Depth 44.6 m CVSR and MSR Analysis

A comparison between the CVSR plot and the MSR plot for Pile H-6.5 at an installation tip depth of 44.6 m can be seen in Figure 12.

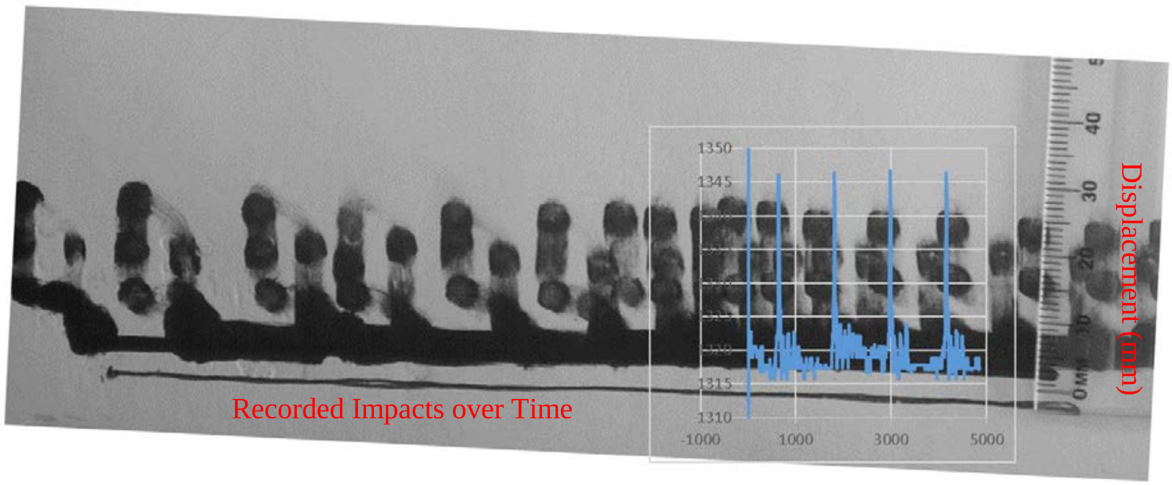

Figure 12 – Pile H-6.5 Depth 44.6 m CVSR Plot and MSR Plot Comparison

For clarity, the plot axis was not included in Figure 12 and were overlain manually based on the scale included in the image. The blue plot is the CVSR plot and the horizontal axis represents the time step in milliseconds and the vertical axis represents the vertical position in millimeters. The thick black plot is the MSR plot and the vertical axis represents the displacement in mm. There is no scale or measurement for the horizontal plot as this was an arbitrary position selected during the pile driving. The time step for the MSR plot goes from left to right, where the first impact is represented by the first vertical displacement on the left side of the Figure.

Table 2 – Pile H-6.5 at Depth 44.6 m CVSR and MSR Comparison

	MSR Plot	CVSR Plot
Set (mm)	< 0.5	0
Rebound (mm)	25	29

The values measured for the MSR plot in Table 2 were done with a ruler. Due to the coarse nature of the permanent marker, it is difficult to get an accurate measurement in the MSR plot. In this case, the middle of the line was utilized as the reference point. It is also difficult to make out the rebound peaks in Figure 12 because of the coarse nature of the plot. The line thickness varies in the plot due to the lateral movement of the pile.

5.3.2 Pile I-4 at Depth 45.5 m CVSR and MSR Analysis

A comparison between the CVSR plot and the MSR plot for Pile I-4 at an installation tip depth of 45.5 m can be seen in Figure 13, and the measured values are presented in Table 3

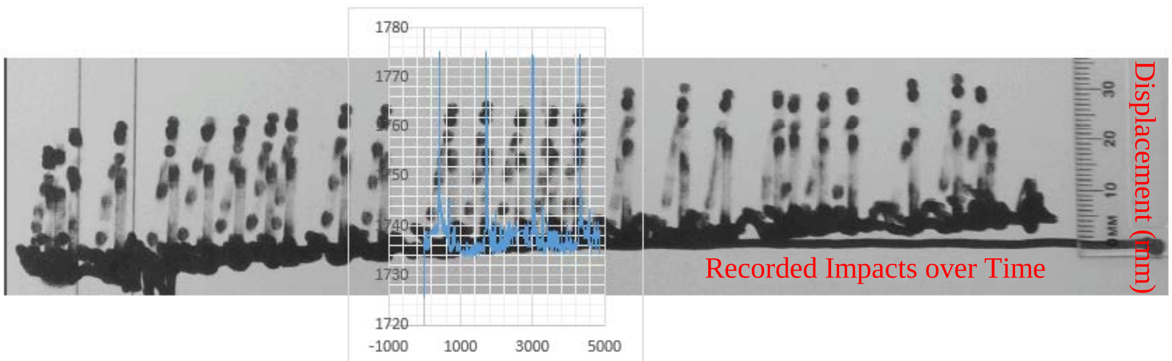

Figure 13 - Pile I-4 Depth 44.6 m CVSR Plot and MSR Plot Comparison

The blue plot is the CVSR plot and the horizontal axis represents the time step in milliseconds and the vertical axis represents the vertical position in millimeters. The thick black plot is the MSR plot and the vertical axis represents the displacement in mm. There is no scale or measurement for the horizontal plot as this was an arbitrary position selected during the pile driving. The time step for the MSR plot goes from left to right, where the first impact is represented by the first vertical displacement on the left side of the Figure.

Table 3 – Pile I-4 at Depth 45.5 m CVSR and MSR Comparison

	MSR Plot	**CVSR Plot**
Set (mm)	< 0.5	0
Rebound (mm)	25	39

The values measured for the MSR plot in Table 3 were done with a standard ruler. Due to the coarse nature of the permanent marker, it is difficult to get an accurate measurement in the MSR plot. The coarse marker is a problem that was evident in all the plots discussed in Chapter 4.1. It is also difficult to make out the rebound peaks in Figure 13 because of the coarse nature of the plot and the appearance that the marker was "skipping" on the page as the marker appears to fade and get darker in the image. The line thickness varies in the plot due to the lateral movement of the pile.

5.3.3 Pile I-2 at Depth 45.7 m CVSR and MSR Analysis

A comparison between the CVSR plot and the MSR plot for Pile I-2 at an installation tip depth of 45.7 m can be seen in Figure 14.

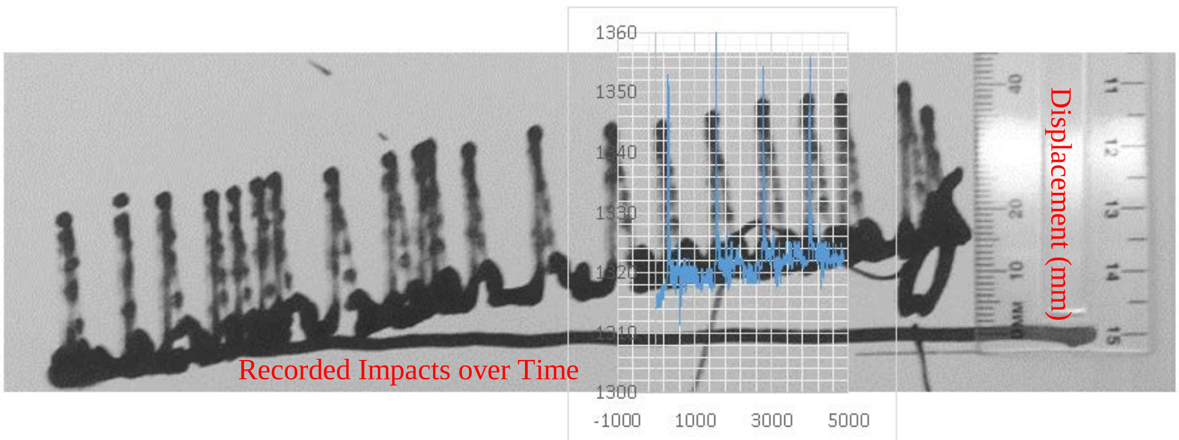

Figure 14 – Pile I-2 Depth 45.7 m CVSR and MSR Comparison

The blue plot is the CVSR plot and the horizontal axis represents the time step in milliseconds and the vertical axis represents the vertical position in millimeters. The thick black plot is the MSR plot and the vertical axis represents the displacement in mm. There is no scale or measurement for the horizontal plot as this was an arbitrary position selected during the pile driving. The time step for the MSR plot goes from left to right, where the first impact is represented by the first vertical displacement on the left side of the Figure. A high resolution of the CVSR plot from Figure 14 is also presented in Figure 15 to show the fine vertical movements of the pile within very short time periods.

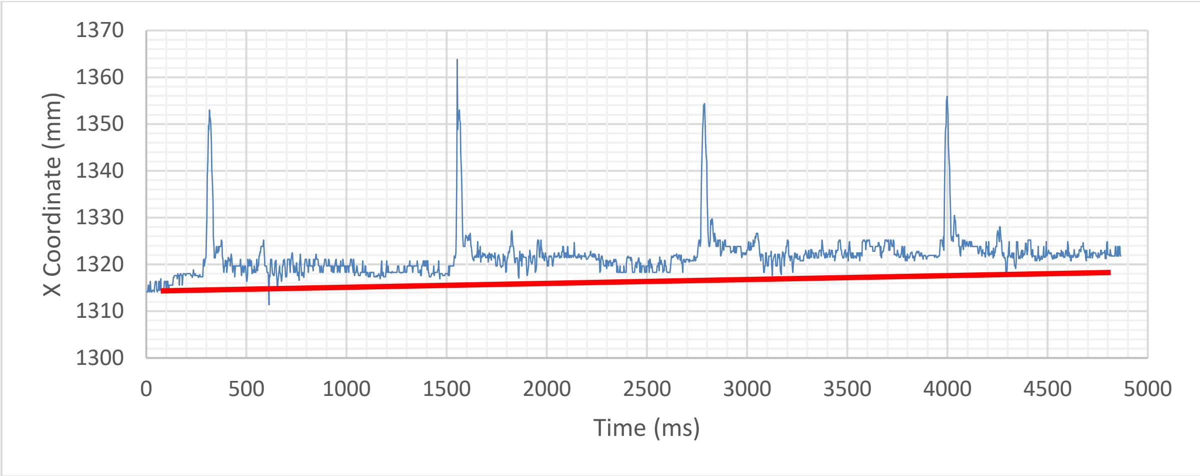

Figure 15 – Pile I-2 Depth 45.7 m CVSR Plot

A slight trend upwards can be seen Figure 15. The general trend is conceptually shown with the red line in the table. This upward trend in the CVSR plot indicates that the pile is being driven into the ground. This trend is also indicated on the MSR plot in Figure 14. Figure 12 and Figure 13 did not show this trend as the pile encountered refusal; or a stratigraphy where it would no longer penetrate the subsurface layer.

When recording data for Pile I-2, the view to the pile was partially obstructed by a worker as shown in Figure 16.

Figure 16 – Pile I-2 Raw Video Image with Obstruction Near the Target

The worker in the image did not affect the post processing of the image since there were no gaps in the data collection as presented in Figure 15 and Figure 16. Therefore, the post processing of the image is not affected if the target itself is not obstructed.

Values measured for the MSR plot for Pile I-2 are presented in Table 4.

Table 4 – Pile I-2 at Depth 45.7 m CVSR and MSR Comparison

	MSR Plot	**CVSR Plot**
Set (mm)	< 1	1.1
Rebound (mm)	25	34

The values measured for the MSR plot in Table 4 were done with a standard ruler. Due to the coarse nature of the permanent marker, it is difficult to get an accurate measurement in the MSR plot. The coarse marker is a problem that was evident in all the plots discussed in Chapter 4.1. It is also difficult to make out the rebound peaks in Figure 14 because of the coarse nature of the plot and the appearance that the marker was "skipping" on the page as the marker appears to fade and get darker in the image. The line thickness varies in the plot due to the lateral movement of the pile.

5.3.4 Pile G.5-2 at Depth 46.0 m CVSR and MSR Analysis

Pile G.5-2 was filmed at the end of a shift and prior to processing it was thought the image was too dark to utilize. During processing, it was found that there was a reduced number of artifacts encountered making it easier for the program to differentiate between the target and the surrounding image. Figure 17 is an image of the video recorded for pile G.5-2.

Figure 17 – Pile G.5-2 Raw Video Image with Low Light Levels

While difficult to see in Figure 16, pile G.5-2 was installed at a 1:10 (Horizontal : Vertical) Batter. Utilizing the computer vision method, it is possible to record the movement during a hammer impact and after the pile hammer impacts the pile. The CVSR plot for Pile G.5-2 and Pile I4 are presented in Figure 18 and Figure 19, respectively to compare the characteristics of horizontal movement.

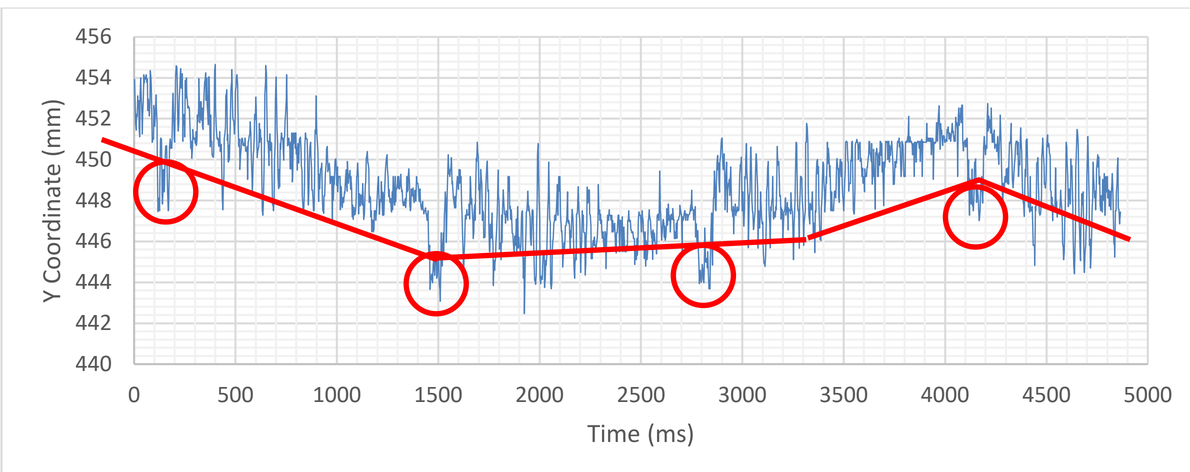

Figure 18 – Pile G.5-2 Depth 46.0 m CVSR Horizontal Plot (Battered Pile)

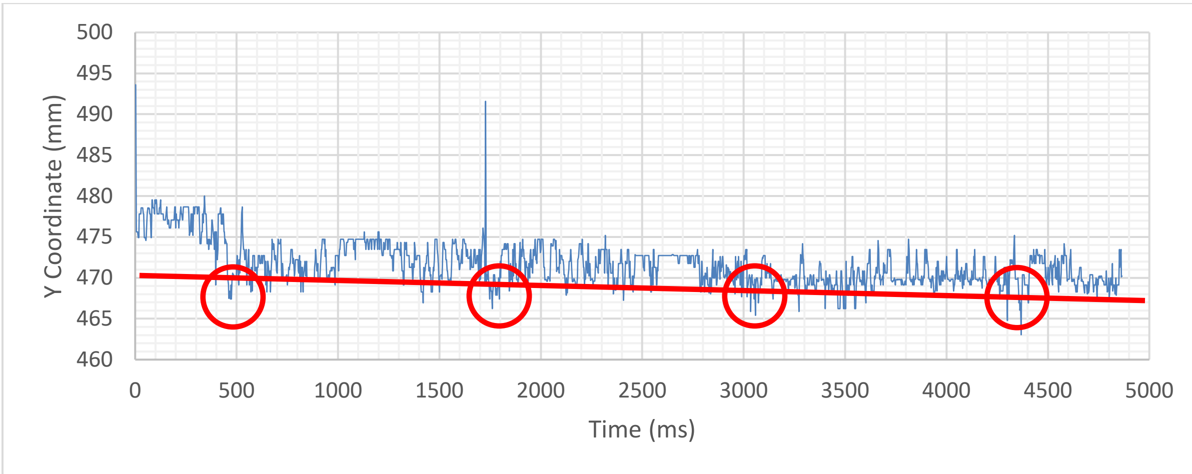

Figure 19 – Pile I-4 Depth 45.5 m CVSR Horizontal Plot (Vertical Pile)

When comparing Figure 18 and Figure 19 the approximate pile impact time steps are shown as a red circle and the general trend and movement is approximated by a red line. A difference in the movement pattern between the battered pile and vertical pile is caused by the misalignment of the pile driving hammer and the pile being installed.

A comparison between the CVSR plot and the MSR plot for Pile G.5-2 at an installation tip depth of 45.7 m can be seen in Figure 20.

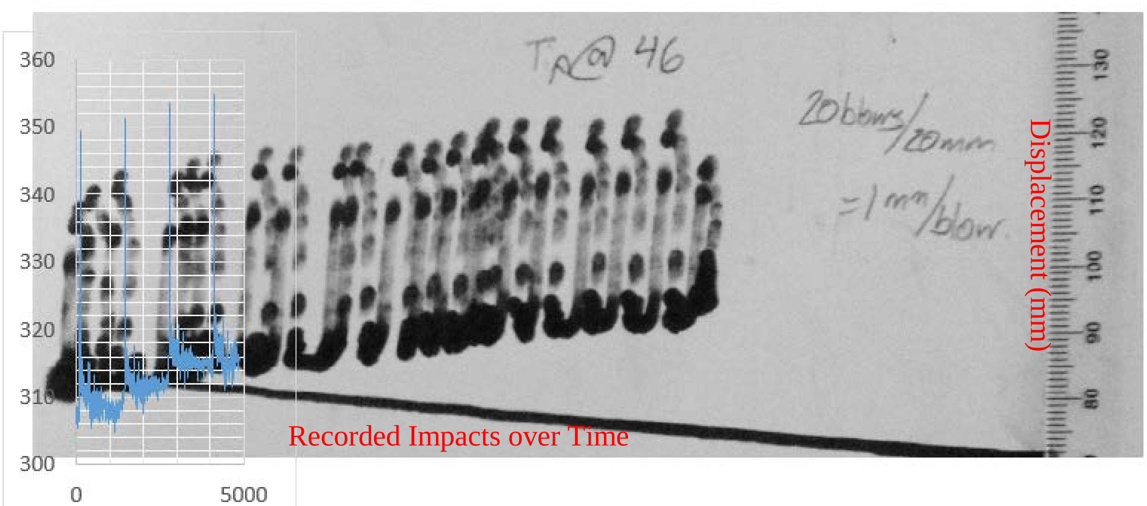

Figure 20 – Pile G.5-2 Depth 46.0 m CVSR and MSR Comparison

The blue plot is the CVSR plot and the horizontal axis represents the time step in milliseconds and the vertical axis represents the vertical position in millimeters. The thick black plot is the MSR plot and the vertical axis represents the displacement in mm. There is no scale or measurement for the horizontal plot as this was an arbitrary position selected during the pile driving. The time step for the MSR plot goes from left to right, where the first impact is represented by the first vertical displacement on the left side of the Figure.

The measured set and rebound values are presented in Table 5.

Table 5 – Pile G.5-2 at Depth 46.0 m CVSR and MSR Comparison

	MSR Plot	CVSR Plot
Set (mm)	1	2.2
Rebound (mm)	25	38

The values measured for the MSR plot in Table 5 were done with a standard ruler. Due to the coarse nature of the permanent marker, it is difficult to get an accurate measurement in the MSR plot. In this case, the middle of the line was utilized as the reference point. It is difficult to determine the rebound peaks in Figure 20 because of the coarse nature of the plot. The line thickness varies in the plot due to the lateral movement of the pile. Figure 21 shows the CVSR plot for the comparison.

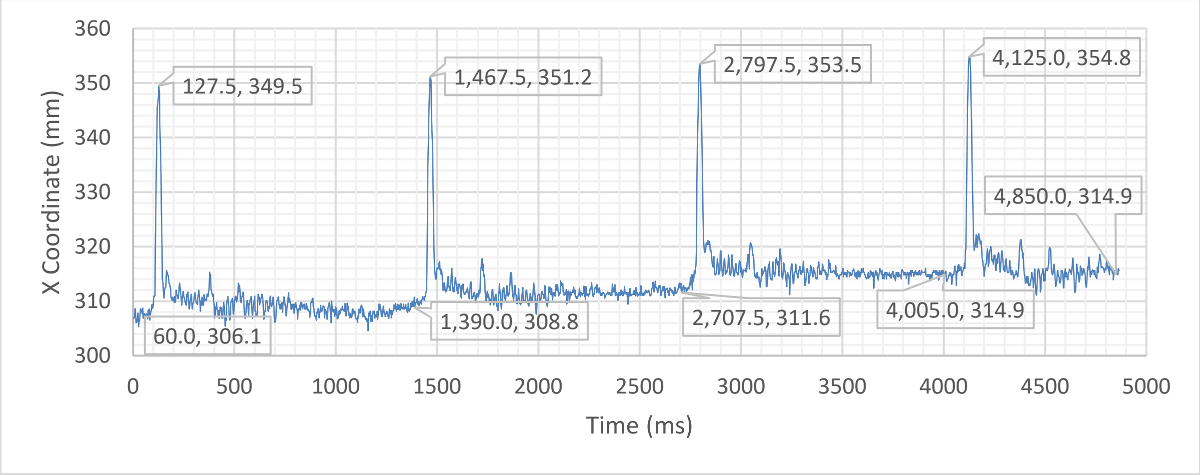

Figure 21 – Pile G.5-2 Depth 46.0 m CVSR Plot

The first three impacts shown from left to right in Figure 21 result in a set of 2.7 mm, 2.8 mm and 3.3 mm for impacts 1, 2 and 3, respectively. Impact 4 shows a movement of 0 mm causing the CSVR set value to be higher than the MSR plot. The MSR plot set value is averaged over 20 hammer blows, and most of the blows resulted in very little set, thus decreasing the overall set average from the MSR plot.

5.3.5 Pile B-9.5 at Depth 48.3 m CVSR and MSR Analysis

A comparison between the CVSR plot and the MSR plot for Pile B-9.5 at an installation tip depth of 48.3 m can be seen in Figure 22. The determined set and rebound values are presented in Table 6, and the CVSR plot is presented in Figure 23.

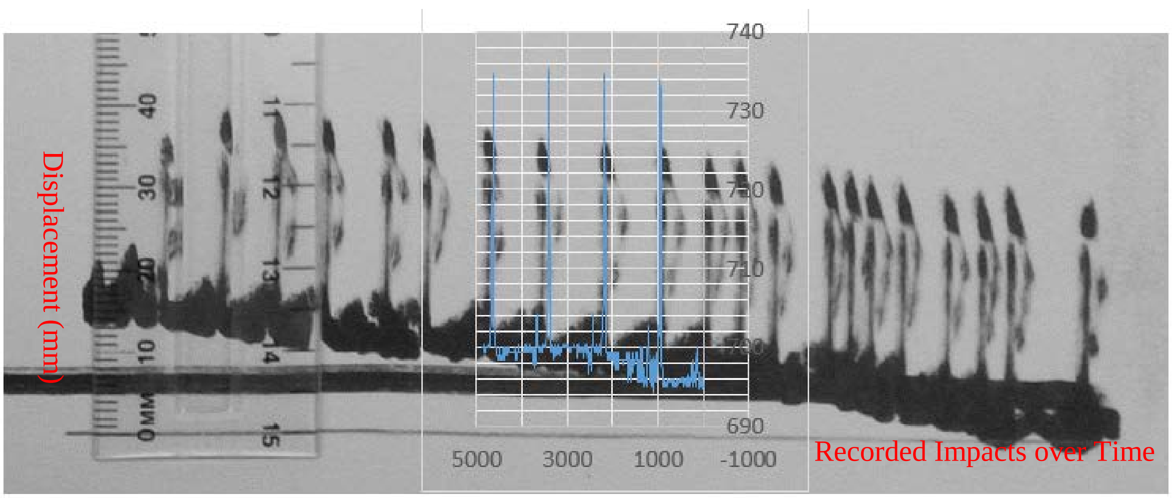

Figure 22 – Pile B-9.5 Depth 48.3 m CVSR and MSR Comparison

The blue plot is the CVSR plot and the horizontal axis represents the time step in ms and the vertical axis represents the vertical position in mm. The thick black plot is the MSR plot and the vertical axis represents the displacement in mm. There is no scale or measurement for the horizontal plot as this was an arbitrary position selected during the pile driving. The time step for the MSR plot goes from left to right, where the first impact is represented by the first vertical displacement on the left side of the Figure.

Table 6 – Pile B-9.5 at Depth 48.3 m CVSR and MSR Comparison

	MSR Plot	CVSR Plot
Set (mm)	0.7	0.2
Rebound (mm)	27	35

The values measured for the MSR plot in Table 6 were done with a standard ruler. Due to the coarse nature of the permanent marker, it is difficult to get an accurate measurement in the MSR plot. In this case, the middle of the line was utilized as the reference point. It is also difficult to make out the rebound peaks in Figure 22 because of the coarse nature of the plot. The line thickness varies in the plot due to the lateral movement of the pile. Figure 23 shows the CVSR plot for the comparison.

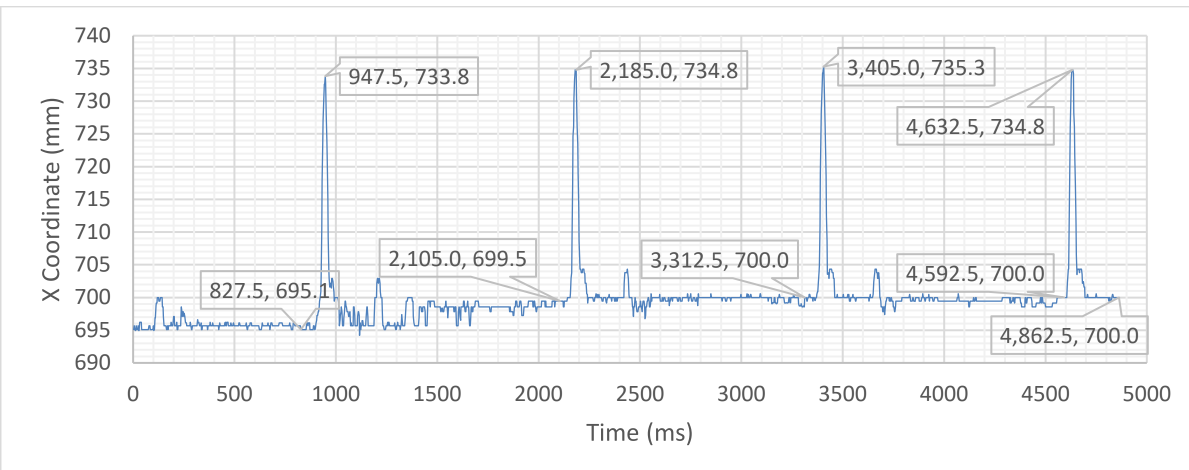

Figure 23 – Pile B-9.5 Depth 48.3 m CVSR Plot

The first impact shown from left to right in Figure 23 resulted in a set of 4.4 mm. Impacts 2,3 and 4 shows movements of 0.5, 0 and 0 mm respectively causing the CSVR set value to be higher than the MSR plot. The MSR plot set value is averaged over 20 hammer blows, most of the blows resulted in very little set, decreasing the overall set average from the MSR plot. Upon reviewing the cause of the first set result being higher than the others, it was found the centroid of the target shifted due to sunlight hitting the pile. This brightness change in the video was not accounted for in the CSVR code which caused inconsistent readings of the impacts.

5.3.6 Pile B.5-11 at Depth 49.0 m CVSR and MSR Analysis

A comparison between the CVSR plot and the MSR plot for Pile B.5-11 at an installation tip depth of 49.0 m can be seen in Figure 24, and the determined set and rebound values are presented in Table 7.

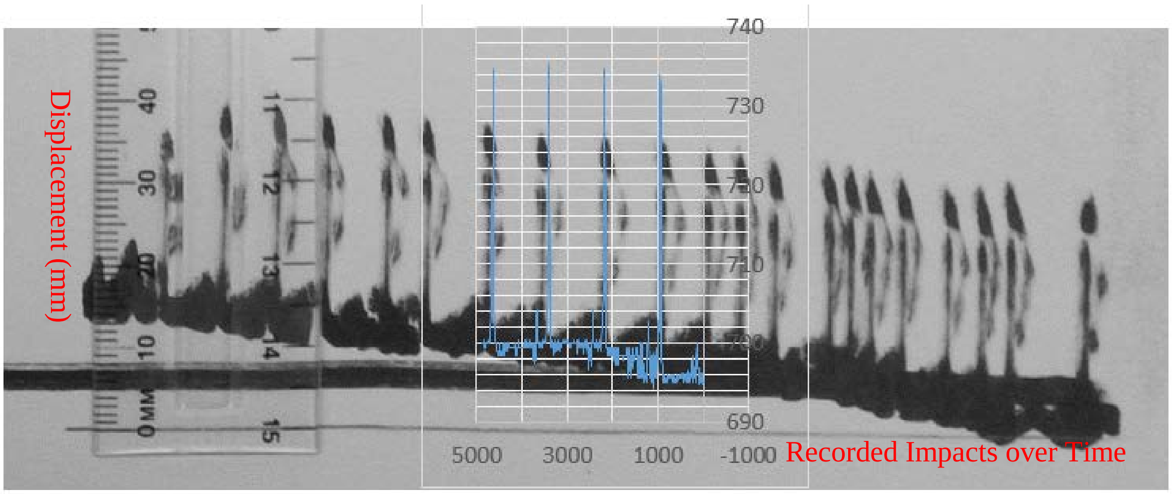

Figure 24 – Pile B.5-11 Depth 49.0 m CVSR and MSR Comparison

The blue plot is the CVSR plot and the horizontal axis represents the time step in ms and the vertical axis represents the vertical position in mm. The thick black plot is the MSR plot and the vertical axis represents the displacement in mm. There is no scale or measurement for the horizontal plot as this was an arbitrary position selected during the pile driving. The time step for the MSR plot goes from left to right, where the first impact is represented by the first vertical displacement on the left side of the Figure.

Table 7 – Pile B-9.5 at Depth 48.3 m CVSR and MSR Comparison

	MSR Plot	CVSR Plot
Set (mm)	1.1	1.1
Rebound (mm)	27	32

The values measured for the MSR plot in Table 7 were done with a standard ruler. Due to the coarse nature of the permanent marker, it is difficult to get an accurate measurement in the MSR plot. In this case, the middle of the line was utilized as the reference point. It is also difficult to make out the rebound peaks in Figure 24 because of the coarse nature of the plot. The line thickness varies in the plot due to the lateral movement of the pile. Figure 25 shows the CVSR plot for the comparison.

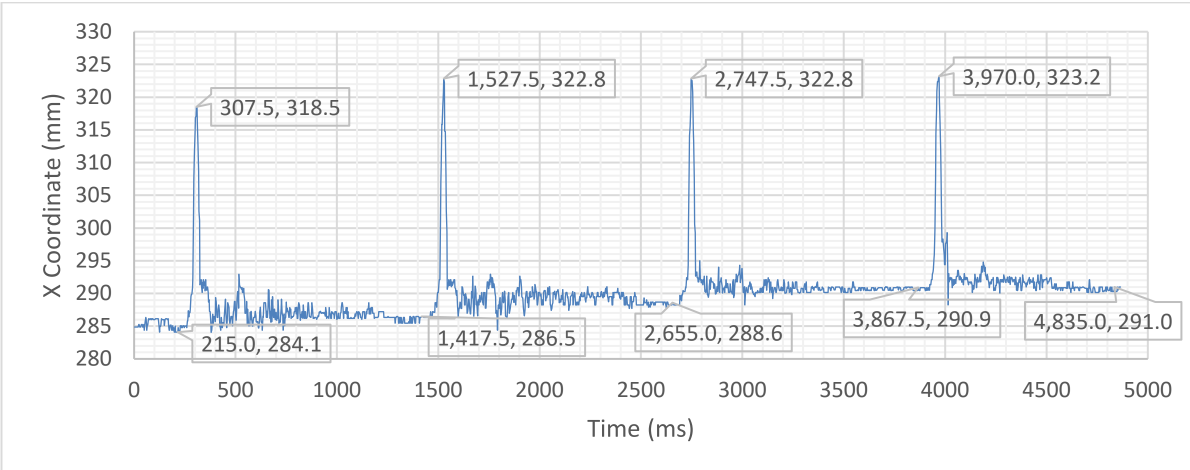

Figure 25 – Pile B.5-11 Depth 49.0 m CVSR Plot

The first 3 impacts shown from left to right in Figure 25 result in a set of 2.4 mm, 2.1 mm and 2.3 mm for impacts 1, 2 and 3, respectively. Impact 4 shows a movement of 0.1 mm. The MSR and CVSR plots for Pile B.5-11 correlated well.

5.3.7 Pile D-4 at Depth 46.2 m CVSR and MSR Analysis

A comparison between the CVSR plot and the MSR plot for Pile D-4 at an installation tip depth of 46.2 m can be seen in Figure 26.

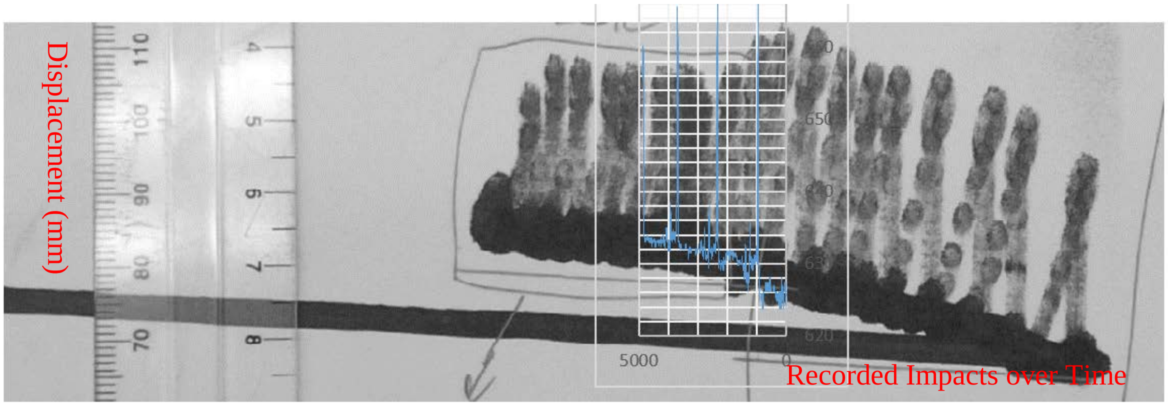

Figure 26 – Pile D-4 Depth 46.2 m CVSR and MSR Comparison

The blue plot is the CVSR plot and the horizontal axis represents the time step in ms and the vertical axis represents the vertical position in mm. The thick black plot is the MSR plot and the vertical axis represents the displacement in mm. There is no scale or measurement for the horizontal plot as this was an arbitrary position selected during the pile driving. The time step for the MSR plot goes from left to right, where the first impact is represented by the first vertical displacement on the left side of the Figure.

For Pile D-4, both CVSR and MSR plots capture a change in the pile driving behavior. It can be seen in Figure 26that the driving changes from a higher set and rebound to slightly lower set and rebound half way through the CVSR plot and MSR plot. Figure 27 shows the CVSR plot for the comparison.

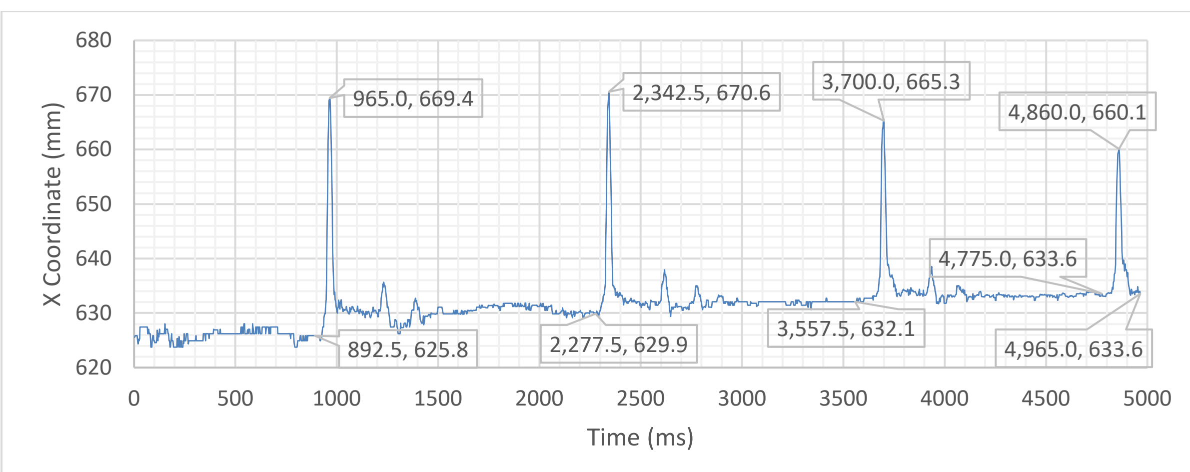

Figure 27 – Pile D-4 Depth 46.2 m CVSR Plot

The impacts shown from left to right in Figure 27 result in a set of 4.1 mm, 2.2 mm, 1.5 mm and 0 mm for impacts 1, 2, 3 and 4 respectively. The MSR and CVSR plots for Pile D-4 show good set correlation between one another despite the change in driving characteristics.

5.3.8 Pile B.5-1 at Depth 47.5 m CVSR and MSR Analysis

When filming pile B.5-1 at a depth of 47.5 m, the duct tape used to hold the target in place failed during the pile driving. Figure 28 shows the failure as the tape crunching up on the left side and the right side completely released from the pile.

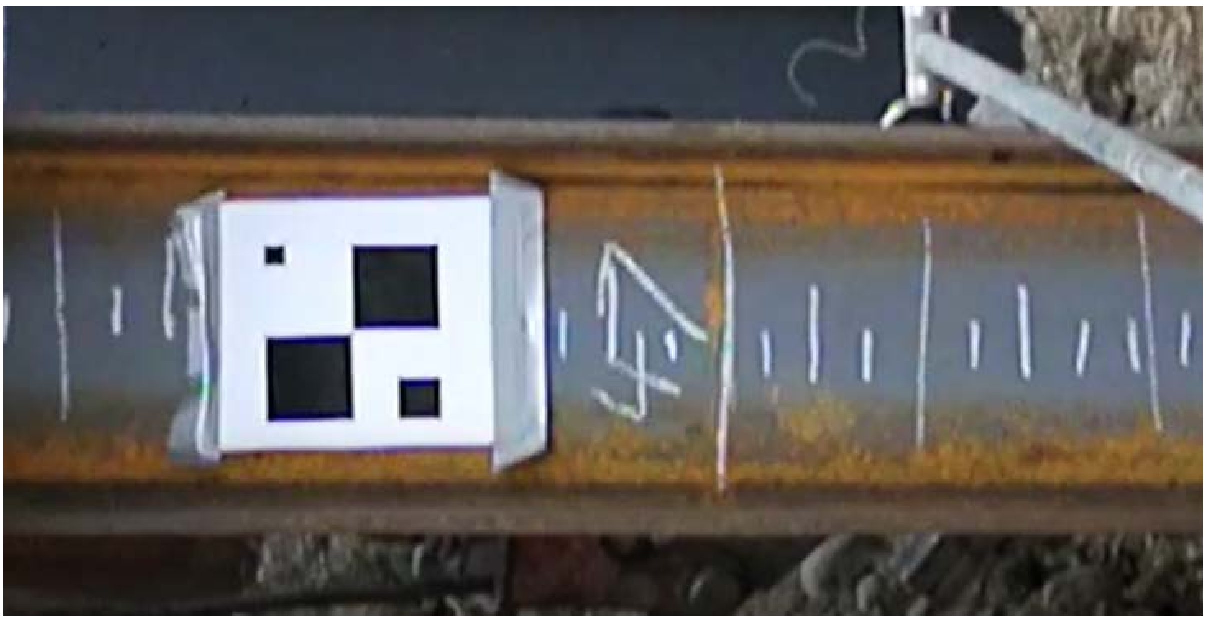

Figure 28 – Duct Tape Adhesion Failure

This target adhesion failure does not affect the pile driving activities, but it results in inaccurate processing of the video code as the target is no longer moving with the pile. This can also be seen in the CSVR plot in Figure 29.

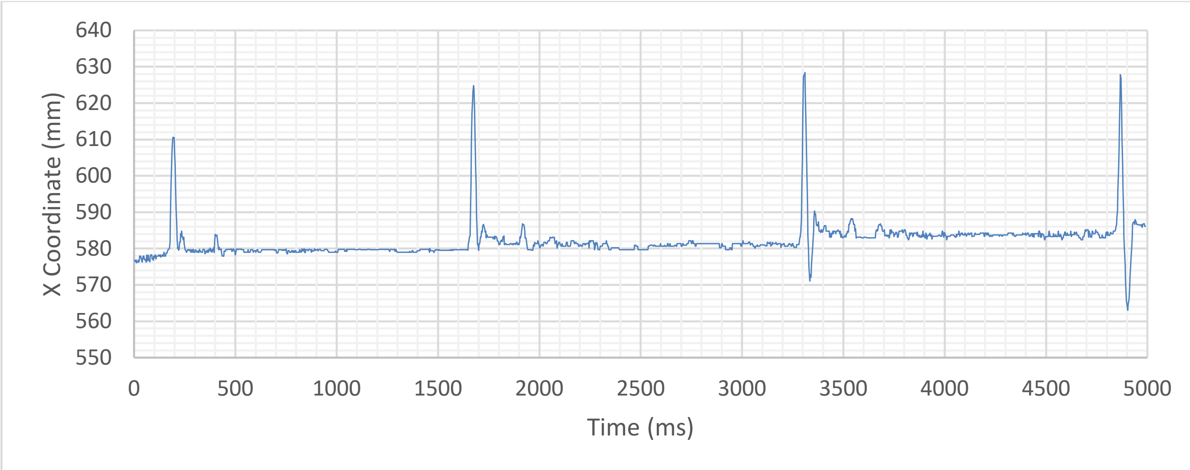

Figure 29 – Pile B.5-1 Depth 47.5 m CVSR Plot

Impacts 1 and 2 in Figure 29 show a consistent set and a slight increase in the rebound. Impacts 3 and 4 are quite different as they are showing a much larger set movement shown in red circles during the pile impact event but show a consistent set value with impacts 1 and 2. The inconsistencies in values was caused by the target lifting during the impact event, resulting in more movement than the pile was subjected to. Upon completion of the impact event the target returned to the normal position resulting in a consistent set value with the first two impacts.

5.4 Observations

The data collected and generated in this chapter was gathered while piles were being driven into bedrock or very dense material. The low set and high rebound conditions encountered herein would provide inaccurate pile capacity results. Instead the major variables, set and rebound, used in the calculation of pile capacity were compared instead. This was the only opportune time to gather data on a time and cost sensitive foundation construction program. It would have been ideal to gather data simultaneously in less dense material and to generate both the CVSR and MSR plot simultaneously.

In MSR plots a black marker results in thick black lines that can be difficult to interpret. When a pen or pencil are utilized the violent action from the pile being driven can break the tip. It is rare that a pile is installed perfectly vertical with no rotation or unexpected movements, it is these unexpected movements that damage the writing instrument.

Visual obstructions were occasionally encountered in the form of construction personnel or components of the pile driver equipment. During driving these are sometimes overlooked and can lead to missing data or strange results. When this is observed on the CVSR plots the video recorded must be reviewed to determine if data should be disregarded. If the target mounted on the pile does not get obstructed the data gathered from the CVSR plot has a higher chance of still being accurate.

Low light, very bright conditions or partial detachment of pile target can also affect the data processing portion as the computer vision software cannot track the target accurately. This can cause sudden or unexpected vertical or horizontal displacement recordings. A review of the video recorded during the pile driving should then be completed to determine which data points are not due to pile displacement.

5.5 Summary

Based on the data gathered herein there exists a strong correlation between the CVSR and MSR plots. Due to the very dense nature of the material the pile was installed in, the rebound values differed to a greater degree than the set values. This could be caused by the inherent inaccuracy in the MSR data collection method or slight movements in the writing instrument such as the marker tip bending can lead to millimeters of inaccurate readings. Only further data collection and comparison in better soil conditions will help isolate the cause of the inconsistencies. The consistent results from the CVSR plots between subsequent impacts provide confidence in the accuracy of the method and will be utilized for the predictive calculations in the next chapter.

Chapter 6

Pile Capacity Estimation

The main purpose of developing this method was to provide a "quick and dirty" estimation of the pile capacity using the Hiley Formula. This section discusses the calculations for the estimated bearing capacity using the CVSR plots. Calculated values using the Hiley, ENR and FHWA Gates formulas will also be compared.

6.1 Nipigon Pile Driving Program

There were 30 CVSR plots generated during the investigation. These plots were recorded at various depths, with various steel lengths and at varying hammer energies. The piles that were tested are summarized in the table below.

Table 8 – CVSR Plot Summary

Pile Number	Depth (m)	Pile Number	Depth (m)	Pile Number	Depth (m)
I-10.5	41.8	H-6.5	29	C-12	41.7
I-9.5	21	H-6.5	50.2	B-12	16.4
I-9.5	41.8	I-6	6.2	B-12	37.6
H-10.5	21.3	H-1	21	B-9.5	20.4
G-10.5	21.2	H-1	42.2	B.5-11	14.8
G-10.5	42.4	I-2	21	E-10	20.4
H-9.5	21	I-2	42.2	D-9	17.1
H-8.5	21.1	H-3	16.8	D-4	34.8
H-8.5	42.3	H-1	41.8	B.5-1	19.9
H-7.5	42	C-12	20.5	E-7	48.8

This section will discuss the site conditions, stratigraphy and parameters utilized to calculate each one. It will also cover the assumptions included in the MTO Modified Hiley Formula.

6.2 Hammer Energy

Hammer energy will be established from the manufacturer specifications sheet. These energies will be used to determine the energy imparted on the pile during generation of the CVSR plot.

6.3 Estimated Bearing Capacity

A constant value used in Equation 6 is e_f, hammer efficiency, and is equal to a value of 1.0 as the Nipigon pile driving program utilized a diesel hammer. This parameter is set from the MTO Ontario Provincial Standard Drawing (OPSD) SS103-11 in Appendix B. The mass of the piston, or W_r, is a constant in the equation and was obtained from the manufacturer of the pile driver. The value for the mass of the anvil was 1,524 kg and is obtained from the pile anvil manufacturer and the full length of the pile. The coefficient of restitution, or e, is given as a value of 0.55 for steel piles driven without a cushion and is a value specified on OPSD SS103-11. The other parameters or values used in the MTO Modified Hiley Formula, henceforth known as the MTO Hiley Formula, are based on the measured pile penetration, rebound and the mass of the pile being driven.

6.4 Summary of CVSR Plots

The CVSR plots outlined in this section were generated after a pile splice was completed. This provided enough time on site to affix the tracking target to the pile just prior to recommencement of pile driving activities. It was not possible to affix the target for the full time of driving as this would have delayed the site work significantly and due to cost constraints was not carried out. These CVSR plots reflect the pile movement while being installed into silt and sand. More detailed pile driving information for the piles discussed in this chapter can be found in Appendix D.

6.4.1 Pile I-10.5 CVSR Plot at Pile Tip Depth of 41.8 m

Pile I-10.5 was installed with a total steel length of 63.3 m. The CVSR plot was generated at an approximate pile tip depth of 41.8 m. This means that the bottom section of the pile was buried approximately 41.8 m in the ground and the remaining length was located above ground. Figure 30 presents the CVSR plot for Pile I-10.5.

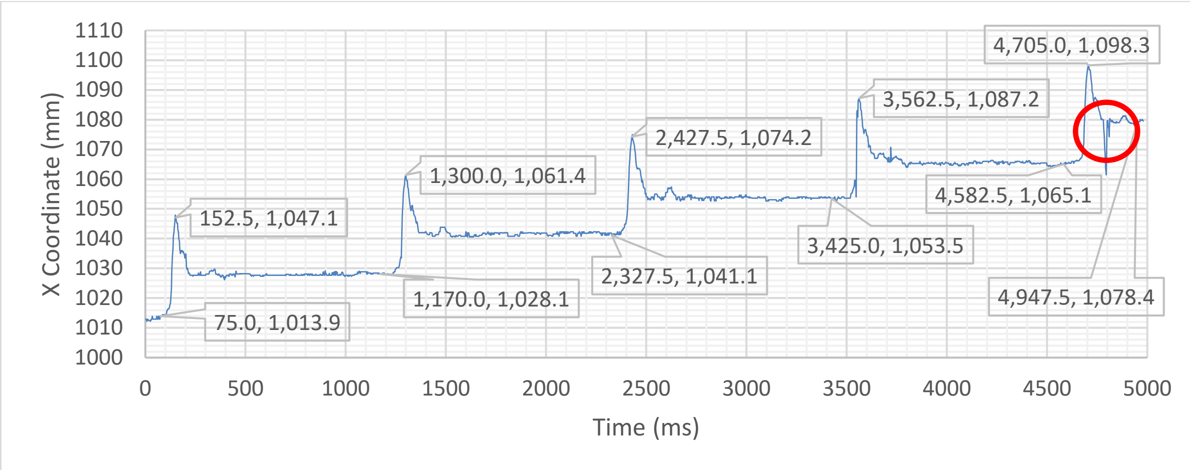

Figure 30 – Pile I-10.5 with 42.4 m of Pile Length

A total of five impacts can be seen in Figure 30 indicated by the peaks followed by the permanent change in the x coordinate value. The change in the x coordinate indicates a permanent displacement of the pile relative to the ground surface. The red circle indicates an anomaly that was detected, upon inspection of the video this is a processing outlier in the video where the centroid being calculated has shifted.

The set and rebound values are 12.9 mm and 20.7 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 52 resulting in a Hammer Energy of approximately 70,000 kJ.

6.4.2 Pile I-9.5 CVSR Plot at Pile Tip Depth of 20.5 m

Pile I-9.5 was installed with a total steel length of 42.3 m. The CVSR plot was generated at an approximate pile tip depth of 20.5 m. As this pile was installed at a tip depth approximately 21 m higher than Pile I-10.5, the soil resistance to drive the pile is much lower as indicated by very small rebound peaks after each impact event. This will be discussed in greater detail in Chapter 7. Figure 31 presents the CVSR plot for Pile I-9.5 and is an example of a CVSR plot with high set and low rebound characteristics.

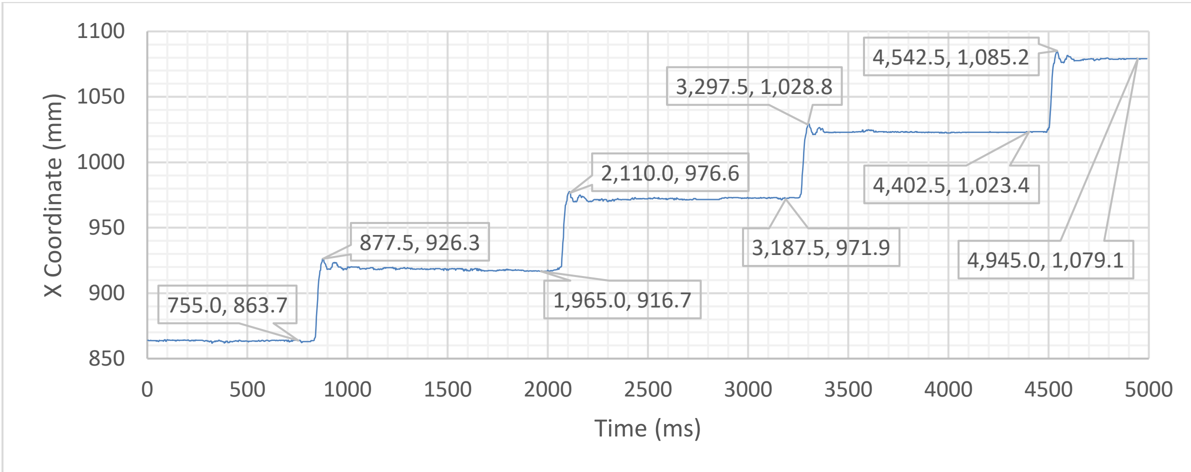

Figure 31 – Pile I-9.5 with 42.3 m of Pile Length

A total of four impacts can be seen on Figure 31. The set and rebound values are 60.6 mm and 5.4 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 49 resulting in a Hammer Energy of approximately 79,000 kJ.

6.4.3 Pile I-9.5 CVSR Plot at Pile Tip Depth of 41.3 m

Pile I-9.5 was installed with a total steel length of 58.7 m. The CVSR plot was generated at an approximate pile tip depth of 41.3 m. As this pile was installed at a tip depth approximately 21 m higher than Pile I-10.5 the soil resistance to driving the pile is much lower. Figure 32 presents the CVSR plot for Pile I-9.5 and is an example of a CVSR plot with moderate set and moderate rebound characteristics.

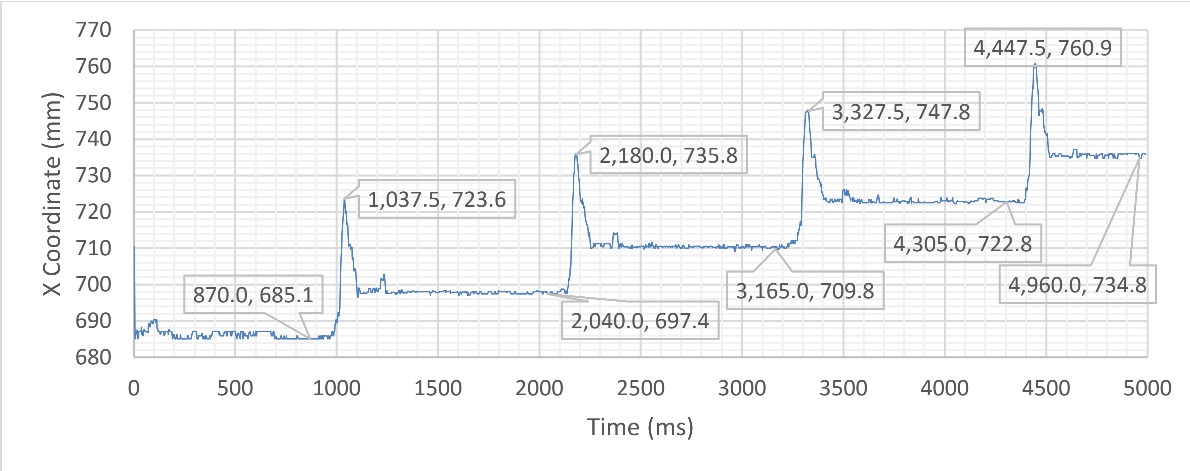

Figure 32 – Pile I-9.5 with 58.7 m of Pile Length

A total of four impacts can be seen on Figure 32. The set and rebound values are 12.4 mm and 25.0 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 55, as the hammer information does not show a corresponding hammer value at 55 BPM the minimum Hemmer Energy of 70,000 kJ was applied.

6.4.4 Pile H-10.5 CVSR Plot at Pile Tip Depth of 20.8 m

Pile H-10.5 was installed with a total steel length of 42.4 m. The CVSR plot was generated at an approximate pile tip depth of 20.8 m, and it is presented in Appendix D.

A total of four impacts were imparted on Pile H-10.5 during CVSR data collection. The set and rebound values are 32.2 mm and 8.6 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 53, as the hammer information does not show a corresponding hammer value at 53 BPM the minimum Hemmer Energy of 70,000 kJ was applied. The first and second impacts of the hammer registered higher set values of 46.0 mm and 34.8 mm. If these values are excluded the average set value is 26.8 mm.

6.4.5 Pile G-10.5 CVSR Plot at Pile Tip Depth of 20.7 m

Pile G-10.5 was installed with a total steel length of 42.5 m. The CVSR plot was generated at an approximate pile tip depth of 20.7 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile G10.5 during CVSR data collection. The set and rebound values are 26.6 mm and 15.0 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 49 resulting in a Hammer Energy of approximately 79,000 kJ.

6.4.6 Pile G-10.5 CVSR Plot at Pile Tip Depth of 41.9 m

Pile G-10.5 was installed with a total steel length of 50.5 m. The CVSR plot was generated at an approximate pile tip depth of 41.9 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile G10.5 during CVSR data collection. The set and rebound values are 22.8 mm and 18.7 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 50 resulting in a Hammer Energy of approximately 76,000 kJ.

6.4.7 Pile H-9.5 CVSR Plot at Pile Tip Depth of 20.5 m

Pile H-9.5 was installed with a total steel length of 42.5 m. The CVSR plot was generated at an approximate pile tip depth of 20.5 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile H-9.5 during CVSR data collection. The set and rebound values are 48.5 mm and 9.5 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 48 resulting in a Hammer Energy of approximately 82,000 kJ.

6.4.8 Pile H-8.5 CVSR Plot at Pile Tip Depth of 20.6 m

Pile H-8.5 was installed with a total steel length of 42.6 m. The CVSR plot was generated at an approximate pile tip depth of 20.6 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile H-8.5 during CVSR data collection. The set and rebound values are 42.6 mm and 6.3 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 46 resulting in a Hammer Energy of approximately 90,000 kJ. The plot was cut short as the hammer was stopped shortly after the last impact.

6.4.9 Pile H-8.5 CVSR Plot at Pile Tip Depth of 41.8 m

Pile H-8.5 was installed with a total steel length of 57.3 m. The CVSR plot was generated at an approximate pile tip depth of 41.8 m, and it is presented in Figure 33.

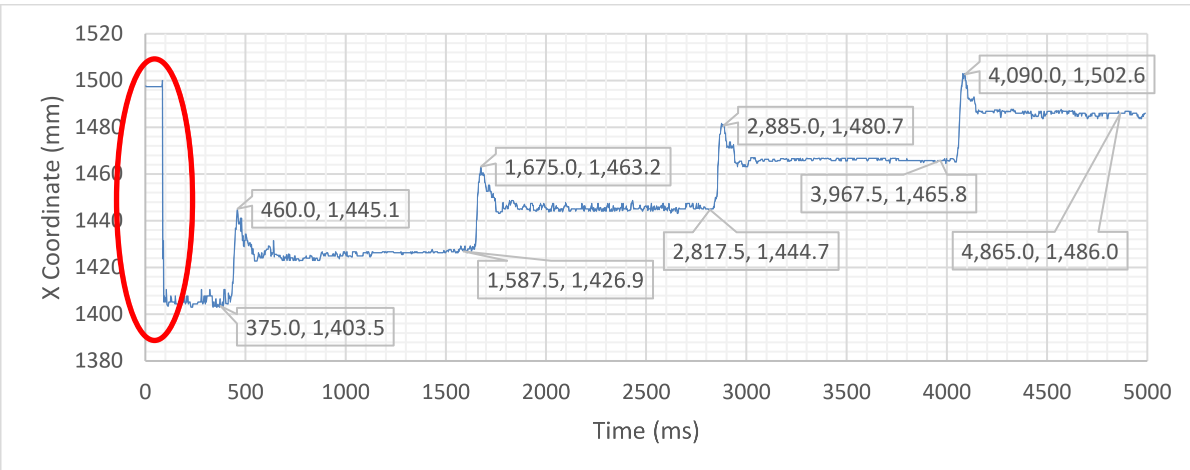

Figure 33 – Pile H-8.5 with 57.3 m of Pile Length

A total of four impacts can be seen on Figure 33. The set and rebound values are 20.6 mm and 14.9 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 50 resulting in a Hammer Energy of approximately 76,000 kJ.

The red circle on the plot indicates an outlier glitch in the plot, and it was disregarded in the calculations. The outlier was most likely caused by a difference in lighting on the pile and did not identify the target markings on the pile correctly.

6.4.10 Pile H-7.5 CVSR Plot at Pile Tip Depth of 42.0 m

Pile H-7.5 was installed with a total steel length of 53.8 m. The CVSR plot was generated at an approximate pile tip depth of 42.0 m. The CVSR plot is presented in Appendix D.

A total of four impacts were imparted on pile H-7.5 during CVSR data collection. The set and rebound values are 13.2 mm and 19.8 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 46 resulting in a Hammer Energy of approximately 90,000 kJ.

6.4.11 Pile H-6.5 CVSR Plot at Pile Tip Depth of 28.5 m

Pile H-6.5 was installed with a total steel length of 50.7 m. The CVSR plot was generated at an approximate pile tip depth of 28.5 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile H-6.5 during CVSR data collection. The set and rebound values are 39.6 mm and 10.7 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 45 resulting in a Hammer Energy of approximately 94,000 kJ.

6.4.12 Pile H-6.5 CVSR Plot at Pile Tip Depth of 49.7 m

Pile H-6.5 was installed with a total steel length of 56.7 m. The CVSR plot was generated at an approximate pile tip depth of 49.7 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile H-6.5 during CVSR data collection. The set and rebound values are 29.7 mm and 8.3 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 50 resulting in a Hammer Energy of approximately 76,000 kJ.

6.4.13 Pile I-6 CVSR Plot at Pile Tip Depth of 6.2 m

Pile I-6 was installed with a total steel length of 27.6 m. The CVSR plot was generated at an approximate pile tip depth of 26.2 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile I-6 during CVSR data collection. The set and rebound values are 60.6 mm and 11.3 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 51 resulting in a Hammer Energy of approximately 73,000 kJ.

6.4.14 Pile H-1 CVSR Plot at Pile Tip Depth of 20.5 m

Pile H-1 was installed with a total steel length of 42.3 m. The CVSR plot was generated at an approximate pile tip depth of 20.5 m, and it is presented in Figure 34.

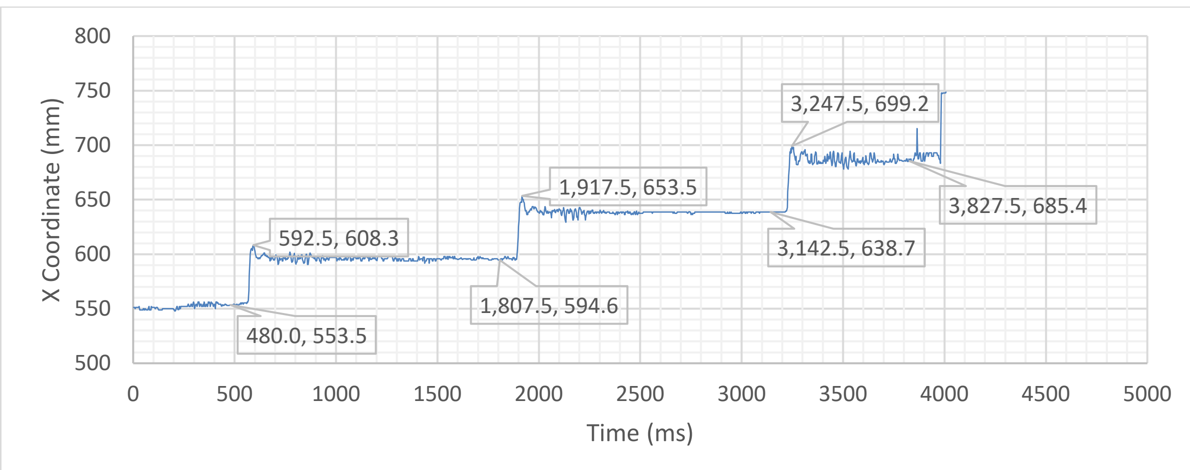

Figure 34 – Pile H-1 with 42.3 m of Pile Length

A total of three impacts can be seen on Figure 34. The set and rebound values are 44.0 mm and 14.8 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 45 resulting in a Hammer Energy of approximately 94,000 kJ.

The plot was stopped early as the post processing code lost track of the target when the rope that controls the pile driver swung in between the camera and target as shown in Figure 35.

Figure 35 – Pile H-1 with Rope Interfering with Processing of the Image

The code was not written to obtain the target after it was blocked or lost. However sufficient data was collected to calculate the required values.

6.4.15 Pile H-1 CVSR Plot at Pile Tip Depth of 41.7 m

Pile H-1 was installed with a total steel length of 63.5 m. The CVSR plot was generated at an approximate pile tip depth of 41.7 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile H-1 during CVSR data collection. The set and rebound values are 25.1 mm and 23.5 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 46 resulting in a Hammer Energy of approximately 90,000 kJ.

6.4.16 Pile I-2 CVSR Plot at Pile Tip Depth of 20.5 m

Pile I-2 was installed with a total steel length of 42.7 m. The CVSR plot was generated at an approximate pile tip depth of 20.5 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile I-2 during CVSR data collection. The set and rebound values are 53.4 mm and 8.6 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 44 resulting in a Hammer Energy of approximately 99,000 kJ.

6.4.17 Pile I-2 CVSR Plot at Pile Tip Depth of 41.7 m

Pile I-2 was installed with a total steel length of 41.7 m. The CVSR plot was generated at an approximate pile tip depth of 62.9 m, and it is presented in Figure 36.

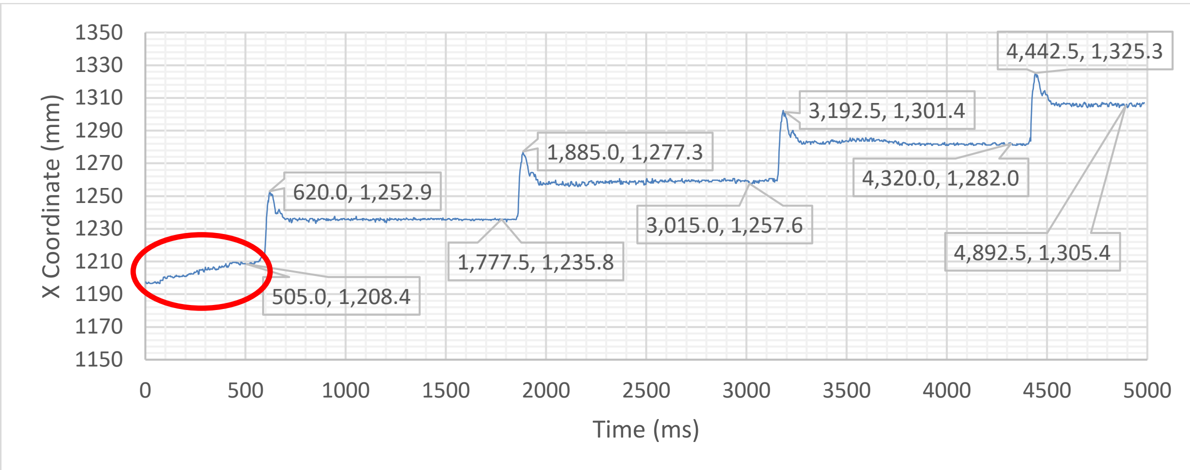

Figure 36 – Pile I-2 with 62.9 m of Pile Length

A total of four impacts can be seen on Figure 36. The set and rebound values are 24.3 mm and 19.4 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 47 resulting in a Hammer Energy of approximately 86,000 kJ. The area highlighted in a red circle shows an increasing value. The gradual rise in values can be due to a drift in the camera placement, or an issue with the computer vision processing software. This trend does not affect the parameters required for the calculation of pile capacity that it can be disregarded.

6.4.18 Pile H-3 CVSR Plot at Pile Tip Depth of 16.3 m

Pile H-3 was installed with a total steel length of 38.4 m. The CVSR plot was generated at an approximate pile tip depth of 16.3 m, and it is presented in Appendix D.

A total of three impacts were imparted on pile H-3 during CVSR data collection. The set and rebound values are 60.6 mm and 12.5 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 46 resulting in a Hammer Energy of approximately 90,000 kJ.

6.4.19 Pile H-1 CVSR Plot at Pile Tip Depth of 41.3 m

Pile H-1 was installed with a total steel length of 63.5 m. The CVSR plot was generated at an approximate pile tip depth of 41.3 m, and it is presented in Figure 37

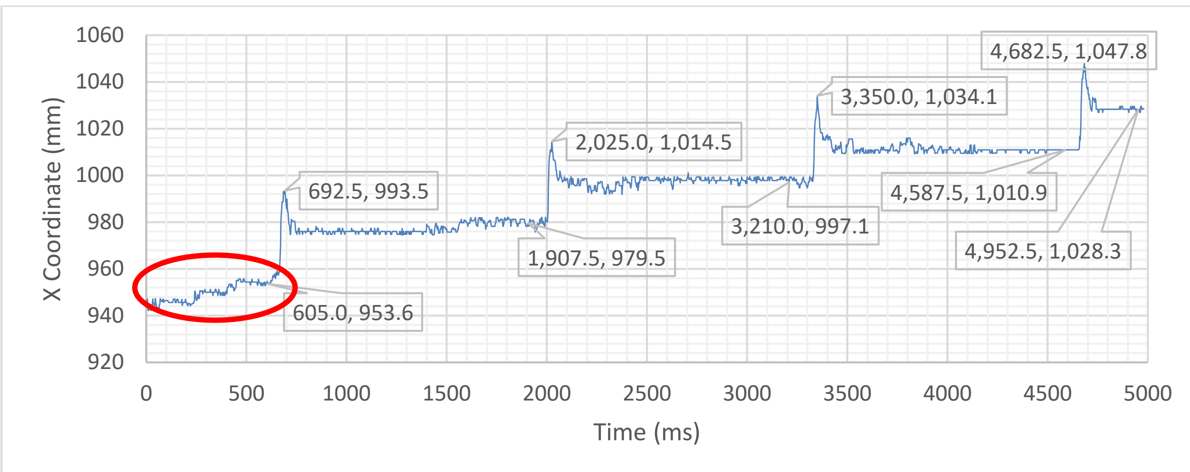

Figure 37 – Pile H-1 with 63.5 m of Pile Length

A total of four impacts can be seen on Figure 37. The set and rebound values are 18.7 mm and 23.2 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 45 resulting in a Hammer Energy of approximately 94,000 kJ. The same trend at the beginning of the plot as Figure 36 can be seen in this plot. The reason behind the behavior circled in red could not be determined. The best guess would be the way the centroid on the target was interpreted by the CVSR code.

6.4.20 Pile C-12 CVSR Plot at Pile Tip Depth of 20.5 m

Pile C-12 was installed with a total steel length of 42.7 m. The CVSR plot was generated at an approximate pile tip depth of 20.5 m, and it is presented in Figure 38.

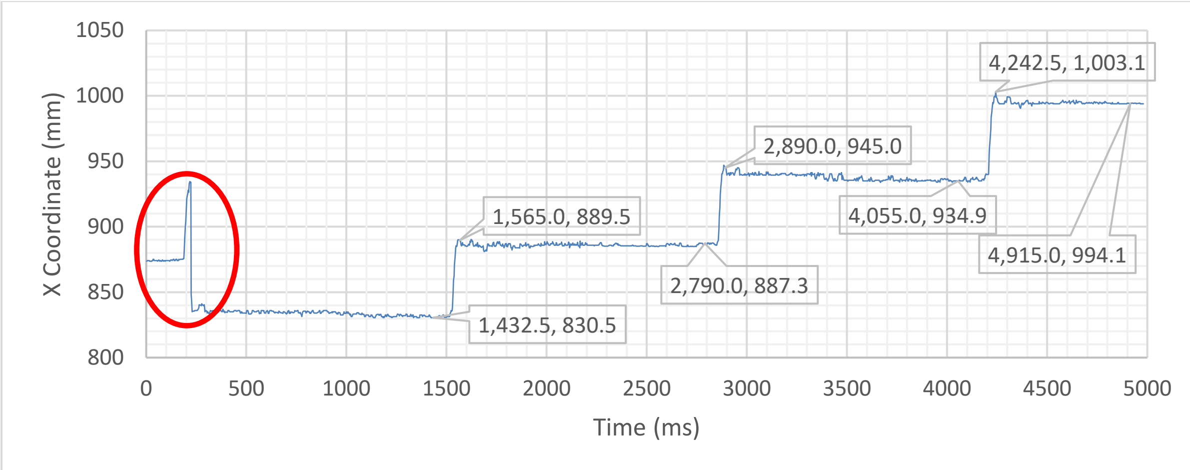

Figure 38 – Pile C-12 with 42.7 m of Pile Length

A total of four impacts can be seen on Figure 38. The set and rebound values are 54.5 mm and 9.0 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 45 resulting in a Hammer Energy of approximately 94,000 kJ. The first impact shown on the plot with a red circle was tracking an incorrect position during processing. The software could not correct for this difference and would have to be manually corrected. This data was not included in determining the set and rebound values

6.4.21 Pile C-12 CVSR Plot at Pile Tip Depth of 41.7 m

Pile C-12 was installed with a total steel length of 63.9 m. The CVSR plot was generated at an approximate pile tip depth of 41.7 m, and it is presented in Appendix D.

A total of three impacts were imparted on pile C-12 during CVSR data collection. The set and rebound values are 49.0 mm and 13.5 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 42 resulting in a Hammer Energy of approximately 109,000 kJ.

6.4.22 Pile B-12 CVSR Plot at Pile Tip Depth of 16.4 m

Pile B-12 was installed with a total steel length of 37.2 m. The CVSR plot was generated at an approximate pile tip depth of 16.4 m, and it is presented in Appendix D.

A total of three impacts were imparted on pile B-12 during CVSR data collection. The set and rebound values are 55.9 mm and 7.8 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 45 resulting in a Hammer Energy of approximately 94,000 kJ.

6.4.23 Pile B-12 CVSR Plot at Pile Tip Depth of 37.6 m

Pile B-12 was installed with a total steel length of 58.8 m. The CVSR plot was generated at an approximate pile tip depth of 37.6 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile B-12 during CVSR data collection. The set and rebound values are 19.6 mm and 30.0 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 46 resulting in a Hammer Energy of approximately 90,000 kJ.

6.4.24 Pile B-9.5 CVSR Plot at Pile Tip Depth of 20.4 m

Pile B-9.5 was installed with a total steel length of 42.6 m. The CVSR plot was generated at an approximate pile tip depth of 20.4 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile B-9.5 during CVSR data collection. The set and rebound values are 23.9 mm and 20.1 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 47 resulting in a Hammer Energy of approximately 86,000 kJ.

6.4.25 Pile B.5-11 CVSR Plot at Pile Tip Depth of 14.8 m

Pile B.5-11 was installed with a total steel length of 37.0 m. The CVSR plot was generated at an approximate pile tip depth of 14.8 m, and it is included in Appendix D.

A total of four impacts were imparted on pile B.5-11 during CVSR data collection. The set and rebound values are 60.2 mm and 6.4 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 50 resulting in a Hammer Energy of approximately 76,000 kJ.

6.4.26 Pile E-10 CVSR Plot at Pile Tip Depth of 20.4 m

Pile E-10 was installed with a total steel length of 42.6 m. The CVSR plot was generated at an approximate pile tip depth of 20.4 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile E-10 during CVSR data collection. The set and rebound values are 88.6 mm and 2.3 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 47 resulting in a Hammer Energy of approximately 86,000 kJ.

6.4.27 Pile D-9 CVSR Plot at Pile Tip Depth of 17.1 m

Pile D-9 was installed with a total steel length of 39.3 m. The CVSR plot was generated at an approximate pile tip depth of 17.1 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile D-9 during CVSR data collection. The set and rebound values are 94.0 mm and 6.0 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 46 resulting in a Hammer Energy of approximately 90,000 kJ.

6.4.28 Pile D-4 CVSR Plot at Pile Tip Depth of 34.8 m

Pile D-4 was installed with a total steel length of 57.4 m. The CVSR plot was generated at an approximate pile tip depth of 34.8 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile D-4 during CVSR data collection. The set and rebound values are 33.4 mm and 17.4 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 45 resulting in a Hammer Energy of approximately 94,000 kJ.

6.4.29 Pile B.5-1 CVSR Plot at Pile Tip Depth of 19.9 m

Pile B.5-1 was installed with a total steel length of 32.5 m. The CVSR plot was generated at an approximate pile tip depth of 19.9 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile B.5-1 during CVSR data collection. The set and rebound values are 56.0 mm and 14.8 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 47 resulting in a Hammer Energy of approximately 86,000 kJ.

6.4.30 Pile E-7 CVSR Plot at Pile Tip Depth of 48.8 m

Pile I-9.5 was installed with a total steel length of 51.0 m. The CVSR plot was generated at an approximate pile tip depth of 48.8 m, and it is presented in Appendix D.

A total of four impacts were imparted on pile E-7 during CVSR data collection. The set and rebound values are 18.9 mm and 46.2 mm and were calculated as an average over all the impact events. The approximate BPM averaged over the plot was calculated at 51 resulting in a Hammer Energy of approximately 73,000 kJ.

6.5 Analysis Based on CVSR Plots

The CVSR plots summarized in Section 6.4 are discussed further in this section. The figures below present the anomalies identified in the plots and how the data is impacted. Contrary to the low set and high rebound values observed in Chapter 5, the data collected and processed in Chapter 6 is a better representation of what is typically encountered in the field during data collection. A summary of the data calculated, and parameters used in the calculations summarized in this section can be found in Appendix E.

Figure 39 compares the predicted ultimate pile resistance at a given depth calculated using the CVSR method and the MTO Modified Hiley to the ENR Bearing formula and FHWA gates formula.

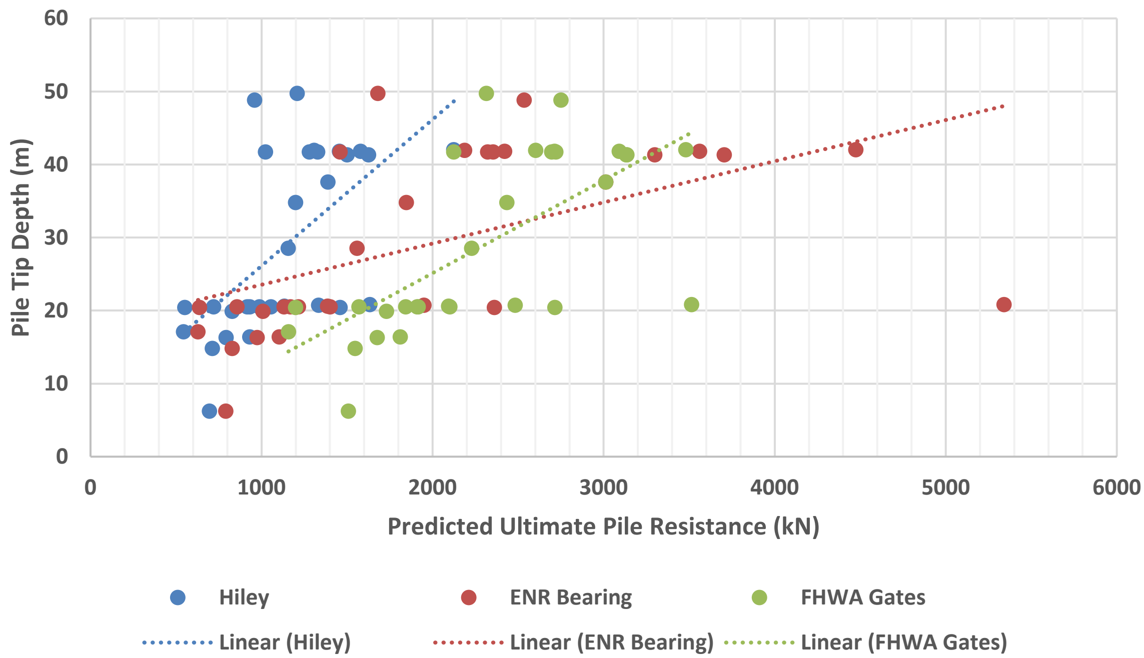

Figure 39 – CVSR Predicted Ultimate Pile Resistance (kN) Vs. Pile Tip Depth (m) For MTO Modified Hiley, ENR Bearing and FHWA Gates

All three formulas show pile tip depth increases with ultimate pile resistance. The Hiley plot also predicts conservative values compared to the others. These conservative values are attributed to the Hiley formula considering energy losses in the form of mobilizing the pile with each strike of the hammer. None of the predictive formulae take into consideration or correct for the soil type that is encountered. The Hiley formula may indirectly take this into consideration with the dynamic values of set and rebound. The ENR and FHWA Gates formulae only include the set parameter to reflect soil conditions.

Figure 40 summarizes the relation between the hammer energy imparted on the pile and the predicted ultimate pile resistance.

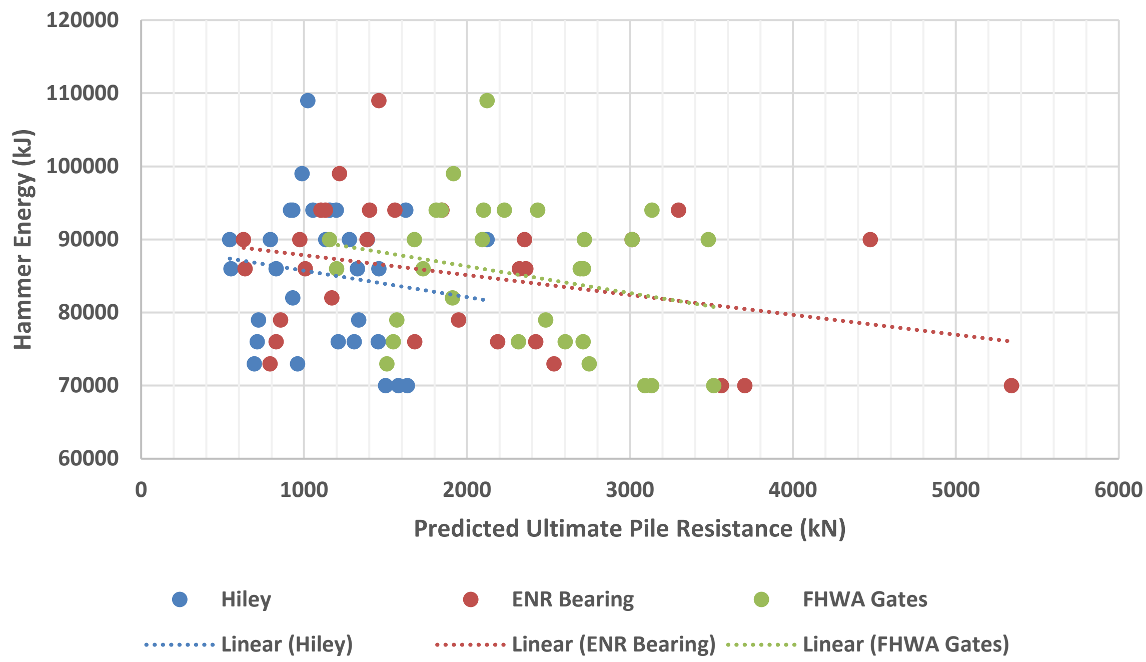

Figure 40 – CVSR Predicted Ultimate Pile Resistance (kN) Vs. Hammer Energy (kJ) For MTO Modified Hiley, ENR Bearing and FHWA Gates

The hammer energy defines the magnitude of the ultimate pile resistance and all the other variables in the equations reflect the losses encountered in the entire pile driving system. A higher hammer energy generally results in higher pile resistance if other variables do not change. According to Figure 40, the ENR Bearing and FHWA Gates formulae calculate higher pile resistance compared to the Hiley method.

Figure 41 compares the predicted pile resistance calculations between the ENR Bearing and FHWA Gates Formulae.

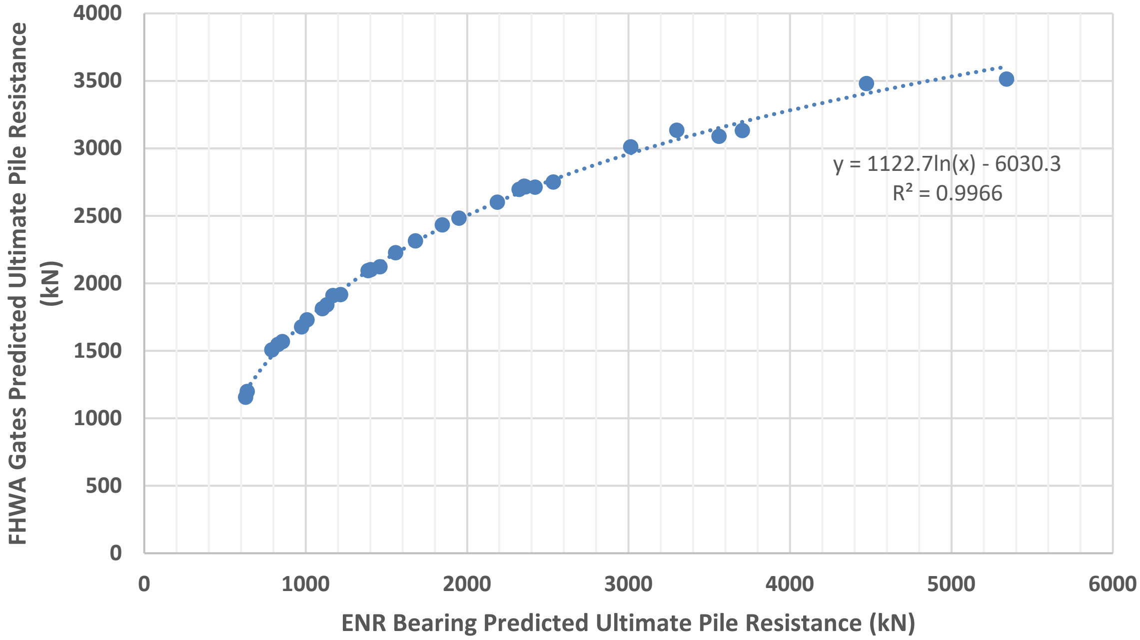

Figure 41 – ENR Bearing Predicted Ultimate Pile Resistance (kN) Vs. FHWA Gates Predicted Ultimate Pile Resistance (kN)

The FHWA Gates predicted results to the ENR predicted results have a logarithmic relationship. The FHWA Gates formula predicts higher ultimate pile resistance than the ENR for values below 3,000 kN. The ENR predicts higher ultimate pile resistance values above 3,000 kN. ENR utilizes established constants in the formula and only uses the energy imparted on the pile and the set to compute the ultimate pile resistance. FHWA also uses established constants, energy on the pile and set but incorporates a log function to account for further losses in the pile at higher energy values. Figure 42 and Figure 43 indicate a linear relationship when comparing the Hiley to FHWA Gates and ENR, respectively.

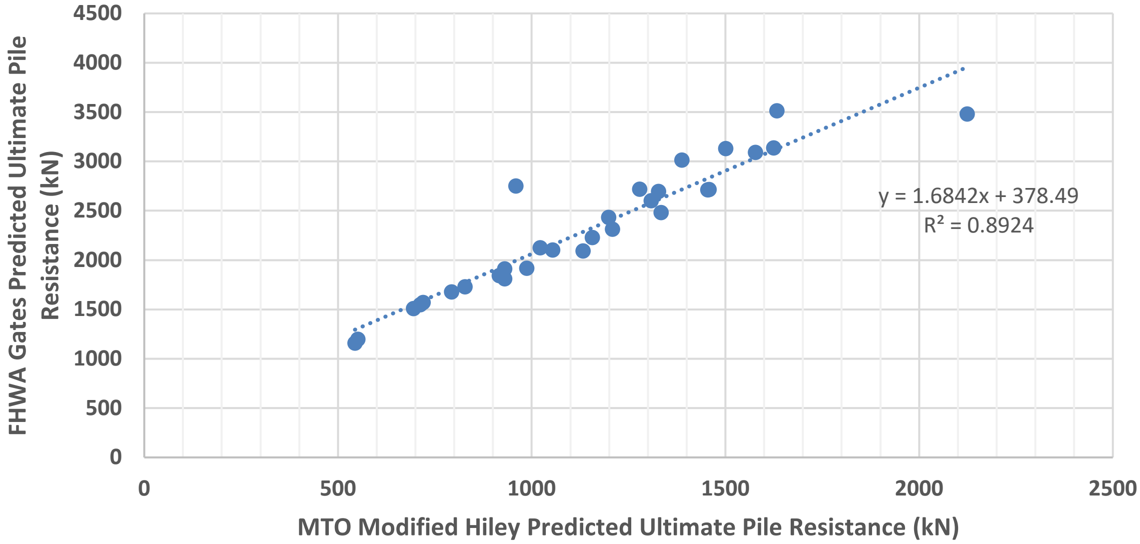

Figure 42 – MTO Modified Hiley Predicted Ultimate Pile Resistance (kN) Vs. FHWA Gates Predicted Ultimate Pile Resistance (kN)

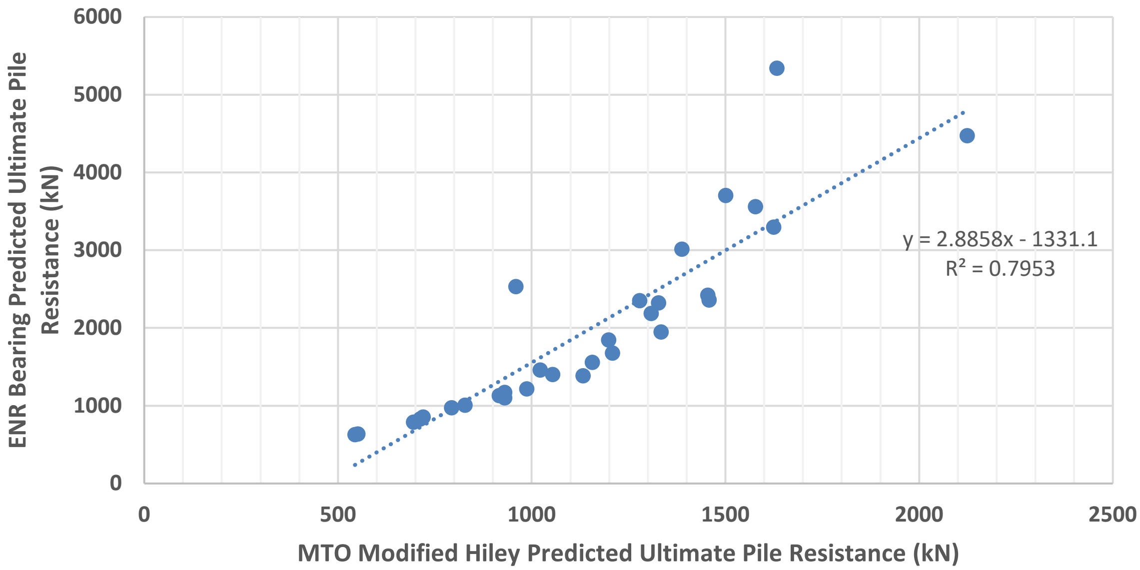

Figure 43 – MTO Modified Hiley Predicted Ultimate Pile Resistance Vs. ENR Bearing Predicted Ultimate Pile Resistance (kN)

Figure 42 and Figure 43 show the FHWA Gates and ENR Bearing formulas predict higher ultimate pile resistance when compared with the MTO Modified Hiley formula. The Hiley formula takes into consideration the weight of the pile, weight of the hammer, weight of the anvil and applies these as losses in the system. Furthermore, the Hiley formula takes into consideration the rebound in the system due to the steel pile and soil which accounts for additional losses.

To verify the accuracy of the predictive formulae pile load testing, or at minimum Pile Dynamic Analyzer (PDA) testing, should be conducted on piles that had CVSR analysis carried out on them.

The CVSR method has shown that it can obtain the required parameters that can also be obtained from traditional MSR methods. The safe and repeatable values generated by the CVSR method provide an encouraging method to obtain parameters that were historically avoided by personnel on site while carrying out traditional MSR methods.

Chapter 7
Evaluation of the CVSR Method

This chapter will summarize the challenges encountered during the field data acquisition and data processing segments. Additional data collected not pertinent to the computations described herein will be summarized.

7.1 Discussion

From the 30 CVSR plots generated, there were issues encountered relating to the data collection and processing of the high-speed videos. Despite a perfect video recording for pile I-10 at 41.8 m depth, a processing anomaly was encountered as can be seen on the red circle in Figure 30. This was a processing outlier where the centroid shifted momentarily and returned.

Pile I-9.5 at 41.3 m depth encountered a secondary peak as shown in Figure 44.

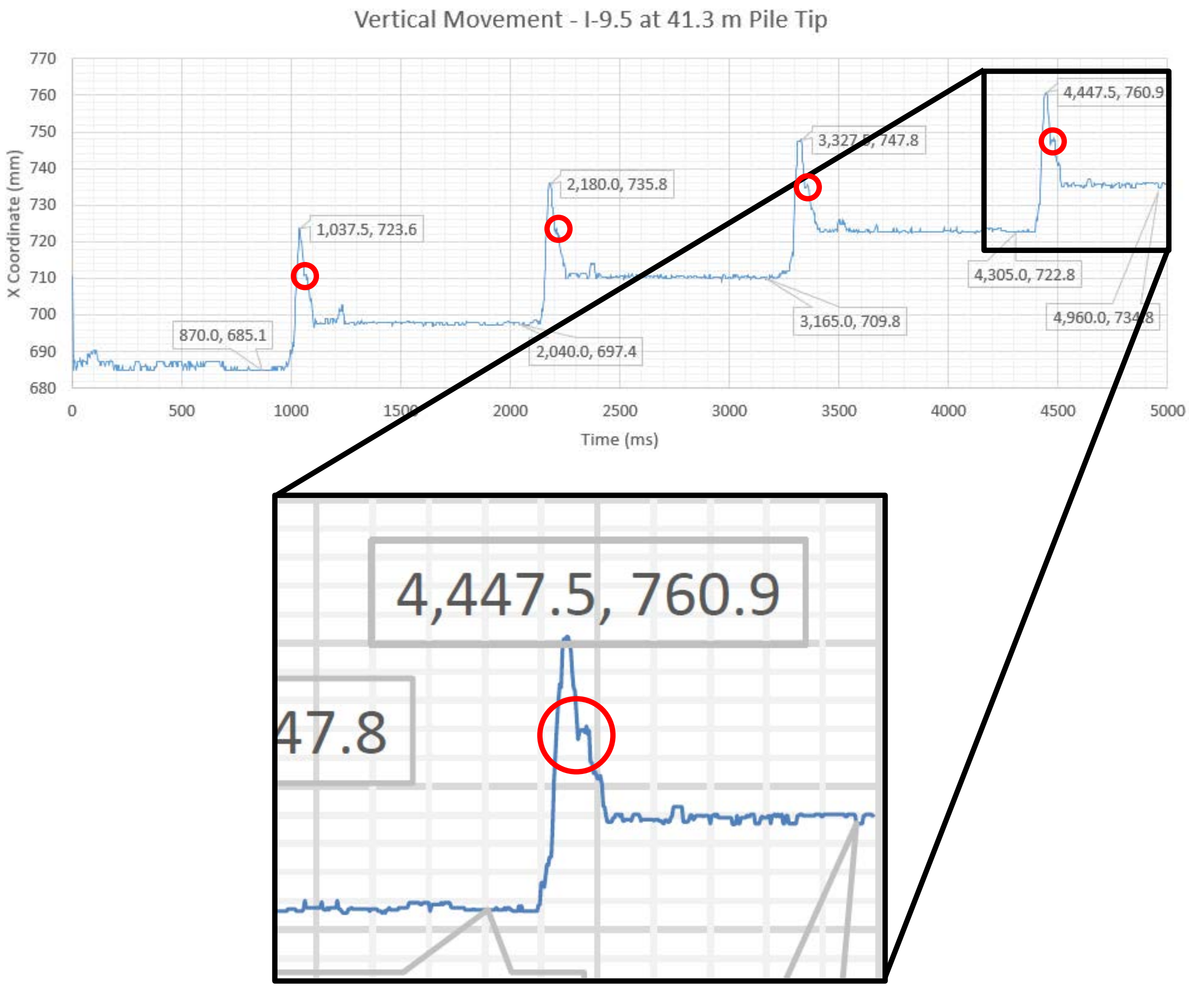

Figure 44 – Secondary Peak on Rebound Section of CVSR Plot

This secondary peak circled in red in Figure 44 is caused by the helmet and anvil bouncing off the top of the pile just after the hammer impact and falling back down.

When comparing driving events at different pile tip depths, the CVSR plots reflect the differences in the pile driving performance and resistance to driving the pile. Figure 45 compares a pile tip depth at 20.5 m and one at 41.3 m.

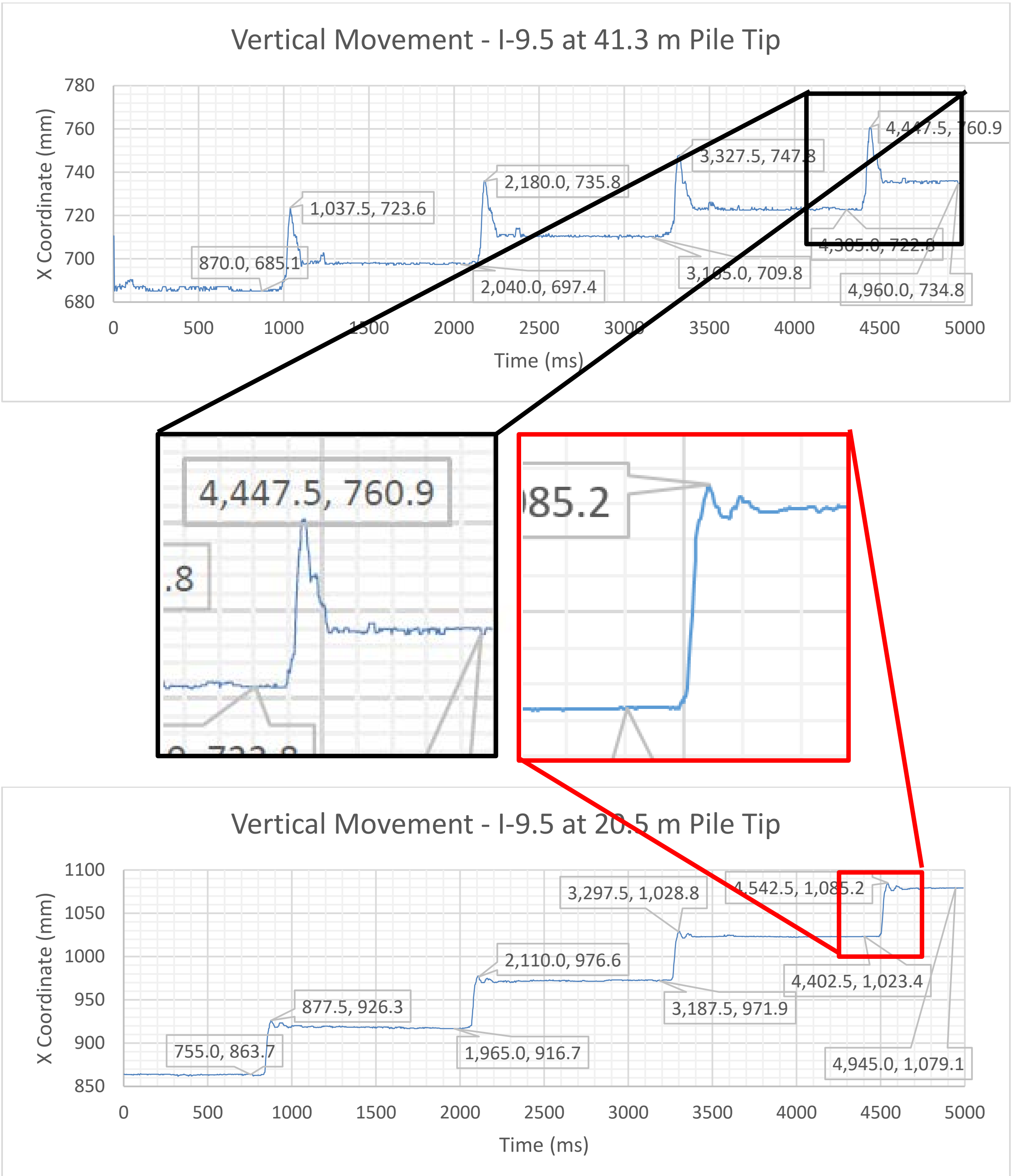

Figure 45 – Shallow Vs Deep Pile Tip Depth Set Rebound Performance

The left image inside the black box of Figure 45 shows a pile impact at a pile tip depth of 41.3 m and the image on the right inside the red box shows a pile tip depth of 20.5 m. The right image reflects a very large set parameter when compared to the rebound parameter, indicating that most of the driving energy was used for penetrating into the soil. The left image has a higher rebound parameter when compared to the set, indicating the hammer energy is used to mobilize the steel, overcome any skin friction in the pile and with residual energy to penetrate the soil.

Another anomaly in the data interpretation of the CVSR method is reflected in Figure 33. The data points in the red circle in Figure 33disrupted the computation algorithm due to a change in the lighting on the pile and caused the centroid of the target to register incorrectly.

Varying degrees of noise or vibrations within the pile were observed in both the video recordings and CVSR plot. Figure 46 shows the difference in vibrations between two impact events.

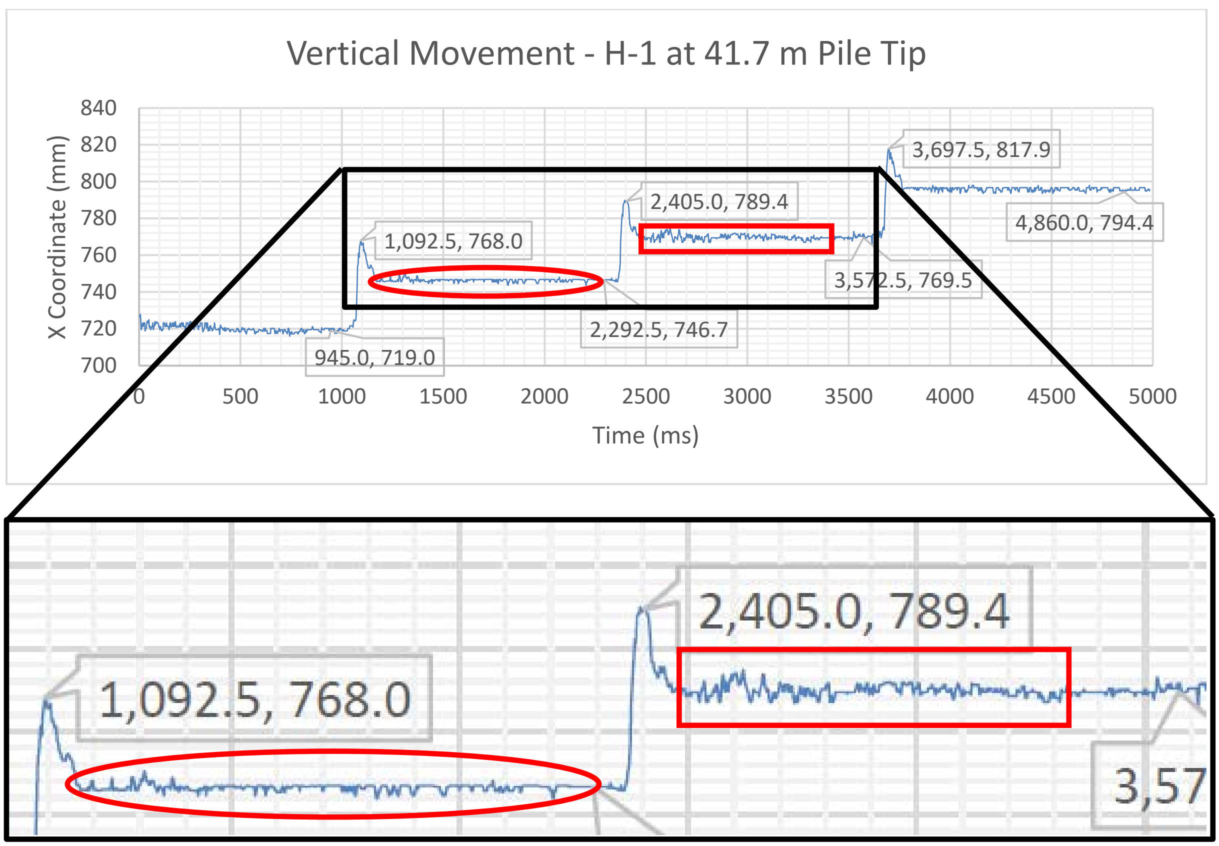

Figure 46 – Vibration or Noise Observed After Hammer Impact on Pile

The red circles in Figure 46 outline the difference in vibration. The red circle shows a lower degree of vibration or noise, the red rectangle shows more vibration or noise. This difference may be vibration from the hammer impacting the pile or the pile hit an obstruction or change in material at the pile tip. This could also be caused by slight changes in how the computer vision algorithm processes the low-resolution image. As time progresses the vibration or noise appears to reduce prior to the next impact.

Further to the vibrations shown in Figure 46, Figure 47 shows the horizontal movement encountered during pile driving. Additional horizontal movement plots can be found in Appendix D.

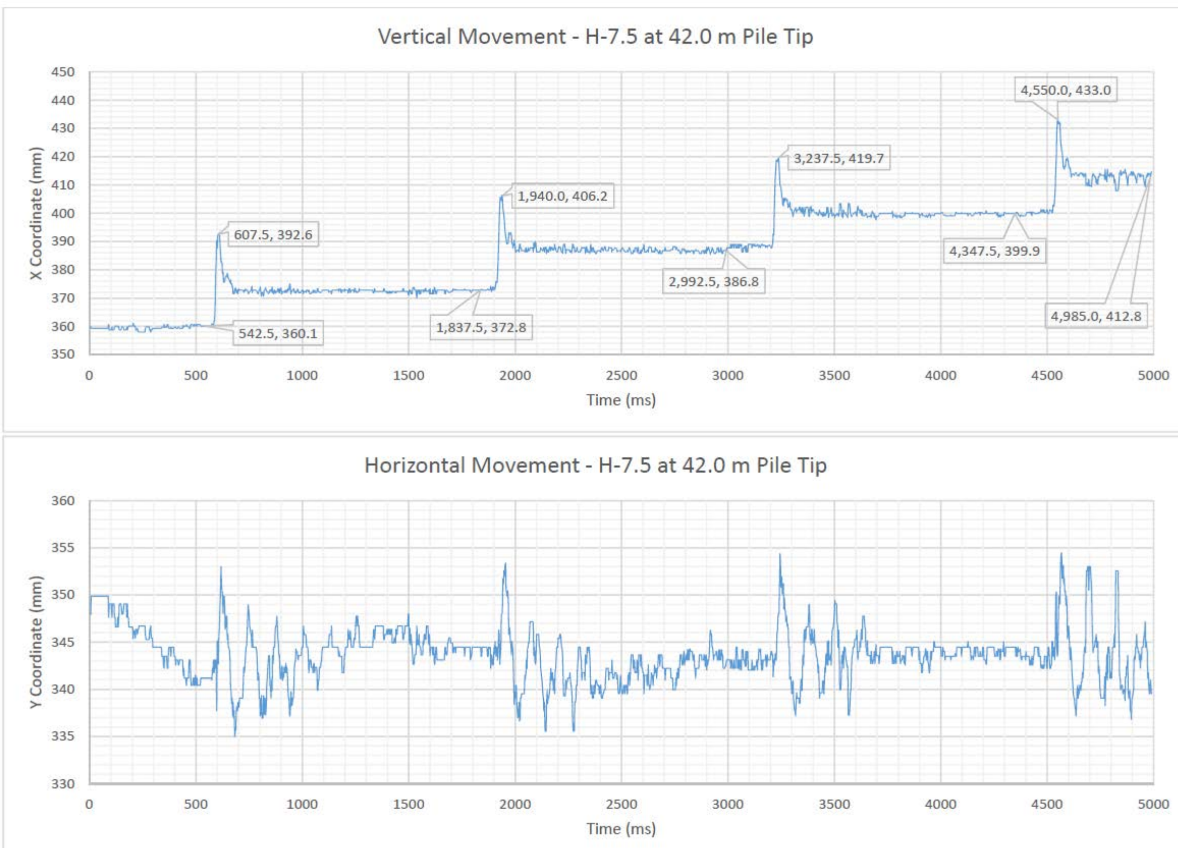

Figure 47 – Vertical and Horizontal Movement for Pile H-7.5 at 42.0 m Pile Tip Depth

Oscillations are recorded after each hammer impact in Figure 47. These oscillations were caused by the hammer not lined up perfectly with the pile. These oscillations would have contributed to the additional movements seen on the vertical movement plot. The Horizontal movement data provides recording of additional pile behavior, but it does not contribute in the estimation of pile capacity. Perhaps further study into the effects of pile oscillations vs skin friction or settlement around the pile should be revisited.

Figure 48 indicates a difference in duration of the rebound event for a given impact when compared with other CVSR plots.

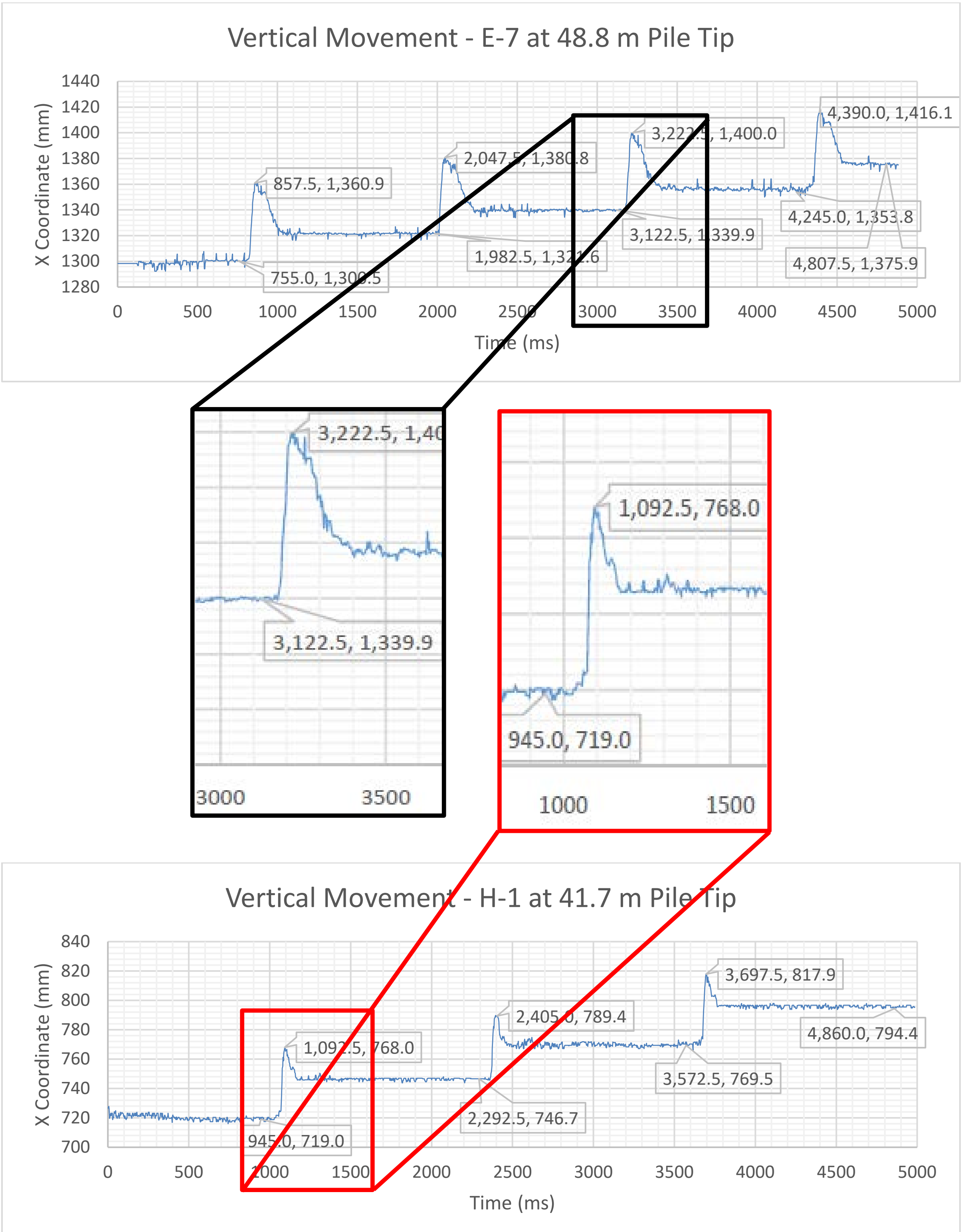

Figure 48 – Delayed Rebound Event Due to Suspected Pile Damage

The plot on the left in the black rectangle appears to take longer to complete the rebound event versus the plot on the right in the red rectangle, approximately 200 ms vs 100 ms, respectively. Without completely extracting the pile and inspecting it there is difficulty in determining the cause for this time difference. It is hypothesized that the pile was damaged in some way. During pile driving the performance was consistent until the very end when the driving characteristics changed suddenly.

7.2 Limitations of Method

The CVSR method takes personnel away from standing near or below the pile driving and provides an alternative method for collecting the data. Issues encountered during the method are summarized below:

- Low light, bright light and varying lighting conditions can affect the image capture and data processing
- Obstructions during video recording such as falling debris, swinging ropes, site personnel movements can cause strange results in post processing
- Pile target must be of high contrast and adhered properly to the pile
- CVSR software requires a qualified operator to understand and run it at this time

Chapter 8
Conclusions

Current methods used by the Ontario Ministry of Transportation (MTO) require personnel to stand near or next to a pile while it is being installed which can be dangerous. An alternative method on obtaining parameters for carrying out predictive calculations of pile bearing capacity were proposed.

Field work was carried out between September 23, 2013 and November 22, 2013. Data collected during pile driving activities included pile blow counts, generation of manual set-rebound plots and recording high speed videos of pile penetration. The field data was collected at the Nipigon River Bridge Twinning pile program along Highway 11/17 in Nipigon, Ontario.

The manually collected set rebound data was used on site with Dynamic Pile Driving Formulae, specifically the MTO Modified Hiley Formula. This formula was specified by the MTO to use on site and required parameters to be collected while standing near the pile being driven into the ground. As this is inherently unsafe it was decided to record the piles with high speed video equipment and post process the images to confirm whether this is a feasible data gathering method.

Initial stages compared the hand generated set-rebound (MSR) plots to the high-speed video post processed (CVSR) plots. Correlations and trends were observed between the two methods. The set and rebound values appears to be estimated higher than values obtained using the MSR plots. This difference was attributed to the very dense nature of the soil the piles were being installed in, the inaccuracy of the MSR data gathering method and thick marker used to generate the MSR plot. Despite post processing issues of the CVSR data the plots were generated in a consistent manner and were clear and made it very easy to gather the required data for use in the MTO Modified Hiley Formula.

Based on the promising results from the comparison of MSR and CVSR plots, data collected during the pile driving activities was used to generate CVSR plots at varying depths and pile hammer energies. Thirty CVSR plots were generated after a pile splice was completed on site to reduce the down time necessary to setup the video recording equipment. Data that was gathered collected results consistent with traditional MSR methods carried out on site. Set values were high at low tip depth values and rebound values were very low. As the tip depth increased, set values decreased or remained the same, but with higher rebound values being encountered. It was also determined that the Blows Per Minute (BPM) can be observed from the CVSR plot from peak to peak instead of manually recording the reading. All the parameters required for the MTO Modified Hiley were able to be computed, pulled from the data plot or obtained from the manufacturer. Since all the information is accessible from a digital plot, human error and inconsistencies in the data collection process are reduced.

When comparing the MTO Modified Hiley, ENR Bearing and FHWA Gates formulae it was found that the Hiley formula provided the lowest predicted pile capacities. This was due to more loss variables included in the Hiley formula. The ENR Bearing and FHWA gates formulae also did not include the pile rebound parameter in their calculations.

Further research and data collection should be carried out. The priority should be given to obtaining data sets where a full-scale pile load test is carried out to verify the predicted values. Further recommendations are provided in Section 8.1.

8.1 Future Research

The CVSR method is a safer method for acquiring set rebound plots compared to the MSR method. Unfortunately, the method is still in its infancy and requires far more research and data acquisition prior to use as a reliable engineering tool.

Use of a higher resolution camera capable of 400 frames per second recording may assist with the data processing or reduce the noise observed in the CVSR plots due to higher resolution video.

More data acquisition and research should be tested on varying soil conditions with different driving methods. With the repeatability and accuracy of the CVSR method, further research could be undertaken in developing new dynamic formulae.

The CVSR processing algorithm should be revisited as new computer vision algorithms become available. These new algorithms may resolve the issues outlined herein but also allow the data collection method to not requiring a high contrast target. One may be able to select an imperfection on the pile, or a weld mark and track the pile motion without stopping pile driving activities.

The horizontal plots should be analyzed further as they may provide insight into how the skin friction of the pile is affected by pile driving, or how the pile settlement is influenced with some movement or no movement.

To provide more accuracy, CVSR data should be collected and compared with full scale load tests and Pile Dynamic Analyzer (PDA) testing. By comparing to the tried and true methods used in engineering it will allow the CVSR to become not only a "quick and dirty" test but also one that is accurate at predicting pile capacity. This will provide more confidence and reliability in this method to allow for wide acceptance in industry practice.

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Appendix A

Pile Bearing Capacity Chart

PILECO, INC.
P.O.Box 16099 Houston, TX 77222
Tel: 713-691-3000 800-474-5326
Fax: 713-691-0089 e-mail: pileco@pileco.com
Web: www.pileco.com

PILECO Diesel Hammer D46

Pile Hammer Bearing Chart

This chart is based on the Engineering News Record (ENR) formula for pile bearing capacity and is provided as a convenience only.

Pile bearing (Tons) **= 2E/(S + 0.1)/2000** , where **E** = Hammer energy (given by the Saximeter formula)
S = Pile set (inch per blow)

Blow per Minute	Ram Stroke (ft)	Hammer Energy (lb.ft)	Pile Set (Blows per inch)											
			1	2	3	4	5	6	7	8	9	10	11	12
35	11.52	116,857	106	195	270	334	390	438	481	519	554	584	612	637
36	10.88	110,289	100	184	255	315	368	414	454	490	522	551	578	602
37	10.28	104,245	95	174	241	298	347	391	429	463	494	521	546	569
38	9.73	98,673	90	164	228	282	329	370	406	439	467	493	517	538
39	9.22	93,524	85	156	216	267	312	351	385	416	443	468	490	510
40	8.75	88,756	81	148	205	254	296	333	365	394	420	444	465	484
41	8.32	84,332	77	141	195	241	281	316	347	375	399	422	442	460
42	7.91	80,221	73	134	185	229	267	301	330	357	380	401	420	438
43	7.53	76,394	69	127	176	218	255	286	315	340	362	382	400	417
44	7.18	72,824	66	121	168	208	243	273	300	324	345	364	381	397
45	6.85	69,489	63	116	160	199	232	261	286	309	329	347	364	379
46	6.54	66,370	60	111	153	190	221	249	273	295	314	332	348	362
47	6.26	63,448	58	106	146	181	211	238	261	282	301	317	332	346
48	5.99	60,706	55	101	140	173	202	228	250	270	288	304	318	331
49	5.73	58,131	53	97	134	166	194	218	239	258	275	291	304	317
50	5.49	55,708	51	93	129	159	186	209	229	248	264	279	292	304
51	5.27	53,427	49	89	123	153	178	200	220	237	253	267	280	291
52	5.06	51,276	47	85	118	147	171	192	211	228	243	256	269	280

Caution: Driving at more than 20 blows per inch (set of 0.05 inch per blow) is considered practical refusal.

PILECO, INC.
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Web: www.pileco.com

PILECO Diesel Hammer D46

Pile Hammer Bearing Chart

This chart is based on the Engineering News Record (ENR) formula for pile bearing capacity and is provided as a convenience only.

Pile bearing (kN) = **100E/(S + 0.254)/6,** where **E** = Hammer energy (given by the Saximeter formula)
S = Pile set (cm per blow)

Blows per Minute	Ram Stroke (m)	Hammer Energy (kJ)	Pile Set (Blows per 2cm)											
			5	6	7	8	9	10	11	12	13	14	15	16
35	3.51	159	4041	4499	4896	5243	5549	5821	6064	6282	6479	6659	6823	6973
36	3.32	150	3814	4247	4621	4949	5237	5494	5723	5929	6115	6285	6439	6581
37	3.13	141	3605	4014	4368	4678	4951	5193	5409	5604	5780	5941	6087	6220
38	2.97	134	3412	3800	4135	4428	4686	4915	5120	5305	5472	5623	5761	5888
39	2.81	127	3234	3601	3919	4197	4442	4659	4853	5028	5186	5330	5461	5581
40	2.67	120	3069	3418	3719	3983	4215	4422	4606	4772	4922	5058	5183	5297
41	2.54	114	2917	3248	3534	3785	4005	4201	4377	4534	4677	4806	4924	5033
42	2.41	109	2774	3089	3362	3600	3810	3997	4163	4313	4449	4572	4685	4788
43	2.30	104	2642	2942	3202	3428	3628	3806	3965	4108	4237	4354	4461	4559
44	2.19	99	2519	2805	3052	3268	3459	3628	3780	3916	4039	4151	4253	4346
45	2.09	94	2404	2676	2912	3119	3301	3462	3607	3737	3854	3961	4058	4147
46	2.00	90	2296	2556	2782	2979	3153	3307	3445	3569	3681	3783	3876	3961
47	1.91	86	2195	2444	2659	2848	3014	3161	3293	3412	3519	3617	3706	3787
48	1.83	82	2100	2338	2545	2725	2884	3025	3151	3265	3367	3461	3546	3624
49	1.75	79	2011	2239	2437	2609	2762	2897	3018	3126	3225	3314	3395	3470
50	1.68	76	1927	2146	2335	2501	2647	2776	2892	2996	3090	3176	3254	3326
51	1.61	73	1848	2058	2240	2398	2538	2663	2774	2874	2964	3046	3121	3189
52	1.54	70	1774	1975	2150	2302	2436	2555	2662	2758	2845	2923	2995	3061

Caution: Driving at more than 8 blows per cm (set of 0.125 cm per blow) is considered practical refusal.

Appendix B

OPSD SS103-11 Drawing and Pile Target

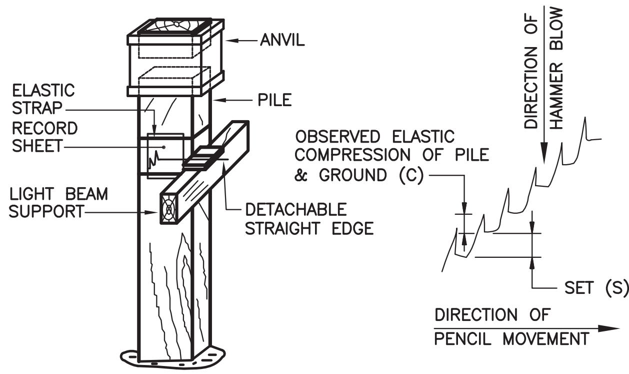
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No

SHEET

PILE DRIVING CONTROL



FIELD MEASUREMENT TECHNIQUE DURING PILE DRIVING

HAMMERS*		
TYPE	MASS OF RAM W (Kilograms)	RATED ENERGY E (Joules/blow)
9B3	726	12419
10B3	1361	16948
50C	2268	20337
11B3	2268	26005
D12	1250	30506
B225	1360	39300
LB520	2300	40675
B300	1700	46100
D22	2200	53826
B400	2268	62400
D22–02	2200	67000
D22–13	2200	67000
D30–02	3000	91000
D30–13	3000	91000
B500	3129	107100
D36–02	3600	115000
D36–13	3600	115000

NOTE:

Ram may also be referred to as Piston

* See General Notes 5) and 6).

METHOD OF APPLYING THE HILEY FORMULA

The Hiley Formula for:

(a) Double–acting, differential–acting Steam and Diesel Hammers,

$R = \frac{n\ e_f\ E}{S + C/2}$ e_f = 0.6 to 0.8 for steam hammers; e_f = 1.0 for diesel hammers

(b) Drop Hammers and single–acting Steam Hammers,

$R = \frac{n\ e_f\ WgH}{S + C/2}$ e_f = 0.75 for drop hammers; H = height of free fall of mass in metres

Where
- R = Ultimate pile resistance in kilonewtons
- S = Measured penetration of pile per hammer blow in millimetres
- C = Measured rebound of pile per hammer blow in millimetres
- E = Rated Energy of hammer blow in joules
- e_f = efficiency based on manufacturer's gross rated energy (typ. 0.6 to 0.8)
- n = efficiency of blow
- e = coefficient of restitution
- g = 9.80665 m/s^2
- $n = \frac{W + Pe^2}{W + P}$

  where e = 0.32 for steel (or e = 0.55. See Note 1 below.)
  = 0.25 for timber

  P = Mass of pile + anvil or helmet in kilograms (See Note 2 below)

  W = Mass of ram (piston) in kilograms

NOTE 1:

It is assumed that piles are driven with a pile cushion. Where Steel H–Piles are driven without a cushion, the ultimate pile capacity R should be calculated assuming a coefficient of Restitution e = 0.55.

NOTE 2:

Assume mass of anvil = 600 kg unless otherwise noted.

NOTE 3:

The resulting Ultimate Pile Resistance, R, as calculated by Hiley Formula must exceed the Ultimate Geotechnical Resistance given in the Pile Driving Notes on the Contract Drawings.

EXAMPLE FOR DIESEL HAMMERS

Given: Pile HP 310x110, length = 50m
Mass of anvil = 600 kg
Pile driven without a cushion
Hammer is Delmag D22–13
From the Pile Driving Notes on the Contract Drawings,
Ultimate Geotechnical Resistance = 3000 kN

Observations: measured penetration = S = 5mm
measured rebound = C = 10mm

Hiley Formula Calculations

P = 50(110) + 600 = 6100 kg

W = 2200 kg   e = 0.55

$$n = \frac{W + Pe^2}{W + P} = \frac{2200 + 6100\ (0.55)^2}{2200 + 6100} = 0.49$$

E = 67,000 Joules/blow

$$R = \frac{n\ e_f\ E}{S + C/2} = \frac{0.49\ (1.0)\ (67{,}000)}{5 + (10/2)} = \underline{3283\ kN} > 3000\ kN \quad O.K.$$

EXAMPLE FOR DROP HAMMERS

Given: Timber Pile: length = 15m, density = 641 kg/m^3
butt dia. = 0.36m, tip dia. = 0.20m
Mass of Helmet = 300 kg
Mass of Hammer = 2268 kg = W
Fall of Hammer = 1.0 metre = H
e = 0.25
From Pile Driving Notes on Contract Drawings,
Ultimate Geotechnical Resistance = 750 kN

Observations: measured penetration = S = 5mm
measured rebound = C = 20mm

Hiley Formula Calculations

$$P = (15 \times \frac{\pi}{4} \left(\frac{0.36 + 0.20}{2}\right)^2 \times 641) + 300 = 892\ kg$$

e_f = 0.75

W = 2268 kg

$$n = \frac{W + Pe^2}{W + P} = \frac{2268 + 892(0.25)^2}{2268 + 892} = 0.74$$

$$R = \frac{n\ e_f\ WgH}{S + C/2} = \frac{0.74(0.75)(2268)(9.806)(1.0)}{5 + (20/2)} = \underline{823\ kN} > 750\ kN \quad O.K.$$

NOTES:

1. THIS STANDARD DRAWING IS FOR THE CONTROL OF PILE INSTALLATIONS BY VALIDATING DESIGN ASSUMPTIONS.
2. THE HILEY FORMULA SHALL BE USED TO CONFIRM PILE RESISTANCE FOR FRICTION–TYPE PILES IN NON–COHESIVE SOILS. FOR USE IN COHESIVE SOILS, THE GEOTECHNICAL ENGINEER WILL HAVE TO BE CONSULTED.
3. DURING PILE DRIVING, THE HAMMER HAS TO REBOUND ENOUGH TO MAINTAIN ITS ENERGY PER BLOW. ACCORDINGLY, THE SOIL MUST PROVIDE SUFFICIENT REBOUND FOR THE HILEY FORMULA TO BE EFFECTIVE.
4. IF THE ULTIMATE PILE RESISTANCE, AS CALCULATED BY THE HILEY FORMULA, IS NOT REACHED WHEN REFERENCED TO A PRESCRIBED PILE TIP ELEVATION OR RANGE OF ELEVATIONS, THE ADVICE AND RECOMMENDATIONS OF A GEOTECHNICAL ENGINEER SHALL BE SOUGHT.
5. THE CONTRACTOR SHALL SUBMIT THE PERTINENT HAMMER PROPERTIES, AS REQUIRED BY OPSS 903.
6. THE TABLE OF HAMMERS GIVEN ON THIS STANDARD DRAWING CAN BE USED FOR COMPARING THE SUBMITTED HAMMER PROPERTIES. IT IS APPROXIMATE AND MAY NOT INCLUDE ALL HAMMERS. THE CONTRACTOR SHALL CONTACT THE MANUFACTURER FOR RATED AND ACTUAL HAMMER ENERGIES.
7. WHEN APPLYING THE HILEY FORMULA, THE HAMMER SHALL BE OPERATED AT FULL CAPACITY.

NOTES TO DESIGNER

1. WHEN USING THIS STANDARD THE DESIGNER SHOULD ENSURE THAT THE ULTIMATE GEOTECHNICAL RESISTANCE IS GIVEN ON THE CONTRACT DRAWINGS AS DETAILED IN SECTION 3.3.2/3 OF THE STRUCTURAL MANUAL.
2. THE 'NOTES TO DESIGNER' SHALL BE DELETED FROM THIS DRAWING PRIOR TO ISSUING OF THE CONTRACT.

REFER TO 1.1.8 IN THE STRUCTURAL MANUAL FOR PROFESSIONAL ENGINEER STAMPING REQUIREMENTS.

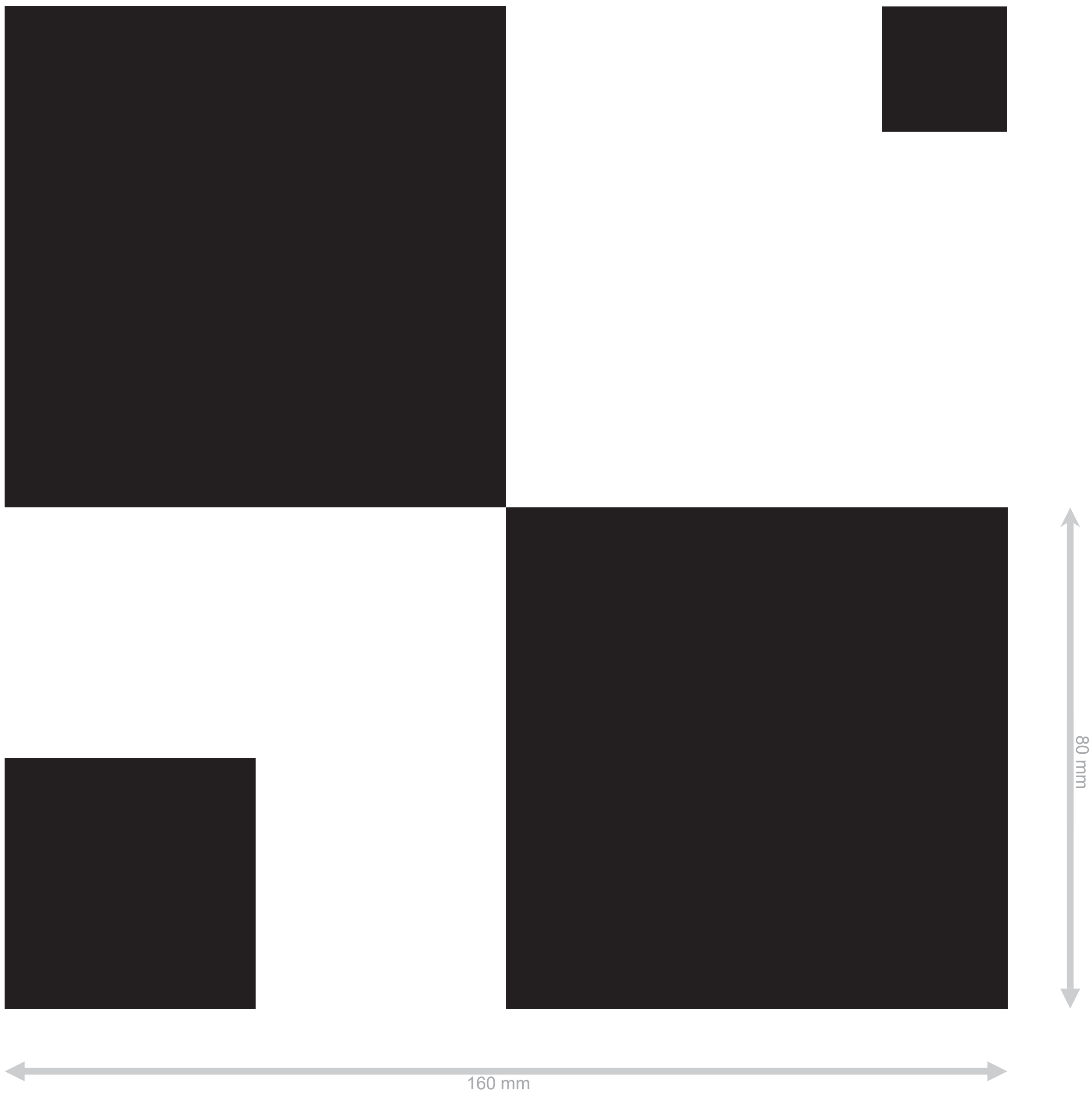
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

STANDARD DRAWING
APRIL 2008
SS103–11
PILE DRIVING CONTROL

REVISIONS | DESCRIPTION
DESIGN | CHK | CODE CHBDC–00 | CL 625–ONT | DATE
DRAWN | CHK | SITE | | DWG

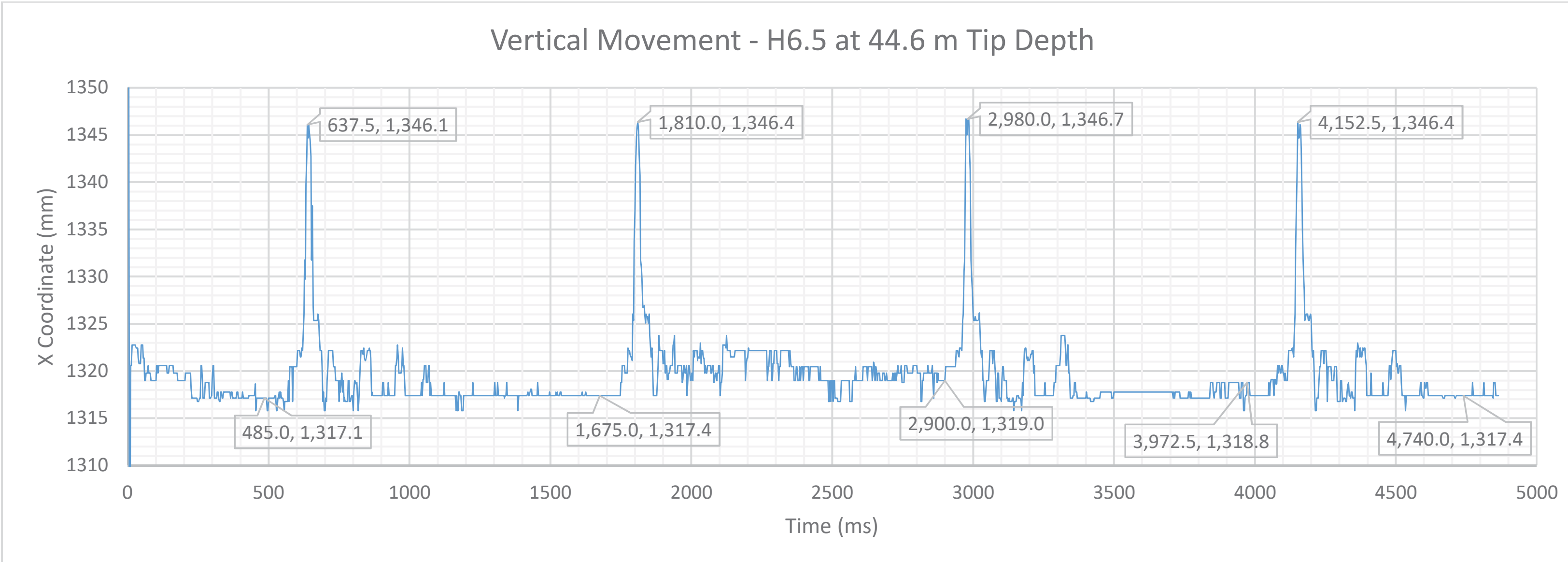
MINISTRY OF TRANSPORTATION, ONTARIO   PR–D–707   88–05

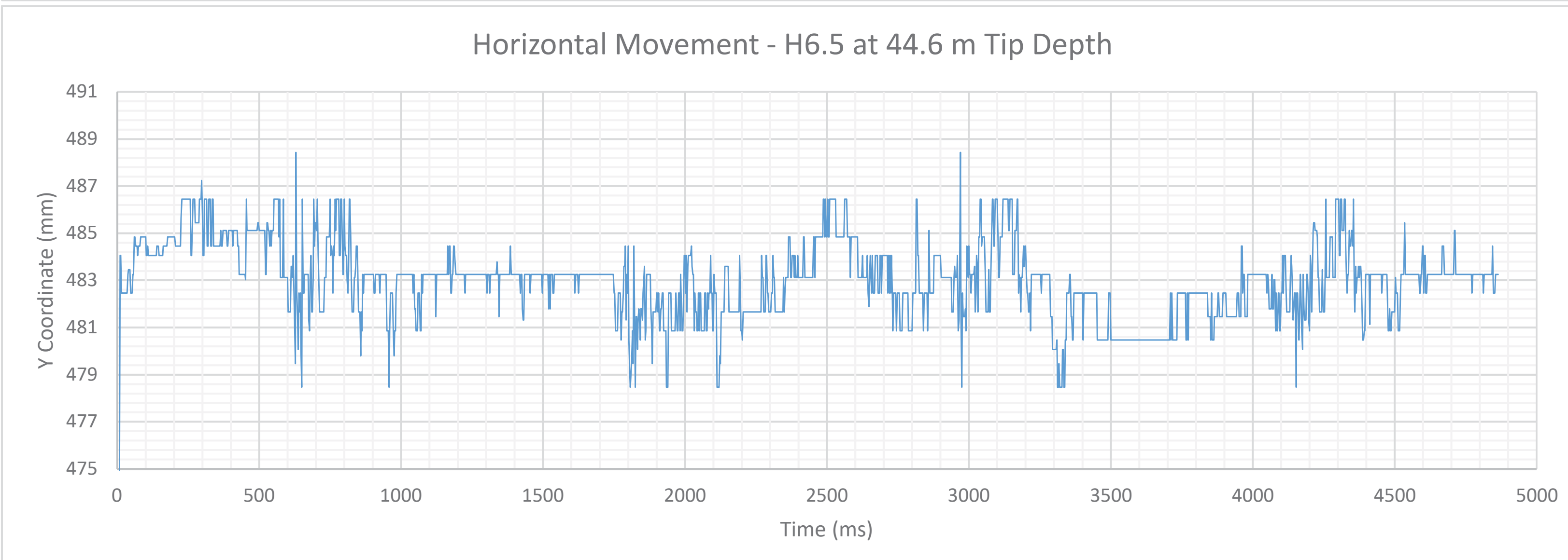
DRAWING NAME: s103–11.dwg   CREATED: 1996/12/17   MODIFIED: 2008/03/27 14:26:49


80 mm
160 mm

Appendix C

CVSR and MSR Plot Comparison


Vertical Movement - H6.5 at 44.6 m Tip Depth
X Coordinate (mm)
Time (ms)
1350
1345
1340
1335
1330
1325
1320
1315
1310
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
637.5, 1,346.1
1,810.0, 1,346.4
2,980.0, 1,346.7
4,152.5, 1,346.4
485.0, 1,317.1
1,675.0, 1,317.4
2,900.0, 1,319.0
3,972.5, 1,318.8
4,740.0, 1,317.4


Horizontal Movement - H6.5 at 44.6 m Tip Depth
Y Coordinate (mm)
Time (ms)
491
489
487
485
483
481
479
477
475
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION					
Type: Diesel		**Model:** D46-32		**Make:** Delmag	
Hammer Weight (kg): 4600		**Fall (m):** 1.42 to 3.5		**Mass of Helmet (kg):** ~908	
Rated Energy (kJ Range): 71 to 166		**Hammer Cushion:** Yes			
Other Notes: Helmet was changed on September 26, 2013, the mass is an approximate value from Tom Jones					

PILE DETAILS							
Pile No. H-6.5		**Pile Type:** H-Pile		**Design Capacity:** 3000 kN		**Size:** 360x132	
Pile Shoe: Rock Injector		**Batter (H:V):** 1:10		**Total Length (m):** 44.4		**Mass (kg):** 5900.4	
Pile Segment	**Section 1**	**Splice 1**	**Section 2**	**Splice 2**	**Section 3**	**Splice 3**	**Section 4**
Length / Cut Off (m)	8.3	0.0	21.2	0.0	21.2	6.0	
Start Time:	15:07	15:42	17:15	7:45	8:40		
End Time:	15:09	17:05	17:28	8:30	9:20		
Set Criteria (mm/blow) <1.5 - 2		**Actual Tip Elev. (m):** 139.8			**Cut off Elev. (m):** 184.5		
Approximate Ground Elev. (m) 184.8							

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**	5	**18.2**	4	**24.2**	4	**30.2**	8	**36.2**	7
0.4		**6.4**		**12.4**	4	**18.4**	4	**24.4**	4	**30.4**	10	**36.4**	9
0.6		**6.6**		**12.6**	5	**18.6**	4	**24.6**	4	**30.6**	10	**36.6**	8
0.8		**6.8**		**12.8**	4	**18.8**	5	**24.8**	4	**30.8**	10	**36.8**	8
1.0		**7.0**		**13.0**	5	**19.0**	5	**25.0**	5	**31.0**	9	**37.0**	8
1.2		**7.2**	↓	**13.2**	4	**19.2**	4	**25.2**	5	**31.2**	9	**37.2**	8
1.4		**7.4**	IR	**13.4**	4	**19.4**	5	**25.4**	4	**31.4**	9	**37.4**	9
1.6		**7.6**	9	**13.6**	5	**19.6**	4	**25.6**	4	**31.6**	9	**37.6**	8
1.8		**7.8**	4	**13.8**	5	**19.8**	4	**25.8**	4	**31.8**	8	**37.8**	9
2.0		**8.0**	7	**14.0**	4	**20.0**	4	**26.0**	5	**32.0**	8	**38.0**	9
2.2		**8.2**	10	**14.2**	5	**20.2**	3	**26.2**	4	**32.2**	8	**38.2**	9
2.4		**8.4**	5	**14.4**	4	**20.4**	3	**26.4**	6	**32.4**	10	**38.4**	10
2.6		**8.6**	4	**14.6**	4	**20.6**	4	**26.6**	6	**32.6**	8	**38.6**	9
2.8	↓	**8.8**		**14.8**	4	**20.8**	4	**26.8**	6	**32.8**	7	**38.8**	9
3.0	IR	**9.0**		**15.0**	5	**21.0**	3	**27.0**	6	**33.0**	8	**39.0**	11
3.2	12	**9.2**		**15.2**	4	**21.2**	4	**27.2**	5	**33.2**	8	**39.2**	10
3.4	6	**9.4**		**15.4**	5	**21.4**	4	**27.4**	5	**33.4**	7	**39.4**	12
3.6	8	**9.6**	↓	**15.6**	5	**21.6**	3	**27.6**	6	**33.6**	7	**39.6**	10
3.8	8	**9.8**	IR	**15.8**	5	**21.8**	4	**27.8**	7	**33.8**	7	**39.8**	10
4.0	8	**10.0**	4	**16.0**	4	**22.0**	3	**28.0**	-	**34.0**	7	**40.0**	11
4.2	7	**10.2**	4	**16.2**	5	**22.2**	4	**28.2**	-	**34.2**	7	**40.2**	10
4.4	8	**10.4**	5	**16.4**	4	**22.4**	4	**28.4**	-	**34.4**	7	**40.4**	9
4.6	10	**10.6**	5	**16.6**	5	**22.6**	3	**28.6**	-	**34.6**	8	**40.6**	11
4.8		**10.8**	4	**16.8**	5	**22.8**	3	**28.8**	7	**34.8**	7	**40.8**	10
5.0		**11.0**	4	**17.0**	4	**23.0**	4	**29.0**	8	**35.0**	8	**41.0**	10
5.2		**11.2**	5	**17.2**	4	**23.2**	4	**29.2**	6	**35.2**	6	**41.2**	9
5.4		**11.4**	5	**17.4**	4	**23.4**	4	**29.4**	6	**35.4**	9	**41.4**	11
5.6		**11.6**	5	**17.6**	5	**23.6**	3	**29.6**	8	**35.6**	7	**41.6**	13
5.8		**11.8**	5	**17.8**	5	**23.8**	4	**29.8**	8	**35.8**	10	**41.8**	14
6.0	↓	**12.0**	5	**18.0**	5	**24.0**	3	**30.0**	9	**36.0**	8	**42.0**	15

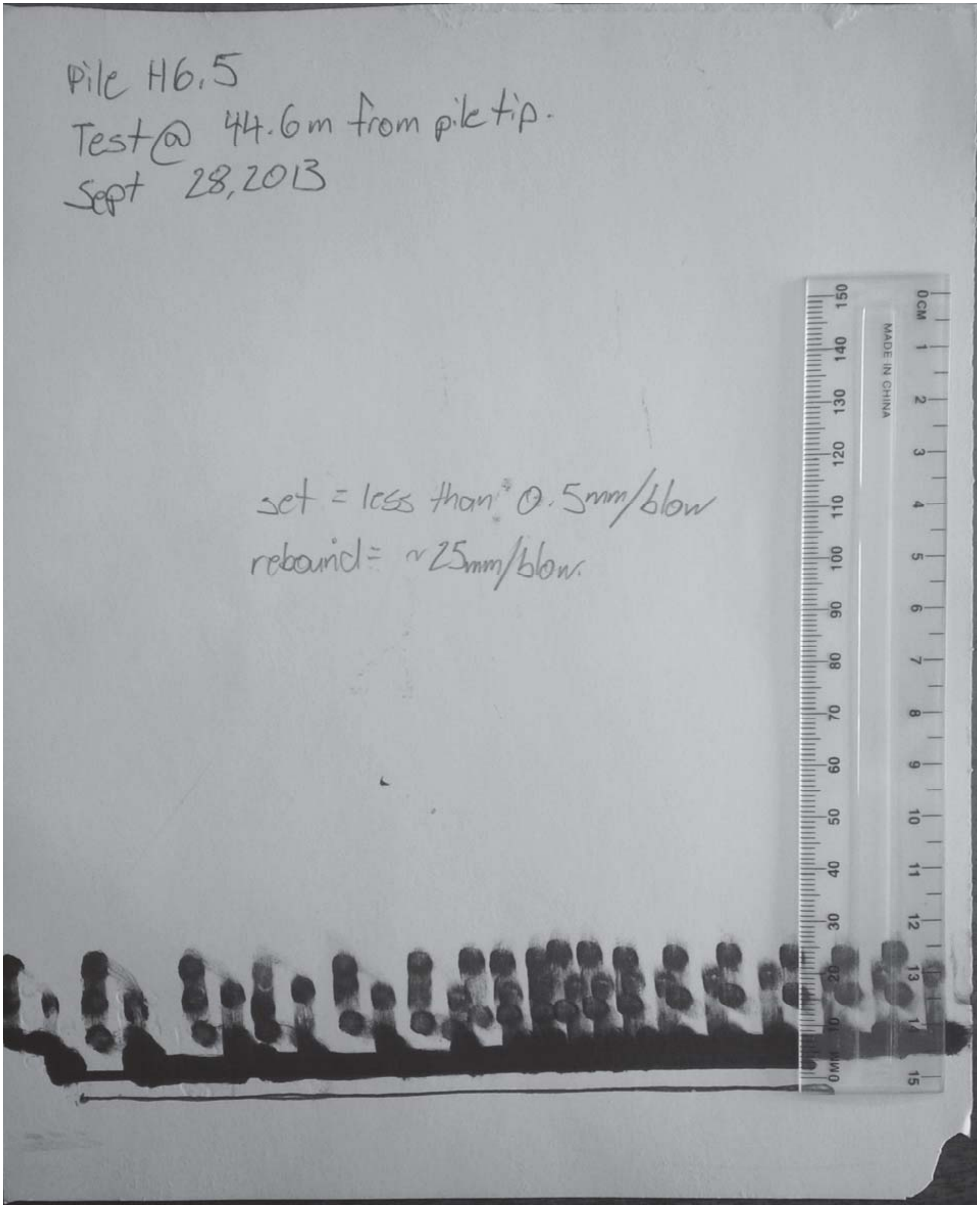
42.2	15	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	15	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	15	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	18	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	19	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	19	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	22	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	27	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	26	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	29	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	38	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	71	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	Set	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8		**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0		**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2		**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4		**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6		**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8		**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

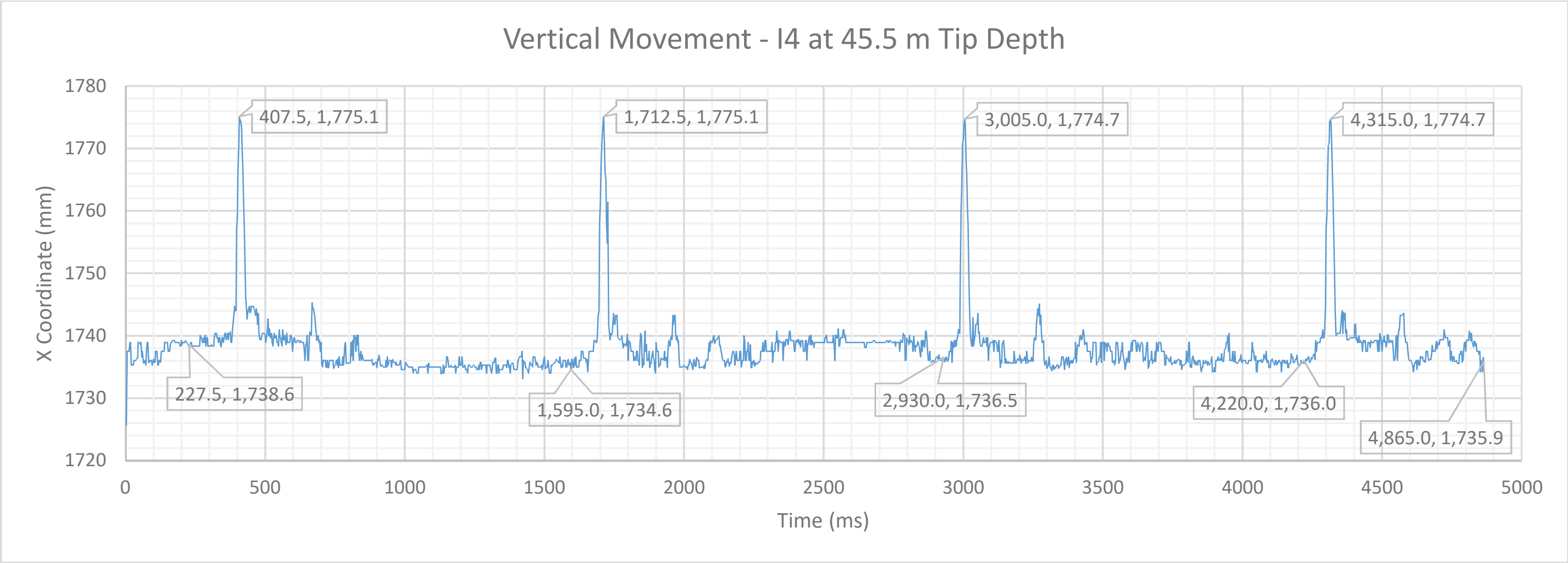
ADDITONAL NOTES/OBSERVATIONS

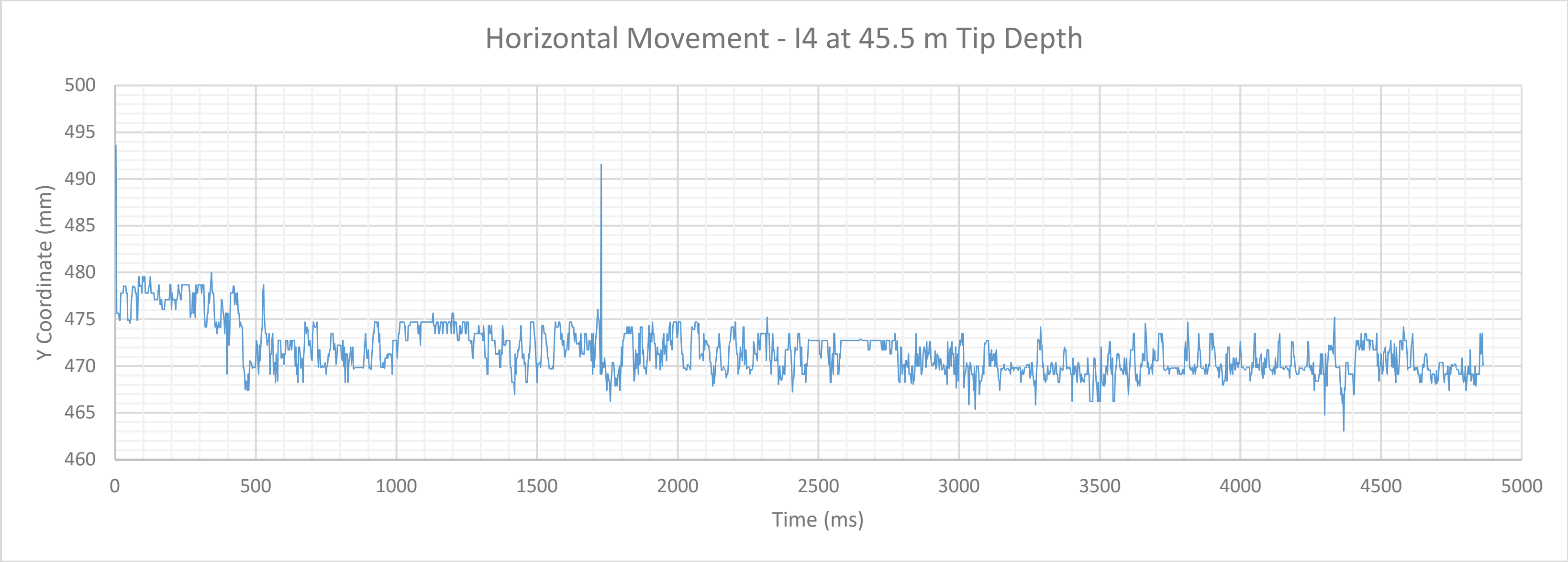
IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
11 to 30	52 to 46	Hammer Setting 3
30 to 41	45 to 43	Hammer Setting 3
41 to 44.2	47 to 43	Hammer Setting 3
44.2	43	Hammer Setting 2 then 1

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 139.8 m. The final set was 0.46 mm/blow.


Pile H6.5
Test @ 44.6m from pile tip.
Sept 28, 2013
set = less than 0.5mm/blow
rebound = ~25mm/blow
MADE IN CHINA


Vertical Movement - I4 at 45.5 m Tip Depth
X Coordinate (mm)
Time (ms)
407.5, 1,775.1
1,712.5, 1,775.1
3,005.0, 1,774.7
4,315.0, 1,774.7
227.5, 1,738.6
1,595.0, 1,734.6
2,930.0, 1,736.5
4,220.0, 1,736.0
4,865.0, 1,735.9


Horizontal Movement - I4 at 45.5 m Tip Depth
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. I-4 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** Vertical **Total Length (m):** 45.2 **Mass (kg):** 6006

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	14.2	0.0	21.2	0.0	21.2	11.1	
Start Time:	15:44	16:55	18:36	8:10	9:55		
End Time:	15:51	17:45	18:47	9:10	10:21		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 139.0 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	5	**12.2**	7	**18.2**	4	**24.2**	5	**30.2**	6	**36.2**	17
0.4		**6.4**	6	**12.4**	7	**18.4**	4	**24.4**	5	**30.4**	7	**36.4**	13
0.6		**6.6**	5	**12.6**	3	**18.6**	4	**24.6**	5	**30.6**	7	**36.6**	14
0.8		**6.8**	7	**12.8**	3	**18.8**	4	**24.8**	5	**30.8**	8	**36.8**	15
1.0		**7.0**	5	**13.0**	3	**19.0**	4	**25.0**	5	**31.0**	8	**37.0**	14
1.2		**7.2**	7	**13.2**	3	**19.2**	4	**25.2**	5	**31.2**	7	**37.2**	12
1.4		**7.4**	6	**13.4**	3	**19.4**	4	**25.4**	5	**31.4**	7	**37.4**	11
1.6	4	**7.6**	6	**13.6**	3	**19.6**	4	**25.6**	5	**31.6**	7	**37.6**	11
1.8	4	**7.8**	7	**13.8**	3	**19.8**	3	**25.8**	5	**31.8**	7	**37.8**	11
2.0	4	**8.0**	6	**14.0**	4	**20.0**	3	**26.0**	5	**32.0**	7	**38.0**	9
2.2	4	**8.2**	6	**14.2**	4	**20.2**	3	**26.2**	6	**32.2**	10	**38.2**	10
2.4	5	**8.4**	6	**14.4**	3	**20.4**	4	**26.4**	6	**32.4**	9	**38.4**	10
2.6	3	**8.6**	6	**14.6**	3	**20.6**	3	**26.6**	6	**32.6**	9	**38.6**	9
2.8	5	**8.8**	6	**14.8**	3	**20.8**	4	**26.8**	5	**32.8**	9	**38.8**	11
3.0	5	**9.0**	5	**15.0**	3	**21.0**	4	**27.0**	5	**33.0**	11	**39.0**	9
3.2	4	**9.2**	5	**15.2**	4	**21.2**	4	**27.2**	5	**33.2**	9	**39.2**	11
3.4	5	**9.4**	7	**15.4**	4	**21.4**	4	**27.4**	5	**33.4**	8	**39.4**	10
3.6	3	**9.6**	6	**15.6**	5	**21.6**	4	**27.6**	5	**33.6**	8	**39.6**	10
3.8	5	**9.8**	6	**15.8**	3	**21.8**	4	**27.8**	6	**33.8**	8	**39.8**	10
4.0	3	**10.0**	6	**16.0**	3	**22.0**	4	**28.0**	6	**34.0**	7	**40.0**	10
4.2	4	**10.2**	6	**16.2**	4	**22.2**	5	**28.2**	5	**34.2**	7	**40.2**	10
4.4	5	**10.4**	7	**16.4**	4	**22.4**	5	**28.4**	5	**34.4**	9	**40.4**	9
4.6	4	**10.6**	6	**16.6**	4	**22.6**	4	**28.6**	5	**34.6**	10	**40.6**	10
4.8	3	**10.8**	6	**16.8**	4	**22.8**	4	**28.8**	4	**34.8**	10	**40.8**	10
5.0	5	**11.0**	5	**17.0**	4	**23.0**	4	**29.0**	5	**35.0**	9	**41.0**	10
5.2	4	**11.2**	5	**17.2**	4	**23.2**	5	**29.2**	6	**35.2**	13	**41.2**	11
5.4	4	**11.4**	4	**17.4**	3	**23.4**	4	**29.4**	6	**35.4**	13	**41.4**	14
5.6	4	**11.6**	8	**17.6**	4	**23.6**	4	**29.6**	6	**35.6**	15	**41.6**	14
5.8	4	**11.8**	8	**17.8**	4	**23.8**	4	**29.8**	6	**35.8**	14	**41.8**	17
6.0	5	**12.0**	4	**18.0**	4	**24.0**	4	**30.0**	6	**36.0**	14	**42.0**	15

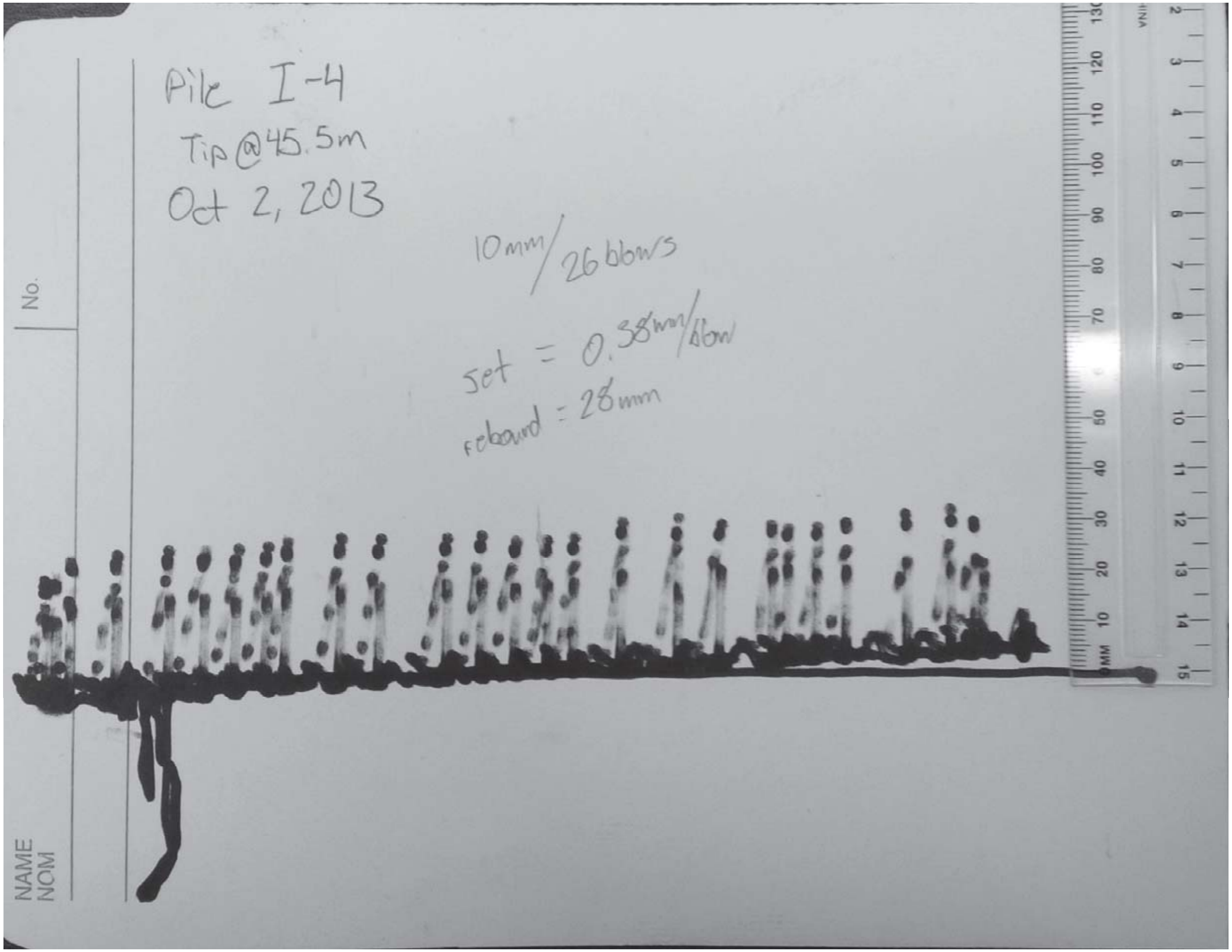
42.2	17	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	16	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	17	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	17	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	15	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	17	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	16	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	20	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	19	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	18	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	18	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	15	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	19	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	24	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	44	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	48	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	70	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	Set	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8		**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

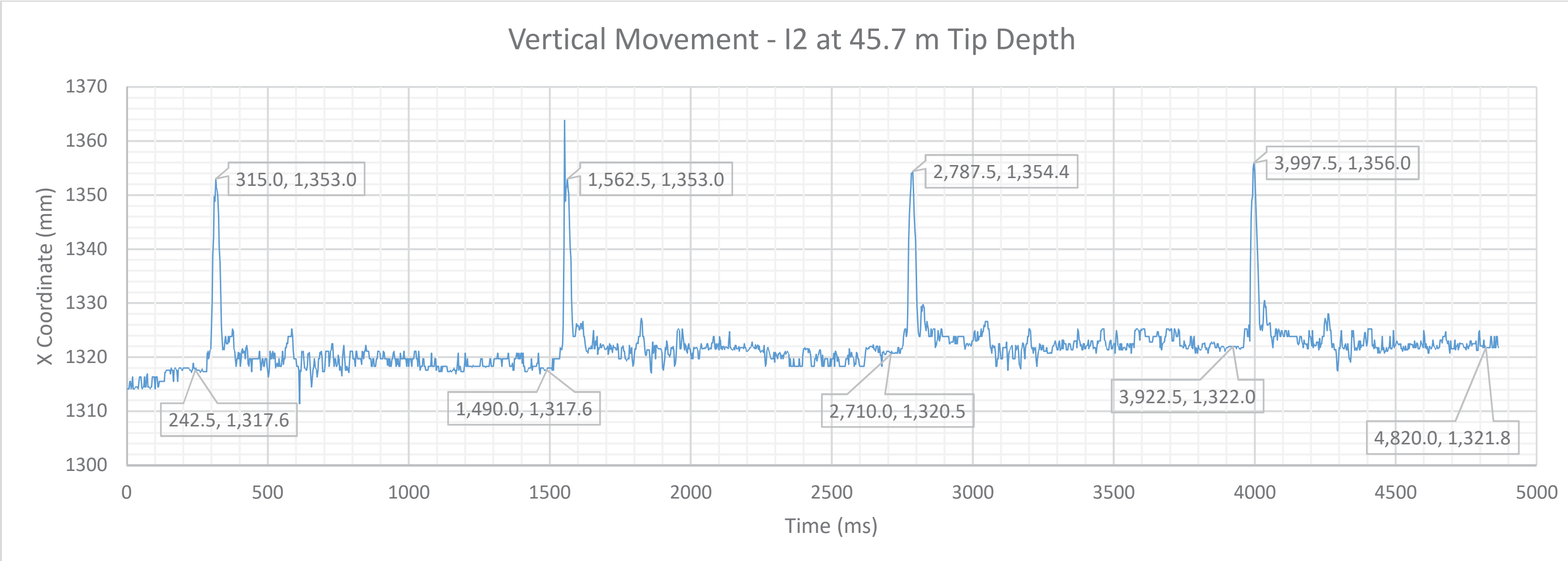
ADDITONAL NOTES/OBSERVATIONS

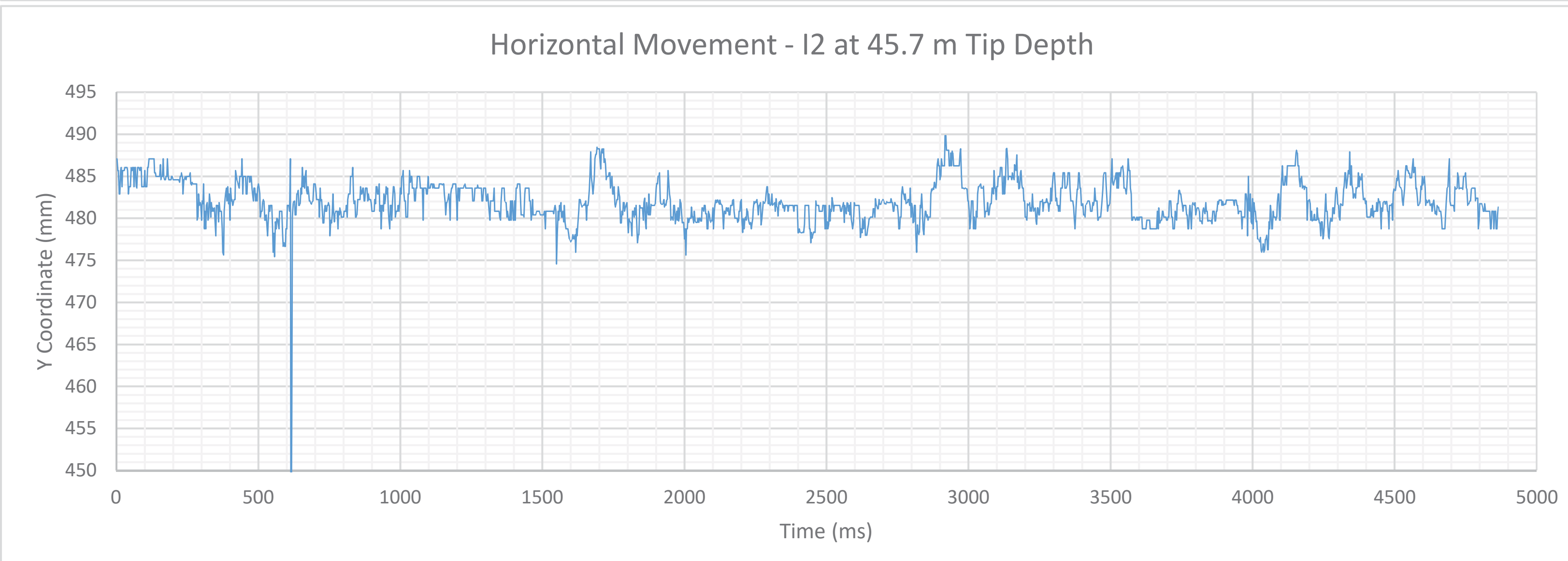
IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
16 - 24	49 to 48	Hammer Setting 4
24 - 30	45 to 46	Hammer Setting 4
30 - 35	41 to 43	Hammer Setting 4
35 - 44.8	48 to 44	Hammer Setting 3
44.8-45.4	42 to 43	Hammer Setting 2
45.4 - 45.6	46	Hammer Setting 1

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 139 m. The final set was 0.5 mm/blow.


Pile I-4
Tip @ 45.5m
Oct 2, 2013
10mm/26 blows
set = 0.38mm/blow
rebound = 28mm
No.
NAME
NOM


Vertical Movement - I2 at 45.7 m Tip Depth
X Coordinate (mm)
Time (ms)
315.0, 1,353.0
1,562.5, 1,353.0
2,787.5, 1,354.4
3,997.5, 1,356.0
242.5, 1,317.6
1,490.0, 1,317.6
2,710.0, 1,320.5
3,922.5, 1,322.0
4,820.0, 1,321.8


Horizontal Movement - I2 at 45.7 m Tip Depth
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. I-2 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** Vertical **Total Length (m):** 45.6 **Mass (kg):** 6058.8

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.5	0.0	21.2	1.0	21.2	17.0	
Start Time:	9:00	9:40	10:55	12:15	13:15		
End Time:	9:18	10:48	11:12	13:10	13:30		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.6 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	4	**12.2**	7	**18.2**	5	**24.2**	5	**30.2**	5	**36.2**	8
0.4		**6.4**	6	**12.4**	5	**18.4**	5	**24.4**	6	**30.4**	7	**36.4**	8
0.6		**6.6**	7	**12.6**	5	**18.6**	5	**24.6**	6	**30.6**	9	**36.6**	8
0.8		**6.8**	8	**12.8**	5	**18.8**	6	**24.8**	5	**30.8**	8	**36.8**	8
1.0		**7.0**	7	**13.0**	4	**19.0**	5	**25.0**	7	**31.0**	9	**37.0**	8
1.2		**7.2**	9	**13.2**	5	**19.2**	4	**25.2**	6	**31.2**	7	**37.2**	9
1.4		**7.4**	8	**13.4**	5	**19.4**	5	**25.4**	5	**31.4**	9	**37.4**	9
1.6		**7.6**	7	**13.6**	5	**19.6**	4	**25.6**	6	**31.6**	9	**37.6**	7
1.8	↓	**7.8**	10	**13.8**	5	**19.8**	4	**25.8**	5	**31.8**	8	**37.8**	9
2.0	13	**8.0**	8	**14.0**	5	**20.0**	4	**26.0**	6	**32.0**	7	**38.0**	8
2.2	4	**8.2**	9	**14.2**	5	**20.2**	4	**26.2**	5	**32.2**	8	**38.2**	9
2.4	4	**8.4**	9	**14.4**	8	**20.4**		**26.4**	6	**32.4**	9	**38.4**	7
2.6	4	**8.6**	13	**14.6**	5	**20.6**		**26.6**	6	**32.6**	8	**38.6**	8
2.8	4	**8.8**	12	**14.8**	5	**20.8**		**26.8**	6	**32.8**	10	**38.8**	8
3.0	3	**9.0**	13	**15.0**	5	**21.0**		**27.0**	6	**33.0**	9	**39.0**	8
3.2	5	**9.2**	16	**15.2**	5	**21.2**		**27.2**	6	**33.2**	8	**39.2**	8
3.4	4	**9.4**	17	**15.4**	5	**21.4**		**27.4**	6	**33.4**	9	**39.4**	7
3.6	4	**9.6**	12	**15.6**	4	**21.6**		**27.6**	6	**33.6**	7	**39.6**	7
3.8	3	**9.8**	15	**15.8**	5	**21.8**	↓	**27.8**	6	**33.8**	8	**39.8**	8
4.0	4	**10.0**	8	**16.0**	5	**22.0**	14	**28.0**	7	**34.0**	8	**40.0**	8
4.2	4	**10.2**	9	**16.2**	6	**22.2**	5	**28.2**	7	**34.2**	8	**40.2**	7
4.4	3	**10.4**	8	**16.4**	6	**22.4**	6	**28.4**	6	**34.4**	7	**40.4**	7
4.6		**10.6**	7	**16.6**	6	**22.6**	6	**28.6**	7	**34.6**	8	**40.6**	5
4.8		**10.8**	7	**16.8**	5	**22.8**	5	**28.8**	6	**34.8**	6	**40.8**	10
5.0		**11.0**	6	**17.0**	5	**23.0**	6	**29.0**	7	**35.0**	7	**41.0**	11
5.2	↓	**11.2**	6	**17.2**	5	**23.2**	6	**29.2**	6	**35.2**	8	**41.2**	11
5.4	IR	**11.4**	8	**17.4**	6	**23.4**	6	**29.4**	7	**35.4**	8	**41.4**	8
5.6		**11.6**	7	**17.6**	5	**23.6**	6	**29.6**	6	**35.6**	8	**41.6**	8
5.8	↓	**11.8**	7	**17.8**	5	**23.8**	5	**29.8**	7	**35.8**	9	**41.8**	12
6.0	15	**12.0**	6	**18.0**	4	**24.0**	5	**30.0**	7	**36.0**	8	**42.0**	12

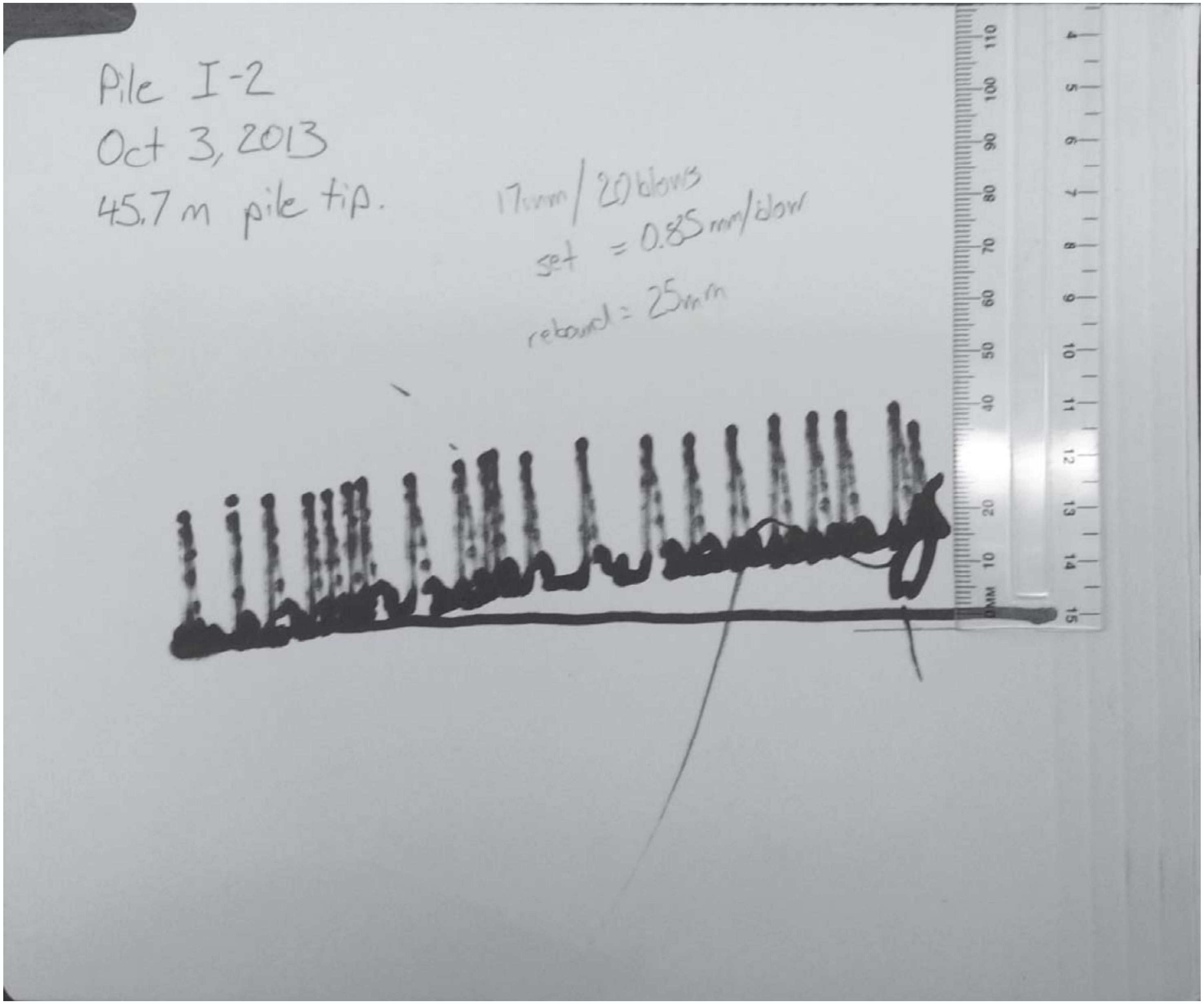
42.2	12	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	14	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	14	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	14	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	14	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	19	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	17	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	17	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	15	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	16	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	16	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	19	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	18	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	21	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	18	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	23	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	32	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	50	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	Set	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

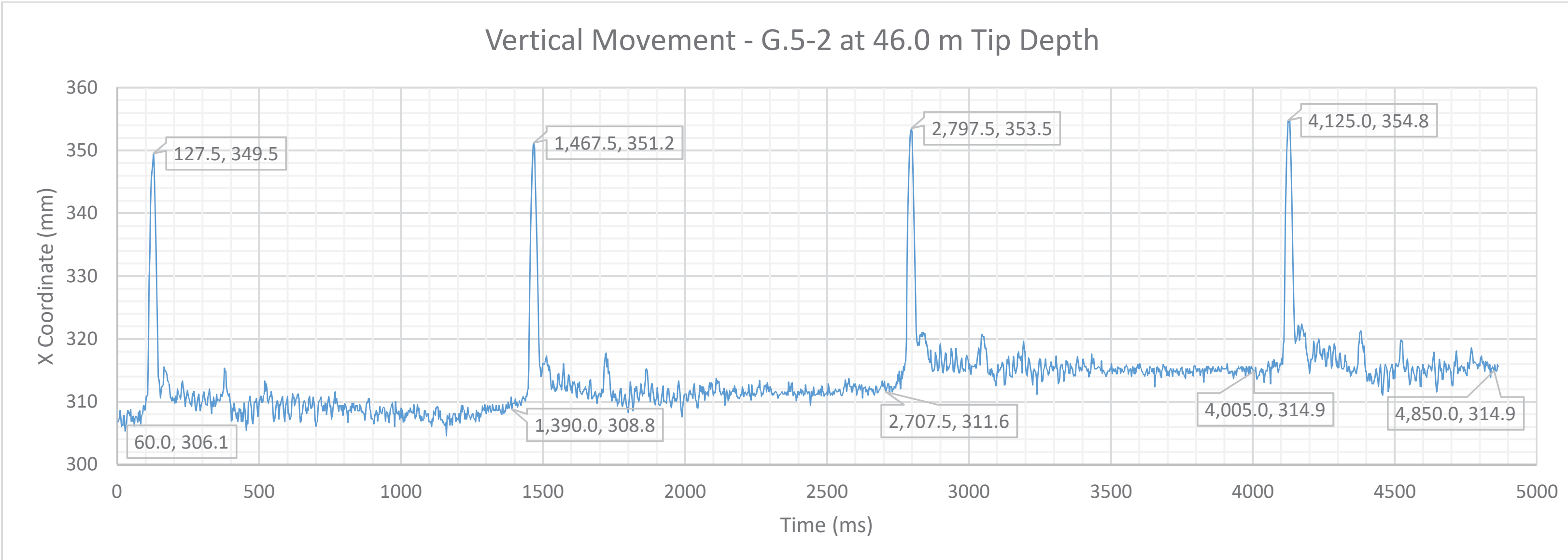
ADDITONAL NOTES/OBSERVATIONS

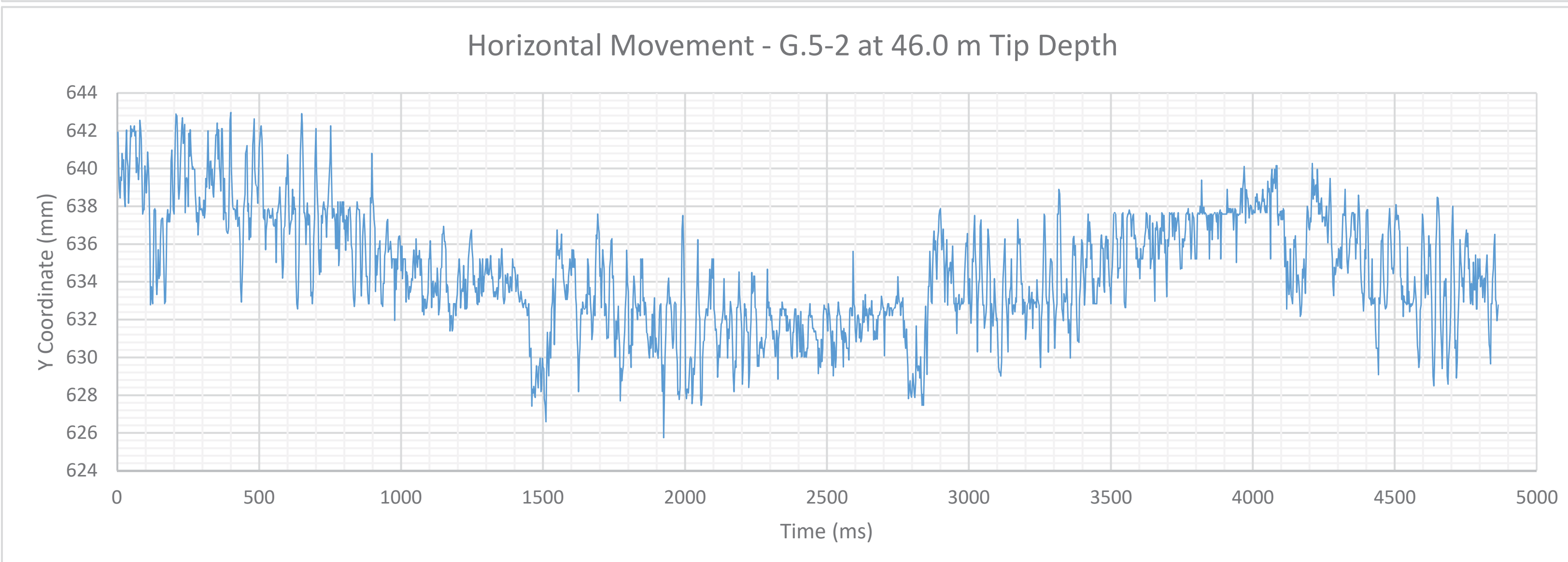
IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
6 - 18	44 to 47	Hammer Setting 3
18 - 30	43 to 45	Hammer Setting 4
30 - 42.2	42 to 43	Hammer Setting 4
42.2 - 45.8	47 to 42	Hammer Setting 3
45.8 - 46	42, 47	Hammer Setting 2 then 1

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.6 m. The final set was 1.11 mm/blow.


Pile I-2
Oct 3, 2013
45.7 m pile tip.
17mm / 20 blows
set = 0.85 mm/blow
rebound = 25mm


Vertical Movement - G.5-2 at 46.0 m Tip Depth
X Coordinate (mm)
Time (ms)
127.5, 349.5
1,467.5, 351.2
2,797.5, 353.5
4,125.0, 354.8
60.0, 306.1
1,390.0, 308.8
2,707.5, 311.6
4,005.0, 314.9
4,850.0, 314.9


Horizontal Movement - G.5-2 at 46.0 m Tip Depth
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION					
Type: Diesel		**Model:** D46-32		**Make:** Delmag	
Hammer Weight (kg): 4600		**Fall (m):** 1.42 to 3.5		**Mass of Helmet (kg):** ~908	
Rated Energy (kJ Range): 71 to 166		**Hammer Cushion:** Yes			
Other Notes:					

PILE DETAILS

Pile No. G.5-2 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** 1:10 **Total Length (m):** 45.9 **Mass (kg):** 6098.4

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	16.7	0.0	21.2	0.0	21.2	12.9	
Start Time:	14:55	15:45	16:40	17:15	17:55		
End Time:	15:15	16:35	17:00	17:50	8:02		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.3 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**	4	**18.2**	5	**24.2**	8	**30.2**	7	**36.2**	7
0.4		**6.4**	↓	**12.4**	4	**18.4**	5	**24.4**	7	**30.4**	8	**36.4**	8
0.6		**6.6**	14	**12.6**	4	**18.6**	5	**24.6**	6	**30.6**	9	**36.6**	10
0.8		**6.8**	5	**12.8**	4	**18.8**	6	**24.8**	6	**30.8**	10	**36.8**	12
1.0		**7.0**	6	**13.0**	4	**19.0**	6	**25.0**	8	**31.0**	10	**37.0**	10
1.2		**7.2**	6	**13.2**	3	**19.2**	5	**25.2**	8	**31.2**	11	**37.2**	8
1.4	↓	**7.4**	6	**13.4**	4	**19.4**	7	**25.4**	6	**31.4**	9	**37.4**	9
1.6	18	**7.6**	5	**13.6**	3	**19.6**	6	**25.6**	6	**31.6**	8	**37.6**	10
1.8	4	**7.8**	6	**13.8**	4	**19.8**	5	**25.8**	7	**31.8**	7	**37.8**	9
2.0	5	**8.0**	5	**14.0**	5	**20.0**	4	**26.0**	7	**32.0**	10	**38.0**	10
2.2	4	**8.2**	4	**14.2**	3	**20.2**	5	**26.2**	6	**32.2**	10	**38.2**	11
2.4	3	**8.4**	3	**14.4**	4	**20.4**	5	**26.4**	6	**32.4**	10	**38.4**	10
2.6	4	**8.6**	6	**14.6**	4	**20.6**	5	**26.6**	6	**32.6**	11	**38.6**	11
2.8	3	**8.8**	6	**14.8**		**20.8**	4	**26.8**	6	**32.8**	11	**38.8**	10
3.0	3	**9.0**	9	**15.0**		**21.0**	5	**27.0**	5	**33.0**	10	**39.0**	10
3.2		**9.2**	7	**15.2**		**21.2**	5	**27.2**	7	**33.2**	15	**39.2**	12
3.4		**9.4**	7	**15.4**		**21.4**	5	**27.4**	5	**33.4**	7	**39.4**	12
3.6		**9.6**	6	**15.6**		**21.6**	5	**27.6**	6	**33.6**	7	**39.6**	12
3.8		**9.8**	6	**15.8**		**21.8**	6	**27.8**	6	**33.8**	5	**39.8**	16
4.0		**10.0**	6	**16.0**		**22.0**	5	**28.0**	6	**34.0**	5	**40.0**	19
4.2		**10.2**	7	**16.2**		**22.2**	5	**28.2**	6	**34.2**	5	**40.2**	19
4.4		**10.4**	5	**16.4**		**22.4**	6	**28.4**	7	**34.4**	6	**40.4**	20
4.6		**10.6**	6	**16.6**	↓	**22.6**	6	**28.6**	6	**34.6**	7	**40.6**	19
4.8		**10.8**	4	**16.8**	IR	**22.8**	6	**28.8**	5	**34.8**	7	**40.8**	16
5.0		**11.0**	5	**17.0**	5	**23.0**	6	**29.0**	7	**35.0**	7	**41.0**	8
5.2		**11.2**	8	**17.2**		**23.2**	6	**29.2**	6	**35.2**	7	**41.2**	8
5.4		**11.4**	4	**17.4**		**23.4**	6	**29.4**	6	**35.4**	7	**41.4**	24
5.6		**11.6**	4	**17.6**		**23.6**	6	**29.6**	6	**35.6**	7	**41.6**	21
5.8	↓	**11.8**	3	**17.8**	↓	**23.8**	5	**29.8**	7	**35.8**	7	**41.8**	20
6.0	IR	**12.0**	4	**18.0**	30	**24.0**	6	**30.0**	5	**36.0**	8	**42.0**	16

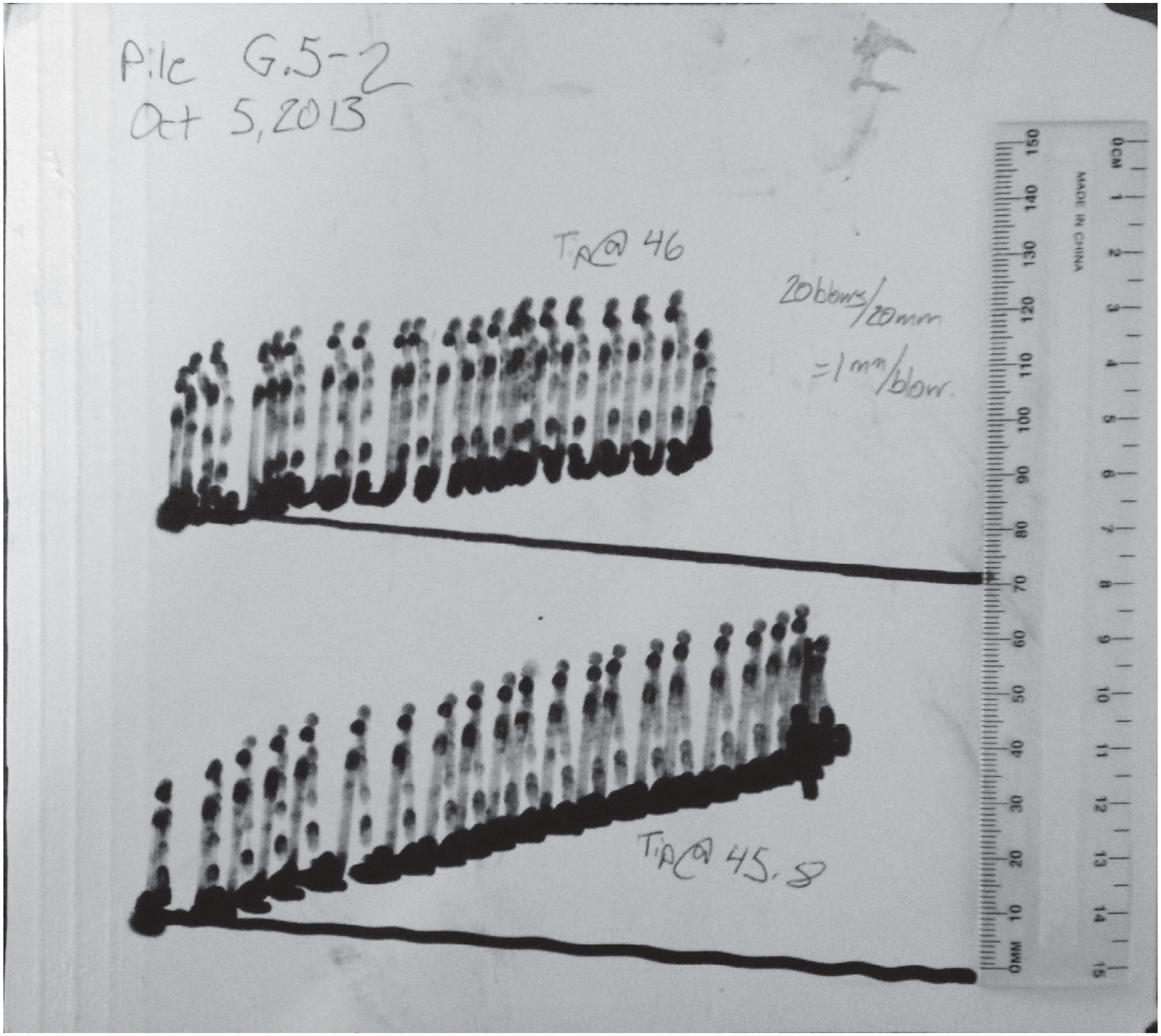
42.2	16	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	16	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	18	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	17	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	18	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	15	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	14	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	14	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	14	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	17	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	17	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	17	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	21	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	24	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	23	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	29	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	29	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	71	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	Set	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

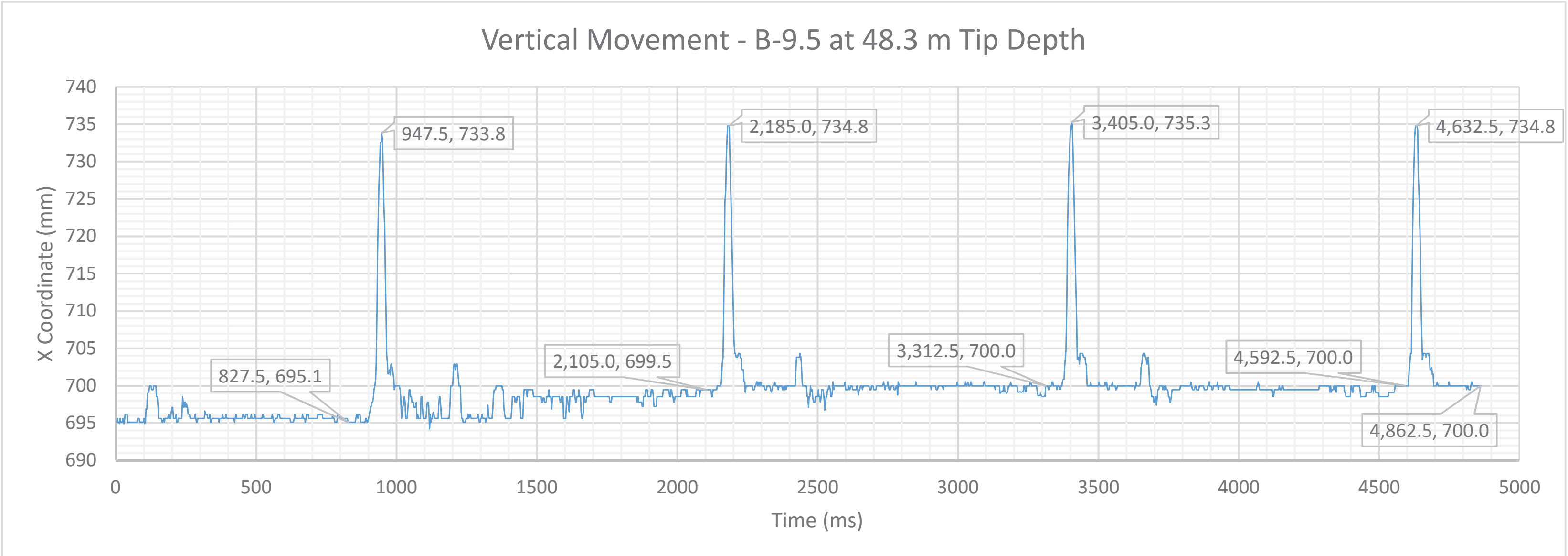
ADDITONAL NOTES/OBSERVATIONS

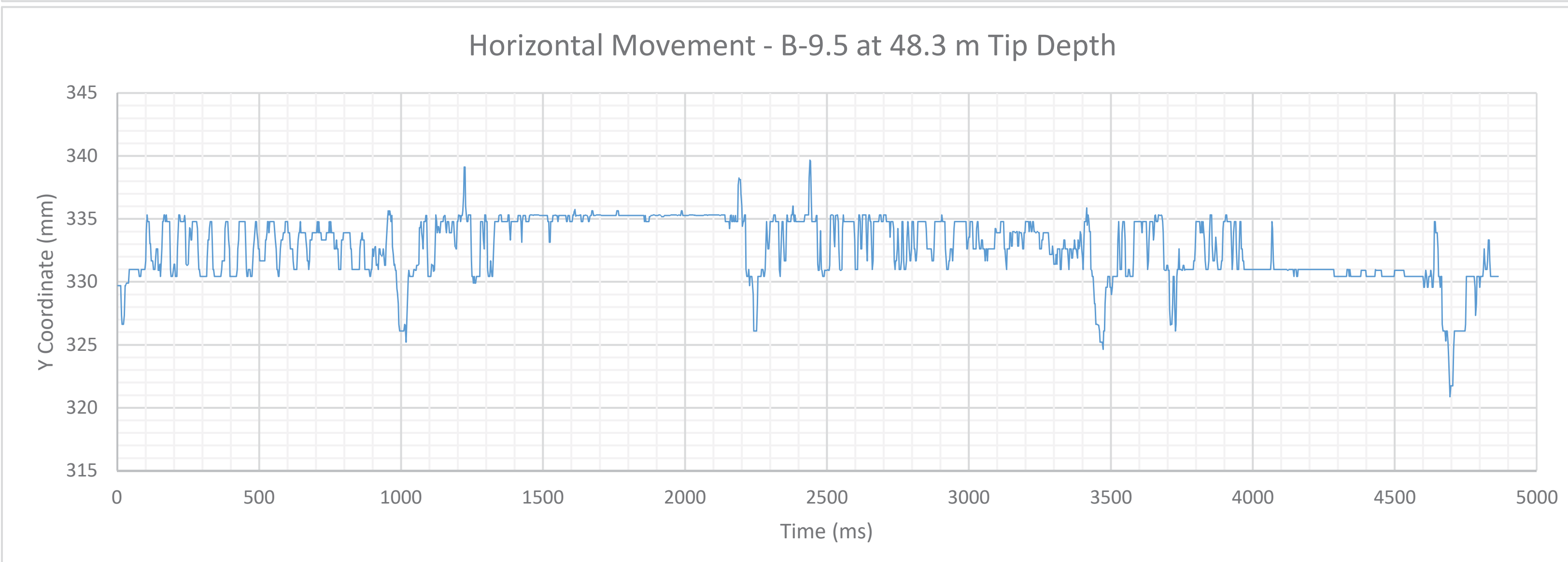
IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
7 to 14	46 to 49	Hammer Setting 4
18 to 30	44 to 46	Hammer Setting 3
30 to 39	41 to 44	Hammer Setting 3
39 to 43.4	46 to 50	Hammer Setting 3
43.4 - 45.8	41 to 44	Hammer Setting 3
45.8	43 to 44	Hammer Setting 2, then 1

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.3 m. The final set was 1.11 mm/blow.


Pile G.5-2
Oct 5, 2013
Tip @ 46
20 blows/20mm
=1mm/blow.
Tip @ 45.8
MADE IN CHINA


Vertical Movement - B-9.5 at 48.3 m Tip Depth
X Coordinate (mm)
Time (ms)
947.5, 733.8
2,185.0, 734.8
3,405.0, 735.3
4,632.5, 734.8
827.5, 695.1
2,105.0, 699.5
3,312.5, 700.0
4,592.5, 700.0
4,862.5, 700.0


Horizontal Movement - B-9.5 at 48.3 m Tip Depth
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. B-9.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** 1:10 **Total Length (m):** 48.0 **Mass (kg):** 6375.6

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.4	0.0	21.2	0.0	21.2	15.5	
Start Time:	9:45	10:15	11:10	11:40	12:25		
End Time:	9:56	11:05	11:30	12:20	12:45		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 136.2 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**	5	**18.2**	3	**24.2**	5	**30.2**	7	**36.2**	8
0.4		**6.4**		**12.4**	4	**18.4**	5	**24.4**	5	**30.4**	6	**36.4**	8
0.6		**6.6**		**12.6**	4	**18.6**	4	**24.6**	7	**30.6**	6	**36.6**	8
0.8		**6.8**	↓	**12.8**	4	**18.8**	4	**24.8**	7	**30.8**	8	**36.8**	10
1.0		**7.0**	14	**13.0**	4	**19.0**	4	**25.0**	7	**31.0**	8	**37.0**	9
1.2		**7.2**		**13.2**	5	**19.2**	4	**25.2**	6	**31.2**	9	**37.2**	8
1.4		**7.4**		**13.4**	4	**19.4**	5	**25.4**	7	**31.4**	8	**37.4**	10
1.6		**7.6**		**13.6**	6	**19.6**	5	**25.6**	7	**31.6**	9	**37.6**	9
1.8	↓	**7.8**	↓	**13.8**	8	**19.8**	5	**25.8**	7	**31.8**	9	**37.8**	9
2.0	2	**8.0**	17	**14.0**	6	**20.0**	4	**26.0**	6	**32.0**	7	**38.0**	9
2.2		**8.2**		**14.2**	7	**20.2**		**26.2**	7	**32.2**	8	**38.2**	8
2.4		**8.4**		**14.4**	6	**20.4**		**26.4**	7	**32.4**	9	**38.4**	9
2.6		**8.6**		**14.6**	7	**20.6**		**26.6**	7	**32.6**	8	**38.6**	9
2.8	↓	**8.8**	↓	**14.8**	5	**20.8**		**26.8**	7	**32.8**	7	**38.8**	9
3.0	8	**9.0**	17	**15.0**	5	**21.0**		**27.0**	7	**33.0**	7	**39.0**	8
3.2		**9.2**		**15.2**	8	**21.2**		**27.2**	7	**33.2**	7	**39.2**	9
3.4		**9.4**		**15.4**	4	**21.4**	↓	**27.4**	6	**33.4**	10	**39.4**	9
3.6		**9.6**		**15.6**	5	**21.6**	32	**27.6**	7	**33.6**	9	**39.6**	8
3.8	↓	**9.8**	↓	**15.8**	3	**21.8**	6	**27.8**	6	**33.8**	8	**39.8**	12
4.0	5	**10.0**	16	**16.0**	4	**22.0**	6	**28.0**	7	**34.0**	10	**40.0**	11
4.2		**10.2**		**16.2**	3	**22.2**	6	**28.2**	7	**34.2**	9	**40.2**	11
4.4		**10.4**		**16.4**	4	**22.4**	6	**28.4**	6	**34.4**	8	**40.4**	13
4.6		**10.6**		**16.6**	4	**22.6**	6	**28.6**	7	**34.6**	8	**40.6**	13
4.8	↓	**10.8**	↓	**16.8**	4	**22.8**	6	**28.8**	6	**34.8**	8	**40.8**	13
5.0	5	**11.0**	18	**17.0**	4	**23.0**	7	**29.0**	7	**35.0**	9	**41.0**	11
5.2		**11.2**		**17.2**	4	**23.2**	7	**29.2**	7	**35.2**	8	**41.2**	11
5.4		**11.4**		**17.4**	5	**23.4**	7	**29.4**	7	**35.4**	8	**41.4**	13
5.6		**11.6**		**17.6**	4	**23.6**	6	**29.6**	7	**35.6**	9	**41.6**	11
5.8	↓	**11.8**	↓	**17.8**	3	**23.8**	6	**29.8**	6	**35.8**	8	**41.8**	11
6.0	6	**12.0**	18	**18.0**	5	**24.0**	5	**30.0**	6	**36.0**	9	**42.0**	11

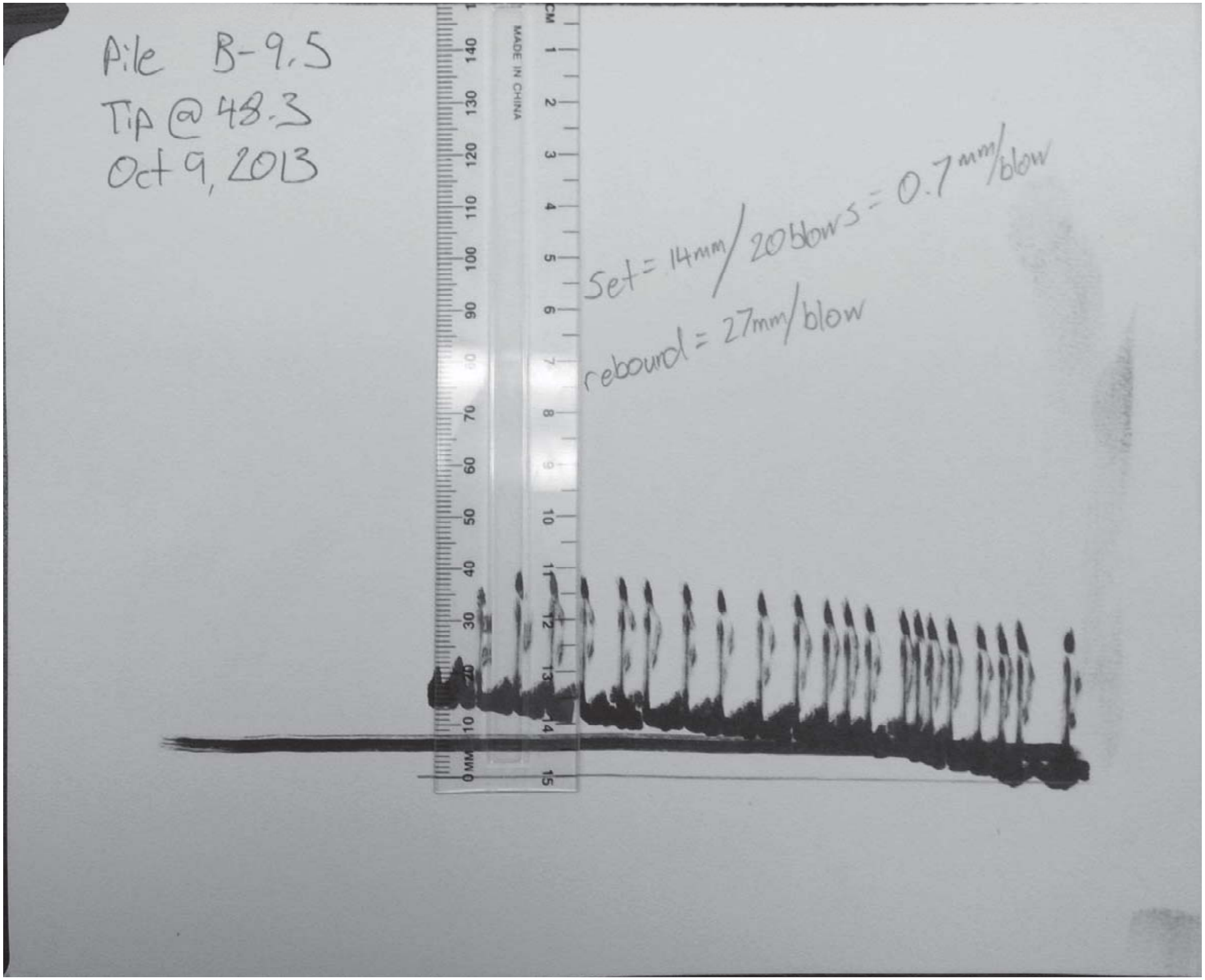
42.2	8	**48.2**	50	**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	9	**48.4**	69	**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	8	**48.6**	Set	**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	9	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	10	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	11	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	9	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	10	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	10	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	11	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	10	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	11	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	10	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	11	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	11	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	12	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	11	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	12	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	10	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	10	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	12	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	12	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6	11	**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8	18	**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0	19	**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2	23	**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4	33	**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6	34	**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8	42	**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0	41	**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

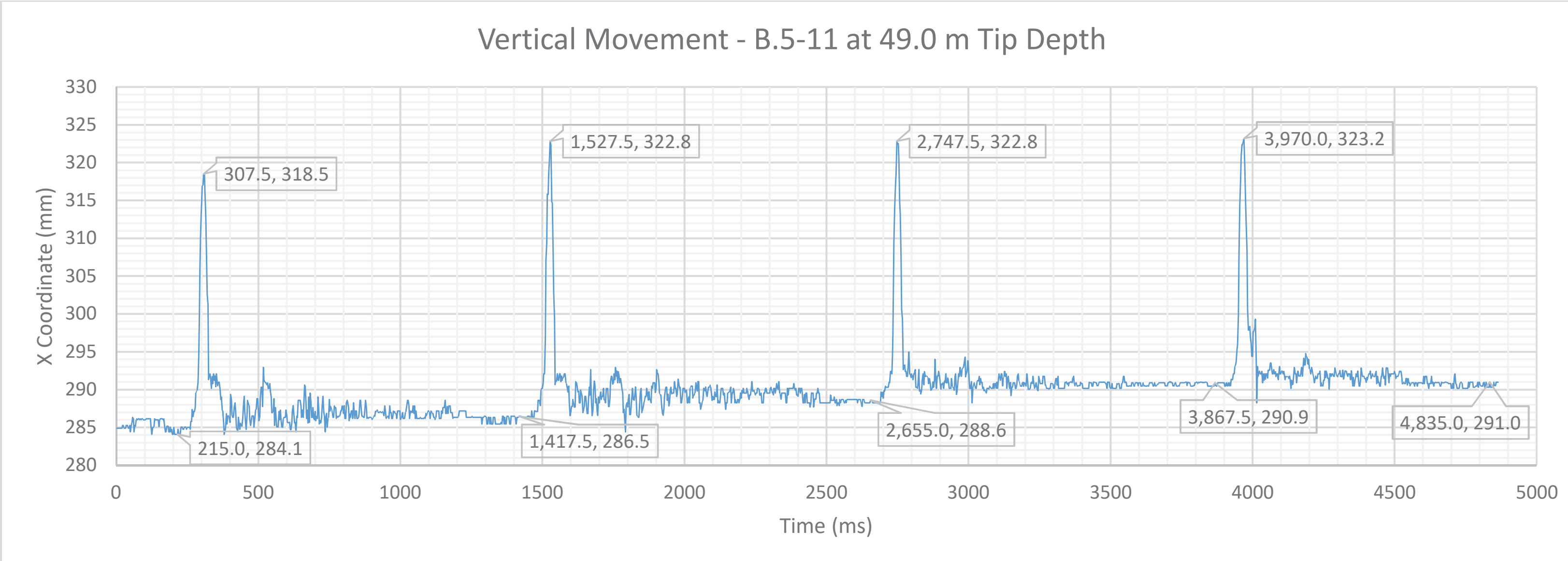
ADDITONAL NOTES/OBSERVATIONS

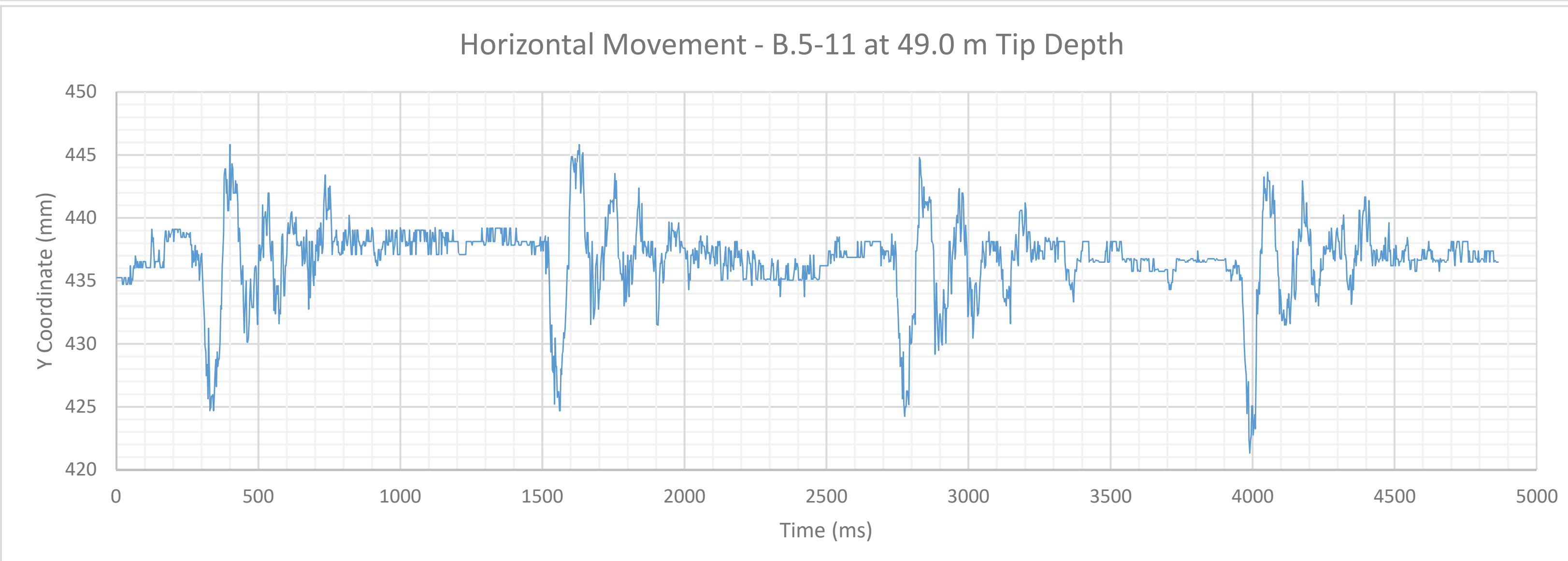
Depth (m)	**BPM**	
11 to 20	43 to 47	Hammer Setting 4
20 to 41.4	44 to 47	Hammer Setting 4
41.4 - 47.2	46 to 49	Hammer Setting 3
47.2 - 48.4	44 to 45	Hammer Setting 2

IR - Insufficient Soil Resistance for Sustained Driving

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 136.2 m. The final set was 0.98 mm/blow.


Pile B-9.5
Tip @ 48.3
Oct 9, 2013
Set = 14mm/20 blows = 0.7 mm/blow
rebound = 27mm/blow


Vertical Movement - B.5-11 at 49.0 m Tip Depth
X Coordinate (mm)
Time (ms)
307.5, 318.5
1,527.5, 322.8
2,747.5, 322.8
3,970.0, 323.2
215.0, 284.1
1,417.5, 286.5
2,655.0, 288.6
3,867.5, 290.9
4,835.0, 291.0


Horizontal Movement - B.5-11 at 49.0 m Tip Depth
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag
Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908
Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes
Other Notes:

PILE DETAILS

Pile No. B.5-11 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132
Pile Shoe: Rock Injector **Batter (H:V):** 1:10 **Total Length (m):** 48.7 **Mass (kg):** 6468

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	15.8	0.0	21.2	0.0	21.2	9.2	
Start Time:	14:05	14:20	14:55	15:40	16:20		
End Time:	14:10	14:50	15:05	16:15	16:45		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 135.5 **Cut off Elev. (m):** 184.5
Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**		**18.2**		**24.2**		**30.2**	3	**36.2**	14
0.4		**6.4**		**12.4**		**18.4**		**24.4**		**30.4**	4	**36.4**	11
0.6		**6.6**		**12.6**		**18.6**		**24.6**		**30.6**	4	**36.6**	10
0.8		**6.8**	↓	**12.8**	↓	**18.8**	↓	**24.8**	↓	**30.8**	5	**36.8**	13
1.0		**7.0**	17	**13.0**	20	**19.0**	15	**25.0**	15	**31.0**	4	**37.0**	9
1.2		**7.2**		**13.2**	5	**19.2**		**25.2**		**31.2**	5	**37.2**	6
1.4		**7.4**		**13.4**	5	**19.4**		**25.4**		**31.4**	4	**37.4**	6
1.6		**7.6**		**13.6**	6	**19.6**		**25.6**		**31.6**	5	**37.6**	6
1.8	↓	**7.8**	↓	**13.8**	5	**19.8**	↓	**25.8**	↓	**31.8**	5	**37.8**	6
2.0	4	**8.0**	18	**14.0**	4	**20.0**	16	**26.0**	16	**32.0**	4	**38.0**	6
2.2		**8.2**		**14.2**	5	**20.2**		**26.2**		**32.2**	5	**38.2**	7
2.4		**8.4**		**14.4**		**20.4**		**26.4**		**32.4**	5	**38.4**	6
2.6		**8.6**		**14.6**		**20.6**		**26.6**		**32.6**	4	**38.6**	7
2.8	↓	**8.8**	↓	**14.8**	↓	**20.8**	↓	**26.8**	↓	**32.8**	4	**38.8**	8
3.0	2	**9.0**	17	**15.0**	16	**21.0**	14	**27.0**	17	**33.0**	4	**39.0**	6
3.2		**9.2**		**15.2**		**21.2**		**27.2**		**33.2**	6	**39.2**	7
3.4		**9.4**		**15.4**		**21.4**		**27.4**		**33.4**	5	**39.4**	6
3.6		**9.6**		**15.6**		**21.6**		**27.6**		**33.6**	5	**39.6**	6
3.8	↓	**9.8**	↓	**15.8**	↓	**21.8**	↓	**27.8**	↓	**33.8**	5	**39.8**	7
4.0	4	**10.0**	15	**16.0**	16	**22.0**	13	**28.0**	16	**34.0**	5	**40.0**	6
4.2		**10.2**		**16.2**		**22.2**		**28.2**		**34.2**	5	**40.2**	6
4.4		**10.4**		**16.4**		**22.4**		**28.4**		**34.4**	3	**40.4**	7
4.6		**10.6**		**16.6**		**22.6**		**28.6**		**34.6**	5	**40.6**	6
4.8	↓	**10.8**	↓	**16.8**	↓	**22.8**	↓	**28.8**	↓	**34.8**	4	**40.8**	6
5.0	10	**11.0**	15	**17.0**	13	**23.0**	16	**29.0**	19	**35.0**	5	**41.0**	6
5.2		**11.2**		**17.2**		**23.2**		**29.2**	4	**35.2**	5	**41.2**	7
5.4		**11.4**		**17.4**		**23.4**		**29.4**	4	**35.4**	5	**41.4**	6
5.6		**11.6**		**17.6**		**23.6**		**29.6**	5	**35.6**	4	**41.6**	6
5.8	↓	**11.8**	↓	**17.8**	↓	**23.8**	↓	**29.8**	4	**35.8**	5	**41.8**	6
6.0	18	**12.0**	17	**18.0**	14	**24.0**	15	**30.0**	4	**36.0**	5	**42.0**	6

42.2	6	**48.2**	31	**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	5	**48.4**	34	**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	6	**48.6**	40	**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	6	**48.8**	58	**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	5	**49.0**	Set	**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	5	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	6	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	5	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	6	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	6	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	7	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	8	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	8	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	9	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	9	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	9	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	10	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	9	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	9	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	9	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	9	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	9	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6	11	**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8	13	**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0	12	**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2	15	**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4	16	**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6	21	**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8	29	**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0	34	**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

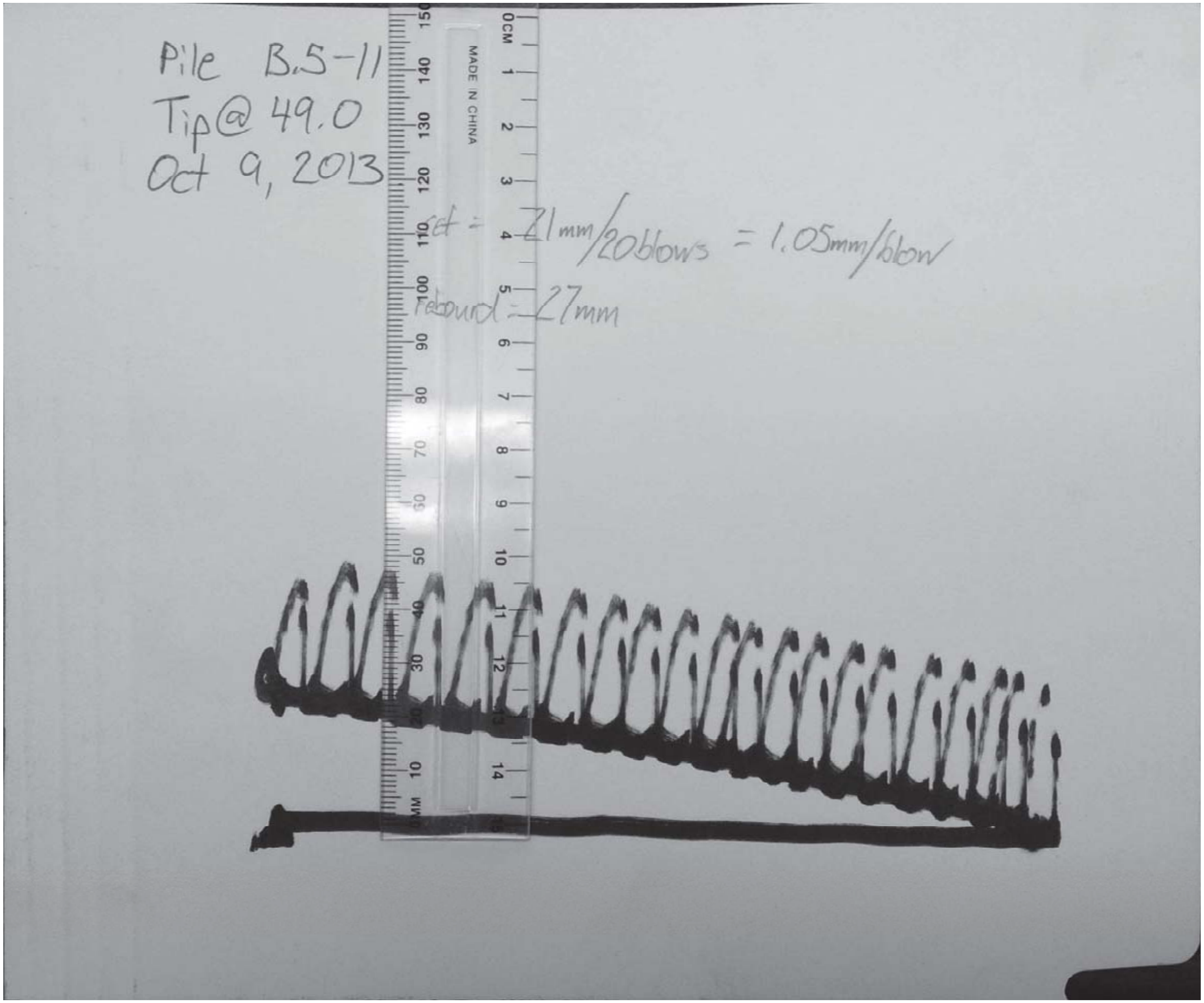
ADDITONAL NOTES/OBSERVATIONS

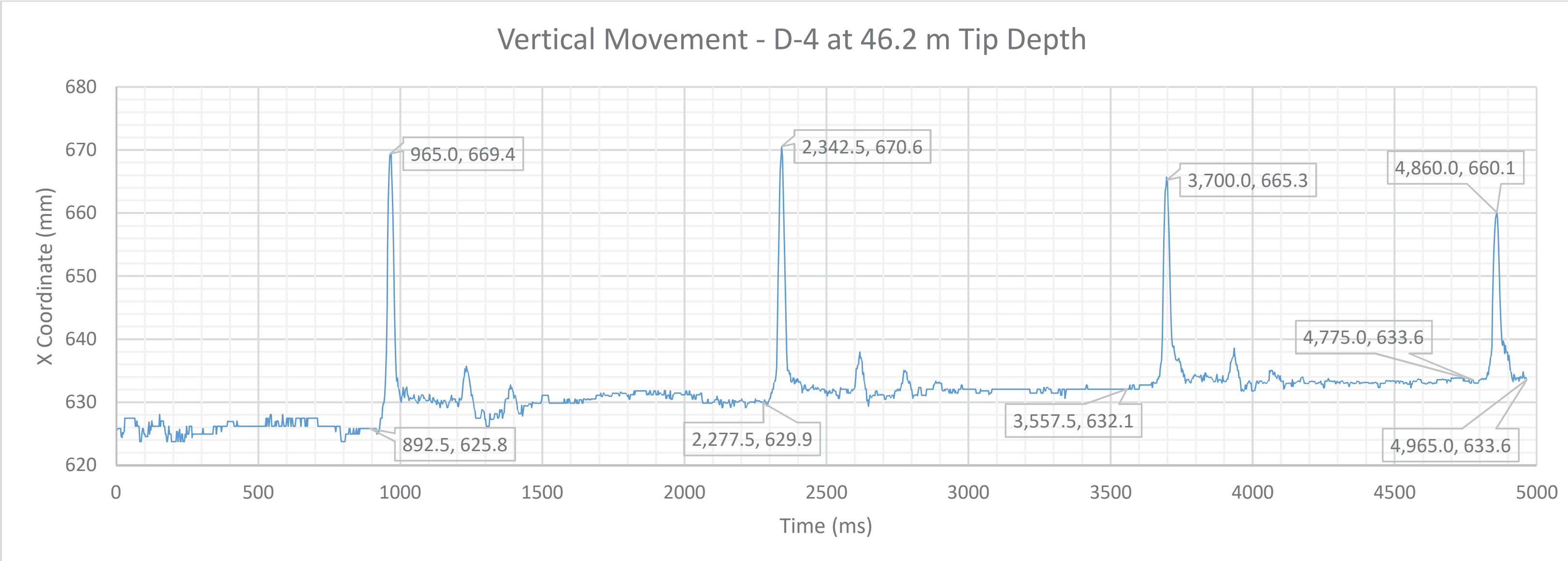
IR - Insufficient Soil Resistance for Sustained Driving

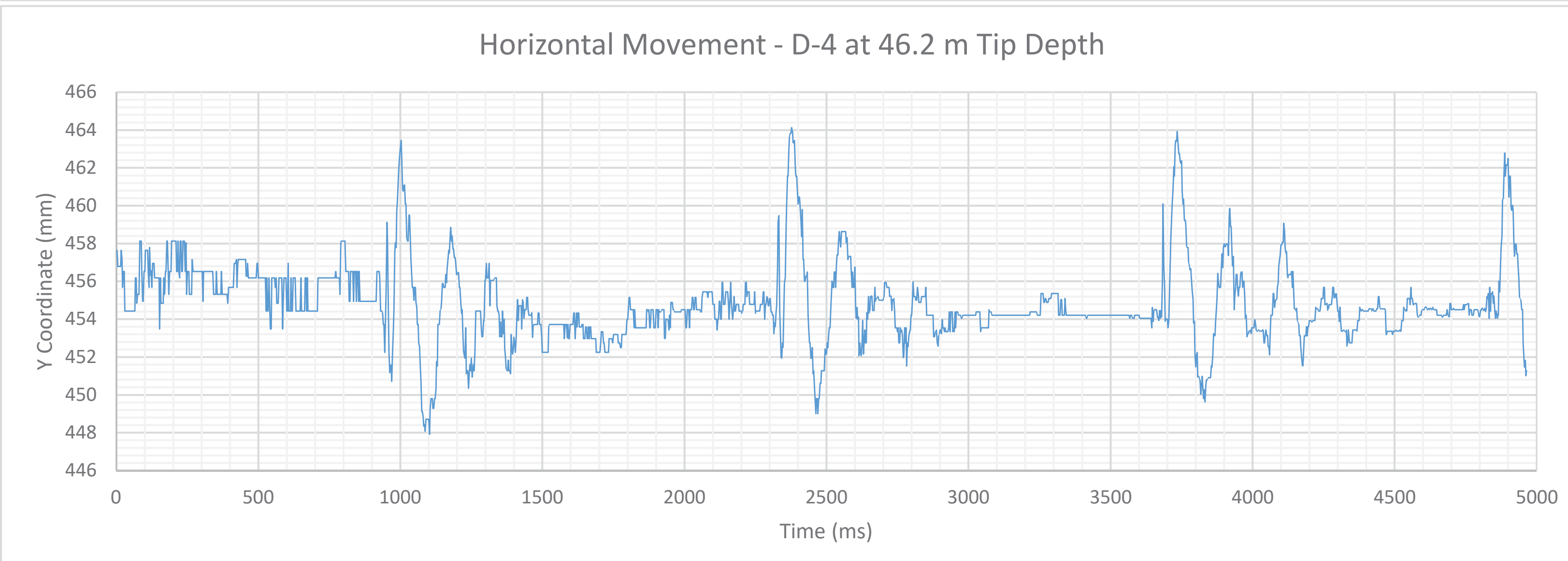
Depth (m)	**BPM**	
22 to 36.2	50 to 46	Hammer Energy 4
36.2 - 44	45 to 47	Hammer Energy 4
44 - 47.6	51 to 46	Hammer Energy 3
47.6 - 48	46 to 45	Hammer Energy 2
48 to 48.8	45 to 44	Hammer Energy 2
49 to 49.1	48	Hammer Energy 1

First and second attempt to drive pile met an obstruction at approximately 1.5 m below the ground surface. The obstruction was excavated and the pile was driven successfully.

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 135.5 m. The final set was 1.14 mm/blow.


Pile B.5-11
Tip@ 49.0
Oct 9, 2013
set = 21mm/20blows = 1.05mm/blow
Rebound = 27mm
MADE IN CHINA


Vertical Movement - D-4 at 46.2 m Tip Depth
X Coordinate (mm)
680
670
660
650
640
630
620
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Time (ms)
965.0, 669.4
892.5, 625.8
2,342.5, 670.6
2,277.5, 629.9
3,700.0, 665.3
3,557.5, 632.1
4,860.0, 660.1
4,775.0, 633.6
4,965.0, 633.6


Horizontal Movement - D-4 at 46.2 m Tip Depth
Y Coordinate (mm)
466
464
462
460
458
456
454
452
450
448
446
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Time (ms)

HAMMER INFORMATION					
Type: Diesel		**Model:** D46-32		**Make:** Delmag	
Hammer Weight (kg): 4600		**Fall (m):** 1.42 to 3.5		**Mass of Helmet (kg):** ~908	
Rated Energy (kJ Range): 71 to 166		**Hammer Cushion:** Yes			
Other Notes:					

PILE DETAILS							
Pile No. D-4		**Pile Type:** H-Pile		**Design Capacity:** 3000 kN		**Size:** 360x132	
Pile Shoe: Rock Injector		**Batter (H:V):** Vertical		**Total Length (m):** 46.0		**Mass (kg):** 6111.6	
Pile Segment	**Section 1**	**Splice 1**	**Section 2**	**Splice 2**	**Section 3**	**Splice 3**	**Section 4**
Length / Cut Off (m)	21.5	0.0	14.7	0.0	21.2	11.1	
Start Time:	10:16	11:45	12:47	15:50	16:29		
End Time:	10:25	12:40	12:57	16:20	16:43		
Set Criteria (mm/blow) <1.5 - 2		**Actual Tip Elev. (m):** 138.2		**Cut off Elev. (m):** 184.5			
Approximate Ground Elev. (m) 184.8							

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**		**18.2**		**24.2**	4	**30.2**	4	**36.2**	10
0.4		**6.4**		**12.4**		**18.4**		**24.4**	6	**30.4**	5	**36.4**	6
0.6		**6.6**		**12.6**		**18.6**		**24.6**	4	**30.6**	6	**36.6**	7
0.8	↓	**6.8**	↓	**12.8**	↓	**18.8**	↓	**24.8**	6	**30.8**	6	**36.8**	8
1.0	10	**7.0**	7	**13.0**	24	**19.0**	17	**25.0**	5	**31.0**	6	**37.0**	6
1.2		**7.2**		**13.2**		**19.2**		**25.2**	6	**31.2**	6	**37.2**	8
1.4		**7.4**		**13.4**		**19.4**		**25.4**	4	**31.4**	5	**37.4**	7
1.6		**7.6**		**13.6**		**19.6**		**25.6**	5	**31.6**	5	**37.6**	7
1.8	↓	**7.8**	↓	**13.8**	↓	**19.8**	↓	**25.8**	5	**31.8**	5	**37.8**	7
2.0	9	**8.0**	10	**14.0**	23	**20.0**	18	**26.0**	5	**32.0**	5	**38.0**	7
2.2		**8.2**		**14.2**		**20.2**		**26.2**	6	**32.2**	6	**38.2**	7
2.4		**8.4**		**14.4**		**20.4**		**26.4**	4	**32.4**	7	**38.4**	7
2.6		**8.6**		**14.6**		**20.6**		**26.6**	5	**32.6**	5	**38.6**	8
2.8	↓	**8.8**	↓	**14.8**	↓	**20.8**	↓	**26.8**	5	**32.8**	6	**38.8**	8
3.0	12	**9.0**	18	**15.0**	19	**21.0**	19	**27.0**	4	**33.0**	6	**39.0**	8
3.2		**9.2**		**15.2**		**21.2**	3	**27.2**	5	**33.2**	5	**39.2**	7
3.4		**9.4**		**15.4**		**21.4**	4	**27.4**	4	**33.4**	5	**39.4**	9
3.6		**9.6**		**15.6**		**21.6**	3	**27.6**	5	**33.6**	6	**39.6**	5
3.8	↓	**9.8**	↓	**15.8**	↓	**21.8**	4	**27.8**	4	**33.8**	5	**39.8**	8
4.0	13	**10.0**	24	**16.0**	20	**22.0**	3	**28.0**	5	**34.0**	5	**40.0**	7
4.2		**10.2**		**16.2**		**22.2**	3	**28.2**	5	**34.2**	4	**40.2**	8
4.4		**10.4**		**16.4**		**22.4**	4	**28.4**	4	**34.4**	5	**40.4**	7
4.6		**10.6**		**16.6**		**22.6**	5	**28.6**	5	**34.6**	5	**40.6**	7
4.8	↓	**10.8**	↓	**16.8**	↓	**22.8**	5	**28.8**	6	**34.8**	7	**40.8**	7
5.0	12	**11.0**	21	**17.0**	18	**23.0**	4	**29.0**	5	**35.0**	9	**41.0**	7
5.2		**11.2**		**17.2**		**23.2**	4	**29.2**	5	**35.2**	7	**41.2**	8
5.4		**11.4**		**17.4**		**23.4**	5	**29.4**	4	**35.4**	9	**41.4**	7
5.6		**11.6**		**17.6**		**23.6**	4	**29.6**	4	**35.6**	10	**41.6**	7
5.8	↓	**11.8**	↓	**17.8**	↓	**23.8**	5	**29.8**	4	**35.8**	8	**41.8**	7
6.0	10	**12.0**	16	**18.0**	17	**24.0**	4	**30.0**	5	**36.0**	8	**42.0**	7

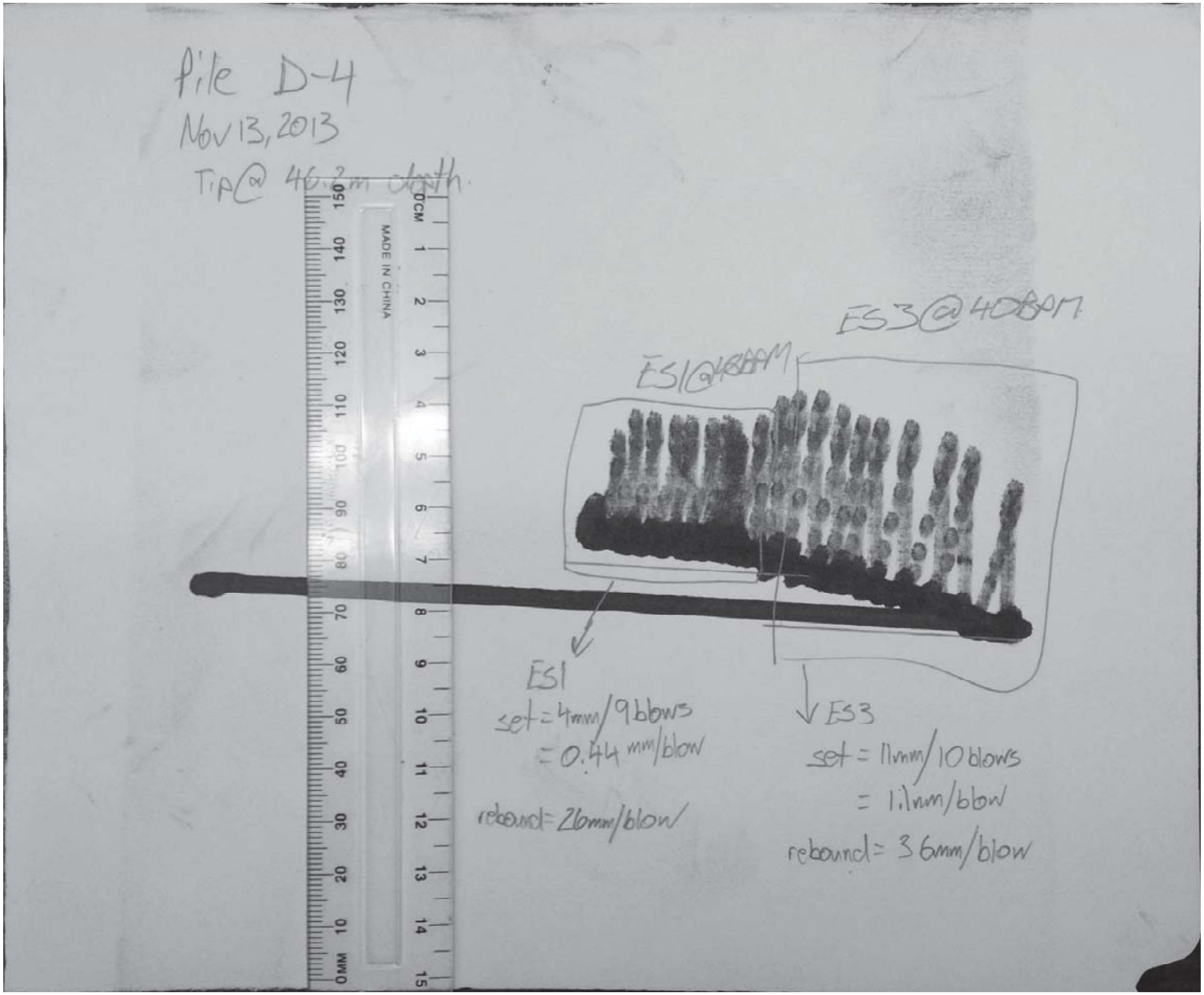
42.2	7	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	10	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	8	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	8	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	8	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	11	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	7	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	7	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	7	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	9	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	8	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	8	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	8	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	10	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	10	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	13	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	14	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	14	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	17	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	26	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	94/150mm	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

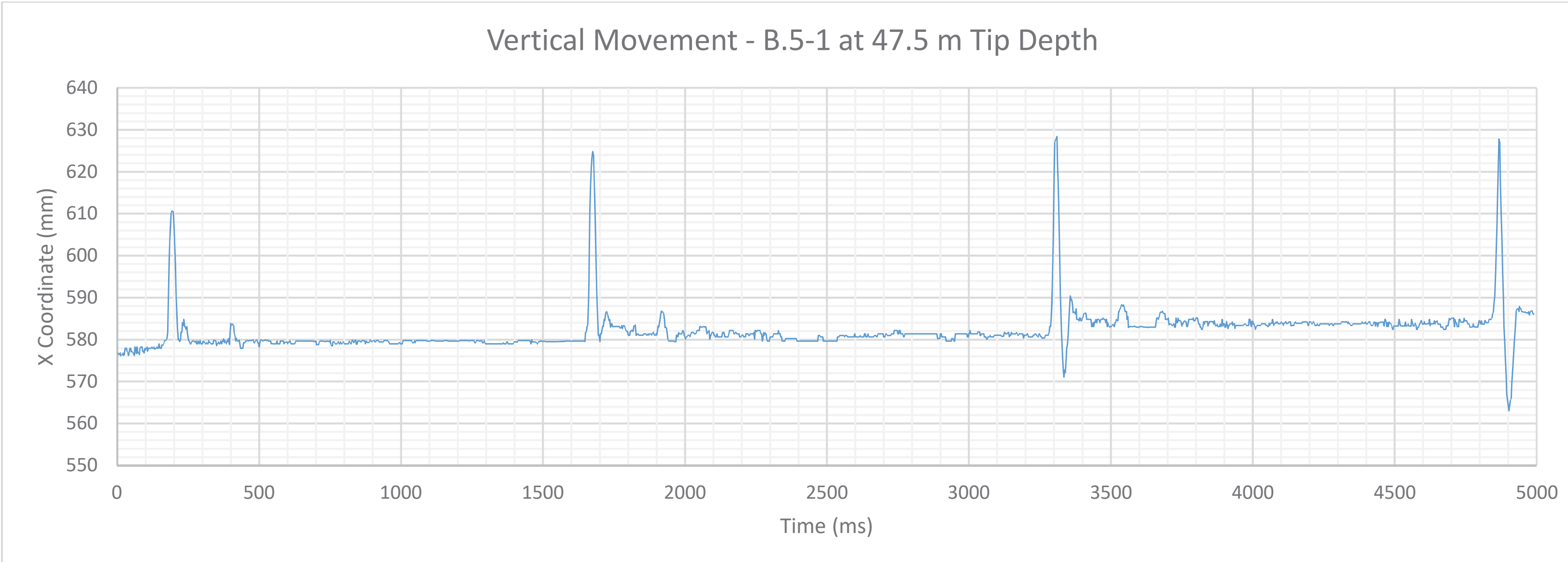
ADDITONAL NOTES/OBSERVATIONS

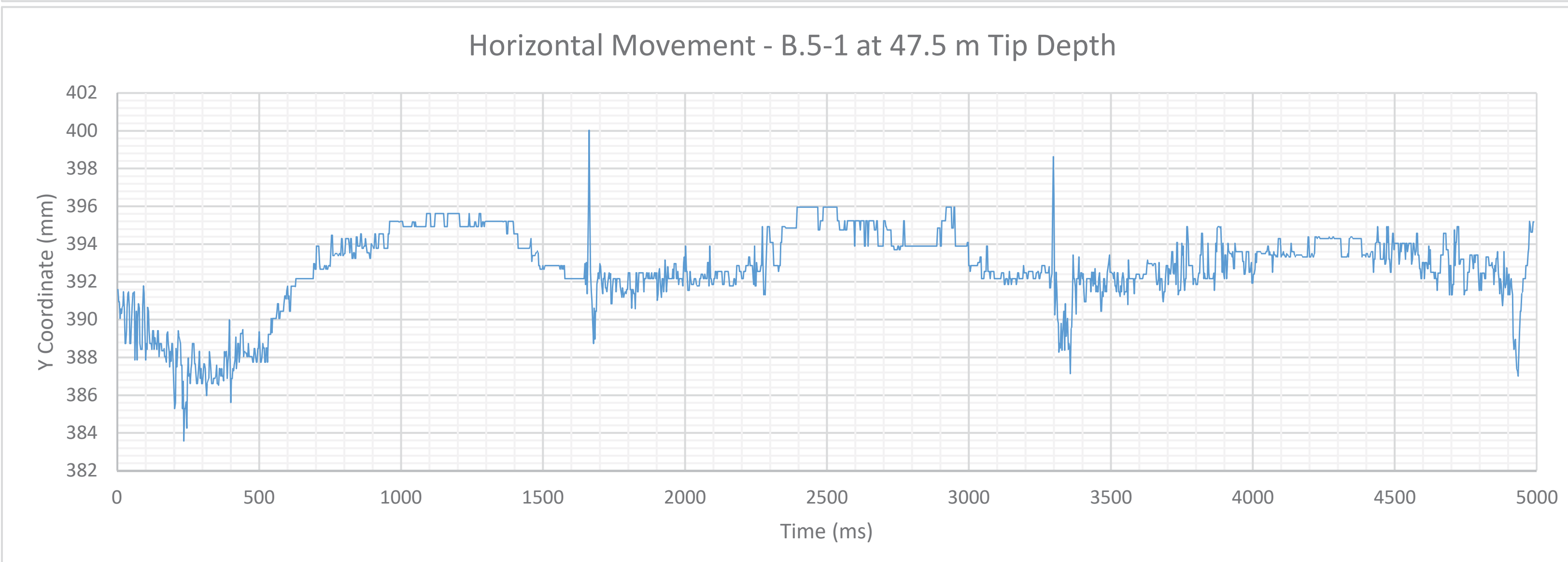
IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
42.8-46	50 to 43	Hammer Setting 4
46-46.1	43	Hammer Setting 3

The pile was set at a tip elevation of 138.2 m. The final set was 0.44 mm/blow.


Pile D-4
Nov 13, 2013
Tip@ 46.3m depth
ES3@ 40BPM
ES1@ 48BPM
ES1
set = 4mm/9 blows
= 0.44 mm/blow
rebound = 26mm/blow
ES3
set = 11mm/10 blows
= 1.1mm/blow
rebound = 36mm/blow
MADE IN CHINA


Vertical Movement - B.5-1 at 47.5 m Tip Depth
640
630
620
610
600
590
580
570
560
550
X Coordinate (mm)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Time (ms)


Horizontal Movement - B.5-1 at 47.5 m Tip Depth
402
400
398
396
394
392
390
388
386
384
382
Y Coordinate (mm)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag
Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908
Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes
Other Notes:

PILE DETAILS

Pile No. B.5-1 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132
Pile Shoe: Rock Injector **Batter (H:V):** Vertical **Total Length (m):** 47.1 **Mass (kg):** 6256.8

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.4	0.0	11.1	0.0	21.2	6.3	
Start Time:	8:32	8:53	9:37	10:28	11:06		
End Time:	8:39	9:35	9:47	11:03	11:25		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 137.1 **Cut off Elev. (m):** 184.5
Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2	↓	**6.2**	↓	**12.2**	↓	**18.2**	↓	**24.2**	5	**30.2**	6	**36.2**	7
0.4	↓	**6.4**	↓	**12.4**	↓	**18.4**	↓	**24.4**	5	**30.4**	6	**36.4**	8
0.6	↓	**6.6**	↓	**12.6**	↓	**18.6**	↓	**24.6**	4	**30.6**	5	**36.6**	7
0.8	↓	**6.8**	↓	**12.8**	↓	**18.8**	↓	**24.8**	6	**30.8**	6	**36.8**	8
1.0	2	**7.0**	11	**13.0**	14	**19.0**	23	**25.0**	6	**31.0**	7	**37.0**	8
1.2	↓	**7.2**	↓	**13.2**	↓	**19.2**	↓	**25.2**	5	**31.2**	8	**37.2**	7
1.4	↓	**7.4**	↓	**13.4**	↓	**19.4**	↓	**25.4**	6	**31.4**	6	**37.4**	8
1.6	↓	**7.6**	↓	**13.6**	↓	**19.6**	↓	**25.6**	4	**31.6**	6	**37.6**	7
1.8	↓	**7.8**	↓	**13.8**	↓	**19.8**	↓	**25.8**	6	**31.8**	6	**37.8**	8
2.0	9	**8.0**	11	**14.0**	18	**20.0**	23	**26.0**	6	**32.0**	7	**38.0**	8
2.2	↓	**8.2**	↓	**14.2**	↓	**20.2**	↓	**26.2**	5	**32.2**	7	**38.2**	7
2.4	↓	**8.4**	↓	**14.4**	↓	**20.4**	↓	**26.4**	5	**32.4**	8	**38.4**	7
2.6	↓	**8.6**	↓	**14.6**	↓	**20.6**	↓	**26.6**	5	**32.6**	8	**38.6**	7
2.8	↓	**8.8**	↓	**14.8**	↓	**20.8**	↓	**26.8**	5	**32.8**	8	**38.8**	8
3.0	11	**9.0**	14	**15.0**	18	**21.0**	17	**27.0**	4	**33.0**	8	**39.0**	7
3.2	↓	**9.2**	↓	**15.2**	↓	**21.2**		**27.2**	5	**33.2**	7	**39.2**	8
3.4	↓	**9.4**	↓	**15.4**	↓	**21.4**		**27.4**	6	**33.4**	7	**39.4**	7
3.6	↓	**9.6**	↓	**15.6**	↓	**21.6**		**27.6**	5	**33.6**	7	**39.6**	7
3.8	↓	**9.8**	↓	**15.8**	↓	**21.8**		**27.8**	6	**33.8**	4	**39.8**	7
4.0	5	**10.0**	13	**16.0**	18	**22.0**	1	**28.0**	5	**34.0**	6	**40.0**	6
4.2	↓	**10.2**	↓	**16.2**	↓	**22.2**		**28.2**	6	**34.2**	6	**40.2**	7
4.4	↓	**10.4**	↓	**16.4**	↓	**22.4**		**28.4**	5	**34.4**	6	**40.4**	7
4.6	↓	**10.6**	↓	**16.6**	↓	**22.6**		**28.6**	6	**34.6**	7	**40.6**	7
4.8	↓	**10.8**	↓	**16.8**	↓	**22.8**		**28.8**	6	**34.8**	7	**40.8**	7
5.0	13	**11.0**	14	**17.0**	19	**23.0**	17	**29.0**	6	**35.0**	7	**41.0**	6
5.2	↓	**11.2**	↓	**17.2**	↓	**23.2**	5	**29.2**	5	**35.2**	7	**41.2**	8
5.4	↓	**11.4**	↓	**17.4**	↓	**23.4**	5	**29.4**	5	**35.4**	8	**41.4**	6
5.6	↓	**11.6**	↓	**17.6**	↓	**23.6**	5	**29.6**	6	**35.6**	8	**41.6**	7
5.8	↓	**11.8**	↓	**17.8**	↓	**23.8**	5	**29.8**	5	**35.8**	8	**41.8**	7
6.0	14	**12.0**	13	**18.0**	22	**24.0**	4	**30.0**	6	**36.0**	7	**42.0**	7

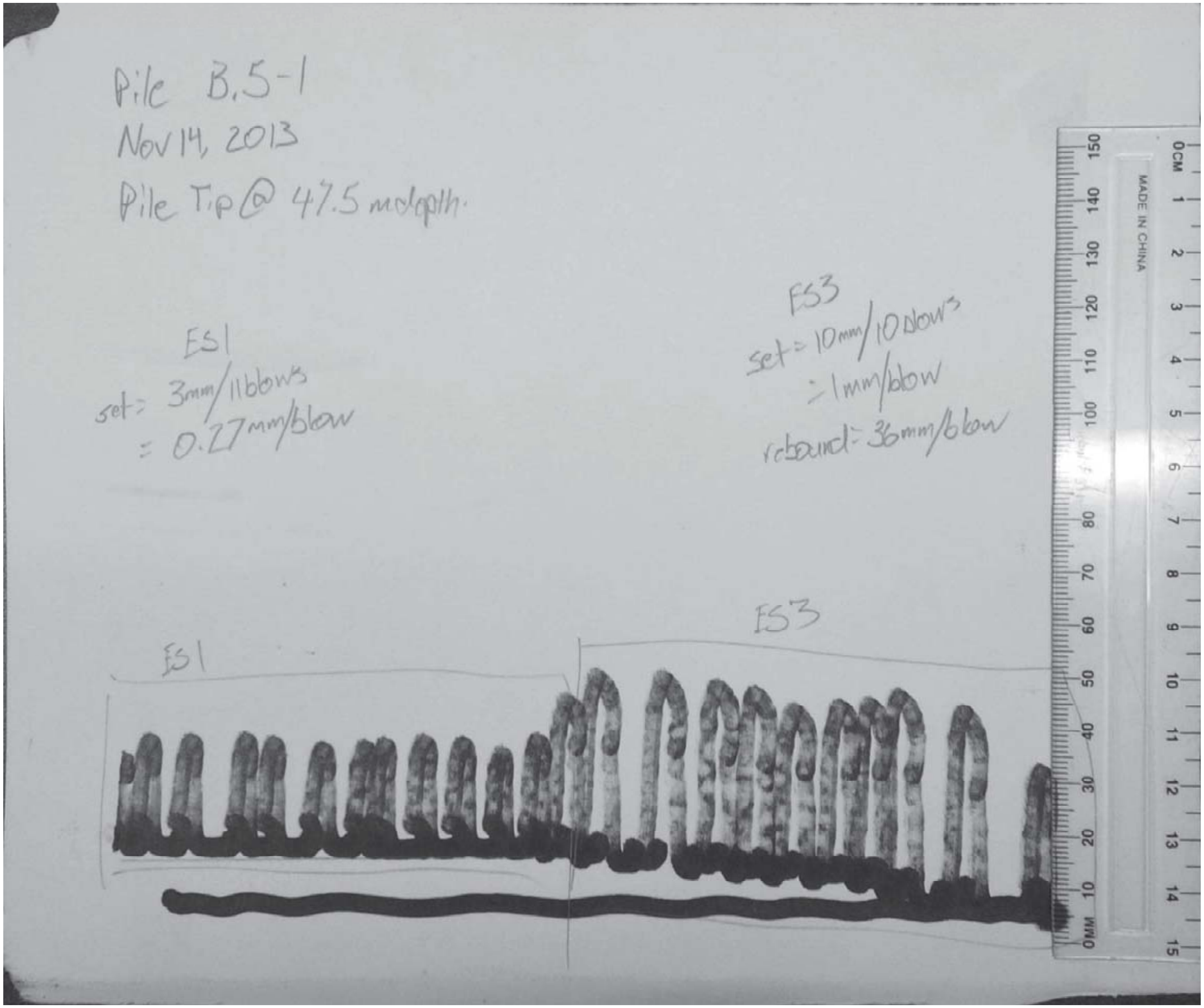
42.2	7	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	8	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	9	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	7	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	8	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	7	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	8	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	7	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	17	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	18	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	12	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	15	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	16	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	14	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	13	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	15	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	18	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	31	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	29	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	62	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	38/50mm	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**	
25-44.4	45 to 41	Hammer Setting 4
44.4-46.2	44 to 40	Hammer Setting 3

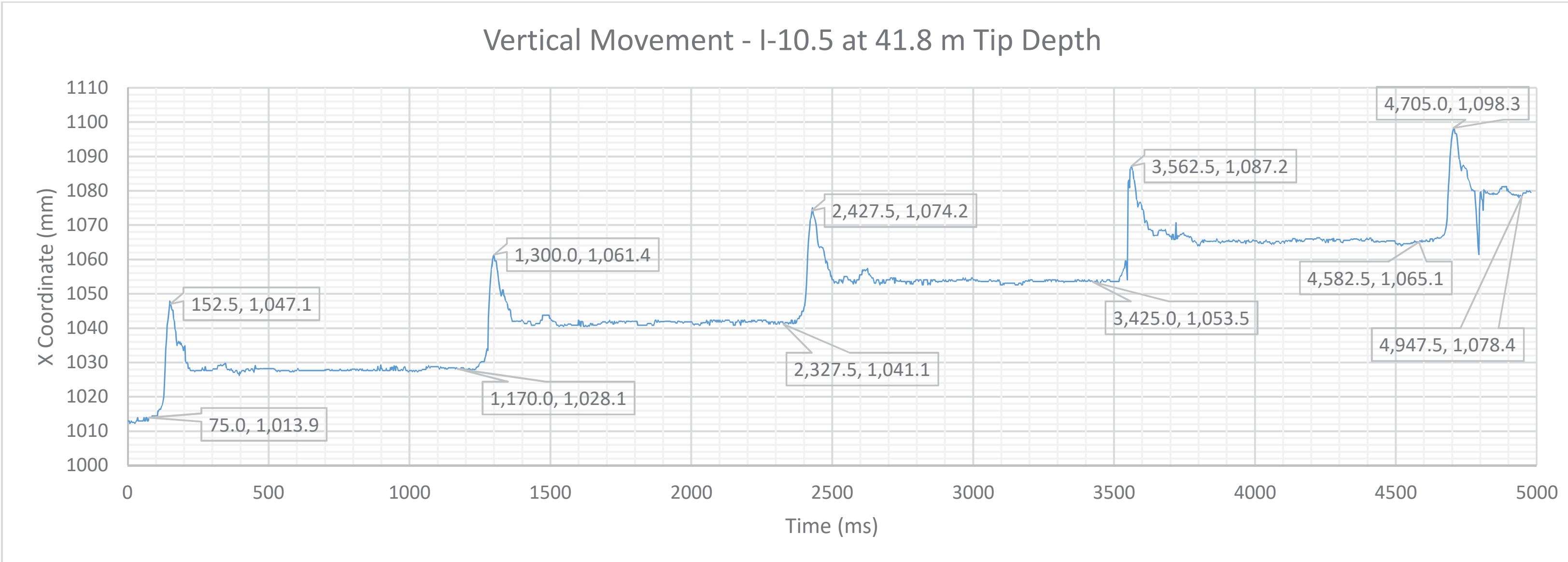
IR - Insufficient Soil Resistance for Sustained Driving

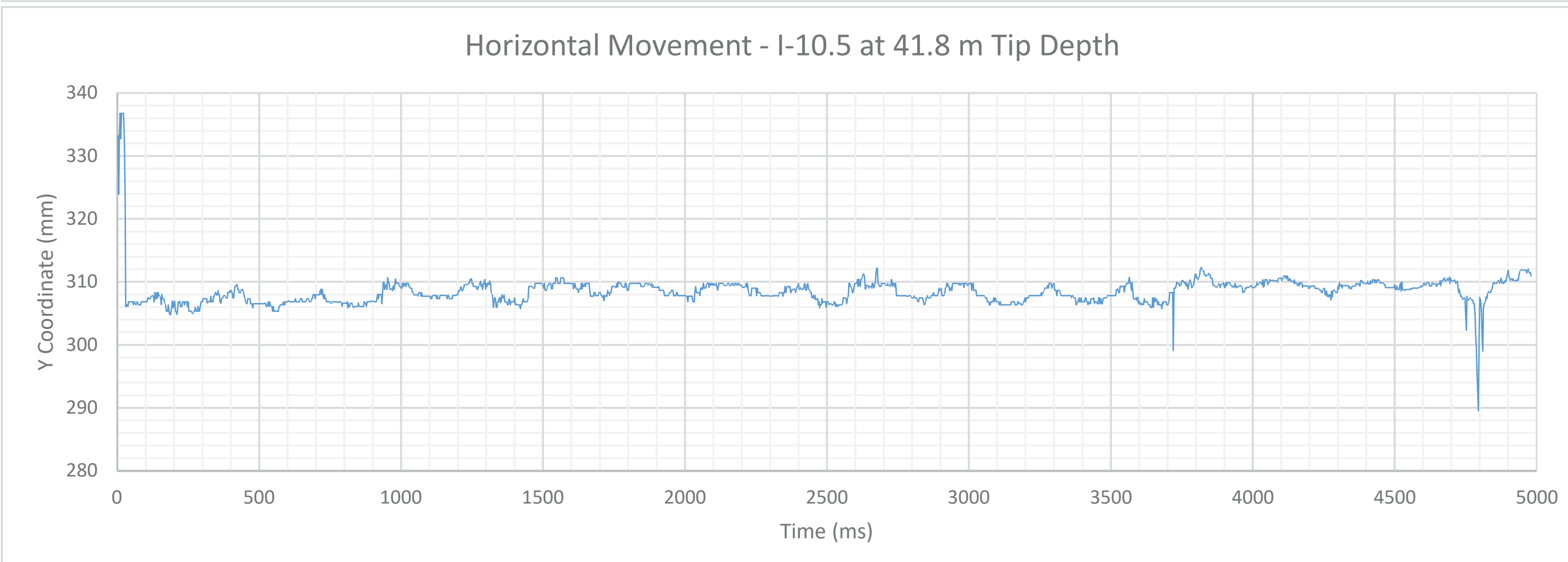
The pile was set at a tip elevation of 137.1 m. The final set was 0.27 mm/blow.


Pile B.5-1
Nov 14, 2013
Pile Tip @ 47.5 m depth.
ES1
set = 3mm/11 blows
= 0.27 mm/blow
ES3
set = 10mm/10 blows
= 1mm/blow
rebound = 36mm/blow
ES1
ES3
MADE IN CHINA

Appendix D

CVSR Plots


Vertical Movement - I-10.5 at 41.8 m Tip Depth
X Coordinate (mm)
Time (ms)
152.5, 1,047.1
75.0, 1,013.9
1,300.0, 1,061.4
1,170.0, 1,028.1
2,427.5, 1,074.2
2,327.5, 1,041.1
3,562.5, 1,087.2
3,425.0, 1,053.5
4,705.0, 1,098.3
4,582.5, 1,065.1
4,947.5, 1,078.4


Horizontal Movement - I-10.5 at 41.8 m Tip Depth
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** 1524

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. I-10.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** **Total Length (m):** 46.4 **Mass (kg):** 6164.4

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.5	0.4	21.2	0.2	21.2	16.6	
Start Time:	8:07	9:55	11:09	15:50	16:40		
End Time:	8:25	10:50	11:23	16:30	17:12		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 137.8 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

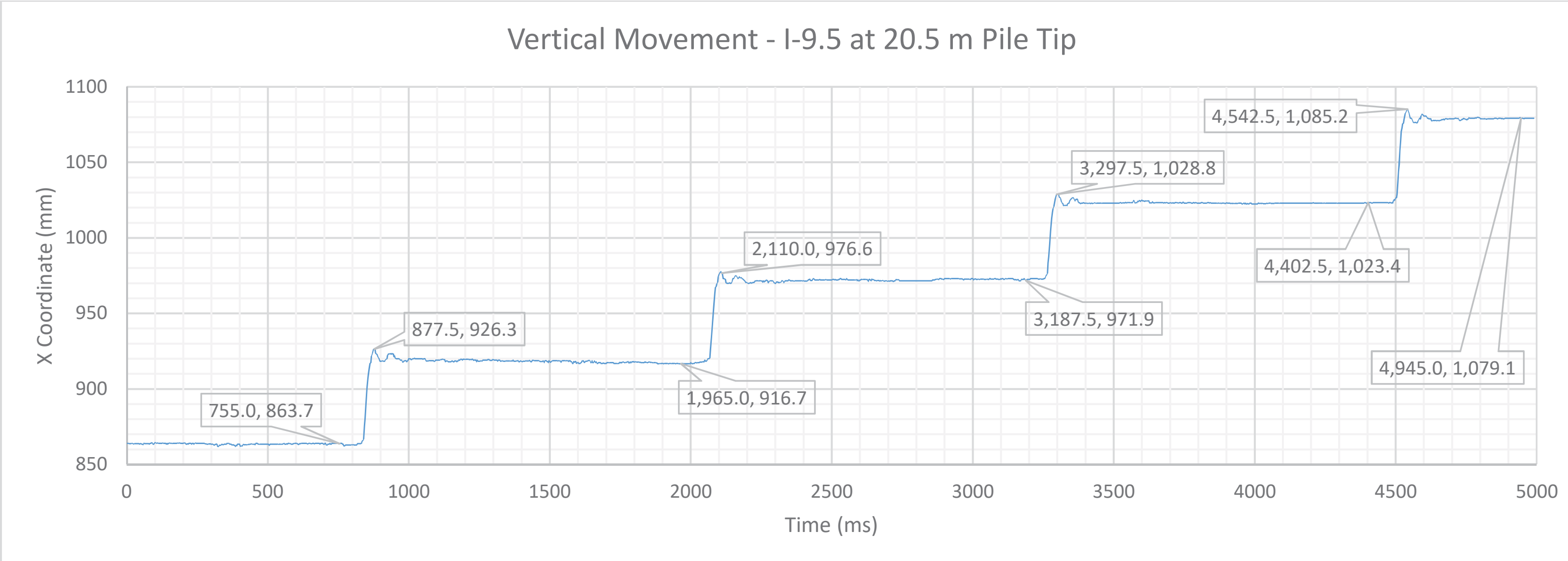
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	8	**12.2**	6	**18.2**	5	**24.2**	7	**30.2**	7	**36.2**	6
0.4		**6.4**	6	**12.4**	6	**18.4**	5	**24.4**	7	**30.4**	6	**36.4**	6
0.6		**6.6**	7	**12.6**	6	**18.6**	6	**24.6**	9	**30.6**	9	**36.6**	7
0.8		**6.8**	6	**12.8**	6	**18.8**	6	**24.8**	8	**30.8**	7	**36.8**	5
1.0		**7.0**	8	**13.0**	6	**19.0**	7	**25.0**	8	**31.0**	6	**37.0**	6
1.2		**7.2**	8	**13.2**	7	**19.2**	6	**25.2**	9	**31.2**	5	**37.2**	5
1.4		**7.4**	7	**13.4**	6	**19.4**	8	**25.4**	7	**31.4**	6	**37.4**	6
1.6		**7.6**	8	**13.6**	6	**19.6**	10	**25.6**	7	**31.6**	6	**37.6**	6
1.8		**7.8**	9	**13.8**	6	**19.8**	10	**25.8**	7	**31.8**	6	**37.8**	6
2.0		**8.0**	8	**14.0**	6	**20.0**	10	**26.0**	7	**32.0**	6	**38.0**	4
2.2		**8.2**	8	**14.2**	4	**20.2**	-	**26.2**	8	**32.2**	8	**38.2**	5
2.4		**8.4**	7	**14.4**	6	**20.4**	-	**26.4**	7	**32.4**	5	**38.4**	6
2.6		**8.6**	7	**14.6**	4	**20.6**	-	**26.6**	8	**32.6**	7	**38.6**	5
2.8		**8.8**	7	**14.8**	6	**20.8**	8	**26.8**	7	**32.8**	5	**38.8**	6
3.0		**9.0**	7	**15.0**	6	**21.0**	8	**27.0**	7	**33.0**	6	**39.0**	4
3.2		**9.2**	8	**15.2**	6	**21.2**	8	**27.2**	8	**33.2**	6	**39.2**	6
3.4		**9.4**	6	**15.4**	5	**21.4**	9	**27.4**	7	**33.4**	4	**39.4**	6
3.6		**9.6**	6	**15.6**	5	**21.6**	8	**27.6**	6	**33.6**	5	**39.6**	6
3.8		**9.8**	7	**15.8**	6	**21.8**	8	**27.8**	8	**33.8**	6	**39.8**	6
4.0		**10.0**	7	**16.0**	5	**22.0**	9	**28.0**	7	**34.0**	5	**40.0**	5
4.2		**10.2**	7	**16.2**	6	**22.2**	7	**28.2**	7	**34.2**	5	**40.2**	7
4.4		**10.4**	6	**16.4**	6	**22.4**	8	**28.4**	7	**34.4**	6	**40.4**	8
4.6	↓	**10.6**	7	**16.6**	6	**22.6**	8	**28.6**	6	**34.6**	6	**40.6**	8
4.8	37	**10.8**	7	**16.8**	7	**22.8**	7	**28.8**	7	**34.8**	6	**40.8**	8
5.0	10	**11.0**	7	**17.0**	5	**23.0**	7	**29.0**	7	**35.0**	5	**41.0**	7
5.2	9	**11.2**	6	**17.2**	6	**23.2**	7	**29.2**	6	**35.2**	6	**41.2**	
5.4	9	**11.4**	6	**17.4**	6	**23.4**	6	**29.4**	6	**35.4**	6	**41.4**	
5.6	9	**11.6**	6	**17.6**	5	**23.6**	8	**29.6**	9	**35.6**	7	**41.6**	
5.8	9	**11.8**	6	**17.8**	8	**23.8**	7	**29.8**	9	**35.8**	6	**41.8**	
6.0	9	**12.0**	6	**18.0**	7	**24.0**	7	**30.0**	6	**36.0**	4	**42.0**	

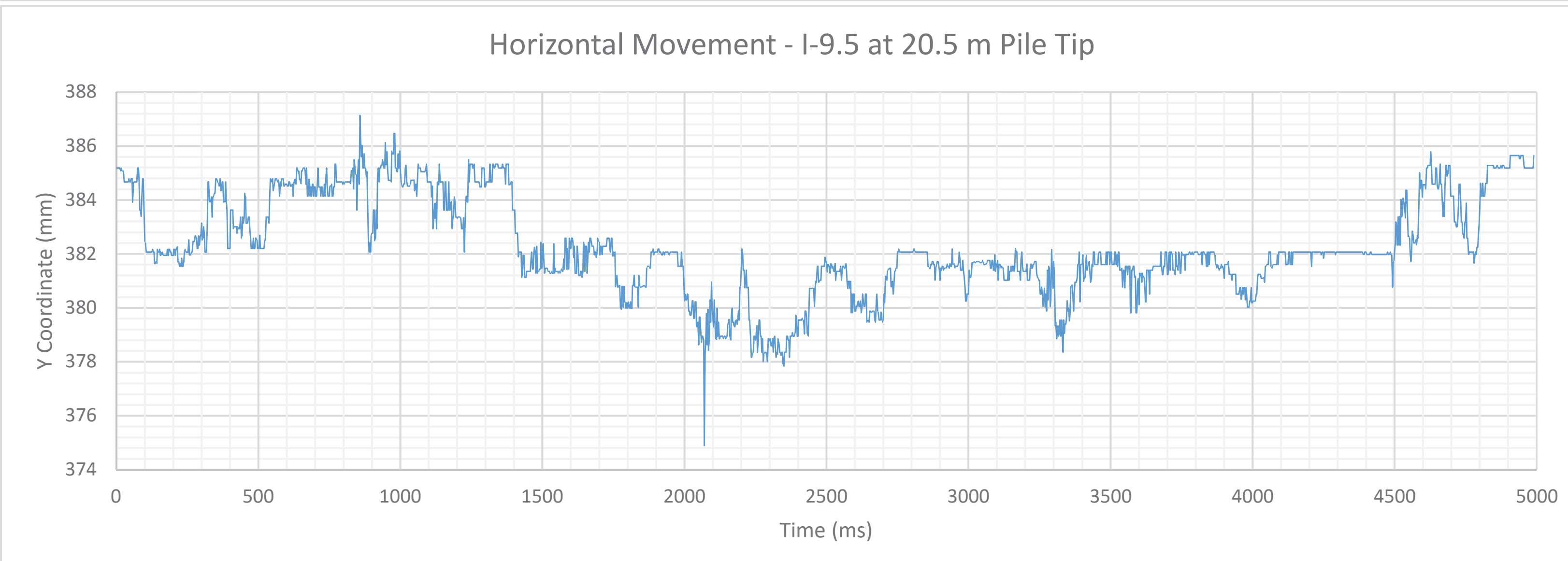
42.2	8	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	11	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	6	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	10	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	11	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	9	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	10	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	9	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	10	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	7	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	10	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	10	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	9	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	8	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	8	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	10	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	11	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	13	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	16	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	14	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	24	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	Set	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

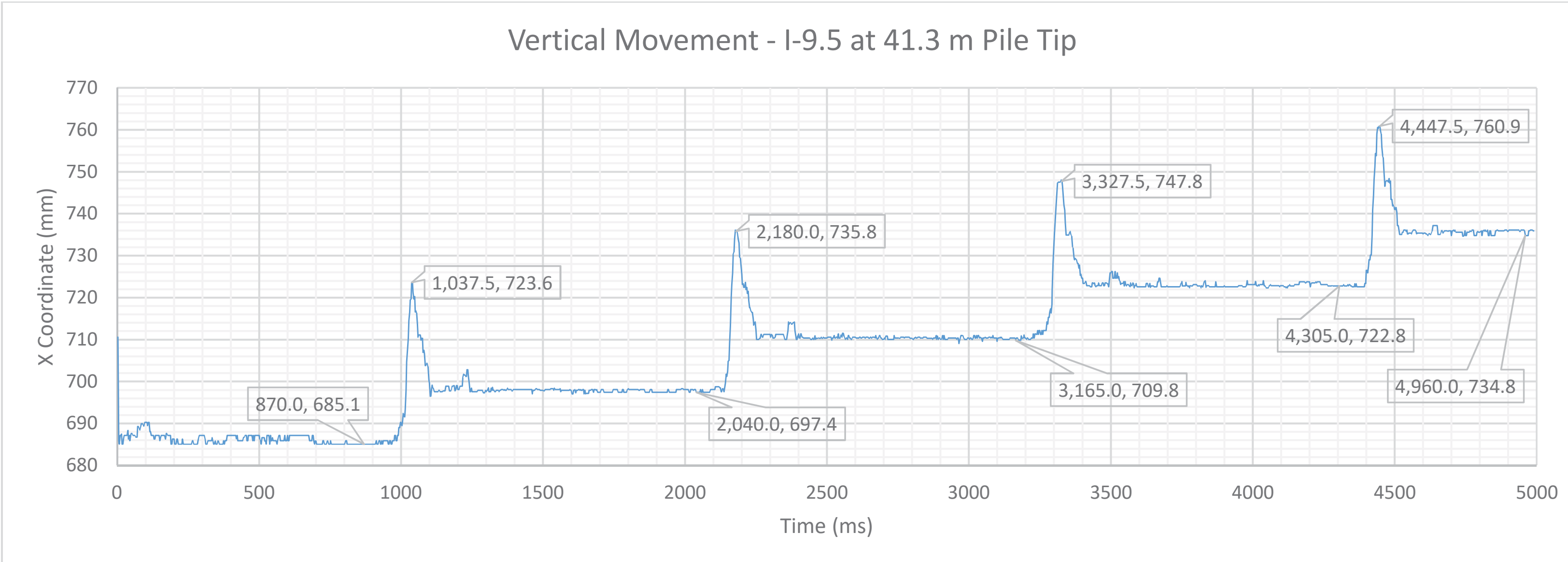
ADDITONAL NOTES/OBSERVATIONS

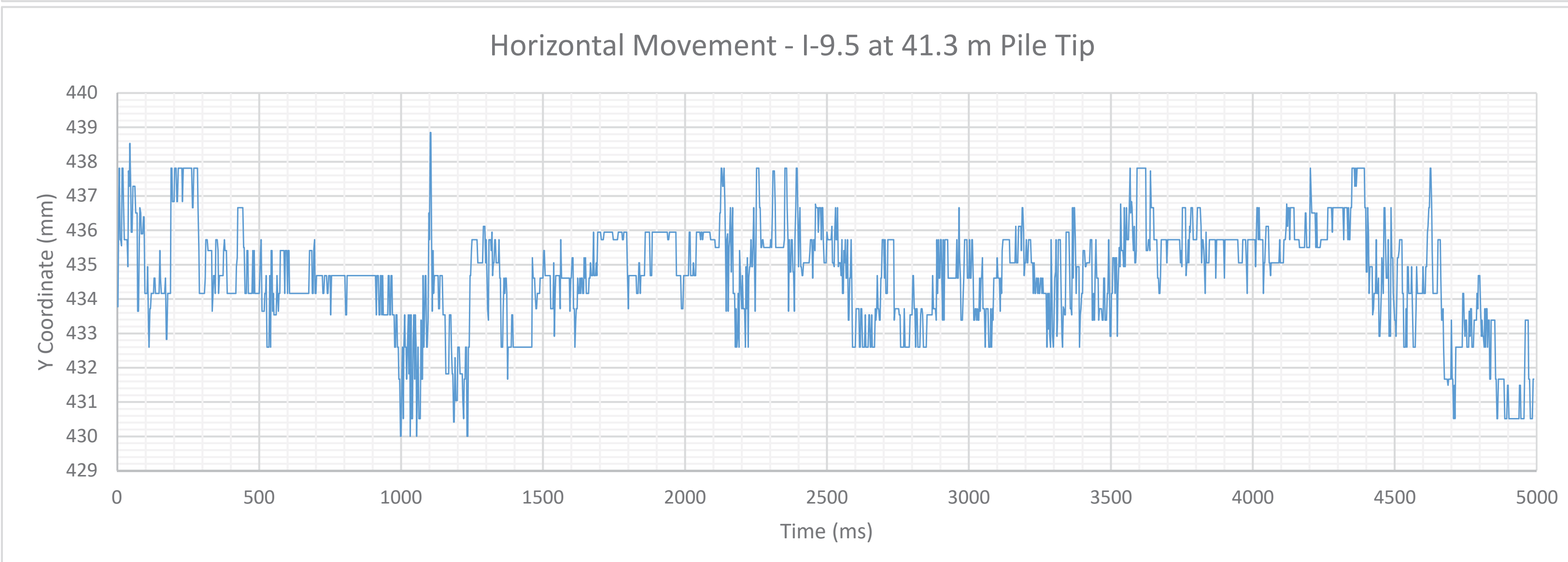
Depth (m)	**BPM**	
20 to 25	46 to 47	
25 to 41	44 to 46	
42 to 47.5	45 to 47	Hammer Setting 1

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 137.8 m. The final set was 2.0 mm/blow.


Vertical Movement - I-9.5 at 20.5 m Pile Tip
X Coordinate (mm)
Time (ms)
755.0, 863.7
877.5, 926.3
1,965.0, 916.7
2,110.0, 976.6
3,187.5, 971.9
3,297.5, 1,028.8
4,402.5, 1,023.4
4,542.5, 1,085.2
4,945.0, 1,079.1
1100
1050
1000
950
900
850
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Horizontal Movement - I-9.5 at 20.5 m Pile Tip
Y Coordinate (mm)
Time (ms)
388
386
384
382
380
378
376
374
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Vertical Movement - I-9.5 at 41.3 m Pile Tip
X Coordinate (mm)
Time (ms)
870.0, 685.1
1,037.5, 723.6
2,040.0, 697.4
2,180.0, 735.8
3,165.0, 709.8
3,327.5, 747.8
4,305.0, 722.8
4,447.5, 760.9
4,960.0, 734.8


Horizontal Movement - I-9.5 at 41.3 m Pile Tip
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** 1524

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. I-9.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** **Total Length (m):** 45.9 **Mass (kg):** 6098.4

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.5	0.4	21.2	0.2	16.6	12.5	
Start Time:	8:00	8:40	9:24	10:20	11:06		
End Time:	8:12	9:18	9:33	11:05	11:24		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.3 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

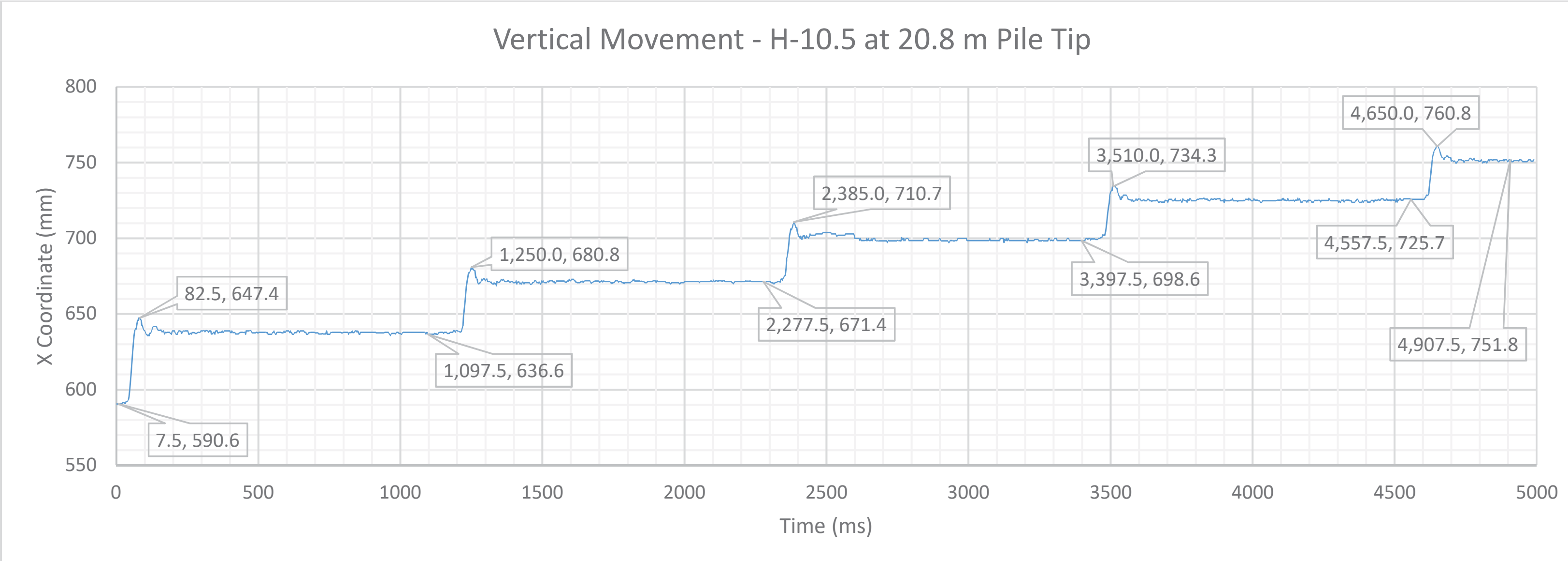
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2	↓	**6.2**	6	**12.2**	6	**18.2**	6	**24.2**	7	**30.2**	6	**36.2**	5
0.4	↓	**6.4**	7	**12.4**	7	**18.4**	6	**24.4**	5	**30.4**	7	**36.4**	4
0.6	↓	**6.6**	7	**12.6**	6	**18.6**	↓	**24.6**	4	**30.6**	6	**36.6**	4
0.8	↓	**6.8**	5	**12.8**	5	**18.8**	↓	**24.8**	3	**30.8**	6	**36.8**	4
1.0	↓	**7.0**	7	**13.0**	6	**19.0**	17	**25.0**	4	**31.0**	6	**37.0**	5
1.2	↓	**7.2**	7	**13.2**	4	**19.2**	5	**25.2**	4	**31.2**	5	**37.2**	3
1.4	↓	**7.4**	5	**13.4**	6	**19.4**	5	**25.4**	5	**31.4**	6	**37.4**	4
1.6	↓	**7.6**	7	**13.6**	5	**19.6**	6	**25.6**	4	**31.6**	6	**37.6**	4
1.8	↓	**7.8**	8	**13.8**	5	**19.8**	6	**25.8**	3	**31.8**	5	**37.8**	4
2.0	↓	**8.0**	6	**14.0**	4	**20.0**	5	**26.0**	3	**32.0**	7	**38.0**	4
2.2	↓	**8.2**	5	**14.2**	5	**20.2**	5	**26.2**	4	**32.2**	5	**38.2**	4
2.4	↓	**8.4**	5	**14.4**	5	**20.4**	9	**26.4**	4	**32.4**	5	**38.4**	6
2.6	↓	**8.6**	5	**14.6**	5	**20.6**	7	**26.6**	5	**32.6**	6	**38.6**	7
2.8	↓	**8.8**	6	**14.8**	5	**20.8**	7	**26.8**	4	**32.8**	5	**38.8**	4
3.0	↓	**9.0**	5	**15.0**	5	**21.0**	8	**27.0**	4	**33.0**	5	**39.0**	5
3.2	↓	**9.2**	6	**15.2**	5	**21.2**	5	**27.2**	4	**33.2**	5	**39.2**	4
3.4	↓	**9.4**	7	**15.4**	5	**21.4**	5	**27.4**	5	**33.4**	5	**39.4**	4
3.6	35	**9.6**	7	**15.6**	5	**21.6**	4	**27.6**	4	**33.6**	4	**39.6**	5
3.8	3	**9.8**	9	**15.8**	6	**21.8**	4	**27.8**	5	**33.8**	4	**39.8**	5
4.0	4	**10.0**	5	**16.0**	5	**22.0**	5	**28.0**	5	**34.0**	5	**40.0**	6
4.2	8	**10.2**	7	**16.2**	6	**22.2**	5	**28.2**	5	**34.2**	5	**40.2**	6
4.4	8	**10.4**	7	**16.4**	6	**22.4**	5	**28.4**	4	**34.4**	5	**40.4**	6
4.6	6	**10.6**	8	**16.6**	6	**22.6**	4	**28.6**	5	**34.6**	6	**40.6**	6
4.8	7	**10.8**	4	**16.8**	5	**22.8**	5	**28.8**	4	**34.8**	7	**40.8**	6
5.0	5	**11.0**	5	**17.0**	7	**23.0**	4	**29.0**	5	**35.0**	5	**41.0**	4
5.2	6	**11.2**	6	**17.2**	5	**23.2**	5	**29.2**	5	**35.2**	5	**41.2**	-
5.4	5	**11.4**	5	**17.4**	6	**23.4**	5	**29.4**	4	**35.4**	5	**41.4**	-
5.6	6	**11.6**	6	**17.6**	5	**23.6**	4	**29.6**	4	**35.6**	5	**41.6**	-
5.8	6	**11.8**	7	**17.8**	7	**23.8**	4	**29.8**	5	**35.8**	5	**41.8**	-
6.0	7	**12.0**	7	**18.0**	5	**24.0**	4	**30.0**	6	**36.0**	4	**42.0**	-

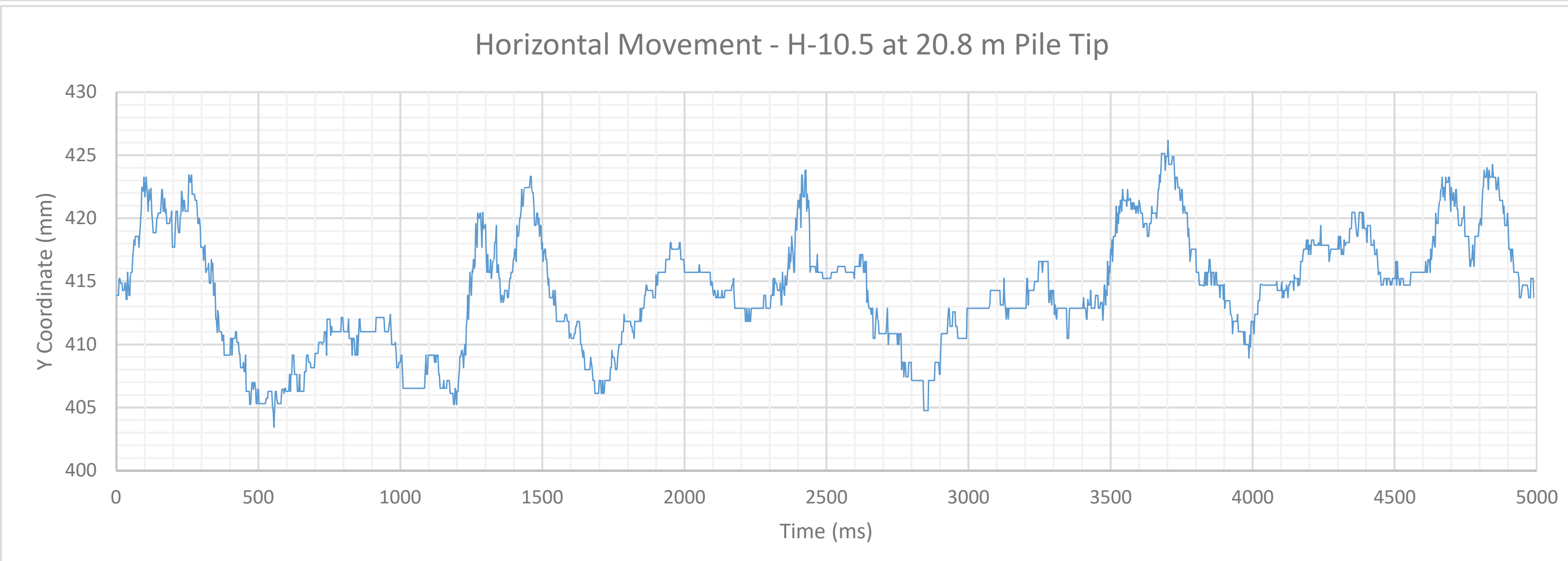
42.2	10	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	9	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	11	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	10	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	10	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	10	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	13	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	9	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	11	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	13	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	11	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	12	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	14	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	13	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	15	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	17	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	14	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	17	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	19	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	21	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	32	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	22	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6	Set	**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**	
5 to 6	50	
9 to 18	48 to 53	
33 to 45	45 to 49	
45 to 46.6	43 to 44	Hammer Setting 1

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.3 m. The final set was 1.35 mm/blow.


Vertical Movement - H-10.5 at 20.8 m Pile Tip
X Coordinate (mm)
Time (ms)
800
750
700
650
600
550
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
7.5, 590.6
82.5, 647.4
1,097.5, 636.6
1,250.0, 680.8
2,277.5, 671.4
2,385.0, 710.7
3,397.5, 698.6
3,510.0, 734.3
4,557.5, 725.7
4,650.0, 760.8
4,907.5, 751.8


Horizontal Movement - H-10.5 at 20.8 m Pile Tip
Y Coordinate (mm)
Time (ms)
430
425
420
415
410
405
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** 1524

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. H-10.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** **Total Length (m):** 46.0 **Mass (kg):** 6111.6

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.5	0.3	21.2	0.2	12.5	8.4	
Start Time:	12:57	14:02	14:34	16:35	17:00		
End Time:	1:10	14:29	14:55	16:58	17:12		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.2 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

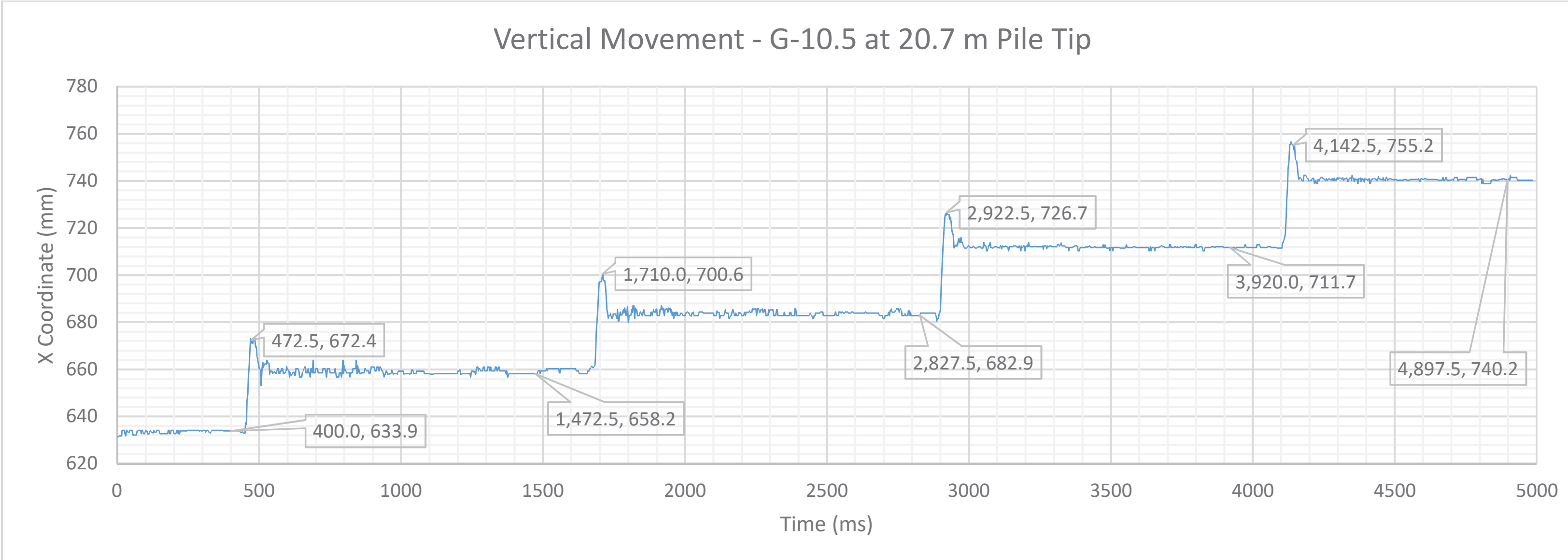
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	8	**12.2**	6	**18.2**	8	**24.2**	4	**30.2**	8	**36.2**	10
0.4		**6.4**	7	**12.4**	4	**18.4**	8	**24.4**	4	**30.4**	9	**36.4**	9
0.6		**6.6**	6	**12.6**	6	**18.6**	6	**24.6**	6	**30.6**	9	**36.6**	10
0.8		**6.8**	7	**12.8**	5	**18.8**	8	**24.8**	6	**30.8**	8	**36.8**	10
1.0		**7.0**	7	**13.0**	4	**19.0**	7	**25.0**	6	**31.0**	9	**37.0**	8
1.2	↓	**7.2**	6	**13.2**	5	**19.2**	7	**25.2**	4	**31.2**	9	**37.2**	10
1.4	7	**7.4**	5	**13.4**	5	**19.4**	8	**25.4**	11	**31.4**	7	**37.4**	10
1.6	2	**7.6**	7	**13.6**	6	**19.6**	7	**25.6**	8	**31.6**	9	**37.6**	10
1.8	4	**7.8**	6	**13.8**	5	**19.8**	6	**25.8**	8	**31.8**	7	**37.8**	8
2.0	4	**8.0**	5	**14.0**	5	**20.0**	7	**26.0**	7	**32.0**	9	**38.0**	11
2.2	5	**8.2**	6	**14.2**	6	**20.2**	7	**26.2**	8	**32.2**	8	**38.2**	8
2.4	7	**8.4**	6	**14.4**	6	**20.4**	5	**26.4**	8	**32.4**	9	**38.4**	11
2.6	8	**8.6**	6	**14.6**	6	**20.6**	5	**26.6**	9	**32.6**	8	**38.6**	10
2.8	6	**8.8**	5	**14.8**	6	**20.8**	8	**26.8**	9	**32.8**	9	**38.8**	11
3.0	7	**9.0**	5	**15.0**	7	**21.0**	8	**27.0**	9	**33.0**	8	**39.0**	11
3.2	7	**9.2**	6	**15.2**	6	**21.2**	9	**27.2**	8	**33.2**	9	**39.2**	11
3.4	9	**9.4**	5	**15.4**	8	**21.4**	6	**27.4**	8	**33.4**	9	**39.4**	12
3.6	2	**9.6**	6	**15.6**	7	**21.6**	5	**27.6**	9	**33.6**	9	**39.6**	12
3.8	2	**9.8**	5	**15.8**	8	**21.8**	7	**27.8**	9	**33.8**	8	**39.8**	12
4.0	2	**10.0**	5	**16.0**	7	**22.0**	5	**28.0**	8	**34.0**	9	**40.0**	11
4.2		**10.2**	5	**16.2**	7	**22.2**	8	**28.2**	7	**34.2**	8	**40.2**	10
4.4		**10.4**	5	**16.4**	7	**22.4**	6	**28.4**	9	**34.4**	8	**40.4**	13
4.6		**10.6**	5	**16.6**	7	**22.6**	6	**28.6**	9	**34.6**	9	**40.6**	10
4.8	↓	**10.8**	5	**16.8**	7	**22.8**	7	**28.8**	8	**34.8**	8	**40.8**	13
5.0	21	**11.0**	5	**17.0**	7	**23.0**	5	**29.0**	9	**35.0**	10	**41.0**	11
5.2	7	**11.2**	5	**17.2**	6	**23.2**	7	**29.2**	8	**35.2**	8	**41.2**	11
5.4	7	**11.4**	8	**17.4**	6	**23.4**	6	**29.4**	8	**35.4**	9	**41.4**	14
5.6	6	**11.6**	6	**17.6**	7	**23.6**	6	**29.6**	8	**35.6**	9	**41.6**	13
5.8	7	**11.8**	5	**17.8**	8	**23.8**	5	**29.8**	8	**35.8**	10	**41.8**	15
6.0	6	**12.0**	6	**18.0**	7	**24.0**	5	**30.0**	8	**36.0**	9	**42.0**	15

42.2	13	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	20	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	14	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	15	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	16	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	13	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	17	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	14	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	17	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	13	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	13	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	14	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	14	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	14	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	12	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	14	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	15	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	18	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	21	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	Set	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

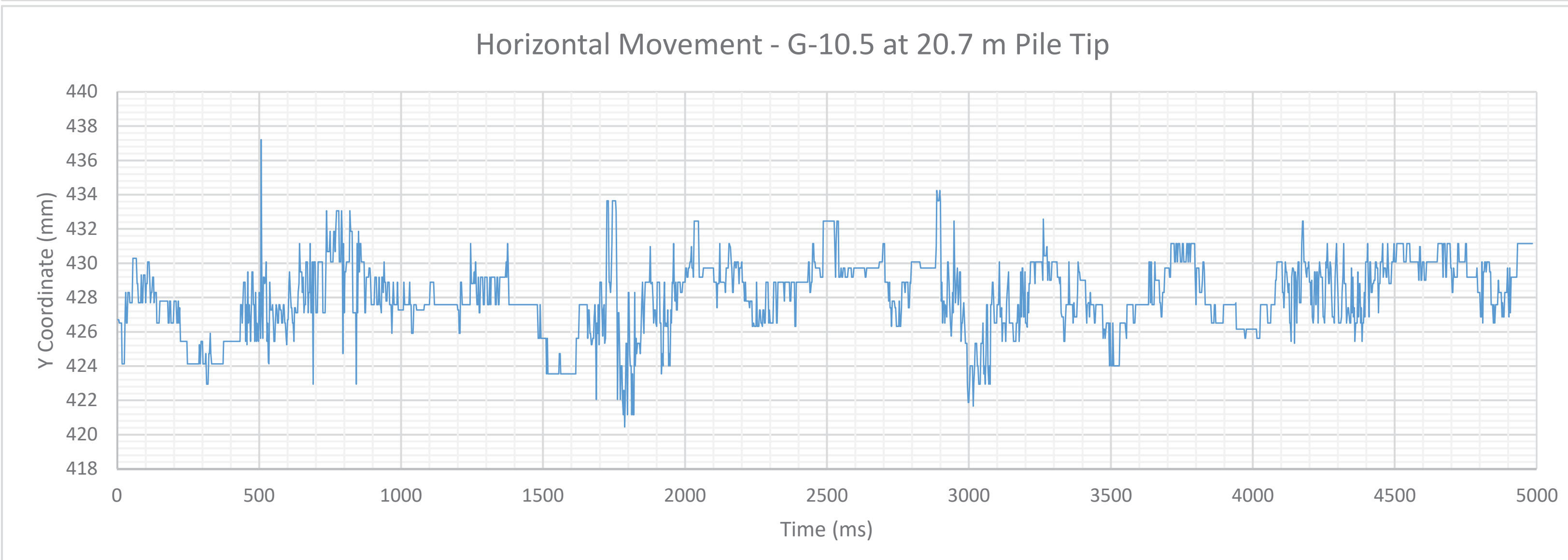
ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**	
3 to 21	50 to 55	
21 to 24	48	
24 to 42	44 to 46	
42 to 44	48	Hammer Setting 1
44 to 46	44 to 46	

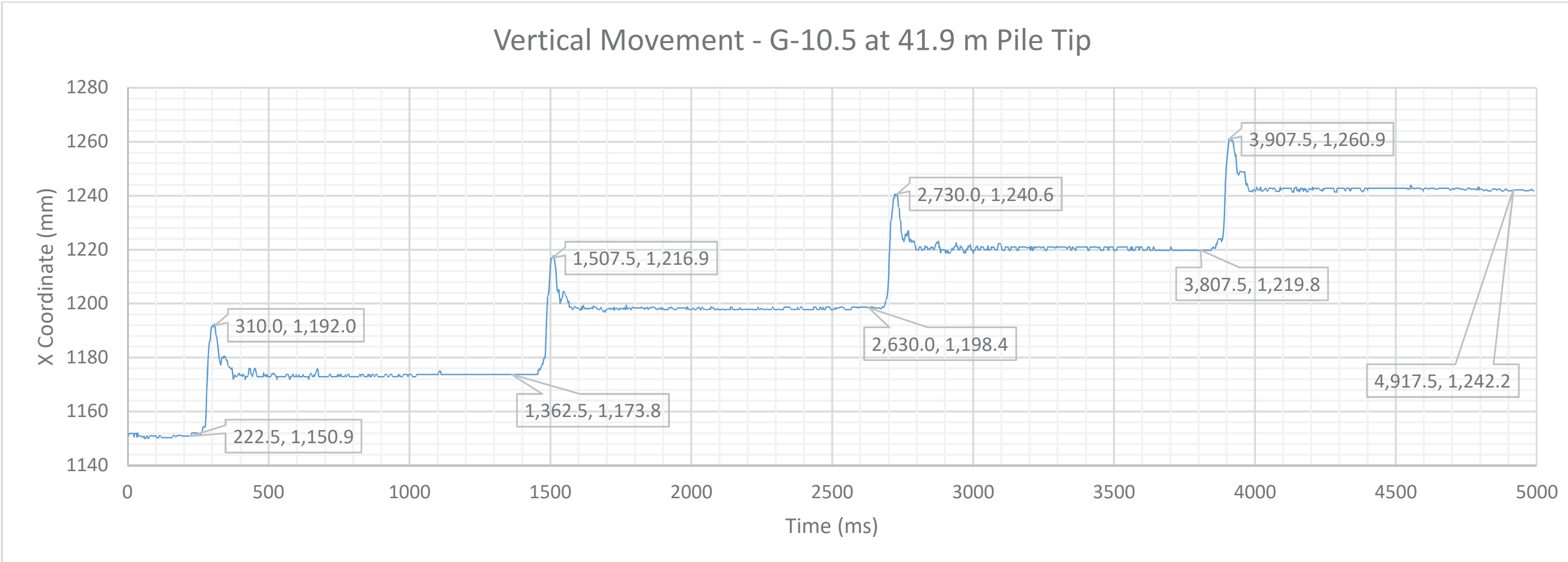
Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.2 m. The final set was 1.39 mm/blow.

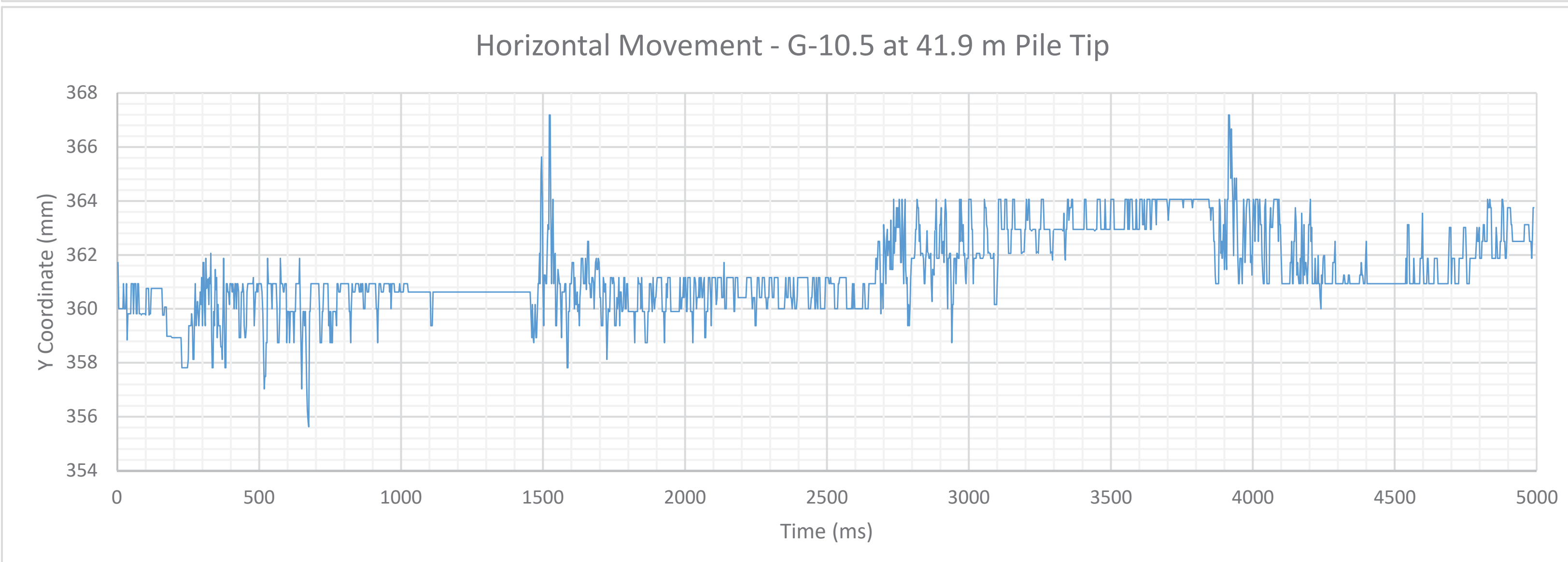


Vertical Movement - G-10.5 at 20.7 m Pile Tip
X Coordinate (mm)
Time (ms)
780
760
740
720
700
680
660
640
620
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
472.5, 672.4
400.0, 633.9
1,710.0, 700.6
1,472.5, 658.2
2,922.5, 726.7
2,827.5, 682.9
3,920.0, 711.7
4,142.5, 755.2
4,897.5, 740.2



Horizontal Movement - G-10.5 at 20.7 m Pile Tip
Y Coordinate (mm)
Time (ms)
440
438
436
434
432
430
428
426
424
422
420
418
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Vertical Movement - G-10.5 at 41.9 m Pile Tip
X Coordinate (mm)
Time (ms)
310.0, 1,192.0
222.5, 1,150.9
1,507.5, 1,216.9
1,362.5, 1,173.8
2,730.0, 1,240.6
2,630.0, 1,198.4
3,907.5, 1,260.9
3,807.5, 1,219.8
4,917.5, 1,242.2


Horizontal Movement - G-10.5 at 41.9 m Pile Tip
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** 1524

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. G-10.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** **Total Length (m):** 46.2 **Mass (kg):** 6138

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.5	0.2	21.2	0.2	8.4	4.2	
Start Time:	7:57	8:25	9:10	10:00	11:00		
End Time:	8:11	9:05	9:26	10:55	11:14		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.0 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

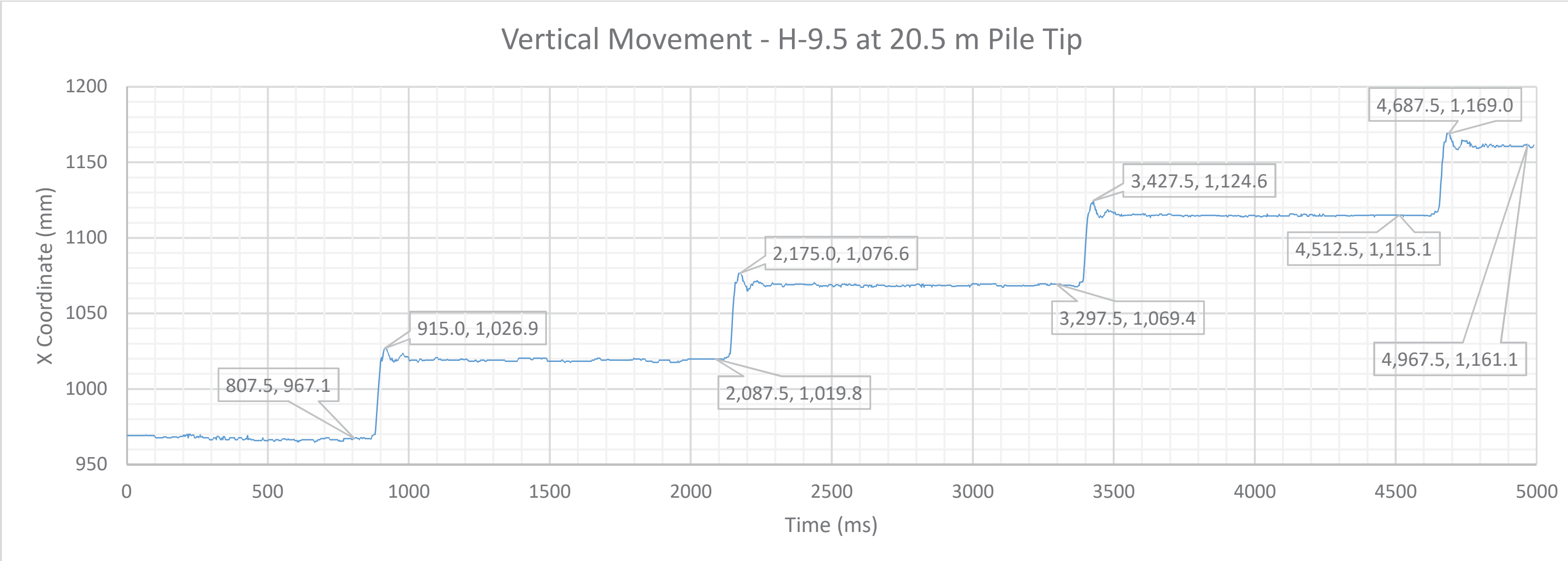
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2	↓	**6.2**	5	**12.2**	4	**18.2**	6	**24.2**	6	**30.2**	5	**36.2**	6
0.4	↓	**6.4**	4	**12.4**	5	**18.4**	5	**24.4**	7	**30.4**	6	**36.4**	5
0.6	↓	**6.6**	5	**12.6**	6	**18.6**	6	**24.6**	7	**30.6**	8	**36.6**	6
0.8	↓	**6.8**	5	**12.8**	4	**18.8**	5	**24.8**	7	**30.8**	9	**36.8**	6
1.0	3	**7.0**	5	**13.0**	5	**19.0**	7	**25.0**	7	**31.0**	8	**37.0**	5
1.2	2	**7.2**	4	**13.2**	5	**19.2**	7	**25.2**	7	**31.2**	7	**37.2**	5
1.4	4	**7.4**	5	**13.4**	4	**19.4**	7	**25.4**	8	**31.4**	9	**37.4**	5
1.6	6	**7.6**	4	**13.6**	5	**19.6**	6	**25.6**	7	**31.6**	8	**37.6**	5
1.8	5	**7.8**	4	**13.8**	6	**19.8**	6	**25.8**	7	**31.8**	7	**37.8**	4
2.0	6	**8.0**	3	**14.0**	5	**20.0**	6	**26.0**	7	**32.0**	8	**38.0**	4
2.2	5	**8.2**	4	**14.2**	5	**20.2**	4	**26.2**	8	**32.2**	8	**38.2**	5
2.4	6	**8.4**	2	**14.4**	6	**20.4**	5	**26.4**	8	**32.4**	6	**38.4**	5
2.6	6	**8.6**		**14.6**	5	**20.6**	-	**26.6**	7	**32.6**	6	**38.6**	5
2.8	6	**8.8**		**14.8**	5	**20.8**	-	**26.8**	7	**32.8**	9	**38.8**	5
3.0	4	**9.0**		**15.0**	5	**21.0**	-	**27.0**	7	**33.0**	6	**39.0**	6
3.2	5	**9.2**		**15.2**	6	**21.2**	5	**27.2**	7	**33.2**	8	**39.2**	6
3.4	5	**9.4**		**15.4**	7	**21.4**	6	**27.4**	7	**33.4**	7	**39.4**	6
3.6	5	**9.6**		**15.6**	6	**21.6**	5	**27.6**	6	**33.6**	6	**39.6**	7
3.8	4	**9.8**		**15.8**	6	**21.8**	9	**27.8**	7	**33.8**	5	**39.8**	6
4.0	2	**10.0**	20	**16.0**	6	**22.0**	5	**28.0**	7	**34.0**	7	**40.0**	5
4.2	↓	**10.2**	5	**16.2**	6	**22.2**	7	**28.2**	7	**34.2**	7	**40.2**	7
4.4	↓	**10.4**	6	**16.4**	6	**22.4**	8	**28.4**	6	**34.4**	6	**40.4**	6
4.6	↓	**10.6**	5	**16.6**	7	**22.6**	5	**28.6**	8	**34.6**	6	**40.6**	8
4.8	↓	**10.8**	4	**16.8**	6	**22.8**	6	**28.8**	7	**34.8**	6	**40.8**	5
5.0	10	**11.0**	4	**17.0**	6	**23.0**	6	**29.0**	7	**35.0**	6	**41.0**	11
5.2	↓	**11.2**	5	**17.2**	7	**23.2**	6	**29.2**	6	**35.2**	7	**41.2**	-
5.4	↓	**11.4**	5	**17.4**	6	**23.4**	6	**29.4**	6	**35.4**	5	**41.4**	-
5.6	↓	**11.6**	5	**17.6**	6	**23.6**	6	**29.6**	6	**35.6**	7	**41.6**	4
5.8	↓	**11.8**	5	**17.8**	6	**23.8**	6	**29.8**	7	**35.8**	7	**41.8**	8
6.0	22	**12.0**	5	**18.0**	6	**24.0**	7	**30.0**	6	**36.0**	6	**42.0**	11

42.2	11	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	12	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	9	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	12	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	11	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	11	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	12	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	13	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	11	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	11	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	10	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	11	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	11	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	11	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	11	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	12	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	14	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	13	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	17	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	59	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	↓	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	Set	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

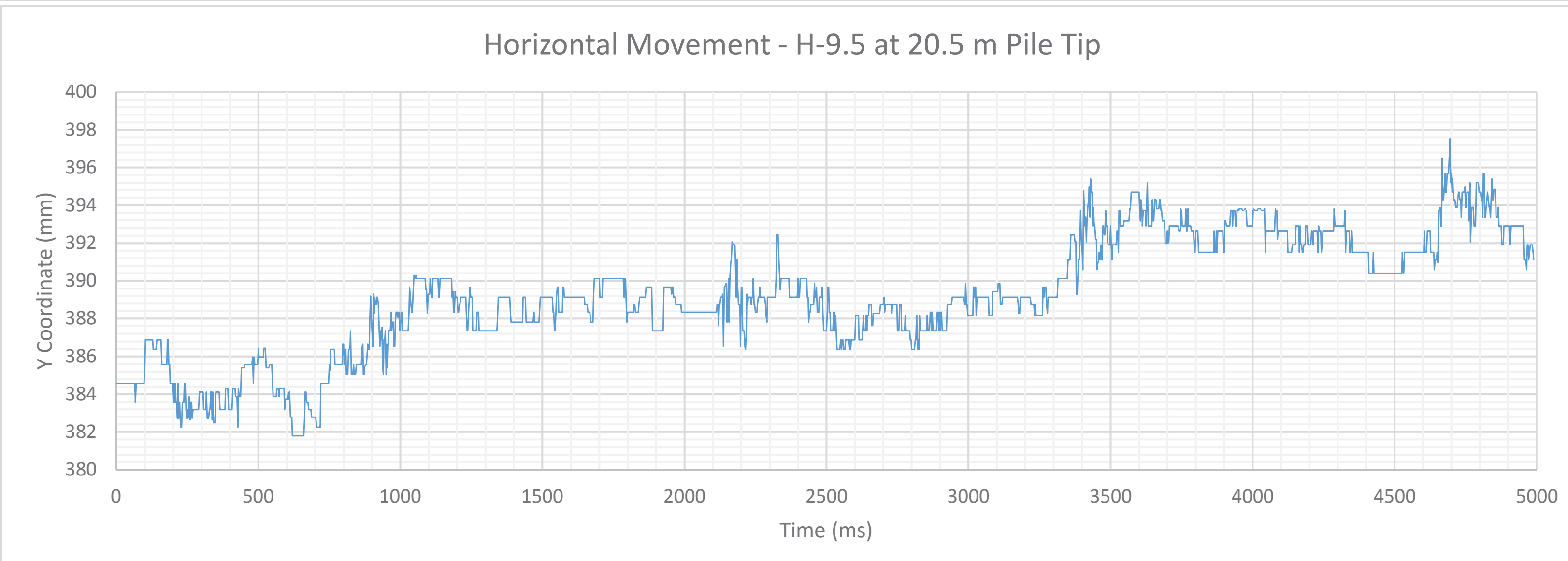
ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**	
3 to 11	51 to 52	
11 to 15	47 to 48	
15 to 44	45 to 47	
44 to 45	48	Hammer Setting 1
45 to 46	51	Hammer Setting 1

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138 m. The final set was 1.19 mm/blow.



Vertical Movement - H-9.5 at 20.5 m Pile Tip
X Coordinate (mm)
Time (ms)
807.5, 967.1
915.0, 1,026.9
2,087.5, 1,019.8
2,175.0, 1,076.6
3,297.5, 1,069.4
3,427.5, 1,124.6
4,512.5, 1,115.1
4,687.5, 1,169.0
4,967.5, 1,161.1



Horizontal Movement - H-9.5 at 20.5 m Pile Tip
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** 1524

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. H-9.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** **Total Length (m):** 45.2 **Mass (kg):** 6006

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.5	0.2	21.2	0.2	21.2	18.0	
Start Time:	11:25	12:35	13:14	13:55	14:30		
End Time:	11:36	13:08	13:33	14:29	14:48		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 139.0 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

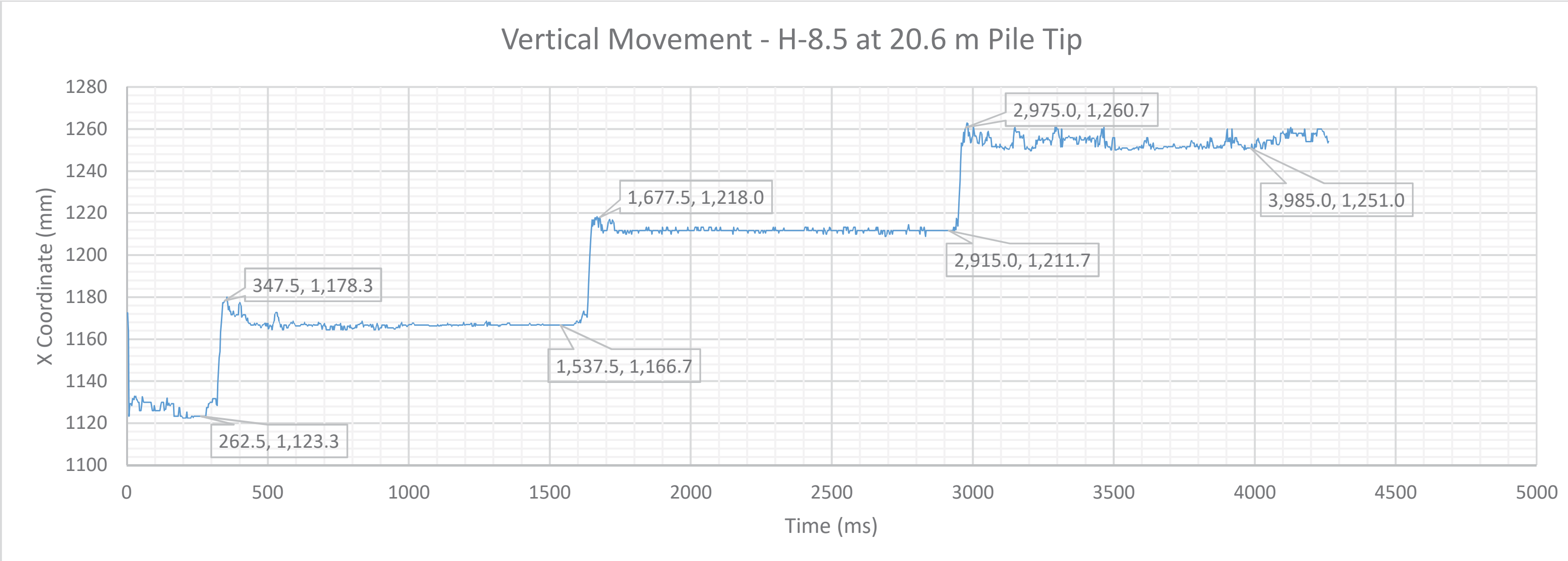
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	5	**12.2**	7	**18.2**	5	**24.2**	5	**30.2**	5	**36.2**	7
0.4		**6.4**	4	**12.4**	6	**18.4**	6	**24.4**	5	**30.4**	6	**36.4**	7
0.6		**6.6**	4	**12.6**	5	**18.6**	6	**24.6**	6	**30.6**	8	**36.6**	8
0.8		**6.8**	4	**12.8**	5	**18.8**	6	**24.8**	5	**30.8**	8	**36.8**	7
1.0		**7.0**	4	**13.0**	6	**19.0**	6	**25.0**	6	**31.0**	7	**37.0**	9
1.2		**7.2**	3	**13.2**	4	**19.2**	6	**25.2**	5	**31.2**	6	**37.2**	8
1.4		**7.4**	3	**13.4**	6	**19.4**	5	**25.4**	5	**31.4**	7	**37.4**	10
1.6		**7.6**	3	**13.6**	5	**19.6**	6	**25.6**	5	**31.6**	6	**37.6**	10
1.8		**7.8**	3	**13.8**	4	**19.8**	6	**25.8**	5	**31.8**	6	**37.8**	10
2.0	26	**8.0**	5	**14.0**	6	**20.0**	9	**26.0**	6	**32.0**	8	**38.0**	11
2.2		**8.2**	4	**14.2**	5	**20.2**	-	**26.2**	5	**32.2**	6	**38.2**	10
2.4		**8.4**	5	**14.4**	6	**20.4**	-	**26.4**	6	**32.4**	7	**38.4**	10
2.6		**8.6**	5	**14.6**	5	**20.6**	-	**26.6**	5	**32.6**	6	**38.6**	11
2.8		**8.8**	6	**14.8**	6	**20.8**	-	**26.8**	6	**32.8**	7	**38.8**	11
3.0	31	**9.0**	6	**15.0**	5	**21.0**	8	**27.0**	5	**33.0**	6	**39.0**	12
3.2	6	**9.2**	9	**15.2**	6	**21.2**	5	**27.2**	5	**33.2**	7	**39.2**	12
3.4	5	**9.4**	11	**15.4**	7	**21.4**	6	**27.4**	5	**33.4**	7	**39.4**	12
3.6	5	**9.6**	10	**15.6**	6	**21.6**	6	**27.6**	4	**33.6**	7	**39.6**	14
3.8	5	**9.8**	3	**15.8**	5	**21.8**	5	**27.8**	5	**33.8**	7	**39.8**	15
4.0	5	**10.0**	7	**16.0**	6	**22.0**	5	**28.0**	6	**34.0**	6	**40.0**	15
4.2	5	**10.2**	6	**16.2**	7	**22.2**	5	**28.2**	6	**34.2**	8	**40.2**	14
4.4	2	**10.4**	6	**16.4**	6	**22.4**	6	**28.4**	5	**34.4**	5	**40.4**	18
4.6	3	**10.6**	6	**16.6**	6	**22.6**	5	**28.6**	6	**34.6**	6	**40.6**	14
4.8	5	**10.8**	6	**16.8**	5	**22.8**	5	**28.8**	6	**34.8**	6	**40.8**	10
5.0	5	**11.0**	5	**17.0**	7	**23.0**	6	**29.0**	5	**35.0**	7	**41.0**	-
5.2	5	**11.2**	4	**17.2**	6	**23.2**	4	**29.2**	5	**35.2**	6	**41.2**	-
5.4	3	**11.4**	5	**17.4**	6	**23.4**	5	**29.4**	5	**35.4**	5	**41.4**	8
5.6	5	**11.6**	4	**17.6**	6	**23.6**	5	**29.6**	5	**35.6**	6	**41.6**	21
5.8	4	**11.8**	5	**17.8**	7	**23.8**	5	**29.8**	5	**35.8**	7	**41.8**	18
6.0	5	**12.0**	8	**18.0**	6	**24.0**	5	**30.0**	5	**36.0**	7	**42.0**	15

42.2	16	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	16	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	18	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	19	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	20	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	21	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	24	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	24	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	15	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	18	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	22	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	26	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	28	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	88	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	Set	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2		**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4		**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6		**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8		**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

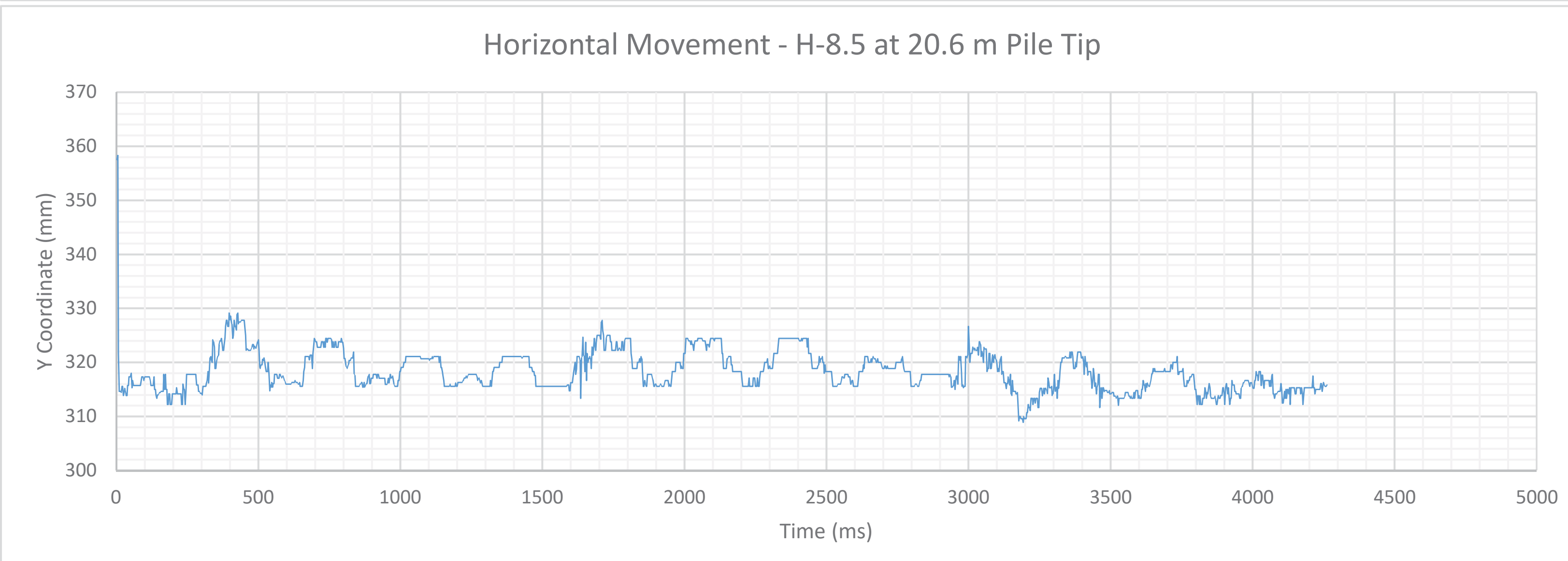
ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**	
2 to 20	49 to 59	Low Resistance Material
21 to 35	46 to 48	
35 to 41	45 to 43	
43 to 45	45	

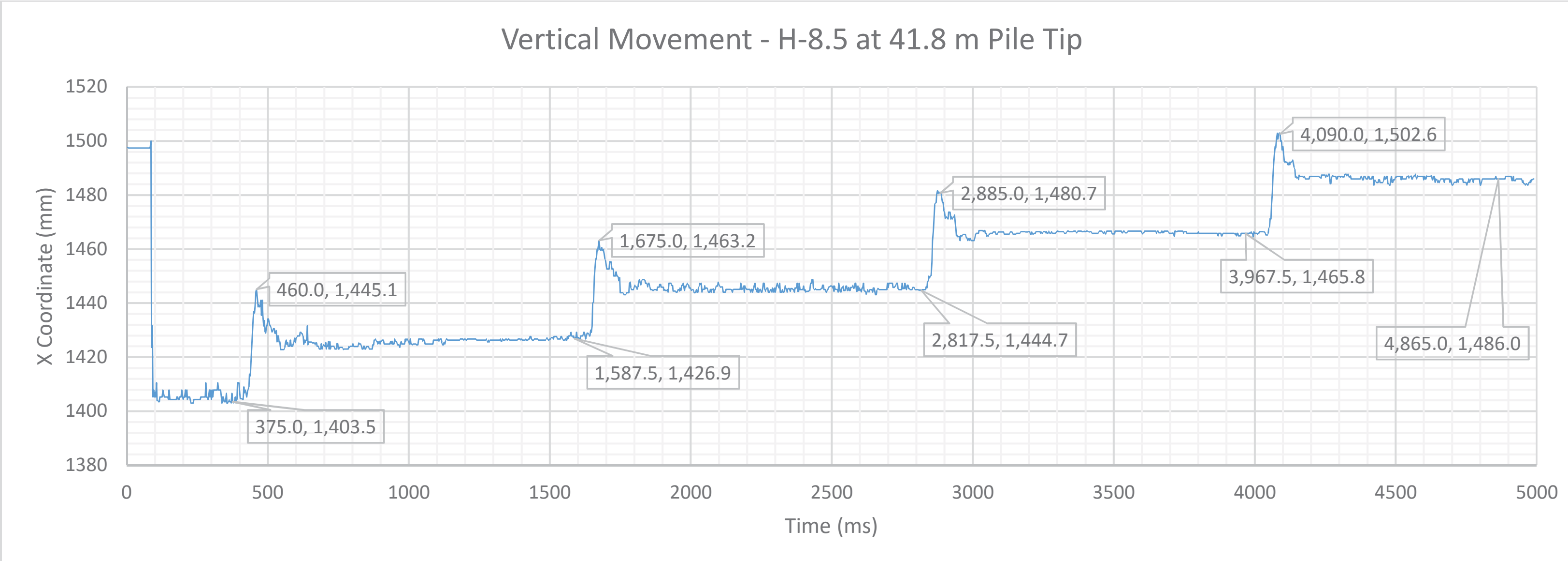
Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 139 m. The final set was 1.39 mm/blow.

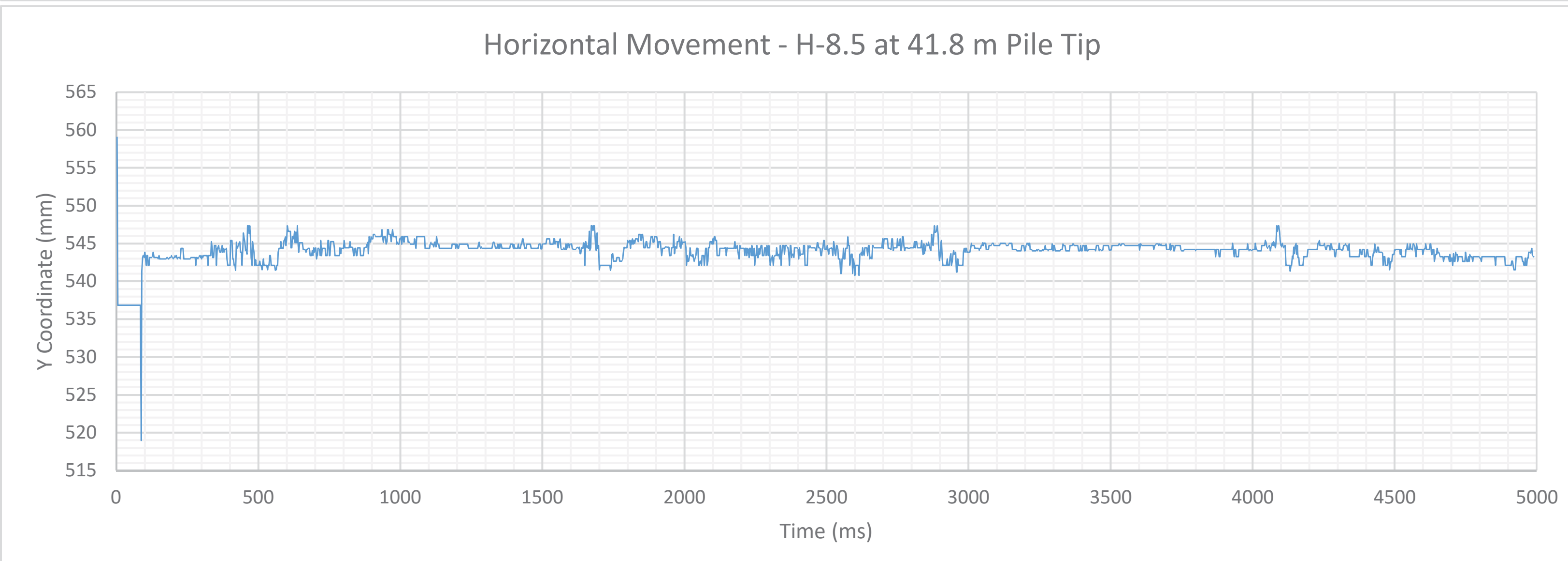


Vertical Movement - H-8.5 at 20.6 m Pile Tip
X Coordinate (mm)
Time (ms)
2,975.0, 1,260.7
1,677.5, 1,218.0
3,985.0, 1,251.0
2,915.0, 1,211.7
347.5, 1,178.3
1,537.5, 1,166.7
262.5, 1,123.3



Horizontal Movement - H-8.5 at 20.6 m Pile Tip
Y Coordinate (mm)
Time (ms)


Vertical Movement - H-8.5 at 41.8 m Pile Tip
X Coordinate (mm)
Time (ms)
1520
1500
1480
1460
1440
1420
1400
1380
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
4,090.0, 1,502.6
2,885.0, 1,480.7
1,675.0, 1,463.2
460.0, 1,445.1
3,967.5, 1,465.8
2,817.5, 1,444.7
4,865.0, 1,486.0
1,587.5, 1,426.9
375.0, 1,403.5


Horizontal Movement - H-8.5 at 41.8 m Pile Tip
Y Coordinate (mm)
Time (ms)
565
560
555
550
545
540
535
530
525
520
515
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes: Helmet was changed on September 26, 2013, the mass is an approximate value from Tom Jones

PILE DETAILS

Pile No. H-8.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** 1:10 **Total Length (m):** 45.9 **Mass (kg):** 6098.4

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.5	0.1	21.2	0.1	14.8	11.1	
Start Time:	12:50	13:35	14:53	15:40	16:52		
End Time:	13:15	14:30	15:10	16:50	17:01		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.3 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

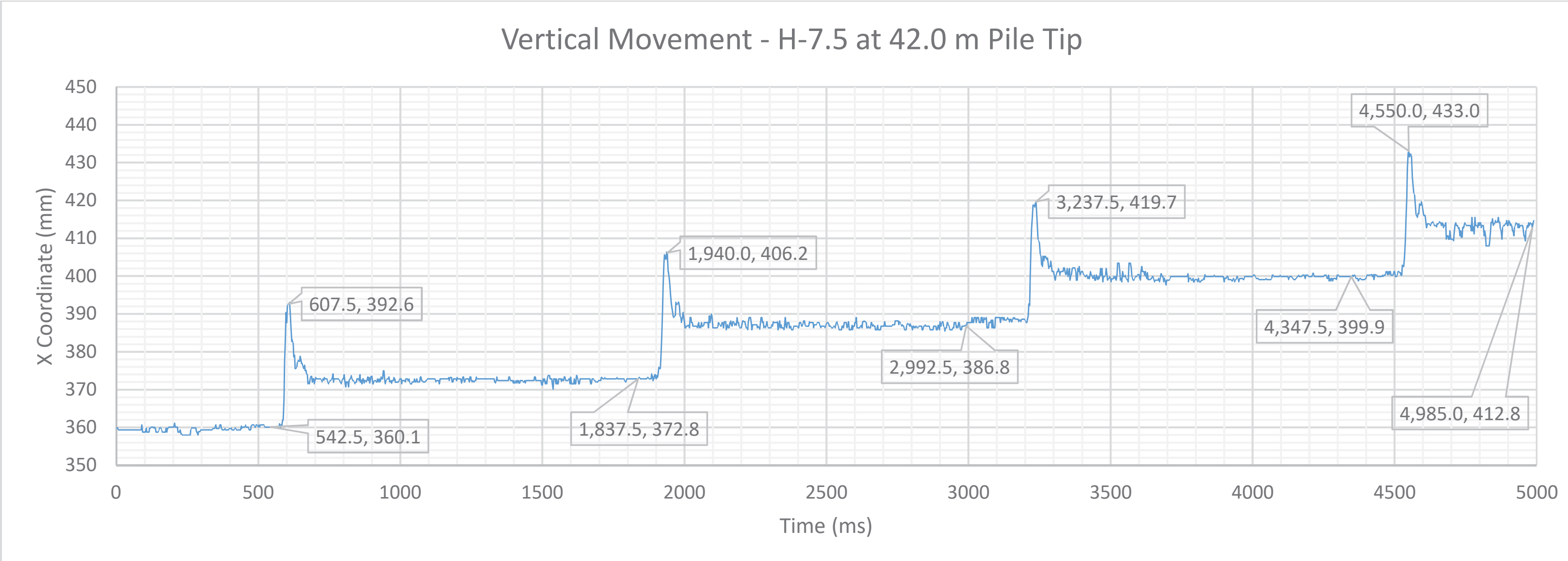
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	4	**12.2**	5	**18.2**	6	**24.2**	5	**30.2**	5	**36.2**	6
0.4		**6.4**	5	**12.4**	5	**18.4**	5	**24.4**	5	**30.4**	5	**36.4**	5
0.6		**6.6**	4	**12.6**	5	**18.6**	5	**24.6**	7	**30.6**	7	**36.6**	5
0.8		**6.8**	5	**12.8**	5	**18.8**	6	**24.8**	6	**30.8**	9	**36.8**	6
1.0		**7.0**	5	**13.0**	5	**19.0**	5	**25.0**	5	**31.0**	7	**37.0**	5
1.2		**7.2**	3	**13.2**	5	**19.2**	6	**25.2**	6	**31.2**	7	**37.2**	5
1.4		**7.4**	5	**13.4**	4	**19.4**	6	**25.4**	6	**31.4**	8	**37.4**	6
1.6		**7.6**	4	**13.6**	3	**19.6**	6	**25.6**	6	**31.6**	7	**37.6**	6
1.8	↓	**7.8**	5	**13.8**	5	**19.8**	5	**25.8**	6	**31.8**	7	**37.8**	5
2.0	12	**8.0**	5	**14.0**	5	**20.0**	6	**26.0**	6	**32.0**	6	**38.0**	5
2.2	7	**8.2**	5	**14.2**	5	**20.2**	7	**26.2**	5	**32.2**	7	**38.2**	5
2.4	7	**8.4**	4	**14.4**	6	**20.4**	7	**26.4**	7	**32.4**	6	**38.4**	5
2.6	7	**8.6**	5	**14.6**	6	**20.6**	5	**26.6**	7	**32.6**	7	**38.6**	5
2.8	7	**8.8**	5	**14.8**	5	**20.8**	7	**26.8**	5	**32.8**	7	**38.8**	4
3.0	7	**9.0**	4	**15.0**	4	**21.0**	7	**27.0**	6	**33.0**	8	**39.0**	6
3.2	6	**9.2**	6	**15.2**	4	**21.2**	6	**27.2**	5	**33.2**	6	**39.2**	5
3.4	7	**9.4**	5	**15.4**	5	**21.4**	7	**27.4**	7	**33.4**	7	**39.4**	6
3.6	6	**9.6**	5	**15.6**	5	**21.6**	7	**27.6**	6	**33.6**	6	**39.6**	7
3.8	6	**9.8**	4	**15.8**	5	**21.8**	5	**27.8**	5	**33.8**	5	**39.8**	6
4.0	5	**10.0**	5	**16.0**	6	**22.0**	5	**28.0**	6	**34.0**	6	**40.0**	5
4.2	6	**10.2**	5	**16.2**	5	**22.2**	6	**28.2**	5	**34.2**	6	**40.2**	5
4.4	7	**10.4**	5	**16.4**	6	**22.4**	6	**28.4**	7	**34.4**	6	**40.4**	7
4.6	3	**10.6**	4	**16.6**	6	**22.6**	5	**28.6**	6	**34.6**	5	**40.6**	5
4.8	4	**10.8**	5	**16.8**	6	**22.8**	7	**28.8**	5	**34.8**	6	**40.8**	7
5.0	5	**11.0**	5	**17.0**	6	**23.0**	6	**29.0**	6	**35.0**	5	**41.0**	5
5.2	5	**11.2**	4	**17.2**	5	**23.2**	6	**29.2**	6	**35.2**	6	**41.2**	6
5.4	4	**11.4**	5	**17.4**	6	**23.4**	6	**29.4**	5	**35.4**	4	**41.4**	5
5.6	4	**11.6**	5	**17.6**	5	**23.6**	6	**29.6**	6	**35.6**	6	**41.6**	
5.8	5	**11.8**	5	**17.8**	6	**23.8**	6	**29.8**	5	**35.8**	5	**41.8**	27
6.0	5	**12.0**	5	**18.0**	6	**24.0**	5	**30.0**	6	**36.0**	6	**42.0**	25

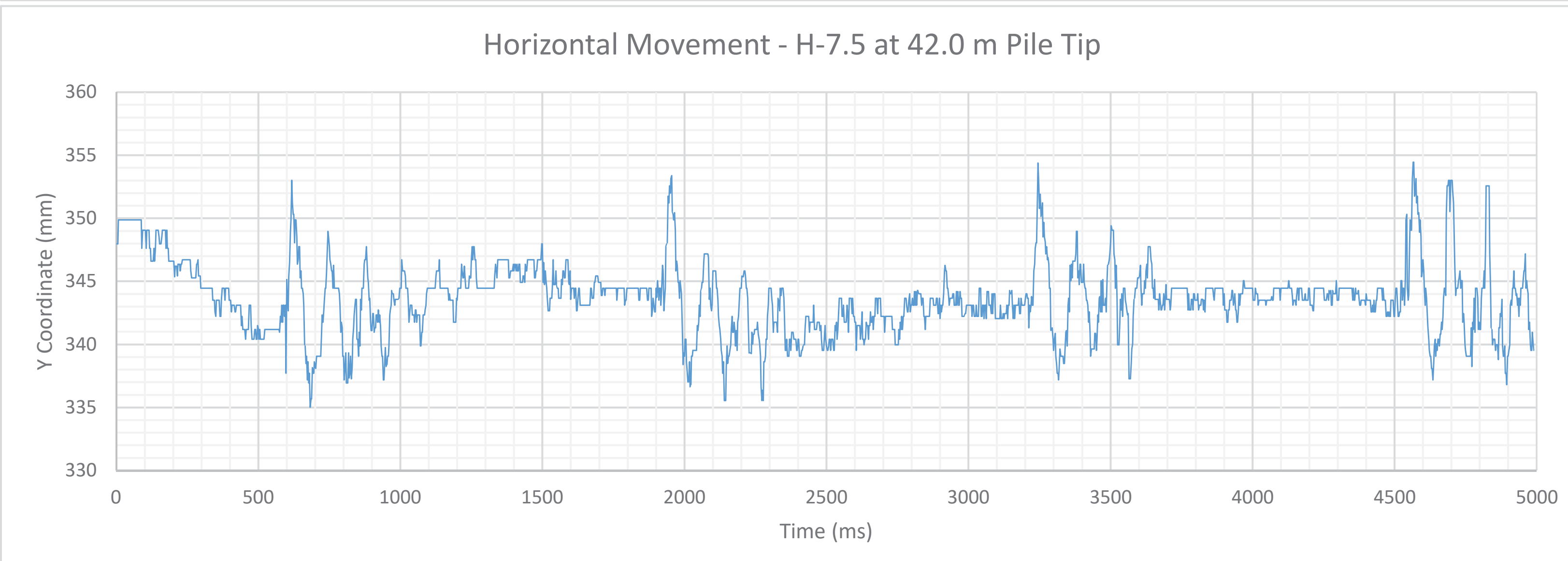
42.2	17	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	9	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	13	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	12	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	12	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	18	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	16	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	18	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	18	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	18	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	19	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	20	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	24	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	15	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	20	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	16	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	17	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	25	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	27	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	Set	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**	
2 to 16	48 to 51	Hammer Setting 3
16 to 28	45 to 46	Hammer Setting 3
28 to 41	43 to 44	Hammer Setting 3
44 to 45	47 to 46	Hammer Setting 2
45 to 45.8	45 to 43	Hammer Setting 2

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.3 m. The final set was 1.16 mm/blow.


Vertical Movement - H-7.5 at 42.0 m Pile Tip
X Coordinate (mm)
Time (ms)
450
440
430
420
410
400
390
380
370
360
350
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
607.5, 392.6
542.5, 360.1
1,837.5, 372.8
1,940.0, 406.2
2,992.5, 386.8
3,237.5, 419.7
4,347.5, 399.9
4,550.0, 433.0
4,985.0, 412.8


Horizontal Movement - H-7.5 at 42.0 m Pile Tip
Y Coordinate (mm)
Time (ms)
360
355
350
345
340
335
330
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION							
Type: Diesel		**Model:** D46-32			**Make:** Delmag		
Hammer Weight (kg): 4600		**Fall (m):** 1.42 to 3.5			**Mass of Helmet (kg):** ~908		
Rated Energy (kJ Range): 71 to 166			**Hammer Cushion:** Yes				
Other Notes: Helmet was changed on September 26, 2013, the mass is an approximate value from Tom Jones							
PILE DETAILS							
Pile No. H-7.5		**Pile Type:** H-Pile		**Design Capacity:** 3000 kN		**Size:** 360x132	
Pile Shoe: Rock Injector		**Batter (H:V):** 1:10		**Total Length (m):** 45.5		**Mass (kg):** 6045.6	
Pile Segment	**Section 1**	**Splice 1**	**Section 2**	**Splice 2**	**Section 3**	**Splice 3**	**Section 4**
Length / Cut Off (m)	21.5	0	21.2	0.0	11.1	8.0	
Start Time:	8:00	8:43	9:46	11:22	12:20		
End Time:	8:16	9:40	10:05	12:10	12:45		
Set Criteria (mm/blow) <1.5 - 2		**Actual Tip Elev. (m):** 138.7			**Cut off Elev. (m):** 184.5		
Approximate Ground Elev. (m) 184.8							

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	8	**12.2**		**18.2**	4	**24.2**	5	**30.2**	7	**36.2**	9
0.4		**6.4**	9	**12.4**		**18.4**	5	**24.4**	6	**30.4**	7	**36.4**	8
0.6		**6.6**	9	**12.6**		**18.6**	4	**24.6**	5	**30.6**	8	**36.6**	9
0.8		**6.8**	8	**12.8**		**18.8**	5	**24.8**	7	**30.8**	9	**36.8**	10
1.0		**7.0**	7	**13.0**		**19.0**	6	**25.0**	7	**31.0**	9	**37.0**	9
1.2		**7.2**	8	**13.2**		**19.2**	5	**25.2**	7	**31.2**	10	**37.2**	8
1.4		**7.4**	7	**13.4**		**19.4**	4	**25.4**	7	**31.4**	12	**37.4**	10
1.6		**7.6**	6	**13.6**		**19.6**	4	**25.6**	9	**31.6**	10	**37.6**	9
1.8		**7.8**	5	**13.8**		**19.8**	5	**25.8**	8	**31.8**	11	**37.8**	11
2.0		**8.0**	7	**14.0**		**20.0**	5	**26.0**	8	**32.0**	11	**38.0**	11
2.2		**8.2**	7	**14.2**		**20.2**	5	**26.2**	8	**32.2**	9	**38.2**	10
2.4		**8.4**	6	**14.4**		**20.4**		**26.4**	9	**32.4**	11	**38.4**	11
2.6		**8.6**	6	**14.6**		**20.6**		**26.6**	9	**32.6**	10	**38.6**	12
2.8		**8.8**	6	**14.8**	↓	**20.8**	↓	**26.8**	8	**32.8**	10	**38.8**	11
3.0		**9.0**	6	**15.0**	IR	**21.0**	16	**27.0**	9	**33.0**	11	**39.0**	13
3.2		**9.2**	6	**15.2**	8	**21.2**	7	**27.2**	8	**33.2**	8	**39.2**	11
3.4		**9.4**	5	**15.4**	7	**21.4**	6	**27.4**	8	**33.4**	8	**39.4**	12
3.6		**9.6**	6	**15.6**	6	**21.6**	6	**27.6**	9	**33.6**	9	**39.6**	12
3.8		**9.8**	6	**15.8**	6	**21.8**	5	**27.8**	10	**33.8**	9	**39.8**	13
4.0		**10.0**	6	**16.0**	6	**22.0**	7	**28.0**	8	**34.0**	8	**40.0**	12
4.2		**10.2**		**16.2**	4	**22.2**	7	**28.2**	8	**34.2**	9	**40.2**	13
4.4		**10.4**		**16.4**	5	**22.4**	6	**28.4**	10	**34.4**	9	**40.4**	12
4.6		**10.6**		**16.6**	4	**22.6**	5	**28.6**	10	**34.6**	7	**40.6**	13
4.8		**10.8**		**16.8**	5	**22.8**	7	**28.8**	10	**34.8**	10	**40.8**	19
5.0		**11.0**		**17.0**	5	**23.0**	6	**29.0**	10	**35.0**	9	**41.0**	21
5.2		**11.2**		**17.2**	4	**23.2**	5	**29.2**	8	**35.2**	7	**41.2**	14
5.4		**11.4**		**17.4**	4	**23.4**	7	**29.4**	9	**35.4**	9	**41.4**	20
5.6		**11.6**		**17.6**	5	**23.6**	6	**29.6**	9	**35.6**	9	**41.6**	15
5.8	↓	**11.8**		**17.8**	4	**23.8**	6	**29.8**	8	**35.8**	9	**41.8**	15
6.0	IR	**12.0**	↓	**18.0**	5	**24.0**	6	**30.0**	8	**36.0**	9	**42.0**	15

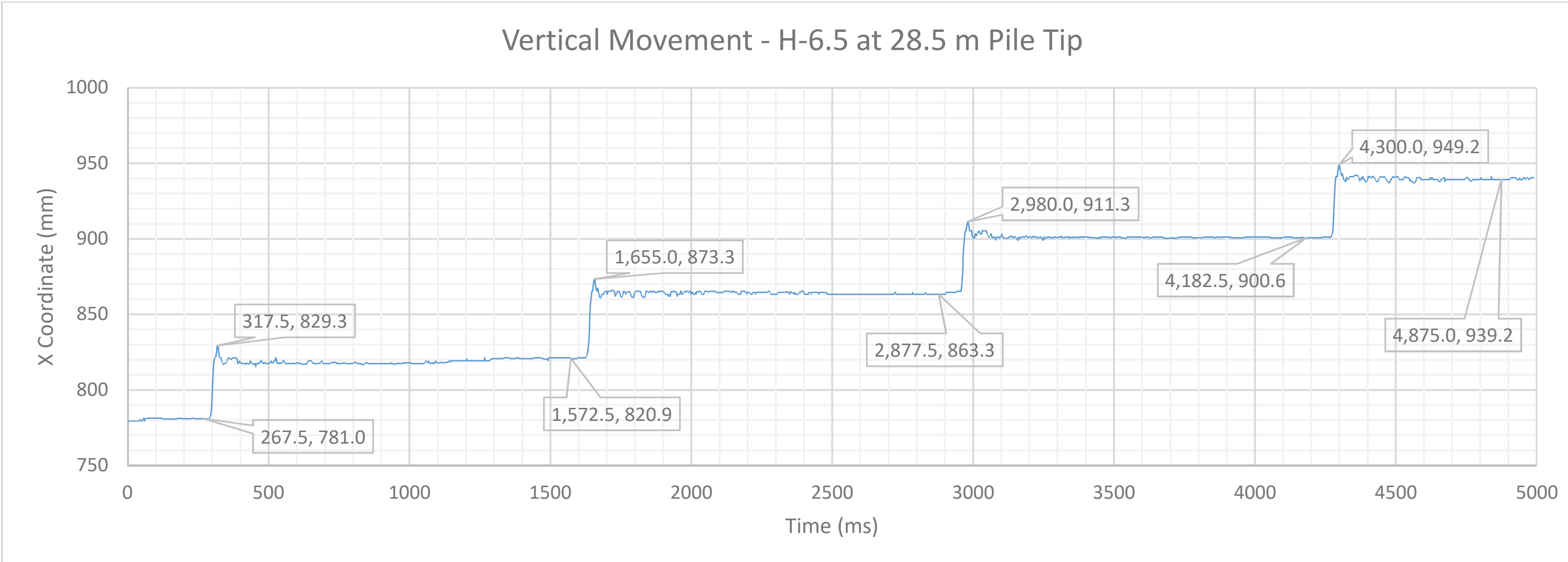
42.2	23	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	21	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	17	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	18	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	20	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	24	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	24	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	25	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	24	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	32	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	54	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	44	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	64	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	78	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	81	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	68	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	71	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	88	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	100	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	Set	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

ADDITONAL NOTES/OBSERVATIONS

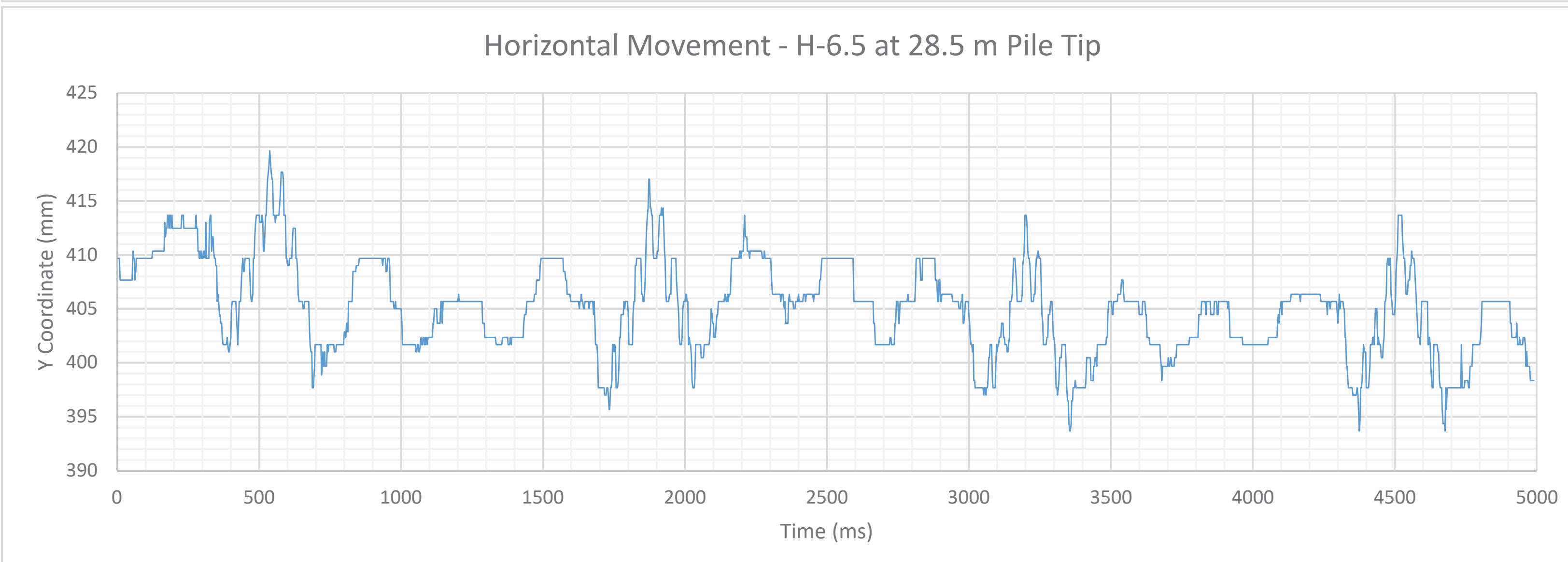
IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
15 to 18	50	Hammer Setting 3
18 to 20	47	Hammer Setting 3
20 to 26	45 to 47	Hammer Setting 3
26 to 42	43 to 39	Hammer Setting 3
42 to 46	46 to 41	Hammer Setting 2

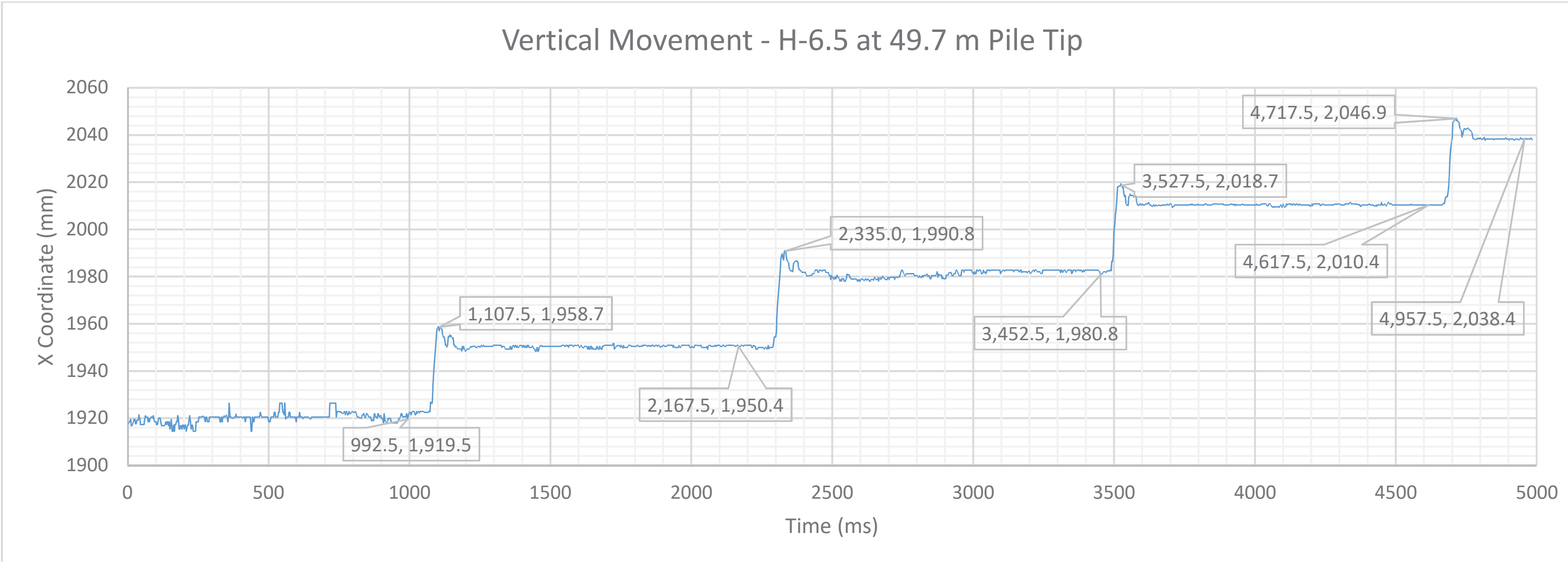
Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.7 m. The final set was 0.7 mm/blow.

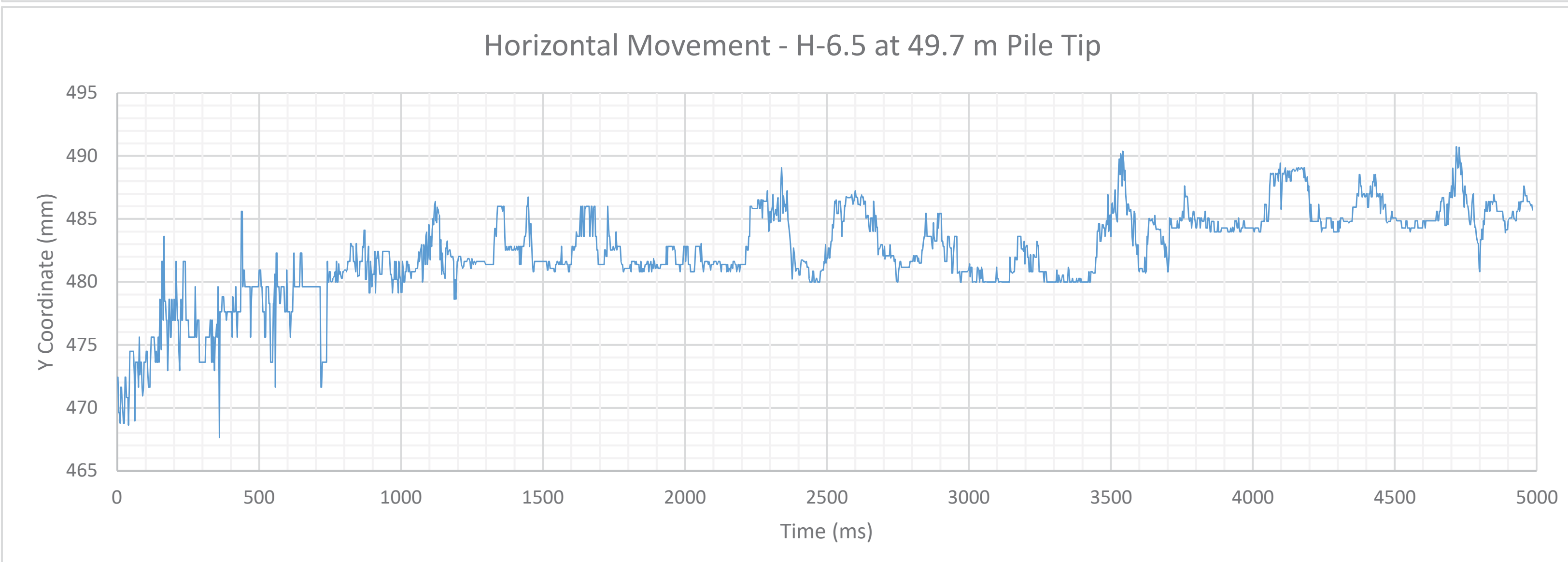


Vertical Movement - H-6.5 at 28.5 m Pile Tip
X Coordinate (mm)
Time (ms)
317.5, 829.3
267.5, 781.0
1,655.0, 873.3
1,572.5, 820.9
2,980.0, 911.3
2,877.5, 863.3
4,300.0, 949.2
4,182.5, 900.6
4,875.0, 939.2



Horizontal Movement - H-6.5 at 28.5 m Pile Tip
Y Coordinate (mm)
Time (ms)


Vertical Movement - H-6.5 at 49.7 m Pile Tip
X Coordinate (mm)
Time (ms)
2060
2040
2020
2000
1980
1960
1940
1920
1900
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
4,717.5, 2,046.9
3,527.5, 2,018.7
2,335.0, 1,990.8
4,617.5, 2,010.4
1,107.5, 1,958.7
4,957.5, 2,038.4
3,452.5, 1,980.8
2,167.5, 1,950.4
992.5, 1,919.5


Horizontal Movement - H-6.5 at 49.7 m Pile Tip
Y Coordinate (mm)
Time (ms)
495
490
485
480
475
470
465
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes: Helmet was changed on September 26, 2013, the mass is an approximate value from Tom Jones

PILE DETAILS

Pile No. H-6.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** 1:10 **Total Length (m):** 44.4 **Mass (kg):** 5900.4

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	8.3	0.0	21.2	0.0	21.2	6.0	
Start Time:	15:07	15:42	17:15	7:45	8:40		
End Time:	15:09	17:05	17:28	8:30	9:20		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 139.8 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**	5	**18.2**	4	**24.2**	4	**30.2**	8	**36.2**	7
0.4		**6.4**		**12.4**	4	**18.4**	4	**24.4**	4	**30.4**	10	**36.4**	9
0.6		**6.6**		**12.6**	5	**18.6**	4	**24.6**	4	**30.6**	10	**36.6**	8
0.8		**6.8**		**12.8**	4	**18.8**	5	**24.8**	4	**30.8**	10	**36.8**	8
1.0		**7.0**		**13.0**	5	**19.0**	5	**25.0**	5	**31.0**	9	**37.0**	8
1.2		**7.2**	↓	**13.2**	4	**19.2**	4	**25.2**	5	**31.2**	9	**37.2**	8
1.4		**7.4**	IR	**13.4**	4	**19.4**	5	**25.4**	4	**31.4**	9	**37.4**	9
1.6		**7.6**	9	**13.6**	5	**19.6**	4	**25.6**	4	**31.6**	9	**37.6**	8
1.8		**7.8**	4	**13.8**	5	**19.8**	4	**25.8**	4	**31.8**	8	**37.8**	9
2.0		**8.0**	7	**14.0**	4	**20.0**	4	**26.0**	5	**32.0**	8	**38.0**	9
2.2		**8.2**	10	**14.2**	5	**20.2**	3	**26.2**	4	**32.2**	8	**38.2**	9
2.4		**8.4**	5	**14.4**	4	**20.4**	3	**26.4**	6	**32.4**	10	**38.4**	10
2.6		**8.6**	4	**14.6**	4	**20.6**	4	**26.6**	6	**32.6**	8	**38.6**	9
2.8	↓	**8.8**		**14.8**	4	**20.8**	4	**26.8**	6	**32.8**	7	**38.8**	9
3.0	IR	**9.0**		**15.0**	5	**21.0**	3	**27.0**	6	**33.0**	8	**39.0**	11
3.2	12	**9.2**		**15.2**	4	**21.2**	4	**27.2**	5	**33.2**	8	**39.2**	10
3.4	6	**9.4**		**15.4**	5	**21.4**	4	**27.4**	5	**33.4**	7	**39.4**	12
3.6	8	**9.6**	↓	**15.6**	5	**21.6**	3	**27.6**	6	**33.6**	7	**39.6**	10
3.8	8	**9.8**	IR	**15.8**	5	**21.8**	4	**27.8**	7	**33.8**	7	**39.8**	10
4.0	8	**10.0**	4	**16.0**	4	**22.0**	3	**28.0**	-	**34.0**	7	**40.0**	11
4.2	7	**10.2**	4	**16.2**	5	**22.2**	4	**28.2**	-	**34.2**	7	**40.2**	10
4.4	8	**10.4**	5	**16.4**	4	**22.4**	4	**28.4**	-	**34.4**	7	**40.4**	9
4.6	10	**10.6**	5	**16.6**	5	**22.6**	3	**28.6**	-	**34.6**	8	**40.6**	11
4.8		**10.8**	4	**16.8**	5	**22.8**	3	**28.8**	7	**34.8**	7	**40.8**	10
5.0		**11.0**	4	**17.0**	4	**23.0**	4	**29.0**	8	**35.0**	8	**41.0**	10
5.2		**11.2**	5	**17.2**	4	**23.2**	4	**29.2**	6	**35.2**	6	**41.2**	9
5.4		**11.4**	5	**17.4**	4	**23.4**	4	**29.4**	6	**35.4**	9	**41.4**	11
5.6		**11.6**	5	**17.6**	5	**23.6**	3	**29.6**	8	**35.6**	7	**41.6**	13
5.8		**11.8**	5	**17.8**	5	**23.8**	4	**29.8**	8	**35.8**	10	**41.8**	14
6.0	↓	**12.0**	5	**18.0**	5	**24.0**	3	**30.0**	9	**36.0**	8	**42.0**	15

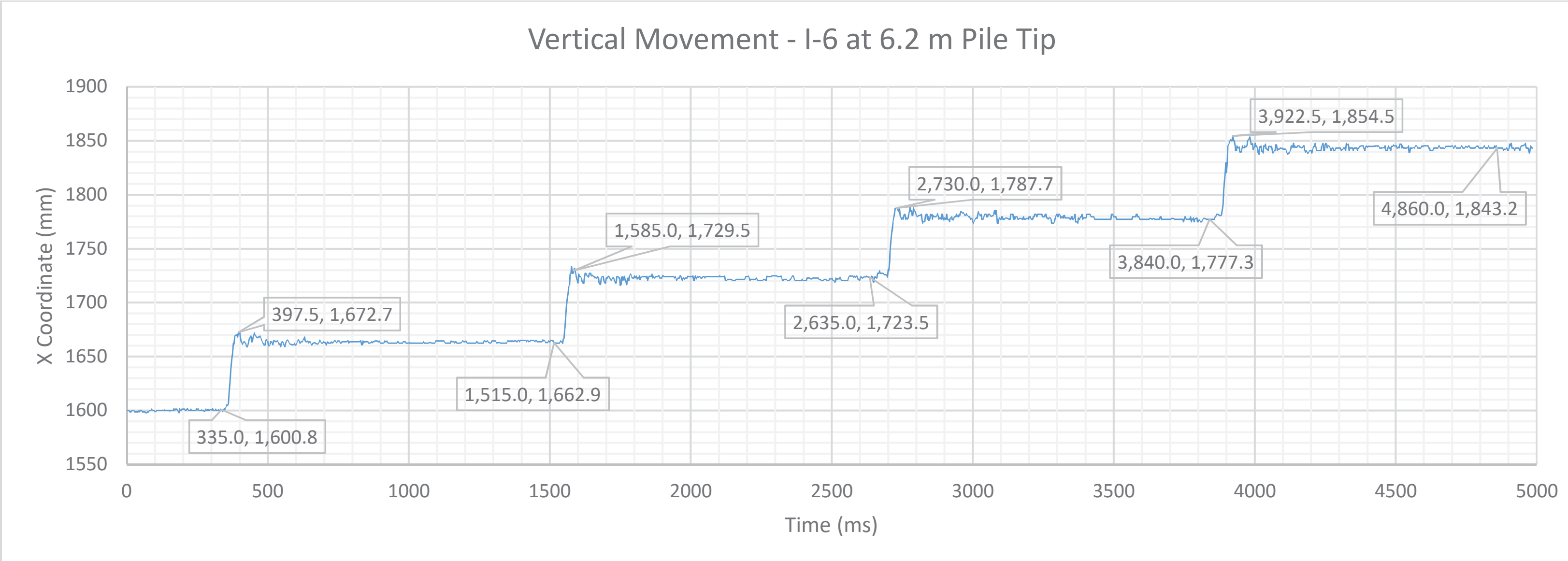
42.2	15	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	15	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	15	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	18	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	19	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	19	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	22	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	27	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	26	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	29	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	38	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	71	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	Set	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8		**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0		**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2		**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4		**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6		**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8		**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

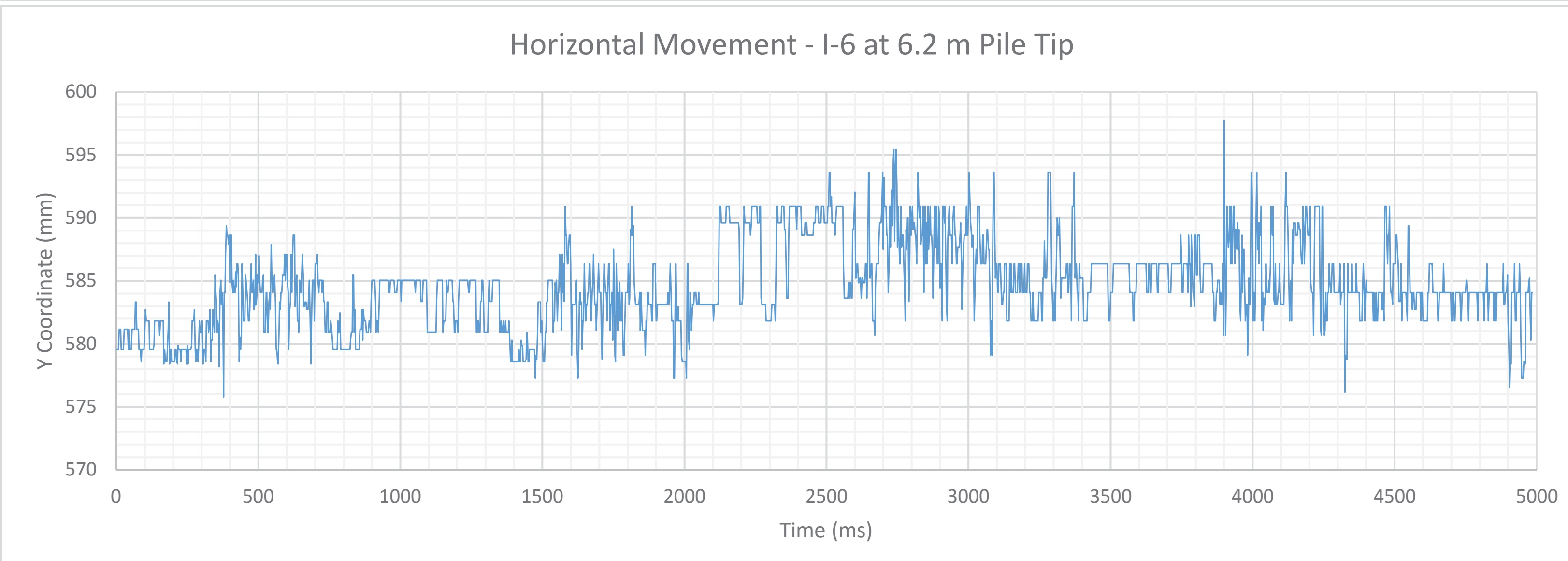
ADDITONAL NOTES/OBSERVATIONS

IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
11 to 30	52 to 46	Hammer Setting 3
30 to 41	45 to 43	Hammer Setting 3
41 to 44.2	47 to 43	Hammer Setting 3
44.2	43	Hammer Setting 2 then 1

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 139.8 m. The final set was 0.46 mm/blow.


Vertical Movement - I-6 at 6.2 m Pile Tip
X Coordinate (mm)
Time (ms)
335.0, 1,600.8
397.5, 1,672.7
1,515.0, 1,662.9
1,585.0, 1,729.5
2,635.0, 1,723.5
2,730.0, 1,787.7
3,840.0, 1,777.3
3,922.5, 1,854.5
4,860.0, 1,843.2


Horizontal Movement - I-6 at 6.2 m Pile Tip
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes: Helmet was changed on September 26, 2013, the mass is an approximate value from Tom Jones

PILE DETAILS

Pile No. I-6 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** Vertical **Total Length (m):** 46.0 **Mass (kg):** 6111.6

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	6.3	0.1	21.2	0.0	21.2	2.3	
Start Time:	10:46	11:30	12:25	13:35	14:25		
End Time:	10:50	12:20	12:40	15:05	15:05		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.2 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	5	**12.2**	5	**18.2**	8	**24.2**	7	**30.2**	14	**36.2**	10
0.4		**6.4**	6	**12.4**	4	**18.4**	8	**24.4**	7	**30.4**	9	**36.4**	9
0.6		**6.6**	8	**12.6**	3	**18.6**	7	**24.6**	9	**30.6**	13	**36.6**	10
0.8		**6.8**	8	**12.8**	5	**18.8**	8	**24.8**	7	**30.8**	11	**36.8**	12
1.0		**7.0**	8	**13.0**	4	**19.0**	7	**25.0**	9	**31.0**	11	**37.0**	10
1.2		**7.2**	8	**13.2**	4	**19.2**	8	**25.2**	9	**31.2**	10	**37.2**	11
1.4		**7.4**	7	**13.4**	4	**19.4**	6	**25.4**	4	**31.4**	11	**37.4**	11
1.6		**7.6**	7	**13.6**	6	**19.6**	7	**25.6**	4	**31.6**	11	**37.6**	11
1.8		**7.8**	7	**13.8**	5	**19.8**	6	**25.8**	5	**31.8**	11	**37.8**	11
2.0		**8.0**	8	**14.0**	6	**20.0**	6	**26.0**		**32.0**	14	**38.0**	9
2.2		**8.2**	6	**14.2**	6	**20.2**	7	**26.2**		**32.2**	13	**38.2**	10
2.4		**8.4**	7	**14.4**	6	**20.4**	7	**26.4**		**32.4**	10	**38.4**	11
2.6		**8.6**	6	**14.6**	7	**20.6**	7	**26.6**		**32.6**	9	**38.6**	11
2.8		**8.8**	5	**14.8**	7	**20.8**	7	**26.8**	9	**32.8**	11	**38.8**	11
3.0		**9.0**	5	**15.0**	7	**21.0**	9	**27.0**	10	**33.0**	11	**39.0**	11
3.2		**9.2**	4	**15.2**	7	**21.2**	7	**27.2**	8	**33.2**	10	**39.2**	10
3.4		**9.4**	4	**15.4**	8	**21.4**	8	**27.4**	10	**33.4**	8	**39.4**	10
3.6		**9.6**	4	**15.6**	7	**21.6**	7	**27.6**	8	**33.6**	9	**39.6**	10
3.8		**9.8**	5	**15.8**	7	**21.8**	8	**27.8**	10	**33.8**	10	**39.8**	9
4.0		**10.0**	4	**16.0**	7	**22.0**	7	**28.0**	11	**34.0**	8	**40.0**	8
4.2		**10.2**	4	**16.2**	7	**22.2**	7	**28.2**	12	**34.2**	11	**40.2**	11
4.4		**10.4**	4	**16.4**	8	**22.4**	6	**28.4**	9	**34.4**	10	**40.4**	7
4.6		**10.6**	4	**16.6**	10	**22.6**	7	**28.6**	9	**34.6**	10	**40.6**	9
4.8	↓	**10.8**	4	**16.8**	8	**22.8**	6	**28.8**	9	**34.8**	10	**40.8**	8
5.0	IR	**11.0**	5	**17.0**	9	**23.0**	7	**29.0**	10	**35.0**	11	**41.0**	9
5.2		**11.2**	5	**17.2**	8	**23.2**	7	**29.2**	11	**35.2**	11	**41.2**	9
5.4		**11.4**	5	**17.4**	8	**23.4**	6	**29.4**	10	**35.4**	11	**41.4**	9
5.6		**11.6**	5	**17.6**	7	**23.6**	6	**29.6**	13	**35.6**	11	**41.6**	8
5.8	↓	**11.8**	5	**17.8**	7	**23.8**	6	**29.8**	12	**35.8**	11	**41.8**	8
6.0	14	**12.0**	5	**18.0**	7	**24.0**	7	**30.0**	11	**36.0**	10	**42.0**	8

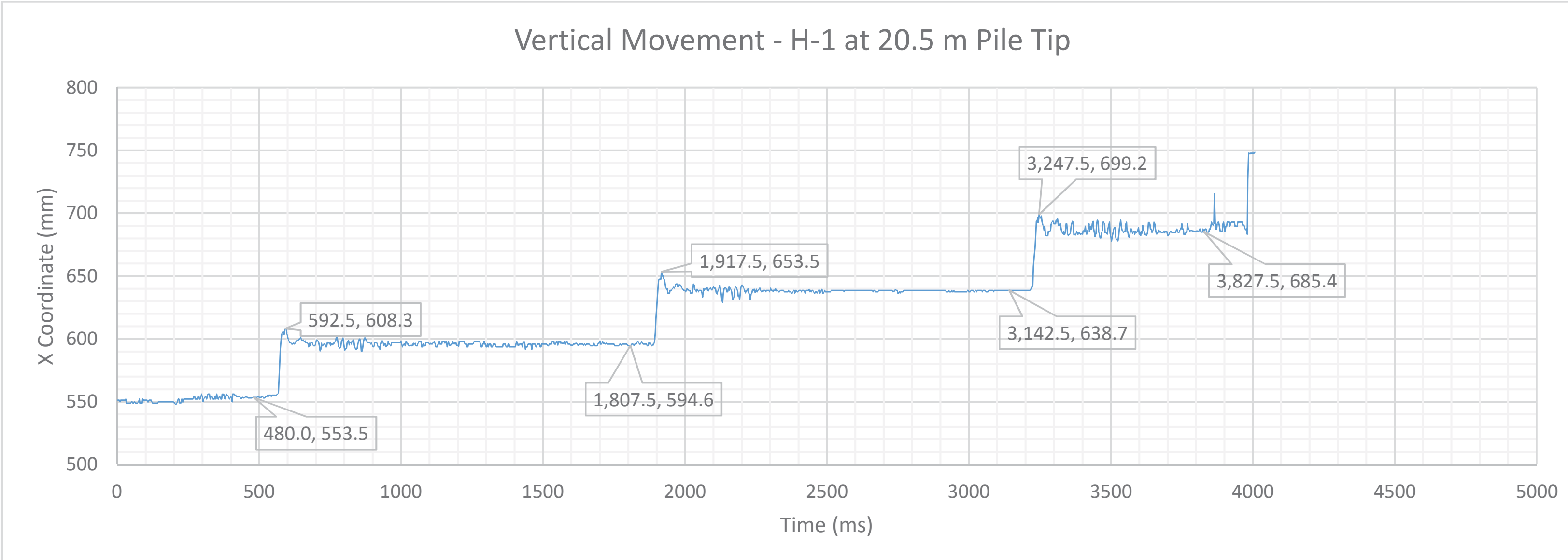
42.2	8	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	9	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	10	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	10	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	12	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	13	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	15	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	17	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	19	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	16	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	27	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	44	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	42	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	38	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	55	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	104	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	110	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	119	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	Set	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

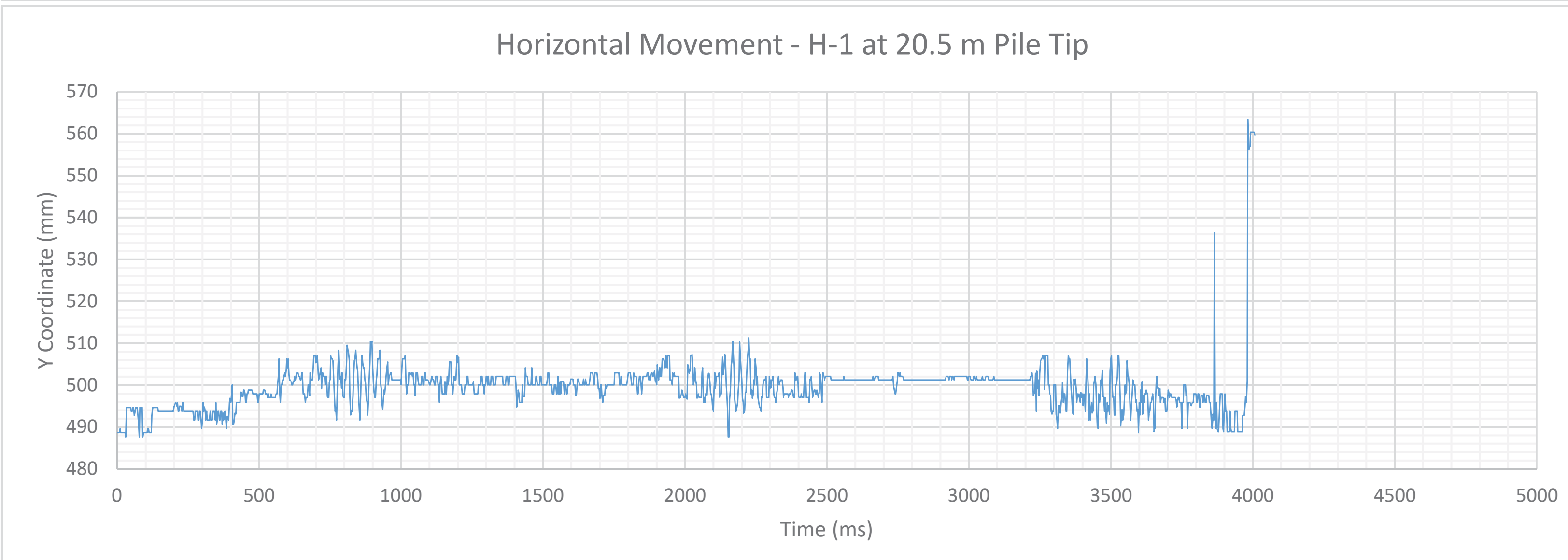
ADDITONAL NOTES/OBSERVATIONS

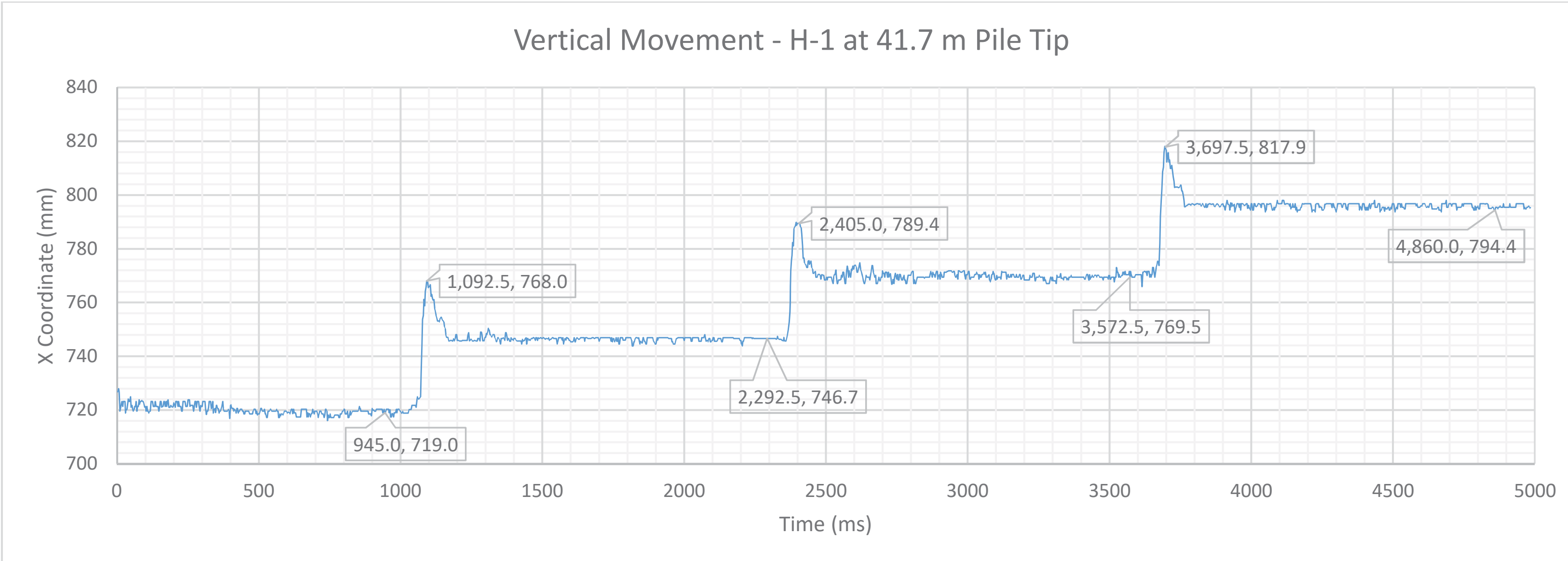
Depth (m)	**BPM**	
6 to 25	44 to 48	Hammer Setting 3
27 to 40	47 to 49	Hammer Setting 3
40 to 44.6	45 to 41	Hammer Setting 3
44.6 to 45	42 to 41	Hammer Setting 2
45 to 45.8	46 to 45	Hammer Setting 1

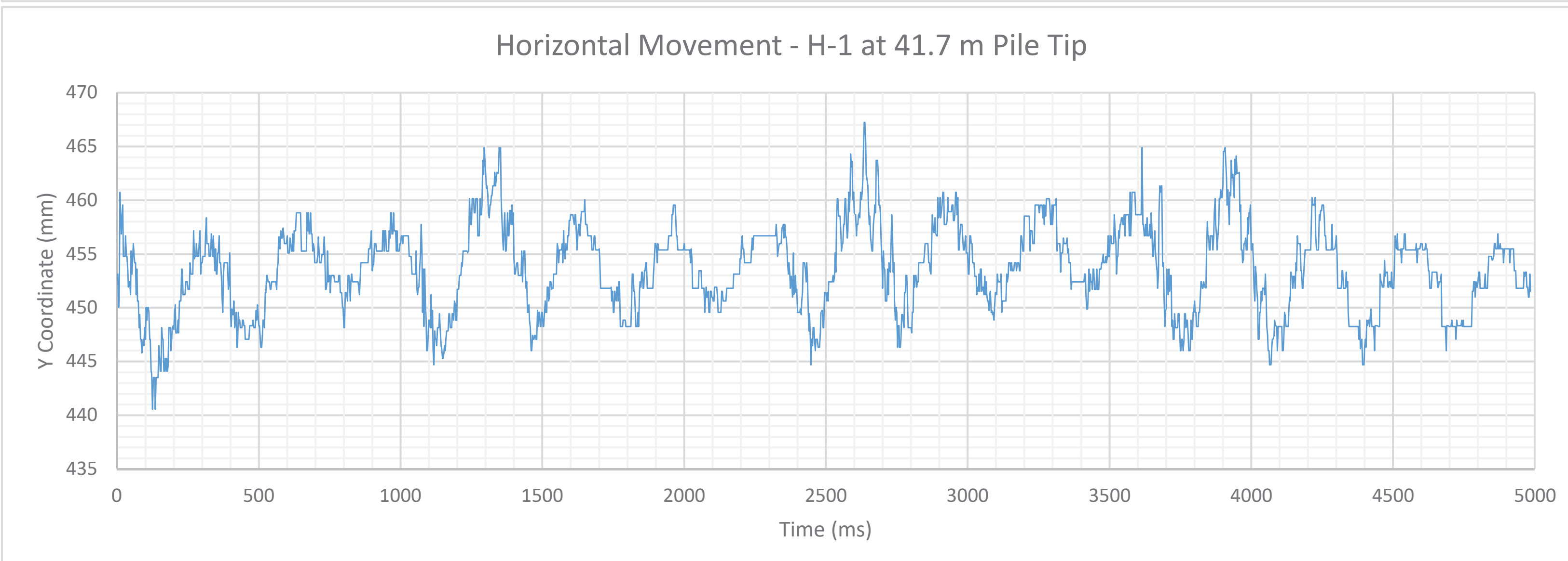
IR - Insufficient Soil Resistance for Sustained Driving

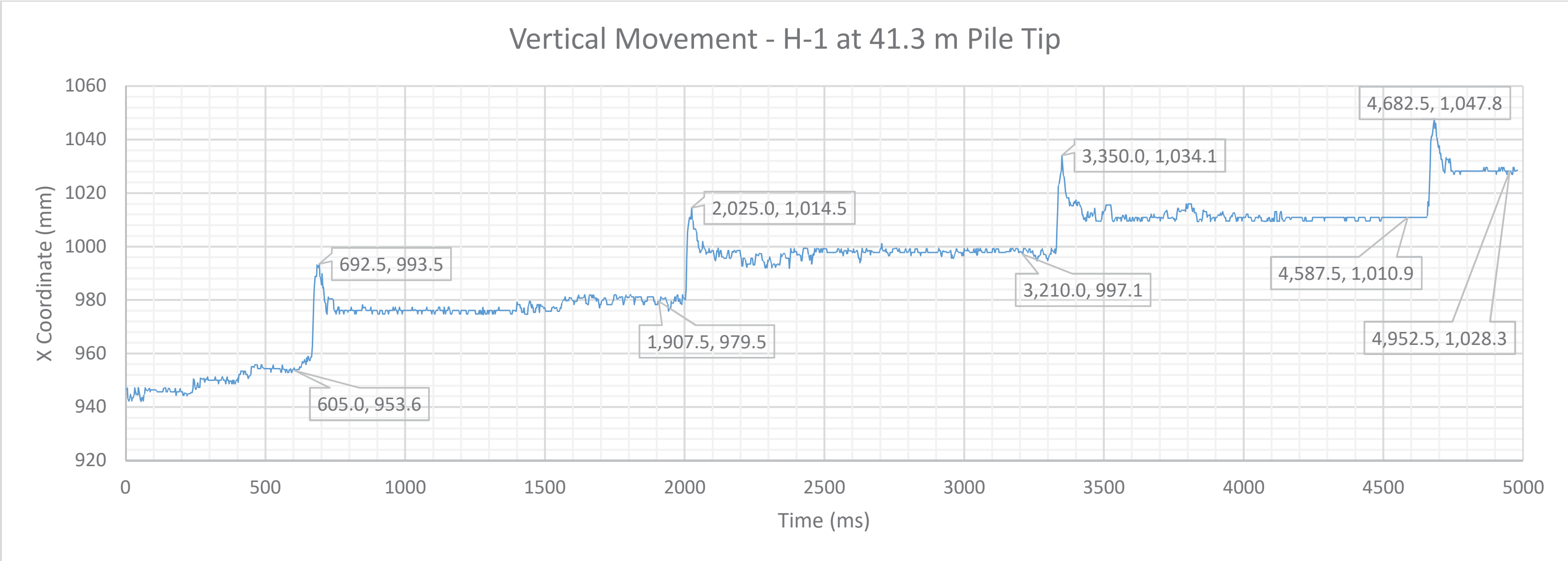
Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.2 m. The final set was 1.32 mm/blow.

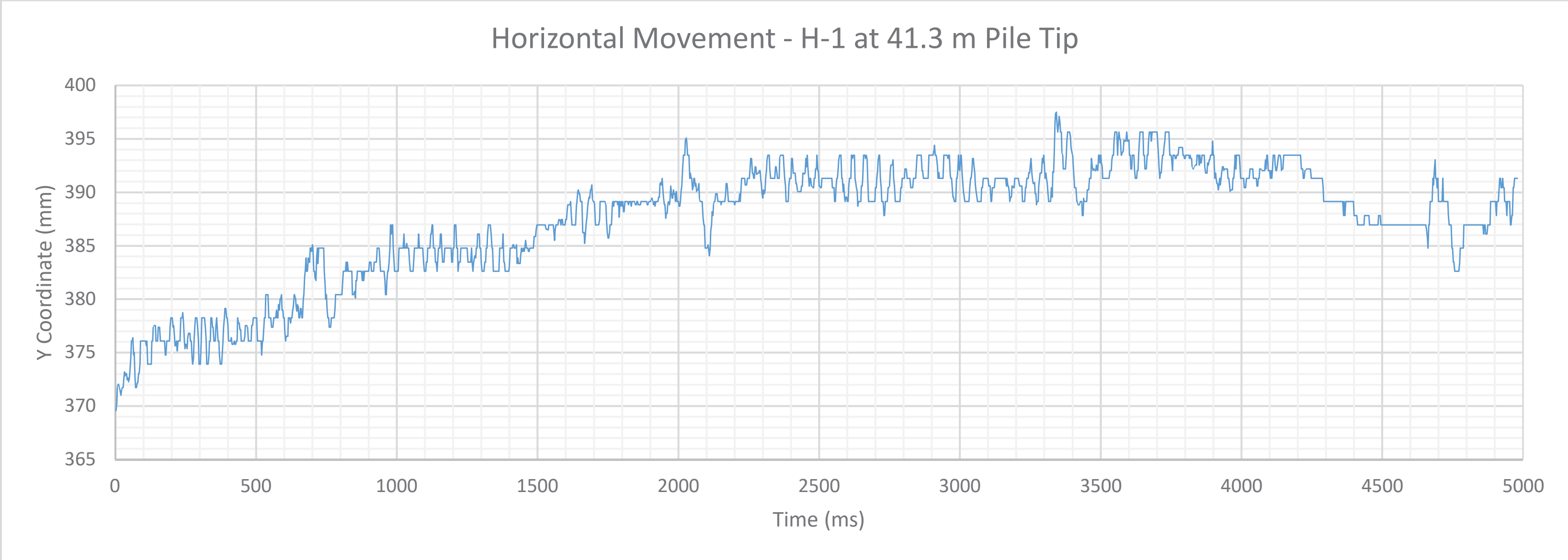

Vertical Movement - H-1 at 20.5 m Pile Tip
X Coordinate (mm)
Time (ms)
800
750
700
650
600
550
500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
480.0, 553.5
592.5, 608.3
1,807.5, 594.6
1,917.5, 653.5
3,142.5, 638.7
3,247.5, 699.2
3,827.5, 685.4


Horizontal Movement - H-1 at 20.5 m Pile Tip
Y Coordinate (mm)
Time (ms)
570
560
550
540
530
520
510
500
490
480
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Vertical Movement - H-1 at 41.7 m Pile Tip
X Coordinate (mm)
Time (ms)
840
820
800
780
760
740
720
700
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
945.0, 719.0
1,092.5, 768.0
2,292.5, 746.7
2,405.0, 789.4
3,572.5, 769.5
3,697.5, 817.9
4,860.0, 794.4


Horizontal Movement - H-1 at 41.7 m Pile Tip
Y Coordinate (mm)
Time (ms)
470
465
460
455
450
445
440
435
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Vertical Movement - H-1 at 41.3 m Pile Tip
X Coordinate (mm)
Time (ms)
1060
1040
1020
1000
980
960
940
920
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
605.0, 953.6
692.5, 993.5
1,907.5, 979.5
2,025.0, 1,014.5
3,210.0, 997.1
3,350.0, 1,034.1
4,587.5, 1,010.9
4,682.5, 1,047.8
4,952.5, 1,028.3


Horizontal Movement - H-1 at 41.3 m Pile Tip
Y Coordinate (mm)
Time (ms)
400
395
390
385
380
375
370
365
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION						
Type: Diesel		**Model:** D46-32		**Make:** Delmag		
Hammer Weight (kg): 4600		**Fall (m):** 1.42 to 3.5		**Mass of Helmet (kg):** ~908		
Rated Energy (kJ Range): 71 to 166		**Hammer Cushion:** Yes				
Other Notes:						

PILE DETAILS							
Pile No. H-1		**Pile Type:** H-Pile		**Design Capacity:** 3000 kN		**Size:** 360x132	
Pile Shoe: Rock Injector		**Batter (H:V):** Vertical		**Total Length (m):** 46.8		**Mass (kg):** 6217.2	
Pile Segment	**Section 1**	**Splice 1**	**Section 2**	**Splice 2**	**Section 3**	**Splice 3**	**Section 4**
Length / Cut Off (m)	21.5	0.4	21.2	0.0	21.2	16.4	
Start Time:	9:25	10:40	11:20	13:00	13:55		
End Time:	9:48	11:15	12:00	13:50	14:14		
Set Criteria (mm/blow) <1.5 - 2		**Actual Tip Elev. (m):** 137.4			**Cut off Elev. (m):** 184.5		
Approximate Ground Elev. (m) 184.8							

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	3	**12.2**	8	**18.2**	13	**24.2**	15	**30.2**	16	**36.2**	14
0.4		**6.4**	3	**12.4**	9	**18.4**	14	**24.4**	13	**30.4**	16	**36.4**	17
0.6		**6.6**	4	**12.6**	8	**18.6**	13	**24.6**	12	**30.6**	12	**36.6**	19
0.8	↓	**6.8**	5	**12.8**	8	**18.8**	12	**24.8**	11	**30.8**	15	**36.8**	17
1.0	2	**7.0**	6	**13.0**	8	**19.0**	12	**25.0**	12	**31.0**	10	**37.0**	15
1.2		**7.2**	6	**13.2**	9	**19.2**	15	**25.2**	15	**31.2**	14	**37.2**	12
1.4		**7.4**	6	**13.4**	9	**19.4**	13	**25.4**	14	**31.4**	13	**37.4**	15
1.6		**7.6**	6	**13.6**	10	**19.6**	11	**25.6**	11	**31.6**	10	**37.6**	13
1.8	↓	**7.8**	6	**13.8**	11	**19.8**	11	**25.8**	13	**31.8**	10	**37.8**	13
2.0	16	**8.0**	6	**14.0**	11	**20.0**	11	**26.0**	11	**32.0**	9	**38.0**	13
2.2		**8.2**	6	**14.2**	12	**20.2**		**26.2**	14	**32.2**	11	**38.2**	13
2.4		**8.4**	8	**14.4**	14	**20.4**		**26.4**	12	**32.4**	11	**38.4**	13
2.6		**8.6**	7	**14.6**	16	**20.6**		**26.6**	11	**32.6**	10	**38.6**	11
2.8	↓	**8.8**	7	**14.8**	18	**20.8**	↓	**26.8**	14	**32.8**	10	**38.8**	14
3.0	18	**9.0**	10	**15.0**	22	**21.0**	18	**27.0**	13	**33.0**	10	**39.0**	15
3.2		**9.2**	10	**15.2**	21	**21.2**		**27.2**	13	**33.2**	9	**39.2**	14
3.4		**9.4**	8	**15.4**	30	**21.4**		**27.4**	13	**33.4**	9	**39.4**	14
3.6		**9.6**	8	**15.6**	38	**21.6**	22	**27.6**	11	**33.6**	9	**39.6**	13
3.8	↓	**9.8**	9	**15.8**	46	**21.8**	8	**27.8**	14	**33.8**	10	**39.8**	13
4.0	12	**10.0**	10	**16.0**	28	**22.0**	8	**28.0**	13	**34.0**	8	**40.0**	12
4.2		**10.2**	9	**16.2**	15	**22.2**	9	**28.2**	14	**34.2**	8	**40.2**	15
4.4		**10.4**	10	**16.4**	15	**22.4**	7	**28.4**	17	**34.4**	8	**40.4**	14
4.6		**10.6**	10	**16.6**	15	**22.6**	13	**28.6**	16	**34.6**	8	**40.6**	14
4.8		**10.8**	9	**16.8**	10	**22.8**		**28.8**	17	**34.8**	12	**40.8**	12
5.0		**11.0**	9	**17.0**	9	**23.0**	51	**29.0**	14	**35.0**	14	**41.0**	15
5.2		**11.2**	8	**17.2**	11	**23.2**	15	**29.2**	19	**35.2**	15	**41.2**	12
5.4		**11.4**	9	**17.4**	11	**23.4**	14	**29.4**	16	**35.4**	16	**41.4**	12
5.6		**11.6**	8	**17.6**	11	**23.6**	13	**29.6**	16	**35.6**	12	**41.6**	10
5.8	↓	**11.8**	7	**17.8**	11	**23.8**	13	**29.8**	18	**35.8**	13	**41.8**	10
6.0	IR	**12.0**	7	**18.0**	12	**24.0**	14	**30.0**	17	**36.0**	15	**42.0**	14

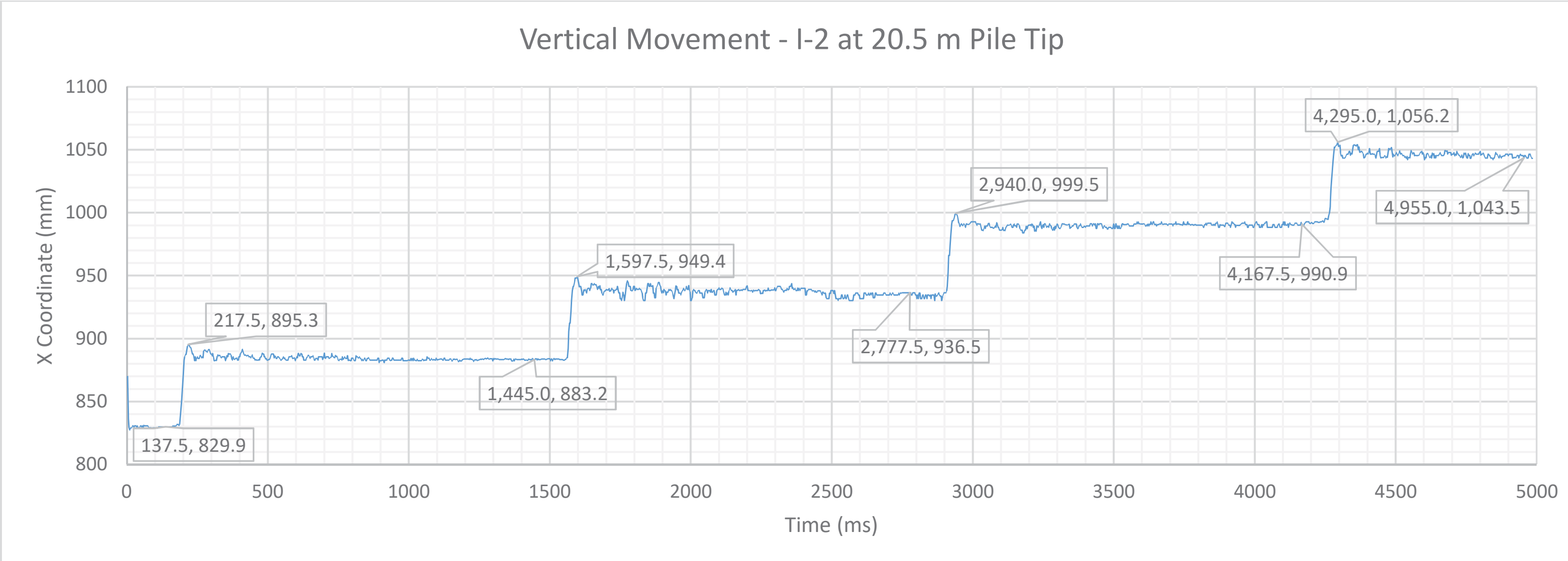
42.2	17	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	14	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	16	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	14	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	13	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	15	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	14	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	15	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	16	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	15	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	15	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	14	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	18	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	17	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	19	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	22	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	20	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	21	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	20	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	20	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	20	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	30	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6	54	**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8	75	**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0	95	**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2	Set	**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

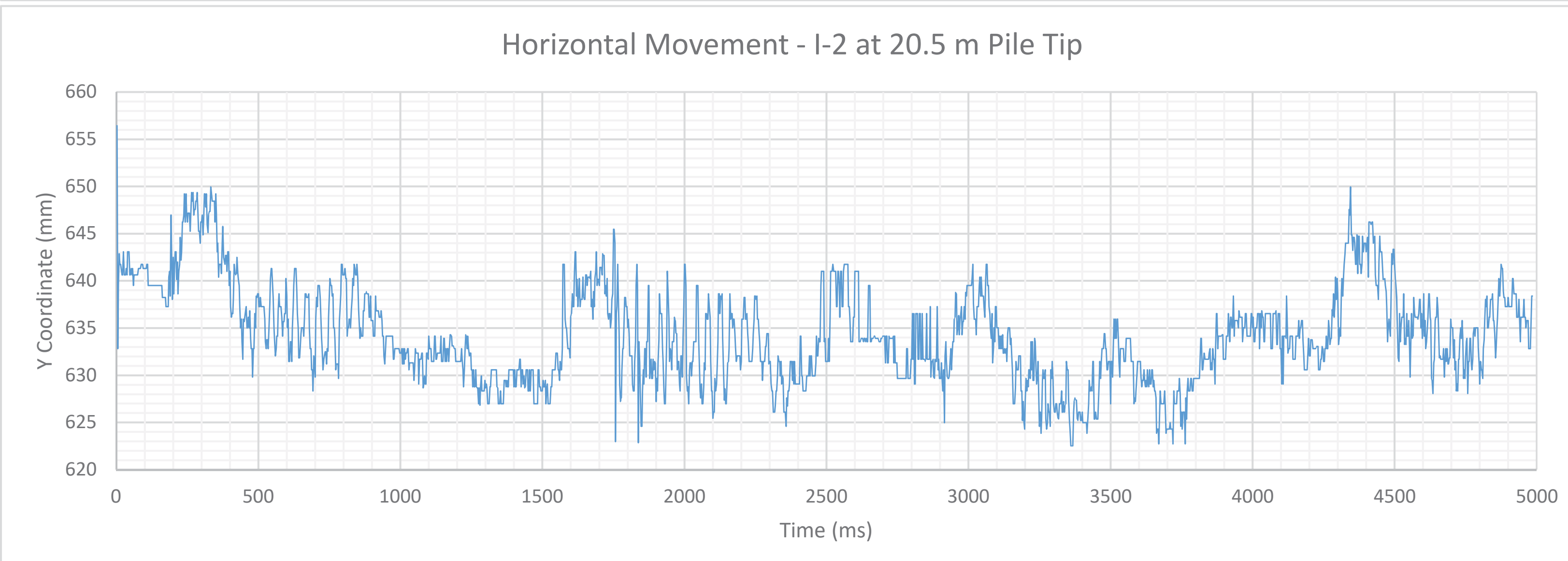
ADDITONAL NOTES/OBSERVATIONS

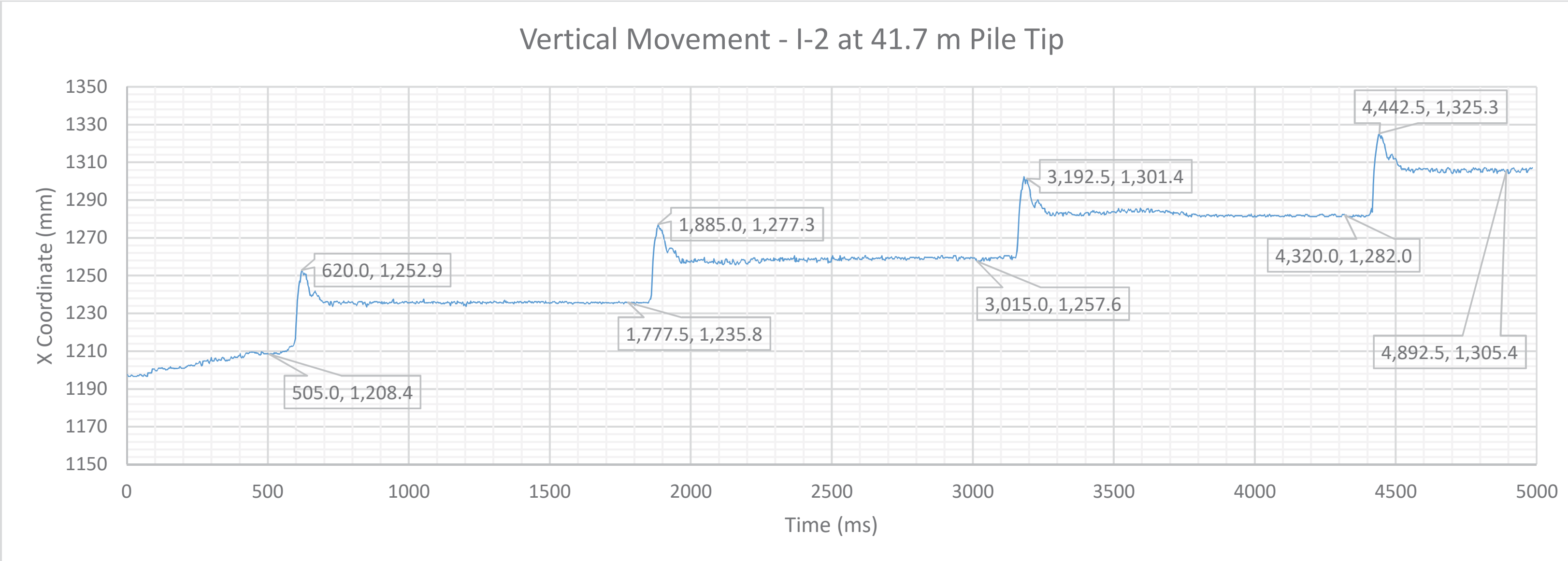
IR - Insufficient Soil Resistance for Sustained Driving

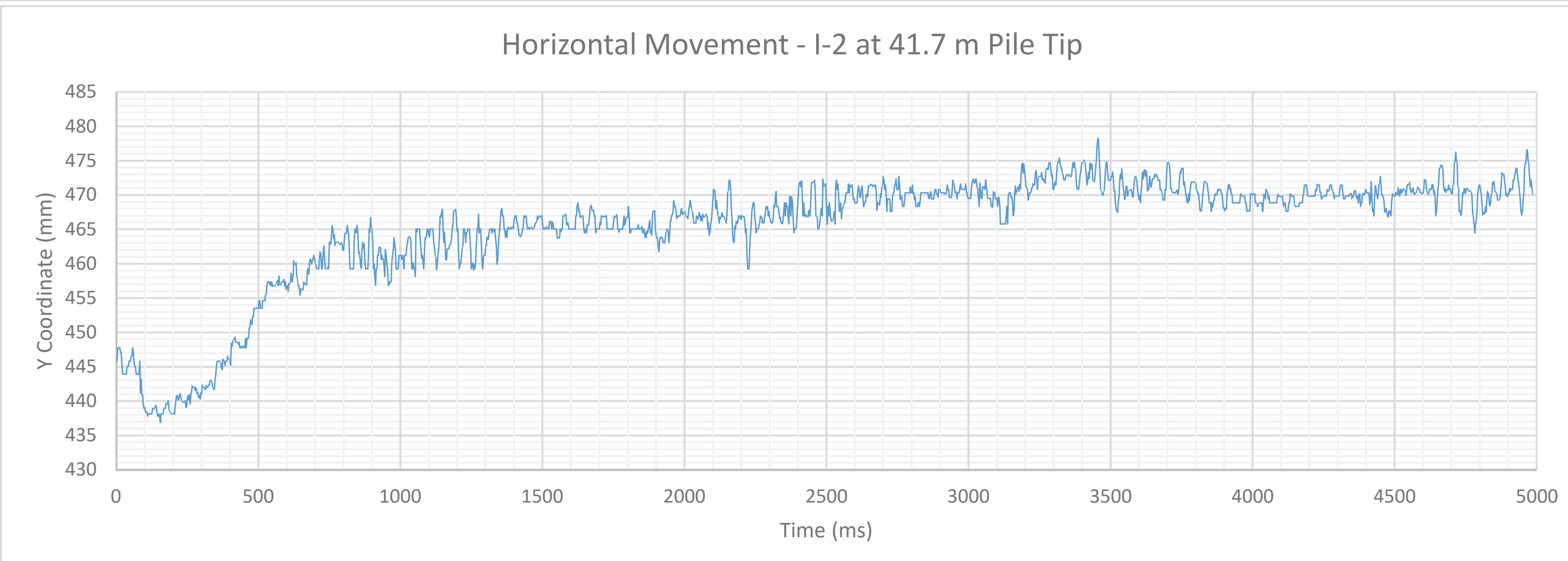
Depth (m)	**BPM**	
9 to 15	45	Hammer Setting 3
15 to 16.2	41 to 44	Hammer Setting 3
16.2 to 23	44 to 42	Hammer Setting 4
23 to 31	47 to 48	Hammer Setting 2
31 to 47	44 to 46	hammer Setting 3

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 137.4 m. The final set was 1.25 mm/blow.


Vertical Movement - I-2 at 20.5 m Pile Tip
X Coordinate (mm)
Time (ms)
137.5, 829.9
217.5, 895.3
1,445.0, 883.2
1,597.5, 949.4
2,777.5, 936.5
2,940.0, 999.5
4,167.5, 990.9
4,295.0, 1,056.2
4,955.0, 1,043.5


Horizontal Movement - I-2 at 20.5 m Pile Tip
Y Coordinate (mm)
Time (ms)


Vertical Movement - I-2 at 41.7 m Pile Tip
X Coordinate (mm)
Time (ms)
1350
1330
1310
1290
1270
1250
1230
1210
1190
1170
1150
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
505.0, 1,208.4
620.0, 1,252.9
1,777.5, 1,235.8
1,885.0, 1,277.3
3,015.0, 1,257.6
3,192.5, 1,301.4
4,320.0, 1,282.0
4,442.5, 1,325.3
4,892.5, 1,305.4


Horizontal Movement - I-2 at 41.7 m Pile Tip
Y Coordinate (mm)
Time (ms)
485
480
475
470
465
460
455
450
445
440
435
430
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. I-2 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** Vertical **Total Length (m):** 45.6 **Mass (kg):** 6058.8

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.5	0.0	21.2	1.0	21.2	17.0	
Start Time:	9:00	9:40	10:55	12:15	13:15		
End Time:	9:18	10:48	11:12	13:10	13:30		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.6 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

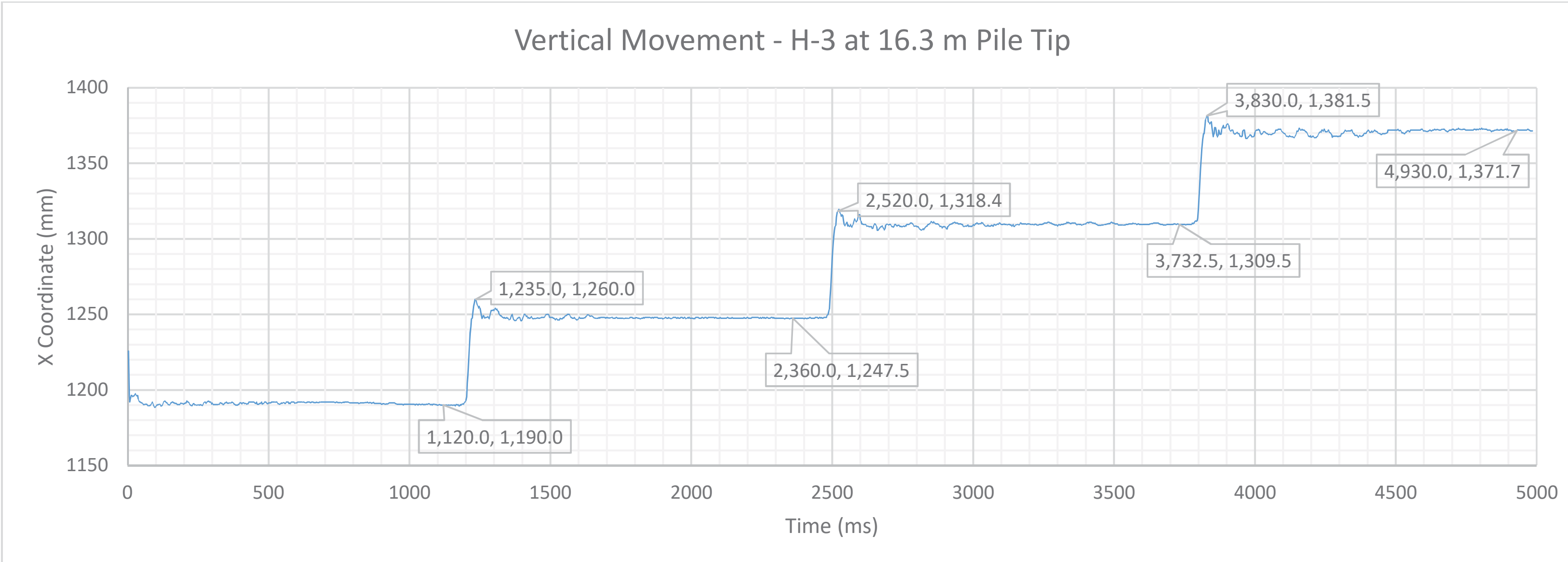
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	4	**12.2**	7	**18.2**	5	**24.2**	5	**30.2**	5	**36.2**	8
0.4		**6.4**	6	**12.4**	5	**18.4**	5	**24.4**	6	**30.4**	7	**36.4**	8
0.6		**6.6**	7	**12.6**	5	**18.6**	5	**24.6**	6	**30.6**	9	**36.6**	8
0.8		**6.8**	8	**12.8**	5	**18.8**	6	**24.8**	5	**30.8**	8	**36.8**	8
1.0		**7.0**	7	**13.0**	4	**19.0**	5	**25.0**	7	**31.0**	9	**37.0**	8
1.2		**7.2**	9	**13.2**	5	**19.2**	4	**25.2**	6	**31.2**	7	**37.2**	9
1.4		**7.4**	8	**13.4**	5	**19.4**	5	**25.4**	5	**31.4**	9	**37.4**	9
1.6		**7.6**	7	**13.6**	5	**19.6**	4	**25.6**	6	**31.6**	9	**37.6**	7
1.8	↓	**7.8**	10	**13.8**	5	**19.8**	4	**25.8**	5	**31.8**	8	**37.8**	9
2.0	13	**8.0**	8	**14.0**	5	**20.0**	4	**26.0**	6	**32.0**	7	**38.0**	8
2.2	4	**8.2**	9	**14.2**	5	**20.2**	4	**26.2**	5	**32.2**	8	**38.2**	9
2.4	4	**8.4**	9	**14.4**	8	**20.4**		**26.4**	6	**32.4**	9	**38.4**	7
2.6	4	**8.6**	13	**14.6**	5	**20.6**		**26.6**	6	**32.6**	8	**38.6**	8
2.8	4	**8.8**	12	**14.8**	5	**20.8**		**26.8**	6	**32.8**	10	**38.8**	8
3.0	3	**9.0**	13	**15.0**	5	**21.0**		**27.0**	6	**33.0**	9	**39.0**	8
3.2	5	**9.2**	16	**15.2**	5	**21.2**		**27.2**	6	**33.2**	8	**39.2**	8
3.4	4	**9.4**	17	**15.4**	5	**21.4**		**27.4**	6	**33.4**	9	**39.4**	7
3.6	4	**9.6**	12	**15.6**	4	**21.6**		**27.6**	6	**33.6**	7	**39.6**	7
3.8	3	**9.8**	15	**15.8**	5	**21.8**	↓	**27.8**	6	**33.8**	8	**39.8**	8
4.0	4	**10.0**	8	**16.0**	5	**22.0**	14	**28.0**	7	**34.0**	8	**40.0**	8
4.2	4	**10.2**	9	**16.2**	6	**22.2**	5	**28.2**	7	**34.2**	8	**40.2**	7
4.4	3	**10.4**	8	**16.4**	6	**22.4**	6	**28.4**	6	**34.4**	7	**40.4**	7
4.6		**10.6**	7	**16.6**	6	**22.6**	6	**28.6**	7	**34.6**	8	**40.6**	5
4.8		**10.8**	7	**16.8**	5	**22.8**	5	**28.8**	6	**34.8**	6	**40.8**	10
5.0		**11.0**	6	**17.0**	5	**23.0**	6	**29.0**	7	**35.0**	7	**41.0**	11
5.2	↓	**11.2**	6	**17.2**	5	**23.2**	6	**29.2**	6	**35.2**	8	**41.2**	11
5.4	IR	**11.4**	8	**17.4**	6	**23.4**	6	**29.4**	7	**35.4**	8	**41.4**	8
5.6		**11.6**	7	**17.6**	5	**23.6**	6	**29.6**	6	**35.6**	8	**41.6**	8
5.8	↓	**11.8**	7	**17.8**	5	**23.8**	5	**29.8**	7	**35.8**	9	**41.8**	12
6.0	15	**12.0**	6	**18.0**	4	**24.0**	5	**30.0**	7	**36.0**	8	**42.0**	12

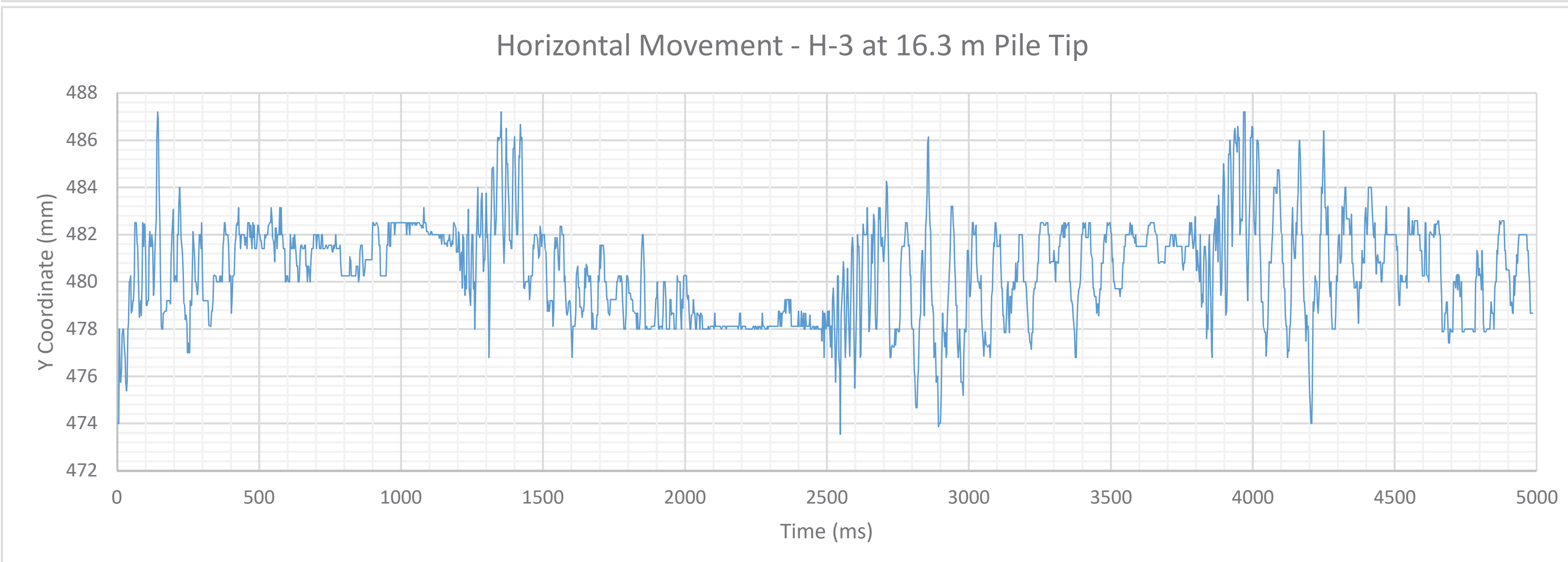
42.2	12	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	14	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	14	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	14	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	14	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	19	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	17	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	17	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	15	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	16	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	16	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	19	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	18	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	21	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	18	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	23	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	32	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	50	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	Set	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**		IR - Insufficient Soil Resistance for Sustained Driving
6 - 18	44 to 47	Hammer Setting 3	
18 - 30	43 to 45	Hammer Setting 4	
30 - 42.2	42 to 43	Hammer Setting 4	
42.2 - 45.8	47 to 42	Hammer Setting 3	
45.8 - 46	42, 47	Hammer Setting 2 then 1	

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.6 m. The final set was 1.11 mm/blow.


Vertical Movement - H-3 at 16.3 m Pile Tip
X Coordinate (mm)
Time (ms)
1400
1350
1300
1250
1200
1150
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
3,830.0, 1,381.5
4,930.0, 1,371.7
2,520.0, 1,318.4
3,732.5, 1,309.5
1,235.0, 1,260.0
2,360.0, 1,247.5
1,120.0, 1,190.0


Horizontal Movement - H-3 at 16.3 m Pile Tip
Y Coordinate (mm)
Time (ms)
488
486
484
482
480
478
476
474
472
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. H-3 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** 1:10 **Total Length (m):** 45.0 **Mass (kg):** 5979.6

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	17.3	0.1	21.2	0.0	8.6	1.7	
Start Time:	14:22	15:45	16:40	17:20	8:20		
End Time:	15:26	16:35	16:56	8:10	8:40		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 139.2 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**	5	**18.2**	5	**24.2**	6	**30.2**	5	**36.2**	9
0.4		**6.4**	16	**12.4**	4	**18.4**	5	**24.4**	5	**30.4**	5	**36.4**	11
0.6		**6.6**	4	**12.6**	5	**18.6**	5	**24.6**	5	**30.6**	6	**36.6**	9
0.8		**6.8**	5	**12.8**	4	**18.8**	5	**24.8**	5	**30.8**	5	**36.8**	7
1.0		**7.0**	6	**13.0**	4	**19.0**	5	**25.0**	6	**31.0**	6	**37.0**	7
1.2		**7.2**	6	**13.2**	3	**19.2**	6	**25.2**	5	**31.2**	5	**37.2**	7
1.4		**7.4**	10	**13.4**	3	**19.4**	5	**25.4**	5	**31.4**	7	**37.4**	3
1.6		**7.6**		**13.6**	4	**19.6**	6	**25.6**	5	**31.6**	7	**37.6**	4
1.8		**7.8**	↓	**13.8**	4	**19.8**	6	**25.8**	6	**31.8**	7	**37.8**	6
2.0		**8.0**	9	**14.0**	4	**20.0**	6	**26.0**	6	**32.0**	6	**38.0**	8
2.2	↓	**8.2**	11	**14.2**	3	**20.2**	6	**26.2**	6	**32.2**	7	**38.2**	7
2.4	10	**8.4**	10	**14.4**	3	**20.4**	5	**26.4**	5	**32.4**	7	**38.4**	6
2.6	4	**8.6**	14	**14.6**	3	**20.6**	6	**26.6**	7	**32.6**	7	**38.6**	6
2.8	3	**8.8**	14	**14.8**	4	**20.8**	5	**26.8**	4	**32.8**	7	**38.8**	5
3.0	3	**9.0**	13	**15.0**	3	**21.0**	7	**27.0**	4	**33.0**	8	**39.0**	7
3.2	3	**9.2**	13	**15.2**	4	**21.2**	5	**27.2**	6	**33.2**	7	**39.2**	5
3.4	3	**9.4**	14	**15.4**	3	**21.4**	6	**27.4**	5	**33.4**	8	**39.4**	7
3.6	3	**9.6**	6	**15.6**	3	**21.6**	6	**27.6**	5	**33.6**	8	**39.6**	6
3.8	2	**9.8**	8	**15.8**	4	**21.8**	6	**27.8**	5	**33.8**	8	**39.8**	6
4.0	2	**10.0**	8	**16.0**	6	**22.0**	7	**28.0**	5	**34.0**	7	**40.0**	7
4.2	4	**10.2**	9	**16.2**	3	**22.2**	4	**28.2**	5	**34.2**	7	**40.2**	6
4.4	4	**10.4**	7	**16.4**		**22.4**	6	**28.4**	5	**34.4**	8	**40.4**	7
4.6	3	**10.6**	5	**16.6**		**22.6**	6	**28.6**	6	**34.6**	8	**40.6**	6
4.8		**10.8**	5	**16.8**		**22.8**	6	**28.8**	6	**34.8**	7	**40.8**	7
5.0		**11.0**	5	**17.0**		**23.0**	7	**29.0**	6	**35.0**	8	**41.0**	8
5.2		**11.2**	5	**17.2**		**23.2**	6	**29.2**	6	**35.2**	8	**41.2**	6
5.4		**11.4**	6	**17.4**		**23.4**	6	**29.4**	6	**35.4**	8	**41.4**	7
5.6		**11.6**	6	**17.6**		**23.6**	5	**29.6**	5	**35.6**	8	**41.6**	8
5.8		**11.8**	5	**17.8**		**23.8**	6	**29.8**	6	**35.8**	9	**41.8**	7
6.0	↓	**12.0**	5	**18.0**		**24.0**	5	**30.0**	6	**36.0**	9	**42.0**	9

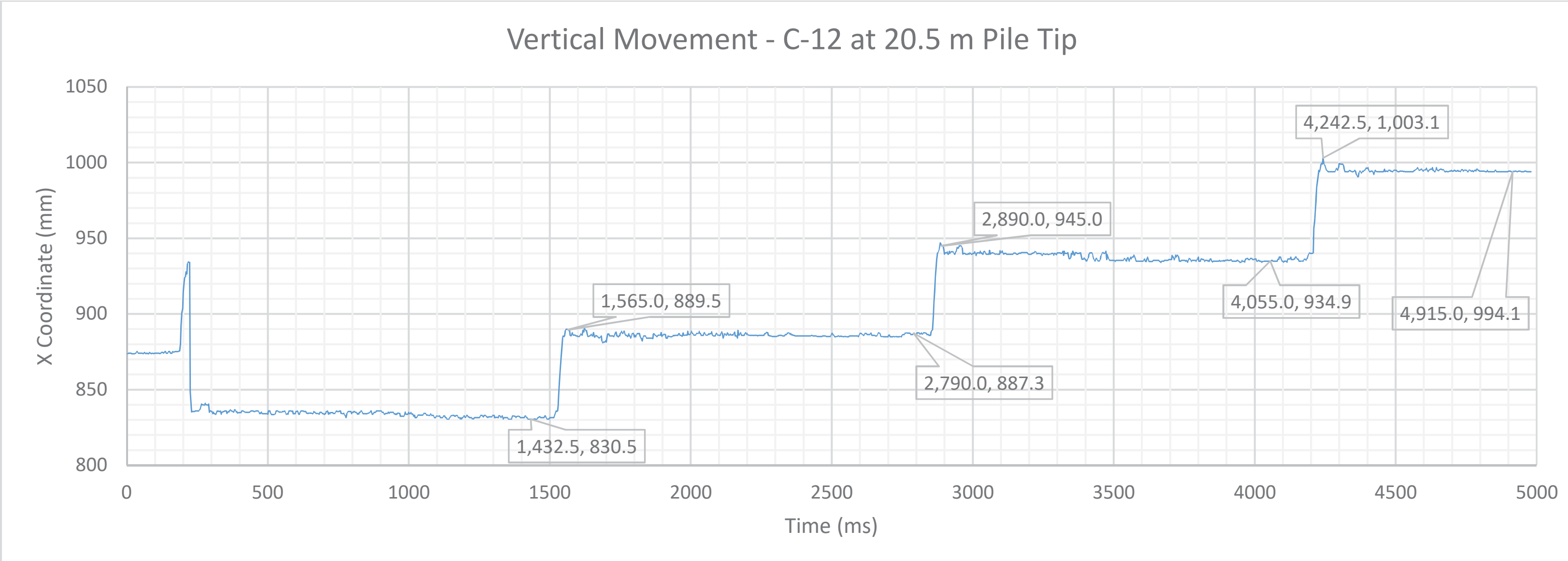
42.2	11	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	12	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	11	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	13	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	16	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	17	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	16	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	21	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	29	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	25	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	29	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	34	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	42	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	52	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	62	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	Set	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4		**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6		**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8		**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0		**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2		**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

ADDITONAL NOTES/OBSERVATIONS

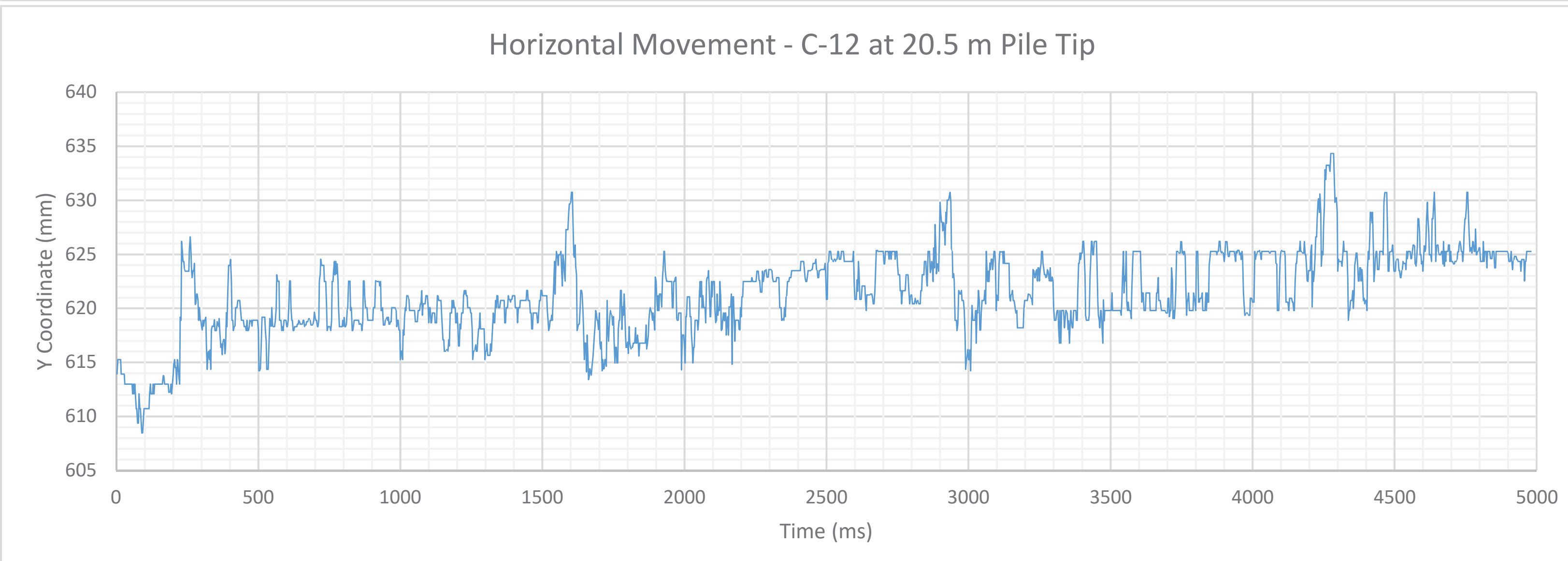
IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
6 to 9	51	Hammer Setting 3
9 to 28	46 to 50	Hammer Setting 3
28 to 37	45 to 47	Hammer Setting 3
40 to 45.2	42 to 46	Hammer Setting 3
45.2-45.3	43	Hammer Setting 2
45.3	48	Hammer Setting 1

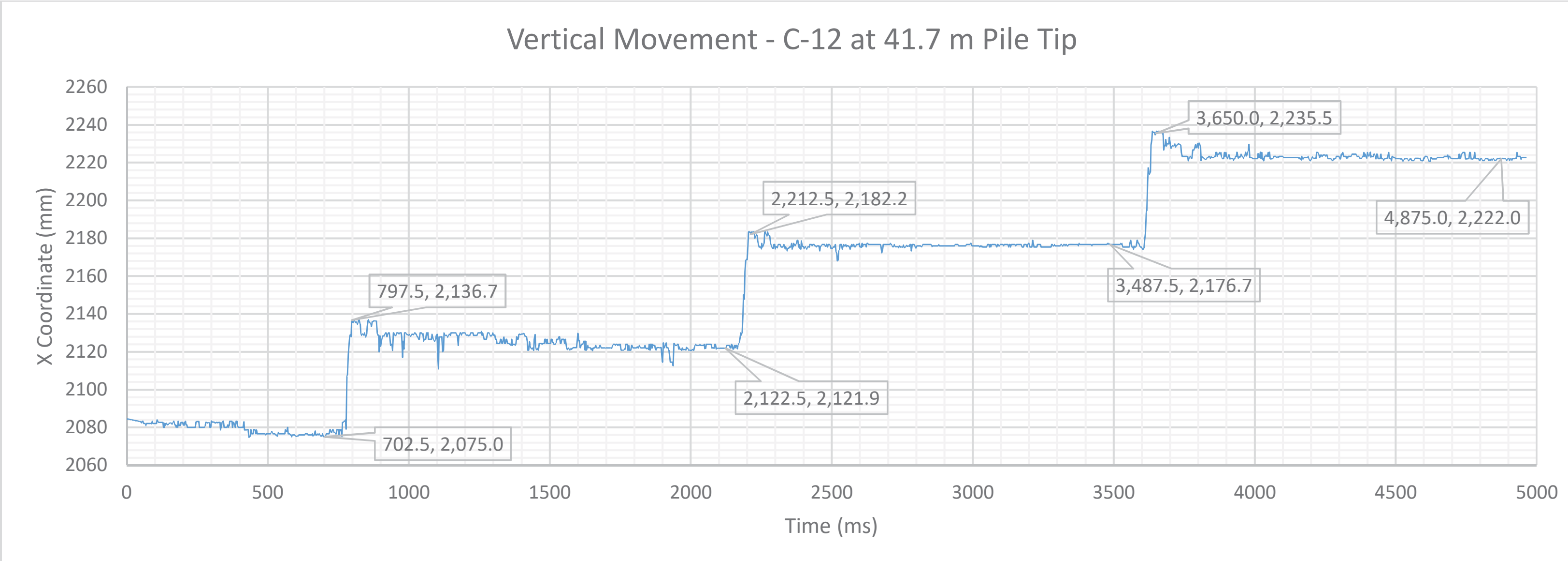
Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 139.2 m. The final set was 1.32 mm/blow.

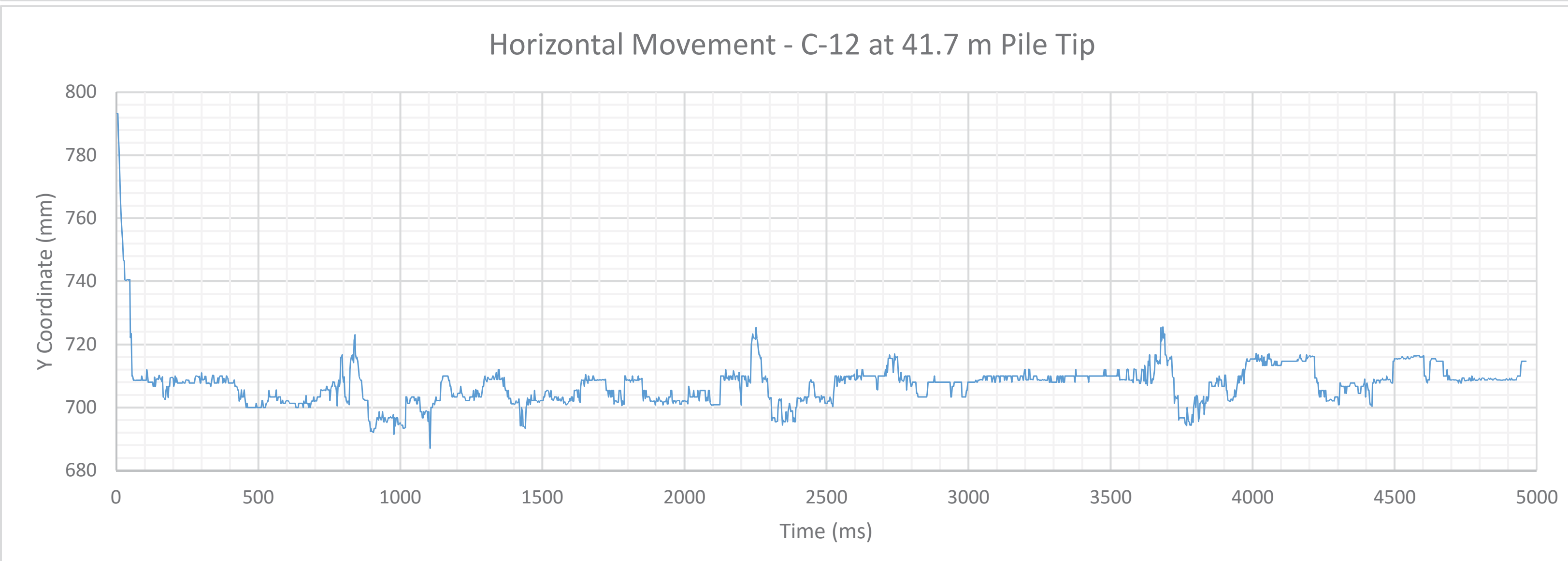


Vertical Movement - C-12 at 20.5 m Pile Tip
X Coordinate (mm)
Time (ms)
1050
1000
950
900
850
800
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
4,242.5, 1,003.1
2,890.0, 945.0
1,565.0, 889.5
4,055.0, 934.9
4,915.0, 994.1
2,790.0, 887.3
1,432.5, 830.5



Horizontal Movement - C-12 at 20.5 m Pile Tip
Y Coordinate (mm)
Time (ms)
640
635
630
625
620
615
610
605
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Vertical Movement - C-12 at 41.7 m Pile Tip
X Coordinate (mm)
Time (ms)
797.5, 2,136.7
702.5, 2,075.0
2,212.5, 2,182.2
2,122.5, 2,121.9
3,650.0, 2,235.5
3,487.5, 2,176.7
4,875.0, 2,222.0
2260
2240
2220
2200
2180
2160
2140
2120
2100
2080
2060
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Horizontal Movement - C-12 at 41.7 m Pile Tip
Y Coordinate (mm)
Time (ms)
800
780
760
740
720
700
680
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION							
Type: Diesel		**Model:** D46-32			**Make:** Delmag		
Hammer Weight (kg): 4600		**Fall (m):** 1.42 to 3.5			**Mass of Helmet (kg):** ~908		
Rated Energy (kJ Range): 71 to 166			**Hammer Cushion:** Yes				
Other Notes:							
PILE DETAILS							
Pile No. C-12		**Pile Type:** H-Pile	**Design Capacity:** 3000 kN			**Size:** 360x132	
Pile Shoe: Rock Injector		**Batter (H:V):** Vertical	**Total Length (m):** 47.5			**Mass (kg):** 6309.6	
Pile Segment	**Section 1**	**Splice 1**	**Section 2**	**Splice 2**	**Section 3**	**Splice 3**	**Section 4**
Length / Cut Off (m)	21.5	0.0	21.2	0.0	21.2	16.1	
Start Time:	9:25	10:10	10:50	11:15	11:55		
End Time:	9:36	10:45	11:00	11:50	12:10		
Set Criteria (mm/blow) <1.5 - 2		**Actual Tip Elev. (m):** 136.7			**Cut off Elev. (m):** 184.5		
Approximate Ground Elev. (m) 184.8							

PILING DATA

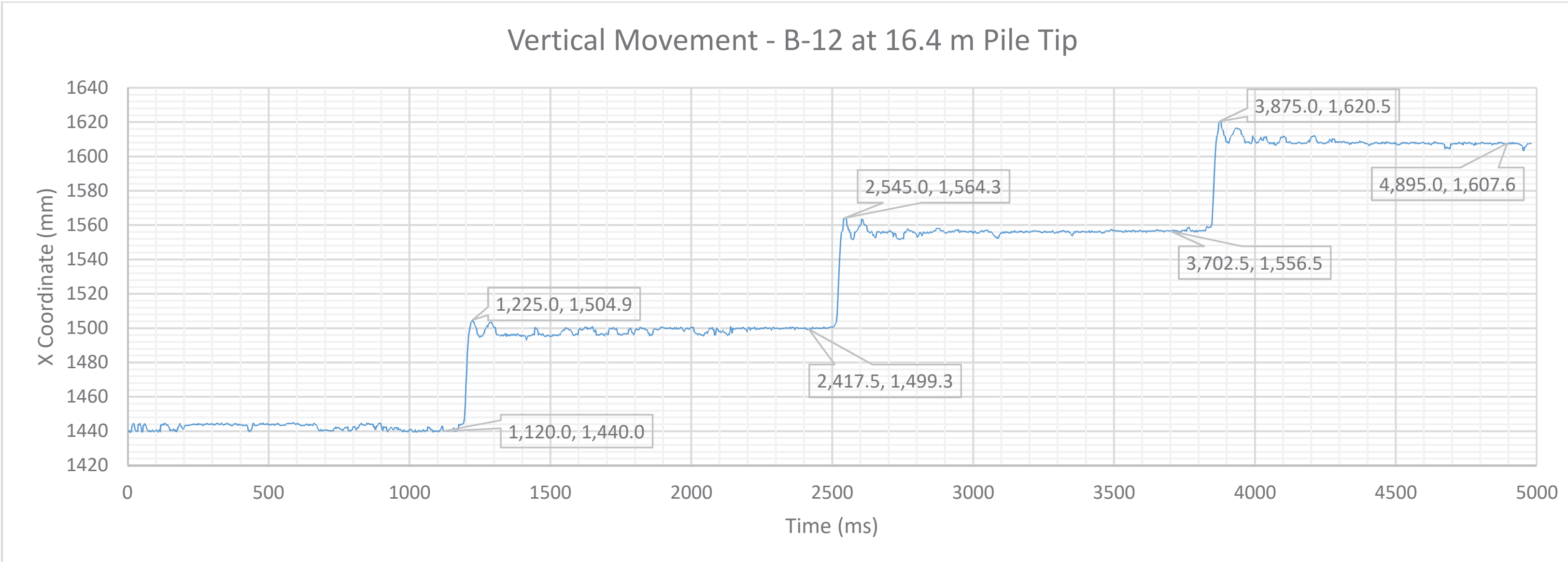
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**	4	**12.2**	5	**18.2**	5	**24.2**	4	**30.2**	5	**36.2**	8
0.4		**6.4**	3	**12.4**	6	**18.4**	5	**24.4**	6	**30.4**	6	**36.4**	7
0.6		**6.6**	4	**12.6**	6	**18.6**	5	**24.6**	6	**30.6**	6	**36.6**	7
0.8	↓	**6.8**	3	**12.8**	6	**18.8**	5	**24.8**	5	**30.8**	6	**36.8**	5
1.0	1	**7.0**	4	**13.0**	7	**19.0**	5	**25.0**	5	**31.0**	8	**37.0**	5
1.2		**7.2**	4	**13.2**	8	**19.2**	7	**25.2**	6	**31.2**	7	**37.2**	5
1.4		**7.4**	4	**13.4**	8	**19.4**	6	**25.4**	6	**31.4**	6	**37.4**	5
1.6		**7.6**	3	**13.6**	7	**19.6**	6	**25.6**	5	**31.6**	7	**37.6**	5
1.8	↓	**7.8**	4	**13.8**	7	**19.8**	5	**25.8**	5	**31.8**	6	**37.8**	4
2.0	9	**8.0**	4	**14.0**	7	**20.0**	5	**26.0**	6	**32.0**	8	**38.0**	4
2.2		**8.2**	4	**14.2**	6	**20.2**	4	**26.2**	6	**32.2**	6	**38.2**	5
2.4		**8.4**	3	**14.4**	7	**20.4**	3	**26.4**	5	**32.4**	6	**38.4**	4
2.6		**8.6**	4	**14.6**	6	**20.6**	5	**26.6**	6	**32.6**	6	**38.6**	4
2.8		**8.8**	4	**14.8**	7	**20.8**	3	**26.8**	6	**32.8**	5	**38.8**	4
3.0		**9.0**	3	**15.0**	5	**21.0**	4	**27.0**	5	**33.0**	8	**39.0**	5
3.2		**9.2**	3	**15.2**	5	**21.2**	6	**27.2**	6	**33.2**	6	**39.2**	5
3.4		**9.4**	4	**15.4**	5	**21.4**	5	**27.4**	5	**33.4**	6	**39.4**	5
3.6		**9.6**	3	**15.6**	4	**21.6**	4	**27.6**	5	**33.6**	6	**39.6**	5
3.8	↓	**9.8**	3	**15.8**	5	**21.8**	4	**27.8**	6	**33.8**	5	**39.8**	5
4.0	6	**10.0**	4	**16.0**	6	**22.0**	5	**28.0**	6	**34.0**	6	**40.0**	5
4.2		**10.2**	3	**16.2**	5	**22.2**	5	**28.2**	6	**34.2**	4	**40.2**	6
4.4		**10.4**	3	**16.4**	5	**22.4**	4	**28.4**	7	**34.4**	5	**40.4**	5
4.6		**10.6**	4	**16.6**	5	**22.6**	5	**28.6**	6	**34.6**	6	**40.6**	6
4.8	↓	**10.8**	3	**16.8**	5	**22.8**	4	**28.8**	6	**34.8**	5	**40.8**	4
5.0	15	**11.0**	4	**17.0**	7	**23.0**	5	**29.0**	6	**35.0**	5	**41.0**	5
5.2		**11.2**	3	**17.2**	5	**23.2**	5	**29.2**	5	**35.2**	5	**41.2**	6
5.4		**11.4**	4	**17.4**	5	**23.4**	5	**29.4**	5	**35.4**	5	**41.4**	6
5.6		**11.6**	4	**17.6**	5	**23.6**	5	**29.6**	5	**35.6**	5	**41.6**	21
5.8	↓	**11.8**	4	**17.8**	5	**23.8**	5	**29.8**	5	**35.8**	5	**41.8**	11
6.0	15	**12.0**	6	**18.0**	5	**24.0**	3	**30.0**	5	**36.0**	6	**42.0**	16

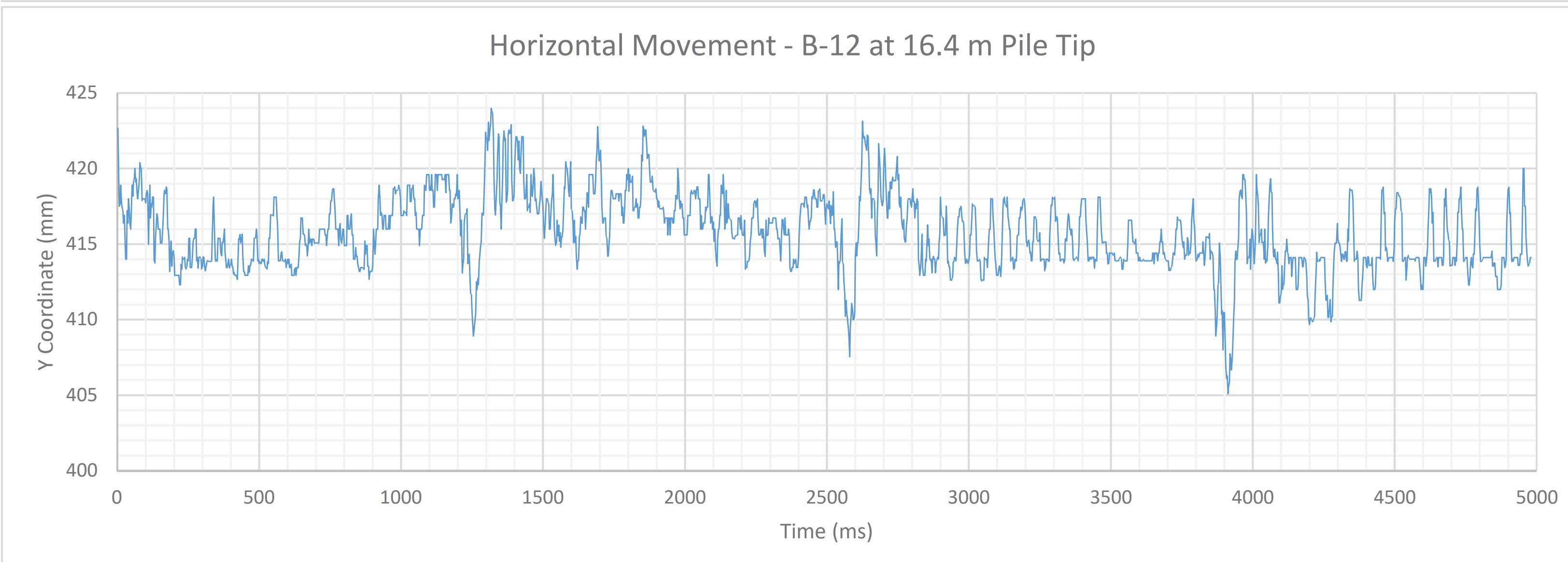
42.2		**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4		**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	18	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	4	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	8	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	11	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	12	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	7	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	6	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	8	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	8	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	8	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	7	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	8	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	8	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	7	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	8	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	8	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	9	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	10	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	12	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	12	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6	13	**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8	12	**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0	13	**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2	17	**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4	31	**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6	72	**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8	75	**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0	Set	**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

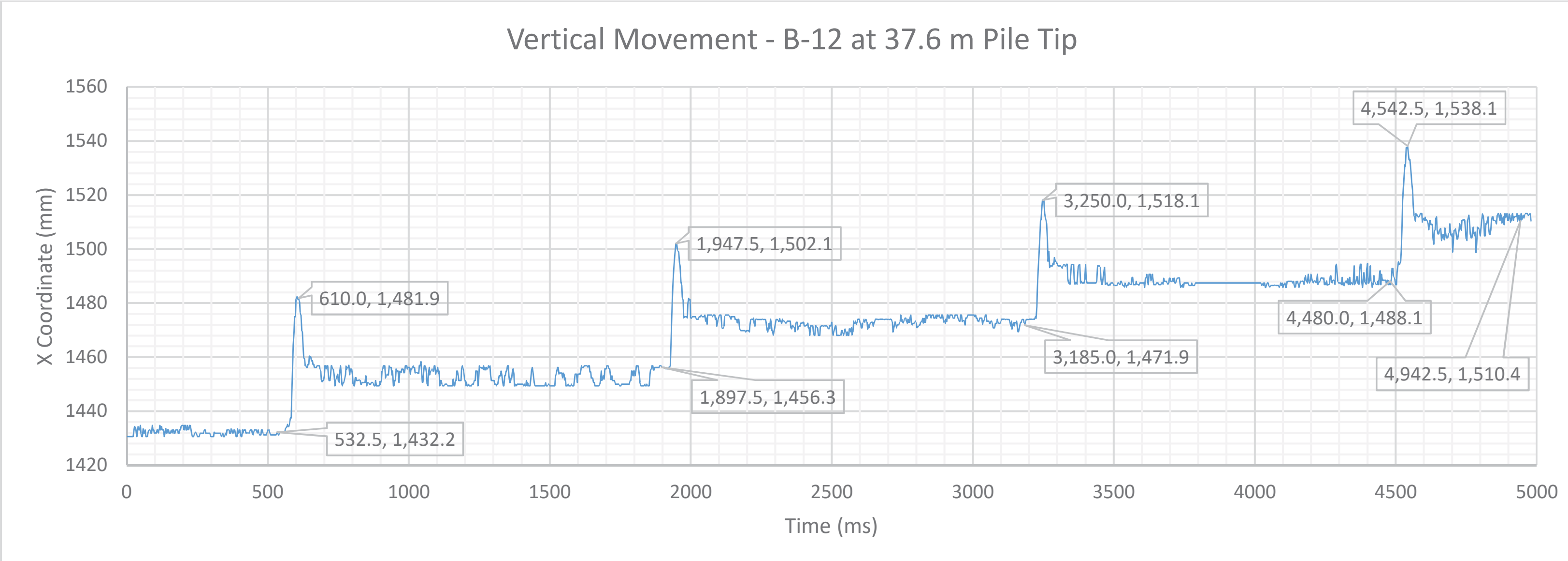
ADDITONAL NOTES/OBSERVATIONS

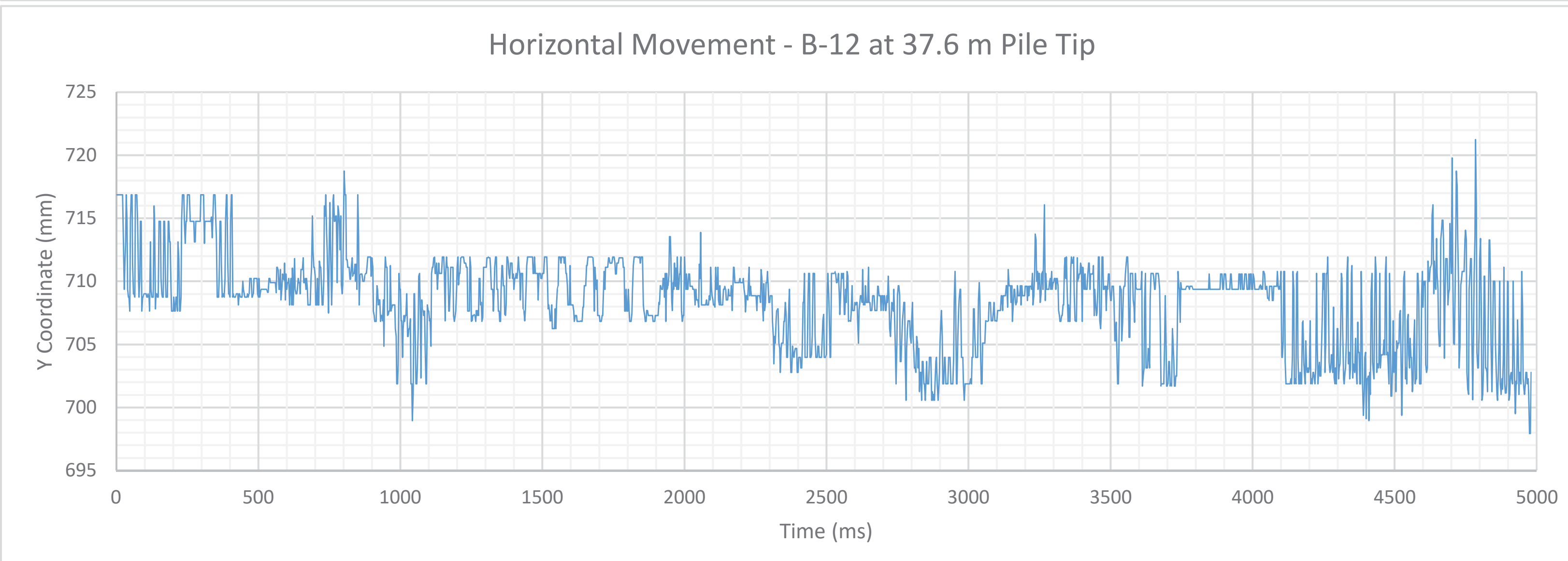
Depth (m)	**BPM**		IR - Insufficient Soil Resistance for Sustained Driving
9 to 12	46 - 49	Hammer Setting 4	
12 to 21	42 to 44	Hammer Setting 4	
21 to 42	43 to 45	Hammer Setting 4	
44.4 - 47.6	48 to 43	Hammer Setting 3	
47.6 to 48	44	Hammer Setting 2, then 1	

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 136.7 m. The final set was 1.19 mm/blow.


Vertical Movement - B-12 at 16.4 m Pile Tip
X Coordinate (mm)
Time (ms)
1640
1620
1600
1580
1560
1540
1520
1500
1480
1460
1440
1420
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
3,875.0, 1,620.5
2,545.0, 1,564.3
4,895.0, 1,607.6
3,702.5, 1,556.5
1,225.0, 1,504.9
2,417.5, 1,499.3
1,120.0, 1,440.0


Horizontal Movement - B-12 at 16.4 m Pile Tip
Y Coordinate (mm)
Time (ms)
425
420
415
410
405
400
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Vertical Movement - B-12 at 37.6 m Pile Tip
X Coordinate (mm)
Time (ms)
1560
1540
1520
1500
1480
1460
1440
1420
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
4,542.5, 1,538.1
3,250.0, 1,518.1
1,947.5, 1,502.1
610.0, 1,481.9
4,480.0, 1,488.1
3,185.0, 1,471.9
4,942.5, 1,510.4
1,897.5, 1,456.3
532.5, 1,432.2


Horizontal Movement - B-12 at 37.6 m Pile Tip
Y Coordinate (mm)
Time (ms)
725
720
715
710
705
700
695
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. B-12 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** Vertical **Total Length (m):** 47.6 **Mass (kg):** 6322.8

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	16.4	0.0	21.2	0.0	21.2	10.9	
Start Time:	13:15	13:50	14:25	14:50	15:25		
End Time:	13:30	14:20	15:40	15:20	15:45		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 136.6 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

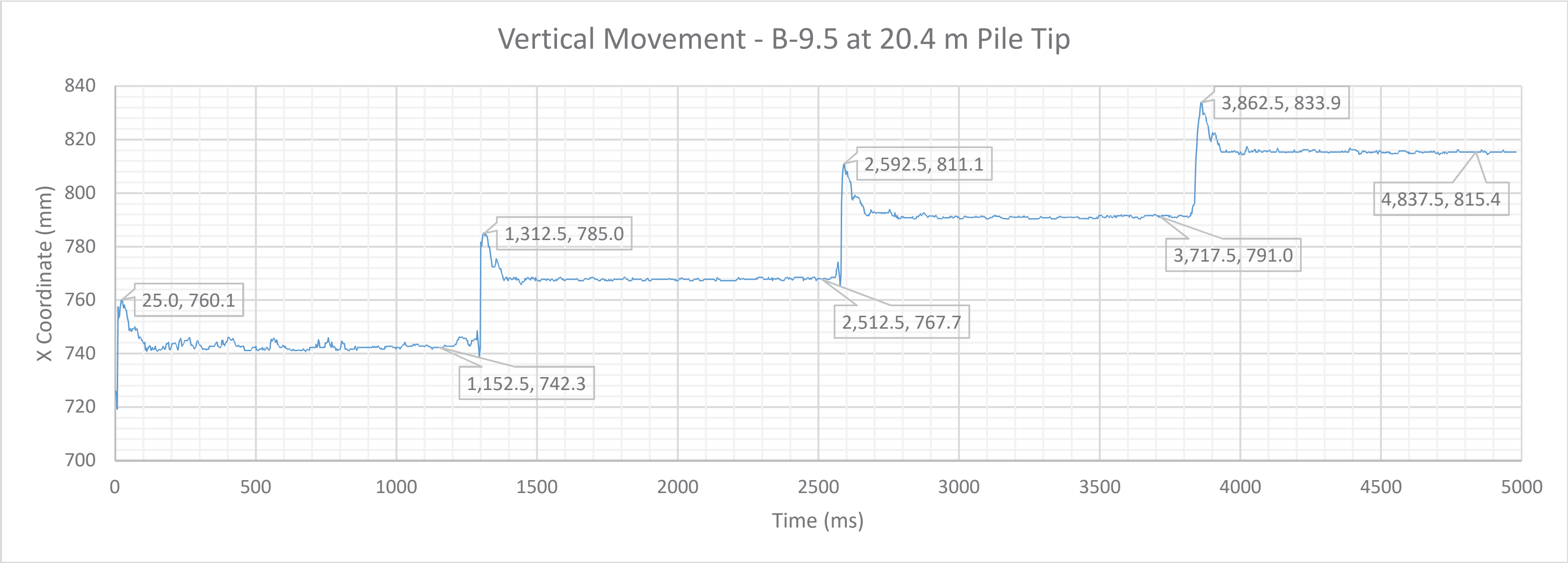
Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**		**18.2**	6	**24.2**	7	**30.2**	8	**36.2**	9
0.4		**6.4**	↓	**12.4**	↓	**18.4**	6	**24.4**	7	**30.4**	9	**36.4**	14
0.6		**6.6**	15	**12.6**	16	**18.6**	5	**24.6**	7	**30.6**	11	**36.6**	12
0.8		**6.8**		**12.8**	5	**18.8**	4	**24.8**	7	**30.8**	11	**36.8**	11
1.0		**7.0**		**13.0**	4	**19.0**	5	**25.0**	7	**31.0**	11	**37.0**	11
1.2		**7.2**		**13.2**	5	**19.2**	6	**25.2**	7	**31.2**	13	**37.2**	11
1.4		**7.4**	↓	**13.4**	3	**19.4**	7	**25.4**	8	**31.4**	10	**37.4**	9
1.6		**7.6**	19	**13.6**	6	**19.6**	8	**25.6**	8	**31.6**	12	**37.6**	8
1.8		**7.8**		**13.8**	5	**19.8**	7	**25.8**	8	**31.8**	12	**37.8**	11
2.0		**8.0**		**14.0**	6	**20.0**	6	**26.0**	10	**32.0**	12	**38.0**	9
2.2		**8.2**		**14.2**	6	**20.2**	7	**26.2**	9	**32.2**	11	**38.2**	11
2.4	↓	**8.4**	↓	**14.4**	7	**20.4**	6	**26.4**	9	**32.4**	12	**38.4**	10
2.6	12	**8.6**	20	**14.6**	8	**20.6**	4	**26.6**	8	**32.6**	9	**38.6**	9
2.8		**8.8**		**14.8**	7	**20.8**	6	**26.8**	9	**32.8**	9	**38.8**	7
3.0		**9.0**		**15.0**		**21.0**	6	**27.0**	8	**33.0**	10	**39.0**	9
3.2		**9.2**		**15.2**		**21.2**	6	**27.2**	9	**33.2**	13	**39.2**	11
3.4		**9.4**	↓	**15.4**	↓	**21.4**	5	**27.4**	8	**33.4**	10	**39.4**	9
3.6		**9.6**	20	**15.6**	26	**21.6**	6	**27.6**	7	**33.6**	11	**39.6**	10
3.8		**9.8**		**15.8**	7	**21.8**	7	**27.8**	9	**33.8**	11	**39.8**	10
4.0		**10.0**		**16.0**	6	**22.0**	8	**28.0**	8	**34.0**	9	**40.0**	8
4.2		**10.2**		**16.2**	7	**22.2**	7	**28.2**	9	**34.2**	11	**40.2**	9
4.4	↓	**10.4**	↓	**16.4**	7	**22.4**	7	**28.4**	9	**34.4**	9	**40.4**	8
4.6	7	**10.6**	15	**16.6**	4	**22.6**	7	**28.6**	10	**34.6**	8	**40.6**	8
4.8		**10.8**		**16.8**	5	**22.8**	6	**28.8**	9	**34.8**	9	**40.8**	8
5.0		**11.0**		**17.0**	8	**23.0**	7	**29.0**	10	**35.0**	8	**41.0**	7
5.2		**11.2**		**17.2**	14	**23.2**	9	**29.2**	10	**35.2**	11	**41.2**	9
5.4	↓	**11.4**	↓	**17.4**	7	**23.4**	8	**29.4**	9	**35.4**	9	**41.4**	8
5.6	12	**11.6**	17	**17.6**	7	**23.6**	6	**29.6**	7	**35.6**	9	**41.6**	7
5.8		**11.8**		**17.8**	4	**23.8**	8	**29.8**	7	**35.8**	8	**41.8**	8
6.0	↓	**12.0**	↓	**18.0**	3	**24.0**	7	**30.0**	9	**36.0**	7	**42.0**	8

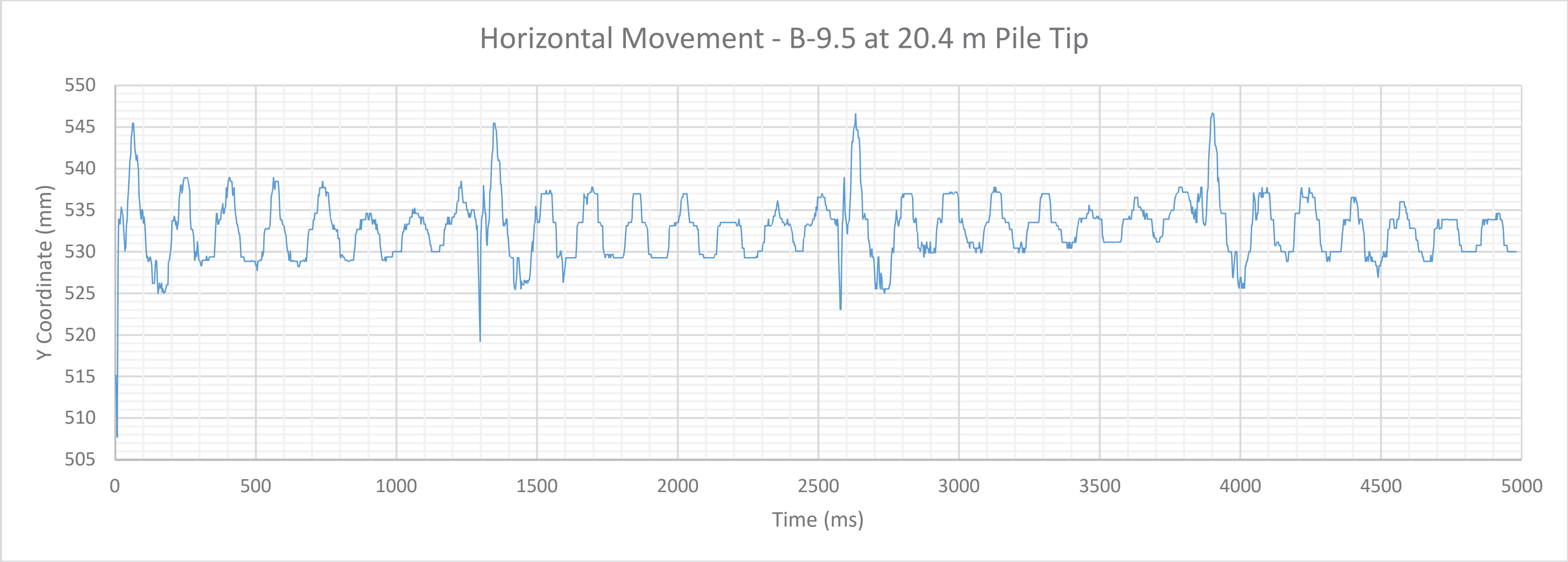
42.2	7	**48.2**	Set	**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	7	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	7	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	8	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	10	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	10	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	9	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	9	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	10	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	9	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	10	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	7	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	10	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	10	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	11	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	9	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	10	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	9	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	10	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	10	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	10	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	21	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6	31	**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8	25	**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0	27	**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2	42	**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4	24	**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6	62	**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8	56	**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0	46	**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**		IR - Insufficient Soil Resistance for Sustained Driving
18 - 36.4	46 to 50	Hammer Setting 2	
36.4 - 46.2	48 to 50	Hammer Setting 3	
46.2 - 47.2	44 to 43	Hammer Setting 3	
47.2 - 48	44 then 48	Hammer Setting 2, then 1	

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 136.6 m. The final set was 1.19 mm/blow.


Vertical Movement - B-9.5 at 20.4 m Pile Tip
X Coordinate (mm)
Time (ms)
25.0, 760.1
1,152.5, 742.3
1,312.5, 785.0
2,512.5, 767.7
2,592.5, 811.1
3,717.5, 791.0
3,862.5, 833.9
4,837.5, 815.4


Horizontal Movement - B-9.5 at 20.4 m Pile Tip
Y Coordinate (mm)
Time (ms)

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag

Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908

Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes

Other Notes:

PILE DETAILS

Pile No. B-9.5 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132

Pile Shoe: Rock Injector **Batter (H:V):** 1:10 **Total Length (m):** 48.0 **Mass (kg):** 6375.6

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.4	0.0	21.2	0.0	21.2	15.5	
Start Time:	9:45	10:15	11:10	11:40	12:25		
End Time:	9:56	11:05	11:30	12:20	12:45		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 136.2 **Cut off Elev. (m):** 184.5

Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**	5	**18.2**	3	**24.2**	5	**30.2**	7	**36.2**	8
0.4		**6.4**		**12.4**	4	**18.4**	5	**24.4**	5	**30.4**	6	**36.4**	8
0.6		**6.6**		**12.6**	4	**18.6**	4	**24.6**	7	**30.6**	6	**36.6**	8
0.8		**6.8**	↓	**12.8**	4	**18.8**	4	**24.8**	7	**30.8**	8	**36.8**	10
1.0		**7.0**	14	**13.0**	4	**19.0**	4	**25.0**	7	**31.0**	8	**37.0**	9
1.2		**7.2**		**13.2**	5	**19.2**	4	**25.2**	6	**31.2**	9	**37.2**	8
1.4		**7.4**		**13.4**	4	**19.4**	5	**25.4**	7	**31.4**	8	**37.4**	10
1.6		**7.6**		**13.6**	6	**19.6**	5	**25.6**	7	**31.6**	9	**37.6**	9
1.8	↓	**7.8**	↓	**13.8**	8	**19.8**	5	**25.8**	7	**31.8**	9	**37.8**	9
2.0	2	**8.0**	17	**14.0**	6	**20.0**	4	**26.0**	6	**32.0**	7	**38.0**	9
2.2		**8.2**		**14.2**	7	**20.2**		**26.2**	7	**32.2**	8	**38.2**	8
2.4		**8.4**		**14.4**	6	**20.4**		**26.4**	7	**32.4**	9	**38.4**	9
2.6		**8.6**		**14.6**	7	**20.6**		**26.6**	7	**32.6**	8	**38.6**	9
2.8	↓	**8.8**	↓	**14.8**	5	**20.8**		**26.8**	7	**32.8**	7	**38.8**	9
3.0	8	**9.0**	17	**15.0**	5	**21.0**		**27.0**	7	**33.0**	7	**39.0**	8
3.2		**9.2**		**15.2**	8	**21.2**		**27.2**	7	**33.2**	7	**39.2**	9
3.4		**9.4**		**15.4**	4	**21.4**	↓	**27.4**	6	**33.4**	10	**39.4**	9
3.6		**9.6**		**15.6**	5	**21.6**	32	**27.6**	7	**33.6**	9	**39.6**	8
3.8	↓	**9.8**	↓	**15.8**	3	**21.8**	6	**27.8**	6	**33.8**	8	**39.8**	12
4.0	5	**10.0**	16	**16.0**	4	**22.0**	6	**28.0**	7	**34.0**	10	**40.0**	11
4.2		**10.2**		**16.2**	3	**22.2**	6	**28.2**	7	**34.2**	9	**40.2**	11
4.4		**10.4**		**16.4**	4	**22.4**	6	**28.4**	6	**34.4**	8	**40.4**	13
4.6		**10.6**		**16.6**	4	**22.6**	6	**28.6**	7	**34.6**	8	**40.6**	13
4.8	↓	**10.8**	↓	**16.8**	4	**22.8**	6	**28.8**	6	**34.8**	8	**40.8**	13
5.0	5	**11.0**	18	**17.0**	4	**23.0**	7	**29.0**	7	**35.0**	9	**41.0**	11
5.2		**11.2**		**17.2**	4	**23.2**	7	**29.2**	7	**35.2**	8	**41.2**	11
5.4		**11.4**		**17.4**	5	**23.4**	7	**29.4**	7	**35.4**	8	**41.4**	13
5.6		**11.6**		**17.6**	4	**23.6**	6	**29.6**	7	**35.6**	9	**41.6**	11
5.8	↓	**11.8**	↓	**17.8**	3	**23.8**	6	**29.8**	6	**35.8**	8	**41.8**	11
6.0	6	**12.0**	18	**18.0**	5	**24.0**	5	**30.0**	6	**36.0**	9	**42.0**	11

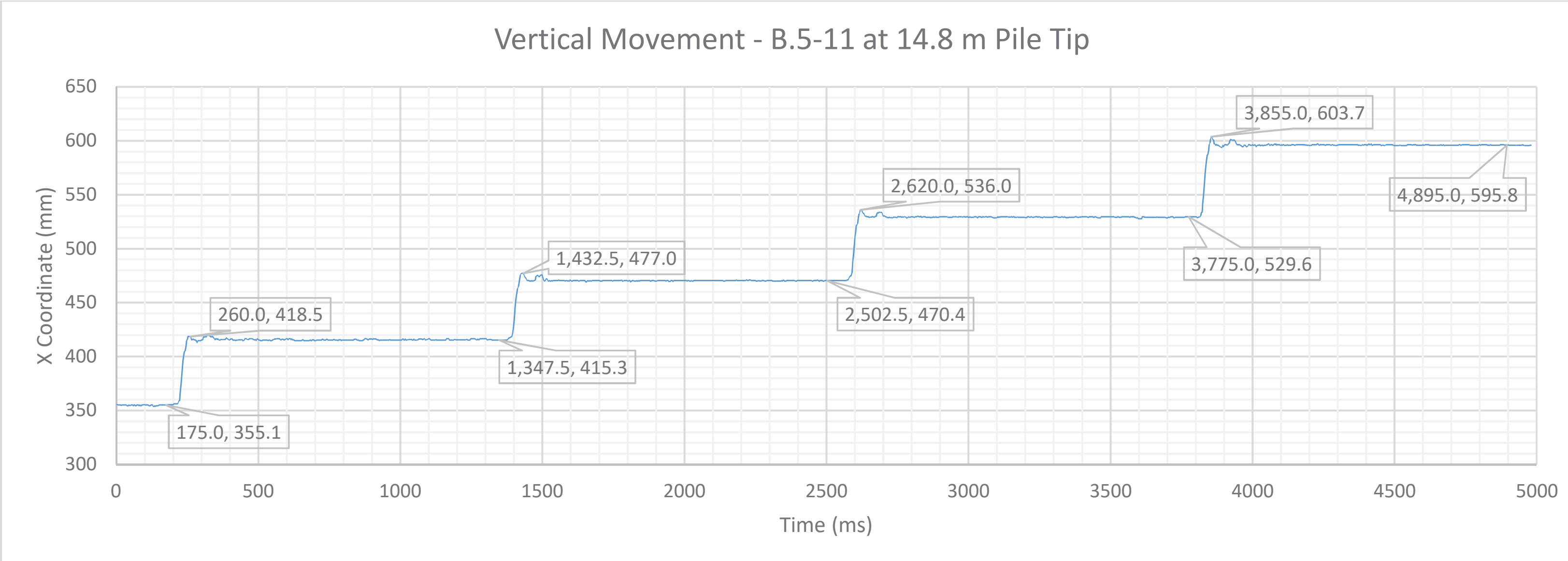
42.2	8	**48.2**	50	**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	9	**48.4**	69	**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	8	**48.6**	Set	**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	9	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	10	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	11	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	9	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	10	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	10	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	11	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	10	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	11	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	10	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	11	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	11	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	12	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	11	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	12	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	10	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	10	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	12	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	12	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6	11	**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8	18	**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0	19	**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2	23	**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4	33	**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6	34	**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8	42	**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0	41	**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

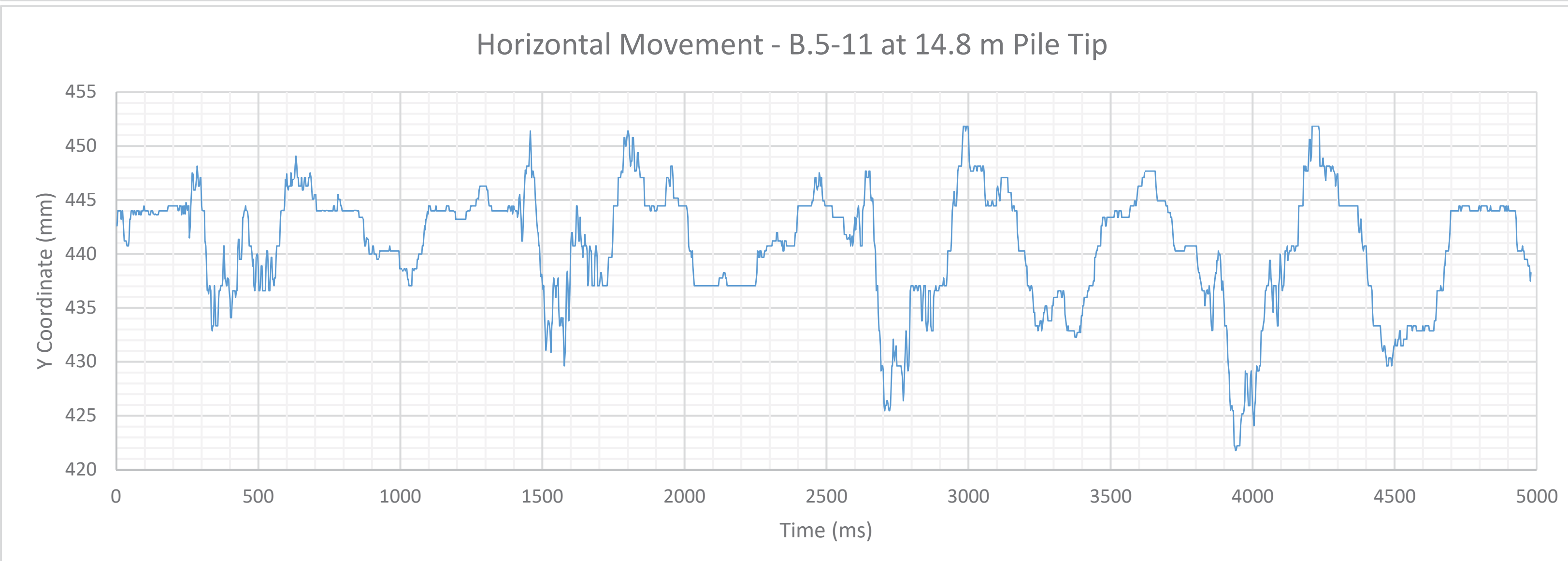
ADDITONAL NOTES/OBSERVATIONS

Depth (m)	**BPM**	
11 to 20	43 to 47	Hammer Setting 4
20 to 41.4	44 to 47	Hammer Setting 4
41.4 - 47.2	46 to 49	Hammer Setting 3
47.2 - 48.4	44 to 45	Hammer Setting 2

IR - Insufficient Soil Resistance for Sustained Driving

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 136.2 m. The final set was 0.98 mm/blow.


Vertical Movement - B.5-11 at 14.8 m Pile Tip
X Coordinate (mm)
Time (ms)
650
600
550
500
450
400
350
300
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
175.0, 355.1
260.0, 418.5
1,347.5, 415.3
1,432.5, 477.0
2,502.5, 470.4
2,620.0, 536.0
3,775.0, 529.6
3,855.0, 603.7
4,895.0, 595.8


Horizontal Movement - B.5-11 at 14.8 m Pile Tip
Y Coordinate (mm)
Time (ms)
455
450
445
440
435
430
425
420
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION					
Type:	Diesel	**Model:**	D46-32	**Make:**	Delmag
Hammer Weight (kg):	4600	**Fall (m):**	1.42 to 3.5	**Mass of Helmet (kg):**	~908
Rated Energy (kJ Range):	71 to 166	**Hammer Cushion:**	Yes		
Other Notes:					

PILE DETAILS							
Pile No.	B.5-11	**Pile Type:**	H-Pile	**Design Capacity:**	3000 kN	**Size:**	360x132
Pile Shoe:	Rock Injector	**Batter (H:V):**	1:10	**Total Length (m):**	48.7	**Mass (kg):**	6468

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	15.8	0.0	21.2	0.0	21.2	9.2	
Start Time:	14:05	14:20	14:55	15:40	16:20		
End Time:	14:10	14:50	15:05	16:15	16:45		

Set Criteria (mm/blow)	<1.5 - 2	**Actual Tip Elev. (m):**	135.5	**Cut off Elev. (m):**	184.5
Approximate Ground Elev. (m)	184.8				

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**		**18.2**		**24.2**		**30.2**	3	**36.2**	14
0.4		**6.4**		**12.4**		**18.4**		**24.4**		**30.4**	4	**36.4**	11
0.6		**6.6**		**12.6**		**18.6**		**24.6**		**30.6**	4	**36.6**	10
0.8		**6.8**	↓	**12.8**	↓	**18.8**	↓	**24.8**	↓	**30.8**	5	**36.8**	13
1.0		**7.0**	17	**13.0**	20	**19.0**	15	**25.0**	15	**31.0**	4	**37.0**	9
1.2		**7.2**		**13.2**	5	**19.2**		**25.2**		**31.2**	5	**37.2**	6
1.4		**7.4**		**13.4**	5	**19.4**		**25.4**		**31.4**	4	**37.4**	6
1.6		**7.6**		**13.6**	6	**19.6**		**25.6**		**31.6**	5	**37.6**	6
1.8	↓	**7.8**	↓	**13.8**	5	**19.8**	↓	**25.8**	↓	**31.8**	5	**37.8**	6
2.0	4	**8.0**	18	**14.0**	4	**20.0**	16	**26.0**	16	**32.0**	4	**38.0**	6
2.2		**8.2**		**14.2**	5	**20.2**		**26.2**		**32.2**	5	**38.2**	7
2.4		**8.4**		**14.4**		**20.4**		**26.4**		**32.4**	5	**38.4**	6
2.6		**8.6**		**14.6**		**20.6**		**26.6**		**32.6**	4	**38.6**	7
2.8	↓	**8.8**	↓	**14.8**	↓	**20.8**	↓	**26.8**	↓	**32.8**	4	**38.8**	8
3.0	2	**9.0**	17	**15.0**	16	**21.0**	14	**27.0**	17	**33.0**	4	**39.0**	6
3.2		**9.2**		**15.2**		**21.2**		**27.2**		**33.2**	6	**39.2**	7
3.4		**9.4**		**15.4**		**21.4**		**27.4**		**33.4**	5	**39.4**	6
3.6		**9.6**		**15.6**		**21.6**		**27.6**		**33.6**	5	**39.6**	6
3.8	↓	**9.8**	↓	**15.8**	↓	**21.8**	↓	**27.8**	↓	**33.8**	5	**39.8**	7
4.0	4	**10.0**	15	**16.0**	16	**22.0**	13	**28.0**	16	**34.0**	5	**40.0**	6
4.2		**10.2**		**16.2**		**22.2**		**28.2**		**34.2**	5	**40.2**	6
4.4		**10.4**		**16.4**		**22.4**		**28.4**		**34.4**	3	**40.4**	7
4.6		**10.6**		**16.6**		**22.6**		**28.6**		**34.6**	5	**40.6**	6
4.8	↓	**10.8**	↓	**16.8**	↓	**22.8**	↓	**28.8**	↓	**34.8**	4	**40.8**	6
5.0	10	**11.0**	15	**17.0**	13	**23.0**	16	**29.0**	19	**35.0**	5	**41.0**	6
5.2		**11.2**		**17.2**		**23.2**		**29.2**	4	**35.2**	5	**41.2**	7
5.4		**11.4**		**17.4**		**23.4**		**29.4**	4	**35.4**	5	**41.4**	6
5.6		**11.6**		**17.6**		**23.6**		**29.6**	5	**35.6**	4	**41.6**	6
5.8	↓	**11.8**	↓	**17.8**	↓	**23.8**	↓	**29.8**	4	**35.8**	5	**41.8**	6
6.0	18	**12.0**	17	**18.0**	14	**24.0**	15	**30.0**	4	**36.0**	5	**42.0**	6

42.2	6	**48.2**	31	**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	5	**48.4**	34	**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	6	**48.6**	40	**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	6	**48.8**	58	**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	5	**49.0**	Set	**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	5	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	6	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	5	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	6	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	6	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	7	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	8	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	8	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	9	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	9	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	9	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	10	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	9	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	9	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	9	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	9	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4	9	**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6	11	**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8	13	**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0	12	**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2	15	**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4	16	**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6	21	**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8	29	**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0	34	**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

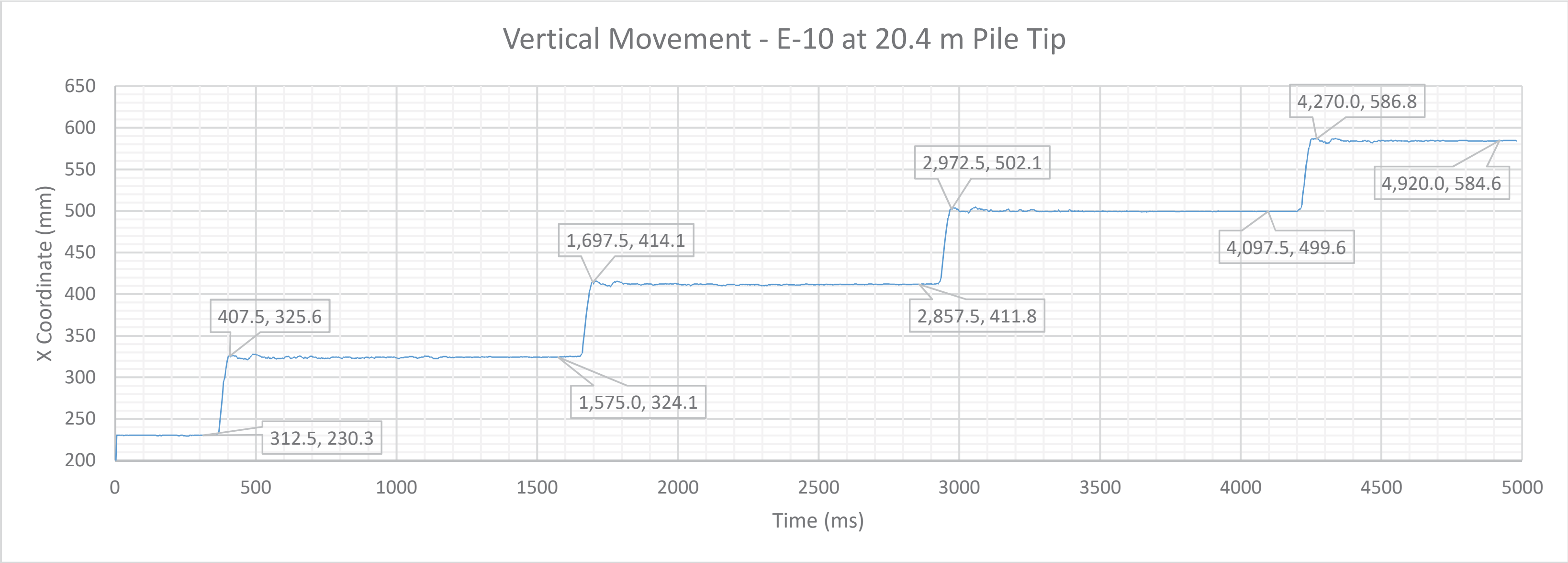
ADDITONAL NOTES/OBSERVATIONS

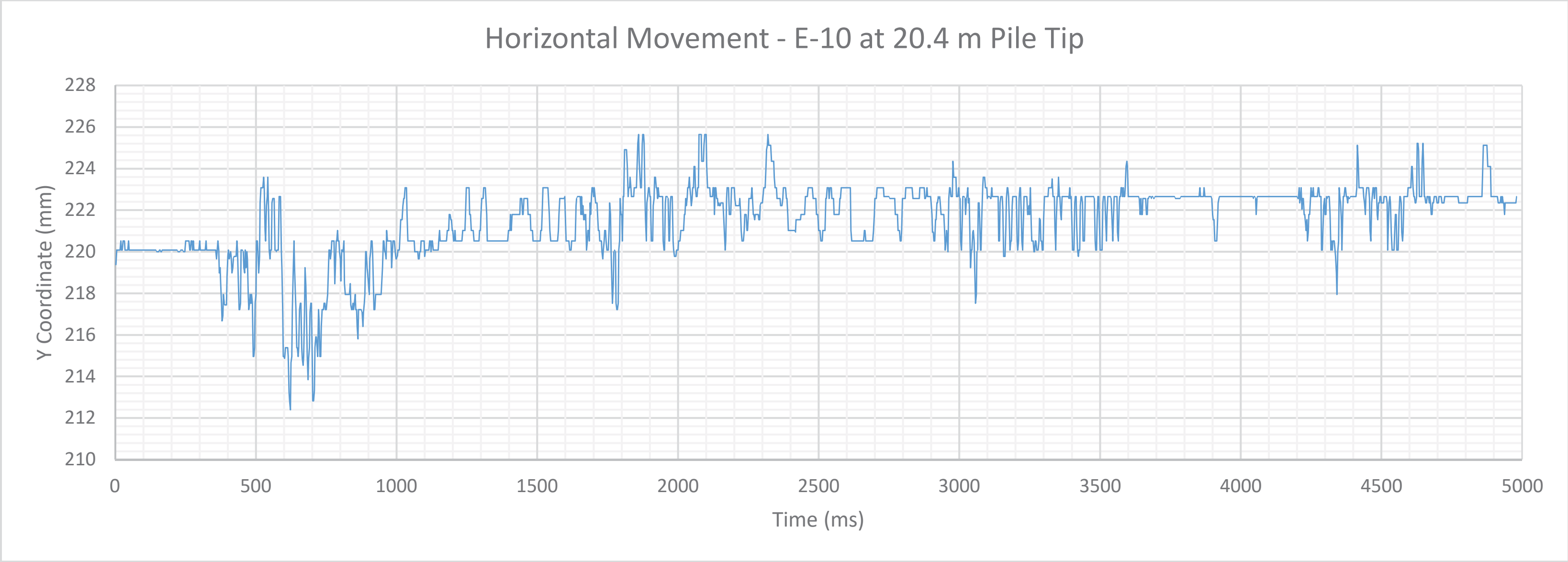
IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
22 to 36.2	50 to 46	Hammer Energy 4
36.2 - 44	45 to 47	Hammer Energy 4
44 - 47.6	51 to 46	Hammer Energy 3
47.6 - 48	46 to 45	Hammer Energy 2
48 to 48.8	45 to 44	Hammer Energy 2
49 to 49.1	48	Hammer Energy 1

First and second attempt to drive pile met an obstruction at approximately 1.5 m below the ground surface. The obstruction was excavated and the pile was driven successfully.

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 135.5 m. The final set was 1.14 mm/blow.


Vertical Movement - E-10 at 20.4 m Pile Tip
X Coordinate (mm)
Time (ms)
650
600
550
500
450
400
350
300
250
200
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
312.5, 230.3
407.5, 325.6
1,575.0, 324.1
1,697.5, 414.1
2,857.5, 411.8
2,972.5, 502.1
4,097.5, 499.6
4,270.0, 586.8
4,920.0, 584.6


Horizontal Movement - E-10 at 20.4 m Pile Tip
Y Coordinate (mm)
Time (ms)
228
226
224
222
220
218
216
214
212
210
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

HAMMER INFORMATION

Type: Diesel **Model:** D46-32 **Make:** Delmag
Hammer Weight (kg): 4600 **Fall (m):** 1.42 to 3.5 **Mass of Helmet (kg):** ~908
Rated Energy (kJ Range): 71 to 166 **Hammer Cushion:** Yes
Other Notes:

PILE DETAILS

Pile No. E-10 **Pile Type:** H-Pile **Design Capacity:** 3000 kN **Size:** 360x132
Pile Shoe: Rock Injector **Batter (H:V):** Vertical **Total Length (m):** 45.9 **Mass (kg):** 6098.4

Pile Segment	Section 1	Splice 1	Section 2	Splice 2	Section 3	Splice 3	Section 4
Length / Cut Off (m)	21.3	0.5	12.8	0.0	21.2	8.6	
Start Time:	7:55	10:20	12:47	13:20	16:25		
End Time:	8:01	11:40	12:57	15:00	17:15		

Set Criteria (mm/blow) <1.5 - 2 **Actual Tip Elev. (m):** 138.3 **Cut off Elev. (m):** 184.5
Approximate Ground Elev. (m) 184.8

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		**6.2**		**12.2**		**18.2**		**24.2**		**30.2**	8	**36.2**	14
0.4		**6.4**		**12.4**		**18.4**		**24.4**		**30.4**	9	**36.4**	13
0.6		**6.6**		**12.6**		**18.6**		**24.6**		**30.6**	11	**36.6**	13
0.8	↓	**6.8**	↓	**12.8**	↓	**18.8**	↓	**24.8**	↓	**30.8**	11	**36.8**	13
1.0	2	**7.0**	15	**13.0**	12	**19.0**	13	**25.0**	22	**31.0**	11	**37.0**	13
1.2		**7.2**		**13.2**		**19.2**		**25.2**		**31.2**	11	**37.2**	13
1.4		**7.4**		**13.4**		**19.4**		**25.4**		**31.4**	11	**37.4**	13
1.6		**7.6**		**13.6**		**19.6**		**25.6**		**31.6**	11	**37.6**	12
1.8	↓	**7.8**	↓	**13.8**	↓	**19.8**	↓	**25.8**	↓	**31.8**	9	**37.8**	12
2.0	8	**8.0**	11	**14.0**	10	**20.0**	12	**26.0**	28	**32.0**	10	**38.0**	12
2.2		**8.2**		**14.2**		**20.2**		**26.2**	6	**32.2**	10	**38.2**	12
2.4		**8.4**		**14.4**		**20.4**		**26.4**	6	**32.4**	11	**38.4**	12
2.6		**8.6**		**14.6**		**20.6**		**26.6**	6	**32.6**	15	**38.6**	12
2.8	↓	**8.8**	↓	**14.8**	↓	**20.8**		**26.8**	6	**32.8**	12	**38.8**	12
3.0	10	**9.0**	11	**15.0**	11	**21.0**		**27.0**	6	**33.0**	10	**39.0**	11
3.2		**9.2**		**15.2**		**21.2**		**27.2**	6	**33.2**	10	**39.2**	12
3.4		**9.4**		**15.4**		**21.4**		**27.4**	6	**33.4**	13	**39.4**	12
3.6		**9.6**		**15.6**		**21.6**		**27.6**	7	**33.6**	8	**39.6**	12
3.8	↓	**9.8**	↓	**15.8**	↓	**21.8**	↓	**27.8**	8	**33.8**	9	**39.8**	13
4.0	IR	**10.0**	13	**16.0**	10	**22.0**	22	**28.0**	8	**34.0**	11	**40.0**	14
4.2		**10.2**		**16.2**		**22.2**		**28.2**	8	**34.2**	11	**40.2**	16
4.4		**10.4**		**16.4**		**22.4**		**28.4**	7	**34.4**	10	**40.4**	17
4.6		**10.6**		**16.6**		**22.6**		**28.6**	8	**34.6**	11	**40.6**	17
4.8	↓	**10.8**	↓	**16.8**	↓	**22.8**	↓	**28.8**	9	**34.8**	11	**40.8**	16
5.0	3	**11.0**	10	**17.0**	12	**23.0**	18	**29.0**	8	**35.0**	11	**41.0**	17
5.2		**11.2**		**17.2**		**23.2**		**29.2**	9	**35.2**	11	**41.2**	18
5.4		**11.4**		**17.4**		**23.4**		**29.4**	8	**35.4**	10	**41.4**	17
5.6		**11.6**		**17.6**		**23.6**		**29.6**	7	**35.6**	11	**41.6**	17
5.8	↓	**11.8**	↓	**17.8**	↓	**23.8**	↓	**29.8**	7	**35.8**	11	**41.8**	16
6.0	6	**12.0**	12	**18.0**	11	**24.0**	19	**30.0**	8	**36.0**	10	**42.0**	16

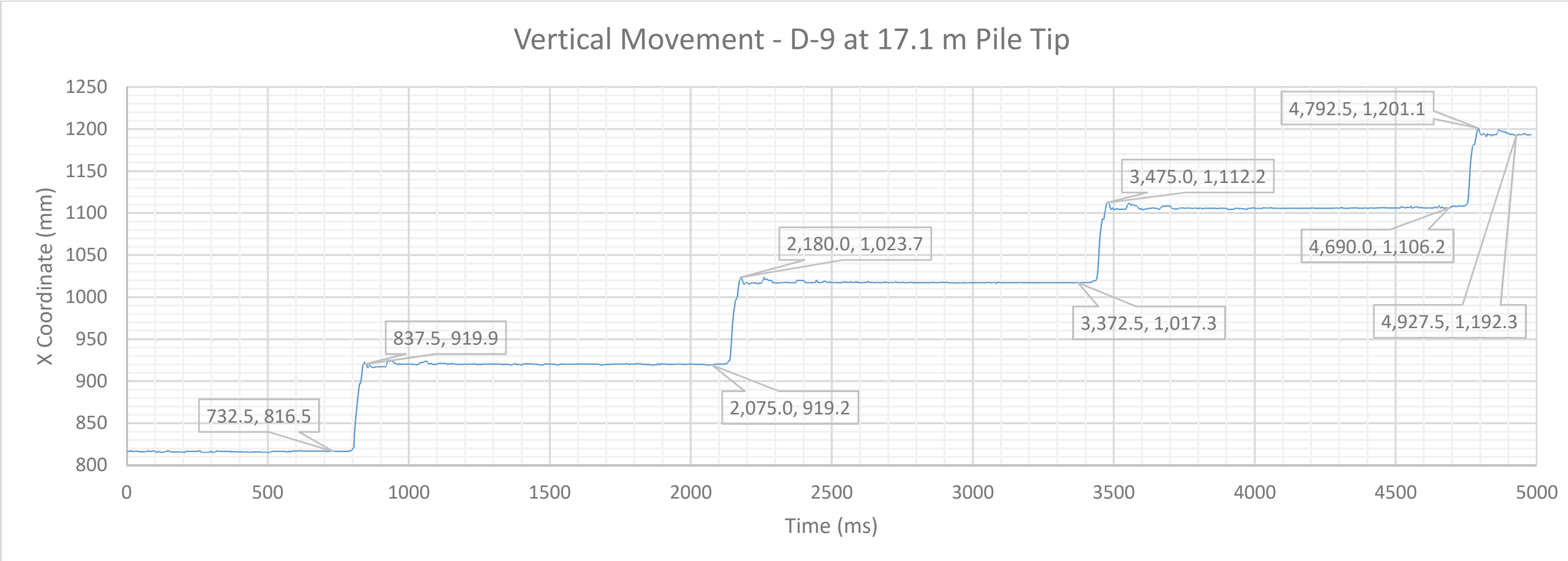
42.2	17	**48.2**		**54.2**		**60.2**		**66.2**		**72.2**		**78.2**	
42.4	14	**48.4**		**54.4**		**60.4**		**66.4**		**72.4**		**78.4**	
42.6	19	**48.6**		**54.6**		**60.6**		**66.6**		**72.6**		**78.6**	
42.8	22	**48.8**		**54.8**		**60.8**		**66.8**		**72.8**		**78.8**	
43.0	22	**49.0**		**55.0**		**61.0**		**67.0**		**73.0**		**79.0**	
43.2	27	**49.2**		**55.2**		**61.2**		**67.2**		**73.2**		**79.2**	
43.4	35	**49.4**		**55.4**		**61.4**		**67.4**		**73.4**		**79.4**	
43.6	42	**49.6**		**55.6**		**61.6**		**67.6**		**73.6**		**79.6**	
43.8	44	**49.8**		**55.8**		**61.8**		**67.8**		**73.8**		**79.8**	
44.0	61	**50.0**		**56.0**		**62.0**		**68.0**		**74.0**		**80.0**	
44.2	51	**50.2**		**56.2**		**62.2**		**68.2**		**74.2**		**80.2**	
44.4	69	**50.4**		**56.4**		**62.4**		**68.4**		**74.4**		**80.4**	
44.6	83	**50.6**		**56.6**		**62.6**		**68.6**		**74.6**		**80.6**	
44.8	109	**50.8**		**56.8**		**62.8**		**68.8**		**74.8**		**80.8**	
45.0	106	**51.0**		**57.0**		**63.0**		**69.0**		**75.0**		**81.0**	
45.2	103	**51.2**		**57.2**		**63.2**		**69.2**		**75.2**		**81.2**	
45.4	87	**51.4**		**57.4**		**63.4**		**69.4**		**75.4**		**81.4**	
45.6	108	**51.6**		**57.6**		**63.6**		**69.6**		**75.6**		**81.6**	
45.8	152	**51.8**		**57.8**		**63.8**		**69.8**		**75.8**		**81.8**	
46.0	84	**52.0**		**58.0**		**64.0**		**70.0**		**76.0**		**82.0**	
46.2	153	**52.2**		**58.2**		**64.2**		**70.2**		**76.2**		**82.2**	
46.4		**52.4**		**58.4**		**64.4**		**70.4**		**76.4**		**82.4**	
46.6		**52.6**		**58.6**		**64.6**		**70.6**		**76.6**		**82.6**	
46.8		**52.8**		**58.8**		**64.8**		**70.8**		**76.8**		**82.8**	
47.0		**53.0**		**59.0**		**65.0**		**71.0**		**77.0**		**83.0**	
47.2		**53.2**		**59.2**		**65.2**		**71.2**		**77.2**		**83.2**	
47.4		**53.4**		**59.4**		**65.4**		**71.4**		**77.4**		**83.4**	
47.6		**53.6**		**59.6**		**65.6**		**71.6**		**77.6**		**83.6**	
47.8		**53.8**		**59.8**		**65.8**		**71.8**		**77.8**		**83.8**	
48.0		**54.0**		**60.0**		**66.0**		**72.0**		**78.0**		**84.0**	

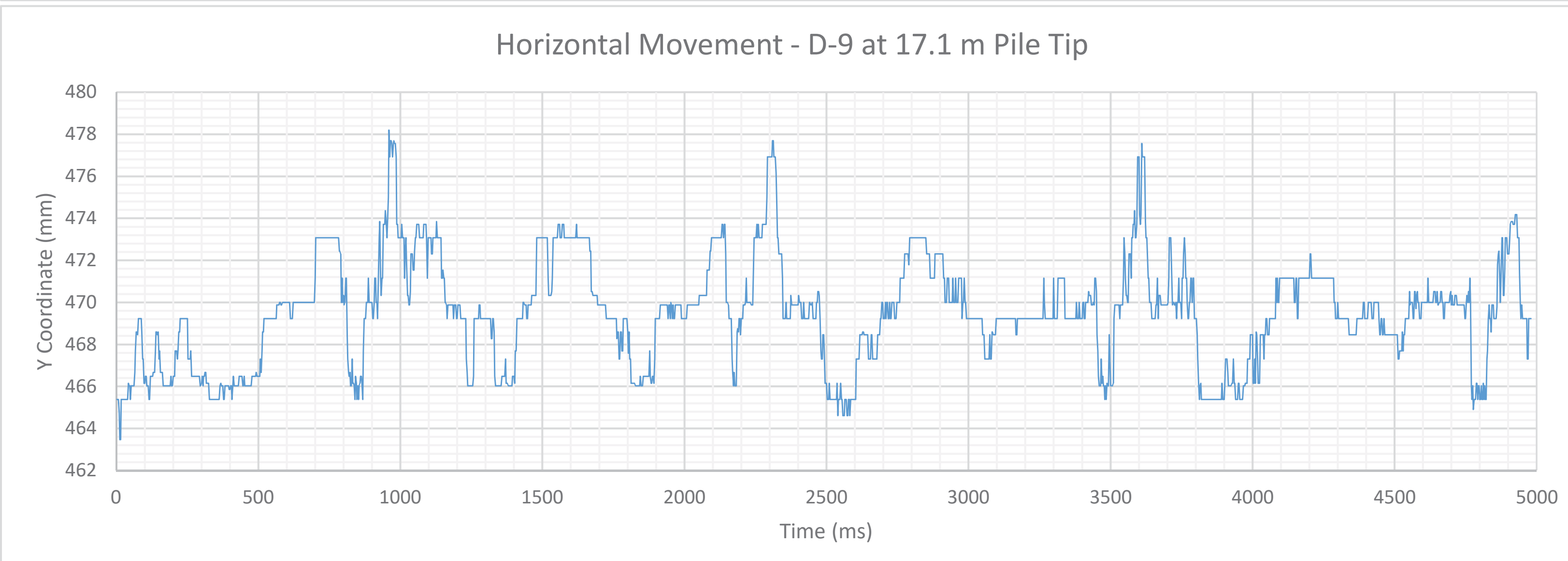
ADDITONAL NOTES/OBSERVATIONS

IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
22 - 32.6	46 to 42	Hammer Setting 4
22.6 - 43	44 to 40	Hammer Setting 4
43 - 44.4	43	Hammer Setting 3
44.4-44.8	45	Hammer Setting 2
44.8-45.4	47	Hammer Setting 1
45.4-45.8	45	Hammer Setting 2

Set established by counting the number of blows over 50 mm intervals. The pile was set at a tip elevation of 138.3 m. The final set was 1.00 mm/blow.


Vertical Movement - D-9 at 17.1 m Pile Tip
X Coordinate (mm)
1250
1200
1150
1100
1050
1000
950
900
850
800
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Time (ms)
732.5, 816.5
837.5, 919.9
2,075.0, 919.2
2,180.0, 1,023.7
3,372.5, 1,017.3
3,475.0, 1,112.2
4,690.0, 1,106.2
4,792.5, 1,201.1
4,927.5, 1,192.3


Horizontal Movement - D-9 at 17.1 m Pile Tip
Y Coordinate (mm)
480
478
476
474
472
470
468
466
464
462
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Time (ms)

HAMMER INFORMATION					
Type: Diesel		**Model:** D46-32		**Make:** Delmag	
Hammer Weight (kg): 4600		**Fall (m):** 1.42 to 3.5		**Mass of Helmet (kg):** ~908	
Rated Energy (kJ Range): 71 to 166		**Hammer Cushion:** Yes			
Other Notes:					

PILE DETAILS							
Pile No. D-9		**Pile Type:** H-Pile		**Design Capacity:** 3000 kN		**Size:** 360x132	
Pile Shoe: Rock Injector		**Batter (H:V):** Vertical		**Total Length (m):** 46.8		**Mass (kg):** 6217.2	
Pile Segment	**Section 1**	**Splice 1**	**Section 2**	**Splice 2**	**Section 3**	**Splice 3**	**Section 4**
Length / Cut Off (m)	18.1	0.0	21.2	0.0	12.1	4.3	
Start Time:	15:10	8:20	8:55	9:15	10:27		
End Time:	15:20	8:50	9:06	10:03	11:05		
Set Criteria (mm/blow) <1.5 - 2		**Actual Tip Elev. (m):** 137.4			**Cut off Elev. (m):** 184.5		
Approximate Ground Elev. (m) 184.8							

PILING DATA

Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows	Length in Ground (m)	Blows
0.2		6.2	↓	12.2	↓	18.2	4	24.2	4	30.2	4	36.2	4
0.4		6.4	3	12.4	12	18.4	3	24.4	4	30.4	5	36.4	5
0.6		6.6		12.6		18.6	3	24.6	3	30.6	5	36.6	5
0.8		6.8		12.8		18.8	3	24.8	3	30.8	6	36.8	6
1.0		7.0		13.0		19.0	3	25.0	4	31.0	6	37.0	5
1.2	↓	7.2	↓	13.2	↓	19.2	3	25.2	4	31.2	6	37.2	5
1.4	4	7.4	3	13.4	14	19.4	3	25.4	4	31.4	6	37.4	5
1.6		7.6		13.6		19.6	3	25.6	4	31.6	6	37.6	6
1.8		7.8		13.8		19.8	3	25.8	4	31.8	6	37.8	6
2.0		8.0		14.0		20.0	3	26.0	4	32.0	6	38.0	5
2.2	↓	8.2	↓	14.2	↓	20.2	3	26.2	4	32.2	6	38.2	5
2.4	12	8.4	4	14.4	13	20.4	3	26.4	4	32.4	5	38.4	5
2.6		8.6		14.6		20.6	3	26.6	4	32.6	6	38.6	6
2.8		8.8		14.8		20.8	3	26.8	5	32.8	6	38.8	6
3.0		9.0		15.0		21.0	3	27.0	4	33.0	5	39.0	6
3.2	↓	9.2	↓	15.2	↓	21.2	3	27.2	5	33.2	5	39.2	7
3.4	11	9.4	13	15.4	14	21.4	4	27.4	4	33.4	5	39.4	8
3.6		9.6		15.6		21.6	3	27.6	5	33.6	5	39.6	8
3.8		9.8		15.8		21.8	4	27.8	4	33.8	6	39.8	8
4.0		10.0		16.0		22.0	3	28.0	5	34.0	4	40.0	7
4.2	↓	10.2	↓	16.2	↓	22.2	4	28.2	5	34.2	4	40.2	7
4.4	1	10.4	4	16.4	11	22.4	3	28.4	4	34.4	4	40.4	7
4.6		10.6		16.6		22.6	4	28.6	5	34.6	4	40.6	7
4.8		10.8		16.8		22.8	4	28.8	5	34.8	5	40.8	7
5.0		11.0		17.0		23.0	4	29.0	4	35.0	4	41.0	7
5.2	↓	11.2	↓	17.2	↓	23.2	4	29.2	5	35.2	4	41.2	7
5.4	2	11.4	10	17.4	4	23.4	3	29.4	5	35.4	4	41.4	9
5.6		11.6		17.6	3	23.6	3	29.6	5	35.6	5	41.6	9
5.8		11.8		17.8	3	23.8	3	29.8	5	35.8	5	41.8	9
6.0	↓	12.0	↓	18.0	6	24.0	4	30.0	4	36.0	5	42.0	9

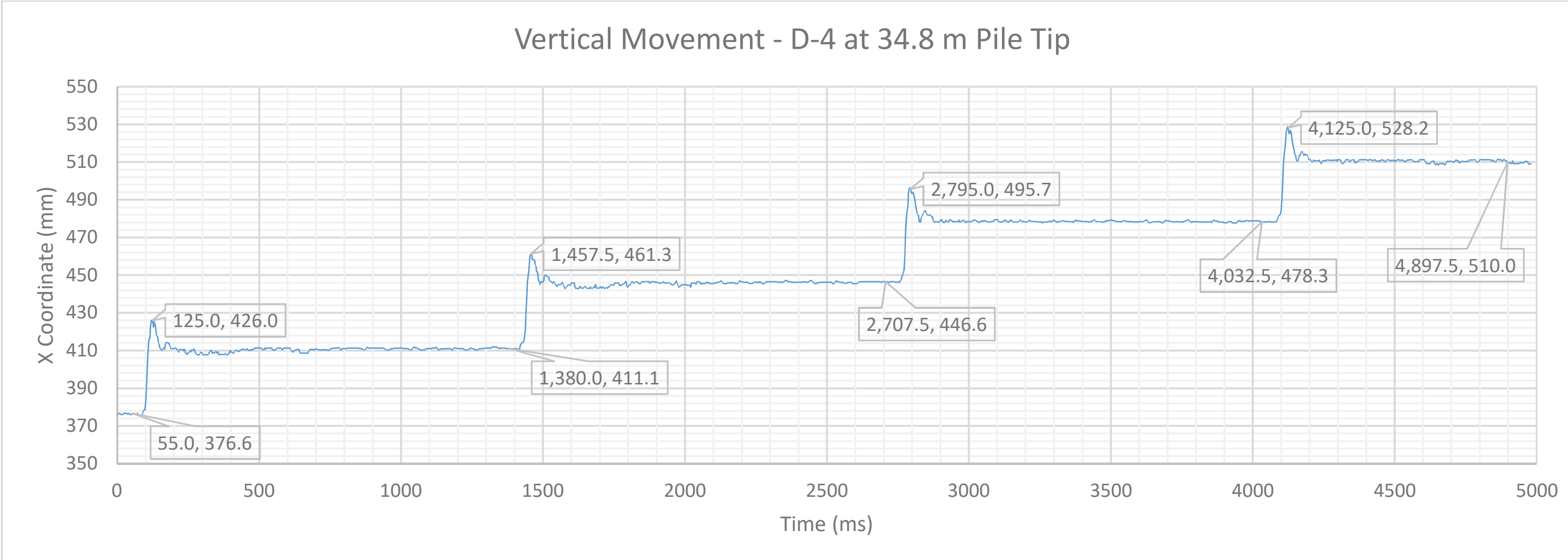
42.2	10	48.2		54.2		60.2		66.2		72.2		78.2	
42.4	10	48.4		54.4		60.4		66.4		72.4		78.4	
42.6	8	48.6		54.6		60.6		66.6		72.6		78.6	
42.8	9	48.8		54.8		60.8		66.8		72.8		78.8	
43.0	10	49.0		55.0		61.0		67.0		73.0		79.0	
43.2	12	49.2		55.2		61.2		67.2		73.2		79.2	
43.4	13	49.4		55.4		61.4		67.4		73.4		79.4	
43.6	14	49.6		55.6		61.6		67.6		73.6		79.6	
43.8	14	49.8		55.8		61.8		67.8		73.8		79.8	
44.0	28	50.0		56.0		62.0		68.0		74.0		80.0	
44.2	28	50.2		56.2		62.2		68.2		74.2		80.2	
44.4	33	50.4		56.4		62.4		68.4		74.4		80.4	
44.6	27	50.6		56.6		62.6		68.6		74.6		80.6	
44.8	26	50.8		56.8		62.8		68.8		74.8		80.8	
45.0	29	51.0		57.0		63.0		69.0		75.0		81.0	
45.2	25	51.2		57.2		63.2		69.2		75.2		81.2	
45.4	30	51.4		57.4		63.4		69.4		75.4		81.4	
45.6	30	51.6		57.6		63.6		69.6		75.6		81.6	
45.8	50	51.8		57.8		63.8		69.8		75.8		81.8	
46.0	70	52.0		58.0		64.0		70.0		76.0		82.0	
46.2	66	52.2		58.2		64.2		70.2		76.2		82.2	
46.4	83	52.4		58.4		64.4		70.4		76.4		82.4	
46.6	85	52.6		58.6		64.6		70.6		76.6		82.6	
46.8	92	52.8		58.8		64.8		70.8		76.8		82.8	
47.0	50	53.0		59.0		65.0		71.0		77.0		83.0	
47.2		53.2		59.2		65.2		71.2		77.2		83.2	
47.4		53.4		59.4		65.4		71.4		77.4		83.4	
47.6		53.6		59.6		65.6		71.6		77.6		83.6	
47.8		53.8		59.8		65.8		71.8		77.8		83.8	
48.0		54.0		60.0		66.0		72.0		78.0		84.0	

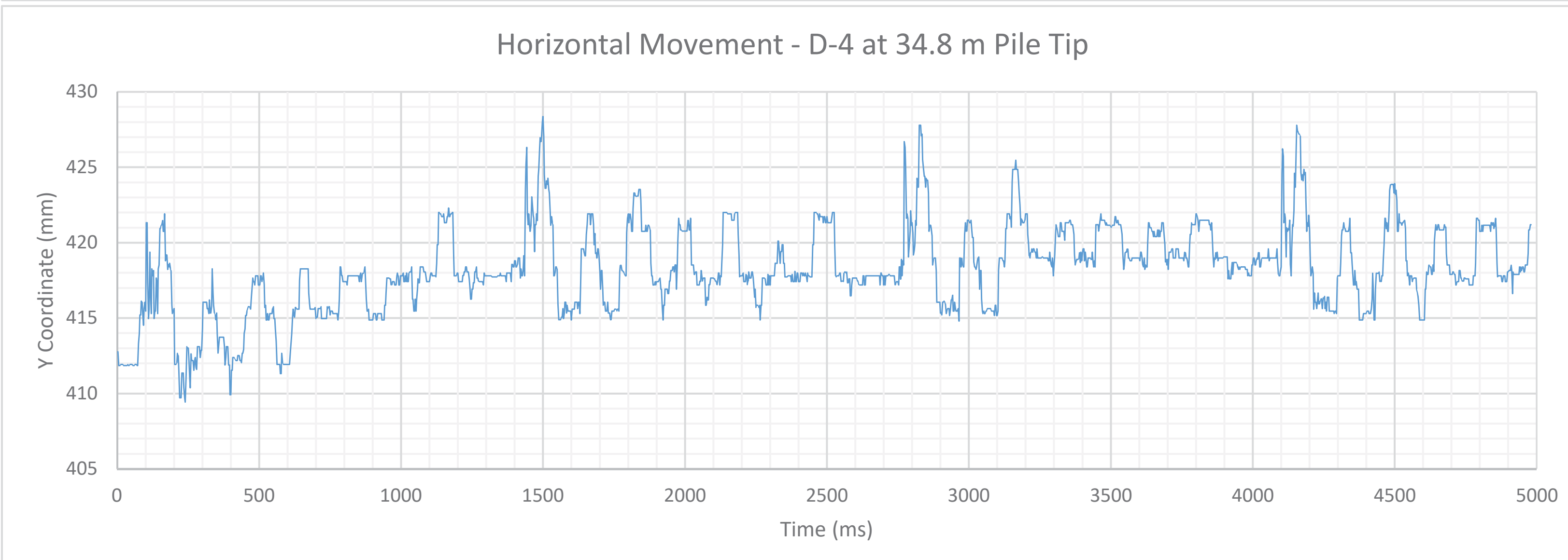
ADDITONAL NOTES/OBSERVATIONS

IR - Insufficient Soil Resistance for Sustained Driving

Depth (m)	**BPM**	
24.6 - 43.8	42 to 46	Hammer Setting 4
43.8 - 45.6	42 to 43	Hammer Setting 3
45.6 - 46.6	42 to 43	Hammer Setting 2
46.6 - 47.0	44 to 45	Hammer Setting 1

The pile was set at a tip elevation of 137.4 m.
The final set was 1.20 mm/blow.


Vertical Movement - D-4 at 34.8 m Pile Tip
X Coordinate (mm)
Time (ms)
550
530
510
490
470
450
430
410
390
370
350
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
125.0, 426.0
55.0, 376.6
1,457.5, 461.3
1,380.0, 411.1
2,795.0, 495.7
2,707.5, 446.6
4,125.0, 528.2
4,032.5, 478.3
4,897.5, 510.0


Horizontal Movement - D-4 at 34.8 m Pile Tip
Y Coordinate (mm)
Time (ms)
430
425
420
415
410
405
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

Appendix E

Ultimate Pile Resistance Calculations

											Ultimate Pile Resistance		
	Pile Tip										Hiley	ENR Bearing	FHWA Gates
Pile #	Depth (m)	Length (m)	BPM	ef	W (kg)	P (kg)	n	E (kJ)	S	C	R (kN)	R (kN)	R (kN)
I-6	6.2	27.6	51	1	4600	5167.2	0.630997	73000	60.6	11.3	695	790	1508
B.5-11	14.8	37	50	1	4600	6408	0.59397	76000	60.2	6.4	712	828	1546
H-3	16.3	38.4	46	1	4600	6592.8	0.589157	90000	60.6	12.5	793	975	1677
B-12	16.4	37.6	45	1	4600	6487.2	0.591888	94000	55.9	7.8	930	1103	1812
D-9	17.1	39.3	46	1	4600	6711.6	0.586147	90000	94	6	544	628	1157
B.5-1	19.9	32.5	47	1	4600	5814	0.610595	86000	56	14.8	828	1008	1730
B-9.5	20.4	42.6	47	1	4600	7147.2	0.575629	86000	23.9	20.1	1458	2361	2715
E-10	20.4	42.6	47	1	4600	7147.2	0.575629	86000	88.6	2.3	552	637	1199
I-9.5	20.5	42.3	49	1	4600	7107.6	0.576553	79000	60.6	5.4	720	855	1570
H-9.5	20.5	42.5	48	1	4600	7134	0.575936	82000	46	9.5	931	1170	1911
H-1	20.5	42.3	45	1	4600	7107.6	0.576553	94000	44	14.8	1054	1402	2101
I-2	20.5	42.7	44	1	4600	7160.4	0.575322	99000	53.4	8.6	987	1216	1916
C-12	20.5	42.7	45	1	4600	7160.4	0.575322	94000	54.5	9	917	1132	1842
H-8.5	20.6	42.6	46	1	4600	7147.2	0.575629	90000	42.6	6.3	1132	1386	2094
G-10.5	20.7	42.5	49	1	4600	7134	0.575936	79000	26.6	15	1334	1949	2482
H-10.5	20.8	42.4	52	1	4600	7120.8	0.576244	70000	8.6	32.2	1633	5341	3514
H-6.5	28.5	50.7	45	1	4600	8216.4	0.552843	94000	39.6	10.7	1156	1558	2228
D-4	34.8	57.4	45	1	4600	9100.8	0.536683	94000	33.4	17.4	1198	1847	2434
B-12	37.6	58.8	46	1	4600	9285.6	0.533567	90000	19.6	30	1388	3013	3012
I-9.5	41.3	58.7	52	1	4600	9272.4	0.533787	70000	12.4	25	1501	3704	3132
H-1	41.3	63.5	45	1	4600	9906	0.523684	94000	18.7	23.2	1625	3298	3136
H-1	41.7	63.5	46	1	4600	9906	0.523684	90000	25.1	23.5	1279	2353	2720
I-2	41.7	62.9	47	1	4600	9826.8	0.524899	86000	24.3	19.4	1328	2322	2696
C-12	41.7	63.9	42	1	4600	9958.8	0.522882	109000	49	13.5	1022	1460	2124
I-10.5	41.8	63.3	52	1	4600	9879.6	0.524088	70000	12.9	20.7	1578	3561	3091
H-8.5	41.8	57.3	50	1	4600	9087.6	0.536909	76000	20.6	14.9	1455	2421	2712
G-10.5	41.9	50.5	50	1	4600	8190	0.55336	76000	22.8	18.7	1308	2187	2602
H-7.5	42	53.8	46	1	4600	8625.6	0.545098	90000	13.2	19.8	2124	4474	3480
E-7	48.8	51	51	1	4600	8256	0.552072	73000	18.9	46.2	960	2534	2750
H-6.5	49.7	56.7	50	1	4600	9008.4	0.538273	76000	29.7	8.3	1209	1679	2315