Kiewit
Infrastructure Group

Anchorage Port Modernization Project

Test Pile Program

Municipality of Anchorage

PORT of Anchorage

Contract No: C 20150888

PORT of ANCHORAGE

FINAL REPORT

AUGUST 1, 2016

(UPDATED - SEPTEMBER 20, 2016)

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1.0 INTRODUCTION AND CONSTRUCTION SUMMARY

The primary purpose of the Anchorage Port Modernization Project (APMP) Test Pile Program was to evaluate the performance of the installation equipment and methods under conditions similar to what will be used for production pile installation. In doing so, the following information was collected and evaluated from the test program which will help to establish tentative pile installation criteria:

- Monitoring of hydro-acoustic noise made by vibratory and impact pile driving.
- Testing of alternative noise abatement systems through use of a confined bubble curtain and resonator system.
- Performance of the pile driving equipment with regard to hydro-acoustic noise, relative driving stresses and transferred energy.
- Pile drivability, the effectiveness of pile driving equipment, installation procedures, and developing data to help determine production pile toe elevations.
- Marine mammal behavior during project activities, specifically Beluga Whales.

1.1 SCOPE OF WORK

Kiewit Infrastructure West Co. (KIWC) installed ten (10) 48-inch diameter, 1-inch wall thickness steel piling to various toe depths around the Port of Anchorage at four (4) locations.

The ten (10) piling were installed utilizing a combination of different pile hammers, as well as testing the effectiveness of two (2) separate noise abatement systems with regard to hydro-acoustic noise. Dynamic monitoring was performed with a Pile Driving Analyzer (PDA) on all ten (10) of the piles during the initial drive as well as during re-strikes of the piles to evaluate pile setup.

During the time pile driving activities were being performed, KIWC utilized three (3) specialty subcontractors to monitor and collect data:

- Robert Miner Dynamic Testing of Alaska, Inc. – Dynamic Pile Measurement and Analyses
- JASCO Applied Services – Hydro Acoustic Monitoring
- AECOM – Marine Mammal Observation

1.2 TIME ON SITE

KIWC began mobilizing its marine equipment down in the Seattle area in late March of 2016 and towed its equipment up to Anchorage arriving to the Port in late April. Pile driving activities began at the Port the first week of May with activities continuing through June. Activities included: initial driving of the piles to the required toe elevations, pile re-strikes after a two-week wait period and cutting off the piles at mudline. KIWC finished its field activities at the Port and demobilized its equipment by the end of June 2016.

1.3 MARINE EQUIPMENT and HAMMER DETAILS

KIWC mobilized and utilized the following major pieces of equipment and pile driving hammers to execute the Test Pile Program (TPP):

- Derrick Barge (DB) General
    - 300’ x 100’ x 18’ Barge
    - 700T Lifting Capacity Crane
- Kiewit 204 Barge
    - 200’ x 54’ x 12’ Barge
- APE 400 Vibratory Hammer
    - Eccentric Moment: 13,000 (in-lbs)
- APE D180 Diesel Impact Hammer
    - Rated Energy: 446.4 (k-ft)
- APE 15-4 Hydraulic Impact Hammer
    - Rated Energy: 120 (k-ft)

1.4 BASICS OF NOISE ABATEMENT SYSTEMS

1.4.1 Confined Bubble Curtain:

The Confined Bubble Curtain was designed and constructed to work in varying depths of water. The system allowed for the pile driving operation to be completely enclosed by bubbles for the full depth of the water column. Aeration pipe layers were installed within to provide a minimum bubble flux of 2.0 cubic meters per minute per lineal meter of pipe in each aeration layer, while maintaining contact with the mudline.

The air delivery system consisted of one (1) 1600 CFM compressor linked directly to a manifold with pressure gauges and air flow monitors. The structural element was comprised of a telescoping steel pipe system made up of a 5-foot inner pipe and a 6-foot diameter outer pipe. The inner pipe housed four (4) pipe aeration layers at 9-foot spacing. Two winches were mounted at the top of the outer pipe to raise and lower the inner pipe to accommodate the varying water depths due to the extreme tidal fluctuations.

1.4.2 Resonator System:

The Resonator system as specified in the contract specifications was designed by AdBm Technologies. The resonator is an underwater noise attenuation system that uses resonant attenuation for mitigating underwater noise. The system uses thousands of Helmholtz resonators to accomplish this. Resonators are molded from HDPE (High-Density Polyethylene) into blocks containing multiple resonators. The resonators are placed in a framework that completely surrounds the noise source from the sea floor to near the surface of the water. The framework for this project consisted of four sides, each side resembling a venetian blind acting in an accordion like fashion, extending down to the mudline using four (4) winches mounted to a steel support frame. The bottom structure of the resonator is called the ballast assembly which acts as an anchor for the resonator slats that provide the framework for the resonant attenuation. The ballast assembly helped to stabilize the system in the strong currents of the Cook Inlet. Each slat layer was suspended from the layer above using alloy chains. As the system is retracted up, the slat layers stacked on top of each other.

1.5 DEPLOYMENT MECHANISMS AND CHALLENGES

KIWC utilized a steel fabricated frame attached to the end and cantilevered off the barge as its main support system. Hydraulic winches were mounted to the frame and used to deploy and retrieve each of the noise abatement systems. Four (4) were used for the resonator system and two (2) were used for the confined bubble curtain system. The winches were powered by a single hydraulic power unit staged on the barge. Each system had a set of lifting lugs attached to its main components that allowed the winch cables to be secured, allowing each of the systems to be either lowered or raised by the winch controls.

Overall, the deployment mechanism for each of the systems worked well. The extreme tidal fluctuations required full time attention to the winch controls to ensure the system was following the varying water depths throughout each of the pile driving activities. Continuous monitoring and communication of the currents also played a vital role in the successful execution of deployment or retrieval of each system.

1.6 PORT COMMUNICATIONS AND CHALLENGES

KIWC understood from the start of the project the importance of communication with both the Port operations team as well as the other stakeholders and tenants. KIWC performed a lot of upfront coordination with other contractors at the Port as well as re-communicating its plan of activities as the work progressed. KIWC sent out a communication email to all tenants and users of the Port anytime it would move its marine equipment and/or change its mooring configuration. This allowed a timely response to mitigate any berthing or coordination conflicts. KIWC recognized the challenges with performing work within an active Port facility and was able to accommodate the changes of the differing berthing schedules. Upfront planning and communication was the key.

For future projects that require a lot of coordination between the marine contractor, its equipment with the Port operations team, and its tenants, KIWC recommends ensuring communication meetings are conducted and the contractor’s work plan is disseminated to key points of contact of the Port’s tenants and other contractors working within the Port limits as early as possible.

1.7 SUMMARY REPORTS

Throughout the course of the APMP Test Pile Program, KIWC's specialty subcontractors monitored and collected various sources of data. This data was analyzed and summarized into three (3) major reports:

- Dynamic Pile Measurements and Analyses
- Hydroacoustic Monitoring (HAM) Report
- Marine Mammal Observation (MMO) Report

1.7.1 Dynamic Pile Measurements and Analyses:

This report provides results obtained from dynamic pile measurements and analyses completed for installation and restrike of ten (10) Indicator Piles. The measurements and analyses were completed by Robert Miner Dynamic Testing of Alaska, Inc. (RMDT). See ***Attachment 1*** for complete report.

1.7.2 Hydroacoustic Monitoring (HAM):

This report provides results obtained from hydroacoustic monitoring to analyze underwater sound pressure levels throughout the installation of ten (10) Indicator Piles, during both vibratory and impact hammer pile driving. Autonomous sound recorders were deployed at nominal distances of 10 m and 1 km from each pile and a mobile hyrdrophone system drifted during measurements to target data collection at ranges corresponding to marine mammal disturbance thresholds. Measurements and analyses were completed by JASCO Applied Sciences. See ***Attachment 2*** for complete report.

1.7.3 Marine Mammal Observation (MMO):

This report presents the information for monitoring and data collection of beluga whale and other marine mammal observations during the pile driving activities. The monitoring and data collection was completed by AECOM. See ***Attachment 3*** for complete report.

ATTACHMENT 1

Dynamic Pile Measurements and Analyses

Robert Miner Dynamic Testing of Alaska Inc.
Dynamic Measurements and Analyses for Deep Foundations

July 26, 2016

Mr. Tanner Vetsch
Kiewit Infrastructure West Company
33455 6th Ave South
Federal Way, WA 98003

Re: Dynamic Pile Measurements and Analyses
PP48"x1.0", May 3- June 21, 2016
APE D180-42 Diesel Hammer & APE 15-4 Hydraulic Hammer
Test Pile Program, Anchorage Port Modernization Program
Kiewit Job No 102887 RMDT Job 16F03

Dear Mr. Vetsch,

This report provides results obtained from dynamic pile measurements and analyses completed for installation and restrike of the ten Indicator Piles referenced above. The measurements and analyses presented herein were completed by Robert Miner Dynamic Testing of Alaska, Inc. (RMDT) at the request of Kiewit Infrastructure West Company (KIWC).

TEST DETAILS

Piles:

The Anchorage Municipality Port Modernization Project Test Pile Program included installation and restrike of ten Indicator Piles, numbered IP 1-10, installed in four different zones (Locations 1, 4, 5 & 6) within the port waterfront. All Indicator Piles are vertical, 48" O.D. steel pipe piles with a wall thickness of 1.00". Indicator Pile 6 has a bearing plate (internal diaphragm) located approximately 82 ft above the pile tip; the other nine Indicator Piles were installed open-end. We understand that the pile material conforms to the specifications of the ASTM A252 Grade 3 and API 5L X52 designations. At the time of driving the pile lengths ranged from 192 to 205 ft. For further information regarding the piles please refer to project documents prepared by KIWC.

Measurement and Analysis Method:

We collected dynamic measurements using strain sensors and accelerometers attached to the piles. Four strain sensors and 4 accelerometers were attached to all piles for all drive and restrike tests except the initial drive of IP 8. At the start of monitoring on each pile, and for all restrikes the sensors were located 15 to 18 ft from the pile top. For some piles this sensor configuration was altered near the end of installation driving if the sensor location was approaching or entering the water or entering the confined bubble curtain. Changes to the sensor configuration included moving the sensor location higher on the pile, or replacing the eight sensors with two or four water resistant strain sensors and two water resistant accelerometers. The installation of IP 8 was monitored using the industry standard configuration of two strain sensors and two accelerometers. Signals from these sensors were collected and processed using a Pile Driving Analyzer ® (PDA) manufactured by Pile Dynamics, Inc.

Following the testing we used the CAPWAP® program to compute the soil resistance acting on the pile. The CAse Pile Wave Analysis Program (CAPWAP) computes soil resistance forces and their approximate distribution using the force and velocity data recorded in the field during dynamic monitoring. Final CAPWAP results include an evaluation of the soil resistance distribution, pile axial stress as a function of distance below the sensors, soil quake and damping factors, and a simulated static load-set graph. The static load-set graph is based on the CAPWAP calculated static resistance parameters and the elastic compression characteristics of the pile. Appendix A is a description of the PDA and CAPWAP methods.

***Hammer*s:**
Installation of each pile started with the APE 400 vibratory having quad-clamps. In most cases the pile tip was driven approximately 50 ft below the mud-line using the vibratory hammer, after which depth impact driving started. Two different impact hammers drove the piles. The APE D180-42 open end diesel impact hammer is reported to have a nominal ram weight and manufacturer's maximum rated energy of 39.7 kips and 447 kip-ft, respectively. The APE 15-4 impact hammer is reported to have a 30 kip ram and a maximum stroke of 4.0 ft, yielding a 120 kip-ft rated energy. Both hammers operated in "off-shore" type swinging leads. The hammer used for impact installation of each pile is listed in Table 1. The Delmag D180-42 was used for all restrikes.

Test Sequence:

Appendix E contains a project site map with overlays depicting the approximate location of each pile. Pile Driving Records are also presented in Appendix E. The site map and the Pile Driving Records in Appendix E were provided by KIWC.

Beginning May 3 and ending June 7 the ten Indicator Piles were installed in four different zones identified as Locations 1, 4, 5 & 6. Table 1a is a summary of selected pile details ordered by the Indicator Pile No. Table 1b contains the same information reordered to group piles by Location. Pile installation involved various combinations of hammers, target tip elevations, and sound attenuation methods. In this report the tip elevations, mudline elevations and penetration resistance data (blows/ft) are based on driving logs provided by KIWC. Field reports prepared by RMDT presented the PDA field results and CAPWAP analysis results as the Port's Test Pile Program progressed. Appendix D contains the various field reports which RMDT issued for the installation of the ten piles. However, the Case Method and CAPWAP results originally included with the field reports were removed from Appendix D; those results are now assembled in Appendices B and C.

The restrike tests began on June 8 and ended on June 21, 2016. The waiting times between driving and restrike ranged from 13 to 38 days and are given with the restrike CAPWAP results in Tables 3a-d. Field reports were issued for the restrikes as the data collection progressed. We used the KIWC Pile Driving Records to correlate the sequence of measured hammer blows to depth below mudline. The KIWC Pile Driving Records for pile installation are based on observation of the pile relative to the template structure attached to the floating pile barge. Because changes in the tide level effected the position of the template, penetration resistance values recorded for each ft on the Pile Driving Record corresponded to a distance that may have been slightly greater than 1 ft if the tide level was falling during driving. To account for this circumstance the Pile Driving Records indicate "No Count" for some depth intervals; this recording method provides suitable piecewise correction to the effect which a gradually lowered template reference would otherwise have on the depths listed in the Pile Driving Record.

We used the KIWC records as if the "No Count" entries were not present because use of those entries would put discontinuities in the plots of results versus depth and thus distract the reader from the trends and more important aspects of the data. The plotted and tabulated depths given in Appendix B are thus correct *for the end of driving*, but diverge in one ft intervals each time a “No Count” entry is present in the logs as one moves *upward* in the logs. The net effect, with respect to depth information in Appendix B, is that the depths at the end of driving are correct and the depths for the start of monitoring are shown deeper than was actually the case. Such downward shift for the shallowest depths is approximately equal to the number of “No Count” entries in the logs prepared by KIWC. During restrike tests KIWC observed the axial advance of each pile using a survey instrument located on either land or a stable pier structure and thus obtained penetration resistance observations that were not biased by water level changes.

PRESENTATION OF RESULTS

Case Method Results:

In the field, the PDA processed dynamic measurements and computed a variety of results, some of which are summarized in Table 2 for the end of initial driving. The data in Table 2 include the approximate pile penetration, penetration resistance, energy transferred to the sensor location on the pile, EMX, and the calculated maximum axial compressive stress, CSX. For the D180-42 open-end diesel hammer the computed ram stroke height, STK, is included in the Case Method results. Penetration and penetration resistance data (blows per ft, or blows per inch) used and presented herein is based on the KIWC Pile Driving Records.

Figures and numerical summaries in Appendix B provide Case Method results for the sequence of installation driving and for the sequence of all restrikes. These plot and figures include results for driving stress, transfer energy and other quantities as a function of approximate depth for driving and as a function of blow number for restrikes.

All Case Method and CAPWAP results were computed using values for the overall wave speed and pile steel Young’s Modulus which were consistent with measurements collected during driving. Based on the measured reflections times and the known pile lengths we computed a compressional wave speed of approximately 17,100 ft per second; a value of approximately 31,000 ksi for Young’s modulus corresponded to this relatively high wave speed and we applied that modulus value to compute force from measured strain. This back-calculated modulus was approximately 1.03 times the normally assumed value, and it thus increased by approximately 2 to 3 percent all results which included force units, such as soil resistance and transfer energy (kip-ft). Results given in this report incorporate use of this stiffer modulus and thus yield increased force magnitude relative to the commonly applied 30,000 ksi modulus.

In routine testing, the PDA uses the average of the signals from the strain transducers to compute the average maximum axial compression stress at the sensor location, CSX. The PDA also calculates the maximum compressive stress at the sensor location using the largest strain from a single strain transducer, CSI. Table 2 lists CSX values that are characteristic of the end of driving and Appendix B presents additional CSX and CSI data. The PDA computed CSX and CSI values apply to the sensor location near the pile top. In Appendix C the “Extrema Table” for each CAPWAP analysis gives axial compressive stress values computed for locations other than the sensor location. Excluding IP 6 the Extrema Table results indicate that CSX values were within 1.0 ksi of the corresponding peak axial stress lower in the pile. Neither the Case Method CSX values or the CAPWAP computed axial stress values include stresses associated with bending or uneven loading across the pile cross-section.

During data acquisition, force and velocity records were evaluated for indications of pile damage below the sensor location. If present during testing, damage that yields a significant reduction of axial compressive stiffness would normally be detected provided that it is not too close to the pile toe. During field testing and data review we did not observe in the PDA results indications of pile damage below the sensors; it is our opinion that the piles were installed without deformation or damage which would effect soil-pile interactions, driveability or pile performance.

The Case Method transfer energy values, EMX, varied significantly during the course of driving on each pile and also between piles. The EMX values are thus helpful when considering the differences in penetration resistance (blows per ft) during driving. For example at Location 1 driving on IP 3 and IP 4 ended with the same penetration (149 ft) but the penetration resistance was 72 blows per ft (BPF) for IP 3 and 30 BPF for IP 4, thus differing by a factor of 2.4. The transfer energy values shown for final driving in Table 2 for IP 3 and IP 4 differ by a factor of approximately 0.4, so that the difference in penetration resistance is matched by a commensurate and reciprocal difference in transfer energy. Although these two piles were driven with different hammers the EMX values allow rational comparisons of the penetration resistances. The results in Appendix B include transfer energy values throughout impact driving for all piles and thus support rational comparisons of driving resistances for other piles and depths.

Soil Resistance:

CAPWAP analyses were completed for a variety of test conditions. For all piles CAPWAP® analyses were completed for the end of driving and for early restrike blows. Also, depending upon the conditions and based on discussion with the project team, CAPWAP analyses were completed for intermediate installation depths and later restrike blows. Tables 3a-d summarize the CAPWAP results and detailed program output is in Appendix C. Our opinions and comments on the CAPWAP results for each pile follow grouped by Location Number.

Location 1, Indicator Pile 3: The CAPWAP analyses are for driving data at soil penetration depths of 116 and 149 ft, and for restrike at 149 ft depth (Tip Elevation -184) after a 13 day waiting period. For the end of driving at 149 ft depth the CAPWAP computed ultimate resistance was 1240 kips derived from 840 kips of shaft friction and 400 kips of end bearing. When compared with the end of driving, the CAPWAP for restrike at 149 ft depth yielded a large increase of shaft friction and 2900 kips of total resistance. Due to the high penetration resistance upon restrike, and corresponding small net pile movement it is our opinion that the 2900 kip ultimate resistance computed for restrike is a lower bound value for resistance the would be mobilized given larger transfer energy and larger impact forces during restrike.

The intermediate depth of 116 ft was selected for supplemental CAPWAP analysis of installation data because the restrike analysis yielded friction values of approximately 1200 kips in the upper 116 ft of soil. Based on synthesis of the 160 kip CAPWAP computed end bearing for 116 ft, and the restrike CAPWAP computed 1200 kip shaft friction for soil between the mudline and 116 ft, the restrike ultimate resistance for a pile embedded 116 ft might be computed as 1360 kips. However, the approach used for summing restrike friction over specific depth range with end bearing from a driving at a different depth entails uncertainty and it is our opinion the likely range for restrike at 116 ft would 1250 to 1400 kips. Our estimated range considers uncertainty in the CAPWAP computed shaft friction distribution and the effect of such uncertainty upon our synthesis of shaft friction and end bearing from two different CAPWAP analyses to estimate restrike results for a depth where restrike did not occur. Similar considerations apply to our estimates given below for restrike total resistance for any depth at which a restrike did not occur.

Location 1, Indicator Pile 4: IP 4 was driven to a Tip Elevation of approximately -175 ft where the soil penetration was 149 ft. CAPWAP analyses were completed using data for soil penetration depths of 103 and 149 ft during installation, and for the 149 ft depth after a 33 day restrike waiting period. The CAPWAP computed ultimate resistance for drive and restrike at 149 ft was 1070 and 2550 kips, respectively, with approximately 90 percent of the restrike resistance from friction.

The intermediate depth of 103 ft was selected for supplemental CAPWAP analysis of installation data because the 33 day restrike yielded friction values of approximately 1260 kips in the upper 103 ft of soil . Based on synthesis of the end bearing for 103 ft, and the restrike shaft friction we estimate that the restrike ultimate resistance for a pile embedded 103 ft would likely range from 1250 to 1400 kips.

The APE 15-4 hammer drove IP 4 to approximately 113 ft below mudline on May 12. Approximately 15 hour later, on May 13, driving resumed with the D180-42 hammer. The detailed Case Method results shown in Appendix B provide further measured results associated with this hammer change and pause in driving.

Location 4, Indicator Pile 2: IP 2 was driven to a Tip Elevation and soil depth of -170 ft and 141 ft, respectively. Using dynamic measurements from installation driving we completed CAPWAP analysis for hammer blows when the depth in soil was 115 and 141 ft. For the 115 ft depth the CAPWAP resistance was modest, totaling 630 kips derived from 520 kips of friction and 110 kips of end bearing. The intermediate depth of 115 ft was chosen for CAPWAP because the restrike results suggest that restrike shaft friction from the mudline to 115 ft was approximately 1100 to 1200 kips.

For the end of driving at 141 ft depth the CAPWAP resistance was 1210 kips composed of 780 kips of friction and 430 kips of end bearing. IP 2 was tested during restrike on June 9 and June 21. CAPWAP analysis for the first restrike yielded 2760 kips, of which 1940 kips was from friction. However, the penetration resistance was quite high during this first restrike and the full ultimate resistance may not have been mobilized. The second restrike occurred with larger ram stroke heights and transfer energy values that were typically 3 times larger than the first restrike. The CAPWAP computed resistance for the second restrike was 3420 kips, with increases in both friction and end bearing relative to the first restrike. It is not clear to what extent the larger soil resistance for the second restrike was due to the effects of better mobilization of resistance given the greater transfer energy, or to the effects of the 12 additional days of soil setup time. However, the lower penetration resistance (blows per inch) observed for the second restrike is very likely caused by the fact that transfer energy was significantly greater during the second restrike.

Location 4, Indicator Pile 5: IP 5 was driven to a Tip Elevation and soil depth of -173 ft and 144 ft, respectively. Using dynamic measurements from installation driving we completed CAPWAP analysis for hammer blows when the depth in soil was 111 and 144 ft. The restrike on IP 5 at a depth of 144 ft yielded an ultimate resistance of 3560 kips, composed of 2360 kips of friction and 1200 kips of end bearing. We consider it likely that the 1200 kip end bearing reflects partial plugging upon restrike. Also, we consider it likely that the 3560 kip CAPWAP restrike resistance is a lower bound value and that a larger resistance would have been activated given a stronger hammer blow.

For the 111 ft depth the CAPWAP resistance was modest, totaling 500 kips derived from 470 kips of friction and 30 kips of end bearing. The intermediate depth of 111 ft was chosen for

CAPWAP because the restrike results suggest that restrike shaft friction from the mudline to 111 ft was approximately 1170 kips. Based on the available data we estimate that a suitable restrike at 111 ft would an ultimate resistance of approximately 1100 to 1250 kips.

Location 4, Indicator Pile 6: IP 6 was driven with an internal bearing plate located approximately 82 ft above the pile tip. This bearing plate is reported to have a 3" diameter hole to allow the upward movement of fluid and soil during driving. Although all three piles at Location 4 were driven with the APE D180-42 hammer the penetration resistance for IP 6 were significantly higher than for IP 2 and IP 5. It is our opinion that this harder driving resulted from resistance on, or associated with, the plate. Driving on IP 6 ended with Tip Elevation -156 and a soil penetration of 129 ft. Although the penetration resistance was substantially larger for IP 6 that is was for IP 2 and IP 5 the CAPWAP computed resistance was values for IP 6 were lower at the end of driving; shaft friction was computed as 580 kips, “end bearing” on the internal plate was computed as 220 kips, and end bearing at the pile tip was computed as 100 kips.

CAPWAP analysis for restrike Blow 3 on IP 6 at 129 ft depth yielded 2060 kips ultimate resistance, composed of 1580 kip of shaft friction, 180 kips on the internal plate and 290 kips of tip resistance. For IP 6 we also completed CAPWAP analysis for restrike Blows 10 and 31. Comparison of the results for restrike Blows 3, 10 and 31 suggest that as the restrike progressed the shaft friction and tip resistance decreased and the resistance on the internal plate increased. Due to the complexities and uncertainties of resistance on the internal plate, and models of such resistance, the CAPWAP results for IP 6 contain somewhat more uncertainty than is normally expected for CAPWAP of uniform piles. Notwithstanding this uncertainty, it is our opinion that the available CAPWAP results suggest that soil resistance on the internal plate decreased following initial driving, was low at the start of restrike and then increased as the restrike progressed. Shaft friction and tip resistance, however, followed a common pattern wherein friction increased during the time between drive and restrike then decreased as the restrike progressed, and end bearing on restrike showed a modest initial increase attributable to internal friction and partial plugging which decreased as the restrike progressed.

Comparison of the CAPWAP computed Smith damping values for the resistance on the plate indicates that unusually large damping resistances are present below the plate, with the highest damping for the end of driving and end of restrike, and lower damping for the start of restrike. This pattern together with the patten of computed resistance on the plate suggest that resistance of the plate during driving may be greater than the long term resistance, with resistance relaxing somewhat following driving. This is consistent with the decrease in penetration resistance noted for the restrike relative to the end of driving; the end of driving resistance was 84 blows per ft, the start of restrike was 4 blows per inch, and the end of restrike was 6 blows per inch.

In addition to the aspects of resistance discussed above, we note that driveability of IP 6 was apparently also altered by the effect of the plate on transfer energy. This is discussed in our field report for IP 6 as reproduced in Appendix D. The ram stroke heights observed for IP 6 were somewhat lower than those recorded for other piles driven with the D180-42 for this project. We noted, qualitatively, that pile ‘elastic’ displacement and rebound was markedly higher for this pile at all depths, and especially at intermediate depths. Such elastic rebound is sometimes referred to as “bouncy” driving or a “large quake” condition and is often associated with a reduction in ram stroke height relative to the stroke expected for a diesel hammer operating under otherwise comparable conditions.

The transfer energy values for IP 6 are significantly lower than those for other Indicator Piles driven with the D180-42, and the modestly lower ram stroke heights do not fully account for this lower energy. CAPWAP analyses completed for a hammer blow near 129 ft depth indicate that approximately 100 ft below the PDA sensors a very large and abrupt reduction in energy transfer occurred; about one-half of the energy arriving at that zone passed into the pile below that zone. Our sensors were mounted 15 ft from the pile and thus 103 ft from the internal bearing plate. It is our opinion that the interaction between the internal water or soil and the bearing plate markedly reduced energy transfer to the lower portion of the pile. We consider it likely that the energy was mostly reflected upward from the plate and associated internal soil resistance and this reflection of energy reduced the maximum energy transfer, EMX, at our sensor location. However, we presently do not have a clear understanding of the wave mechanics associated with this apparent cause for the lower EMX values measured during driving on IP 6.

The Case Method RX7 soil resistance calculations for IP 6 were relatively similar for the last 30 ft of driving and were close to 600 kips . However, it is our opinion that the Case Method results are dominated by the behavior of the soil beneath the bearing plate and thus do not reveal driveability changes normally associated with soil resistance changes much lower on the pile. Moreover, a primary use of Case Method resistance results involves assumed correlation with other methods and comparison of results for different piles and depths. Due to the presence of the bearing plate in IP 6 , such relative comparisons for driveability and resistance are likely to require more data than is presently available.

Based, in part, on the apparent high damping values for soil below the bearing plate it is our opinion that there is significant uncertainty regarding the nature of the driving resistance on the bearing plate. Also, the large displacements and rebound observed during driving on IP 6 may cause greater disturbance at the soil pile interface and (temporarily) reduce the shaft friction relative to end-of-drive friction for an open-end pile which is driven without the larger number of high rebound hammer blows that occurred with IP6. Comparison of end-of-drive friction values for IP 6 and other piles may require extra consideration of such driving disturbance.

The CAPWAP computed 900 kip ultimate resistance for the end of driving on IP 6 is low relative to the penetration resistance when compared with the other Indicator Piles. We attribute part of the increased penetration resistance (blows per ft) with IP 6 to the lower transfer energy values computed for the sensor location near the top of IP 6. The average final transfer energy, EMX, was 132 kip-ft, and thus approximately 0.6 times the 227 kip-ft average for final driving on other piles with the D180-42. Moreover, energy transfer computed in CAPWAP analyses for a location approximately 20 ft from the pile toe was far less for IP 6 than for all other piles, including those driven with the APE 15-4 hammer. Reduced energy transfer past the bearing plate and into the bottom portion of the pile would cause a significant reduction in driveability, as would the large elastic rebound noted above. If production piles have a bearing plate then these aspects of driveability should be carefully considered when interpreting any pile driving observations.

Location 5, Indicator Pile 1: IP 1 was driven with the APE 15-4 hammer to a Tip Elevation of -150 ft where the soil penetration was 128 ft. CAPWAP analyses for restrike indicate yield a significant increase in shaft friction during the 14 day period between drive and restrike. Also, it is our opinion that the increase in CAPWAP computed end bearing upon restrike likely results from partial plugging inside the lower part of the pile with the resulting resistance expressing as apparent end bearing. The CAPWAP computed ultimate resistance upon restrike was 2450 kips, composed from 1900 kips of friction and 550 kips of end bearing.

Location 5, Indicator Pile 7: IP 7 was driven approximately 11 ft deeper than nearby IP 1 and yielded significantly higher resistance at the end of driving, with approximately one-half of the friction resistance coming from the lower 40 ft of the pile, and significantly more end bearing than IP 1. The restrike on IP 7 yielded an ultimate resistance of 3900 kips of which 2960 kips was shaft friction. Using the restrike friction results we estimate that the restrike friction resistance acting within the upper 99 ft was approximately 1280 kips. A supplemental CAPWAP analysis for driving at 99 ft yielded an end bearing resistance of approximately 30 kips at that depth. Based on the available CAPWAP results we estimate that the for a depth of 99 ft the restrike resistance would have been approximately 1200 to 1300 kips.

Location 6, Indicator Pile 8: IP 8 was driven to Tip Elevation -133 ft and soil penetration 105 ft. The CAPWAP computed ultimate resistance for the end of driving and the start of restrike was 1160, and 2780 kips, respectively. Approximately 88 percent of the restrike resistance was computed as shaft friction; end bearing for the end of driving and restrike was similar in magnitude.

Location 6, Indicator Pile 9: IP 9 was driven to Tip Elevation -140 ft and soil penetration 115 ft. The CAPWAP computed ultimate resistance for the end of driving and the start of restrike was 1310, and 4030 kips, respectively. Approximately 82 percent of the restrike resistance was computed as shaft friction.

Location 6, Indicator Pile 10: IP 10 was driven to Tip Elevation -137 ft and soil penetration 113 ft and was in these regards similar to IP 9. The CAPWAP computed ultimate resistance for the end of driving and the start of restrike was 1190, and 2220 kips, respectively. Approximately 72 percent of the restrike resistance was computed as shaft friction. Comparison of the shaft friction results for IP 10, 9 and 8 suggest that the longer waiting time for IP 8 and 9 yielded substantial additional time-dependent strength increases. The restrike waiting times of IP 8, 9 and 10 were 38, 34 and 15 days, respectively.

Additional Considerations

The static soil resistance values computed with the Case Method are estimates of the mobilized, axial compressive soil resistance at the time of testing. These soil resistance results are ultimate resistance values and they must be reduced by an appropriate factor of safety or resistance factor to obtain working loads or factored resistances.

During pile driving, excess positive pore pressures are often generated. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and the pile capacity at the time of driving. As these pore pressures dissipate, the soil strength may increase and the soil resistance may increase. This phenomena is called soil setup or soil freeze. Alternately, relaxation of end bearing may occur for piles driven into dense granular soils. Dynamic testing during restrike with adequate set per blow usually yields a better indication of long term soil resistance than a test at the end of pile driving.

Numerous factors are usually considered in pile foundation design. Some of these considerations include cyclic loading performance, lateral and uplift loading requirements, effective stress changes (due to changes in water table, excavations, fills or other changes in overburden pressure), settlement from underlying weaker layers, the effects of scour or liquefaction on pile capacity, as well as pile group effects, strong ground motion, and time dependant changes in pile structural strength or corrosion. These factors have not been evaluated by RMDT in the interpretation of the dynamic testing results. The foundation designer should determine if these considerations are applicable to this project and, if so, their impact on the foundation design.

We enjoyed performing these analyses for you. If you or your client have any questions or if we can provide further assistance, please contact us.

Sincerely,

Robert F. Miner

ROBERT F. MINER
No. CE 11584

Robert F. Miner, P.E.

Robert Miner Dynamic Testing of Alaska, Inc.

July 26, 2016

Table 1a. Summary of Pile and Test Details

Indicator Pile No.	Location No.	Installation Impact Hammer	Date Installed	Tip Elevation as Installed, ft	Soil Penetration, as Installed, ft	Date of Restrike
IP 1	5	APE 15-4	07June2016	-150	128	21June2016
IP 2	4	APE D180-42	19May2016	-170	141	09 & 21June
IP 3	1	APE 15-4	03June2016	-184	149	16June2016
IP 4	1	APE 15-4 & D180-42	12&13May2016	-175	149	15June2016
IP 5	4	APE D180-42	18May2016	-173	144	09June2016
IP 6	4	APE D180-42	01June2106	-156	129	21June2016
IP 7	5	APE D180-42	25May2016	-165	139	08June2016
IP 8	6	APE 15-4	03May2016	-133	~105	10June2016
IP 9	6	APE D180-42	06&07May2016	-140	~115	10June2016
IP 10	6	APE 15-4	26May2016	-137	113	10June2016

Table 1b. Summary of Pile and Test Details sorted by Location

Indicator Pile No.	Location No.	Installation Impact Hammer	Date Installed	Tip Elevation as Installed, ft	Soil Penetration, as Installed, ft	Date of Restrike
IP 3	1	APE 15-4	03June2016	-184	149	16June2016
IP 4	1	APE 15-4 & D180-42	12&13May2016	-175	149	15June2016
IP 2	4	APE D180-42	19May2016	-170	141	09 & 21June
IP 5	4	APE D180-42	18May2016	-173	144	09June2016
IP 6	4	APE D180-42	01June2106	-156	129	21June2016
IP 1	5	APE 15-4	07June2016	-150	128	21June2016
IP 7	5	APE D180-42	25May2016	-165	139	08June2016
IP 8	6	APE 15-4	03May2016	-133	~105	10June2016
IP 9	6	APE D180-42	06&07May2016	-140	~115	10June2016
IP 10	6	APE 15-4	26May2016	-137	113	10June2016

Table 2. Summary of Case Method Results

Pile	Test	Approx. Depth Below Mud-Line (ft)	Approximate Penetration Resistance blows/set	Average Transfer Energy (EMX) kip-ft	Computed Ram Stroke (STK) ft	Compressive Stress (CSX) ksi
IP 3, Loc. 1	Drive	149	72/ft	96	NA	22
IP 4, Loc. 1	Drive	149	30/ft	226	9.7	29
IP 2, Loc. 4	Drive	141	16/ft	226	9.7	30
IP 5, Loc. 4	Drive	144	23/ft	239	10.0	29
IP 6, Loc. 4	Drive	129	84/ft	132	8.9	23
IP 1, Loc. 5	Drive	128	54/ft	89	NA	21
IP 7, Loc. 5	Drive	139	22/ft	236	9.9	29
IP 8, Loc. 6	Drive	105	31/3"	97	NA	22
IP 9, Loc. 6	Drive	115	37/ft	206	9.2	27
IP 10, Loc. 6	Drive	113	77/ft	110	NA	30

Table 3a. Summary of CAPWAP Results for Location 1

Pile	Hammer	Test	Date of Test	Restrike Waiting Time (days)	Approx Depth in Soil (ft)	Reported Penetration Resistance (blows/set)	Computed Soil Resistance, kips		
							Total	Shaft	Toe
IP 3 (Loc 1)	APE 15-4	Drive	03Jun201	--	116	65/ft	600	440	160
IP 3 (Loc. 1)	APE 15-4	Drive	03Jun2016	--	149	72/ft	1240	840	400
IP 3 (Loc. 1)	D180-42	Restrike	16Jun2016	13 Days	149	~43/ 1 inch	2900	2500	400
IP 4 (Loc. 1)	D180-42	Drive	13May2016	--	103	45/ft	530	400	130
IP 4 (Loc. 1)	D180-42	Drive	13May2016	--	149 ft	30/ft	1070	940	130
IP 4 (Loc. 1)	D180-42	Restrike	15Jun2016	33 Days	149 ft	~10/ 1 inch	2550	2270	280

Table 3b. Summary of CAPWAP Results for Location 4

Pile	Hammer	Test	Date of Test	Restrike Waiting Time (days)	Approx Depth in Soil (ft)	Reported Penetration Resistance (blows/set)	Computed Soil Resistance, kips		
							Total	Shaft	Toe
IP 2 (Loc. 4)	D180-42	Drive	19May2016	--	115	24/ft	630	520	110
IP 2 (Loc. 4)	D180-42	Drive	19May2016	--	141	16/ft	1210	780	430
IP 2 (Loc. 4)	D180-42	Restrike	09Jun2016	21 Days	141	~22/1 inch	2760	1940	820
IP 2 (Loc. 4)	D180-42	2nd Restrike	21Jun2016	21 + 12 Days	~141	10/ 1 inch	3420	2420	1000
IP 5 (Loc. 4)	D180-42	Drive	18May2016	--	111	60/ft	500	470	30
IP 5 (Loc. 4)	D180-42	Drive	18May2016	--	144	23/ft	1340	840	500
IP 5 (Loc. 4)	D180-42	Restrike	09Jun2016	22 Days	144	~28/1 inch	3560	2360	1200
IP 6 (Loc. 4)	D180-42	Drive	01Jun2016	--	129	84/ft	900	580	220+100
IP 6 (Loc. 4)	D180-42	Restrike Blow 3	21Jun2016	20 Days	129	4/ 1 inch	2060	1580	180+290
IP 6 (Loc. 4)	D180-42	Restrike Blow 10	21Jun2016	20 Days	129	5/ 1 inch	1790	1360	170+260
IP 6 (Loc. 4)	D180-42	Restrike Blow 31	21Jun2016	20 Days	129	6/ 1 inch	1580	1170	230+180

Note: IP 6 has an internal bearing plate located approximately 82 ft above the pile tip. For IP 6 the tabulated end bearing results are the computed end bearing for the internal plate and the pile tip. For example, for Restrike Blow 3 the computed end bearing totaled 470 kips composed of 180 kips on the internal plate and 290 kips on the pile toe.

Table 3c. Summary of CAPWAP Results for Location 5

Pile	Hammer	Test	Date of Test	Restrike Waiting Time (days)	Approx Depth in Soil (ft)	Reported Penetration Resistance (blows/set)	Computed Soil Resistance, kips		
							Total	Shaft	Toe
IP 1 (Loc. 5)	APE 15-4	Drive	07Jun2016	--	128	54/ft	690	500	190
IP 1 (Loc. 5)	D180-42	Restrike	21Jun2016	14 Days	128	5/ 1 inch	2450	1900	550
IP 7 (Loc. 5)	D180-42	Drive	25May2016	--	~99	23/ft	400	370	30
IP 7 (Loc. 5)	D180-42	Drive	25May2016	--	139	22/ft	1750	800	850
IP 7 (Loc. 5)	D180-42	Restrike	08Jun16	14 Days	139	~21/1 inch	3900	2960	940

Table 3d. Summary of CAPWAP Results for Location 6

Pile	Hammer	Test	Date of Test	Restrike Waiting Time (days)	Approx Depth in Soil (ft)	Reported Penetration Resistance (blows/set)	Computed Soil Resistance, kips		
							Total	Shaft	Toe
IP 8 (Loc. 6)	APE 15-4	Drive	03May2016	--	105	31/3"	1160	880	280
IP 8 (Loc. 6)	D180-42	Restrike	10Jun2016	38 Days	105	~7/1 inch	2780	2450	330
IP 9 (Loc. 6)	D180-42	Drive	07May2016	--	115	37/ft	1310	820	490
IP 9 (Loc. 6)	D180-42	Restrike	10Jun2016	34 Days	115	~20/1 inch	4030	3310	720
IP 10 (Loc. 6)	APE 15-4	Drive	26May2016	--	113	77/ft	1190	610	580
IP 10 (Loc. 6)	D180-42	Restrike	10Jun2016	15 Days	113	~5/1 inch	2220	1590	630

APPENDIX A
AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

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BACKGROUND

Modern procedures of design and construction control require verification of bearing capacity and integrity of deep foundations during preconstruction test programs and also production installation. Dynamic pile testing methods meet this need economically and reliably, and therefore, form an important part of a quality assurance program when deep foundations are executed. Several dynamic pile testing methods exist; they have different benefits and limitations and different requirements for proper execution.

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (such as that of a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. The method is therefore also referred to as a "High Strain Method". The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then an evaluation of various quantities based on closed form solutions of the wave equation, a partial differential equation describing the motion of a rod under the effect of an impact. Conveniently, measurements and analyses are done by a single piece of equipment: the Pile Driving Analyzer® (PDA). However, for bearing capacity evaluations an important additional method is CAPWAP® which performs a much more rigorous analysis of the dynamic records than the simpler Case Method.

A related analysis method is the "Wave Equation Analysis" which calculates a relationship between bearing capacity and pile stress and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data.

The following description deals primarily with the Case Method or "High Strain Test" Method of pile testing, however, for the sake of completeness, the "Low Strain Test" performed with the Pile Integrity Test™ (PIT), mainly for pile integrity evaluation, will also be described.

RESULTS FROM DYNAMIC TESTING

There are two main objectives of high strain dynamic pile testing:

- *Dynamic Pile Monitoring* and
- *Dynamic Load Testing*.

Dynamic pile monitoring is conducted during the installation of impact driven piles to achieve a safe and economical pile installation. Dynamic load testing, on the other hand, has as its primary goal the assessment of pile bearing capacity. It is applicable to both cast *insitu* piles or drilled shafts and impact driven piles during restrike.

Dynamic Pile Monitoring

During pile installation, the sensors attached to the pile measure pile top force and velocity. A PDA conditions and processes these signals and calculates or evaluates:

- Bearing capacity at the time of testing, including an assessment of shaft resistance development and driving resistance. This information supports formulation of a driving criterion.

- Dynamic pile stresses, axial and averaged over the pile cross section, both tensile and compressive, during pile driving to limit the potential of damage either near the pile top or along its length. Bending stresses can be evaluated at the point of sensor attachment.

- Pile integrity assessment by the PDA is based on the recognition of certain wave reflections from along the pile. If detected early enough, a pile may be saved from complete destruction. On the other hand, once damage is recognized measures can be taken to prevent reoccurrence.

- Hammer performance parameters including the energy transferred to the pile, the hammer speed in blows per minute and the stroke of open ended diesel hammers.

Dynamic Pile Load Testing

Bearing capacity testing of either driven piles or drilled shafts applies the same basic measurement approach of dynamic pile monitoring. However, the test is done independent of the pile installation process and therefore a pile driving hammer or other dynamic loading device may not be available. If a special ram has to be mobilized then its weight should be between 0.8 and 2% of the test load (e.g. between 4 and 10 tons for a 500 ton test load) to assure sufficient soil resistance activation.

For a successful test, it most important that the test is conducted after a sufficient waiting time following pile installation for soil properties approaching their long term condition or concrete to properly set. During testing, PDA results of pile/shaft stresses and transferred energy are used to maintain safe stresses and assure sufficient resistance activation. For safe and sufficient testing of drilled shafts, ram energies are often increased from blow to blow until the test capacity has been activated. On the other hand, restrike tests on driven piles may require a warm hammer so that the very first blow produces a complete resistance activation. Data must be evaluated by CAPWAP for bearing capacity.

After the dynamic load test has been conducted with sufficient energy and safe stresses, the CAPWAP analysis provides the following results:

- Bearing capacity i.e. the mobilized capacity present at the time of testing

- Resistance distribution including shaft resistance and end bearing components

- Stresses in pile or shaft calculated for both the static load application and the dynamic test. These stresses are averages over the cross section and do not include bending effects or nonuniform contact stresses, e.g. when the pile toe is on uneven rock.

- Shaft impedance vs depth; this is an estimate of the shaft shape if it differs substantially from the planned profile

- Dynamic soil parameters for shaft and toe, i.e. damping factors and quakes (related to the dynamic stiffness of the resistance at the pile/soil interface.)

MEASUREMENTS

PDA

The basis for the results calculated by the PDA are pile top strain and acceleration measurements which are converted to force and velocity records, respectively. The PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. Using closed form Case Method solutions, based on the one-dimensional linear wave equation, the PDA calculates the results described in the analytical solutions section below.

HPA

The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. For this unit to be applicable, the ram must be visible. The impact velocity results can be automatically processed with a PC or recorded on a strip chart.

Saximeter™

For open end diesel hammers, the time between two impacts indicates the magnitude of the ram fall height or stroke. This information is not only measured and calculated by the PDA but also by the convenient, hand-held Saximeter.

PIT

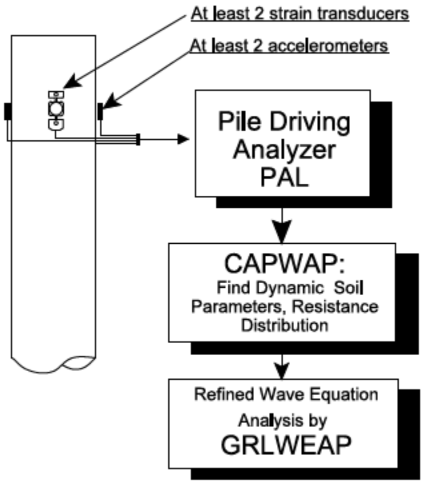
The Pile Integrity Tester™ (PIT) can be used to evaluate defects in concrete piles or shafts which may have occurred during driving or casting. Also timber piles of limited length can be tested in that manner. This so-called "Low Strain Method" or “Pulse-Echo Method” of integrity testing requires only the measurement of acceleration at the pile top. The stress wave producing impact is then generated by a small hand-held hammer and the records interpreted in the time domain. PIT also supports the so-called “Transient Response Method” which requires the additional measurement of the hammer force and an analysis in the frequency domain. This method may also be used to evaluate the unknown length of deep foundations under existing structures.

ANALYTICAL SOLUTIONS
BEARING CAPACITY

Wave Equation

GRL has written the GRLWEAP™ program which calculates a relationship between bearing capacity, pile stress and blow count. This relationship is often called the "bearing graph." Once the blow count is known from pile installation logs, the bearing graph yields the bearing capacity. This approach requires no measurements and therefore can be performed during the design stage of a project, for example for the selection of hammer, cushion and pile size.

After dynamic pile monitoring and/or dynamic load testing has been performed, the "Refined Wave Equation Analysis" or RWEA (see schematic below) is often performed by inputting the PDA and CAPWAP calculated parameters. Then the bearing graph from the RWEA is the basis for a safe and sufficient driving criteria.



Case Method

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force F(t) and pile top velocity v(t), the total soil resistance is

$$R(t) = ½\{[F(t) + F(t_2)] + Z[v(t) - v(t_2)]\} \tag{1}$$

where

t = a point in time after impact
t_2 = time $t + 2L/c$
L = pile length below gages
c = $(E/\rho)^{½}$ is the speed of the stress wave
ρ = pile mass density
Z = EA/c is the pile impedance
E = elastic modulus of the pile ($\rho\ c^2$)
A = pile cross sectional area

The total soil resistance consists of a dynamic (R_d) and a static (R_s) component. The static component is therefore

$$R_s(t) = R(t) - R_d(t) \tag{2}$$

The dynamic component may be computed from a soil damping factor, J, and a pile toe velocity, $v_t(t)$ which is conveniently calculated for the pile toe. Using wave considerations, this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \tag{3}$$

and finally to the static resistance by means of Equation 2.

There are a number of ways in which Eq. 1 through 3 can be evaluated. Most commonly, t_2 is set to that time at which the static resistance becomes maximum. The result is the so-called **RMX** capacity. Damping factors for RMX typically range between 0.5 for coarse grained materials to 1.0 for clays. The **RSP** capacity (this method is most commonly referred to in the literature, yet it is not very frequently used) requires damping factors between 0.1 for sand and 1.0 for clay. Another capacity, **RA2**, determines the capacity at a time when the pile is essentially at rest and thus damping is small; RA2 therefore requires no damping parameter. In any event, the proper Case Method and its associated damping parameter is most conveniently found after a CAPWAP analysis has been performed.

The static resistance calculated by Case Method or CAPWAP is the mobilized resistance at the time of testing. Consideration therefore has to be given to soil setup or relaxation effects and whether or not a sufficient set has been achieved under the test loading that would correspond to a full activation of the ultimate soil resistance.

The PDA also calculates an estimate of shaft resistance as the difference between force and velocity times impedance at the time immediately prior to the return of the stress wave from the pile toe. This shaft resistance is not reduced by damping effects and is therefore called the total shaft resistance **SFT**. A correction for damping effects produces the static shaft resistance estimate, **SFR**.

The Case Method solution is simple enough to be evaluated "in real time," i.e. between hammer blows, using the PDA. It is therefore possible to calculate all relevant results for all hammer blows and plot these results as a function of depth or blow number. This is done in the PDAPLOT program.

CAPWAP

The CAse Pile Wave Analysis Program combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the shaft resistance, end bearing, damping factors and soil stiffnesses. The method iteratively calculates a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters.

STRESSES

During pile monitoring, it is important that compressive stress maxima at pile top and toe and tensile stress maxima somewhere along the pile be calculated for each hammer blow.

At the pile top (location of sensors) both the maximum compression stress, **CSX**, and the maximum stress from individual strain transducers, **CSI**, are directly obtained from the measurements. Note that CSI is greater than or equal to CSX and the difference between CSI and CSX is a measure of bending in the plane of the strain transducers. Note also that all stresses calculated for locations below the sensors are averaged over the pile cross section and therefore do not include components from either bending or eccentric soil resistance effects.

The PDA calculates the compressive stress at the pile bottom, **CSB**, assuming (a) a uniform pile and (b) that the pile toe force is the maximum value of the total resistance R(t) minus the total shaft resistance, SFT. Again, for this stress estimation uniform resistance force are assumed (e.g. not a sloping rock.)

For concrete piles, the maximum tension stress, **TSX**, is also of great importance. It occurs at some point below the pile top. The maximum tension stress can be computed from the pile top measurements by finding the maximum tension wave (either traveling upward, W_U, or downward, W_d) and reducing it by the minimum compressive wave traveling in opposite direction.

$$W_u = ½[F(t) - Zv(t)] \tag{4}$$

$$W_d = ½[F(t) + Zv(t)] \tag{5}$$

CAPWAP also calculates tensile and compressive stresses along the pile and, in general, more accurately than the PDA. In fact, for non-uniform piles or piles with joints, cracks or other discontinuities, the closed form solutions from the PDA may be in error.

PILE INTEGRITY

High Strain Tests (PDA)

Stress waves in a pile are reflected wherever the pile impedance, $Z = EA/c = \rho cA = A \sqrt{(E\ \rho)}$, changes. Therefore, the pile impedance is a measure of the quality of the pile material (E, ρ, c) and the size of its cross section (A). The reflected waves arrive at the pile top at a time which is greater the farther away from the pile top the reflection occurs. The magnitude of the change of the upward traveling wave (calculated from the measured force and velocity, Eq. 4) indicates the extent of the cross sectional change. Thus, with β_i (**BTA**) being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following is calculated by the PDA.

$$\beta_i = (1 - \alpha_i)/(1 + \alpha_i) \quad (6)$$

with

$$\alpha_i = ½(W_{UR} - W_{UD})/(W_{Di} - W_{UR}) \quad (7)$$

where

W_{UR} is the upward traveling wave at the onset of the reflected wave. It is caused by resistance.

W_{UD} is the upwards traveling wave due to the damage reflection.

W_{Di} is the maximum downward traveling wave due to impact.

It can be shown that this formulation is quite accurate as long as individual reflections from different pile impedance changes have no overlapping effects on the stress wave reflections.

Without rigorous derivation, it has been proposed to consider as slight damage when β is above 0.8 and a serious damage when β is less than 0.6.

Low Strain Tests (PIT)

The pile top is struck with a held hand hammer and the resulting pile top velocity is measured, displayed and interpreted for signs of wave reflections. In general, a comparison of the reflected acceleration leads to a relative measure of extent of damage, again the location of the problem is indicated by the arrival time of the reflection. PIT records can also be interpreted by the β-Method. However, low strain tests do not activate much resistance which simplifies Eq. 7 since W_{UR} is then equal to zero.

For drilled shafts and PIT records that clearly show a toe reflection, an approximate shaft profile can be calculated from low strain records using the PITSTOP program's PROFILE routine.

HAMMER PERFORMANCE

The PDA calculates the energy transferred to the pile top from:

$$E(t) = {}_o\int^t F(t)v(t)\, dt \quad (8a)$$

The maximum of the E(t) curve is the most important information for an overall evaluation of the performance of a hammer and driving system. This **EMX** value allows for a classification of the hammer's performance when presented as the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency

$$e_T = EMX/E_R \quad (8b)$$

where

E_R is the manufacturer's rated energy value.

Both Saximeter and PDA calculate the stroke (**STK**) of an open end diesel hammer using

$$STK = (g/8)\, T_B^2 - h_L \quad (9)$$

where

g is the earth's gravitational acceleration,
T_B is the time between two hammer blows,
h_L is a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m).

DETERMINATION OF WAVE SPEED

An important facet of dynamic pile testing is an assessment of pile material properties. Since in general force is determined from strain by multiplication with elastic modulus, E, and cross sectional area, A, the dynamic elastic modulus has to be determined for pile materials other than steel. In general, the records measured by the PDA clearly indicate a pile toe reflection as long as pile penetration per blow is greater than 1 mm or .04 inches. The time between the onset of the force and velocity records at impact and the onset of the reflection from the toe (usually apparent by a local maximum of the wave up curve) is the so-called wave travel time, T. Dividing 2L (L is here the length of the pile below sensors) by T leads to the stress wave speed in the pile:

$$c = 2L/T \quad (10)$$

The elastic modulus of the pile material is related to the wave speed according to the linear elastic wave equation theory by

$$E = c^2\rho \qquad (11)$$

Since the mass density of the pile material, ρ, is usually well known (an exception is timber for which samples should be weighed), the elastic modulus is easily found from the wave speed. Note, however, that this is a dynamic modulus which is generally higher than the static one and that the wave speed depends to some degree on the strain level of the stress wave. For example, experience shows that the wave speed from PIT is roughly 5% higher than the wave speed observed during a high strain test.

Other Notes:

- If the pile material is nonuniform then the wave speed c, according to Eq. 10, is an average wave speed and does not necessarily reflect the pile material properties of the location where the strain sensors are attached to the pile top. For example, pile driving often causes fine tension cracks some distance below the top of concrete piles. Then the average c is slower than that at the pile top. It is therefore recommended to determine E in the beginning of pile driving and not adjust it when the average c changes.

- If the pile has such a high resistance that there is no clear indication of a toe reflection then the wave speed of the pile material must be determined either by assumption or by taking a sample of the concrete and measuring its wave speed in a simple free column test. Another possibility is to use the proportionality relationship, discussed under "DATA QUALITY CHECKS" to find c as the ratio between the measured velocity and measured strain.

DATA QUALITY CHECKS

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing PDA or PIT tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to certain relationships.

Proportionality

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the pile, force and velocity measured at the pile top are proportional

$$F = v\,Z = v\,(EA/c) \qquad (12a)$$

This relationship can also be expressed in terms of stress

$$\sigma = v\,(E/c) \qquad (12b)$$

or strain

$$\epsilon = v\,/\,c \qquad (12c)$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements.

Measurements are always taken at opposite sides of the pile as a means of calculating the average force and velocity in the pile. The velocity on the two sides of the pile is very similar even when high bending exists. Thus, an independent check of the velocity measurements is easy and simple.

Strain measurements may differ greatly between the two sides of the pile when bending exists. It is even possible that tension is measured on one side while very high compression exists on the other side of the pile. In extreme cases, bending might be so high that it leads to a nonlinear stress distribution. The averaging of the two strain signals does then not lead to the average pile force and proportionality will not be achieved.

When testing drilled shafts, measurements of strain may also be affected by local concrete quality variations. It is then often necessary to use four strain transducers spaced at 90 degrees around the pile for an improved strain data quality. The use of four transducers is also recommended for large pile diameters, particularly when it is difficult to mount the sensors at least two pile widths or diameters below the pile top.

LIMITATIONS, ADDITIONAL CONSIDERATIONS

Mobilization of capacity

Estimates of pile capacity from dynamic testing indicate the **mobilized pile capacity at the time of testing**. At very high blow counts (low set per blow), dynamic test methods tend to produce lower bound capacity estimates as not all resistance (particularly at and near the toe) is fully activated.

Time dependent soil resistance effects

Static pile capacity from dynamic method calculations provide an estimate of the axial pile capacity. Increases and decreases in the pile capacity with time typically occur (soil setup/relaxation). Therefore, **restrike testing usually yields a better indication of long term pile capacity than a test at the end of pile driving**. Often a wait period of one or two days between end of driving and restrike is satisfactory for a realistic prediction of pile capacity but this waiting time depends, among other factors, on the permeability of the soil.

(A) Soil setup

Because excess positive pore pressures often develop during pile driving in fine grained soil (clays, silts or even fine sands), the capacity of a pile at the time of driving may often be less than the long term pile capacity. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and thus the pile capacity at the time of driving. As these pore pressures dissipate, the soil resistance acting on the pile increases as does the axial pile capacity. This phenomena is routinely called soil setup or soil freeze.

(*B) Relaxation*

Relaxation (capacity reduction with time) has been observed for piles driven into weathered shale, and may take several days to fully develop. Pile capacity estimates based upon initial driving or short term restrike tests can significantly overpredict long term pile capacity. Therefore, piles driven into shale should be tested after a minimum one week wait either statically or dynamically (with particular emphasis than on the first few blows). Relaxation has also been observed for displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe. Again, restrike tests should be used, with great emphasis on early blows.

Capacity results for open pile profiles

Larger diameter open ended pipe piles (or H-piles which do not bear on rock) may behave differently under dynamic and static loading conditions. Under dynamic loads the soil inside the pile or between its flanges may slip and produce internal friction while under static loads the plug may move with the pile, thereby creating end bearing over the full pile cross section. As a result both friction and end bearing components may be different under static and dynamic conditions.

CAPWAP Analysis Results

A portion of the soil resistance calculated on an individual soil segment in a CAPWAP analysis can usually be shifted up or down the shaft one soil segment without significantly altering the match quality. Therefore, use of the CAPWAP resistance distribution for uplift, downdrag, scour, or other geotechnical considerations should be made with an understanding of these analysis limitations.

Stresses

PDA and CAPWAP calculated stresses are average values over the cross section. Additional allowance has to be made for bending or non-uniform contact stresses. To prevent damage it is therefore important to maintain good hammer-pile alignment and to protect the pile toes using appropriate devices or an increased cross sectional area.

In the United States is has become generally acceptable to limit the dynamic installation stresses of driven piles to the following levels:

90%	of yield strength for steel piles
85%	of the concrete compressive strength - after subtraction of the effective prestress - for concrete piles in compression

100% of effective prestress plus ½ of the concrete's tension strength for prestressed piles in tension

70% of the reinforcement strength for regularly reinforced concrete piles in tension

300% of the static design allowable stress for timber

Note that the dynamic stresses may either be directly measured at the pile top by the PDA or calculated by the PDA for other locations along the pile based on the pile top measurements.

Additional design considerations

Numerous factors have to be considered in pile foundation design. Some of these considerations include

- additional pile loading from downdrag or negative skin friction,
- lateral and uplift loading requirements
- effective stress changes (due to changes in water table, excavations, fills or other changes in overburden),
- long term settlements in general and settlement from underlying weaker layers and/or pile group effects,

These factors have not been evaluated by GRL and have not been considered in the interpretation of the dynamic testing results. The foundation designer should determine if these or any other considerations are applicable to this project and the foundation design.

Wave equation analysis results

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input parameters. Although attempts have been made to base the analysis on the best available information, actual field conditions may vary and therefore stresses and blow counts may differ from the predictions reported. Capacity predictions derived from wave equation analyses should use restrike information. However, because of the uncertainties associated with restrike blow counts and restrike hammer energies, correlations of such results with static test capacities with have often displayed considerable scatter.

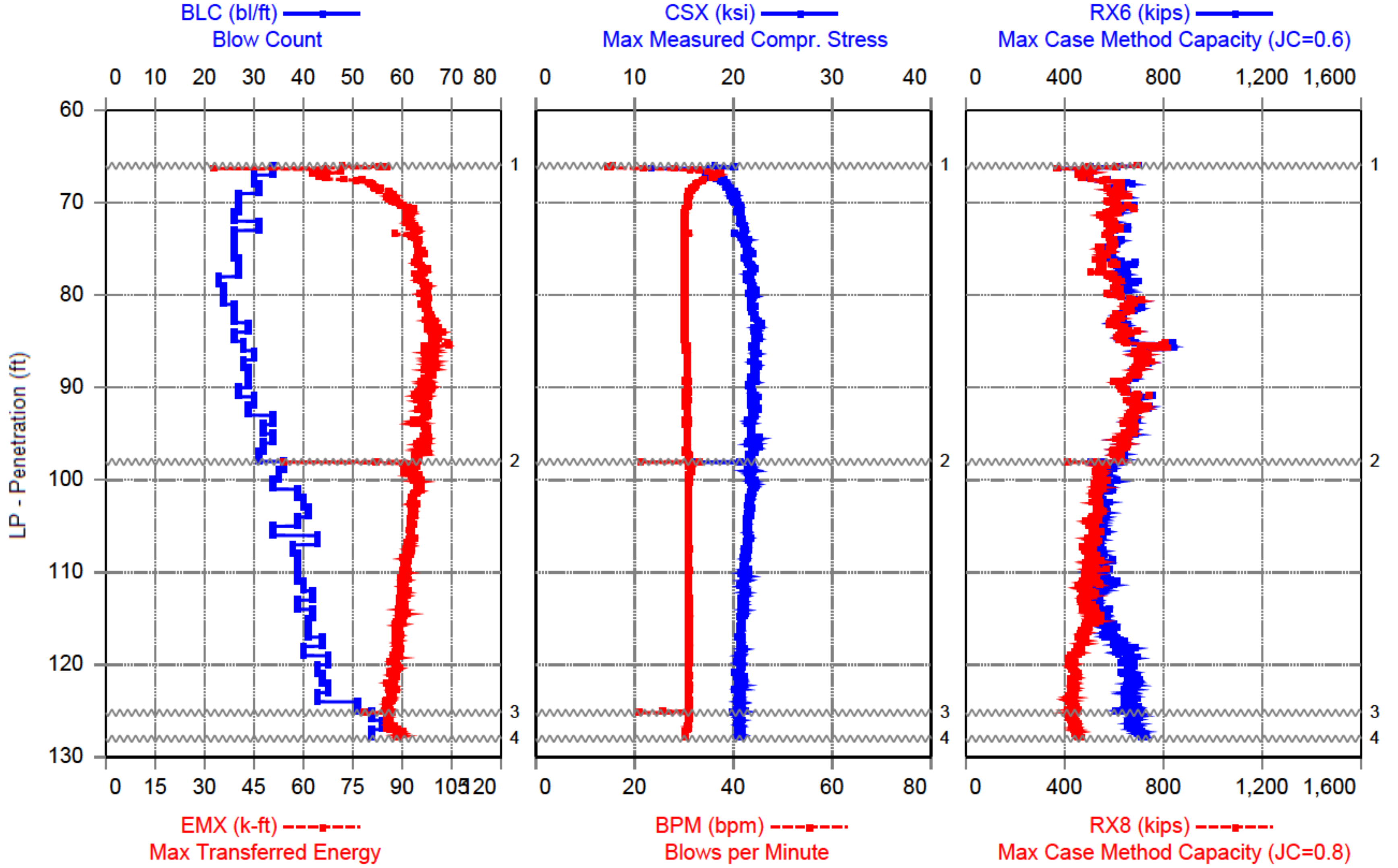
As for PDA and CAPWAP, the theory on which GRLWEAP is based is the one-dimensional wave equation. For that reason, stress predictions by the wave equation analysis can only be averages over the pile cross section. Thus, bending stresses or stress concentrations due to non-uniform impact or uneven soil or rock resistance are not considered in these results. Stress maxima calculated by the wave equation are usually subjected to the same limits as those measured directly or calculated from measurements by the PDA.

Appendix B

Summary of Case Method Field Results

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results
Printed: 07-June-2016
Test started: 07-June-2016

KIWC, POA TPP - IP 1 (Loc. 5)



1 - Begin PDA monitoring, near Tip El. -81 ft, 6/7/2016, 11:39:40 AM
2 - Restart after 4 min pause including reset of strain sensor.
3 - Restart after 2 min pause to reset strain sensor.
4 - End Driving near Tip El -150, 128 ft soil penetration, 6/7/20161:01:50 PM

KIWC, POA TPP - IP 1 (Loc. 5) PP48x1.0", APE 15-4
OP: RMDT Date: 07-June-2016

AR: 147.65 in² SP: 0.492 k/ft³
LE: 178.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
BPM: Blows per Minute
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
FMX: Maximum Force
VMX: Maximum Velocity
CSI: Max F1 or F2 Compr. Stress
RX7: Max Case Method Capacity (JC=0.7)

BL#	Depth	BLC	TYPE	EMX	CSX	BPM	RX6	RX8	FMX	VMX	CSI	RX7
	ft	bl/ft		k-ft	ksi	bpm	kips	kips	kips	f/s	ksi	kips
34	67	34	AV34	67.0	17.6	28.0	517	509	2,597	9.3	21.9	511
			STD	14.6	2.3	11.0	164	163	345	1.4	2.7	163
			MAX	95.9	21.5	37.8	1,364	1,357	3,172	11.9	25.4	1,357
64	68	30	AV30	72.4	18.3	34.7	538	529	2,708	9.6	23.6	532
			STD	6.5	0.7	1.4	74	67	111	0.5	1.0	71
			MAX	84.8	19.8	36.8	693	649	2,918	10.6	25.5	668
95	69	31	AV31	82.9	19.6	31.9	628	615	2,900	10.3	25.7	620
			STD	2.5	0.4	0.7	23	26	60	0.2	0.5	25
			MAX	87.3	20.4	33.1	693	664	3,012	10.6	26.8	665
122	70	27	AV27	86.9	20.1	31.1	616	613	2,971	10.6	26.3	614
			STD	1.6	0.3	0.4	36	37	42	0.2	0.3	37
			MAX	89.9	20.5	31.9	755	755	3,026	10.8	26.7	755
149	71	27	AV27	91.1	20.6	30.7	635	625	3,046	11.0	26.9	627
			STD	3.0	0.3	0.5	50	53	51	0.2	0.6	52
			MAX	96.6	21.1	31.5	738	736	3,118	11.3	27.9	737
175	72	26	AV26	92.1	20.7	30.3	580	573	3,062	11.0	27.9	575
			STD	1.7	0.3	0.3	26	28	49	0.2	0.5	29
			MAX	95.8	21.2	30.7	647	635	3,132	11.4	28.9	641
206	73	31	AV31	92.9	21.0	30.3	610	595	3,099	11.1	28.5	600
			STD	1.6	0.3	0.2	34	26	50	0.2	0.4	29
			MAX	96.0	21.5	30.7	685	646	3,175	11.6	29.3	658
232	74	26	AV23	93.1	20.9	30.4	587	582	3,085	11.0	28.6	583
			STD	3.3	0.5	0.5	16	16	75	0.3	0.7	15
			MAX	97.2	21.5	32.4	627	617	3,179	11.4	29.5	617
258	75	26	AV26	95.0	21.3	30.3	596	586	3,146	11.1	29.1	589
			STD	1.2	0.3	0.2	30	31	41	0.1	0.5	31
			MAX	97.5	21.9	30.5	653	626	3,240	11.5	29.9	632
284	76	26	AV26	95.8	21.7	30.2	582	569	3,206	11.2	29.4	572
			STD	1.3	0.3	0.1	17	24	47	0.2	0.6	21
			MAX	98.2	22.3	30.5	609	605	3,291	11.5	30.4	606
311	77	27	AV27	94.9	21.5	30.3	632	567	3,178	11.1	29.8	591
			STD	1.3	0.4	0.1	45	40	52	0.2	0.4	46
			MAX	97.0	22.1	30.5	728	654	3,263	11.5	30.3	688
338	78	27	AV27	96.2	21.9	30.3	628	554	3,237	11.4	30.1	576
			STD	1.7	0.4	0.1	43	31	57	0.2	0.3	36
			MAX	98.6	22.5	30.5	686	610	3,323	11.6	30.7	644
361	79	23	AV23	96.2	21.7	30.2	662	612	3,199	11.4	30.5	631
			STD	1.9	0.4	0.2	36	25	60	0.2	0.4	30

KIWC, POA TPP - IP 1 (Loc. 5) PP48x1.0", APE 15-4
OP: RMDT Date: 07-June-2016

BL#	Depth	BLC	TYPE	EMX	CSX	BPM	RX6	RX8	FMX	VMX	CSI	RX7
	ft	bl/ft		k-ft	ksi	bpm	kips	kips	kips	f/s	ksi	kips
			MAX	100.0	22.4	30.5	738	646	3,310	11.8	31.3	677
385	80	24	AV24	97.1	22.0	30.3	639	608	3,253	11.7	30.7	611
			STD	1.9	0.5	0.2	31	28	67	0.2	0.5	28
			MAX	100.4	22.9	30.6	690	661	3,378	12.0	31.4	661
409	81	24	AV24	97.4	21.9	30.2	666	657	3,240	11.9	31.0	659
			STD	1.1	0.3	0.1	45	45	48	0.1	0.4	43
			MAX	99.4	22.6	30.6	735	735	3,331	12.2	31.9	735
435	82	26	AV26	97.5	22.0	30.3	683	655	3,243	11.9	30.9	661
			STD	1.7	0.3	0.2	41	20	48	0.1	0.6	24
			MAX	100.6	22.5	30.6	774	707	3,320	12.1	31.9	707
461	83	26	AV25	98.4	22.3	30.3	623	609	3,294	11.9	31.3	611
			STD	2.2	0.4	0.2	27	22	56	0.2	0.9	22
			MAX	101.8	22.9	30.7	694	654	3,379	12.2	32.3	654
490	84	29	AV29	99.1	22.5	30.2	645	627	3,323	12.0	31.7	633
			STD	1.9	0.5	0.2	45	39	69	0.2	0.8	40
			MAX	102.0	23.5	30.6	734	734	3,468	12.4	33.1	734
516	85	26	AV26	100.3	22.4	30.2	642	639	3,304	12.1	32.2	639
			STD	2.1	0.3	0.2	28	26	45	0.2	0.5	26
			MAX	103.2	23.1	30.7	703	703	3,408	12.4	33.0	703
544	86	28	AV28	100.3	22.2	30.5	768	738	3,281	12.1	32.1	744
			STD	3.0	0.3	0.3	95	81	42	0.2	0.6	86
			MAX	105.0	22.9	31.2	1,003	920	3,380	12.4	32.9	957
574	87	30	AV30	98.7	22.2	30.7	712	710	3,283	11.9	31.7	711
			STD	2.7	0.3	0.3	34	35	47	0.3	0.9	35
			MAX	102.4	22.7	31.2	777	776	3,359	12.4	32.9	777
602	88	28	AV28	99.0	22.3	30.7	719	717	3,291	12.0	31.8	718
			STD	2.8	0.4	0.3	36	35	57	0.3	0.8	35
			MAX	102.6	22.9	31.2	809	808	3,381	12.4	32.8	809
631	89	29	AV29	98.9	22.2	30.7	690	688	3,281	12.0	31.8	689
			STD	1.9	0.3	0.2	32	31	47	0.2	0.6	31
			MAX	102.4	22.7	31.1	759	759	3,357	12.3	32.5	759
660	90	29	AV29	97.5	22.0	30.7	639	634	3,247	12.0	31.6	635
			STD	2.3	0.5	0.4	38	32	69	0.3	0.8	33
			MAX	100.1	22.9	31.3	753	720	3,376	12.4	32.5	727
687	91	27	AV27	96.8	21.9	30.7	667	662	3,231	11.7	31.4	663
			STD	3.2	0.4	0.4	43	38	60	0.4	1.1	39
			MAX	100.2	22.5	31.3	783	783	3,326	12.2	32.8	783
717	92	30	AV30	96.9	22.2	30.7	694	682	3,274	11.6	31.4	686
			STD	2.3	0.5	0.3	42	34	73	0.3	1.0	36
			MAX	99.3	23.0	31.4	791	753	3,399	12.0	32.6	772
746	93	29	AV29	97.2	22.2	30.7	700	696	3,274	11.6	31.3	697
			STD	2.3	0.4	0.3	33	33	63	0.3	1.1	33
			MAX	99.7	23.0	31.4	767	758	3,392	12.1	32.4	758
780	94	34	AV34	95.9	21.8	30.7	674	668	3,225	11.7	31.2	670
			STD	2.7	0.5	0.4	29	24	69	0.3	0.9	26
			MAX	98.1	23.0	31.3	755	730	3,394	12.1	32.4	730

KIWC, POA TPP - IP 1 (Loc. 5) PP48x1.0", APE 15-4
OP: RMDT Date: 07-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	BPM bpm	RX6 kips	RX8 kips	FMX kips	VMX f/s	CSI ksi	RX7 kips
812	95	32	AV32	97.1	21.8	30.7	680	677	3,224	11.9	31.2	678
			STD	1.3	0.2	0.2	16	17	29	0.2	0.4	17
			MAX	98.4	22.3	31.3	718	718	3,287	12.2	31.7	718
846	96	34	AV34	97.0	22.1	30.7	651	647	3,257	11.7	30.4	648
			STD	1.3	0.4	0.2	26	23	60	0.2	0.7	24
			MAX	99.4	22.9	31.1	713	689	3,379	12.0	31.6	689
878	97	32	AV32	96.2	22.1	30.7	631	630	3,268	11.5	30.4	630
			STD	2.0	0.5	0.3	23	25	74	0.1	0.6	24
			MAX	99.4	23.0	31.2	673	673	3,401	11.8	31.6	673
909	98	31	AV31	95.5	21.8	31.1	626	616	3,225	11.4	30.2	619
			STD	2.4	0.4	0.4	19	18	54	0.2	0.7	18
			MAX	102.0	22.7	31.6	669	658	3,350	11.8	31.9	658
945	99	36	AV36	88.5	21.2	30.8	573	542	3,138	11.2	29.0	553
			STD	13.7	2.2	4.9	32	57	323	1.2	3.0	42
			MAX	98.5	22.9	33.7	656	656	3,381	12.0	31.5	656
980	100	35	AV35	94.0	21.8	31.2	561	543	3,212	11.6	30.5	547
			STD	3.2	0.4	0.4	21	16	59	0.2	0.9	17
			MAX	97.5	22.6	31.9	610	581	3,333	12.0	31.9	586
1014	101	34	AV34	95.1	22.0	31.1	575	537	3,254	11.6	30.2	549
			STD	1.4	0.4	0.1	27	23	56	0.2	0.9	26
			MAX	97.6	22.7	31.5	676	615	3,348	11.9	32.0	645
1053	102	39	AV39	94.2	21.9	31.1	556	530	3,235	11.6	30.6	537
			STD	1.3	0.2	0.2	27	17	34	0.1	0.7	20
			MAX	98.0	22.5	31.5	614	569	3,324	11.9	31.7	587
1093	103	40	AV40	93.5	21.7	31.0	560	535	3,209	11.6	31.0	541
			STD	0.8	0.2	0.1	19	13	29	0.1	0.3	16
			MAX	97.0	22.2	31.2	615	566	3,277	11.8	31.8	579
1134	104	41	AV41	93.5	21.7	31.0	558	538	3,200	11.6	31.0	544
			STD	0.6	0.2	0.1	23	19	27	0.1	0.5	21
			MAX	94.6	22.1	31.2	638	581	3,262	11.9	31.7	606
1173	105	39	AV39	93.0	21.5	31.1	547	517	3,176	11.5	30.9	524
			STD	0.7	0.2	0.1	20	21	27	0.1	0.4	21
			MAX	94.2	21.8	31.3	584	564	3,221	11.8	31.6	573
1207	106	34	AV34	92.7	21.6	31.1	557	525	3,185	11.5	30.9	538
			STD	0.7	0.2	0.1	21	19	29	0.1	0.5	21
			MAX	94.3	22.1	31.3	596	567	3,263	11.8	31.5	581
1250	107	43	AV43	92.7	21.5	31.1	541	519	3,179	11.5	30.9	524
			STD	0.8	0.2	0.1	22	20	31	0.1	0.6	20
			MAX	94.5	22.1	31.3	586	577	3,257	11.8	31.6	577
1288	108	38	AV38	92.4	21.4	31.1	528	500	3,166	11.4	31.0	506
			STD	1.1	0.2	0.2	19	21	33	0.2	0.6	23
			MAX	94.1	22.0	31.5	571	532	3,242	11.8	32.0	545
1327	109	39	AV39	91.7	21.3	31.1	555	515	3,143	11.3	30.6	527
			STD	0.8	0.2	0.1	26	22	32	0.1	0.6	25
			MAX	93.1	21.7	31.4	618	572	3,209	11.6	31.6	593
1366	110	39	AV39	91.0	21.2	31.1	540	515	3,137	11.1	30.0	523

KIWC, POA TPP - IP 1 (Loc. 5) PP48x1.0", APE 15-4
OP: RMDT Date: 07-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	BPM bpm	RX6 kips	RX8 kips	FMX kips	VMX f/s	CSI ksi	RX7 kips
			STD	1.0	0.3	0.1	29	32	41	0.2	0.7	32
			MAX	92.7	21.9	31.4	617	606	3,231	11.3	31.4	611
1405	111	39	AV39	91.2	21.3	31.1	553	508	3,141	11.1	30.0	512
			STD	1.1	0.3	0.1	29	28	48	0.1	0.8	29
			MAX	93.6	22.0	31.3	602	563	3,243	11.3	31.4	563
1445	112	40	AV40	90.9	21.2	31.1	575	490	3,125	11.0	29.8	494
			STD	1.1	0.3	0.1	32	32	48	0.1	0.6	30
			MAX	92.8	21.7	31.4	640	565	3,209	11.2	31.1	567
1487	113	42	AV42	90.5	21.1	31.1	529	492	3,116	10.9	29.7	495
			STD	1.3	0.3	0.2	25	30	46	0.2	0.8	29
			MAX	93.2	21.6	31.5	594	594	3,191	11.3	31.0	594
1526	114	39	AV39	90.3	21.1	31.1	531	489	3,110	10.9	29.8	495
			STD	1.5	0.3	0.2	23	25	43	0.2	0.7	24
			MAX	93.0	21.6	31.6	582	545	3,191	11.2	30.9	551
1568	115	42	AV42	90.1	21.0	31.2	553	507	3,098	10.9	29.7	511
			STD	1.1	0.3	0.2	24	31	37	0.1	0.6	31
			MAX	92.6	21.4	31.5	606	602	3,163	11.1	30.8	604
1609	116	41	AV41	89.2	20.9	31.2	568	511	3,084	10.8	29.4	512
			STD	1.0	0.2	0.2	26	32	28	0.1	0.5	32
			MAX	91.4	21.3	31.5	621	574	3,141	11.1	30.3	574
1650	117	41	AV41	88.9	20.8	31.2	581	482	3,070	10.8	29.3	482
			STD	0.9	0.2	0.2	25	24	27	0.1	0.5	24
			MAX	90.3	21.3	31.5	642	552	3,138	11.1	30.1	552
1694	118	44	AV44	88.7	20.8	31.2	618	472	3,069	10.7	29.0	475
			STD	0.8	0.2	0.1	24	18	29	0.2	0.6	17
			MAX	90.9	21.2	31.5	659	518	3,137	11.0	30.1	518
1734	119	40	AV40	88.8	20.8	31.2	644	457	3,076	10.5	28.5	460
			STD	0.9	0.2	0.2	28	17	29	0.1	0.7	17
			MAX	91.1	21.4	31.5	702	491	3,157	10.8	30.0	497
1779	120	45	AV45	88.0	20.8	31.1	655	433	3,070	10.5	27.8	436
			STD	1.0	0.3	0.2	24	15	39	0.1	0.5	14
			MAX	90.5	21.3	31.4	715	474	3,140	10.8	29.6	475
1822	121	43	AV43	88.0	20.7	31.1	663	437	3,053	10.5	28.0	442
			STD	0.9	0.3	0.1	29	12	39	0.2	0.4	13
			MAX	90.2	21.2	31.3	715	466	3,126	10.8	29.4	472
1866	122	44	AV44	87.4	20.8	31.1	682	440	3,071	10.5	27.8	446
			STD	0.8	0.4	0.1	28	14	56	0.2	0.7	13
			MAX	88.8	21.4	31.4	730	477	3,154	11.0	29.0	477
1911	123	45	AV45	87.0	20.7	31.1	669	436	3,057	10.4	26.8	441
			STD	1.1	0.5	0.1	27	13	67	0.3	0.7	14
			MAX	90.2	21.6	31.5	739	461	3,195	11.1	28.2	473
1954	124	43	AV43	86.9	20.8	31.1	663	429	3,067	10.3	27.2	432
			STD	0.8	0.2	0.1	23	15	33	0.1	0.8	13
			MAX	88.4	21.2	31.3	710	457	3,128	10.6	28.6	461
2005	125	51	AV51	85.8	20.6	31.1	669	435	3,044	10.3	26.1	440
			STD	0.7	0.2	0.1	29	18	34	0.1	0.9	16

KIWC, POA TPP - IP 1 (Loc. 5) PP48x1.0", APE 15-4
OP: RMDT Date: 07-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	BPM bpm	RX6 kips	RX8 kips	FMX kips	VMX f/s	CSI ksi	RX7 kips
			MAX	87.5	21.3	31.4	732	477	3,150	11.0	27.7	477
2059	126	54	AV54	85.2	20.6	30.3	680	432	3,044	10.3	24.5	441
			STD	2.7	0.5	4.4	39	19	68	0.2	0.8	18
			MAX	87.5	21.6	31.5	754	492	3,182	10.8	26.6	492
2115	127	56	AV56	86.1	20.7	31.1	681	445	3,053	10.4	23.9	447
			STD	1.0	0.2	0.2	21	14	28	0.1	0.4	12
			MAX	89.5	21.1	31.5	718	468	3,118	10.8	25.0	468
2169	128	54	AV54	89.0	20.8	30.5	711	455	3,068	10.6	24.0	459
			STD	1.7	0.3	0.3	19	11	38	0.1	0.4	11
			MAX	92.3	21.3	31.4	749	482	3,142	10.8	24.9	483
			Average	91.6	21.2	30.9	619	545	3,137	11.1	29.1	550
			Std. Dev.	6.5	1.0	1.8	71	91	146	0.7	2.6	91
			Maximum	105.0	23.5	37.8	1,364	1,357	3,468	12.4	33.1	1,357

Total number of blows analyzed: 2165

BL#	Sensors
1-910	F1: [H263] 92.0 (1.00); F2: [H289] 94.0 (1.00); F3: off; ; F4: off; ; A1: off; A2: [39150] 1075.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)
911-2005	F1: [H263] 92.0 (1.00); F2: [H289] 94.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: [39150] 1075.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)
2006-2015	F1: off; ; F2: off; ; F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: [39150] 1075.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)
2016-2169	F1: [H263] 92.0 (1.00); F2: [H289] 94.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: [39150] 1075.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
1	Begin PDA monitoring, near Tip El. -81 ft, 6/7/2016, 11:39:40 AM
911	Restart after 4 min pause including reset of strain sensor.
2016	Restart after 2 min pause to reset strain sensor.
2169	End Driving near Tip El -150, 128 ft soil penetration, 6/7/20161:01:50 PM

Time Summary

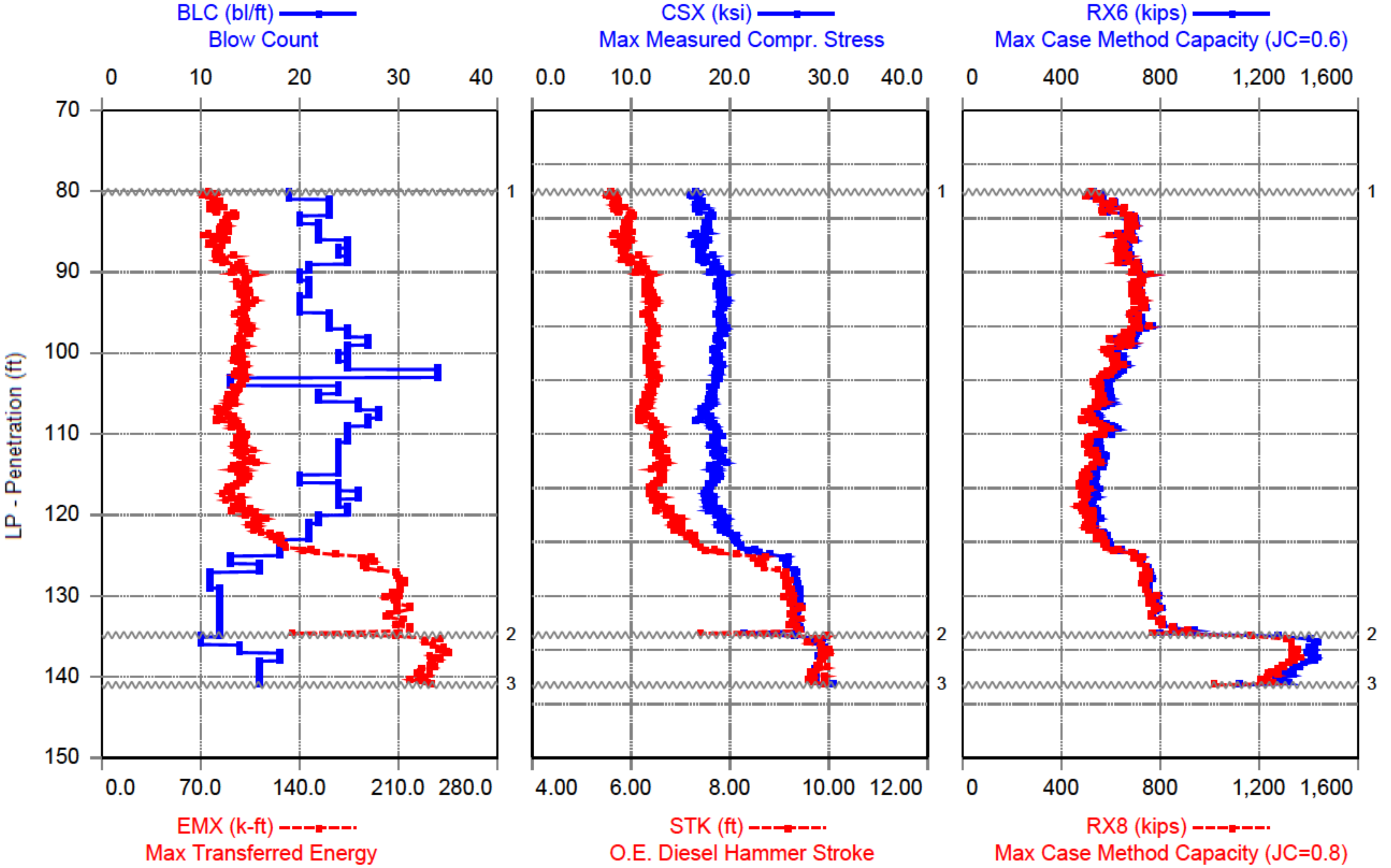
Drive	5 seconds	11:39 AM - 11:39 AM (6/7/2016) BN 1 - 3
Stop	1 minute 7 seconds	11:39 AM - 11:40 AM
Drive	5 seconds	11:40 AM - 11:40 AM BN 4 - 6
Stop	1 minute 15 seconds	11:40 AM - 11:42 AM
Drive	5 seconds	11:42 AM - 11:42 AM BN 7 - 9
Stop	2 minutes 20 seconds	11:42 AM - 11:44 AM
Drive	6 minutes 25 seconds	11:44 AM - 11:51 AM BN 10 - 214
Stop	1 minute 3 seconds	11:51 AM - 11:52 AM
Drive	22 minutes 45 seconds	11:52 AM - 12:14 PM BN 215 - 910

Stop	4 minutes 54 seconds	12:14 PM - 12:19 PM
Drive	35 minutes 27 seconds	12:19 PM - 12:55 PM BN 911 - 2015
Stop	1 minute 35 seconds	12:55 PM - 12:56 PM
Drive	4 minutes 56 seconds	12:56 PM - 1:01 PM BN 2016 - 2169

Total time [01:22:09] = (Driving [01:09:52] + Stop [00:12:17])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results
Printed: 19-May-2016
Test started: 19-May-2016

KIWC, POA TPP - IP 2 (Loc. 4)



1 - Begin monitoring near Tip El. -110 ft, 11:09:10 AM, 5/19/2016
2 - Continue after a 4 min pause near Tip El. -164. 11:38:12 AM
3 - End of Driving, near Tip El. -170 ft, 141 ft soil penetration, 5/19/2016, 11:40:38 AM

KIWC, POA TPP - IP 2 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 19-May-2016

AR: 147.65 in^2 SP: 0.492 k/ft^3
LE: 185.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
19	81.0	19	AV18	77.3	16.6	5.61	542	527	18.6	2,455	49.5	591
			STD	6.9	0.8	0.17	37	43	0.9	123	0.7	58
			MAX	90.9	18.3	5.96	627	627	20.6	2,706	51.1	657
42	82.0	23	AV23	80.7	17.0	5.72	595	588	19.0	2,504	49.1	597
			STD	5.3	0.6	0.14	40	49	0.7	90	0.6	37
			MAX	91.4	18.1	6.01	684	684	20.3	2,667	50.4	663
65	83.0	23	AV23	85.3	17.4	5.85	624	617	19.4	2,573	48.5	602
			STD	8.7	0.9	0.20	47	52	1.0	128	0.8	33
			MAX	106.7	19.5	6.31	713	713	21.8	2,873	49.8	666
85	84.0	20	AV20	89.3	17.9	5.97	687	683	20.1	2,646	48.1	600
			STD	7.1	0.8	0.18	37	40	1.0	123	0.7	33
			MAX	102.7	19.4	6.25	738	737	21.8	2,859	49.8	664
107	85.0	22	AV22	85.4	17.6	5.90	688	678	19.7	2,592	48.3	621
			STD	6.6	0.7	0.16	30	34	0.9	110	0.6	29
			MAX	101.5	19.6	6.34	762	761	22.2	2,894	49.6	673
129	86.0	22	AV22	81.8	17.2	5.84	664	653	19.2	2,534	48.6	601
			STD	8.2	0.9	0.19	37	42	1.1	132	0.8	31
			MAX	97.0	19.0	6.23	712	712	21.2	2,808	50.0	666
154	87.0	25	AV25	80.3	17.0	5.81	661	648	19.0	2,508	48.7	605
			STD	7.4	0.8	0.18	36	40	0.9	120	0.7	54
			MAX	95.1	18.7	6.17	727	711	21.0	2,759	50.3	709
178	88.0	24	AV24	82.9	17.2	5.89	661	645	19.3	2,540	48.4	627
			STD	5.9	0.7	0.15	25	31	0.8	100	0.6	41
			MAX	98.8	18.7	6.28	709	709	21.0	2,756	49.4	710
203	89.0	25	AV25	86.6	17.5	5.97	663	652	19.6	2,589	48.1	586
			STD	6.1	0.7	0.16	32	38	0.7	96	0.6	28
			MAX	99.4	18.7	6.28	717	717	21.0	2,761	49.1	633
224	90.0	21	AV21	97.7	18.7	6.23	711	707	21.0	2,756	47.1	595
			STD	6.4	0.7	0.16	24	27	0.8	107	0.6	29
			MAX	107.2	19.6	6.48	753	750	22.2	2,898	48.0	669
244	91.0	20	AV20	102.3	19.1	6.35	731	727	21.5	2,824	46.7	606
			STD	8.4	0.8	0.20	29	31	1.0	125	0.7	20
			MAX	118.1	20.6	6.72	796	796	23.3	3,045	47.8	645
265	92.0	21	AV21	99.0	19.0	6.32	711	707	21.3	2,802	46.8	605
			STD	6.6	0.7	0.15	27	28	0.8	99	0.5	34
			MAX	114.5	20.6	6.69	778	776	23.3	3,046	47.5	659
286	93.0	21	AV21	102.3	19.2	6.39	715	709	21.5	2,842	46.5	596
			STD	4.9	0.5	0.11	18	20	0.6	70	0.4	28

KIWC, POA TPP - IP 2 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 19-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			MAX	112.0	20.3	6.63	747	744	22.9	3,001	47.2	646
306	94.0	20	AV20	104.6	19.5	6.46	725	719	21.9	2,878	46.3	600
			STD	5.3	0.5	0.12	23	27	0.6	77	0.4	30
			MAX	113.5	20.3	6.63	776	776	22.9	3,000	47.1	651
326	95.0	20	AV20	100.2	19.1	6.39	723	713	21.5	2,827	46.5	625
			STD	5.5	0.6	0.13	28	32	0.7	88	0.5	49
			MAX	108.9	20.1	6.60	768	764	22.5	2,963	47.5	702
349	96.0	23	AV23	99.5	19.1	6.37	711	701	21.4	2,814	46.6	639
			STD	5.2	0.5	0.11	17	21	0.6	78	0.4	50
			MAX	110.8	20.3	6.60	740	737	23.0	3,000	47.4	710
372	97.0	23	AV23	101.6	19.3	6.44	728	715	21.7	2,845	46.4	641
			STD	5.2	0.5	0.12	28	28	0.6	77	0.4	60
			MAX	110.8	20.1	6.63	786	775	22.6	2,969	47.2	766
397	98.0	25	AV25	102.3	19.3	6.46	705	681	21.8	2,847	46.3	677
			STD	4.3	0.4	0.10	25	29	0.5	62	0.4	63
			MAX	112.1	20.2	6.66	742	742	22.9	2,982	47.0	786
424	99.0	27	AV27	98.5	18.9	6.40	670	647	21.4	2,789	46.5	663
			STD	5.3	0.6	0.11	30	39	0.7	81	0.4	55
			MAX	112.1	20.4	6.69	717	714	23.2	3,010	47.4	731
449	100.0	25	AV25	97.9	18.8	6.38	643	615	21.3	2,772	46.6	636
			STD	7.1	0.7	0.15	34	41	0.8	106	0.5	48
			MAX	118.4	20.7	6.82	744	730	23.5	3,052	47.9	738
473	101.0	24	AV24	96.1	18.6	6.36	637	610	21.1	2,744	46.6	595
			STD	5.6	0.6	0.14	22	27	0.7	93	0.5	57
			MAX	107.5	19.9	6.66	681	662	22.5	2,939	47.8	680
498	102.0	25	AV25	99.3	18.9	6.43	652	623	21.4	2,792	46.4	605
			STD	5.6	0.6	0.12	22	24	0.7	87	0.4	46
			MAX	110.2	20.1	6.69	694	687	22.7	2,962	47.4	661
532	103.0	34	AV34	98.1	18.8	6.44	627	594	21.2	2,770	46.4	573
			STD	6.1	0.6	0.12	25	27	0.8	94	0.4	53
			MAX	108.9	20.0	6.66	677	667	22.8	2,960	47.3	662
545	104.0	13	AV13	100.4	18.7	6.50	594	550	21.1	2,767	46.2	608
			STD	4.5	0.5	0.09	24	29	0.6	77	0.3	31
			MAX	107.2	19.5	6.66	642	616	22.2	2,883	46.6	678
569	105.0	24	AV24	96.0	18.4	6.42	591	555	20.6	2,711	46.4	559
			STD	6.0	0.6	0.12	26	29	0.7	94	0.4	48
			MAX	108.8	19.5	6.63	636	617	22.0	2,879	47.3	619
591	106.0	22	AV22	91.7	18.1	6.34	592	558	20.3	2,675	46.7	503
			STD	4.1	0.5	0.09	23	21	0.5	66	0.3	29
			MAX	101.8	19.2	6.54	651	616	21.5	2,837	47.2	621
617	107.0	26	AV26	89.9	17.9	6.32	581	550	20.1	2,650	46.8	492
			STD	6.7	0.8	0.12	31	29	0.9	115	0.4	15
			MAX	102.7	19.2	6.54	651	614	21.6	2,837	47.6	520
645	108.0	28	AV28	86.9	17.5	6.26	542	514	19.5	2,585	47.0	475
			STD	6.3	0.7	0.13	14	20	0.8	99	0.5	11
			MAX	102.3	19.3	6.54	576	575	21.6	2,851	47.8	510

KIWC, POA TPP - IP 2 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 19-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
672	109.0	27	AV27	89.1	17.6	6.34	554	522	19.7	2,598	46.7	485
			STD	7.8	0.8	0.17	33	35	0.9	120	0.6	22
			MAX	102.2	19.0	6.60	645	606	21.2	2,808	47.7	522
697	110.0	25	AV25	97.6	18.7	6.55	613	580	20.8	2,756	46.0	520
			STD	7.9	0.8	0.16	26	25	0.9	122	0.6	16
			MAX	113.9	20.4	6.88	666	632	22.9	3,011	47.8	547
722	111.0	25	AV25	99.7	18.8	6.56	564	529	21.0	2,769	45.9	494
			STD	8.0	0.8	0.17	29	33	1.0	124	0.6	20
			MAX	116.5	20.5	6.91	632	601	23.2	3,032	47.3	548
746	112.0	24	AV24	98.5	18.6	6.56	543	509	20.9	2,742	46.0	495
			STD	7.1	0.7	0.15	17	24	0.9	109	0.5	15
			MAX	111.7	19.9	6.82	576	575	22.3	2,936	47.1	513
770	113.0	24	AV24	100.4	18.7	6.60	561	529	21.1	2,768	45.8	501
			STD	7.1	0.7	0.16	23	27	0.8	109	0.5	16
			MAX	118.7	20.6	6.98	638	596	23.3	3,039	46.9	530
794	114.0	24	AV24	102.4	19.0	6.65	572	544	21.4	2,809	45.6	493
			STD	6.6	0.6	0.13	18	24	0.7	89	0.4	13
			MAX	117.2	20.5	6.95	600	583	23.3	3,028	46.4	516
818	115.0	24	AV24	97.4	18.5	6.57	545	512	20.8	2,727	45.9	489
			STD	7.5	0.8	0.15	21	25	0.9	114	0.5	12
			MAX	113.7	20.3	6.88	584	578	22.9	2,990	47.4	513
838	116.0	20	AV20	101.1	18.7	6.62	535	497	21.0	2,758	45.7	480
			STD	6.2	0.6	0.12	15	20	0.8	96	0.4	15
			MAX	116.2	20.1	6.88	567	532	22.7	2,968	46.4	506
862	117.0	24	AV24	94.2	18.0	6.47	527	493	20.3	2,664	46.3	472
			STD	7.1	0.7	0.12	26	28	0.8	100	0.4	25
			MAX	106.0	19.1	6.66	587	549	21.5	2,819	47.2	529
888	118.0	26	AV26	92.0	17.9	6.48	534	498	20.1	2,645	46.2	486
			STD	7.0	0.7	0.15	20	21	0.8	99	0.5	13
			MAX	105.3	19.1	6.79	578	537	21.4	2,817	47.2	508
912	119.0	24	AV24	95.0	18.1	6.55	521	487	20.3	2,673	46.0	477
			STD	8.8	0.8	0.15	18	25	1.0	121	0.5	17
			MAX	111.8	19.8	6.82	563	531	22.4	2,930	46.9	520
937	120.0	25	AV25	102.8	18.8	6.73	539	507	21.1	2,771	45.4	493
			STD	8.3	0.8	0.17	18	28	0.9	119	0.5	40
			MAX	114.9	20.1	7.04	569	552	22.6	2,970	46.4	626
959	121.0	22	AV22	110.0	19.4	6.90	542	515	21.8	2,858	44.9	505
			STD	8.0	0.8	0.16	23	27	0.9	117	0.5	56
			MAX	128.0	20.9	7.25	594	565	23.5	3,085	46.1	646
980	122.0	21	AV21	108.2	19.2	6.92	531	510	21.7	2,841	44.8	468
			STD	4.0	0.5	0.11	12	18	0.6	70	0.3	17
			MAX	115.5	20.0	7.11	551	536	22.6	2,954	45.5	523
1001	123.0	21	AV21	121.0	20.3	7.18	572	553	22.8	2,990	44.0	561
			STD	7.1	0.7	0.14	17	22	0.8	97	0.4	60
			MAX	130.5	21.4	7.42	601	589	24.2	3,162	44.9	648
1019	124.0	18	AV18	126.9	20.8	7.30	594	579	23.5	3,071	43.7	617

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			STD	6.0	0.6	0.12	21	24	0.7	82	0.3	70
			MAX	139.1	21.9	7.49	636	619	24.9	3,238	44.3	700
1037	125.0	18	AV18	150.5	22.8	7.76	661	651	25.8	3,362	42.4	652
			STD	11.6	1.0	0.27	37	44	1.2	147	0.7	80
			MAX	169.6	24.4	8.23	726	726	27.7	3,602	43.7	829
1050	126.0	13	AV13	189.7	25.8	8.63	720	715	29.2	3,807	40.3	799
			STD	4.8	0.5	0.14	33	35	0.5	67	0.3	72
			MAX	198.1	26.7	8.89	779	779	30.5	3,949	40.8	880
1066	127.0	16	AV16	189.4	26.0	8.77	748	743	29.5	3,845	40.0	722
			STD	8.0	0.7	0.23	24	26	0.8	111	0.5	112
			MAX	202.3	27.1	9.17	790	789	30.6	3,995	41.1	913
1077	128.0	11	AV11	210.5	26.7	9.11	761	749	30.2	3,938	39.2	896
			STD	4.7	0.5	0.11	22	26	0.5	71	0.2	22
			MAX	218.0	27.5	9.32	791	786	31.2	4,066	39.5	930
1088	129.0	11	AV11	214.2	26.8	9.19	740	731	30.2	3,961	39.1	914
			STD	6.5	0.6	0.12	19	18	0.7	84	0.3	20
			MAX	224.7	27.7	9.37	764	753	31.3	4,089	39.6	940
1100	130.0	12	AV12	209.8	27.0	9.25	771	761	30.5	3,985	38.9	875
			STD	5.3	0.6	0.15	35	36	0.6	81	0.3	105
			MAX	219.2	28.1	9.52	819	810	31.8	4,145	39.4	997
1112	131.0	12	AV12	204.8	26.7	9.20	770	762	30.1	3,944	39.0	791
			STD	5.4	0.5	0.15	27	31	0.6	79	0.3	109
			MAX	213.3	27.7	9.47	838	838	31.2	4,096	39.5	990
1124	132.0	12	AV12	216.3	27.3	9.41	798	791	30.7	4,027	38.6	885
			STD	4.2	0.3	0.12	32	34	0.4	51	0.2	112
			MAX	223.8	28.0	9.67	832	832	31.3	4,131	38.9	1,003
1136	133.0	12	AV12	204.8	26.9	9.29	780	776	30.2	3,966	38.9	753
			STD	5.5	0.4	0.15	25	26	0.5	59	0.3	94
			MAX	217.0	27.4	9.52	834	834	30.8	4,052	39.5	969
1148	134.0	12	AV12	213.7	26.9	9.29	811	806	30.0	3,967	38.9	967
			STD	7.7	0.5	0.15	26	27	0.6	81	0.3	28
			MAX	224.3	27.8	9.57	871	869	31.2	4,109	39.5	1,007
1160	135.0	12	AV12	183.8	24.8	8.78	971	924	27.7	3,664	37.4	1,054
			STD	72.3	5.9	1.68	206	189	6.7	866	11.7	247
			MAX	262.2	30.6	10.33	1,326	1,258	34.2	4,521	53.6	1,530
1170	136.0	10	AV10	236.9	29.2	9.77	1,416	1,318	32.6	4,319	37.9	1,660
			STD	11.0	0.7	0.21	46	40	0.8	105	0.4	72
			MAX	260.8	30.7	10.22	1,482	1,397	34.4	4,533	38.4	1,785
1184	137.0	14	AV14	240.8	29.4	9.92	1,414	1,342	32.8	4,348	37.6	1,674
			STD	6.2	0.3	0.12	22	19	0.4	49	0.2	48
			MAX	251.6	30.0	10.11	1,452	1,383	33.4	4,434	38.1	1,765
1202	138.0	18	AV18	238.8	29.4	9.90	1,421	1,348	32.7	4,335	37.7	1,677
			STD	8.9	0.5	0.19	29	27	0.6	79	0.3	54
			MAX	254.5	30.2	10.22	1,489	1,413	33.6	4,459	38.3	1,774
1218	139.0	16	AV16	233.7	29.1	9.85	1,374	1,311	32.4	4,293	37.8	1,648
			STD	4.2	0.3	0.10	33	29	0.3	39	0.2	47

KIWC, POA TPP - IP 2 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 19-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
			MAX	239.5	29.5	10.00	1,444	1,377	32.9	4,352	38.1	1,721
1234	140.0	16	AV16	227.6	28.7	9.74	1,325	1,260	32.0	4,236	38.0	1,581
			STD	7.9	0.5	0.17	23	25	0.6	74	0.3	41
			MAX	239.6	29.5	10.00	1,361	1,305	32.9	4,359	38.7	1,660
1250	141.0	16	AV16	226.0	28.8	9.72	1,285	1,217	32.3	4,247	38.0	1,503
			STD	5.9	0.6	0.16	51	57	0.7	87	0.3	97
			MAX	236.8	30.6	10.05	1,357	1,285	34.5	4,520	38.5	1,582
			Average	117.5	20.1	6.91	689	664	22.6	2,964	45.2	668
			Std. Dev.	47.5	3.7	1.21	210	201	4.1	543	3.5	293
			Maximum	262.2	30.7	10.33	1,489	1,413	34.5	4,533	53.6	1,785

Total number of blows analyzed: 1249

BL# Sensors

2-1250 F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00);
F4: [H324] 93.0 (1.00); A1: off; A2: off; A3: [K3257] 340.0 (1.00);
A4: [K3259] 365.0 (1.00)

BL# Comments

2 Begin monitoring near Tip El. -110 ft, 11:09:10 AM, 5/19/2016
1158 Continue after a 4 min pause near Tip El. -164. 11:38:12 AM
1250 End of Driving, near Tip El. -170 ft, 141 ft soil penetration, 5/19/2016, 11:40:38 AM

Time Summary

Drive 25 minutes 16 seconds 11:09 AM - 11:34 AM (5/19/2016) BN 2 - 1157
Stop 3 minutes 45 seconds 11:34 AM - 11:38 AM
Drive 2 minutes 25 seconds 11:38 AM - 11:40 AM BN 1158 - 1250

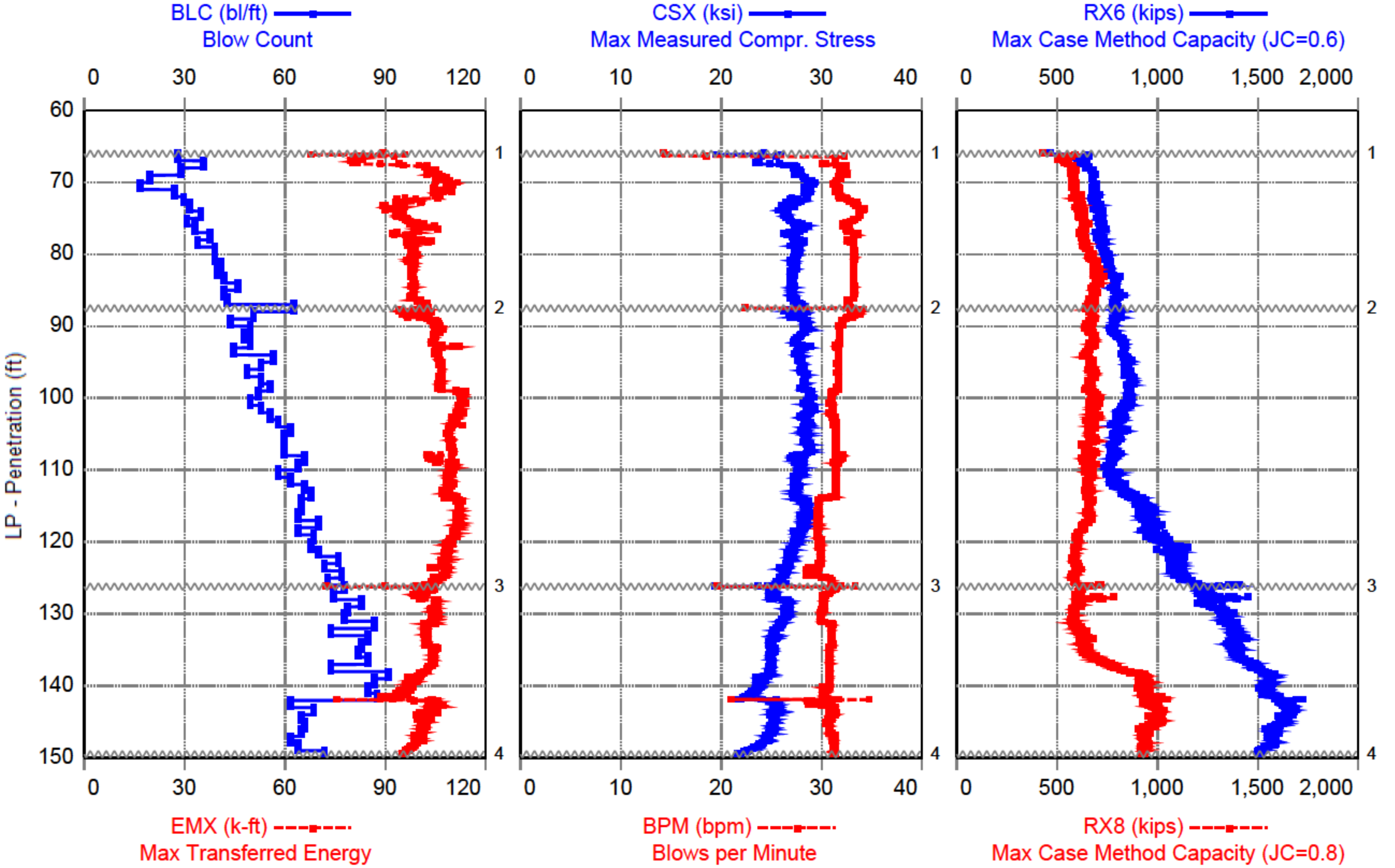
Total time [00:31:27] = (Driving [00:27:41] + Stop [00:03:45])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 06-June-2016

Test started: 03-June-2016

KIWC, POA TPP - IP 3 (Loc. 1)



1 - Begin driving & monitoring, near Tip El -92 ft, 6/3/2016, 10:33 AM

2 - Restart after 4 minutes 4 seconds

3 - Move PDA sensor up closer to top of pile. Restart @ 12:48:00 PM

4 - End drivng, near Tip El -184 ft, soil penetration approx 149 ft, 2:02:12 PM

KIWC, POA TPP - IP 3 (Loc. 1) PP48x1.0", APE 15-4
OP: RMDT Date: 03-June-2016

AR: 147.65 in^2
LE: 188.00 ft
WS: 17,100.0 f/s

SP: 0.492 k/ft^3
EM: 31,052 ksi
JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
BPM: Blows per Minute
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
FMX: Maximum Force
VMX: Maximum Velocity
CSI: Max F1 or F2 Compr. Stress
RX7: Max Case Method Capacity (JC=0.7)

BL#	Depth	BLC	TYPE	EMX	CSX	BPM	RX6	RX8	FMX	VMX	CSI	RX7
	ft	bl/ft		k-ft	ksi	bpm	kips	kips	kips	f/s	ksi	kips
28	67.0	28	AV28	84.2	23.8	24.7	616	533	3,519	13.5	26.3	572
			STD	16.2	3.5	10.4	76	60	510	2.0	4.0	68
			MAX	108.0	28.1	33.0	698	621	4,146	15.6	31.5	654
64	68.0	36	AV36	89.7	25.2	31.5	639	556	3,724	14.3	26.9	589
			STD	9.3	1.6	0.7	21	21	234	1.0	2.2	21
			MAX	102.8	27.7	32.6	688	600	4,084	15.9	30.3	627
93	69.0	29	AV29	103.3	27.6	32.4	673	585	4,077	15.8	29.8	620
			STD	1.5	0.4	0.3	19	17	55	0.2	0.7	18
			MAX	109.4	28.8	32.8	711	631	4,252	16.5	31.4	660
113	70.0	20	AV20	106.8	28.4	31.8	687	586	4,197	16.3	30.8	628
			STD	1.9	0.4	0.2	13	14	55	0.2	0.6	14
			MAX	110.7	29.2	32.1	713	626	4,314	16.6	32.2	666
130	71.0	17	AV17	108.8	28.9	31.5	686	587	4,274	16.6	31.0	633
			STD	2.6	0.4	0.2	16	11	59	0.2	0.6	15
			MAX	113.4	29.6	31.9	716	612	4,374	17.1	31.9	663
157	72.0	27	AV27	105.9	28.6	31.8	693	602	4,221	16.4	30.6	641
			STD	2.5	0.3	0.2	19	20	38	0.3	0.5	22
			MAX	115.6	29.2	32.0	735	641	4,316	17.2	31.6	685
187	73.0	30	AV30	99.3	27.6	32.6	693	605	4,081	15.7	30.0	645
			STD	4.8	0.8	0.7	18	20	115	0.4	0.9	19
			MAX	106.3	28.9	34.0	721	643	4,269	16.5	31.9	671
219	74.0	32	AV32	92.5	26.5	33.8	701	613	3,908	15.0	29.4	656
			STD	3.6	0.6	0.6	18	19	92	0.4	0.7	19
			MAX	100.2	27.9	35.1	733	645	4,116	15.7	30.6	688
254	75.0	35	AV35	94.5	26.5	33.8	722	630	3,911	15.1	29.2	672
			STD	1.4	0.2	0.1	17	18	37	0.2	0.7	18
			MAX	97.5	27.0	34.2	752	661	3,985	15.4	30.5	705
285	76.0	31	AV31	97.8	27.2	33.0	718	637	4,014	15.5	29.3	669
			STD	2.2	0.5	0.5	16	16	71	0.3	1.0	14
			MAX	104.8	28.3	33.8	753	677	4,173	16.2	32.0	702
318	77.0	33	AV33	101.2	27.9	32.6	729	641	4,119	15.8	30.8	680
			STD	2.8	0.5	0.3	22	14	76	0.2	0.9	18
			MAX	107.5	29.1	33.4	770	667	4,298	16.4	32.6	714
356	78.0	38	AV38	95.7	27.0	33.3	711	627	3,986	15.3	29.9	663
			STD	3.9	0.6	0.5	20	14	88	0.3	1.0	17
			MAX	101.7	28.1	34.8	755	651	4,149	16.0	31.7	703
390	79.0	34	AV34	99.9	27.7	33.0	727	640	4,086	15.6	30.8	680
			STD	2.9	0.5	0.3	19	15	72	0.2	0.6	16

KIWC, POA TPP - IP 3 (Loc. 1) PP48x1.0", APE 15-4
OP: RMDT Date: 03-June-2016

BL#	Depth	BLC	TYPE	EMX	CSX	BPM	RX6	RX8	FMX	VMX	CSI	RX7
	ft	bl/ft		k-ft	ksi	bpm	kips	kips	kips	f/s	ksi	kips
			MAX	105.3	28.6	33.6	759	668	4,219	16.1	32.0	713
429	80.0	39	AV39	98.8	27.6	33.3	739	663	4,074	15.5	31.1	697
			STD	0.6	0.2	0.1	15	17	31	0.1	0.5	16
			MAX	100.1	27.9	33.4	765	708	4,125	15.8	31.8	731
468	81.0	39	AV39	98.5	27.4	33.3	745	671	4,048	15.4	30.9	703
			STD	1.2	0.3	0.1	14	16	39	0.2	0.5	15
			MAX	101.7	28.0	33.5	785	701	4,131	15.8	31.7	738
509	82.0	41	AV41	98.4	27.3	33.3	763	694	4,037	15.4	30.7	721
			STD	0.7	0.3	0.1	14	19	40	0.1	0.6	18
			MAX	100.1	27.9	33.4	793	742	4,121	15.7	31.6	766
549	83.0	40	AV40	98.3	27.2	33.3	767	697	4,021	15.3	30.8	727
			STD	0.5	0.2	0.1	14	18	33	0.1	0.6	17
			MAX	99.7	27.8	33.6	793	747	4,098	15.6	31.6	766
591	84.0	42	AV42	98.5	27.1	33.3	795	717	4,004	15.3	30.5	752
			STD	0.4	0.2	0.1	18	20	30	0.2	0.5	20
			MAX	99.9	27.5	33.6	833	755	4,058	15.6	31.2	794
637	85.0	46	AV46	98.9	27.1	33.3	790	698	4,000	15.3	30.6	736
			STD	0.6	0.3	0.1	16	21	39	0.2	0.6	21
			MAX	100.1	27.7	33.7	825	740	4,096	15.6	31.3	782
679	86.0	42	AV42	98.4	27.1	33.3	809	689	4,005	15.3	30.6	733
			STD	0.5	0.2	0.1	18	17	30	0.1	0.6	15
			MAX	100.0	27.5	33.6	858	724	4,055	15.6	31.6	766
722	87.0	43	AV43	99.6	27.3	33.0	795	676	4,037	15.5	30.9	714
			STD	1.8	0.4	0.3	21	17	58	0.3	0.8	18
			MAX	106.1	28.4	33.5	840	715	4,187	16.0	32.8	748
785	88.0	63	AV63	99.2	27.6	32.7	793	669	4,071	15.6	30.8	708
			STD	3.8	0.7	4.0	19	22	100	0.3	1.0	22
			MAX	109.9	28.8	34.3	852	726	4,251	16.2	32.6	765
836	89.0	51	AV51	99.0	27.5	33.3	807	676	4,064	15.5	30.6	709
			STD	3.4	0.7	0.4	24	18	106	0.4	0.9	18
			MAX	108.7	29.2	34.2	871	728	4,305	16.3	33.4	772
880	90.0	44	AV44	104.8	28.4	32.2	786	670	4,186	16.0	31.1	702
			STD	1.3	0.3	0.2	15	17	39	0.3	0.7	19
			MAX	106.8	29.0	32.7	825	711	4,277	16.5	32.8	761
930	91.0	50	AV50	106.4	28.5	31.9	778	660	4,212	16.0	31.2	691
			STD	0.8	0.2	0.1	13	16	33	0.2	0.7	13
			MAX	109.5	29.0	32.3	817	699	4,284	16.4	33.5	722
978	92.0	48	AV48	104.9	27.9	31.9	805	689	4,113	15.7	30.3	712
			STD	0.4	0.3	0.0	21	16	40	0.2	0.6	14
			MAX	105.7	28.4	31.9	850	723	4,187	16.1	31.4	743
1028	93.0	50	AV50	106.1	27.8	31.7	836	683	4,103	15.6	30.2	719
			STD	2.7	0.6	0.2	17	17	82	0.3	0.9	11
			MAX	112.8	29.2	31.9	866	714	4,318	16.4	33.1	739
1073	94.0	45	AV45	105.7	27.9	31.7	835	657	4,116	15.6	30.1	706
			STD	1.0	0.4	0.1	14	15	54	0.3	0.6	16
			MAX	110.4	28.9	31.8	871	702	4,267	16.4	31.8	751

KIWC, POA TPP - IP 3 (Loc. 1) PP48x1.0", APE 15-4
OP: RMDT Date: 03-June-2016

BL#	Depth	BLC	TYPE	EMX	CSX	BPM	RX6	RX8	FMX	VMX	CSI	RX7
	ft	bl/ft		k-ft	ksi	bpm	kips	kips	kips	f/s	ksi	kips
1130	95.0	57	AV57	106.0	27.8	31.7	850	660	4,108	15.5	30.0	713
			STD	0.6	0.2	0.0	21	20	30	0.2	0.5	17
			MAX	107.6	28.3	31.8	899	693	4,175	15.8	31.2	757
1183	96.0	53	AV53	106.8	28.1	31.7	850	676	4,151	15.7	30.5	718
			STD	0.4	0.1	0.1	11	15	19	0.1	0.5	11
			MAX	108.1	28.4	31.8	881	699	4,191	16.0	31.6	739
1232	97.0	49	AV49	106.9	28.2	31.7	854	683	4,166	15.9	30.8	717
			STD	0.4	0.2	0.0	14	19	31	0.2	0.6	12
			MAX	107.8	28.8	31.8	897	725	4,246	16.2	32.2	749
1285	98.0	53	AV53	106.8	28.4	31.7	874	669	4,196	16.0	31.1	730
			STD	0.6	0.2	0.1	14	18	28	0.1	0.6	13
			MAX	109.0	28.9	31.8	902	713	4,266	16.2	32.6	757
1341	99.0	56	AV56	106.4	28.3	31.7	864	660	4,176	15.9	30.9	724
			STD	0.5	0.2	0.0	15	16	28	0.2	0.6	13
			MAX	107.5	28.7	31.7	896	709	4,238	16.2	32.7	753
1393	100.0	52	AV52	112.8	29.0	31.1	862	686	4,284	16.4	31.7	727
			STD	1.2	0.2	0.2	17	22	31	0.2	0.6	15
			MAX	114.7	29.4	31.8	893	732	4,345	16.8	33.0	765
1443	101.0	50	AV50	113.4	28.8	31.0	863	694	4,250	16.4	31.6	738
			STD	0.5	0.3	0.1	24	22	50	0.2	0.8	19
			MAX	114.8	29.5	31.2	925	735	4,362	16.8	33.2	773
1496	102.0	53	AV53	112.1	28.9	31.2	829	685	4,266	16.4	32.0	723
			STD	0.5	0.3	0.1	21	19	46	0.2	1.0	18
			MAX	113.4	29.6	31.3	902	739	4,375	16.8	34.2	773
1552	103.0	56	AV56	111.7	28.5	31.2	825	693	4,213	16.2	31.3	747
			STD	1.1	0.4	0.2	20	25	60	0.3	1.0	30
			MAX	114.6	29.4	31.6	871	740	4,345	16.8	33.7	805
1610	104.0	58	AV58	110.5	28.7	31.4	797	665	4,231	16.3	31.8	713
			STD	1.0	0.3	0.1	18	16	42	0.2	0.8	15
			MAX	114.1	29.3	31.6	852	702	4,332	16.8	34.1	763
1672	105.0	62	AV62	109.3	28.3	31.5	813	670	4,183	16.1	31.1	714
			STD	0.4	0.2	0.1	23	17	37	0.2	0.6	17
			MAX	110.1	28.9	31.6	872	706	4,265	16.6	32.7	751
1732	106.0	60	AV60	109.4	28.4	31.5	797	675	4,201	16.1	31.2	712
			STD	0.5	0.2	0.1	19	18	33	0.2	0.6	17
			MAX	111.0	29.0	31.7	840	714	4,275	16.4	32.6	747
1792	107.0	60	AV60	109.9	28.6	31.5	783	654	4,224	16.1	31.5	692
			STD	0.4	0.3	0.1	17	24	40	0.2	0.6	20
			MAX	110.9	29.2	31.6	816	715	4,317	16.7	33.2	749
1852	108.0	60	AV60	110.0	28.7	31.5	798	674	4,241	16.2	31.6	711
			STD	1.5	0.3	0.1	19	21	46	0.2	0.8	16
			MAX	111.3	29.4	32.3	847	706	4,339	16.6	33.6	740
1918	109.0	66	AV66	104.3	27.5	32.0	781	645	4,056	15.4	29.9	680
			STD	1.4	0.3	0.2	21	14	50	0.3	0.6	13
			MAX	107.7	28.1	32.3	851	687	4,150	15.9	31.3	715
1982	110.0	64	AV64	109.9	27.9	31.5	763	669	4,116	15.6	30.0	706

KIWC, POA TPP - IP 3 (Loc. 1) PP48x1.0", APE 15-4
OP: RMDT Date: 03-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	BPM bpm	RX6 kips	RX8 kips	FMX kips	VMX f/s	CSI ksi	RX7 kips
			STD	1.4	0.3	0.1	16	20	38	0.2	0.5	18
			MAX	113.7	28.9	31.9	798	710	4,262	16.1	32.1	741
2040	111.0	58	AV58	109.5	27.9	31.5	781	663	4,121	15.6	30.1	700
			STD	0.9	0.3	0.1	27	16	43	0.2	0.6	14
			MAX	112.1	28.7	31.6	850	696	4,234	16.2	31.8	728
2102	112.0	62	AV62	109.1	27.5	31.5	787	657	4,062	15.4	29.5	696
			STD	0.9	0.2	0.1	34	13	30	0.2	0.5	11
			MAX	111.4	28.0	31.6	847	698	4,131	15.7	30.4	732
2168	113.0	66	AV66	109.2	27.6	31.5	826	658	4,081	15.4	29.7	692
			STD	1.0	0.2	0.1	36	12	31	0.2	0.4	12
			MAX	111.3	28.2	31.7	891	687	4,164	15.8	30.5	726
2236	114.0	68	AV68	108.8	27.5	31.4	864	659	4,059	15.3	29.7	695
			STD	1.6	0.3	0.2	45	11	42	0.2	0.4	12
			MAX	112.3	28.2	31.7	954	689	4,167	16.0	31.0	728
2301	115.0	65	AV65	111.6	28.3	29.8	924	671	4,173	16.0	31.0	709
			STD	1.4	0.4	0.2	41	13	64	0.3	0.6	13
			MAX	113.5	28.9	30.8	997	698	4,264	16.5	32.0	738
2366	116.0	65	AV65	112.4	28.5	29.8	951	661	4,209	16.1	31.1	702
			STD	0.6	0.2	0.2	47	13	33	0.2	0.4	12
			MAX	113.4	29.0	30.1	1,017	696	4,275	16.6	31.9	736
2430	117.0	64	AV64	112.4	28.4	29.8	950	665	4,188	16.0	31.1	713
			STD	0.6	0.3	0.2	44	14	45	0.2	0.6	15
			MAX	113.5	29.0	30.0	1,031	699	4,288	16.3	32.5	741
2500	118.0	70	AV70	112.0	28.3	29.7	978	645	4,179	16.0	30.9	693
			STD	0.7	0.4	0.2	54	16	55	0.2	0.7	16
			MAX	113.4	29.0	30.0	1,088	678	4,284	16.4	32.2	728
2564	119.0	64	AV64	111.3	27.8	29.7	969	621	4,111	15.7	30.2	664
			STD	1.0	0.5	0.2	48	14	70	0.3	1.0	18
			MAX	113.0	28.9	30.1	1,056	645	4,274	16.3	32.5	693
2633	120.0	69	AV69	110.5	27.7	29.8	1,014	606	4,093	15.5	30.0	637
			STD	1.0	0.4	0.2	56	10	57	0.3	0.8	12
			MAX	112.4	28.6	30.1	1,150	631	4,225	16.1	31.6	698
2701	121.0	68	AV68	109.1	27.3	29.9	1,072	603	4,035	15.3	29.1	657
			STD	0.8	0.3	0.1	57	11	39	0.2	0.7	32
			MAX	110.7	28.1	30.0	1,184	620	4,155	15.8	31.0	749
2771	122.0	70	AV70	108.3	27.0	29.9	1,085	597	3,981	14.9	28.3	665
			STD	0.7	0.3	0.1	51	8	41	0.2	0.7	39
			MAX	110.0	27.6	30.0	1,182	622	4,072	15.4	30.1	753
2847	123.0	76	AV76	108.0	26.9	29.9	1,103	589	3,976	14.9	28.0	678
			STD	0.8	0.2	0.1	38	9	28	0.2	0.4	34
			MAX	109.7	27.6	30.0	1,158	617	4,077	15.4	29.5	734
2919	124.0	72	AV72	107.9	26.7	29.4	1,100	609	3,940	14.8	28.1	681
			STD	1.6	0.3	0.5	37	10	47	0.3	0.7	28
			MAX	109.7	27.1	30.0	1,159	639	4,006	15.3	29.4	726
2996	125.0	77	AV77	107.8	26.3	28.9	1,110	589	3,881	14.5	27.1	698
			STD	1.0	0.2	0.7	32	13	28	0.2	0.3	31

KIWC, POA TPP - IP 3 (Loc. 1) PP48x1.0", APE 15-4
OP: RMDT Date: 03-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	BPM bpm	RX6 kips	RX8 kips	FMX kips	VMX f/s	CSI ksi	RX7 kips
			MAX	109.1	26.7	30.6	1,188	622	3,941	15.0	28.3	772
3069	126.0	73	AV73	105.1	26.0	31.0	1,179	600	3,836	14.3	27.1	784
			STD	0.9	0.2	0.1	71	39	36	0.2	0.6	85
			MAX	106.6	26.6	31.1	1,451	782	3,927	14.7	28.5	1,115
3147	127.0	78	AV78	100.8	25.0	30.9	1,250	639	3,686	13.5	26.6	887
			STD	10.3	2.0	3.4	96	43	298	1.1	2.2	91
			MAX	105.0	26.0	34.2	1,441	777	3,841	14.2	27.8	1,108
3222	128.0	75	AV75	100.9	25.2	30.5	1,282	634	3,717	13.6	26.7	929
			STD	1.4	0.2	0.3	83	63	37	0.2	0.3	90
			MAX	103.3	25.7	31.2	1,458	796	3,797	13.9	27.7	1,127
3305	129.0	83	AV83	104.9	26.6	30.3	1,263	618	3,923	14.8	28.0	852
			STD	1.4	0.5	0.1	51	41	70	0.4	0.6	68
			MAX	106.5	27.1	30.5	1,481	829	4,006	15.2	29.1	1,155
3384	130.0	79	AV79	104.6	26.7	30.2	1,323	590	3,936	14.8	28.6	914
			STD	0.9	0.2	0.2	47	14	33	0.2	0.5	46
			MAX	107.1	27.2	30.5	1,403	627	4,011	15.1	29.6	994
3462	131.0	78	AV78	105.5	26.5	30.0	1,342	589	3,917	14.7	28.2	936
			STD	0.8	0.3	0.1	33	10	44	0.2	0.6	33
			MAX	107.0	27.1	30.3	1,394	612	4,003	15.2	29.6	996
3549	132.0	87	AV87	103.2	26.0	30.8	1,373	593	3,836	14.4	27.5	979
			STD	1.3	0.2	0.5	31	22	31	0.1	0.4	31
			MAX	106.3	26.6	31.3	1,421	636	3,922	14.6	28.4	1,028
3623	133.0	74	AV74	102.4	25.5	31.0	1,389	624	3,763	14.0	26.8	1,006
			STD	0.4	0.2	0.1	22	23	24	0.1	0.3	22
			MAX	103.3	25.9	31.1	1,433	677	3,821	14.3	27.6	1,055
3708	134.0	85	AV85	102.6	25.3	31.0	1,403	646	3,736	13.9	27.1	1,024
			STD	0.4	0.2	0.1	29	24	34	0.2	0.3	26
			MAX	103.4	25.8	31.1	1,463	695	3,807	14.3	27.8	1,079
3791	135.0	83	AV83	103.8	25.1	31.0	1,382	638	3,699	13.6	27.1	1,010
			STD	1.4	0.2	0.1	30	25	32	0.2	0.5	27
			MAX	106.2	25.5	31.3	1,450	697	3,772	14.1	28.0	1,073
3873	136.0	82	AV82	104.6	25.1	30.9	1,396	654	3,705	13.6	27.2	1,025
			STD	0.5	0.2	0.1	25	28	28	0.2	0.3	26
			MAX	105.6	25.6	31.0	1,463	746	3,776	14.0	27.8	1,104
3958	137.0	85	AV85	104.5	25.1	30.9	1,441	717	3,703	13.7	27.7	1,079
			STD	0.4	0.1	0.1	31	33	19	0.1	0.2	32
			MAX	105.5	25.4	31.0	1,509	790	3,757	14.0	28.3	1,150
4032	138.0	74	AV74	103.4	25.1	30.9	1,489	794	3,704	13.7	27.8	1,142
			STD	0.6	0.1	0.1	24	26	20	0.1	0.3	25
			MAX	104.6	25.3	31.0	1,540	856	3,742	14.0	28.5	1,198
4123	139.0	91	AV91	100.7	24.7	30.9	1,558	908	3,647	13.4	27.8	1,233
			STD	1.1	0.2	0.1	25	36	36	0.2	0.2	30
			MAX	103.3	25.1	31.0	1,601	973	3,707	13.8	28.5	1,287
4210	140.0	87	AV87	97.9	24.0	30.9	1,563	941	3,545	12.9	27.3	1,252
			STD	1.3	0.3	0.1	21	24	47	0.2	0.5	22
			MAX	102.7	24.6	31.0	1,605	984	3,633	13.4	28.3	1,290

KIWC, POA TPP - IP 3 (Loc. 1) PP48x1.0", APE 15-4
OP: RMDT Date: 03-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	BPM bpm	RX6 kips	RX8 kips	FMX kips	VMX f/s	CSI ksi	RX7 kips
4295	141.0	85	AV85	96.9	23.6	30.5	1,551	935	3,482	12.6	26.0	1,243
			STD	1.2	0.3	0.3	23	27	42	0.1	0.7	25
			MAX	100.3	24.0	31.0	1,612	1,011	3,551	12.9	27.5	1,312
4383	142.0	88	AV88	92.6	22.9	30.2	1,583	973	3,384	12.2	24.5	1,278
			STD	5.2	0.8	3.2	58	53	122	0.4	1.2	55
			MAX	107.2	26.1	38.8	1,746	1,089	3,847	13.5	28.7	1,410
4445	143.0	62	AV62	104.7	25.4	29.7	1,646	980	3,753	13.2	28.1	1,313
			STD	2.0	0.3	0.9	35	35	49	0.2	0.4	35
			MAX	108.1	26.2	31.4	1,727	1,065	3,870	13.5	28.8	1,396
4514	144.0	69	AV69	104.2	25.6	31.0	1,672	1,018	3,780	13.1	28.2	1,345
			STD	2.0	0.3	0.2	22	23	46	0.2	0.5	22
			MAX	107.5	26.2	31.8	1,708	1,066	3,871	13.4	29.2	1,386
4579	145.0	65	AV65	101.5	25.3	31.0	1,637	1,002	3,735	13.0	27.7	1,320
			STD	1.4	0.2	0.3	21	25	36	0.1	0.3	22
			MAX	105.0	25.9	31.6	1,681	1,040	3,826	13.3	28.3	1,360
4645	146.0	66	AV66	101.7	25.2	30.8	1,611	979	3,715	13.1	28.4	1,295
			STD	0.7	0.2	0.2	29	34	31	0.1	0.6	31
			MAX	103.8	25.7	31.1	1,663	1,039	3,794	13.4	30.1	1,349
4710	147.0	65	AV65	100.8	25.0	31.0	1,578	941	3,685	13.1	29.7	1,260
			STD	1.0	0.3	0.2	27	28	41	0.1	0.6	28
			MAX	102.7	25.6	31.5	1,632	1,024	3,777	13.4	30.8	1,326
4772	148.0	62	AV62	100.0	24.6	31.2	1,570	938	3,632	13.1	30.0	1,254
			STD	0.9	0.3	0.1	23	20	38	0.1	0.6	21
			MAX	102.4	25.2	31.4	1,636	990	3,727	13.3	31.0	1,313
4836	149.0	64	AV64	98.4	23.7	31.3	1,557	941	3,496	12.6	29.2	1,249
			STD	0.9	0.4	0.1	30	24	60	0.3	0.8	26
			MAX	100.2	24.2	31.5	1,607	992	3,578	13.0	30.6	1,298
4872	149.5	72	AV36	96.2	22.4	31.3	1,517	929	3,312	11.9	27.6	1,223
			STD	0.9	0.3	0.1	14	12	50	0.3	0.6	12
			MAX	98.4	23.2	31.5	1,547	957	3,421	12.2	28.8	1,251
			Average	104.4	26.7	31.1	1,083	702	3,944	14.8	29.2	853
			Std. Dev.	5.9	1.7	1.6	322	125	245	1.2	1.9	228
			Maximum	115.6	29.6	38.8	1,746	1,089	4,375	17.2	34.2	1,410

Total number of blows analyzed: 4872

BL#	Sensors
1-754	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: off; A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)
755-4872	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: off; A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
1	Begin driving & monitoring, near Tip El -92 ft, 6/3/2016, 10:33 AM
755	Restart after 4 minutes 4 seconds
3085	Move PDA sensor up closer to top of pile. Restart @ 12:48:00 PM
4373	LE = 196.00 ft
4872	End drivng, near Tip El -184 ft, soil penetration approx 149 ft, 2:02:12 PM

Time Summary

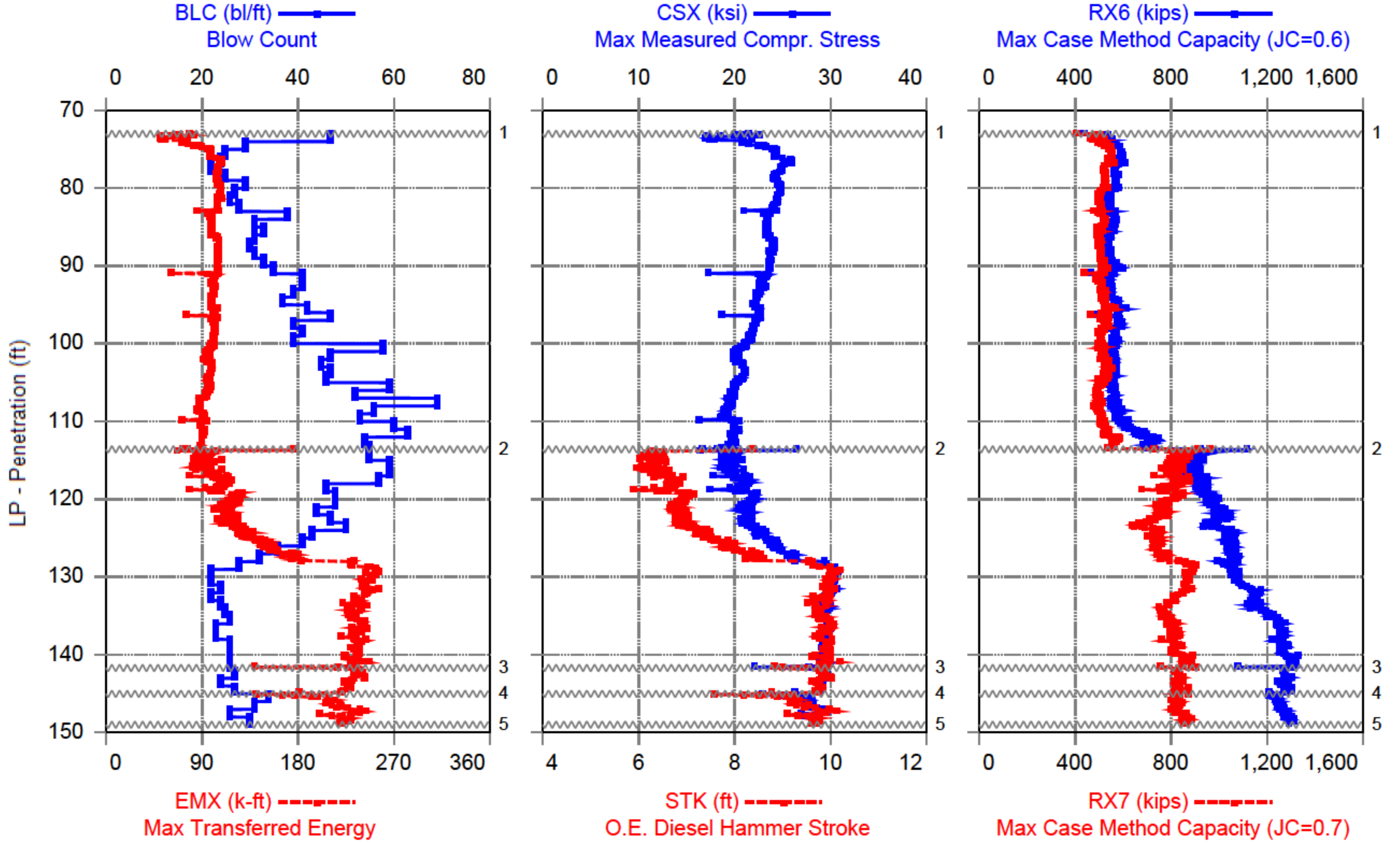
Drive	27 minutes 38 seconds	10:33 AM - 11:01 AM (6/3/2016) BN 1 - 754
Stop	4 minutes 4 seconds	11:01 AM - 11:05 AM
Drive	1 hour 15 minutes 6 seconds	11:05 AM - 12:20 PM BN 755 - 3084
Stop	27 minutes 15 seconds	12:20 PM - 12:48 PM
Drive	41 minutes 51 seconds	12:48 PM - 1:29 PM BN 3085 - 4372
Stop	16 minutes 12 seconds	1:29 PM - 1:46 PM
Drive	16 minutes 6 seconds	1:46 PM - 2:02 PM BN 4373 - 4872

Total time [03:28:16] = (Driving [02:40:43] + Stop [00:47:33])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 17-May-2016 Test started: 12-May-2016

KIWC, POA TPP - IP 4 (Loc. 1)



1 - Begin Driving, APE 15-4, pile tip near -92 ft, 5/12/2016 2:56:23 PM

2 - Halt APE 15-4, 4:10 PM 5/12/2016. D180-42 5/13/2016 7:40:14 AM

3 - Stop and restart D180-42

4 - 14 min pause, install water resistant PDA sensors, continue 8:32:29 AM

5 - End of driving, tip near -175 ft, 5/13/2016 8:35:35 AM

KIWC, POA TPP - IP 4 (Loc. 1) PP48x1.0", APE D180-42
OP: RMDT Date: 12-May-2016

AR: 147.65 in^2 SP: 0.492 k/ft^3
LE: 189.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
47	74.0	47	AV47	64.1	19.4	**	511	454	20.5	2,868	32.9	433
			STD	12.8	2.2	**	36	32	2.3	325	11.8	88
			MAX	93.6	24.3	**	563	498	25.7	3,582	41.6	616
76	75.0	29	AV29	82.7	22.3	**	562	487	23.3	3,290	32.2	397
			STD	8.8	1.2	**	25	17	1.2	171	0.9	53
			MAX	98.8	24.2	**	595	516	25.4	3,579	33.5	522
101	76.0	25	AV25	98.6	24.4	**	596	514	25.4	3,596	30.8	447
			STD	0.6	0.1	**	8	8	0.1	22	0.1	27
			MAX	99.3	24.6	**	613	531	25.6	3,630	30.9	535
125	77.0	24	AV24	106.5	25.5	**	598	508	26.6	3,768	30.3	481
			STD	4.2	0.6	**	12	12	0.7	90	0.4	22
			MAX	110.1	26.2	**	620	526	27.3	3,861	30.9	532
147	78.0	22	AV22	105.8	25.0	**	571	490	25.9	3,687	29.9	427
			STD	0.8	0.2	**	10	8	0.2	29	0.1	11
			MAX	107.1	25.4	**	591	509	26.2	3,757	30.2	450
172	79.0	25	AV25	103.8	24.3	**	572	494	25.4	3,587	29.9	445
			STD	0.7	0.2	**	6	8	0.2	23	0.1	41
			MAX	105.5	24.7	**	589	517	25.7	3,643	30.0	578
201	80.0	29	AV29	106.3	24.7	**	576	499	25.9	3,644	29.6	563
			STD	1.7	0.2	**	8	6	0.3	33	0.2	65
			MAX	108.8	25.0	**	594	509	26.3	3,694	30.0	628
228	81.0	27	AV27	107.4	24.8	**	554	483	26.1	3,664	29.5	478
			STD	0.7	0.1	**	11	9	0.3	22	0.0	47
			MAX	108.7	25.0	**	577	509	26.5	3,697	29.6	609
254	82.0	26	AV26	106.1	24.5	**	547	478	25.6	3,615	29.5	483
			STD	1.2	0.1	**	6	7	0.2	17	0.1	42
			MAX	109.2	24.8	**	556	494	26.1	3,662	29.6	545
282	83.0	28	AV28	102.5	23.7	**	547	481	24.9	3,500	28.4	513
			STD	13.8	2.2	**	31	20	2.3	327	5.1	68
			MAX	108.0	24.6	**	584	494	25.8	3,628	29.7	619
320	84.0	38	AV38	99.3	23.6	**	560	491	24.7	3,481	30.1	514
			STD	2.9	0.3	**	11	10	0.5	49	0.4	49
			MAX	108.3	24.5	**	588	514	26.1	3,624	30.8	626
351	85.0	31	AV31	100.2	23.5	**	564	497	24.9	3,467	29.9	537
			STD	0.6	0.1	**	9	8	0.3	15	0.2	30
			MAX	101.0	23.7	**	579	516	25.3	3,504	30.2	586
384	86.0	33	AV33	100.1	23.4	**	538	476	25.6	3,462	29.7	525
			STD	0.9	0.1	**	15	11	0.5	20	0.4	41

KIWC, POA TPP - IP 4 (Loc. 1) PP48x1.0", APE D180-42
OP: RMDT Date: 12-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			MAX	101.7	23.7	**	575	501	26.4	3,503	30.3	614
415	87.0	31	AV31	104.2	23.8	**	539	489	26.1	3,513	28.1	518
			STD	2.3	0.3	**	10	16	0.3	38	0.3	9
			MAX	106.8	24.3	**	564	518	26.7	3,588	29.0	536
445	88.0	30	AV30	106.3	24.1	**	540	484	26.4	3,560	27.8	516
			STD	0.7	0.2	**	11	14	0.3	23	0.1	15
			MAX	107.4	24.4	**	565	521	26.9	3,600	27.9	536
476	89.0	31	AV31	105.7	23.8	**	548	488	25.7	3,521	27.7	521
			STD	0.6	0.2	**	9	11	0.5	26	0.1	24
			MAX	106.8	24.3	**	569	510	26.9	3,582	27.8	558
509	90.0	33	AV33	104.9	23.8	**	554	489	25.4	3,511	27.7	530
			STD	0.9	0.1	**	17	9	0.2	20	0.1	56
			MAX	108.1	24.1	**	602	512	25.8	3,560	27.8	599
544	91.0	35	AV35	100.6	23.0	**	560	483	24.5	3,391	27.4	477
			STD	17.0	2.5	**	46	31	2.7	372	5.0	54
			MAX	106.6	24.0	**	610	516	25.6	3,538	42.7	585
585	92.0	41	AV41	101.3	23.1	**	542	483	24.6	3,412	28.3	488
			STD	3.1	0.4	**	15	12	0.6	63	0.3	47
			MAX	106.5	23.9	**	571	512	25.8	3,527	29.5	569
626	93.0	41	AV41	101.1	23.0	**	545	506	24.8	3,389	28.4	502
			STD	1.9	0.3	**	10	14	0.3	42	0.2	18
			MAX	106.2	23.6	**	573	536	25.7	3,487	28.7	559
665	94.0	39	AV39	100.8	22.6	**	550	509	24.4	3,331	28.2	505
			STD	0.9	0.2	**	7	12	0.4	35	0.1	20
			MAX	102.3	23.1	**	572	540	25.1	3,417	28.5	567
702	95.0	37	AV37	99.8	22.3	**	567	506	23.5	3,291	28.1	510
			STD	0.7	0.1	**	14	11	0.3	20	0.1	12
			MAX	101.1	22.6	**	597	544	24.1	3,342	28.4	540
744	96.0	42	AV42	101.8	22.4	**	581	528	23.4	3,314	28.0	514
			STD	2.1	0.3	**	18	19	0.2	41	0.2	14
			MAX	104.9	22.9	**	623	574	23.9	3,386	28.3	537
791	97.0	47	AV47	99.8	22.2	**	575	503	22.9	3,281	27.6	512
			STD	11.1	1.6	**	34	30	1.6	235	4.0	27
			MAX	105.7	23.0	**	612	553	23.9	3,394	37.1	547
830	98.0	39	AV39	102.0	22.2	**	586	498	23.1	3,277	28.7	529
			STD	1.1	0.1	**	12	9	0.2	20	0.2	14
			MAX	103.7	22.5	**	610	514	23.5	3,323	29.0	553
871	99.0	41	AV41	102.6	21.9	**	569	491	22.7	3,239	29.2	531
			STD	0.7	0.2	**	10	8	0.2	29	0.1	19
			MAX	104.0	22.3	**	588	516	23.2	3,289	29.4	562
910	100.0	39	AV39	100.9	21.5	**	566	485	22.6	3,181	29.3	534
			STD	0.7	0.3	**	11	9	0.3	37	0.1	14
			MAX	102.0	22.0	**	591	509	23.1	3,247	29.4	554
968	101.0	58	AV58	99.3	20.9	**	559	498	22.1	3,081	30.0	511
			STD	1.8	0.3	**	12	12	0.6	51	0.5	15
			MAX	102.6	21.5	**	588	526	23.1	3,173	30.5	541

KIWC, POA TPP - IP 4 (Loc. 1) PP48x1.0", APE D180-42
OP: RMDT Date: 12-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
1015	102.0	47	AV47	95.9	20.2	**	561	501	21.2	2,983	30.3	488
			STD	1.7	0.2	**	8	11	0.2	36	0.1	16
			MAX	99.1	20.7	**	585	526	21.8	3,054	30.5	520
1060	103.0	45	AV45	97.8	20.5	**	568	511	21.3	3,033	30.2	493
			STD	3.2	0.4	**	13	13	0.4	66	0.3	13
			MAX	101.7	21.1	**	591	536	22.0	3,121	30.5	519
1107	104.0	47	AV47	99.5	21.1	**	570	520	22.0	3,112	30.2	518
			STD	1.0	0.1	**	7	19	0.2	16	0.2	9
			MAX	100.7	21.4	**	586	556	22.6	3,154	30.4	534
1153	105.0	46	AV46	97.0	20.8	**	561	506	21.6	3,066	30.2	518
			STD	1.1	0.3	**	10	10	0.3	38	0.1	8
			MAX	99.1	21.2	**	590	532	22.2	3,123	30.4	534
1212	106.0	59	AV59	97.6	20.1	**	557	498	21.6	2,962	29.9	508
			STD	1.1	0.2	**	9	14	0.3	29	3.7	10
			MAX	99.4	20.5	**	579	526	22.0	3,025	30.9	531
1264	107.0	52	AV52	94.7	19.9	**	565	472	21.8	2,933	30.6	516
			STD	1.3	0.2	**	11	9	0.4	25	0.1	23
			MAX	97.6	20.2	**	605	494	23.4	2,982	30.8	563
1333	108.0	69	AV69	89.0	19.5	**	565	465	21.8	2,885	30.0	479
			STD	1.6	0.3	**	12	10	0.3	37	0.2	23
			MAX	94.5	20.1	**	604	521	22.7	2,975	30.8	550
1389	109.0	56	AV56	87.3	19.3	**	576	471	22.2	2,844	29.8	490
			STD	1.0	0.3	**	18	11	0.5	42	0.2	29
			MAX	89.8	19.9	**	615	492	23.2	2,932	30.1	563
1442	110.0	53	AV53	90.3	19.0	**	586	493	22.9	2,810	29.2	525
			STD	8.6	1.3	**	22	23	1.3	191	4.2	33
			MAX	94.5	20.3	**	671	534	24.1	3,005	42.6	572
1502	111.0	60	AV60	90.5	20.1	**	611	499	23.9	2,967	29.4	531
			STD	1.7	0.3	**	18	10	0.3	38	0.2	20
			MAX	95.2	20.6	**	651	528	24.5	3,047	29.9	591
1565	112.0	63	AV63	91.6	20.0	**	664	509	24.2	2,955	28.9	543
			STD	1.1	0.3	**	25	11	0.3	49	0.1	34
			MAX	93.5	20.7	**	723	534	24.8	3,052	29.3	655
1619	113.0	54	AV54	90.6	20.0	**	728	548	24.0	2,953	28.9	632
			STD	0.7	0.2	**	19	13	0.3	29	0.1	63
			MAX	91.9	20.4	**	771	573	24.8	3,006	29.2	711
1674	114.0	55	AV55	93.9	19.6	6.86	850	643	23.2	2,894	30.4	747
			STD	40.1	3.5	1.87	184	158	3.8	510	13.7	193
			MAX	348.1	37.7	13.41	1,267	1,083	40.3	5,569	51.7	1,357
1729	115.0	55	AV55	91.2	19.5	6.29	902	779	21.3	2,884	46.9	887
			STD	9.2	0.8	0.19	42	47	0.8	117	0.7	70
			MAX	111.8	21.3	6.72	1,012	907	23.2	3,143	48.1	1,141
1788	116.0	59	AV59	93.4	19.7	6.35	880	759	21.5	2,904	46.7	880
			STD	10.3	0.8	0.20	36	39	0.9	123	0.7	65
			MAX	124.2	21.9	6.91	981	877	23.9	3,227	48.2	1,145
1847	117.0	59	AV59	96.5	19.9	6.37	886	756	21.5	2,932	46.6	882

KIWC, POA TPP - IP 4 (Loc. 1) PP48x1.0", APE D180-42
OP: RMDT Date: 12-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
			STD	10.2	0.9	0.22	31	30	0.9	134	0.8	55
			MAX	120.9	22.1	6.95	977	843	23.7	3,259	48.2	1,030
1904	118.0	57	AV56	108.4	20.9	6.68	918	767	22.6	3,083	45.0	913
			STD	13.9	1.5	0.26	40	53	1.6	216	4.3	74
			MAX	131.0	22.8	7.18	1,028	878	24.6	3,359	49.7	1,105
1950	119.0	46	AV46	103.7	20.4	6.53	930	732	22.0	3,011	46.1	886
			STD	12.8	1.2	0.31	33	53	1.3	182	1.1	77
			MAX	131.4	22.5	7.08	1,012	814	24.3	3,327	48.8	1,137
1998	120.0	48	AV48	121.1	22.0	6.97	957	761	23.7	3,243	44.7	990
			STD	11.5	0.9	0.24	35	44	0.9	131	0.8	86
			MAX	144.3	23.9	7.53	1,041	916	25.7	3,534	47.6	1,115
2046	121.0	48	AV48	115.9	21.6	6.87	979	718	23.2	3,185	44.9	961
			STD	7.5	0.7	0.17	29	29	0.7	98	0.5	88
			MAX	131.8	23.0	7.25	1,046	790	24.7	3,402	46.7	1,089
2090	122.0	44	AV44	111.7	21.2	6.81	1,006	716	22.8	3,132	45.1	940
			STD	8.2	0.7	0.19	23	25	0.7	102	0.6	89
			MAX	129.4	22.7	7.21	1,056	781	24.5	3,357	46.5	1,082
2137	123.0	47	AV47	115.8	21.5	6.92	1,013	684	23.0	3,168	44.8	957
			STD	7.5	0.5	0.14	30	32	0.6	79	0.4	78
			MAX	134.6	22.2	7.14	1,091	755	23.8	3,278	46.0	1,094
2187	124.0	50	AV50	120.9	21.8	7.05	978	626	23.2	3,213	44.4	927
			STD	9.0	0.7	0.20	42	39	0.7	99	0.6	75
			MAX	143.7	23.3	7.49	1,065	723	24.7	3,438	45.4	1,084
2230	125.0	43	AV43	132.1	22.9	7.39	1,044	678	24.3	3,376	43.4	1,018
			STD	7.4	0.6	0.16	26	26	0.6	88	0.5	77
			MAX	150.3	24.2	7.75	1,097	745	25.7	3,580	44.3	1,138
2271	126.0	41	AV41	146.8	24.0	7.77	1,053	685	25.4	3,541	42.4	1,045
			STD	8.4	0.6	0.20	31	25	0.6	90	0.5	64
			MAX	162.8	25.4	8.19	1,102	754	27.0	3,751	43.4	1,159
2307	127.0	36	AV36	158.5	24.8	8.05	1,054	680	26.2	3,661	41.7	1,077
			STD	11.6	0.8	0.25	32	24	0.8	121	0.6	55
			MAX	189.5	26.6	8.61	1,142	746	28.1	3,935	42.9	1,193
2339	128.0	32	AV32	179.7	26.3	8.53	1,065	707	27.7	3,878	40.5	1,141
			STD	18.6	1.2	0.41	36	34	1.3	184	0.9	55
			MAX	247.1	30.4	9.89	1,124	799	32.1	4,486	42.1	1,264
2367	129.0	28	AV28	236.6	29.7	9.73	1,040	795	31.4	4,393	38.0	1,257
			STD	10.2	0.5	0.20	33	21	0.6	80	0.4	46
			MAX	257.5	31.0	10.16	1,103	832	32.8	4,583	38.6	1,343
2389	130.0	22	AV22	252.3	30.6	10.09	1,067	806	32.3	4,521	37.3	1,300
			STD	8.8	0.5	0.17	34	15	0.5	76	0.3	32
			MAX	267.7	31.5	10.39	1,128	830	33.3	4,655	38.2	1,336
2411	131.0	22	AV22	246.0	30.3	9.99	1,076	797	31.9	4,477	37.5	1,288
			STD	9.6	0.6	0.19	36	13	0.6	83	0.3	25
			MAX	270.7	31.5	10.39	1,165	822	33.2	4,645	38.3	1,329
2435	132.0	24	AV24	246.0	30.2	9.98	1,135	785	31.9	4,463	37.5	1,250
			STD	7.9	0.4	0.15	34	18	0.4	64	0.3	37

KIWC, POA TPP - IP 4 (Loc. 1) PP48x1.0", APE D180-42
OP: RMDT Date: 12-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			MAX	263.1	31.1	10.28	1,191	828	32.6	4,592	38.2	1,305
2457	133.0	22	AV22	237.7	29.8	9.83	1,156	747	31.4	4,393	37.8	1,246
			STD	10.3	0.6	0.23	26	23	0.7	94	0.4	28
			MAX	251.0	30.6	10.16	1,204	789	32.3	4,522	38.8	1,285
2481	134.0	24	AV24	234.9	29.5	9.77	1,153	712	31.1	4,361	37.9	1,199
			STD	11.5	0.8	0.26	37	29	0.8	112	0.5	38
			MAX	252.9	30.5	10.16	1,211	757	32.1	4,507	39.1	1,247
2506	135.0	25	AV25	232.1	29.3	9.76	1,190	684	30.9	4,330	37.9	1,167
			STD	8.5	0.6	0.18	40	18	0.7	95	0.3	41
			MAX	254.4	31.0	10.22	1,259	727	32.7	4,570	38.6	1,261
2532	136.0	26	AV26	237.5	29.6	9.89	1,242	676	31.2	4,374	37.7	1,151
			STD	7.3	0.4	0.15	27	11	0.5	65	0.3	22
			MAX	250.0	30.3	10.16	1,290	702	32.1	4,474	38.2	1,190
2555	137.0	23	AV23	240.7	29.8	9.99	1,256	661	31.5	4,404	37.5	1,137
			STD	6.9	0.4	0.15	18	16	0.4	56	0.3	24
			MAX	255.7	30.6	10.28	1,291	696	32.6	4,521	38.3	1,180
2578	138.0	23	AV23	231.7	29.3	9.80	1,266	612	30.8	4,320	37.9	1,101
			STD	8.2	0.5	0.18	29	24	0.6	75	0.3	20
			MAX	250.9	30.4	10.28	1,325	656	32.4	4,493	38.4	1,144
2604	139.0	26	AV26	238.5	29.6	9.98	1,260	619	31.1	4,373	37.5	1,080
			STD	5.4	0.4	0.12	35	28	0.4	56	0.2	20
			MAX	247.8	30.4	10.28	1,323	671	32.2	4,483	37.9	1,126
2630	140.0	26	AV26	235.5	29.5	9.95	1,263	582	30.9	4,349	37.6	1,019
			STD	6.6	0.4	0.12	30	21	0.4	62	0.2	18
			MAX	247.3	30.2	10.22	1,314	627	31.8	4,466	38.1	1,054
2656	141.0	26	AV26	232.7	29.3	9.90	1,302	563	30.7	4,325	37.7	998
			STD	11.3	0.6	0.22	35	31	0.6	94	0.4	20
			MAX	252.3	30.4	10.33	1,392	673	31.9	4,494	38.4	1,030
2682	142.0	26	AV26	215.5	27.9	9.54	1,272	564	29.2	4,123	37.3	904
			STD	59.1	4.6	1.35	118	72	4.9	686	8.0	173
			MAX	311.1	34.1	11.72	1,393	808	35.6	5,028	53.3	1,069
2709	143.0	27	AV27	238.7	29.7	9.92	1,278	533	30.9	4,380	37.6	943
			STD	6.6	0.4	0.14	25	19	0.5	62	0.3	15
			MAX	251.8	30.5	10.28	1,331	574	31.8	4,496	38.2	975
2733	144.0	24	AV24	229.3	29.2	9.79	1,270	509	30.3	4,311	37.9	891
			STD	8.2	0.5	0.17	27	24	0.5	71	0.3	29
			MAX	245.4	30.1	10.11	1,329	546	31.3	4,449	38.3	958
2760	145.0	27	AV27	223.9	29.0	9.73	1,284	489	30.2	4,281	38.0	871
			STD	9.4	0.5	0.18	51	30	0.5	68	0.3	103
			MAX	235.9	29.7	9.94	1,340	542	30.9	4,389	39.1	928
2794	146.0	34	AV34	187.7	26.2	8.74	1,230	467	26.8	3,874	40.1	766
			STD	28.5	2.1	0.68	26	48	2.2	303	1.6	65
			MAX	221.6	28.6	9.52	1,275	626	29.3	4,220	44.6	877
2825	147.0	31	AV31	216.0	28.0	9.40	1,258	450	28.7	4,128	38.6	835
			STD	8.2	0.6	0.22	22	19	0.6	82	0.4	21
			MAX	234.4	29.2	9.83	1,306	509	30.0	4,305	39.5	887

KIWC, POA TPP - IP 4 (Loc. 1) PP48x1.0", APE D180-42
OP: RMDT Date: 12-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
2851	148.0	26	AV26	227.0	28.5	9.70	1,271	482	29.4	4,211	38.1	835
			STD	18.6	1.2	0.44	25	33	1.2	173	0.9	47
			MAX	258.4	30.6	10.45	1,312	566	31.6	4,524	39.8	910
2881	149.0	30	AV30	225.7	28.5	9.71	1,300	464	29.4	4,211	38.0	831
			STD	6.0	0.4	0.14	30	17	0.4	63	0.3	27
			MAX	236.5	29.2	9.94	1,341	495	30.1	4,309	38.9	878
			Average	126.8	23.1	8.19	791	572	24.7	3,405	34.6	715
			Std. Dev.	53.7	3.5	1.52	270	115	3.4	521	7.2	260
			Maximum	348.1	37.7	13.41	1,393	1,083	40.3	5,569	53.3	1,357

Total number of blows analyzed: 2880

BL#	Sensors
1-1298	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: off; A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)
1299-2760	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: [28243] 1025.0 (1.00); A2: [34329] 1085.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)
2761-2881	F1: [E021] 92.0 (1.00); F2: [E022] 94.0 (1.00); A1: [30602] 1130.0 (1.00); A2: [30603] 1120.0 (1.00)

BL#	Comments
1	Begin Driving, APE 15-4, pile tip near -92 ft, 5/12/2016 2:56:23 PM
1651	Halt APE 15-4, 4:10 PM 5/12/2016. D180-42 5/13/2016 7:40:14 AM
2674	Stop and restart D180-42
2761	14 min pause, install water resistant PDA sensors, continue 8:32:29 AM
2881	End of driving, tip near -175 ft, 5/13/2016 8:35:35 AM

Time Summary

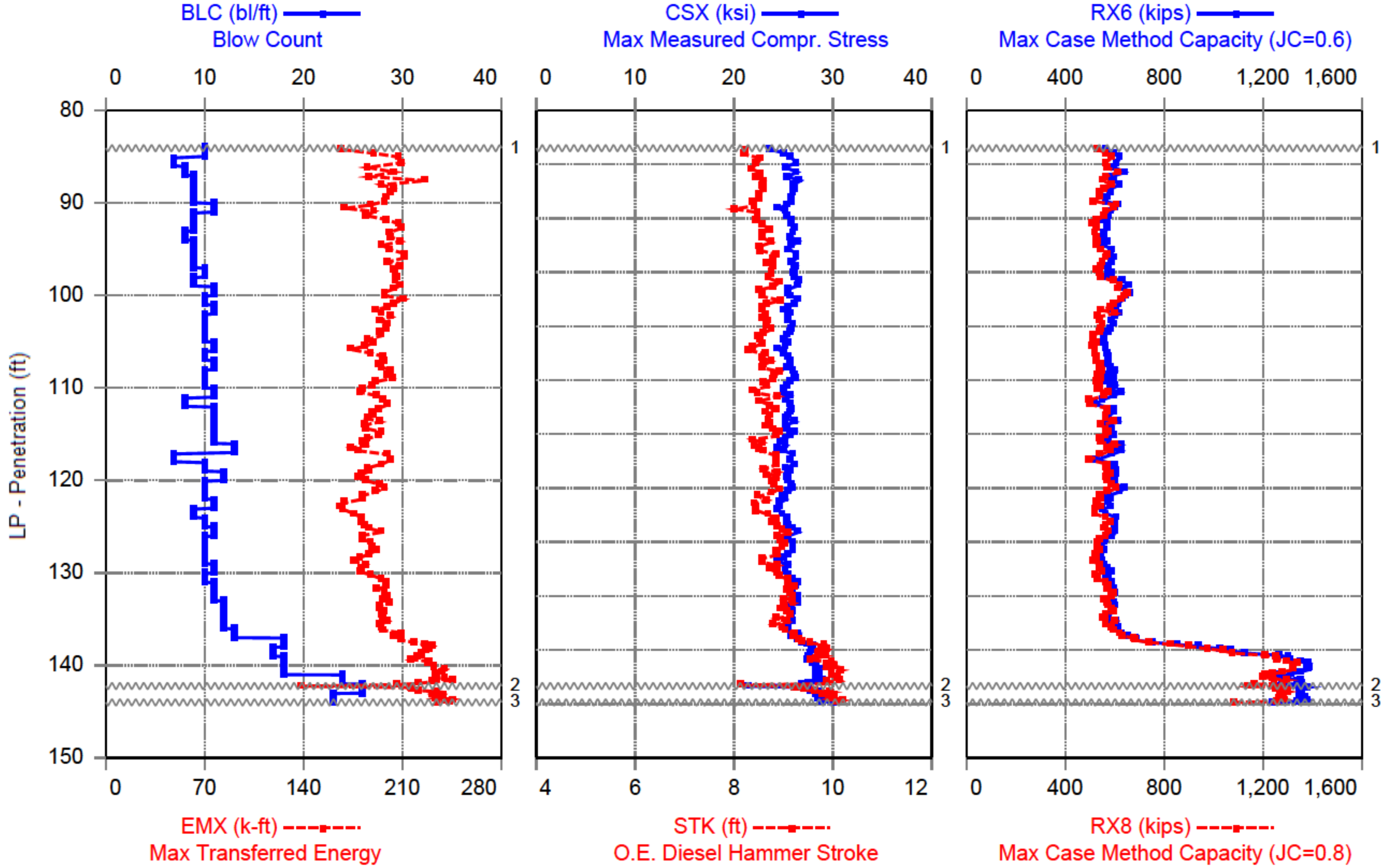
Drive	59 minutes 57 seconds	2:56 PM - 3:56 PM (5/12/2016) BN 1 - 1429
Stop	6 minutes 19 seconds	3:56 PM - 4:02 PM
Drive	7 minutes 31 seconds	4:02 PM - 4:10 PM BN 1430 - 1650
Stop	15 hours 30 minutes 3 seconds	4:10 PM - 7:40 AM
Drive	37 minutes 17 seconds	7:40 AM - 8:17 AM BN 1651 - 2760
Stop	14 minutes 57 seconds	8:17 AM - 8:32 AM
Drive	3 minutes 5 seconds	8:32 AM - 8:35 AM BN 2761 - 2881

Total time [17:39:12] = (Driving [01:47:52] + Stop [15:51:19])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 18-May-2016 Test started: 18-May-2016

KIWC, POA TPP - IP 5 (Loc. 4)



1 - Begin PDA Monitoring near Tip El. -114, 5/18/2016, 12:08:37 PM

2 - Pause for 6 minutes, Continue.12:30:30 PM

3 - End of Drive, Near Tip El. -173, 144 ft depth below mudline. 5/18/2016, 12:31:38 PM

KIWC, POA TPP - IP 5 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 18-May-2016

AR: 147.65 in^2
LE: 185.00 ft
WS: 17,100.0 f/s

SP: 0.492 k/ft^3
EM: 31,052 ksi
JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)

CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
10	85.0	10	AV10	183.6	24.6	8.24	590	562	26.9	3,630	37.3	602
			STD	27.6	1.9	0.12	67	66	1.9	275	11.8	51
			MAX	209.8	25.7	8.48	651	615	28.1	3,802	41.6	667
17	86.0	7	AV7	205.8	26.0	8.51	611	566	28.4	3,844	40.6	628
			STD	13.1	0.6	0.19	48	59	0.6	85	0.4	51
			MAX	225.6	26.6	8.66	676	636	29.1	3,926	41.5	685
25	87.0	8	AV8	196.2	25.9	8.45	611	584	28.3	3,819	40.7	605
			STD	10.0	0.6	0.18	39	40	0.6	82	0.4	53
			MAX	210.2	26.5	8.66	693	659	29.1	3,908	41.3	695
34	88.0	9	AV9	204.8	26.1	8.53	594	556	28.5	3,847	40.5	647
			STD	23.4	0.8	0.24	18	26	0.9	112	0.6	55
			MAX	241.0	27.0	8.89	622	586	29.6	3,983	41.6	704
43	89.0	9	AV9	202.5	26.1	8.56	598	572	28.4	3,849	40.4	614
			STD	11.3	0.5	0.13	56	59	0.5	69	0.3	35
			MAX	219.9	26.6	8.70	700	673	29.0	3,929	40.9	690
52	90.0	9	AV9	198.0	25.8	8.51	567	525	28.3	3,817	40.6	617
			STD	13.7	0.5	0.17	29	41	0.6	79	0.4	62
			MAX	212.0	26.4	8.70	594	576	29.2	3,902	41.5	768
63	91.0	11	AV11	182.1	25.0	8.28	601	589	27.3	3,689	41.1	614
			STD	16.4	0.7	0.21	29	41	0.9	109	0.5	55
			MAX	200.7	26.2	8.61	657	657	28.8	3,866	41.8	708
72	92.0	9	AV9	190.8	25.6	8.47	566	546	27.9	3,775	40.6	576
			STD	11.6	0.5	0.15	31	32	0.5	68	0.3	55
			MAX	213.8	26.6	8.79	615	595	29.1	3,925	41.2	701
81	93.0	9	AV9	208.7	26.1	8.61	563	512	28.4	3,848	40.3	648
			STD	12.4	0.6	0.19	46	42	0.7	92	0.4	46
			MAX	224.4	26.9	8.89	642	586	29.5	3,977	40.9	733
89	94.0	8	AV8	200.9	25.9	8.58	565	530	28.2	3,821	40.4	619
			STD	7.8	0.6	0.20	27	32	0.8	94	0.5	75
			MAX	209.8	26.9	8.93	605	575	29.4	3,974	41.1	719
98	95.0	9	AV9	199.6	25.9	8.61	568	534	28.2	3,829	40.3	577
			STD	8.1	0.5	0.16	21	30	0.6	81	0.4	10
			MAX	210.6	26.9	8.89	602	580	29.3	3,970	40.9	593
107	96.0	9	AV9	209.5	26.2	8.75	591	563	28.5	3,864	40.0	642
			STD	8.0	0.5	0.17	21	18	0.6	78	0.4	48
			MAX	225.2	27.3	9.07	627	594	29.9	4,031	40.6	753
116	97.0	9	AV9	205.7	26.2	8.75	579	548	28.6	3,872	40.0	604
			STD	8.1	0.4	0.16	17	12	0.5	63	0.3	18

KIWC, POA TPP - IP 5 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 18-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
			MAX	220.4	26.8	8.98	614	564	29.4	3,964	40.6	636
126	98.0	10	AV10	205.3	26.1	8.75	583	535	28.4	3,857	40.0	607
			STD	8.2	0.3	0.12	19	19	0.4	48	0.3	42
			MAX	223.4	26.6	8.93	631	567	28.9	3,924	40.4	718
135	99.0	9	AV9	204.5	26.3	8.79	627	590	28.7	3,889	39.9	653
			STD	8.5	0.5	0.14	33	40	0.6	73	0.3	32
			MAX	220.3	27.2	9.07	672	656	29.8	4,012	40.4	718
146	100.0	11	AV11	201.5	25.7	8.62	647	633	28.0	3,801	40.3	676
			STD	7.9	0.6	0.18	22	30	0.7	88	0.4	28
			MAX	216.1	27.0	9.03	679	672	29.4	3,983	40.8	745
156	101.0	10	AV10	205.1	26.1	8.74	630	619	28.6	3,857	40.0	641
			STD	12.2	0.7	0.25	34	39	0.8	107	0.5	18
			MAX	226.8	27.3	9.12	672	660	30.0	4,035	40.7	671
167	102.0	11	AV11	194.3	25.4	8.56	602	573	27.6	3,746	40.4	619
			STD	5.8	0.4	0.12	23	27	0.5	56	0.3	16
			MAX	201.9	25.9	8.70	636	623	28.3	3,827	40.9	644
177	103.0	10	AV10	200.0	25.8	8.68	596	545	28.1	3,806	40.2	611
			STD	9.3	0.5	0.15	18	28	0.6	75	0.3	15
			MAX	217.1	26.5	8.93	622	602	29.1	3,920	40.7	633
187	104.0	10	AV10	197.8	25.8	8.70	582	544	28.2	3,813	40.1	621
			STD	4.2	0.4	0.14	18	17	0.5	66	0.3	11
			MAX	205.0	26.5	8.98	617	570	29.0	3,917	40.5	638
197	105.0	10	AV10	190.2	25.3	8.53	561	520	27.6	3,729	40.5	622
			STD	9.6	0.7	0.21	30	37	0.8	101	0.5	19
			MAX	206.0	26.2	8.89	598	561	28.6	3,863	41.2	653
208	106.0	11	AV11	180.7	25.0	8.43	558	515	27.3	3,692	40.7	631
			STD	7.6	0.6	0.17	18	23	0.7	89	0.4	24
			MAX	195.5	26.1	8.66	581	545	28.4	3,849	41.3	687
218	107.0	10	AV10	192.1	25.3	8.58	572	520	27.6	3,740	40.4	639
			STD	8.4	0.4	0.14	15	21	0.5	66	0.3	16
			MAX	201.8	25.8	8.75	596	567	28.3	3,816	41.2	656
229	108.0	11	AV11	195.5	25.6	8.63	582	542	27.9	3,774	40.3	642
			STD	8.7	0.4	0.13	23	21	0.5	62	0.3	25
			MAX	217.1	26.2	8.84	607	582	28.7	3,874	40.8	690
239	109.0	10	AV10	202.6	26.2	8.86	591	544	28.5	3,872	39.8	637
			STD	6.4	0.4	0.12	25	21	0.5	60	0.3	29
			MAX	209.7	26.8	9.07	640	582	29.4	3,960	40.1	674
249	110.0	10	AV10	189.9	25.5	8.67	583	529	27.8	3,771	40.2	611
			STD	6.9	0.5	0.15	27	27	0.5	67	0.3	15
			MAX	200.7	26.2	8.89	624	561	28.6	3,865	40.8	649
260	111.0	11	AV11	185.3	25.3	8.58	604	561	27.6	3,738	40.4	630
			STD	10.8	1.0	0.30	30	30	1.0	142	0.7	24
			MAX	209.0	27.3	9.22	667	614	29.8	4,037	41.2	662
268	112.0	8	AV8	198.1	25.4	8.65	535	497	27.6	3,754	40.2	583
			STD	10.5	0.7	0.23	31	32	0.8	108	0.5	7
			MAX	213.4	26.5	8.98	595	532	28.9	3,920	41.2	591

KIWC, POA TPP - IP 5 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 18-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
279	113.0	11	AV11	191.0	25.7	8.74	593	569	27.9	3,794	40.0	627
			STD	6.9	0.7	0.22	39	34	0.8	106	0.5	22
			MAX	202.9	26.9	9.12	661	613	29.3	3,975	40.7	689
290	114.0	11	AV11	187.0	25.5	8.69	587	569	27.6	3,760	40.1	636
			STD	9.2	0.8	0.18	32	36	0.9	117	0.4	31
			MAX	207.5	27.0	9.07	657	651	29.2	3,985	40.8	681
301	115.0	11	AV11	189.4	25.8	8.80	584	568	28.0	3,808	39.9	649
			STD	6.1	0.5	0.15	16	20	0.6	69	0.3	36
			MAX	197.2	26.4	8.98	610	601	28.8	3,898	40.5	712
312	116.0	11	AV11	186.2	25.1	8.60	573	547	27.3	3,713	40.3	670
			STD	8.0	0.7	0.25	27	28	0.8	108	0.6	33
			MAX	197.2	26.2	8.93	623	593	28.6	3,875	41.2	726
325	117.0	13	AV13	179.3	25.0	8.52	618	590	27.1	3,692	40.5	662
			STD	7.2	0.7	0.21	21	28	0.8	97	0.5	35
			MAX	190.6	25.9	8.79	654	650	28.3	3,824	41.7	711
332	118.0	7	AV7	203.5	25.8	8.83	544	503	28.0	3,812	39.8	612
			STD	5.4	0.4	0.10	29	25	0.5	58	0.2	22
			MAX	211.9	26.4	8.98	604	539	28.7	3,895	40.2	643
342	119.0	10	AV10	189.1	25.5	8.76	597	561	27.7	3,772	40.0	663
			STD	7.4	0.7	0.21	22	19	0.8	101	0.5	30
			MAX	201.3	26.7	9.07	627	597	29.2	3,946	40.5	716
354	120.0	12	AV12	181.6	25.6	8.80	604	577	27.8	3,782	39.9	600
			STD	7.5	0.7	0.17	13	18	0.8	96	0.4	28
			MAX	197.2	26.8	9.12	628	615	29.2	3,962	40.5	656
364	121.0	10	AV10	193.7	25.8	8.86	613	593	28.0	3,812	39.8	677
			STD	6.1	0.5	0.15	31	23	0.6	75	0.3	28
			MAX	201.4	26.5	9.07	665	644	28.8	3,916	40.3	713
374	122.0	10	AV10	186.5	25.2	8.68	594	553	27.4	3,727	40.2	668
			STD	7.8	0.7	0.18	35	27	0.8	107	0.4	24
			MAX	195.6	26.4	8.98	643	584	28.8	3,894	41.0	708
385	123.0	11	AV11	169.0	24.7	8.47	578	539	26.7	3,642	40.6	587
			STD	5.6	0.5	0.14	19	19	0.5	71	0.3	20
			MAX	184.4	25.8	8.84	606	568	27.9	3,810	41.0	624
394	124.0	9	AV9	175.1	24.9	8.60	569	526	27.0	3,681	40.3	632
			STD	6.0	0.5	0.17	24	22	0.6	79	0.4	38
			MAX	182.9	25.7	8.89	616	577	27.8	3,792	41.0	711
404	125.0	10	AV10	181.6	25.4	8.82	601	573	27.6	3,757	39.8	631
			STD	6.0	0.6	0.16	21	20	0.7	95	0.3	52
			MAX	187.5	26.1	9.03	629	602	28.3	3,854	40.6	736
415	126.0	11	AV11	187.8	26.0	8.98	597	567	28.2	3,839	39.5	602
			STD	8.8	0.7	0.21	21	20	0.7	100	0.4	30
			MAX	201.2	27.1	9.37	631	610	29.4	4,000	40.4	680
425	127.0	10	AV10	186.5	25.9	9.02	562	539	28.2	3,826	39.4	598
			STD	8.1	0.8	0.20	18	17	0.9	112	0.4	15
			MAX	195.1	26.6	9.32	602	562	29.1	3,928	40.4	624
435	128.0	10	AV10	188.3	25.7	8.92	551	534	28.0	3,801	39.6	681

KIWC, POA TPP - IP 5 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 18-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			STD	6.4	0.6	0.19	18	25	0.7	86	0.4	56
			MAX	201.2	26.9	9.22	601	601	29.3	3,969	40.4	749
445	129.0	10	AV10	179.3	24.9	8.63	547	518	27.0	3,675	40.3	652
			STD	4.4	0.5	0.17	14	20	0.6	68	0.4	39
			MAX	188.9	25.9	9.03	573	544	28.3	3,827	40.7	724
456	130.0	11	AV11	181.6	25.4	8.83	573	546	27.6	3,750	39.8	607
			STD	5.6	0.5	0.18	21	17	0.6	81	0.4	14
			MAX	189.4	26.1	9.07	617	575	28.4	3,858	40.6	627
466	131.0	10	AV10	193.3	26.0	9.01	573	535	28.3	3,837	39.5	663
			STD	5.9	0.5	0.17	14	22	0.6	74	0.4	39
			MAX	202.9	26.9	9.27	591	574	29.2	3,973	40.1	711
477	132.0	11	AV11	195.9	26.2	9.14	596	571	28.4	3,867	39.2	689
			STD	4.4	0.5	0.12	19	17	0.5	67	0.2	66
			MAX	203.9	26.9	9.37	635	606	29.3	3,969	39.6	772
488	133.0	11	AV11	197.4	26.1	9.12	588	579	28.4	3,858	39.2	726
			STD	4.6	0.5	0.16	22	30	0.6	78	0.3	54
			MAX	204.0	26.8	9.32	626	626	29.2	3,959	39.8	813
500	134.0	12	AV12	196.2	26.0	9.08	596	579	28.2	3,844	39.3	732
			STD	3.6	0.4	0.13	14	19	0.5	56	0.3	46
			MAX	202.2	26.7	9.32	617	614	29.0	3,949	39.7	820
512	135.0	12	AV12	196.5	25.9	9.01	581	570	28.0	3,825	39.4	727
			STD	6.5	0.6	0.21	24	28	0.8	95	0.4	37
			MAX	208.8	27.2	9.37	629	629	29.2	4,010	40.1	785
524	136.0	12	AV12	196.6	25.6	8.96	601	584	27.8	3,784	39.6	715
			STD	5.4	0.5	0.17	20	22	0.6	74	0.4	35
			MAX	203.8	26.3	9.22	631	611	28.4	3,883	40.2	758
537	137.0	13	AV13	204.1	26.0	9.13	634	622	28.3	3,846	39.2	778
			STD	6.9	0.5	0.20	19	25	0.6	75	0.4	38
			MAX	213.0	26.8	9.42	666	661	29.3	3,958	40.0	834
555	138.0	18	AV18	219.0	27.1	9.56	782	763	29.5	4,005	38.3	984
			STD	11.5	0.7	0.25	97	84	0.8	105	0.5	53
			MAX	240.9	28.5	10.00	960	915	31.1	4,214	39.0	1,107
572	139.0	17	AV17	225.9	27.8	9.78	1,113	1,066	30.1	4,107	37.9	1,195
			STD	9.4	0.6	0.20	100	91	0.7	92	0.4	123
			MAX	239.2	28.8	10.05	1,293	1,230	31.1	4,249	38.8	1,410
590	140.0	18	AV18	224.4	27.8	9.77	1,341	1,290	30.2	4,111	37.9	1,541
			STD	8.0	0.5	0.18	36	37	0.5	74	0.3	42
			MAX	239.7	28.8	10.11	1,404	1,354	31.3	4,259	38.5	1,617
608	141.0	18	AV18	235.9	28.5	10.02	1,361	1,294	30.7	4,203	37.5	1,564
			STD	6.0	0.4	0.14	35	41	0.4	60	0.2	45
			MAX	249.4	29.5	10.28	1,435	1,384	31.7	4,349	38.0	1,649
632	142.0	24	AV24	234.5	28.4	10.01	1,314	1,240	30.7	4,191	37.5	1,511
			STD	8.8	0.5	0.20	41	35	0.6	78	0.4	64
			MAX	247.5	29.4	10.28	1,378	1,313	31.7	4,336	38.3	1,625
658	143.0	26	AV26	207.9	26.8	9.31	1,327	1,236	29.0	3,952	37.6	1,493
			STD	45.2	3.4	1.00	97	110	3.8	503	7.6	145

KIWC, POA TPP - IP 5 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 18-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			MAX	241.2	29.4	10.16	1,440	1,332	32.2	4,342	50.7	1,617
681	144.0	23	AV23	238.7	28.8	10.01	1,356	1,267	31.3	4,254	37.5	1,596
			STD	7.4	0.5	0.18	34	43	0.6	76	0.3	70
			MAX	253.3	30.0	10.33	1,410	1,308	32.8	4,430	38.3	1,648
			Average	200.0	26.1	8.94	726	688	28.4	3,857	39.5	809
			Std. Dev.	21.0	1.4	0.55	284	269	1.5	203	2.4	341
			Maximum	253.3	30.0	10.33	1,440	1,384	32.8	4,430	50.7	1,649

Total number of blows analyzed: 681

BL# Sensors

1-681 F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: [28243] 1025.0 (1.00); A2: [34329] 1085.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL# Comments

1 Begin PDA Monitoring near Tip El. -114, 5/18/2016, 12:08:37 PM
638 Pause for 6 minutes, Continue.12:30:30 PM
681 End of Drive, Near Tip El. -173, 144 ft depth below mudline. 5/18/2016, 12:31:38 PM

Time Summary

Drive 15 minutes 59 seconds 12:08 PM - 12:24 PM (5/18/2016) BN 1 - 637
Stop 5 minutes 54 seconds 12:24 PM - 12:30 PM
Drive 1 minute 7 seconds 12:30 PM - 12:31 PM BN 638 - 681

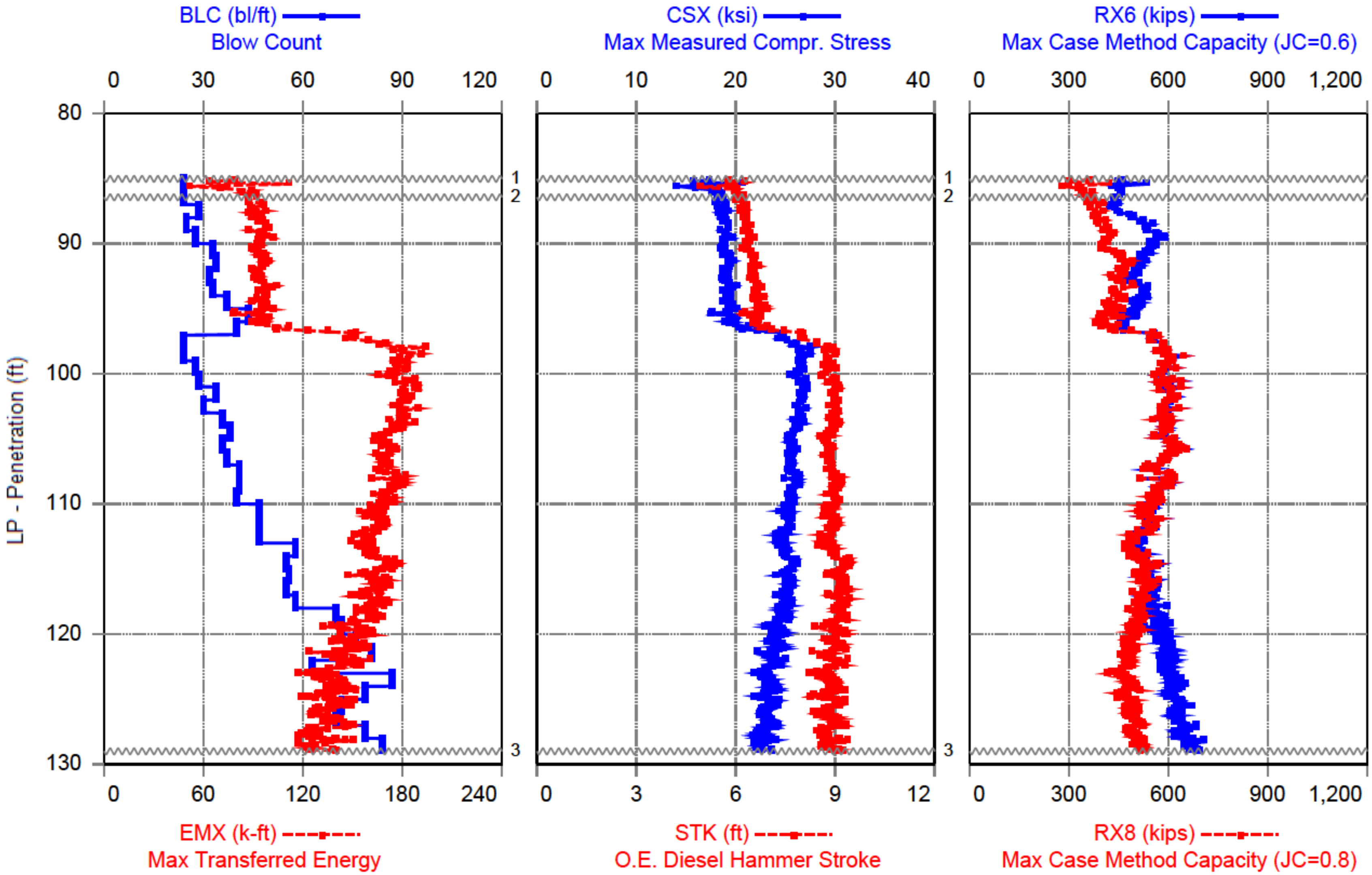
Total time [00:23:01] = (Driving [00:17:07] + Stop [00:05:54])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 02-June-2016

Test started: 01-June-2016

KIWC, POA TPP - IP 6 (Loc. 4)



1 - Begin PDA monitoring near Tip El. -108 ft. 6/1/2016, 9:45:26 AM

2 - Approx time at which the bearing plate reached the external mudline.

3 - End of driving, near Tip El -156, 129 ft soil penetration, 6/1/2016, 10:37:30 AM

KIWC, POA TPP - IP 6 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 01-June-2016

AR: 147.65 in^2 SP: 0.492 k/ft^3
LE: 185.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
BPM: Blows per Minute
FMX: Maximum Force
CSI: Max F1 or F2 Compr. Stress
RX6: Max Case Method Capacity (JC=0.6)
RX7: Max Case Method Capacity (JC=0.7)
RX8: Max Case Method Capacity (JC=0.8)

BL#	Depth	BLC	TYPE	EMX	CSX	STK	BPM	FMX	CSI	RX6	RX7	RX8
	ft	bl/ft		k-ft	ksi	ft	bpm	kips	ksi	kips	kips	kips
24	86.0	24	AV24	77.8	17.0	5.80	45.1	2,516	18.1	464	360	342
			STD	28.0	3.1	0.87	13.4	461	3.4	49	61	63
			MAX	174.4	27.3	8.98	54.3	4,033	29.2	658	587	515
48	87.0	24	AV24	89.6	18.4	6.16	47.4	2,717	19.4	446	372	369
			STD	6.8	0.8	0.19	0.7	111	0.8	17	41	42
			MAX	104.9	20.2	6.63	48.6	2,987	21.5	498	497	495
77	88.0	29	AV29	92.7	18.7	6.26	47.0	2,765	19.8	455	391	382
			STD	6.2	0.6	0.15	0.5	91	0.7	26	21	23
			MAX	103.9	20.0	6.57	48.0	2,959	21.2	518	450	450
102	89.0	25	AV25	95.3	19.0	6.36	46.6	2,809	20.1	530	412	402
			STD	6.2	0.6	0.16	0.6	95	0.7	20	25	25
			MAX	107.0	20.2	6.66	47.8	2,976	21.3	590	444	439
130	90.0	28	AV28	95.8	19.1	6.40	46.5	2,817	20.2	566	428	418
			STD	5.9	0.6	0.16	0.5	92	0.7	23	17	21
			MAX	107.4	20.3	6.72	47.6	2,998	21.6	613	475	458
163	91.0	33	AV33	93.1	18.9	6.39	46.5	2,798	20.1	543	434	428
			STD	4.2	0.5	0.14	0.5	77	0.6	20	27	30
			MAX	100.5	20.0	6.69	47.6	2,954	21.2	576	501	499
197	92.0	34	AV34	95.9	19.4	6.58	45.9	2,863	20.6	515	471	468
			STD	4.6	0.6	0.14	0.5	84	0.6	27	23	23
			MAX	103.6	20.5	6.88	46.7	3,022	21.8	583	528	526
229	93.0	32	AV32	92.7	19.0	6.53	46.1	2,799	20.1	495	460	450
			STD	3.7	0.5	0.14	0.5	80	0.6	21	29	32
			MAX	101.3	20.0	6.79	47.1	2,957	21.1	533	513	513
262	94.0	33	AV33	98.3	19.4	6.69	45.5	2,869	20.6	525	464	458
			STD	4.9	0.6	0.14	0.5	87	0.6	17	34	34
			MAX	108.6	20.7	6.91	47.0	3,052	21.7	560	544	542
299	95.0	37	AV37	95.4	19.4	6.72	45.4	2,861	20.4	513	449	439
			STD	4.8	0.5	0.14	0.5	75	0.5	24	27	31
			MAX	103.3	20.2	7.01	46.4	2,984	21.3	567	504	504
343	96.0	44	AV44	92.9	19.3	6.61	45.8	2,849	20.0	485	436	427
			STD	8.8	1.0	0.24	0.8	146	1.0	23	30	30
			MAX	105.5	20.5	7.01	47.6	3,029	21.7	526	498	495
383	97.0	40	AV40	115.2	21.5	7.15	44.2	3,180	22.4	481	453	451
			STD	21.0	1.9	0.55	1.6	286	2.1	41	59	60
			MAX	158.8	25.3	8.36	46.6	3,735	26.5	574	574	574
407	98.0	24	AV24	163.4	25.5	8.36	40.9	3,766	26.7	572	570	570
			STD	15.6	1.1	0.39	0.9	161	1.2	29	34	34

KIWC, POA TPP - IP 6 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 01-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	BPM bpm	FMX kips	CSI ksi	RX6 kips	RX7 kips	RX8 kips
			MAX	202.2	28.3	9.32	42.2	4,175	29.4	657	657	657
431	99.0	24	AV24	181.8	26.8	8.88	39.7	3,958	28.0	601	600	600
			STD	8.3	0.6	0.19	0.4	95	0.7	34	35	35
			MAX	196.3	27.9	9.22	40.7	4,118	29.2	686	686	686
459	100.0	28	AV28	178.6	26.6	8.82	39.8	3,924	27.9	594	594	594
			STD	7.4	0.6	0.19	0.4	87	0.6	26	26	26
			MAX	193.0	27.6	9.22	40.5	4,073	29.1	643	643	643
488	101.0	29	AV29	179.5	26.6	8.90	39.7	3,923	28.0	594	593	593
			STD	9.8	0.7	0.23	0.5	103	0.8	39	39	39
			MAX	192.5	27.5	9.17	40.6	4,061	29.0	671	671	671
522	102.0	34	AV34	183.2	26.8	9.01	39.4	3,961	28.3	609	608	608
			STD	6.5	0.5	0.16	0.3	77	0.6	34	36	36
			MAX	194.7	27.7	9.27	40.1	4,089	29.2	661	661	661
552	103.0	30	AV30	181.7	26.6	9.03	39.4	3,925	28.1	606	601	600
			STD	7.2	0.6	0.18	0.4	85	0.6	44	52	52
			MAX	195.7	27.6	9.32	40.5	4,081	29.2	682	682	682
588	104.0	36	AV36	179.9	26.5	9.03	39.4	3,910	28.0	595	592	592
			STD	6.8	0.5	0.16	0.3	77	0.6	45	48	49
			MAX	193.8	27.6	9.37	40.4	4,082	29.2	675	675	675
626	105.0	38	AV38	171.9	25.8	8.84	39.8	3,816	27.3	585	585	584
			STD	7.6	0.6	0.21	0.5	92	0.7	44	44	45
			MAX	185.2	27.0	9.17	41.0	3,982	28.5	682	682	682
662	106.0	36	AV36	171.0	25.8	8.81	39.9	3,810	27.2	622	622	622
			STD	6.9	0.6	0.17	0.4	84	0.6	30	30	30
			MAX	185.9	27.1	9.12	40.9	3,994	28.5	687	687	687
699	107.0	37	AV37	169.0	25.5	8.83	39.8	3,771	26.9	591	591	590
			STD	5.6	0.5	0.14	0.3	75	0.6	37	38	38
			MAX	179.1	26.5	9.07	40.4	3,916	28.0	660	660	660
740	108.0	41	AV41	172.4	25.8	8.97	39.5	3,808	27.1	575	574	574
			STD	7.0	0.6	0.17	0.4	85	0.7	48	48	49
			MAX	185.1	26.7	9.32	40.5	3,937	28.2	642	642	642
781	109.0	41	AV41	175.6	26.0	9.07	39.3	3,833	27.2	582	580	579
			STD	7.6	0.6	0.17	0.4	95	0.7	51	52	53
			MAX	190.4	27.0	9.42	40.1	3,993	28.4	676	676	676
821	110.0	40	AV40	171.0	25.7	8.99	39.5	3,793	26.9	569	567	567
			STD	6.5	0.5	0.18	0.4	81	0.6	39	41	41
			MAX	184.0	26.7	9.32	40.4	3,941	28.1	634	634	634
868	111.0	47	AV47	164.1	25.3	8.84	39.8	3,729	26.4	538	537	536
			STD	7.3	0.6	0.18	0.4	90	0.7	35	35	35
			MAX	180.2	26.4	9.22	40.6	3,900	27.6	606	606	606
915	112.0	47	AV47	166.6	25.4	8.95	39.6	3,749	26.5	558	555	555
			STD	7.3	0.6	0.18	0.4	90	0.7	36	37	37
			MAX	178.2	26.5	9.22	40.6	3,915	27.8	622	622	622
962	113.0	47	AV47	159.4	24.9	8.81	39.9	3,673	26.0	522	508	507
			STD	7.8	0.7	0.20	0.4	101	0.7	29	32	33
			MAX	176.7	26.5	9.27	41.2	3,906	27.6	620	620	620

KIWC, POA TPP - IP 6 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 01-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	BPM bpm	FMX kips	CSI ksi	RX6 kips	RX7 kips	RX8 kips
1020	114.0	58	AV58	158.9	24.9	8.90	39.7	3,672	25.8	506	490	490
			STD	7.4	0.7	0.20	0.4	97	0.7	28	31	31
			MAX	173.8	26.1	9.22	40.7	3,854	27.0	594	594	594
1075	115.0	55	AV55	171.1	25.7	9.31	38.8	3,798	26.6	537	531	530
			STD	7.4	0.6	0.19	0.4	82	0.6	36	39	39
			MAX	184.5	26.7	9.62	39.8	3,935	27.7	617	617	617
1131	116.0	56	AV56	163.1	25.2	9.10	39.3	3,723	26.1	538	525	524
			STD	8.9	0.7	0.22	0.5	99	0.7	29	30	30
			MAX	177.7	26.4	9.47	40.4	3,904	27.5	626	626	626
1186	117.0	55	AV55	164.5	25.3	9.23	39.0	3,733	26.2	550	532	531
			STD	8.2	0.6	0.21	0.4	94	0.7	26	26	26
			MAX	180.6	26.6	9.62	40.3	3,922	27.8	609	609	609
1244	118.0	58	AV58	162.5	25.1	9.21	39.0	3,702	26.0	546	519	518
			STD	9.1	0.7	0.22	0.4	101	0.7	27	22	23
			MAX	179.6	26.6	9.62	40.1	3,930	27.7	625	562	562
1314	119.0	70	AV70	160.6	24.9	9.20	39.0	3,682	25.8	565	514	514
			STD	7.0	0.6	0.17	0.3	85	0.6	31	18	18
			MAX	173.7	26.1	9.52	39.8	3,859	27.0	644	558	557
1386	120.0	72	AV72	150.3	24.2	8.97	39.5	3,575	25.1	575	502	501
			STD	11.6	0.9	0.29	0.6	132	0.9	31	24	23
			MAX	172.0	25.9	9.47	41.4	3,819	26.9	654	591	588
1462	121.0	76	AV76	149.8	24.2	9.04	39.4	3,570	25.1	591	487	485
			STD	9.1	0.7	0.23	0.5	109	0.8	28	21	21
			MAX	168.2	25.7	9.47	40.7	3,792	26.7	651	540	540
1543	122.0	81	AV81	145.2	23.9	8.94	39.6	3,526	24.8	603	483	482
			STD	11.3	0.9	0.31	0.7	128	0.9	24	25	25
			MAX	165.6	25.6	9.47	41.9	3,781	26.5	661	540	540
1606	123.0	63	AV63	142.0	23.6	8.90	39.7	3,491	24.5	599	471	470
			STD	11.1	0.9	0.29	0.6	126	0.9	26	25	26
			MAX	165.1	25.3	9.42	41.5	3,728	26.1	673	525	525
1693	124.0	87	AV87	136.7	23.3	8.83	39.8	3,439	24.2	618	477	477
			STD	9.8	0.8	0.27	0.6	117	0.8	33	24	24
			MAX	155.5	25.0	9.42	41.8	3,696	26.2	688	539	539
1772	125.0	79	AV79	137.7	23.4	8.85	39.8	3,450	24.2	615	478	477
			STD	10.5	0.8	0.30	0.7	123	0.9	27	27	28
			MAX	162.7	25.1	9.52	41.5	3,711	26.0	679	545	545
1844	126.0	72	AV72	139.6	23.5	8.97	39.5	3,476	24.2	635	493	492
			STD	9.8	0.8	0.29	0.6	114	0.8	26	19	19
			MAX	160.9	25.2	9.47	41.1	3,726	26.0	690	547	546
1914	127.0	70	AV70	135.4	23.2	8.85	39.8	3,422	23.9	632	499	498
			STD	9.7	0.8	0.30	0.7	115	0.8	32	20	20
			MAX	158.3	25.0	9.47	41.2	3,690	25.8	712	539	539
1993	128.0	79	AV79	129.2	22.8	8.72	40.1	3,360	23.3	643	498	496
			STD	11.3	0.9	0.30	0.7	132	1.0	28	26	26
			MAX	160.4	24.9	9.52	41.1	3,672	25.5	713	560	559
2077	129.0	84	AV83	131.7	22.9	8.92	39.6	3,387	23.7	673	517	516

KIWC, POA TPP - IP 6 (Loc. 4) PP48x1.0", APE D180-42
OP: RMDT Date: 01-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	BPM bpm	FMX kips	CSI ksi	RX6 kips	RX7 kips	RX8 kips
			STD	10.5	0.8	0.28	0.6	123	0.9	28	23	23
			MAX	155.5	25.0	9.47	41.2	3,695	25.8	735	559	559
			Average	144.6	23.7	8.51	40.7	3,493	24.7	573	508	506
			Std. Dev.	29.4	2.5	0.99	2.9	375	2.6	60	64	66
			Maximum	202.2	28.3	9.62	54.3	4,175	29.4	735	687	687

Total number of blows analyzed: 2076

BL#	Sensors
1-2076	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: off; A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

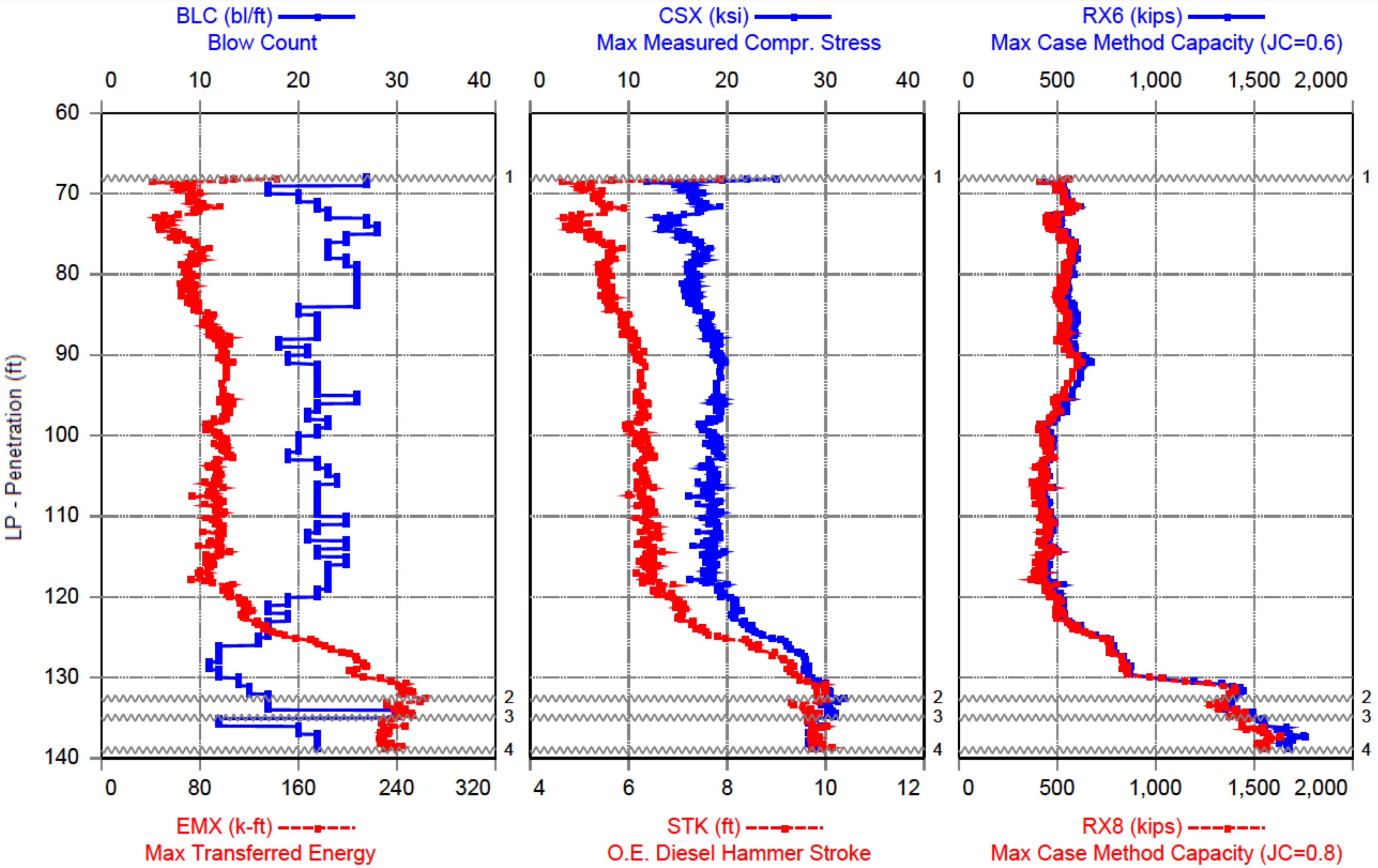
BL#	Comments
1	Begin PDA monitoring near Tip El. -108 ft. 6/1/2016, 9:45:26 AM
35	Approx time at which the bearing plate reached the external mudline.
2077	End of driving, near Tip El -156, 129 ft soil penetration, 6/1/2016, 10:37:30 AM

Time Summary

Drive 52 minutes 4 seconds 9:45 AM - 10:37 AM BN 1 - 2077

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results
Printed: 25-May-2016 Test started: 25-May-2016

KIWC, POA TPP - IP 7 (Loc. 5)



1 - Begin Monitoring near Tip Elevation -93, 1:37:05 PM, 5/25/2016
2 - Pause for 9 minutes near tip elevation -159 ft, 2:18:41 PM
3 - Pause, change PDA sensors to water resistant units, near tip el -161, 2:34:33 PM
4 - End of Driving, near Tip Elevation -165, 139 ft soil penetration, 2:36:35 PM, 5/25/2016

KIWC, POA TPP - IP 7 (Loc. 5) PP48x1.0", APE D180-42
OP: RMDT Date: 25-May-2016

AR: 147.65 in²
LE: 185.00 ft
WS: 17,100.0 f/s
SP: 0.492 k/ft³
EM: 31,052 ksi
JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
27	69.0	27	AV25	88.7	18.4	5.74	523	514	19.7	2,722	40.3	562
			STD	46.5	5.6	1.59	70	78	5.8	820	19.8	71
			MAX	242.0	33.9	10.63	652	646	35.2	5,010	56.3	780
44	70.0	17	AV17	69.8	16.1	5.22	523	515	17.3	2,379	51.2	533
			STD	9.6	1.3	0.25	28	27	1.3	186	1.1	26
			MAX	89.8	18.4	5.71	576	564	19.7	2,723	53.1	581
64	71.0	20	AV20	74.1	16.7	5.36	544	537	17.9	2,467	50.6	545
			STD	4.5	0.5	0.11	17	16	0.6	81	0.5	20
			MAX	87.5	18.4	5.71	585	583	19.6	2,713	51.4	592
86	72.0	22	AV22	81.1	17.6	5.59	580	573	18.8	2,599	49.6	579
			STD	10.0	1.1	0.24	33	34	1.2	161	1.0	25
			MAX	110.5	20.6	6.28	686	673	21.9	3,040	51.3	628
109	73.0	23	AV23	65.9	15.9	5.25	537	517	16.8	2,348	51.1	579
			STD	13.4	1.7	0.33	46	56	1.9	250	1.5	32
			MAX	84.2	18.3	5.71	626	602	19.2	2,699	54.1	657
136	74.0	27	AV27	52.1	14.1	4.96	510	479	14.8	2,083	52.5	587
			STD	7.4	1.1	0.18	22	33	1.2	156	0.9	22
			MAX	72.7	16.7	5.45	568	568	17.9	2,461	54.9	650
164	75.0	28	AV28	52.4	14.2	5.00	521	491	14.9	2,093	52.3	600
			STD	7.8	1.1	0.20	26	36	1.2	169	1.0	30
			MAX	66.5	16.2	5.38	578	566	17.0	2,393	54.4	667
189	76.0	25	AV25	64.5	15.9	5.33	551	531	16.8	2,348	50.7	617
			STD	6.9	0.9	0.17	16	20	0.9	129	0.8	27
			MAX	78.5	17.9	5.68	587	567	18.8	2,648	52.1	667
212	77.0	23	AV23	78.8	17.4	5.66	594	582	18.4	2,576	49.3	629
			STD	8.1	0.9	0.19	21	23	1.1	138	0.8	23
			MAX	96.3	19.3	6.04	636	630	20.5	2,848	50.8	679
235	78.0	23	AV23	78.4	17.4	5.65	591	571	18.5	2,576	49.4	618
			STD	7.0	0.8	0.16	21	16	0.9	125	0.7	32
			MAX	91.5	18.7	5.96	630	607	20.1	2,766	50.6	710
260	79.0	25	AV25	74.0	17.0	5.58	579	561	18.1	2,503	49.6	634
			STD	8.9	1.1	0.21	23	24	1.2	166	0.9	40
			MAX	92.6	19.1	6.04	629	612	20.4	2,827	51.5	745
286	80.0	26	AV26	69.9	16.4	5.49	572	555	17.5	2,421	50.0	631
			STD	5.4	0.7	0.13	16	18	0.8	111	0.6	37
			MAX	82.0	18.1	5.83	600	593	19.4	2,677	51.2	728
312	81.0	26	AV26	72.5	16.7	5.57	557	539	17.8	2,463	49.7	617
			STD	4.9	0.7	0.13	23	18	0.7	98	0.5	36

KIWC, POA TPP - IP 7 (Loc. 5) PP48x1.0", APE D180-42
OP: RMDT Date: 25-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			MAX	81.4	18.0	5.80	619	590	19.2	2,655	50.8	704
338	82.0	26	AV26	71.0	16.4	5.56	552	527	17.4	2,421	49.7	646
			STD	8.0	1.0	0.18	19	23	1.1	148	0.8	36
			MAX	84.8	18.2	5.88	605	569	19.4	2,688	51.3	726
364	83.0	26	AV26	72.9	16.7	5.60	540	513	17.8	2,459	49.5	619
			STD	7.4	0.9	0.17	19	21	1.0	131	0.7	43
			MAX	84.5	18.0	5.88	591	548	19.3	2,663	51.1	691
390	84.0	26	AV26	74.3	16.6	5.61	555	518	17.9	2,448	49.5	571
			STD	6.2	0.7	0.14	29	25	0.8	109	0.6	31
			MAX	83.9	17.8	5.88	615	571	19.2	2,623	50.4	647
410	85.0	20	AV20	79.5	17.3	5.73	580	540	18.6	2,547	49.0	563
			STD	6.8	0.8	0.15	23	24	0.8	113	0.6	24
			MAX	91.9	18.7	6.04	618	582	20.1	2,754	50.5	626
432	86.0	22	AV22	88.1	18.1	5.92	598	554	19.5	2,669	48.2	569
			STD	4.7	0.6	0.10	18	19	0.6	83	0.4	20
			MAX	94.0	18.9	6.06	644	602	20.3	2,793	49.2	607
454	87.0	22	AV22	88.8	18.0	5.93	586	545	19.4	2,661	48.2	553
			STD	5.6	0.6	0.12	18	18	0.6	84	0.5	44
			MAX	103.3	19.4	6.20	626	594	20.9	2,858	49.2	745
476	88.0	22	AV22	94.5	18.3	6.03	571	533	19.7	2,706	47.8	626
			STD	7.8	0.9	0.17	25	34	0.9	126	0.6	82
			MAX	111.1	20.3	6.45	634	615	22.0	3,002	48.9	770
494	89.0	18	AV18	100.2	18.9	6.18	562	532	20.4	2,783	47.3	610
			STD	6.7	0.7	0.14	31	32	0.8	105	0.5	54
			MAX	113.5	20.0	6.40	612	585	21.6	2,957	48.3	715
515	90.0	21	AV21	99.7	19.0	6.16	581	560	20.6	2,803	47.3	642
			STD	6.1	0.6	0.14	26	31	0.7	92	0.5	61
			MAX	111.6	20.3	6.45	637	630	21.9	2,994	48.3	733
534	91.0	19	AV19	100.4	19.2	6.23	645	606	20.8	2,841	47.1	625
			STD	6.9	0.7	0.14	30	27	0.8	111	0.5	49
			MAX	108.9	20.2	6.42	699	657	22.0	2,982	48.1	782
556	95.0	22	AV22	100.3	19.2	6.25	610	568	20.7	2,832	47.0	635
			STD	5.2	0.5	0.12	29	25	0.6	81	0.4	68
			MAX	112.2	20.3	6.51	677	623	21.9	3,001	47.9	836
582	96.0	26	AV26	100.2	18.9	6.22	554	509	20.5	2,788	47.1	708
			STD	6.3	0.7	0.14	30	29	0.8	108	0.5	54
			MAX	107.7	19.9	6.42	605	568	21.6	2,937	48.5	773
604	97.0	22	AV22	103.2	19.3	6.34	534	505	20.8	2,847	46.7	643
			STD	5.6	0.6	0.14	23	23	0.7	95	0.5	72
			MAX	112.9	20.4	6.63	610	565	22.1	3,009	47.8	755
625	98.0	21	AV21	101.2	19.2	6.33	506	484	20.7	2,835	46.8	582
			STD	5.8	0.7	0.15	26	24	0.8	106	0.5	61
			MAX	107.1	20.2	6.51	564	526	21.7	2,976	47.9	658
648	99.0	23	AV23	90.8	18.0	6.09	464	444	19.5	2,663	47.6	543
			STD	6.3	0.8	0.16	25	28	0.7	112	0.6	66
			MAX	104.2	19.7	6.48	508	486	21.2	2,907	48.9	666

KIWC, POA TPP - IP 7 (Loc. 5) PP48x1.0", APE D180-42
OP: RMDT Date: 25-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
670	100.0	22	AV22	90.8	17.9	6.11	452	430	19.5	2,650	47.6	570
			STD	7.7	1.1	0.21	34	40	1.2	158	0.8	56
			MAX	106.8	20.6	6.63	521	506	22.4	3,042	48.7	642
690	101.0	20	AV20	98.8	18.8	6.31	468	450	20.5	2,781	46.8	541
			STD	5.6	0.9	0.17	25	32	0.9	127	0.6	67
			MAX	108.9	20.4	6.63	542	519	22.0	3,011	48.1	652
710	102.0	20	AV20	97.5	18.7	6.28	465	449	20.4	2,763	46.9	554
			STD	5.3	0.7	0.17	16	22	0.8	108	0.6	57
			MAX	106.9	20.1	6.54	501	501	21.8	2,962	47.8	636
729	103.0	19	AV19	102.3	19.1	6.45	473	463	20.8	2,820	46.3	559
			STD	6.5	0.8	0.16	26	32	0.8	116	0.6	34
			MAX	112.6	20.7	6.72	548	548	22.5	3,053	47.2	608
751	104.0	22	AV22	92.4	18.1	6.22	436	426	19.7	2,679	47.1	517
			STD	7.8	0.9	0.16	23	28	1.0	131	0.6	64
			MAX	102.1	19.2	6.45	478	478	21.1	2,840	48.1	624
774	105.0	23	AV23	94.4	18.5	6.28	440	429	20.1	2,728	46.9	500
			STD	5.0	0.8	0.14	19	22	0.8	115	0.5	46
			MAX	102.0	19.6	6.51	481	468	21.3	2,898	48.2	612
798	106.0	24	AV24	92.1	18.4	6.29	436	427	19.9	2,710	46.9	492
			STD	5.2	0.9	0.12	28	35	0.9	130	0.4	43
			MAX	101.0	19.6	6.48	491	486	21.2	2,901	47.7	636
820	107.0	22	AV22	92.7	18.3	6.33	435	414	19.9	2,709	46.7	512
			STD	6.3	1.0	0.16	28	39	1.1	146	0.6	53
			MAX	102.9	20.0	6.63	514	514	21.7	2,947	47.7	625
842	108.0	22	AV22	88.6	17.8	6.25	426	407	19.3	2,629	47.0	513
			STD	11.2	1.4	0.22	29	32	1.5	207	0.8	68
			MAX	106.8	20.5	6.76	474	463	22.3	3,020	49.1	630
864	109.0	22	AV22	94.2	18.7	6.38	440	426	20.2	2,762	46.6	495
			STD	5.6	0.9	0.17	24	29	1.0	139	0.6	30
			MAX	104.5	20.6	6.76	505	492	22.2	3,041	47.8	551
886	110.0	22	AV22	95.8	18.8	6.43	462	444	20.3	2,770	46.4	501
			STD	5.4	0.9	0.18	18	27	0.9	131	0.6	43
			MAX	106.4	20.4	6.76	495	481	22.1	3,012	47.4	624
911	111.0	25	AV25	91.7	18.3	6.32	461	446	19.8	2,706	46.8	480
			STD	4.7	0.6	0.12	27	33	0.7	96	0.4	23
			MAX	98.5	19.2	6.54	532	532	20.7	2,841	47.9	522
933	112.0	22	AV22	94.3	18.6	6.40	463	451	20.1	2,749	46.5	484
			STD	7.8	1.1	0.19	28	29	1.2	161	0.7	23
			MAX	107.7	20.3	6.76	506	499	22.0	2,998	47.9	534
954	113.0	21	AV21	97.3	19.0	6.54	463	452	20.7	2,810	46.0	501
			STD	3.9	0.6	0.13	17	17	0.7	92	0.4	38
			MAX	103.5	20.1	6.72	487	485	21.9	2,975	46.9	624
979	114.0	25	AV25	90.4	18.0	6.36	451	434	19.6	2,665	46.7	507
			STD	9.2	1.2	0.21	30	36	1.2	182	0.7	69
			MAX	103.1	20.1	6.69	513	513	21.8	2,965	49.0	661
1001	115.0	22	AV22	96.5	18.7	6.47	472	455	20.4	2,768	46.3	528

KIWC, POA TPP - IP 7 (Loc. 5) PP48x1.0", APE D180-42
OP: RMDT Date: 25-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
			STD	7.5	1.0	0.17	29	35	1.2	154	0.6	59
			MAX	108.8	20.6	6.82	524	521	22.4	3,042	47.2	662
1026	116.0	25	AV25	88.6	18.3	6.39	440	421	19.9	2,705	46.5	488
			STD	4.6	0.8	0.15	22	29	0.8	112	0.5	29
			MAX	95.6	19.9	6.57	468	464	21.4	2,945	47.7	534
1049	117.0	23	AV23	87.8	18.5	6.48	444	424	20.1	2,733	46.2	496
			STD	7.6	1.1	0.20	39	46	1.2	164	0.7	31
			MAX	100.9	20.3	6.85	509	500	22.1	2,993	47.8	536
1072	118.0	23	AV23	82.8	17.9	6.39	427	404	19.5	2,644	46.5	477
			STD	8.4	1.3	0.21	37	44	1.4	194	0.7	29
			MAX	102.2	20.5	6.88	528	528	22.2	3,031	47.8	524
1095	119.0	23	AV23	97.0	18.8	6.60	485	452	20.4	2,776	45.8	515
			STD	10.7	1.3	0.28	37	46	1.3	193	0.9	70
			MAX	119.6	21.8	7.25	580	580	23.4	3,218	47.4	690
1117	120.0	22	AV22	102.1	19.4	6.65	488	455	20.7	2,858	45.7	521
			STD	6.3	0.9	0.18	30	40	1.0	130	0.6	39
			MAX	119.1	21.7	7.14	607	598	23.5	3,201	46.9	625
1136	121.0	19	AV19	114.2	20.7	6.99	519	509	22.3	3,053	44.6	535
			STD	3.6	0.5	0.14	22	29	0.6	73	0.4	40
			MAX	119.2	21.5	7.21	556	553	23.1	3,169	45.3	644
1153	122.0	17	AV17	119.8	21.0	7.11	528	509	22.8	3,096	44.2	541
			STD	4.9	0.6	0.13	35	34	0.7	85	0.4	39
			MAX	128.8	22.2	7.39	598	580	23.9	3,275	45.1	618
1172	123.0	19	AV19	116.4	20.7	7.07	528	512	22.4	3,063	44.3	540
			STD	5.5	0.7	0.15	32	40	0.7	100	0.5	40
			MAX	130.4	22.2	7.53	605	600	24.1	3,285	45.1	687
1189	124.0	17	AV17	129.9	22.0	7.34	584	577	23.8	3,255	43.5	568
			STD	5.2	0.6	0.14	48	50	0.7	91	0.4	20
			MAX	137.2	23.0	7.57	659	649	24.9	3,392	44.4	624
1206	125.0	17	AV17	142.1	23.0	7.59	652	644	24.7	3,402	42.8	605
			STD	6.1	0.6	0.13	49	51	0.6	84	0.4	24
			MAX	154.4	24.0	7.79	750	741	26.0	3,550	43.5	650
1222	126.0	16	AV16	169.8	25.6	8.33	767	759	27.5	3,775	41.0	685
			STD	11.2	1.2	0.35	28	34	1.3	180	0.8	35
			MAX	191.1	27.9	9.03	824	824	30.2	4,126	42.4	758
1234	127.0	12	AV12	187.7	26.6	8.65	781	769	28.8	3,929	40.2	696
			STD	8.6	0.7	0.24	48	50	1.0	110	0.5	25
			MAX	200.2	27.7	9.03	896	887	30.1	4,091	41.2	753
1246	128.0	12	AV12	205.8	27.8	9.08	826	818	30.0	4,110	39.3	753
			STD	5.5	0.5	0.15	28	31	0.6	68	0.3	25
			MAX	215.3	28.5	9.37	872	865	30.9	4,203	39.9	819
1257	129.0	11	AV11	212.9	28.1	9.28	856	844	30.4	4,154	38.9	793
			STD	4.1	0.4	0.12	25	23	0.3	56	0.3	47
			MAX	221.0	28.9	9.52	883	871	30.9	4,268	39.4	905
1269	130.0	12	AV12	206.1	28.1	9.34	883	877	30.8	4,149	38.8	781
			STD	5.9	0.5	0.11	53	55	0.5	71	0.2	44

KIWC, POA TPP - IP 7 (Loc. 5) PP48x1.0", APE D180-42
OP: RMDT Date: 25-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			MAX	222.6	29.1	9.57	1,041	1,040	31.9	4,290	39.1	896
1283	131.0	14	AV14	236.9	29.4	9.67	1,196	1,156	31.9	4,337	38.1	1,143
			STD	11.4	0.7	0.23	134	113	0.8	107	0.4	161
			MAX	257.1	30.7	10.05	1,394	1,346	33.4	4,535	38.8	1,390
1298	132.0	15	AV15	247.4	30.2	9.90	1,428	1,391	33.0	4,457	37.7	1,555
			STD	7.5	0.5	0.13	26	30	0.6	68	0.2	68
			MAX	259.7	31.0	10.16	1,476	1,431	33.8	4,572	38.2	1,649
1315	133.0	17	AV11	255.6	31.2	9.96	1,407	1,361	34.2	4,601	37.6	1,464
			STD	14.4	1.0	0.27	72	64	1.2	150	0.5	94
			MAX	286.1	33.2	10.63	1,509	1,454	36.6	4,895	38.2	1,617
1332	134.0	17	AV17	239.3	30.2	9.49	1,347	1,315	33.2	4,453	38.5	1,464
			STD	9.4	0.6	0.20	33	36	0.7	94	0.4	64
			MAX	255.3	31.4	9.89	1,420	1,394	34.6	4,637	39.3	1,597
1362	135.0	30	AV30	244.5	30.6	9.72	1,456	1,428	33.7	4,512	38.0	1,647
			STD	7.5	0.7	0.15	58	60	0.9	97	0.3	89
			MAX	256.9	31.5	10.00	1,575	1,516	34.6	4,647	38.8	1,789
1374	136.0	12	AV12	232.7	28.7	9.72	1,539	1,441	30.6	4,240	38.0	1,664
			STD	7.9	0.5	0.20	19	17	0.5	71	0.4	54
			MAX	247.3	29.7	10.16	1,575	1,469	31.7	4,387	38.5	1,726
1394	137.0	20	AV20	232.1	28.8	9.82	1,644	1,520	30.9	4,257	37.8	1,748
			STD	8.4	0.5	0.19	45	53	0.6	75	0.4	91
			MAX	247.7	29.8	10.16	1,730	1,592	31.9	4,394	38.4	1,982
1416	138.0	22	AV22	228.6	28.6	9.79	1,710	1,598	30.5	4,221	37.9	1,811
			STD	10.9	0.5	0.14	70	79	0.6	70	0.3	127
			MAX	245.4	29.5	10.05	1,914	1,826	31.5	4,356	38.5	2,207
1438	139.0	22	AV22	235.7	28.8	9.92	1,668	1,542	30.7	4,250	37.6	1,732
			STD	7.6	0.5	0.18	26	27	0.5	73	0.3	30
			MAX	250.5	29.8	10.28	1,728	1,593	31.9	4,401	38.3	1,798
			Average	110.6	19.8	6.63	643	616	21.3	2,921	46.1	691
			Std. Dev.	53.9	4.4	1.39	327	310	4.8	648	4.8	346
			Maximum	286.1	33.9	10.63	1,914	1,826	36.6	5,010	56.3	2,207

Total number of blows analyzed: 1430

BL#	Sensors
2-1360	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: off; A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)
1361-1438	F1: [E021] 92.0 (1.00); F2: [E022] 94.0 (1.00); A1: [30602] 1130.0 (1.00); A2: [30603] 1120.0 (1.00)

BL#	Comments
2	Begin Monitoring near Tip Elevation -93, 1:37:05 PM, 5/25/2016
1308	Pause for 9 minutes near tip elevation -159 ft, 2:18:41 PM
1361	Pause, change PDA sensors to water resistant units, near tip el -161, 2:34:33 PM

1438 End of Driving, near Tip Elevation -165, 139 ft soil penetration, 2:36:35 PM, 5/25/2016

Time Summary

Drive	32 minutes 18 seconds	1:37 PM - 2:09 PM (5/25/2016) BN 2 - 1307
Stop	9 minutes 17 seconds	2:09 PM - 2:18 PM
Drive	1 minute 21 seconds	2:18 PM - 2:20 PM BN 1308 - 1360
Stop	14 minutes 29 seconds	2:20 PM - 2:34 PM
Drive	2 minutes 1 second	2:34 PM - 2:36 PM BN 1361 - 1438

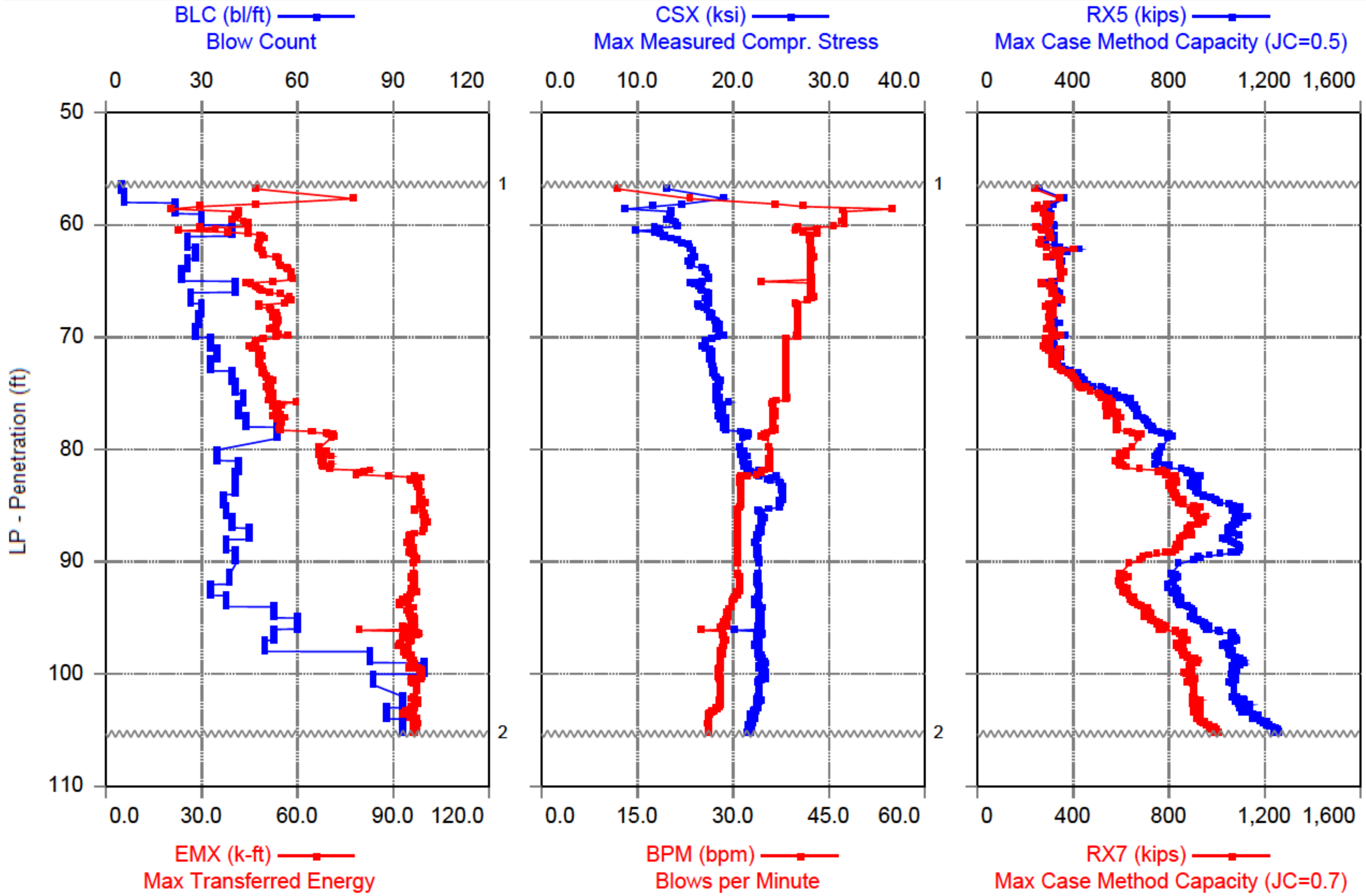
Total time [00:59:29] = (Driving [00:35:42] + Stop [00:23:47])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 08-May-2016

Test started: 03-May-2016

KIWC, POA TPP - IP 8 (Loc. 6)



1 - Begin driving with APE 15-4 impact hammer, near tip -84 ft, 8:07:34 PM 2 - End driving, near tip -133 ft, 5/3/2016, 9:29:38 PM

KIWC, POA TPP - IP 8 (Loc. 6) PP48x1.0", APE 15-4
OP: RMDT Date: 03-May-2016

AR: 147.65 in^2 SP: 0.492 k/ft^3
LE: 174.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.70 []

CSX: Max Measured Compr. Stress
CSI: Max F1 or F2 Compr. Stress
EMX: Max Transferred Energy
ETR: Energy Transfer Ratio - Rated
FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows per Minute
RX5: Max Case Method Capacity (JC=0.5)
RX6: Max Case Method Capacity (JC=0.6)

BL#	Depth	BLC	TYPE	CSX	CSI	EMX	ETR	FMX	VMX	BPM	RX5	RX6
	ft	bl/ft		ksi	ksi	k-ft	(%)	kips	f/s	bpm	kips	kips
5	57.00	5	AV4	12.3	15.6	43.3	36.1	1,812	6.6	14.4	237	227
			STD	1.9	1.7	8.5	7.1	287	1.0	12.1	49	40
			MAX	14.8	18.2	55.6	46.4	2,189	7.9	26.8	316	286
11	58.00	6	AV6	18.6	22.5	74.9	62.4	2,751	9.9	19.8	362	344
			STD	1.6	1.8	9.8	8.2	234	0.8	8.1	9	24
			MAX	21.0	25.4	90.0	75.0	3,095	11.1	25.1	379	379
33	59.00	22	AV22	12.4	14.9	35.4	29.5	1,824	6.6	45.2	283	272
			STD	3.2	3.8	16.3	13.6	467	1.7	17.2	52	44
			MAX	21.3	25.6	89.0	74.2	3,151	11.3	84.9	416	378
63	60.00	30	AV30	13.6	16.6	42.1	35.1	2,010	7.2	47.4	306	297
			STD	0.4	0.4	1.9	1.6	52	0.2	0.3	12	13
			MAX	14.2	17.4	45.4	37.8	2,100	7.6	47.8	324	324
103	61.00	40	AV40	12.4	16.1	38.6	32.2	1,830	6.6	42.5	302	292
			STD	2.1	3.1	11.4	9.5	307	1.1	8.6	34	31
			MAX	16.3	19.5	52.4	43.7	2,400	8.6	63.0	343	325
129	62.00	26	AV26	14.4	17.9	48.5	40.4	2,130	7.7	42.2	308	287
			STD	1.0	0.8	1.2	1.0	149	0.6	0.2	38	39
			MAX	15.9	19.0	51.2	42.6	2,348	8.5	42.6	411	401
157	63.00	28	AV28	15.8	18.7	49.7	41.4	2,335	8.4	42.4	364	344
			STD	0.3	0.3	2.4	2.0	37	0.1	0.3	57	59
			MAX	16.4	19.5	54.9	45.7	2,416	8.7	42.9	460	457
183	64.00	26	AV26	15.9	18.8	55.1	45.9	2,348	8.5	42.2	350	347
			STD	0.8	0.6	1.3	1.1	111	0.4	0.2	14	14
			MAX	17.4	19.9	58.2	48.5	2,563	9.2	42.8	383	370
207	65.00	24	AV24	17.3	19.9	58.2	48.5	2,557	9.2	42.3	353	353
			STD	0.2	0.3	0.6	0.5	35	0.1	0.2	11	11
			MAX	17.8	20.4	59.6	49.6	2,629	9.5	42.7	374	374
248	66.00	41	AV41	16.4	17.7	47.4	39.5	2,421	8.7	41.3	305	301
			STD	0.6	0.6	3.1	2.6	83	0.3	6.2	31	32
			MAX	17.7	19.8	58.5	48.7	2,612	9.4	42.9	421	405
275	67.00	27	AV27	17.4	19.4	56.5	47.1	2,568	9.2	41.9	347	339
			STD	0.3	0.6	2.4	2.0	46	0.2	1.2	18	18
			MAX	18.2	20.6	61.0	50.8	2,693	9.6	43.2	386	372
305	68.00	30	AV30	17.1	18.0	50.8	42.3	2,523	9.1	40.2	311	308
			STD	0.6	0.3	2.3	1.9	91	0.3	0.2	17	18
			MAX	18.3	18.8	55.7	46.4	2,703	9.8	40.4	346	346
334	69.00	29	AV29	18.1	18.3	53.4	44.5	2,671	9.6	40.2	322	311
			STD	0.4	0.3	1.1	0.9	60	0.2	0.1	23	17
			MAX	18.7	18.9	56.1	46.8	2,767	10.0	40.5	388	364
362	70.00	28	AV28	18.6	18.8	53.7	44.8	2,743	9.9	40.2	324	317
			STD	0.4	0.4	2.6	2.1	59	0.2	0.2	34	30
			MAX	19.6	19.8	60.6	50.5	2,893	10.6	40.5	404	403
395	71.00	33	AV33	17.4	17.5	47.7	39.8	2,565	9.3	38.5	318	301
			STD	0.6	0.6	3.1	2.6	90	0.3	0.7	22	21
			MAX	19.3	19.4	57.6	48.0	2,851	10.2	40.4	384	353

KIWC, POA TPP - IP 8 (Loc. 6) PP48x1.0", APE 15-4
OP: RMDT Date: 03-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	CSX ksi	CSI ksi	EMX k-ft	ETR (%)	FMX kips	VMX f/s	BPM bpm	RX5 kips	RX6 kips
430	72.00	35	AV35	17.7	17.9	48.2	40.2	2,612	9.4	38.3	338	328
			STD	0.2	0.2	1.2	1.0	34	0.1	0.2	26	30
			MAX	18.3	18.6	51.6	43.0	2,698	9.8	38.6	412	411
463	73.00	33	AV33	17.9	18.1	48.7	40.6	2,640	9.5	38.3	347	335
			STD	0.3	0.3	1.3	1.1	38	0.1	0.2	19	18
			MAX	18.5	18.7	52.2	43.5	2,730	9.9	38.7	393	372
503	74.00	40	AV40	18.3	18.5	50.5	42.1	2,696	9.7	38.3	427	410
			STD	0.4	0.4	1.8	1.5	53	0.2	0.2	20	19
			MAX	19.1	19.5	54.5	45.4	2,823	10.2	38.7	480	460
544	75.00	41	AV41	18.4	18.7	51.4	42.8	2,724	9.8	38.3	507	459
			STD	0.2	0.2	1.2	1.0	32	0.1	0.2	47	29
			MAX	19.2	19.3	54.2	45.1	2,831	10.2	38.6	595	527
587	76.00	43	AV43	18.6	18.9	53.0	44.2	2,747	9.9	37.6	613	548
			STD	0.6	0.6	3.8	3.2	93	0.3	1.0	31	26
			MAX	20.2	20.6	64.0	53.3	2,986	10.7	38.7	672	599
629	77.00	42	AV42	18.7	19.0	53.8	44.8	2,768	10.0	36.4	663	584
			STD	0.5	0.5	2.8	2.3	80	0.3	0.2	13	14
			MAX	20.0	20.3	61.1	50.9	2,951	10.7	36.8	688	613
673	78.00	44	AV44	19.1	19.3	54.9	45.7	2,813	10.2	36.4	702	620
			STD	0.3	0.3	1.6	1.3	48	0.2	0.1	19	16
			MAX	19.7	19.9	58.0	48.3	2,911	10.6	36.6	740	656
727	79.00	54	AV54	20.6	20.8	64.0	53.3	3,035	11.0	35.7	769	679
			STD	1.2	1.2	7.8	6.5	174	0.7	0.8	33	28
			MAX	22.9	23.5	79.7	66.4	3,383	12.5	36.9	836	736
728	80.03	35	AV1	20.8	21.3	67.9	56.6	3,064	11.2	35.7	762	666
			STD	0.0	0.0	0.0	0.0	0	0.0	0.0	0	0
			MAX	20.8	21.3	67.9	56.6	3,064	11.2	35.7	762	666
762	81.00	35	AV34	21.1	21.4	68.4	57.0	3,111	11.4	35.8	756	660
			STD	0.4	0.4	2.3	1.9	55	0.2	0.2	18	17
			MAX	22.1	22.2	73.6	61.4	3,258	11.8	36.3	795	700
804	82.00	42	AV42	21.5	21.9	71.2	59.3	3,177	11.7	35.6	805	711
			STD	0.7	0.7	5.8	4.9	99	0.4	0.5	51	54
			MAX	23.7	24.0	86.6	72.2	3,500	12.8	36.2	904	818
845	83.00	41	AV41	23.2	24.1	90.8	75.6	3,428	12.6	32.2	910	836
			STD	1.3	1.3	8.3	6.9	195	0.8	1.4	24	27
			MAX	25.0	25.7	100.7	83.9	3,690	13.7	34.8	956	896
886	84.00	41	AV41	25.1	25.7	98.3	81.9	3,709	13.6	31.3	910	835
			STD	0.2	0.2	0.7	0.6	25	0.1	0.1	18	13
			MAX	25.4	26.0	99.8	83.2	3,753	13.8	31.5	943	865
923	85.00	37	AV37	25.1	25.6	98.8	82.4	3,706	13.6	31.2	996	889
			STD	0.2	0.2	1.0	0.8	29	0.1	0.1	43	40
			MAX	25.5	26.0	100.6	83.8	3,759	13.9	31.5	1,085	975
961	86.00	38	AV38	23.4	25.1	98.7	82.3	3,459	12.7	30.8	1,092	997
			STD	0.8	0.3	1.4	1.1	122	0.5	0.2	25	26
			MAX	25.0	25.5	101.4	84.5	3,694	13.6	31.5	1,152	1,070
1001	87.00	40	AV40	23.0	24.7	100.1	83.4	3,402	12.5	30.8	1,087	998
			STD	0.2	0.3	1.0	0.8	25	0.1	0.2	27	25
			MAX	23.6	25.3	102.4	85.4	3,485	12.8	31.0	1,128	1,035
1046	88.00	45	AV45	22.7	24.8	97.5	81.3	3,352	12.2	30.8	1,057	964
			STD	0.2	0.2	2.1	1.8	27	0.1	0.1	19	17
			MAX	23.0	25.2	100.6	83.9	3,392	12.4	31.0	1,103	995
1084	89.00	38	AV38	22.5	24.6	95.7	79.7	3,327	12.1	30.8	1,080	952
			STD	0.1	0.2	0.9	0.8	17	0.1	0.1	21	13

KIWC, POA TPP - IP 8 (Loc. 6) PP48x1.0", APE 15-4
OP: RMDT Date: 03-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	CSX ksi	CSI ksi	EMX k-ft	ETR (%)	FMX kips	VMX f/s	BPM bpm	RX5 kips	RX6 kips
			MAX	22.8	24.9	97.4	81.2	3,361	12.3	31.1	1,112	978
1125	90.00	41	AV41	22.6	24.9	96.3	80.3	3,344	12.2	30.8	977	847
			STD	0.1	0.3	1.0	0.8	15	0.1	0.1	79	72
			MAX	22.8	25.5	98.1	81.7	3,373	12.3	31.0	1,105	971
1126	91.03	39	AV1	22.8	25.1	97.0	80.8	3,369	12.3	30.7	828	720
			STD	0.0	0.0	0.0	0.0	0	0.0	0.0	0	0
			MAX	22.8	25.1	97.0	80.8	3,369	12.3	30.7	828	720
1164	92.00	39	AV38	22.6	24.5	96.7	80.5	3,335	12.2	31.0	822	707
			STD	0.1	0.2	0.8	0.7	18	0.1	0.2	15	18
			MAX	22.9	25.1	98.1	81.7	3,381	12.3	31.4	857	756
1197	93.00	33	AV33	22.8	25.1	96.5	80.5	3,362	12.3	30.9	816	711
			STD	0.1	0.2	0.8	0.6	13	0.1	0.2	22	22
			MAX	22.9	25.5	98.2	81.9	3,385	12.4	31.2	857	750
1235	94.00	38	AV38	22.5	24.8	93.8	78.2	3,323	12.2	30.1	849	747
			STD	0.2	0.4	1.6	1.4	36	0.1	0.3	15	19
			MAX	22.9	25.6	97.3	81.1	3,387	12.4	30.7	901	807
1288	95.00	53	AV53	22.9	25.0	95.4	79.5	3,380	12.4	29.4	899	801
			STD	0.2	0.4	0.9	0.8	26	0.1	0.3	15	16
			MAX	23.3	25.8	97.3	81.1	3,446	12.6	30.0	937	843
1348	96.00	60	AV60	22.8	25.0	95.9	79.9	3,374	12.4	28.8	940	844
			STD	0.1	0.2	1.6	1.4	22	0.1	0.3	25	27
			MAX	23.2	25.5	98.3	81.9	3,424	12.6	29.2	998	902
1401	97.00	53	AV53	22.5	24.2	94.1	78.4	3,325	12.2	28.2	1,044	940
			STD	1.3	1.3	8.2	6.8	191	0.7	3.9	54	49
			MAX	23.2	25.2	99.7	83.0	3,431	12.6	38.6	1,109	1,003
1451	98.00	50	AV50	22.6	24.1	94.0	78.3	3,344	12.2	28.5	1,052	943
			STD	0.3	0.3	1.7	1.4	37	0.1	0.2	22	22
			MAX	23.1	24.8	96.9	80.7	3,413	12.5	28.9	1,096	989
1534	99.00	83	AV83	22.9	24.0	95.2	79.4	3,385	12.4	28.2	1,077	973
			STD	0.2	0.3	1.2	1.0	27	0.1	0.1	26	30
			MAX	23.4	24.9	98.5	82.1	3,452	12.7	28.4	1,158	1,047
1634	100.00	100	AV100	23.1	24.0	97.4	81.1	3,415	12.5	28.0	1,082	983
			STD	0.2	0.3	1.6	1.3	36	0.1	0.2	22	17
			MAX	23.6	24.9	100.0	83.3	3,485	12.8	28.3	1,150	1,037
1718	101.00	84	AV84	23.1	23.8	97.6	81.4	3,404	12.4	28.0	1,069	978
			STD	0.3	0.3	1.4	1.2	47	0.2	0.2	12	11
			MAX	23.6	24.6	100.1	83.4	3,482	12.8	28.3	1,103	1,008
1719	102.01	93	AV1	23.0	23.8	97.1	80.9	3,395	12.4	28.1	1,066	995
			STD	0.0	0.0	0.0	0.0	0	0.0	0.0	0	0
			MAX	23.0	23.8	97.1	80.9	3,395	12.4	28.1	1,066	995
1811	103.00	93	AV92	22.7	23.7	97.0	80.9	3,348	12.2	28.1	1,106	993
			STD	0.2	0.4	0.8	0.7	29	0.1	0.1	26	15
			MAX	23.2	24.6	99.1	82.6	3,430	12.5	28.3	1,165	1,044
1899	104.00	88	AV88	22.3	22.9	95.4	79.5	3,290	12.0	26.7	1,135	1,010
			STD	0.2	0.3	1.4	1.1	35	0.1	0.6	27	17
			MAX	22.9	23.7	98.1	81.7	3,383	12.3	27.8	1,192	1,048
1992	105.00	93	AV93	22.0	23.1	96.9	80.8	3,246	11.9	26.1	1,209	1,061
			STD	0.2	0.3	0.6	0.5	28	0.1	0.1	29	30
			MAX	22.4	23.8	99.2	82.7	3,307	12.1	26.3	1,278	1,126
2023	105.33	93	AV31	21.8	23.3	96.8	80.7	3,217	11.8	26.2	1,254	1,111
			STD	0.2	0.3	0.5	0.4	24	0.1	0.1	20	20
			MAX	22.1	23.9	98.3	82.0	3,259	11.9	26.3	1,295	1,153
			Average	20.8	22.0	79.1	65.9	3,067	11.2	33.0	813	734

KIWC, POA TPP - IP 8 (Loc. 6) PP48x1.0", APE 15-4
OP: RMDT Date: 03-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	CSX ksi	CSI ksi	EMX k-ft	ETR (%)	FMX kips	VMX f/s	BPM bpm	RX5 kips	RX6 kips
			Std. Dev.	3.1	3.0	22.2	18.5	459	1.7	6.3	317	276
			Maximum	25.5	26.0	102.4	85.4	3,759	13.9	84.9	1,295	1,153

Total number of blows analyzed: 2022

BL#	Sensors
2-2023	F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
2	Begin driving with APE 15-4 impact hammer, near tip -84 ft, 8:07:34 PM, 5/3/2016
2023	End driving, near tip -133 ft, 5/3/2016, 9:29:38 PM

Time Summary

Drive	8 minutes 43 seconds	8:07 PM - 8:16 PM (5/3/2016) BN 2 - 209
Stop	4 minutes 3 seconds	8:16 PM - 8:20 PM
Drive	33 minutes 32 seconds	8:20 PM - 8:53 PM BN 210 - 1353
Stop	11 minutes 29 seconds	8:53 PM - 9:05 PM
Drive	24 minutes 13 seconds	9:05 PM - 9:29 PM BN 1354 - 2023

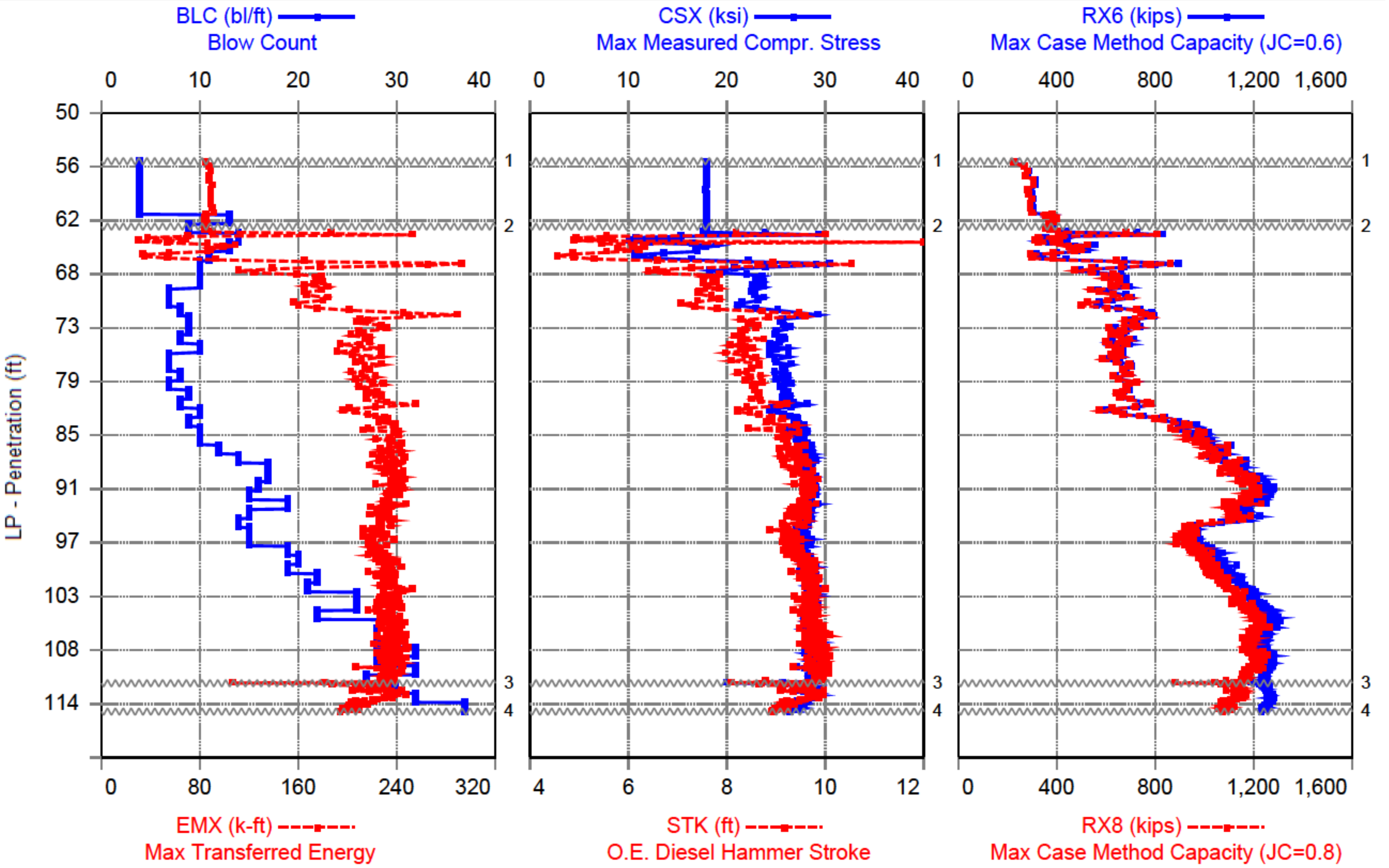
Total time [01:22:03] = (Driving [01:06:30] + Stop [00:15:33])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 08-May-2016

Test started: 06-May-2016

KIWC, POA TPP - IP 9 (Loc. 6)



1 - Begin driving with D180-42, tip near -81, 10:38:09 AM, 5/6/2016

2 - 5/6/2016, 11:01:34 AM remove D180, 5/6/2016, 11:01:34 AM continue.

3 - Pause, continue. 11:17:32 AM

4 - End of Driving, Tip near -140, 115 ft depth, 11:20:09 AM, 5/7/2016

KIWC, POA TPP - IP 9 (Loc. 6) PP48x1.0", APE D180-42
OP: RMDT Date: 06-May-2016

AR: 147.65 in² SP: 0.492 k/ft³
LE: 173.40 ft EM: 29,972 ksi
WS: 16,800.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
4	56.0	4	AV4	87.1	18.0	**	252	247	19.4	2,665	1.9	254
			STD	1.2	0.2	**	35	39	0.1	24	0.0	25
			MAX	88.4	18.3	**	277	272	19.6	2,699	1.9	281
8	57.0	4	AV4	88.7	18.1	**	287	279	19.4	2,666	1.9	272
			STD	1.4	0.0	**	8	11	0.0	3	0.0	12
			MAX	90.2	18.1	**	296	291	19.5	2,668	1.9	284
12	58.0	4	AV4	88.9	18.0	**	312	306	19.4	2,661	1.9	290
			STD	1.0	0.0	**	8	9	0.0	4	0.0	2
			MAX	90.1	18.0	**	321	315	19.5	2,665	1.9	292
16	59.0	4	AV4	89.5	17.9	**	300	288	19.4	2,650	2.0	268
			STD	0.5	0.0	**	5	6	0.0	3	0.0	3
			MAX	90.0	18.0	**	306	293	19.4	2,655	2.0	273
20	60.0	4	AV4	88.9	18.0	**	304	296	19.4	2,654	2.0	272
			STD	0.8	0.0	**	11	12	0.0	2	0.0	6
			MAX	90.0	18.0	**	322	314	19.4	2,658	2.0	278
24	61.0	4	AV4	90.7	18.0	**	306	299	19.4	2,658	2.0	262
			STD	1.3	0.0	**	16	19	0.0	3	0.0	10
			MAX	92.1	18.0	**	328	323	19.5	2,662	2.0	277
37	62.0	13	AV13	84.9	18.0	**	386	386	19.4	2,656	2.0	315
			STD	1.0	0.1	**	16	16	0.1	8	0.0	4
			MAX	86.6	18.1	**	408	408	19.5	2,671	2.0	324
46	63.0	9	AV9	86.7	17.9	**	392	374	19.2	2,643	1.9	367
			STD	4.2	0.2	**	35	31	0.2	25	0.0	81
			MAX	97.8	18.1	**	457	411	19.5	2,677	2.0	560
60	64.0	14	AV14	102.1	17.1	6.40	506	479	18.4	2,526	45.7	489
			STD	82.0	6.8	2.00	192	189	7.4	1,010	9.7	136
			MAX	276.6	30.2	10.28	944	904	32.4	4,456	55.0	756
73	65.0	13	AV13	88.4	16.7	7.08	477	449	18.0	2,467	46.2	483
			STD	17.6	2.1	3.62	61	67	2.4	316	5.7	58
			MAX	112.4	18.9	19.56	573	544	20.4	2,792	51.1	550
84	66.0	11	AV11	56.7	13.1	5.16	382	350	14.1	1,935	51.7	420
			STD	22.8	2.5	0.53	61	67	2.7	366	2.4	54
			MAX	110.9	18.1	6.31	500	496	19.5	2,668	54.7	517
94	67.0	10	AV10	208.4	25.3	8.45	721	701	27.2	3,736	41.1	599
			STD	63.2	4.0	1.39	129	126	4.3	594	3.2	149
			MAX	305.9	31.6	10.81	936	914	34.0	4,662	45.1	849
104	68.0	10	AV10	149.8	21.4	7.13	601	579	22.9	3,153	44.3	544
			STD	28.3	2.2	0.61	69	68	2.2	322	1.8	96

KIWC, POA TPP - IP 9 (Loc. 6) PP48x1.0", APE D180-42
OP: RMDT Date: 06-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
			MAX	188.4	24.3	7.99	727	690	26.0	3,592	46.8	699
114	69.0	10	AV10	176.4	23.4	7.72	675	647	25.1	3,455	42.5	564
			STD	8.4	0.6	0.20	24	31	0.6	89	0.5	78
			MAX	188.1	24.4	8.07	719	700	26.1	3,599	43.1	732
121	70.0	7	AV7	171.5	22.9	7.54	636	601	24.4	3,377	43.0	540
			STD	8.4	0.4	0.15	58	65	0.5	64	0.4	32
			MAX	187.8	23.6	7.83	718	716	25.3	3,488	43.5	594
128	71.0	7	AV7	169.4	22.3	7.40	604	565	23.9	3,295	43.4	615
			STD	13.5	1.1	0.33	53	70	1.2	162	0.9	56
			MAX	191.0	24.1	7.91	693	680	25.8	3,561	44.5	677
136	72.0	8	AV8	228.4	26.2	8.67	741	710	28.1	3,873	40.3	673
			STD	43.6	2.4	0.83	70	82	2.7	357	1.9	115
			MAX	291.2	29.6	9.83	851	831	31.9	4,366	42.9	873
145	73.0	9	AV9	223.4	26.2	8.64	726	713	28.2	3,868	40.3	635
			STD	18.4	1.1	0.38	51	63	1.2	166	0.8	69
			MAX	263.2	28.8	9.52	825	815	30.9	4,259	41.1	770
154	74.0	9	AV9	220.3	25.7	8.46	688	673	27.5	3,792	40.7	684
			STD	10.8	0.6	0.19	52	63	0.7	90	0.4	54
			MAX	241.6	26.9	8.84	774	773	28.7	3,970	41.2	744
162	75.0	8	AV8	213.3	25.5	8.39	663	647	27.3	3,763	40.8	660
			STD	12.2	0.7	0.23	51	63	0.8	101	0.5	68
			MAX	228.0	26.7	8.79	732	732	28.7	3,941	41.5	762
172	76.0	10	AV10	206.2	25.0	8.28	660	650	26.8	3,695	41.1	641
			STD	13.5	0.8	0.25	36	41	0.9	120	0.6	58
			MAX	232.3	26.9	8.84	705	698	28.8	3,968	42.0	708
179	77.0	7	AV7	212.8	25.2	8.33	633	619	26.9	3,716	41.0	638
			STD	12.5	0.9	0.27	34	38	1.0	129	0.6	31
			MAX	229.6	26.6	8.75	701	701	28.5	3,926	41.7	680
186	78.0	7	AV7	219.6	26.0	8.60	695	690	27.9	3,841	40.3	719
			STD	6.9	0.5	0.15	32	34	0.5	70	0.3	28
			MAX	231.0	26.7	8.84	746	746	28.7	3,944	40.8	757
194	79.0	8	AV8	211.5	25.5	8.43	670	664	27.2	3,767	40.7	691
			STD	10.2	0.6	0.21	31	34	0.7	92	0.5	56
			MAX	228.0	26.4	8.75	729	729	28.2	3,896	41.4	749
201	80.0	7	AV7	218.6	26.0	8.59	702	700	27.7	3,839	40.4	691
			STD	9.7	0.5	0.17	32	33	0.6	77	0.4	95
			MAX	233.0	26.6	8.79	735	735	28.4	3,929	41.1	779
210	81.0	9	AV9	221.3	26.1	8.62	669	665	27.9	3,850	40.3	705
			STD	5.8	0.3	0.09	20	26	0.3	47	0.2	69
			MAX	230.8	26.5	8.75	697	697	28.4	3,909	40.7	749
218	82.0	8	AV8	231.7	26.9	8.91	747	744	28.8	3,965	39.7	703
			STD	16.1	0.9	0.32	42	46	1.1	138	0.7	122
			MAX	264.5	28.6	9.57	815	813	30.7	4,216	40.4	870
228	83.0	10	AV10	209.0	25.3	8.42	661	652	27.1	3,739	40.8	670
			STD	10.3	0.8	0.24	61	62	0.9	114	0.6	78
			MAX	223.8	26.7	8.84	795	775	28.5	3,937	41.5	792

KIWC, POA TPP - IP 9 (Loc. 6) PP48x1.0", APE D180-42
OP: RMDT Date: 06-May-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
237	84.0	9	AV9	233.8	27.3	9.06	877	867	29.3	4,025	39.3	740
			STD	9.9	0.7	0.24	55	50	0.7	99	0.5	39
			MAX	252.0	28.6	9.52	956	929	30.6	4,221	40.2	802
247	85.0	10	AV10	229.3	27.3	9.07	959	931	29.4	4,038	39.3	853
			STD	16.4	1.0	0.36	50	55	1.1	153	0.8	38
			MAX	249.0	28.6	9.52	1,052	1,036	30.9	4,228	40.7	931
257	86.0	10	AV10	233.3	27.7	9.19	997	969	29.8	4,087	39.1	935
			STD	7.3	0.4	0.13	35	40	0.4	53	0.3	26
			MAX	239.5	28.0	9.27	1,068	1,051	30.3	4,132	39.8	982
269	87.0	12	AV12	239.3	28.2	9.41	1,061	1,043	30.4	4,169	38.6	1,038
			STD	10.6	0.7	0.23	43	48	0.7	97	0.5	35
			MAX	259.0	29.4	9.78	1,123	1,110	31.6	4,338	39.8	1,120
283	88.0	14	AV14	233.3	28.2	9.37	1,083	1,058	30.4	4,167	38.7	1,080
			STD	10.4	0.7	0.22	55	55	0.7	98	0.4	87
			MAX	249.6	29.3	9.73	1,173	1,156	31.7	4,330	39.3	1,234
300	89.0	17	AV17	234.1	28.4	9.45	1,142	1,107	30.5	4,188	38.5	1,065
			STD	9.9	0.6	0.19	28	31	0.6	84	0.4	74
			MAX	250.3	29.4	9.78	1,187	1,162	31.7	4,338	39.7	1,255
317	90.0	17	AV17	240.3	28.8	9.60	1,185	1,165	31.1	4,257	38.2	1,120
			STD	7.2	0.5	0.17	48	51	0.5	69	0.3	71
			MAX	253.3	29.8	9.94	1,294	1,257	32.1	4,393	38.8	1,236
333	91.0	16	AV16	238.3	28.8	9.65	1,248	1,190	31.1	4,257	38.2	1,245
			STD	7.3	0.4	0.16	41	32	0.5	60	0.3	47
			MAX	247.0	29.4	9.83	1,301	1,238	31.7	4,343	39.0	1,397
348	92.0	15	AV15	235.5	28.7	9.63	1,250	1,189	31.0	4,244	38.2	1,210
			STD	4.5	0.3	0.12	21	32	0.4	45	0.2	39
			MAX	243.5	29.3	9.83	1,283	1,229	31.6	4,320	38.6	1,285
367	93.0	19	AV19	233.6	28.5	9.57	1,178	1,134	30.9	4,213	38.3	1,145
			STD	7.7	0.5	0.16	41	51	0.5	68	0.3	43
			MAX	251.8	29.4	9.89	1,259	1,245	31.8	4,340	39.0	1,213
382	94.0	15	AV15	226.8	28.1	9.42	1,183	1,129	30.4	4,152	38.6	1,159
			STD	7.7	0.5	0.18	34	32	0.6	72	0.4	31
			MAX	241.0	29.1	9.78	1,271	1,208	31.4	4,292	39.2	1,208
396	95.0	14	AV14	230.0	28.2	9.45	1,070	1,042	30.4	4,157	38.5	1,059
			STD	8.0	0.5	0.19	94	93	0.6	75	0.4	82
			MAX	247.7	29.2	9.83	1,221	1,200	31.5	4,310	39.2	1,189
411	96.0	15	AV15	221.0	27.6	9.23	955	941	29.8	4,075	39.0	977
			STD	9.0	0.5	0.18	26	25	0.6	76	0.4	105
			MAX	233.2	28.2	9.52	1,010	993	30.5	4,160	40.0	1,200
426	97.0	15	AV15	221.7	27.8	9.28	961	923	30.0	4,098	38.9	988
			STD	7.7	0.5	0.17	30	34	0.5	70	0.3	22
			MAX	239.6	29.0	9.73	1,013	973	31.3	4,275	39.4	1,024
445	98.0	19	AV19	224.1	27.9	9.37	1,019	970	30.1	4,123	38.7	1,030
			STD	6.5	0.5	0.16	32	38	0.5	67	0.3	34
			MAX	232.8	28.6	9.57	1,116	1,085	30.9	4,221	39.4	1,116
465	99.0	20	AV20	230.2	28.3	9.55	1,052	1,008	30.6	4,183	38.3	1,063

KIWC, POA TPP - IP 9 (Loc. 6) PP48x1.0", APE D180-42
OP: RMDT Date: 06-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
			STD	7.5	0.4	0.16	21	27	0.5	64	0.3	36
			MAX	246.3	29.1	9.83	1,085	1,046	31.6	4,302	38.9	1,143
484	100.0	19	AV19	232.5	28.5	9.64	1,077	1,019	30.9	4,214	38.2	1,125
			STD	7.9	0.5	0.19	31	24	0.6	76	0.4	31
			MAX	246.7	29.4	9.94	1,164	1,074	31.9	4,341	39.4	1,196
506	101.0	22	AV22	232.8	28.5	9.67	1,125	1,059	30.9	4,215	38.1	1,186
			STD	7.9	0.5	0.15	31	29	0.6	75	0.3	47
			MAX	246.0	29.4	9.89	1,185	1,111	31.8	4,335	38.7	1,298
527	102.0	21	AV21	238.7	28.8	9.75	1,165	1,096	31.1	4,245	38.0	1,247
			STD	7.8	0.4	0.15	26	26	0.4	55	0.3	29
			MAX	261.7	29.6	10.11	1,200	1,135	31.9	4,371	38.4	1,297
553	103.0	26	AV26	234.3	28.6	9.68	1,199	1,141	30.9	4,225	38.1	1,310
			STD	8.2	0.5	0.17	14	21	0.5	71	0.3	36
			MAX	250.1	29.5	10.05	1,231	1,189	32.0	4,362	38.7	1,366
579	104.0	26	AV26	233.8	28.6	9.70	1,225	1,162	30.9	4,221	38.1	1,368
			STD	9.2	0.5	0.20	28	31	0.6	81	0.4	40
			MAX	247.9	29.4	10.00	1,290	1,225	32.0	4,346	39.0	1,438
601	105.0	22	AV22	232.4	28.5	9.68	1,270	1,202	30.8	4,206	38.1	1,412
			STD	7.2	0.3	0.13	22	22	0.4	49	0.2	38
			MAX	244.8	29.0	9.89	1,312	1,245	31.4	4,280	38.6	1,477
631	106.0	30	AV30	237.0	28.7	9.79	1,279	1,225	31.1	4,237	37.9	1,404
			STD	6.8	0.4	0.15	21	20	0.5	66	0.3	31
			MAX	248.4	29.6	10.11	1,326	1,276	32.2	4,377	38.6	1,467
659	107.0	28	AV28	236.7	28.7	9.79	1,247	1,202	31.1	4,241	37.9	1,396
			STD	7.8	0.5	0.19	19	19	0.6	72	0.4	37
			MAX	250.7	29.7	10.11	1,292	1,250	32.2	4,378	38.5	1,465
687	108.0	28	AV28	235.2	28.7	9.78	1,237	1,182	31.1	4,234	37.9	1,436
			STD	8.8	0.6	0.19	13	23	0.7	83	0.4	25
			MAX	248.9	29.5	10.05	1,268	1,227	32.2	4,361	38.7	1,477
719	109.0	32	AV32	238.4	28.9	9.90	1,249	1,199	31.5	4,265	37.7	1,439
			STD	8.6	0.5	0.20	18	30	0.8	78	0.4	24
			MAX	250.1	29.6	10.22	1,302	1,271	32.8	4,374	38.7	1,499
747	110.0	28	AV28	235.4	28.8	9.86	1,262	1,212	31.3	4,252	37.7	1,426
			STD	8.6	0.5	0.19	12	22	0.7	78	0.4	21
			MAX	252.6	29.8	10.22	1,299	1,266	32.8	4,398	38.4	1,463
779	111.0	32	AV32	234.3	28.7	9.86	1,258	1,196	31.2	4,236	37.8	1,413
			STD	10.8	0.7	0.25	14	30	0.9	97	0.5	24
			MAX	252.8	29.9	10.39	1,290	1,268	33.2	4,414	39.2	1,469
806	112.0	27	AV27	220.0	27.9	9.66	1,238	1,129	30.3	4,112	36.9	1,361
			STD	35.9	2.5	0.67	33	84	2.8	370	7.0	130
			MAX	245.2	29.4	10.11	1,284	1,210	32.3	4,336	44.8	1,466
836	113.0	30	AV30	222.0	28.2	9.45	1,252	1,125	30.7	4,159	38.6	1,386
			STD	15.5	1.0	0.36	13	30	1.1	148	0.7	28
			MAX	245.0	29.6	10.00	1,271	1,174	32.5	4,378	40.7	1,439
868	114.0	32	AV32	229.7	28.6	9.70	1,270	1,132	31.1	4,221	38.1	1,394
			STD	11.6	0.7	0.23	10	26	0.8	100	0.4	27

KIWC, POA TPP - IP 9 (Loc. 6) PP48x1.0", APE D180-42
OP: RMDT Date: 06-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
			MAX	253.9	29.9	10.16	1,298	1,185	32.4	4,411	39.3	1,457
905	115.0	37	AV37	206.0	27.2	9.18	1,251	1,091	29.5	4,015	39.1	1,350
			STD	7.0	0.5	0.15	13	23	0.5	67	0.3	30
			MAX	220.1	28.1	9.47	1,276	1,148	30.6	4,150	39.7	1,401
			Average	213.3	26.8	9.23	1,028	976	28.9	3,952	37.2	1,078
			Std. Dev.	46.9	3.7	1.04	291	270	4.1	546	8.7	355
			Maximum	305.9	31.6	19.56	1,326	1,276	34.0	4,662	55.0	1,499

Total number of blows analyzed: 905

BL#	Sensors
1-499	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: off; A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)
500-905	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: [28243] 1025.0 (1.00); A2: [34329] 1085.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
1	Begin driving with D180-42, tip near -81, 10:38:09 AM, 5/6/2016
40	5/6/2016, 11:01:34 AM remove D180, 5/6/2016, 11:01:34 AM continue.
804	Pause, continue. 11:17:32 AM
905	End of Driving, Tip near -140, 115 ft depth, 11:20:09 AM, 5/7/2016

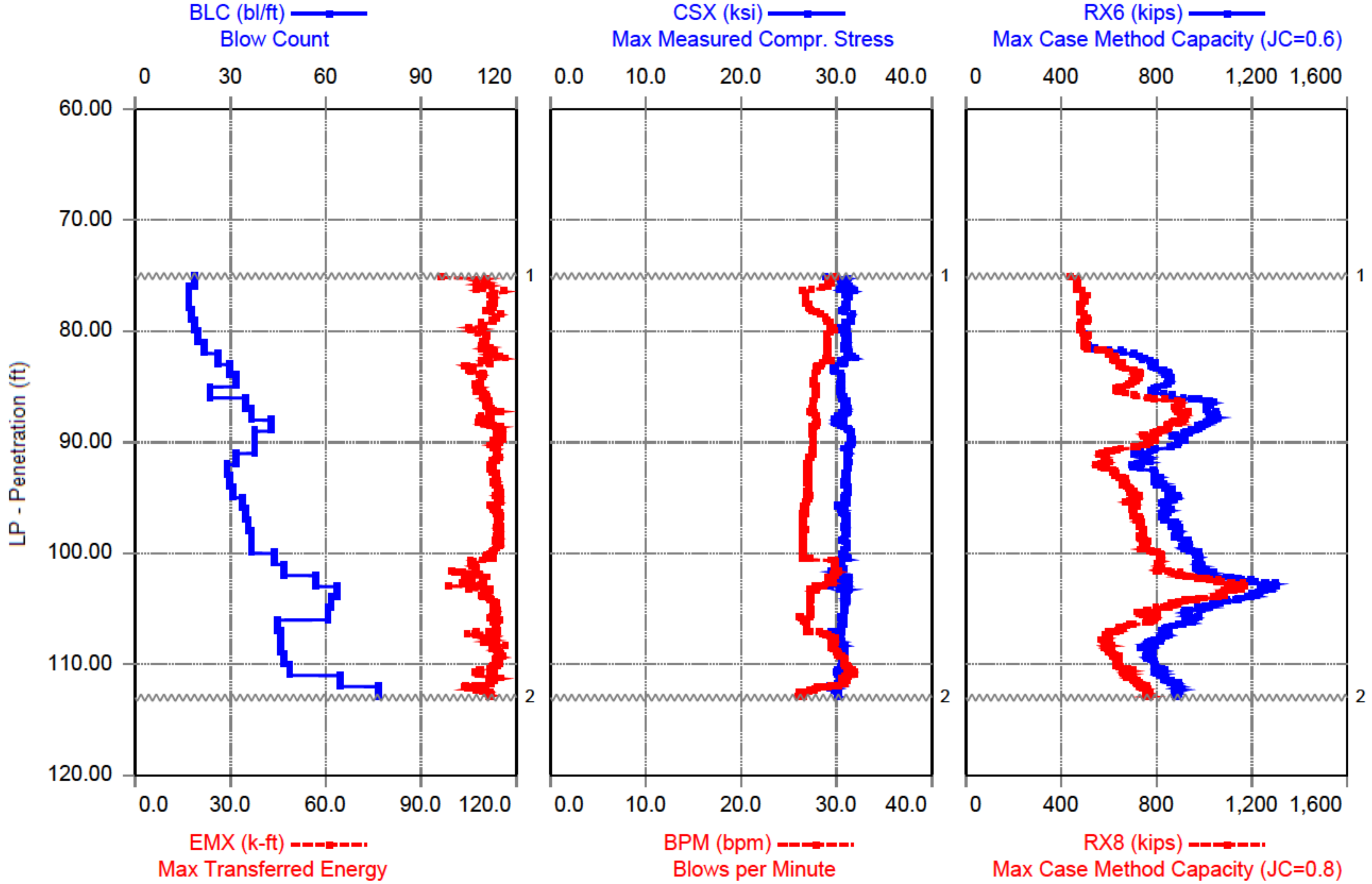
Time Summary

Drive	23 minutes 24 seconds	10:38 AM - 11:01 AM (5/6/2016) BN 1 - 40
Stop	23 hours 45 minutes 34 seconds	11:01 AM - 10:47 AM
Drive	33 minutes 0 second	10:47 AM - 11:20 AM BN 41 - 905

Total time [1: 00:41:59] = (Driving [00:56:24] + Stop [23:45:34])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results
Printed: 31-May-2016 Test started: 26-May-2016

KIWC, POA TPP - IP 10 (Loc. 6)



1 - Begin PDA Monitoring, 5/26/2016, 2:43:20 PM

2 - End driving near Tip El -137 with approximately 113 ft soil penetration, 5/26/2016, , 3:37

KIWC, POA TPP - IP 10 (Loc. 6) PP48x1.0", APE 15-4
OP: RMDT Date: 26-May-2016

AR: 147.65 in² SP: 0.492 k/ft³
LE: 174.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows per Minute
CSI: Max F1 or F2 Compr. Stress
RX6: Max Case Method Capacity (JC=0.6)
RX7: Max Case Method Capacity (JC=0.7)
RX8: Max Case Method Capacity (JC=0.8)

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	FMX kips	VMX f/s	BPM bpm	CSI ksi	RX6 kips	RX7 kips	RX8 kips
19	76.00	19	AV18	107.6	30.7	4,528	17.0	29.5	33.9	464	464	464
			STD	7.4	1.2	177	0.7	0.6	1.3	16	16	16
			MAX	115.3	31.9	4,715	17.8	31.0	35.8	488	488	488
36	77.00	17	AV17	111.9	31.1	4,599	17.2	27.2	34.4	488	488	488
			STD	3.1	0.6	90	0.5	0.8	0.5	16	16	16
			MAX	117.0	32.3	4,769	18.1	28.9	35.4	519	519	519
53	78.00	17	AV17	112.8	31.2	4,600	17.2	26.9	34.7	491	491	491
			STD	0.8	0.2	31	0.2	0.2	0.2	14	14	14
			MAX	113.8	31.6	4,659	17.7	27.3	35.0	526	526	526
71	79.00	18	AV18	112.9	31.3	4,621	17.6	28.3	34.0	492	492	492
			STD	2.1	0.5	69	0.4	0.6	0.4	17	17	17
			MAX	116.8	32.1	4,739	18.0	29.0	34.7	527	527	527
90	80.00	19	AV19	109.5	31.0	4,584	17.4	29.4	33.3	492	492	492
			STD	4.7	0.8	113	0.5	0.4	0.8	16	16	16
			MAX	114.3	31.9	4,710	18.1	30.1	34.3	523	523	523
110	81.00	20	AV20	109.8	31.0	4,577	17.5	29.2	33.5	503	502	502
			STD	3.6	0.5	80	0.5	0.3	0.7	14	14	14
			MAX	115.6	31.8	4,699	18.3	30.1	34.5	527	527	527
132	82.00	22	AV22	110.9	31.2	4,606	17.6	29.1	33.4	564	541	531
			STD	3.1	0.5	69	0.3	0.2	0.5	60	43	38
			MAX	116.3	32.0	4,731	18.1	29.4	34.6	672	619	605
158	83.00	26	AV26	112.3	31.2	4,605	17.5	29.1	33.5	748	669	626
			STD	3.3	0.7	98	0.3	0.3	0.6	36	37	21
			MAX	117.1	32.3	4,773	18.2	29.9	34.6	821	749	677
188	84.00	30	AV30	106.8	30.1	4,441	17.0	28.1	32.5	817	750	689
			STD	2.7	0.4	65	0.4	0.3	0.7	30	31	34
			MAX	111.8	31.1	4,588	17.6	29.3	33.8	859	797	744
220	85.00	32	AV32	108.6	30.6	4,517	17.3	27.7	33.2	853	780	709
			STD	1.0	0.1	22	0.2	0.1	0.3	18	19	22
			MAX	110.5	30.8	4,553	17.7	28.0	33.8	894	819	757
244	86.00	24	AV24	109.3	30.6	4,516	17.3	27.9	33.1	818	737	662
			STD	1.4	0.2	29	0.2	0.1	0.3	36	36	32
			MAX	111.7	31.0	4,574	17.5	28.1	33.5	894	810	726
279	87.00	35	AV35	111.0	31.0	4,570	17.5	27.6	34.3	1,003	934	870
			STD	0.9	0.2	36	0.2	0.1	0.6	38	41	47
			MAX	112.5	31.5	4,647	18.0	28.0	35.1	1,047	982	922
316	88.00	37	AV37	111.7	30.7	4,533	17.4	27.7	33.9	1,039	969	909
			STD	2.0	0.5	67	0.4	0.3	0.5	22	20	18

KIWC, POA TPP - IP 10 (Loc. 6) PP48x1.0", APE 15-4
OP: RMDT Date: 26-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	FMX kips	VMX f/s	BPM bpm	CSI ksi	RX6 kips	RX7 kips	RX8 kips
			MAX	115.7	31.4	4,638	18.0	28.5	34.9	1,085	1,017	951
359	89.00	43	AV43	112.4	30.6	4,524	17.4	27.8	33.4	998	931	866
			STD	2.6	0.6	83	0.4	0.3	0.5	30	29	29
			MAX	117.1	31.6	4,661	18.1	28.4	34.3	1,064	999	934
397	90.00	38	AV38	114.9	31.6	4,659	18.0	27.6	34.3	906	842	780
			STD	1.1	0.2	27	0.2	0.1	0.4	27	27	26
			MAX	116.3	32.0	4,721	18.2	27.9	35.1	955	892	828
435	91.00	38	AV38	113.9	31.4	4,634	17.6	27.6	34.6	833	760	692
			STD	1.0	0.3	42	0.3	0.1	0.5	60	66	67
			MAX	115.7	31.9	4,715	18.3	27.8	35.7	927	864	801
467	92.00	32	AV32	113.6	31.2	4,612	17.6	27.3	34.6	745	660	584
			STD	1.0	0.2	24	0.2	0.2	0.4	25	23	16
			MAX	115.3	31.6	4,661	18.0	27.7	35.4	800	708	621
496	93.00	29	AV29	112.7	31.2	4,601	17.7	27.1	34.0	756	672	600
			STD	1.1	0.2	34	0.2	0.1	0.4	42	37	31
			MAX	114.7	31.7	4,677	18.0	27.3	34.9	821	731	663
526	94.00	30	AV30	113.6	31.0	4,570	17.5	27.1	33.6	804	724	658
			STD	0.7	0.2	31	0.2	0.1	0.5	17	16	16
			MAX	115.2	31.4	4,642	17.9	27.3	34.4	835	758	686
557	95.00	31	AV31	114.7	31.2	4,600	17.6	27.1	34.1	860	779	699
			STD	0.7	0.2	28	0.3	0.1	0.3	25	24	22
			MAX	116.1	31.5	4,645	17.9	27.3	34.8	929	843	758
591	96.00	34	AV34	114.0	30.7	4,540	17.4	26.9	33.9	847	771	706
			STD	1.1	0.4	54	0.3	0.2	0.5	23	20	21
			MAX	115.8	31.3	4,618	17.9	27.2	34.7	910	836	762
626	97.00	35	AV35	114.3	30.9	4,567	17.5	26.7	33.8	839	768	713
			STD	1.0	0.3	43	0.3	0.1	0.4	18	16	15
			MAX	115.9	31.5	4,655	18.0	26.9	34.7	883	802	752
662	98.00	36	AV36	114.6	31.0	4,576	17.5	26.6	33.9	875	798	736
			STD	0.7	0.2	26	0.1	0.1	0.4	27	19	12
			MAX	115.9	31.4	4,635	17.8	26.8	34.7	930	847	764
699	99.00	37	AV37	114.4	31.0	4,571	17.6	26.6	33.7	898	809	742
			STD	0.8	0.2	32	0.2	0.1	0.5	24	21	13
			MAX	116.1	31.3	4,617	18.0	26.8	34.6	945	859	773
736	100.00	37	AV37	114.0	31.0	4,583	17.5	26.6	33.3	931	839	759
			STD	0.8	0.2	25	0.2	0.1	0.3	21	23	18
			MAX	115.7	31.5	4,645	17.9	26.7	34.0	973	887	803
780	101.00	44	AV44	109.7	30.7	4,531	17.3	27.9	32.9	976	893	817
			STD	2.9	0.4	63	0.3	1.6	0.5	15	17	15
			MAX	116.9	32.0	4,718	18.0	30.0	34.0	1,011	930	848
827	102.00	47	AV47	105.9	30.4	4,490	17.0	29.9	32.6	993	905	835
			STD	4.0	0.6	96	0.4	0.3	0.9	33	40	39
			MAX	114.8	31.5	4,644	17.8	30.8	33.8	1,078	1,003	929
884	103.00	57	AV57	107.7	30.9	4,565	17.4	29.3	33.3	1,181	1,109	1,041
			STD	4.7	0.8	123	0.5	0.5	1.0	79	85	85
			MAX	111.5	31.7	4,683	17.9	30.6	34.5	1,316	1,255	1,193

KIWC, POA TPP - IP 10 (Loc. 6) PP48x1.0", APE 15-4
OP: RMDT Date: 26-May-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	FMX kips	VMX f/s	BPM bpm	CSI ksi	RX6 kips	RX7 kips	RX8 kips
948	104.00	64	AV63	109.4	30.9	4,564	17.5	27.6	33.0	1,241	1,170	1,102
			STD	2.2	0.3	48	0.2	0.3	0.3	36	38	39
			MAX	112.8	31.6	4,661	17.9	28.1	34.0	1,345	1,279	1,213
1010	105.00	62	AV62	112.9	31.0	4,575	17.7	27.4	32.9	1,072	981	906
			STD	1.0	0.2	24	0.1	0.1	0.2	60	59	62
			MAX	114.7	31.4	4,632	17.9	27.6	33.3	1,196	1,124	1,051
1071	106.00	61	AV61	113.3	30.8	4,545	17.6	27.1	32.8	945	855	769
			STD	0.8	0.1	21	0.2	0.5	0.3	29	32	32
			MAX	115.3	31.0	4,580	17.9	27.5	33.3	1,024	937	850
1116	107.00	45	AV45	113.9	30.7	4,534	17.5	26.9	32.7	895	798	707
			STD	0.7	0.1	21	0.2	0.1	0.2	51	55	57
			MAX	115.6	30.9	4,569	17.9	27.1	33.3	969	883	797
1162	108.00	46	AV46	111.0	30.1	4,440	16.9	29.0	32.8	832	706	598
			STD	3.7	0.6	84	0.4	1.0	0.7	24	27	23
			MAX	116.2	31.1	4,585	17.6	30.2	34.2	870	772	675
1208	109.00	46	AV46	113.6	30.6	4,521	17.4	29.8	32.9	772	675	597
			STD	2.2	0.4	52	0.2	0.2	0.4	18	16	15
			MAX	117.8	31.1	4,597	17.8	30.4	33.9	820	716	630
1255	110.00	47	AV47	114.6	30.8	4,554	17.6	30.7	32.9	779	687	631
			STD	0.8	0.1	19	0.2	0.3	0.3	16	15	12
			MAX	116.5	31.2	4,610	17.8	31.1	33.5	812	725	657
1304	111.00	49	AV49	111.0	30.5	4,499	17.4	31.5	32.2	809	735	664
			STD	2.7	0.3	41	0.2	0.4	0.3	18	21	22
			MAX	115.0	30.9	4,565	17.8	32.2	32.9	853	782	711
1369	112.00	65	AV65	111.7	30.4	4,482	17.4	31.0	32.4	855	776	711
			STD	3.1	0.4	64	0.3	0.5	0.5	27	29	23
			MAX	115.8	31.1	4,587	17.9	32.1	33.2	926	857	787
1446	113.00	77	AV77	109.7	30.0	4,431	17.2	27.2	32.0	890	818	759
			STD	2.7	0.4	60	0.3	1.0	0.5	16	17	16
			MAX	113.0	30.4	4,495	17.6	29.7	32.9	930	859	796
			Average	111.7	30.8	4,545	17.4	28.2	33.3	877	803	739
			Std. Dev.	3.4	0.6	82	0.4	1.5	0.9	173	161	151
			Maximum	117.8	32.3	4,773	18.3	32.2	35.8	1,345	1,279	1,213

Total number of blows analyzed: 1444

BL#	Sensors
1-1446	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: off; A2: off; A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
1	Begin PDA Monitoring, 5/26/2016, 2:43:20 PM
1446	End driving near Tip El -137 with approximately 113 ft soil penetration, 5/26/2016, , 3:37:31 PM

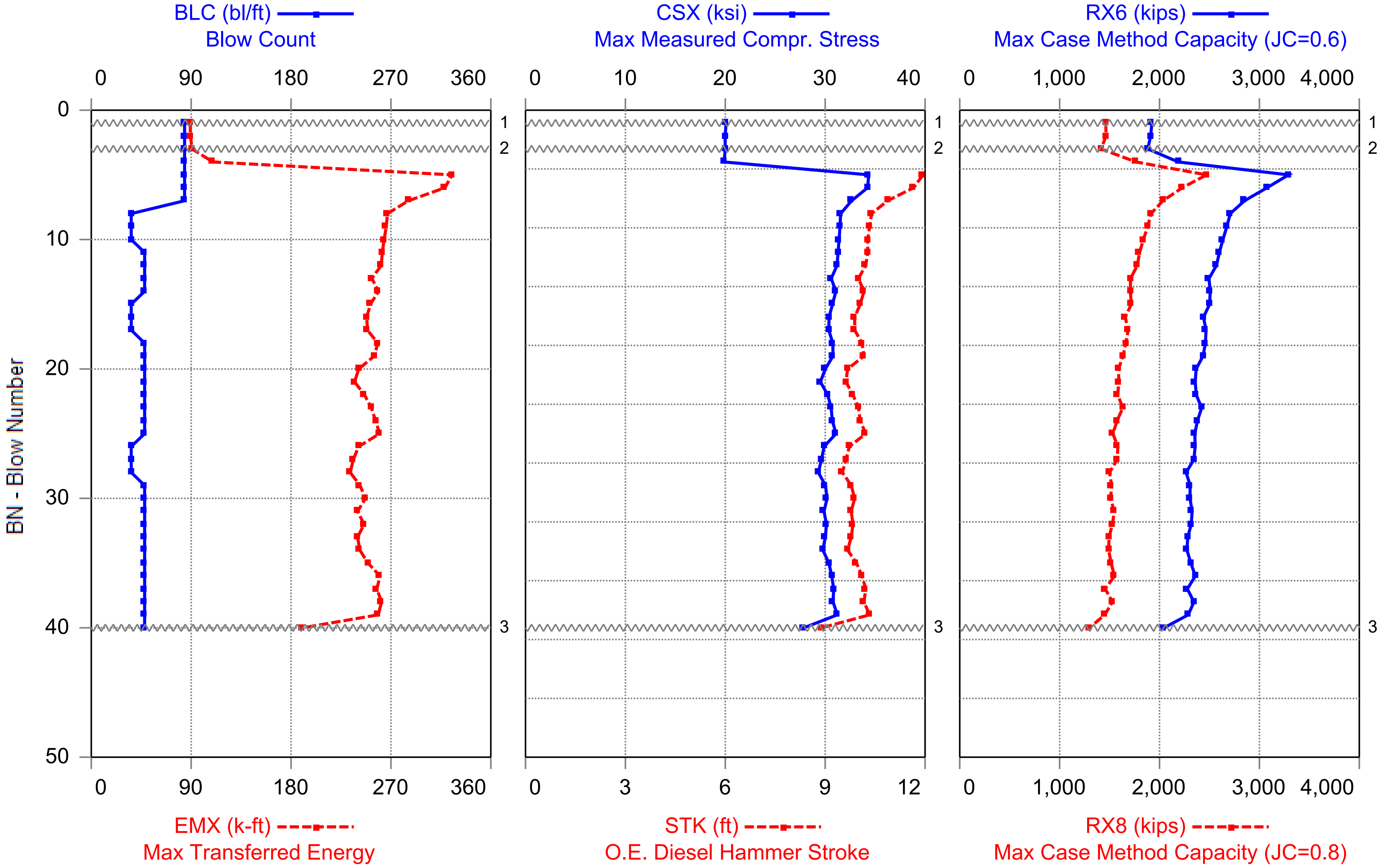
Time Summary

Drive 54 minutes 10 seconds 2:43 PM - 3:37 PM BN 1 - 1446

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 24-June-2016 Test started: 21-June-2016

KIWC, POA TPP - IP 1 RESTRIKE



1 - Start of test on 6/21/2016 at 2:48 PM

2 - End of "soft start"

3 - End of test on 6/21/2016 at 2:54 PM

KIWC, POA TPP - IP 1 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 21-June-2016

AR: 147.65 in^2 SP: 0.492 k/ft^3
LE: 178.50 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
1	84	AV1	89.2	20.1	**	1,923	1,461	20.8	2,965	1.9	925
2	84	AV1	89.3	20.0	**	1,911	1,464	20.6	2,950	1.9	1,031
3	84	AV1	90.8	20.0	**	1,882	1,415	20.6	2,950	1.9	1,043
4	84	AV1	109.6	19.9	**	2,188	1,764	20.6	2,938	1.9	1,686
5	84	AV1	325.1	34.4	11.93	3,292	2,471	35.7	5,073	34.4	2,084
6	84	AV1	318.7	34.2	11.66	3,075	2,228	35.7	5,055	34.8	1,930
7	84	AV1	285.8	32.6	10.87	2,850	2,033	34.0	4,820	36.0	1,861
8	36	AV1	266.8	31.5	10.39	2,707	1,914	32.8	4,658	36.8	1,827
9	36	AV1	265.8	31.5	10.33	2,673	1,881	32.7	4,649	36.9	1,765
10	36	AV1	263.8	31.4	10.28	2,634	1,839	32.4	4,634	37.0	1,722
11	48	AV1	262.2	31.3	10.28	2,598	1,799	32.5	4,620	37.0	1,770
12	48	AV1	261.3	31.2	10.22	2,570	1,777	32.2	4,605	37.1	1,728
13	48	AV1	252.8	30.6	10.00	2,494	1,710	31.8	4,518	37.5	1,773
14	48	AV1	258.8	31.1	10.16	2,506	1,708	32.1	4,586	37.2	1,752
15	36	AV1	251.5	30.7	10.05	2,501	1,716	31.7	4,538	37.4	1,734
16	36	AV1	248.1	30.4	9.89	2,439	1,656	31.4	4,487	37.7	1,667
17	36	AV1	248.8	30.4	9.89	2,465	1,686	31.4	4,482	37.7	1,700
18	48	AV1	258.1	30.8	10.11	2,458	1,662	31.8	4,542	37.3	1,730
19	48	AV1	254.9	30.8	10.16	2,435	1,634	31.9	4,545	37.2	1,667
20	48	AV1	240.9	30.0	9.67	2,366	1,589	30.7	4,432	38.1	1,664
21	48	AV1	237.2	29.5	9.62	2,357	1,591	30.5	4,359	38.2	1,680
22	48	AV1	246.2	30.3	9.83	2,368	1,582	31.1	4,468	37.8	1,683
23	48	AV1	252.4	30.6	10.00	2,422	1,632	31.5	4,516	37.5	1,740
24	48	AV1	256.2	30.7	10.05	2,379	1,576	31.6	4,536	37.4	1,704
25	48	AV1	259.9	31.1	10.22	2,353	1,532	31.9	4,588	37.1	1,606
26	36	AV1	240.9	29.9	9.73	2,356	1,583	30.6	4,414	38.0	1,636
27	36	AV1	236.1	29.6	9.62	2,343	1,576	30.4	4,375	38.2	1,619
28	36	AV1	233.3	29.3	9.52	2,266	1,499	30.0	4,329	38.4	1,632
29	48	AV1	242.1	30.0	9.78	2,307	1,520	30.8	4,433	37.9	1,629
30	48	AV1	247.1	30.2	9.89	2,304	1,510	31.0	4,457	37.7	1,643
31	48	AV1	239.9	29.9	9.78	2,326	1,547	30.7	4,412	37.9	1,701
32	48	AV1	245.8	30.1	9.83	2,317	1,529	30.9	4,448	37.8	1,668
33	48	AV1	239.9	30.0	9.78	2,282	1,494	30.9	4,431	37.9	1,745
34	48	AV1	242.0	29.8	9.67	2,274	1,492	30.5	4,394	38.1	1,625
35	48	AV1	249.2	30.4	9.94	2,313	1,515	31.3	4,484	37.6	1,629
36	48	AV1	260.1	30.7	10.11	2,359	1,549	31.6	4,527	37.3	1,667
37	48	AV1	257.3	30.8	10.22	2,278	1,456	31.8	4,554	37.1	1,635
38	48	AV1	261.5	30.8	10.16	2,343	1,529	31.5	4,545	37.2	1,616

KIWC, POA TPP - IP 1 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 21-June-2016

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
39	48	AV1	258.6	31.2	10.33	2,287	1,451	32.2	4,610	36.9	1,651
40	48	AV1	190.4	27.8	8.89	2,044	1,299	28.4	4,112	39.7	1,273
		Average	238.5	29.6	10.08	2,406	1,647	30.6	4,376	33.8	1,646

Total number of blows analyzed: 40

BL# Sensors

1-40 F1: [H263] 92.0 (1.00); F2: [H289] 94.0 (1.00); F3: [H283] 92.3 (1.00);
F4: [H340] 94.0 (1.00); A1: off; A2: off; A3: [K1066] 332.0 (1.00);
A4: [K1717] 368.0 (1.00)

BL# Comments

1 Start of test on 6/21/2016 at 2:48 PM
3 End of "soft start"
40 End of test on 6/21/2016 at 2:54 PM

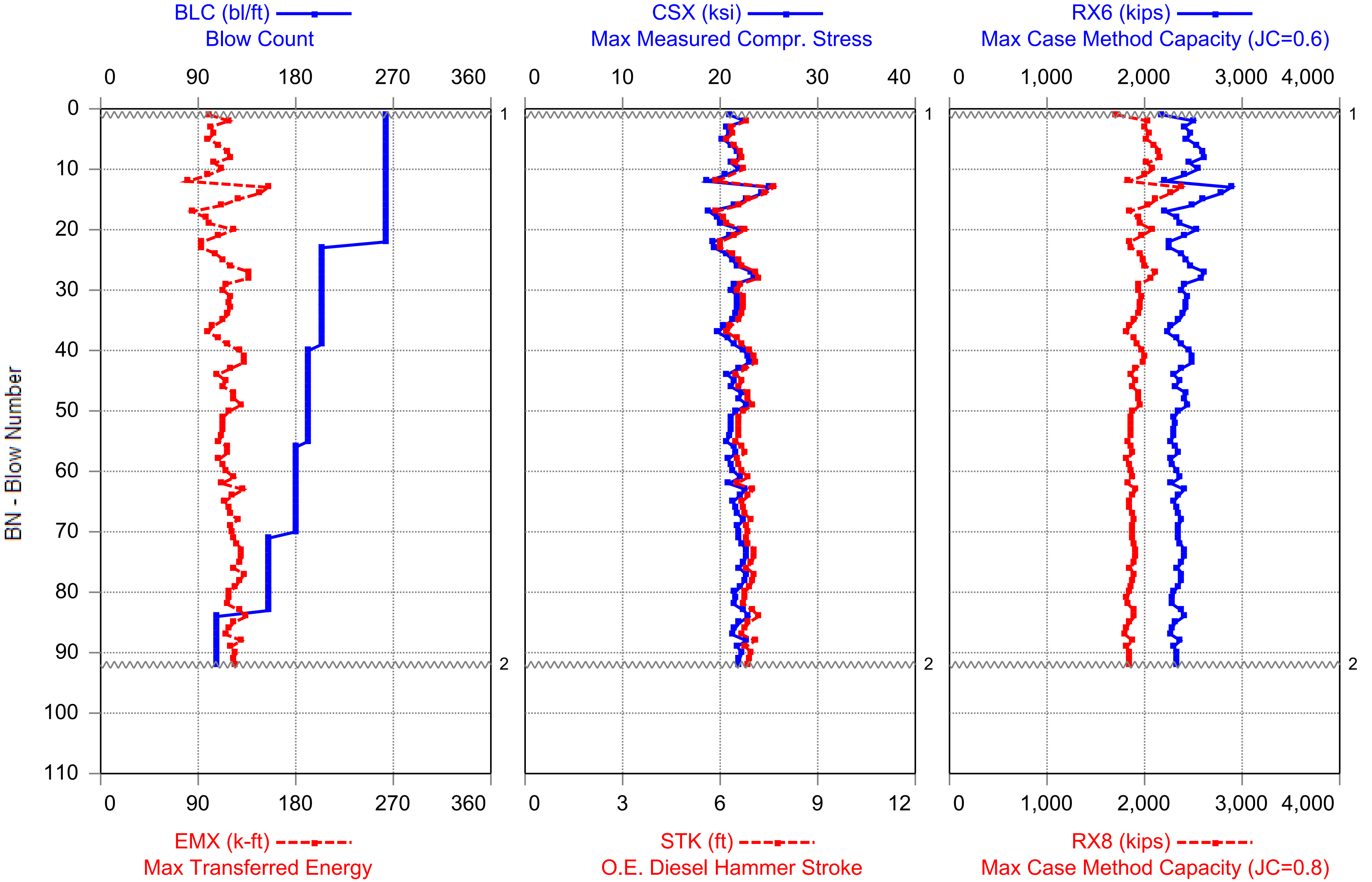
Time Summary

Drive	0 second	2:48 PM - 2:48 PM (6/21/2016) BN 1 - 1
Stop	1 minute 13 seconds	2:48 PM - 2:50 PM
Drive	0 second	2:50 PM - 2:50 PM BN 2 - 2
Stop	1 minute 10 seconds	2:50 PM - 2:51 PM
Drive	0 second	2:51 PM - 2:51 PM BN 3 - 3
Stop	2 minutes 2 seconds	2:51 PM - 2:53 PM
Drive	57 seconds	2:53 PM - 2:54 PM BN 4 - 40

Total time [00:05:24] = (Driving [00:00:57] + Stop [00:04:26])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results
Printed: 14-June-2016 Test started: 09-June-2016

KIWC, POA TPP - IP 2 RESTRIKE



1 - Start of test on 6/9/2016 at 4:19 PM
2 - End of test on 6/9/2016 at 4:24 PM

KIWC, POA TPP - IP 2 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 09-June-2016

AR: 147.65 in² SP: 0.492 k/ft³
LE: 185.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
1	264	AV1	100.1	20.9	**	2,175	1,715	22.0	3,090	1.9	1,304
2	264	AV1	118.3	22.5	6.82	2,502	2,030	24.0	3,322	45.1	1,519
3	264	AV1	101.4	20.7	6.34	2,412	1,998	22.1	3,052	46.7	1,530
4	264	AV1	105.0	21.0	6.40	2,472	2,045	22.4	3,099	46.5	1,587
5	264	AV1	99.6	20.3	6.20	2,433	2,019	21.6	2,991	47.2	1,586
6	264	AV1	109.0	21.1	6.42	2,533	2,102	22.6	3,118	46.4	1,678
7	264	AV1	116.9	21.7	6.63	2,597	2,152	23.2	3,207	45.7	1,728
8	264	AV1	120.3	22.1	6.69	2,607	2,164	23.6	3,259	45.5	1,731
9	264	AV1	105.2	21.1	6.45	2,465	2,026	22.6	3,121	46.3	1,613
10	264	AV1	112.3	21.9	6.72	2,549	2,086	23.5	3,238	45.4	1,587
11	264	AV1	98.8	20.5	**	2,412	2,002	21.9	3,024	1.9	1,582
12	264	AV1	80.3	18.7	5.88	2,211	1,837	20.0	2,761	48.4	1,440
13	264	AV1	154.6	25.1	7.64	2,890	2,377	27.0	3,700	42.7	1,908
14	264	AV1	146.7	24.3	7.39	2,786	2,265	26.1	3,589	43.4	1,823
15	264	AV1	126.5	22.6	6.88	2,599	2,121	24.3	3,344	44.9	1,737
16	264	AV1	111.4	21.5	6.57	2,488	2,037	23.2	3,176	45.9	1,690
17	264	AV1	84.4	18.8	5.86	2,213	1,841	20.2	2,783	48.5	1,505
18	264	AV1	97.3	19.7	6.12	2,334	1,935	21.2	2,916	47.5	1,629
19	264	AV1	100.7	20.1	6.20	2,363	1,958	21.6	2,970	47.2	1,660
20	264	AV1	123.1	22.1	6.79	2,533	2,075	23.8	3,263	45.2	1,729
21	264	AV1	109.0	21.0	6.42	2,405	1,972	22.6	3,098	46.4	1,680
22	264	AV1	94.0	19.3	6.01	2,248	1,853	20.7	2,854	47.9	1,576
23	204	AV1	93.1	19.4	6.01	2,262	1,868	20.8	2,864	47.9	1,576
24	204	AV1	106.5	20.6	6.40	2,382	1,964	22.2	3,045	46.5	1,672
25	204	AV1	113.1	21.3	6.57	2,430	1,985	22.9	3,139	45.9	1,710
26	204	AV1	119.9	21.7	6.69	2,467	2,010	23.3	3,208	45.5	1,730
27	204	AV1	137.0	23.3	7.11	2,611	2,112	25.0	3,434	44.2	1,804
28	204	AV1	137.4	23.5	7.18	2,583	2,074	25.2	3,463	44.0	1,632
29	204	AV1	116.0	21.5	6.63	2,408	1,946	23.1	3,176	45.7	1,681
30	204	AV1	112.6	21.1	6.54	2,379	1,936	22.7	3,117	46.0	1,689
31	204	AV1	119.8	21.8	6.72	2,441	1,975	23.4	3,220	45.4	1,722
32	204	AV1	118.7	21.7	6.72	2,426	1,963	23.4	3,211	45.4	1,698
33	204	AV1	119.5	21.7	6.72	2,424	1,960	23.4	3,210	45.4	1,690
34	204	AV1	117.6	21.6	6.66	2,393	1,934	23.2	3,191	45.6	1,663
35	204	AV1	112.9	21.3	6.57	2,354	1,899	22.8	3,141	45.9	1,647
36	204	AV1	103.5	20.4	6.31	2,268	1,842	21.9	3,005	46.8	1,609
37	204	AV1	99.5	19.8	6.23	2,232	1,818	21.2	2,926	47.1	1,628
38	204	AV1	109.5	20.8	6.51	2,325	1,890	22.3	3,072	46.1	1,651

KIWC, POA TPP - IP 2 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 09-June-2016

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
39	204	AV1	116.7	21.4	6.66	2,376	1,928	23.0	3,162	45.6	1,688
40	192	AV1	127.9	22.4	6.91	2,462	1,980	24.2	3,309	44.8	1,648
41	192	AV1	132.7	22.9	7.04	2,490	2,000	24.7	3,380	44.4	1,627
42	192	AV1	132.3	23.0	7.08	2,491	1,986	24.9	3,394	44.3	1,607
43	192	AV1	119.9	21.9	6.79	2,375	1,903	23.6	3,228	45.2	1,659
44	192	AV1	108.1	20.7	6.48	2,300	1,860	22.4	3,063	46.2	1,683
45	192	AV1	115.3	21.5	6.69	2,358	1,903	23.1	3,172	45.5	1,702
46	192	AV1	113.3	21.1	6.57	2,317	1,875	22.7	3,118	45.9	1,588
47	192	AV1	123.1	22.2	6.85	2,421	1,943	23.9	3,275	45.0	1,713
48	192	AV1	123.3	22.0	6.85	2,410	1,941	23.7	3,244	45.0	1,613
49	192	AV1	130.1	22.8	7.01	2,450	1,956	24.6	3,359	44.5	1,633
50	192	AV1	119.2	21.7	6.72	2,350	1,883	23.4	3,199	45.4	1,555
51	192	AV1	113.2	21.1	6.60	2,307	1,858	22.8	3,114	45.8	1,544
52	192	AV1	112.8	21.2	6.60	2,311	1,865	22.8	3,130	45.8	1,575
53	192	AV1	112.7	21.1	6.57	2,303	1,857	22.7	3,116	45.9	1,568
54	192	AV1	112.3	21.1	6.60	2,304	1,858	22.7	3,111	45.8	1,661
55	192	AV1	109.0	20.6	6.48	2,265	1,829	22.2	3,045	46.2	1,515
56	180	AV1	117.3	21.4	6.66	2,323	1,870	23.0	3,160	45.6	1,503
57	180	AV1	116.8	21.6	6.76	2,342	1,877	23.3	3,186	45.3	1,681
58	180	AV1	109.2	20.8	6.51	2,265	1,817	22.5	3,076	46.1	1,513
59	180	AV1	112.5	21.2	6.60	2,293	1,843	22.8	3,126	45.8	1,627
60	180	AV1	115.9	21.4	6.66	2,326	1,871	23.1	3,158	45.6	1,572
61	180	AV1	123.4	22.1	6.85	2,367	1,886	23.9	3,262	45.0	1,523
62	180	AV1	111.6	20.9	6.51	2,272	1,826	22.5	3,081	46.1	1,535
63	180	AV1	131.8	22.6	7.01	2,406	1,914	24.4	3,341	44.5	1,533
64	180	AV1	121.9	22.0	6.88	2,350	1,872	23.8	3,255	44.9	1,541
65	180	AV1	114.8	21.3	6.66	2,299	1,842	23.0	3,151	45.6	1,519
66	180	AV1	118.6	21.6	6.72	2,328	1,855	23.4	3,194	45.4	1,504
67	180	AV1	119.7	21.8	6.76	2,346	1,880	23.5	3,217	45.3	1,570
68	180	AV1	126.5	22.4	6.95	2,381	1,892	24.2	3,308	44.7	1,531
69	180	AV1	120.0	21.8	6.82	2,344	1,874	23.6	3,225	45.1	1,550
70	180	AV1	121.8	22.0	6.85	2,351	1,880	23.8	3,248	45.0	1,543
71	156	AV1	122.4	21.9	6.82	2,347	1,875	23.7	3,234	45.1	1,522
72	156	AV1	125.8	22.2	6.88	2,370	1,893	24.0	3,283	44.9	1,552
73	156	AV1	130.5	22.7	7.04	2,406	1,909	24.6	3,350	44.4	1,550
74	156	AV1	130.7	22.7	7.04	2,403	1,904	24.5	3,349	44.4	1,528
75	156	AV1	128.3	22.4	6.98	2,380	1,896	24.3	3,314	44.6	1,525
76	156	AV1	122.6	22.0	6.82	2,339	1,853	23.8	3,244	45.1	1,506
77	156	AV1	132.4	22.6	7.04	2,387	1,889	24.5	3,344	44.4	1,529
78	156	AV1	128.7	22.5	7.01	2,374	1,872	24.4	3,323	44.5	1,491
79	156	AV1	124.8	22.1	6.91	2,343	1,863	24.0	3,267	44.8	1,509
80	156	AV1	118.9	21.5	6.76	2,297	1,841	23.3	3,181	45.3	1,480
81	156	AV1	118.7	21.7	6.76	2,292	1,819	23.4	3,197	45.3	1,455
82	156	AV1	117.1	21.4	6.72	2,288	1,831	23.1	3,160	45.4	1,504
83	156	AV1	128.1	22.4	7.01	2,376	1,891	24.3	3,309	44.5	1,511
84	108	AV1	134.7	23.0	7.18	2,404	1,898	24.9	3,389	44.0	1,522

KIWC, POA TPP - IP 2 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 09-June-2016

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
85	108	AV1	122.8	22.0	6.88	2,314	1,843	23.8	3,247	44.9	1,484
86	108	AV1	118.4	21.5	6.76	2,283	1,815	23.3	3,177	45.3	1,441
87	108	AV1	115.8	21.2	6.66	2,271	1,801	23.1	3,136	45.6	1,475
88	108	AV1	129.9	22.7	7.08	2,369	1,877	24.6	3,346	44.3	1,469
89	108	AV1	120.2	21.7	6.79	2,296	1,817	23.6	3,211	45.2	1,485
90	108	AV1	125.0	22.2	6.95	2,337	1,849	24.1	3,281	44.7	1,467
91	108	AV1	122.8	22.0	6.91	2,326	1,847	23.8	3,247	44.8	1,516
92	108	AV1	124.7	22.0	6.88	2,331	1,851	23.8	3,249	44.9	1,506
		Average	117.4	21.6	6.71	2,385	1,925	23.3	3,192	44.5	1,592

Total number of blows analyzed: 92

BL# Sensors

1-92 F1: [H263] 92.0 (1.00); F2: [H289] 94.0 (1.00); F3: [H340] 94.0 (1.00);
F4: [H283] 92.3 (1.00); A1: [39148] 1075.0 (1.00); A2: [39150] 1075.0 (1.00);
A3: [K1066] 332.0 (1.00); A4: [1717] 368.0 (1.00)

BL# Comments

1 Start of test on 6/9/2016 at 4:19 PM
92 End of test on 6/9/2016 at 4:24 PM

Time Summary

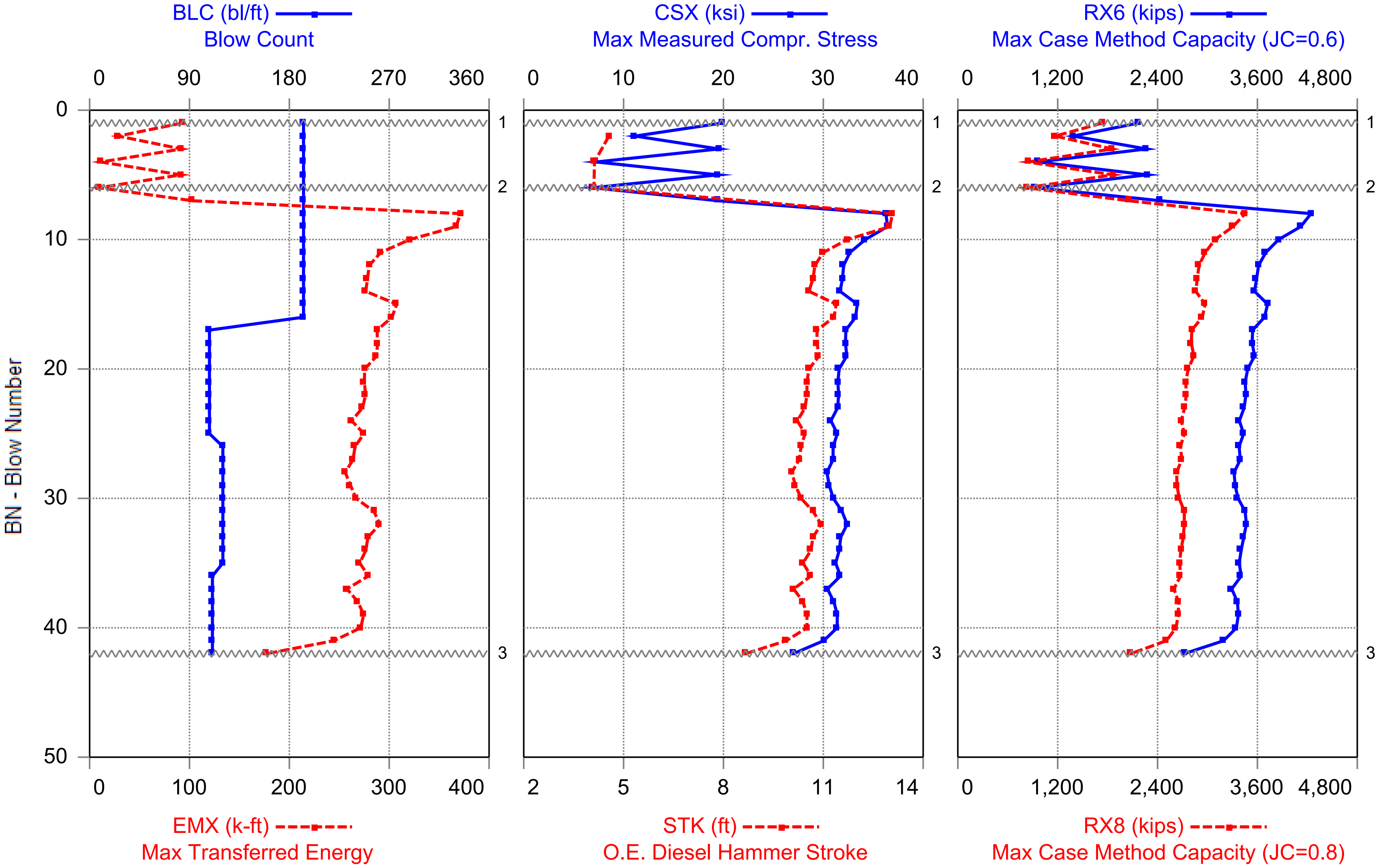
Drive 4 minutes 10 seconds 4:19 PM - 4:24 PM BN 1 - 92

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 24-June-2016

Test started: 21-June-2016

KIWC, POA TPP - IP 2 2ND RESTRIKE



1 - Start of test on 6/21/2016 at 1:33 PM

2 - End of "soft start".1:36:19 PM

3 - End of test on 6/21/2016 at 1:39 PM

KIWC, POA TPP - IP 2 2ND RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 21-June-2016

AR: 147.65 in²
LE: 185.00 ft
WS: 17,100.0 f/s
SP: 0.492 k/ft³
EM: 31,052 ksi
JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
1	193	AV1	92.6	19.9	**	2,171	1,736	21.3	2,932	1.9	1,380
2	193	AV1	28.6	11.1	4.56	1,385	1,170	11.9	1,646	54.6	1,005
3	193	AV1	92.1	19.5	**	2,268	1,854	20.9	2,883	1.9	1,434
4	193	AV1	11.3	7.2	4.13	961	841	7.8	1,070	57.2	903
5	193	AV1	91.3	19.5	**	2,275	1,864	20.9	2,875	1.9	1,449
6	193	AV1	9.4	6.9	4.11	932	825	7.4	1,016	57.3	921
7	193	AV1	103.1	19.5	**	2,437	2,052	21.0	2,873	1.9	1,749
8	193	AV1	371.3	36.3	13.08	4,243	3,451	38.4	5,355	32.9	2,364
9	193	AV1	367.0	36.4	13.00	4,120	3,306	38.7	5,379	33.0	2,319
10	193	AV1	320.5	34.2	11.72	3,854	3,090	36.4	5,051	34.7	2,193
11	193	AV1	291.4	32.6	11.00	3,701	2,973	34.9	4,821	35.8	2,120
12	193	AV1	280.0	32.0	10.75	3,613	2,897	34.4	4,730	36.2	2,039
13	193	AV1	278.3	31.9	10.69	3,590	2,876	34.3	4,713	36.3	2,058
14	193	AV1	276.4	31.7	10.57	3,565	2,859	34.0	4,676	36.5	2,017
15	193	AV1	307.4	33.4	11.39	3,722	2,970	35.9	4,932	35.2	2,155
16	193	AV1	302.9	33.2	11.32	3,685	2,937	35.6	4,904	35.3	2,117
17	108	AV1	287.8	32.3	10.81	3,543	2,811	34.7	4,762	36.1	2,074
18	108	AV1	288.2	32.2	10.81	3,536	2,806	34.6	4,756	36.1	2,084
19	108	AV1	287.4	32.3	10.87	3,566	2,836	34.9	4,775	36.0	2,085
20	108	AV1	275.5	31.6	10.57	3,483	2,768	33.9	4,664	36.5	2,046
21	108	AV1	275.0	31.4	10.51	3,452	2,738	33.9	4,643	36.6	2,043
22	108	AV1	276.3	31.5	10.51	3,461	2,745	33.9	4,656	36.6	2,024
23	108	AV1	273.3	31.4	10.45	3,440	2,725	33.9	4,641	36.7	2,037
24	108	AV1	262.4	30.8	10.22	3,382	2,685	33.1	4,541	37.1	2,004
25	108	AV1	274.7	31.4	10.45	3,434	2,721	33.9	4,637	36.7	2,023
26	120	AV1	265.7	31.0	10.33	3,380	2,674	33.4	4,574	36.9	2,017
27	120	AV1	263.8	31.0	10.28	3,393	2,690	33.4	4,573	37.0	2,022
28	120	AV1	255.9	30.4	10.05	3,319	2,629	32.7	4,482	37.4	1,983
29	120	AV1	261.2	30.6	10.16	3,331	2,633	32.9	4,516	37.2	1,997
30	120	AV1	266.7	31.0	10.33	3,367	2,660	33.3	4,577	36.9	2,014
31	120	AV1	284.6	31.9	10.69	3,452	2,722	34.4	4,705	36.3	2,049
32	120	AV1	290.7	32.4	10.93	3,466	2,720	34.9	4,781	35.9	2,053
33	120	AV1	278.7	31.7	10.69	3,435	2,709	34.1	4,687	36.3	2,030
34	120	AV1	276.6	31.6	10.63	3,404	2,680	34.1	4,665	36.4	2,034
35	120	AV1	270.5	31.2	10.39	3,381	2,666	33.6	4,612	36.8	1,997
36	111	AV1	279.1	31.7	10.63	3,405	2,675	34.2	4,683	36.4	2,000
37	111	AV1	257.7	30.4	10.11	3,292	2,595	32.9	4,491	37.3	1,962
38	111	AV1	268.7	31.0	10.39	3,359	2,651	33.5	4,585	36.8	2,004

KIWC, POA TPP - IP 2 2ND RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 21-June-2016

BL#	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
39	111	AV1	274.4	31.4	10.51	3,370	2,648	33.9	4,636	36.6	2,020
40	111	AV1	271.4	31.4	10.51	3,347	2,621	33.7	4,634	36.6	1,970
41	111	AV1	244.6	30.0	9.89	3,194	2,507	32.3	4,436	37.7	1,889
42	111	AV1	177.1	27.0	8.66	2,719	2,077	29.1	3,986	40.2	1,519
		Average	243.1	29.0	10.18	3,201	2,550	31.1	4,275	34.5	1,910

Total number of blows analyzed: 42

BL# Sensors

1-42 F1: [1458W] 129.0 (1.00); F2: [1463W] 127.0 (1.00); F3: [H278] 99.0 (1.00);
F4: [H324] 93.0 (1.00); A1: [W10287] 970.0 (1.00); A2: [W10356] 980.0 (1.00);
A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

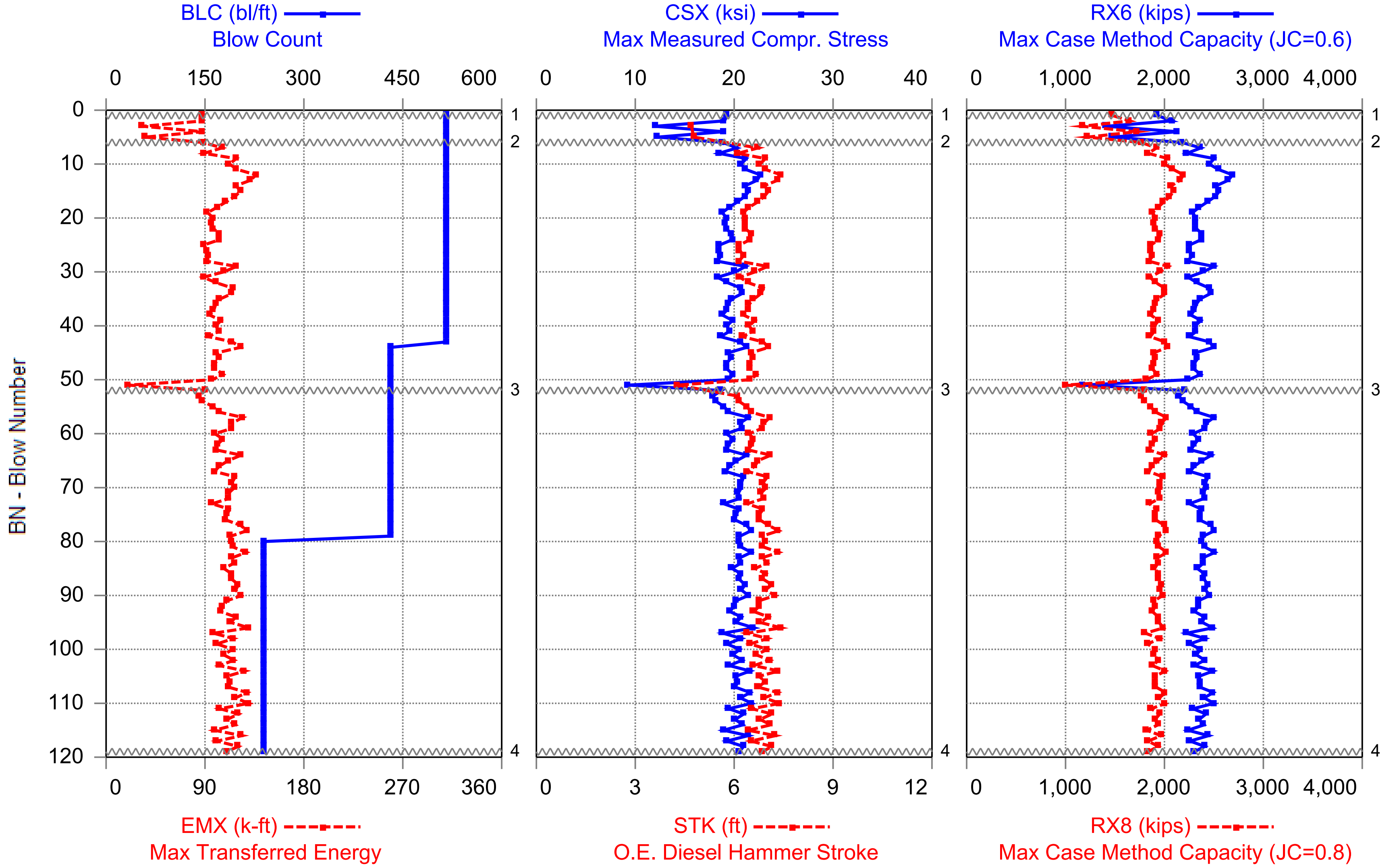
BL#	Comments
1	Start of test on 6/21/2016 at 1:33 PM
6	End of "soft start".1:36:19 PM
42	End of test on 6/21/2016 at 1:39 PM

Time Summary

Drive	1 second	1:33 PM - 1:34 PM (6/21/2016) BN 1 - 2
Stop	1 minute 11 seconds	1:34 PM - 1:35 PM
Drive	1 second	1:35 PM - 1:35 PM BN 3 - 4
Stop	1 minute 6 seconds	1:35 PM - 1:36 PM
Drive	1 second	1:36 PM - 1:36 PM BN 5 - 6
Stop	1 minute 56 seconds	1:36 PM - 1:38 PM
Drive	57 seconds	1:38 PM - 1:39 PM BN 7 - 42

Total time [00:05:14] = (Driving [00:01:00] + Stop [00:04:13])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results
Printed: 17-June-2016
Test started: 16-June-2016
KIWC, POA TPP - IP 3 Restirke



1 - Start of test on 6/16/2016 at 12:17 PM
2 - End of "soft starts".

3 - Restart after 2 minutes 29 seconds
4 - End of test on 6/16/2016 at 12:26 PM

KIWC, POA TPP - IP 3 Restirke PP48x1.0", APE D180-42
OP: RMDT Date: 16-June-2016

AR: 147.65 in² SP: 0.492 k/ft³
LE: 188.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
1	516	AV1	88.2	19.3	**	1,931	1,478	20.4	2,848	1.9	1,122
2	516	AV1	88.3	19.0	**	2,075	1,647	20.2	2,809	1.9	1,255
3	516	AV1	33.5	12.0	4.70	1,416	1,170	12.8	1,773	53.8	858
4	516	AV1	88.1	18.9	**	2,132	1,716	20.1	2,796	1.9	1,269
5	516	AV1	35.6	12.3	4.78	1,476	1,225	13.1	1,814	53.4	898
6	516	AV1	88.8	18.9	**	2,178	1,767	20.1	2,785	1.9	1,319
7	516	AV1	105.4	20.3	6.72	2,367	1,921	21.7	2,996	45.4	1,427
8	516	AV1	89.2	18.5	6.12	2,226	1,835	19.7	2,725	47.5	1,386
9	516	AV1	118.4	21.2	6.95	2,503	2,038	22.8	3,135	44.7	1,531
10	516	AV1	112.3	20.7	6.79	2,452	2,002	22.2	3,057	45.2	1,545
11	516	AV1	119.4	21.2	6.95	2,545	2,089	22.9	3,127	44.7	1,591
12	516	AV1	136.5	22.6	7.42	2,688	2,192	24.6	3,344	43.3	1,652
13	516	AV1	131.5	22.3	7.32	2,645	2,157	24.3	3,295	43.6	1,630
14	516	AV1	118.3	21.1	6.91	2,525	2,071	22.8	3,121	44.8	1,616
15	516	AV1	122.3	21.5	7.04	2,556	2,091	23.4	3,173	44.4	1,609
16	516	AV1	117.5	21.1	6.91	2,514	2,056	22.8	3,113	44.8	1,622
17	516	AV1	109.4	20.3	6.72	2,435	1,996	22.2	3,003	45.4	1,565
18	516	AV1	101.2	19.5	6.45	2,353	1,934	20.9	2,882	46.3	1,528
19	516	AV1	92.4	18.8	6.28	2,282	1,882	20.5	2,776	46.9	1,479
20	516	AV1	97.6	19.2	6.37	2,321	1,908	20.5	2,842	46.6	1,497
21	516	AV1	96.1	19.1	6.34	2,310	1,901	20.9	2,818	46.7	1,508
22	516	AV1	98.0	19.2	6.34	2,325	1,912	20.4	2,839	46.7	1,519
23	516	AV1	103.5	19.7	6.54	2,382	1,958	21.6	2,915	46.0	1,561
24	516	AV1	103.6	19.9	6.48	2,373	1,946	21.1	2,931	46.2	1,551
25	516	AV1	89.1	18.5	6.17	2,255	1,863	20.3	2,737	47.3	1,482
26	516	AV1	91.9	18.5	6.17	2,255	1,860	19.7	2,736	47.3	1,513
27	516	AV1	92.8	18.7	6.28	2,281	1,884	20.5	2,758	46.9	1,516
28	516	AV1	91.3	18.3	6.14	2,233	1,842	19.5	2,703	47.4	1,519
29	516	AV1	118.6	21.2	7.01	2,501	2,041	23.3	3,124	44.5	1,590
30	516	AV1	107.2	20.1	6.63	2,392	1,952	21.6	2,972	45.7	1,566
31	516	AV1	88.5	18.3	6.17	2,239	1,852	20.1	2,705	47.3	1,475
32	516	AV1	100.1	19.3	6.42	2,328	1,913	20.7	2,855	46.4	1,569
33	516	AV1	115.3	20.7	6.88	2,454	2,001	22.8	3,052	44.9	1,603
34	516	AV1	114.7	20.8	6.82	2,466	2,011	22.3	3,071	45.1	1,596
35	516	AV1	103.8	19.7	6.60	2,359	1,931	21.8	2,914	45.8	1,546
36	516	AV1	99.7	19.4	6.45	2,321	1,903	20.7	2,860	46.3	1,552
37	516	AV1	98.2	19.3	6.42	2,307	1,890	21.3	2,851	46.4	1,529
38	516	AV1	94.3	18.8	6.28	2,266	1,861	20.1	2,776	46.9	1,530

KIWC, POA TPP - IP 3 Restirke PP48x1.0", APE D180-42
OP: RMDT Date: 16-June-2016

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
39	516	AV1	104.7	19.8	6.63	2,370	1,940	21.9	2,928	45.7	1,585
40	516	AV1	99.8	19.3	6.45	2,310	1,897	20.6	2,846	46.3	1,562
41	516	AV1	102.9	19.5	6.57	2,325	1,898	21.5	2,886	45.9	1,479
42	516	AV1	93.1	18.6	6.25	2,252	1,855	19.9	2,750	47.0	1,542
43	516	AV1	115.1	20.6	6.88	2,455	2,006	22.8	3,044	44.9	1,596
44	432	AV1	122.3	21.3	7.04	2,499	2,029	22.8	3,139	44.4	1,654
45	432	AV1	101.0	19.4	6.51	2,315	1,893	21.5	2,865	46.1	1,535
46	432	AV1	103.5	19.7	6.57	2,339	1,909	21.2	2,905	45.9	1,573
47	432	AV1	98.7	19.2	6.48	2,300	1,887	21.3	2,836	46.2	1,499
48	432	AV1	99.6	19.3	6.48	2,297	1,878	20.6	2,845	46.2	1,529
49	432	AV1	106.7	19.9	6.69	2,367	1,932	22.0	2,939	45.5	1,563
50	432	AV1	96.8	19.4	6.48	2,244	1,812	20.8	2,868	46.2	1,441
51	432	AV1	20.6	9.3	4.28	1,180	1,001	10.3	1,375	56.2	878
52	432	AV1	90.0	18.7	**	2,208	1,801	20.4	2,765	1.9	1,458
53	432	AV1	84.4	17.9	6.09	2,147	1,763	19.4	2,637	47.6	1,449
54	432	AV1	88.1	18.2	6.14	2,188	1,796	19.9	2,681	47.4	1,473
55	432	AV1	97.6	19.0	6.40	2,272	1,858	20.5	2,806	46.5	1,547
56	432	AV1	103.0	19.4	6.51	2,332	1,911	21.3	2,869	46.1	1,543
57	432	AV1	124.6	21.5	7.08	2,501	2,023	23.2	3,168	44.3	1,559
58	432	AV1	115.0	20.6	6.91	2,424	1,972	22.9	3,044	44.8	1,540
59	432	AV1	115.0	20.8	6.85	2,417	1,964	22.3	3,066	45.0	1,623
60	432	AV1	99.0	19.2	6.45	2,289	1,871	21.3	2,836	46.3	1,496
61	432	AV1	106.6	20.0	6.60	2,345	1,907	21.4	2,948	45.8	1,517
62	432	AV1	101.2	19.4	6.54	2,302	1,878	21.4	2,868	46.0	1,551
63	432	AV1	100.4	19.3	6.42	2,267	1,842	20.6	2,852	46.4	1,503
64	432	AV1	122.8	21.3	7.11	2,475	2,005	23.5	3,140	44.2	1,579
65	432	AV1	111.2	20.3	6.72	2,379	1,933	21.7	2,991	45.4	1,515
66	432	AV1	103.3	19.6	6.63	2,306	1,877	21.7	2,888	45.7	1,486
67	432	AV1	98.6	19.1	6.40	2,258	1,839	20.5	2,826	46.5	1,486
68	432	AV1	117.6	21.0	7.01	2,441	1,981	23.3	3,094	44.5	1,636
69	432	AV1	114.8	20.7	6.88	2,417	1,955	22.1	3,064	44.9	1,569
70	432	AV1	116.9	20.7	6.98	2,423	1,965	23.0	3,061	44.6	1,573
71	432	AV1	111.6	20.4	6.82	2,390	1,943	21.9	3,016	45.1	1,588
72	432	AV1	112.3	20.6	6.91	2,404	1,953	22.9	3,041	44.8	1,596
73	432	AV1	96.5	18.9	6.40	2,252	1,846	20.2	2,797	46.5	1,563
74	432	AV1	112.1	20.5	6.88	2,376	1,921	22.9	3,026	44.9	1,526
75	432	AV1	110.3	20.2	6.76	2,358	1,910	21.4	2,979	45.3	1,571
76	432	AV1	109.2	20.1	6.79	2,356	1,914	22.4	2,971	45.2	1,525
77	432	AV1	122.5	21.2	7.04	2,471	2,001	22.7	3,137	44.4	1,579
78	432	AV1	128.3	21.7	7.35	2,507	2,022	24.2	3,207	43.5	1,632
79	432	AV1	113.8	20.6	6.85	2,394	1,937	22.1	3,042	45.0	1,592
80	240	AV1	113.9	20.5	6.95	2,379	1,926	22.8	3,025	44.7	1,499
81	240	AV1	115.3	20.7	6.88	2,406	1,946	22.0	3,055	44.9	1,590
82	240	AV1	127.6	21.7	7.35	2,511	2,027	24.2	3,210	43.5	1,574
83	240	AV1	114.8	20.6	6.85	2,389	1,931	22.0	3,040	45.0	1,587
84	240	AV1	116.7	20.7	7.01	2,395	1,934	23.1	3,057	44.5	1,524

KIWC, POA TPP - IP 3 Restirke PP48x1.0", APE D180-42
OP: RMDT Date: 16-June-2016

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
85	240	AV1	107.1	19.8	6.63	2,333	1,901	21.3	2,920	45.7	1,561
86	240	AV1	114.4	20.7	6.98	2,404	1,945	23.1	3,059	44.6	1,529
87	240	AV1	114.5	20.5	6.88	2,401	1,947	22.0	3,028	44.9	1,584
88	240	AV1	120.5	21.1	7.14	2,437	1,968	23.5	3,115	44.1	1,614
89	240	AV1	117.8	20.7	6.95	2,416	1,959	22.2	3,063	44.7	1,577
90	240	AV1	123.3	21.4	7.25	2,460	1,983	24.0	3,167	43.8	1,561
91	240	AV1	109.9	20.2	6.76	2,341	1,896	21.7	2,981	45.3	1,536
92	240	AV1	106.6	20.0	6.76	2,343	1,906	22.3	2,951	45.3	1,498
93	240	AV1	104.1	19.6	6.60	2,306	1,877	20.9	2,889	45.8	1,554
94	240	AV1	118.1	20.8	7.04	2,404	1,939	23.1	3,065	44.4	1,593
95	240	AV1	113.5	20.2	6.79	2,382	1,944	21.6	2,980	45.2	1,583
96	240	AV1	130.1	22.0	7.42	2,489	1,991	24.5	3,249	43.3	1,610
97	240	AV1	97.9	18.9	6.40	2,222	1,807	20.2	2,788	46.5	1,489
98	240	AV1	115.9	20.7	7.01	2,411	1,953	23.1	3,060	44.5	1,510
99	240	AV1	100.9	19.3	6.48	2,256	1,831	20.7	2,845	46.2	1,513
100	240	AV1	115.2	20.6	7.01	2,366	1,908	23.0	3,040	44.5	1,565
101	240	AV1	106.8	19.8	6.66	2,322	1,887	21.3	2,931	45.6	1,573
102	240	AV1	116.6	20.8	7.08	2,406	1,944	23.3	3,074	44.3	1,512
103	240	AV1	103.2	19.5	6.60	2,304	1,877	20.7	2,880	45.8	1,556
104	240	AV1	126.4	21.6	7.35	2,493	2,010	24.2	3,192	43.5	1,582
105	240	AV1	110.1	20.2	6.76	2,351	1,904	21.6	2,978	45.3	1,580
106	240	AV1	113.4	20.4	6.95	2,362	1,911	22.7	3,017	44.7	1,567
107	240	AV1	111.3	20.1	6.72	2,357	1,914	21.5	2,966	45.4	1,544
108	240	AV1	128.3	21.6	7.32	2,494	2,011	24.1	3,192	43.6	1,647
109	240	AV1	117.7	20.6	6.91	2,400	1,946	22.1	3,045	44.8	1,577
110	240	AV1	129.6	21.8	7.39	2,502	2,011	24.3	3,217	43.4	1,670
111	240	AV1	103.8	19.5	6.54	2,289	1,866	20.8	2,874	46.0	1,573
112	240	AV1	120.5	21.0	7.14	2,420	1,953	23.4	3,096	44.1	1,602
113	240	AV1	110.2	20.1	6.79	2,350	1,904	21.5	2,968	45.2	1,580
114	240	AV1	117.4	20.9	7.11	2,401	1,934	23.2	3,081	44.2	1,486
115	240	AV1	98.7	18.9	6.42	2,238	1,821	20.2	2,795	46.4	1,526
116	240	AV1	123.5	21.4	7.25	2,445	1,966	23.8	3,161	43.8	1,630
117	240	AV1	101.1	19.3	6.51	2,259	1,836	20.5	2,843	46.1	1,491
118	240	AV1	120.2	21.0	7.14	2,408	1,938	23.4	3,094	44.1	1,604
119	240	AV1	109.6	20.5	6.85	2,299	1,832	21.9	3,028	45.0	1,430
		Average	106.4	19.9	6.69	2,336	1,901	21.6	2,934	43.8	1,523

Total number of blows analyzed: 119

BL#	Sensors
1-119	F1: [1458W] 129.0 (1.00); F2: [1463W] 127.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: [W10287] 970.0 (1.00); A2: [W10356] 980.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
1	Start of test on 6/16/2016 at 12:17 PM
6	End of "soft starts".
52	Restart after 2 minutes 29 seconds
119	End of test on 6/16/2016 at 12:26 PM

Time Summary

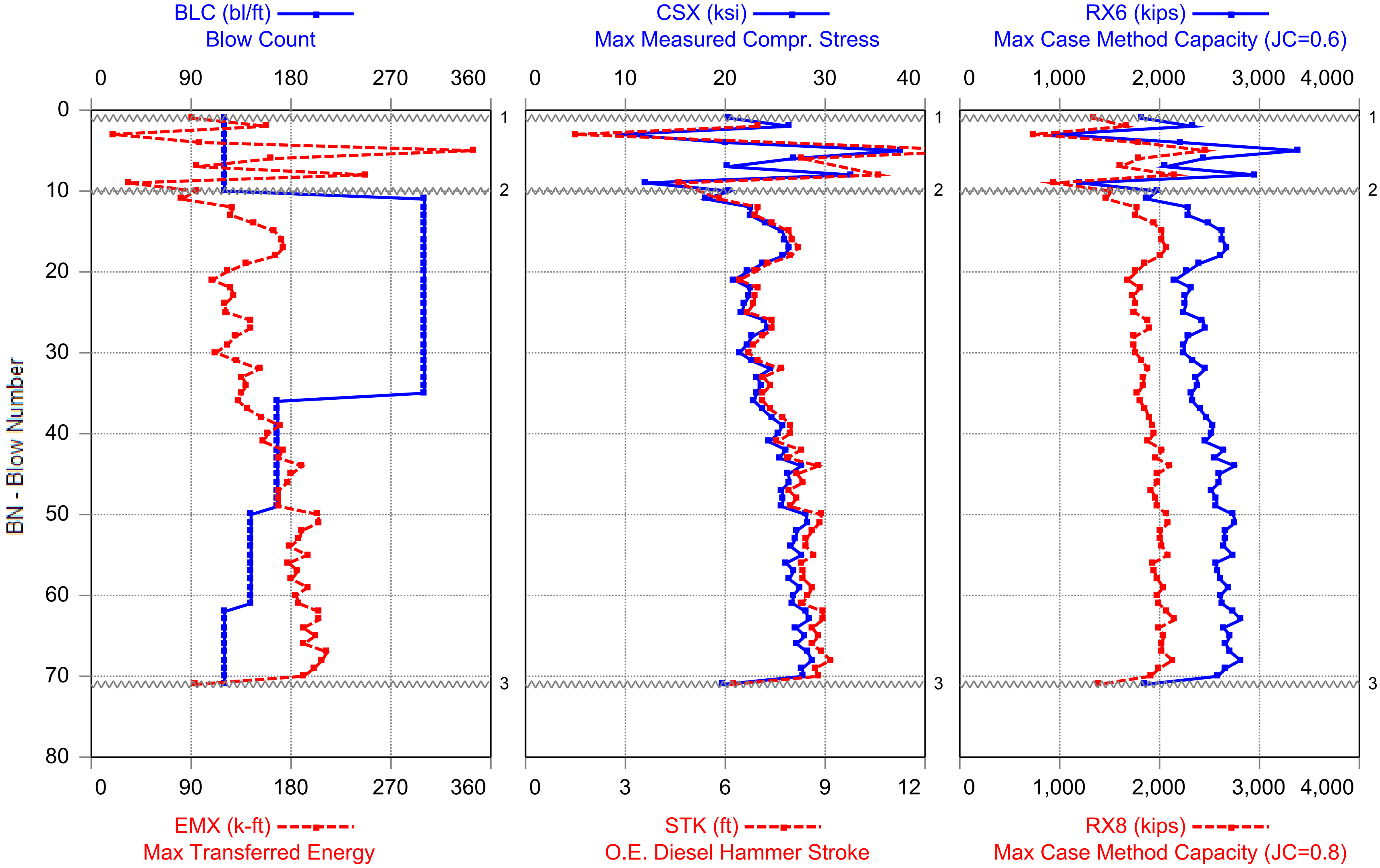
Drive	0 second	12:17 PM - 12:17 PM (6/16/2016) BN 1 - 1
Stop	1 minute 10 seconds	12:17 PM - 12:18 PM
Drive	1 minute 2 seconds	12:18 PM - 12:19 PM BN 2 - 5
Stop	1 minute 30 seconds	12:19 PM - 12:21 PM
Drive	58 seconds	12:21 PM - 12:22 PM BN 6 - 51
Stop	2 minutes 29 seconds	12:22 PM - 12:24 PM
Drive	1 minute 29 seconds	12:24 PM - 12:26 PM BN 52 - 119

Total time [00:08:40] = (Driving [00:03:29] + Stop [00:05:10])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 15-June-2016 Test started: 15-June-2016

KIWC, POA TPP - IP 4 RESTRIKE



1 - Start of test on 6/15/2016 at 11:06 AM

3 - End of test on 6/15/2016 at 11:12 AM

2 - End of "soft starts". IP 4 advanced 1 inch during soft start blows.

KIWC, POA TPP - IP 4 RESTRIKE
PP48x1.0", APE D180-42
OP: RMDT
Date: 15-June-2016

AR: 147.65 in^2
LE: 189.00 ft
WS: 17,100.0 f/s
SP: 0.492 k/ft^3
EM: 31,052 ksi
JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
1	120	AV1	90.5	20.3	**	1,828	1,347	22.0	3,000	1.9	948
2	120	AV1	158.2	26.5	6.98	2,330	1,666	28.4	3,909	44.6	1,156
3	120	AV1	19.6	9.4	1.49	954	734	10.2	1,385	90.0	483
4	120	AV1	98.5	20.0	**	2,216	1,790	21.7	2,957	1.9	1,446
5	120	AV1	344.1	37.5	13.66	3,387	2,454	40.5	5,534	32.2	1,616
6	120	AV1	162.5	26.8	8.31	2,445	1,796	28.6	3,958	41.0	1,288
7	120	AV1	95.6	20.2	**	2,062	1,610	21.5	2,981	1.9	1,241
8	120	AV1	247.3	32.5	10.63	2,952	2,148	35.0	4,802	36.4	1,386
9	120	AV1	33.4	12.0	4.61	1,209	946	12.9	1,773	54.3	737
10	120	AV1	95.1	20.4	**	1,979	1,514	21.4	3,012	1.9	1,177
11	300	AV1	81.1	18.1	5.83	1,875	1,469	19.4	2,671	48.6	1,289
12	300	AV1	127.4	22.6	6.98	2,291	1,769	24.3	3,336	44.6	1,452
13	300	AV1	126.1	22.5	6.91	2,282	1,766	24.0	3,320	44.8	1,494
14	300	AV1	146.7	24.1	7.42	2,490	1,942	25.9	3,560	43.3	1,550
15	300	AV1	165.1	25.7	7.91	2,623	2,032	27.5	3,794	42.0	1,635
16	300	AV1	172.0	26.0	8.03	2,622	2,018	27.9	3,840	41.7	1,499
17	300	AV1	173.3	26.5	8.19	2,680	2,070	28.4	3,909	41.3	1,694
18	300	AV1	166.6	25.8	7.99	2,606	2,006	27.7	3,817	41.8	1,539
19	300	AV1	139.6	23.7	7.28	2,394	1,848	25.3	3,502	43.7	1,531
20	300	AV1	122.4	22.2	6.88	2,275	1,769	23.7	3,282	44.9	1,382
21	300	AV1	109.2	20.9	6.42	2,155	1,683	22.2	3,084	46.4	1,399
22	300	AV1	126.1	22.5	6.98	2,316	1,804	24.0	3,317	44.6	1,442
23	300	AV1	128.1	22.4	6.88	2,257	1,736	23.9	3,304	44.9	1,412
24	300	AV1	120.1	21.9	6.85	2,263	1,768	23.4	3,233	45.0	1,432
25	300	AV1	121.5	21.7	6.66	2,244	1,750	23.1	3,199	45.6	1,475
26	300	AV1	143.9	24.0	7.42	2,434	1,878	25.7	3,544	43.3	1,486
27	300	AV1	143.2	24.2	7.42	2,453	1,898	25.8	3,568	43.3	1,568
28	300	AV1	129.7	22.7	7.11	2,281	1,752	24.3	3,350	44.2	1,349
29	300	AV1	122.7	22.2	6.85	2,249	1,743	23.7	3,273	45.0	1,410
30	300	AV1	112.3	21.4	6.69	2,240	1,759	22.9	3,164	45.5	1,408
31	300	AV1	131.0	22.7	7.01	2,342	1,826	24.2	3,351	44.5	1,553
32	300	AV1	151.7	24.5	7.68	2,458	1,882	26.2	3,625	42.6	1,519
33	300	AV1	135.7	23.2	7.14	2,370	1,844	24.6	3,420	44.1	1,543
34	300	AV1	140.4	23.6	7.35	2,383	1,835	25.2	3,482	43.5	1,471
35	300	AV1	135.0	23.1	7.14	2,319	1,783	24.7	3,413	44.1	1,519
36	168	AV1	132.7	22.9	7.14	2,330	1,805	24.4	3,383	44.1	1,424
37	168	AV1	141.2	23.7	7.35	2,404	1,862	25.3	3,505	43.5	1,566
38	168	AV1	154.2	24.6	7.72	2,470	1,894	26.3	3,639	42.5	1,495

KIWC, POA TPP - IP 4 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 15-June-2016

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
39	168	AV1	169.7	25.7	7.99	2,536	1,929	27.4	3,798	41.8	1,581
40	168	AV1	158.9	25.3	7.95	2,527	1,940	27.0	3,736	41.9	1,560
41	168	AV1	155.3	24.4	7.57	2,457	1,890	26.0	3,599	42.9	1,573
42	168	AV1	172.7	26.1	8.27	2,641	2,032	27.9	3,851	41.1	1,603
43	168	AV1	168.7	25.4	7.87	2,553	1,966	27.0	3,751	42.1	1,612
44	168	AV1	190.0	27.6	8.79	2,752	2,106	29.6	4,077	39.9	1,647
45	168	AV1	180.3	26.3	8.15	2,597	1,976	28.1	3,885	41.4	1,596
46	168	AV1	177.2	26.4	8.36	2,600	1,977	28.2	3,903	40.9	1,515
47	168	AV1	169.1	25.6	7.91	2,518	1,917	27.3	3,779	42.0	1,547
48	168	AV1	169.2	25.8	8.15	2,569	1,965	27.5	3,815	41.4	1,587
49	168	AV1	169.6	25.6	7.95	2,571	1,976	27.3	3,782	41.9	1,606
50	144	AV1	204.4	28.0	8.89	2,738	2,074	29.7	4,140	39.7	1,680
51	144	AV1	205.0	28.2	8.84	2,759	2,091	30.0	4,169	39.8	1,682
52	144	AV1	189.8	27.2	8.61	2,652	2,007	28.8	4,012	40.3	1,618
53	144	AV1	187.6	27.0	8.44	2,653	2,015	28.6	3,992	40.7	1,621
54	144	AV1	179.2	26.6	8.44	2,652	2,029	28.2	3,928	40.7	1,626
55	144	AV1	194.8	27.7	8.66	2,732	2,082	29.4	4,083	40.2	1,692
56	144	AV1	177.9	26.1	8.27	2,559	1,937	27.7	3,858	41.1	1,560
57	144	AV1	186.2	26.8	8.36	2,582	1,944	28.4	3,962	40.9	1,599
58	144	AV1	180.5	26.4	8.36	2,606	1,981	28.0	3,899	40.9	1,598
59	144	AV1	195.0	27.5	8.61	2,687	2,036	29.2	4,060	40.3	1,630
60	144	AV1	184.6	26.8	8.48	2,609	1,973	28.4	3,956	40.6	1,549
61	144	AV1	187.0	26.7	8.31	2,623	1,992	28.5	3,949	41.0	1,653
62	120	AV1	204.9	28.1	8.93	2,736	2,069	29.7	4,142	39.6	1,659
63	120	AV1	205.5	28.4	8.93	2,816	2,153	30.1	4,191	39.6	1,725
64	120	AV1	191.1	27.1	8.61	2,641	1,994	28.7	4,001	40.3	1,602
65	120	AV1	201.8	28.0	8.79	2,708	2,044	29.7	4,132	39.9	1,683
66	120	AV1	191.7	27.1	8.61	2,663	2,021	28.7	4,008	40.3	1,610
67	120	AV1	212.6	28.2	8.89	2,709	2,031	29.9	4,166	39.7	1,672
68	120	AV1	208.1	28.7	9.17	2,810	2,131	30.4	4,237	39.1	1,710
69	120	AV1	201.1	27.7	8.70	2,662	1,999	29.6	4,091	40.1	1,631
70	120	AV1	191.3	27.8	8.79	2,583	1,909	29.5	4,111	39.9	1,487
71	120	AV1	93.8	19.8	6.23	1,858	1,387	21.0	2,926	47.1	1,129
		Average	157.7	24.7	7.82	2,448	1,870	26.4	3,650	40.7	1,491

Total number of blows analyzed: 71

BL#	Sensors
1-71	F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: [7734] 1060.0 (1.00); A2: off; A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
1	Start of test on 6/15/2016 at 11:06 AM
10	End of "soft starts". IP 4 advanced 1 inch during soft start blows.

71 End of test on 6/15/2016 at 11:12 AM

Time Summary

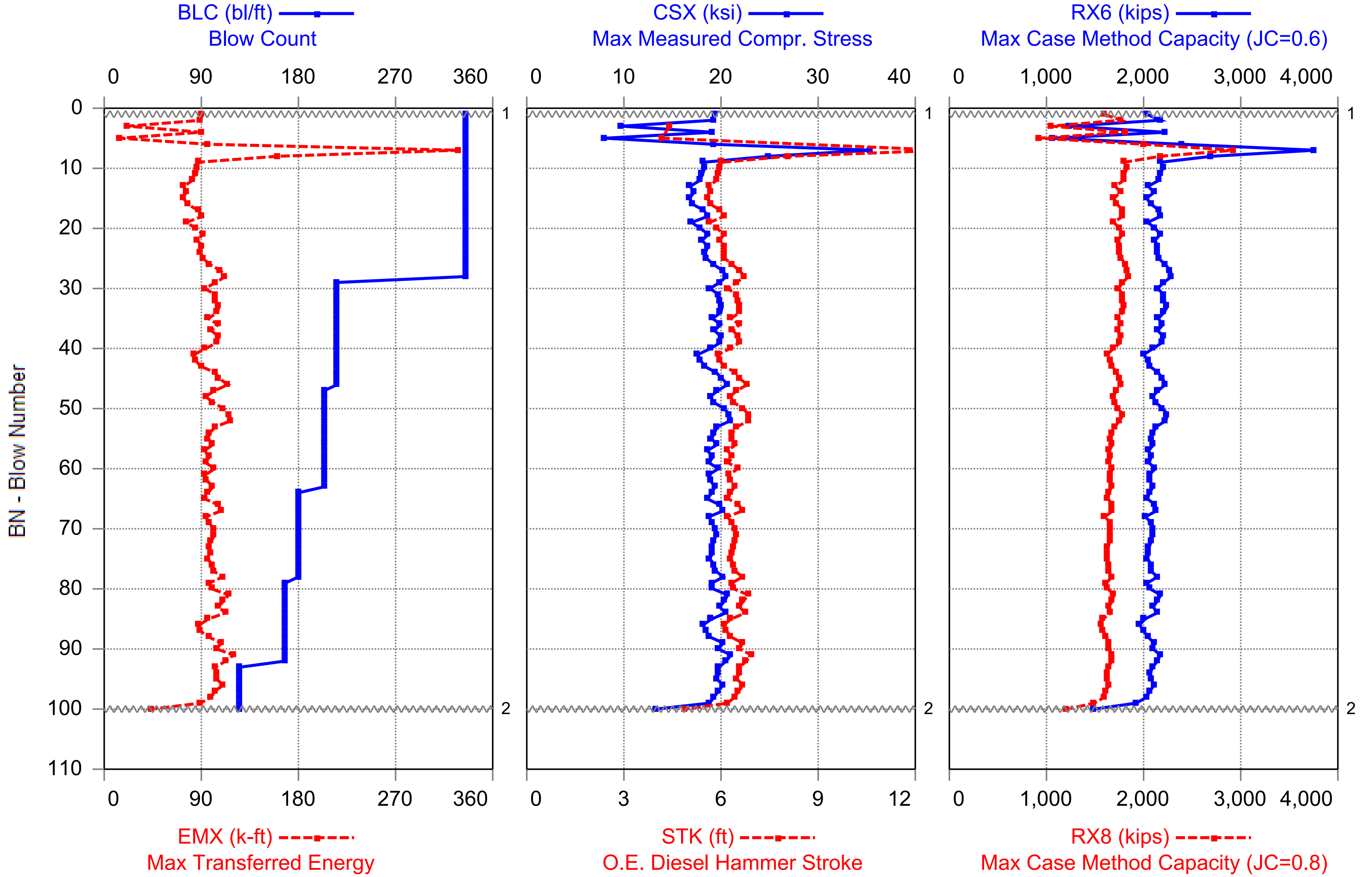
Drive	2 seconds	11:06 AM - 11:06 AM (6/15/2016) BN 1 - 3
Stop	1 minute 18 seconds	11:06 AM - 11:07 AM
Drive	3 seconds	11:07 AM - 11:07 AM BN 4 - 6
Stop	1 minute 19 seconds	11:07 AM - 11:09 AM
Drive	2 seconds	11:09 AM - 11:09 AM BN 7 - 9
Stop	1 minute 31 seconds	11:09 AM - 11:10 AM
Drive	1 minute 26 seconds	11:10 AM - 11:12 AM BN 10 - 71

Total time [00:05:44] = (Driving [00:01:34] + Stop [00:04:09])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 14-June-2016 Test started: 09-June-2016

KIWC, POA TPP - IP 5 RESTRIKE



1 - Start of test on 6/9/2016 at 4:04 PM

2 - End of test on 6/9/2016 at 4:10 PM

KIWC, POA TPP - IP 5 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 09-June-2016

AR: 147.65 in^2 SP: 0.492 k/ft^3
LE: 185.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
1	144.0	336	AV1	90.4	19.4	**	2,029	1,593	22.2	2,866	1.9	1,266
2	144.0	336	AV1	89.7	19.2	**	2,175	1,765	21.7	2,836	1.9	1,410
3	144.0	336	AV1	21.9	9.8	4.40	1,232	1,049	11.0	1,443	55.5	964
4	144.0	336	AV1	90.0	19.1	**	2,222	1,817	21.6	2,827	1.9	1,454
5	144.0	336	AV1	14.8	8.1	4.19	1,065	923	9.1	1,189	56.8	877
6	144.0	336	AV1	96.6	19.2	**	2,391	2,004	21.7	2,836	1.9	1,774
7	144.0	336	AV1	328.1	35.4	12.91	3,761	2,930	39.9	5,229	33.1	2,396
8	144.0	336	AV1	160.2	24.9	8.07	2,699	2,171	28.1	3,677	41.6	1,834
9	144.0	336	AV1	87.2	18.2	6.01	2,175	1,802	20.6	2,688	47.9	1,532
10	144.0	336	AV1	86.9	18.3	5.98	2,201	1,829	20.7	2,701	48.0	1,530
11	144.0	336	AV1	85.1	18.1	5.93	2,169	1,802	20.4	2,672	48.2	1,518
12	144.0	336	AV1	81.9	17.8	5.86	2,158	1,795	20.1	2,633	48.5	1,494
13	144.0	336	AV1	73.8	16.8	5.63	2,046	1,708	19.0	2,486	49.4	1,450
14	144.0	336	AV1	76.0	17.2	5.71	2,108	1,763	19.4	2,542	49.1	1,465
15	144.0	336	AV1	73.4	16.8	5.59	2,029	1,691	18.9	2,475	49.6	1,465
16	144.0	336	AV1	77.5	17.1	5.68	2,079	1,729	19.2	2,523	49.2	1,451
17	144.1	336	AV1	87.2	18.2	5.98	2,161	1,785	20.5	2,693	48.0	1,531
18	144.1	336	AV1	90.9	18.6	6.09	2,173	1,783	21.0	2,750	47.6	1,538
19	144.1	336	AV1	76.2	17.0	5.66	2,042	1,692	19.2	2,507	49.3	1,437
20	144.1	336	AV1	85.0	17.8	5.88	2,121	1,755	20.2	2,635	48.4	1,521
21	144.1	336	AV1	91.5	18.7	6.09	2,171	1,781	21.1	2,764	47.6	1,543
22	144.1	336	AV1	86.3	18.0	5.96	2,117	1,740	20.4	2,663	48.1	1,504
23	144.1	336	AV1	91.1	18.7	6.12	2,146	1,758	21.1	2,757	47.5	1,523
24	144.1	336	AV1	89.5	18.4	6.09	2,145	1,760	20.8	2,717	47.6	1,524
25	144.1	336	AV1	91.6	18.5	6.12	2,154	1,768	20.9	2,734	47.5	1,545
26	144.1	336	AV1	98.0	19.2	6.34	2,223	1,820	21.7	2,837	46.7	1,593
27	144.1	336	AV1	107.7	20.1	6.57	2,273	1,828	22.7	2,975	45.9	1,648
28	144.1	336	AV1	112.3	20.6	6.72	2,288	1,845	23.3	3,038	45.4	1,666
29	144.1	216	AV1	103.5	19.8	6.48	2,209	1,784	22.4	2,930	46.2	1,584
30	144.1	216	AV1	93.1	18.9	6.20	2,143	1,743	21.3	2,787	47.2	1,562
31	144.1	216	AV1	102.9	19.7	6.48	2,207	1,785	22.3	2,915	46.2	1,589
32	144.1	216	AV1	103.7	19.8	6.51	2,211	1,784	22.4	2,929	46.1	1,604
33	144.1	216	AV1	106.4	20.1	6.60	2,244	1,806	22.7	2,972	45.8	1,623
34	144.1	216	AV1	104.7	20.0	6.57	2,210	1,782	22.6	2,948	45.9	1,622
35	144.1	216	AV1	96.5	19.1	6.31	2,151	1,742	21.5	2,825	46.8	1,553
36	144.1	216	AV1	105.7	20.0	6.57	2,199	1,765	22.5	2,949	45.9	1,590
37	144.1	216	AV1	99.2	19.3	6.37	2,146	1,732	21.8	2,853	46.6	1,569
38	144.1	216	AV1	106.1	20.0	6.54	2,203	1,765	22.6	2,953	46.0	1,608

KIWC, POA TPP - IP 5 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 09-June-2016

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
39	144.1	216	AV1	104.8	19.9	6.57	2,193	1,760	22.5	2,940	45.9	1,589
40	144.1	216	AV1	94.0	18.9	6.28	2,096	1,689	21.4	2,796	46.9	1,521
41	144.1	216	AV1	83.2	17.6	5.91	2,002	1,625	19.9	2,600	48.3	1,420
42	144.1	216	AV1	84.6	17.9	5.96	2,045	1,667	20.2	2,643	48.1	1,492
43	144.2	216	AV1	89.9	18.4	6.12	2,067	1,677	20.7	2,711	47.5	1,519
44	144.2	216	AV1	103.2	19.5	6.45	2,150	1,725	22.0	2,879	46.3	1,611
45	144.2	216	AV1	106.5	20.1	6.57	2,197	1,752	22.6	2,968	45.9	1,618
46	144.2	216	AV1	114.9	20.7	6.82	2,224	1,766	23.4	3,055	45.1	1,655
47	144.2	204	AV1	102.3	19.6	6.48	2,149	1,721	22.2	2,901	46.2	1,574
48	144.2	204	AV1	94.2	18.9	6.28	2,092	1,687	21.3	2,792	46.9	1,519
49	144.2	204	AV1	101.0	19.3	6.40	2,125	1,703	21.8	2,849	46.5	1,641
50	144.2	204	AV1	110.8	20.3	6.69	2,199	1,738	22.9	3,002	45.5	1,633
51	144.2	204	AV1	115.9	20.9	6.85	2,246	1,788	23.6	3,085	45.0	1,699
52	144.2	204	AV1	117.7	21.0	6.88	2,230	1,754	23.6	3,101	44.9	1,623
53	144.2	204	AV1	103.6	19.6	6.48	2,131	1,700	22.1	2,896	46.2	1,622
54	144.2	204	AV1	97.8	19.3	6.37	2,097	1,682	21.7	2,854	46.6	1,535
55	144.2	204	AV1	96.3	19.0	6.34	2,077	1,659	21.5	2,811	46.7	1,511
56	144.2	204	AV1	100.9	19.6	6.45	2,104	1,679	22.0	2,893	46.3	1,520
57	144.2	204	AV1	92.7	18.6	6.20	2,048	1,646	21.0	2,742	47.2	1,584
58	144.2	204	AV1	97.7	19.2	6.37	2,081	1,662	21.6	2,834	46.6	1,519
59	144.2	204	AV1	94.2	18.8	6.23	2,056	1,647	21.2	2,770	47.1	1,516
60	144.2	204	AV1	102.4	19.7	6.51	2,119	1,680	22.2	2,912	46.1	1,571
61	144.2	204	AV1	94.0	18.7	6.25	2,061	1,653	21.1	2,766	47.0	1,499
62	144.2	204	AV1	95.3	18.9	6.28	2,066	1,654	21.3	2,790	46.9	1,513
63	144.3	204	AV1	100.8	19.4	6.42	2,099	1,671	21.8	2,860	46.4	1,554
64	144.3	180	AV1	96.4	19.1	6.28	2,061	1,642	21.4	2,816	46.9	1,499
65	144.3	180	AV1	93.2	18.6	6.23	2,039	1,635	21.0	2,744	47.1	1,564
66	144.3	180	AV1	105.5	19.8	6.54	2,119	1,677	22.3	2,930	46.0	1,563
67	144.3	180	AV1	108.6	20.2	6.66	2,133	1,682	22.8	2,988	45.6	1,530
68	144.3	180	AV1	94.3	18.7	6.20	2,020	1,601	21.1	2,768	47.2	1,444
69	144.3	180	AV1	97.3	19.1	6.34	2,078	1,657	21.6	2,821	46.7	1,575
70	144.3	180	AV1	101.4	19.4	6.42	2,098	1,658	21.9	2,870	46.4	1,556
71	144.3	180	AV1	102.4	19.6	6.48	2,091	1,654	22.1	2,888	46.2	1,550
72	144.3	180	AV1	99.4	19.2	6.42	2,079	1,654	21.7	2,838	46.4	1,545
73	144.3	180	AV1	97.9	19.2	6.40	2,059	1,635	21.6	2,830	46.5	1,486
74	144.3	180	AV1	98.5	19.1	6.37	2,050	1,624	21.6	2,821	46.6	1,501
75	144.3	180	AV1	95.8	18.8	6.31	2,042	1,627	21.3	2,783	46.8	1,543
76	144.3	180	AV1	100.6	19.3	6.40	2,079	1,648	21.9	2,854	46.5	1,536
77	144.3	180	AV1	101.2	19.4	6.42	2,075	1,644	21.9	2,871	46.4	1,519
78	144.3	180	AV1	109.7	20.2	6.66	2,142	1,673	22.9	2,990	45.6	1,474
79	144.3	168	AV1	97.6	19.1	6.34	2,040	1,618	21.5	2,819	46.7	1,503
80	144.3	168	AV1	99.8	19.2	6.40	2,066	1,633	21.7	2,832	46.5	1,560
81	144.4	168	AV1	115.3	20.7	6.85	2,176	1,694	23.3	3,055	45.0	1,568
82	144.4	168	AV1	110.8	20.4	6.69	2,142	1,679	23.0	3,007	45.5	1,510
83	144.4	168	AV1	105.8	19.8	6.57	2,099	1,639	22.4	2,931	45.9	1,488
84	144.4	168	AV1	112.5	20.5	6.76	2,139	1,665	23.1	3,024	45.3	1,451

KIWC, POA TPP - IP 5 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 09-June-2016

BL#	Depth	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	ft	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
85	144.4	168	AV1	96.4	19.0	6.31	2,011	1,578	21.4	2,810	46.8	1,380
86	144.4	168	AV1	88.3	18.1	6.09	1,960	1,559	20.5	2,679	47.6	1,474
87	144.4	168	AV1	89.2	18.5	6.17	2,000	1,585	20.8	2,726	47.3	1,465
88	144.4	168	AV1	96.9	18.9	6.31	2,045	1,619	21.4	2,783	46.8	1,476
89	144.4	168	AV1	108.4	20.2	6.66	2,108	1,638	22.7	2,985	45.6	1,479
90	144.4	168	AV1	104.4	19.7	6.57	2,099	1,647	22.3	2,915	45.9	1,517
91	144.4	168	AV1	119.9	21.0	6.95	2,171	1,675	23.6	3,104	44.7	1,496
92	144.4	168	AV1	112.8	20.5	6.79	2,142	1,674	23.2	3,034	45.2	1,522
93	144.4	126	AV1	103.0	19.8	6.57	2,092	1,637	22.3	2,922	45.9	1,539
94	144.4	126	AV1	104.5	19.8	6.57	2,069	1,622	22.4	2,923	45.9	1,455
95	144.4	126	AV1	104.2	19.6	6.48	2,076	1,623	22.0	2,890	46.2	1,458
96	144.4	126	AV1	110.3	20.2	6.69	2,109	1,646	22.9	2,984	45.5	1,470
97	144.5	126	AV1	102.7	19.7	6.54	2,064	1,605	22.2	2,910	46.0	1,472
98	144.5	126	AV1	99.2	19.3	6.42	2,032	1,599	21.8	2,848	46.4	1,510
99	144.5	126	AV1	89.4	18.8	6.20	1,924	1,491	21.1	2,775	47.2	1,348
100	144.5	126	AV1	44.2	13.3	4.91	1,490	1,211	15.1	1,966	52.7	1,025
			Average	98.8	19.2	6.38	2,116	1,698	21.6	2,829	45.0	1,525

Total number of blows analyzed: 100

BL#	Sensors
1-100	F1: [1458W] 129.0 (1.00); F2: [1463W] 127.0 (1.00); F3: [H278] 99.0 (1.00); F4: [H324] 93.0 (1.00); A1: [W10287] 970.0 (1.00); A2: [W10356] 980.0 (1.00); A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
1	Start of test on 6/9/2016 at 4:04 PM
100	End of test on 6/9/2016 at 4:10 PM

Time Summary

Drive	0 second	4:04 PM - 4:04 PM (6/9/2016) BN 1 - 1
Stop	1 minute 19 seconds	4:04 PM - 4:05 PM
Drive	1 second	4:05 PM - 4:05 PM BN 2 - 3
Stop	1 minute 2 seconds	4:05 PM - 4:06 PM
Drive	1 second	4:06 PM - 4:06 PM BN 4 - 5
Stop	1 minute 0 second	4:06 PM - 4:07 PM
Drive	2 minutes 1 second	4:07 PM - 4:10 PM BN 6 - 100

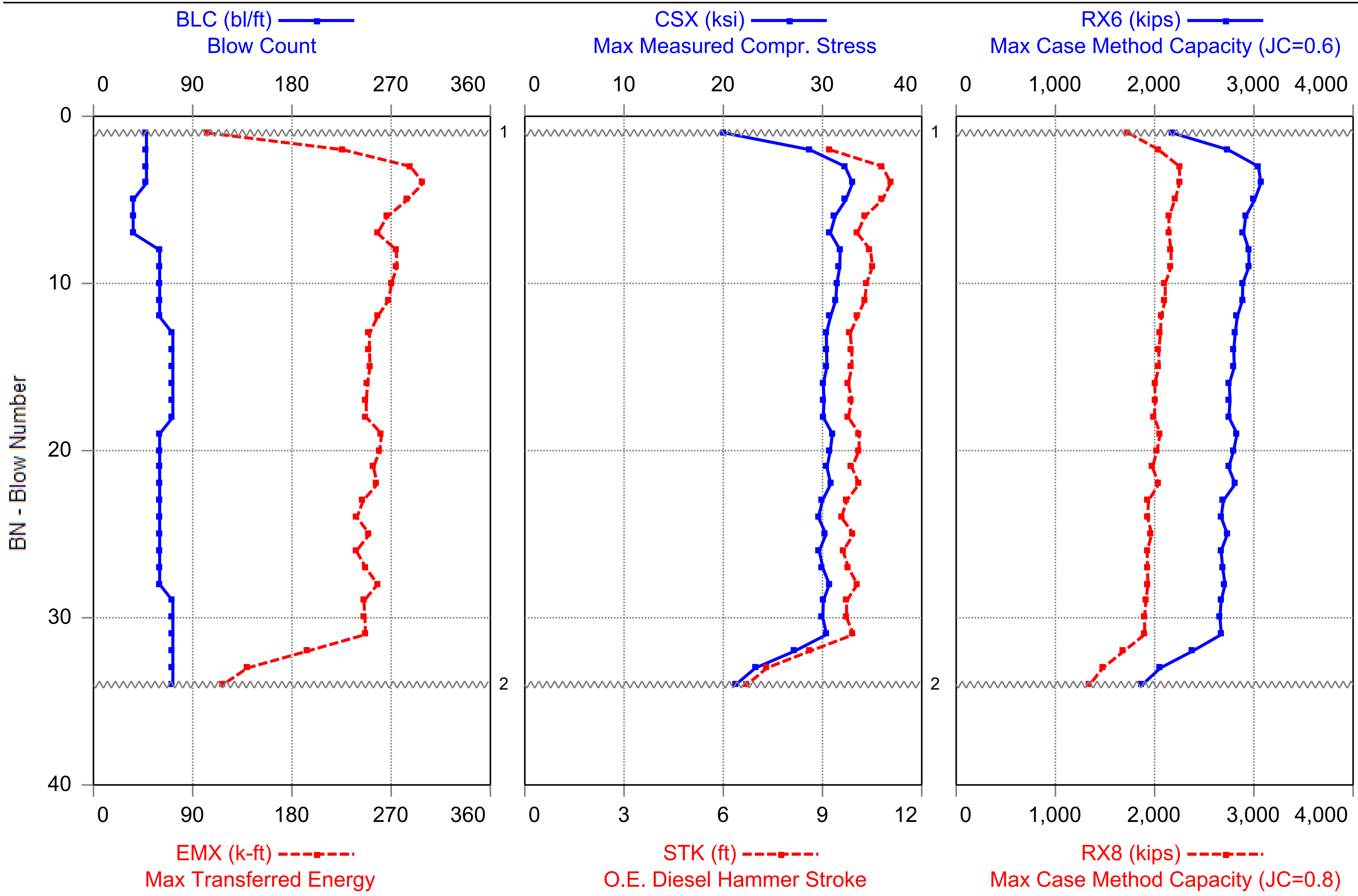
Total time [00:05:25] = (Driving [00:02:03] + Stop [00:03:22])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 24-June-2016

Test started: 21-June-2016

KIWC, POA TPP - IP 6 RESTRIKE



1 - Start of test on 6/21/2016 at 1:47 PM

2 - End of test on 6/21/2016 at 1:48 PM

KIWC, POA TPP - IP 6 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 21-June-2016

AR: 147.65 in^2 SP: 0.492 k/ft^3
LE: 185.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
1	48	AV1	103.4	20.1	**	2,176	1,736	21.5	2,967	1.9	1,143
2	48	AV1	225.9	28.7	9.22	2,738	2,038	29.3	4,239	39.0	1,274
3	48	AV1	287.5	32.3	10.81	3,045	2,250	32.8	4,765	36.1	1,364
4	48	AV1	299.0	33.0	11.06	3,071	2,251	33.6	4,876	35.7	1,520
5	36	AV1	284.7	32.3	10.81	3,007	2,204	32.9	4,776	36.1	1,294
6	36	AV1	266.5	31.2	10.28	2,917	2,145	31.7	4,614	37.0	1,340
7	36	AV1	257.6	30.8	10.05	2,896	2,143	31.4	4,547	37.4	1,305
8	60	AV1	274.6	31.8	10.45	2,949	2,165	32.3	4,693	36.7	1,310
9	60	AV1	275.3	31.7	10.51	2,950	2,165	32.3	4,686	36.6	1,262
10	60	AV1	270.3	31.4	10.33	2,888	2,106	31.9	4,642	36.9	1,248
11	60	AV1	267.8	31.3	10.28	2,884	2,105	31.8	4,627	37.0	1,246
12	60	AV1	257.5	30.8	10.05	2,832	2,065	31.2	4,547	37.4	1,207
13	72	AV1	250.3	30.4	9.83	2,812	2,058	30.8	4,486	37.8	1,151
14	72	AV1	250.3	30.4	9.89	2,797	2,041	30.8	4,491	37.7	1,154
15	72	AV1	250.8	30.4	9.89	2,803	2,045	30.8	4,494	37.7	1,112
16	72	AV1	248.5	30.1	9.78	2,752	2,001	30.4	4,440	37.9	1,087
17	72	AV1	247.4	30.2	9.89	2,760	2,006	30.5	4,452	37.7	1,075
18	72	AV1	247.3	30.1	9.78	2,748	1,996	30.4	4,441	37.9	1,084
19	60	AV1	261.2	31.0	10.11	2,831	2,055	31.4	4,575	37.3	1,044
20	60	AV1	259.6	30.8	10.11	2,796	2,025	31.1	4,546	37.3	1,039
21	60	AV1	254.0	30.4	9.89	2,745	1,978	30.8	4,496	37.7	1,011
22	60	AV1	257.5	30.8	10.11	2,811	2,041	31.2	4,552	37.3	1,005
23	60	AV1	244.6	30.0	9.73	2,691	1,938	30.4	4,428	38.0	973
24	60	AV1	239.0	29.6	9.57	2,671	1,929	29.9	4,368	38.3	976
25	60	AV1	250.4	30.3	9.94	2,733	1,970	30.7	4,480	37.6	992
26	60	AV1	238.4	29.7	9.62	2,669	1,925	30.0	4,382	38.2	964
27	60	AV1	246.9	30.0	9.78	2,684	1,928	30.4	4,433	37.9	988
28	60	AV1	257.6	30.7	10.05	2,709	1,932	31.1	4,530	37.4	980
29	72	AV1	245.2	30.1	9.73	2,669	1,910	30.5	4,441	38.0	975
30	72	AV1	246.2	30.0	9.73	2,658	1,897	30.4	4,432	38.0	961
31	72	AV1	246.8	30.4	9.94	2,672	1,899	30.8	4,491	37.6	875
32	72	AV1	193.8	27.2	8.61	2,380	1,690	27.6	4,012	40.3	760
33	72	AV1	139.6	23.2	7.32	2,058	1,476	23.5	3,430	43.6	692
34	72	AV1	117.5	21.3	6.72	1,877	1,346	21.5	3,140	45.4	696
		Average	243.0	29.8	9.81	2,726	1,984	30.2	4,397	36.9	1,091

Total number of blows analyzed: 34

KIWC, POA TPP - IP 6 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 21-June-2016

BL#	Sensors
1-34	F1: [H263] 92.0 (1.00); F2: [H289] 94.0 (1.00); F3: [H283] 92.3 (1.00); F4: [H340] 94.0 (1.00); A1: off; A2: off; A3: [K1066] 332.0 (1.00); A4: [K1717] 368.0 (1.00)

BL#	Comments
1	Start of test on 6/21/2016 at 1:47 PM
34	End of test on 6/21/2016 at 1:48 PM

Time Summary

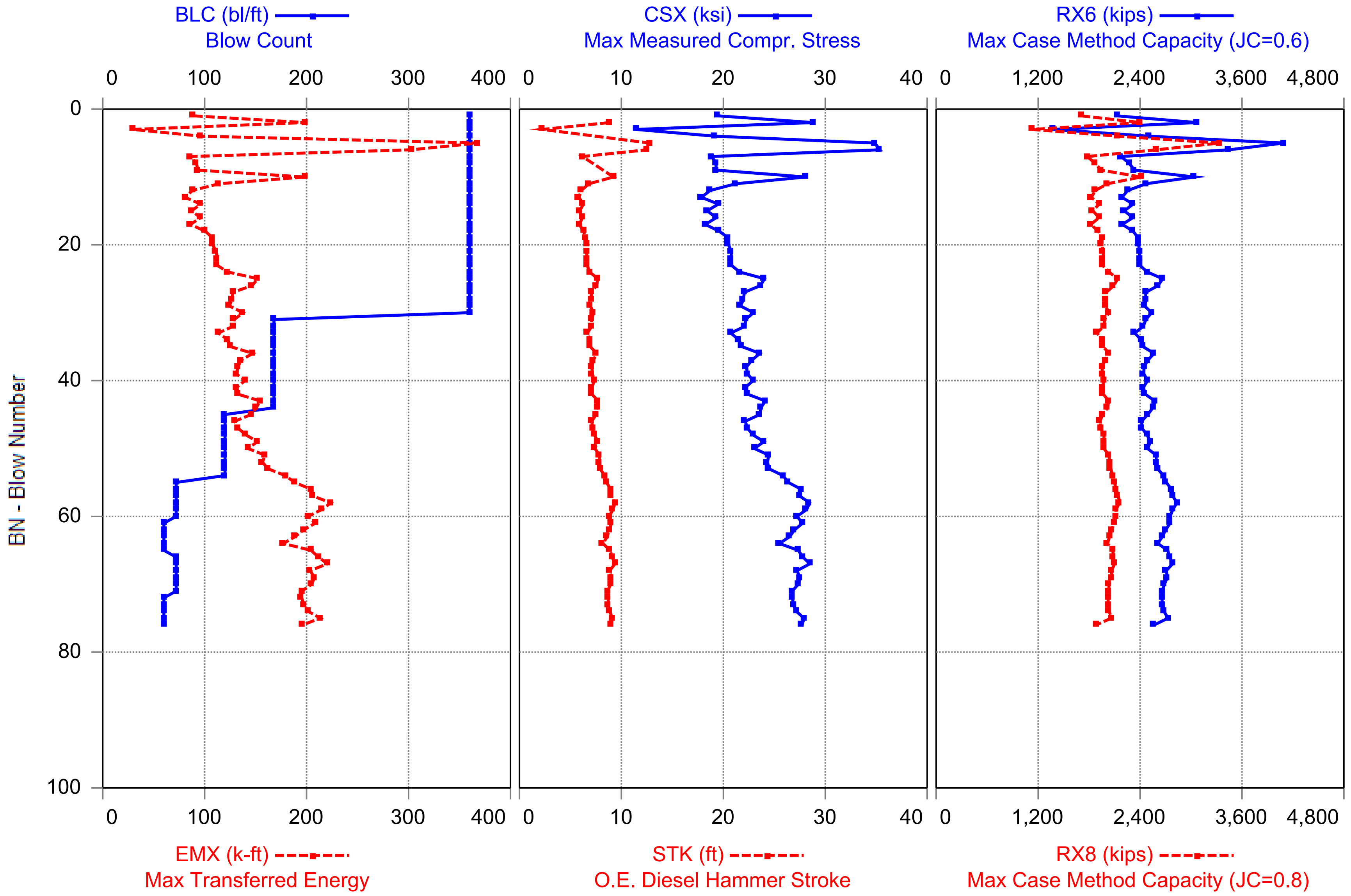
Drive 52 seconds 1:47 PM - 1:48 PM BN 1 - 34

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 09-June-2016

Test started: 08-June-2016

KIWC, POA TPP - IP 7 RESTRIKE



KIWC, POA TPP - IP 7 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 08-June-2016

AR: 147.65 in^2 SP: 0.492 k/ft^3
LE: 185.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	Depth ft	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
30	139.08	360	AV30	126.5	21.6	7.09	2,478	2,017	25.4	3,193	39.7	1,630
			STD	65.2	4.7	1.99	454	344	5.6	695	16.3	315
			MAX	368.4	35.4	12.76	4,092	3,336	41.6	5,222	75.4	2,745
44	139.17	168	AV14	133.9	22.5	7.19	2,468	1,975	26.5	3,319	44.0	1,666
			STD	10.7	0.9	0.28	61	36	1.0	127	0.8	43
			MAX	154.4	24.1	7.72	2,574	2,038	28.4	3,561	45.6	1,757
54	139.25	120	AV10	150.0	23.7	7.61	2,529	1,995	28.0	3,502	42.8	1,740
			STD	14.2	1.1	0.37	80	50	1.3	159	1.0	69
			MAX	179.1	25.9	8.36	2,675	2,078	30.5	3,817	44.3	1,860
60	139.33	72	AV6	206.5	27.6	8.96	2,772	2,125	32.5	4,069	39.6	1,913
			STD	11.0	0.7	0.27	38	20	0.8	100	0.6	27
			MAX	223.8	28.5	9.37	2,834	2,158	33.5	4,204	40.5	1,955
65	139.42	60	AV5	195.1	26.8	8.70	2,690	2,059	31.6	3,960	40.1	1,874
			STD	11.2	0.8	0.29	51	28	0.9	116	0.7	26
			MAX	208.5	27.8	9.03	2,755	2,097	32.8	4,102	41.3	1,909
71	139.50	72	AV6	207.3	27.5	8.98	2,718	2,065	32.5	4,064	39.5	1,886
			STD	7.7	0.5	0.22	40	26	0.6	78	0.5	34
			MAX	220.3	28.5	9.37	2,783	2,101	33.6	4,205	40.2	1,934
76	139.58	60	AV5	200.7	27.3	8.87	2,659	2,006	32.2	4,030	39.7	1,821
			STD	6.7	0.4	0.16	53	63	0.5	66	0.3	100
			MAX	213.4	27.9	9.12	2,729	2,062	32.9	4,122	40.1	1,901
			Average	153.0	23.7	7.73	2,551	2,021	27.9	3,500	40.9	1,722
			Std. Dev.	53.1	3.9	1.45	308	222	4.6	571	10.4	228
			Maximum	368.4	35.4	12.76	4,092	3,336	41.6	5,222	75.4	2,745

Total number of blows analyzed: 76

BL# Sensors

1-76 F1: [1458W] 129.0 (1.00); F2: [1463W] 127.0 (1.00); F3: [H278] 99.0 (1.00);
F4: [H324] 93.0 (1.00); A1: [W10287] 970.0 (1.00); A2: [W10356] 980.0 (1.00);
A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

Time Summary

Drive	2 seconds	1:36 PM - 1:36 PM (6/8/2016) BN 1 - 3
Stop	1 minute 20 seconds	1:36 PM - 1:37 PM
Drive	4 seconds	1:37 PM - 1:37 PM BN 4 - 7
Stop	1 minute 1 second	1:37 PM - 1:38 PM

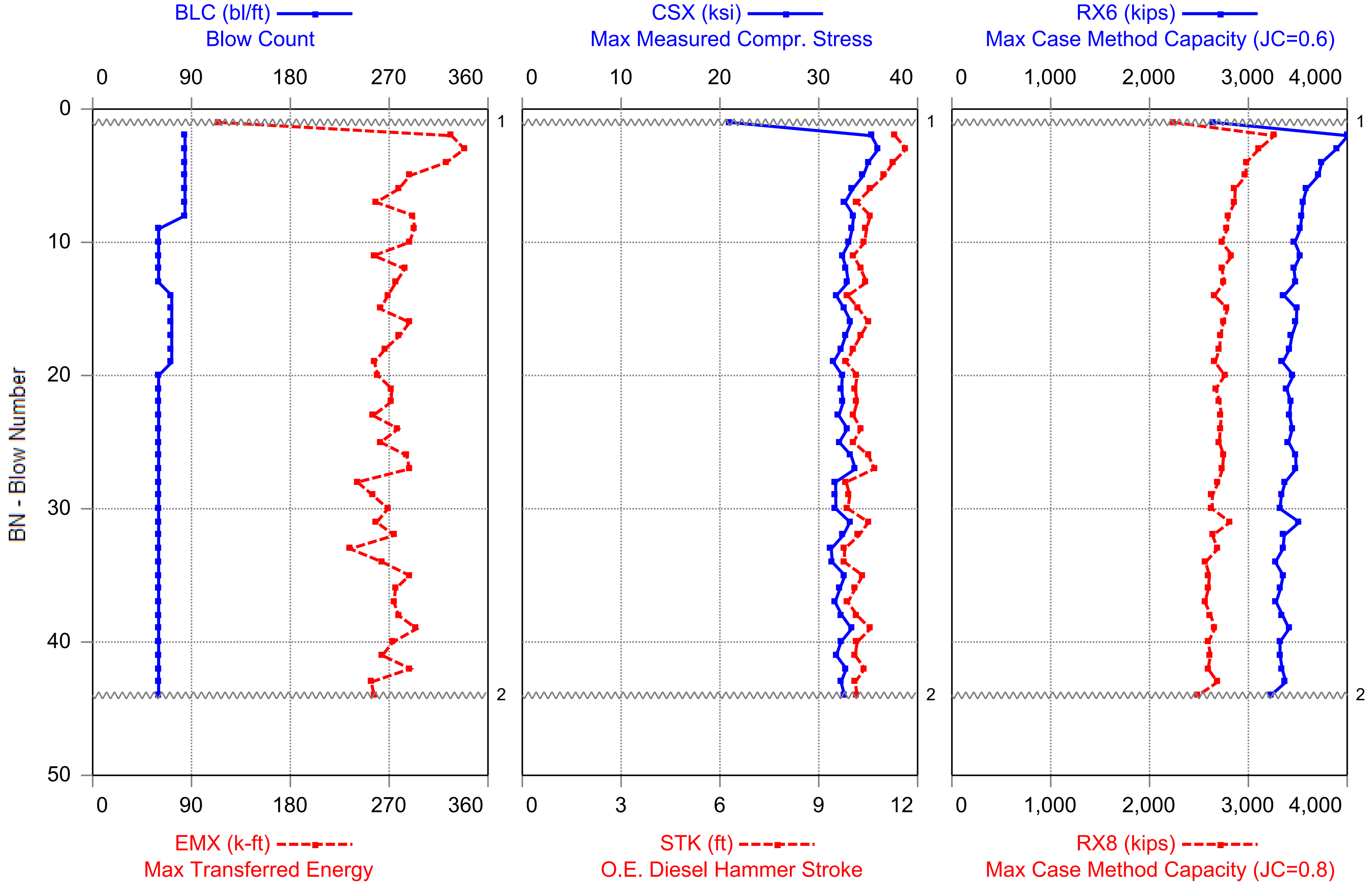
Drive	0 second	1:38 PM - 1:38 PM	BN 8 - 8
Stop	1 minute 20 seconds	1:38 PM - 1:39 PM	
Drive	1 minute 33 seconds	1:39 PM - 1:41 PM	BN 9 - 76

Total time [00:05:23] = (Driving [00:01:41] + Stop [00:03:42])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results

Printed: 14-June-2016 Test started: 10-June-2016

KIWC, POA TPP - IP 8 RESTRIKE



1 - Start of test on 6/10/2016 at 10:14 AM

2 - End of test on 6/10/2016 at 10:15 AM

KIWC, POA TPP - IP 8 RESTRIKE
PP48x1.0", APE D180-42
OP: RMDT
Date: 10-June-2016

AR: 147.65 in²
LE: 192.00 ft
WS: 17,100.0 f/s
SP: 0.492 k/ft³
EM: 31,052 ksi
JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
1	0	AV1	114.3	20.9	**	2,643	2,237	22.6	3,088	1.9	1,938
2	84	AV1	326.9	35.3	11.32	4,007	3,261	38.1	5,215	35.3	2,318
3	84	AV1	338.6	36.0	11.66	3,891	3,110	38.8	5,320	34.8	2,051
4	84	AV1	322.3	35.0	11.25	3,742	2,978	38.0	5,170	35.4	1,855
5	84	AV1	288.8	34.5	11.00	3,709	2,974	37.4	5,094	35.8	2,117
6	84	AV1	278.7	33.4	10.57	3,588	2,866	36.5	4,935	36.5	1,835
7	84	AV1	258.1	32.7	10.16	3,550	2,862	35.3	4,824	37.2	2,039
8	84	AV1	292.3	33.5	10.57	3,540	2,797	36.5	4,951	36.5	1,740
9	60	AV1	292.8	33.4	10.45	3,526	2,785	36.2	4,928	36.7	1,717
10	60	AV1	288.4	33.1	10.39	3,470	2,730	36.2	4,885	36.8	1,650
11	60	AV1	256.1	32.4	10.05	3,525	2,837	35.1	4,782	37.4	1,989
12	60	AV1	284.2	32.8	10.28	3,462	2,733	35.9	4,843	37.0	1,664
13	60	AV1	276.1	33.0	10.45	3,476	2,755	35.8	4,869	36.7	1,792
14	72	AV1	268.9	31.8	9.89	3,362	2,657	34.8	4,693	37.7	1,656
15	72	AV1	261.9	32.6	10.22	3,488	2,790	35.6	4,812	37.1	2,011
16	72	AV1	288.6	33.3	10.51	3,485	2,747	36.2	4,912	36.6	1,700
17	72	AV1	279.8	32.7	10.28	3,441	2,720	35.6	4,831	37.0	1,672
18	72	AV1	266.5	32.3	10.05	3,417	2,707	35.1	4,763	37.4	1,693
19	72	AV1	256.5	31.5	9.83	3,347	2,664	34.3	4,649	37.8	1,674
20	60	AV1	259.7	32.4	10.16	3,455	2,760	35.3	4,782	37.2	1,965
21	60	AV1	272.4	32.3	10.11	3,388	2,671	35.2	4,771	37.3	1,678
22	60	AV1	271.7	32.5	10.16	3,428	2,711	35.3	4,794	37.2	1,702
23	60	AV1	255.4	32.0	10.05	3,416	2,726	35.0	4,731	37.4	1,801
24	60	AV1	278.3	32.9	10.28	3,444	2,714	35.8	4,858	37.0	1,700
25	60	AV1	262.1	32.1	10.05	3,407	2,706	35.0	4,735	37.4	1,769
26	60	AV1	285.9	33.3	10.51	3,478	2,750	36.3	4,913	36.6	1,805
27	60	AV1	288.5	33.7	10.69	3,483	2,738	36.9	4,976	36.3	1,775
28	60	AV1	241.1	31.7	9.83	3,373	2,697	34.5	4,681	37.8	2,026
29	60	AV1	255.5	31.7	9.94	3,334	2,636	34.7	4,683	37.6	1,701
30	60	AV1	268.8	31.7	9.89	3,319	2,634	34.6	4,684	37.7	1,657
31	60	AV1	258.7	33.2	10.51	3,516	2,815	36.5	4,895	36.6	2,122
32	60	AV1	274.5	32.5	10.22	3,362	2,637	35.5	4,794	37.1	1,640
33	60	AV1	234.4	31.3	9.78	3,351	2,690	34.3	4,615	37.9	2,044
34	60	AV1	264.0	31.4	9.78	3,273	2,568	34.2	4,630	37.9	1,619
35	60	AV1	288.4	32.6	10.33	3,351	2,605	35.6	4,820	36.9	1,670
36	60	AV1	275.7	32.1	10.11	3,325	2,595	35.1	4,745	37.3	1,636
37	60	AV1	274.3	31.7	9.89	3,281	2,561	34.5	4,673	37.7	1,658
38	60	AV1	278.6	32.3	10.16	3,346	2,620	35.4	4,776	37.2	1,682

KIWC, POA TPP - IP 8 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 10-June-2016

BL#	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
39	60	AV1	295.1	33.3	10.57	3,411	2,660	36.4	4,921	36.5	1,699
40	60	AV1	273.5	32.2	10.16	3,320	2,594	35.2	4,761	37.2	1,638
41	60	AV1	263.7	31.8	10.11	3,320	2,616	34.7	4,691	37.3	1,694
42	60	AV1	289.2	32.8	10.39	3,341	2,592	35.8	4,840	36.8	1,636
43	60	AV1	253.5	32.3	10.11	3,379	2,688	35.3	4,762	37.3	2,005
44	60	AV1	256.4	32.6	10.16	3,226	2,494	35.6	4,815	37.2	1,512
		Average	271.8	32.5	10.30	3,432	2,720	35.4	4,793	36.2	1,794

Total number of blows analyzed: 44

BL# Sensors

1-44 F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00);
F4: [H324] 93.0 (1.00); A1: [28243] 1025.0 (1.00); A2: [21461] 950.0 (1.00);
A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

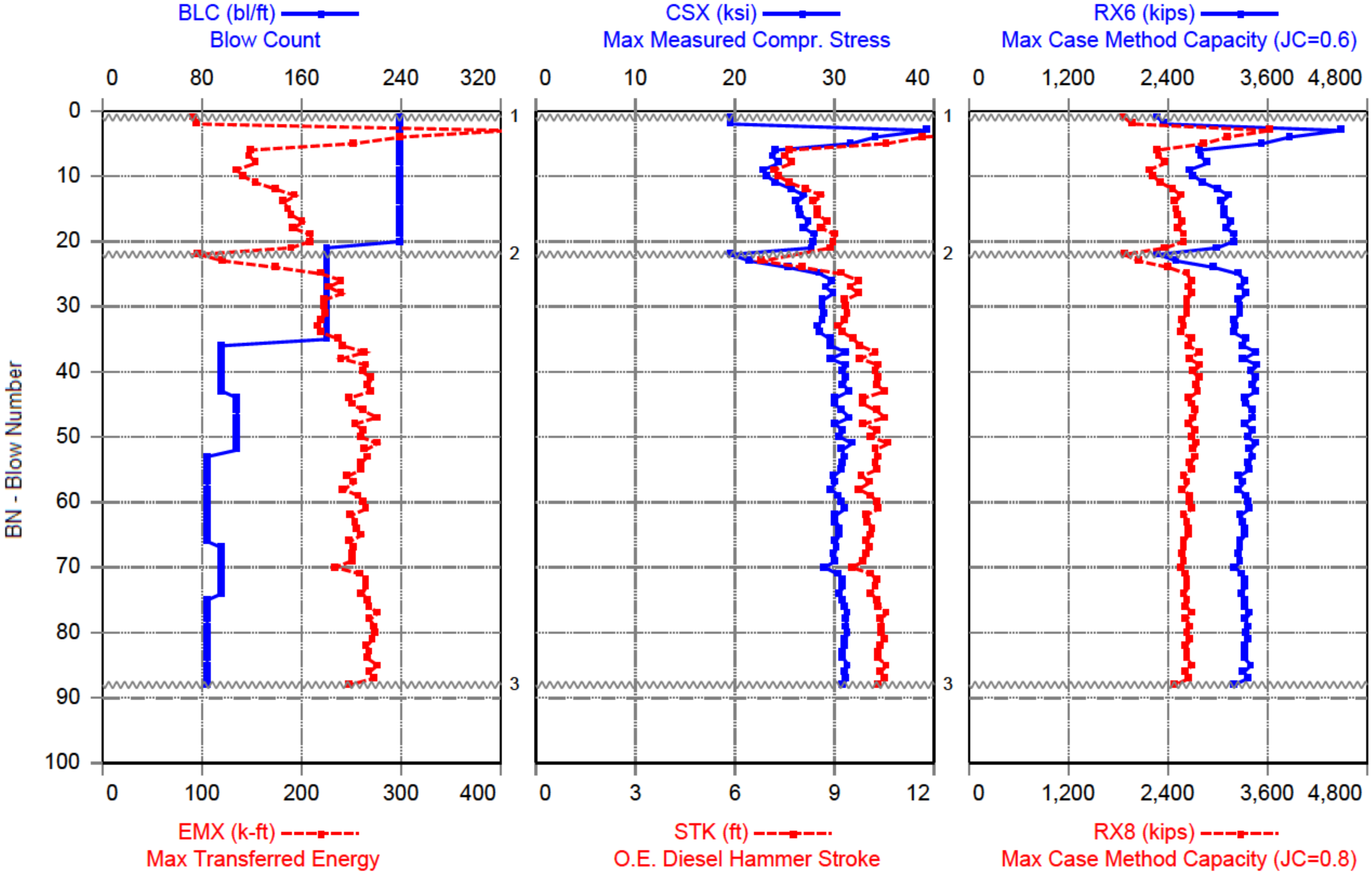
BL#	Comments
1	Start of test on 6/10/2016 at 10:14 AM
44	End of test on 6/10/2016 at 10:15 AM

Time Summary

Drive 1 minute 9 seconds 10:14 AM - 10:15 AM BN 1 - 44

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results
Printed: 14-June-2016
Test started: 10-June-2016

KIWC, POA TPP - IP 9 RESTRIKE



1 - Start of test on 6/10/2016 at 9:57 AM
2 - RMDT requests pause to review data.
3 - End of test on 6/10/2016 at 10:03 AM

KIWC, POA TPP - IP 9 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 10-June-2016

AR: 147.65 in² SP: 0.492 k/ft³
LE: 192.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
1	240	AV1	92.0	19.6	**	2,276	1,867	21.2	2,892	1.9	1,089
2	240	AV1	94.8	19.5	**	2,353	1,971	21.2	2,884	1.9	1,374
3	240	AV1	409.0	39.3	14.57	4,485	3,621	42.4	5,802	31.2	2,336
4	240	AV1	299.9	34.1	11.66	3,865	3,115	36.4	5,031	34.8	1,922
5	240	AV1	252.1	31.7	10.57	3,534	2,836	34.4	4,674	36.5	1,617
6	240	AV1	148.8	24.1	7.64	2,786	2,274	26.0	3,565	42.7	1,467
7	240	AV1	148.1	23.8	7.53	2,794	2,293	25.8	3,514	43.0	1,448
8	240	AV1	154.0	24.4	7.72	2,874	2,362	26.2	3,604	42.5	1,497
9	240	AV1	134.4	22.9	7.21	2,659	2,172	25.0	3,380	43.9	1,425
10	240	AV1	140.9	23.2	7.32	2,712	2,219	25.2	3,425	43.6	1,465
11	240	AV1	153.4	24.2	7.64	2,820	2,307	26.3	3,571	42.7	1,476
12	240	AV1	173.8	25.7	8.15	3,003	2,462	27.6	3,797	41.4	1,605
13	240	AV1	193.6	27.0	8.61	3,128	2,550	29.0	3,988	40.3	1,534
14	240	AV1	181.6	26.2	8.36	3,039	2,478	28.5	3,865	40.9	1,566
15	240	AV1	186.8	26.5	8.48	3,073	2,508	28.6	3,906	40.6	1,652
16	240	AV1	190.1	26.7	8.53	3,082	2,509	28.8	3,939	40.5	1,615
17	240	AV1	201.1	27.4	8.79	3,164	2,574	29.5	4,052	39.9	1,705
18	240	AV1	191.7	27.0	8.61	3,106	2,526	29.4	3,987	40.3	1,705
19	240	AV1	209.3	28.0	9.03	3,199	2,592	30.4	4,136	39.4	1,672
20	240	AV1	208.6	27.9	8.98	3,188	2,584	30.2	4,127	39.5	1,719
21	180	AV1	189.2	27.7	8.89	2,990	2,369	30.2	4,093	39.7	1,313
22	180	AV1	96.2	19.6	**	2,281	1,870	21.5	2,892	1.9	1,299
23	180	AV1	121.7	21.5	6.82	2,499	2,043	23.4	3,169	45.1	1,386
24	180	AV1	174.1	25.4	8.03	2,948	2,404	27.6	3,743	41.7	1,557
25	180	AV1	220.0	28.5	9.22	3,243	2,621	31.2	4,213	39.0	1,658
26	180	AV1	240.2	29.8	9.73	3,334	2,679	32.5	4,405	38.0	1,659
27	180	AV1	227.1	29.1	9.47	3,278	2,641	31.8	4,297	38.5	1,732
28	180	AV1	240.3	29.9	9.73	3,340	2,682	32.2	4,408	38.0	1,646
29	180	AV1	222.2	28.8	9.32	3,253	2,621	31.5	4,259	38.8	1,724
30	180	AV1	223.1	28.9	9.37	3,260	2,630	31.5	4,263	38.7	1,713
31	180	AV1	224.9	29.0	9.42	3,265	2,630	31.6	4,279	38.6	1,727
32	180	AV1	219.1	28.8	9.32	3,200	2,566	31.5	4,251	38.8	1,606
33	180	AV1	215.9	28.3	9.12	3,203	2,587	30.3	4,178	39.2	1,668
34	180	AV1	219.9	28.5	9.27	3,191	2,563	31.7	4,215	38.9	1,661
35	180	AV1	237.3	29.6	9.57	3,335	2,692	31.7	4,365	38.3	1,818
36	96	AV1	240.7	29.6	9.78	3,304	2,647	33.0	4,378	37.9	1,671
37	96	AV1	263.8	31.1	10.22	3,459	2,774	33.3	4,591	37.1	1,863
38	96	AV1	240.2	29.6	9.78	3,309	2,658	32.9	4,369	37.9	1,787

KIWC, POA TPP - IP 9 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 10-June-2016

BL#	BLC	TYPE	EMX	CSX	STK	RX6	RX8	CSI	FMX	BPM	RA2
	bl/ft		k-ft	ksi	ft	kips	kips	ksi	kips	bpm	kips
39	96	AV1	265.1	31.2	10.33	3,473	2,785	33.6	4,604	36.9	1,778
40	96	AV1	261.2	30.9	10.22	3,392	2,703	33.9	4,560	37.1	1,834
41	96	AV1	270.1	31.2	10.33	3,464	2,772	33.8	4,600	36.9	1,904
42	96	AV1	266.6	30.9	10.28	3,426	2,737	34.1	4,566	37.0	1,765
43	96	AV1	269.2	31.4	10.51	3,461	2,761	34.3	4,640	36.6	1,784
44	108	AV1	248.1	30.1	9.89	3,318	2,648	33.0	4,447	37.7	1,792
45	108	AV1	251.1	30.1	9.89	3,348	2,682	32.4	4,439	37.7	1,872
46	108	AV1	262.1	30.8	10.28	3,416	2,733	34.0	4,542	37.0	1,869
47	108	AV1	275.4	31.5	10.51	3,425	2,714	33.8	4,653	36.6	1,708
48	108	AV1	253.4	30.1	9.89	3,325	2,653	32.9	4,438	37.7	1,710
49	108	AV1	261.8	30.9	10.28	3,412	2,727	33.4	4,556	37.0	1,925
50	108	AV1	259.5	30.5	10.11	3,358	2,677	33.9	4,510	37.3	1,860
51	108	AV1	276.0	31.7	10.63	3,461	2,749	34.2	4,687	36.4	1,835
52	108	AV1	263.9	30.7	10.22	3,388	2,702	33.8	4,540	37.1	1,828
53	84	AV1	266.3	31.0	10.33	3,422	2,730	33.7	4,577	36.9	1,884
54	84	AV1	259.5	30.8	10.22	3,359	2,669	33.7	4,547	37.1	1,849
55	84	AV1	260.1	30.7	10.28	3,380	2,692	33.4	4,532	37.0	1,778
56	84	AV1	246.1	29.9	9.83	3,257	2,584	32.8	4,420	37.8	1,759
57	84	AV1	253.0	30.1	10.05	3,314	2,638	32.4	4,447	37.4	1,704
58	84	AV1	242.2	29.6	9.73	3,241	2,577	32.3	4,374	38.0	1,814
59	84	AV1	256.5	30.4	10.11	3,343	2,661	33.3	4,496	37.3	1,899
60	84	AV1	261.1	30.8	10.28	3,355	2,665	34.0	4,541	37.0	1,847
61	84	AV1	265.1	31.1	10.33	3,378	2,681	33.4	4,585	36.9	1,920
62	84	AV1	249.4	30.1	9.94	3,272	2,598	32.7	4,449	37.6	1,866
63	84	AV1	254.2	30.1	10.00	3,307	2,630	33.0	4,450	37.5	1,793
64	84	AV1	255.4	30.6	10.16	3,329	2,646	33.4	4,512	37.2	1,885
65	84	AV1	260.8	30.5	10.11	3,329	2,643	32.7	4,506	37.3	1,887
66	84	AV1	248.3	30.1	9.94	3,264	2,591	32.8	4,446	37.6	1,887
67	96	AV1	252.7	30.2	10.05	3,273	2,592	32.7	4,454	37.4	1,808
68	96	AV1	251.4	30.0	9.94	3,258	2,581	33.2	4,428	37.6	1,840
69	96	AV1	250.3	30.1	9.89	3,276	2,597	32.1	4,451	37.7	1,773
70	96	AV1	233.5	29.0	9.52	3,203	2,559	31.9	4,275	38.4	1,884
71	96	AV1	259.1	30.3	10.11	3,295	2,609	32.6	4,476	37.3	1,838
72	96	AV1	265.4	30.9	10.28	3,320	2,624	33.6	4,559	37.0	1,906
73	96	AV1	264.6	30.9	10.22	3,326	2,637	33.2	4,556	37.1	1,857
74	96	AV1	261.0	30.5	10.11	3,286	2,596	33.4	4,499	37.3	1,914
75	84	AV1	266.1	30.9	10.28	3,329	2,632	33.2	4,555	37.0	1,917
76	84	AV1	268.0	31.0	10.33	3,320	2,620	33.8	4,573	36.9	1,931
77	84	AV1	276.4	31.3	10.57	3,390	2,679	33.9	4,627	36.5	2,012
78	84	AV1	268.1	31.2	10.39	3,324	2,620	33.8	4,603	36.8	1,936
79	84	AV1	273.1	31.1	10.45	3,365	2,660	33.7	4,596	36.7	1,957
80	84	AV1	275.0	31.4	10.45	3,338	2,622	34.2	4,634	36.7	1,933
81	84	AV1	271.3	31.1	10.51	3,367	2,670	33.6	4,586	36.6	1,970
82	84	AV1	265.5	31.0	10.39	3,319	2,618	33.9	4,579	36.8	1,917
83	84	AV1	267.9	30.8	10.33	3,333	2,632	33.5	4,546	36.9	1,915
84	84	AV1	266.4	30.9	10.33	3,322	2,623	34.0	4,565	36.9	1,939

KIWC, POA TPP - IP 9 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 10-June-2016

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
85	84	AV1	276.0	31.4	10.57	3,399	2,688	34.0	4,634	36.5	1,986
86	84	AV1	268.1	30.9	10.39	3,313	2,610	33.9	4,569	36.8	1,965
87	84	AV1	272.4	31.2	10.51	3,360	2,655	33.8	4,608	36.6	1,943
88	84	AV1	248.2	30.9	10.33	3,198	2,482	33.7	4,560	36.9	1,630
		Average	234.6	29.2	9.73	3,238	2,593	31.7	4,308	36.9	1,754

Total number of blows analyzed: 88

BL# Sensors

1-88 F1: [H263] 92.0 (1.00); F2: [H289] 94.0 (1.00); F3: [H340] 94.0 (1.00);
F4: [H283] 92.3 (1.00); A1: [39148] 1075.0 (1.00); A2: [39150] 1075.0 (1.00);
A3: [K1066] 332.0 (1.00); A4: [1717] 368.0 (1.00)

BL#	Comments
1	Start of test on 6/10/2016 at 9:57 AM
22	RMDT requests pause to review data.
88	End of test on 6/10/2016 at 10:03 AM

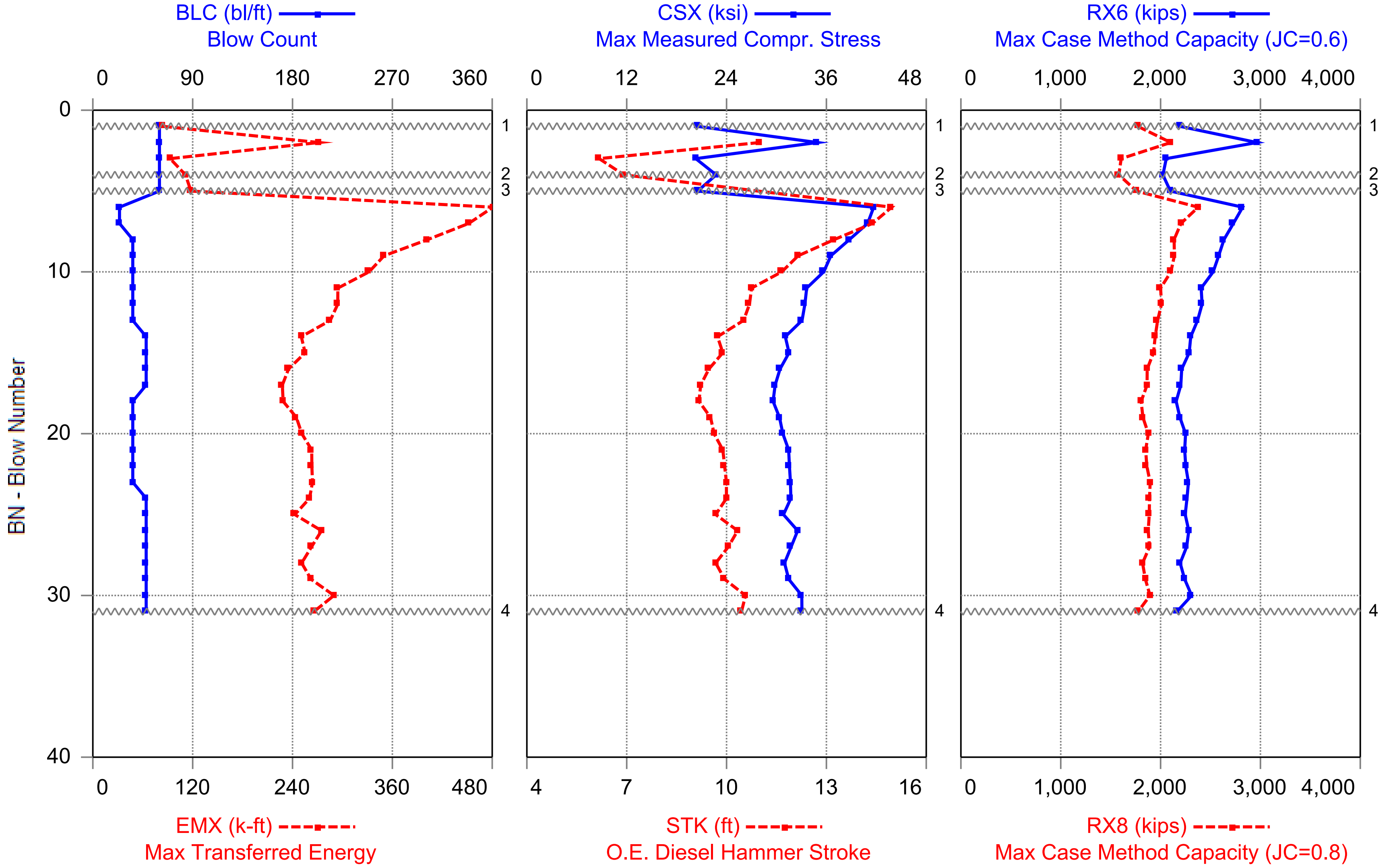
Time Summary

Drive	0 second	9:57 AM - 9:57 AM (6/10/2016) BN 1 - 1
Stop	1 minute 49 seconds	9:57 AM - 9:59 AM
Drive	28 seconds	9:59 AM - 10:00 AM BN 2 - 21
Stop	1 minute 23 seconds	10:00 AM - 10:01 AM
Drive	1 minute 45 seconds	10:01 AM - 10:03 AM BN 22 - 88

Total time [00:05:26] = (Driving [00:02:13] + Stop [00:03:12])

Robert Miner Dynamic Testing, Inc. - PDIPLOT2 Ver 2016.1.999.0 - Case Method & iCAP® Results
Printed: 14-June-2016 Test started: 10-June-2016

KIWC, POA TPP - IP 10 RESTRIKE



1 - Start of test on 6/10/2016 at 1:03 PM
2 - Restart after 2 minutes 11 seconds
3 - Restart after 1 minute 39 seconds
4 - End of test on 6/10/2016 at 1:08 PM

Robert Miner Dynamic Testing, Inc.
Case Method & iCAP® Results PDIPLOT2 2016.1.999.0 - Printed 14-June-2016

KIWC, POA TPP - IP 10 RESTRIKE PP48x1.0", APE D180-42
OP: RMDT Date: 10-June-2016

AR: 147.65 in² SP: 0.492 k/ft³
LE: 174.00 ft EM: 31,052 ksi
WS: 17,100.0 f/s JC: 0.35 []

EMX: Max Transferred Energy
CSX: Max Measured Compr. Stress
STK: O.E. Diesel Hammer Stroke
RX6: Max Case Method Capacity (JC=0.6)
RX8: Max Case Method Capacity (JC=0.8)
CSI: Max F1 or F2 Compr. Stress
FMX: Maximum Force
BPM: Blows per Minute
RA2: Auto Capacity Friction Piles

BL#	BLC bl/ft	TYPE	EMX k-ft	CSX ksi	STK ft	RX6 kips	RX8 kips	CSI ksi	FMX kips	BPM bpm	RA2 kips
1	60	AV1	83.9	20.4	**	2,192	1,769	21.4	3,018	1.9	1,602
2	60	AV1	271.5	34.9	11.00	2,965	2,102	37.5	5,155	35.8	1,685
3	60	AV1	92.8	20.3	6.17	2,056	1,605	22.1	2,997	47.3	1,425
4	60	AV1	111.2	22.7	6.91	2,022	1,581	24.5	3,358	44.8	1,601
5	60	AV1	118.0	20.5	**	2,098	1,759	21.9	3,031	1.9	1,844
6	24	AV1	480.8	41.7	14.96	2,821	2,376	44.0	6,153	30.8	2,599
7	24	AV1	451.7	40.9	14.38	2,728	2,203	43.2	6,045	31.4	2,274
8	36	AV1	402.5	38.8	13.24	2,634	2,136	41.2	5,725	32.7	2,200
9	36	AV1	350.1	36.5	12.15	2,581	2,137	38.7	5,395	34.1	2,348
10	36	AV1	331.9	35.7	11.66	2,526	2,102	37.9	5,266	34.8	2,253
11	36	AV1	294.4	33.6	10.75	2,406	2,000	35.8	4,966	36.2	2,051
12	36	AV1	294.3	33.4	10.69	2,414	2,008	35.5	4,933	36.3	2,043
13	36	AV1	285.3	33.1	10.51	2,369	1,969	35.1	4,882	36.6	2,008
14	48	AV1	250.5	31.1	9.73	2,301	1,945	33.1	4,586	38.0	2,006
15	48	AV1	255.1	31.5	9.89	2,286	1,929	33.6	4,652	37.7	1,965
16	48	AV1	235.2	30.4	9.47	2,211	1,866	32.4	4,491	38.5	1,835
17	48	AV1	227.7	29.8	9.22	2,202	1,864	31.9	4,406	39.0	1,924
18	36	AV1	228.6	29.6	9.17	2,155	1,804	31.7	4,369	39.1	1,807
19	36	AV1	244.5	30.4	9.52	2,193	1,822	32.4	4,481	38.4	1,808
20	36	AV1	251.1	30.8	9.62	2,249	1,878	32.8	4,543	38.2	1,976
21	36	AV1	263.0	31.5	9.89	2,240	1,850	33.5	4,645	37.7	1,926
22	36	AV1	263.2	31.6	9.94	2,251	1,861	33.8	4,659	37.6	2,000
23	36	AV1	263.9	31.7	10.00	2,279	1,895	34.0	4,677	37.5	2,013
24	48	AV1	260.4	31.7	10.00	2,264	1,889	34.0	4,684	37.5	2,019
25	48	AV1	242.7	30.8	9.67	2,246	1,887	33.2	4,553	38.1	2,020
26	48	AV1	274.8	32.5	10.33	2,282	1,875	34.8	4,805	36.9	2,064
27	48	AV1	262.7	31.7	10.05	2,261	1,888	34.1	4,687	37.4	2,001
28	48	AV1	250.9	31.0	9.67	2,195	1,819	33.3	4,571	38.1	1,954
29	48	AV1	262.2	31.5	9.94	2,241	1,847	33.9	4,647	37.6	2,018
30	48	AV1	289.8	33.0	10.57	2,310	1,894	35.4	4,878	36.5	2,087
31	48	AV1	265.7	33.1	10.45	2,163	1,773	35.4	4,880	36.7	1,810
		Average	263.2	31.5	10.33	2,327	1,914	33.6	4,650	35.0	1,973

Total number of blows analyzed: 31

BL# Sensors

1-31 F1: [G133] 97.0 (1.00); F2: [5235] 98.0 (1.00); F3: [H278] 99.0 (1.00);
F4: [H324] 93.0 (1.00); A1: [28243] 1025.0 (1.00); A2: [21461] 950.0 (1.00);
A3: [K3257] 340.0 (1.00); A4: [K3259] 365.0 (1.00)

BL#	Comments
1	Start of test on 6/10/2016 at 1:03 PM
4	Restart after 2 minutes 11 seconds
5	Restart after 1 minute 39 seconds
31	End of test on 6/10/2016 at 1:08 PM

Time Summary

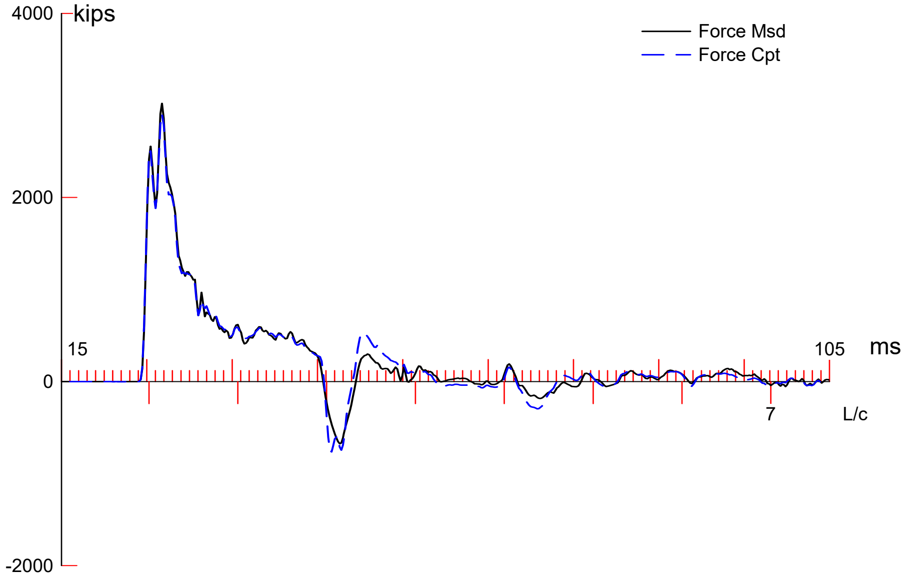
Drive	2 seconds	1:03 PM - 1:04 PM (6/10/2016) BN 1 - 3
Stop	2 minutes 11 seconds	1:04 PM - 1:06 PM
Drive	0 second	1:06 PM - 1:06 PM BN 4 - 4
Stop	1 minute 39 seconds	1:06 PM - 1:07 PM
Drive	42 seconds	1:07 PM - 1:08 PM BN 5 - 31

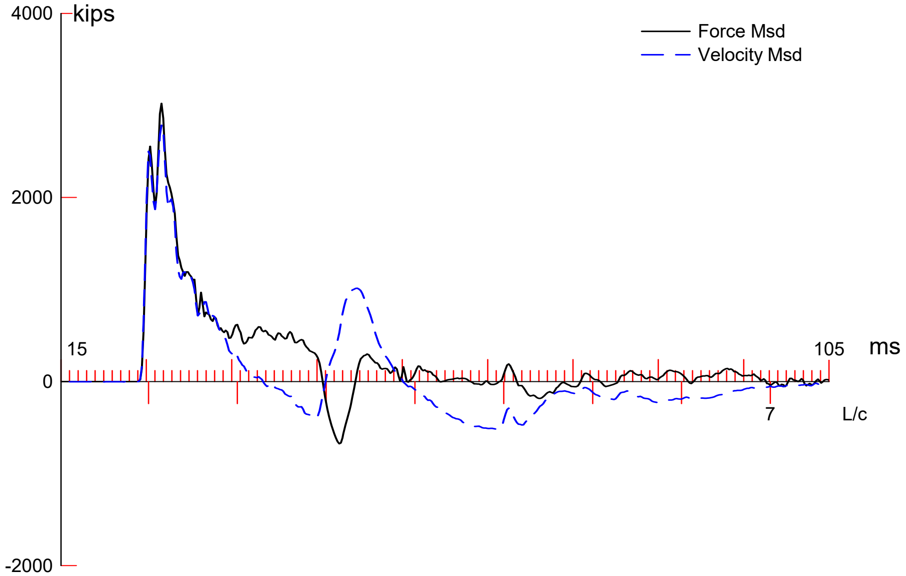
Total time [00:04:35] = (Driving [00:00:45] + Stop [00:03:50])

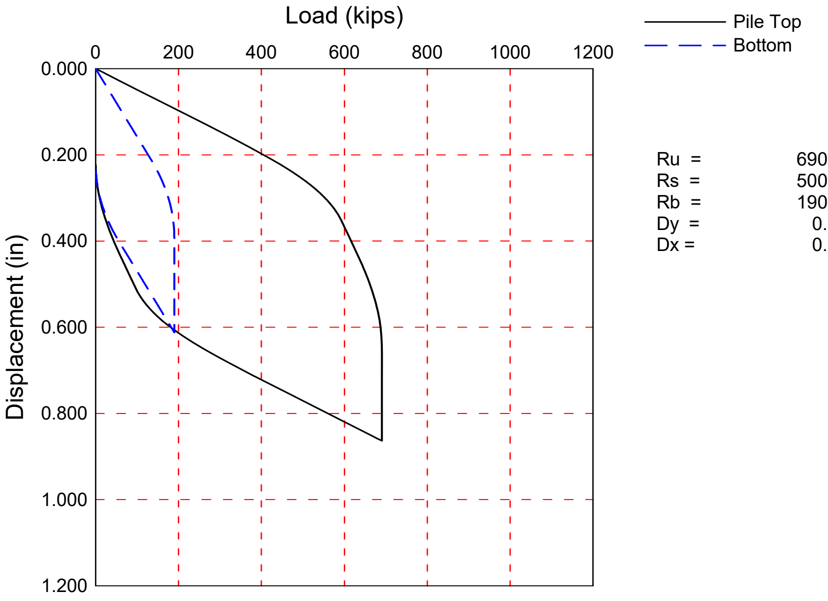
Appendix C

Results of CAPWAP Analysis

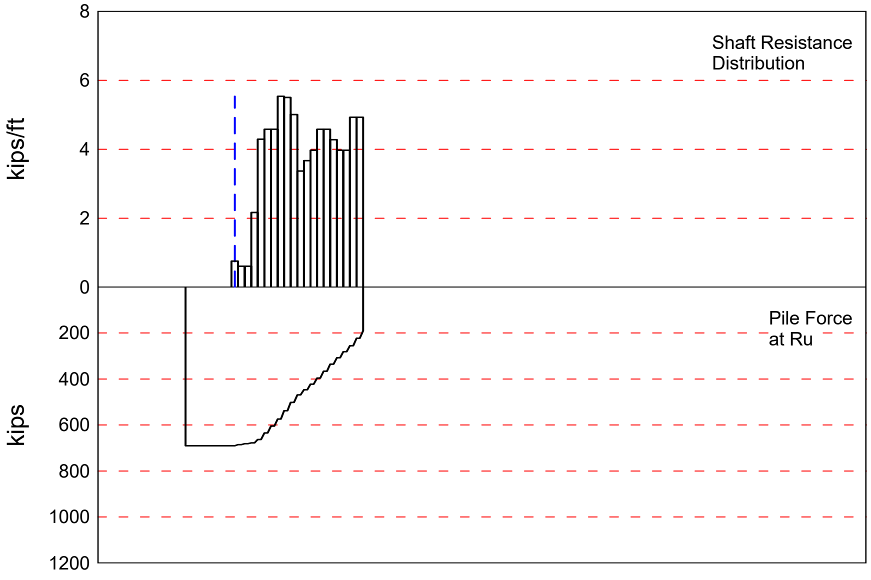
KIWC, POA TPP; Pile: IP 1 (Loc. 5); PP48x1.0", APE 15-4; Blow: 2167 (Test: 07-Jun-2016 13:01:) 07-Jun-2016
Robert Miner Dynamic Testing, Inc. CAPWAP(R) 2006-3







Ru = 690.4 kips
Rs = 500.4 kips
Rb = 190.0 kips
Dy = 0.64 in
Dx = 0.86 in



```
KIWC, POA TPP; Pile: IP 1 (Loc. 5)                               Test: 07-Jun-2016 13:01:
PP48x1.0'', APE 15-4; Blow: 2167                                         CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                               OP: RMDT
                                 CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:    690.4; along Shaft    500.4; at Toe    190.0  kips
   Soil     Dist.     Depth       Ru      Force        Sum      Unit       Unit      Smith
  Sgmnt     Below     Below             in Pile         of   Resist.    Resist.    Damping
    No.     Gages     Grade                             Ru   (Depth)     (Area)     Factor
               ft        ft     kips       kips       kips   kips/ft        ksf       s/ft

                                          690.4
      1      52.7       2.7      5.0      685.4        5.0      1.85       0.15      0.280
      2      59.3       9.3      4.0      681.4        9.0      0.61       0.05      0.280
      3      65.9      15.9      4.0      677.4       13.0      0.61       0.05      0.280
      4      72.5      22.5     14.3      663.1       27.3      2.17       0.17      0.280
      5      79.1      29.1     28.3      634.8       55.6      4.29       0.34      0.280
      6      85.7      35.7     30.2      604.6       85.8      4.58       0.36      0.280
      7      92.3      42.3     30.2      574.4      116.0      4.58       0.36      0.280
      8      98.9      48.9     36.5      537.9      152.5      5.54       0.44      0.280
      9     105.5      55.4     36.3      501.6      188.8      5.51       0.44      0.280
     10     112.1      62.0     33.0      468.6      221.8      5.01       0.40      0.280
     11     118.7      68.6     22.2      446.4      244.0      3.37       0.27      0.280
     12     125.3      75.2     24.2      422.2      268.2      3.67       0.29      0.280
     13     131.9      81.8     26.2      396.0      294.4      3.97       0.32      0.280
     14     138.4      88.4     30.2      365.8      324.6      4.58       0.36      0.280
     15     145.0      95.0     30.2      335.6      354.8      4.58       0.36      0.280
     16     151.6     101.6     28.2      307.4      383.0      4.28       0.34      0.280
     17     158.2     108.2     26.2      281.2      409.2      3.97       0.32      0.280
     18     164.8     114.8     26.2      255.0      435.4      3.97       0.32      0.280
     19     171.4     121.4     32.5      222.5      467.9      4.93       0.39      0.280
     20     178.0     128.0     32.5      190.0      500.4      4.93       0.39      0.280

  Avg. Shaft                    25.0                            3.91       0.31      0.280

       Toe                     190.0                                      15.12      0.160

Soil Model Parameters/Extensions                          Shaft      Toe

Quake                      (in)                           0.120    0.300
Case Damping Factor                                       0.523    0.113
Unloading Quake            (% of loading quake)              30      100
Reloading Level            (% of Ru)                        100      100
Unloading Level            (% of Ru)                          5
Soil Plug Weight           (kips)                                   0.70
Soil Support Dashpot                                      0.200    0.000
Soil Support Weight        (kips)                          8.65     0.00

max. Top Comp. Stress      =    19.7 ksi      (T=  27.2 ms, max= 1.017 x Top)
max. Comp. Stress          =    20.0 ksi      (Z=  72.5 ft, T=  31.2 ms)
max. Tens. Stress          =   -5.90 ksi      (Z=   6.6 ft, T=  47.8 ms)
max. Energy (EMX)          =    88.8 kip-ft;  max. Measured Top Displ. (DMX)= 0.77 in
```

EXTREMA TABLE

```
   Pile    Dist.     max.     min.     max.     max.     max.     max.     max.
  Sgmnt    Below    Force    Force    Comp.    Tens.   Trnsfd.   Veloc.   Displ.
    No.    Gages                     Stress   Stress   Energy
              ft     kips     kips      ksi      ksi   kip-ft     ft/s       in

      1      3.3   2903.8   -827.9     19.7    -5.61    88.75     10.8    0.746
      2      6.6   2902.7   -870.7     19.7    -5.90    88.62     10.8    0.744
      5     16.5   2899.1   -851.8     19.6    -5.77    88.21     10.8    0.738
      8     26.4   2895.3   -805.5     19.6    -5.45    87.79     10.8    0.733
     11     36.3   2894.3   -739.6     19.6    -5.01    87.38     10.8    0.727
     14     46.1   2899.6   -671.4     19.6    -4.55    87.06     10.7    0.722
     17     56.0   2893.7   -600.7     19.6    -4.07    86.24     10.6    0.715
     20     65.9   2924.8   -562.7     19.8    -3.81    85.55     10.4    0.708
     23     75.8   2923.0   -556.0     19.8    -3.76    82.88     10.1    0.700
     26     85.7   2900.7   -546.0     19.6    -3.70    79.19      9.8    0.692
     29     95.6   2768.2   -675.1     18.7    -4.57    72.75      9.5    0.683
     32    105.5   2709.6   -549.1     18.3    -3.72    68.66      9.2    0.674
     35    115.4   2534.6   -639.3     17.2    -4.33    61.49      8.9    0.664
     38    125.3   2520.7   -518.2     17.1    -3.51    57.94      8.6    0.654
     41    135.1   2417.7   -493.1     16.4    -3.34    51.76      8.4    0.644
     44    145.0   2381.6   -536.8     16.1    -3.63    46.08      8.1    0.644
     47    154.9   2260.9   -357.1     15.3    -2.42    38.10      9.3    0.644
     50    164.8   1957.3   -217.8     13.3    -1.47    34.17     12.0    0.642
     51    168.1   1911.8    -90.8     12.9    -0.61    30.37     12.3    0.641
     52    171.4   1826.7    -75.1     12.4    -0.51    30.35     11.5    0.640
     53    174.7   1383.4    -33.7      9.4    -0.23    25.49     11.6    0.639
     54    178.0    765.6    -16.3      5.2    -0.11    20.36     12.5    0.638

Absolute    72.5                       20.0                       (T =     31.2 ms)
             6.6                                -5.90             (T =     47.8 ms)
```

```
                                       CASE METHOD
J =           0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP         2378.0  2101.6  1825.2  1548.7  1272.3   995.9   719.4   443.0   166.6     0.0
RX         2378.0  2101.6  1825.2  1548.7  1272.3   995.9   719.4   446.1   446.1   446.1
RU         2363.2  2085.2  1807.3  1529.4  1251.5   973.6   695.6   417.7   139.8     0.0

RAU =    396.3 (kips);  RA2 =    543.4 (kips)

Current CAPWAP Ru = 690.4 (kips); Corresponding J(RP)= 0.61; J(RX) = 0.61

      VMX      TVP   VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms    kips     kips     kips       in       in       in   kip-ft     kips
    10.58    25.45  2595.2   2547.1   3062.9    0.775    0.222    0.222     89.2   2147.8


                               PILE PROFILE AND PILE MODEL
             Depth              Area         E-Modulus      Spec. Weight             Perim.
                ft               in²               ksi             lb/ft³                ft

              0.00            147.65           31043.9           492.000            12.566
            178.00            147.65           31043.9           492.000            12.566

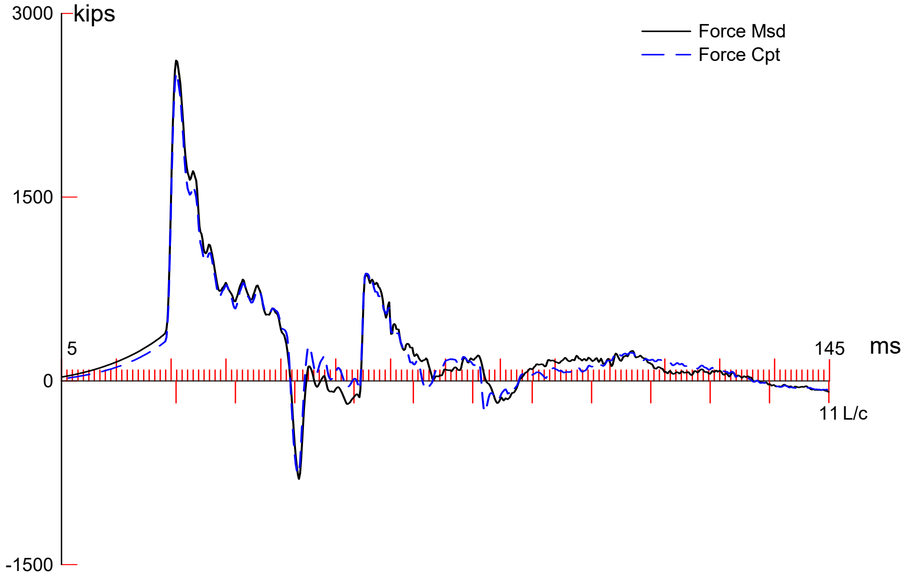
Toe Area                      12.566       ft²

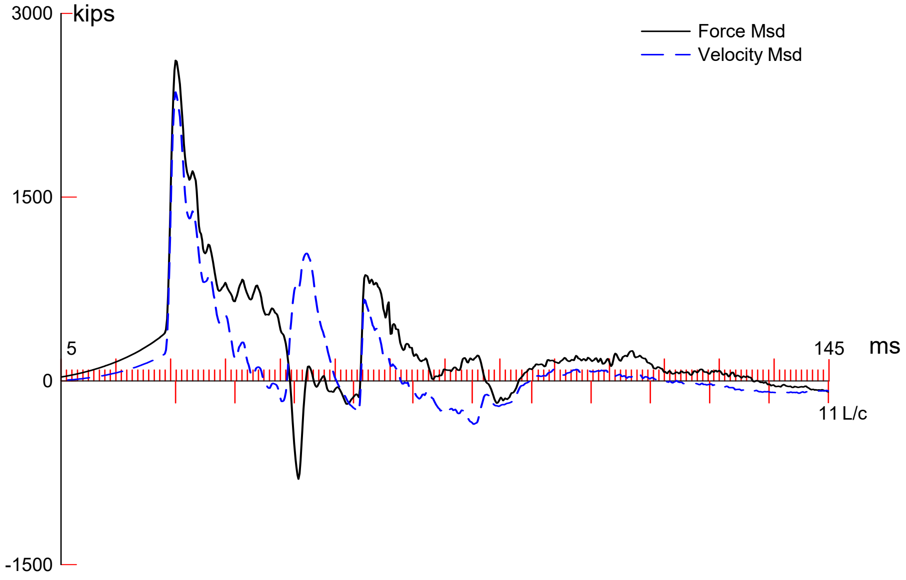
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

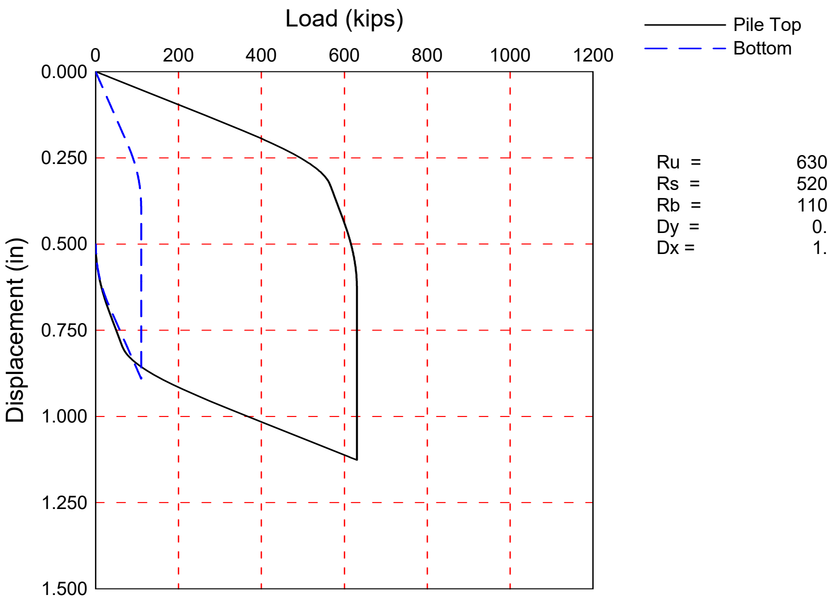
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  20.8 ms
```

KIWC, POA TPP; Pile: IP 2; PP48x1.0", APE D180-42; Blow: 818 (Test: 19-May-2016 11:26:)
Robert Miner Dynamic Testing, Inc.

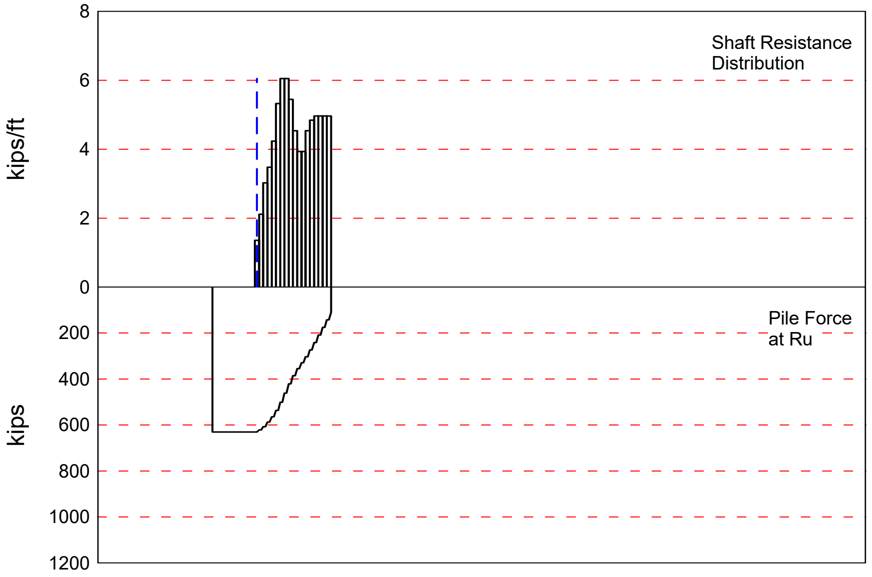
12-Jul-2016
CAPWAP(R) 2006-3







Ru = 630.4 kips
Rs = 520.4 kips
Rb = 110.0 kips
Dy = 0.63 in
Dx = 1.13 in



```
                               CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:    630.4; along Shaft    520.4; at Toe    110.0  kips
   Soil     Dist.    Depth       Ru      Force        Sum      Unit      Unit     Smith
  Sgmnt     Below    Below              in Pile        of    Resist.   Resist.   Damping
    No.     Gages    Grade                             Ru    (Depth)   (Area)    Factor
               ft       ft     kips       kips       kips    kips/ft       ksf      s/ft

                                         630.4
      1      72.7      2.7      9.0      621.4        9.0       3.36      0.27     0.240
      2      79.3      9.3     14.0      607.4       23.0       2.12      0.17     0.240
      3      85.9     15.9     20.0      587.4       43.0       3.03      0.24     0.240
      4      92.5     22.5     23.0      564.4       66.0       3.48      0.28     0.240
      5      99.1     29.1     28.0      536.4       94.0       4.24      0.34     0.240
      6     105.7     35.7     35.2      501.2      129.2       5.33      0.42     0.240
      7     112.3     42.3     40.0      461.2      169.2       6.05      0.48     0.240
      8     118.9     48.9     40.0      421.2      209.2       6.05      0.48     0.240
      9     125.5     55.5     36.0      385.2      245.2       5.45      0.43     0.240
     10     132.1     62.1     30.0      355.2      275.2       4.54      0.36     0.240
     11     138.8     68.8     26.0      329.2      301.2       3.94      0.31     0.240
     12     145.4     75.4     26.0      303.2      327.2       3.94      0.31     0.240
     13     152.0     82.0     30.0      273.2      357.2       4.54      0.36     0.240
     14     158.6     88.6     32.0      241.2      389.2       4.84      0.39     0.240
     15     165.2     95.2     32.8      208.4      422.0       4.96      0.40     0.240
     16     171.8    101.8     32.8      175.6      454.8       4.96      0.40     0.240
     17     178.4    108.4     32.8      142.8      487.6       4.96      0.40     0.240
     18     185.0    115.0     32.8      110.0      520.4       4.96      0.40     0.240

  Avg. Shaft                   28.9                             4.53      0.36     0.240

       Toe                    110.0                                       8.75     0.160
Soil Model Parameters/Extensions                      Shaft       Toe

Quake                  (in)                           0.100     0.300
Case Damping Factor                                   0.466     0.066
Unloading Quake        (% of loading quake)              30        70
Reloading Level        (% of Ru)                        100       100
Unloading Level        (% of Ru)                         40
Soil Support Dashpot                                  0.250     0.000
Soil Support Weight    (kips)                          8.67      0.00
max. Top Comp. Stress      =    17.0 ksi      (T=  26.3 ms, max= 1.024 x Top)
max. Comp. Stress          =    17.4 ksi      (Z=  72.7 ft, T=  30.5 ms)
max. Tens. Stress          =   -4.65 ksi      (Z=   3.3 ft, T=  48.5 ms)
max. Energy (EMX)          =    94.1 kip-ft;  max. Measured Top Displ. (DMX)= 0.99 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	2513.1	-686.6	17.0	-4.65	94.14	9.2	1.014
2	6.6	2514.1	-619.6	17.0	-4.20	94.12	9.2	1.014
5	16.5	2517.8	-664.8	17.0	-4.50	94.08	9.1	1.012
8	26.4	2521.7	-611.5	17.1	-4.14	94.04	9.1	1.010
11	36.3	2526.3	-485.8	17.1	-3.29	93.99	9.1	1.006
14	46.3	2531.8	-516.9	17.1	-3.50	93.95	9.0	0.999
17	56.2	2538.5	-381.9	17.2	-2.59	93.90	9.0	0.992
20	66.1	2554.0	-403.5	17.3	-2.73	93.86	8.9	0.981
23	76.0	2559.4	-353.8	17.3	-2.40	92.29	8.8	0.970
26	85.9	2560.3	-281.1	17.3	-1.90	89.94	8.6	0.957
29	95.8	2486.0	-465.7	16.8	-3.15	83.15	8.4	0.946
32	105.7	2468.8	-332.0	16.7	-2.25	78.94	8.2	0.936
35	115.6	2324.6	-446.7	15.7	-3.02	68.36	7.9	0.934
38	125.5	2265.8	-423.4	15.3	-2.87	62.83	7.7	0.933
41	135.4	2127.9	-309.7	14.4	-2.10	53.43	7.6	0.932
44	145.4	2096.7	-346.9	14.2	-2.35	49.57	7.4	0.930
47	155.3	1991.2	-209.2	13.5	-1.42	41.10	8.7	0.929
50	165.2	1946.3	-102.4	13.2	-0.69	36.12	8.8	0.926
53	175.1	1542.7	-55.3	10.4	-0.37	25.76	10.8	0.923
54	178.4	1231.3	-37.4	8.3	-0.25	25.74	11.3	0.921
55	181.7	727.6	-23.9	4.9	-0.16	20.38	11.7	0.920
56	185.0	410.1	-22.0	2.8	-0.15	15.05	11.8	0.920
Absolute	72.7			17.4			(T =	30.5 ms)
	3.3				-4.65		(T =	48.5 ms)

```
                                    CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        1836.6  1522.7  1208.7   894.8   580.9   266.9     0.0     0.0     0.0     0.0
RX        1836.6  1522.7  1208.7   894.8   598.3   538.9   516.8   494.6   472.9   472.2
RU        1840.9  1527.4  1213.9   900.4   586.8   273.3     0.0     0.0     0.0     0.0

RAU =    320.3 (kips);  RA2 =    484.9 (kips)

Current CAPWAP Ru = 630.4 (kips); Corresponding J(RP)= 0.38; J(RX) = 0.39

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
     8.86    26.08   2375.7   2600.3   2629.7    0.989    0.500    0.500     92.2   1486.9


                              PILE PROFILE AND PILE MODEL
             Depth              Area          E-Modulus     Spec. Weight            Perim.
                ft               in²                ksi            lb/ft³               ft

              0.00            147.65            31043.9          492.000            12.566
            185.00            147.65            31043.9          492.000            12.566

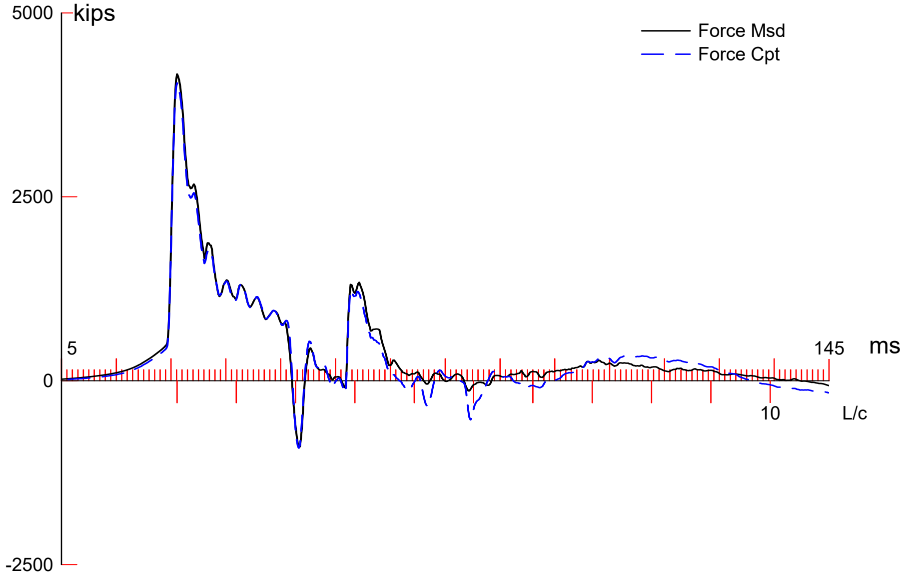
Toe Area                      12.566       ft²

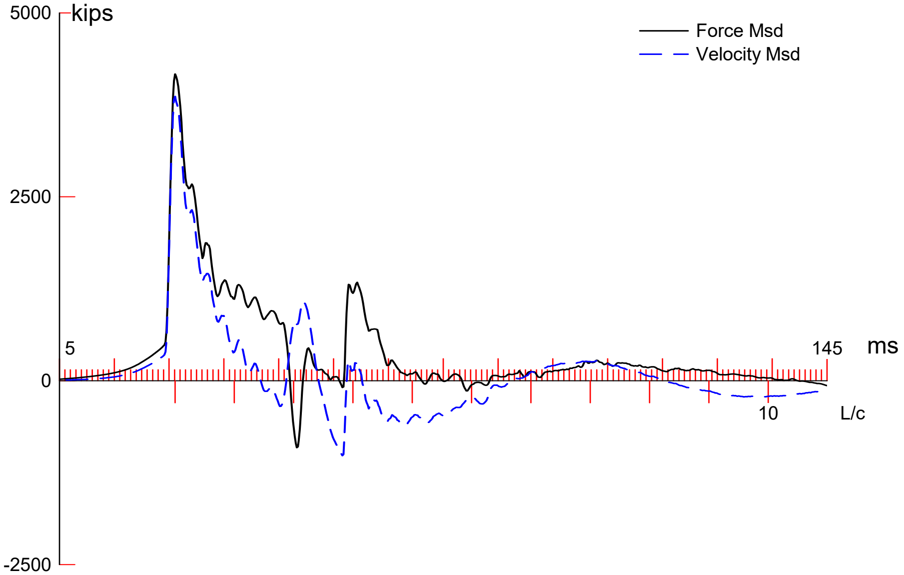
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

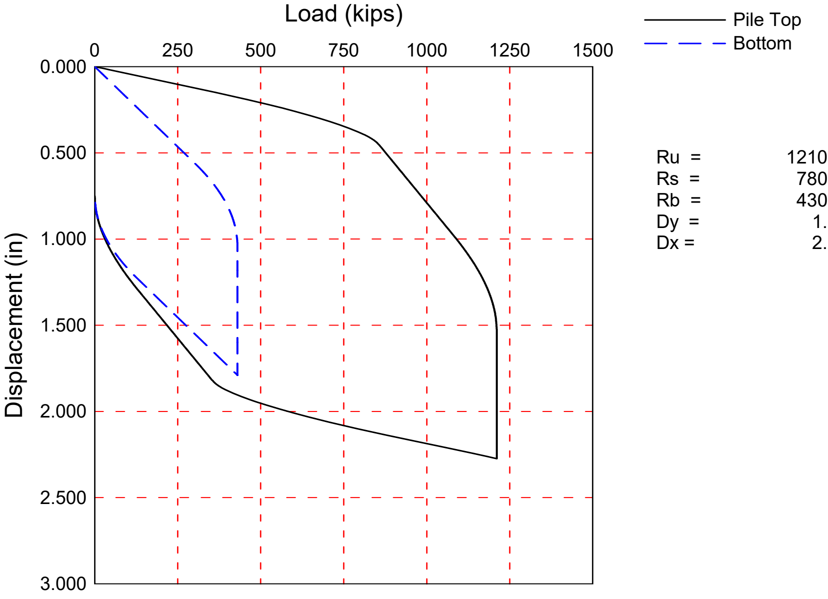
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 2; PP48x1.0", APE D180-42; Blow: 1248 (Test: 19-May-2016 11:40:)
Robert Miner Dynamic Testing, Inc.

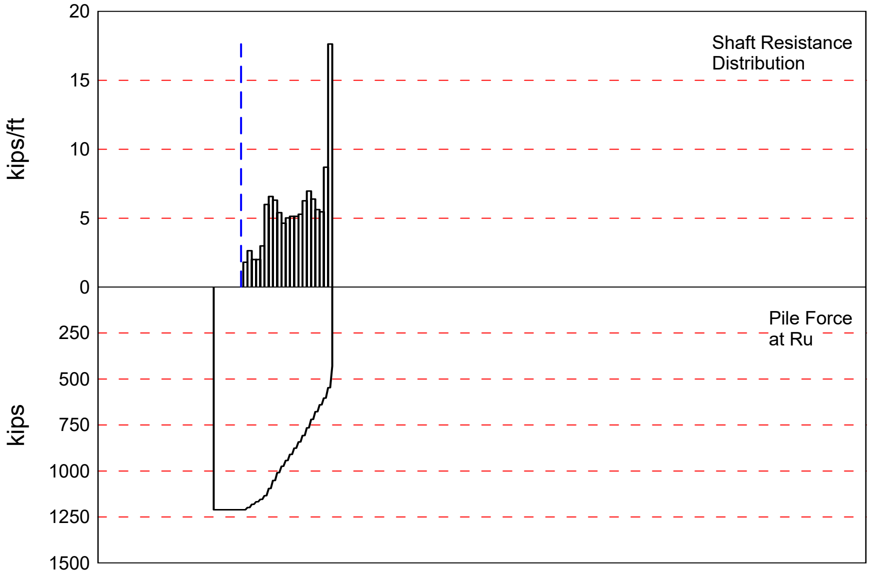
22-May-2016
CAPWAP(R) 2006-3







Ru = 1210.4 kips
Rs = 780.4 kips
Rb = 430.0 kips
Dy = 1.52 in
Dx = 2.27 in



```
                              CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1210.4; along Shaft    780.4; at Toe    430.0  kips
    Soil     Dist.     Depth        Ru      Force        Sum       Unit       Unit      Smith
   Sgmnt     Below     Below               in Pile        of     Resist.    Resist.    Damping
     No.     Gages     Grade                              Ru     (Depth)    (Area)     Factor
                ft        ft      kips       kips       kips     kips/ft       ksf       s/ft

                                           1210.4
       1      52.9       8.7      12.0     1198.4       12.0        1.37       0.11      0.180
       2      59.5      15.3      17.5     1180.9       29.5        2.65       0.21      0.180
       3      66.1      21.9      13.3     1167.6       42.8        2.01       0.16      0.180
       4      72.7      28.6      13.3     1154.3       56.1        2.01       0.16      0.180
       5      79.3      35.2      19.8     1134.5       75.9        3.00       0.24      0.180
       6      85.9      41.8      39.7     1094.8      115.6        6.01       0.48      0.180
       7      92.5      48.4      43.5     1051.3      159.1        6.58       0.52      0.180
       8      99.1      55.0      41.7     1009.6      200.8        6.31       0.50      0.180
       9     105.7      61.6      35.7      973.9      236.5        5.40       0.43      0.180
      10     112.3      68.2      30.7      943.2      267.2        4.65       0.37      0.180
      11     118.9      74.8      33.2      910.0      300.4        5.02       0.40      0.180
      12     125.5      81.4      34.0      876.0      334.4        5.15       0.41      0.180
      13     132.1      88.0      34.0      842.0      368.4        5.15       0.41      0.180
      14     138.8      94.6      35.0      807.0      403.4        5.30       0.42      0.180
      15     145.4     101.2      41.4      765.6      444.8        6.27       0.50      0.180
      16     152.0     107.8      46.1      719.5      490.9        6.98       0.56      0.180
      17     158.6     114.4      42.2      677.3      533.1        6.39       0.51      0.180
      18     165.2     121.1      37.2      640.1      570.3        5.63       0.45      0.180
      19     171.8     127.7      36.1      604.0      606.4        5.46       0.43      0.180
      20     178.4     134.3      57.5      546.5      663.9        8.70       0.69      0.180
      21     185.0     140.9     116.5      430.0      780.4       17.63       1.40      0.180

  Avg. Shaft                      37.2                              5.54       0.44      0.180

       Toe                       430.0                                        34.22      0.070

Soil Model Parameters/Extensions                    Shaft       Toe

Quake                      (in)                     0.110     0.800
Case Damping Factor                                 0.533     0.114
Unloading Quake            (% of loading quake)        50       100
Reloading Level            (% of Ru)                  100       100
Soil Plug Weight           (kips)                              0.50

max. Top Comp. Stress      =    27.4 ksi      (T=  26.5 ms, max= 1.021 x Top)
max. Comp. Stress          =    28.0 ksi      (Z=  52.9 ft, T=  29.4 ms)
max. Tens. Stress          =   -5.70 ksi      (Z=   3.3 ft, T=  48.5 ms)
max. Energy (EMX)          =   228.8 kip-ft;  max. Measured Top Displ. (DMX)= 1.27 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	4050.7	-842.3	27.4	-5.70	228.84	14.9	1.309
2	6.6	4052.7	-738.2	27.4	-5.00	228.77	14.8	1.306
5	16.5	4059.8	-574.2	27.5	-3.89	228.56	14.8	1.293
8	26.4	4069.0	-629.6	27.6	-4.26	228.33	14.7	1.281
11	36.3	4080.6	-608.9	27.6	-4.12	228.10	14.7	1.262
14	46.3	4104.9	-551.8	27.8	-3.74	227.86	14.6	1.239
17	56.2	4105.1	-565.9	27.8	-3.83	224.45	14.4	1.225
20	66.1	4083.9	-645.1	27.7	-4.37	219.68	14.2	1.213
23	76.0	4046.9	-539.9	27.4	-3.66	212.81	14.0	1.200
26	85.9	4067.3	-483.9	27.5	-3.28	208.00	13.6	1.189
29	95.8	3871.9	-473.2	26.2	-3.20	189.33	13.3	1.173
32	105.7	3806.6	-438.7	25.8	-2.97	180.09	13.0	1.158
35	115.6	3658.7	-342.9	24.8	-2.32	165.43	12.7	1.145
38	125.5	3620.8	-421.7	24.5	-2.86	157.97	12.4	1.128
41	135.4	3475.1	-290.8	23.5	-1.97	143.44	12.1	1.114
44	145.4	3446.0	-208.5	23.3	-1.41	135.86	11.8	1.097
47	155.3	3251.7	-206.2	22.0	-1.40	117.39	12.1	1.080
50	165.2	3187.9	0.0	21.6	0.00	108.10	12.5	1.065
53	175.1	2755.5	0.0	18.7	0.00	91.61	15.6	1.051
54	178.4	2342.6	0.0	15.9	0.00	91.56	16.5	1.047
55	181.7	1617.4	0.0	11.0	0.00	77.90	17.0	1.043
56	185.0	1161.5	0.0	7.9	0.00	50.10	17.3	1.039
Absolute	52.9			28.0			(T =	29.4 ms)
	3.3				-5.70		(T =	48.5 ms)

```
                                  CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        3355.7  2891.7  2427.8  1963.8  1499.8  1035.8   571.8   107.8     0.0     0.0
RX        3355.7  2891.7  2427.8  1963.8  1499.8  1343.6  1309.0  1274.3  1239.6  1204.9
RU        3405.2  2946.1  2487.1  2028.1  1569.0  1110.0   650.9   191.9     0.0     0.0

RAU =    934.5 (kips);  RA2 =   1451.3 (kips)

Current CAPWAP Ru = 1210.4 (kips); Corresponding J(RP)= 0.46; J(RX) = 0.88

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    14.53    26.27   3830.2   4165.3   4187.2    1.266    0.750    0.750    228.6   2721.7


                             PILE PROFILE AND PILE MODEL
                    Depth             Area         E-Modulus    Spec. Weight           Perim.
                       ft              in²               ksi           lb/ft³               ft

                     0.00           147.65           31043.9         492.000           12.566
                   185.00           147.65           31043.9         492.000           12.566

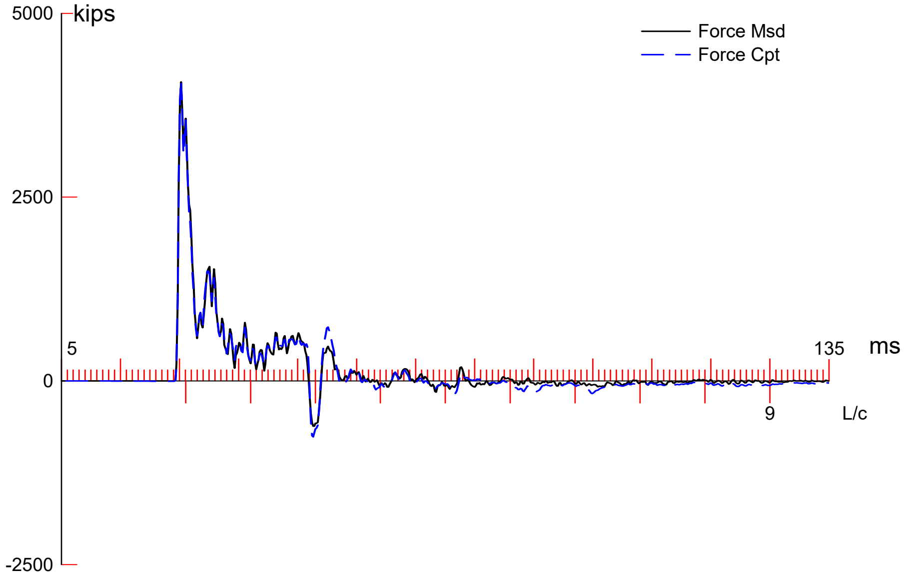
Toe Area                            12.566       ft²

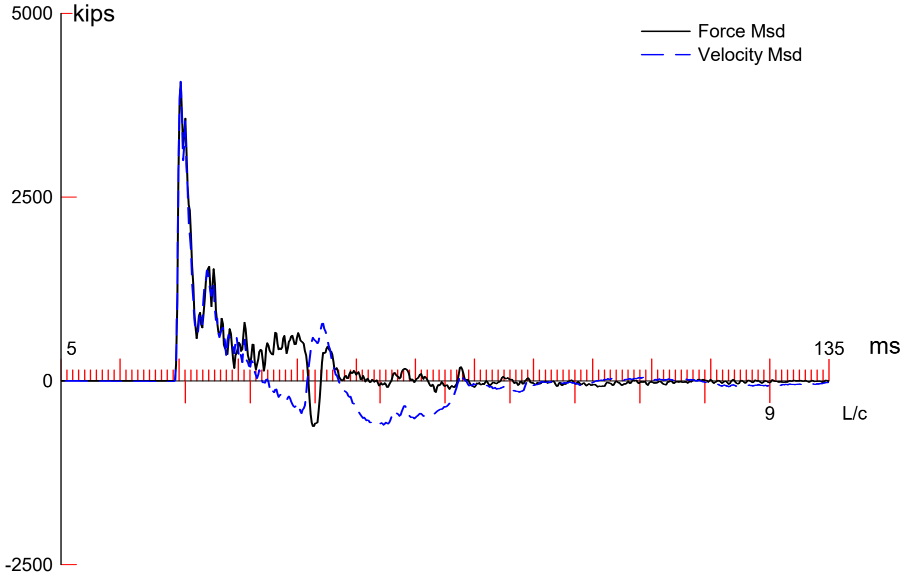
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

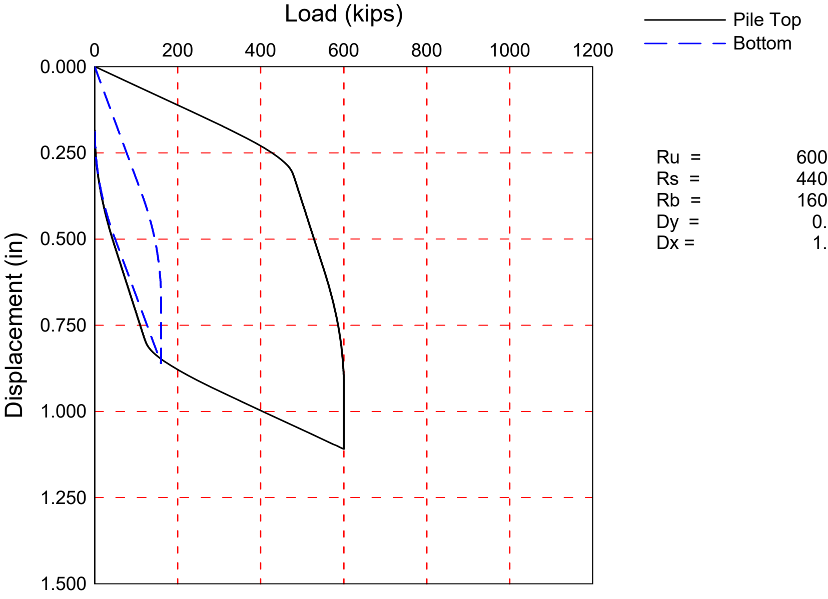
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 3_1; PP48x1.0", APE 15-4; Blow: 2366 (Test: 03-Jun-2016 11:56:)
Robert Miner Dynamic Testing, Inc.

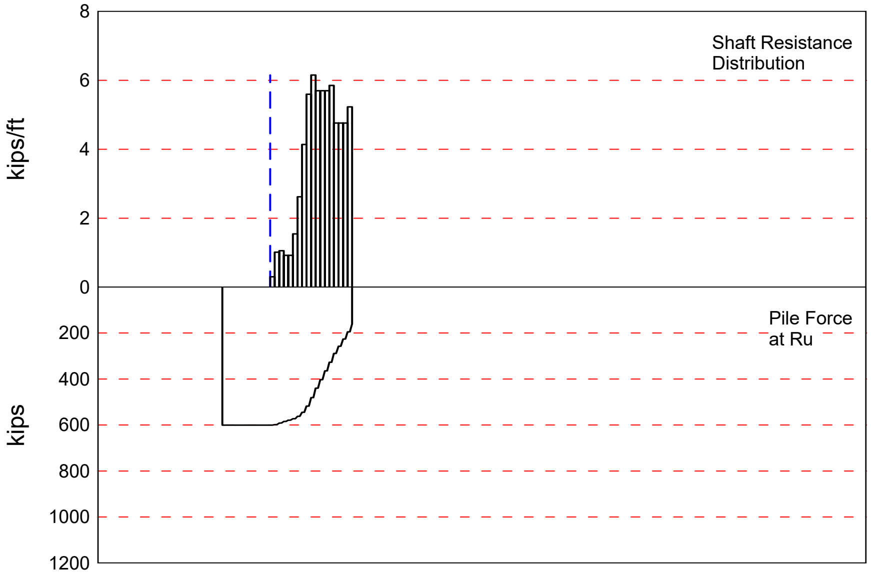
12-Jul-2016
CAPWAP(R) 2006-3







Ru = 600.3 kips
Rs = 440.3 kips
Rb = 160.0 kips
Dy = 0.93 in
Dx = 1.11 in



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KIWC, POA TPP; Pile: IP 3_1                                          Test: 03-Jun-2016 11:56:
PP48x1.0'', APE 15-4; Blow: 2366                                            CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                                   OP: RMDT
---------------------------------------------------------------------------------------------
                                  CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:    600.3; along Shaft    440.3; at Toe    160.0  kips
---------------------------------------------------------------------------------------------
    Soil     Dist.     Depth        Ru      Force        Sum       Unit       Unit      Smith
   Sgmnt     Below     Below               in Pile        of    Resist.    Resist.    Damping
     No.     Gages     Grade                              Ru    (Depth)     (Area)     Factor
                ft        ft      kips       kips       kips    kips/ft        ksf       s/ft
---------------------------------------------------------------------------------------------

                                             600.3
       1      75.9       3.9       2.0      598.3        2.0       0.52       0.04      0.400
       2      82.5      10.5       6.7      591.6        8.7       1.02       0.08      0.400
       3      89.1      17.1       7.0      584.6       15.7       1.06       0.08      0.400
       4      95.6      23.6       6.1      578.5       21.8       0.92       0.07      0.400
       5     102.2      30.2       6.1      572.4       27.9       0.92       0.07      0.400
       6     108.8      36.8      10.2      562.2       38.1       1.55       0.12      0.400
       7     115.4      43.4      17.3      544.9       55.4       2.62       0.21      0.400
       8     122.0      50.0      27.3      517.6       82.7       4.14       0.33      0.400
       9     128.6      56.6      36.9      480.7      119.6       5.59       0.45      0.400
      10     135.2      63.2      40.6      440.1      160.2       6.15       0.49      0.400
      11     141.8      69.8      37.6      402.5      197.8       5.70       0.45      0.400
      12     148.4      76.4      37.6      364.9      235.4       5.70       0.45      0.400
      13     155.0      83.0      37.6      327.3      273.0       5.70       0.45      0.400
      14     161.6      89.6      38.6      288.7      311.6       5.85       0.47      0.400
      15     168.2      96.2      31.4      257.3      343.0       4.76       0.38      0.400
      16     174.8     102.8      31.4      225.9      374.4       4.76       0.38      0.400
      17     181.4     109.4      31.4      194.5      405.8       4.76       0.38      0.400
      18     188.0     116.0      34.5      160.0      440.3       5.23       0.42      0.400

  Avg. Shaft                      24.5                             3.80       0.30      0.400

       Toe                       160.0                                       12.73      0.330

Soil Model Parameters/Extensions                          Shaft       Toe
---------------------------------------------------------------------------------------------

Quake                      (in)                           0.100    0.520
Case Damping Factor                                       0.657    0.197
Reloading Level            (% of Ru)                        100      100
Unloading Level            (% of Ru)                         60
Soil Plug Weight           (kips)                                   0.40

max. Top Comp. Stress      =    27.6 ksi      (T=  25.7 ms, max= 1.000 x Top)
max. Comp. Stress          =    27.6 ksi      (Z=   3.3 ft, T=  25.7 ms)
max. Tens. Stress          =   -6.41 ksi      (Z= 164.9 ft, T=  38.0 ms)
max. Energy (EMX)          =   110.2 kip-ft;  max. Measured Top Displ. (DMX)= 0.69 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	4077.8	-767.0	27.6	-5.19	110.17	15.2	0.684
2	6.6	4075.0	-675.8	27.6	-4.58	110.07	15.2	0.683
5	16.5	4066.2	-699.4	27.5	-4.74	109.74	15.2	0.680
8	26.4	4056.7	-675.1	27.5	-4.57	109.33	15.1	0.671
11	36.3	4046.5	-685.5	27.4	-4.64	108.79	15.1	0.660
14	46.2	4035.7	-626.7	27.3	-4.24	108.18	15.1	0.647
17	56.1	4024.1	-643.1	27.2	-4.35	107.45	15.0	0.635
20	66.0	4011.8	-553.9	27.2	-3.75	106.61	15.0	0.627
23	75.9	4006.1	-544.3	27.1	-3.69	105.67	14.9	0.621
26	85.8	3969.8	-509.5	26.9	-3.45	103.31	14.7	0.614
29	95.6	3941.4	-423.0	26.7	-2.86	101.69	14.6	0.608
32	105.5	3886.0	-390.7	26.3	-2.65	99.05	14.4	0.601
35	115.4	3878.3	-417.7	26.3	-2.83	96.91	14.1	0.593
38	125.3	3731.4	-512.5	25.3	-3.47	88.57	13.5	0.586
41	135.2	3671.4	-365.4	24.9	-2.47	81.98	12.8	0.579
44	145.1	3380.7	-236.1	22.9	-1.60	68.38	12.2	0.573
47	155.0	3316.7	-375.2	22.5	-2.54	61.74	11.6	0.565
50	164.9	3056.9	-946.7	20.7	-6.41	49.40	11.1	0.559
53	174.8	3006.4	-682.7	20.4	-4.62	43.90	11.0	0.553
56	184.7	2197.2	-46.2	14.9	-0.31	32.84	14.4	0.550
57	188.0	1265.1	-0.6	8.6	-0.00	25.50	16.2	0.549
Absolute	3.3			27.6			(T =	25.7 ms)
	164.9				-6.41		(T =	38.0 ms)

```
                                  CASE METHOD
J =         0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP       3826.3  3352.1  2878.0  2403.8  1929.7  1455.6   981.4   507.3    33.2     0.0
RX       3826.3  3352.1  2878.0  2403.8  1929.7  1455.6   981.4   702.2   657.5   620.9
RU       3990.1  3532.3  3074.6  2616.8  2159.1  1701.3  1243.6   785.8   328.1     0.0

RAU =    579.1 (kips);  RA2 =    528.2 (kips)

Current CAPWAP Ru = 600.3 (kips); Corresponding J(RP)= 0.68; matches RX9 within 5%

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    16.25    26.23   4357.5   4210.2   4210.2    0.692    0.184    0.185    111.4   3051.5


                              PILE PROFILE AND PILE MODEL
             Depth               Area          E-Modulus     Spec. Weight            Perim.
                ft                in²                ksi            lb/ft³               ft

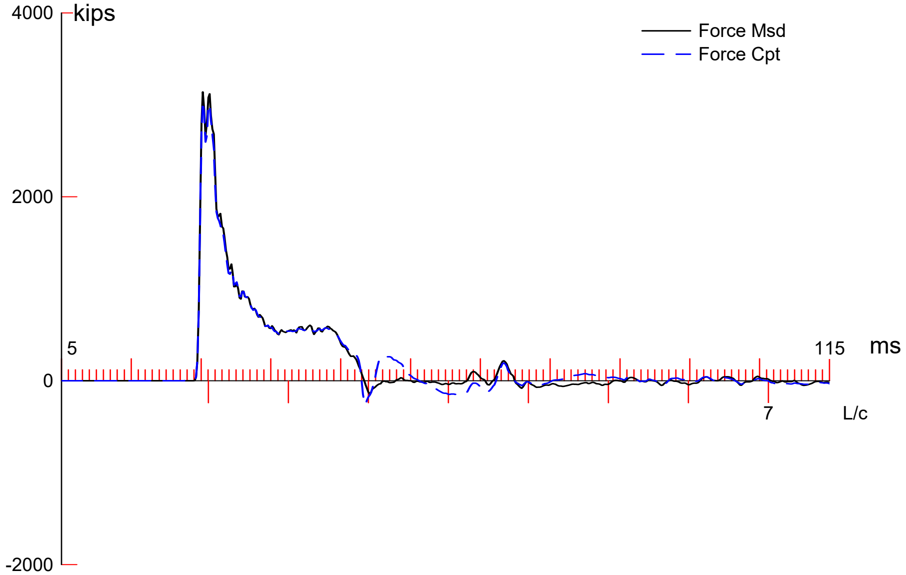
              0.00             147.65            31043.9          492.000            12.566
            188.00             147.65            31043.9          492.000            12.566

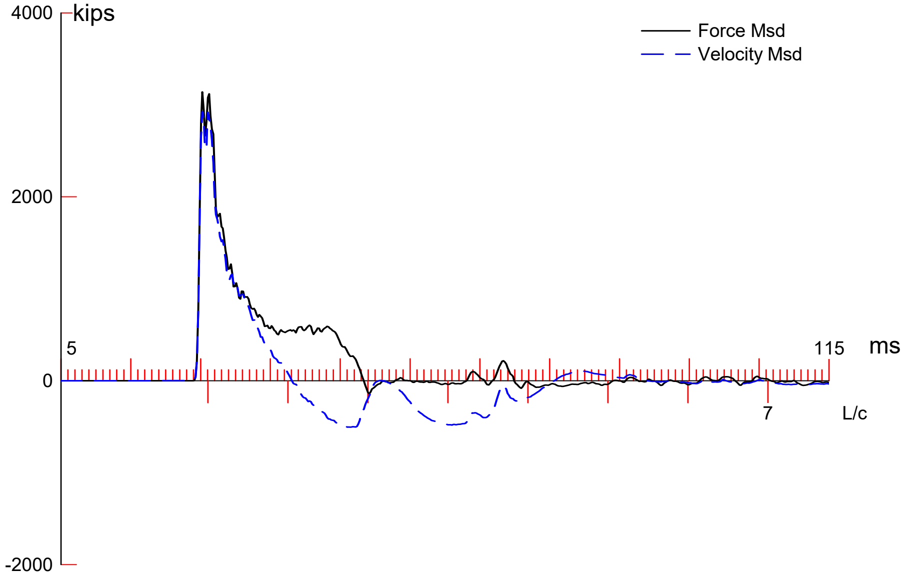
Toe Area                       12.566       ft²

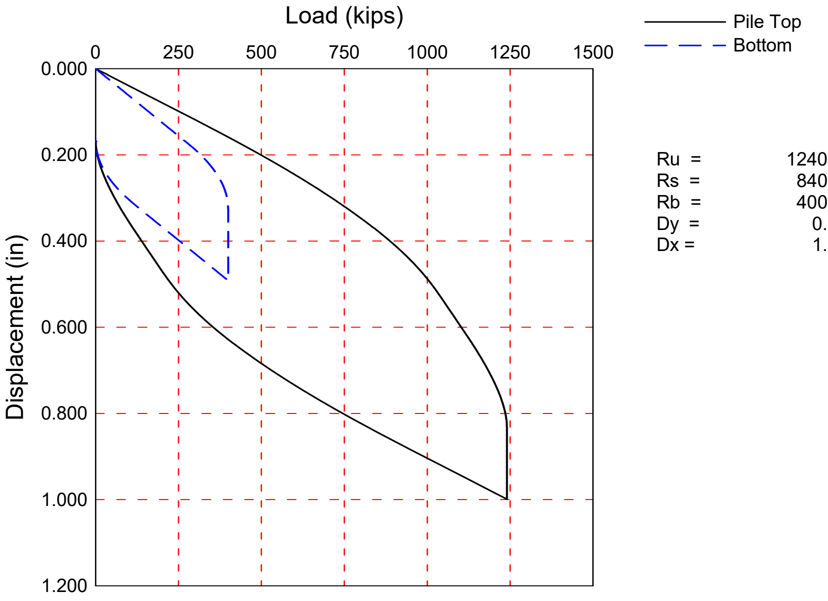
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  22.0 ms
```

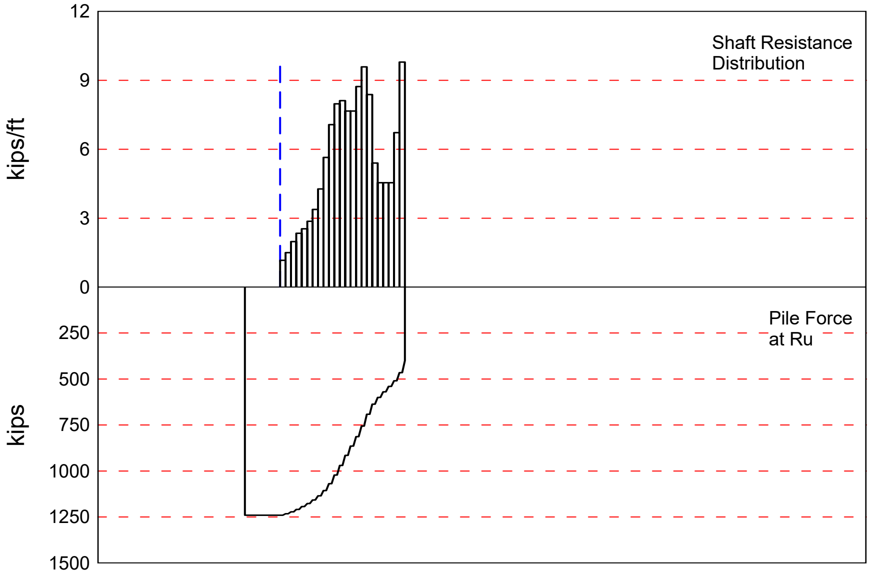
KIWC, POA TPP; Pile: IP 3 (Loc. 1); PP48x1.0", APE 15-4; Blow: 4872 (Test: 03-Jun-2016 14:02:) 06-Jun-2016
Robert Miner Dynamic Testing, Inc. CAPWAP(R) 2006-3







Ru = 1240.4 kips
Rs = 840.4 kips
Rb = 400.0 kips
Dy = 0.83 in
Dx = 1.00 in



```
                                 CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1240.4; along Shaft    840.4; at Toe    400.0  kips
    Soil     Dist.     Depth        Ru      Force        Sum      Unit       Unit      Smith
   Sgmnt     Below     Below              in Pile         of    Resist.    Resist.    Damping
     No.     Gages     Grade                              Ru    (Depth)     (Area)     Factor
                ft        ft      kips       kips       kips    kips/ft        ksf       s/ft

                                           1240.4
       1      49.8       3.3       7.8     1232.6        7.8       2.34       0.19      0.260
       2      56.5      10.0      10.0     1222.6       17.8       1.51       0.12      0.260
       3      63.1      16.6      13.2     1209.4       31.0       1.99       0.16      0.260
       4      69.8      23.3      15.6     1193.8       46.6       2.35       0.19      0.260
       5      76.4      29.9      16.9     1176.9       63.5       2.54       0.20      0.260
       6      83.1      36.6      19.1     1157.8       82.6       2.87       0.23      0.260
       7      89.7      43.2      22.5     1135.3      105.1       3.39       0.27      0.260
       8      96.3      49.8      28.4     1106.9      133.5       4.27       0.34      0.260
       9     103.0      56.5      37.5     1069.4      171.0       5.64       0.45      0.260
      10     109.6      63.1      47.0     1022.4      218.0       7.07       0.56      0.260
      11     116.3      69.8      53.0      969.4      271.0       7.98       0.63      0.260
      12     122.9      76.4      53.9      915.5      324.9       8.11       0.65      0.260
      13     129.6      83.1      50.9      864.6      375.8       7.66       0.61      0.260
      14     136.2      89.7      50.9      813.7      426.7       7.66       0.61      0.260
      15     142.8      96.3      58.0      755.7      484.7       8.73       0.69      0.260
      16     149.5     103.0      63.7      692.0      548.4       9.59       0.76      0.260
      17     156.1     109.6      55.7      636.3      604.1       8.38       0.67      0.260
      18     162.8     116.3      35.9      600.4      640.0       5.40       0.43      0.260
      19     169.4     122.9      30.2      570.2      670.2       4.55       0.36      0.260
      20     176.1     129.6      30.2      540.0      700.4       4.55       0.36      0.260
      21     182.7     136.2      30.2      509.8      730.6       4.55       0.36      0.260
      22     189.4     142.9      44.7      465.1      775.3       6.73       0.54      0.260
      23     196.0     149.5      65.1      400.0      840.4       9.80       0.78      0.260

  Avg. Shaft                      36.5                             5.62       0.45      0.260

       Toe                       400.0                                       31.83      0.225

Soil Model Parameters/Extensions                              Shaft      Toe

Quake                       (in)                              0.100    0.250
Case Damping Factor                                           0.815    0.336
Unloading Quake             (% of loading quake)                 30       60
Reloading Level             (% of Ru)                           100      100
Unloading Level             (% of Ru)                            10
Soil Plug Weight            (kips)                                      0.40
Soil Support Dashpot                                          0.330    0.000
Soil Support Weight         (kips)                             8.72     0.00
```

max. Top Comp. Stress = 20.5 ksi (T= 25.6 ms, max= 1.000 x Top)
max. Comp. Stress = 20.5 ksi (Z= 3.3 ft, T= 25.6 ms)
max. Tens. Stress = -1.69 ksi (Z= 3.3 ft, T= 48.6 ms)
max. Energy (EMX) = 97.1 kip-ft; max. Measured Top Displ. (DMX)= 0.63 in

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	3033.6	-249.5	20.5	-1.69	97.11	11.3	0.643
2	6.6	3030.6	-249.1	20.5	-1.69	96.97	11.3	0.638
5	16.6	3020.9	-215.8	20.5	-1.46	96.47	11.3	0.622
8	26.6	3010.8	-162.7	20.4	-1.10	95.89	11.2	0.604
11	36.5	3000.1	-156.0	20.3	-1.06	95.23	11.2	0.584
14	46.5	3012.4	-158.9	20.4	-1.08	94.49	11.1	0.564
17	56.5	3015.3	-155.3	20.4	-1.05	92.71	11.0	0.542
20	66.4	2972.8	-176.6	20.1	-1.20	89.12	10.8	0.519
23	76.4	2962.6	-180.2	20.1	-1.22	86.43	10.6	0.495
26	86.4	2898.0	-172.8	19.6	-1.17	81.76	10.4	0.486
29	96.3	2903.4	-182.6	19.7	-1.24	79.30	10.2	0.476
32	106.3	2797.3	-174.6	18.9	-1.18	73.06	9.8	0.465
35	116.3	2761.1	-164.3	18.7	-1.11	68.93	9.4	0.454
38	126.2	2539.4	-137.1	17.2	-0.93	60.49	8.9	0.442
41	136.2	2502.4	-122.7	16.9	-0.83	56.55	8.5	0.431
44	146.2	2305.4	-87.3	15.6	-0.59	48.85	8.1	0.420
47	156.1	2220.4	-93.6	15.0	-0.63	44.50	7.7	0.409
50	166.1	2067.0	-85.9	14.0	-0.58	38.36	7.5	0.398
53	176.1	2045.8	-107.3	13.9	-0.73	36.17	7.3	0.388
56	186.0	1970.2	-95.6	13.3	-0.65	31.93	8.9	0.377
59	196.0	1199.4	-72.6	8.1	-0.49	24.73	9.9	0.366
Absolute	3.3			20.5			(T =	25.6 ms)
	3.3				-1.69		(T =	48.6 ms)

```
                                      CASE METHOD
J =         0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP       3287.1  2995.7  2704.3  2412.9  2121.5  1830.1  1538.7  1247.3   955.9   664.5
RX       3287.1  2995.7  2704.3  2412.9  2121.5  1830.1  1538.7  1247.3   955.9   664.5
RU       3313.2  3024.4  2735.6  2446.8  2158.0  1869.2  1580.4  1291.6  1002.8   714.0

RAU =    423.9 (kips);  RA2 =    665.4 (kips)

Current CAPWAP Ru = 1240.4 (kips); Corresponding J(RP)= 0.70; J(RX) = 0.70

      VMX      TVP   VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms    kips     kips     kips       in       in       in   kip-ft     kips
    11.26    26.23  2974.6   3226.5   3228.0    0.633    0.169    0.167     97.7   2931.0

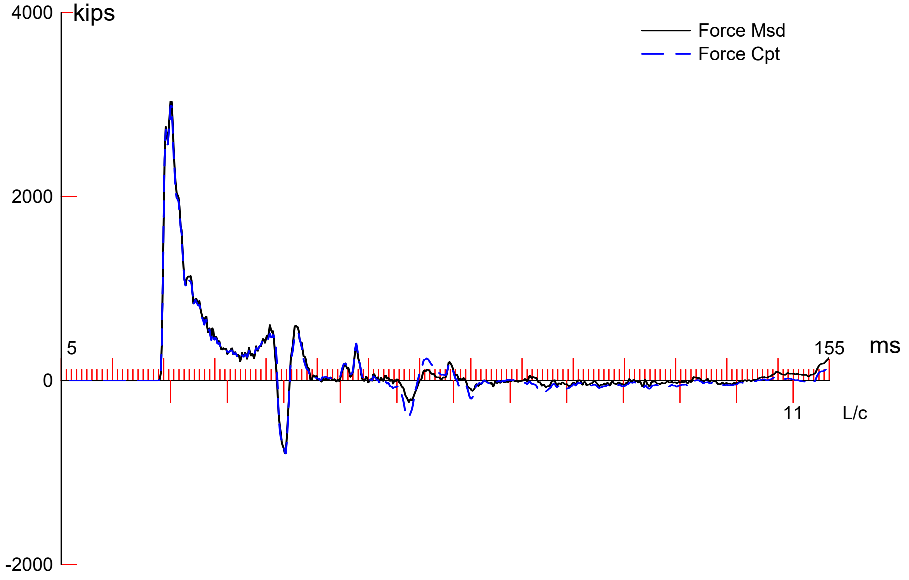

                              PILE PROFILE AND PILE MODEL
             Depth                Area          E-Modulus       Spec. Weight           Perim.
                ft                 in²                ksi              lb/ft³              ft

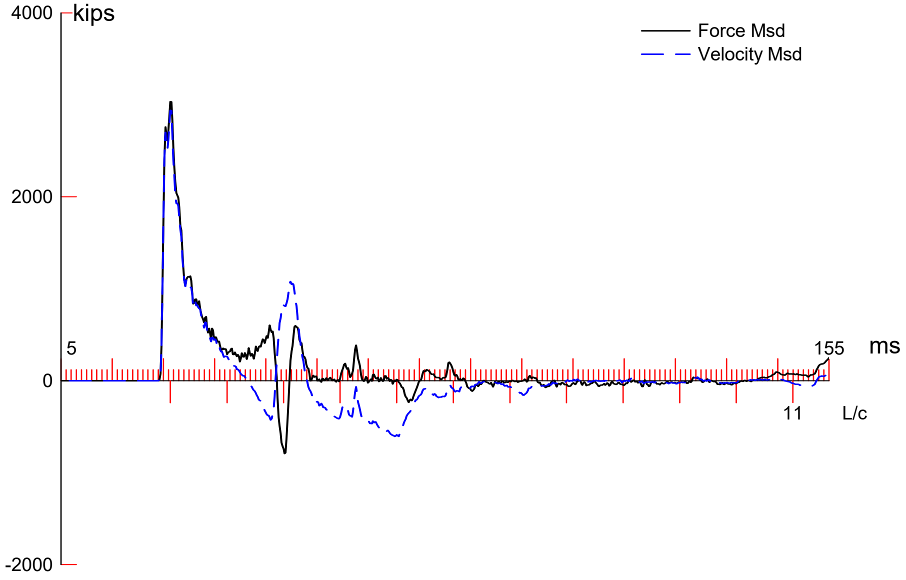
              0.00              147.65            31043.9            492.000           12.566
            196.00              147.65            31043.9            492.000           12.566

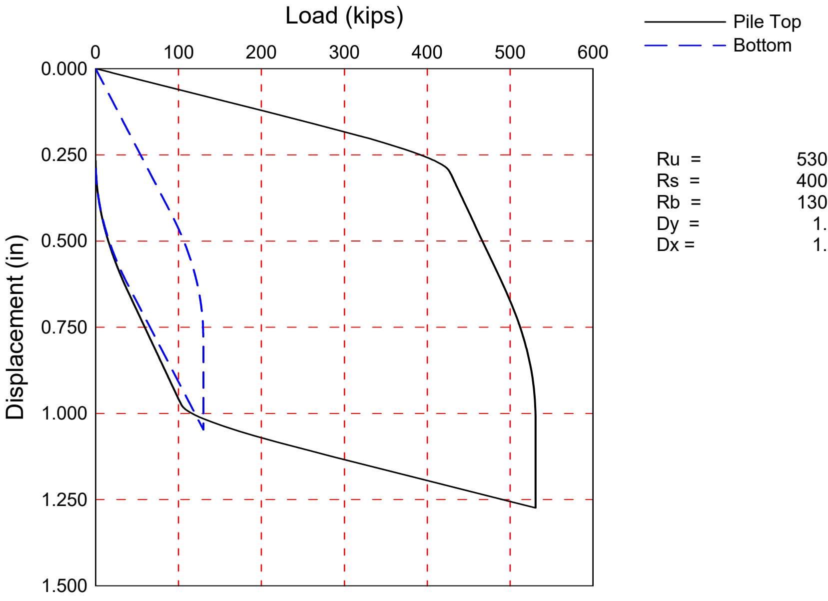
Toe Area                        12.566       ft²

Top Segment Length      3.32 ft, Top Impedance   268.13 kips/ft/s

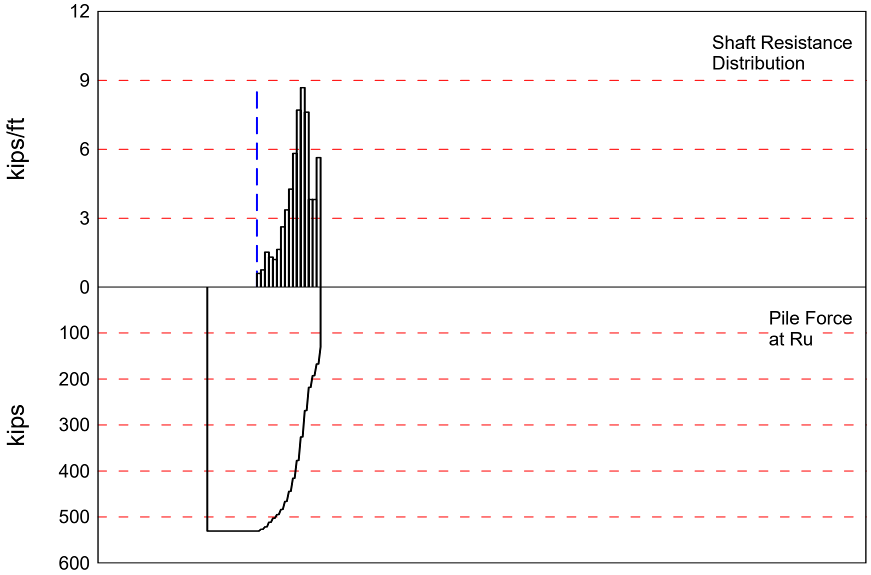
Pile Damping    1.0 %, Time Incr  0.194 ms, Wave Speed  17100.0 ft/s, 2L/c  22.9 ms
```







Ru = 530.5 kips
Rs = 400.5 kips
Rb = 130.0 kips
Dy = 1.01 in
Dx = 1.27 in



```
KIWC, POA TPP; Pile: IP 4                                         Test: 12-May-2016 15:43:
PP48x1.0'', APE D180-42; Blow: 1102                                      CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                                OP: RMDT
                                  CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:    530.5; along Shaft    400.5; at Toe    130.0  kips
   Soil     Dist.     Depth       Ru      Force        Sum      Unit       Unit      Smith
  Sgmnt     Below     Below             in Pile         of   Resist.    Resist.    Damping
    No.     Gages     Grade                             Ru   (Depth)     (Area)     Factor
               ft        ft     kips       kips       kips   kips/ft        ksf       s/ft

                                           530.5
      1      89.5       3.5      4.0      526.5        4.0      1.13       0.09      0.300
      2      96.2      10.2      5.0      521.5        9.0      0.75       0.06      0.300
      3     102.8      16.8     10.1      511.4       19.1      1.52       0.12      0.300
      4     109.4      23.4      8.7      502.7       27.8      1.31       0.10      0.300
      5     116.1      30.1      8.0      494.7       35.8      1.21       0.10      0.300
      6     122.7      36.7     10.9      483.8       46.7      1.64       0.13      0.300
      7     129.3      43.3     17.4      466.4       64.1      2.62       0.21      0.300
      8     135.9      49.9     22.3      444.1       86.4      3.36       0.27      0.300
      9     142.6      56.6     28.3      415.8      114.7      4.27       0.34      0.300
     10     149.2      63.2     38.6      377.2      153.3      5.82       0.46      0.300
     11     155.8      69.8     51.1      326.1      204.4      7.71       0.61      0.300
     12     162.5      76.5     57.6      268.5      262.0      8.69       0.69      0.300
     13     169.1      83.1     50.5      218.0      312.5      7.62       0.61      0.300
     14     175.7      89.7     25.3      192.7      337.8      3.82       0.30      0.300
     15     182.4      96.4     25.3      167.4      363.1      3.82       0.30      0.300
     16     189.0     103.0     37.4      130.0      400.5      5.64       0.45      0.300

  Avg. Shaft                    25.0                            3.89       0.31      0.300

       Toe                     130.0                                      10.35      0.350
Soil Model Parameters/Extensions                          Shaft      Toe

Quake                      (in)                           0.100    0.600
Case Damping Factor                                       0.448    0.170
Reloading Level            (% of Ru)                        100      100
Unloading Level            (% of Ru)                         45
Soil Plug Weight           (kips)                                   0.40

max. Top Comp. Stress      =    20.2 ksi      (T=  26.8 ms, max= 1.007 x Top)
max. Comp. Stress          =    20.4 ksi      (Z=  96.2 ft, T=  32.4 ms)
max. Tens. Stress          =   -5.18 ksi      (Z=   6.6 ft, T=  48.7 ms)
max. Energy (EMX)          =    96.9 kip-ft;  max. Measured Top Displ. (DMX)= 0.80 in
```

KIWC, POA TPP; Pile: IP 4 Test: 12-May-2016 15:43:
PP48x1.0'', APE D180-42; Blow: 1102 CAPWAP(R) 2006-3
Robert Miner Dynamic Testing, Inc. OP: RMDT

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	2988.0	-764.9	20.2	-5.18	96.94	11.1	0.819
2	6.6	2986.5	-765.3	20.2	-5.18	96.90	11.1	0.817
5	16.6	2985.8	-725.6	20.2	-4.91	96.73	11.1	0.813
8	26.5	2985.7	-721.1	20.2	-4.88	96.54	11.1	0.806
11	36.5	2985.3	-734.6	20.2	-4.97	96.29	11.1	0.796
14	46.4	2984.8	-733.1	20.2	-4.96	95.95	11.1	0.786
17	56.4	2984.3	-696.9	20.2	-4.72	95.56	11.1	0.775
20	66.3	2983.7	-653.0	20.2	-4.42	95.09	11.1	0.763
23	76.3	2986.5	-652.5	20.2	-4.42	94.49	11.1	0.751
26	86.2	3000.0	-582.9	20.3	-3.95	93.96	11.1	0.738
29	96.2	3008.7	-542.0	20.4	-3.67	93.17	10.9	0.725
32	106.1	2970.9	-521.5	20.1	-3.53	90.47	10.8	0.713
35	116.1	2969.6	-409.1	20.1	-2.77	88.92	10.7	0.702
38	126.0	2950.3	-396.6	20.0	-2.69	85.72	10.5	0.696
41	135.9	2962.6	-346.0	20.1	-2.34	82.83	10.1	0.689
44	145.9	2887.6	-304.2	19.6	-2.06	74.64	9.7	0.682
47	155.8	2878.4	-241.6	19.5	-1.64	68.46	9.1	0.676
50	165.8	2582.8	-416.9	17.5	-2.82	51.03	9.2	0.670
53	175.7	2199.5	-143.6	14.9	-0.97	42.45	11.6	0.665
56	185.7	1471.5	-23.5	10.0	-0.16	33.08	13.2	0.664
57	189.0	871.2	-3.5	5.9	-0.02	25.80	13.6	0.663
Absolute	96.2			20.4			(T =	32.4 ms)
	6.6				-5.18		(T =	48.7 ms)

```
                                      CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        2257.9  1926.8  1595.6  1264.5   933.4   602.3   271.1     0.0     0.0     0.0
RX        2257.9  1926.8  1595.6  1264.5   933.4   671.2   573.8   518.9   491.0   489.1
RU        2265.7  1935.3  1605.0  1274.6   944.3   613.9   283.6     0.0     0.0     0.0

RAU =    463.0 (kips);  RA2 =    511.3 (kips)

Current CAPWAP Ru = 530.5 (kips); Corresponding J(RP)= 0.52; J(RX) = 0.68

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   11.20    26.57   2760.2   2808.9   3086.0    0.799    0.267    0.267     97.3   2191.7


                              PILE PROFILE AND PILE MODEL
                   Depth               Area        E-Modulus     Spec. Weight          Perim.
                      ft                in²              ksi            lb/ft³              ft

                    0.00             147.65          31043.9          492.000          12.566
                  189.00             147.65          31043.9          492.000          12.566

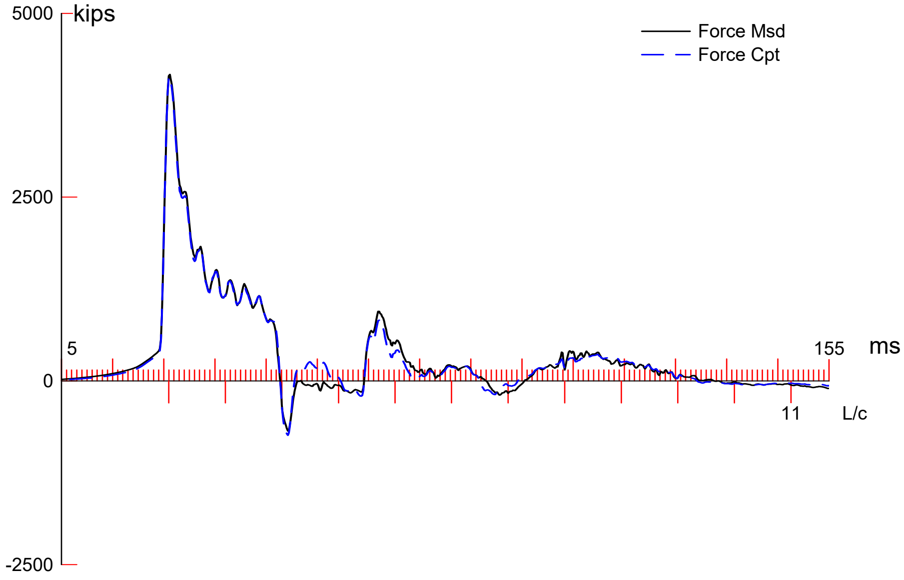
Toe Area                             12.566       ft²

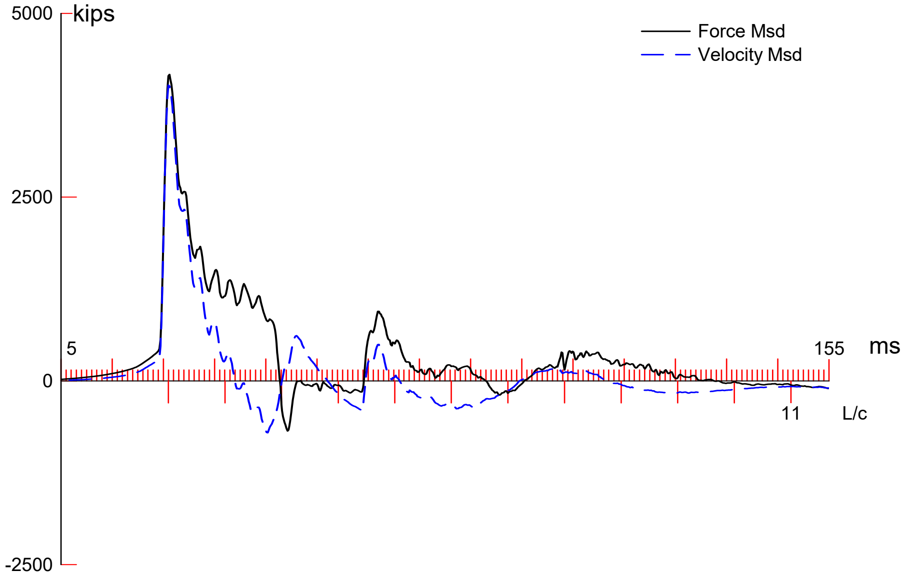
Top Segment Length      3.32 ft, Top Impedance   268.13 kips/ft/s

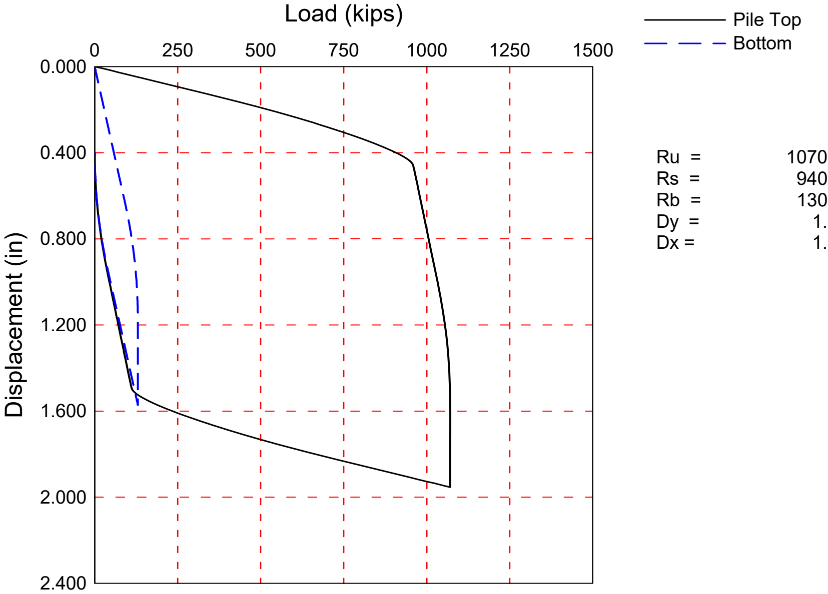
Pile Damping    1.0 %, Time Incr  0.194 ms, Wave Speed  17100.0 ft/s, 2L/c  22.1 ms
```

KIWC, POA TPP; Pile: IP 4_2; PP48x1.0", APE D180-42; Blow: 2879 (Test: 13-May-2016 08:35:)
Robert Miner Dynamic Testing, Inc.

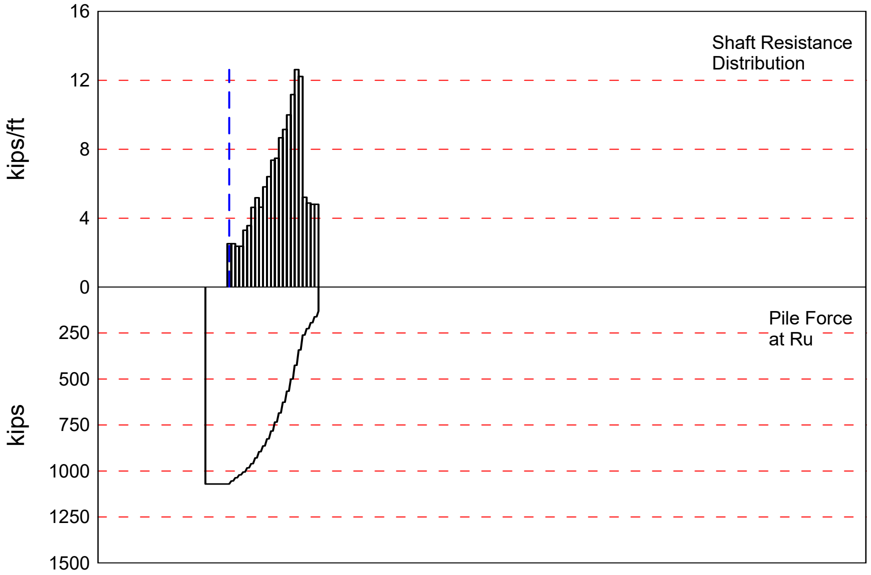
16-May-2016
CAPWAP(R) 2006-3







Ru = 1070.5 kips
Rs = 940.5 kips
Rb = 130.0 kips
Dy = 1.55 in
Dx = 1.95 in



CAPWAP(R) 2006-3 Licensed to Robert Miner Dynamic Testing, Inc.

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                                  CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1070.5; along Shaft    940.5; at Toe    130.0  kips
    Soil    Dist.     Depth       Ru      Force        Sum      Unit       Unit      Smith
   Sgmnt    Below     Below             in Pile         of   Resist.    Resist.    Damping
     No.    Gages     Grade                             Ru   (Depth)     (Area)     Factor
               ft        ft     kips       kips       kips   kips/ft        ksf       s/ft

                                         1070.5
       1     43.1       3.0     16.8     1053.7       16.8      5.53       0.44      0.300
       2     49.7       9.7     16.8     1036.9       33.6      2.53       0.20      0.300
       3     56.4      16.3     15.8     1021.1       49.4      2.38       0.19      0.300
       4     63.0      22.9     15.8     1005.3       65.2      2.38       0.19      0.300
       5     69.6      29.6     21.9      983.4       87.1      3.30       0.26      0.300
       6     76.3      36.2     23.7      959.7      110.8      3.57       0.28      0.300
       7     82.9      42.8     30.7      929.0      141.5      4.63       0.37      0.300
       8     89.5      49.5     34.4      894.6      175.9      5.19       0.41      0.300
       9     96.2      56.1     30.8      863.8      206.7      4.64       0.37      0.300
      10    102.8      62.7     38.6      825.2      245.3      5.82       0.46      0.300
      11    109.4      69.4     42.5      782.7      287.8      6.41       0.51      0.300
      12    116.1      76.0     48.9      733.8      336.7      7.37       0.59      0.300
      13    122.7      82.6     49.6      684.2      386.3      7.48       0.60      0.300
      14    129.3      89.2     57.5      626.7      443.8      8.67       0.69      0.300
      15    135.9      95.9     60.7      566.0      504.5      9.15       0.73      0.300
      16    142.6     102.5     66.3      499.7      570.8     10.00       0.80      0.300
      17    149.2     109.1     74.1      425.6      644.9     11.17       0.89      0.300
      18    155.8     115.8     83.7      341.9      728.6     12.62       1.00      0.300
      19    162.5     122.4     81.1      260.8      809.7     12.23       0.97      0.300
      20    169.1     129.0     34.6      226.2      844.3      5.22       0.42      0.300
      21    175.7     135.7     32.4      193.8      876.7      4.89       0.39      0.300
      22    182.4     142.3     31.9      161.9      908.6      4.81       0.38      0.300
      23    189.0     148.9     31.9      130.0      940.5      4.81       0.38      0.300

  Avg. Shaft                    40.9                            6.31       0.50      0.300

       Toe                     130.0                                      10.35      0.100

Soil Model Parameters/Extensions                          Shaft      Toe

Quake                      (in)                           0.110    0.900
Case Damping Factor                                       1.052    0.048
Unloading Quake            (% of loading quake)              30       50
Reloading Level            (% of Ru)                        100      100
Unloading Level            (% of Ru)                          0
Soil Plug Weight           (kips)                                   1.60
Soil Support Dashpot                                      0.370    0.000
Soil Support Weight        (kips)                          8.70     0.00
```

max. Top Comp. Stress = 28.0 ksi (T= 26.6 ms, max= 1.027 x Top)
max. Comp. Stress = 28.7 ksi (Z= 43.1 ft, T= 28.9 ms)
max. Tens. Stress = -4.81 ksi (Z= 6.6 ft, T= 49.1 ms)
max. Energy (EMX) = 223.9 kip-ft; max. Measured Top Displ. (DMX)= 1.07 in

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	4128.9	-698.8	28.0	-4.73	223.89	15.1	1.094
2	6.6	4131.6	-710.0	28.0	-4.81	223.38	15.1	1.084
5	16.6	4140.8	-525.4	28.0	-3.56	221.66	15.1	1.052
8	26.5	4152.1	-389.9	28.1	-2.64	219.67	15.0	1.017
11	36.5	4195.5	-414.9	28.4	-2.81	218.62	14.8	1.016
14	46.4	4172.7	-214.8	28.3	-1.45	213.62	14.6	1.019
17	56.4	4149.1	-257.8	28.1	-1.75	208.72	14.3	1.016
20	66.3	4066.2	-157.2	27.5	-1.06	199.86	14.0	1.012
23	76.3	4053.3	-226.7	27.4	-1.53	193.98	13.7	1.009
26	86.2	3900.6	-279.8	26.4	-1.89	180.30	13.2	1.004
29	96.2	3851.2	-233.1	26.1	-1.58	172.06	12.8	0.999
32	106.1	3669.7	-213.4	24.8	-1.44	156.37	12.3	0.990
35	116.1	3624.1	-194.3	24.5	-1.32	147.15	11.7	0.983
38	126.0	3375.5	-244.5	22.9	-1.66	127.03	11.1	0.976
41	135.9	3307.7	-255.0	22.4	-1.73	115.68	10.5	0.969
44	145.9	3006.7	-156.1	20.4	-1.06	91.40	9.9	0.965
47	155.8	2896.6	-347.9	19.6	-2.36	77.50	9.2	0.958
50	165.8	2422.3	-399.5	16.4	-2.70	51.65	11.0	0.956
53	175.7	2319.5	-226.9	15.7	-1.54	38.78	11.9	0.950
56	185.7	1283.4	-105.5	8.7	-0.71	22.70	14.4	0.947
57	189.0	782.6	0.0	5.3	0.00	14.00	14.8	0.946
Absolute	43.1			28.7			(T =	28.9 ms)
	6.6				-4.81		(T =	49.1 ms)

```
                                      CASE METHOD
J =           0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP         3918.5  3486.0  3053.4  2620.8  2188.3  1755.7  1323.1   890.6   458.0    25.4
RX         3918.5  3486.0  3053.4  2620.8  2188.3  1755.7  1323.1   890.6   458.0   440.0
RU         4230.4  3829.1  3427.7  3026.3  2624.9  2223.5  1822.2  1420.8  1019.4   618.0

RAU =    416.2 (kips);  RA2 =    808.5 (kips)

Current CAPWAP Ru = 1070.5 (kips); Corresponding J(RP)= 0.66; J(RX) = 0.66

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    15.16    26.18   4065.6   4178.6   4210.0    1.068    0.394    0.400    224.2   3665.0


                              PILE PROFILE AND PILE MODEL
             Depth              Area         E-Modulus      Spec. Weight            Perim.
                ft               in²               ksi            lb/ft³                ft

              0.00            147.65           31043.9           492.000            12.566
            189.00            147.65           31043.9           492.000            12.566

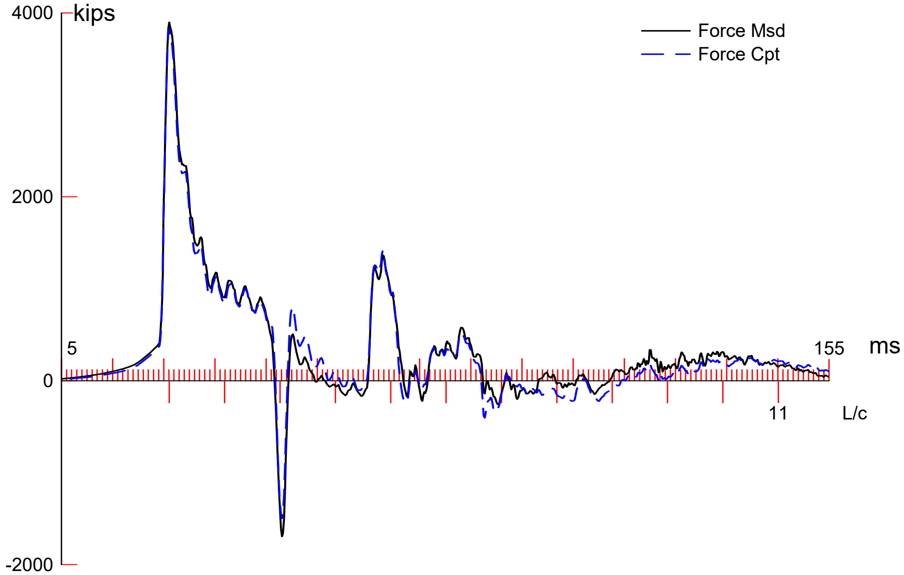
Toe Area                      12.566       ft²

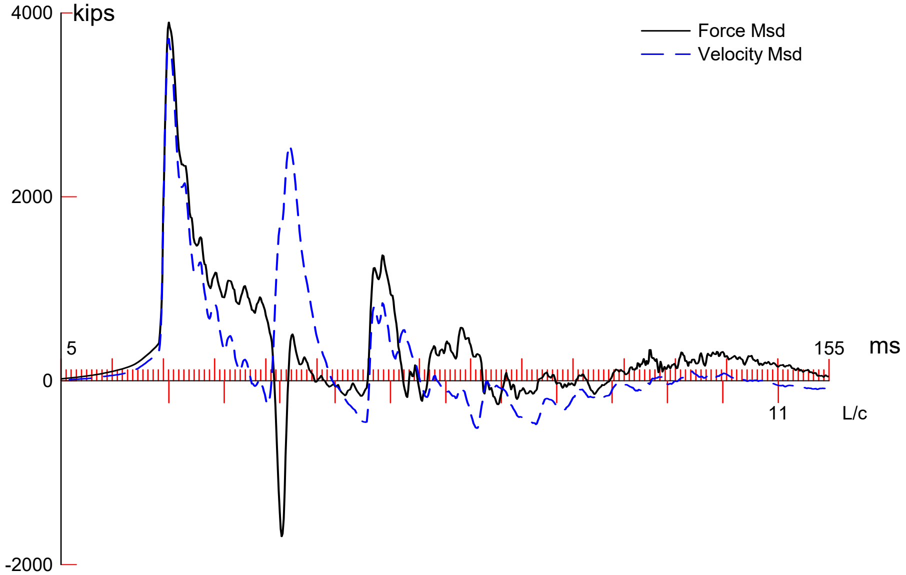
Top Segment Length      3.32 ft, Top Impedance   268.13 kips/ft/s

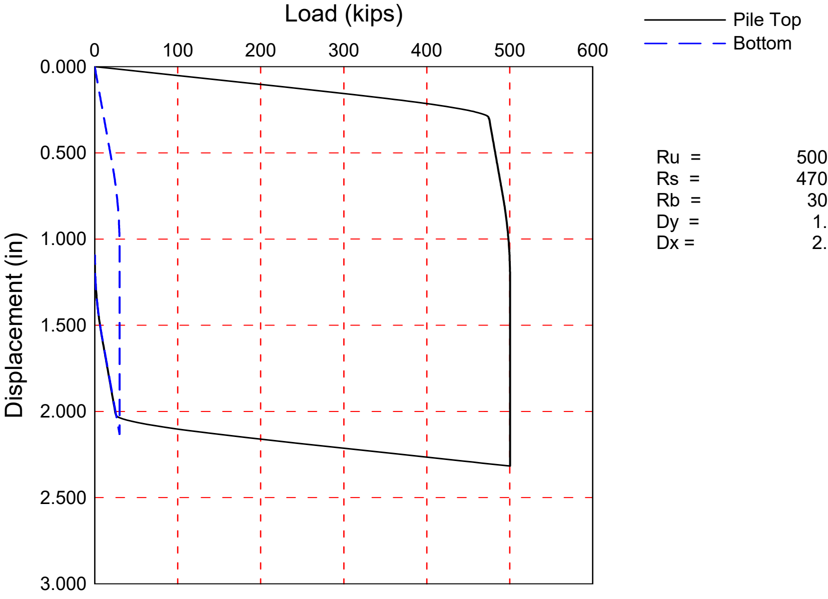
Pile Damping    1.0 %, Time Incr  0.194 ms, Wave Speed  17100.0 ft/s, 2L/c  22.1 ms
```

KIWC, POA TPP; Pile: IP 5; PP48x1.0", APE D180-42; Blow: 260 (Test: 18-May-2016 12:15:)
Robert Miner Dynamic Testing, Inc.

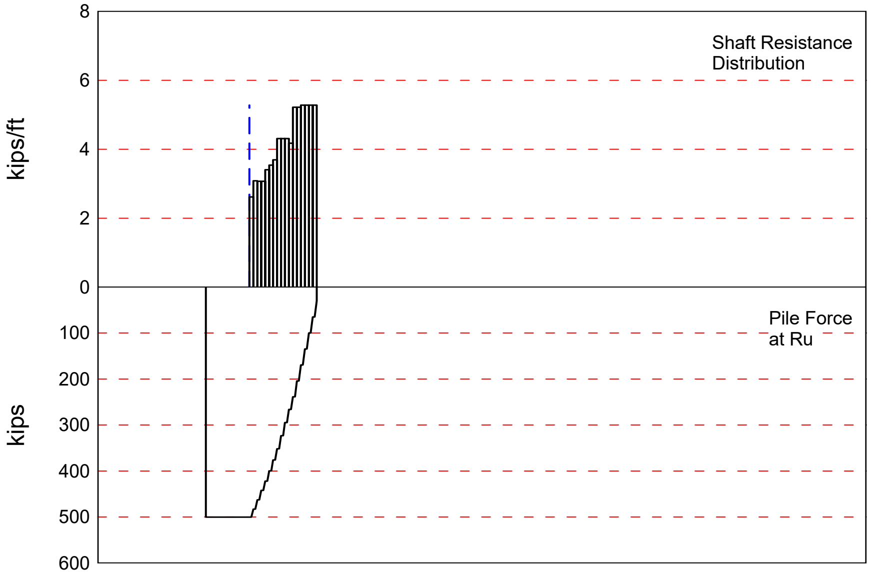
12-Jul-2016
CAPWAP(R) 2006-3







Ru =	500.3 kips
Rs =	470.3 kips
Rb =	30.0 kips
Dy =	1.23 in
Dx =	2.32 in



```
KIWC, POA TPP; Pile: IP 5                               Test: 18-May-2016 12:15:
PP48x1.0'', APE D180-42; Blow: 260                             CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                      OP: RMDT
                              CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:    500.3; along Shaft    470.3; at Toe     30.0  kips
   Soil    Dist.    Depth      Ru     Force      Sum      Unit     Unit     Smith
  Sgmnt    Below    Below           in Pile       of   Resist.  Resist.   Damping
    No.    Gages    Grade                         Ru   (Depth)   (Area)    Factor
              ft       ft    kips      kips     kips   kips/ft      ksf      s/ft

                                      500.3
      1     79.3      5.3    17.3     483.0     17.3      3.27     0.26     0.290
      2     85.9     11.9    20.4     462.6     37.7      3.09     0.25     0.290
      3     92.5     18.5    20.3     442.3     58.0      3.07     0.24     0.290
      4     99.1     25.1    20.3     422.0     78.3      3.07     0.24     0.290
      5    105.7     31.7    22.5     399.5    100.8      3.41     0.27     0.290
      6    112.3     38.3    23.4     376.1    124.2      3.54     0.28     0.290
      7    118.9     44.9    24.4     351.7    148.6      3.69     0.29     0.290
      8    125.5     51.5    28.5     323.2    177.1      4.31     0.34     0.290
      9    132.1     58.1    28.5     294.7    205.6      4.31     0.34     0.290
     10    138.8     64.8    28.5     266.2    234.1      4.31     0.34     0.290
     11    145.4     71.4    27.6     238.6    261.7      4.18     0.33     0.290
     12    152.0     78.0    34.5     204.1    296.2      5.22     0.42     0.290
     13    158.6     84.6    34.5     169.6    330.7      5.22     0.42     0.290
     14    165.2     91.2    34.9     134.7    365.6      5.28     0.42     0.290
     15    171.8     97.8    34.9      99.8    400.5      5.28     0.42     0.290
     16    178.4    104.4    34.9      64.9    435.4      5.28     0.42     0.290
     17    185.0    111.0    34.9      30.0    470.3      5.28     0.42     0.290

  Avg. Shaft                 27.7                         4.24     0.34     0.290

       Toe                   30.0                                  2.39     0.100
Soil Model Parameters/Extensions                   Shaft     Toe

Quake                   (in)                       0.100   0.800
Case Damping Factor                                0.509   0.011
Damping Type                                               Smith
Unloading Quake         (% of loading quake)          30      90
Reloading Level         (% of Ru)                    100     100
Unloading Level         (% of Ru)                     30
max. Top Comp. Stress   =    25.9 ksi     (T=  26.5 ms, max= 1.029 x Top)
max. Comp. Stress       =    26.7 ksi     (Z=  79.3 ft, T=  30.9 ms)
max. Tens. Stress       =   -9.69 ksi     (Z=   3.3 ft, T=  48.3 ms)
max. Energy (EMX)       =   209.6 kip-ft;  max. Measured Top Displ. (DMX)= 1.78 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	3828.0	-1430.8	25.9	-9.69	209.60	14.1	1.737
2	6.6	3829.0	-1309.7	25.9	-8.87	209.55	14.1	1.737
5	16.5	3832.6	-1314.4	25.9	-8.90	209.39	14.1	1.732
8	26.4	3836.3	-1257.2	26.0	-8.51	209.23	14.1	1.724
11	36.3	3841.3	-1067.8	26.0	-7.23	209.07	14.1	1.716
14	46.3	3848.4	-1152.3	26.1	-7.80	208.90	14.0	1.707
17	56.2	3856.5	-966.5	26.1	-6.54	208.74	14.0	1.698
20	66.1	3868.6	-993.7	26.2	-6.73	208.58	13.9	1.690
23	76.0	3919.1	-955.4	26.5	-6.47	208.42	13.7	1.682
26	85.9	3900.2	-787.0	26.4	-5.33	201.29	13.4	1.673
29	95.8	3770.4	-1048.4	25.5	-7.10	185.17	13.2	1.670
32	105.7	3745.6	-862.7	25.4	-5.84	177.22	12.9	1.665
35	115.6	3604.3	-984.7	24.4	-6.67	159.50	12.6	1.662
38	125.5	3570.1	-932.3	24.2	-6.31	150.03	12.3	1.657
41	135.4	3383.4	-760.7	22.9	-5.15	127.70	12.0	1.665
44	145.4	3324.3	-844.3	22.5	-5.72	116.21	11.9	1.669
47	155.3	3129.2	-707.3	21.2	-4.79	90.30	14.2	1.670
50	165.2	3049.3	-462.0	20.6	-3.13	74.98	14.8	1.669
53	175.1	2369.4	-471.2	16.0	-3.19	42.12	18.0	1.670
54	178.4	1824.2	-214.6	12.4	-1.45	41.94	18.9	1.670
55	181.7	951.5	-93.7	6.4	-0.63	24.01	19.4	1.670
56	185.0	266.4	-2.9	1.8	-0.02	5.72	19.6	1.670
Absolute	79.3			26.7			(T =	30.9 ms)
	3.3				-9.69		(T =	48.3 ms)

```
                                     CASE METHOD
J =           0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP         2302.6  1764.2  1225.8   687.4   149.0     0.0     0.0     0.0     0.0     0.0
RX         2302.6  1764.2  1225.8   856.2   723.2   621.8   587.2   570.4   568.5   566.6
RU         2360.0  1827.4  1294.7   762.0   229.4     0.0     0.0     0.0     0.0     0.0

RAU =    450.1 (kips);  RA2 =    659.9 (kips)

Current CAPWAP Ru = 500.3 (kips); Corresponding J(RP)= 0.33;

RMX requires higher damping; see PDA-W

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   14.08    26.27   3774.3   3912.3   3921.2    1.780    1.062    1.091    199.7   1669.6


                               PILE PROFILE AND PILE MODEL
                Depth                Area           E-Modulus       Spec. Weight          Perim.
                   ft                 in²                 ksi             lb/ft³              ft

                 0.00              147.65             31043.9            492.000          12.566
               185.00              147.65             31043.9            492.000          12.566

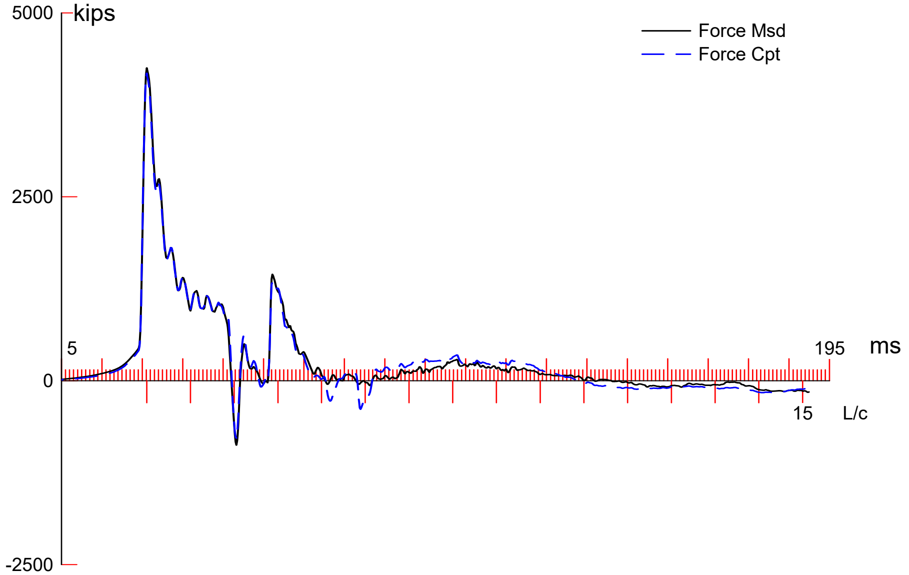
Toe Area                           12.566       ft²

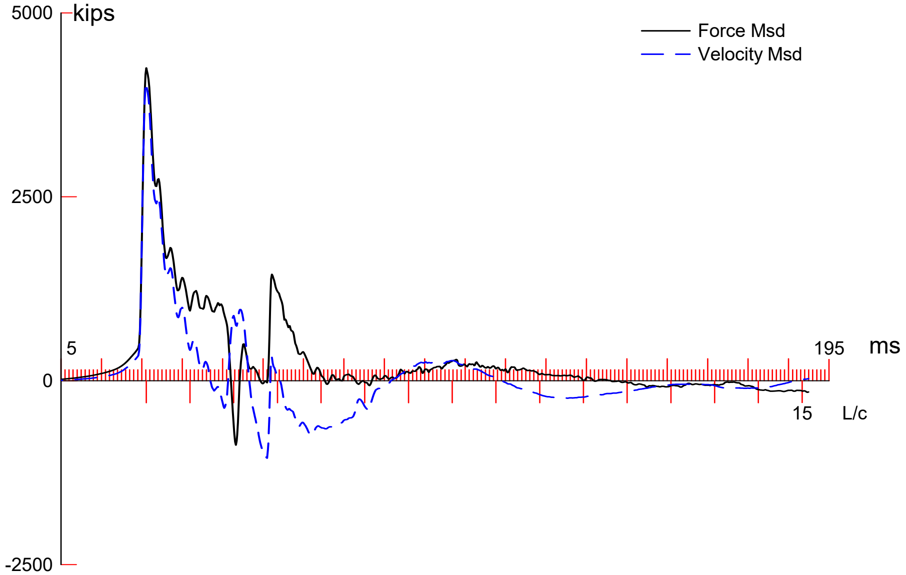
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

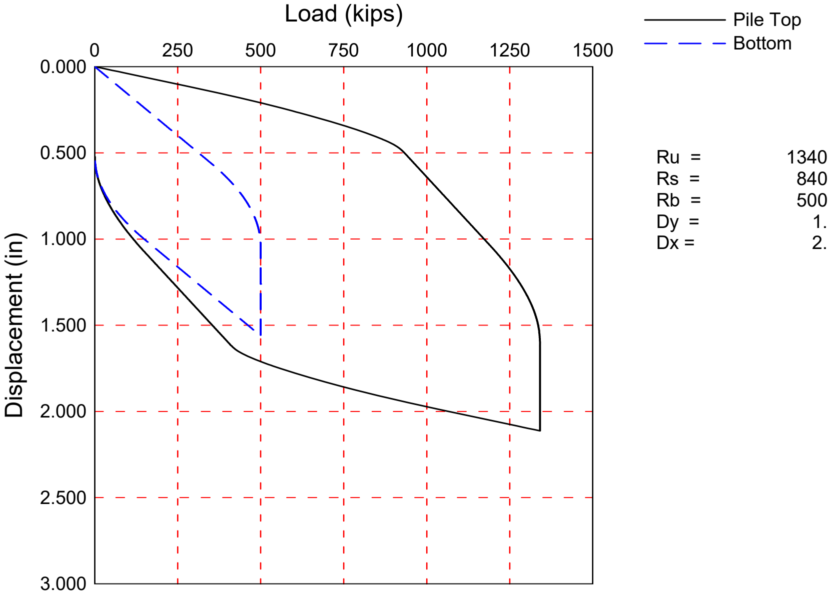
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 5; PP48x1.0", APE D180-42; Blow: 676 (Test: 18-May-2016 12:31:)
Robert Miner Dynamic Testing, Inc.

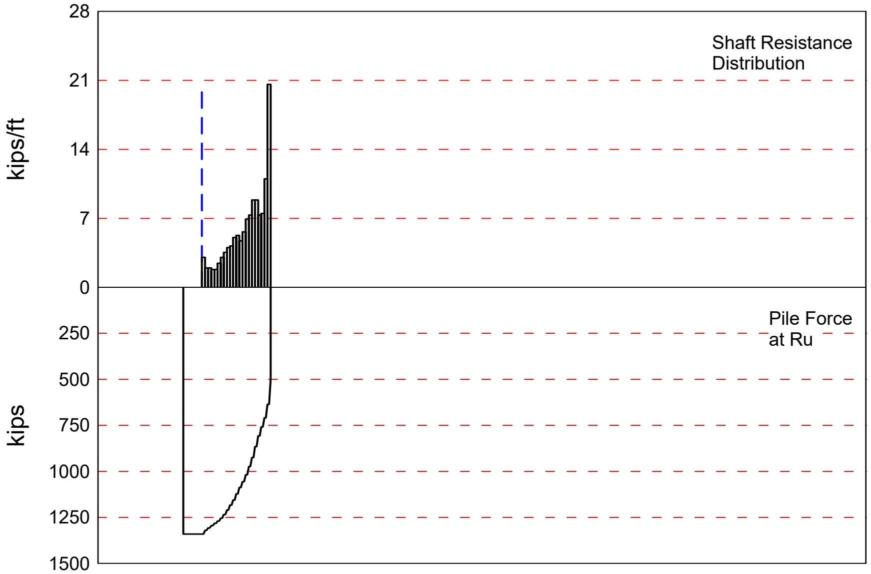
18-May-2016
CAPWAP(R) 2006-3







Ru = 1340.7 kips
Rs = 840.7 kips
Rb = 500.0 kips
Dy = 1.59 in
Dx = 2.11 in



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KIWC, POA TPP; Pile: IP 5                                  Test: 18-May-2016 12:31:
PP48x1.0'', APE D180-42; Blow: 676                                 CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                          OP: RMDT
------------------------------------------------------------------------------------
                               CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1340.7; along Shaft    840.7; at Toe    500.0  kips
------------------------------------------------------------------------------------
   Soil     Dist.     Depth        Ru      Force        Sum      Unit      Unit    Smith
  Sgmnt     Below     Below              in Pile         of    Resist.   Resist.  Damping
    No.     Gages     Grade                              Ru    (Depth)    (Area)   Factor
               ft        ft      kips       kips       kips    kips/ft       ksf      s/ft
------------------------------------------------------------------------------------
                                          1340.7
      1      46.3       5.0      20.2     1320.5       20.2       4.01      0.32     0.190
      2      52.9      11.6      13.1     1307.4       33.3       1.98      0.16     0.190
      3      59.5      18.2      13.1     1294.3       46.4       1.98      0.16     0.190
      4      66.1      24.9      12.1     1282.2       58.5       1.83      0.15     0.190
      5      72.7      31.5      12.1     1270.1       70.6       1.83      0.15     0.190
      6      79.3      38.1      16.2     1253.9       86.8       2.45      0.20     0.190
      7      85.9      44.7      20.2     1233.7      107.0       3.06      0.24     0.190
      8      92.5      51.3      23.6     1210.1      130.6       3.57      0.28     0.190
      9      99.1      57.9      26.7     1183.4      157.3       4.04      0.32     0.190
     10     105.7      64.5      27.8     1155.6      185.1       4.21      0.33     0.190
     11     112.3      71.1      33.5     1122.1      218.6       5.07      0.40     0.190
     12     118.9      77.7      34.9     1087.2      253.5       5.28      0.42     0.190
     13     125.5      84.3      31.3     1055.9      284.8       4.74      0.38     0.190
     14     132.1      90.9      37.3     1018.6      322.1       5.65      0.45     0.190
     15     138.8      97.5      45.8      972.8      367.9       6.93      0.55     0.190
     16     145.4     104.1      48.5      924.3      416.4       7.34      0.58     0.190
     17     152.0     110.7      58.6      865.7      475.0       8.87      0.71     0.190
     18     158.6     117.4      58.6      807.1      533.6       8.87      0.71     0.190
     19     165.2     124.0      48.6      758.5      582.2       7.36      0.59     0.190
     20     171.8     130.6      49.6      708.9      631.8       7.51      0.60     0.190
     21     178.4     137.2      72.8      636.1      704.6      11.02      0.88     0.190
     22     185.0     143.8     136.1      500.0      840.7      20.60      1.64     0.190

  Avg. Shaft                     38.2                             5.85      0.47     0.190

       Toe                      500.0                                      39.79     0.045

Soil Model Parameters/Extensions                         Shaft       Toe
------------------------------------------------------------------------------------
Quake                       (in)                         0.110     0.800
Case Damping Factor                                      0.596     0.084
Reloading Level             (% of Ru)                      100       100
Unloading Level             (% of Ru)                       40

max. Top Comp. Stress       =    28.3 ksi      (T=  26.5 ms, max= 1.019 x Top)
max. Comp. Stress           =    28.8 ksi      (Z=  46.3 ft, T=  29.0 ms)
max. Tens. Stress           =   -4.70 ksi      (Z=   3.3 ft, T=  48.5 ms)
max. Energy (EMX)           =   243.7 kip-ft;  max. Measured Top Displ. (DMX)= 1.31 in
```

```
                                 EXTREMA TABLE
   Pile     Dist.      max.      min.      max.      max.      max.      max.      max.
  Sgmnt     Below     Force     Force     Comp.     Tens.   Trnsfd.    Veloc.    Displ.
    No.     Gages                        Stress    Stress    Energy
               ft      kips      kips       ksi       ksi    kip-ft      ft/s        in

      1       3.3    4181.2    -694.4      28.3     -4.70    243.71      15.3     1.322
      2       6.6    4183.0    -553.7      28.3     -3.75    243.30      15.3     1.319
      5      16.5    4189.6    -487.7      28.4     -3.30    241.93      15.3     1.302
      8      26.4    4197.9    -465.8      28.4     -3.15    240.38      15.3     1.283
     11      36.3    4216.3    -516.7      28.5     -3.50    239.27      15.2     1.263
     14      46.3    4259.2    -544.5      28.8     -3.69    239.08      15.0     1.249
     17      56.2    4168.8    -509.3      28.2     -3.45    229.60      14.8     1.235
     20      66.1    4156.4    -550.5      28.1     -3.73    225.82      14.7     1.219
     23      76.0    4110.6    -516.7      27.8     -3.50    219.17      14.5     1.201
     26      85.9    4107.7    -435.4      27.8     -2.95    214.75      14.2     1.184
     29      95.8    4013.6    -474.4      27.2     -3.21    204.04      14.0     1.164
     32     105.7    3991.2    -423.1      27.0     -2.86    197.58      13.7     1.146
     35     115.6    3856.0    -276.1      26.1     -1.87    183.53      13.3     1.126
     38     125.5    3818.7    -276.8      25.9     -1.87    175.25      13.0     1.104
     41     135.4    3684.0    -343.1      24.9     -2.32    160.13      12.6     1.085
     44     145.4    3638.0    -263.0      24.6     -1.78    149.69      12.2     1.063
     47     155.3    3398.5     -80.4      23.0     -0.54    126.68      12.2     1.045
     50     165.2    3304.0       0.0      22.4      0.00    113.54      12.5     1.026
     53     175.1    2706.3       0.0      18.3      0.00     91.20      16.0     1.006
     54     178.4    2232.1       0.0      15.1      0.00     91.06      16.8     1.001
     55     181.7    1432.7       0.0       9.7      0.00     74.16      17.2     0.996
     56     185.0    1136.6       0.0       7.7      0.00     43.26      17.3     0.991

Absolute     46.3                          28.8                         (T =     29.0 ms)
              3.3                                    -4.70              (T =     48.5 ms)
```

```
------------------------------------------------------------------------------------------
                                       CASE METHOD
------------------------------------------------------------------------------------------
J =             0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP           3412.4  2918.4  2424.4  1930.4  1436.4   942.4   448.4     0.0     0.0     0.0
RX           3412.4  2918.4  2424.4  1930.4  1564.7  1434.7  1382.8  1340.8  1298.9  1257.0
RU           3430.7  2938.6  2446.4  1954.2  1462.0   969.8   477.7     0.0     0.0     0.0

RAU =   1139.5 (kips);  RA2 =   1647.3 (kips)

Current CAPWAP Ru = 1340.7 (kips); Corresponding J(RP)= 0.42; J(RX) = 0.70

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    15.18    26.27   4070.2   4282.4   4282.4    1.313    0.522    0.522    244.2   3194.7


                               PILE PROFILE AND PILE MODEL
------------------------------------------------------------------------------------------
             Depth              Area         E-Modulus      Spec. Weight            Perim.
                ft               in²               ksi            lb/ft³                ft
------------------------------------------------------------------------------------------
              0.00            147.65           31043.9           492.000            12.566
            185.00            147.65           31043.9           492.000            12.566

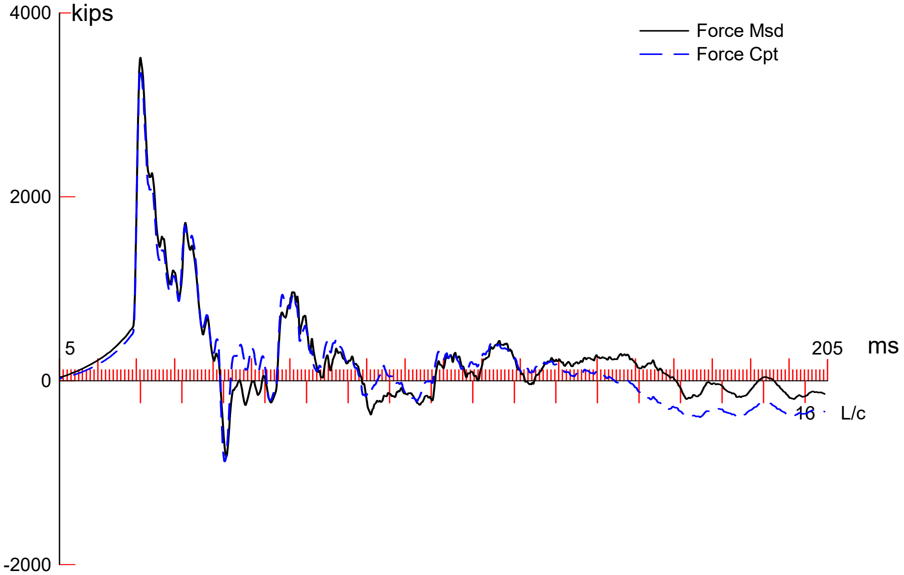
Toe Area                      12.566       ft²

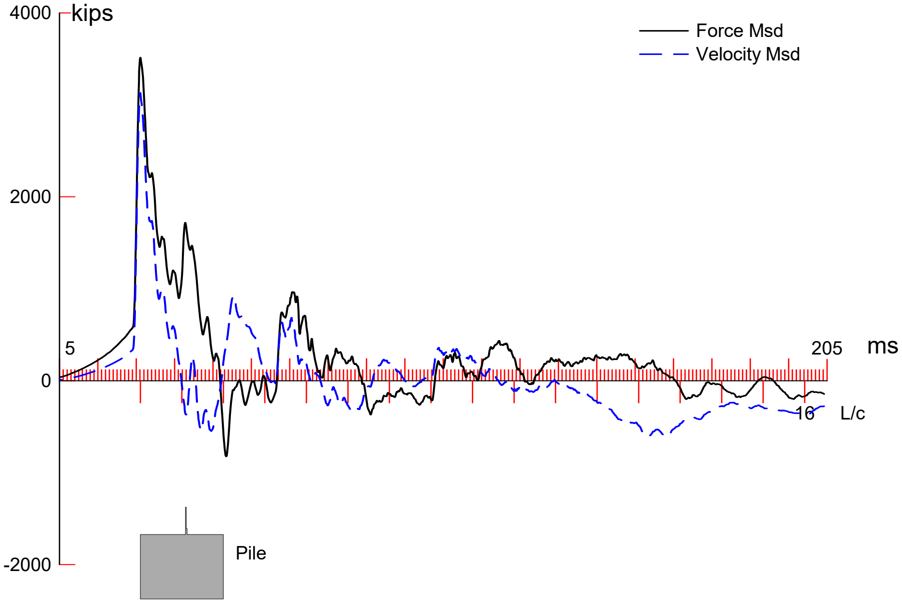
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

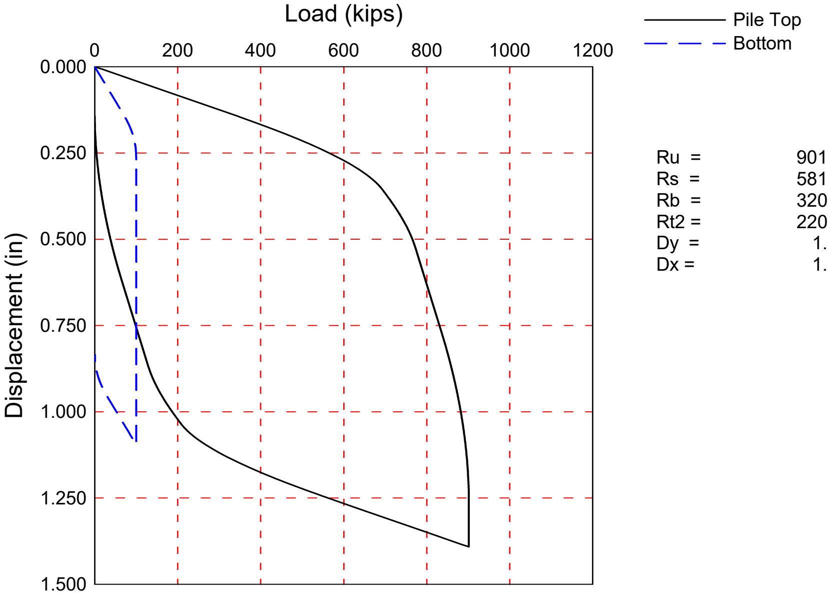
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 6 (Loc. 4); PP48x1.0", APE D180-42; Blow: 2074 (Test: 01-Jun-2016 10:37:)
Robert Miner Dynamic Testing, Inc.

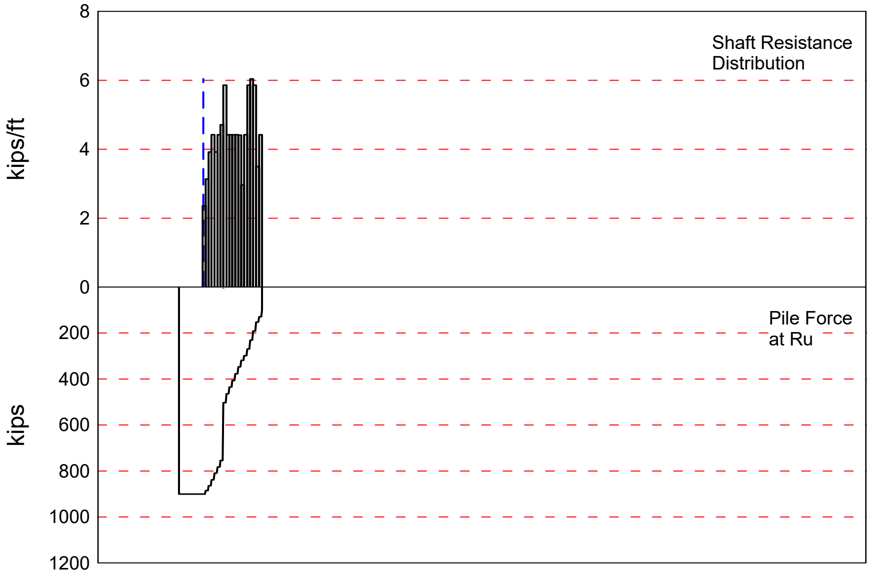
01-Jun-2016
CAPWAP(R) 2006-3







Ru = 901.3 kips
Rs = 581.0 kips
Rb = 320.2 kips
Rt2 = 220.0 kips
Dy = 1.25 in
Dx = 1.39 in



```
                                  CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:    901.3; along Shaft    581.0; at Toe    320.2  kips
   Soil   Dist.    Depth       Ru    Force      Sum      Unit     Unit     Smith     Quake
  Sgmnt   Below    Below           in Pile       of   Resist.  Resist.   Damping
    No.   Gages    Grade                         Ru   (Depth)   (Area)    Factor
             ft       ft     kips     kips     kips   kips/ft      ksf      s/ft        in

                                     901.3
      1    59.5      3.4     15.6    885.7     15.6      4.55     0.36     0.120     0.100
      2    66.1     10.0     20.7    864.9     36.3      3.14     0.25     0.120     0.100
      3    72.7     16.6     25.9    839.0     62.2      3.92     0.31     0.120     0.100
      4    79.3     23.3     29.2    809.8     91.5      4.42     0.35     0.120     0.100
      5    85.9     29.9     25.9    783.9    117.4      3.92     0.31     0.120     0.100
      6    92.5     36.5     29.2    754.7    146.6      4.42     0.35     0.120     0.100
      7    99.1     43.1     31.1    723.5    177.7      4.71     0.37     0.120     0.100
    2nd     Toe             220.2                                          0.799     0.800
      8   105.7     49.7     38.7    464.6    436.6      5.86     0.47     0.120     0.100
      9   112.3     56.3     29.2    435.4    465.8      4.42     0.35     0.120     0.100
     10   118.9     62.9     29.2    406.2    495.1      4.42     0.35     0.120     0.100
     11   125.5     69.5     29.2    377.0    524.3      4.42     0.35     0.120     0.100
     12   132.1     76.1     29.2    347.8    553.5      4.42     0.35     0.120     0.100
     13   138.8     82.7     29.1    318.6    582.6      4.41     0.35     0.120     0.100
     14   145.4     89.3     19.6    299.0    602.2      2.97     0.24     0.120     0.100
     15   152.0     95.9     29.2    269.8    631.5      4.42     0.35     0.120     0.100
     16   158.6    102.5     38.7    231.1    670.2      5.86     0.47     0.120     0.100
     17   165.2    109.1     39.9    191.1    710.1      6.04     0.48     0.120     0.100
     18   171.8    115.8     38.7    152.4    748.9      5.86     0.47     0.120     0.100
     19   178.4    122.4     23.1    129.3    772.0      3.50     0.28     0.120     0.100
     20   185.0    129.0     29.2    100.1    801.2      4.42     0.35     0.120     0.100

  Avg. Shaft                 29.1                           4.51     0.36     0.120     0.100

      Toe                   100.1                                     7.96     0.150     0.200

Soil Model Parameters/Extensions                          Shaft      Toe

Case Damping Factor                                       0.260    0.056
Unloading Quake            (% of loading quake)              30       30
Reloading Level            (% of Ru)                        100      100
Soil Support Dashpot                                      0.200    0.000
Soil Support Weight        (kips)                          8.67     0.00

max. Top Comp. Stress      =    23.0 ksi      (T=  26.4 ms, max= 1.189 x Top)
max. Comp. Stress          =    27.4 ksi      (Z=  99.1 ft, T=  32.1 ms)
max. Tens. Stress          =   -8.60 ksi      (Z= 100.8 ft, T=  42.3 ms)
max. Energy (EMX)          =   151.6 kip-ft;  max. Measured Top Displ. (DMX)= 1.23 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	1.7	3399.4	-862.4	23.0	-5.84	151.62	12.1	1.077
2	3.3	3401.4	-838.6	23.0	-5.68	151.59	12.1	1.076
8	13.2	3413.8	-656.7	23.1	-4.45	151.44	12.0	1.070
14	23.1	3426.9	-793.0	23.2	-5.37	151.28	12.0	1.060
20	33.0	3440.6	-699.9	23.3	-4.74	151.11	11.9	1.049
26	42.9	3457.4	-550.0	23.4	-3.72	150.93	11.9	1.032
32	52.9	3482.4	-624.2	23.6	-4.23	150.74	11.8	1.011
38	62.8	3483.6	-440.9	23.6	-2.99	148.15	11.6	0.994
44	72.7	3480.0	-430.1	23.6	-2.91	144.93	11.4	0.977
50	82.6	3399.1	-389.3	23.0	-2.64	137.31	11.2	0.963
56	92.5	3944.8	-360.2	26.7	-2.44	133.84	9.5	0.951
62	102.4	2454.9	-1229.4	11.7	-5.84	70.24	8.5	0.942
68	112.3	2407.8	-929.7	16.3	-6.30	66.47	8.4	0.944
74	122.2	2323.8	-872.3	15.7	-5.91	61.23	8.2	0.943
80	132.1	2294.4	-693.8	15.5	-4.70	56.74	8.1	0.940
86	142.1	2201.9	-714.6	14.9	-4.84	50.87	8.1	0.940
92	152.0	2191.3	-587.8	14.8	-3.98	45.16	9.2	0.939
98	161.9	2091.0	-323.7	14.2	-2.19	35.34	10.0	0.939
104	171.8	1970.4	-280.5	13.3	-1.90	27.62	11.3	0.935
110	181.7	770.1	-35.4	5.2	-0.24	19.28	13.3	0.933
111	183.3	526.6	-32.7	3.6	-0.22	19.27	13.4	0.933
112	185.0	377.7	-30.4	2.6	-0.21	15.27	13.5	0.932
Absolute	99.1			27.4			(T =	32.1 ms)
	100.8				-8.60		(T =	42.3 ms)

```
                                     CASE METHOD
J =           0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP         2933.4  2559.6  2185.9  1812.1  1438.3  1064.6   690.8   317.0     0.0     0.0
RX         2933.4  2559.6  2185.9  1812.1  1438.3  1064.6   690.8   507.8   507.8   507.8
RU         3373.1  3043.3  2713.6  2383.8  2054.0  1724.2  1394.4  1064.6   734.8   405.0

RAU =    136.5 (kips);  RA2 =    463.4 (kips)

Current CAPWAP Ru = 901.3 (kips); Corresponding J(RP)= 0.54; J(RX) = 0.54

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   11.74    26.18   3148.7   3522.4   3522.4    1.232    0.143    0.143    143.0   2497.1


                              PILE PROFILE AND PILE MODEL
                  Depth              Area         E-Modulus     Spec. Weight          Perim.
                     ft               in²               ksi           lb/ft³              ft

                   0.00            147.65           31043.9          492.000          12.566
                 102.00            147.65           31043.9          492.000          12.566
                 102.00            400.00           31043.9          492.000          12.566
                 102.50            400.00           31043.9          492.000          12.566
                 102.50            147.65           31043.9          492.000          12.566
                 185.00            147.65           31043.9          492.000          12.566

Toe Area                           12.566       ft²

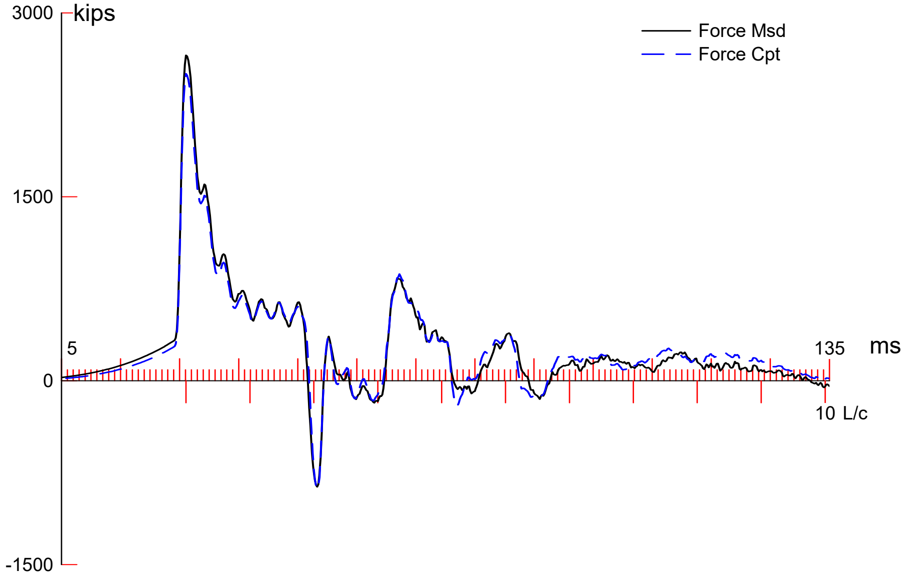
  Segmnt   Dist.  Impedance    Imped.              Tension         Compression    Perim.
  Number    B.G.               Change     Slack       Eff.      Slack      Eff.
              ft  kips/ft/s         %        in                    in                 ft

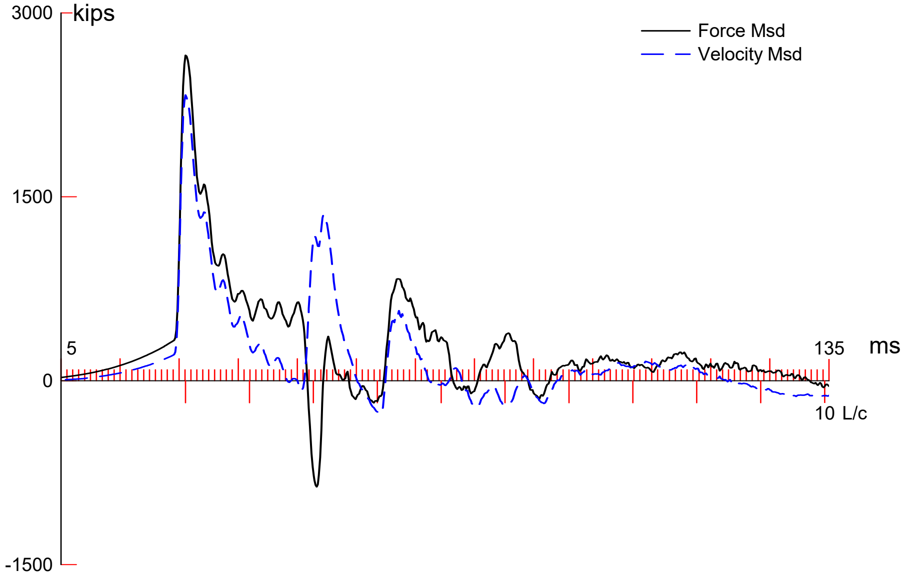
       1    1.65     268.12      0.00     0.000      0.000     -0.000     0.000     12.566
      62  102.41     382.06      0.00     0.000      0.000     -0.000     0.000     12.566
      63  104.06     292.89      0.00     0.000      0.000     -0.000     0.000     12.566
      64  105.71     268.12      0.00     0.000      0.000     -0.000     0.000     12.566
     112  185.00     268.12      0.00     0.000      0.000     -0.000     0.000     12.566

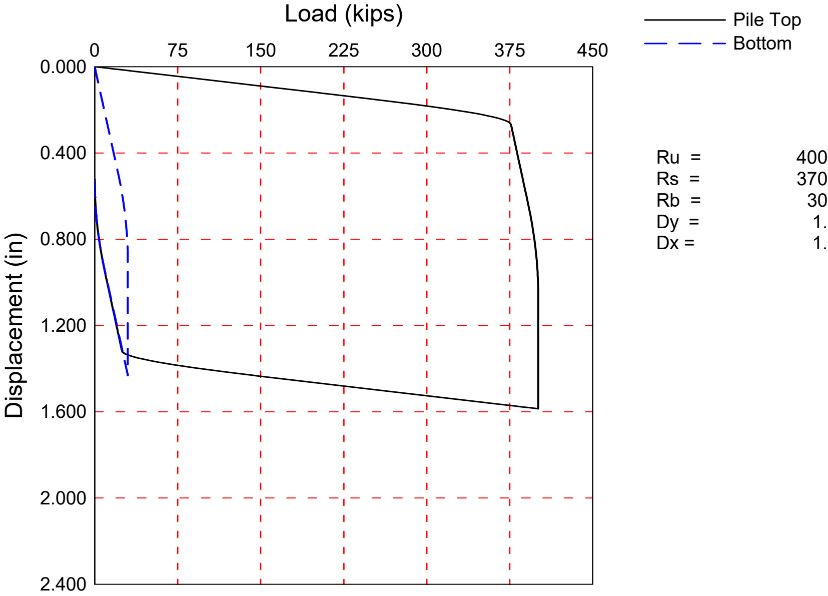
Pile Damping    1.0 %, Time Incr  0.097 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 7; PP48x1.0", APE D180-42; Blow: 648 (Test: 25-May-2016 13:54:)
Robert Miner Dynamic Testing, Inc.

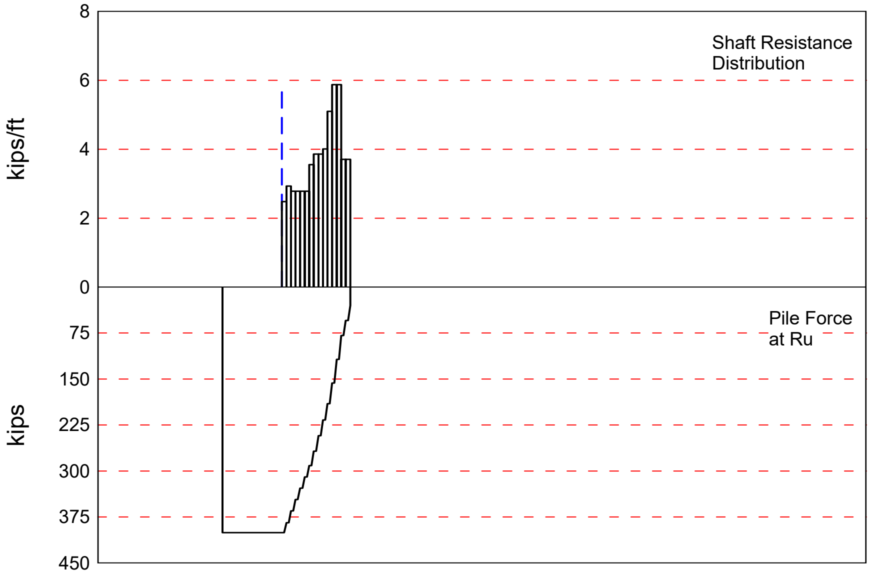
12-Jul-2016
CAPWAP(R) 2006-3







Ru = 400.7 kips
Rs = 370.7 kips
Rb = 30.0 kips
Dy = 1.07 in
Dx = 1.59 in



```
                             CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:    400.7; along Shaft    370.7; at Toe     30.0  kips
     Soil     Dist.     Depth        Ru      Force        Sum      Unit      Unit     Smith
    Sgmnt     Below     Below              in Pile         of    Resist.   Resist.   Damping
      No.     Gages     Grade                              Ru   (Depth)    (Area)    Factor
                 ft        ft      kips       kips       kips    kips/ft       ksf      s/ft

                                             400.7
        1      92.5       6.5      16.4      384.3       16.4      2.52      0.20     0.300
        2      99.1      13.1      19.4      364.9       35.8      2.94      0.23     0.300
        3     105.7      19.7      18.4      346.5       54.2      2.78      0.22     0.300
        4     112.3      26.3      18.4      328.1       72.6      2.78      0.22     0.300
        5     118.9      32.9      18.4      309.7       91.0      2.78      0.22     0.300
        6     125.5      39.5      18.4      291.3      109.4      2.78      0.22     0.300
        7     132.1      46.1      23.5      267.8      132.9      3.56      0.28     0.300
        8     138.8      52.8      25.5      242.3      158.4      3.86      0.31     0.300
        9     145.4      59.4      25.5      216.8      183.9      3.86      0.31     0.300
       10     152.0      66.0      26.5      190.3      210.4      4.01      0.32     0.300
       11     158.6      72.6      33.7      156.6      244.1      5.10      0.41     0.300
       12     165.2      79.2      38.8      117.8      282.9      5.87      0.47     0.300
       13     171.8      85.8      38.8       79.0      321.7      5.87      0.47     0.300
       14     178.4      92.4      24.5       54.5      346.2      3.71      0.30     0.300
       15     185.0      99.0      24.5       30.0      370.7      3.71      0.30     0.300

  Avg. Shaft                       24.7                              3.74      0.30     0.300

       Toe                         30.0                                        2.39     0.300
Soil Model Parameters/Extensions                          Shaft       Toe

Quake                      (in)                           0.100     0.700
Case Damping Factor                                       0.415     0.034
Unloading Quake            (% of loading quake)              30       100
Reloading Level            (% of Ru)                        100       100
Unloading Level            (% of Ru)                         16
Soil Plug Weight           (kips)                                    0.30

max. Top Comp. Stress      =    17.0 ksi      (T=  26.5 ms, max= 1.034 x Top)
max. Comp. Stress          =    17.5 ksi      (Z=  92.5 ft, T=  31.9 ms)
max. Tens. Stress          =   -5.69 ksi      (Z=  13.2 ft, T=  47.5 ms)
max. Energy (EMX)          =    90.2 kip-ft;  max. Measured Top Displ. (DMX)= 1.11 in
```

```
                                      EXTREMA TABLE
      Pile     Dist.      max.      min.      max.      max.      max.      max.      max.
     Sgmnt     Below     Force     Force     Comp.     Tens.   Trnsfd.    Veloc.    Displ.
       No.     Gages                        Stress    Stress    Energy
                  ft      kips      kips       ksi       ksi    kip-ft      ft/s        in

         1       3.3    2505.5    -831.5      17.0     -5.63     90.20       9.2     1.128
         2       6.6    2505.9    -815.0      17.0     -5.52     90.17       9.2     1.128
         5      16.5    2507.5    -838.1      17.0     -5.67     90.09       9.2     1.127
         8      26.4    2509.8    -706.1      17.0     -4.78     90.00       9.2     1.124
        11      36.3    2512.8    -784.3      17.0     -5.31     89.91       9.2     1.117
        14      46.3    2516.1    -735.5      17.0     -4.98     89.81       9.1     1.109
        17      56.2    2519.9    -629.6      17.1     -4.26     89.71       9.1     1.101
        20      66.1    2526.9    -704.3      17.1     -4.77     89.61       9.1     1.091
        23      76.0    2535.6    -593.6      17.2     -4.02     89.51       9.0     1.082
        26      85.9    2562.3    -615.5      17.3     -4.17     89.40       8.9     1.071
        29      95.8    2546.0    -649.4      17.2     -4.40     85.83       8.8     1.060
        32     105.7    2517.9    -485.9      17.0     -3.29     81.70       8.6     1.062
        35     115.6    2427.0    -637.2      16.4     -4.31     74.11       8.5     1.064
        38     125.5    2406.7    -558.0      16.3     -3.78     70.30       8.3     1.065
        41     135.4    2310.7    -458.1      15.6     -3.10     61.66       8.1     1.065
        44     145.4    2272.5    -541.4      15.4     -3.67     56.32       7.9     1.063
        47     155.3    2155.1    -382.7      14.6     -2.59     45.16       9.3     1.061
        50     165.2    2103.3    -273.3      14.2     -1.85     37.56       9.5     1.059
        53     175.1    1667.5    -341.3      11.3     -2.31     19.21      11.7     1.058
        54     178.4    1354.3    -177.6       9.2     -1.20     19.17      12.4     1.058
        55     181.7     814.0     -64.4       5.5     -0.44     13.05      12.8     1.058
        56     185.0     293.8      -6.5       2.0     -0.04      6.72      13.0     1.058

Absolute        92.5                          17.5                         (T =     31.9 ms)
                13.2                                    -5.69              (T =     47.5 ms)
```

```
                                   CASE METHOD
J =           0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP         1537.3  1188.8   840.2   491.7   143.1     0.0     0.0     0.0     0.0     0.0
RX         1537.3  1188.8   840.2   598.1   468.6   435.3   422.9   416.4   412.9   412.3
RU         1469.2  1113.8   758.4   403.1    47.7     0.0     0.0     0.0     0.0     0.0

RAU =    384.9 (kips);  RA2 =    583.0 (kips)

Current CAPWAP Ru = 400.7 (kips); Corresponding J(RP)= 0.33; matches RX9 within 5%

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
     8.78    26.27   2353.2   2669.5   2669.5    1.105    0.522    0.522     91.2   1345.3

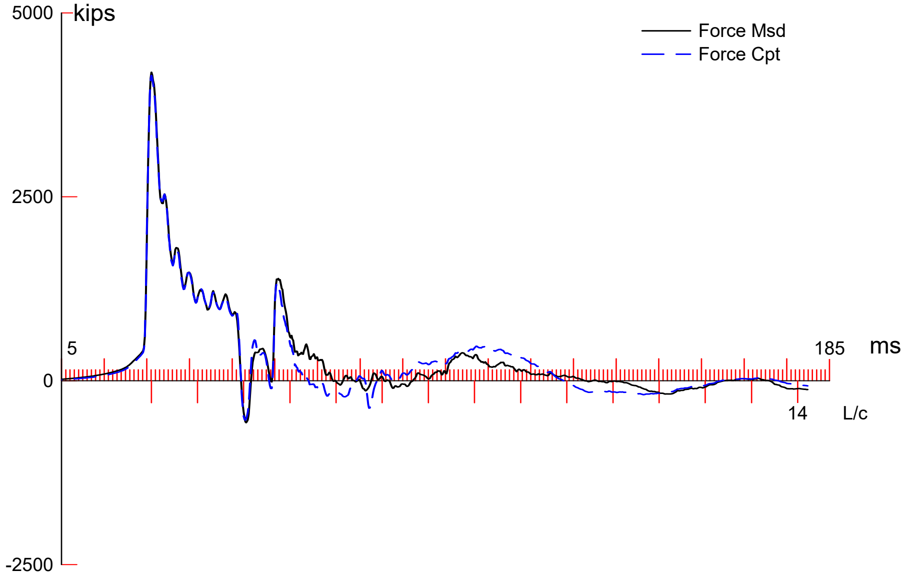

                           PILE PROFILE AND PILE MODEL
             Depth                Area          E-Modulus     Spec. Weight           Perim.
                ft                 in²                ksi            lb/ft³               ft

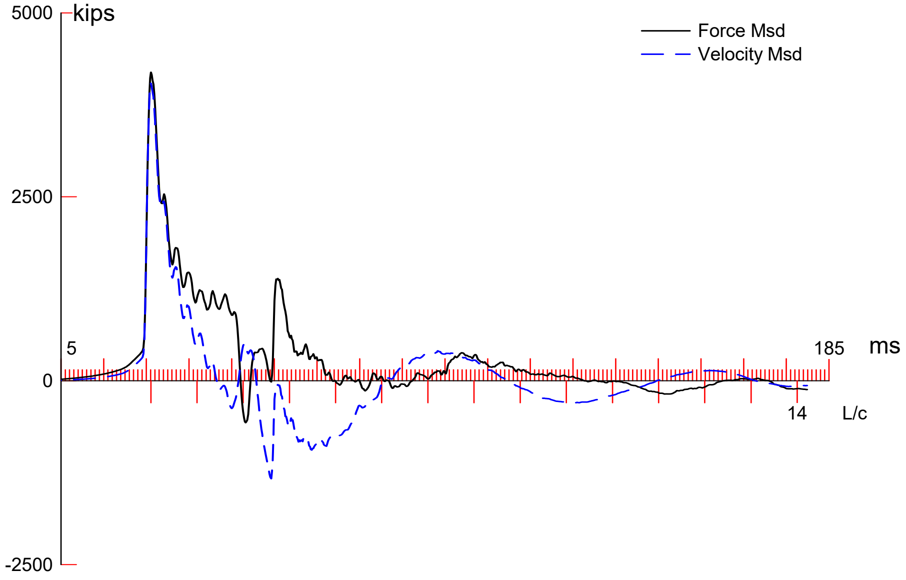
              0.00              147.65            31043.9          492.000           12.566
            185.00              147.65            31043.9          492.000           12.566

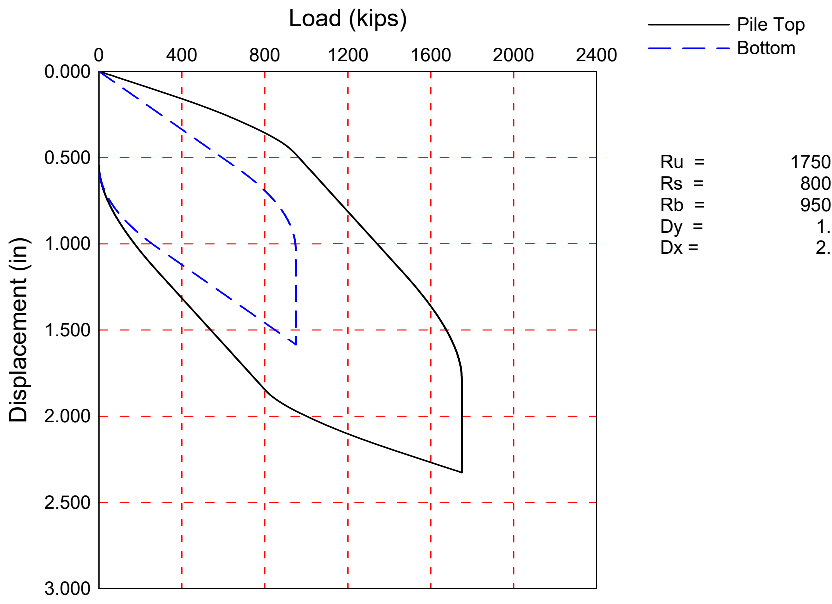
Toe Area                        12.566       ft²

Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

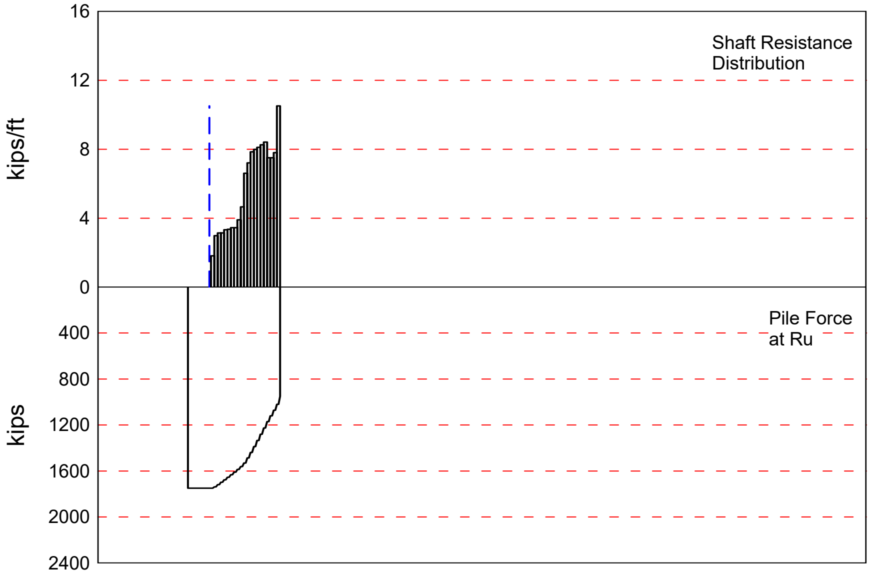
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```







Ru = 1750.0 kips
Rs = 800.0 kips
Rb = 950.0 kips
Dy = 1.78 in
Dx = 2.33 in



```
                                 CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1750.0; along Shaft    800.0; at Toe    950.0  kips
   Soil     Dist.    Depth       Ru     Force       Sum     Unit     Unit    Smith
  Sgmnt     Below    Below              in Pile      of   Resist.  Resist.  Damping
    No.     Gages    Grade                           Ru   (Depth)   (Area)   Factor
               ft       ft     kips      kips      kips   kips/ft      ksf     s/ft

                                        1750.0
      1      52.9      6.7     12.0    1738.0      12.0      1.79     0.14    0.180
      2      59.5     13.3     19.8    1718.2      31.8      3.00     0.24    0.180
      3      66.1     19.9     20.8    1697.4      52.6      3.15     0.25    0.180
      4      72.7     26.5     20.8    1676.6      73.4      3.15     0.25    0.180
      5      79.3     33.1     22.0    1654.6      95.4      3.33     0.26    0.180
      6      85.9     39.8     22.2    1632.4     117.6      3.36     0.27    0.180
      7      92.5     46.4     22.8    1609.6     140.4      3.45     0.27    0.180
      8      99.1     53.0     22.8    1586.8     163.2      3.45     0.27    0.180
      9     105.7     59.6     25.8    1561.0     189.0      3.90     0.31    0.180
     10     112.3     66.2     30.8    1530.2     219.8      4.66     0.37    0.180
     11     118.9     72.8     43.7    1486.5     263.5      6.61     0.53    0.180
     12     125.5     79.4     47.7    1438.8     311.2      7.22     0.57    0.180
     13     132.1     86.0     51.9    1386.9     363.1      7.86     0.63    0.180
     14     138.8     92.6     52.8    1334.1     415.9      7.99     0.64    0.180
     15     145.4     99.2     53.6    1280.5     469.5      8.11     0.65    0.180
     16     152.0    105.8     54.6    1225.9     524.1      8.26     0.66    0.180
     17     158.6    112.4     55.6    1170.3     579.7      8.42     0.67    0.180
     18     165.2    119.0     49.6    1120.7     629.3      7.51     0.60    0.180
     19     171.8    125.6     49.6    1071.1     678.9      7.51     0.60    0.180
     20     178.4    132.3     51.6    1019.5     730.5      7.81     0.62    0.180
     21     185.0    138.9     69.5     950.0     800.0     10.52     0.84    0.180

  Avg. Shaft                   38.1                          5.76     0.46    0.180

       Toe                    950.0                                  75.60    0.060

Soil Model Parameters/Extensions                   Shaft      Toe

Quake                       (in)                   0.100    0.800
Case Damping Factor                                0.537    0.213
Unloading Quake             (% of loading quake)      30      100
Reloading Level             (% of Ru)                100      100

max. Top Comp. Stress      =    28.1 ksi      (T=  26.5 ms, max= 1.019 x Top)
max. Comp. Stress          =    28.6 ksi      (Z=  52.9 ft, T=  29.4 ms)
max. Tens. Stress          =   -3.87 ksi      (Z=  59.5 ft, T=  74.0 ms)
max. Energy (EMX)          =   235.6 kip-ft;  max. Measured Top Displ. (DMX)= 1.19 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	4151.3	-478.8	28.1	-3.24	235.63	15.2	1.199
2	6.6	4153.0	-425.7	28.1	-2.88	235.19	15.2	1.196
5	16.5	4158.7	-394.9	28.2	-2.67	233.76	15.2	1.196
8	26.4	4166.2	-421.4	28.2	-2.85	232.78	15.2	1.191
11	36.3	4175.7	-461.8	28.3	-3.13	232.43	15.1	1.178
14	46.3	4199.4	-486.0	28.4	-3.29	232.03	15.0	1.163
17	56.2	4203.9	-566.3	28.5	-3.83	228.26	14.8	1.148
20	66.1	4185.7	-518.9	28.3	-3.51	222.43	14.6	1.130
23	76.0	4090.8	-451.1	27.7	-3.05	212.50	14.4	1.105
26	85.9	4069.8	-470.8	27.6	-3.19	207.14	14.1	1.083
29	95.8	3971.0	-344.5	26.9	-2.33	197.07	13.9	1.059
32	105.7	3965.1	-273.0	26.8	-1.85	191.21	13.6	1.030
35	115.6	3872.6	-279.1	26.2	-1.89	179.33	13.2	1.004
38	125.5	3837.9	-168.0	26.0	-1.14	170.13	12.8	0.977
41	135.4	3625.2	-35.1	24.5	-0.24	151.29	12.4	0.952
44	145.4	3560.4	-133.0	24.1	-0.90	140.62	12.0	0.923
47	155.3	3326.3	0.0	22.5	0.00	120.52	11.6	0.893
50	165.2	3244.1	0.0	22.0	0.00	109.73	11.3	0.866
53	175.1	2701.8	0.0	18.3	0.00	91.26	15.0	0.841
54	178.4	2263.6	0.0	15.3	0.00	90.97	15.7	0.833
55	181.7	1597.0	0.0	10.8	0.00	81.35	16.1	0.825
56	185.0	1481.1	0.0	10.0	0.00	70.24	16.1	0.817
Absolute	52.9			28.6			(T =	29.4 ms)
	59.5				-3.87		(T =	74.0 ms)

```
                                            CASE METHOD
J =            0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP          3660.7  3199.4  2738.2  2276.9  1815.6  1354.4   893.1   431.9     0.0     0.0
RX          3660.7  3199.4  2738.2  2276.9  1932.4  1829.3  1728.0  1627.5  1580.8  1539.3
RU          3751.2  3299.0  2846.8  2394.5  1942.3  1490.1  1037.9   585.7   133.5     0.0

RAU =   1151.6 (kips);  RA2 =   1760.7 (kips)

Current CAPWAP Ru = 1750.0 (kips); Corresponding J(RP)= 0.41; J(RX) = 0.58

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    15.15    26.27   4061.6   4211.7   4211.7    1.194    0.546    0.545    236.2   3258.4

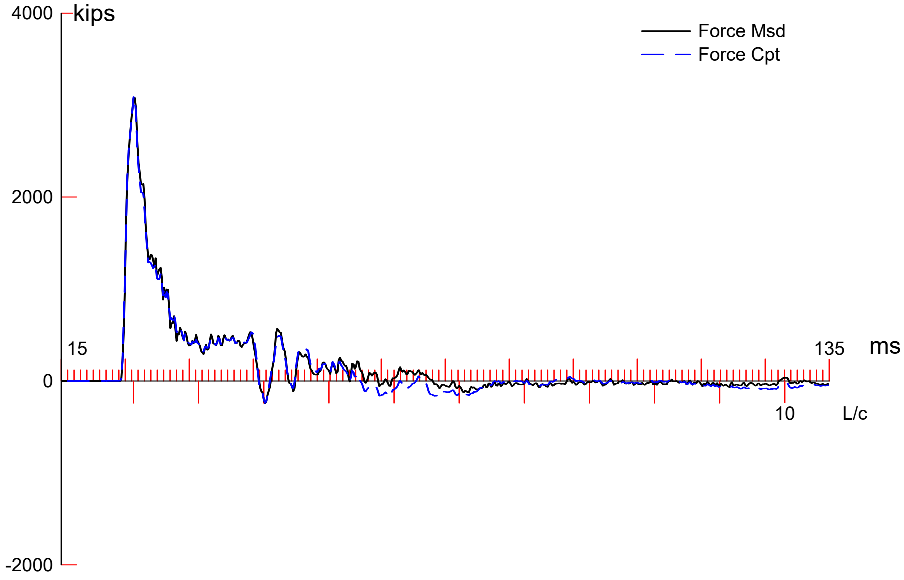

                                PILE PROFILE AND PILE MODEL
                  Depth                Area          E-Modulus     Spec. Weight          Perim.
                     ft                 in²                ksi            lb/ft³              ft

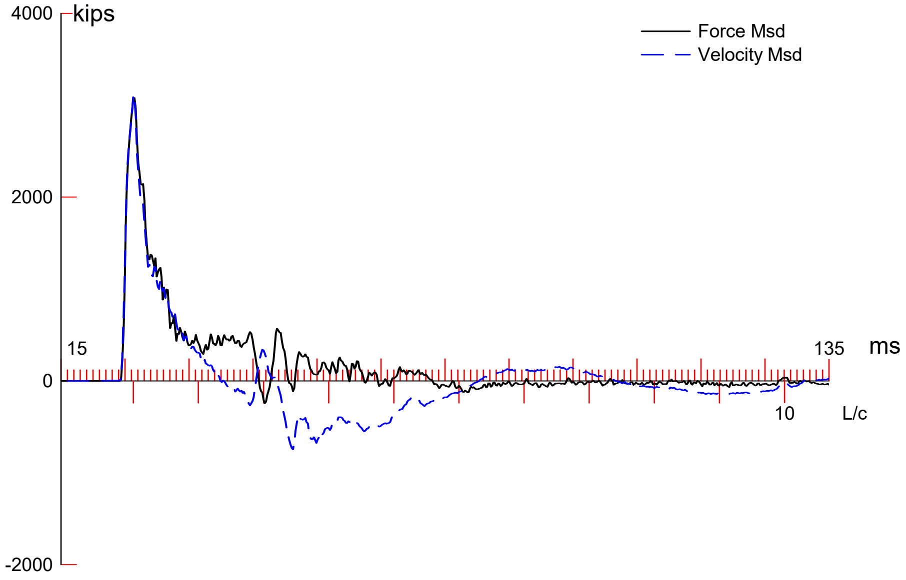
                   0.00              147.65            31043.9          492.000          12.566
                 185.00              147.65            31043.9          492.000          12.566

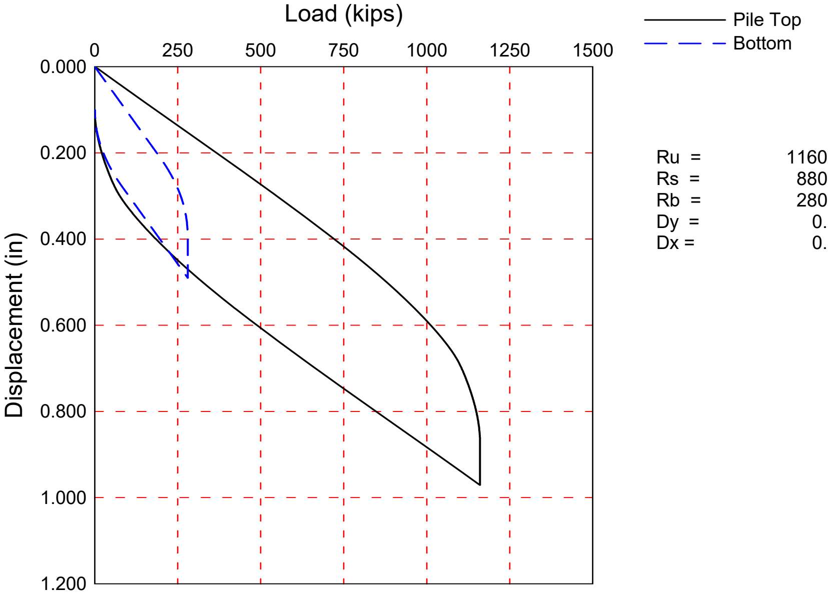
Toe Area                             12.566       ft²

Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

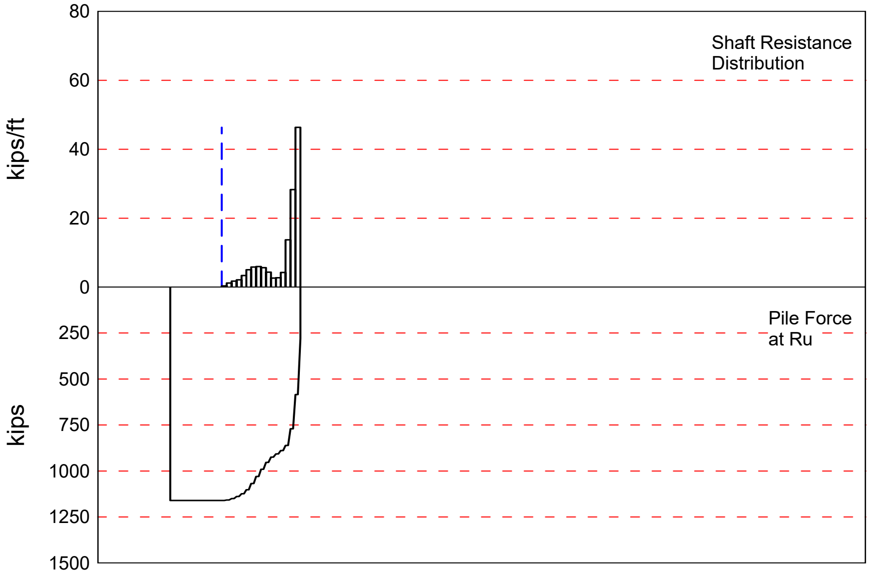
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```







Ru = 1160.3 kips
Rs = 880.3 kips
Rb = 280.0 kips
Dy = 0.87 in
Dx = 0.97 in



```
KIWC, POA TPP; Pile: IP 8 (Loc. 6)                                Test: 03-May-2016 21:29:
PP48x1.0'', APE 15-4; Blow: 2023                                         CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                                OP: RMDT
------------------------------------------------------------------------------------------
                                  CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1160.3; along Shaft    880.3; at Toe    280.0  kips
------------------------------------------------------------------------------------------
   Soil     Dist.     Depth        Ru     Force        Sum      Unit       Unit      Smith
  Sgmnt     Below     Below             in Pile         of   Resist.    Resist.    Damping
    No.     Gages     Grade                             Ru   (Depth)     (Area)     Factor
               ft        ft      kips      kips       kips   kips/ft        ksf       s/ft
------------------------------------------------------------------------------------------
                                         1160.3
      1      75.5       6.5       2.5    1157.8        2.5      0.38       0.03      0.219
      2      82.1      13.1       8.1    1149.7       10.6      1.23       0.10      0.219
      3      88.6      19.6      11.7    1138.0       22.3      1.78       0.14      0.219
      4      95.2      26.2      14.1    1123.9       36.4      2.15       0.17      0.219
      5     101.8      32.8      22.4    1101.5       58.8      3.41       0.27      0.219
      6     108.3      39.3      33.3    1068.2       92.1      5.07       0.40      0.219
      7     114.9      45.9      38.4    1029.8      130.5      5.85       0.47      0.219
      8     121.5      52.5      39.3     990.5      169.8      5.99       0.48      0.219
      9     128.0      59.0      37.3     953.2      207.1      5.68       0.45      0.219
     10     134.6      65.6      28.6     924.6      235.7      4.36       0.35      0.219
     11     141.2      72.2      17.7     906.9      253.4      2.70       0.21      0.219
     12     147.7      78.7      18.1     888.8      271.5      2.76       0.22      0.219
     13     154.3      85.3      28.0     860.8      299.5      4.26       0.34      0.219
     14     160.9      91.9      90.2     770.6      389.7     13.74       1.09      0.219
     15     167.4      98.4     186.0     584.6      575.7     28.33       2.25      0.219
     16     174.0     105.0     304.6     280.0      880.3     46.39       3.69      0.219

  Avg. Shaft                     55.0                           8.38       0.67      0.219

       Toe                      280.0                                    272.43      0.099

Soil Model Parameters/Extensions                          Shaft      Toe
------------------------------------------------------------------------------------------
Quake                      (in)                           0.190    0.300
Case Damping Factor                                       0.720    0.103
Unloading Quake            (% of loading quake)              50      100
Reloading Level            (% of Ru)                        100      100
Unloading Level            (% of Ru)                         40
Soil Support Dashpot                                      1.000    0.000
Soil Support Weight        (kips)                          8.62     0.00

max. Top Comp. Stress      =    20.9 ksi      (T=  26.7 ms, max= 1.004 x Top)
max. Comp. Stress          =    21.0 ksi      (Z=  82.1 ft, T=  31.5 ms)
max. Tens. Stress          =   -2.15 ksi      (Z=  75.5 ft, T=  69.5 ms)
max. Energy (EMX)          =    96.1 kip-ft;  max. Measured Top Displ. (DMX)= 0.67 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	3094.1	-177.9	20.9	-1.20	96.15	11.5	0.670
2	6.6	3092.5	-186.8	20.9	-1.26	96.06	11.5	0.666
5	16.4	3087.8	-197.6	20.9	-1.34	95.76	11.5	0.661
8	26.3	3082.9	-270.6	20.9	-1.83	95.43	11.5	0.656
11	36.1	3079.1	-282.3	20.8	-1.91	95.09	11.5	0.650
14	46.0	3079.0	-249.2	20.8	-1.69	94.72	11.5	0.643
17	55.8	3078.7	-294.8	20.8	-2.00	94.36	11.5	0.635
20	65.7	3081.2	-303.9	20.9	-2.06	94.15	11.5	0.625
23	75.5	3096.4	-317.1	21.0	-2.15	93.91	11.4	0.613
26	85.4	3090.4	-307.6	20.9	-2.08	92.45	11.3	0.601
29	95.2	3101.5	-312.9	21.0	-2.12	90.81	11.1	0.586
32	105.1	3061.0	-286.0	20.7	-1.94	86.76	10.8	0.573
35	114.9	3043.7	-273.4	20.6	-1.85	83.15	10.5	0.559
38	124.8	2886.3	-252.4	19.5	-1.71	75.48	10.2	0.545
41	134.6	2826.8	-219.2	19.1	-1.48	71.67	10.1	0.531
44	144.5	2741.9	-211.7	18.6	-1.43	67.11	9.9	0.517
47	154.3	2843.2	-288.0	19.3	-1.95	65.08	9.3	0.502
50	164.2	2267.6	-160.2	15.4	-1.08	54.50	11.1	0.487
51	167.4	2000.5	-140.2	13.5	-0.95	54.36	11.6	0.482
52	170.7	1332.2	-44.8	9.0	-0.30	39.02	11.7	0.477
53	174.0	1349.3	-28.0	9.1	-0.19	15.63	11.7	0.473
Absolute	82.1			21.0			(T =	31.5 ms)
	75.5				-2.15		(T =	69.5 ms)

```
                                  CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        2836.4  2496.7  2156.9  1817.1  1477.4  1137.6   797.8   458.1   118.3     0.0
RX        2836.4  2496.7  2157.5  1820.6  1483.7  1247.1  1112.7  1016.2   919.8   823.3
RU        2792.0  2447.8  2103.7  1759.5  1415.3  1071.1   726.9   382.7    38.5     0.0

RAU =    774.9 (kips);  RA2 =    774.9 (kips)

Current CAPWAP Ru = 1160.3 (kips); Corresponding J(RP)= 0.49; J(RX) = 0.56

    VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
   ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
  11.66    26.49   3126.3   3107.7   3107.7    0.666    0.089    0.100     96.4   3021.1

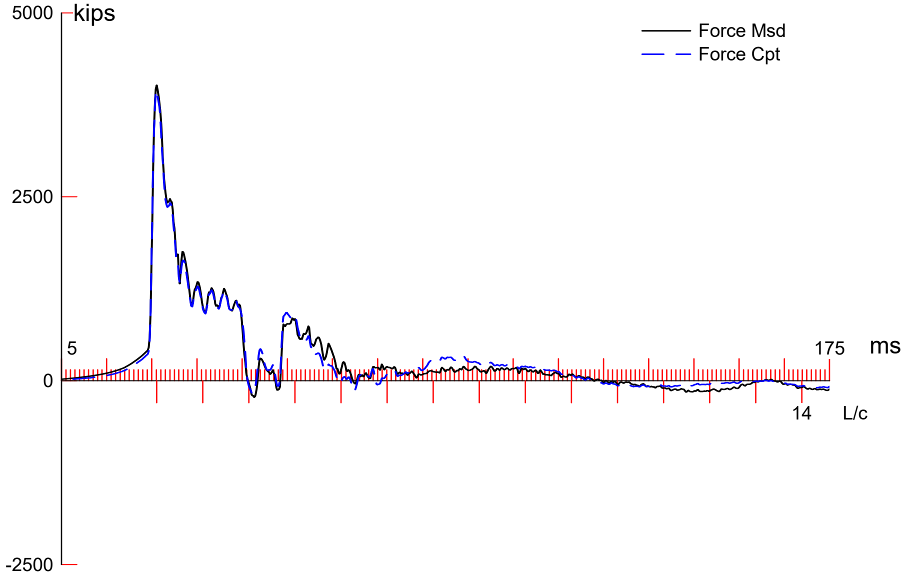

                            PILE PROFILE AND PILE MODEL
             Depth               Area          E-Modulus     Spec. Weight            Perim.
                ft                in²                ksi            lb/ft³               ft

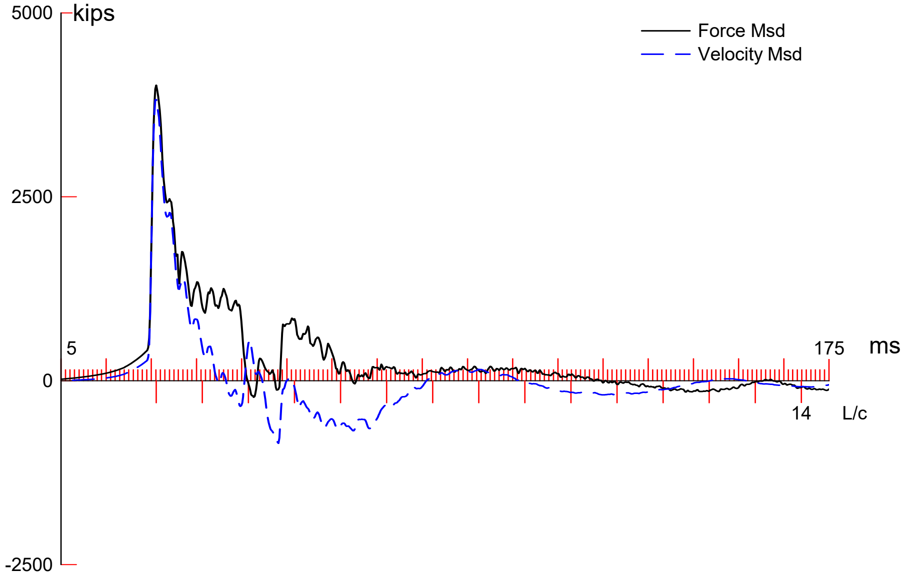
              0.00             147.65            31043.9          492.000            12.566
            174.00             147.65            31043.9          492.000            12.566

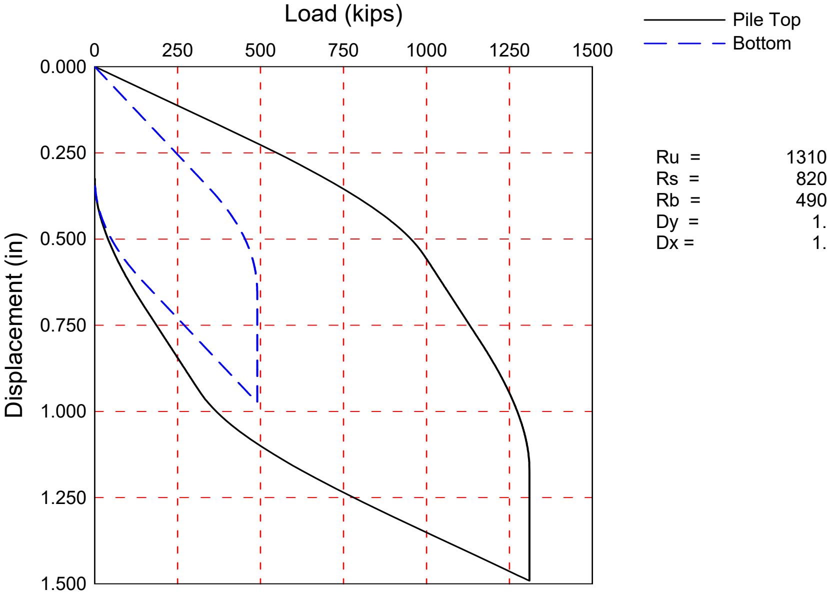
Toe Area                        1.028       ft²

Top Segment Length      3.28 ft, Top Impedance   268.13 kips/ft/s

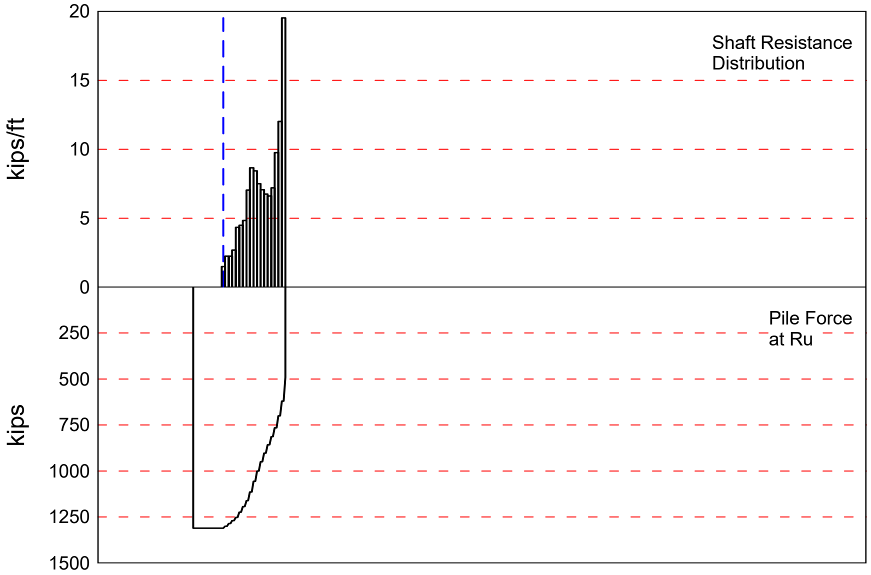
Pile Damping    1.0 %, Time Incr  0.192 ms, Wave Speed  17100.0 ft/s, 2L/c  20.4 ms
```







Ru = 1310.3 kips
Rs = 820.3 kips
Rb = 490.0 kips
Dy = 1.17 in
Dx = 1.49 in



```
KIWC, POA TPP; Pile: IP 9                                Test: 07-May-2016 11:20:
PP48x1.0'', APE D180-42; Blow: 902                                 CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                          OP: RMDT
------------------------------------------------------------------------------------
                                 CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1310.3; along Shaft    820.3; at Toe    490.0  kips
------------------------------------------------------------------------------------
    Soil     Dist.     Depth        Ru     Force       Sum      Unit      Unit     Smith
   Sgmnt     Below     Below             in Pile        of    Resist.   Resist.   Damping
     No.     Gages     Grade                            Ru    (Depth)    (Area)    Factor
                ft        ft      kips      kips      kips    kips/ft       ksf      s/ft
------------------------------------------------------------------------------------
                                          1310.3
       1      60.0       1.6      10.0    1300.3      10.0      6.16      0.49     0.215
       2      66.7       8.3      15.0    1285.3      25.0      2.25      0.18     0.215
       3      73.4      15.0      15.0    1270.3      40.0      2.25      0.18     0.215
       4      80.0      21.6      18.0    1252.3      58.0      2.70      0.21     0.215
       5      86.7      28.3      29.0    1223.3      87.0      4.35      0.35     0.215
       6      93.4      35.0      30.0    1193.3     117.0      4.50      0.36     0.215
       7     100.0      41.6      32.3    1161.0     149.3      4.84      0.39     0.215
       8     106.7      48.3      47.0    1114.0     196.3      7.05      0.56     0.215
       9     113.4      55.0      57.7    1056.3     254.0      8.65      0.69     0.215
      10     120.0      61.6      56.3    1000.0     310.3      8.44      0.67     0.215
      11     126.7      68.3      50.1     949.9     360.4      7.51      0.60     0.215
      12     133.4      75.0      47.1     902.8     407.5      7.06      0.56     0.215
      13     140.1      81.7      45.1     857.7     452.6      6.76      0.54     0.215
      14     146.7      88.3      44.1     813.6     496.7      6.61      0.53     0.215
      15     153.4      95.0      48.1     765.5     544.8      7.21      0.57     0.215
      16     160.1     101.7      65.1     700.4     609.9      9.76      0.78     0.215
      17     166.7     108.3      80.2     620.2     690.1     12.03      0.96     0.215
      18     173.4     115.0     130.2     490.0     820.3     19.52      1.55     0.215

   Avg. Shaft                     45.6                          7.13      0.57     0.215

        Toe                      490.0                                   38.99     0.090
Soil Model Parameters/Extensions                                Shaft       Toe
------------------------------------------------------------------------------------
Quake                      (in)                                 0.140     0.500
Case Damping Factor                                             0.662     0.165
Unloading Quake            (% of loading quake)                    30       100
Reloading Level            (% of Ru)                              100       100
Unloading Level            (% of Ru)                                0
Soil Plug Weight           (kips)                                           0.50

max. Top Comp. Stress      =    26.7 ksi      (T=  26.5 ms, max= 1.021 x Top)
max. Comp. Stress          =    27.3 ksi      (Z=  60.0 ft, T=  29.8 ms)
max. Tens. Stress          =   -1.66 ksi      (Z=  46.7 ft, T=  72.8 ms)
max. Energy (EMX)          =   209.7 kip-ft;  max. Measured Top Displ. (DMX)= 1.07 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	3943.4	-136.2	26.7	-0.92	209.67	14.6	1.120
2	6.7	3945.0	-186.5	26.7	-1.26	209.17	14.6	1.119
5	16.7	3950.5	-200.9	26.7	-1.36	207.56	14.6	1.112
8	26.7	3957.2	-177.0	26.8	-1.20	206.44	14.5	1.102
11	36.7	3965.6	-158.8	26.9	-1.08	206.20	14.5	1.091
14	46.7	3976.6	-245.0	26.9	-1.66	205.93	14.4	1.079
17	56.7	4009.6	-219.2	27.1	-1.48	205.40	14.3	1.062
20	66.7	4017.2	-162.6	27.2	-1.10	202.36	14.1	1.040
23	76.7	3957.4	-175.2	26.8	-1.19	195.22	13.9	1.019
26	86.7	3967.5	-188.9	26.9	-1.28	190.64	13.6	0.995
29	96.7	3832.7	-199.8	26.0	-1.35	178.37	13.2	0.975
32	106.7	3835.1	-178.7	26.0	-1.21	171.30	12.7	0.951
35	116.7	3583.7	-200.7	24.3	-1.36	151.30	12.2	0.925
38	126.7	3494.8	-164.2	23.7	-1.11	140.67	11.8	0.905
41	136.7	3256.5	-155.3	22.0	-1.05	123.07	11.4	0.883
44	146.7	3202.2	-139.6	21.7	-0.95	114.82	11.0	0.866
47	156.7	3026.5	-57.4	20.5	-0.39	98.18	10.9	0.845
48	160.1	3046.8	-54.6	20.6	-0.37	97.90	12.1	0.838
49	163.4	2722.1	-48.6	18.4	-0.33	86.30	13.3	0.832
50	166.7	2425.2	-47.9	16.4	-0.32	86.15	14.1	0.826
51	170.1	1715.2	-40.6	11.6	-0.27	71.60	14.5	0.822
52	173.4	1386.0	-36.9	9.4	-0.25	48.30	14.7	0.817
Absolute	60.0			27.3			(T =	29.8 ms)
	46.7				-1.66		(T =	72.8 ms)

```
                                  CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        3694.2  3280.7  2867.2  2453.7  2040.2  1626.7  1213.2   799.7   386.2     0.0
RX        3717.6  3297.5  2877.4  2457.3  2037.2  1617.1  1281.6  1165.7  1119.4  1119.4
RU        3808.8  3397.8  2986.9  2575.9  2164.9  1754.0  1343.0   932.0   521.0   110.1

RAU =   1096.1 (kips);  RA2 =   1361.2 (kips)

Current CAPWAP Ru = 1310.3 (kips); Corresponding J(RP)= 0.58; J(RX) = 0.59

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   14.56    26.28   3845.4   3983.9   4037.1    1.071    0.323    0.324    209.5   3605.0


                          PILE PROFILE AND PILE MODEL
                Depth             Area        E-Modulus     Spec. Weight           Perim.
                   ft              in²              ksi            lb/ft³               ft

                 0.00           147.65          30681.9          492.000           12.566
               173.40           147.65          30681.9          492.000           12.566

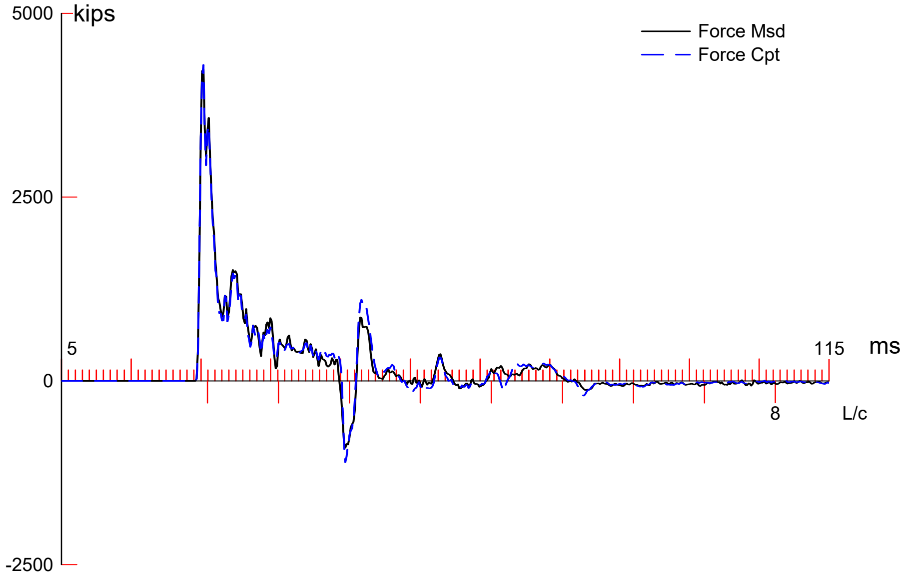
Toe Area                        12.566       ft²

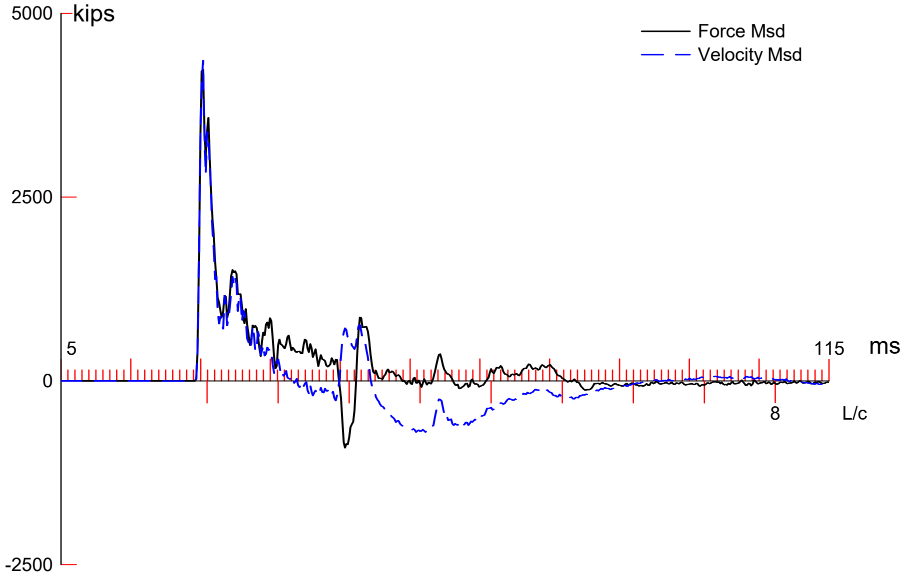
Top Segment Length      3.33 ft, Top Impedance   266.56 kips/ft/s

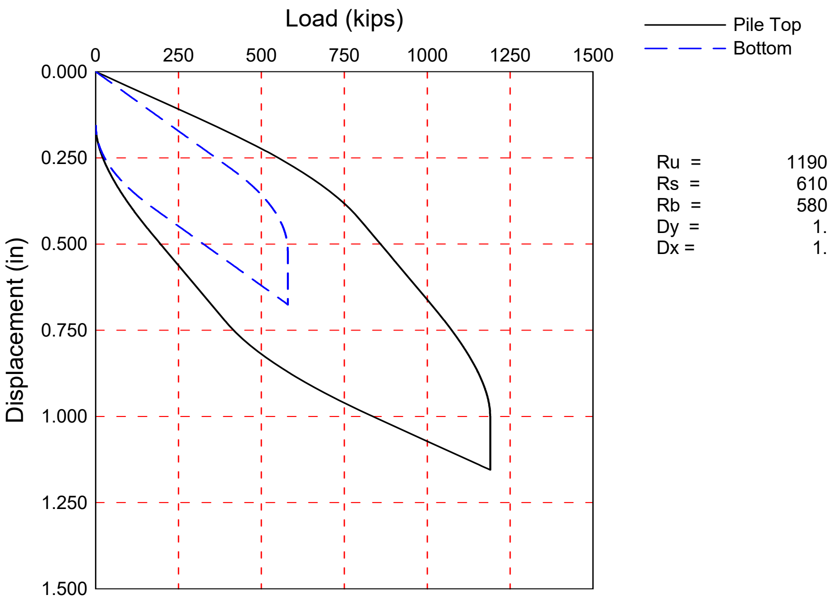
Pile Damping    1.0 %, Time Incr  0.196 ms, Wave Speed  17000.0 ft/s, 2L/c  20.4 ms
```

KIWC, POA TPP; Pile: IP 10; PP48x1.0", APE 15-4; Blow: 1445 (Test: 26-May-2016 15:37:)
Robert Miner Dynamic Testing, Inc.

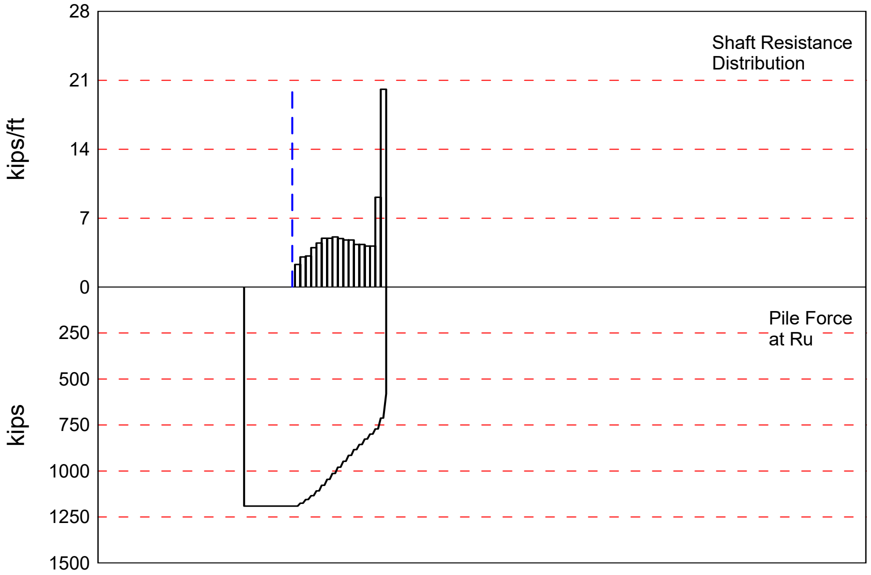
31-May-2016
CAPWAP(R) 2006-3







Ru = 1190.2 kips
Rs = 610.2 kips
Rb = 580.0 kips
Dy = 1.00 in
Dx = 1.16 in



```
KIWC, POA TPP; Pile: IP 10                                        Test: 26-May-2016 15:37:
PP48x1.0", APE 15-4; Blow: 1445                                          CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                                OP: RMDT
                                  CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1190.2; along Shaft    610.2; at Toe    580.0  kips
    Soil     Dist.     Depth        Ru     Force       Sum      Unit      Unit     Smith
   Sgmnt     Below     Below             in Pile        of   Resist.   Resist.   Damping
     No.     Gages     Grade                            Ru   (Depth)    (Area)    Factor
                ft        ft      kips      kips      kips   kips/ft       ksf      s/ft

                                            1190.2
       1      68.9       7.9      15.2    1175.0      15.2      1.92      0.15     0.180
       2      75.5      14.5      20.2    1154.8      35.4      3.08      0.24     0.180
       3      82.1      21.1      20.8    1134.0      56.2      3.17      0.25     0.180
       4      88.6      27.6      26.4    1107.6      82.6      4.02      0.32     0.180
       5      95.2      34.2      29.5    1078.1     112.1      4.49      0.36     0.180
       6     101.8      40.8      32.6    1045.5     144.7      4.96      0.40     0.180
       7     108.3      47.3      32.6    1012.9     177.3      4.96      0.40     0.180
       8     114.9      53.9      33.5     979.4     210.8      5.10      0.41     0.180
       9     121.5      60.5      32.5     946.9     243.3      4.95      0.39     0.180
      10     128.0      67.0      31.5     915.4     274.8      4.80      0.38     0.180
      11     134.6      73.6      31.5     883.9     306.3      4.80      0.38     0.180
      12     141.2      80.2      28.5     855.4     334.8      4.34      0.35     0.180
      13     147.7      86.7      28.5     826.9     363.3      4.34      0.35     0.180
      14     154.3      93.3      27.5     799.4     390.8      4.19      0.33     0.180
      15     160.9      99.9      27.5     771.9     418.3      4.19      0.33     0.180
      16     167.4     106.4      60.0     711.9     478.3      9.14      0.73     0.180
      17     174.0     113.0     131.9     580.0     610.2     20.09      1.60     0.180

  Avg. Shaft                      35.9                          5.40      0.43     0.180

       Toe                       580.0                                   46.15     0.100
Soil Model Parameters/Extensions                          Shaft      Toe

Quake                      (in)                           0.100    0.400
Case Damping Factor                                       0.410    0.216
Unloading Quake            (% of loading quake)              30       70
Reloading Level            (% of Ru)                        100      100
Unloading Level            (% of Ru)                         22
Soil Support Dashpot                                      0.400    0.000
Soil Support Weight        (kips)                          8.62     0.00

max. Top Comp. Stress      =    29.1 ksi      (T=  25.7 ms, max= 1.000 x Top)
max. Comp. Stress          =    29.1 ksi      (Z=   3.3 ft, T=  25.7 ms)
max. Tens. Stress          =   -7.03 ksi      (Z=   6.6 ft, T=  45.5 ms)
max. Energy (EMX)          =   111.1 kip-ft;  max. Measured Top Displ. (DMX)= 0.69 in
```

```
                                      EXTREMA TABLE
    Pile      Dist.      max.       min.      max.      max.       max.      max.      max.
   Sgmnt      Below     Force      Force     Comp.     Tens.     Trnsfd.    Veloc.    Displ.
     No.      Gages                         Stress    Stress     Energy
                 ft      kips       kips       ksi       ksi     kip-ft      ft/s        in

       1        3.3    4299.4    -1034.7      29.1     -7.01     111.07      16.0     0.673
       2        6.6    4297.7    -1038.2      29.1     -7.03     110.94      16.0     0.669
       5       16.4    4292.4     -956.2      29.1     -6.47     110.51      16.0     0.658
       8       26.3    4286.4     -963.4      29.0     -6.52     110.05      16.0     0.656
      11       36.1    4279.9     -887.8      29.0     -6.01     109.55      16.0     0.654
      14       46.0    4272.6     -871.0      28.9     -5.90     109.02      15.9     0.651
      17       55.8    4264.8     -888.8      28.9     -6.02     108.46      15.9     0.646
      20       65.7    4272.4     -806.7      28.9     -5.46     107.92      15.8     0.637
      23       75.5    4257.6     -804.7      28.8     -5.45     105.79      15.6     0.627
      26       85.4    4169.2     -956.0      28.2     -6.47     101.16      15.4     0.617
      29       95.2    4140.5     -587.8      28.0     -3.98      97.26      15.1     0.604
      32      105.1    4010.1     -751.3      27.2     -5.09      90.66      14.7     0.593
      35      114.9    3972.7     -827.5      26.9     -5.60      86.64      14.4     0.576
      38      124.8    3834.1     -584.9      26.0     -3.96      78.91      14.1     0.562
      41      134.6    3797.4     -231.5      25.7     -1.57      73.49      13.8     0.553
      44      144.5    3673.3     -777.9      24.9     -5.27      67.04      13.5     0.538
      47      154.3    3638.9     -756.1      24.6     -5.12      63.67      13.3     0.520
      50      164.2    3554.3     -132.7      24.1     -0.90      57.92      15.0     0.504
      51      167.4    3484.2     -136.2      23.6     -0.92      57.73      16.3     0.499
      52      170.7    2545.0     -114.3      17.2     -0.77      51.51      17.0     0.495
      53      174.0    1721.1     -110.6      11.7     -0.75      39.26      19.1     0.491

Absolute        3.3                         29.1                          (T =     25.7 ms)
                6.6                                   -7.03               (T =     45.5 ms)
```

```
                                    CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        3765.6  3225.3  2685.1  2144.8  1604.5  1064.2   523.9     0.0     0.0     0.0
RX        3765.6  3225.3  2685.1  2144.8  1604.5  1064.2   880.7   810.7   764.5   746.6
RU        3943.5  3421.0  2898.5  2376.0  1853.5  1331.0   808.5   286.0     0.0     0.0

RAU =    587.7 (kips);  RA2 =    882.2 (kips)

Current CAPWAP Ru = 1190.2 (kips); Corresponding J(RP)= 0.48; J(RX) = 0.48

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    17.54    26.11   4702.6   4465.8   4465.8    0.692    0.141    0.156    112.4   3180.6


                             PILE PROFILE AND PILE MODEL
             Depth              Area         E-Modulus      Spec. Weight            Perim.
                ft               in²               ksi            lb/ft³                ft

              0.00            147.65           31043.9           492.000            12.566
            174.00            147.65           31043.9           492.000            12.566

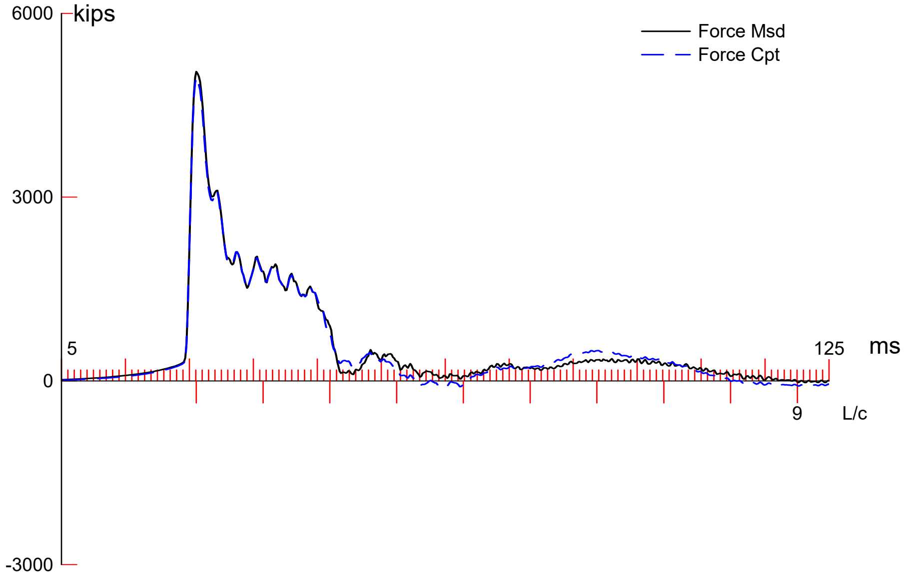
Toe Area                      12.566       ft²

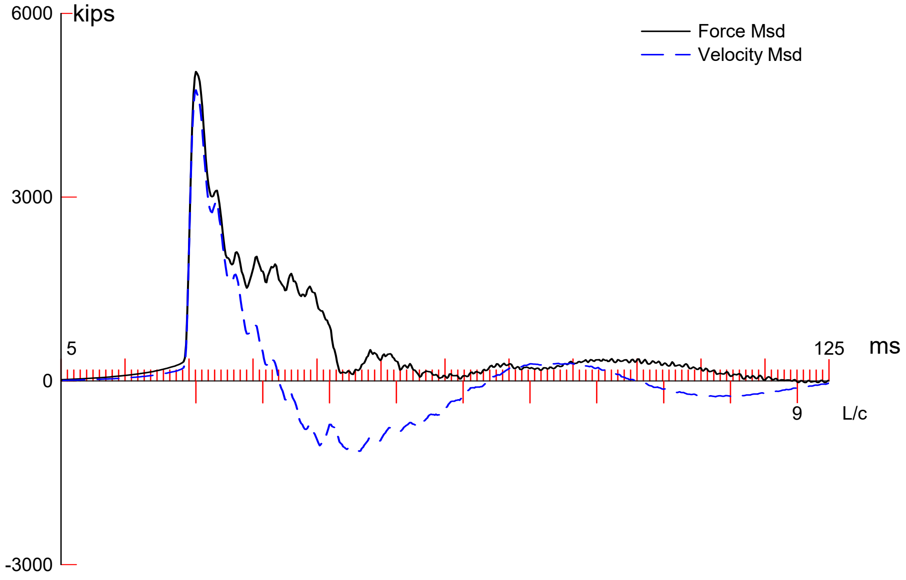
Top Segment Length      3.28 ft, Top Impedance   268.13 kips/ft/s

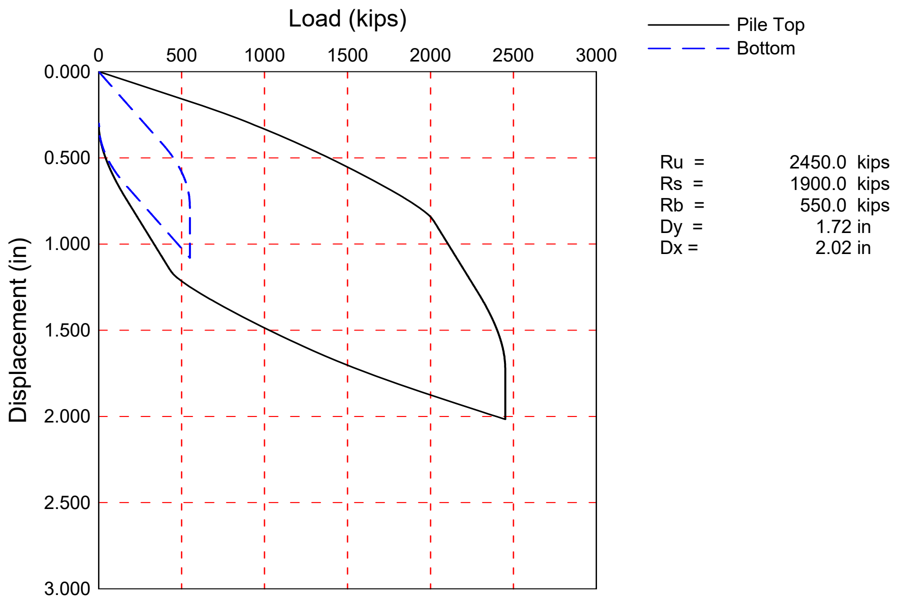
Pile Damping    1.0 %, Time Incr  0.192 ms, Wave Speed  17100.0 ft/s, 2L/c  20.4 ms
```

KIWC, POA TPP; Pile: IP 1 RESTRIKE; PP48x1.0", APE D180-42; Blow: 5 (Test: 21-Jun-2016 14:53:)
Robert Miner Dynamic Testing, Inc.

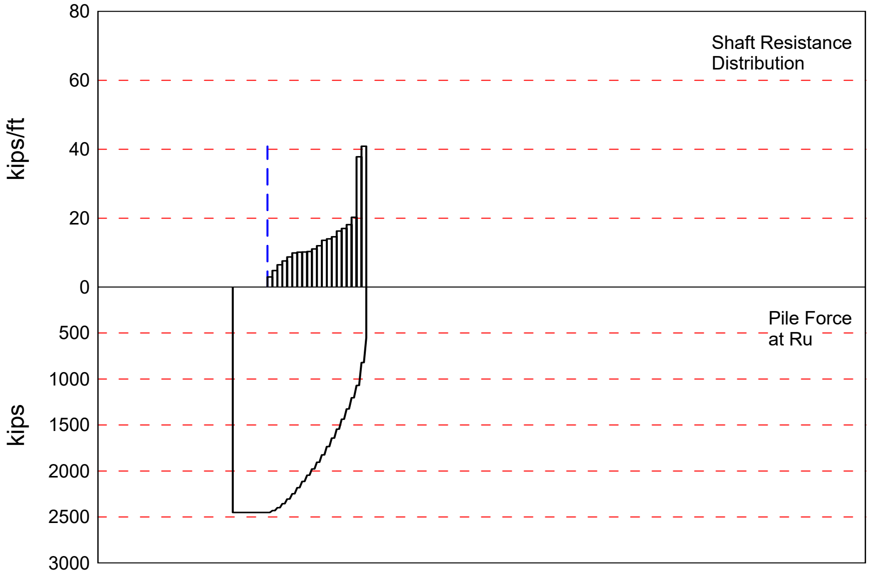
24-Jun-2016
CAPWAP(R) 2006-3







Ru = 2450.0 kips
Rs = 1900.0 kips
Rb = 550.0 kips
Dy = 1.72 in
Dx = 2.02 in



```
                                 CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   2450.0; along Shaft   1900.0; at Toe    550.0  kips
   Soil     Dist.     Depth       Ru      Force       Sum       Unit      Unit      Smith
  Sgmnt     Below     Below             in Pile        of    Resist.   Resist.    Damping
    No.     Gages     Grade                            Ru    (Depth)    (Area)     Factor
               ft        ft     kips       kips      kips    kips/ft       ksf       s/ft

                                          2450.0
      1      52.9       3.4     19.6     2430.4      19.6       5.68      0.45      0.200
      2      59.5      10.1     32.0     2398.4      51.6       4.84      0.39      0.200
      3      66.1      16.7     43.1     2355.3      94.7       6.52      0.52      0.200
      4      72.7      23.3     50.3     2305.0     145.0       7.61      0.61      0.200
      5      79.3      29.9     58.1     2246.9     203.1       8.79      0.70      0.200
      6      85.9      36.5     65.9     2181.0     269.0       9.97      0.79      0.200
      7      92.6      43.1     67.4     2113.6     336.4      10.19      0.81      0.200
      8      99.2      49.7     67.5     2046.1     403.9      10.21      0.81      0.200
      9     105.8      56.3     68.5     1977.6     472.4      10.36      0.82      0.200
     10     112.4      62.9     73.5     1904.1     545.9      11.12      0.88      0.200
     11     119.0      69.6     79.6     1824.5     625.5      12.04      0.96      0.200
     12     125.6      76.2     90.0     1734.5     715.5      13.61      1.08      0.200
     13     132.2      82.8     92.7     1641.8     808.2      14.02      1.12      0.200
     14     138.8      89.4     96.7     1545.1     904.9      14.63      1.16      0.200
     15     145.4      96.0    107.8     1437.3    1012.7      16.31      1.30      0.200
     16     152.1     102.6    112.9     1324.4    1125.6      17.08      1.36      0.200
     17     158.7     109.2    120.0     1204.4    1245.6      18.15      1.44      0.200
     18     165.3     115.8    134.0     1070.4    1379.6      20.27      1.61      0.200
     19     171.9     122.4    250.0      820.4    1629.6      37.82      3.01      0.200
     20     178.5     129.1    270.4      550.0    1900.0      40.90      3.25      0.200

  Avg. Shaft                    95.0                           14.72      1.17      0.200

       Toe                     550.0                                     43.77      0.060

Soil Model Parameters/Extensions                         Shaft      Toe

Quake                      (in)                          0.100    0.600
Case Damping Factor                                      1.417    0.123
Unloading Quake            (% of loading quake)             30       30
Reloading Level            (% of Ru)                       100      100
Unloading Level            (% of Ru)                        10
Soil Plug Weight           (kips)                                  0.35
Soil Support Dashpot                                     1.400    0.000
Soil Support Weight        (kips)                         8.70     0.00

max. Top Comp. Stress      =    33.5 ksi      (T=  26.5 ms, max= 1.026 x Top)
max. Comp. Stress          =    34.4 ksi      (Z=  52.9 ft, T=  29.4 ms)
max. Tens. Stress          =   -2.07 ksi      (Z=  59.5 ft, T=  64.8 ms)
max. Energy (EMX)          =   327.5 kip-ft;  max. Measured Top Displ. (DMX)= 1.27 in
```

```
                                      EXTREMA TABLE
     Pile     Dist.      max.      min.      max.      max.      max.      max.      max.
    Sgmnt     Below     Force     Force     Comp.     Tens.   Trnsfd.    Veloc.    Displ.
      No.     Gages                        Stress    Stress    Energy
                 ft      kips      kips       ksi       ksi    kip-ft      ft/s        in

        1       3.3    4947.8    -127.5      33.5     -0.86    327.54      18.1     1.291
        2       6.6    4949.9    -147.6      33.5     -1.00    326.45      18.1     1.276
        5      16.5    4956.7    -156.4      33.6     -1.06    322.75      18.0     1.228
        8      26.4    4964.9    -208.1      33.6     -1.41    318.54      18.0     1.177
       11      36.4    4974.9    -228.3      33.7     -1.55    313.75      17.9     1.123
       14      46.3    5015.3    -242.9      34.0     -1.64    308.88      17.8     1.068
       17      56.2    5028.7    -296.1      34.0     -2.00    298.92      17.4     1.013
       20      66.1    5031.3    -273.1      34.1     -1.85    285.86      16.8     0.956
       23      76.0    4812.1    -207.2      32.6     -1.40    263.11      16.2     0.923
       26      85.9    4761.6    -228.5      32.2     -1.55    249.01      15.5     0.886
       29      95.9    4427.1    -184.3      30.0     -1.25    221.67      14.8     0.848
       32     105.8    4356.2    -185.2      29.5     -1.25    207.94      14.1     0.812
       35     115.7    4048.7    -184.0      27.4     -1.25    183.13      13.3     0.774
       38     125.6    3988.1    -160.4      27.0     -1.09    169.38      12.5     0.736
       41     135.5    3619.0    -150.7      24.5     -1.02    143.58      11.7     0.701
       44     145.4    3545.0    -135.9      24.0     -0.92    130.24      10.8     0.669
       47     155.4    3159.9     -77.2      21.4     -0.52    104.29       9.9     0.641
       50     165.3    2993.1     -85.3      20.3     -0.58     90.84      10.0     0.621
       51     168.6    2539.5     -64.5      17.2     -0.44     76.70      10.8     0.615
       52     171.9    2316.6     -62.8      15.7     -0.43     76.56      11.2     0.610
       53     175.2    1423.9     -25.3       9.6     -0.17     51.85      11.4     0.605
       54     178.5    1313.2     -23.2       8.9     -0.16     25.26      11.4     0.600

Absolute       52.9                          34.4                         (T =     29.4 ms)
               59.5                                    -2.07              (T =     64.8 ms)
```

```
                                   CASE METHOD
J =            0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP          5735.4  5323.3  4911.1  4499.0  4086.8  3674.7  3262.5  2850.4  2438.2  2026.1
RX          5735.4  5323.3  4911.1  4499.0  4086.8  3674.7  3262.5  2850.4  2438.2  2026.1
RU          5956.2  5566.1  5176.0  4786.0  4395.9  4005.8  3615.7  3225.7  2835.6  2445.5

RAU =    581.4 (kips);  RA2 =   1995.2 (kips)

Current CAPWAP Ru = 2450.0 (kips); Corresponding J(RP)= 0.80; J(RX) = 0.80

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   17.84    26.29   4783.5   5073.4   5073.4    1.274    0.304    0.300    328.5   5010.1


                           PILE PROFILE AND PILE MODEL
             Depth                Area        E-Modulus     Spec. Weight            Perim.
                ft                 in²              ksi           lb/ft³                ft

              0.00              147.65          31043.9          492.000            12.566
            178.50              147.65          31043.9          492.000            12.566

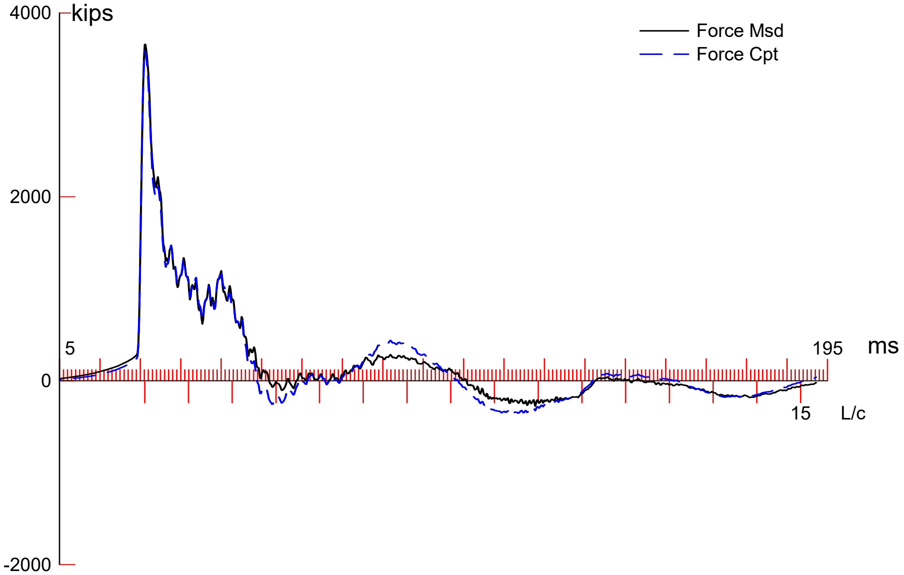
Toe Area                        12.566       ft²

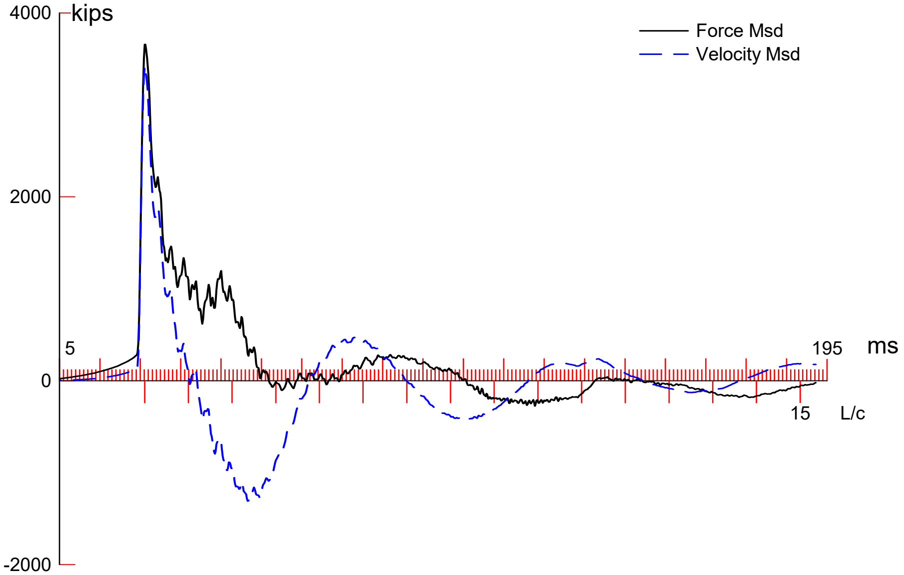
Top Segment Length      3.31 ft, Top Impedance   268.13 kips/ft/s

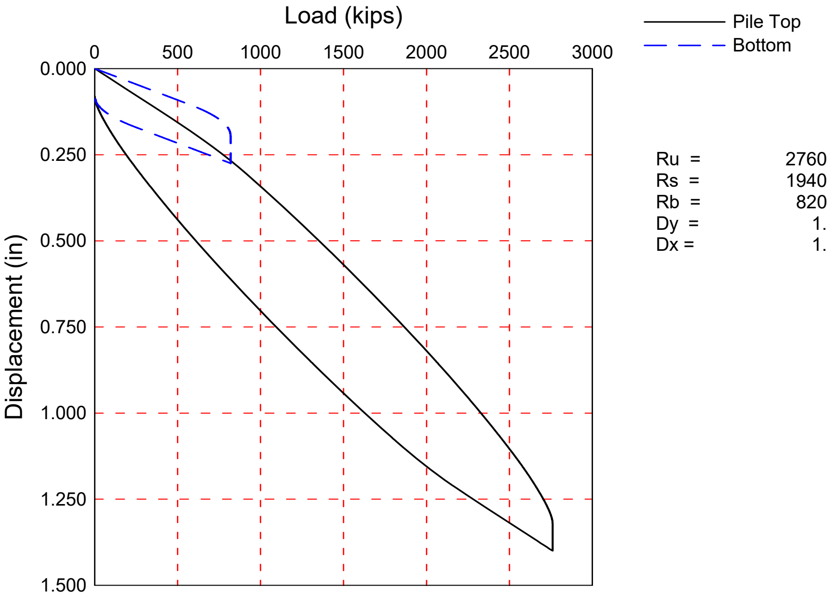
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  20.9 ms
```

KIWC, POA TPP; Pile: IP 2 RESTRIKE; PP48x1.0", APE D180-42; Blow: 13 (Test: 09-Jun-2016 16:22:)
Robert Miner Dynamic Testing, Inc.

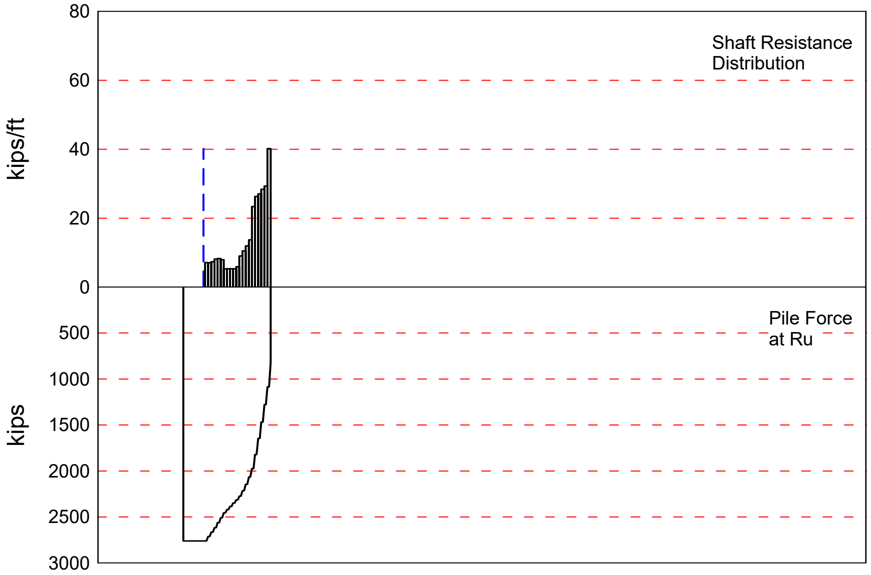
10-Jun-2016
CAPWAP(R) 2006-3







Ru = 2760.0 kips
Rs = 1940.0 kips
Rb = 820.0 kips
Dy = 1.32 in
Dx = 1.40 in



```
                                CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   2760.0; along Shaft   1940.0; at Toe    820.0  kips
   Soil     Dist.    Depth        Ru      Force        Sum      Unit      Unit     Smith
  Sgmnt     Below    Below              in Pile         of    Resist.   Resist.   Damping
    No.     Gages    Grade                              Ru    (Depth)   (Area)    Factor
               ft       ft      kips       kips       kips    kips/ft      ksf      s/ft

                                          2760.0
      1      52.9      8.9      47.5     2712.5       47.5       5.33      0.42     0.200
      2      59.5     15.5      47.0     2665.5       94.5       7.11      0.57     0.200
      3      66.1     22.1      49.0     2616.5      143.5       7.42      0.59     0.200
      4      72.7     28.7      53.9     2562.6      197.4       8.16      0.65     0.200
      5      79.3     35.3      54.8     2507.8      252.2       8.29      0.66     0.200
      6      85.9     41.9      52.8     2455.0      305.0       7.99      0.64     0.200
      7      92.5     48.5      35.0     2420.0      340.0       5.30      0.42     0.200
      8      99.1     55.2      35.3     2384.7      375.3       5.34      0.43     0.200
      9     105.7     61.8      35.3     2349.4      410.6       5.34      0.43     0.200
     10     112.3     68.4      35.3     2314.1      445.9       5.34      0.43     0.200
     11     118.9     75.0      39.4     2274.7      485.3       5.96      0.47     0.200
     12     125.5     81.6      59.9     2214.8      545.2       9.07      0.72     0.200
     13     132.1     88.2      69.7     2145.1      614.9      10.55      0.84     0.200
     14     138.8     94.8      79.3     2065.8      694.2      12.00      0.96     0.200
     15     145.4    101.4      90.9     1974.9      785.1      13.76      1.09     0.200
     16     152.0    108.0     154.6     1820.3      939.7      23.40      1.86     0.200
     17     158.6    114.6     174.1     1646.2     1113.8      26.35      2.10     0.200
     18     165.2    121.2     178.9     1467.3     1292.7      27.08      2.15     0.200
     19     171.8    127.8     187.9     1279.4     1480.6      28.44      2.26     0.200
     20     178.4    134.4     193.7     1085.7     1674.3      29.32      2.33     0.200
     21     185.0    141.0     265.7      820.0     1940.0      40.21      3.20     0.200

  Avg. Shaft                    92.4                             13.75      1.09     0.200

       Toe                     820.0                                       65.25     0.160

Soil Model Parameters/Extensions                         Shaft       Toe

Quake                        (in)                        0.100    0.150
Case Damping Factor                                      1.446    0.490
Reloading Level              (% of Ru)                     100      100
Unloading Level              (% of Ru)                      60

max. Top Comp. Stress      =    24.3 ksi      (T=  26.5 ms, max= 1.044 x Top)
max. Comp. Stress          =    25.4 ksi      (Z=  52.9 ft, T=  29.6 ms)
max. Tens. Stress          =   -3.12 ksi      (Z=  52.9 ft, T=  60.9 ms)
max. Energy (EMX)          =   154.2 kip-ft;  max. Measured Top Displ. (DMX)= 0.81 in
```

```
                                    EXTREMA TABLE
     Pile     Dist.      max.      min.      max.      max.      max.      max.      max.
    Sgmnt     Below     Force     Force     Comp.     Tens.   Trnsfd.    Veloc.    Displ.
      No.     Gages                        Stress    Stress    Energy
                 ft      kips      kips       ksi       ksi    kip-ft      ft/s        in

        1       3.3    3588.5    -371.0      24.3     -2.51    154.24      13.0     0.843
        2       6.6    3589.9    -377.2      24.3     -2.55    153.81      13.0     0.833
        5      16.5    3594.7    -391.7      24.3     -2.65    152.53      12.9     0.806
        8      26.4    3600.5    -405.9      24.4     -2.75    151.24      12.9     0.778
       11      36.3    3607.8    -417.9      24.4     -2.83    149.74      12.8     0.747
       14      46.3    3671.8    -437.2      24.9     -2.96    147.95      12.6     0.714
       17      56.2    3623.2    -413.4      24.5     -2.80    139.55      12.2     0.678
       20      66.1    3580.3    -400.3      24.2     -2.71    131.16      11.7     0.640
       23      76.0    3366.4    -355.6      22.8     -2.41    117.10      11.3     0.606
       26      85.9    3285.7    -353.2      22.2     -2.39    109.00      10.9     0.570
       29      95.8    3091.6    -335.6      20.9     -2.27     97.50      10.6     0.531
       32     105.7    3060.6    -358.0      20.7     -2.42     91.24      10.3     0.488
       35     115.6    2940.9    -343.4      19.9     -2.32     81.87       9.9     0.443
       38     125.5    2953.5    -361.8      20.0     -2.45     75.90       9.4     0.399
       41     135.4    2748.1    -295.5      18.6     -2.00     64.61       8.8     0.357
       44     145.4    2762.9    -282.5      18.7     -1.91     57.80       8.1     0.317
       47     155.3    2444.0    -143.4      16.5     -0.97     44.43       7.2     0.277
       50     165.2    2315.7     -63.8      15.7     -0.43     35.66       6.3     0.236
       53     175.1    1725.9       0.0      11.7      0.00     23.43       5.8     0.200
       54     178.4    1702.6       0.0      11.5      0.00     22.90       5.8     0.190
       55     181.7    1453.5       0.0       9.8      0.00     18.22       5.8     0.181
       56     185.0    1568.9       0.0      10.6      0.00     13.27       5.5     0.172

Absolute       52.9                          25.4                        (T =     29.6 ms)
               52.9                                   -3.12              (T =     60.9 ms)
```

```
                                     CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        4480.5  4214.6  3948.8  3682.9  3417.0  3151.2  2885.3  2619.4  2353.6  2087.7
RX        4480.5  4214.6  3948.8  3682.9  3418.0  3153.8  2889.6  2629.8  2375.9  2122.1
RU        4862.6  4634.9  4407.3  4179.6  3952.0  3724.3  3496.6  3269.0  3041.3  2813.7

RAU =    570.1 (kips);  RA2 =   1907.9 (kips)

Current CAPWAP Ru = 2760.0 (kips); Corresponding J(RP)= 0.65; J(RX) = 0.65

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    12.90    26.27   3457.8   3681.3   3700.4    0.807    0.080    0.080    154.7   4183.9


                            PILE PROFILE AND PILE MODEL
             Depth             Area        E-Modulus     Spec. Weight              Perim.
                ft              in²              ksi            lb/ft³                  ft

              0.00           147.65          31043.9          492.000              12.566
            185.00           147.65          31043.9          492.000              12.566

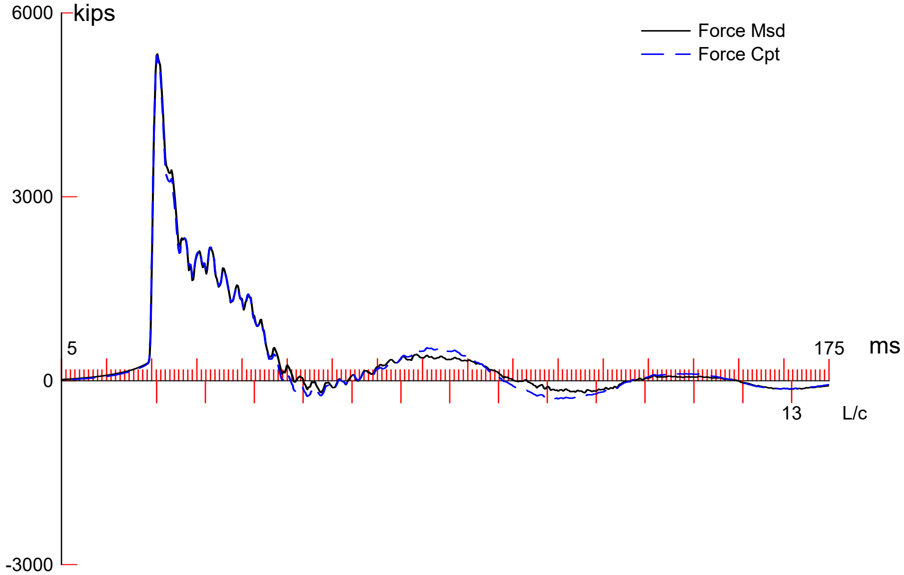
Toe Area                     12.566       ft²

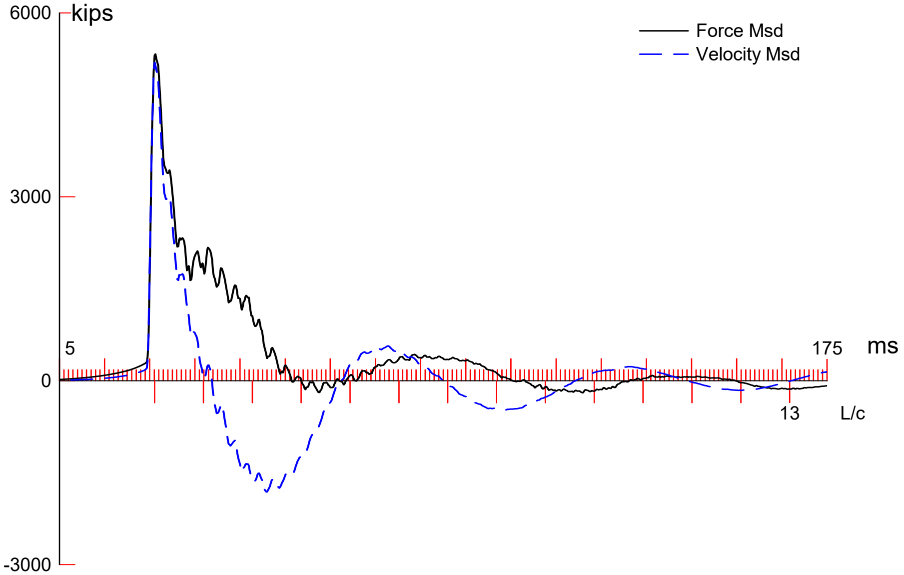
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

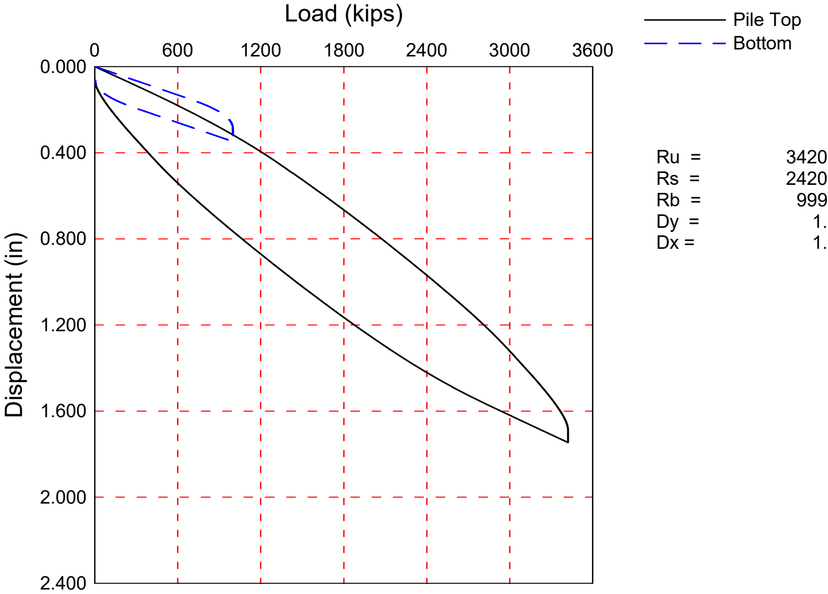
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 2 2ND RESTRIKE; PP48x1.0", APE D180-42; Blow: 8 (Test: 21-Jun-2016 13:38:)
Robert Miner Dynamic Testing, Inc.

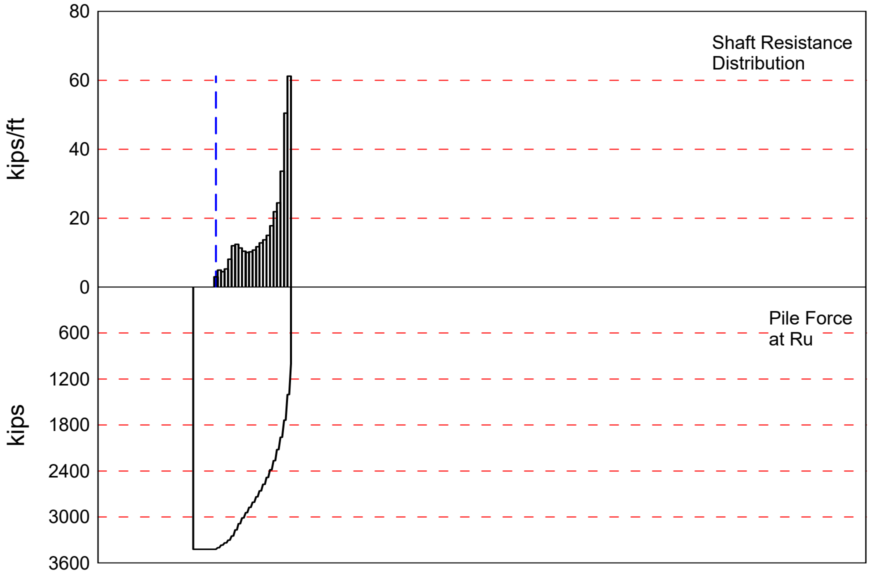
23-Jun-2016
CAPWAP(R) 2006-3







Ru = 3420.0 kips
Rs = 2420.6 kips
Rb = 999.4 kips
Dy = 1.68 in
Dx = 1.75 in



```
KIWC, POA TPP; Pile: IP 2 2ND RESTRIKE                     Test: 21-Jun-2016 13:38:
PP48x1.0'', APE D180-42; Blow: 8                                CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                       OP: RMDT
-----------------------------------------------------------------------------------
                              CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   3420.0; along Shaft   2420.6; at Toe    999.4  kips
-----------------------------------------------------------------------------------
   Soil     Dist.    Depth        Ru     Force       Sum     Unit     Unit    Smith
  Sgmnt     Below    Below             in Pile        of   Resist.  Resist.  Damping
    No.     Gages    Grade                            Ru   (Depth)   (Area)   Factor
               ft       ft      kips      kips      kips   kips/ft      ksf     s/ft
-----------------------------------------------------------------------------------
                                        3420.0
      1      46.3      2.8      20.0    3400.0      20.0      7.21     0.57    0.250
      2      52.9      9.4      32.8    3367.2      52.8      4.96     0.40    0.250
      3      59.5     16.0      30.0    3337.2      82.8      4.54     0.36    0.250
      4      66.1     22.6      35.0    3302.2     117.8      5.30     0.42    0.250
      5      72.7     29.2      53.7    3248.5     171.5      8.13     0.65    0.250
      6      79.3     35.8      79.6    3168.9     251.1     12.05     0.96    0.250
      7      85.9     42.4      82.2    3086.7     333.3     12.44     0.99    0.250
      8      92.5     49.0      75.1    3011.6     408.4     11.37     0.90    0.250
      9      99.1     55.6      69.1    2942.5     477.5     10.46     0.83    0.250
     10     105.7     62.2      66.8    2875.7     544.3     10.11     0.80    0.250
     11     112.3     68.8      67.7    2808.0     612.0     10.25     0.82    0.250
     12     118.9     75.5      71.1    2736.9     683.1     10.76     0.86    0.250
     13     125.5     82.1      77.6    2659.3     760.7     11.74     0.93    0.250
     14     132.1     88.7      85.1    2574.2     845.8     12.88     1.02    0.250
     15     138.8     95.3      90.7    2483.5     936.5     13.73     1.09    0.250
     16     145.4    101.9      99.4    2384.1    1035.9     15.04     1.20    0.250
     17     152.0    108.5     117.9    2266.2    1153.8     17.84     1.42    0.250
     18     158.6    115.1     144.7    2121.5    1298.5     21.90     1.74    0.250
     19     165.2    121.7     161.7    1959.8    1460.2     24.47     1.95    0.250
     20     171.8    128.3     222.3    1737.5    1682.5     33.65     2.68    0.250
     21     178.4    134.9     333.7    1403.8    2016.2     50.51     4.02    0.250
     22     185.0    141.5     404.4     999.4    2420.6     61.21     4.87    0.250

  Avg. Shaft                   110.0                        17.10     1.36    0.250

       Toe                     999.4                                 79.53    0.070
Soil Model Parameters/Extensions                          Shaft      Toe
-----------------------------------------------------------------------------------
Quake                      (in)                           0.100    0.220
Case Damping Factor                                       2.256    0.261
Reloading Level            (% of Ru)                        100      100
Unloading Level            (% of Ru)                         41

max. Top Comp. Stress      =    35.9 ksi      (T=  26.5 ms, max= 1.030 x Top)
max. Comp. Stress          =    37.0 ksi      (Z=  46.3 ft, T=  29.2 ms)
max. Tens. Stress          =   -4.05 ksi      (Z=  72.7 ft, T=  63.9 ms)
max. Energy (EMX)          =   369.0 kip-ft;  max. Measured Top Displ. (DMX)= 1.29 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	5305.0	-300.6	35.9	-2.04	369.05	19.4	1.304
2	6.6	5305.7	-307.7	35.9	-2.08	367.47	19.4	1.286
5	16.5	5308.8	-358.5	35.9	-2.43	362.51	19.3	1.231
8	26.4	5317.3	-449.8	36.0	-3.05	357.19	19.2	1.174
11	36.3	5350.5	-501.0	36.2	-3.39	352.21	19.1	1.119
14	46.3	5462.4	-562.7	37.0	-3.81	346.80	18.7	1.061
17	56.2	5297.4	-569.0	35.9	-3.85	324.01	18.2	1.001
20	66.1	5309.2	-585.2	35.9	-3.96	308.96	17.5	0.940
23	76.0	5114.2	-567.9	34.6	-3.84	278.67	16.5	0.876
26	85.9	4975.5	-541.8	33.7	-3.67	252.84	15.5	0.812
29	95.8	4458.6	-470.3	30.2	-3.18	213.14	14.6	0.752
32	105.7	4357.2	-465.3	29.5	-3.15	193.61	13.9	0.689
35	115.6	3999.2	-409.0	27.1	-2.77	164.14	13.0	0.625
38	125.5	3944.5	-420.7	26.7	-2.85	147.65	12.2	0.563
41	135.4	3574.1	-340.7	24.2	-2.31	121.41	11.2	0.502
44	145.4	3538.3	-332.1	24.0	-2.25	106.03	10.2	0.442
47	155.3	3157.1	-235.8	21.4	-1.60	82.41	9.1	0.383
50	165.2	3127.1	-180.0	21.2	-1.22	68.35	7.8	0.330
53	175.1	2237.7	-18.8	15.2	-0.13	45.48	6.7	0.282
54	178.4	2341.4	-23.6	15.9	-0.16	44.45	6.7	0.268
55	181.7	1734.4	0.0	11.7	0.00	30.92	6.6	0.256
56	185.0	1811.6	0.0	12.3	0.00	16.77	6.3	0.243
Absolute	46.3			37.0			(T =	29.2 ms)
	72.7				-4.05		(T =	63.9 ms)

```
                                  CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        6619.7  6223.7  5827.6  5431.5  5035.4  4639.4  4243.3  3847.2  3451.2  3055.1
RX        6619.7  6223.7  5827.6  5431.5  5035.4  4639.4  4243.3  3847.2  3451.2  3055.1
RU        7201.5  6863.6  6525.7  6187.9  5850.0  5512.1  5174.2  4836.3  4498.4  4160.5

RAU =    404.4 (kips);  RA2 =   2363.9 (kips)

Current CAPWAP Ru = 3420.0 (kips); Corresponding J(RP)= 0.81; J(RX) = 0.81

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    19.52    26.27   5233.9   5346.6   5354.8    1.290    0.062    0.062    371.3   6590.2


                            PILE PROFILE AND PILE MODEL
             Depth            Area        E-Modulus    Spec. Weight           Perim.
                ft             in²              ksi          lb/ft³               ft

              0.00          147.65          31043.9         492.000           12.566
            185.00          147.65          31043.9         492.000           12.566

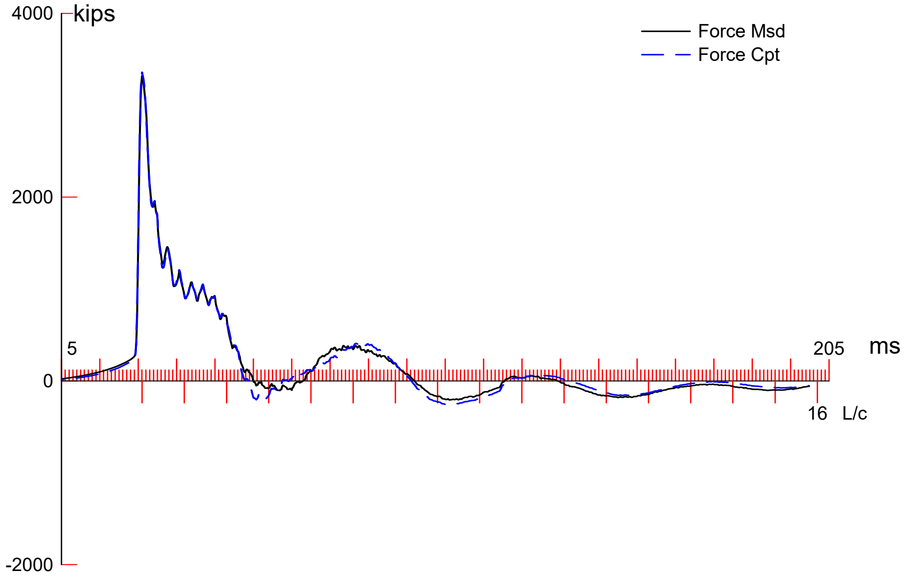
Toe Area                    12.566      ft²

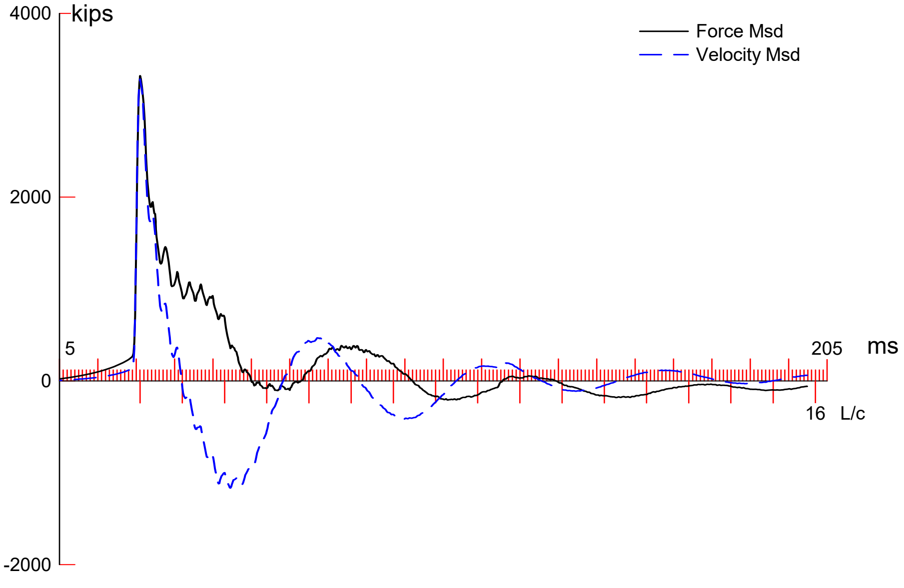
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

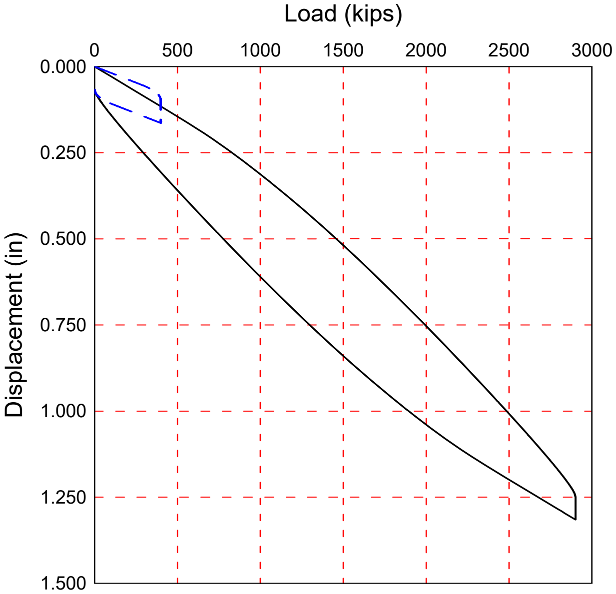
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 3 Restirke; PP48x1.0", APE D180-42; Blow: 12 (Test: 16-Jun-2016 12:21:)
Robert Miner Dynamic Testing, Inc.

16-Jun-2016
CAPWAP(R) 2006-3

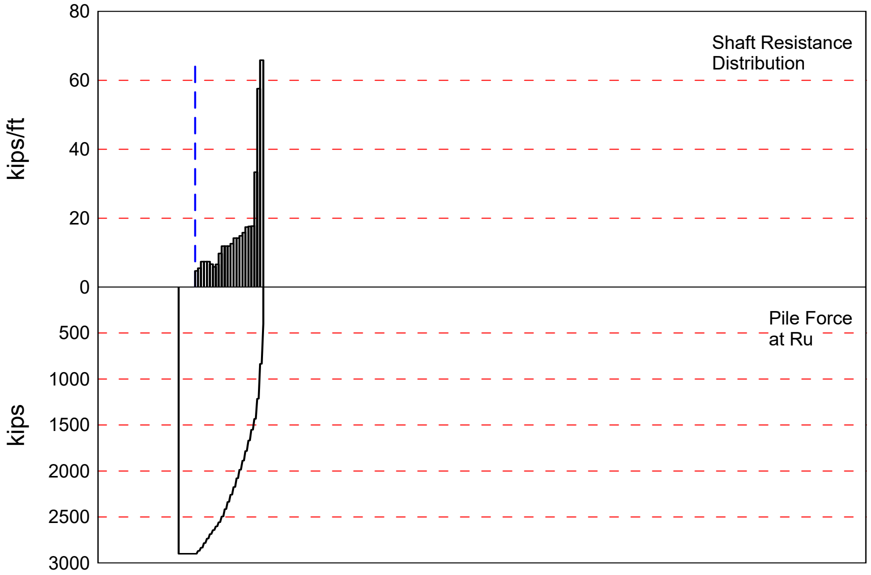






Pile Top
Bottom

Ru = 2900.6 kips
Rs = 2500.6 kips
Rb = 400.0 kips
Dy = 1.25 in
Dx = 1.32 in



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KIWC, POA TPP; Pile: IP 3 Restirke                          Test: 16-Jun-2016 12:21:
PP48x1.0'', APE D180-42; Blow: 12                                  CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                          OP: RMDT
------------------------------------------------------------------------------------
                                CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   2900.6; along Shaft   2500.6; at Toe    400.0  kips
------------------------------------------------------------------------------------
  Soil    Dist.   Depth       Ru     Force       Sum      Unit      Unit    Smith     Quake
 Sgmnt    Below   Below            in Pile        of   Resist.   Resist.  Damping
   No.   Gages    Grade                           Ru   (Depth)    (Area)   Factor
             ft      ft     kips      kips      kips   kips/ft       ksf     s/ft        in
------------------------------------------------------------------------------------
                                    2900.6
     1     42.9     3.9     31.2    2869.4      31.2      8.05      0.64    0.180     0.100
     2     49.5    10.5     36.5    2832.9      67.7      5.53      0.44    0.180     0.100
     3     56.1    17.1     49.1    2783.8     116.8      7.44      0.59    0.180     0.100
     4     62.7    23.7     49.1    2734.7     165.9      7.44      0.59    0.180     0.100
     5     69.3    30.3     49.1    2685.6     215.0      7.44      0.59    0.180     0.100
     6     75.9    36.9     44.2    2641.4     259.2      6.70      0.53    0.180     0.100
     7     82.5    43.5     39.2    2602.2     298.4      5.94      0.47    0.180     0.100
     8     89.1    50.1     43.9    2558.3     342.3      6.66      0.53    0.180     0.100
     9     95.6    56.6     64.8    2493.5     407.1      9.82      0.78    0.180     0.100
    10    102.2    63.2     78.7    2414.8     485.8     11.93      0.95    0.180     0.100
    11    108.8    69.8     78.7    2336.1     564.5     11.93      0.95    0.180     0.100
    12    115.4    76.4     78.7    2257.4     643.2     11.93      0.95    0.180     0.100
    13    122.0    83.0     83.5    2173.9     726.7     12.66      1.01    0.180     0.100
    14    128.6    89.6     94.0    2079.9     820.7     14.25      1.13    0.180     0.100
    15    135.2    96.2     94.0    1985.9     914.7     14.25      1.13    0.180     0.100
    16    141.8   102.8     98.4    1887.5    1013.1     14.92      1.19    0.180     0.100
    17    148.4   109.4    104.6    1782.9    1117.7     15.86      1.26    0.180     0.100
    18    155.0   116.0    115.2    1667.7    1232.9     17.46      1.39    0.180     0.100
    19    161.6   122.6    116.3    1551.4    1349.2     17.63      1.40    0.180     0.095
    20    168.2   129.2    117.2    1434.2    1466.4     17.77      1.41    0.180     0.090
    21    174.8   135.8    220.0    1214.2    1686.4     33.35      2.65    0.180     0.085
    22    181.4   142.4    379.9     834.3    2066.3     57.59      4.58    0.180     0.080
    23    188.0   149.0    434.3     400.0    2500.6     65.84      5.24    0.180     0.075

 Avg. Shaft                108.7                         16.78      1.34    0.180     0.091

      Toe                  400.0                                   31.83    0.120     0.075

Soil Model Parameters/Extensions                             Shaft      Toe
------------------------------------------------------------------------------------
Case Damping Factor                                          1.679    0.179
Reloading Level           (% of Ru)                            100      100
Unloading Level           (% of Ru)                             45
Soil Plug Weight          (kips)                                       0.70

max. Top Comp. Stress     =    22.8 ksi      (T=  26.4 ms, max= 1.032 x Top)
max. Comp. Stress         =    23.5 ksi      (Z=  42.9 ft, T=  28.7 ms)
max. Tens. Stress         =   -2.62 ksi      (Z=  42.9 ft, T=  58.4 ms)
max. Energy (EMX)         =   135.9 kip-ft;  max. Measured Top Displ. (DMX)= 0.77 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	3363.3	-262.6	22.8	-1.78	135.91	12.1	0.779
2	6.6	3365.9	-271.2	22.8	-1.84	135.49	12.1	0.770
5	16.5	3374.0	-304.4	22.8	-2.06	134.04	12.0	0.740
8	26.4	3383.3	-325.2	22.9	-2.20	132.31	12.0	0.708
11	36.3	3419.5	-350.1	23.2	-2.37	130.29	11.8	0.672
14	46.2	3404.7	-372.6	23.1	-2.52	124.48	11.5	0.636
17	56.1	3390.0	-351.2	23.0	-2.38	118.50	11.2	0.601
20	66.0	3197.0	-323.2	21.6	-2.19	106.45	10.8	0.565
23	75.9	3139.6	-317.8	21.3	-2.15	99.65	10.4	0.528
26	85.8	2995.0	-295.1	20.3	-2.00	90.16	10.1	0.491
29	95.6	3005.0	-325.0	20.3	-2.20	84.28	9.6	0.452
32	105.5	2769.0	-268.1	18.7	-1.81	71.90	9.1	0.412
35	115.4	2710.2	-271.8	18.4	-1.84	64.44	8.5	0.372
38	125.3	2466.7	-215.5	16.7	-1.46	53.77	8.0	0.336
41	135.2	2401.0	-189.7	16.3	-1.28	47.28	7.4	0.299
44	145.1	2135.0	-140.0	14.5	-0.95	37.92	6.9	0.265
47	155.0	2082.2	-109.1	14.1	-0.74	32.65	6.3	0.231
50	164.9	1841.1	-29.8	12.5	-0.20	24.63	5.8	0.196
53	174.8	1895.0	-13.2	12.8	-0.09	20.34	4.9	0.162
56	184.7	1086.2	0.0	7.4	0.00	10.19	5.1	0.134
57	188.0	1170.5	0.0	7.9	0.00	4.62	5.0	0.128
Absolute	42.9			23.5			(T =	28.7 ms)
	42.9				-2.62		(T =	58.4 ms)

```
                                     CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        4163.4  3914.4  3665.5  3416.5  3167.6  2918.6  2669.7  2420.8  2171.8  1922.9
RX        4163.4  3914.4  3665.5  3416.5  3167.6  2918.6  2669.7  2420.8  2171.8  1922.9
RU        4667.2  4468.7  4270.1  4071.5  3873.0  3674.4  3475.9  3277.3  3078.8  2880.2

RAU =      0.0 (kips);  RA2 =   1641.5 (kips)

Current CAPWAP Ru = 2900.6 (kips); Corresponding J(RP)= 0.51; J(RX) = 0.51

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    12.37    26.23   3315.7   3337.1   3344.1    0.773    0.067    0.067    136.5   3900.1


                             PILE PROFILE AND PILE MODEL
             Depth             Area        E-Modulus    Spec. Weight              Perim.
                ft              in²              ksi          lb/ft³                  ft

              0.00           147.65          31043.9         492.000              12.566
            188.00           147.65          31043.9         492.000              12.566

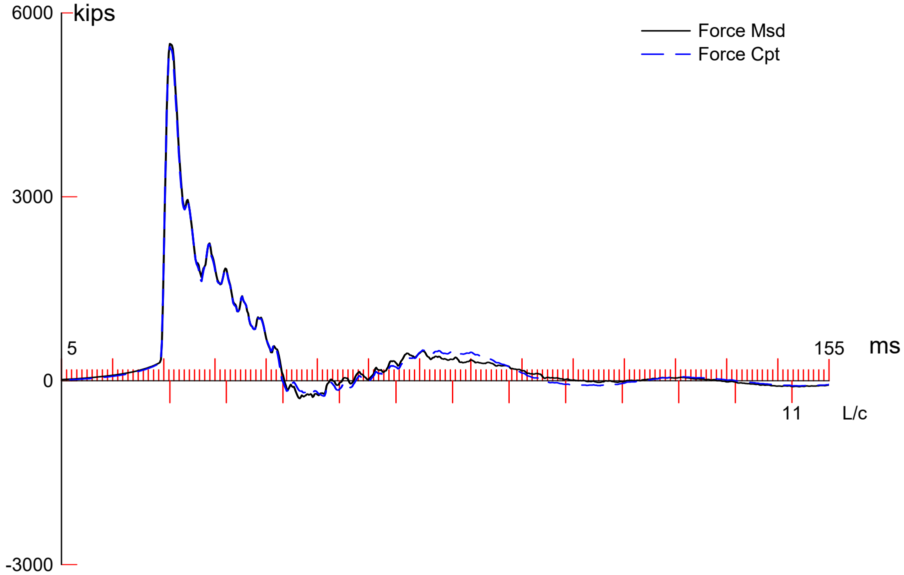
Toe Area                     12.566       ft²

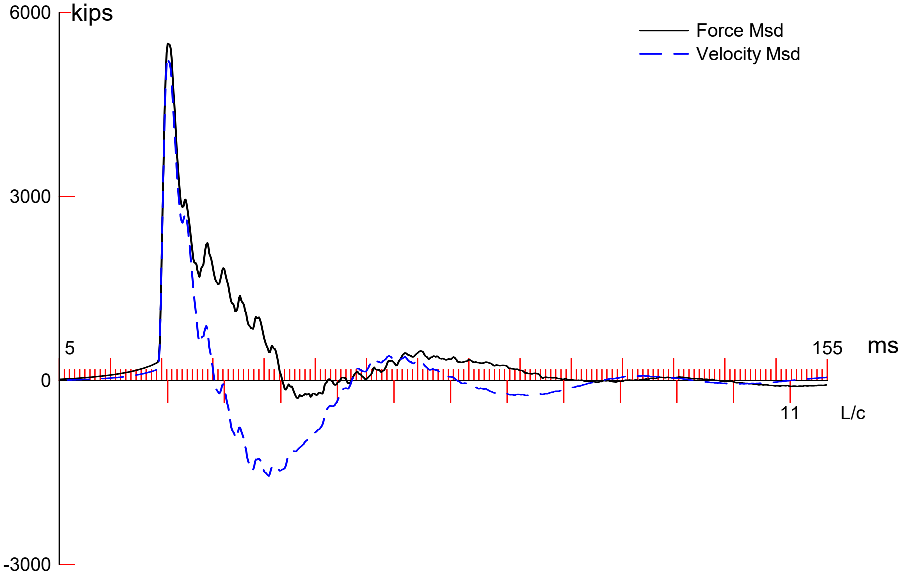
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

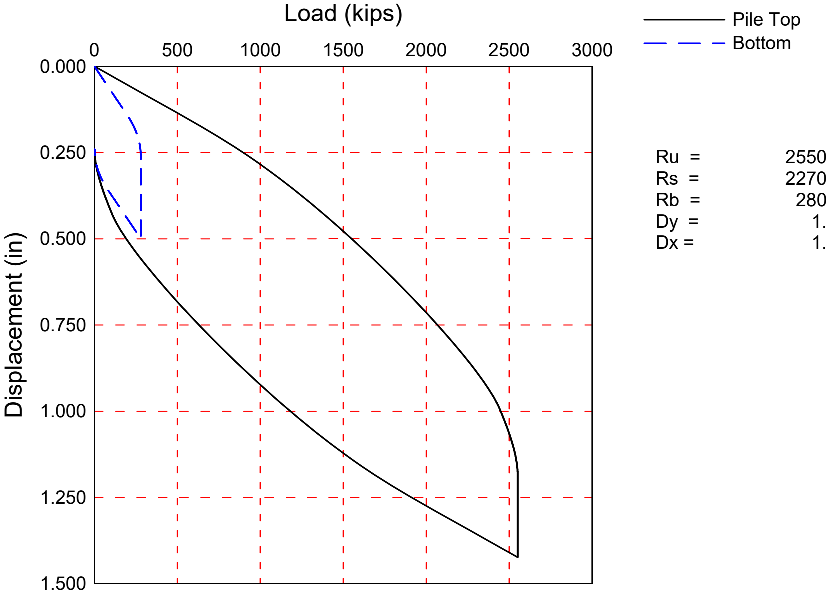
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  22.0 ms
```

KIWC, POA TPP; Pile: IP 4 RESTRIKE; PP48x1.0", APE D180-42; Blow: 5 (Test: 15-Jun-2016 11:07:)
Robert Miner Dynamic Testing, Inc.

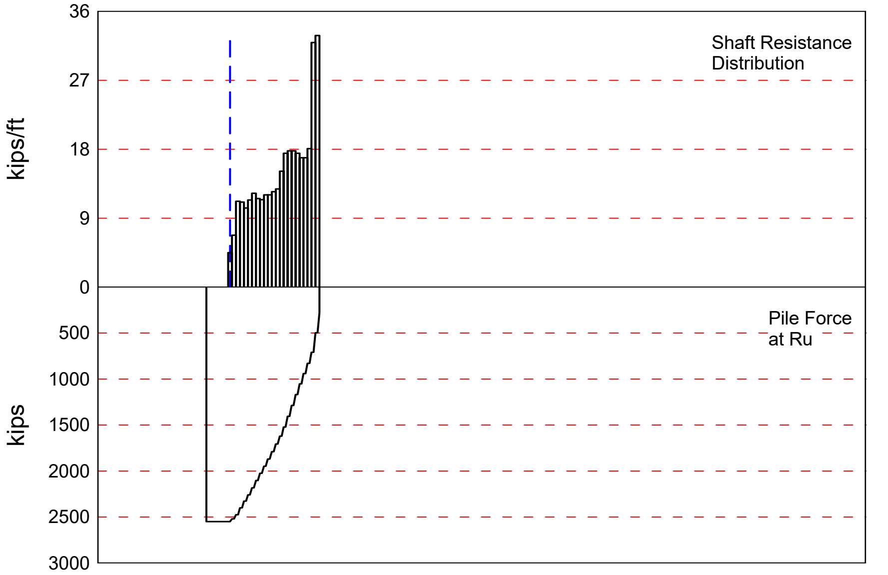
15-Jun-2016
CAPWAP(R) 2006-3







Ru = 2550.8 kips
Rs = 2270.8 kips
Rb = 280.0 kips
Dy = 1.18 in
Dx = 1.42 in



```
KIWC, POA TPP; Pile: IP 4 RESTRIKE                             Test: 15-Jun-2016 11:07:
PP48x1.0'', APE D180-42; Blow: 5                                      CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                             OP: RMDT
                               CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   2550.8; along Shaft   2270.8; at Toe    280.0  kips
   Soil    Dist.    Depth       Ru     Force       Sum      Unit      Unit     Smith
  Sgmnt    Below    Below            in Pile        of   Resist.   Resist.   Damping
    No.    Gages    Grade                           Ru   (Depth)    (Area)    Factor
              ft       ft     kips      kips      kips   kips/ft       ksf      s/ft

                                      2550.8
      1     43.1      3.1     30.0    2520.8      30.0      9.53      0.76     0.210
      2     49.7      9.8     45.0    2475.8      75.0      6.79      0.54     0.210
      3     56.4     16.4     74.4    2401.4     149.4     11.22      0.89     0.210
      4     63.0     23.0     73.8    2327.6     223.2     11.13      0.89     0.210
      5     69.6     29.7     68.6    2259.0     291.8     10.34      0.82     0.210
      6     76.3     36.3     75.5    2183.5     367.3     11.38      0.91     0.210
      7     82.9     42.9     81.3    2102.2     448.6     12.26      0.98     0.210
      8     89.5     49.6     76.8    2025.4     525.4     11.58      0.92     0.210
      9     96.2     56.2     75.8    1949.6     601.2     11.43      0.91     0.210
     10    102.8     62.8     80.0    1869.6     681.2     12.06      0.96     0.210
     11    109.4     69.5     80.0    1789.6     761.2     12.06      0.96     0.210
     12    116.1     76.1     82.7    1706.9     843.9     12.47      0.99     0.210
     13    122.7     82.7     85.0    1621.9     928.9     12.82      1.02     0.210
     14    129.3     89.4    100.4    1521.5    1029.3     15.14      1.20     0.210
     15    135.9     96.0    115.9    1405.6    1145.2     17.48      1.39     0.210
     16    142.6    102.6    118.0    1287.6    1263.2     17.79      1.42     0.210
     17    149.2    109.3    118.0    1169.6    1381.2     17.79      1.42     0.210
     18    155.8    115.9    116.0    1053.6    1497.2     17.49      1.39     0.210
     19    162.5    122.5    112.0     941.6    1609.2     16.89      1.34     0.210
     20    169.1    129.1    112.0     829.6    1721.2     16.89      1.34     0.210
     21    175.7    135.8    120.0     709.6    1841.2     18.10      1.44     0.210
     22    182.4    142.4    211.8     497.8    2053.0     31.94      2.54     0.210
     23    189.0    149.0    217.8     280.0    2270.8     32.84      2.61     0.210

  Avg. Shaft                  98.7                         15.24      1.21     0.210

       Toe                   280.0                                   22.28     0.300

Soil Model Parameters/Extensions                      Shaft     Toe

Quake                    (in)                         0.100   0.200
Case Damping Factor                                   1.778   0.313
Unloading Quake          (% of loading quake)            80     100
Reloading Level          (% of Ru)                      100     100
Unloading Level          (% of Ru)                       18
Soil Plug Weight         (kips)                                0.22

max. Top Comp. Stress    =    36.9 ksi     (T=  26.6 ms, max= 1.040 x Top)
max. Comp. Stress        =    38.4 ksi     (Z=  49.7 ft, T=  29.7 ms)
max. Tens. Stress        =   -3.75 ksi     (Z=  49.7 ft, T=  57.2 ms)
max. Energy (EMX)        =   343.2 kip-ft;  max. Measured Top Displ. (DMX)= 1.15 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	5450.4	-268.3	36.9	-1.82	343.20	19.8	1.162
2	6.6	5452.8	-291.0	36.9	-1.97	342.07	19.8	1.146
5	16.6	5460.9	-356.9	37.0	-2.42	338.27	19.8	1.098
8	26.5	5471.2	-435.6	37.0	-2.95	334.09	19.7	1.047
11	36.5	5537.6	-498.4	37.5	-3.37	329.58	19.4	0.994
14	46.4	5588.0	-542.5	37.8	-3.67	316.61	18.8	0.940
17	56.4	5611.3	-542.3	38.0	-3.67	300.09	17.9	0.883
20	66.3	5154.6	-512.5	34.9	-3.47	260.80	17.0	0.827
23	76.3	5092.4	-527.8	34.5	-3.57	241.26	16.1	0.770
26	86.2	4647.6	-467.4	31.5	-3.16	206.82	15.2	0.714
29	96.2	4556.9	-470.2	30.9	-3.18	189.03	14.4	0.659
32	106.1	4165.7	-440.5	28.2	-2.98	161.08	13.5	0.605
35	116.1	4094.6	-422.9	27.7	-2.86	147.65	12.7	0.564
38	126.0	3756.7	-383.7	25.4	-2.60	126.25	11.8	0.531
41	135.9	3683.1	-364.8	24.9	-2.47	114.19	10.8	0.498
44	145.9	3201.4	-292.5	21.7	-1.98	91.84	9.9	0.467
47	155.8	3074.0	-274.0	20.8	-1.86	81.47	9.0	0.442
50	165.8	2673.5	-198.3	18.1	-1.34	64.18	8.2	0.419
53	175.7	2484.8	-171.1	16.8	-1.16	55.96	8.0	0.396
56	185.7	1416.8	-56.9	9.6	-0.39	34.74	8.5	0.381
57	189.0	1462.2	-58.7	9.9	-0.40	21.28	8.4	0.376
Absolute	49.7			38.4			(T =	29.7 ms)
	49.7				-3.75		(T =	57.2 ms)

```
                                      CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        6183.0  5716.4  5249.8  4783.2  4316.6  3850.0  3383.5  2916.9  2450.3  1983.7
RX        6183.0  5716.4  5249.8  4783.2  4316.6  3850.0  3383.5  2916.9  2450.3  1983.7
RU        7106.0  6731.8  6357.5  5983.2  5608.9  5234.7  4860.4  4486.1  4111.8  3737.6

RAU =      0.0 (kips);  RA2 =   1613.5 (kips)

Current CAPWAP Ru = 2550.8 (kips); Corresponding J(RP)= 0.78; J(RX) = 0.78

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    19.82    26.37   5314.6   5534.1   5534.1    1.148    0.240    0.240    344.1   5950.4

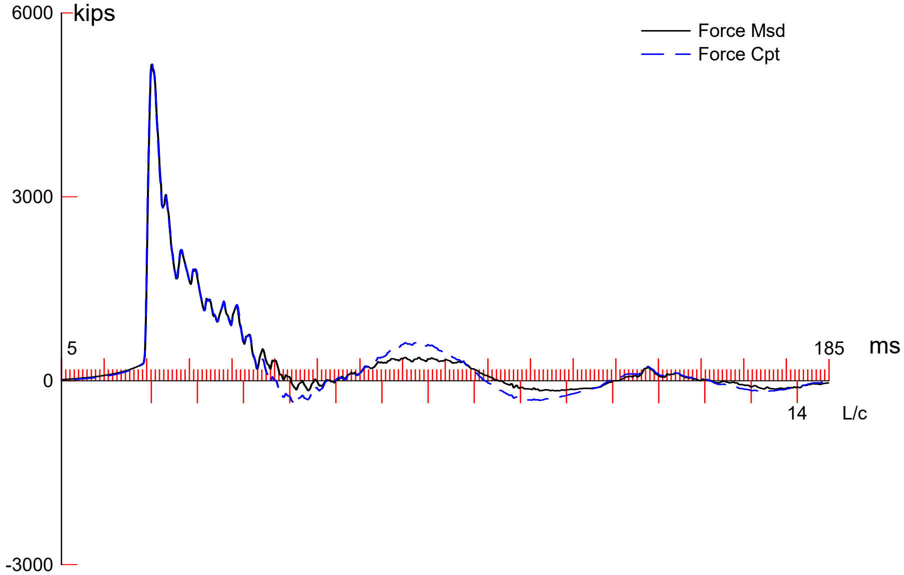

                               PILE PROFILE AND PILE MODEL
             Depth              Area         E-Modulus      Spec. Weight            Perim.
                ft               in²               ksi             lb/ft³               ft

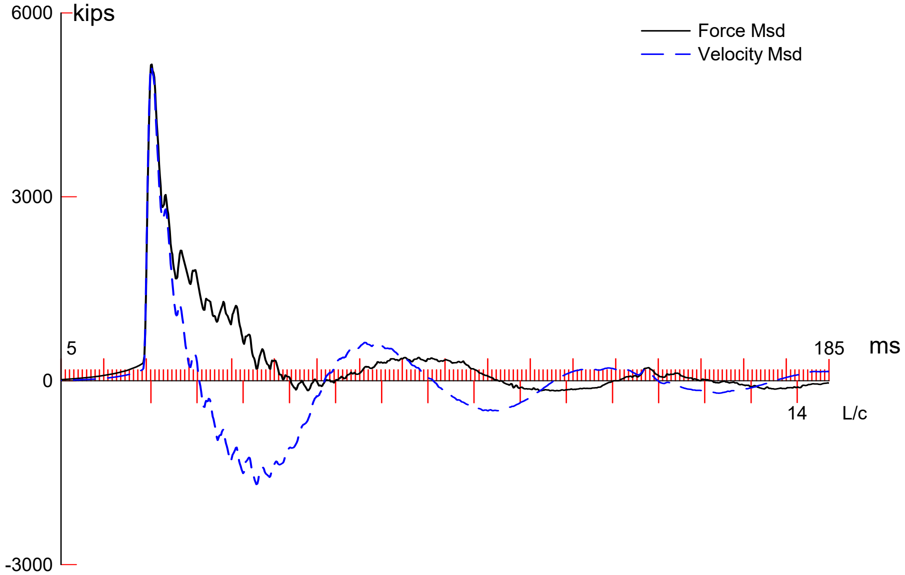
              0.00            147.65           31043.9           492.000            12.566
            189.00            147.65           31043.9           492.000            12.566

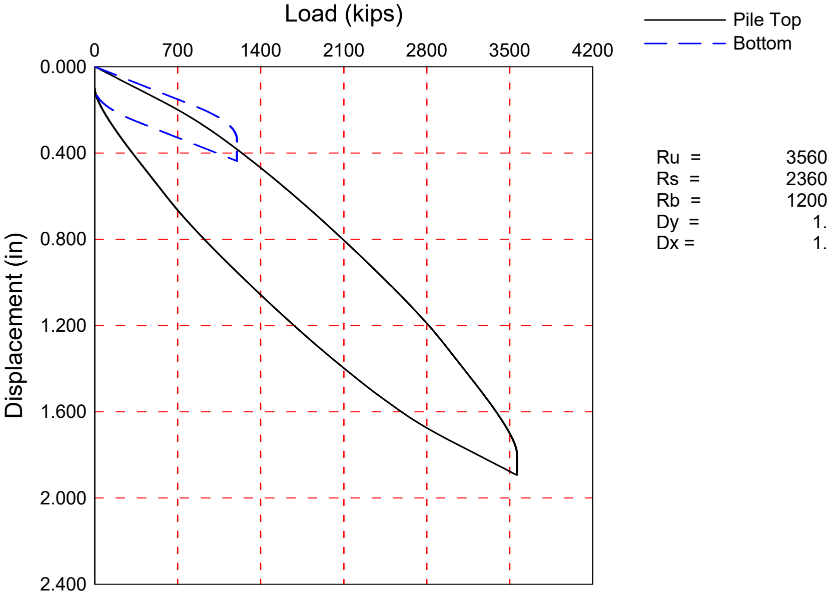
Toe Area                      12.566       ft²

Top Segment Length      3.32 ft, Top Impedance   268.13 kips/ft/s

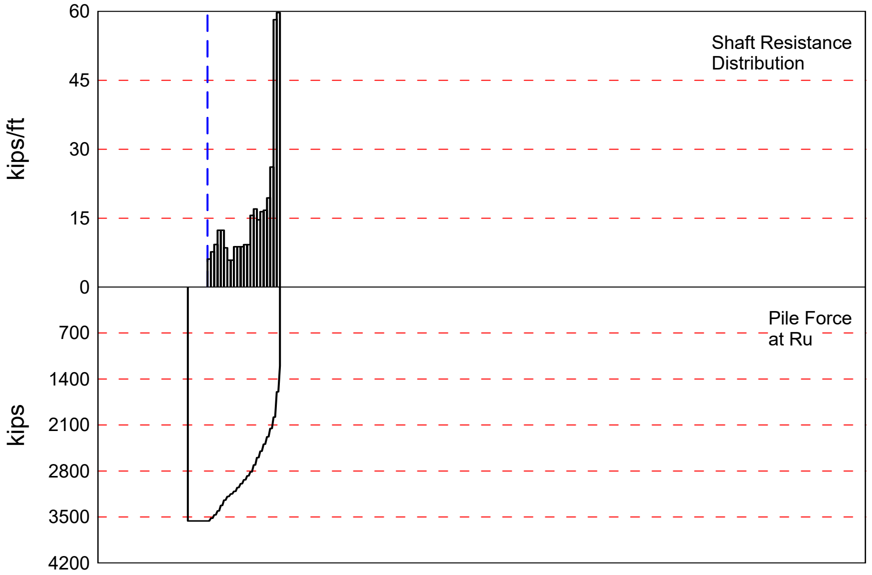
Pile Damping    1.0 %, Time Incr  0.194 ms, Wave Speed  17100.0 ft/s, 2L/c  22.1 ms
```







Ru = 3560.5 kips
Rs = 2360.5 kips
Rb = 1200.0 kips
Dy = 1.79 in
Dx = 1.89 in



```
KIWC, POA TPP; Pile: IP 5 RESTRIKE                             Test: 09-Jun-2016 16:08:
PP48x1.0'', APE D180-42; Blow: 7                                      CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                             OP: RMDT
---------------------------------------------------------------------------------------
                               CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   3560.5; along Shaft   2360.5; at Toe   1200.0  kips
---------------------------------------------------------------------------------------
   Soil     Dist.    Depth       Ru      Force       Sum      Unit      Unit     Smith
  Sgmnt     Below    Below             in Pile        of    Resist.   Resist.   Damping
    No.     Gages    Grade                            Ru    (Depth)    (Area)    Factor
               ft       ft     kips       kips      kips    kips/ft       ksf      s/ft
---------------------------------------------------------------------------------------
                                        3560.5
      1      46.3      5.3     40.6     3519.9      40.6       7.70      0.61     0.190
      2      52.9     11.9     50.9     3469.0      91.5       7.70      0.61     0.190
      3      59.5     18.5     61.5     3407.5     153.0       9.31      0.74     0.190
      4      66.1     25.1     81.9     3325.6     234.9      12.40      0.99     0.190
      5      72.7     31.7     81.9     3243.7     316.8      12.40      0.99     0.190
      6      79.3     38.3     56.7     3187.0     373.5       8.58      0.68     0.190
      7      85.9     44.9     38.8     3148.2     412.3       5.87      0.47     0.190
      8      92.5     51.5     38.8     3109.4     451.1       5.87      0.47     0.190
      9      99.1     58.1     58.2     3051.2     509.3       8.81      0.70     0.190
     10     105.7     64.7     58.2     2993.0     567.5       8.81      0.70     0.190
     11     112.3     71.3     58.2     2934.8     625.7       8.81      0.70     0.190
     12     118.9     77.9     61.3     2873.5     687.0       9.28      0.74     0.190
     13     125.5     84.6     61.3     2812.2     748.3       9.28      0.74     0.190
     14     132.1     91.2    103.2     2709.0     851.5      15.62      1.24     0.190
     15     138.8     97.8    112.5     2596.5     964.0      17.03      1.35     0.190
     16     145.4    104.4     96.9     2499.6    1060.9      14.67      1.17     0.190
     17     152.0    111.0    108.7     2390.9    1169.6      16.45      1.31     0.190
     18     158.6    117.6    110.6     2280.3    1280.2      16.74      1.33     0.190
     19     165.2    124.2    128.4     2151.9    1408.6      19.43      1.55     0.190
     20     171.8    130.8    172.8     1979.1    1581.4      26.15      2.08     0.190
     21     178.4    137.4    384.6     1594.5    1966.0      58.21      4.63     0.190
     22     185.0    144.0    394.5     1200.0    2360.5      59.71      4.75     0.190

  Avg. Shaft                  107.3                           16.39      1.30     0.190

       Toe                   1200.0                                     95.49     0.080
Soil Model Parameters/Extensions                           Shaft       Toe
---------------------------------------------------------------------------------------
Quake                     (in)                             0.100     0.260
Case Damping Factor                                        1.673     0.358
Reloading Level           (% of Ru)                          100       100
Unloading Level           (% of Ru)                           60
Soil Plug Weight          (kips)                                      1.00

max. Top Comp. Stress      =    35.2 ksi      (T=  26.5 ms, max= 1.040 x Top)
max. Comp. Stress          =    36.6 ksi      (Z=  46.3 ft, T=  29.2 ms)
max. Tens. Stress          =   -4.04 ksi      (Z=  46.3 ft, T=  62.6 ms)
max. Energy (EMX)          =   327.7 kip-ft;  max. Measured Top Displ. (DMX)= 1.19 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	5199.9	-392.5	35.2	-2.66	327.66	19.0	1.186
2	6.6	5201.1	-418.3	35.2	-2.83	326.79	18.9	1.173
5	16.5	5205.7	-482.7	35.2	-3.27	323.97	18.9	1.132
8	26.4	5217.8	-506.9	35.3	-3.43	320.92	18.8	1.088
11	36.3	5262.6	-552.8	35.6	-3.74	317.43	18.7	1.042
14	46.3	5408.0	-596.1	36.6	-4.04	313.17	18.1	0.991
17	56.2	5200.6	-529.2	35.2	-3.58	286.78	17.4	0.938
20	66.1	5164.1	-540.0	35.0	-3.66	269.15	16.5	0.888
23	76.0	4662.4	-422.5	31.6	-2.86	231.88	15.9	0.840
26	85.9	4550.0	-422.6	30.8	-2.86	217.14	15.5	0.790
29	95.8	4398.8	-426.0	29.8	-2.88	199.27	14.9	0.739
32	105.7	4329.5	-400.7	29.3	-2.71	185.05	14.3	0.684
35	115.6	4063.8	-371.4	27.5	-2.51	162.53	13.7	0.624
38	125.5	4054.4	-362.8	27.5	-2.46	149.86	13.0	0.570
41	135.4	3750.8	-259.7	25.4	-1.76	126.76	12.0	0.514
44	145.4	3622.9	-229.4	24.5	-1.55	112.05	11.2	0.465
47	155.3	3258.7	-100.3	22.1	-0.68	91.35	10.3	0.416
50	165.2	3324.9	-59.0	22.5	-0.40	79.48	9.2	0.364
53	175.1	2816.3	0.0	19.1	0.00	59.01	7.8	0.313
54	178.4	2788.1	0.0	18.9	0.00	57.85	7.9	0.298
55	181.7	1995.7	0.0	13.5	0.00	40.76	8.0	0.285
56	185.0	2119.3	0.0	14.3	0.00	25.40	7.9	0.272
Absolute	46.3			36.6			(T =	29.2 ms)
	46.3				-4.04		(T =	62.6 ms)

```
                                     CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        6248.4  5831.9  5415.4  4998.8  4582.3  4165.8  3749.2  3332.7  2916.2  2499.6
RX        6248.4  5831.9  5415.4  4998.8  4582.3  4165.8  3749.2  3332.7  2916.2  2499.6
RU        6905.0  6554.2  6203.3  5852.4  5501.6  5150.7  4799.8  4449.0  4098.1  3747.2

RAU =    924.1 (kips);  RA2 =   2292.7 (kips)

Current CAPWAP Ru = 3560.5 (kips); Corresponding J(RP)= 0.65; J(RX) = 0.65

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   19.34    26.27   5184.9   5228.8   5228.8    1.192    0.102    0.100    329.3   6116.0


                               PILE PROFILE AND PILE MODEL
             Depth             Area        E-Modulus     Spec. Weight            Perim.
                ft              in²              ksi            lb/ft³               ft

              0.00           147.65          31043.9          492.000            12.566
            185.00           147.65          31043.9          492.000            12.566

Toe Area                     12.566      ft²

Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
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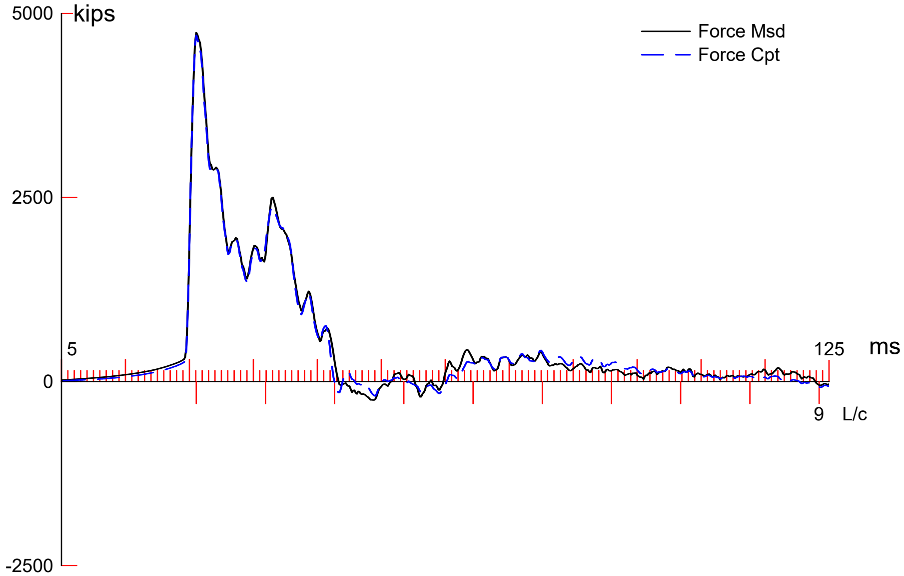
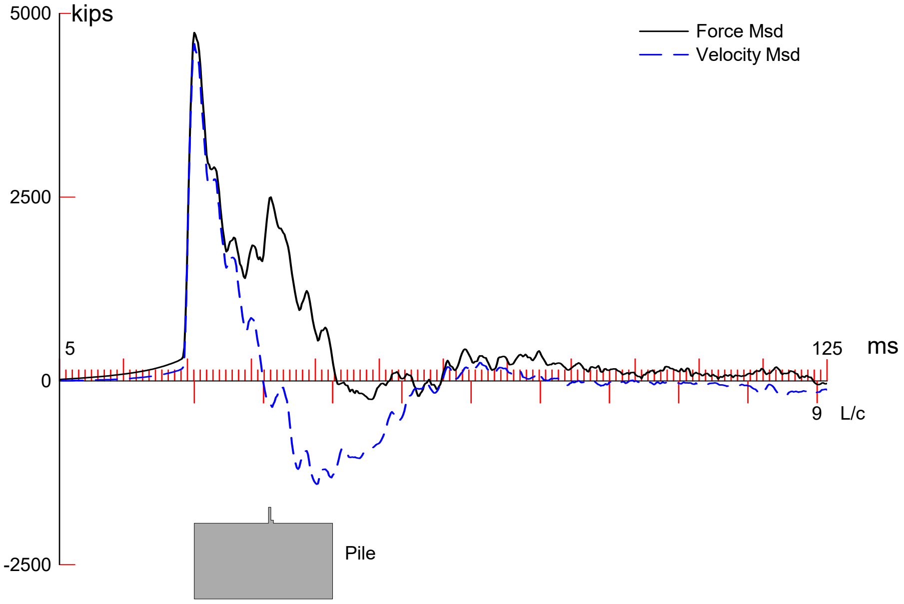
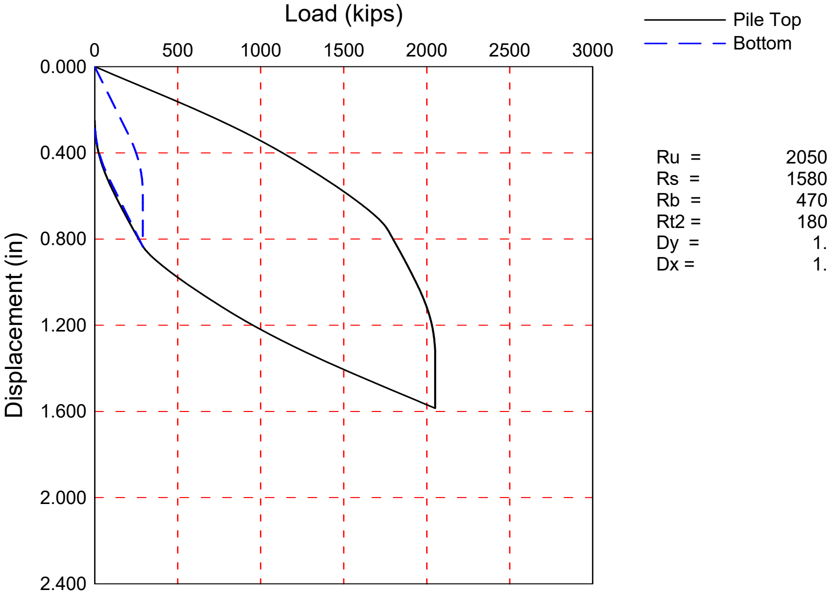
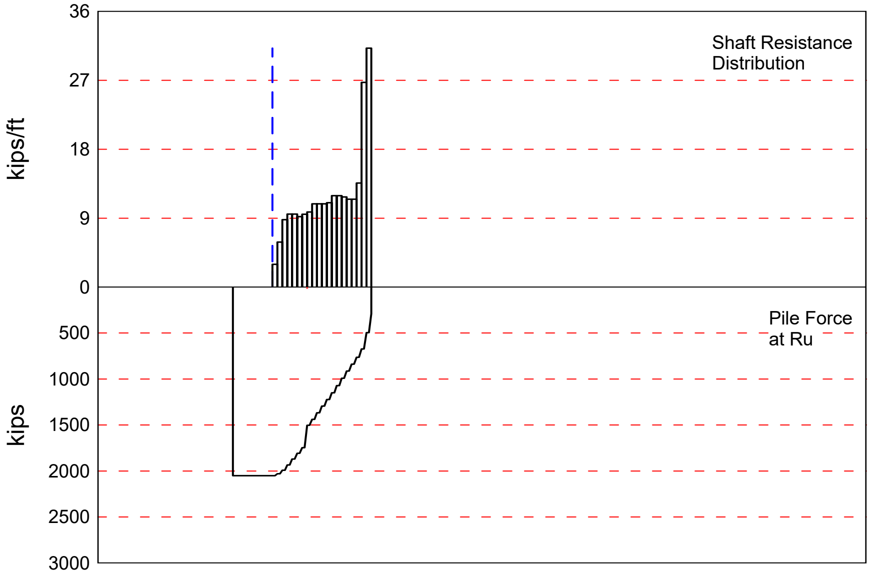






Ru = 2050.4 kips
Rs = 1580.4 kips
Rb = 470.0 kips
Rt2 = 180.0 kips
Dy = 1.34 in
Dx = 1.59 in



```
KIWC, POA TPP; Pile: IP 6 RESTRIKE                          Test: 21-Jun-2016 13:47:
PP48x1.0'', APE D180-42; Blow: 3                                   CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                          OP: RMDT
----------------------------------------------------------------------------------------
                               CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   2050.4; along Shaft   1580.4; at Toe    470.0  kips
----------------------------------------------------------------------------------------
  Soil    Dist.   Depth      Ru    Force      Sum     Unit     Unit    Smith     Quake
 Sgmnt    Below   Below           in Pile      of  Resist.  Resist.  Damping
   No.    Gages   Grade                        Ru  (Depth)   (Area)   Factor
             ft      ft    kips     kips     kips  kips/ft      ksf     s/ft        in
----------------------------------------------------------------------------------------
                                  2050.4
     1     59.5     3.5    19.8   2030.6     19.8     5.61     0.45    0.200     0.100
     2     66.1    10.1    38.9   1991.7     58.7     5.89     0.47    0.200     0.100
     3     72.7    16.7    58.2   1933.5    116.9     8.81     0.70    0.200     0.100
     4     79.3    23.3    63.1   1870.4    180.0     9.55     0.76    0.200     0.100
     5     85.9    30.0    63.1   1807.3    243.1     9.55     0.76    0.200     0.100
     6     92.5    36.6    60.8   1746.5    303.9     9.20     0.73    0.200     0.100
     7     99.1    43.2    62.9   1683.6    366.8     9.52     0.76    0.200     0.100
   2nd      Toe           180.0                                         0.642     0.550
     8    105.7    49.8    64.9   1438.7    611.7     9.82     0.78    0.200     0.100
     9    112.3    56.4    71.9   1366.8    683.6    10.88     0.87    0.200     0.100
    10    118.9    63.0    71.9   1294.9    755.5    10.88     0.87    0.200     0.100
    11    125.5    69.6    71.9   1223.0    827.4    10.88     0.87    0.200     0.100
    12    132.1    76.2    72.9   1150.1    900.3    11.03     0.88    0.200     0.100
    13    138.8    82.8    78.9   1071.2    979.2    11.94     0.95    0.200     0.100
    14    145.4    89.4    78.9    992.3   1058.1    11.94     0.95    0.200     0.100
    15    152.0    96.0    77.9    914.4   1136.0    11.79     0.94    0.200     0.100
    16    158.6   102.6    75.9    838.5   1211.9    11.49     0.91    0.200     0.100
    17    165.2   109.2    75.9    762.6   1287.8    11.49     0.91    0.200     0.100
    18    171.8   115.8    89.9    672.7   1377.7    13.61     1.08    0.200     0.100
    19    178.4   122.5   176.6    496.1   1554.3    26.73     2.13    0.200     0.100
    20    185.0   129.1   206.1    290.0   1760.4    31.19     2.48    0.200     0.100

 Avg. Shaft                79.0                       12.25     0.97    0.200     0.100

      Toe                 290.0                                23.08    0.060     0.450

Soil Model Parameters/Extensions                         Shaft      Toe
----------------------------------------------------------------------------------------
Case Damping Factor                                      1.179    0.065
Unloading Quake           (% of loading quake)              50       75
Reloading Level           (% of Ru)                        100      100
Unloading Level           (% of Ru)                         10
Soil Support Dashpot                                     1.100    0.000
Soil Support Weight       (kips)                          8.67     0.00

max. Top Comp. Stress      =    31.9 ksi      (T=  26.5 ms, max= 1.074 x Top)
max. Comp. Stress          =    34.2 ksi      (Z=  92.5 ft, T=  32.3 ms)
max. Tens. Stress          =   -4.21 ksi      (Z=  99.1 ft, T=  59.7 ms)
max. Energy (EMX)          =   286.3 kip-ft;  max. Measured Top Displ. (DMX)= 1.16 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	4704.8	-205.9	31.9	-1.39	286.28	17.2	1.183
2	6.6	4705.9	-240.5	31.9	-1.63	284.75	17.2	1.165
5	16.5	4709.6	-258.5	31.9	-1.75	278.74	17.2	1.104
8	26.4	4714.5	-356.8	31.9	-2.42	271.88	17.1	1.039
11	36.3	4721.0	-373.1	32.0	-2.53	266.47	17.1	0.981
14	46.3	4730.3	-514.7	32.0	-3.48	260.93	17.0	0.922
17	56.2	4788.7	-558.0	32.4	-3.78	260.09	16.7	0.868
20	66.1	4838.9	-588.5	32.8	-3.98	255.28	16.2	0.844
23	76.0	4626.8	-562.9	31.3	-3.81	235.30	15.5	0.815
26	85.9	4897.8	-552.8	33.2	-3.74	223.69	14.8	0.783
29	95.8	4939.8	-614.1	33.4	-4.16	203.83	11.9	0.754
32	105.7	3486.8	-470.2	22.7	-3.06	141.25	11.3	0.727
35	115.6	3223.4	-409.3	21.8	-2.77	123.35	10.7	0.701
38	125.5	3154.3	-353.7	21.4	-2.39	114.52	10.1	0.676
41	135.4	2897.4	-274.6	19.6	-1.86	97.94	9.6	0.651
44	145.4	2824.0	-256.6	19.1	-1.74	89.42	9.0	0.629
47	155.3	2553.2	-153.9	17.3	-1.04	73.16	8.5	0.609
50	165.2	2519.3	-104.3	17.1	-0.71	65.41	8.0	0.593
53	175.1	2025.7	-29.6	13.7	-0.20	49.25	10.3	0.581
54	178.4	1719.5	-33.0	11.6	-0.22	49.19	10.6	0.577
55	181.7	986.3	0.0	6.7	0.00	32.80	10.8	0.574
56	185.0	872.6	0.0	5.9	0.00	13.88	10.8	0.571
Absolute	92.5			34.2			(T =	32.3 ms)
	99.1				-4.21		(T =	59.7 ms)

```
                                 CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        5431.5  5033.8  4636.2  4238.5  3840.8  3443.2  3045.5  2647.8  2250.2  1852.5
RX        5431.5  5033.8  4636.2  4238.5  3840.8  3443.2  3045.5  2647.8  2250.2  1852.5
RU        6392.7  6091.1  5789.5  5488.0  5186.4  4884.9  4583.3  4281.8  3980.2  3678.6

RAU =     74.2 (kips);  RA2 =   1364.4 (kips)

Current CAPWAP Ru = 2050.4 (kips); Corresponding J(RP)= 0.85; J(RX) = 0.85

     VMX       TVP     VT1*Z       FT1       FMX       DMX       DFN       SET       EMX       QUS
    ft/s        ms      kips      kips      kips        in        in        in    kip-ft      kips
   17.32     26.27    4643.5    4764.7    4764.7     1.156     0.250     0.250     287.5    4905.4


                         PILE PROFILE AND PILE MODEL
             Depth                Area           E-Modulus        Spec. Weight             Perim.
                ft                 in²                 ksi              lb/ft³                 ft

              0.00              147.65             31043.9             492.000             12.566
            102.00              147.65             31043.9             492.000             12.566
            102.00              400.00             31043.9             492.000             12.566
            102.49              400.00             31043.9             492.000             12.566
            102.49              147.65             31043.9             492.000             12.566
            185.00              147.65             31043.9             492.000             12.566

Toe Area                        12.566      ft²

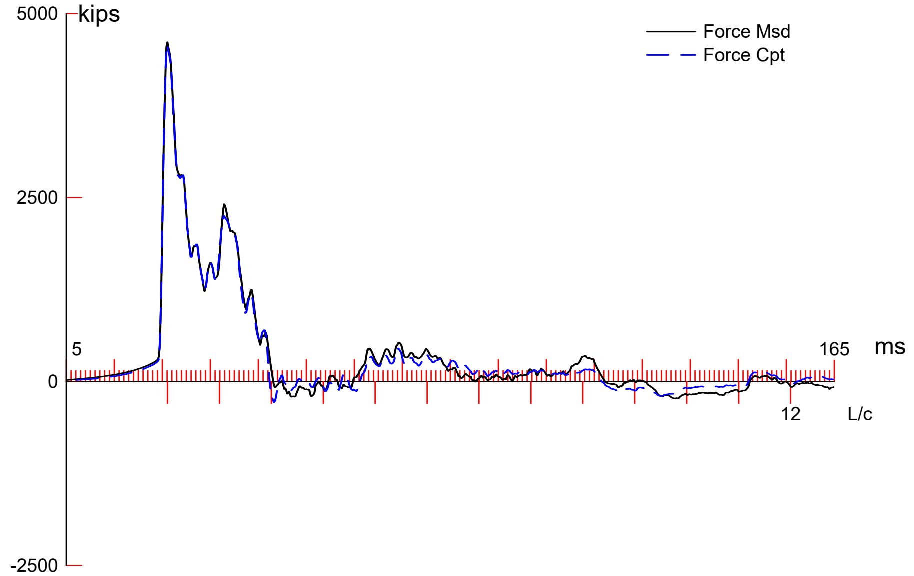
  Segmnt   Dist.  Impedance     Imped.              Tension           Compression       Perim.
  Number    B.G.                Change     Slack       Eff.      Slack       Eff.
              ft  kips/ft/s          %        in                    in                      ft

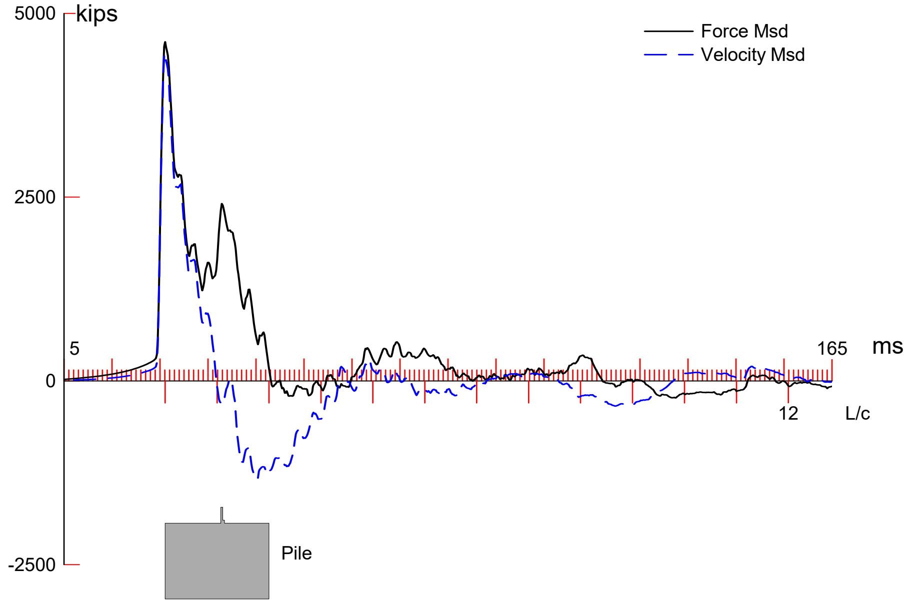
       1    3.30     268.12       0.00     0.000      0.000     -0.000      0.000       12.566
      31  102.41     325.09       0.00     0.000      0.000     -0.000      0.000       12.566
      32  105.71     279.12       0.00     0.000      0.000     -0.000      0.000       12.566
      33  109.02     268.12       0.00     0.000      0.000     -0.000      0.000       12.566
      56  185.00     268.12       0.00     0.000      0.000     -0.000      0.000       12.566

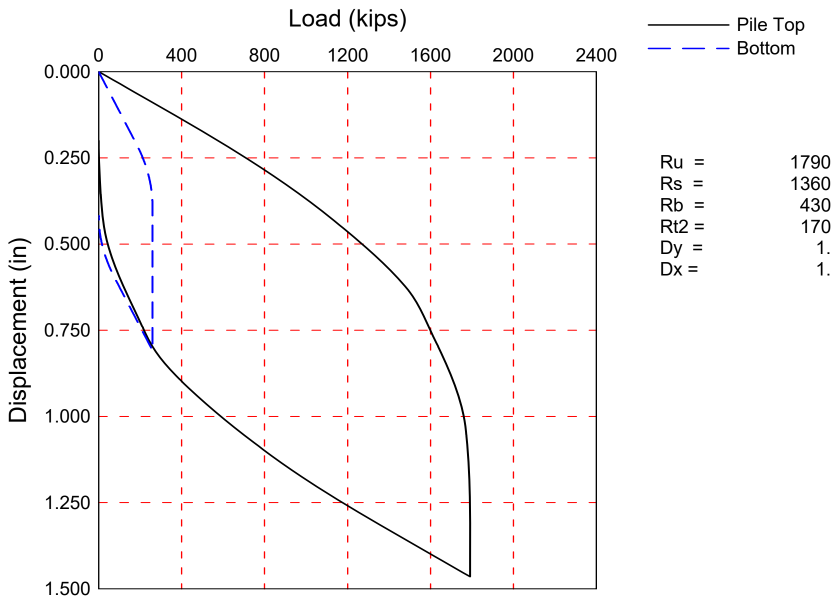
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 6 RESTRIKE; PP48x1.0", APE D180-42; Blow: 10 (Test: 21-Jun-2016 13:47:)
Robert Miner Dynamic Testing, Inc.

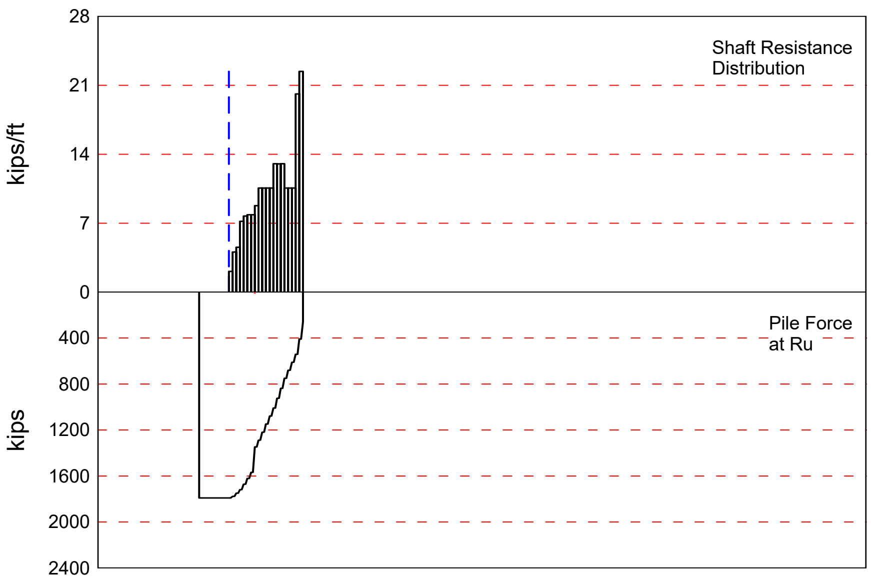
12-Jul-2016
CAPWAP(R) 2006-3







Ru = 1790.5 kips
Rs = 1360.5 kips
Rb = 430.0 kips
Rt2 = 170.0 kips
Dy = 1.27 in
Dx = 1.46 in



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                                CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1790.5; along Shaft   1360.5; at Toe    430.0  kips
  Soil    Dist.    Depth       Ru     Force       Sum      Unit      Unit     Smith     Quake
 Sgmnt    Below    Below             in Pile       of   Resist.   Resist.   Damping
   No.    Gages    Grade                           Ru   (Depth)    (Area)    Factor
             ft       ft     kips      kips      kips   kips/ft       ksf      s/ft        in

                                     1790.5
     1     59.5      3.7     14.0    1776.5      14.0      3.80      0.30     0.196     0.100
     2     66.1     10.3     26.9    1749.6      40.9      4.07      0.32     0.196     0.100
     3     72.7     16.9     30.2    1719.4      71.1      4.57      0.36     0.196     0.100
     4     79.3     23.5     47.6    1671.8     118.7      7.20      0.57     0.196     0.100
     5     85.9     30.1     51.1    1620.7     169.8      7.73      0.62     0.196     0.100
     6     92.5     36.7     51.9    1568.8     221.7      7.86      0.63     0.196     0.100
     7     99.1     43.3     51.9    1516.9     273.6      7.86      0.63     0.196     0.100
   2nd      Toe             170.0                                           0.700     0.640
     8    105.7     49.9     58.1    1288.8     501.7      8.79      0.70     0.196     0.100
     9    112.3     56.5     69.9    1218.9     571.6     10.58      0.84     0.196     0.100
    10    118.9     63.1     69.9    1149.0     641.5     10.58      0.84     0.196     0.100
    11    125.5     69.8     69.9    1079.1     711.4     10.58      0.84     0.196     0.100
    12    132.1     76.4     69.9    1009.2     781.3     10.58      0.84     0.196     0.100
    13    138.8     83.0     86.2     923.0     867.5     13.05      1.04     0.196     0.100
    14    145.4     89.6     86.1     836.9     953.6     13.03      1.04     0.196     0.100
    15    152.0     96.2     86.2     750.7    1039.8     13.05      1.04     0.196     0.100
    16    158.6    102.8     69.9     680.8    1109.7     10.58      0.84     0.196     0.100
    17    165.2    109.4     69.9     610.9    1179.6     10.58      0.84     0.196     0.100
    18    171.8    116.0     69.9     541.0    1249.5     10.58      0.84     0.196     0.100
    19    178.4    122.6    132.9     408.1    1382.4     20.11      1.60     0.196     0.100
    20    185.0    129.2    148.1     260.0    1530.5     22.42      1.78     0.196     0.100

  Avg. Shaft                 68.0                          10.53      0.84     0.196     0.100

       Toe                  260.0                                    20.69     0.110     0.300
Soil Model Parameters/Extensions                               Shaft       Toe

Case Damping Factor                                            0.993     0.107
Unloading Quake            (% of loading quake)                   30       100
Reloading Level            (% of Ru)                             100       100
Unloading Level            (% of Ru)                               5
Soil Plug Weight           (kips)                                           0.40

max. Top Comp. Stress      =    31.0 ksi      (T=  26.5 ms, max= 1.106 x Top)
max. Comp. Stress          =    34.3 ksi      (Z=  92.5 ft, T=  32.3 ms)
max. Tens. Stress          =   -4.13 ksi      (Z=  66.1 ft, T=  56.0 ms)
max. Energy (EMX)          =   268.8 kip-ft;  max. Measured Top Displ. (DMX)= 1.15 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	4579.4	-249.5	31.0	-1.69	268.80	16.8	1.156
2	6.6	4581.5	-244.8	31.0	-1.66	267.62	16.7	1.141
5	16.5	4588.4	-287.5	31.1	-1.95	262.68	16.7	1.086
8	26.4	4596.4	-300.7	31.1	-2.04	256.37	16.7	1.023
11	36.3	4605.9	-391.6	31.2	-2.65	251.42	16.6	0.968
14	46.3	4618.4	-419.3	31.3	-2.84	248.35	16.6	0.912
17	56.2	4666.7	-490.0	31.6	-3.32	248.26	16.4	0.864
20	66.1	4694.7	-609.4	31.8	-4.13	244.95	16.0	0.845
23	76.0	4590.6	-582.2	31.1	-3.94	232.89	15.5	0.819
26	85.9	4855.6	-603.8	32.9	-4.09	223.83	14.8	0.788
29	95.8	4992.5	-530.7	33.8	-3.59	206.74	11.9	0.760
32	105.7	3520.9	-504.3	22.9	-3.28	144.02	11.5	0.734
35	115.6	3268.0	-484.0	22.1	-3.28	126.45	10.9	0.710
38	125.5	3196.7	-402.3	21.6	-2.72	117.47	10.3	0.686
41	135.4	2957.5	-336.2	20.0	-2.28	100.56	9.7	0.661
44	145.4	2869.3	-307.2	19.4	-2.08	90.69	9.1	0.639
47	155.3	2542.7	-176.9	17.2	-1.20	71.63	8.6	0.618
50	165.2	2490.7	-143.5	16.9	-0.97	63.95	8.1	0.605
53	175.1	2086.3	-72.3	14.1	-0.49	48.83	10.4	0.591
54	178.4	1806.3	-65.8	12.2	-0.45	48.74	10.9	0.588
55	181.7	1130.5	-37.7	7.7	-0.26	34.69	11.1	0.585
56	185.0	914.9	-33.9	6.2	-0.23	18.91	11.3	0.582
Absolute	92.5			34.3			(T =	32.3 ms)
	66.1				-4.13		(T =	56.0 ms)

```
                                    CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        5233.3  4842.4  4451.5  4060.6  3669.7  3278.7  2887.8  2496.9  2106.0  1715.1
RX        5233.3  4842.4  4451.5  4060.6  3669.7  3278.7  2887.8  2496.9  2106.0  1715.1
RU        6243.1  5953.2  5663.3  5373.3  5083.4  4793.5  4503.5  4213.6  3923.7  3633.7

RAU =      0.0 (kips);  RA2 =   1247.7 (kips)

Current CAPWAP Ru = 1790.5 (kips); Corresponding J(RP)= 0.88; J(RX) = 0.88

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    16.78    26.27   4500.4   4642.1   4642.1    1.147    0.200    0.200    270.3   4814.8


                               PILE PROFILE AND PILE MODEL
                Depth              Area          E-Modulus     Spec. Weight           Perim.
                   ft               in²                ksi           lb/ft³               ft

                 0.00            147.65            31043.9          492.000           12.566
               102.00            147.65            31043.9          492.000           12.566
               102.00            400.00            31043.9          492.000           12.566
               102.49            400.00            31043.9          492.000           12.566
               102.49            147.65            31043.9          492.000           12.566
               185.00            147.65            31043.9          492.000           12.566

Toe Area                         12.566       ft²

  Segmnt    Dist.  Impedance    Imped.              Tension          Compression     Perim.
  Number     B.G.               Change     Slack       Eff.      Slack       Eff.
               ft  kips/ft/s         %        in                    in                   ft

        1    3.30     268.12      0.00     0.000      0.000     -0.000      0.000     12.566
       31  102.41     325.09      0.00     0.000      0.000     -0.000      0.000     12.566
       32  105.71     279.12      0.00     0.000      0.000     -0.000      0.000     12.566
       33  109.02     268.12      0.00     0.000      0.000     -0.000      0.000     12.566
       56  185.00     268.12      0.00     0.000      0.000     -0.000      0.000     12.566

Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
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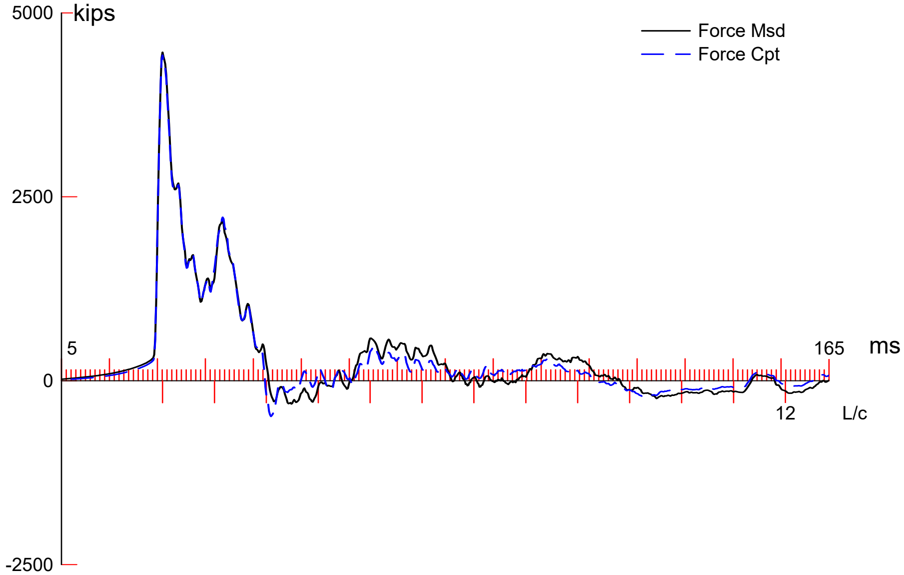
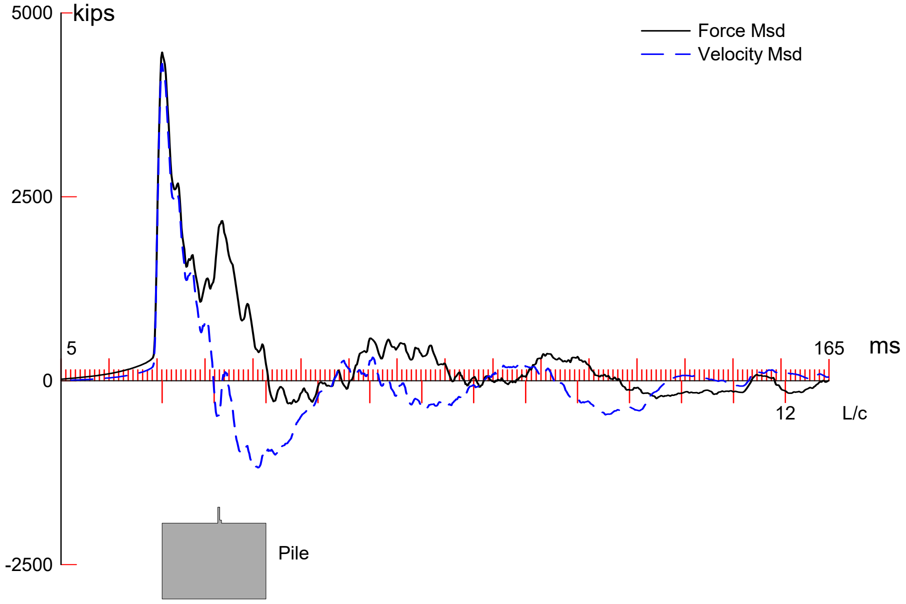
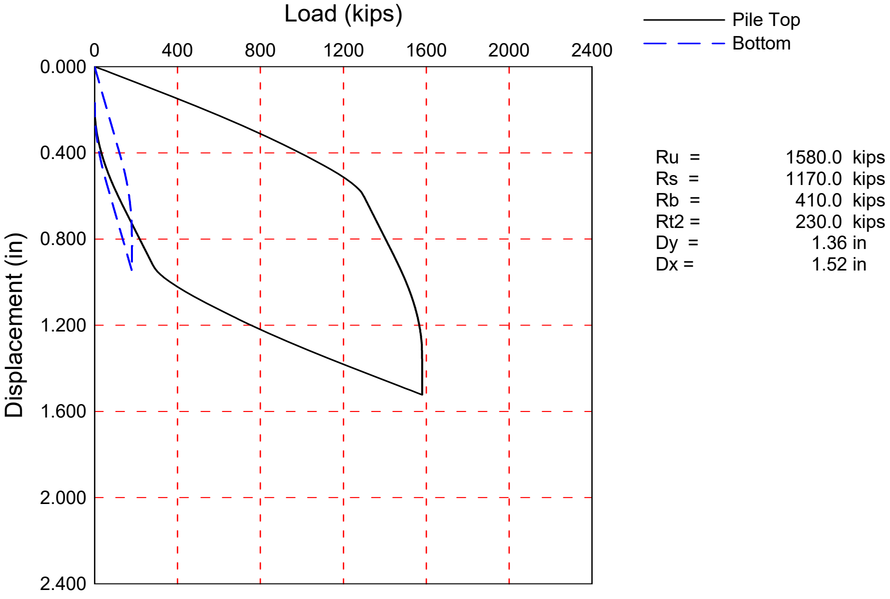
KIWC, POA TPP; Pile: IP 6 RESTRIKE; PP48x1.0", APE D180-42; Blow: 31 (Test: 21-Jun-2016 13:48:)
Robert Miner Dynamic Testing, Inc.

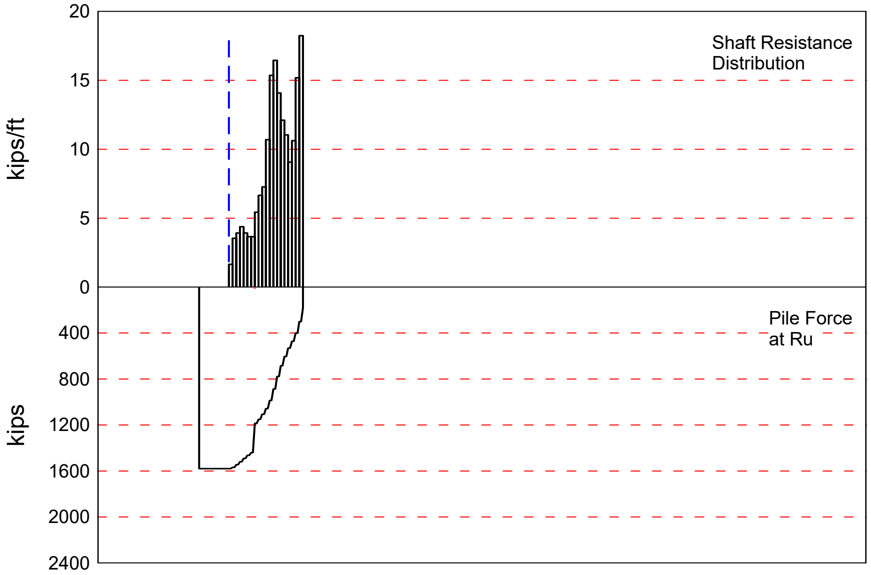
12-Jul-2016
CAPWAP(R) 2006-3







Ru = 1580.0 kips
Rs = 1170.0 kips
Rb = 410.0 kips
Rt2 = 230.0 kips
Dy = 1.36 in
Dx = 1.52 in



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KIWC, POA TPP; Pile: IP 6 RESTRIKE                               Test: 21-Jun-2016 13:48:
PP48x1.0'', APE D180-42; Blow: 31                                       CAPWAP(R)  2006-3
Robert Miner Dynamic Testing, Inc.                                               OP: RMDT
                                 CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   1580.0; along Shaft   1170.0; at Toe    410.0  kips
   Soil   Dist.    Depth      Ru     Force      Sum      Unit     Unit     Smith    Quake
  Sgmnt   Below    Below           in Pile       of   Resist.  Resist.   Damping
    No.   Gages    Grade                         Ru   (Depth)   (Area)    Factor
             ft       ft    kips      kips     kips   kips/ft      ksf      s/ft       in

                                    1580.0
      1    59.5      4.0    11.0    1569.0     11.0      2.75     0.22     0.170    0.100
      2    66.1     10.6    23.5    1545.5     34.5      3.56     0.28     0.170    0.100
      3    72.7     17.2    26.0    1519.5     60.5      3.94     0.31     0.170    0.100
      4    79.3     23.8    29.0    1490.5     89.5      4.39     0.35     0.170    0.100
      5    85.9     30.4    26.0    1464.5    115.5      3.94     0.31     0.170    0.100
      6    92.5     37.0    24.2    1440.3    139.7      3.66     0.29     0.170    0.100
      7    99.1     43.6    24.2    1416.1    163.9      3.66     0.29     0.170    0.100
    2nd     Toe            230.0                                          0.700    0.700
      8   105.7     50.3    36.0    1150.1    429.9      5.45     0.43     0.170    0.100
      9   112.3     56.9    44.0    1106.1    473.9      6.66     0.53     0.170    0.100
     10   118.9     63.5    48.1    1058.0    522.0      7.28     0.58     0.170    0.100
     11   125.5     70.1    70.7     987.3    592.7     10.70     0.85     0.170    0.100
     12   132.1     76.7   101.5     885.8    694.2     15.36     1.22     0.170    0.100
     13   138.8     83.3   108.7     777.1    802.9     16.45     1.31     0.170    0.100
     14   145.4     89.9    93.1     684.0    896.0     14.09     1.12     0.170    0.100
     15   152.0     96.5    80.0     604.0    976.0     12.11     0.96     0.170    0.100
     16   158.6    103.1    73.0     531.0   1049.0     11.05     0.88     0.170    0.100
     17   165.2    109.7    60.0     471.0   1109.0      9.08     0.72     0.170    0.100
     18   171.8    116.3    70.2     400.8   1179.2     10.62     0.85     0.170    0.100
     19   178.4    122.9   100.3     300.5   1279.5     15.18     1.21     0.170    0.100
     20   185.0    129.5   120.5     180.0   1400.0     18.24     1.45     0.170    0.100

  Avg. Shaft                58.5                         9.03     0.72     0.170    0.100

       Toe                 180.0                                 14.32     0.160    0.600

Soil Model Parameters/Extensions                         Shaft      Toe

Case Damping Factor                                      0.742    0.107
Unloading Quake            (% of loading quake)             50      100
Reloading Level            (% of Ru)                       100      100
Unloading Level            (% of Ru)                        10
Soil Plug Weight           (kips)                                  0.90

max. Top Comp. Stress      =    30.0 ksi      (T=  26.5 ms, max= 1.178 x Top)
max. Comp. Stress          =    35.3 ksi      (Z=  99.1 ft, T=  32.1 ms)
max. Tens. Stress          =   -4.21 ksi      (Z=  95.8 ft, T=  55.4 ms)
max. Energy (EMX)          =   245.6 kip-ft;  max. Measured Top Displ. (DMX)= 1.09 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	4428.1	-426.8	30.0	-2.89	245.63	16.2	1.110
2	6.6	4429.8	-349.1	30.0	-2.36	244.57	16.2	1.095
5	16.5	4435.4	-294.3	30.0	-1.99	239.97	16.2	1.042
8	26.4	4441.9	-349.4	30.1	-2.37	235.96	16.1	0.992
11	36.3	4449.6	-361.0	30.1	-2.44	230.62	16.1	0.935
14	46.3	4459.6	-348.5	30.2	-2.36	229.82	16.0	0.876
17	56.2	4494.8	-479.4	30.4	-3.25	229.73	15.9	0.833
20	66.1	4519.2	-588.5	30.6	-3.98	227.45	15.6	0.826
23	76.0	4415.6	-597.3	29.9	-4.04	218.19	15.3	0.809
26	85.9	4790.1	-521.1	32.4	-3.53	213.17	14.8	0.786
29	95.8	5164.6	-621.1	35.0	-4.21	205.52	11.6	0.767
32	105.7	3316.6	-428.4	21.6	-2.79	130.61	11.2	0.747
35	115.6	3186.3	-441.8	21.6	-2.99	120.31	10.8	0.728
38	125.5	3211.1	-376.2	21.7	-2.55	114.42	10.2	0.708
41	135.4	2939.2	-389.0	19.9	-2.63	94.52	9.6	0.688
44	145.4	2801.8	-351.4	19.0	-2.38	82.42	9.0	0.669
47	155.3	2494.2	-218.2	16.9	-1.48	63.39	8.5	0.657
50	165.2	2423.1	-230.9	16.4	-1.56	55.42	8.3	0.650
53	175.1	2079.8	-121.9	14.1	-0.83	41.43	10.8	0.640
54	178.4	1816.9	-89.2	12.3	-0.60	41.37	11.5	0.637
55	181.7	1225.6	-18.8	8.3	-0.13	30.25	11.9	0.635
56	185.0	847.1	0.0	5.7	0.00	16.35	12.1	0.633
Absolute	99.1			35.3			(T =	32.1 ms)
	95.8				-4.21		(T =	55.4 ms)

```
                                        CASE METHOD
------------------------------------------------------------------------------------------
J =          0.0      0.1      0.2      0.3      0.4      0.5      0.6      0.7      0.8      0.9
RP        4989.3   4603.0   4216.7   3830.5   3444.2   3057.9   2671.7   2285.4   1899.1   1512.9
RX        4989.3   4603.0   4216.7   3830.5   3444.2   3057.9   2671.7   2285.4   1899.1   1512.9
RU        5932.7   5640.7   5348.8   5056.9   4764.9   4473.0   4181.1   3889.1   3597.2   3305.3

RAU =      0.0 (kips);  RA2 =    875.4 (kips)

Current CAPWAP Ru = 1580.0 (kips); Corresponding J(RP)= 0.88; J(RX) = 0.88

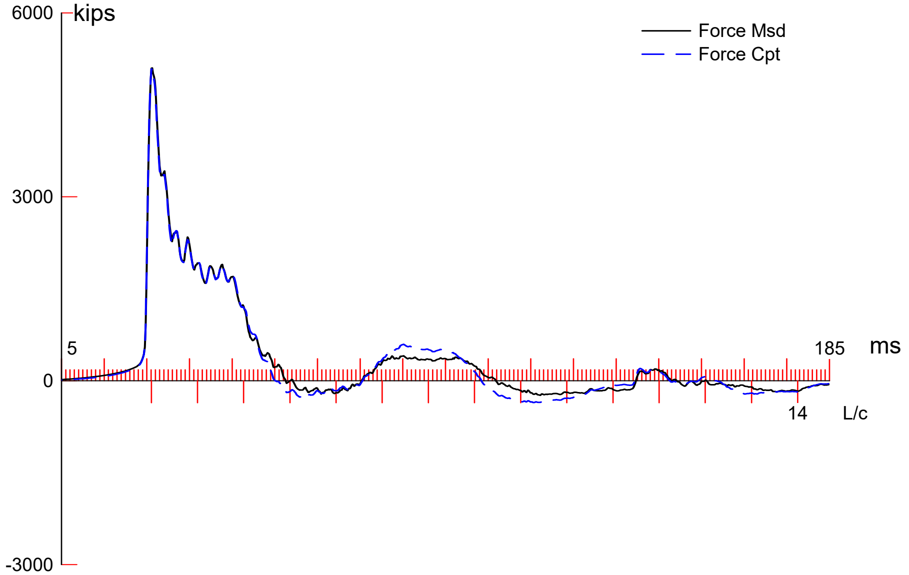
      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    16.27    26.27   4361.4   4490.6   4490.6    1.092    0.167    0.167    246.8   4706.1

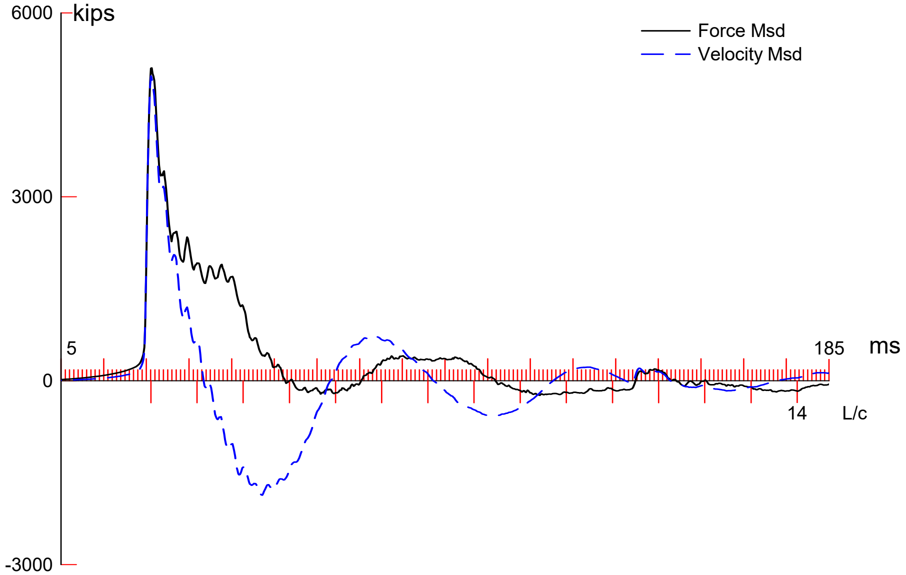

                                 PILE PROFILE AND PILE MODEL
------------------------------------------------------------------------------------------
                Depth             Area        E-Modulus     Spec. Weight            Perim.
                   ft              in²              ksi           lb/ft³                ft
------------------------------------------------------------------------------------------
                 0.00           147.65          31043.9          492.000            12.566
               102.00           147.65          31043.9          492.000            12.566
               102.00           400.00          31043.9          492.000            12.566
               102.49           400.00          31043.9          492.000            12.566
               102.49           147.65          31043.9          492.000            12.566
               185.00           147.65          31043.9          492.000            12.566

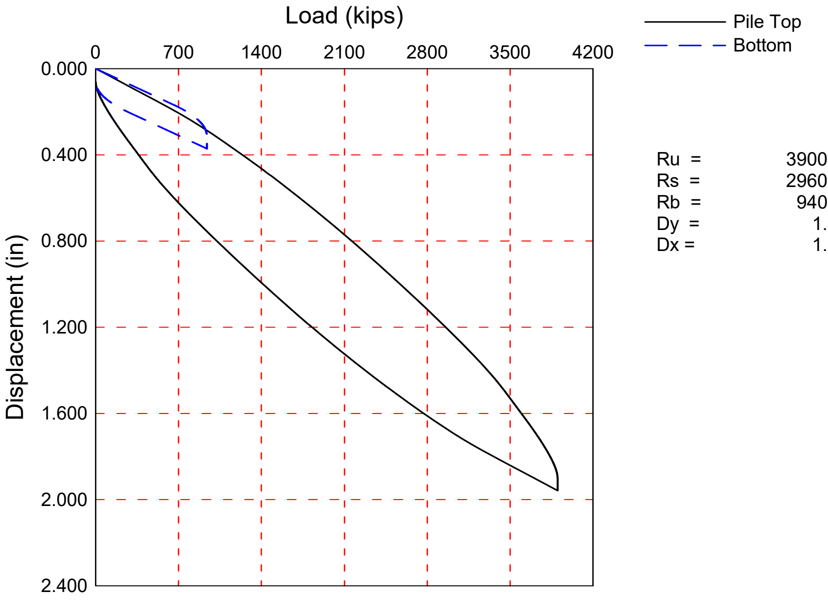
Toe Area                        12.566       ft²

  Segmnt    Dist.  Impedance     Imped.              Tension          Compression     Perim.
  Number     B.G.                Change      Slack      Eff.       Slack      Eff.
               ft  kips/ft/s          %         in                    in                  ft
------------------------------------------------------------------------------------------
       1     3.30     268.12       0.00      0.000     0.000      -0.000     0.000     12.566
      31   102.41     325.09       0.00      0.000     0.000      -0.000     0.000     12.566
      32   105.71     279.12       0.00      0.000     0.000      -0.000     0.000     12.566
      33   109.02     268.12       0.00      0.000     0.000      -0.000     0.000     12.566
      56   185.00     268.12       0.00      0.000     0.000      -0.000     0.000     12.566

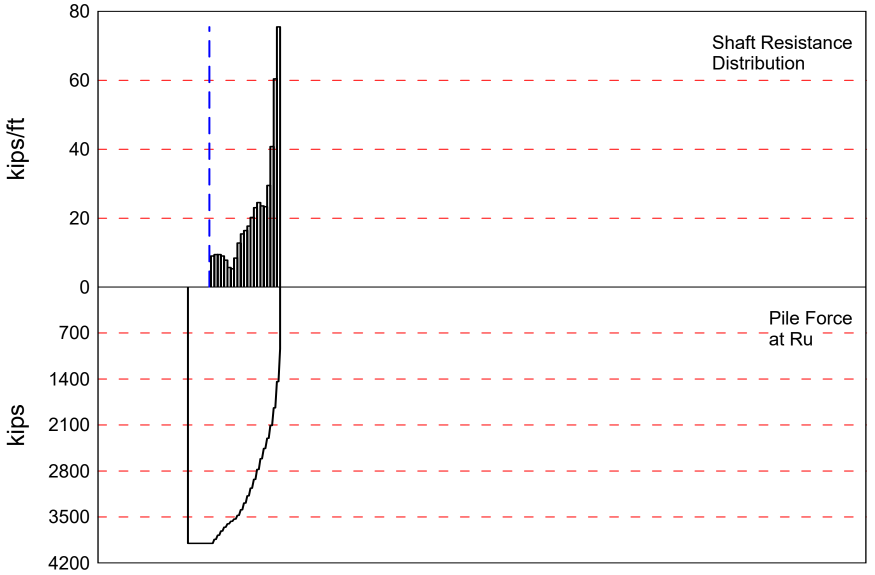
Pile Damping    1.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```







Ru = 3900.2 kips
Rs = 2960.2 kips
Rb = 940.0 kips
Dy = 1.90 in
Dx = 1.96 in



```
                               CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   3900.2; along Shaft   2960.2; at Toe    940.0  kips
    Soil     Dist.    Depth        Ru     Force       Sum      Unit      Unit     Smith
   Sgmnt     Below    Below             in Pile        of   Resist.   Resist.   Damping
     No.     Gages    Grade                            Ru   (Depth)    (Area)    Factor
                ft       ft      kips      kips      kips   kips/ft       ksf      s/ft

                                         3900.2
       1      52.9      6.9      59.8    3840.4      59.8      8.70      0.69     0.170
       2      59.5     13.5      62.7    3777.7     122.5      9.49      0.76     0.170
       3      66.1     20.1      62.5    3715.2     185.0      9.46      0.75     0.170
       4      72.7     26.7      59.9    3655.3     244.9      9.07      0.72     0.170
       5      79.3     33.3      51.8    3603.5     296.7      7.84      0.62     0.170
       6      85.9     39.9      37.8    3565.7     334.5      5.72      0.46     0.170
       7      92.5     46.5      35.3    3530.4     369.8      5.34      0.43     0.170
       8      99.1     53.1      55.8    3474.6     425.6      8.45      0.67     0.170
       9     105.7     59.7      84.7    3389.9     510.3     12.82      1.02     0.170
      10     112.3     66.3     102.2    3287.7     612.5     15.47      1.23     0.170
      11     118.9     72.9     108.6    3179.1     721.1     16.44      1.31     0.170
      12     125.5     79.5     117.3    3061.8     838.4     17.75      1.41     0.170
      13     132.1     86.2     133.9    2927.9     972.3     20.27      1.61     0.170
      14     138.8     92.8     152.6    2775.3    1124.9     23.10      1.84     0.170
      15     145.4     99.4     162.4    2612.9    1287.3     24.58      1.96     0.170
      16     152.0    106.0     155.9    2457.0    1443.2     23.60      1.88     0.170
      17     158.6    112.6     154.3    2302.7    1597.5     23.35      1.86     0.170
      18     165.2    119.2     194.9    2107.8    1792.4     29.50      2.35     0.170
      19     171.8    125.8     269.7    1838.1    2062.1     40.82      3.25     0.170
      20     178.4    132.4     399.4    1438.7    2461.5     60.45      4.81     0.170
      21     185.0    139.0     498.7     940.0    2960.2     75.48      6.01     0.170

  Avg. Shaft                    141.0                          21.29      1.69     0.170

       Toe                      940.0                                    74.80     0.060

Soil Model Parameters/Extensions                          Shaft       Toe
Quake                      (in)                           0.100     0.240
Case Damping Factor                                       1.877     0.210
Unloading Quake            (% of loading quake)              50        30
Reloading Level            (% of Ru)                        100       100
Unloading Level            (% of Ru)                         50

max. Top Comp. Stress      =    34.5 ksi      (T=  26.5 ms, max= 1.046 x Top)
max. Comp. Stress          =    36.1 ksi      (Z=  52.9 ft, T=  29.6 ms)
max. Tens. Stress          =   -5.06 ksi      (Z=  99.1 ft, T=  66.8 ms)
max. Energy (EMX)          =   368.0 kip-ft;  max. Measured Top Displ. (DMX)= 1.36 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	5090.2	-363.7	34.5	-2.46	368.04	18.6	1.370
2	6.6	5089.5	-374.3	34.5	-2.53	366.95	18.5	1.355
5	16.5	5088.0	-403.2	34.4	-2.73	363.13	18.5	1.307
8	26.4	5096.9	-488.2	34.5	-3.31	358.45	18.4	1.253
11	36.3	5114.0	-559.2	34.6	-3.79	352.70	18.3	1.194
14	46.3	5216.2	-646.8	35.3	-4.38	345.89	17.9	1.129
17	56.2	5143.8	-667.3	34.8	-4.52	324.14	17.3	1.062
20	66.1	5058.3	-679.7	34.2	-4.60	302.54	16.7	0.996
23	76.0	4725.3	-674.2	32.0	-4.56	268.94	16.2	0.929
26	85.9	4634.1	-691.8	31.4	-4.68	250.95	15.8	0.859
29	95.8	4516.1	-723.1	30.6	-4.90	229.28	15.2	0.786
32	105.7	4549.0	-736.4	30.8	-4.99	211.95	14.4	0.713
35	115.6	4182.5	-671.6	28.3	-4.55	178.56	13.4	0.643
38	125.5	4119.0	-648.5	27.9	-4.39	158.94	12.4	0.578
41	135.4	3685.9	-531.5	25.0	-3.60	127.59	11.2	0.514
44	145.4	3554.0	-496.8	24.1	-3.36	108.66	10.1	0.451
47	155.3	3050.0	-343.3	20.7	-2.32	81.32	9.0	0.391
50	165.2	3054.5	-302.8	20.7	-2.05	68.04	7.8	0.335
53	175.1	2173.6	-87.7	14.7	-0.59	44.47	7.0	0.284
54	178.4	2263.6	-86.5	15.3	-0.59	43.29	7.0	0.268
55	181.7	1667.4	0.0	11.3	0.00	29.54	7.0	0.256
56	185.0	1747.9	0.0	11.8	0.00	14.62	6.6	0.243
Absolute	52.9			36.1			(T =	29.6 ms)
	99.1				-5.06		(T =	66.8 ms)

```
                                     CASE METHOD
J =           0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP         6359.6  5980.9  5602.3  5223.6  4844.9  4466.3  4087.6  3708.9  3330.2  2951.6
RX         6359.6  5980.9  5602.3  5223.6  4844.9  4466.3  4087.6  3708.9  3330.2  2951.6
RU         6903.9  6579.6  6255.4  5931.1  5606.9  5282.6  4958.4  4634.1  4309.9  3985.7

RAU =      0.0 (kips);  RA2 =   2745.5 (kips)

Current CAPWAP Ru = 3900.2 (kips); Corresponding J(RP)= 0.65; J(RX) = 0.65

      VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
     ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
    18.65    26.27   5000.1   5146.3   5146.3    1.359    0.064    0.060    369.0   6241.5


                             PILE PROFILE AND PILE MODEL
             Depth              Area         E-Modulus     Spec. Weight               Perim.
                ft               in²               ksi            lb/ft³                  ft

              0.00            147.65           31043.9          492.000               12.566
            185.00            147.65           31043.9          492.000               12.566

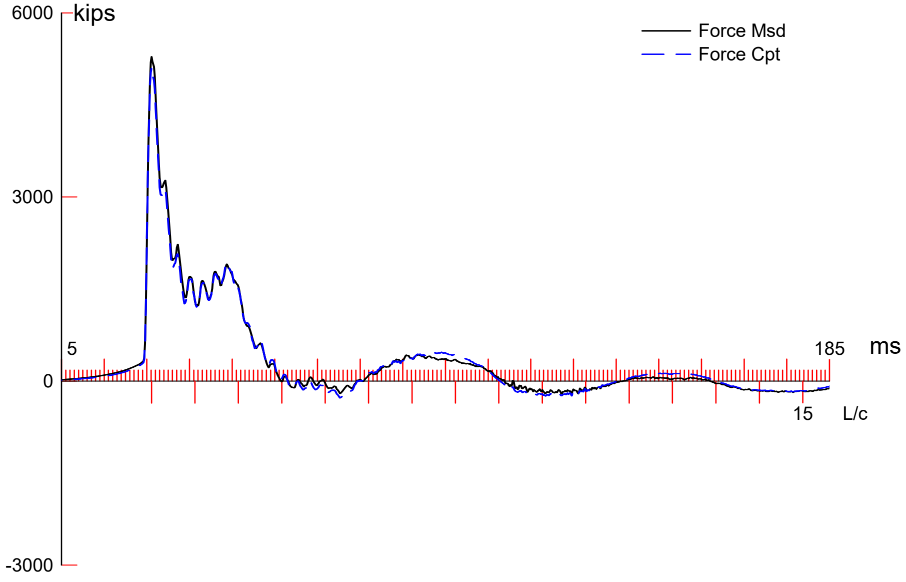
Toe Area                      12.566       ft²

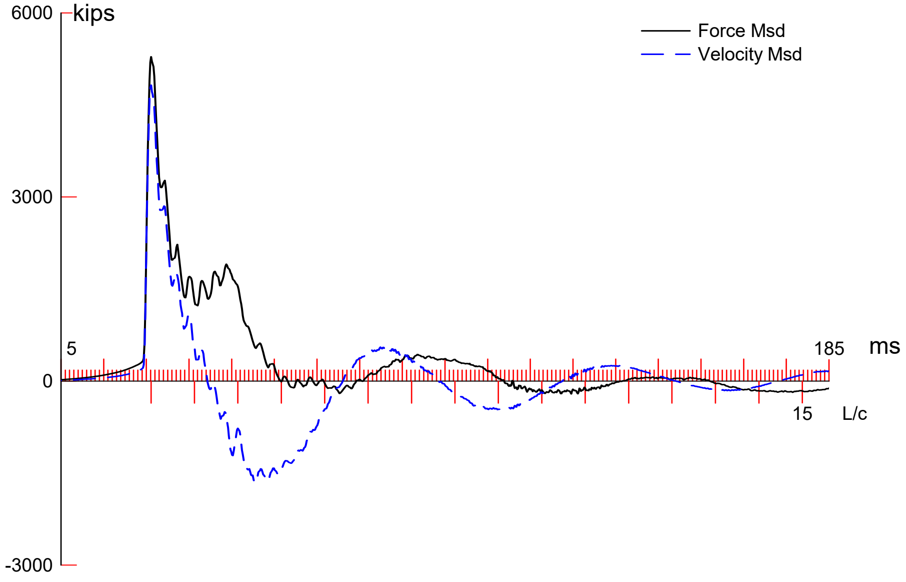
Top Segment Length      3.30 ft, Top Impedance   268.13 kips/ft/s

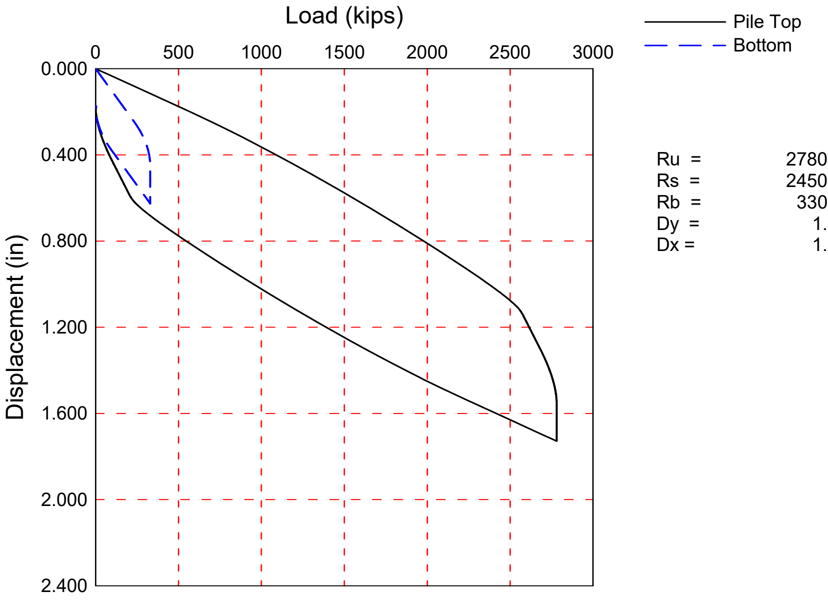
Pile Damping    2.0 %, Time Incr  0.193 ms, Wave Speed  17100.0 ft/s, 2L/c  21.6 ms
```

KIWC, POA TPP; Pile: IP 8 RESTRIKE; PP48x1.0", APE D180-42; Blow: 3 (Test: 10-Jun-2016 10:14:)
Robert Miner Dynamic Testing, Inc.

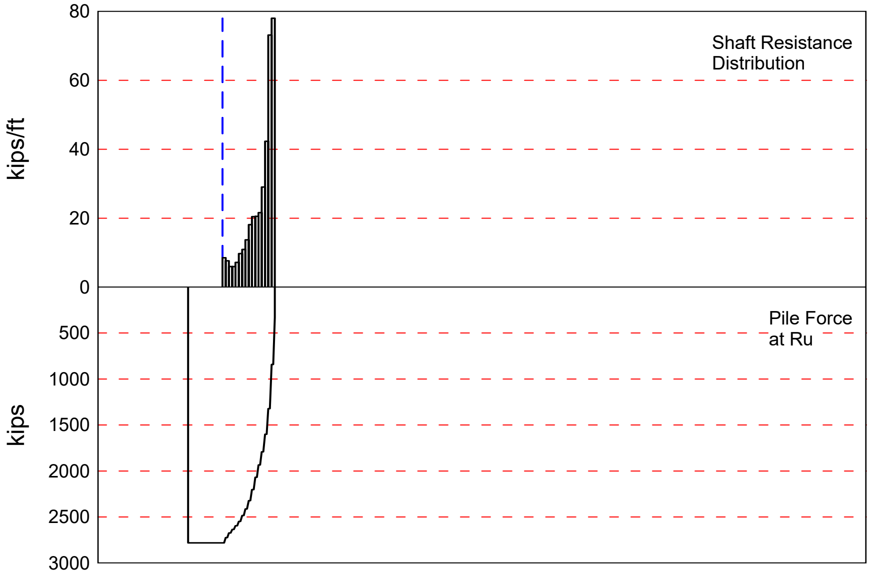
14-Jun-2016
CAPWAP(R) 2006-3







Ru = 2780.6 kips
Rs = 2450.6 kips
Rb = 330.0 kips
Dy = 1.56 in
Dx = 1.73 in



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                               CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   2780.6; along Shaft   2450.6; at Toe    330.0  kips
    Soil     Dist.    Depth        Ru      Force        Sum      Unit      Unit     Smith
   Sgmnt     Below    Below              in Pile         of   Resist.   Resist.   Damping
     No.     Gages    Grade                              Ru   (Depth)    (Area)    Factor
                ft       ft      kips       kips       kips   kips/ft       ksf      s/ft

                                          2780.6
       1      75.5      6.5      56.1     2724.5       56.1      8.59      0.68     0.165
       2      82.1     13.1      50.4     2674.1      106.5      7.68      0.61     0.165
       3      88.6     19.7      39.3     2634.8      145.8      5.99      0.48     0.165
       4      95.2     26.2      39.3     2595.5      185.1      5.99      0.48     0.165
       5     101.8     32.8      47.3     2548.2      232.4      7.20      0.57     0.165
       6     108.3     39.4      64.0     2484.2      296.4      9.75      0.78     0.165
       7     114.9     45.9      72.0     2412.2      368.4     10.97      0.87     0.165
       8     121.5     52.5      90.1     2322.1      458.5     13.72      1.09     0.165
       9     128.0     59.1     119.3     2202.8      577.8     18.17      1.45     0.165
      10     134.6     65.6     134.4     2068.4      712.2     20.47      1.63     0.165
      11     141.2     72.2     135.0     1933.4      847.2     20.56      1.64     0.165
      12     147.7     78.8     142.0     1791.4      989.2     21.63      1.72     0.165
      13     154.3     85.3     190.9     1600.5     1180.1     29.07      2.31     0.165
      14     160.9     91.9     278.1     1322.4     1458.2     42.35      3.37     0.165
      15     167.4     98.5     480.2      842.2     1938.4     73.13      5.82     0.165
      16     174.0    105.0     512.2      330.0     2450.6     78.01      6.21     0.165

  Avg. Shaft                    153.2                           23.33      1.86     0.165

       Toe                      330.0                                     26.26     0.065
Soil Model Parameters/Extensions                          Shaft      Toe

Quake                     (in)                            0.100    0.350
Case Damping Factor                                       1.508    0.080
Damping Type                                                       Smith
Unloading Quake           (% of loading quake)               65      100
Reloading Level           (% of Ru)                         100      100
Unloading Level           (% of Ru)                          15

max. Top Comp. Stress      =    34.5 ksi      (T=  26.5 ms, max= 1.043 x Top)
max. Comp. Stress          =    36.0 ksi      (Z=  75.5 ft, T=  30.7 ms)
max. Tens. Stress          =   -5.47 ksi      (Z= 108.3 ft, T=  66.0 ms)
max. Energy (EMX)          =   339.8 kip-ft;  max. Measured Top Displ. (DMX)= 1.29 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	5100.4	-286.2	34.5	-1.94	339.75	18.7	1.356
2	6.6	5102.2	-301.2	34.5	-2.04	338.97	18.7	1.343
5	16.4	5108.0	-350.0	34.6	-2.37	336.11	18.6	1.302
8	26.3	5114.8	-397.6	34.6	-2.69	332.33	18.6	1.254
11	36.1	5122.6	-455.7	34.7	-3.09	328.33	18.5	1.205
14	46.0	5132.0	-534.2	34.7	-3.62	324.57	18.5	1.157
17	55.8	5143.2	-590.9	34.8	-4.00	319.78	18.4	1.103
20	65.7	5183.3	-688.7	35.1	-4.66	313.99	18.3	1.043
23	75.5	5319.1	-744.1	36.0	-5.04	306.73	17.7	0.976
26	85.4	5020.3	-759.8	34.0	-5.14	277.52	17.3	0.915
29	95.2	4986.7	-773.7	33.8	-5.24	262.78	16.8	0.850
32	105.1	4825.2	-797.4	32.7	-5.40	241.18	16.2	0.790
35	114.9	4799.5	-790.9	32.5	-5.36	224.95	15.4	0.730
38	124.8	4527.5	-694.0	30.7	-4.70	197.10	14.4	0.677
41	134.6	4440.3	-677.4	30.1	-4.59	177.73	13.3	0.625
44	144.5	3967.6	-548.6	26.9	-3.71	145.10	12.1	0.579
47	154.3	4062.1	-495.4	27.5	-3.35	130.19	10.6	0.536
50	164.2	2890.1	-320.5	19.6	-2.17	88.12	10.4	0.502
51	167.4	2710.4	-317.8	18.4	-2.15	88.10	10.6	0.492
52	170.7	1541.9	-124.7	10.4	-0.84	50.86	10.6	0.486
53	174.0	1611.2	-123.6	10.9	-0.84	11.21	10.3	0.479
Absolute	75.5			36.0			(T =	30.7 ms)
	108.3				-5.47		(T =	66.0 ms)

```
                                 CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        6249.2  5854.5  5459.8  5065.1  4670.4  4275.7  3881.0  3486.3  3091.6  2696.9
RX        6249.2  5854.5  5459.8  5065.1  4670.4  4275.7  3881.0  3486.3  3091.6  2702.0
RU        6273.2  5880.9  5488.6  5096.3  4704.0  4311.7  3919.4  3527.1  3134.8  2742.5

RAU =    927.0 (kips);  RA2 =   2376.4 (kips)

Current CAPWAP Ru = 2780.6 (kips); Corresponding J(RP)= 0.88; J(RX) = 0.88

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   18.19    26.30   4876.5   5319.7   5319.7    1.287    0.167    0.171    339.2   5582.3


                           PILE PROFILE AND PILE MODEL
             Depth              Area         E-Modulus     Spec. Weight            Perim.
                ft               in²               ksi           lb/ft³                ft

              0.00            147.65           31043.9          492.000            12.566
            174.00            147.65           31043.9          492.000            12.566

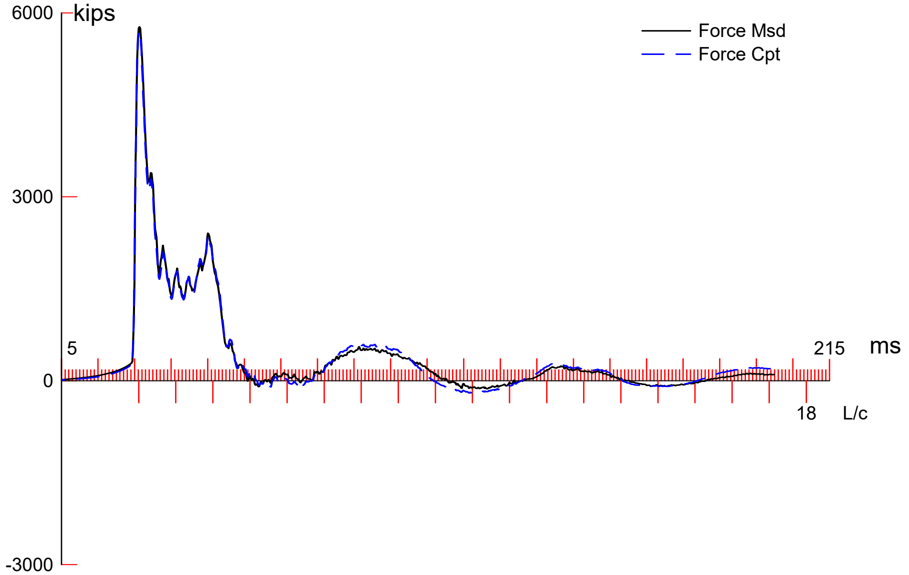
Toe Area                      12.566       ft²

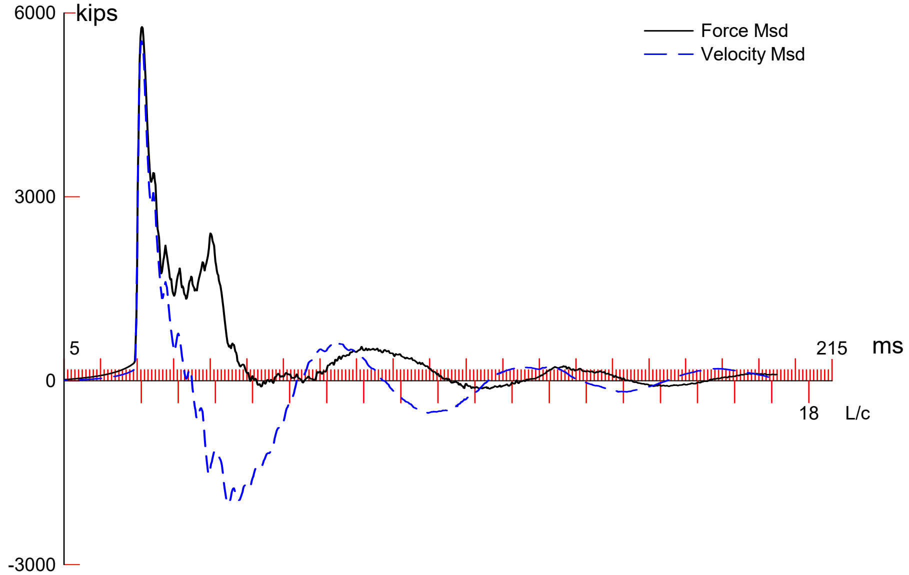
Top Segment Length      3.28 ft, Top Impedance   268.13 kips/ft/s

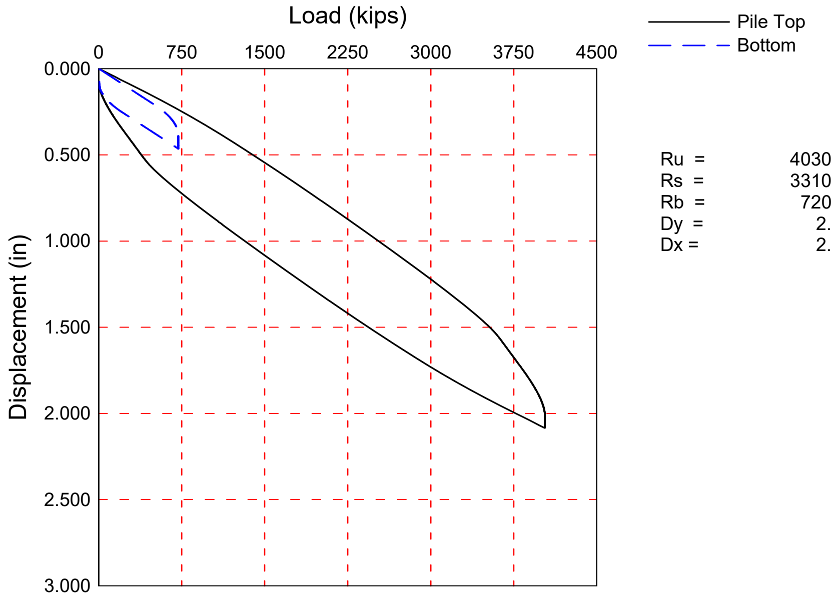
Pile Damping    1.0 %, Time Incr  0.192 ms, Wave Speed  17100.0 ft/s, 2L/c  20.4 ms
```

KIWC, POA TPP; Pile: IP 9 RESTRIKE; PP48x1.0", APE D180-42; Blow: 3 (Test: 10-Jun-2016 09:59:)
Robert Miner Dynamic Testing, Inc.

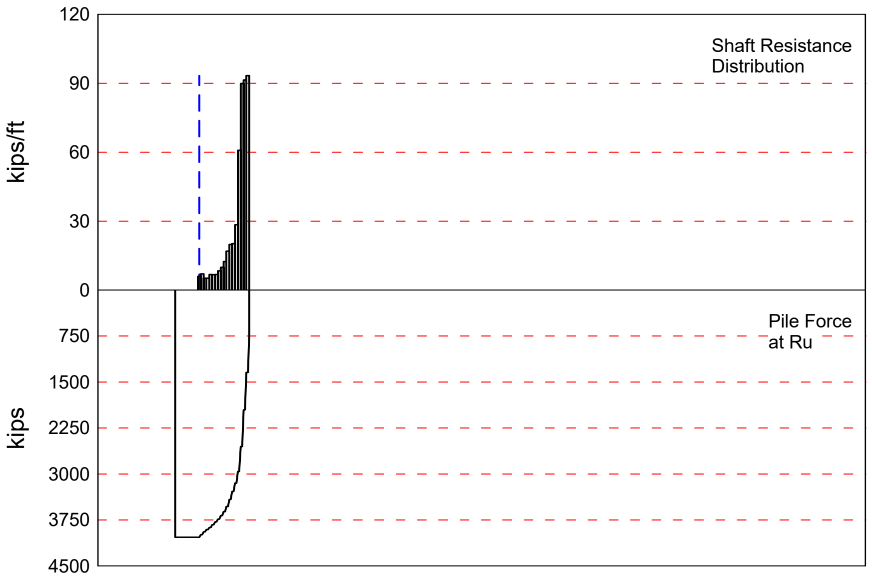
14-Jun-2016
CAPWAP(R) 2006-3







Ru = 4030.6 kips
Rs = 3310.6 kips
Rb = 720.0 kips
Dy = 2.01 in
Dx = 2.09 in



```
                                  CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   4030.6; along Shaft   3310.6; at Toe    720.0  kips
    Soil    Dist.     Depth       Ru      Force       Sum       Unit      Unit      Smith
   Sgmnt    Below     Below             in Pile        of    Resist.   Resist.    Damping
     No.    Gages     Grade                            Ru    (Depth)    (Area)     Factor
               ft        ft     kips       kips      kips    kips/ft       ksf       s/ft

                                          4030.6
       1     60.0       1.6     40.0     3990.6      40.0      24.46      1.95      0.170
       2     66.7       8.3     47.8     3942.8      87.8       7.17      0.57      0.170
       3     73.4      15.0     35.0     3907.8     122.8       5.25      0.42      0.170
       4     80.0      21.6     35.0     3872.8     157.8       5.25      0.42      0.170
       5     86.7      28.3     45.7     3827.1     203.5       6.85      0.55      0.170
       6     93.4      35.0     45.0     3782.1     248.5       6.75      0.54      0.170
       7    100.0      41.7     45.8     3736.3     294.3       6.87      0.55      0.170
       8    106.7      48.3     56.2     3680.1     350.5       8.43      0.67      0.170
       9    113.4      55.0     66.7     3613.4     417.2      10.00      0.80      0.170
      10    120.0      61.7     83.5     3529.9     500.7      12.52      1.00      0.170
      11    126.7      68.3    113.4     3416.5     614.1      17.00      1.35      0.170
      12    133.4      75.0    133.0     3283.5     747.1      19.94      1.59      0.170
      13    140.1      81.7    135.0     3148.5     882.1      20.24      1.61      0.170
      14    146.7      88.3    190.0     2958.5    1072.1      28.49      2.27      0.170
      15    153.4      95.0    406.0     2552.5    1478.1      60.88      4.84      0.170
      16    160.1     101.7    600.0     1952.5    2078.1      89.97      7.16      0.170
      17    166.7     108.3    610.0     1342.5    2688.1      91.47      7.28      0.170
      18    173.4     115.0    622.5      720.0    3310.6      93.34      7.43      0.170

  Avg. Shaft                   183.9                           28.78      2.29      0.170

       Toe                     720.0                                     57.30      0.040

Soil Model Parameters/Extensions                          Shaft    Toe

Quake                      (in)                           0.100    0.300
Case Damping Factor                                       2.099    0.107
Unloading Quake            (% of loading quake)              30       70
Reloading Level            (% of Ru)                        100      100
Unloading Level            (% of Ru)                         10
Soil Plug Weight           (kips)                                   0.20

max. Top Comp. Stress      =    38.5 ksi      (T=  26.5 ms, max= 1.038 x Top)
max. Comp. Stress          =    40.0 ksi      (Z=  60.0 ft, T=  30.0 ms)
max. Tens. Stress          =   -5.52 ksi      (Z= 106.7 ft, T=  65.5 ms)
max. Energy (EMX)          =   409.1 kip-ft;  max. Measured Top Displ. (DMX)= 1.37 in
```

```
                                      EXTREMA TABLE
      Pile     Dist.      max.      min.      max.      max.      max.      max.      max.
     Sgmnt     Below     Force     Force     Comp.     Tens.   Trnsfd.    Veloc.    Displ.
       No.     Gages                        Stress    Stress    Energy
                  ft      kips      kips       ksi       ksi    kip-ft      ft/s        in

         1       3.3    5691.2    -209.2      38.5     -1.42    409.08      20.9     1.414
         2       6.7    5692.4    -218.5      38.5     -1.48    407.88      20.9     1.399
         5      16.7    5696.8    -243.6      38.6     -1.65    405.16      20.8     1.358
         8      26.7    5704.5    -321.4      38.6     -2.18    401.80      20.8     1.313
        11      36.7    5716.0    -409.5      38.7     -2.77    397.51      20.7     1.261
        14      46.7    5737.8    -518.3      38.8     -3.51    392.07      20.7     1.203
        17      56.7    5856.9    -636.2      39.7     -4.31    386.26      20.3     1.144
        20      66.7    5808.6    -689.1      39.3     -4.67    369.49      19.8     1.086
        23      76.7    5571.2    -698.0      37.7     -4.73    340.79      19.3     1.023
        26      86.7    5564.1    -763.7      37.7     -5.17    323.56      18.8     0.950
        29      96.7    5338.8    -788.3      36.1     -5.34    291.41      18.2     0.865
        32     106.7    5347.9    -815.5      36.2     -5.52    272.03      17.5     0.786
        35     116.7    5119.6    -783.5      34.7     -5.30    237.41      16.7     0.698
        38     126.7    5130.8    -770.2      34.7     -5.21    210.24      15.5     0.603
        41     136.7    4665.9    -705.9      31.6     -4.78    168.86      14.2     0.520
        44     146.7    4986.2    -666.7      33.8     -4.51    146.46      12.2     0.444
        47     156.7    4176.3    -500.3      28.3     -3.39     99.86       9.1     0.378
        48     160.1    4201.3    -515.4      28.4     -3.49     99.49       8.1     0.358
        49     163.4    2846.3    -330.8      19.3     -2.24     67.37       8.3     0.342
        50     166.7    2936.4    -338.3      19.9     -2.29     66.34       8.1     0.328
        51     170.1    1819.1    -191.0      12.3     -1.29     39.59       8.2     0.317
        52     173.4    1874.9    -187.9      12.7     -1.27     13.14       7.9     0.305

Absolute        60.0                          40.0                       (T =     30.0 ms)
               106.7                                    -5.52            (T =     65.5 ms)
```

```
                                     CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        7241.8  6826.5  6411.1  5995.8  5580.5  5165.1  4749.8  4334.5  3919.1  3503.8
RX        7241.8  6826.5  6411.1  5995.8  5580.5  5165.1  4749.8  4334.5  3919.1  3503.8
RU        7442.2  7046.9  6651.6  6256.3  5861.0  5465.7  5070.4  4675.2  4279.9  3884.6

RAU =   1855.3 (kips);  RA2 =   2700.7 (kips)

Current CAPWAP Ru = 4030.6 (kips); Corresponding J(RP)= 0.77; J(RX) = 0.77

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   20.86    26.33   5593.5   5801.6   5801.6    1.370    0.062    0.075    409.5   6803.7


                             PILE PROFILE AND PILE MODEL
             Depth               Area         E-Modulus     Spec. Weight           Perim.
                ft                in²               ksi            lb/ft³               ft

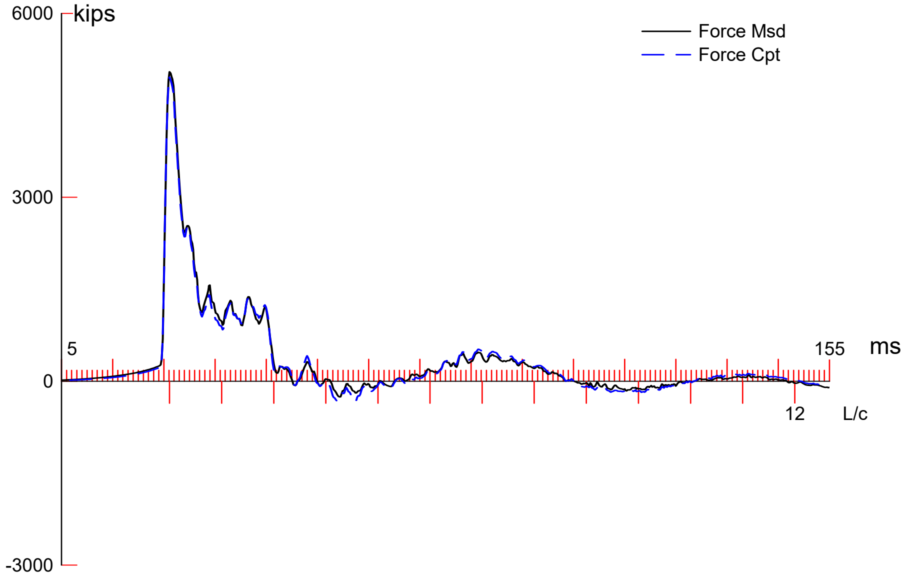
              0.00             147.65           31043.9          492.000           12.566
            173.40             147.65           31043.9          492.000           12.566

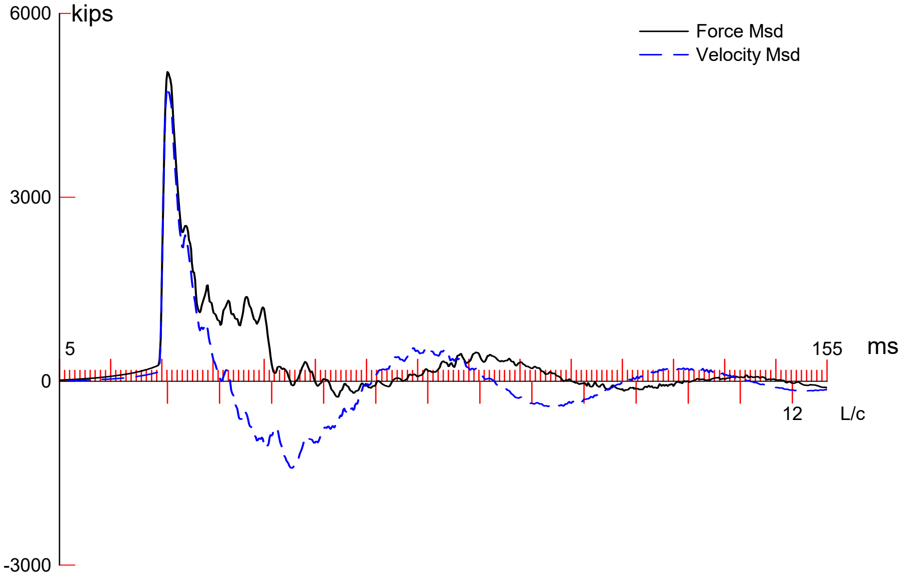
Toe Area                       12.566       ft²

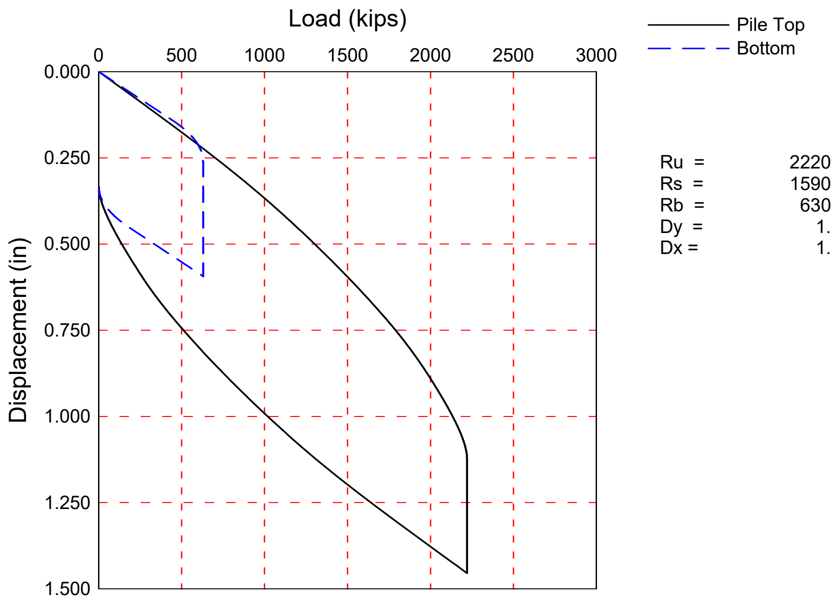
Top Segment Length      3.33 ft, Top Impedance   268.13 kips/ft/s

Pile Damping    1.0 %, Time Incr  0.195 ms, Wave Speed  17100.0 ft/s, 2L/c  20.3 ms
```

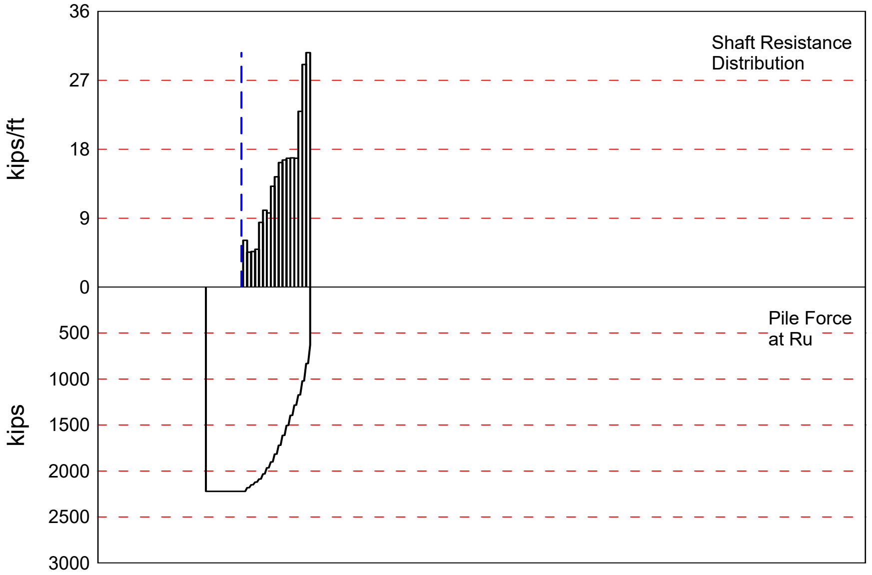
KIWC, POA TPP; Pile: IP 10 RESTRIKE; PP48x1.0", APE D180-42; Blow: 2 (Test: 10-Jun-2016 13:04:) 13-Jun-2016
Robert Miner Dynamic Testing, Inc. CAPWAP(R) 2006-3







Ru = 2220.4 kips
Rs = 1590.4 kips
Rb = 630.0 kips
Dy = 1.12 in
Dx = 1.45 in



```
                                 CAPWAP SUMMARY RESULTS
Total CAPWAP Capacity:   2220.4; along Shaft   1590.4; at Toe    630.0  kips
    Soil     Dist.    Depth       Ru     Force        Sum      Unit      Unit     Smith
   Sgmnt     Below    Below            in Pile         of    Resist.   Resist.   Damping
     No.     Gages    Grade                            Ru    (Depth)   (Area)    Factor
                ft       ft     kips      kips       kips    kips/ft      ksf      s/ft

                                        2220.4
       1      68.9      8.0     40.2    2180.2       40.2      5.04      0.40     0.190
       2      75.5     14.5     30.1    2150.1       70.3      4.58      0.36     0.190
       3      82.1     21.1     30.6    2119.5      100.9      4.66      0.37     0.190
       4      88.6     27.7     32.6    2086.9      133.5      4.96      0.40     0.190
       5      95.2     34.2     55.6    2031.3      189.1      8.47      0.67     0.190
       6     101.8     40.8     66.0    1965.3      255.1     10.05      0.80     0.190
       7     108.3     47.4     63.7    1901.6      318.8      9.70      0.77     0.190
       8     114.9     53.9     86.5    1815.1      405.3     13.17      1.05     0.190
       9     121.5     60.5     94.6    1720.5      499.9     14.41      1.15     0.190
      10     128.0     67.1    106.9    1613.6      606.8     16.28      1.30     0.190
      11     134.6     73.6    109.0    1504.6      715.8     16.60      1.32     0.190
      12     141.2     80.2    110.6    1394.0      826.4     16.84      1.34     0.190
      13     147.7     86.8    110.8    1283.2      937.2     16.87      1.34     0.190
      14     154.3     93.3    110.6    1172.6     1047.8     16.84      1.34     0.190
      15     160.9     99.9    150.7    1021.9     1198.5     22.95      1.83     0.190
      16     167.4    106.5    190.9     831.0     1389.4     29.07      2.31     0.190
      17     174.0    113.0    201.0     630.0     1590.4     30.61      2.44     0.190

  Avg. Shaft                    93.6                         14.07      1.12     0.190

       Toe                     630.0                                   50.13     0.070
Soil Model Parameters/Extensions                       Shaft       Toe

Quake                      (in)                        0.100     0.200
Case Damping Factor                                    1.127     0.164
Unloading Quake            (% of loading quake)           70        80
Reloading Level            (% of Ru)                     100       100
Unloading Level            (% of Ru)                      40
Soil Plug Weight           (kips)                                 0.70

max. Top Comp. Stress      =    33.6 ksi      (T=  26.5 ms, max= 1.030 x Top)
max. Comp. Stress          =    34.6 ksi      (Z=  68.9 ft, T=  30.5 ms)
max. Tens. Stress          =   -4.14 ksi      (Z=  75.5 ft, T=  64.1 ms)
max. Energy (EMX)          =   281.0 kip-ft;  max. Measured Top Displ. (DMX)= 1.08 in
```

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.3	4960.3	-317.2	33.6	-2.15	281.05	18.2	1.133
2	6.6	4961.1	-316.4	33.6	-2.14	280.42	18.2	1.122
5	16.4	4963.9	-394.6	33.6	-2.67	278.54	18.2	1.090
8	26.3	4967.5	-470.1	33.6	-3.18	276.94	18.1	1.059
11	36.1	4972.0	-449.5	33.7	-3.04	274.87	18.1	1.024
14	46.0	4977.6	-515.8	33.7	-3.49	272.30	18.0	0.984
17	55.8	4985.9	-558.5	33.8	-3.78	269.04	18.0	0.940
20	65.7	5074.5	-570.9	34.4	-3.87	265.12	17.6	0.891
23	75.5	4999.7	-610.9	33.9	-4.14	251.95	17.2	0.839
26	85.4	4860.3	-591.6	32.9	-4.01	234.90	16.8	0.786
29	95.2	4898.3	-604.5	33.2	-4.09	224.80	16.2	0.742
32	105.1	4608.9	-531.3	31.2	-3.60	202.86	15.4	0.716
35	114.9	4603.7	-566.2	31.2	-3.83	191.45	14.6	0.687
38	124.8	4212.4	-517.9	28.5	-3.51	164.27	13.6	0.655
41	134.6	4100.4	-446.6	27.8	-3.02	149.10	12.6	0.625
44	144.5	3637.6	-323.1	24.6	-2.19	122.01	11.7	0.599
47	154.3	3588.8	-325.8	24.3	-2.21	108.50	10.7	0.571
50	164.2	2891.4	-202.0	19.6	-1.37	79.78	12.1	0.544
51	167.4	2669.4	-191.9	18.1	-1.30	79.57	12.5	0.538
52	170.7	1816.0	-96.1	12.3	-0.65	59.26	12.7	0.532
53	174.0	1743.1	-99.9	11.8	-0.68	38.43	12.7	0.526
Absolute	68.9			34.6			(T =	30.5 ms)
	75.5				-4.14		(T =	64.1 ms)

```
                                  CASE METHOD
J =          0.0     0.1     0.2     0.3     0.4     0.5     0.6     0.7     0.8     0.9
RP        5530.5  5088.6  4646.8  4205.0  3763.2  3321.4  2879.5  2437.7  1995.9  1554.1
RX        5530.5  5088.6  4646.8  4205.0  3763.2  3321.4  2879.5  2437.7  1995.9  1632.9
RU        5877.8  5470.7  5063.7  4656.6  4249.5  3842.4  3435.3  3028.2  2621.1  2214.1

RAU =    374.8 (kips);  RA2 =   1771.8 (kips)

Current CAPWAP Ru = 2220.4 (kips); Corresponding J(RP)= 0.75; J(RX) = 0.75

     VMX      TVP    VT1*Z      FT1      FMX      DMX      DFN      SET      EMX      QUS
    ft/s       ms     kips     kips     kips       in       in       in   kip-ft     kips
   18.13    26.30   4861.3   5087.4   5087.4    1.079    0.333    0.333    280.4   4766.9


                             PILE PROFILE AND PILE MODEL
                Depth            Area       E-Modulus    Spec. Weight              Perim.
                   ft             in²             ksi           lb/ft³                 ft

                 0.00          147.65         31043.9         492.000              12.566
               174.00          147.65         31043.9         492.000              12.566

Toe Area                       12.566       ft²

Top Segment Length      3.28 ft, Top Impedance   268.13 kips/ft/s

Pile Damping    1.0 %, Time Incr  0.192 ms, Wave Speed  17100.0 ft/s, 2L/c  20.4 ms
```

Appendix D

Field Reports for Pile Installation

(Case Method and CAPWAP results originally included with the Field Reports have been removed from these reproductions of field reports. Case Method and CAPWAP results are now included in Appendix B and C, respectively.)

Robert Miner Dynamic Testing of Alaska Inc.
Dynamic Measurements and Analyses for Deep Foundations

June 8, 2016

Mr. Tanner Vetsch
Kiewit Infrastructure West Company
33455 6th Ave South
Federal Way, WA 98003

Re: Dynamic Pile Measurements and Analyses
IP 1 (Location 5), June 7, 2016
PP48"x1.0", APE 15-4 Hammer
Test Pile Program, Anchorage Municipality Port Modernization
Kiewit Job No 102887 RMDT Job 16F03

Dear Mr. Vetsch,

This report provides results obtained from dynamic pile measurements and analyses completed for the Indicator Pile referenced above. The subject measurements and analyses were completed by Robert Miner Dynamic Testing, Inc. (RMDT) at the request of Kiewit Infrastructure West Company (KIWC).

TEST DETAILS

Pile:
Indicator Pile 1 (IP 1) is a vertical, 195 ft long 48" O.D. open-end steel pipe pile with a wall thickness of 1.00". We understand that the pile material conforms to the specifications of the ASTM A252 Grade 3 and API 5L X52 designations.

Measurement and Analysis Method:
We collected dynamic measurements using strain gages and accelerometers attached to the pile near the pile top. Signals from these sensors were collected and processed using a Pile Driving Analyzer ® (PDA) manufactured by Pile Dynamics, Inc. Following the testing we used the CAPWAP® program to compute the soil resistance acting on the pile. A description of the PDA and CAPWAP methods was included in our report for IP 9 dated May 9, 2016.

Hammer:
An APE 15-4 hydraulically powered hammer drove IP 1 during our dynamic monitoring. The APE 15-4 hammer is reported to have a nominal ram weight and manufacturer’s maximum rated energy of 30 kips and 120 kip-ft, respectively.

Test Sequence:
Installation of IP 1 began on June 7 when the APE 400 vibratory hammer drove IP 1 to a tip elevation of approximately -81 ft. Dynamic testing began at -81 ft when impact driving began, and ended when driving terminated near a tip elevation of -150 ft. The pile tip was approximately 128 ft below the mud line at the conclusion of driving. Table 1 contains information about the test sequence and certain information pertinent to that sequence.

Table 1. Summary of Test Sequence, Location 5		
Indicator Pile No.	**IP 1**	IP 7
Impact Hammer	**APE 15-4**	APE D180-42
Date of Impact Driving	**07 June 2016**	25 May 2016
Pile Length	**195**	200 ft
Mudline Elevation	**-22 ft**	-26
Self-weight Penetration	**20 ft**	approx. 14 ft
Tip El. at Start of Impact Drive	**-81**	approx. -93 ft
Tip El. at Start of PDA Test	**-81**	approx. -93 ft
Tip El. at End of Drive	**-150**	-165 ft
Final Soil Penetration	**128 ft**	139 ft
Final Penetration Resistance	**54/ft**	22/ft
For reference purposes this table includes information for IP 7 which was also at Location 5.		

RESULTS

Case Method Results

Table 2 summarizes selected field Case Method results and other observed details for the end of installation driving. These results include measured transfer energy, EMX, the calculated stroke height, STK, if the D180 hammer was used, and the peak axial compressive driving stress at our sensor location, CSX.

Appendix A contains graphic and numeric summaries of the Case Method Results as a function of pile penetration. The summaries in Appendix A and also the tip elevations referenced for this and all prior Indicator Piles are based on use of the KIWC Pile Driving Record to correlate Case Method results with depth and tip elevation.

During the final one foot interval of driving the measured transfer energy, EMX averaged 89 kip-ft. The computed axial stress, CSX, was typically below 22 ksi and did not exceed 24 ksi.

Soil Resistance

Using a hammer blow from very near the end of driving at a soil depth of 128 ft (Tip El. -150 ft) RMDT completed a CAPWAP analysis to evaluate soil resistance to axial compressive pile loads. Table 3 summarizes the CAPWAP results. Detailed CAPWAP results, including the computed friction distribution appear in Appendix B. Our CAPWAP analyses for the end of driving on IP 1 yielded an ultimate resistance of 690 kips, of which 500 and 190 kips were attributed to shaft friction and end bearing, respectively.

The results presented herein apply to the conditions present when the testing occurred. Please see the cover sheet of Appendix A for information applicable to all of our measurements and analyses for this project.

Please do not hesitate to contact us if you have questions regarding this report or the work we completed for this project. It was a pleasure to work with you and all other project participants.

Sincerely,

ROBERT F. MINER
No. CE 11584

Robert Miner. P.E.

Robert Miner Dynamic Testing of Alaska, Inc.

June 8, 2016

Table 2. Summary of Case Method Results

Pile	Test	Approx. Depth Below Grade (ft)	Approx. Penetration Resistance blows/set	Average Transfer Energy (EMX) kip-ft	Computed Ram Stroke (STK) ft	Comp. Stress (CSX) ksi
IP 3, Loc. 1	Drive	149	64/ft	96	NA	22
IP 4, Loc. 1	Drive	149	30/ft	226	9.7	29
IP 2, Loc. 4	Drive	141	16/ft	226	9.7	30
IP 5, Loc. 4	Drive	144	23/ft	239	10.0	29
IP 6, Loc. 4	Drive	129	84/ft	132	8.9	23
IP 1, Loc. 5	**Drive**	**128**	**54/ft**	**89**	**NA**	**21**
IP 7, Loc. 5	Drive	139	20/ft	236	9.9	29
IP 8, Loc. 6	Drive	105	31/3"	97	NA	22
IP 9, Loc. 6	Drive	115	37/ft	206	9.2	27
IP 10, Loc. 6	Drive	113	77/ft	110	NA	30

For reference purposes this table includes prior results for other piles.

Table 3. Summary of CAPWAP Results

Pile	Hammer	Test	Approx Depth in Soil (ft)	Reported Penetration Resistance blows/set	Computed Soil Resistance, kips		
					Total	Shaft	Toe
IP 3 L1	APE 15-4	Drive	149	64/ft	1240	840	400
IP 4 L1	D180-42	Drive	149 ft	30/ft	1070	940	130
IP 2 L4	D180-42	Drive	141	16/ft	1210	780	430
IP 5 L4	D180-42	Drive	144	23/ft	1340	840	500
IP 6 L4	D180-42	Drive	129	84/ft	900	580	220
IP 1 L5	**APE 15-4**	**Drive**	**128**	**54/ft**	**690**	**500**	**190**
IP 7 L5	D180-42	Drive	139	20/ft	1750	800	850
IP 8 L6	APE 15-4	Drive	105	31/3"	1160	880	280
IP 9 L6	D180-42	Drive	115	37/ft	1310	820	490
IP 10 L6	APE 15-4	Drive	113	77/ft	1190	610	580

For reference purposes this table includes prior results for other piles.

Robert Miner Dynamic Testing of Alaska Inc.
Dynamic Measurements and Analyses for Deep Foundations

May 22, 2016

Mr. Tanner Vetsch
Kiewit Infrastructure West Company
33455 6th Ave South
Federal Way, WA 98003

Re: Dynamic Pile Measurements and Analyses
IP 2 (Location 4), May 19, 2016
PP48"x1.0", APE D180-42 Hammer
Test Pile Program, Anchorage Port Modernization Program
Kiewit Job No 102887 RMDT Job 16F03

Dear Mr. Vetsch,

This report provides results obtained from dynamic pile measurements and analyses completed for the Indicator Pile referenced above. The subject measurements and analyses were completed by Robert Miner Dynamic Testing, Inc. (RMDT) at the request of Kiewit Infrastructure West Company (KIWC).

TEST DETAILS

Pile:

Indicator Pile 2 is a vertical, 200 ft long 48" O.D. open-end steel pipe pile with a wall thickness of 1.00". We understand that the pile material conforms to the specifications of the ASTM A252 Grade 3 and API 5L X52 designations.

Measurement and Analysis Method:

We collected dynamic measurements using four strain gages and four accelerometers attached to the pile near the pile top. Signals from these sensors were collected and processed using a Pile Driving Analyzer ® (PDA) manufactured by Pile Dynamics, Inc. Following the testing we used the CAPWAP® program to compute the soil resistance acting on the pile. A description of the PDA and CAPWAP methods was included in our report for IP 9 dated May 9, 2016.

Hammer:

An APE D180-42 open end diesel hammer drove Indicator Pile 2 (IP 2) during our dynamic monitoring. The APE D180-42 hammer is reported to have a nominal ram weight and manufacturer's maximum rated energy of 39.7 kips and 447 kip-ft, respectively.

Test Sequence:

Installation of IP 2 began on May 19 when the APE 400 vibratory hammer drove IP 2 to a tip elevation of approximately -93 ft, after which the APE D180-42 hammer advanced the pile. Dynamic testing began on May 19 near a tip elevation of -110 ft and ended when driving terminated near a tip elevation of -170 ft. The pile tip was approximately 141 ft below the mud line at the conclusion of driving. Table 1 contains information about the test sequence and certain information pertinent to that sequence.

Table 1. Summary of Test Sequence, Location 4			
	IP 2	IP 5	IP 6
Impact Hammer	**APE D180-42**	APE D180-42	TBD
Date of Impact Driving	**19 May 2016**	18 May 2016	TBD
Pile Length	**200 ft**	200 ft	
Mudline Elevation	**-29 ft**	-29 ft	
Self-weight Penetration	**approx. 14 ft**	approx. 16 ft	
Tip El. at Start of Impact Drive	**approx. -93 ft**	approx. -85 ft	
Tip El. at Start of PDA Test	**-110 ft**	approx. -114 ft	
Tip El. at End of Drive	**-170 ft**	-173 ft	
Final Soil Penetration	**141 ft**	144 ft	
Final Penetration Resistance	**16/ft**	23 blows/ft	

RESULTS

Case Method Results

Table 2 summarizes selected field Case Method results and other observed details for the end of installation driving. These results include measured transfer energy, EMX, the calculated stroke height, STK, if the D180 hammer was used, and the peak axial compressive driving stress at our sensor location, CSX.

Appendix A contains graphic and numeric summaries of the Case Method Results as a function of pile penetration. The summaries in Appendix A and also the tip elevations referenced for this and all prior Indicator Piles are based on use of the KIWC Pile Driving Record to correlate Case Method results with depth and tip elevation.

During the final one foot interval of driving the measured transfer energy, EMX averaged 226 kip-ft and the ram stroke height averaged 9.7 ft. The computed axial stress, CSX, was typically below 30 ksi and did not exceed 31ksi.

Soil Resistance

The Case Method RX7 soil resistance calculations were typically between 550 and 750 kips as the pile was driven from tip elevation -110 to -162 ft. Between -162 and -165 the soil resistance increased markedly, with RX7 resistance values of approximately 1300 kips at -165 ft tip elevation. Most of the resistance increase which occurred between -162 and -165 occurred during the end of that interval. However, very near tip elevation -164 the hammer was stopped for 4 minutes such that some degree of temporary soil setup at that depth may have increased the apparent resistance for reasons other than advancing tip depth. Considering the available data it is our opinion that the largest resistance change with depth was likely to have occurred near tip elevation -165 ft. The Case Method RX7 resistance values ranged from approximately 1300 to 1400 kips from tip elevation -165 to -169, and decreased slightly to 1250 kips near tip elevation -170 where driving halted.

Using a hammer blow from the end of driving at a soil depth of 141ft (Tip El. -170 ft) RMDT completed a CAPWAP analysis to evaluate soil resistance to axial compressive pile loads. Table 2 summarizes the CAPWAP results. Detailed CAPWAP results, including the computed friction distribution appear in Appendix B. Our CAPWAP analyses for the end of driving on IP 2 yielded an ultimate resistance of 1210 kips, of which 780 and 430 kips were attributed to shaft friction and end bearing, respectively.

The results presented herein apply to the conditions present when the testing occurred. Please see the cover sheet of Appendix A for information applicable to all of our measurements and analyses for this project.

Please do not hesitate to contact us if you have questions regarding this report or the work we completed for this project. It was a pleasure to work with you and all other project participants.

Sincerely,

Robert F. Miner

ROBERT F. MINER
No. CE 11584

Robert Miner. P.E.

Robert Miner Dynamic Testing of Alaska, Inc.

May 22, 2016

Table 2. Summary of Case Method Results

Pile	Test	Approx. Depth Below Grade (ft)	Approx. Penetration Resistance blows/set	Average Transfer Energy (EMX) kip-ft	Computed Ram Stroke (STK) ft	Comp. Stress (CSX) ksi
IP 4, Loc. 1	Drive	149	30/ft	226	9.7	29
IP 2, Loc. 4	**Restrike**	**141**	**16/ft**	**226**	**9.7**	**30**
IP 5, Loc. 4	Drive	144	23/ft	239	10.0	29
IP 8, Loc. 6	Drive	105	31/3"	97	NA	22
IP 9, Loc. 6	Drive	115	37/ft	206	9.2	27

For reference purposes this table includes prior results for other piles.

Table 3. Summary of CAPWAP Results

Pile	Hammer	Test	Approx. Depth in Soil (ft)	Reported Penetration Resistance blows/set	Computed Soil Resistance, kips		
					Total	Shaft	Toe
IP 4 L1	D180-42	Drive	149 ft	30/ft	1070	940	130
IP 2 L4	**D180-42**	**Drive**	**141**	**16/ft**	**1210**	**780**	**430**
IP 5 L4	D180-42	Drive	144	23/ft	1340	840	500
IP 8 L6	APE 15-4	Drive	105	31/3"	1160	880	280
IP 9 L6	D180-42	Drive	115	37/ft	1310	820	490

For reference purposes this table includes prior results for other piles.

Robert Miner Dynamic Testing of Alaska Inc.
Dynamic Measurements and Analyses for Deep Foundations

June 6, 2016

Mr. Tanner Vetsch
Kiewit Infrastructure West Company
33455 6th Ave South
Federal Way, WA 98003

Re: Dynamic Pile Measurements and Analyses
IP 3 (Location 1), June 3, 2016
PP48"x1.0" , APE 15-4 Hammer
Test Pile Program, Anchorage Port Modernization Program
Kiewit Job No 102887 RMDT Job 16F03

Dear Mr. Vetsch,

This report provides results obtained from dynamic pile measurements and analyses completed for the Indicator Pile referenced above. The subject measurements and analyses were completed by Robert Miner Dynamic Testing, Inc. (RMDT) at the request of Kiewit Infrastructure West Company (KIWC).

TEST DETAILS

Pile:

Indicator Pile 3 (IP 3) is a vertical, 203 ft long 48" O.D. open-end steel pipe pile with a wall thickness of 1.00". We understand that the pile material conforms to the specifications of the ASTM A252 Grade 3 and API 5L X52 designations.

Measurement and Analysis Method:

We collected dynamic measurements using strain gages and accelerometers attached to the pile near the pile top. Signals from these sensors were collected and processed using a Pile Driving Analyzer ® (PDA) manufactured by Pile Dynamics, Inc. Following the testing we used the CAPWAP® program to compute the soil resistance acting on the pile. A description of the PDA and CAPWAP methods was included in our report for IP 9 dated May 9, 2016.

Hammer:

An APE 15-4 hydraulically powered impact hammer drove IP 3 during our dynamic monitoring. The APE 15-4 hammer is reported to have a nominal ram weight and manufacturer's maximum rated energy of 30 kips and 120 kip-ft, respectively.

Test Sequence:

Installation of IP 3 began on June 3 when the APE 400 vibratory hammer drove IP 3 to a tip elevation of approximately -92 ft, after which the APE 15-4 hammer advanced the pile. Dynamic testing began near tip elevation -92 ft and ended when driving terminated near a tip elevation of -184 ft. The pile tip was approximately 149 ft below the mud line at the conclusion of driving. Table 1 contains information about the test sequence and certain information pertinent to that sequence.

Table 1. Summary of Test Sequence, Location 1		
	IP 3	IP 4
Impact Hammer	**APE 15-4**	APE 15-4 & D180-42
Date of Impact Driving	**3 June 2016**	12 & 13 May2016
Pile Length	**203**	205 ft
Mudline Elevation	**-35 ft**	-26 ft
Self-weight Penetration	**approx. 7 ft**	approx. 17 ft
Tip El. at Start of Impact Drive	**-92**	approx. -92 ft
Tip El. at Start of PDA Test	**-92**	approx. -92 ft
Tip El. at Hammer Change	**NA**	approx. -139 (~113 ft depth)
Tip El. at End of Drive	**-184**	-175 ft
Final Soil Penetration	**149**	149 ft
Final Penetration Resistance	**64/ft**	30 blows/ft (D180-42)
For reference purposes this table includes prior results for other piles at this Location Number.		

RESULTS

Case Method Results

Table 2 summarizes selected field Case Method results and other observed details for the end of installation driving. These results include measured transfer energy, EMX, the calculated stroke height, STK, if the D180 hammer was used, and the peak axial compressive driving stress at our sensor location, CSX.

Appendix A contains graphic and numeric summaries of the Case Method Results as a function of pile penetration. The summaries in Appendix A and also the tip elevations referenced for this and all prior Indicator Piles are based on use of the KIWC Pile Driving Record to correlate Case Method results with depth and tip elevation.

During the final one foot interval of driving the measured transfer energy, EMX, averaged 96 kip-ft and the computed axial stress, CSX, was typically below 29 ksi and did not exceed 30 ksi.

Soil Resistance

Using a hammer blow from very near the end of driving at a soil depth of 149 ft (Tip El. -184 ft) RMDT completed a CAPWAP analysis to evaluate soil resistance to axial compressive pile loads.

Table 3 summarizes the CAPWAP results. Detailed CAPWAP results, including the computed friction distribution appear in Appendix B. Our CAPWAP analyses for the end of driving on IP 3 yielded an ultimate resistance of 1240 kips, of which 840 and 400 kips were attributed to shaft friction and end bearing, respectively

The results presented herein apply to the conditions present when the testing occurred. Please see the cover sheet of Appendix A for information applicable to all of our measurements and analyses for this project.

Please do not hesitate to contact us if you have questions regarding this report or the work we completed for this project. It was a pleasure to work with you and all other project participants.

Sincerely,

Robert F. Miner

ROBERT F. MINER
No. CE 11584

June 6, 2016

Robert Miner. P.E.

Robert Miner Dynamic Testing of Alaska, Inc.

Table 2. Summary of Case Method Results

Pile	Test	Approx. Depth Below Grade (ft)	Approx. Penetration Resistance blows/set	Average Transfer Energy (EMX) kip-ft	Computed Ram Stroke (STK) ft	Comp. Stress (CSX) ksi
IP 3, Loc. 1	**Drive**	**149**	**64/ft**	**96**	**NA**	**22**
IP 4, Loc. 1	Drive	149	30/ft	226	9.7	29
IP 2, Loc. 4	Drive	141	16/ft	226	9.7	30
IP 5, Loc. 4	Drive	144	23/ft	239	10.0	29
IP 6, Loc. 4	Drive	129	84/ft	132	8.9	23
IP 7, Loc. 5	Drive	139	20/ft	236	9.9	29
IP 8, Loc. 6	Drive	105	31/3"	97	NA	22
IP 9, Loc. 6	Drive	115	37/ft	206	9.2	27
IP 10, Loc. 6	Drive	113	77/ft	110	NA	30

For reference purposes this table includes prior results for other piles.

Table 3. Summary of CAPWAP Results

Pile	Hammer	Test	Approx Depth in Soil (ft)	Reported Penetration Resistance blows/set	Computed Soil Resistance, kips		
					Total	Shaft	Toe
IP 3 L1	**APE 15-4**	**Drive**	**149**	**64/ft**	**1240**	**840**	**400**
IP 4 L1	D180-42	Drive	149 ft	30/ft	1070	940	130
IP 2 L4	D180-42	Drive	141	16/ft	1210	780	430
IP 5 L4	D180-42	Drive	144	23/ft	1340	840	500
IP 6 L4	D180-42	Drive	129	84/ft	900	580	220
IP 7 L5	D180-42	Drive	139	20/ft	1750	800	850
IP 8 L6	APE 15-4	Drive	105	31/3"	1160	880	280
IP 9 L6	D180-42	Drive	115	37/ft	1310	820	490
IP 10 L6	APE 15-4	Drive	113	77/ft	1190	610	580

For reference purposes this table includes prior results for other piles.

Robert Miner Dynamic Testing of Alaska Inc.
Dynamic Measurements and Analyses for Deep Foundations

May 17, 2016

Mr. Tanner Vetsch
Kiewit Infrastructure West Company
33455 6th Ave South
Federal Way, WA 98003

Re: Dynamic Pile Measurements and Analyses
IP 4 (Location 1), May 12 & 13, 2016
PP48"x1.0", APE 15-4 Hydraulic Hammer and APE D180-42 Hammer
Test Pile Program, Anchorage Port Modernization Program
Kiewit Job No 102887 RMDT Job 16F03

Dear Mr. Vetsch,

This report provides results obtained from dynamic pile measurements and analyses completed for the Indicator Pile referenced above. The subject measurements and analyses were completed by Robert Miner Dynamic Testing, Inc. (RMDT) at the request of Kiewit Infrastructure West Company (KIWC).

TEST DETAILS

Pile:

Indicator Pile 4 is a vertical, 205 ft long 48" O.D. open-end steel pipe pile with a wall thickness of 1.00". We understand that the pile material conforms to the specifications of the ASTM A252 Grade 3 and API 5L X52 designations.

Measurement and Analysis Method:

We collected dynamic measurements using four strain gages and either two or four accelerometers until the tip reached elevation -171, after which depth we used two of each sensor type as the pile was driven to tip elevation -175. Signals from these sensors were collected and processed using a Pile Driving Analyzer ® (PDA) manufactured by Pile Dynamics, Inc. Following the testing we used the CAPWAP® program to compute the soil resistance acting on the pile. A description of the PDA and CAPWAP methods was included in our report for IP 9 dated May 9, 2016.

Hammer:

On May 12 the APE 15-4 hydraulic impact hammer drove IP 4 to a tip elevation of approximately -139 ft. On May 13 the APE D180-42 drove the pile to tip elevation -175 ft. For an APE 15-4 hammer the nominal ram weight and manufacturer's maximum rated energy are 30 kips and 120 kip-ft, respectively. The APE D180-42 hammer is reported to have a nominal ram weight and manufacturer's maximum rated energy of 39.7 kips and 447 kip-ft, respectively.

Test Sequence:

Installation of IP 4 began on May 12 when the APE 400 vibratory hammer drove IP 4 to a tip elevation of approximately -92 ft. Dynamic testing began on May 12 at the start of impact driving at tip elevation -92 ft. On May 12, near a tip elevation of -139 ft the APE 15-4 was stopped at 4:10 PM and removed from the pile. Impact driving resumed May 13 at 7:40 AM and the APE D180-42 hammer drove IP 4 from -139 to -175 ft tip elevation. Near tip elevation -171 driving paused for 14 minutes while the PDA monitoring sensors were changed so as to accommodate the potential for the sensors to go below the water surface. This change involved removal of all eight sensors in use prior to that depth, and attachment of two strain sensors and two accelerometers, each of which were water resistant. Table 1 contains information about the test sequence and certain information pertinent to that sequence.

Table 1. Summary of Test Sequence, Location 1

	IP 3	**IP 4**
Impact Hammer	TBD	**APE 15-4 & D180-42**
Date of Impact Driving	TBD	**12 & 13 May2016**
Pile Length		**205 ft**
Mudline Elevation		**-26 ft**
Self-weight Penetration		**approx. 17 ft**
Tip El. at Start of Impact Drive		**approx. -92 ft**
Tip El. at Start of PDA Test		**approx. -92 ft**
Tip El. at Hammer Change		**approx. -139 (~113 ft depth)**
Tip El. at End of Drive		**-175 ft**
Final Soil Penetration		**149 ft**
Final Penetration Resistance		**30 blows/ft (D180-42)**

RESULTS

Case Method Results

Table 2 summarizes selected field Case Method results and other observed details for the end of installation driving. These results include measured transfer energy, EMX, the calculated stroke height, STK, if the D180 hammer was used, and the peak axial compressive driving stress at our sensor location, CSX.

Appendix A contains graphic and numeric summaries of the Case Method Results as a function of pile penetration. The summaries in Appendix A are based on use of the KIWC Pile Driving Record to correlate Case Method results with depth.

The APE 15-4 hammer drove IP 4 from 74 ft depth (~Tip El -92) to 114 ft depth (~Tip El -139). Between depths of approximately 76 and 101 ft energy transfer from the hammer to the pile was typically close to 100 kip-ft and was thus typically more than 80 percent of the rated energy of the APE 14-5. The CSX peak axial stress shows a gradual reduction with depth between depths of 90 and 110 ft. Beginning near 101 ft depth a gradual reduction in energy was noticeable until the hammer was removed for maintenance near a depth of 114 ft; for the final two ft of such driving the transfer energy averaged 91 kip ft.

Table 2. Summary of Case Method Results

Pile	Test	Approx. Depth Below Grade (ft)	Approx. Penetration Resistance blows/set	Average Transfer Energy (EMX) kip-ft	Computed Ram Stroke (STK) ft	Comp. Stress (CSX) ksi
IP 4	**Drive**	**149**	**30/ft**	**226**	**9.7**	**29**
IP 8	Drive	105	31/3"	97	NA	22
IP 9	Drive	115	37/ft	206	9.2	27

For reference purposes this table includes prior results for other piles.

Soil Resistance

Comparison of the Case Method soil resistance calculations for May 12 and May 13 suggest that the 14 hour interruption near 114 ft depth (Tip El -139) caused the soil resistance to temporarily increase by a factor of approximately 1.6, or 400 kips. However, in the depth interval surrounding the overnight halt there is also a noticeable change in soil resistance; this condition, coupled with the change in hammer, produce some uncertainty regarding the amount that soil resistance increased during the 14 hour waiting time.

Using a hammer blow from the end of driving at a soil depth of 149 ft (Tip El. -175 ft) RMDT completed CAPWAP analyses to evaluate soil resistance to axial compressive pile loads. Table 2 summarizes the CAPWAP results. Detailed CAPWAP results, including the computed friction distribution appear in Appendix B. Our CAPWAP analyses for the end of driving on IP 4 yielded an ultimate resistance of 1070 kips, of which 940 and 130 kips were attributed to shaft friction and end bearing, respectively.

Table 3. Summary of CAPWAP Results

Pile	Hammer	Test	Approx. Depth in Soil (ft)	Reported Penetration Resistance blows/set	Computed Soil Resistance, kips		
					Total	Shaft	Toe
IP 4	**D180-42**	**Drive**	**149 ft**	**30/ft**	**1070**	**940**	**130**
IP 8	APE 15-4	Drive	105	31/3"	1160	880	280
IP 9	D180-42	Drive	115	37/ft	1310	820	490

For reference purposes this table includes prior results for other piles.

The results presented herein apply to the conditions present when the testing occurred. Please see the cover sheet of Appendix A for information applicable to all of our measurements and analyses for this project.

Please to not hesitate to contact us if you have questions regarding this report or the work we completed for this project. It was a pleasure to work with you and all other project participants.

Sincerely,

Robert Miner. P.E.

Robert Miner Dynamic Testing of Alaska, Inc.

ROBERT F. MINER
No. CE 11584

May 17, 2016

Robert Miner Dynamic Testing of Alaska Inc.
Dynamic Measurements and Analyses for Deep Foundations

May 25, 2016

Mr. Tanner Vetsch
Kiewit Infrastructure West Company
33455 6th Ave South
Federal Way, WA 98003

Re: Dynamic Pile Measurements and Analyses
IP 5 (Location 4), May 18, 2016
PP48"x1.0", APE D180-42 Hammer
Test Pile Program, Anchorage Port Modernization Program
Kiewit Job No 102887 RMDT Job 16F03

Dear Mr. Vetsch,

This report provides results obtained from dynamic pile measurements and analyses completed for the Indicator Pile referenced above. The subject measurements and analyses were completed by Robert Miner Dynamic Testing, Inc. (RMDT) at the request of Kiewit Infrastructure West Company (KIWC).

TEST DETAILS

Pile:

Indicator Pile 5 is a vertical, 200 ft long 48" O.D. open-end steel pipe pile with a wall thickness of 1.00". We understand that the pile material conforms to the specifications of the ASTM A252 Grade 3 and API 5L X52 designations.

Measurement and Analysis Method:

We collected dynamic measurements using four strain gages and four accelerometers attached to the pile near the pile top. Signals from these sensors were collected and processed using a Pile Driving Analyzer ® (PDA) manufactured by Pile Dynamics, Inc. Following the testing we used the CAPWAP® program to compute the soil resistance acting on the pile. A description of the PDA and CAPWAP methods was included in our report for IP 9 dated May 9, 2016.

Hammer:

An APE D180-42 open end diesel hammer drove Indicator Pile 5 (IP 5) during our dynamic monitoring. The APE D180-42 hammer is reported to have a nominal ram weight and manufacturer's maximum rated energy of 39.7 kips and 447 kip-ft, respectively.

Test Sequence:

Installation of IP 5 began on May 18 when the APE 400 vibratory hammer drove IP 5 to a tip elevation of approximately -85 ft, after which the APE D180-42 hammer advanced the pile. Dynamic testing began on May 18 near a tip elevation of -114 ft and ended when driving terminated near a tip elevation of -173 ft. The pile tip was approximately 144 ft below the mud line at the conclusion of driving. Table 1 contains information about the test sequence and certain information pertinent to that sequence.

Table 1. Summary of Test Sequence, Location 4	
	IP 5
Impact Hammer	**APE D180-42**
Date of Impact Driving	**18 May 2016**
Pile Length	**200 ft**
Mudline Elevation	**-29 ft**
Self-weight Penetration	**approx. 16 ft**
Tip El. at Start of Impact Drive	**approx. -85 ft**
Tip El. at Start of PDA Test	**approx. -114 ft**
Tip El. at End of Drive	**-173 ft**
Final Soil Penetration	**144 ft**
Final Penetration Resistance	**23 blows/ft**

RESULTS

Case Method Results

Table 2 summarizes selected field Case Method results and other observed details for the end of installation driving. These results include measured transfer energy, EMX, the calculated stroke height, STK, if the D180 hammer was used, and the peak axial compressive driving stress at our sensor location, CSX.

Appendix A contains graphic and numeric summaries of the Case Method Results as a function of pile penetration. The summaries in Appendix A are based on use of the KIWC Pile Driving Record to correlate Case Method results with depth.

During the final one foot interval of driving the measured transfer energy, EMX averaged 239 kip-ft and the ram stroke height averaged 10.0 ft. These energy and stroke values are somewhat higher than those measured during final driving on previous piles in this program. The computed axial stress, CSX, was typically below 29 ksi and did not exceed 31 ksi.

Soil Resistance

The Case Method RX7 soil resistance calculations were close to 600 kips until the pile tip reached elevation -167.5 ft, after which there was rapid increase to approximately 1300 kips. However, the RX7 values remained near 1300 kips from tip elevation -168 ft to the end of driving near -173 ft.

Using a hammer blow from the end of driving at a soil depth of 144 ft (Tip El. -173 ft) RMDT completed a CAPWAP analysis to evaluate soil resistance to axial compressive pile loads. Table 2 summarizes the CAPWAP results. Detailed CAPWAP results, including the computed friction distribution appear in Appendix B. Our CAPWAP analyses for the end of driving on IP 5 yielded an ultimate resistance of 1340 kips, of which 840 and 500 kips were attributed to shaft friction and end bearing, respectively.

The results presented herein apply to the conditions present when the testing occurred. Please see the cover sheet of Appendix A for information applicable to all of our measurements and analyses for this project.

Please to not hesitate to contact us if you have questions regarding this report or the work we completed for this project. It was a pleasure to work with you and all other project participants.

Sincerely,

Robert F. Miner

ROBERT F. MINER
No. CE 11584

May 18, 2016

Robert Miner. P.E.

Robert Miner Dynamic Testing of Alaska, Inc.

Table 2. Summary of Case Method Results

Pile	Test	Approx. Depth Below Grade (ft)	Approx. Penetration Resistance blows/set	Average Transfer Energy (EMX) kip-ft	Computed Ram Stroke (STK) ft	Comp. Stress (CSX) ksi
IP 4	Drive	149	30/ft	226	9.7	29
IP 5	**Drive**	**144**	**23/ft**	**239**	**10.0**	**29**
IP 8	Drive	105	31/3"	97	NA	22
IP 9	Drive	115	37/ft	206	9.2	27

For reference purposes this table includes prior results for other piles.

Table 3. Summary of CAPWAP Results

Pile	Hammer	Test	Approx. Depth in Soil (ft)	Reported Penetration Resistance blows/set	Computed Soil Resistance, kips		
					Total	Shaft	Toe
IP 4	D180-42	Drive	149 ft	30/ft	1070	940	130
IP 5	**D180-42**	**Drive**	**144**	**23/ft**	**1340**	**840**	**500**
IP 8	APE 15-4	Drive	105	31/3"	1160	880	280
IP 9	D180-42	Drive	115	37/ft	1310	820	490

For reference purposes this table includes prior results for other piles.

Robert Miner Dynamic Testing of Alaska Inc.
Dynamic Measurements and Analyses for Deep Foundations

June 2, 2016

Mr. Tanner Vetsch
Kiewit Infrastructure West Company
33455 6th Ave South
Federal Way, WA 98003

Re: Dynamic Pile Measurements and Analyses
IP 6 (Location 4), June 1, 2016
PP48"x1.0" with Internal Bearing Plate, APE D180-42 Hammer
Test Pile Program, Anchorage Port Modernization Program
Kiewit Job No 102887 RMDT Job 16F03

Dear Mr. Vetsch,

This report provides results obtained from dynamic pile measurements and analyses completed for the Indicator Pile referenced above. The subject measurements and analyses were completed by Robert Miner Dynamic Testing, Inc. (RMDT) at the request of Kiewit Infrastructure West Company (KIWC).

TEST DETAILS

Pile:

Indicator Pile 6 (IP 6) is a vertical, 200 ft long 48" O.D. open-end steel pipe pile with a wall thickness of 1.00". We understand that the pile material conforms to the specifications of the ASTM A252 Grade 3 and API 5L X52 designations. An internal bearing plate was present inside the pile. We understand that the plate is 2" thick, has a central 3" diameter relief hole, is backed with stiffeners and reaction tabs from above, and the plate underside is located 82.5 ft above the pile tip.

Measurement and Analysis Method:

We collected dynamic measurements using strain gages and accelerometers attached to the pile near the pile top. Signals from these sensors were collected and processed using a Pile Driving Analyzer ® (PDA) manufactured by Pile Dynamics, Inc. Following the testing we used the CAPWAP® program to compute the soil resistance acting on the pile. A description of the PDA and CAPWAP methods was included in our report for IP 9 dated May 9, 2016.

Hammer:

An APE D180-42 open-end diesel hammer drove IP 6 during our dynamic monitoring. The APE D180-42 hammer is reported to have a nominal ram weight and manufacturer's maximum rated energy of 39.7 kips and 447 kip-ft, respectively.

Test Sequence:

Installation of IP 6 began on June 1 when the APE 400 vibratory hammer drove IP 6 to a tip elevation of approximately -92 ft, after which the D180-42 hammer advanced the pile. Dynamic testing began near tip elevation -108 ft and ended when driving terminated near a tip elevation of -156 ft. The pile tip was approximately 129 ft below the mud line at the conclusion of driving. Table 1 contains information about the test sequence and certain information pertinent to that sequence.

Table 1. Summary of Test Sequence, Location 4

	IP 2	IP 5	**IP 6**
Impact Hammer	APE D180-42	APE D180-42	**APE D180-42**
Date of Impact Driving	19 May 2016	18 May 2016	**01 June 2016**
Pile Length	200 ft	200 ft	**200 ft**
Mudline Elevation	-29 ft	-29 ft	**-27 ft**
Self-weight Penetration	approx. 14 ft	approx. 16 ft	**approx. 15 ft**
Tip El. at Start of Impact Drive	approx. -93 ft	approx. -85 ft	**approx. -92 ft**
Tip El. at Start of PDA Test	-110 ft	approx. -114 ft	**-108 ft**
Tip El. at End of Drive	-170 ft	-173 ft	**-156 ft**
Final Soil Penetration	141 ft	144 ft	**129 ft**
Final Penetration Resistance	16/ft	23 blows/ft	**84 ft**

For reference purposes this table includes information for other piles at Location 4.

RESULTS

Case Method Results

Table 2 summarizes selected field Case Method results and other observed details for the end of installation driving. These results include measured transfer energy, EMX, the calculated stroke height, STK, if the D180 hammer was used, and the peak axial compressive driving stress at our sensor location, CSX.

Appendix A contains graphic and numeric summaries of the Case Method Results as a function of pile penetration. The summaries in Appendix A and also the tip elevations referenced for this and all prior Indicator Piles are based on use of the KIWC Pile Driving Record to correlate Case Method results with depth and tip elevation.

The KWIC Pile Driving Record for this and other piles is based on observation of the pile relative to the template structure attached to the floating pile barge. Because changes in the tide level effect the position of the template, penetration resistance recorded for each ft on the Pile Driving Record correspond to a distance that is slightly greater than 1 ft if the tide level was falling during driving. To account for this circumstance the Pile Driving Records indicate “No Count” for some depth intervals; this recording method provides suitable piecewise correction to the effect which a gradually lowered template reference would otherwise have on the depths listed in the Pile Driving Record. We have used the KWIC records as if the “No Count” entries were not present because use of those entries would put discontinuities in the plots of results versus depth and thus distract the reader from the trends and more important aspects of the data. The plotted and tabulated depths given in Appendix A are thus correct *for the end of driving*, but diverge in one ft intervals each time a “No Count” entry is present in the logs as one moves *upward* in the logs.

The net effect, with respect to depth information in Appendix A, is that the depths at the end of driving are correct and the depths for the start of monitoring are shown deeper than was actually the case. Such downward shift for the shallowest depths is approximately equal to the number of "No Count" entries in the logs.

During the final one foot interval of driving the measured transfer energy, EMX, averaged 132 kip-ft and the ram stroke height averaged 8.9 ft. The computed axial stress, CSX, was typically below 24 ksi and did not exceed 29 ksi.

The ram stroke heights observed for IP 6 were somewhat lower than those recorded for other piles driven with the D180-42 for this project. We noted, qualitatively, that pile 'elastic' displacement and rebound was markedly higher for this pile at all depths, and especially at intermediate depths. Such elastic rebound is sometimes referred to as "bouncy" driving or a "large quake" condition and is often associated with a reduction in ram stroke height relative to the stroke expected for a diesel hammer operating under otherwise comparable conditions.

The transfer energy values for IP 6 are significantly lower than those for other Indicator Piles driven with the D180-42, and the modestly lower ram stroke heights do not fully account for this lower energy. CAPWAP analyses completed for a hammer blow near 129 ft depth indicate that approximately 100 ft below the PDA sensors a very large and abrupt reduction in energy transfer occured; about one-half of the energy arriving at that zone passed into the pile below that zone. Our sensors were mounted 15 ft from the pile and thus 103 ft from the internal bearing plate. It is our opinion that the interaction between the internal water or soil and the bearing plate markedly reduced energy transfer to the lower portion of the pile. We consider it likely that the energy was mostly reflected upward from the plate and internal soil resistance and thus reduced the maximum energy transfer, EMX, at our sensor location. However, we presently do not have a clear understanding of the wave mechanics associated with this apparent cause for the lower EMX values measured during driving on IP 6.

Soil Resistance

As noted above, an internal bearing plate was present 82.5 ft above the bottom of IP 6. We understand that a 3" diameter relief hole allowed material under the plate to flow upward into the interior of the upper pile section. Given a mudline elevation of -27, this plate reached the mudline when the pile tip was near Tip Elevation -109 ft and the pile depth in soil was approximately 83 ft, and our dynamic monitoring started on IP 6 just prior to that tip elevation. (As discussed above the data in Appendix A is shifted downward and suggests that monitoring started at a lower tip elevation.)

The Case Method RX7 soil resistance calculations were relatively similar for the last 30 ft of driving and were close to 600 kips. However, it is our opinion that the Case Method results are dominated by the behavior of the soil beneath the bearing plate and may thus do not reveal driveability changes normally associated with soil resistance changes much lower on the pile. Moreover, a primary use of Case Method resistance results involves assumed correlation with other methods and comparison of results for different piles and depths. Due to the presence of the bearing plate in IP 6 , such relative comparisons for driveability and resistance are likely to require more data than is presently available.

Using a hammer blow from very near the end of driving at a soil depth of 129 ft (Tip El. -156 ft) RMDT completed a CAPWAP analysis to evaluate soil resistance to axial compressive pile loads.

Table 3 summarizes the CAPWAP results. Detailed CAPWAP results, including the computed friction distribution appear in Appendix B. Our CAPWAP analyses for the end of driving on IP 6 yielded an ultimate resistance of 900 kips, of which 580 and 320 kips were attributed to shaft friction and end bearing, respectively. The total 320 kip end bearing value was split between a computed 220 kips on the bearing plate and 100 kip at the bottom of the pile. However, through our CAPWAP signal matching process the damping on the end bearing associated with the bearing plate was set to 0.8 sec/ft, which value is considered very high. Based, in part, on this high damping value for soil below the bearing plate it is our opinion that there is significant uncertainty regarding the nature of the driving resistance on the bearing plate. Also, the large displacements and rebound observed during driving on IP 6 may cause greater disturbance at the soil pile interface and (temporarily) reduce the shaft friction relative to end-of-drive friction for an open-end pile hich is driven without the larger number of high rebound hammer blows that occurred with IP6. Comparison of end-of-drive friction values for IP 6 and other piles may require extra consideration of such driving disturbance – we anticipate that restrike results for IP 6 will provide more helpful information about shaft friction on IP 6.

Although the CAPWAP computed 900 kip ultimate resistance is the lowest value computed thus far for final drive of an Indicator Pile, the penetration resistance of 84 blows per ft for final driving on IP 6 is significantly higher than values recorded for other piles driven with the D180-42 hammer. We attribute part of the increased penetration resistance (blows per ft) with IP 6 to the lower transfer energy values computed for the sensor location near the pile top of IP6. The average final transfer energy, EMX, was 132 kip-ft, and thus approximately 0.6 times the 227 kip-ft average for final driving on other piles with the D180-42. Moreover, energy transfer computed in CAPWAP analyses for a location approximately 20 ft from the pile toe was far less for IP 6 than for all other piles, including those driven with the APE 15-4 hammer. Reduced energy transfer past the bearing plate and into the bottom portion of the pile would cause a significant reduction in driveability, as would the large elastic rebound noted above. During any restrike on IP 6 the initial soil response may be stiffer on the lower portion and resistance on the plate may be initially reduced such that further information of interest may be obtained.

The results presented herein apply to the conditions present when the testing occurred. Please see the cover sheet of Appendix A for information applicable to all of our measurements and analyses for this project.

Please do not hesitate to contact us if you have questions regarding this report or the work we completed for this project. It was a pleasure to work with you and all other project participants.

Sincerely,

Robert F. Miner

ROBERT F. MINER
No. CE 11584

Robert Miner. P.E.

Robert Miner Dynamic Testing of Alaska, Inc.

June 2, 2016

Table 2. Summary of Case Method Results

Pile	Test	Approx. Depth Below Grade (ft)	Approx. Penetration Resistance blows/set	Average Transfer Energy (EMX) kip-ft	Computed Ram Stroke (STK) ft	Comp. Stress (CSX) ksi
IP 4, Loc. 1	Drive	149	30/ft	226	9.7	29
IP 2, Loc. 4	Drive	141	16/ft	226	9.7	30
IP 5, Loc. 4	Drive	144	23/ft	239	10.0	29
IP 6, Loc. 4	**Drive**	**129**	**84/ft**	**132**	**8.9**	**23**
IP 7, Loc. 5	Drive	139	20/ft	236	9.9	29
IP 8, Loc. 6	Drive	105	31/3"	97	NA	22
IP 9, Loc. 6	Drive	115	37/ft	206	9.2	27
IP 10, Loc. 6	Drive	113	77/ft	110	NA	30

For reference purposes this table includes prior results for other piles.

Table 3. Summary of CAPWAP Results

Pile	Hammer	Test	Approx Depth in Soil (ft)	Reported Penetration Resistance blows/set	Computed Soil Resistance, kips		
					Total	Shaft	Toe
IP 4 L1	D180-42	Drive	149 ft	30/ft	1070	940	130
IP 2 L4	D180-42	Drive	141	16/ft	1210	780	430
IP 5 L4	D180-42	Drive	144	23/ft	1340	840	500
IP 6 L4	**D180-42**	**Drive**	**129**	**84/ft**	**900**	**580**	**220**
IP 7 L5	D180-42	Drive	139	20/ft	1750	800	850
IP 8 L6	APE 15-4	Drive	105	31/3"	1160	880	280
IP 9 L6	D180-42	Drive	115	37/ft	1310	820	490
IP 10 L6	APE 15-4	Drive	113	77/ft	1190	610	580

For reference purposes this table includes prior results for other piles.

Robert Miner Dynamic Testing of Alaska Inc.
Dynamic Measurements and Analyses for Deep Foundations

May 25, 2016

Mr. Tanner Vetsch
Kiewit Infrastructure West Company
33455 6th Ave South
Federal Way, WA 98003

Re: Dynamic Pile Measurements and Analyses
IP 7 (Location 5), May 25, 2016
PP48"x1.0", APE D180-42 Hammer
Test Pile Program, Anchorage Port Modernization Program
Kiewit Job No 102887 RMDT Job 16F03

Dear Mr. Vetsch,

This report provides results obtained from dynamic pile measurements and analyses completed for the Indicator Pile referenced above. The subject measurements and analyses were completed by Robert Miner Dynamic Testing, Inc. (RMDT) at the request of Kiewit Infrastructure West Company (KIWC).

TEST DETAILS

Pile:

Indicator Pile 7 is a vertical, 200 ft long 48" O.D. open-end steel pipe pile with a wall thickness of 1.00". We understand that the pile material conforms to the specifications of the ASTM A252 Grade 3 and API 5L X52 designations.

Measurement and Analysis Method:

We collected dynamic measurements using strain gages and accelerometers attached to the pile near the pile top. Signals from these sensors were collected and processed using a Pile Driving Analyzer ® (PDA) manufactured by Pile Dynamics, Inc. Following the testing we used the CAPWAP® program to compute the soil resistance acting on the pile. A description of the PDA and CAPWAP methods was included in our report for IP 9 dated May 9, 2016.

Hammer:

An APE D180-42 open end diesel hammer drove Indicator Pile 7 (IP 7) during our dynamic monitoring. The APE D180-42 hammer is reported to have a nominal ram weight and manufacturer’s maximum rated energy of 39.7 kips and 447 kip-ft, respectively.

Test Sequence:

Installation of IP 7 began on May 25 when the APE 400 vibratory hammer drove IP 7 to a tip elevation of approximately -93 ft, after which the APE D180-42 hammer advanced the pile. Dynamic testing began at -93 ft when impact driving began, and ended when driving terminated near a tip elevation of -165 ft. The pile tip was approximately 139 ft below the mud line at the conclusion of driving. Table 1 contains information about the test sequence and certain information pertinent to that sequence.

Table 1. Summary of Test Sequence, Location 5	
Indicator Pile No.	IP 7
Impact Hammer	APE D180-42
Date of Impact Driving	25 May 2016
Pile Length	200 ft
Mudline Elevation	-26
Self-weight Penetration	approx. 14 ft
Tip El. at Start of Impact Drive	approx. -93 ft
Tip El. at Start of PDA Test	approx. -93 ft
Tip El. at End of Drive	-165 ft
Final Soil Penetration	139 ft
Final Penetration Resistance	22/ft

RESULTS

Case Method Results

Table 2 summarizes selected field Case Method results and other observed details for the end of installation driving. These results include measured transfer energy, EMX, the calculated stroke height, STK, if the D180 hammer was used, and the peak axial compressive driving stress at our sensor location, CSX.

Appendix A contains graphic and numeric summaries of the Case Method Results as a function of pile penetration. The summaries in Appendix A and also the tip elevations referenced for this and all prior Indicator Piles are based on use of the KIWC Pile Driving Record to correlate Case Method results with depth and tip elevation.

During the final one foot interval of driving the measured transfer energy, EMX averaged 236 kip-ft and the ram stroke height averaged 9.9 ft. The computed axial stress, CSX, was typically below 30 ksi and did not exceed 34 ksi.

Soil Resistance

The Case Method RX7 soil resistance calculations were typically between 400 and 600 kips as the pile was driven from tip elevation -93 to -146 ft (67 to 120 ft depth below mudline) . Between -146 and -156 ft tip elevation (120 to 130 ft depth) soil resistance increased gradually, followed by a marked resistance increase with depth near tip elevation -156 ft. Near the end of driving the Case Method RX7 resistance value averaged approximately 1750 kips.

Using a hammer blow from very near the end of driving at a soil depth of 139 ft (Tip El. -165 ft)

RMDT completed a CAPWAP analysis to evaluate soil resistance to axial compressive pile loads. Table 2 summarizes the CAPWAP results. Detailed CAPWAP results, including the computed friction distribution appear in Appendix B. Our CAPWAP analyses for the end of driving on IP 7 yielded an ultimate resistance of 1750 kips, of which 800 and 850 kips were attributed to shaft friction and end bearing, respectively.

The results presented herein apply to the conditions present when the testing occurred. Please see the cover sheet of Appendix A for information applicable to all of our measurements and analyses for this project.

Please do not hesitate to contact us if you have questions regarding this report or the work we completed for this project. It was a pleasure to work with you and all other project participants.

Sincerely,

Robert F. Miner

ROBERT F. MINER
No. CE 11584

Robert Miner. P.E.

Robert Miner Dynamic Testing of Alaska, Inc.

May 25, 2016

Table 2. Summary of Case Method Results

Pile	Test	Approx. Depth Below Grade (ft)	Approx. Penetration Resistance blows/set	Average Transfer Energy (EMX) kip-ft	Computed Ram Stroke (STK) ft	Comp. Stress (CSX) ksi
IP 4, Loc. 1	Drive	149	30/ft	226	9.7	29
IP 2, Loc. 4	Restrike	141	16/ft	226	9.7	30
IP 5, Loc. 4	Drive	144	23/ft	239	10.0	29
IP 7, Loc. 5	**Drive**	**139**	**20/ft**	**236**	**9.9**	**29**
IP 8, Loc. 6	Drive	105	31/3"	97	NA	22
IP 9, Loc. 6	Drive	115	37/ft	206	9.2	27

For reference purposes this table includes prior results for other piles.

Table 3. Summary of CAPWAP Results

Pile	Hammer	Test	Approx. Depth in Soil (ft)	Reported Penetration Resistance blows/set	Computed Soil Resistance, kips		
					Total	Shaft	Toe
IP 4 L1	D180-42	Drive	149 ft	30/ft	1070	940	130
IP 2 L4	D180-42	Drive	141	16/ft	1210	780	430
IP 5 L4	D180-42	Drive	144	23/ft	1340	840	500
IP 7 L5	**D180-42**	**Drive**	**139**	**20/ft**	**1750**	**800**	**850**
IP 8 L6	APE 15-4	Drive	105	31/3"	1160	880	280
IP 9 L6	D180-42	Drive	115	37/ft	1310	820	490

For reference purposes this table includes prior results for other piles.

Robert Miner

To: Tanner.Vetsch@kiewit.com
Subject: Initial Field Synopsis, IP 8, Location 6, Installed May 3, 2016, AMPM Test Pile

Hi Tanner,

This email transmittal provides a synopsis of my observations and results for the work on IP 8 yesterday, May 3, 2016.

The mudline was reported as approximately -28 ft, the pile self-weight penetration was approximately 6 ft, and the APE 400 hammer advanced the pile from approximately -34 to -84 ft elevation. The APE 15-4 advanced the pile from approximately -84 ft to approximately -133 ft elevation. RMDT collected dynamic measurements during all impact driving – there were approximately 2023 hammer blows and driving ended at about 9:30 PM.

During early driving, perhaps the first 600 blows, the APE 15-4 provided approximately 40 to 45 kip-ft of transfer energy per typical hammer blow. The energy level was later increased and at the end of driving the transfer energy was typically between 89 and 95 kip-ft. An energy transfer of 93 kip-ft represents about 78 percent of the hammers nominal 120 kip-ft maximum rating. In my opinion, the measured transfer ratio values we obtained for the end of driving are within normally expected values for this hammer type driving steel piles.

One attached page provides a plot of the measured force and velocity and computed Case Method results for the final hammer blow on IP 8. For this final hammer blow the average axial driving stress was 21.4 ksi, transfer energy was 95.4 kip-ft, and the measured blows per minute was 26. Based on the Case Method results and review of the force and velocity data I expect that the soil resistance to axial compressive loading will be between 900 and 1100 kips. Although there is appreciable friction, it is my judgement that the last 5 to 7 ft of driving were associated with an increase in end bearing. Visual or qualitative evaluation of the magnitude of end bearing using the force and velocity alone is difficult because the end bearing was not large relative to either the pile impedance or the end reflection which pertained at somewhat shallower depths. CAPWAP analysis will be completed for evaluation of resistance. Preliminary information provided to RMDT suggest that the las full ft of driving yielded approximately 93 blows per ft, and the final several inches of driving may have yielded 10 blows per inch.

Later today I expect to submit the results of CAPWAP analyses for the hammer blow shown on the attached page. This was the final blow and it was a strong blow suitable for CAPWAP analysis.

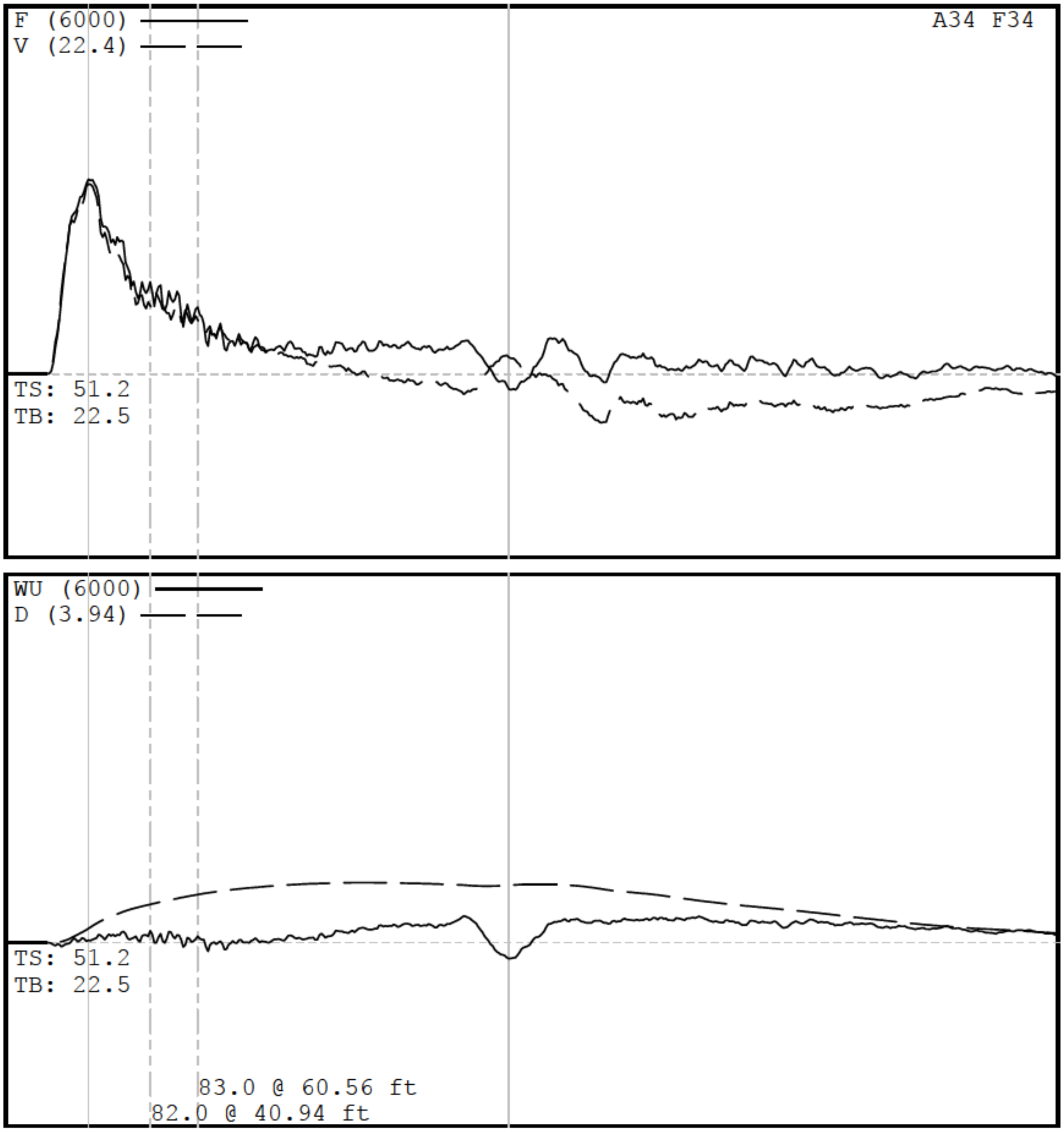
Please do not hesitate to contact me if you or other project participants have questions for me.

Sincerely,

Bert Miner

Robert Miner Dynamic Testing, Inc.
Mail: Box 340, Manchester, WA, 98353
Location: 2288 Colchester Drive East, Manchester, WA 98353
Office: 360-871-5480 Fax: 360-871-5483
Bert's Mobile: 360-981-3317 --
www.pilesound.com

KIWC, POA TPP IP 8 (Loc. 6)



Project Information

PROJECT: KIWC, POA TPP
PILE NAME: IP 8 (Loc. 6)
DESCR: PP48x1.0", APE 15-4
OPERATOR: RMDT
FILE: IP 8_1.W01
5/3/2016 9:29:38 PM
Blow Number 2023

Pile Properties

LE	174.00 ft
AR	147.65 in^2
EM	31052 ksi
SP	0.492 k/ft3
WS	17100.0 f/s
EA/C	268.1 ksec/ft
2L/C	20.40 ms
JC	0.70 []

Quantity Results

CSX	21.4 ksi
CSI	23.9 ksi
EMX	95.4 k-ft
FMX	3161 kips
VMX	11.5 f/s
BPM	26.2 bpm
RX6	1147 kips
RX7	1049 kips
RX9	863 kips

Sensors

F3: [H278] 99 (1)
F4: [H324] 93 (1)
A3: [K3257] 340 mv/5000g's (1)
A4: [K3259] 365 mv/5000g's (1)
CLIP: OK

Robert Miner

To: Tanner.Vetsch@kiewit.com
Subject: Summary of Field Results and CAPWAP Analysis Results, Installation of IP 8, May 3, 2016, AMPM Test Piles

Dear Mr. Vetsch,

This email transmittal provides a summary of results for IP 8, as installed on May 3, 2016.

IP 8 is a 48” OD open-end steel pile having a wall thickness of 1.00” and a total length of 192 ft during installation. IP 8 was installed at Location 6; the mudline elevation was reported as approximately -28 ft, the pile self-weight penetration was approximately 6 ft. An APE 400 vibratory hammer advanced IP 8 from approximately -34 to -84 ft elevation. An APE 15-4 hydraulic impact hammer advanced the pile from approximately -84 ft to approximately -133 ft elevation. RMDT collected dynamic measurements during all impact driving; there were approximately 2023 hammer blows and driving ended at about 8:30 PM.

During early driving, perhaps the first 600 blows, the APE 15-4 provided approximately 40 to 45 kip-ft of transfer energy per typical hammer blow. The energy level was later increased and at the end of driving the transfer energy was typically between 89 and 95 kip-ft. An energy transfer of 93 kip-ft represents about 78 percent of the hammer’s nominal 120 kip-ft maximum rating. In my opinion, the measured transfer ratio values we obtained for the end of driving are within normally expected values for this hammer type driving steel piles.

One attached page provides a plot of the measured force and velocity and computed Case Method results for the final hammer blow on IP 8. For this final hammer blow the average axial driving stress was 21.4 ksi, transfer energy was 95.4 kip-ft, and the measured blows per minute was 26. Preliminary information provided to RMDT suggest that the last full ft of driving yielded approximately 93 blows per ft, and the final several inches of driving may have yielded 10 blows per inch.

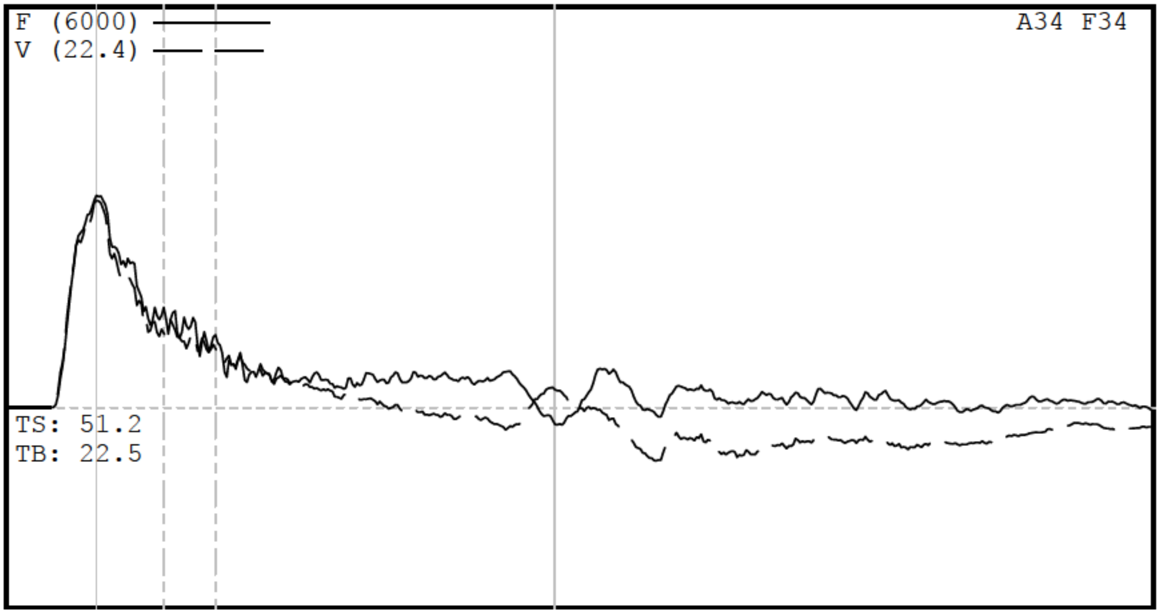
I selected the final hammer blow for CAPWAP analysis of the end of driving. The CAPWAP computed ultimate resistance is 1160 kip, of which 880 and 280 kips were attributed to shaft friction and end bearing, respectively. Attached pages provide detailed CAPWAP output including the compute distribution of the shaft friction.

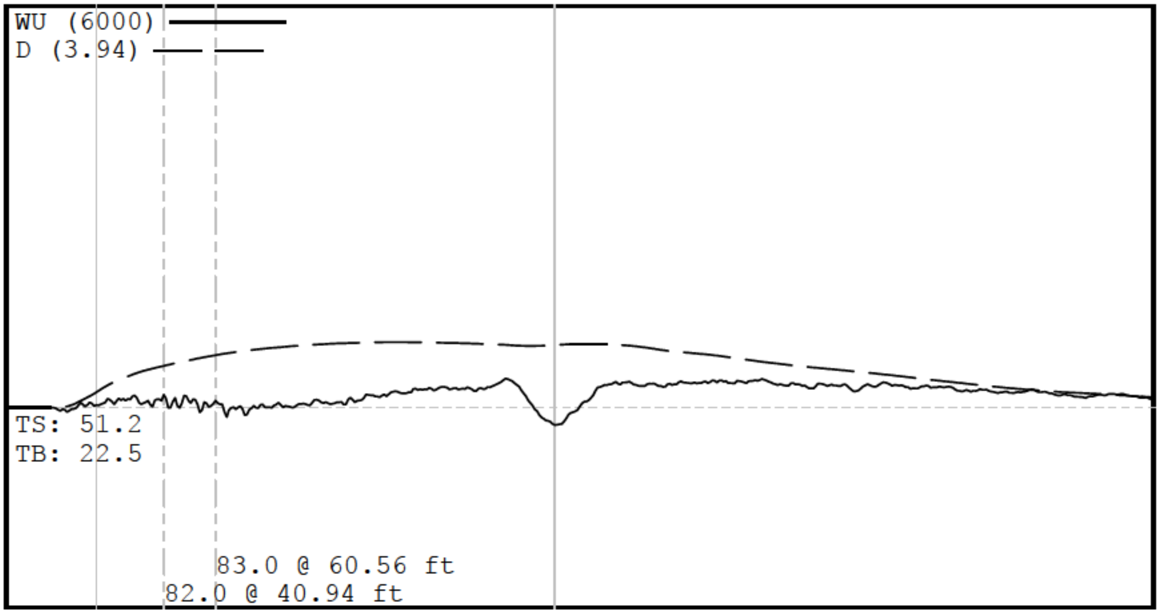
Please do not hesitate to contact me if you or other project participants have questions for me.

Sincerely,

Bert Miner

Robert Miner Dynamic Testing, Inc.
Mail: Box 340, Manchester, WA, 98353
Location: 2288 Colchester Drive East, Manchester, WA 98353
Office: 360-871-5480 Fax: 360-871-5483
Bert’s Mobile: 360-981-3317 --
www.pilesound.com





Project Information

PROJECT: KIWC, POA TPP
PILE NAME: IP 8 (Loc. 6)
DESCR: PP48x1.0", APE 15-4
OPERATOR: RMDT
FILE: IP 8_1.W01
5/3/2016 9:29:38 PM
Blow Number 2023

Pile Properties

LE	174.00 ft
AR	147.65 in^2
EM	31052 ksi
SP	0.492 k/ft3
WS	17100.0 f/s
EA/C	268.1 ksec/ft
2L/C	20.40 ms
JC	0.70 []

Quantity Results

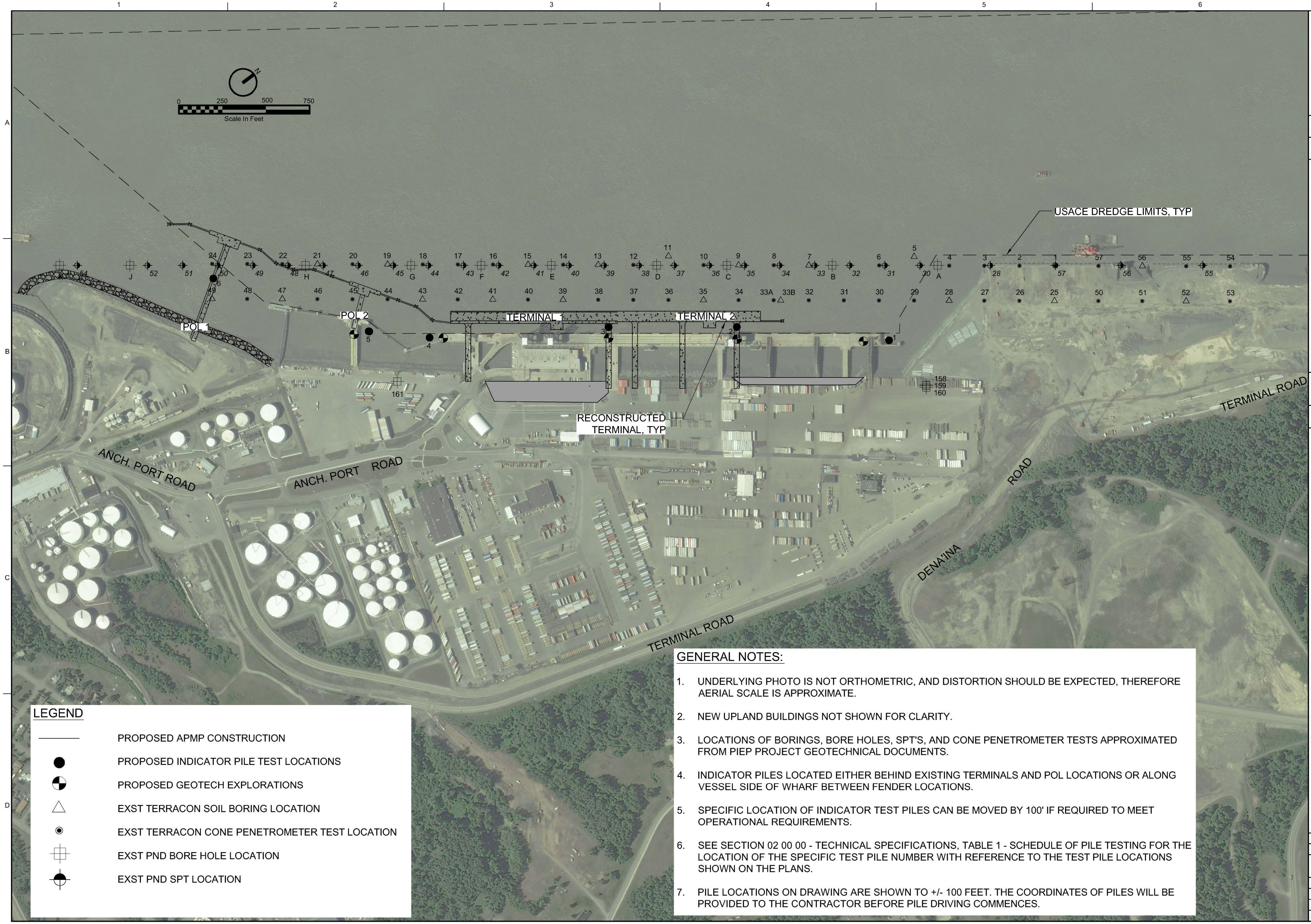
CSX	21.4 ksi
CSI	23.9 ksi
EMX	95.4 k-ft
FMX	3161 kips
VMX	11.5 f/s
BPM	26.2 bpm
RX6	1147 kips
RX7	1049 kips
RX9	863 kips

Sensors

F3: [H278] 99 (1)
F4: [H324] 93 (1)
A3: [K3257] 340 mv/5000g's (1)
A4: [K3259] 365 mv/5000g's (1)
CLIP: OK

Appendix E

Pile Driving Records
(as provided by Kiewit Infrastructure West Company)



LEGEND

——	PROPOSED APMP CONSTRUCTION
●	PROPOSED INDICATOR PILE TEST LOCATIONS
◐	PROPOSED GEOTECH EXPLORATIONS
△	EXST TERRACON SOIL BORING LOCATION
◉	EXST TERRACON CONE PENETROMETER TEST LOCATION
⊞	EXST PND BORE HOLE LOCATION
⊕	EXST PND SPT LOCATION

GENERAL NOTES:

1. UNDERLYING PHOTO IS NOT ORTHOMETRIC, AND DISTORTION SHOULD BE EXPECTED, THEREFORE AERIAL SCALE IS APPROXIMATE.
2. NEW UPLAND BUILDINGS NOT SHOWN FOR CLARITY.
3. LOCATIONS OF BORINGS, BORE HOLES, SPT'S, AND CONE PENETROMETER TESTS APPROXIMATED FROM PIEP PROJECT GEOTECHNICAL DOCUMENTS.
4. INDICATOR PILES LOCATED EITHER BEHIND EXISTING TERMINALS AND POL LOCATIONS OR ALONG VESSEL SIDE OF WHARF BETWEEN FENDER LOCATIONS.
5. SPECIFIC LOCATION OF INDICATOR TEST PILES CAN BE MOVED BY 100' IF REQUIRED TO MEET OPERATIONAL REQUIREMENTS.
6. SEE SECTION 02 00 00 - TECHNICAL SPECIFICATIONS, TABLE 1 - SCHEDULE OF PILE TESTING FOR THE LOCATION OF THE SPECIFIC TEST PILE NUMBER WITH REFERENCE TO THE TEST PILE LOCATIONS SHOWN ON THE PLANS.
7. PILE LOCATIONS ON DRAWING ARE SHOWN TO +/- 100 FEET. THE COORDINATES OF PILES WILL BE PROVIDED TO THE CONTRACTOR BEFORE PILE DRIVING COMMENCES.

NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
M. HAAPALA	S. DONAHUE	J. TAYLOR	D. PLAYTER

ANCHORAGE
PORT MODERNIZATION PROJECT
TEST PILE PROGRAM
ANCHORAGE, ALASKA

CH2MHILL®

PORT OF ANCHORAGE
CIVIL
PROPOSED LOCATIONS OF
PILE TESTS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	
PROJ	491266
DWG	C-02
SHEET	3 of 5

FILENAME: 491266_ConceptD_C2-POA.dwg PLOT DATE: April 22, 2015 PLOT TIME: 6:12 PM

Pile Driving Record

Job Name APMP - Test Pile Program
Contractor Kiewit Infrastructure West Co.
KIWC # 7
Date 6/7/16

Pile Location

Location # 5
Pile # 1

Pile Data

Type 4 FT DIAMETER X 1 IN WALL
Length 195 ft
Weight 103,000

Impact Hammer

Make APE
Model 15 - 4
Ram Wt. 30 000 lbs
Ram Stroke 48 IN
Rated Energy 120000 ft -lb
Cushion Type ALUM/MICARTA
Cap Type STEEL

Vibratory Hammer

Make APE
Model 400
Accessories QUAD BEAMS W/ 4 CLAMPS

Elevation Data

Tide Reading SEE BELOW
Mudline Sounding -22
Reference Description WATER
Pile Tip EL. -150

Noise Abatement

Resonator ____
Confined Bubbles ____
None X

Depth (ft)

VIBE

AD	PD	BPF	Stroke/RPM
-23	1	SELF	08:30
	2	WEIGHT	
-25	3		
	4		
	5		
	6		
	7		
-30	8		
	9		
	10		
	11		
	12		
-35	13		
	14		
	15		
	16		
	17		
-40	18		
	19		
	20		
	21	CLAMPING	09:10
	22	S.START	09:34
★	23	A.START	09:39
	24		
	25	RPM 1570	09:41
	26	DP 1400	
	27	RPM 1690	09:43
-50	28	DP 1800	
	29	RPM 1945	09:47
	30	DP 2500	
	31		
★	32	S/S	09:49/09:51
	33		
	34	RPM 1500	09:54
	35	DP 1500	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	36		
	37	RPM 1540	09:56
-60	38	DP 2000	
	39		
	40	RPM 1540	10:01
	41	DP 2100	
	42		
-65	43	RPM 1750	10:02
	44	DP 2500	
	45		
	46	RPM 1940	10:04
	47	DP 3200	
-70	48		
	49	RPM 1840	10:07
	50	DP 3000	
	51		
	52	RPM 1935	10:15
-75	53	DP 3000	
	54		
	55		
	56		
★	57	S/S	10:11 / 10:13
-80	58		
	59	STOPPED	10:18
	60	S.START	11:40
	61	42	11:44
	62	30	
-85	63	31	
	64	27	
	65	27	
	66	26	
	67	31	
-90	68	26	
	69	26	
	70	26	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	71	27	
	72	27	
-75	73	23	
	74	24	
	75	24	
	76	26	
	77	26	
-100	78	29	
	79	26	
	80	28	
	81	30	
	82	28	
-105	83	29	
	84	29	
	85	27	
	86	30	
	87	NO COUNT	
-110	88	29	
	89	34	
	90	32	
	91	34	
	92	32	
-115	93	18	STOP
	94	36	
	95	35	
	96	34	
	97	39	
-120	98	40	
	99	41	
	100	39	
	101	34	
	102	43	
-125	103	NO COUNT	
	104	38	
	105	39	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	106	39	
	107	39	
-130	108	40	
	109	NO COUNT	
	110	42	
	111	39	
	112	42	
-135	113	41	
	114	41	
	115	44	
	116	40	
	117	45	
-140	118	NO COUNT	
	119	43	
	120	44	
	121	45	
	122	43	
-145	123	NO COUNT	
	124	51	
	125	NO COUNT → INTERFERENCE	
	126	54	
	127	56	
-150	128	54	STOP
	129		13:02
	130		
	131		
	132		
	133		
	134		
	135		
	136		
	137		
	138		
	139		
	140		

Depth (ft)

AD	PD	BPF	Stroke/RPM
	141		
	142		
	143		
	144		
	145		
	146		
	147		
	148		
	149		
	150		
	151		
	152		
	153		
	154		
	155		
	156		
	157		
	158		
	159		
	160	INTERFERENCE	
	161		
	162		
	163		
	164		
	165		
	166		
	167		
	168		
	169		
	170		
	171		
	172		
	173		
	174		
	175		

Depth (ft)

Depth (f		BPF	Stroke/RPM
	176		
	177		
	178		
	179		
	180		
	181		
	182		
	183		
	184		
	185		
	186		
	187		
	188		
	189		
	190	INSIDE	PLUG
	191	ELEVATION	
	192		
	193	BEFORE	R/S: -17.5
	194	AFTER	R/S: -17.5
	195	CHANGE	: 0
	19	PLUG EL: -17.5	
	19		
	198		
	199		
	200		
	201		
	202		
	203		
	204		
	205		
	206		
	207		
	208		
	209		
	210		

6/21/16

Restrike Hammer Info

Make APE
Model D180 - 42
Ram Wt. 59670 lbs
Ram Stroke 135 IN
Rated Energy 446513 ft -lbs
Cushion ALUM/MICARTA
Cap STEEL

*NO NOISE ABATE-MENT

*S.START @14:49

Final Drive	
Depth(in)	Blows/in
0.25	S.START
1	5
2	3
3	4
4	3
5	4
6	4
7	3.
8	4
9	4
10	4

Driving Times		Total Time
Start Vibe	09:34	Vibe
Fin Vibe	10:18	44 MINS
Start Impact	11:40	Impact
Fin Impact	13:02	82 MINS
Start Restrike	14:53	Restrike
Fin Restrike	14:54	1 min

Drive Pressure 1500 - 3200
RPM Range 1500 - 1945

Notes: SOUNDING : TIDE -31 ft - WATER 53 ft = (-22) MUDLINE

SOFT START. VIBE FOR 15 SEC. WAIT 1 MIN. REPEAT 2 MORE TIMES ★ ADJUSTED FOR PLUM ↑↓
S/S STOP/START

↳ WAITED FOR 20 min FOR ALL CLEAR FROM AE/OM.

STOPPED @ D/C SOMETHING ON THE HAMMER BROKE OFF WHILE VIBING. VIBED FOR 38 FT INSTEAD OF 50 FT.

IMPACT DRIVE: 11:51 STOP HAMMER, 11:52 RESUME / STOP 12:15 START 12:19 / STOP 12:56 START / STOP 13:02

Inspector: (print) TYLER JANSSEN (sign) Ty (date) 06/07/16
Bo Youn (Sarah) Bo 6/7/16

TIDE READING

09:10	+32	12:00	+20
09:34	+32	12:18	+18
09:49	+31	12:35	+16
10:05	+30	12:46	+14
10:18	+29		
11:39	+22		

TJ

Pile Driving Record

Job Name APMP - Test Pile Program
Contractor Kiewit Infrastructure West Co.
KIWC # 8
Date 05/19/16

Pile Location
Location # 4
Pile # 2

Pile Data
Type 4 FT DIAMETER X 1 IN WALL
Length 200 FT
Weight 103,000

Impact Hammer
Make APE
Model D180-42
Ram Wt. 59690 lbs
Ram Stroke 135 IN
Rated Energy 446 513 FT-lbs
Cushion Type ALUM / MICARTA
Cap Type STEEL

Vibratory Hammer
Make APE
Model 400
Accessories QUAD BEAM W/ 4 CLAMPS

Elevation Data
Tide Reading SEE BELOW
Mudline Sounding -29
Reference Description HINGED TOWER
Pile Tip EL. -170

Noise Abatement
Resonator X
Confined Bubbles ___
None ___

-13
-14

VIBE

Depth (ft)

AD	PD	BPF	Stroke/RPM	AD	PD	BPF	Stroke/RPM
-30	1	SELF	07:05	★	36	START	8:40
	2	WEIGHT			37		
	3				38	VIBE	
	4				39		
	5				40		
	6			-70	41		
	7				42		
	8				43		
	9				44		
	10				45		
-40	11				46		
	12				47		
-42	13		7:33		48		
-43	14	Hammer On	8:00		49	STOP	8:48
	15	S. START	8:04		50	START	8:50
★	16	STOP/START	8:11/8:12	-80	51		
	17	STOP	8:13		52		
	18	START	8:14		53		
	19				54		
	20				55		
-50	21				56		
★	22	STOP/START	8:19/8:20		57		
	23	STOP	8:22		58		
	24	START	8:25		59		
	25				60		
-55	26	STOP	8:32	-90	61		
	27	START	8:34		62		
	28				63		
	29			-93	64	STOP	8:54
	30			-94	65	S. START	10:28
-60	31				66	22	6.9
	32				67	17	5.4
	33				68	23	5.3
	34				69	18	5.7
★	35	STOP/START	8:30/8:38		70	20	5.7

AD	PD	BPF	Stroke/RPM	AD	PD	BPF	Stroke/RPM
-100	71	18	5.7	-135	106	26	6.3
	72	20	5.8		107	28	6.2
	73	17	5.9		108	27	6.3
	74	19	6.0		109	25	6.4
	75	18	5.9		110	25	6.5
-105	76	16	6.3	-140	111	24	6.5
	77	18	6.1		112	24	6.5
	78	20	6		113	24	6.6
-108	79	★ PDA	SENSORS		114	24	6.5
	80	11	5.5		115	20	6.6
-110	81	23	5.6	-145	116	24	6.5
	82	23	5.7		117	26	6.3
	83	20	5.9		118	24	6.5
	84	22	5.9		119	25	6.6
	85	22	5.8		120	22	6.8
	86	25	5.7	-150	121	21	6.8
	87	24	5.8		122	21	6.9
	88	25	5.8		123	18	7.1
	89	21	6.1		124	18	7.4
	90	20	6.2		125	13	7.9
-120	91	21	6.3	-155	126	16	8.5
	92	21	6.3		127	NO	COUNT
	93	20	6.3		128	11	8.8
	94	20	6.4		129	11	9.0
	95	23	6.3		130	12	9.1
-125	96	23	6.3	-160	131	12	9.2
	97	25	6.4		132	12	9.1
	98	27	6.4		133	12	9.3
	99	25	6.3		134	12	9.2
	100	24	6.3		135	12	8.4
-130	101	25	6.3	-165	136	10	8
	102	34	6.4		137	14	9.7
	103	13	6.4		138	18	9.8
	104	24	6.4		139	16	9.7
	105	22	6.3		140	16	9.7

AD	PD	BPF	Stroke/RPM	Depth (ft)	BPF	Stroke/RPM
-170	141	16	9.6	176		
	142			177		
	143			178		
	144			179		
	145			180		
	146			181		
	147			182		
	148			183		
	149			184		
	150			185		
	151			186		
	152			187		
	153			188		
	154			~~189~~	INSIDE	PLUG
	155			~~190~~	ELEVATION	
	156			~~191~~		
	157			~~192~~	BEFORE R/S: -28	
	158			~~193~~	AFTER R/S: -28	
	159			~~194~~	CHANGE : 0	
	160			195	PLUG EL: -28	
	161			196		
	162			197		
	163			198		
	164			199		
	165			200		
	166			201		
	167			202		
	168			203		
	169			204		
	170			205		
	171			206		
	172			207		
	173			208		
	174			209		
	175			210		

06/09/16

Restrike Hammer Info
Make APE
Model D180-42
Ram Wt. 59690 lbs
Ram Stroke 135 IN
Rated Energy 446513 ft-lbs
Cushion ALUM / MICARTA
Cap STEEL

* NO S. START
*NO NOISE ABATEMENT

Final Drive	
Depth(in)	Blows/in
1	22
2	17
3	16
4	15
5	13
	10 + partial inch

Driving Times		Total Time
Start Vibe	08:04	Vibe
Fin Vibe	08:54	50 min
Start Impact	10:34	Impact
Fin Impact	11:40	66 min
Start Restrike	16:22	Restrike
Fin Restrike	16:24	2 min

Drive Pressure 1800 — 3500
RPM Range 1605 - 1956

Notes: SOUNDING @ 06:56 : 57 ft (57 - 28) = -29 mudline
★ adjusted for plum (typically have been pulling up 5 FT)
SOFTSTART FOR VIBE: VIBE 15 SECONDS WAIT 1min REPEAT 2 MORE TIMES
SOFTSTART FOR IMPACT: STRIKE 2 TIMES 40% ENERGY WAIT 1min REPEAT 2 MORE TIMES.
START IMPACT @ 10:34 → STOP 10:44 TO INSTALL SENSORS → START 11:08
STOP 11:34 TO MANAGE PDA WIRES → STOP 11:40 FINAL (FINAL TOE -170)
HAMMER SETTING: 4 TO START

Inspector: (print) ___ (sign) ___ (date) ___

VIBE HAMMER

TIME	RPM	DP
08:17	1605	2100
08:24	1670	1800
08:28	1650	2500
08:30	1725	2500
08:36	1930	3500
08:53	1955	2500
08:54	1940	3000

Tide Readings

06:53	+28	+11	10:35
07:23	+27	+8	11:15
08:08	+24	+6	11:40
08:29	+22		
08:40	+21		
08:55	+20		

NOTES:
16:19 → 7 dead blows
6 dead blows
3 dead blows
*HAMMER WOULD NOT START

Pile Driving Record

Job Name: APMP - Test Pile Program
Contractor: Kiewit Infrastructure West Co.
KIWC #: 6
Date: 6/3/16

Pile Location
Location #: 1
Pile #: 3

Pile Data
Type: 4 FT DIAMETER x 1 IN WALL
Length: 203
Weight: 103,000

Impact Hammer
Make: APE
Model: 15-4
Ram Wt.: 30 000 lbs
Ram Stroke: 48 IN
Rated Energy: 120,000 ft-lb
Cushion Type: ALUM/MICARTA
Cap Type: STEEL

Vibratory Hammer
Make: APE
Model: 400
Accessories: QUAD BEAMS w/ 4 CLAMPS

Elevation Data
Tide Reading: SEE BELOW
Mudline Sounding: -35
Reference Description: TOP OF BABBLE / TOP OF SLIDER
Pile Tip EL.: -184

Noise Abatement
Resonator: ___
Confined Bubbles: X
None: ___

VIBE

Depth (ft)

AD	PD	BPF	Stroke/RPM
-36	1	SELF	06:55
	2	WEIGHT	
	3		
	4		
-40	5		
	6		
	7	CLAMPING	07:28
	8	S.START	07:32
*	9	A.START	07:37
	10		
	11		
	12	RPM 1745	DP 1800
	13		
	14		
-50	15		
	16		
	17		
	18		
	19	RPM 1940	DP2700
	20	RPM 1940	DP2800
	21		
	22		
	23		
	24		
-60	25		
	26		
	27		
	28		
	29		
	30		
	31		
	32		
	33		
	34		
-70	35		

Depth (ft)

AD	PD	BPF	Stroke/RPM
	36	VIBE	
	37		
	38		
	39		
-75	40		
	41		
	42		
	43	RPM 1935	DP2900
	44		
-80	45		
	46		
	47		
	48		
	49		
	50		
	51		
	52		
	53		
	54		
-90	55		
	56	RPM 1930	DP 3000
-92	57	STOP	08:07
	58	S. START	10:34
	59	28	10:39
	60	36	
	61	29	
	62	20	
!	63	16	
	64	27	
-100	65	30	
	66	32	
	67	35	
	68	31	
	69	33	
	70	NO COUNT	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	71	38	
	72	34	
	73	39	
	74	39	
-110	75	41	
	76	40	
	77	42	
	78	46	
	79	42	
	80	43	
S/S	81	35+28	11:01/11:15
	82	NO COUNT	
	83	51	
	84	44	
-120	85	50	
	86	48	
	87	50	
	88	45	
	89	NO COUNT	
	90	57	
	91	63	
	92	48	
	93	53	
	94	56	
-130	95	NO COUNT	
	96	52	
	97	50	
	98	53	
	99	56	
	100	58	
	101	62	
	102	60	
	103	NO COUNT	
	104	60	
-140	105	60	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	106	66	
	107	64	
	108	58	
	109	62	
	110	66	
	111	68	
	112	65	
	113	NO COUNT	
	114	65	
-150	115	64	
	116	70	
	117	64	
	118	69	—
	119	68	
	120	70	
	121	76	
	122	72	
	123	NO COUNT	
	124	77	
-160	125	73	
S/S	126	28+50	12:20/12:49
	127	75	
	128	83	
	129	79	
	130	78	
	131	87	
	132	74	
	133	85	
	134	83	
-170	135	NO COUNT	
	136	82	
	137	85	
	138	79	
	139	92	
	140	87	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	141	85	
S/S	142	87+77	13:30/13:46
	143	62	
	144	69	
-180	145	65	
	146	66	
	147	65	
	148	62	
**	149	64	14:03
Δ	150	41 / 6in	
	151		
	152		
	153		
	154		
	155		
	156		
	157		
	158		
	159		
	160		
	161		
	162		
	163		
	164		
	165		
	166		
	167		
	168		
	169		
	170		
	171		
	172		
	173		
	174		
	175		

Depth (ft)

Depth (f		BPF	Stroke/RPM
	176		
	177		
	178		
	179		
	180		
	181		
	182		
	183		
	184		
	185		
	186		
	187		
	188		
	189		
	190		
	191	INSIDE	PLUG
	192	ELEVATION	
	193		
	194	BEFORE R/S: -27	
	195	AFTER R/S: -27	
	196	CHANGE: 0	
	197	PLUG EL: -27	
	198		
	199		
	200		
	201		
	202		
	203		
	204		
	205		
	206		
	207		
	208		
	209		
	210		

06/16/16

Restrike Hammer Info
Make: APE
Model: D180 - 46
Ram Wt.: 39690 lbs
Ram Stroke: 135 IN
Rated Energy: 446
Cushion: ALUM/MICARTA
Cap: STEEL

*NO NOISE ABATEMENT
S.START
12:17

Final Drive	
Depth(in)	Blows/in
.5	S.START
1	43
1.001	16
2	28
3	20
4	20
5	

HAMMER DIED MOST BLOWS WEREN'T FULL STROKES

Driving Times		Total Time
Start Vibe	07:32	Vibe
Fin Vibe	08:07	35 min
Start Impact	10:34	Impact
Fin Impact	14:03	209 min
Start Restrike	12:21	Restrike
Fin Restrike	12:27	6 MINS

Drive Pressure: 1800 - 3000
RPM Range: 1745 - 1940

Notes: SOUNDING - TIDE 31 - WATER 66 = -35 MUDLINE
SOFT START VIBE FOR 15 SEC. WAIT 1 MIN. REPEAT 2 MORE TIMES
HYD HAMMER HAD CRACK ON LUMP. DELAYED OPERATION BY 1/2 HR

2nd S/S: GREASED HAMMER
3rd S/S: MOVED SENSORS HIGHER

KEY
* ADJUSTED FOR PLUM ↑↓
! CHANGED REFERENCE POINT. DROVE 0.5ft
S/S STOPPED / STARTED
** STOPPED DRIVING @ -184 DUE TO RISING TIDE
Δ ACCOUNTS FOR 0.5ft LOST WHEN REF CHANGED @ 'PD63'

Inspector: (print) Bo Youn (Sarah) Chae (sign) Bo Yh Ch. (date) 6/3/16

TIDE READINGS

06:55	+30.5	11:18	+7	13:55	-1
07:00	+30	11:25	+6	14:00	0
07:32	+28.5	11:37	+5		
08:07	+24.5	11:53	+4		
10:27	+11	12:12	+2.5		
10:46	+9	12:17	+2		
11:01	+8	13:46	-2		

Page ____ of ____

Pile Driving Record

FINISH DRIVE W/ D180

Job Name: APMP - Test Pile Program
Contractor: Kiewit Infrastructure West Co.
KIWC #: RPS # 4
Date: 05/12/16 → 05/13/16

Pile Location

Location #: 1
Pile #: 4

Pile Data

Type: 4 FT DIAMETER x 1 IN WALL
Length: 205 FT
Weight: 103,000

Impact Hammer

Make: APE
Model: 15-4
Ram Wt.: 30,000 lbs
Ram Stroke: 48 IN
Rated Energy: 120000 ft-lbs
Cushion Type: ALUM/MICARTA
Cap Type: STEEL

Vibratory Hammer

Make: APE
Model: 400
Accessories: 11' QUAD BEAMS w/ 4 CLAMPS

Elevation Data

Tide Reading: SEE BELOW
Mudline Sounding: -26
Reference Description: TOP OF TEMPLATE 12 FT OVER WATER
Pile Tip EL.: -175

Noise Abatement

Resonator: X
Confined Bubbles: ____
None: ____

Depth (ft)

AD	PD	BPF	Stroke/RPM
-27	1		
	2		
	3		
-30	4	PENETRATION	SELF WEIGHT
	5		
	6		
	7		
	8		
-35	9		
	10		
	11		
	12		
	13		
-40	14		
	15		
	16		
-43	17		
	18	S. START	11:44
	19	START	11:57
	20		
	21		
	22		
	23		
-50	24		
	25	STOP	12:00
	26	START	12:05
	27	STOP	12:08
	28	START	12:09
	29	DP 1700	RPM 1790
	30		
	31		
	32		
	33		
-60	34		12:12
	35	DP 2500	RPM 1950

Depth (ft)

AD	PD	BPF	Stroke/RPM
	36		
	37		
	38		
	39		
	40		
	41		
	42		
	43		
-70	44		12:16
	45	DP3000	RPM 1940
	46	STOP	12:16
	47	START	12:18
	48	DP3200	RPM 1935
	49		
	50		
	51		
	52		
	53		
-80	54		
	55		12:21
	56	DP3200	RPM 1930
	57		
	58		
	59		
	60		
	61		
	62		
	63		
-90	64		
	65	DP3500	RPM 1920
-92	66	STOP	12:25
-93	67	S. START	14:56
	68	47	
	69	29	
	70	25	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	71	24	
	72	22	
	73	25	
-100	74	24	
	75	27	
	76	26	
	77	28	15:10
	78	NO COUNT	STOP
	79	38	
	80	31	
	81	33	
	82	31	
	83	29	
-110	84	31	
	85	33	
	86	35	15:22
	87	41	STOP
	88	41	
	89	39	
	90	NO COUNT	
	91	37	
	92	42	
	93	47	15:30
-120	94	39	STOP
	95	41	
	96	39	
	97	58	
	98	47	
	99	45	
	100	47	
	101	46	
	102	59	15:46
	103	No COUNT	STOP
-130	104	52	
	105	69	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	106	56	
	107	No COUNT	15:56
	108	33	STOP
	109	60	
	110	63	
	111	54	
	112	NO COUNT	16:10
-139	113	60	STOP
-140	114	S. START	07:40
156	115	55	6.3
	116	59	6.3
	117	59	6.2
	118	57	6.4
	119	43	6.6
	120	48	6.6
	121	48	6.9
	122	44	6.7
	123	47	6.8
-150	124	50	6.9
	125	43	7.2
	126	41	7.6
	127	36	7.8
	128	32	8.3
	129	28	8.9
	130	22	9.8
	131	21	10
	132	24	9.9
	133	22	9.9
-160	134	24	9.7
	135	25	9.6
	136	26	9.7
	137	23	9.8
	138	23	9.8
	139	26	9.7
	140	26	9.8

Depth (ft)

AD	PD	BPF	Stroke/RPM
	141	26	9.8
	142	26	9.8
	143	27	8.9
-170	144	23	9.8
	145	27	9.6
	146	34	8.6
	147	31	9.3
	148	26	9.6
-175	149	30	9.3
3	150		
	151	FINISH 08:30	
	152		
	153		
4 -180	154		
	155		
	156		
	157		
	158		
-185	159		
	160		
	161		
	162		
	163		
	164		
	165		
	166		
	167		
	168		
	169		
	170		
	171		
	172		
	173		
	174		
	175		

Depth (ft)

Depth (ft)	BPF	Stroke/RPM
176		
177		
178		
179		
180		
181		
182		
183		
184		
185		
186		
187		
188		
189		
190		
~~191~~	INSIDE PLUG	
~~192~~	ELEVATION	
~~193~~		
~~194~~	BEFORE	R/S: +21
~~195~~	AFTER	R/S: +21
~~196~~	CHANGE	: 0
197		
198		
199		
200		
201		
202		
203		
204		
205		
206		
207		
208		
209		
210		

Restrike Hammer Info

Make: APE
Model: D180-46
Ram Wt.: 39690 lbs
Ram Stroke: 135 IN
Rated Energy: 446,513 ft-lbs
Cushion: ALUM/MICARTA
Cap: STEEL

NO NOISE ABATEMENT

S. START 11:06

Final Drive

Depth(in)	Blows/in
1	S. START
2	25
3	14
4	12
5	10

Driving Times		Total Time
Start Vibe	11:44	Vibe
Fin Vibe	12:25	41 MINS
Start Impact	14:56	Impact
Fin Impact	16:10	74 MINS
Start Restrike	11:11	Restrike
Fin Restrike	11:12	1 MIN

FINISH DRIVE W/ D180 07:40 - 08:30 50 MINS

Drive Pressure: 1700-3500
RPM Range: 1790-1950

Notes: SOUNDING @ 09:50 - TIDE READING +24 FT - 47 WATER DEPTH = -26 MUDLINE (BASED ON TIDE BOARD @ NORTH END TERMINAL 3)
SOFTSTART VIBE HAMMER @ 11:44 VIBE 15 SECS WAIT 1MIN REPEAT 2 TIMES MORE - STOP VIBE 12:25
SOFTSTART 15-4 HAMMER @ 14:56 LOWER ENERGY (40%) HIT THREE TIMES WAIT 1MIN REPEAT 2 TIMES MORE.
STOP @ 16:10 DUE TO HAMMER PROBLEMS. PLAN TO FINISH WITH D180 MORNING OF 5/13.
5/13 - SOFT START D180 @ 07:40 TRIP HAMMER ONCE WAIT 1MIN REPEAT 2 TIMES MORE. START DRIVE @ 07:47
STOP DRIVE 08:12 → STOP 08:18 CHANGE SENSORS, START 08:24 → STOP 08:30
START @ SETTING 3 FOR 5 FEET THEN SETTING 4 FOR REMAINDER. TIP OF PILE @ -175

Inspector: (print) TYLER JANSSEN (sign) Ty J (date) 05/13/16

TIDE READINGS

5/12
+25 @ 11:00
+26 @ 11:44
+26 @ 12:23
+16 @ 14:56
+15 @ 15:10
+11 @ 16:00

5/13
+5 @ 0730
+8 @ 0830

Pile Driving Record

Job Name: APMP - Test Pile Program
Contractor: Kiewit Infrastructure West Co.
KIWC #: #9
Date: 05/18/16

Pile Location
Location #: 4
Pile #: 5

Pile Data
Type: 4FT DIAMETER × 1 INCH WALL
Length: 200 FT
Weight: 103,000

Impact Hammer
Make: APE
Model: D180-42
Ram Wt.: 39 690 lbs
Ram Stroke: 135 IN
Rated Energy: 446,513 FT-lbs
Cushion Type: ALUM/MICARTA
Cap Type: STEEL

Vibratory Hammer
Make: APE
Model: 400
Accessories: QUAD BEAM W/ 4 CLAMPS

Elevation Data
Tide Reading: SEE BELOW
Mudline Sounding: -29
Reference Description: HINGED TOWER
Pile Tip EL.: -173

Noise Abatement
Resonator: ____
Confined Bubbles: ____
None: X

VIBE

Depth (ft)

AD	PD	BPF	Stroke/RPM	AD	PD	BPF	Stroke/RPM
-30	1	SELF		-65	36		09:01
	2	WEIGHT			37	STOP	09:02
	3				38	START	09:05
	4				39		
	5				40	VIBE	
	6			-70	41		2500 DP
	7				42		1630 RPM
	8				43		
	9				44		
	10				45		
	11			-75	46	STOP	09:09
	12				47	START	09:12
	13				48		
	14				49	STOP	09:13
	15				50	START	09:14
-45	16			-80	51		
	17	S. START	08:40		52		2500 DP
	18	START	08:45		53		1785 RPM
	19		2000 DP		54		
	20		1715RPM		55		
-50	21	STOP	08:55	-85	56	STOP	09:18
	22	START	08:56		57	S. START	11:21
	23		2500DP		58	START	11:27
	24		1626RPM		59	40	5.6
	25				60	32	5.4
-55	26	STOP	08:52		61	35	5.5
	27	START	08:53		62	27	5.9
	28				63	26	6
	29				64	27	6.1
	30				65	25	6.2
-60	31		2000 DP	-95	66	23	6.2
	32		1630 RPM		67	22	6.2
	33				68	20	6.5
	34				69	27	6.2
	35				70	25	6.1

AD	PD	BPF	Stroke/RPM	AD	PD	BPF	Stroke/RPM
	71	21	6.2	-135	106	11	8.7
	72	22	6.1		107	10	8.6
	73	20	6.3		108	11	8.4
	74	17	6.7		109	10	8.6
	75	21	6.5		110	10	8.6
-105	76	17	6.7	-140	111	11	8.7
	77	16	6.9		112	8	8.6
★	78	14	6.8		113	11	8.7
	79	19	6.9		114	11	8.3
	80	13	7.4		115	11	8.7
	81	11	7.6	-145	116	11	8.7
-111	82	11	8		117	13	8.7
★	83	9	8		118	7	8.7
	84	12	8.4		119	10	8.7
	85	12	8.4		120	12	8.5
-115	86	7	8.4	-150	121	10	8.5
	87	8	8.5		122	10	8.7
	88	10	8.4		123	11	8.9
	89	12	8.2		124	9	8.9
	90	9	8.4		125	10	8.8
-120	91	11	8.5	-155	126	11	8.6
	92	9	8.5		127	10	8.7
	93	9	8.5		128	10	8.9
	94	11	8.7		129	10	9.1
	95	9	8.8		130	11	9
-125	96	10	8.6	-160	131	10	9
	97	9	8.7		132	11	8.9
	98	11	8.5		133	11	8.9
	99	13	8.6		134	12	8.8
	100	11	8.5		135	12	9.1
-130	101	10	8.6	-165	136	12	9.5
	102	11	8.5		137	13	9.7
	103	10	8.4		138	18	9.6
	104	12	8.4		139	17	9.8
	105	10	8.5		140	18	9.9

AD	PD	BPF	Stroke/RPM	Depth (ft)	BPF	Stroke/RPM
-170	141	18	9.9	176		
★	142	24	8.9	177		
	143	26	9.5	178		
-173	144	23	9.9	179		
	145	STOP	12:30	180		
	146			181		
	147			182		
	148			183		
	149			184		
	150			185		
	151			186		
	152			187		
	153			188		
	154			~~189~~	INSIDE PLUG	
	155			~~190~~	ELEVATION	
	156			~~191~~	———	
	157			~~192~~	BEFORE R/S: -28.5	
	158			~~193~~	AFTER R/S: -28.5	
	159			~~194~~	CHANGE: 0	
	160			195	PLUG EL: -28.5	
	161			196		
	162			197		
	163			198		
	164			199		
	165			200		
	166			201		
	167			202		
	168			203		
	169			204		
	170			205		
	171			206		
	172			207		
	173			208		
	174			209		
	175			210		

06/09/16

Restrike Hammer Info
Make: APE
Model: D180-42
Ram Wt.: 39690 lbs
Ram Stroke: 135 IN
Rated Energy: 446,513 FT
Cushion: ALUM/MICARTA
Cap: STEEL

S. START

* NO NOISE ABATEMENT

Final Drive	
Depth(in)	Blows/in
1	28
2	18
3	17
4	15
5	14
	6 * partial inch

Driving Times		Total Time
Start Vibe	08:40	Vibe
Fin Vibe	09:18	38 MINS
Start Impact	11:21	Impact
Fin Impact	12:30	69 MINS
Start Restrike	16:05	Restrike
Fin Restrike	16:11	6 min

Drive Pressure: 2000-2500
RPM Range: 1626-1785

Notes: SOUNDING @ 7:30 : +24 - 53 FT DEPTH = -29 MUDLINE AFTER MOVING FARTHER IN SHORE
STOP @ 09:18 DUE TO MAMMAL OBS VIEW OBSTRUCTED - WEATHER
SOFT START W/ VIBE : VIBE 15 SEC WAIT 1MIN REPEAT 2 MORE TIMES
SOFT START W/ IMPACT: 3 STRIKES @ 40% ENERGY WAIT 1MIN REPEAT 2 MORE TIMES
★ STOP @ 11:40 / START -> STOP AGAIN 11:42 TO INSTALL PDA SENSORS.
★A DRIVE ADDITIONAL 2 FT PER BERT MINER, END 12:30
HAMMER ON SETTING 3 FOR FIRST 20 FT THEN BUMPED TO SETTING 4 FOR REMAINDER OF DRIVE

Final TOE @ -173

Inspector: (print) TYLER JANSSEN (sign) Ty (date) 05/18/16

TIDE READINGS

07:01	+26
07:21	+25
08:40	+18
09:05	+16
09:12	+15.5
11:22	+6
12:30	+2

Pile Driving Record

Job Name APMP - Test Pile Program
Contractor Kiewit Infrastructure West Co.
KIWC # 10
Date 6/1/16

Pile Location
Location # 4
Pile # 6

Pile Data
Type 4 FT DIAMETER X 1 IN WALL
Length 200 ft
Weight 103,000

Impact Hammer
Make APE
Model D180-42
Ram Wt. 59690 lbs
Ram Stroke 135 IN
Rated Energy 446513 ft-lbs
Cushion Type ALUM/MICARTA
Cap Type STEEL

Vibratory Hammer
Make APE
Model 400
Accessories QUAD BEAM W/4 CLAMPS

Elevation Data
Tide Reading SEE BELOW
Mudline Sounding -27
Reference Description HINGED TOWER
Pile Tip EL. -156

Noise Abatement
Resonator ____
Confined Bubbles X
None ____

Depth (ft)

AD	PD	BPF	Stroke/RPM
-28	1	SELF	05:45
	2	WEIGHT	
-30	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
-40	13		
	14	↓	
	15	CLAMPING	06:37
	16	S START	06:42
*	17	A.START	06:48
	18		
	19	RPM 1400	DP 1490
	20		
	21	RPM 1775	DP 2400
	22		
-50	23		
	24		
	25		
	26	RPM 1945	DP 2500
	27		
	28		
	29		
	30		
	31		
	32		
-60	33		
	34		
	35		

VIBE ↓

Depth (ft)

AD	PD	BPF	Stroke/RPM
	36	VIBE	
	37		
	38		
	39	↓	
	40	RPM 1870	DP 2800
	41		
	42		
-70	43		
	44		
	45		
	46		
	47	↓	
	48		
*	49	STOP/START	07:12/07:14
	50		
	51		
	52	↓	
-80	53	RPM 1930	DP 3000
	54	↓	
	55	RPM 1920	DP 3,500
	56		
	57		
	58		
	59		
	60		
	61		
	62		
-90	63		
	64	↓	
-92	65	STOP	07:32
	66	S.START	09:08
	67	14	09:16
	68	NO COUNT	
	69	14	5.1
	70	17	5.3

Depth (ft)

AD	PD	BPF	Stroke/RPM
	71	20	5.2
	72	18	5.1
-100	73	22	5.3
	74	23	5.3
	75	23	5.4
	76	22	5.8
	77	21	6.0
	78	22	5.9
	79	24	5.9
	80	22	6.2
PDA	81	24	5.8
	82	NO COUNT	
-110	83	10 + 14	5.8
	84	24	6.1
	85	23	6.2
	86	25	6.3
	87	28	6.3
	88	36	6.3
	89	34	6.5
	90	32	6.4
	91	33	6.6
	92	37	6.6
-120	93	44	6.5
	94	40	6.9
	95	24	8.1
	96	24	8.8
	97	28	8.6
	98	29	8.9
◎	99	34	8.9
	100	30	8.9
	101	36	8.9
	102	38	8.8
-130	103	36	8.7
	104	37	8.8
	105	41	8.8

Depth (ft)

AD	PD	BPF	Stroke/RPM
	106	41	9.0
	107	40	8.9
	108	47	8.8
	109	47	8.9
	110	47	8.7
	111	NO COUNT	
	112	58	8.8
-140	113	55	9.2
	114	56	9.0
	115	55	9.1
	116	58	9.1
	117	70	9.1
	118	NO COUNT	
	119	72	8.7
	120	76	9.0
	121	81	9.1
	122	63	8.9
-150	123	87	8.7
	124	79	8.8
	125	72	8.9
	126	NO COUNT	
	127	70	8.7
	128	79	8.7
-156	129	84	8.8
	130	STOP @	10:38
	131		
	132		
	133		
	134		
	135		
	136		
	137		
	138		
	139		
	140		

Depth (ft)

AD	PD	BPF	Stroke/RPM
	141		
	142		
	143		
	144		
	145		
	146		
	147		
	148		
	149		
	150		
	151		
	152		
	153		
	154		
	155		
	156		
	157		
	158		
	159		
	160		
	161		
	162		
	163		
	164		
	165		
	166		
	167		
	168		
	169		
	170		
	171		
	172		
	173		
	174		
	175		

Depth (ft)

Depth (f		BPF	Stroke/RPM
	176		
	177		
	178		
	179		
	180		
	181		
	182		
	183		
	184		
	185		
	186		
	187		
	188		
	189		
	190	INSIDE	PLUG
	191	ELEVATION	
	192		
	193	NO MEASUREMENT	
	194	BEARING	PL
	195	IS ~ 82 FT	
	196	FROM	BTM/TIP
	197	OF PILE.	
	198		
	199		
	200		
	201		
	202		
	203		
	204		
	205		
	206		
	207		
	208		
	209		
	210		

6/21/16

Restrike Hammer Info
Make APE
Model D180-42
Ram Wt. 59690 lbs
Ram Stroke 135 IN
Rated Energy 446513 ft-lbs
Cushion ALUM/MICARTA
Cap STEEL

*NO NOISE ABATEMENT

*NO S.START

Final Drive

Depth(in)	Blows/in
1	4
2	3
3	5
4	6
5	5
6	5
≈ 6 7/8"	6

Driving Times		Total Time
Start Vibe	06:42	Vibe
Fin Vibe	07:32	50 min
Start Impact	09:08	Impact
Fin Impact	10:38	90 min
Start Restrike	13:47	Restrike
Fin Restrike	13:49	2 min

Drive Pressure 1490 - 3500
RPM Range 1400 - 1945

Notes: SOUNDING @ 4:50 . TIDE - WATER DEPTH = 29 - 56 = -27 MUDLINE
SOFTSTART FOR VIBE FOR 15 SEC. WAIT 1 MIN. REPEAT 2 MORE TIMES
SOFT START FOR D180: STRIKE 3 times 40% ENERGY. WAIT 1 MIN. REPEAT 2 MORE TIMES

@ 09:22 STOPPED FOR PDA SENSORS. STARTED @ 09:45
6 extra blows @ the end.
SETTING ~~#2~~ @ the BEGINNING. # 4 @ 2ND START (09:45)

* adjust for plum ↑↓
PDA STOPPED FOR PDA SENSORS
◎ BUBBLE CURTAIN ON
} KEY

Inspector: (print) Bo Youn (Sarah) Chae (sign) Bo Youn C (date) 6/1/16

TIDE READINGS

04:50	+29
05:45	+26.5
06:41	+22
06:52	+21
07:10	+19
07:20	+18
07:28	+17.5
07:31	+17
09:08	+9
09:24	+8
09:45	+6.5
10:19	+4
10:30	+3

Pile Driving Record

Job Name APMP - Test Pile Program
Contractor Kiewit Infrastructure West Co.
KIWC # 1
Date 5/25/16

Pile Location
Location # 5
Pile # 7

Pile Data
Type 4FT DIAMETER X 1 IN WALL
Length 200FT
Weight 103,000

Impact Hammer
Make APE
Model D180-42
Ram Wt. 59690 lbs
Ram Stroke 135 IN
Rated Energy 446513 ft-lbs
Cushion Type ALUM/MICARTA
Cap Type STEEL

Vibratory Hammer
Make APE
Model 400
Accessories QUAD BEAM W/4 CLAMPS

Elevation Data
Tide Reading SEE BELOW
Mudline Sounding -26
Reference Description HINGED TOWER
Pile Tip EL. -165

Noise Abatement
Resonator ___
Confined Bubbles X
None ___

VIBE

Depth (ft)

AD	PD	BPF	Stroke/RPM
-27	1	SELF	08:46
	2	WEIGHT	
	3		
-30	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
-40	14		
	15		
	16		
-47	17	CLAMPING	9:01
	18	S.START	11:00
	19	A.START	11:05
	20		
	21	DP 2000	RPM 1775
	22		
	23		
	24		
	25		
	26		
	27		
	28		
	29		
	30		
★	31	STOP/START	11:11/11:13
	32		
	33		
-60	34		
	35		

Depth (ft)

AD	PD	BPF	Stroke/RPM
	36	VIBE	
	37		
	38		
	39		
	40		
	41		
	42		
	43		
-70	44		
	45		
	46		
	47		
★	48	STOP/START	11:17/11:19
	49		
	50		
	51		
	52		
	53		
-80	54		
▲	55	STOP/START	11:23/11:29
	56		
	57	DP 2910	RPM 1946
	58	DP 2900	RPM 1945
	59		
	60		
	61		
	62		
	63		
-90	64		
	65		
	66		
-73	67	STOP	11:34
	68	S.START	13:31
	69	27	5.5
	70	17	5.3

Depth (ft)

AD	PD	BPF	Stroke/RPM
	71	20	5.3
?	72	9+?	5.3
	73	NO COUNT	
-100	74	23	5.1
	75	32	4.9
	76	31	5.1
	77	25	5.4
	78	23	5.6
	79	23	5.6
	80	25	5.5
	81	28	5.4
	82	27	5.5
	83	30	5.5
-110	84	NO COUNT	
	85	26	5.5
	86	26	5.6
	87	20	5.8
	88	22	5.8
	89	22	5.8
	90	22	6.0
	91	18	6.1
	92	21	6.1
	93	19	6.1
-120	94	24	6.2
	95	28	6.1
	96	22	6.3
	97	21	6.3
	98	23	6.0
	99	22	6.0
	100	20	6.2
	101	20	6.2
	102	19	6.4
	103	22	6.2
-130	104	23	6.2
	105	24	6.2

Depth (ft)

AD	PD	BPF	Stroke/RPM
	106	22	6.3
	107	23	6.2
?	108	11+?	6.2
	109	22	6.4
	110	25	6.2
	111	22	6.3
	112	21	6.5
	113	25	6.3
-140	114	22	6.4
	115	26	6.3
	116	23	6.4
	117	23	6.3
	118	23	6.5
	119	22	6.6
	120	NO COUNT	
	121	19	6.9
	122	17	7.0
	123	20	7.0
-150	124	17	7.3
	125	17	7.6
	126	16	8.3
	127	12	8.7
	128	12	9.0
	129	11	9.2
	130	12	9.3
	131	14	9.6
	132	15	9.8
S/S	133	17	9.6
-160	134	17	9.4
STOP	135	30	9.6
★★	136	12	9.5
	137	20	9.7
	138	22	9.7
-165	139	22	9.8
△	140	5	7.3

Depth (ft)

AD	PD	BPF	Stroke/RPM
	141		
	142		
	143		
	144		
	145		
	146		
	147		
	148		
	149		
	150		
	151		
	152		
	153		
	154		
	155		
	156		
	157		
	158		
	159		
	160		
	161		
	162		
	163		
	164		
	165		
	166		
	167		
	168		
	169		
	170		
	171		
	172		
	173		
	174		
	175		

Depth (ft)

Depth (f	BPF	Stroke/RPM
176		
177		
178		
179		
180		
181		
182		
183		
184		
185		
186		
187		
~~188~~	INSIDE	PLUG
~~189~~	ELEVATION	
~~190~~		
~~191~~	BEFORE R/S: -24	
~~192~~	AFTER R/S: -24.75	
~~193~~	CHANGE: -0.75	
	PLUG EL: -24.75	
196		
197		
198		
199		
200		
201		
202		
203		
204		
205		
206		
207		
208		
209		
210		

6/8/16

Restrike Hammer Info
Make APE
Model D180-42
Ram Wt. 59690 lbs
Ram Stroke 135 IN
Rated Energy 446513 ft-lbs
Cushion ALUM/MICARTA
Cap STEEL

* S.START
*NO NOISE ABATE-MENT

Final Drive	
Depth(in)	Blows/in
1	21
2	14
3	10
4	6
5	5
6	6
7	5

Driving Times		Total Time
Start Vibe	11:00	Vibe
Fin Vibe	11:34	34 min
Start Impact	13:31	Impact
Fin Impact	14:37	66 min
Start Restrike	13:36	Restrike
Fin Restrike	13:41	5 min

Drive Pressure 2000 - 2900
RPM Range 1775 - 1946

Notes: SOUNDING : 21.5 - 47.5 = -26 MUDLINE
B.WHALE SIGHTING @ 9:30. OPERATION STOPS.
SOFT START FOR VIBE: VIBE 15 SEC. WAIT 1 MIN. REPEAT 2 MORE TIMES.
SOFT START FOR IMPACT: STRIKE 3 TIMES 40% ENERGY. WAIT 1 MIN. REPEAT 2 MORE TIMES.
↳ COUNTED 14 BLOWS FOR SOFT START
1st BLOW COUNT WAS FOR 1.5 FT
HAMMER SETTING STARTED @ 3, CHANGED TO 4 @ TOE -110. FINISHED DRIVING @ 14:37.

KEY → ★ ADJUSTED FOR PLUM ↑↓
▲ ADJUSTED BUBBLE CURTAIN
? ACCIDENTALLY HIT A WRONG BUTTON. STOPPED COUNTING BLOWS
△ BLOWS SLIGHTLY PAST THE FOOT
S/S STOP/START for COMMUNICATION. (14:09)
★★ SENSOR CHANGE @ 14:20

Inspector: (print) Bo Youn (Sarah) Chae (sign) Bo Y. Ch. (date) 5/25/16

ADDITIONAL NOTES:
NEW SENSORS STARTING AT PD 136, TOE -162

TIDE READING

08:46	+27
09:15	+28
10:41	+27
10:55	+26
11:15	+25
13:31	+13
14:30	+8

Indicator Pile Driving Re

Page ___ of ___

Pile Driving Record

KIWC # RPS # 5

Date 5/03/16

Job Name APMP - Test Pile Program
Contractor Kiewit Infrastructure West Co.

Pile Location
Location # 6 Pile # 8

Pile Data
Type 4 FT DIAMETER X 1 IN WALL
Length 191.5 FT Weight 103,000 lbs

Impact Hammer
Make APE Model 15-4
Ram Wt. 30,000 lbs Ram Stroke 48 IN
Rated Energy 120,000 ft-lbs
Cushion Type ALUM/MICARTA Cap Type STEEL

Vibratory Hammer
Make APE
Model 400
Accessories QUAD BEAMS & 4 CLAMPS

Elevation Data
Tide Reading SEE BELOW
Mudline Sounding -28
Reference Description TOP OF TEMPLATE +12 FROM WATER
Pile Tip EL -133

Noise Abatement
Resonator X
Confined Bubbles ___
None ___

Depth (ft) CUT OFF 13'6"

AD	PD	BPF	Stroke/RPM
-29	1	SELF WT. PENETRATION	
	2		
	3		
	4		
	5		
	6		
-35	7	SOFT S.	16:28
	8	START	16:29
	9		RPM
	10	V	1942
	11	I	
	12	B	
	13	E	
	14		
	15		
	16		
-45	17		
	18		
	19		
	20		
	21		
	22		
	23		
	24	STOP	16:32
	25	START	16:42
	26	STOP	16:46
-55	27	START	16:48
	28	STOP	16:53
	29	START	16:55
	30		
	31	V	
	32	I	
	33	B	
	34	E	RPM
	35		1936

Depth (ft)

AD	PD	BPF	Stroke/RPM
	36	V	RPM
-65	37	I	1936
	38	B	
	39	E	
	40		
	41		
	42		
	43		
	44		
	45		
	46		
-75	47		
	48		
	49		
	50		
	51		
	52		
	53		
	54		
	55		
-84	56		17:03
	57	SOFT S.	19:09
	58	22	
	59	30	
	60	40	
	61	26	
	62	28	
	63	26	
	64	24	
	65	41	
	66	27	
-95	67	30	
★	68	NO BLOW COUNT	
	69	28	
	70	33	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	71	35	
	72	33	
	73	40	
	74	41	
	75	43	
	76	42	
-105	77	44	
	78	54	
★	79	NO BLOW COUNT	
	80	35	
	81	42	
	82	41	
	83	41	
	84	37	
	85	38	
	86	40	
-115	87	45	
	88	38	
	89	41	
★	90	NO BLOW COUNT	
	91	39	
	92	33	
	93	38	
	94	53	
	95	60	
	96	53	
-125	97	50	
	98	83	
	99	100	
	100	84	
★	101	NO BLOW COUNT	
	102	93	
	103	88	
	104	93	
-133	105	31	

Depth (ft)

AD	PD	BPF	Stroke/RPM
	106		
	107		
	108		
	109		
	110		
	111		
	112		
	113		
	114		
	115		
	116		
	117		
	118		
	119		
	120		
	121		
	122		
	123		
	124		
	125		
	126		
	127	31 BLOWS/3IN	
	128		
	129	PARTIAL	FOOT
	130	BLOWS	RECORDED
	131	DUE TO	REFUSAL
	132		
	133	REFUSAL=	10
	134		BLOWS
	135		
	136		INCH
	137		
	138		
	139		
	140		

Depth (ft)

AD	PD	BPF	Stroke/RPM
	141		
	142		
	143		
	144		
	145		
	146		
	147		
	148		
	149		
	150		
	151		
	152		
	153		
	154		
	155		
	156		
	157		
	158		
	159		
	160		
	161		
	162		
	163		
	164		
	165		
	166		
	167		
	168		
	169		
	170		
	171		
	172		
	173		
	174		
	175		

Depth (ft)

Depth (ft)	BPF	Stroke/RPM
176		
177		
178		
179		
180		
181		
182		
183		
184		
185		
186		
187		
188		
~~189~~	INSIDE	PLUG
~~190~~	ELEVATION	
~~191~~		
~~192~~	BEFORE R/S: -20.5	
~~193~~	AFTER R/S: -20.5	
~~194~~	CHANGE :	0
195	PLUG EL: -20.5	
196		
197		
198		
199		
200		
201		
202		
203		
204		
205		
206		
207		
208		
209		
210		

6/10/16

Restrike Hammer Info
Make APE
Model D180-42
Ram Wt. 59690 lbs
Ram Stroke 135 IN
Rated Energy 446513 ft-lbs
Cushion ALUM/MICARTA
Cap STEEL

S. START @ 09:52

★ NO NOISE ABATEMENT

Final Drive	
Depth(in)	Blows/in
1	20
2	15
3	8
4	9
5	7
6	7
7	8
8	7
9	7 ★ PARTIAL INCH

Driving Times / Total Time
Start Vibe 16:28 Vibe
Fin Vibe 17:03 35 MINS
Start Impact 19:09 Impact
Fin Impact 20:32 83 MINS
Start Restrike 09:56 Restrike
Fin Restrike 09:59 3 MINS

Drive Pressure ~ 3000 PSI
RPM Range 1910 - 1950

Notes: SOUNDING @ 08:20 → WATER 16⁰⁰ - 44 FT SOUNDING = -28 MUDLINE (BASED ON COAST GUARD TIDE BOARD)

STOPS & STARTS VIBING PILE DUE TO ATTEMPTS TO PLUM PILE BY PULLING UP FOR 5-10 FT & DRIVING BACK DOWN.

★★ NO BLOW COUNTS = BLOW COUNTER CHECKS TIDE EVERY 10 FT. SEE TIDE READINGS.

Inspector: (print) TYLER JANSSEN (sign) (date) 05/03/16

AD : ACTUAL DEPTH FROM MLLW 0 FT

PD : PILE FT MARKS

FINAL READING & EL TOE CHECK
+16 @ 20:32
149 PILE EL @ WATER LINE @ 20:32
→ -133 PILE TIP ELEVATION

TIDE READINGS
+26 @ 16:25
+27⁵⁰ @ 17:03
+23 @ 19:09
+21 @ 19:35
+18 @ 20:13
+16 @ 20:32

Printed: 5/3/2016 6:07 PM

TJ

FINISH IMPACT

Pile Driving Record

Job Name APMP - Test Pile Program
Contractor Kiewit Infrastructure West Co.
KIWC # RPS # 3
Date 05/06/16 → 05/07/16

Pile Location
Location # 6
Pile # 9

Pile Data
Type 4 FT DIAMETER X 1 IN WALL
Length 191' 2"
Weight 103,000
CUT OFF 13 FT 10 IN

Impact Hammer
Make APE
Model D180-42
Ram Wt. 39 690 lbs
Ram Stroke 135 IN
Rated Energy 446,513 ft-lbs
Cushion Type ALUM/MICARTA
Cap Type STEEL

Vibratory Hammer
Make APE
Model 400
Accessories QUAD BEAM W/ 4 CLAMPS

Elevation Data
Tide Reading SEE BELOW
Mudline Sounding -25
Reference Description TOP OF TEMPLATE
Pile Tip EL. -140

Noise Abatement
Resonator X
Confined Bubbles ____
None ____

Depth (ft)

AD	PD	BPF	Stroke/RPM
-26	1		
	2	SELF WEIGHT	
	3	PENETRATION	
	4		
	5		
-31	6		
	7	S. START	07:40
	8	START	07:49
	9		
-35	10	V	
	11	I	
	12	B	
	13	E	
	14		
	15		
	16		
	17		
	18		
	19		
-45	20		
	21		
	22		
	23		
	24		
	25		
	26		
	27		
	28		
	29		
-55	30		
	31	STOP	07:54
	32	START	07:57
	33		
	34		
	35	STOP	07:58

Depth (ft)

AD	PD	BPF	Stroke/RPM
	36	START	08:01
	37		
	38		2600 DP
	39		1940 RPM
-65	40		
	41	STOP	08:06
	42	START	08:09
	43		
	44		2900 DP
	45		1938 RPM
	46		
	47		
	48	STOP	08:14
	49	START	08:14
-75	50		
	51	V	3100 DP
	52	I	1935 RPM
	53	B	
	54	E	
	55		
-81	56	STOP	08:19
	57	S. START	10:35
	58	START	10:41
	59	D180	
-85	60		★★★
-86	61		
	62	13	6.4
	63	9	5
	64	14	5.8
	65	13	6.9
	66	11	7
	67	10	7.6
	68	10	7.6
	69	10	7.4
-95	70	7	9.1

Depth (ft)

AD	PD	BPF	Stroke/RPM
	71	7	8.4
	72	8	8.4
	73	9	8.3
	74	9	8.2
	75	8	—
	76	10	8.4
	77	7	8.4
	78	7	8.6
	79	8	8.5
-105	80	7	8.9
	81	9	8.3
	82	8	8.8
	83	10	9
	84	9	9.1
	85	10	9.2
	86	10	9.2
	87	12	9.4
	88	14	9.3
	89	17	9.5
-115	90	17	9
	91	16	9.5
	92	15	9.5
	93	19	9.4
	94	15	9.3
	95	14	9.1
	96	15	9.2
	97	15	9.2
	98	19	9.4
	99	20	9.5
-125	100	19	9.5
	101	22	9.6
	102	21	9.7
	103	26	9.6
	104	26	9.3
	105	22	9.2

Depth (ft)

AD	PD	BPF	Stroke/RPM
	106	30	9.7
	107	28	9.7
	108	28	9.7
	109	32	9.8
-135	110	28	9.7
-136	111	32	9.8
-137	112	27	9.8
-138	113	30	9.4
-139	114	32	9.5
-140	115	37	9.5
	116	STOP	11:20
	117		
	118		
	119		
	120		
	121		
	122		
	123		
	124		
	125		
	126		
	127		
	128		
	129		
	130		
	131		
	132		
	133		
	134		
	135		
	136		
	137		
	138		
	139		
	140		

Depth (ft)

AD	PD	BPF	Stroke/RPM
	141		
	142		
	143		
	144		
	145		
	146	→ STOP	11:15
	147	CONTINUE	
	148	DRIVING FOR	
	149	MORE DATA	
	150		
	151		
	152		
	153		
	154		
	155		
	156		
	157		
	158		
	159		
	160		
	161		
	162		
	163		
	164		
	165		
	166		
	167		
	168		
	169		
	170		
	171		
	172		
	173		
	174		
	175		

Depth (ft)

Depth (ft)	BPF	Stroke/RPM
176		
177		
178		
179		
180		
181		
182		
183		
184		
185		
186		
187		
188		
189	INSIDE PLUG	
190	ELEVATION	
191		
192	BEFORE R/S: -22.5	
193	AFTER R/S: -22.5	
194	CHANGE: 0	
19	PLUG EL: -22.5	
19		
197		
198		
199		
200		
201		
202		
203		
204		
205		
206		
207		
208		
209		
210		

06/10/16

Restrike Hammer Info
Make APE
Model D180-42
Ram Wt. 39690 lbs
Ram Stroke 135 IN
Rated Energy 446,513 ft-lbs
Cushion ALUM/MICARTA
Cap STEEL

*NO S. START
*NO NOISE ABATEMENT

Final Drive	
Depth(in)	Blows/in
1	7
2	5
3	6
4	5
5	5
6	5
7	5
8	5

Driving Times		Total Time
Start Vibe	07:40	Vibe
Fin Vibe	08:19	39 MINS
Start Impact	10:47	Impact
Fin Impact	11:20	37 MINS
Start Restrike	10:14	Restrike
Fin Restrike	10:16	2 MIN

Drive Pressure 2600 - 3100
RPM Range 1930 - 1940
FUEL SETTING # 4

Notes: 05/06 ~~SOUNDING @ 0700: 32 FT TIDE - 60 FT SOUNDING = -28 FT MUDLINE~~ (NOT GOOD) MEASUREMENT TAKEN DURING STRONG CURRENT
05/06 SOUNDING @ 13:07 (SLACK CURRENT) 4 FT TIDE - 29 FT SOUNDING = -25 FT MUDLINE
VIBE SOFT START 3 EA @ 07:40 WAITING 1 MIN BTW.
★★★ D180 WOULD NOT START, DRY FIRINGS DROVE PILE APPROXIMATELY 5 FT
FIX D180 05/07 AM.
D180 HAMMER ON SETTING 4
IMPACT SOFT START @ 10:47, 10:54 TRY TO START HAMMER → SUCCESSFUL

Inspector: (print) TYLER JANSSEN (sign) Ty (date) 05/07/15

TIDE READINGS
05/06
+32 @ 07:00
+31 @ 08:10
+30 @ 08:19
+17 @ 10:46

05/07
+20 @ 10:55
+19 @ 11:04
+18 @ 11:15

FINAL TOE EL: -140 FT

Printed: 5/3/2016 6:07 PM

TJ

Pile Driving Record

Job Name: APMP - Test Pile Program
Contractor: Kiewit Infrastructure West Co.
KIWC #: 2
Date: 5/26/16

Pile Location

Location #: 6
Pile #: 10

Pile Data

Type: 4 FT DIAMETER X 1 IN WALL
Length: 192 FT
Weight: 103,000

Impact Hammer

Make: APE
Model: 15-4
Ram Wt.: 30,000 lbs
Ram Stroke: 48 IN
Rated Energy: 120,000 ft-lb
Cushion Type: ALUM/MICARTA
Cap Type: STEEL

Vibratory Hammer

Make: APE
Model: 400
Accessories: QUAD BEAMS w/ 4 CLAMPS

Elevation Data

Tide Reading: SEE BELOW
Mudline Sounding: -24
Reference Description: HINGED TOWER 12FT OVER WATER
Pile Tip EL.: -137

Noise Abatement

Resonator: ______
Confined Bubbles: X
None: ______

Depth (ft)

AD	PD	BPF	Stroke/RPM
-25	1	SELF WEIGHT	10:23
	2	CLAMPING	11:14
-27	3	S.START	11:18
	4	A.START	11:23
	5		
-30	6	DP 1600	RPM 1555
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
-40	16		
★	17	STOP/START	11:28/11:30
	18		
	19	DP 2700	RPM 1950
	20		
	21		
	22		
	23		
	24	DP 2900	RPM 1945
	25		
-50	26		
	27		
	28		
	29		
	30		
	31		
	32	DP 3000	RPM 1940
★	33	DP 2700	RPM 1700
	34	DP 3000	RPM 1940
	35		

VIBE

11:40 ←
11:41 ←
11:42 ←

Depth (ft)

AD	PD	BPF	Stroke/RPM
-60	36	VIBE	
	37		
	38		
	39		
	40		
	41		
	42		
	43		
	44		
	45		
-70	46		
	47		
	48		
	49		
	50		
	51	↓	
-76	52	STOP	11:46
	53	S.START	14:04
	54	21	14:08
	55	16	
-80	56	14	
	57	16	
	58	15	
	59	14	
	60	17	
	61	14	
	62	15	
	63	15	
	64	15	
	65	15	
-90	66	16	
	67	17	
	68	15	
	69	15	
PDA	70	6+13	14:17/14:41

Depth (ft)

AD	PD	BPF	Stroke/RPM
-95	71	NO COUNT	
	72	17	
	73	15	
	74	17	
	75	17	
-100	76	19	
	77	17	
	78	23	
	79	27	
-104	80	32	
	81	31	
	82	35	
	83	27	
	84	43	
	85	NO COUNT	
-110	86	28	
	87	38	
	88	27	
	89	29	
	90	27	
	91	31	
	92	34	
	93	35	
	94	30	
	95	36	
-120	96	37	
	97	NO COUNT	
	98	44	
	99	47	
	100	51	
-125	101	37+27	15:15/15:18
	102	52	
	103	61	
	104	NO COUNT	
	105	45	

Depth (ft)

AD	PD	BPF	Stroke/RPM
-130	106	46	
	107	40	
	108	45	
	109	49	
	110	NO COUNT	
	111	50	
-136	112	65	
△	113	77	15:39
	114	STOP	
	115		
-140	116		
	117		
	118		
	119		
	120		
	121		
	122		
	123		
	124		
	125		
-150	126		
	127		
	128		
	129		
	130		
	131		
	132		
	133		
	134		
	135		
-160	136		
	137		
	138		
	139		
	140		

Depth (ft)

AD	PD	BPF	Stroke/RPM
	141		
	142		
	143		
	144		
	145		
-170	146		
	147		
	148		
	149		
	150		
	151		
	152		
	153		
	154		
	155		
	156		
	157		
	158		
	159		
	160		
	161		
	162		
	163		
	164		
	165		
	166		
	167		
	168		
	169		
	170		
	171		
	172		
	173		
	174		
	175		

Depth (ft)

Depth (ft)	BPF	Stroke/RPM
176		
177		
178		
179		
180		
181		
182		
183		
184		
185		
186		
187		
188		
189		
190		
~~191~~	INSIDE	PLUG
~~192~~	ELEVATION	
~~193~~		
~~194~~	BEFORE R/S:	-20
~~195~~	AFTER R/S:	-20
~~196~~	CHANGE:	0
197	PLUG EL: -20	
198		
199		
200		
201		
202		
203		
204		
205		
206		
207		
208		
209		
210		

06/10/16

Restrike Hammer Info

Make: APE
Model: D180-42
Ram Wt.: 59690 lbs
Ram Stroke: 135 IN
Rated Energy: 446513 ft-lbs
Cushion: ALUM/MICARTA
Cap: STEEL

S. START @13:04 DROVE ½" + NO NOISE ABATEMENT

Final Drive

Depth(in)	Blows/in
1	5
2	2
3	3
4	3
5	4
6	3
7	3
8	4
9	4

Driving Times		Total Time
Start Vibe	11:18	Vibe
Fin Vibe	11:46	28 min
Start Impact	14:04	Impact
Fin Impact	15:39	95 min
Start Restrike	13:08	Restrike
Fin Restrike	13:10	2 mins

Drive Pressure: 2700 - 3000
RPM Range: 1700 - 1945

Notes: SOUNDING @ 9:50 TIDE (27) - WATER DEPTH (51) = -24 MUDLINE
SOFT START FOR VIBE: VIBE FOR 15 SEC. WAIT 1 MIN. REPEAT 2 MORE TIMES
SOFT START FOR HYD. HAMMER:
PDA SENSORS @ PD 70, AD -94, halfway through the foot, 2:17 stop/ 2:41 Start
STOP AGAIN @ 3:15. START AGAIN @ 3:18
AT END FOOT KEPT DRIVING AS LIFTING BUBBLE CURTAIN which LIFTED THE PILE &
EVENTUALLY DROVE ANOTHER FOOT INTO SOIL

KEY
★ ADJUSTED FOR PLUM ↑↓
~~[illegible]~~
~~[illegible]~~
PDA BERT INSTALL SENSORS
△ REFER TO ...

Inspector: (print) Bo Youn Chae (sign) Bo Youn Chae (date) 5/26/16

TIDE READINGS

09:50	+27	2:01	+13
10:23	+28	2:19	+12
11:01	+27	2:24	+11
11:17	+26	3:24	+7
11:28	+25.5	3:31	+6
11:38	+25		

ATTACHMENT 2

Hydroacoustic Monitoring (HAM) Report

Hydroacoustic Monitoring Report

Anchorage Port Modernization Project Test Pile Program

Submitted to:
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Kiewit Infrastructure West Co.
Contract: PSA 2572

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19 September 2016

P001317
Version 3.0

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Document Version Control

Version	Date	Name	Change
1.0	2016 Jul 11	M Austin	Draft released to client for review.
1.1	2016 Jul 26	M. Austin	Addressed comments received from client
2.0	2016 Sep 6	M Austin	Addressed comments received from client 2016 Aug 11
3.0	2016 Sep 19	S Denes	Addressed comments received from client 2016 Sep 15

Suggested citation:

Austin, M., S. Denes, J. MacDonnell, and G. Warner. 2016. *Hydroacoustic Monitoring Report: Anchorage Port Modernization Project Test Pile Program*. Version 3.0. Technical report by JASCO Applied Sciences for Kiewit Infrastructure West Co.

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Executive Summary

Underwater sound pressure levels were recorded while ten hollow steel piles, 48 inches in diameter, were installed by means of both vibratory and impact hammer pile driving during the Anchorage Port Modernization Project Test Pile Program in Knik Arm, Cook Inlet, Alaska. Autonomous sound recorders were deployed at nominal distances of 10 m and 1 km from each pile and a mobile hydrophone system drifted during measurements to target data collection at ranges corresponding to marine mammal disturbance thresholds. Ambient sound recordings at two locations were also measured when pile driving activities stopped for three days.

Pile driving activities for each pile included vibratory pile driving, followed by impact pile driving with either a diesel or hydraulic impact hammer. One pile had a bearing plate, a 1-inch thick steel plate, welded to the inside of the pile, 25 m (82 ft) from the toe of the pile. Two different noise attenuation systems (NAS) were tested during the program—a passive resonator system was deployed for four of the piles and a confined bubble curtain was deployed for four separate piles (air flow to the bubble curtain was turned on and off intermittently during installation of one of these piles). Two piles were installed without any noise attenuation systems.

The goals of the sound measurements were to quantify the underwater sound pressure levels (SPL) during ambient conditions and during vibratory and impact hammer pile driving events. From these data, the sound transmission loss was characterized and distances to marine mammal disturbance thresholds (160 dB re 1 µPa rms SPL during impact pile driving and 125 dB re 1 µPa rms SPL during vibratory pile driving) were verified. The effectiveness of the two different noise attenuation systems was assessed in terms of the degree to which they reduced the pile driving sound levels near the source and the distances to the marine mammal disturbance thresholds. The relative sound levels for each of the hammer types were also compared.

Overall the highest median SPL was attributed to the hydraulic impact hammer with an average computed level at 10 m range of 202 dB re 1 µPa with no noise attenuation in place, 196 dB re 1 µPa when the passive resonator was applied and 190 dB re 1 µPa when the confined bubble curtain was used to attenuate noise. The diesel impact hammer had the next highest median SPL with values at 10 m range computed to be 199, 192, and 190 dB re 1 µPa for no noise attenuation, attenuation by the passive resonator, and attenuation by the confined bubble curtain, respectively. The vibratory hammer generated the lowest median SPL at 10 m range, with computed values of 168 dB re 1 µPa with no noise attenuation and 161 and 160 dB re 1 µPa when either the passive resonator or the confined bubble curtain were applied, respectively.

Near-source levels for un-attenuated pile driving exceeded those for pile driving events with NAS applied for each hammer type. On average, the bubble curtain reduced near-source levels more than did the passive resonator NAS. This trend was most strongly observed for the hydraulic impact hammer; the sound attenuation achieved by the passive resonator NAS and the bubble curtain NAS was more similar for the diesel impact hammer and was very similar for the vibratory hammer. The passive resonator NAS was variably effective for the diesel impact and vibratory hammers but more consistently effective for the hydraulic impact hammer and the bubble curtain NAS was more effective at reducing near-source levels of the hydraulic impact hammer than of the diesel impact hammer. When the bubble curtain was applied, median near-source levels of the hydraulic impact hammer decreased by 12 dB on average, compared to an average 6 dB reduction of the hydraulic hammer near-source level when the passive resonator was applied. The bubble curtain decreased the diesel impact hammer near-source levels by an average of 9 dB, the reduction was 6 dB on average when the passive resonator was applied. The bubble curtain and passive resonator both decreased the near-source level for vibratory pile driving by nearly the same average amount, 9 and 8 dB respectively.

Computed transmission loss (TL) coefficients, derived from fits of the received sound level data versus range, varied between piles with values ranging from 13 to 19.2 for impact pile driving and from 12.6 to 17.9 for vibratory pile driving. This variability was somewhat reduced when the results were grouped by hammer model and NAS but some variability remained due to differences of the pile locations. Results for the un-attenuated hydraulic impact hammer yielded the highest TL coefficient, 19.2, indicating that sounds from the hydraulic impact hammer decayed most rapidly with range compared to the other hammers. The TL coefficient for the un-attenuated diesel impact hammer averaged 17.5. Sounds from the un-attenuated vibratory hammer had the lowest TL coefficient, with values of 16.1 and 16.9. TL coefficients consistently decreased when a NAS was applied compared to the un-attenuated results, in part because the frequency content of the signals changed by the NAS, but also because both types of NAS only attenuated in-water sound levels and some sound propagated directly from the pile into the seafloor un-attenuated. This un-attenuated sound propagated through the seafloor then refracted into the water column at longer ranges. Thus each NAS attenuated the near-source sound levels, dominated by water-borne propagation paths, more strongly than the long-range sound levels, resulting in an apparent decrease of the rate of sound level decay between recorders. The TL coefficients for each type of NAS were relatively consistent across locations for the diesel impact hammer, they were more variable across location for the hydraulic impact hammer (for which the data were collected at locations more widely separated compared to the diesel impact hammer locations) and varied considerably across location for the vibratory hammer. Long-range received levels were not independent of the near-source levels. The transmission loss estimates accounted for the difference in source levels and range from the pile at the recorders. The transmission loss combined with the near-source levels were used to determine the range to marine mammal thresholds. The range to threshold reduces the variability from source level, NAS, and transmission loss to one value.

Distances to marine mammal disturbance thresholds were derived from regressions of rms SPL versus range. The maximum computed range to the threshold of 160 dB re 1 µPa was 4340 m from the diesel impact hammer and 2570 m from the hydraulic impact hammer. These distances are extrapolations from measured values. The maximum measured distance to this threshold was 1611 m for the diesel hammer and 2280 m for the hydraulic hammer. The maximum computed (and measured) distance to the rms SPL threshold of 125 dB re 1 µPa during vibratory pile driving was 4340 m.

Excluding data points derived from measurement extrapolations, grouping by hammer type and NAS, and averaging over location, applying the noise attenuation systems reduced the distance to the marine mammal thresholds for both vibratory and impact pile driving. Sounds levels generated by the piles driven using the hydraulic impact hammer decayed to the threshold of 160 dB re 1 µPa at an average distance of 1500 m when no noise attenuation was in place, of 1050 m when the passive resonator attenuation was applied, and of 1100 m when the confined bubble curtain was in place. The corresponding distances were 1290 m, 1300 m, and 700 m from piles installed with the diesel impact hammer and 3880 m, 2420 m, and 1980 m from piles driven with the vibratory hammer.

1. Introduction

From May 3 to June 7, 2016, JASCO Applied Sciences conducted hydroacoustic monitoring during the Port of Anchorage Port Modernization Test Pile Program at Knik Arm in Cook Inlet, Alaska. Hydroacoustic monitoring consisted of one mobile, real-time system, and two fixed, autonomous systems recording underwater sounds. The Test Pile Program involved the installation of ten indicator piles by means of both vibratory and impact pile driving to determine design load information, pile drivability, and additional pile installation parameters in the area in anticipation of future development for the Anchorage Port Modernization Project.

Elevated underwater sound levels, generated by activities such as pile driving, can harass marine mammals by injuring or disturbing them. There is concern that noise from pile driving during the Port of Anchorage Port Modernization Project has the potential to negatively impact nearby marine mammals. The Test Pile Program used hydroacoustic monitoring to collect empirical data and characterize sound propagation for pile driving at the Port of Anchorage, to better understand the distances at which these sounds can affect marine mammals and to help Port planners reduce future potential effects of noise on marine mammals. The Test Pile Program provided an opportunity to assess the viability and effectiveness of two noise attenuation systems—an encapsulated bubble curtain and a resonance panel system—and to compare the underwater sounds generated by two different impact hammer designs, one diesel and the other hydraulic, and a vibratory hammer.

Fixed, autonomous acoustic recording systems measured underwater sound pressure levels (SPLs) at nominal distances of 10 m and 1 km from each pile location. Simultaneous measurements were made with a mobile hydrophone system deployed from a monitoring vessel that drifted freely in the current and displayed, in real-time, the incoming SPLs while concurrently logging the recorded sound levels for later analysis. The drifting measurements were targeted to collect data at ranges that corresponded to specific marine mammal disturbance thresholds (160 dB re 1 µPa during impact pile driving and 125 dB re 1 µPa during vibratory pile driving) that the National Marine Fisheries Service (NMFS) authorized for the Test Pile Program Marine Mammal Monitoring program.

Hydroacoustic monitoring objectives were to:

- Collect underwater ambient (background) noise measurements in the absence of project construction activities.
- Measure SPLs for each of the ten piles and for each hammer type (impact and vibratory) to estimate source sound levels.
- Determine the transmission loss for each of the ten piles and for each hammer type (impact and vibratory).
- Empirically verify the location of the 125 dB re 1 µPa harassment isopleth for vibratory pile installation for each of the ten piles.
- Empirically verify the location of the 160, 180, and 190 dB re 1 µPa harassment isopleths for impact pile installation for each of the ten piles.
- Determine the relative effectiveness of the encapsulated bubble curtain and resonance panel systems by assessing reductions in underwater noise.
- Determine the relative underwater noise levels produced by diesel and hydraulic impact hammers by measuring the underwater noise.

To fulfill these objectives, this report describes the methods used to collect and analyze the data, details pile driving and hydroacoustic monitoring activities, presents SPLs measured during pile driving and during ambient conditions and summarizes these data through statistical measures, examines SPLs to determine whether the noise mitigation systems were effective, and compares the sound output among different hammer types.

1.1. Pile Details

Ten indicator piles were installed between May 3 and June 7, 2016 (Table 1) at four locations at the Port of Anchorage (Figure 1). Each pile was a cylindrical steel pile, 48 in in diameter with a 1 in thick wall. Pile IP6 had a 1” thick, steel bearing plate (with a 3” diameter hole in the center) installed inside the pile, 82’ from the pile toe. The bearing plate was intended to prevent the soil plug from entering the pile.

Table 1. Specifications for installed indicator piles.

Pile	Latitude	Longitude	Location	Date Installed	Tip Elevation (ft)
IP1	61°14.216'N	149°53.456'W	5	June 7, 2016	-150
IP2	61°14.235'N	149°53.441'W	4	May 19, 2016	-170
IP3	61°14.650'N	149°53.126'W	1	June 03, 2016	-184
IP4	61°14.658'N	149°53.119'W	1	May 12-13, 2016	-175
IP5	61°14.245'N	149°53.434'W	4	May 18, 2016	-173
IP6*	61°14.232'N	149°53.445'W	4	June 01, 2016	-156
IP7	61°14.203'N	149°53.484'W	5	May 25, 2016	-165
IP8	61°14.077'N	149°53.716'W	6	May 03, 2016	-133
IP9	61°14.074'N	149°53.722'W	6	May 6-7, 2016	-140
IP10	61°14.061'N	149°53.776'W	6	May 26, 2016	-137

*Pile IP6 had a bearing plate installed.

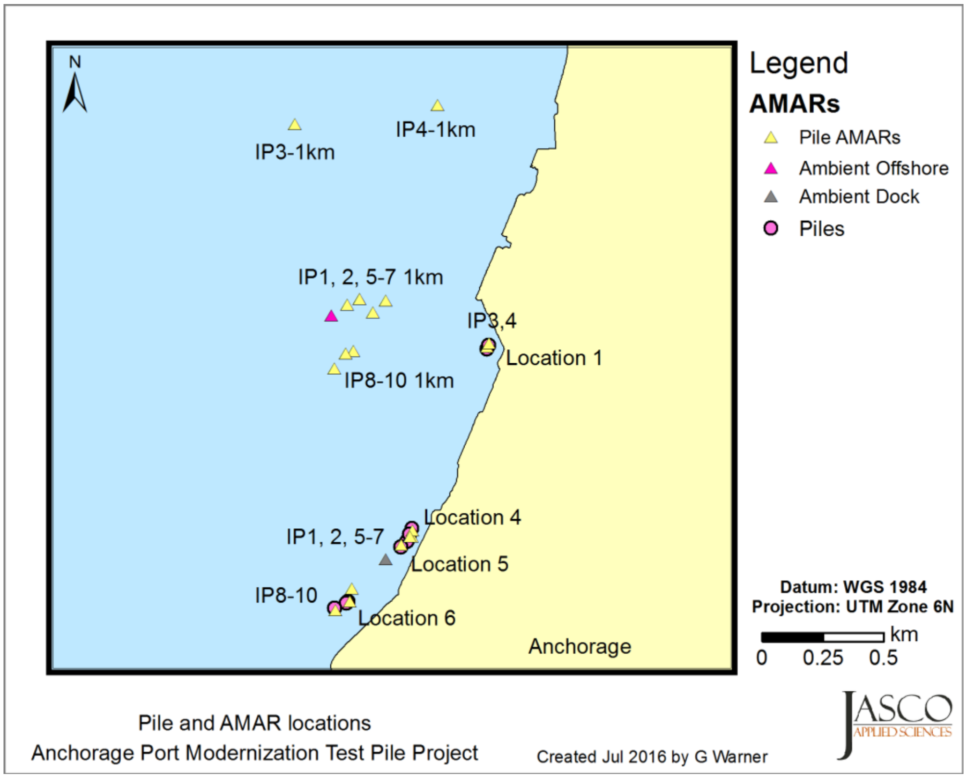


Figure 1. AMAR (Table 4) and pile (Table 1) locations.

1.2. Hammer Types

Piles were driven with three hammer types: a vibratory hammer initiated installation for all piles, then a diesel impact hammer was used for completion of some piles, and a hydraulic impact hammer for others (Section 2.4).

1.2.1. Impact Hammers

Diesel impact driving was performed using the APE D180-42 diesel impact hammer (Table 2, Figure 2), which struck 34–53 blows per minute with rated energies ranging between 272,373 and 446,513 ft-lbs. Hydraulic impact pile driving was performed using the APE model 15-4 hydraulic impact hammer (Table 2,Figure 2), which struck 30–65 blows per minute with a rated energy of 120,000 ft-lbs.

Table 2. Diesel and hydraulic impact hammer specifications.

	Diesel Hammer		Hydraulic Hammer	
Specifications	**Imperial**	**Metric**	**Imperial**	**Metric**
Stroke at maximum rated energy	135 in	343 cm	48 in	121.92 cm
Maximum rated energy	446,513 ft-lbs	602.79 kNm	120,000 ft-lbs	162.7 kNm
Minimum rated energy	272,373 ft-lbs	367.70 kNm		
Maximum obtainable stroke	150 in	381 cm		
Maximum obtainable energy	666,395 ft-lbs	196 kNm		
Ram	39,690 lbs	18,000 kg	30,000 lbs	13,607.77 kg
Anvil	10,223 lbs	4,642 kg		
Hammer weight	92,000 lbs	11,286 kg	42,000 lbs	19,050.88 kg
Speed (blows per min)	34–53	34–53	30–65	30–65

Figure 2. APE D-180-42 diesel impact hammer (left) and APE model 15-4 hydraulic impact hammer (right).

1.2.2. Vibratory Hammer

Vibratory pile driving was performed using an APE model 400 vibratory driver (Table 3, Figure 3) with associated APE Model 1050 Power Unit. The hammer has an eccentric moment of 11,500 in-lbs and weighs 31,570 lbs.

Table 3. Vibratory hammer specifications.

Specifications	Imperial	Metric
Eccentric Moment	11,500 in-lbs	132.49 kg
Drive force	298 tons	2,648 kN
Max line pull	234 tons	2,082 kN
Bare hammer weight (w/o clamp)	31,570 lbs	14,320 kg
Frequency Maximum (VPM)	0-1,350 vpm	0-1,350 vpm

Figure 3. APE model 400 vibratory driver.

1.3. Noise Attenuation Systems

Two different noise attenuation systems (NASs) were employed during the Test Pile Program (Table 6). The NASs reduce water-borne sound levels caused by pile driving.

1.3.1. Passive Resonator

A passive Helmholtz resonator NAS (AdBm Techologies) was used on four test piles (IP2, IP4, IP8, and IP9; Table 6). This system uses thousands of Helmholtz resonators that are placed in a metal framework surrounding the pile from the sea floor to the water surface. The framework consists of four sides, each comprised of slat layers, which house the resonators, and a bottom ballast structure that anchors the system (Figure 4). The slats operate in an accordion-like fashion when the system is being extended or retracted. The resonator system designed for this project was suitable for water depths ranging 10–75 ft.

The Helmholtz resonators are inverted cylinders, each with an open bottom, that remain partially air-filled when submerged. A mass-spring type of oscillation of the air-water system inside the cylinders is excited by the passing sound pressure waves that emanate from the driven piles, attenuating the pile driving sound pressure signal at the resonant frequency. The resonators' size determines the attenuated frequency. For this project the resonators were designed to attenuate sound near a frequency of 100 Hz.

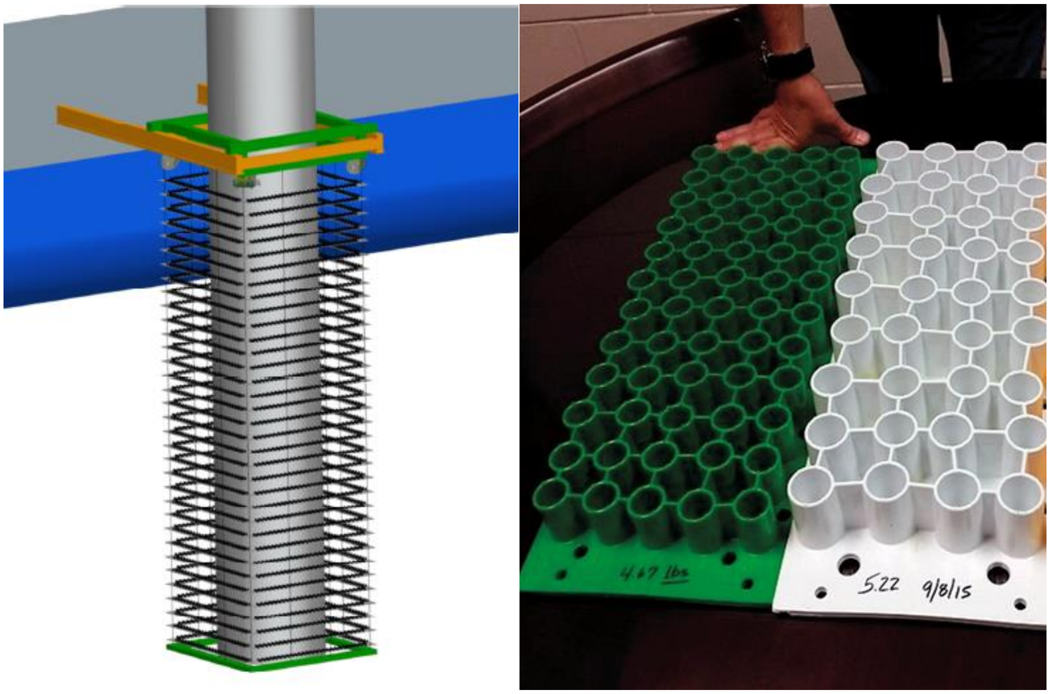


Figure 4. Schematic of deployed AdBm Passive Resonator system (left) and Helmholtz resonators (right). The open ends of the resonators face downward when deployed.

1.3.2. Confined Bubble Curtain

A confined bubble curtain NAS was used on four test piles (IP3, IP6, IP7, and IP10; Table 6). This telescoping, steel pipe system creates an isolation surrounding the pile. The confined bubble curtain consists of four, vertically-distributed, bubble rings, welded to the inside of a 5-foot casing pipe. Each bubble ring is a 3-inch inner-diameter, half-ring steel pipe, with four rows of 1/16-inch holes on 0.78-inch spacing. A 1600 CFM compressor provides a continuous supply of compressed air to the four aeration pipes (Figure 5), with flow nominally distributed among the stages from top to bottom as follows: Stage 1 = 160 cfm, Stage 2 = 320 cfm, Stage 3 = 560 cfm, Stage 4 = 560 cfm. Air is then released from the small holes in the pipeline to create a curtain of air bubbles surrounding the pipe, while maintaining contact with the sea floor. The curtain of air bubbles inhibits the transmission of pile driving sounds to the surrounding water. This confined bubble curtain is ideal for water depths of 26–60 ft.

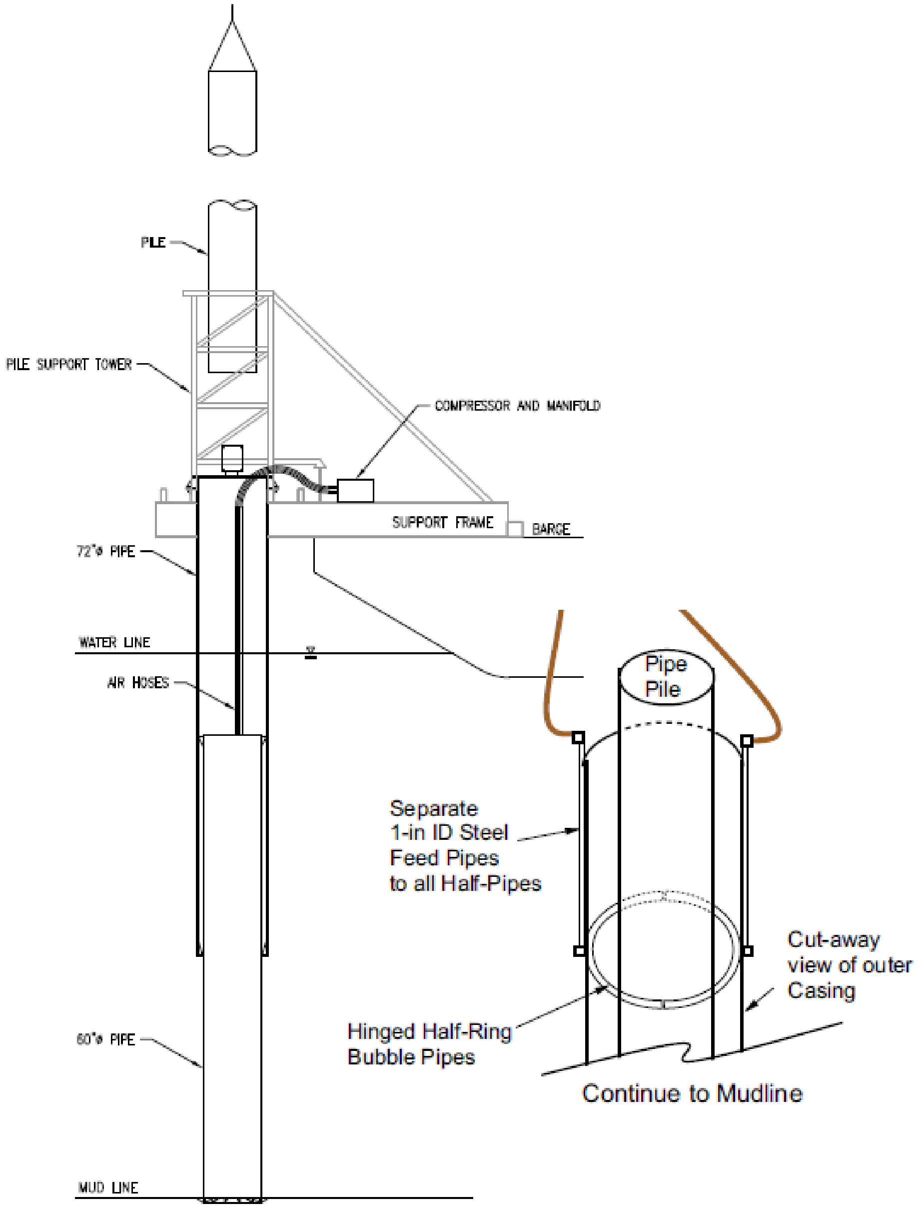


Figure 5. Confined bubble curtain system schematic.

2. Methods

2.1. Monitoring Locations

Table 4. AMAR deployment locations. Water depths measured using vessel echo sounder. Times in UTC, Datum WGS84. IP = Indicator Pile. N/A = Not available.

Location	Deployment date and time	Retrieval date and time	Latitude	Longitude	Deployment Water Depth (m)
IP1-10M	2016-Jun-07 00:45	2016-Jun-07 21:54	61°14.209’ N	149°53.466’ W	N/A
IP1-1KM	2016-Jun-07 00:35	2016-Jun-07 21:23	61°14.719' N	149°53.659' W	18
IP2-10M	2016-May-19 14:12	2016-May-19 20:35	61°14.227' N	149°53.433' W	N/A
IP2-1KM	2016-May-18 14:44	2016-May-19 20:23	61°14.748' N	149°53.722' W	27
IP3-10M	2016-Jun-03 00:21	2016-Jun-03 22:50	61°14.654’ N	149°53.127’ W	19
IP3-1KM	2016-Jun-03 00:51	2016-Jun-03 22:16	61°15.128' N	149°54.055' W	30
IP4-10M	2016-May-11 23:01	2016-May-13 17:09	61°14.662' N	149°53.119' W	10
IP4-1KM	2016-May-11 22:26	2016-May-14 22:50	61°15.185' N	149°53.404' W	18
IP5-10M	2016-May-18 15:16	2016-May-18 20:51	61°14.241' N	149°53.433' W	15
IP5-1KM	2016-May-18 14:44	2016-May-19 20:23	61°14.748' N	149°53.722' W	27
IP6-10M	2016-Jun-01 00:51	2016-Jun-01 19:15	61°14.227' N	149°53.443' W	N/A
IP6-1KM	2016-Jun-01 01:36	2016-Jun-01 18:51	61°14.734' N	149°53.777' W	25
IP7-10M	2016-May-25 15:56	2016-May-26 23:08	61°14.207' N	149°53.482' W	8
IP7-1KM	2016-May-25 01:14	2016-May-26 23:31	61°14.747' N	149°53.602' W	18
IP8-10M	2016-May-02 17:56	2016-May-04	61°14.106' N	149°53.699' W	14
IP8-1KM	2016-May-02 01:16	2016-May-04 20:37	61°14.591' N	149°53.823' W	27
IP9-10M	2016-May-05 03:18	2016-May-07 20:23	61°14.077' N	149°53.705' W	17
IP9-1KM	2016-May-05 02:46	2016-May-07 20:35	61°14.632' N	149°53.740' W	28
IP10-10M	2016-May-26 16:34	2016-May-27 00:50	61°14.056' N	149°53.769' W	8
IP10-1KM	2016-May-26 14:37	2016-May-27 01:00	61°14.626' N	149°53.776' W	23
Ambient-Offshore	2016-May-27 21:03	2016-May-30 23:42	61°14.708' N	149°53.849' W	17
Ambient-Dock	2016-May-27 20:50	2016-May-30 23:16	61°14.174' N	149°53.548' W	N/A

2.2. Monitoring Equipment

Underwater sounds were recorded at fixed locations with Autonomous Multichannel Acoustic Recorders (AMARs, JASCO, Figure 6). Each AMAR was fitted with two hydrophones with different sensitivities so both high and low intensity sounds could be measured (Table 5). One fixed recorder (referenced by the name “AMAR-10M” in this report) was targeted for measurement at a nominal distance of 10 m from each pile. The low sensitivity channel of this recorder was suitable for measuring high amplitude sounds from close-range impact pile driving, with a nominal sensitivity of - 220 dB re 1 V/µPa. The other fixed recorder (referenced by the name “AMAR-1KM” in this report) was targeted for measurements at a nominal distance of 1 km from each pile using a hydrophone with nominal sensitivity of -200 dB re 1 V/µPa.

The AMAR hydrophones were protected by a hydrophone cage, which was covered with a shroud to minimize noise artifacts due to water flow and mounted 0.6 m above the mooring base plate. The AMARs recorded continuously at 128,000 samples per second for a recording bandwidth of 1 Hz to 64 kHz. The recording channel had 24-bit resolution with a spectral noise floor of 20 dB re 1 µPa2/Hz. Acoustic data were stored on internal solid-state flash memory.

Mobile sound measurements were collected from a vessel that was shut down and drifting freely. Two hydrophones, connected to a 50 m cable, were lowered to a depth of 10 m from over the side of the vessel. A leaded line was secured to the cable to cause the cable to hang vertically in the water during measurements. The surface end of the cable connected through an Ocean Sound Meter (OSM, JASCO, Figure 7) deck box to a Toughbook computer that provided a real-time display of the incoming data as well as digital recordings. This recording system will be referred to by the name “AMAR-DRIFT” in this report.

A 42AC pistonphone calibrator (G.R.A.S. Sound & Vibration A/S) verified the sensitivity of the whole recording apparatus of both the AMAR and the OSM systems. The pressure response of the recording system was verified by placing the pistonphone and its adapter over each hydrophone independently while the pistonphone produced a known pressure signal on the hydrophone element (a 250 Hz sinusoid at 152.2 dB re 1 µPa). Calibrations were performed in JASCO’s warehouse before the recorders were shipped and again immediately before and after each deployment to confirm consistency of the system sensitivity throughout the project. Readings were verified between each deployment and before data analysis was performed.

Table 5 Underwater sound recorder details.

Recorder Name	Recorder Serial Number	Hydrophones	Nominal Sensitivity (±3 dB re 1 V/µPa)	Nominal Distance from Piles (m)
AMAR-10M	AMAR 269	M36-V35-100-B000900, M36-V0-101-A004282	-165, -220	10
AMAR-1KM	AMAR 300	M36-V35-100-B000901, M36-V0-100-A002377	-165, -200	1,000
AMAR-DRIFT	OSM 15	M36-C35-100-A003278, M36-C0-100-A003291	-165, -200	variable

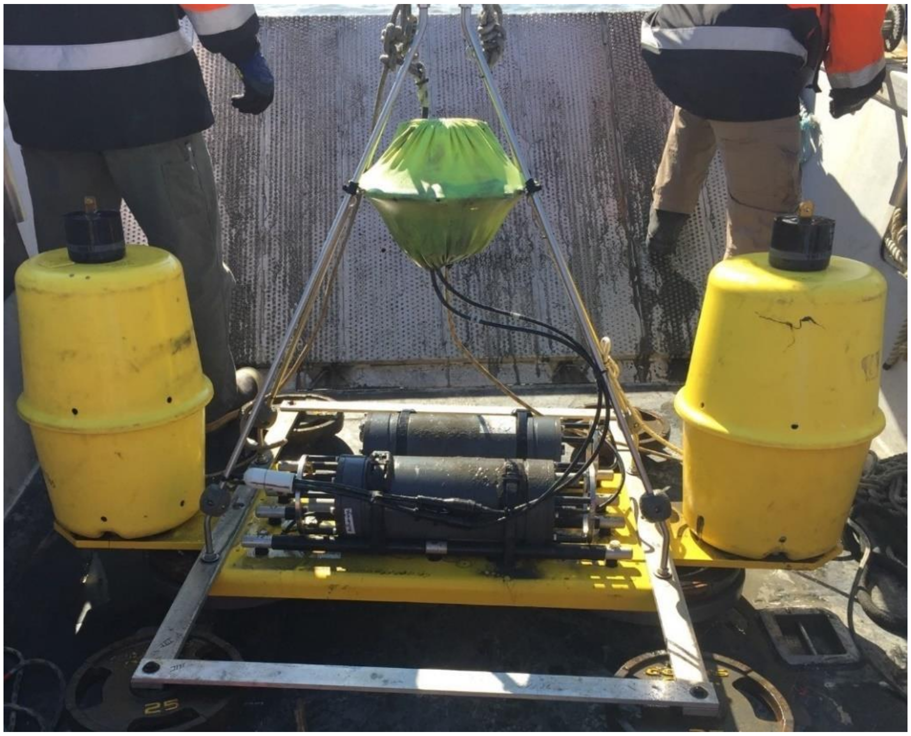


Figure 6. Photo of AMAR-1KM system about to be deployed in Cook Inlet.

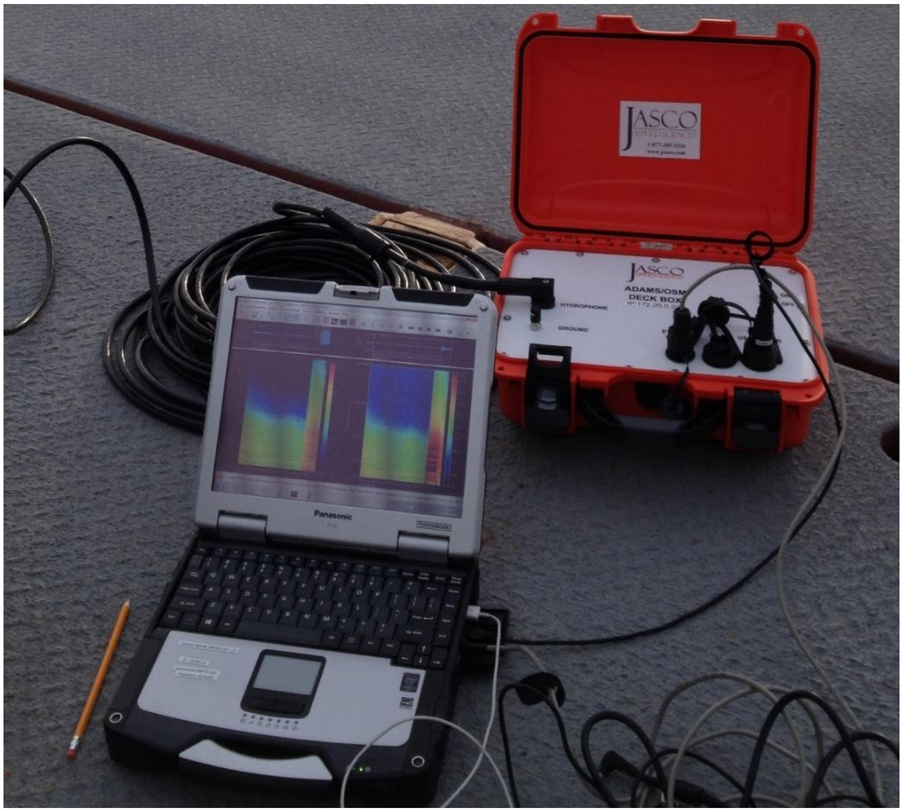


Figure 7 Photo of OSM system showing the hydrophone cable, deckbox, and laptop with live display of data from two hydrophones of different sensitivity.

2.3. Monitoring Activities

The fixed AMARs were deployed from the acoustic monitoring vessel *My Marie* (Figure 8) before driving each pile. AMAR-1KM was deployed as close as practicable to the period of slack current preceding pile driving activities. AMAR-10M was deployed when the derrick barge was in final position, generally in the morning prior to the beginning of pile driving. Prior to deployment, a calibrated signal was applied to each channel of the recorders (Section 2.2). Drift measurements were collected on the OSM when pile driving activities were underway. Concurrent with acoustic measurements, a marine GPS collected location tracks with sample intervals of 2 seconds (Appendix B). The goals of the drift measurements were to collect data at additional ranges, with a focus on capturing the marine mammal impact threshold distance for each hammer type. Without power, location of the vessel during drift measurements was based on positioning of the vessel prior to deployment of the OSM and the current. When the drift of the vessel resulted in received levels that were diverging from the thresholds, or the vessel was drifting towards a hazard, the hydrophones were brought on deck, the vessel powered up and repositioned. When practicable, repositioning was timed to breaks in the pile driving, such as when sensors were being adjusted. More detailed logs of the monitoring activities are included in Appendix A.

Ambient sound levels were recorded continuously during a 72-hour period during which no pile driving activities were taking place, between May 27 and May 30, 2016. One AMAR was deployed at a location just south of Pile Location 5 (Ambient Dock, Figure 1) and the other at a nominal position where the AMAR-1KM recordings were made (Ambient Offshore, Figure 1). The AMARs were deployed and left in place for 72 hours before retrieval. Test Pile Program activities did not occur during this time but other noted industrial noise activities included dredging by Manson Construction near Pile Location 1 and the arrival of a cruise ship at the Port of Anchorage.

Figure 8 *My Marie*, the acoustic monitoring vessel, deploying an AMAR.

2.4. Pile Driving Activities

At the start of each pile-driving day, the pile was lofted into position using the crane on the DB General derrick barge. The pile settled under its own weight and then the vibratory hammer was employed for initial installation. After vibropiling, five of the ten indicator piles were driven to total depth using the hydraulic impact hammer and five using the diesel impact hammer. Two of the ten indicator piles were installed with no NAS in place, four were installed with the AdBm Passive Resonator system in place, and four with the use of the confined bubble curtain (Table 6). Pile IP6 contained a bearing plate, a 1-inch thick steel plate welded to the inside of the pile 25 m (82 ft) from the pile toe.

Air flow to the lower two stages of the confined bubble curtain NAS was reduced by 50% during the final 15 minutes of vibratory pile driving of Pile IP6. During the last hour of impact pile driving of Pile IP6, flow to the confined bubble curtain was turned on and off at 10-minute intervals.

Impact hammer installation of Pile IP4 began using the hydraulic impact hammer on May 12, 2016. An issue with the hammer arose and the remainder of the pile was driven the following day using the diesel impact hammer.

Table 6. Summary of pile driving activities.

Indicator Pile	Date (2016)	Impact Hammer Type	Noise Attenuation System	Pile Location
IP1	June 07	Hydraulic	Un-attenuated	5
IP2	May 19	Diesel	Resonator	4
IP3	June 03	Hydraulic	Bubble Curtain	1
IP4 (Vibratory, Impact Pt 1)	May 12	Hydraulic	Resonator	1
IP4 (Impact Pt 2)	May 13	Diesel	Resonator	1
IP5	May 18	Diesel	Un-attenuated	4
IP6*	June 01	Diesel	Bubble Curtain	4
IP7	May 25	Diesel	Bubble Curtain	5
IP8	May 03	Hydraulic	Resonator	6
IP9 (Vibratory)	May 06	---	Resonator	6
IP9 (Impact)	May 07	Diesel	Resonator	6
IP10	May 26	Hydraulic	Bubble Curtain	6

*Pile IP6 had a bearing plate installed.

2.5. Analysis Methods

2.5.1. Pile Driving Data Analysis

Acoustic data files were downloaded from the recorders and redundant copies were made prior to analysis. JASCO's SpectroPlotter software was used for the first step in analysis. SpectroPlotter applied frequency response calibration values to the signal. The signal was filtered with a bandpass filter with a pass-band from 15 Hz to 20,000 Hz. The 15 Hz low-frequency cutoff was selected to remove flow noise contamination from the recordings and the 20,000 Hz high-frequency cutoff was selected following NMFS Northwest Region 2012 Guidance Document for Sound Propagation Modeling to Characterize Pile Driving Sounds Relevant to Marine Mammals.

SpectroPlotter calculated calibrated metrics over 1 second, 10 seconds, and 60 seconds for vibratory driving. The results in this report are the 10 second calculations. For impact pile driving, individual strike records were detected using SpectroPlotter's Impulse detection algorithm. The detector computed the Teager-Kaiser (TK) Energy of the acoustic file for windows of length 0.7 seconds, and triggered detections when the value of the TK energy exceeded a threshold of 70. TK energy is useful for impulsive sources as it amplifies the effect of big changes between subsequent samples within the acoustic record. The 90% energy window was determined from the 0.7 second detection, and rms SPL metrics were computed over the 90% window. Detections were limited to intervals greater than 0.5 seconds to prevent detection of multiple path arrivals. The threshold value of 70 was selected empirically as a parameter that performed well when reviewing detection results. Computed acoustic metrics (Appendix E) included 90% rms sound pressure level (rms SPL), sound exposure level (SEL), and peak sound level (peak SPL). Single-strike SELs from pile driving impulses received on the fixed AMARs were summed on a linear scale to yield cumulative SELs for each pile. Data from the fixed AMARs and drifting OSM system were processed using this procedure.

SpectroPlotter outputs were synthesized with the ranges of the recorders, fixed and drifting, to the pile. A linear fit was computed between the rms SPL and the logarithm of the ranges to determine the transmission loss (TL) coefficient, *n* according to Equation 1.

$$RL = SL - n \log R \qquad \text{Equation 1}$$

The regressions were performed for a sub-set of the recordings when pile driving levels received at AMAR-10M were relatively consistent and when the signal recorded at AMAR-DRIFT and AMAR-1KM sufficiently exceeded background levels, determined through examination of the spectrograms of the recorded data. The TL coefficients thus calculated for each pile were then used in Equation 1 to back-calculate the source level (*SL*) statistics based on the mean, median, and 90th percentile received levels (RL) computed from the full record of data from AMAR-10M at range *R*. The ranges to marine mammal impact threshold levels were computed from the source level statistics and transmission loss coefficients for each pile, using Equation 1, as were statistics for RL at 10 m range for direct comparison to other pile driving sound source characterization studies.

For each indicator pile we present the following results:

- A representative waveform (sound pressure versus time) and spectral density curve (sound pressure level as a function of frequency, at a resolution of 1 Hz) received on each recorder for impact and vibratory installation of each pile.
- A spectrogram plot (sound intensity as a function of time and frequency, 10 second window) for a few representative pulses received at each recorder during impact installation of each pile.
- A spectrogram plot (sound intensity as a function of time and frequency, 10 second window) for data received at each recorder during vibratory installation of each pile.
- Received sound pressure levels versus time for peak SPL, rms SPL, single strike SEL (SELss), and cumulative SEL (cSEL), received on each recorder for impact and vibratory installation of each pile. These acoustic metrics are defined in Appendix E.
- Received sound pressure levels (rms SPL) versus range for a subset of data recorded on each recorder during impact and vibratory installation of each pile.
- Frequency-weighted statistics are summarized in Appendix C. Frequency-weighting was applied following the specific methods and thresholds for injury summarized by National Oceanic and Atmospheric Administration (NOAA) criteria for injury (NMFS, 2016), described in Appendix E. The frequency-weighting filters were applied to the pile driving data and the rms SPL and SEL values were computed as above.
- 1/3-octave band level box plots for vibratory and impact installation of each pile are provided in Appendix D, in which beige bars indicate the first, second, and third quartiles (L_{25}, $L_{5}0$, and L_{75}) in each 1/3-octave band. Upper error bars indicate the maximum levels (L_{max}). Lower error bars indicate the 95% exceedance percentiles (L_{95}). The maroon line indicates the arithmetic mean (L_{mean})

2.5.2. Ambient Data Analysis

Ambient noise levels at each recording station were measured as:

- Broadband and approximate-decade band sound pressure levels (SPLs) over time for these frequency bands: 10 Hz to 64 kHz, 10–100 Hz, 100 Hz to 1 kHz, and 1–10 kHz, 10–64 kHz.
- Spectrograms: Ambient noise at each station was analyzed by Hamming-windowed fast Fourier transforms (FFTs), with 1 Hz resolution and 50% window overlap.
- Statistical distribution of sound pressure levels (exceedance levels) in each 1/3-octave band and for the power spectral density. The boxes of the 1/3-octave band statistical distributions indicate the first (25%, L_{25}), second (50%, L_{50}), and third (75%, L_{75}) quartiles. The whiskers indicate the maximum and minimum range of the data and short dashes (–) indicate the 5% (L_5) and 95% (L_{95}) exceedance percentiles.

3. Results

3.1. Impact Hammer Pile Driving Sound Levels

3.1.1. Pile IP1: Un-attenuated, Hydraulic Impact Hammer, Location 5

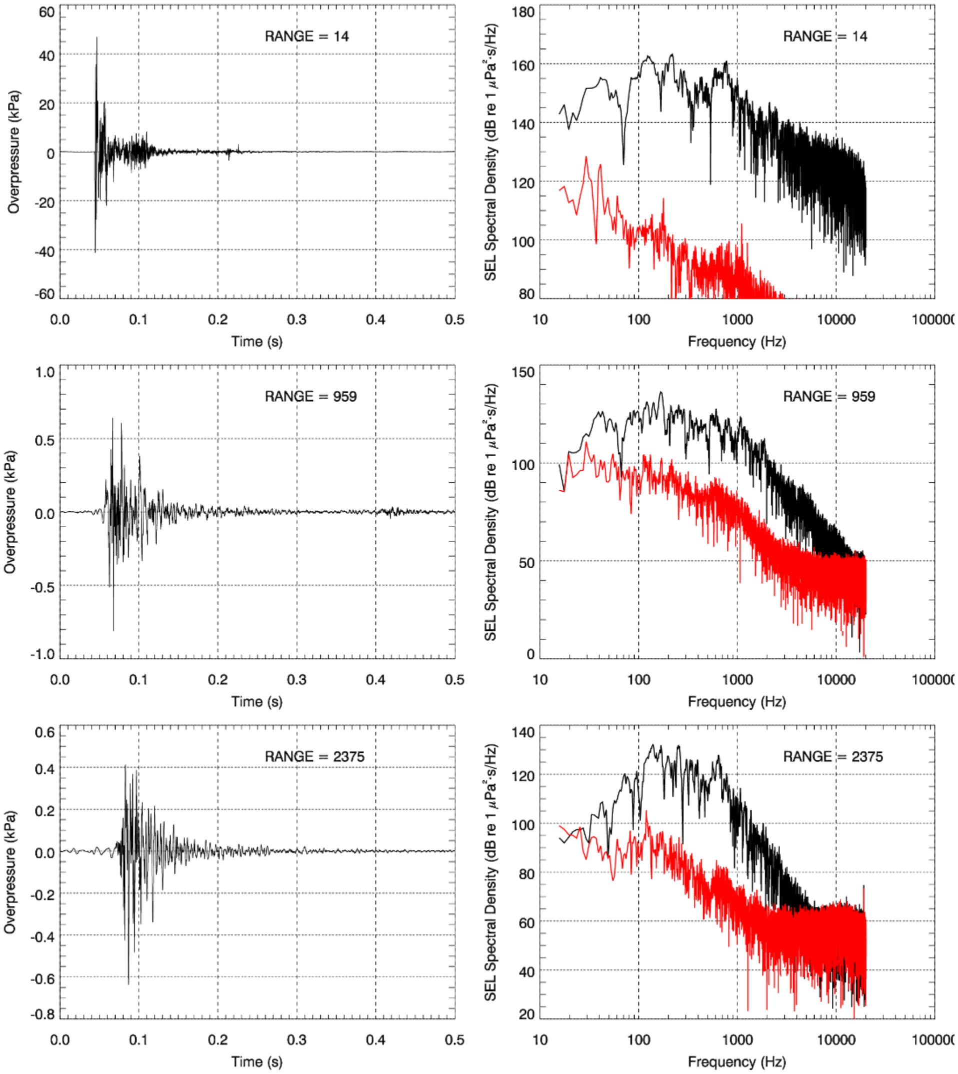


Figure 9. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP1-10M (top), IP1-1KM (middle), and IP1-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

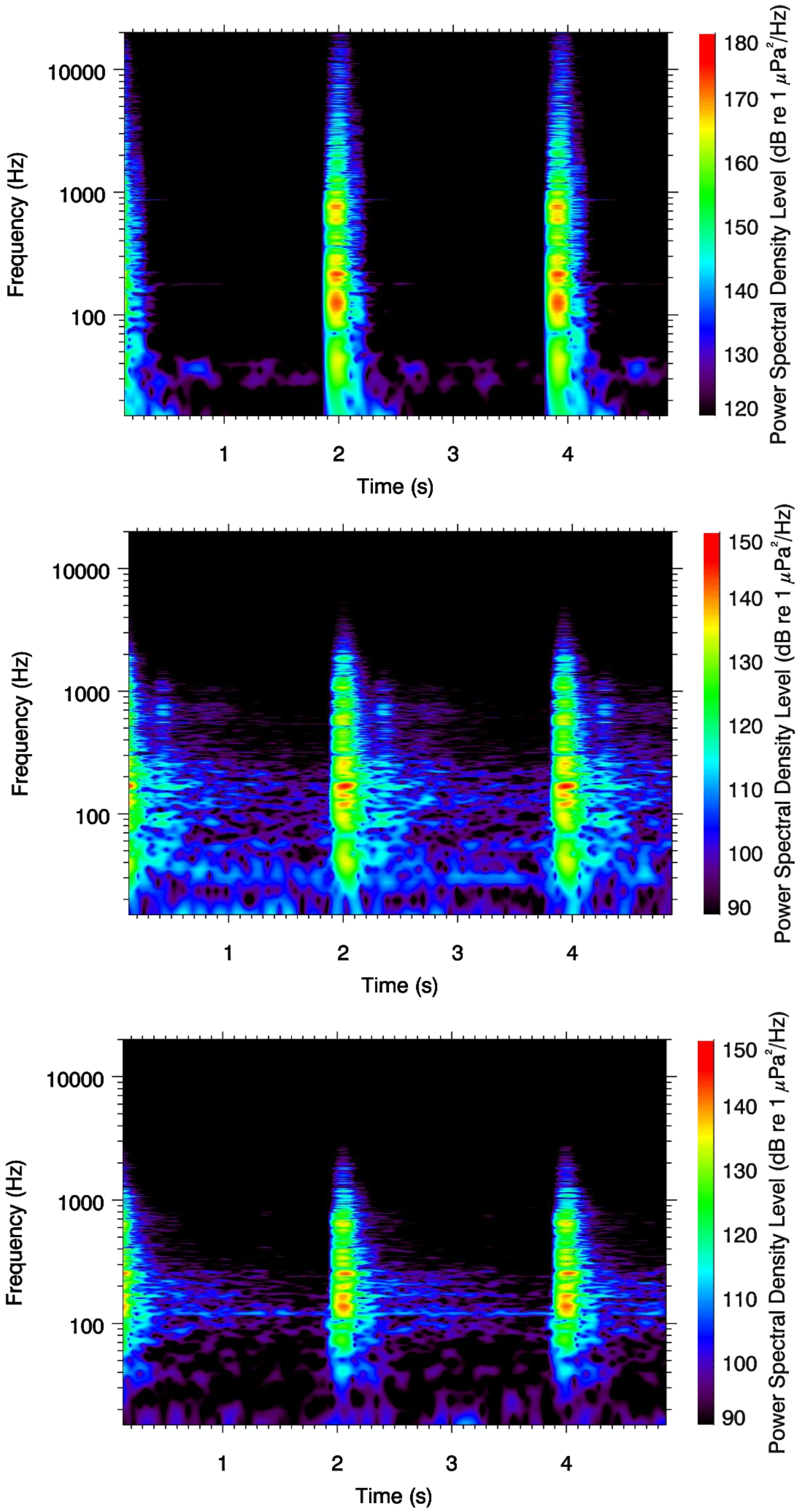
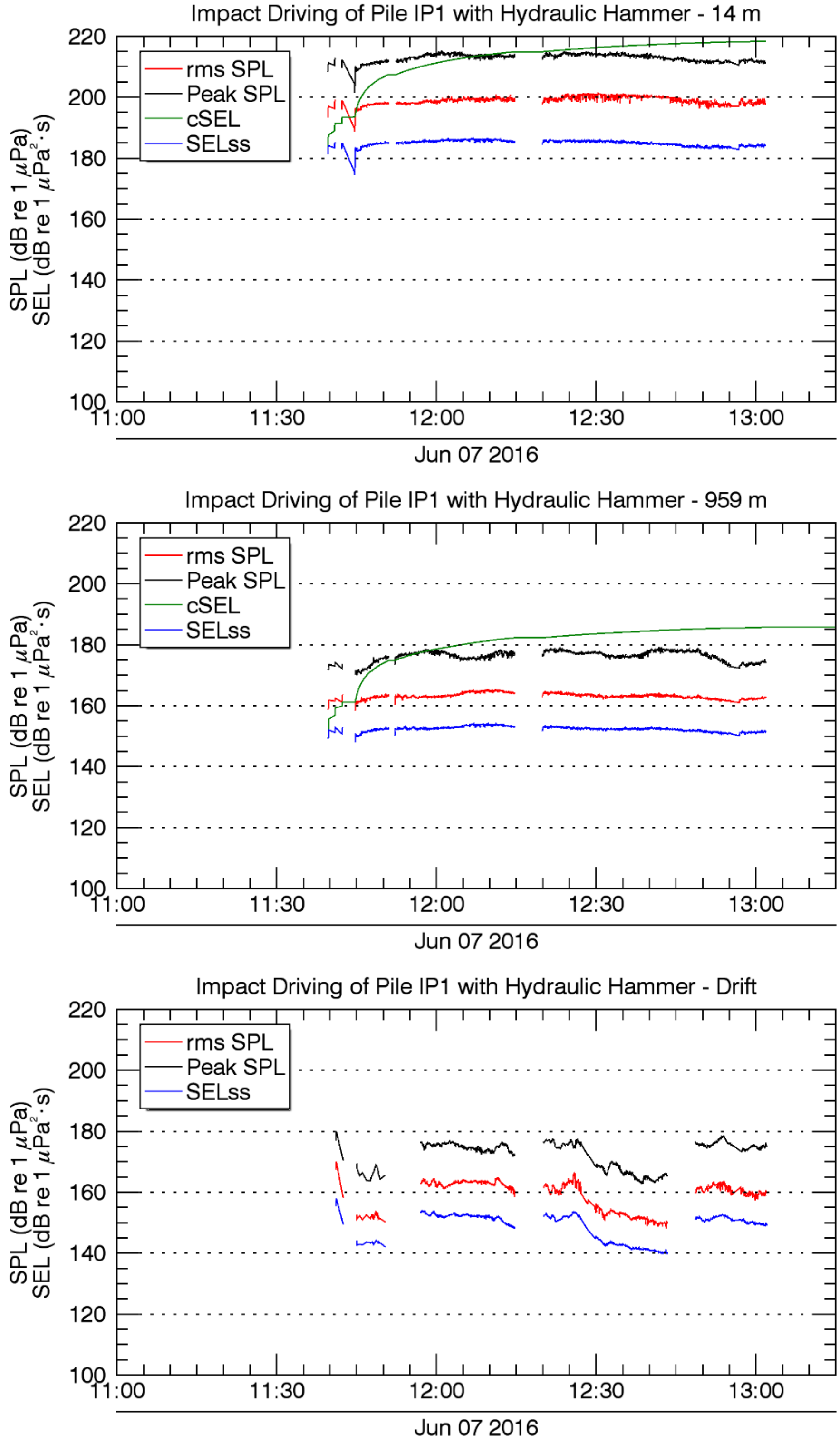


Figure 10. Spectrogram of strikes by the hydraulic impact hammer on Pile IP1 at a distance of 14 m at IP1-10M (top), 959 m at IP1-1KM (middle), and 2375 m at IP1-DRIFT (bottom).



Impact Driving of Pile IP1 with Hydraulic Hammer - 14 m

Impact Driving of Pile IP1 with Hydraulic Hammer - 959 m

Impact Driving of Pile IP1 with Hydraulic Hammer - Drift

Figure 11. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP1 by the hydraulic impact hammer, measured at distances of 14 m at IP1-10M (top) 959 m at IP1-1KM (middle) and between 1040 m and 2800 m on IP1-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.2. Pile IP2: Resonator, Diesel Impact Hammer, Location 4

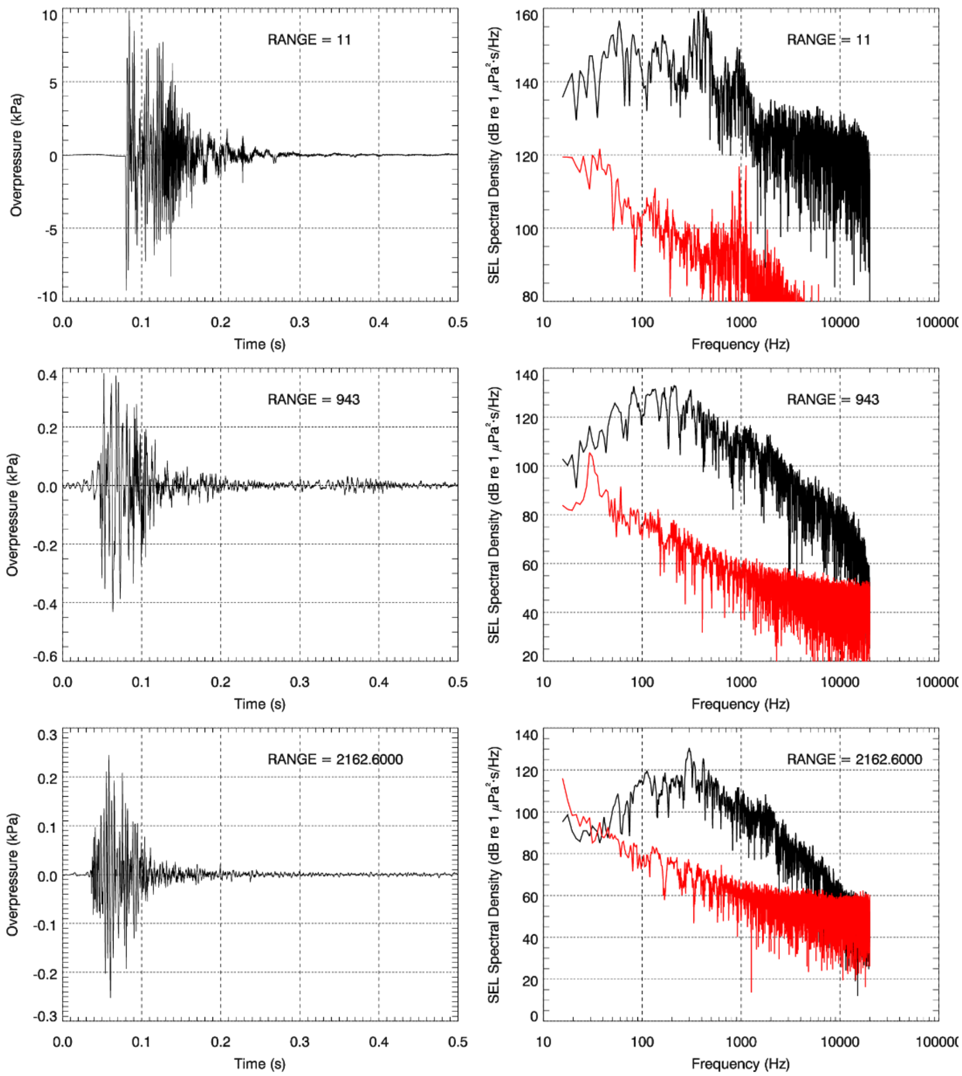


Figure 12. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP2-10m (top), IP2-1km (middle), and IP2-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

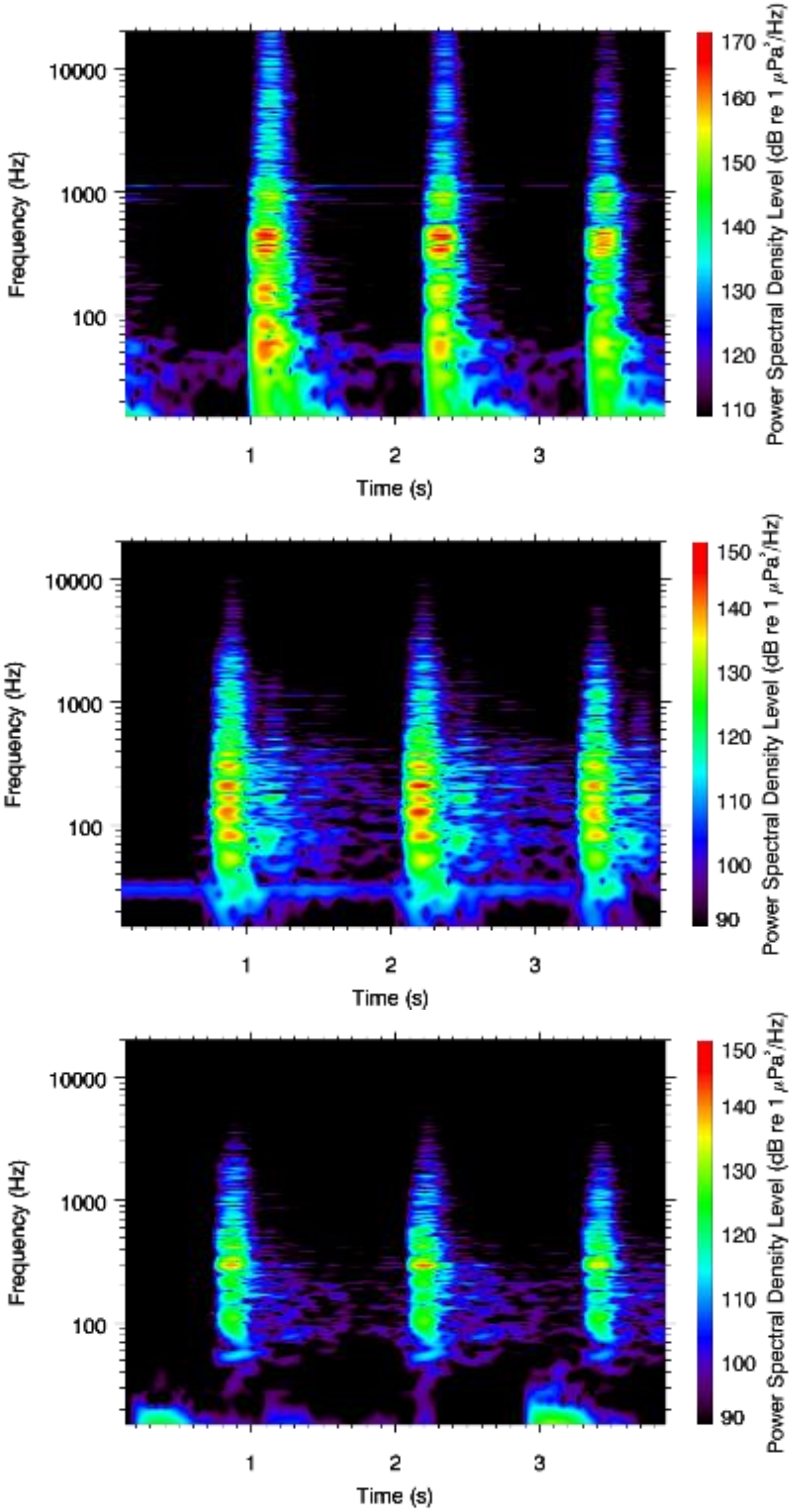


Figure 13. Spectrogram of strikes by the diesel impact hammer on Pile IP2 at a distance of 11 m at IP2-10M (top), 943 m at IP2-1KM (middle), and 2260 m at IP2-DRIFT (bottom).

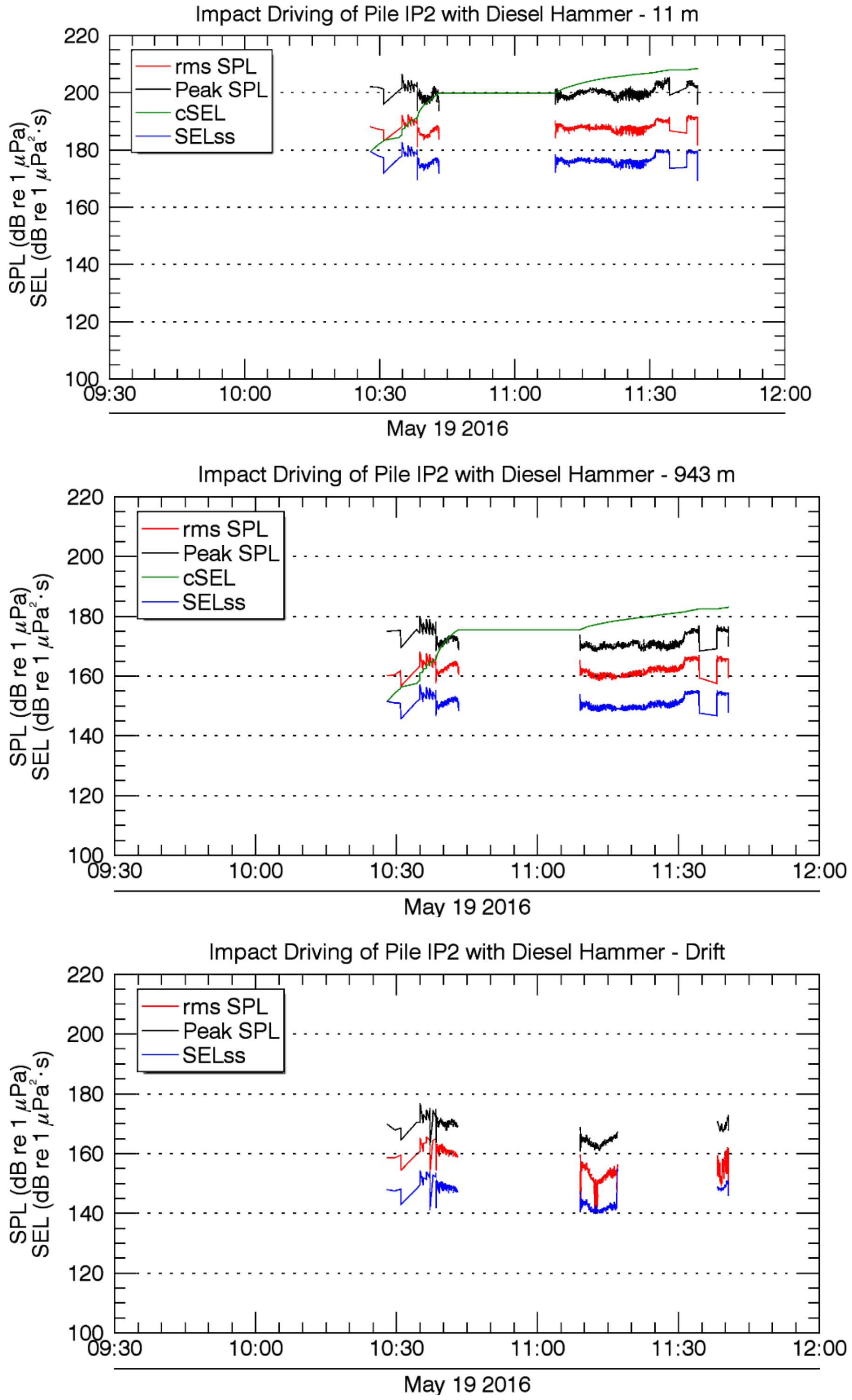


Figure 14. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP2 by the diesel impact hammer, measured at distances of 11 m at IP2-10M (top) 943 m at IP2-1KM (middle) and between 1700 m and 3500 m on IP2-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.3. Pile IP3: Bubble Curtain, Hydraulic Impact Hammer, Location 1

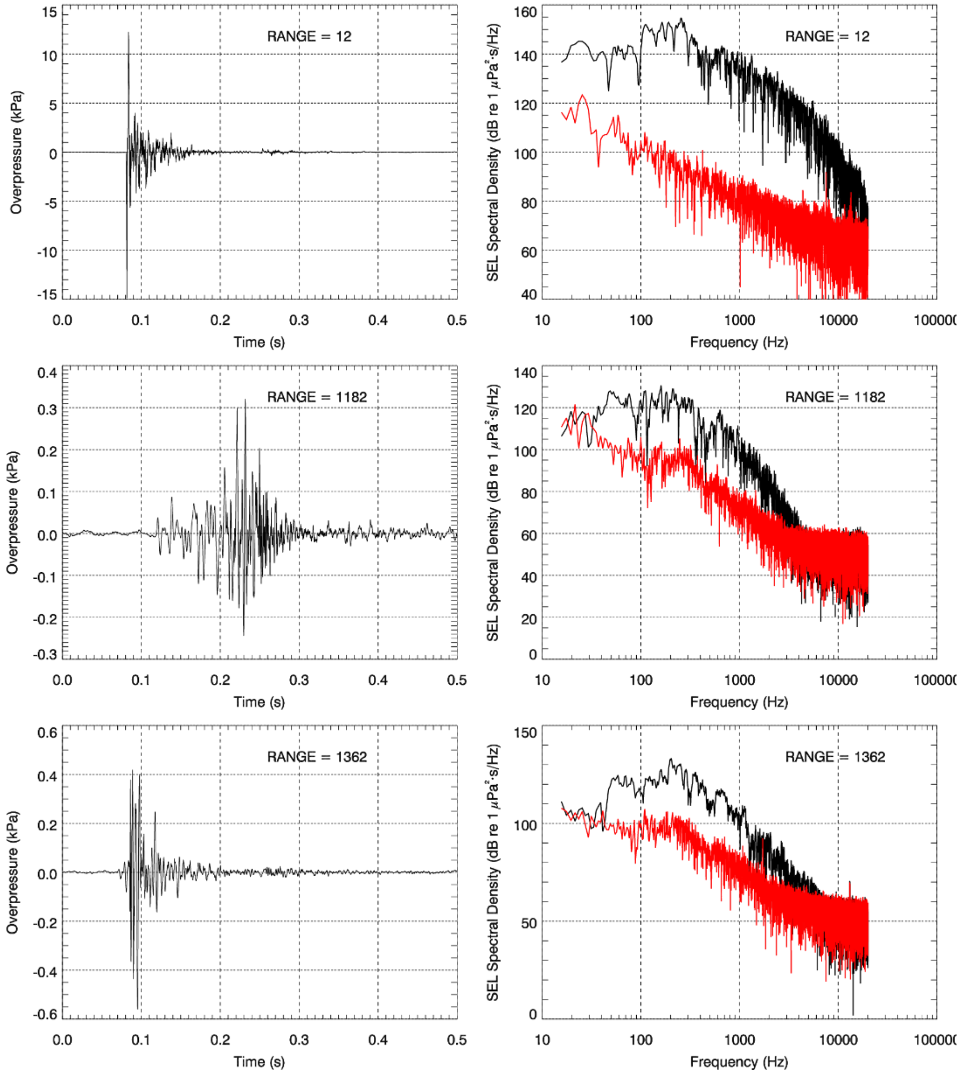


Figure 15. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP3-10M (top), IP3-1KM (middle), and IP3-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

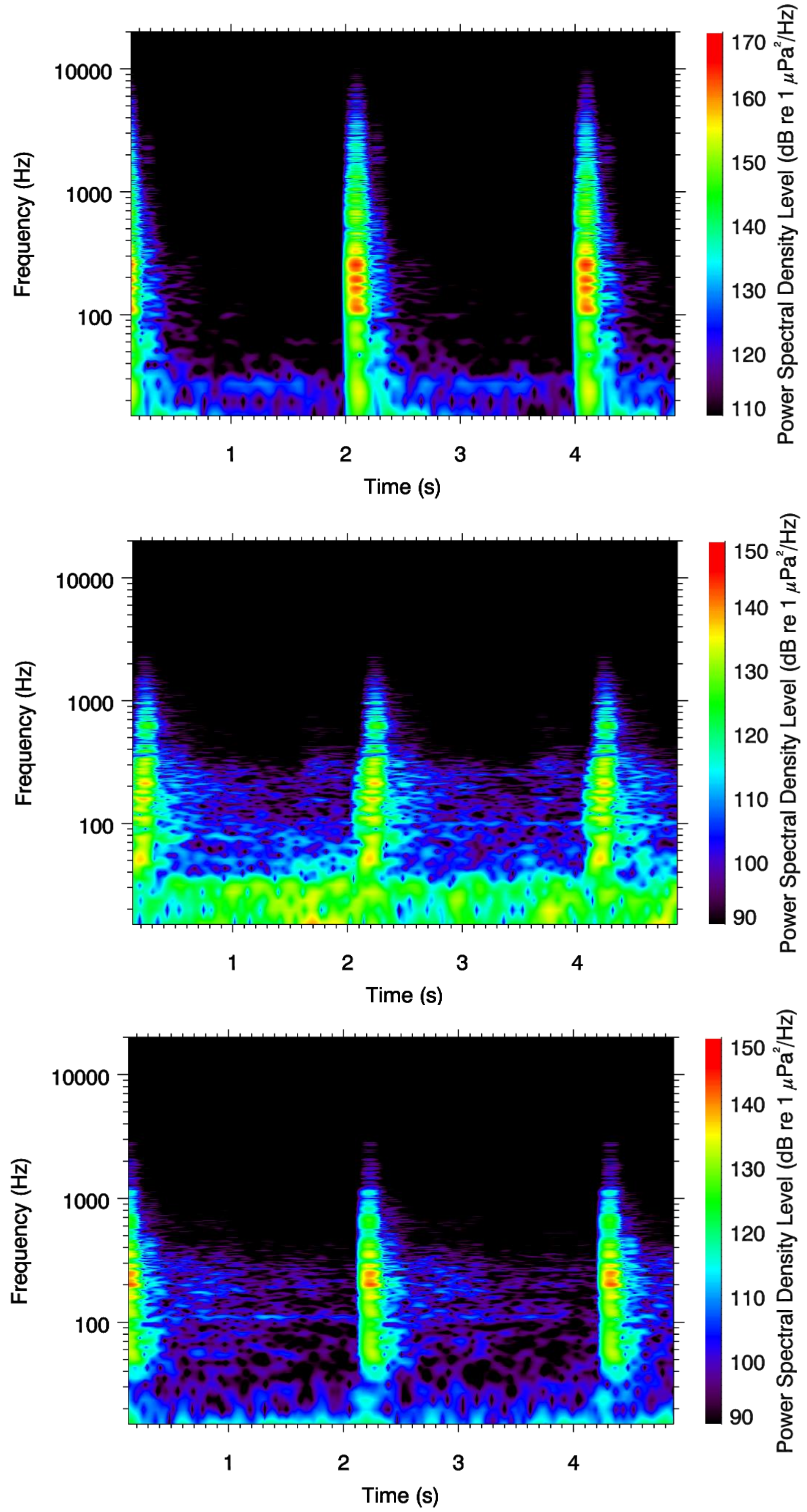


Figure 16. Spectrogram of strikes by the hydraulic impact hammer on Pile IP3 at a distance of 12 m at IP3-10M (top), 1182 m at IP3-1KM (middle), and 1362 m at IP3-DRIFT (bottom).

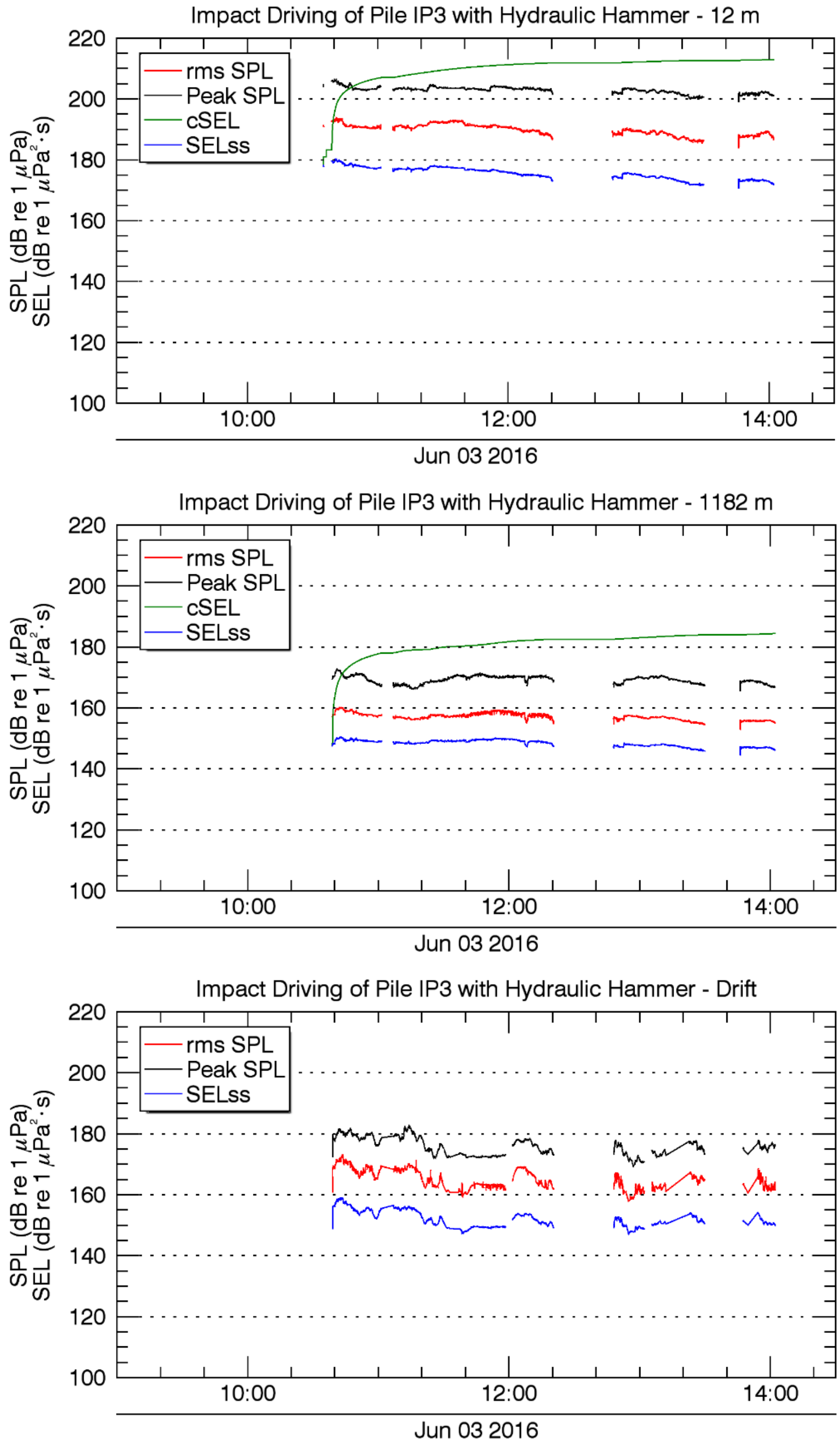


Figure 17. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP3 by the hydraulic impact hammer, measured at distances of 12 m at IP3-10M (top) 1182 m at IP3-1KM (middle) and between 860 m and 1867 m on IP3-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.4. Pile IP4: Resonator, Hydraulic Impact Hammer, Location 1

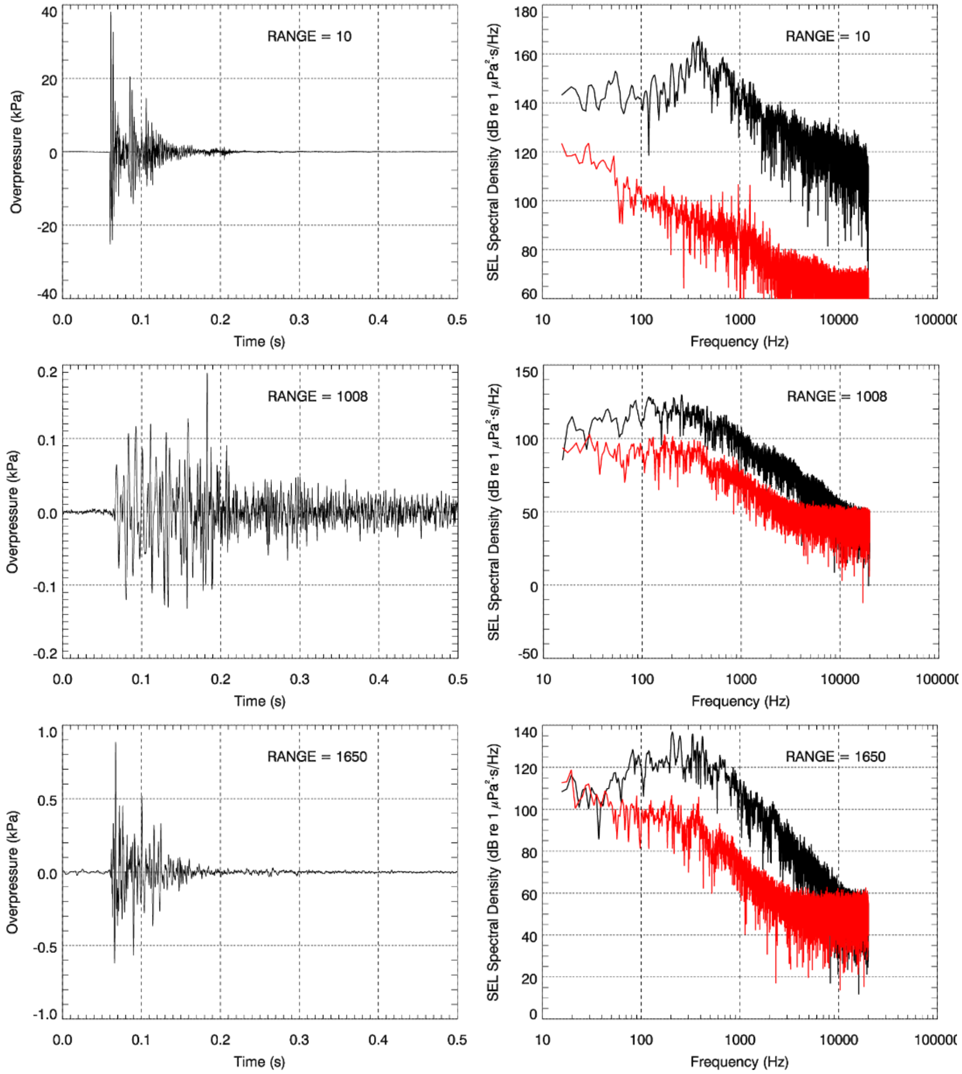


Figure 18. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP4-10M (top), IP4-1KM (middle), and IP4-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

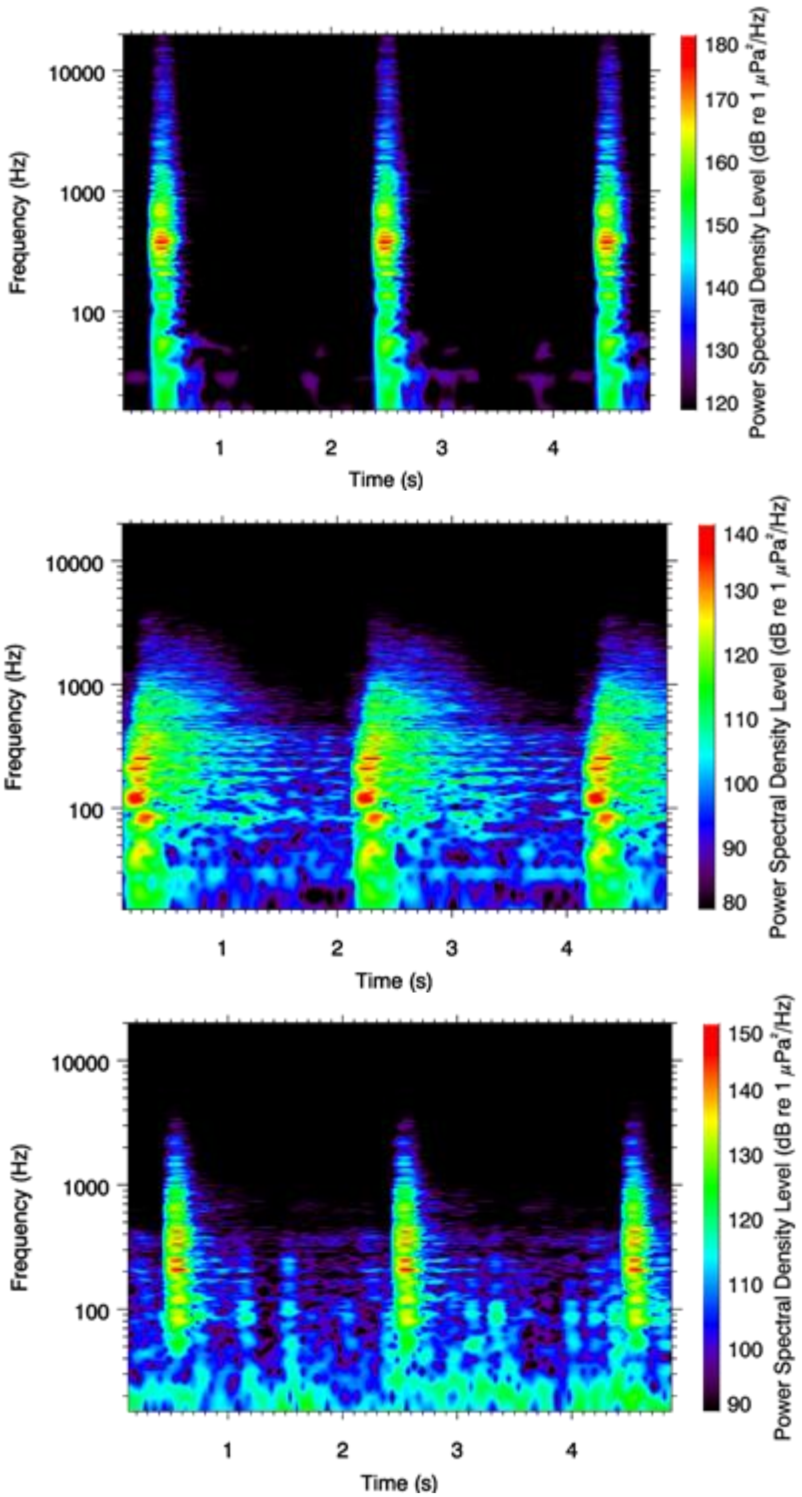


Figure 19. Spectrogram of strikes by the hydraulic impact hammer on Pile IP4 at a distance of 10 m at IP4-10M (top), 1008 m at IP4-1KM (middle), and 1650 m at IP4-DRIFT (bottom).

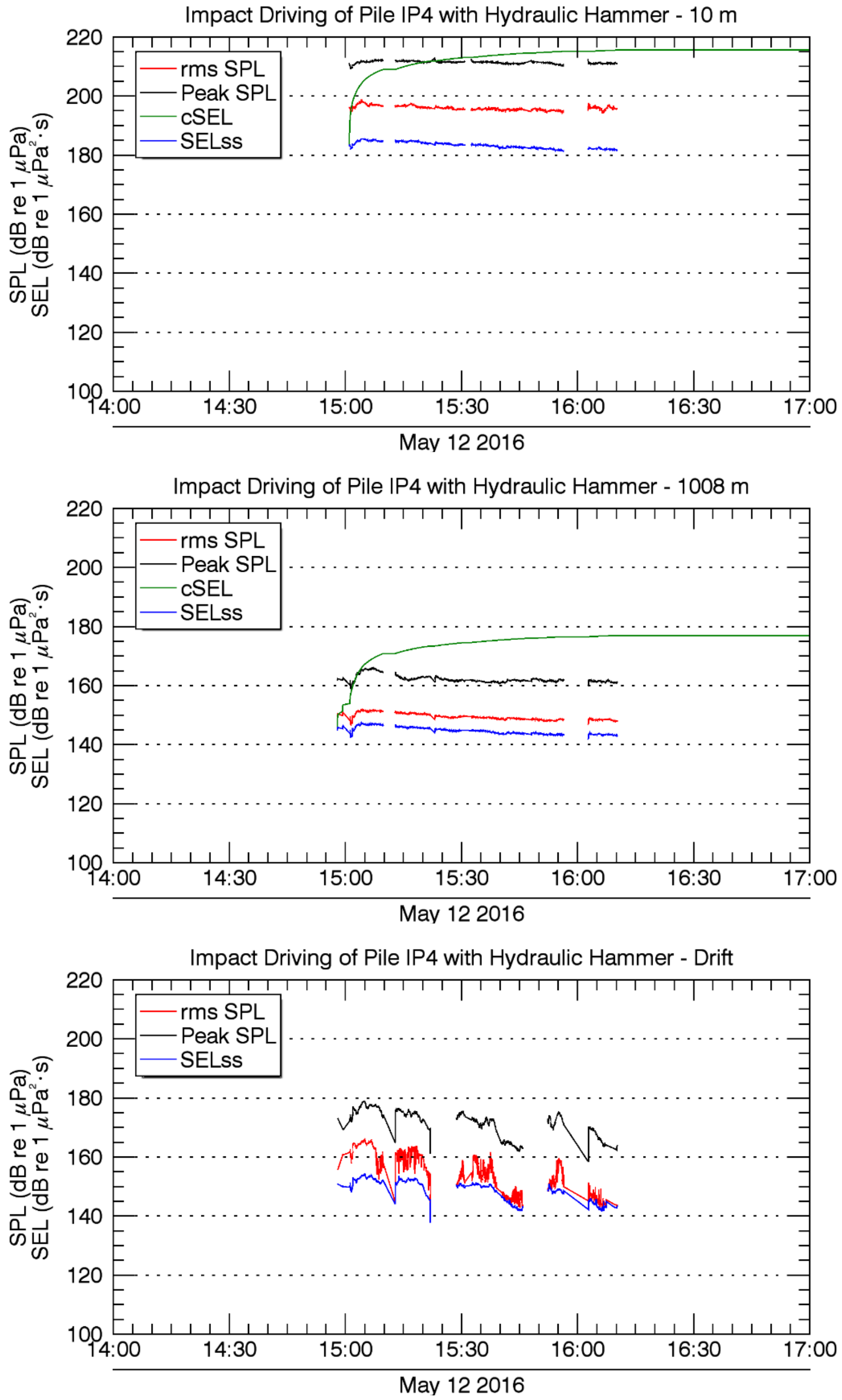


Figure 20. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP4 by the hydraulic impact hammer, measured at distances of 10 m at IP4-10M (top) 1008 m at IP4-1KM (middle) and between 1630 m and 3020 m on IP4-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.5. Pile IP4: Resonator, Diesel Impact Hammer, Location 1

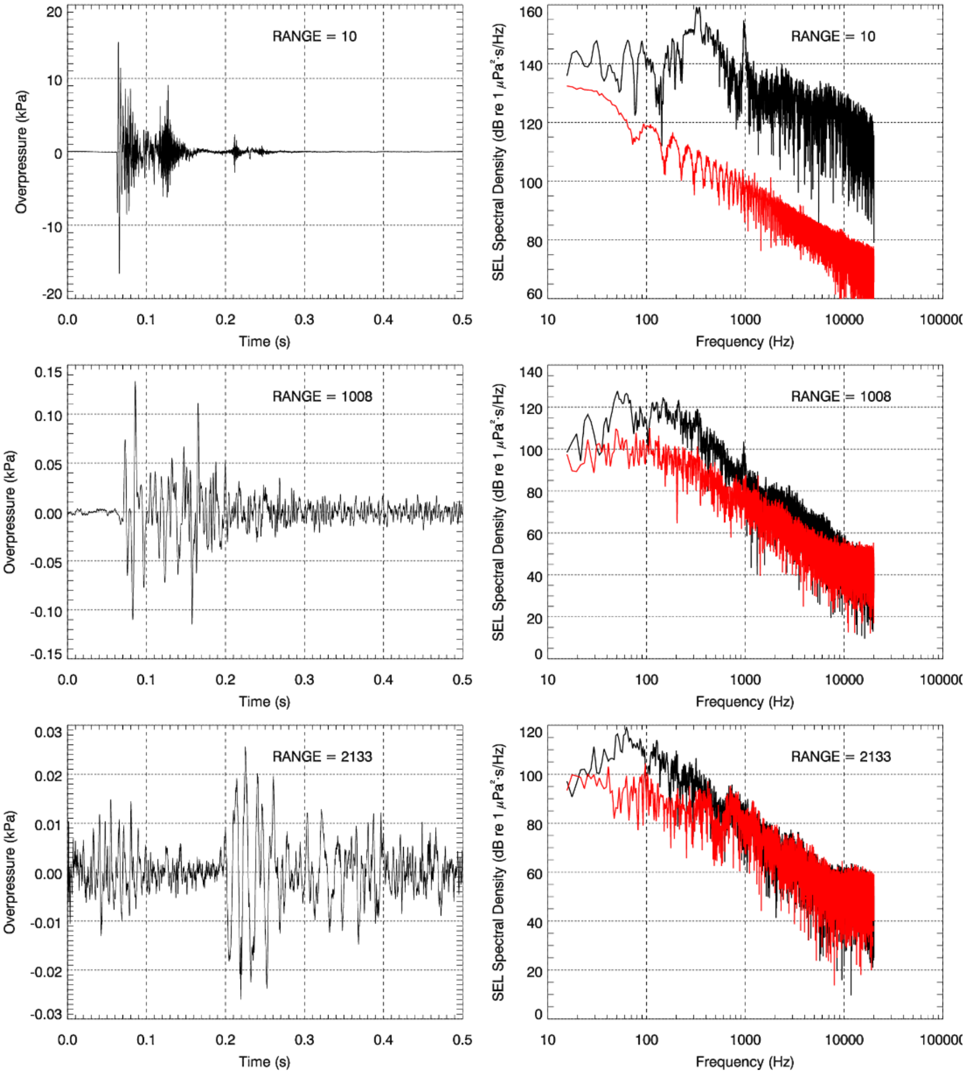


Figure 21. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP4-10M (top), IP4-1KM (middle), and IP4-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

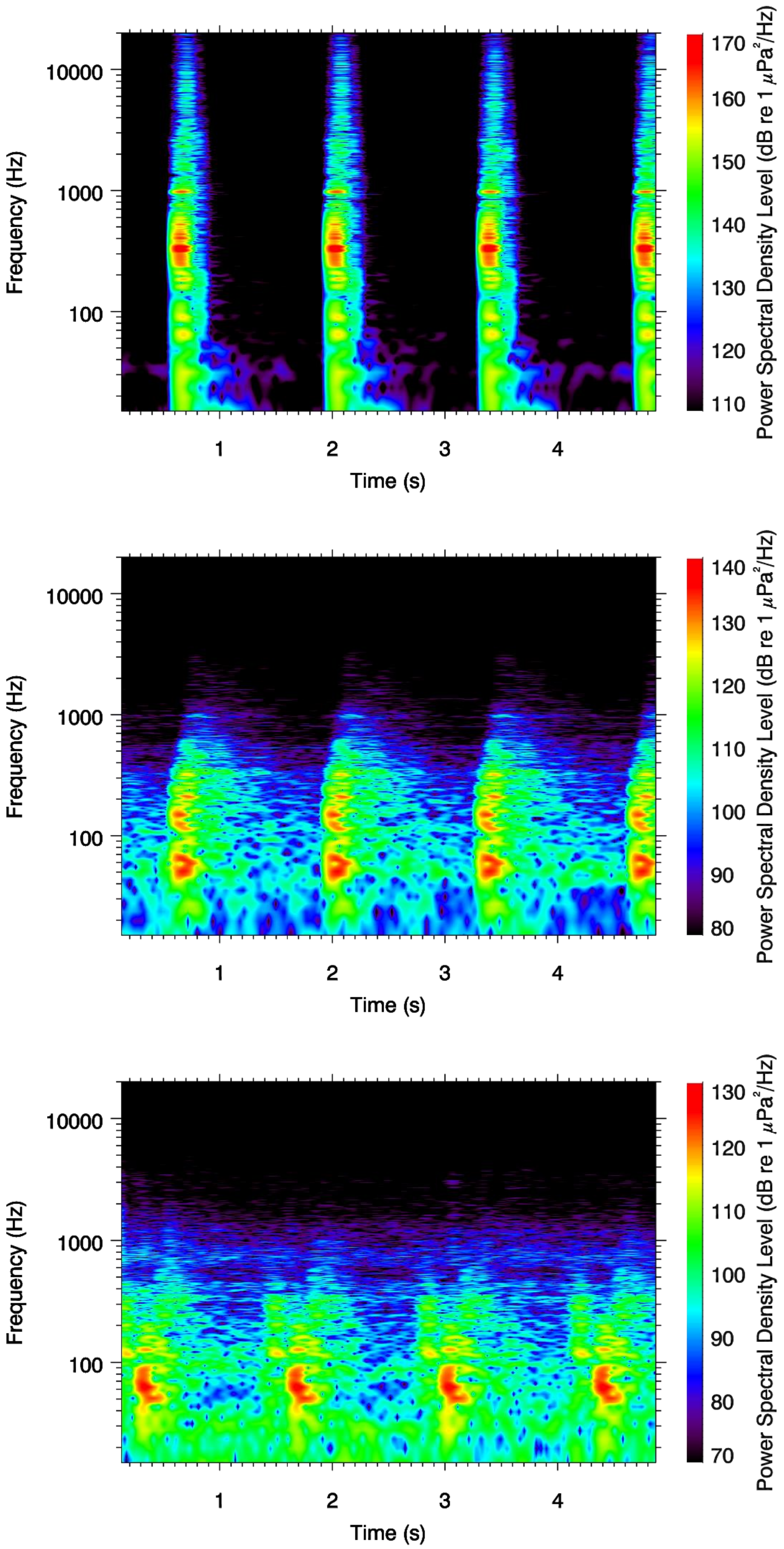


Figure 22. Spectrogram of strikes by the diesel impact hammer on Pile IP4 at a distance of 10 m at IP4-10M (top), 1008 m at IP4-1KM (middle), and 2133 m at IP4-DRIFT (bottom).

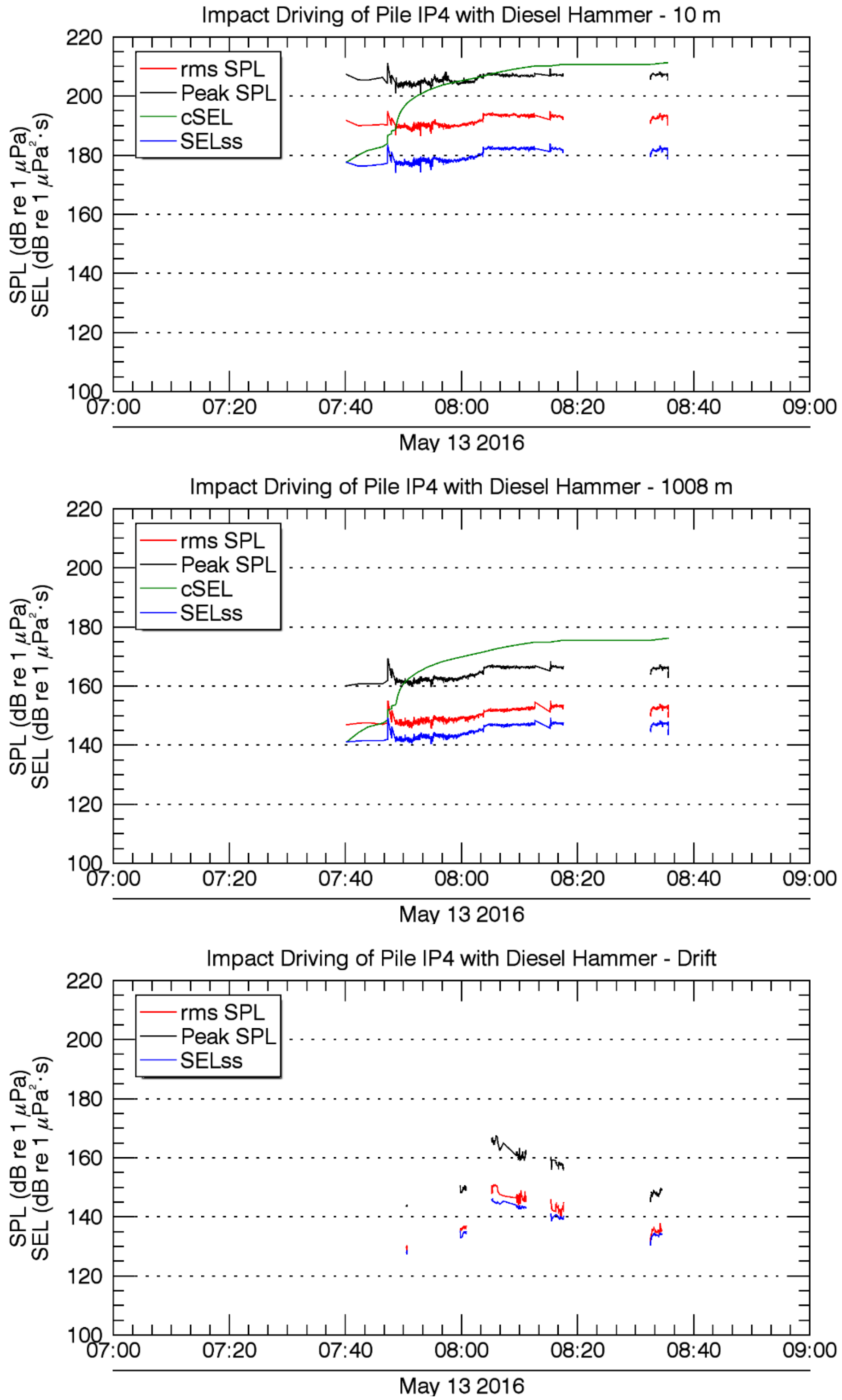


Figure 23. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP4 by the diesel impact hammer, measured at distances of 10 m at IP4-10M (top) 1008 m at IP4-1KM (middle) and between 1470 m and 2670 m on IP4-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.6. Pile IP5: Un-attenuated, Diesel Impact Hammer, Location 4

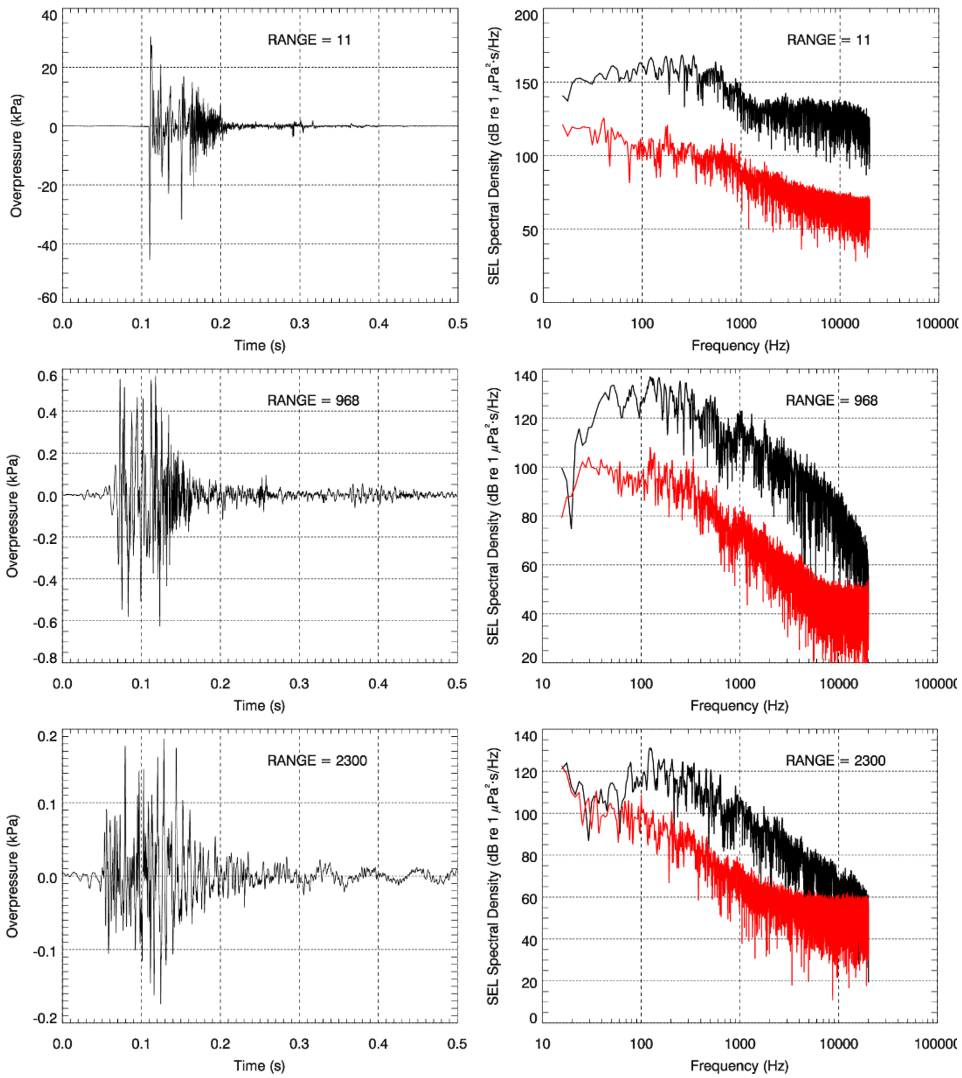


Figure 24. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP5-10M (top), IP5-1KM (middle), and IP5-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

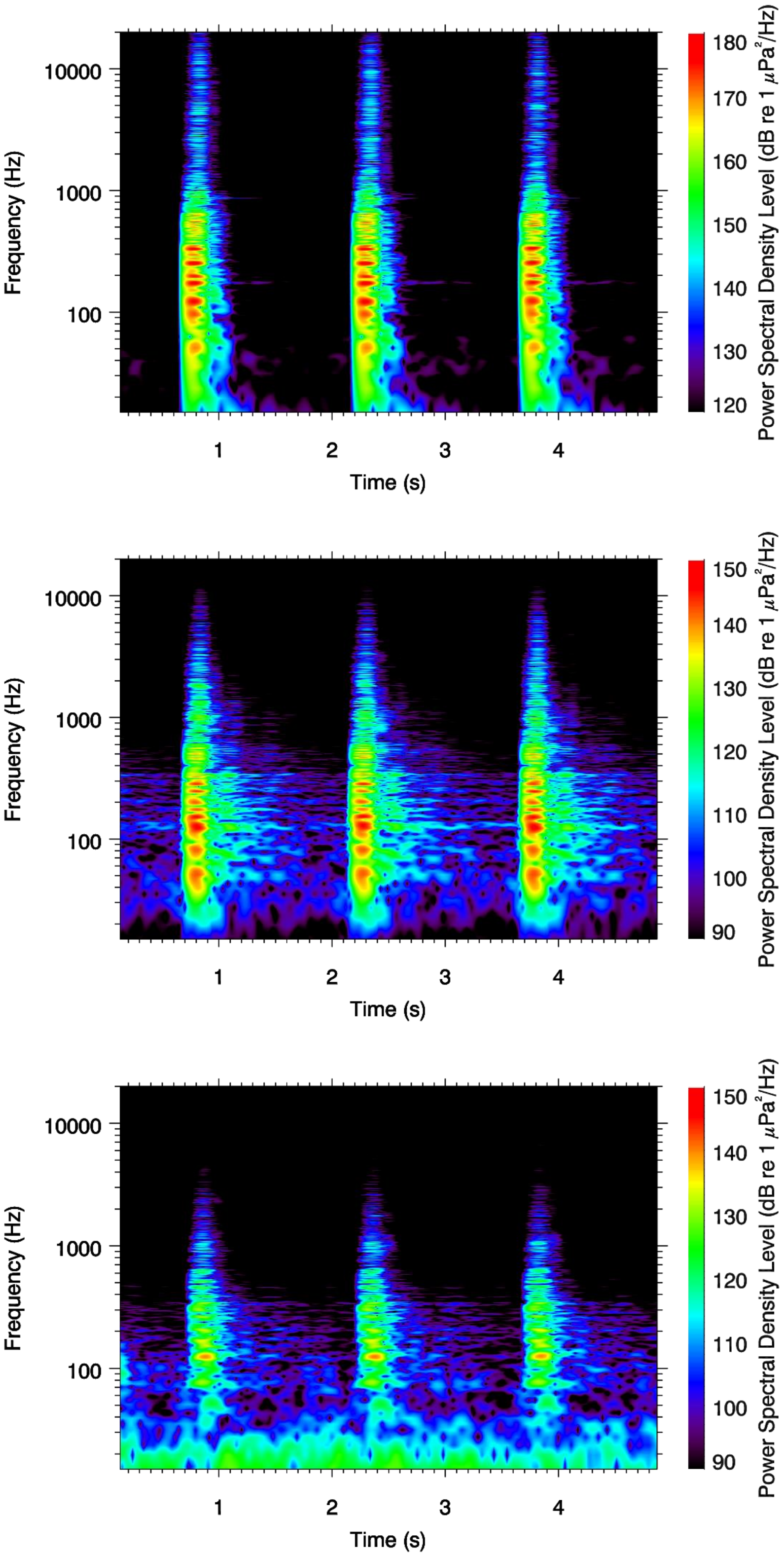


Figure 25. Spectrogram of strikes by the diesel impact hammer on Pile IP5 at a distance of 11 m at IP5-10M (top), 968 m at IP5-1KM (middle), and 2300 m at IP5-DRIFT (bottom).

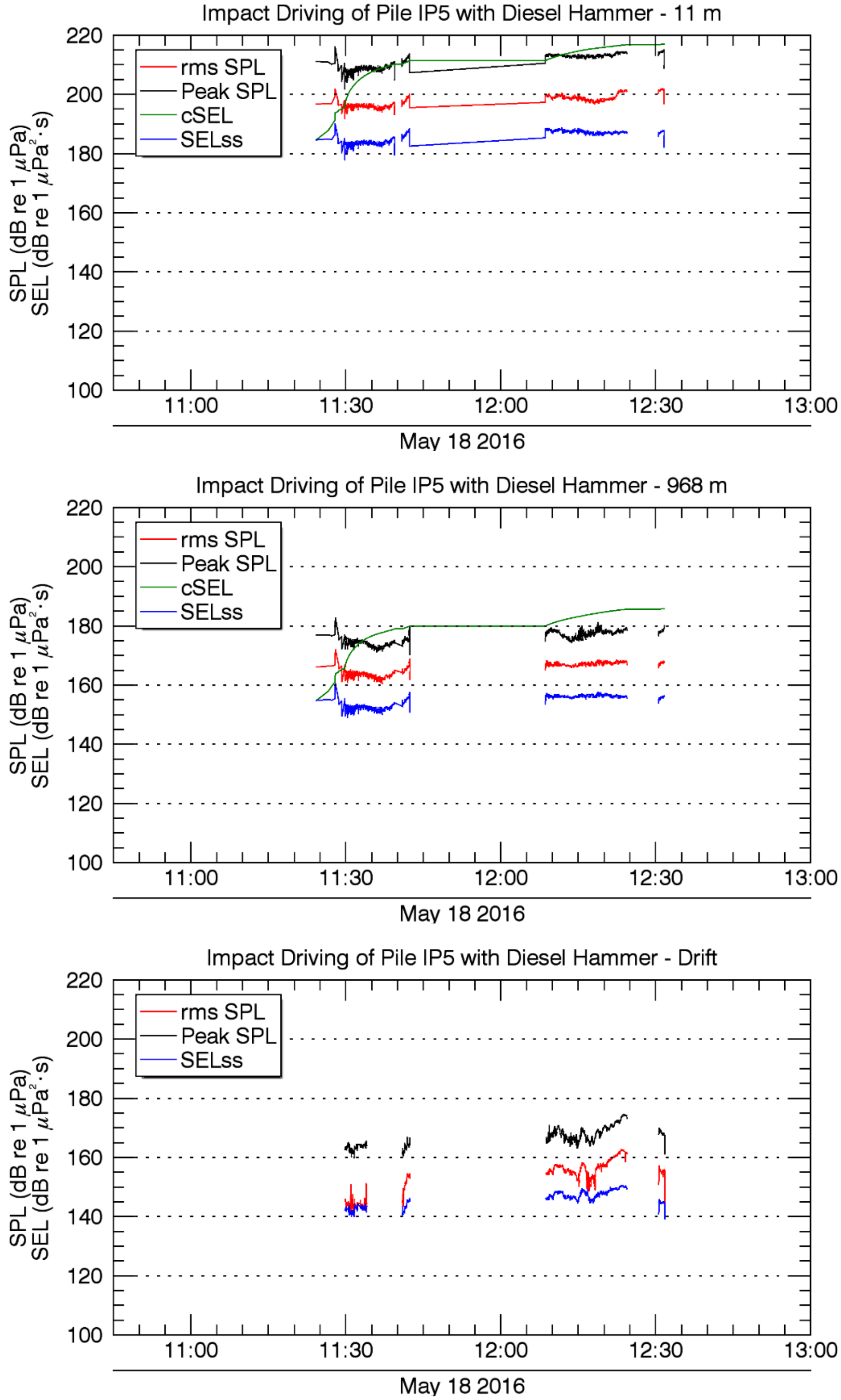


Figure 26. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP5 by the diesel impact hammer, measured at distances of 11 m at IP5-10M (top) 968 m at IP5-1KM (middle) and between 1900 m and 3200 m on IP5-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.7. Pile IP6: Un-attenuated and Bubble Curtain, Diesel Impact Hammer, Location 4

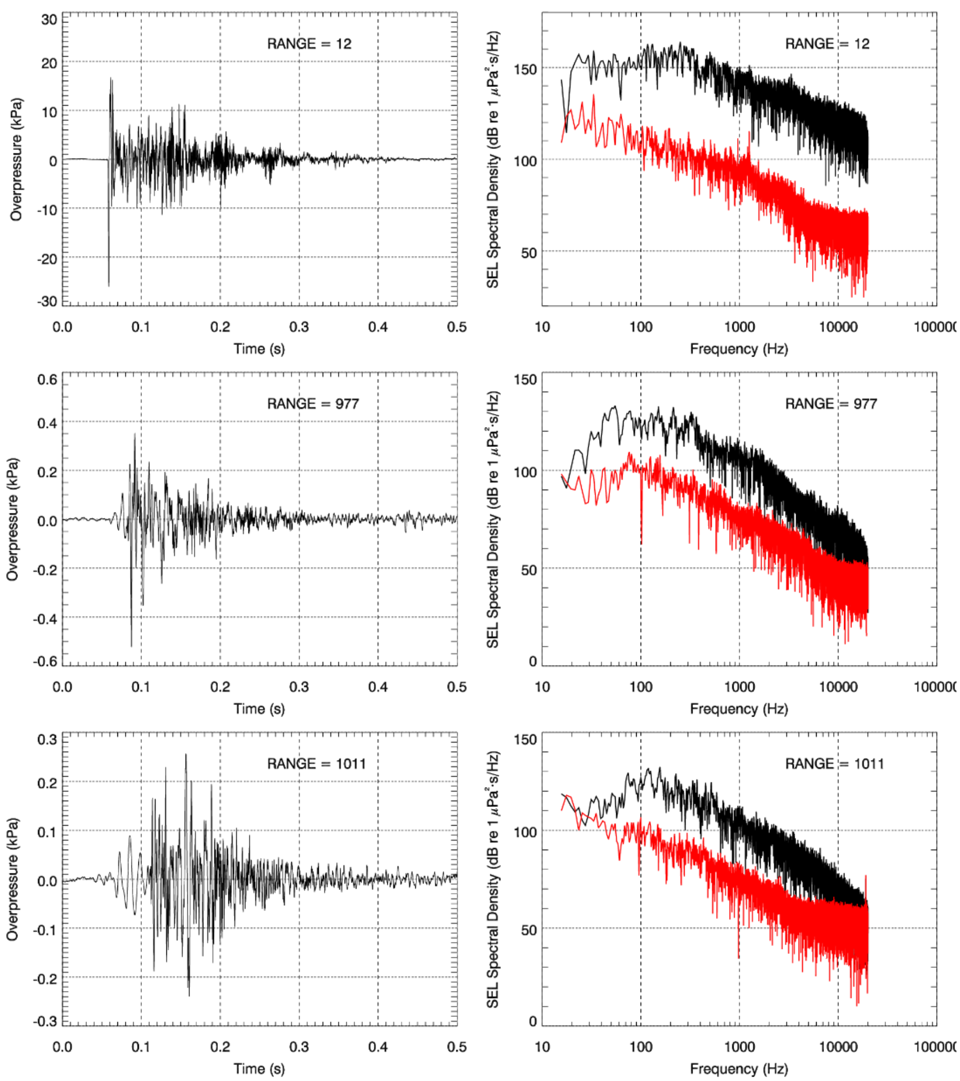


Figure 27. Waveforms (left) and spectra (right) for the same (un-attenuated) strike during impact hammering of 48 in steel pile recorded at IP6-10M (top), IP6-1KM (middle), and IP6-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

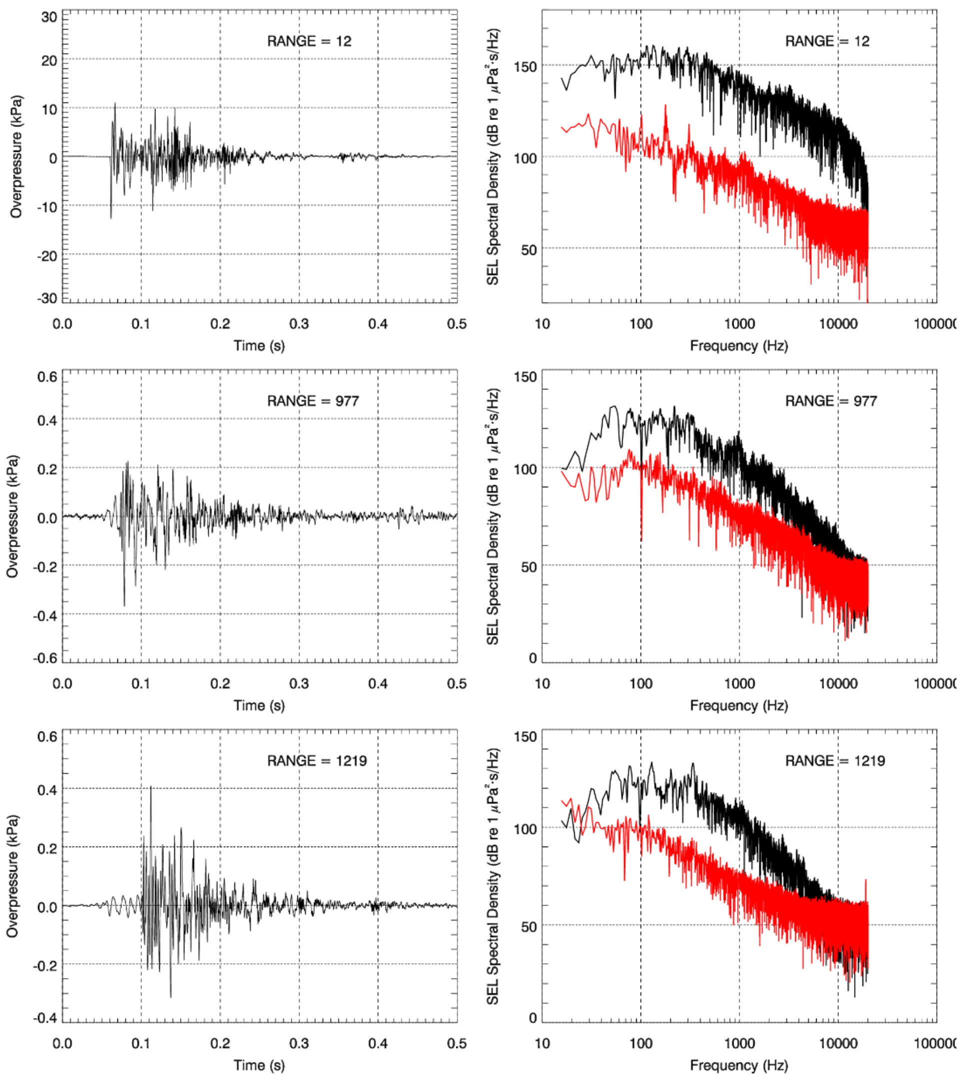


Figure 28. Waveforms (left) and spectra (right) for the same bubble curtain-attenuated strike during impact hammering of 48 in steel pile recorded at IP6-10M (top), IP6-1KM (middle), and IP6-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

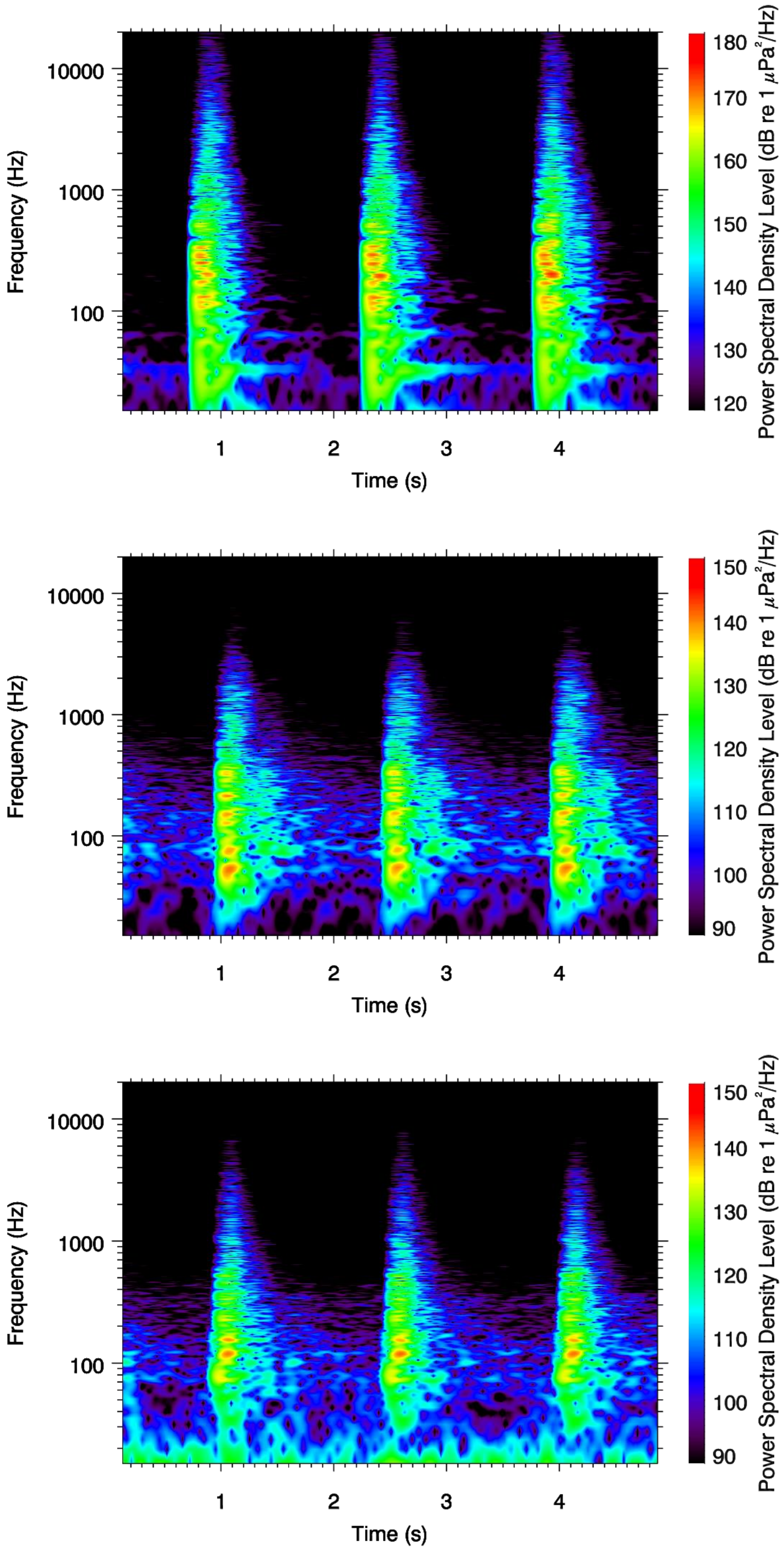


Figure 29. Spectrogram of un-attenuated strikes by the diesel impact hammer on Pile IP6 at a distance of 12 m at IP6-10M (top), 977 m at IP6-1KM (middle), and 1011 m at IP6-DRIFT (bottom).

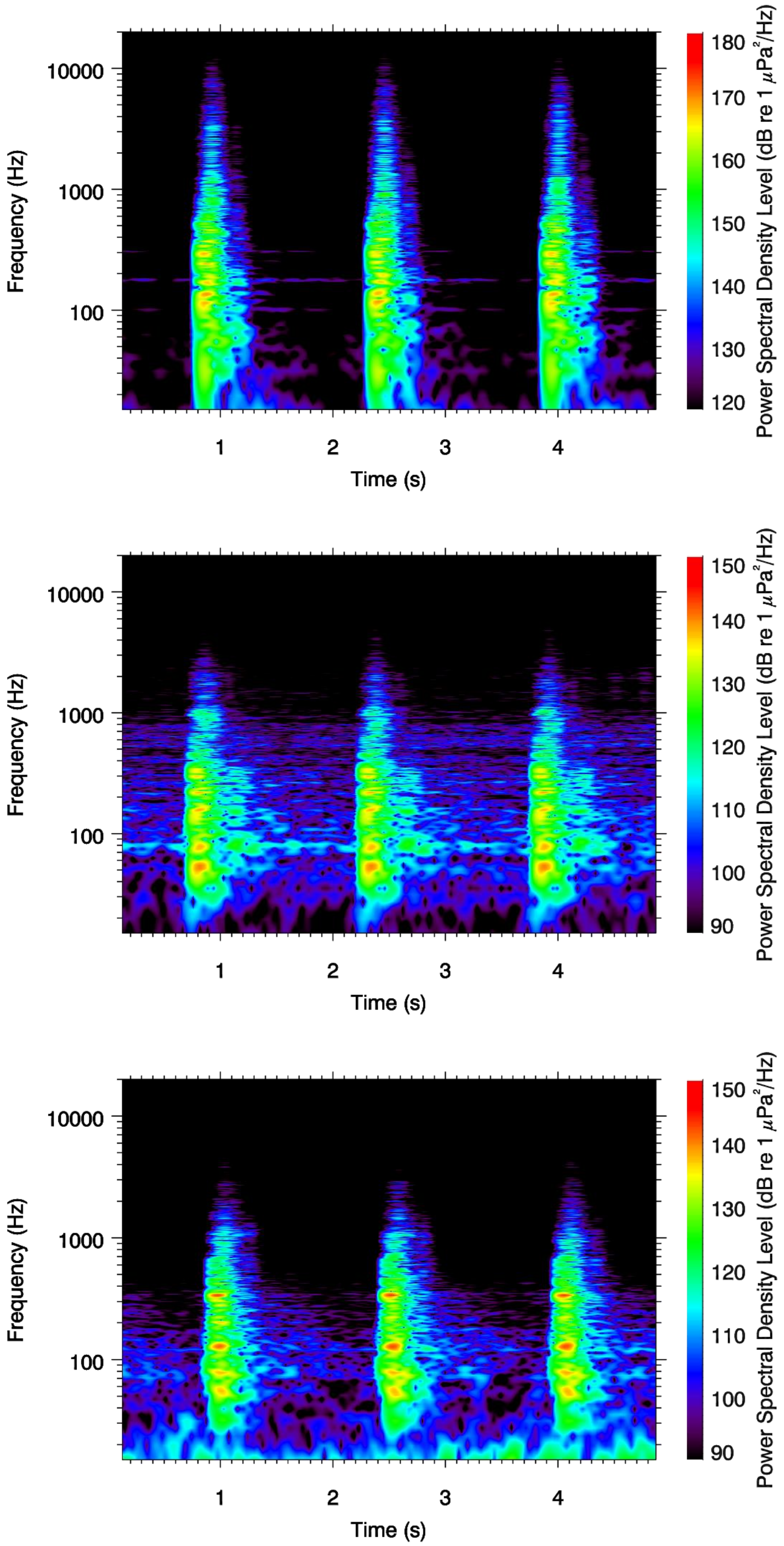


Figure 30. Spectrogram of bubble curtain-attenuated strikes by the diesel impact hammer on Pile IP6 at a distance of 12 m at IP6-10M (top), 977 m at IP6-1KM (middle), and 1219 m at IP6-DRIFT (bottom).

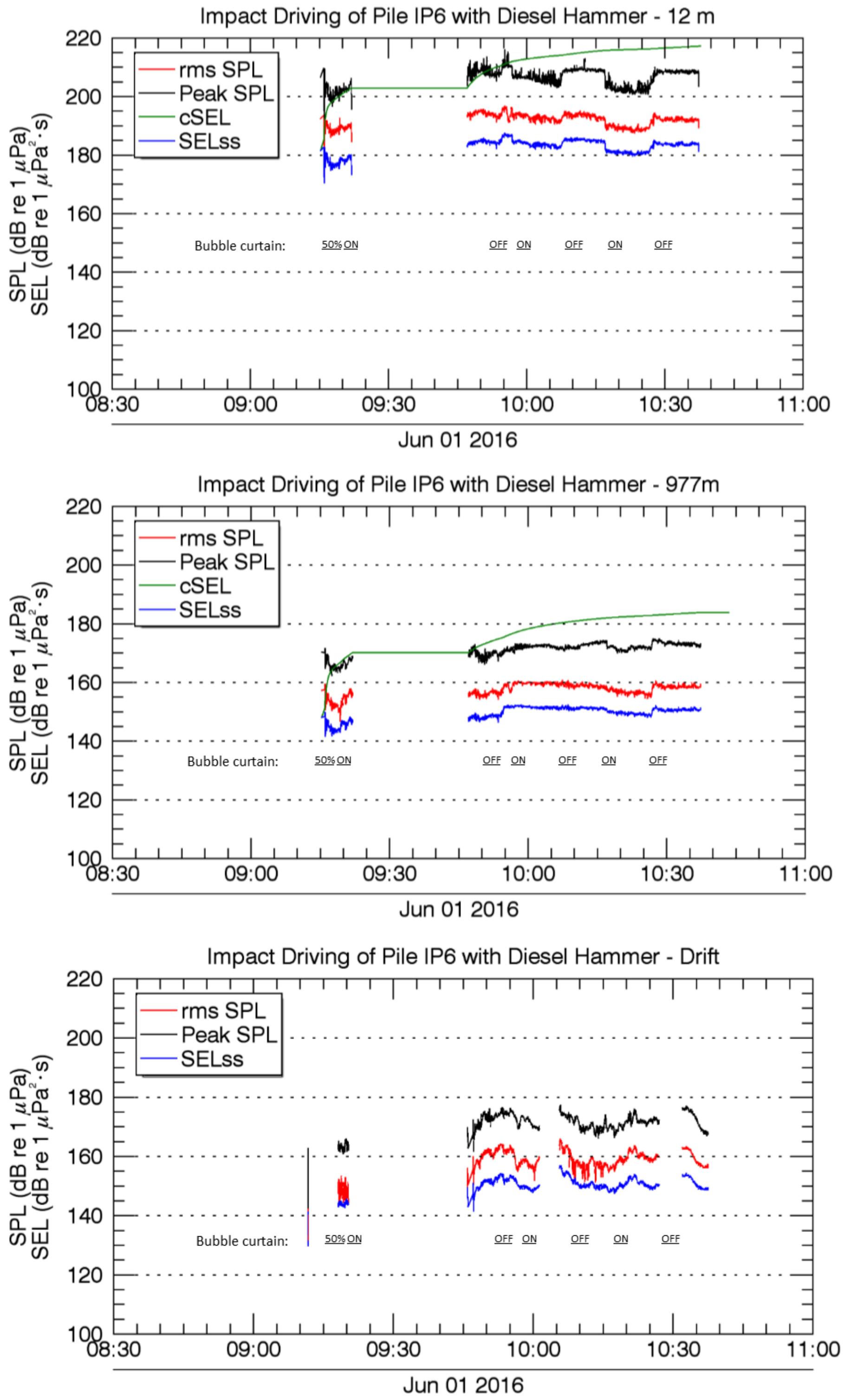


Figure 31. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP6 by the diesel impact hammer, measured at distances of 12 m at IP6-10M (top) 977 m at IP6-1KM (middle) and between 975 m and 2400 m on IP6-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.8. Pile IP7: Bubble Curtain, Diesel Impact Hammer, Location 5

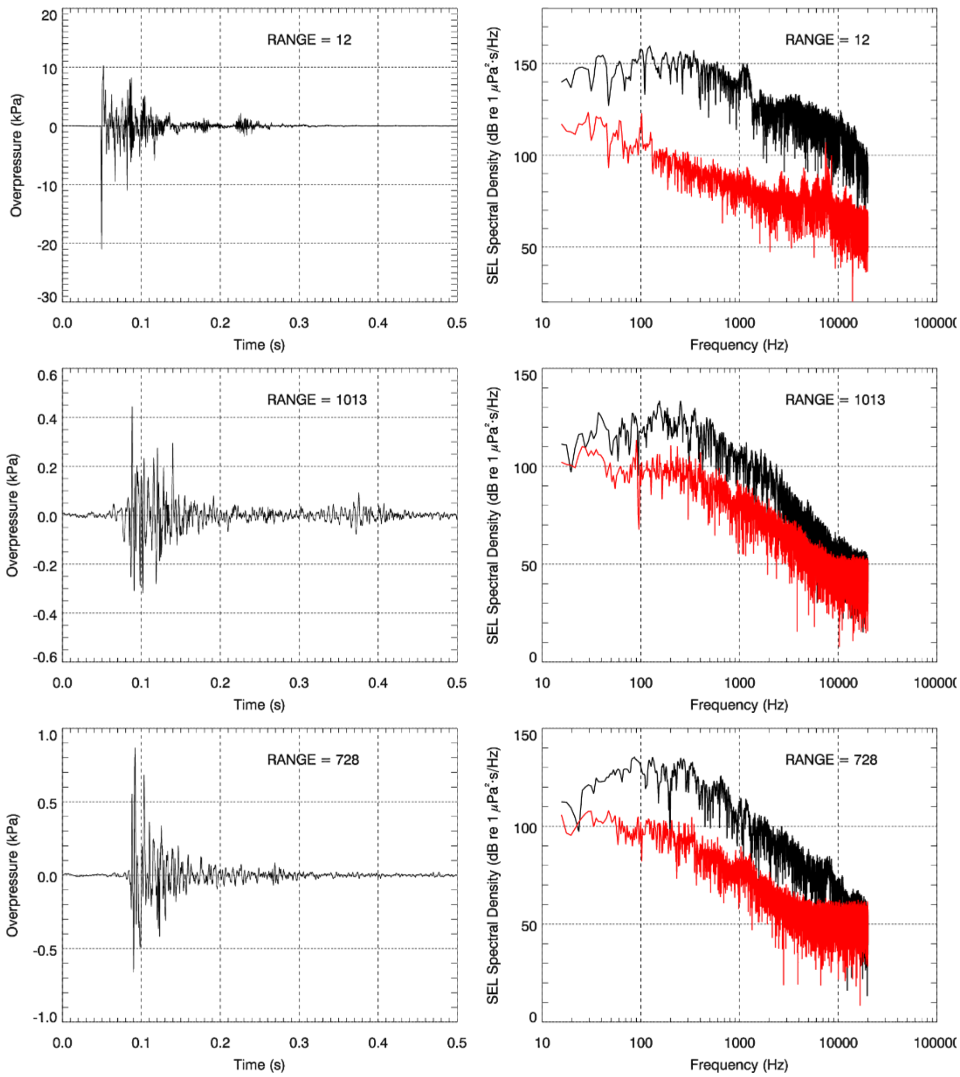


Figure 32. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP7-10M (top), IP7-1KM (middle), and IP7-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red. Signals were band-pass filtered between 15 Hz and 20 kHz.

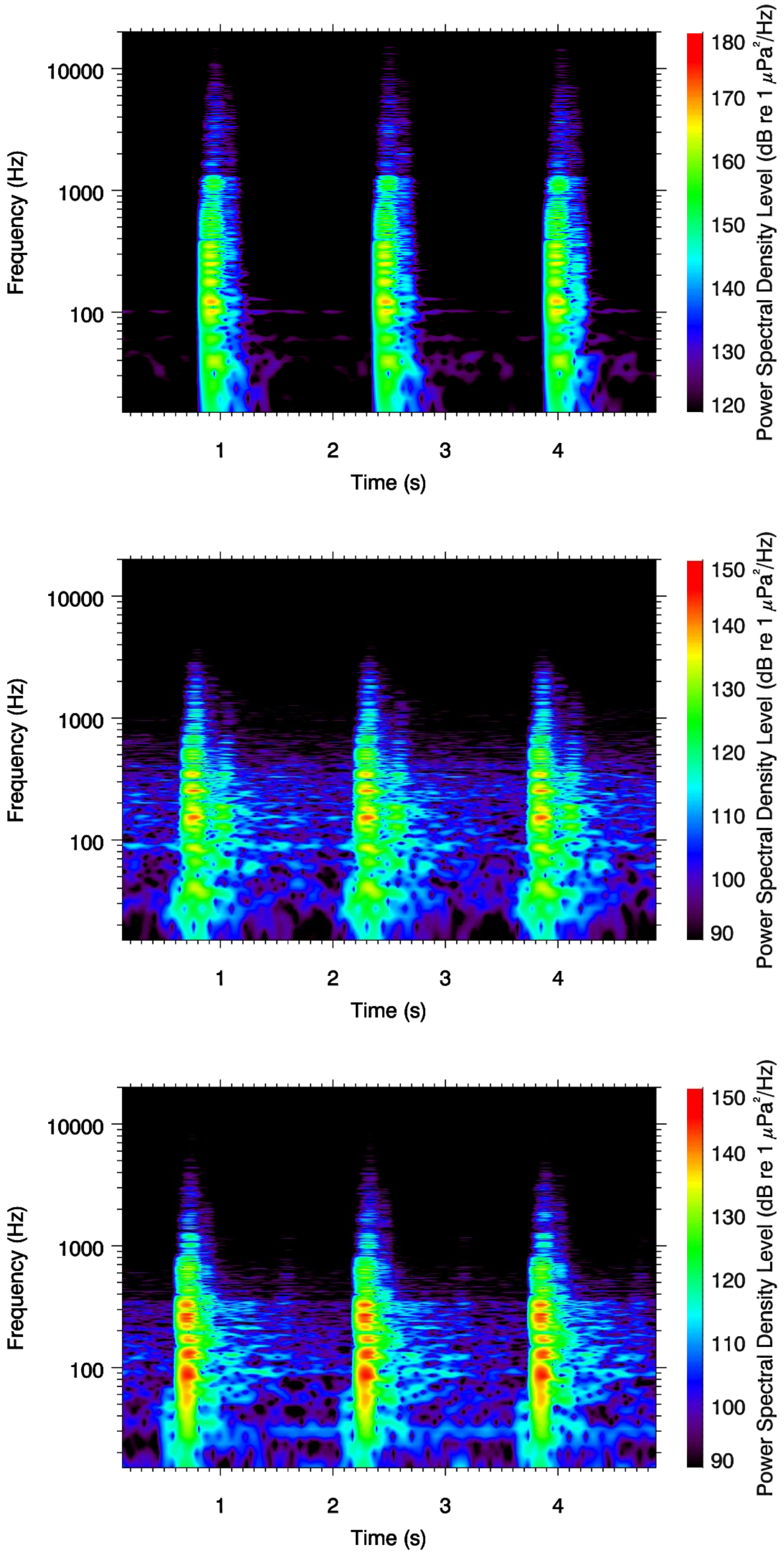
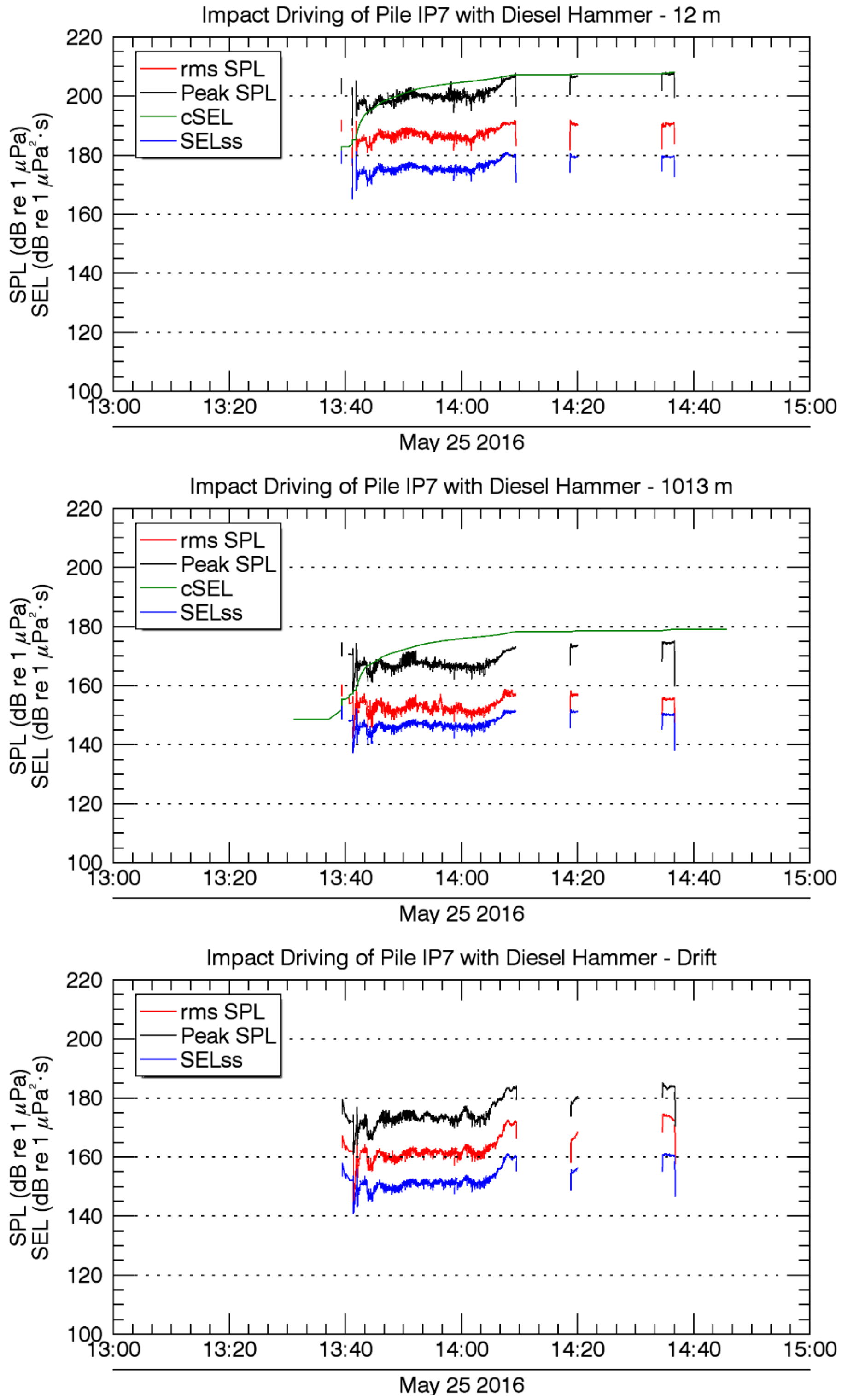


Figure 33. Spectrogram of strikes by the diesel impact hammer on Pile IP7 at a distance of 12 m at IP7-10M (top), 1013 m at IP7-1KM (middle), and 728 m at IP7-DRIFT (bottom).



Impact Driving of Pile IP7 with Diesel Hammer - 12 m

Impact Driving of Pile IP7 with Diesel Hammer - 1013 m

Impact Driving of Pile IP7 with Diesel Hammer - Drift

Figure 34. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP7 by the diesel impact hammer, measured at distances of 12 m at IP7-10M (top) 1013 m at IP7-1KM (middle) and between 290 m and 740 m on IP7-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.9. Pile IP8: Resonator, Hydraulic Impact Hammer, Location 6

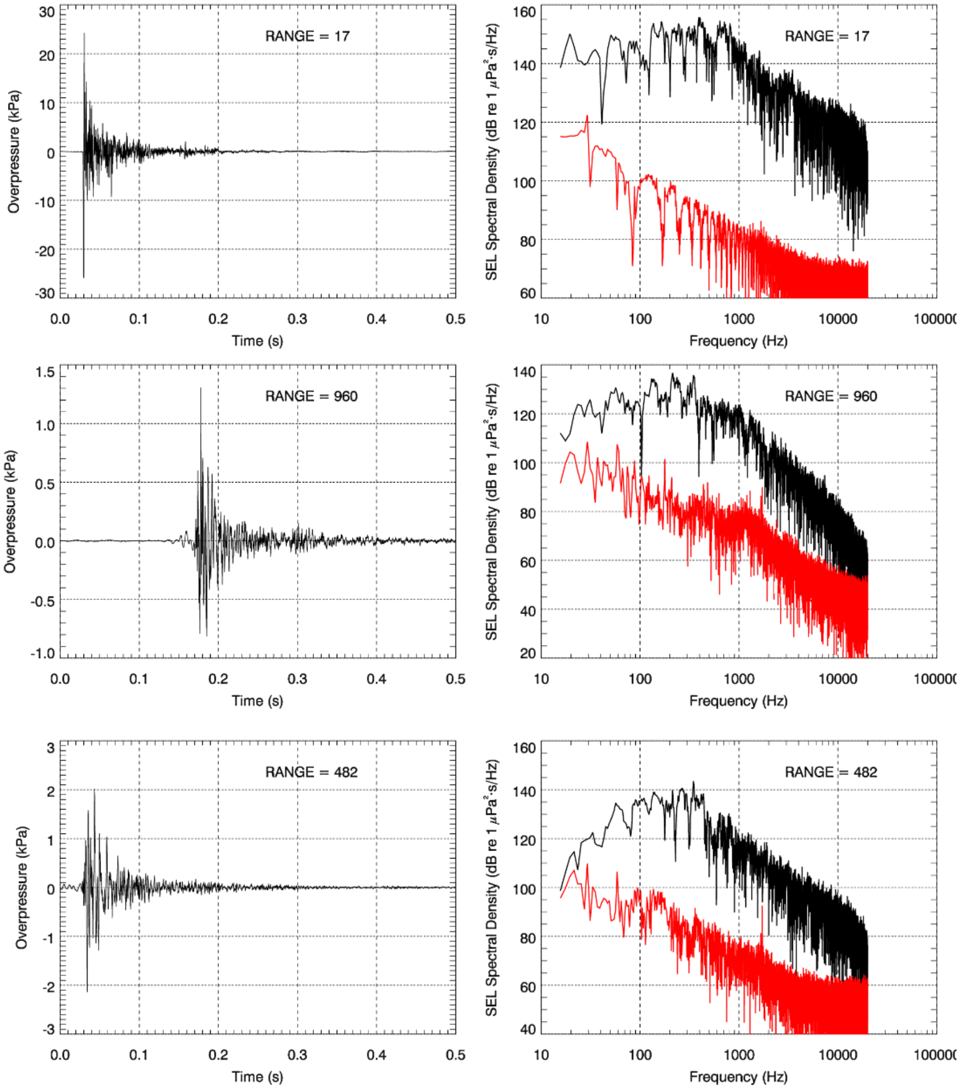


Figure 35. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP8-10M (top), IP8-1KM (middle), and IP8-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red.

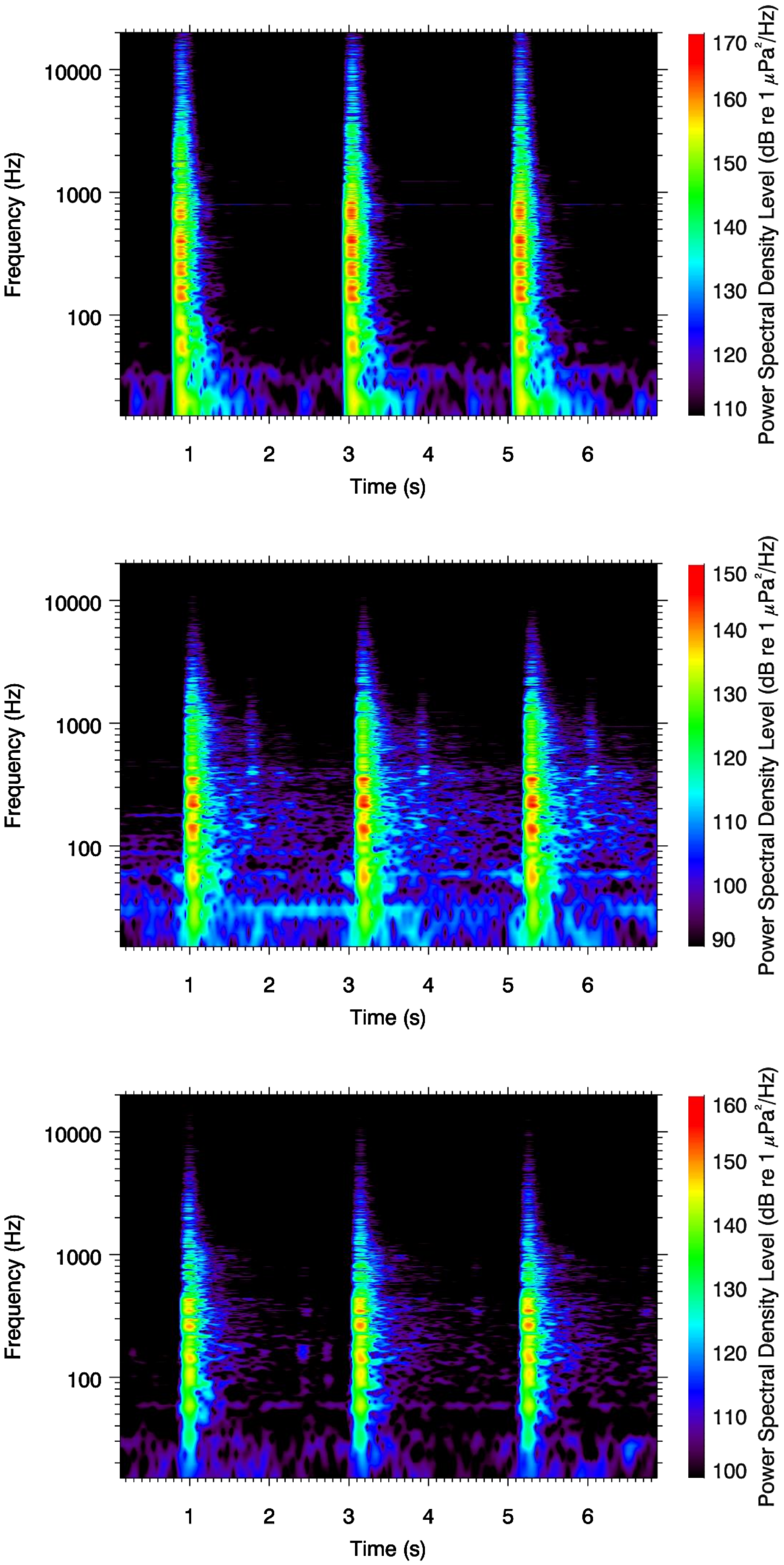


Figure 36. Spectrogram of strikes by the hydraulic impact hammer on Pile IP8 at a distance of 17 m at IP8-10M (top), 960 m at IP8-1KM (middle), and 482 m at IP8-DRIFT (bottom).

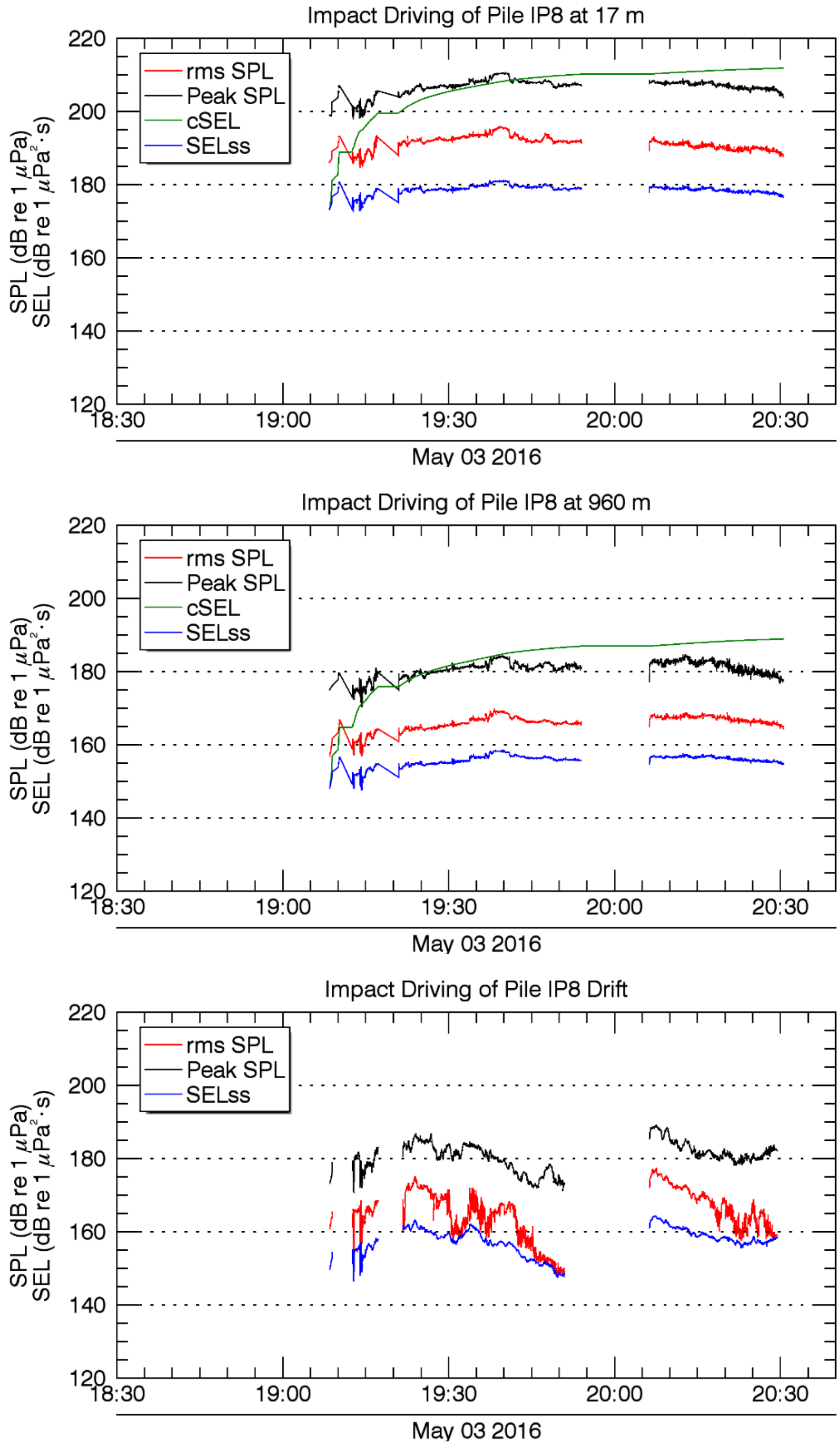


Figure 37. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP8 by the hydraulic impact hammer, measured at distances of 17 m at IP8-10M (top) 960 m at IP8-1KM (middle) and between 480 m and 2400 m on IP8-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.10. Pile IP9: Resonator, Diesel Impact Hammer, Location 6

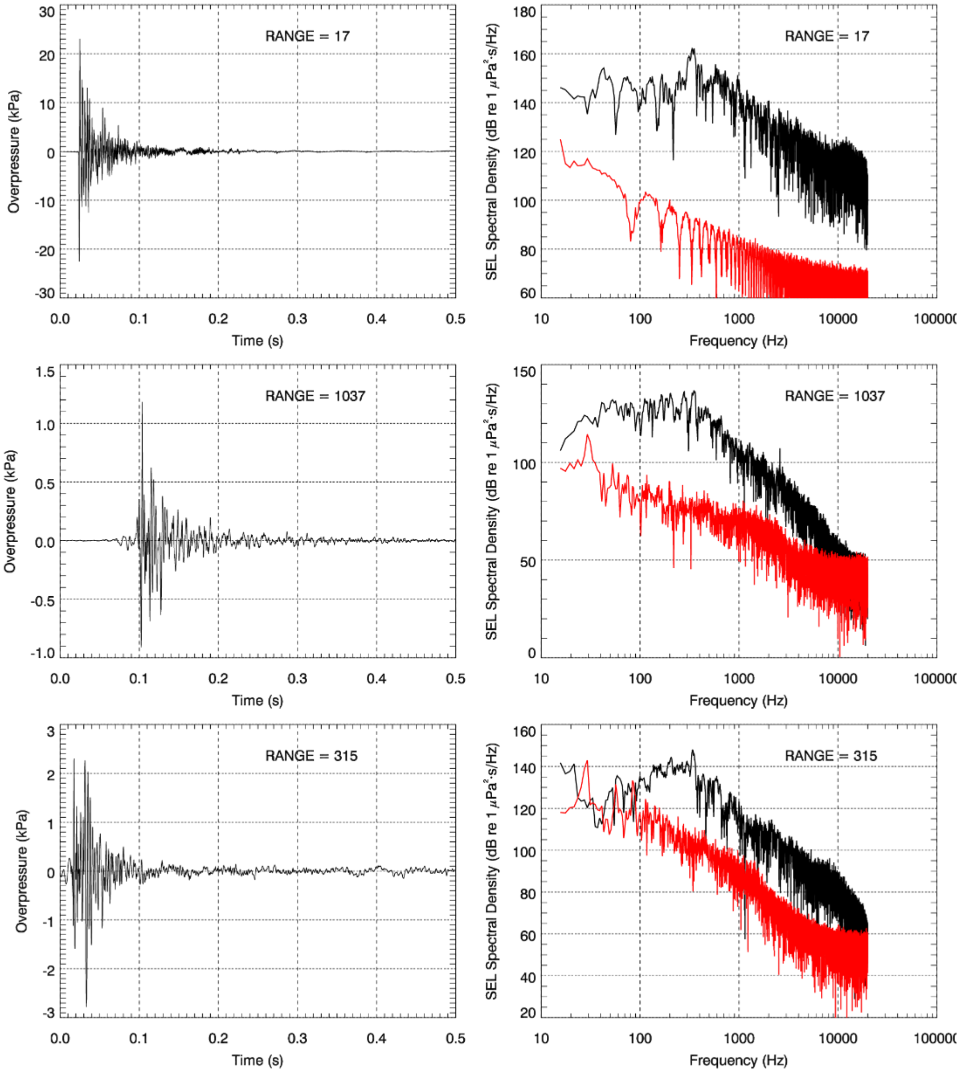


Figure 38. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP9-10M (top), IP9-1KM (middle), and IP9-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red.

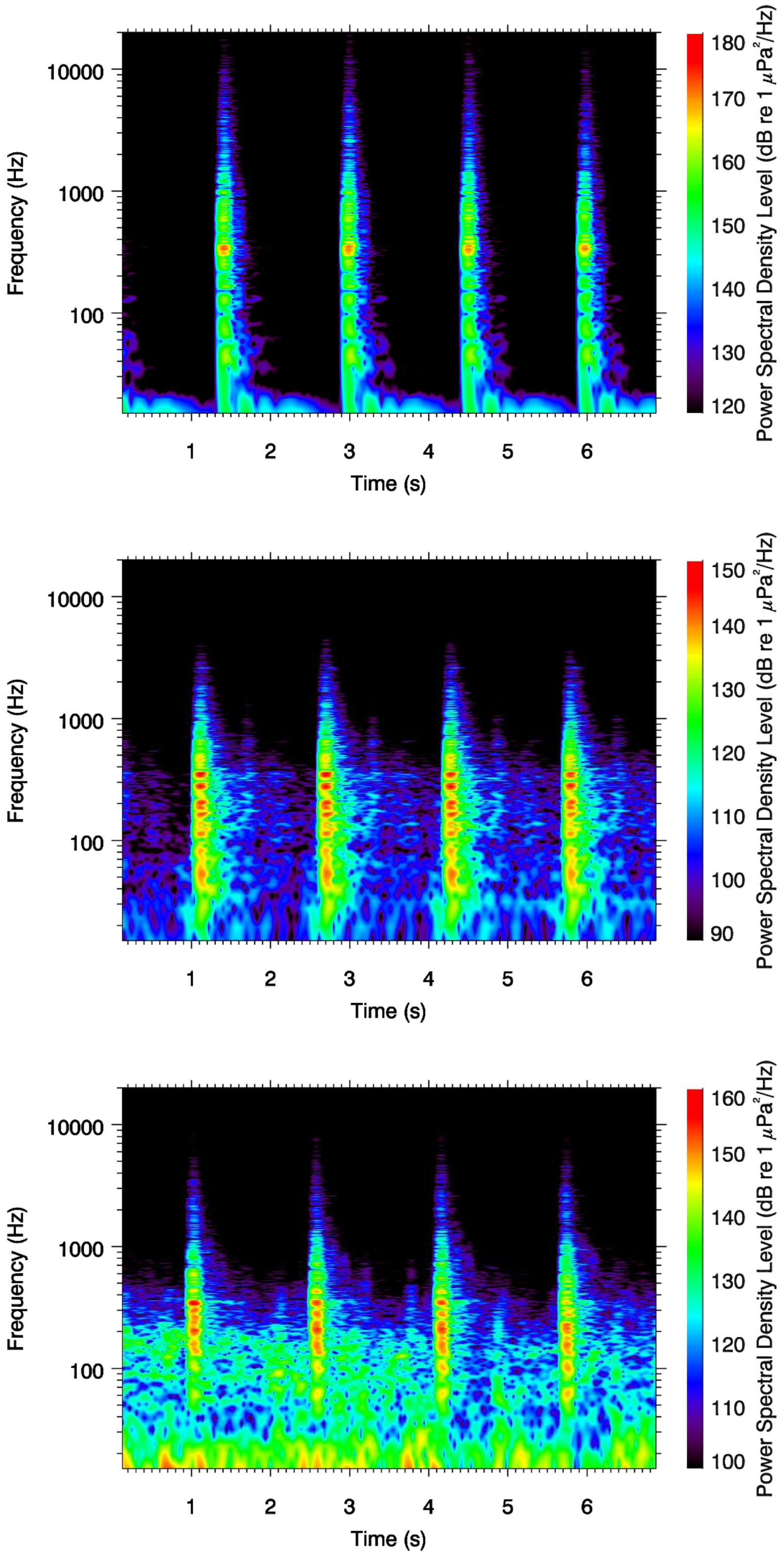


Figure 39. Spectrogram of strikes by the hydraulic impact hammer on Pile IP9 at a distance of 17 m at IP9-10M (top), 1037 m at IP9-1KM (middle), and 315 m at IP9-DRIFT (bottom).

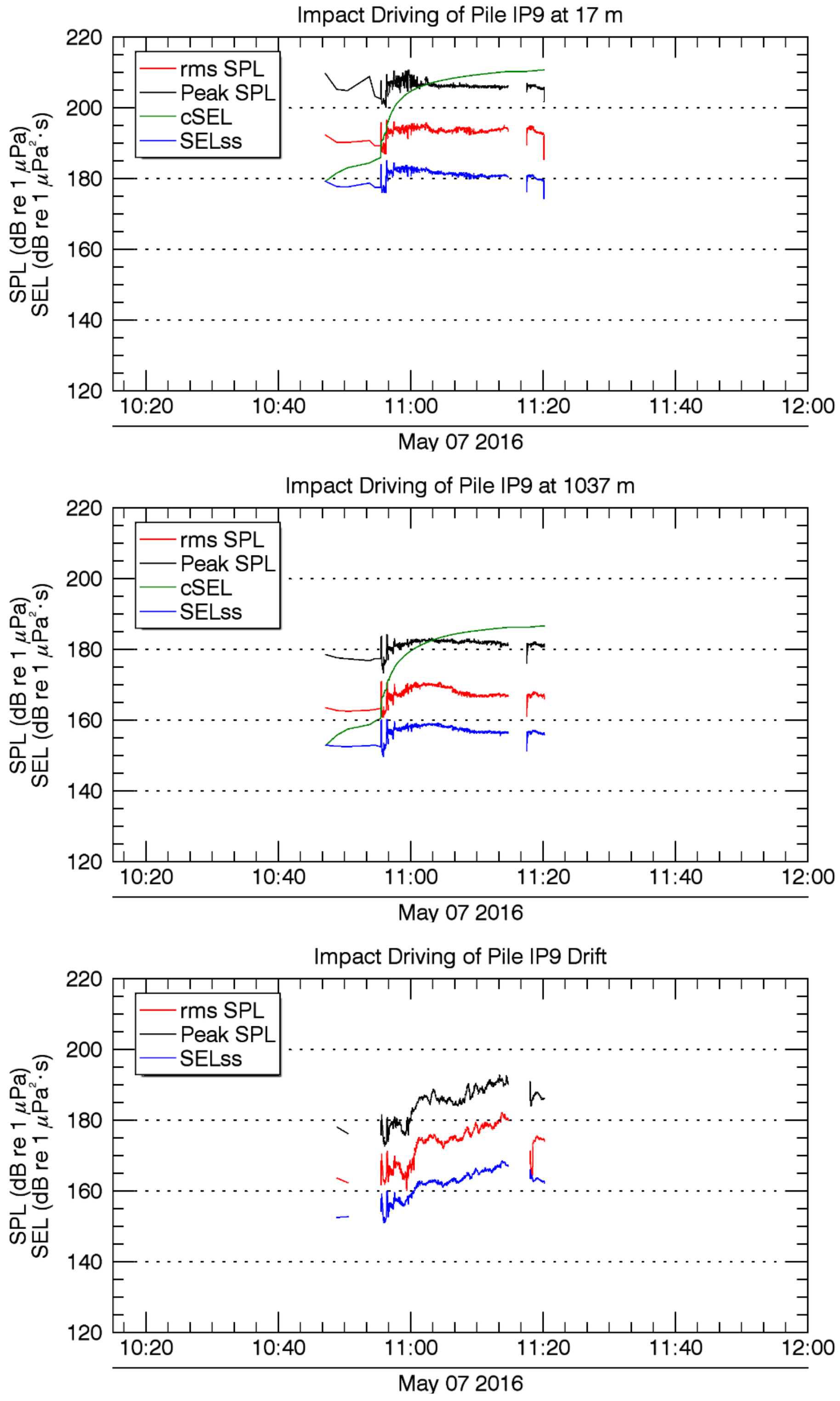


Figure 40. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP9 by the hydraulic impact hammer, measured at distances of 17 m at IP9-10M (top) 1037 m at IP9-1KM (middle) and between 206 m and 909 m on IP9-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.1.11. Pile IP10: Bubble Curtain, Hydraulic Impact Hammer, Location 6

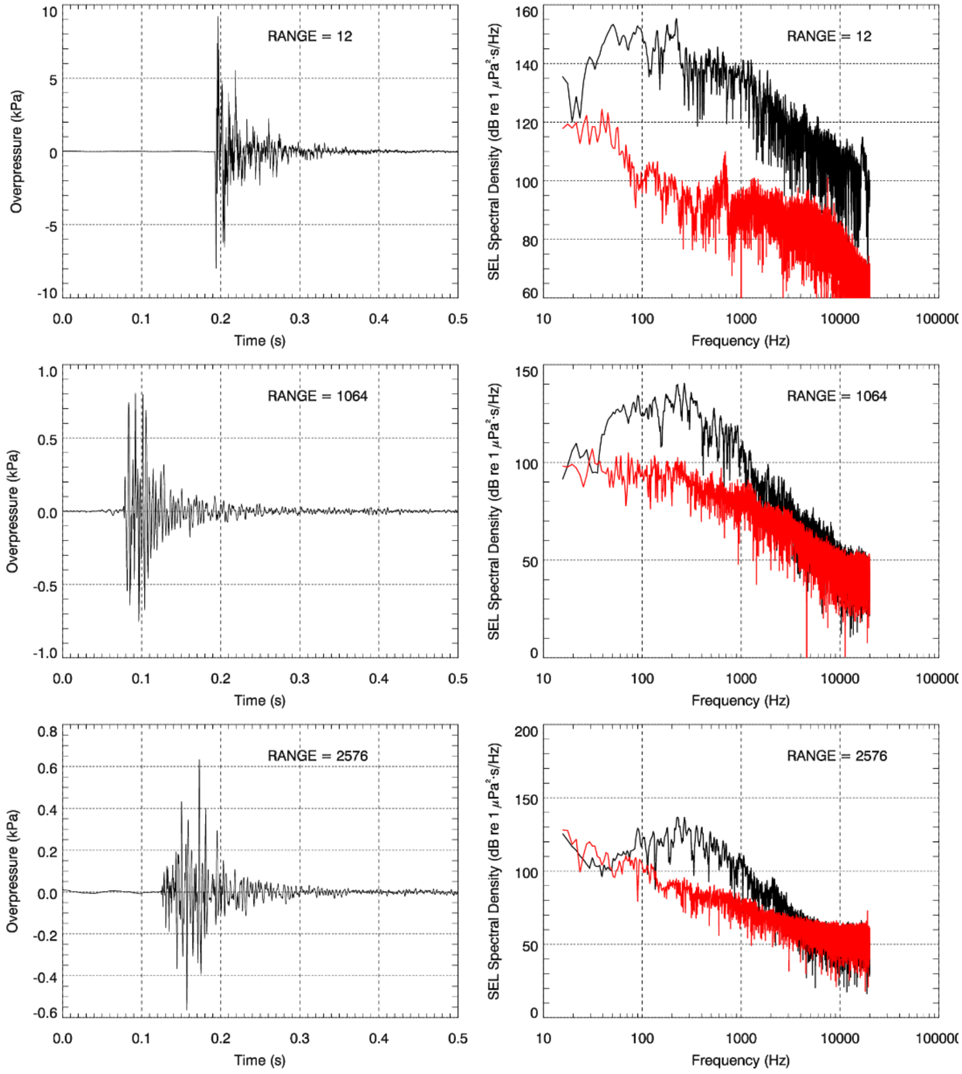


Figure 41. Waveforms (left) and spectra (right) for the same strike during impact hammering of 48 in steel pile recorded at IP10-10M (top), IP10-1KM (middle), and IP10-DRIFT (bottom). Background noise spectrum from the 0.5 s window preceding the pulse is shown in red.

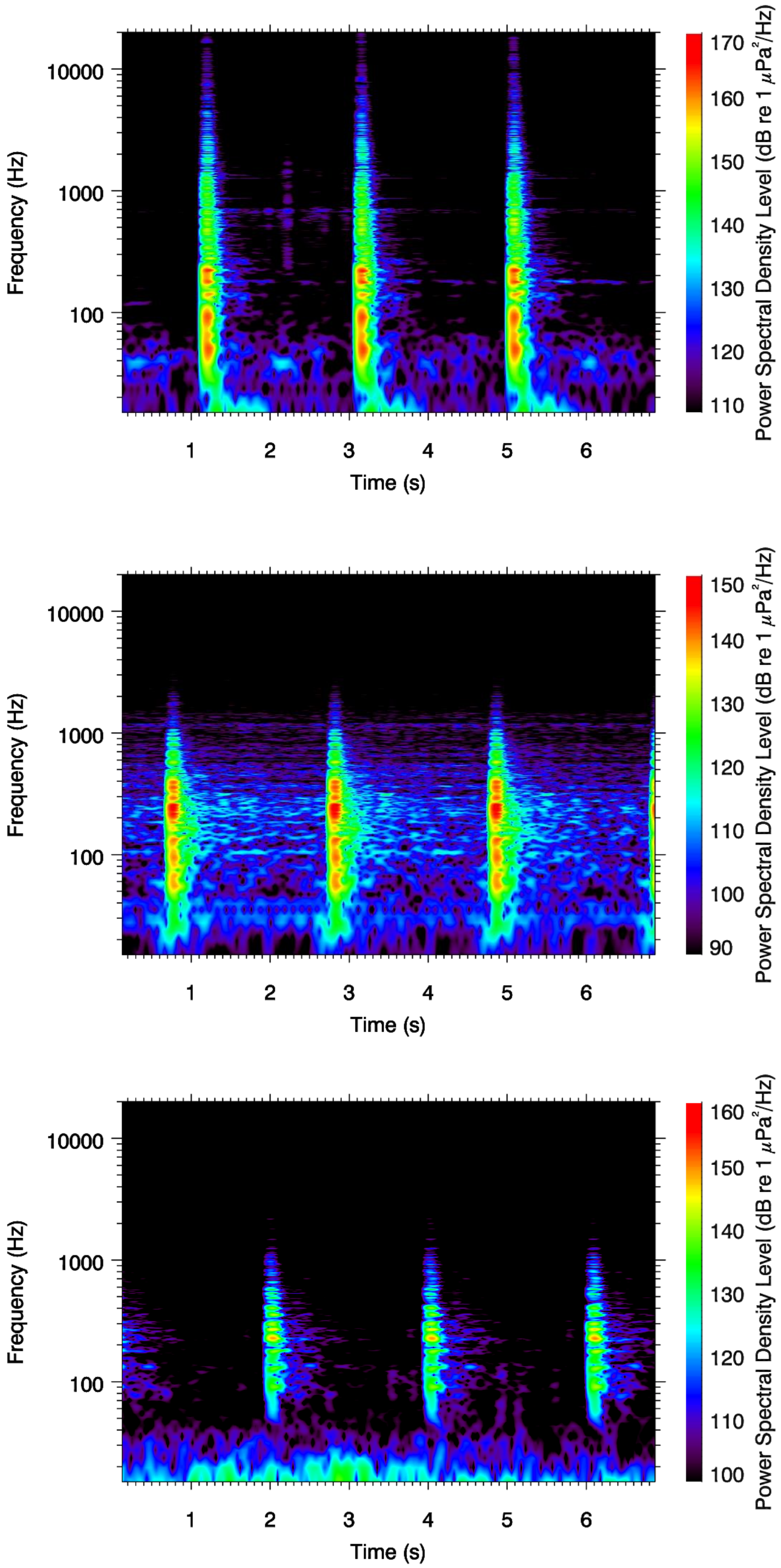


Figure 42. Spectrogram of strikes by the hydraulic impact hammer on Pile IP10 at a distance of 12 m at IP10-10M (top), 1064 m at IP10-1KM (middle), and 2576 m at IP10-DRIFT (bottom).

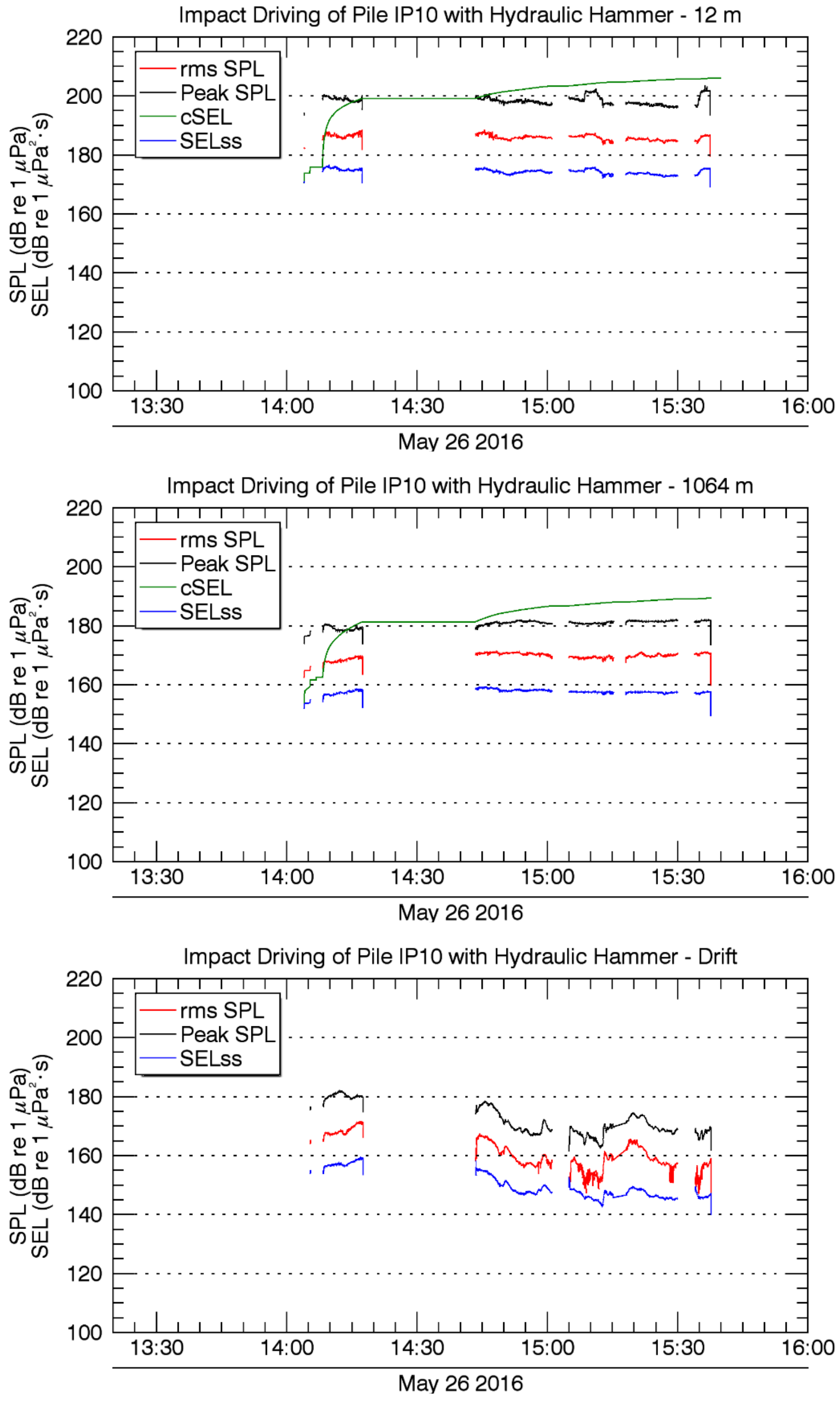


Figure 43. Plot of peak SPL, rms SPL, and single-strike SEL vs time (AKDT) for pile driving of Pile IP10 by the diesel impact hammer, measured at distances of 12 m at IP10-10M (top) 1064 m at IP10-1KM (middle) and between 1300 m and 3600 m on IP10-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.2. Vibratory Pile Driving Sound Levels

3.2.1. Pile IP1: Un-attenuated, Pile Location 5

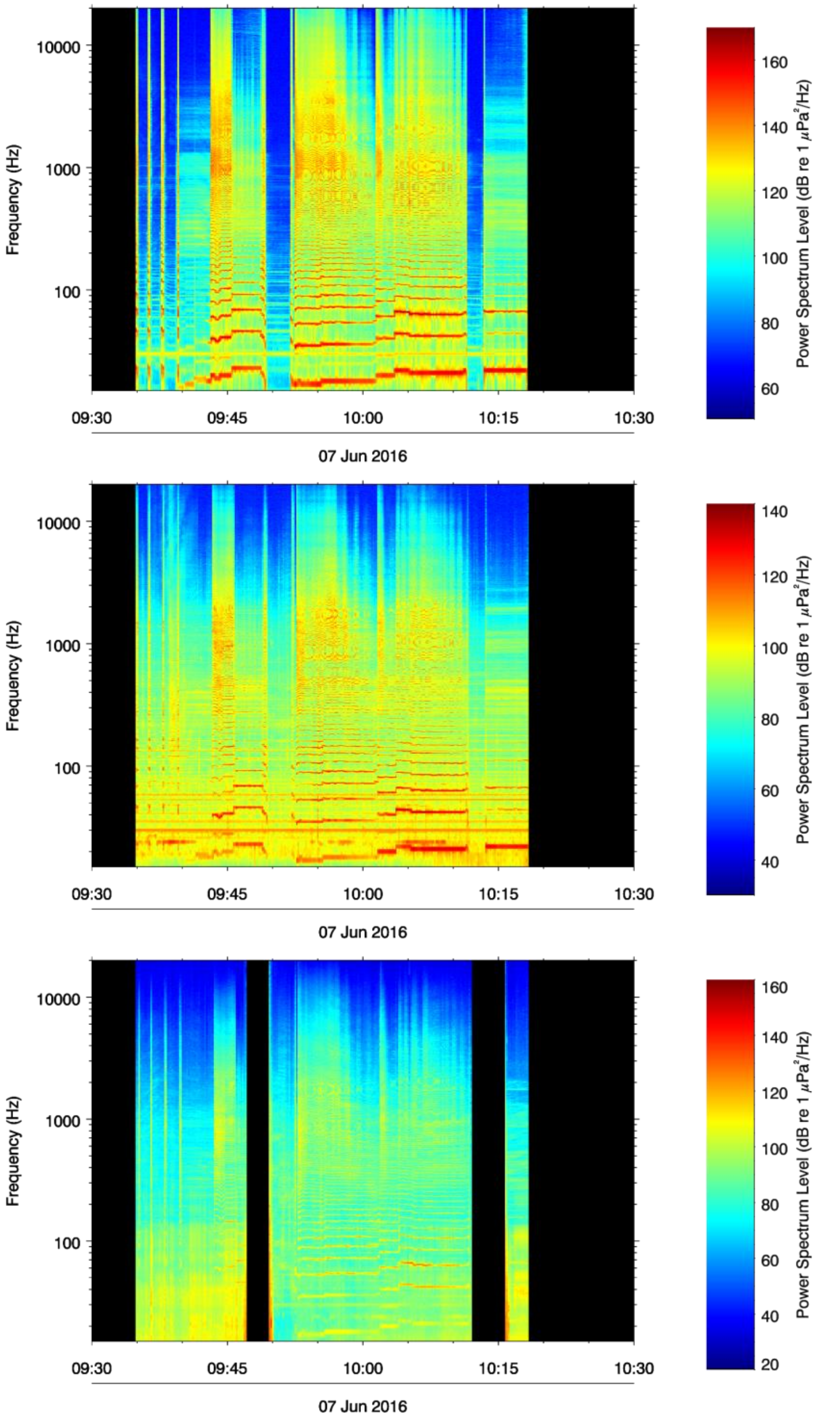


Figure 44. Spectrogram of vibratory driving of Pile IP1 at a distances of 14 m on IP1-10M (top), 959 m on IP1-1KM (middle) and between 2100 m and 3100 m on IP1-DRIFT (bottom).

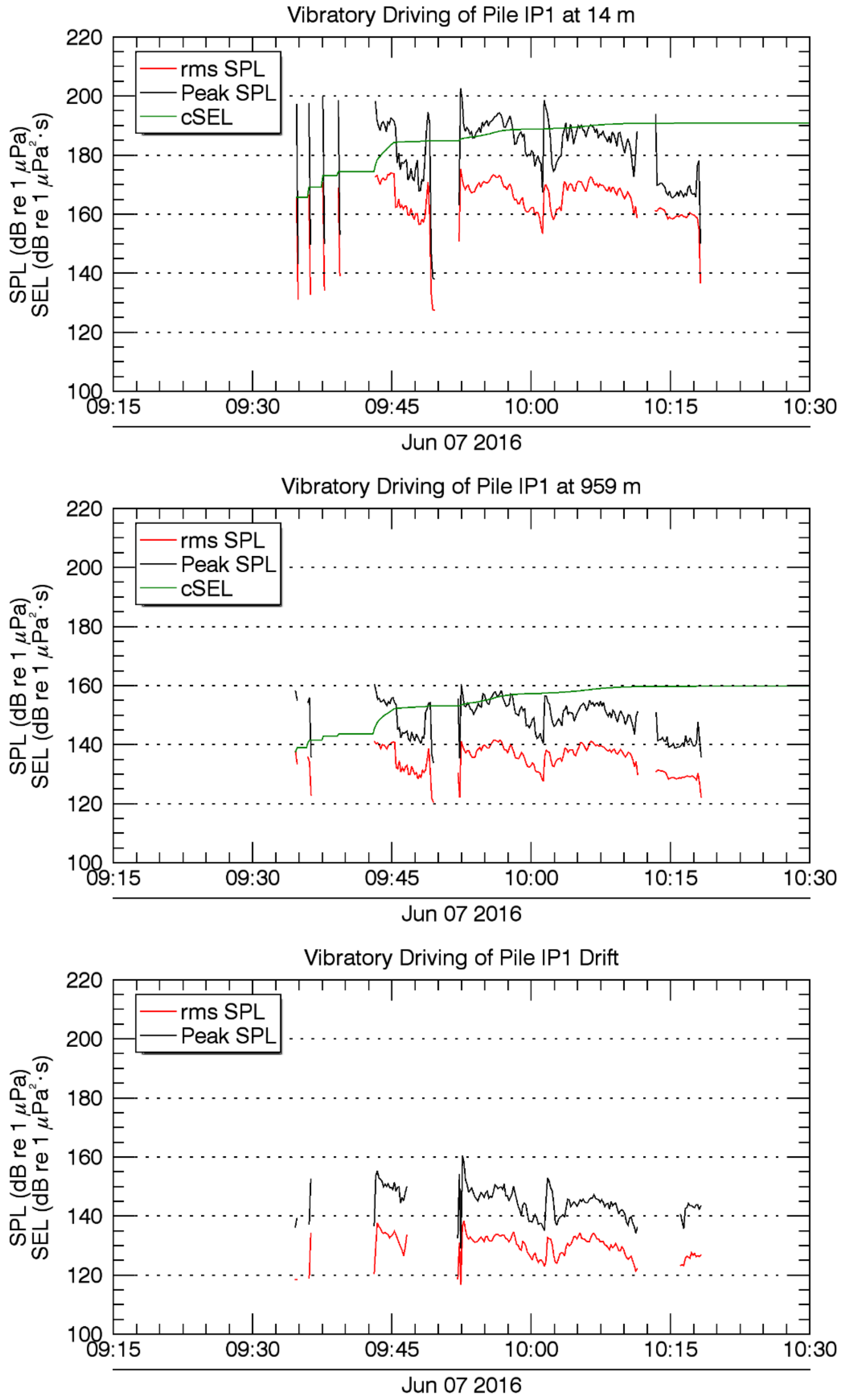


Figure 45. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP1 of 14 m at IP1-10M (top), 959 m at IP1-1KM (middle) and between 2100 m to 3100 m on IP1 Drift (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.2. Pile IP2: Resonator, Pile Location 4

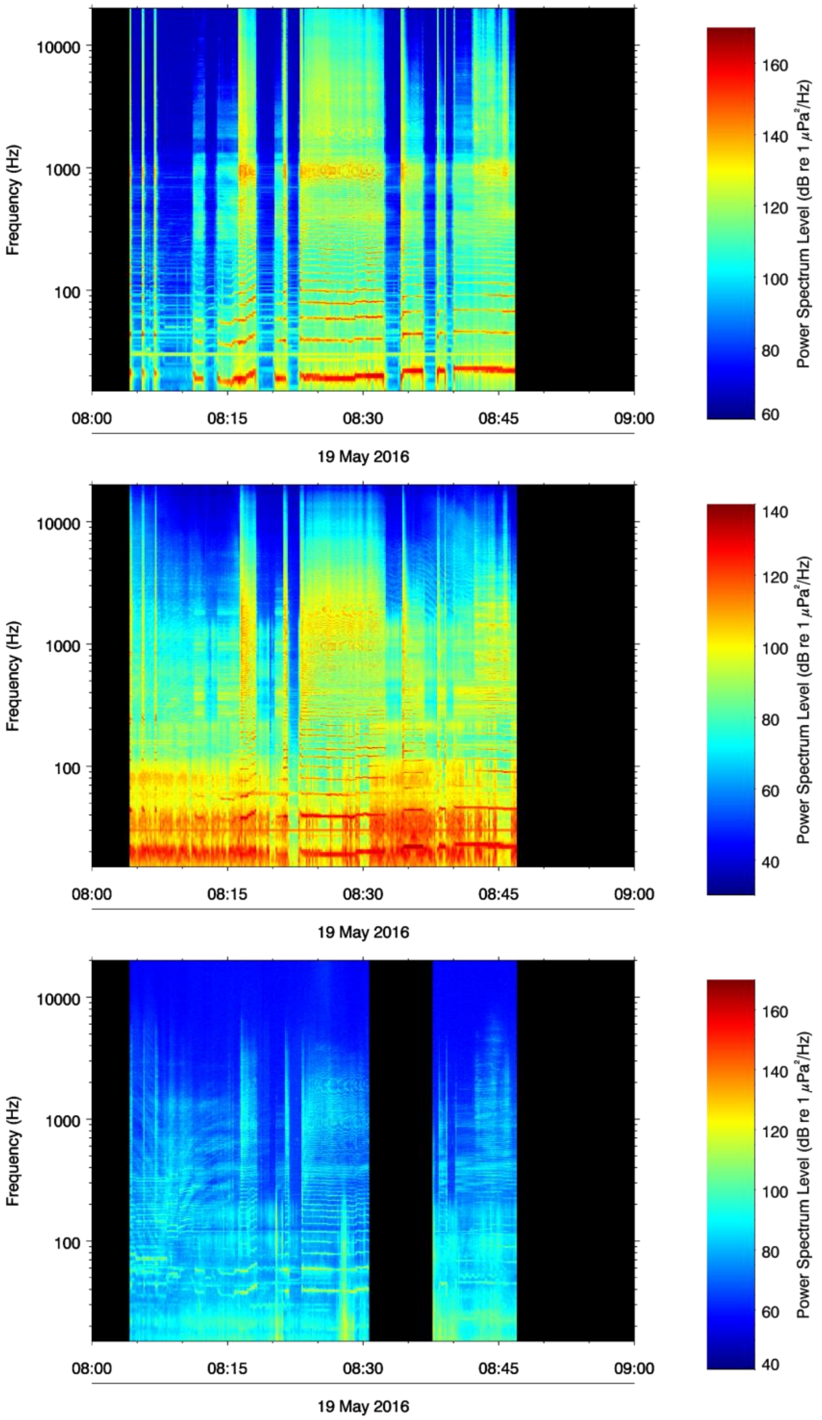


Figure 46. Spectrogram of vibratory driving of Pile IP2 at a distances of 11 m on IP2-10M (top), 943 m on IP2-1KM (middle) and between 4262 m and 4594 m on IP2-DRIFT (bottom).

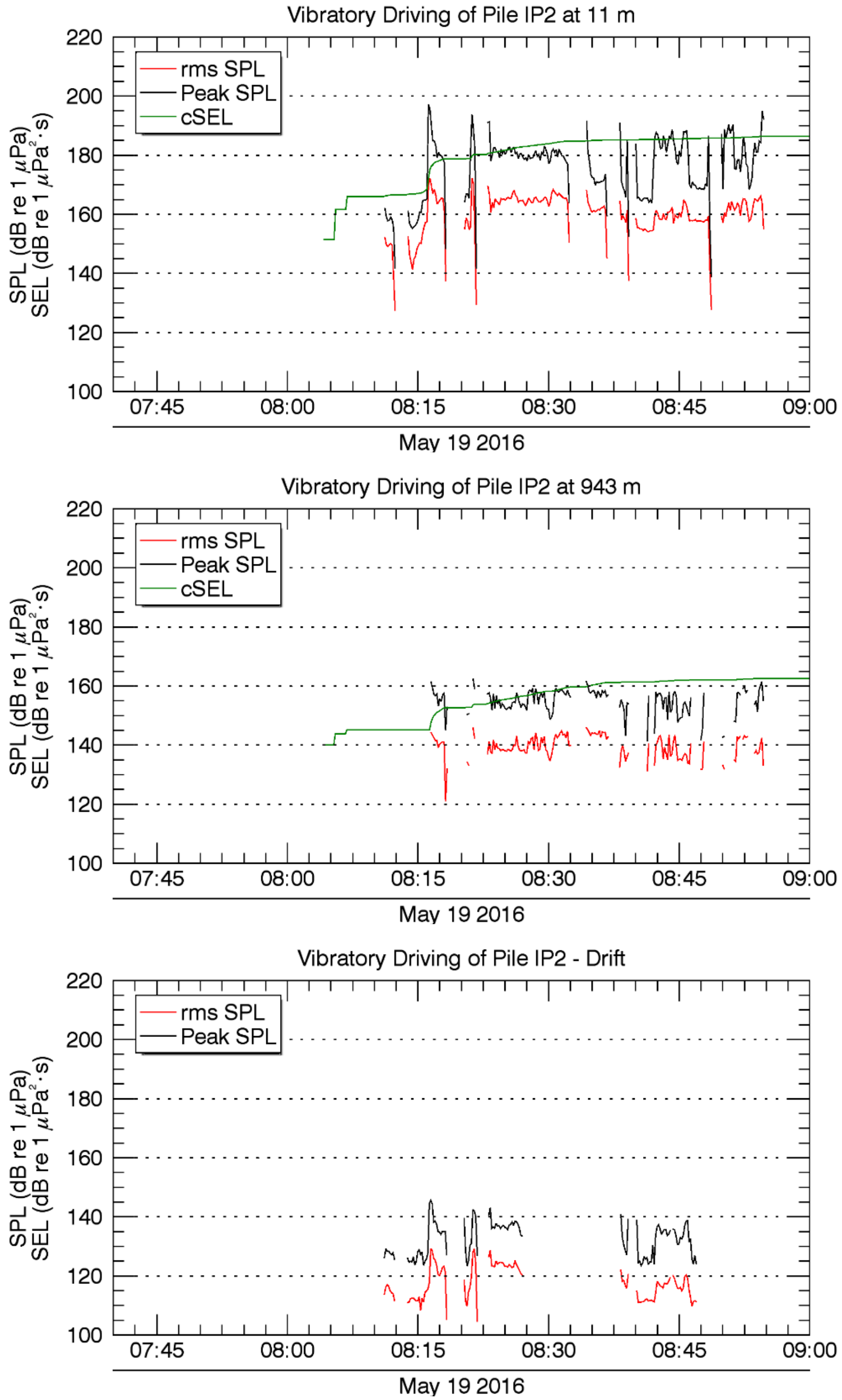


Figure 47. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP2 at distances of 11 m at IP2-10M (top), 943 m at IP2-1KM (middle) and between 3300 m to 5100 m on IP2-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.3. Pile IP3: Bubble Curtain, Location 1

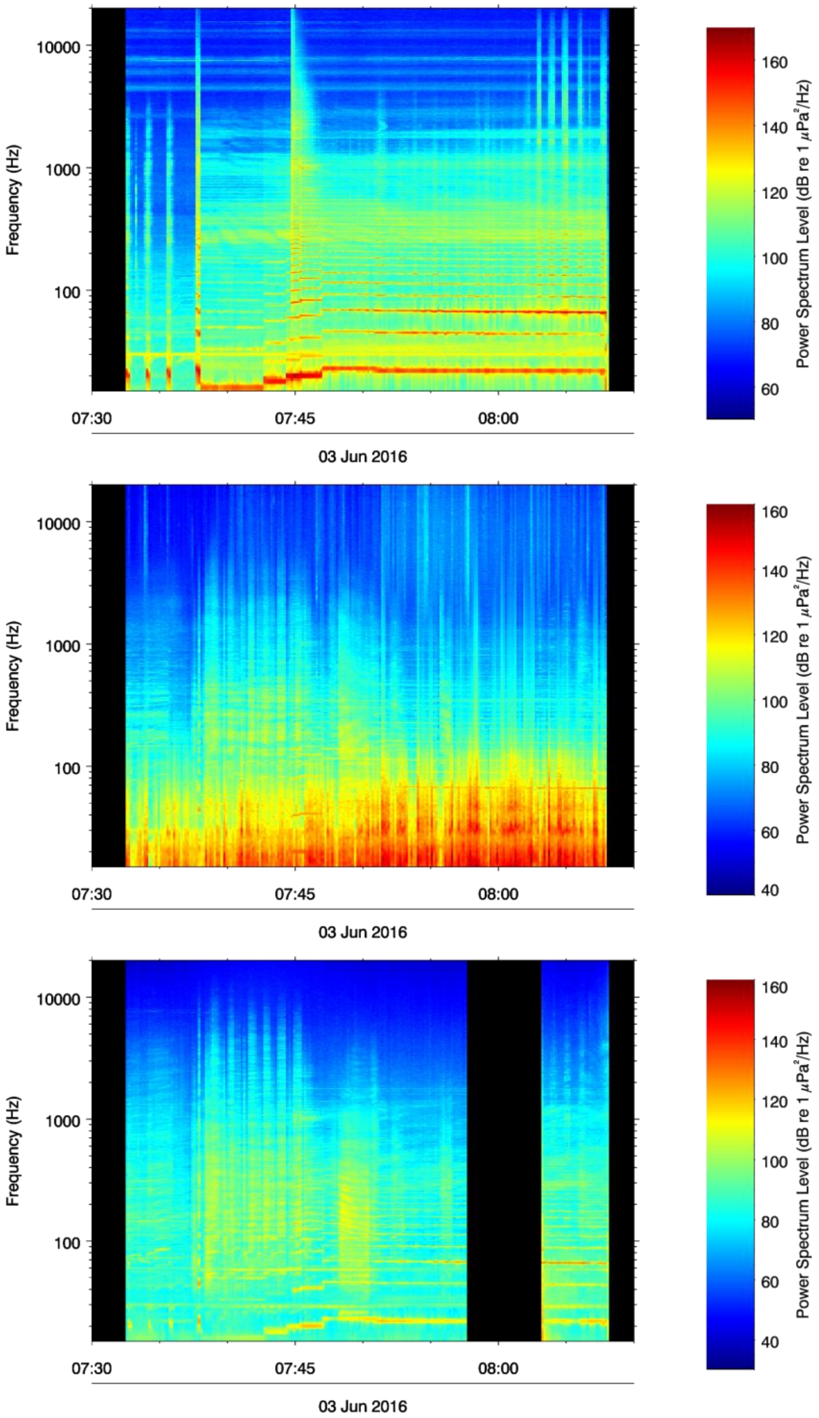


Figure 48. Spectrogram of vibratory driving of Pile IP3 at a distances of 12 m on IP3-10M (top), 1182 m on IP3-1KM (middle) and between 1408 m and 3179 m on IP3-DRIFT (bottom).

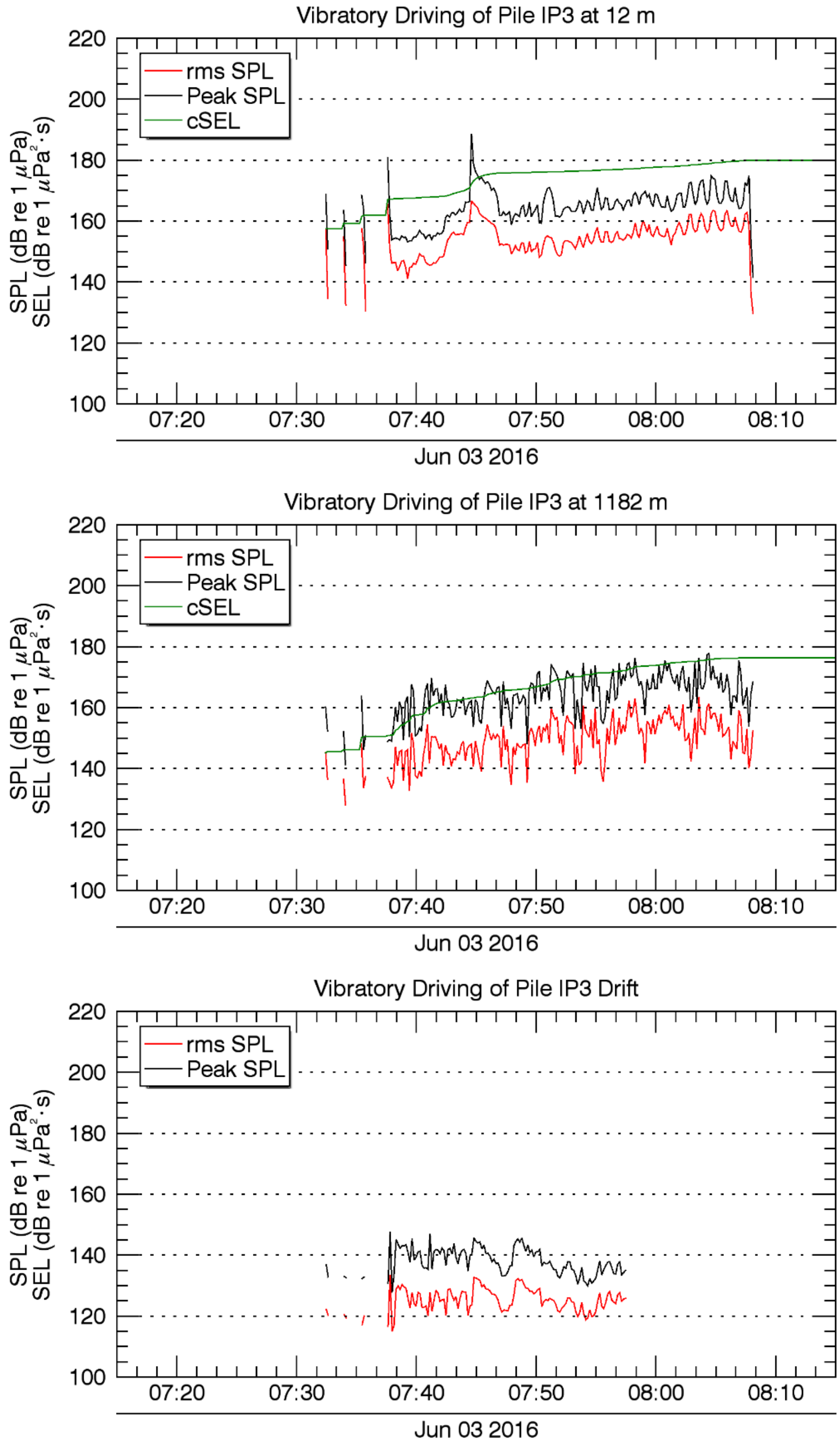


Figure 49. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP3 at distances of 12 m at IP3-10M (top), 1182 m at IP3-1KM (middle) and between 1350 m to 3278 m on IP3-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.4. Pile IP4: Resonator, Location 1

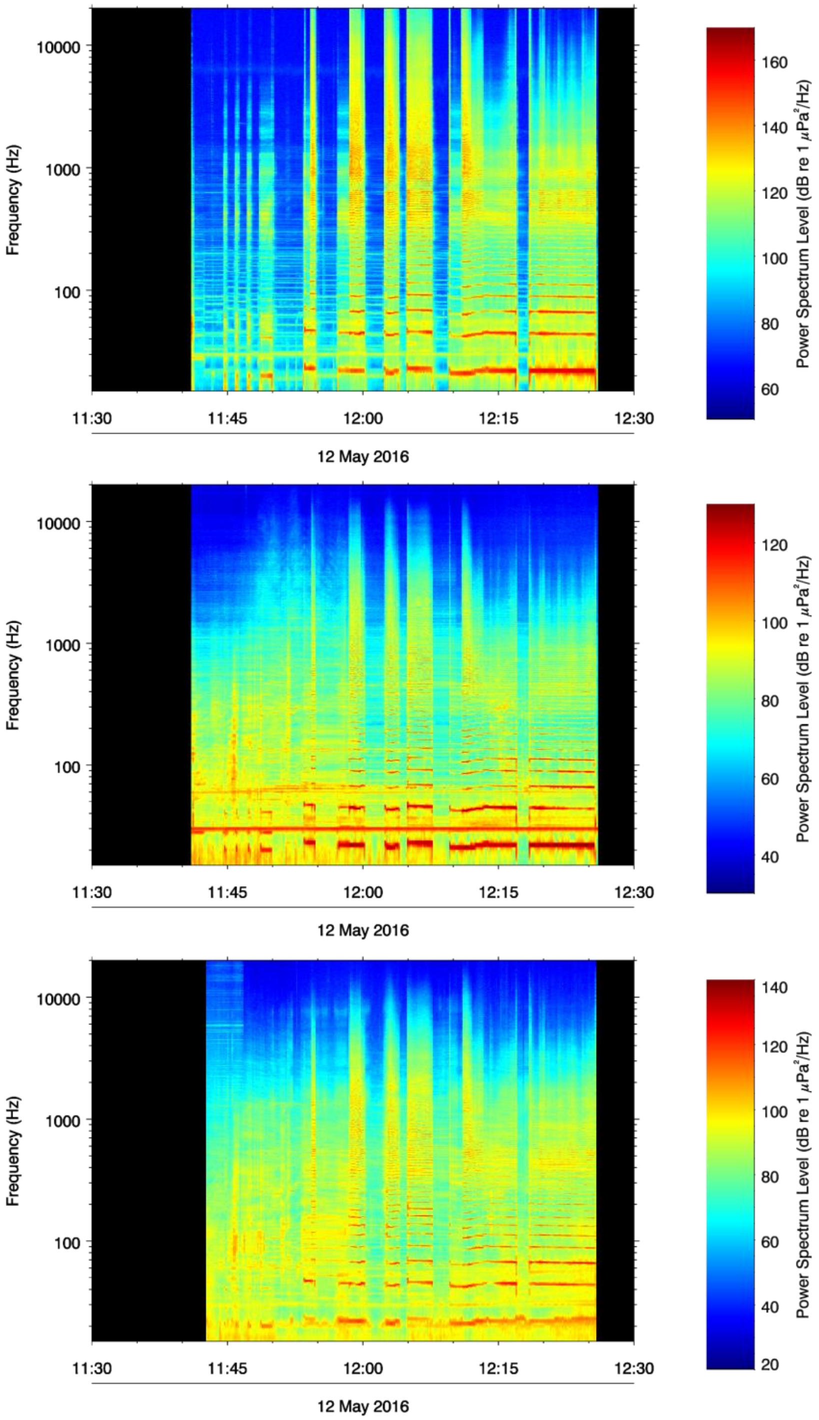


Figure 50. Spectrogram of vibratory driving of Pile IP4 at a distances of 10 m on IP4-10M (top), 1008 m on IP4-1KM (middle) and between 1623 m and 2875 m on IP4-DRIFT (bottom).

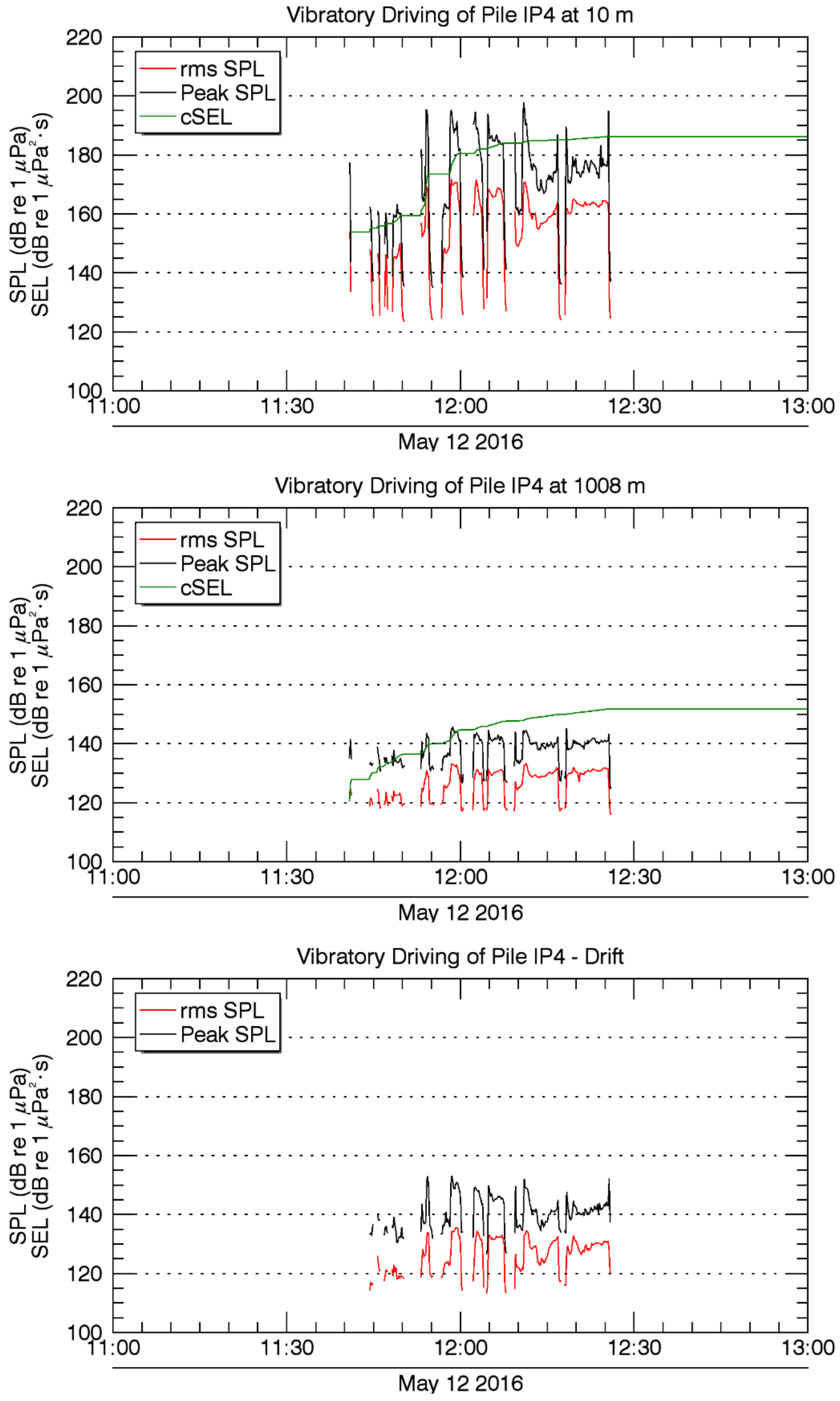


Figure 51. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP4 at distances of 10 m at IP4-10M (top), 1008 m at IP4-1KM (middle) and between 1620 m to 2510 m on IP4-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.5. Pile IP5: Un-attenuated, Location 4

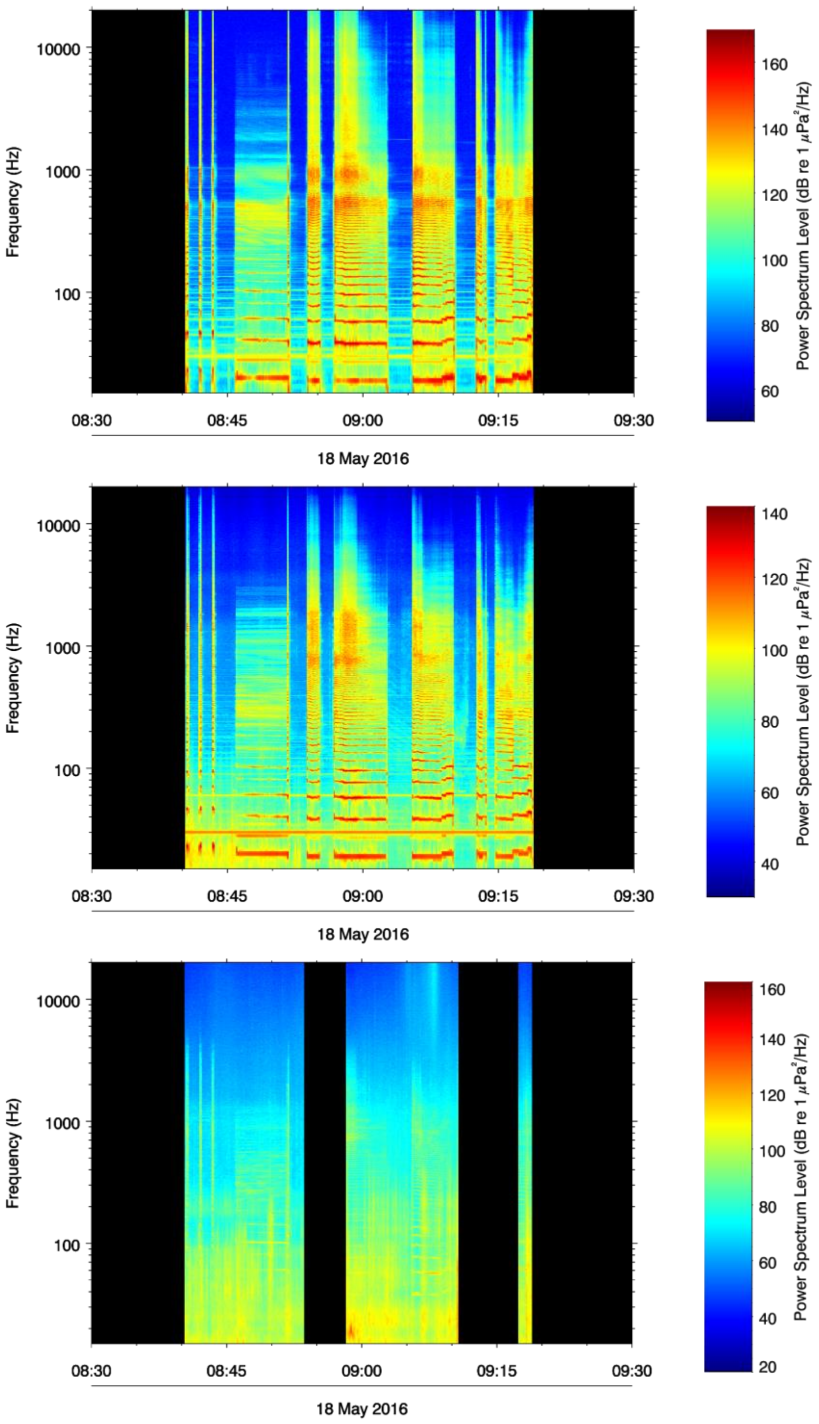
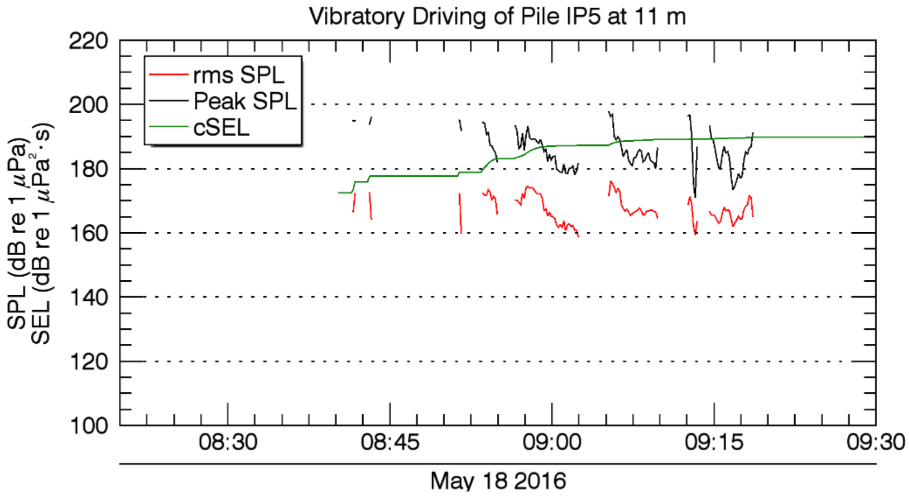
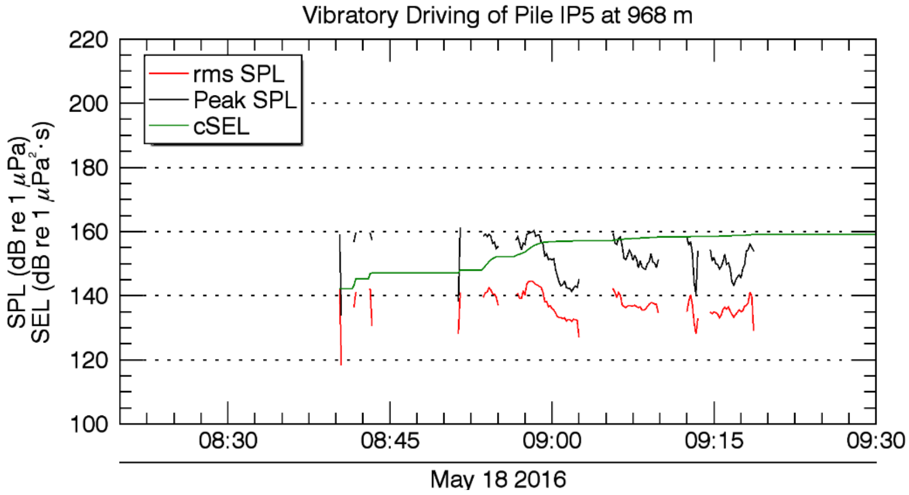


Figure 52. Spectrogram of vibratory driving of Pile IP5 at a distances of 11 m on IP5-10M (top), 968 m on IP5-1KM (middle) and between 3769 m and 5324 m on IP5-DRIFT (bottom).





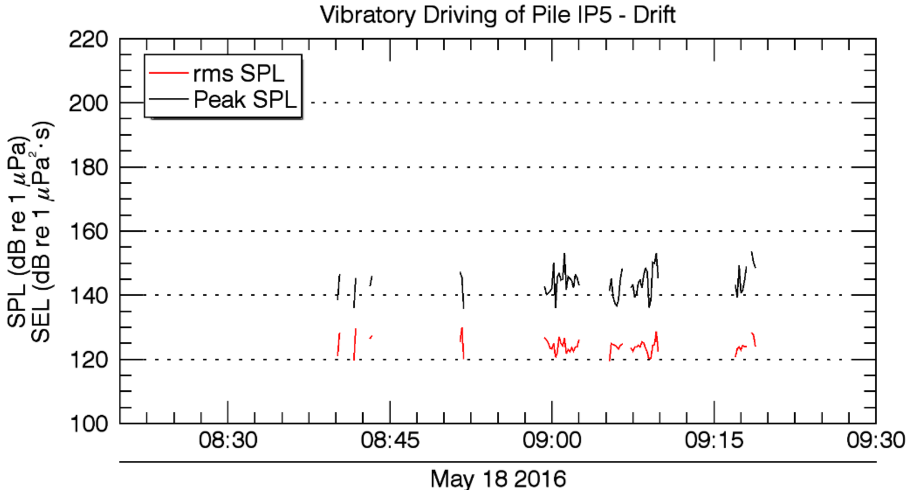


Figure 53. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP5 at distances of 11 m at IP5-10M (top), 968 m at IP5-1KM (middle) and between 3000 m to 5000 m on IP5-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.6. Pile IP6: Bubble Curtain, Location 4

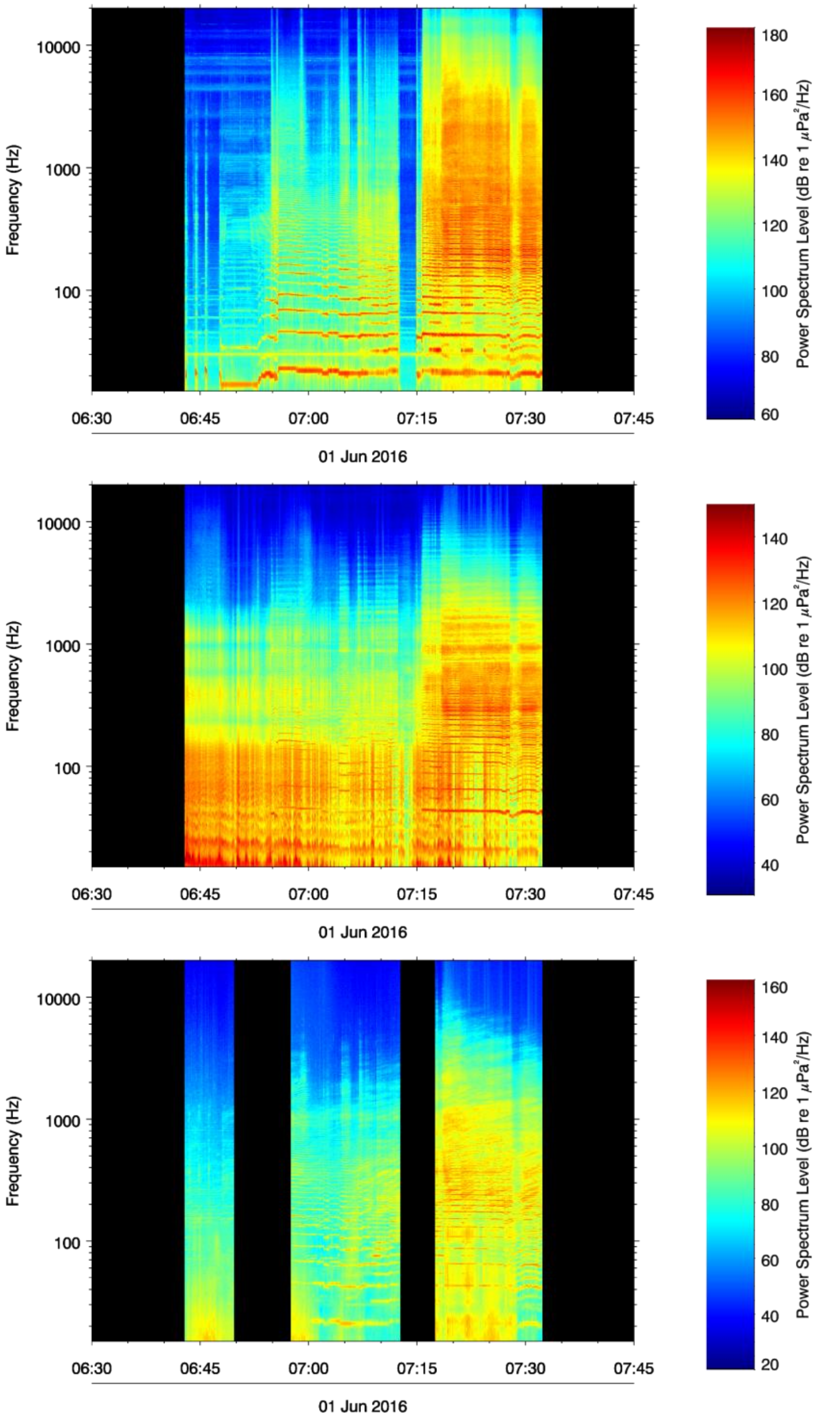


Figure 54. Spectrogram of vibratory driving of Pile IP6 at a distances of 12 m on IP6-10M (top), 977 m on IP6-1KM (middle) and between 1457 m and 3083 m on IP6-DRIFT (bottom).

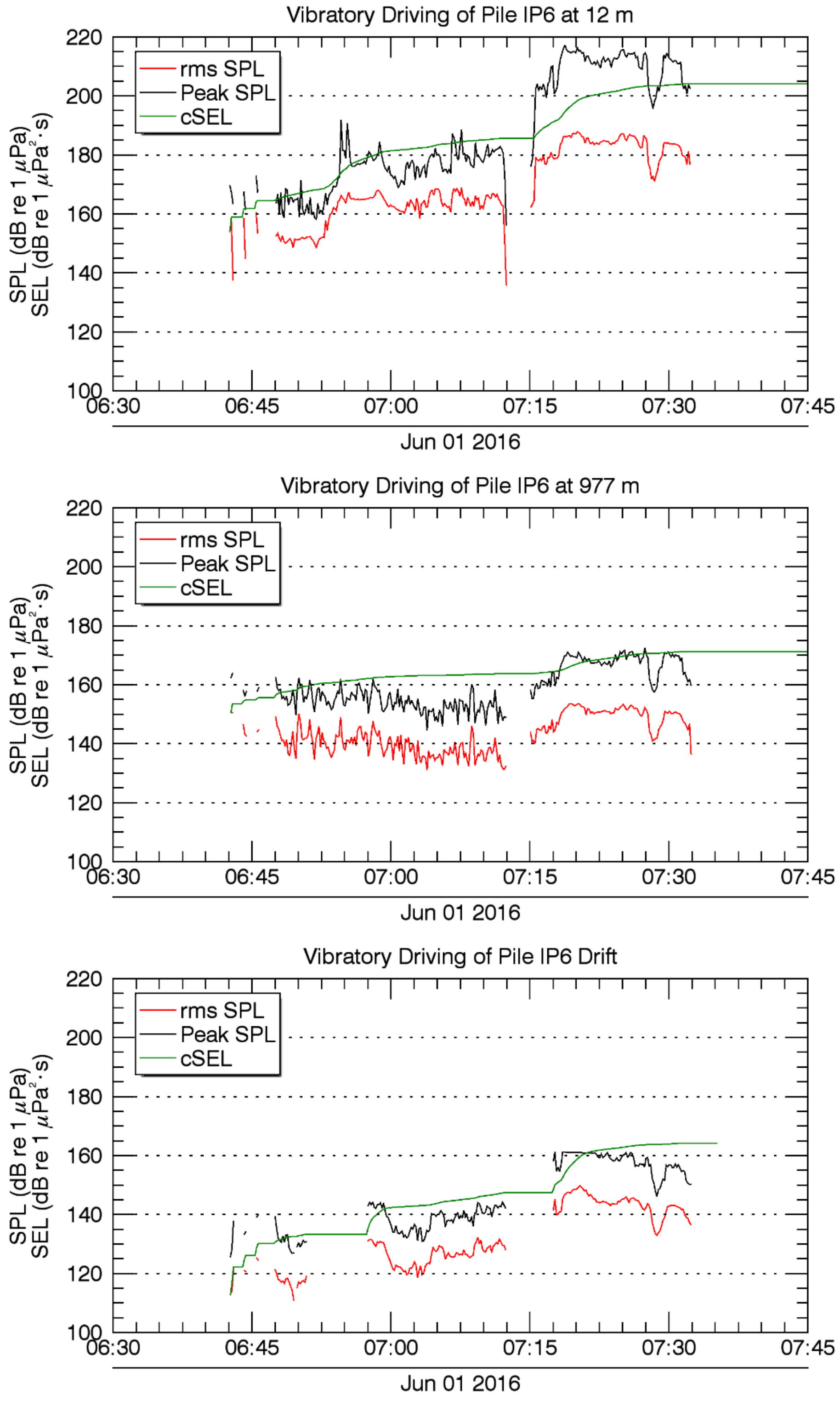


Figure 55. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP6 at distances of 12 m at IP6-10M (top), 977 m at IP6-1KM (middle) and between 1324 m to 3184 m on IP6 Drift (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.7. Pile IP7: Bubble Curtain, Location 5

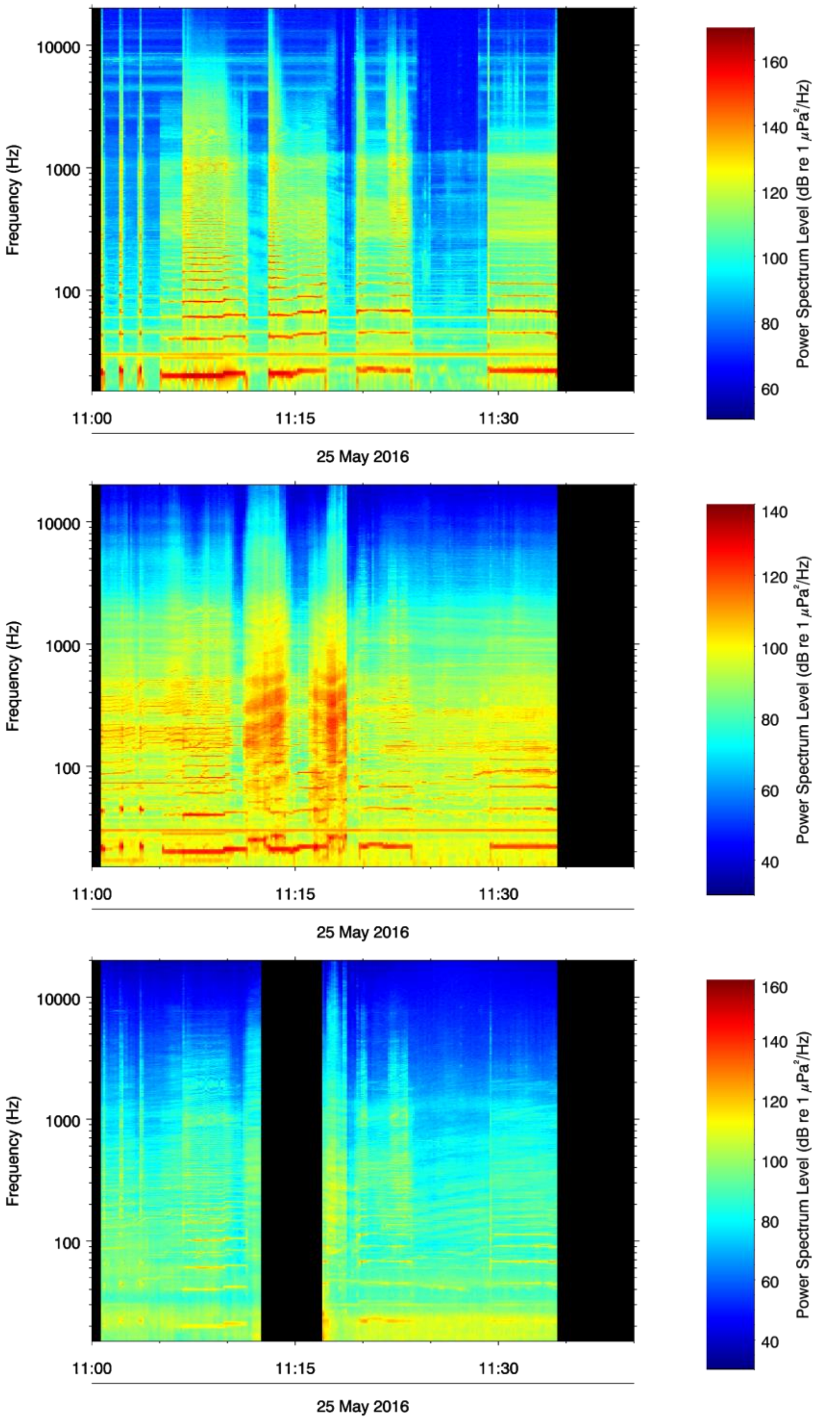


Figure 56. Spectrogram of vibratory driving of Pile IP7 at a distances of 12 m on IP7-10M (top), 1013 m on IP7-1KM (middle) and between 1027 m and 1680 m on IP7-DRIFT (bottom).

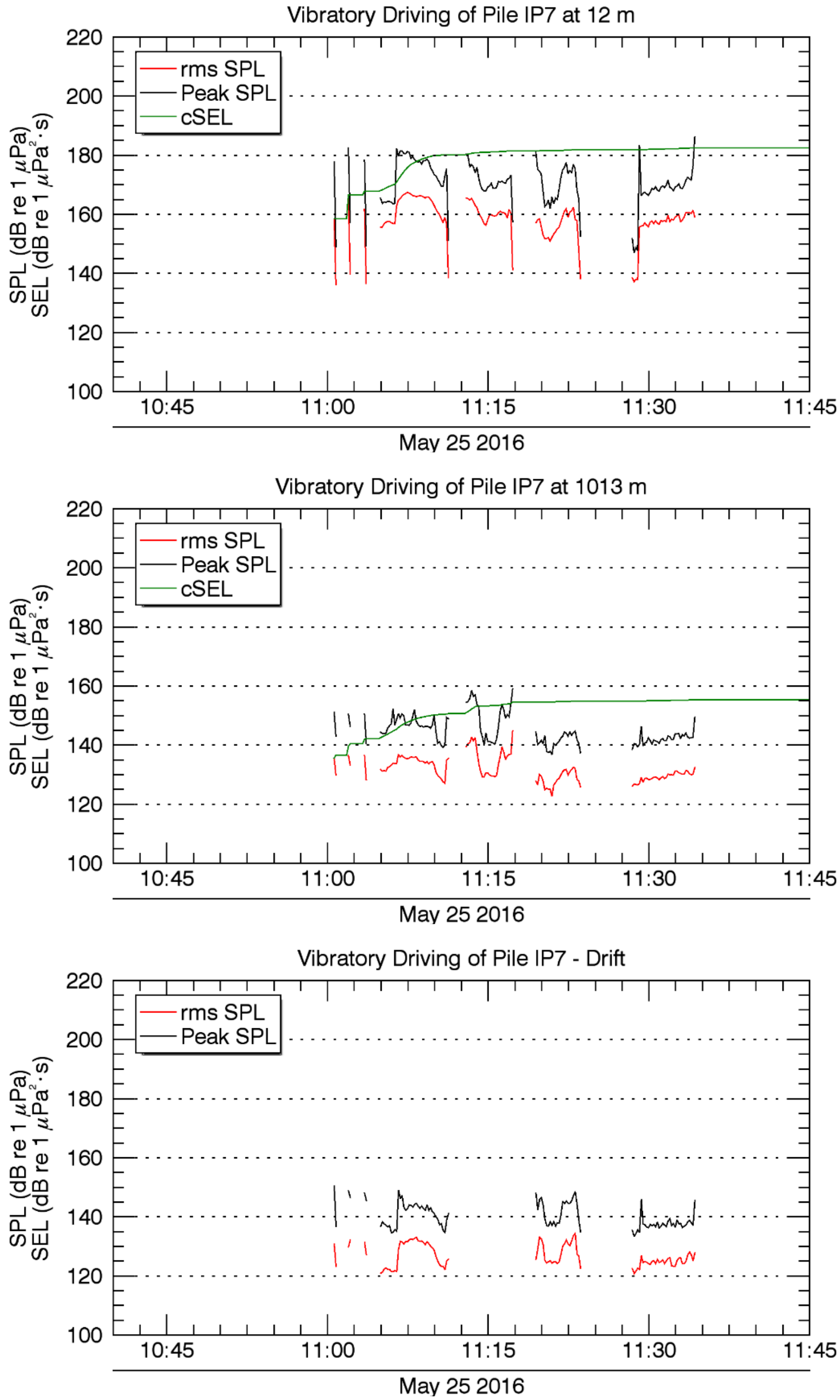


Figure 57. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP7 at distances of 12 m at IP7-10M (top), 1013 m at IP7-1KM (middle) and between 1000 m to 1700 m on IP7 Drift (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.8. Pile IP8: Resonator, Location 6

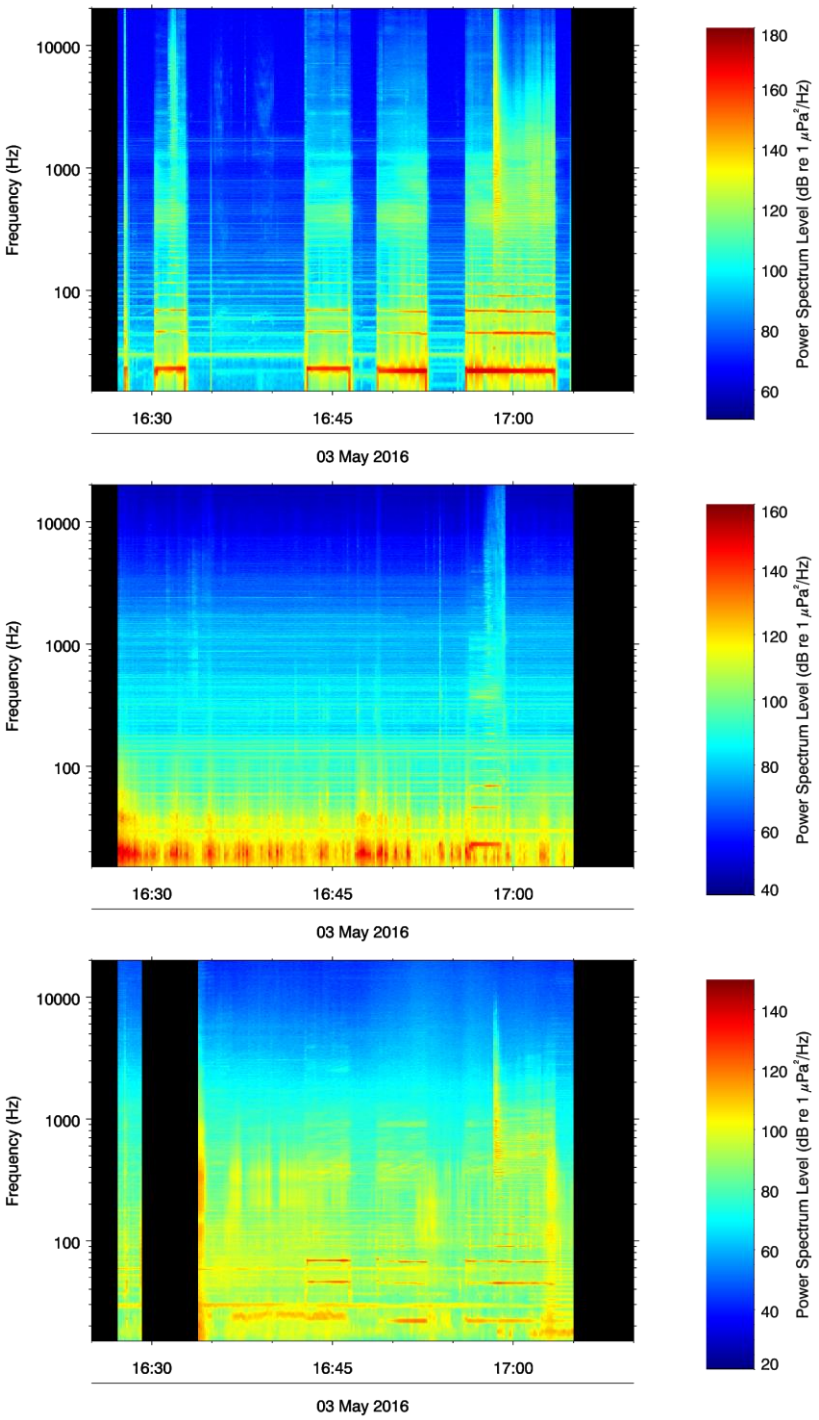


Figure 58. Spectrogram of vibratory driving of Pile IP8 at a distances of 17 m on IP8-10M (top), 960 m on IP8-1KM (middle) and between 2357 m and 3046 m on IP8-DRIFT (bottom).

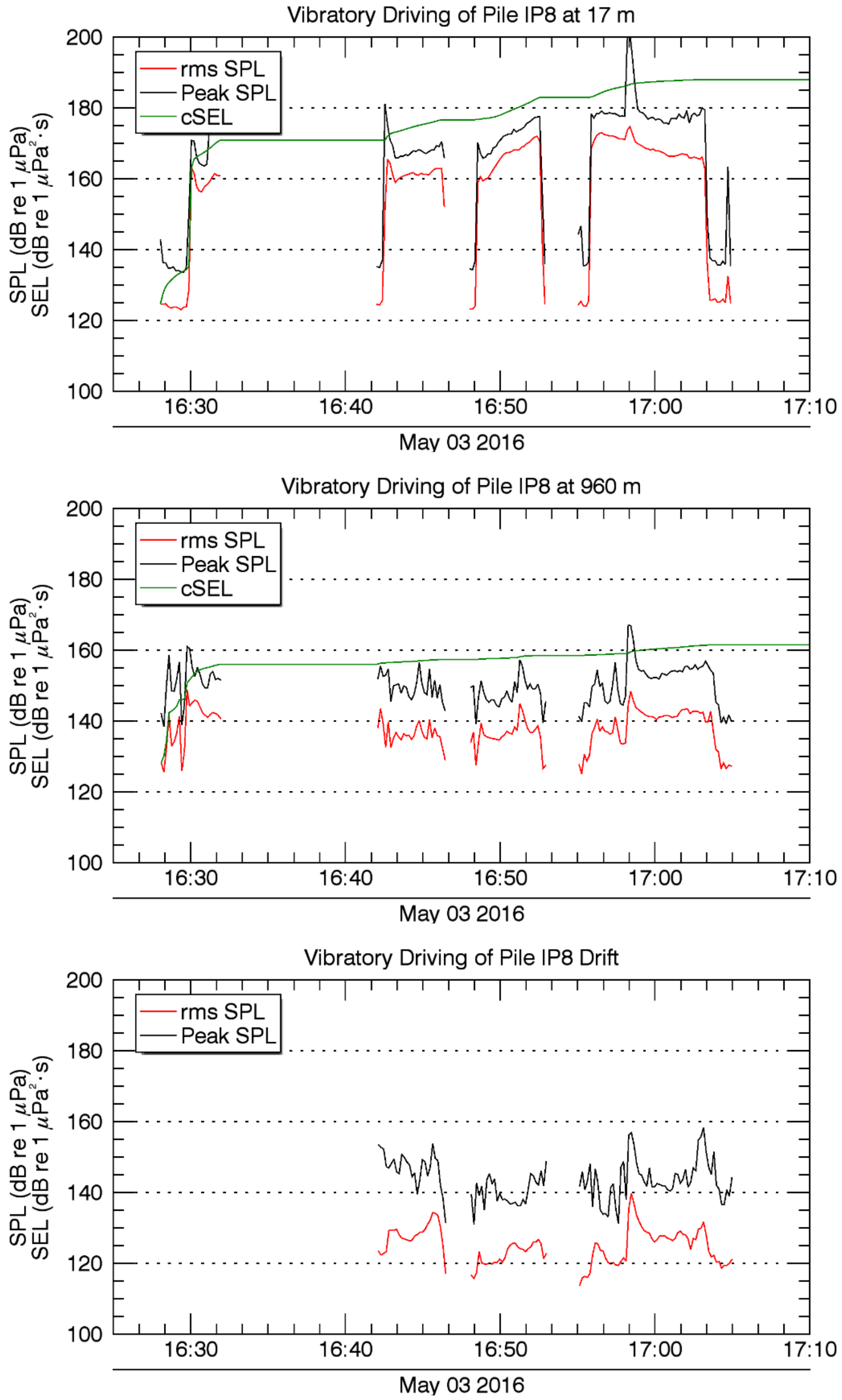


Figure 59. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP8 at distances of 17 m at IP8-10M (top), 960 mat IP8-1KM (middle) and between 1470 m to 2900 m on IP8-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.9. Pile IP9: Resonator, Location 6

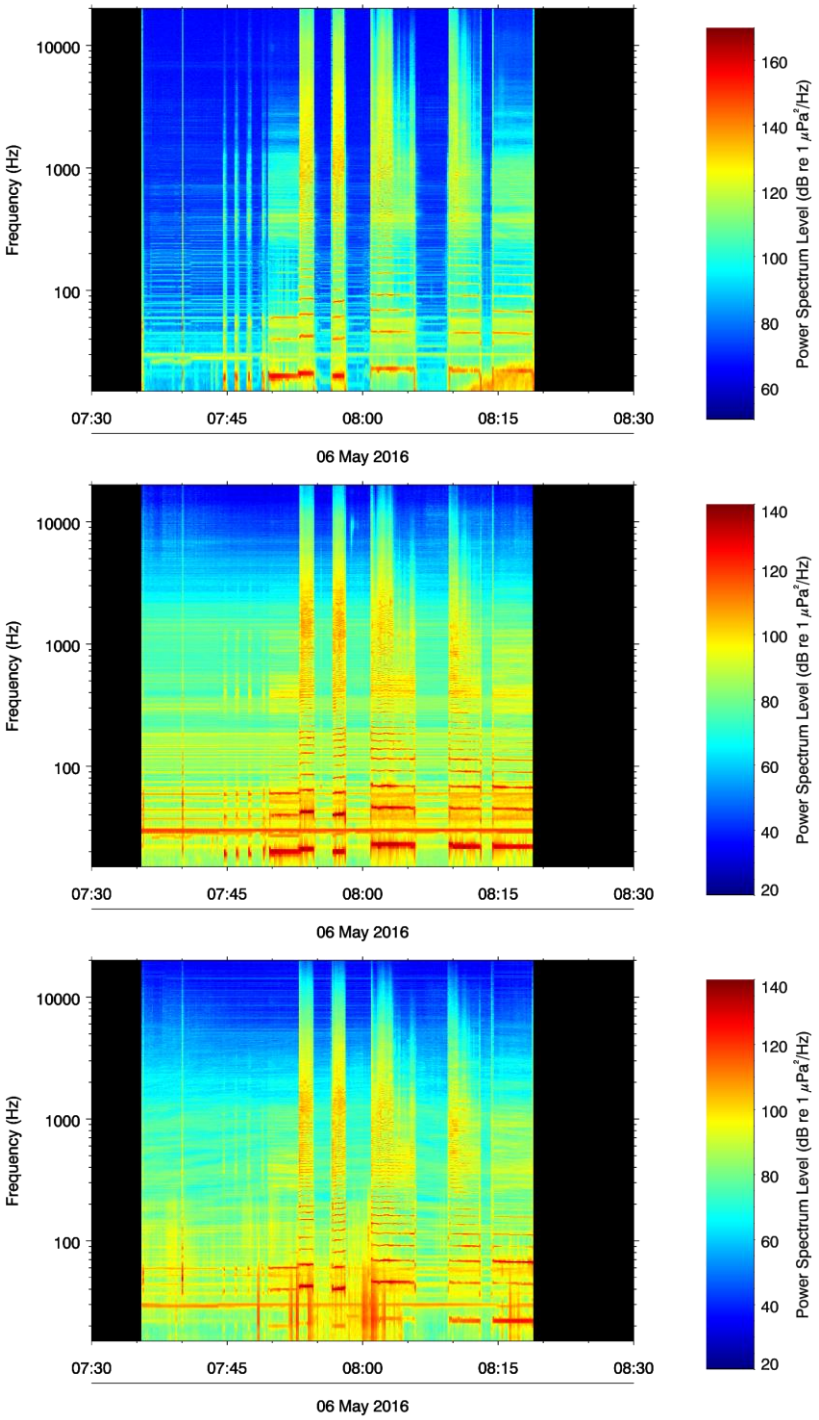


Figure 60. Spectrogram of vibratory driving of Pile IP9 at a distances of 17 m on IP9-10M (top), 1037 m on IP9-1KM (middle) and between 1271 m and 1646 m on IP9-DRIFT (bottom).

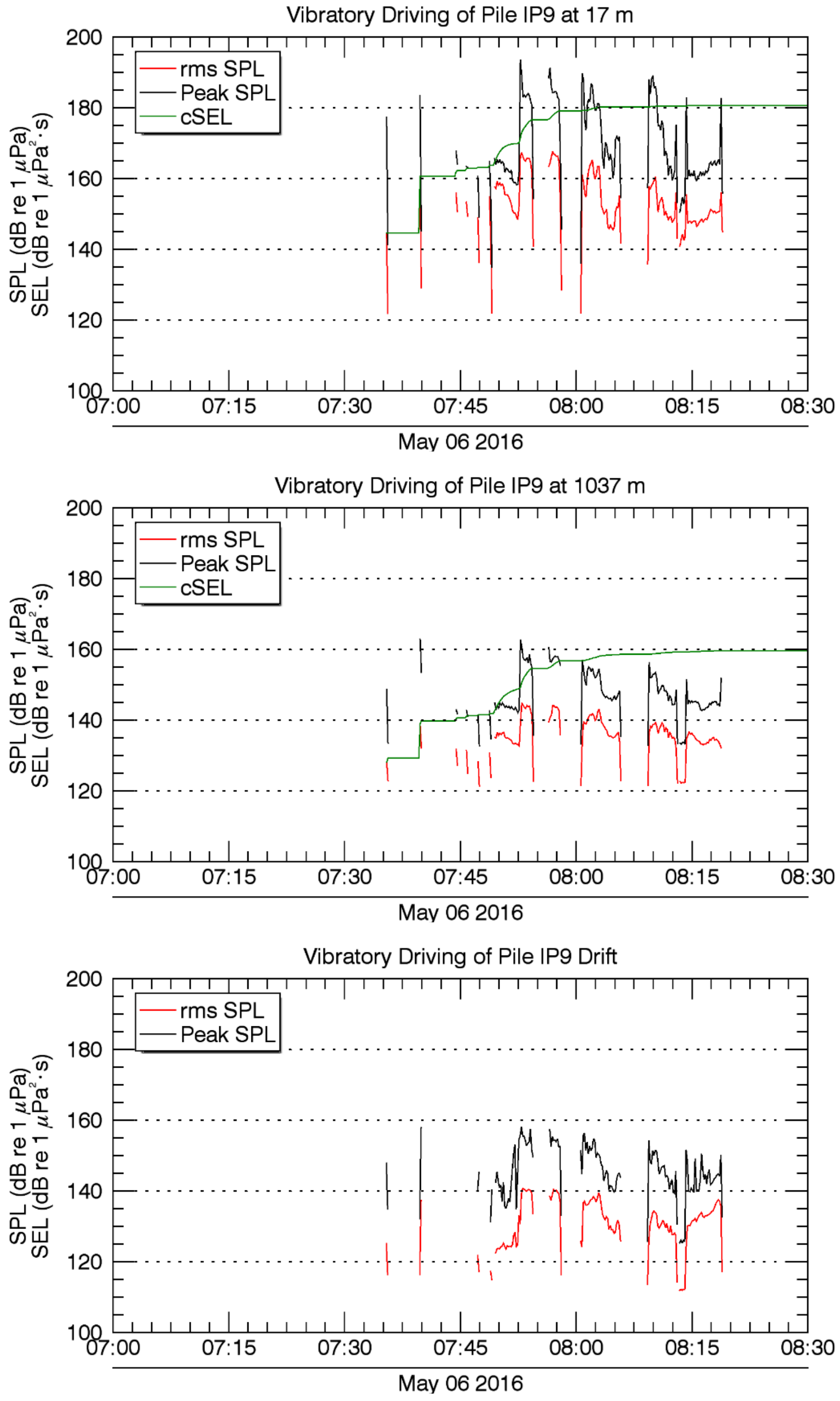


Figure 61. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP9 at distances of 17 m at IP9-10M (top), 1037 m at IP9-1KM (middle) and between 1620 m to 2510 m on IP9-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.2.10. Pile IP10: Bubble Curtain, Location 6

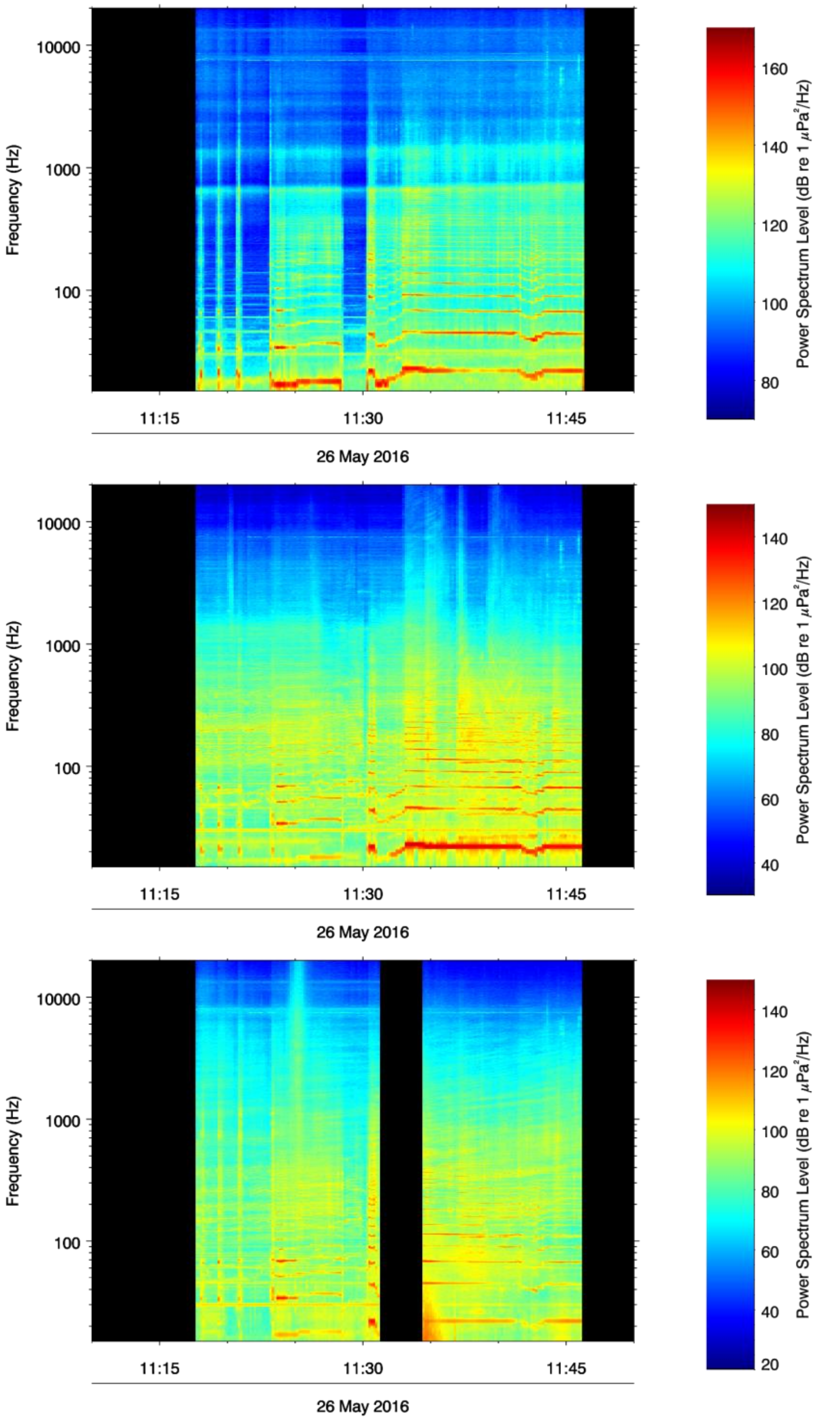


Figure 62. Spectrogram of vibratory driving of Pile IP10 at a distances of 12 m on IP10-10M (top), 1064 m on IP10-1KM (middle) and between 789 m and 1872 m on IP10-DRIFT (bottom).

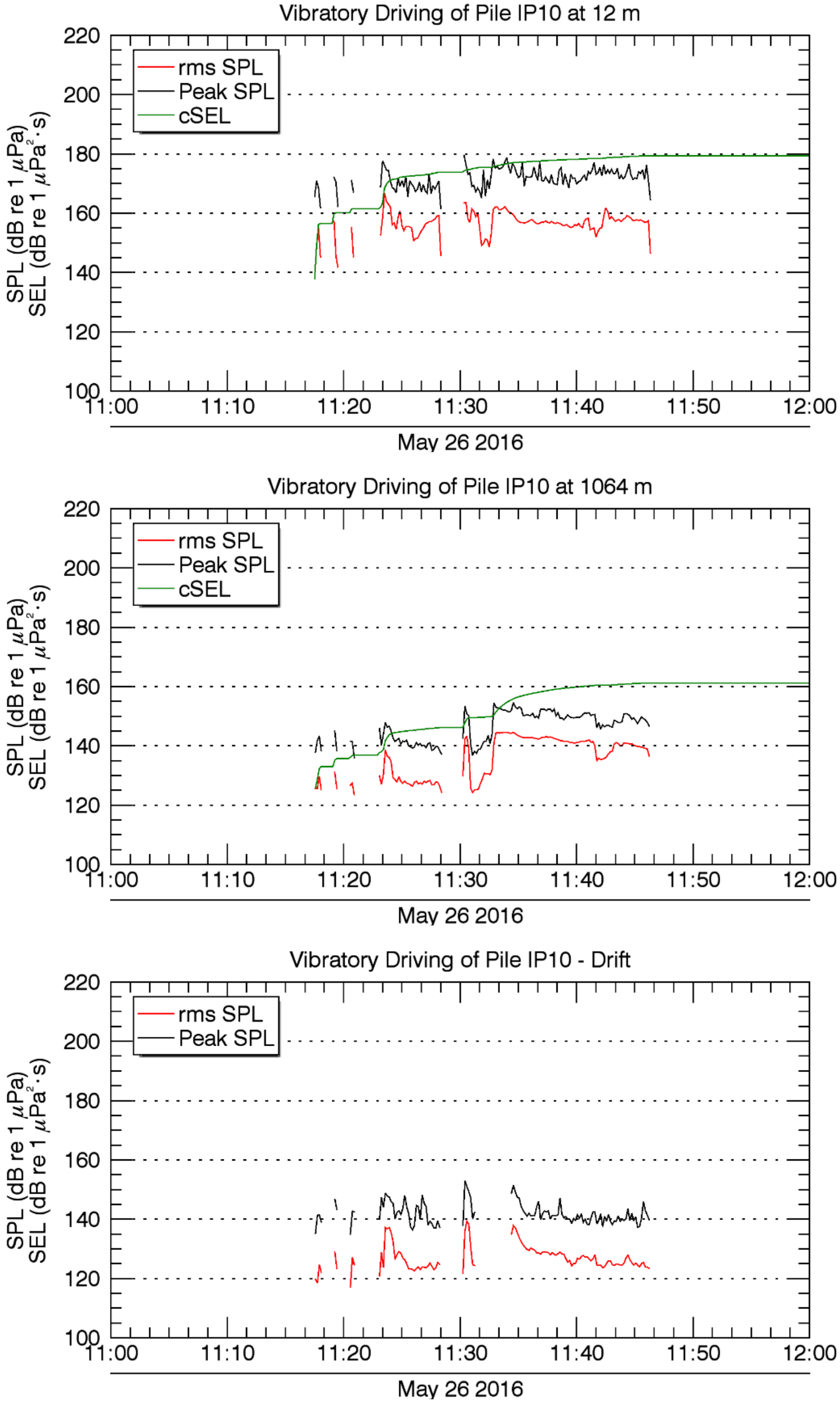


Figure 63. Plot of peak SPL and rms SPL vs time (AKDT) for pile driving of Pile IP10 at distances of 12 m at IP10-10M (top), 1064 m at IP10-1KM (middle) and between 800 m to 1930 m on IP10-DRIFT (bottom). Drift distances as a function of time are shown in Appendix B.

3.3. Sound Level Statistics

3.3.1. Impact Pile Driving

Table 7. Statistics of peak SPL for impact pile driving. Column headers include the pile details: Hammer type: H = hydraulic, D=diesel; NAS method: U = Un-attenuated, R=Passive Resonator, B=Bubble curtain; Location is given by number, pile-AMAR range (R) and the number (n) of strikes over which the percentiles are calculated. Levels for IP4 are given for the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and on.

	Sound level (dB re 1 μPa)											
AMAR-10M												
	IP1 **H; U; 5** **R = 14 m** **n = 2153**	**IP2** **D; R; 4** **R = 11 m** **n = 1504**	**IP3** **H; B; 1** **R = 12 m** **n = 4801**	**IP4(H)** **H; R; 1** **R = 10 m** **n = 1626**	**IP4(D)** **D; R; 1** **R = 10 m** **n = 1218**	**IP5** **D; U; 4** **R = 11 m** **n = 1213**	**IP6(off)*** **D; U; 4** **R = 12 m** **n = 1246**	**IP6(on)*** **D; B; 4** **R = 12 m** **n = 1087**	**IP7** **D; B; 5** **R = 12 m** **n = 1427**	**IP8** **H; R; 6** **R = 17 m** **n = 2000**	**IP9** **D; R; 6** **R = 17 m** **n = 845**	**IP10** **H; B; 6** **R = 12 m** **n = 1459**
Mean	213.1	200.4	203.1	211.4	206.1	211.9	208.9	204.4	202.0	207.2	206.5	198.6
Median	213.2	200.0	203.1	211.4	206.3	212.5	208.7	203.4	200.0	207.2	206.1	198.2
Max	215.3	206.7	206.7	212.8	211.1	216.2	216.2	210.0	208.2	210.5	210.7	203.7
90th percentile	214.4	202.7	204.0	211.9	207.4	213.8	210.1	206.6	206.4	208.4	207.9	200.5
AMAR-1KM												
	IP1 **H; U; 5** **R = 959 m** **n = 2151**	**IP2** **D; R; 4** **R = 943 m** **n = 1499**	**IP3** **H; B; 1** **R = 1182 m** **n = 3905**	**IP4(H)** **H; R; 1** **R = 1008 m** **n = 1634**	**IP4(D)** **D; R; 1** **R = 1008 m** **n = 1214**	**IP5** **D; U; 4** **R = 968 m** **n = 1207**	**IP6(off)*** **D; U; 4** **R = 977 m** **n = 1248**	**IP6(on)*** **D; B; 4** **R = 977 m** **n = 1087**	**IP7** **D; B; 5** **R = 1013 m** **n = 1428**	**IP8** **H; R; 6** **R = 960 m** **n = 1999**	**IP9** **D; R; 6** **R = 1037 m** **n = 840**	**IP10** **H; B; 6** **R = 1064m** **n = 1463**
Mean	176.7	171.8	169.5	162.4	164.6	176.5	172.2	171.1	169.0	181.1	181.8	180.9
Median	176.7	170.6	169.4	161.8	163.9	176.0	172.4	171.7	167.3	181.0	182.0	181.0
Max	179.2	180.1	172.9	166.2	169.4	182.8	175.1	175.0	175.3	184.7	184.3	182.0
90th percentile	178.2	174.9	170.7	164.6	166.6	178.6	173.8	172.7	172.7	183.2	182.6	181.7

*Pile IP6 had a bearing plate installed.

Table 8. Statistics of rms SPL for impact pile driving. Column headers include the pile : Hammer type: H = hydraulic, D=diesel; NAS method: U = Un-attenuated, R=Passive Resonator, B=Bubble curtain; Location is given by number, pile-AMAR range (R) and the number (n) of strikes over which the percentiles are calculated. Levels for IP4 are given for the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and on.

	Sound level (dB re 1 µPa)											
AMAR-10M												
	IP1 H; U; 5 R = 14 m n = 2153	**IP2 D; R; 4 R = 11 m n = 1504**	**IP3 H; B; 1 R = 12 m n = 4801**	**IP4(H) H; R; 1 R = 10 m n = 1626**	**IP4(D) D; R; 1 R = 10 m n = 1218**	**IP5 D; U; 4 R = 11 m n = 1213**	**IP6(off)* D; U; 4 R = 12 m n = 1246**	**IP6(on)* D; B; 4 R = 12 m n = 1087**	**IP7 D; B; 5 R = 12 m n = 1427**	**IP8 H; R; 6 R = 17 m n = 2000**	**IP9 D; R; 6 R = 17 m n = 845**	**IP10 H; B; 6 R = 12 m n = 1459**
Mean	199.1	188.1	190.3	196.0	191.9	198.1	193.4	191.0	187.6	191.8	193.7	186.0
Median	199.0	187.8	190.3	195.8	191.2	197.9	193.2	189.9	187.0	191.7	193.7	185.9
Max	201.6	192.4	194.1	198.7	194.9	202.0	196.9	194.9	191.9	195.9	196.6	188.5
90th percentile	200.6	190.4	192.3	197.0	193.7	200.3	194.8	193.4	190.5	193.6	194.6	187.1
AMAR-1KM												
	IP1 H; U; 5 R = 959 m n = 2151	**IP2 D; R; 4 R = 943 m n = 1499**	**IP3 H; B; 1 R = 1182 m n = 3905**	**IP4(H) H; R; 1 R = 1008 m n = 1634**	**IP4(D) D; R; 1 R = 1008 m n = 1214**	**IP5 D; U; 4 R = 968 m n = 1207**	**IP6(off)* D; U; 4 R = 977 m n = 1248**	**IP6(on)* D; B; 4 R = 977 m n = 1087**	**IP7 D; B; 5 R = 1013 m n = 1428**	**IP8 H; R; 6 R = 960 m n = 1999**	**IP9 D; R; 6 R = 1037 m n = 840**	**IP10 H; B; 6 R = 1064m n = 1463**
Mean	163.3	162.6	157.4	149.5	150.7	166.0	158.3	157.7	153.6	166.3	168.1	169.9
Median	163.1	161.8	157.1	149.1	149.7	166.5	158.4	156.9	152.7	166.2	167.4	169.8
Max	165.3	168.2	160.3	151.9	155.1	172.1	160.9	160.5	160.1	170.0	171.1	171.3
90th percentile	164.5	165.6	158.9	151.3	152.8	167.9	159.5	160.0	156.1	168.0	170.0	170.9

*Pile IP6 had a bearing plate installed.

Table 9. Statistics of single-strike SEL and cumulative SEL for impact pile driving. Column headers include the pile : Hammer type: H = hydraulic, D=diesel; NAS method: U = Un-attenuated, R=Passive Resonator, B=Bubble curtain; Location is given by number, pile-AMAR range (R) and the number (n) of strikes over which the percentiles are calculated. Levels for IP4 are given for the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and on.

	Sound level (dB re 1 µPa^2·s)											
AMAR-10M												
	IP1 H; U; 5 R = 14 m n = 2153	**IP2 D; R; 4 R = 11 m n = 1504**	**IP3 H; B; 1 R = 12 m n = 4801**	**IP4(H) H; R; 1 R = 10 m n = 1626**	**IP4(D) D; R; 1 R = 10 m n = 1218**	**IP5 D; U; 4 R = 11 m n = 1213**	**IP6(off)* D; U; 4 R = 12 m n = 1246**	**IP6(on)* D; B; 4 R = 12 m n = 1087**	**IP7 D; B; 5 R = 12 m n = 1427**	**IP8 H; R; 6 R = 17 m n = 2000**	**IP9 D; R; 6 R = 17 m n = 845**	**IP10 H; B; 6 R = 12 m n = 1459**
Mean	185.1	176.7	176.1	183.4	180.5	186.2	184.6	181.7	176.5	178.8	181.4	174.4
Median	185.1	176.2	175.9	183.3	179.5	186.7	184.5	181.0	175.6	178.8	181.1	174.4
Max	186.5	182.8	180.2	185.6	184.0	190.2	187.6	185.4	181.3	181.0	185.1	176.4
90th percentile	186.0	179.2	177.9	184.8	182.5	187.9	185.6	184.1	179.5	179.8	182.8	175.4
Cumulative	218.4	208.5	212.9	215.6	211.3	217.0	215.6	212.1	208.1	211.8	210.7	206.0
AMAR-1KM												
	IP1 H; U; 5 R = 959 m n = 2151	**IP2 D; R; 4 R = 943 m n = 1499**	**IP3 H; B; 1 R = 1182 m n = 3905**	**IP4(H) H; R; 1 R = 1008 m n = 1634**	**IP4(D) D; R; 1 R = 1008 m n = 1214**	**IP5 D; U; 4 R = 968 m n = 1207**	**IP6(off)* D; U; 4 R = 977 m n = 1248**	**IP6(on)* D; B; 4 R = 977 m n = 1087**	**IP7 D; B; 5 R = 1013 m n = 1428**	**IP8 H; R; 6 R = 960 m n = 1999**	**IP9 D; R; 6 R = 1037 m n = 840**	**IP10 H; B; 6 R = 1064m n = 1463**
Mean	152.4	151.3	148.5	144.8	145.3	155.0	150.5	149.8	147.5	155.9	157.4	157.7
Median	152.4	150.4	148.4	144.6	144.6	155.8	150.7	149.6	146.7	155.9	157.1	157.5
Max	154.2	157.2	150.5	147.4	149.3	160.6	152.5	152.5	152.9	158.4	160.3	159.4
90th percentile	153.4	154.2	149.7	146.7	147.3	156.9	151.6	151.8	150.4	157.0	158.7	158.4
Cumulative	185.7	183.0	184.4	177.0	176.2	185.8	181.4	180.1	179.1	188.9	186.6	189.4

*Pile IP6 had a bearing plate installed.

3.3.2. Vibratory Pile Driving

Table 10. Statistics of peak SPL for vibratory pile driving. Column headers include the pile details: NAS method: U=Un-attenuated, R=Passive Resonator, B=Bubble curtain; Location is given by number, pile-AMAR range (R) and the number (n) of sound levels from 10-s analysis windows over which the percentiles are calculated.

Sound level (dB re 1 µPa)											
AMAR-10M											
	IP1 U; 5 R = 14 m n = 193	**IP2 R; 4 R = 11 m n = 209**	**IP3 B; 1 R = 12 m n = 191**	**IP4 R; 1 R = 10 m n = 192**	**IP5 U; 4 R = 11 m n = 111**	**IP6a* B; 4 R = 12 m n = 157**	**IP6b* B; 4 R = 12 m n = 104**	**IP7 B; 5 R = 12 m n = 134**	**IP8 R; 6 R = 17 m n = 141**	**IP9 R; 6 R = 17 m n = 145**	**IP10 B; 6 R = 12 m n = 138**
Mean	189.4	183.8	170.1	184.7	189.2	179.0	211.9	175.2	183.1	180.6	172.9
Median	185.9	179.2	164.7	173.8	185.3	1761.	211.8	170.5	170.6	164.9	172.0
Max	202.6	197.2	188.6	198.0	197.7	191.8	217.3	186.2	200.9	193.6	179.5
90th percentile	182.2	187.8	172.4	189.0	194.1	181.9	215.1	179.6	178.6	184.6	176.2
AMAR-1KM											
	IP1 U; 5 R = 959 m n = 193	**IP2 R; 4 R = 943 m n = 152**	**IP3** B; 1 R = 1182 m n = 191**	**IP4 R; 1 R = 1008 m n = 202**	**IP5 U; 4 R = 968 m n = 111**	**IP6a* B; 4 R = 977 m n = 157**	**IP6b* B; 4 R = 977 m n = 105**	**IP7 B; 5 R = 1013 m n = 134**	**IP8 R; 6 R = 960 m n = 159**	**IP9 R; 6 R = 1037 m n = 142**	**IP10 B; 6 R = 1064m n = 139**
Mean	152.3	156.3	168.4	139.8	154.8	156.0	168.0	148.2	153.4	152.2	148.8
Median	150.7	156.0	165.4	139.7	152.2	154.4	168.1	143.9	149.7	146.0	148.2
Max	160.5	162.3	177.7	145.5	161.1	163.8	172.5	159.0	167.0	162.9	154.6
90th percentile	156.4	158.6	172.6	143.2	159.0	159.0	170.9	152.0	155.5	156.9	152.4

*Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT

**Levels from AMAR-1KM during vibratory pile driving of IP3 are contaminated with noise from dredging and are not representative of pile driving sounds.

Table 11. Statistics of rms SPL for vibratory pile driving. Column headers include the pile : NAS method: U=Un-attenuated, R=Passive Resonator, B=Bubble curtain; Location is given by number, pile-AMAR range (R) and the number (n) of sound levels from 10-s analysis windows over which the percentiles are calculated.

	Sound level (dB re 1 µPa)										
AMAR-10M											
	IP1 U; 5 R = 14 m n = 193	**IP2 R; 4 R = 11 m n = 209**	**IP3 B; 1 R = 12 m n = 191**	**IP4 R; 1 R = 10 m n = 192**	**IP5 U; 4 R = 11 m n = 111**	**IP6a* B; 4 R = 12 m n = 157**	**IP6b* B; 4 R = 12 m n = 104**	**IP7 B; 5 R = 12 m n = 134**	**IP8 R; 6 R = 17 m n = 141**	**IP9 R; 6 R = 17 m n = 145**	**IP10 B; 6 R = 12 m n = 138**
Mean	168.0	163.2	157.1	163.4	169.3	163.7	183.8	161.2	166.5	159.0	158.0
Median	166.3	161.3	154.7	160.1	166.8	162.9	183.9	158.9	162.6	151.3	156.9
Max	175.3	172.2	166.6	171.9	176.0	168.8	187.8	167.4	174.7	167.6	166.7
90th percentile	171.8	166.3	161.3	168.4	172.9	166.9	186.6	165.9	171.2	164.9	161.2
AMAR-1KM											
	IP1 U; 5 R = 959 m n = 193	**IP2 R; 4 R = 943 m n = 152**	IP3** B; 1 R = 1182 m n = 191	**IP4 R; 1 R = 1008 m n = 202**	**IP5 U; 4 R = 968 m n = 111**	**IP6a* B; 4 R = 12 m n = 157**	**IP6b* B; 4 R = 977 m n = 105**	**IP7 B; 5 R = 1013 m n = 134**	**IP8 R; 6 R = 960 m n = 159**	**IP9 R; 6 R = 1037 m n = 142**	**IP10 B; 6 R = 1064m n = 139**
Mean	136.9	140.8	153.6	128.7	138.6	141.7	150.2	134.0	139.5	138.1	139.8
Median	136.2	139.8	149.8	129.1	136.7	139.2	150.4	131.0	136.8	135.6	139.6
Max	141.5	145.9	163.5	133.3	144.5	150.6	153.6	144.9	148.9	144.9	144.5
90th percentile	140.2	158.6	157.6	131.4	142.1	145.0	152.7	136.5	143.2	142.4	143.3

*Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT.

**Levels from AMAR-1KM during vibratory pile driving of IP3 are contaminated with noise from dredging and are not representative of pile driving sounds.

3.4. Threshold Distances

3.4.1. Impact Pile Driving

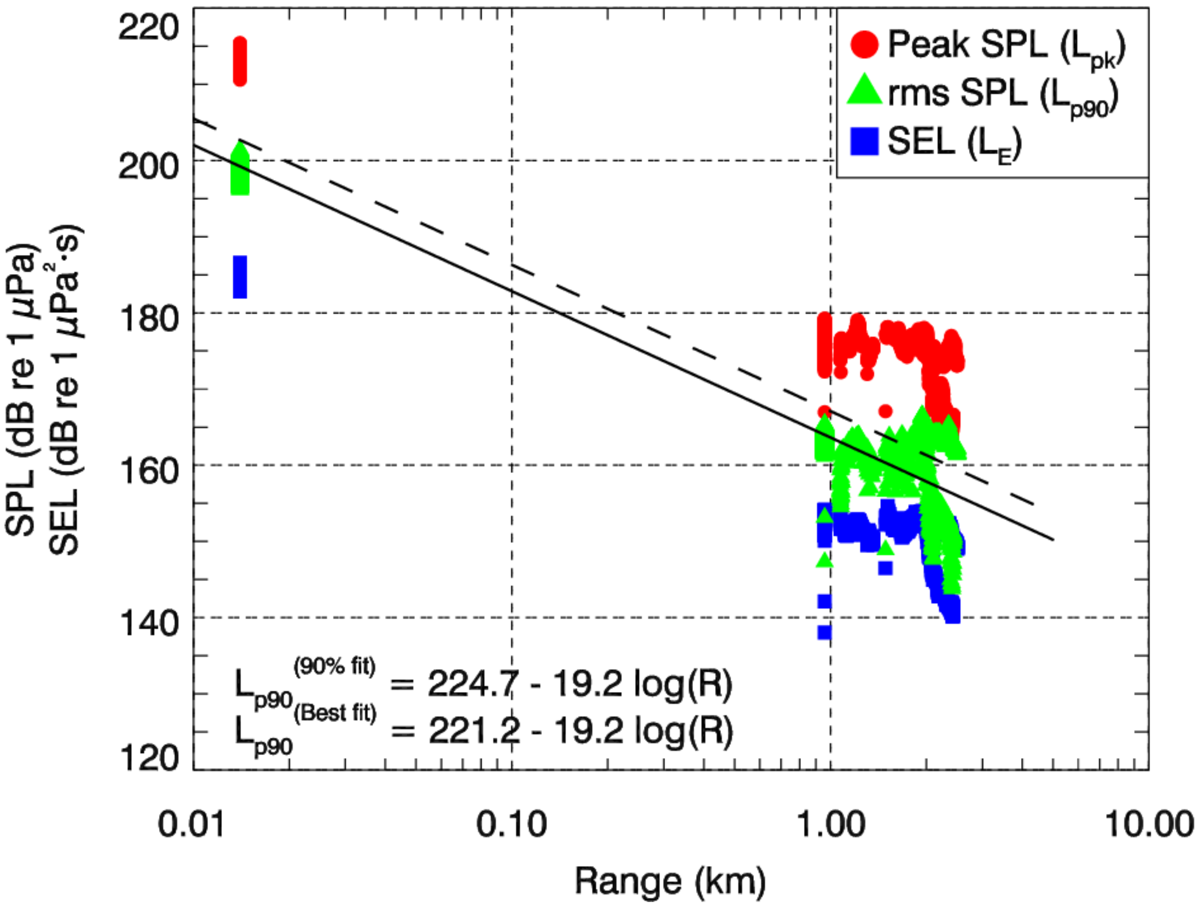


Figure 64. Pile IP1: Plot of peak SPL, rms SPL, and SEL versus range for hydraulic impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

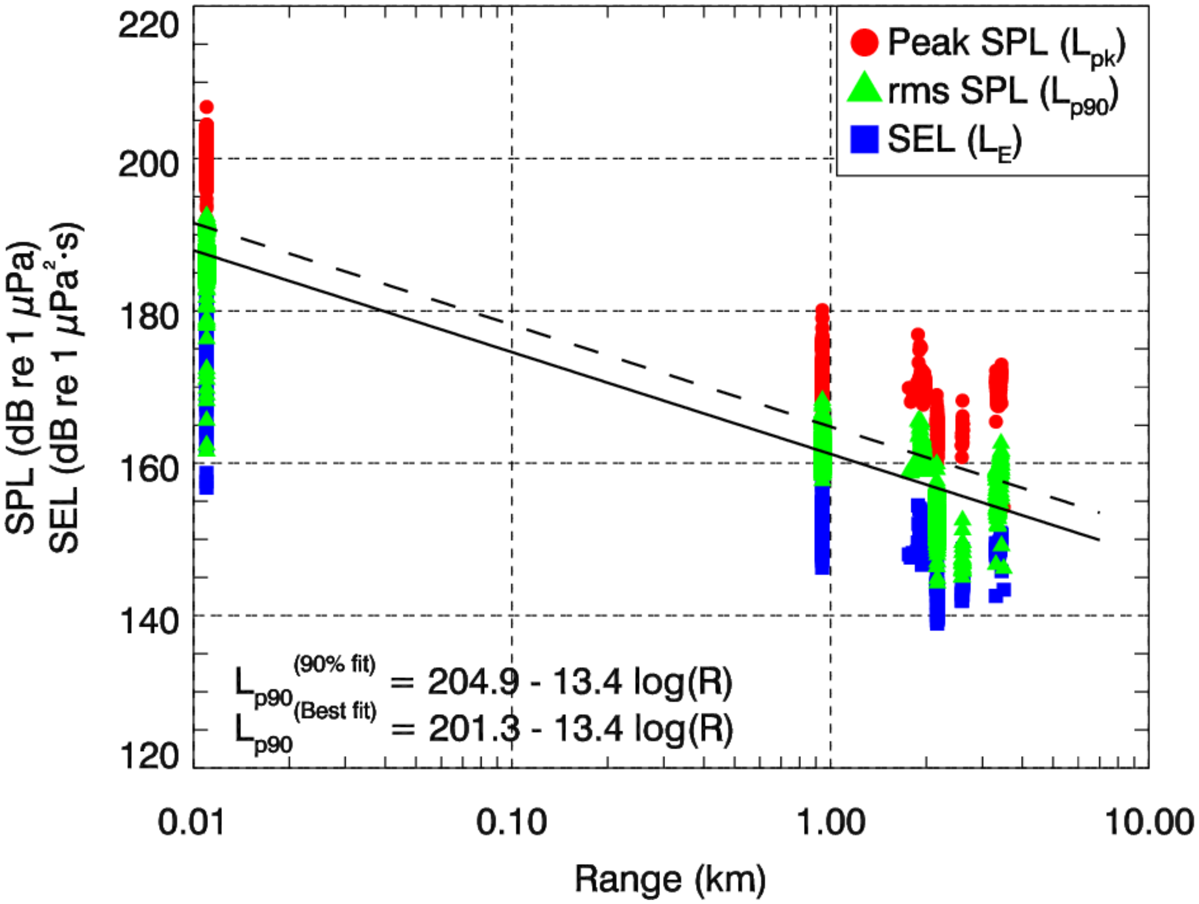


Figure 65. Pile IP2: Plot of peak SPL, rms SPL, and SEL versus range for diesel impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

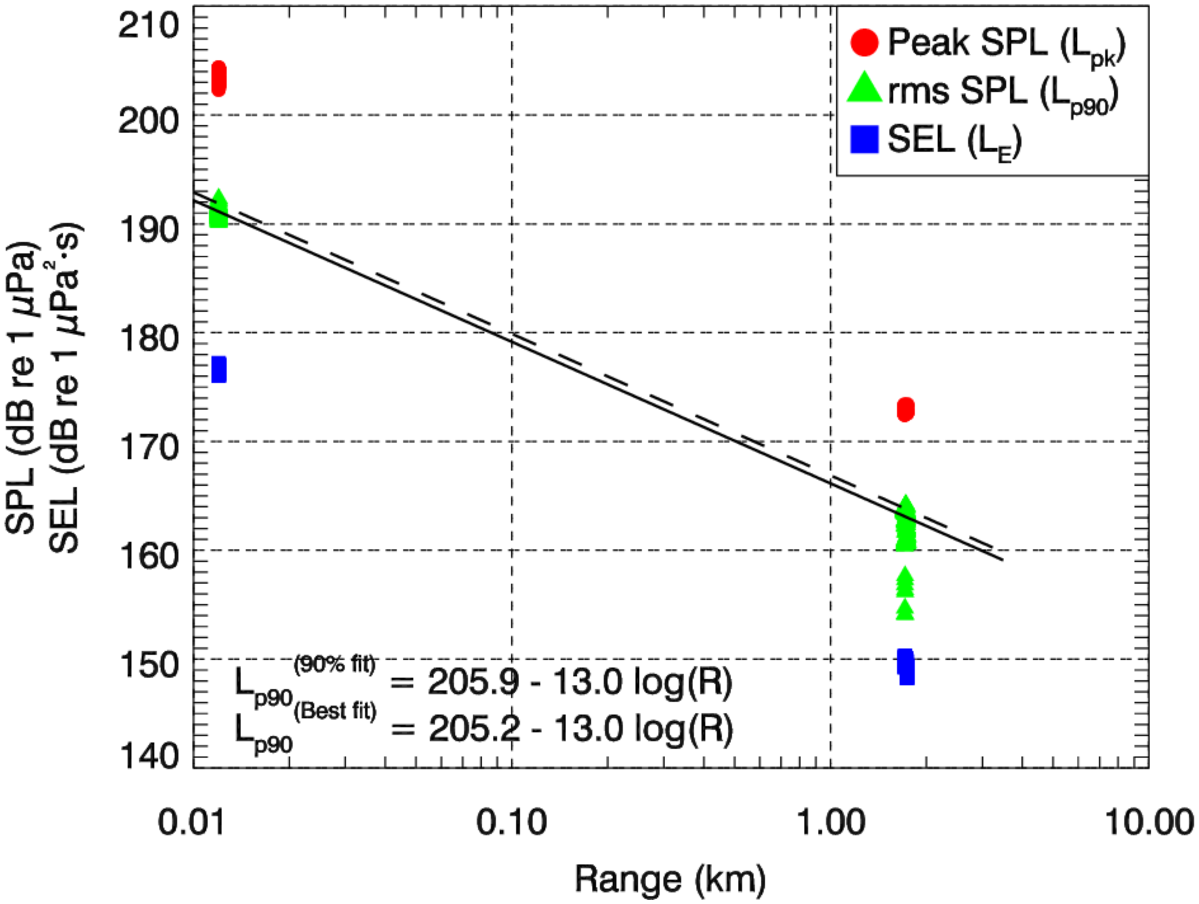


Figure 66. Pile IP3: Plot of peak SPL, rms SPL, and SEL versus range for hydraulic impact driving, for a propagation path to AMAR-Drift to the south of the Port. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th measured levels. Levels included in this plot are from strikes that were recorded simultaneously on AMAR-10M and the drifting system. Data from AMAR-1KM were excluded and treated separately because the levels were suspected to be attenuated by an unresolved propagation effect.

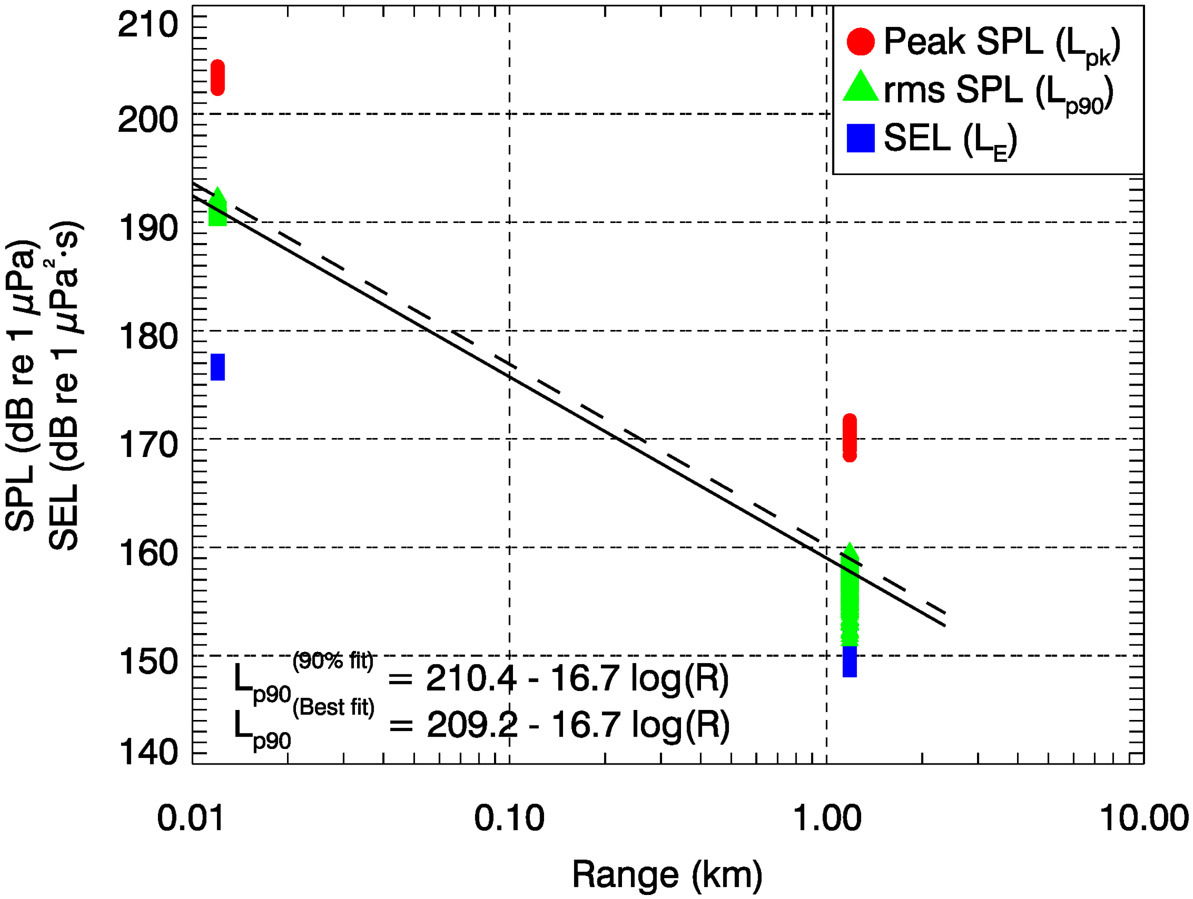


Figure 67 Pile IP3: Plot of peak SPL, rms SPL, and SEL versus range for hydraulic impact driving, for a westward propagation path to AMAR-1KM in the dredge disposal area. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th measured levels. Levels included in this plot are from strikes that were recorded simultaneously on AMAR-10M and the drifting system. Data from AMAR-1KM were excluded and treated separately because the levels were suspected to be attenuated by an unresolved propagation effect.

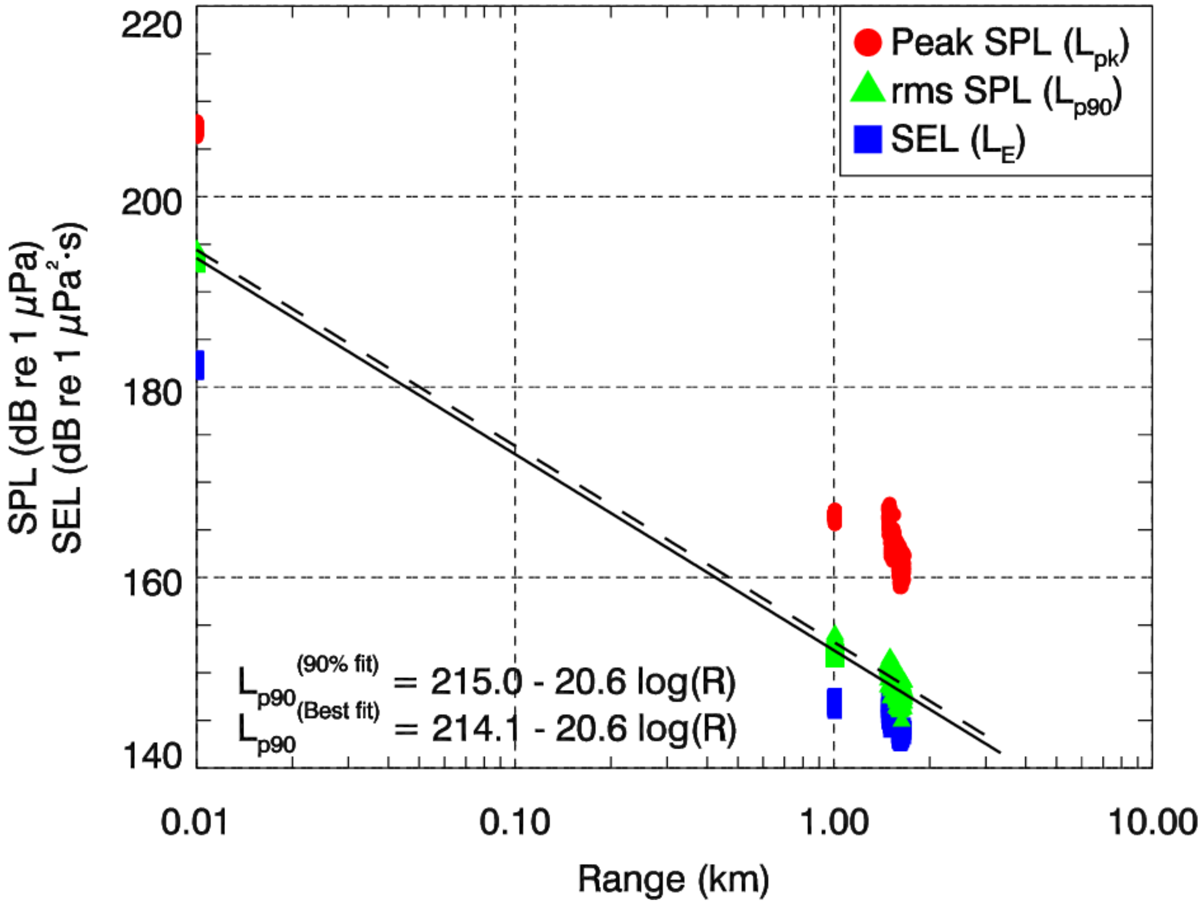


Figure 68. Pile IP4 (diesel): Plot of peak SPL, rms SPL, and SEL versus range for diesel impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system. Note: The data from AMAR-1KM and the drift data are likely artificially attenuated due to shielding by land between the recorders and the pile, these data are presented for completeness but are an anomalous result.

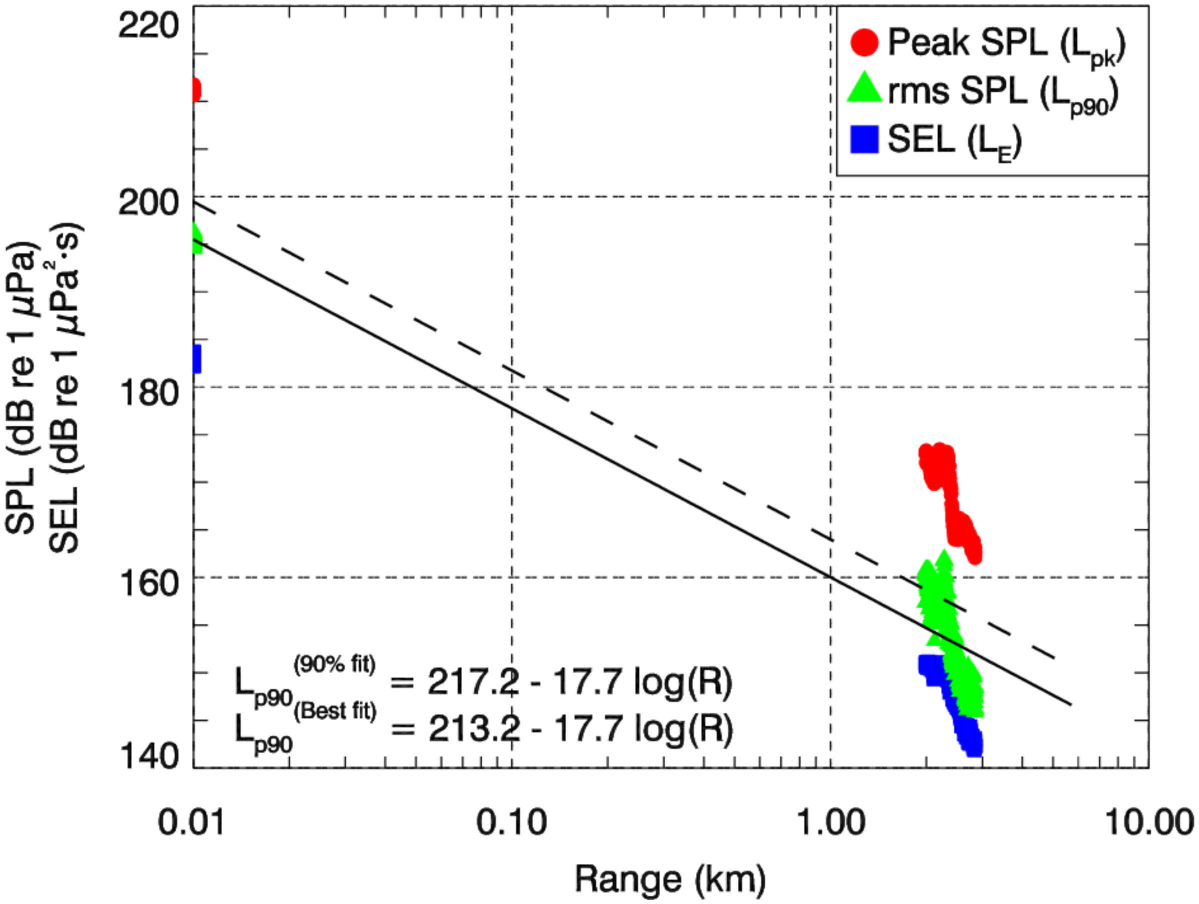


Figure 69. Pile IP4 (hydraulic): Plot of peak SPL, rms SPL, and SEL versus range for hydraulic impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th measured levels. Levels included in this plot are from strikes that were recorded simultaneously on AMAR-10M and the drifting system. Data from AMAR-1KM were excluded from this plot because the levels were artificially attenuated by shielding from land between the recorder and the pile. Inclusion of the data from AMAR-1KM prevented suitable fitting of the valid data at AMAR-10M and AMAR-DRIFT.

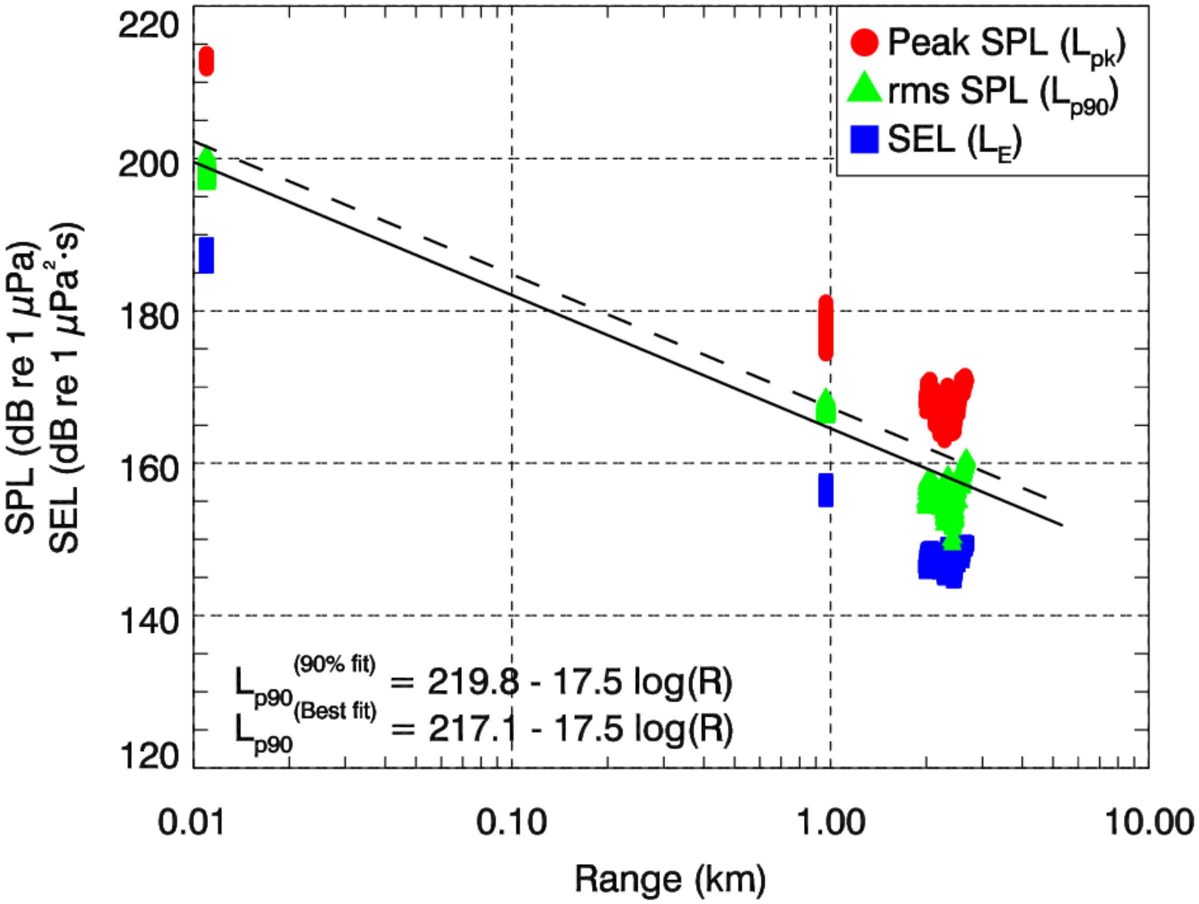


Figure 70. Pile IP5: Plot of peak SPL, rms SPL, and SEL versus range for diesel impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

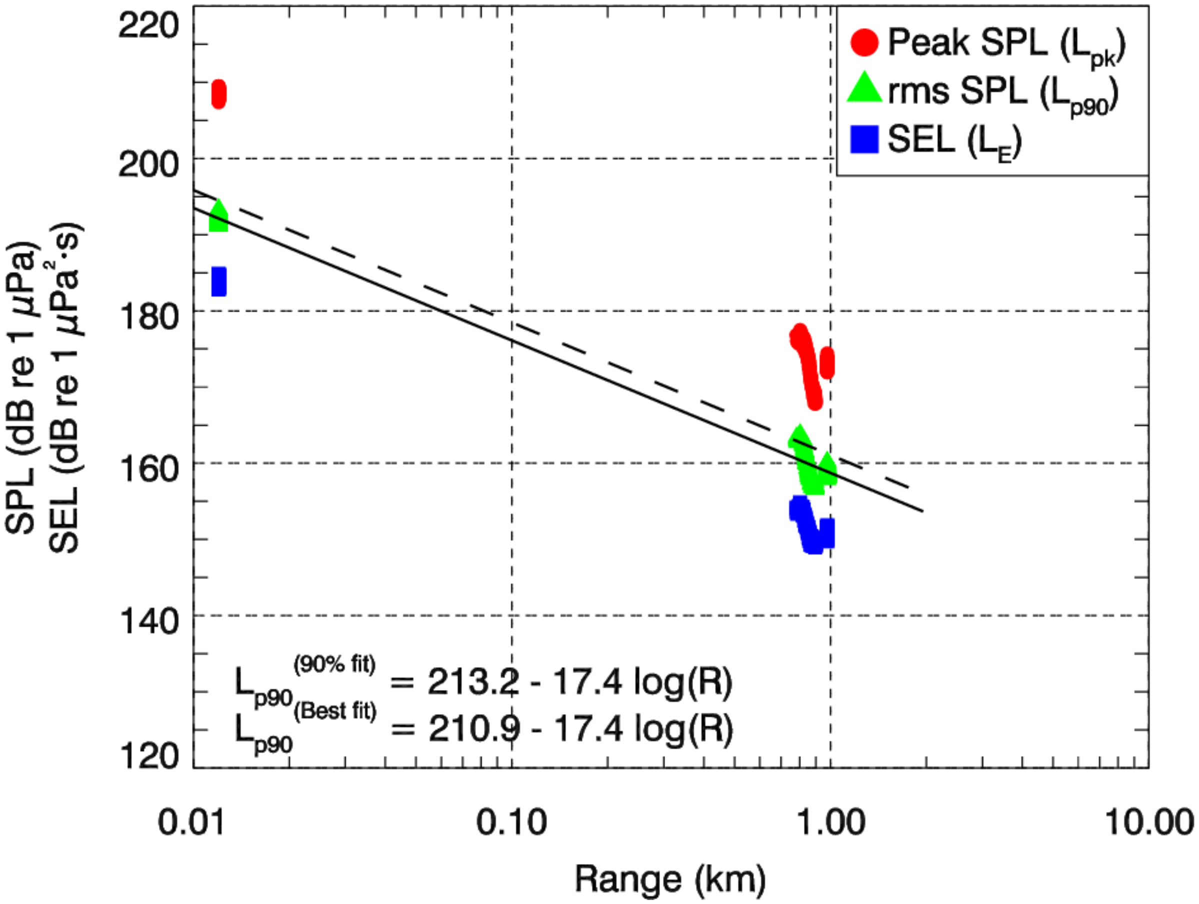


Figure 71. Pile IP6 (un-attenuated): Plot of peak SPL, rms SPL, and SEL versus range for un-attenuated diesel impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

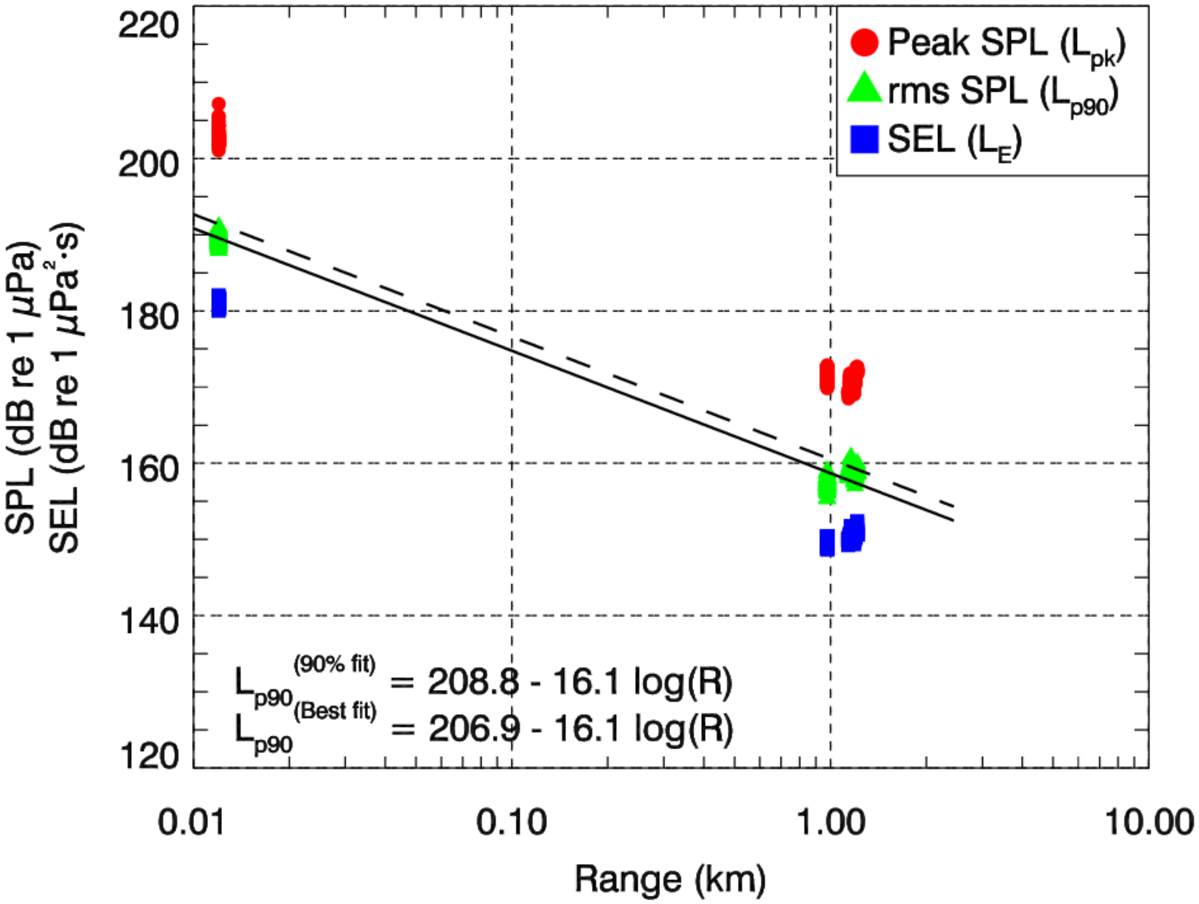


Figure 72 Pile IP6 (attenuated): Plot of peak SPL, rms SPL, and SEL versus range for bubble curtain-attenuated diesel impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

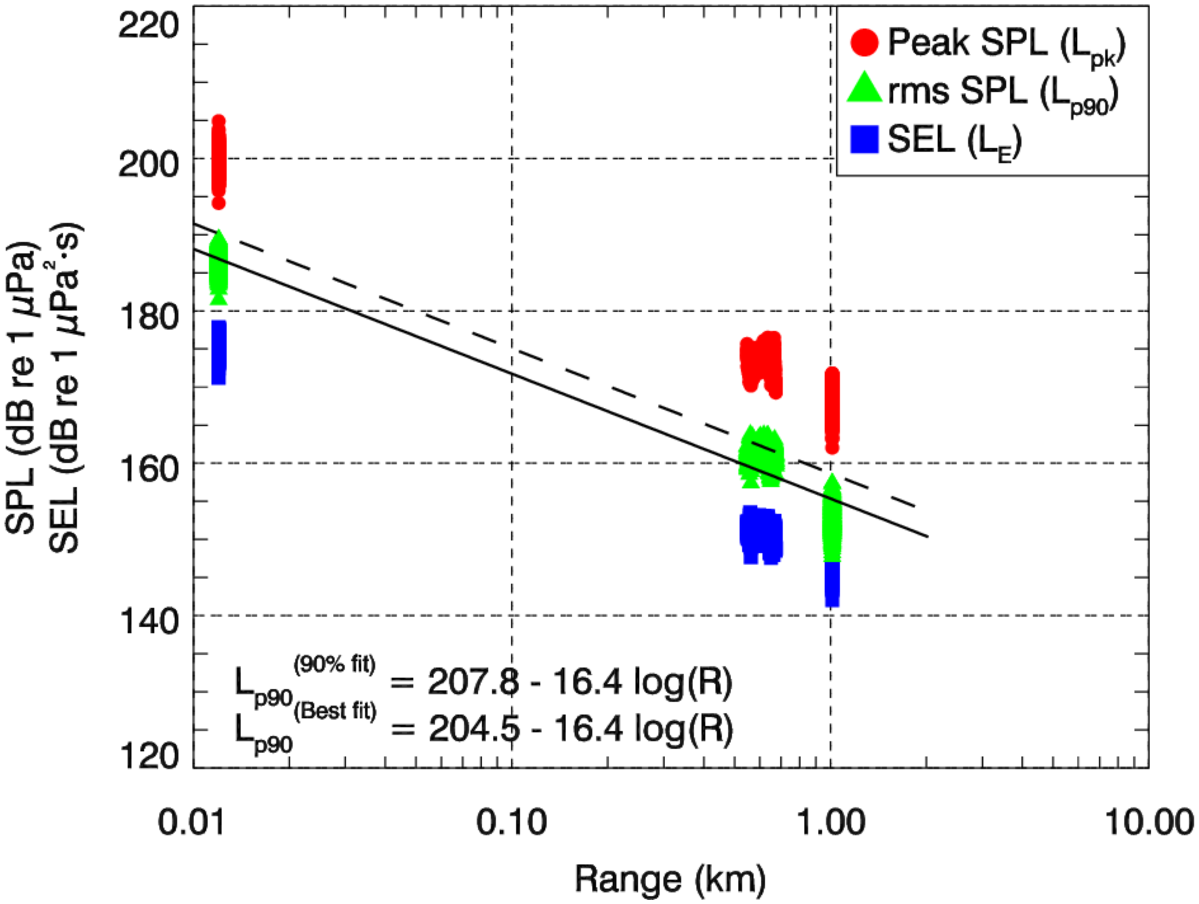


Figure 73. Pile IP7: Plot of peak SPL, rms SPL, and SEL versus range for diesel impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

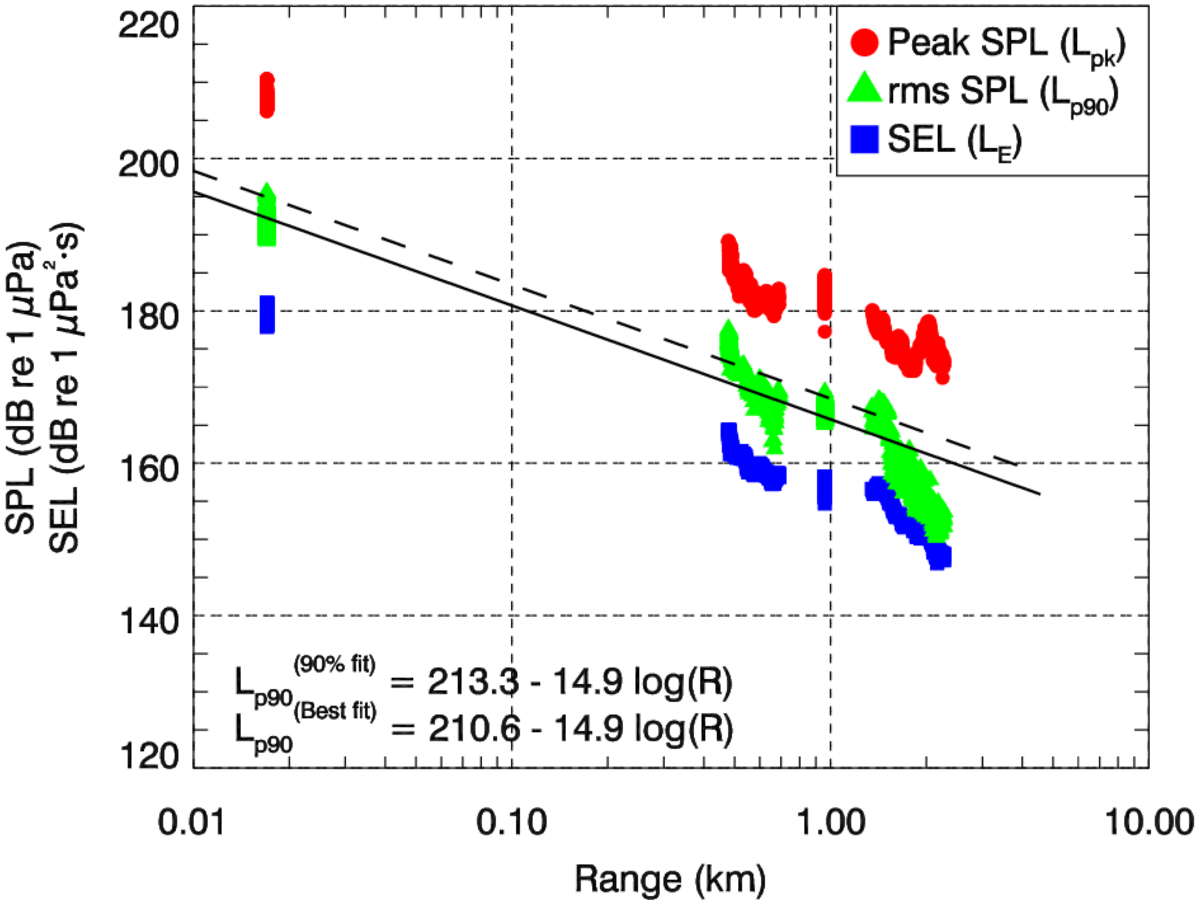


Figure 74. Pile IP8: Plot of peak SPL, rms SPL, and SEL versus range for hydraulic impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

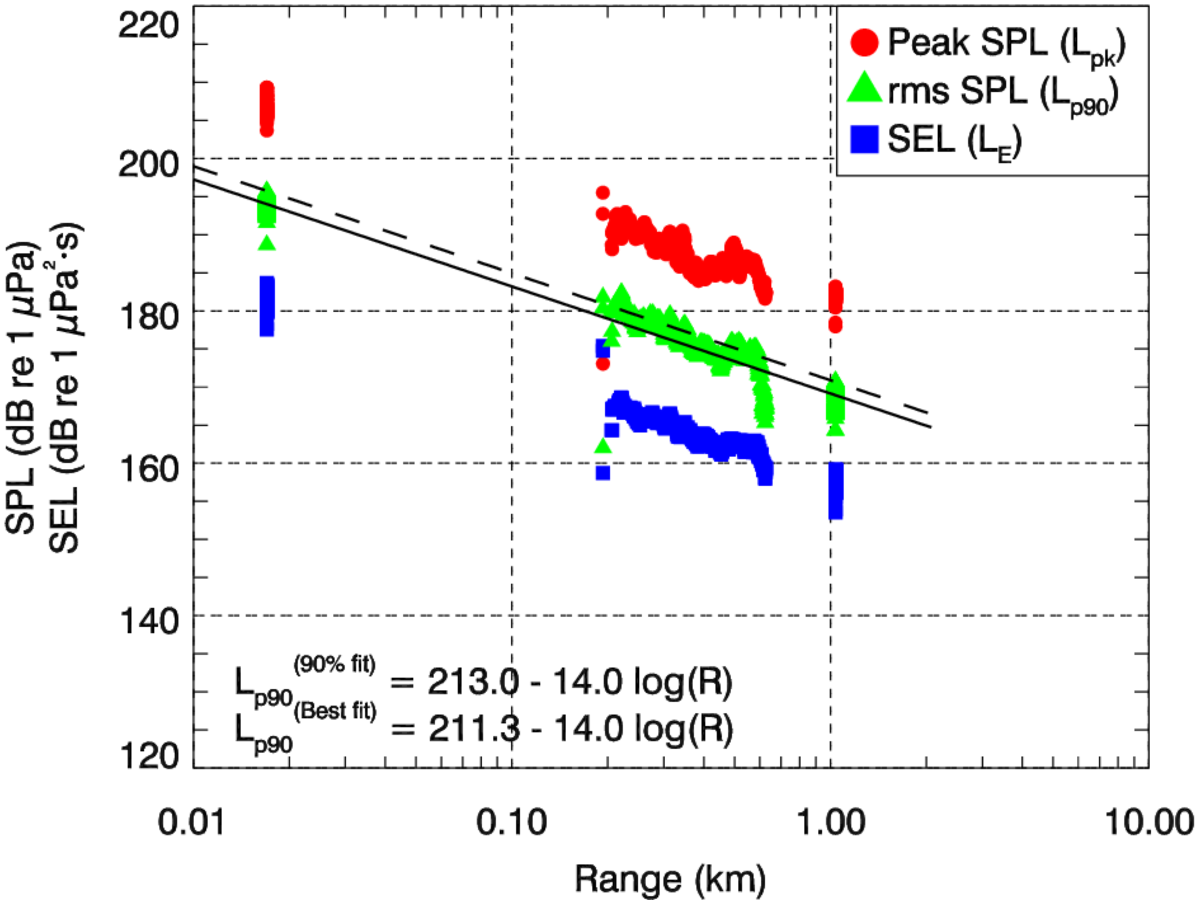


Figure 75. Pile IP9: Plot of peak SPL, rms SPL, and SEL versus range for diesel impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

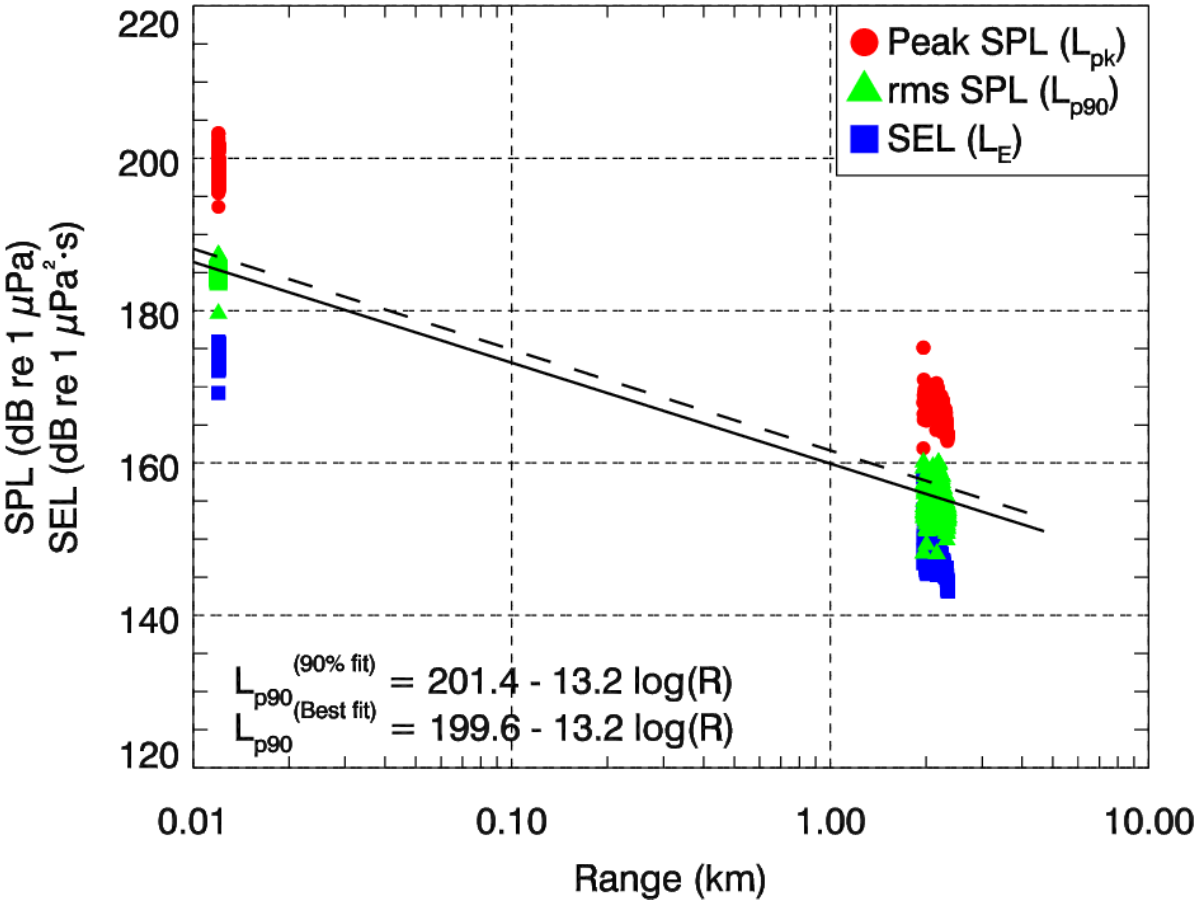


Figure 76. Pile IP10: Plot of peak SPL, rms SPL, and SEL versus range for hydraulic impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th measured levels. Levels included in this plot are from strikes that were recorded simultaneously on AMAR-10M and the drifting system. Anomalous data at AMAR-1KM were excluded from the plot.

Table 12. TL Coefficients, Source Levels (SL), Received Level (RL) at 10 m and ranges to rms SPL thresholds for impact pile driving determined from best-fit transmission loss coefficient and SPLs on AMAR-10M (mean, median, and 90th percentile). Hammer type: H=hydraulic, D=diesel; NAS method: U=Un-attenuated, R=Passive Resonator, B=Bubble curtain; Location is indicated by number.

	IP1 H; U; 5	IP2 D; R; 4	IP3, Path 1 H; B; 1	IP3, Path 2 H; B; 1	IP4(H) H; R; 1	IP4(D)** D; R; 1	IP5 D; U; 4	IP6(off)^ D; U; 4	IP6(on)^ D; B; 4	IP7 D; B; 5	IP8 H; R; 6	IP9 D; R; 6	IP10 H; B; 6
TL Coefficient	19.2	13.4	13	16.6	17.7	20.6	17.5	17.4	16.1	16.4	14.9	14	13.2
Mean SL (dB re 1µPa)	221.1	202.1	204.3	208.2	213.7	212.5	216.3	212.2	208.4	205.3	210.1	210.9	200.2
Median SL (dB re 1µPa)	221.0	201.8	204.3	208.2	213.5	211.8	216.1	212.0	207.3	204.7	210.0	210.9	200.1
90% SL (dB re 1µPa)	222.6	204.4	206.3	210.2	214.7	214.3	218.5	213.6	210.8	208.2	211.9	211.8	201.3
Mean RL @ 10 m (dB re 1µPa)	201.9	188.7	191.3	191.6	196.0	191.9	198.8	194.8	192.3	188.9	195.2	196.9	187.0
Median RL @10 m (dB re 1µPa)	201.8	188.4	191.3	191.6	195.8	191.2	198.6	194.6	191.2	188.3	195.1	196.9	186.9
90% RL @10 m (dB re 1 µPa)	203.4	191.0	193.3	193.6	197.0	193.7	201.0	196.2	194.7	191.8	197.0	197.8	188.1
Mean Range to 190 dB re 1 µPa (m)	42	<10	13	13	22	12	32	21	15	<10	22	31	<10
Median Range to 190 dB re 1 µPa (m)	41	<10	13	13	21	11	31	19	12	<10	22	31	<10
90% Range to 190 dB re 1 µPa (m)	50	12	18	17	25	15	43	25	20	13	30	36	<10
Mean Range to 180 dB re 1 µPa (m)	138	44	74	50	80	38	119	81	61	35	105	162	34
Median Range to 180 dB re 1 µPa (m)	137	42	74	50	78	35	116	72	52	32	104	162	34
90% Range to 180 dB re 1 µPa (m)	166	66	106	66	91	46	159	93	84	52	139	188	41
Mean Range to 160 dB re 1 µPa (m)	1523	1375	2570*	803	1081	354	1654	997*	1011	578	2316	4341*	1119
Median Range to 160 dB re 1 µPa (m)	1504	1306	2570*	803	1053	327	1611	971	864	532	2280	4341*	1100
90% Range to 160 dB re 1 µPa (m)	1823	2042	3663*	1059	1231	432	2209	1200*	1425*	869	3058*	5034*	1356

*Extrapolated beyond maximum measured range.

** Anomalous result due to sound attenuation by land shielding.

^ Pile IP6 had a bearing plate installed.

3.4.2. Vibratory Pile Driving

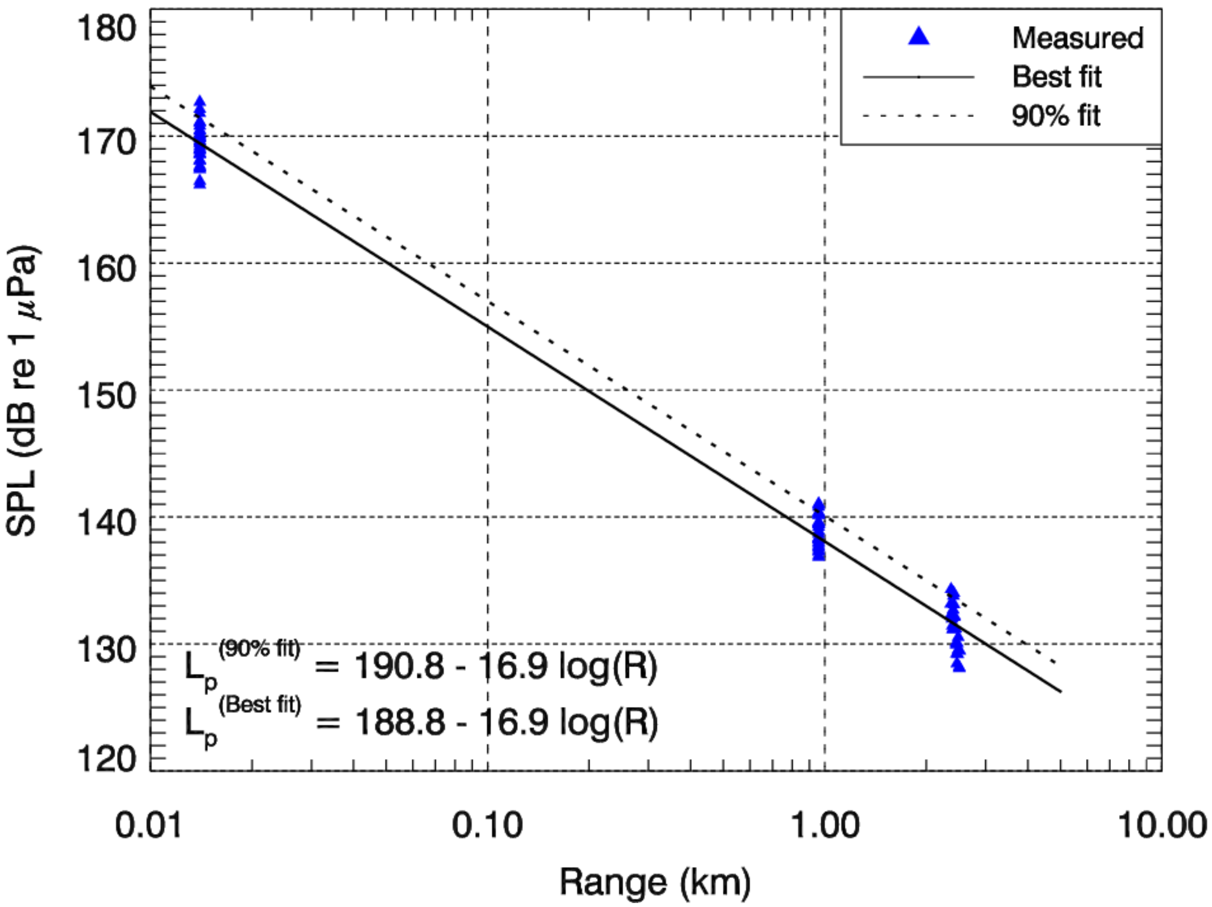


Figure 77. Pile IP1: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

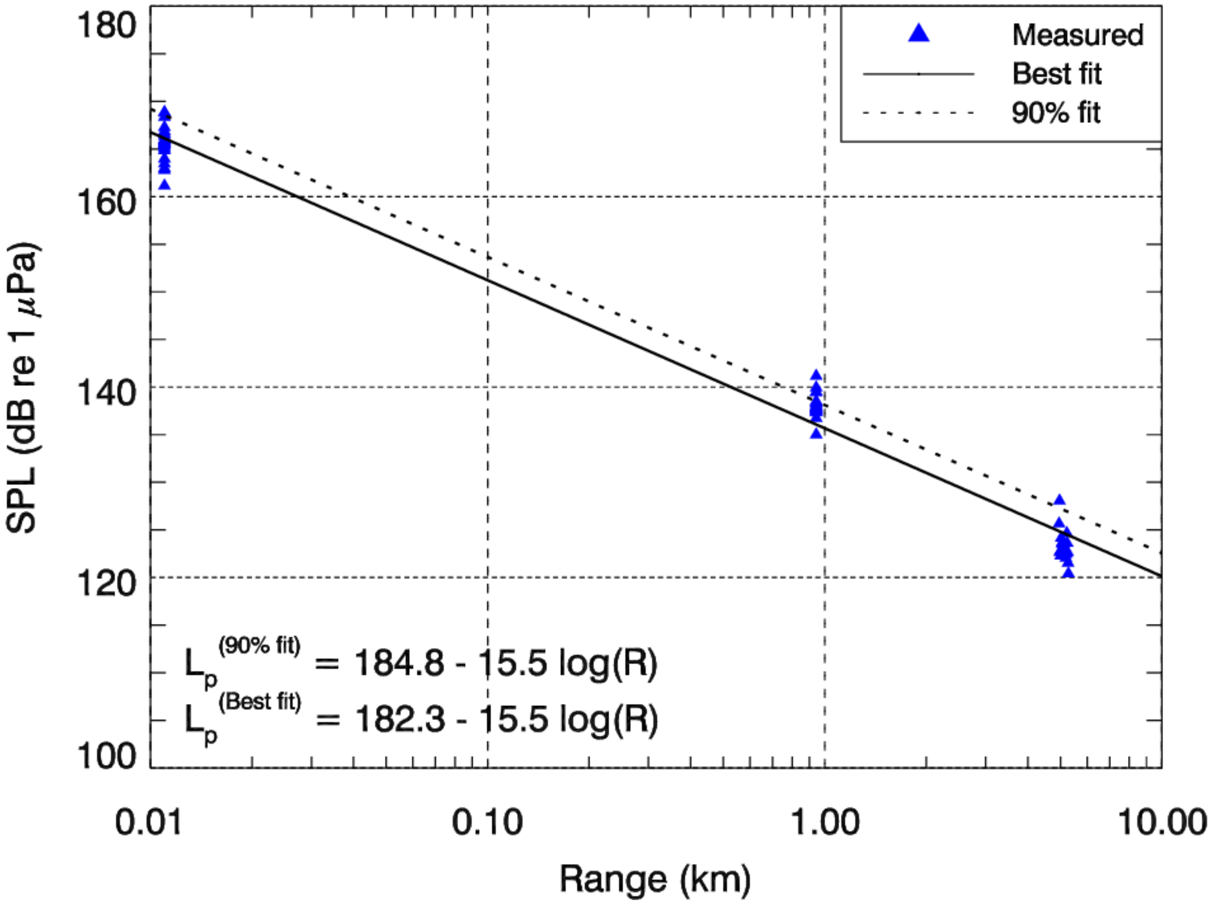


Figure 78. Pile IP2: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

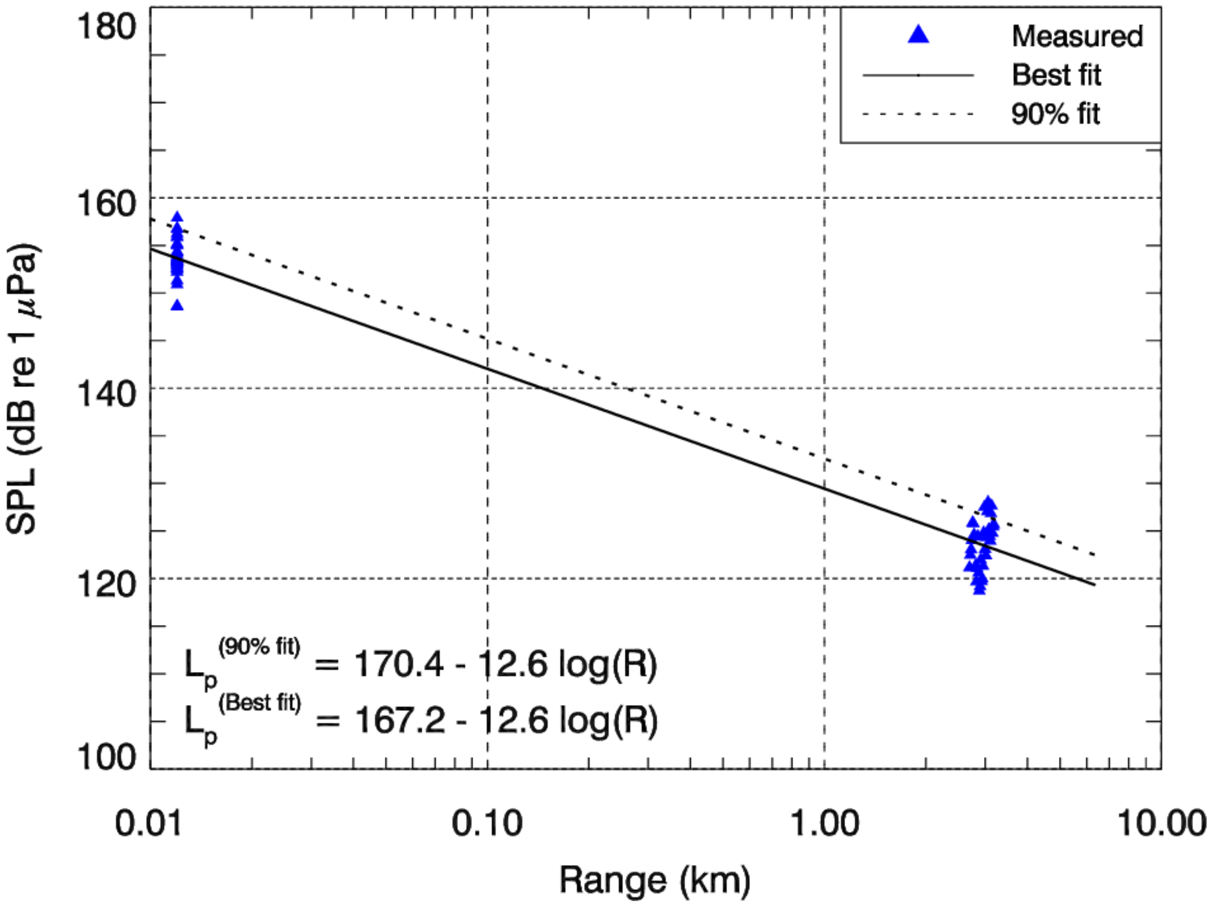


Figure 79. Pile IP3: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th measured levels. Levels included in this plot are from strikes that were recorded simultaneously on AMAR-10M and the drifting system. Data from AMAR-1KM were excluded from this plot because they were artificially elevated by noise from dredging at the north end of the Port that occurred during pile driving.

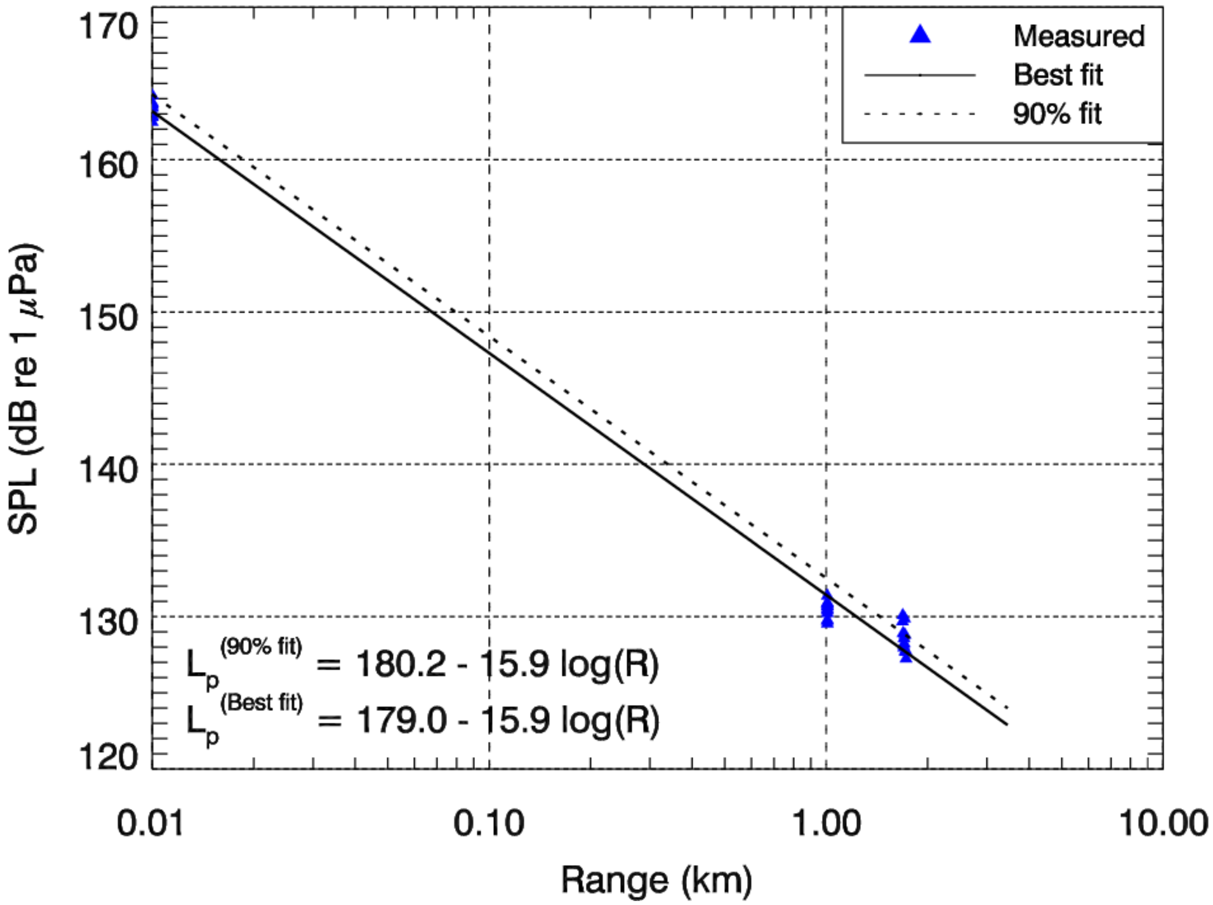


Figure 80. Pile IP4: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

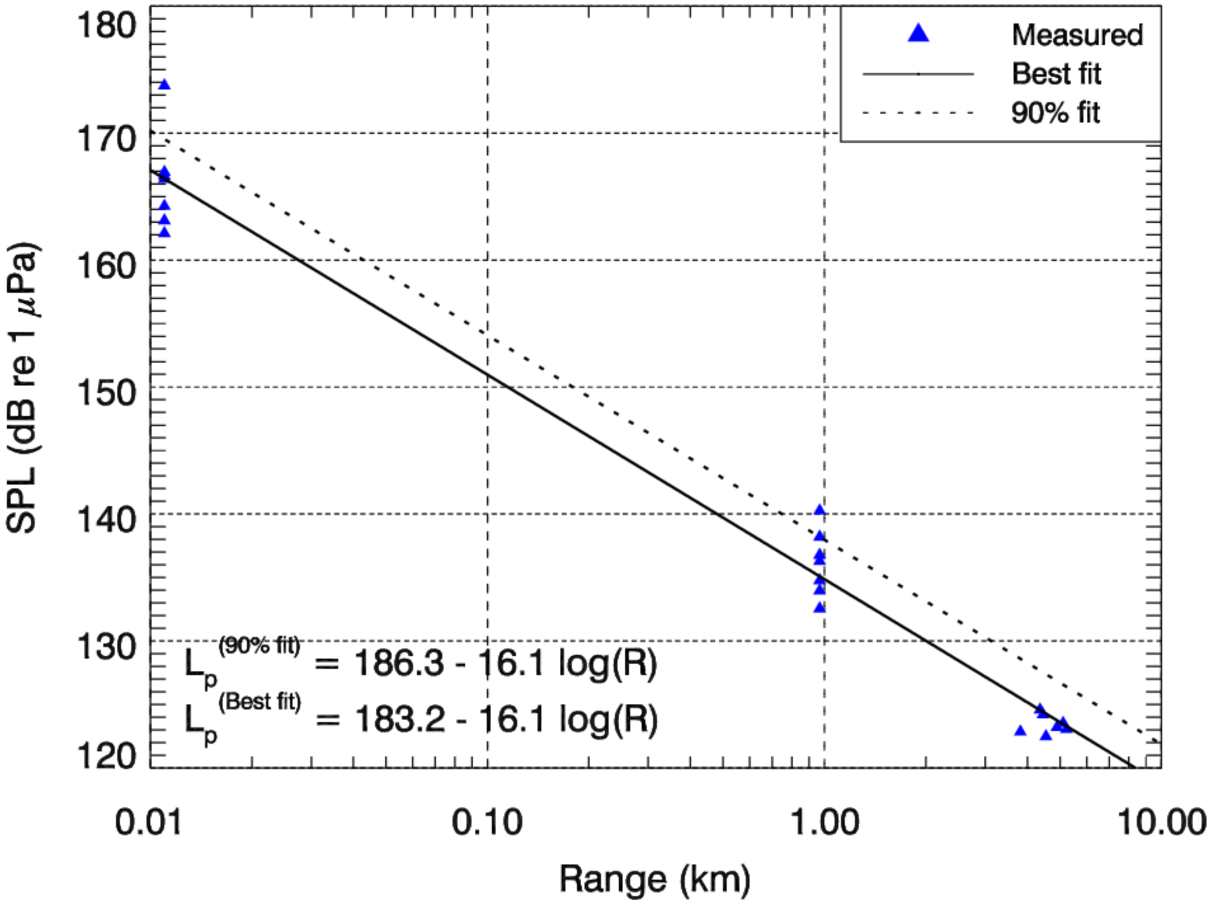


Figure 81. Pile IP5: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

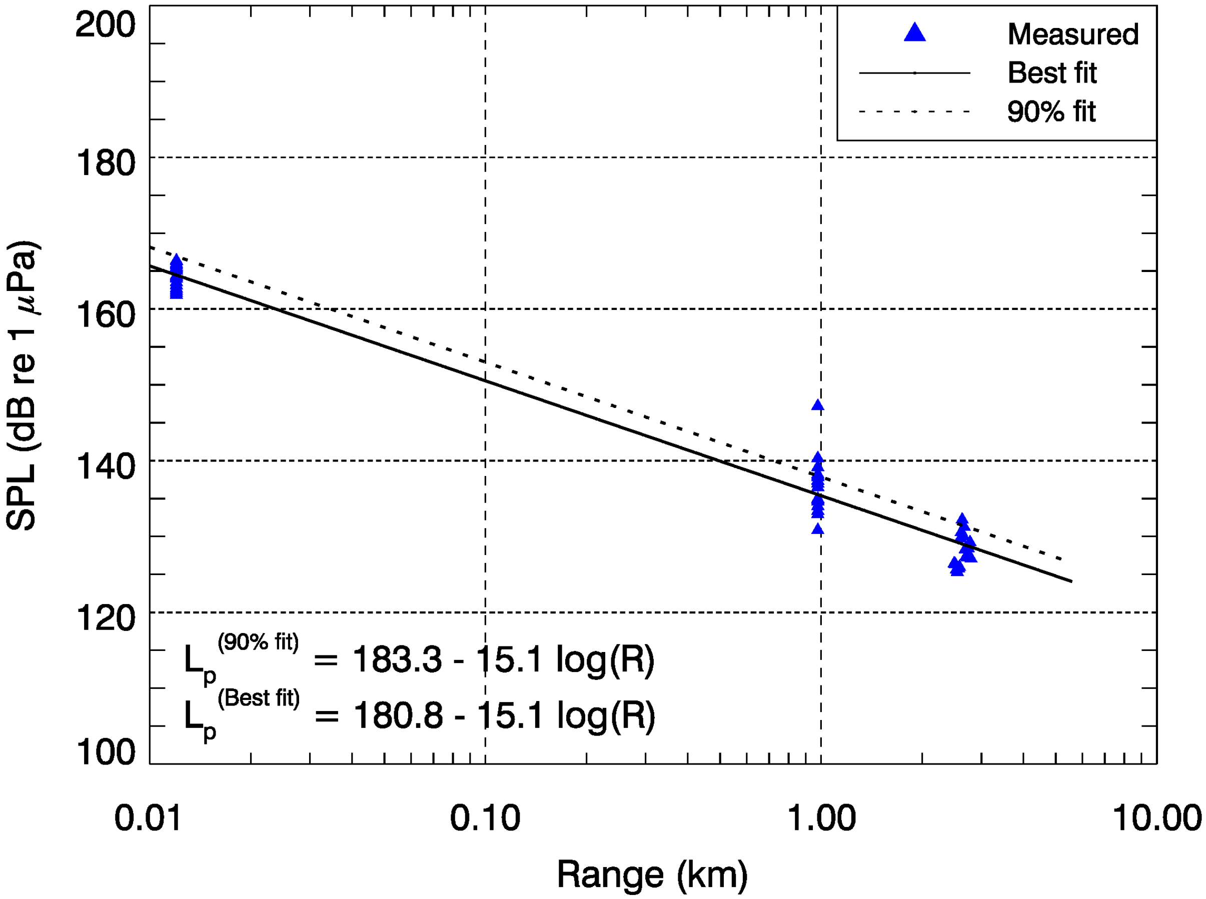


Figure 82 Pile IP6a: Plot of rms SPL versus range for vibratory driving before 07:18 AKDT, when vibratory sound levels were elevated. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

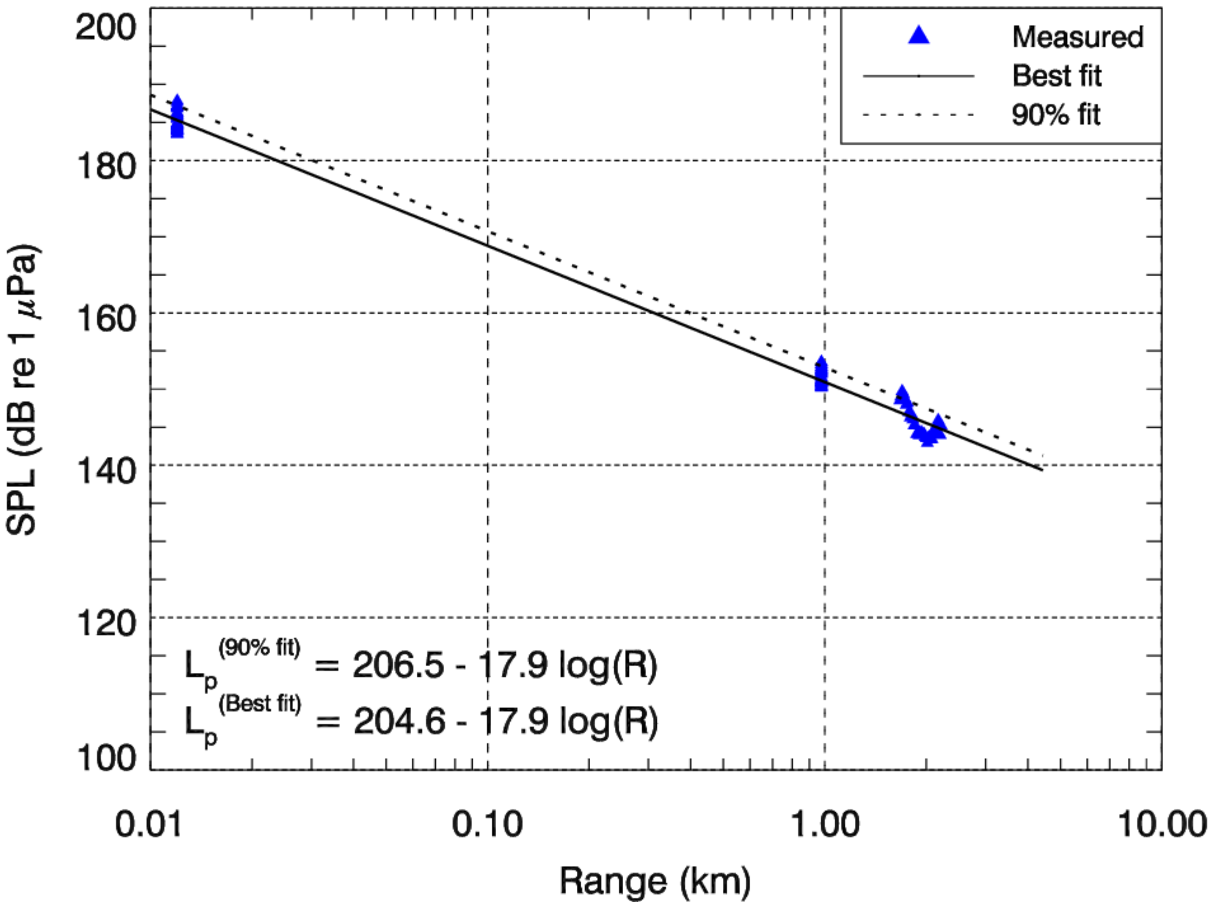


Figure 83. Pile IP6b: Plot of rms SPL versus range for vibratory driving after 07:18 AKDT, when vibratory sound levels were elevated. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

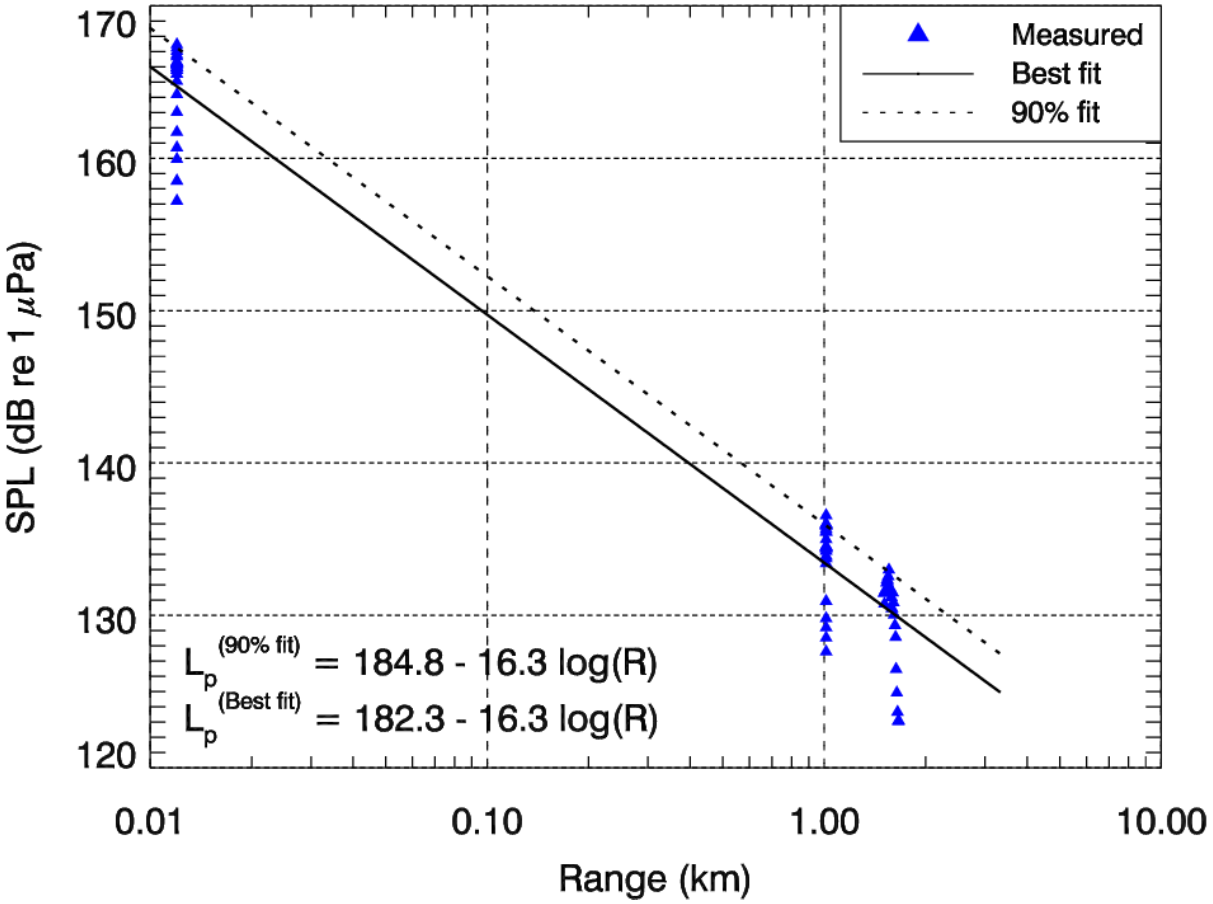


Figure 84. Pile IP7: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

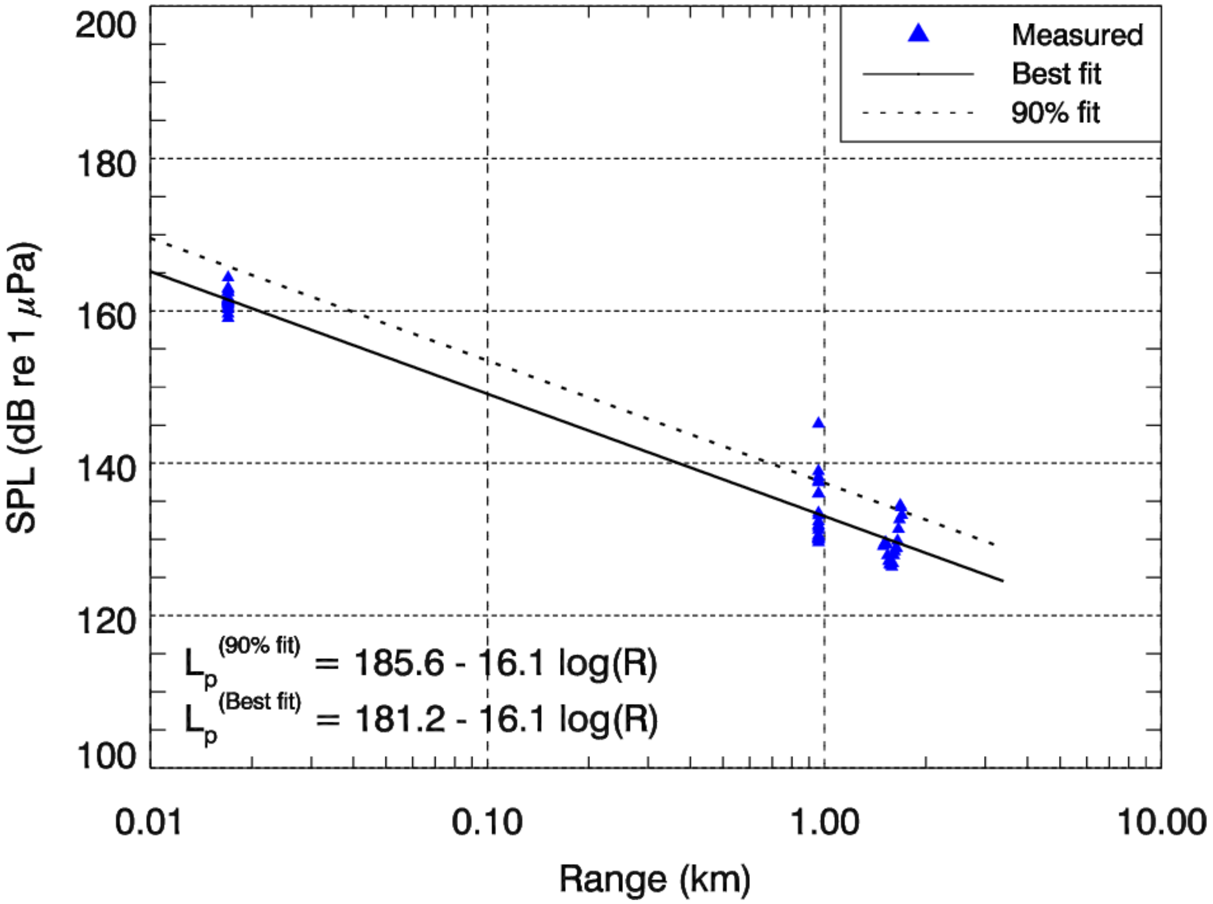


Figure 85. Pile IP8: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

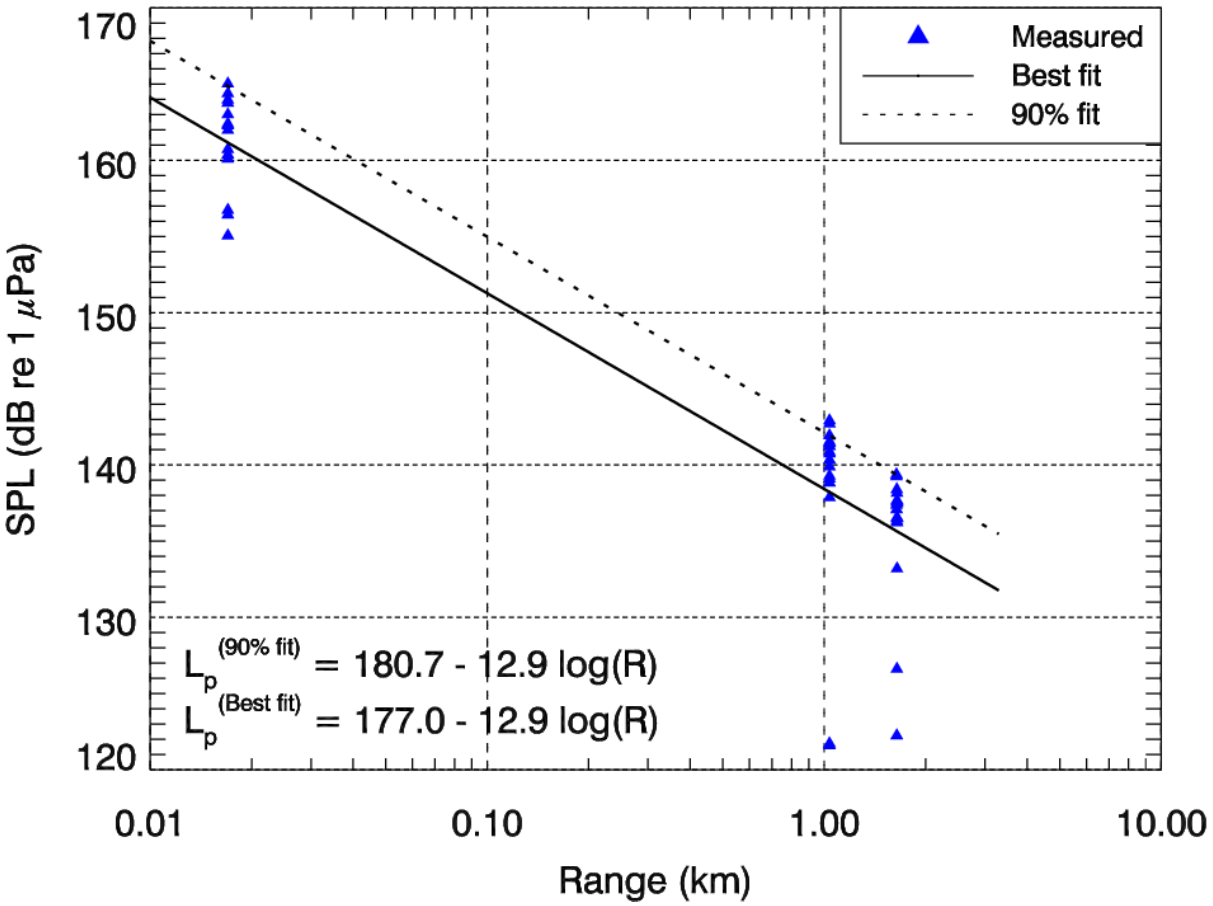


Figure 86. Pile IP9: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

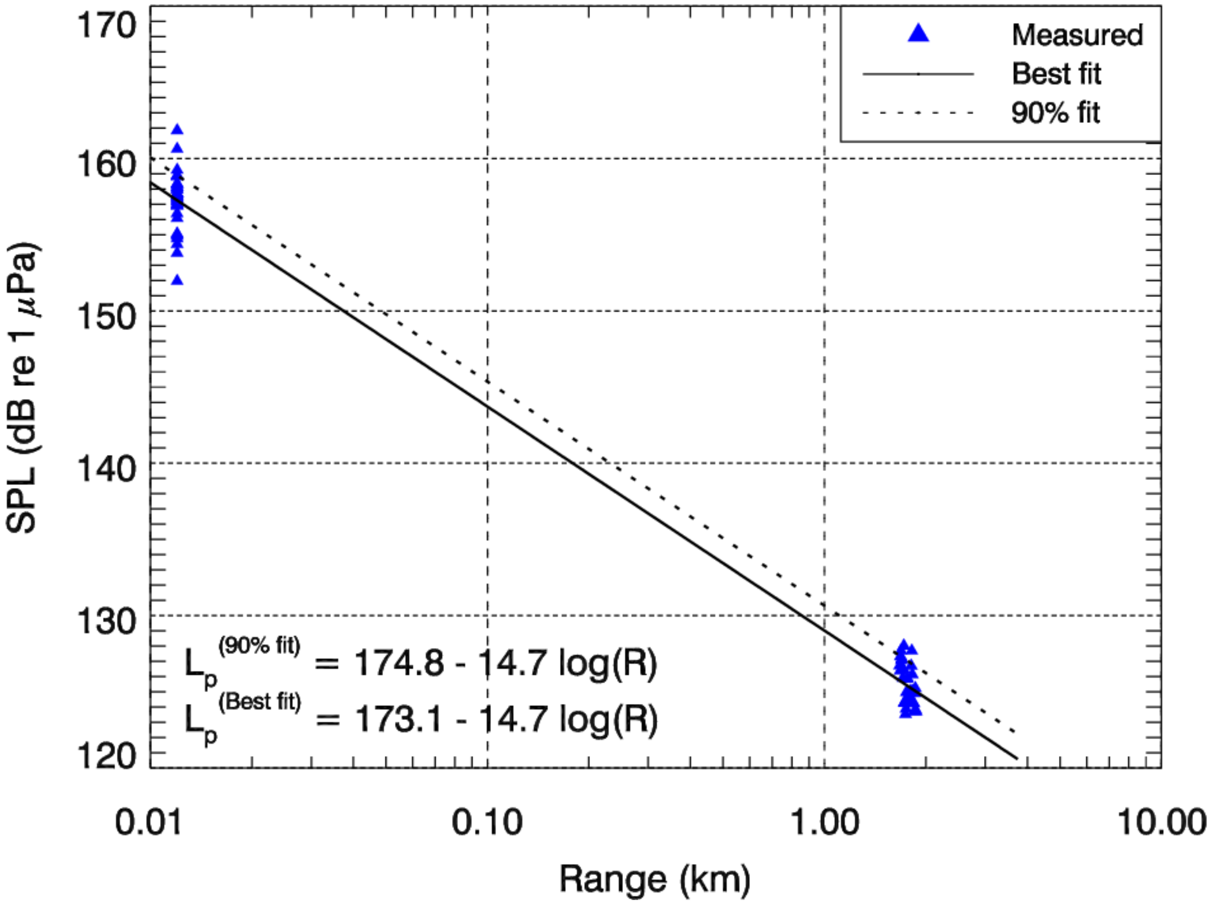


Figure 87. Pile IP10: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th measured levels. Levels included in this plot are from strikes that were recorded simultaneously on AMAR-10M and the drifting system. Data from AMAR-1KM were excluded from this plot.

Table 13. Distance to rms SPL thresholds for vibratory pile driving determined from best-fit transmission loss coefficient and SPLs on AMAR-10M (mean, median, and 90th percentile. NAS method: U=Un-attenuated, R=Passive Resonator, B=Bubble curtain; Location is indicated by the final number.

	IP1 U; 5	IP2 R; 4	IP3 B; 1	IP4 R; 1	IP5 U; 4	IP6a^ B; 4	IP6b^ B; 4	IP7 B; 5	IP8 R; 6	IP9 R; 6	IP10 B; 6
TL Coefficient	16.9	15.5	12.6	15.9	16.1	15.1	17.9	16.3	16.1	12.9	14.7
Mean SL (dB re 1μPa)	187.4	179.3	170.7	179.3	186.1	180.0	203.1	178.8	186.3	174.9	173.9
Median SL (dB re 1μPa)	185.7	177.4	168.3	176.0	183.6	179.2	203.2	176.5	182.4	167.2	172.8
90% SL (dB re 1μPa)	191.2	182.4	174.9	184.3	189.7	183.2	205.9	183.5	191.0	180.8	177.1
Mean RL @ 10 m (dB re 1μPa)	170.5	163.8	158.1	163.4	170.0	164.9	185.2	162.5	170.2	162.0	159.2
Median RL @10 m (dB re 1μPa)	168.8	161.9	155.7	160.1	167.5	164.1	185.3	160.2	166.3	154.3	158.1
90% RL @10 m (dB re 1 μPa)	174.3	166.9	162.3	168.4	173.6	168.1	188.0	167.2	174.9	167.9	162.4
Mean Range to 125 dB re 1 μPa (m)	4904*	3206	4234*	2601*	6208*	4386*	23126*	1995*	6428*	7347*	2109*
Median Range to 125 dB re 1 μPa (m)	3890*	2417	2731	1613	4342	3883*	23425*	1442	3680*	1859*	1775
90% Range to 125 dB re 1 μPa (m)	8229*	5081	9123*	5365*	10388*	7145*	33153*	3876*	12590*	21061*	3481*
Mean Range to 120 dB re 1 μPa (m)	9691*	6737*	10559*	5365*	12691*	9402*	43997*	4044*	13142*	17935*	4615*
Median Range to 120 dB re 1 μPa (m)	7687*	5081*	6810*	3327*	8876*	8322*	44567*	2922*	7523*	4537*	3885*
90% Range to 120 dB re 1 μPa (m)	16264*	10678*	22749*	11067*	21238*	15316*	63074*	7855*	25738*	51413*	7619*

*Extrapolated beyond maximum measurement range.

^ Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT.

3.5. Ambient Data

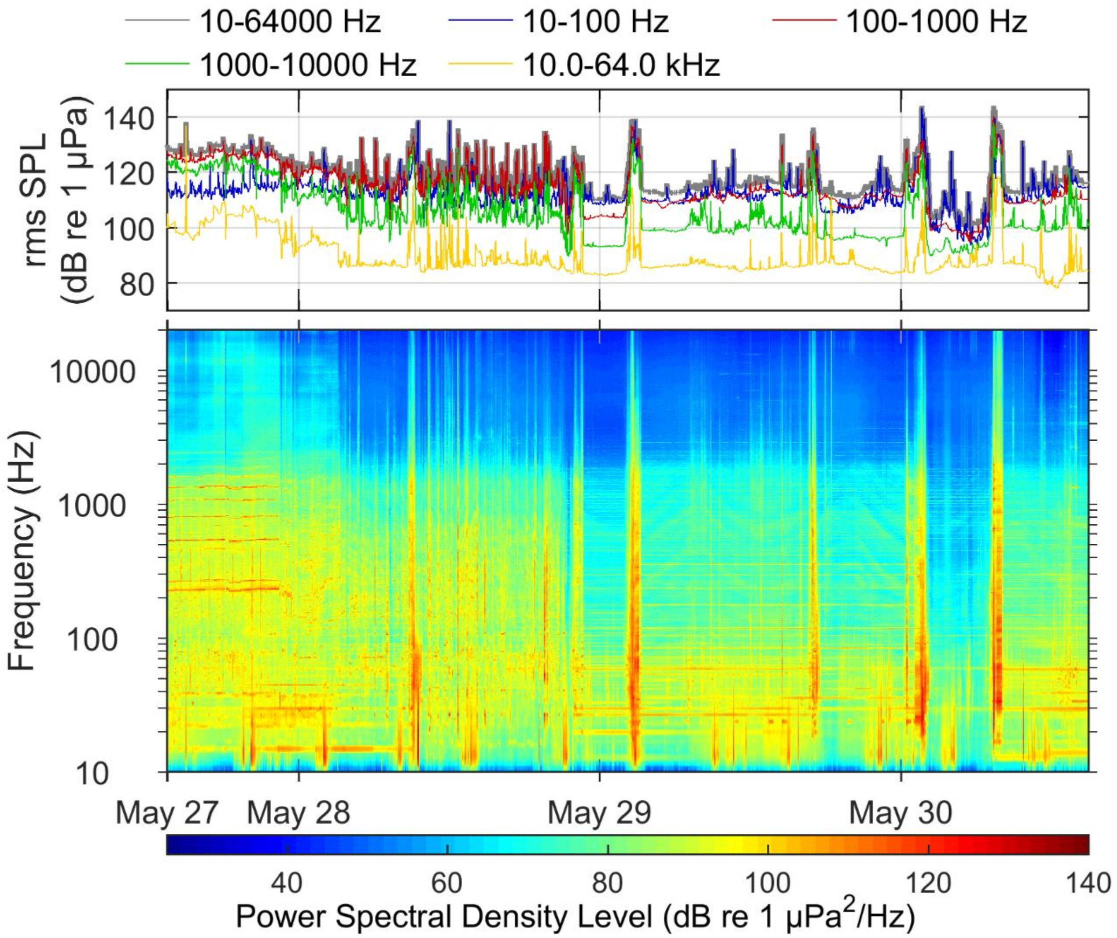


Figure 88. Background sound levels recorded May 27—May 30 at a location within the Port of Anchorage (Ambient-Dock).

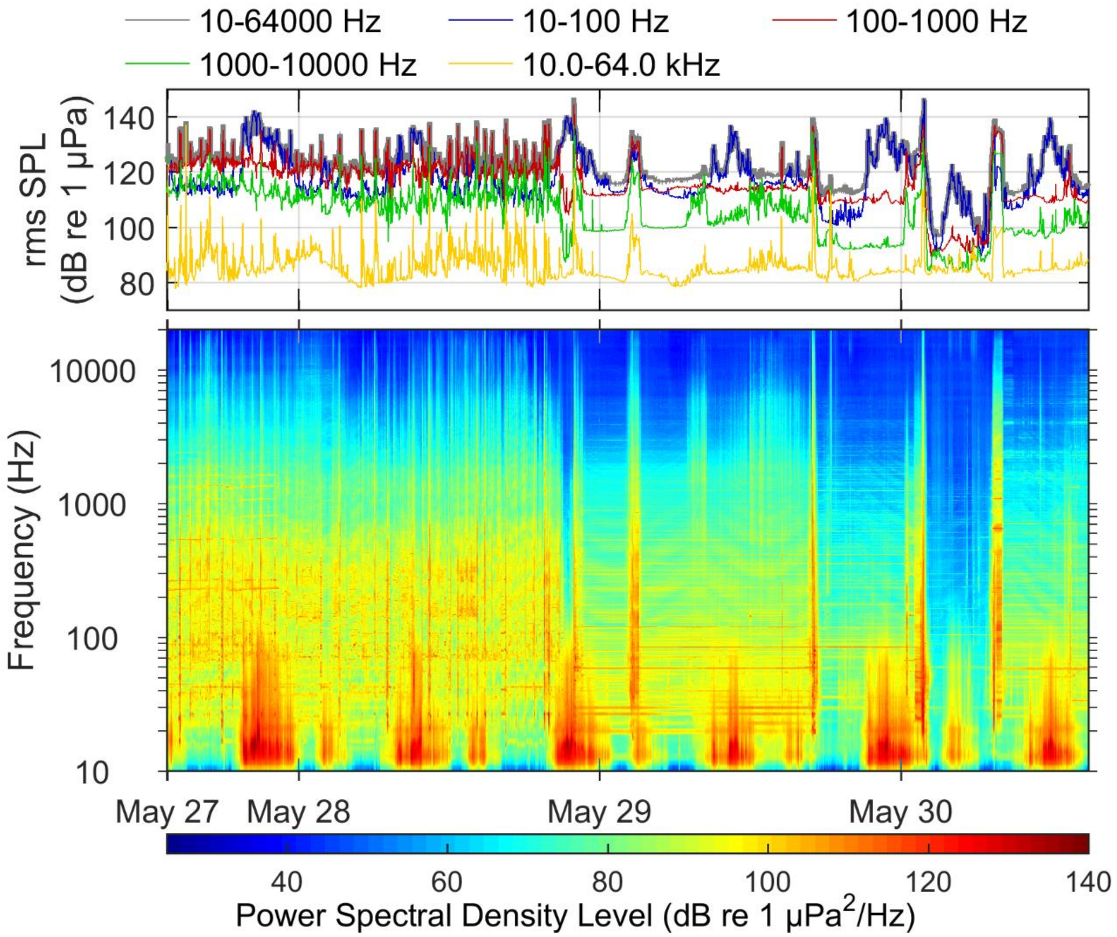


Figure 89. Background sound levels recorded May 27–May 30 at a location within Cook Inlet (Ambient-Offshore).

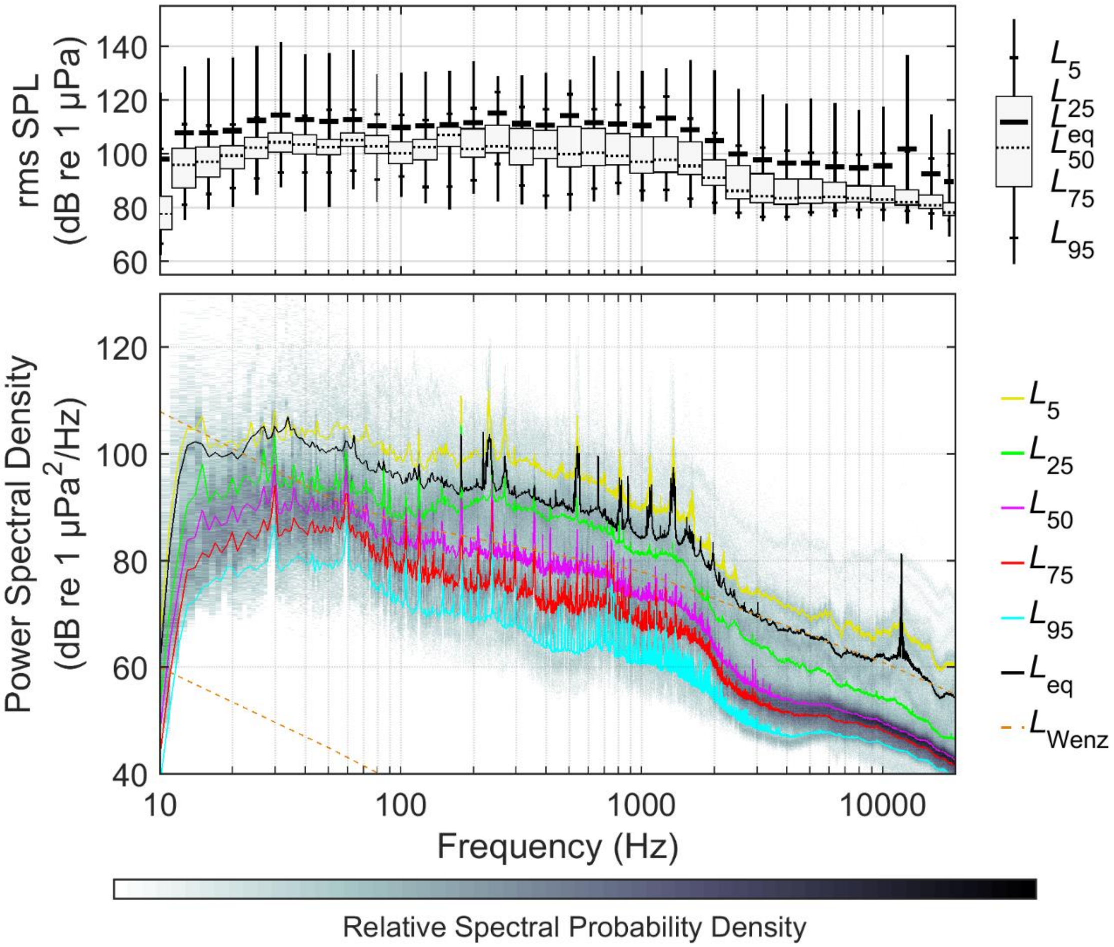


Figure 90. Exceedance levels (5th, 25th, 50th, 75th, and 95th percentiles and L_{eq}) for ambient sound levels recorded May 27–May 30 at a location within the Port of Anchorage (Ambient-Dock).

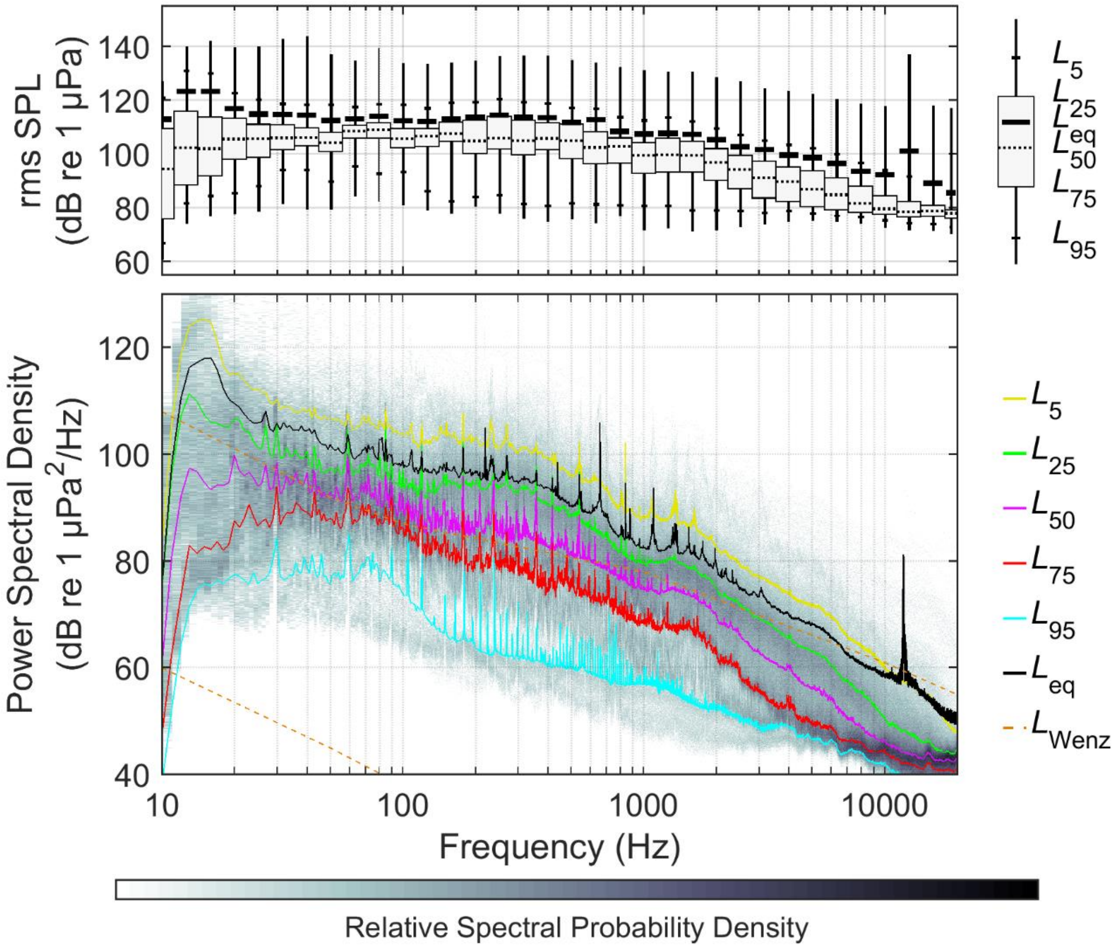


Figure 91. Exceedance levels for ambient sound levels recorded May 27–May 30 at a location within Cook Inlet (Ambient-Offshore).

Table 14. Exceedance levels of broadband background noise levels measured in Cook Inlet, Alaska (60 s average). The *L*n value is the SPL exceeded by n% of the data. For a location within the Port of Anchorage (Ambient-Dock). Exceedance levels are expressed in terms of un-weighted (Unw) and frequency-weighted data, according to the filters in Appendix E for the following species groups: LFC = low-frequency cetacean, MFC = mid-frequency cetacean, HFC=high-frequency cetacean and PPW=pinnipeds in water.

Exceedance level	**SPL (dB re 1 µPa)**				
	Unw	LFC	MFC	HFC	PPW
L_{max}	164.7	166.2	151.0	150.7	151.7
L_5	132.5	132.5	129.6	128.9	130.6
L_{25}	124.0	124.1	120.5	119.6	122.0
L_{50} (median)	117.0	117.2	111.9	110.9	113.9
L_{75}	113.7	113.9	108.5	107.3	110.7
L_{95}	106.8	107.3	100.0	98.9	101.9
L_{mean}	138.8	139.9	125.2	124.2	128.3

Table 15. Exceedance levels of broadband background noise levels measured in Cook Inlet, Alaska (60 s average). The *L*n value is the SPL exceeded by n% of the data. For a location in Cook Inlet (Ambient-Offshore). Exceedance levels are expressed in terms of un-weighted (Unw) and frequency-weighted data, according to the filters in Appendix E for the following species groups: LFC = low-frequency cetacean, MFC = mid-frequency cetacean, HFC=high-frequency cetacean and PPW=pinnipeds in water.

Exceedance level	**SPL (dB re 1 µPa)**				
	Unw	**LFC**	**MFC**	**HFC**	**PPW**
L_{max}	159.1	160.0	151.6	151.4	152.5
L_5	136.1	136.6	129.3	128.1	131.8
L_{25}	126.8	127.2	121.2	120.2	123.1
L_{50} (median)	122.2	122.5	115.4	114.6	117.3
L_{75}	118.0	118.2	110.6	109.3	113.1
L_{95}	110.1	111.1	95.4	94.5	99.3
L_{mean}	136.0	136.9	125.2	124.1	127.8

4. Discussion and Conclusion

This section summarizes and discusses the key results in light of each objective for the hydroacoustic monitoring program.

4.1. Pile Driving Sound Level Measurements

High-quality underwater sound pressure levels were successfully recorded during vibratory and impact pile driving of all ten indicator piles during the Test Pile Program. During vibratory pile driving, underwater sound levels fluctuated due to the dynamic nature of the activity. Sound level fluctuations occurred as the pile moved through different sediment layers with variable resistance, as the pile was extracted and reinserted to ensure vertical installation, and occasionally when the pile rattled against the hammer or pile template. During impact pile driving, peak sound levels were very consistent compared to the vibratory levels, but some fluctuations were also noted when impact pile driving began and the hammer 'warmed up'. The diesel impact hammer in particular experienced occasional misfires at the beginning stages, which was noted in the sound pressure level time history.

Given the experimental nature of the study, there is some inherent variability in the data from factors such as the current flow (affecting the data signal to noise ratio and potentially impacting the effectiveness of the noise attenuation systems) and tidal stage (affecting the water depth), directivity effects due to directional differences of sound propagation characteristics, directivity effects due to the placement of the pile derrick barge relative to the sound receivers, and source variability. These factors could not always be controlled. A few data anomalies were noted, described in the text that follows, and these were excluded from analyses where they lead to misleading or non-precautionary interpretation of the results.

Dredging activities were ongoing at the Port during the Test Pile Program. At most times the dredge was sufficiently separated from the acoustic recorders that its noise did not interfere with the recordings of pile driving sounds. However, dredging noise did dominate the recordings at AMAR-1KM during vibratory hammer installation of Pile IP3 at Location 1 (Figure 48 and Figure 49). The levels from AMAR-1KM were thus excluded from the TL regression for vibratory piling of Pile IP3 (Figure 79) since they were not representative of the pile driving sounds.

Pile driving impulses received at AMAR-1KM during hydraulic hammer impact installation of pile IP3 were reduced in amplitude compared to measurements at AMAR-1KM for the other piles. It is possible that this a directional propagation effect since the position of AMAR-1KM for IP3 was inside the dredge disposal zone where newly deposited sediments in the dredge disposal area could have resulted in increased sound attenuation or shielding by a pile of disposed sediment. The dredge was active in the area at this time and dumped sediments in the dredge disposal area (within a few hundred meters of AMAR-1KM) immediately prior to this measurement. This was the only time that AMAR-1KM was placed in the dredge disposal area. The IP3 impulses received at AMAR-1KM were lower in amplitude and of longer duration compared to the same impulses received at AMAR-DRIFT at a similar, though slightly further, range from IP3 (Figure 92). Following the hypothesis that a sound propagation directivity effect causes this difference in levels, two separate TL regressions were conducted for impact pile driving of IP3; the first using data from AMAR-10M and AMAR-DRIFT and the second using data from AMAR-10M and AMAR-1KM (Figure 66 and Figure 67). The TL coefficient for the propagation toward AMAR-DRIFT, generally to the south of IP3, was 13; it was 16.6 for the propagation path to AMAR-1KM inside the dredge disposal area. A regression of received level versus range including data recorded simultaneously on all three recorders yielded a poor fit to the data, with a TL coefficient of 14.4 (Figure 93).

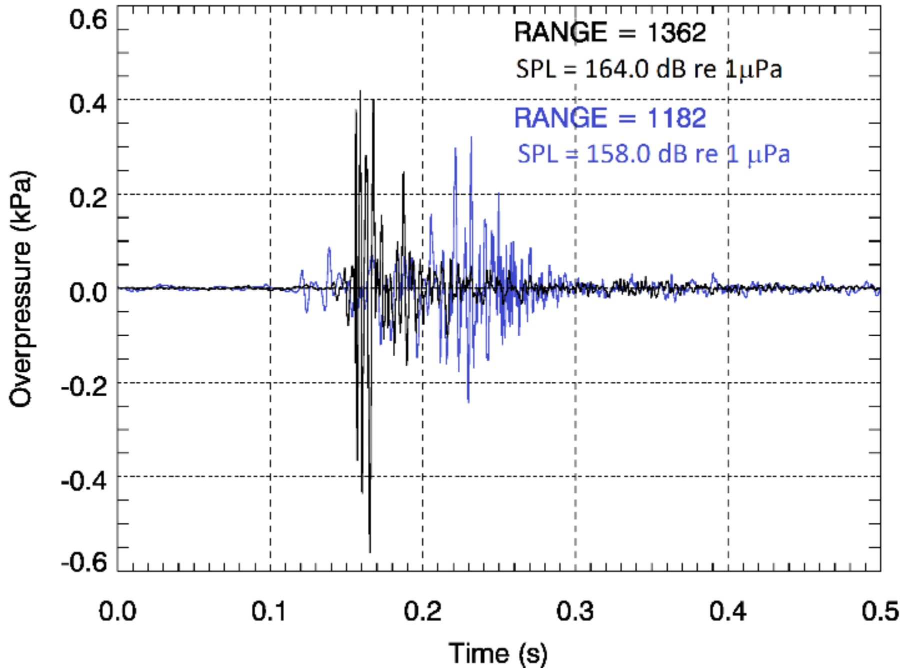


Figure 92 IP3: Waveform for a single hydraulic impact hammer impulse received at AMAR-1KM (blue) and AMAR-DRIFT (black).

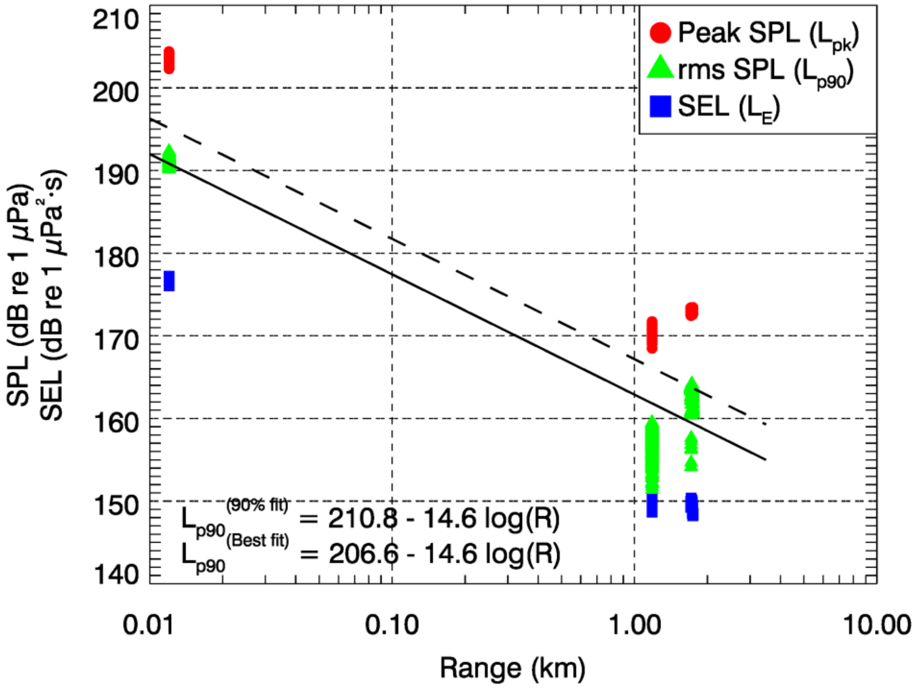


Figure 93 Pile IP3: Plot of peak SPL, rms SPL, and SEL versus range for diesel impact driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th percent measured levels. Levels included in this plot are from data that were recorded simultaneously on both AMARs and the drifting system.

Underwater sound levels recorded 1008 m from Pile IP4 at Location 1 were also strongly attenuated in comparison to levels recorded on AMAR-1KM for the other piles. This was due to the placement of AMAR-1KM for IP4, which was unintentionally shielded from the pile by an outcropping of the shoreline (Figure B-7); sound recorded on AMAR-1KM for Pile IP4 was attenuated by ground propagation. This land-shielding propagation effect also impacted the data collected on AMAR-DRIFT during diesel impact hammer installation of IP4, but drifts during hydraulic impact hammer and vibratory installation were further south and did not experience this attenuation effect. These drift data could therefore not be combined with the AMAR-1KM data for the TL regressions. As a result, the AMAR-1KM data were excluded from the TL regression for hydraulic impact hammer and vibratory hammer installation of IP4 (Figure 68 and Figure 80). Data from both AMAR-1KM and AMAR-DRIFT were used in the TL regression for diesel impact hammer installation of IP4 since both recorders were north of the land-shadow boundary, thus experienced the same propagation effects. The resulting TL coefficient for IP4 diesel impact hammer installation is only valid north of the land-shadow boundary for Location 1 and is not representative for sound that propagates directly through the water. It is not believed that this land-shadow effect attenuated the impact hammer pile driving levels discussed above for IP3 (also at Location 1) because AMAR-1KM was not placed within the land-shadow boundary for IP3 (Figure B-5).

Pile IP6 was the only indicator pile which had a bearing plate installed inside the pile. The presence of the bearing plate did not result in underwater sound levels that differed significantly from those generated by any of the other piles, considering the variability among piles. The median near-source level for diesel hammer installation of Pile IP6 with bubble curtain attenuation was approximately 3 dB greater than the median near-source level for diesel hammer installation of Pile IP7 with bubble curtain attenuation but no bearing plate. This is no greater than the variability between the median near-source levels for two piles without bearing plates. Namely, hydraulic impact hammer installation with bubble curtain attenuation of Piles IP3 and IP10, which differed by 4 dB. Furthermore, the pulse waveforms, spectral density curves, and spectrograms for IP6 resembled those of similar piles that did not have a bearing plate.

Pile IP6 was also unique in the type of noise attenuation methodology used. The confined bubble curtain was installed for IP6 but, unlike any other piles, air flow to the bubble curtain was turned on and off throughout piling. During vibratory pile driving the bubble curtain air flow was reduced by 50% for the final 15 minutes of operation and during the last stages of impact pile driving the bubble curtain was turned on and off at 10 min intervals. This is evident in the sound pressure level time history for impact pile driving, particularly for recordings at AMAR-10M (Figure 31). Impact hammer data for IP6 were split between times when the bubble curtain was On and Off and the two data sets were treated separately when computing TL regressions and summary statistics. The median received rms SPL at AMAR-10M when the bubble curtain was on was 3 dB less than that received when the bubble curtain was off. The vibratory pile driving data for IP6 was treated as a single representation of bubble curtain-attenuated pile driving. Although sound levels at the end of the vibratory pile driving record for IP6 did increase, this is believed to be unrelated to the bubble curtain. JASCO scientists on the acoustic monitoring vessel noted increased sound levels both underwater and in the air during this time, believed to be from vibration of the pile against the template or bubble curtain sheath. Air flow to the bubble curtain was reduced at 07:15 but the dramatic increase of sound levels occurred three minutes later. The data received after 07:18 were processed separately from the rest of the vibratory data for pile IP6. The median received level at 10m range was 164.0 dB re 1 µPa prior to 07:18 and it was 185.3 dB re 1 µPa after 07:18, a level that far exceeded any of the other recorded vibratory sounds. The reason for this 20 dB increase of sound levels at the end of vibratory installation of IP6 is unknown.

The final pile with anomalous results requiring discussion is data from AMAR-1KM for Pile IP10. The levels at AMAR-1KM were elevated relative to the AMAR-1KM measurements of the other piles and relative to the trend of the levels between AMAR-10M and AMAR-DRIFT for the same pile. A regression of the vibratory pile driving received sound level versus range, including data from AMAR-10M and AMAR-1KM, yielded a TL coefficient of only 8.7 (Figure 94, left), which is less sound attenuation compared to that for other piles over similar distances. A regression plot including data from all three recorders yielded a TL coefficient of only 11.8 for vibratory pile driving and did not fit the data well (Figure 94, right). The AMAR-10M data were consistent with bubble curtain attenuated levels for other piles (within expected variability) so the shallow slope of the TL curve is not expected to be due to an issue with the levels at AMAR-10M. Background sound levels recorded between impulses on AMAR-1KM were comparable to those recorded for other piles, indicating that this is also not an issue relating to recorder calibration or sensitivity. The AMAR-1KM data were deemed anomalous in this case and were excluded from the final TL coefficient regressions for this reason (Figure 76 and Figure 87). This resulted in TL coefficient values for pile IP10 that were consistent with those for similar piles (Section 4.4, Figure 101).

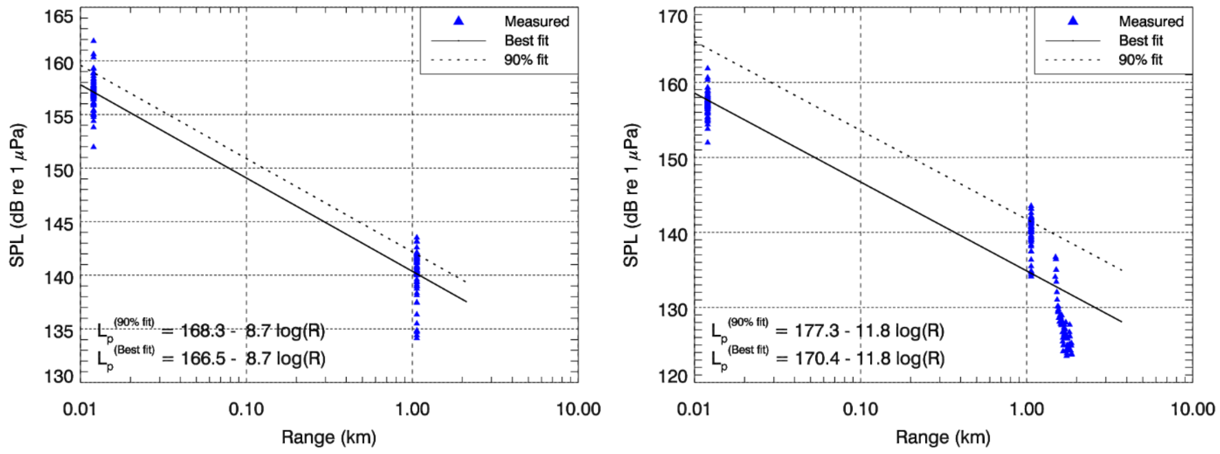


Figure 94 Pile IP10: Plot of rms SPL versus range for vibratory driving. The solid line shows best-fit transmission loss curve to rms SPL data. The dashed line is the best-fit curve shifted up to the 90th measured levels. Levels included in the left plot were recorded on AMAR-10M and AMAR-1KM, those in the plot on the right are from data recorded simultaneously on all three recording systems.

4.2. Underwater Ambient Noise Measurements

The unweighted, median ambient sound level was 117 dB re 1 µPa at the Ambient-Dock location and it was 122 dB re 1 µPa at the Ambient-Offshore location. Mean ambient levels were higher (138 and 136 dB re 1 µPa at the Ambient-Dock and Ambient-Offshore locations, respectively) owing to a few shorter-duration and higher-amplitude sound events that might not represent nominal ambient conditions.

During the first day of ambient recordings, high sound levels with tonal structure were attributed to dredging noise at the north end of the Port. There were also periodic bursts of elevated sound levels at frequencies between 10 Hz and 100 Hz at Ambient-Dock likely caused by flow noise or system noise generated during maximum current flow. The few brief peaks of broadband, high amplitude sounds noted concurrently on each AMAR might be attributable to tug activities associated with the arrival of the cruise ship or other normal vessel activities at the Port. The dominant sound sources, dredging and tug activities, occur throughout the recording. There was no diurnal trend in the ambient sound environment.

4.3. Near-Source Levels

Computed median received sound levels at 10 m range (broadband, rms SPL) will be referred to here as ‘near-source levels’. Near-source levels varied between 187 and 202 dB re 1 µPa for impact pile driving, depending on whether the hammer used was hydraulic or diesel and on the noise attenuating system (NAS) application. Median near-source levels for vibratory pile driving also depended on NAS application and ranged between 155 and 169 dB re 1 µPa (Figure 95).

Un-attenuated piles were driven using the hydraulic (IP1) and diesel (IP5) impact hammers, in addition to which there were times during diesel impact hammer installation of IP6 when the bubble curtain was turned off. These data served as controls against which the NAS effectiveness could be compared. Correspondingly, there were two un-attenuated vibratory pile driving data points as controls (IP1 and IP5). Un-attenuated, diesel impact hammer, near-source levels for IP5 were 4 dB greater than those for IP6 with the bubble curtain off, which may indicate that some bubbles were still escaping from the bubble curtain when it was deemed to be ‘off’ during installation of pile IP6 and that may not have been truly representative of un-attenuated levels. The un-attenuated near-source level for the hydraulic impact hammer was 3.2 dB greater than that for the truly un-attenuated diesel impact hammer and 7.2 dB greater than the diesel impact hammer for IP6 when the bubble curtain was deemed to be turned off.

For all hammer types, near-source levels were consistently lower with a NAS applied compared to the un-attenuated levels. The single exception to this is the vibratory pile driving event for IP6 that yielded near-source levels that exceeded all other vibratory results by 20 dB; that data point is excluded from the discussion that follows. For the hydraulic impact hammer, near-source levels decreased by 6.0 to 6.7 dB when the passive resonator was applied and by 10.2 to 14.9 dB using the air bubble curtain. The near-source levels for the diesel impact hammer decreased by 1.7 to 10.3 dB with the passive resonator and by 7.4 and 10.3 dB with the bubble curtain, comparing against truly un-attenuated levels from IP5. The confined bubble curtain NAS decreased near-source levels by only 3.4 and 6.3 dB compared against levels for IP6 when the bubble curtain was turned off; this is further indication that not all bubbles were completely eliminated when the bubble curtain was turned off intermittently during installation of IP6. Near-source levels for the vibratory hammer decreased by between 1.2 and 14.5 dB with the passive resonator and between 3.4 and 13.1 dB with the bubble curtain. Thus, the bubble curtain NAS consistently provided more attenuation of the near-source levels than the passive resonator NAS did for the hydraulic impact hammer, though the two NAS performed similarly for near-source level attenuation of the diesel impact and vibratory hammers. For the diesel impact hammer and the vibratory hammer, the achieved attenuation was more variable for the passive resonator system compared to the bubble curtain system, though the opposite was true for the hydraulic impact hammer.

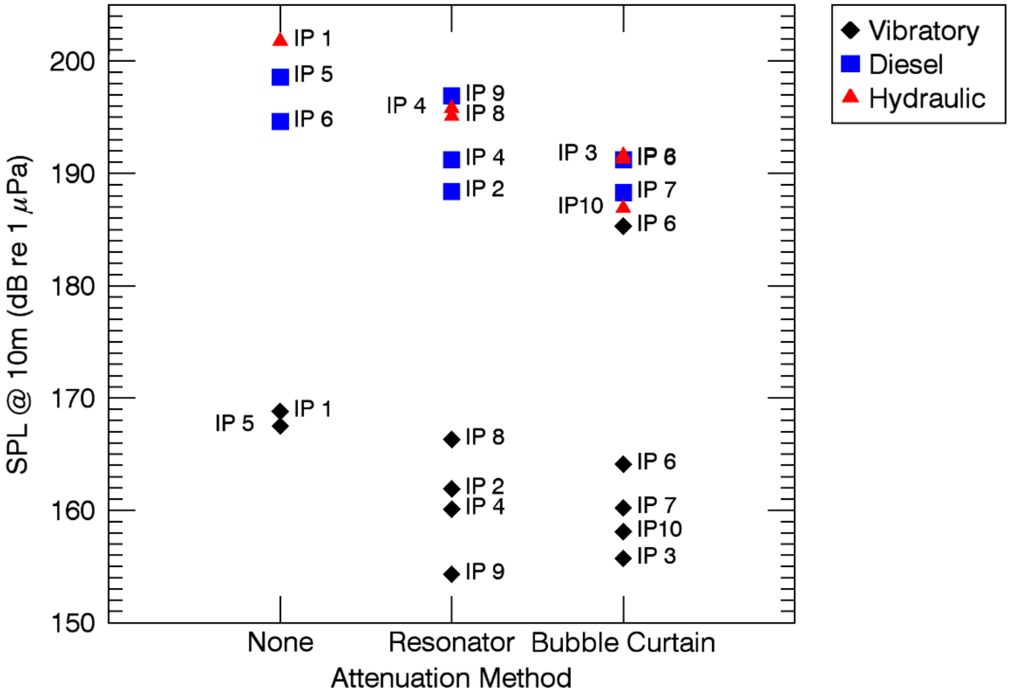


Figure 95. Median received level at 10 m range for impact and vibratory pile driving hammers versus noise attenuation method.

To aid an investigation of variability of the near-source levels owing to location differences, Figure 96 is a plot of received level at 10 m as a function of pile location, grouped by hammer type and NAS. Hydraulic impact hammer levels plotted with like symbols (i.e. with the same NAS application) were within 5 dB across location. The same is true for the diesel impact hammer levels with the bubble curtain NAS but the values differed by 7.7 dB when the passive resonator NAS was applied. Received levels for the vibratory hammer plotted with like symbols were more variable across location. Vibratory hammer near-source levels varied across location by as much as 8.4 dB with the bubble curtain NAS. The variability across locations was 7.7 dB with the passive resonator NAS, and near-source levels for vibratory installation of two piles using the passive resonator NAS at location 6 differed by 12 dB. These results indicate that the passive resonator NAS was variably effective for the diesel impact and vibratory hammers but more consistently effective for the hydraulic impact hammer. Near-source levels of the two examples of un-attenuated vibratory hammer installation differed by 1.3 dB.

There are two impact hammer data points for IP4 at Location 1; one with the diesel impact hammer and passive resonator NAS, the other with the hydraulic impact hammer and passive resonator NAS. The median near-source levels for these data points differ by 4.6 dB, with the hydraulic impact hammer yielding the larger value. Near-source levels for installation with the passive resonator NAS and the hydraulic impact hammer exceeded those for the diesel impact hammer by between 3.9 and 7.4 dB across all locations. The one exception was diesel hammer installation of IP9 at Location 6 (with passive resonator NAS) which exceeded the hydraulic hammer examples by 1.1 and 1.8 dB. Given that the un-attenuated near-source level for the hydraulic impact hammer was 3.2 dB greater than that for the diesel impact hammer, these results indicate that the passive resonator NAS was generally more effective at reducing near-source levels of the diesel impact hammer than of the hydraulic impact hammer, though not always.

Similar comparisons can be made of the effectiveness of the bubble curtain NAS for the hydraulic versus the diesel impact hammer. Near-source levels for installation with the bubble curtain NAS and the hydraulic impact hammer exceeded those for the diesel impact hammer by between 0.2 and 3.3 dB, and near-source levels for the diesel hammer installation of IP10 at Location 6 exceeded those for the hydraulic hammer examples (all with bubble curtain NAS) by 4.2 and 4.6 dB. Given that the un-attenuated near-source level for the hydraulic impact hammer was 3.2 dB greater than that for the diesel impact hammer, these results indicate that the bubble curtain NAS more effectively reduced near-source levels of the hydraulic impact hammer than of the diesel impact hammer.

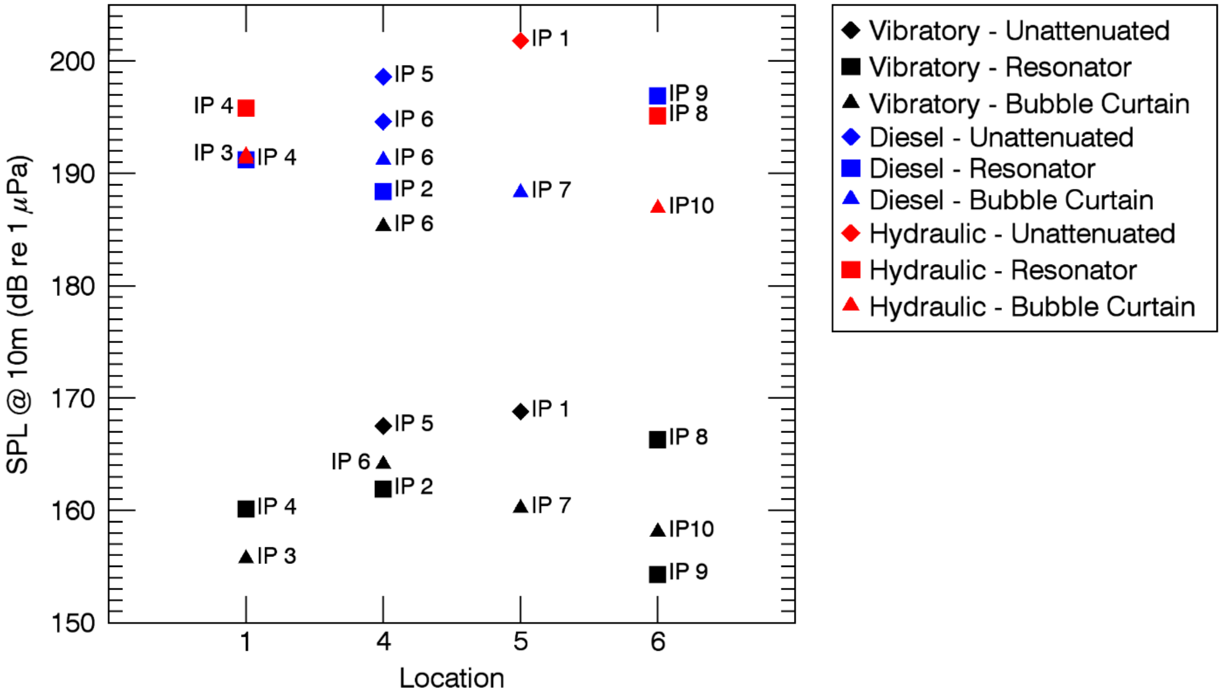


Figure 96. Median received levels at 10 m for impact and vibratory pile driving hammers, grouped by noise attenuation method, as a function of pile location.

Examination of the frequency content of the impulses for the diesel and hydraulic impact hammers aids an understanding of the relative NAS effectiveness for these hammer types. Figure 97 is a plot of the median 1/3-octave band received levels from AMAR-10M for un-attenuated impulses from the hydraulic and diesel impact hammers. Band levels for the hydraulic impact hammer exceeded those for the diesel hammer at frequencies greater than 550 Hz, the opposite was true at frequencies below 550 Hz. The hydraulic impact hammer had dominant sound energy at frequencies between 600 and 1000 Hz, whereas the diesel impact hammer had dominant sound energy between 100 and 500 Hz. This supports the assertions made above regarding the relative effectiveness of the passive resonator NAS for the diesel and hydraulic impact hammers; because the passive resonator NAS is designed to attenuate sound at frequencies near 100 Hz the passive resonator NAS was more effective for attenuating the dominant frequencies of the diesel impact hammer than for those of the hydraulic impact hammer. The air bubble curtain NAS was expected to be effective over a broader range of frequencies and was thus more effective at attenuating the dominant frequencies of the hydraulic impact hammer compared to the passive resonator NAS.

A comparison of the 1/3-octave band received levels for the un-attenuated diesel impact hammer and those using the passive resonator NAS and the air bubble curtain NAS (Figure 98) indicates graphically that the passive resonator attenuated sound most strongly at frequencies between 100 and 300 Hz, whereas the air bubble curtain NAS attenuated sounds more evenly across frequencies. The data included were limited to the subset of piles at Locations 4 and 5. This subset attempts to control for any effects that may be due to the location of the piles. Figure 99 shows the same comparison for the hydraulic impact hammer at Locations 5 & 6. For the hydraulic impact hammer, the air bubble curtain NAS attenuated sound levels the most at frequencies greater than 300 Hz.

Un-attenuated near-source levels for vibratory pile driving contained dominant sound energy at frequencies between 20 and 1000 Hz. As discussed above for the impact hammers, the air bubble curtain NAS attenuated sound energy over a broader range of frequencies compared to the passive resonator NAS, as seen by comparison of plots of the 1/3-octave band received levels for vibratory pile driving of piles IP2, IP5, and IP7 at Locations 4 and 5 (Figure 100). In this example, the passive resonator NAS attenuated sound at frequencies between 100 and 600 Hz by as much as 15 dB but did not appreciably attenuate sound outside of this frequency range that contributed importantly to the broadband levels. The bubble curtain NAS attenuated sounds more evenly across frequencies.

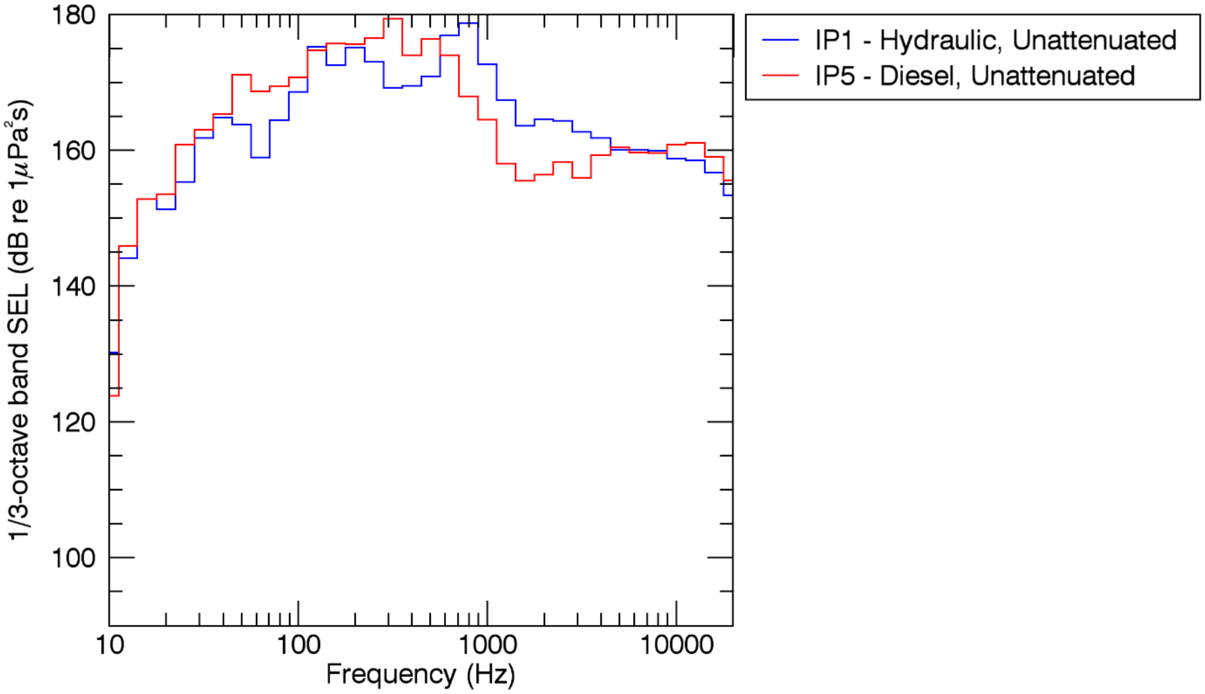


Figure 97 Median 1/3-octave band received levels from AMAR-10M for un-attenuated pile driving using the hydraulic impact hammer (blue) and the diesel impact hammer (red).

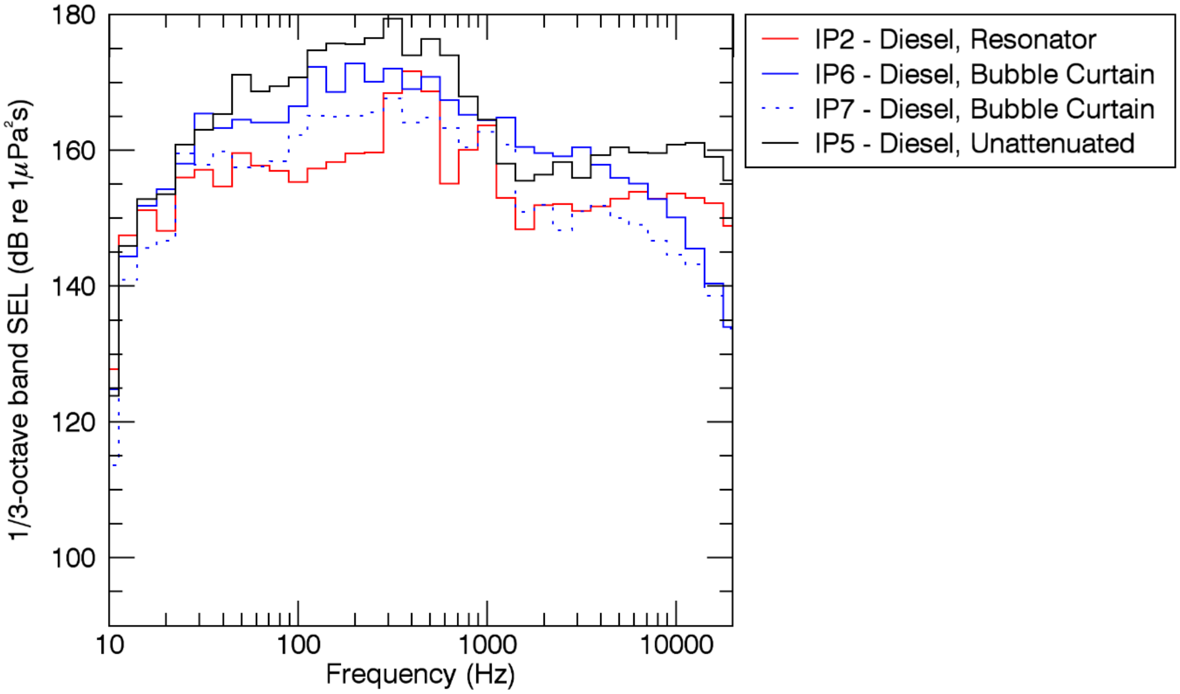


Figure 98 Median 1/3-octave band received levels from AMAR-10M for pile driving using the diesel impact hammer with the passive resonator NAS (red), with the air bubble curtain NAS (blue) and un-attenuated (black).

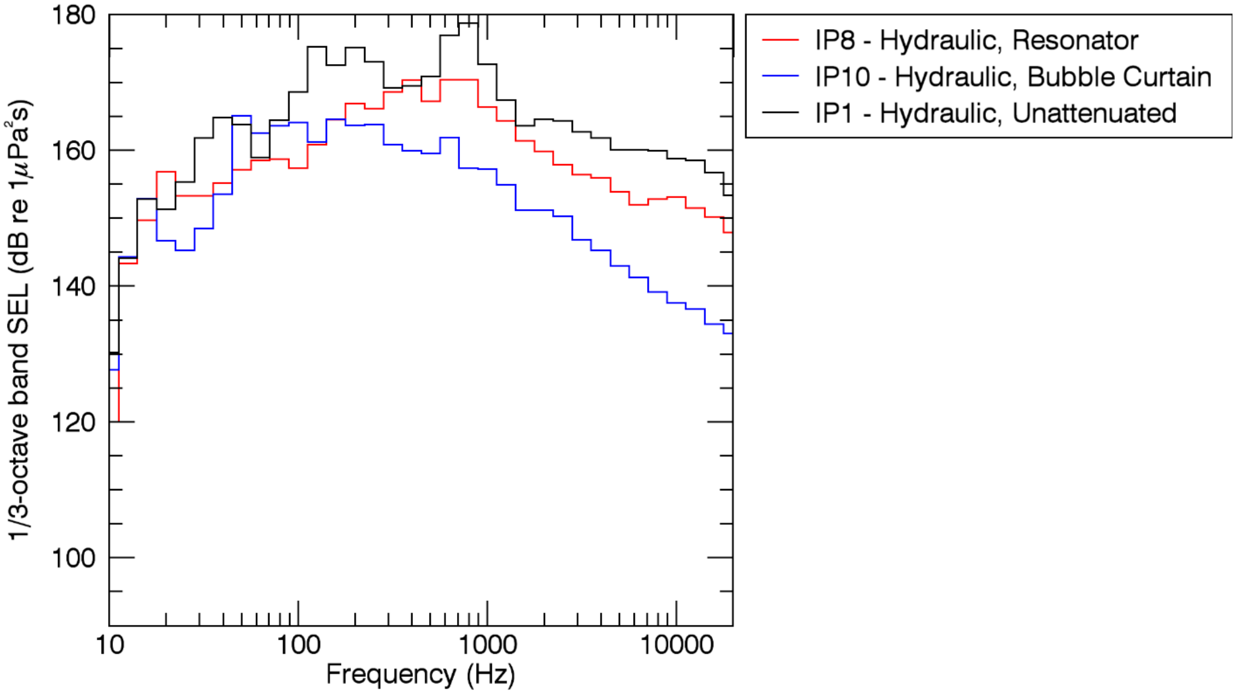


Figure 99 Median 1/3-octave band received levels from AMAR-10M for pile driving using the hydraulic impact hammer with the passive resonator NAS (red), with the air bubble curtain NAS (blue) and un-attenuated (black).

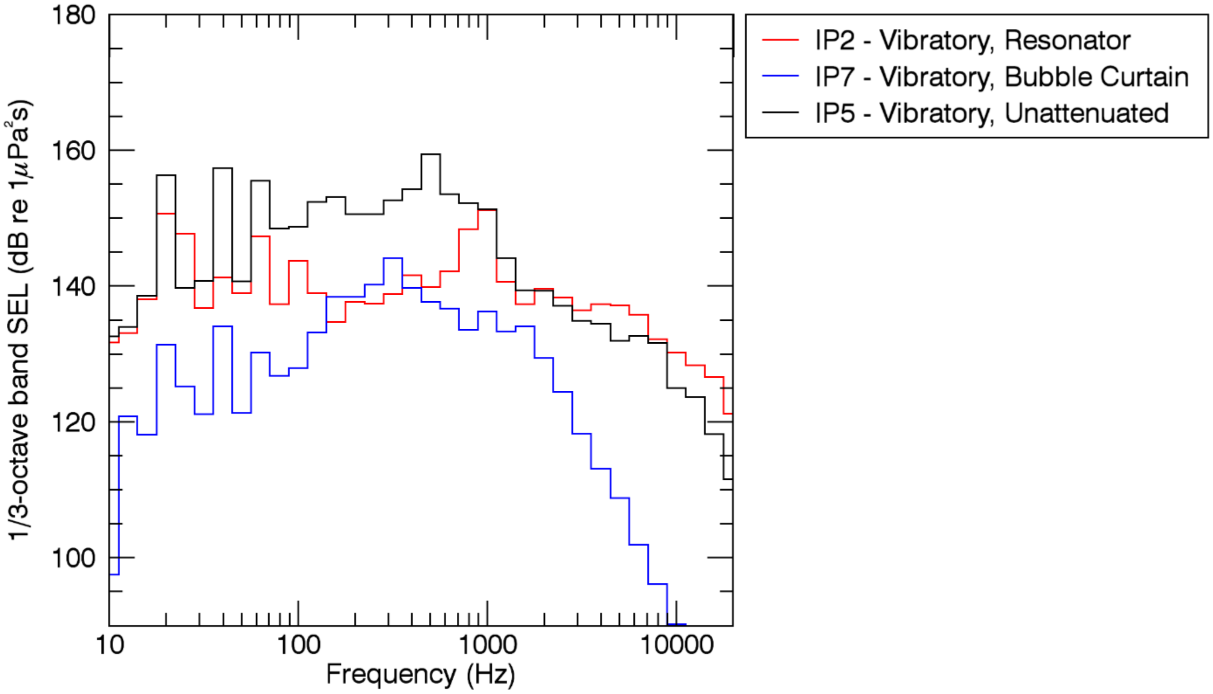


Figure 100 Median 1/3-octave band received levels from AMAR-10M for pile driving using the vibratory hammer with the passive resonator NAS (red), with the air bubble curtain NAS (blue) and un-attenuated (black).

4.4. Transmission Loss

Computed TL coefficients varied between piles with values ranging from 13 to 20.6 for impact pile driving and from 12.6 to 17.9 for vibratory pile driving. This variability was somewhat reduced when the results were grouped by hammer model and NAS (Figure 101). The remaining variability is partially due to differences of pile locations (discussed below) and partially due to experimental variability discussed in Section 4.1. Note that the data point for IP4 (diesel impact hammer with passive resonator NAS) corresponds to the ground-attenuated results discussed in Section 4.1 and is considered to be distinct from the other data points and is excluded from the plot.

TL is a frequency-dependent phenomenon, and the frequency content of underwater sounds from pile driving varies with hammer type. Therefore, the TL coefficient is expected to vary with hammer type. Because the application of a NAS also alters the frequency content of the pile driving sounds, the TL coefficient also varies with NAS application. In this section it is demonstrated that the derived TL coefficients were consistent for piles that were installed using the same hammer and the same NAS, at the same location. This provides confidence in the methodology used to derive the TL coefficients, and the subsequent calculations of the distances to the marine mammal thresholds.

Results for the un-attenuated hydraulic impact hammer yielded the highest TL coefficient, 19.2, indicating that sounds from the hydraulic impact hammer decayed most rapidly with range compared to the other hammers. This could be because the hydraulic impact hammer contains more sound energy at higher frequencies, which decay more rapidly with range compared to lower frequencies. Results for the diesel impact hammer were consistent over IP5 and IP6 with values of 17.4 and 17.5 respectively. Sounds from the vibratory hammer had the lowest TL coefficient, with values of 16.1 and 16.9.

TL coefficients consistently decreased when a NAS was applied compared to the un-attenuated results, except for the one event from the final stages of vibratory pile driving of IP6 that has been considered distinct from the other data points, as described previously. This is in part because the frequency content of the signals changed by the NAS, but also because both types of NAS only attenuated in-water sound levels and some sound propagated directly from the pile into the seafloor un-attenuated. This un-attenuated sound propagated through the seafloor then refracted into the water column at longer ranges. Thus each NAS attenuated the near-source sound levels, dominated by water-borne propagation paths, more strongly than the long-range sound levels, resulting in an apparent decrease of the rate of sound level decay between AMAR-10M and AMAR-1KM.

For the hydraulic impact hammer and bubble curtain NAS, there were two results for IP3 from separate consideration of the propagation path toward AMAR-1KM from that toward AMAR-DRIFT. The path toward AMAR-1KM yielded a greater value for the TL coefficient due to an effect from the newly deposited dredge disposal near that location. The path toward AMAR-DRIFT yielded a TL coefficient of 13 that was consistent with the value of 13.2 for the other example of hydraulic impact pile driving with bubble curtain attenuation, IP10. The two examples for diesel impact pile driving with bubble curtain attenuation (IP7 and IP6) also yielded consistent TL coefficients (greater than those for the hydraulic impact hammer) of 16.4 and 16.1. TL coefficients for bubble curtain attenuated vibratory pile driving were more variable, although the piles were installed at different locations. Derived TL coefficients for diesel impact hammer installation using the passive resonator NAS were similar, with values of 13.4 (IP2) and 14 (IP9), for different pile locations. The TL coefficients for hydraulic impact hammer installation with passive resonator NAS were very different (14.9 for IP8 and 17.7 for IP4) but these data were collected at opposite ends of the Port, at locations 6 and 1, respectively. Vibratory pile driving with passive resonator NAS yielded TL coefficients of 14.7, 15.5, 15.9, 16.1; again these corresponded to piles at different locations. Derived TL coefficients for un-attenuated pile driving (from data collected at locations close to one another) were consistent when grouped by hammer type.

TL coefficient variability with pile location was examined by plotting the derived TL coefficients for each NAS as a function of pile location (Figure 102 through Figure 104 for the hydraulic impact, diesel impact and vibratory hammers respectively). The TL coefficients for each type of NAS were relatively consistent across locations for the diesel impact hammer, they were more variable across location for the hydraulic impact hammer (for which the data were collected at locations more widely separated compared to the diesel impact hammer locations) and varied considerably across location for the vibratory hammer.

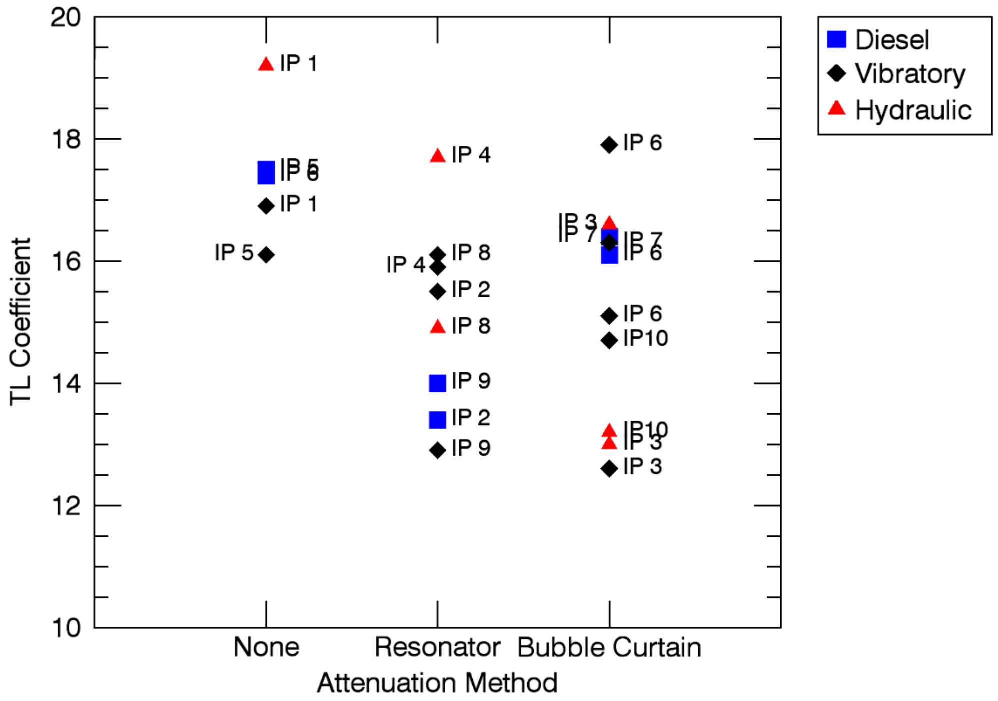


Figure 101. Transmission loss coefficient as a function of noise attenuation method for each hammer type.

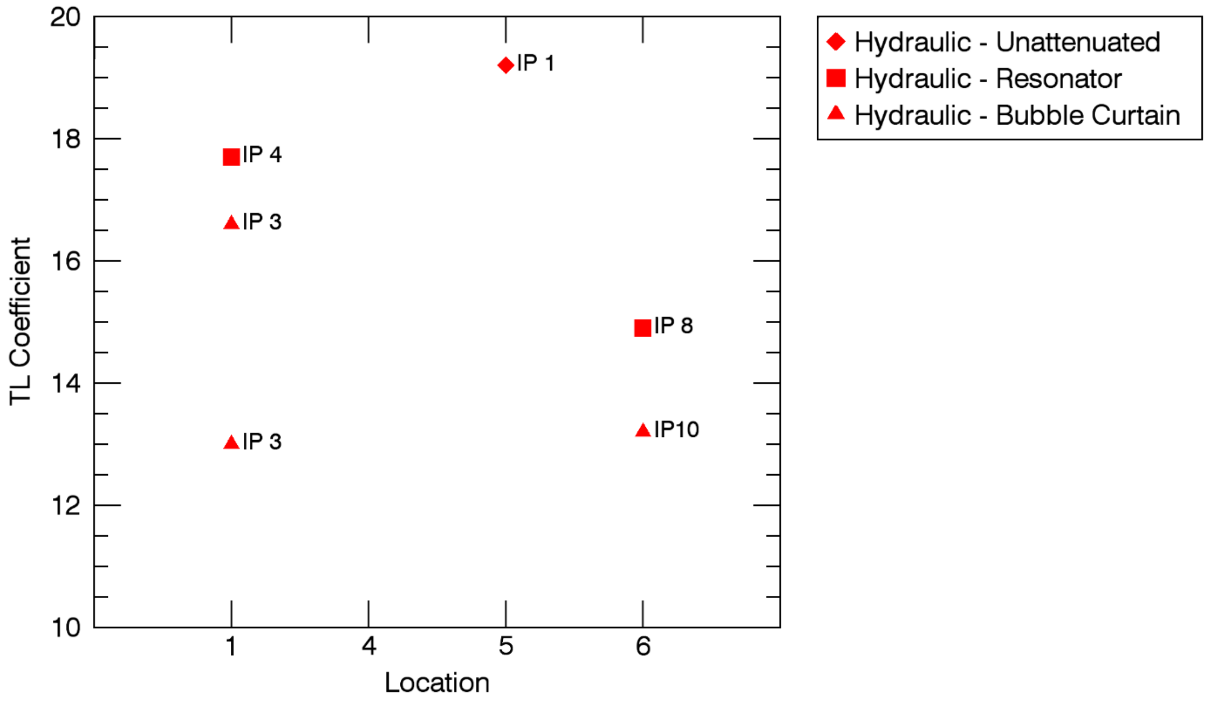


Figure 102 Transmission Loss coefficient as a function of pile location for the hydraulic impact hammer and with the passive resonator NAS (squares), bubble curtain NAS (triangles) and un-attenuated (diamonds).

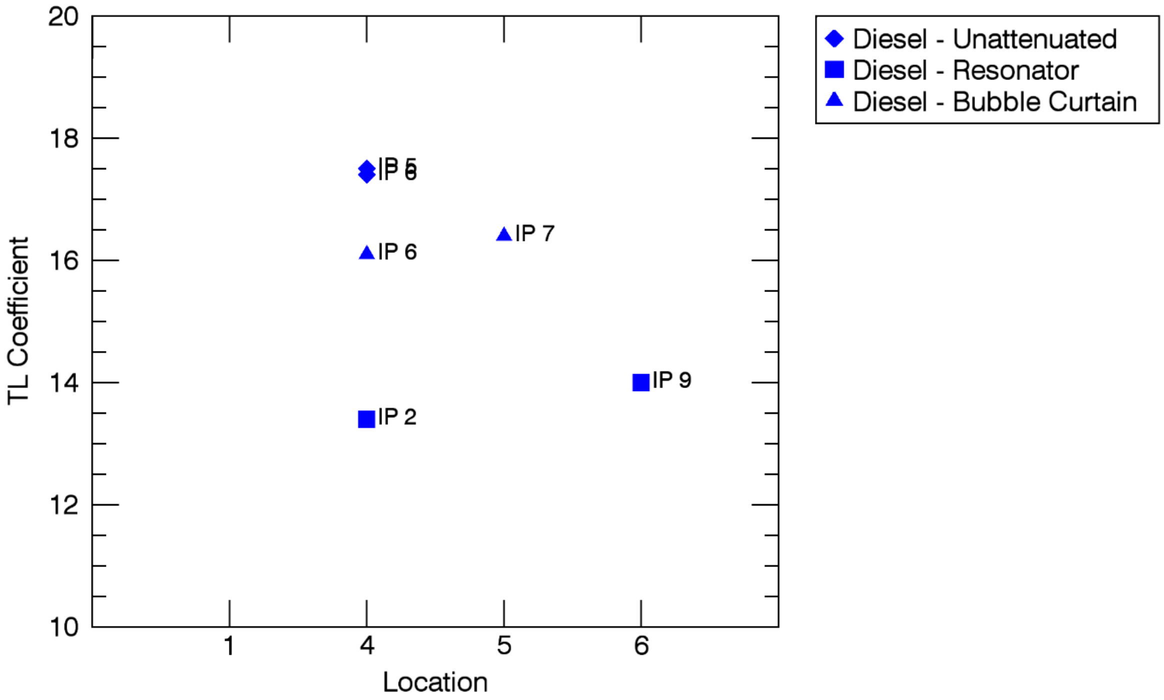


Figure 103 Transmission Loss coefficient as a function of pile location for the diesel impact hammer and with the passive resonator NAS (squares), bubble curtain NAS (triangles) and un-attenuated (diamonds).

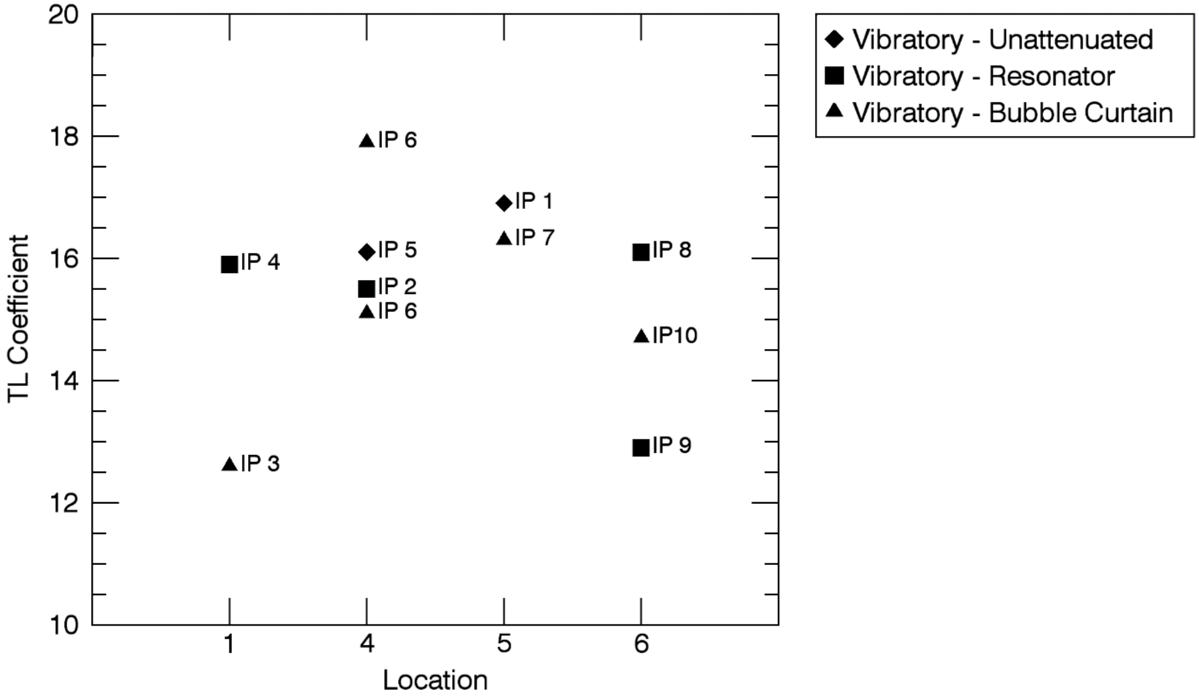


Figure 104 Transmission Loss coefficient as a function of pile location for the vibratory hammer and with the passive resonator NAS (squares), bubble curtain NAS (triangles) and un-attenuated (diamonds).

4.5. Sound Threshold Distances

The median distance to the marine mammal threshold of 160 dB re 1 µPa rms SPL for impact pile driving varied over all piles between 800 and 4340 m. The upper end of that range of distances is comprised of estimates extrapolated beyond the maximum ranges of measurement; there is uncertainty associated with the extrapolated distances and they are assumed to overestimate the true distances. The maximum distance to the 160 dB threshold that was actually measured (i.e. excluding values based on data extrapolations) was 2280 m. For vibratory pile driving, the median distance to the marine mammal impact threshold used for this project of 125 dB re 1 µPa rms SPL varied between 1440 m and 4340 m (measured, not extrapolated). The median distance to 120 dB re 1 µPa for vibratory pile driving varied between 2920 and 8880 m based on extrapolated data (we were not able to reliably measure the distance to 120 dB re 1 µPa during this study due to background noise).

There was no clear correlation between sound threshold distance and the applied NAS, plotted as a function of location (Figure 105 through Figure 109), for any of the hammers. This implies that, although both noise attenuation systems reduced the source sound levels appreciably, the long range received sound levels likely contained sufficient contributions of bottom propagating sound energy that is not attenuated by the NAS, i.e. that the attenuation of the waterborne sound levels did not result in an appreciable decrease in the sound threshold distances. In fact, there are some instances where the distances to the marine mammal thresholds are shorter for un-attenuated pile driving with a given hammer type when compared to a pile with NAS application at a different location.

Trends in the marine mammal threshold distances are difficult to quantify because of the inherent uncertainty of the computed threshold distances. Even a small amount of variability of the source sound levels and derived TL coefficients leads to large differences in the marine mammal impact thresholds. For example, the median range to the 160 dB re 1 µPa threshold was 864 m for pile IP6 and 532 m for pile IP7, both examples of diesel impact hammer pile driving with bubble curtain NAS. The derived TL coefficients for these piles were relatively consistent, with values of 16.1 and 16.4, and the near-source levels agreed within 2.9 dB. This results in wide variability of the computed distances over piles.

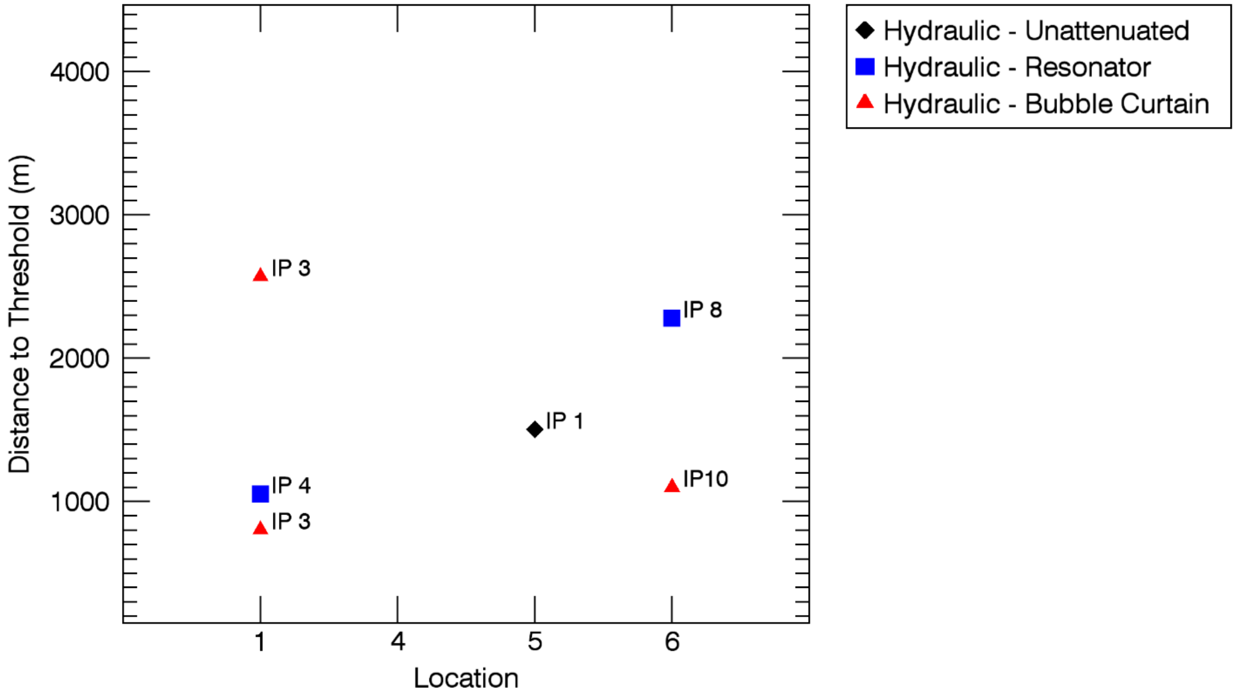


Figure 105. Distance to marine mammal threshold of 160 dB re 1 μPa for hydraulic impact hammer pile driving as a function of pile location.

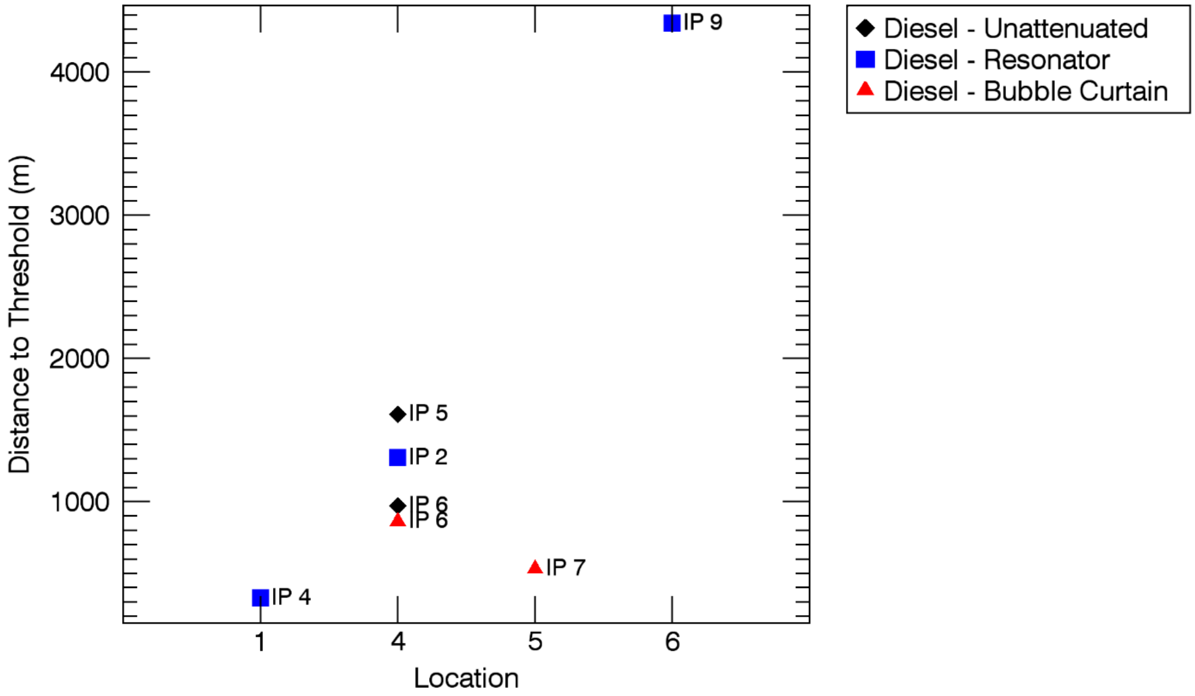


Figure 106. Distance to marine mammal threshold of 160 dB re 1 μPa for diesel impact hammer pile driving as a function of pile location.

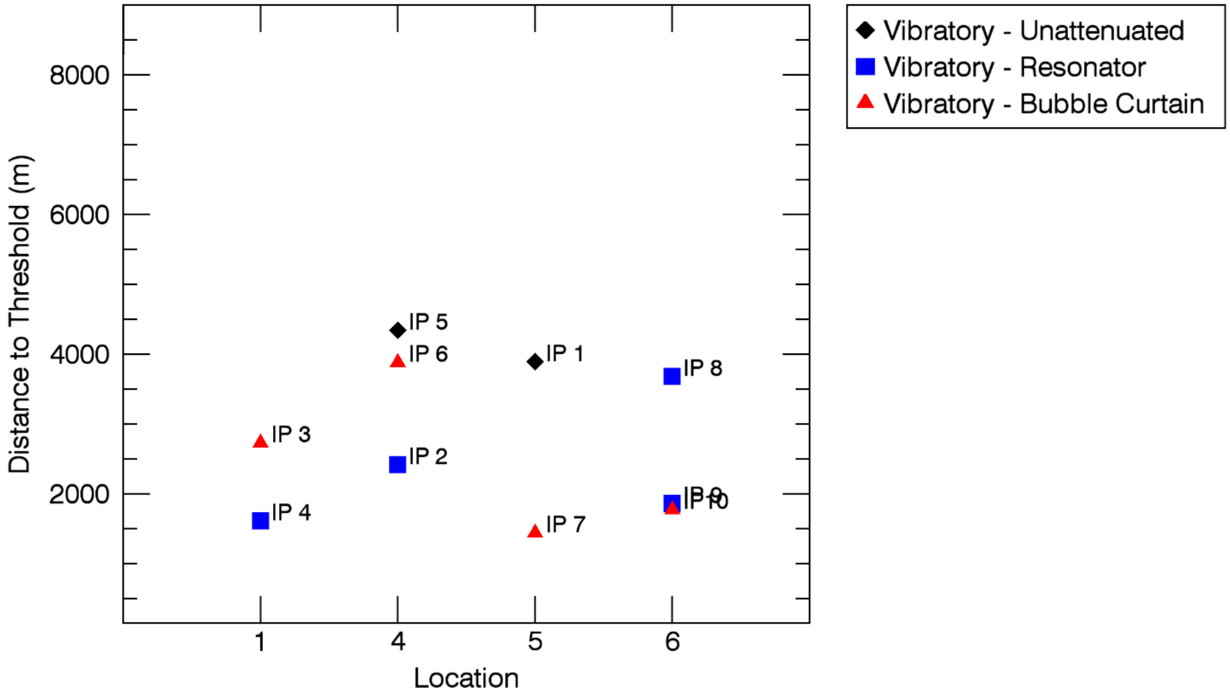


Figure 107. Distance to marine mammal threshold of 125 dB re 1 μPa for vibratory hammer pile driving as a function of pile location.

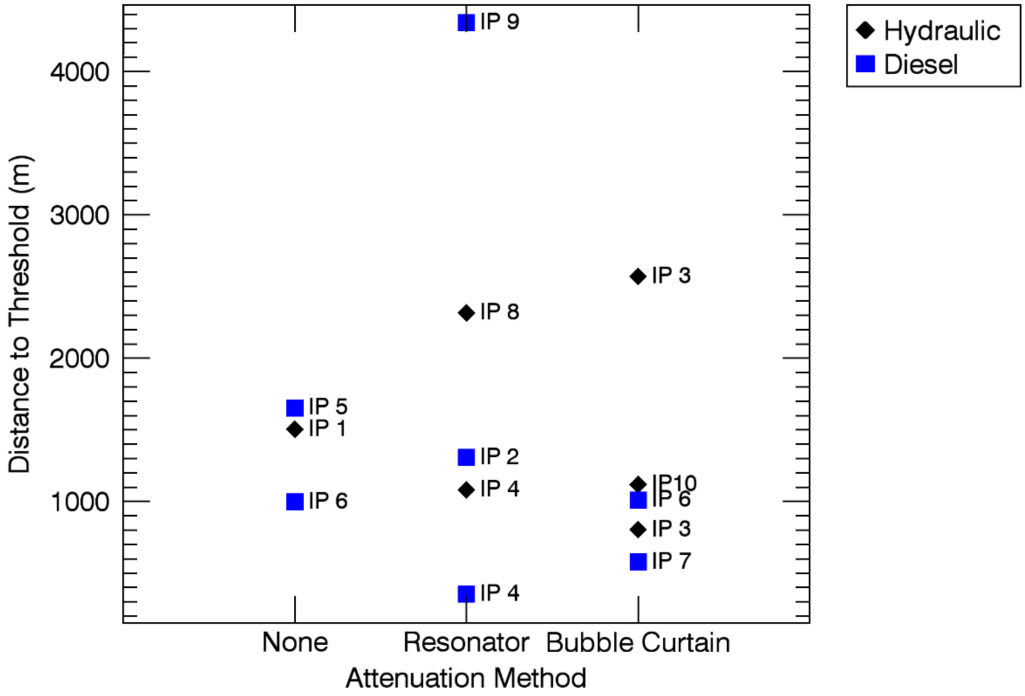


Figure 108. Distance to marine mammal threshold of 160 dB re 1 μPa for hydraulic and diesel impact hammer pile driving as a function of NAS application. Data points derived from measurement extrapolations (IP3 (~2500 m) and IP9) are included for reference.

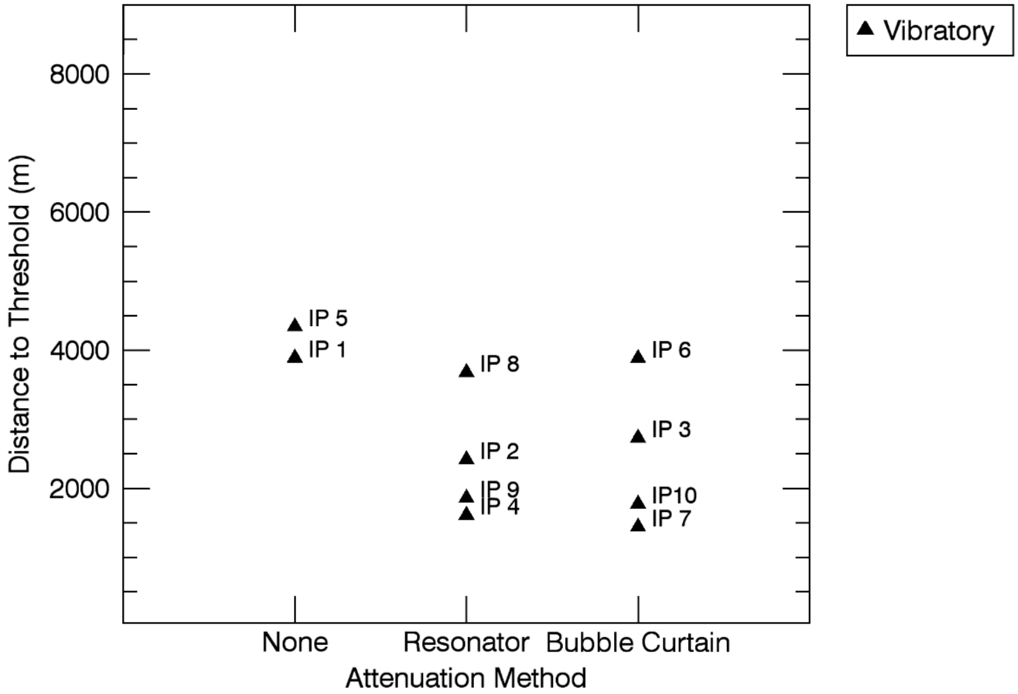


Figure 109. Distance to marine mammal threshold of 125 dB re 1 µPa for vibratory hammer pile driving as a function of NAS application. Data points derived from measurement extrapolations (IP1, IP6, IP8, IP9) are included.

4.6. Comparison of Hammer Types and of Noise Attenuation Systems

Median received levels at 10 m range (here called near-source levels) were greatest for the hydraulic impact hammer with an average un-attenuated value of 201.8 dB re 1 µPa, it was 198.6 dB re 1 µPa for the diesel impact hammer and 168.2 dB re 1 µPa for the vibratory hammer. The average near-source level when the passive resonator NAS was applied was 195.5 for the hydraulic impact hammer, 192.2 dB re 1 µPa for the diesel impact hammer and 160.7 dB re 1 µPa for the vibratory hammer. When the bubble curtain NAS was applied the average near-source levels were 190.0, 189.7 and 159.5 for the hydraulic impact, diesel impact, and vibratory hammers, respectively. This information is summarized in Table 16.

Near-source levels for un-attenuated pile driving exceeded those for pile driving events with NAS applied for each hammer type. On average, the bubble curtain reduced near-source levels more than the passive resonator NAS did. This trend was most strongly observed for the hydraulic impact hammer; the sound attenuation achieved by the passive resonator NAS and the bubble curtain NAS was more similar for the diesel impact hammer and was very similar for the vibratory hammer. When the bubble curtain was applied, median near-source levels of the hydraulic impact hammer decreased by 12 dB on average, compared to an average 6 dB reduction of the hydraulic hammer near-source level when the passive resonator was applied. The bubble curtain decreased the diesel impact hammer near-source levels by an average of 9 dB, the reduction was 6 dB on average when the passive resonator was applied. The bubble curtain and passive resonator both decreased the near-source level for vibratory pile driving by nearly the same average amount, 9 and 8 dB respectively. This information is summarized in Table 17.

Excluding data points derived from measurement extrapolations, grouping by hammer type and NAS, and then averaging over location, NAS application generally resulted in a reduction of the distance to the marine mammal thresholds for both vibratory and impact pile driving (Table 18). Long-range received levels were not independent of the near-source levels. The transmission loss estimates accounted for the difference in source levels and range from the pile at the recorders. The transmission loss combined with the near-source levels were used to determine the range to marine mammal thresholds. The range to threshold reduces the variability from source level, NAS, and transmission loss to one value.

Table 16. Median received levels at 10m for impact and vibratory pile driving, averaged over n available data samples.

	rms Sound Pressure Level at 10 m Range (dB re 1 µPa)		
	Un-attenuated	Passive Resonator NAS	Bubble Curtain NAS
Hydraulic Impact Hammer	201.8 (n=1)	195.5 (n=2)	190.0 (n=3)
Diesel Impact Hammer	198.6 (n=1)	192.2 (n=3)	189.7 (n=2)
Vibratory Hammer	168.2 (n=2)	160.7 (n=4)	159.5 (n=4)

Table 17. Reduction of the median received levels at 10m for impact and vibratory pile driving compared to the un-attenuated values, averaged over n available data samples.

	Average Reduction (dB)	
	Passive Resonator NAS	Bubble Curtain NAS
Hydraulic Impact Hammer	6 (n=2)	12 (n=3)
Diesel Impact Hammer	6 (n=3)	9 (n=2)
Vibratory Hammer	8 (n=4)	9 (n=4)

Table 18. Median range to marine mammal threshold of 160 dB re 1 µPa for impact pile driving and 125 dB re 1 µPa for vibratory pile driving, averaged over n data samples, excluding data from extrapolation of measured levels.

Range to marine mammal threshold (m)			
	Un-attenuated	Passive Resonator NAS	Bubble Curtain NAS
Hydraulic Impact Hammer	1504 (n=1)	1053 (n=1)	1100 (n=1)
Diesel Impact Hammer	1291 (n=1)	1306 (n=1)	698 (n=2)
Vibratory Hammer	3883 (n=1)	2417 (n=2)	1983 (n=3)

5. Acknowledgements

We thankfully acknowledge the captain and crew of the M/V *My Marie* (operated by Sundog Charters) for their skillful assistance with the AMAR deployments and retrievals and support during drifting measurements. Robert Mills of JASCO Applied Sciences also helped collect field data.

Glossary

1/3-octave band
Non-overlapping passbands that are one-third of an octave wide (where an octave is a doubling of frequency). Three adjacent 1/3-octave bands make up one octave. One-third-octave-bands become wider with increasing frequency. See also octave.

90%-energy time window
The time interval over which the cumulative energy rises from 5% to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

90% root-mean-square sound pressure level (90% rms SPL)
The root-mean-square sound pressure levels calculated over the 90%-energy time window of a pulse. Used only for pulsed sounds.

ambient noise
All-encompassing sound at a given place, usually a composite of sound from many sources near and far (ANSI S1.1-1994 R2004), e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

background noise
Total of all sources of interference in a system used for the production, detection, measurement, or recording of a signal, independent of the presence of the signal (ANSI S1.1-1994 R2004). Ambient noise detected, measured, or recorded with a signal is part of the background noise.

broadband sound level
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

continuous sound
A sound whose sound pressure level remains above ambient sound during the observation period (ANSI/ASA S1.13-2005 R2010). A sound that gradually varies in intensity with time, for example, sound from a vibratory pile driver.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI S1.1-1994 R2004).

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

functional hearing group
Grouping of marine mammal species with similar hearing ranges. Commonly defined functional hearing groups include low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

geoacoustic
Relating to the acoustic properties of the seabed.

Global Positioning System (GPS)
A satellite based navigation system providing accurate worldwide location and time information.

hertz (Hz)
A unit of frequency defined as one cycle per second.

high-frequency cetacean (HFC)
The functional hearing group that represents odontocetes specialized for using high frequencies.

hydrophone
An underwater sound pressure transducer. A passive electronic device for recording or listening to underwater sound.

impulsive sound
Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, ANSI S12.7-1986 R2006). For example, impact pile driving.

low-frequency cetacean (LFC)
The functional hearing group that represents mysticetes (baleen whales).

median
The 50th percentile of a statistical distribution.

mid-frequency cetacean (MFC)
The functional hearing group that represents some odontocetes (dolphins, toothed whales, beaked whales, and bottlenose whales).

M-weighting
The process of band-pass filtering loud sounds to reduce the importance of inaudible or less-audible frequencies for broad classes of marine mammals. “Generalized frequency weightings for various functional hearing groups of marine mammals, allowing for their functional bandwidths and appropriate in characterizing auditory effects of strong sounds” (Southall et al. 2007).

mysticete
Mysticeti, a suborder of cetaceans, use their baleen plates, rather than teeth, to filter food from water. They are not known to echolocate, but use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and the gray whale (*Eschrichtius robustus*).

non-impulsive sound
Sound that is broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically does not have a high peak pressure with rapid rise time (typically only small fluctuations in decibel level) that impulsive signals have (ANSI/ASA S3.20-1995 R2008). For example, vibratory pile driving (NIOSH 1998, NOAA 2015).

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete
The presence of teeth, rather than baleen, characterizes these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The toothed whales' skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

peak sound pressure level (peak SPL)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak sound pressure level. Unit: decibel (dB).

peak-to-peak sound pressure level (peak-to-peak SPL)
The difference between the maximum and minimum instantaneous sound pressure levels. Unit: decibel (dB).

percentile level, exceedance
The sound level exceeded *n*% of the time during a measurement.

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

pinniped
A common term used to describe all three groups that form the superfamily Pinnipedia: phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

power spectrum density
The acoustic signal power per unit frequency as measured at a single frequency. Unit: $\mu Pa^2/Hz$, or $\mu Pa^2 \cdot s$.

power spectral density level
The decibel level ($10\log_{10}$) of the power spectrum density, usually presented in 1 Hz bins. Unit: dB re 1 $\mu Pa^2/Hz$.

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

pressure, hydrostatic
The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

received level
The sound level measured at a receiver.

rms
root-mean-square.

rms sound pressure level (rms SPL)
The root-mean-square average of the instantaneous sound pressure as measured over some specified time interval. See also sound pressure level (SPL) and 90% rms SPL.

sound
A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure
Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second ($Pa^2 \cdot s$) (ANSI S1.1-1994 R2004).

sound exposure level (SEL)
A measure related to the sound energy in one or more pulses. Unit: dB re 1 $\mu Pa^2 \cdot s$.

sound pressure level (SPL)
The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 R2004).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 μPa) and the unit for SPL is dB re 1 μPa:

$$\mathrm{SPL} = 10\log_{10}\left(p^2/p_0^2\right) = 20\log_{10}\left(p/p_0\right)$$

Unless otherwise stated, SPL refers to the root-mean-square sound pressure level (rms SPL).

source level (SL)
The sound pressure level measured 1 meter from a theoretical point source that radiates the same total sound power as the actual source. Unit: dB re 1 μPa @ 1 m.

spectrogram
A visual representation of acoustic amplitude compared with time and frequency.

spectrum
An acoustic signal represented in terms of its power (or energy) distribution compared with frequency.

temporary threshold shift (TTS)
Temporary loss of hearing sensitivity caused by excessive noise exposure.

transmission loss (TL)
The decibel reduction in sound level between two stated points that results from sound spreading away from an acoustic source subject to the influence of the surrounding environment. Also called propagation loss.

Acronyms

AMAR - Autonomous Multichannel Acoustic Recorder

CFM - cubic feet per minute

FFT - fast Fourier transform

HFC - high frequency cetacean

IP - indicator pile

LFC - low frequency cetacean

MFC - high frequency cetacean

NAS - noise attenuation system

NMFS - National Marine Fisheries Service

PPW - pinnipeds in water

RL - received level

RMS - root-mean-square

SEL - sound exposure level

SL - source level

SPL - sound pressure level

ssSEL - single-strike sound exposure level

TK - Teager-Kaiser

TL - transmission loss

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Appendix A. Activity Logs

A.1. IP1 Activity Logs

A.1.1. Log of JASCO Activities for IP1

Date (UTC)	Time (UTC)	Activity
2016-Jun-06	23:47	Calibrated AMAR 1 km
2016-Jun-07	00:35	Deployed AMAR 1 km
2016-Jun-06	23:41	Calibrated AMAR 10 m
2016-Jun-07	N/A	Deployed AMAR 10 m
2016-Jun-07	17:05	Calibrated drift system
2016-Jun-07	17:28	Drift recording of vibro piling
2016-Jun-07	19:37	Drift recording of impact piling
2016-Jun-07	21:08	Calibrated drift system
2016-Jun-07	21:22	Retrieved AMAR 1 km
2016-Jun-07	21:53	Retrieved AMAR 10 m
2016-Jun-07	22:21	Calibrated AMAR 1
2016-Jun-07	22:26	Calibrated AMAR 2

A.1.2. Log of Pile Driving Activities for IP1

Date (UTC)	Time (UTC)	Activity
2016-Jun-07	17:34	Soft start of vibratory driving of IP1
2016-Jun-07	17:39	Vibratory driving of IP1
2016-Jun-07	18:11	Finished vibratory driving of IP1
2016-Jun-07	19:39	Soft start of impact driving of IP1
2016-Jun-07	19:44	Impact driving of IP1
2016-Jun-07	N/A	Attaching sensors
2016-Jun-07	20:57	Re-start impact driving of IP1
2016-Jun-07	21:02	Finished impact driving of IP1

A.2. IP2 Activity Logs

A.2.1. Log of JASCO Activities for IP2

Date (UTC)	Time (UTC)	Activity
2016-May-18	13:49	Calibrated AMAR 1 km
2016-May-18	14:44	Deployed AMAR 1 km
2016-May-19	13:50	Calibrated AMAR 10 m
2016-May-19	14:12	Deployed AMAR 10 m
2016-May-19	15:34	Calibrated drift system
2016-May-19	16:04	Drift recording of vibro piling
2016-May-19	18:28	Drift recording of impact piling
2016-May-19	19:51	Calibrated drift system
2016-May-19	20:11	Retrieved AMAR 1 km
2016-May-19	20:35	Retrieved AMAR 10 m
2016-May-19	21:16	Calibrated AMAR 2
2016-May-19	21:23	Calibrated AMAR 1

A.2.2. Log of Pile Driving Activities for IP2

Date (UTC)	Time (UTC)	Activity
2016-May-19	16:04	Soft start of vibratory driving of IP2
2016-May-19	16:23	Vibratory driving of IP2
2016-May-19	17:02	Finished vibratory driving of IP2
2016-May-19	18:28	Soft start of impact driving of IP2
2016-May-19	18:38	Impact driving of IP2
2016-May-19	18:43	Attaching sensors
2016-May-19	19:09	Re-start impact driving of IP2
2016-May-19	19:41	Finished impact driving of IP2

A.3. IP3 Activity Logs

A.3.1. Log of JASCO Activities for IP3

Date (UTC)	Time (UTC)	Activity
2016-Jun-02	21:08	Calibrated AMAR 1 km
2016-Jun-03	00:51	Deployed AMAR 1 km
2016-Jun-02	21:01	Calibrated AMAR 10 m
2016-Jun-03	00:21	Deployed AMAR 10 m
2016-Jun-03	14:23	Calibrated drift system
2016-Jun-03	15:21	Drift recording of vibro piling
2016-Jun-03	17:40	Drift recording of impact piling
2016-Jun-03	22:02	Calibrated drift system
2016-Jun-03	22:16	Retrieved AMAR 1 km
2016-Jun-03	22:50	Retrieved AMAR 10 m
2016-Jun-03	23:25	Calibrated AMAR 2
2016-Jun-03	23:05	Calibrated AMAR 1

A.3.2. Log of Pile Driving Activities for IP3

Date (UTC)	Time (UTC)	Activity
2016-Jun-03	15:32	Soft start of vibratory driving of IP3
2016-Jun-03	15:44	Vibratory driving of IP3
2016-Jun-03	16:08	Finished vibratory driving of IP3
2016-Jun-03	18:25	Soft start of impact driving of IP3
2016-Jun-03	18:36	Impact driving of IP3
2016-Jun-03	21:36	Adjusting sensors
2016-Jun-03	21:46	Re-start impact driving of IP3
2016-Jun-03	22:02	Finished impact driving of IP3

A.4. IP4 Activity Logs

A.4.1. Log of JASCO Activities for IP4

Date (UTC)	Time (UTC)	Activity
2016-May-11	21:43	Calibrated AMAR 1 km
2016-May-11	22:24	Deployed AMAR 1 km
2016-May-11	21:21	Calibrated AMAR 10 m
2016-May-11	22:59	Deployed AMAR 10 m
2016-May-12	N/A	Calibrated drift system
2016-May-12	19:42	Drift recording of vibro piling
2016-May-12	22:57	Drift recording of impact piling
2016-May-13	01:00	Calibrated drift system
2016-May-13	14:58	Calibrated drift system
2016-May-13	15:37	Drift recording of impact piling
2016-May-13	16:49	Calibrated drift system
2016-May-14	15:57	Retrieved AMAR 1 km
2016-May-13	17:07	Retrieved AMAR 10 m
2016-May-13	18:00	Calibrated AMAR 2
2016-May-14	23:03	Calibrated AMAR 1

A.4.2. Log of Pile Driving Activities for IP4

Date (UTC)	Time (UTC)	Activity
2016-May-12	19:54	Soft start of vibratory driving of IP4
2016-May-12	20:11	Vibratory driving of IP4
2016-May-12	20:25	Finished vibratory driving of IP4
2016-May-12	22:57	Soft start of impact driving of IP4
2016-May-12	23:01	Impact driving of IP4
2016-May-13	00:02	Re-start impact driving of IP4
2016-May-13	00:10	Finished impact driving of IP4
2016-May-13	15:40	Soft start of impact driving of IP4
2016-May-13	15:48	Impact driving of IP4
2016-May-13	16:34	Finished impact driving of IP4

A.5. IP5 Activity Logs

A.5.1. Log of JASCO Activities for IP5

Date (UTC)	Time (UTC)	Activity
2016-May-18	13:49	Calibrated AMAR 1 km
2016-May-18	14:36	Deployed AMAR 1 km
2016-May-18	13:41	Calibrated AMAR 10 m
2016-May-18	15:16	Deployed AMAR 10 m
2016-May-18	15:45	Calibrated drift system
2016-May-18	16:06	Drift recording of vibro piling
2016-May-18	19:18	Drift recording of impact piling
2016-May-18	20:34	Calibrated drift system
2016-May-19	20:11	Retrieved AMAR 1 km
2016-May-18	20:51	Retrieved AMAR 10 m
2016-May-18	21:21	Calibrated AMAR 2
2016-May-19	21:23	Calibrated AMAR 1

A.5.2. Log of Pile Driving Activities for IP5

Date (UTC)	Time (UTC)	Activity
2016-May-18	16:40	Soft start of vibratory driving of IP5
2016-May-18	17:05	Vibratory driving of IP5
2016-May-18	17:18	Finished vibratory driving of IP5
2016-May-18	19:20	Soft start of impact driving of IP5
2016-May-18	19:29	Impact driving of IP5
2016-May-18	N/A	Attaching sensors
2016-May-18	20:08	Re-start impact driving of IP5
2016-May-18	20:31	Finished impact driving of IP5

A.6. IP6 Activity Logs

A.6.1. Log of JASCO Activities for IP6

Date (UTC)	Time (UTC)	Activity
2016-Jun-01	00:13	Calibrated AMAR 1 km
2016-Jun-01	01:34	Deployed AMAR 1 km
2016-Jun-01	00:19	Calibrated AMAR 10 m
2016-Jun-01	00:48	Deployed AMAR 10 m
2016-Jun-01	12:36	Calibrated drift system
2016-Jun-01	14:37	Drift recording of vibro piling
2016-Jun-01	17:05	Drift recording of impact piling
2016-Jun-01	18:38	Calibrated drift system
2016-Jun-01	18:51	Retrieved AMAR 1 km
2016-Jun-01	19:15	Retrieved AMAR 10 m
2016-Jun-01	19:52	Calibrated AMAR 2
2016-Jun-01	19:37	Calibrated AMAR 1

A.6.2. Log of Pile Driving Activities for IP6

Date (UTC)	Time (UTC)	Activity
2016-Jun-01	14:57	Soft start of vibratory driving of IP6
2016-Jun-01	15:00	Vibratory driving of IP6
2016-Jun-01	15:32	Finished vibratory driving of IP6
2016-Jun-01	17:08	Soft start of impact driving of IP6
2016-Jun-01	17:15	Impact driving of IP6
2016-Jun-01	17:24	Attaching sensors
2016-Jun-01	17:45	Re-start impact driving of IP6
2016-Jun-01	18:38	Finished impact driving of IP6

A.7. IP7 Activity Logs

A.7.1. Log of JASCO Activities for IP7

Date (UTC)	Time (UTC)	Activity
2016-May-24	23:53	Calibrated AMAR 1 km
2016-May-25	01:00	Deployed AMAR 1 km
2016-May-25	15:16	Calibrated AMAR 10 m
2016-May-25	N/A	Deployed AMAR 10 m
2016-May-25	18:30	Calibrated drift system
2016-May-25	18:35	Drift recording of vibro piling
2016-May-25	20:58	Drift recording of impact piling
2016-May-25	22:39	Calibrated drift system
2016-May-25	23:31	Retrieved AMAR 1 km
2016-May-25	23:08	Retrieved AMAR 10 m
2016-May-26	00:01	Calibrated AMAR 2
2016-May-26	00:05	Calibrated AMAR 1

A.7.2. Log of Pile Driving Activities for IP7

Date (UTC)	Time (UTC)	Activity
2016-May-25	19:00	Soft start of vibratory driving of IP7
2016-May-25	19:09	Vibratory driving of IP7
2016-May-25	19:34	Finished vibratory driving of IP7
2016-May-25	21:31	Soft start of impact driving of IP7
2016-May-25	21:39	Impact driving of IP7
2016-May-25	22:13	Attaching sensors
2016-May-25	22:18	Re-start impact driving of IP7
2016-May-25	22:39	Finished impact driving of IP7

A.8. IP8 Activity Logs

A.8.1. Log of JASCO Activities for IP8

Date (UTC)	Time (UTC)	Activity
2016-May-01	20:36	Calibrated AMAR 1 km
2016-May-02	01:16	Deployed AMAR 1 km
2016-May-01	19:02	Calibrated AMAR 10 m
2016-May-02	17:56	Deployed AMAR 10 m
2016-May-03	24:00	Calibrated drift system
2016-May-04	00:11	Drift recording of vibro piling
2016-May-04	03:00	Drift recording of impact piling
2016-May-04	04:35	Calibrated drift system
2016-May-04	20:37	Retrieved AMAR 1 km
2016-May-04	N/A	Retrieved AMAR 10 m
2015-May-04	06:04	Calibrated AMAR 2
2016-May-04	22:12	Calibrated AMAR 1

A.8.2. Log of Pile Driving Activities for IP8

Date (UTC)	Time (UTC)	Activity
2016-May-04	00:42	Soft start of vibratory driving of IP8
2016-May-04	00:50	Vibratory driving of IP8
2016-May-04	01:03	Finished vibratory driving of IP8
2016-May-04	03:08	Soft start of impact driving of IP8
2016-May-04	03:10	Impact driving of IP8
2016-May-04	N/A	Attaching sensors
2016-May-04	03:21	Re-start impact driving of IP8
2016-May-04	04:30	Finished impact driving of IP8

A.9. IP9 Activity Logs

A.9.1. Log of JASCO Activities for IP9

Date (UTC)	Time (UTC)	Activity
2016-May-05	01:57	Calibrated AMAR 1 km
2016-May-05	N/A	Deployed AMAR 1 km
2016-May-05	03:01	Calibrated AMAR 10 m
2016-May-05	N/A	Deployed AMAR 10 m
2016-May-06	N/A	Calibrated drift system
2016-May-06	15:19	Drift recording of vibro piling
2016-May-07	18:47	Drift recording of impact piling
2016-May-07	19:24	Calibrated drift system
2016-May-07	20:35	Retrieved AMAR 1 km
2016-May-07	20:23	Retrieved AMAR 10 m
2016-May-07	21:42	Calibrated AMAR 2
2016-May-07	21:30	Calibrated AMAR 1

A.9.2. Log of Pile Driving Activities for IP9

Date (UTC)	Time (UTC)	Activity
2016-May-06	15:44	Soft start of vibratory driving of IP9
2016-May-06	15:49	Vibratory driving of IP9
2016-May-06	16:18	Finished vibratory driving of IP9
2016-May-07	18:48	Soft start of impact driving of IP9
2016-May-07	18:55	Impact driving of IP9
2016-May-07	N/A	Attaching sensors
2016-May-07	19:18	Re-start impact driving of IP9
2016-May-07	19:20	Finished impact driving of IP9

A.10. IP10 Activity Logs

A.10.1. Log of JASCO Activities for IP10

Date (UTC)	Time (UTC)	Activity
2016-May-26	13:43	Calibrated AMAR 1 km
2016-May-26	14:36	Deployed AMAR 1 km
2016-May-26	13:40	Calibrated AMAR 10 m
2016-May-26	16:28	Deployed AMAR 10 m
2016-May-26	18:59	Calibrated drift system
2016-May-26	19:04	Drift recording of vibro piling
2016-May-26	22:03	Drift recording of impact piling
2016-May-26	23:44	Calibrated drift system
2016-May-27	01:00	Retrieved AMAR 1 km
2016-May-27	00:50	Retrieved AMAR 10 m
2016-May-27	01:30	Calibrated AMAR 2
2016-May-27	01:33	Calibrated AMAR 1

A.10.2. Log of Pile Driving Activities for IP10

Date (UTC)	Time (UTC)	Activity
2016-May-26	19:14	Soft start of vibratory driving of IP10
2016-May-26	19:17	Vibratory driving of IP10
2016-May-26	19:50	Finished vibratory driving of IP10
2016-May-26	22:04	Soft start of impact driving of IP10
2016-May-26	22:08	Impact driving of IP10
2016-May-26	22:17	Adjusting sensors
2016-May-26	22:43	Re-start impact driving of IP10
2016-May-26	23:37	Finished impact driving of IP10

A.11. Ambient Measurements Activity Logs

A.11.1. Log of JASCO Activities for Ambient Monitoring

Date (UTC)	Time (UTC)	Activity
2016-May-27	20:10	Calibrated ambient dock AMAR
2016-May-27	20:17	Calibrated ambient offshore AMAR
2016-May-27	20:50	Deployed ambient offshore AMAR
2016-May-27	21:03	Deployed ambient dock AMAR
2016-May-27	21:27	Calibrated drift system
2016-May-27	21:41	Began ambient drift recordings
2016-May-27	23:29	Finished ambient drift recordings
2016-May-30	22:29	Calibrated drift system
2016-May-30	22:34	Began ambient drift recordings
2016-May-30	23:00	Finished ambient drift recordings
2016-May-30	23:01	Calibrated drift recordings
2016-May-30	23:16	Retrieved ambient offshore AMAR
2016-May-30	23:42	Retrieved ambient dock AMAR
2016-May-31	00:00	Calibrated ambient offshore AMAR
2016-May-31	00:08	Calibrated ambient dock AMAR

Appendix B. Drift Measurement Distances

B.1. IP1 Drift Measurement Distances

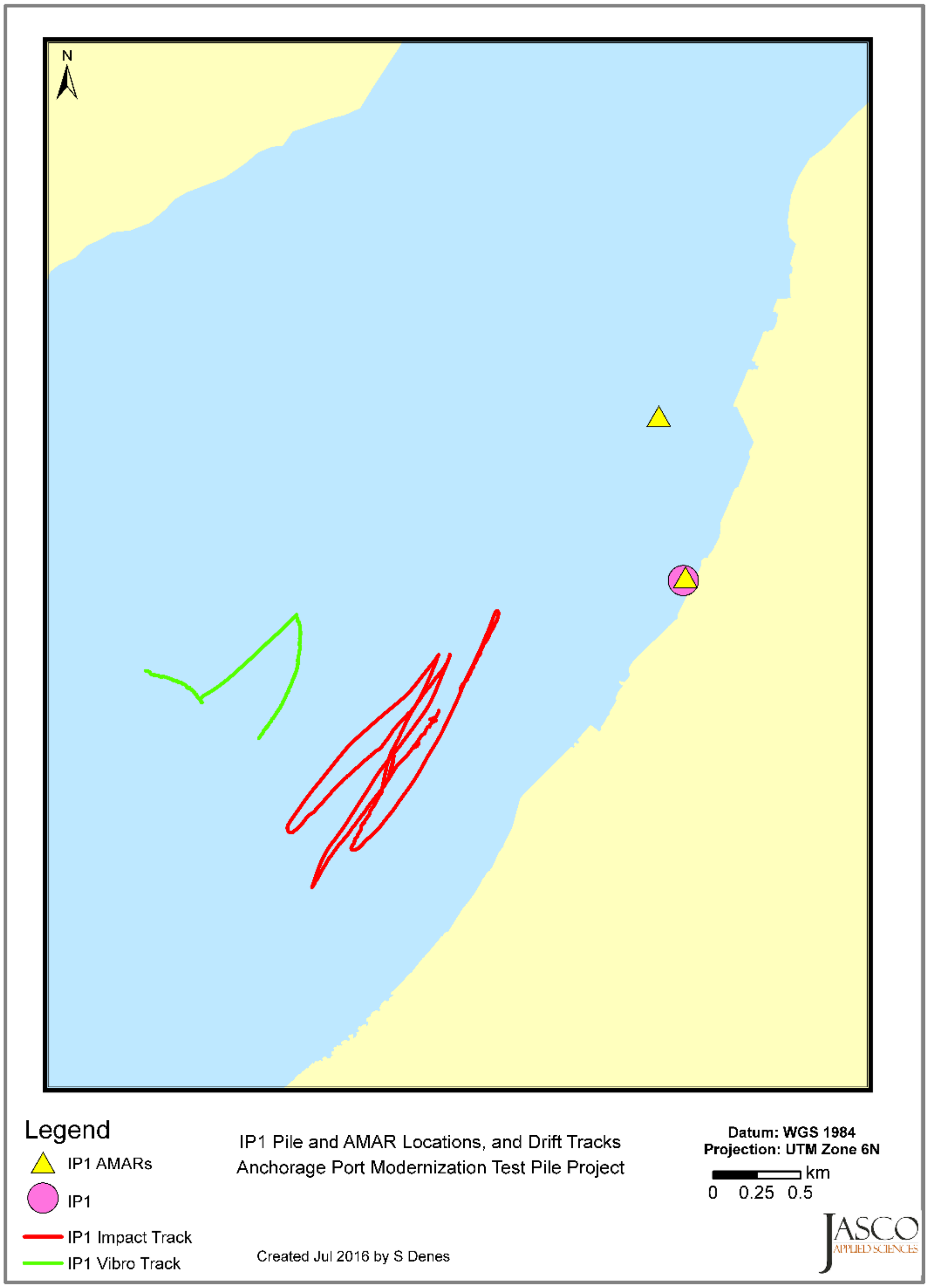

Figure B-1. Map of IP1 pile and AMAR locations, and drift tracks.

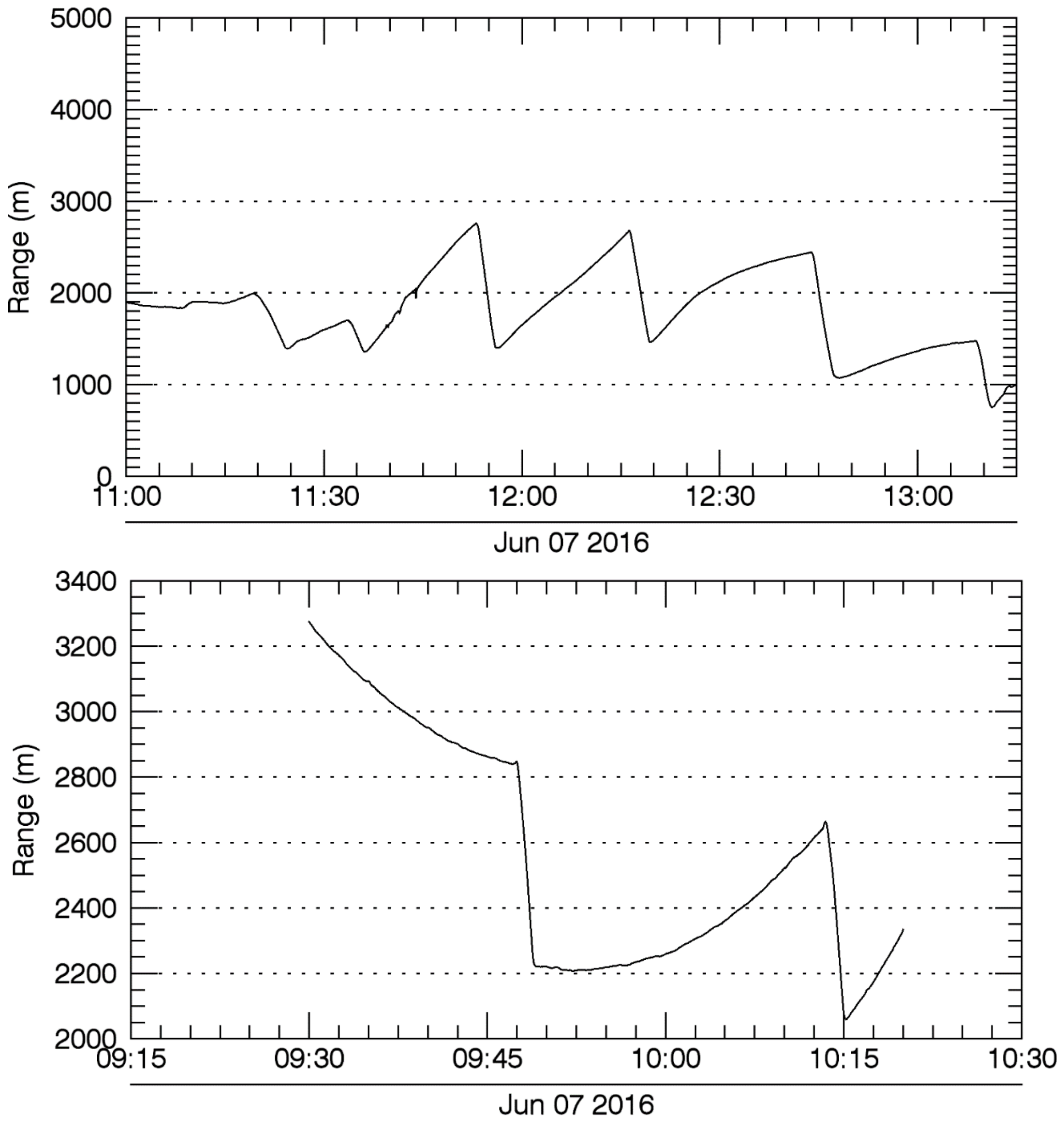

Figure B-2. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP1.

B.2. IP2 Drift Measurement Distances

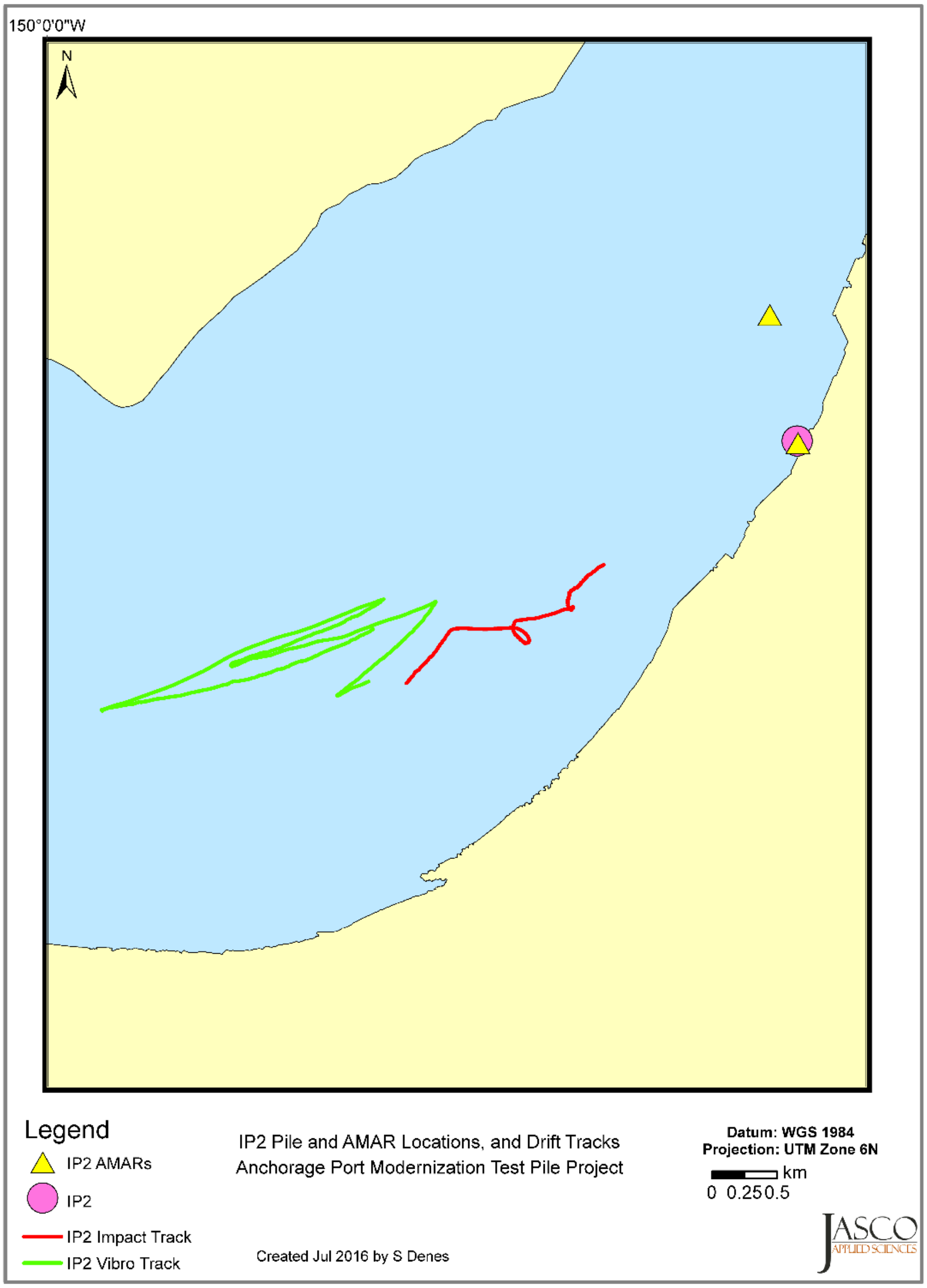

Figure B-3. Map of IP2 pile and AMAR locations, and drift tracks.

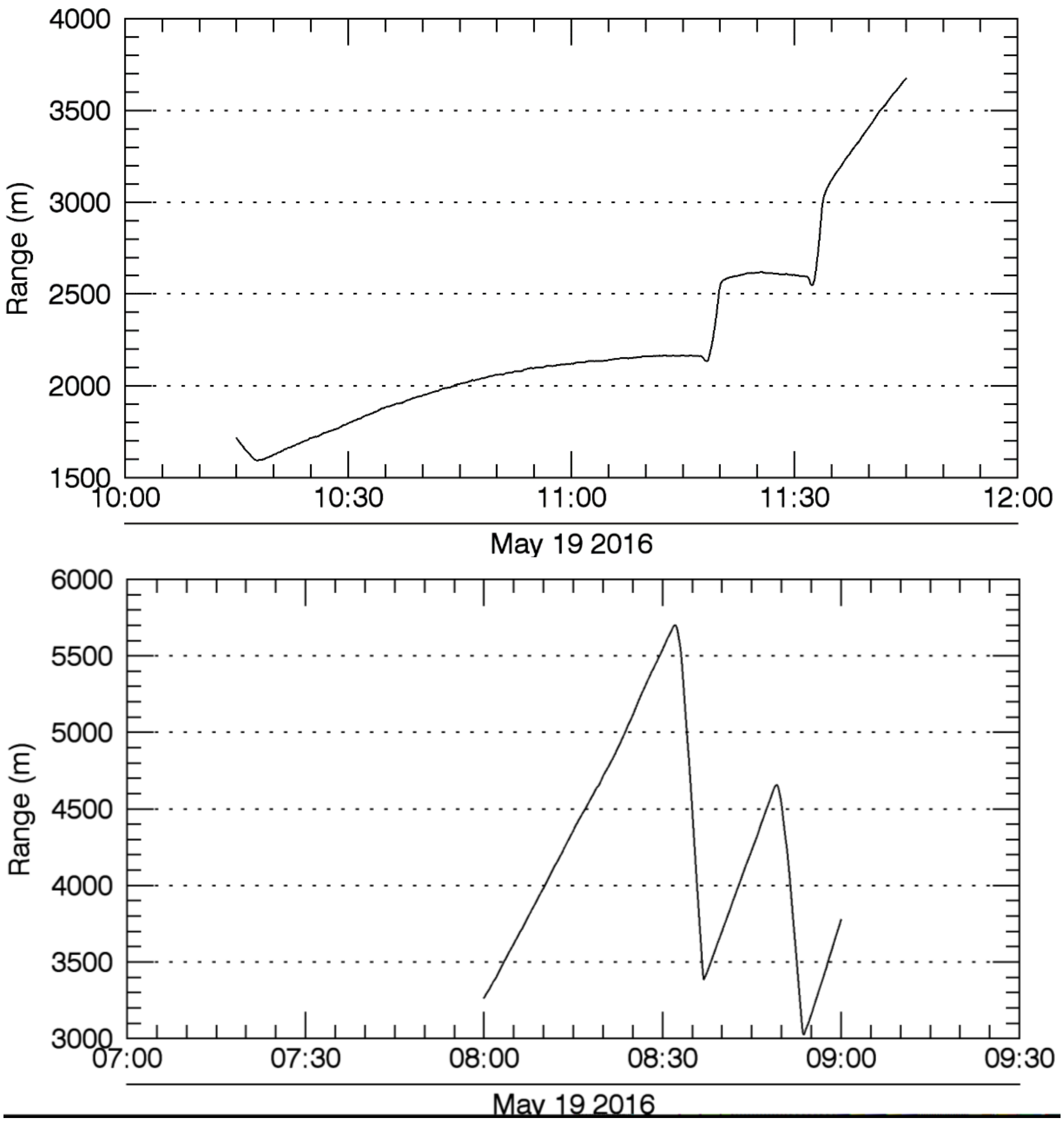

Figure B-4. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP2.

B.3. IP3 Drift Measurement Distances

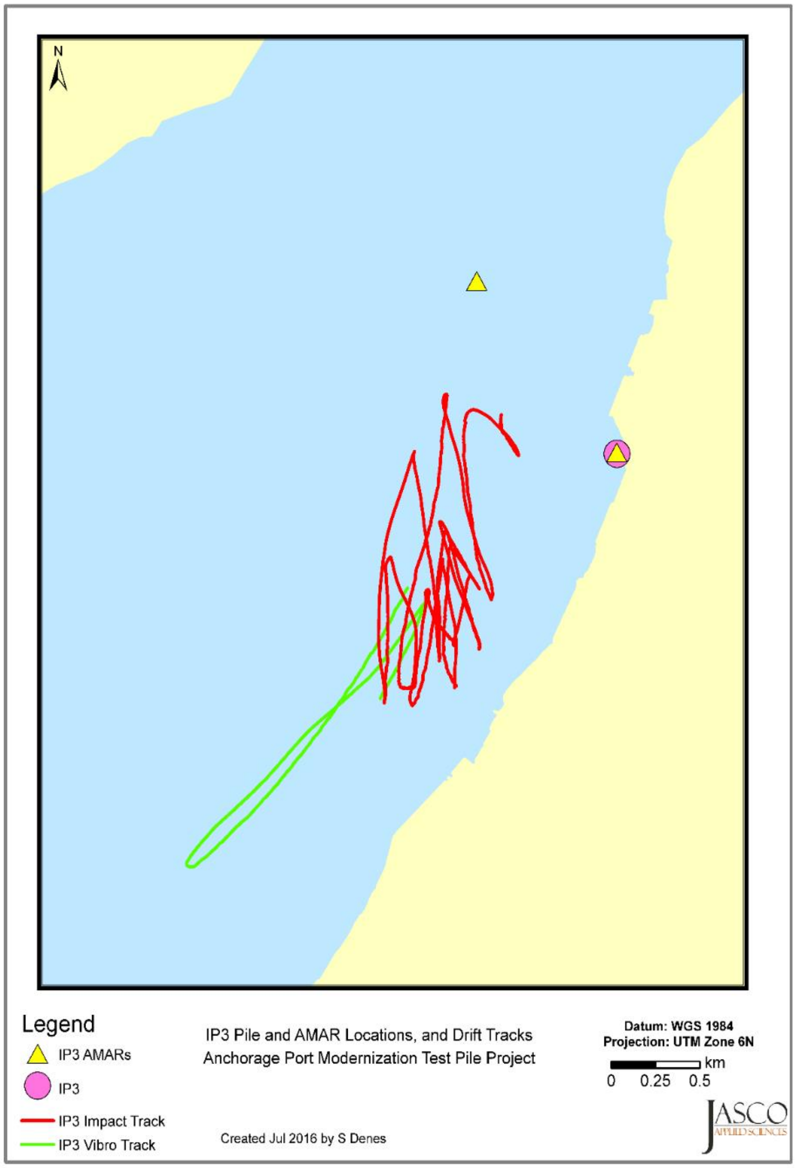

Figure B-5. Map of IP3 pile and AMAR locations, and drift tracks.

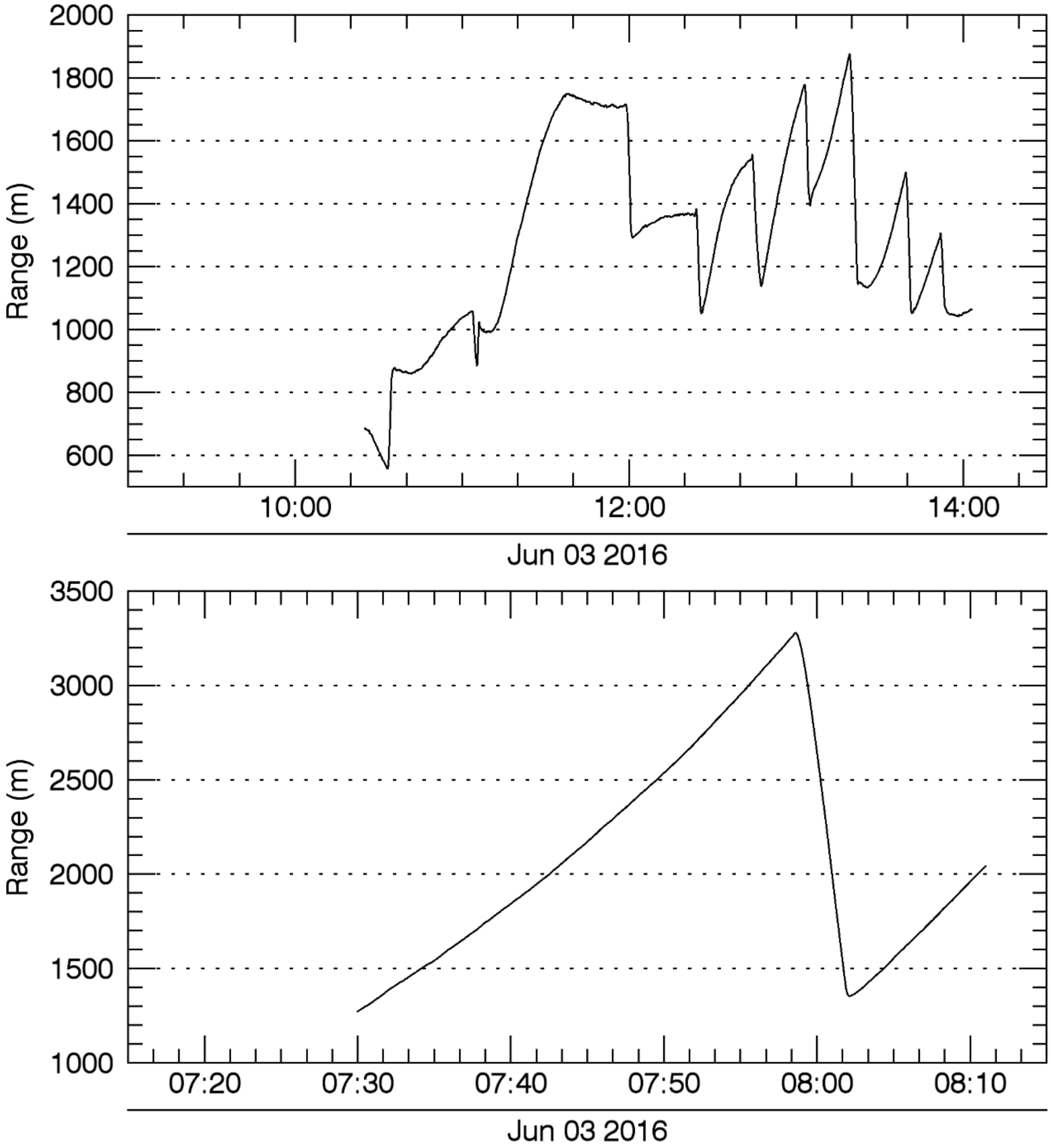

Figure B-6. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP3.

B.4. IP4 Drift Measurement Distances

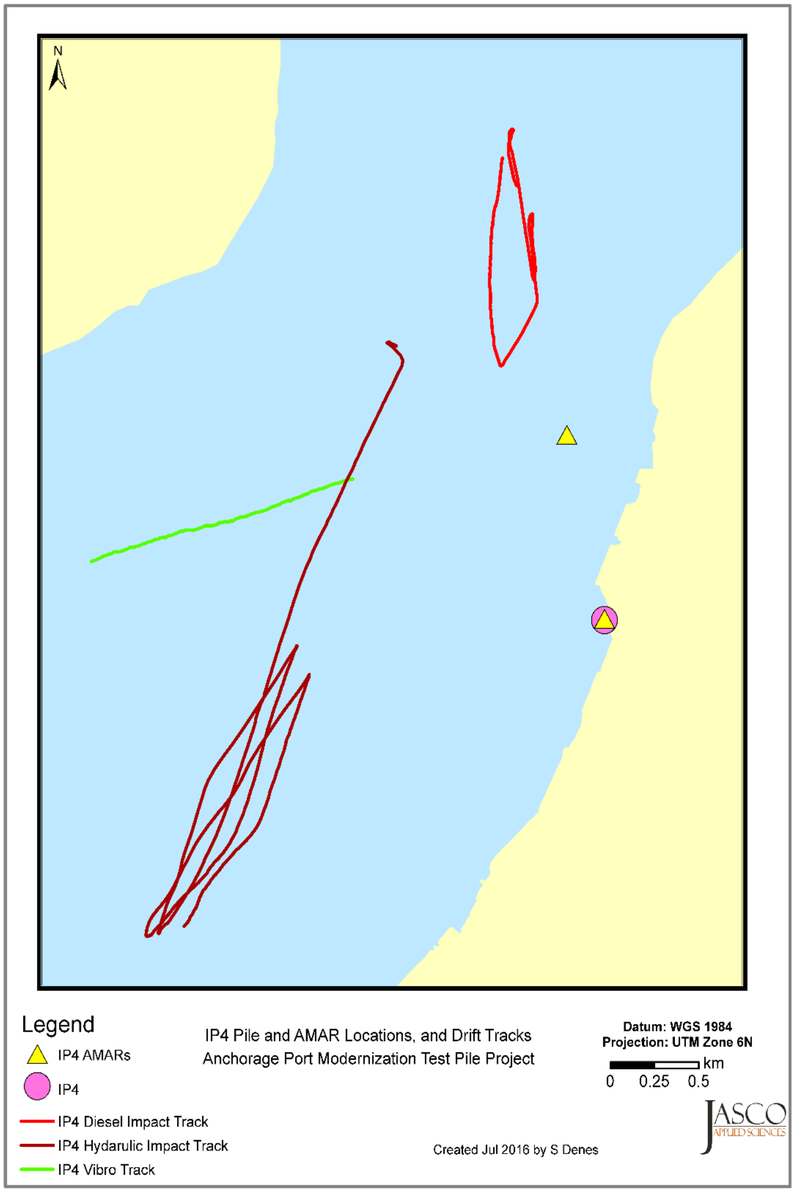

Figure B-7. Map of IP4 pile and AMAR locations, and drift tracks.

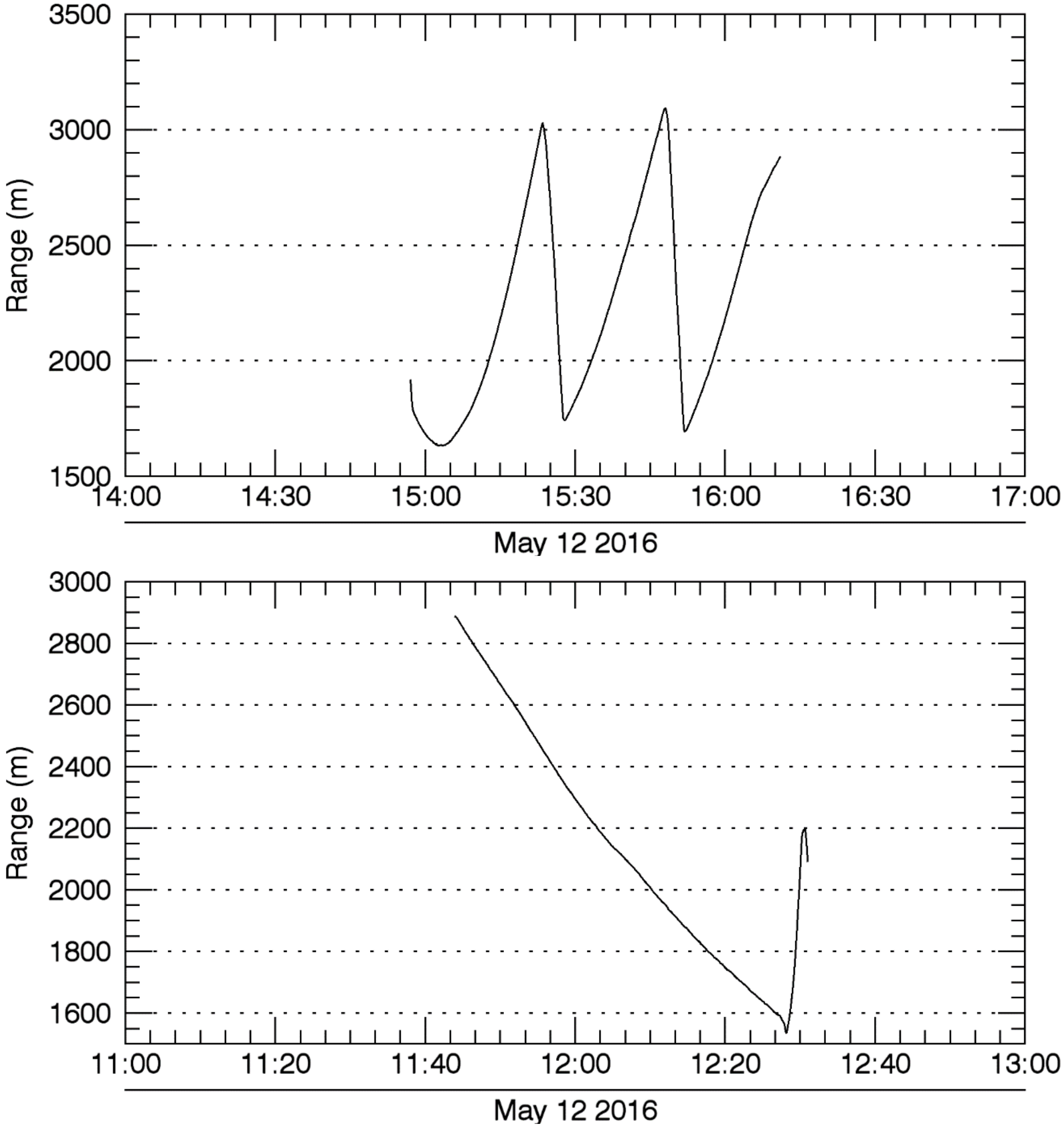

Figure B-8. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP4.

B.5. IP5 Drift Measurement Distances

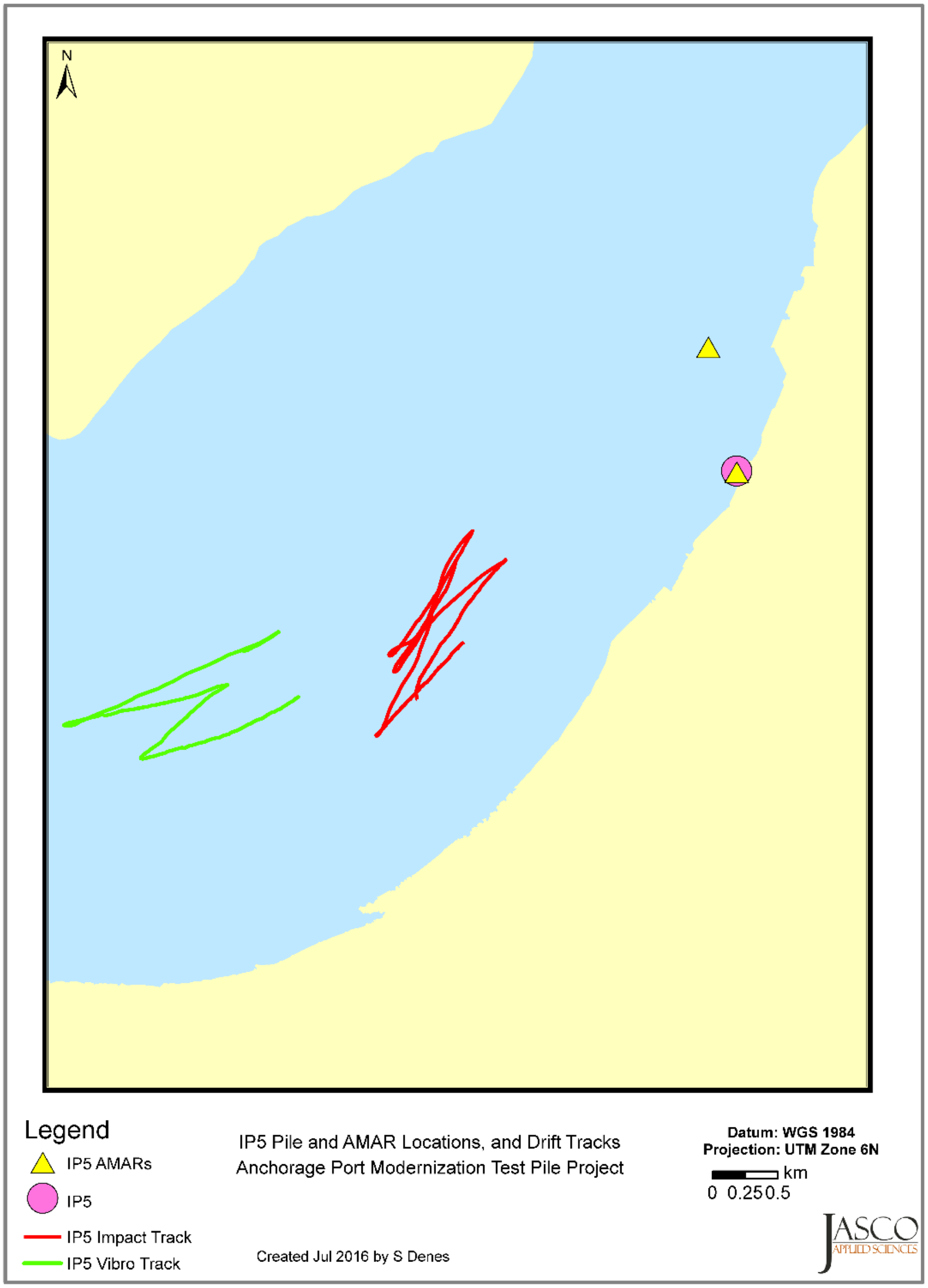

Figure B-9. Map of IP5 pile and AMAR locations, and drift tracks.

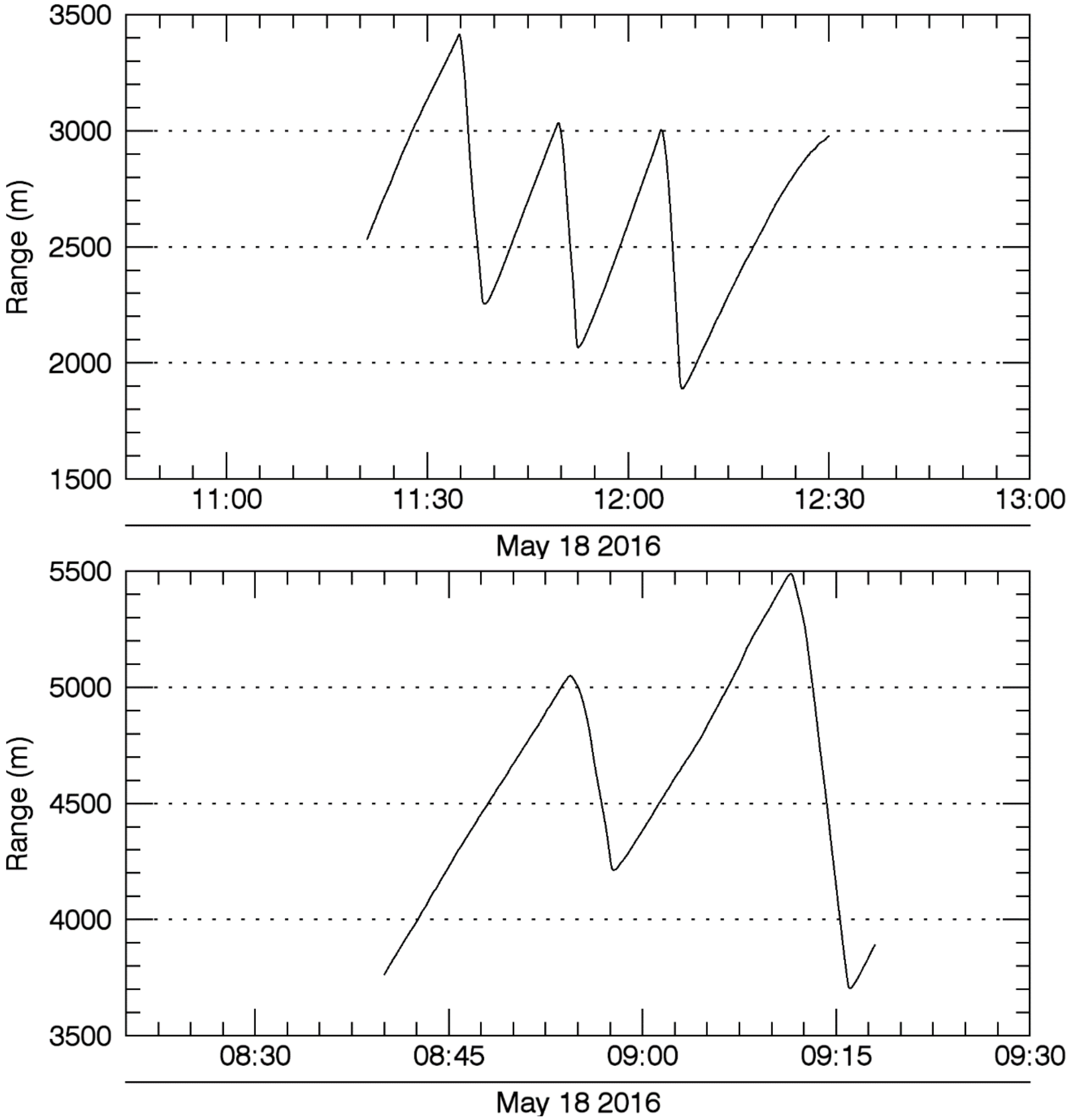

Figure B-10. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP5.

B.6. IP6 Drift Measurement Distances

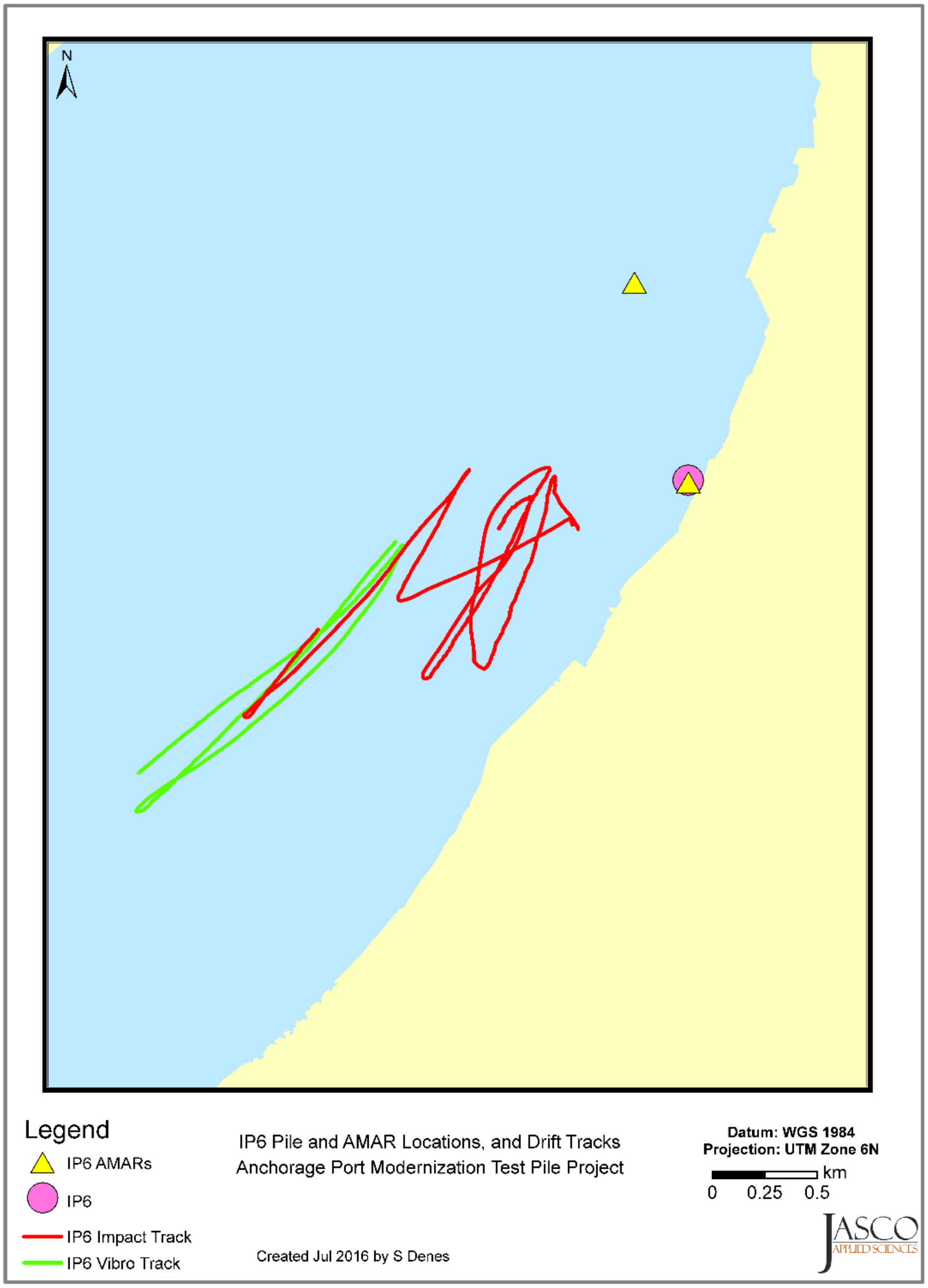

Figure B-11. Map of IP6 pile and AMAR locations, and drift tracks.

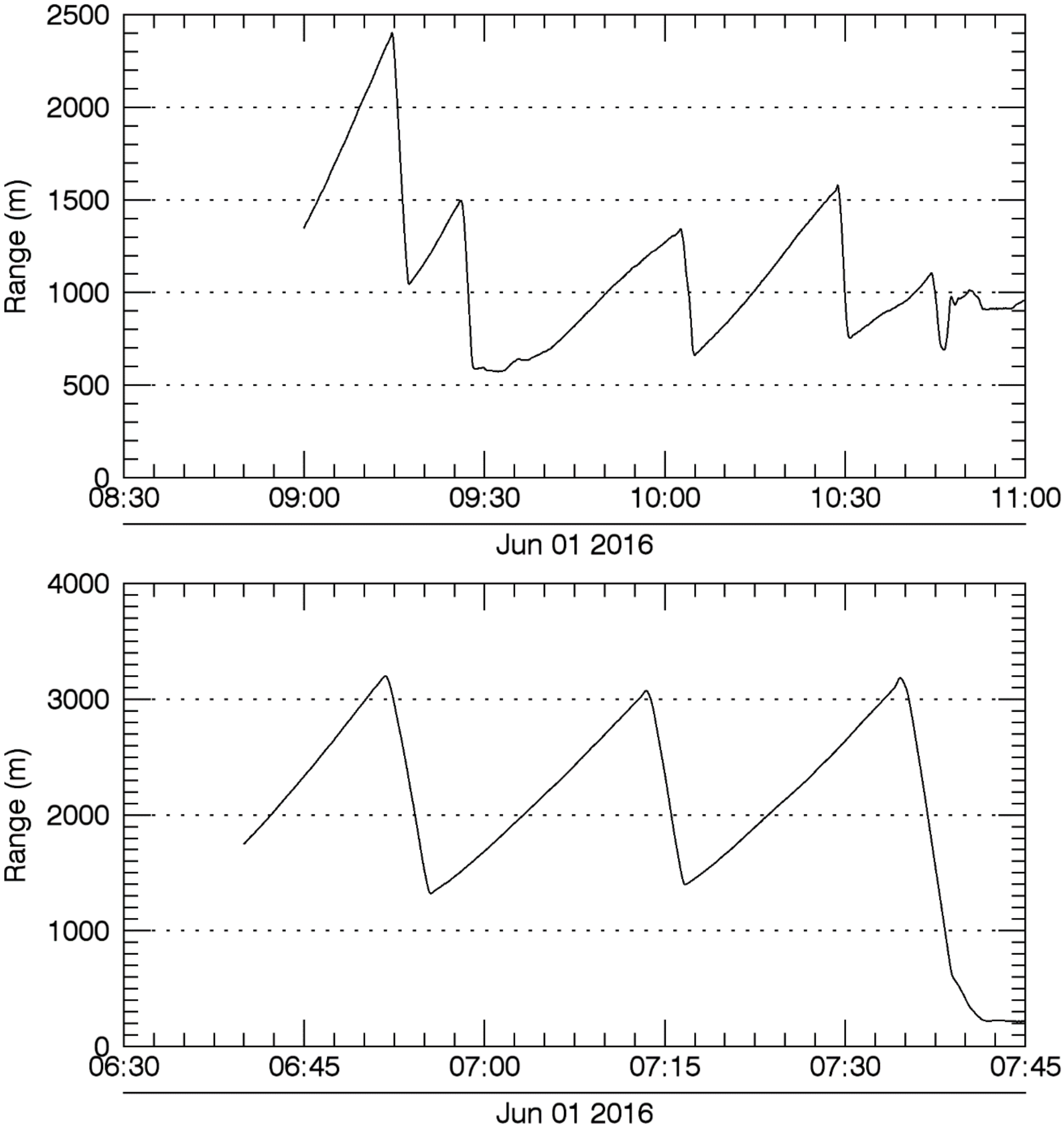

Figure B-12. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP6.

B.7. IP7 Drift Measurement Distances

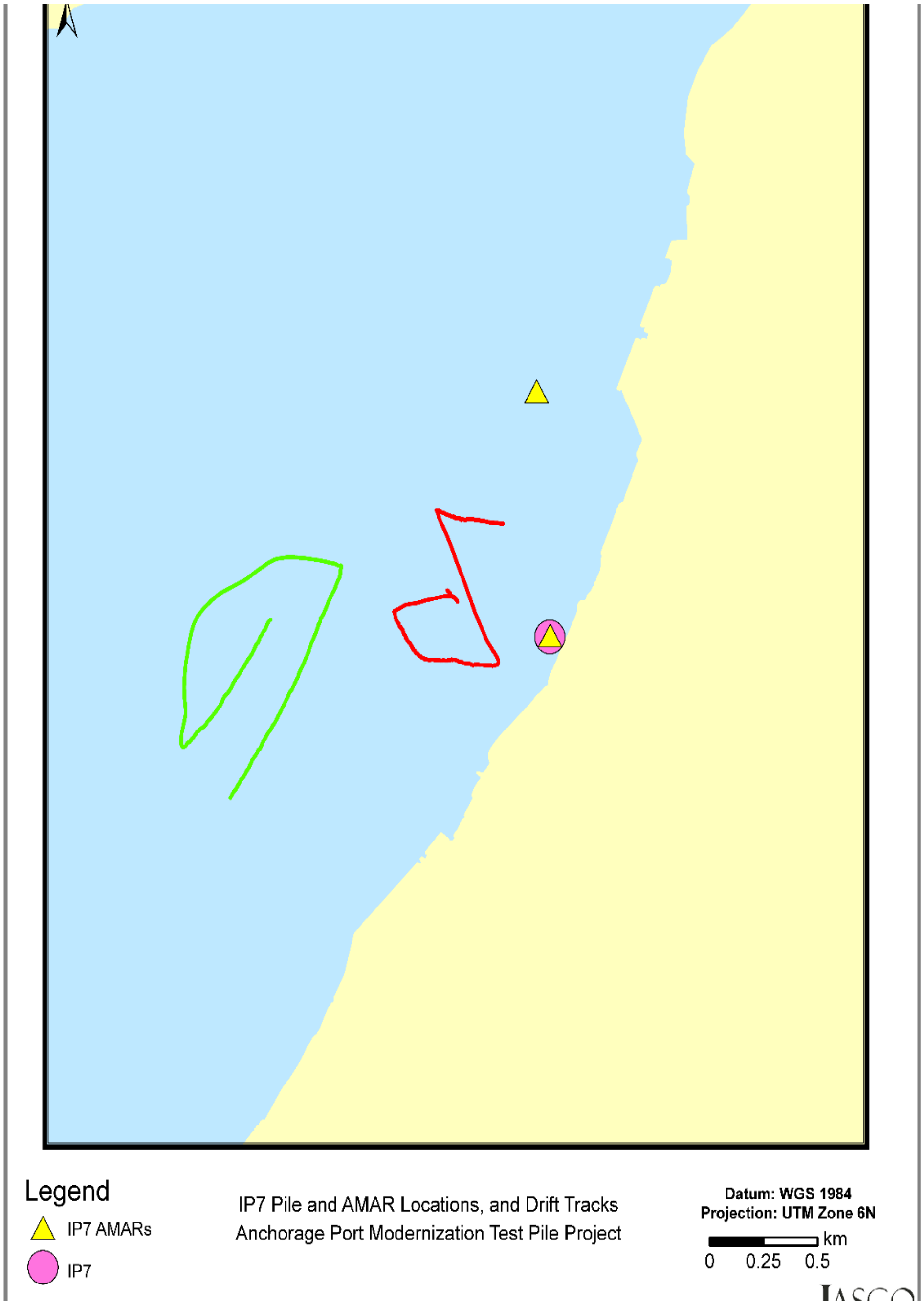

Figure B-13. Map of IP7 pile and AMAR locations, and drift tracks.

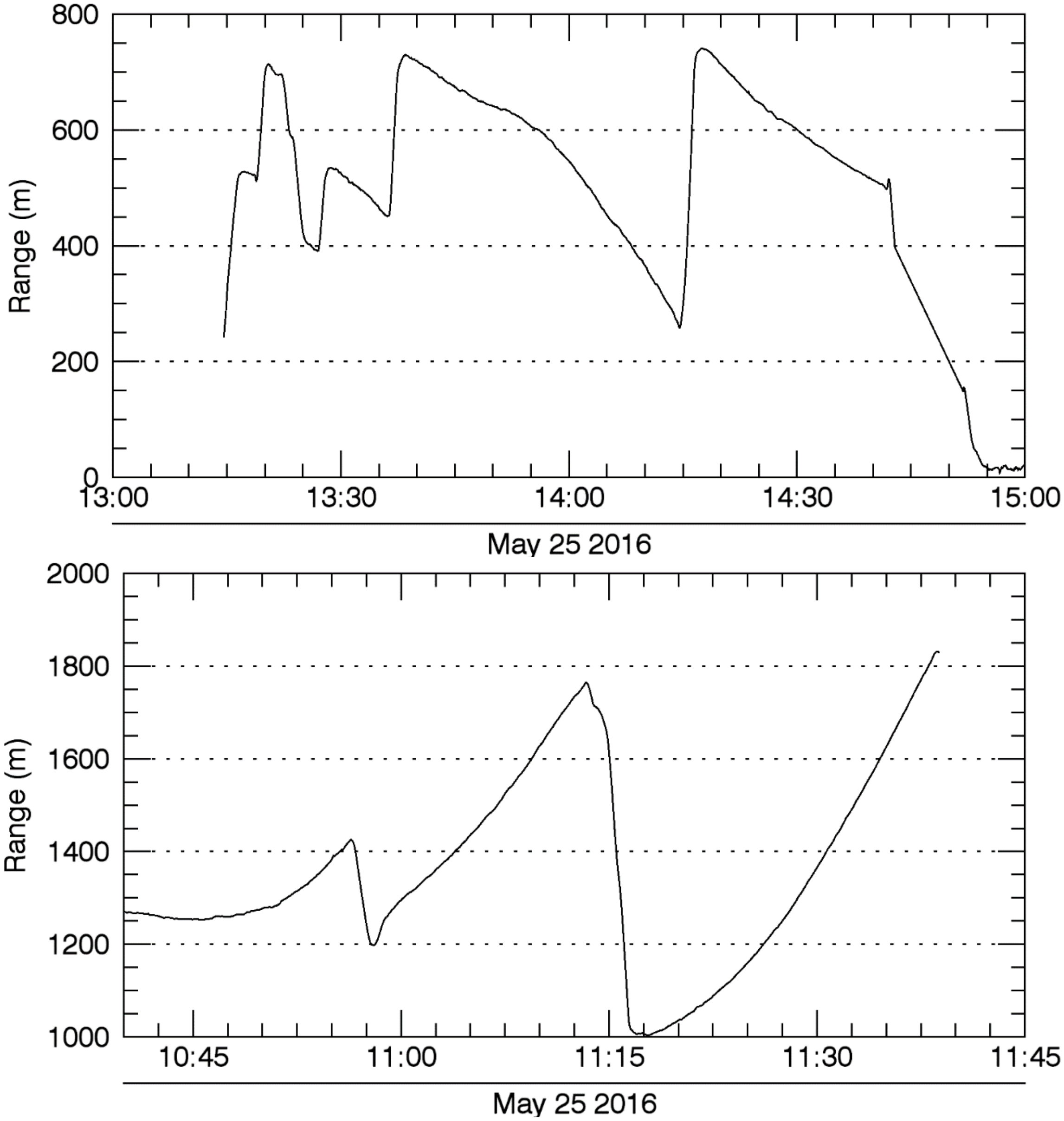

Figure B-14. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP7.

B.8. IP8 Drift Measurement Distances

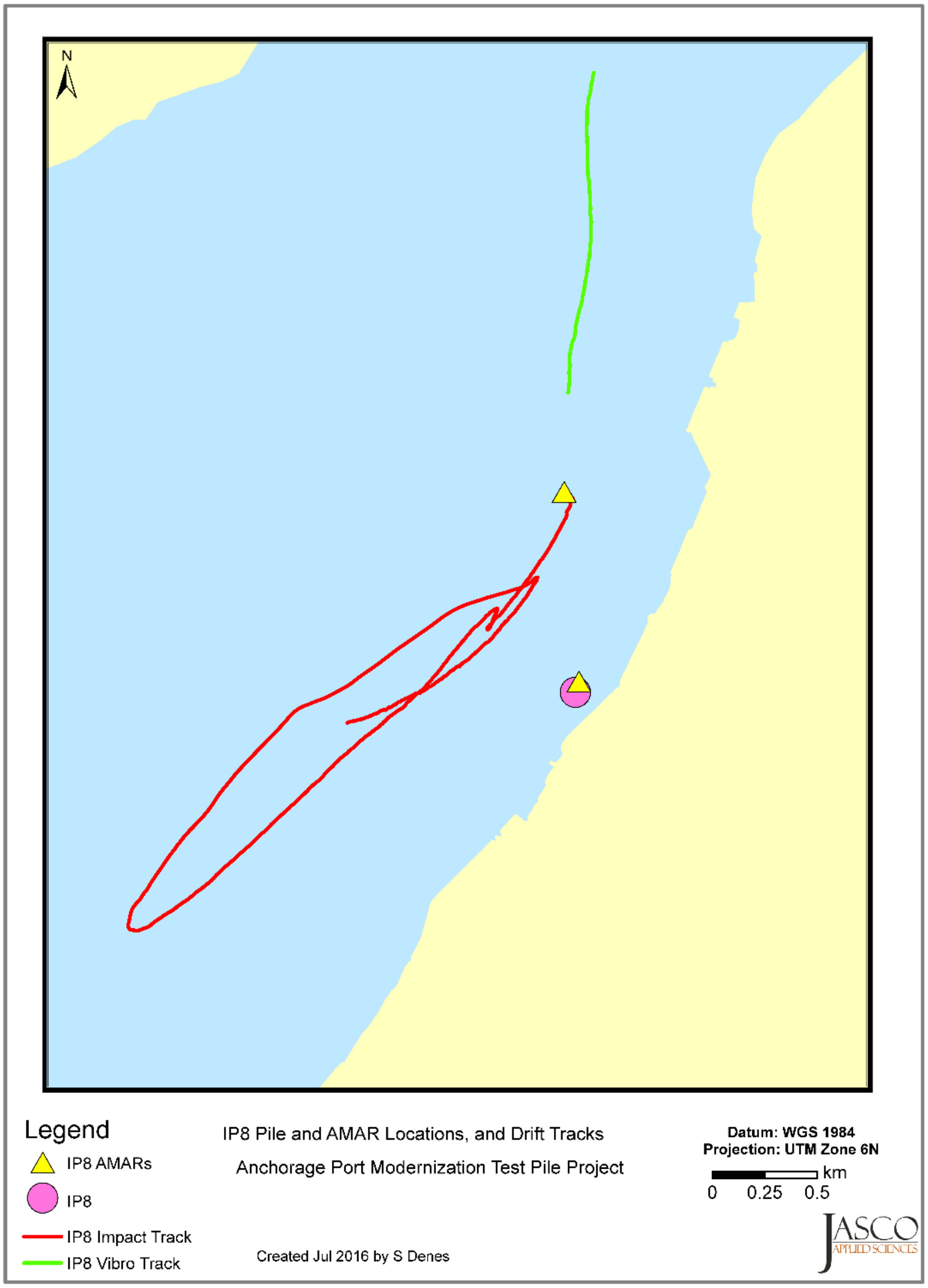

Figure B-15. Map of IP8 pile and AMAR locations, and drift tracks.

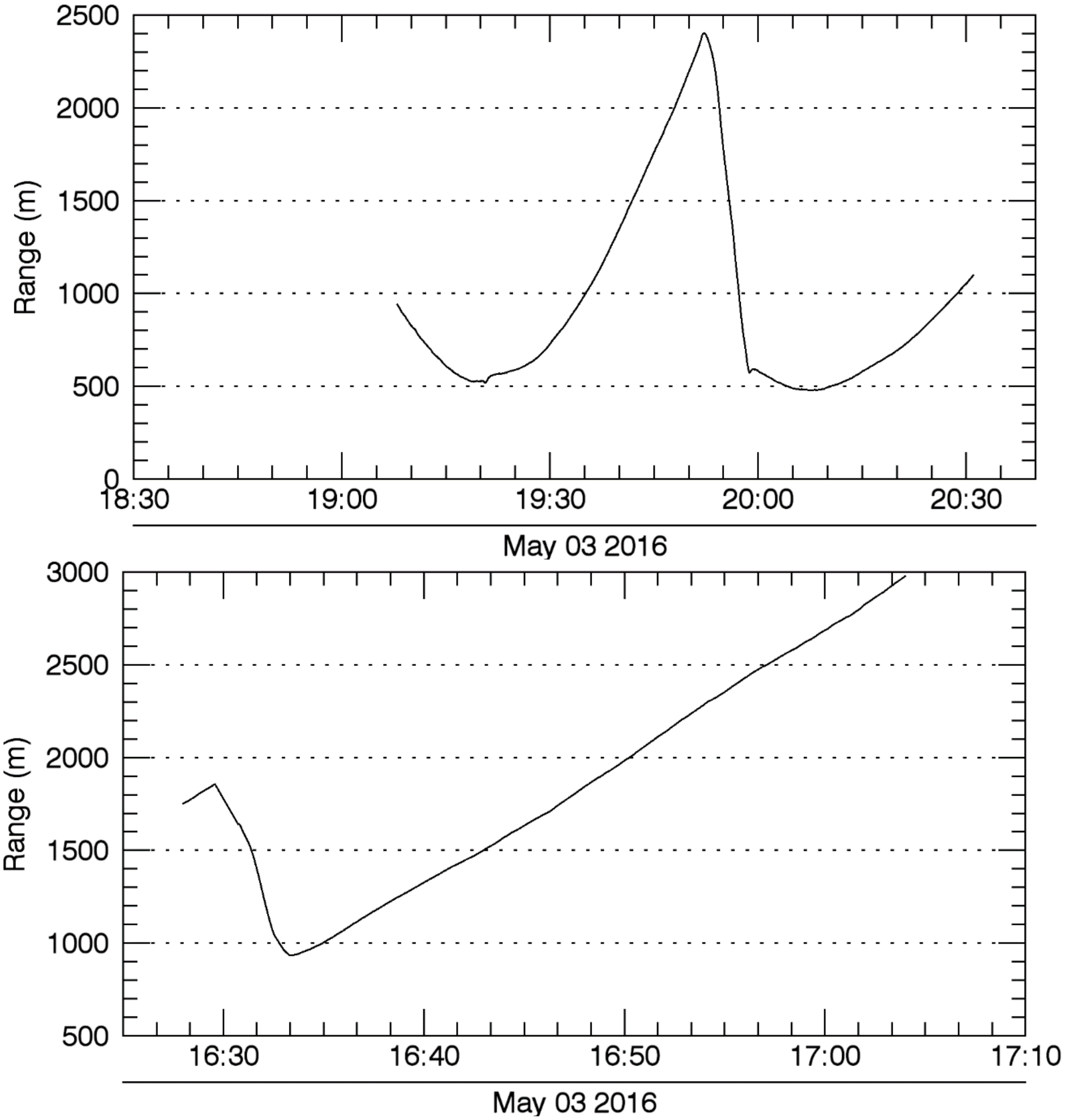

Figure 110. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP8.

B.9. IP9 Drift Measurement Distances

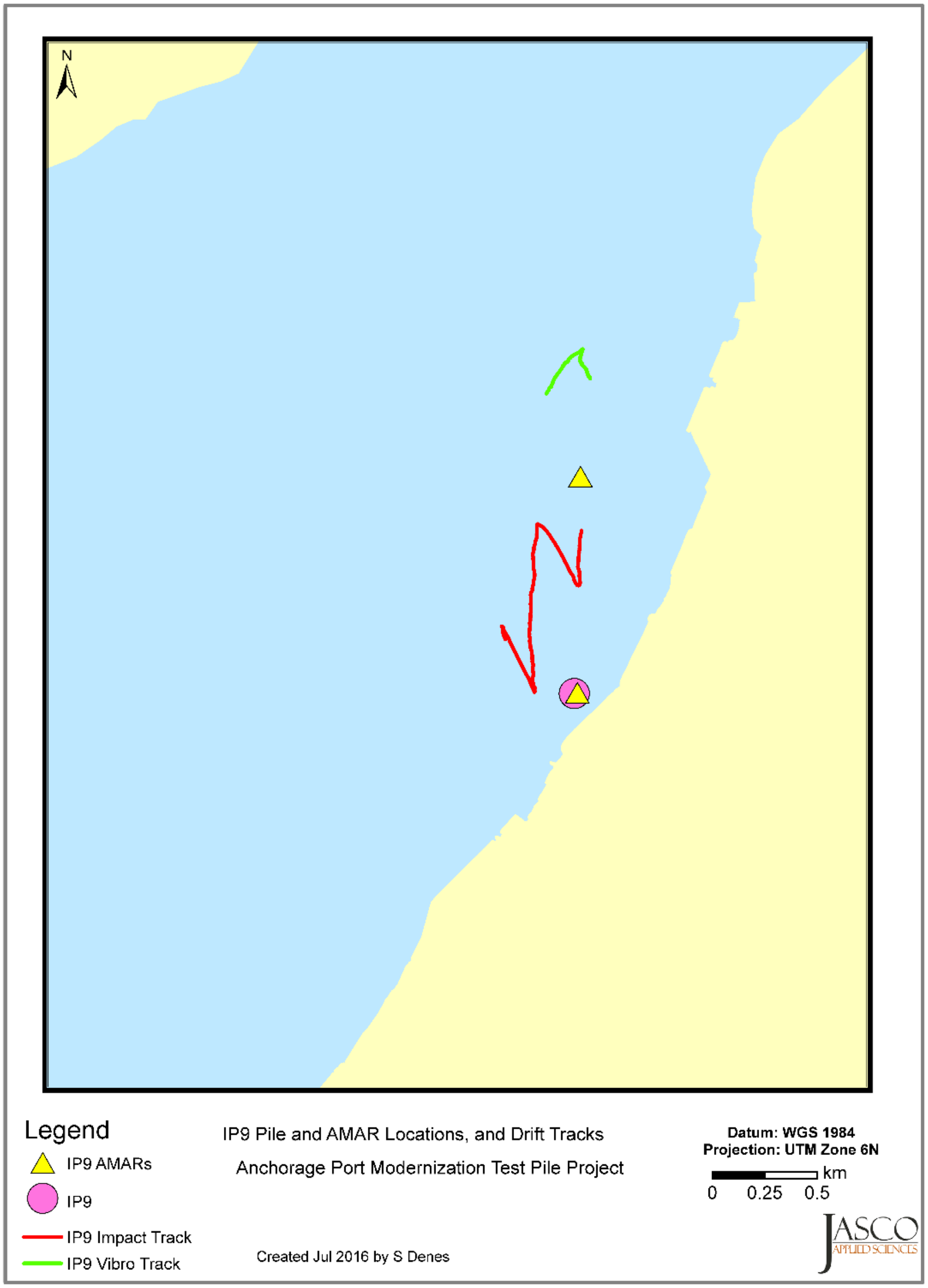

Figure B-16. Map of IP9 pile and AMAR locations, and drift tracks.

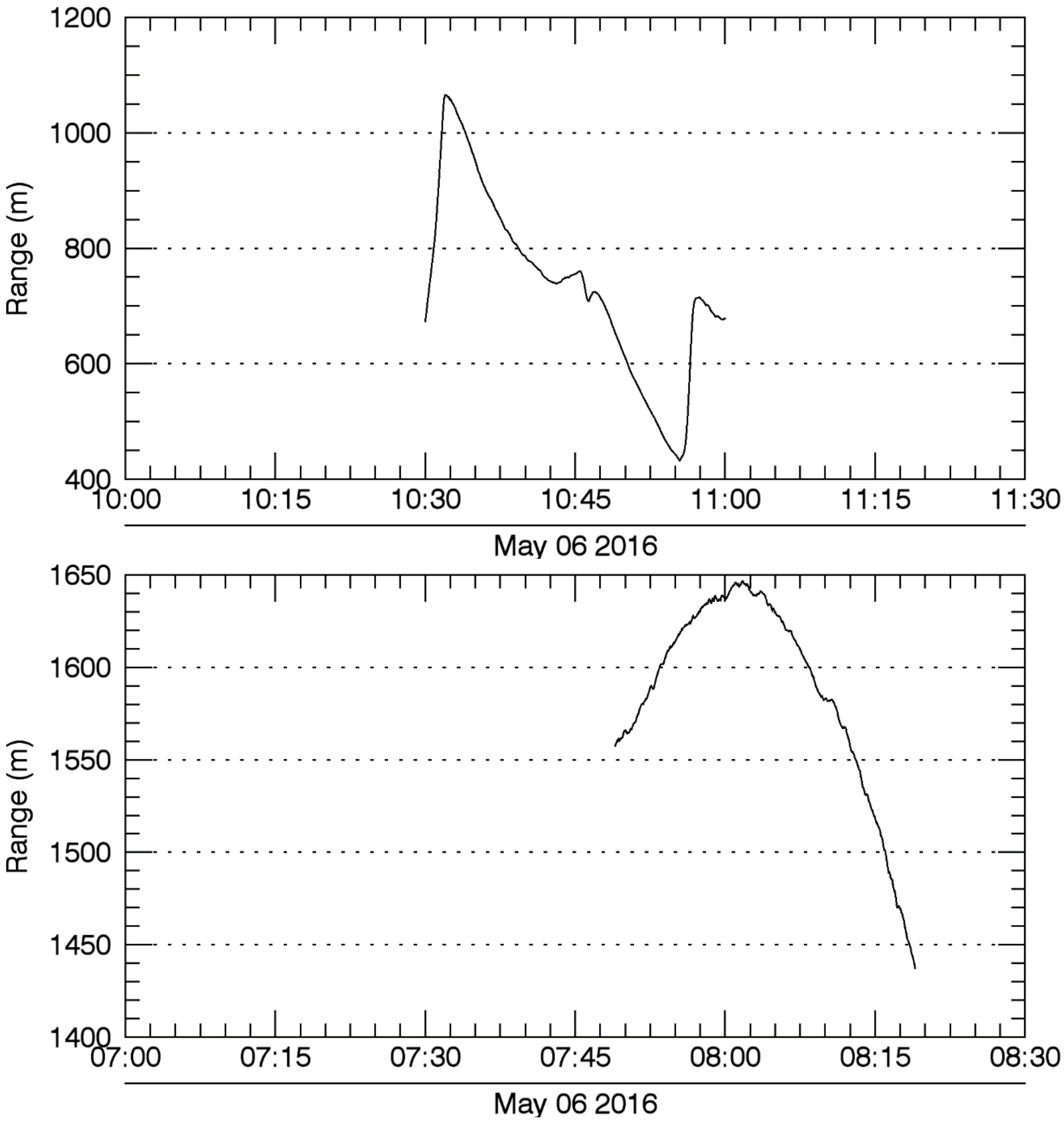

Figure B-17. Distances for drifting measurements during vibratory pile driving of Pile IP9.

B.10. IP10 Drift Measurement Distances

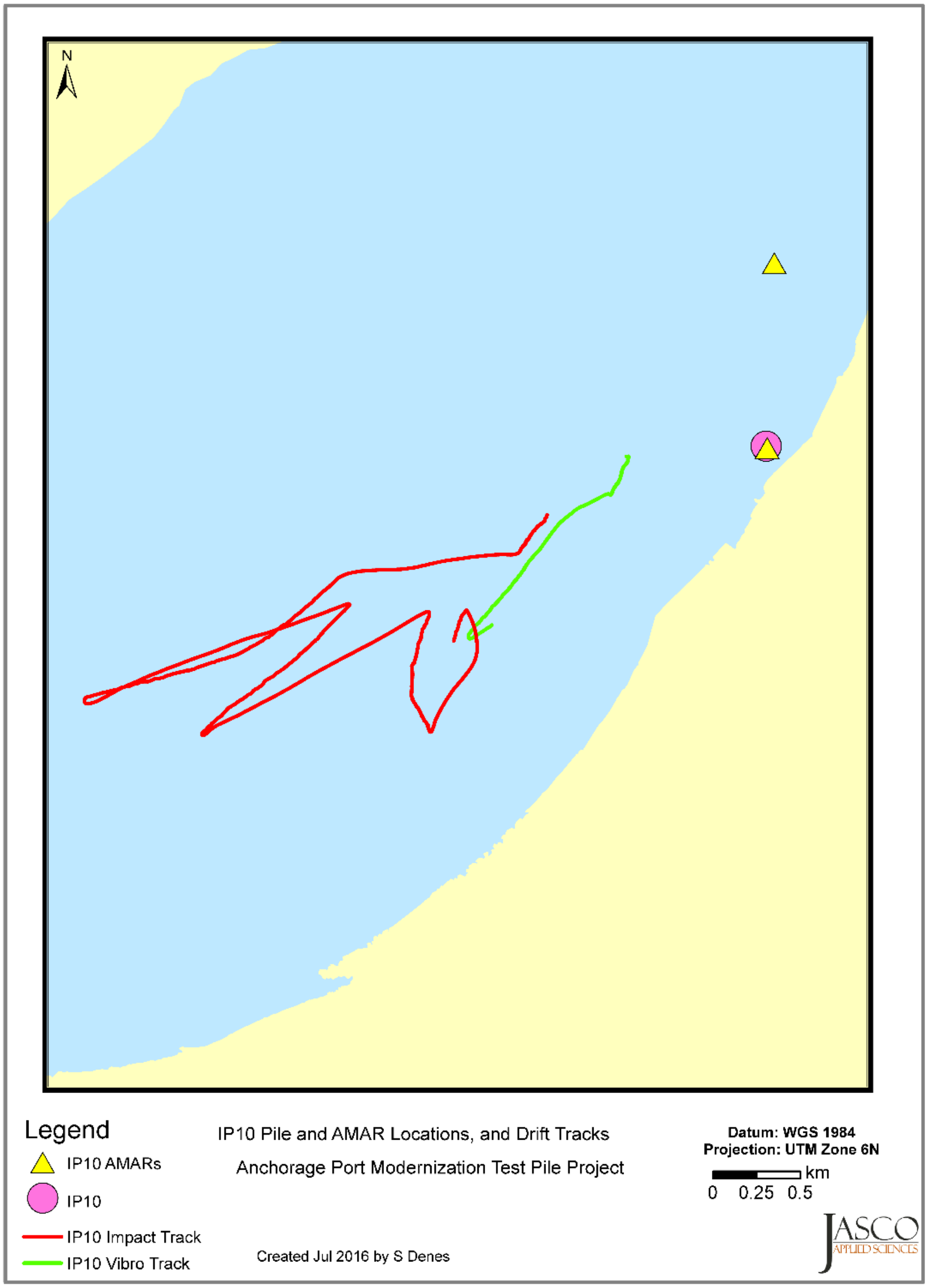

Figure B-18. Map of IP10 pile and AMAR locations, and drift tracks.

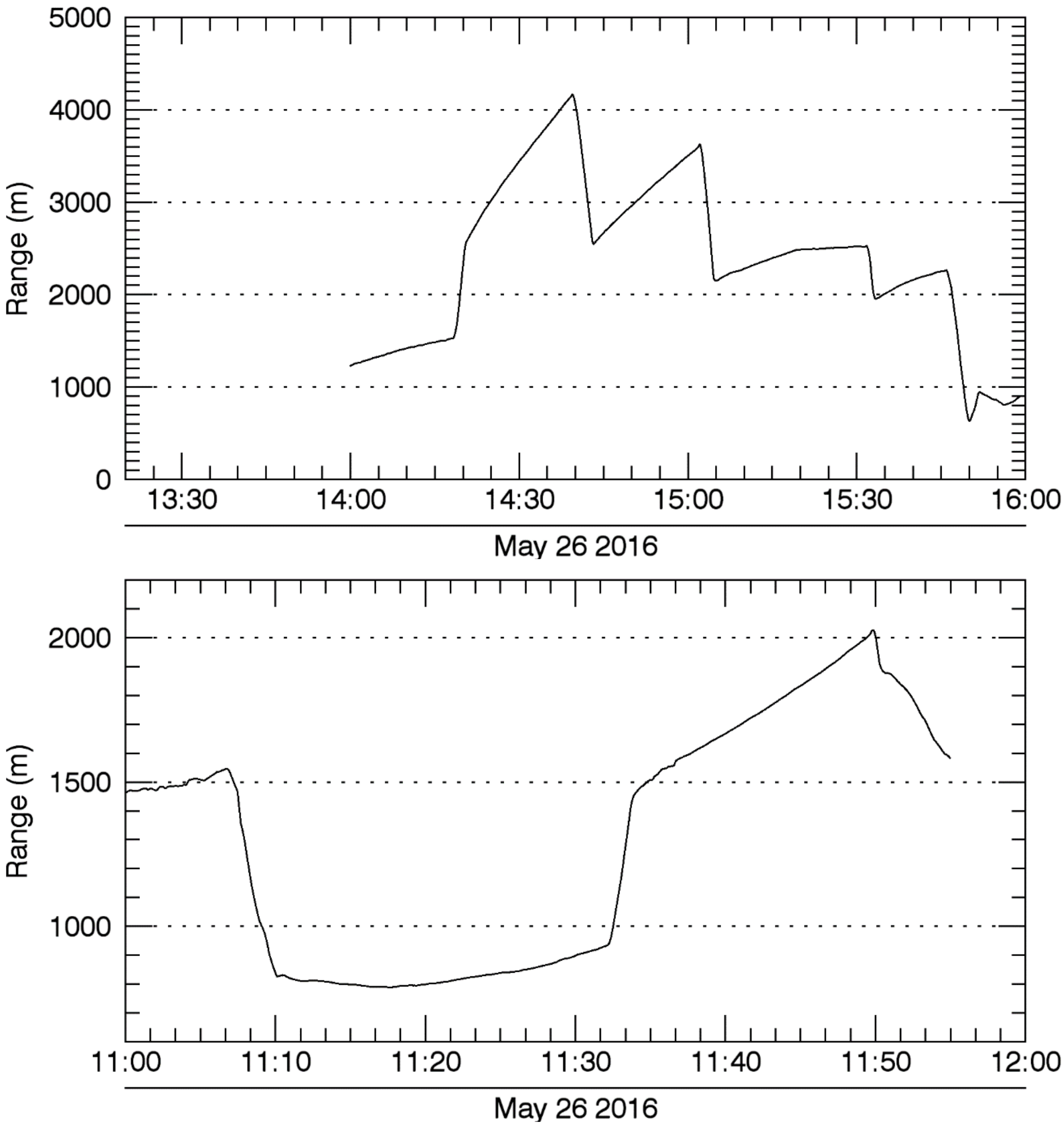

Figure B-19. Distances for drifting measurements during impact (top) and vibratory (bottom) pile driving of Pile IP10.

Appendix C. M-Weighted Pile Driving Statistics

C.1. M-weighted Impulse Statistics

C.1.1. SEL statistics

Table C-1. Statistics of low-frequency cetacean M-weighted single-strike SEL for impact pile driving. R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

	Sound level (dB re 1 $\mu Pa^2 \cdot s$)											
AMAR-10M												
	IP1 R = 14 m n = 2153	**IP2 R = 11 m n = 1504**	**IP3 R = 12 m n = 4801**	**IP4(H) R = 10 m n = 1626**	**IP4(D) R = 10 m n = 1218**	**IP5 R = 11 m n = 1213**	**IP6(off) R = 12 m n = 1246**	**IP6(on) R = 12 m n = 1087**	**IP7 R = 12 m n = 1427**	**IP8 R = 17 m n = 2000**	**IP9 R = 17 m n = 845**	**IP10 R = 12 m n = 1459**
Mean	183.6	175.4	173.9	182.6	179.3	183.9	182.6	179.5	174.4	177.7	180.2	171.2
Median	183.6	175.0	173.5	182.4	178.3	184.4	182.6	178.7	173.5	177.7	179.9	171.0
Max	185.1	180.7	178.6	184.6	182.8	188.0	185.4	183.2	179.1	180.0	184.0	174.1
90th percentile	184.6	177.9	175.8	183.9	181.3	185.6	183.7	182.0	177.3	178.7	181.7	172.9
Cumulative	216.9	207.1	210.7	214.7	210.2	214.7	213.6	209.8	206.0	210.7	209.5	202.9
AMAR-1KM												
	IP1 R = 959 m n = 2151	**IP2 R = 943 m n = 1499**	**IP3 R = 1182 m n = 4721**	**IP4(H) R = 1008 m n = 1634**	**IP4(D) R = 1008 m n = 1214**	**IP5 R = 968 m n = 1207**	**IP6(off) R = 977 m n = 1248**	**IP6(on) R = 977 m n = 1087**	**IP7 R = 1013 m n = 1428**	**IP8 R = 960 m n = 1999**	**IP9 R = 1037 m n = 840**	**IP10 R = 1064m n = 1463**
Mean	150.0	147.9	144.8	141.3	140.3	151.7	146.9	145.9	144.6	153.5	154.7	154.9
Median	150.1	147.1	144.8	141.0	139.5	152.4	147.0	145.8	143.7	153.4	154.3	154.7
Max	151.8	153.5	147.0	144.2	144.3	157.6	149.0	148.7	149.8	156.1	158.1	156.5
90th percentile	150.9	150.8	145.9	143.4	142.2	153.2	147.9	148.0	147.4	154.6	156.0	155.6
Cumulative	183.3	179.7	181.5	173.4	171.1	182.5	177.9	176.3	176.1	186.5	183.9	186.5

Table C-2. Statistics of mid-frequency cetacean M-weighted single-strike SEL for impact pile driving. R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

	Sound level (dB re 1 $\mu\text{Pa}^2\cdot\text{s}$)											
AMAR-10M												
	IP1 R = 14 m n = 2153	**IP2 R = 11 m n = 1504**	**IP3 R = 12 m n = 4801**	**IP4(H) R = 10 m n = 1626**	**IP4(D) R = 10 m n = 1218**	**IP5 R = 11 m n = 1213**	**IP6(off) R = 12 m n = 1246**	**IP6(on) R = 12 m n = 1087**	**IP7 R = 12 m n = 1427**	**IP8 R = 17 m n = 2000**	**IP9 R = 17 m n = 845**	**IP10 R = 12 m n = 1459**
Mean	164.3	158.7	146.4	160.4	161.9	165.3	163.7	157.6	152.5	157.7	159.3	147.0
Median	154.3	158.1	145.7	160.0	161.3	165.3	163.7	156.2	150.8	157.9	157.3	144.8
Max	166.9	164.7	151.4	163.3	168.2	169.4	167.4	162.1	160.5	160.2	164.0	155.9
90th percentile	165.8	160.7	148.8	162.0	164.8	168.0	164.9	160.6	156.1	158.9	162.4	150.3
Cumulative	197.6	190.5	183.2	192.5	192.7	196.1	194.6	188.0	184.1	190.7	188.6	178.6
AMAR-1KM												
	IP1 R = 959 m n = 2151	**IP2 R = 943 m n = 1499**	**IP3 R = 1182 m n = 4721**	**IP4(H) R = 1008 m n = 1634**	**IP4(D) R = 1008 m n = 1214**	**IP5 R = 968 m n = 1207**	**IP6(off) R = 977 m n = 1248**	**IP6(on) R = 977 m n = 1087**	**IP7 R = 1013 m n = 1428**	**IP8 R = 960 m n = 1999**	**IP9 R = 1037 m n = 840**	**IP10 R = 1064m n = 1463**
Mean	118.3	116.9	107.1	103.6	100.2	123.6	115.1	110.4	108.3	1523.6	116.3	112.6
Median	118.3	116.0	107.0	103.2	99.0	123.4	114.9	110.7	107.1	123.4	115.6	112.7
Max	120.5	122.7	117.7	106.2	104.3	127.3	118.2	117.3	113.4	127.0	120.8	114.2
90th percentile	119.8	119.2	108.0	105.5	102.6	125.9	116.8	112.0	111.4	125.0	118.3	113.3
Cumulative	151.6	148.6	143.8	135.8	131.1	154.4	146.1	140.7	139.9	156.6	145.5	144.3

Table C-3. Statistics of high-frequency cetacean M-weighted single-strike SEL for impact pile driving. R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

	Sound level (dB re 1 µPa²·s)											
AMAR-10M												
	IP1 R = 14 m n = 2153	**IP2 R = 11 m n = 1504**	**IP3 R = 12 m n = 4801**	**IP4(H) R = 10 m n = 1626**	**IP4(D) R = 10 m n = 1218**	**IP5 R = 11 m n = 1213**	**IP6(off) R = 12 m n = 1246**	**IP6(on) R = 12 m n = 1087**	**IP7 R = 12 m n = 1427**	**IP8 R = 17 m n = 2000**	**IP9 R = 17 m n = 865**	**IP10 R = 12 m n = 1459**
Mean	161.3	156.3	141.2	157.5	159.2	162.9	160.4	153.9	149.1	154.8	156.5	143.5
Median	175.3	155.7	140.3	157.2	158.7	162.9	160.4	151.9	147.0	154.9	154.5	140.9
Max	163.9	162.5	147.3	160.7	166.0	167.1	164.6	159.4	157.4	157.5	161.3	153.1
90th percentile	162.8	158.3	143.9	159.2	162.2	165.7	161.8	157.1	153.2	155.9	159.7	147.0
Cumulative	194.7	188.1	178.1	189.6	190.1	193.7	191.4	184.2	180.7	187.8	185.8	175.1
AMAR-1KM												
	IP1 R = 959 m n = 2151	**IP2 R = 943 m n = 1499**	**IP3 R = 1182 m n = 4721**	**IP4(H) R = 1008 m n = 1634**	**IP4(D) R = 1008 m n = 1214**	**IP5 R = 968 m n = 1207**	**IP6(off) R = 977 m n = 1248**	**IP6(on) R = 977 m n = 1087**	**IP7 R = 1013 m n = 1428**	**IP8 R = 960 m n = 1999**	**IP9 R = 1037 m n = 840**	**IP10 R = 1064m n = 1463**
Mean	110.5	111.3	99.6	96.2	94.1	118.7	108.9	103.2	101.0	117.9	108.3	103.4
Median	110.5	110.6	98.9	95.6	93.2	118.5	108.9	103.5	99.6	116.8	107.4	103.3
Max	112.8	117.7	114.9	99.9	98.5	122.8	112.3	112.4	106.8	121.6	112.8	107.5
90th percentile	112.1	113.1	100.5	98.1	96.5	121.2	110.6	104.8	104.1	119.7	110.6	104.3
Cumulative	143.8	143.1	136.4	128.3	124.9	149.6	139.9	133.5	132.6	150.9	137.6	135.0

Table C-4. Statistics of phocid pinniped M-weighted single-strike SEL for impact pile driving R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

	Sound level (dB re 1 $\mu\text{Pa}^2\cdot\text{s}$)											
AMAR-10M												
	IP1 R = 14 m n = 2153	**IP2 R = 11 m n = 1504**	**IP3 R = 12 m n = 4801**	**IP4(H) R = 10 m n = 1626**	**IP4(D) R = 10 m n = 1218**	**IP5 R = 11 m n = 1213**	**IP6(off) R = 12 m n = 1246**	**IP6(on) R = 12 m n = 1087**	**IP7 R = 12 m n = 1427**	**IP8 R = 17 m n = 2000**	**IP9 R = 17 m n = 845**	**IP10 R = 12 m n = 1459**
Mean	176.2	166.7	164.0	173.5	171.0	173.6	174.9	170.5	165.5	170.1	171.2	161.7
Median	176.3	166.3	163.3	173.3	170.3	173.7	174.7	169.9	164.6	169.5	170.6	160.7
Max	178.2	172.1	169.3	175.3	175.3	176.7	178.5	174.4	171.1	172.8	175.9	166.0
90th percentile	177.4	168.5	166.4	174.8	173.1	175.6	176.4	173.0	168.3	171.2	173.1	164.5
Cumulative	209.5	198.5	200.8	205.6	201.9	204.4	205.9	200.9	197.1	203.1	200.5	193.3
AMAR-1KM												
	IP1 R = 959 m n = 2151	**IP2 R = 943 m n = 1499**	**IP3 R = 1182 m n = 4721**	**IP4(H) R = 1008 m n = 1634**	**IP4(D) R = 1008 m n = 1214**	**IP5 R = 968 m n = 1207**	**IP6(off) R = 977 m n = 1248**	**IP6(on) R = 977 m n = 1087**	**IP7 R = 1013 m n = 1428**	**IP8 R = 960 m n = 1999**	**IP9 R = 1037 m n = 840**	**IP10 R = 1064m n = 1463**
Mean	141.0	136.4	132.6	128.8	125.7	140.7	135.7	133.7	132.5	143.6	142.2	141.2
Median	141.1	135.4	132.7	128.7	124.7	141.0	135.6	133.8	131.6	143.6	141.9	141.1
Max	142.9	142.2	134.6	131.5	129.7	145.5	138.0	136.7	137.0	146.6	146.3	142.5
90th percentile	142.2	139.4	133.4	130.8	127.7	142.4	136.7	135.6	135.3	145.0	143.7	141.7
Cumulative	174.3	168.2	169.3	161.0	156.6	171.5	166.7	164.0	164.0	176.6	171.5	172.8

Table C-5. Statistics of otariid pinniped M-weighted single-strike SEL for impact pile driving R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

Sound level (dB re 1 $\mu\text{Pa}^2\cdot\text{s}$)												
AMAR-10M												
	IP1 R = 14 m n = 2153	**IP2 R = 11 m n = 1504**	**IP3 R = 12 m n = 4801**	**IP4(H) R = 10 m n = 1626**	**IP4(D) R = 10 m n = 1218**	**IP5 R = 11 m n = 1213**	**IP6(off) R = 12 m n = 1246**	**IP6(on) R = 12 m n = 1087**	**IP7 R = 12 m n = 1427**	**IP8 R = 17 m n = 2000**	**IP9 R = 17 m n = 845**	**IP10 R = 12 m n = 1459**
Mean	176.5	166.2	163.8	173.3	170.8	172.5	175.1	170.4	165.5	170.3	170.9	161.6
Median	176.6	165.8	163.1	173.1	170.2	172.6	174.7	169.9	164.5	170.5	170.3	160.4
Max	178.6	171.7	169.5	175.1	175.4	175.9	178.7	174.2	171.2	173.1	176.1	166.2
90th percentile	177.7	167.9	166.3	174.4	172.9	174.7	176.6	172.8	168.3	171.5	173.0	164.5
Cumulative	209.8	198.0	200.6	205.4	201.7	203.4	206.0	200.7	197.1	203.4	200.2	193.2
AMAR-1KM												
	IP1 R = 959 m n = 2151	**IP2 R = 943 m n = 1499**	**IP3 R = 1182 m n = 4721**	**IP4(H) R = 1008 m n = 1634**	**IP4(D) R = 1008 m n = 1214**	**IP5 R = 968 m n = 1207**	**IP6(off) R = 977 m n = 1248**	**IP6(on) R = 977 m n = 1087**	**IP7 R = 1013 m n = 1428**	**IP8 R = 960 m n = 1999**	**IP9 R = 1037 m n = 840**	**IP10 R = 1064m n = 1463**
Mean	141.2	135.5	131.4	127.3	122.1	140.0	135.2	132.5	131.0	143.5	140.2	137.9
Median	141.3	134.2	131.5	127.1	121.0	140.1	135.0	132.7	130.2	143.5	139.8	137.9
Max	143.1	141.6	133.2	129.7	126.2	144.2	138.1	135.7	135.5	146.7	144.8	139.1
90th percentile	142.6	138.6	132.4	129.0	124.1	141.9	136.6	134.4	133.9	145.1	141.9	138.4
Cumulative	174.5	167.3	168.1	159.4	153.0	170.9	166.2	162.9	162.6	176.5	169.4	169.5

C.1.2. 90% rms SPL statistics

Table C-6. Statistics of low-frequency cetacean M-weighted rms SPL for impact pile driving. R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

	Sound level (dB re 1 µPa)											
AMAR-10M												
	IP1 **R = 14 m** **n = 2148**	**IP2** **R = 11 m** **n = 1516**	**IP3** **R = 12 m** **n = 4825**	**IP4(H)** **R = 10 m** **n = 1640**	**IP4(D)** **R = 10 m** **n = 1237**	**IP5** **R = 11 m** **n = 1217**	**IP6(off)** **R = 12 m** **n = 1248**	**IP6(on)** **R = 12 m** **n = 1090**	**IP7** **R = 12 m** **n = 1473**	**IP8** **R = 17 m** **n = 2018**	**IP9** **R = 17 m** **n = 867**	**IP10** **R = 12 m** **n = 1461**
Mean	197.0	186.3	186.9	194.7	189.8	194.1	190.5	187.6	184.5	190.3	192.0	181.6
Median	196.7	186.0	186.7	194.5	189.2	194.0	190.1	186.1	183.8	190.2	192.0	181.0
Max	199.9	190.8	191.0	197.3	193.3	198.1	193.8	191.8	191.7	194.4	195.1	185.6
90th percentile	198.8	188.4	188.5	195.9	191.7	196.0	192.2	190.3	187.2	192.1	193.1	183.5
AMAR-1KM												
	IP1 **R = 959 m** **n = 2156**	**IP2** **R = 943 m** **n = 1525**	**IP3** **R = 1182 m** **n = 4817**	**IP4(H)** **R = 1008 m** **n = 1613**	**IP4(D)** **R = 1008 m** **n = 1226**	**IP5** **R = 968 m** **n = 1208**	**IP6(off)** **R = 977 m** **n = 1249**	**IP6(on)** **R = 977 m** **n = 1093**	**IP7** **R = 1013 m** **n = 1429**	**IP8** **R = 960 m** **n = 2009**	**IP9** **R = 1037 m** **n = 863**	**IP10** **R = 1064m** **n = 1467**
Mean	161.1	157.9	153.2	143.8	141.9	161.2	153.3	152.4	151.2	163.1	165.7	166.3
Median	161.1	157.1	153.0	143.7	140.9	161.5	153.2	152.0	149.9	162.9	165.4	166.6
Max	164.1	163.9	156.4	146.9	146.4	167.5	156.3	155.6	157.5	167.2	169.4	167.4
90th percentile	162.5	160.7	154.4	146.0	144.0	162.8	154.2	154.6	154.3	164.9	167.2	167.2

Table C-7. Statistics of mid-frequency cetacean M-weighted rms SPL for impact pile driving. R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

Sound level (dB re 1 µPa)												
AMAR-10M												
	IP1 R = 14 m n = 2148	**IP2 R = 11 m n = 1507**	**IP3 R = 12 m n = 4812**	**IP4(H) R = 10 m n = 1638**	**IP4(D) R = 10 m n = 1224**	**IP5 R = 11 m n = 1209**	**IP6(off) R = 12 m n = 1252**	**IP6(on) R = 12 m n = 1091**	**IP7 R = 12 m n = 1424**	**IP8 R = 17 m n = 2015**	**IP9 R = 17 m n = 853**	**IP10 R = 12 m n = 1460**
Mean	173.4	170.8	152.3	169.6	170.6	177.1	170.3	164.7	162.7	167.5	169.2	160.8
Median	173.3	170.2	151.4	169.2	170.4	175.8	170.1	159.8	161.0	167.3	165.3	155.1
Max	176.5	176.0	159.4	172.9	177.3	182.8	177.2	175.1	171.0	172.0	176.2	174.5
90th percentile	175.3	173.6	154.9	171.6	173.7	180.8	172.2	168.9	167.0	168.8	173.6	165.1
AMAR-1KM												
	IP1 R = 959 m n = 2167	**IP2 R = 943 m n = 1545**	**IP3* R = 1182 m n = 3905**	**IP4(H)* R = 1008 m n = 1634**	**IP4(D)* R = 1008 m n = 1214**	**IP5 R = 968 m n = 1205**	**IP6(off) R = 977 m n = 1225**	**IP6(on) R = 977 m n = 959**	**IP7 R = 1013 m n = 880**	**IP8 R = 960 m n = 2010**	**IP9 R = 1037 m n = 862**	**IP10 R = 1064m n = 1167**
Mean	105.2	119.1	99.7	95.6	96.1	130.4	112.1	100.4	98.0	125.8	106.2	96.3
Median	104.8	117.8	97.1	95.2	95.5	129.7	111.6	99.6	96.9	125.0	102.7	95.5
Max	109.7	126.5	123.2	98.6	102.3	136.2	119.1	119.1	104.8	133.7	113.4	108.8
90th percentile	107.2	122.6	100.7	97.0	97.9	133.8	114.7	102.1	100.2	128.4	110.2	98.1

*Levels from AMAR-1KM IP3 and IP4 are calculated from the filtered signal based on detections identified in the unweighted signal. Signal-to-noise levels of filtered impact pile driving was insufficient to trigger automated detector. Reported levels are not representative of impact driving signals only.

Table C-8. Statistics of high-frequency cetacean M-weighted rms SPL for impact pile driving. R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

Sound level (dB re 1 µPa)												
AMAR-10M												
	IP1 R = 14 m n = 2152	**IP2 R = 11 m n = 1505**	**IP3 R = 12 m n = 4821**	**IP4(H) R = 10 m n = 1638**	**IP4(D) R = 10 m n = 1222**	**IP5 R = 11 m n = 1208**	**IP6(off) R = 12 m n = 1288**	**IP6(on) R = 12 m n = 1105**	**IP7 R = 12 m n = 1434**	**IP8 R = 17 m n = 2011**	**IP9 R = 17 m n = 861**	**IP10 R = 12 m n = 1465**
Mean	170.5	168.1	146.1	166.8	167.6	174.4	166.7	161.8	159.1	165.0	166.1	162.0
Median	170.3	167.5	143.8	166.4	167.3	173.4	166.6	153.4	156.3	164.7	162.4	155.0
Max	174.0	174.1	156.8	170.5	174.7	180.4	173.6	173.2	170.3	170.2	173.5	175.5
90th percentile	172.6	171.0	149.0	168.8	170.7	178.2	168.7	166.6	163.7	166.5	170.0	166.0
AMAR-1KM												
	IP1 R = 959 m n = 2089	**IP2 R = 943 m n = 1408**	IP3* R = 1182 m n = 3905	IP4(H)* R = 1008 m n = 1634	IP4(D)* R = 1008 m n = 1214	**IP5 R = 968 m n = 1184**	**IP6(off) R = 977 m n = 1195**	IP6(on)* R = 977 m n = 1087	IP7* R = 1013 m n = 1428	**IP8 R = 960 m n = 2007**	**IP9 R = 1037 m n = 767**	IP10* R = 1064m n = 1463
Mean	96.0	109.4	97.9	93.6	93.9	123.5	103.5	97.5	95.4	119.8	95.9	96.2
Median	96.0	107.0	95.2	93.6	93.8	122.5	101.9	96.3	94.8	118.5	95.2	95.7
Max	99.5	119.8	122.3	96.0	98.9	129.5	111.7	113.8	100.6	129.1	99.1	103.9
90th percentile	96.7	112.8	99.0	94.1	94.5	127.1	107.0	99.5	97.1	122.9	97.7	97.2

*Levels from AMAR-1KM IP3, IP4, IP6(on), IP7, and IP10 are calculated from the filtered signal based on detections identified in the unweighted signal. Signal-to-noise levels of filtered impact pile driving was insufficient to trigger automated detector. Reported levels are not representative of impact driving signals only.

Table C-9. Statistics of phocid pinniped M-weighted rms SPL for impact pile driving R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

	Sound level (dB re 1 µPa)											
AMAR-10M												
	IP1 R = 14 m n = 2148	IP2 R = 11 m n = 1509	IP3 R = 12 m n = 4810	IP4(H) R = 10 m n = 1639	IP4(D) R = 10 m n = 1229	IP5 R = 11 m n = 1209	IP6(off) R = 12 m n = 1225	IP6(on) R = 12 m n = 1090	IP7 R = 12 m n = 1445	IP8 R = 17 m n = 2001	IP9 R = 17 m n = 868	IP10 R = 12 m n = 1469
Mean	183.6	173.9	172.8	179.7	178.0	179.7	181.0	176.6	172.1	178.1	177.2	169.8
Median	183.6	173.1	172.5	179.6	176.8	179.1	180.1	176.0	171.3	178.0	176.1	168.5
Max	186.6	179.5	180.4	181.9	182.1	183.8	186.1	182.0	178.5	182.5	182.6	176.1
90th percentile	185.0	176.6	174.1	181.0	180.9	182.7	183.7	179.1	174.6	179.3	179.9	173.1
AMAR-1KM												
	IP1 R = 959 m n = 2157	IP2 R = 943 m n = 1547	IP3 R = 1182 m n = 4810	IP4(H)* R = 1008 m n = 1634	IP4(D)* R = 1008 m n = 1214	IP5 R = 968 m n = 1209	IP6(off) R = 977 m n = 1250	IP6(on) R = 977 m n = 1093	IP7 R = 1013 m n = 1416	IP8 R = 960 m n = 2005	IP9 R = 1037 m n = 872	IP10 R = 1064m n = 1469
Mean	147.6	140.8	134.8	124.4	119.4	145.8	138.2	134.2	132.4	148.2	142.7	141.4
Median	147.2	139.6	134.7	123.8	118.4	145.4	137.2	134.1	131.3	148.1	142.1	141.3
Max	152.0	147.1	137.0	127.2	123.5	150.7	143.1	139.1	139.2	152.0	147.7	144.2
90th percentile	149.9	144.0	136.2	126.6	121.6	148.2	140.9	136.2	135.4	150.2	145.0	142.3

*Levels from AMAR-1KM IP4 are calculated from the filtered signal based on detections identified in the unweighted signal. Signal-to-noise levels of filtered impact pile driving was insufficient to trigger automated detector. Reported levels are not representative of impact driving signals only.

Table C-10. Statistics of otariid pinniped M-weighted rms SPL for impact pile driving R=the pile to AMAR range. n=the number of strikes over which the percentiles were calculated. Levels for IP4 include the (H) hydraulic and (D) diesel impact hammer. Levels for IP6 are given for impact hammering when bubble curtain mitigation was off and when it was on.

	Sound level (dB re 1 µPa)											
AMAR-10M												
	IP1 R = 14 m n = 2148	**IP2 R = 11 m n = 1509**	**IP3 R = 12 m n = 4811**	**IP4(H) R = 10 m n = 1631**	**IP4(D) R = 10 m n = 1232**	**IP5 R = 11 m n = 1211**	**IP6(off) R = 12 m n = 1250**	**IP6(on) R = 12 m n = 1082**	**IP7 R = 12 m n = 1445**	**IP8 R = 17 m n = 2014**	**IP9 R = 17 m n = 868**	**IP10 R = 12 m n = 1469**
Mean	184.5	173.9	174.1	180.5	178.5	179.6	182.0	177.7	173.1	179.2	178.0	170.9
Median	184.5	173.2	173.8	180.4	177.5	178.9	180.9	177.2	172.3	179.1	177.2	169.7
Max	187.6	179.5	181.8	182.6	182.6	183.7	187.2	183.4	179.3	183.7	183.7	177.4
90th percentile	186.0	176.6	175.5	181.7	181.4	182.6	184.7	180.1	175.6	180.4	180.6	174.2
AMAR-1KM												
	IP1 R = 959 m n = 2159	**IP2 R = 943 m n = 1546**	**IP3 R = 1182 m n = 4813**	IP4(H)* R = 1008 m n = 1634	IP4(D)* R = 1008 m n = 1214	**IP5 R = 968 m n = 1210**	**IP6(off) R = 977 m n = 1250**	**IP6(on) R = 977 m n = 1093**	**IP7 R = 1013 m n = 1407**	**IP8 R = 960 m n = 2007**	**IP9 R = 1037 m n = 861**	**IP10 R = 1064m n = 1468**
Mean	149.4	142.4	135.5	125.4	119.9	146.9	139.9	135.8	133.3	149.8	142.1	139.7
Median	148.8	140.9	135.5	125.0	119.0	146.4	138.8	135.7	132.1	149.6	141.3	139.4
Max	154.4	148.6	138.0	127.8	124.2	152.1	144.9	140.7	140.7	154.3	147.4	144.3
90th percentile	151.9	145.9	137.0	127.2	122.0	149.5	142.6	137.8	136.4	151.9	144.6	141.3

*Levels from AMAR-1KM IP4 are calculated from the filtered signal based on detections identified in the unweighted signal. Signal-to-noise levels of filtered impact pile driving was insufficient to trigger automated detector. Reported levels are not representative of impact driving signals only.

C.2. M-weighted Vibratory Statistics

C.2.1. 1 second rms SPL statistics

Table C-11. Statistics of unweighted rms SPL for vibratory pile driving. R=AMAR to pile range. n=the number of sound levels from 1 s analysis windows over which the percentiles were calculated.

Sound level (dB re 1 µPa)											
AMAR-10M											
	IP1 **R = 14 m** **n = 1928**	**IP2** **R = 11 m** **n = 2089**	**IP3** **R = 12 m** **n = 1895**	**IP4** **R = 10 m** **n = 1924**	**IP5** **R = 11 m** **n = 1124**	**IP6a^** **R = 12 m** **n = 1567**	**IP6b^** **R = 12 m** **n = 1043**	**IP7** **R = 12 m** **n = 1323**	**IP8** **R = 17 m** **n = 1413**	**IP9** **R = 17 m** **n = 1422**	**IP10** **R = 12 m** **n = 1377**
Mean	168.2	163.3	157.2	163.4	169.3	163.7	183.8	161.4	166.5	159.1	158.0
Median	166.4	161.4	154.7	159.8	166.7	163.0	183.8	159.0	162.0	151.2	156.9
Max	177.7	175.4	168.8	172.6	177.7	171.4	188.2	169.1	175.9	171.1	168.3
90th percentile	172.2	166.3	161.0	168.4	173.5	167.2	186.9	166.0	171.4	164.8	161.4
AMAR-1KM											
	IP1 **R = 959 m** **n = 1922**	**IP2** **R = 943 m** **n = 1519**	**IP3** **R = 1182 m** **n = 1893**	**IP4** **R = 1008 m** **n = 1921**	**IP5** **R = 968 m** **n = 1070**	**IP6a^** **R = 977 m** **n = 1572**	**IP6b^** **R = 977 m** **n = 1046**	**IP7** **R = 1013 m** **n = 1323**	**IP8** **R = 960 m** **n = 1594**	**IP9** **R = 1037 m** **n = 1422**	**IP10** **R = 1064m** **n = 1380**
Mean	137.0	140.8	153.6	128.9	138.7	141.9	150.2	133.9	139.5	138.1	139.8
Median	136.4	138.6	146.3	129.4	136.7	138.0	150.4	130.7	136.2	135.5	139.5
Max	143.8	148.7	168.4	133.9	145.3	153.1	155.2	146.3	154.7	147.8	146.0
90th percentile	140.3	144.4	157.8	131.6	142.7	145.8	152.9	136.7	142.9	142.6	143.3

^ Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT.

Table C-12. Statistics of low-frequency cetacean rms SPL for vibratory pile driving. R=AMAR to pile range. n=the number of sound levels from 1 s analysis windows over which the percentiles were calculated.

	Sound level (dB re 1 µPa)										
AMAR-10M											
	IP1 **R = 14 m** **n = 1928**	**IP2** **R = 11 m** **n = 2089**	**IP3** **R = 12 m** **n = 1895**	**IP4** **R = 10 m** **n = 1924**	**IP5** **R = 11 m** **n = 1124**	**IP6a^** **R = 12 m** **n = 1567**	**IP6b^** **R = 12 m** **n = 1043**	**IP7** **R = 12 m** **n = 1323**	**IP8** **R = 17 m** **n = 1413**	**IP9** **R = 17 m** **n = 1422**	**IP10** **R = 12 m** **n = 1377**
Mean	166.3	160.9	148.8	161.6	167.2	157.8	182.5	155.3	156.2	157.4	150.3
Median	162.7	1656.4	145.6	153.1	163.8	154.9	182.5	150.7	149.0	143.2	149.5
Max	176.4	173.9	162.8	172.1	175.9	167.1	186.9	163.9	173.0	169.2	161.5
90th percentile	171.0	164.4	152.1	167.5	172.0	161.9	185.6	160.7	158.0	163.6	153.2
AMAR-1KM											
	IP1 **R = 959 m** **n = 1922**	**IP2** **R = 943 m** **n = 1519**	**IP3** **R = 1182 m** **n = 1893**	**IP4** **R = 1008 m** **n = 1921**	**IP5** **R = 968 m** **n = 1070**	**IP6a^** **R = 977 m** **n = 1572**	**IP6b^** **R = 977 m** **n = 1046**	**IP7** **R = 1013 m** **n = 1323**	**IP8** **R = 960 m** **n = 1594**	**IP9** **R = 1037 m** **n = 1422**	**IP10** **R = 1064m** **n = 1380**
Mean	134.5	135.4	136.9	121.4	136.1	131.7	148.0	130.8	131.0	132.1	129.8
Median	132.5	134.8	130.6	119.3	132.8	130.0	148.4	126.2	124.6	125.3	128.9
Max	142.5	145.4	152.2	128.9	143.7	140.7	151.8	144.3	147.4	140.5	137.2
90th percentile	138.5	138.2	140.6	125.8	140.6	135.2	150.7	133.8	134.8	137.4	133.4

^ Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT.

Table C-13. Statistics of mid-frequency cetacean rms SPL for vibratory pile driving. R=AMAR to pile range. n=the number of sound levels from 1 s analysis windows over which the percentiles were calculated.

Sound level (dB re 1 µPa)											
AMAR-10M											
	IP1 R = 14 m n = 1928	**IP2 R = 11 m n = 2089**	**IP3 R = 12 m n = 1895**	**IP4 R = 10 m n = 1924**	**IP5 R = 11 m n = 1124**	**IP6a^ R = 12 m n = 1567**	**IP6b^ R = 12 m n = 1043**	**IP7 R = 12 m n = 1323**	**IP8 R = 17 m n = 1413**	**IP9 R = 17 m n = 1422**	**IP10 R = 12 m n = 1377**
Mean	154	149.7	125.9	149.6	152.7	134.0	165.9	133	142.3	147.5	134.4
Median	141.7	137.5	117.6	123.1	134.8	124.6	164.2	122	121.7	116.5	134
Max	169.5	168.4	151.2	162.7	165.7	153.5	172.9	151.7	164.8	163.6	143.3
90th percentile	159.2	153.4	121	154.9	157.4	136.3	170.4	135.4	131	153.5	136
AMAR-1KM											
	IP1 R = 959 m n = 1922	**IP2 R = 943 m n = 1519**	**IP3 R = 1182 m n = 1893**	**IP4 R = 1008 m n = 1921**	**IP5 R = 968 m n = 1070**	**IP6a^ R = 977 m n = 1572**	**IP6b^ R = 977 m n = 1046**	**IP7 R = 1013 m n = 1323**	**IP8 R = 960 m n = 1594**	**IP9 R = 1037 m n = 1422**	**IP10 R = 1064m n = 1380**
Mean	115.2	114.3	111.6	97.7	113.1	98.5	117.7	103.4	107.7	113.9	99.2
Median	108.4	110.6	107.3	89.8	104.3	96.9	117.3	97.4	95.4	95.3	96.9
Max	129.8	129.4	132.2	108.7	122.5	109.7	122.7	119.4	129.3	125.0	108.9
90th percentile	119.8	117.3	114.1	102.6	118.3	101.5	121.1	105.4	104.8	120.0	103.1

^ Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT.

Table C-14. Statistics of high-frequency cetacean rms SPL for vibratory pile driving R=AMAR to pile range. n=the number of sound levels from 1 s analysis windows over which the percentiles were calculated.

	Sound level (dB re 1 µPa)										
AMAR-10M											
	IP1 R = 14 m n = 1928	**IP2 R = 11 m n = 2089**	**IP3 R = 12 m n = 1895**	**IP4 R = 10 m n = 1924**	**IP5 R = 11 m n = 1124**	**IP6a^ R = 12 m n = 1567**	**IP6b^ R = 12 m n = 1043**	**IP7 R = 12 m n = 1323**	**IP8 R = 17 m n = 1413**	**IP9 R = 17 m n = 1422**	**IP10 R = 12 m n = 1377**
Mean	150.9	147.0	122.4	146.6	149.9	129.7	161.4	128.8	139.2	144.6	131.6
Median	138.0	133.6	114.6	117.3	130.0	121.2	159.5	118.3	119.1	113.1	131.2
Max	167.0	166.0	148.6	160.1	163.4	150.0	168.9	148.5	161.8	161.1	140.4
90th percentile	156.0	150.3	117.6	151.7	154.4	131.4	166.0	130.2	126.5	150.6	133.3
AMAR-1KM											
	IP1 R = 959 m n = 1922	**IP2 R = 943 m n = 1519**	**IP3 R = 1182 m n = 1893**	**IP4 R = 1008 m n = 1921**	**IP5 R = 968 m n = 1070**	**IP6a^ R = 977 m n = 1572**	**IP6b^ R = 977 m n = 1046**	**IP7 R = 1013 m n = 1323**	**IP8 R = 960 m n = 1594**	**IP9 R = 1037 m n = 1422**	**IP10 R = 1064m n = 1380**
Mean	110.8	109.1	109.7	92.5	107.4	94.8	110.9	98.5	102.7	109.3	95.9
Median	103.3	105.1	105.4	86.1	97.6	92.4	110.2	91.9	91.8	91.4	93.5
Max	126.6	124.8	130.3	103.4	117.7	107.9	118.9	115.2	124.5	120.9	104.6
90th percentile	115.5	111.9	112.3	97.0	112.4	97.1	114.3	100.4	99.3	115.3	99.9

^ Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT.

Table C-15. Statistics of phocid pinniped rms SPL for vibratory pile driving. R=AMAR to pile range. n=the number of sound levels from 1 s analysis windows over which the percentiles were calculated.

	Sound level (dB re 1 µPa)										
AMAR-10M											
	IP1 R = 14 m n = 1928	**IP2 R = 11 m n = 2089**	**IP3 R = 12 m n = 1895**	**IP4 R = 10 m n = 1924**	**IP5 R = 11 m n = 1124**	**IP6a^ R = 12 m n = 1567**	**IP6b^ R = 12 m n = 1043**	**IP7 R = 12 m n = 1323**	**IP8 R = 17 m n = 1413**	**IP9 R = 17 m n = 1422**	**IP10 R = 12 m n = 1377**
Mean	162.7	157.1	138.6	158.0	160.3	148.0	178.1	147.0	150.9	155.0	141.5
Median	155.7	151.0	131.0	143.4	154.1	140.4	177.3	139.5	133.6	133.3	140.7
Max	175.1	172.9	158.2	169.1	169.8	162.3	183.6	160.7	171.4	168.2	149.0
90th percentile	168.1	161.0	138.4	163.6	165.3	151.6	181.9	151.9	147.8	161.2	144.2
AMAR-1KM											
	IP1 R = 959 m n = 1922	**IP2 R = 943 m n = 1519**	**IP3 R = 1182 m n = 1893**	**IP4 R = 1008 m n = 1921**	**IP5 R = 968 m n = 1070**	**IP6a^ R = 977 m n = 1572**	**IP6b^ R = 977 m n = 1046**	**IP7 R = 1013 m n = 1323**	**IP8 R = 960 m n = 1594**	**IP9 R = 1037 m n = 1422**	**IP10 R = 1064m n = 1380**
Mean	129.7	129.9	120.4	113.9	130.3	118.7	138.7	121.2	123.6	127.3	116.5
Median	125.9	127.5	116.8	106.8	125.0	117.4	139.1	116.3	113.0	113.7	114.5
Max	139.6	142.0	134.2	123.5	138.6	127.2	142.7	134.3	143.0	136.9	125.6
90th percentile	134.1	133.0	123.6	119.1	135.5	122.1	141.4	123.9	124.7	133.3	120.2

^ Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT.

Table C-16. Statistics of otariid pinniped rms SPL for vibratory pile driving. R=AMAR to pile range. n=the number of sound levels from 1 s analysis windows over which the percentiles were calculated.

	Sound level (dB re 1 µPa)										
AMAR-10M											
	IP1 R = 14 m n = 1928	**IP2 R = 11 m n = 2089**	**IP3 R = 12 m n = 1895**	**IP4 R = 10 m n = 1924**	**IP5 R = 11 m n = 1124**	**IP6a^ R = 12 m n = 1567**	**IP6b^ R = 12 m n = 1043**	**IP7 R = 12 m n = 1323**	**IP8 R = 17 m n = 1413**	**IP9 R = 17 m n = 1422**	**IP10 R = 12 m n = 1377**
Mean	163.2	157.5	138.6	158.4	160.3	147.8	178.5	147.3	151.2	155.4	141.2
Median	156.2	151.4	128.8	143.5	153.7	138.1	177.8	139.4	130.9	133.5	140.3
Max	175.3	172.9	158.4	169.6	169.5	162.5	184.2	161.1	171.5	168.3	149.4
90th percentile	168.6	161.2	137.0	163.9	165.3	151.2	182.4	152.3	148.0	161.7	144.0
AMAR-1KM											
	IP1 R = 959 m n = 1922	**IP2 R = 943 m n = 1519**	**IP3 R = 1182 m n = 1893**	**IP4 R = 1008 m n = 1921**	**IP5 R = 968 m n = 1070**	**IP6a^ R = 977 m n = 1572**	**IP6b^ R = 977 m n = 1046**	**IP7 R = 1013 m n = 1323**	**IP8 R = 960 m n = 1594**	**IP9 R = 1037 m n = 1422**	**IP10 R = 1064m n = 1380**
Mean	130.4	130.7	116.5	114.3	131.0	117.8	138.8	121.1	124.2	128.0	115.0
Median	126.6	128.1	113.8	106.2	125.5	116.1	139.0	116.1	112.3	112.9	112.7
Max	140.2	142.7	133.4	124.1	139.4	126.4	142.8	134.5	143.8	137.5	125.2
90th percentile	134.8	133.8	119.0	119.7	136.3	121.4	141.5	123.9	124.7	133.9	118.7

^ Pile IP6 had a bearing plate installed. IP6a includes data prior to 07:18 AKDT, IP6b includes data after 07:18 AKDT.

Appendix D. Third-Octave Band Received Levels

D.1. Impact Hammer Pile Driving Sound Levels

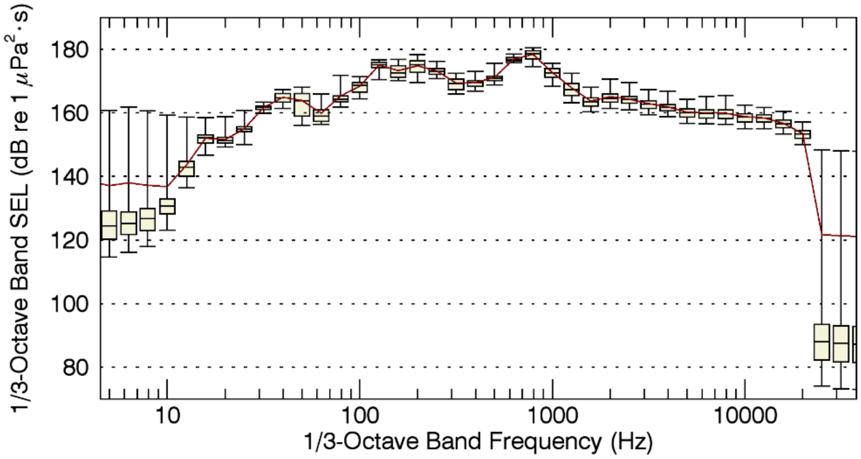

Figure D-1. Pile IP1 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 14 m.

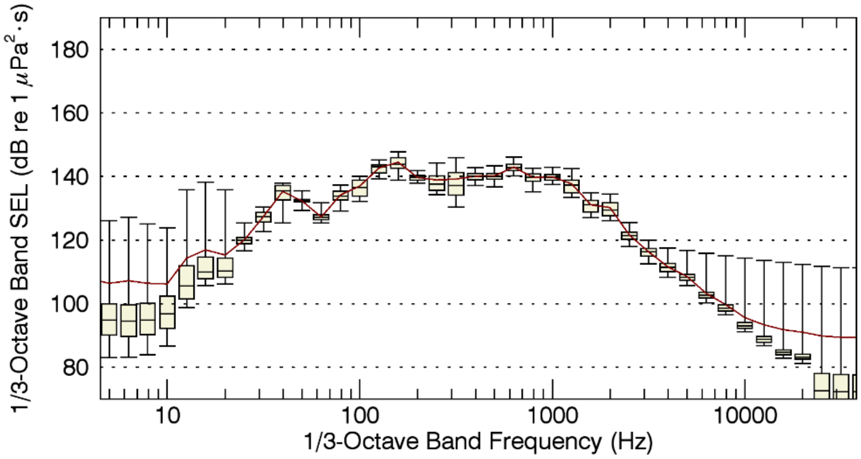

Figure D-2. Pile IP1 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 959 m.

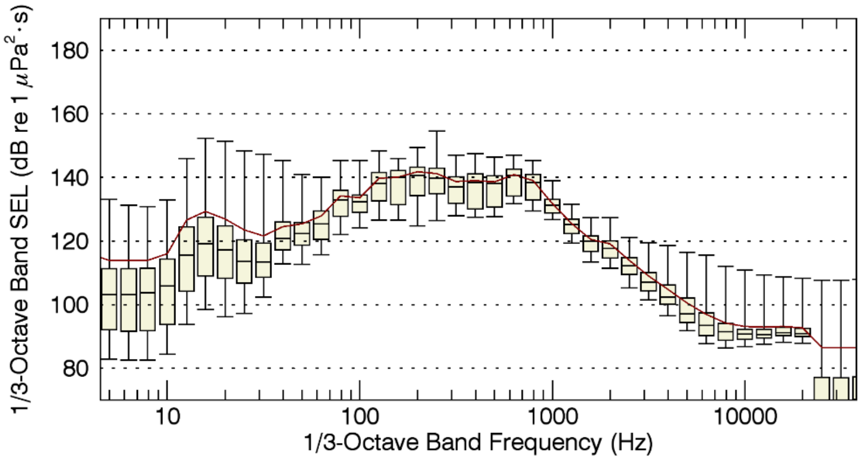

Figure D-3. Pile IP1 1/3-octave band level box plots for impact hammer driving from the drift system.

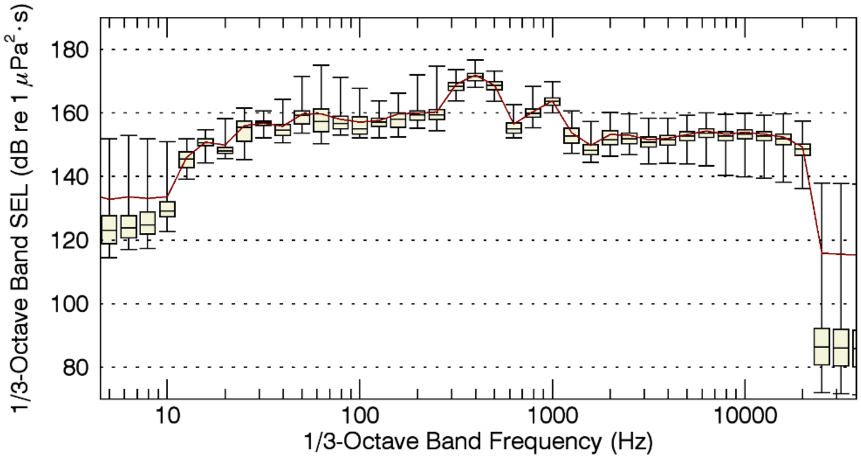

Figure D-4. Pile IP2 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 12 m.

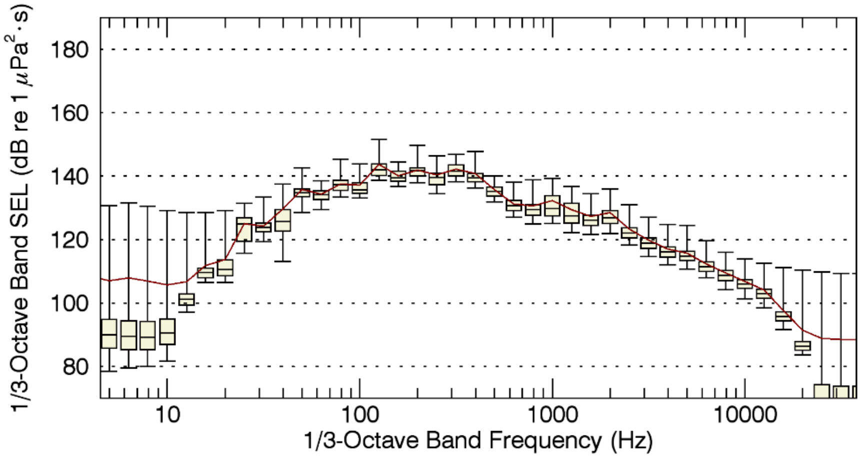

Figure D-5. Pile IP2 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 943 m.

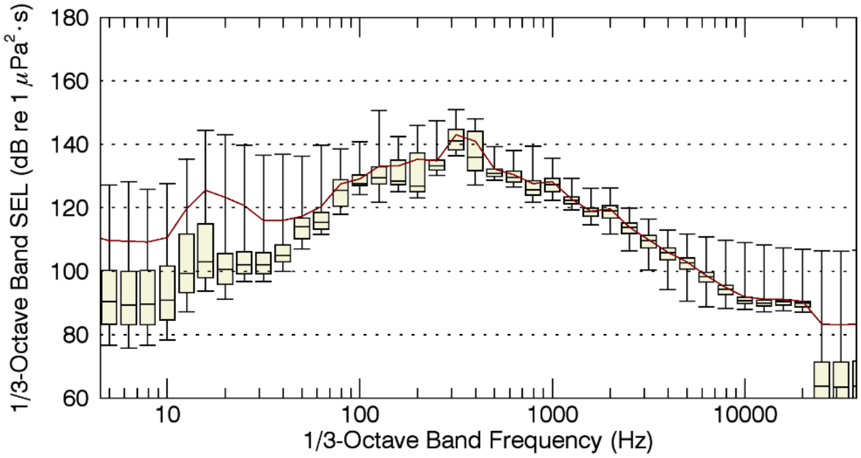

Figure D-6. Pile IP2 1/3-octave band level box plots for impact hammer driving from the drift system.

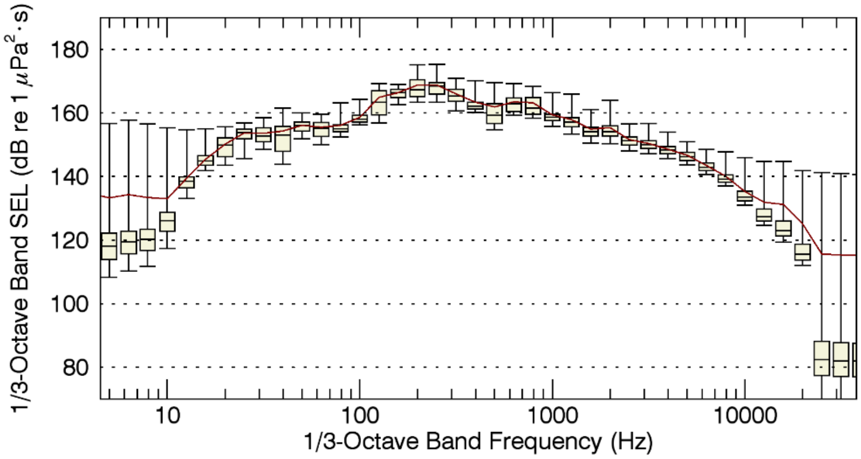

Figure D-7. Pile IP3 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 12 m.

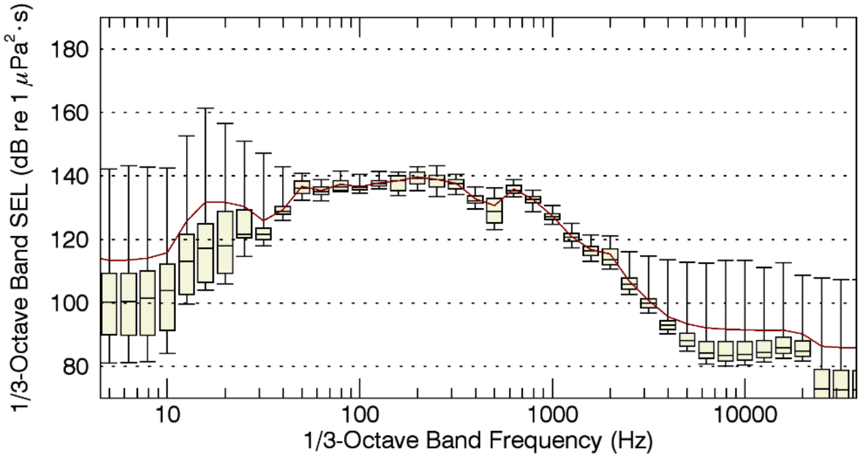

Figure D-8. Pile IP3 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 1182 m.

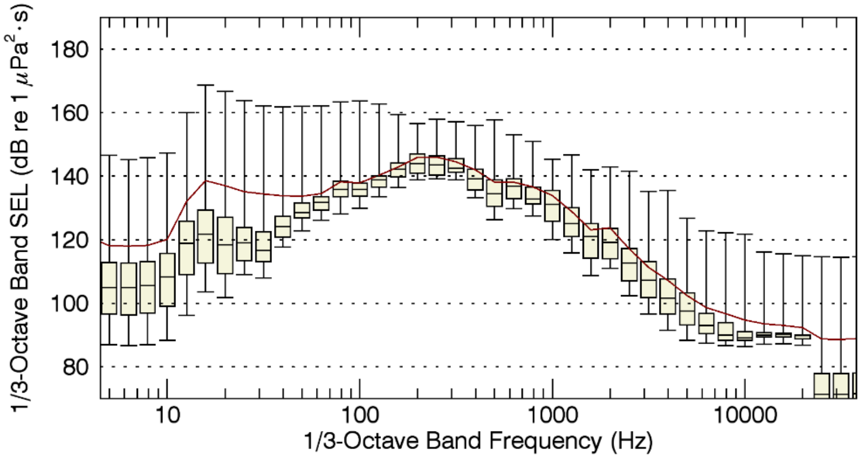

Figure D-9. Pile IP3 1/3-octave band level box plots for impact hammer driving from the drift system.

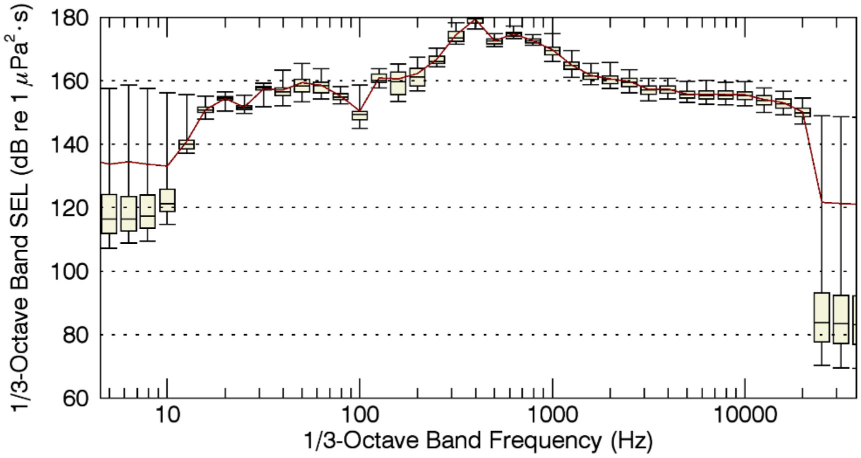

Figure D-10. Pile IP4 1/3-octave band level box plots for hydraulic impact hammer driving from AMAR recordings at a range of 12 m.

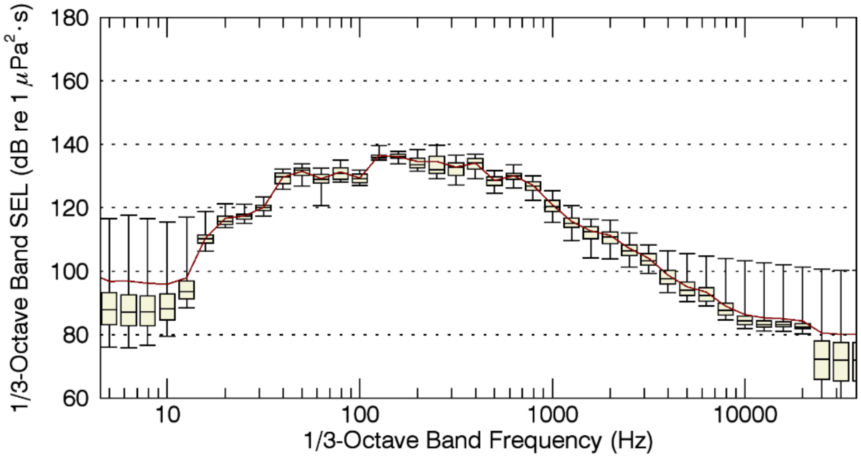

Figure D-11. Pile IP4 1/3-octave band level box plots for hydraulic impact hammer driving from AMAR recordings at a range of 1008 m.

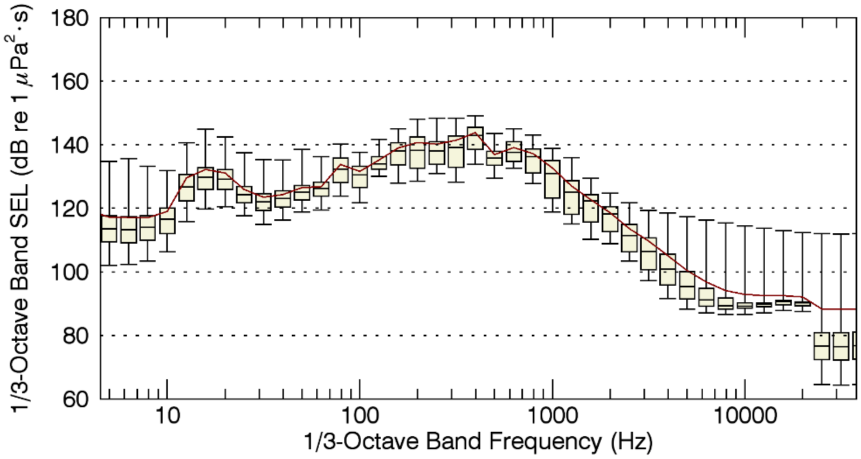

Figure D-12. Pile IP4 1/3-octave band level box plots for hydraulic impact hammer driving from the drift system.

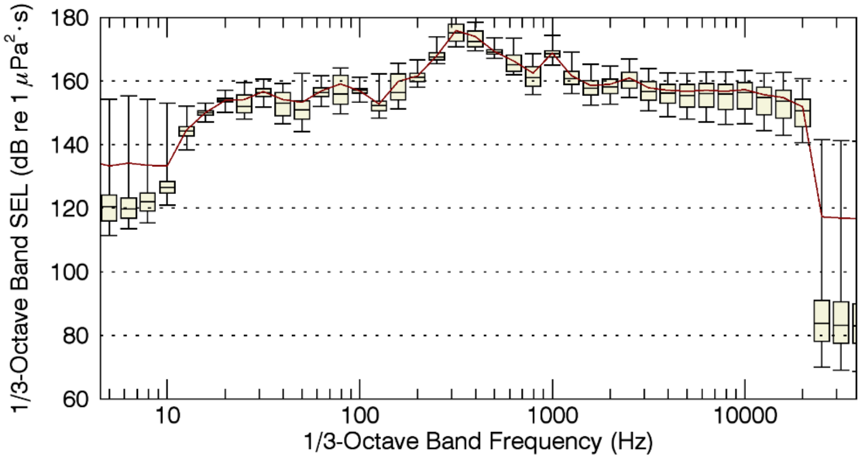

Figure D-13. Pile IP4 1/3-octave band level box plots for diesel impact hammer driving from AMAR recordings at a range of 12 m.

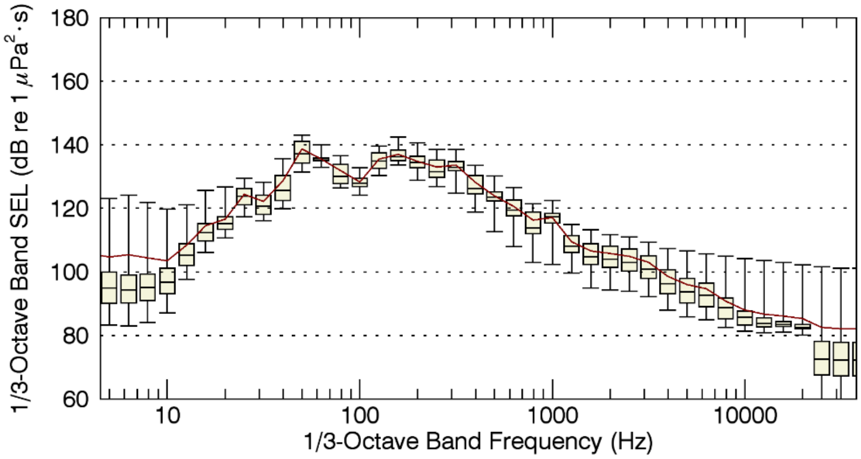

Figure D-14. Pile IP4 1/3-octave band level box plots for diesel impact hammer driving from AMAR recordings at a range of 1008 m.

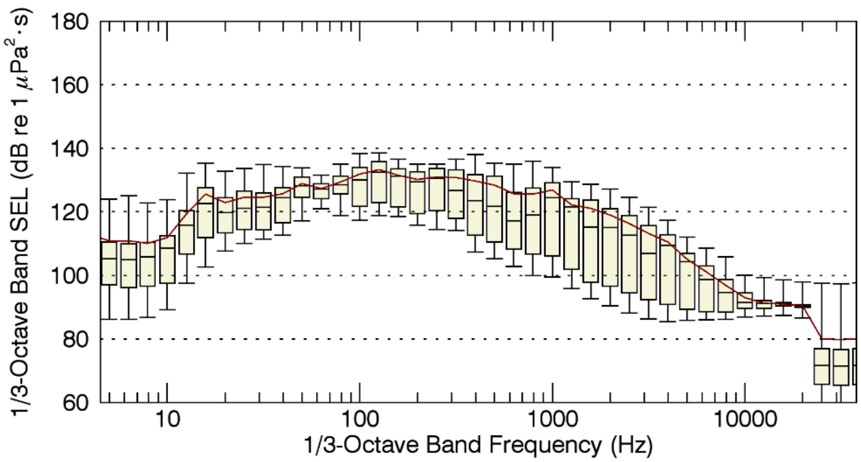

Figure D-15. Pile IP4 1/3-octave band level box plots for diesel impact hammer driving from the drift system.

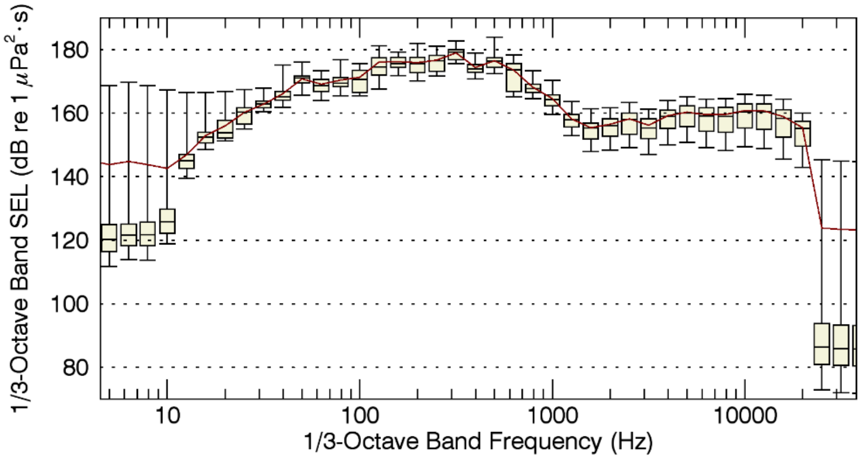

Figure D-16. Pile IP5 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 11 m.

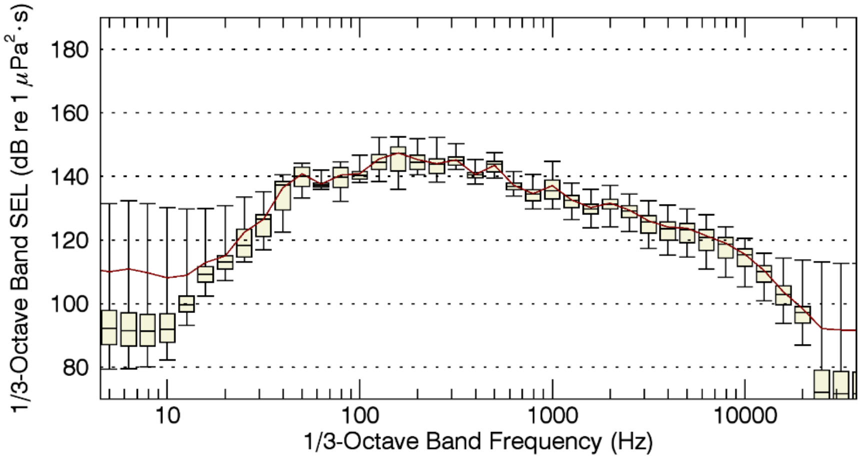

Figure D-17. Pile IP5 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 968 m.

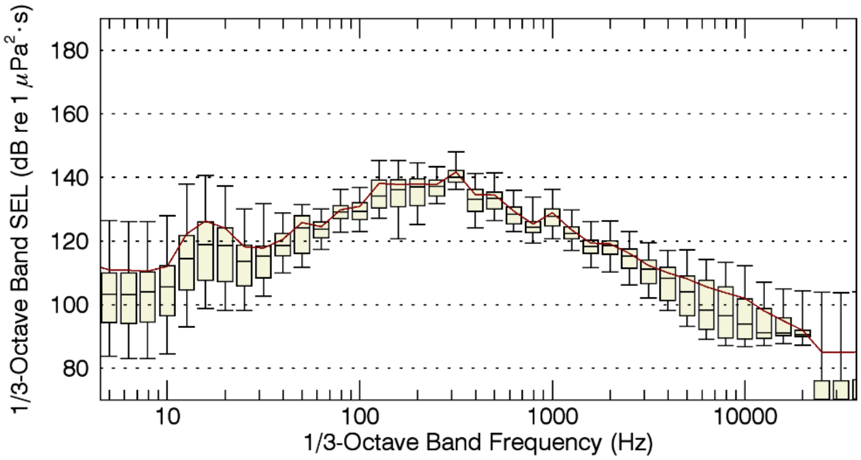

Figure D-18. Pile IP5 1/3-octave band level box plots for impact hammer driving from the drift system.

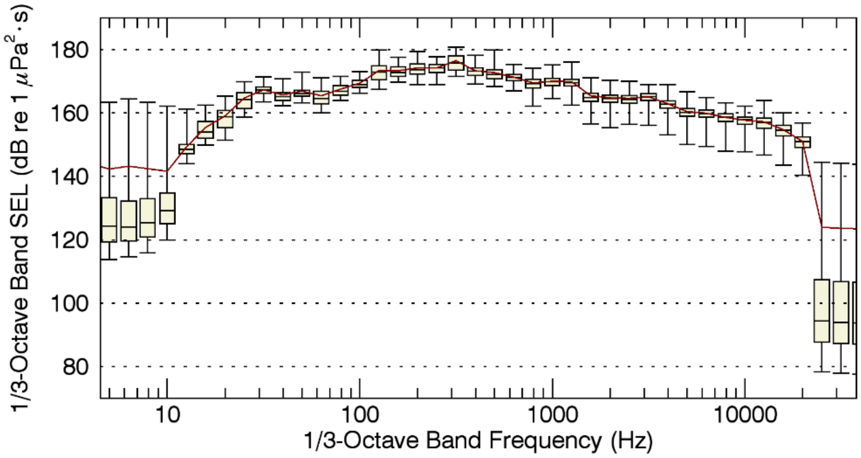

Figure D-19. Pile IP6 1/3-octave band level box plots for un-attenuated impact hammer driving from AMAR recordings at a range of 12 m.

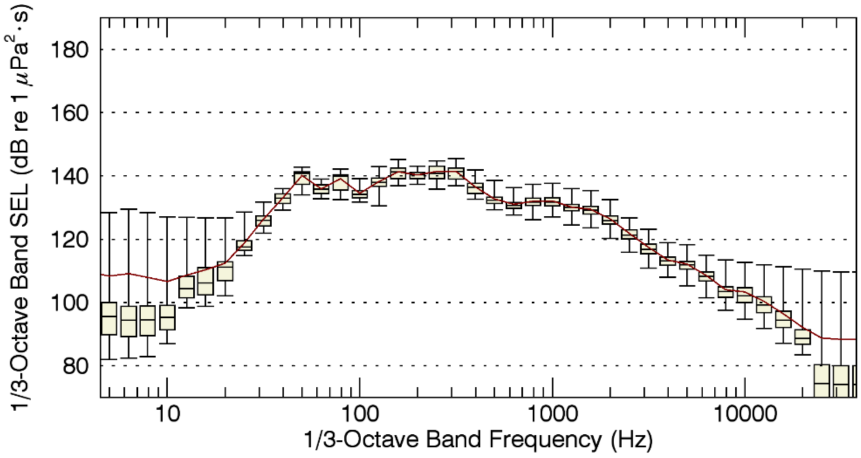

Figure D-20. Pile IP6 1/3-octave band level box plots for un-attenuated impact hammer driving from AMAR recordings at a range of 977 m.

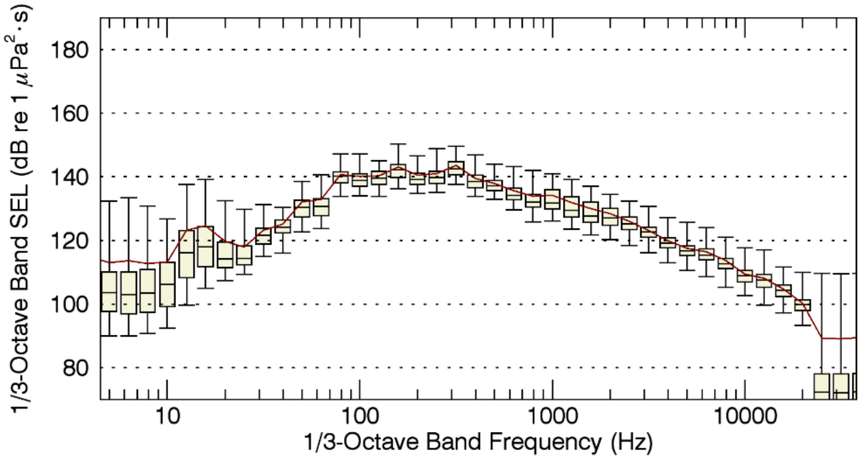

Figure D-21. Pile IP6 1/3-octave band level box plots for un-attenuated impact hammer driving from the drift system.

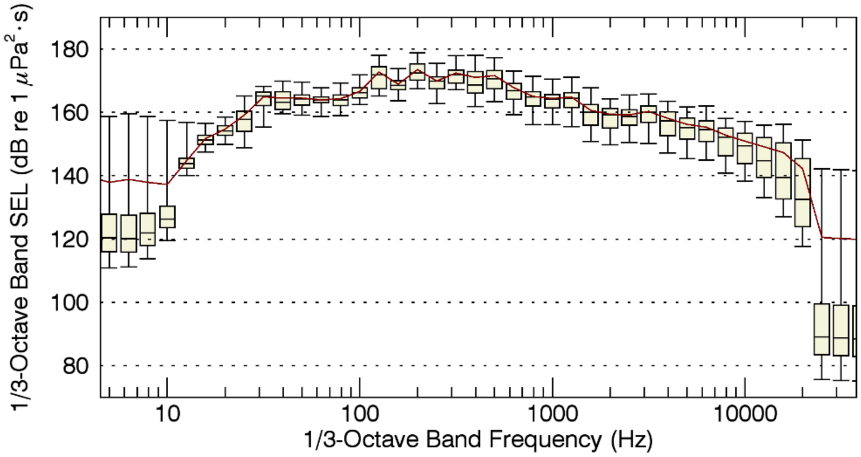

Figure D-22. Pile IP6 1/3-octave band level box plots for impact hammer driving while a bubble curtain attenuation was operating from AMAR recordings at a range of 12 m.

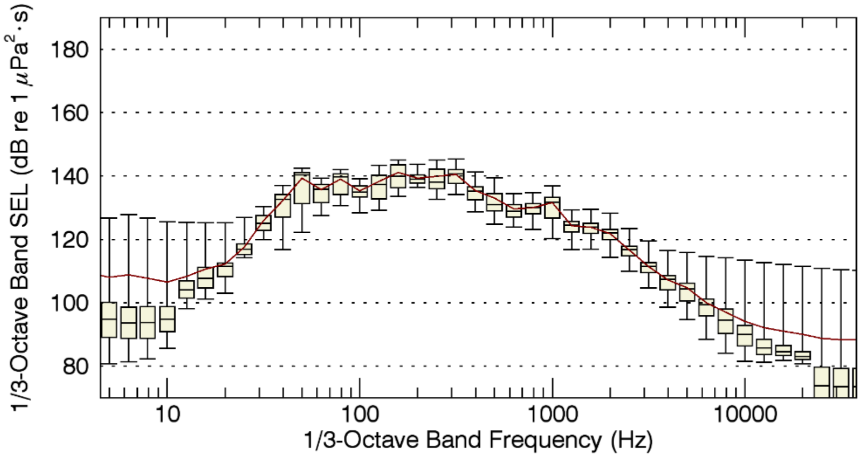

Figure D-23. Pile IP6 1/3-octave band level box plots for impact hammer driving while a bubble curtain attenuation was operating from AMAR recordings at a range of 977 m.

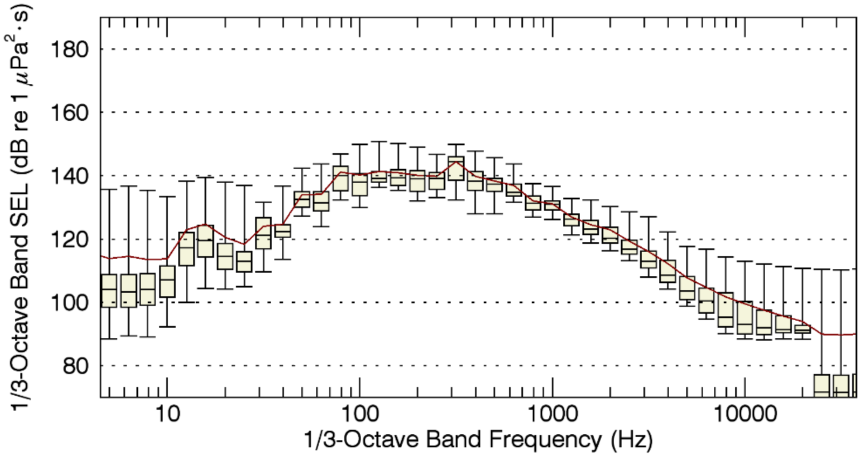

Figure D-24. Pile IP6 1/3-octave band level box plots for impact hammer driving while a bubble curtain attenuation was operating from the drift system.

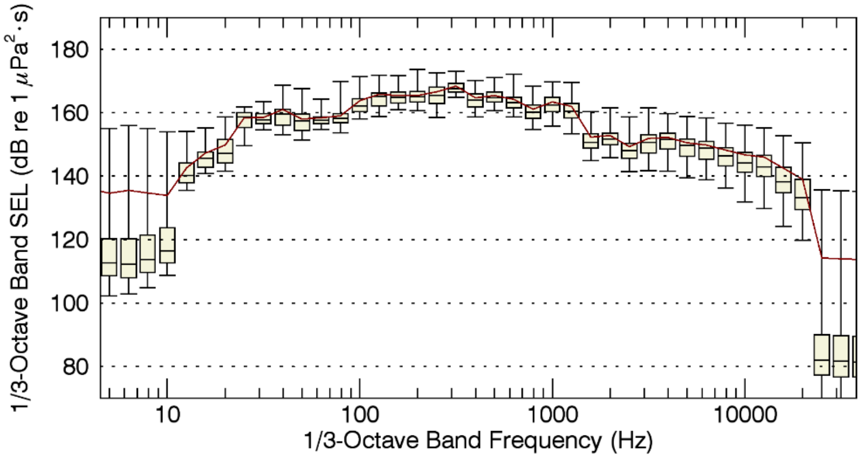

Figure D-25. Pile IP7 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 12 m.

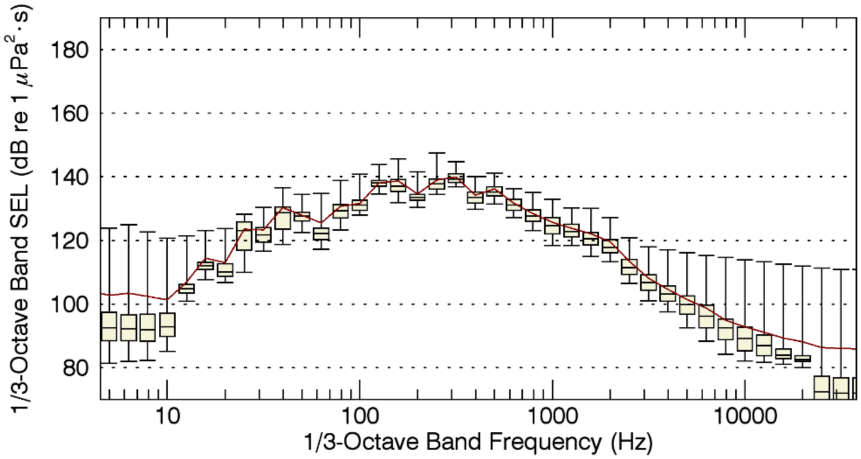

Figure D-26. Pile IP7 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 1013 m.

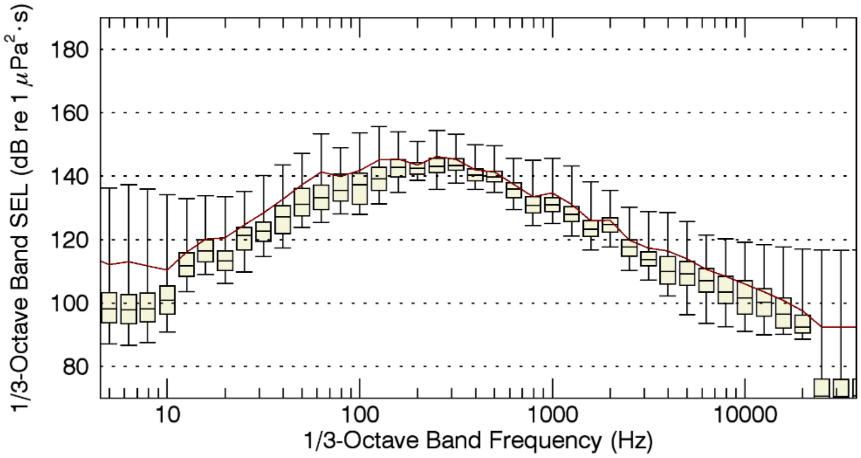

Figure D-27. Pile IP7 1/3-octave band level box plots for impact hammer driving from the drift system.

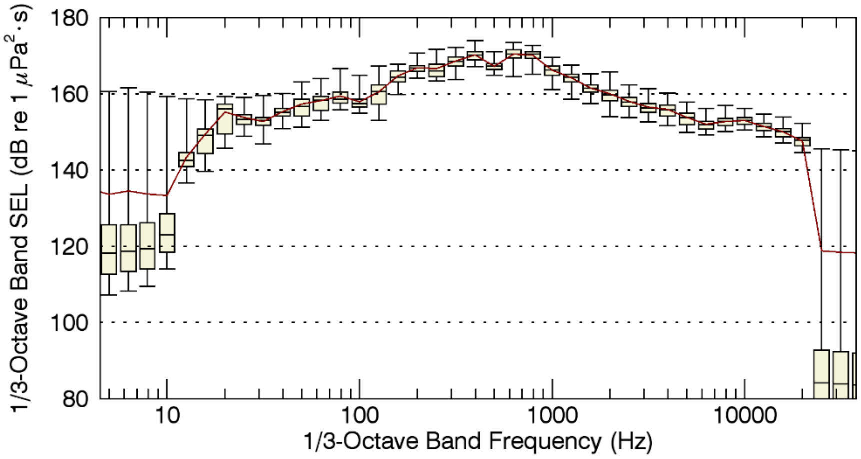

Figure D-28. Pile IP8 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 17 m.

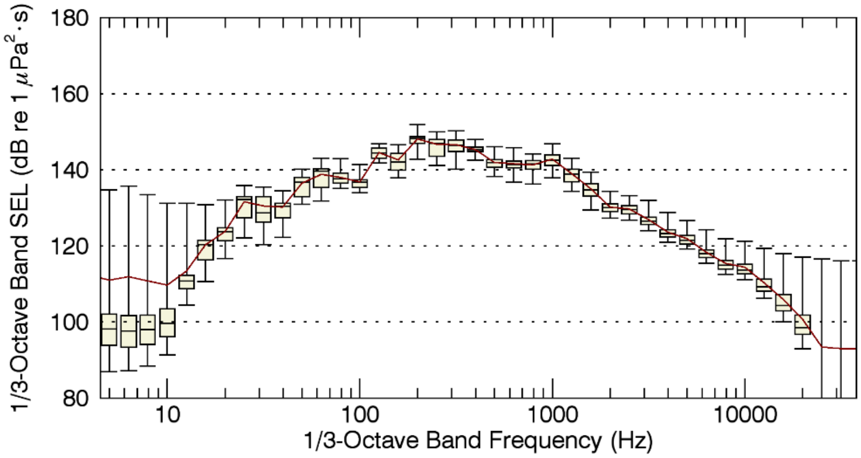

Figure D-29. Pile IP8 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 960 m.

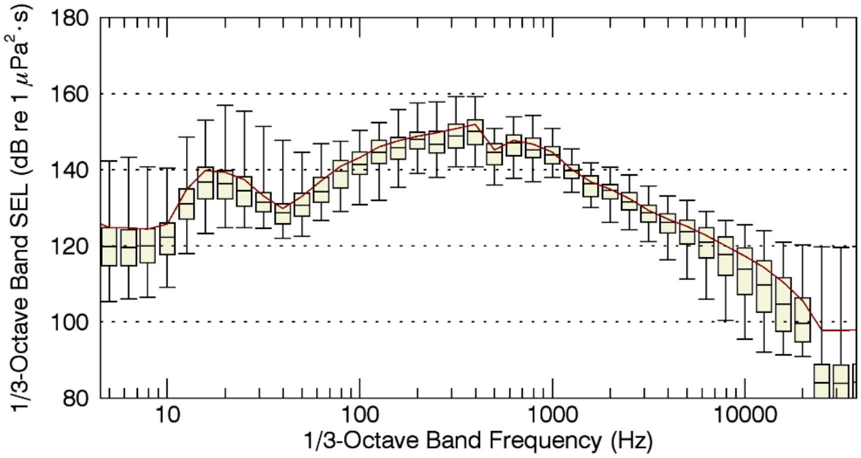

Figure D-30. Pile IP8 1/3-octave band level box plots for impact hammer driving from the drift system.

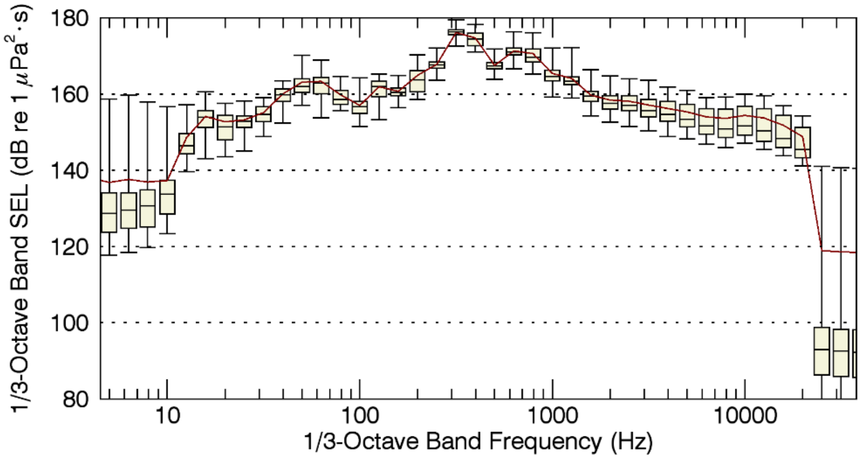

Figure D-31. Pile IP9 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 17 m.

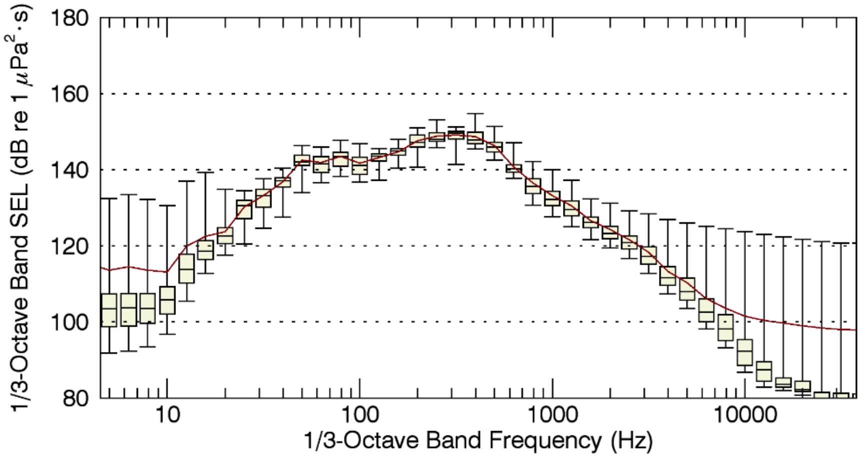

Figure D-32. Pile IP9 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 1037 m.

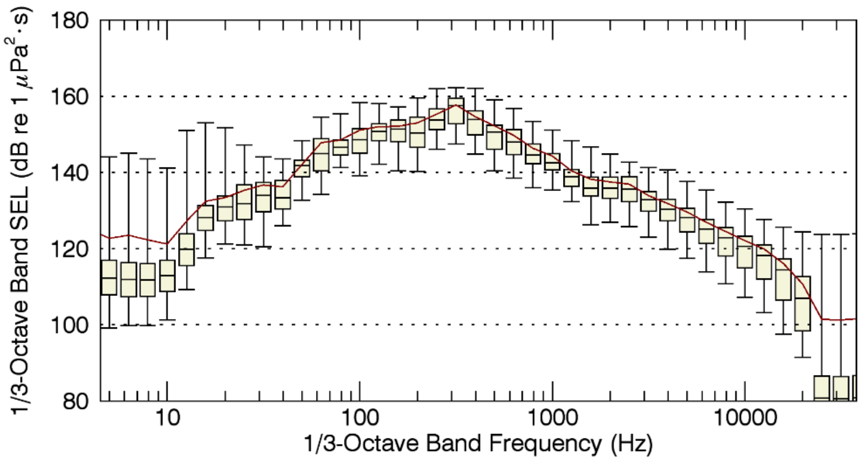

Figure D-33. Pile IP9 1/3-octave band level box plots for impact hammer driving from the drift system.

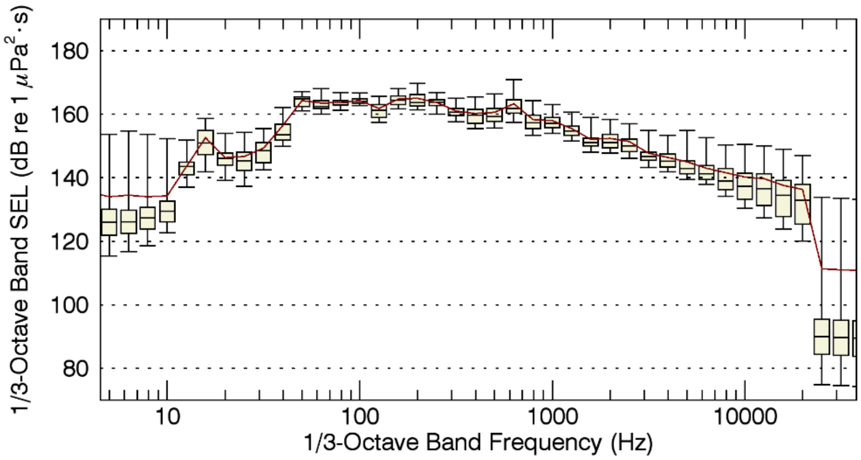

Figure D-34. Pile IP10 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 12 m.

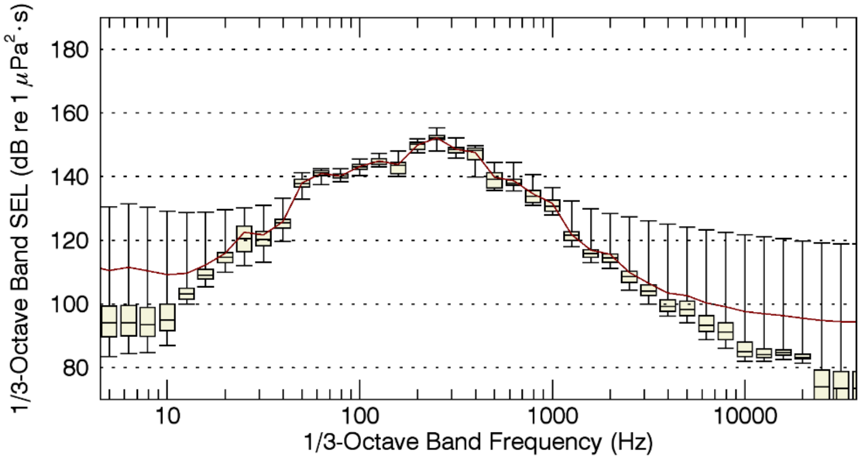

Figure D-35. Pile IP10 1/3-octave band level box plots for impact hammer driving from AMAR recordings at a range of 1064 m.

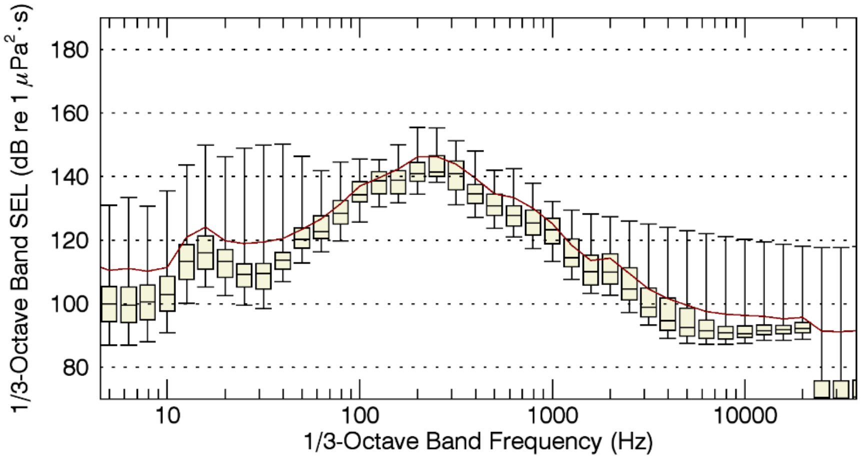

Figure D-36. Pile IP10 1/3-octave band level box plots for impact hammer driving from the drift system.

D.2. Vibratory Pile Driving Sound Levels

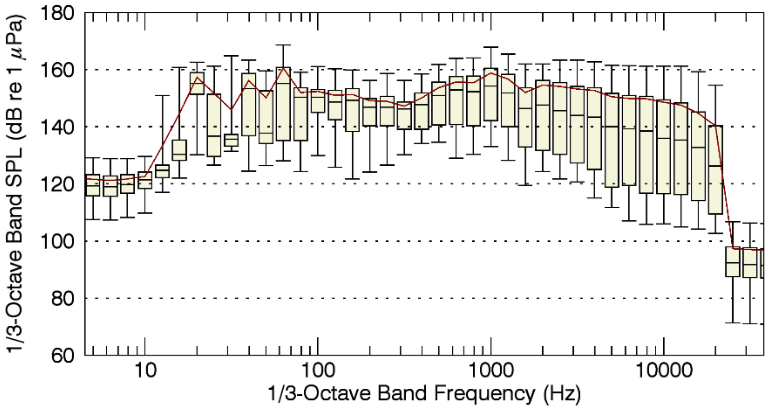

Figure D-37. Pile IP1 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 14 m.

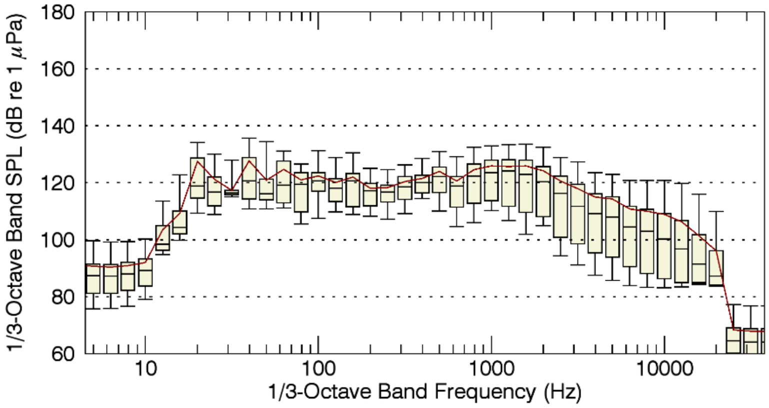

Figure D-38. Pile IP1 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 959 m.

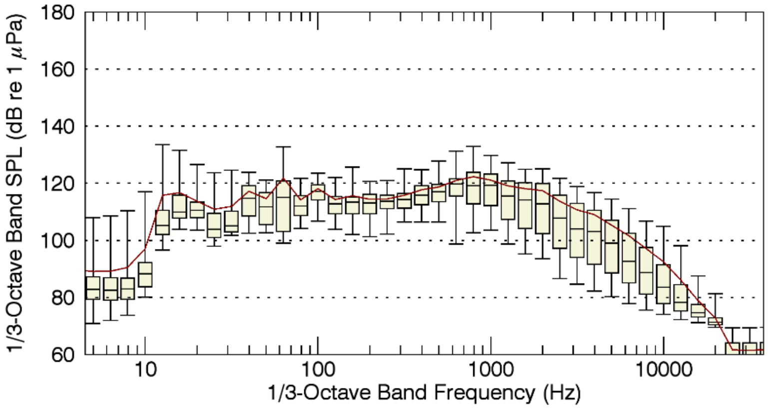

Figure D-39. Pile IP1 1/3-octave band level box plot for vibratory driving from the drift system recordings.

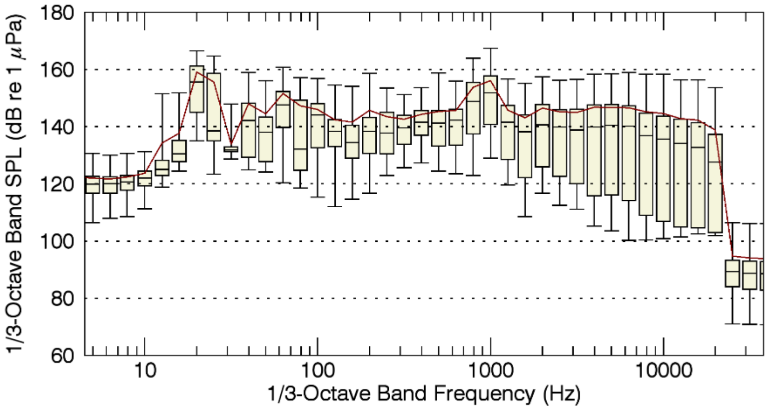

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Figure D-40. Pile IP2 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 12 m.

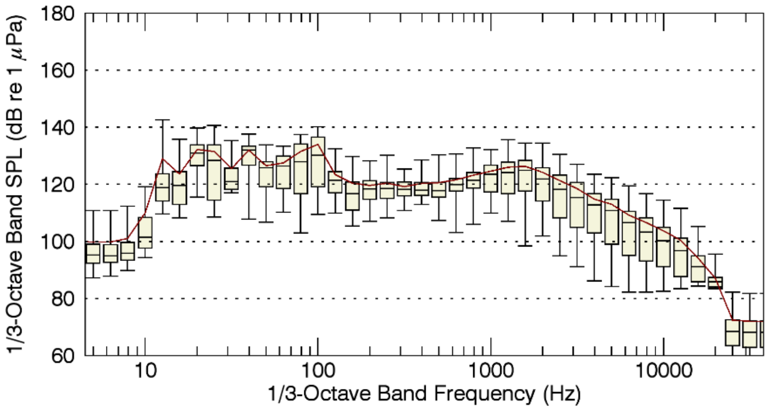


Figure D-41. Pile IP2 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 943 m.

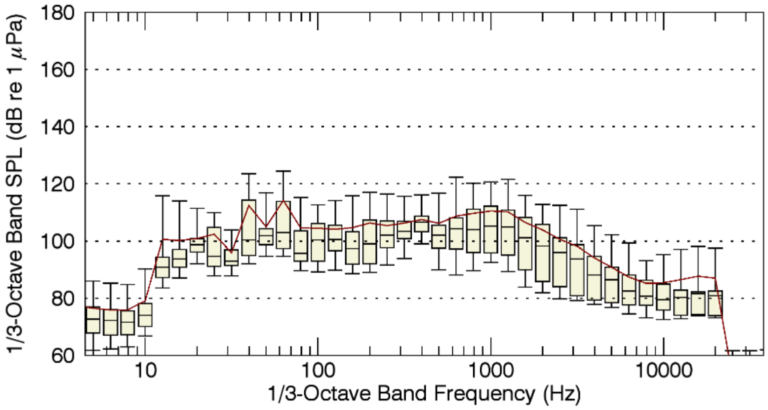


Figure D-42. Pile IP2 1/3-octave band level box plot for vibratory driving from the drift system recordings.

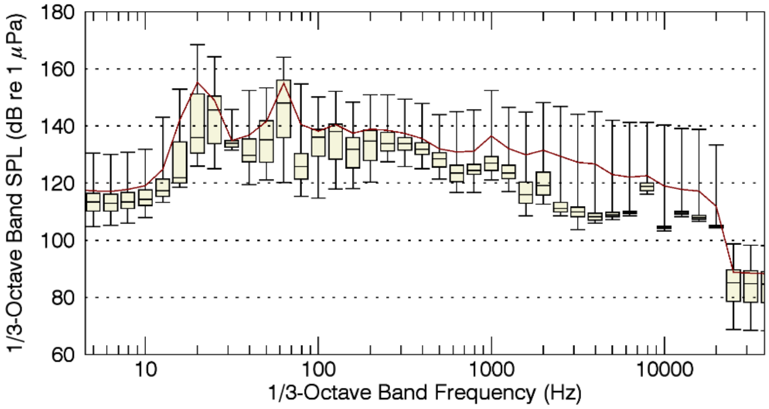


Figure D-43. Pile IP3 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 12 m.

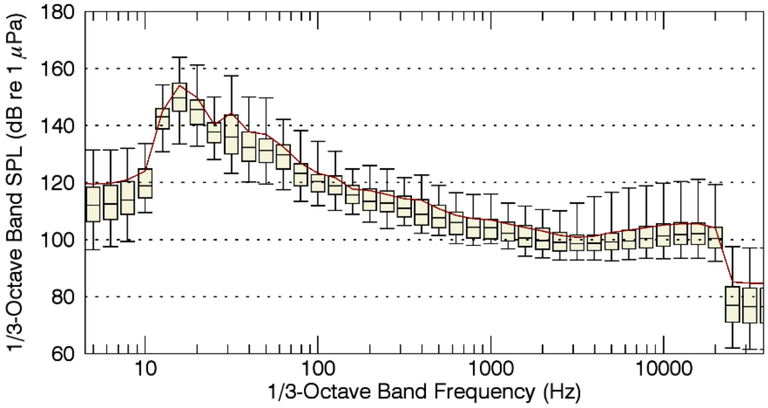


Figure D-44. Pile IP3 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 1182 m.

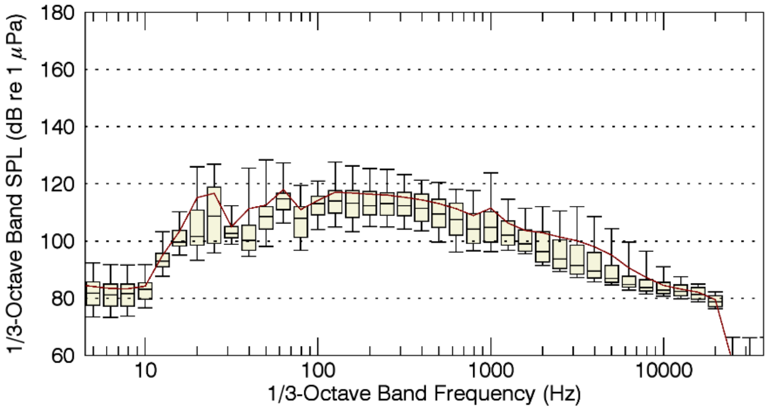


Figure D-45. Pile IP3 1/3-octave band level box plot for vibratory driving from the drift system recordings.

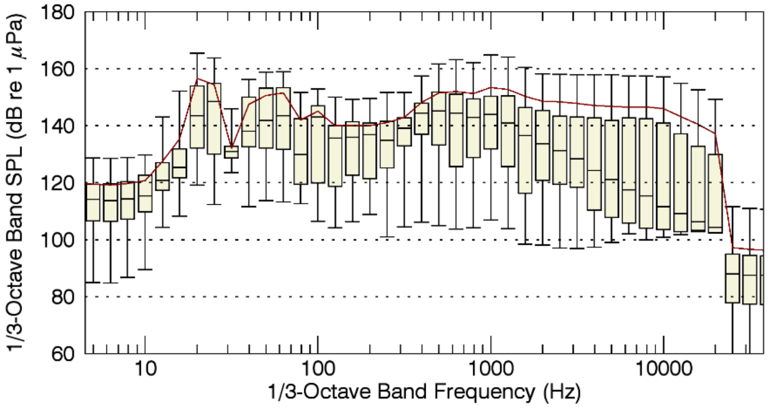


Figure D-46. Pile IP4 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 12 m.

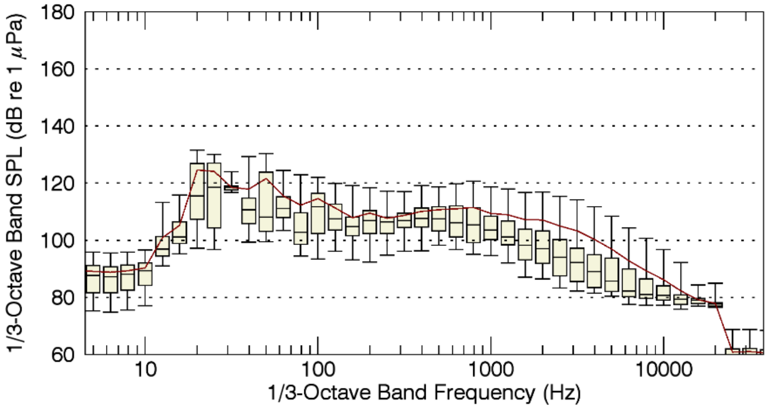


Figure D-47. Pile IP4 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 1008 m.

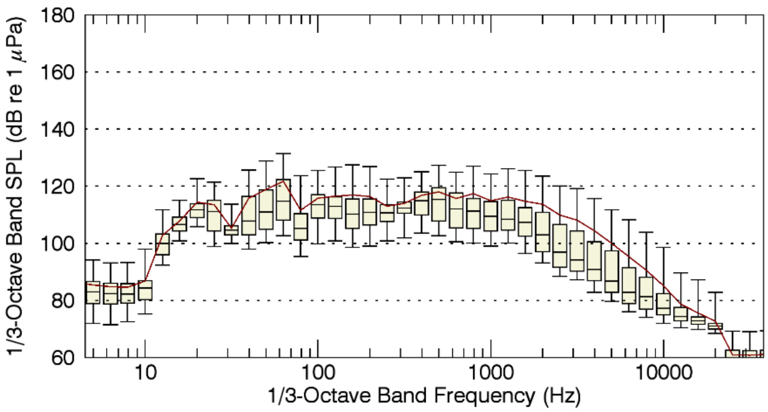


Figure D-48. Pile IP4 1/3-octave band level box plot for vibratory driving from the drift system recordings.

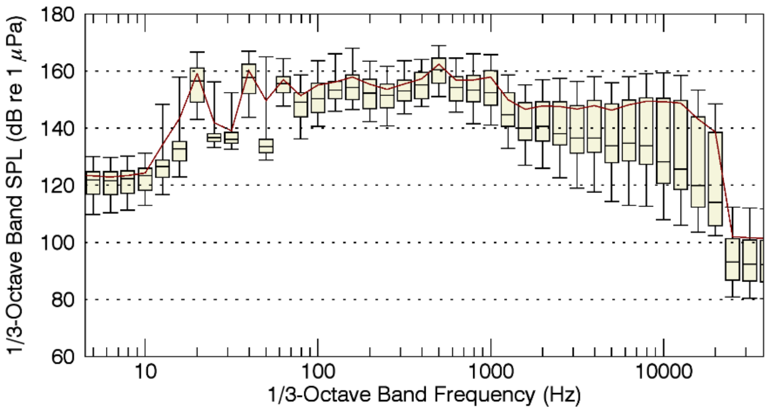


Figure D-49. Pile IP5 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 11 m.

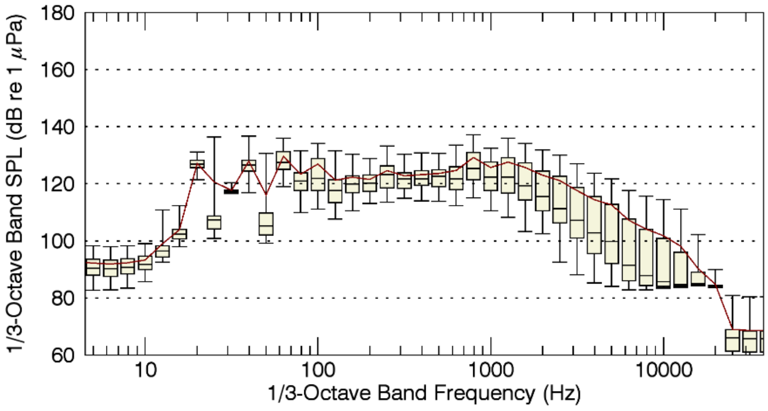


Figure D-50. Pile IP5 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 968 m.

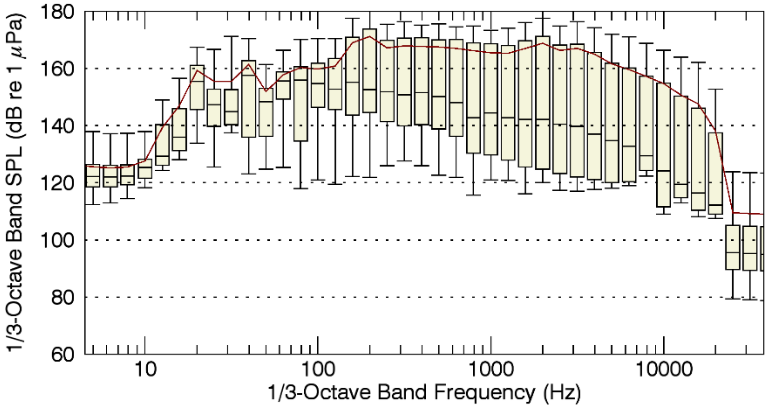


Figure D-51. Pile IP6 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 12 m.

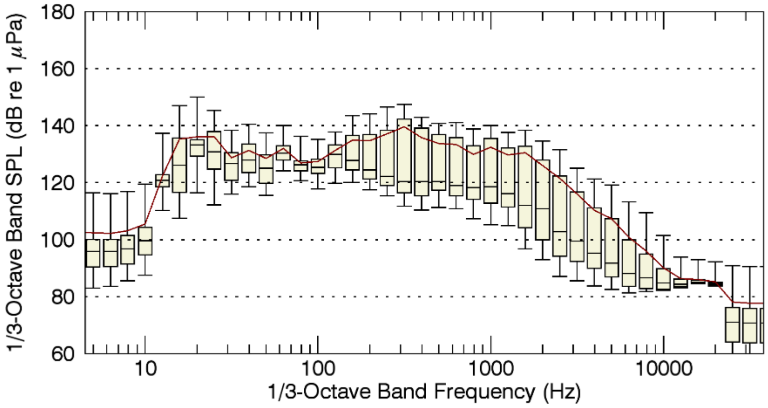


Figure D-52. Pile IP6 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 977 m.

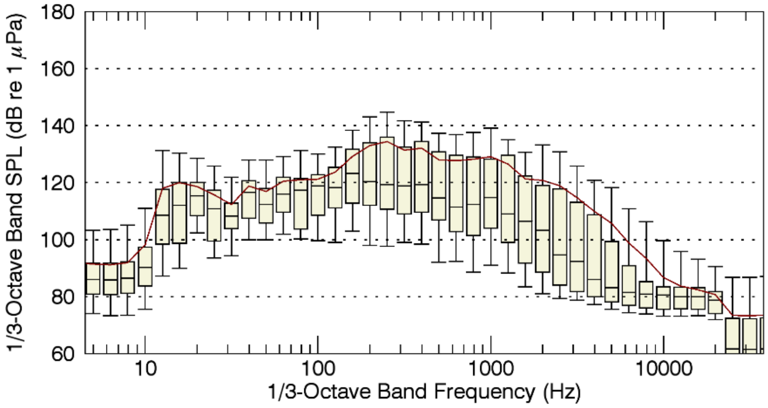


Figure D-53. Pile IP6 1/3-octave band level box plot for vibratory driving from the drift system recordings.

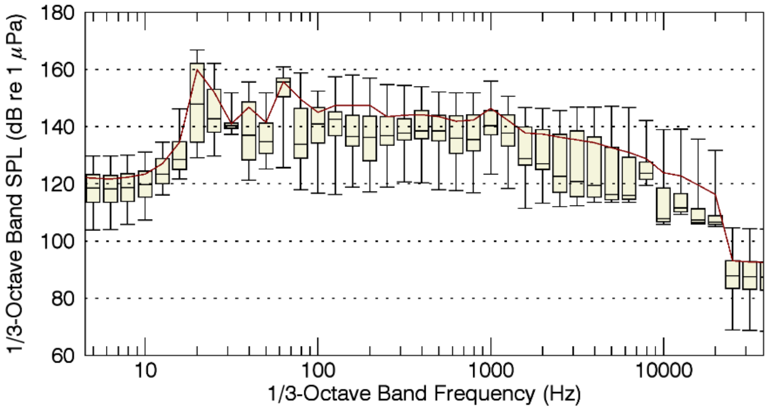


Figure D-54. Pile IP7 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 12 m.

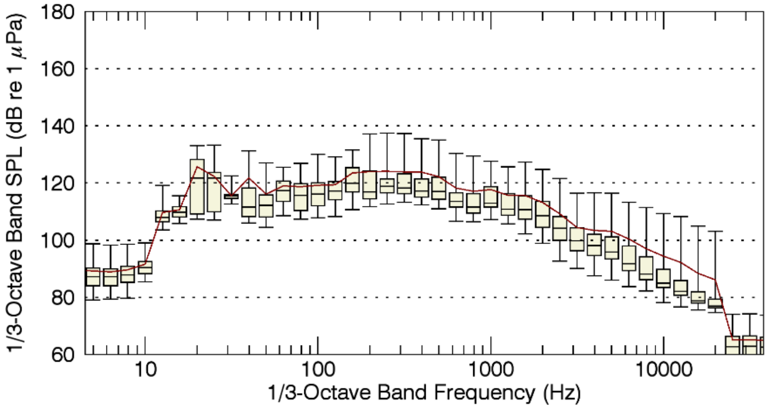


Figure D-55. Pile IP7 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 1013 m.

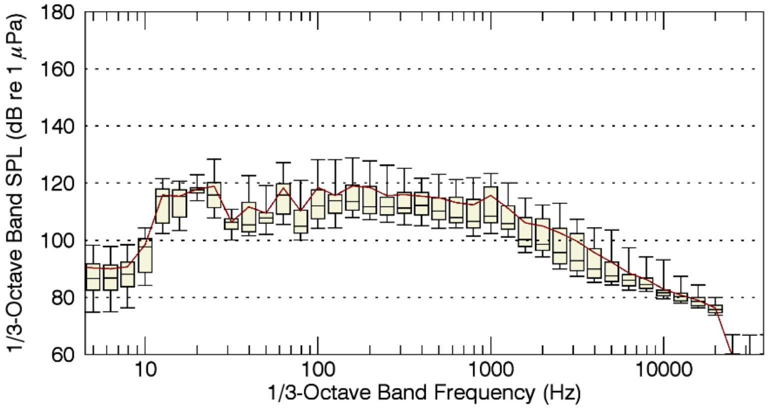


Figure D-56. Pile IP7 1/3-octave band level box plot for vibratory driving from the drift system recordings.

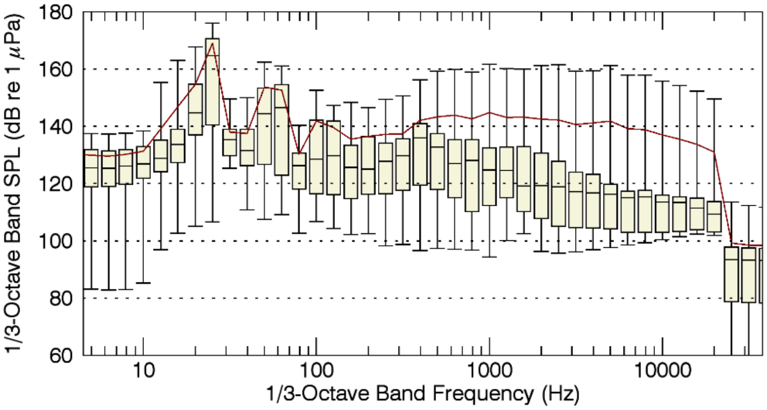


Figure D-57. Pile IP8 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 17 m.

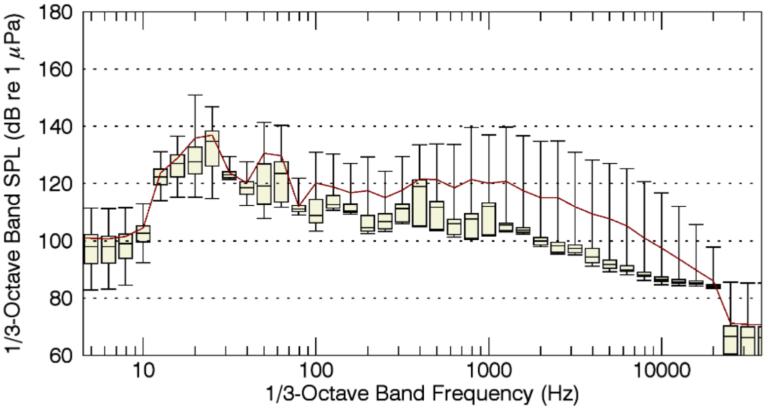


Figure D-58. Pile IP8 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 960 m.

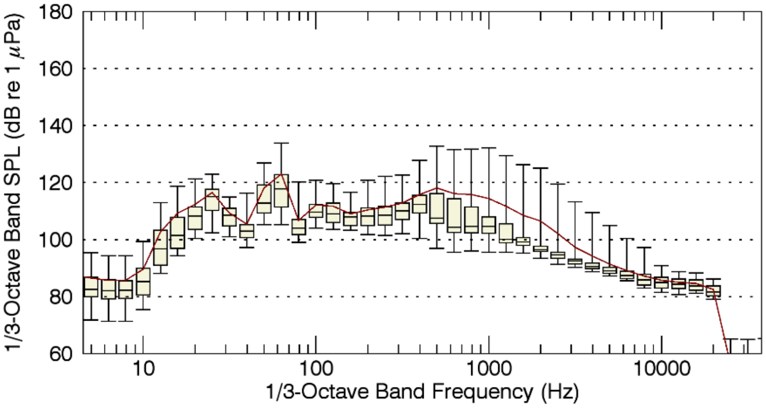


Figure D-59. Pile IP8 1/3-octave band level box plot for vibratory driving from the drift system recordings.

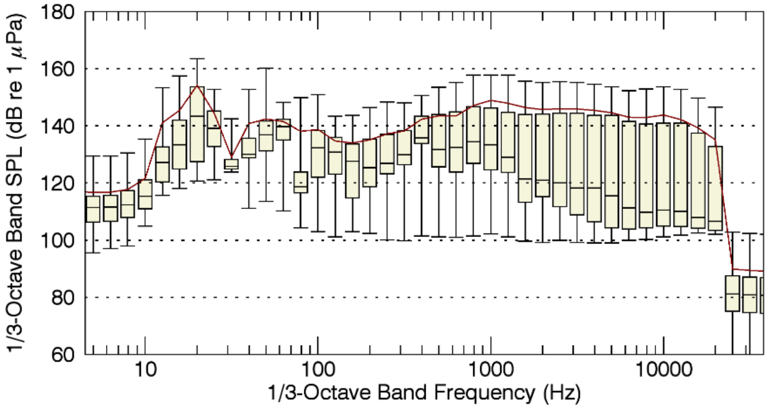


Figure D-60. Pile IP9 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 17 m.

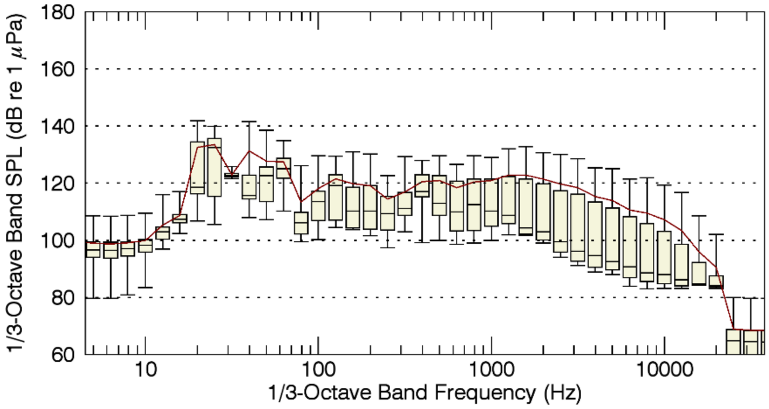


Figure D-61. Pile IP9 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 1037 m.

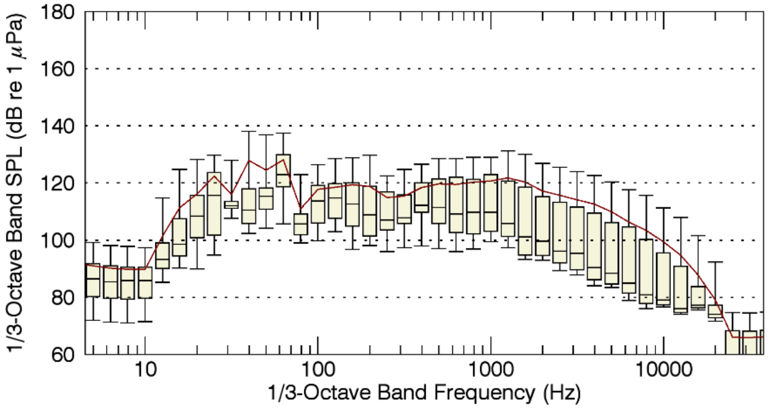


Figure D-62. Pile IP9 1/3-octave band level box plot for vibratory driving from the drift system recordings.

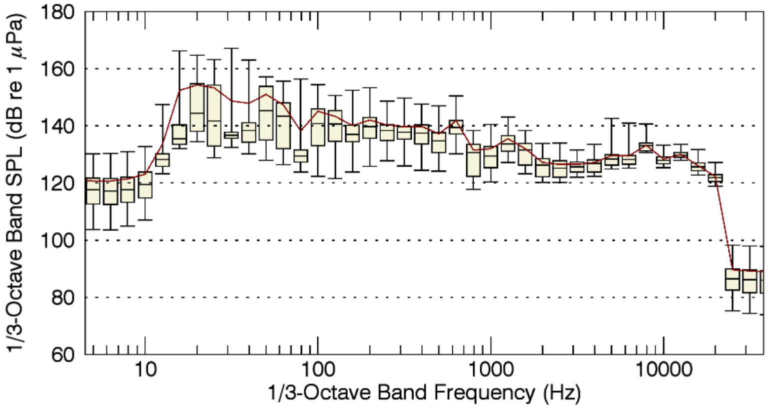


Figure D-63. Pile IP10 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 12 m.

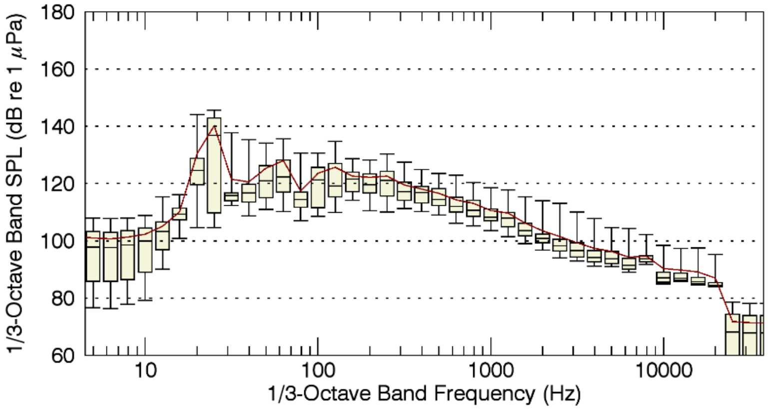


Figure D-64. Pile IP10 1/3-octave band level box plot for vibratory driving from AMAR recordings at a range of 1064 m.

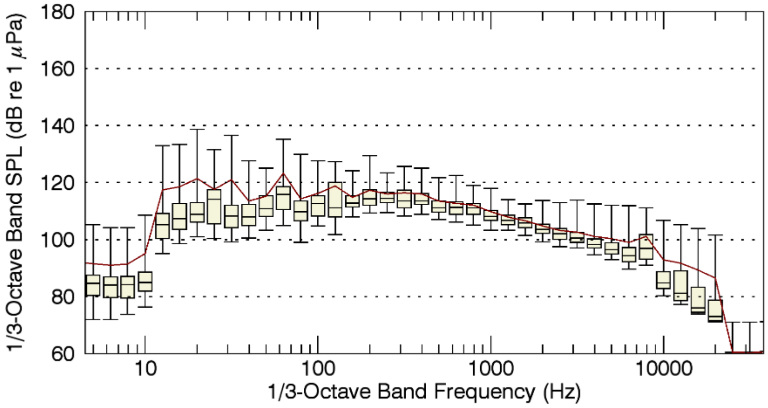


Figure D-65. Pile IP10 1/3-octave band level box plot for vibratory driving from the drift system recordings.

Appendix E. Acoustic Metrics

Underwater sound amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially impulsive noise such as from impact-hammer pile driving, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life.

The zero-to-peak SPL, or peak SPL (dB re 1 μPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$\text{Peak SPL} = 10\log_{10}\left[\frac{\max\left(\left|p^2(t)\right|\right)}{p_0^2}\right] \tag{E-1}$$

At high intensities, the peak SPL can be a valid criterion for assessing whether a sound is potentially injurious; however, because the peak SPL does not account for the duration of a noise event, it is a poor indicator of perceived loudness.

The root-mean-square (rms) SPL (dB re 1 μPa) is the rms pressure level in a stated frequency band over a time window (T, s) containing the acoustic event:

$$\text{rms SPL} = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \tag{E-2}$$

The rms SPL is a measure of the average pressure or of the effective pressure over the duration of an acoustic event, such as the emission of one acoustic pulse. Because the window length, T, is the divisor, events more spread out in time have a lower rms SPL for the same total acoustic energy density.

In studies of impulsive noise, T is often defined as the “90% energy pulse duration” (T_{90}): the interval over which the pulse energy curve rises from 5% to 95% of the total energy. The SPL computed over this T_{90} interval is commonly called the 90% rms SPL (dB re 1 μPa):

$$\text{90\% rms SPL} = 10\log_{10}\left(\frac{1}{T_{90}}\int_{T_{90}} p^2(t)dt \Big/ p_0^2\right) \tag{E-3}$$

The sound exposure level (SEL, dB re 1 μPa^2·s) is a measure of the total acoustic energy contained in one or more (N) acoustic events. The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T_{100}):

$$\text{SEL} = 10\log_{10}\left(\int_{T_{100}} p^2(t)dt \Big/ T_0 p_0^2\right) \tag{E-4}$$

where T_0 is a reference time interval of 1 s. The SEL represents the total acoustic energy received at some location during an acoustic event; it measures the total sound energy to which an organism at that location would be exposed.

SEL can be calculated over periods with multiple acoustic events (e.g. multiple pile driving impulses) or over a fixed period. For multiple events, the cumulative SEL (dB re 1 µPa²·s) can be computed by summing (in linear units) the SELs of the *N* individual events:

$$\text{Cumulative SEL} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{\text{SEL}_i}{10}}\right) \tag{E-5}$$

Because the rms SPL and SEL are both computed from the integral of square pressure, these metrics are related by the following expression, which depends only on the duration of the energy time window *T*:

$$\text{rms SPL} = \text{SEL} - 10\log_{10}(T) \tag{E-6}$$

$$\text{rms SPL} = \text{SEL} - 10\log_{10}(T_{90}) - 0.458 \tag{E-7}$$

where the term -0.458 dB, which is $10\log_{10}(0.9)$, accounts for the rms SPL containing 90% of the total energy from the per-pulse SEL.

E.1. 1/3-Octave Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the "power spectral density" of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analyzing a sound spectrum with passbands that increase exponentially in size is more meaningful to marine-mammal hearing. In underwater acoustics, a spectrum is commonly split into 1/3-octave bands, which are one-third of an octave wide; each octave represents a doubling in sound frequency. The center frequency of the *i*th 1/3-octave band, $f_c(i)$, is defined as:

$$f_c(i) = 10^{i/10}, \tag{E-8}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the *i*th 1/3-octave band are defined as:

$$f_{lo} = 10^{-1/20} f_c(i) \quad \text{and} \quad f_{hi} = 10^{1/20} f_c(i) \tag{E-9}$$

The 1/3-octave bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure E-1).

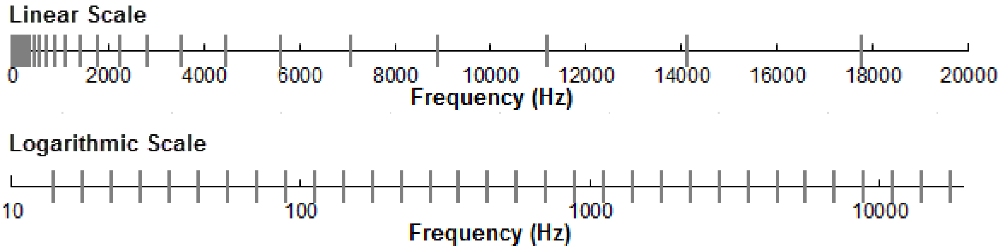


Figure E-1. One-third-octave bands shown on a linear frequency scale and on a logarithmic scale.

The sound pressure level in the ith 1/3-octave band $(L_b^{(i)})$ is computed from the power spectrum $S(f)$ between f_{lo} and f_{hi}:

$$L_{\text{b}}^{(i)} = 10\log_{10}\left(\int_{f_{lo}}^{f_{hi}} S(f)df\right) \qquad \text{(E-10)}$$

Summing the sound pressure level of all the 1/3-octave bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10\log_{10}\sum_{i} 10^{L_{\text{b}}^{(i)}/10} \qquad \text{(E-11)}$$

Figure E-2 shows an example of how the 1/3-octave band sound pressure levels compare to the power spectrum of an ambient noise signal. Because the 1/3-octave bands are wider with increasing frequency, the 1/3-octave band SPL is higher than the power spectrum, especially at higher frequencies.

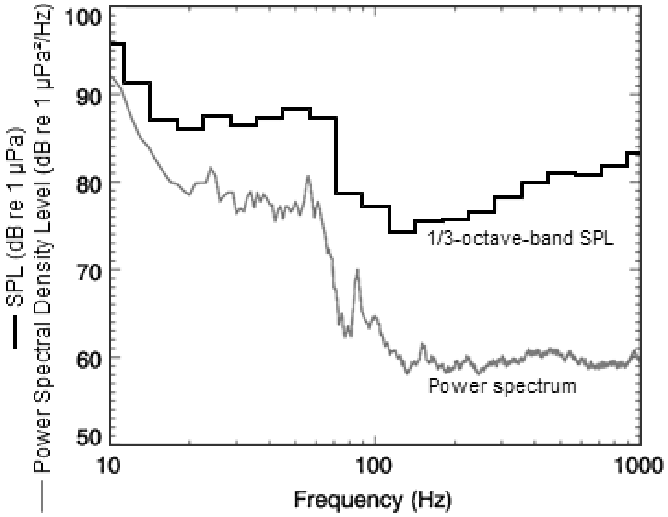


Figure E-2. A power spectrum and the corresponding 1/3-octave band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.

E.2. Marine Mammal Auditory Weighting Functions

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

Prior to August 2016, the NMFS SPL criteria for acoustic exposure injury to marine mammals were set according to recommendations for cautionary estimates of sound levels leading to onset of permanent hearing threshold shift (PTS). These criteria prescribed injury thresholds of 190 dB re 1 µPa SPL for pinnipeds and 180 dB re 1 µPa SPL for cetaceans. A corresponding injury threshold was not defined for non-impulsive sounds at that time. NMFS indicated that the SPL criteria should be used for all sources including sonars and explosives. These injury thresholds were applied to individual noise pulses and did not consider the overall duration of the noise or its acoustic frequency distribution.

Criteria that do not take into account exposure duration or noise spectra are generally insufficient for assessing hearing injury. Human workplace noise assessments consider the SPL as well as the duration of exposure and sound spectral characteristics. For example, the International Institute of Noise Control Engineering (I-INCE) and the Occupational Safety and Health Administration (OSHA) suggests thresholds in C-weighted peak pressure level and A-weighted time-average sound level (dB(A) Leq). They also suggest exchange rates that increase the allowable thresholds for each halving or doubling of exposure time. This approach assumes that hearing damage depends on the relative loudness perceived by the human ear. It also assumes that the ear might partially recover from past exposures, particularly if there are periods of quiet nested within the overall exposure.

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and cumulative SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species functional hearing groups: Low-, Mid- and High-Frequency Cetaceans (LFC, MFC, and HFC respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it infers a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LFC and HFC while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HFC of 179 dB re 1 $\mu Pa^2 \cdot s$. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LFC on results obtained from MFC studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LFC of 192 dB re 1 $\mu Pa^2 \cdot s$

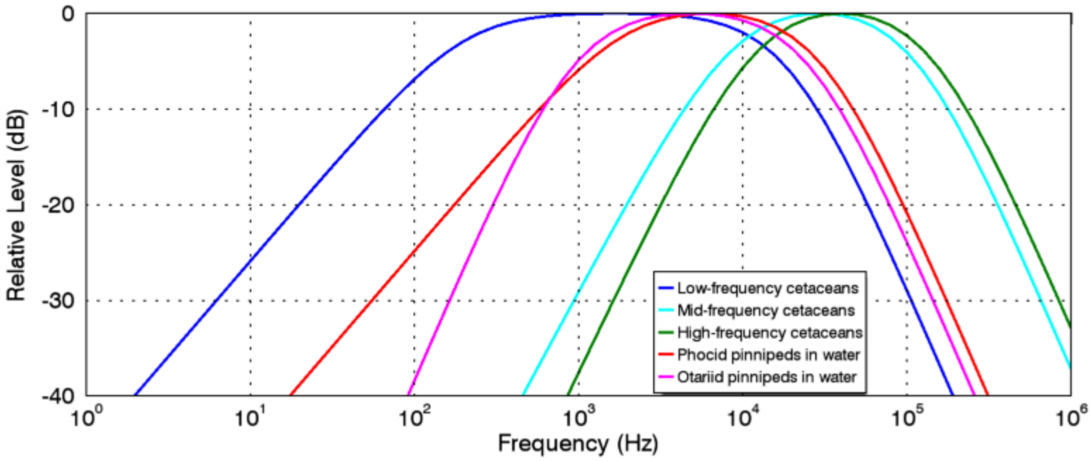
Also in 2012, the US Navy recommended a different set of criteria for assessing Navy operations (Finneran and Jenkins 2012). Their analysis incorporated new dolphin equal-loudness contours to update weighting functions and injury thresholds for LFC, MFC, and HFC. They recommended separating the pinniped group into otariids (eared seals) and phocids (earless seals) and assigning adjusted frequency thresholds to the former based on several sensitivity studies (Schusterman et al. 1972, Moore and Schusterman 1987, Babushina et al. 1991, Kastak and Schusterman 1998, Kastelein et al. 2005, Mulsow and Reichmuth 2007, Mulsow et al. 2011a, Mulsow et al. 2011b).

In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature, NMFS finalized technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing. The guidance describes injury criteria with new thresholds and frequency weighting functions for five functional hearing groups described by Finneran and Jenkins (2012).

In the NMFS proposed guidelines the cumulative SEL are computed as frequency-weighted sums of per-pulse SEL at the receiver (animal) position. These levels are directly compared with set thresholds to determine if a take has occurred. The frequency weighting filters and thresholds have been designed for up to five marine mammal classes: Low-Frequency Cetaceans (LFC), Mid-Frequency Cetaceans (MFC), High-Frequency Cetaceans (HFC), and two classes of Pinnipeds in water: phocids (PPW) and otariids (OPW). These weighting functions are graphed in the figure below.

To compute frequency weighted 90% SPL, a time domain filter corresponding to each functional hearing group weighting function was applied. FIR filters (order=65536) with magnitude specified by the NOAA

2016 weighting functions for each functional hear group were generated. The time domain filter was applied to the recorded signal prior to automated detection of individual impacts.



Frequency weighting filters defined the NMFS Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS, 2016).

ATTACHMENT 3

Marine Mammal Observation (MMO) Report

Final Project Report

Anchorage Port Modernization Project Test Pile Program Marine Mammal Observing Program

Submitted to:

Kiewit

2200 Columbia House Boulevard
Vancouver, Washington 98681
Contract No. C-20150888

31 July 2016

Prepared in Consultation With:

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Suggested citation:

Cornick, L. and Seagars, D.J. 2016. Final Report: Anchorage Port Modernization Project Test Pile Program. Technical report by AECOM for Kiewit.

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List of Acronyms

APMP	Anchorage Port Modernization Project
APU	Alaska Pacific University
ESA	Endangered Species Act
IHA	Incidental Harassment Authorization
MMPA	Marine Mammal Protection Act
MMOs	Marine Mammal Observers
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
POA	Port of Anchorage Administration
TPP	Test Pile Program

1.0 Introduction

This document presents the final report for monitoring and data collection of beluga whale (*Delphinapterus leucas*) and other marine mammal observations during project activities associated with the Anchorage Port Modernization Project (APMP) Test Pile Program (TPP). Kiewit was contracted by the Port of Anchorage (POA) to conduct the TTP. AECOM and its subcontractor Alaska Pacific University (APU) were part of the Kiewit team, responsible for marine mammal observation tasks.

The monitoring effort and data collection were conducted at three locations: 1) the Anchorage Public Boat Dock, 2) the North End, which is located just above shore level at the north end of the APMP, and 3) a roving observer with primary responsibility for the mandatory 100 m shutdown zone and areas immediately adjacent to TPP in-water activity that were not observable from other stations under all scenarios. Marine mammal monitoring was conducted by Marine Mammal Observers (MMOs) primarily from APU, during 19 non-consecutive days from 03 May through 21 June, 2016. Monitoring was conducted according to the conditions of the Incidental Harassment Authorization (IHA) issued to the POA on 4 March, 2016, Sections 4(f) and 5(b-c) and the Marine Mammal Monitoring and Mitigation Plan (updated 3 March, 2016) submitted to the POA by CH2M, their prime contractor for the APMP.

2.0 Monitoring Effort and Methods

2.1 Observation Stations

Monitoring was conducted by trained MMOs primarily from the Marine and Environmental Sciences program at APU, with additional MMOs provided by AECOM. In order to ensure full MMO coverage of the Level-B harassment and shutdown zones implemented in the IHA, we used two observation stations located at the northern and southern extents of the project area (Figure 2.1). One station was located at the Anchorage Public Boat Dock and the other at the North End of the Port, based on previous monitoring conducted for the Port (Cornick et al. 2011). The alignment, configuration, and height of these stations generally provided a wide sweeping view of the required monitoring area with good overlap between stations (Figures 2.2 - 2.3 a-b).

However, once the pile barge and crane arrived on scene and were positioned for driving, it was discovered that a portion of the nearshore areas where pile driving was to occur was obscured from view by the barges themselves, various other Port machinery, and topography. At the South Station, stacks of unloaded shipping containers and a barge, grounded off the Spenard Builders yard with the landing gate lofted high in the air, obscured the view to the north towards the inshore side of the Coast Guard pier. At the North station the view of a small bight at the northern end of the existing Matson pier and ~500m south along the northern extent of that pier was also obscured.

As a result, an additional MMO (Rover) was stationed adjacent to TPP activities in order to monitor the 100m mandatory shutdown zone for all marine mammals, as well as portions of the beluga shutdown zones not observable from the North and South stations under all scenarios. By virtue of being directly adjacent to the driving location, the Rover was able to serve as primary contact between the pile drivers and the observers, manage decision making for the MMO teams, ensure the area immediately adjacent to the in-water activities was effectively monitored, and relayed specific information about TPP activities to both stations. This facilitated appropriate preparations and monitoring without having to involve construction staff in additional communications.

A team of four MMOs (3 observers, 1 Field Chief) was positioned at each of the two observation stations. Each morning the teams were provided with large format maps depicting the monitoring, take, and shutdown zones defined in the IHA (Table 2.1) and specific to the location of the particular pile being driven that date. These maps facilitated correctly determining if a marine mammal sighting was within a particular zone. We recommend a similar protocol for future monitoring, with each station staffed by 4 MMOs, rotating between active and resting periods, in order to avoid eye strain, particularly for shifts in excess of 6 hours. A minimum of 3 MMOs is needed at each station in order to accommodate any necessary rest.

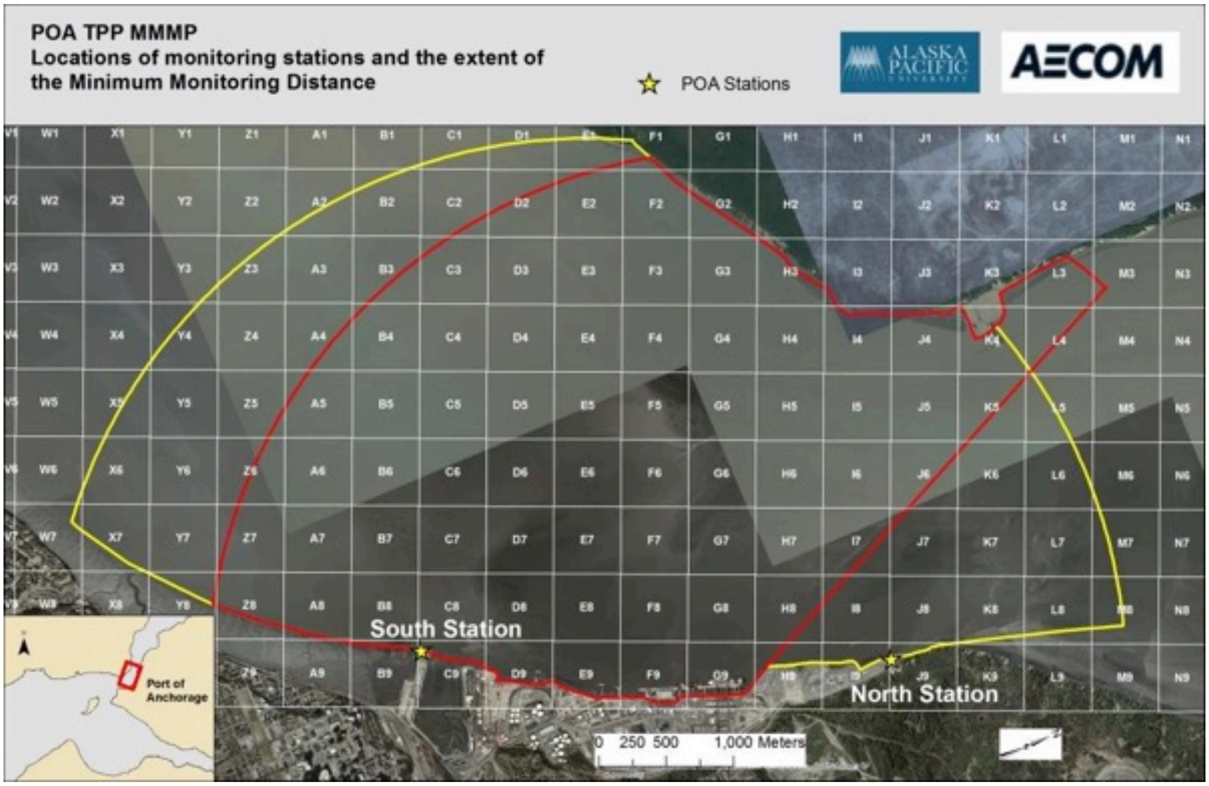


Figure 2.1. Aerial map of study area with 500 x 500 m grid overlay and extent of monitoring zones. The APMP footprint is enclosed within grid cells D9 – I9. Observation stations at Anchorage Public Boat Dock (South; grid cell C9) and POA (North; grid cell I9) are denoted by yellow stars.

Figure 2.2. Configuration of observation stations. Elevated platform provided maximum field of view of the water's surface.

Figure 2.3. Panoramic views of field of view from the North Station (panel a) and South Station (panel b).

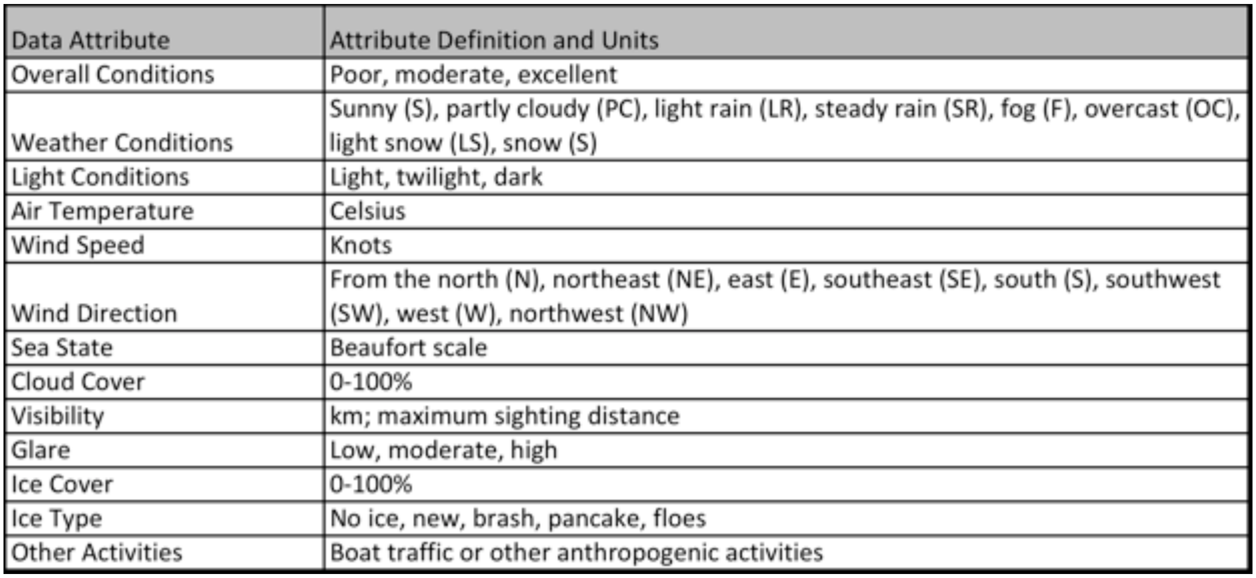
Table 2.1. Required monitoring and Level-B harassment (take) zones for beluga whales and other marine mammals (as defined by NMFS, IHA issued to the Port of Anchorage, March 4, 2016). Red is mandatory shut down, orange is inferred Level-B harassment take, yellow is stated Level-B harassment take with the ability to continue pile driving operations; green is the overall "minimum required monitoring area."

Pile Activity	**Unattenuated Piles**		**Attenuated Piles**	
	Belugas	**Other marine mammals**	**Belugas**	**Other Marine Mammals**
All activity – shut down		100 m		100 m
Impact	1,400		300 m	
Vibratory	4,000		900 m	
Level B Harassment Take				
Impact	1,400	1,400	1,400	1,400
Vibratory	4,000	4,000	4,000	4,000
Minimum radial distance for monitoring				
Impact	1,400 m			
Vibratory	4,000 m			
Non-Pile Driving Activities				
All operations cease if marine mammal within 10 m of vessel, machinery.				

2.2 Environmental Sampling Protocols

Environmental data pertaining to monitoring conditions were logged every 30 minutes during observation sessions, or when conditions changed (Table 2.2). These data were used to assess overall monitoring conditions and determine if observations were obstructed by environmental conditions.

Table 2.2. Attribute definitions and units for environmental data.



Data Attribute	Attribute Definition and Units
Overall Conditions	Poor, moderate, excellent
Weather Conditions	Sunny (S), partly cloudy (PC), light rain (LR), steady rain (SR), fog (F), overcast (OC), light snow (LS), snow (S)
Light Conditions	Light, twilight, dark
Air Temperature	Celsius
Wind Speed	Knots
Wind Direction	From the north (N), northeast (NE), east (E), southeast (SE), south (S), southwest (SW), west (W), northwest (NW)
Sea State	Beaufort scale
Cloud Cover	0-100%
Visibility	km; maximum sighting distance
Glare	Low, moderate, high
Ice Cover	0-100%
Ice Type	No ice, new, brash, pancake, floes
Other Activities	Boat traffic or other anthropogenic activities

2.3 Pile Driving

Pile driving activities were documented during observation sessions based on daily construction information provided by Kiewit during real-time communications with the Rover. Specific notations included whether the activity was impact or vibratory, unattenuated or attenuated, and type of attenuation, if applicable. “All clear” notice and start and stop times of all pile driving activity were recorded.

2.4 Marine Mammal Monitoring and Observations

Monitoring was conducted throughout the study period during all pile driving operations. MMOs arrived onsite ~1 hour before scheduled pile driving startup, and monitoring commenced 30 minutes before the scheduled pile driving startup. The Rover served as the primary point of contact between Kiewit and the observation stations to coordinate activity and notifications of marine mammal sightings and shutdown recommendations, as appropriate. Communication between the Rover, station MMOs, and Kiewit staff was maintained throughout observation periods via hand-held radios and cellular phone. MMOs at the observation stations rotated through 3 duty stations (2 observing, 1 recording data) and a rest period every 30 min in order to minimize eye strain. MMOs were provided additional breaks during periods of TPP downtime as practicable. Monitoring shifts lasted between 3-10 hours.

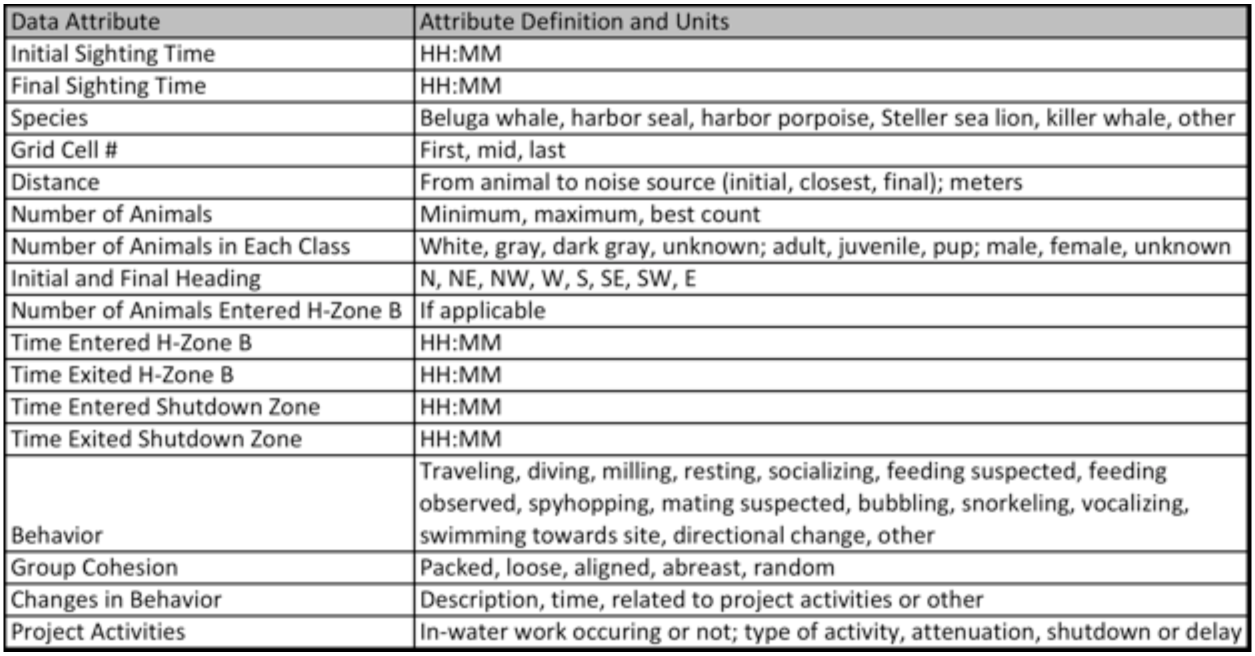
All required harassment and shutdown zones were monitored continuously using binoculars (Bushnell 7x50 with internal compass and range-finding reticle or Nikon Monarch ATB 10x42). The South station was also equipped with Celestron 71008 SkyMaster 25x70 long-range binoculars mounted on a tripod in order to provide additional viewing power of the 4 km beluga whale shutdown zone for vibratory pile driving.

Beluga whales were classified by color (white, gray, or dark gray, which are classified as calves) and proximity (calves remain in close proximity to mothers, usually in direct contact). White beluga whales are typically adults and gray beluga whales are typically juveniles; however, there is considerable variation in the age at which beluga whales acquire their full white color. Therefore, color cannot be used reliably to determine age class beyond calves. Gray beluga whales (normally considered juveniles) have been reported closely associated with calves, suggesting that they may be reproductively mature (NMFS, unpublished data). Other marine mammals (harbor seals, Steller sea lions, harbor porpoises, killer whales) were classified as adult, juvenile or unknown; sex was noted if observable. Primary behavioral states of observed marine mammals were recorded, and secondary and/or abrupt behavioral changes were recorded, if applicable.

Attributes for data collection when beluga whales or other marine mammals were observed are summarized in **Table 2.3**. Locations were classified according to the grid-cell map using bearings obtained from sighting binoculars and distances from known landmarks estimated by eye (Figure 2.1). A surveyor’s theodolite was used to mark GPS locations when animals were in view long enough to obtain a fix.

Other anthropogenic activity in the study area was also recorded. If a marine mammal was observed within 10m of any in-water project-related work other than pile driving (e.g., movement of the barge to the pile location, positioning the pile on the substrate, support watercraft activity), communication was initiated and appropriate action recommended (e.g., shutdown of pile driving, reduced watercraft speed).

Table 2.3. Attribute definitions and units for marine mammal data.



Data Attribute	Attribute Definition and Units
Initial Sighting Time	HH:MM
Final Sighting Time	HH:MM
Species	Beluga whale, harbor seal, harbor porpoise, Steller sea lion, killer whale, other
Grid Cell #	First, mid, last
Distance	From animal to noise source (initial, closest, final); meters
Number of Animals	Minimum, maximum, best count
Number of Animals in Each Class	White, gray, dark gray, unknown; adult, juvenile, pup; male, female, unknown
Initial and Final Heading	N, NE, NW, W, S, SE, SW, E
Number of Animals Entered H-Zone B	If applicable
Time Entered H-Zone B	HH:MM
Time Exited H-Zone B	HH:MM
Time Entered Shutdown Zone	HH:MM
Time Exited Shutdown Zone	HH:MM
Behavior	Traveling, diving, milling, resting, socializing, feeding suspected, feeding observed, spyhopping, mating suspected, bubbling, snorkeling, vocalizing, swimming towards site, directional change, other
Group Cohesion	Packed, loose, aligned, abreast, random
Changes in Behavior	Description, time, related to project activities or other
Project Activities	In-water work occuring or not; type of activity, attenuation, shutdown or delay

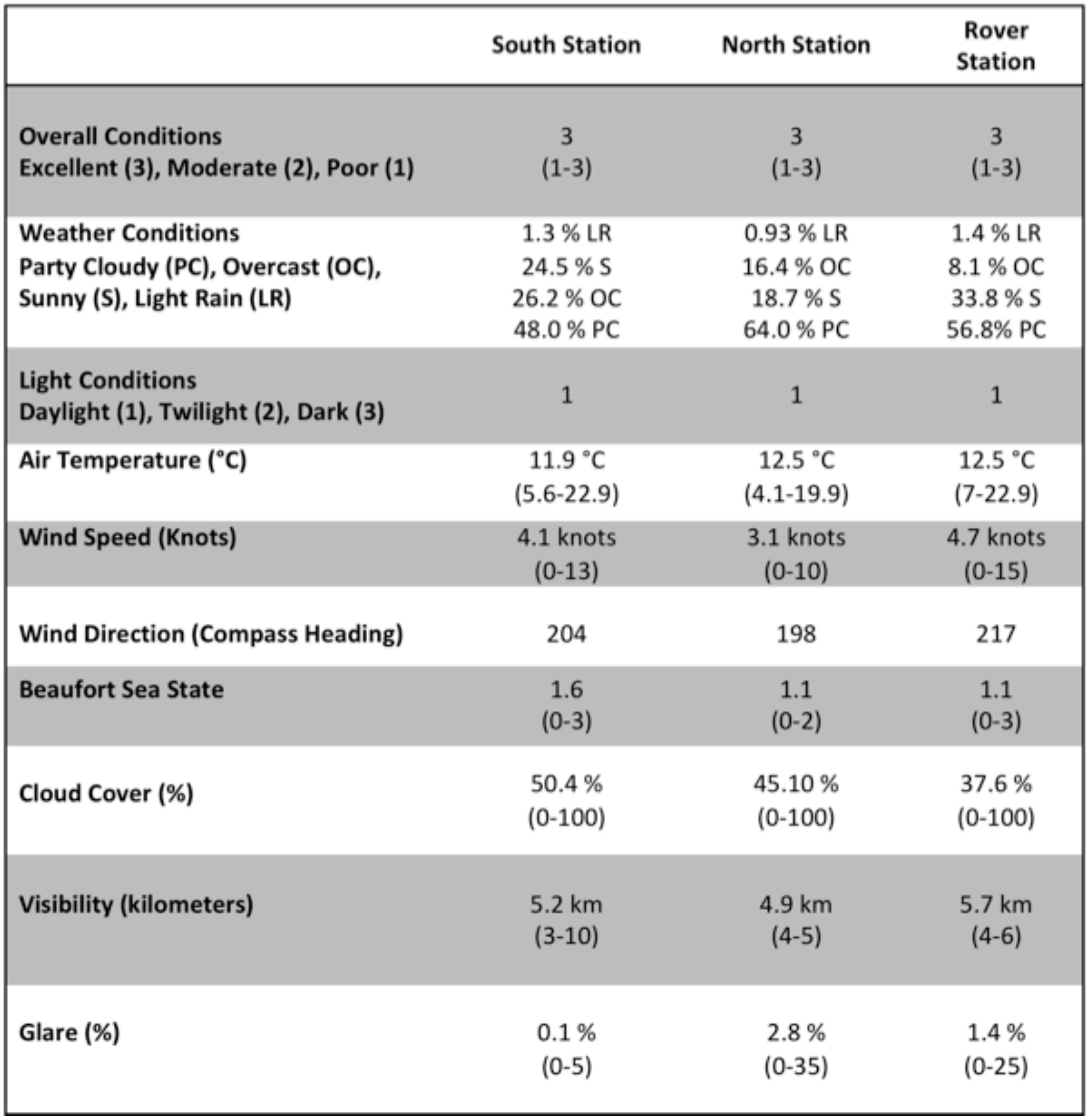
3.0 Results

3.1 Environmental Conditions

Environmental conditions during the observation periods are summarized in Table 3.1.

Overall conditions were excellent; however, on 18 May at ~0911 a storm front moved through the monitoring zone from south to north over a period of ~20 minutes during unattenuated vibratory pile driving. Observers at the South Station reported the onset of obscured visibility at the edge of the 4000m monitoring zone to the Rover at ~0919 and shutdown was recommended; Kiewit indicated that vibratory was near completion, so the decision was made to shutdown due to weather and prepare for impact pile driving. At that time MMOs initiated the 30-min post strike monitoring period. Visibility of the complete 4000m monitoring zone returned at ~0941, for a total shutdown period of 22 min. Post-strike monitoring was completed at 0949.

Table 3.1. Summary of environmental conditions. Weather conditions are reported as % occurrence. All others are means.



	South Station	North Station	Rover Station
Overall Conditions **Excellent (3), Moderate (2), Poor (1)**	3 (1-3)	3 (1-3)	3 (1-3)
Weather Conditions **Party Cloudy (PC), Overcast (OC), Sunny (S), Light Rain (LR)**	1.3 % LR 24.5 % S 26.2 % OC 48.0 % PC	0.93 % LR 16.4 % OC 18.7 % S 64.0 % PC	1.4 % LR 8.1 % OC 33.8 % S 56.8% PC
Light Conditions **Daylight (1), Twilight (2), Dark (3)**	1	1	1
Air Temperature (°C)	11.9 °C (5.6-22.9)	12.5 °C (4.1-19.9)	12.5 °C (7-22.9)
Wind Speed (Knots)	4.1 knots (0-13)	3.1 knots (0-10)	4.7 knots (0-15)
Wind Direction (Compass Heading)	204	198	217
Beaufort Sea State	1.6 (0-3)	1.1 (0-2)	1.1 (0-3)
Cloud Cover (%)	50.4 % (0-100)	45.10 % (0-100)	37.6 % (0-100)
Visibility (kilometers)	5.2 km (3-10)	4.9 km (4-5)	5.7 km (4-6)
Glare (%)	0.1 % (0-5)	2.8 % (0-35)	1.4 % (0-25)

3.2 Marine Mammal Observations

Beluga whale and other marine mammal observations are summarized in Tables 3.2 and 3.3. Received sound levels (RL) for marine mammal sightings were calculated by JASCO Applied Sciences using the following equation:

$$RL=SL-nlog(R)$$

where *R* is the distance between the pile and the sighted marine mammal (in meters), *SL* is the pile driving source level, and *n* is the transmission loss coefficient. The calculations applied the median measured source level and the appropriate transmission loss coefficient (Table 12 in Austin et al, 2016) for the pile and hammer that corresponded to the time of the sighting.

Marine mammal sightings occurred throughout the observation area (Figures 3.1-3.3). There were a total of 10 beluga whales observed, with 1 take (see Section 3.4). There were a total of 6 Steller sea lions observed, with 1 take, and 28 harbor seals observed with 7 takes. No other marine mammal species were observed.

There was only one sighting of a marine mammal in a “shut-down” zone – a beluga whale, observed twice within the “pending” shutdown zone for pile # 7 at 0809 and 0811 on 25 May. The observation occurred during a “30 min pre-strike” watch period that was subsequently extended for mechanical adjustments; thus the animal was last observed 2 hours 49 minutes prior to pile driving activity. No shut down was initiated.

At 1007 on 03 June, the North Station reported what appeared to be a floating dead whale, or perhaps debris shaped as such, on the far side of the Inlet (grid cells K4-F2) drifting south with the outgoing tide. Despite additional observations with 25x binoculars from the South Station, no positive identification was possible and the object was recorded as “unidentified” at 1037. At 1256 on 08 June a similarly shaped object was observed on the far side of the Inlet in H3, again moving south. No positive identification was made. On the morning of 10 June a NOAA Law Enforcement Officer visited the North station to inform MMOs that they had a report of a large floating dead cetacean in the upper Inlet. The MMOs were alerted to watch for the whale during regular observations. At 0848 a large object, with similar shape and appearance to that seen previously, was sighted outside of the monitoring zone ~9100m to the west. Over the next 20 minutes the object drifted rapidly north into the monitoring zone on the incoming tide. By 0908, multiple MMOs could clearly see buccal grooves on an inflated throat region with numerous sea birds roosting on the carcass of the floating dead whale. The sighting was reported to Kiewit for forwarding on to NOAA. A NOAA vessel inspecting the object later that morning confirmed it was a large dead cetacean, with positive identification pending analysis of skin samples taken on site. In retrospect, improved lighting conditions (sun behind observers and at a relatively lower angle than prior dates) associated with the earlier observation time of the 08 June sighting may have facilitated visual identification of this object as a dead whale floating on the far side of the inlet nearly 4000m away.

Primary marine mammal behaviors were limited to traveling and milling (Figure 3.4). Diving was observed as a secondary behavior on 3 occasions; once in a beluga whale and in two Steller sea lion observations. There were two events where an abrupt change in behavior was noted (see Section 3.4). No other behaviors were observed.

Table 3.2. Beluga whale observations.

Beluga Whales - All Stations													
Date	White (#)	Gray (#)	Dark Gray (#)	Unknown (#)	First Sighted	Sighting Duration (min)	Grid Cells Occupied	In-Water TPP Activity	Attenuation Method	Received Sound Level (dB re 1 µPa)	Entered Level-B	Shutdown	Takes (#)
3-May-16	0	2	0	0	20:52	1	J4	None	N/A	N/A	N	N/A	0
12-May-16	0	1	0	0	12:53	1	G2	None	N/A	N/A	N	N/A	0
25-May-16	0	1	0	0	8:09	2	F9	None	N/A	N/A	N	N/A	0
25-May-16	0	0	0	1	8:13	1	G9	None	N/A	N/A	N	N/A	0
25-May-16	0	1	0	0	8:31	23	D9, C9, B8, A8, A7	None	N/A	N/A	N	N/A	0
25-May-16	0	1	0	0	9:14	10	D9	None	N/A	N/A	N	N/A	0
25-May-16	0	1	0	0	9:58	8	I8, J8, K8, L9	None	N/A	N/A	N	N/A	0
25-May-16	0	1	0	0	10:19	9	J8, I9, H9	None	N/A	N/A	N	N/A	0
25-May-16	0	1	0	0	11:02	13	H8, I9, J8, K8	Vibratory	Bubble	125.7	Y	N	1
Totals	**0**	**9**	**0**	**1**							**Total Takes**		**1**

Table 3.3. Other marine mammal observations.

Other Marine Mammals - All Stations												
Date	Adults (#)	Juveniles/ Pups (#)	Unknown Age Class (#)	First Sighted	Sighting Duration (min)	Grid Cells Occupied	In-Water TPP Activity	Attenuation Method	Received Sound Level (dB re 1 µPa)	Entered Level-B	Shutdown	Takes (#)
						Harbor Seals						
3-May-16	0	0	1	19:55	1	C8	Impact	Resonance	166.1	Y	N	1
6-May-16	0	0	1	9:01	1	I8	None	N/A		N	N/A	0
25-May-16	0	0	1	8:20	6	D4, E5, G5	None	N/A		N	N/A	0
26-May-16	0	0	1	10:21	2	A5	None	N/A		N	N/A	0
7-Jun-16	0	0	1	10:37	8	I6, G5, H7	None	N/A		Y	N/A	0
7-Jun-16	0	0	1	11:12	43	G8, B8, C8	None	N/A		Y	N/A	1
7-Jun-16	0	0	1	12:19	1	B9	Impact	None	156	N	N	0
7-Jun-16	0	0	1	12:29	63	C8, C9, C8	Impact	None	162.8	Y	N	1
7-Jun-16	0	0	1	13:16	2	J8, I9	None	N/A		Y	N/A	0
10-Jun-16	0	0	2	7:42	75	C8, C9	None	N/A		Y	N/A	0
10-Jun-16	0	0	1	9:26	3	B8, C8	None	N/A		Y	N/A	0
10-Jun-16	0	0	1	9:40	35	D8, C8, C9	Impact	None	Not Measured	Y	N	1
10-Jun-16	0	0	1	10:42	36	C9, C8, C9	None	N/A		Y	N/A	0
10-Jun-16	0	0	1	11:13	1	Z5	None	N/A		N	N/A	0
10-Jun-16	0	0	1	11:29	18	C9	None	N/A		Y	N/A	0
10-Jun-16	0	0	1	11:39	6	D8	None	N/A		Y	N/A	0
10-Jun-16	0	0	1	12:10	68	C9, C7, B7	Impact	None	Not Measured	Y	N	1
15-Jun-16	0	0	1	10:32	27	C9, B6, A6	None	N/A		N	N/A	0
16-Jun-16	0	0	1	11:32	16	J8, I8, G8	None	N/A		Y	N/A	0
16-Jun-16	0	0	1	12:20	1	G7	Impact	None	Not Measured	Y	N	1
21-Jun-16	0	0	1	12:03	38	C9	None	N/A		Y	N/A	0
21-Jun-16	0	0	1	12:16	12	I7, J8	None	N/A		N	N/A	0
21-Jun-16	0	0	1	12:38	1	J8	None	N/A		N	N/A	0
21-Jun-16	0	0	1	12:48	6	J9, J8	None	N/A		N	N/A	0
21-Jun-16	0	0	1	12:56	33	C9, C8	None	N/A		Y	N/A	0
21-Jun-16	0	0	1	13:24	5	B7	None	N/A		N	N/A	0
21-Jun-16	0	0	1	13:32	2	A5	None	N/A		N	N/A	1
Totals	**0**	**0**	**28**									**7**
						Steller Sea Lions						
2-May-16	0	0	1	13:52	30	A3, C4, E4, I5, K5	None	N/A		Y	N/A	0
25-May-16	0	1	0	9:08	2	F9, G8	None	N/A		Y	N/A	0
25-May-16	0	0	1	9:16	1	I8	None	N/A		N	N/A	0
25-May-16	0	1	0	9:38	6	E9	None	N/A		Y	N/A	1
25-May-16	0	0	1	9:51	1	D8	None	N/A		N	N/A	0
25-May-16	1	0	0	9:58	6	A7, Y5	None	N/A		N	N/A	0
Totals	**1**	**2**	**3**									**1**

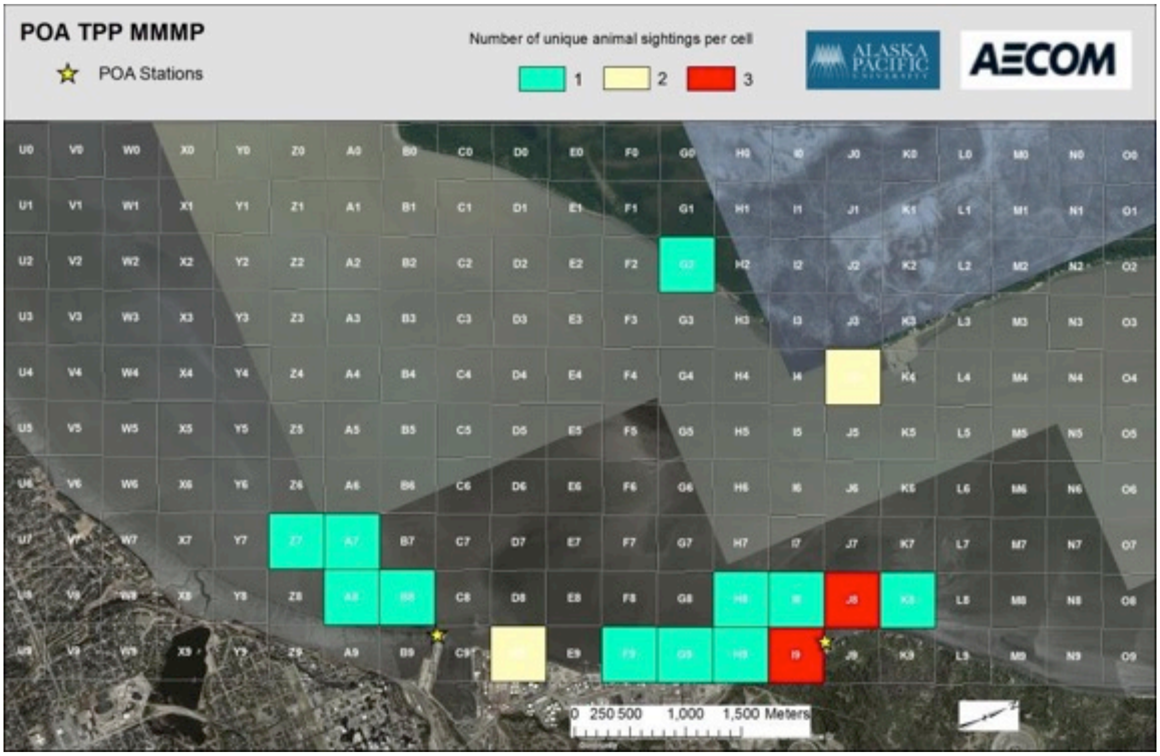


Figure 3.1. Distribution of beluga whale observations. Shaded cells represent all grid cells where animals were observed. Green = one observation in the cell, yellow = two observations in the cell, and red = three observations in the cell. Observations may be of the same or multiple individuals.

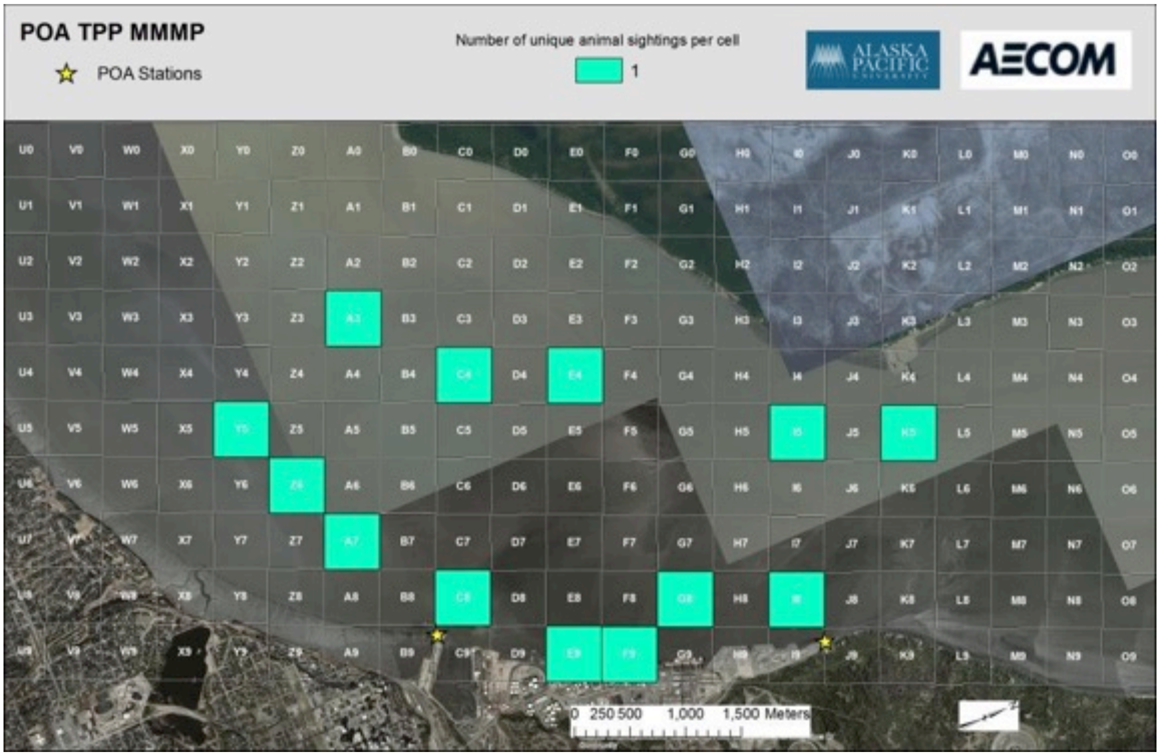


Figure 3.2. Distribution of Steller sea lion observations. Shaded cells represent all grid cells where animals were observed. Green = one observation in the cell. Observations may be of the same or multiple individuals.

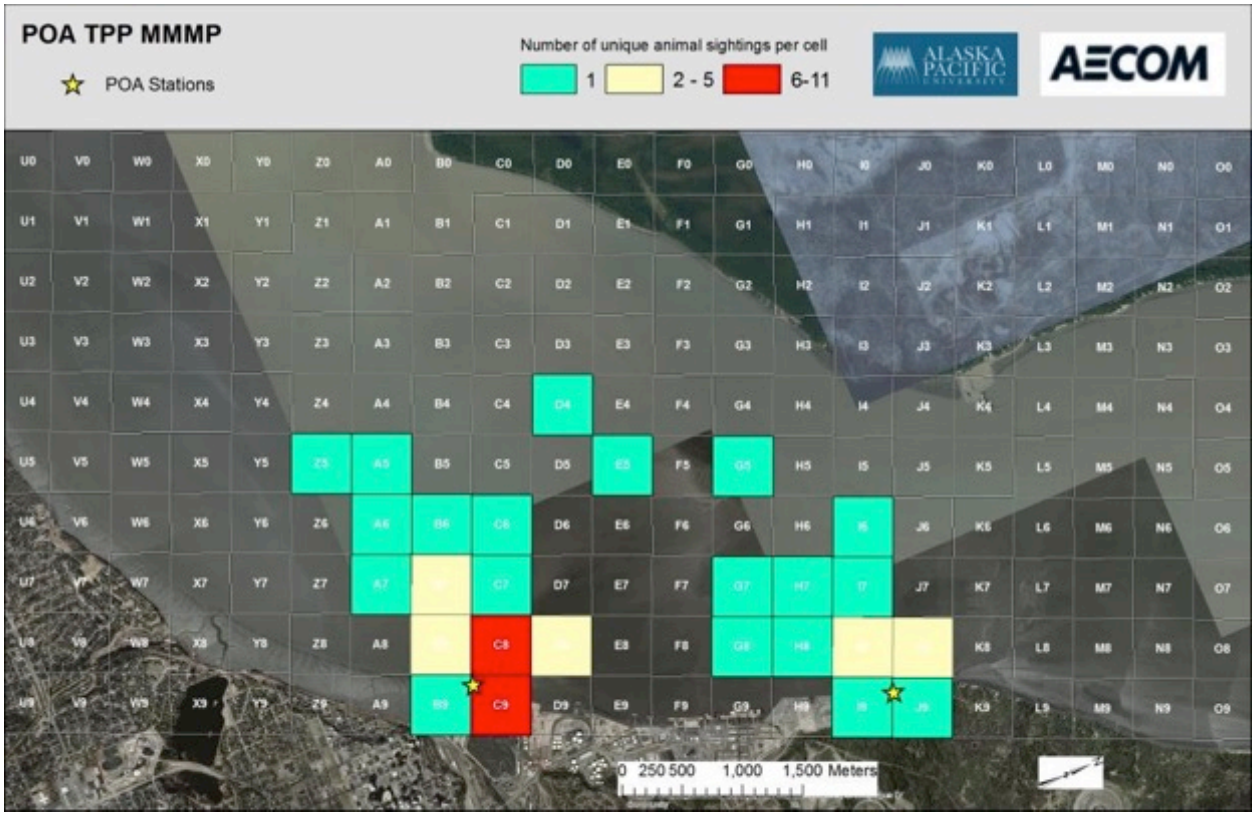


Figure 3.3. Distribution of harbor seal observations. Shaded cells represent all grid cells where animals were observed. Green = one observation in the cell, yellow = 2-5 observations in the cell, and red = 6-11 observations in the cell. Observations may be of the same or multiple individuals.

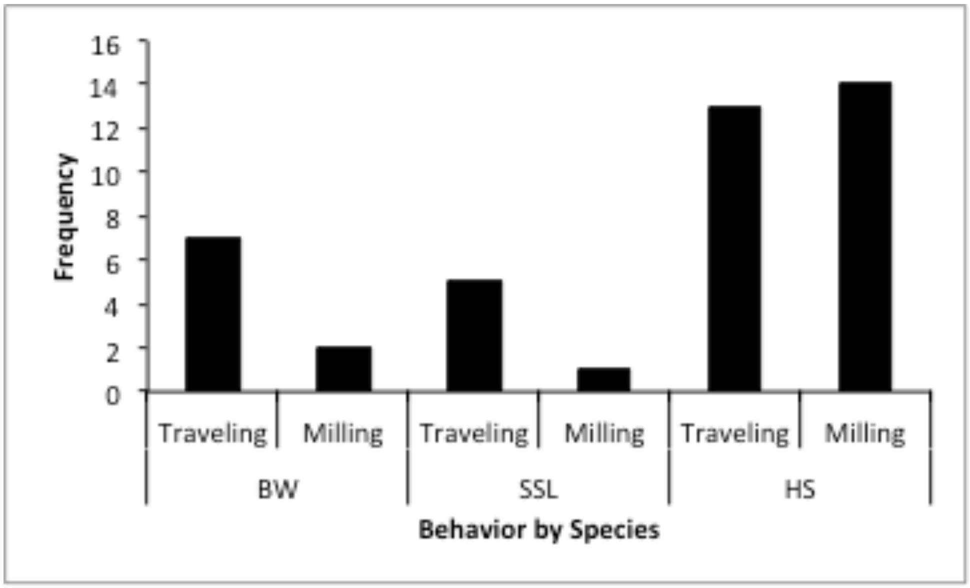


Figure 3.4. Frequency of primary marine mammal behaviors by species. BW = beluga whale, SSL = Steller sea lion, HS = harbor seal.

3.3 Sighting Rates and Detectability

Observations were conducted over 19 field days with a total of 85.3 hours of effort. Daily and cumulative sighting rates for each marine mammal species observed are summarized in Table 3.4. There were insufficient data to perform detectability analyses.

Table 3.4. Daily and cumulative sighting rates. Total effort is calculated as the total hours of active monitoring (total on-site time – stand down periods).

Date	Start	End	Total Effort (hr) excluding breaks	Beluga whale groups observed	Beluga whale sighting rate (groups/hour)	Harbor seals observed	Harbor seal sighting rate (individuals/hour)	Steller sea lions observed	Steller sea lion sighting rate (individuals/hour)
2-May	10:06	15:17	3.7	0	0	0	0.00	1	0.27
3-May	8:45	21:07	7.9	1	0.13	1	0.13	0	0.00
6-May	6:15	11:45	3.0	0	0	1	0.33	0	0.00
7-May	9:10	11:52	1.7	0	0	0	0.00	0	0.00
12-May	10:47	16:51	4.8	1	0.21	0	0.00	0	0.00
13-May	7:13	9:16	2.1	0	0	0	0.00	0	0.00
18-May	7:20	13:04	4.8	0	0	0	0.00	0	0.00
19-May	7:09	12:18	4.7	0	0	0	0.00	0	0.00
25-May	8:05	15:10	6.2	7	1.13	1	0.16	5	0.80
26-May	8:41	16:07	6.7	0	0	1	0.15	0	0.00
1-Jun	4:47	11:09	5.9	0	0	0	0.00	0	0.00
3-Jun	6:30	14:32	7.8	0	0	0	0.00	0	0.00
7-Jun	9:04	13:32	6.2	0	0	5	0.81	0	0.00
8-Jun	12:00	14:02	2.0	0	0	0	0.00	0	0.00
9-Jun	13:50	16:56	4.1	0	0	0	0.00	0	0.00
10-Jun	7:31	13:39	6.4	0	0	9	1.41	0	0.00
15-Jun	10:30	11:30	1.0	0	0	1	1.00	0	0.00
16-Jun	10:05	13:00	2.9	0	0	2	0.69	0	0.00
21-Jun	12:00	15:27	3.5	0	0	7	2.03	0	0.00
Cumulative Totals			**85.3**	**9**	**0.11**	**28**	**0.33**	**6**	**0.07**

3.4 Marine Mammal Takes

Marine mammal takes are summarized in Table 3.5. A brief narrative follows for each event including observations noted, a description of sighting conditions, in-water activity, location, behavior, and behavioral changes reported when applicable. There was 1 Level-B beluga whale take, 1 Level-B Steller sea lion take, and 7 Level-B harbor seal takes. Take limits were not reached for any species.

On 3 May 1 unknown age and sex harbor seal surfaced in the Level-B harassment zone in grid cell C8, ~900 m from TPP activity (pile #9; impact with resonance-based attenuation; Figure 3.5). The seal immediately submerged and was not re-sighted. TPP activity was not shut down because the seal did not enter the 100 m shutdown zone for other marine mammals. Sighting conditions at the time of the take were rated as excellent – overcast skies, light wind (2.5 kts), sea state of 1, 5+ km visibility, with no glare.

On 25 May 1 gray beluga whale surfaced in the Level-B harassment zone in grid cell H8, ~1300 m from TPP activity (pile #7; vibratory with air bubble curtain attenuation; Figure 3.6). The closest distance fixed with the theodolite was ~238m. The animal was traveling north and tracked for 13 min alongshore. It left the monitoring zone in grid cell I9 and continued traveling until it was no longer in view. It was last sighted in grid cell K8 at 1115. TPP activity was not shut down because the whale did not enter the 900 m shutdown zone for attenuated vibratory pile driving. There were no abrupt changes in behavior. Sighting conditions at the time of the take were rated as excellent – partly cloudy skies, moderate wind (5 kts), sea state of 1, 5+ km visibility, with no glare.

On 25 May at 0938 a large juvenile (sub-adult) Steller sea lion was observed traveling and milling ~100m to west of POL#2 dock in grid cell E9 during a pre-strike scanning period (Figure 3.6). This individual was moving towards the dock at an oblique angle and dove, resurfacing twice less than a minute later within about 60m away. About this time a small workboat used by the project left the stern of the pile barge and began to travel to the south at approximately 6-7 kts (a small wake was produced). Kiewit estimated the speed at ~4-5 kts (Daily Report CN-SUB-052a). As the workboat approached POL#2, the SSL surfaced off its port beam, roughly 20m away. The SSL swam rapidly alongside the boat and as it dove, it was headed to the front of the bow of the boat. A few seconds later the SSL surfaced just ahead of the bow within 3 m, and at that point both the skipper and the passengers noticed the SSL as it dove beneath the bow within 1m. The workboat then proceeded to the Coast Guard dock. Shortly thereafter the workboat returned to the pile barge. On this return trip, the workboat appeared to travel somewhat faster than before, approaching planing speed, as the wake was initially large as it left the dock but then diminished slightly as it increased speed. The boat's route crossed with the sea lion's path as it swam off the port side, passing either within 1m or directly over the spot where the sea lion had been surface swimming, and then it dove a few seconds (<3) before course intersection. In both events the sea lion abruptly changed its direction of travel and dove rapidly at vessel approach. This sighting was not initially recorded as a take, but upon further review, due to the abrupt change in behavior during both encounters, the sighting was reclassified as a take. Sighting conditions at the time of the take were rated excellent (6+km visibility) with partly cloudy to sunny skies, no glare, sea state 1, and a south wind at 4-5 kts.

On 07 June a single harbor seal was observed traveling and then milling at the edge of the Level-B Harassment zone (grid cell C8) at 1112 (Figure 3.7). Unattenuated impact pile driving commenced at 1139; at that time the seal was inside the Level-B zone and the take was recorded. The seal left the Level-B zone at 1148 and went out of view at 1155. There were no abrupt changes in behavior. Sighting conditions at the time of the take were rated as excellent – partly cloudy skies, moderate wind (5-6 kts), sea state of 1-2, 5+ km of visibility, with no glare.

On 07 June another single harbor seal was observed in the same general area (grid cell C8) at 1229 during unattenuated impact pile driving, which ended at 1302 (Figure 3.7). It left the Level-B Harassment zone at 1322, and was still in view at 1332 when the 30 min post scan was completed. This may have been the same animal that was described in the previous sighting given the location; however, because there was more than 10 min between observations it was recorded as a separate sighting. There were no abrupt changes in behavior. Sighting conditions at the time of the take were rated as excellent – partly cloudy skies, moderate wind (5-6 kts), sea state of 1-2, 5+ km of visibility, with no glare.

On 10 June a single harbor seal was observed at 0940 inside the Level-B Harassment zone (grid cell D8) during unattenuated impact pile driving (Figure 3.8). It continued to mill inside the Level-B zone until it went out of view at 1015. There were no abrupt changes in behavior. Sighting conditions at the time of the take were rated as excellent – partly cloudy skies, moderate wind (5-6 kts), sea state of 1-2, 5+ km of visibility, with no glare.

On 10 June another single harbor seal was observed milling in the same general area in grid cell C9 at 1210 during unattenuated impact pile driving (Figure 3.8). This animal exhibited an abrupt behavioral change at 1311, moving NW, and then changed direction again at 1315 and moved S away from the Level-B zone. It was not apparent whether the animal was responding to a specific stimulus. It left the Level-B zone at 1311 and went out of view at 1318. This may have been the same animal that was described in the previous sighting given the location; however, because there was more than 10 min between observations it was recorded as a separate sighting. Sighting conditions at the time of the take were rated as excellent – partly cloudy skies, moderate wind (5-6 kts), sea state of 1-2, 5+ km of visibility, with no glare.

On 16 June a single harbor seal was observed inside the Level-B Harassment zone (grid cell G7) at 1220 during unattenuated impact pile driving (Figure 3.9). It immediately submerged and went out of view, and was not re-sighted. Sighting conditions at the time of the take were rated as excellent – sunny skies, light wind (2.4 kts), sea state of 1, 5+ km of visibility, with no glare.

On 21 June a single harbor seal was observed inside the Level-B Harassment zone (grid cell C8) at 1332, 2 min before the start of unattenuated impact pile driving (Figure 3.10). It immediately submerged and went out of view. Because of the timing of the observation and the MMO's inability to determine if the animal had left the Level-B zone it was recorded as a take. Sighting conditions at the time of the take were rated as excellent – sunny skies, moderate wind (5-7 kts), sea state of 2, 5+ km of visibility, with no glare.

Table 3.5. Summary of marine mammal takes with rationale.

Date	Station reporting observation	Initial sighting time	Final sighting time	Time entered take zone	Time exited take zone	Take location (Grid Cell)	Pile number	Activity type	Rationale for take
Beluga whale									
5/25/16	North	11:02	11:15	11:02	11:15	H8	7 Loc 5	Vibratory, Bubble attenuation	Appeared within Take zone during project activity
Steller sea lion									
5/25/16	Rover	9:38	9:44	9:38	9:44	E9	7 Loc 5	Non-pile driving project activity	Approach by project boat within less than 10 m on two occasions resulting in a dive reaction and a change in direction.
Harbor seal									
5/3/16	South	19:55	19:55	19:55	-	C8	8 Loc 6	Impact with resonance attenuation	Observed once in take zone during project activity
6/7/16	South	11:12	11:55	11:12	11:48	C8	1 Loc 5	Impact w/no attenuation	Observed 5 times in take zone during project activity
6/7/16	South	12:29	13:32	12:50	13:22	C8	1 Loc 5	Impact w/no attenuation	Initially seen outside of take zone during project activity, moved into take zone where observed 5 times; remained in area during post scan period
6/10/16	South	9:40	10:15	9:48	10:15	D8	9 & 8 Loc 6	Restrike: Impact w/no attenuation	Observed multiple times in take zone continuously for both piles TWO TAKES?
6/10/16	South	12:10	13:18	12:10	13:11	C9	10 Loc 6	Restrike: Impact w/no attenuation	Observed before and after activity in take zone; moved away from sound w/in 2 min of end of pile drive.
6/16/16	South	12:20	12:20	12:20	12:20	G7	3 Loc 1	Restrike: Impact w/no attenuation	Observed once in take zone during project activity
6/21/16	South	13:32	13:32	13:32	13:32	C8	2 Loc 5	Restrike: Impact w/no attenuation	Observed once in take zone 2 min prior to project activity; presumed to be in area at onset of driving.

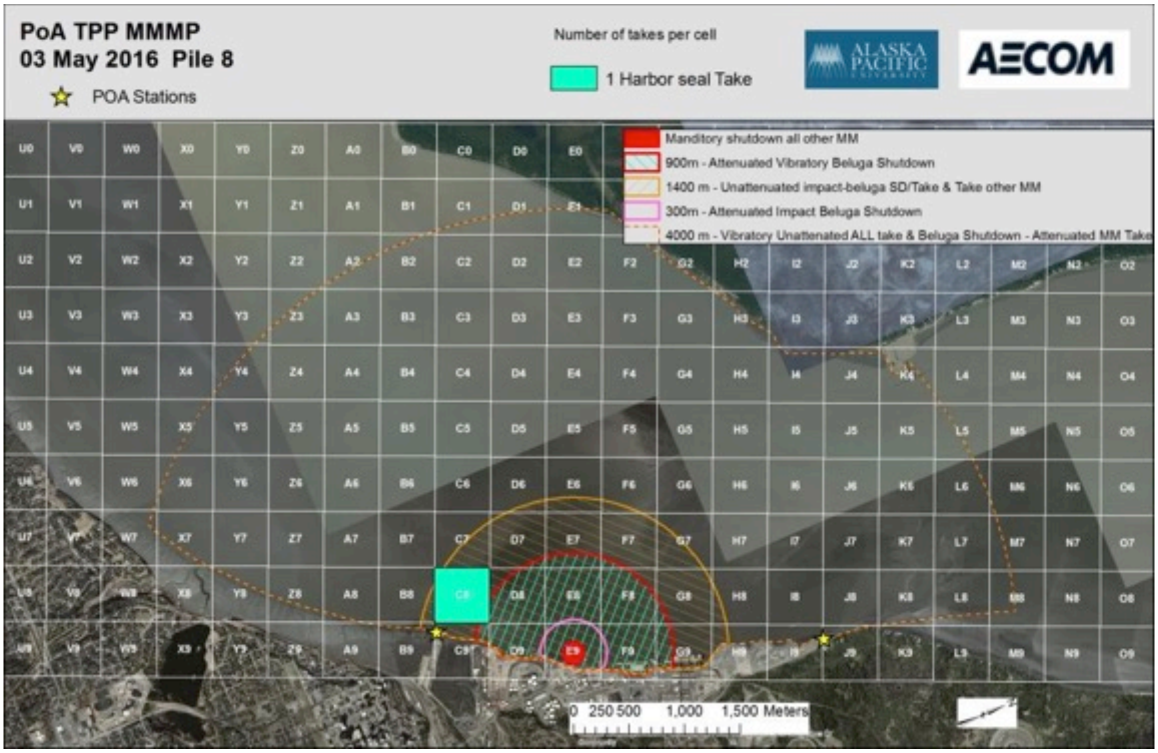


Figure 3.5. Location of marine mammal take 03 May 2016.

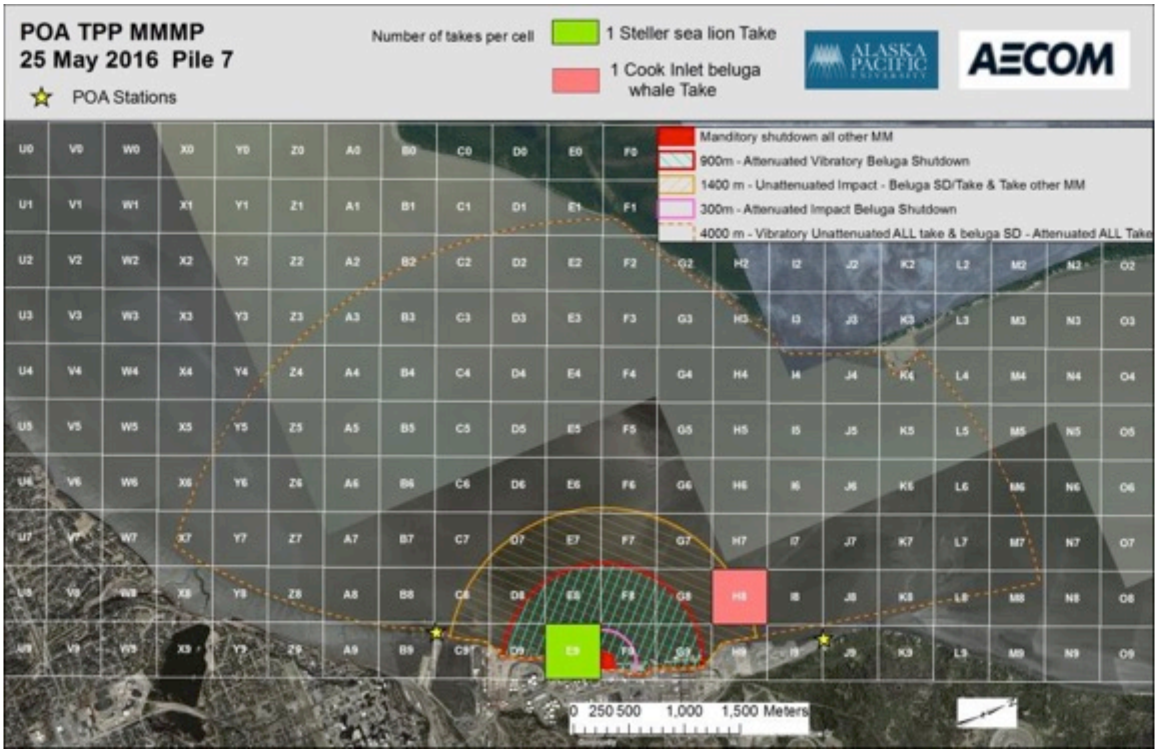


Figure 3.6. Locations of marine mammal takes 25 May, 2016.

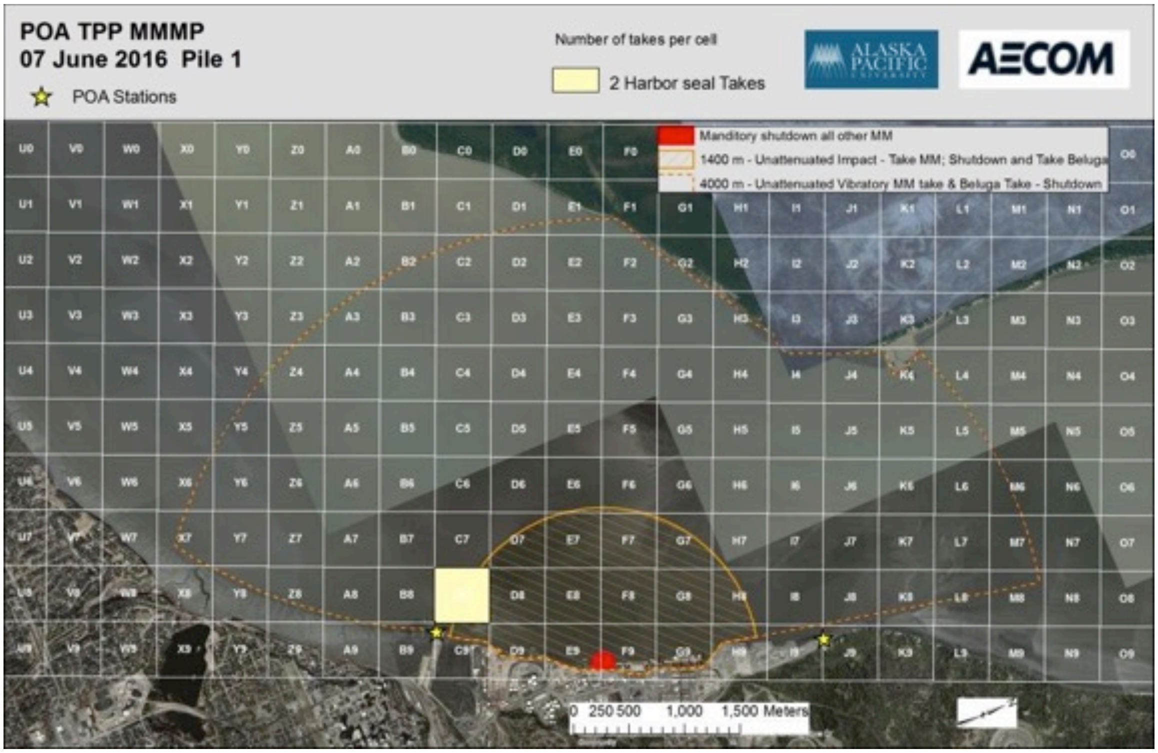


Figure 3.7. Locations of marine mammal takes 07 June, 2016.

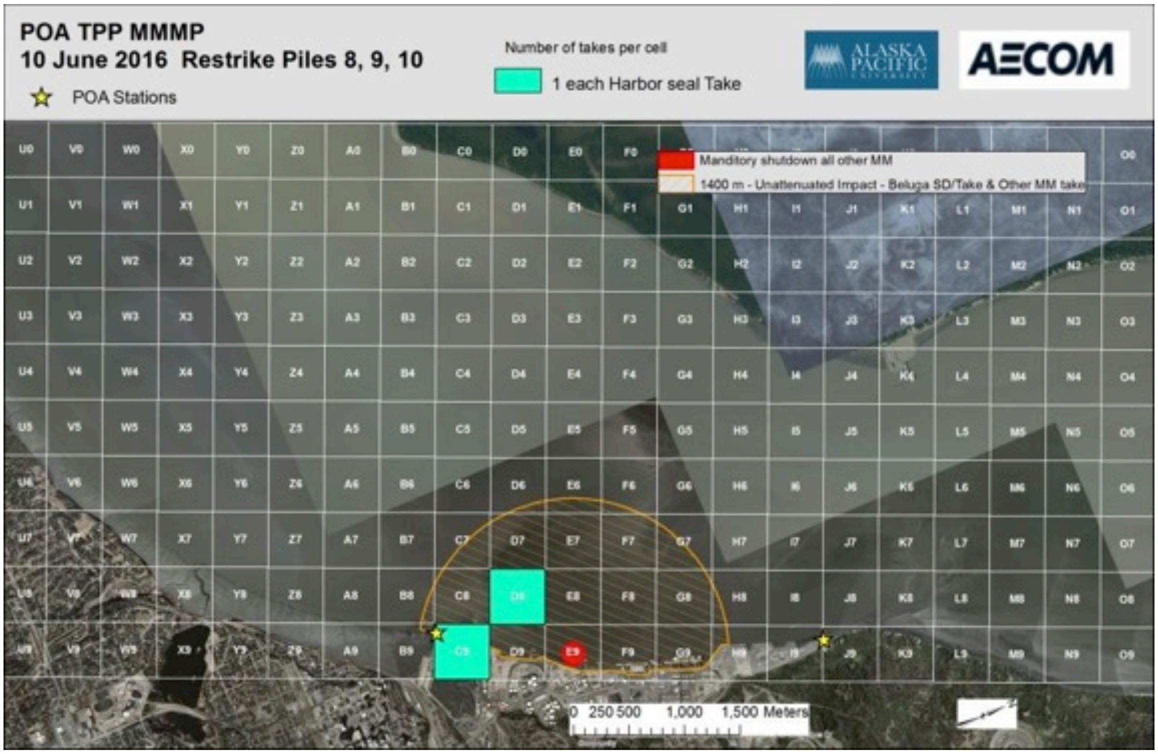


Figure 3.8. Locations of marine mammal takes 10 June, 2016.

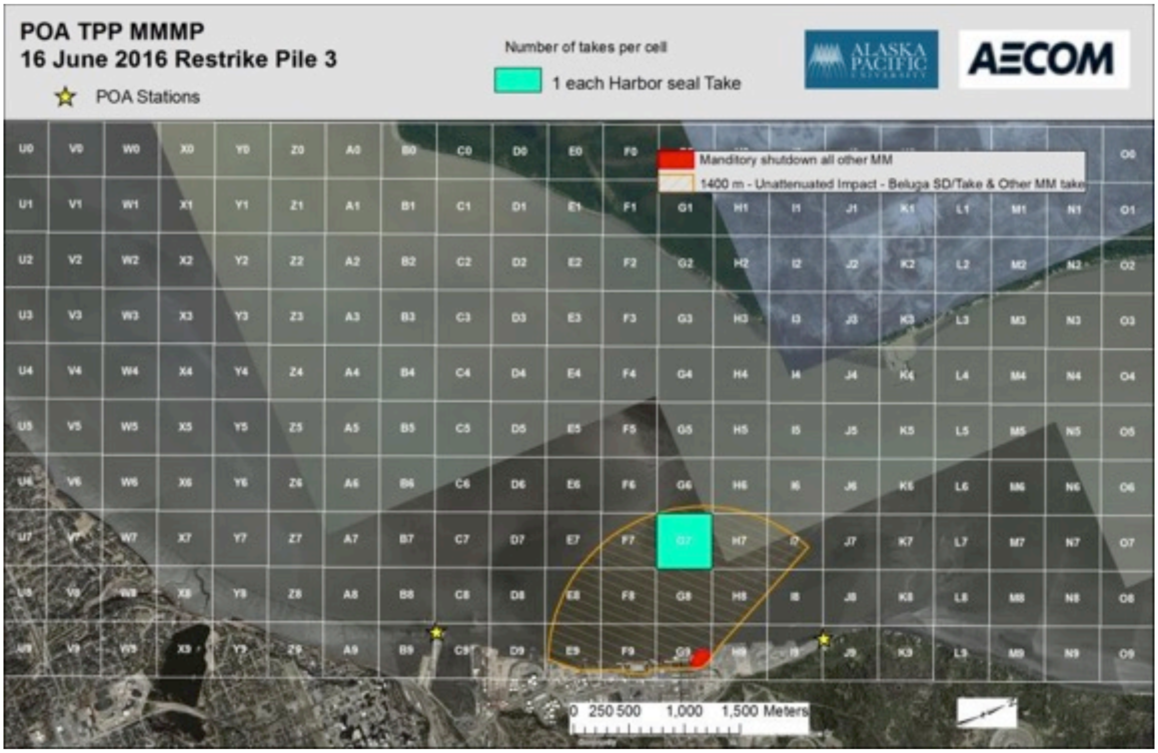


Figure 3.9. Location of marine mammal take 16 June, 2016.

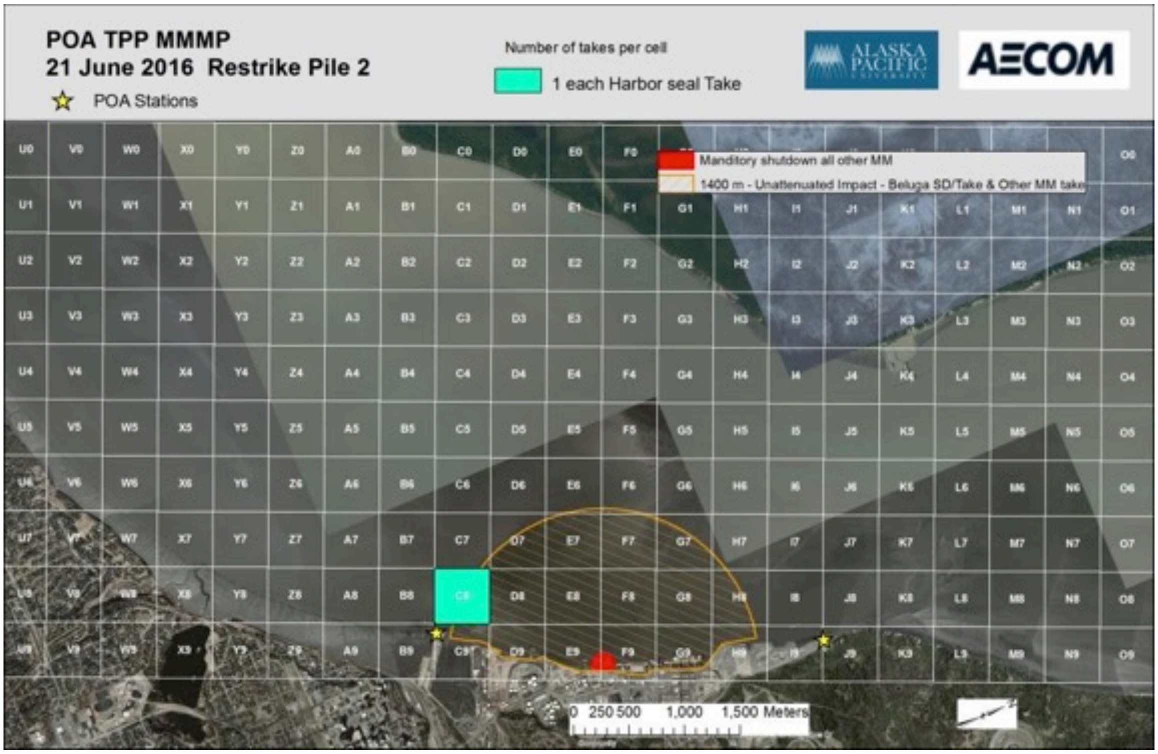


Figure 3.10. Location of marine mammal take 21 June, 2016

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5.0 Acknowledgements

The authors acknowledge the following individuals who served as MMOs and *Field Chiefs: Mabel Baldwin-Schaeffer*, Haley Baliles, Jenipher Cate*, Meagan DeBenedetto, Amy Dowling, Martin Erickson, Angela Gravitt*, Freya Hately, Lauren Himmelreich*, Fran Honea, Olivia Kramer, Caitlin Marsteller, Josh Moffi*, Emily Smith, and Jennifer Tennyson. Lauren Himmelreich entered and proofed marine mammal and environmental data and developed Table 3.1.

Our thanks to APU staff member Brenda Fahlsing for budget and invoice processing.

Our thanks to a number of AECOM staff: Jon Isaacs, Laura Young, and Erin Dunable handled contract oversight and budgeting. Courtney Brozovsky unhesitantly produced a shapefile when monitoring zones changed on short notice. Mary Lusk and Noa Lesa assisted with short notice printing of the weatherproof large format observation maps for the field crew. Brian Giese filled in as an MMO.

Tanner Vetsch, Kiewit, provided on-site daily coordination and clear field communications concerning pile driving operations.

Radios were loaned by Mike Hanscam.