

ANNUAL SUMMARY REPORT

P60: Best Practice in the Quality Assurance of Pavement Layers and Subgrade – Year 3 (2018/19)

ARRB Project No.: PRP18027

Author/s: Jeffrey Lee, David Lacey, Burt Look & Kyle Tarr

Prepared for: Queensland Department of Transport and Main Roads

01/06/2020

FINAL

SUMMARY

Industry's familiarity with density-based assessments for the quality assurance (QA) of pavement layers and subgrades currently favours conventional density measurements over other field tests that have the potential to better validate design parameters achieved during construction. Although such alternative tests (e.g. Prima 100 LWD, Geogauge or PANDA probe) are not necessarily as precise as conventional density testing, the density test itself has significant limitations. These limitations include the time required to undertake the tests and its inability to reliably assess the in situ devices evaluated in this report.

The background to Phase 3 of the study is covered in Section 2 which discusses the interim findings from Phases 1 and 2. The field testing and analysis conducted on a live construction site to evaluate the alternatives test method is summarised in Section 3. A proposed technical specification is outlined in Section 4 and conclusions and recommendations are discussed in Section 5.

Although the report is believed to be correct at the time of publication, the Australian Road Research Board, to the extent lawful, excludes all liability for loss (whether arising under contract, tort, statute or otherwise) arising from the contents of the report or from its use. Where such liability cannot be excluded, it is reduced to the full extent lawful. Without limiting the foregoing, people should apply their own skill and judgement when using the information contained in the report.

Queensland Department of Transport and Main Roads Disclaimer

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained within. To the best of our knowledge, the content was correct at the time of publishing.

ACKNOWLEDGEMENTS

ARRB would like to acknowledge the contribution made by FSG Geotechnics and Foundations to the delivery of this project. The ARRB study team also acknowledges Albem and Highway Constructions (HC) for allowing access to the test site and for providing their QA data. The authors also thank Queensland TMR for allowing testing to be conducted at the site.

CONTENTS

1	INTRODUCTION.....	1
1.1	BACKGROUND	1
1.2	PROJECT AIM AND OBJECTIVES	1
1.3	REPORT STRUCTURE.....	2
2	PREVIOUS RESEARCH (PHASE 1 AND PHASE 2 FINDINGS)	3
3	FIELD TESTING AND ANALYSIS	6
3.1	FIELD TESTING	6
3.2	ANALYSIS	7
3.3	KEY OBSERVATIONS	9
4	PROPOSED TECHNICAL SPECIFICATION	12
4.1	REQUIREMENTS FOR A MODULUS-BASED TECHNICAL SPECIFICATION.....	12
4.2	METHODOLOGY	12
5	CONCLUSIONS AND RECOMMENDATIONS	15
	REFERENCES	16
	APPENDIX A FSG PHASE 3 REPORT	17

FIGURES

Figure 2.1	Industry attractiveness – current usage strength matrix (Phase 1).....	3
Figure 2.2	Equipment evaluated in Phase 3 of the project.....	4
Figure 2.3	Outcome matrix from Phase 2 of the project.....	5
Figure 3.1	Test sites and number of tests for different devices.....	7
Figure 3.2	LWD (Prima 100) vs density graph	8
Figure 3.3	Dendrogram showing the hierarchy of correlation between different test methods	8
Figure 3.4	Correlation relationship when varying moisture content	10
Figure 3.5	Zone of influence for different devices	10
Figure 4.1	Flowchart of the simplified and advanced methods	13

1 INTRODUCTION

1.1 BACKGROUND

Queensland Department of Transport and Main Roads (TMR) and contractors primarily use in situ dry density ratio (DDR) and California Bearing Ratio (CBR) testing when measuring pavement strength, during the construction of earthworks, subgrades, and unbound granular pavement layers.

There are, however, two major disadvantages to this approach in so far that these traditional tests do not measure the in situ modulus of the layers constructed, which is a key parameter used as input into the mechanistic design of pavement structures. Secondly, there can be a significant delay between undertaking the DDR and CBR testing, and when the final results are available for checking the compliance of the construction works. This delay in obtaining test results can lead to costly rework by the contractor if the results are found to be non-conforming at a later stage.

Density measurements are relatively easy to undertake during construction and they can provide a precise measurement in an easy-to-understand manner. The use of the nuclear density gauge (NDG) has an additional benefit in terms of the speed in obtaining field density results compared to sand replacement methods. However, there remains a delay in the determination of a test site's relative compaction due to the time taken to obtain the laboratory maximum dry density (MDD) (unless an assumed value is used). Although a better measure of modulus than density testing, CBR testing also involves a time delay due to curing and the testing procedures required.

Previous National Asset Centre of Excellence (NACoE) research has found that although density measurements are precise, they are not very accurate due to their poor correlation with the results of other modulus or strength-based tests. The structural design of pavements, working platforms or other bridging layers require either strength or modulus input, it is imperative that any verification testing undertaken can accurately assess, or be strongly correlated to such parameters (Lacey 2019)

Over the past several decades, alternative testing devices such as the Prima 100 LWD (Light Weight Deflectometer) have been developed to provide modulus measurements soon or immediately after testing. Pre-existing devices such as the Clegg Hammer, and the Dynamic Cone Penetrometer (DCP) are also used to evaluate pavement or earthwork strength characteristics. Some of these devices also report moduli which negate the need to rely on correlation relationships (which are often material type specific) to relate measured density or CBR to in situ moduli.

1.2 PROJECT AIM AND OBJECTIVES

This project aims to modernise the testing procedures currently used for the evaluation of earthworks and pavement layers in Queensland. The project scope is mainly focussed on assessing alternative techniques, their benefits and disadvantages, and developing guidelines and specifications that will facilitate the implementation of these alternative techniques. The introduction of techniques with short turnaround times will allow non-conforming work to be identified and rectified sooner than is currently possible with the current testing. The focus of the study is the in situ moduli parameters; it does not address other characteristics that density testing, or other testing, may evaluate such as settlement potential, permeability, etc. A direct relationship between design moduli and in situ moduli falls outside of the scope of this study.

The key project objectives for year 3 (2018/2019) are:

- Undertake a field trial and collect test data.
- Analyse the results and develop a proposal specification that will allow the implementation of the devices.
- Share findings through a report and webinar.

1.3 REPORT STRUCTURE

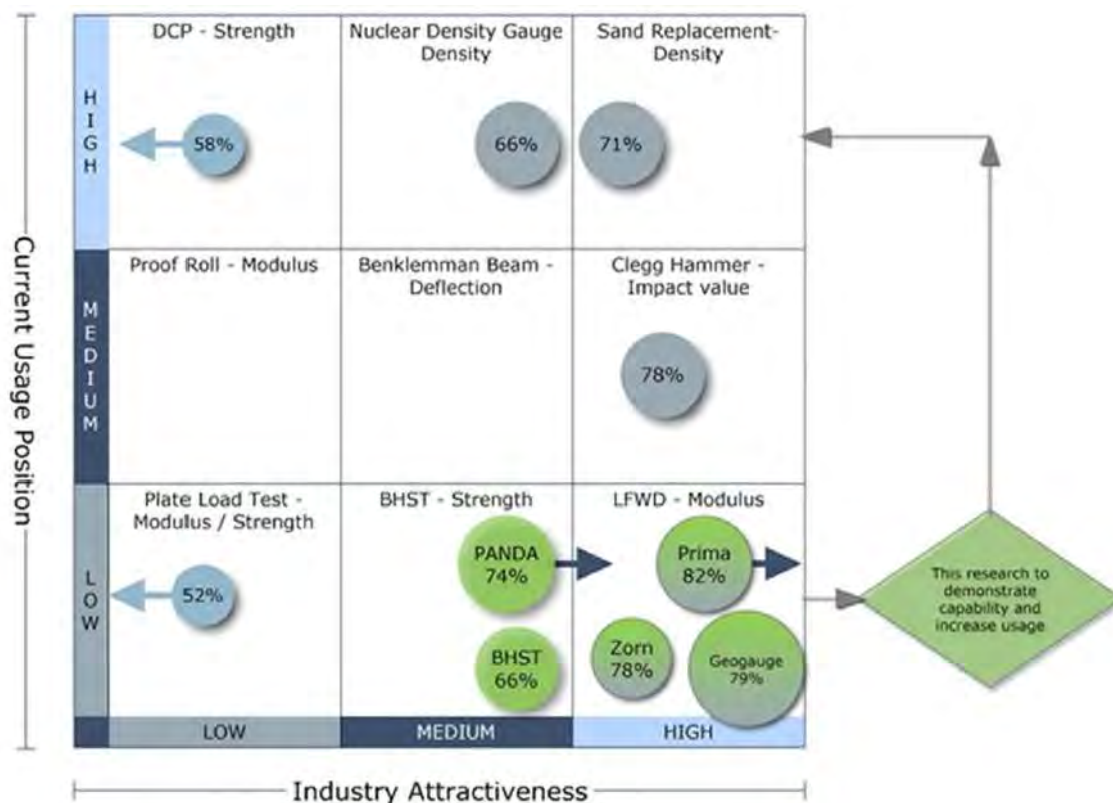
The background to Phase 3 of the study is covered in Section 2 which discusses the interim findings from Phases 1 and 2 of the study. The field testing and analysis conducted on a live construction site to evaluate the alternatives test methods are summarised in Section 3. A proposed technical specification is outlined in Section 4 and conclusions and recommendations for Phase 3 are discussed in Section 5.

2 PREVIOUS RESEARCH (PHASE 1 AND PHASE 2 FINDINGS)

A literature review was conducted in 2016/2017 (Phase 1) which selected several testing devices to be evaluated that have the potential to minimise turnaround time for test results and possibly offer a direct modulus measurement (Lacey 2019). Figure 2.1 shows the relationship between industry attractiveness and current usage, where industry attractiveness is a metric comprised of cost, test duration, accuracy, etc.

The main output of Phase 1 of the project was a list of devices that showed a high attractiveness – indicated by the percentage inside the labels shown in Figure 2.1. The PANDA, Zorn, Geogauge, and Prima devices proved to be the most promising.

Figure 2.1 Industry attractiveness – current usage strength matrix (Phase 1)



Source: Lacey (2019).

Testing using the above equipment was carried out in 2017-18 (Phase 2), to assess their suitability for use as testing devices in construction. The following equipment was selected after Phase 1 for further evaluation (see Figure 2.2):

- Light Falling Weight Deflectometer (LWD) – Prima 100 manufactured by Sweco.
- Light Falling Weight Deflectometer (LWD) – Terratest 5000 manufactured by Terratest.
- Clegg Hammer – developed by Dr. Baden Clegg and manufactured by GSR Laser Tools.
- H4140 Soil Stiffness Gauge (SSG) or also known as 'Geogauge' – manufactured by Humbolt.
- PANDA Probe (Variable Energy Dynamic Penetrometer).
- Dynamic Cone Penetrometer (DCP).

Figure 2.2 Equipment evaluated in Phase 3 of the project



Source: Lacey (2019).

The test devices were evaluated in parallel with the following conventional tests:

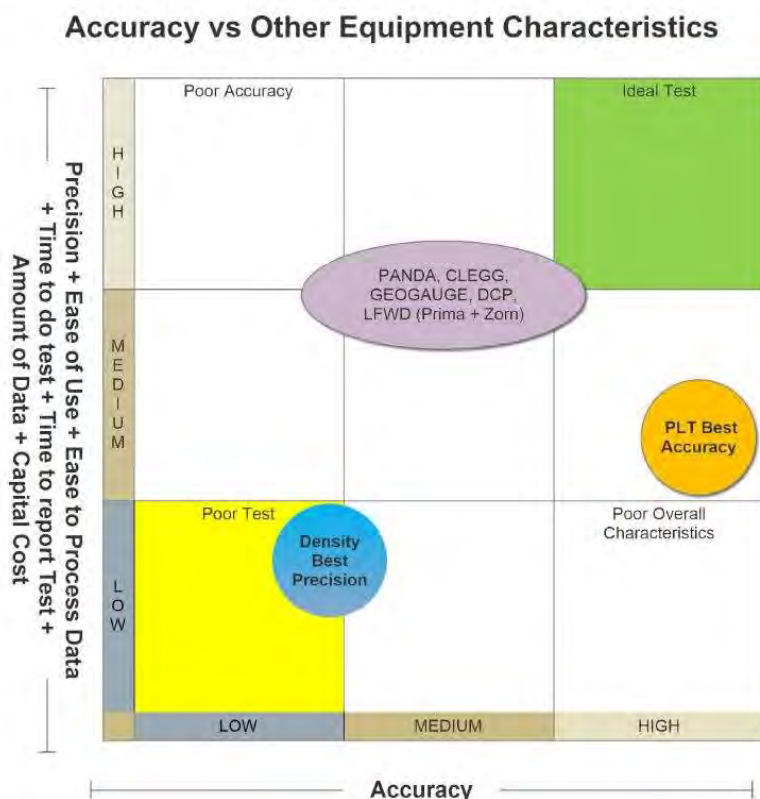
- Static Plate Load Testing (PLT)
- Nuclear Density Gauge (NDG)
- Moisture content.

Engineers within the road consulting and construction industry were asked to rank the most desirable characteristics of a test method in a survey. The findings of the survey were used to develop a weighting factor for the evaluation of the more qualitative data being collected. The characteristics ranked were:

1. accuracy
2. precision
3. test duration
4. ease of use
5. ease of data processing
6. data processing times
7. the volume of data obtained
8. the capital cost of the equipment.

These characteristics were combined using weightings from the same survey conducted in Phase 2 and used to assign values to the vertical axis of the matrix shown in Figure 2.3.

Figure 2.3 Outcome matrix from Phase 2 of the project



Source: Lacey (2019).

A key finding from Phase 2 was that higher density did not necessarily indicate a higher modulus; in other words, current testing does not necessarily confirm that the design parameters have been achieved during construction. The previous study also showed that the outputs of some of the alternative tests were dependent on material properties, which meant that the actual test value needed to be calibrated to be meaningful in terms of how it related to the design values. Whilst this calibration may need to be project specific, a generalised calibration range could still be provided to users if these tests were implemented. It was suggested that a relative acceptance value could be used for acceptance purposes during construction, similar to the relative density approach currently being used.

It was concluded from Phase 2 that there were clear benefits associated with adopting tests other than density testing to evaluate the material strength and modulus properties achieved during construction. Considering the findings from Phase 2, it was agreed that procedures and standards need to be developed to promote the use of alternative devices in Phase 3 of the project (Lee, Lacey & Look 2019).

3 FIELD TESTING AND ANALYSIS

Testing was conducted on the Smithfield Bypass Project where construction started in late 2018. The project site is located approximately 11.5 km northwest of the Cairns CBD.

The scope for Phase 3 was to identify a test site and undertake comparative testing on a live construction site using both conventional techniques and the alternative devices identified in Stage 1. Additionally, the field testing also allowed the project team to evaluate the alternative device's ability to be used on construction sites and produce interpretable results within a relatively short period (e.g. within 24 hours). A quantitative and qualitative assessment of the different techniques, similar to Phase 2, was also undertaken.

A method specification for the use of these alternative devices was also developed based on the findings from the field testing undertaken to date.

3.1 FIELD TESTING

Foundation Specialist Group (FSG) was engaged by ARRB to undertake the field testing. The testing was conducted on a uniform fill material placed and compacted in 300 mm thick layers. Conventional density testing was undertaken in parallel with the PLT, Clegg Hammer, DCP, PANDA, LWD PRIMA, and LWD Terratest devices.

Details of the test sites and the number of tests conducted using the different devices are presented in Figure 3.1. Fewer tests were undertaken using the PLT and Clegg Hammer relative to the other test methods. This was a result of the limited time available to conduct all the testing and the amount of time required to conduct each test. Due to the project being a live construction site, a range of compaction values were specified and targeted (i.e. 90% to 97% Dry Density Ratio (DDR)), and the compaction values achieved ranged between 95% to 104% RDD. This means that data below 95% RDD were not obtained, which was a similar shortcoming of the Phase 2 study (Lacey 2019).

The number of each test carried out at the different locations is shown in Figure 3.1 (Lacey 2019). Further details of the field testing undertaken can be found in the report prepared by Lacey & Look (2019) which is also included in Appendix A.

Figure 3.1 Test sites and number of tests for different devices

Table 6-1 Details of number of Test 'Sites', 'Sub-sites' and test techniques completed within each 'Site'

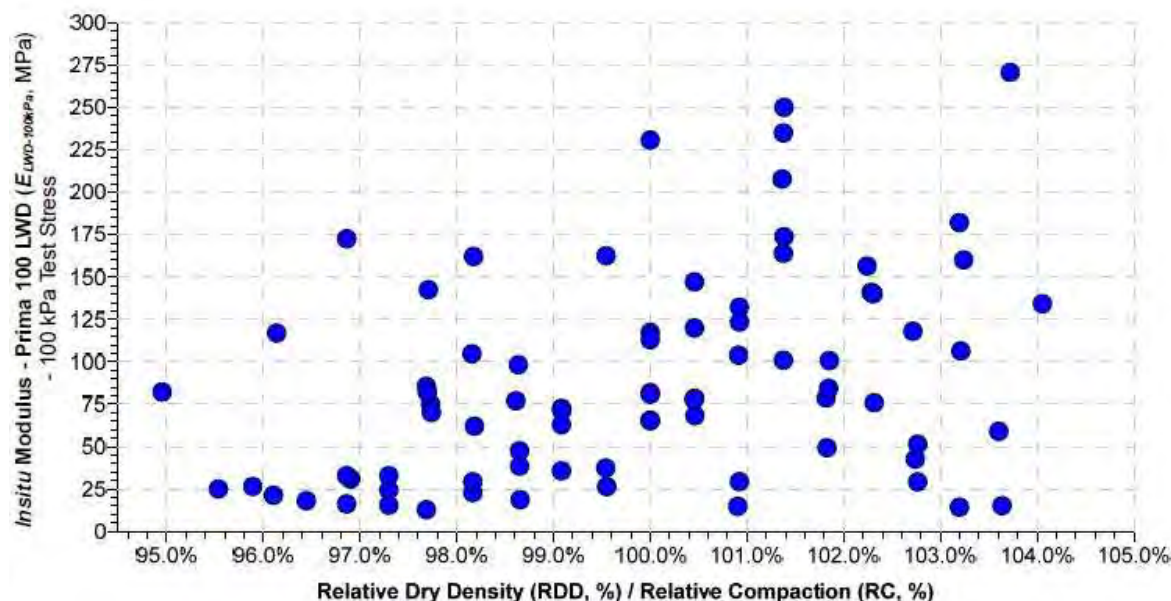
Site ID	No. of Sub-Sites	Density Testing	Surface Based Plate Testing				Penetration Testing		Other
			300 mm Diameter Plate			130 mm Dia. Plate	Dynamic Cone Penetrometer (DCP)	PANDA Probe (Variable Energy DCP)	Field Moisture Content
		Nuclear Density Gauge (NDG)	Static Plate Load Test (PLT)	LWD – Prima 100	LWD - Terratest	9.1 kg Clegg Hammer			
Site 7	4	4	–	–	–	–	–	4	–
Site 8	4	4	–	–	–	–	–	4	–
Site 9	4	4	–	–	–	–	4	4	–
Site 10	4	4	–	–	–	–	4	4	–
Site 11	4	4	–	–	–	–	7	4	–
Site 12	4	4	–	4	–	–	6	7	–
Site 13	4	4	–	4	–	–	8	7	–
Site 14	4	4	–	4	–	–	6	5	–
Site 15	4	4	–	5	–	–	7	8	–
Site 16	4	4	–	4	–	–	8	6	4
Site 17	4	4	–	5	–	–	4	5	4
Site 18	4	4	–	4	–	–	6	5	4
Site 19	14	4	–	15	–	14	18	17	16
Site 21	14	4	2	18	15	14	26	27	18
Site 22	14	4	2	14	16	14	22	20	15
Site 23	6	5	1	6	6	7	10	8	6
Site 24	12	6	3	23	15	15	15	21	12
Site 25	12	5	2	12	15	13	15	21	12
Site 26	12	5	2	12	12	13	18	18	12
Site 27	5	5	–	5	–	–	6	8	5
Site 28	5	5	–	5	–	–	5	6	5
Site 29	5	5	–	5	–	–	5	7	6
Site 30	5	4	–	5	5	–	–	–	–
Site 31	4	4	–	–	4	–	–	–	–
Site 32	4	4	–	–	4	–	–	–	–
Site 33	4	4	–	–	4	–	–	–	–
Site 34	4	4	–	–	4	–	–	–	–
Site 35	4	4	–	–	4	–	–	–	–
Site 36	4	4	–	–	4	–	–	–	–
Site 37	4	4	–	–	4	–	–	–	–
Site 38	4	4	–	–	4	–	–	–	–
Total	184	132	12	150	116	90	200	216	119

Source: Lacey (2019).

3.2 ANALYSIS

FSG also undertook a detailed analysis of the test results obtained from the Smithfield Bypass Project. Figure 3.2 is a representative graph of the relative density and modulus results as measured by the LWD Prima 100. There is a wide range in the modulus results compared to the density values. This can be expected because the current construction methods and testing target density requirements. Results similar to those in Figure 3.2 are seen when the modulus derived from the alternative methods is compared to the measured density. The full set of results is presented in Appendix A.

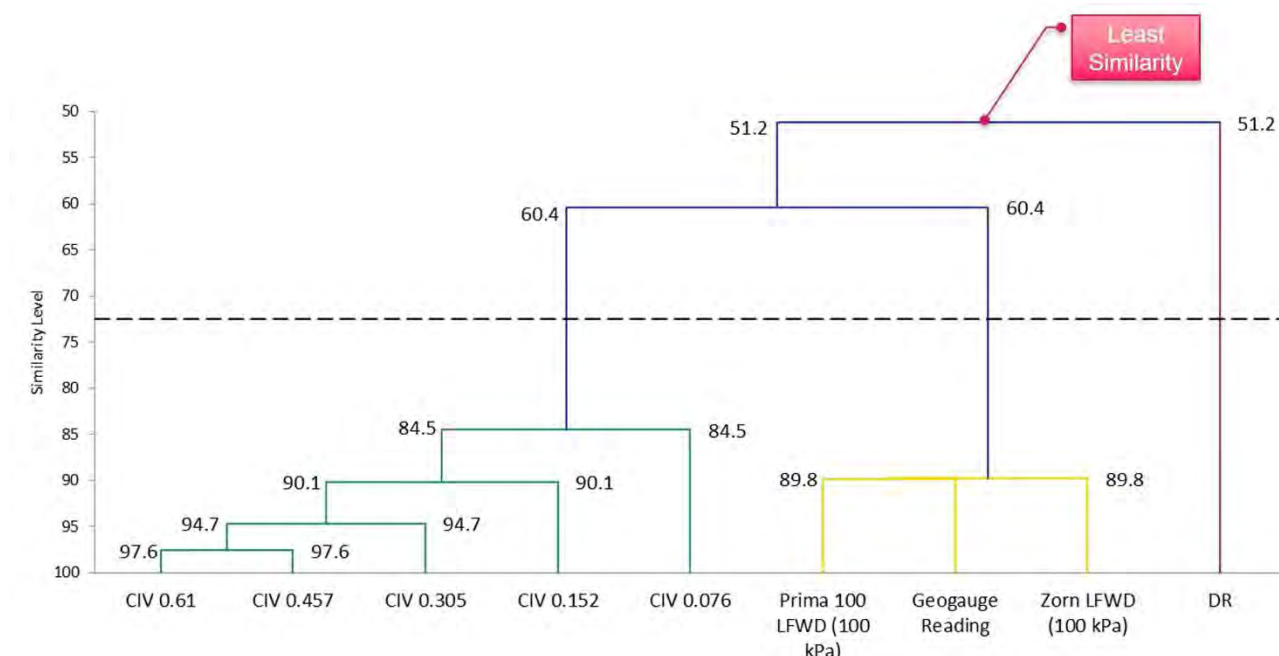
Figure 3.2 LWD (Prima 100) vs density graph



Source: Lacey (2019).

The dendrogram shown in Figure 3.3 shows the similarity between the results and how these results group together. The analysis found that the modulus measuring devices such as the Clegg Hammer, Prima 100, Zorn, and Geogauge produced results that were the least similar to the density measurements. Furthermore, there was more similarity between the Clegg Impact Values (CIV) than the results produced by the Prima, Zorn, and Geogauge. This suggests that the alternative devices are attempting to measure the same property, i.e. in situ modulus. Similarly, the penetration test results (i.e. DCP and PANDA) correlated with each other better than they did with the other test results.

Figure 3.3 Dendrogram showing the hierarchy of correlation between different test methods



Source: Look (2020).

Surface modulus testing was determined to be the favoured category of testing due to the fact that it measures a fundamental design parameter. The consistency in the measurements is evident even when testing was carried out with differing tools having different characteristics (Look, Lee & Lacey 2020).

The detailed analysis undertaken is documented in Appendix A.

3.3 KEY OBSERVATIONS

Some key observations are as follows:

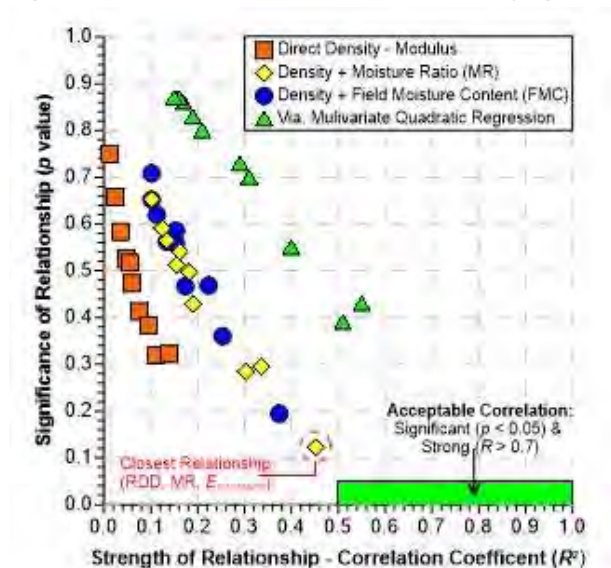
- There was a poor correlation between the density results and the other test results. Another method of quality acceptance without reliance on density is required.
- The contractors view parallel testing as introducing additional costs and time. This, combined with the point above, means that such methods may not be advanced unless industry accepts a different method of testing.
- Density (as the current standard method) is not as relevant to changing site conditions: the test results indicated that density is not able to assess change in moisture conditions during construction.
- The alternative test techniques measure modulus, or some other characteristic, which can be influenced by moisture and density. Density had less influence than previously thought.
- The results from the DCP and Clegg Hammer (at low drop heights) appeared to be more related to the moisture condition of the materials rather than the relative density.
- The density testing that was undertaken on-site resulted in the acceptance of 'poor' results and the rejection of 'good' results as measured by the other tests. This is not within the 10% consumer/producer risk philosophy currently adopted in the road construction industry.

In addition to these observations, the in situ moisture content of the materials being tested was a concern given that the modulus of the compacted materials could potentially be dependent on the moisture content. Comparing the DDR to in situ moduli with respect to moisture content cannot be done adequately as the DDR does not reflect the effect that in situ moisture content has. This is problematic when moisture changes occur in the field, (e.g. rain or insufficient dry-back); these changes are not reflected in the test results when subsequent layers are placed

These alternative test methods should not be disregarded because they are measuring a parameter that includes the effect of moisture (e.g. modulus) that was previously not being considered in the construction process. As an example, the LWD can be used to ensure the modulus of the material after compaction is within the derived acceptance thresholds before another layer is placed without needing to verify its moisture content, as this effect is already captured in its modulus.

Figure 3.4 shows the relationship between the level of significance and the correlation co-efficient when correlating the PLT results and density. The PLT results from five different stress levels and two modulus values for each (i.e the stress modulus, E_{v2} , and secant modulus, E_{s2}) resulted in ten PLT datasets. Other combinations such as density and moisture, density, and field moisture as well as multivariate regression were also used in attempting to derive an acceptable correlation between the PLT datasets and density. A comparison of the resulting level of significance values (p-value) and correlation values (R^2) from each comparison showed that a meaningful correlation between modulus and density was not evident in the data. The comparison that came closest to the requirements for a strong, significant correlation was that between the secant modulus at 200 kPa (E_{s2}) and the combination of density and moisture ratio. A more detailed discussion of the analysis is presented in Appendix A.

Figure 3.4 Correlation relationship when varying moisture content



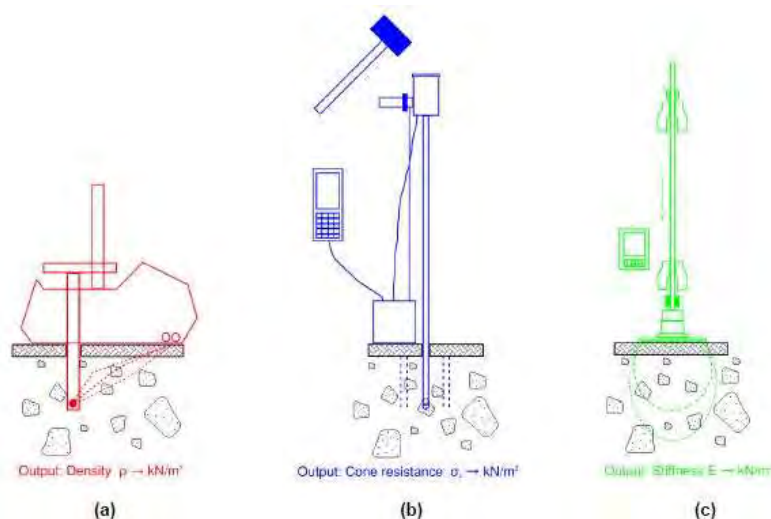
Source: Lacey (2019).

All the alternative devices that were evaluated provide a more accurate measurement of design parameters (strength or modulus) when compared to traditional methods. Additionally, these devices, in comparison to traditional density testing, provide near-instantaneous results that can be used in situ to change the compaction process to suit the project and material-specific conditions encountered on site.

However, such devices provide different units of measurements to the DDR and can demonstrate poor correlation to the industry-accepted DDR test results. The existence of a poor correlation can be due to several factors, including:

- Varying zone of influence – the condition of the underlying earthworks can affect the result of the in situ strength/modulus test as shown in Figure 3.5.

Figure 3.5 Zone of influence for different devices



Source: Lacey (2019).

- Material quality, moisture content, and achieved compaction are measured – an increased variability within a test dataset can arise, where density testing only evaluates compaction state.
- The difference in nature of the dataset – the variation in the density results were low and the results are normally distributed, while other test instruments frequently demonstrated a larger variation which can result in non-normally distributed data.

The implementation of alternative (non-density) measurement devices for the in situ verification of strength or modulus parameters has been further hampered by:

- No standard specification – no Australian Standards currently exist. and limited international specifications exist. This is largely related to the fact that the potential variables associated with each measurement device are not standardised in many cases.
- The reluctance of industry to adopt a different unit of measurement; they are familiar with using an easily interpreted density ratio, whilst individual-measurement devices provide various other parameters.
- The requirement for an initial requirement to correlate to density test results – as density is not a direct measurement of strength, a lack of a 1:1 correlation is a poor means to develop confidence in alternative test methods.
- The existence of a large variety of non-density modern equipment – with no clear guidance on their use, interpretation of the results, and which tool is best suited to specific applications.

To alleviate some of these issues a technical specification that allows the usage of these alternative test methods is discussed in Section 4.

4 PROPOSED TECHNICAL SPECIFICATION

Based on the findings of Phases 1 and 2, as well as the latest testing and analysis that was undertaken in Phase 3, the project team recommends that LWDs be considered as an alternative to standard density testing of earthworks during construction. The LWD is a portable, self-contained device that can assess the modulus of pavement layers directly in the field from a measurement of the surface deflection.

However, one barrier to widespread adoption is the availability of a variety of different LWDs, each of which can provide different in situ modulus results (due to the effect of different stress states, equipment arrangements, and boundary conditions adopted by individual manufacturers). The potential non-linearity of the material modulus parameter (e.g. stress-dependency) and the effect of moisture can also affect the in situ modulus results (Lacey 2019). Therefore, the modulus results determined by LWD's are not intended to be equal to design moduli but rather attempts to measure the same parameter, compared to other tests like the DDR.

As per the typical requirements of a technical standard, the testing device used should be manufacturer-blind to ensure a choice of different devices is available. However, by understanding and accounting for the characteristics of the specific LWD and the material being utilised on site, any of the LWDs evaluated can provide a consistent and traceable result which can be readily used for the testing of earthworks.

A modulus-based specification that has been developed as part of this project now presented.

4.1 REQUIREMENTS FOR A MODULUS-BASED TECHNICAL SPECIFICATION

This section provides a recommended methodology for using an LWD as a testing device during the construction of earthworks layers. A modulus-based technical specification would require:

- A target modulus for acceptable compaction – although in situ moduli may be dependent on moisture content, density, and/or material quality, current (density centric) compaction specifications measure each of these separately.
- A simple methodology for field assessment – any specified tests should be simple to conduct and have a standardised methodology.
- Testing should not require significant duplication – due to associated costs and delays.
- An understanding of the various factors that may affect the modulus results – and control account for such factors within the test procedure, interpretation, and nominated threshold (target) values.

Many variables exist between the different types of LWD equipment, including plate size, drop height, falling mass, etc.

Control of these variables should be included in the LWD technical specification, which should also limit the zone of influence that the measurements intend to represent. A procedure to normalise results should also be included to allow the nomination of a targeted modulus for acceptance. In the absence of project-specific requirements, it is proposed that the following standards be used:

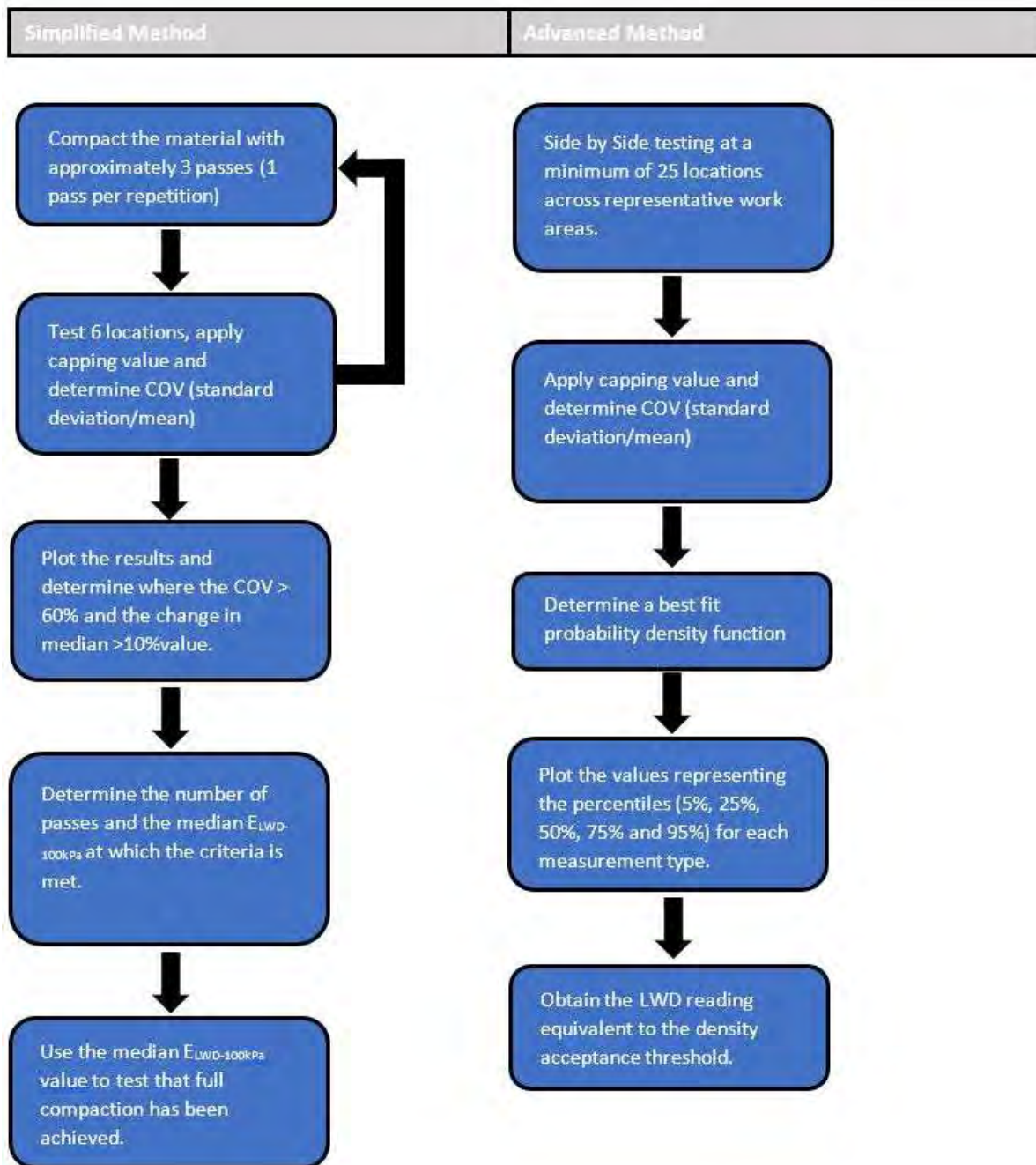
- plate diameter = 300 mm (providing a 'zone of influence' of approximately 390–450 mm)
- modulus parameter standardised to a 100 kPa test stress (to remove the influences of varied drop height and drop mass configurations).

4.2 METHODOLOGY

The flow chart in Figure 4.1 gives an overview of the simplified and advanced methods proposed based on the findings of the study. It is recommended that the simplified method be used first. However, if there is a poor relationship between the density and the resulting modulus (i.e $R^2 < 0.5$) or the probability distributions

are different, then the advanced method should be used. The detailed methodology is provided in Appendix A of this report.

Figure 4.1 Flowchart of the simplified and advanced methods



A simplified methodology for LWD field testing which would apply to a specific site, material, and lift height follows. The capping value used in the two methods is a value decided on by the user to replace uncharacteristically high values.

1. Undertake LWDs testing at six (6) testing locations after the completion of an initial, limited number of plant passes (say, three (3) passes).
2. Interpret the standardised in situ modulus parameter for each test location – $E_{LWD-100kPa}$. Discard the highest value and apply the defined capping value (e.g. $E_{LWD-100kPa} = 200 \text{ MPa}$) to any other uncharacteristically high values. Determine the characteristic values of the dataset and establish the Coefficient Of Variation (COV).

3. Repeat Steps 1 and 2 after the application of additional compaction plant passes (e.g. after six and eight passes).
4. Plot the progression of the characteristic LWD values under each considered arrangement.
5. From the curve developed in Step 4, assess when the COV of the dataset is less than 60% and when the change in the median standardised in situ modulus parameter ($E_{LWD-100kPa}$) between considered passes is less than 10%. This scenario would be considered the characteristic number of compaction plant 'passes' required to achieve full effective compaction.
6. If a correlation between the DDR and E_{LWD} parameters is required, then carry out corresponding side-by-side density testing on effectively compacted materials.
7. Compare the median of the DDR dataset to the median of the corresponding E_{LWD} dataset – adopt the corresponding median values as the 'equivalent' in situ target values to be achieved to represent acceptable compaction.

An alternative, advanced, acceptance threshold determination method includes side-by-side density testing. It adopts a similar method as described above; however, it also determines the acceptance threshold modulus using the equivalent (transformed) value from the density acceptance criteria. The procedure is as follows:

1. Carry out side-by-side DDR and LWD testing at a minimum of 25 locations. Locations should be spread across representative earthworks lots (say spread across five (5) lots, each including five (5) test locations).
2. Interpret the standardised in situ modulus parameter for each test location – e.g. $E_{LWD-100\text{ kPa}}$. Discard the highest value and apply the defined capping value (e.g. $E_{LWD-100\text{ kPa}} = 200\text{ MPa}$) to any other uncharacteristically high values. Determine the characteristic values of the dataset and establish the COV of the dataset (standard deviation/mean).
3. Fit a probability distribution function (PDF) of best fit to both the density dataset (likely to be a normal distribution function) and the in situ modulus dataset (likely to be a non-normal distribution function).
4. Plot the corresponding characteristic elements of each fitted PDF.
5. Obtain the 'equivalent' acceptance threshold in situ modulus parameters to be applied to the LWD results.

The proposed testing frequency of both test methods would be:

- minimum of 10 LWD tests per 1500 m² when the test surface is within 0 m below the top of the subgrade
- minimum of six LWD tests per 1500 m² when the test surface is greater than 1 m below the top of the subgrade.

The testing is to be conducted within 2 hours after the completion of compaction to minimise the effect of surface drying on the test results.

5 CONCLUSIONS AND RECOMMENDATIONS

Industry's familiarity with density-based assessments for the quality assurance (QA) of pavement layers and subgrades currently favours conventional density measurements over other field tests that have the potential to better validate design parameters achieved during construction. Although such alternative tests (e.g. Prima 100 LWD or PANDA probe) are not necessarily as precise as conventional in situ density testing, the density test itself has significant limitations. These limitations include the time required to undertake the tests and its inability to reliably assess the in situ strength or modulus parameters attributable to the pavement layers and subgrades in-service. Plate load testing (PLT) is another industry-accepted reference test which is highly accuracy but suffers from low precision. Recent NACOE research has identified several alternative QA tests that have the potential to provide improved accuracy (as compared to density), and simultaneously offer an improvement in precision (as compared to the PLT).

Despite the clear benefits, the alternative tests may not routinely provide a direct reliable correlation with DDR as density itself is not a measure of strength. Many of these tests do not currently have Australian Standards, which further impedes their implementation.

In the interim, this report provides scientific support for the adoption of, the LWD as a tool that can be implemented within earthworks QA technical specifications. The framework of the methodology detailed herein can be similarly applied for any of the large range of non-density test instruments that are currently commercially available, with minor alterations to account for the specific parameter (and sensitivity of measurement) associated with each instrument type.

Any side-by-side testing that produces pass results for density and not for any of the alternative QA methods is not necessarily a failure on the part of the alternative QA method. The development of an approach where density testing and alternative assessment techniques are used in parallel for strength evaluation was not a long-term aim of this study. Rather, the outcomes of this study, and the methodologies proposed in this report, should result in an improved level of confidence in the use of these techniques until such time that these new techniques become mainstream assessment tool.

REFERENCES

Lee, J, Lacey, D & Look, B 2019, Best practice in compaction QA for pavement and subgrade materials (Year 2 – 2017/18), PRP16113, ARRB, Brisbane, Qld.

Lacey, D 2019, Best practice in compaction QA for pavement and subgrade materials: year 3: field trials of alternative QA methods upon live construction site, 2091RDLA, FSG Geotechnics, Brisbane, Qld.

Look, B, Lee, J & Lacey, D 2020, NACoE P60 webinar 2 advanced methods for compaction quality control, webpage, ARRB, Port Melbourne, Vic, viewed 2 March 2020, <<https://www.gotostage.com/channel/974ee3d7c0604afaa2e4fee5fdc07c2a/recording/528470d5df3b45c391dc9a49d43257a8/watch>>.

APPENDIX A FSG PHASE 3 REPORT



BEST PRACTICE IN COMPACTION QA FOR PAVEMENT AND SUBGRADE MATERIALS

YEAR 3: FIELD TRIALS OF ALTERNATIVE QA METHODS UPON LIVE CONSTRUCTION SITE

ARRB
NACOE P60

REPORT NO. 2091RDLA
16 August 2019

REV	DATE	COMMENTS	AUTHOR	REVIEWED	AUTHORISED
A	16 Aug 2019	Final Report for client issue	D. Lacey	B. Look	B. Look



FSG GEOTECHNICS + FOUNDATIONS
fsg-geotechnics.com.au
contact@fsg-geotechnics.com.au

ACN 167 316 921
ABN 69 167 316 921

Brisbane

Gnd Fl, 74 Astor Tce
Spring Hill QLD 4000
PO Box 1241
Spring Hill QLD 4004
P: +61 7 3831 4600

Melbourne

Gnd Fl, 1G Marine Pde
Abbotsford VIC 3067
PO Box 1177
Collingwood VIC 3066
P: +61 3 9417 4333



Table of Contents

1. Introduction	4
1.1 Previous work within Project (2016 – 2018)	4
2. Phase 3 - Additional Field Testing (Live Construction Site) & Specification Development.....	9
2.1 Scope of Work	9
2.2 Industry Participation and Test Sites	10
2.3 Test Site used for Phase 3 Study	11
3. Details of Fieldwork Test Site	12
3.1 Location of Site	12
3.2 Details of Earthworks Trial Embankment	13
3.3 Climactic Conditions of Site	16
4. Overview of Alternative QA Test Techniques	19
4.1 Rationale for the use of Alternative QA testing	19
4.2 Details of Alternative QA Test Methods	20
4.3 Comparative Ease of Use (Fieldwork Component)	21
5. Material Characterisation	22
5.1 Available material characterisation data	22
5.2 Classification of Source Materials	22
5.3 Classification of Post-Compaction Fill Materials	24
5.4 Material Breakdown / Effect of Compactive Effort	25
5.5 Summary – Material Characterisation	27
6. Details of Field Testing / Field Test Datasets	28
6.1 Testing Layout	28
6.2 Testing Frequency	29
6.3 Test Techniques	30
6.4 Details of Applicable Traditional QA Specification	30
6.5 Assessment of Test Repeatability	31
6.6 Site observations relating to potential sources of variation in earthworks quality	32
6.7 Summary – Site Practices	35
7. Summary of Test Results	36
7.1 Density Testing – Nuclear Density Gauge	36
7.2 <i>Insitu</i> Modulus Assessment – Static Plate Load Tests (PLTs)	38
7.3 <i>Insitu</i> Modulus Assessment – Light Falling weight Deflectometer (LWD) – Prima 100 (Sweco)	44
7.4 <i>Insitu</i> Modulus Assessment – Light Falling weight Deflectometer (LWD) – Terratest 5000 (Terratest)	50
7.5 <i>Insitu</i> Modulus Assessment – Clegg Hammer	53
7.6 Penetration Testing – Dynamic Cone Penetrometer (DCP)	57
8. Measurement of Field Moisture Content	59



8.1 Moisture Content Assessment – Oven Drying of Soil Sample	59
8.2 Moisture Content Assessment – TEROS 12 Sensor	61
8.3 Moisture Content Assessment – Comparison of Test Methods	63
9. Correlation with Density Test Results	65
9.1 Introduction	65
9.2 Assessment of Derived Relationships	66
9.3 Density vs. Static Plate Load Test (PLT)	66
9.4 Density vs. Prima 100 LWD	71
9.5 Density vs. Terratest LWD	75
10. QA assessment in practice – the traditional vs nascent technology	81
10.1 Lot 21	81
10.2 Lot 24	82
11. Towards QA Specifications – Analysis Methodology	84
11.1 Quality Control Methodology	84
11.2 PDFs – Methodology	84
11.3 Box and Whisker Plot – Analysis	87
11.4 PDFs – Density Tests	95
11.5 PDFs – Non - Density Tests	98
11.6 PDFs – Modulus Tests	99
11.7 Scree Analysis	101
11.8 Principal Component Analysis	103
11.9 Principal Component and cluster analysis	105
11.10 Summary	109
12. Reducing testing variability	111
12.1 LFWD Tests population	111
13. A Transformation method for acceptance testing	117
13.1 Methodology for the method of matching PDFs	117
13.2 Comparative percentiles for the method of matching PDFs	120
13.3 Summary	122
14. Testing Specifications	126
15. Summary	127
15.1 Introduction	127
15.2 Light Falling Weight Deflectometers (LWDs)	129
15.3 Modulus Based Technical Specification – Adopting LWDs for Earthworks QA Testing	129
15.4 Summary	134
15.5 Further References	136
Important Information about your FSG Report	137



Appendix A Material Quality (Material Source & Post Compaction) – Test Certificates

Appendix B Results of Traditional QA Testing Regime – Density Testing (Nuclear Density Gauge) & Moisture Content – Test Certificates

Appendix C Static Plate Load Tests – Test Certificates

Appendix D Prima 100 (Sweco), Light Falling weight Deflectometer (LWD) – Test Certificates

Appendix E Terratest 5000 (Terratest), Light Falling weight Deflectometer (LWD) – Test Certificates

Appendix F Clegg Hammer – Test Certificates

Appendix G Dynamic Cone Penetrometer (DCP) – Test Certificates

Appendix H Variable Energy Dynamic Cone Penetrometer (PANDA Probe) – Test Certificates

Appendix I Field Assessment of Volumetric Moisture Content via TEROS 12 Sensor – Test Certificates

Appendix J Probability Density Functions (PDFs)

Appendix K Correlation Matrix Summary

1. Introduction

1.1 Previous work within Project (2016 – 2018)

1.1.1 Phase 1 - Summary Outcomes from Phase 1

Year 1 of this project saw the completion of a comprehensive literature review of potentially suitable QA test techniques and a summary of previous international trials completed to assess the test techniques for such use. The literature review concluded that there is a high potential for a number of innovative (i.e. non-density based) QA methods to be utilised on construction sites. These “new” methods would provide a reduction in both the duration of onsite testing and turnaround of test results (e.g. by reducing the duration of subsequent laboratory testing required to be completed prior to issue of final test results). This could also potentially facilitate the direct measurement of an inside stiffness (modulus) value, and could also

The relative industry attractiveness of the various potential QA equipment considered are summarised in Figure 1-1, which classifies the available equipment according to expected industry attractiveness (based on cost, test duration, accuracy etc.) compared to current industry usage. The finding as summarised in Figure 1-1, demonstrates that a number of the “new” equipment evaluated offer significant opportunities to industry (i.e. high attractiveness) but their current adoption is significantly lower than the “traditional” QA methods (DCP, Nuclear Density and Sand Replacement tests)

Industry Attractiveness - Current Usage Strength Matrix

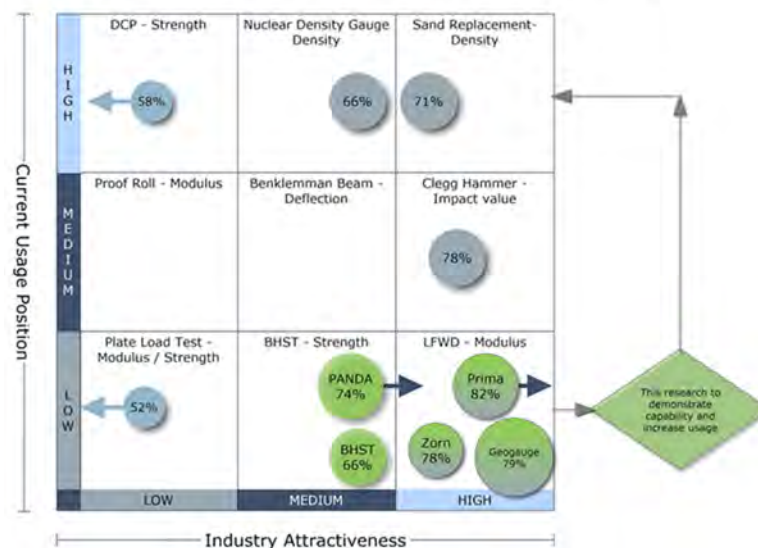


Figure 1-1 Findings from Phase 1 – Current industry acceptance / usage of innovative QA/QC tools compared to evaluated potential and suitability for their use (industry attractiveness)

The recommendations of Phase 1 were that subsequent phases of study should have the following broad objectives:

- o Assess the reliability of alternative equipment types assessed on actual ‘live’ earthworks compaction projects
- o Complete material specific assessments, such that material-specific parameters / thresholds could be provided for industry use in adoption of such QA techniques
- o Provide knowledge transfer to road authorities and industry of completed assessment and evaluation of current technologies and potential for use as suitable QA methods

Previous experience and learnings from recent Queensland projects were also documented as part of Phase 1 of the project. A testing plan was proposed for future years of this project in order to have a comprehensive evaluation and select the best technologies for use. Phase 2 proposed commencing an



equipment validation trial where a range of QA methods will be assessed parallel to each other. This would be followed by further field trials in future years (Phase 3 onwards) to assess the top candidate equipment and using different material to establish the necessary material-specific relationships and standards.

1.1.2 Phase 2 - Summary Outcomes from Phase 2

Phase 2 of the project required that equipment acceptance testing was to be undertaken using the equipment recommended for further evaluation by the Phase 1 review.

The purpose of this research was to evaluate the use of a number of *insitu* test equipment for use as Quality Assurance (QA) tools for the assessment of compacted earthworks. Currently QA assessment techniques are anchored in historical earthwork practices rather than the use of appropriate (current) technology.

Phase 2 of the study aimed to, via the completion of field testing within 'live' construction sites, provide an assessment of each evaluated test equipment's:

1. Time to complete insitu testing and turnaround of factual report ('Test Duration')
2. Accuracy of the result provided by the equipment ('Test Accuracy');
3. Repeatability and reproducibility of the result provided by the equipment ('Test Repeatability'); and
4. Evaluate the amount of data, and the relevance thereof, obtained during the test ('Test Data').

A range of testing equipment was trialled at various sites. The various equipment was ranked in terms of

1. Accuracy
2. Precision
3. Time to do the test
4. Ease of use
5. Time to process and report the results
6. Ease to Process Data
7. Amount of data obtained
8. Capital Cost

That order captured the results of a survey on what are the characteristics of a QA test equipment. However, Nos 5 to 8 were not clearly defined. Minor changes in these weightings would influence the position of the ranked equipment, as they are all congregated in a narrow band quite apart from the PLT and the Density tests. The latter is the current state of practice, with a high precision and low accuracy.

Data from 5 tests sites were used to compare measurements. Figure 1-2 summarises the key testing aims and the equipment used at the various test sites.

Figure 1-3 show some of this equipment used next to a sand replacement density test.

The 3 most common tests are PLTs, Density and DCPs. Overall, these 3 common tests do not correlate well with each other.

- o Density Ratio testing is the most precise test. However, it is a poor indicator of strength or modulus, once the pass compaction has been achieved
- o PLT is very accurate, but has poor precision. It is a costly test which does not provide a statistically significant number of tests to be used in QA on its own.
- o DCPs has a low precision but has other characteristics (ease of use and depth profiling) which make this test attractive

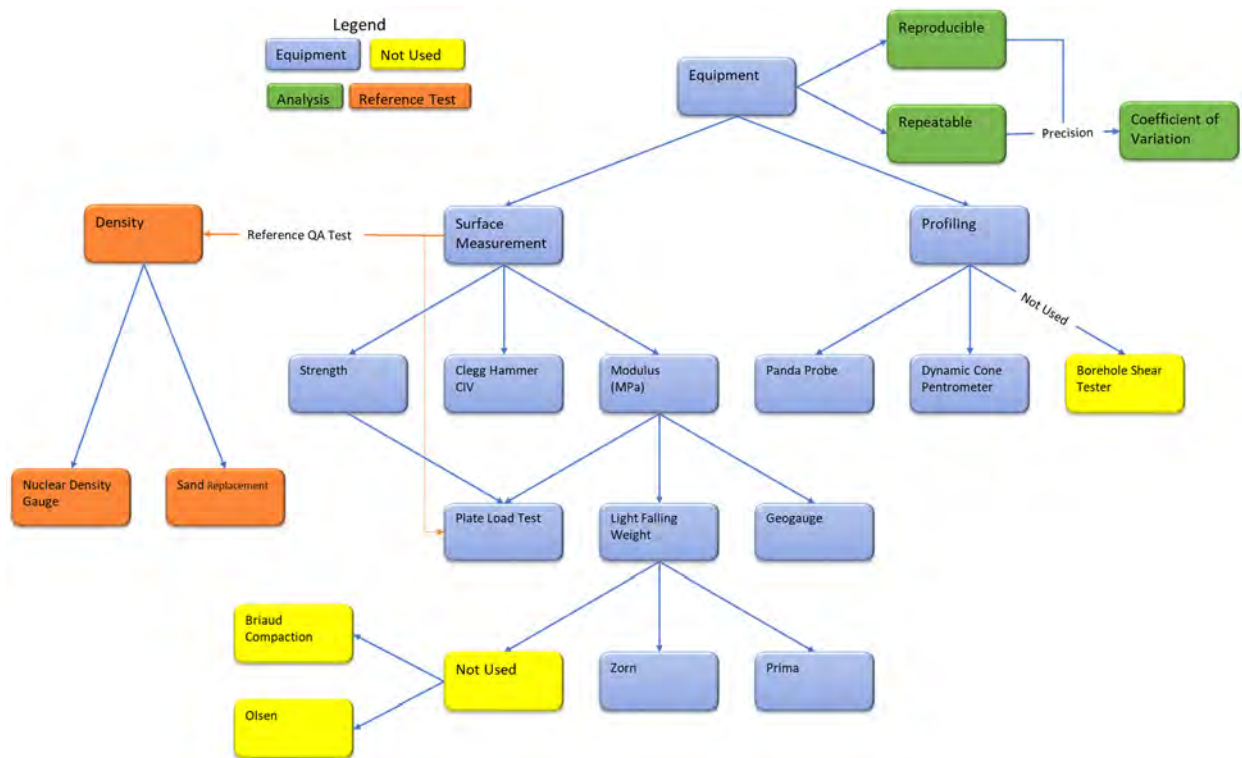


Figure 1-2 Phase 2 – Testing Aims and actual tests carried out



Figure 1-3 Phase 2 – Multiple equipment items in a single test location

Most equipment tests seem to be positioned between the PLT and Density in terms of accuracy and precision (Figure 1-4). All the equipment examined herein were more attractive overall than the two common “Standard” test equipment, when all considerations are integrated. However, there was no clear leader for the combined 8 criteria used in this phase 2 study, as the best test for accuracy is not the best test for ease of use, or precision, or time to do the test, or report the test.

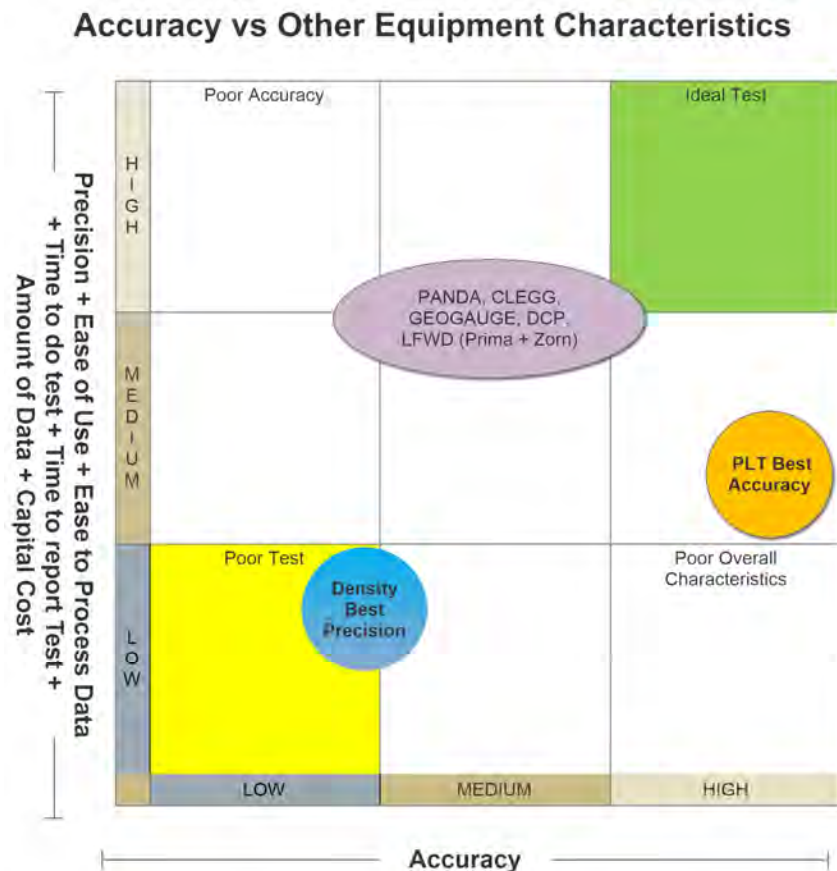


Figure 1-4 Findings from Phase 2 – Accuracy (Most preferred) vs other preferred attributes for equipment tested vs the two traditional tests of density and PLT

Direct or meaningful correlations should be on a project specific as each test represents a different zone of influence. This correlation was not carried out for this phase of the project. The literature survey carried out in phase 1 provided some of these general correlations. Additionally, there seems to be a material dependency where some tests may be more suited to some materials. This should be investigated further.

The phase 2 report concludes there are clear benefits in adopting tests other than density for QA.

A key finding was that a higher density (for a well compacted material) does not indicate an increase in modulus. Hence QA tests do not relate back to any design parameter. Many instruments showed a decreasing value with increasing density ratio. This was attributed to those instruments measuring a combination of Compaction + quality + interaction with the underlying layer

These alternative tests have the added benefit of providing for both a more meaningful QA + design value. However, industry or various road authorities are unlikely to adopt these tests or realise these clear benefits unless Standards for the various equipment are developed. Currently the most used tests of DCPs, CBR and density all have Australian Standards with no current Standards for the other tests examined in this study.

There are overseas standards on LFWDs and Clegg. But even then, there are variables such as plate size, drop heights and weight used.

This phase 2 trial testing has also shown the actual test value output needs to be calibrated to be meaningful as a design value. This may need to be project specific, but a generalised range can still



be provided to users. Importantly, a relative value for QA assessment can be used, similar to the currently used relative density approach. The latter has been shown to not provide a meaningful strength or modulus value, yet is still the state of practice.

Developing such procedures and Standards should then be the next phase of this research project. There may be material specific limitations which will also need to be examined.



2. Phase 3 - Additional Field Testing (Live Construction Site) & Specification Development

It is recommended that this report – Phase 3 – should be read in conjunction the Phase 1 & Phase 2 reports. The Phase 1 report includes a greater amount of detail relating to each specific test equipment evaluated and provides detail of the previous use / trial of the equipment in international technical literature, whilst the Phase 2 report provides greater detail in the use of specific equipment for field testing of compacted earthworks.

The learnings of the Phase 2 of the project have been adopted for the field-testing component of the Phase 3 of the project (detailed herein).

2.1 Scope of Work

The scope of work undertaken for Phase 3 of the Project – completed in Financial Year 2018/19 (FY18/19) – can be summarised as the following:

- Identification of a ‘live’ earthworks construction site that could be accessed by project personnel to undertake QA testing via alternative methods (in parallel with others completing ‘traditional’ QA assessment)
- Mobilisation to site and completion of fieldwork / data collection
- Demonstration that, for duration of onsite works, alternative QA test results could be interpreted and standardised test certificates – suitable for use in QA documentation – could be issued within 24 hrs of test completion
- Analysis of all collected data and assessment of relative benefits of each alternative QA test trialled
- Quantitative and Qualitative evaluation of each alternative QA Method trialled
- Production of example ‘Alternative QA Method Specification’ documents that could be utilised for ongoing use of alternative tools for QA for tested site.

Based on the works completed in Phase 3 of the project (i.e. this report), the procedure for developing a site - or material-specific Specification for use of an Alternative QA Site Assessment technique for evaluation of achieved earthworks compaction has been proven.

2.1.1 Traditional / Conventional QA Tools utilised

All field assessment involved the direct (side-by-side) comparison testing of the “innovative” (alternative) test equipment with “conventional” techniques implemented for routine QA assessment of compacted earthworks, namely:

- **In situ Relative Density** – As measured onsite via use of Nuclear Density Gauge (NDG) and reported as Relative Dry Density ratio (RDD)
- **Field Moisture Content** – As measured via laboratory testing of recovered post-compaction sample and reported as Gravitational Field Moisture Content (FMC) and as a Moisture Ratio (MR) of Optimum Moisture Content (OMC)
- **Static Plate Load Testing (PLT)** – considered the ‘reference’ test for determination of *in situ* modulus parameter.

2.1.2 Alternative QA Tools utilised

The following ‘alternative’ / ‘innovative’ field assessment test equipment were trialled within the Phase 3 field work:

Surface Based Plate Testing:

- Light Falling weight Deflectometer (LWD) – **Prima 100 LWD** (Manufactured by Sweco)
- Light Falling weight Deflectometer (LWD) – **Terratest 5000 BT USB LWD** (Manufactured by Terratest)

- 9.1 kg, Variable Height **Clegg Hammer** – Manufactured by Dr. Baden Clegg
- H4140 **Soil Stiffness Gauge** (SSG or Geogauge) – manufactured by Humbolt

Near-Surface Penetration Testing:

- **PANDA Probe** (Variable Energy Dynamic Penetrometer)
- **Dynamic Cone Penetrometer (DCP)**
- **TEROS 12 – Field Measurement of Volumetric Water Content (VWC)**, Temperature and Electrical Conductivity (EC) in soil

Further details relating to specific equipment arrangements associated with each test technique considered are provided in the relevant sections of Chapter 7 of this report.

2.2 Industry Participation and Test Sites

As research funding did not facilitate project specific trial earthworks embankments to be built and tested, industry participation was sought to provide a suitable site to deploy the “innovative” testing regime for assessment and evaluation against the “conventional” QA tests.

Industry construction participants to advance the project’s objectives through field trials was sought for project test sites that was active in 2018/19 within South-East Queensland (to limit travel requirements, and thus project costs). No cost to the industry partner was envisaged, but with the following requests were made / expectations of suitable assistance:

1. Inform ARRB that a suitable test site was available (with sufficient time for mobilisation of equipment and staff to site). A suitable test site was defined as a site where three (3) or more “traditional” compaction tests were to be completed upon a compacted earthworks fill / embankment within a “live” construction site;
2. Allow access for ARRB representatives to attend the compacted earthworks site at the same time that the “traditional” QA testing was to occur, such that the “innovative” tests could be completed in parallel (i.e. both “traditional” and “innovative” tests completed same location under same material and climactic conditions);
3. Provide the results of the completed “traditional” QA tests to ARRB, such that direct comparison could be made with the results of the “innovative” testing

Within such an approach, it was expected that industry participants would operate on a “business as usual” approach in their QA process – in order to satisfy their own project QA specifications – whilst ARRB (or its delegates) would be allowed to access the site and carry out parallel testing, as suitable opportunities arose. Effective co-ordination between the industry partners’ onsite personnel and ARRB representatives was considered the greatest potential hindrance, as ARRB required accurate long-term QA testing timeframes and to be provided by the Industry Partner – in the form of a 6 to 8-week future schedule – in order to source the required equipment from 3rd party suppliers. Similarly, once onsite, effective co-ordination was required to ensure a maximum number of test sites could be accessed (whilst “traditional” testing was being undertaken) such that the down-time of the onsite ARRB researchers was minimised.

The ARRB project team discussed various potential opportunities with major earthwork contractors and relevant regulatory bodies over several months (for both Phases 2 and 3) in order to access suitable sites within live construction projects. However, achieving an onsite presence proved difficult due to:

- ☐ A lack of suitable sites within the South-East Queensland region – based on the current infrastructure project load that included “live” sites with major earthworks operations (i.e. a number of potential sites had yet to commence significant construction operations)
- ☐ A perceived potential that the site may be audited with the additional QA testing – Although a high level of technical interest was noted within several meetings with a variety of contractor, final approval for site testing was often not forthcoming as there was an (incorrect) belief that



the results from the additional QA testing may be required to be incorporated into the project's own lot conformance documentation, which may potentially have an adverse outcome in lot acceptance status.

2.3 Test Site used for Phase 3 Study

With no suitable sites identified to exist within SEQ, other sites located throughout the state of QLD were considered. As the outcome of the Phase 3 component of the project was to produce site / material-specific specifications that could be incorporated into the project's QA regime – i.e. to demonstrate how alternative site assessment tools could be successfully used for live site assessment – the size of the construction project needed to include a significant volume of earthworks.

A single site, located in Far North Queensland, was identified and accessed by ARRB representatives during the Phase 3 program of work. This site was the 'early works' component (trial embankment and surcharge) of a major road upgrade project, and was successfully utilised to obtain suitable side-by-side test results for both the "innovative" and "conventional" test techniques. This site is fully detailed in Chapter 3 of this report.

The ARRB study team acknowledges Albem and Highway Constructions (HC) for allowing access to this site and providing their QA data. The permission of the Queensland Department of Transport and Main Roads (QTMR) is also acknowledged to allow the testing to occur at the site.

Many other contractors who expressed interest were not able to provide a suitable size site.

Due to the comparatively remote location of the site, significant overhead costs of travel and accommodation of the ARRB field team were incurred.

3. Details of Fieldwork Test Site

3.1 Location of Site

The onsite field-testing component of the Phase 3 of the ARRB project was conducted between 15 February 2019 to 26 April 2019 on a live, greenfield road project, namely the Smithfield Bypass Project. This is a QMTR Project, with construction starting in late 2018. The bypass links McGregor Road to Cairns Western Arterial Road and the Captain Cook Highway, and is located approximately 11.5 km North-West of Cairns CBD. The general location of the site is shown in Figure 3-1.



Figure 3-1 Location of Phase 3 Field Trial Site, in comparison to location of Cairns, Far North Queensland (source: www.google.com.au/maps)

Specifically, all field testing was undertaken upon an embankment being constructed over Avondale Creek as part of an 'early works' component of the project (also to be used as surcharge prior to the commencement of the remainder of the project's construction). A detailed aerial imagery showing the footprint of the trial embankment utilized for all testing is identified in Figure 3-2.



Figure 3-2 Location of Phase 3 Field Trial Site, in comparison to location of Cairns, Far North Queensland (aerial image extracted from Nearmap 13/06/2019)

3.2 Details of Earthworks Trial Embankment

3.2.1 Trial Embankment Design

Construction of the trial embankment commenced in early February 2019. The trial embankment was located along the footprint of a 385 m length of the upgrade roadway alignment. Onsite the trial embankment was divided into two (2) distinct sections, separated by Avondale Creek (refer Figure 3-3).

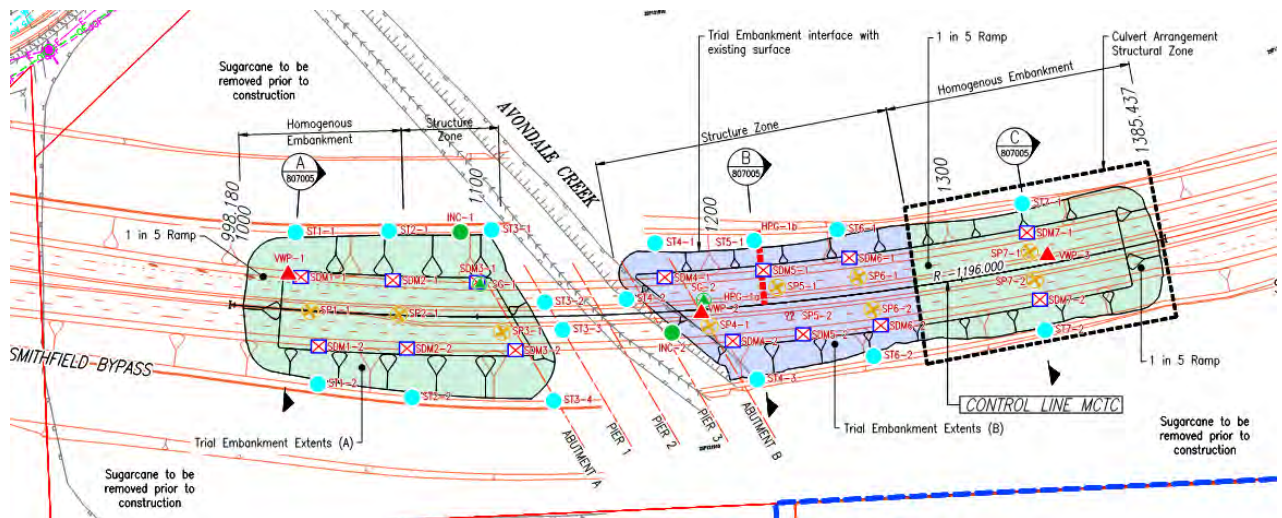


Figure 3-3 General Arrangement Plan Trail embankment

The trial embankment required placement of fill material to be undertaken at various densities, therefore (in theory) a range of densities could be checked with the various QA tools being evaluated by the ARRB test regime. The embankment was installed upon compressible ground (natural materials) and was to be comprised of, in general order of construction (base to top of trial embankment):

- An initial working platform layer at the base with a nominal 90% relative compaction (*medium dense*)
- The general fill which required 95% relative compaction (*dense*)
- The subgrade zone which required 97% relative compaction (*very dense*)
- The surcharge fill which would settle into a subgrade position required 97% relative compaction, and
- An upper surcharge fill which would be removed prior to construction of the pavements required 90% relative compaction (*medium dense*)

An elevation view of the proposed trial embankment, demonstrating the anticipated variability of achieved compaction, is shown in Figure 3-4.

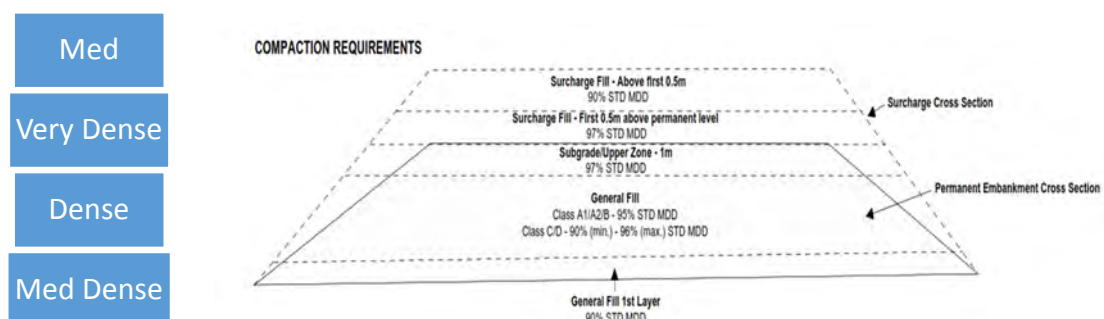


Figure 3-4 Plan view of Trial Embankment, showing variable compaction levels within embankment



3.2.2 Trial Embankment Construction

The trial embankment design was completed and approved in November 2018, with geotechnical instrumentation installed to monitor the settlement of the compressible material underlying the embankment. The construction phase of the trial embankment – and thus the ARRB project team's onsite presence for data collection – was expected to take two (2) weeks, contained within a three (3) week mobilisation / onsite period.

At the time of award of the contract for the TMR project, the trial embankment / surcharging works was targeted to have been completed before the Christmas shutdown of 2018 (late December 2018). This date was selected, as due to the location of the site, it was expected extreme tropical rains and cyclones would increase in the early 2019 (approximately January to April). This is reflected in the typical annual climatic conditions of the Far North Queensland site, as summarised in Section 3.3.

Mobilisation of the geotechnical monitoring occurred at the start of November 2019. However, due to administrative permission to access the site not being in place, equipment and personnel – including ARRB project personnel – remained on standby for the entirety of December 2018. No significant construction work relating to the trial embankment was completed prior to December 2018.

Cyclones and repeated flooding events occurred from the end of December 2018 to mid-February 2019 (as expected). Fill placement for the trial embankment commenced in mid-February 2019 and at mid-June (at time of completion of this Phase 3 report) the embankment was only now nearing completion. Thus, the construction phase of the trial embankment exceeded a period of 4 months, well in excess of the two (2) weeks initially expected in the “dry” period.

The construction methodology adopted by the project's Contractor for the trial embankment – over which the ARRB project team had no control – resulted in the various sections of the trial embankment typically being over compacted. As a result, there was little variation in the compacted densities achieved onsite, especially towards the range of lower compaction values (Figure 3-4).

As further detailed in Section 7.1, the minimum observed achieved relative density was 95.0%, whilst the average and median RDD values were 99.7% and 100.0% respectively. This is considered a major departure from the design intent of the trial embankment. Note that high and/or over-compaction is considered good by most engineers. However, for this research, this high compaction limited the direct measurement of parameters arising from the alternative QA methods being evaluated at the lower RDD thresholds typically included in earthworks QA specifications (i.e. no side by side testing completed for materials with RDD < 95%).

Due to the significant extension of the construction duration, ARRB fieldwork was undertaken during only a portion of the trial embankment's construction. The ARRB project's field team – typically comprising 3 to 4 personnel – was deployed onsite for approximately one (1) month, from 15 February 2019 to 16 March 2019. The scope of works completed by the team is further detailed in Section 6.

3.2.3 Source of Fill Material

Pioneer EDQ General Fill material – processed material conforming to ‘Class A1’ specification, as per TMR's *MRTS04 - General Earthworks* – was imported for the construction of the trial embankment. Via onsite observation, the fill material was predominantly Clayey Gravel / Gravelly CLAY with Cobble and Boulders mixed during the embankment construction. It has been noted that, the origin of the rock, weathering and strength of cobble and bolder mixed in the fill are potentially different.

The material is fully characterised in accordance with the Unified Soil Classification System (USCS) and definitions included in Australian Standard AS1726 – *Geotechnical Site Investigations* (2017) in Section 5. The Particle Size Distribution (PSD) of the general fill, and observed change due to the compactive efforts applied, is also detailed in Section 5.

3.2.4 Equipment Utilised

The construction plant observed to have been utilised by the contractor during construction of the trial embankment included:

- 38 T Compactor (Caterpillar 825K)
- 18 T Padfoot Vibratory Drum Soil Roller (Caterpillar CS76XT)

- 18 T Smooth Vibratory Drum Soil Roller (Caterpillar CP76)
- Water Cart
- Grader (Caterpillar 140M)
- Truck and Dog

Figure 3-5 presents photos of examples of each of the construction plant utilised during the construction of the trial embankment.



(a)



(b)



(c)



(d)



(e)



(f)

Figure 3-5 Equipment utilised during the construction of Trial Embankment – (a) 38 T Compactor; (b) 18 T Padfoot Vibratory Drum Roller (c) 18 T Smooth Vibratory Drum Roller Grader (d) Water Cart; (e) Grader (f) Truck and Dog



3.2.5 Typical Lift Construction Procedure and Compaction Effort

The typical lift construction sequence employed onsite, can be summarised in the following steps:

- **Step 1 – Material Import** via truck and dogs from Pioneer EDQ quarry, and unloaded onsite;
- **Step 2 – Material Spread** with grader / compactor, to achieve an uncompacted lift thickness of approximately 400 mm;
- **Step 3 – Moisture Conditioning** of material, if required, via use of sprayed water from water cart. Need for moisture conditioning was at the discretion of the site Forman / Grader operator;
- **Step 4 – Compaction** of spread material undertaken by either: (A) 4 heavy and 2 light return passes of 18 T Padfoot Vibratory Drum Soil Roller; OR (B) 6 return passes of 38 T Compactor. Note the use of the compactor would include re-distribution (additional spreading) of material at same time that compactive effort was being applied.
- **Step 5 – Surface Sealing** via application of 1 heavy and 2 light return passes with 18 T Smooth Vibratory Drum Soil Roller

The preparation of each lot, with approximate dimensions of 300 mm (compacted thickness) x 20 m (W) x 150 m (L) would typically be completed in less than a single day's plant operation.

3.3 Climactic Conditions of Site

3.3.1 Annual Climactic Statistics

The site is located within the Cairns region of Far North Queensland, Australia. Based on the site location, tropical climactic conditions are typically experienced – including distinct 'wet' (December to April) and 'dry' seasons (June to October). Additionally, there is an expectation that frequent extreme weather events (e.g. cyclones, flooding due to intense rainfall events) may occur within the 'wet' season. A monthly summary of the annual climactic statistics of the site are included in Figure 3-6 (sourced from the Australian Bureau of Meteorology).

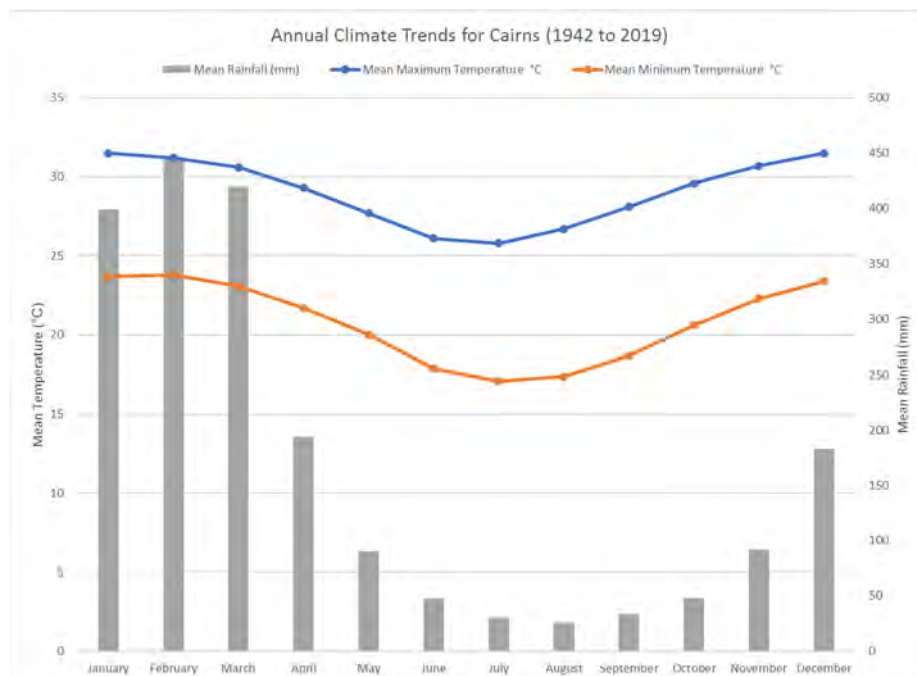


Figure 3-6 Monthly Climactic Data – monthly average rainfall, average minimum and maximum daily temperatures – for meteorological installations nearest to fieldwork site (Source: www.bom.gov.au)

The fieldwork site is defined to be in a 'high' rainfall environment as per TMR guidelines (*MRTS04 – General Earthworks*)



3.3.2 Observed weather events

Immediately prior to the period of trial embankment construction and the fieldwork component of this project, cyclones and repeated flooding events were observed onsite (from December 2018 to Mid-February 2019).

Fill placement for the trial embankment commenced in mid-February 2019, with the data considered by this report being collected between 12 February 2019 through 26 April 2019.

Daily Temperatures

As the fieldwork site was located in a tropical region, relatively high daily temperatures were expected for the duration of field testing. This is reflected in the maximum daily temperatures recorded by BOM as seen in Figure 3-7. Minimum and maximum temperature values recorded at the Cairns Airport and Cairns Racecourse (RC) weather stations are plotted in the figure above. The maximum daily temperature fluctuated between 30 to 32°C. The highest daily temperatures occurred during the QA process of Site 15 - 18, between the 19th February to the 22nd February.

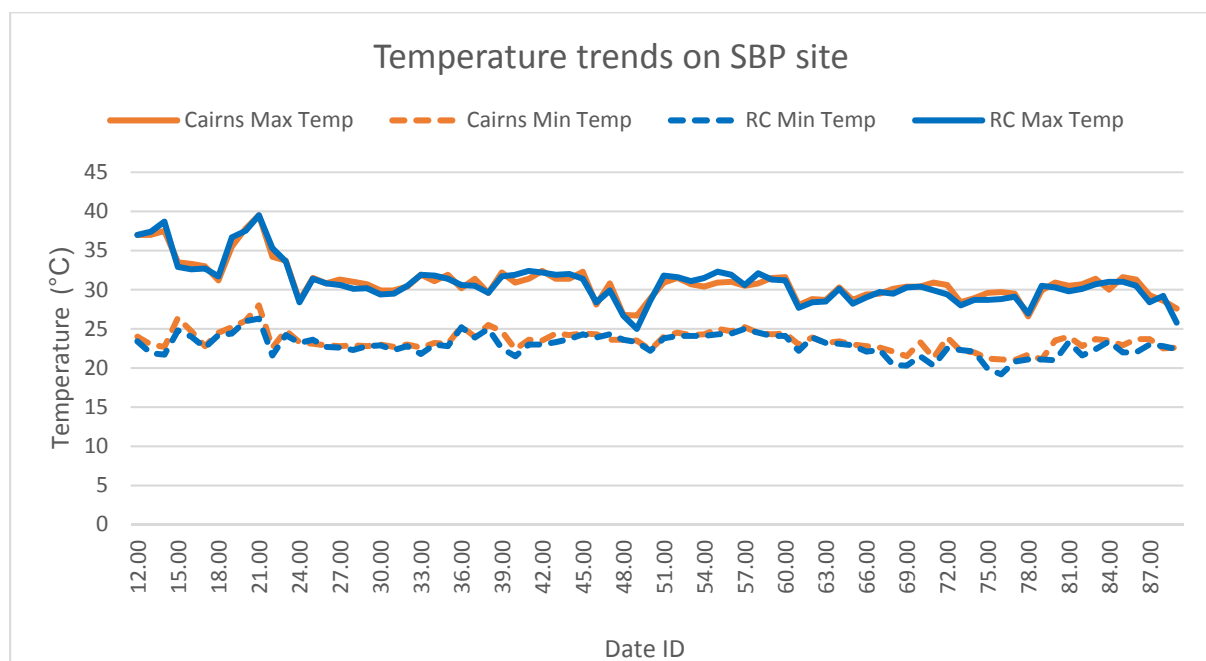


Figure 3-7 Recorded Daily Maximum and Minimum Temperatures for duration of onsite testing, for meteorological installations nearest to fieldwork site (12/02/2019 – 26/04/2019)
(Source: www.bom.gov.au)

Daily Rainfall

Light showers of rain were encountered occurred throughout the field-testing duration, typical of the tropical climate of the site. Daily rainfall totals generally fluctuated between 0 to 20 mm for the period of onsite fieldwork considered herein. Dry periods were observed during the assessment of Sites 6 through 14. Similarly, a dry period was also observed during the 12th March to the 16th March. Significant rainfall occurred during the placement and field testing of Site 19.

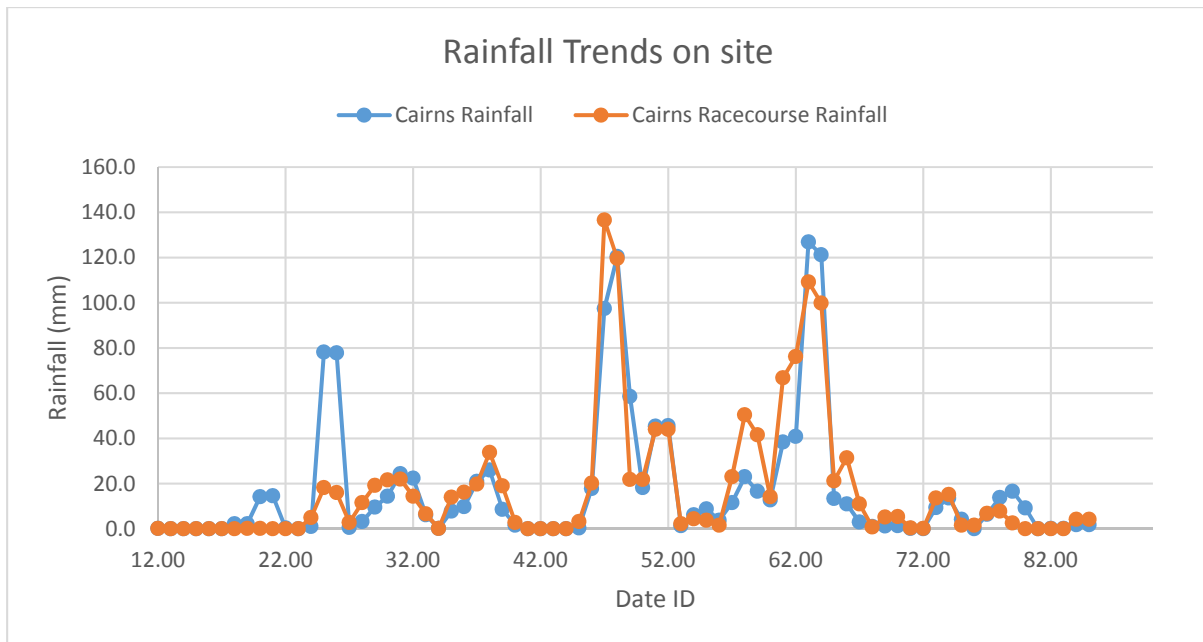


Figure 3-8 Recorded Daily Rainfall Totals for duration of onsite testing, for meteorological installations nearest to fieldwork site (12/02/2019 – 26/04/2019) (Source: www.bom.gov.au)

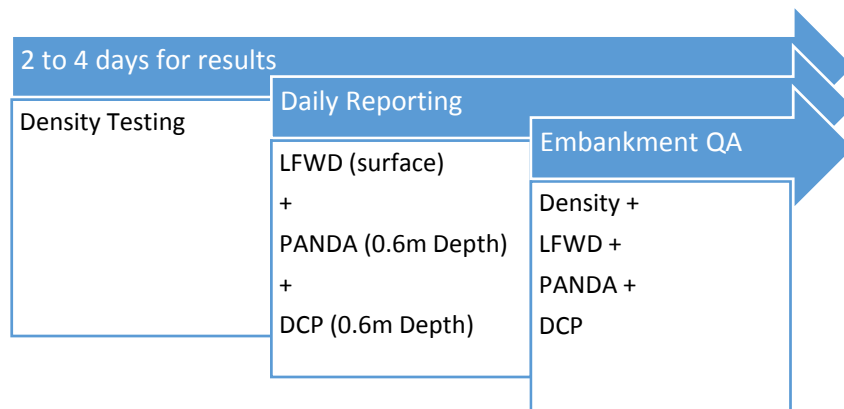
4. Overview of Alternative QA Test Techniques

4.1 Rationale for the use of Alternative QA testing

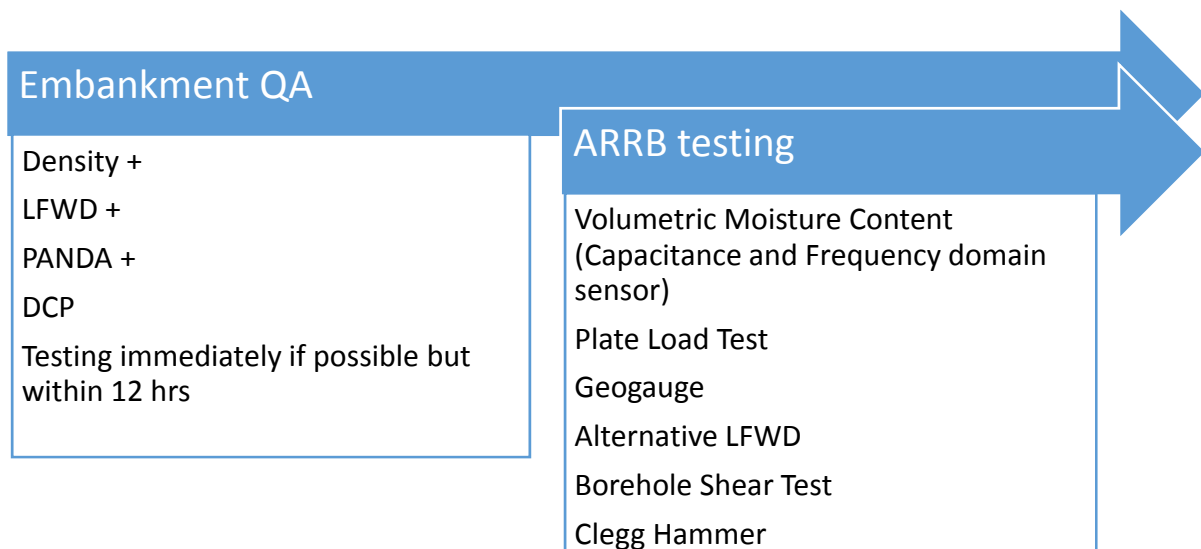
The time lag typically required in obtaining density tests prompted the use of alternative equipment for quality control testing at this site.

The LFWD, DCP and PANDA were selected as the Quality Assurance (QA) tests to be utilised upon the trial embankment, as such tests were considered to have previously demonstrated the greatest potential for effective use within a QA specification framework. These tests would also be able to provide certification within 24 hrs (provided the parameters arising from these tests were initially calibrated to suitable QA acceptance thresholds).

Previous studies had shown the LFWD is accurate and traceable with high quality data. The PANDA was more accurate than the DCP and traceable. The DCP was less reliable and less traceable but is better able to penetrate very dense material or at high compaction levels.



Although the LFWD, DCP and PANDA were to be utilised throughout the trial embankment's construction, and adopted as a 'live' demonstration of their use for QA purposes, the *insitu* testing undertaken by the ARRB fieldwork was to occur on a limited sub-set of test lots (sites) within the trial embankment. These tests are shown below. Note that due to the project delay (refer Chapter 3), not all of the planned alternative QA test techniques were able to be employed on the trial embankment due to equipment no longer being available.



4.2 Details of Alternative QA Test Methods

This section provides a high-level review of three (3) 'Alternative QA' testing methods utilised for field testing undertaken upon the trial embankment, in terms of a description of the equipment and the data collection methodology. The three (3) types of equipment detailed within this section are:

- **Nuclear Density Gauge**
- **PANDA Variable Energy DCP**
- **PRIMA100 LWD**

Figure 4-1 presents a schematic diagram of the equipment associated with each of the three (3) 'Alternative QA' methods considered herein. The 'zone of influence' / extent of disturbance associated with each test technique is also presented in Figure 4-1, represented as a dashed line.

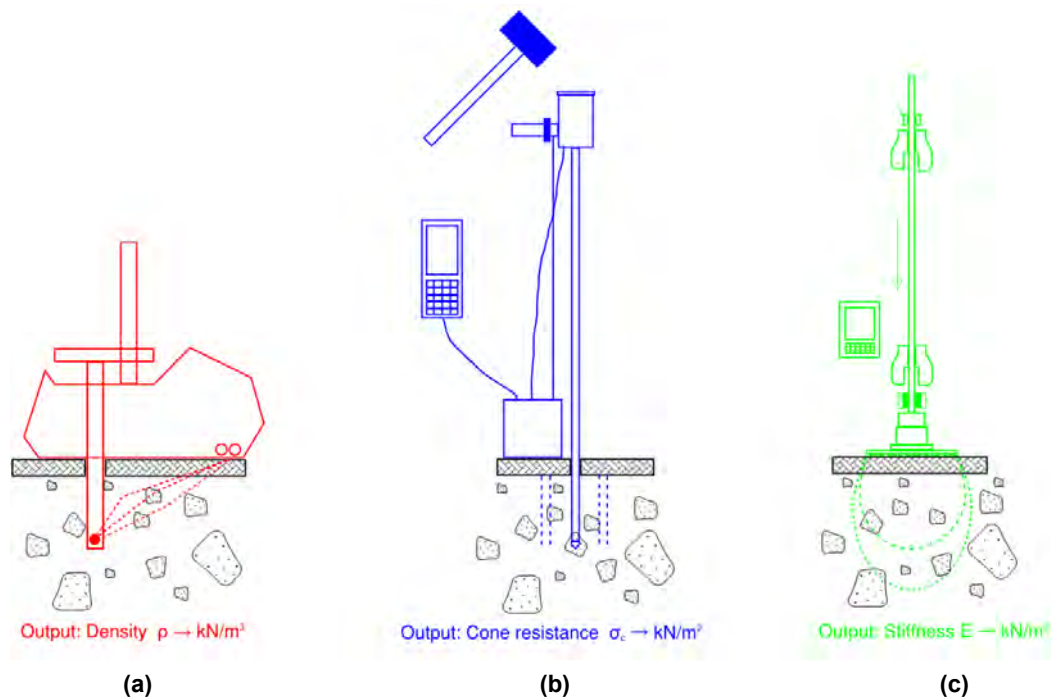


Figure 4-1 Schematic diagram (a) Nuclear Density gauge Direct Transmission, (b) Panda, (c) LFWD Prima 100

It should be noted that in addition to the above three (3) test types, a number of other field tests were completed in side-by-side testing arrangements. These additional field tests included: (a) Dynamic Cone Penetrometer (DCP), (b) ProCheck TEROS-12 Moisture Gauge, (c) Terratest LWD, (d) Variable height Clegg Hammer; and (e) Plate Load Test PLTs.

4.2.1 Nuclear Density Gauge (NDG):

Wet density is measured using a Caesium 137 (Cs-137) gamma radiation source, a pea-sized pellet fixed in the bottom of the source rod, and two Geiger-Muller tube gamma detectors at the rear of the gauge. The Caesium gamma source is lowered to the desired test depth by releasing the handle (L-G-002, RMS, 2015).

Desired depth can be achieved by hammering a rigid rod to the required depth using a sledge hammer, refusal is also possible (although it is not expected often) at a specific location when the pilot rod encountering an unbreakable high strength cobble/boulder.

When the test is commenced, the detectors in the gauge record the count rate of the radiation transmitted directly through the soil layer, displaying wet density readings on the keypad. A denser material absorbs more gamma radiation, resulting in a lower gamma count reading, which converts to a higher wet density value. The volume of material assessed includes the material between the source and the detectors. Material must be sampled from each field test site in the lot and tested in accordance with the relevant test method (L-G-002, RMS, 2015).

For a site required to be tested at 5 locations (100 m length of the stretch), all insitu tests including the sample collection are expected to be completed at approximately 60 minutes. Refusal during the penetration of the pilot rod occur in 2 or 3 instances during the 4 weeks FSG presence on site.

4.2.2 Instrumented Dynamic Cone Penetrometer (PANDA Variable Energy DCP)

The test requires manual hammering a cone down into the required depth and recording the cone resistance during the penetration. Refusal is likely to occur at shallow depth when fill material comprised of cobble and boulders. Cone resistance is being recorded at 1 – 20 mm penetration depth intervals and for 300 mm penetration depth, average of 60 data is expected be collected. Zone of disturbance could be varied between 50- and 80-mm radius from the test location and is extended beyond the penetration depth.

For a site required to be tested at 5 locations (100 m length of the stretch), all tests are expected to be completed at approximately 60 minutes. In almost all locations Panda test has to be repeated due to early refusal. Where refusal occurred, the test location has been relocated and tested repeated (i.e. in 200 mm radius from the original location)

4.2.3 PRIMA100 Light Falling Weight Deflectometers (LFWD)

Light Falling Weight Deflectometers utilise an integrated load cell and a centre-mounted geophone for measurement of impact load and ground displacement under each individual loading impact energy. The results can be reported as stiffness for a specific location. Depth of influence varied between 300 and 450 mm for a 300 mm plate. For a site required to be tested at 5 locations (100 m length of the site), all tests are expected to be completed at approximately 30 minutes.

4.3 Comparative Ease of Use (Fieldwork Component)

Table 4-1 provides a comparison amongst testing equipment from their perceived ease of use to complete the field component of the test. This ranking has been compiled based on feedback from all operators onsite.

Table 4-1 Comparison between the testing equipment ease of use

Testing Equipment	Test Type	Additional Equipment Required	Ease of Use for FIELDWORK (5=Easiest to 1= Hardest)
Terratest LWD	Surface based Plate (Dynamic)	NIL	5
PRIMA100 LWD	Surface based Plate (Dynamic)	NIL	4
ProCheck TEROS-12 Moisture Gauge	Penetration	NIL	4
Clegg hammer	Surface based Plate (Dynamic)	NIL	4
Nuclear Density Gauge	Penetration	Rigid Rod & Sledge Hammer	3
Static Plate Load (PLT)	Surface based Plate (Static)	External Reaction Force	3
Dynamic Cone Penetrometer (DCP)	Penetration	Rod Extractor	2
PANDA Variable Energy DCP	Penetration	Rod Extractor	1

5. Material Characterisation

This chapter summarises the results of material classification and characterisation tests completed at the Phase 3 trial embankment site, such that the material being utilised as embankment fill is understood and the variation within the material – both natural and due to any material breakdown caused by the compactive effort being applied – may be quantified.

The tests detailed herein have all been undertaken by others, as part of the live project's QA requirement, with the relevant *insitu* density and material quality certificates supplied to FSG for review.

NATA registered authorities conducted all testing in accordance with the relevant specifications included within the Department of Transport and Main Roads Materials Testing Manual ('Q Test Methods'). Listed below are the specific documentation observed for the testing program.

- Test Method Q102A – Standard Moisture Content of Soil – Oven Drying
- Test Method Q103A – Particle Size Distribution of Soil – Wet Sieving
- Test Method Q104D – Liquid Limit of Soil – One Point
- Test Method Q105 – Plastic Limit and Plasticity Index of Soil
- Test Method Q106 – Linear Shrinkage of Soil

Certificates for the results of material characterisation testing program can be found in Appendix A of this document.

5.1 Available material characterisation data

During the construction phase of the trial embankment, representative samples were collected for material classification tests – namely Particle Size Distribution (PSD) and Atterberg Limit determination. The total number of samples collected prior to (source) and after material compaction were.

- Stockpiled (pre-compaction) material – four (4) samples
- Post-compaction material (sampled *insitu* from Fill Embankment) – 37 no. samples

5.2 Classification of Source Materials

The results of laboratory tests completed upon source materials were completed and provided to the project by the owner of the quarry from which the fill materials were being sourced. The results of the PSD testing completed on the pre-compaction / source materials is presented in Figure 5-1, and shows both the grading curve for the individual test results as well as the averaged PSD curve.

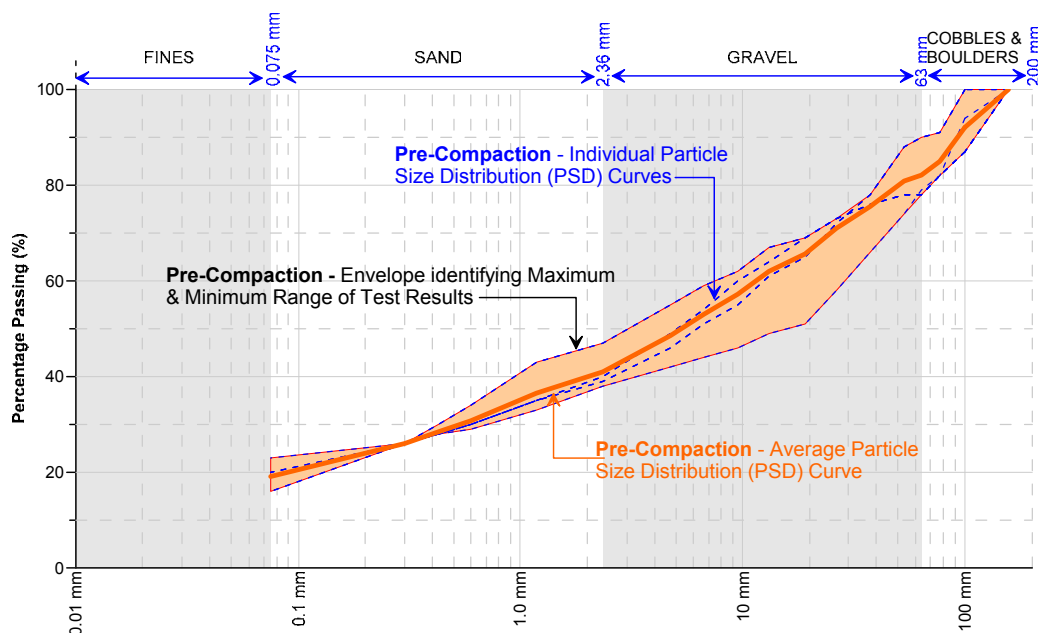


Figure 5-1 Particle Size Distribution (PSD) curves and grading envelope of source FILL materials (pre-compaction).

As detailed in these Material Quality Reports and summarised in Table 5-1, the Particle Size Distribution (PSD) of the four (4) tested samples demonstrate the source material would be considered to be granular in nature (with typically 80% of materials being considered granular). The material is GRAVEL and SAND dominated (23% & 22% content respectively), with a significant proportion of COBBLES present. In accordance with AS1726 – *Geotechnical Site Investigations*, the material would be considered to classify as a 'Mixture of Soil and Cobbles', with the soil component (particles demonstrating a grain size of 63 mm or less) being typically classified as a 'Clayey GRAVEL with SAND'. All four (4) material samples would be classified as the same material type if the PSD curves were considered individually.

Table 5-1 FILL (pre-compaction / source) – Summary of Particle Size Distribution (PSD) test results

Material	No. of Samples	COBBLES (63.0 – 150 mm)		GRAVELS (2.36 – 63.0 mm)		SAND (0.075 – 2.36 mm)		FINES (< 0.075 mm)	
		Range	Average	Range	Average	Range	Average	Range	Average
Source Material (Uncompacted)	<i>n</i> = 4	10 – 22%	19 %	31 – 51%	40 %	15 – 31%	22 %	16 – 23%	20 %

Based on the results of the Atterberg Limits testing completed upon the source materials, the fines component would be considered likely to be Low Plasticity, CLAY materials (USC Classification = CL). Table 5-2, whilst Figure 5-2 plots the results upon the 'A Line'. summarises the results of the Atterberg Limit tests completed on the fines component of the soil sample. Based on the results of the grading and Atterberg Limits, the Weighted Plasticity Index of the source material would range between 191 & 301 (average = 240). The materials would typically classify as "Class A1" General Fill materials as per the requirements of *MRTS04 – General Earthworks* (2018).

Table 5-2 FILL (pre-compaction / source) – Summary of Atterberg Limits test results

Material	No. of Samples	Liquid Limit (LL, %)		Plastic Limit (PL, %)		Plasticity Index (PI, %)		Linear Shrinkage (%)	
		Range	Average	Range	Average	Range	Average	Range	Average
Source Material (Uncompacted)	<i>n</i> = 4	24.4 – 38.8 %	29.15 %	16.2 – 28.0 %	20.70 %	6.8 – 10.8 %	8.45%	3.2 – 5.4%	4.15 %

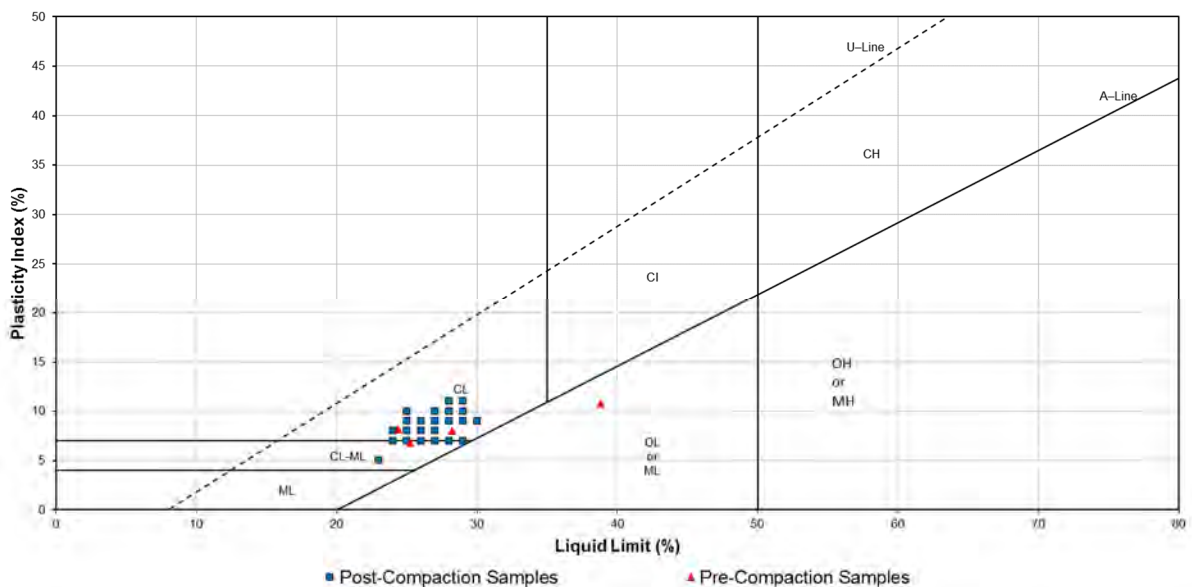


Figure 5-2 Atterberg Limits of fines component of source (red) and post-compaction (blue) samples plotted against the 'A-Line'

Four (4) California Bearing Ratio test results were also supplied for the source material samples, demonstrating CBR values of 13, 20, 40 & 40 % (average = 28 %). It is noted that the lowest CBR value (13%) corresponds with the maximum reported swell value (+2.3%), fines content (23%) and Plasticity Index (10.8%). This lower CBR result is thus considered to likely have been affected by the comparatively higher fines content of the sample, and thus demonstrates the likely sensitivity of the source material behaviour to the localised fines content. It is also noted that a large portion (> 50%) of the source material (cobbles and gravels) would have been removed from the sample during CBR test preparation, and the CBR test results should be viewed with this in consideration.

5.3 Classification of Post-Compaction Fill Materials

Thirty-seven (37) PSD test results were provided for samples of post-compaction materials, with each sample removed from the upper lift (approx. initial 300 mm thickness) of the trial embankment as it was progressively constructed. The grading envelopes reported from these tests, and material variation encountered throughout the period of sampling, is presented graphically in Figure 5-3, with the major components of the samples summarised in Table 5-3. The post-compacted material was, on average, were classified as a Clayey Sandy GRAVEL in accordance with AS1726 (2017), whilst the classification applicable individual material samples varied between 'Clayey Sandy GRAVEL' (26 no.), 'Clayey GRAVEL with SAND' (8 no.) or 'Clayey Gravelly SAND' (3 no.).

Table 5-3 Post-compaction FILL – Summary of Particle Size Distribution (PSD) test results

Material	No. of Samples	COBBLES (63.0 – 150 mm)		GRAVELS (2.36 – 63.0 mm)		SAND (0.075 – 2.36 mm)		FINES (< 0.075 mm)	
		Range	Average	Range	Average	Range	Average	Range	Average
Compacted Fill Material	<i>n</i> = 37	0 – 11 %	4 %	29 – 55%	43 %	25 – 41%	32 %	14 – 27%	21 %

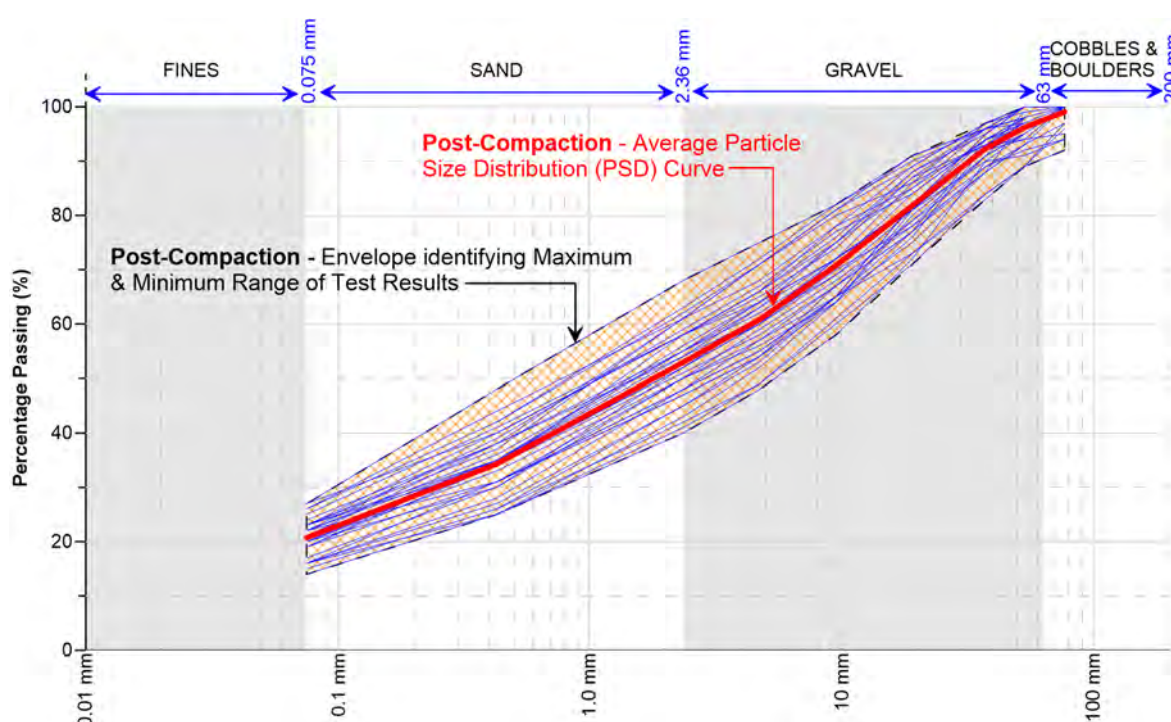


Figure 5-3 Particle Size Distribution (PSD) curves and grading envelope of post-compaction FILL materials (*n* =37).

Twenty-seven (27) unique Atterberg Limits test results were reported for the materials sampled from within the compacted trial embankment. Based upon these results, the 'fines' component of the material would be classified as a Low Plasticity material. These results, as well as the potential reactivity of the composite FILL is consistent with the corresponding test results of the 'source' material samples.

Table 5-4 Post-compaction FILL – Summary of Atterberg Limits test results

Material	No. of Samples	Liquid Limit (LL, %)		Plastic Limit (PL, %)		Plasticity Index (PI, %)		Weighted Plasticity Index	
		Range	Average	Range	Average	Range	Average	Range	Average
Source Material (Uncompacted)	$n = 27$	23.0 – 30.0 %	26.6 %	15.0 – 22.0 %	18.2 %	5.0 – 11.0 %	8.4 %	174 – 466	290

5.4 Material Breakdown / Effect of Compactive Effort

Figure 5-4 presents the variation in the average PSD results and grading envelope as observed from the test results reported for 'source' materials and those sampled in the 'post-compaction' condition.

Based on the average PSD curve for the material in each state – as summarised in Table 5-5 – the quantity of cobble sized particles is significantly diminished due to application of the compactive effort (19 % reduced to less than 4%). Comparatively, the overall volume of GRAVEL sized particles is increased in the 'post-compaction' condition (by > 2.8%) and the quantity of SAND sized particles is increased by 10.9%. The percentage of 'fines' (i.e. particles < 75 μm) remained essentially constant for both material states (19.5% from 'source' vs. 20.7% from 'compacted' samples). The variation observed within the full test datasets does not appear to significantly vary for individual sieve sizes, as measured by the Coefficient of Variation observed at each sieve size (average CoV = 8.6 % for 'source' material dataset compared to average CoV = 9.3 % for 'post-compaction' materials). This indicates that the spread of PSD results within each dataset is not comparatively any greater for either the 'source' or 'post-compaction' materials.

These results suggest the compactive effort applied has caused a reduction in particle size for all materials that had particle sizes of sand or above. This reduction in characteristic particle size due to the compaction effort is represented in Figure 5-4 as a distinct shift in the data envelope and average PSD value to the left (finer) for materials sized above 0.075 mm. However, this material breakdown effect does not appear to have continued through to the 'fines' component of the 'post-compaction' samples.

However, on site observations suggests that post compaction sampling leaving larger sizes on site (refer section 6.6.4). This has been observed by the authors of this report on many other projects and it is usual for soils testers to not sample larger size material behind.

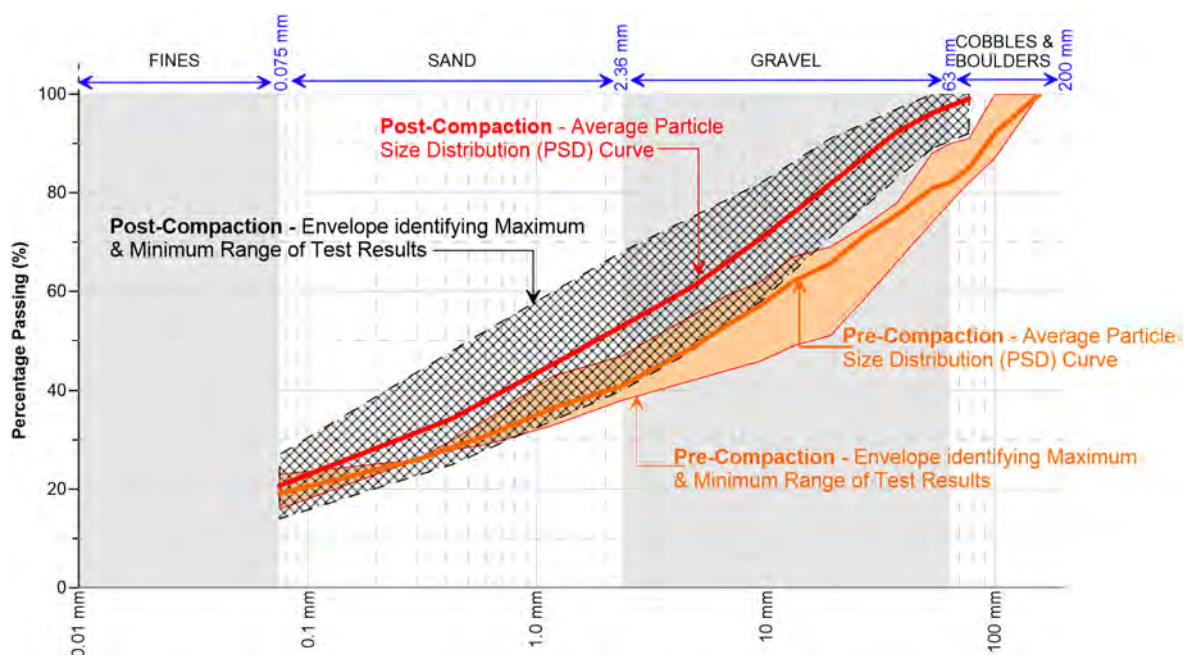


Figure 5-4 Particle Size Distribution (PSD) curves and grading envelopes for materials sampled in the 'source' and 'post-compaction' state.

Table 5-5 Particle Size Distribution (PSD) – Comparison between ‘source’ and ‘post-compaction’ data

Material Type	Sieve Size (mm)	Average PSD (% Passing)			Volume of Material Components (%)		
		Source	Post-Compaction	Change	Source	Post-Compaction	Change
Cobbles	150 mm	100.0 %	–	–	18.8 %	< 3.9 %	> -14.9 %
	100 mm	92.0 %	–	–			
	75 mm	84.3 %	99.1 %	-14.8 %			
	63 mm	81.3 %	–	–			
Gravel	53 mm	79.5 %	96.1 %	-16.6 %	40.2 %	> 43.0 %	+ > 2.8 %
	37.5 mm	74.0 %	92.3 %	-18.3 %			
	26.5 mm	69.0 %	–	–			
	19.0 mm	63.5 %	81.8 %	-18.3 %			
	13.2 mm	60.3 %	–	–			
	9.5 mm	55.8 %	70.9 %	-15.2 %			
	6.7 mm	52.0 %	–	–			
	4.75 mm	48.0 %	61.0 %	-13.0 %			
	2.36 mm	41.0 %	53.1 %	-12.1 %			
Sand	1.18 mm	36.5 %	–	–	21.5 %	32.4 %	+10.9 %
	600 µm	30.8 %	–	–			
	425 µm	28.5 %	34.4 %	-5.9 %			
Fines (Clay / Silt)	75 µm	19.5 %	20.7 %	-1.2 %	19.5 %	20.7 %	+1.2 %

As shown in Figure 5-5, the results of the Atterberg Limits testing completed upon the ‘source’ and ‘post-compaction’ materials demonstrate the behaviour of the ‘fines’ was not fundamentally altered by the application of the compactive effort. Similarly, as the volume of ‘fines’ also did not significantly increase between the two (2) material states being evaluated, the Weighted Plasticity Index (WPI) parameter also was not greatly altered between the ‘source’ and ‘post-compaction’ materials. This result indicates that the reactivity and sensitivity of the Fill material would not be expected to have been altered throughout the trial embankment, regardless of the capacitive effort being applied (or variation thereof).

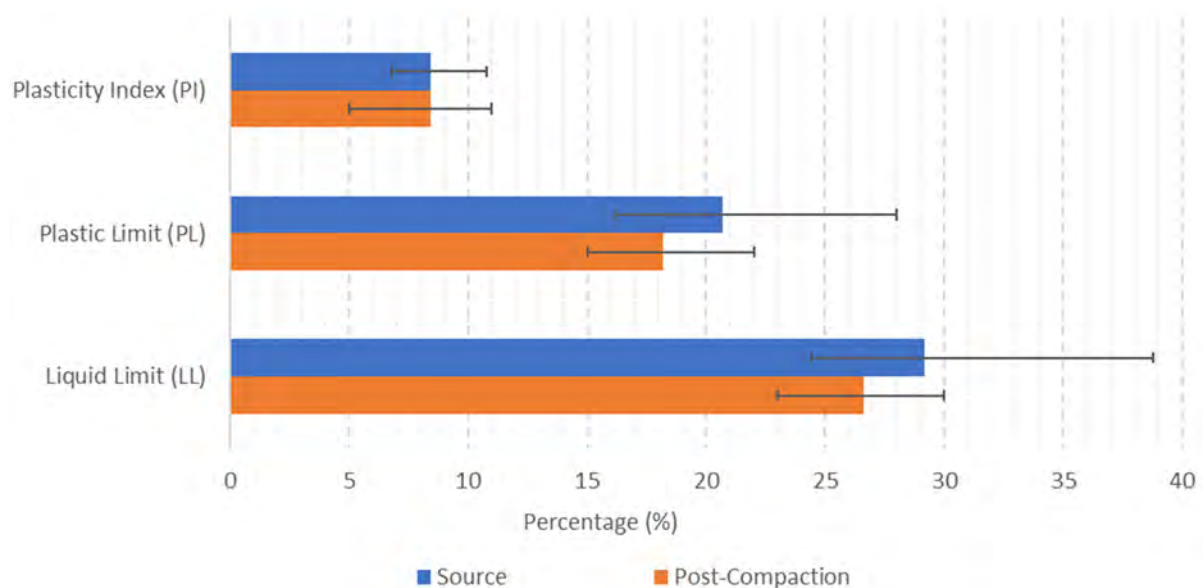


Figure 5-5 Atterberg Limits – Comparison between ‘source’ and ‘post-compaction’ data



5.5 Summary – Material Characterisation

The following key points relating to material characterisation have been identified by this study:

- Representative samples from ‘source’ (pre-compaction) and insitu from the construction trial embankment (post-compaction) were submitted to classification testing – Particle Size Distribution (PSD) and Atterberg Limits.
- Material breakdown was observed to occur due to the compactive effort applied, for all material particle size that were greater than 75 um size. No significant increase in ‘fines’ was observed to have occurred due to the compactive effort (remaining at ~20% of sample).
- The source material would classify as ‘Clayey GRAVEL with SAND’ in accordance with AS1726 – *Geotechnical Site Investigations*. The material breakdown associated with the compactive effort would result in increased GRAVEL and SAND contents, and result in the material being classified as a ‘Clayey Sandy GRAVEL’ (i.e. name change reflects the significantly increased SAND component)
- Both the pre- and post-compaction materials would be classified as having a low Weighted Plasticity Index (WPI < 1200), and would conform to the requirements of “Class A1” General Fill materials as per the requirements of *MRTS04 – General Earthworks* (2018). The material evaluated by this study – in both states submitted for testing - would be considered to be good quality bulk earthworks material.

6. Details of Field Testing / Field Test Datasets

As previously identified, Fill placement for the trial embankment used by Phase 3 of the ARRB project commenced in mid-February 2019, with the data considered by this report being collected between 12 February 2019 through 26 April 2019.

6.1 Testing Layout

Insitu testing was progressively completed as each lift of material was placed and compacted, and was completed at the same time as per the traditional density testing of the post-compaction material (which was required by the existing QA specification being applied to the earthworks). Individual ‘sites’ were evaluated, with a ‘site’ being effectively defined as the trafficable surface arising from the area prepared by a single day’s placement and compaction work. All *insitu* tests were completed from the trafficable surface of the ‘site’ (i.e. the top of the earthworks lifts under assessment), as per the Nuclear Density Gauge (NDG) testing being completed onsite.

Within a single ‘site’ a number of ‘sub-sites’ were submitted to side-by-side testing of both the innovative and traditional QA test techniques. The exact test types completed at each sub-site varied based on equipment availability and test duration, with additional test ‘sub-sites’ defined for the comparatively quicker test techniques (e.g. LWDs, Clegg Hammer) in order to maximise the amount of data collected during the fieldwork component of the project (i.e. the total number of ‘sub-sites’ within each ‘site’ varied based on available time to complete *insitu* time). Both the slowest test technique (static PLT) and the *insitu* density test (NDG) were only completed at a limited number of ‘sub-sites’. Section 6.2 further details the quantity of ‘sub-sites’ completed within each ‘site’.

Within each ‘sub-site’ all testing was completed within a circle with a radius of 500 mm, with the NDG location placed at the centre of the defined area. Figure 6-1 conceptually presents the layout of the testing completed at each site, with the approximate footprint size associated with each test type also demonstrated.

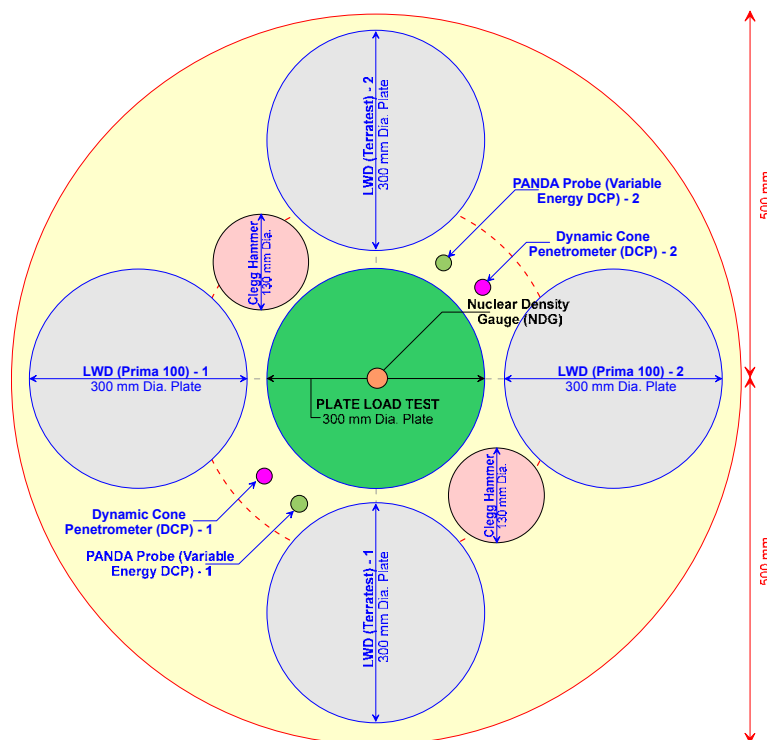


Figure 6-1 Conceptual figure showing the relative location of each test within a single ‘sub-site’ location (500 mm radius circle)

6.2 Testing Frequency

Table 6-1 summarises both the test techniques undertaken and the frequency at which they were completed across the field-testing component of the Phase 3 ARRB project. The number of tests detailed in Table 6-1 considers 'duplicate' testing (completed for assessment of the repeatability of each test type and the inherent variability of *insitu* material within a single test site – refer Section 6.5) and repeated penetration tests due to premature refusal as individual tests.

Table 6-1 Details of number of Test 'Sites', 'Sub-sites' and test techniques completed within each 'Site'

Site ID	No. of Sub-Sites	Density Testing	Surface Based Plate Testing				Penetration Testing		Other
		Nuclear Density Gauge (NDG)	300 mm Diameter Plate			130 mm Dia. Plate	Dynamic Cone Penetrometer (DCP)	PANDA Probe (Variable Energy DCP)	Field Moisture Content
			Static Plate Load Test (PLT)	LWD – Prima 100	LWD - Terratest	9.1 kg Clegg Hammer			
Site 7	4	4	–	–	–	–	–	4	–
Site 8	4	4	–	–	–	–	–	4	–
Site 9	4	4	–	–	–	–	4	4	–
Site 10	4	4	–	–	–	–	4	4	–
Site 11	4	4	–	–	–	–	7	4	–
Site 12	4	4	–	4	–	–	6	7	–
Site 13	4	4	–	4	–	–	8	7	–
Site 14	4	4	–	4	–	–	6	5	–
Site 15	4	4	–	5	–	–	7	8	–
Site 16	4	4	–	4	–	–	8	6	4
Site 17	4	4	–	5	–	–	4	5	4
Site 18	4	4	–	4	–	–	6	5	4
Site 19	14	4	–	15	–	14	18	17	16
Site 21	14	4	2	18	15	14	26	27	18
Site 22	14	4	2	14	16	14	22	20	15
Site 23	6	5	1	6	6	7	10	8	6
Site 24	12	6	3	23	15	15	15	21	12
Site 25	12	5	2	12	15	13	15	21	12
Site 26	12	5	2	12	12	13	18	18	12
Site 27	5	5	–	5	–	–	6	8	5
Site 28	5	5	–	5	–	–	5	6	5
Site 29	5	5	–	5	–	–	5	7	6
Site 30	5	4	–	5	5	–	–	–	–
Site 31	4	4	–	–	4	–	–	–	–
Site 32	4	4	–	–	4	–	–	–	–
Site 33	4	4	–	–	4	–	–	–	–
Site 34	4	4	–	–	4	–	–	–	–
Site 35	4	4	–	–	4	–	–	–	–
Site 36	4	4	–	–	4	–	–	–	–
Site 37	4	4	–	–	4	–	–	–	–
Site 38	4	4	–	–	4	–	–	–	–
Total	184	132	12	150	116	90	200	216	119



6.3 Test Techniques

Site testing was undertaken at nominated locations (sub-sites) via the completion of two (2) or more of the following *insitu* test techniques / equipment:

- **Density Testing** – Undertaken via use of a calibrated **Nuclear Density Gauge (NDG)**, with the tested material sampled and laboratory determined *insitu* **moisture content** (and moisture ratio) determined for each test location
- **Modulus Testing** – Deformation parameter directly measured via a number of surface-based plate test techniques, namely:
 - o **Static Plate Load Test (PLT)** – Test stress imparted into surface using a circular (300 mm diameter), rigid plate
 - o **Light Falling weight Deflectometer (LWD), Prima 100** – Test stresses of multiple magnitudes imparted into surface using circular (300 mm diameter and, at isolated locations, 100 mm diameter), flexible plate. Test stresses generated using a 10 kg drop weight (variable drop heights).
 - o **Light Falling weight Deflectometer (LWD), Terratest 5000** – Test stress of uniform magnitude imparted into surface using circular (300 mm diameter), rigid plate. Test stresses generated using a 10 kg drop weight (single drop height).
 - o **Clegg Hammer** – Test stresses of multiple magnitudes imparted into surface using circular (130 mm diameter) base of drop hammer. Test stresses generated using a 9.1 kg drop hammer (variable drop heights).
 - o **Geogauge (Soil Stiffness Gauge)** – Multiple steady-state frequencies (100 – 196 Hz) used to induce very small displacements of the soil ($\leq 1.27 \times 10^{-6}$ m) at a very low strain condition. The average stiffness observed across all 25 frequencies generated is calculated as reported as the Geogauge Stiffness (HSG) parameter.
- **Penetration Testing** – Completed via two (2) individual tests, namely:
 - o **Dynamic Cone Penetrometer (DCP)** – Rod penetration measured as number of hammer blows (*n*) required to drive cone over a 100 mm depth interval
 - o **Variable Energy Dynamic Cone Penetrometer (PANDA Probe)** – Rod penetration and imparted driving energy measured for each hammer blow during test.
- **Field Moisture Content Testing** – *Insitu* measurement of moisture content of surface and immediate near-surface of sub-site (upper ~100 mm) via use of a three (3) no. 75 mm length needle probes penetrated into the earthworks Fill. (commercially available **TEROS 12 Soil Moisture sensor**, manufactured by METER Group).

The subsequent sections of this report include further relevant details of each test technique employed during this study.

Although geogauge testing (soil stiffness device) was commenced during the completion of Site 19, it was subsequently discontinued as the test results appeared to be affected by construction plant operating within the immediate vicinity of the test site. Accordingly, as no relevant dataset was recorded, no further discussion of this *insitu* test technique is included in this report.

All *insitu* tests were performed by a team of 2 to 3 Senior Geotechnical Engineers from FSG Geotechnics + Foundations, except for the PLT and density (NDG) tests. The PLT was sub-contracted to Construction Sciences and the NDG tests was subcontracted to ETS (as per the traditional QA test requirements of the trial embankments – refer Section 6.4).

6.4 Details of Applicable Traditional QA Specification

As a component of a live roadworks project, the trial embankment was constructed in full accordance TMR's *MRTS04 – Earthworks* (2018) which, via a project-specific annexure, defined that each earthworks lot ('site' as per the notation used in this report) should be verified by the completion of the greater of (i) a minimum of four (4) no. NDG tests; or (ii) sufficient NDG tests such that one (1) test is

completed per 500 m³ of placed materials. This resulted in a typical 'site' having four (4) NDG tests completed (as per Table 6-1).

Each QA (NDG) test was required to assess the *insitu* field dry density achieved within the compacted earthworks, with the characteristic value of the ratio of the field dry density to the Maximum Dry Density (MDD) of the material to exceed 95% for each site. Note that for this study, reference MDD and Optimum Moisture Content (OMC) values were used, with the frequency of their assessment in accordance with Australian Standard AS 1289.5.4.2 (2007).

Throughout the trial embankment construction considered by this project, NDG testing was completed within 24 hours of the completion of the site preparation (i.e. conclusion of compaction of materials), with the NDG tests typically completed within 12 hours of the compactive effort (and frequently undertaken immediately upon completion of construction plant finalisation). However, an isolated number of sites were tested after significant rain event and after re-compaction of the site. The fieldwork component of the NDG tests were completed by the external, independent third party (ETS) within approximately an hour from the commencement of site testing.

Although further detailed in Section 7.1, all sub-sites submitted to NDG assessment demonstrated an adequate field compaction had been achieved (i.e. Relative Dry Density (RDD) > 95%). The reported range of RDD was 95.0 % to 104.1 % (average RDD = 99.7 %; median RDD = 100.0%).

The corresponding moisture ratio (MR) – defined as ratio of the measured field moisture content to the OMC of the material – of the *insitu* density testing varied between 52.5 % to 126.3 % (average MR = 86.6 %; median MR = 83.8 %) indicating that the material was typically compacted dry of optimum.

6.5 Assessment of Test Repeatability

The close proximity of all tests completed within a single test site (refer Section 6.1) was aimed at completing all *insitu* testing upon a 'uniform' material sample – or as close as possible to a 'uniform' sample as available in a live construction project – such that all test results could be considered to have arisen under identical test conditions.

However, in order to measure a combination of both (i) the equipment error (i.e. repeatability); and (ii) variation of the *insitu* material condition across individual test sites could be quantified, each individual test technique (with the exception of density testing) was repeated within individual test sub-sites. Table 6-2 details the frequency that each test was repeated, and also identifies if the duplicate tests were undertaken at the same time or after an additional period of time (e.g. to assess if the moisture content [typically drying] variation would have on the reported test parameter). Subsequent sections of this report evaluate the variation in the parameter arising from the repeated testing within a single sub-site, based on individual test techniques.

Table 6-2 Repeatability – No. of locations where individual tests were repeated within individual sub-sites

Site ID	Surface Based Plate Testing				Penetration Testing ^[1]		Other
	300 mm Diameter Plate			130 mm Dia. Plate	Dynamic Cone Penetrometer (DCP)	PANDA Probe (Variable Energy DCP)	Field Moisture Content
	Static Plate Load Test (PLT)	LWD – Prima 100	LWD - Terratest	9.1 kg Clegg Hammer			
Site 11					3	3	
Site 12					2	3	
Site 13					3	3	
Site 14					2	1	
Site 15		1 (< 24 hrs)			2	3	
Site 16					4	2	
Site 17		1 (< 24 hrs)				1	
Site 18					2	1	
Site 19		1 (< 24 hrs)			3	3	2
Site 21		4 (> 24 hrs)	1		7 + 5 (> 24 hrs)	9 + 4 (> 24 hrs)	4 (> 24 hrs)

Site ID	Surface Based Plate Testing				Penetration Testing ^[1]		Other
	300 mm Diameter Plate			130 mm Dia. Plate	Dynamic Cone Penetrometer (DCP)	PANDA Probe (Variable Energy DCP)	Field Moisture Content
	Static Plate Load Test (PLT)	LWD – Prima 100	LWD - Terratest	9.1 kg Clegg Hammer			
Site 22	1		2		8	5	1
Site 23				1	4	2	
Site 24		6 (< 24 hrs) 1 (> 24 hrs)	3	2	3	5 + 3 (< 24 hrs) 1 (> 24 hrs)	
Site 25			3	1	3	6 + 1 (> 24 hrs)	
Site 26		1 (< 24 hrs)		1 (> 24 hrs)	6	6	
Site 27					1	3	
Site 28						1	
Site 29						2	1
TOTAL (Repeated Locations)	1	10 (< 24 hrs) + 5 (> 24 hrs)	9	4 + 1 (> 24 hrs)	53 ^[1] + 5 (> 24 hrs)	59 ^[1] + 3 (< 24 hrs) + 6 (> 24 hrs)	4 + 4 (> 24 hrs)

^[1] Comparatively higher number of repeated tests largely associated with penetration tests due to repeated testing required because of premature test failure (test refusal) with initial test.

6.6 Site observations relating to potential sources of variation in earthworks quality

Assuming consistent compaction efforts have been applied to a specific area/lot during the preparation for, say, a 300 mm thick compacted layer, all sections of the same lot may not exhibit the similar compaction/quality level. (See Figure 6-2). The following sub-sections of the report provide illustrated examples of potential causes of variation in the embankment earthwork quality. However, these issues may not necessarily be identified or reflected within the traditional QA (RDD) reports.

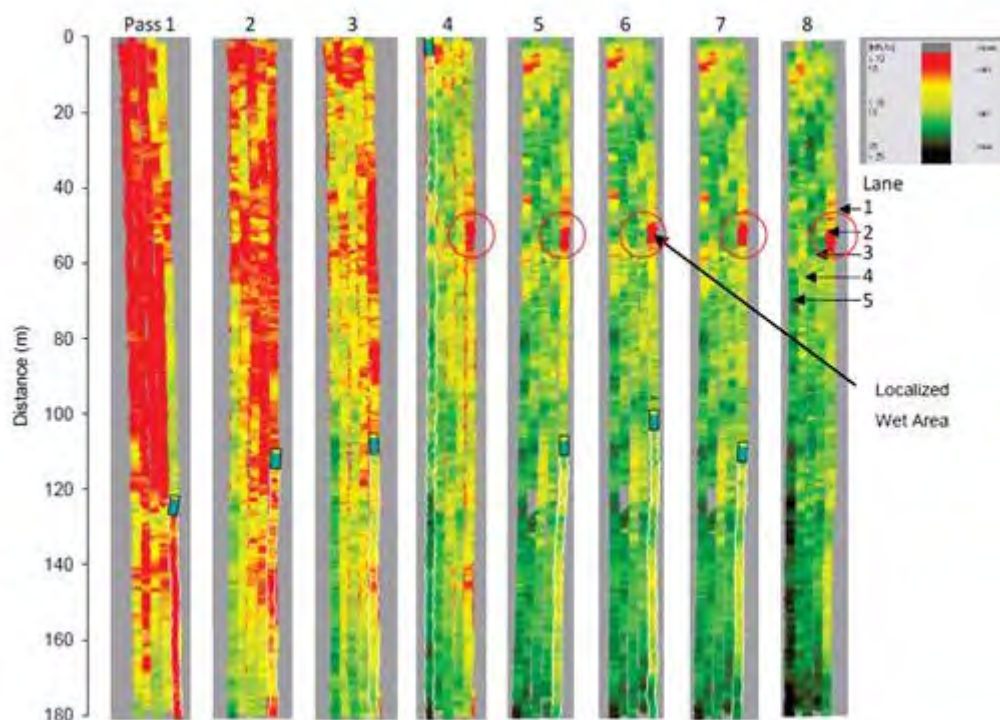


Figure 6-2 Variation of Relative Degree of Compaction after application of similar compaction effort
(source: txdot.gov)



6.6.1 Variation in Material Moisture Content

Spot check utilising NDG testing may not be able to effectively identify the soft spots such as wet / comparatively high moisture content zone that cannot be compacted to the similar level as the remainder of a lot. Figure 6-3 illustrates a testing area selected for NDG testing surrounded by materials exhibiting a relatively higher moisture content at the exposed surface.



Figure 6-3 Localised wet area and Testing Area

6.6.2 Presence of Surficial Cracks

The presence of surficial cracks is frequently indicative of the application of excessive compaction effort, regions that have been previously overloaded or locations where inappropriate compaction techniques have been implemented. Examples of such surficial cracking is presented in Figure 6-4, and is often a sign that the compacted area would underperform (e.g. create preferential locations for permanent deformation to occur) under subsequent, repeated wheel loading.



Figure 6-4 Surface cracks

6.6.3 Quality of Material

Material with significantly different grading profiles or 'fines' contents would be expected to perform differently under the application of a similar compaction effort. This includes differing levels of material breakdown within a limited area or achieved compaction, which in turn results in localised regions that potentially exhibit different levels of reactivity or bearing capacity (e.g. 'hard' or 'soft' spots, that can reflect into overlying layers / pavements). Figure 6-5 demonstrates locations where, within a single layer of compacted Fill within the trial embankment, significant variations in material grading was observed (within areas subjected to QA testing).



(a)



(b)

Figure 6-5 Variation of the material subjected to QA testing, (a) presence of relatively large number of gravel, cobble and boulder (b) presence of relatively higher fine content

6.6.4 Sampling for laboratory testing

In order to obtain an accurate Dry Density Ratio (RDD) outcome based on NDG site assessment, appropriate sampling techniques must be followed and a sufficient (representative) quantity of material should be taken to obtain both (i) reliable moisture content and (ii) maximum wet density results. Sufficient material should be taken when sampling at each test sub-site to facilitate all required testing to be completed.

The failure to take the representative sample properly during the completion of the fieldwork component of the typically QA specified testing can lead to very erroneous results being reported, and thus (incorrectly) considered representative of the materials and adopted for QA purposes. Examples of observed poor practices regarding the representative sampling of individual sub-sites across the trial embankment included:

- Excavations not vertically sided (refer Figure 6-6(a))
- Excavation is not advanced to the depth that the NDG source rod was placed (refer Figure 6-6(b))
- Large rock particles discarded from sample, upsetting the oversize correction process for subsequently calculated density and moisture ratios (refer Figure 6-6(a), (c) & (d))



(a)



(b)



(c)



(d)

Figure 6-6 Commonly observed poor practices regarding sampling (a) Excavations not vertically sided; (b) Shallow excavation, (c) & (d) Discarding large (~300 mm Dia.) samples present within compacted Fill

6.7 Summary – Site Practices

Key observations which are regularly occurring at most construction sites have been documented. These include

1. Soil testers leaving large size material behind. Gradations may not reflect all materials on site
2. Soil compaction does change the grading curve. However, the percentage fines pre and post compaction does not seem to change
3. There is a notable difference in material if surface material or is sampled from a vertical trench. "Crushed" material are more predominant for surface sampling
4. Conditions do change from the time of sampling. This change includes both wetting and drying. The field density test does not capture such changes due to the time lag. A passing density test does not mean a suitable layer for placement of additional lifts.



7. Summary of Test Results

This chapter summarises the results of each test technique completed within the Trial Embankment site during the completion of the Phase 3 fieldwork. Full factual test certificates, suitable for incorporation into the documentation associated with a QA test regime, were individually produced for each test result and are attached within the nominated appendices of this report.

Details of the standard method adopted for each test technique (fieldwork component and, where applicable, interpretation of results), along with a short summary of the test results and an assessment of the repeatability of the test are included within this chapter.

7.1 Density Testing – Nuclear Density Gauge

7.1.1 Standardised Methodology of NDG Test

All density testing completed upon the trial embankment site was undertaken *insitu* utilising a calibrated Nuclear Density Gauge (NDG), and undertaken by trained operators (external provider to FSG Foundations + Geotechnics). The material's *insitu* wet density was measured via the direct transmission method, in accordance with the standardised test procedure as detailed within the applicable standards:

- *Australian Standard AS1259.5.8.1 (2007)* – Methods of testing soils for engineering purposes, Method 5.8.1: Soil compaction and density tests – Determination of field density and field moisture content of a soil using a nuclear surface moisture – Density gauge – Direct transmission mode

Subsequent laboratory work to determine the relevant ratio between the Field Density and Field Moisture Content (FMC) and Maximum Dry Density and Optimum Moisture Content were undertaken by a NATA registered laboratory, utilising the standardised test procedures as detailed within the following Australian Standards:

- *AS 1259.2.1.1 (2005)* – Methods of testing soils for engineering purposes Method 2.1.1: Soil moisture content tests – Determination of the moisture content of a soil – Oven drying method (standard method)
- *AS 1259.5.1.1 (2017)* – Methods of testing soils for engineering purposes, Method 5.1.1: Soil compaction and density tests – Determination of the dry density / moisture content relation of a soil using standard compactive effort
- *AS 1259.5.4.1 (2017)* – Methods of testing soils for engineering purposes, Method 5.4.1: Soil compaction and density tests – Compaction control test – Dry density ratio, moisture variation and moisture ratio
- *AS 1259.5.4.2 (2017)* – Methods of testing soils for engineering purposes Method 5.4.2: Soil compaction and density tests – Compaction control test – Assignment of maximum dry density and optimum moisture content values

As identified in Section 6.4, the QA (NDG and Moisture Ratio) regime adopted for the project utilised reference (assigned) OMC and MDD values for the assessment of RDD and Moisture Ratio (MR) values, rather than applying individual sub-site assessment to recovered bulk samples (i.e. not a 1:1 ratio).

For all test results where alternative QA data was recovered, all *insitu* NDG testing was completed such that the nuclear source was placed at a constant 275 mm depth of the instrument. Thus, all test results should be considered a composite value over such a depth interval (depth from the trafficable surface at the time of testing). The 275 mm probe depth was selected to ensure the NDG probe did not penetrate through more than the upper compacted layer of the earthworks (i.e. density assessment was limited to the newest layer of compacted Fill, and should not be affected by underlying materials).

7.1.2 Standardised Results & Interpretation

Resulting from the *insitu* and laboratory assessment of the material associated with the NDG testing, the following material qualities have been reported (by others) and utilised as the basis for comparison and correlation of the results of other *insitu* test methods:

- Field Dry Density (FDD)
- Maximum Dry Density (MDD) – Adjusted for oversize component reported onsite
- Relative Dry Density (%) = Field Dry Density / Adjusted Max. Dry Bulk Density (MDD)
- Field Moisture Content (FMC, %)
- Moisture Ratio (MR, %) = Field Moisture Content / Optimum Moisture Content (OMC)

No specific additional interpretation of the results of the density and associated laboratory testing was required to process the test results into a standardised dataset.

All test certificates received for the specified QA regime – a dataset of 132 no. Density and Moisture Content details – relied upon for the comparison of alternative QA test methods are included in Appendix B of this report.

7.1.3 Summary of Test Results

Density (NDG) test results were completed at all Sites considered by Phase 3 of the ARRB project, with a total of 132 no. NDG test results being reported. Within each site, a total of four (4) to six (6) NDG tests were completed. This represents NDG testing undertaken at approximately 71% of the total individual sub-sites assessed during this phase of testing – and is analogous to the percentage of test sub-sites that were part of the project's specific QA regime, and those that were undertaken as additional test sites with only alternative QA methods employed (29%, or 52 sub-sites).

Table 7-1 presents a summary of the RDD values determined for each site, demonstrating the typically close grouping of results (average CoV within a Site = 1.8%).

Table 7-1 Summary of Relative Compaction / Relative Dry Density (RDD) Results – Nuclear Density Gauge

Site ID	Results of Density (NDG) Testing – Relative Compaction (RDD, %)					
	No. of Tests	Minimum	Median	Average	Maximum	Co-efficient of Variation (CoV)
Site 7	4	97.7 %	98.4 %	99.1 %	101.8 %	1.9 %
Site 8	4	96.4 %	98.7 %	99.2 %	103.1 %	2.8 %
Site 9	4	98.2 %	99.5 %	99.4 %	100.5 %	1.2 %
Site 10	4	100.0 %	100.7 %	100.9 %	102.2 %	1.0 %
Site 11	4	98.2 %	99.8 %	100.4 %	103.7 %	2.4 %
Site 12	4	98.2 %	100.4 %	100.3 %	102.3 %	1.7 %
Site 13	4	102.2 %	103.2 %	103.1 %	103.6 %	0.6 %
Site 14	4	101.4 %	102.3 %	102.5 %	104.1 %	1.3 %
Site 15	4	95.0 %	100.9 %	100.1 %	103.6 %	3.7 %
Site 16	4	96.1 %	98.1 %	98.5 %	101.9 %	2.9 %
Site 17	4	100.9 %	101.4 %	101.5 %	102.3 %	0.6 %
Site 18	4	96.4 %	98.2 %	98.1 %	99.5 %	1.4 %
Site 19	4	98.2 %	98.6 %	98.9 %	100.0 %	0.9 %
Site 21	4	97.7 %	99.5 %	99.8 %	102.3 %	1.9 %
Site 22	4	98.7 %	100.2 %	100.4 %	102.3 %	1.5 %
Site 23	5	97.7 %	100.7 %	100.2 %	101.8 %	1.8 %
Site 24	6	98.6 %	100.5 %	100.6 %	102.7 %	1.5 %
Site 25	5	96.9 %	98.6 %	99.3 %	102.7 %	2.5 %
Site 26	5	97.7 %	99.1 %	99.6 %	103.2 %	2.1 %
Site 27	5	97.3 %	100.0 %	99.5 %	101.4 %	1.7 %
Site 28	5	97.7 %	99.1 %	99.3 %	100.9 %	1.4 %
Site 29	5	95.5 %	101.8 %	100.0 %	102.8 %	3.5 %
Site 30	4	95.9 %	96.9 %	97.3 %	98.6 %	1.1 %
Site 31	4	99.5 %	100.9 %	101.3 %	103.7 %	1.9 %

Site ID	Results of Density (NDG) Testing – Relative Compaction (RDD, %)					
	No. of Tests	Minimum	Median	Average	Maximum	Co-efficient of Variation (CoV)
Site 32	4	99.1 %	99.5 %	99.7 %	100.5 %	0.7 %
Site 33	4	97.2 %	99.5 %	99.8 %	102.7 %	2.4 %
Site 34	4	97.3 %	99.8 %	99.8 %	102.3 %	2.2 %
Site 35	4	96.3 %	98.6 %	98.9 %	101.9 %	2.6 %
Site 36	4	97.7 %	100.0 %	99.6 %	100.9 %	1.6 %
Site 37	4	96.4 %	99.3 %	98.9 %	100.5 %	1.8 %
Site 38	4	95.0 %	97.7 %	97.3 %	98.6 %	1.6 %
Full Dataset	132	95.0 %	100.0 %	99.7 %	104.1 %	2.1 %

7.1.4 Repeatability of Test

No duplicate NDG tests were completed within a single ‘sub-site’ throughout the ARRB monitored phase of the Trial Embankment’s construction. Accordingly, the repeatability of the NDG test result has not been determined in the same manner as the other test results completed.

Australian Standard AS1289.5.1.1 (2017) provides some guidance on the expected (acceptable) “precision” of the test, indicating that the MDD parameter could typically be expected to vary by +/- 4% about a mean value. Thus, for a field dry density value that reported a result of 95% RDD of a the average MDD value calculated for this project (MDD = 2.20 t/m³), the reported ‘acceptable’ range of RDD would be come 91.3 % to 99.0 %.

7.2 Insitu Modulus Assessment – Static Plate Load Tests (PLTs)

7.2.1 Standardised Methodology of PLT Test

A total of 12 no. PLTs were undertaken across six (6) ‘Sites’ considered for the Phase 3 project fieldwork (Sites 21 to Site 26). Within each PLT, two (2) load cycles were completed such that an initial and reloading load vs. deformation response could be recorded. All tests were completed using a provided external load force (roller), with a minimum final pressure (test stress) of 500 kPa applied during each load cycle of each test (uncorrected test stress). Figure 7-1 presents an example of the PLT set-up adopted on the project.



Figure 7-1 Pictures of the equipment arrangement typically adopted onsite for PLTs setup (note the presence of the independent reference beam for measurement of observed settlements and jacking against external reaction force)

All PLTs undertaken during this study utilised a 300 mm diameter, circular rigid plate and plate deflections were measured by a single, centrally placed digital Linear Variable Differential Transformer, LVDT, providing displacement resolution of 0.01 mm. All load cycles included a minimum of 7 load steps, with the test completed in general accordance with the procedure detailed in the relevant German Standard (DIN 18134):

- DIN 18134 – Soil – Testing Procedures and testing equipment – Plate Load Test, English translation of DIN 18134:2012-04

After the initial levelling of each test site, bedding sand (<10 mm thick) was utilised to ensure full contact between the rigid plate and trafficable surface undergoing testing.

7.2.2 Standardised Results & Interpretation

The 'zone of influence' (i.e. the depth to which the PLT measures) is typically accepted as twice the rigid plate diameter (2D). Accordingly, for all test results of the PLTs undertaken for this study, it is expected that the resultant *insitu* modulus parameter reflects the composite *insitu* material condition over the initial 600 mm depth interval.

The interpretation of *insitu* modulus parameter as determined by the PLT has been undertaken via the application of a standardised methodology. This interpretation procedure has resulted in the *insitu* modulus parameter being able to be determined at a number of standardised test pressures. For consistency across the Phase 3 project, a Poisson's ratio of 0.35 was adopted during the interpretation of all modulus parameters.

The processing of the individual load vs. deflection datapoints was initially completed adopting the typical interpretation of unreplicative plate loading (uPLT) as follows (completed for each load cycle of each test):

- (i) Test Stress (kPa) vs. observed deflection (mm) plotted
- (ii) Intervals of test stress where linear stress vs. deflection relationship was observed were isolated – these intervals represent regions of linear-elastic deformation, and are test pressure intervals where consistent coefficient of subgrade reaction (k_s) parameter are applicable.
- (iii) Determination of the standardised subgrade reaction modulus, K_{30} , defined as the ratio between the imparted test stress required to produce a deformation of 1.25 mm under the 300 mm diameter plate and such a deformation (i.e. $K_{30} = \sigma / \delta$, at the point where $\delta = 1.25$ mm)
- (iv) Secant Elastic modulus (E_s) calculated for the upper test stress magnitude within each identified linear load vs. deformation interval via application of Boussinesq (elastic) theory – Note this calculation has adopted a consistent Poisson's ratio of 0.35 (which has also been adopted for all other modulus parameter calculations, where required by other test techniques).
- (v) *Insitu*, composite secant Elastic modulus (E_s) parameters determined for standardised test pressures of 100, 200, 300, 400 and 500 kPa.
- (vi) *Insitu* secant modulus determined based on full range of test pressure applied within the load cycle – the calculation of this parameter adopts the full dataset applicable to the load cycle (excluding seating).

The process adopted in steps (i) to (vi) is shown in a series of conceptual sketches in Figure 7-2. This shows

- (a) Initial plotting of load vs. deformation data;
- (b) identification of phases of linear behaviour (including fitting of best fit linear relationship);
- (c) determination of standardised k_{30} parameter (1.25 mm plate displacement);
- (d) determination of Secant Modulus (E_s) for each identified linear phase; and
- (e) determination of secant modulus inputs (load & deformation) for standardised test stresses for 100 – 500 kPa (data for initial loading cycle of Site 24-1 utilised for figure)

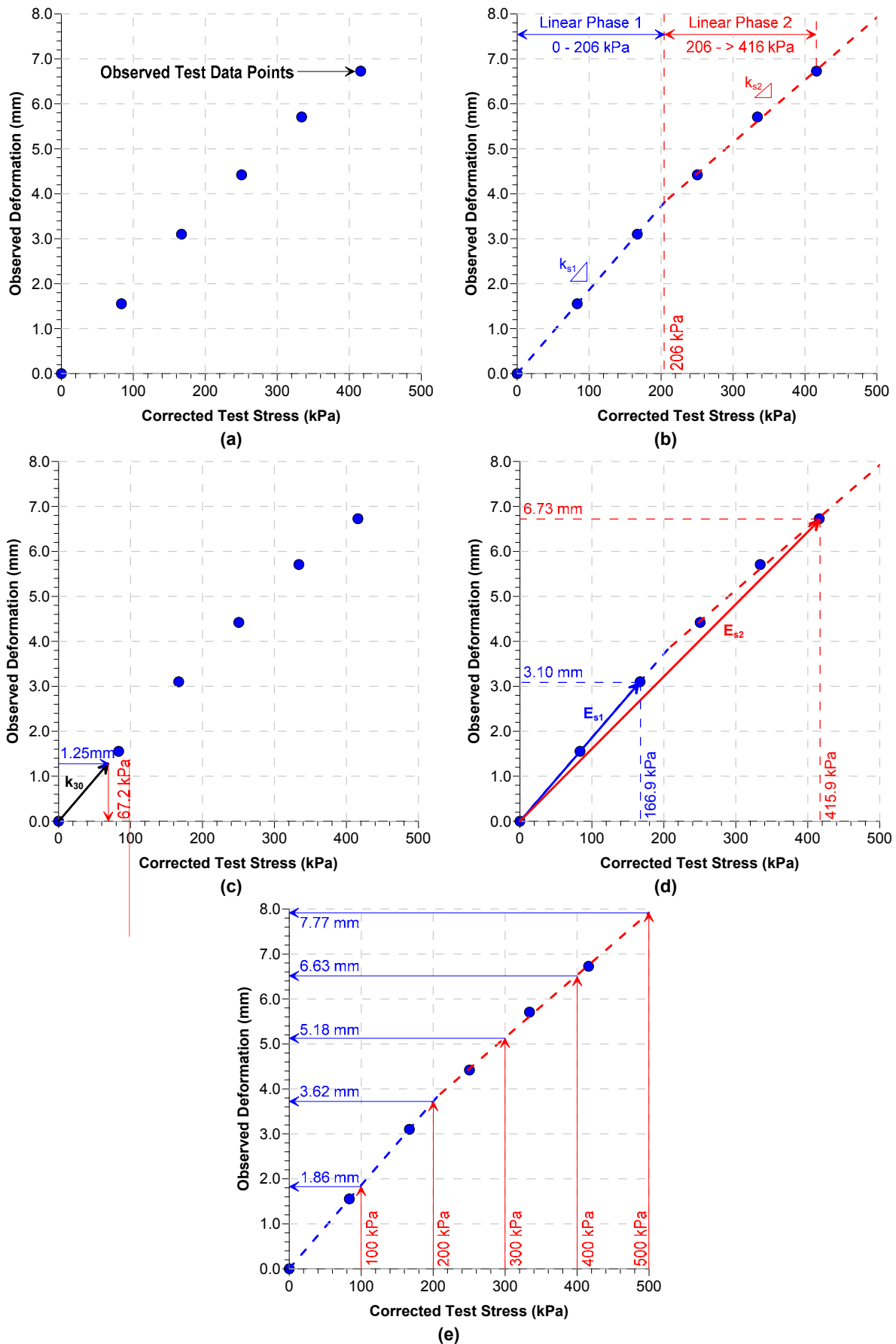


Figure 7-2 Conceptual sketches demonstrating the standardised method for interpretation of the PLT test results via uPLT methodology

The processing of the PLT load vs. deformation data has also been completed via a secondary method, as per the typical procedure applied to the repetitive plate load test (rPLT) methodology, such that standardised strain modulus (E_v) parameters could be determined. This was completed as per the methodology included in *DIN 18134:2012-04* whereby, for each load cycle:

- (vii) A 2nd order polynomial curve fitted to the datapoints of the load cycle – where points of inflection were observed to exist within the load vs. deformation curves, polynomials were fitted to multiple isolated segments of the dataset
- (viii) The *insitu* strain modulus (E_v) parameter was calculated via the use of Equation 7-1:

$$E_v = [(1.5 \times r) / (a_1 + a_2 \times \sigma_{0\max})] \quad (\text{Equation 7-1})$$

Where:

E_v = Strain modulus (composite of material within zone of influence) for a single load cycle

r = Radius of plate

a_1, a_2 = the constant of the second-degree polynomial fitted to the stress / deformation data for the load cycle being considered

$\sigma_{0\max}$ = maximum average normal stress applied to loading plate

- (ix) The *insitu* strain modulus (E_v) parameter was calculated at each 100 kPa test pressure increment (i.e. 100, 200, 300, 400 and 500 kPa) adopting the 2nd order polynomials fitted to each individual segment and the full cycle dataset.

The process adopted in steps (vii) to (ix) is shown in a series of conceptual sketches in Figure 7-3.

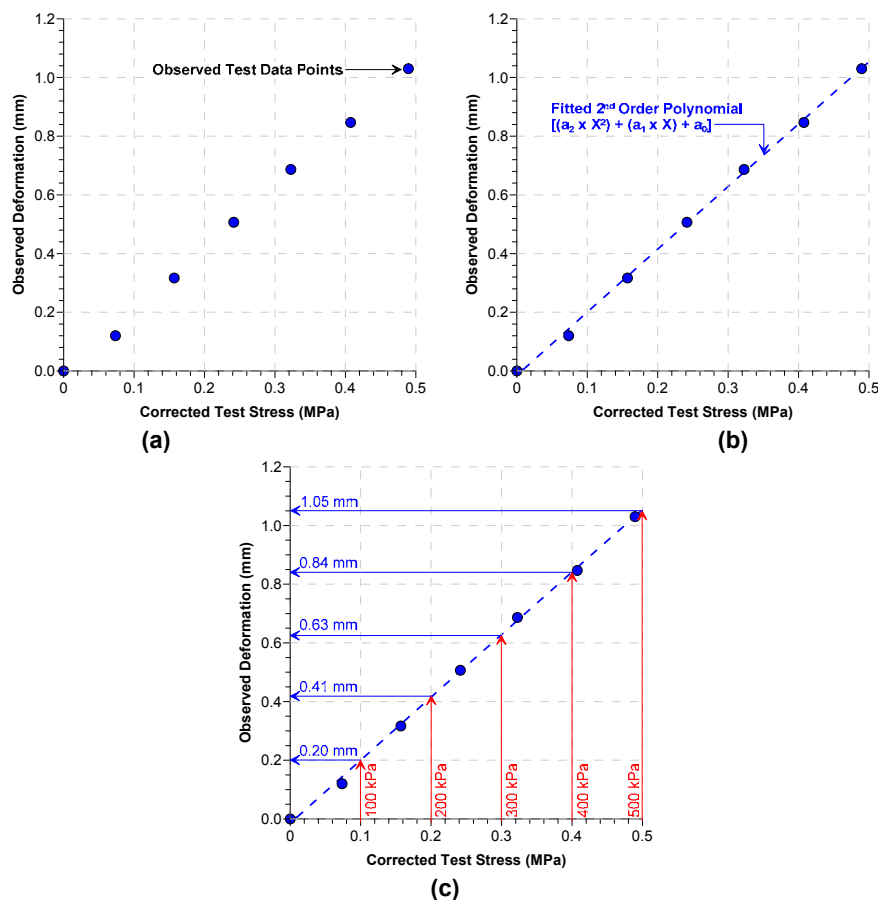


Figure 7-3 Conceptual sketches demonstrating the standardised method for interpretation of the PLT test results via rPLT methodology – (a) Initial plotting of load vs. deformation data; (b) fitting of 2nd order polynomial to observed data-points; and (c) determination of strain modulus (E_v) inputs (load & deformation) for standardised test stresses for 100 – 500 kPa (data for reloading loading cycle of Site 26-3 utilised for figure)

7.2.3 Summary of Tests and Results – PLT

Only 12 no. PLTs were completed due to the significant time taken to complete each PLT – with an average of two (2) tests completed during each day of fieldwork – and the limited availability of access to each test site. One (1) to three (3) PLT tests were completed at ‘sub-sites’ within each of the six (6) Sites submitted to PLT assessment. This represents approximately 6% of the total individual sub-sites assessed during this phase of testing, and represents approximately a PLT undertaken for every 16 sub-sites assessed during the entire Phase 3 fieldwork campaign.

As detailed in Section 7.2.2, the following standardised parameters were derived via a standard method of interpretation and utilised as the basis for comparison and correlation of the PLT results with the results of the other *insitu* test methods:

- Subgrade Reaction Modulus (k_{30}) in MN/m^3 – for both initial and reloading cycles of PLT
- Secant Elastic Modulus (E_s) at the standardised test stresses of 100, 200, 300, 400 & 500 kPa – determined for both the initial (E_{s1}) and reloading cycles (E_{s2}) of PLT
- Strain Elastic Modulus (E_v) at the standardised test stresses of 100, 200, 300, 400 & 500 kPa – determined for both the initial (E_{v1}) and reloading cycles (E_{v2}) of PLT

All test certificates produced for the PLT tests – detailing the individual load / deformation data points and all subsequently determined, standardised modulus parameters – completed during this study are included as Error! Reference source not found. **of this report.**

Subgrade Reaction Modulus, k_{30} & Secant Modulus, E_s

Table 7-2 summarises the results of the modulus derived from the PLT load / deformation data pairs, as interpreted by adoption via the uPLT method. This interpretation includes the interpreted secant modulus and subgrade reaction modulus parameters derived for each identified interval of linear load / deformation response within each load cycle. Table 7-2 also presents the interpreted standardised subgrade reaction modulus parameter (K_{30}).

Table 7-2 Summary of PLT test results – subgrade reaction modulus (k_{30}) and Secant Elastic Modulus (E_s), as interpreted adopting Boussineq theory

Test Location ID	Initial Loading Cycle				Reloading Cycle			
	Normalised Stress Range (kPa)	Linear Gradient (k_s , MN/m^3)	k_{30} (MN/m^3)	Secant Modulus (E_s , MPa)	Normalised Stress Range (kPa)	Linear Gradient (k_s , MN/m^3)	k_{30} (MN/m^3)	Secant Modulus (E_s , MPa)
21-1	0.0 – 462.2	256.5	261.3	53.8	0.0 – 485.5	540.2	620.5*	123.4
21-3	0.0 – 225.5	113.4	111.9	23.4	0.0 – 489.5	355.5	354.4	73.5
	225.5 – 462.2	179.1		29.2				
22-1	0.0 – 425.0	222.4	201.1	44.2	0.0 – 489.5	436.3	506.5*	104.3
22-1A	0.0 – 415.9	199.6	190.7	41.3	0.0 – 489.5*	414.8	408.4*	85.8
23-2	0.0 – 425.0	175.6	178.8	36.3	0.0 – 407.5	1,880.5	1,241.2*	388.8
					407.5 – 489.5**	328.2**	N/A	216.9**
24-1	0.0 – 206.2	53.9	53.7	11.1	0.0 – 489.5*	160.5*	167.8	33.2*
	206.2 – 415.9	71.8		12.8				
24-2	0.0 – 415.9	284.9	273.7	51.2	0.0 – 489.5*	779.9*	656.2*	123.4*
24-5	0.0 – 183.5	58.2	54.3	12.0	0.0 – 489.5*	229.1*	207.4	47.4*
	183.5 – 415.9	96.8		15.4				
25-2	0.0 – 415.9	229.4	227.3	47.4	0.0 – 489.5*	535.9*	529.7*	110.8*
25-3	0.0 – 206.9	89.8	88.8	18.6	0.0 – 489.5*	258.5*	258.0	53.5*
	206.9 – 415.9	118.5		21.1				
26-2	0.0 – 192.4	50.8	52.2	10.5	0.0 – 489.5*	245.2*	238.7	50.7*
	192.4 – 415.9	86.8		13.5				
26-3	0.0 – 226.9	189.0	193.8	39.1	0.0 – 489.5*	475.2*	470.4*	98.3*
	226.9 – 415.9	265.5		44.9				

* Extrapolated K_{30} parameter – assumes continuation of linear relationship (i.e. required settlement magnitude not observed during test completion).

* Final load step of re-loading cycle represented virgin loading – inspection of the load vs. deformation identifies all loading represents linear response and thus final load step is included in determination of secant modulus parameters.

** Final load step of re-loading cycle represents virgin loading - inspection of the load vs. deformation identifies final load step in non-linear, and not included in determination of secant modulus parameters.

Table 7-3 presents the standardised secant modulus (E_s) parameters derived by this method under standardised test pressure magnitudes – 100, 200, 300, 400 and 500 kPa – and demonstrates the stress dependency of the derived modulus parameter for each site tested.

Table 7-3 Summary of PLT test results – Secant Elastic modulus (E_s) calculated to standardised test pressures

Test Location ID	Initial Loading Cycle (E_{s1} , MPa)					Reloading Cycle (E_{s2} , MPa)				
	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
21-1	55.8	55.7	53.7	54.4	53.5*	203.2	143.2	129.2	121.3	123.7*
21-3	21.9	23.4	25.7	28.2	29.7*	69.8	70.3	72.9	73.0	73.6*
22-1	39.2	41.4	42.8	44.1	44.4*	251.8	129.9	113.4	104.5	104.4*
22-1A	40.7	41.1	40.0	41.2	41.8*	77.2	85.1	89.5	92.7	85.1*
23-2	44.1	37.8	36.4	36.4	36.1*	540.1	484.3	474.5	393.9	344.3*
24-1	11.1	11.4	12.0*	12.7*	13.3**	38.3	34.8	34.2	34.3	33.1*
24-2	55.6	57.7	57.5	58.5	60.8*	62.9	85.4	102.6	117.2	124.0*
24-5	11.5	12.7	14.1	15.2*	16.2**	44.9	41.7	44.2	47.0	47.4*
25-2	47.2	47.6	47.0	47.4	47.7*	105.9	108.0	109.8	111.7	110.7*
25-3	18.3	19.0	20.0	21.0	21.8*	59.5	54.5	53.4	54.6	53.3*
26-2	10.7	11.0	12.2*	13.4*	14.2**	53.7	47.8	49.4	51.5	50.6*
26-3	37.3	39.6	41.8	44.6	46.6*	113.4	100.0	97.4	99.3	98.1*

* Extrapolated E_s parameter, assuming continuation of linear relationship (required pressure / settlement beyond the observed range).

* E_s parameter based on observed data, but test result continued beyond a measured settlement magnitude of 5.0 mm

Strain Modulus, E_v

Table 7-4 provides details of the 2nd order polynomial fitted to the each of the full load cycle datapoints and provides the correlation co-efficient (R^2) reflecting the fitted quadratic and field record. In all cases, the fitted 2nd order polynomial demonstrates an excellent fit with the field data ($R^2 \geq 0.98$). Table 7-5 summarises the strain modulus (E_v) parameters associated with both the initial (E_{v1}) and reloading (E_{v2}), as derived by the interpretation method detailed in *DIN 18134:2012-04*, and calculated under the various standardised test pressure magnitudes – 100, 200, 300, 400 and 500 kPa. Note that the adopted standardised test method uses a test stress of 500 kPa as the standardised maximum stress magnitude at which E_v parameters are typically reported.

Table 7-4 Summary of PLT test results – Details of fitted 2nd order polynomial to load / deflection datasets (for calculation of strain modulus parameters, E_v)

Test Location ID	Initial Loading Cycle					Reloading Cycle				
	Normalised Stress Range (kPa)	Details of Fitted Quadratic				Normalised Stress Range (kPa)	Details of Fitted Quadratic			
		α_0	α_1	α_2	R^2		α_0	α_1	α_2	R^2
21-1	0 – 462.2	-0.004	3.713	0.305	> 0.99	0 – 489.5	-0.024	1.400	0.747	> 0.99
21-3	46.3 – 462.2	0.111	9.153	-5.080	> 0.99	0 – 489.5	0.003	2.946	-0.300	> 0.99
22-1	9.1 – 425.0	0.069	4.747	-0.540	> 0.99	0 – 489.5	-0.161	2.459	-0.275	> 0.99
22-1A	0 – 415.9	-0.007	5.287	-0.575	> 0.99	0 – 489.5	0.020	2.220	0.187	> 0.99
23-2	0 – 425.0	0.002	5.127	1.428	> 0.99	0 – 407.4	0.003	0.265	0.621	> 0.99
24-1	0 – 415.9	-0.022	20.123	-9.225	> 0.99	0 – 489.5	0.008	4.714	4.834	0.99
24-2	0 – 415.9	0.002	3.678	-0.344	> 0.99	0 – 489.5	0.047	2.642	-2.303	0.99
24-5	0 – 415.9	0.028	18.962	-13.691	> 0.99	0 – 489.5	-0.020	5.307	-1.904	> 0.99
25-2	0 – 415.9	-0.001	4.370	0.005	> 0.99	0 – 489.5	0.003	1.953	-0.229	> 0.99

Test Location ID	Initial Loading Cycle					Reloading Cycle				
	Normalised Stress Range (kPa)	Details of Fitted Quadratic				Normalised Stress Range (kPa)	Details of Fitted Quadratic			
		α_0	α_1	α_2	R^2		α_0	α_1	α_2	R^2
25-3	0 – 415.9	-0.003	11.989	-5.298	> 0.99	0 – 489.5	-0.017	3.831	0.110	> 0.99
26-2	0 – 415.9	-0.027	21.947	-15.947	> 0.99	0 – 489.5	-0.022	4.488	-0.811	> 0.99
26-3	0 – 415.9	-0.002	5.878	-3.066	> 0.99	0 – 489.5	-0.015	2.158	-0.040	> 0.99

Table 7-5 Summary of PLT test results – Strain Elastic modulus (E_v) calculated to standardised test pressures

Test Location ID	Initial Loading Cycle (E_{v1} , MPa)					Reloading Cycle (E_{v2} , MPa)				
	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
21-1	60.1	59.6	59.1	58.7	58.2*	152.6	145.2	138.5	132.4	126.9*
21-3	26.0	27.7	29.5	31.6	34.0*	77.2	78.0	78.8	79.6	80.5*
22-1	47.9	48.5	49.1	49.7	50.3*	92.5	93.6	94.7	95.8	96.9*
22-1A	43.0	43.5	44.0	44.5	45.0*	100.5	99.7	98.8	98.0	97.2*
23-2	42.7	41.6	40.5	39.5	38.5*	688.4	578.4	498.8	438.4	391.0*
24-1	11.7	12.3	13.0*	13.7*	14.5**	43.3	39.6	36.5	33.8	31.6*
24-2	61.8	62.3	62.9	63.6	64.2*	93.3	103.1	115.3	130.7	150.9*
24-5	12.8	13.9	15.1	16.7*	18.6**	44.0	45.7	47.5	49.5	51.7*
25-2	51.5	51.5	51.5	51.5	51.5*	116.6	118.0	119.4	120.9	122.4*
25-3	19.6	20.6	21.6	22.8	24.1*	58.6	58.4	58.2	58.1	57.9*
26-2	11.1	12.0	13.1*	14.5*	16.1**	51.1	52.0	53.0	54.0	55.1*
26-3	40.4	42.7	45.4	48.4	51.8*	104.5	104.7	104.9	105.1	105.3*

* Extrapolated E_v parameter, assuming continuation of linear relationship (required pressure / settlement beyond the observed range).

† E_v parameter based on observed data, but test result continued beyond a measured settlement magnitude of 5.0 mm

7.3 Insitu Modulus Assessment – Light Falling weight Deflectometer (LWD) – Prima 100 (Sweco)

7.3.1 Standardised Methodology of LWD Test

One (1) of the two (2) LWD's utilised as 'alternative QA' tools for the Phase 3 fieldwork was the Sweco (formerly Grontmij and Carl Bro) manufactured and calibrated 'Prima 100' model. This model of LWD is fitted with a load cell, such that an individual weight drop produces a time fitted record of imparted load and (via the associated geophones) magnitude of ground deflection.

The Prima 100 LWD testing completed during the Phase 3 fieldwork was undertaken primarily with a 300 mm diameter plate fitted, and used only the standard 10 kg drop weight. Only a single, geophone – in direct contact with the prepared surface through the central annulus of the plate – was utilised to record the surface deflection magnitude arising from the imparted test stress. A single test was completed with the repeated weight drops – minimum of six (6) – from four (4) distinct heights, with the height drops completed sequentially in ascending order. This, a single test includes the compilation of a minimum of 24 load-deflection test records over four (4) imparted test stress magnitudes. Due to the arrangement of equipment adopted, the typical range of test stresses over which data was recorded was between 40 and 115 kPa.

A limited number of Prima 100 LWD tests (8 no.) – typically located within the same sub-site as selected PLTs – further extended the range of test stress applied, via employment a 100 mm diameter plate. At such locations, a maximum test stress of approximately 1,050 kPa was realised.

Figure 7-4 presents pictures of the Prima 100 LWD being used upon the prepared surface of the trial embankment.



Figure 7-4 (a) Picture of the 'Prima 100' LWD equipment typically adopted onsite, fitted with 300 mm diameter plate; and (b) minimal bedding sand and circular indentation of plate typically observed at conclusion of 'Prima 100' testing (note also limited offset between LWD and material sampling site from side-by-side density and field moisture content assessments)

All onsite testing completed using the Prima 100 LWD was undertaken by trained test operators (FSG Foundations + Geotechnics personnel), and completed in accordance with the standardised test procedure as detailed within the applicable standard:

- *ASTM E2583 – 07 (2015) – Standard Test Method for Measuring Deflections with a Light Weight Deflectometer (LWD)*

Where required, after the initial levelling of each test site, bedding sand (<10 mm thick) was utilised to ensure full contact between the LWD's base plate and the trafficable surface undergoing testing. No material sampling or additional laboratory testing was completed specifically for the LWD test program.

7.3.2 Standardised Results & Interpretation

The processing of the Prima 100 LWD test results from raw data – a paired and time matched test stress and deflection dataset for each weight drop – to a standardised *insitu* modulus parameter was initialised by the completion of a number of test record validation steps:

- *Initial data inspection* – Data was initially inspected for any data that indicated the weight had not being dropped from the full test height (i.e. records that indicated a “rebound” or weight “bounce” from the preceding test).
- *Removal of 'seating blows'* – 'Seating blows' were removed from the data set, defined as up to the first three 'weight drops' for any particular LWD configuration, if the dataset's maximum or minimum value were observed within these records.
- *Removal of data outside calibration range of equipment* – Results that indicated the test occurred outside the calibrated range of the LWD instrument. In the case of the Prima 100 LWD utilised in these studies, the equipment is rated to measure deflections between 50 and 2200 μ m.
- *Removal of Identified Outliers* – Outliers were defined as modulus values that were more than 1.5 times the interquartile range below or above the 1st and 3rd quartile values respectively, calculated after the removal of any identified 'seating blows'.
- *Data Integrity Review* – Any other records that indicated within the record a significant departure from the remaining records (e.g. extremely low deflection or extremely high imparted load) were also reviewed on an individual basis, and evaluated for inclusion of the subsequent calculation of the E_{LWD} value.

After the identification and removal of the non-conforming individual Prima 100 LWD records, the individual test stress and deflection records applicable to each “weight drop height” (test stress) were

then averaged to produce a single data pair (four (4) no. per LWD test). At this time the CoV was also calculated for each filtered dataset

Although the relevant ASTM standard details the procedure to complete the field component of the Prima 100 LWD testing, there is no standard approach to interpret the final *insitu* modulus parameter (E_{LWD}), which will vary with plate size and the magnitude of the imparted test pressure (drop height) due to stress and strain dependency. Fleming et. al. (2002, 2007) has previously identified that the calculated E_{LWD} value is largely meaningless unless also reported with the pressure at which was determined, and stated the need for the LWD derived modulus to be reported with both the plate diameter and test stress applied. Following the procedure fully detailed by Lacey (2016), and as illustrated conceptually in Figure 7-5, the Prima 100 LWD results for the Phase 3 testing were processed such that the standardised LWD modulus parameters were derived – with E_{FWD} parameters derived for each test both at $\sigma = 50$ kPa and $\sigma = 100$ kPa test states via Equation 7-2. For this report, these parameters have been denoted E_{LWD-50} and $E_{LWD-100}$ respectively. This processing of the Prima 100 LWD data facilitates direct E_{LWD} parameter comparison between test sites and sub-sites.

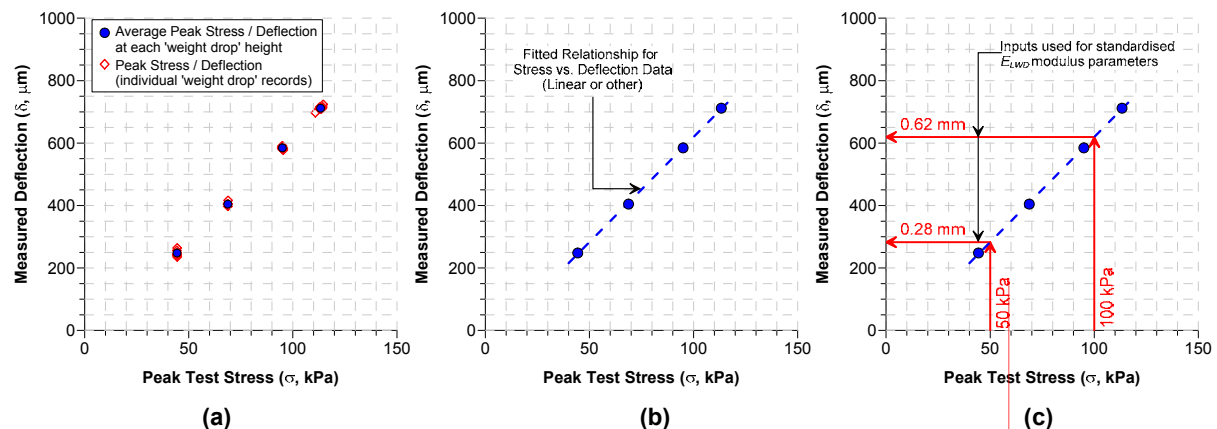


Figure 7-5 Process of LWD interpretation, showing major steps taken to determine standardised input values for derivation of standardised *insitu* modulus parameters (at 50 kPa and 100 kPa test stresses)

Insitu modulus values arising from the Prima 100 LWD were determined using the classic static elastic theory (Boussinesq elastic half-space) equation, as presented in Equation 7-2:

$$E_{LWD} = [A \times P \times R \times (1 - \nu^2)] / d_0 \quad (\text{Equation 7-2})$$

Where:

A = Plate Rigidity Factor

P = Maximum Contact Pressure

R = Radius of plate

ν = Poisson's Ratio

d_0 = Peak Deflection

As per the PLT modulus parameter interpretation, and for consistency across the Phase 3 project, a Poisson's ratio of 0.35 was adopted during the derivation of all modulus parameters.

All test certificates produced for the Prima 100 LWD tests – detailing the averaged test stress / deformation data points for each weight drop height (four (4) no. per LWD test) and both of the standardised *insitu* modulus parameters (E_{LWD-50} and $E_{LWD-100}$) – completed during this study are included as Appendix D of this report.

7.3.3 Summary of Test Results

Prima 100 LWD test results were completed at Site 12 through Site 30, with a total of 150 no. Prima 100 tests being undertaken. Within each Site, a minimum of four (4) Prima 100 tests were completed at the sub-sites corresponding to the NDG testing being undertaken. A total of 80 sub-sites had both NDG and at least a single side-by-side Prima 100 LWD test being completed. In addition, at a number of Sites additional sub-sites were investigated with the Prima 100 LWD, with a total of 12 to 14 sub-sites being tested within Sites 19 through 26. After the removal of locations where multiple Prima 100

LWD tests were completed (refer Section 7.3.4), Prima 100 LWD testing was completed at approximately 72% (135 no.) of the total individual sub-sites assessed during this phase of testing.

Table 7-6 presents a summary of the *insitu* modulus parameters derived for each Site, and variation thereof. The wide range of modulus values and comparatively high COV observed within single Sites frequently arose from the testing being completed over a multiple day period (and thus different moisture contents occurring at time of LWD testing). However, as shown in Figure 7-6, the average E_{LWD} parameters arising from standardising the test stresses to both 50 and 100 kPa remains proportional for each Site (i.e. sites that report a comparatively high $E_{LWD-50kPa}$ also report a high $E_{LWD-100kPa}$).

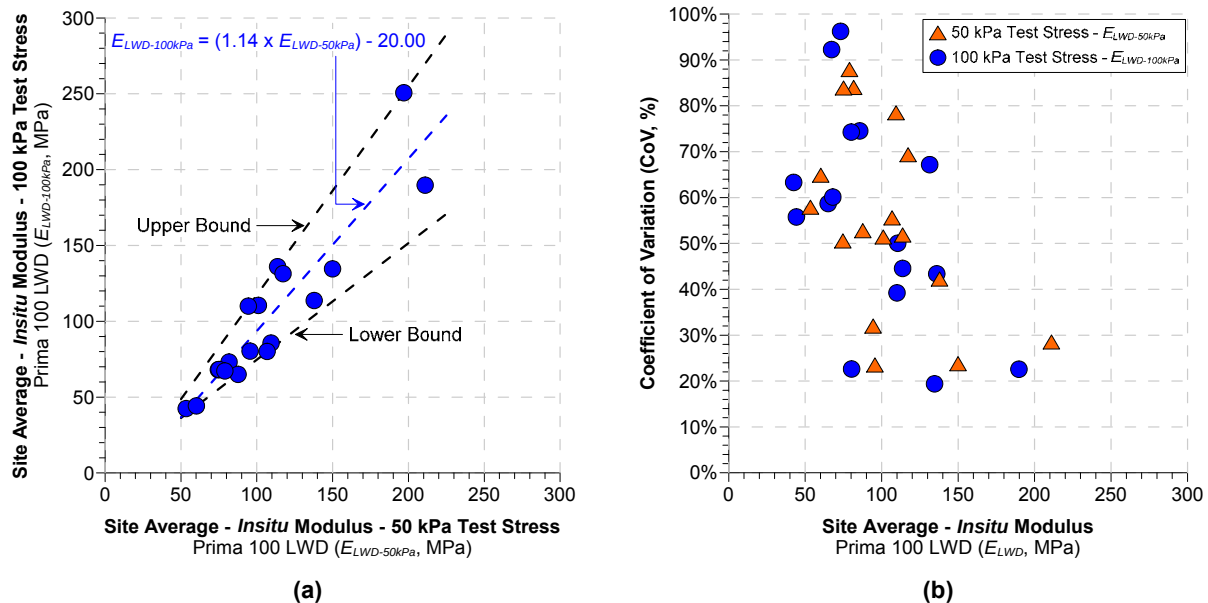


Figure 7-6 Summary of LWD derived modulus, averaged per site (a) Comparison of LWD derived modulus, based on standardised test stress (50 or 100 kPa); and (b) Coefficient of Variations (CoV) of E_{LWD} parameter



Table 7-6 Summary of *Insitu* Modulus values arising from Prima 100 LWD testing – Categorised by Test Site

Site ID	Results of Prima 100 LWD Testing – <i>Insitu</i> LWD Modulus (MPa)								
	No. of Tests	<i>Insitu</i> Prima 100 LWD Modulus at $\sigma = 50$ kPa ($E_{LWD-50kPa}$ MPa)				<i>Insitu</i> Prima 100 LWD Modulus at $\sigma = 100$ kPa ($E_{LWD-100kPa}$ MPa)			
		Range	Median	Average	Coefficient of Variation (CoV)	Range	Median	Average	Coefficient of Variation (CoV)
Site 12	4	19.2 – 146.9 MPa	82.7 MPa	82.8 MPa	81.2 %	14.4 – 156.5 MPa	60.8 MPa	73.1 MPa	96.2 %
Site 13	4	127.2 – 255.4 MPa	230.7 MPa	211.0 MPa	28.5 %	134.3 – 234.9 MPa	194.9 MPa	189.8 MPa	22.6 %
Site 14	4	20.0 – 124.8 MPa	102.9 MPa	87.7 MPa	52.8 %	14.8 – 103.9 MPa	70.7 MPa	65.0 MPa	58.7 %
Site 15	5 ³	35.3 – 119.5 MPa	57.4 MPa	74.6 MPa	50.6 %	21.4 – 117 MPa	65.4 MPa	68.1 MPa	60.1 %
Site 16	4	114.9 – 198.1 MPa	143.4 MPa	149.9 MPa	23.8 %	101.0 – 164 MPa	136.6 MPa	134.6 MPa	19.4 %
Site 17	5 ³	31.8 – 205.0 MPa	61.6 MPa	109.4 MPa	78.5 %	18.2 – 162.6 MPa	66.4 MPa	85.6 MPa	74.5 %
Site 18	4	64.3 – 115.5 MPa	101.3 MPa	95.6 MPa	23.5 %	62.1 – 104.8 MPa	77.2 MPa	80.3 MPa	22.6 %
Site 19	14 ^{1,2,3}	63.9 – 262.7 MPa	131.5 MPa	137.8 MPa	42.3 %	65.4 – 251 MPa	99.6 MPa	113.7 MPa	44.5 %
Site 21	18 ^{1,3}	23.9 – 213.1 MPa	76.6 MPa	101.1 MPa	51.4 %	18.8 – 242.9 MPa	99.5 MPa	110.5 MPa	50.0 %
Site 22	14 ³	51.7 – 232.1 MPa	86.4 MPa	113.7 MPa	51.8 %	58.7 – 189.8 MPa	92.8 MPa	110.0 MPa	39.2 %
Site 23	6	64.7 – 142.4 MPa	108.5 MPa	111.2 MPa	27.0 %	77.1 – 250.0 MPa	119.0 MPa	136.0 MPa	43.4 %
Site 24	22 ^{1,2,3}	13.8 – 248.8 MPa	58.7 MPa	75.1 MPa	83.9 %	10.5 – 261.9 MPa	38.5 MPa	68.2 MPa	102.0 %
Site 25	9 ^{1,2,3}	37.3 – 241.9 MPa	78.8 MPa	117.3 MPa	69.3 %	26.5 – 264.3 MPa	145.5 MPa	131.4 MPa	67.2 %
Site 26	11 ^{1,3}	23.7 – 214.0 MPa	89.7 MPa	106.8 MPa	55.6 %	15.9 – 186.7 MPa	72.7 MPa	80.1 MPa	74.3 %
Site 27	5	16.5 – 91.2 MPa	40.3 MPa	53.4 MPa	57.9 %	12.8 – 77.7 MPa	29.4 MPa	42.4 MPa	63.3 %
Site 28	5	30.9 – 128.4 MPa	46.4 MPa	60.2 MPa	64.9 %	25.0 – 84.4 MPa	30.9 MPa	44.2 MPa	55.8 %
Site 29	5	29.4 – 192.7 MPa	37.8 MPa	78.9 MPa	87.9 %	16.3 – 162.1 MPa	33.0 MPa	67.2 MPa	92.3 %
Site 30	2 ^{1,2}	196.9 – 196.9 MPa	196.9 MPa	196.9 MPa	N/A	230.7 – 270.7 MPa	250.7 MPa	250.7 MPa	11.3 %
Full Dataset	141^{1,2,3}	13.8 – 262.7 MPa	88.1 MPa	103.3 MPa	60.5 %	10.5 – 270.7 MPa	83.6 MPa	97.2 MPa	66.3 %

¹ After test sites removed due to results being outside calibrated range of Prima 100 LWD

² After test sites removed due to existence of statistical outliers

³ Data includes tests completed on multiple dates and / or multiple tests completed at a single sub-site

7.3.4 Repeatability of Test

During the completion of the Prima 100 LWD testing program, tests were repeated within the same Sub-Site on 15 occasions. This resulted in 15 test locations where a pair of $E_{LWD-50kPa}$ and $E_{LWD-100kPa}$ test data existed, and for site which the variation due to (i) equipment error; (ii) operator error and (iii) inherent material variability could be assessed. Both (i) and (ii) were considered to be fundamental errors associated with taking Prima 100 LWD measurements, which (iii) was considered to be site-specific and related to both the Fill material's engineering properties and the compaction process to which it had been submitted.

Of the 15 locations where the Prima 100 LWD test program was completed, 10 locations had the pair of LWDs undertaken within the same day, whilst the remaining five (5) locations had at least a 24-hour period between the original and repeated test. As the trafficable surface of the trial embankment was, after the completion of initial compaction, exposed to both the climate (heat, rain etc.) and repeatedly wet during the application of dust suppression measures it would be expected that the variation in the modulus parameters would become greater as the duration between the time of test repetition increased.

Figure 7-7 presents the CoV associated with each test pair, plotted against the average *insitu* modulus reported at the individual test location. The key statistics of the material repeatability dataset are summarised in Table 7-7, and demonstrate the standardised *insitu* modulus determined under the 100 kPa test stress appears to consistently report less variation than the corresponding $E_{LWD-50kPa}$ parameter. Consistent with expectations, the repeated tests that were separated by more than 24 hours also demonstrated a significantly higher CoV – an approx. 20% increase - than for locations where the repeated tests were undertaken within the same testing day.

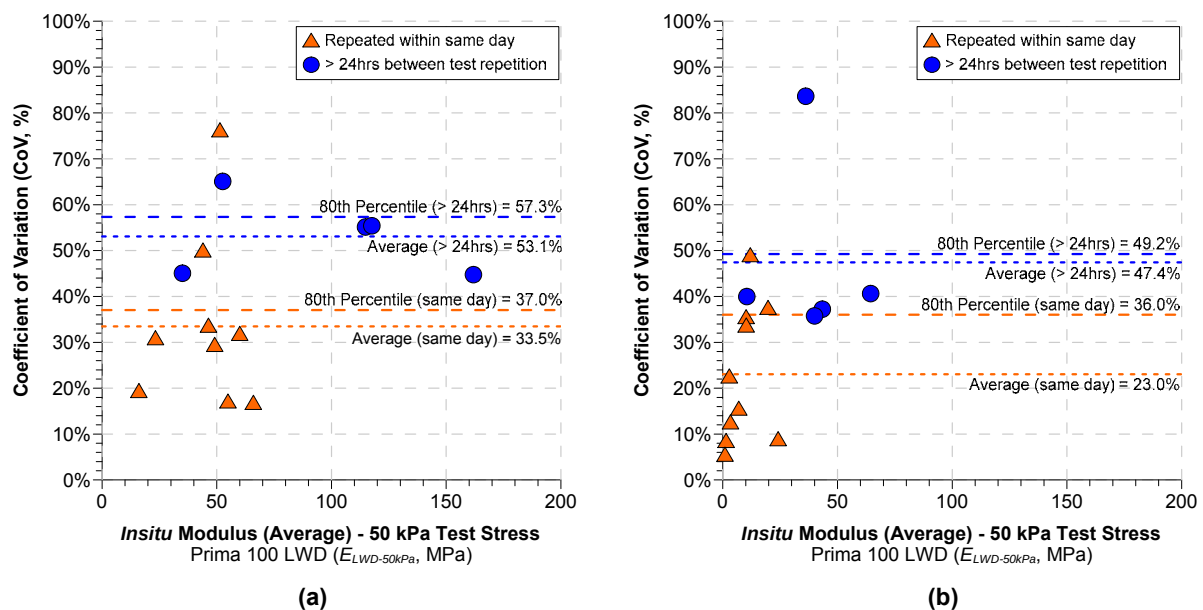


Figure 7-7 Repeatability of Prima 100 LWD (a) E_{LWD} vs. COV for *insitu* modulus under 50 kPa test stress; and (b) E_{LWD} vs. COV for *insitu* modulus under 100 kPa test

Table 7-7 Details of repeatability of Prima 100 LWD testing – variability in derived standardised *insitu* modulus parameters from repeated tests

Time of Repeated Testing	No. of Tests	50 kPa Test Stress – $E_{LWD-50kPa}$		100 kPa Test Stress – $E_{LWD-100kPa}$	
		Average CoV of E_{LWD} pairs (%)	80 th Percentile COV of E_{LWD} pairs (%)	Average CoV of E_{LWD} pairs (%)	80 th Percentile COV of E_{LWD} pairs (%)
Immediate / Same Day	10	33.5 %	37.0 %	23.0 %	36.0 %
Greater than 24 hrs	5	53.1 %	57.3 %	47.4 %	49.2 %
All Data	15	40.0 %	55.2 %	31.2 %	40.1 %



Based on the results, for the Phase 3 trial site the Prima 100 LWD test repeatability was assessed to be approximately 36% - and represents the 80th percentile threshold of all the paired data for tests repeated within 24 hours of each other. This value is expected to incorporate both equipment / operator error (anticipated to be responsible for less than 5% of observed CoV) and inherent material variability within a single test (subsite) location. The calculated repeatability value for the current project is consistent with the repeatability reported by others for Prima 100 LWD testing completed upon natural materials (e.g. Lacey et. al., 2016; Ashibili, 2005; Nazzal, 2003).

7.4 Insitu Modulus Assessment – Light Falling weight Deflectometer (LWD) – Terratest 5000 (Terratest)

7.4.1 Details of Equipment and Standardised Methodology of LWD Test

A Terratest 5000 BT USB LWD ('Terratest LWD') was trialled as a second type of LWD for use as an 'alternative QA' tools for the Phase 3 fieldwork. The Terratest LWD is a German manufactured (Terratest GmbH) LWD and primarily differs from the 'Prima 100' LWD in that (i) there is no internal load cell, (ii) the 300 mm diameter base plate is thicker and considered fully rigid; and (iii) deflection measurements are made by an accelerometer fully contained within the base plate. Accordingly, when compared to the Prima 100 LWD the major differences in operation and recorded test data of the Terratest include:

- Imparted load (and thus test stress) is assumed to be a consistent 7.07 kN (i.e. 100 kPa) for each full height weight drop. However, no load cell was present within the Terratest LWD to provide an individual record of the actual imparted load, and no time-fitted record of load is available.
- Deflection measurements are made by double integration of the accelerometer recorded acceleration of the plate – thus producing a velocity (mm/s) and plate deflection (mm) by integration. This is in contrast to the geophone included in the Prima 100 LWD that provides a direct measurement of velocity.
- The embedment of the accelerometer within the rigid plate, and the increased rigidity of the plate itself, results in typically lower deflections being recorded by the Terratest LWD than the Prima 100 LWD. In contrast, the Prima 100 LWD's geophone is in direct contact with the ground through an annulus present within the plate. The lower deflection magnitudes recorded by the Terratest would result in a comparatively higher *insitu* modulus parameter being determined, if all other input parameters were maintained

All Terratest LWD testing completed during the Phase 3 fieldwork was undertaken with a 300 mm diameter plate and only utilised a standard 10 kg drop weight. As per the test method embedded within the equipment, all tests were completed via the completion of an initial three (3) 'seating' weight drops followed by three (3) 'test' weight drops. The records for the 'seating' weight drops are discarded by the instrument, and only the velocity and settlement records of the 'test' weight drops are recorded.

Due to the absence of a load cell, tests were only completed from the full weight drop height – equivalent (calibrated) to a test stress of 100 kPa imparted through the 300 mm diameter plate. Thus, unlike the Prima 100 LWD, all Terratest LWD tests were comprised of only three (3) weight drops and from a single, standardised test stress.

All onsite testing completed using the Terratest LWD was undertaken by trained test operators – both FSG Foundations + Geotechnics personnel and external providers – and completed in accordance with the standardised test procedure as detailed within the applicable standard:

- *ASTM E2835 – 11 (2015)* – Standard Test Method for Measuring Deflections using a Portable Impulse Plate Load Test Device

Where required, after the initial levelling of each test site, bedding sand (<10 mm thick) was utilised to ensure full contact between the LWD's base plate and the trafficable surface undergoing testing. No material sampling or additional laboratory testing was completed specifically for the LWD test program.

7.4.2 Standardised Results & Interpretation

The processing of the Terratest LWD test results from raw data was limited to the inspection of the (peak) velocity and settlement magnitudes reported for each of the three (3) 'test' weight drops. Outliers within each dataset were identified and removed – adopting the same definition as used for the Prima 100 LWD data inspection – prior to the *insitu* dynamic strain modulus (E_{vd}) parameter being determined via Equation 7-3:

$$E_{vd} = 1.5 \times r \times (\sigma_{\max} / S_{\max}) \quad (\text{Equation 7-3})$$

Where:

r = Radius of plate

$\sigma_{\max}$ = Maximum Contact Pressure (assumed to be 0.1 MN/m²)

$S_{\max}$ = Average settlement of valid 'test' blows

Note that in comparison to the relationship used to calculate the *insitu* modulus parameter for the Prima 100 LWD (Equation 7-2), the Terratest LWD manufacturer adopts a constant function to account for Poisson's Ratio (ν) and the Stress Reduction Factor (S) – with (S , ν) fixed such that $S(1 - \nu^2)$ is considered a constant of 1.5.

According to the manufacturer (Terratest, 2013), the range of calibration for the 'Terratest 5000 Blu' LWD extended across a settlement range of 0.3 to 1.5 mm, representing the range of the *insitu* modulus (E_{vd}) parameter between 15 and 70 MPa. This nominated range is largely due to the requirements of the relevant German standard (country of Terratest LWD manufacture). However, the components within the test equipment are identified to also fully conform to ASTM E2825, and thus to deflection measurements must be calibrated across the range of 0.1 mm to 2.0 mm. Accordingly, this study has adopted a settlement range of 0.1 to 2.0 mm as a 'valid' test result (i.e. 11.3 to 225 MPa); but individual test certificates identify if the observed test results exceed the manufacturers stated range.

All test certificates produced for the Terratest LWD tests – detailing the recorded velocity and settlement magnitudes under each of the three (3) 'test' weight drops as well as the *insitu* dynamic strain modulus parameter (E_{vd}) – completed during this study are included as Appendix E of this report.

7.4.3 Summary of Test Results

Terratest LWD tests were completed at Site 19 through Site 26 and at Site 30 through Site 38. A total of 115 no. valid Terratest LWD tests were undertaken during the trial embankment construction. Table 7-8 presents a summary of the Terratest LWD derived *insitu* modulus parameter, E_{vd} , derived for each Site, and variation thereof. Note that unlike the Prima 100 LWD, all Terratest LWD's undertaken for any specific site were completed within a single day of testing.

Table 7-8 Summary of *insitu* modulus (E_{vd}) arising from Terratest LWD testing – Categorised by Test Site

Site ID	Results of Terratest LWD Testing – <i>Insitu</i> LWD Modulus (E_{vd} , MPa)					
	No. of Tests	Minimum	Median	Average	Maximum	Co-efficient of Variation (CoV)
Site 21	15 ²	39.2 MPa	66.0 MPa	64.0 MPa	118.4 MPa	34.5 %
Site 22	16	28.5 MPa	48.0 MPa	48.1 MPa	69.0 MPa	28.1 %
Site 23	6 ²	30.9 MPa	65.1 MPa	60.0 MPa	111.0 MPa	46.1 %
Site 24	14 ^{1, 2}	16.5 MPa	55.2 MPa	68.5 MPa	143.3 MPa	57.0 %
Site 25	15 ²	36.9 MPa	96.6 MPa	98.0 MPa	160.0 MPa	38.3 %
Site 26	12 ²	12.1 MPa	73.3 MPa	72.5 MPa	110.7 MPa	43.9 %
Site 30	5 ²	63.3 MPa	104.9 MPa	117.8 MPa	141.2 MPa	30.6 %
Site 31	4	93.0 MPa	105.6 MPa	103.7 MPa	122.1 MPa	11.9 %
Site 32	4	49.3 MPa	76.8 MPa	75.2 MPa	107.5 MPa	34.7 %
Site 33	4 ²	48.1 MPa	71.7 MPa	69.6 MPa	99.6 MPa	31.8 %
Site 34	4 ²	49.4 MPa	60.4 MPa	60.4 MPa	71.4 MPa	16.7 %

Site ID	Results of Terratest LWD Testing – <i>Insitu</i> LWD Modulus (E_{vd} , MPa)					
	No. of Tests	Minimum	Median	Average	Maximum	Co-efficient of Variation (CoV)
Site 35	4 ²	46.5 MPa	69.3 MPa	67.6 MPa	95.5 MPa	31.5 %
Site 36	4 ²	55.5 MPa	92.6 MPa	88.8 MPa	137.5 MPa	41.5 %
Site 37	4 ²	76.8 MPa	97.7 MPa	99.4 MPa	115.2 MPa	16.2 %
Site 38	4 ²	46.0 MPa	94.2 MPa	96.6 MPa	137.5 MPa	40.6 %
Full Dataset	115 ^{1,2}	12.1 MPa	67.6 MPa	75.1 MPa	160.0 MPa	43.1 %

¹ After test sites removed due to results being outside calibrated range of Terratest LWD

² After test results corrected due to existence of statistical outliers

Figure 7-8 plots the variation of test results observed across each of the 15 Site's assessed, and demonstrates no correlation exists that relates the magnitude of test variance (reported as CoV, per site) compared to the average stiffness (E_{vd}) reported for each Site.

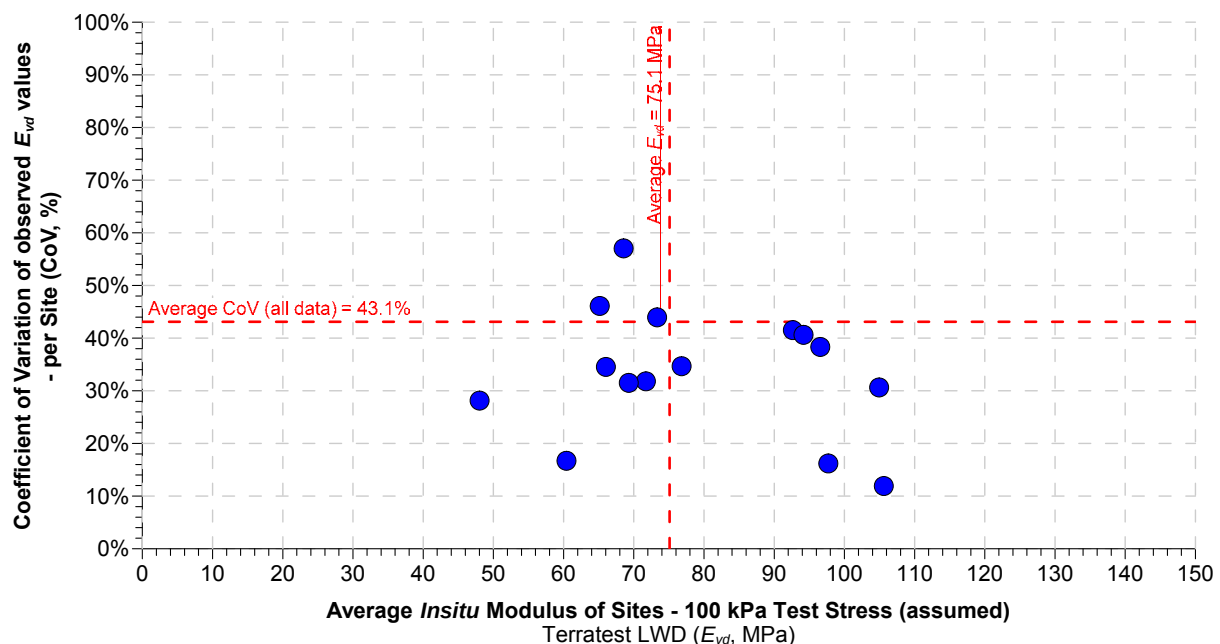


Figure 7-8 Average Terratest LWD insitu modulus parameter (E_{vd}), per site, plotted against variation of E_{vd} within Site Tests ($n = 4$ to 16 [per site])

Within each Site, a minimum of four (4) Terratest LWD tests were completed at the sub-sites corresponding to the NDG testing being undertaken. A total of 64 sub-sites had both NDG and at least a single side-by-side Terratest LWD test being completed. In addition, at a number of Sites additional sub-sites were investigated with the Terratest LWD, with a total of 12 to 14 sub-sites being tested within Sites 19 through 26. After the removal of locations where multiple Terratest LWD tests were completed (refer Section 7.4.4), Terratest LWD testing was completed at approximately 56% (106 no.) of the total individual sub-sites assessed during this phase of fieldwork.

7.4.4 Repeatability of Test

A limited number (8 no.) of sub-sites had repeated Terratest LWDs undertaken during the ARRB fieldwork testing program. This limited dataset of repeated measurements has been used to estimate the composite value of the (i) Terratest LWD's equipment error; (ii) typical operator error and (iii) inherent material variability within the near-surface of the site being assessed. As the dynamic modulus parameter reported by the Terratest (E_{vd}) is directly derived from the measured deflection (refer Equation 7-3, with the test stress assumed a constant 100 kPa), the calculated Coefficient of Variation (CoV) remains a constant value regardless of if the assessment of repeatability is made upon the

measured velocity, deflection or E_{vd} data. In contrast, the Prima 100 LWD derived modulus parameter is based on two (2) measured variables - the measured test load and deflection magnitude.

Figure 7-9 presents the observed variability within the paired E_{vd} parameters, as measured by the CoV, plotted against the averaged E_{vd} parameter. The average CoV value for the available data was 26.8%, with the 80th percentile of the data reported at 40.3%. This result is approximately a 10% increase (~4% increase in CoV value, both for average and 80th percentile thresholds) when the Terratest LWD result is compared to the CoV arising from the comparable assessment of the Prima 100 LWD derived modulus (36.0 % vs. 40.3 %).

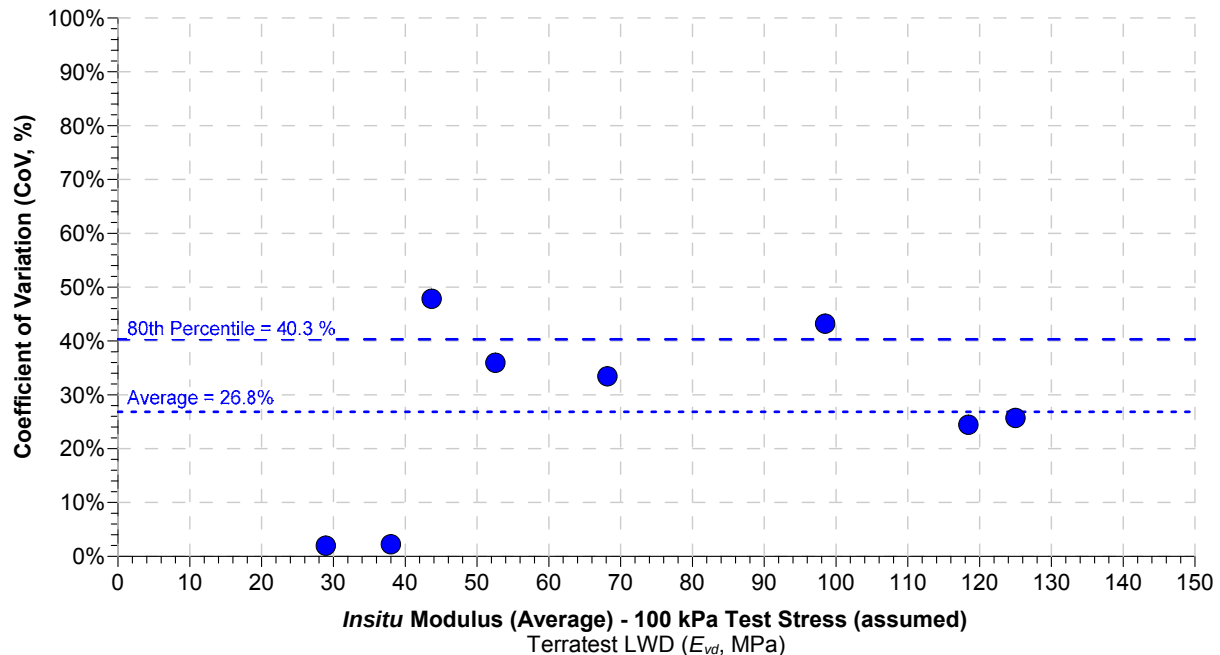


Figure 7-9 Repeatability of Terratest LWD testing during Phase 3 ARRB Fieldwork – *insitu* modulus (E_{vd}) vs. COV (%) ($n= 8$)

7.5 *Insitu* Modulus Assessment – Clegg Hammer

7.5.1 Standardised Methodology of Clegg Hammer Test

The Clegg Hammer test equipment consists of an instrumented compaction hammer operating within a vertical guide tube. When the hammer (weight) is released from a fixed height it falls through the tube and strikes the ground surface under footprint of the guide tube. The deceleration of the hammer occurs at a rate determined by the stiffness of the material within the region of impact. A precision accelerometer mounted on the hammer feeds its output to a hand-held digital readout unit which registers the hammer deceleration.

Specifically, the current study has utilised a 9.1 kg version of the Clegg Hammer which is enable to be complete testing from five (5) variable drop heights – 76 mm, 152 mm, 305 mm, 457 mm & 610 mm. The Clegg Hammer capable of delivering hammer blows from variable drop heights was selected as (i) the observed variation in behaviour of the compacted material under a number of test stress magnitudes would allow assessment of the material’s consistency throughout the lift thickness; and (ii) allow evaluation of the height drop (test stress) that is best correlated to density and other modulus test results.

The standard methodology adopted for all Clegg Hammer testing completed during the period of onsite work detailed herein was in general accordance with:

- Australian Standard – AS 1289.6.9.1—2000 (R2013): *Methods for testing soils for engineering purposes – Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil – Clegg Impact Value (CIV)*

- ASTM International – D5874–16 - *Standard Test Method for Determination of the Impact Value (IV) of a Soil*
- Methodology as outlined in Clegg Hammer Manufacturer (and developer) user guide and advice offered during personal communication (2018)

For each test completed during the current study, a minimum of four (4) hammer blows were imparted by the Clegg Hammer at each of the (5) variable drop heights, with all hammer blows completed at a particular test height prior to commencing the next (ascending) height drop. As the testing always commenced at the lowest height drop and increased until the highest drop height was reached, the test stress being imparted at each variable height drop level was always of an increased magnitude on the previous testing series completed at the same location. A single full test represented a minimum of 20 hammer blows being made within a single test footprint.

As with all surface-based plate test techniques adopted within this study, after the initial clearing and levelling of each test site was completed a limited amount of bedding sand (<10 mm thick) was utilised to ensure full contact occurred between the flat base of the hammer and trafficable surface undergoing testing.

Figure 7-10 presents pictures of the 9.1 kg variable height drop Clegg Hammer being used upon the prepared surface of the trial embankment.

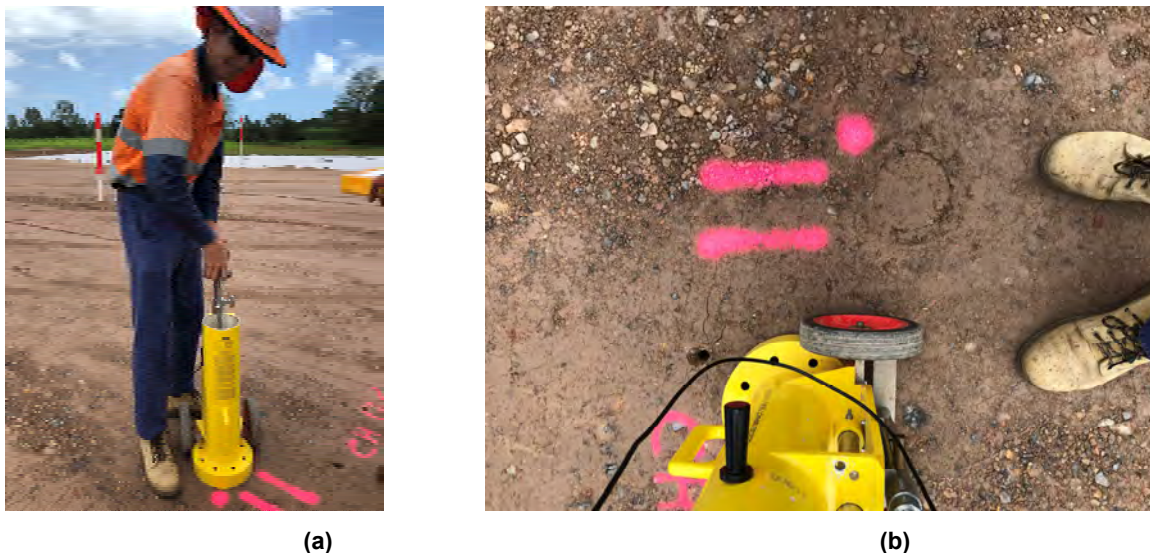


Figure 7-10 (a) Picture of the Clegg Hammer equipment typically adopted onsite, 9.1 kg weight fitted with 130 mm diameter hammer; and (b) typical footprint / impression made after full testing regime adopted (min. 20 hammer blows).

7.5.2 Standardised Results & Interpretation

The result obtained from each drop of the Clegg Hammer has been reported in Clegg Impact Value (CIV) units, which is the peak deceleration force (G_{max}) as measured in terms of a multiple of standard gravities (g) divided by a factor of 10 (i.e. $CIV = G_{max} / 10$). Typically, the harder / stiffer a material is, the greater the deceleration of the hammer under the applied force and thus the higher the G_{max} or CIV value returned by the Clegg Hammer (for repeated tests under the same test conditions).

During the completion of Clegg Hammer testing the hammer is repeatedly dropped from the same vertical height a minimum of four (4) times. As per the manufacturer recommendations, the initial two (2) drops are considered seating blows, and the results are discarded. Of the remaining dataset – a minimum of two (2) CIV values – the maximum result is designated C_{MAX} and the average result designated C_{AVE} . Although manufacturer literature suggests the use of C_{MAX} in preference to C_{AVE} for use with correlation to other material parameters, but both have been compiled for the studies completed to date in order to assess this claim.

Formulas have been previously proposed (refer Clegg web site <http://www.clegg.com.au/news.html>)

to relate the CIV to an equivalent modulus parameter. As the CIV is an index value only, and does not include a term that reflects the drop height of the hammer (i.e. energy imparted to return the observed CIV), individual formulas for CIV $\leftrightarrow$ E correlation are provided for each hammer drop height. For the 9.1 kg Clegg Hammer used by this study, the following relationships have been previously proposed to convert C_{MAX} to E values:

- For 0.076 m hammer drop height – $E_{CLEGG-0.076m}$ (MPa) = $0.400 \times (C_{MAX-0.076m})^2$
- For 0.152 m hammer drop height – $E_{CLEGG-0.152m}$ (MPa) = $0.200 \times (C_{MAX-0.152m})^2$
- For 0.305 m hammer drop height – $E_{CLEGG-0.305m}$ (MPa) = $0.100 \times (C_{MAX-0.305m})^2$
- For 0.457 m hammer drop height – $E_{CLEGG-0.457m}$ (MPa) = $0.067 \times (C_{MAX-0.457m})^2$
- For 0.610 m hammer drop height – $E_{CLEGG-0.610m}$ (MPa) = $0.050 \times (C_{MAX-0.610m})^2$

It is noted the format of this relationship is consistent – that is, a 2nd order polynomial – for all drop heights, with only the constant altering based on the height of the weight drop (i.e. test stress value).

For the purposes of this study, in which all values were reported in CIV terms, the standardisation of the C_{MAX} and C_{AVE} values for each sub-site involved (i) disregard of initial two (2) hammer drops (seating blows) for each drop height; (ii) inspection of remaining data to identify outlier values (defined as recorded values remaining 1.5 times the Inter-Quartile Range (IQR) below or above the first and third quartiles respectively).

Unlike the Prima 100 LWD or the static Plate Load Test, the Clegg Hammer is not fitted with any form of load cell to measure imparted test stress due to each weight drop. However, based on the formulas included in Clegg (1995) and the known arrangements of the variable height hammer used for the testing completed for the study detailed herein, the total test load and imparted test stress produced completed test can also be determined. The typical test stress associated with each equipment arrangement are summarised in Table 7-9 for the site characterised by the Phase 3 ARRB fieldwork.

Table 7-9 Summary of test stress imparted by each of the variable weight drop heights of Clegg Hammer

Equipment	Hammer Drop Height	Average Test Stress (kPa)	Average Test Load (kN)	Coefficient of Variation (CoV)
Clegg Hammer: 9.1 kg Drop Weight 130 mm Diameter <i>(Stresses estimated by formulas detailed in Clegg, 1995)</i>	76 mm	1497.0 kPa	19.9 kN	37.4 %
	152 mm	1851.7 kPa	24.6 kN	40.6 %
	305 mm	2559.0 kPa	34.0 kN	32.6 %
	456 mm	3124.1 kPa	41.5 kN	33.2 %
	605 mm	3374.2 kPa	44.8 kN	31.9 %

It should be noted that as the nature of the Clegg Hammer test involves direct contact between the equipment's drop weight and the surface being tested, and does not include any 'buffering' of the load (as is the case with the LWDs). Thus, the magnitude of test stress associated with the Clegg Hammer is significantly higher than that applied by the other plate-based testing methods. Similarly, as the Clegg Hammer is fitted with a comparatively small diameter hammer (130 mm diameter) whilst the LWDs all utilised a 300 mm diameter, the Clegg Hammer results in a comparatively higher test stress magnitude for comparable weights dropped from similar heights.

All test certificates produced for the Clegg Hammer tests – detailing the result (in CIV units) for each individual weight drop completed under each of the five (5) 'test' weight drops – completed during this study are included as Appendix F of this report.

7.5.3 Summary of Test Results

Clegg Hammer testing was completed at Site 19 through Site 26 only. A total of 90 no. sites had valid Clegg Hammer testing undertaken during the trial embankment construction. Table 7-10 presents the standardised maximum (C_{MAX}) and average (C_{AVE}) parameters for each test sub-site and each of the five (5) hammer drop heights / test stresses associated with each Clegg Hammer test.



Table 7-10 Summary of Clegg Impact Values (CIV) values arising from variable height Clegg Hammer testing – Categorised by Test Site

Site ID	No. of Sub-Sites / Tests	Results of 9.1 kg Clegg Hammer Testing – Clegg Impact Value (CIV)											
		Maximum Clegg Impact Value (C _{MAX})						Average Clegg Impact Value (C _{Ave})					
			0.076 m Height Drop	0.152 m Height Drop	0.305 m Height Drop	0.457 m Height Drop	0.610 m Height Drop		0.076 m Height Drop	0.152 m Height Drop	0.305 m Height Drop	0.457 m Height Drop	0.610 m Height Drop
Site 19	14	Ave.	77.9	124.7	184.8	238.6	285.6	Ave.	74.5	119.8	179.0	228.3	273.7
		Range	53.0 – 118.0	85.0 – 185.0	126.0 – 257.0	176.0 – 338.0	201.0 – 404.0	Range	51.0 – 114.5	83.5 – 173.5	124.5 – 249.5	166.0 – 330.3	200.5 – 391.7
		CoV	25.4 %	26.2 %	23.6 %	22.8 %	23.6 %	CoV	26.2 %	25.3 %	22.4 %	21.8 %	22.3 %
Site 21	14	Ave.	74.5	131.0	192.9	254.4	299.4	Ave.	70.4	125.4	185.3	243.8	290.5
		Range	18.0 – 96.0	22.0 – 212.0	48.0 – 257.0	50.0 – 369.0	167.0 – 432.0	Range	17.5 – 92.5	21.5 – 186.5	41.0 – 256.5	42.5 – 344.5	164.5 – 414.0
		CoV	28.6 %	35.0 %	29.1 %	31.0 %	21.8 %	CoV	28.6 %	33.3 %	29.5 %	30.6 %	21.4 %
Site 22	14	Ave.	14.4	19.4	26.6	33.8	38.4	Ave.	13.1	18.4	25.0	32.3	36.4
		Range	11.0 – 36.0	12.0 – 54.0	38.0 – 55.0	23.0 – 56.0	30.0 – 56.0	Range	9.7 – 34	12.0 – 49.0	18.7 – 55.0	23.0 – 51.0	28.7 – 47.7
		CoV	19.0 %	20.7 %	18.3 %	22.7 %	17.6 %	CoV	19.2 %	19.6 %	16.6 %	19.6 %	14.8 %
Site 23	7 ¹	Ave.	27.6	31.1	40.7	37.8	42.7	Ave.	24.8	28.3	36.7	35.0	36.9
		Range	21.0 – 36.0	17.0 – 54.0	31.0 – 55.0	33.0 – 44.0	34.0 – 59.0	Range	15.4 – 34.0	16.5 – 49.0	29.7 – 55.0	31.5 – 41.3	33.0 – 43.4
		CoV	26.5 %	45.2 %	22.2 %	12.2 %	20.6 %	CoV	30.0 %	40.9 %	24.0 %	9.5 %	10.2 %
Site 24	15 ¹	Ave.	29.3	36.0	45.5	60.1	56.2	Ave.	27.4	33.0	41.4	55.7	52.9
		Range	18.0 – 58.0	19.0 – 82.0	21.0 – 86.0	29.0 – 113.0	29.0 – 105.0	Range	17.5 – 57.5	17.7 – 71.7	20.5 – 81.0	29.0 – 111.3	26.5 – 101.0
		CoV	36.8 %	44.0 %	42.4 %	37.2 %	42.8 %	CoV	38.6 %	42.6 %	43.2 %	40.7 %	43.9 %
Site 25	13 ¹	Ave.	22.3	28.2	41.5	50.8	58.5	Ave.	20.3	25.9	38.8	46.8	51.7
		Range	20.0 – 28.0	20.0 – 35.0	35.0 v 47.0	40.0 – 66.0	37.0 – 75.0	Range	17.3 – 24.0	20.0 – 32.0	34.0 – 46.3	37.8 – 59.3	33.0 – 68.3
		CoV	10.9 %	14.5 %	9.0 %	14.3 %	18.3 %	CoV	8.9 %	13.6 %	9.4 %	11.8 %	17.2 %
Site 26	13 ¹	Ave.	19.7	23.9	36.9	45.1	51.5	Ave.	18.1	22.6	34.1	41.2	46.1
		Range	14.0 – 27.0	16.0 – 34.0	28.0 – 44.0	38.0 – 63.0	39.0 – 75.0	Range	13.7 – 24.3	15.5 – 31.0	26.3 – 39.7	34.7 – 53.5	35.4 – 57.3
		CoV	22.5 %	19.0 %	14.2 %	14.4 %	20.4 %	CoV	17.6 %	18.1 %	13.0 %	12.2 %	14.5 %
Full Dataset	90 ¹	Ave.	39.0	58.7	85.0	110.1	128.2	Ave.	36.6	55.7	80.9	104.5	121.8
		Range	11.0 – 118.0	12.0 – 212.0	21.0 – 257.0	23.0 – 369.0	29.0 – 432.0	Range	9.7 – 114.5	12.0 – 186.5	18.7 – 256.5	23.0 – 344.5	26.5 – 414.0
		CoV	72.6 %	89.0 %	89.4 %	92.3 %	93.9 %	CoV	74.6 %	89.8 %	91.3 %	93.5 %	95.9 %

¹ Data includes tests completed on multiple dates and / or multiple tests completed at a single sub-site



7.5.4 Repeatability of Test

A very small number (5 no.) of sub-sites had repeated Clegg Hammer tests completed during the ARRB fieldwork testing program. Not all drop heights were completed during both of the repeated tests, resulting in a dataset size of five ($n = 5$) for the 75, 152- and 305-mm drop heights; four ($n = 4$) for the 456 mm drop height; and three ($n = 3$) for the 605 mm drop height.

This limited dataset of repeated measurements has been considered as a measure of the Clegg Hammer's test repeatability, and such a measure would include (i) Clegg Hammer equipment error; (ii) typical operator error associated with completion of the test; and (iii) inherent material variability within the near-surface of the site being assessed.

Table 7-11 summarises the variation in the results obtained from the locations where the repeated Clegg Hammer was completed. Typically, it appears that the median CoV of variation between test results varies between 15 and 25% for individual drop heights. Considering the full dataset ($n = 22$), the mean and median CoV of the test results is 25.5 % and 20.7 % respectively, with the 80th percentile of the CoV values calculated to be 50.5 %.

Table 7-11 Variation of repeated Clegg Hammer Testing at individual test locations

Site ID	Sub-Site ID	Clegg Hammer Test Result – Average +/- Variation (CIV)				
		0.076 m Height Drop	0.152 m Height Drop	0.305 m Height Drop	0.457 m Height Drop	0.610 m Height Drop
Site 23	23-1	29.50 +/- 6.50	38.50 +/- 15.50	43.00 +/- 12.00		
Site 24	24-1	19.67 +/- 0.33	24.33 +/- 2.67	27.33 +/- 4.67	36.00 +/- 7.00	32.25 +/- 5.75
	24-11	43.25 +/- 14.75	54.83 +/- 27.17	62.38 +/- 23.63	83.00 +/- 30.00	73.00 +/- 32.00
Site 25	25-7	20.50 +/- 0.50	21.00 +/- 1.00	40.10 +/- 4.90	49.08 +/- 0.92	40.57 +/- 3.57
Site 26	26-3	18.50 +/- 0.50	23.50 +/- 0.50	37.83 +/- 0.83	38.33 +/- 0.33	
ALL	CoV (%)	Median = 3.8 % (2.4 % – 48.2 %)	Median = 15.5 % (3.0 % – 70.1 %)	Median = 24.1 % (3.1 % – 53.6 %)	Median = 15.1 % (1.2 % – 51.1 %)	Median = 25.2 % (12.4 % – 62.0 %)

7.6 Penetration Testing – Dynamic Cone Penetrometer (DCP)

7.6.1 Standardised Methodology of DCP Test

The Dynamic Cone Penetrometer (DCP) is a simple, portable and low-cost penetration tool used as an indicator of strength and variation within a sub-surface profile.

For the current study, the DCP was completed using a standard methodology that was in general accordance with:

- AS 1289.6.3.2-1997 (R2013) – *Methods of testing soils for engineering purposes – Soil strength and consolidation tests - Determination of the penetration resistance of a soil - 9kg dynamic cone penetrometer test*

The equipment utilised for the DCP all conformed to the Australian Standard – including the use of a 20 mm diameter cone with sides angled at 15 degrees to the centreline and use of a 9 kg hammer dropped a vertical height of 510 mm.

To increase the resolution of the DCP results for the current study, the field test was completed via the assessment of the number of hammer blows (n) required to penetrate the cone tip and rods a vertical depth of 50 mm. Although conforming to the Australian Standard, the use of 50 mm graduation is in contrast to the general Australian industry standard usage of the DCP, in which a test is typically completed by assessing the number of hammer blows required to achieve a penetration of 100 mm.

As the expected deepest zone of influence of other side-by-side tests was to be twice the plate diameter (2D), to a maximum of 600 mm depth (for static PLT), the penetration tests completed during the Phase 3 fieldwork were targeted to extend to such a depth. However, due to the presence of 'oversize' (gravel) materials within the compacted fill under assessment, premature termination due to cone tip 'refusal' was frequently observed. For this fieldwork, 'refusal' was typically defined as the application of a minimum of 20 hammer blows resulting in the test progressing less than the 50 mm reporting increment

(i.e. test 'refusal' observed if average penetration rate was less than 2.5 mm / hammer blow for no less than 20 hammer blows).

Figure 7-11 shows the DCP being used as a penetration test from the prepared surface of the trial embankment.



Figure 7-11 Pictures of the DCP equipment typically adopted onsite, with testing locations shown in close proximity to the sampling locations associated with the traditional QA assessment undertaken

7.6.2 Standardised Results & Interpretation

Each DCP test yielded an index value (n) for each 50 mm penetration achieved. These values have been converted into an average rate of penetration for the 50 mm depth increment – termed DCP_i herein, and reported in millimetres per hammer blow. Thus, as the depth increment over which the average rate was standardised, each recorded depth increment was be directly comparable to each other (in comparison to the PANDA Probe test results, which required further standardisation to achieve such a result due to the variable energy nature of that test technique).

The termination condition of each DCP test was also evaluated during the interpretation and standardisation of results. Where the test did not extend to the full length of the final 50 mm depth increment (i.e. where test 'refusal' occurred), the final depth increment was excluded from further analysis. This exclusion was undertaken to remove any influence of unrepresentative / excessively low DCP_i values skewing the resulting datasets, expected to be associated with the intersection of the DCP equipment with gravel / cobble sized particles.

The standardised results for each DCP test were then converted into an average penetration rate (DCP_{i-AVE}) over the full depth profile, such that a single DCP_{i-AVE} was determined for each progressive 50 mm depth interval and thus a series of averaged penetration rates were determined for each test (e.g. $DCP_{i-AVE-50mm}$ represents the average penetration rate over the 0 – 50 mm depth increment, whilst $DCP_{i-AVE-450mm}$ represents the average penetration rate over the 0 – 450 mm depth increment

As a standard processing method was adopted, the resulting DCP_i and DCP_{i-AVE} parameters arising for each completed DCP test are considered directly comparable to each other.

Test certificates produced for all the Dynamic Cone Penetrometer (DCP) tests completed during this study are included as Appendix G of this report. These certificates detail the raw indexed profile recorded for each test – i.e. hammer blows (n) per 50 mm rod penetration. Appendix G also includes a summary of the interpreted DCP_i and DCP_{i-AVE} parameters calculated for each DCP test undertaken.



8. Measurement of Field Moisture Content

In situ (field) moisture content was measured onsite via two (2) methods – (i) by use oven drying of recovered soil samples from locations of Nuclear Density Gauge (NDG) assessment (i.e. for traditional QA regime) and (ii) by the use of a TEROS 12 Soil Moisture (probe) sensor. The following sub-sections of the report detail the standard assessment methodology adopted for each method of *insitu* moisture content assessment.

8.1 Moisture Content Assessment – Oven Drying of Soil Sample

8.1.1 Standardised Methodology of testing

As previously detailed in Section 7.1, a calibrated NDG was utilised for *insitu* measurements of field density and moisture content. All NDG testing was undertaken by trained operators (external provider to FSG Foundations + Geotechnics) in accordance with the applicable Australian Standard:

- *Australian Standard AS1259.5.8.1 (2007)* – Methods of testing soils for engineering purposes, Method 5.8.1: Soil compaction and density tests – Determination of field density and field moisture content of a soil using a nuclear surface moisture – Density gauge – Direct transmission mode.

At each location of NDG assessment, a representative soil sample was recovered and submitted for Field Moisture Content (FMC) determination via laboratory methods. The laboratory work undertaken determine the Field Moisture Content (FMC) and relevant ratio between the FMC and Optimum Moisture Content (OMC) were undertaken by a NATA registered laboratory, utilising the standardised test procedures as previously identified in Section 7.1. The size the reference panel of OMC tests completed was maintained as per the frequency specified by Australian Standard AS1289.5.4.2 (2007).

For all NDG tested locations the nuclear source was placed at a constant 275 mm depth of the instrument and the material sample taken from the test site should reflect this test depth. Thus, derived Field Moisture Content (FMC) values should be considered a composite value over such a depth interval (depth from the trafficable surface at the time of testing).

As identified in Section 6.4, the QA (NDG and Moisture Ratio) regime adopted for the project utilised reference (assigned) OMC and MDD values for the assessment of Moisture Ratio (MR) values, rather than applying individual sub-site assessment to recovered bulk samples (i.e. not a 1:1 ratio).

8.1.2 Standardised Results & Interpretation

No specific additional interpretation of the provided results of the field and associated laboratory testing was required to process the test results into a standardised dataset. The *insitu* and laboratory assessment of the material associated with the traditional QA test regime being employed by the site's earthworks (completed by others) yielded the following material parameters related to moisture content:

- Field Moisture Content (FMC, %)
- Moisture Ratio (%) = Field Moisture Content / Optimum Moisture Content (OMC) – Note that the OMC was corrected for the measured 'oversize' content present at each test location.

All test certificates received for the specified QA regime – a dataset of 132 no. NDG tested sites – relied upon for the comparison of alternative QA test methods are included in Appendix B of this report.

8.1.3 Summary of Test Results

FMC and MR parameters were reported for all 132 no. locations where NDG testing was completed across the project site. Within each Site, a total of four (4) to six (6) FMC / MR test results were provided. As per the *insitu* density testing, this represents a coverage of approximately 71% of the total individual sub-sites assessed during this phase of testing – and is analogous to the percentage of test sub-sites that were part of the project's specific QA regime, and those that were undertaken as additional test sites with only alternative QA methods employed (29%, or 52 sub-sites).

Table 8-1 presents a summary of the FMC and MR values determined for each of the 31 Sites for which results were available. Of these, five (5) Sites showed an average moisture content in excess of the OMC (i.e. materials compacted wet of OMC), by between 1.5 & 13.3 % wet of OMC (average of these sites = 7.9% wet of OMC). The remaining 26 Sites were compacted dry of OMC, with averaged MR parameters of between 2.0 and 32.5 % dry of OMC (average of these sites was compacted 18% dry of OMC).

Table 8-1 Summary of Field Moisture Content & Moisture Ratio Results – Oven Dried determination

Site ID	No. of Tests	Field Moisture Content (FMC, %)				Moisture Ratio (MR, %)			
		Range	Median	Average	COV (%)	Range	Median	Average	COV (%)
Site 7	4	4.9 – 6.4 %	5.8 %	5.7 %	11.4 %	61.3 – 80.0 %	71.9 %	71.3 %	11.4 %
Site 8	4	6.0 – 6.6 %	6.4 %	6.3 %	4.0 %	75.0 – 82.5 %	79.4 %	79.1 %	4.0 %
Site 9	4	4.9 – 5.9 %	5.4 %	5.4 %	10.7 %	61.3 – 73.8 %	67.5 %	67.5 %	10.7 %
Site 10	4	4.2 – 6.2 %	5.7 %	5.5 %	16.0 %	52.5 – 77.5 %	71.3 %	68.1 %	16.0 %
Site 11	4	4.9 – 7.7 %	5.9 %	6.1 %	22.4 %	61.3 – 96.3 %	73.1 %	75.9 %	22.4 %
Site 12	4	5.7 – 6.5 %	6.0 %	6.0 %	5.6 %	71.3 – 81.3 %	74.4 %	75.3 %	5.6 %
Site 13	4	5.1 – 6.6 %	6.0 %	5.9 %	10.6 %	63.8 – 82.5 %	74.4 %	73.8 %	10.6 %
Site 14	4	6.5 – 7.5 %	6.6 %	6.8 %	6.9 %	81.3 – 93.8 %	82.5 %	85.0 %	6.9 %
Site 15	4	6.8 – 8.3 %	7.8 %	7.7 %	8.5 %	85.0 – 103.8 %	97.5 %	95.9 %	8.5 %
Site 16	4	4.9 – 6.3 %	5.7 %	5.7 %	11.1 %	59.8 – 78.8 %	71.3 %	70.3 %	12.0 %
Site 17	4	5.0 – 6.7 %	6.1 %	6.0 %	13.3 %	62.5 – 83.8 %	75.6 %	74.4 %	13.3 %
Site 18	4	6.1 – 7.7 %	6.8 %	6.9 %	10.2 %	76.3 – 96.3 %	85 %	85.6 %	10.2 %
Site 19	4	7.3 – 8.4 %	7.8 %	7.8 %	7.1 %	91.3 – 105.0 %	97.5 %	97.8 %	7.1 %
Site 21	4	8.5 – 9.4 %	8.9 %	8.9 %	4.8 %	106.3 – 117.5 %	110.6 %	111.3 %	4.8 %
Site 22	4	7.9 – 8.8 %	8.1 %	8.2 %	4.8 %	98.8 – 110.0 %	101.3 %	102.8 %	4.8 %
Site 23	5	5.5 – 7.8 %	6.6 %	6.6 %	12.3 %	64.7 – 91.8 %	78.8 %	78.6 %	12.2 %
Site 24	6	6.1 – 8.6 %	7.7 %	7.5 %	14.3 %	71.8 – 101.2 %	90.6 %	88.4 %	14.3 %
Site 25	5	6.4 – 7.6 %	7.3 %	7.2 %	6.4 %	80.0 – 95.0 %	91.3 %	89.5 %	6.4 %
Site 26	5	7.1 – 9.5 %	7.7 %	7.8 %	12.5 %	88.8 – 118.8 %	96.3 %	98.0 %	12.5 %
Site 27	5	7.4 – 9.3 %	9.2 %	8.9 %	9.3 %	92.5 – 116.3 %	115.0 %	110.8 %	9.3 %
Site 28	5	8.0 – 10.1 %	9.1 %	9.1 %	8.4 %	100.0 – 126.3 %	113.8 %	113.3 %	8.4 %
Site 29	5	6.7 – 9.3 %	8.1 %	8.1 %	11.8 %	83.8 – 116.3 %	101.3 %	101.5 %	11.8 %
Site 30	4	6.3 – 8.5 %	7.2 %	7.3 %	13.9 %	74.1 – 100.0 %	84.1 %	85.6 %	13.9 %
Site 31	4	6.7 – 8.4 %	7.7 %	7.6 %	9.4 %	78.8 – 98.8 %	90.6 %	89.7 %	9.4 %
Site 32	4	7.0 – 8.4 %	7.4 %	7.5 %	8.1 %	82.4 – 98.8 %	86.5 %	88.5 %	8.1 %
Site 33	4	7.6 – 8.3 %	7.9 %	7.9 %	3.8 %	89.4 – 97.6 %	92.9 %	93.2 %	3.8 %
Site 34	4	6.3 – 6.9 %	6.8 %	6.7 %	3.9 %	74.1 – 81.2 %	79.4 %	78.5 %	3.9 %
Site 35	4	7.4 – 8.4 %	7.6 %	7.8 %	6.1 %	87.1 – 98.8 %	89.4 %	91.2 %	6.1 %
Site 36	4	5.4 – 6.9 %	6.2 %	6.2 %	9.9 %	63.5 – 81.2 %	72.9 %	72.6 %	9.9 %
Site 37	4	6.8 – 7.7 %	7.1 %	7.2 %	5.7 %	80.0 – 90.6 %	82.9 %	84.1 %	5.7 %
Site 38	4	5.4 – 7.3 %	6.3 %	6.3 %	12.5 %	63.5 – 85.9 %	74.1 %	74.4 %	12.5 %
Full Dataset	132	4.2 – 10.1 %	7.1 %	7.1 %	17.1 %	52.5 – 126.3 %	84.9 %	86.8 %	17.5 %

8.1.4 Repeatability of Test

No duplicate FMC tests were completed within a single ‘sub-site’ throughout the ARRB monitored phase of the Trial Embankment’s construction. Accordingly, the repeatability of the FMC test result has not been determined in the same manner as the other test results completed.

Australian Standard AS1289.5.1.1 (2017) provides some guidance on the expected (acceptable) “precision” of the OMC parameter. For 95% of tests completed in accordance with the standard, it is

expected the OMC parameter could typically be expected to vary by $\pm 20\%$ about a mean value. This value appears to include operator and equipment errors. Thus, for the average OMC value applied to the Phase 3 dataset (7.5%, when corrected for oversized materials), the 'acceptable' range of OMC would vary between 6.0% and 9.0%.

By extension, whilst assuming all reported FMC values were precise to the reported 0.1%, the use of the upper and lower bound OMC ($\pm 20\%$) would result in Moisture Ratio's (MR) varying by between ± 10.9 and $\pm 26.3\%$, with a median and average of $\pm 17.4\%$ and $\pm 18.0\%$ respectively. This suggests that the MR parameter should also be considered accurate to approximately $\pm 20\%$ of that reported.

8.2 Moisture Content Assessment – TEROS 12 Sensor

8.2.1 Standardised Methodology of Test

The field moisture content, determined as a Volumetric Water Content (VWC) measurement, was also assessed at specific test locations via the use of an *insitu* needle probe – the commercially available TEROS 12 sensor. For data collection purposes, this equipment was coupled with a KD2 Pro Thermal Properties Analyser, such that an effective handheld sensor read-out and data storage system was available to the FSG team onsite. Figure 8-1 shows the equipment arrangement and during use onsite.

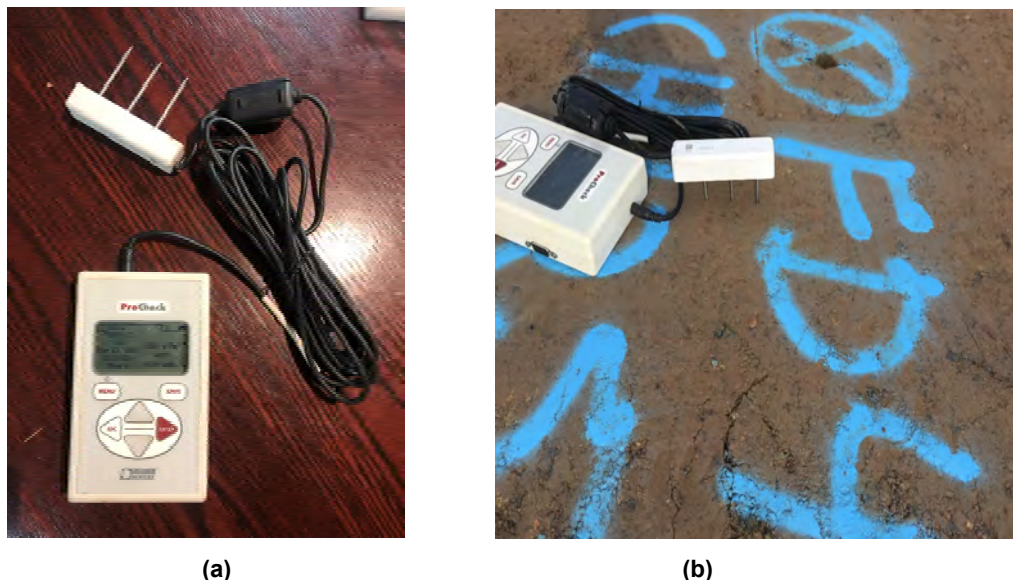


Figure 8-1 Pictures of the TEROS 12 probe utilised for insitu VMC assessment (a) showing needle probes; and (b) in use during field testing.

The methodology adopted for VWC assessment was as per the manufacturer recommendations (METER Group, 2019); whereby a site measurement was completed via insertion of the TEROS 12 Sensor's three (3) no. needle probes into the compacted earthworks. Once the needle probes are embedded, the probe generates an electromagnetic field within two (2) of the sensor needles such that the dielectric permittivity of the surrounding medium can be assessed.

The dimensions of the surface-based portion of the utilised TEROS 12 probe was 93 mm (L) x 30 mm (W) x 25 mm (D). As shown in Figure 8-2, the effective depth (zone of influence) of the TEROS 12 sensor is approximately 105 mm (75 mm needle probe length + 30 mm depth below base of probe).

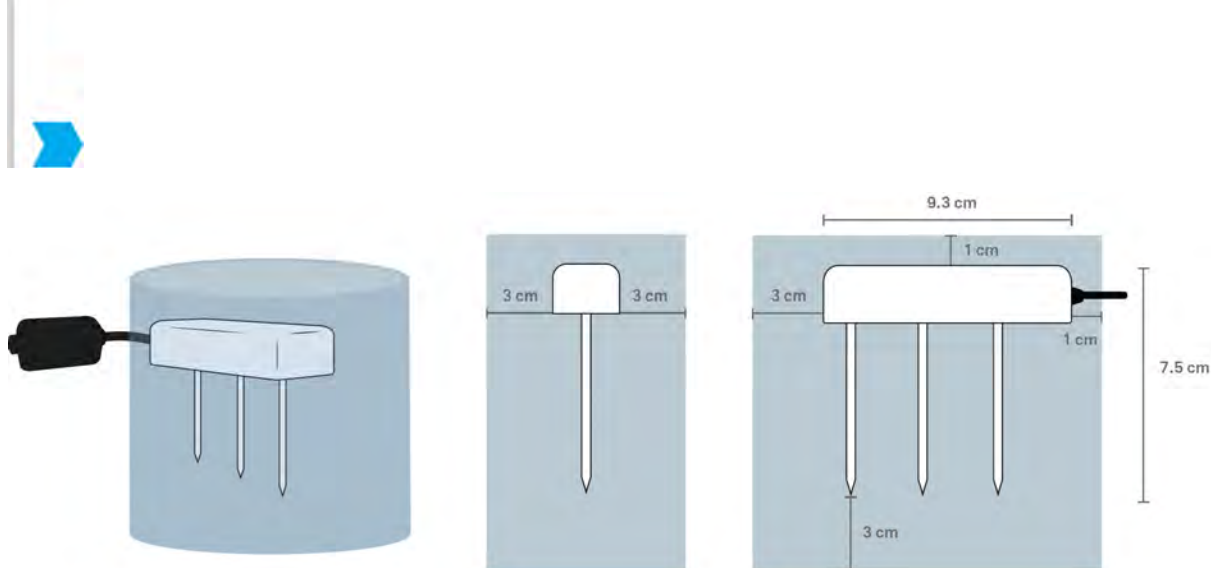


Figure 8-2 Figure showing dimensions of TEROS 12 probe utilised for Phase 3 fieldwork (from user manual, METER Group, 2019)

The completion of each test took less than 30 seconds, and thus the results provided by the probe are considered to be near-instantaneous.

8.2.2 Standardised Results & Interpretation

The VWC results provided by the TEROS 12 sensor are provided in as a m^3/m^3 parameter, and thus require no further interpretation prior to use.

However, it is noted that due to inaccessibility to suitable materials or laboratory resources, no material specific calibration of the TEROS 12 probe was undertaken prior to the ARRB fieldwork. Accordingly, the factory default calibration of the sensor was adopted for VWC parameter estimation. As identified by Schwartz, Afsharikia & Khosravifar (2017), such defaults may not be relevant to the levels of material compaction typically achieved in earthworks and pavement arrangements.

The VWC measurements made by the TEROS 12 probe were also considered to be significantly affected by the inability to consistently achieve full embedment of the needle probes into the compacted materials – either due to the level of material compaction achieved or the presence of high strength gravel cobble and boulders within the earthworks' Fill material. Similar problems were reported by Schwartz, Afsharikia & Khosravifar (2017), whom determined the use of a similar sensor was impractical for base course materials that contained comparatively large nominal maximum aggregate sizes and who reported that a drill or a placebo sensor was required to prefabricate holes when using the sensor on stiff, fine-grained soils.

8.2.3 Summary of Test Results

Field measurements of VMC utilising the TEROS 12 sensor were completed across 13 Sites considered during the Phase 3 ARRB fieldwork. The results of the testing are summarised for each individual Site assessed in Table 8-2, noting that these results have not been corrected for variation in the achieved needle embedment (refer Section 8.2.2).

Table 8-2 Summary of Field Moisture Content Results – Volumetric Water Content via TEROS 12 Sensor

Site ID	No. of Sub-Sites	No. of VMC Tests	Volumetric Water Content (VWC, %)			
			Range	Median	Average	COV (%)
Site 16	4	4	2.55 % – 10.05 %	3.47 %	4.88 %	71.1 %
Site 17	4	4	1.13 % – 13.93 %	5.91 %	6.72 %	79.0 %
Site 18	4	4	2.20 % – 8.54 %	5.62 %	5.50 %	49.2 %
Site 19	14 ¹	16 ^{1,2}	3.03 % – 11.35 %	4.86 %	5.83 %	40.8 %
Site 21	14 ¹	18 ^{1,2}	4.25 % – 25.95 %	15.81 %	16.70 %	41.3 %
Site 22	14 ¹	15 ¹	2.94 % – 15.15 %	7.56 %	8.25 %	49.7 %
Site 23	6	6	1.33 % – 3.18 %	1.53 %	1.83 %	38.7 %
Site 24	12	12	0.83 % – 2.62 %	1.44 %	1.43 %	31.8 %
Site 25	12	12	1.18 % – 3.29 %	1.45 %	1.79 %	42.8 %

Site ID	No. of Sub-Sites	No. of VMC Tests	Volumetric Water Content (VWC, %)			
			Range	Median	Average	COV (%)
Site 26	12	12	0.87 % – 5.78 %	1.57 %	1.89 %	70.7 %
Site 27	5	5	6.34 % – 16.95 %	12.49 %	12.35 %	32.1 %
Site 28	5	5	7.78 % – 12.53 %	8.39 %	9.14 %	21.1 %
Site 29	5	6 ²	3.81 % – 24.73 %	9.09 %	12.44 %	66.8 %
Full Dataset	111	119^{1,2}	0.83 % – 25.95 %	4.71 %	6.99 %	92.4 %

1 Includes tests completed upon 2 distinct dates, between 1 & 3 days apart

2 Data includes tests multiple tests completed at a single sub-site

All test certificates for the completed *insitu* measurement of site conditions via use of the TEROS 12 sensor – Field Volumetric Water Content (VWC), Soil Temperature and Bulk Electrical Conductivity (EC) – are included as Appendix I of this report.

8.2.4 Repeatability of Test

In order to evaluate the repeatability of the TEROS 12 sensor determination of the *insitu* VMC and variation of the VMC parameter over time, multiple TEROS 12 sensor readings were recorded within the same test area at a total of eight (8) sub-site locations.

Of these repeated tests, four (4) tests were repeated after a period of at least 24 hours had elapsed, and thus the VMC parameter would be expected to have changed. Thus, only four (4) sub-sites had tests repeated within a period testing that should have shown limited moisture content change and can be considered to be representative of the direct repeatability of the TEROS 12 sensor. The variation between these repeated tests was +/- 0.02 % (Site 19-13), +/- 1.13 % (Site 22-8), +/- 2.15 % (Site 29-1) and +2.77 % (Site 19-3) about an average value.

All repeated tests are summarised in Table 8-3, and suggest (for the locations where repeated tests were completed):

- The repeatability of the TEROS 12 was approximately +/- 3%, which represents an 80th Percentile Coefficient of Variation (CoV) of approximately 50%.
- The magnitude of rainfall did not appear to directly influence the variation in TEROS 12 VMC measurements taken multiple days apart, suggesting that the moisture conditioning being undertaken onsite was controlling the *insitu* near-surface moisture condition.

Table 8-3 Variation of repeated Volumetric Water Content assessment via TEROS 12 Sensor at individual test locations

Site ID	Sub-Site ID	Volumetric Water Content (VMC) – As measured by TEROS 12 Sensor				
		Repeated VMC Readings (%)	Change in VMC (%)	Time between Readings (Days)	Rainfall between dates of Testing	CoV (%)
Site 19	19-3	5.82 % / 11.35 %	+5.54 %	0	N/A	45.6 %
	19-13	4.71 % / 4.75 %	+0.04 %	0	N/A	0.7 %
Site 21	21-1	5.82 % / 14.12 %	+8.30 %	2	9.6 mm	58.9 %
	21-2	13.27 % / 17.50 %	+4.23 %	2	9.6 mm	19.4 %
	21-3	13.01 % / 24.26 %	+11.24 %	2	9.6 mm	42.7 %
	21-4	4.25 % / 25.95 %	+21.70 %	2	9.6 mm	101.6 %
Site 22	22-8	14.17 % / 11.90 %	-2.27 %	0	N/A	12.3 %
Site 29	29-1	3.57 % / 7.87 %	+4.29 %	0	N/A	53.1 %

Note this assessment of repeatability has not considered variation in the test result due to the variation in the achieved needle embedment (refer Section 8.2.2).

8.3 Moisture Content Assessment – Comparison of Test Methods

A total of 60 subsites had the same sub-site's field moisture content determined via laboratory testing (oven drying of recovered sample) and *insitu* VMC assessment.

Whereas the laboratory determination of the field moisture content was completed on a disturbed sample that was representative of an entire compacted layer (~275 mm depth), the TEROS 12 Sensor's zone of influence was calculated to be shallower, at approximately 105 mm (refer Section 8.2.1). Accordingly, the field moisture content result should be considered representative of only the upper portion of the compacted layer, and approximately 25% of the full thickness of the compacted layer being considered.

Without any further assessment, and noting that one parameter was a volumetric measurement and the other a gravimetric measurement, the paired data have been compared. Of the dataset ($n = 60$), a total of two (2) outliers were identified. The fitted relationships – both linear and 2nd order polynomial – are defined in Equation 8-1 and 8-2, whilst the data pairs are plotted in Figure 8-3. The correlation coefficient (R^2) relating the two (2) moisture content parameters indicates the presence of a 'weak' relationship.

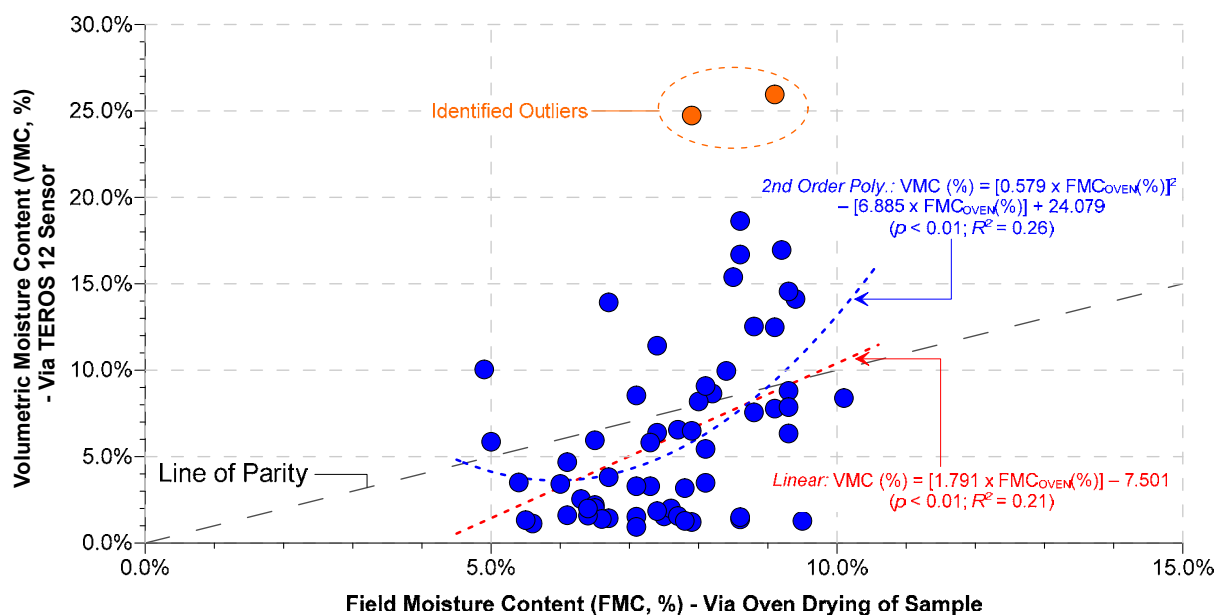


Figure 8-3 Plot of FMC (via oven drying of field sample taken to 275 mm depth) compared to *insitu* VMC as measured by TEROS 12 sensor

$$VMC (\%) = [1.791 \times FMC_{OVEN} (\%)] - 7.501 \quad (p < 0.01; R^2 = 0.21) \quad (\text{Eq. 8-1})$$

$$VMC (\%) = [0.579 \times FMC_{OVEN} (\%)]^2 - [6.885 \times FMC_{OVEN} (\%)] + 24.079 \quad (p < 0.01; R^2 = 0.26) \quad (\text{Eq. 8-2})$$

As per Table 8-4, which summarises the key statistics of the 'paired' data, the variation within the VMC dataset ($CoV = 79.8\%$) is nearly 500% higher than that within the comparable FMC (oven dried) dataset ($CoV = 16.5\%$).

Table 8-4 Comparable statistics for paired dataset of Field Moisture Content ($n = 60$)

Method of FMC determination	Range	Median	Average	Standard Deviation	Coefficient of Variation (%)
Oven Dried (NDG Bulk Samples)	4.9 – 10.1 %	7.7 %	7.6 %	1.25 %	16.5 %
TEROS 12 (<i>insitu</i> sensor)	0.9 – 18.6 %	5.1 %	6.1 %	4.85 %	79.8 %

As per previous assessments using the TEROS 12 sensor, the derived relationship has not considered the variability likely present within the VMC parameter arising due to the variation in the achieved needle embedment.



9. Correlation with Density Test Results

9.1 Introduction

In order to be accepted as an 'equivalent' test for QA purposes, it is often mentioned that the results of any alternative QA test method must demonstrate a high level of correlation with *insitu* density testing (the current 'accepted' method of earthworks QA). However, the authors consider this approach to be profoundly flawed, in that density tests were originally (1930's / 40's) identified as a simplified, quasi-method for field evaluation / verification of design parameters – namely strength and / or stiffness parameters – whilst the newer, innovative test methods directly measure the design parameters in the *insitu* (compacted) setting. Thus, the requirement to demonstrate strong correlation between the direct measure of a design parameter (i.e. one aims of implementing a QA regime) back to a test result that is only a quasi-approximation of the design parameter appears to misplace the identification of the 'reference' value to the density test. Instead, the reference parameter should be to an accepted (and standardised) *insitu* measure of the design parameter – for example, a static Plate Load Test (PLT) for the *insitu* measurement of deformation (modulus) parameters.

The Phase 2 analysis repeatedly showed density was poorly correlated with the other tests carried out. This was either a low R^2 value but often a negative correlation i.e. as density increased the modulus decreased. This is counter intuitive and suggested that direct paired bivariate analysis may be meaningless. However, unlike the Phase 2 sites when several sites were tested, this Phase 2 was on one uniform material.

Due to the current, albeit mistaken, approach that density is the standard to which direct, *insitu* modulus or strength measurements are compared, there is also a frequently applied assumption that any lack of correlation between the two (2) fundamentally different test techniques is due to the inaccuracy or insensitivity of the alternative test method. This again should be considered on a case by case basis, and the assessor contemplate if the observed departures between the two (2) test types is due to the limitations of the density assessment or alternative QA method being considered.

Within the context of this report, the assessment of test acceptability is completed by (i) initially comparing the results of the alternative QA method directly with the results of side-by-side density testing; and (ii) subsequently repeating the exercise by direct comparison of the results of the modulus parameters arising from the various instruments under consideration (both with each other and with the results of the industry accepted measure of *insitu* modulus, the static Plate Load Test). From this approach, it was expected that the following outcomes could occur:

- If the results of density testing do reflect the achieved modulus parameter AND the alternative QA methods do appropriately measure *insitu* modulus parameter – then correlations of practical strength would arise in both phases (i) – correlation to density – and Phase (ii) of the analysis.
- If the results of density testing do not reflect the achieved modulus parameter BUT the alternative QA methods do appropriately measure the *insitu* modulus parameter – then correlations of practical strength would arise in only Phase (ii) of the analysis (i.e. correlation amongst the results reported by some of the plate-based tests under consideration).
- If the results of density testing do reflect the achieved modulus parameter BUT the alternative QA methods do not appropriately measure the *insitu* modulus parameter – then the only correlation of practical strength would be expected to be between the PLT and NDG test results.
- If all tests do not appropriately measure the *insitu* modulus parameter – then no test type should correlate with any other, either in Phase (i) or (ii) of the analysis.

This chapter of the Phase 3 report details the relevant datasets and analysis that have been compiled in order to assess the relationship (or lack thereof) between the results of *insitu* density tests (from NDG testing for this project site) and the alternative QA methods being evaluated.

9.2 Assessment of Derived Relationships

For each constructed dataset, a paired sample *t*-test was performed to determine whether observed differences between test results were statistically significant. In interpreting these results, a two-tailed alpha level cut-off of .05 was adopted (i.e. $p < .05$), whereby the chance of finding a significant relationship between the paired test values due to sampling error or random chance (known as a type I error) is 5%.

The objective of the paired parameter studies was to investigate and demonstrate a relationship between the *insitu* density parameter and the parameters arising from the alternative QA test. Any demonstrated correlation should demonstrate statistical significance (i.e. $p < .05$) between the data pairs. Accordingly, if a statistically insignificant relationship was demonstrated – regardless of the calculated strength of the relationship – this was interpreted to suggest that the two (2) datasets that comprised the data pairs (density & alternative QA test parameter) were not directly comparable.

Non-parametric correlation analyses were used to determine the strength of the correlation between the fitted relationship of the paired parameter datasets. The strength of correlation between comparable parameters was defined by the calculated correlation coefficient (R^2). As there was no assumption that the any data pairs would necessarily display a normal distribution or linear relationship, R^2 values based on both the determined Pearson's R (for normally distributed data and linear relationship) and Spearman's ρ (for non-normally distributed data) were calculated.

As defined in Dancey and Reidy (2004), the strength of correlation was then categorised by the resultant R^2 value. The categorisation of the strength of the relationship between the density and alternative QA test result, as fitted by the regression analysis, was assessed in accordance with Table 9-1.

Table 9-1 Categorisation of strength of correlation based on correlation coefficient (R^2)

Correlation Coefficient (R^2) Value	Strength of Correlation
$R^2 \geq 0.7$	Strong Correlation
$0.3 \leq R^2 < 0.7$	Moderate Correlation
$0.1 \leq R^2 < 0.3$	Weak Correlation
$R^2 < 0.1$	Trivial (No Correlation)

In summary, the relationships between paired datasets were assessed to be strongest when statistical significance was determined to exist between the defined correlation (i.e. $p < .05$) and the correlation coefficient (R^2) was closest to 1.0.

It is noted that for acceptance in many international earthworks QA specifications that an alternative test technique may be accepted in lieu of traditional QA testing if the strength of the demonstrated data pairing reports $R \geq 0.7$ (i.e. $R^2 \geq 0.5$).

9.3 Density vs. Static Plate Load Test (PLT)

9.3.1 Available Datasets

The Phase 2 testing showed the PLT to be the most correlated test with the other tests carried out. This test was therefore examined in more detail for this Phase 3.

Data relating to PLT and Density tests completed at side-by-side locations were extracted from the available datasets and paired together (along with moisture content data recovered from the provided QA (density) test certificates). After inspection of the data for outliers, a total of 10 or 11 data pairs were available for comparison (a single PLT data record was rejected, for the second loading cycle only, due to unrealistic low settlement measurements). Figure 9-1 plots an example of the available dataset, with the reloading strain modulus parameter (E_{v2} , calculated for a 500 kPa imparted test stress) plotted against the reported RDD of the *insitu* material.

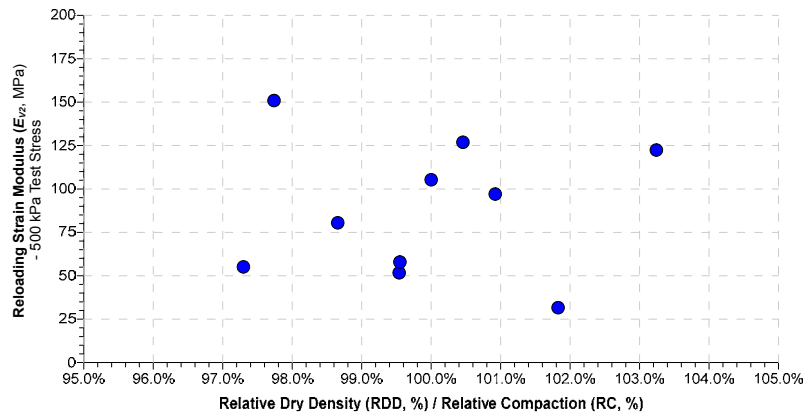


Figure 9-1 Example of Paired Dataset for PLT and Density test result correlation – Density (RDD) and E_{v2} (at 500 kPa test stress) is presented in figure ($n = 10$)

As the results of the PLT provided a series of modulus parameters – refer Section 7.2 – there existed a series of similar datasets available for assessment. The variables considered in the PLT vs. Density correlation assessment are summarised in Table 9-2.

Table 9-2 Summary of available parameters for correlation between Density and PLT derived modulus

Density Test Results	Moisture Content Test Results	Modulus Parameter – from static PLT Tests
- Field Dry Density (t/m^3) - Adjusted Maximum Dry Density (MDD, t/m^3) - Relative Dry Density (RDD, %)	- Field Moisture Content (FMC, %) - Moisture Ratio (MR, %)	- Subgrade Reaction Modulus (K_{30}) – Initial Loading Cycle (MN/m^3) - Subgrade Reaction Modulus (K_{30}) – Re-Loading Cycle (MN/m^3) - Secant Modulus – Initial Loading Cycle (E_{s1}, MPa) - Under 100 kPa Stress ($E_{s1-100kPa}$, MPa) - Under 200 kPa Stress ($E_{s1-200kPa}$, MPa) - Under 300 kPa Stress ($E_{s1-300kPa}$, MPa) - Under 400 kPa Stress ($E_{s1-400kPa}$, MPa) - Under 500 kPa Stress ($E_{s1-500kPa}$, MPa) - Secant Modulus – Re-Loading Cycle (E_{s2}, MPa) - Under 100 kPa Stress ($E_{s2-100kPa}$, MPa) - Under 200 kPa Stress ($E_{s2-200kPa}$, MPa) - Under 300 kPa Stress ($E_{s2-300kPa}$, MPa) - Under 400 kPa Stress ($E_{s2-400kPa}$, MPa) - Under 500 kPa Stress ($E_{s2-500kPa}$, MPa) - Strain Modulus – Initial Loading Cycle (E_{v1}, MPa) - Under 100 kPa Stress ($E_{v1-100kPa}$, MPa) - Under 200 kPa Stress ($E_{v1-200kPa}$, MPa) - Under 300 kPa Stress ($E_{v1-300kPa}$, MPa) - Under 400 kPa Stress ($E_{v1-400kPa}$, MPa) - Under 500 kPa Stress ($E_{v1-500kPa}$, MPa) - Strain Modulus – Re-Loading Cycle (E_{v2}, MPa) - Under 100 kPa Stress ($E_{v2-100kPa}$, MPa) - Under 200 kPa Stress ($E_{v2-200kPa}$, MPa) - Under 300 kPa Stress ($E_{v2-300kPa}$, MPa) - Under 400 kPa Stress ($E_{v2-400kPa}$, MPa) - Under 500 kPa Stress ($E_{v2-500kPa}$, MPa)

9.3.2 Single Variable Correlation

Direct correlation between the strain modulus parameters (E_{v1} and E_{v2}) derived from the PLT with the various density measurements yielded no significant correlations, or relationships with anything greater than a ‘co-incidental’ or ‘trivial’ strength (i.e. $p > 0.05$ & $R^2 < 0.2$ for all assessments). This included the use of three (3) density measurements (FDD, MDD, RDD) and strain modulus parameters for five (5) test stress magnitudes, producing a total of 30 attempted correlations. The resultant R^2 values from this initial curve fitting are summarised in Table 9-3.

Table 9-3 Strength of direct correlation between Strain Modulus (E_v) and Density parameters (R^2 values)

Test Stress (for modulus parameters)	Initial Loading Cycle			Reloading Cycle		
	E_{v1} vs. FDD	E_{v1} vs. MDD	E_{v1} vs. RDD	E_{v2} vs. FDD	E_{v2} vs. MDD	E_{v2} vs. RDD
100 kPa	$R^2 = 0.00$	$R^2 = 0.09$	$R^2 = 0.03$	$R^2 = 0.05$	$R^2 = 0.07$	$R^2 = 0.02$
200 kPa	$R^2 = 0.00$	$R^2 = 0.07$	$R^2 = 0.02$	$R^2 = 0.03$	$R^2 = 0.06$	$R^2 = 0.02$
300 kPa	$R^2 = 0.00$	$R^2 = 0.06$	$R^2 = 0.02$	$R^2 = 0.01$	$R^2 = 0.05$	$R^2 = 0.05$
400 kPa	$R^2 = 0.00$	$R^2 = 0.05$	$R^2 = 0.02$	$R^2 = 0.00$	$R^2 = 0.04$	$R^2 = 0.05$
500 kPa	$R^2 = 0.00$	$R^2 = 0.03$	$R^2 = 0.02$	$R^2 = 0.01$	$R^2 = 0.02$	$R^2 = 0.07$

A similar result was observed when the use of the secant modulus parameter (E_{S1} and E_{S2}) was adopted as the independent variable for the correlation with density measurements. As summarised in Table 9-4, although the magnitude of the calculated R^2 improved in comparison to the strain modulus assessment, the maximum correlation coefficient magnitude ($R^2 = 0.14$) still indicated the correlation would be considered 'weak'.

All p values indicated the correlations were non-significant, supporting the lack of identifiable direct relationship between a PLT derived modulus and a measure of *insitu* density or compaction.

Table 9-4 Strength of direct correlation between Secant Modulus (E_s) and Density parameters (R^2 values)

Test Stress (for modulus parameters)	Initial Loading Cycle			Reloading Cycle		
	E_{S1} vs. FDD	E_{S1} vs. MDD	E_{S1} vs. RDD	E_{S2} vs. FDD	E_{S2} vs. MDD	E_{S2} vs. RDD
100 kPa	Not Assessed	$R^2 = 0.11$	Not Assessed	Not Assessed	Not Assessed	$R^2 = 0.14$
200 kPa		$R^2 = 0.08$				$R^2 = 0.10$
300 kPa		$R^2 = 0.06$				$R^2 = 0.05$
400 kPa		$R^2 = 0.05$				$R^2 = 0.05$
500 kPa		$R^2 = 0.03$				$R^2 = 0.01$

9.3.3 Multi-Variate Correlation (inclusion of Moisture Content parameter)

Multiple variate regression that incorporated the variation in the moisture content (as measured at the time of density testing) was also completed for modulus parameter to density correlation. Both the Field Moisture Content (FMC) and Moisture Ratio (MR) term was evaluated via such a technique, with the use of the FMC term observed to provide the stronger relationship (i.e. higher R^2) in the majority of assessments.

The use of linear multiple regression analysis, as summarised in Table 9-5, demonstrates an improvement in the reported correlation strength; R^2 increases by at least 100% when compared to the same correlation that doesn't incorporate a moisture parameter. However, the strength of the relationship still typically remains predominantly 'trivial' or 'weak' and no statistical significance of any potential relationship, or even individual independent parameter, was identified ($p > 0.05$ in all scenarios evaluated).

Table 9-5 Strength of multiple linear correlation assessments between Strain Modulus (E_v), moisture content and Density parameters (R^2 values)

Test Stress (for modulus parameters)	Initial Loading Cycle (Dependent Variable = E_{v1})			Reloading Cycle (Dependent Variable = E_{v2})		
	Field Dry Density	Maximum Dry Density	Relative Dry Density	Field Dry Density	Maximum Dry Density	Relative Dry Density
100 kPa	$R^2 = 0.04$	$R^2 = 0.17$	$R^2 = 0.13$ (FMC*)	$R^2 = 0.32$	$R^2 = 0.27$	$R^2 = 0.14$
200 kPa	$R^2 = 0.05$	$R^2 = 0.16$	$R^2 = 0.12$ (FMC)	$R^2 = 0.25$	$R^2 = 0.24$	$R^2 = 0.13$
300 kPa	$R^2 = 0.05$	$R^2 = 0.14$	$R^2 = 0.12$ (FMC)	$R^2 = 0.17$	$R^2 = 0.20$	$R^2 = 0.12$

Test Stress (for modulus parameters)	Initial Loading Cycle (Dependent Variable = E_{v1})			Reloading Cycle (Dependent Variable = E_{v2})		
	Field Dry Density	Maximum Dry Density	Relative Dry Density	Field Dry Density	Maximum Dry Density	Relative Dry Density
400 kPa	$R^2 = 0.05$	$R^2 = 0.12$	$R^2 = 0.11$	$R^2 = 0.11$	$R^2 = 0.16$	$R^2 = 0.11$
500 kPa	$R^2 = 0.06$	$R^2 = 0.11$	$R^2 = 0.11$ (FMC)	$R^2 = 0.09$ (FMC)	$R^2 = 0.12$ (FMC)	$R^2 = 0.11$ (FMC)

* Moisture Ratio (MR) provides higher R^2 value, except where indicated (FMC = Field Moisture Content)

An identical multi-variate assessment was completed that adopted the secant modulus parameter (E_{s1} and E_{s2}) as the dependent variable. In all cases, the use of the MR parameter yielded a marginally higher strength relationship than that determined using the FMC parameter; on average by a value of +0.04. As summarised in Table 9-6, a marginal improvement in the R^2 value was observed for the relationships that adopted E_{s1} when compared to the direct density-PLT modulus relationship.

A much larger improvement – of between 2.4 to 12 times greater – was observed for the RDD values that incorporated the moisture ratio into the analysis. The highest strength relationship for all considered scenarios was observed when the RDD and MR parameters were combined and compared to the $E_{s2-200 \text{ kPa}}$ modulus parameter ($R^2 = 0.45$, representing a ‘moderate’ strength relationship). However, as per other analyses, the test of significance still indicated the correlations were non-significant (min. p value = 0.126), and thus all correlations were not considered to demonstrate an acceptable relationship between the PLT derived Secant Modulus and density parameters.

Table 9-6 Strength of multiple linear correlation assessments between Secant Modulus (E_s), moisture content and Density parameters (R^2 values)

Test Stress (for modulus parameters)	Initial Loading Cycle (Dependent Variable = E_{s1})			Reloading Cycle (Dependent Variable = E_{s2})		
	Field Dry Density	Maximum Dry Density	Relative Dry Density	Field Dry Density	Maximum Dry Density	Relative Dry Density
100 kPa	Not Assessed	$R^2 = 0.19$	Not Assessed	Not Assessed	Not Assessed	$R^2 = 0.33$
200 kPa		$R^2 = 0.15$				$R^2 = 0.45$
300 kPa		$R^2 = 0.13$				$R^2 = 0.30$
400 kPa		$R^2 = 0.12$				$R^2 = 0.30$
500 kPa		$R^2 = 0.10$				$R^2 = 0.16$

* Moisture Ratio (MR) provides higher R^2 value in all considered scenarios

Multi-variable quadratic regression was also undertaken upon select datasets to relate *insitu* modulus to equivalent density tests. Datasets were selected based on the reported strength of the linear regression analysis. As demonstrated in Table 9-7, the benefit to the calculated strength of the relationship was determined to be minimal via the inclusion of higher order polynomial terms. Conversely, all tested correlations again failed to reach the required significance level; and although not a true measure for evaluation, the calculated p value was observed to have increased when the fitted two variable quadratic function was compared to the corresponding value calculated for the linear multivariate relationship.

Table 9-7 Significance and Strength of Correlations arising from Multi-variable Quadratic Analysis of paired PLT vs. Density Test results

Test Stress (for modulus parameters)	Initial Loading Cycle (Dependent Variable = E_{v1} or E_{s1})			Reloading Cycle (Dependent Variable = E_{v2} or E_{s2})		
	Variables Considered	Significance (p value)	Correlation Coefficient (R^2)	Variables Considered	Significance (p value)	Correlation Coefficient (R^2)
100 kPa	E_{v1} , MDD, MR	0.83 (+0.36*)	0.20 (+0.03*)	E_{v2} , MDD, MR	0.53 (+0.28)	0.36 (+0.02)
	E_{s1} , MDD, MR	0.80 (+0.37)	0.21 (+0.02)	E_{s2} , RDD, MR	0.43 (+0.13)	0.55 (+0.21)
200 kPa	E_{v1} , MDD, MR	0.84 (+0.34)	0.18 (+0.03)	E_{v2} , MDD, MR	0.76 (+0.37)	0.27 (+0.03)
	E_{s1} , MDD, MR	0.83 (+0.32)	0.19 (+0.04)	E_{s2} , RDD, MR	0.39 (+0.27)	0.51 (+0.05)
300 kPa	E_{v1} , MDD, MR	0.86 (+0.32)	0.17 (+0.03)	E_{v2} , MDD, MR	0.84 (+0.39)	0.22 (+0.01)

Test Stress (for modulus parameters)	Initial Loading Cycle (Dependent Variable = E_{v1} or E_{s1})			Reloading Cycle (Dependent Variable = E_{v2} or E_{s2})		
	Variables Considered	Significance (p value)	Correlation Coefficient (R^2)	Variables Considered	Significance (p value)	Correlation Coefficient (R^2)
	E_{s1} , MDD, MR	0.86 (+0.30)	0.17 (+0.04)	E_{s2} , RDD, MR	0.55 (+0.27)	0.40 (+0.10)
400 kPa	E_{v1} , MDD, MR	0.88 (+0.29)	0.16 (+0.04)	E_{v2} , MDD, MR	0.90 (+0.35)	0.16 (+0.01)
	E_{s1} , MDD, MR	0.87 (+0.30)	0.16 (+0.04)	E_{s2} , RDD, MR	0.70 (+0.20)	0.31 (+0.13)
500 kPa	E_{v1} , MDD, MR	0.89 (+0.26)	0.15 (+0.04)	E_{v2} , MDD, MR	0.94 (+0.26)	0.12 (+0.02)
	E_{s1} , MDD, MR	0.87 (+0.24)	0.15 (+0.05)	E_{s2} , RDD, MR	0.73 (+0.19)	0.29 (+0.13)

* Bracketed values represent change from corresponding multi-variate linear regression output.

Although not deemed to be statistically significant, the best fit function to relate the results of density testing to PLT derived modulus was considered to be for the reloading Secant Modulus parameter, derived under 200 kPa test stress ($E_{S2-200 \text{ kPa}}$) in the following form:

$$E_{S2-200 \text{ kPa}} (\text{MPa}) = 1195.1 \times \text{RDD}(\%) + 181.4 \times \text{MR}(\%) - 1287.1$$

$$(p = 0.12; R^2 = 0.45) \quad (\text{Eq. 8-1})$$

9.3.4 Interpretation and Conclusions

Based on the results of the attempted correlation, no rational relationship that displayed sufficient statistical significance was identified to exist between the results of density testing and any of the modulus parameters derived from the PLT testing. This result was consistently observed regardless of (i) which aspect of the density test was adopted;

(ii) the absence or inclusion of a parameter to account for the moisture state of the soil; or

(iii) the test stress to which the modulus parameter was resolved.

This result indicates that the PLT derived modulus parameters are not dependent on the density or moisture content measures considered.

The lack of correlation was also evident the non-significant R^2 values calculated for each element of the attempted multivariate correlations. In all such fitted relationships the p value remained outside the defined level of significance, identifying that there was no confirmation that an individual term – either density or moisture content – was required to be included within the constructed models (i.e. each density and moisture content term continually demonstrated no discernible relationship to the PLT derived modulus parameters).

Accordingly, no demonstratable relationship was identified to exist between the PLT and Density test results for the trial embankment earthworks used as the Phase 3 fieldwork site. This is an extremely important result, in that it demonstrates the rationale by which density testing is routinely adopted as the standard measure for QA specifications – that it directly reflects the *insitu* stiffness of the earthworks and thus is a quasi-measurement to predict the earthworks will perform in accordance with design expectations once loaded – does not hold true for this site.

To illustrate the disconnect between an acceptable relationship between PLT derived modulus values and measurements arising from density testing within the Phase 3 project, Figure 9-2 plots the calculated significance measure (p value) and correlation co-efficient (R^2).

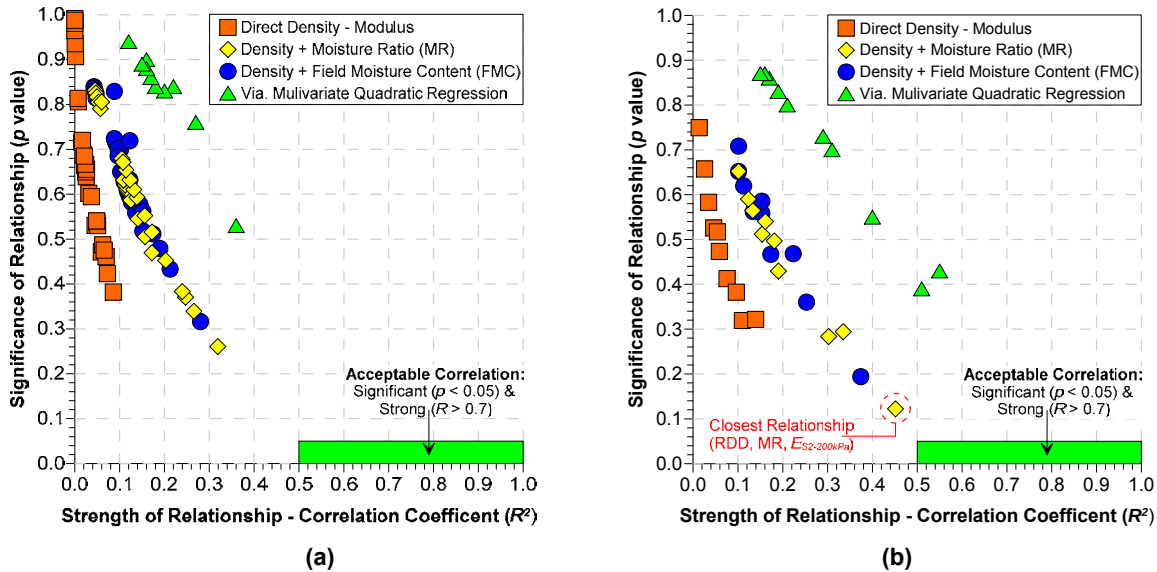


Figure 9-2 Plots demonstrating reported significance (p value) and strength (R^2) of attempted correlations between density, moisture content and PLT derived modulus; (a) using Strain Modulus (E_v); and (b) using Secant Modulus (E_s) as dependent parameter.

No assessed relationship reported a value that even approached either of the criteria required for an acceptable relationship ($p < 0.05$ and $R^2 > 0.5$). However, the calculated strength (R^2) of the relationship between the modulus and the density parameters were observed to be higher for the lower stress scenarios and the p comparatively lowest for the same results (i.e. lower stress scenarios were closest to providing statistically relevant relationships). Similarly, the use of the Secant Modulus (E_s) parameter appeared to provide correlations that reported comparatively higher R^2 and lower p values (although still not indicative of a significant correlation), in comparison to correlations that adopted the Strain Modulus parameters (E_v).

9.4 Density vs. Prima 100 LWD

9.4.1 Available Datasets

Paired data arising from side-by-side Prima 100 LWD and Density tests were extracted from the available datasets. After inspection of the data for outliers, a total of 79 data pairs were available for direct comparison. Figure 9-3 plots an example of the available dataset, with the standardised *insitu* (composite) modulus at 100 kPa test stress parameter, $E_{LWD-100kPa}$, plotted against the reported RDD of the *insitu* material.

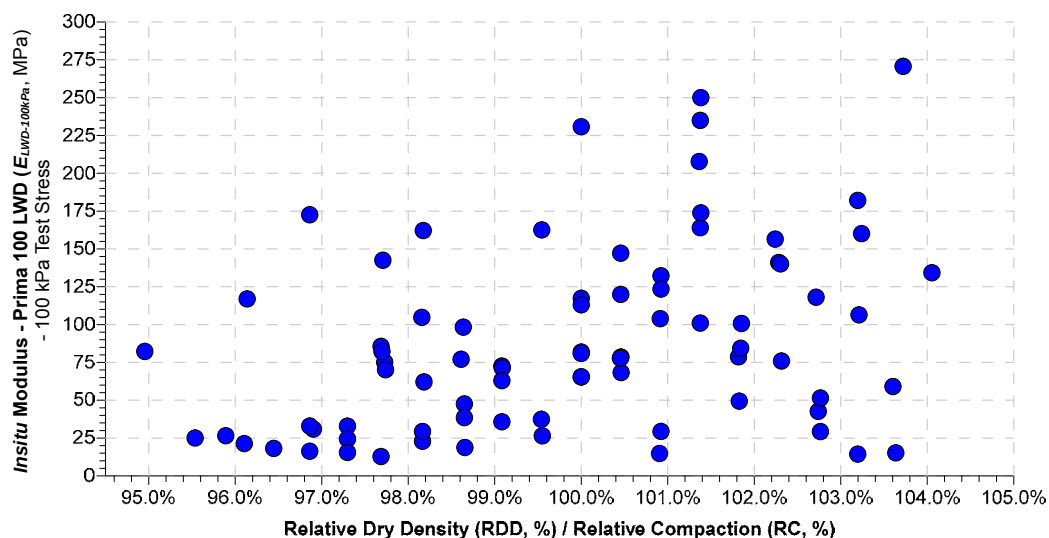


Figure 9-3 Example of Paired Dataset for Prima 100 LWD and Density test result correlation – Density (RDD) and E_{LWD} (at 100 kPa test stress) is presented in figure ($n = 79$)

The moisture condition of the tested surface has been primarily taken from the FMC parameter stated in the associated density test report (refer Section 8.1). For comparative purposes, correlations were also been attempted utilising the results of the VMC measurement made by the TEROS 12 probe (refer Section 8.2), although the availability of the VMC measurement resulted in the use of a markedly smaller paired dataset ($n = 61$).

Table 9-8 summaries the variables considered in the Density vs. Prima 100 LWD correlation assessment.

Table 9-8 Summary of parameters incorporated into correlation between Density and Prima 100 LWD derived modulus

Density Test Results	Moisture Content Test Results	Modulus Parameter – from Prima 100 LWD Tests
- Field Dry Density (t/m^3) - Adjusted Maximum Dry Density (MDD, t/m^3) - Relative Dry Density (RDD, %)	- Field Moisture Content (FMC, %) - Moisture Ratio (MR, %) - Volumetric Moisture Content (VMC, %)	<i>Insitu</i> Modulus under 50 kPa test stress ($E_{LWD-50kPa}$) <i>Insitu</i> Modulus under 100 kPa test stress ($E_{LWD-100kPa}$)

9.4.2 Single Variable Correlation

Direct correlation between the Prima 100 LWD derived composite modulus parameters and the various density measurements were undertaken, with the best-fit single variable relationships summarised in Table 9-9. Typically, linear and 2nd order polynomial equations were found to provide the correlations of highest strength for the constructed datasets across the ranges of paired data. Although the relationships were found to be significantly significant when the MDD or RDD parameter was used for correlation with the *insitu* modulus ($p < 0.05$), the strength of each correlation was, at best, 'weak' ($0.1 \leq R^2 < 0.2$ for all assessments using RDD). All other attempted direct correlations were of 'trivial' strength and not significantly significant. It was further observed that the relationships derived using the MDD parameter were negative across the range of values analysed (i.e. LWD derived modulus reduced as MDD increased).

Table 9-9 Definition and Strength of direct correlation between Prima 100 LWD and Density parameters

Density Parameter Adopted	Insitu Modulus under 50 kPa Test Stress		Insitu Modulus under 100 kPa Test Stress	
	Defined Relationship	Strength	Defined Relationship	Strength
Field Dry Density (t/m^3 , FDD)	$E_{LWD-50kPa} = 306.32 \times FDD(t/m^3) - 568.68$	$R^2 = 0.04$ $p = 0.07$	$E_{LWD-100kPa} = 276.67 \times FDD(t/m^3) - 517.67$	$R^2 = 0.04$ $p = 0.06$
	$E_{LWD-50kPa} = -1511.7 \times FDD(t/m^3)^2 + 6940.67 \times FDD(t/m^3) - 7844.47$	$R^2 = 0.05$ $p = 0.16$	$E_{LWD-100kPa} = -1457.59 \times FDD(t/m^3)^2 + 6673.82 \times FDD(t/m^3) - 1457.59$	$R^2 = 0.05$ $p = 0.15$
Adjusted Maximum Dry Density (t/m^3 , MDD)	$E_{LWD-50kPa} = -685.07 \times RDD(\%) + 1606.02$	$R^2 = 0.10$ $p < 0.01$	$E_{LWD-100kPa} = -558.51 \times RDD(\%) + 1314.44$	$R^2 = 0.08$ $p < 0.01$
	$E_{LWD-50kPa} = 7808.76 \times MDD(t/m^3)^2 - 35403.74 \times MDD(t/m^3) + 40182.77$	$R^2 = 0.14$ $p < 0.01$	$E_{LWD-100kPa} = 6636.37 \times MDD(t/m^3)^2 - 30059.18 \times MDD(t/m^3) + 34087.72$	$R^2 = 0.12$ $p < 0.01$
Relative Dry Density (%), RDD)	$E_{LWD-50kPa} = 11.45 \times RDD(\%) - 1041.27$	$R^2 = 0.15$ $p < 0.01$	$E_{LWD-100kPa} = 9.95 \times RDD(\%) - 905.49$	$R^2 = 0.14$ $p < 0.01$
	$E_{LWD-50kPa} = -0.27 \times RDD(\%)^2 + 64.71 \times RDD(\%) - 3697.58$	$R^2 = 0.15$ $p < 0.01$	$E_{LWD-100kPa} = -0.73 \times RDD(\%)^2 + 154.86 \times RDD(\%) - 8131.16$	$R^2 = 0.14$ $p < 0.01$

9.4.3 Multi-Variate Correlation (inclusion of Moisture Content parameter)

As per the methodology described for the PLT correlation to the Density test parameters, multiple variate regression that incorporated a moisture content parameter was completed for the Prima 100 LWD derived modulus parameter correlation to density results. As presented in Table 9-10, the use of the Field Moisture Content (FMC) or Moisture Ratio (MR) – as measured at the time of density testing – within multi-variate regression demonstrated minor improvements in the strength of the produced correlations in comparison to the single variable assessment. Although reporting no better than a 'weak'

relationship, the returned correlations demonstrated the *insitu* modulus parameter improved as the compaction ratio (RDD) increased and the soil moisture condition decreased. This result is in line with traditional expectations, as the higher the achieved compaction level (i.e. RDD) would result in a lower volume of voids present within the material's particle arrangement and thus the lower the comparable deformation (i.e. modulus) observed under a standardised loading scenario.

Also undertaken was a comparative analysis that utilised the VMC result for each test's moisture condition, as measured by the TEROS12 probe. As presented in Table 9-10, the strength of correlation reported by such relationships were not as strong as those derived using the (traditional) moisture conditions determined by laboratory testing of field recovered samples. Similarly, as the either the full correlation (with FDD) for the individual VMC factor (for MDD and RDD) were not considered to be statistically significant within the developed correlations, no further assessment using the VMC data has been attempted.

Table 9-10 Strength of multiple linear correlation assessments between Prima 100 LWD modulus, moisture content and Density parameters

Moisture Parameter	Insitu Modulus under 50 kPa Test Stress (Dependent Variable = $E_{LWD-50kPa}$)			Insitu Modulus under 100 kPa Test Stress (Dependent Variable = $E_{LWD-100kPa}$)		
	Field Dry Density (FDD)	Maximum Dry Density (MDD)	Relative Dry Density (RDD)	Field Dry Density (FDD)	Maximum Dry Density (MDD)	Relative Dry Density (RDD)
Field Moisture Content (FMC) ($n = 79$)	$R^2 = 0.14$ ($p < 0.01$)	$R^2 = 0.27$ ($p < 0.01$)	$R^2 = 0.21$ ($p < 0.01$)	$R^2 = 0.13$ ($p < 0.01$)	$R^2 = 0.22$ ($p < 0.01$)	$R^2 = 0.19$ ($p < 0.01$)
Moisture Ratio (MR) ($n = 79$)	$R^2 = 0.15$ ($p < 0.01$)	$R^2 = 0.28$ ($p < 0.01$)	$R^2 = 0.22$ ($p < 0.01$)	$R^2 = 0.14$ ($p < 0.01$)	$R^2 = 0.24$ ($p < 0.01$)	$R^2 = 0.21$ ($p < 0.01$)
Volumetric Moisture Content (VMC) ($n = 61$)	$R^2 = 0.08$ ($p = 0.10$)	$R^2 = 0.18$ ($p < 0.01$)*	$R^2 = 0.20$ ($p < 0.01$)*	$R^2 = 0.07$ ($p = 0.11$)	$R^2 = 0.14$ ($p < 0.05$)*	$R^2 = 0.17$ ($p < 0.01$)*

* VMC factor remains non-significant ($p > 0.05$)

As identified in Table 9-10, the correlations presenting the highest strength ('weak') relationships were achieved adopting the Moisture Ratio (MR) and $E_{LWD-50kPa}$ parameter. Equation 8-2 and 8-3 present the formulas of these correlations when using the MDD and RDD density parameters respectively:

$$E_{LWD-50kPa} \text{ (MPa)} = -1.80 \times \text{MDD}(\text{t/m}^3) - 791.01 \times \text{MR}(\%) + 2003.93$$

$$(p < 0.01; R^2 = 0.28) \quad (\text{Eq. 8-2})$$

$$E_{LWD-50kPa} \text{ (MPa)} = -1.22 \times \text{RDD}(\%) + 8.97 \times \text{MR}(\%) - 682.40$$

$$(p < 0.01; R^2 = 0.22) \quad (\text{Eq. 8-3})$$

A marginal further improvement in the strength of the correlation was achieved with the use of multi-variable quadratic regression when the MDD density term was adopted. No similar improvement was observed when the FDD and RDD parameters was adopted. In addition, in order to achieve statistical significance of each element within the defined correlation, the exclusion of up to two (2) terms within the proposed quadratic was undertaken, as summarised in Table 9-11 for correlations using the MDD and RDD density terms. The strength of the correlation improves to a maximum of $R^2 = 0.34$ when multiple quadratic functions are assessed, corresponding to a 'moderate' strength relationship between a density parameter (MDD) and a Prima 100 derived modulus parameter (in this case $E_{LWD-50kPa}$).

Table 9-11 Results of multiple variable quadratic correlation assessments between Prima 100 LWD modulus, moisture content and Density parameters

Density Parameter Adopted	Insitu Modulus under 50 kPa Test Stress		Insitu Modulus under 100 kPa Test Stress	
	Defined Relationship (Multi-Variate Quadratic Regression)	Strength	Defined Relationship (Multi-Variate Quadratic Regression)	Strength
Adjusted Maximum Dry Density (t/m^3 , MDD)	$E_{LWD-50kPa} = 9592.84 \times MDD(t/m^3)^2 - 43437.47 \times MDD(t/m^3) - 1.93 \times MR(\%) + 49396.59$	$R^2 = 0.34$ $p < 0.01$	$E_{LWD-100kPa} = 7974.78 \times MDD(t/m^3)^2 - 36065.54 \times MDD(t/m^3) - 1.65 \times MR(\%) + 40973.23$	$R^2 = 0.29$ $p < 0.01$
Relative Dry Density (% , RDD)	$E_{LWD-50kPa} = 9.13 \times RDD(\%) - 0.007 \times MR(\%)^2 - 752.78$	$R^2 = 0.22$ $p < 0.01$	$E_{LWD-100kPa} = 7.57 \times RDD(\%) - 0.006 \times MR(\%)^2 - 615.35$	$R^2 = 0.21$ $p < 0.01$

9.4.4 Interpretations and Conclusions

Figure 9-4 plots the comparable maximum strength (R^2) of the Prima 100 LWD to density parameter correlations calculated using the various single (direct E_{LWD} to density) and multi-variate (E_{LWD} , density and moisture condition) regressions types. As presented in this figure, the use of multi-variate regression and the inclusion of a moisture condition factor results in the effective doubling of the strength of the developed correlation.

Although found to be statistically significant correlations ($p < 0.01$ in most cases), the strength (R^2) of each attempted correlation remained below the threshold for an acceptable, 'strong' relationship (i.e. R^2 remained below 0.5). Even with the incorporation of moisture content variation within correlations, which was shown to be a significant factor in the developed correlations, most relationships reported only 'weak' correlation ($R^2 < 0.3$) between density and *insitu* modulus.

As such, **no demonstrable relationship of sufficient strength was identified to exist between the Prima 100 LWD's *insitu* modulus parameters and the results of (traditional) Density testing completed upon the trial embankment earthworks used as the Phase 3 fieldwork site.**

In line with the conclusions made with the inability to correlate the results of density tests with PLT derived modulus parameters, this result infers that adopting density testing for QA purposes does not directly ensure that a design modulus parameter would be met *insitu*.

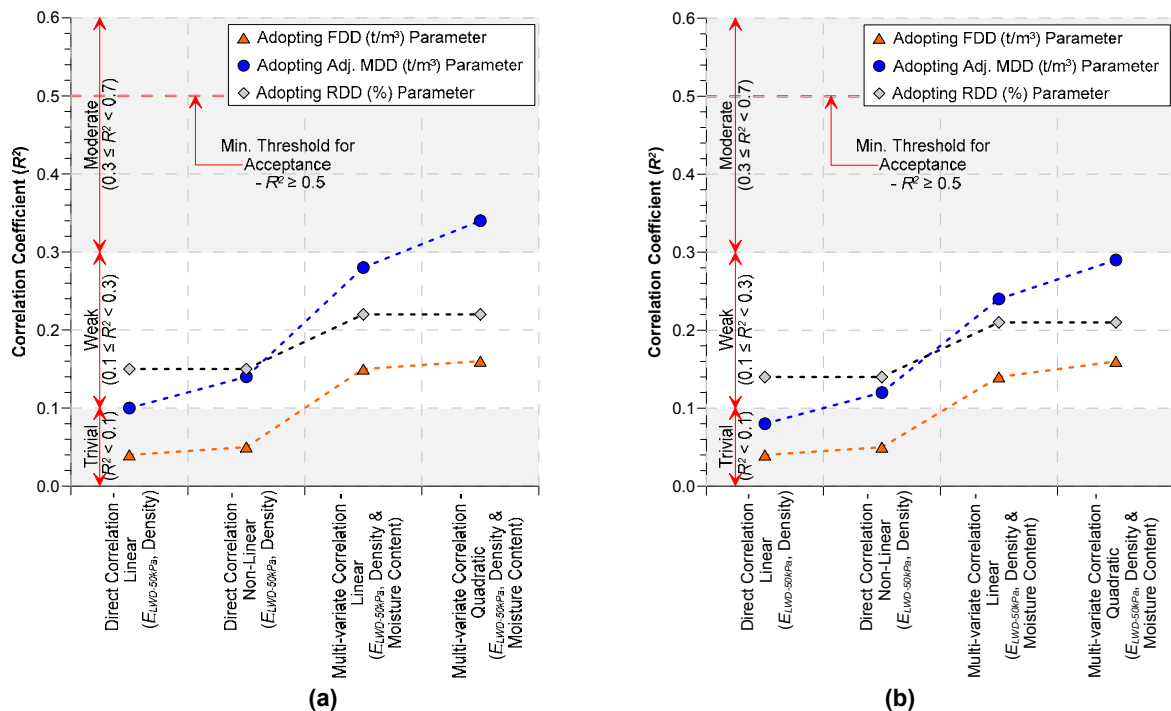


Figure 9-4 Plots demonstrating maximum reported strength (R^2) of various attempted correlations between density, moisture content and Prima 100 LWD derived modulus; (a) using $E_{LWD-50kPa}$ parameter; and (b) using $E_{LWD-100kPa}$ parameter.

9.5 Density vs. Terratest LWD

9.5.1 Available Datasets

After initial inspection of paired (side-by-side) Terratest LWD and Density tests, a total of 65 data pairs were used for attempted correlation of the *insitu* (composite) modulus and density parameters. Figure 9-5 plots an example of the available dataset, with the standardised *insitu* (composite) modulus parameter, E_{vd} , plotted against the reported RDD ratio.

Although spatial variation between the density and Terratest LWD was limited by the site-by-side testing completed, in terms of vertical depth comparability all density test results represented the material condition to a depth of 275 mm from the test surface (depth of probe penetration), whilst the expected 'zone of influence' that would affect the Terratest LWD's measurement was estimated to be 300 to 450 mm (i.e. 1 to 1.5 x Plate Diameter [300 mm]) as reported by applicable ASTM standard (ASTM, 2015).

As per the assessment completed for the Prima 100 LWD, the Terratest LWD dataset has also had matching moisture content values assigned to the data pairs, with moisture condition parameters recorded from both density test result certificates ($n = 65$) and from VMC estimates made using the TEROS 12 probe (albeit for a much smaller dataset, $n = 29$). Table 9-12 summaries the variables considered in the Density vs. Prima 100 LWD correlation assessment.

Table 9-12 Summary of parameters incorporated into attempted correlation between Density and Terratest LWD derived modulus

Density Test Results	Moisture Content Test Results	Modulus Parameter – from Prima 100 LWD Tests
- Field Dry Density (t/m^3) - Adjusted Maximum Dry Density (MDD, t/m^3) - Relative Dry Density (RDD, %)	- Field Moisture Content (FMC, %) - Moisture Ratio (MR, %) - Volumetric Moisture Content (VMC, %)	<i>Insitu</i> composite dynamic modulus (E_{vd})

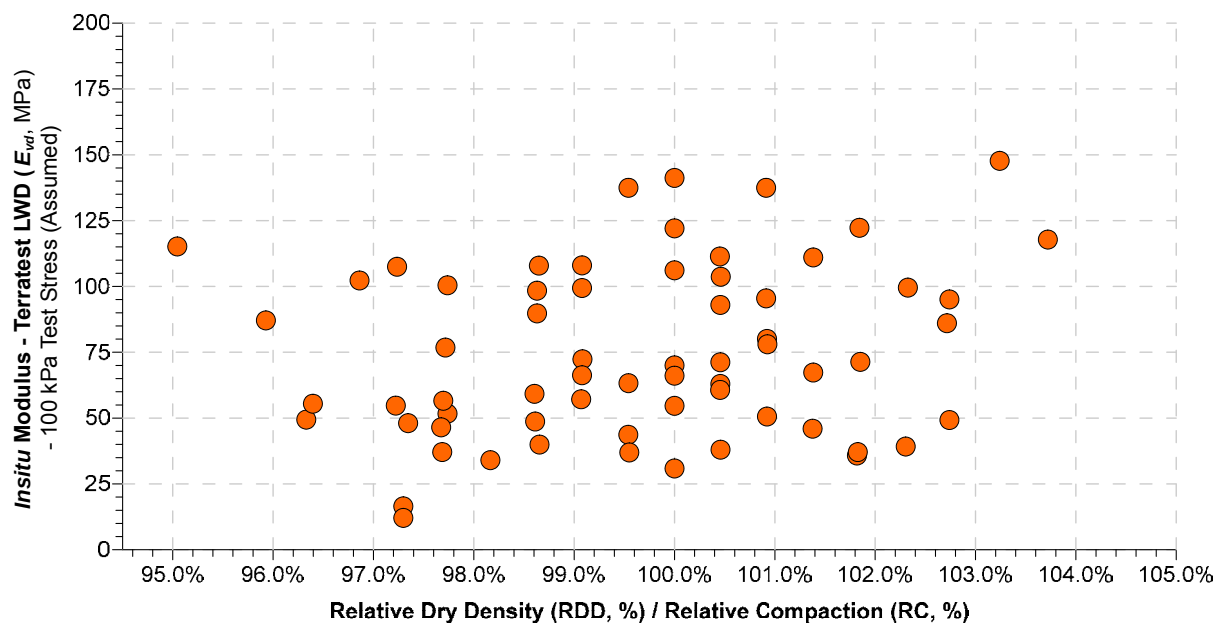


Figure 9-5 Example of Paired Dataset for Terratest LWD and Density test result correlation – Density (RDD) vs E_{vd} (*insitu* dynamic modulus) presented in figure ($n = 65$)

9.5.2 Single Variable Correlation

Based on the use of a single density variable, no correlation of a suitable format was identified to exist that related the 1:1 paired density and E_{vd} parameters. Even after the manufacturer recommended removal of the two (2) upper and lower bound values applicable to each of the ratios being assessed, the maximum strength of relationship was determined to be trivial ($R^2 < 0.1$) and all derived correlations

was found to be non-significant ($p < 0.05$). As presented in Table 9-13, the best-fit linear and simple non-linear relationships demonstrated no major difference in strength of correlation.

Table 9-13 Definition and Strength of direct correlation between Terratest LWD and Density test pairs

Density Parameter Adopted	Relationship to <i>Insitu Modulus</i> , E_{vd} (under assumed 100 kPa Test Stress)			
	Defined (best-fit) Relationship		Correlation Coefficient (R^2)	Significance (p)
Field Dry Density (t/m^3 , FDD)	Linear	$E_{vd} \text{ (MPa)} = 48.18 \times \text{FDD}(t/m^3) - 30.08$	$R^2 < 0.01$	$p = 0.60$
	Non-Linear	$E_{vd} \text{ (MPa)} = [-2262.38 \times \text{FDD}(t/m^3)^2] + [9885.41 \times \text{FDD}(t/m^3)] - 10719.86$	$R^2 < 0.03$	$p = 0.45$
Adjusted Maximum Dry Density (t/m^3 , MDD)	Linear	$E_{vd} \text{ (MPa)} = -28.71 \times \text{MDD}(t/m^3) + 137.51$	$R^2 < 0.01$	$p = 0.86$
	Non-Linear	$E_{vd} \text{ (MPa)} = [-4608.94 \times \text{MDD}(t/m^3)^2] + [20187.84 \times \text{MDD}(t/m^3)] - 22029.06$	$R^2 < 0.02$	$p = 0.66$
Relative Dry Density (% , RDD)	Linear	$E_{vd} \text{ (MPa)} = 1.27 \times \text{RDD}(\%) - 51.76$	$R^2 < 0.01$	$p = 0.53$
	Non-Linear	$E_{vd} \text{ (MPa)} = [0.93 \times \text{RDD}(\%)^2] - [182.89 \times \text{RDD}(\%)] + 9105.82$	$R^2 < 0.03$	$p = 0.47$

9.5.3 Multi-Variate Correlation

The dataset was reanalysed via multivariate correlation – both linear and non-linear assessments – after a moisture condition variable was incorporated into the Terratest LWD: Density paired data. No dramatic improvement in the determined correlations were observed via the inclusion of the second variable, as identified in Table 9-14, Table 9-15 and Table 9-16 (for FDD, MDD and RDD parameters respectively).

Table 9-14 Results of multi-variate correlation for Terratest LWD – Field Dry Density and various Moisture Conditions

Density & Moisture Content Parameter Adopted		Relationship to Terratest LWD's <i>Insitu Modulus</i> , E_{vd} (under assumed 100 kPa Test Stress)			
		Defined (best-fit) Multi-Variate Relationship		Correlation Coefficient (R^2)	Significance (p)
Field Dry Density (t/m^3 , FDD)	Field Moisture Content (FMC, %)	Linear	$E_{vd} \text{ (MPa)} = -33.25 \times \text{FDD}(t/m^3) - 12.12 \times \text{FMC}(\%) + 236.61$	$R^2 = 0.14$	$p < 0.01$
		Non-Linear	$E_{vd} \text{ (MPa)} = [-3655.98 \times \text{FDD}(t/m^3)^2] + [15847.05 \times \text{FDD}(t/m^3)] + [0.98 \times \text{FMC}(\%)^2] - [28.20 \times \text{FMC}(\%)] - 16937.22$	$R^2 = 0.20$	$p < 0.02$
	Moisture Ratio (MR, %)	Linear	$E_{vd} \text{ (MPa)} = -23.81 \times \text{FDD}(t/m^3) - 1.00 \times \text{MR}(\%) + 215.43$	$R^2 = 0.19$	$p < 0.01$
		Non-Linear	$E_{vd} \text{ (MPa)} = [-3686.40 \times \text{FDD}(t/m^3)^2] + [15997.00 \times \text{FDD}(t/m^3)] - [1.12 \times \text{MR}(\%)] - 17174.39$	$R^2 = 0.24$	$p < 0.01$
	Volumetric Moisture Content (VMC, %) ($n = 29$)	Linear	$E_{vd} \text{ (MPa)} = 102.96 \times \text{FDD}(t/m^3) - 1.02 \times \text{VMC}(\%) - 160.78$	$R^2 = 0.11$	$p = 0.27$
		Non-Linear	$E_{vd} \text{ (MPa)} = [-797.46 \times \text{FDD}(t/m^3)^2] + [11096.25 \times \text{FDD}(t/m^3)] - [1.06 \times \text{VMC}(\%)] - 3972.92$	$R^2 = 0.12$	$p = 0.44$

Table 9-15 Results of multi-variate correlation for Terratest LWD – Adjusted Maximum Dry Density and various Moisture Conditions

Density & Moisture Content Parameter Adopted		Relationship to Terratest LWD's <i>Insitu Modulus</i> , E_{vd} (under assumed 100 kPa Test Stress)			
		Defined (best-fit) Multi-Variate Relationship		Correlation Coefficient (R^2)	Significance (p)
Adjusted Maximum Dry Density (t/m^3 , MDD)	Field Moisture Content (FMC, %)	Linear	$E_{vd} \text{ (MPa)} = -11.81 \times \text{MDD}(t/m^3) - 61.33 \times \text{FMC}(\%) + 295.94$	$R^2 = 0.15$	$p < 0.01$
		Non-Linear	$E_{vd} \text{ (MPa)} = [-1024.66 \times \text{MDD}(t/m^3)^2] + [4433.75 \times \text{MDD}(t/m^3)] - [11.62 \times \text{FMC}(\%)] - 4634.71$	$R^2 = 0.15$	$p < 0.04$
	Moisture Ratio (MR, %)	Linear	$E_{vd} \text{ (MPa)} = -52.70 \times \text{MDD}(t/m^3) - 0.99 \times \text{MR}(\%) + 277.54$	$R^2 = 0.19$	$p < 0.01$

Density & Moisture Content Parameter Adopted		Relationship to Terratest LWD's <i>In situ</i> Modulus, E_{vd} (under assumed 100 kPa Test Stress)		
		Defined (best-fit) Multi-Variate Relationship		Significance (p)
Volumetric Moisture Content (VMC, %) ($n = 29$)	Non-Linear	E_{vd} (MPa) = $[-47.00 \times \text{MDD}(\text{t/m}^3)] - [0.007 \times \text{MR}(\%)^2] + [0.20 \times \text{MR}(\%)] + 212.46$		$R^2 = 0.19$ $p < 0.01$
	Linear	E_{vd} (MPa) = $240.81 \times \text{MDD}(\text{t/m}^3) - 0.97 \times \text{VMC}(\%) - 463.20$		$R^2 = 0.13$ $p = 0.22$
	Non-Linear	E_{vd} (MPa) = $[5389.04 \times \text{MDD}(\text{t/m}^3)^2] - [23413.32 \times \text{MDD}(\text{t/m}^3)] - [1.04 \times \text{VMC}(\%)] + 25491.05$		$R^2 = 0.14$ $p = 0.36$

Table 9-16 Results of multi-variate correlation for Terratest LWD – Relative Dry Density Ratio and various Moisture Conditions

Density & Moisture Content Parameter Adopted		Relationship to Terratest LWD's <i>In situ</i> Modulus, E_{vd} (under assumed 100 kPa Test Stress)		
		Defined (best-fit) Multi-Variate Relationship		Significance (p)
Relative Dry Density (% RDD)	Field Moisture Content (FMC, %)	Linear	E_{vd} (MPa) = $-0.20 \times \text{RDD}(\%) - 11.81 \times \text{FMC}(\%) + 181.39$	$R^2 = 0.15$ $p < 0.02$
		Non-Linear	E_{vd} (MPa) = $[0.56 \times \text{RDD}(\%)^2] - [111.82 \times \text{RDD}(\%)] - [11.41 \times \text{FMC}(\%)] + 5726.44$	$R^2 = 0.15$ $p < 0.03$
	Moisture Ratio (MR, %)	Linear	E_{vd} (MPa) = $-0.08 \times \text{RDD}(\%) - 0.99 \times \text{MR}(\%) + 170.16$	$R^2 = 0.18$ $p < 0.01$
		Non-Linear	E_{vd} (MPa) = $[-0.43 \times \text{RDD}(\%)^2] - [86.40 \times \text{RDD}(\%)] - [0.96 \times \text{MR}(\%)] - 4458.48$	$R^2 = 0.19$ $p < 0.01$
	Volumetric Moisture Content (VMC, %) ($n = 29$)	Linear	E_{vd} (MPa) = $0.87 \times \text{RDD}(\%) - 1.00 \times \text{VMC}(\%) - 22.99$	$R^2 = 0.09$ $p = 0.36$
		Non-Linear	E_{vd} (MPa) = $[2.26 \times \text{RDD}(\%)^2] - [451.77 \times \text{RDD}(\%)] - [0.96 \times \text{VMC}(\%)] + 22591.33$	$R^2 = 0.16$ $p = 0.30$

9.5.4 Interpretation and Conclusions

In all cases where moisture condition was included alongside a density parameter, a statistically significant correlation of 'weak' strength was consistently identified ($0.1 \leq R^2 < 0.3$). This result was an improvement over the correlations developed for direct E_{vd} – Density comparison, where only non-significant, 'trivial' or 'co-incidental' relationships were identified (i.e. $R^2 < 0.1$). As with the analyses for other modulus parameter measuring tools considered herein, the use of the Moisture Ratio (MR) parameter provided the strongest strength correlation for the multi-variate analyses completed.

Although not considered suitable for direct application for QA purposes, the strongest correlations developed between the Terratest LWD and density are defined in Equations 8-4 and 8-5 for the FDD and RDD density parameters respectively:

$$E_{vd} \text{ (MPa)} = [-3686.40 \times \text{FDD}(\text{t/m}^3)^2] + [15997.00 \times \text{FDD}(\text{t/m}^3)] - [1.12 \times \text{MR}(\%)] - 17174.39$$

$$(p < 0.01; R^2 = 0.24) \quad (\text{Eq. 8-4})$$

$$E_{vd} \text{ (MPa)} = [-0.43 \times \text{RDD}(\%)^2] + [86.40 \times \text{RDD}(\%)] - [0.96 \times \text{MR}(\%)] - 4458.48$$

$$(p < 0.01; R^2 = 0.19) \quad (\text{Eq. 8-5})$$

When compared to the corresponding analyses that utilised the Prima 100 LWD's standardised 100 kPa test stress parameter ($E_{LWD-100kPa}$), the Terratest LWD typically reported a slightly lower strength correlation. However, the average magnitude of the difference in corresponding R^2 values was only 0.06, and nearly all multi-variate relationships derived using the density and moisture content as the two (2) independent variables reported only 'weak' correlations regardless of the type of LWD utilised.

The incorporation of the VMC factor into the completed analyses yielded correlations that were both weaker strength (when compared to the use of the FMC or MR parameters) and of no statistical

significance. This result is consistent with the comparable analysis done with the Prima 100 LWD dataset, and again indicates the VMC results collected during the Phase 3 fieldwork are of limited use. (refer Section 8.3 for further discussion regarding the VMC data validity).

It is noted that at a number of sites the Terratest LWD testing was completed at least 24 hrs after the density test and bulk sample was taken. Accordingly, the FMC determined on a sample taken at the time of density assessment may not reflect the material condition at the time of Terratest LWD, either due to moisture conditioning (e.g. rainfall or water cart) or surface drying. The delay between density and Terratest testing occurred at 23 sub-sites (~35% of dataset); with 11 sub-sites tested the day following the density test; eight (8) subsites assessed two (2) days later; and four (4) sub-sites tested the third day after density testing.

However, as presented in Figure 9-6, which plots the residual between the best-fitted relationship (Equation 8-4 and the Terratest's *insitu* modulus parameter (E_{vd}), the length of delay between density / moisture condition assessment and the completion of the Terratest LWD does not appear to be reflected in the magnitude of deviation from the best-fitted relationship. The average (absolute) residual value did not widely vary based on the timeframe between density testing (and thus field moisture content determination) and the Terratest LWD testing – with average absolute residual values of 21.8 MPa for a zero (0) day test date difference; 18.6 MPa for LWDs undertaken one (1) day after the paired density test; 19.3 MPa for LWD tests undertaken after a two (2) day lag; and 24.7 MPa for test pairs completed three (3) days apart.

Within the multi-variate analyses completed, all cases reported that the moisture condition variable (FMC or MR) was reported to present a statistically significant correlation with the Terratest LWD E_{vd} parameter whilst the density variable was not. This suggests the moisture condition of the near surface influenced the Terratest LWD result more than the relative density achieved by the compactive effort applied.

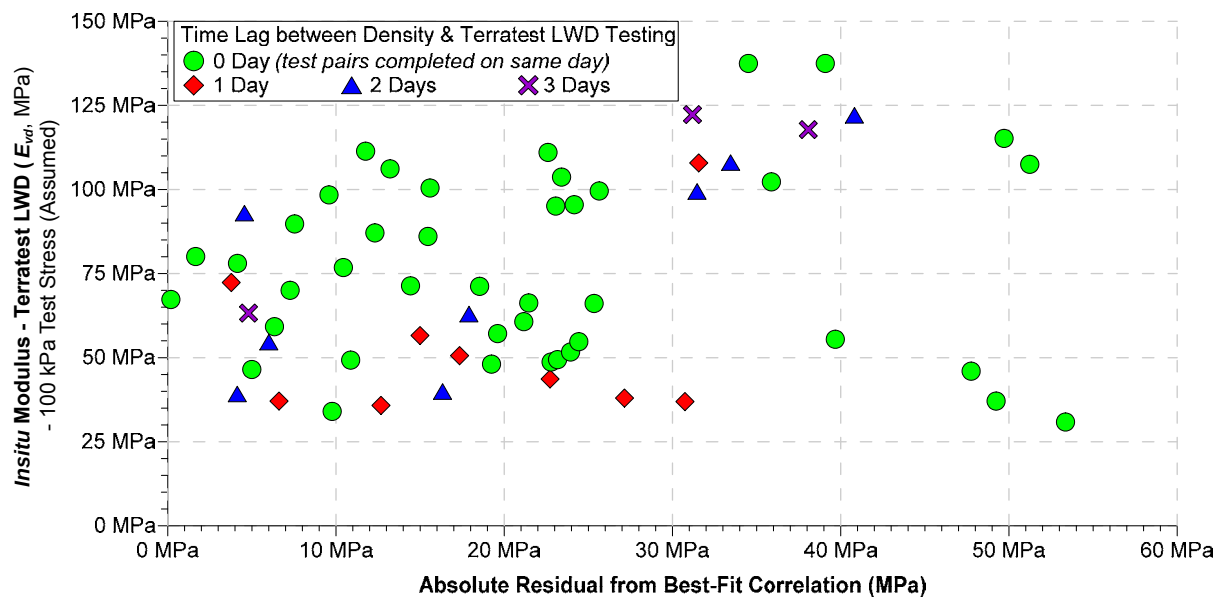


Figure 9-6 Difference (absolute residual) between E_{vd} value predicted by best fit equation (Eq. 8-4) and that measured by *insitu* LWD testing – test pairs plotted by time lag between completion of density and Terratest LWD testing.

To illustrate this outcome, Figure 9-7 plots the FMC and MR parameters against the Terratest LWD *insitu* modulus (E_{vd}) and reports direct correlation coefficients well in excess of those derived for the direct density: E_{vd} comparison (refer Table 9-13). The relationship was as expected, demonstrating a higher moisture content results in a lower reported modulus parameter. Furthermore, the strength (R^2) of the direct, linear moisture : E_{vd} correlations – as defined in Equations 8-6 and 8-7 for FMC and MR parameters respectively – is approximately equivalent to the correlation strength derived from the

multivariate analyses completed; suggesting that the influence of the density parameter in the multivariate relationships is comparatively minor.

$$E_{vd} \text{ (MPa)} = [-12.85 \times \text{FMC}(\%)] + 169.86 \quad (p < 0.01; R^2 = 0.13) \quad (\text{Eq. 8-6})$$

$$E_{vd} \text{ (MPa)} = [-1.07 \times \text{MR}(\%)] + 169.70 \quad (p < 0.01; R^2 = 0.16) \quad (\text{Eq. 8-7})$$

Although a number of defined correlations were found to be statistically significant ($p < 0.01$), the calculated R^2 values indicated, at best, the existence of 'weak' relationships. All correlations between density and Terratest LWD measured modulus parameters remained well below the threshold for an acceptable, 'strong' relationship (i.e. R^2 remained below 0.5). In addition, it was observed that moisture content parameters provided higher strength (increased R^2) direct correlations with the results of the Terratest LWDs than the comparable density: E_{vd} relationship.

As such, **no demonstratable relationship of sufficient strength was identified to exist between the Terratest LWD's *insitu* modulus parameters and the results of (traditional) Density testing completed upon the trial embankment earthworks used as the Phase 3 fieldwork site.** This result infers that adopting density testing for QA purposes does not directly ensure that a design modulus parameter would be met *insitu*.

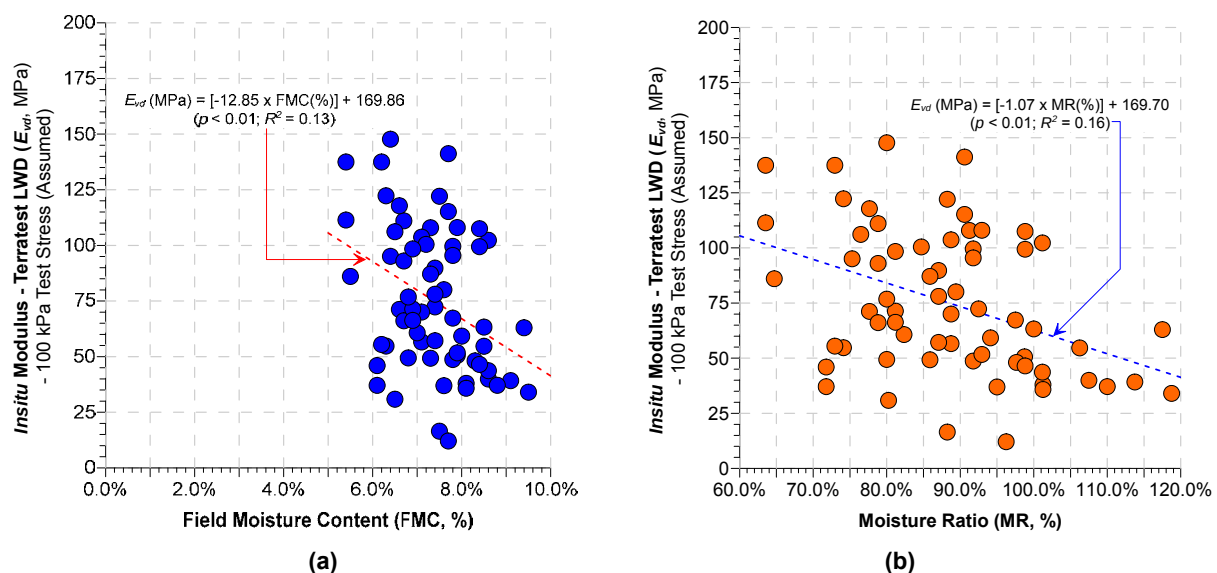


Figure 9-7 Plots demonstrating dataset and strength (R^2) of direct correlations between moisture content parameters and Terratest LWD derived modulus; (a) using FMC parameter; and (b) using MR parameter.

9.6 Clegg Hammer vs Density

9.6.1 Available Datasets

A similar methodology was adopted for the attempted correlation of the results of the Clegg Hammer testing with the side-by-side results of the traditional density testing.

9.6.1 Single Variable Correlation

Direct correlation – via use of both linear and non-linear functions – between the Clegg Hammer test results (Clegg Impact Units, CIV) and the three (3) density parameters (FDD, MDD and RDD) yielded no significant correlations, or relationships typically considered to be 'co-incidental' or 'trivial' strength (i.e. $p > 0.05$ & $R^2 < 0.2$ for all assessments). All five (5) test drop heights (i.e. test stress magnitudes) associated with the Clegg Hammer were considered, as were both the Maximum and Average CIV

value determined from each Clegg Hammer test, producing a total of 30 attempted direct correlations. The resultant R^2 values from this initial curve fitting is summarised in Table 9-18.

Table 9-17 Summary of parameters incorporated into attempted correlation between Density and Clegg Hammer Test Results

Density Test Results	Moisture Content Test Results	Parameter from Clegg Hammer Tests
- Field Dry Density (t/m^3) - Adjusted Maximum Dry Density (MDD, t/m^3) - Relative Dry Density (RDD, %)	- Field Moisture Content (FMC, %) - Moisture Ratio (MR, %) - Volumetric Moisture Content (VMC, %)	- Maximum Clegg Hammer Impact (CIV) Value – C_{MAX} - From 0.076 m drop height ($C_{MAX-0.076m}$) - From 0.152 m drop height ($C_{MAX-0.152m}$) - From 0.305 m drop height ($C_{MAX-0.305m}$) - From 0.457 m drop height ($C_{MAX-0.457m}$) - From 0.605 m drop height ($C_{MAX-0.605m}$) - Average Clegg Hammer Impact (CIV) Value – C_{AVE} - From 0.076 m drop height ($C_{AVE-0.076m}$) - From 0.152 m drop height ($C_{AVE-0.152m}$) - From 0.305 m drop height ($C_{AVE-0.305m}$) - From 0.457 m drop height ($C_{AVE-0.457m}$) - From 0.605 m drop height ($C_{AVE-0.605m}$)

Table 9-18 Strength of direct correlation between Clegg Hammer (CIV) and Density parameters (R^2 values)

Clegg Hammer Drop Height	Maximum Clegg Hammer Impact (CIV) Value – C_{MAX}			Average Clegg Hammer Impact (CIV) Value – C_{AVE}		
	C_{MAX} vs. FDD	C_{MAX} vs. MDD	C_{MAX} vs. RDD	C_{AVE} vs. FDD	C_{AVE} vs. MDD	C_{AVE} vs. RDD
0.076 m (n = 25)	$R^2 = 0.04$ (Linear)	$R^2 = 0.03$ (2 nd Order Poly.)	$R^2 = 0.02$ (2 nd Order Poly.)	$R^2 = 0.07$ (Linear)	$R^2 = 0.06$ (2 nd Order Poly.)	$R^2 = 0.03$ (2 nd Order Poly.)
0.152 m (n = 25)	$R^2 = 0.10$ (2 nd Order Poly.)	$R^2 = 0.08$ (Power)	$R^2 = 0.06$ (2 nd Order Poly.)	$R^2 = 0.12$ (2 nd Order Poly.)	$R^2 = 0.07$ (Power)	$R^2 = 0.11$ (2 nd Order Poly.)
0.305 m (n = 25)	$R^2 < 0.01$ (N/A)	$R^2 = 0.03$ (2 nd Order Poly.)	$R^2 < 0.01$ (N/A)	$R^2 = 0.02$ (2 nd Order Poly.)	$R^2 = 0.04$ (2 nd Order Poly.)	$R^2 < 0.01$ (N/A)
0.457 m (n = 24)	$R^2 = 0.02$ (Power)	$R^2 = 0.07$ (Logarithmic)	$R^2 < 0.01$ (N/A)	$R^2 = 0.05$ (2 nd Order Poly.)	$R^2 = 0.12$ (Logarithmic)	$R^2 = 0.03$ (2 nd Order Poly.)
0.605 m (n = 24)	$R^2 = 0.09$ (2 nd Order Poly.)	$R^2 = 0.22$ (2 nd Order Poly.)	$R^2 = 0.06$ (2 nd Order Poly.)	$R^2 = 0.07$ (2 nd Order Poly.)	$R^2 = 0.13$ (2 nd Order Poly.)	$R^2 = 0.01$ (2 nd Order Poly.)

Although not of an acceptable strength for adoption, it is observed that the most frequently fitted function to the attempted direct CIV: Density parameter relationships was a 2nd order polynomial – a function that requires the CIV value to be squared when matched to the paired density test result. This transformation of the CIV parameter is consistent with the manufacturers recommendation for data manipulation when converting the CIV parameter to an *insitu* modulus parameter.

10. QA assessment in practice – the traditional vs nascent technology

This test site was "live" and during this parallel testing period only the LWD, DCP and PANDA were used. The other instruments (PLT, Clegg, etc) were used only for a limited period.

These sections demonstrate some of the benefits from alternative testing which was not apparent with a density-based quality control (QC) approach. Special considerations applied for Lots 21 and 24.

10.1 Lot 21

The density testing was carried out shortly after the final layer compaction occurred at Lot 21. A period of rain occurred shortly after testing

Table 10-1 Comparison of testing before and after a rain period at Lot 21

Testing Period	No. Of Tests	LWD Modulus (MPa) @					
		50kPa	100kPa	50kPa	100kPa	50kPa	100kPa
		Median		Quartile		Ratio Change Median / Quartile	
Dry – shortly after fill compaction	4	116.9	113.0	64.1	72.8	Reference Value	
Rain fell – adjacent to previous tests	4	91.1	98.3	59.6	67.4	1.28 / 1.07	1.15 / 1.08
Rain fell – additional tests	10	84.5	100.5	70.9	81.1	1.38 / 0.90	1.12 / 0.90

A testing recheck of values after rain fell at lot 21 shows a decrease of median LWD values. Density tests would not have picked that change as no retest was carried out. Yet the tests 2 days after compaction shows significant changes due to rainfall. Density testing would be business as usual i.e. proceeding without explicitly acknowledging or taking action for changing conditions.

Retest was carried out immediately adjacent to the 4 prior tests then at another 10 test locations

Change results show rain falling after the initial testing changed the median modulus to ~ 75% and 88% of the Dry Value, at 50 KPa and 100KPa, respectively.

Note the LWD modulus values were still a pass result despite a reduction.

The results also show that without a direct paired tests (immediately adjacent to the initial tests), the 10 additional tests (at different locations) yields a values varying by 10%.

The key lessons being

1. A passing density should not mean that subsequent layers can be placed, especially following rainfall.
2. Modulus values are constantly changing but is not being recognised by the current DDR approach
3. A few hard spots (values above 200 MPa) can affect the statistical interpretation. These could be due to underlying large stones

10.2 Lot 24

At Lot 24 the LFWD values suggested “failing” results although the assumed density (expected) showed “passing” results. There was a “disagreement” between traditional density testing and LFWD testing. The contractor saw this as the alternative LFWD tests being more stringent or incorrect.

Recheck of values allowed to dry back shows an increase of values. Density tests would not have picked that change as no retest was done or required

- o < 12 hr dry back : Median 125% of Dry Value: 163% of quartile
- o 24 hr dry back : Median 359% of Dry Value: 507% of quartile

Table 10-2 Comparison of testing before and after a rain period at Lot 24

Testing Period	No. Of Tests	LFWD Modulus (MPa) @					
		50kPa	100kPa	50kPa	100kPa	50kPa	100kPa
		Median		Quartile		Ratio Change Median / Quartile	
Shortly after fill compaction	4	46.5	23.0	28.4	15.6	Reference Value	
Next day dry backed	4	58.0	37.4	18.2	16.3	0.80	0.61
Further dry back	10	167.0	116.5	99.4	70.2	0.28	0.20

Yet spot checks utilising NDG testing was not able to effectively identify the soft spots such as weak (wet) zones that cannot be compacted to the similar level. Neither was it able to identify the changes that occurred from drying back. These weak zones would have been identified by deflection testing or proof rolling and action would typically be required.

Such weak zones in itself are OK (if density passes) only if allowed to dry back. It is not acceptable if used with a more expensive layer such as a base / subbase material overlying being placed or as a working platform subgrade for heavy plant. Overlying material on weak zones either punch through during compaction or do not compact properly.

The question now arises on whether the initial test results or the dried back test result applies.

The Modulus is dependent on both moisture and density. As it is the overall stiffness which matters then a passing density with a weak material from excessive moisture is clearly unacceptable. A passing modulus 24 hours after (ie dried back) seems acceptable provided the density test passes.

Figure 10-1 and Figure 10-2 show the wet spots that visually should be a “fail” as rut marks and wet spots are evident. This it has a passing density test.



Figure 10-1 A density pass with a fail LFWD disagreement area



Figure 10-2 A density pass does not "notice" adjacent wet spots

11. Towards QA Specifications – Analysis Methodology

11.1 Quality Control Methodology

The previous chapters show that direct paired correlations show spurious results when density is compared to most other tests. During the application of using the LFWD, PRIMA and DCP as QC tools, a relationship with density was used. Chapter 10 highlighted, how “failing” LFWDs has “passing” DDRs. Field observation was enough to show this failing in DDR testing as many wet spots were evident despite the passing DDR.

Paired correlations resulted in a low R^2 values and non-significant ($p < 0.05$). This created more uncertainty than if the density testing alone had been used. An alternative method was therefore required as small changes in DDR had large variations in modulus values. This poor relationship was also apparent in the previous Phase 2 testing. In contrast, this site had relatively uniform material, yet the same issue has occurred.

A transformation method of matching PDFs is used here. This has not been known to be used previously in the literature but seems to be logical and justifiable step to use these new technologies as an alternative quality test.

The approach follows the QTMR philosophy of 10% Consumer and 10% producer’s risk for Type I Error and Type II Errors.

A Type I error (sometimes called a Type 1 error), is the incorrect rejection of a true null hypothesis. The alpha symbol, α , is usually used to denote a Type I error.

Type II error (sometimes called a Type 2 error) is the failure to reject a false null hypothesis. The probability of a type II error is denoted by the beta symbol β .

QTMR vs Contractor Risk		Quality of Lot	
		Good	Poor
Acceptance Decision	Accept	Correct	Type II Error QTMR's Risk Not Rejecting a Lot when it is Not OK
	Reject	Type I Error Contractor's Risk Rejecting a Lot when it is OK	Correct

Figure 11-1 Errors associated with acceptance and rejection of a lot

11.2 PDFs – Methodology

The Excel add in @Risk was used to assess the Probability density function (PDF).

The Fit Ranking lists all distributions for which valid fits were generated. These distributions are ranked, according to the goodness-of-fit test selected from the Fit Ranking selector.

A goodness-of-fit statistic provides a quantitative measure of how closely the fitted distribution matches the distribution of the data. In general, a lower statistic indicates a better fit. The goodness-of-fit statistic can be used for comparing the fits from various distributions.



Each goodness-of-fit statistic indicates how well a potential fitted distribution matches the distribution of the sample data. Five types of statistics are available. A few of these are described below.

The chi-square is the most common goodness-of-fit test. It can be used with any type of sample data and any type of distribution, discrete or continuous. Its weakness is it requires bins, and there are no clear guidelines for selecting these bins. It is sometimes possible to reach different conclusions from the same data, depending on how the bins are specified.

The Kolmogorov-Smirnov statistic is generally preferred over the chi-square statistic because it doesn't rely on bins.

Anderson Darling goodness of fit was used. The Anderson-Darling statistic is similar to the Kolmogorov-Smirnov statistic, but it places more emphasis on tail values. It doesn't rely on bins. Geotechnical data tends to have "tail" uses hence this has been found superior than other goodness of fit tests.

11.2.1 Multivariate Analysis – Methodology

The Microsoft Excel statistics add-in StatTools (Vers 7.5) was also used. Some of the descriptions below can be found in that manual. Various statistical analysis was carried out on the data as follows:

- ✓ Multivariate Analysis. This is used to study more complex sets of data than what univariate analysis methods can handle. This type of analysis is almost always performed with software as working with even the smallest of data sets can be overwhelming by hand. Multivariate analysis can reduce the likelihood of Type I errors. Sometimes, univariate analysis is preferred as multivariate techniques can result in difficulty interpreting the results of the test. Multivariate analysis is usually unsuitable for small sets of data, but the large data set obtained in this research did not allow simple paired correlation analysis.
- ✓ There are more than 20 different ways to perform multivariate analysis. Principal component analysis (PCA) and Cluster analysis was carried out using StatTools. The PCA decomposes a data table with correlated measures into a new set of uncorrelated measures. PCA is a tool that has two main purposes:
 1. To find variability in a data set.
 2. To reduce the dimensions of the data set.

11.2.2 Principal Component– Methodology

The Principal Component Analysis is a procedure for reducing the dimensionality of a multivariate data set. Specifically, it transforms a set of correlated variables into a smaller number of uncorrelated variables.

Reducing dimensions means that redundancy in the data is eliminated; This can make patterns in the data set clearer. PCA is a tool used if you suspect you have redundancy in your data set

Redundancy doesn't mean that the variables are identical; it means that there is a strong correlation between them. For example, in density compaction testing, the following is measured:

1. Field Dry Density
2. % Oversize > 38mm
3. Maximum Dry Density
4. Optimum Moisture Content
5. Adjusted Maximum Dry Density
6. Adjusted Optimum Moisture Content
7. Relative compaction (Density Ratio)
8. Field Moisture Content
9. Moisture Ratio
10. Adjusted Moisture Ratio



Yet adjusted MDD and OMC are dependent on % oversize. Moisture and Density ratio is dependent on those adjusted values. A Principal Component Analysis on this example, could theoretically reduce the 10 components to two or three components.

As data sets obtained similarly contain multiple, redundancy is not always easy to identify. Principal Component Analysis clears the “noise” to allow identification of patterns in the data. PCA reduces dimensions by projecting the whole data set onto a completely separate space. The original variables are transformed into a new set of artificial ones, which are the “Principal Components” of Principal Component Analysis. These components can be extremely useful as criterion variables or predictor variables in later data analysis. PCA analysis is often used as input to other analyses:

- o In linear regression it is used if there are multicollinearity problems, or if the number of independent variables is relatively large relative to the number of observations.
- o It is useful to construct a scatterplot of the first two principal components to check for outliers and the presence of clusters

11.2.3 Scree test Analysis – Methodology

Scree tests are part of the PCA analysis. This involves finding the place where the smooth decrease of eigenvalues appears to level off to the right of the plot. "Scree" is the geological term referring to the debris which collects on the lower part of a rocky slope. In multivariate statistics, a scree plot is a line plot of the eigenvalues of factors or principal components in an analysis. The procedure of finding statistically significant factors or components using a scree plot is also known as a scree test. A scree plot displays the eigenvalues in a downward curve, ordering the eigenvalues from largest to smallest. According to the scree test, the "elbow" of the graph where the eigenvalues seem to level off is found and factors or components to the left of this point should be retained as significant.

11.2.4 Clustering and dendrogram Analysis – Methodology

This refers to how data is gathered (“clustered”). Sorting data into clusters sometimes leads to more investigation into the data. Cluster Analysis tends to be subjective in many cases; it depends on what you perceive as common threads in the data. The technique isn’t really anything new in statistics; a bar graph is a type of “cluster”.

The Cluster Analysis command searches for patterns in a data set in order to classify observations or variables into groups of similar items. This procedure uses several "agglomerative hierarchical" methods. Each of these methods begins with each observation in a separate cluster and then, in a series of steps, combine clusters to end with one single cluster containing all observations. By selecting one of the steps in the procedure before you get to a single cluster, you obtain a division of the data set into groups of similar items. The analysis supports a variety of agglomerative hierarchical methods and distance measures. The clustering process is summarized by a "dendrogram" graph.

11.2.5 Correlation Matrix and multiple regression – Methodology

The Multiple regression procedure builds an equation all at once, using the selected independent variables. (It includes the procedure usually called “simple” regression, where there is a single independent variable.) The other procedures allow variables (or blocks of variables) to enter or leave the equation sequentially. Specifically, the stepwise procedure allows variables to enter one at a time. The next variable to enter is the one most highly correlated with the unexplained part of the dependent variable. However, the stepwise option also allows variables to leave once they have entered if they no longer contribute significantly. The forward procedure is the same as the stepwise procedure, except that variables are not allowed to leave once they enter. The backward procedure starts with all potential independent variables in the equation and then deletes them one at a time if they do not contribute significantly.

The Spearman's rank correlation coefficient was used. This is a nonparametric measure of rank correlation (statistical dependence between the rankings of two variables). It assesses how well the relationship between two variables can be described using a monotonic function.

The Spearman correlation between two variables will be high when observations have a similar rank between the two variables. The sign of the Spearman correlation indicates the direction of association

between X (the independent variable) and Y (the dependent variable). If Y tends to increase when X increases, the Spearman correlation coefficient is positive. If Y tends to decrease when X increases, the Spearman correlation coefficient is negative. A Spearman correlation of zero indicates that there is no tendency for Y to either increase or decrease when X increases.

11.2.6 Box and Whisker Plot – Methodology

The box-and-whisker plot is an exploratory graphic, used to show the distribution of a dataset (at a glance). This was used initially to summarise and classify the data to assess trends. Figure 11-2 provides an explanation of these graphs.

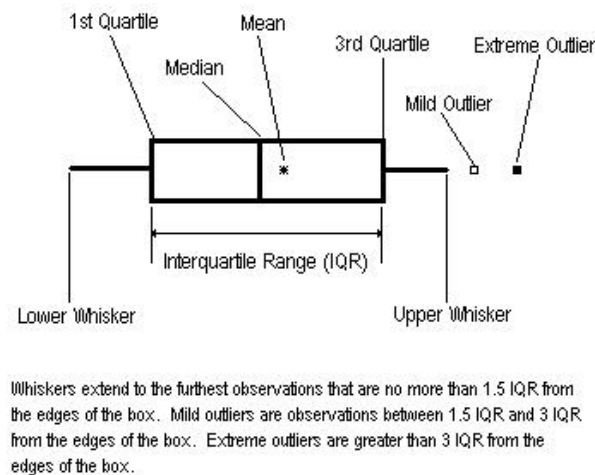


Figure 11-2 Box and Whisker explanation

11.3 Box and Whisker Plot – Analysis

Examples of box and whisker plots are provided in the following figures. This provides a quick and easy assessment of test variations and possible outliers.

11.3.1 LFWD results

Figure 11-3 shows the LFWD modulus @100kPa when the results were grouped in 4 lots. The following observations can be seen from these comparative plots.

- o LFWD modulus varied with each lot by a factor of 3
- o Variability increased at lots 28 to 30
- o Outliers “soft” spots are evident in lots 24 to 27

Note that Lot 24 had repeat testing due to LFWD “failures”, although density tests passed. This was discussed in chapter 10.

Figure 11-4 compares the same lots divided into DDR. This shows

- o LFWD modulus increases as the density ratio increases which should be expected
- o Variability increases at high density ratios
- o Outliers occur at high DDR

Figure 11-5 compares the same lots divided into moisture ratios (MR). This shows

- o LFWD modulus increases as the moisture ratio decreases which should be expected
- o This ratio is 60% to 40%, for MR of 80% to 100% and MR > 10%, respectively
- o Variability increases at low moisture ratios

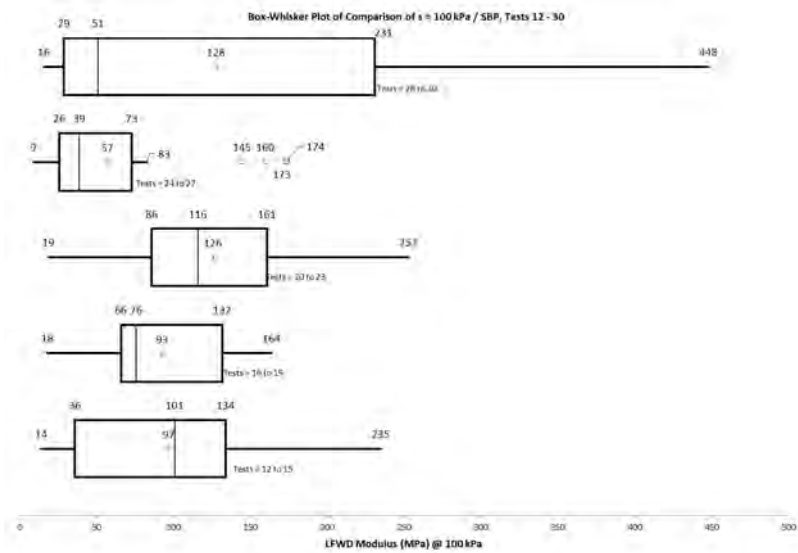


Figure 11-3 LFWD Modulus comparisons between lots

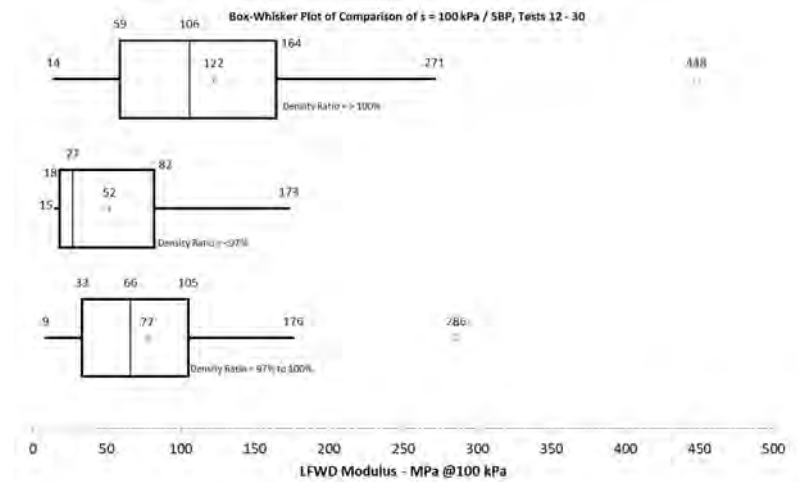


Figure 11-4 LFWD Modulus comparisons: DDR < 97%, DDR between 97% - 100% and DDR > 100%

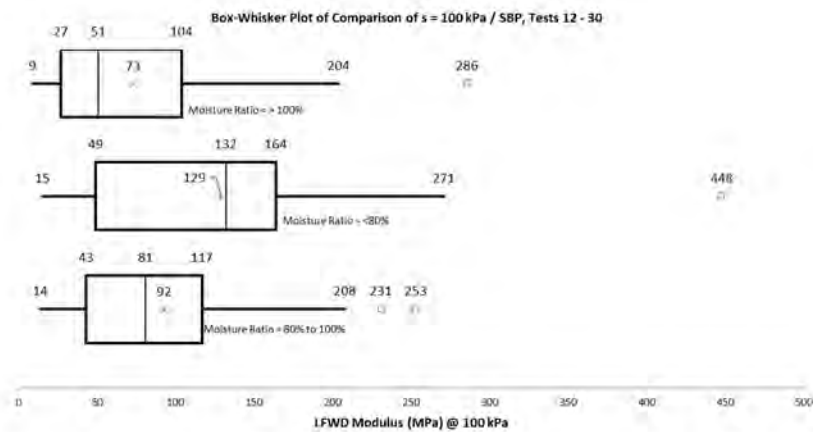


Figure 11-5 LFWD Modulus comparisons: Moisture Ratios < 80%, 80% - 100% and > 100%

11.3.2 PLT results

Figure 11-6 shows the Plate Load Test (PLT) results for varying stress ranges. The following observations can be seen from these comparative plots.

- o The one outlier affects the mean
- o Higher stress ranges have a higher median modulus. A 33% higher value from 100kPa to 400 kPa applied stress
- o There is little change in the lower quartile value

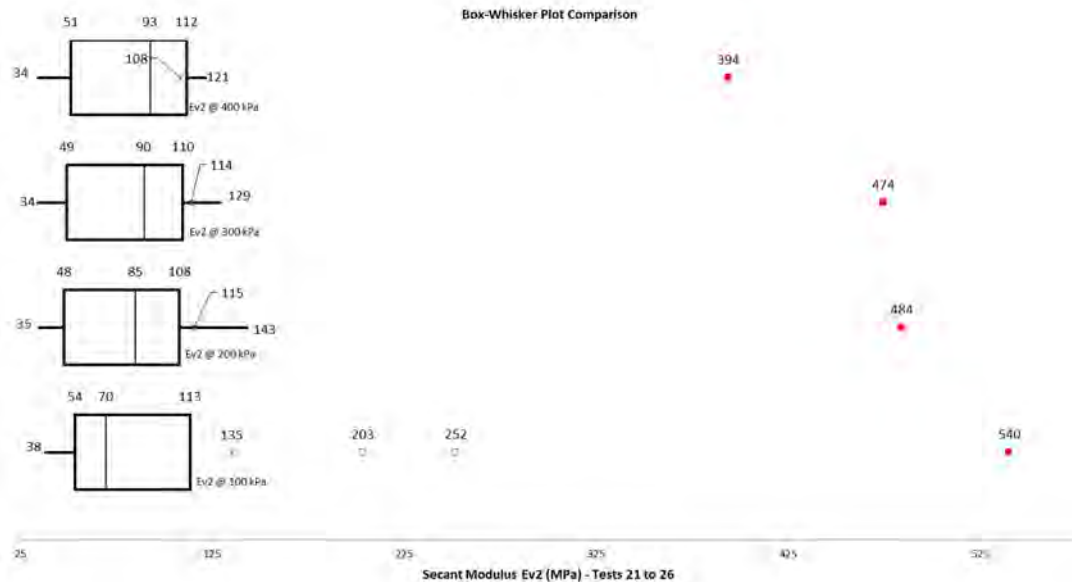


Figure 11-6 PLT EV2 modulus for varying stress ranges

Figure 11-7 shows the PLT Ev2 results for varying stress ranges. This shows

- o $Ev2 = (2.6 \text{ to } 1.9) Ev1$
- o Ev1 has less variability than Ev2
- o Ev1 is not considered stress dependent
- o Unlike EV2 no outliers were apparent

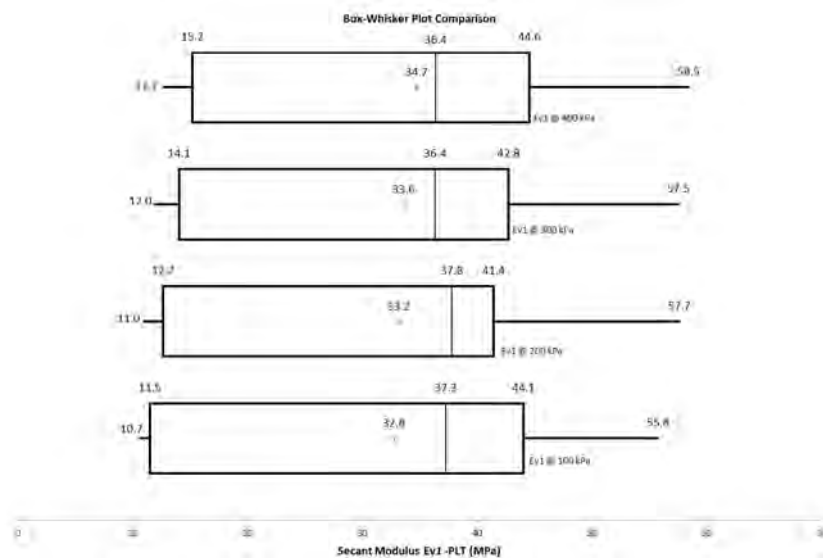


Figure 11-7 PLT EV2 modulus for varying stress ranges



11.3.3 DCP results

Figure 11-8 shows the DCP plot and its variation with each incremental depth of 50mm. Note that DCPs are usually measure at every 100mm and this refinement is for research purposes only. The compacted layers are expected to be 200mm to 300mm. Therefore, at that or about depth a previous layer is being tested. The DCP did not penetrate to a uniform depth, and while 200 No. tests were carried out in the top 100mm, this was reduced to 118 No. at 250 – 300mm and with 25 results at 450 to 500mm depth. The following observations are evident from this data

- o The top 50mm to 100mm is not representative of the other layers
- o Values above 5 are considered extreme outliers, and above 12 is a mild outlier
- o Another layer is likely at 300 to 350mm
- o The lowest range occurs at 150mm to 200mm

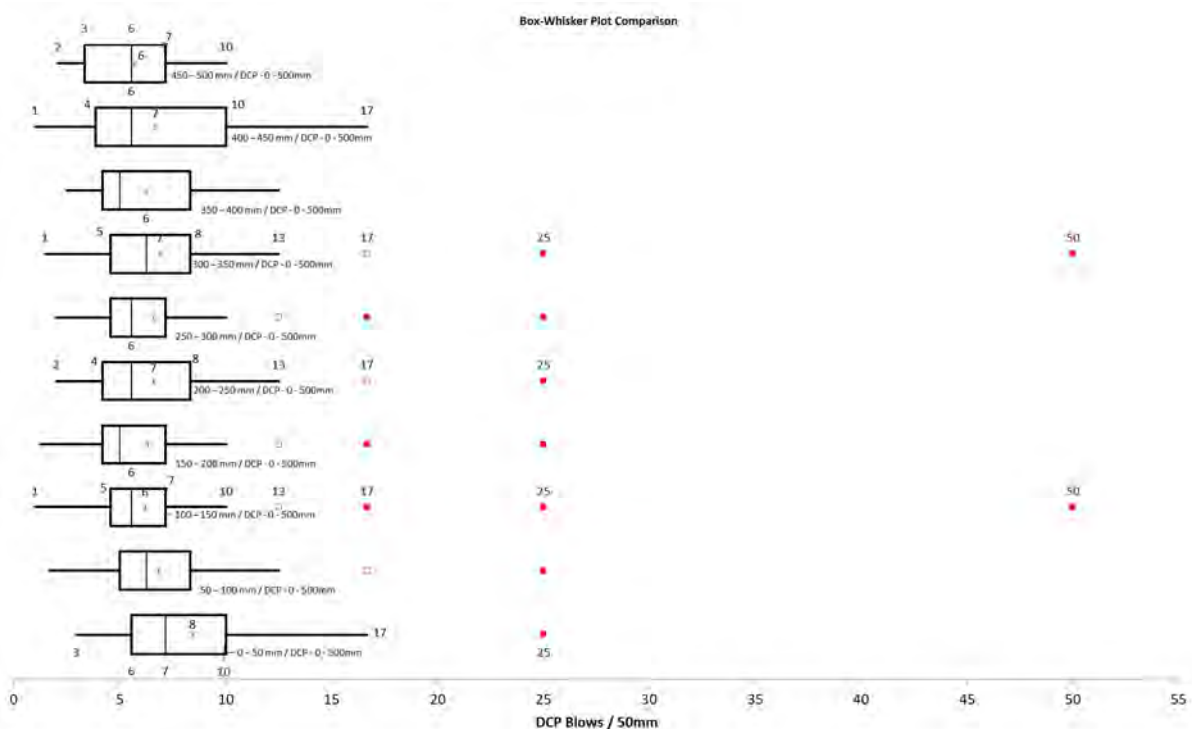


Figure 11-8 DCP Blows / 50mm at varying depth

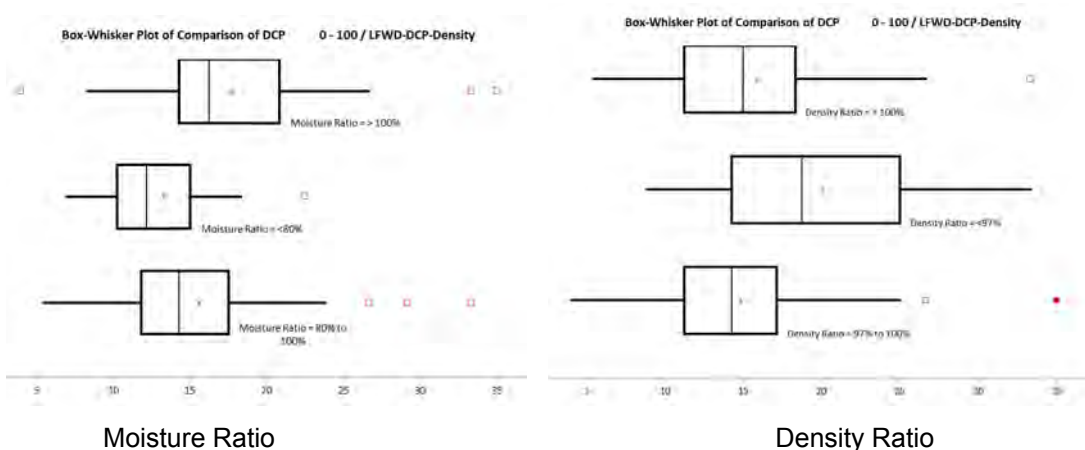


Figure 11-9 DCP Blows 0 - 100mm correlates more with moisture ratio than with density ratio

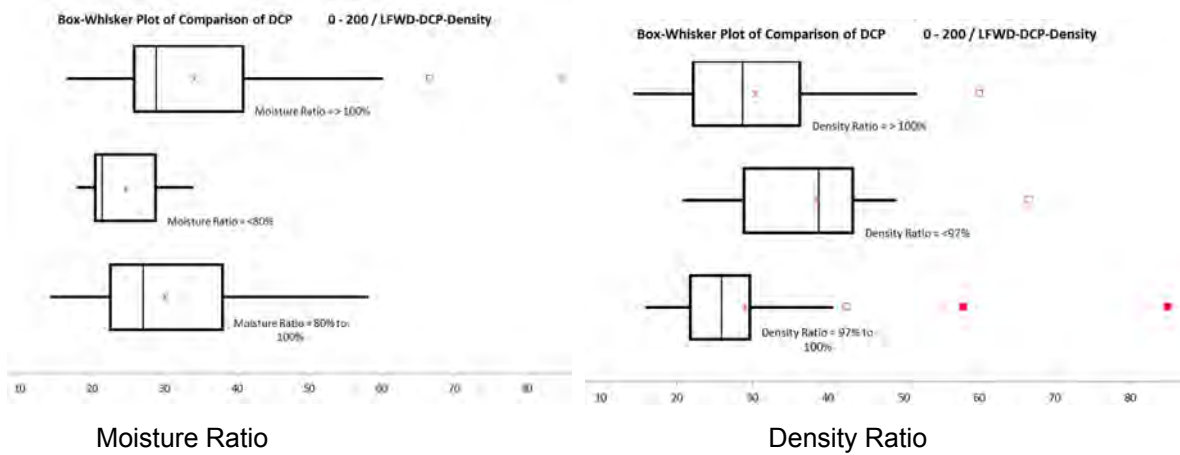


Figure 11-10 DCP Blows 0 - 200mm correlates more with moisture ratio than with density ratio

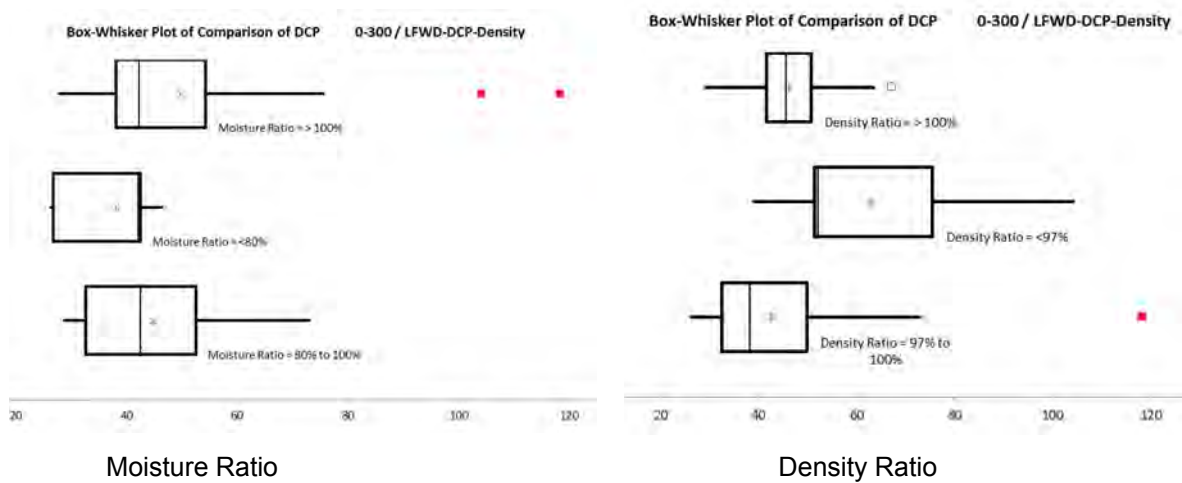


Figure 11-11 DCP Blows 0 - 300mm is not well correlated with moisture ratio or with density ratio

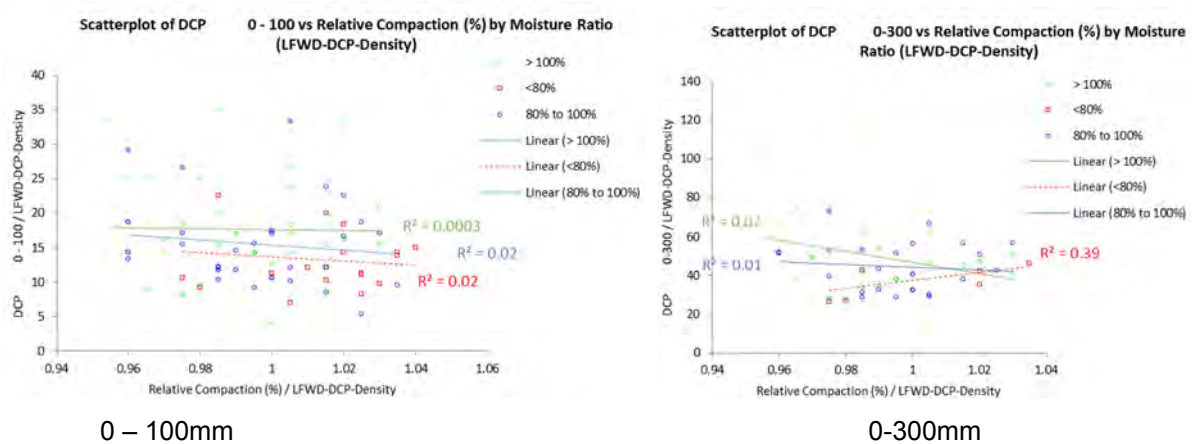


Figure 11-12 DCP correlation is overall poor, but improves with depth for low Moisture ratios only

11.3.4 PANDA results

The PANDA is another penetration test, which is similar to the DCP but measures the energy. Energy would depend on both the input blows and the soil resistance.

Figure 11-19 shows the PANDA results in 50mm increments up to 500mm depth. The following observations are evident from this data

- o The top 150 is not representative of the other layers
 - o At 0 – 50mm the PANDA quartile to median value is ~ 60% than at 0 – 200mm
 - o At 0 – 100mm the PANDA quartile to median value is ~ 80% than at 0 – 200mm
 - o At 0 – 150mm the PANDA quartile to median value is ~ 80% than at 0 – 200mm
- o Below 150mm the measured energy is 10.5 MPa and 14.2 MPa for the quartile to median value, respectively. The quartile value may increase with depth, but is considered likely due to an overlap compaction onto and already compacted lower layer
- o The following lower quartile applies for the PANDA
 - o < 97% RC - qc = 9.2 MPa
 - o 97% - 100% RC - qc = 10.3 MPa
 - o > 100% RC - qc = 12.2 MPa
- o The following lower quartile applies for the PANDA
 - o < 80% MR - qc = 12.8 MPa
 - o 80% - 100% MR - qc = 10.3 MPa
 - o > 100% MR - qc = 10.3 MPa. Similar to 80% to 100% MR
- o At 0 – 100mm values above 12 and 17 are considered mild outliers for RC < 97% and > 97%, respectively

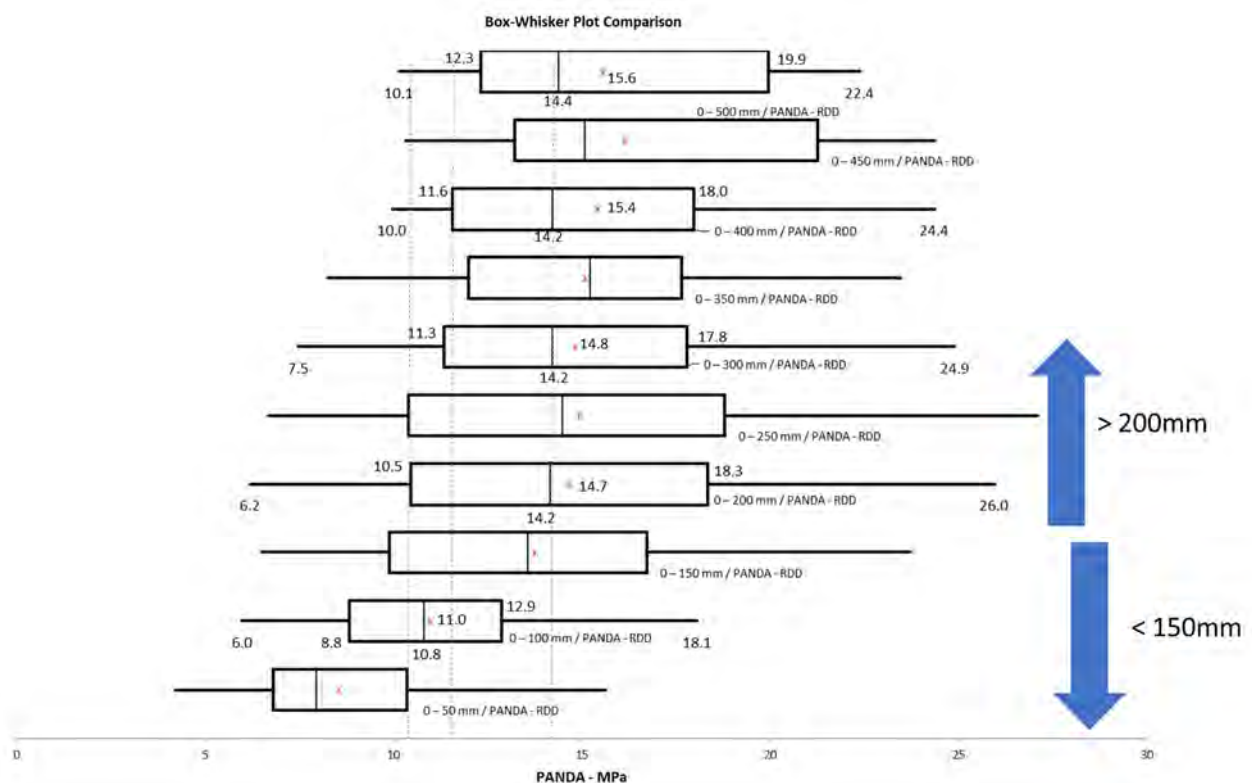


Figure 11-13 PANDA blows at varying depths

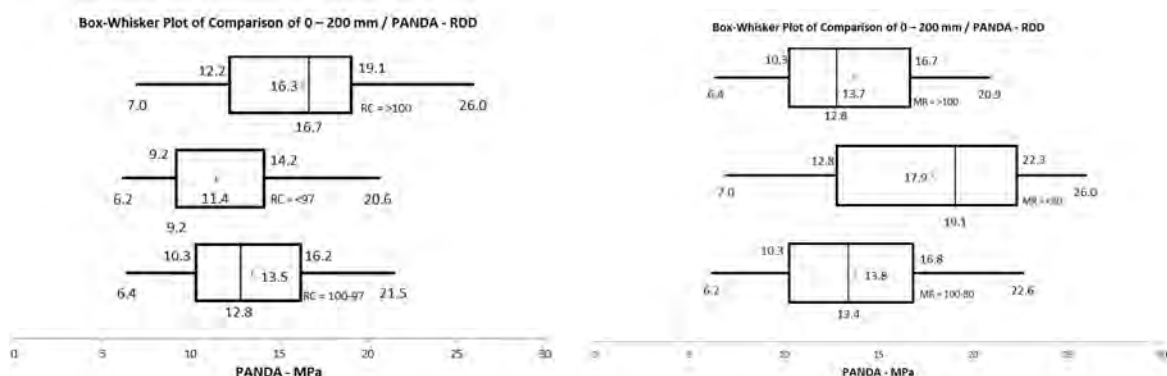


Figure 11-14 PANDA blows at varying RC and MR

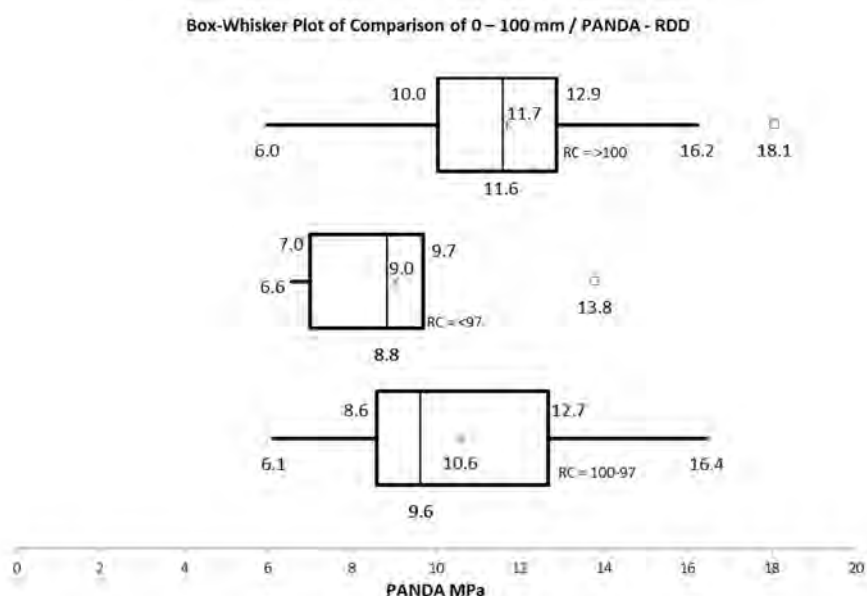


Figure 11-15 PANDA blows at varying RC at 0 – 100mm

11.3.5 Clegg Impact Hammer results

The Clegg impact values varies with drop heights and the test values are shown in Figure 11-16. There is a noted difference from the 0.076m to 0.305m drop height, but with reduced changes between 0.305 and 0.610m. Higher variability occurs at 0.457 and 0.610m.

Figure 11-20 compares the CIV for low to high moisture ratios and relative compaction. These were only from a total of 24 tests, so the sub categorisation had even more limited data.

A low, medium and high moisture ratios have been used in the range <80%, 80% to 100% and >100%, respectively. The expectation should be the lowest moisture ratios should have the lowest values. This is not evident. The conclusion is that at 0.305m drop height a weak relationship with moisture content can be expected.

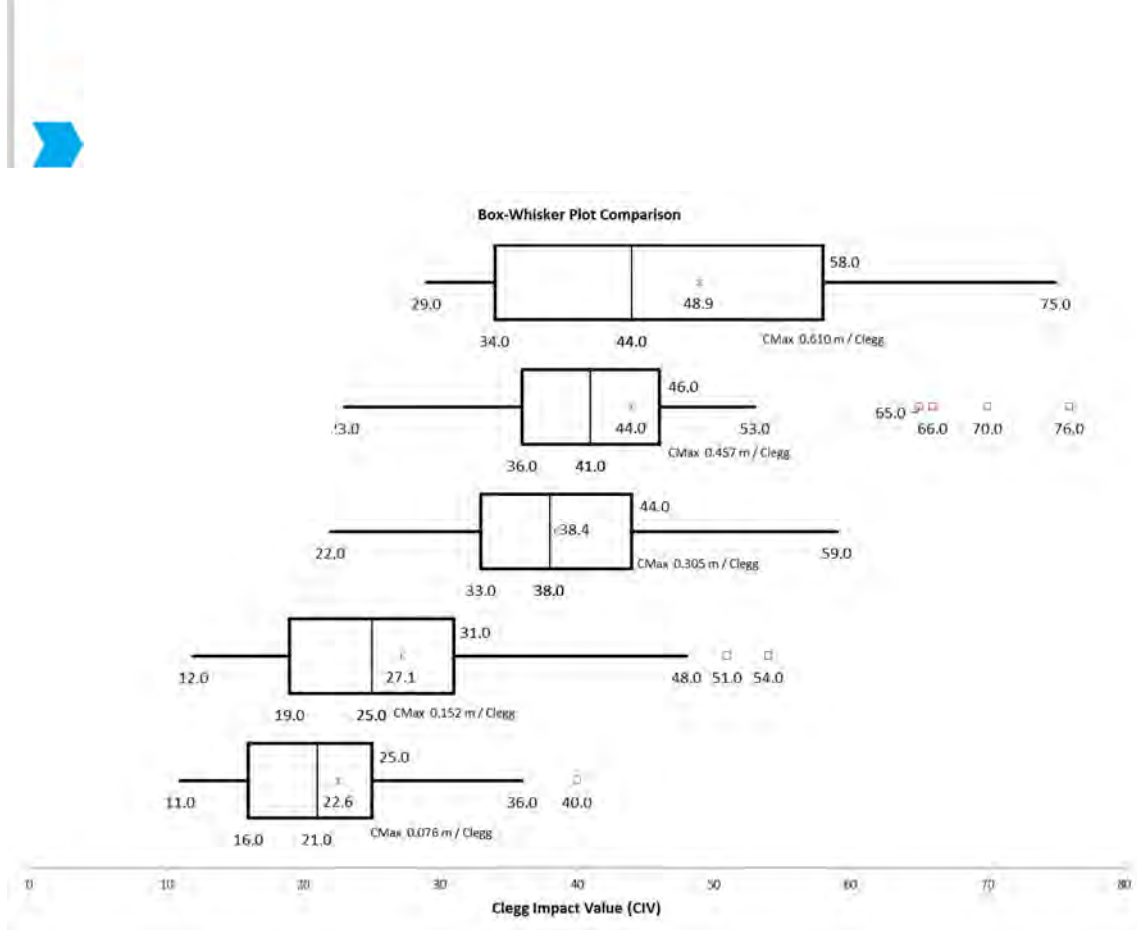


Figure 11-16 Clegg Impact Value at varying drop heights

Similarly, as all compaction were in the medium to very high range this was classified as medium, high and very high relative compaction in the range <98%, 98% to 100% and >100%, respectively. The expectation in this case should be the medium compaction should have the lowest values. This is not evident. The conclusion is that at 0.305m drop height a weak relationship with compaction can be expected.

A similar conclusion is evident at the drop height of 0.076m.

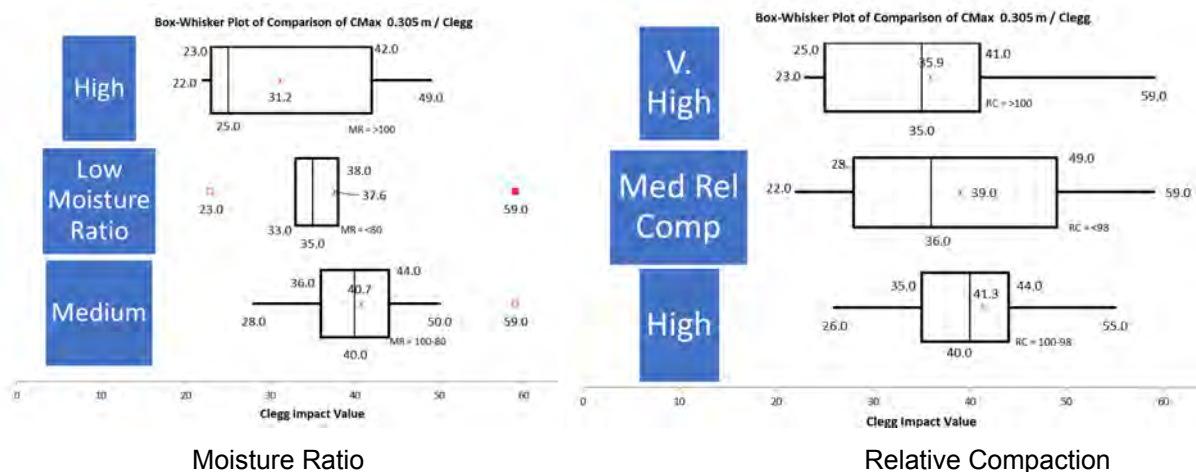


Figure 11-17 Clegg Impact Value at moisture ratio and relative compaction at 0.305m drop height

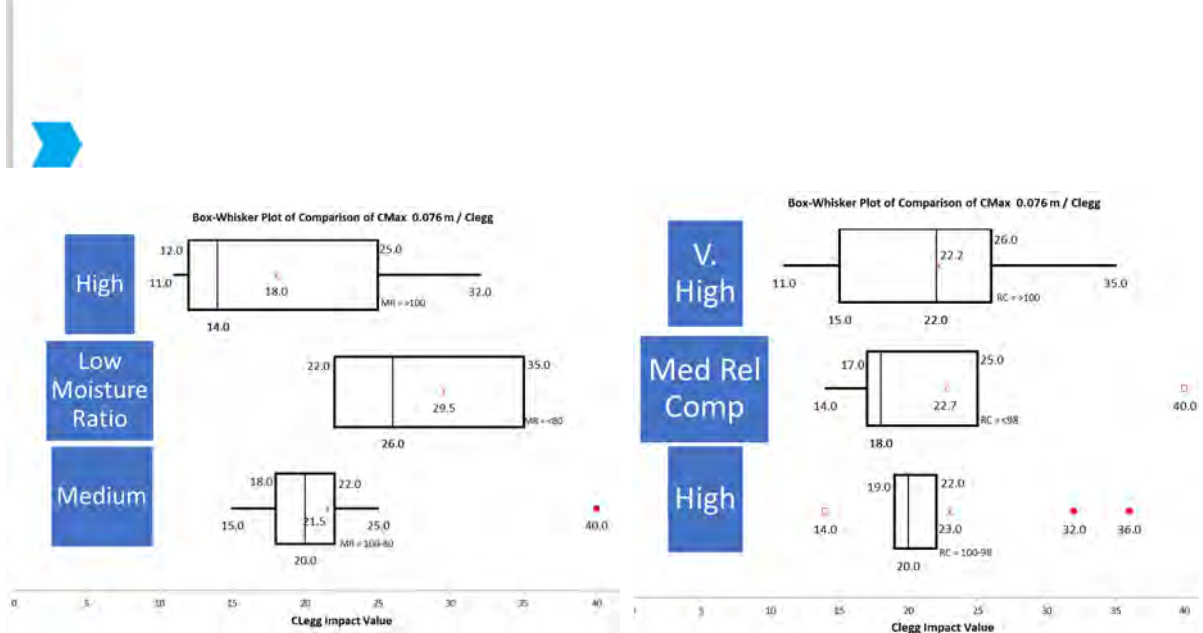


Figure 11-18 Clegg Impact Value at moisture ratio and relative compaction at 0.076m drop height

11.3.6 Summary observations from box and whisker plots

Overall the following broad conclusions can be made for each test

- o Large modulus values are occurring for very small changes in DDR
- o Any LFWD value above 200 MPa should be considered an outlier in any analysis. This is likely large stone sizes immediately below the surface.
- o For the PLT, The EV2 modulus is less variable then the EV1 and should be used. Values above 200 MPa should not be used in any analysis
- o Values above DCP 12/50mm should be removed from the analysis. This is likely large stone sizes. This is ~ 25 blows / 100mm
- o PANDA quartile values above 12 MPa is considered very dense with RC > 100%
- o PANDA quartile values above 12.8 MPa is considered dry with RC < 80%. Above MR of 80% the value reduces to 10.3 MPa
- o PANDA values above 12 should be removed from the analysis for compaction below 97%. Above 97% values above 17 should be removed
- o The Clegg values would change significantly with drop height up to 0.305m. Above that height higher variability may occur, but the value did not seem to change

This box and whisker analysis identified likely outlier and provides the basis to remove such data in any statistical analysis.

11.4 PDFs – Density Tests

Figure 11-19 shows the measured and calculated elements in deriving the relative compaction and moisture ratio. Adjustments are required for oversize material. Chapter 6 showed the common industry practice of not sampling oversize, therefore the lab correction is often incorrect even when done.

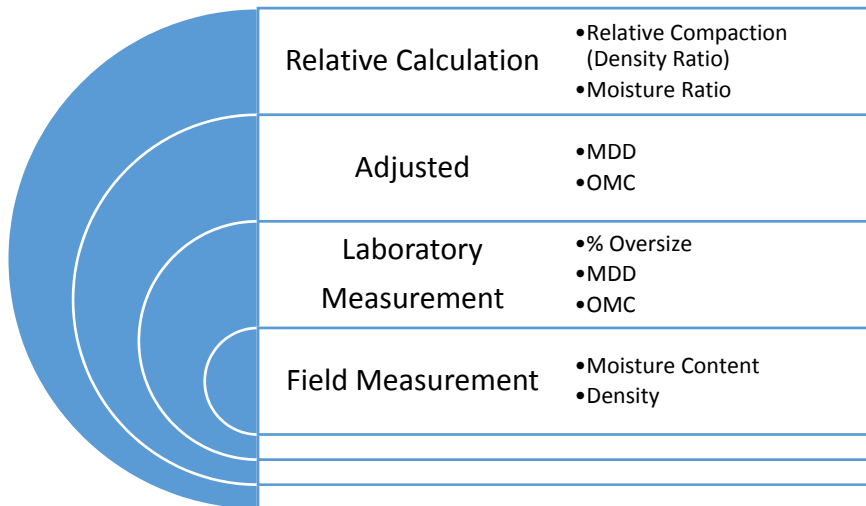


Figure 11-19 Elements of the relative compaction and moisture ratio

These testing elements were examined in detail only because this is the benchmark test to judge other tests against. The probability density functions (PDF) for these elements are shown in Appendix K and summarised in Table 11-1. The QA results for test sites with Lots 12 to 30 are compared with an expanded version of Lots 6 to 38. This compares the PDF and resulting predictive values and its coefficient of variation (COV).

Key conclusions are

- ✓ Relative Compaction and field dry density measurements are very precise i.e. low COV of 2.3% and 2.0, respectively. Similar values are predicted in both the limited lot sizes and larger data size.
- ✓ The maximum dry density and moisture content measurements are not as precise with a COV of 14% to 17%
- ✓ The % oversize varies significantly (COV ~ 60%) for this uniform imported fill and affected the adjusted MDD. Given this is already poor sampling then the use of AS 1289 5.4.2 which allows assignment of values should not be applied even for this “uniform” site material

AS 1289.5.4.2—2007

Australian Standard®

Methods of testing soils for engineering purposes

Method 5.4.2: Soil compaction and density tests—Compaction control test—Assignment of maximum dry density and optimum moisture content values

In using that assigned approach AS 1289 5.4.2 requires 6 samples not differing by $\pm 0.05 \text{ t / m}^3$ to be within limits of the MDD and $\pm 1.0\%$ of mean OMC. This is a side issue but shows this commonly procedure used in industry as an early indicator of likely DDR on site is inherently flawed.

Table 11-1 Elements of density tests compared

Test	Test Sites / No.	PDF (Fit Rank)	10%	25%	Median	Mean / SD	COV
Field Dry Density (t/m ³)	12 – 30 / 95	Input	2.14	2.16	2.19	2.20/.05	2.3%
		Lognormal 2	2.14	2.16	2.19	2.20/.05	2.3%
		Normal 9	2.14	2.16	2.19	2.20/.05	2.3%
Field Dry Density (t/m ³)	6 – 38 / 136	Input	2.13	2.16	2.19	2.19/.05	2.3%
		Normal 1	2.13	2.16	2.19	2.20/.05	2.3%
Relative Compaction %	12 – 30 / 95	Input	97	99	100	100/2	2.0%
		Kumaraswamy 1	97	98	100	100/2	2.0%
		Normal 3	97	98	100	100/2	2.0%
Relative Compaction %	6 – 38 / 136	Input	97	99	100	100/2	2.0%
		Beta General 1	97	98	100	100/2	2.0%
		Normal 4	97	98	100	100/2	2.0%
Relative Compaction %	21 – 26 / 29	Input	97	99	100	100/2	2.0%
		Normal 1	98	99	100	100/2	2.0%
Field Moisture Content %	12 – 30 / 95	Input	5.8	6.5	7.6	7.4/1.2	16%
		Kumaraswamy 1	5.7	6.5	7.4	7.4/1.2	16%
		Normal 4	5.8	6.6	7.4	7.4/1.2	16%
Field Moisture Content %	6 – 38 / 136	Input	5.5	6.2	6.9	7.1/1.2	17%
		Beta General 1	5.5	6.2	7.0	7.0/1.2	17%
		Normal 4	5.5	6.3	7.1	7.1/1.2	17%
Moisture Ratio %	12 – 30 / 95	Input	75	80	96	94/16	17%
		Beta general 1	72	82	94	94/16	17%
		Normal 4	74	83	94	94/16	17%
Adjusted Moisture Ratio %	6 – 38 / 136	Input	77	84	92	95/16	17%
		Lognormal 2	76	84	94	95/16	17%
		Normal 9	75	84	95	95/16	17%
% Oversize > 38mm	6 – 38 / 136	Input	3.0	5.0	9.0	10/5.9	59%
		Lognormal 5	2.9	5.7	9.3	10/6.0	60%
		Normal 8	2.4	6.0	10.0	10/5.9	59%
Adjusted MDD (t/m ³)	6 – 38 / 136	Input	2.16	2.17	2.19	2.2/.03	14%
		Lognormal 3	2.16	2.17	2.19	2.2/.03	14%
		Normal 9	2.16	2.18	2.20	2.2/.03	14%

11.5 PDFs – Non - Density Tests

The alternative parallel tests were then analysed statistically, similarly to the density testing. The objective was to compare the COV and its differences in predicting material change. The probability density functions (PDF) for these elements are shown in Appendix K and summarised in Table 11-2.

Key conclusions are

- ✓ Prima and DCP tests not as precise as density testing
- ✓ For these tests the Normal PDF are poorly ranked in terms of best fit
- ✓ Assessment should avoid the lower 10% values with Normal PDFs for COVs > 25%. This observation is critical as current quality assessment is based on a 10% LCV value for density assessment (Figure 11-1). This highlights that using a similar LCV will provide issues in its implementation as a quality tool.
- ✓ LFWD @ 100kPa is preferable to 50 kPa as a significantly reduced COV at 111% max to 65% max, respectively
- ✓ The subset tests of Lots 21 to 26 show a clear difference in LFWD results, yet density results show no difference (refer Table 11-2). Thus, while density is a very precise test, it does not differentiate the variable modulus changes occurring.
- ✓ DCPs 200 / 300 / 400 are preferable to a DCP of 0 – 100 as a reduced COV
- ✓ Prima LFWD @ 50 KPa, Field Volumetric Moisture Content and Field Bulk Electrical Conductivity has COV > 100% and are not reliable measurements for QA due to the wide spread of results
- ✓ Soil surface temperature showed little variation despite an ambient temperature variation of 39°C to 22°C. The measurements were taken during daylight working hours where the low temperatures would generally be above 27°C.

Table 11-2 Non density tests compared statistical analysis

Test	Test Site / No.	PDF (Fit Rank)	10%	25%	Median	Mean / SD	COV
Prima LFWD (MPa) @50 kPa	12 – 30 / 87	Input	29	46	98	128/146	114%
		Lognormal 3	28	50	90	126/124	98%
		Normal 11	(-59)	29	128	128/146	114%
Prima LFWD (MPa) @100 kPa	12 – 30 / 87	Input	29	37	75	80/44	55%
		Lognormal 4	31	45	68	81/53	65%
		Normal 7	24	51	80	80/44	55%
Prima LFWD (MPa) @100 kPa	21 – 26 / 84	Input	23	43	86	115/98	85%
		Lognormal 4	27	27	84	118/84	71%
		Normal 11	(-10)	49	115	115/98	85%
DCP Blows 0 - 50mm	12 – 29 / 200	Input	5.0	5.6	7.1	8.4/3.6	43%
		Lognormal 1	4.7	5.9	7.7	8.5/3.7	44%
		Normal 9	3.8	6.0	8.4	8.4/3.6	43%
DCP Blows 50 – 100 mm	12 – 29 / 197	Input	3.8	5.0	6.3	6.8/3.1	46%
		Lognormal 3	3.7	4.8	6.3	6.8/2.9	43%
		Normal 10	2.9	4.8	6.8	6.8/3.1	46%

Test	Test Site / No.	PDF (Fit Rank)	10%	25%	Median	Mean / SD	COV
DCP Blows 0 – 100 mm	12 – 29 / 205	Input	8.6	11	14	15/6.2	41%
		Lognormal 4	7.3	11	14	15/6.1	41%
		Normal 6	6.8	11	15	15/6.2	41%
DCP Blows 0 – 200 mm	12 – 29 / 158	Input	19	22	27	29/12	41%
		Loglogistic 1	18	22	27	28/10	36%
		Lognormal 6	17	21	27	29/10	34%
		Normal 9	14	21	29	29/12	41%
DCP Blows 0 – 300 mm	12 – 29 / 118	Input	29	33	41	44/17	39%
		Loglogistic 1	28	34	41	43/14	33%
		Lognormal 4	27	33	41	43/15	35%
		Normal 10	22	32	44	44/17	39%
DCP Blows 0 – 400 mm	12 – 29 / 118	Input	42	47	56	60/22	37%
		Loglogistic 1	40	47	55	59/19	32%
		Lognormal 5	39	46	56	60/19	32%
		Normal 10	32	45	60	60/22	37%
Field Volumetric Moisture Content %	16 – 29 / 119	Input	1.2	1.6	4.7	7.0/6.5	93%
		Lognormal 1	1.3	2.0	3.9	8.3/16	193%
		Normal 10	(-1.3)	2.6	7.0	7.0/6.5	93%
Bulk Electrical Conductivity ds/m X 10 ⁻³	16 – 29 / 119	Input	2	4	10	15/15	100%
		Lognormal 2	19	4	9	15/19	127%
		Normal 7	(4)	5	15	15/15	100%
Soil Temperature °C	16 – 29 / 119	Input	30.5	31.6	33.2	33.5/2.9	8.7%
		Lognormal 5	30.5	31.5	33.0	33.5/2.8	8.4%
		Normal 10	29.7	31.5	33.5	33.5/2.9	8.7%

11.6 PDFs – Modulus Tests

The PLT was noted as the most accurate tests from previous studies in Phase 2. This test is well established with available standards and procedures. Comparing the parallel LFWD tests were then analysed statistically. The objective was to compare the COV and its differences in predicting material change based on a modulus only relative change assessment. Note that this is not direct comparison between actual values which has been done in paired analysis carried out in previous chapters. The probability density functions (PDF) for these elements are shown in Appendix K and summarised in Table 11-3.

The PLT was only part of et ARRB testing component which had a small data set (12 NO.) as compared to the other tests. This test takes longer and needs an equipment reaction, so has a higher associated cost. The PLT would provide a complete stress strain response as compared to the other tests.

Key conclusions are: -

- ✓ The PLT – Ev1 shows little variation at stress ranges 100 kPa to 400 kPa
- ✓ The Prima LFWD and PLT Ev1 have ~ similar precision
- ✓ Normal PDF is OK ranked in terms of best fit for PLT Ev1 but poorly ranked for Ev2. Note that latter value is adopted for design modulus value
- ✓ PLT – Ev2 has high variation at stress ranges 100 to 400 kPa
- ✓ Avoid 10% values with Normal PDFs for PLT Ev2 and PRIMA @100kPa
- ✓ Ev1 and Ev2 @ 400 kPa has less COV than at lower stresses
- ✓ LFWD Prima @100kPa ~ Ev2 for 25%/Median/Mean but ~0.5 @ 10% or less

Table 11-3 Modulus tests compared with statistical analysis

Test	Test Site / No.	PDF (Fit Rank)	10%	25%	Median	Mean / SD	COV
Prima LFWD (MPa)) @50 kPa	12 – 30 / 87	Input	29	46	98	128/146	114%
		Lognormal 3	28	50	90	126/1241	98%
		Normal 11	(-59)	29	128	28/146	114%
Prima LFWD (MPa)) @100 kPa	12 – 30 / 87	Input	29	37	75	80/44	55%
		Lognormal 4	31	45	68	81/53	65%
		Normal 7	24	51	80	80/44	55%
Prima LFWD (MPa)) @100 kPa	21 – 26 / 84	Input	23	43	86	115/98	85%
		Lognormal 4	27	27	84	118/84	71%
		Normal 11	(-10)	49	115	115/98	85%
PLT – Ev1 (MPa) @100 kPa	21 – 26 / 12	Input	11	12	37	33/17	52%
		Uniform 1	12	12	33	33/15	46%
		Normal 3	11	21	33	33/17	52%
PLT – Ev1 (MPa) @200 kPa	21 – 26 / 12	Input	11	13	38	33/17	52%
		Uniform 1	12	21	34	34/16	47%
		Normal 3	11	22	33	33/17	52%
PLT – Ev1 (MPa) @300 kPa	21 – 26 / 12	Input	12	14	34	34/16	47%
		Uniform 1	13	21	35	35/16	46%
		Normal 3	13	23	34	34/16	47%
PLT – Ev1 (MPa) @400 kPa	21 – 26 / 12	Input	13	15	36	35/16	46%
		Uniform 1	14	22	36	36/16	44%
		Normal 3	14	24	35	35/16	46%
PLT – Ev2 (MPa) @100 kPa	21 – 26 / 12	Input	44	54	70	135/143	106%
		Lognormal 3	43	52	78	150/290	193%
		Normal 10	(-49)	38	135	135/143	106%

Test	Test Site / No.	PDF (Fit Rank)	10%	25%	Median	Mean / SD	COV
PLT – Ev2 (MPa) @200 kPa	21 – 26 / 12	Input Lognormal 2 Normal 10	42 41 (-40)	48 51 34	85 75 115	115/121 119/75 115/121	105% 63% 105%
PLT – Ev2 (MPa) @300 kPa	21 – 26 / 12	Input Lognormal 2 Normal 10	44 41 (-36)	49 53 35	90 78 114	114/118 114/1221 14/118	104% 107% 104%
PLT – Ev2 (MPa) @400 kPa	21 – 26 / 12	Input Lognormal 2 Normal 10	47 43 (-13)	52 55 45	93 80 108	108/95 108/94 108/95	88% 87% 88%
LFWD (Prima) / PLT – Ev1 ratio			1.9	3.1	2.4	3.4	
LFWD (Prima) / PLT – Ev2 ratio			0.5	0.9	1.1	1.0	
Ev2 / Ev1 ratio			3.5	3.8	2.4	3.4	

11.7 Scree Analysis

In any factor analysis a key aspect is to determine how many factors affect a result. Statistical programs were used with this selection. Figure 11-19 showed the main components used in obtaining a relative compaction value. Scree plots were used to assess the principal component and shows the eigenvalues on the y-axis and the number of factors on the x-axis. The downward curve represents its relative effect. The “elbow” point where the slope of the curve is levelling off indicates the number of factors generated by the analysis.

The scree plot suggests the principal five factors. This factor analysis reduces the large number of variables that describe a complex concept to a few interpretable latent variables (=factor). These smaller number of interpretable factors explains the maximum amount variability in the data.

This scree analysis in **Figure 11-20** shows the following sequence

Principal Components

1. Field Dry Density (t/m³)
2. "Oversize (%) – Dry: (> 37.5 mm)"
3. Adjusted Max. Dry Density (t/m³)
4. Relative Compaction (%) – RDD

Minor Components

5. Field Moisture Content (%)
6. Assigned OMC (%)
7. Adjusted OMC (%)

Minor Components

1. Moisture Ratio (%) - Reported

2. "Moisture Ratio (%) – Recalculated: (FMC / OMC, %)"
3. Moisture Ratio (%) - (FMC / Adjusted OMC, %) Recalculated

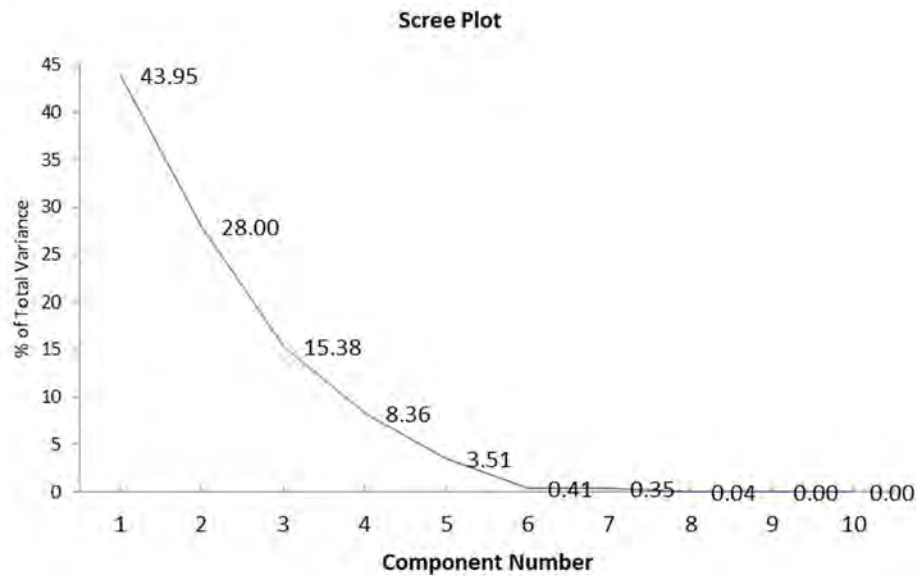


Figure 11-20 Scree plot used to assess the principal components

Table 11-4 Scree analysis Components

Component		Total Variance Explained		
Description	Ref.	Variance	% of Total Variance	Cumulative %
Field Dry Density (t/m ³)	1	4.395	43.95	43.95
"Oversize (%) – Dry: (> 37.5 mm)"	2	2.800	28.00	71.95
Adjusted Max. Dry Density (t/m ³)	3	1.538	15.38	87.33
Relative Compaction (%) - RDD	4	0.836	8.36	95.69
Field Moisture Content (%)	5	0.351	3.51	99.20
Assigned OMC (%)	6	0.041	0.41	99.61
Adjusted OMC (%)	7	0.035	0.35	99.96
Moisture Ratio (%) - Reported	8	0.004	0.04	100.00
Moisture Ratio (%) – Recalculated: (FMC / OMC, %)	9	0.000	0.00	100.00
Moisture Ratio (%) - (FMC / Adjusted OMC, %) Recalculated	10	0.000	0.00	100.00



11.8 Principal Component Analysis

This Principal Component Analysis (PCA) shows 87.3% of variance can be explained by a 3 component analysis. Moisture Ratio is the least relevant parameter based on this data analysis. This does not mean, that it is not useful in the field for the compaction process. However, in an assessment of contributory and related factors, the moisture ratio has little effect compared to other measurements.

Table 11-5 provides the calculated correlation matrix from this PCA. The diagonal all have a value of 1.00 i.e. Field Dry Density (FDD) has a correlation of 1.0 with itself. The upper right is a mirror image of the values in the lower left matrix. The table highlights the significant correlations in red and green for the high positive and negative values, respectively. The following stand out in this Table as the most correlated to Spearman rank: -

- ✓ The adjusted OMC is negatively correlated (-0.93) with the oversize fraction
- ✓ The field moisture ratio (reported, recalculated and adjusted) depends on the field moisture content (0.90 to 0.95). The three moisture ratios are strongly related (0.91 to 0.96). Yet these variables were the least significant in the scree analysis as related to any other test factor
- ✓ FDD has the highest correlation of 0.78 with relative compaction followed by field moisture content – a negative correlation of -0.44
- ✓ The adjusted MDD is highly dependent on the oversize fraction (0.73). Yet this measurement is considered to have a high measurement error.

Conversely the following show little relationship: -

- X The assigned OMC is not related to the oversize (-0.06), the relative compaction (-0.07) or the field moisture content (0.04).
- X The adjusted recalculated moisture ratio does not depend on the oversize fraction (0.10) or the adjusted MDD (0.09) or the assigned OMC (-0.08) or the adjusted OMC (-0.12)
- X The reported moisture ratio is not related to the assigned OMC (-0.07). The recalculated moisture ratio is not related to the latter.

The latter moisture ratios are expected as these are simply recalculations based on actual (rather than assumed OMC) and subsequently refined for oversize.

Table 11-5 Density Correlation Matrix

	Field Dry Density (t/m ³)	Oversize (%) - Dry (> 37.5 mm)	Adjusted Max. Dry Density (t/m ³)	Relative Compaction (%) - RDD	Field Moisture Content (%)	Assigned OMC (%)	Adjusted OMC (%)	Moisture Ratio (%) - Reported	Moisture Ratio (%) - Recalculated (FMC / OMC, %)	Moisture Ratio (%) - (FMC / Adjusted OMC, %) Recalculated
<i>Correlation Matrix</i>	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38	Density Tests - Sites 6 to 38
Field Dry Density (t/m ³)	1.00	0.26	0.35	0.78	-0.44	-0.27	-0.33	-0.38	-0.39	-0.33
Oversize (%) - Dry (> 37.5 mm)	0.26	1.00	0.73	-0.22	-0.31	-0.06	-0.93	-0.16	-0.30	0.10
Adjusted Max. Dry Density (t/m ³)	0.35	0.73	1.00	-0.31	-0.24	-0.30	-0.75	-0.13	-0.19	0.09
Relative Compaction (%) - RDD	0.78	-0.22	-0.31	1.00	-0.28	-0.07	0.17	-0.30	-0.27	-0.39
Field Moisture Content (%)	-0.44	-0.31	-0.24	-0.28	1.00	0.04	0.32	0.95	0.99	0.90
Assigned OMC (%)	-0.27	-0.06	-0.30	-0.07	0.04	1.00	0.31	-0.07	-0.12	-0.08
Adjusted OMC (%)	-0.33	-0.93	-0.75	0.17	0.32	0.31	1.00	0.14	0.27	-0.12
Moisture Ratio (%) - Reported	-0.38	-0.16	-0.13	-0.30	0.95	-0.07	0.14	1.00	0.96	0.94
Moisture Ratio (%) - Recalculated: (FMC / OMC, %)	-0.39	-0.30	-0.19	-0.27	0.99	-0.12	0.27	0.96	1.00	0.91
Moisture Ratio (%) - (FMC / Adjusted OMC, %) Recalculated	-0.33	0.10	0.09	-0.39	0.90	-0.08	-0.12	0.94	0.91	1.00

11.9 Principal Component and cluster analysis

11.9.1 Density Testing

Overall these results suggest that moisture content measurements and its derivatives (moisture ratios, assigned OMC, etc) have little relationship with the density assessment side. One of the key criticisms of alternative testing methods is the fact that moisture is not directly measured. Yet this PCA analysis and its correlation matrix show it has little contribution to the numerical evaluation of compaction assessment from these 136 data points analysed.

A dendrogram diagram shows the hierarchical relationship between these density components. The hierarchical clustering then becomes evident. The Dendrogram from a cluster analysis then shows how the variance is explained in order of these principal components (Figure 11-21): -

1. Adjusted Max Dry density and Oversize %
2. Relative Compaction and Field Dry Density
3. The above combined with the adjusted OMC
4. Other variables are less important

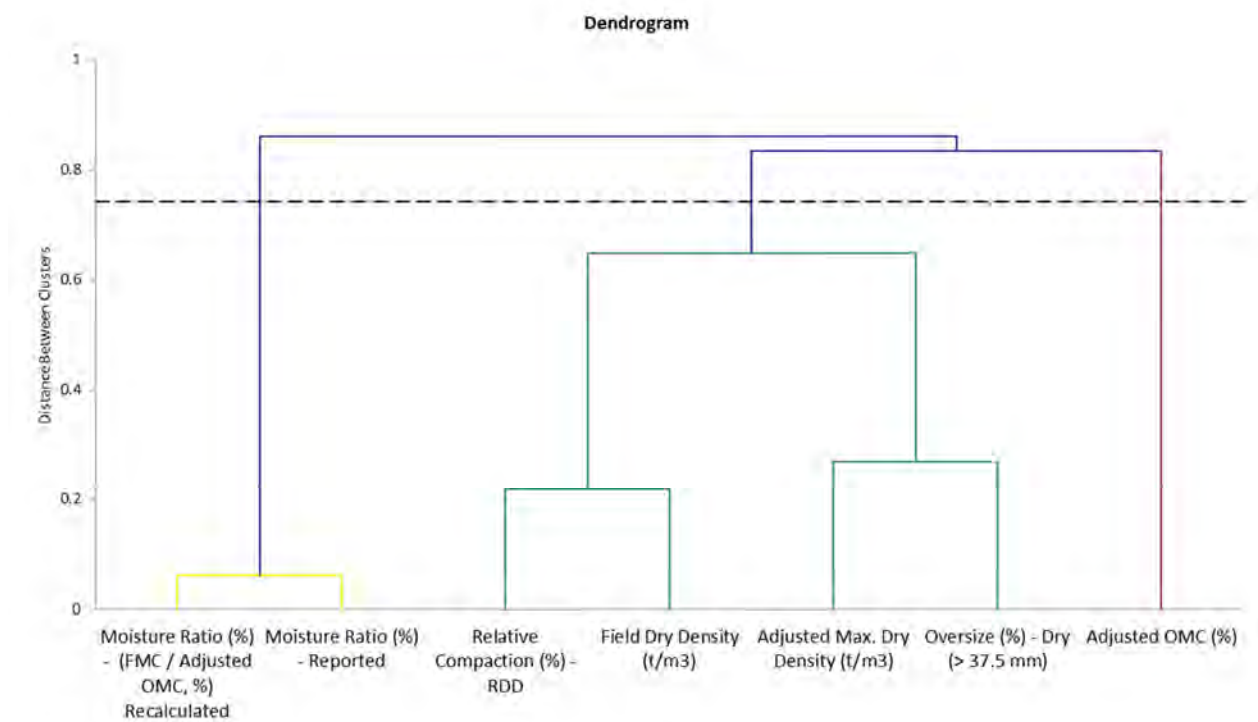


Figure 11-21 Dendrogram plot used to show hierarchical clustering with differences between clusters

Recognising these Principal components and hierarchical relationships, then paired relationships are shown for these 4 components which account for 95.69% of variance. The paired relationships are shown on the paired graphs for MDD with oversize and Relative Compaction with field dry density in Figure 11-22 and Figure 11-23, respectively. These would be site specific to this material, and unlike the dendrogram and scree plots does not provide any direct universal implications.

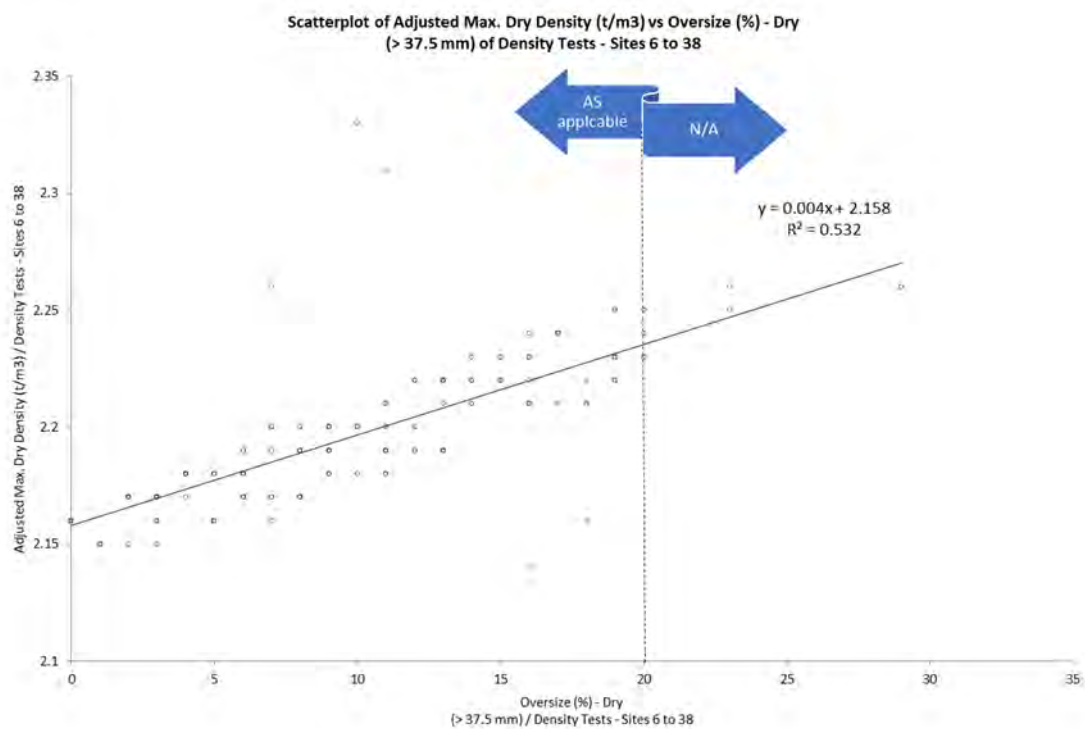


Figure 11-22 Adjusted MDD with oversize are 2 of the 4 Principal components

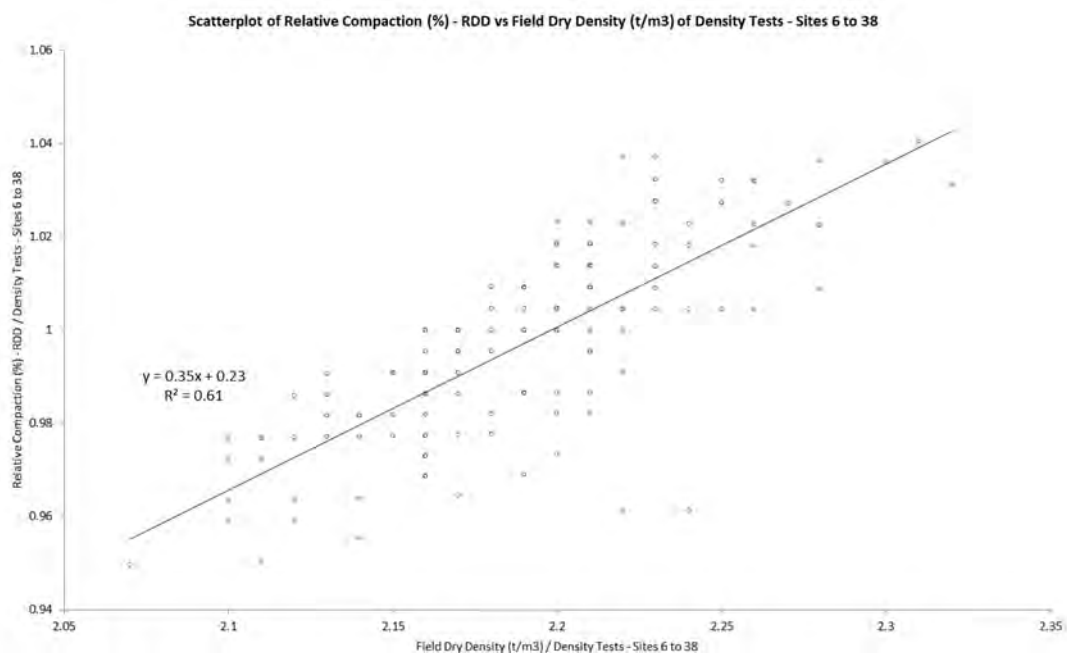


Figure 11-23 Relative Compaction with field dry density are 2 of the 4 Principal components

11.9.2 Clegg and other alternative testing

The Clegg hammer used has a variable energy drop height. In order to assess the effect of Clegg Impact Value (CIV) on other tests, the correlation matrix was established for

1. The 5 drop heights (0.076m to 0.610m)
2. The Density tests of FDD, FMC, Moisture Ratio and Relative Compaction

3. LFWD (Prima @ 100 kPa), and
4. PANDA for 0 – 200mm

The CIV, density, LFWD, and PANDA PDFs are shown in Figure 11-24 through Figure 11-26. Most tests have a non-normal best fit PDF except for the field dry density, the relative compaction and the Clegg at 0.610m. Visually the latter could easily be a uniform PDF. If a chi squared or other goodness of fit test was used then the Uniform PDF would then be the best fit PDF as no “tails” in ted at is evident.

These changing PDFs illustrate the key point that mis -match of PDFs is likely to provide poor correlations which was previously shown.

Table 11-6 shows the Clegg at 0.076m is a very good tool for defining the moisture effects. It is superior to the other field-testing equipment used. However, the Clegg has a poor correlation with density. A large variation occurs at 0.152m drop as compared to the other drop heights

The LFWD would best correlate with the relative compaction, but this was not a string relationship

The filed density and relative compaction show a very high precision.

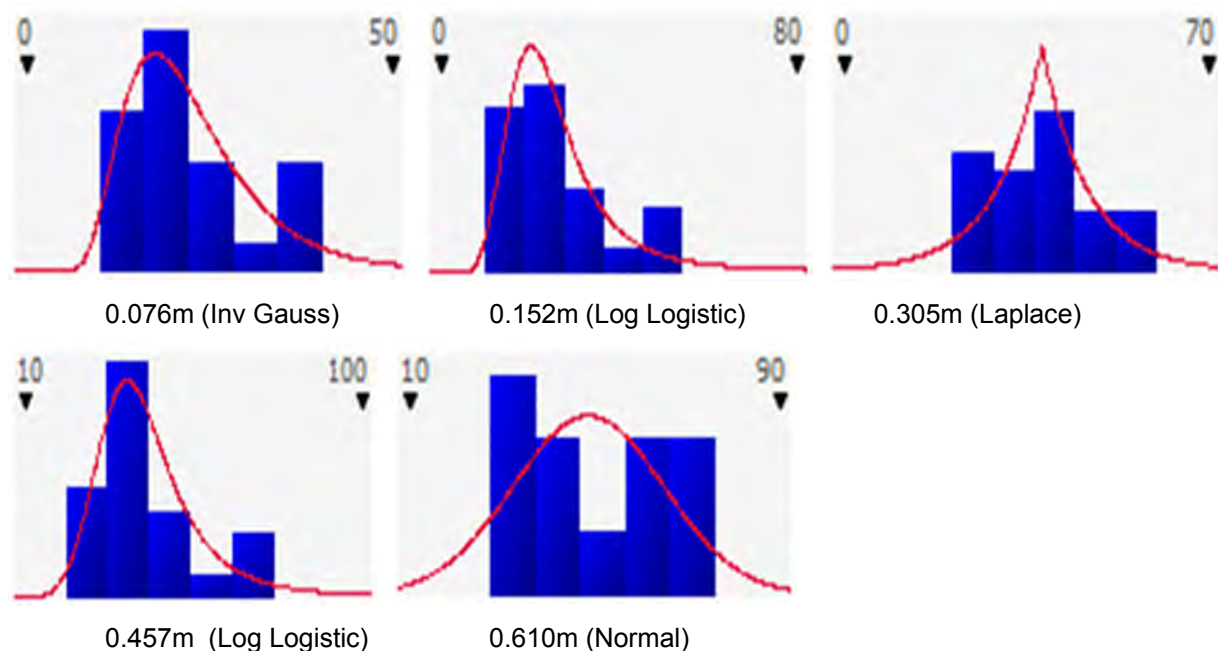


Figure 11-24 Clegg Tests with CIV for varying drop heights – with best fit PDFs



Table 11-6 Density Correlation Matrix

Correlation	CMax 0.076 m	CMax 0.152 m	CMax 0.305 m	CMax 0.457 m	CMax 0.610 m	Field Dry Density (t/m ³)	Field Moisture Content (%)	Moisture Ratio (%) -	Relative Compaction (%) - RDD	LFWD PRIMA s = 100 kPa	PANDA 0 – 200 mm
CMax 0.076 m	1.000										
CMax 0.152 m	0.899	1.000									
CMax 0.305 m	0.448	0.432	1.000								
CMax 0.457 m	0.459	0.455	0.803	1.000							
CMax 0.610 m	0.444	0.518	0.764	0.819	1.000						
Field Dry Density (t/m ³)	0.269	0.222	-0.036	0.075	-0.032	1.000					
Field Moisture Content (%)	-0.512	-0.399	-0.100	-0.144	-0.071	-0.571	1.000				
Moisture Ratio (%) - (FMC / OMC, %)	-0.619	-0.451	-0.170	-0.140	-0.062	-0.475	0.960	1.000			
Relative Compaction (%) - RDD	0.147	0.087	-0.081	-0.063	-0.094	0.830	-0.552	-0.440	1.000		
LFWD PRIMA s = 100 kPa	0.172	0.153	-0.121	-0.198	-0.319	0.192	-0.155	-0.163	0.270	1.000	
PANDA 0 – 200 mm	0.023	0.169	-0.049	-0.022	0.139	0.110	-0.044	0.072	0.165	0.208	1.000
COV	37%	53%	30%	34%	32%	2%	13%	14%	2%	60%	32%

Observations

- ✓ Cmax (0.076m) is well correlated with Cmax (0.152m), and is most influenced by the field moisture content and moisture ratio unlike the other drop heights. Cmax (0.076m) is not correlated to the PANDA (0 – 200mm)
- ✓ With increasing drop height, the influence of moisture reduces with little to no correlation from 0.305m
- ✓ Poor correlation is evident with field density or relative compaction
- ✓ Aside from the obvious high correlation of RDD with field dry density and moisture ratio with field moisture content, no other high correlation exists
- ✓ The density tests have a low COV while the LFWD and CMax (0.152m) has the highest variation

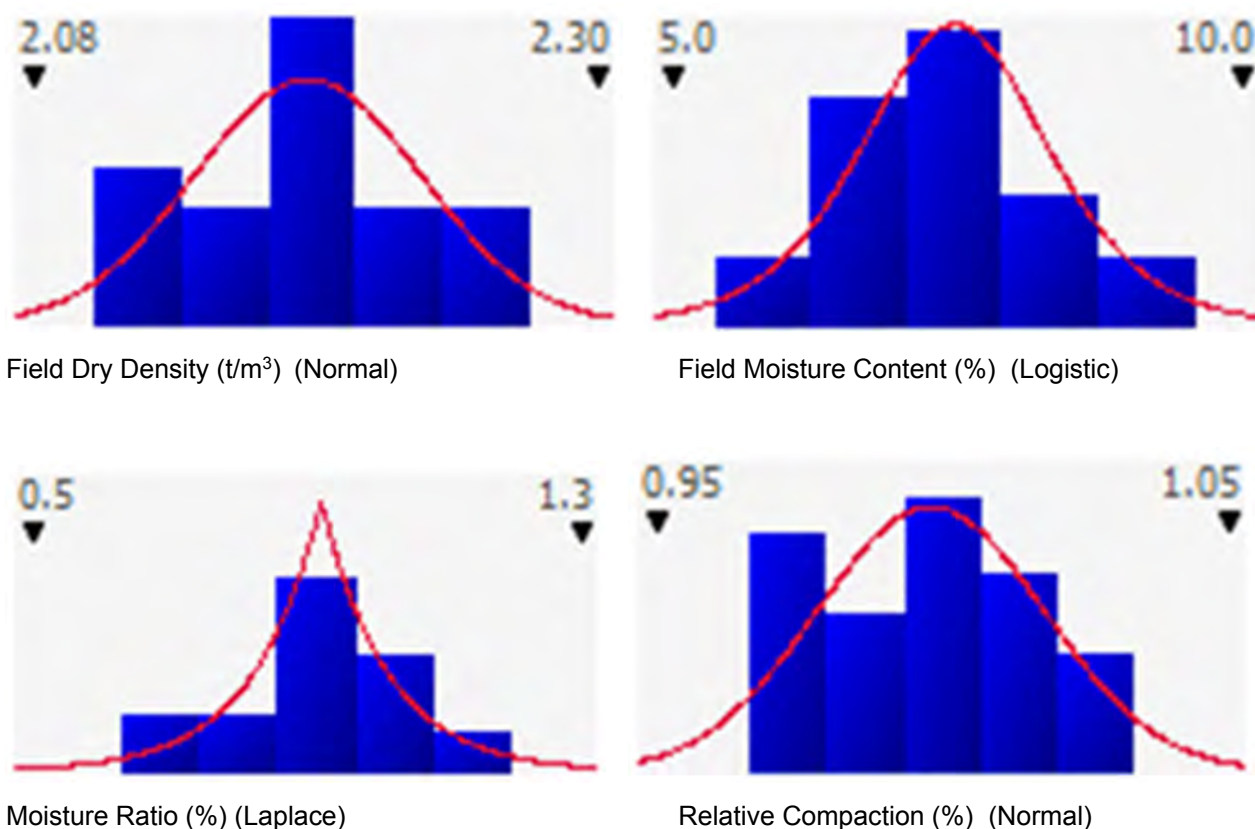


Figure 11-25 Density Tests – with best fit PDFs

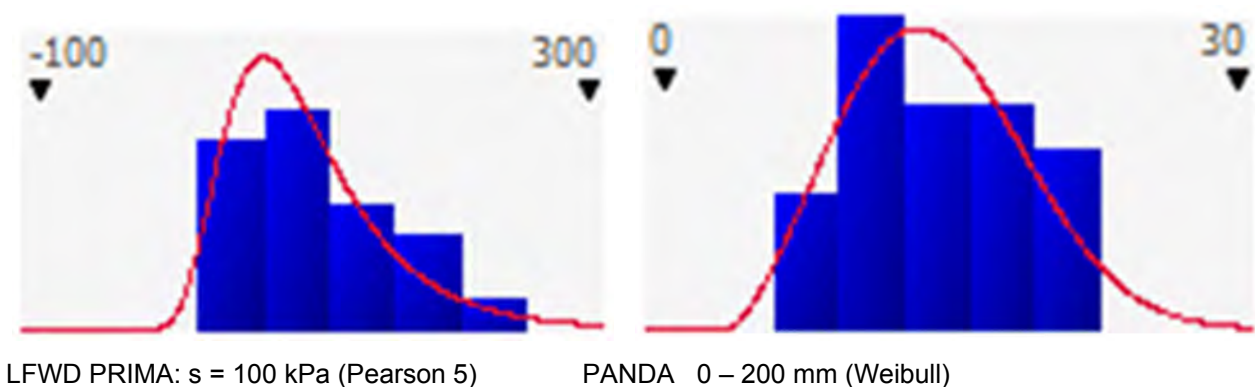


Figure 11-26 LFW and PANDA Tests – with best fit PDFs

11.10 Summary

Density is clearly a superior test in terms of precision and with little variation in measure results. Yet this advantage is exposed with other tests as density shows an inability to differentiate significant changes in modulus or strength from various other tests such as LFW, PLT or DCPs. These tests only were assessed as they represent existing “common” reference tests (DCPs, PLTs and Density) and LFW as on other fully tested at this site.

These latter tests however have significant variation, which means the Lower Characteristic Value (LCV) procedure used with density as the criteria for the acceptance and rejection of a lot should not be applied. This is on part due to the non normal PDF with these tests while Density tests are normally distributed.

Considerations of outliers should form part of the implementation of alternative tests. Significant effect of outliers affecting the upper tail which has implications for the LCV at the typical 10% value. A minimum of a LCV at 25% would then apply for using these alternative tests in any quality control.

Specific equipment considerations shown were

- o LFWDs @ 100 KPa is more reliable than @ 50 KPa applied stress
- o PLTs measurements of Ev1 and Ev2 @ 400 kPa has less COV than at lower stresses, however
- o The PLT – Ev1 shows little variation at stress ranges 100 kPa to 400 kPa
- o The Prima LFWD and PLT Ev1 have ~ similar precision
- o LFWD Prima @100kPa ~ Ev2 value or 25%/Median/Mean values but ~0.5 @ 10% or less
- o The Clegg hammer at 0.076m is useful for defining moisture effects
- o The Least variation of the Clegg would occur at 0.305 to 0.610m drop height
- o The LFWD would best correlate to relative compaction compared to the other tests, but would not have a strong relationship

Principal component analysis shows the following 4 represent 95% of the test relationships

1. Field Dry Density (t/m^3)
2. Oversize (%) – Dry: (> 37.5 mm)
3. Adjusted Max. Dry Density (t/m^3)
4. Relative Compaction (%) – RDD

Moisture ratios are independent of the above, and has little contribution to the above test interrelationships. These relationships are summarised below.

FMC	Moisture Ratio - Recalc	
	Moist Ratio - Reported	
	Moist Ratio Readjusted	
Adjusted OMC	Oversize %	
	Adjusted MDD	
Principal Component Analysis	Relative Compaction	FDD
	Adjusted MDD	Oversize %

The correlation matrix shows the highest Spearman Rank as follows

1. Relative Compaction with Field Dry Density (0.78)
2. Adjusted OMC and % Oversize (-0.93)
3. Field Moisture Content and Moisture Ratios (Reported /recalculated /Adjusted) OMC @ 0.95 / 0.99 / 0.90
4. Moisture Ratios Adjusted and Moisture Ratios (Reported /recalculated) Moisture Ratios @ 0.94 and 0.91

12. Reducing testing variability

A key issue in implementation of any alternative testing was shown to be the large COV of such tests, despite its superiority in most other areas (accuracy, time to do the tests, etc). Outlier effects were evident and described in Chapter 11 - Towards QA Specifications – Analysis Methodology. This chapter therefore uses a stepwise reduction to develop an understanding of this outlier effect.

Given the LFWD was shown to be a likely test for implementation, that test only was analysed in detail. However, the procedure may be used for other test instruments and this analysis does not suggest any preference to that test only. Additionally, different LFWD models may have different reliability so that each should be similarly assessed.

12.1 LFWD Tests population

Figure 12-1 shows the PDF for all “reliable” 71 tests results. Figure 11-3 to Figure 11-5 showed outliers occurring with those tests. This was attributed to likely hard spots from the underlying oversize material.

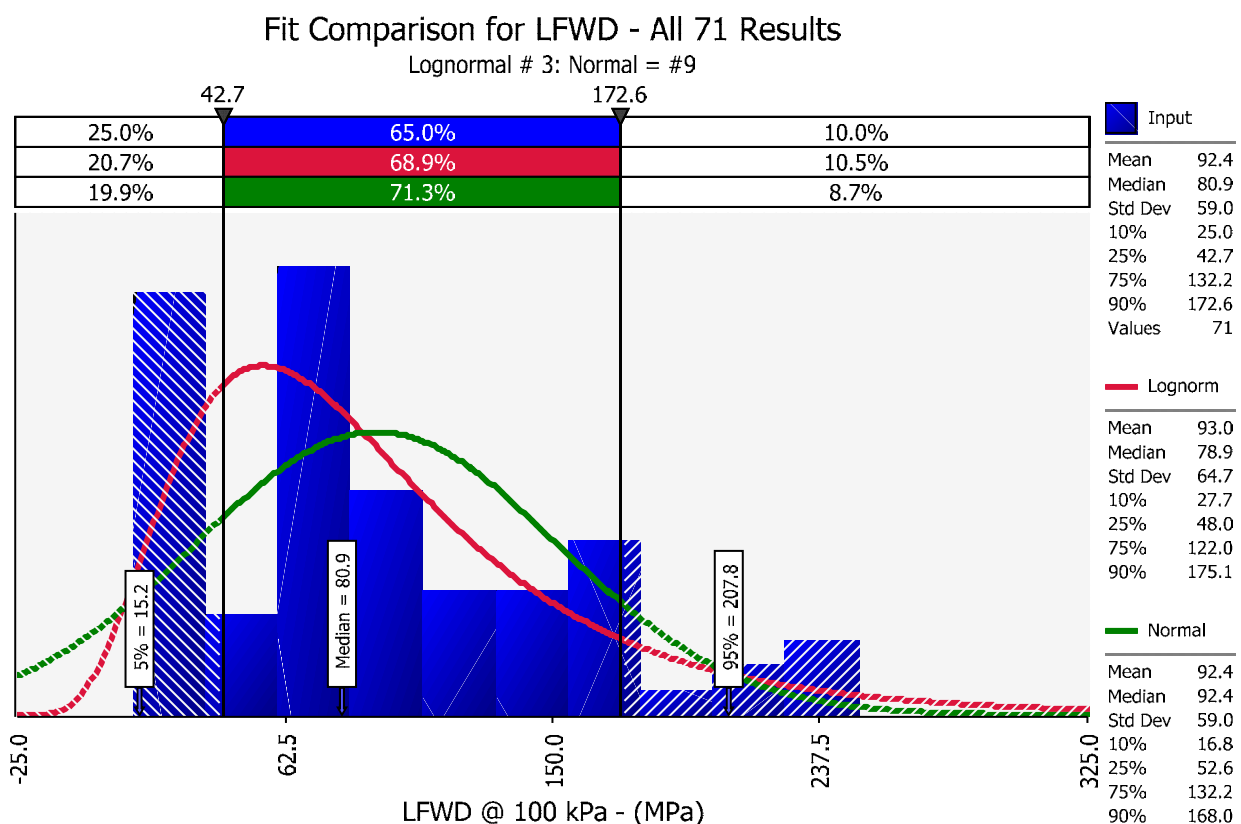


Figure 12-1 PDF for LFWD @ 100 KPa for all 71 tests

Figure 12-2 shows the changing PDFs as the top (1 No.) is progressively removed. Both the shape and best fit PDF is shown.

Significant changes occur for the first 4 high values removal (5.6% of population). By 9 No. removed (12.7%), there seems to be too much change occurring as PDF distortion occurs and the normal PDF dominates its kurtosis values which approaches 3. This is shown in Table 12-1, with the summary statistics of this progressive removal of the upper value – which could be a “high” outlier.

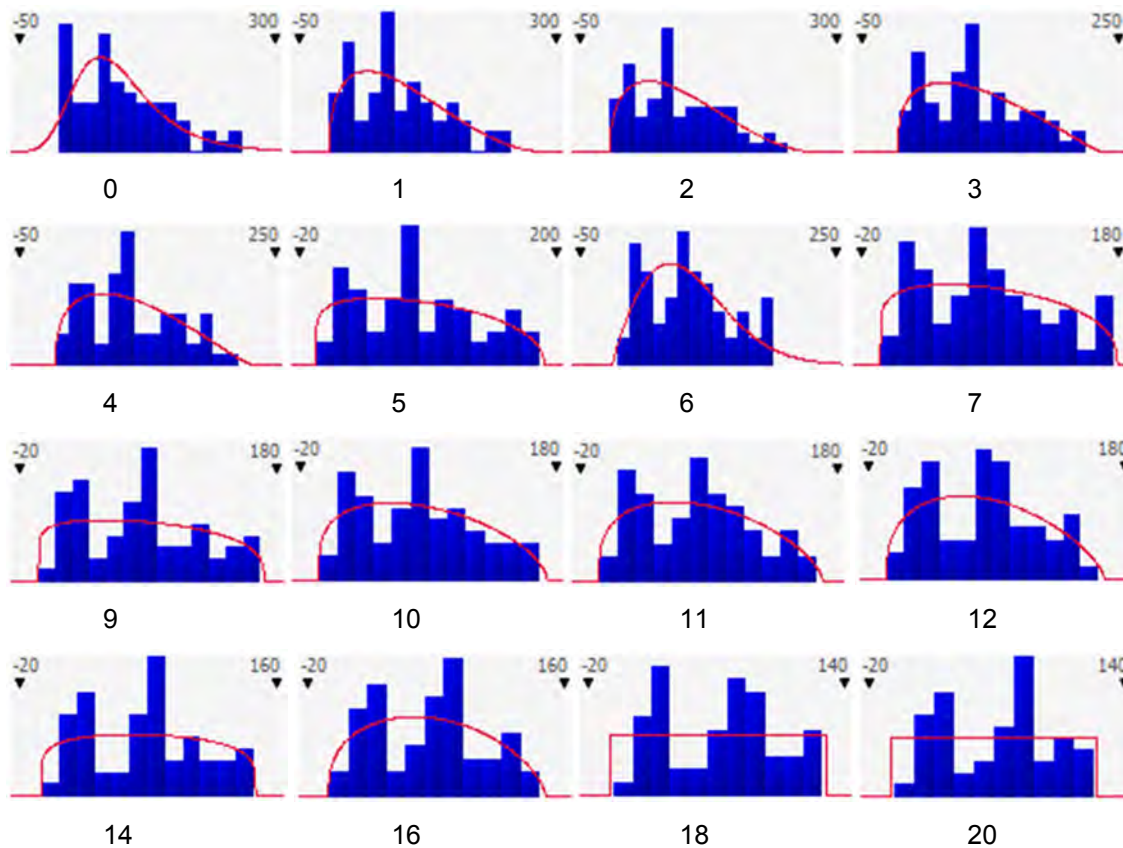


Figure 12-2 PDF for LFWD @ 100 KPa with progressive removal of upper value shown (0 to 20 No. removed)

Table 12-1 Progressive removal of upper value

% Removed	Remove Highest	No. of Tests	Value Removed	Mean	SD	COV	Lognormal Kurtosis	Lognormal / Normal Rank
	0	71	Full Population	92.4	59.0	64%	8.6	3 / 9
1.4%	1	70	235	90.2	56.3	62%	6.4	9 / 12
2.8%	2	69	231	88.1	53.9	61%	5.8	7 / 12
4.2%	3	68	208	86.0	51.3	60%	5.2	7 / 12
5.6%	4	67	204	84.2	49.5	59%	4.8	6 / 12
7.0%	5	66	182	82.3	47.5	58%	4.4	6 / 11
8.5%	6	65	174	80.8	46.2	57%	4.2	3 / 8
9.9%	7	64	173	79.3	45.1	57%	4.1	5 / 8
11.3%	8	63	173	78.0	44.2	57%	4.0	5 / 7
12.7%	9	62	164	76.5	42.8	56%	3.8	6 / 5
14.1%	10	61	164	75.1	41.7	56%	3.7	5 / 4
15.5%	11	60	160	73.6	40.4	55%	3.5	6 / 3
16.9%	12	59	156	72.1	39.1	54%	3.4	6 / 3
18.3%	13	58	143	70.7	37.8	54%		< 14 / 1
19.7%	14	57	141	69.4	36.9	53%		< 14 / 2
21.1%	15	56	140	68.2	35.9	53%		< 15 / 3

% Removed	Remove Highest	No. of Tests	Value Removed	Mean	SD	COV	Lognormal Kurtosis	Lognormal / Normal Rank
22.5%		55	140	67.0	35.1	52%	Lognormal	< 15 / 3
23.9%	17	54	140	65.7	34.3	52%	N/A	< 15 / 3
25.4%	18	53	123	64.3	33.0	51%		< 15 / 3
26.8%	19	52	120	63.2	32.3	51%		< 12 / 2
28.2%	20	51	118	62.1	31.6	51%		< 12 / 3
29.6%	21	50	117	61.0	30.8	51%		< 12 / 3
31.0%	22	49	117	59.8	30.1	50%		< 13 / 3

Values above 200 MPa (upper 5% of tail) are considered outliers and setting this as an upper bound would reduce the COV to below 60%. Removal of additional values beyond that distorts the results. Above 13% removal the normal PDF dominates and this is considered excessive and data distortion.

The revised PDF with the outliers removed is shown in Figure 12-3.

This supports the outlier analysis carried out in Chapter 11, which also identified values above 200 MPa from that approach. Note that the mean would drop from 92.4 MPa to 82.3 MPa with removal of these 4 outliers. This is shown in Table 12-2. Removal of these high values has the most change at the lower characteristic values.

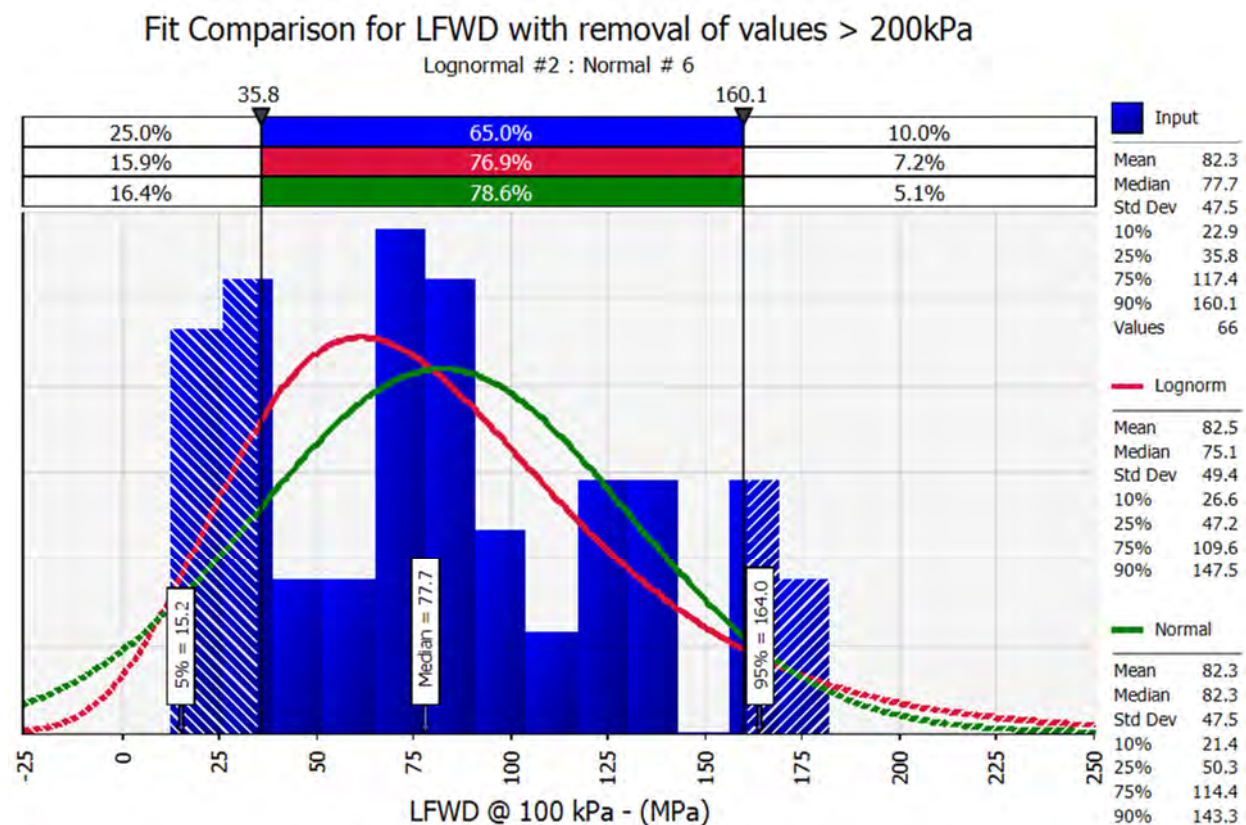


Figure 12-3 PDF for LFWD @ 100 KPa for values above 200 MPa removed (upper 5% of results)

Chapter 11 showed that applying a 10% LCV for modulus-based measurements can create anomalies unless the extra step of carrying out the best fit PDF is used. A 25% LCV approach is this recommended. If a statistical approach is not use then a median based value should be adopted to account for the skewness of the test data.

For this site, a 25% LCV and median approach would have an LFWD modulus @ 100 kPa of 45 MPa and 75 MPa, respectively.

Table 12-2 Comparison summary of LFWD results with and without outliers removed

Header	All values	Values above 200 MPa removed	Change
No. In sample	71	66	5%
Mean	92.4	82.3	10.9%
COV	64%	58%	9.4%
Kurtosis	8.6	4.4	48.8%
10% Value	27.7	22.9	17.3%
25% value	42.7	35.8	16.2%
Median	92.4	77.7	15.9%
75% Value	132.2	117.4	11.1%
90% Value	172.6	160.1	7.2%

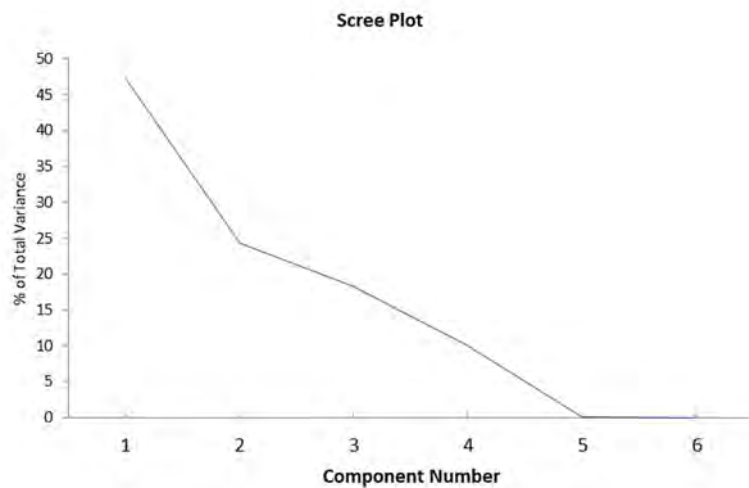
An approach which adopts the lessons learnt from this LFWD testing would be

1. Normalise all results to the modulus value at 100KPa and use e 300mm plate size
2. Remove any outlier above 200 MPa or any value above the 95% value
3. Given the above a minimum number of 20 No. LFWD tests should be carried out if calibrating with density. Use 25 No. tests for any statistical pairing of data
4. In any subsequent lot size testing, a minimum of 6 tests should be done. Remove the upper value and base the quality assessment on the remaining 5 results

Table 12-3 Correlation Matrix with LFWD and Density

Correlation Matrix	LFWD s = 100 kPa	Field Dry Density (t/m3)	Adjusted Max. Dry Density (t/m3)	Field Moisture Content (%)	Moisture Ratio (%) - (FMC / OMC, %)	Relative Compaction (%) - RDD
LFWD s = 100 kPa	1.000					
Field Dry Density (t/m3)	0.234	1.000				
Adjusted Max. Dry Density (t/m3)	-0.231	0.067	1.000			
Field Moisture Content (%)	-0.449	-0.275	0.045	1.000		
Moisture Ratio (%) - (FMC / OMC, %)	-0.466	-0.279	0.030	0.994	1.000	
Relative Compaction (%) - RDD	0.325	0.871	-0.431	-0.268	-0.264	1.000

- ✓ LFWD is affected by FMC and Moisture ratio (negative correlaton) more than the relative compaction
- ✓ The other density compent were previously determined and as expected where
 - o RDD depend mainly on the FDD and least on the FMC or moisture ratio
 - o The Moisture ratio depends mainly on the FMC (from these 6 variables tabulated)
 - o The adjusted MDD is most related to the RDD and is independent of the FDD or moisture ratio or FMC



Component	Variance	% of Total Variance	Cumulative %
1	2.837	47.28	47.28
2	1.458	24.29	71.57
3	1.095	18.26	89.83
4	0.605	10.08	99.91
5	0.006	0.09	100.00
6	0.000	0.00	100.00

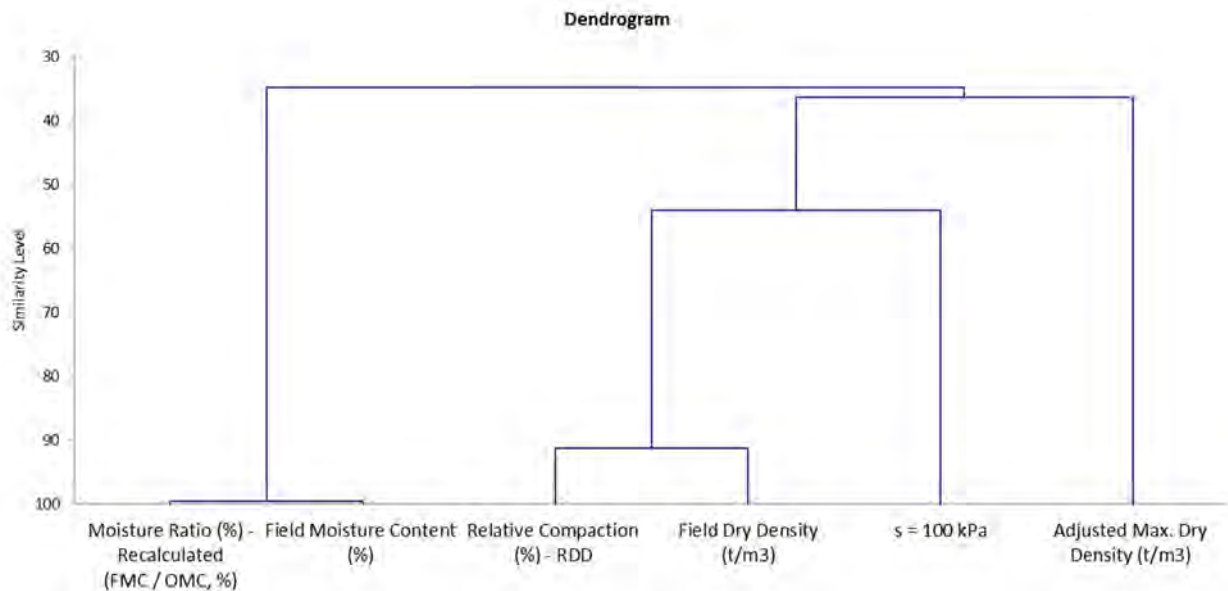


Figure 12-4 Dendrogram with LFWD and density components – nearest neighbour analysis

A dendrogram diagram shows the hierarchical relationship between density and LFWD components for similarity levels. The dendrogram in **Figure 11-21** used differences in its hierarchical clustering relationship. This hierarchical clustering shows (Figure 12-4) :-

1. Adjusted Max Dry density is the principal component affecting the result
2. Moisture ratio and FMC are least similar as compared to the other components
3. Relative Compaction and Field Dry Density are related (expected) and combine with
4. LFWD to be the next cluster affecting the variance

5. The LFWD is more similar to the adjusted MDD than with the relative compaction. Yet the latter is what is being asked to be correlated

Figure 12-5 is the same dendrogram analysis but using the farthest neighbour to show how far the LFWD modulus (@s = 100kPa) from the other components. Note that although the moisture ratio is farthest in this diagram, there is a “stronger” negative correlation as compared to the MDD

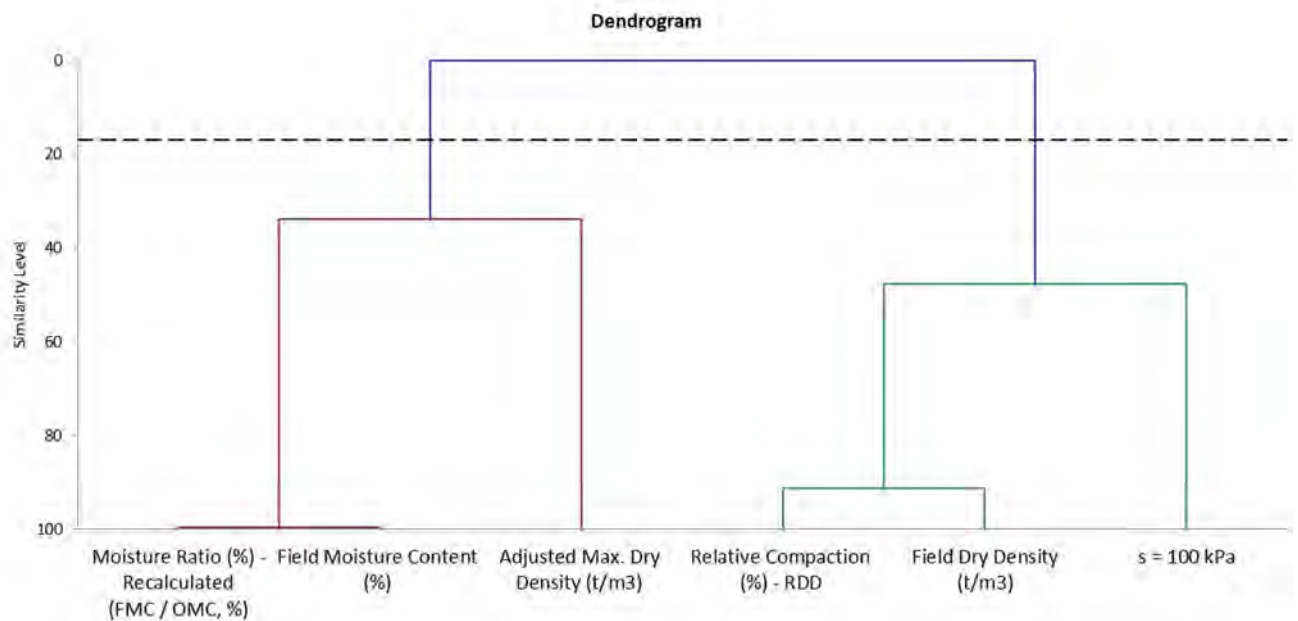


Figure 12-5 Dendrogram with LFWD and density components – farthest neighbour analysis



13. A Transformation method for acceptance testing

The research to date shows there are currently many different measuring devices which provide a more accurate measurement than density and can provide a more direct modulus value. However, such devices provide different unit of measurements and are poorly correlated to density. This poor correlation is due to several factors and include

- o Varying zone of influence. The underlying layer can affect the result
- o Both material quality and compaction are being measured
- o Density ratio and moisture ratio are being measured together while in a density-based approach these are separate considerations
- o Density results have a low variation and the results for a given lot are normally distributed, while other instruments have a larger variation and are usually non-normally distributed.

The current density-based system assumes modulus assumptions have been met, but is not measured. A “95% of standard MDD” does not mean that 95% of peak strength or modulus has been achieved. Thus, density during construction does little to assess a modulus-based design or future pavement assessment over its design life

One of the reasons for the poor correlation is that the density tests are normally distributed, while most of the other tests are not normally distributed. A good correlation is only possible if both have the same distribution functions

Given that paired relationships were shown in previous chapters to be unsatisfactory ito

- Trend lines. Density increasing while the other measurement is decreasing
- Correlation Coefficient (R^2) being weak (<0.3) or trivial (<0.1)
- Significance level (p value) being $<5\%$ shows a type 1 error. A type 1 error is often referred to as a false positive (a result that indicates that a given condition is present when it actually is not present)
- Correlation matrix. Low Spearman rank coefficients

Correlating paired data is a simplified and first choice approach. This simplified approach has shown to have issues. More rigorous statistical approach simply confirmed what is visually evident.

A different methodology is therefore required if these instruments are to be used for QA tests. A transformation method has been used and tested on a construction project and shows promise to overcome the issues associated with the correlation to density approach.

This is not a traditional method and not documented elsewhere. This is herein called a method of matching PDFs and is proposed to advance the use of the various instruments. Without such an approach the industry will keep on back checking to the relative compaction which provides the poor correlations.

13.1 Methodology for the method of matching PDFs

Before introducing “unknown” equipment, two common tests of DCP and density ratio are compared to illustrate the issues. This shows how the different best fit PDF between the two sets of test results is one of the reasons for the poor correlation.

Figure 13-1 shows the normal PDF which is a best fit for the density ratio results with 100 test values. This is for an imported quarry fill material, which targeted above 95% relative (standard) compaction. The mean / median test result of 99.9% / 100% with a standard deviation of 2.3%. The COV is then 2.3% which is relatively low, as this is a very precise test. The best fit PDF (from goodness of fits tests) are shown with the normal PDF with little variation.

The PDFs for the best fit and normal distributions are compared for the DCP in Figure 13-2. A normal PDF would be an incorrect assumption and using a DCP with a normality assumption results in a poor QC assessment. This Figure also shows the DCP is an imprecise test, with a median and COV of 5.8 blows / 100mm and 43%, respectively.

The paired matching of the DCP and DDR results in an $R^2 = 0.06$ for the best fit trend line (Figure 13-3). This poor correlation shows an increasing DCP value resulting in a decreasing DDR, when both should be increasing.

No engineer would accept that a DCP of 9 blows / 100mm achieves 95% density ratio, and 7 blows a better compaction of 100% density ratio is the 7 blows / 100mm. One could then conclude the DCP is unreliable as a QC tool.

This example shows how applying a paired correlation are not applicable simply because of the 2 different PDFs. A different matching procedure is therefore required and the method of matching PDFs is proposed.

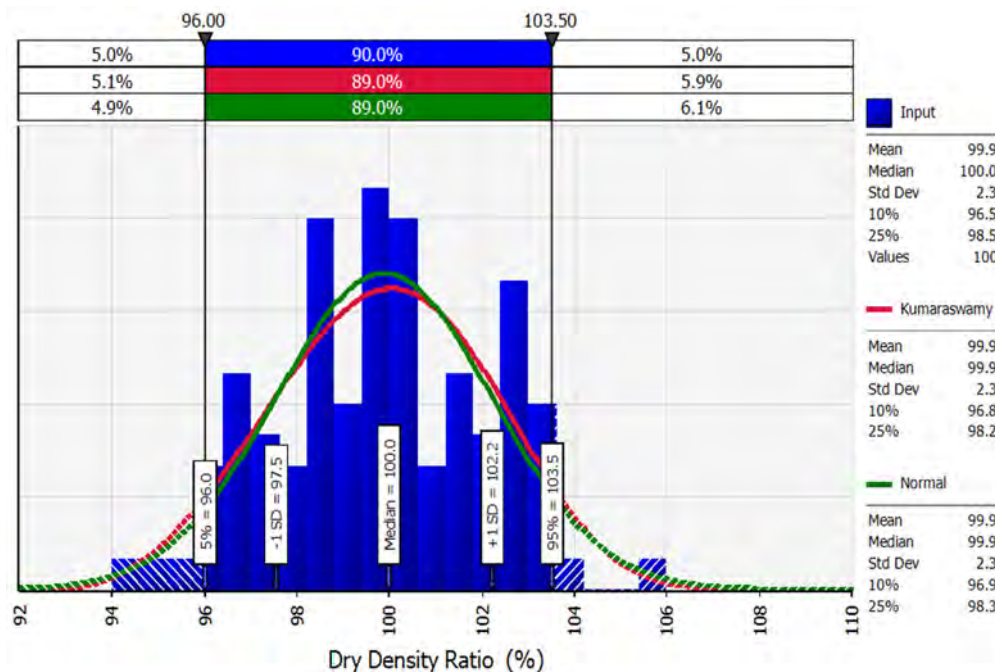


Figure 13-1 Dry Density Ratio with a normal PDF. Normal PDF ranked 4 in goodness of fit test

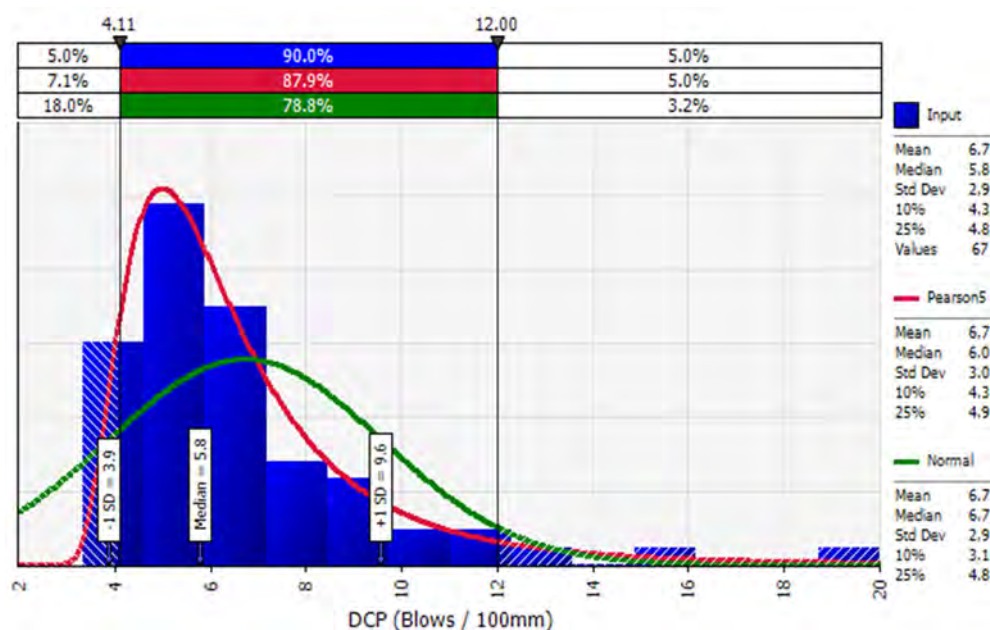


Figure 13-2 DCP tests with a with a non-normal PDF. Normal PDF ranked 11 in goodness of fit test

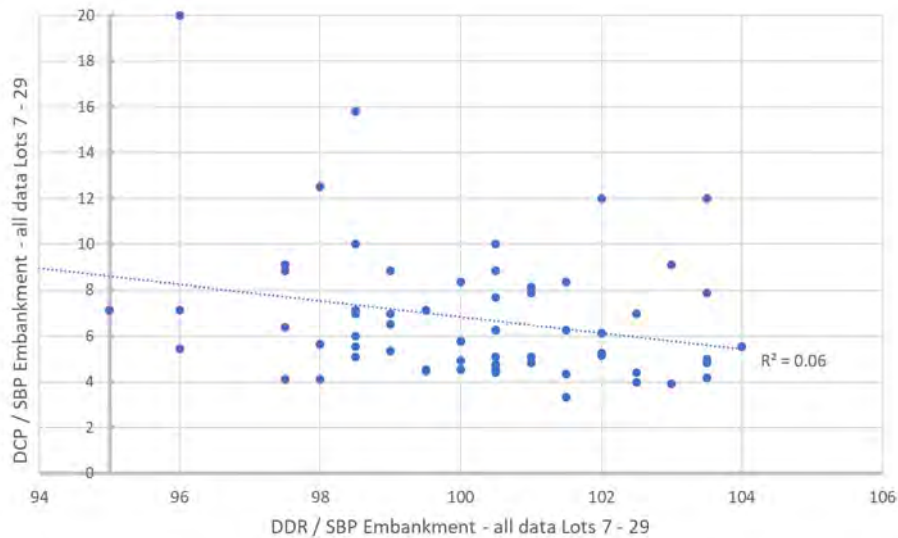


Figure 13-3 Paired matching of DDR and DCP

Using the approach of matching PDFs rather than paired correlations is shown in Figure 13-4. Using an appropriate best fit PDF, the 5% value of both the DCP and Density ratio are paired. Then a similar pairing for the 10% value, 25% value, median and so on.

The consumer / producer philosophy (discussed in Chapter 11) is then maintained for both tests. That QA approach forms the basis to directly apply to these tests results without doubting the DCP reliability as an alternative testing. Thus, the inconsistency of the paired data correlation approach is avoided.

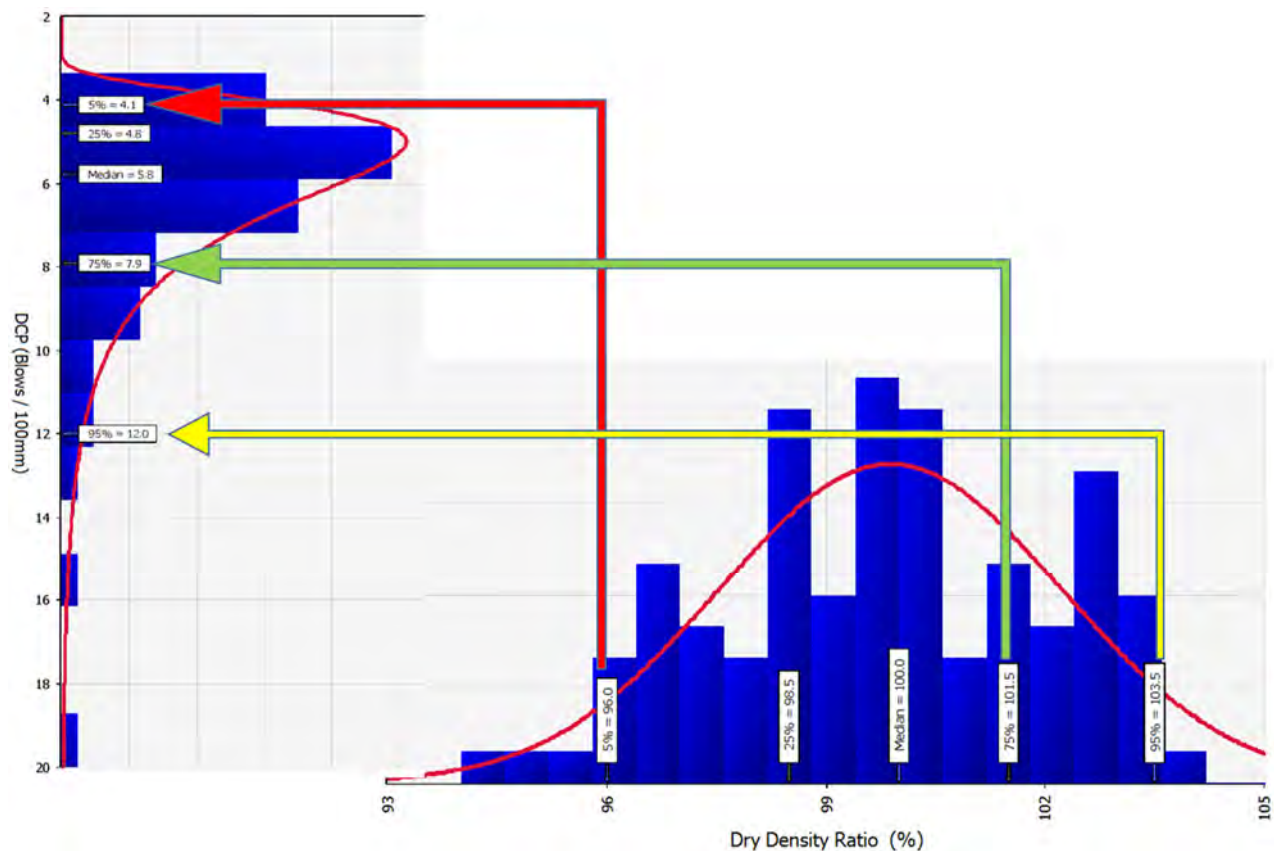


Figure 13-4 Method of matching PDFs – DCP with Dry Density Ratio

Figure 13-5 shows the data can now be paired with a high correlation using this matched PDF approach. QA can then use the corresponding “risk” such as a 10% defective statistical scheme. A 96% and 100% DDR then correspond to 4 blows / 100mm and 7 blows / 100mm, respectively for this material.

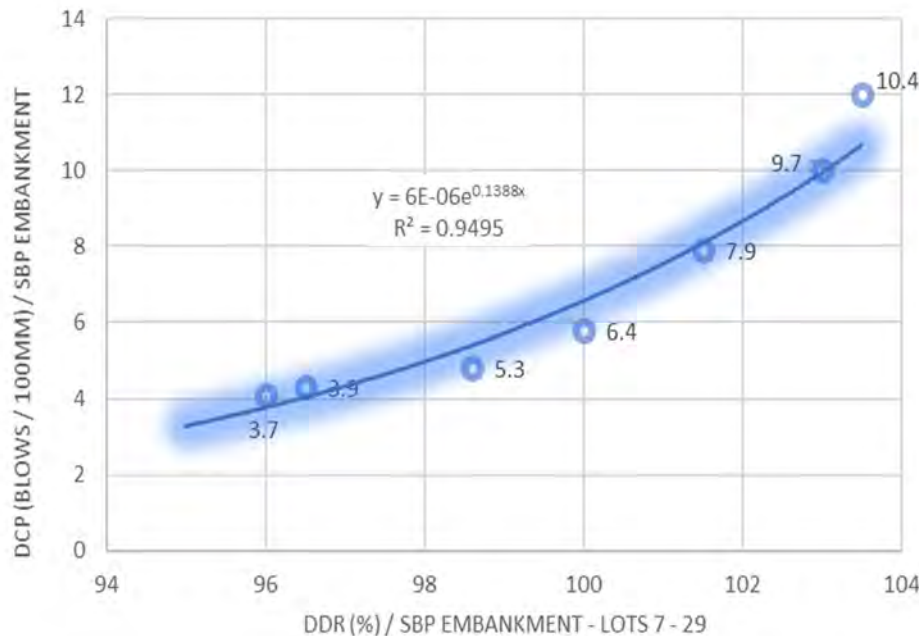


Figure 13-5 Transformed DCP correlation after applying the method of matching PDFs

The same data with a paired PDF matching approach now results in a strong correlation. One now no longer have to deny factual test DCP data in favour of assuming density tests are correct. However, care is required in not extrapolating this data which had limited values at or less than 95% DDR.

All “raw” data has been used in Figure 13-4 and Figure 13-5 . Yet outliers (high values) have been shown to affect the statistical results. Values above 15 blows / 100mm are self-evident as likely outliers. Any value above 3 standard deviations (six sigma approach) should be considered an outlier. The box and whisker approach used 1.5 to 3.0 interquartile range (IQR) as a mild outlier and greater than 3 as an extreme outlier.

13.2 Comparative percentiles for the method of matching PDFs

This transformation method can be used with other alternative test methods.

Figure 13-6 and Figure 13-7 show the LFWD result with and without values above 200 MPa, respectively. These high values were previously shown to distort the results. Figure 13-8 and Figure 13-9 show the data can now be paired with a high correlation using this matched PDF approach with and without the values above 200 MPa, respectively.

In this instance, the change is pronounced at the higher values above the 50-percentile. This would seldom be consequential. However, in applying this method to another larger LFWD data set, Table 12-2 showed the lower percentile values may also change. The higher percentiles reduce but the lower percentiles may increase when high outliers are removed.

Table 13-1 provides comparative values for the more common density and DCP tests at varying penetrations. The [procedure outlined can then be used to cross compare any of tests with a high correlation resulting.

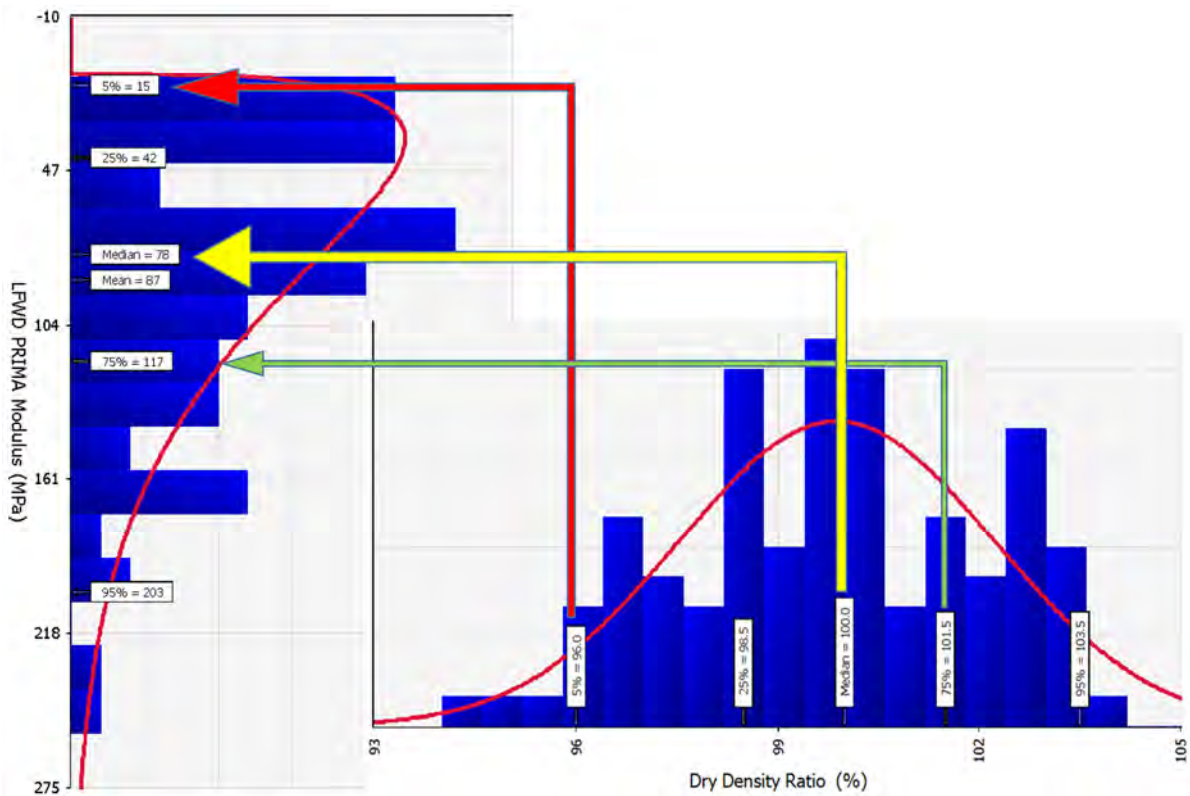


Figure 13-6 Method of matching PDFs – LFWD with Dry Density Ratio – all values

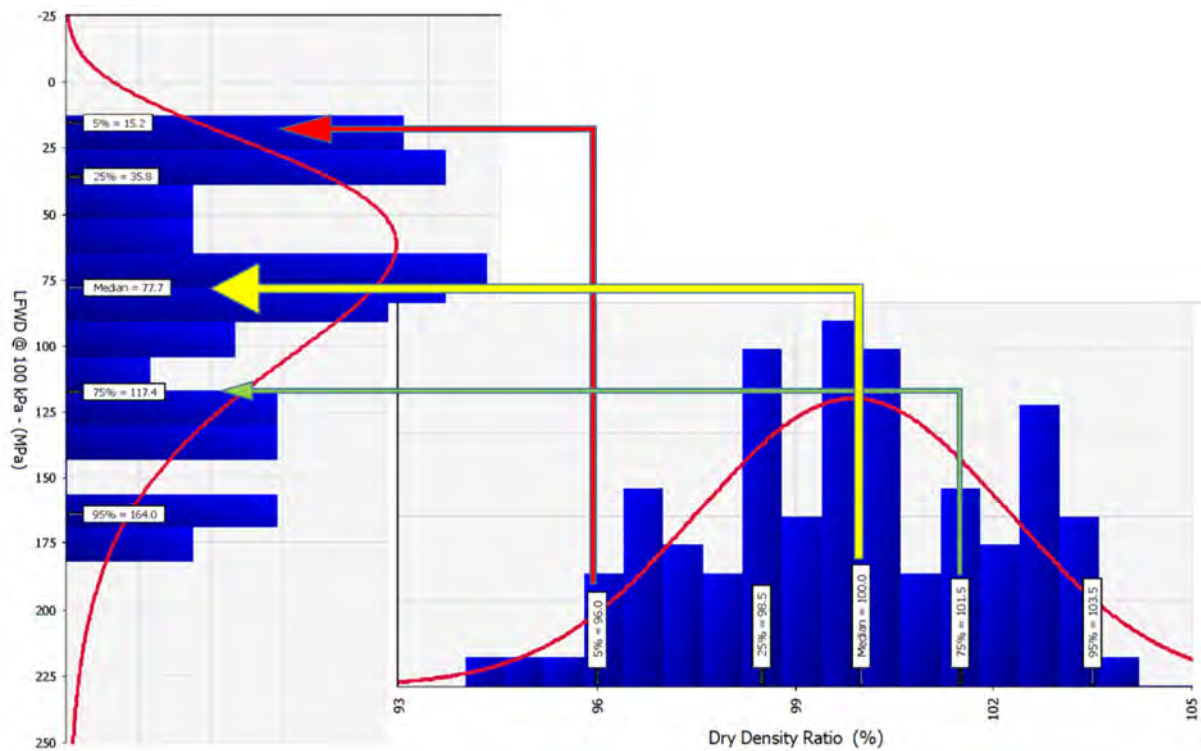


Figure 13-7 Method of matching PDFs – LFWD with Dry Density Ratio – remove values < 200 MPa

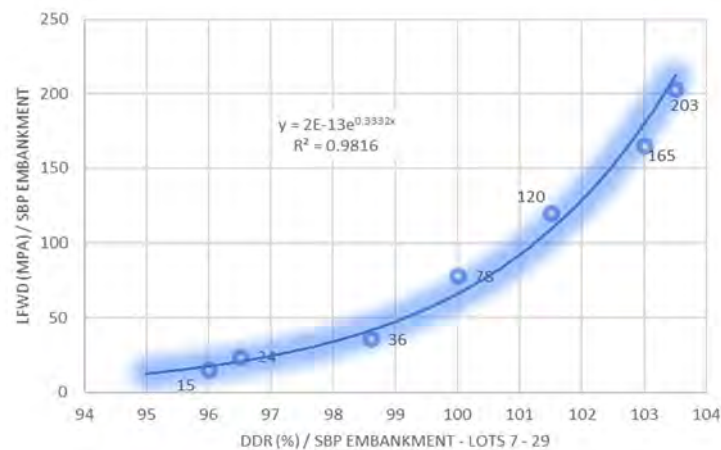


Figure 13-8 Transformed LFWD correlation after applying the method of matching PDFs – all values

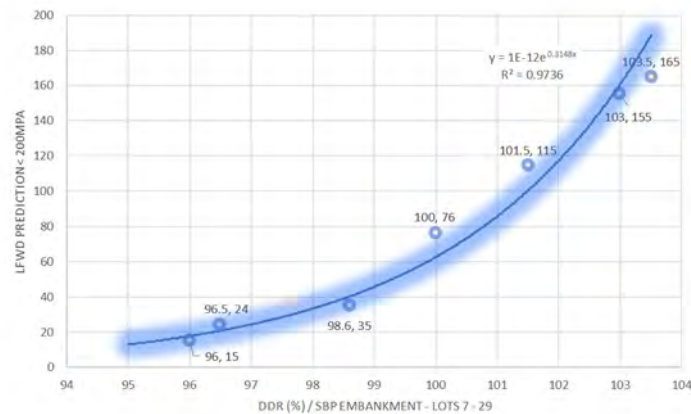


Figure 13-9 Transformed LFWD correlation - remove values < 200 MPa

The data used in the correlation matrix of Table 11-6 was used to generate the matching PDF values of Table 13-1 for the density and the varying Clegg hammer drop heights. **Error! Reference source not found.**

The high COV at 0.152m drop height suggests this should not be used and is not shown in the above table. The 0.076m drop height correlated best with moisture values (moisture ratio or field moisture content) as compared with the other drop heights. This was not evident in the box and whisker plot (Figure 11-18). There is only a minor difference between the 0.457m and 0.610m for the high compaction material examined. At lower compaction levels there could be a difference.

13.3 Summary

Density has a poor correlation with other tests. A method has been presented which uses a transformation with the common percentiles used to have a method of matching PDFs. This then has a high correlation between the alternative tests.

The methodology was demonstrated for a specific Class A material imported from a quarry. The relationships will vary with material. In this case values above 104% relative compaction and below 96% is an extrapolation outside of the data base of tests.



Table 13-1 Percentile distribution compared for density tests, DCPO and LFWD

Percentiles	5%	10%	20%	25%	30%	50%	70%	75%	80%	90%	95%	Total
Field Dry Density	2.13	2.14	2.16	2.16	2.16	2.19	2.21	2.23	2.23	2.26	2.28	95
Relative Compaction	96.0%	96.5%	97.5%	98.5%	98.5%	100.0%	101.5%	102.0%	102.0%	102.5%	103.5%	91
Field Moisture Content	5.50	5.80	6.10	6.50	6.60	7.60	8.30	8.50	8.60	9.10	9.30	91
Moisture Ratio	72%	75%	78%	80%	84%	96%	104%	106%	107%	114%	122%	91
LFWD at 100 kPa stress	15	18	29	33	36	73	109	119	141	164	178	91
DCP - 0 - 100mm	7.0	8.6	10.1	10.7	11.3	14.3	17.1	17.5	18.8	22.5	26.7	205
DCP - 0 - 200mm	17	19	21	22	23	27	31	32	34	39	49	157
DCP - 0 - 300mm	27	29	32	33	35	41	46	48	51	57	73	118
DCP - 0 - 400mm	39	42	45	47	50	56	62	63	64	91	113	76

Percentiles	50%	Kurtosis	Mean	SD	COV	Min	Max	Total
Field Dry Density	2.19	3.2	2.20	0.05	2%	2.10	2.31	95
Relative Compaction	100.0%	2.1	99.8%	2.2%	2%	95.5%	104.0%	91
Field Moisture Content	7.60	2.1	7.42	1.24	17%	4.90	10.10	91
Moisture Ratio	96%	2.1	0.94	0.16	17%	61.0%	125.0%	91
LFWD at 100 kPa stress	73	2.4	82.46	56.32	68%	9.00	231.00	91
DCP - 0 - 100mm	14.3	4.6	14.80	6.22	42%	3	38	205
DCP - 0 - 200mm	27	16.2	28.76	11.87	41%	14	104	157
DCP - 0 - 300mm	41	16.3	43.60	17.27	40%	12	146	118
DCP - 0 - 400mm	56	10.3	59.75	21.95	37%	24	163	76



Table 13-2 Percentile distribution compared for density tests, PLT and LFWDs for a limited data set

Test \ Percentiles	Best Fit	Rank	10%	50%	55%	85%
Relative Compaction - All	Normal	4	96.9%	100.0%	100.0%	102.2%
Moisture Ratio - All	Lognormal	2	77.1%	92.3%	94.3%	110.0%
Relative Compaction – Lots 21 - 26	Normal	1	97.3%	100.0%	100.0%	101.8%
Moisture Ratio – Lots 21 - 26	Lognormal	2	81.3%	101.3%	104.3%	113.8%
EV1 @ 100 kPa - Lots 21 - 26	Normal	3	11.1	37.3	39.2	55.6
EV1 @ 200 kPa - Lots 21 - 26	Normal	3	11.4	37.8	39.6	55.7
EV1 @ 300 kPa - Lots 21 - 26	Normal	3	12.2	36.4	40.0	53.7
EV1 @ 400 kPa - Lots 21 - 26	Normal	3	13.4	36.4	41.2	54.4
LFWD @ 100 KPa - Lots 21 - 26	Lognormal	4	23	86	98	182
EV2 @ 100 kPa - Lots 21 - 26	Lognormal	3	45	70	77	252
EV2 @ 200 kPa - Lots 21 - 26	Lognormal	2	42	85	85	143
EV2 @ 300 kPa - Lots 21 - 26	Lognormal	2	44	90	97	129
EV2 @ 400 kPa - Lots 21 - 26	Lognormal	2	47	93	99	121



Table 13-3 Matching PDF values for Clegg Hammer varying drop heights

Percentiles	10%	20%	25%	30%	40%	50%	60%	70%	75%	80%	90%
Relative Compaction	97%	98%	98%	99%	99%	100%	100%	101%	101%	101%	103%
Moisture Ratio	75%	79%	80%	89%	89%	92%	95%	98%	99%	101%	101%
Field Moisture Content	6.4	6.6	6.7	7.1	7.3	7.5	7.8	7.9	7.9	8.1	8.6
Field Dry Density	2.13	2.16	2.16	2.16	2.19	2.19	2.20	2.20	2.21	2.21	2.24
LFWD (s = 100 kPa) – MPa	35.8	47.6	68.3	70.2	78.6	80.9	85.6	118.1	120.0	123.5	172.6
PANDA 0 – 200mm (MPa)	8.9	10.3	10.3	11.5	13.4	13.7	15.5	16.8	17.6	18.7	20.9
Cmax - 0.076m ¹	14.0	15.0	16.0	18.0	20.0	21.0	22.0	25.0	25.0	32.0	35.0
Cmax - 0.305m	23.0	26.0	33.0	35.0	35.0	38.0	40.0	42.0	44.0	45.0	55.0
Cmax - 0.457m	30.0	32.0	36.0	37.0	40.0	41.0	43.0	46.0	46.0	53.0	66.0
Cmax - 0.610m	30.0	31.0	34.0	39.0	40.0	44.0	57.0	58.0	58.0	66.0	73.0

¹ – Correlates with moisture



14. Testing Specifications

Earthworks assessors use a specific quality control values such as 95% relative compaction. However, the value does not compare directly with other tests.

Using the transformation method previously described, a typical comparative set of values for various tests is shown in Table 14-1 for a specific material. This would be for general embankment fill. A simple change of material to a CBR 20 material of 70% gravel size and 10% fines would change the LFWD at 96% DDR to 30MPa to 50 MPa for basalt or sandstone rock source, respectively.

Most tests seem to be measuring both moisture and density effects. Tests such as DCPs, PANDA or Clegg at 0.076m drop heights or 100mm penetrations correlate more with the moisture condition and not the density per se. As the depths or penetration increases then density relationships improve but are still considered weak using direct correlation methods.

Table 14-1 In-situ Test QA for 4 different tests as obtained for a material with 60% gravel size with 20% of both sand and fines – from weak metasedimentary rock (CBR < 10)

Relative Compaction for Class A material WPI <1200	95%	97%	100%	102%
LFWD @100 kPa	11 MPa	20 MPa	75 MPa	120 MPa
DCP blows @300mm	23	29	41	48
DCP blows @400mm	33	42	56	63
DCP blows @200mm	15	19	27	32
PANDA -0 – 200mm	6 MPa	9 MPa	15 MPa	20 MPa
PLT Ev1 @ 300 kPa	6 MPa	12 MPa	40 MPa	54 MPa
PLT Ev2 @ 300 kPa	19 MPa	44 MPa	97 MPa	129 MPa
Ev2 / Ev1 Ratio	3.2	3.7	2.4	2.4
Ev2 / LFWD Ratio	1.7	2.4	1.3	1.1
Clegg Impact Value				
0.076m	10	15	25	35
0.305m	20	25	40	50

These tests have larger variability in results as compared to density values. However, the results are generally more meaningful and more accurate.

A summary methodology for implementation of these alternative quality tests will be reported separately.



15. Summary

This phase 2 study was for a uniform material with density quality control testing used in parallel with DCPs, PANDA tests and LFWD (PRIMA). A large database was able to be obtained. For a shorter 2-week period PLTs, Clegg and an alternative LFWD (Terratest) were also used.

While a range of compaction from 90% to 97% RDD was specified on the drawings, the end compaction varied from 95% to 104%. Thus, data below 95% (as in phase 2) was not able to be obtained.

Some key findings were

- ✓ Paired correlations have poor correlations between density and the other units of measurements. Thus, a method to avoid such an approach was required
- ✓ Contractors view parallel testing as additional costs and time. Combined with the inconsistencies of the density correlations, then such methods may not be advanced unless industry accepts these different units of measurements
- ✓ Ironically, density (as the standard) is considered not an accurate test as density is not able to assess changes occurring. For example, rain may fall between density testing and the next lift. Most tests can show such changes and one should not then rely on that out of date density measurement in assessing whether another lift can be placed.
- ✓ The many tests measure combination of moisture and density. At the top 100mm or low energy drop heights moisture governs, while correlation at larger drop heights or depths have less of the moisture effect. However, in all cases the correlation is poor
- ✓ DCPs and Clegg at low drop heights are more related to the moisture than the relative compaction
- ✓ Density testing is accepting many “poor” results as measured by the other tests and also failing many “good” results. This is not within the 10% consumer / producer risk
- ✓ A transformation methodology was developed and applied during this phase 2 and shows promise to overcome the poor correlations with density measurements. This poor correlation is partly due to the normal density PDF being compared with a non-normal PDF
- ✓ High outliers need to be considered in this transformation method here called the method of matching PDFs. These outliers are due principally to the oversize and large stony materials not being tested or even sampled in the density-based approach

The following summary provides a methodology to advance these existing technologies for quality testing. Most are already being used for design assessment.

15.1 Introduction

Traditional Quality Assurance (QA) Specifications for earthworks require the achievement of a high relative compaction. The typically applied criteria is the ratio of the field dry density achieved with the maximum dry density (MDD) achieved in the laboratory (i.e. reported as a minimum threshold of Relative Density Ratio – RDD – or Density Ratio – DR). These density-based methodologies for compaction Quality Control (QC) typically utilise either sand replacement or Nuclear Density Gauges (NDG) as their specified test methods.

Density measurements are relatively easy to undertake, provide a very precise measurement in an easy to understand parameter. Use of the NDG has the benefit of speed for obtaining field density results as compared to sand replacement. However, there remains a delay in the determination of a test site's relative compaction due to the time taken to obtain the laboratory MDD (unless an assumed value is used).

Density measurements also have a time lag due to curing and testing times, as conceptually illustrated with the typical the earthworks construction and testing processes detailed in Figure 15-1. Quality Assurance (QA) is not the same as Quality Control (QC), although QC testing and inspection is part of a QA process. Yet density is more aligned as a QC rather than a QA measurement.

Recent research has found density measurements are, although precise, not very accurate due its poor correlation with the results of other modulus or strength-based tests. As the structural design of pavements, working platforms or other bridging layers requires either strength or modulus input, it is imperative that any verification testing undertaken can accurately assess, or be strongly correlated to, such parameters.

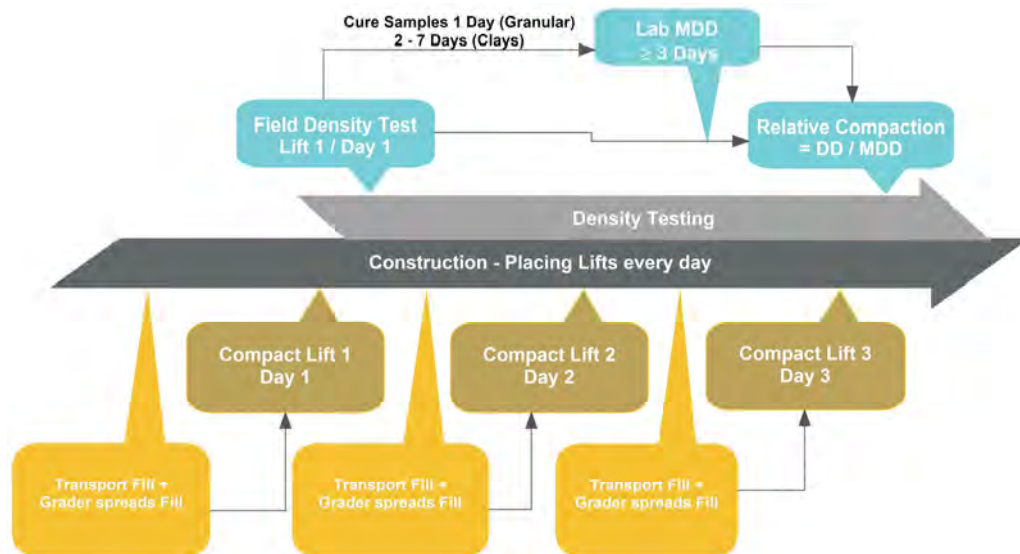


Figure 15-1 Traditional relative compaction tests (e.g. Density Tests) are lag indicators

There are currently many different measuring devices which can provide a more accurate measurement of design parameters (strength or stiffness) and can provide a more direct route for parameter assessment (i.e. limit need for any inclusion of generic relationships). These options should thus be considered better QA tools, in comparison to traditional density testing, and their ability to provide near-instantaneous results can be used insitu to change the compaction process to suit project- and material-specific conditions encountered onsite.

However, such devices provide all different units of measurements and can demonstrate a poor correlation to the industry accepted density test results. The existence of the poor correlation can be due to several factors, including:

- *Varying zone of influence* – The condition of the underlying earthworks / subgrade layer can affect the result of the in-situ strength / stiffness test (compared to density testing that is isolated to a specific layer)
- *Both Material Quality and achieved Compaction State are being measured* – and thus increased variability within a test dataset can arise (compared to density testing that only evaluates compaction state)
- *Difference in nature of dataset* – Density results have a low variation and the results for a given lot are normally distributed, while other test instruments frequently demonstrate a larger variation of the measured parameter (for reasons above) and can present non-normally distributed data.

Additionally, the implementation of alternative (non-density) measurement devices for the in-situ verification of strength or stiffness parameters has been further hampered by:

- *No Standard Specification* – Limited international specifications exist, but the potential arrangements / variables associated with individual measurement device (which directly affects the resulting parameter) is not standardised in many cases. No Australian Standards currently exist.
- *Reluctance of Industry to adopt a different unit of measurement* – Industry is familiar with using an easily interpreted density ratio, whilst individual measurement devices provide various other parameters.
- *Requirement for initial demonstration to correlate to density test results* – Initial trials often require alternative QA tools to demonstrate a strong relationship to the, industry accepted, density test results. However, as stiffness and strength parameters are not directly related to achieved compaction, the alternative QA tool may provide a poor 1:1 correlation to density and thus be disregarded due to lack of confidence in test results.

- *Existence of a large variety of non-density modern equipment* – with no clear guidance of which to use, how to use, how to interpret the results and / or which tool is best suited to specific applications.

At the same time, various tests are consistently showing many of these instruments are superior as QA measurement tools as compared to the density ratio status quo. The use of such modern and more accurate test equipment is then not used due to poor correlation to density.

15.2 Light Falling Weight Deflectometers (LWDs)

One such promising non-density device is the Light Falling Weight Deflectometer (LWD). An LWD is a portable, self-contained device which can assess the surface modulus directly in the field.

The barrier to widespread adoption is the availability of a variety of LWDs within the market, each of which can provide a different in situ modulus parameter – due to the effect of different stress states, equipment arrangements and boundary conditions adopted by individual manufacturers. The potential non-linearity of the material modulus parameter (e.g. stress-dependency) and the effect of moisture can also affect the returned in situ modulus result.

As per the requirements of a universal standard, no preferential selection of any one manufacturer is detailed herein. However, by understanding and accounting for the characteristics of the specific LWD and the material being utilised onsite, any LWD can provide a consistent and traceable result which can be readily used for earthworks QA purposes.

Based on the results of recent Australian research, the use of suitably standardised LWDs is recommended for QA testing of earthworks. Utilising such a tool is expected to offer improved connectivity between design, construction QA and long-term performance.

The use of LWD (or similar direct parameter evaluation tools) would realise the implementation of a true QA regime, moving from the current density-based QC system – as density testing programs only assume design parameters (e.g. modulus) are been met, but do not directly evaluate any such parameter. For example, a requirement to achieve “95% of standard MDD” does not mean that 95% of peak strength or modulus has been achieved. Yet after the construction phase is completed, the asset owner will continue to assess earthworks performance based on modulus parameters rather than any incorporation of density state.

15.3 Modulus Based Technical Specification – Adopting LWDs for Earthworks QA Testing

This remainder of this summary focuses on the considerations of the LWD procedure that would be required to develop of Technical Specification for its implementation as an effective earthworks QA tool. The selection of the LWD tool in particular is to progress the implementation of one such measuring device into industry.

Recent Australian research in using various other non-density measurement tools for similar QA purposes are reported elsewhere. The advancement of Intelligent Compaction (IC) also requires asset owners, consultants and soil testers to deliver alternative QA tools than can similarly verify the in-situ earthworks condition achieved, if IC technologies are to achieve their potential.

Key Requirements of Modulus Based Technical Specifications

Any Modulus based Technical Specification for Earthworks QA assessment would require:

- *A Target Modulus for Acceptable Compaction* – Yet in situ modulus may be dependent on moisture content, density and / or material quality. Current (density centric) compaction specifications measure each of these separately
- *A Simple Methodology for field assessment* – Any specified tests should be simple to completed and have an easily standardised methodology.
- *Testing should not require significant duplication* – due to associated cost and delays.
- *An understanding of the various factors that may affect the modulus results* – and control / account for such factors within the test procedure, interpretation and nominated threshold (target) values.
- *A standardised method for interpretation of LWD results* – as no preferential selection to any particular LWD manufacturer should be made, an allowance for the variation in commercially



available LWD devices should be included. Similarly, a standardised method to evaluate the in-situ measurement / modulus parameter arising from the various devices should be detailed.

LWD Equipment Standardisation

Examples of variables present between types of LWD equipment – either user implemented variables or manufacturer variations – include:

- *Plate Size* – Plate diameters can vary between 100, 150, 200- and 300-mm diameter. The plate size directly influences the contact area with the ground and thus the imparted test stress. Variation in plate size would also affect the zone of influence that the composite in situ modulus parameter represents
- *Drop Height* – Maximum drop heights vary between 600, 720 and 800. Combined with the plate diameter and drop mass, this maximum drop height influences the range of test stresses that can be generated by the LWD. To an extent, the imparted test stress affects the test's 'zone of influence' – with the larger test stress generating a greater 'zone of influence' (for all other variables being equal).
- *Mass of Falling Weight* – Mass used as the generating force can vary between 2, 9, 10, 15 & 20 kg. Of these, the 10 kg weight is the most common. Some LWDs have the facility for weight variation to alter the imparted test stress.
- *Deformation Measurement* – Can either be made by an accelerometer (embedded within the plate) or a geophone (in direct contact with the ground). Due to the various location and types of the measuring sensor, the magnitude of deflection (and thus the derived in situ modulus parameter) varies between LWD types.
- *Presence / Absence of Load Cell* – LWDs fitted with a load cell allow the provision of a specific load assessment per weight drop, and can account for any variation to the theoretical load being imparted. For LWDs without a load cell, the theoretical load has to be assumed to have occurred.
- *Arrangement / Type of Buffer* – Various numbers, materials and thickness of buffers exist between LWD types (and can frequently be altered by the user). The specific arrangement alters the load pulse magnitude actually transmitted to the load cell (if present) and into the ground.
- *Plate Material (rigidity)* – Plate thickness, weight and material varies between LWDs. This influences the rigidity of the LWD arrangement and can affect the shape of the load distribution into the ground (for each test)

Control of such variables should be included in any LWD Technical Specification. However, such 'control' should not necessarily exclude specific LWD types – rather the Specification should identify the required test stress(es) and minimum 'zone of influence' over which the LWD should provide assessment. Details of the normalisation of results that will be undertaken to standardise the derived modulus parameter (for comparison to the nominated target modulus value that would represent acceptable compaction) should also be completed.

In the absence of project-specific requirements, it would be proposed that the following details be included for LWD equipment standardisation in Earthworks QA Technical Specification's:

- Plate Diameter = 300 mm (providing an 'zone of influence' of approximately 390 – 450 mm)
- Modulus Parameter standardised to 100 kPa Test Stress (to remove the influences of varied drop height and drop mass configurations).

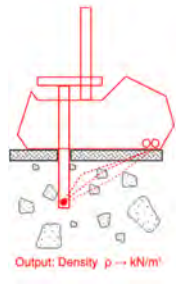
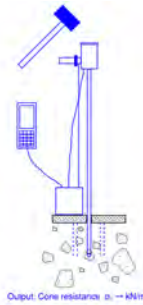
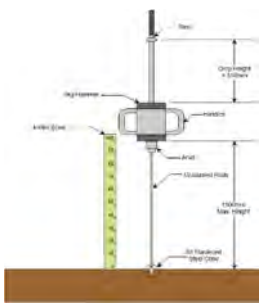
Target In situ Modulus Parameter that represents Acceptable Compaction

A typical comparative set of parameters is presented in Table 15-1 that relates Dry Density Ratio (DDR or DR) thresholds to approximately equivalent parameters measured by alternative, non-density, QA tools – namely the cone tip resistance arising from Variable Energy DCP (Panda Probe) testing; standardised in situ modulus from the Prima 100 brand LWD; and the number of hammer blows required for a DCP rod to be penetrated 100 mm.

Note the values presented in Table 15-1 were derived for a specific material, but can be altered for other soil materials being utilised for earthworks. For example, a change to an alternative Fill material comprised of 70% gravel sized particles and exhibiting a characteristic CBR of 20% would increase the LWD

threshold that represents a 96% DDR to 30 MPa or 50 MPa for Basalt or Sandstone rock materials sources respectively.

Table 15-1 **Example of equivalent thresholds for four (4) in situ test techniques** (as obtained for a material with 60% gravel size and 20% of both sand and fines – sourced from weak metasedimentary rock, CBR < 10 %)

Technique	Traditional Density Testing	Variable Energy (PANDA) Probe	LWD (Prima 100) – 300 mm dia. Plate	Dynamic Cone Penetrometer (DCP)
Reported Parameter	Dry Density Ratio (DDR, %)	Average Cone Tip Resistance (q_d , MPa)	In situ Modulus @ 100 kPa Test Stress ($E_{LWD-100kPa}$, MPa)	n = Hammer Blows / 100 mm rod penetration
Equivalent Threshold Values	≥ 96 %	≥ 8 MPa	≥ 15 MPa	≥ 4 blows
	≥ 98 %	≥ 12 MPa	≥ 25 MPa	≥ 5 blows
	≥ 100 %	≥ 17 MPa	≥ 50 MPa	≥ 6 blows
	≥ 103 %	≥ 24 MPa	≥ 120 MPa	≥ 10 blows
Test Characteristics	Very High Precision	Medium Precision	Medium Precision	Low Precision
	Very Low Accuracy	High Accuracy	Medium to High Accuracy	Low to Medium Accuracy
Schematic of Test Equipment	 Output: Density $\rho \rightarrow \text{kN/m}^3$	 Output: Cone resistance $q_d \rightarrow \text{kN/m}^2$	 Output: Stiffness $E \rightarrow \text{MPa}$	

For comparison purposes the California Bearing Ratio (CBR) test is considered to provide results with medium precision and medium accuracy.

Other aspects that should be noted during the development of a LWD Technical Specification include:

- The in situ modulus derived by static Plate Load Testing (e.g. E_s , E_{v1} or E_{v2}) is not necessarily similar to the insitu modulus derived from LWD testing – this is due to factors such as the varying zone of influence, test stress, and dynamic vs. static nature of the each test technique and adopted arrangement (as detailed previously).
- The in-situ modulus parameters derived from LWD should be inspected and a maximum capping value applied to limit excessive data spread. Outlier / uncharacteristic high values can occur due to the presence of, amongst other factors, high strength rock particles present within a soil matrix. Typically, the highest 10% of LWD derived modulus values should be evaluated and limited to the capping value, if required.
- While density testing (and thus the Dry Density Ratio parameter, DDR) is not influenced by material quality, or variation thereof, many other in situ tests are affected by such quality factors. Hence, there is no singular value that can be universally applied to enable direct conversion between a DDR threshold value and an in-situ modulus / strength parameter. A DDR dataset that demonstrates low variation can have a significant corresponding range of any other in situ parameters being measured by other test techniques completed at identical locations. Direct, single parameter correlation between DDR and other in situ material parameters often results in a low correlation and the adoption of such a simplified approach hinders the industry adoption of these alternative assessment tools.

Simplified Field and Interpretation Methodology for LWD

An advantage of the use of tools that can make in situ modulus measurements and provide near-instantaneous results – such as LWDs – is that, unlike traditional density testing, the progressive change of the stiffness of the near-surface can be monitored until only minor changes are observed (Figure 15-2).

This approach could be used to identify the characteristic number of compaction plant ‘passes’ required to achieve effective compaction.

Utilising the LWD in such an application would be undertaken as follows:

1. Undertake LWDs at six (6) testing locations after the completion of an initial, limited number of plant passes (say, three (3) passes).
2. Interpret the standardised in situ modulus parameter for each test location – $E_{LWD-100kPa}$. Discard the highest value and apply the defined capping value (e.g. $E_{LWD-100kPa} = 200$ MPa) to any other uncharacteristically high values. Determine the characteristic values of the dataset and establish the COV of the dataset (Standard Deviation / Mean).
3. Repeat Steps 1 and 2 after the application of additional compaction plant passes (e.g. after 6 and 8 passes).
4. Plot the progression of the characteristic LWD values under each considered arrangement
5. From the curve constructed in Step 4, assess when the COV of the dataset is less than 60% and the change in the median standardised in situ modulus parameter ($E_{LWD-100kPa}$) is less than 10% occurs between considered passes. This scenario would be considered the characteristic number of compaction plant ‘passes’ required to achieve full effective compaction.
6. Carry out corresponding side-by-side density testing upon effectively compacted materials, if correlation between DRR and E_{LWD} parameters is required
7. Compare median of DDR dataset to median of corresponding E_{LWD} dataset – adopt the corresponding median values as the ‘equivalent’ in situ target values to be achieved to represent acceptable compaction.

Note that the characteristic density and LWD test results will likely not change at the same rate, due to the comparative sensitivity of the parameter being assessed. For example, whilst the compaction state may change by ~10% as a material is progressively compacted from a medium to high compaction state (say 90% DDR to 100% DDR), the standardised LWD in situ modulus may change by a factor of more than 10 (e.g. increase from 10 MPa to > 100 MPa). This is shown conceptually in Figure 15-4.

The methodology of a project specific validation / trial embankment outlined above can be altered to suit the requirements of individual projects.

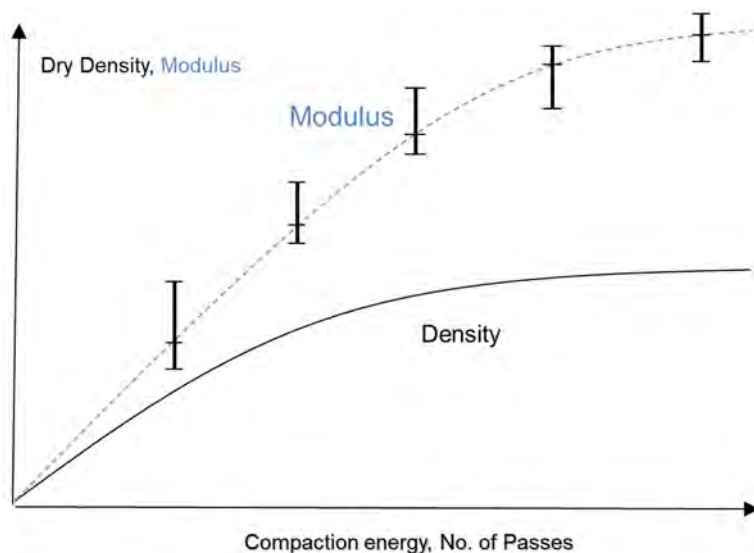


Figure 15-2 Conceptual sketch demonstrating expected relative change in density / compaction state of material and in situ modulus (stiffness) parameters during progressive compaction of earthworks (i.e. as number of ‘passes’ of compaction plant / applied compactive effort is increased)

Proposed LWD Testing Frequency



In the absence of project-specific requirements, it would be proposed that the following testing frequencies be included for LWD equipment standardisation in Earthworks QA Technical Specification's

- For general earthworks and locations within fill embankments where the exposed testing surface remains a minimum of 1,000 mm below top of subgrade (i.e. not subgrade materials) = Min. six (6) LWD minimum per 1,500 m² of works (equivalent to 1 LWD test per 250 m² of prepared earthworks)
- For pavement materials and locations within fill embankments where the exposed testing surface is within 1,000 mm of top of subgrade = Min. ten (10) LWD minimum per 1,500 m² of works (equivalent to 1 LWD test per 150 m² of prepared earthworks)

LWD tests shall be specified to be performed within two (2) hours of the completion of compaction, such that the effect of surface drying on the measured in situ modulus parameter is minimised. Note this method does not account for post compaction wetting or drying and environmental effects.

For some materials (especially fine-grained materials), the in-situ modulus parameter would be expected to vary based on the moisture content of the material at the time of test (i.e. vary based on drying and wetting). Although such a change would be expected to also occur for a density-based assessment, traditional (density) QA regimes are blind to this effect and often install subsequent fill on materials that would have altered moisture contents since the completion of "passing" DDR assessments. Thus, the moisture-dependency nature of the in situ modulus parameter of a earthworks material should not be considered a basis for not implementing a modulus-based QA specification – as it is not specific to the assessment of an in situ modulus parameter and the identification of this as a potential limitation of modulus-based QA Specifications is to hold them to a higher level of requirement than traditional (density) QA Specifications.

If required, the LWD can be used to evaluate and accommodate such moisture dependency within the derived acceptance thresholds. Alternatively, the LWD can be utilised to enhance the compaction quality assessment by continual monitoring of exposed materials following wetting / rainfall events, and should in situ modulus parameters (E_{LWD}) fall below the defined target / threshold values then additional earthworks fill layers should not be placed until suitable dry back occurs (as evidenced by an acceptable recovery of the E_{LWD} parameter assessed onsite).

Method of Matching Probability Density Functions (PDFs) – Advanced Acceptance Threshold Determination

This method requires additional side-by-side testing over a series of defined earthworks lots (5 no.) to establish a baseline range of values for both density (DDR) and the alternative method of QA being utilised (in this example the LWD). The aim of this method is to produce a statistically valid sized dataset that allows the accurate definition of an applicable probability density function (PDF) of each of the two (2) test techniques, and then matching the corresponding characteristic statistical values to establish the project- and material-specific DRR to alternative in situ parameter relationship (in this example the $E_{LWD-100kPa}$ parameter)

This approach is as follows: -

1. Carry out side-by-side DDR and LWD testing at a minimum of 25 no. locations. Locations should be spread across representative earthworks area (say spread across five (5) earthworks lots, each including five (5) test locations)
2. Interpret the standardised in situ modulus parameter for each test location – e.g. $E_{LWD-100kPa}$. Discard the highest value and apply the defined capping value (e.g. $E_{LWD-100kPa} = 200$ MPa) to any other uncharacteristically high values. Determine the characteristic values of the dataset and establish the COV of the dataset (Standard Deviation / Mean).
3. Fit a Probability Distribution Function (PDF) of best fit to both the density dataset (likely a Normal distribution function) and in situ modulus dataset (likely non-normal distribution function).
4. Plot the corresponding characteristic elements of each fitted PDF (Figure 15-3).
5. Obtain the 'equivalent' acceptance threshold in situ modulus parameters to be utilised for LWD QA assessment that correspond to the specified DDR requirements (Figure 15-4**Error! Reference source not found.**).

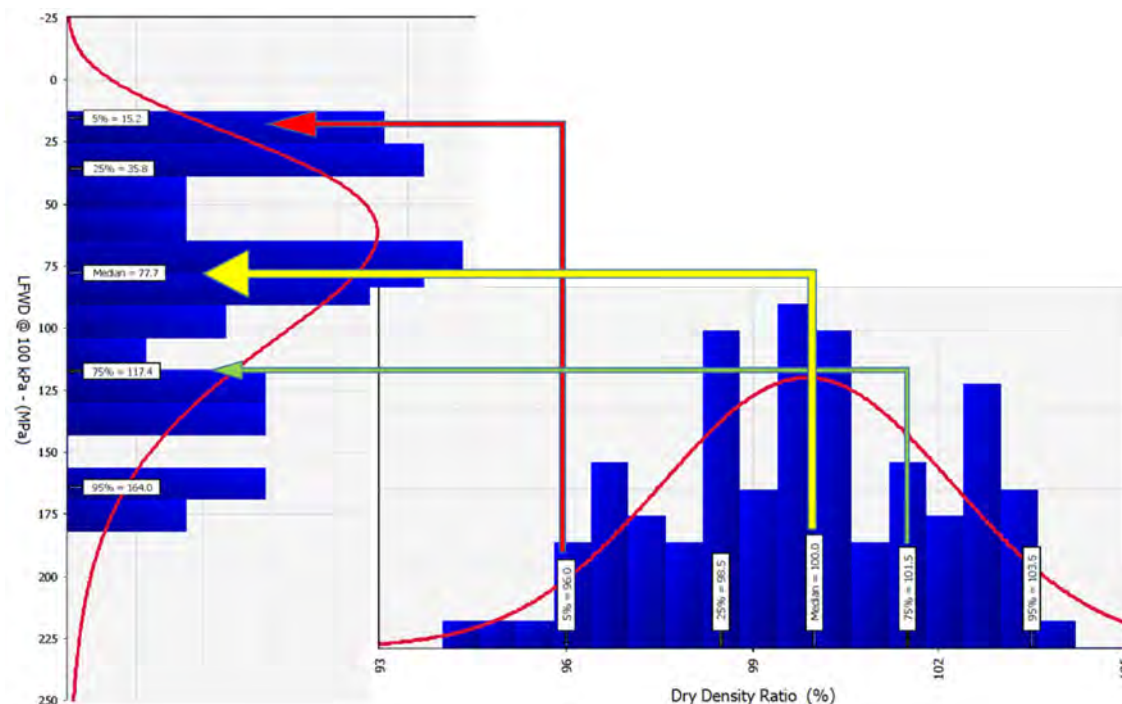


Figure 15-3 Conceptual sketch demonstrating method of matching characteristic elements of fitted PDFs

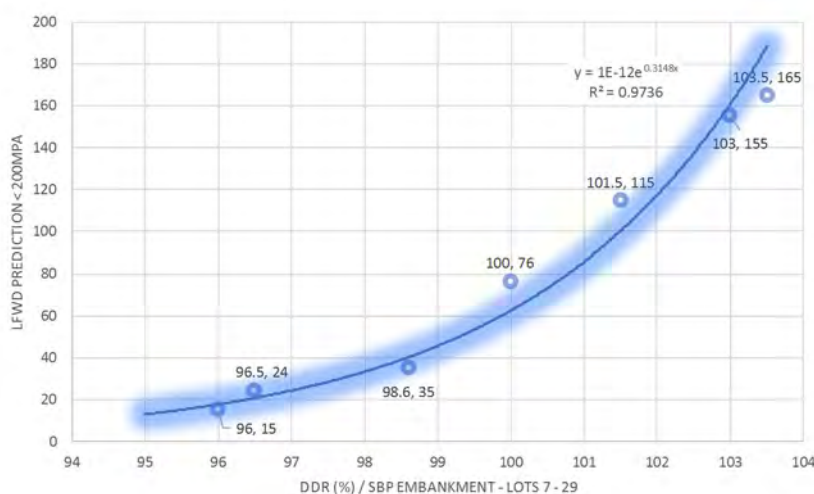


Figure 15-4 Example correlation between density (DDR) and in situ modulus parameter arising from the specified method of matching PDFs fitted to each test dataset.

15.4 Summary

Industry familiarity with density-based assessment for QA purposes currently hampers the use of more accurate tests that can directly validate design parameters are being achieved in the field. Although such alternative QA tests are not as precise as density testing, the density test is itself has the significant limitations of not providing near-instantaneous result and not being able to provide a reliable indication on the ground strength or modulus.

The static Plate Load test (PLT) is another industry accepted, reference test which has high accuracy, but very low precision. Recent Australian research have identified a number of alternative QA tests that have the potential to provide improved accuracy (as compared to density), and simultaneously offer an improvement in precision (as compared to PLT). Thus, the acceptance that DDR and PLT remains the benchmarks for precision and accuracy, respectively, should be considered an outdated viewpoint. This is conceptually

summarised in Figure 15-5, which attempts to correlate accuracy and other considerations for traditional (density and PLT) and 'alternative' QA tools.

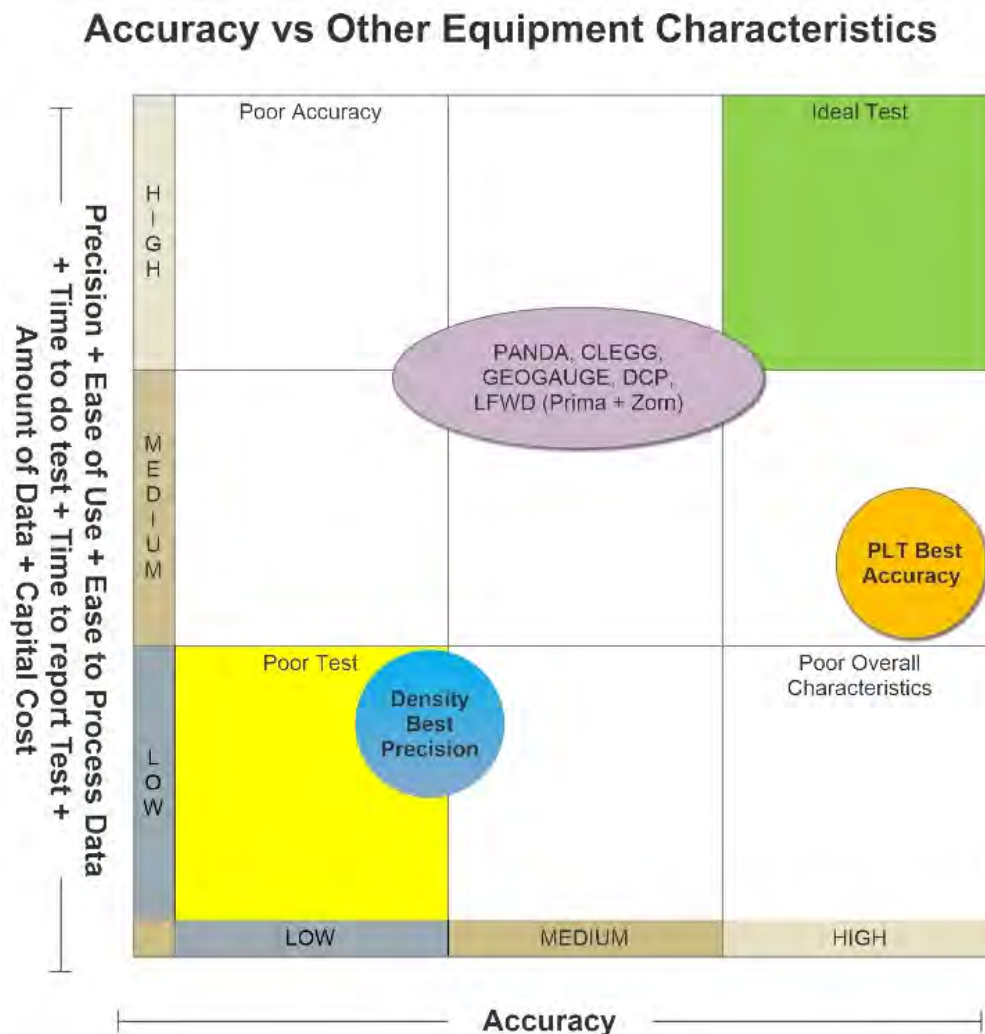


Figure 15-5 Assessment of Traditional (Density & PLT) vs. Alternative QA Tools – Accuracy and other characteristics

Despite the clear benefits of use, the alternative tests may not routinely provide a direct reliable correlation with DDR (as density itself is not directly related to the design stiffness or strength parameters). Many of these identified alternative in suit tests do not currently have Australian Standards, which also impedes their implementation.

In the interim, **this technical note provides a baseline methodology to use the Light Falling Weight Deflectometer (LWD) as an effective tool that can be implemented within earthworks QA Technical Specifications.** The framework of the methodology detailed herein can be similarly applied for any of the large range of non-density test instruments that are currently commercially available, with minor alterations to account for the specific parameter (and sensitivity of measurement) associated with each instrument type.

Continuous parallel testing of DDR with this alternative equipment will be perceived as additional costs to the project – and if considered on a 1-to-1 basis, parallel testing can lead to DDR results demonstrating a “pass” whilst LWD (or other tools) assessment could report a “fail” (or vice versa). Such a divergence of results should be attributed to the poor accuracy of DDR, rather than the more common perception of the ‘failure’ of the alternative QA tool being considered – such a result can frequently be traced to poor sampling practices (e.g. where oversize materials are often not sampled) or evaluation issues (e.g. oversize correction not routinely applied). An ongoing approach whereby parallel density and alternative assessment techniques is employed on a project is therefore not recommended. Instead, as detailed herein, equivalent ‘thresholds’ for



material acceptance should be defined during an initial trial that evaluates project-, material- and test-specific correlations – such that the existing risk profile is maintained – prior to the adoption of the alternative QA technique during production (with specified check testing frequencies to verify / update any project-specific defined correlations).

15.5 Further References

This technical note is a summary note only, detailing key elements for the implementation of a modulus-based QA specification that utilises the LWD as the key assessment tool. The range of alternative equipment available, their relative benefits, and detailed tests results on using such equipment in parallel with DDR, can be found in the 2 previous ARRB technical reports (2017, 2018) and this 2019r report

An overview of these methods can also be found at:

Look B, Lacey D. and Lee J (2018). Advanced Methods for compaction Quality Control - Part 1: Concepts. NACOE webinar <http://nacoee.com.au/publications/videos/>

Finally, we draw your attention to the attached Important Information about your FSG report.

Please contact the undersigned if any further information or clarification is required.

Regards,

David Lacey
Senior Geotechnical Engineer

Burt Look
Principal Geotechnical Engineer



Important Information about your FSG Report

Deep foundation and geotechnical engineering problems are a principal cause of construction delays, cost overruns, claims and disputes. The following information is provided to help you to understand this report and its limitations and manage your risks.

Scope and Applicability of this Report

This report has been prepared for a specific purpose and scope and its applicability is limited. FSG cannot accept any responsibility for the use of this report outside of the stated scope and purpose. If a service has not been explicitly included in the scope, it must be assumed that it has not been provided. Assessment of soil or groundwater contamination does not form part of this geotechnical report and any reference to any potential site contamination is for information only. If you are uncertain about the applicability of the results for any particular purpose, you should consult FSG to avoid any misunderstanding or miss-application.

This report has been prepared for the nominated Client and project only and should not be relied upon by other parties, or for other purposes, without consulting FSG. Any party relying on this report beyond its specific purpose and scope does so entirely at their own risk and responsibility. FSG does not take responsibility for the use of this document by any other person or party than the Client.

Project Details and Information Provided

This report has been based on project details as provided to us at the time of the commission. We have assumed that the information supplied to FSG by the client or other external sources on behalf of the client, is correct unless explicitly stated so. FSG does not accept any responsibility for incomplete or inaccurate data provided by others.

If any project details change during the course of the project or observed conditions are considered to differ from those expected or assumed, FSG should be notified in order to investigate if and how changes in project details affect the conclusions and recommendations in our report. If FSG is not consulted when changes are made to the initial project details, we cannot accept any responsibility for problems arising from these changes.

Geotechnical Information and Interpretation

Site investigations only sample discrete parts of the ground, and that extrapolation and interpolation of collected information can be used with varying degrees of risk and uncertainty depending on the extent and quality of the site investigation, the variability of the subsurface conditions and the consequences to the proposed works.

The analyses and recommendations in this report rely on the results of site investigation information, and other reported geotechnical information that is relevant to the works. This may include the results of pile load testing, other geotechnical testing, and inspections and observations from studies that have been performed as part of the works or in the vicinity of the works previously.

We have endeavoured to incorporate the available information into an appropriate geotechnical model based on our interpretation of the likely subsurface conditions. This process, and the geotechnical analysis and interpretation based on that model, is an inexact science, as a model is but a simplification of reality to derive a geotechnical solution. While we endeavour to incorporate realistic model parameters, our models, interpretations and the outcomes of our work generally may differ from reality for a range of reasons including:

- **Spatial Variability:** Geotechnical and geological variability across the site which may not have been captured in the site investigation works that have been used in our works. Geotechnical site investigations are very limited in the extent of physical investigation compared to the size of the entire site. No site investigation, no matter how comprehensive, can reveal all subsurface details and anomalies and conditions that differ from those observed in the site investigation will occur;
- **Temporal Variability:** Subsurface conditions can change with time due to man-made events such as cutting or filling or any construction works on or adjacent to the site which can also affect the site drainage and hence underlying properties; or by natural events such as floods or groundwater fluctuations.
- **Variability in Mechanical Properties:** Normal geotechnical variability in the inferred properties of materials represented in the boreholes, the performance of foundations or other elements that are tested or observed, and the performance of structures that are in contact with the ground in general. The data collected is only directly relevant to the exact location where the investigation was undertaken. The subsurface conditions between test locations have been inferred based on judgement and experience with the facts available at that time and related to the relative position of the proposed works;
- **Testing Limitations:** Uncertainty associated with geotechnical testing, design correlations associated with those tests or material descriptions, and case histories from which geotechnical parameters may have been inferred or in design and/or analysis methods that have been adopted;
- **Construction Effects:** Variability in the performance of construction equipment, such as hammers, cushions, guides and associated equipment for piling, construction effects that may influence the way structures interact with the ground, as well as inaccuracies in data measurement and testing methods that may have been used to record construction processes.



The results provided should be considered as indicative of the best estimate of likely outcomes (or range thereof), and should not be considered to be definitive or absolute, or represent the full range of possible outcomes at this site. Caution and prudence should be exercised when making decisions with significant implications for your project. The limitations of this report as outlined herein should be incorporated in decision making, and appropriate contingencies should be put in place to accommodate unexpected variability in relation to the works

Geotechnical Modelling

Model parameters that are used may vary in nature depending on the purpose of the analysis. Where it is necessary to make a realistic evaluation of the soil model, we would normally describe this as a 'best estimate' (BE). Depending on the particular application, it may be important to understand the sensitivity of the solution to soil model changes. We may then also define an 'upper-bound' (UB) soil model and a 'lower-bound' soil model, being estimates of the likely, strongest and weakest soil conditions which are anticipated based on the available geotechnical information and inferred geotechnical parameters. In certain circumstances, such as cases where the ground conditions appear to extremely uncertain or variable, we may also define 'extreme upper bound' (XUB) and 'extreme lower bound' (XLB) parameters which are intended to represent the likely extremes of the site conditions. In all cases, these models are inferred using engineering judgement from the available information and actual conditions and associated outcomes may differ from those assumed or given in our report, due to the inherent unpredictability of the ground, as outlined in the preceding section.

It should be noted that depending on the particular application either upper-bound or lower-bound analyses could be deemed conservative.

Disclaimer

The results, opinions, conclusions and any recommendations in this report are based on assumptions made by FSG in order to carry out the work. FSG specifically disclaims responsibility: arising from, or in connection with, any change to the site conditions or the nature of the proposed works including change in position of the structure or proposed works relative to the available data; to update this report if the site conditions or project details change or if the report is used after a protracted delay; and for liability arising from any of the assumptions that have been made or information provided being incorrect, incomplete or inaccurate.

Subject to the terms of an Agreement for Professional Services between FSG and the client, and to the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by FSG and this report are excluded.

Closure

Unless otherwise documented by way of a signed agreement for the services provided, all services in preparing this report have been provided under FSG's standard Terms and Conditions which are referenced in our fee proposal. The report is specific to the brief provided with its associated time and cost constraints.

Should you require any further information or clarification in relation to this report, please contact FSG.



Appendix A

Material Quality (Material Source & Post Compaction) – Test Certificates



Material Test Report

Report No: MAT:WOR18-00668-Q01

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q01'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869

Project: QUALITY CONTROL



Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory
Number: 11470

Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q01
Client Sample ID: PTS/Q-18-292
Date Sampled: 30/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

Other Test Results

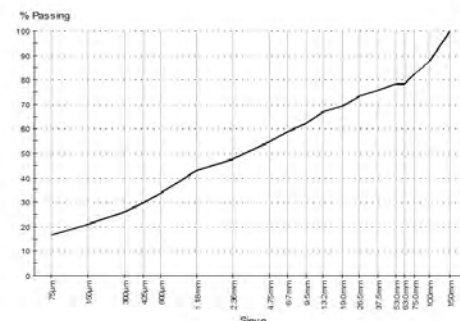
Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	4.0	
Liquid Limit (%)	Q104A	24.4	
Plastic Limit (%)	Q105	16.2	
Plasticity Index (%)	Q105	8.2	
Weighted Plasticity Index (%)	Q105	245	
Weighted Linear Shrinkage (%)	Q106	119	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		40	
CBR at 2.5		40	
CBR at 5.0		40	
Nominated Dry Density (t/m ³)		2.009	
Nominated Moisture Content (%)		7.9	
Achieved Dry Density (t/m ³)		2.010	
Achieved Moisture Content (%)		7.9	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.0	
Achieved % OMC		100.0	
Soaked		Yes	
Swell (%)		-0.28	
MC After Penetration (%)		10.7	
MC After Penetration of Penetrated End (%)		10.9	

Particle Size Distribution

Method: Grading [Q103A]
Drying by: Oven

Sieve Size	% Passing	Limits
150mm	100	
100mm	87	
75.0mm	82	
63.0mm	78	
53.0mm	78	
37.5mm	76	
26.5mm	73	
19.0mm	69	
13.2mm	67	
9.5mm	62	
6.7mm	59	
4.75mm	55	
2.36mm	47	
1.18mm	43	
600µm	34	
425µm	30	
300µm	26	
150µm	21	
75µm	16	

Chart



Comments

Sales Face, Workshop



Material Test Report

Report No: MAT:WOR18-00668-Q01

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q01'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869

Project: QUALITY CONTROL



Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory
Number: 11470

Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q01
Client Sample ID: PTS/Q-18-292
Date Sampled: 30/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

Other Test Results

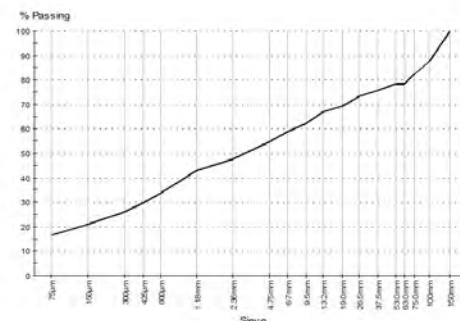
Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	4.0	
Liquid Limit (%)	Q104A	24.4	
Plastic Limit (%)	Q105	16.2	
Plasticity Index (%)	Q105	8.2	
Weighted Plasticity Index (%)	Q105	245	
Weighted Linear Shrinkage (%)	Q106	119	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		40	
CBR at 2.5		40	
CBR at 5.0		40	
Nominated Dry Density (t/m ³)		2.009	
Nominated Moisture Content (%)		7.9	
Achieved Dry Density (t/m ³)		2.010	
Achieved Moisture Content (%)		7.9	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.0	
Achieved % OMC		100.0	
Soaked		Yes	
Swell (%)		-0.28	
MC After Penetration (%)		10.7	
MC After Penetration of Penetrated End (%)		10.9	

Particle Size Distribution

Method: Grading [Q103A]
Drying by: Oven

Sieve Size	% Passing	Limits
150mm	100	
100mm	87	
75.0mm	82	
63.0mm	78	
53.0mm	78	
37.5mm	76	
26.5mm	73	
19.0mm	69	
13.2mm	67	
9.5mm	62	
6.7mm	59	
4.75mm	55	
2.36mm	47	
1.18mm	43	
600µm	34	
425µm	30	
300µm	26	
150µm	21	
75µm	16	

Chart



Comments

Sales Face, Workshop



Material Test Report

Report No: MAT:WOR18-00668-Q01

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q01'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869

Project: QUALITY CONTROL



Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory
Number: 11470

Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q01
Client Sample ID: PTS/Q-18-292
Date Sampled: 30/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

Other Test Results

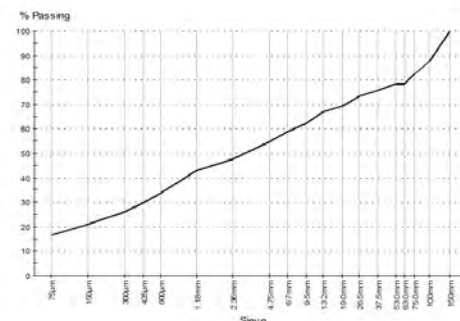
Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	4.0	
Liquid Limit (%)	Q104A	24.4	
Plastic Limit (%)	Q105	16.2	
Plasticity Index (%)	Q105	8.2	
Weighted Plasticity Index (%)	Q105	245	
Weighted Linear Shrinkage (%)	Q106	119	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		40	
CBR at 2.5		40	
CBR at 5.0		40	
Nominated Dry Density (t/m ³)		2.009	
Nominated Moisture Content (%)		7.9	
Achieved Dry Density (t/m ³)		2.010	
Achieved Moisture Content (%)		7.9	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.0	
Achieved % OMC		100.0	
Soaked		Yes	
Swell (%)		-0.28	
MC After Penetration (%)		10.7	
MC After Penetration of Penetrated End (%)		10.9	

Particle Size Distribution

Method: Grading [Q103A]
Drying by: Oven

Sieve Size	% Passing	Limits
150mm	100	
100mm	87	
75.0mm	82	
63.0mm	78	
53.0mm	78	
37.5mm	76	
26.5mm	73	
19.0mm	69	
13.2mm	67	
9.5mm	62	
6.7mm	59	
4.75mm	55	
2.36mm	47	
1.18mm	43	
600µm	34	
425µm	30	
300µm	26	
150µm	21	
75µm	16	

Chart



Comments

Sales Face, Workshop

Material Test Report

Report No: MAT:WOR18-00668-Q03

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q03'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869
Project: QUALITY CONTROL



Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory
Number: 11470
Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018
THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q03
Client Sample ID: PTS/Q-18-295
Date Sampled: 31/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

Other Test Results

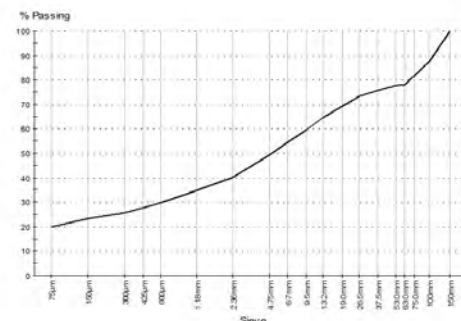
Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	4.0	
Liquid Limit (%)	Q104A	28.2	
Plastic Limit (%)	Q105	20.2	
Plasticity Index (%)	Q105	8.0	
Weighted Plasticity Index (%)	Q105	222	
Weighted Linear Shrinkage (%)	Q106	111	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		40	
CBR at 2.5		30	
CBR at 5.0		40	
Nominated Dry Density (t/m ³)		2.024	
Nominated Moisture Content (%)		8.7	
Achieved Dry Density (t/m ³)		2.024	
Achieved Moisture Content (%)		8.7	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.0	
Achieved % OMC		99.5	
Soaked		Yes	
Swell (%)		-0.31	
MC After Penetration (%)		10.0	
MC After Penetration of Penetrated End (%)		10.3	

Particle Size Distribution

Method: Grading [Q103A]
Drying by: Oven

Sieve Size	% Passing	Limits
150mm	100	
100mm	87	
75.0mm	82	
63.0mm	78	
53.0mm	78	
37.5mm	76	
26.5mm	73	
19.0mm	69	
13.2mm	64	
9.5mm	60	
6.7mm	54	
4.75mm	49	
2.36mm	40	
1.18mm	35	
600µm	30	
425µm	28	
300µm	26	
150µm	23	
75µm	20	

Chart



Comments

Main Pit, Level 3

Material Test Report

Report No: MAT:WOR18-00668-Q03

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q03'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869
Project: QUALITY CONTROL



Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory
Number: 11470
Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018
THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q03
Client Sample ID: PTS/Q-18-295
Date Sampled: 31/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

Other Test Results

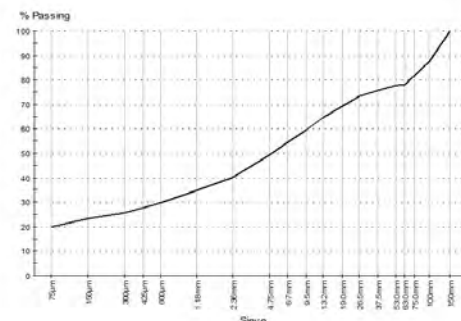
Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	4.0	
Liquid Limit (%)	Q104A	28.2	
Plastic Limit (%)	Q105	20.2	
Plasticity Index (%)	Q105	8.0	
Weighted Plasticity Index (%)	Q105	222	
Weighted Linear Shrinkage (%)	Q106	111	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		40	
CBR at 2.5		30	
CBR at 5.0		40	
Nominated Dry Density (t/m ³)		2.024	
Nominated Moisture Content (%)		8.7	
Achieved Dry Density (t/m ³)		2.024	
Achieved Moisture Content (%)		8.7	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.0	
Achieved % OMC		99.5	
Soaked		Yes	
Swell (%)		-0.31	
MC After Penetration (%)		10.0	
MC After Penetration of Penetrated End (%)		10.3	

Particle Size Distribution

Method: Grading [Q103A]
Drying by: Oven

Sieve Size	% Passing	Limits
150mm	100	
100mm	87	
75.0mm	82	
63.0mm	78	
53.0mm	78	
37.5mm	76	
26.5mm	73	
19.0mm	69	
13.2mm	64	
9.5mm	60	
6.7mm	54	
4.75mm	49	
2.36mm	40	
1.18mm	35	
600µm	30	
425µm	28	
300µm	26	
150µm	23	
75µm	20	

Chart



Comments

Main Pit, Level 3

Material Test Report

Report No: MAT:WOR18-00668-Q03

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q03'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869
Project: QUALITY CONTROL



Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory
Number: 11470
Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018
THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q03
Client Sample ID: PTS/Q-18-295
Date Sampled: 31/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

Other Test Results

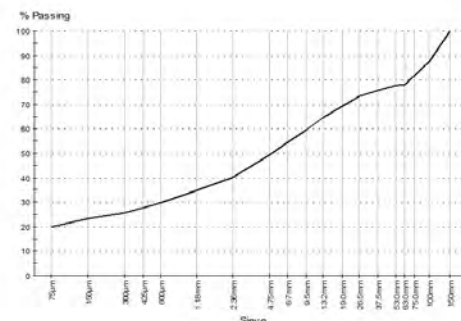
Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	4.0	
Liquid Limit (%)	Q104A	28.2	
Plastic Limit (%)	Q105	20.2	
Plasticity Index (%)	Q105	8.0	
Weighted Plasticity Index (%)	Q105	222	
Weighted Linear Shrinkage (%)	Q106	111	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		40	
CBR at 2.5		30	
CBR at 5.0		40	
Nominated Dry Density (t/m ³)		2.024	
Nominated Moisture Content (%)		8.7	
Achieved Dry Density (t/m ³)		2.024	
Achieved Moisture Content (%)		8.7	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.0	
Achieved % OMC		99.5	
Soaked		Yes	
Swell (%)		-0.31	
MC After Penetration (%)		10.0	
MC After Penetration of Penetrated End (%)		10.3	

Particle Size Distribution

Method: Grading [Q103A]
Drying by: Oven

Sieve Size	% Passing	Limits
150mm	100	
100mm	87	
75.0mm	82	
63.0mm	78	
53.0mm	78	
37.5mm	76	
26.5mm	73	
19.0mm	69	
13.2mm	64	
9.5mm	60	
6.7mm	54	
4.75mm	49	
2.36mm	40	
1.18mm	35	
600µm	30	
425µm	28	
300µm	26	
150µm	23	
75µm	20	

Chart



Comments

Main Pit, Level 3

Material Test Report

Report No: MAT:WOR18-00668-Q04

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q04'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869

Project: QUALITY CONTROL

Accredited for compliance with ISO/IEC 17025 - Testing



NATA Accredited Laboratory
Number: 11470

Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q04
Client Sample ID: PTS/Q-18-296
Date Sampled: 31/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

Other Test Results

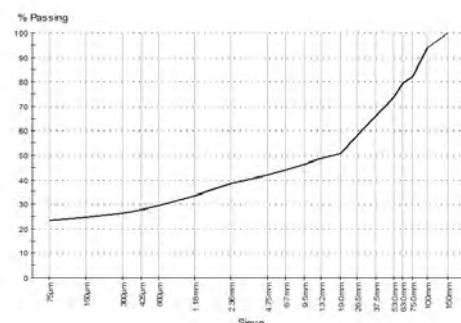
Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	5.4	
Liquid Limit (%)	Q104A	38.8	
Plastic Limit (%)	Q105	28.0	
Plasticity Index (%)	Q105	10.8	
Weighted Plasticity Index (%)	Q105	301	
Weighted Linear Shrinkage (%)	Q106	150	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		13	
CBR at 2.5		8.0	
CBR at 5.0		13	
Nominated Dry Density (t/m ³)		1.807	
Nominated Moisture Content (%)		14.5	
Achieved Dry Density (t/m ³)		1.807	
Achieved Moisture Content (%)		14.5	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.0	
Achieved % OMC		99.7	
Soaked		Yes	
Swell (%)		2.3	
MC After Penetration (%)		16.9	
MC After Penetration of Penetrated End (%)		18.3	

Particle Size Distribution

Method: Grading [Q103A]
Drying by: Oven

Sieve Size	% Passing	Limits
150mm	100	
100mm	94	
75.0mm	82	
63.0mm	79	
53.0mm	74	
37.5mm	66	
26.5mm	58	
19.0mm	51	
13.2mm	49	
9.5mm	46	
6.7mm	44	
4.75mm	42	
2.36mm	38	
1.18mm	33	
600µm	29	
425µm	28	
300µm	26	
150µm	25	
75µm	23	

Chart



Comments

Creek>Husseys

Material Test Report

Report No: MAT:WOR18-00668-Q05

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q05'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869

Project: QUALITY CONTROL

Accredited for compliance with ISO/IEC 17025 - Testing



NATA Accredited Laboratory
Number: 11470

Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q05
Client Sample ID: PTS/Q-18-297
Date Sampled: 31/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

Other Test Results

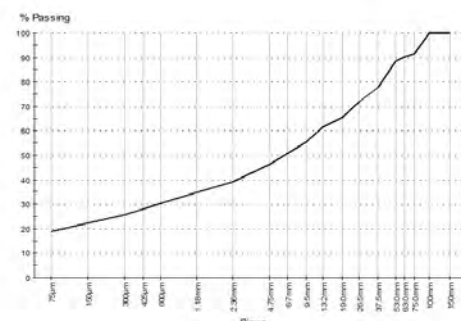
Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	3.2	
Liquid Limit (%)	Q104A	25.2	
Plastic Limit (%)	Q105	18.4	
Plasticity Index (%)	Q105	6.8	
Weighted Plasticity Index (%)	Q105	191	
Weighted Linear Shrinkage (%)	Q106	90	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		20	
CBR at 2.5		12	
CBR at 5.0		20	
Nominated Dry Density (t/m³)		2.028	
Nominated Moisture Content (%)		9.0	
Achieved Dry Density (t/m³)		2.029	
Achieved Moisture Content (%)		9.0	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.1	
Achieved % OMC		99.9	
Soaked		Yes	
Swell (%)		0.87	
MC After Penetration (%)		10.6	
MC After Penetration of Penetrated End (%)		10.8	

Particle Size Distribution

Method: Grading [Q103A]

Sieve Size	% Passing	Limits
150mm	100	
100mm	100	
75.0mm	91	
63.0mm	90	
53.0mm	88	
37.5mm	78	
26.5mm	72	
19.0mm	65	
13.2mm	61	
9.5mm	55	
6.7mm	51	
4.75mm	46	
2.36mm	39	
1.18mm	35	
600µm	30	
425µm	28	
300µm	26	
150µm	22	
75µm	19	

Chart



Comments

Husseys, Level 2

Material Test Report

Report No: MAT:WOR18-00668-Q05

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q05'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869

Project: QUALITY CONTROL

Accredited for compliance with ISO/IEC 17025 - Testing



NATA Accredited Laboratory
Number: 11470

Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q05
Client Sample ID: PTS/Q-18-297
Date Sampled: 31/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

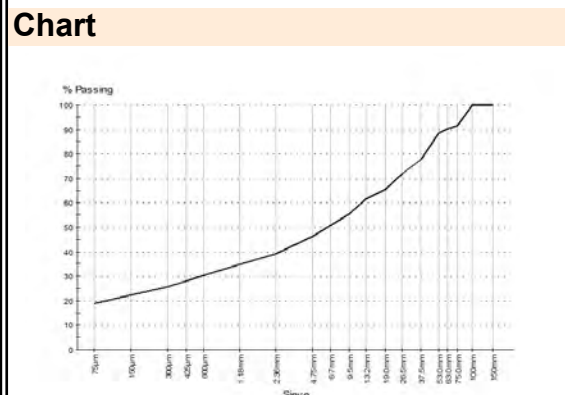
Particle Size Distribution

Method: Grading [Q103A]

Sieve Size	% Passing	Limits
150mm	100	
100mm	100	
75.0mm	91	
63.0mm	90	
53.0mm	88	
37.5mm	78	
26.5mm	72	
19.0mm	65	
13.2mm	61	
9.5mm	55	
6.7mm	51	
4.75mm	46	
2.36mm	39	
1.18mm	35	
600µm	30	
425µm	28	
300µm	26	
150µm	22	
75µm	19	

Other Test Results

Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	3.2	
Liquid Limit (%)	Q104A	25.2	
Plastic Limit (%)	Q105	18.4	
Plasticity Index (%)	Q105	6.8	
Weighted Plasticity Index (%)	Q105	191	
Weighted Linear Shrinkage (%)	Q106	90	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		20	
CBR at 2.5		12	
CBR at 5.0		20	
Nominated Dry Density (t/m³)		2.028	
Nominated Moisture Content (%)		9.0	
Achieved Dry Density (t/m³)		2.029	
Achieved Moisture Content (%)		9.0	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.1	
Achieved % OMC		99.9	
Soaked		Yes	
Swell (%)		0.87	
MC After Penetration (%)		10.6	
MC After Penetration of Penetrated End (%)		10.8	



Comments

Husseys, Level 2

Material Test Report

Report No: MAT:WOR18-00668-Q05

Issue No: 3

This report replaces all previous issues of report no 'MAT:WOR18-00668-Q05'.

Client: PNQ EDMONTON QUARRY
Lot 3 Hussey Road
Edmonton QLD 4869

Project: QUALITY CONTROL

Accredited for compliance with ISO/IEC 17025 - Testing



NATA Accredited Laboratory
Number: 11470

Approved Signatory: Jonathan Ahuriri
(Laboratory Supervisor)
Date of Issue: 13/06/2018

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID: WOR18-00668-Q05
Client Sample ID: PTS/Q-18-297
Date Sampled: 31/05/2018
Source: PNQ - EDMONTON QUARRY
Material: Select Fill
Sampled From: Stockpile Sales Face
Sampling Method: Q060 Clause 8.2
Specification: Non Specified
Location: PNQ Edmonton Quarry
Sampled By: Jonathan Ahuriri
Lot Number: N/A

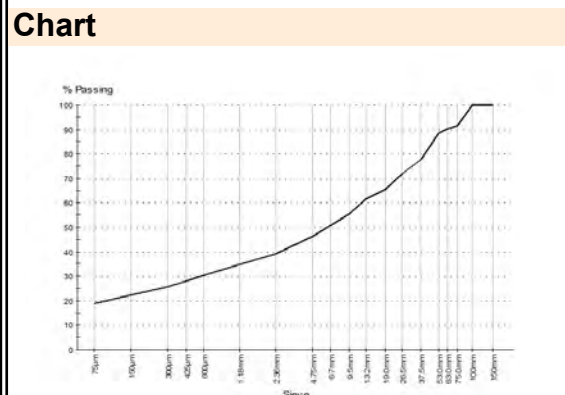
Particle Size Distribution

Method: Grading [Q103A]

Sieve Size	% Passing	Limits
150mm	100	
100mm	100	
75.0mm	91	
63.0mm	90	
53.0mm	88	
37.5mm	78	
26.5mm	72	
19.0mm	65	
13.2mm	61	
9.5mm	55	
6.7mm	51	
4.75mm	46	
2.36mm	39	
1.18mm	35	
600µm	30	
425µm	28	
300µm	26	
150µm	22	
75µm	19	

Other Test Results

Description	Method	Result	Limits
Atterberg Limits [Q104A/Q105/Q106]			
Linear Shrinkage (%)	Q106	3.2	
Liquid Limit (%)	Q104A	25.2	
Plastic Limit (%)	Q105	18.4	
Plasticity Index (%)	Q105	6.8	
Weighted Plasticity Index (%)	Q105	191	
Weighted Linear Shrinkage (%)	Q106	90	
Sample History		Oven-dried	
California Bearing Ratio [Q113C]			
CBR		20	
CBR at 2.5		12	
CBR at 5.0		20	
Nominated Dry Density (t/m³)		2.028	
Nominated Moisture Content (%)		9.0	
Achieved Dry Density (t/m³)		2.029	
Achieved Moisture Content (%)		9.0	
Nominated % MDD		98.0	
Nominated % OMC		100.0	
Achieved % MDD		98.1	
Achieved % OMC		99.9	
Soaked		Yes	
Swell (%)		0.87	
MC After Penetration (%)		10.6	
MC After Penetration of Penetrated End (%)		10.8	



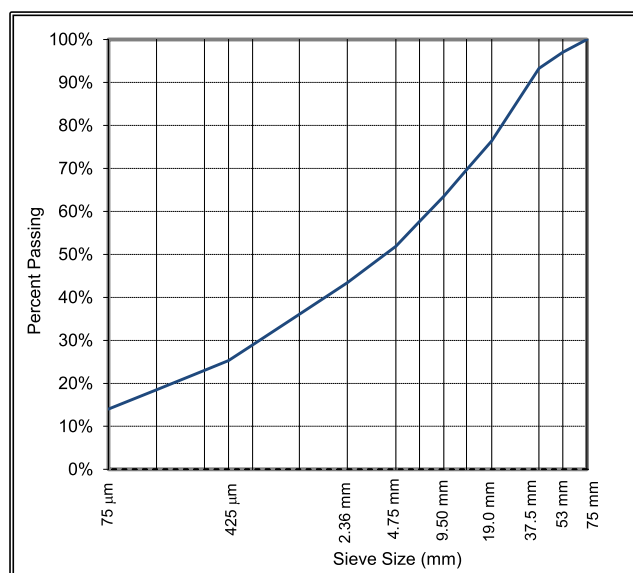
Comments

Husseys, Level 2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28713 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 18/02/2019
Job Number: GT17-474	Test Request No: TR005
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28713	Sample Location: MCTC - LHS Ch: 1303 1.8 m from RHS of Lot Embankment
Date Sampled: 12/02/2019	
Date Tested: 14/02/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	
Material Source: PNQ - Edmonton Quarry	Spec Description: -
For Use As: Embankment	Lot Number: SBP-EF-6
Remarks: -	Spec Number: -

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	-		
Sieve Size	Specification Minimum	Result % Passing	Specification Maximum
75mm		100	
53mm		97	
37.5mm		93	
19.0mm		76	
9.5mm		64	
4.75mm		52	
2.36mm		43	
0.425mm		25	
0.075mm		14	

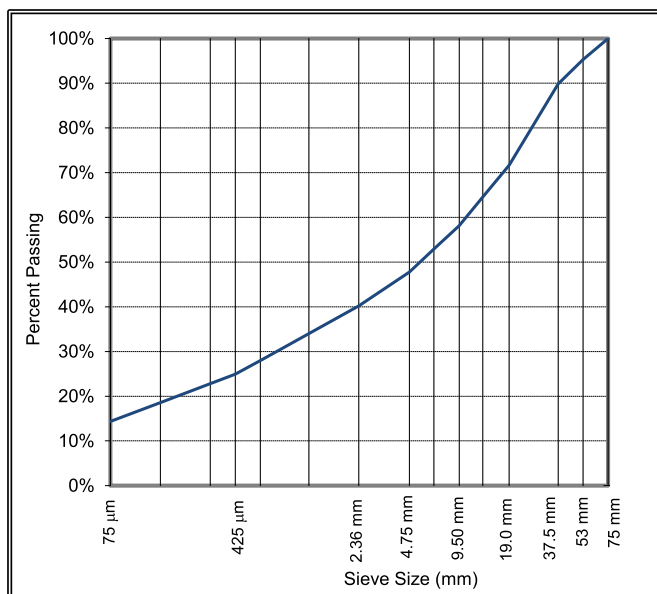
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			177	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.55	

 ACCREDITED FOR TECHNICAL COMPETENCE	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	--	---	----------------------------

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -28716 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	18/02/2019
Job Number:	GT17-474	Test Request No:	TR005
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS28716	Sample Location:	MCTC - LHS
Date Sampled:	12/02/2019	Ch:	1351
Date Tested:	13/02/2019		7.0 m from RHS of Lot
Sampled By:	SA		Embankment
Sample Method:	AS1289.1.2.1.6.4 (b)	Spec Description:	-
Material Source:	PNQ - Edmonton Quarry	Lot Number:	SBP-EF-6
For Use As:	Embankment	Spec Number:	-
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		95	
37.5mm		90	
19.0mm		72	
9.5mm		58	
4.75mm		48	
2.36mm		40	
0.425mm		25	
0.075mm		14	

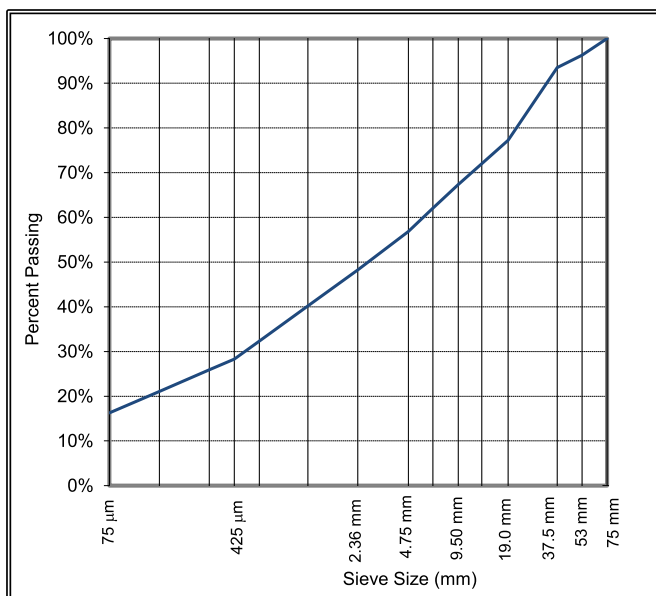
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			174	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.58	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28738 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 19/02/2019
Job Number: GT17-474	Test Request No: TR006
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28738	Sample Location: South of Avondale Ch 1022 15.5m off RHS Edge of Lot Lift 2
Date Sampled: 13/02/2019	
Date Tested: 18/02/2019	
Sampled By: TB	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: Insitu Material	Lot Number: SBP-EF-7
For Use As: -	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		96	
37.5mm		94	
19.0mm		77	
9.5mm		67	
4.75mm		57	
2.36mm		48	
0.425mm		28	
0.075mm		16	

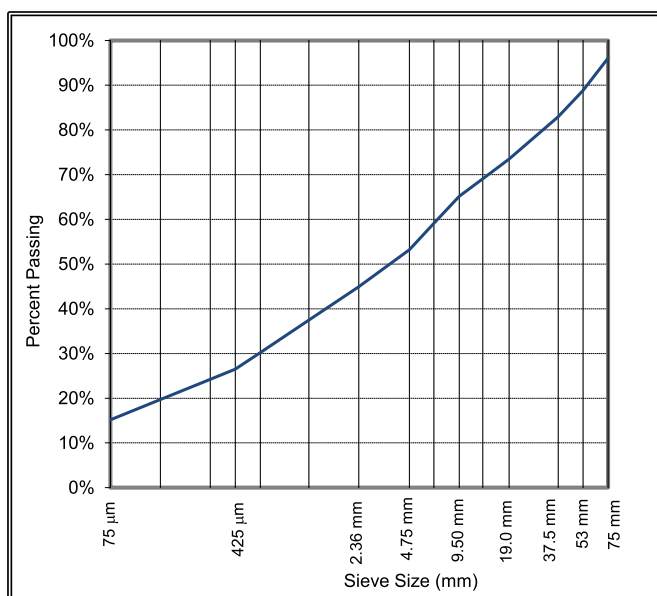
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			198	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.57	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -28740 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	19/02/2019
Job Number:	GT17-474	Test Request No:	TR006
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS28740	Sample Location:	South of Avondale Ch 1059 8.7m off RHS Edge of Lot Lift 2
Date Sampled:	13/02/2019	Spec Description:	-
Date Tested:	18/02/2019	Lot Number:	SBP-EF-7
Sampled By:	TB	Spec Number:	-
Sample Method:	AS1289.1.2.1.6.4 (b)		
Material Source:	Insitu Material		
For Use As:	-		
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		96	
53mm		89	
37.5mm		83	
19.0mm		73	
9.5mm		65	
4.75mm		53	
2.36mm		45	
0.425mm		26	
0.075mm		15	

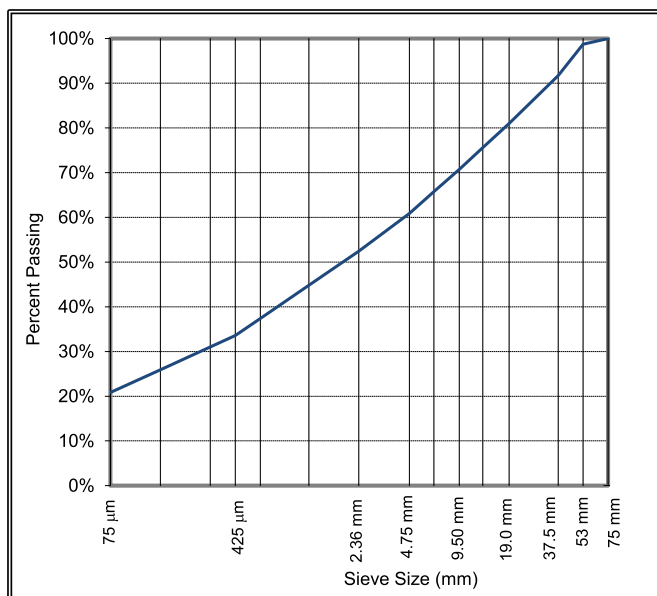
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	26	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	9	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			238	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.57	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28746 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 20/02/2019
Job Number: GT17-474	Test Request No: TR008
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28746	Sample Location: Over Culvert - RHS (Class A1 Fill) Ch 1329 13.8m off RHS Edge of Lot Lift 3
Date Sampled: 14/02/2019	
Date Tested: 18/02/2019	
Sampled By: TB	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-9
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		99	
37.5mm		92	
19.0mm		81	
9.5mm		71	
4.75mm		61	
2.36mm		52	
0.425mm		34	
0.075mm		21	

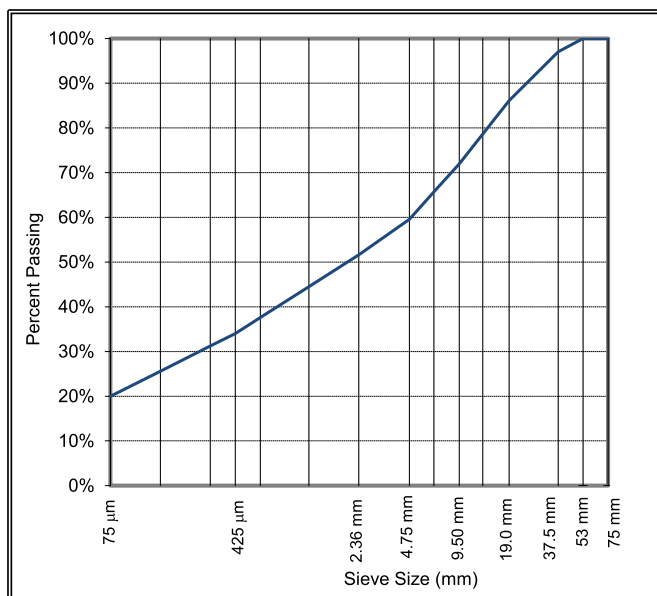
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	28	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	11	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			369	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.62	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -28748 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	20/02/2019
Job Number:	GT17-474	Test Request No:	TR008
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS28748	Sample Location:	Over Culvert - RHS (Class A1 Fill)
Date Sampled:	14/02/2019		Ch 1373
Date Tested:	18/02/2019		3.8m off RHS Edge of Lot
Sampled By:	TB		Lift 3
Sample Method:	AS1289.1.2.1.6.4 (b)	Spec Description:	-
Material Source:	PNQ - Edmonton Quarry	Lot Number:	SBP-EF-9
For Use As:	Embankment	Spec Number:	-
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		100	
37.5mm		97	
19.0mm		86	
9.5mm		72	
4.75mm		60	
2.36mm		52	
0.425mm		34	
0.075mm		20	

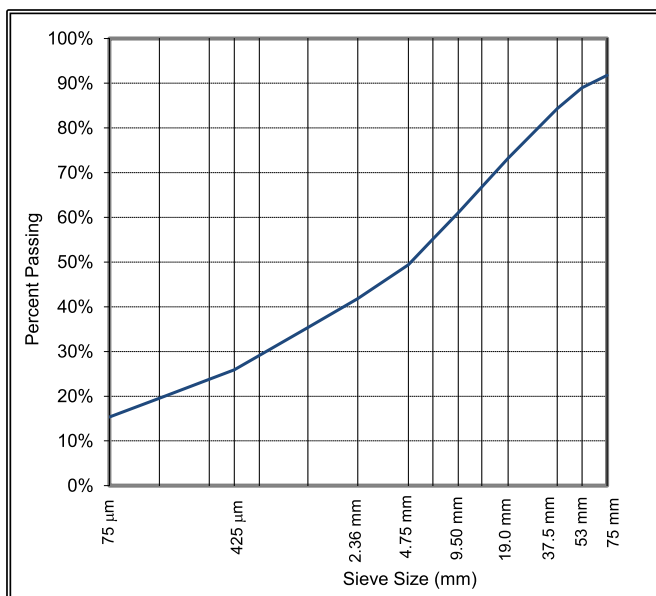
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	26	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	9	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			306	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.59	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

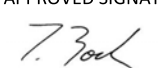
Client:	HAJV	Report Number:	GT17-474 -28750 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	19/02/2019
Job Number:	GT17-474	Test Request No:	TR009
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS28750	Sample Location:	South of Avondale Ch 1325 15.4m off LHS Edge of Lot Lift 2
Date Sampled:	14/02/2019	Spec Description:	-
Date Tested:	18/02/2019	Lot Number:	SBP-EF-10
Sampled By:	TB	Spec Number:	-
Sample Method:	AS1289.1.2.1.6.4 (b)		
Material Source:	Insitu Material		
For Use As:	-		
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		92	
53mm		89	
37.5mm		84	
19.0mm		73	
9.5mm		61	
4.75mm		49	
2.36mm		42	
0.425mm		26	
0.075mm		15	

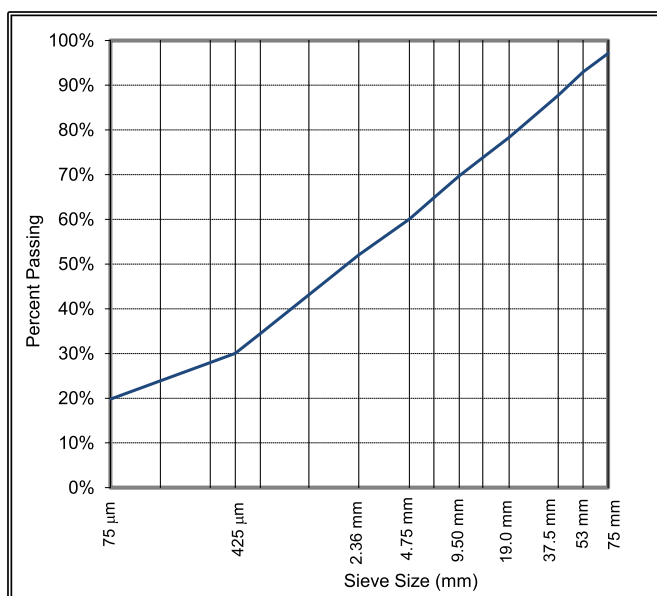
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			207	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.59	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -28752 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	20/02/2019
Job Number:	GT17-474	Test Request No:	TR009
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS28752	Sample Location:	South of Avondale Ch 1381 18.9m off LHS Edge of Lot Lift 2
Date Sampled:	14/02/2019	Spec Description:	-
Date Tested:	18/02/2019	Lot Number:	SBP-EF-10
Sampled By:	TB	Spec Number:	-
Sample Method:	AS1289.1.2.1.6.4 (b)		
Material Source:	PNQ - Edmonton Quarry		
For Use As:	Embankment		
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		97	
53mm		93	
37.5mm		88	
19.0mm		78	
9.5mm		70	
4.75mm		60	
2.36mm		52	
0.425mm		30	
0.075mm		20	

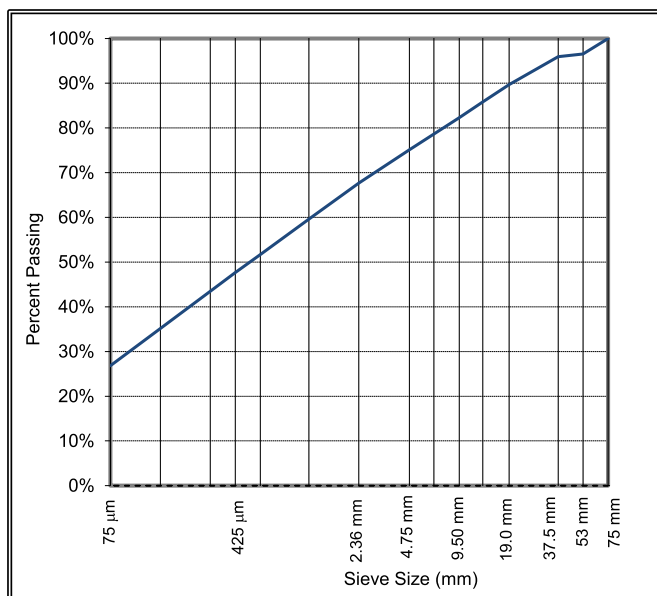
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			240	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.66	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28840 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 23/02/2019
Job Number: GT17-474	Test Request No: TR014
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28840	Sample Location: Over Culvert - LHS (Class A1 Fill) Ch 1288 8.0m from LHS Edge of Lot Lift 5
Date Sampled: 19/02/2019	
Date Tested: 22/02/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-15
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		97	
37.5mm		96	
19.0mm		90	
9.5mm		82	
4.75mm		75	
2.36mm		68	
0.425mm		48	
0.075mm		27	

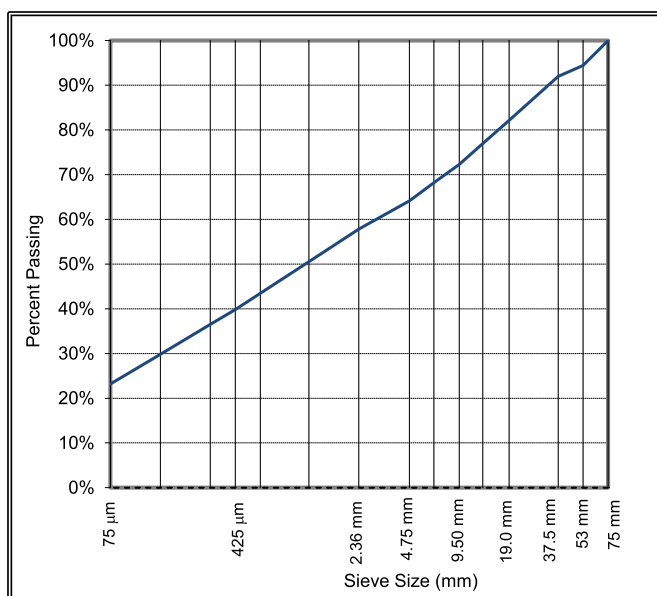
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			381	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.56	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28842 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 23/02/2019
Job Number: GT17-474	Test Request No: TR014
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28842	Sample Location: Over Culvert - LHS (Class A1 Fill) Ch 1354 3.2m from LHS Edge of Lot Lift 5
Date Sampled: 19/02/2019	
Date Tested: 22/02/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-15
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		94	
37.5mm		92	
19.0mm		82	
9.5mm		72	
4.75mm		64	
2.36mm		58	
0.425mm		40	
0.075mm		23	

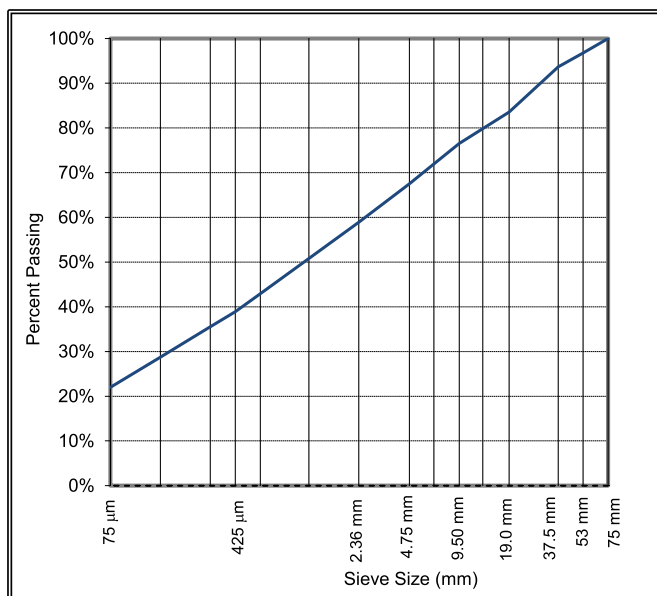
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			319	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.58	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -28878 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	6/03/2019
Job Number:	GT17-474	Test Request No:	TR015
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS28878	Sample Location:	South of Avondale CH 1016 12.7m from LHS Edge of Lot Lift 3
Date Sampled:	21/02/2019	Spec Description:	-
Date Tested:	4/03/2019	Lot Number:	SBP-EF-16
Sampled By:	KB	Spec Number:	-
Sample Method:	AS1289.1.2.1.6.4(b)		
Material Source:	PNQ - Edmonton Quarry		
For Use As:	Embankment		
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		97	
37.5mm		94	
19.0mm		84	
9.5mm		77	
4.75mm		67	
2.36mm		59	
0.425mm		39	
0.075mm		22	

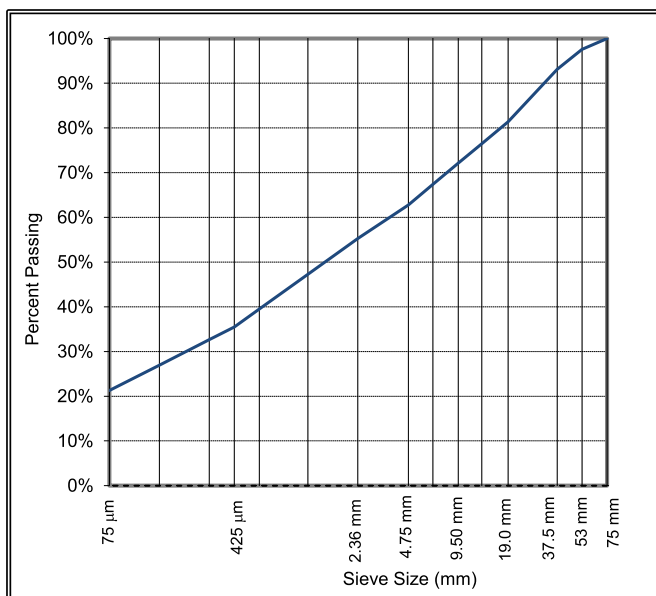
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	15	-
Plasticity Index	AS1289.3.3.1	-	10	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			389	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.57	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY		FORM NUMBER
	Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026		FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28880 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 6/03/2019
Job Number: GT17-474	Test Request No: TR015
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28880	Sample Location: South of Avondale CH 1096 14.1m from LHS Edge of Lot Lift 3
Date Sampled: 21/02/2019	
Date Tested: 4/03/2019	
Sampled By: KB	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-16
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		98	
37.5mm		93	
19.0mm		81	
9.5mm		72	
4.75mm		63	
2.36mm		55	
0.425mm		35	
0.075mm		21	

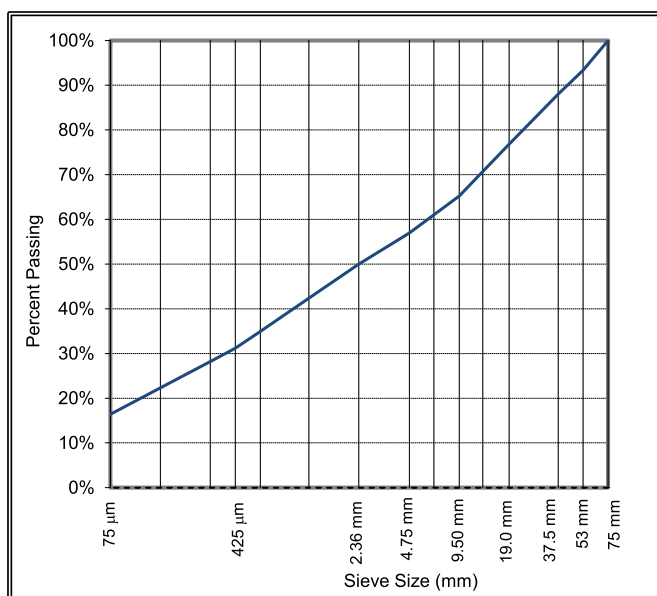
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	15	-
Plasticity Index	AS1289.3.3.1	-	10	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			355	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.60	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28883 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 7/03/2019
Job Number: GT17-474	Test Request No: TR16
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28883	Sample Location: Over Culvert - RHS (Class A1 Fill) CH 1320 3.2m from LHS Edge of Lot Lift 4
Date Sampled: 21/02/2019	
Date Tested: 4/03/2019	
Sampled By: KB	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-17
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		93	
37.5mm		88	
19.0mm		77	
9.5mm		65	
4.75mm		57	
2.36mm		50	
0.425mm		31	
0.075mm		16	

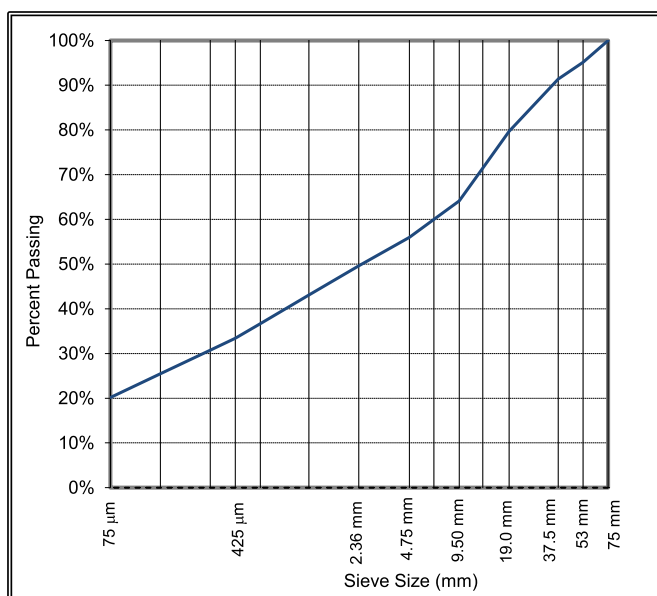
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	24	-
Plastic Limit (%)	AS1289.3.2.1	-	16	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			249	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.53	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28885 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 7/03/2019
Job Number: GT17-474	Test Request No: TR16
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28885	Sample Location: Over Culvert - RHS (Class A1 Fill) CH 1372 21.9m from LHS Edge of Lot Lift 4
Date Sampled: 21/02/2019	
Date Tested: 4/03/2019	
Sampled By: KB	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-17
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		95	
37.5mm		91	
19.0mm		80	
9.5mm		64	
4.75mm		56	
2.36mm		50	
0.425mm		33	
0.075mm		20	

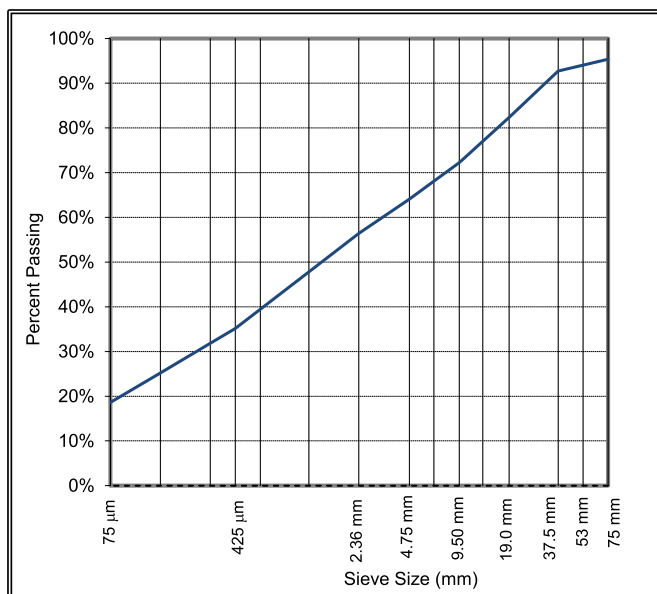
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	16	-
Plasticity Index	AS1289.3.3.1	-	9	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			301	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.60	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

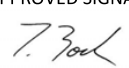
Client:	HAJV	Report Number:	GT17-474 -28915 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	7/03/2019
Job Number:	GT17-474	Test Request No:	TR017
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS28915	Sample Location:	South of Avondale
Date Sampled:	22/02/2019		CH 1062
Date Tested:	4/03/2019		7.8m from LHS
Sampled By:	KB		Lift 4
Sample Method:	AS1289.1.2.1..6.4(b)	Spec Description:	-
Material Source:	PNQ - Edmonton Quarry	Lot Number:	SBP-EF-18
For Use As:	Embankment	Spec Number:	-
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		95	
53mm		94	
37.5mm		93	
19.0mm		82	
9.5mm		72	
4.75mm		64	
2.36mm		56	
0.425mm		35	
0.075mm		19	

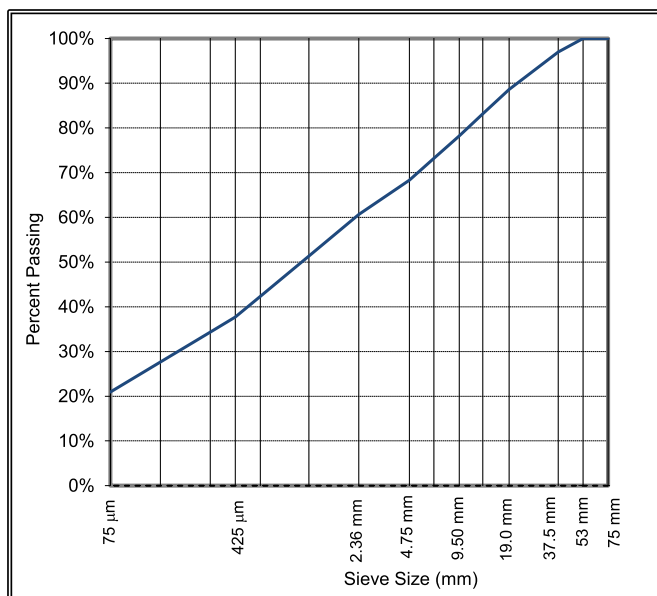
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	23	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	5	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			176	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.53	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER
		FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28917 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 7/03/2019
Job Number: GT17-474	Test Request No: TR017
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28917	Sample Location:
Date Sampled: 22/02/2019	South of Avondale
Date Tested: 4/03/2019	CH 1122
Sampled By: KB	0.4m from LHS
Sample Method: AS1289.1.2.1.6.4(b)	Lift 4
Material Source: PNQ - Edmonton Quarry	Spec Description: -
For Use As: Embankment	Lot Number: SBP-EF-18
Remarks: -	Spec Number: -

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		100	
37.5mm		97	
19.0mm		89	
9.5mm		78	
4.75mm		68	
2.36mm		61	
0.425mm		38	
0.075mm		21	

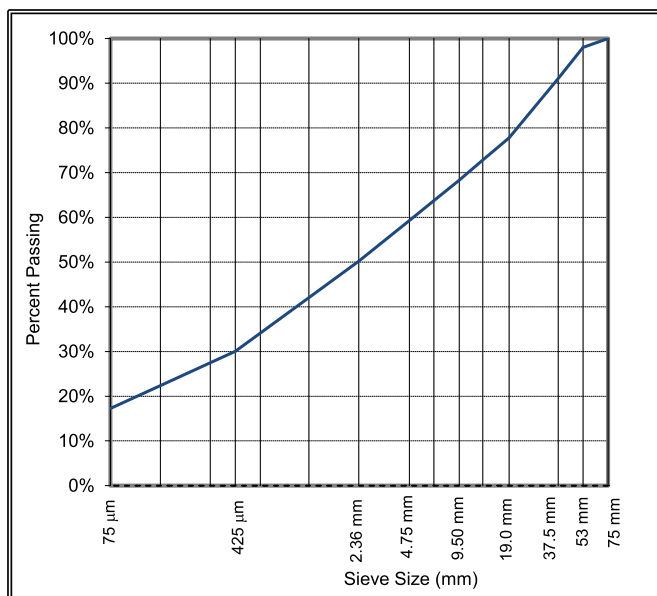
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			264	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.56	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28974 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 6/03/2019
Job Number: GT17-474	Test Request No: TR018
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28974	Sample Location: South of Avondale Ch 1009 6.9 m from RHS Edge of Lot Lift 4
Date Sampled: 25/02/2019	
Date Tested: 4/03/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-19
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		98	
37.5mm		91	
19.0mm		78	
9.5mm		68	
4.75mm		59	
2.36mm		50	
0.425mm		30	
0.075mm		17	

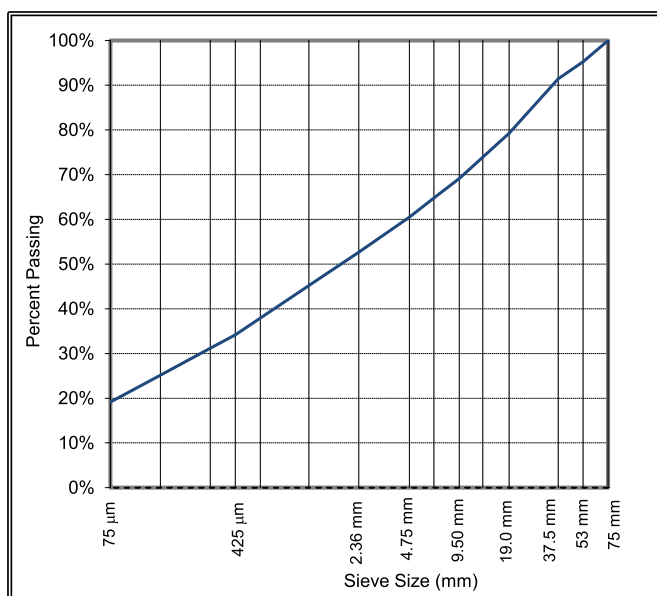
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	26	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			240	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.57	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -28976 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 6/03/2019
Job Number: GT17-474	Test Request No: TR018
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS28976	Sample Location: South of Avondale Ch 1096 20.5 from RHS Edge of Lot Lift 4
Date Sampled: 25/02/2019	
Date Tested: 4/03/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-19
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		95	
37.5mm		91	
19.0mm		79	
9.5mm		69	
4.75mm		60	
2.36mm		53	
0.425mm		34	
0.075mm		19	

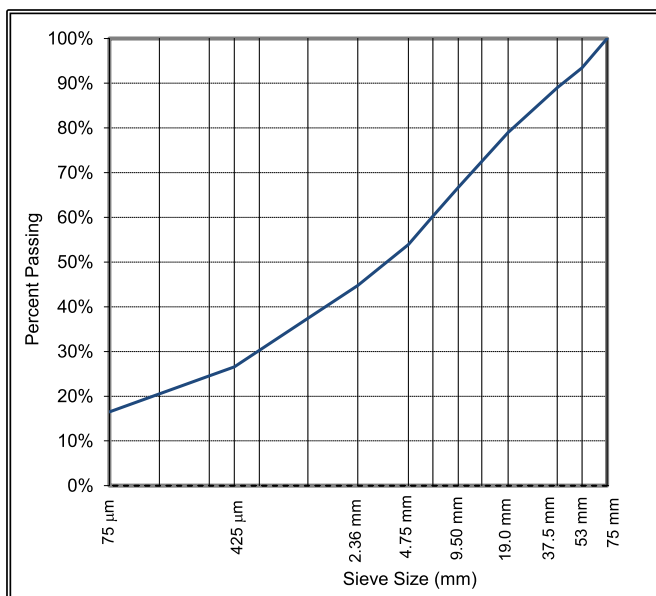
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	24	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			239	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.56	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER
		FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29028 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 7/03/2019
Job Number: GT17-474	Test Request No: TR019
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29028	Sample Location:
Date Sampled: 27/02/2019	South of Avondale
Date Tested: 4/03/2019	CH 1006
Sampled By: KB	0.3m from LH Edge
Sample Method: AS1289.1.2.1.6.4(b)	Lift
Material Source: PNQ - Edmonton Quarry	Spec Description: -
For Use As: Embankment	Lot Number: SBP-EF-21
Remarks: -	Spec Number: -

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		93	
37.5mm		89	
19.0mm		79	
9.5mm		67	
4.75mm		54	
2.36mm		45	
0.425mm		27	
0.075mm		16	

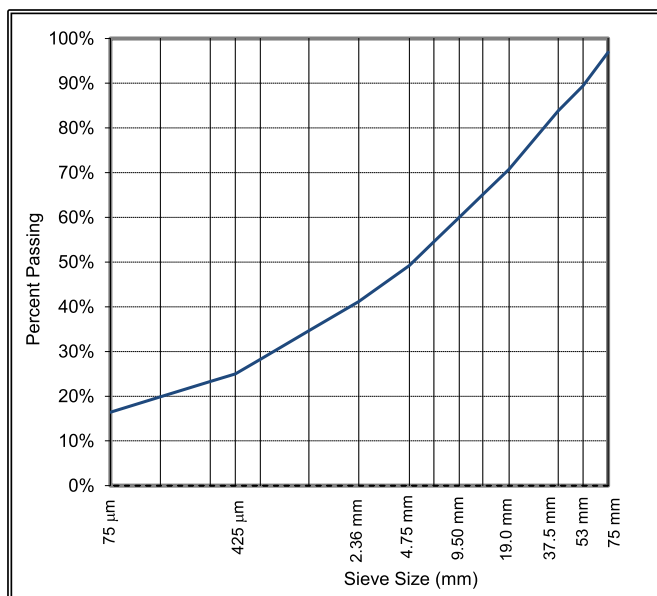
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	25	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			213	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.62	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER
		FM-RP-120-2

Quality of Materials Report

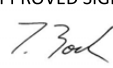
Client: HAJV	Report Number: GT17-474 -29030 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 7/03/2019
Job Number: GT17-474	Test Request No: TR019
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29030	Sample Location:
Date Sampled: 27/02/2019	South of Avondale
Date Tested: 4/03/2019	CH 1071
Sampled By: KB	15.8m from LH Edge
Sample Method: AS1289.1.2.1.6.4(b)	Lift
Material Source: PNQ - Edmonton Quarry	Spec Description: -
For Use As: Embankment	Lot Number: SBP-EF-21
Remarks: -	Spec Number: -

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		97	
53mm		89	
37.5mm		84	
19.0mm		71	
9.5mm		60	
4.75mm		49	
2.36mm		41	
0.425mm		25	
0.075mm		16	

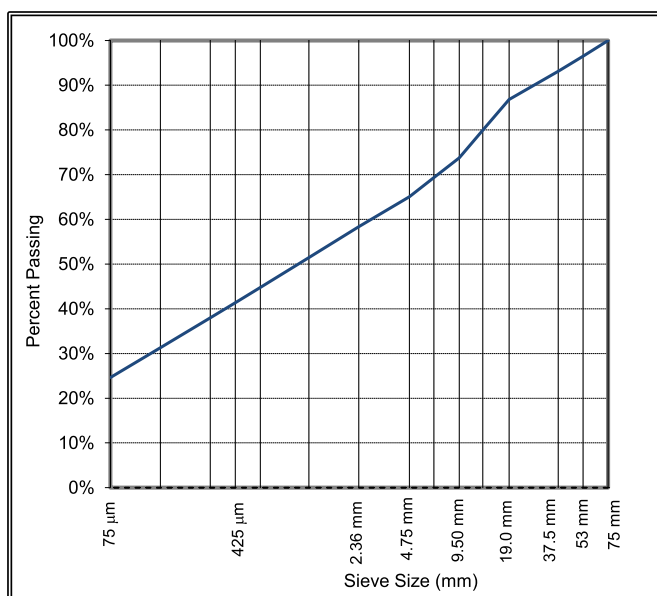
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	24	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			175	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.66	

 ACCREDITED FOR TECHNICAL COMPETENCE	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29431 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 02/04/2019
Job Number: GT17-474	Test Request No: TR031
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29431	Sample Location: South of Avondale - LHS Ch: 1022 6.7 m from LHS Edge of Lot Lift 7
Date Sampled: 25/03/2019	
Date Tested: 27/03/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-30
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		96	
37.5mm		93	
19.0mm		87	
9.5mm		74	
4.75mm		65	
2.36mm		58	
0.425mm		41	
0.075mm		25	

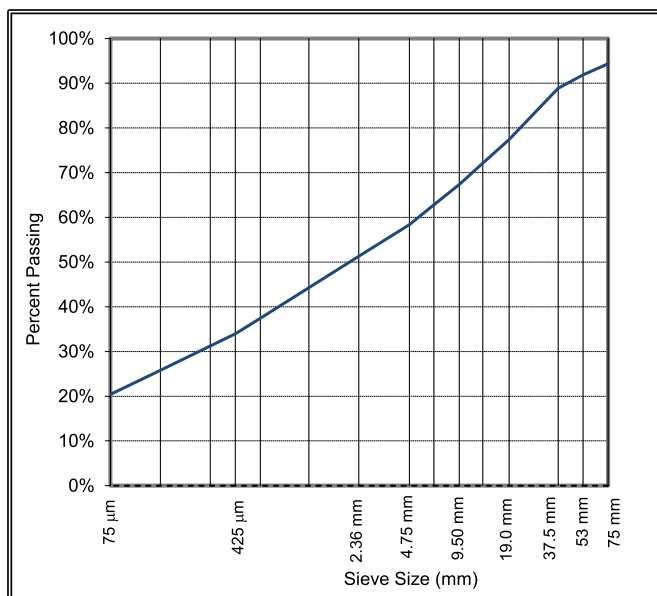
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	27	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	10	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			413	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.60	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER
		FM-RP-120-2

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -29433 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	2/04/2019
Job Number:	GT17-474	Test Request No:	TR031
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS29433	Sample Location:	South of Avondale - LHS
Date Sampled:	25/03/2019	Ch:	1091
Date Tested:	29/03/2019		5.8 m from LHS Edge of Lot
Sampled By:	SA	Lift	7
Sample Method:	AS1289.1.2.1.6.4(b)	Spec Description:	-
Material Source:	PNQ - Edmonton Quarry	Lot Number:	SBP-EF-30
For Use As:	Embankment	Spec Number:	-
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		94	
53mm		92	
37.5mm		89	
19.0mm		77	
9.5mm		67	
4.75mm		58	
2.36mm		51	
0.425mm		34	
0.075mm		20	

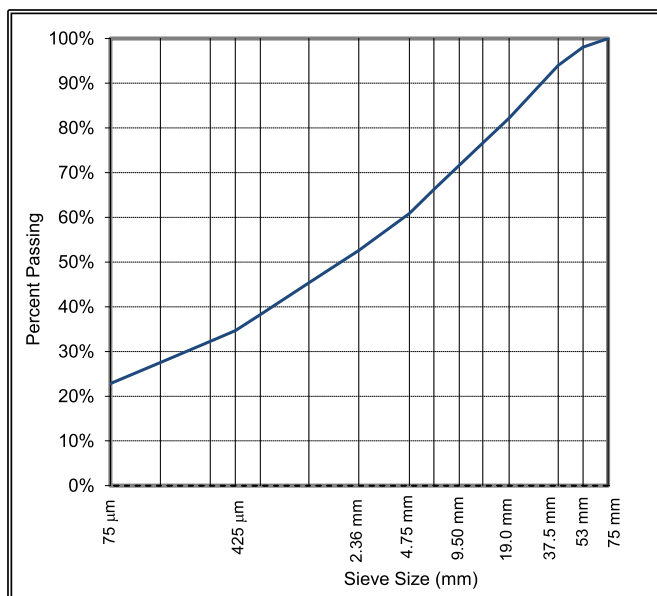
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	27	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	9	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			305	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.60	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29549 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 11/04/2019
Job Number: GT17-474	Test Request No: TR032
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29549	Sample Location: South of Avondale - RHS CH: 1043 15.6 m from LHS Edge of Lot Embankment
Date Sampled: 8/04/2019	
Date Tested: 9/04/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-31
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		98	
37.5mm		94	
19.0mm		82	
9.5mm		72	
4.75mm		61	
2.36mm		53	
0.425mm		35	
0.075mm		23	

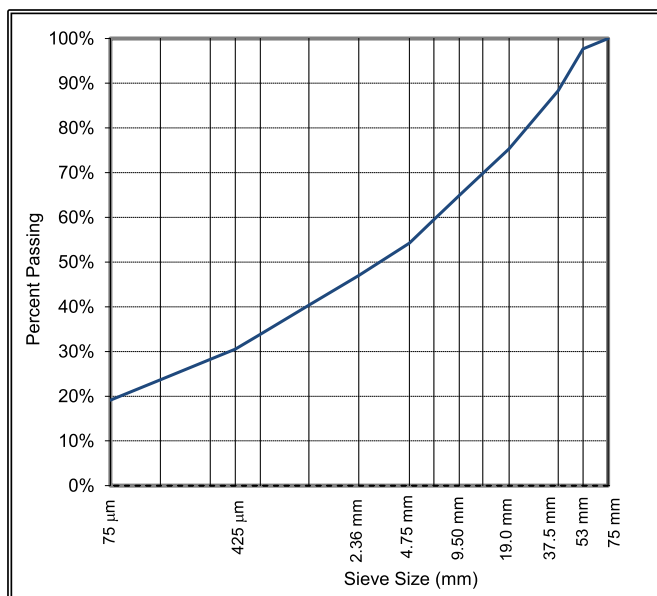
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	27	-
Plastic Limit (%)	AS1289.3.2.1	-	17	-
Plasticity Index	AS1289.3.3.1	-	10	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			347	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.66	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29551 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 11/04/2019
Job Number: GT17-474	Test Request No: TR032
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29551	Sample Location: South of Avondale - RHS CH: 1118 3.4 m from LHS Edge of Lot Embankment
Date Sampled: 8/04/2019	
Date Tested: 9/04/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-31
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		98	
37.5mm		88	
19.0mm		75	
9.5mm		65	
4.75mm		54	
2.36mm		47	
0.425mm		31	
0.075mm		19	

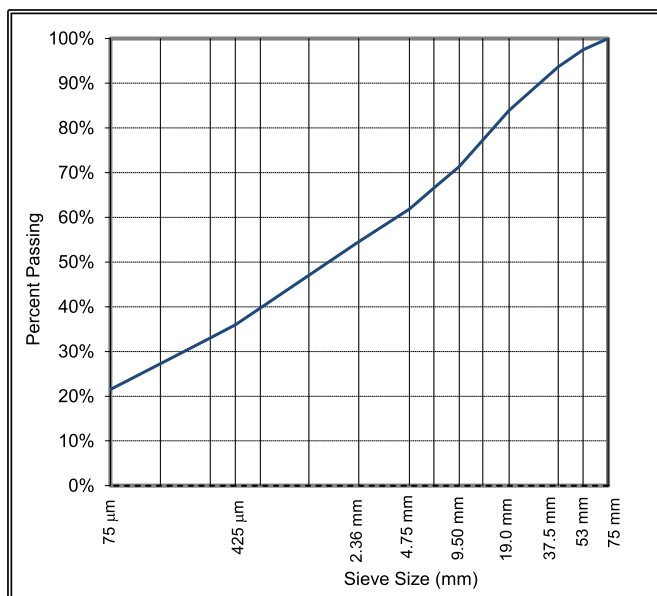
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	28	-
Plastic Limit (%)	AS1289.3.2.1	-	19	-
Plasticity Index	AS1289.3.3.1	-	9	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			275	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.63	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29624 Q
Client Address: PO Box 14353, Mt Sheridan QLD 4868	Report Date: 16/04/2019
Job Number: GT17-474	Test Request No: TR033
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29624	Sample Location: North of Avondale LHS Ch 1318 0.4 m from LHS Edge of Lot Lift 6
Date Sampled: 12/04/2019	
Date Tested: 15/04/2019	
Sampled By: TB	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-32
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		97	
37.5mm		94	
19.0mm		84	
9.5mm		71	
4.75mm		62	
2.36mm		55	
0.425mm		36	
0.075mm		22	

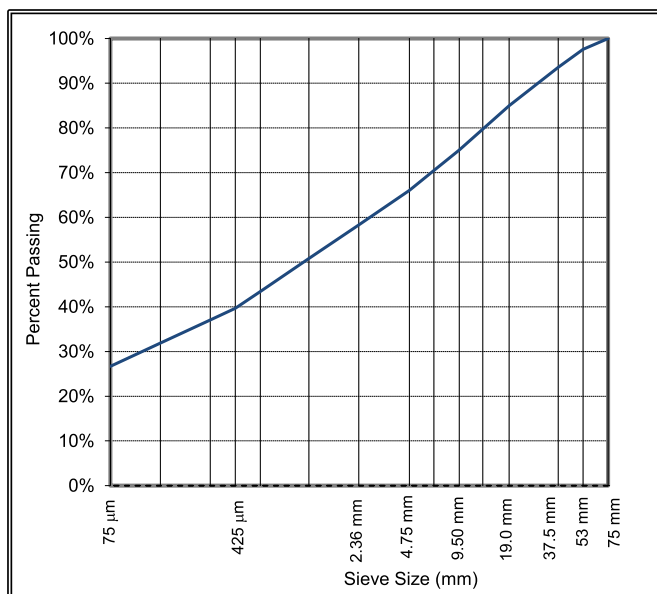
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	28	-
Plastic Limit (%)	AS1289.3.2.1	-	21	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			252	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.60	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

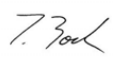
Client:	HAJV	Report Number:	GT17-474 -29626 Q
Client Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	16/04/2019
Job Number:	GT17-474	Test Request No:	TR033
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS29626	Sample Location:	North of Avondale LHS Ch 1357 15.4 m from LHS Edge of Lot Lift 6
Date Sampled:	12/04/2019	Spec Description:	-
Date Tested:	15/04/2019	Lot Number:	SBP-EF-32
Sampled By:	TB	Spec Number:	-
Sample Method:	AS1289.1.2.1.6.4(b)		
Material Source:	PNQ - Edmonton Quarry		
For Use As:	Embankment		
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	-		
Sieve Size	Specification Minimum	Result % Passing	Specification Maximum
75mm		100	
53mm		98	
37.5mm		94	
19.0mm		85	
9.5mm		75	
4.75mm		66	
2.36mm		58	
0.425mm		40	
0.075mm		27	

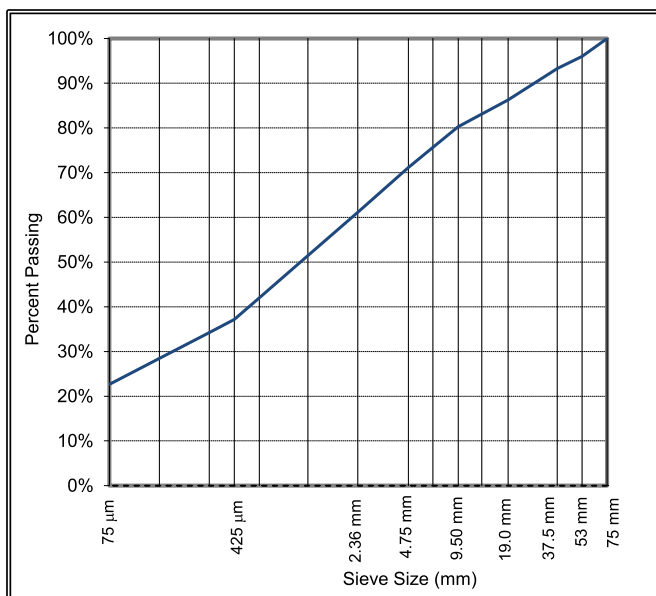
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	28	-
Plastic Limit (%)	AS1289.3.2.1	-	21	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			278	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.67	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29655 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 27/04/2019
Job Number: GT17-474	Test Request No: TR034
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29655	Sample Location: North of Avondale RHS Ch 1318 14.9m off RHS Edge of Lot Lift 6
Date Sampled: 16/04/2019	
Date Tested: 23/04/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-33
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		96	
37.5mm		93	
19.0mm		86	
9.5mm		80	
4.75mm		71	
2.36mm		61	
0.425mm		37	
0.075mm		23	

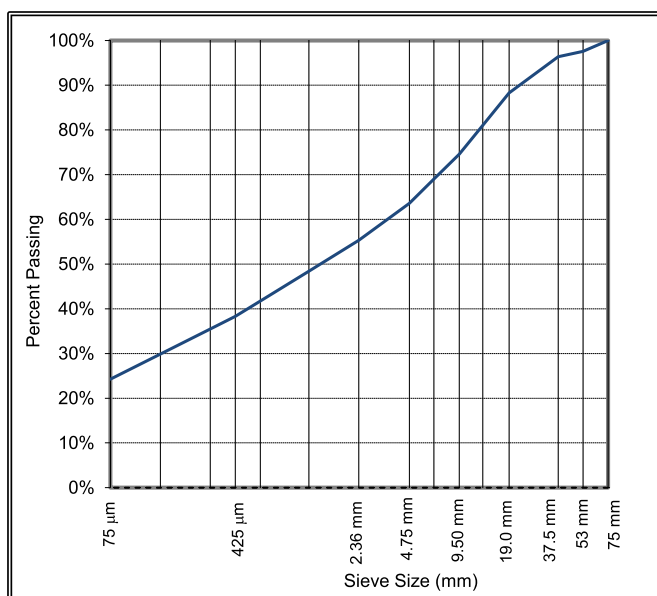
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	29	-
Plastic Limit (%)	AS1289.3.2.1	-	22	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			260	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.61	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29657 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 27/04/2019
Job Number: GT17-474	Test Request No: TR034
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29657	Sample Location: North of Avondale RHS Ch 1364 18.5m off RHS Edge of Lot Lift 6
Date Sampled: 16/04/2019	
Date Tested: 23/04/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-33
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		98	
37.5mm		96	
19.0mm		88	
9.5mm		75	
4.75mm		64	
2.36mm		55	
0.425mm		38	
0.075mm		24	

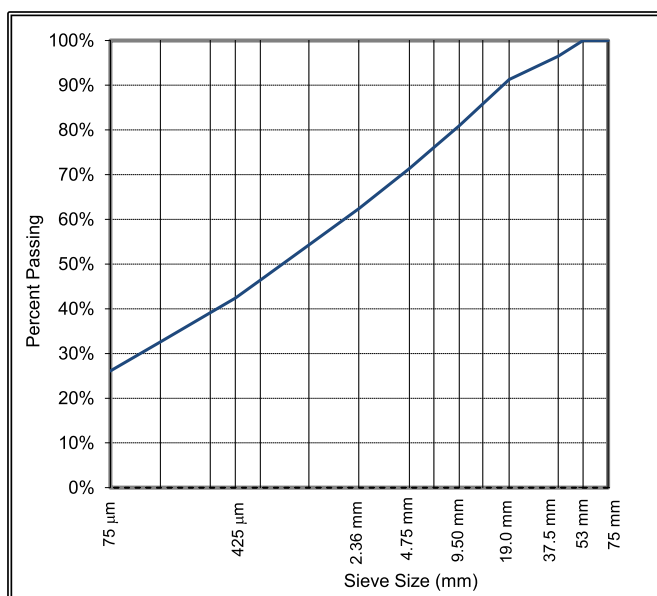
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	30	-
Plastic Limit (%)	AS1289.3.2.1	-	21	-
Plasticity Index	AS1289.3.3.1	-	9	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			345	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.63	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -29683 Q
Client Address:	PO Box 224, Claremont WA 6910	Report Date:	27/04/2019
Job Number:	GT17-474	Test Request No:	TR035
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS29683	Sample Location:	North of Avondale RHS CH: 1316 9.5 m from RHS Edge of Lot Lift 7
Date Sampled:	17/04/2019	Spec Description:	-
Date Tested:	27/04/2019	Lot Number:	SBP-EF-34
Sampled By:	SA	Spec Number:	-
Sample Method:	AS1289.1.2.1.6.4 (b)		
Material Source:	PNQ - Edmonton Quarry		
For Use As:	Embankment		
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		100	
37.5mm		96	
19.0mm		91	
9.5mm		81	
4.75mm		71	
2.36mm		62	
0.425mm		42	
0.075mm		26	

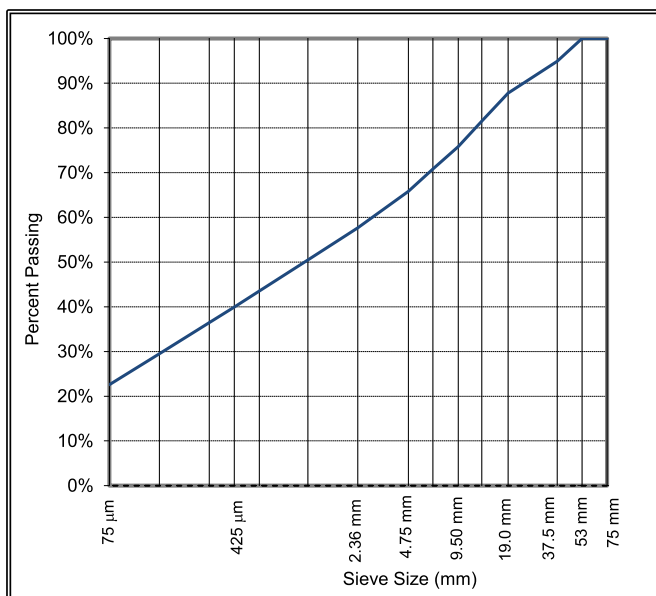
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	29	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	11	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			466	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.62	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29685 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 27/04/2019
Job Number: GT17-474	Test Request No: TR035
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29685	Sample Location: North of Avondale RHS CH 1357 18.9 m from RHS Edge of Lot Lift 7
Date Sampled: 17/04/2019	
Date Tested: 27/04/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-34
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		100	
37.5mm		95	
19.0mm		88	
9.5mm		76	
4.75mm		66	
2.36mm		58	
0.425mm		40	
0.075mm		23	

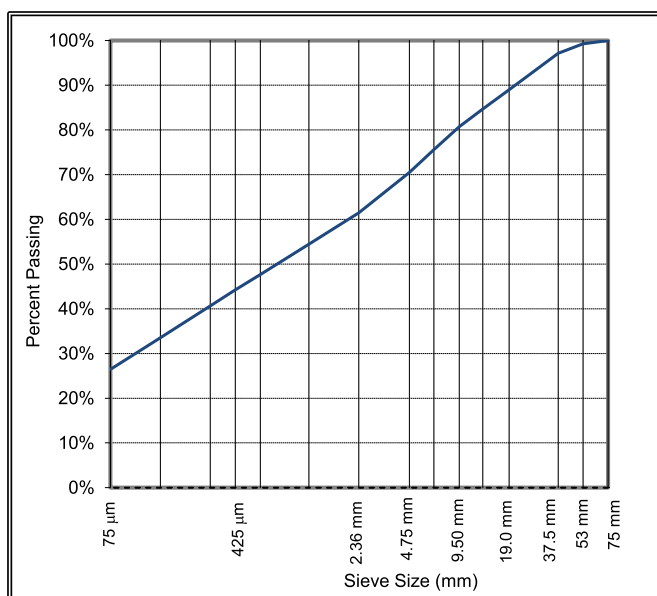
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	29	-
Plastic Limit (%)	AS1289.3.2.1	-	19	-
Plasticity Index	AS1289.3.3.1	-	10	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			399	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.57	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -29688 Q
Client Address:	PO Box 224, Claremont WA 6910	Report Date:	27/04/2019
Job Number:	GT17-474	Test Request No:	TR036
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS29688	Sample Location:	North of Avondale LHS
Date Sampled:	18/04/2019	Ch:	1329
Date Tested:	27/04/2019		13.9 m from LHS Edge of Lot
Sampled By:	SA	Lift	7
Sample Method:	AS1289.1.2.1.6.4 (b)	Spec Description:	-
Material Source:	PNQ - Edmonton Quarry	Lot Number:	SBP-EF-35
For Use As:	Embankment	Spec Number:	-
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		99	
37.5mm		97	
19.0mm		89	
9.5mm		81	
4.75mm		71	
2.36mm		61	
0.425mm		44	
0.075mm		26	

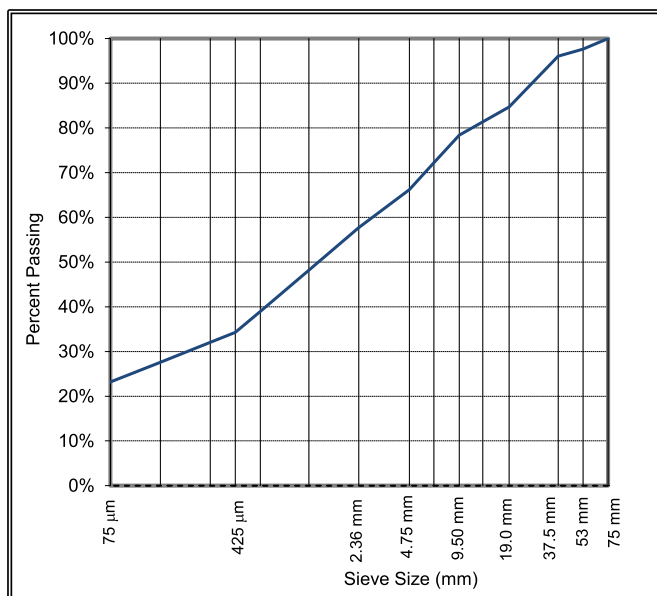
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	29	-
Plastic Limit (%)	AS1289.3.2.1	-	19	-
Plasticity Index	AS1289.3.3.1	-	10	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			442	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.60	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER
		FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29690 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 27/04/2019
Job Number: GT17-474	Test Request No: TR036
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29690	Sample Location: North of Avondale LHS Ch: 1367 11.1 m from LHS Edge of Lot Lift 7
Date Sampled: 18/04/2019	
Date Tested: 27/04/2019	
Sampled By: SA	
Sample Method: AS1289.1.2.1.6.4 (b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-35
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		98	
37.5mm		96	
19.0mm		85	
9.5mm		78	
4.75mm		66	
2.36mm		58	
0.425mm		34	
0.075mm		23	

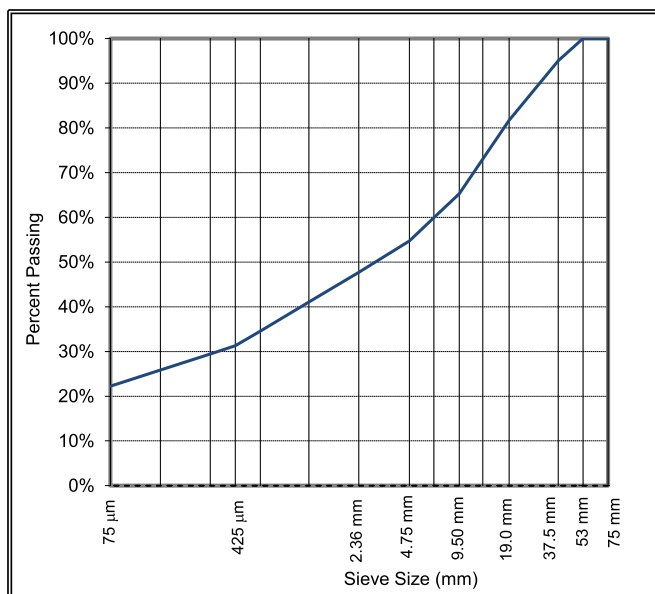
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	29	-
Plastic Limit (%)	AS1289.3.2.1	-	20	-
Plasticity Index	AS1289.3.3.1	-	9	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			308	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.68	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -29752 Q
Client Address:	PO Box 224, Claremont WA 6910	Report Date:	3/05/2019
Job Number:	GT17-474	Test Request No:	TR037
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS29752	Sample Location:	North of Avondale LHS Ch 1295 9.8 m from LHS Edge of Lot Embankment
Date Sampled:	26/04/2019	Spec Description:	-
Date Tested:	29/04/2019	Lot Number:	SBP-EF-036
Sampled By:	KB	Spec Number:	-
Sample Method:	AS1289.1.2.1.6.4(b)		
Material Source:	PNQ - Edmonton Quarry		
For Use As:	Embankment		
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		100	
37.5mm		95	
19.0mm		82	
9.5mm		65	
4.75mm		55	
2.36mm		48	
0.425mm		31	
0.075mm		22	

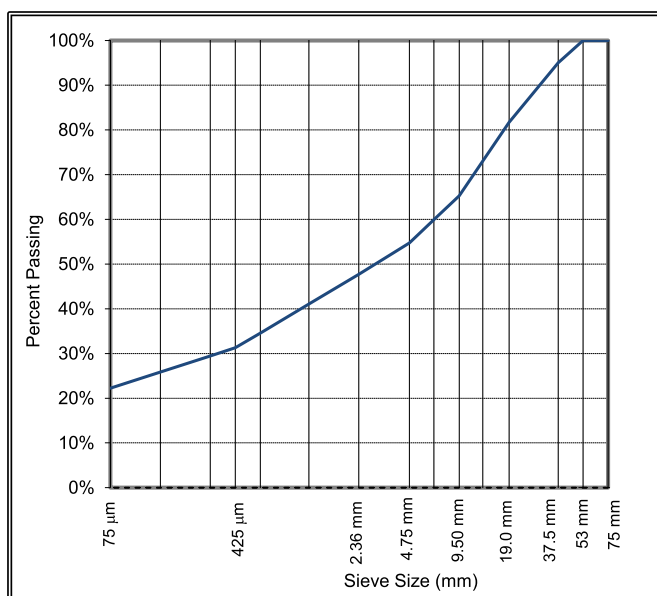
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	26	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			250	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.71	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29754 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 3/05/2019
Job Number: GT17-474	Test Request No: TR037
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29754	Sample Location: North of Avondale LHS Ch 1348 7.3 m from LHS Edge of Lot Embankment
Date Sampled: 26/04/2019	
Date Tested: 1/05/2019	
Sampled By: KB	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-036
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		100	
37.5mm		95	
19.0mm		82	
9.5mm		65	
4.75mm		55	
2.36mm		48	
0.425mm		31	
0.075mm		22	

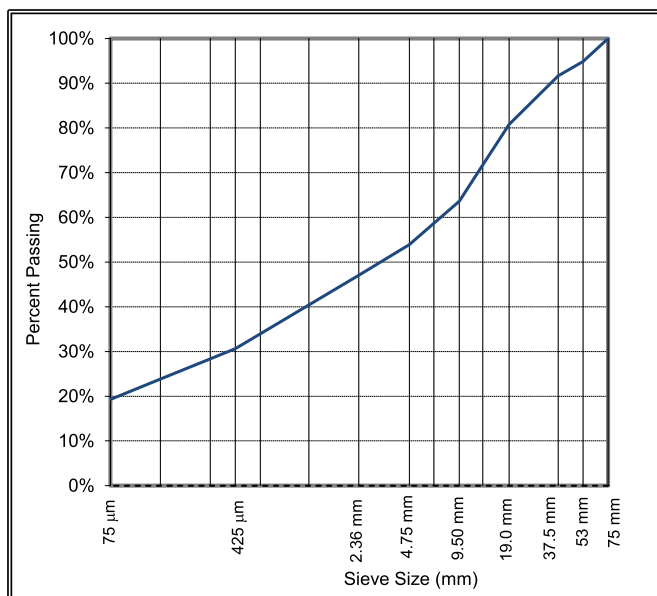
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	26	-
Plastic Limit (%)	AS1289.3.2.1	-	19	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			219	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.71	

	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

Client:	HAJV	Report Number:	GT17-474 -29756 Q
Client Address:	PO Box 224, Claremont WA 6910	Report Date:	3/05/2019
Job Number:	GT17-474	Test Request No:	TR038
Project:	Smithfield Bypass		
Location:	Smithfield.		
Lab No:	CS29756	Sample Location:	North of Avondale LHS Ch 1298 1.2 m from LHS Edge of Lot Embankment
Date Sampled:	26/04/2019	Spec Description:	-
Date Tested:	1/05/2019	Lot Number:	SBP-EF-037
Sampled By:	KB	Spec Number:	-
Sample Method:	AS1289.1.2.1.6.4(b)		
Material Source:	PNQ - Edmonton Quarry		
For Use As:	Embankment		
Remarks:	-		

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		95	
37.5mm		92	
19.0mm		81	
9.5mm		64	
4.75mm		54	
2.36mm		47	
0.425mm		31	
0.075mm		19	

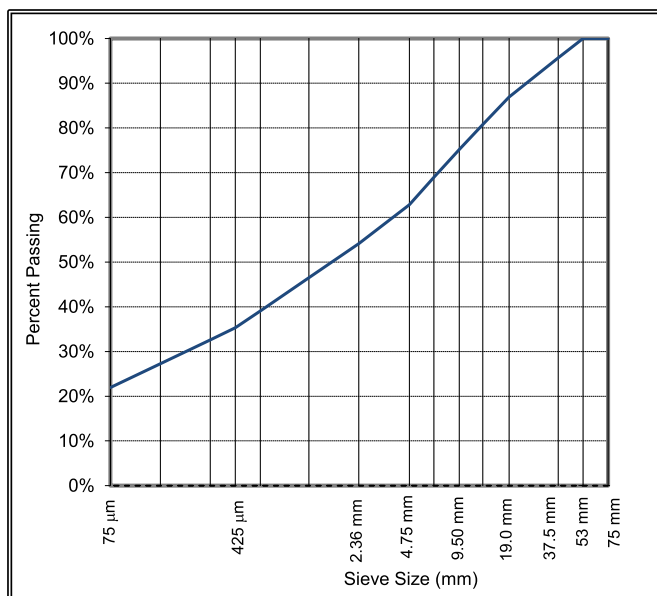
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	27	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	9	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			276	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.63	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER FM-RP-120-2
---	---	---------------------------------------

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29758 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 3/05/2019
Job Number: GT17-474	Test Request No: TR038
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29758	Sample Location: North of Avondale LHS Ch 1334 1.7 m from LHS Edge of Lot Embankment
Date Sampled: 26/04/2019	
Date Tested: 1/05/2019	
Sampled By: KB	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-037
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		100	
37.5mm		96	
19.0mm		87	
9.5mm		75	
4.75mm		63	
2.36mm		54	
0.425mm		35	
0.075mm		22	

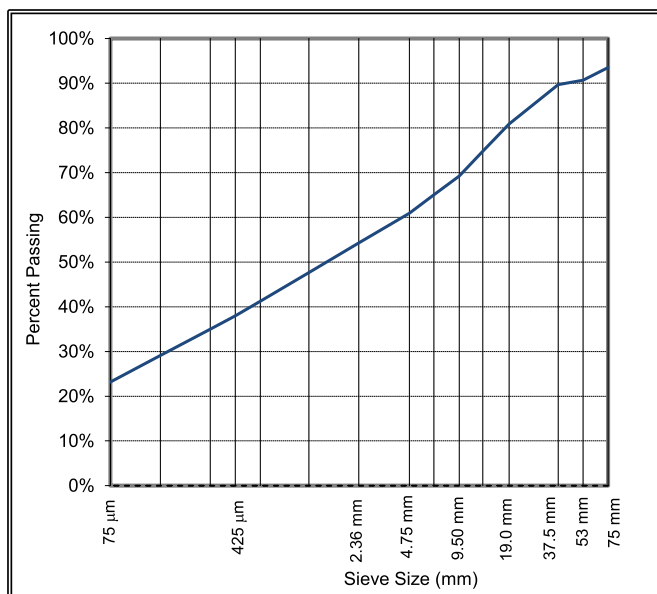
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	27	-
Plastic Limit (%)	AS1289.3.2.1	-	19	-
Plasticity Index	AS1289.3.3.1	-	8	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			282	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.62	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY <i>T. Bock</i> Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER
		FM-RP-120-2

Quality of Materials Report

Client: HAJV	Report Number: GT17-474 -29760 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 3/05/2019
Job Number: GT17-474	Test Request No: TR039
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29760	Sample Location: South of Avondale LHS CH 1090 30.7 m from LHS Edge of Lot Embankment
Date Sampled: 26/04/2019	
Date Tested: 1/05/2019	
Sampled By: KB	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-038
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		94	
53mm		91	
37.5mm		90	
19.0mm		81	
9.5mm		69	
4.75mm		61	
2.36mm		54	
0.425mm		38	
0.075mm		23	

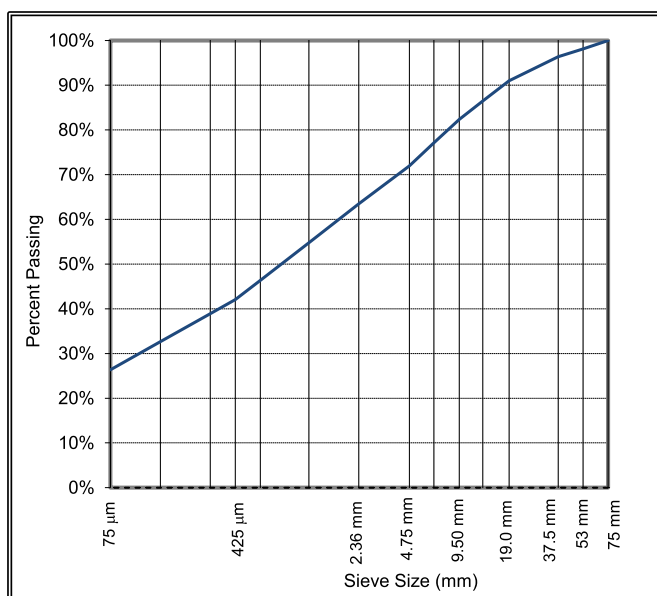
Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	27	-
Plastic Limit (%)	AS1289.3.2.1	-	20	-
Plasticity Index	AS1289.3.3.1	-	7	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			266	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.61	

 ACCREDITED FOR TECHNICAL COMPETENCE	Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY	FORM NUMBER
		 Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FM-RP-120-2

Quality of Materials Report

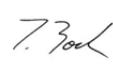
Client: HAJV	Report Number: GT17-474 -29762 Q
Client Address: PO Box 224, Claremont WA 6910	Report Date: 3/05/2019
Job Number: GT17-474	Test Request No: TR039
Project: Smithfield Bypass	
Location: Smithfield.	
Lab No: CS29762	Sample Location: South of Avondale LHS CH 1105 33.6 m from LHS Edge of Lot Embankment
Date Sampled: 26/04/2019	
Date Tested: 1/05/2019	
Sampled By: KB	
Sample Method: AS1289.1.2.1.6.4(b)	Spec Description: -
Material Source: PNQ - Edmonton Quarry	Lot Number: SBP-EF-038
For Use As: Embankment	Spec Number: -
Remarks: -	

Page 1 of 1



Particle Size Distribution			
Test Method AS1289.3.6.1			
A.S.	Specification		Result
	Specification	Result	Specification
Sieve Size	Minimum	% Passing	Maximum
75mm		100	
53mm		98	
37.5mm		96	
19.0mm		91	
9.5mm		82	
4.75mm		72	
2.36mm		63	
0.425mm		42	
0.075mm		26	

Plasticity Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	AS1289.3.1.2	-	28	-
Plastic Limit (%)	AS1289.3.2.1	-	18	-
Plasticity Index	AS1289.3.3.1	-	10	-
Linear Shrinkage (%)	AS1289.3.4.1	-	-	-
P.I. X % Passing 0.425mm			420	
L.S. X % Passing 0.425mm			-	
Ratio of % Passing (0.075 / 0.425)			0.63	

 Accredited for compliance with ISO/IEC 17025 - Testing	APPROVED SIGNATORY  Troy Bock - Senior Technician Cairns Laboratory NATA Accreditation No. 20026	FORM NUMBER
		FM-RP-120-2



Appendix B
Results of Traditional QA Testing Regime – Density Testing
(Nuclear Density Gauge) & Moisture Content – Test
Certificates



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28716 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	14/02/2019
Job Number :	GT17-474	Order Number	TR005
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28713	CS28714	CS28715	CS28716	
ID No :	1	2	3	4	
Lot No :	SBP-EF-6	SBP-EF-6	SBP-EF-6	SBP-EF-6	
Item No :	-	-	-	-	
Date Field Density Tested :	12/02/2019	12/02/2019	12/02/2019	12/02/2019	
Time Field Density Tested :	1:30 PM	1:45 PM	2:00 PM	2:20 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	MCTC - LHS Ch: 1303 1.8 m from RHS of Lot Embankment	MCTC - LHS Ch: 1308 17.5 m from RHS of Lot Embankment	MCTC - LHS Ch: 1332 17.1 m from RHS of Lot Embankment	MCTC - LHS Ch: 1351 7.0 m from RHS of Lot Embankment	
Test/Layer Depth (mm)	175 / 200	175 / 200	200 / 225	125 / 150	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	12	16	12	15	
Oversize Dry (%) :	13	17	13	16	
Field Moisture (%) :	6.6	6.0	6.4	6.3	
MDR/ Assigned MDR No :	CS28714	CS28714	CS28714	CS28714	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/02/19	13/02/19	13/02/19	13/02/19	
Field Wet Density (t/m ³)	2.31	2.36	2.40	2.32	
Field Dry Density (t/m ³)	2.17	2.22	2.26	2.18	
IMDD (t/m ³) :	2.17	2.17	2.17	2.17	
Adjusted MDD (t/m ³) :	2.22	2.24	2.22	2.23	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	7.0	6.5	7.0	7.0	
Variation from OMC	1.0% (Dry)	1.5% (Dry)	1.5% (Dry)	1.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	84.5	75.0	79.5	78.5	
Dry Density Ratio (%) :	97.5	99.5	101.5	97.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28740 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	14/02/2019
Job Number :	GT17-474	Order Number	TR006
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28737	CS28738	CS28739	CS28740	
ID No :	1	2	3	4	
Lot No :	SBP-EF-7	SBP-EF-7	SBP-EF-7	SBP-EF-7	
Item No :	-	-	-	-	
Date Field Density Tested :	13/02/2019	13/02/2019	13/02/2019	13/02/2019	
Time Field Density Tested :	1:10 PM	1:20 PM	1:30 PM	1:40 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale Ch 1010 8.8m off RHS Edge of Lot Lift 2	South of Avondale Ch 1022 15.5m off RHS Edge of Lot Lift 2	South of Avondale Ch 1048 17.2m off RHS Edge of Lot Lift 2	South of Avondale Ch 1059 8.7m off RHS Edge of Lot Lift 2	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	19	15	11	7	
Oversize Dry (%) :	19	16	12	7	
Field Moisture (%) :	4.9	6.0	5.5	6.4	
MDR / Assigned MDR No :	CS28714-AV	CS28714-AV	CS28714-AV	CS28714-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/02/19	13/02/19	13/02/19	13/02/19	
Field Wet Density (t/m ³)	2.44	2.34	2.31	2.25	
Field Dry Density (t/m ³)	2.32	2.21	2.19	2.12	
MDD (t/m ³) :	2.17	2.17	2.17	2.17	
Adjusted MDD (t/m ³) :	2.25	2.24	2.22	2.20	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	6.5	7.0	7.0	7.5	
Variation from OMC	2.5% (Dry)	2.0% (Dry)	2.0% (Dry)	1.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	61.0	74.5	68.5	79.5	
Dry Density Ratio (%) :	103.5	99.0	99.0	96.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28744 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	21/02/2019
Job Number :	GT17-474	Order Number	TR007
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28741	CS28742	CS28743	CS28744	
ID No :	1	2	3	4	
Lot No :	SBP-EF-8	SBP-EF-8	SBP-EF-8	SBP-EF-8	
Item No :	-	-	-	-	
Date Field Density Tested :	13/02/2019	13/02/2019	13/02/2019	13/02/2019	
Time Field Density Tested :	1:10 PM	1:20 PM	1:30 PM	1:40 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	Over Culvert - LHS (Class A1 Fill) Ch 1293 15.2m off LHS Edge of Lot Lift 3	Over Culvert - LHS (Class A1 Fill) Ch 1325 7.4m off LHS Edge of Lot Lift 3	Over Culvert - LHS (Class A1 Fill) Ch 1342 19.3m off LHS Edge of Lot Lift 3	Over Culvert - LHS (Class A1 Fill) Ch 1381 20.4m off LHS Edge of Lot Lift 3	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	11	13	15	12	
Oversize Dry (%) :	11	13	16	13	
Field Moisture (%) :	6.6	6.0	6.4	6.3	
MDR/ Assigned MDR No :	CS28714	CS28714	CS28714	CS28714	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/02/19	13/02/19	13/02/19	13/02/19	
Field Wet Density (t/m ³)	2.37	2.33	2.39	2.32	
Field Dry Density (t/m ³)	2.22	2.19	2.24	2.18	
MDD (t/m ³) :	2.17	2.17	2.17	2.17	
Adjusted MDD (t/m ³) :	2.21	2.22	2.23	2.22	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	7.0	7.0	7.0	7.0	
Variation from OMC	1.0% (Dry)	2.0% (Dry)	1.5% (Dry)	1.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	82.5	74.5	79.5	78.5	
Dry Density Ratio (%) :	100.5	98.5	100.5	98.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28748 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	18/02/2019
Job Number :	GT17-474	Order Number	TR008
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28745	CS28746	CS28747	CS28748	
ID No :	1	2	3	4	
Lot No :	SBP-EF-9	SBP-EF-9	SBP-EF-9	SBP-EF-9	
Item No :	-	-	-	-	
Date Field Density Tested :	14/02/2019	14/02/2019	14/02/2019	14/02/2019	
Time Field Density Tested :	1:10 PM	1:20 PM	1:30 PM	1:40 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	Over Culvert - RHS (Class A1 Fill) Ch 1307 4.5m off RHS Edge of Lot Lift 3	Over Culvert - RHS (Class A1 Fill) Ch 1329 13.8m off RHS Edge of Lot Lift 3	Over Culvert - RHS (Class A1 Fill) Ch 1348 4.5m off RHS Edge of Lot Lift 3	Over Culvert - RHS (Class A1 Fill) Ch 1373 3.8m off RHS Edge of Lot Lift 3	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	22	18	13	13	
Oversize Dry (%) :	23	19	14	14	
Field Moisture (%) :	4.9	4.9	5.9	5.9	
MDR / Assigned MDR No :	CS28714-AV	CS28714-AV	CS28714-AV	CS28714-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/02/19	13/02/19	13/02/19	13/02/19	
Field Wet Density (t/m³)	2.39	2.37	2.35	2.41	
Field Dry Density (t/m³)	2.28	2.26	2.22	2.28	
MDD (t/m³) :	2.17	2.17	2.17	2.17	
Adjusted MDD (t/m³) :	2.26	2.25	2.22	2.23	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	6.5	6.5	7.0	7.0	
Variation from OMC	2.5% (Dry)	2.5% (Dry)	1.5% (Dry)	2.0% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	67.0	61.5	79.0	74.0	
Dry Density Ratio (%) :	101.0	100.5	100.0	102.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28752 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	18/02/2019
Job Number :	GT17-474	Order Number	TR009
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28749	CS28750	CS28751	CS28752	
ID No :	1	2	3	4	
Lot No :	SBP-EF-10	SBP-EF-10	SBP-EF-10	SBP-EF-10	
Item No :	-	-	-	-	
Date Field Density Tested :	14/02/2019	14/02/2019	14/02/2019	14/02/2019	
Time Field Density Tested :	10:30 AM	10:40 AM	10:50 AM	11:00 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale Ch 1293 9.4m off LHS Edge of Lot Lift 2	South of Avondale Ch 1325 15.4m off LHS Edge of Lot Lift 2	South of Avondale Ch 1342 8.7m off LHS Edge of Lot Lift 2	South of Avondale Ch 1381 18.9m off LHS Edge of Lot Lift 2	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	15	19	8	12	
Oversize Dry (%) :	16	20	9	13	
Field Moisture (%) :	4.2	5.8	5.6	6.2	
MDR / Assigned MDR No :	CS28714-AV	CS28714-AV	CS28714-AV	CS28714-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/02/19	13/02/19	13/02/19	13/02/19	
Field Wet Density (t/m ³)	2.31	2.33	2.32	2.35	
Field Dry Density (t/m ³)	2.22	2.21	2.20	2.21	
MDD (t/m ³) :	2.17	2.17	2.17	2.17	
Adjusted MDD (t/m ³) :	2.14	2.25	2.20	2.22	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	7.0	6.5	7.5	7.0	
Variation from OMC	3.5% (Dry)	2.0% (Dry)	2.5% (Dry)	1.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	52.5	72.5	70.5	81.5	
Dry Density Ratio (%) :	103.5	98.0	99.5	100.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28811 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	18/02/2019
Job Number :	GT17-474	Order Number	TR010
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28808	CS28809	CS28810	CS28811	
ID No :	1	2	3	4	
Lot No :	SBP-EF-11	SBP-EF-11	SBP-EF-11	SBP-EF-11	
Item No :	-	-	-	-	
Date Field Density Tested :	15/02/2019	15/02/2019	15/02/2019	15/02/2019	
Time Field Density Tested :	9:10 AM	9:20 AM	9:30 AM	9:40 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	Over Culvert - LHS (Class A1 Fill) Ch 1305 14.4m off LHS Edge of Lot Lift 4	Over Culvert - LHS (Class A1 Fill) Ch 1324 8.7m off LHS Edge of Lot Lift 4	Over Culvert - LHS (Class A1 Fill) Ch 1339 1.7m off LHS Edge of Lot Lift 4	Over Culvert - LHS (Class A1 Fill) Ch 1380 11.5m off LHS Edge of Lot Lift 4	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	17	14	19	11	
Oversize Dry (%) :	17	14	20	11	
Field Moisture (%) :	6.7	5.0	4.9	7.7	
MDR / Assigned MDR No :	CS28714-AV	CS28714-AV	CS28714-AV	CS28714-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/02/19	13/02/19	13/02/19	13/02/19	
Field Wet Density (t/m ³)	2.35	2.35	2.36	2.44	
Field Dry Density (t/m ³)	2.20	2.23	2.25	2.26	
MDD (t/m ³) :	2.17	2.17	2.17	2.17	
Adjusted MDD (t/m ³) :	2.24	2.22	2.24	2.21	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	6.5	7.0	6.5	7.0	
Variation from OMC	0.5% (Dry)	2.5% (Dry)	2.0% (Dry)	--	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	89.0	67.0	69.5	100.0	
Dry Density Ratio (%) :	98.5	100.5	100.5	102.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28815 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	18/02/2019
Job Number :	GT17-474	Order Number	TR011
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28812	CS28813	CS28814	CS28815	
ID No :	1	2	3	4	
Lot No :	SBP-EF-12	SBP-EF-12	SBP-EF-12	SBP-EF-12	
Item No :	-	-	-	-	
Date Field Density Tested :	15/02/2019	15/02/2019	15/02/2019	15/02/2019	
Time Field Density Tested :	1:10 PM	1:20 PM	1:40 PM	1:50 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale Ch 1004 0.2m off RHS Edge of Lot Lift 3	South of Avondale Ch 1023 3.5m off RHS Edge of Lot Lift 3	South of Avondale Ch 1045 4.3m off RHS Edge of Lot Lift 3	South of Avondale Ch 1057 1.5m off RHS Edge of Lot Lift 3	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	12	7	9	15	
Oversize Dry (%) :	11	8	9	15	
Field Moisture (%) :	5.7	6.5	5.9	6.0	
MDR/ Assigned MDR No :	CS28714-AV	CS28714-AV	CS28714-AV	CS28714-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/02/19	13/02/19	13/02/19	13/02/19	
Field Wet Density (t/m³)	2.38	2.41	2.42	2.42	
Field Dry Density (t/m³)	2.25	2.26	2.28	2.28	
MDD (t/m³) :	2.17	2.17	2.17	2.17	
Adjusted MDD (t/m³) :	2.18	2.19	2.20	2.23	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	7.0	7.5	7.5	7.0	
Variation from OMC	--	1.5% (Dry)	2.0% (Dry)	2.0% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	97.5	82.5	76.0	74.5	
Dry Density Ratio (%) :	103.5	103.0	103.5	102.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	Grey Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28828 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	20/02/2019
Job Number :	GT17-474	Order Number	TR013
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28825	CS28826	CS28827	CS28828	
ID No :	1	2	3	4	
Lot No :	SBP-EF-13	SBP-EF-13	SBP-EF-13	SBP-EF-13	
Item No :	-	-	-	-	
Date Field Density Tested :	18/02/2019	18/02/2019	18/02/2019	18/02/2019	
Time Field Density Tested :	12:40 PM	12:50 PM	1:00 PM	1:10 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North of Avondale - RHS Ch: 1310 8.3m from LHS Edge of Lot Lift 3	North of Avondale - RHS Ch: 1328 3.3m from LHS Edge of Lot Lift 3	North of Avondale - RHS Ch: 1357 8.8m from LHS Edge of Lot Lift 3	North of Avondale - RHS Ch: 1378 3.4m from LHS Edge of Lot Lift 3	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	8	4	12	6	
Oversize Dry (%) :	8	4	12	6	
Field Moisture (%) :	6.6	6.1	5.1	5.8	
MDR / Assigned MDR No :	CS28714-AV	CS28714-AV	CS28714-AV	CS28714-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/02/19	13/02/19	13/02/19	13/02/19	
Field Wet Density (t/m³)	2.38	2.35	2.43	2.39	
Field Dry Density (t/m³)	2.23	2.21	2.31	2.26	
MDD (t/m³) :	2.17	2.17	2.17	2.17	
Adjusted MDD (t/m³) :	2.20	2.18	2.22	2.19	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	7.5	8.0	7.0	7.5	
Variation from OMC	1.0% (Dry)	2.0% (Dry)	2.5% (Dry)	2.0% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	84.0	76.5	66.0	72.5	
Dry Density Ratio (%) :	101.5	101.5	104.0	103.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28843 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	21/02/2019
Job Number :	GT17-474	Order Number	TR014
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28840	CS28841	CS28842	CS28843	
ID No :	1	2	3	4	
Lot No :	SBP-EF-15	SBP-EF-15	SBP-EF-15	SBP-EF-15	
Item No :	-	-	-	-	
Date Field Density Tested :	19/02/2019	19/02/2019	19/02/2019	19/02/2019	
Time Field Density Tested :	12:40 PM	12:50 PM	1:00 PM	1:10 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North West Wall Ch 1288 8.0m from LHS Edge of Lot Lift 5	North West Wall Ch 1318 2.7m from LHS Edge of Lot Lift 5	North West Wall Ch 1354 3.2m from LHS Edge of Lot Lift 5	North West Wall Ch 1373 17.1m from LHS Edge of Lot Lift 5	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	0	10	2	10	
Oversize Dry (%) :	0	10	2	11	
Field Moisture (%) :	8.0	6.8	8.3	7.6	
MDR / Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	
Field Wet Density (t/m³)	2.38	2.39	2.35	2.39	
Field Dry Density (t/m³)	2.20	2.24	2.17	2.22	
IMDD (t/m³) :	2.16	2.16	2.16	2.16	
Adjusted MDD (t/m³) :	2.16	2.33	2.17	2.31	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	8.0	7.5	8.0	7.5	
Variation from OMC	--	1.0% (Dry)	--	0.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	98.0	86.0	101.0	97.0	
Dry Density Ratio (%) :	102.0	96.0	100.0	96.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28881 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	28/02/2019
Job Number :	GT17-474	Order Number	TR015
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28878	CS28879	CS28880	CS28881	
ID No :	1	2	3	4	
Lot No :	SBP-EF-16	SBP-EF-16	SBP-EF-16	SBP-EF-16	
Item No :	-	-	-	-	
Date Field Density Tested :	21/02/2019	21/02/2019	21/02/2019	21/02/2019	
Time Field Density Tested :	8:10 AM	8:15 AM	8:25 AM	8:35 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale CH 1016 12.7m rom LHS of lot Lift 3	South of Avondale CH 1035 19.8m rom LHS of lot Lift 3	South of Avondale CH 1096 14.1m rom LHS of lot Lift 3	South of Avondale CH 1105 4.1m rom LHS of lot Lift 3	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	3	5	6	6	
Oversize Dry (%) :	3	5	6	6	
Field Moisture (%) :	4.9	6.3	6.0	5.4	
MDR/ Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	
Field Wet Density (t/m ³)	2.29	2.35	2.34	2.36	
Field Dry Density (t/m ³)	2.19	2.21	2.21	2.24	
IMDD (t/m ³) :	2.16	2.16	2.16	2.16	
Adjusted MDD (t/m ³) :	2.17	2.18	2.18	2.19	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	8.0	8.0	7.5	7.5	
Variation from OMC	3.0% (Dry)	2.0% (Dry)	2.0% (Dry)	2.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	61.0	77.5	74.5	68.0	
Dry Density Ratio (%) :	100.5	101.5	101.0	102.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28885 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	28/02/2019
Job Number :	GT17-474	Order Number	TR16
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28882	CS28883	CS28884	CS28885	
ID No :	1	2	3	4	
Lot No :	SBP-EF-17	SBP-EF-16	SBP-EF-16	SBP-EF-16	
Item No :	-	-	-	-	
Date Field Density Tested :	21/02/2019	21/02/2019	21/02/2019	21/02/2019	
Time Field Density Tested :	8:10 AM	8:15 AM	8:25 AM	8:35 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	Over Culvert - RHS (Class A1 Fill) CH 1303 2.0m rom LHS of lot Lift 4	Over Culvert - RHS (Class A1 Fill) CH 1320 3.2m rom LHS of lot Lift 4	Over Culvert - RHS (Class A1 Fill) CH 1357 15.6m rom LHS of lot Lift 4	Over Culvert - RHS (Class A1 Fill) CH 1372 21.9m rom LHS of lot Lift 4	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	4	13	6	22	
Oversize Dry (%) :	4	13	7	23	
Field Moisture (%) :	5.0	5.6	6.5	6.7	
MDR / Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	
Field Wet Density (t/m³)	2.23	2.31	2.32	2.31	
Field Dry Density (t/m³)	2.13	2.19	2.18	2.17	
MDD (t/m³) :	2.16	2.16	2.16	2.16	
Adjusted MDD (t/m³) :	2.18	2.22	2.19	2.25	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	8.0	7.0	7.5	6.5	
Variation from OMC	3.0% (Dry)	2.0% (Dry)	1.5% (Dry)	1.0% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	62.5	71.5	80.0	88.5	
Dry Density Ratio (%) :	97.5	98.5	99.5	96.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28917 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	28/02/2019
Job Number :	GT17-474	Order Number	TR017
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28914	CS28915	CS28916	CS28917	
ID No :	1	2	3	4	
Lot No :	SBP-EF-18	SBP-EF-18	SBP-EF-18	SBP-EF-18	
Item No :	-	-	-	-	
Date Field Density Tested :	22/02/2019	22/02/2019	22/02/2019	22/02/2019	
Time Field Density Tested :	10:45 AM	10:50 AM	10:55 AM	11:00 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale CH 1028 9.4m from LHS Lift 4	South of Avondale CH 1062 7.8m from LHS Lift 4	South of Avondale CH 1072 18.0m from LHS Lift 4	South of Avondale CH 1122 0.4m from LHS Lift 4	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	2	10	3	3	
Oversize Dry (%) :	2	10	4	3	
Field Moisture (%) :	7.7	6.1	7.1	6.5	
MDR / Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	
Field Wet Density (t/m³)	2.30	2.30	2.31	2.31	
Field Dry Density (t/m³)	2.13	2.16	2.16	2.17	
IMDD (t/m³) :	2.16	2.16	2.16	2.16	
Adjusted MDD (t/m³) :	2.17	2.20	2.18	2.17	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	8.0	7.5	8.0	8.0	
Variation from OMC	0.5% (Dry)	2.0% (Dry)	1.0% (Dry)	1.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1..6.4(b)	AS1289.1.2.1..6.4(b)	AS1289.1.2.1..6.4(b)	AS1289.1.2.1..6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	95.0	77.5	87.0	79.5	
Dry Density Ratio (%) :	98.5	98.0	99.0	100.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS28977 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	28/02/2019
Job Number :	GT17-474	Order Number	TR018
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS28974	CS28975	CS28976	CS28977
ID No :	1	2	3	4
Lot No :	SBP-EF-19	SBP-EF-19	SBP-EF-19	SBP-EF-19
Item No :	-	-	-	-
Date Field Density Tested :	25/02/2019	25/02/2019	25/02/2019	25/02/2019
Time Field Density Tested :	10:45 AM	10:50 AM	10:55 AM	11:00 AM
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction
Stabilization Agent Added :	No	No	No	No
Time Stabilizing Agent Added :	-	-	-	-
Stabilizing Agent MDR Completion Time :	-	-	-	-
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry
For Use As :	Embankment	Embankment	Embankment	Embankment
Sample Location :	South of Avondale Ch 1009 6.9 m from RHS Edge of Lot Lift 4	South of Avondale Ch 1064 19.2 from RHS Edge of Lot Lift 4	South of Avondale Ch 1096 20.5 from RHS Edge of Lot Lift 4	South of Avondale Ch 1123 20.8 from RHS Edge of Lot Lift 4
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300
Max Size (mm) :	37.5	37.5	37.5	37.5
Oversize Wet (%) :	11	8	17	11
Oversize Dry (%) :	12	9	18	11
Field Moisture (%) :	8.4	7.4	7.3	8.2
MDR / Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV
Assigned MDR Used :	Y	Y	Y	Y
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19
Field Wet Density (t/m³)	2.33	2.36	2.38	2.35
Field Dry Density (t/m³)	2.15	2.19	2.21	2.17
IMDD (t/m³) :	2.16	2.16	2.16	2.16
Adjusted MDD (t/m³) :	2.20	2.19	2.16	2.19
OMC (%) :	8.0	8.0	8.0	8.0
Adjusted OMC (%) :	7.0	7.5	7.0	7.5
Variation from OMC	0.5% (Wet)	0.5% (Dry)	0.5% (Dry)	--
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Compactive Effort :	Standard	Standard	Standard	Standard
Moisture Ratio (%) :	106.0	92.5	96.0	103.5
Dry Density Ratio (%) :	98.0	100.5	102.5	99.0
Min Dry Dens Ratio (%)	95	95	95	95
Material Description :	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL
Remarks :	-			



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29031 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	7/03/2019
Job Number :	GT17-474	Order Number	TR019
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29028	CS29029	CS29030	CS29031	
ID No :	1	2	3	4	
Lot No :	SBP-EF-21	SBP-EF-21	SBP-EF-21	SBP-EF-21	
Item No :	-	-	-	-	
Date Field Density Tested :	27/02/2019	27/02/2019	27/02/2019	27/02/2019	
Time Field Density Tested :	9:10 AM	9:20 AM	9:30 AM	9:40 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale CH 1006 0.3m from LH Edge Lift 5	South of Avondale CH 1061 11.2m from LH Edge Lift 5	South of Avondale CH 1071 15.8m from LH Edge Lift 5	South of Avondale CH 1113 5.3m from LH Edge Lift 5	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	9	4	18	3	
Oversize Dry (%) :	9	4	19	3	
Field Moisture (%) :	9.4	8.5	8.6	9.1	
MDR / Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	
Field Wet Density (t/m ³)	2.41	2.37	2.39	2.42	
Field Dry Density (t/m ³)	2.20	2.18	2.20	2.22	
IMDD (t/m ³) :	2.16	2.16	2.16	2.16	
Adjusted MDD (t/m ³) :	2.19	2.18	2.23	2.17	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	7.5	8.0	6.5	8.0	
Variation from OMC	1.5% (Wet)	0.5% (Wet)	1.0% (Wet)	1.0% (Wet)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	123.5	106.0	113.0	111.5	
Dry Density Ratio (%) :	100.5	100.5	98.5	102.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29035 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	6/03/2019
Job Number :	GT17-474	Order Number	TR 020
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29032	CS29033	CS29034	CS29035	
ID No :	1	2	3	4	
Lot No :	SBP-EF-22	SBP-EF-22	SBP-EF-22	SBP-EF-22	
Item No :	-	-	-	-	
Date Field Density Tested :	27/02/2019	27/02/2019	27/02/2019	27/02/2019	
Time Field Density Tested :	10:00 AM	10:15 AM	10:25 AM	10:35 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North of Avondale CH 1162 18.8m from LH Edge Lift 2	North of Avondale CH 1199 16.9m from LH Edge Lift 2	North of Avondale CH 1249 13.3m from LH Edge Lift 2	North of Avondale CH 1260 10m from LH Edge Lift 2	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	2	5	11	0	
Oversize Dry (%) :	3	5	11	0	
Field Moisture (%) :	7.9	8.1	8.1	8.8	
MDR / Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	
Field Wet Density (t/m³)	2.37	2.37	2.42	2.41	
Field Dry Density (t/m³)	2.19	2.19	2.24	2.21	
MDD (t/m³) :	2.16	2.16	2.16	2.16	
Adjusted MDD (t/m³) :	2.17	2.18	2.20	2.16	
OMC (%) :	8.0	8.0	8.0	8.0	
Adjusted OMC (%) :	8.0	8.0	7.5	8.0	
Variation from OMC	--	--	--	1.0% (Wet)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	98.5	100.0	102.0	107.0	
Dry Density Ratio (%) :	101.0	100.5	101.5	102.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29336 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	14/03/2019
Job Number :	GT17-474	Order Number	TR029
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29332	CS29333	CS29334	CS29335	CS29336
ID No :	1	2	3	4	5
Lot No :	SBP-EF-023	SBP-EF-023	SBP-EF-023	SBP-EF-023	SBP-EF-023
Item No :	-	-	-	-	-
Date Field Density Tested :	13/03/2019	13/03/2019	13/03/2019	13/03/2019	14/03/2019
Time Field Density Tested :	8:30 AM	8:40 AM	8:50 AM	9:00 AM	9:10 AM
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	After Compaction
Stabilization Agent Added :	No	No	No	No	No
Time Stabilizing Agent Added :	-	-	-	-	-
Stabilizing Agent MDR Completion Time :	-	-	-	-	-
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry
For Use As :	Embankment	Embankment	Embankment	Embankment	Embankment
Sample Location :	North of Avondale RHS CH 1202 3.1m from LHS edge of lot Lift 5	North of Avondale RHS CH 1253 16.4m from LHS edge of lot Lift 5	North of Avondale RHS CH 1288 12.1m from LHS edge of lot Lift 5	North of Avondale RHS CH 1326 19.1m from LHS edge of lot Lift 5	North of Avondale RHS CH 1347 16.1m from LHS edge of lot Lift 5
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	275 / 300
Max Size (mm) :	37.5	37.5	37.5	37.5	37.5
Oversize Wet (%) :	15	7	17	8	13
Oversize Dry (%) :	16	7	17	8	13
Field Moisture (%) :	6.5	7.8	5.5	6.7	6.6
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV
Assigned MDR Used :	Y	Y	Y	Y	Y
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	13/03/19
Field Wet Density (t/m³)	2.35	2.30	2.39	2.35	2.34
Field Dry Density (t/m³)	2.21	2.13	2.27	2.20	2.20
MDD (t/m³) :	2.14	2.14	2.14	2.14	2.14
Adjusted MDD (t/m³) :	2.21	2.16	2.21	2.17	2.19
OMC (%) :	8.5	8.5	8.5	8.5	8.5
Adjusted OMC (%) :	7.0	8.0	7.0	8.0	7.5
Variation from OMC	1.5% (Dry)	0.5% (Dry)	2.0% (Dry)	1.5% (Dry)	1.5% (Dry)
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1
MC Method :	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1
Compactive Effort :	Standard	Standard	Standard	Standard	Standard
Moisture Ratio (%) :	80.0	97.5	72.0	86.5	83.5
Dry Density Ratio (%) :	100.0	98.5	102.5	101.5	100.0
Min Dry Dens Ratio (%)	95	95	95	95	95
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29291 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	14/03/2019
Job Number :	GT17-474	Order Number	TR028
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29287	CS29288	CS29289	CS29290	CS29291
ID No :	1	2	3	4	5
Lot No :	SBP-EF-24	SBP-EF-24	SBP-EF-24	SBP-EF-24	SBP-EF-24
Item No :	-	-	-	-	-
Date Field Density Tested :	12/03/2019	12/03/2019	12/03/2019	12/03/2019	12/03/2019
Time Field Density Tested :	8:40 AM	8:50 AM	9:00 AM	9:10 AM	9:20 AM
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	After Compaction
Stabilization Agent Added :	No	No	No	No	No
Time Stabilizing Agent Added :	-	-	-	-	-
Stabilizing Agent MDR Completion Time :	-	-	-	-	-
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry
For Use As :	Embankment	Embankment	Embankment	Embankment	Embankment
Sample Location :	North of Avondale LHS Ch 1193 3.7m from LHS Edge of Lot Lift 5	North of Avondale LHS Ch 1209 1.3m from LHS Edge of Lot Lift 5	North of Avondale LHS Ch 1257 13.9m from LHS Edge of Lot Lift 5	North of Avondale LHS Ch 1330 9.6m from LHS Edge of Lot Lift 5	North of Avondale LHS Ch 1376 19.0m from LHS Edge of Lot Lift 5
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	275 / 300
Max Size (mm) :	37.5	37.5	37.5	37.5	37.5
Oversize Wet (%) :	9	15	11	19	4
Oversize Dry (%) :	9	16	11	20	4
Field Moisture (%) :	6.1	7.9	6.4	8.6	8.6
MDR/ Assigned MDR No :	CS29291-AV	CS29291-AV	CS29291-AV	CS29291-AV	CS29291-AV
Assigned MDR Used :	Y	Y	Y	Y	Y
MDR/Assigned MDR Date:	12/03/19	12/03/19	12/03/19	12/03/19	12/03/19
Field Wet Density (t/m³)	2.36	2.33	2.40	2.35	2.34
Field Dry Density (t/m³)	2.23	2.16	2.25	2.16	2.16
IMDD (t/m³) :	2.15	2.15	2.15	2.15	2.15
Adjusted MDD (t/m³) :	2.19	2.21	2.19	2.23	2.17
OMC (%) :	8.5	8.5	8.5	8.5	8.5
Adjusted OMC (%) :	7.5	7.0	7.5	6.5	8.0
Variation from OMC	1.5% (Dry)	--	1.5% (Dry)	1.0% (Wet)	0.5% (Wet)
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1
MC Method :	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1
Compactive Effort :	Standard	Standard	Standard	Standard	Standard
Moisture Ratio (%) :	77.0	102.5	80.0	113.0	104.5
Dry Density Ratio (%) :	102.0	97.5	102.5	96.5	99.5
Min Dry Dens Ratio (%)	95	95	95	95	95
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
 ETS GEO PTY LTD
 ABN: 16 121 817 794
 07 4047 8600
 07 4047 8699
admin@etsgeo.com.au
 PO Box 587
 REDLYNCH QLD 4870
 1/220 Scott Street
 Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29331 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	14/03/2019
Job Number :	GT17-474	Order Number	TR030
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29331				
ID No :	1				
Lot No :	SBP-EF-024				
Item No :	-				
Date Field Density Tested :	13/03/2019				
Time Field Density Tested :	9:20 AM				
MDR Sample Taken :	After Compaction				
Stabilization Agent Added :	No				
Time Stabilizing Agent Added :	-				
Stabilizing Agent MDR Completion Time :	-				
Material Source :	PNQ - Edmonton Quarry				
For Use As :	Embankment				
Sample Location :	North of Avondale LHS CH 1300 16.8m from LHS edge of lot Lift 5				
Test/Layer Depth (mm)	275 / 300				
Max Size (mm) :	37.5				
Oversize Wet (%) :	18				
Oversize Dry (%) :	19				
Field Moisture (%) :	7.5				
MDR/ Assigned MDR No :	CS29331-AV				
Assigned MDR Used :	Y				
MDR/Assigned MDR Date:	13/03/19				
Field Wet Density (t/m³)	2.32				
Field Dry Density (t/m³)	2.16				
MDD (t/m³) :	2.14				
Adjusted MDD (t/m³) :	2.22				
OMC (%) :	8.5				
Adjusted OMC (%) :	7.0				
Variation from OMC	0.5% (Dry)				
MDR Sample Method :	AS1289.1.2.1.6.4(b)				
MDR Method :	AS1289.5.1.1				
MC Method :	AS1289.5.8.1				
Compactive Effort :	Standard				
Moisture Ratio (%) :	94.5				
Dry Density Ratio (%) :	97.0				
Min Dry Dens Ratio (%)	95				
Material Description :	Clayey Sandy GRAVEL				
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
 NATA Accreditation No. 20026
 Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29179 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	8/03/2019
Job Number :	GT17-474	Order Number	TR025
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29175	CS29176	CS29177	CS29178	CS29179
ID No :	1	2	3	4	5
Lot No :	SBP-EF_025	SBP-EF_025	SBP-EF_025	SBP-EF_025	SBP-EF_025
Item No :	-	-	-	-	-
Date Field Density Tested :	6/03/2019	6/03/2019	6/03/2019	6/03/2019	6/03/2019
Time Field Density Tested :	11:45 AM	11:55 AM	12:05 PM	12:15 PM	12:25 PM
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	After Compaction
Stabilization Agent Added :	No	No	No	No	No
Time Stabilizing Agent Added :	-	-	-	-	-
Stabilizing Agent MDR Completion Time :	-	-	-	-	-
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry
For Use As :	Embankment	Embankment	Embankment	Embankment	Embankment
Sample Location :	South of Avondale CH 1026 8.7m from LHS side. Embankment	South of Avondale CH 1042 7.1m from LHS side. Embankment	South of Avondale CH 1062 13.1m from LHS side. Embankment	South of Avondale CH 1096 6.2m from LHS side. Embankment	South of Avondale CH 1124 18.4m from LHS side. Embankment
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	275 / 300
Max Size (mm) :	37.5	37.5	37.5	37.5	37.5
Oversize Wet (%) :	15	0	14	4	3
Oversize Dry (%) :	16	0	15	4	3
Field Moisture (%) :	7.3	6.4	7.6	7.4	7.1
MDR/ Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV
Assigned MDR Used :	Y	Y	Y	Y	Y
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	20/02/19
Field Wet Density (t/m³)	2.35	2.37	2.38	2.32	2.27
Field Dry Density (t/m³)	2.19	2.23	2.21	2.16	2.12
IMDD (t/m³) :	2.16	2.16	2.16	2.16	2.16
Adjusted MDD (t/m³) :	2.22	2.16	2.22	2.18	2.17
OMC (%) :	8.0	8.0	8.0	8.0	8.0
Adjusted OMC (%) :	7.0	8.0	7.0	8.0	8.0
Variation from OMC	0.5% (Dry)	1.5% (Dry)	--	1.0% (Dry)	1.0% (Dry)
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Compactive Effort :	Standard	Standard	Standard	Standard	Standard
Moisture Ratio (%) :	95.0	78.0	98.5	91.0	87.5
Dry Density Ratio (%) :	98.5	103.0	99.5	99.0	97.5
Min Dry Dens Ratio (%)	95	95	95	95	95
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29184 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	8/03/2019
Job Number :	GT17-474	Order Number	TR023
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29180	CS29181	CS29182	CS29183	CS29184
ID No :	1	2	3	4	5
Lot No :	SBP-EF_026	SBP-EF_026	SBP-EF_026	SBP-EF_026	SBP-EF_026
Item No :	-	-	-	-	-
Date Field Density Tested :	6/03/2019	6/03/2019	6/03/2019	6/03/2019	6/03/2019
Time Field Density Tested :	12:00 PM	12:10 PM	12:20 PM	12:30 PM	12:40 PM
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	After Compaction
Stabilization Agent Added :	No	No	No	No	No
Time Stabilizing Agent Added :	-	-	-	-	-
Stabilizing Agent MDR Completion Time :	-	-	-	-	-
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry
For Use As :	Embankment	Embankment	Embankment	Embankment	Embankment
Sample Location :	South of Avondale CH 1020 14.4m from LHS side. Embankment	South of Avondale CH 1046 8.7m from LHS side. Embankment	South of Avondale CH 1067 1.7m from LHS side. Embankment	South of Avondale CH 1083 11.5m from LHS side. Embankment	South of Avondale CH 1125 5m from LHS side. Embankment
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	275 / 300
Max Size (mm) :	37.5	37.5	37.5	37.5	37.5
Oversize Wet (%) :	3	15	9	6	2
Oversize Dry (%) :	3	15	9	6	2
Field Moisture (%) :	7.1	7.7	7.1	9.5	7.8
MDR/ Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV
Assigned MDR Used :	Y	Y	Y	Y	Y
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	20/02/19
Field Wet Density (t/m ³)	2.34	2.33	2.35	2.35	2.37
Field Dry Density (t/m ³)	2.18	2.16	2.20	2.14	2.20
IMDD (t/m ³) :	2.16	2.16	2.16	2.16	2.16
Adjusted MDD (t/m ³) :	2.17	2.22	2.20	2.18	2.17
OMC (%) :	8.0	8.0	8.0	8.0	8.0
Adjusted OMC (%) :	8.0	7.0	7.5	7.5	8.0
Variation from OMC	1.0% (Dry)	--	1.0% (Dry)	1.5% (Wet)	0.5% (Dry)
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Compactive Effort :	Standard	Standard	Standard	Standard	Standard
Moisture Ratio (%) :	88.5	98.5	89.0	119.5	95.5
Dry Density Ratio (%) :	100.5	97.5	100.0	98.5	101.5
Min Dry Dens Ratio (%)	95	95	95	95	95
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29189 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	7/03/2019
Job Number :	GT17-474	Order Number	TR024
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29185	CS29186	CS29187	CS29188	CS29189
ID No :	1	2	3	4	5
Lot No :	SBP-EF_027	SBP-EF_027	SBP-EF_027	SBP-EF_027	SBP-EF_027
Item No :	-	-	-	-	-
Date Field Density Tested :	6/03/2019	6/03/2019	6/03/2019	6/03/2019	6/03/2019
Time Field Density Tested :	10:00 AM	10:10 AM	10:20 AM	10:30 AM	10:40 AM
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	After Compaction
Stabilization Agent Added :	No	No	No	No	No
Time Stabilizing Agent Added :	-	-	-	-	-
Stabilizing Agent MDR Completion Time :	-	-	-	-	-
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry
For Use As :	Embankment	Embankment	Embankment	Embankment	Embankment
Sample Location :	North of Avondale CH 1197 21.2m from LHS side. Embankment	North of Avondale CH 1231 5.1m from LHS side. Embankment	North of Avondale CH 1244 18.412.7m from LHS side. Embankment	North of Avondale CH 1252 0.0m from LHS side. Embankment	North of Avondale CH 1273 9.9m from LHS side. Embankment
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	275 / 300
Max Size (mm) :	37.5	37.5	37.5	37.5	37.5
Oversize Wet (%) :	5	4	0	3	13
Oversize Dry (%) :	6	4	0	3	13
Field Moisture (%) :	9.3	9.2	9.1	9.3	7.4
MDR/ Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV
Assigned MDR Used :	Y	Y	Y	Y	Y
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	20/02/19
Field Wet Density (t/m³)	2.37	2.34	2.30	2.39	2.38
Field Dry Density (t/m³)	2.16	2.14	2.11	2.19	2.22
IMDD (t/m³) :	2.16	2.16	2.16	2.16	2.16
Adjusted IMDD (t/m³) :	2.18	2.18	2.16	2.17	2.21
OMC (%) :	8.0	8.0	8.0	8.0	8.0
Adjusted OMC (%) :	7.5	8.0	8.0	8.0	7.0
Variation from OMC	1.5% (Wet)	1.0% (Wet)	1.0% (Wet)	1.0% (Wet)	--
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Compactive Effort :	Standard	Standard	Standard	Standard	Standard
Moisture Ratio (%) :	115.5	115.5	111.5	114.0	96.0
Dry Density Ratio (%) :	99.0	98.5	97.5	100.5	100.5
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29209 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	12/03/2019
Job Number :	GT17-474	Order Number	TR026
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29205	CS29206	CS29207	CS29208	CS29209
ID No :	1	2	3	4	5
Lot No :	SBP-EF-28	SBP-EF-28	SBP-EF-28	SBP-EF-28	SBP-EF-28
Item No :	-	-	-	-	-
Date Field Density Tested :	7/03/2019	7/03/2019	7/03/2019	7/03/2019	7/03/2019
Time Field Density Tested :	10:00 AM	10:10 AM	10:20 AM	10:30 AM	10:40 AM
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	After Compaction
Stabilization Agent Added :	No	No	No	No	No
Time Stabilizing Agent Added :	-	-	-	-	-
Stabilizing Agent MDR Completion Time :	-	-	-	-	-
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry
For Use As :	Embankment	Embankment	Embankment	Embankment	Embankment
Sample Location :	North of Avondale LHS Ch 1202 3.6m LHS of cL of Rd Lift 4	North of Avondale LHS Ch 1224 0.8m RHS of cL of Rd Lift 4	North of Avondale LHS Ch 1251 1.0m LHS of cL of Rd Lift 4	North of Avondale LHS Ch 1268 1.5m RHS of cL of Rd Lift 4	North of Avondale LHS Ch 1270 1.7m LHS of cL of Rd Lift 4
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	275 / 300
Max Size (mm) :	37.5	37.5	37.5	37.5	37.5
Oversize Wet (%) :	16	2	3	3	28
Oversize Dry (%) :	17	2	3	3	29
Field Moisture (%) :	9.3	10.1	9.1	8.8	8.0
MDR/ Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV
Assigned MDR Used :	Y	Y	Y	Y	Y
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	20/02/19
Field Wet Density (t/m ³)	2.34	2.46	2.41	2.43	2.37
Field Dry Density (t/m ³)	2.14	2.23	2.21	2.23	2.19
IMDD (t/m ³) :	2.16	2.16	2.16	2.16	2.16
Adjusted MDD (t/m ³) :	2.24	2.17	2.17	2.17	2.26
OMC (%) :	8.0	8.0	8.0	8.0	8.0
Adjusted OMC (%) :	7.0	8.0	8.0	8.0	6.0
Variation from OMC	1.0% (Wet)	2.0% (Wet)	1.0% (Wet)	0.5% (Wet)	1.0% (Wet)
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Compactive Effort :	Standard	Standard	Standard	Standard	Standard
Moisture Ratio (%) :	114.5	125.0	112.5	109.0	121.5
Dry Density Ratio (%) :	96.0	103.0	101.5	103.0	97.0
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29227 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	12/03/2019
Job Number :	GT17-474	Order Number	TR027
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29223	CS29224	CS29225	CS29226	CS29227
ID No :	1	2	3	4	5
Lot No :	SBP-EF-29	SBP-EF-29	SBP-EF-29	SBP-EF-29	SBP-EF-29
Item No :	-	-	-	-	-
Date Field Density Tested :	7/03/2019	7/03/2019	7/03/2019	7/03/2019	7/03/2019
Time Field Density Tested :	2:35 PM	2:45 PM	2:55 PM	3:05 PM	3:15 PM
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	After Compaction
Stabilization Agent Added :	No	No	No	No	No
Time Stabilizing Agent Added :	-	-	-	-	-
Stabilizing Agent MDR Completion Time :	-	-	-	-	-
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry
For Use As :	Embankment	Embankment	Embankment	Embankment	Embankment
Sample Location :	North of Avondale - RHS Ch 1166 4.9 m from LHS of Lot Lift 4	North of Avondale - RHS Ch 1206 5.2 m from LHS of Lot Lift 4	North of Avondale - RHS Ch 1216 12.4 m from LHS of Lot Lift 4	North of Avondale - RHS Ch 1245 0.9 m from LHS of Lot Lift 4	North of Avondale - RHS Ch 1281 10.5 m from LHS of Lot Lift 4
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	275 / 300
Max Size (mm) :	37.5	37.5	37.5	37.5	37.5
Oversize Wet (%) :	18	8	10	18	9
Oversize Dry (%) :	19	8	10	19	9
Field Moisture (%) :	9.3	8.6	6.7	8.1	7.9
MDR / Assigned MDR No :	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV	CS28840-AV
Assigned MDR Used :	Y	Y	Y	Y	Y
MDR/Assigned MDR Date:	20/02/19	20/02/19	20/02/19	20/02/19	20/02/19
Field Wet Density (t/m ³)	2.36	2.28	2.31	2.34	2.32
Field Dry Density (t/m ³)	2.16	2.10	2.17	2.16	2.15
IMDD (t/m ³) :	2.16	2.16	2.16	2.16	2.16
Adjusted MDD (t/m ³) :	2.23	2.19	2.20	2.23	2.19
OMC (%) :	8.0	8.0	8.0	8.0	8.0
Adjusted OMC (%) :	6.5	7.5	7.5	6.5	7.5
Variation from OMC	1.5% (Wet)	0.5% (Wet)	1.0% (Dry)	0.5% (Wet)	--
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1
Compactive Effort :	Standard	Standard	Standard	Standard	Standard
Moisture Ratio (%) :	121.5	106.5	85.5	107.0	101.5
Dry Density Ratio (%) :	96.5	95.5	98.5	97.0	98.0
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29434 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	28/03/2019
Job Number :	GT17-474	Order Number	TR031
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29431	CS29432	CS29433	CS29434	
ID No :	1	2	3	4	
Lot No :	SBP-EF-30	SBP-EF-30	SBP-EF-30	SBP-EF-30	
Item No :	-	-	-	-	
Date Field Density Tested :	25/03/2019	25/03/2019	25/03/2019	25/03/2019	
Time Field Density Tested :	2:50 PM	3:00 PM	3:05 PM	3:10 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale - LHS Ch: 1022 6.7 m from LHS Edge of Lot Lift 7	South of Avondale - LHS Ch: 1052 5.9 m from LHS Edge of Lot Lift 7	South of Avondale - LHS Ch: 1091 5.8 m from LHS Edge of Lot Lift 7	South of Avondale - LHS Ch: 1120 11.1 m from LHS Edge of Lot Lift 7	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	3	8	3	8	
Oversize Dry (%) :	3	9	3	8	
Field Moisture (%) :	7.7	8.5	6.6	6.3	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m³)	2.33	2.36	2.38	2.35	
Field Dry Density (t/m³)	2.16	2.17	2.23	2.21	
MDD (t/m³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m³) :	2.16	2.18	2.15	2.17	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	8.0	7.5	8.5	8.0	
Variation from OMC	0.5% (Dry)	0.5% (Wet)	2.0% (Dry)	2.0% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	91.5	102.5	78.5	77.5	
Dry Density Ratio (%) :	100.5	99.5	103.5	102.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29551 FDN
Address:	PO Box 224, Claremont WA 6910	Report Date:	11/04/2019
Job Number :	GT17-474	Order Number	TR032
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29548	CS29549	CS29550	CS29551	
ID No :	1	2	3	4	
Lot No :	SBP-EF-31	SBP-EF-31	SBP-EF-31	SBP-EF-31	
Item No :	-	-	-	-	
Date Field Density Tested :	8/04/2019	8/04/2019	8/04/2019	8/04/2019	
Time Field Density Tested :	2:30 PM	2:45 PM	3:00 PM	3:15 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale - RHS CH: 1008 15.2 m From LHS Edge of Lot Embankment	South of Avondale - RHS CH: 1043 15.6 m from LHS Edge of Lot Embankment	South of Avondale - RHS CH: 1080 11.2 m from LHS Edge of Lot Embankment	South of Avondale - RHS CH: 1118 3.4 m from LHS Edge of Lot Embankment	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	7	6	7	11	
Oversize Dry (%) :	8	6	7	12	
Field Moisture (%) :	7.9	8.4	7.5	6.7	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m ³)	2.32	2.33	2.34	2.35	
Field Dry Density (t/m ³)	2.15	2.15	2.17	2.20	
MDD (t/m ³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m ³) :	2.17	2.17	2.17	2.19	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	8.0	8.0	8.0	7.5	
Variation from OMC	0.5% (Dry)	--	1.0% (Dry)	1.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	94.0	99.0	89.5	79.5	
Dry Density Ratio (%) :	99.0	99.0	100.0	100.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	Brown Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29626 FDN
Address:	PO Box 14353, Mt Sheridan QLD 4868	Report Date:	16/04/2019
Job Number :	GT17-474	Order Number	TR033
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29623	CS29624	CS29625	CS29626	
ID No :	1	2	3	4	
Lot No :	SBP-EF-32	SBP-EF-32	SBP-EF-32	SBP-EF-32	
Item No :	-	-	-	-	
Date Field Density Tested :	12/04/2019	12/04/2019	12/04/2019	12/04/2019	
Time Field Density Tested :	10:30 AM	10:40 AM	10:50 AM	11:00 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North of Avondale LHS Ch 1291 12.9m from LHS Edge of Lot Lift 6	North of Avondale LHS Ch 1318 0.4 m from LHS Edge of Lot Lift 6	North of Avondale LHS Ch 1347 3.1 m from LHS Edge of Lot Lift 6	North of Avondale LHS Ch 1357 15.4 m from LHS Edge of Lot Lift 6	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	10	6	10	6	
Oversize Dry (%) :	11	6	11	7	
Field Moisture (%) :	7.4	8.4	7.3	7.0	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m³)	2.32	2.29	2.41	2.36	
Field Dry Density (t/m³)	2.16	2.11	2.25	2.21	
MDD (t/m³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m³) :	2.19	2.17	2.19	2.20	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	7.5	8.0	7.5	8.0	
Variation from OMC	1.0% (Dry)	--	1.0% (Dry)	2.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	AS1289.5.8.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	87.5	100.0	86.5	67.0	
Dry Density Ratio (%) :	99.0	97.5	102.5	100.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29657 FDN
Address:	PO Box 224, Claremont WA 6910	Report Date:	23/04/2019
Job Number :	GT17-474	Order Number	TR034
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29654	CS29655	CS29656	CS29657	
ID No :	1	2	3	4	
Lot No :	SBP-EF-33	SBP-EF-33	SBP-EF-33	SBP-EF-33	
Item No :	-	-	-	-	
Date Field Density Tested :	16/04/2019	16/04/2019	16/04/2019	16/04/2019	
Time Field Density Tested :	10:30 AM	10:40 AM	10:50 AM	11:00 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North of Avondale RHS Ch 1292 10.5m off RHS Edge of Lot Lift 6	North of Avondale RHS Ch 1318 14.9m off RHS Edge of Lot Lift 6	North of Avondale RHS Ch 1342 6.1m off RHS Edge of Lot Lift 6	North of Avondale RHS Ch 1364 18.5m off RHS Edge of Lot Lift 6	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	1	6	6	1	
Oversize Dry (%) :	1	7	6	1	
Field Moisture (%) :	8.0	8.3	7.6	7.8	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m³)	2.29	2.39	2.36	2.37	
Field Dry Density (t/m³)	2.12	2.20	2.19	2.20	
MDD (t/m³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m³) :	2.15	2.26	2.17	2.15	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	8.5	8.0	8.0	8.5	
Variation from OMC	0.5% (Dry)	--	0.5% (Dry)	1.0% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	94.5	100.0	93.5	91.5	
Dry Density Ratio (%) :	99.0	97.5	101.5	102.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :					



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29685 FDN
Address:	PO Box 224, Claremont WA 6910	Report Date:	26/04/2019
Job Number :	GT17-474	Order Number	TR035
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29682	CS29683	CS29684	CS29685	
ID No :	1	2	3	4	
Lot No :	SBP-EF-34	SBP-EF-34	SBP-EF-34	SBP-EF-34	
Item No :	-	-	-	-	
Date Field Density Tested :	17/04/2019	17/04/2019	17/04/2019	17/04/2019	
Time Field Density Tested :	2:40 PM	2:50 PM	3:00 PM	3:10 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North of Avondale RHS CH: 1300 8.4 m from RHS Edge of Lot Lift 7	North of Avondale RHS CH: 1316 9.5 m from RHS Edge of Lot Lift 7	North of Avondale RHS CH 1333 17.9 m from RHS Edge of Lot Lift 7	North of Avondale RHS CH 1357 18.9 m from RHS Edge of Lot Lift 7	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	5	5	9	3	
Oversize Dry (%) :	5	5	10	3	
Field Moisture (%) :	6.7	6.3	6.8	6.9	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m³)	2.31	2.23	2.24	2.35	
Field Dry Density (t/m³)	2.16	2.10	2.10	2.20	
MDD (t/m³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m³) :	2.16	2.16	2.18	2.16	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	8.0	8.0	7.5	8.0	
Variation from OMC	1.5% (Dry)	2.0% (Dry)	1.0% (Dry)	1.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	82.0	75.0	84.0	81.0	
Dry Density Ratio (%) :	100.0	97.5	96.0	101.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29690 FDN
Address:	PO Box 224, Claremont WA 6910	Report Date:	26/04/2019
Job Number :	GT17-474	Order Number	TR036
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29687	CS29688	CS29689	CS29690	
ID No :	1	2	3	4	
Lot No :	SBP-EF-35	SBP-EF-35	SBP-EF-35	SBP-EF-35	
Item No :	-	-	-	-	
Date Field Density Tested :	18/04/2019	18/04/2019	18/04/2019	18/04/2019	
Time Field Density Tested :	2:00 PM	2:15 PM	2:30 PM	2:45 PM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North of Avondale LHS Ch: 1297 7.4 m from LHS Edge of Lot Lift 7	North of Avondale LHS Ch: 1329 13.9 m from LHS Edge of Lot Lift 7	North of Avondale LHS Ch: 1355 8.2 m from LHS Edge of Lot Lift 7	North of Avondale LHS Ch: 1367 11.1 m from LHS Edge of Lot Lift 7	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	2	10	5	1	
Oversize Dry (%) :	2	11	5	1	
Field Moisture (%) :	8.4	7.8	7.4	7.4	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m³)	2.27	2.39	2.34	2.29	
Field Dry Density (t/m³)	2.10	2.21	2.18	2.13	
MDD (t/m³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m³) :	2.15	2.19	2.16	2.15	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	8.5	7.5	8.0	8.5	
Variation from OMC	--	0.5% (Dry)	1.0% (Dry)	1.0% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	AS1289.1.2.1.6.4 (b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	99.0	95.0	89.5	87.5	
Dry Density Ratio (%) :	97.5	101.5	101.0	99.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29755 FDN
Address:	PO Box 224, Claremont WA 6910	Report Date:	2/05/2019
Job Number :	GT17-474	Order Number	TR037
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29752	CS29753	CS29754	CS29755	
ID No :	1	2	3	4	
Lot No :	SBP-EF-036	SBP-EF-036	SBP-EF-036	SBP-EF-036	
Item No :	-	-	-	-	
Date Field Density Tested :	26/04/2019	26/04/2019	26/04/2019	26/04/2019	
Time Field Density Tested :	8:00 AM	8:10 AM	8:15 AM	8:25 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North of Avondale LHS Ch 1295 9.8 m from LHS Edge of Lot Embankment	North of Avondale LHS Ch 1330 4.6 m from LHS Edge of Lot Embankment	North of Avondale LHS Ch 1348 7.3 m from LHS Edge of Lot Embankment	North of Avondale LHS Ch 1378 4.7 m from LHS Edge of Lot Embankment	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	17	7	15	11	
Oversize Dry (%) :	18	7	16	11	
Field Moisture (%) :	6.2	6.9	5.4	6.2	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m ³)	2.27	2.30	2.34	2.31	
Field Dry Density (t/m ³)	2.14	2.15	2.22	2.17	
MDD (t/m ³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m ³) :	2.22	2.17	2.21	2.18	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	7.0	8.0	7.0	7.5	
Variation from OMC	1.5% (Dry)	1.5% (Dry)	2.0% (Dry)	1.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	79.5	83.5	67.5	80.5	
Dry Density Ratio (%) :	96.5	99.0	100.5	99.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

Troy Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29759 FDN
Address:	PO Box 224, Claremont WA 6910	Report Date:	2/05/2019
Job Number :	GT17-474	Order Number	TR038
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29756	CS29757	CS29758	CS29759	
ID No :	1	2	3	4	
Lot No :	SBP-EF-037	SBP-EF-037	SBP-EF-037	SBP-EF-037	
Item No :	-	-	-	-	
Date Field Density Tested :	26/04/2019	26/04/2019	26/04/2019	26/04/2019	
Time Field Density Tested :	10:45 AM	10:55 AM	10:10 AM	11:15 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	North of Avondale LHS Ch 1298 1.2 m from LHS Edge of Lot Embankment	North of Avondale LHS Ch 1310 6.9 m from LHS Edge of Lot Embankment	North of Avondale LHS Ch 1334 1.7 m from LHS Edge of Lot Embankment	South of Avondale LHS CH 1370 16.5 m from LHS Edge of Lot Embankment	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	18	17	13	12	
Oversize Dry (%) :	19	18	13	12	
Field Moisture (%) :	7.7	7.2	6.9	6.8	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m ³)	2.27	2.31	2.31	2.28	
Field Dry Density (t/m ³)	2.11	2.16	2.16	2.14	
MDD (t/m ³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m ³) :	2.22	2.21	2.19	2.19	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	7.0	7.0	7.5	7.5	
Variation from OMC	0.5% (Dry)	0.5% (Dry)	1.0% (Dry)	1.0% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	96.5	92.0	85.5	85.5	
Dry Density Ratio (%) :	95.0	97.5	98.5	97.5	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4



HEAD OFFICE – CAIRNS
ETS GEO PTY LTD
ABN: 16 121 817 794
07 4047 8600
07 4047 8699
admin@etsgeo.com.au
PO Box 587
REDLYNCH QLD 4870
1/220 Scott Street
Cairns QLD 4870

Dry Density Ratio Report

Client :	HAJV	Report Number:	GT17-474-CS29763 FDN
Address:	PO Box 224, Claremont WA 6910	Report Date:	2/05/2019
Job Number :	GT17-474	Order Number	TR039
Project :	Smithfield Bypass	Test Method:	AS1289.5.8.1/5.4.1
Location :	Smithfield.		AS1289.5.4.2

Page 1 of 1

Lab No :	CS29760	CS29761	CS29762	CS29763	
ID No :	1	2	3	4	
Lot No :	SBP-EF-038	SBP-EF-038	SBP-EF-038	SBP-EF-038	
Item No :	-	-	-	-	
Date Field Density Tested :	26/04/2019	26/04/2019	26/04/2019	26/04/2019	
Time Field Density Tested :	10:45 AM	10:55 AM	10:10 AM	11:15 AM	
MDR Sample Taken :	After Compaction	After Compaction	After Compaction	After Compaction	
Stabilization Agent Added :	No	No	No	No	
Time Stabilizing Agent Added :	-	-	-	-	
Stabilizing Agent MDR Completion Time :	-	-	-	-	
Material Source :	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	PNQ - Edmonton Quarry	
For Use As :	Embankment	Embankment	Embankment	Embankment	
Sample Location :	South of Avondale LHS CH 1090 30.7 m from LHS Edge of Lot Embankment	South of Avondale LHS CH 1102 23.6 m from LHS Edge of Lot Embankment	South of Avondale LHS CH 1105 33.6 m from LHS Edge of Lot Embankment	South of Avondale LHS CH 1114 26.8 m from LHS Edge of Lot Embankment	
Test/Layer Depth (mm)	275 / 300	275 / 300	275 / 300	275 / 300	
Max Size (mm) :	37.5	37.5	37.5	37.5	
Oversize Wet (%) :	18	12	9	13	
Oversize Dry (%) :	18	13	9	13	
Field Moisture (%) :	7.3	6.5	6.1	5.4	
MDR/ Assigned MDR No :	CS29331-AV	CS29331-AV	CS29331-AV	CS29331-AV	
Assigned MDR Used :	Y	Y	Y	Y	
MDR/Assigned MDR Date:	13/03/19	13/03/19	13/03/19	13/03/19	
Field Wet Density (t/m³)	2.28	2.33	2.34	2.33	
Field Dry Density (t/m³)	2.12	2.19	2.21	2.21	
MDD (t/m³) :	2.14	2.14	2.14	2.14	
Adjusted MDD (t/m³) :	2.21	2.19	2.18	2.19	
OMC (%) :	8.5	8.5	8.5	8.5	
Adjusted OMC (%) :	7.0	7.5	7.5	7.5	
Variation from OMC	0.5% (Dry)	1.5% (Dry)	2.0% (Dry)	2.5% (Dry)	
MDR Sample Method :	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	AS1289.1.2.1.6.4(b)	
MDR Method :	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	AS1289.5.1.1	
MC Method :	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	AS1289.2.1.1	
Compactive Effort :	Standard	Standard	Standard	Standard	
Moisture Ratio (%) :	96.0	81.0	74.0	68.5	
Dry Density Ratio (%) :	96.0	99.5	101.5	101.0	
Min Dry Dens Ratio (%)	95	95	95	95	
Material Description :	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	Clayey Sandy GRAVEL	
Remarks :	-				



Accredited for compliance with ISO/IEC 17025 - Testing

APPROVED SIGNATORY

T. Bock

Troy Bock - Senior Technician
NATA Accreditation No. 20026
Cairns Laboratory

Form ID

FM-RP-126-4

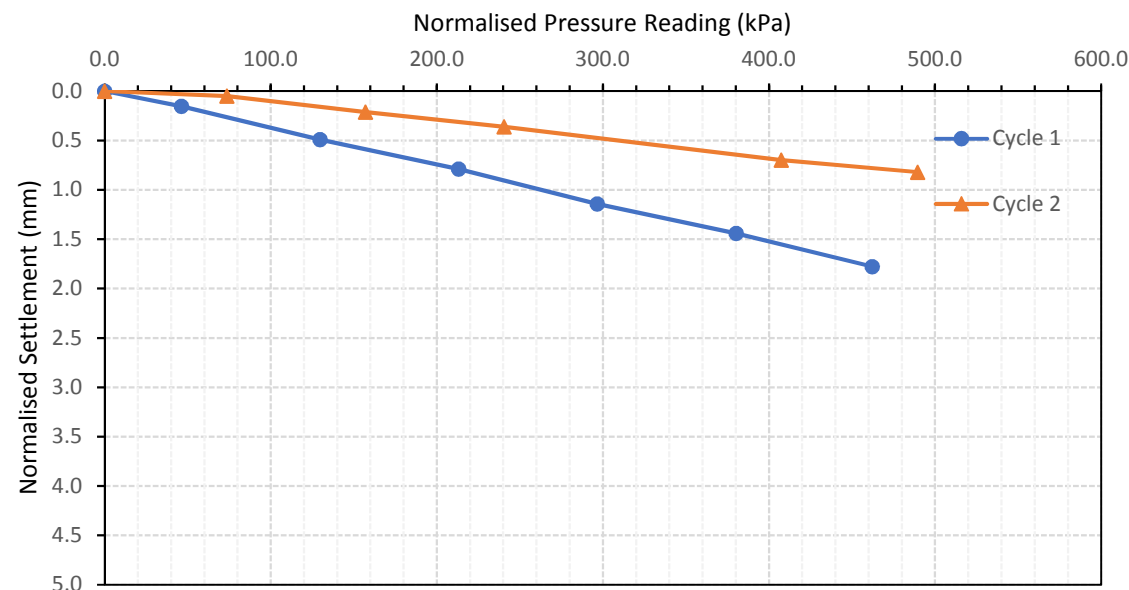


Appendix C

Static Plate Load Tests – Test Certificates

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 21 - Location 1 (Site 21-1)
Test Date: 1/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	213.2	1.69	Cycle 2	0.0	0.00
	46.3	0.16					73.6	0.05
	129.7	0.49					157.0	0.21
	213.2	0.79		87.3	1.52		240.5	0.36
	296.7	1.14					407.4	0.70
	380.1	1.44					489.5	0.82
	462.2	1.78						

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	60.1	59.6	59.1	58.7	58.2*
Reload (E_{v2})	152.6	145.2	138.5	132.4	126.9*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

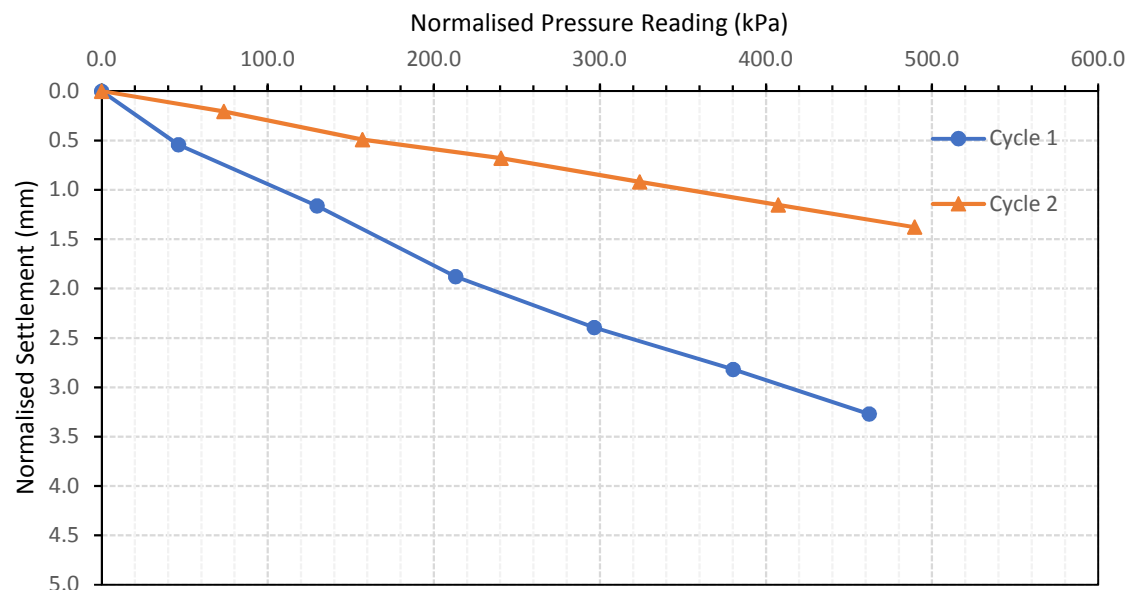
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	55.8	55.7	53.7	54.4	53.5*
Reload (E_s)	203.2	143.2	129.2	121.3	123.7*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 21 - Location 3 (Site 21-3)
Test Date: 1/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	213.2	3.06	Cycle 2	0.0	0.00
	46.3	0.54					73.6	0.21
	129.7	1.16					157.0	0.49
	213.2	1.88		240.5	0.68			
	296.7	2.39		324.0	0.92			
	380.1	2.82		407.4	1.15			
	462.2	3.27		489.5	1.38			

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	26.0	27.7	29.5	31.6	34.0*
Reload (E_{v2})	77.2	78.0	78.8	79.6	80.5*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

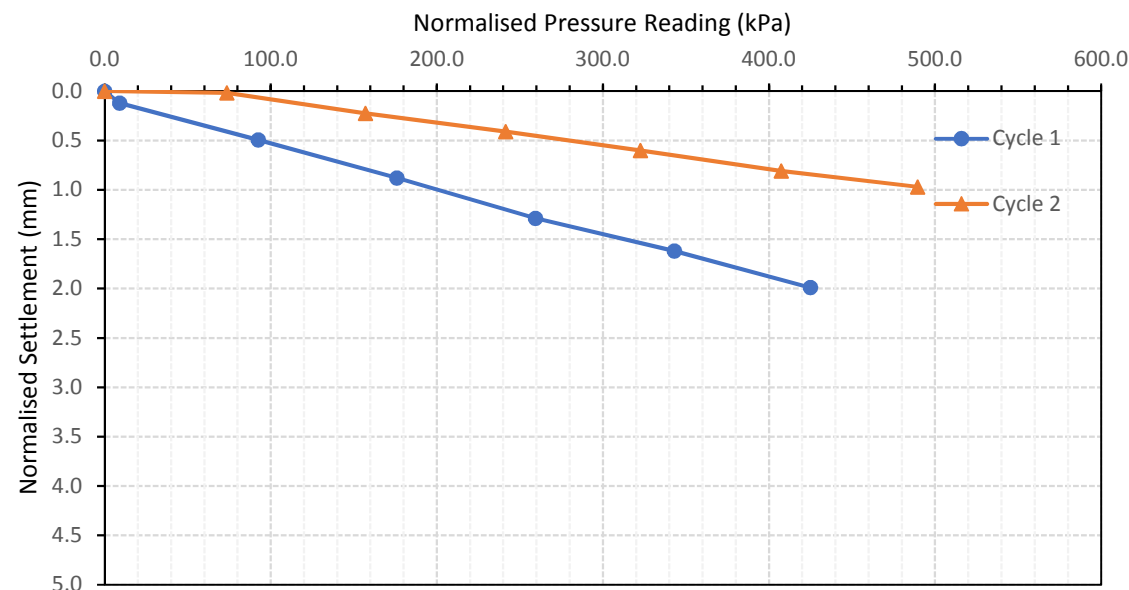
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	21.9	23.4	25.7	28.2	29.7*
Reload (E_s)	69.8	70.3	72.9	73.0	73.6*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 22 - Location 1 (Site 22-1)
Test Date: 28/02/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	176.0	1.96	Cycle 2	0.0	0.00
	9.1	0.12					73.6	0.02
	92.5	0.49					157.0	0.22
	176.0	0.88		50.1	1.85		241.5	0.41
	259.5	1.29					322.6	0.60
	342.9	1.62					407.4	0.81
	425.0	1.99					489.5	0.97

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	47.9	48.5	49.1	49.7	50.3*
Reload (E_{v2})	92.5	93.6	94.7	95.8	96.9*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

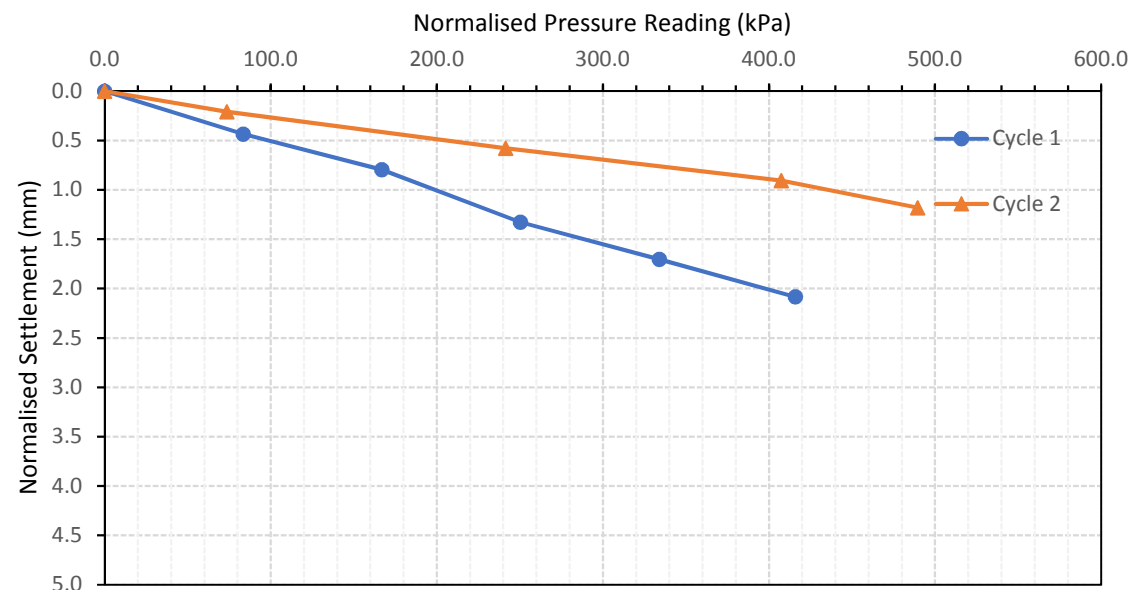
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	39.2	41.4	42.8	44.1	44.4*
Reload (E_s)	251.8	129.9	113.4	104.5	104.4*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 22 - Location 1A (Site 22-1A)
Test Date: 28/02/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	165.8	2.03	Cycle 2	0.0	0.00
	83.5	0.44					73.6	0.21
	166.9	0.80					241.5	0.58
	250.4	1.33		407.4	0.91			
	333.9	1.70		489.5	1.18			
	415.9	2.08						

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	43.0	43.5	44.0	44.5	45.0*
Reload (E_{v2})	100.5	99.7	98.8	98.0	97.2*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

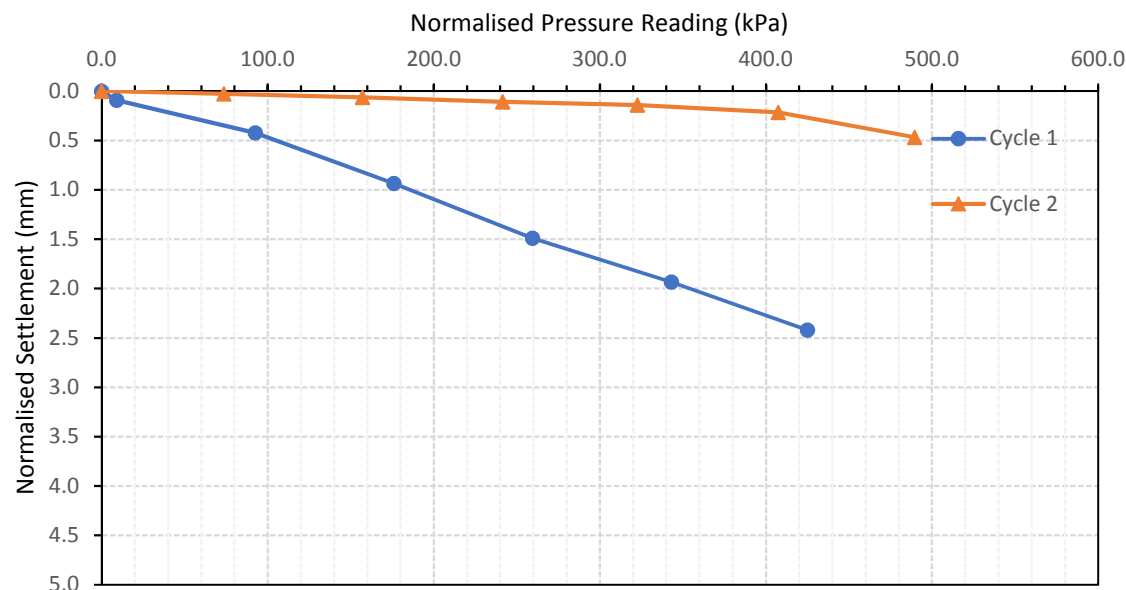
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	40.7	41.1	40.0	41.2	41.8*
Reload (E_s)	77.2	85.1	89.5	92.7	85.1*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 23 - Location 2 (Site 23-2)
Test Date: 13/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	176.0	2.54	Cycle 2	0.0	0.00
	9.1	0.09					73.6	0.03
	92.5	0.42					157.0	0.06
	176.0	0.93		241.5	0.11			
	259.5	1.49		322.6	0.14			
	342.9	1.93		407.4	0.22			
	425.0	2.42		489.5	0.47			

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	42.7	41.6	40.5	39.5	38.5*
Reload (E_{v2})	688.4	578.4	498.8	438.4	391.0*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

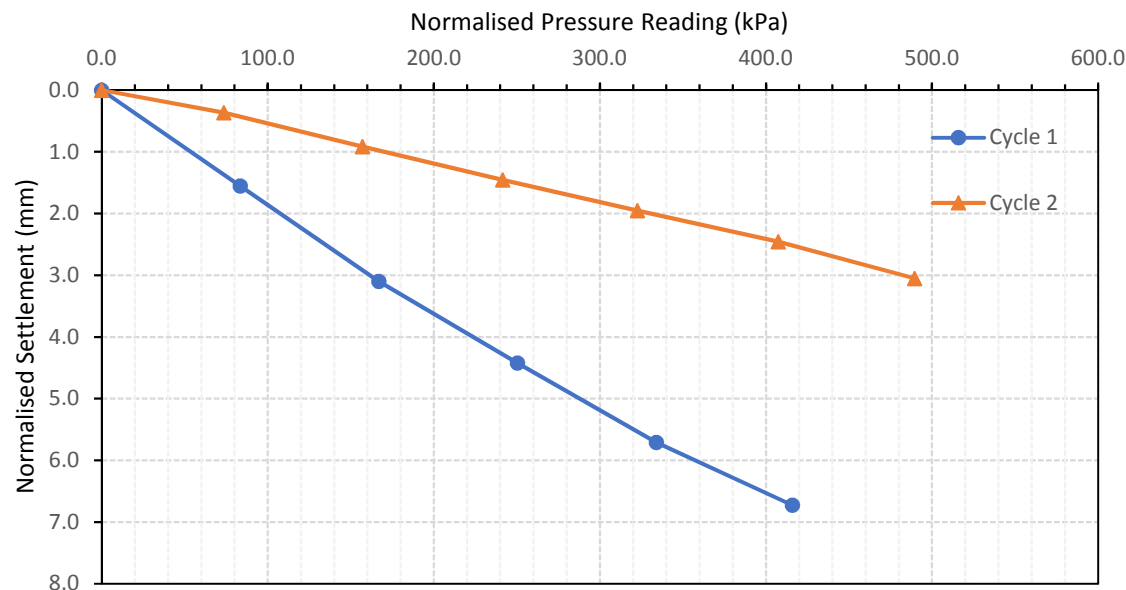
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	44.1	37.8	36.4	36.4	36.1*
Reload (E_s)	540.1	484.3	474.5	393.9	344.3*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 24 - Location 1 (Site 24-1)
Test Date: 12/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	166.9	6.43	Cycle 2	0.0	0.00
	83.5	1.55					73.6	0.37
	166.9	3.10					157.0	0.91
	250.4	4.42		241.5	1.45			
	333.9	5.71		322.6	1.95			
	415.9	6.73		407.4	2.45			
				489.5	3.05			

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	11.7	12.3	13.0 ⁺	13.7 ⁺	14.5 ⁺
Reload (E_{v2})	43.3	39.6	36.5	33.8	31.6 [*]

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

⁺Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

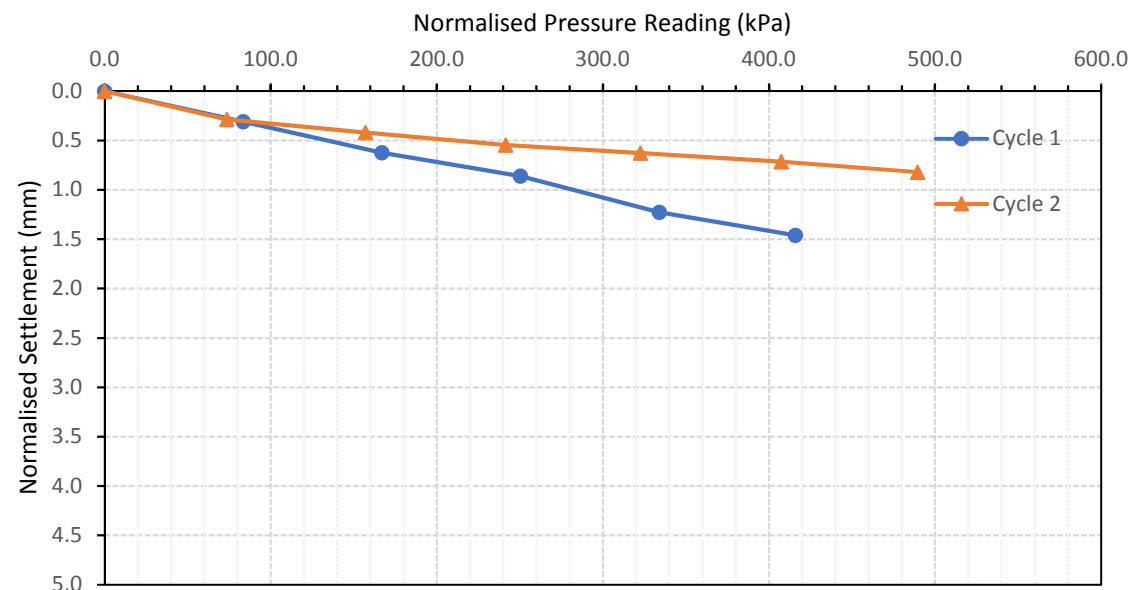
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	11.1	11.4	12.0 ⁺	12.7 ⁺	13.3 ⁺
Reload (E_s)	38.3	34.8	34.2	34.3	33.1 [*]

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

^{*} Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 24 - Location 2 (Site 24-2)
Test Date: 12/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	166.9	1.35	Cycle 2	0.0	0.00
	83.5	0.31					73.6	0.29
	166.9	0.62					157.0	0.42
	250.4	0.86		241.5	0.55			
	333.9	1.23		322.6	0.63			
	415.9	1.46		407.4	0.71			
				489.5	0.82			

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	61.8	62.3	62.9	63.6	64.2*
Reload (E_{v2})	93.3	103.1	115.3	130.7	150.9*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

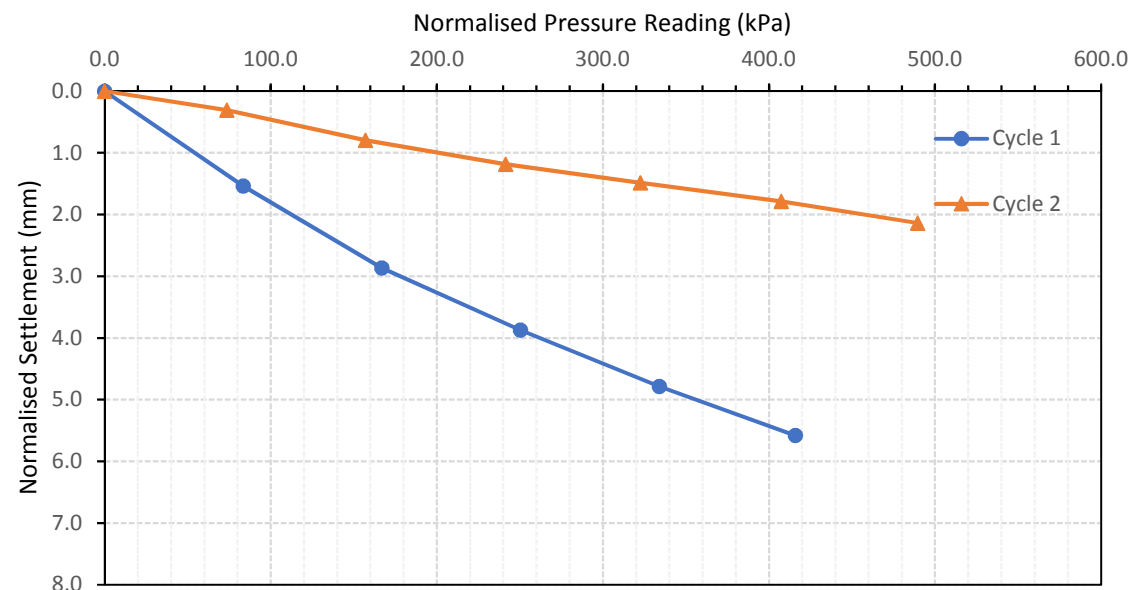
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	55.6	57.7	57.5	58.5	60.8*
Reload (E_s)	62.9	85.4	102.6	117.2	124.0*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 24 - Location 5 (Site 24-5)
Test Date: 12/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	166.9	5.37	Cycle 2	0.0	0.00
	83.5	1.54					73.6	0.31
	166.9	2.87					157.0	0.79
	250.4	3.87		41.0	4.82		241.5	1.18
	333.9	4.79					322.6	1.49
	415.9	5.58					407.4	1.79
							489.5	2.14

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	12.8	13.9	15.1	16.7*	18.6**
Reload (E_{v2})	44.0	45.7	47.5	49.5	51.7*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

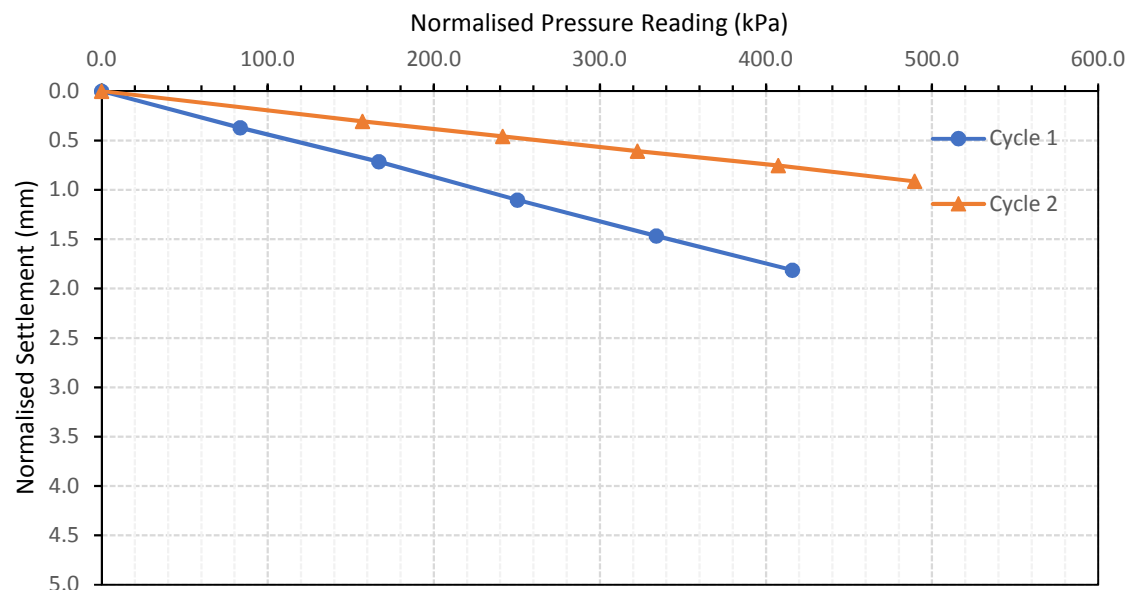
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	11.5	12.7	14.1	15.2*	16.2**
Reload (E_s)	44.9	41.7	44.2	47.0	47.4*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 25 - Location 2 (Site 25-2)
Test Date: 8/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	166.9	1.71	Cycle 2	0.0	0.00
	83.5	0.37					157.0	0.31
	166.9	0.71					241.5	0.46
	250.4	1.10		322.6	0.61			
	333.9	1.47		407.4	0.75			
	415.9	1.81		489.5	0.91			

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	51.5	51.5	51.5	51.5	51.5*
Reload (E_{v2})	116.6	118.0	119.4	120.9	122.4*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

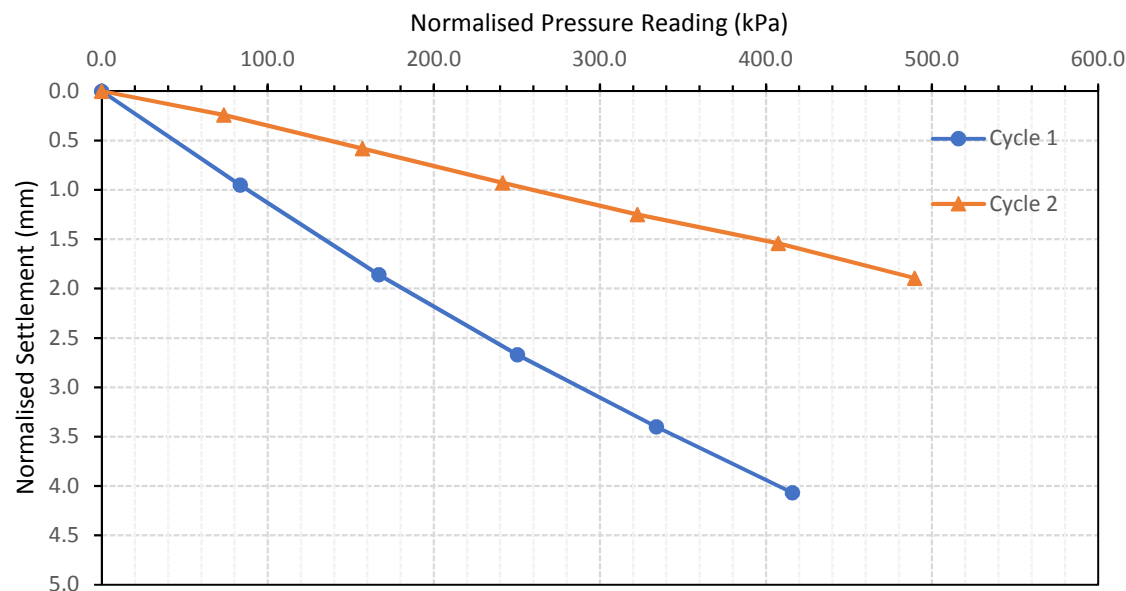
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	47.2	47.6	47.0	47.4	47.7*
Reload (E_s)	105.9	108.0	109.8	111.7	110.7*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 25 - Location 3 (Site 25-3)
Test Date: 7/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	166.9	3.70	Cycle 2	0.0	0.00
	83.5	0.95					73.6	0.24
	166.9	1.86					157.0	0.58
	250.4	2.67		41.0	3.35		241.5	0.93
	333.9	3.40					322.6	1.25
	415.9	4.07					407.4	1.54
							489.5	1.89

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	19.6	20.6	21.6	22.8	24.1*
Reload (E_{v2})	58.6	58.4	58.2	58.1	57.9*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

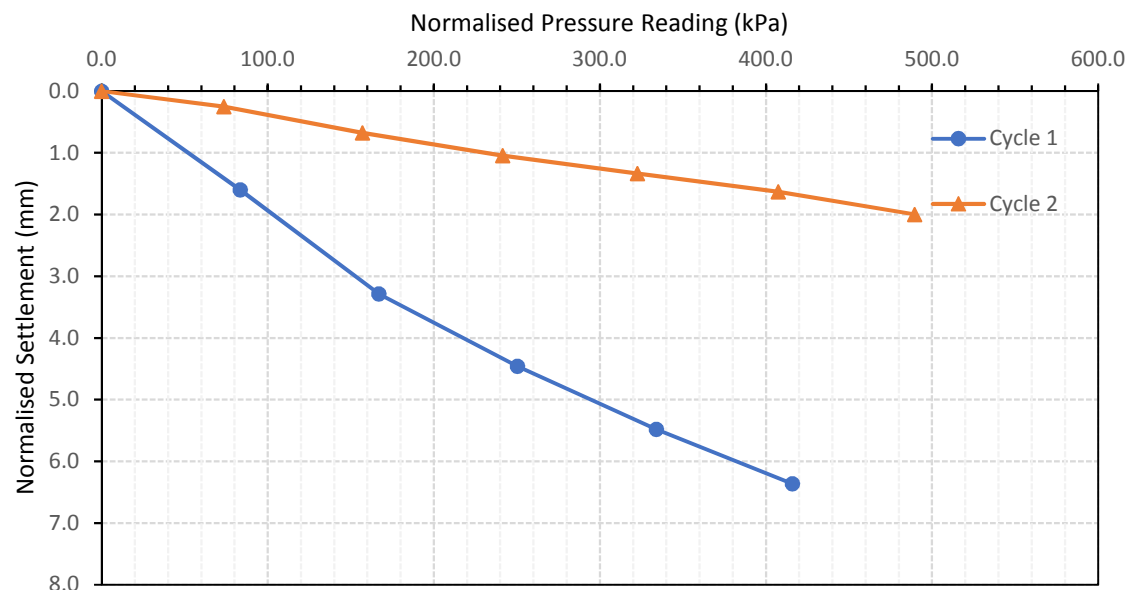
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	18.3	19.0	20.0	21.0	21.8*
Reload (E_s)	59.5	54.5	53.4	54.6	53.3*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 26 - Location 2 (Site 26-2)
Test Date: 6/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	166.9	6.21	Cycle 2	0.0	0.00
	83.5	1.60					73.6	0.25
	166.9	3.29					157.0	0.68
	250.4	4.46		41.0	5.85		241.5	1.05
	333.9	5.48					322.6	1.34
	415.9	6.36					407.4	1.63
							489.5	2.00

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	11.1	12.0	13.1 ⁺	14.5 ⁺	16.1 ⁺⁺
Reload (E_{v2})	51.1	52.0	53.0	54.0	55.1 [*]

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

⁺Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

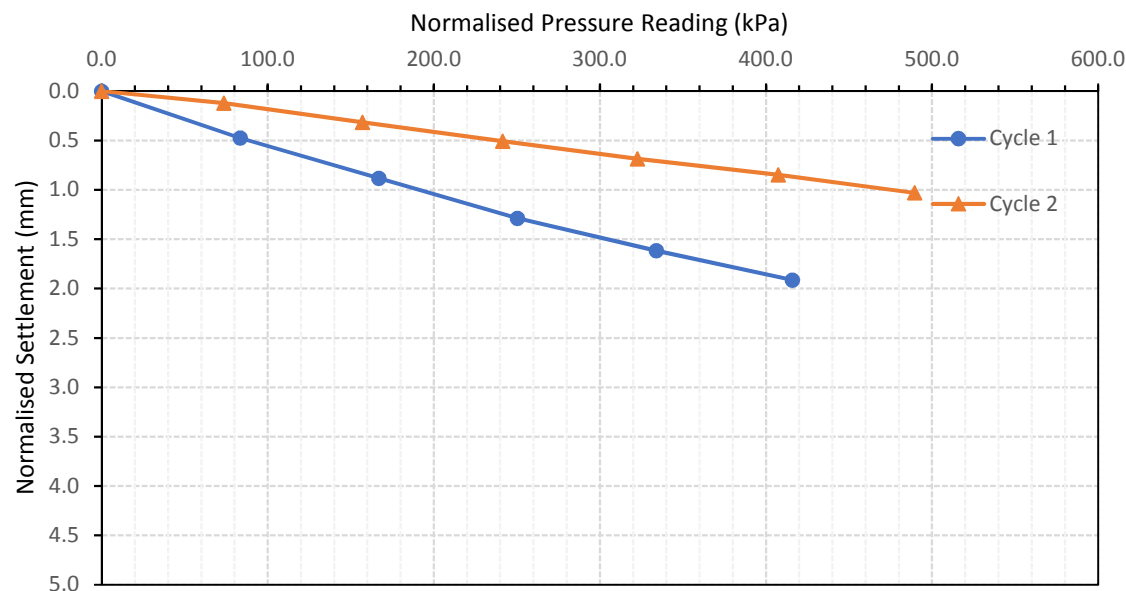
Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	10.7	11.0	12.2 ⁺	13.4 ⁺	14.2 ⁺⁺
Reload (E_s)	53.7	47.8	49.4	51.5	50.6 [*]

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

^{*} Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.

Plate Load Test Certificate

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Site ID: Smithfield Trial Embankment
Test Location ID: Lot 26 - Location 3 (Site 26-3)
Test Date: 6/03/2019
Tested By: MR (Construction Sciences)
Checked By: DWL
Page: 1 / 1



Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement (mm)	Phase	Normalised Test Stress (kPa)	Normalised Settlement - 3 Gauge Average (mm)
Cycle 1	0.0	0.00	Unloading	166.9	1.78	Cycle 2	0.0	0.00
	83.5	0.47					73.6	0.12
	166.9	0.88					157.0	0.32
	250.4	1.29		41.0	1.56		241.5	0.51
	333.9	1.62					322.6	0.69
	415.9	1.91					407.4	0.85
							489.5	1.03

Strain Elastic Modulus (E_v) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_{v1})	40.4	42.7	45.4	48.4	51.8*
Reload (E_{v2})	104.5	104.7	104.9	105.1	105.3*

Test Method: DIN18134 - 2012 Determining the deformation strength characteristics of soil by the plate loading test

*Calculated E_v parameter based on deflection in excess of 5 mm (observed below 300 mm diameter plate)

Secant Modulus (E_s) calculated to standardised test pressures

Load Cycle	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
Initial (E_s)	37.3	39.6	41.8	44.6	46.6*
Reload (E_s)	113.4	100.0	97.4	99.3	98.1*

Test Method: ASTM D 1196: Nonrepetitive Static Plate Load for Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements

* Max. datapoint of PLT remained below standardised test stress. Inferred modulus (E_s or E_v) parameter, assuming continuation of linear load / deformation relationship.



Appendix D

Prima 100 (Sweco), Light Falling weight Deflectometer (LWD) – Test Certificates

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 12-1

Certificate Reference: 2091-LFWD-PRIMA-Site 12-1 Sheet: 1 of 1

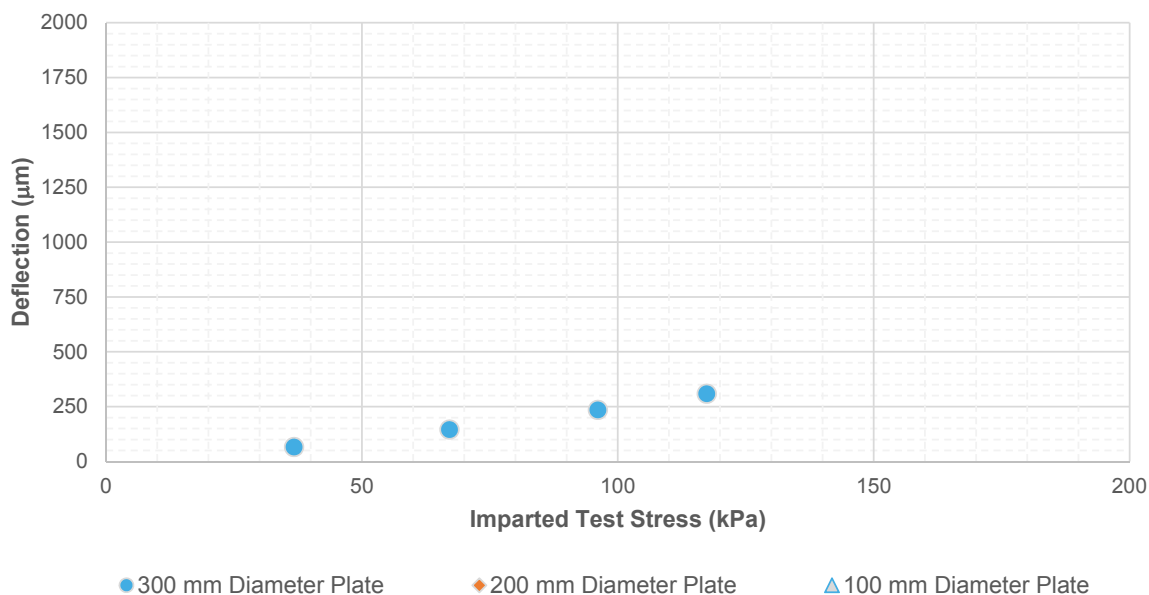
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 15/02/2019
 Location: Site 12-1 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	37	64.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	67	144.3						
4	96	234.0						
3	117	308.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	135
			100	106
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 12-2

Certificate Reference: 2091-LFWD-PRIMA-Site 12-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 15/02/2019

Location: Site 12-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

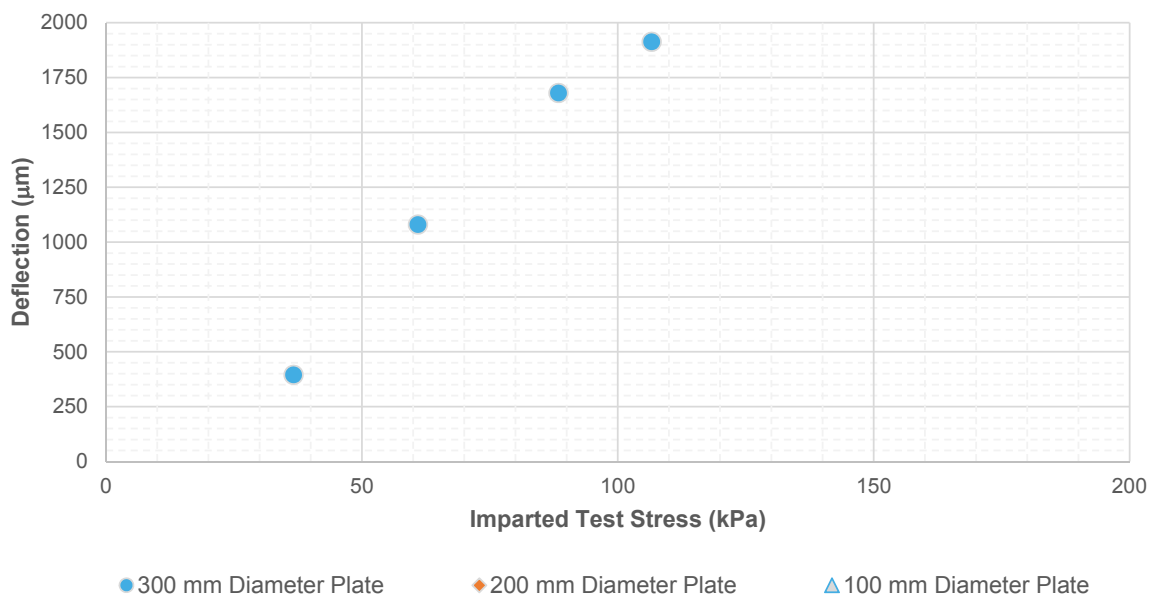
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	37	394.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	61	1079.1						
6	88	1679.0						
9	107	1912.2						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	19.2
			100	14.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 12-3

Certificate Reference: 2091-LFWD-PRIMA-Site 12-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 15/02/2019

Location: Site 12-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

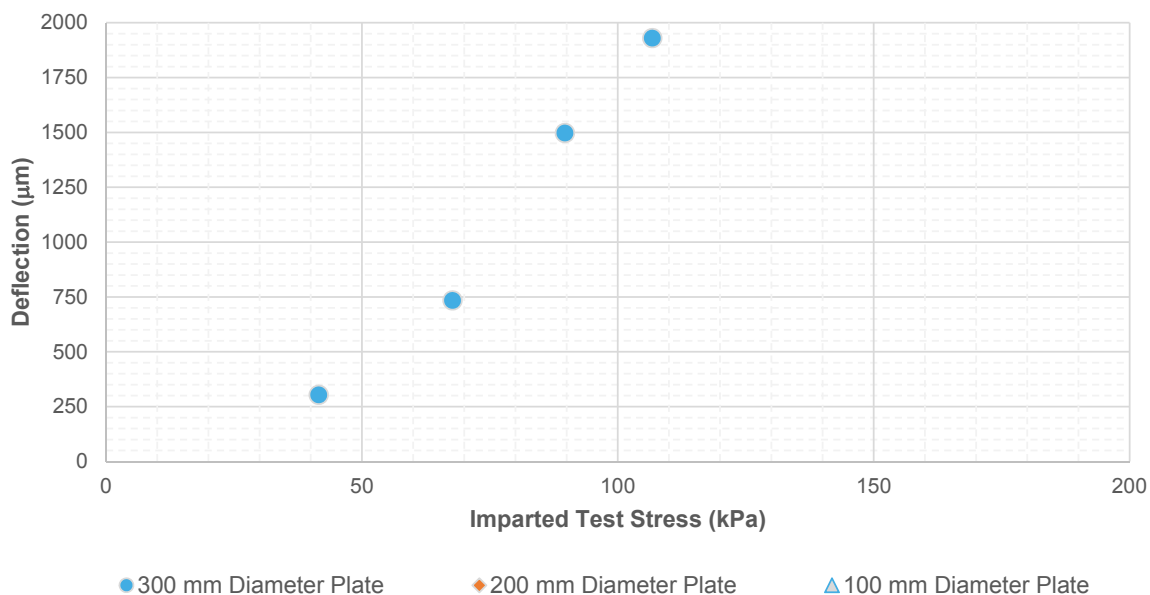
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	42	303.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	68	733.7						
4	90	1496.3						
9	107	1929.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	30.6
			100	15.2
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 12-4

Certificate Reference: 2091-LFWD-PRIMA-Site 12-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 15/02/2019

Location: Site 12-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

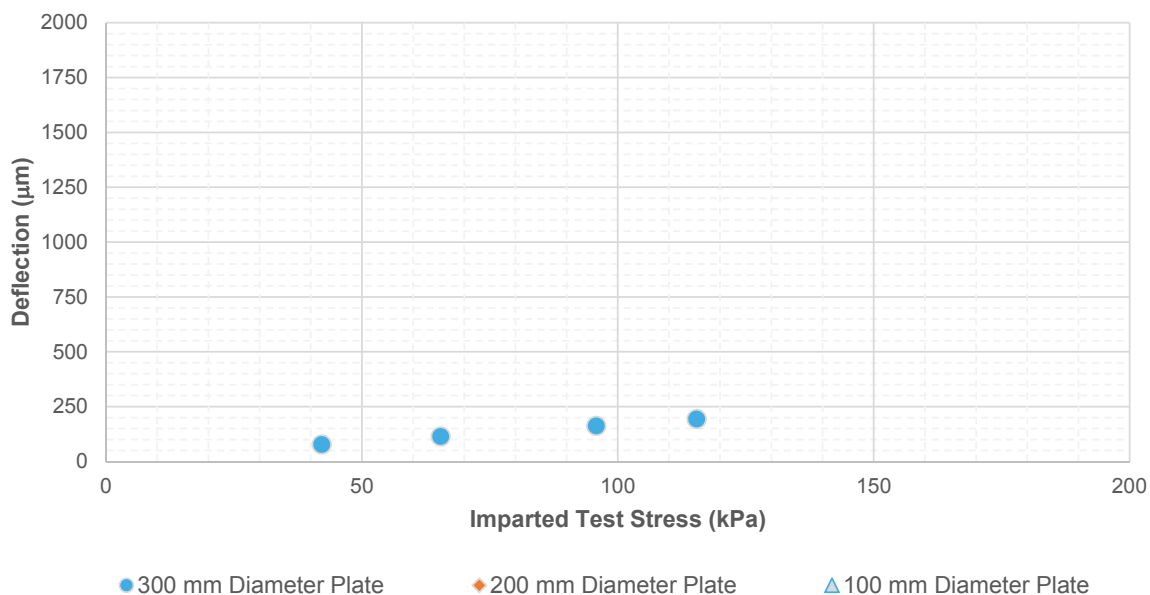
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	42	77.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	65	113.6						
5	96	161.7						
10	115	192.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	147
			100	156
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 13-1

Certificate Reference: 2091-LFWD-PRIMA-Site 13-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/02/2019

Location: Site 13-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

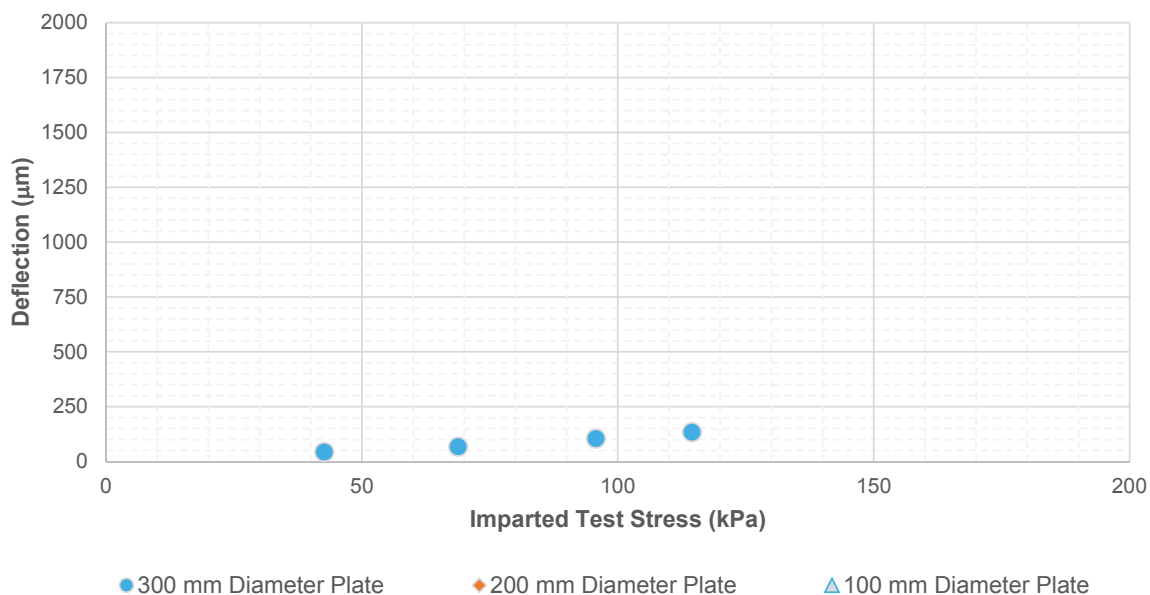
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	43	42.7 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	69	66.7						
4	96	103.4						
8	114	133.3						

⁺Material considered to have yielded at applied stress state

⁺Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	255
			100	208
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 13-2

Certificate Reference: 2091-LFWD-PRIMA-Site 13-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/02/2019

Location: Site 13-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

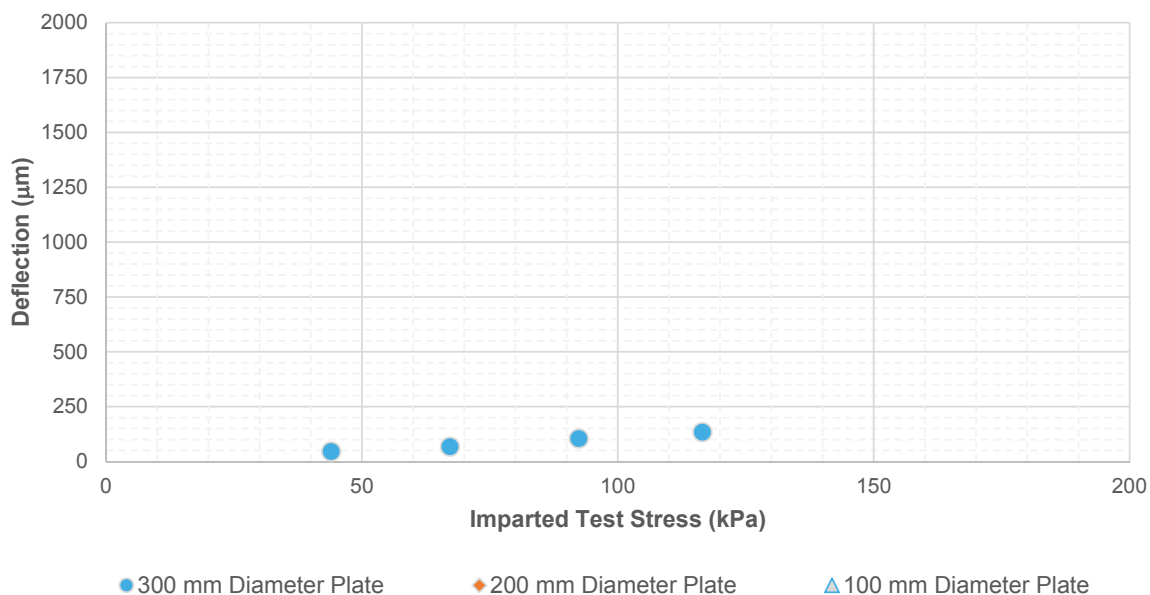
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	44	45.0 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	67	66.7						
9	92	103.4						
9	117	133.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	254
			100	235
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 13-3

Certificate Reference: 2091-LFWD-PRIMA-Site 13-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/02/2019

Location: Site 13-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

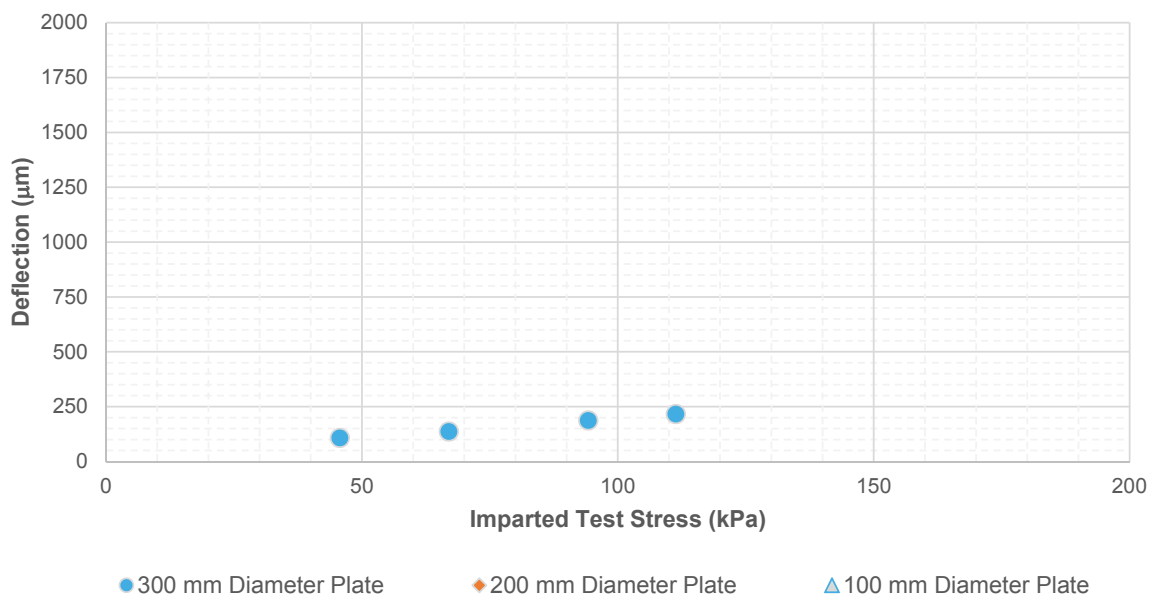
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	46	106.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	67	136.1						
11	94	186.4						
6	111	215.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	127
			100	134
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 13-4

Certificate Reference: 2091-LFWD-PRIMA-Site 13-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/02/2019

Location: Site 13-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

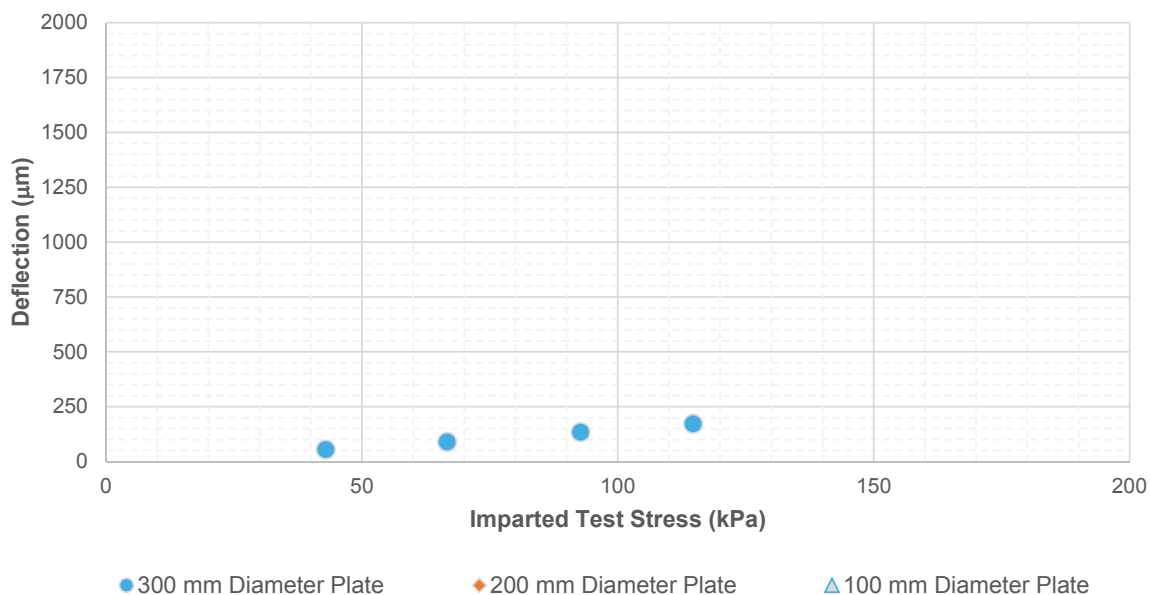
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	43	53.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	67	88.6						
10	93	133.2						
9	115	171.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	207
			100	182
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 14-1

Certificate Reference: 2091-LFWD-PRIMA-Site 14-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/02/2019

Location: Site 14-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

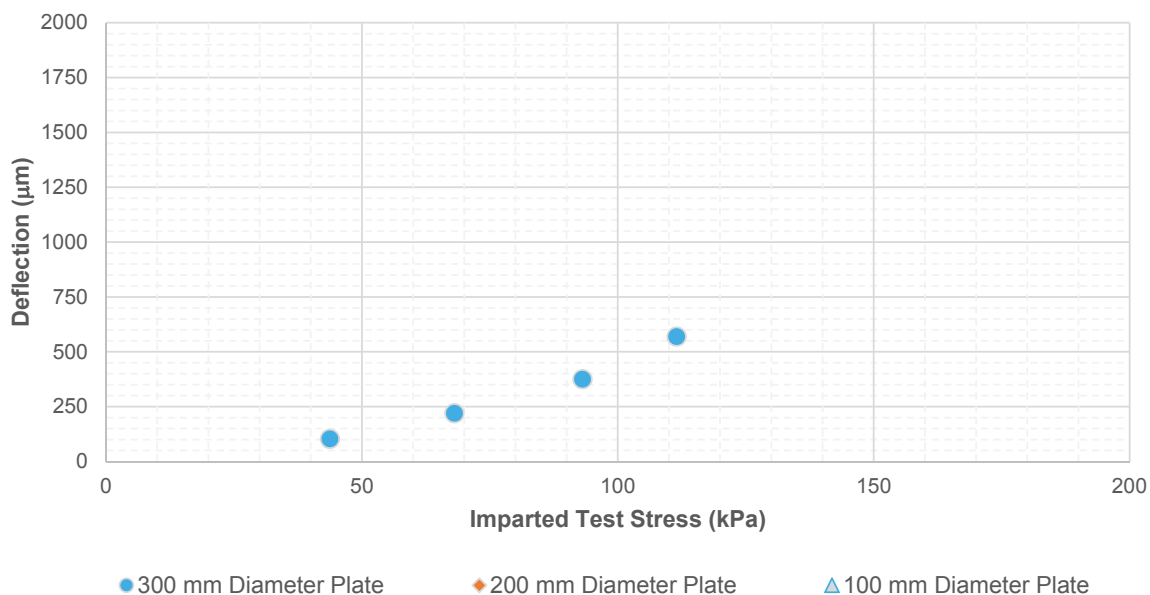
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	44	101.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	68	219.2						
3	93	374.3						
7	112	568.2						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	103
			100	59.1
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 14-2

Certificate Reference: 2091-LFWD-PRIMA-Site 14-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/02/2019

Location: Site 14-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

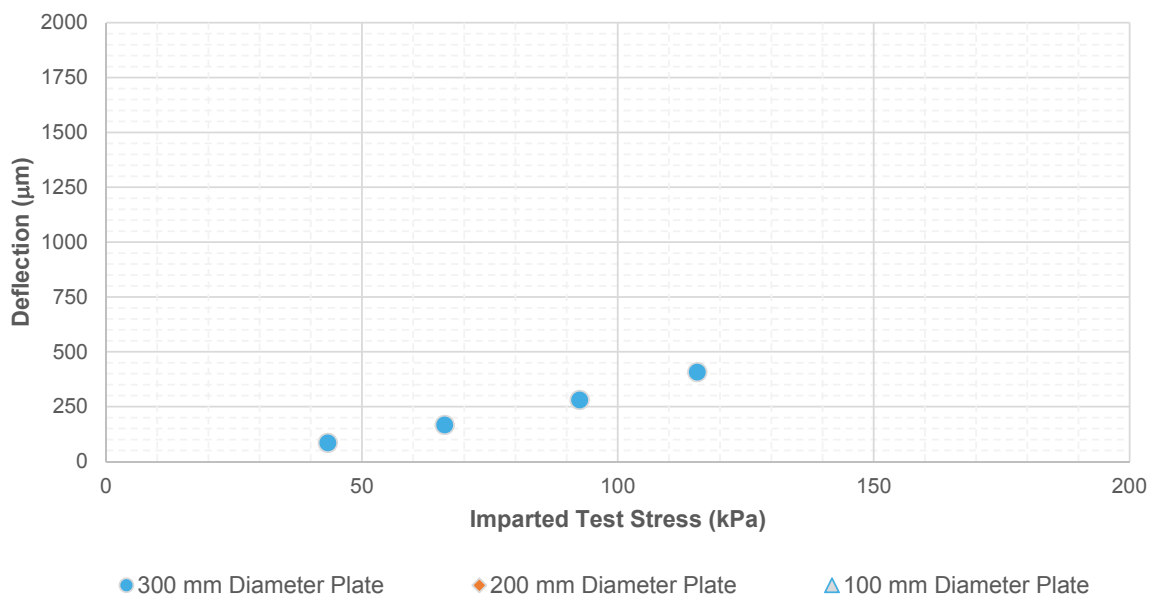
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	43	84.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	66	165.6						
10	93	279.7						
9	116	406.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	125
			100	82.3
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 14-3

Certificate Reference: 2091-LFWD-PRIMA-Site 14-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/02/2019

Location: Site 14-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

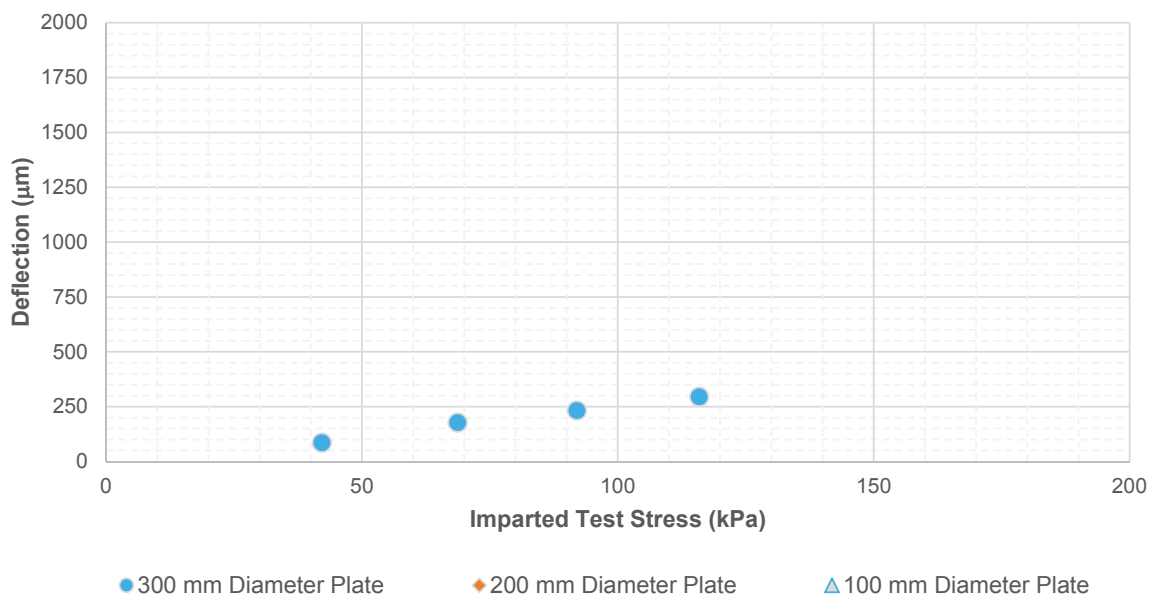
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	42	84.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	69	176.6						
6	92	231.6						
7	116	294.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	103
			100	104
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 14-4

Certificate Reference: 2091-LFWD-PRIMA-Site 14-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/02/2019

Location: Site 14-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

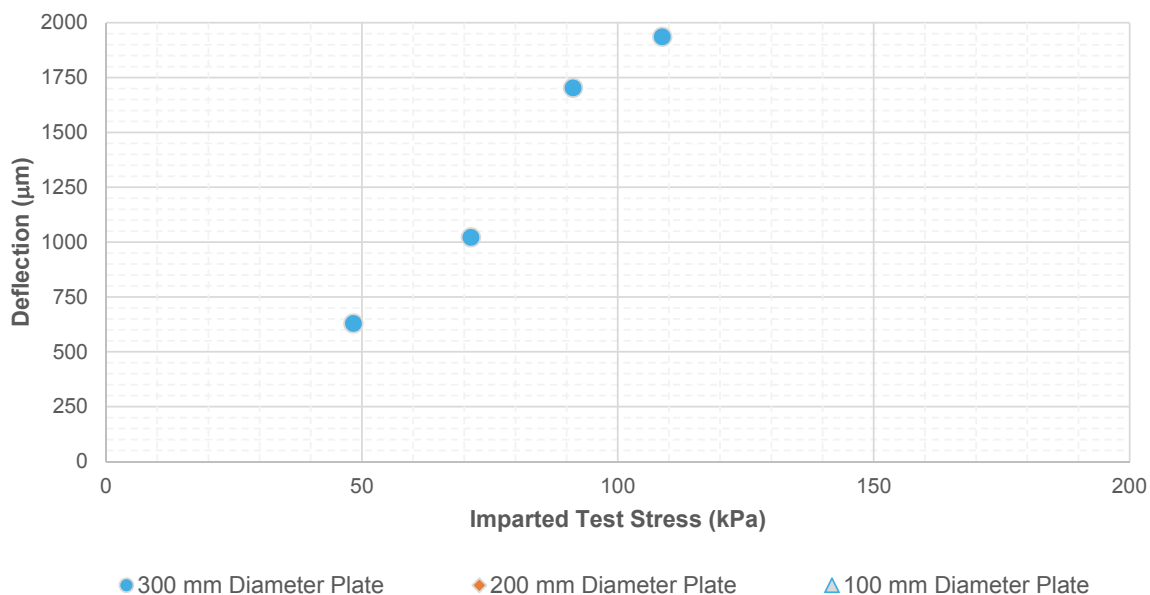
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	48	628.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	71	1021.0						
6	91	1702.3						
6	109	1934.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	20.0
			100	14.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 15-1

Certificate Reference: 2091-LFWD-PRIMA-Site 15-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 19/02/2019

Location: Site 15-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

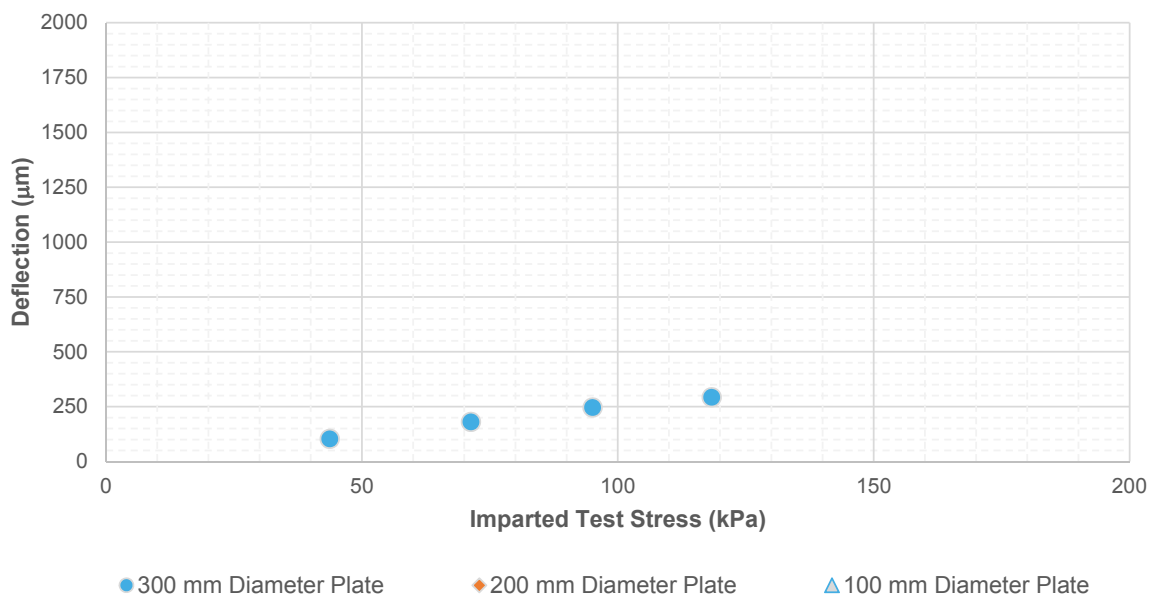
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	44	102.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	71	179.8						
3	95	245.6						
4	118	291.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	110
			100	101
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 15-2

Certificate Reference: 2091-LFWD-PRIMA-Site 15-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 19/02/2019

Location: Site 15-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

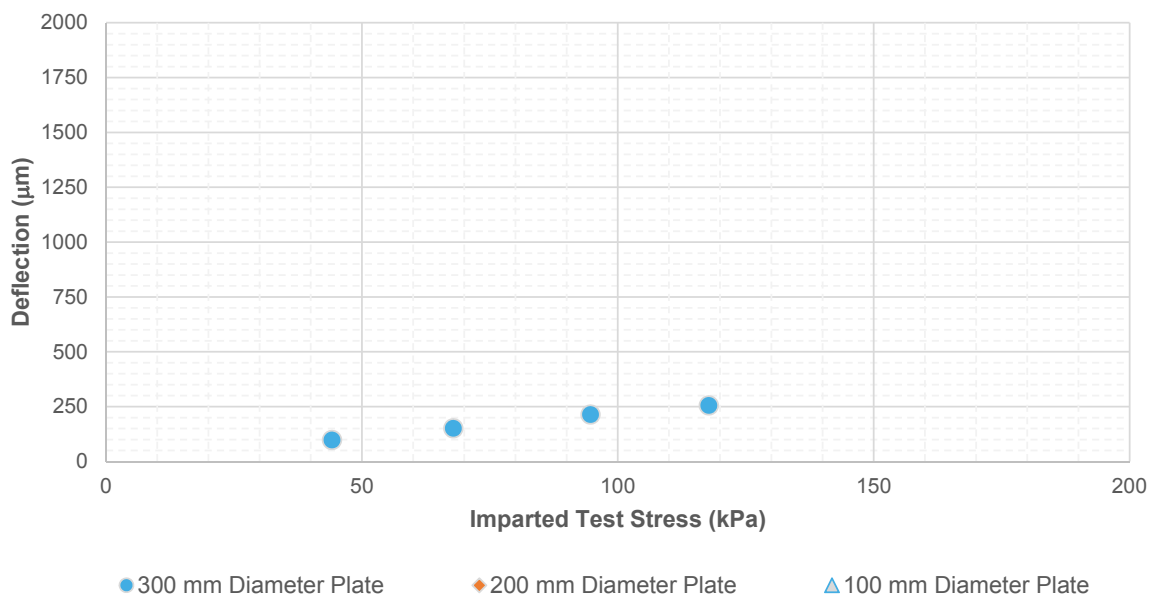
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	44	97.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	68	150.3						
7	95	212.9						
9	118	255.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	119
			100	117
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 15-3

Certificate Reference: 2091-LFWD-PRIMA-Site 15-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 19/02/2019

Location: Site 15-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

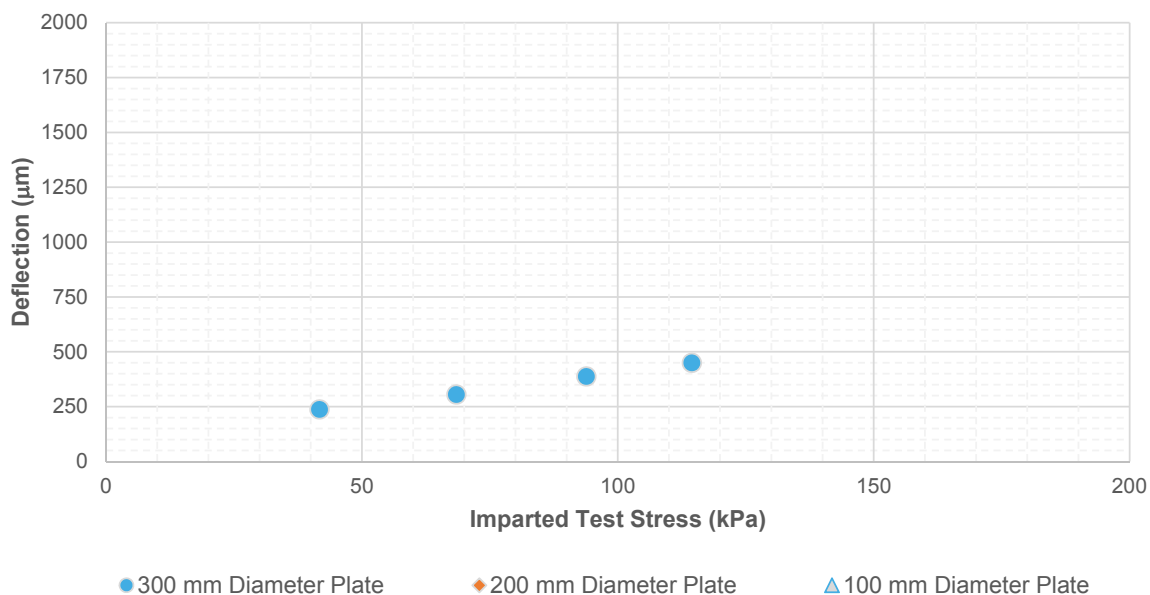
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	42	236.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	68	304.3						
9	94	386.5						
9	114	448.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	50.7
			100	65.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 15-4

Certificate Reference: 2091-LFWD-PRIMA-Site 15-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 19/02/2019

Location: Site 15-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

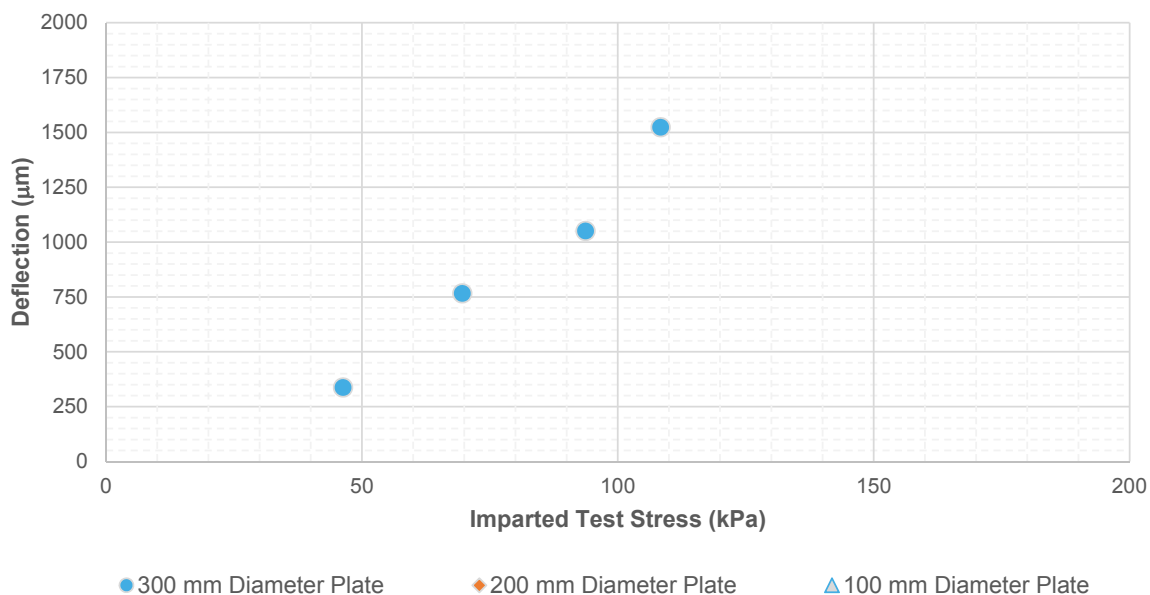
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	46	336.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	70	765.8						
6	94	1049.9						
5	108	1522.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	35.3
			100	21.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 15-4A

Certificate Reference: 2091-LFWD-PRIMA-Site 15-4A

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 19/02/2019

Location: Site 15-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

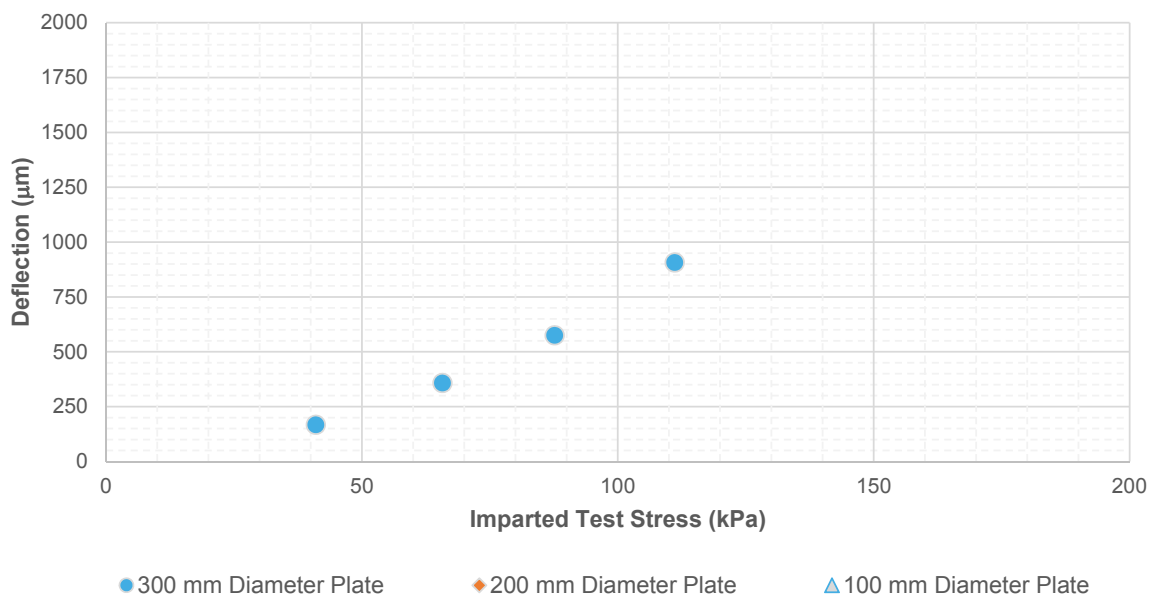
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	41	166.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	66	357.0						
5	88	574.5						
7	111	906.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	57.4
			100	35.7
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 16-1

Certificate Reference: 2091-LFWD-PRIMA-Site 16-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 21/02/2019

Location: Site 16-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

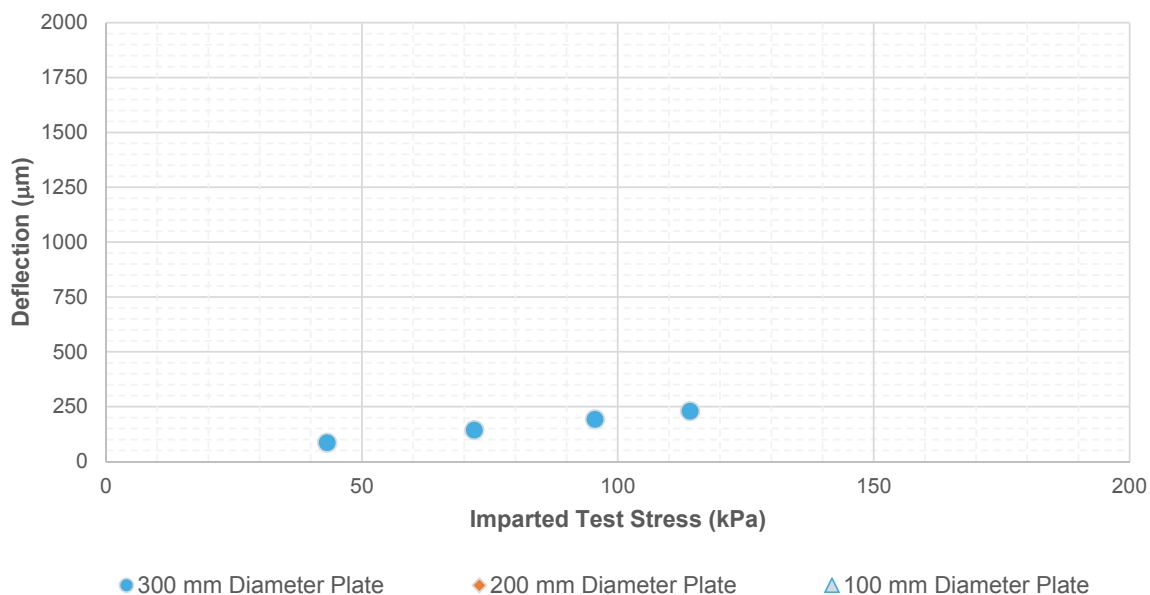
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	43	85.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	72	142.3						
3	96	191.4						
8	114	228.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	134
			100	132
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 16-2

Certificate Reference: 2091-LFWD-PRIMA-Site 16-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 21/02/2019

Location: Site 16-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

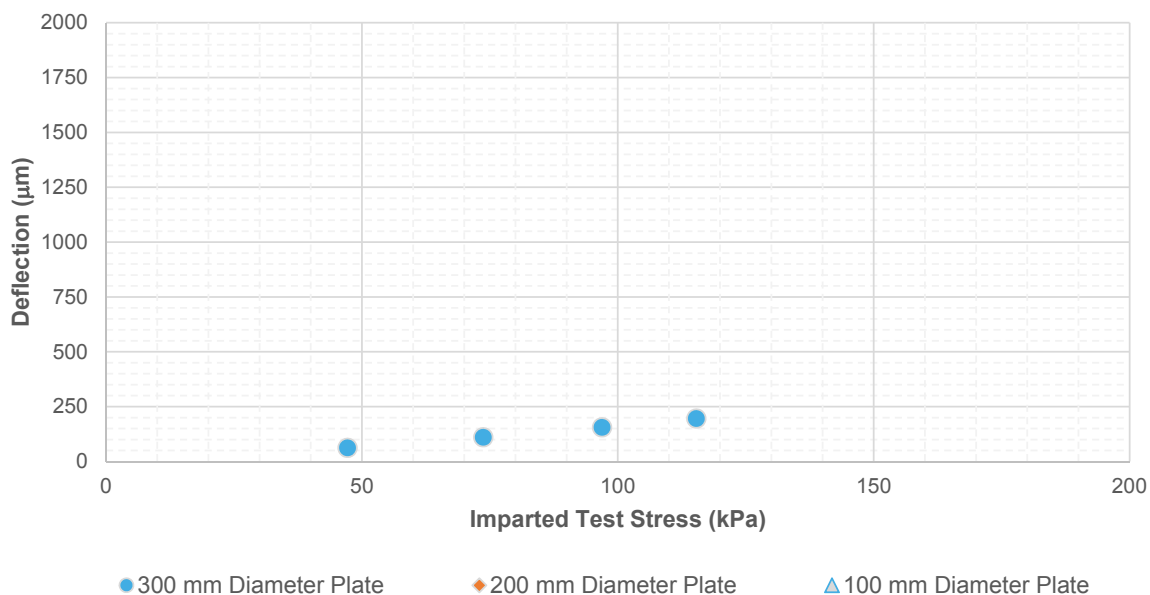
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	47	61.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	74	109.6						
10	97	154.5						
4	115	194.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	198
			100	164
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 16-3

Certificate Reference: 2091-LFWD-PRIMA-Site 16-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 21/02/2019

Location: Site 16-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

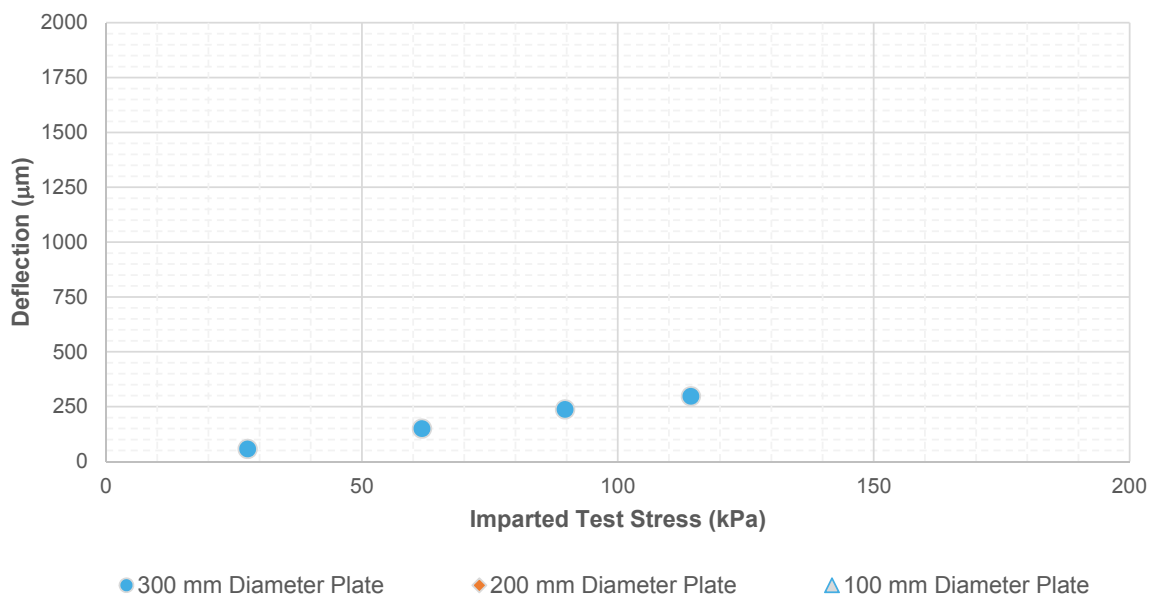
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	28	56.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	62	148.9						
6	90	236.5						
4	114	296.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	115
			100	101
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 16-4

Certificate Reference: 2091-LFWD-PRIMA-Site 16-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 21/02/2019

Location: Site 16-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

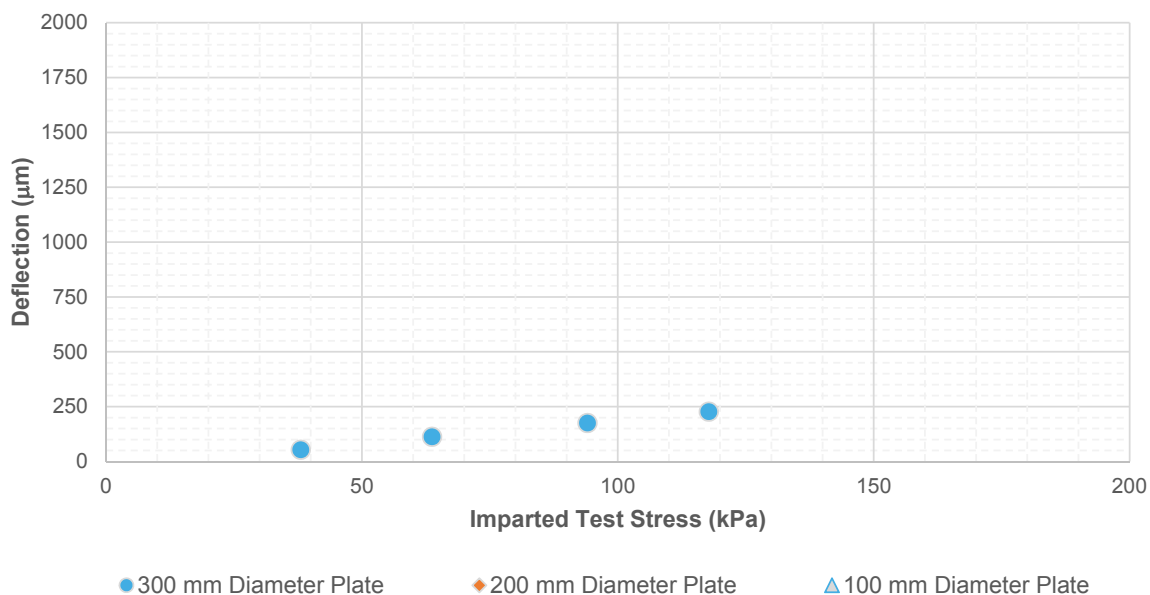
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	38	52.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	64	111.9						
5	94	174.7						
9	118	226.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	153
			100	141
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 17-1

Certificate Reference: 2091-LFWD-PRIMA-Site 17-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 21/02/2019

Location: Site 17-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

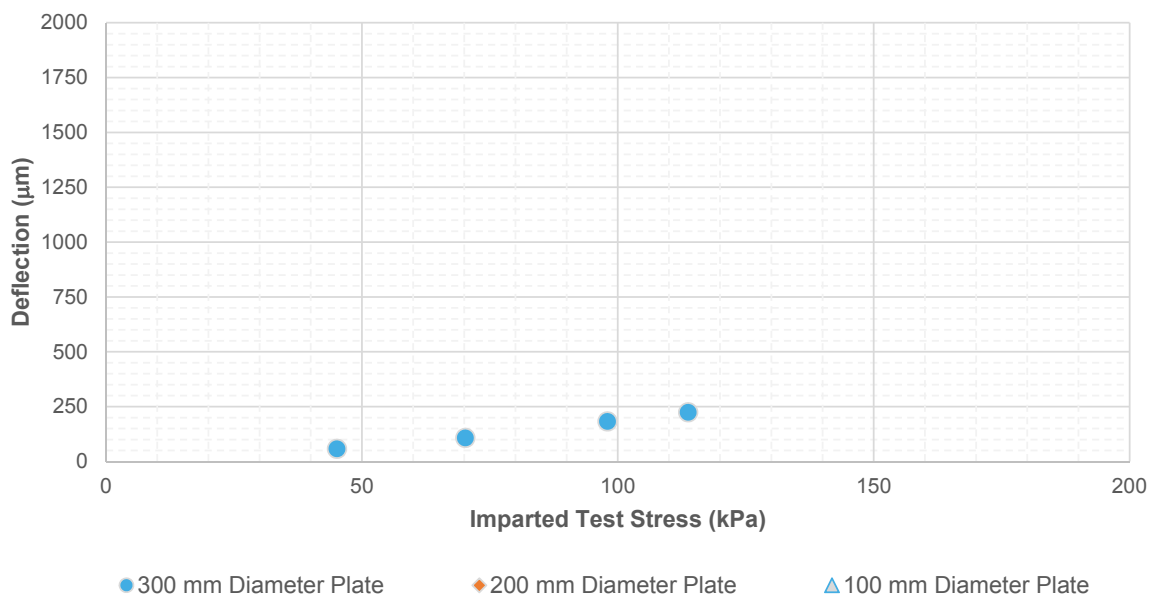
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	45	56.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	70	106.8						
10	98	181.7						
6	114	223.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	200
			100	143
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 17-2

Certificate Reference: 2091-LFWD-PRIMA-Site 17-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 21/02/2019

Location: Site 17-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

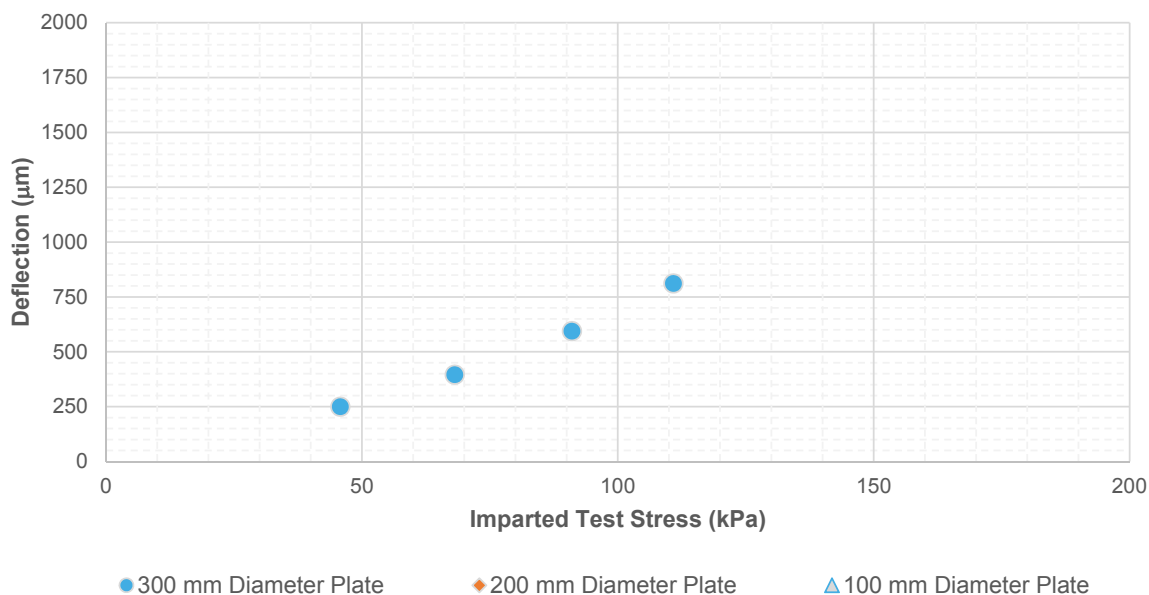
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	46	249.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	68	394.6						
5	91	593.2						
6	111	810.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	48.2
			100	38.5
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 17-2A

Certificate Reference: 2091-LFWD-PRIMA-Site 17-2A **Sheet:** 1 of 1

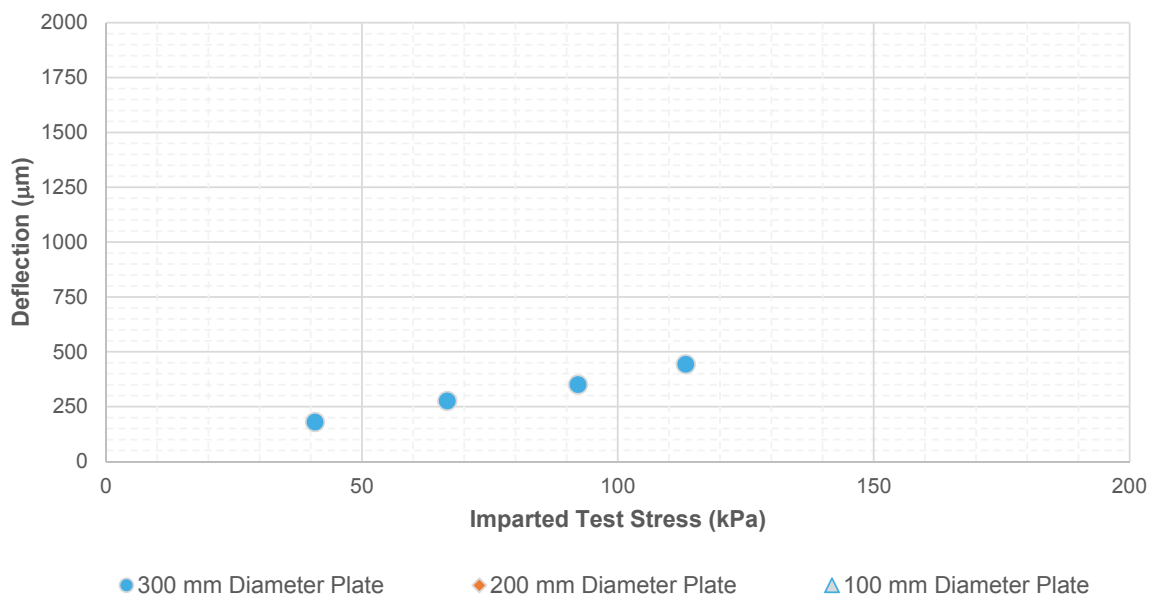
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 21/02/2019
Location: Site 17-2 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	41	178.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	67	275.1						
4	92	349.8						
7	113	442.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	61.6
			100	66.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 17-3

Certificate Reference: 2091-LFWD-PRIMA-Site 17-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 21/02/2019

Location: Site 17-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

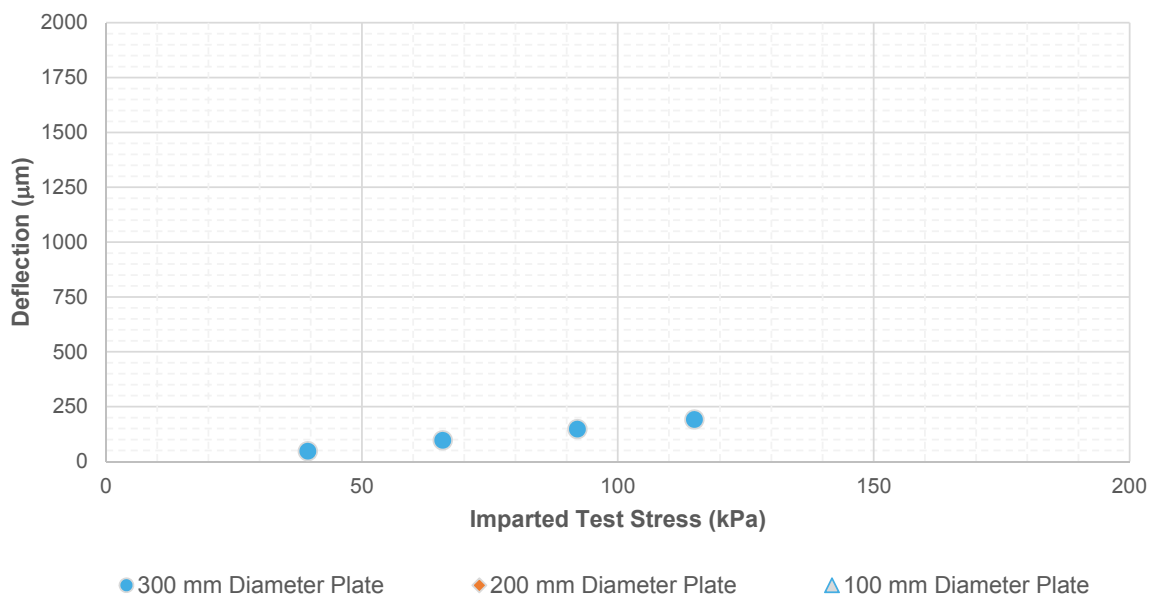
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	39	45.9 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	66	95.5						
7	92	147.0						
5	115	190.4						

⁺Material considered to have yielded at applied stress state

⁺Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	205
			100	163
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 17-4

Certificate Reference: 2091-LFWD-PRIMA-Site 17-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 21/02/2019

Location: Site 17-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

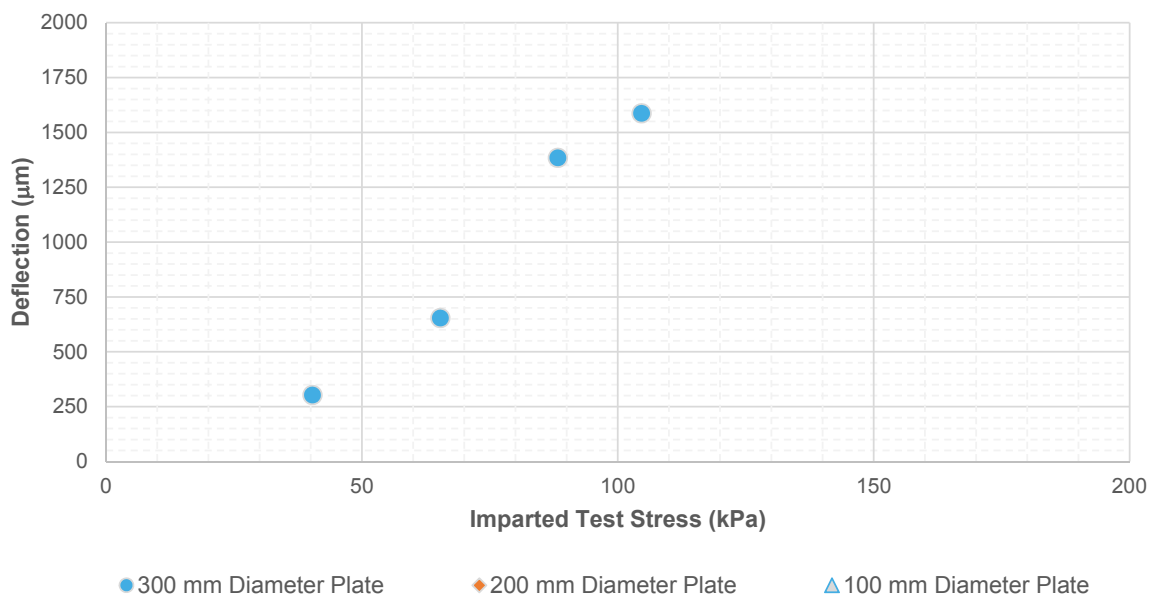
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	40	302.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	65	652.8						
6	88	1383.7						
3	105	1586.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	31.8
			100	18.2
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 18-1

Certificate Reference: 2091-LFWD-PRIMA-Site 18-1 Sheet: 1 of 1

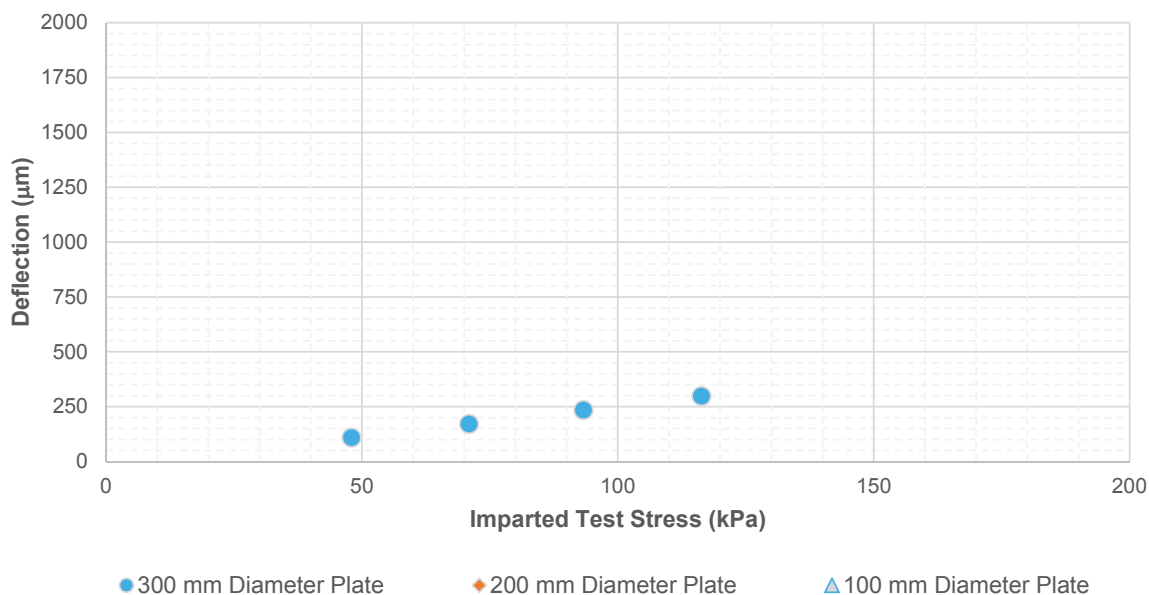
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 22/02/2019
 Location: Site 18-1 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	48	108.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	71	170.2						
4	93	233.3						
5	116	297.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	116
			100	105
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 18-2

Certificate Reference: 2091-LFWD-PRIMA-Site 18-2 **Sheet:** 1 of 1

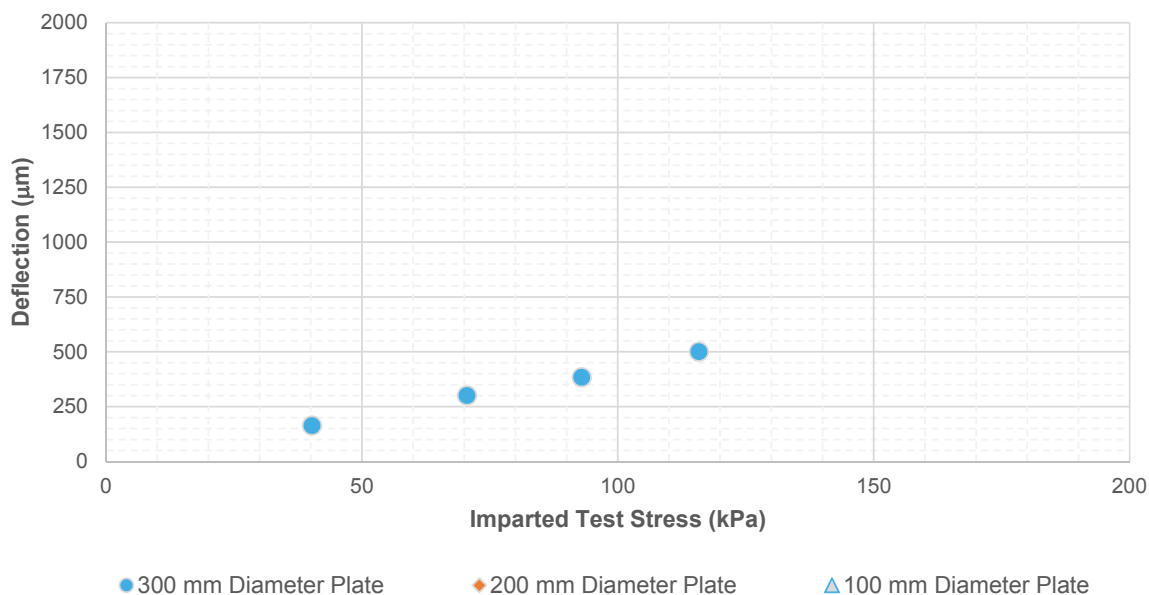
Client: ARRB Project: Best Practice in Compaction QA Location: Site 18-2 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (v): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 22/02/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
---	--

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
4	40	162.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	71	300.4						
4	93	383.1						
4	116	499.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	64.3
			100	62.1
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 18-3

Certificate Reference: 2091-LFWD-PRIMA-Site 18-3 **Sheet:** 1 of 1

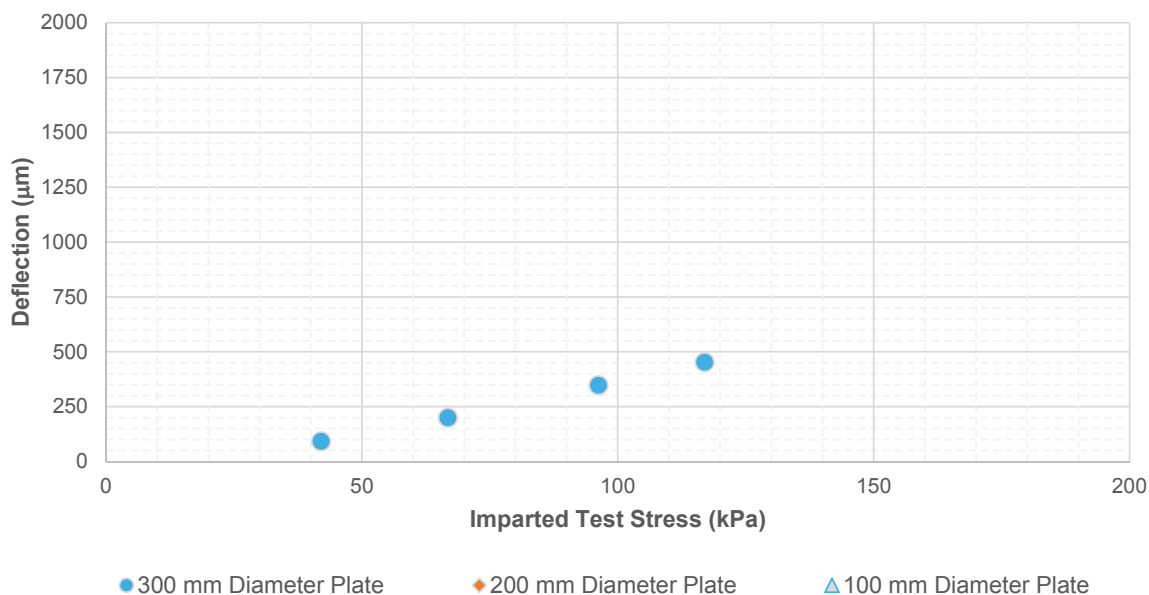
Client: ARRB Project: Best Practice in Compaction QA Location: Site 18-3 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (v): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 22/02/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
---	--

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
5	42	91.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	67	198.9						
9	96	346.8						
6	117	451.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	107
			100	72.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 18-4

Certificate Reference: 2091-LFWD-PRIMA-Site 18-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 22/02/2019

Location: Site 18-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

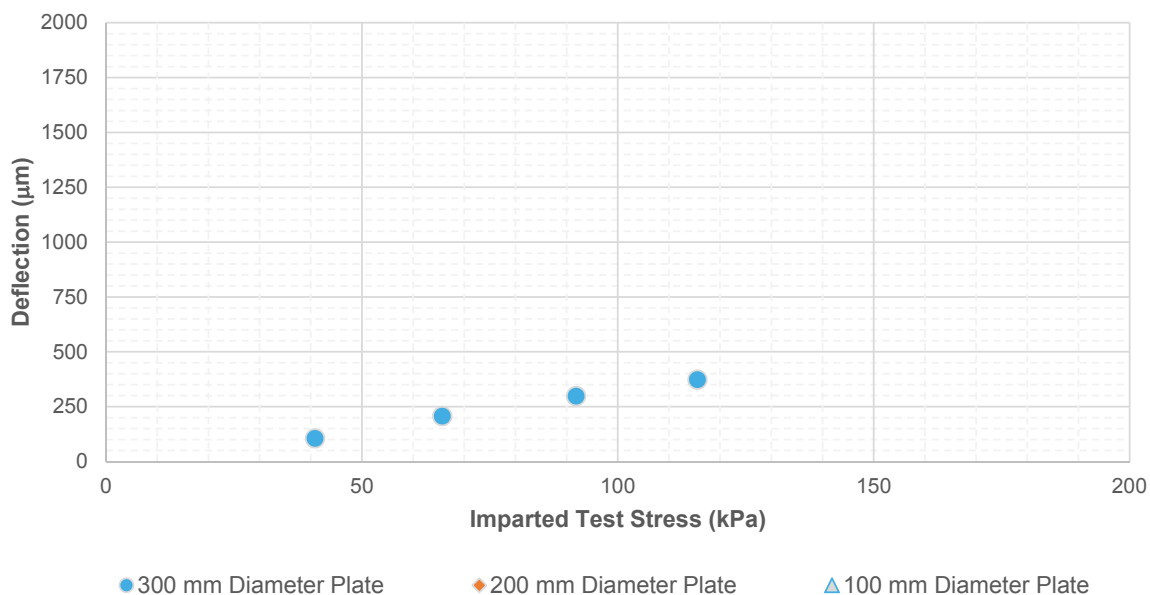
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	41	104.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
10	66	205.6						
3	92	296.8						
6	116	372.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	95.2
			100	81.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-1

Certificate Reference: 2091-LFWD-PRIMA-Site 19-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 25/02/2019

Location: Site 19-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

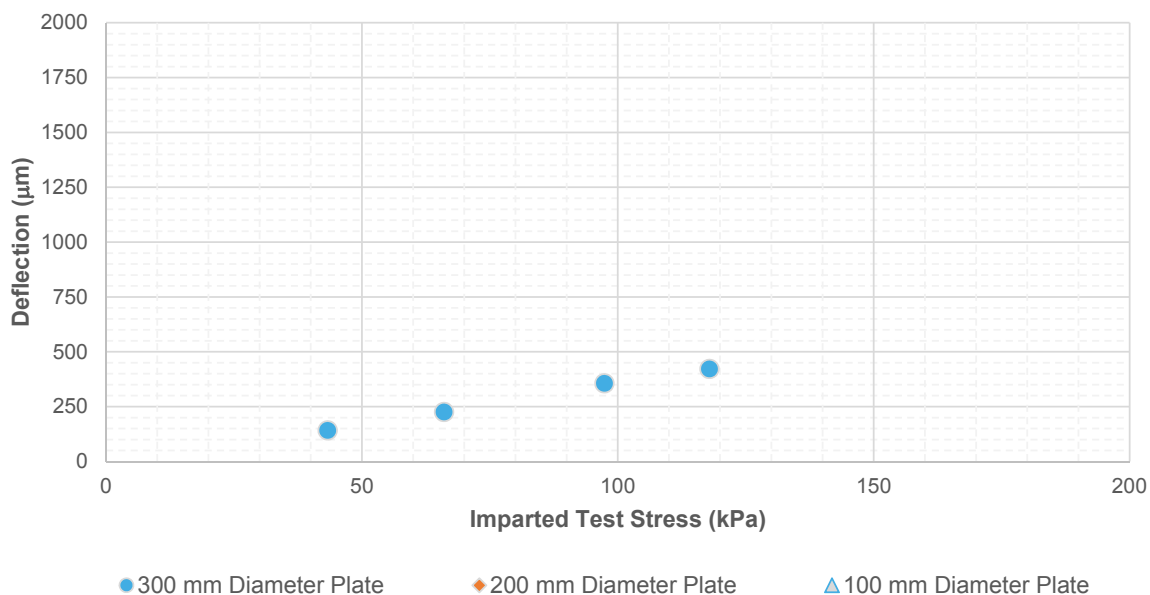
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	43	140.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	66	224.6						
4	97	355.2						
6	118	421.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	79.8
			100	75.1
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-2

Certificate Reference: 2091-LFWD-PRIMA-Site 19-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 25/02/2019

Location: Site 19-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

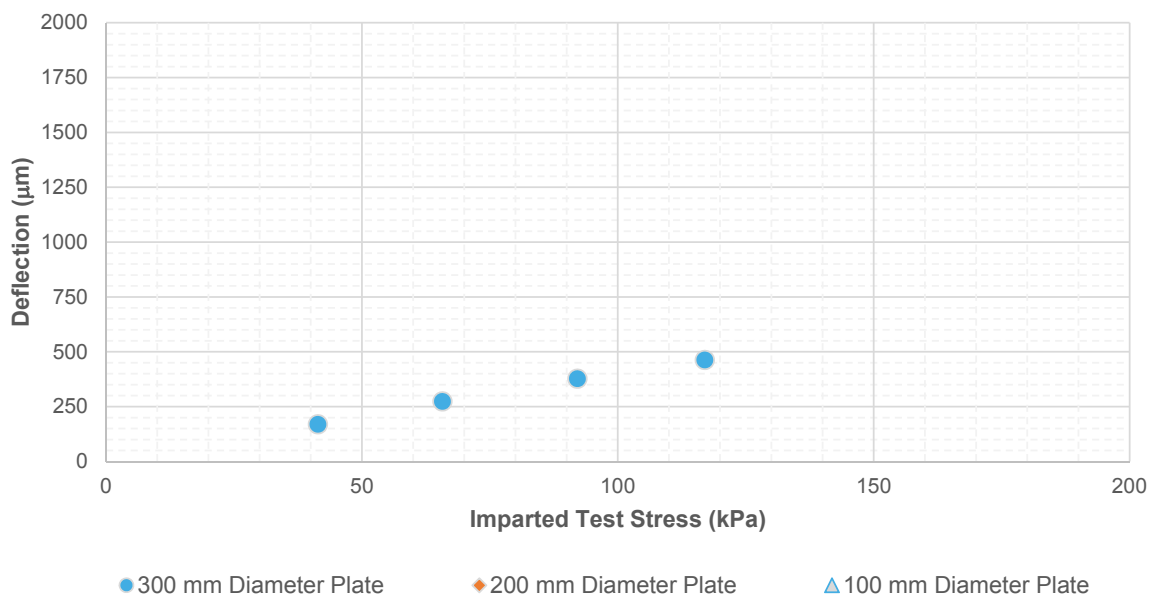
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	41	168.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	66	273.2						
3	92	376.2						
7	117	461.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	63.9
			100	65.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-3

Certificate Reference: 2091-LFWD-PRIMA-Site 19-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 25/02/2019

Location: Site 19-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

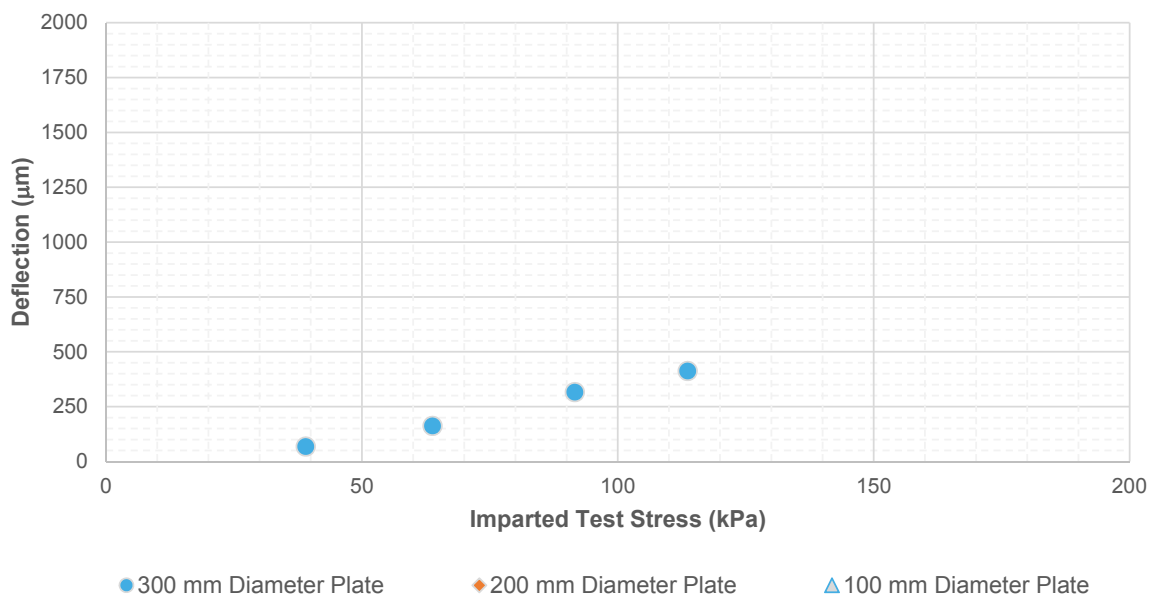
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	39	67.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	64	161.5						
3	92	315.6						
10	114	411.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	126
			100	75.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-4

Certificate Reference: 2091-LFWD-PRIMA-Site 19-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 25/02/2019

Location: Site 19-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

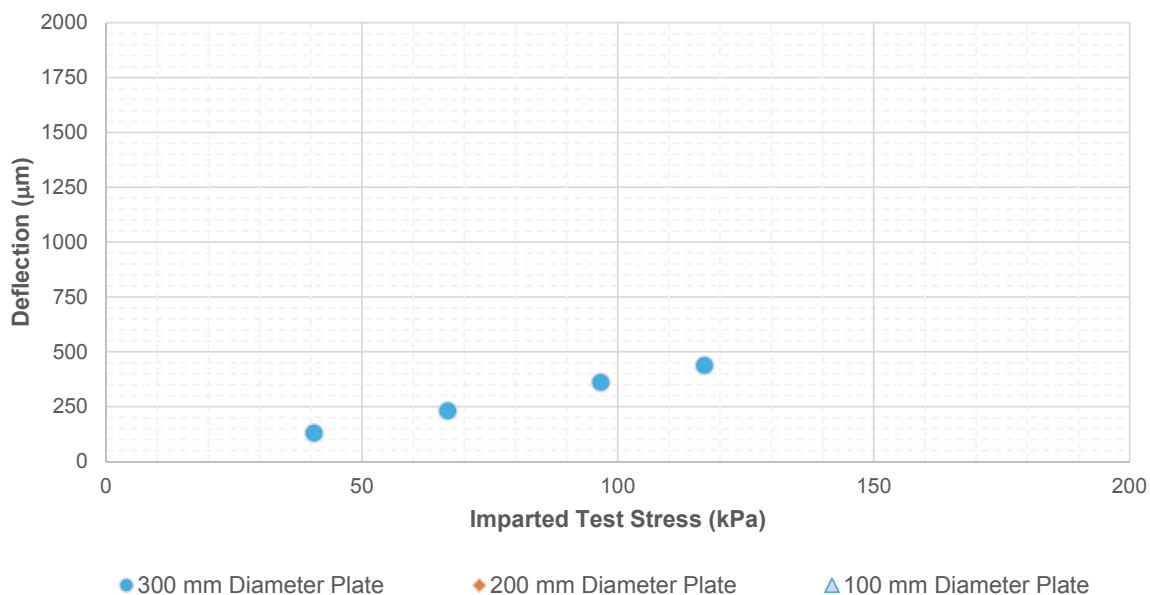
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	41	128.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	67	230.2						
5	97	359.9						
5	117	437.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	80.3
			100	71.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-5

Certificate Reference: 2091-LFWD-PRIMA-Site 19-5

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 26/02/2019

Location: Site 19-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

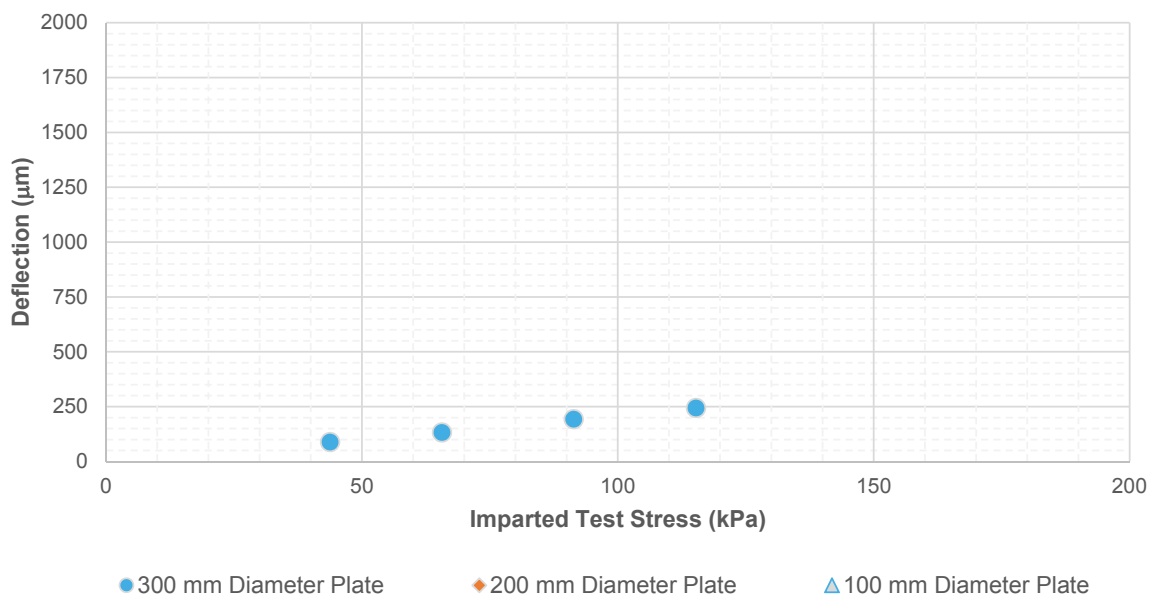
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	44	87.5	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	66	131.6						
5	91	192.0						
4	115	242.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	132
			100	126
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-6

Certificate Reference: 2091-LFWD-PRIMA-Site 19-6

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 26/02/2019

Location: Site 19-6 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

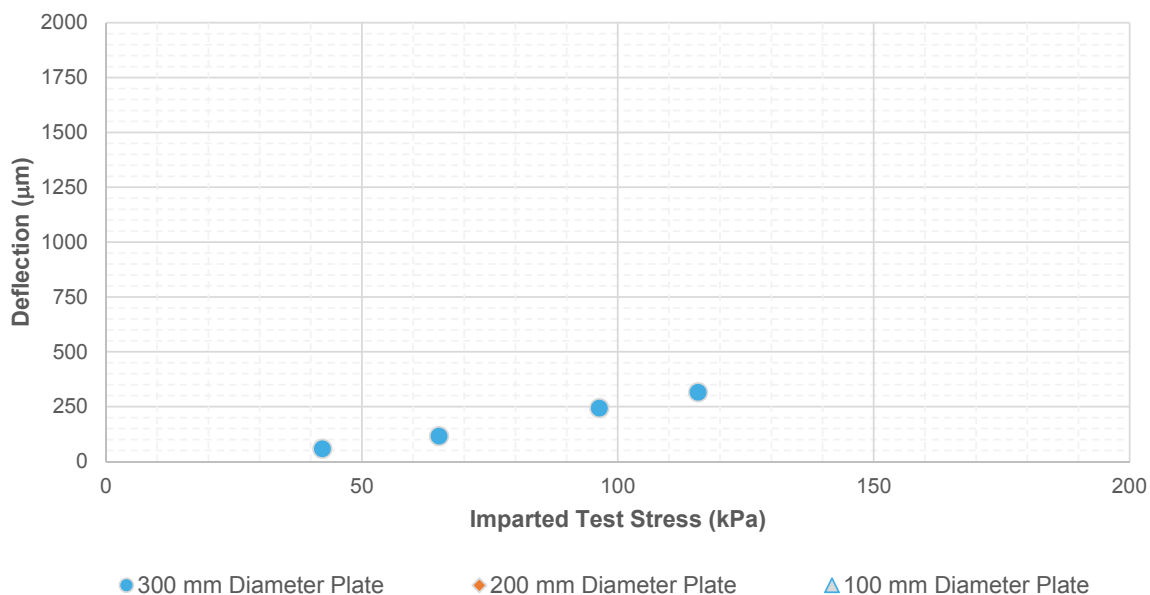
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
12	42	56.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	65	114.4						
5	96	242.6						
5	116	314.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	180
			100	96.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 19-7

Certificate Reference: 2091-LFWD-PRIMA-Site 19-7 **Sheet:** 1 of 1

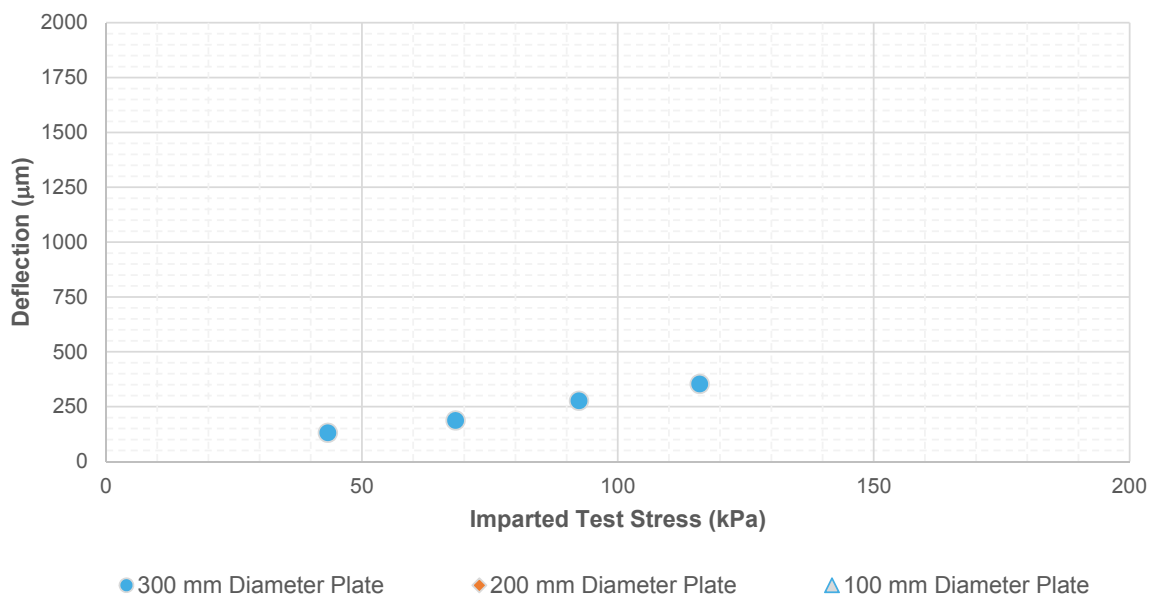
Client: ARRB Project: Best Practice in Compaction QA Location: Site 19-7 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (ν): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 26/02/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	--

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	43	130.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	68	185.8						
4	92	275.8						
7	116	352.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	87.8
			100	87.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 19-8

Certificate Reference: 2091-LFWD-PRIMA-Site 19-8 Sheet: 1 of 1

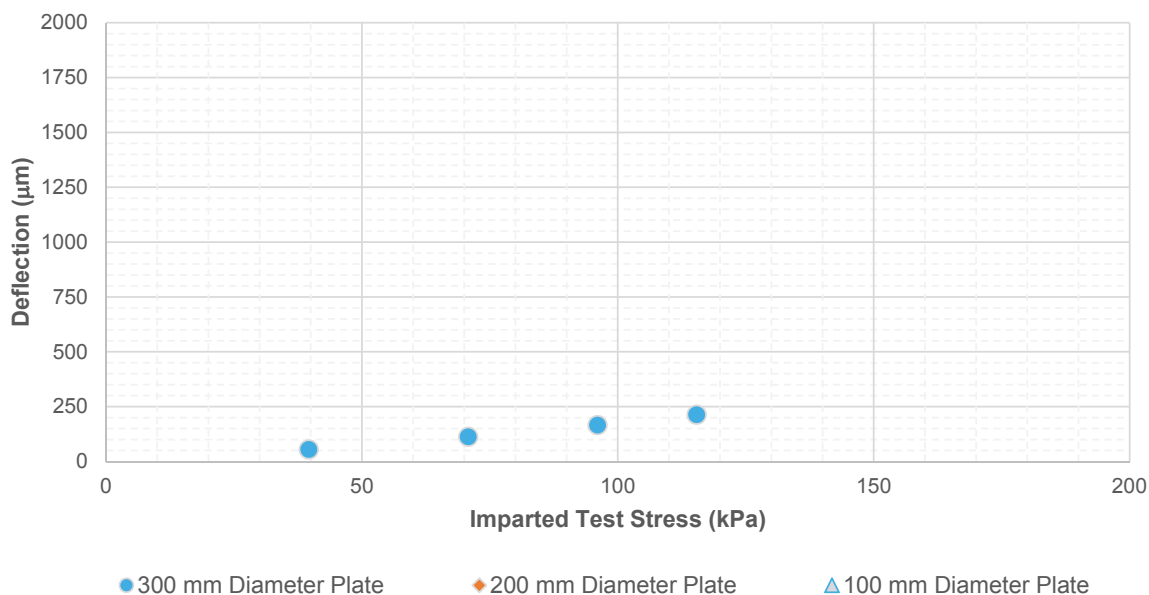
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 26/02/2019
 Location: Site 19-8 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	40	54.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	71	111.8						
6	96	165.0						
7	115	212.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	183
			100	151
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 19-9

Certificate Reference: 2091-LFWD-PRIMA-Site 19-9

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 26/02/2019

Location: Site 19-9 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

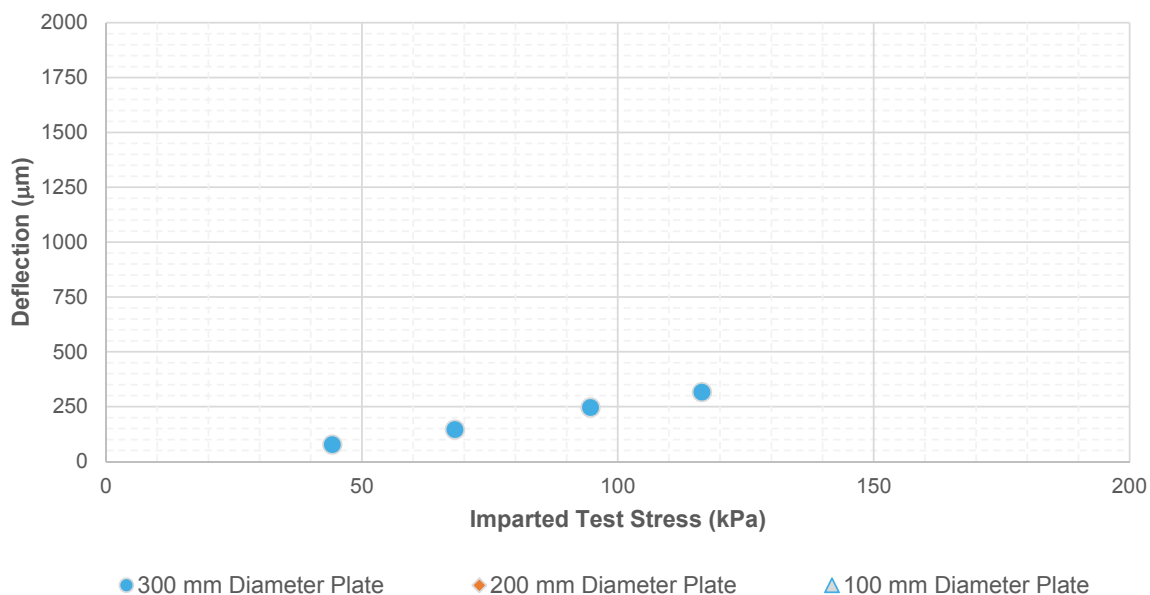
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	44	76.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	68	144.5						
4	95	245.3						
6	116	315.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	143
			100	102
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-10

Certificate Reference: 2091-LFWD-PRIMA-Site 19-10

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 26/02/2019

Location: Site 19-10 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

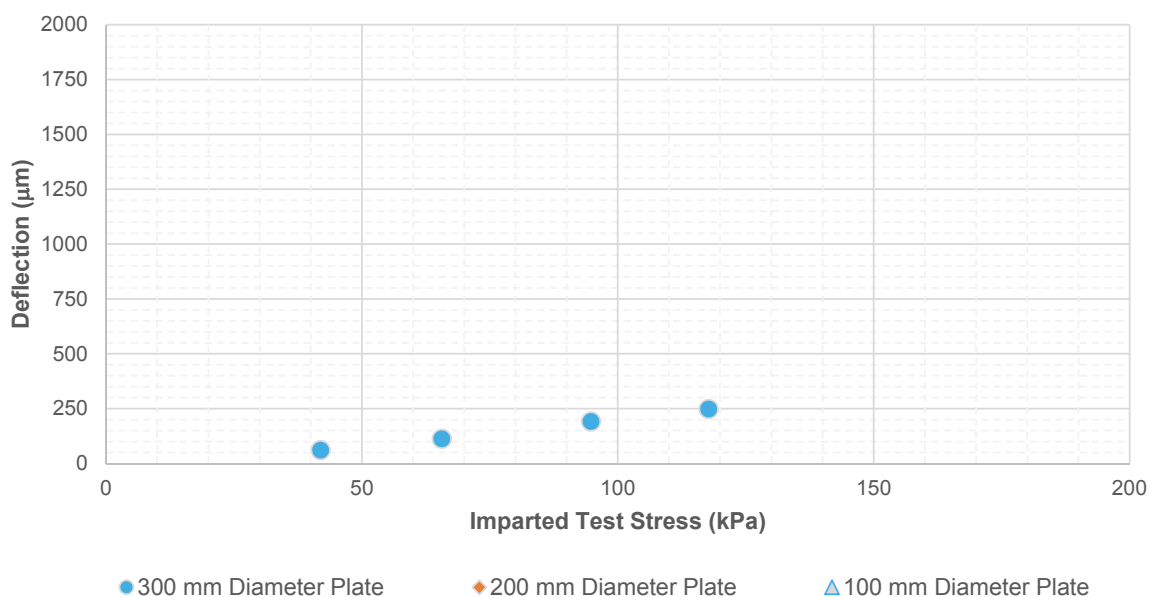
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	42	59.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	66	111.5						
8	95	190.8						
7	118	247.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	172
			100	131
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-11

Certificate Reference: 2091-LFWD-PRIMA-Site 19-11

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 26/02/2019

Location: Site 19-11 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

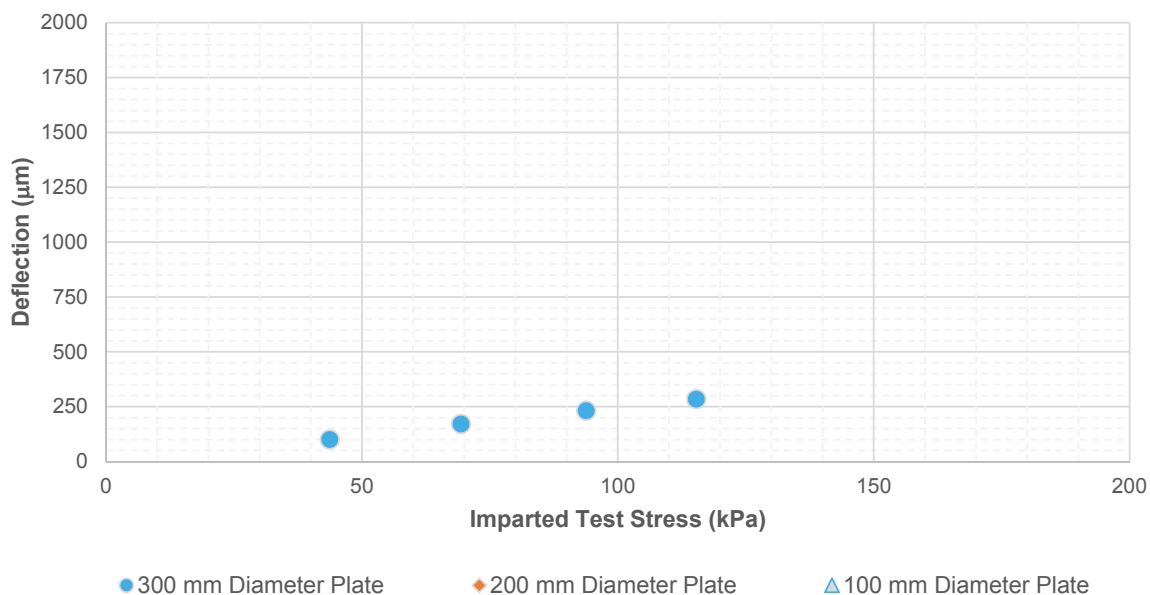
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	44	99.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	69	170.0						
5	94	230.4						
8	115	282.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	107
			100	107
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 19-12

Certificate Reference: 2091-LFWD-PRIMA-Site 19-12 Sheet: 1 of 1

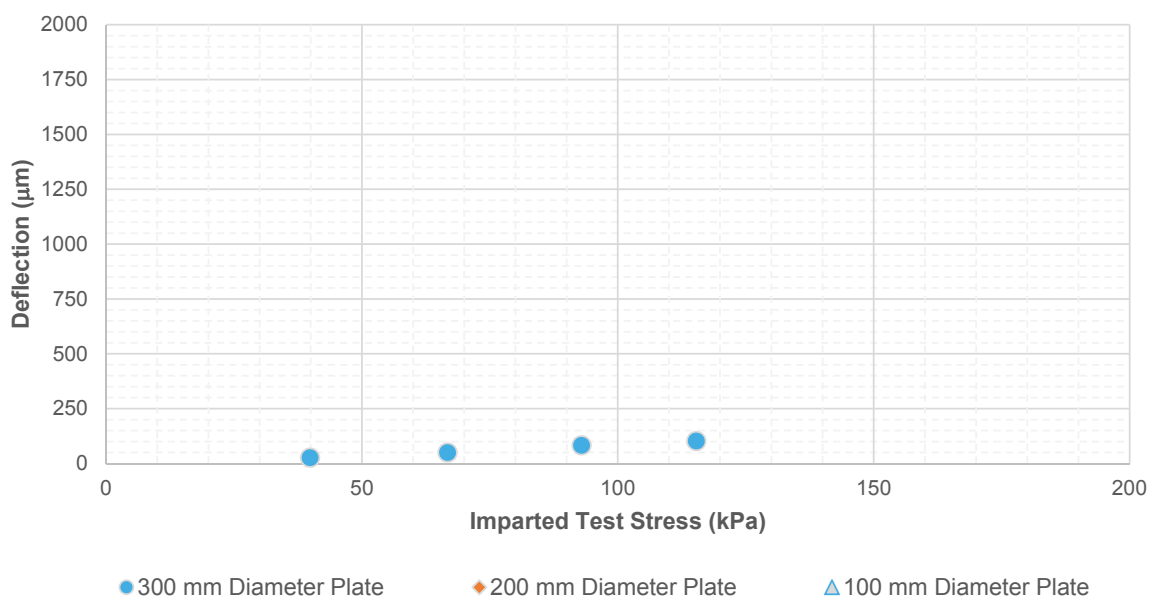
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 26/02/2019
 Location: Site 19-12 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	40	25.4 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
10	67	49.1 ⁺						
5	93	81.5						
6	115	101.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	394 ⁺
			100	285
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 19-12A

Certificate Reference: 2091-LFWD-PRIMA-Site 19-12A Sheet: 1 of 1

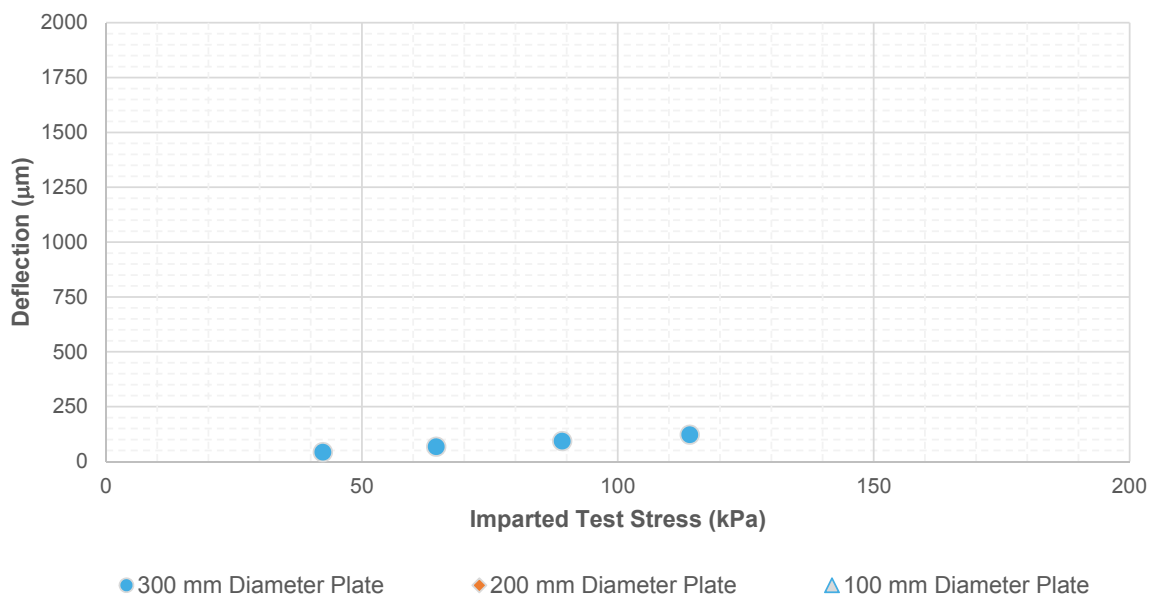
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 26/02/2019
 Location: Site 19-12 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	42	42.0 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	65	66.4						
6	89	92.0						
5	114	121.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	263
			100	251
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 19-13

Certificate Reference: 2091-LFWD-PRIMA-Site 19-13

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 26/02/2019

Location: Site 19-13 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

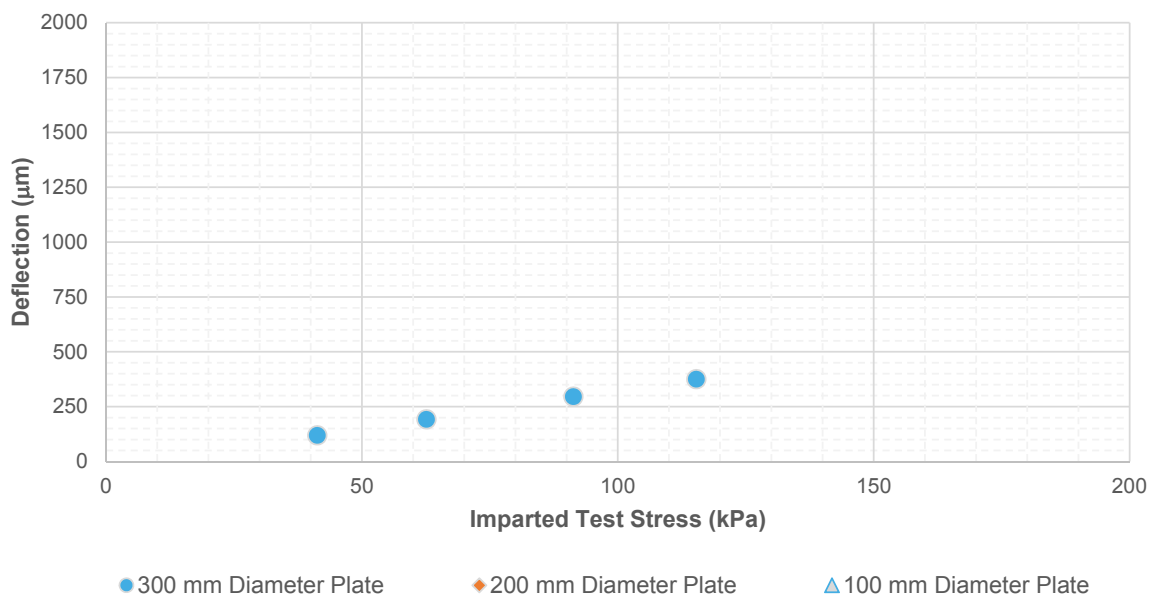
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	41	118.5	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	63	191.6						
9	91	294.6						
7	115	374.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	89.5
			100	79.5
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 19-14

Certificate Reference: 2091-LFWD-PRIMA-Site 19-14 **Sheet:** 1 of 1

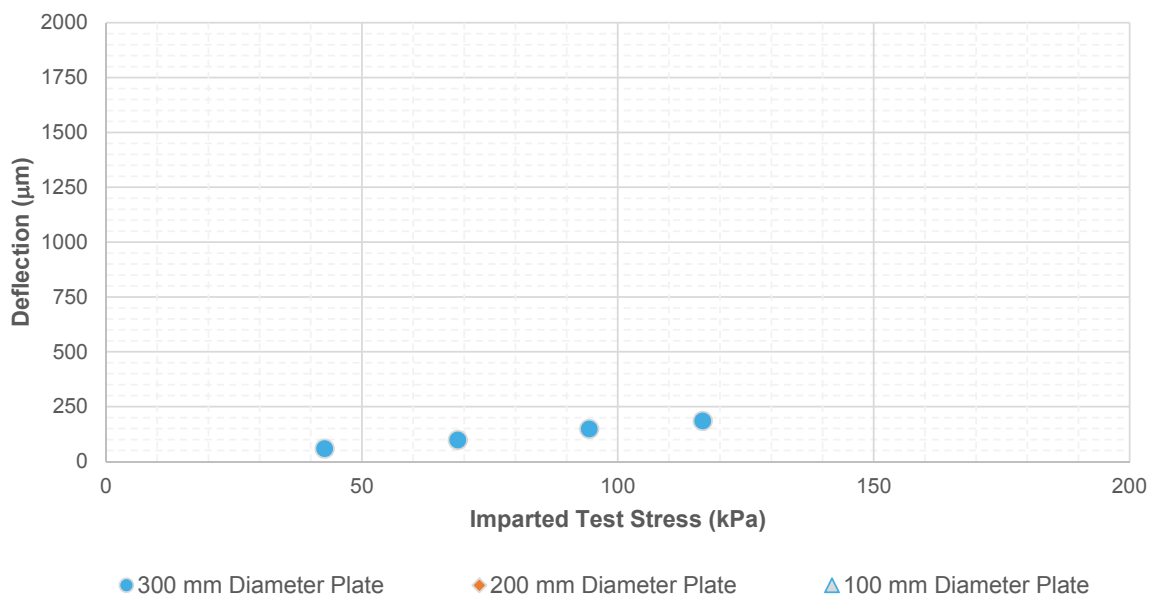
Client: ARRB Project: Best Practice in Compaction QA Location: Site 19-14 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (v): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 26/02/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	--

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
4	43	57.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	69	97.5						
7	94	147.6						
4	117	183.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	192
			100	171
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-1

Certificate Reference: 2091-LFWD-PRIMA-Site 21-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 27/02/2019

Location: Site 21-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

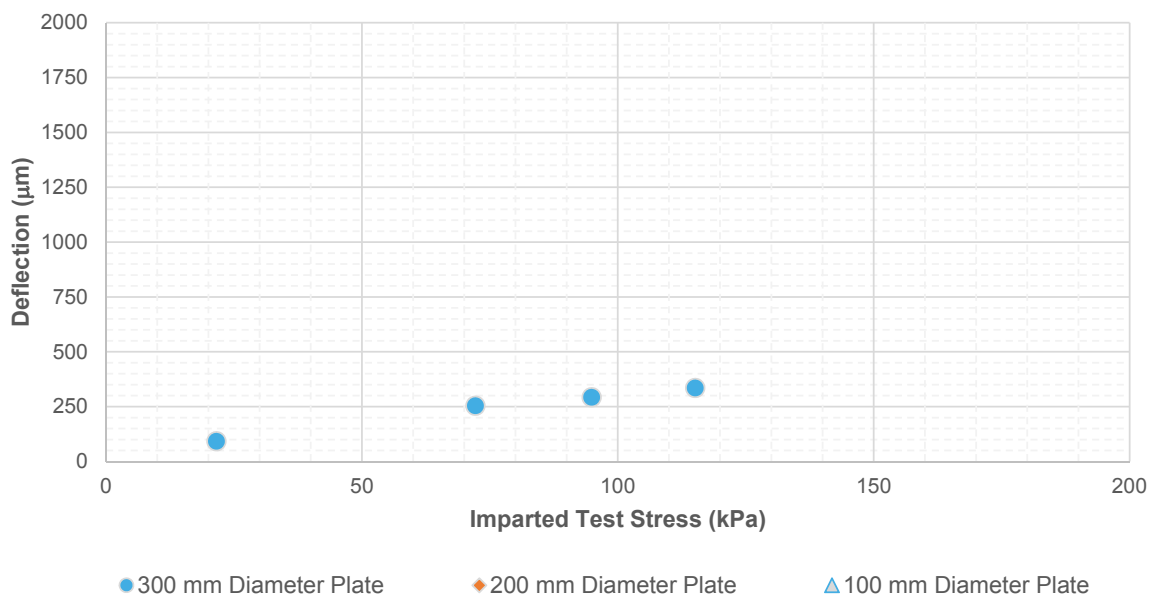
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	22	91.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	72	253.5						
4	95	292.2						
13	115	334.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	70.1
			100	85.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-1 (Retest after > 24hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 21-1-R **Sheet:** 1 of 1

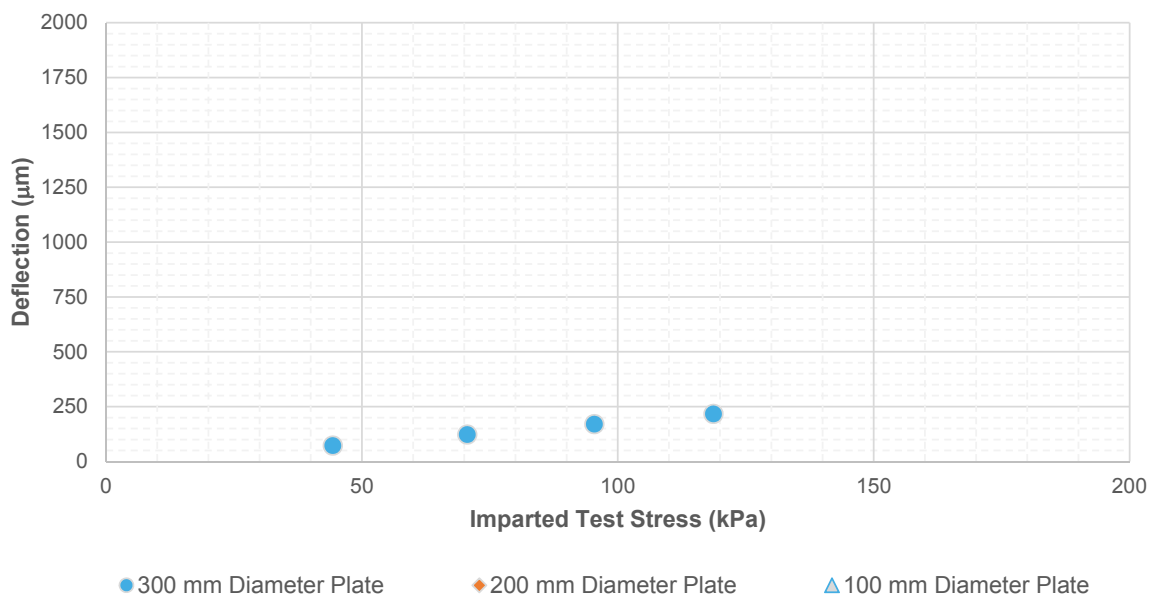
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 1/03/2019
Location: Site 21-1 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	44	71.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	71	122.0						
4	95	169.5						
7	119	216.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	160
			100	147
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-2

Certificate Reference: 2091-LFWD-PRIMA-Site 21-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 27/02/2019

Location: Site 21-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

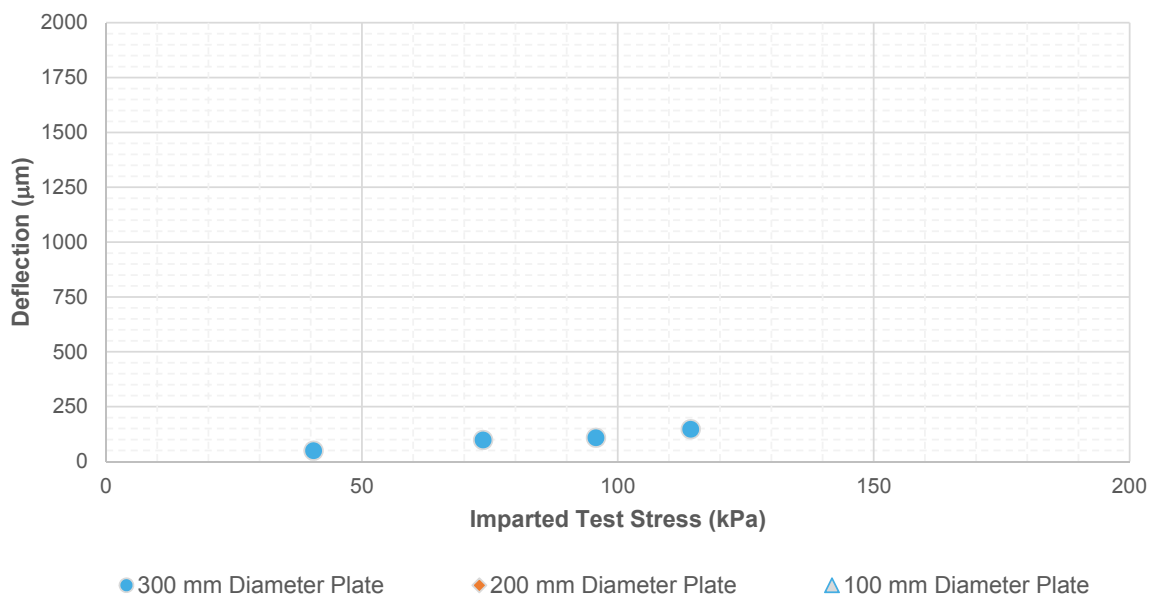
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	41	48.5 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	74	97.4						
5	96	107.3						
4	114	146.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	213
			100	204
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-2 (Retest after > 24hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 21-2-R **Sheet:** 1 of 1

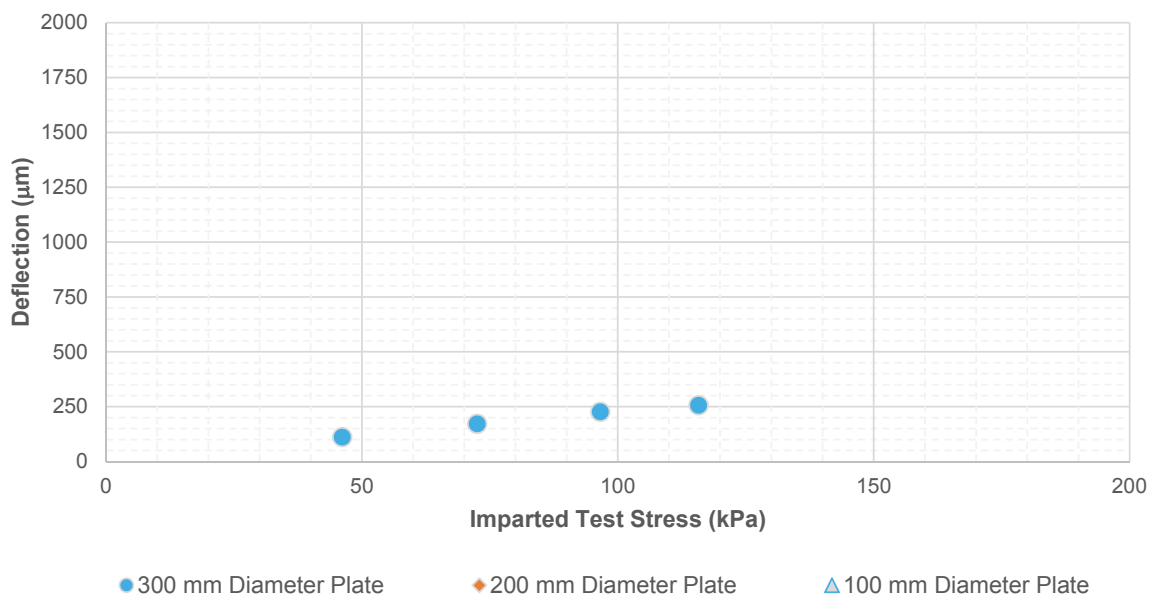
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 1/03/2019
Location: Site 21-2 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	46	110.0	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	73	170.7						
7	97	225.3						
5	116	255.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	111
			100	113
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-3

Certificate Reference: 2091-LFWD-PRIMA-Site 21-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 27/02/2019

Location: Site 21-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

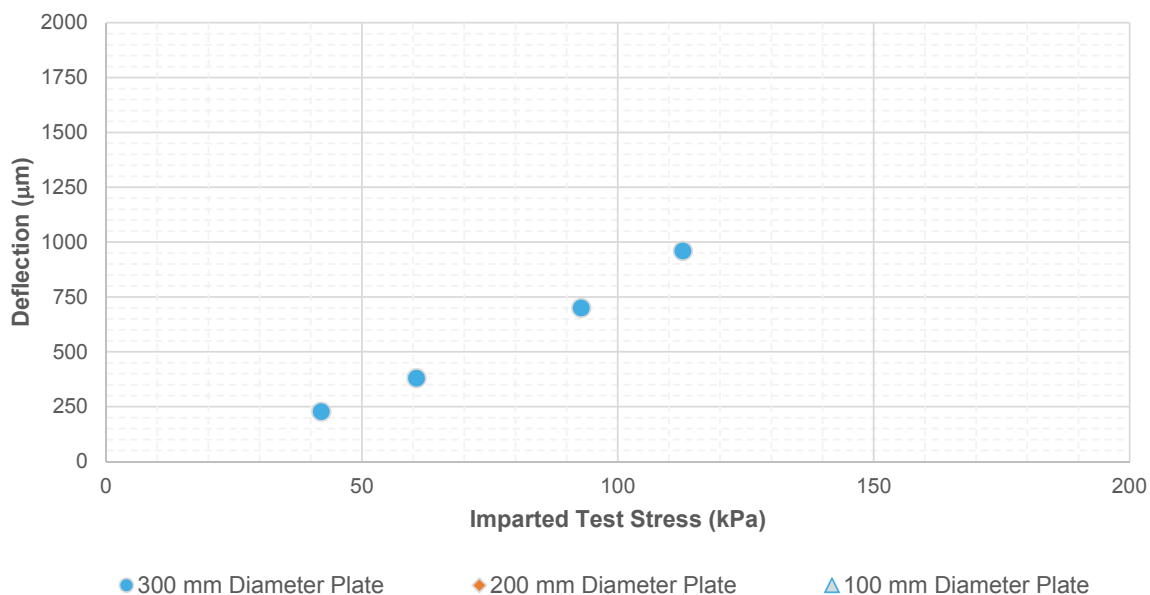
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	42	226.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	61	378.6						
7	93	699.0						
5	113	958.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	46.2
			100	33.5
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-3 (Retest after > 24hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 21-3-R **Sheet:** 1 of 1

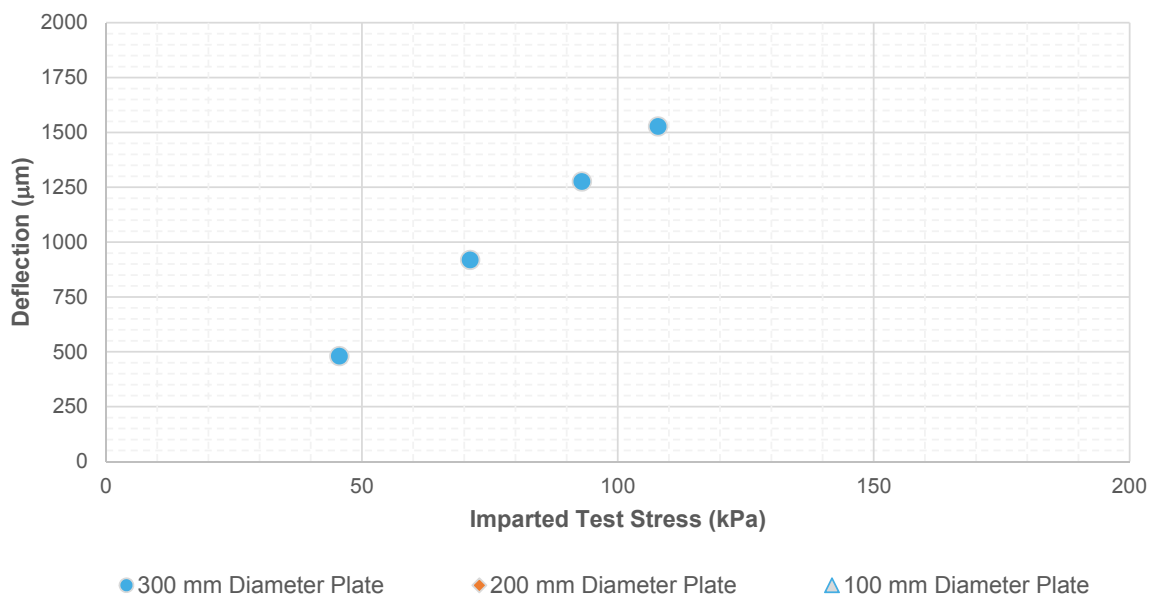
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 1/03/2019
Location: Site 21-3 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (v): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
5	46	479.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	71	917.7						
7	93	1275.2						
4	108	1526.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	23.9
			100	18.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-4

Certificate Reference: 2091-LFWD-PRIMA-Site 21-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 27/02/2019

Location: Site 21-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

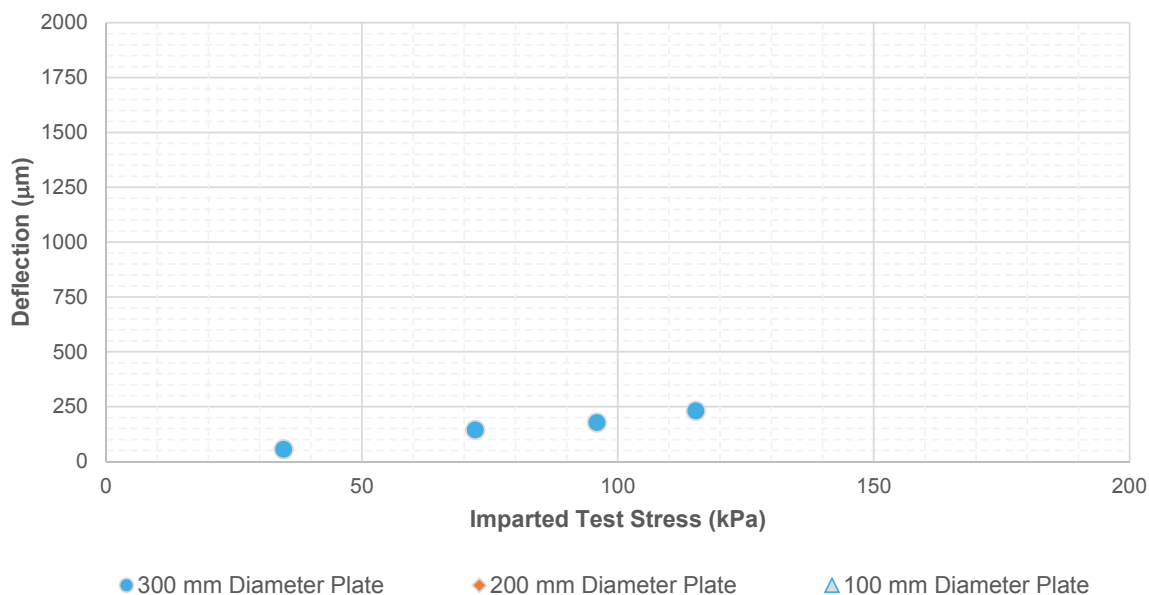
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	35	54.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	72	143.3						
4	96	176.6						
9	115	230.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	164
			100	140
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-4 (Retest after > 24hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 21-4-R **Sheet:** 1 of 1

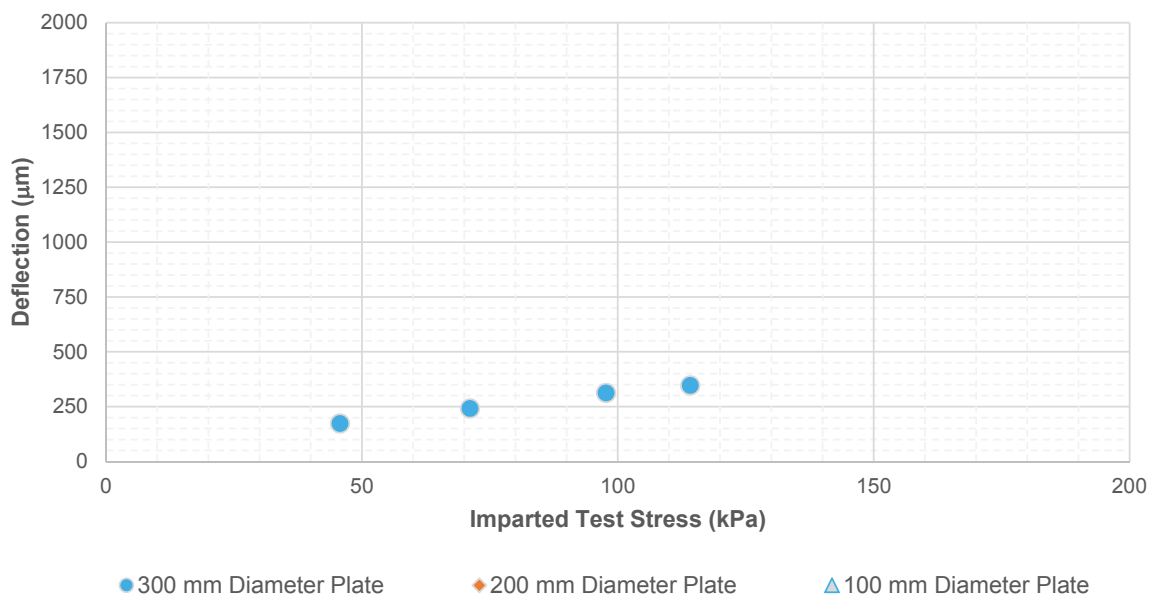
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 1/03/2019
Location: Site 21-4 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	46	172.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	71	241.0						
4	98	311.5						
5	114	346.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	71.5
			100	83.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 21-5

Certificate Reference: 2091-LFWD-PRIMA-Site 21-5 **Sheet:** 1 of 1

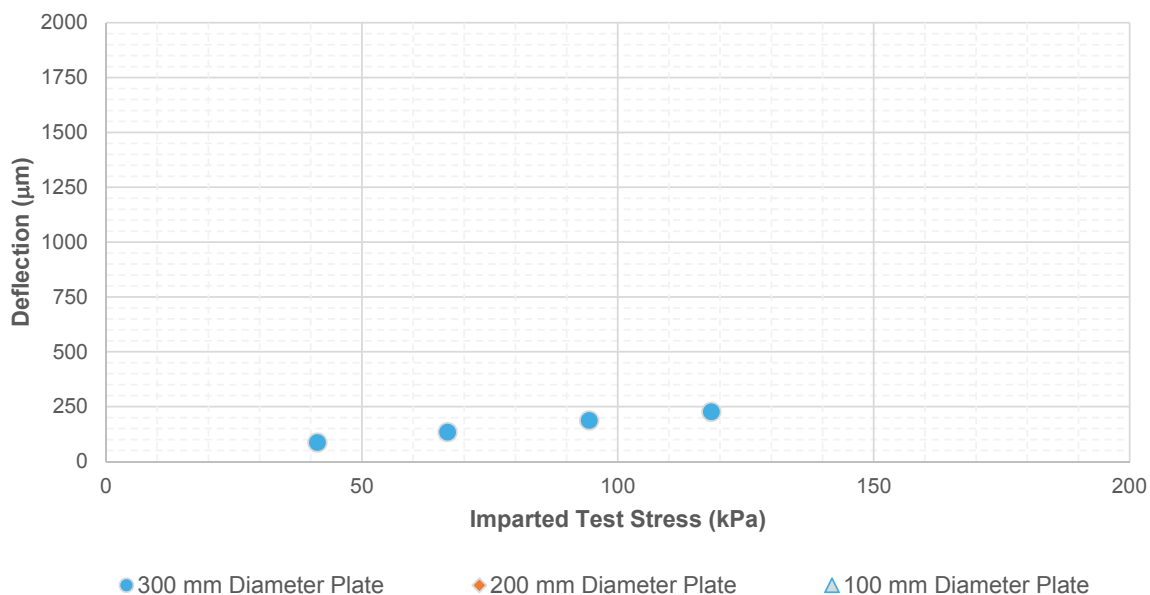
Client: ARRB Project: Best Practice in Compaction QA Location: Site 21-5 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (ν): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 1/03/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	---

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	85.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	67	133.2						
6	94	185.9						
7	118	225.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	129
			100	135
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 21-6

Certificate Reference: 2091-LFWD-PRIMA-Site 21-6 Sheet: 1 of 1

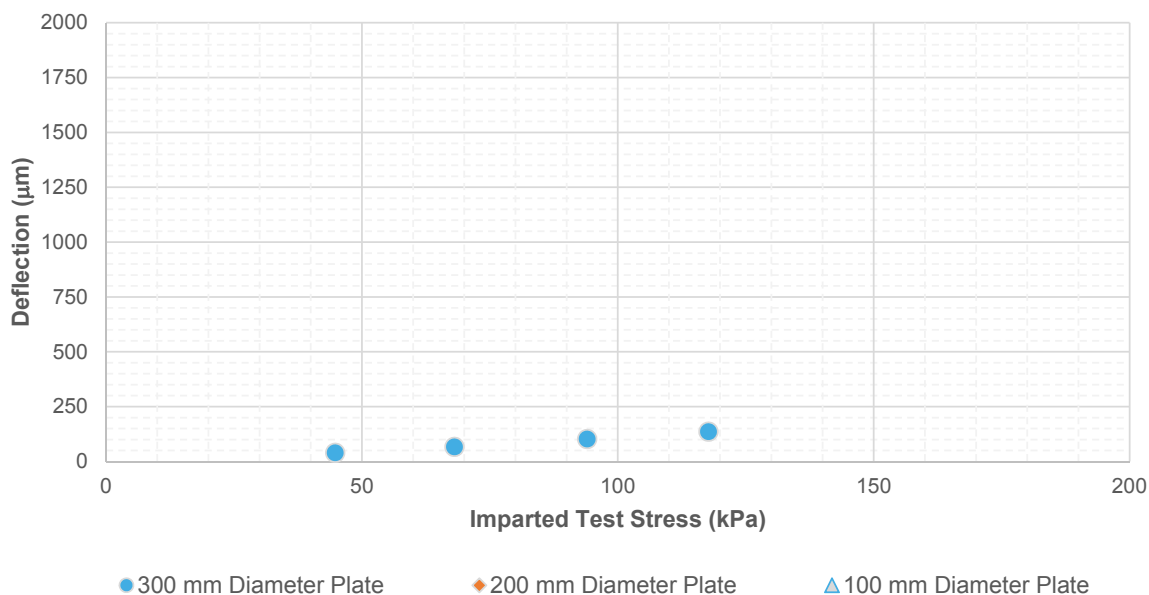
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 1/03/2019
 Location: Site 21-6 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	45	38.9 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	68	66.0						
9	94	101.5						
8	118	135.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	294 ⁺
			100	243
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 21-7

Certificate Reference: 2091-LFWD-PRIMA-Site 21-7 Sheet: 1 of 1

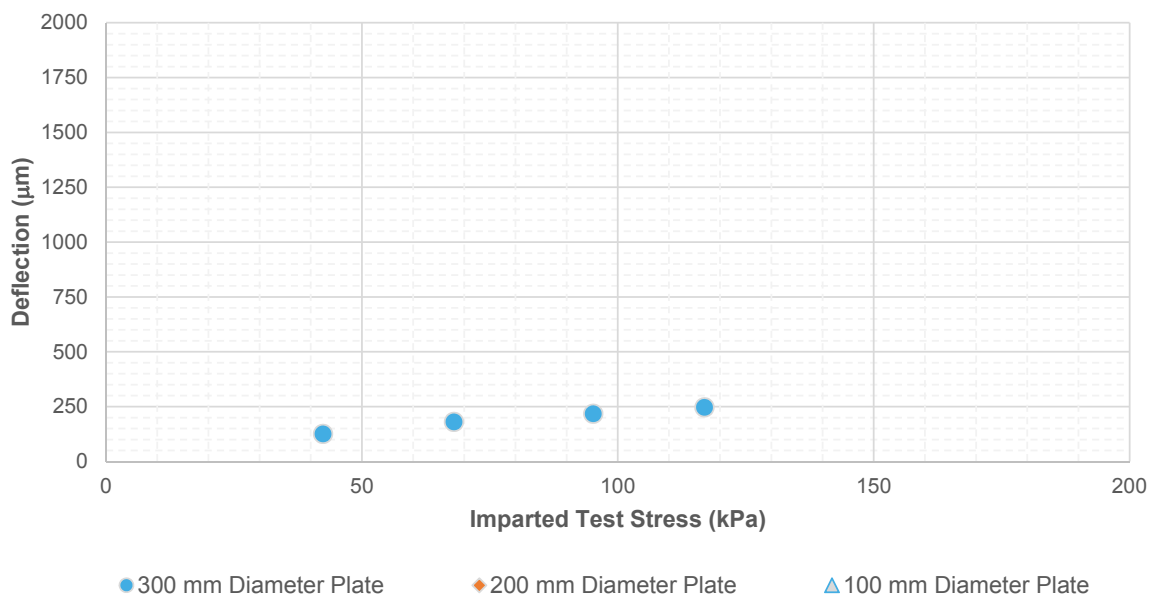
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 1/03/2019
 Location: Site 21-7 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	42	125.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	68	179.4						
6	95	217.0						
8	117	245.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	92.4
			100	117
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 21-8

Certificate Reference: 2091-LFWD-PRIMA-Site 21-8 **Sheet:** 1 of 1

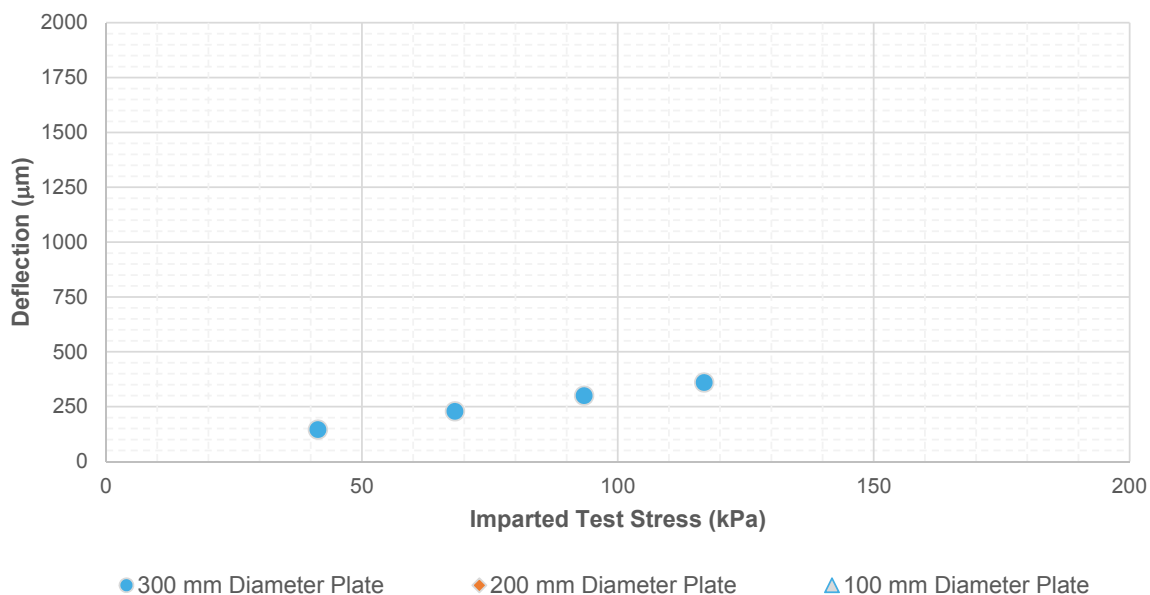
Client: ARRB Project: Best Practice in Compaction QA Location: Site 21-8 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (ν): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 1/03/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	---

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	41	144.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	68	227.7						
5	93	299.6						
8	117	359.2						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	76.6
			100	83.3
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-9

Certificate Reference: 2091-LFWD-PRIMA-Site 21-9

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 1/03/2019

Location: Site 21-9 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

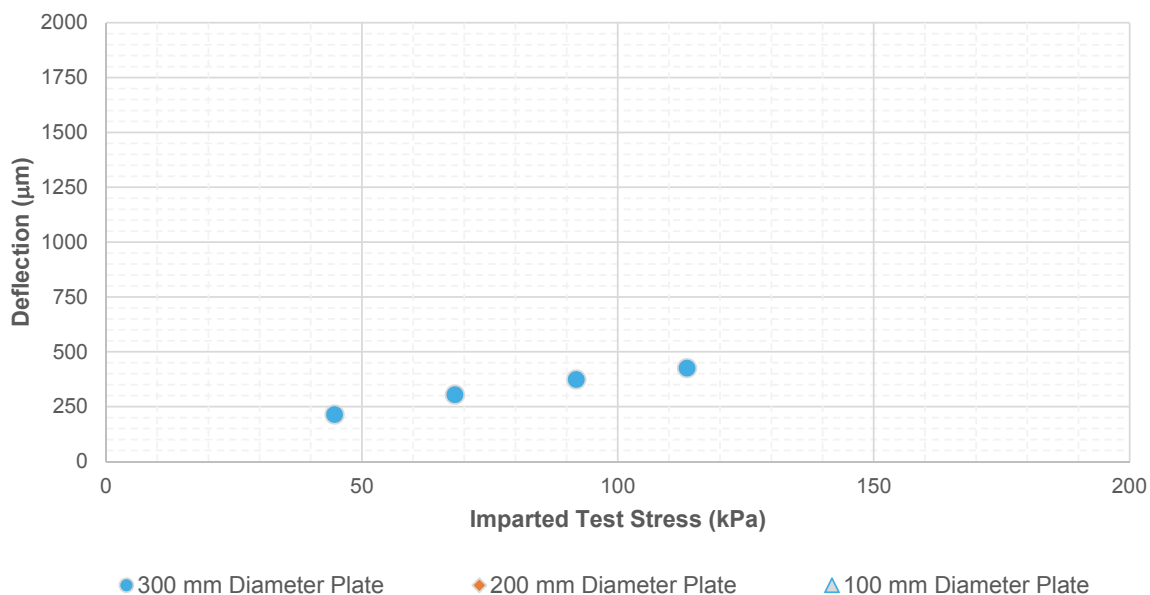
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	45	213.5	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	68	303.6						
6	92	373.1						
8	114	424.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	55.8
			100	67.0
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 21-10

Certificate Reference: 2091-LFWD-PRIMA-Site 21-10 **Sheet:** 1 of 1

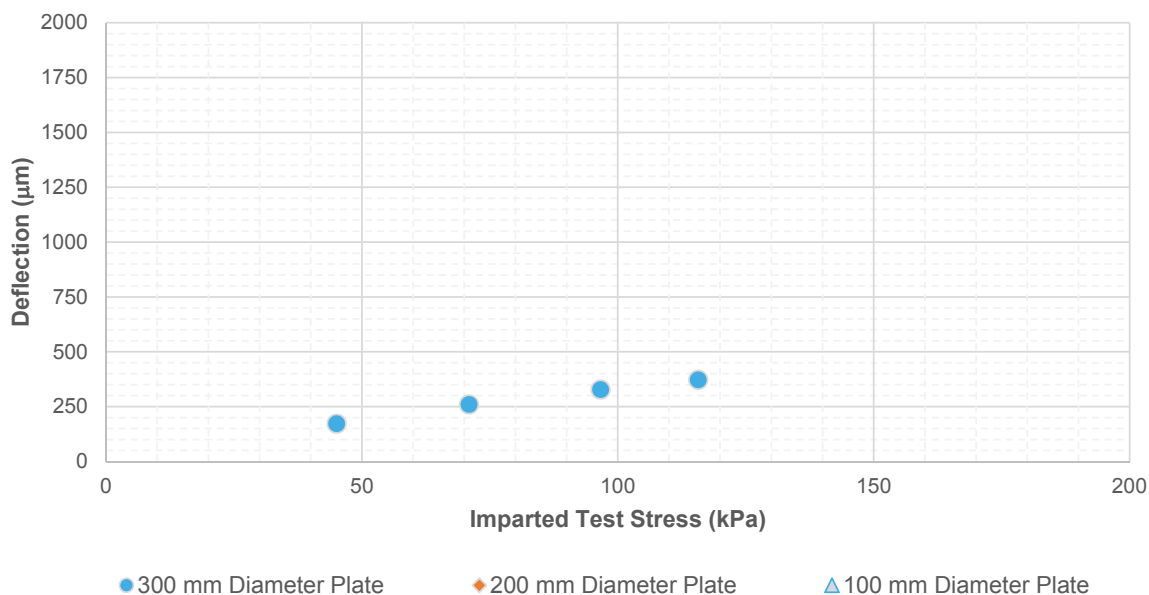
Client: ARRB Project: Best Practice in Compaction QA Location: Site 21-10 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (v): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 1/03/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	---

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
6	45	171.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	71	259.0						
5	97	327.2						
6	116	371.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	69.4
			100	78.5
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 21-11

Certificate Reference: 2091-LFWD-PRIMA-Site 21-11 **Sheet:** 1 of 1

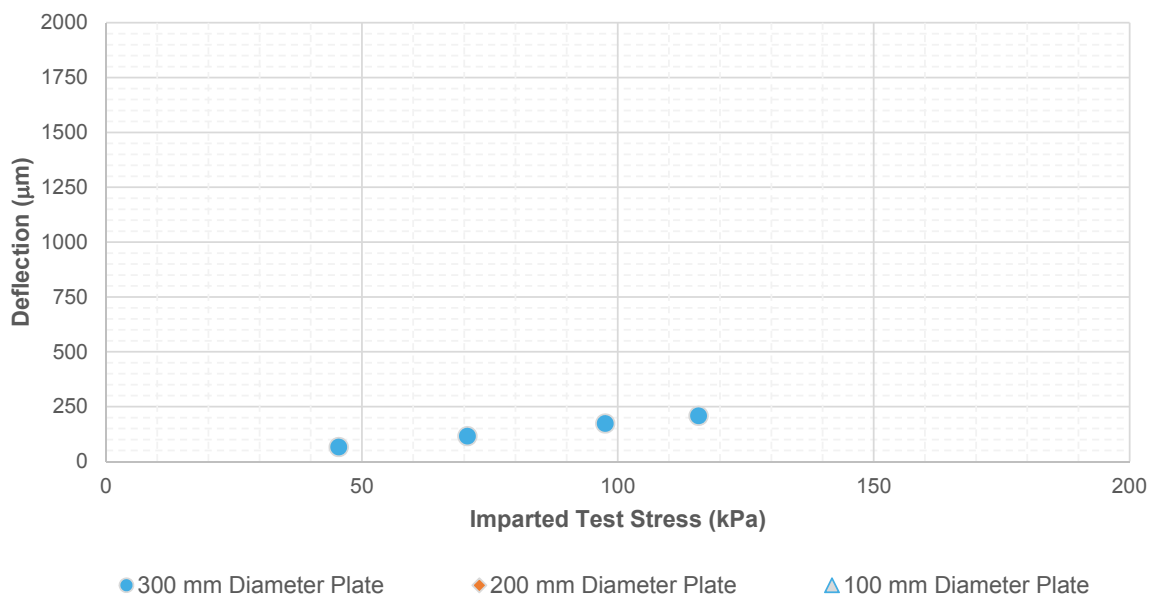
Client: ARRB Project: Best Practice in Compaction QA Location: Site 21-11 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (v): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 1/03/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	---

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
3	45	65.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	71	115.0						
5	98	172.2						
5	116	207.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	177
			100	151
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 21-12

Certificate Reference: 2091-LFWD-PRIMA-Site 21-12 Sheet: 1 of 1

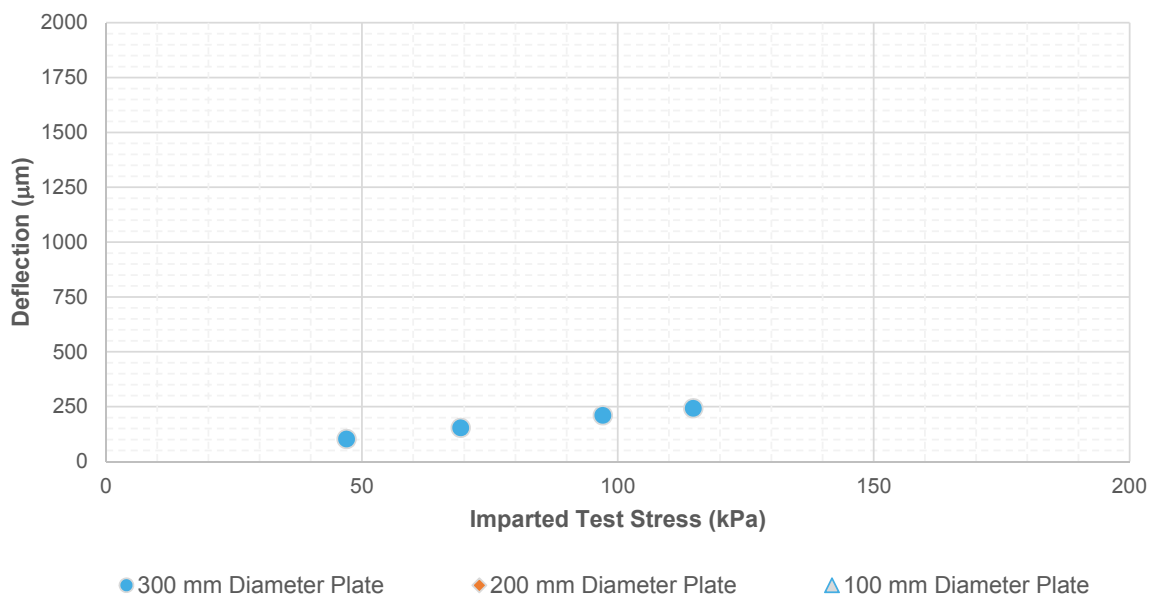
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 1/03/2019
 Location: Site 21-12 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	47	101.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	69	152.7						
6	97	209.5						
7	115	241.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	117
			100	123
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 21-13

Certificate Reference: 2091-LFWD-PRIMA-Site 21-13

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 1/03/2019

Location: Site 21-13 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

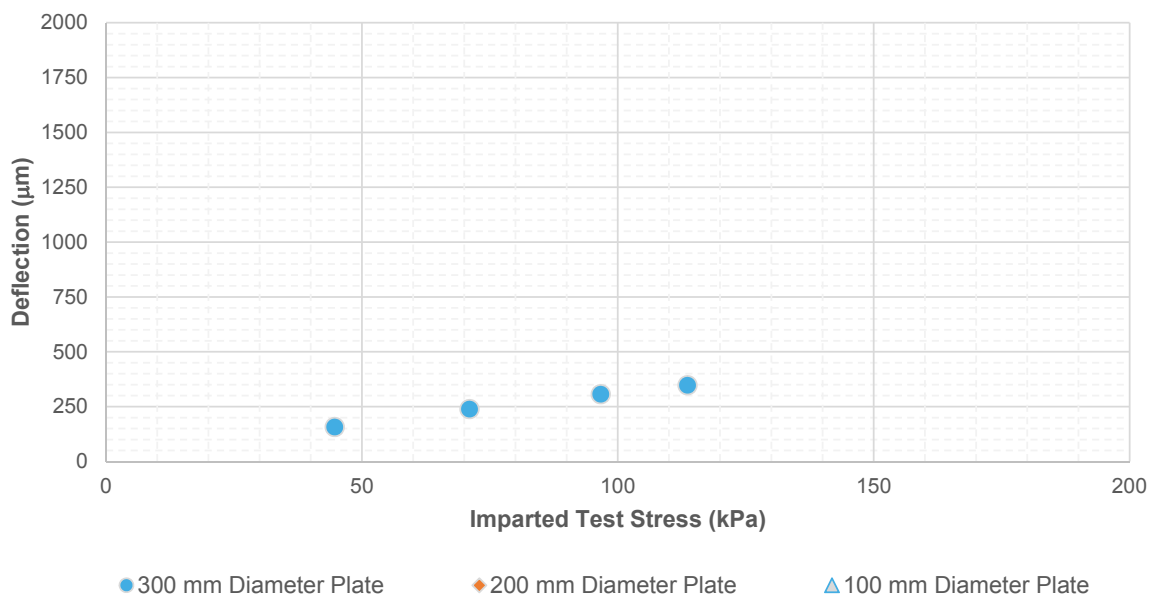
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	45	156.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	71	238.3						
4	97	305.6						
5	114	346.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	75.7
			100	83.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 21-14

Certificate Reference: 2091-LFWD-PRIMA-Site 21-14 **Sheet:** 1 of 1

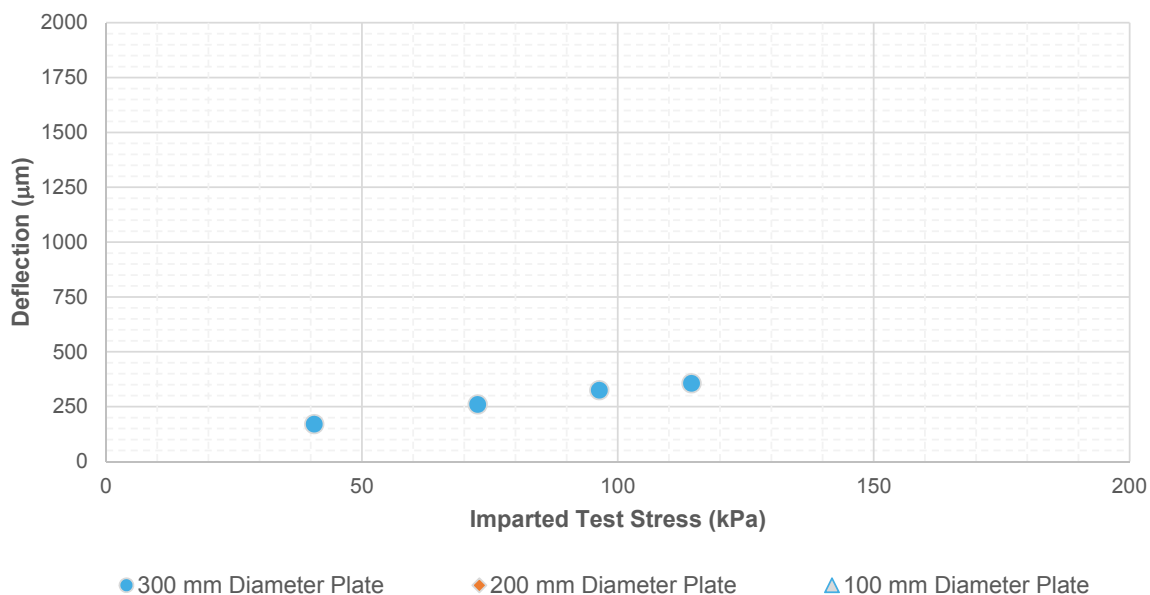
Client: ARRB Project: Best Practice in Compaction QA Location: Site 21-14 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (v): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 1/03/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	---

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
6	41	169.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	73	259.4						
3	96	324.4						
5	114	355.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	66.5
			100	80.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 22-1

Certificate Reference: 2091-LFWD-PRIMA-Site 22-1 Sheet: 1 of 1

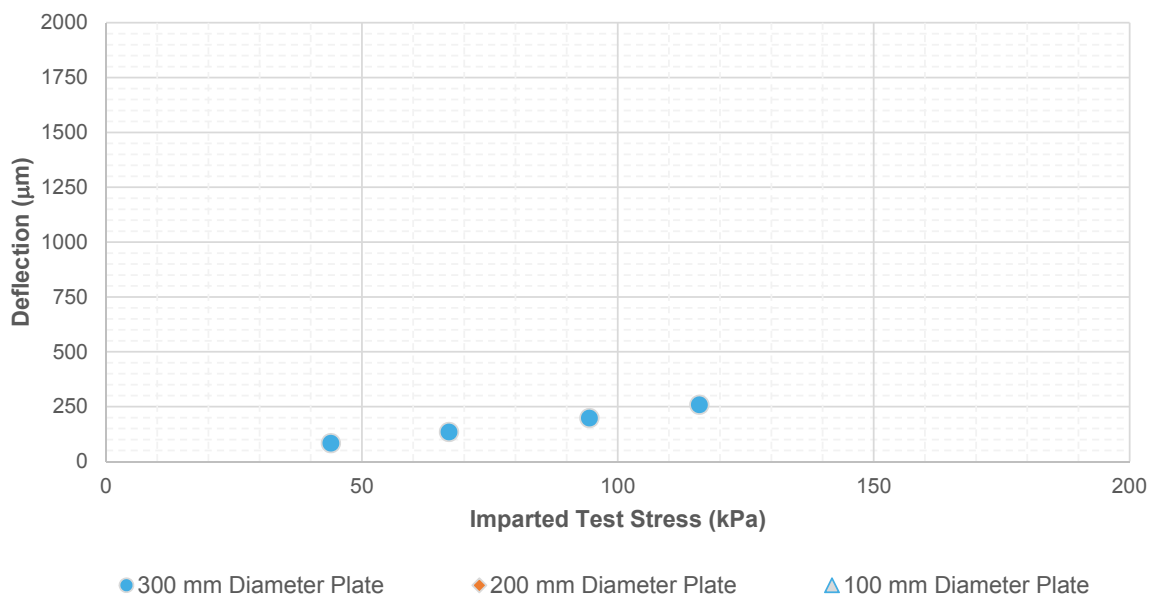
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 27/02/2019
 Location: Site 22-1 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	44	82.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	67	133.9						
4	94	197.2						
6	116	257.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	138
			100	123
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 22-2

Certificate Reference: 2091-LFWD-PRIMA-Site 22-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 27/02/2019

Location: Site 22-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

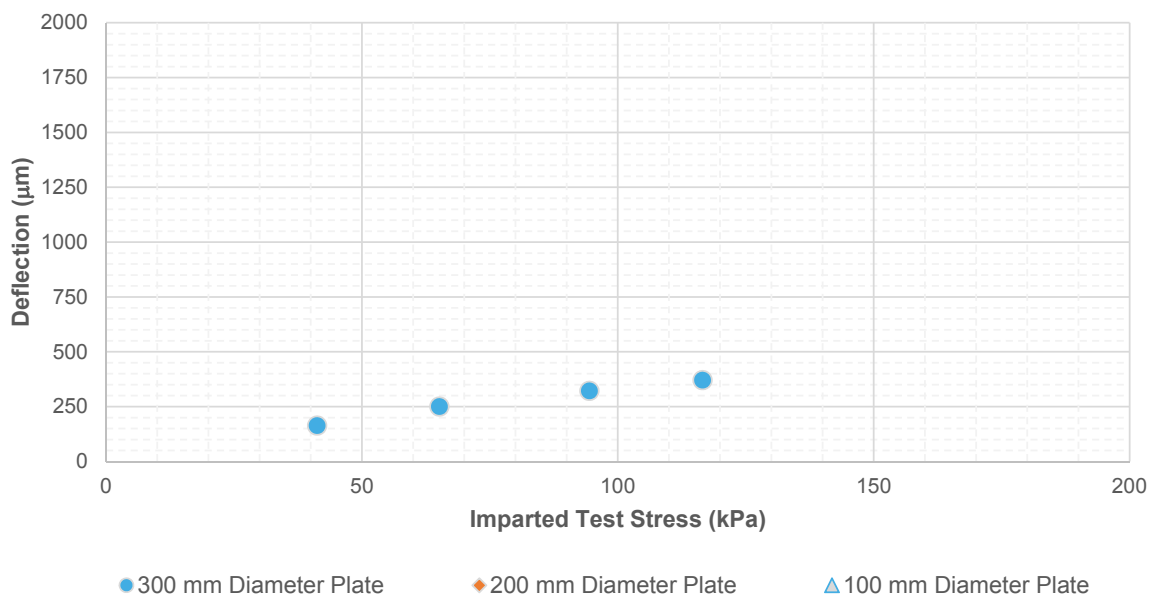
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	41	163.0	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	65	249.5						
7	94	321.5						
10	117	370.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	67.3
			100	78.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 22-3

Certificate Reference: 2091-LFWD-PRIMA-Site 22-3 Sheet: 1 of 1

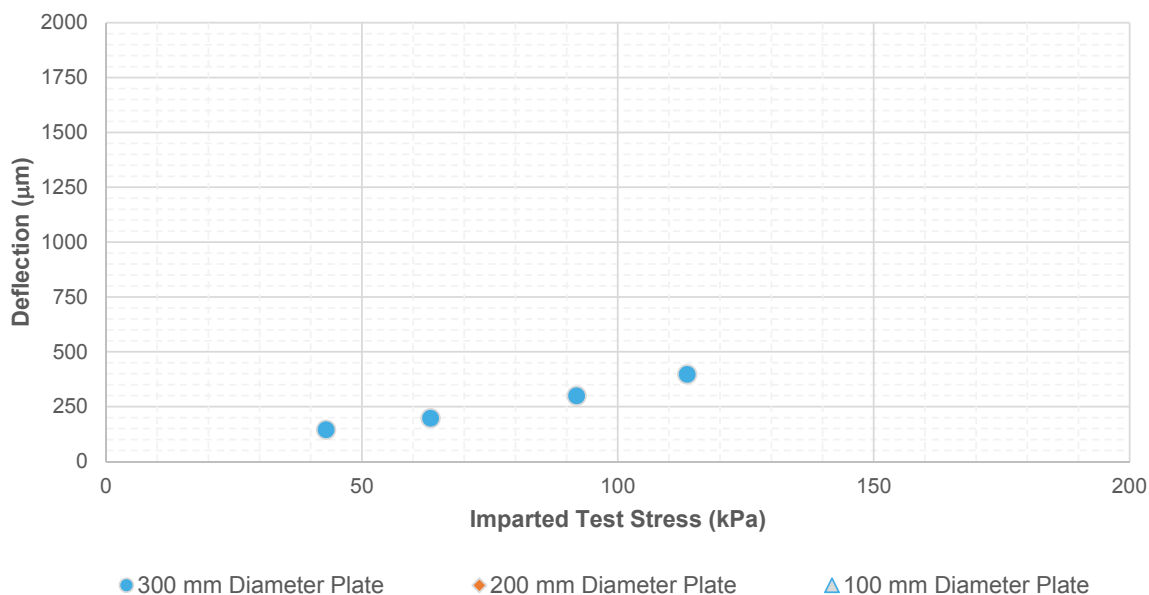
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 27/02/2019
 Location: Site 22-3 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	43	143.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	63	196.2						
7	92	298.3						
10	114	396.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	88.1
			100	78.7
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 22-4

Certificate Reference: 2091-LFWD-PRIMA-Site 22-4 **Sheet:** 1 of 1

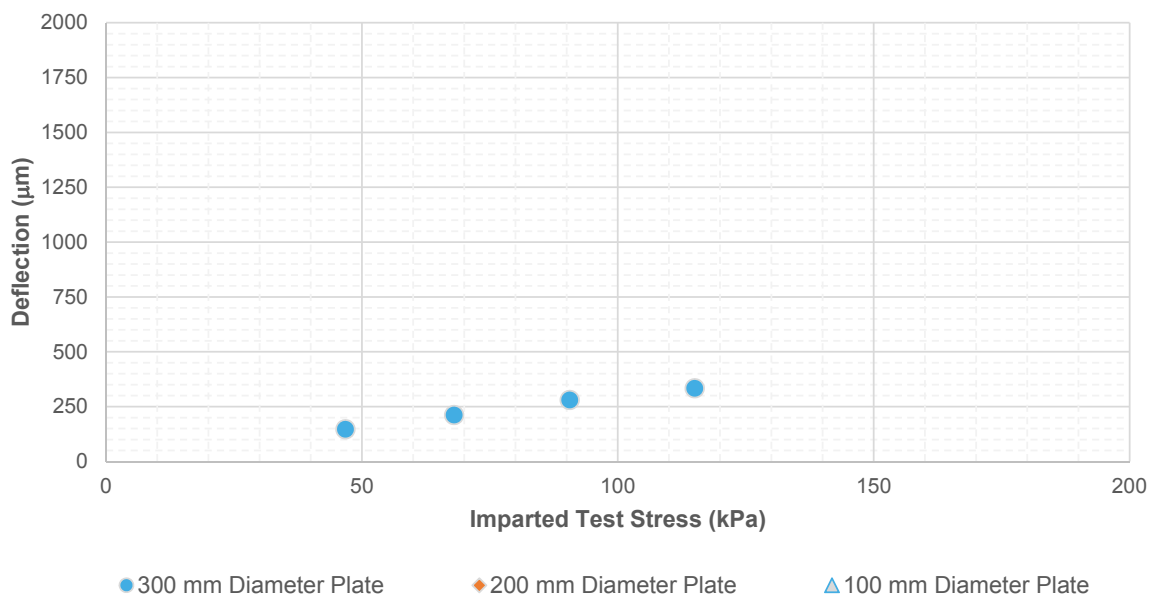
Client: ARRB Project: Best Practice in Compaction QA Location: Site 22-4 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (ν): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 27/02/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	--

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	47	145.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	68	210.7						
8	91	279.3						
7	115	332.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	84.7
			100	85.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 22-5

Certificate Reference: 2091-LFWD-PRIMA-Site 22-5

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 28/02/2019

Location: Site 22-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

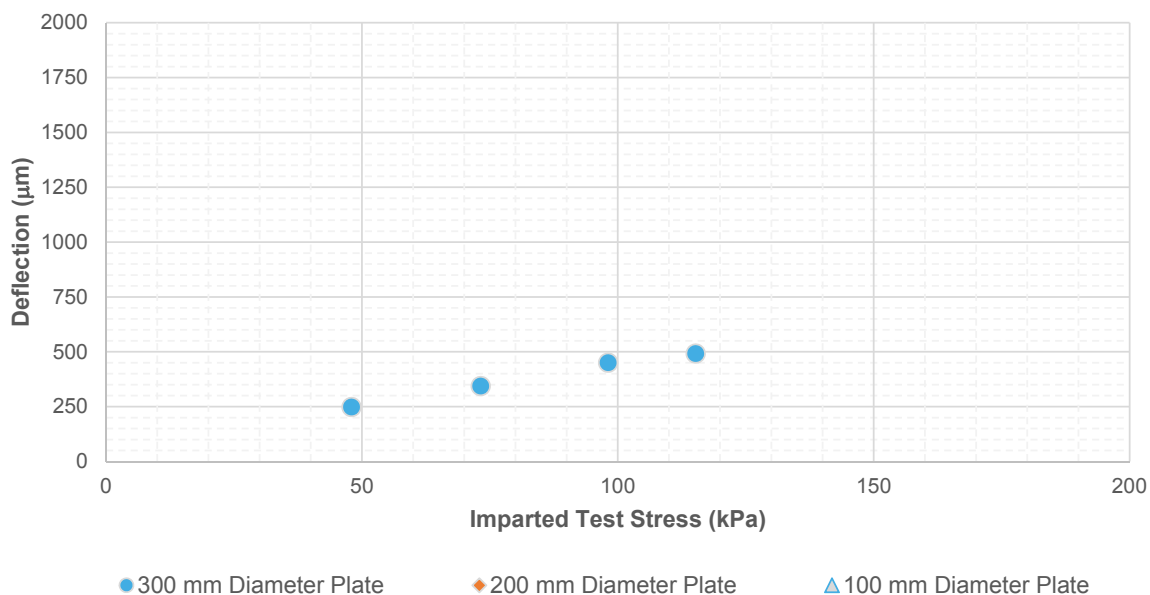
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	48	247.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	73	343.2						
4	98	449.5						
3	115	491.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	51.7
			100	59.0
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 22-6

Certificate Reference: 2091-LFWD-PRIMA-Site 22-6 **Sheet:** 1 of 1

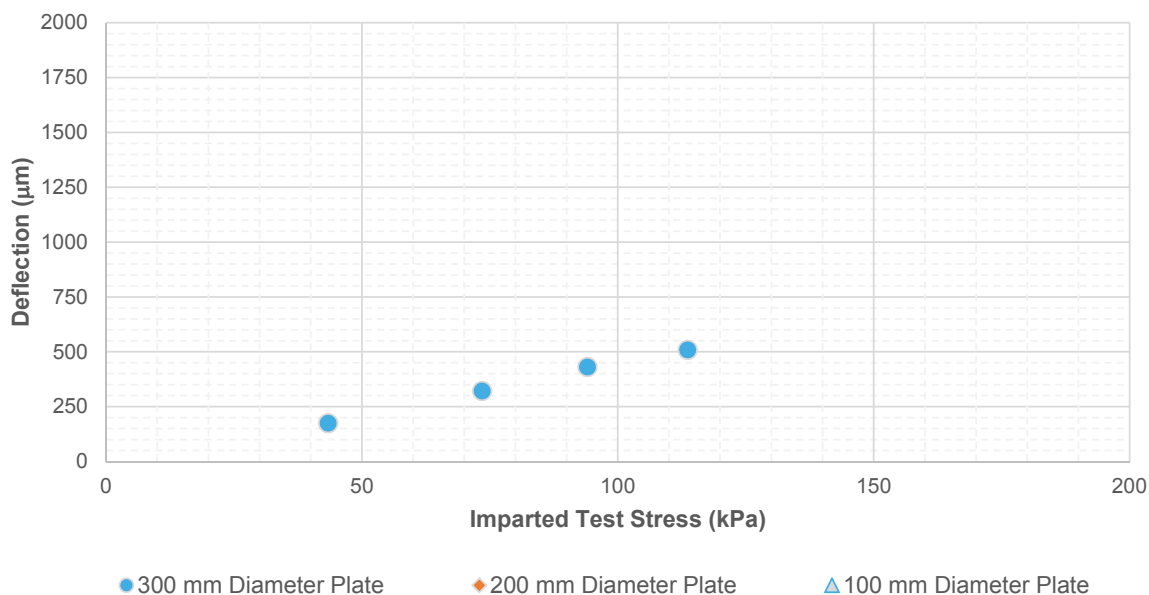
Client: ARRB Project: Best Practice in Compaction QA Location: Site 22-6 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (v): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 28/02/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
---	--

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
5	43	173.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	73	320.2						
3	94	430.0						
7	114	508.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	60.6
			100	58.7
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 22-7

Certificate Reference: 2091-LFWD-PRIMA-Site 22-7 Sheet: 1 of 1

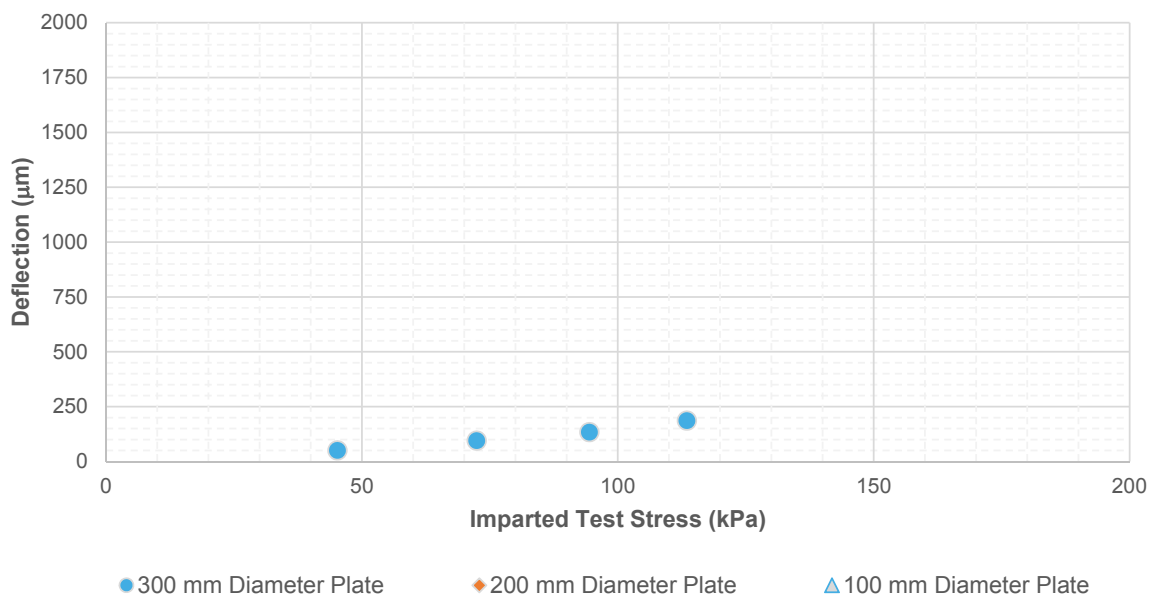
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 28/02/2019
 Location: Site 22-7 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	45	49.7 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	72	94.3						
3	94	133.2						
4	114	185.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	232
			100	177
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 22-8

Certificate Reference: 2091-LFWD-PRIMA-Site 22-8

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 28/02/2019

Location: Site 22-8 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

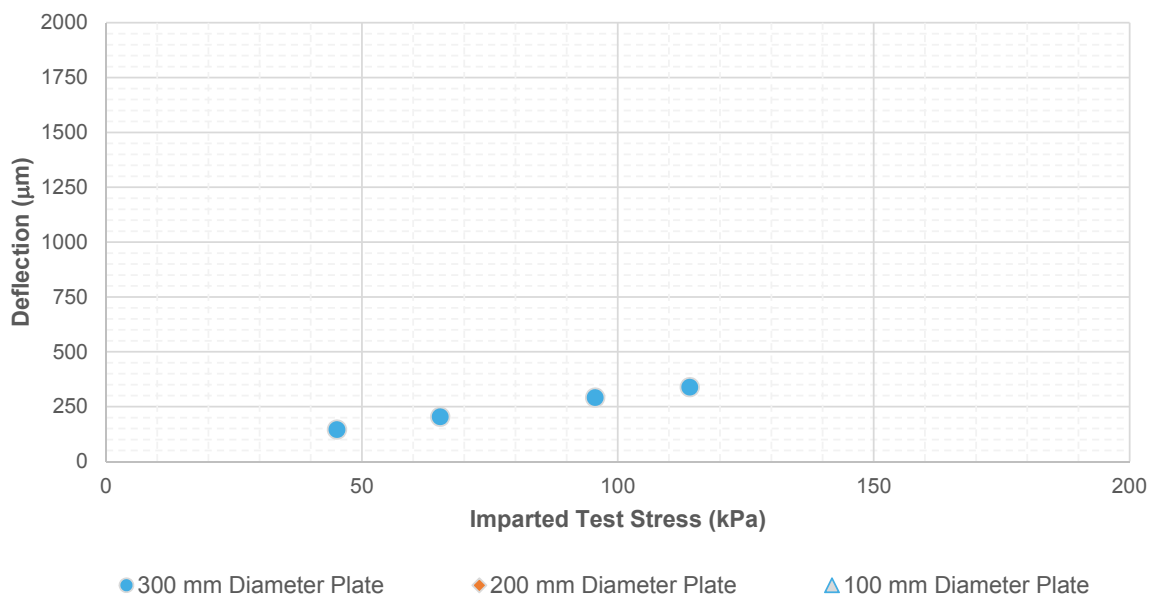
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	45	144.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	65	202.6						
5	96	290.6						
3	114	338.2						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	82.8
			100	87.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 22-9

Certificate Reference: 2091-LFWD-PRIMA-Site 22-9

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 28/02/2019

Location: Site 22-9 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

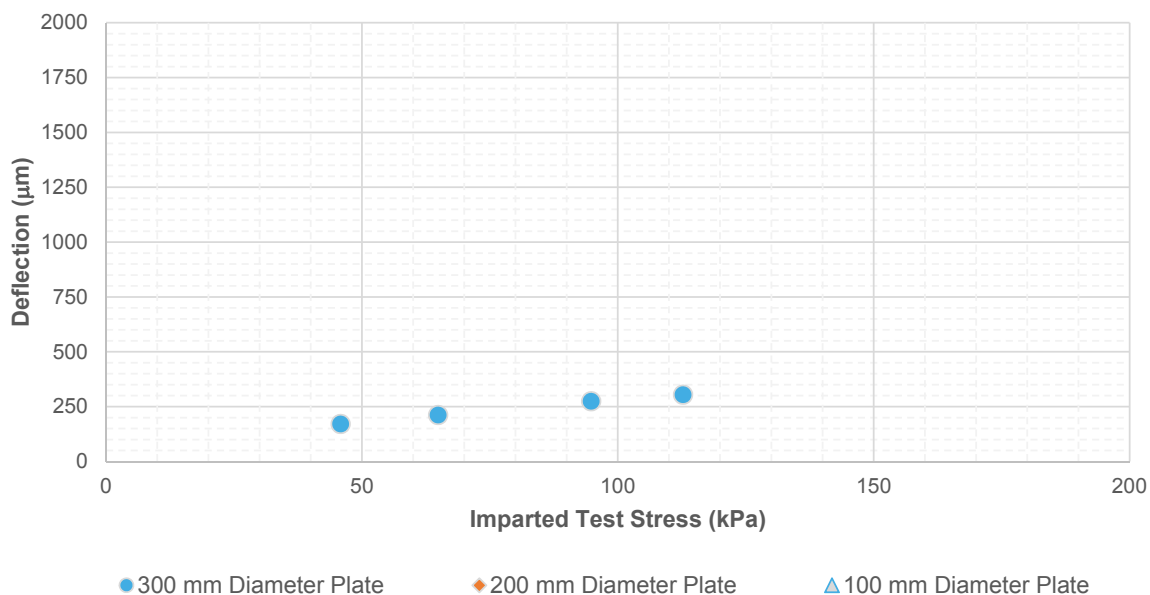
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	46	169.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	65	211.0						
4	95	274.1						
4	113	304.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	73.9
			100	93.2
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 22-10

Certificate Reference: 2091-LFWD-PRIMA-Site 22-10 Sheet: 1 of 1

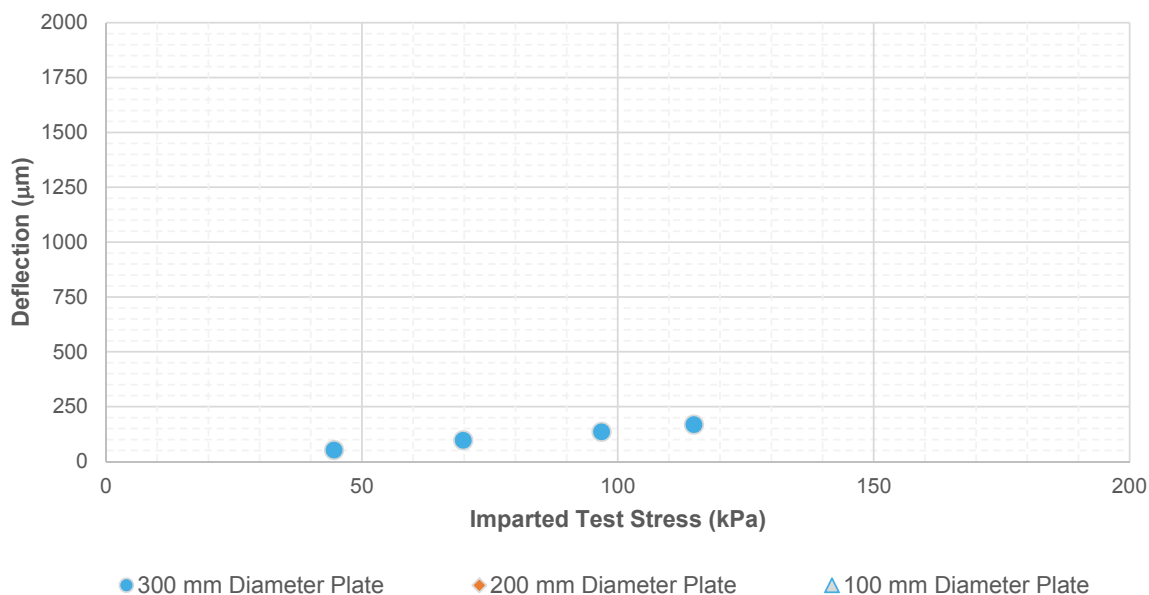
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 28/02/2019
 Location: Site 22-10 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	45	51.0	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	70	95.5						
3	97	134.2						
5	115	167.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	226
			100	190
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 22-11

Certificate Reference: 2091-LFWD-PRIMA-Site 22-11

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 28/02/2019

Location: Site 22-11 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

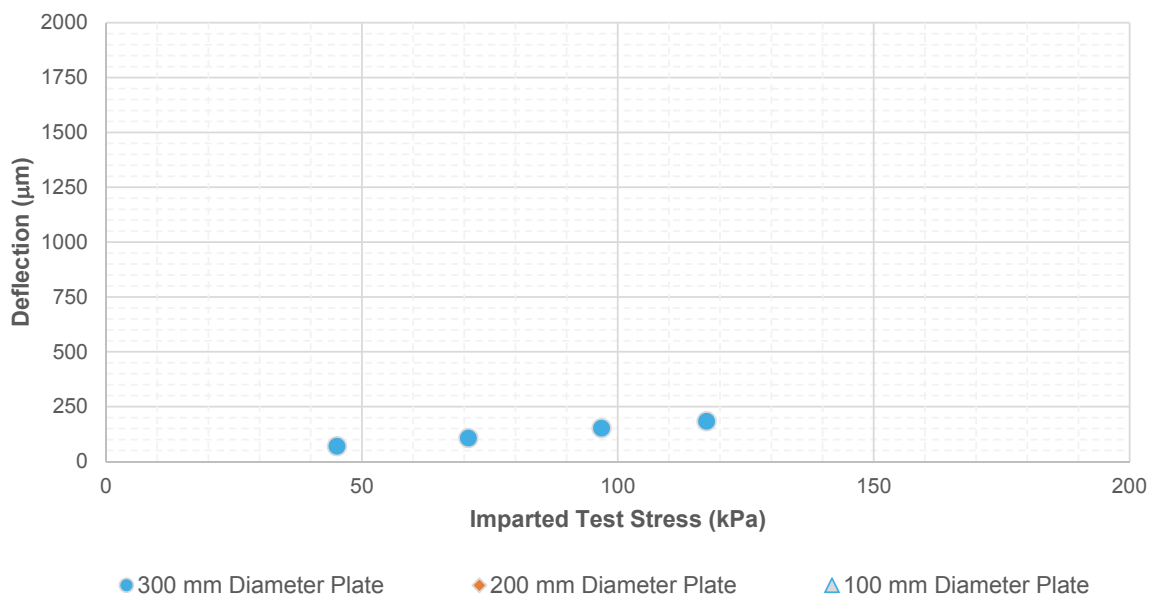
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	45	68.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	71	105.6						
3	97	151.3						
4	117	182.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	175
			100	171
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 22-12

Certificate Reference: 2091-LFWD-PRIMA-Site 22-12 Sheet: 1 of 1

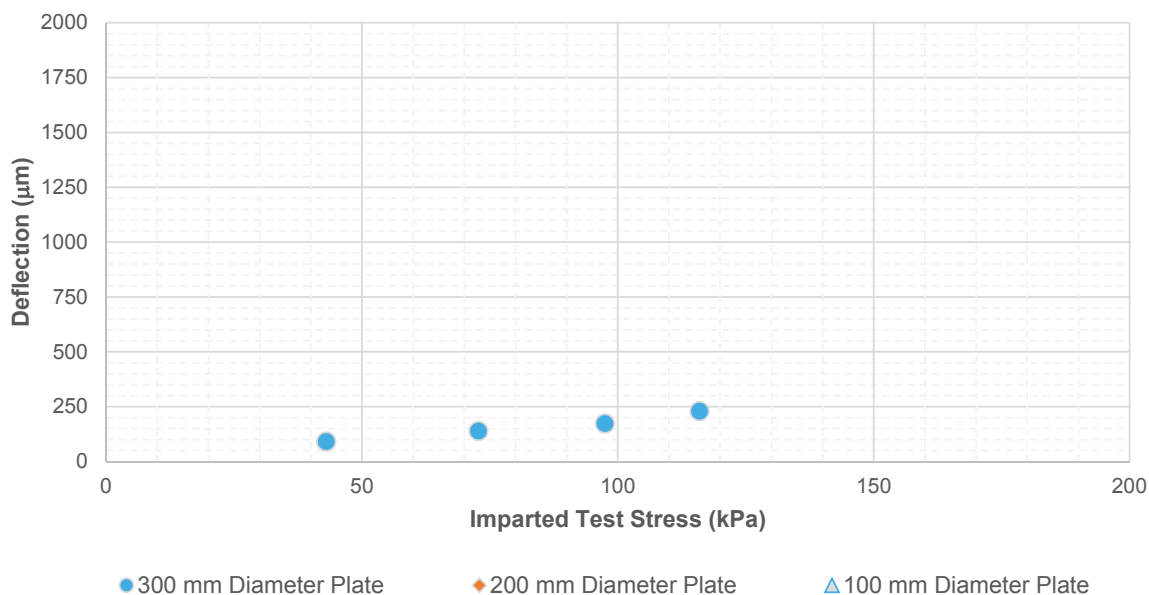
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 28/02/2019
 Location: Site 22-12 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	43	89.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	73	137.9						
4	97	172.2						
3	116	228.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	131
			100	135
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 22-13

Certificate Reference: 2091-LFWD-PRIMA-Site 22-13

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 28/02/2019

Location: Site 22-13 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

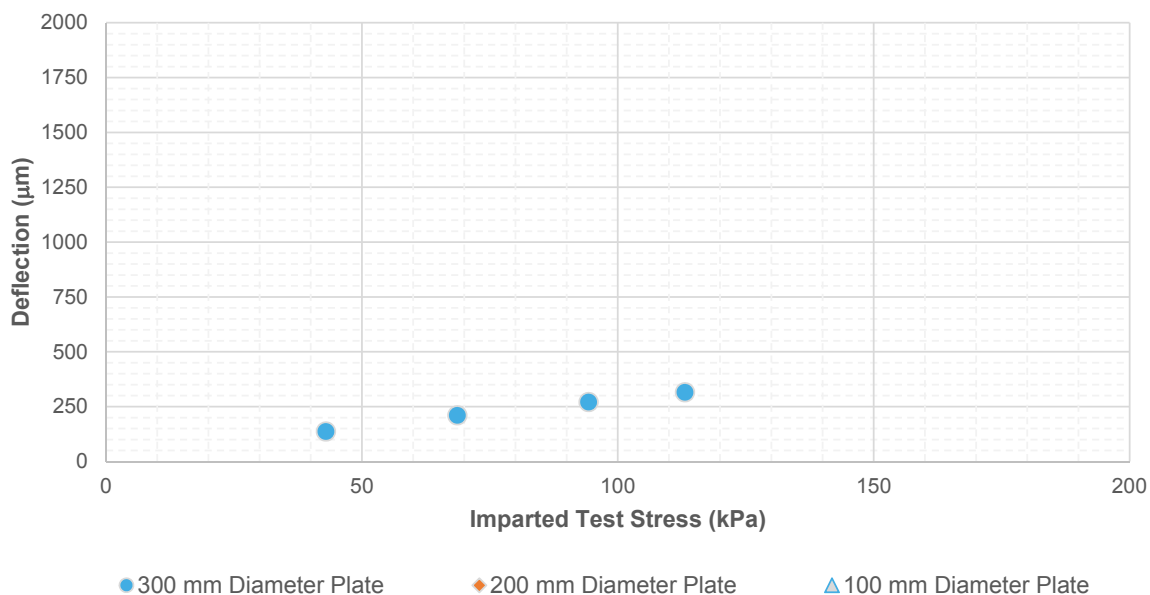
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	43	135.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	69	209.3						
4	94	270.3						
3	113	314.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	84.0
			100	92.5
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 22-14

Certificate Reference: 2091-LFWD-PRIMA-Site 22-14

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 28/02/2019

Location: Site 22-14 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

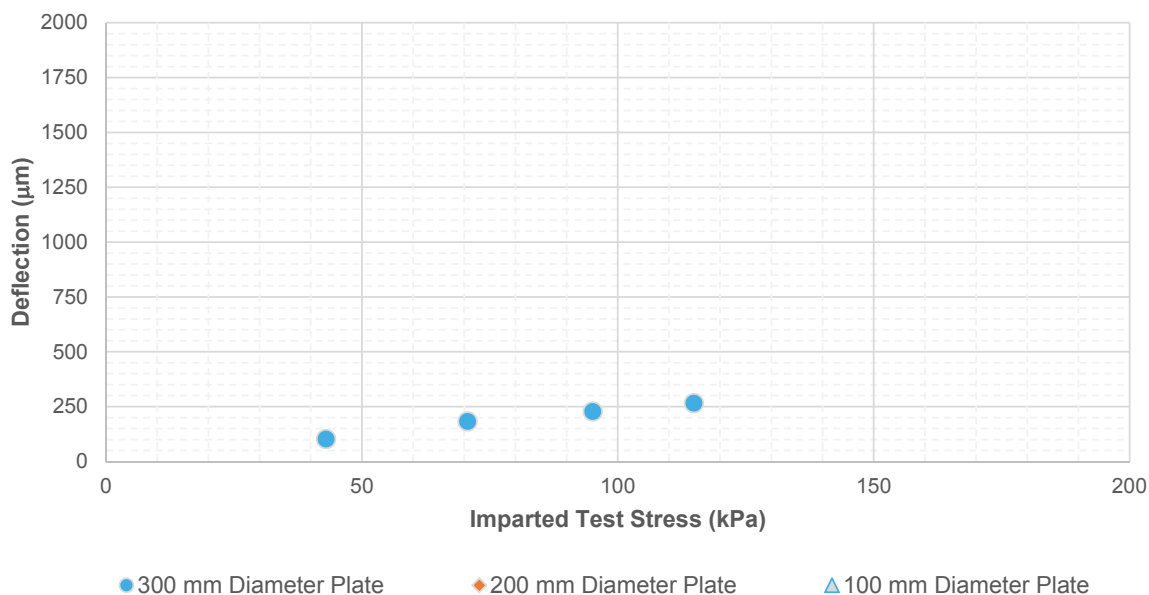
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	43	101.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	71	181.7						
4	95	226.9						
8	115	264.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	97.2
			100	111
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 23-1

Certificate Reference: 2091-LFWD-PRIMA-Site 23-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 13/03/2019

Location: Site 23-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints

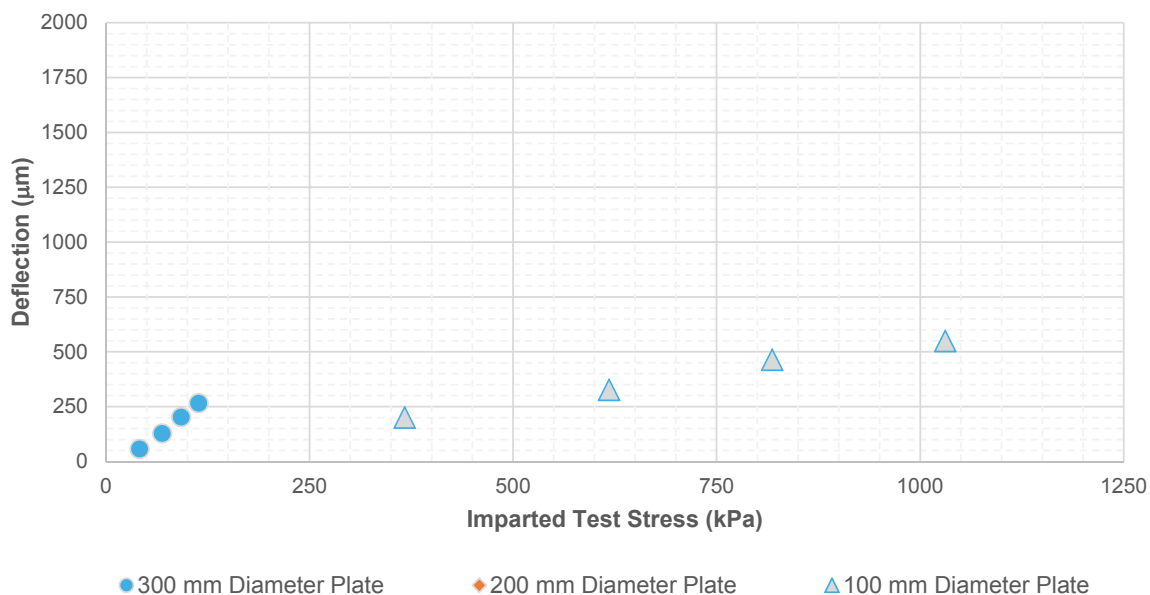
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	56.5	Site Not Tested with 200 mm Diameter Plate			3	367	200.2
4	69	127.0				3	618	326.2
5	92	201.4				11	818	463.2
7	114	265.1				10	1031	548.8

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised *In situ* Modulus (E_{LFWD})

Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>In situ</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	133
			100	117
			500	107
	100 to 300 mm Diameter:	4.55	750	107
			1000	106



Comments / Remarks:

300 mm & 100 mm Diameter Plates utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 23-2

Certificate Reference: 2091-LFWD-PRIMA-Site 23-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 13/03/2019

Location: Site 23-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

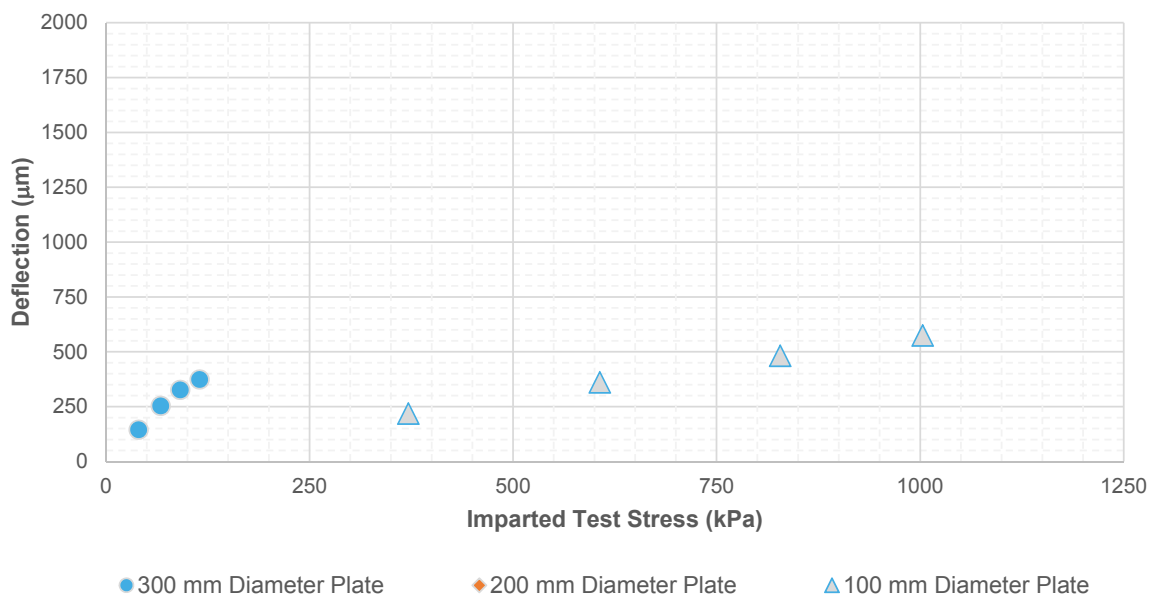
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	40	144.0	Site Not Tested with 200 mm Diameter Plate			5	371	218.2
4	67	252.8				9	606	360.9
4	91	325.6				7	828	481.6
5	115	372.7				5	1003	574.7

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>In situ</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>In situ</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	64.7
			100	77.1
			500	91.1
	100 to 300 mm Diameter:	4.9	750	92.5
			1000	93.2



Comments / Remarks:

300 mm & 100 mm Diameter Plates utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 23-3

Certificate Reference: 2091-LFWD-PRIMA-Site 23-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 13/03/2019

Location: Site 23-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

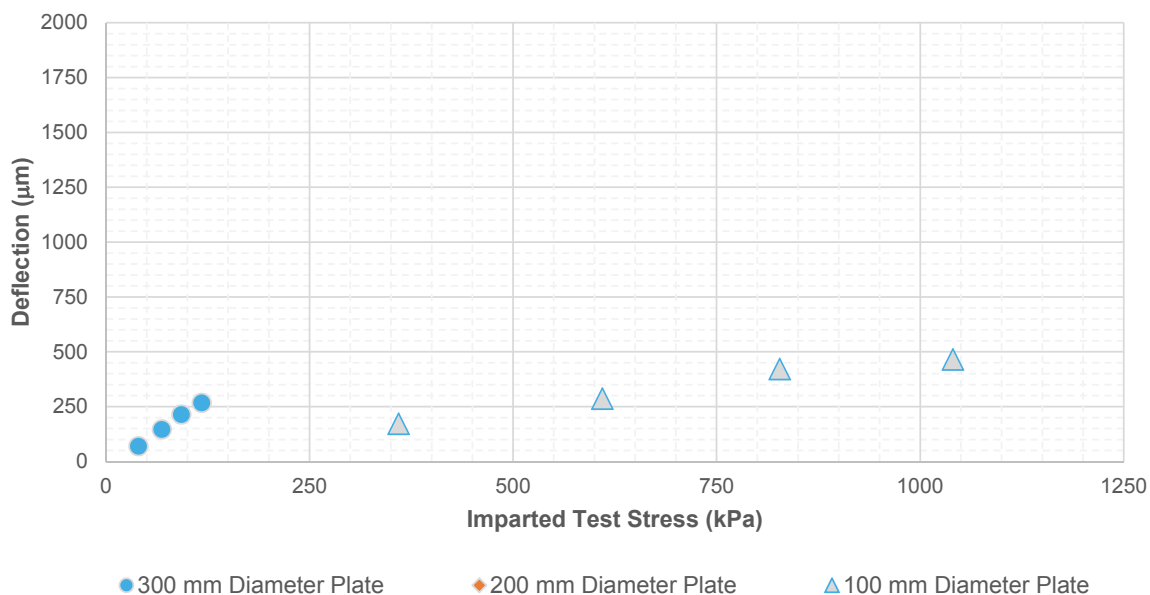
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	40	69.0	Site Not Tested with 200 mm Diameter Plate			4	359	171.7
4	69	145.1				3	610	286.5
6	93	213.4				10	827	420.8
4	117	266.6				8	1040	465.1

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>In situ</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>In situ</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	108
			100	118
			500	128
	100 to 300 mm Diameter:	4.5	750	128
			1000	129



Comments / Remarks:

300 mm & 100 mm Diameter Plates utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 23-4

Certificate Reference: 2091-LFWD-PRIMA-Site 23-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 13/03/2019

Location: Site 23-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

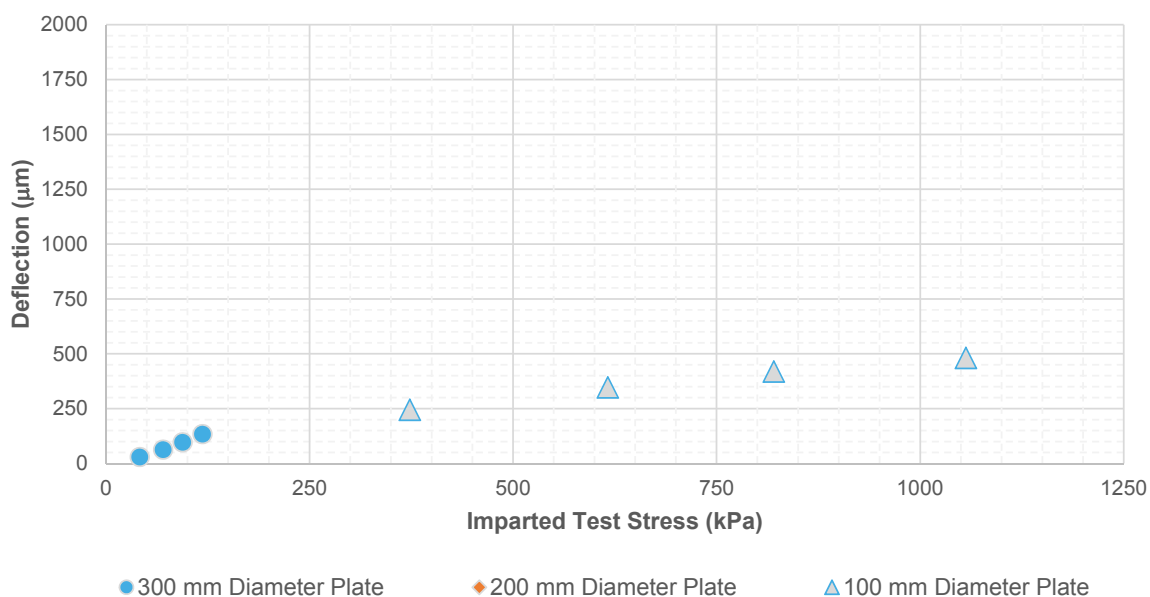
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	41	28.8 ⁺	Site Not Tested with 200 mm Diameter Plate			4	373	244.6
7	70	62.0				3	616	346.4
4	94	95.7				7	820	418.6
4	119	133.1				5	1056	480.7 [*]

⁺Material considered to have yielded at applied stress state

^{*}Deflection magnitude below calibrated range of Equipment

Standardised <i>In situ</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>In situ</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	285 ⁺
			100	250
			500	228
	100 to 300 mm Diameter:	2.2	750	226
			1000	N/A (Material Yielded)



Comments / Remarks:

300 mm & 100 mm Diameter Plates utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 23-5

Certificate Reference: 2091-LFWD-PRIMA-Site 23-5

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 13/03/2019

Location: Site 23-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

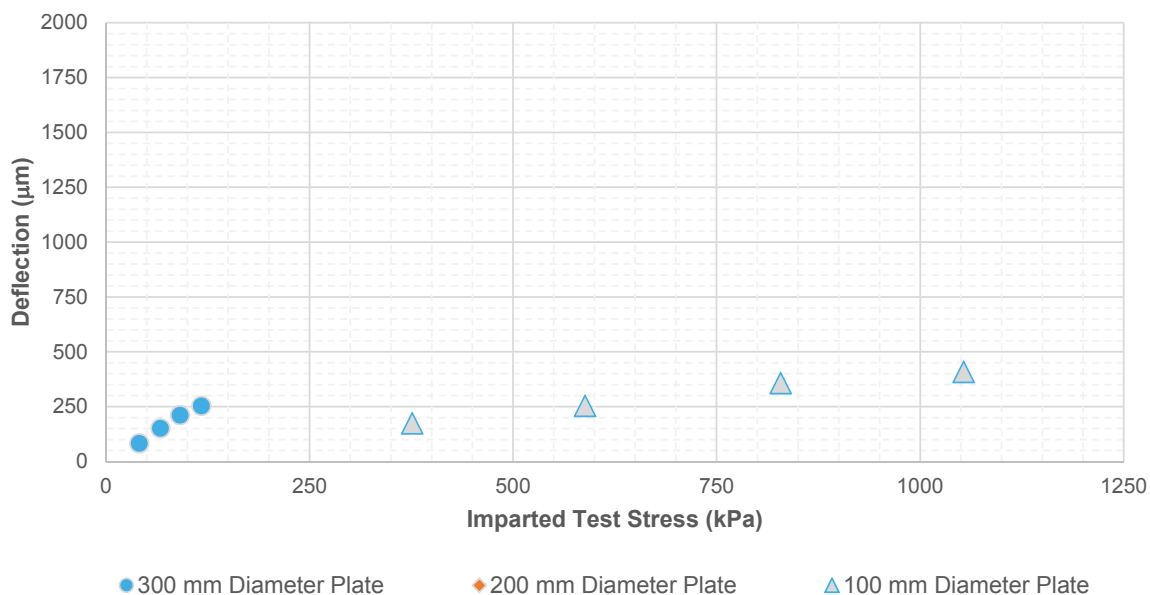
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	41	81.8	Site Not Tested with 200 mm Diameter Plate			3	376	173.7
5	67	150.3				13	588	253.3
7	91	210.4				8	829	356.9
8	117	252.6				8	1053	408.3*

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>In situ</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>In situ</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	108
			100	120
			500	131
	100 to 300 mm Diameter:	4.6	750	132
			1000	N/A (Material Yielded)



Comments / Remarks:

300 mm & 100 mm Diameter Plates utilised at a single location.
Test site fully assessed with ascending test stresses

Certificate Reference: 2091-LFWD-PRIMA-Site 23-6

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 13/03/2019

Location: Site 23-6 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

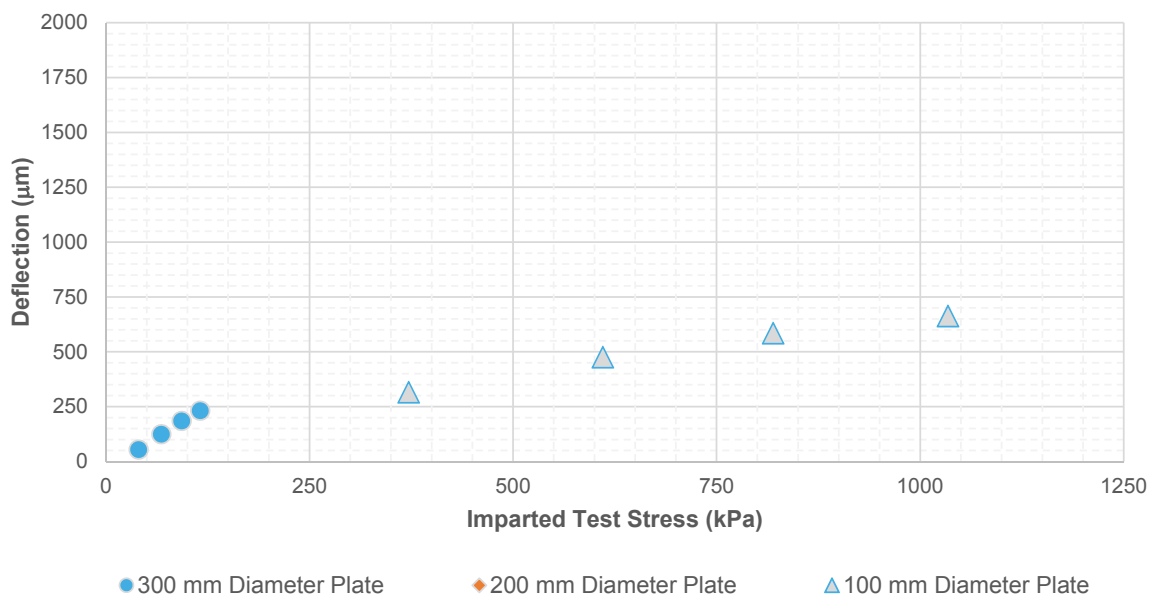
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	40	53.6	Site Not Tested with 200 mm Diameter Plate			4	372	315.1
3	68	123.6				3	610	474.8
5	93	184.1				6	819	584.6*
4	116	230.9				4	1034	662.4*

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>In situ</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>In situ</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	142
			100	134
			500	127
	100 to 300 mm Diameter:	2.6	750	127
			1000	N/A (Material Yielded)



Comments / Remarks:

300 mm & 100 mm Diameter Plates utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-1

Certificate Reference: 2091-LFWD-PRIMA-Site 24-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

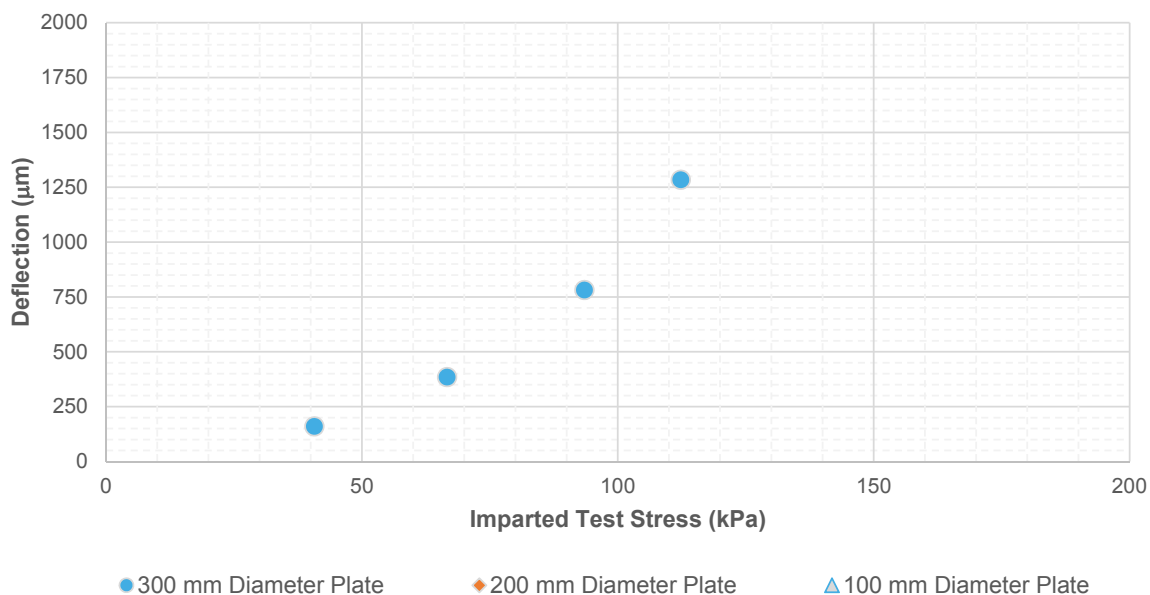
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	41	158.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
11	67	384.1						
5	93	781.1						
10	112	1283.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	59.3
			100	28.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-1 (Retest, < 24 hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 24-1-R **Sheet:** 1 of 1

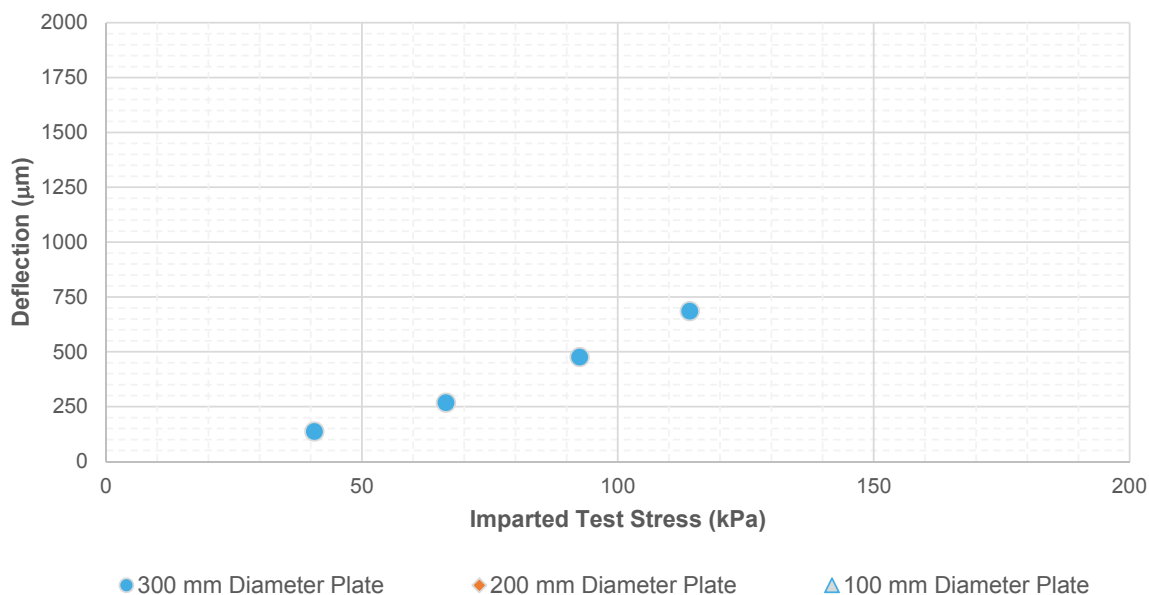
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 12/03/2019
Location: Site 24-1 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	41	135.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	66	266.9						
9	93	475.0						
4	114	684.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	73.8
			100	49.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 24-1A

Certificate Reference: 2091-LFWD-PRIMA-Site 24-1A **Sheet:** 1 of 1

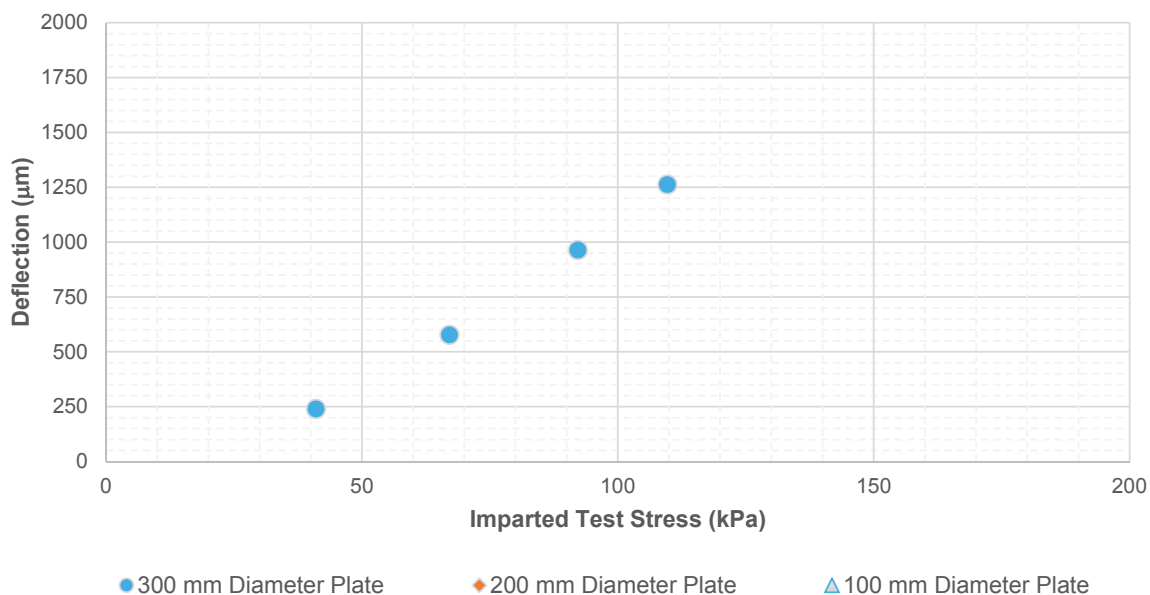
Client: ARRB Project: Best Practice in Compaction QA Location: Site 24-1 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (ν): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 12/03/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	--

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	41	238.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	67	576.5						
5	92	963.3						
10	110	1261.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	38.8
			100	23.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-1A (Retest, < 24 hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 24-1A-R **Sheet:** 1 of 1

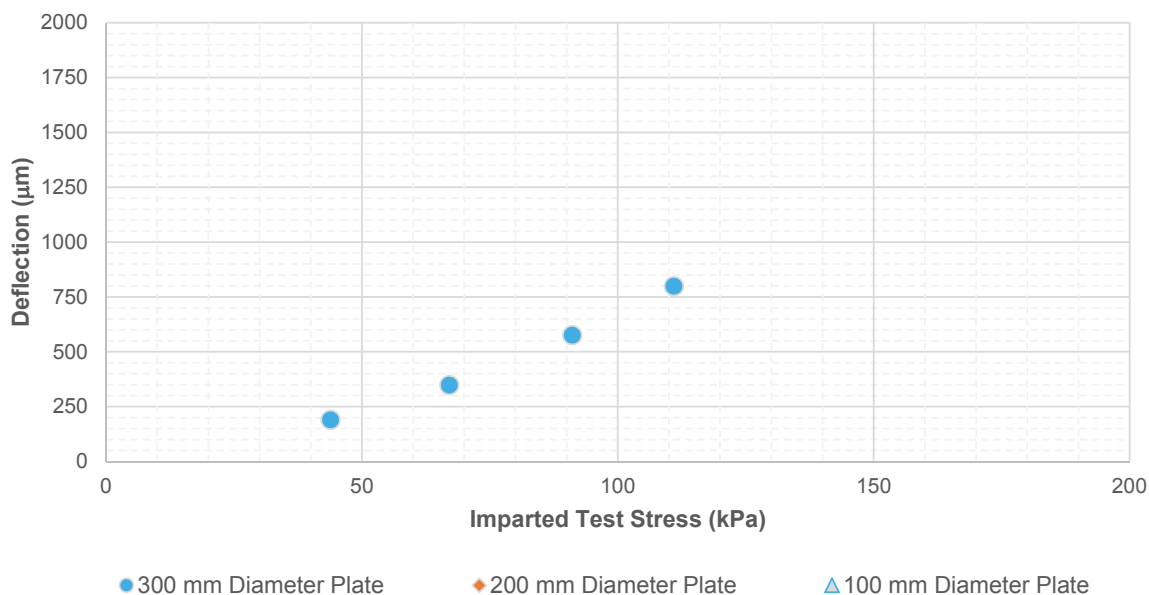
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 12/03/2019
Location: Site 24-1 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	44	188.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	67	347.3						
6	91	574.8						
5	111	798.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	58.0
			100	39.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 24-2

Certificate Reference: 2091-LFWD-PRIMA-Site 24-2 Sheet: 1 of 1

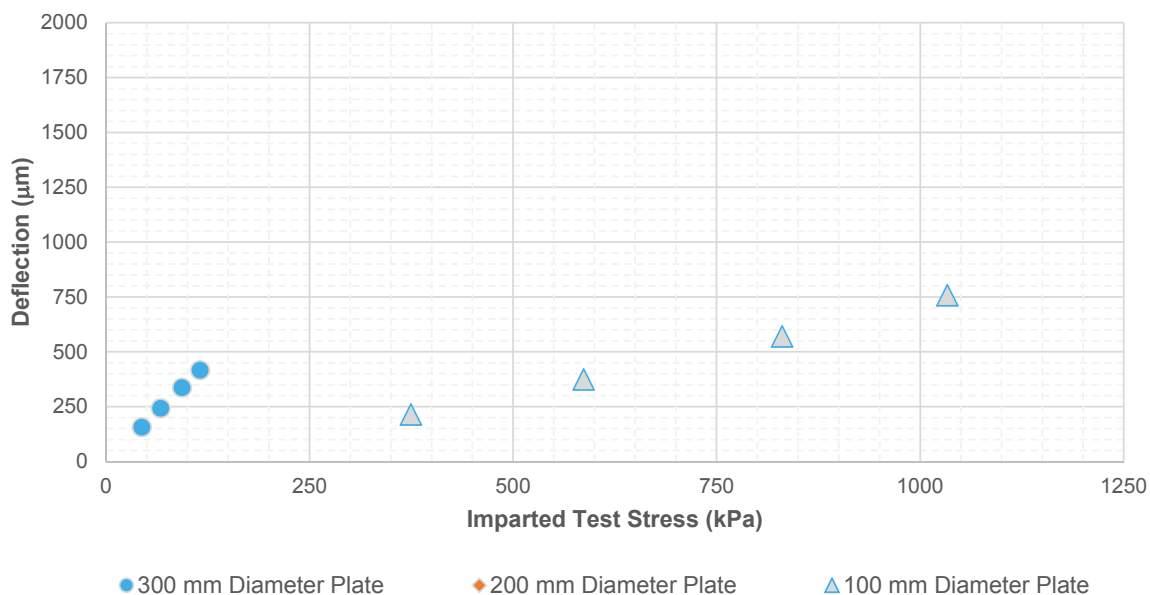
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 12/03/2019 - 13/03/2019
 Location: Site 24-2 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	44	155.7	Site Not Tested with 200 mm Diameter Plate			4	374	214.2
11	67	241.7				6	587	373.8
16	93	335.8				6	830	569.7
10	116	415.4				10	1033	757.6

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	99.4
			100	70.2
			500	56.8
	100 to 300 mm Diameter:	7.5	750	55.9
			1000	55.5



Comments / Remarks:

300 mm & 100 mm Diameter Plates utilised at a single location.
 300 mm Dia. Plate Tests completed 12/03/2019 and 100 mm Dia. Plate Tests completed 13/03/2019 (i.e. +24 hrs)
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-3

Certificate Reference: 2091-LFWD-PRIMA-Site 24-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

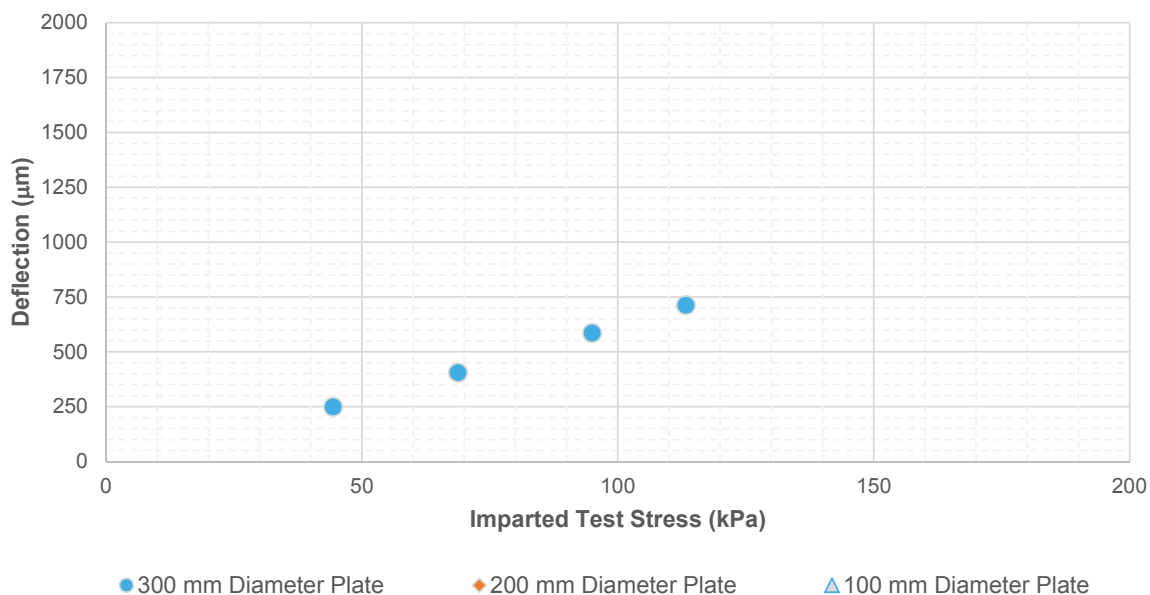
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	44	248.0	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	69	404.5						
8	95	584.6						
8	113	711.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	46.5
			100	42.7
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-4

Certificate Reference: 2091-LFWD-PRIMA-Site 24-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

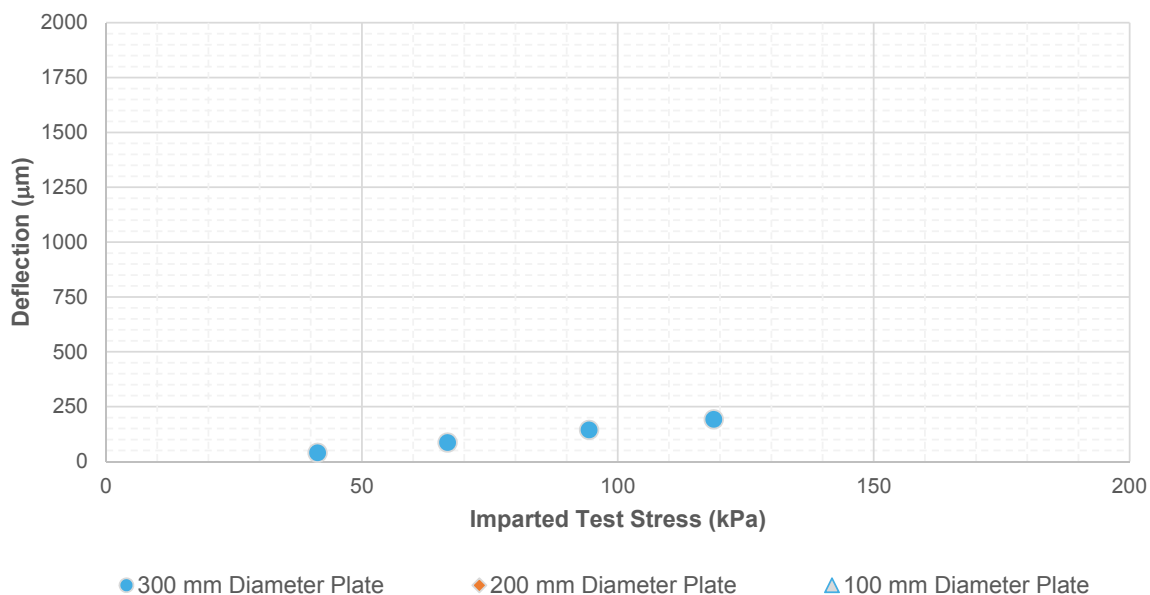
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	41	38.8 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	67	85.6						
7	94	143.2						
6	119	191.2						

⁺Material considered to have yielded at applied stress state

⁺Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	249
			100	173
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-5

Certificate Reference: 2091-LFWD-PRIMA-Site 24-5

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

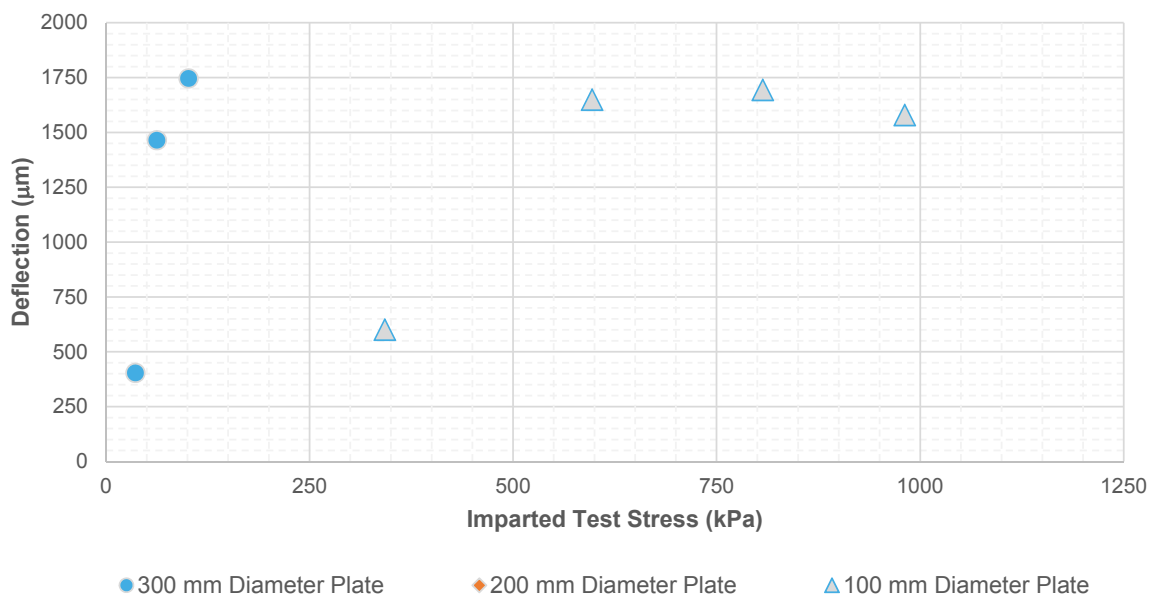
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	36	402.8	Site Not Tested with 200 mm Diameter Plate			7	342	600.7
4	62	1463.6				9	597	1649.1
3	86	2057.6				4	807	1693.6*
5	101	1744.9*				7	981	1578.9*

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>In situ</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>In situ</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	13.8
			100	10.5
			500	8.80
	100 to 300 mm Diameter:	10.9	750	N/A (Material Yielded)
			1000	N/A (Beyond Test Stress Range)



Comments / Remarks:

300 mm & 100 mm Diameter Plates utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-5 (Retest, < 24 hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 24-5-R **Sheet:** 1 of 1

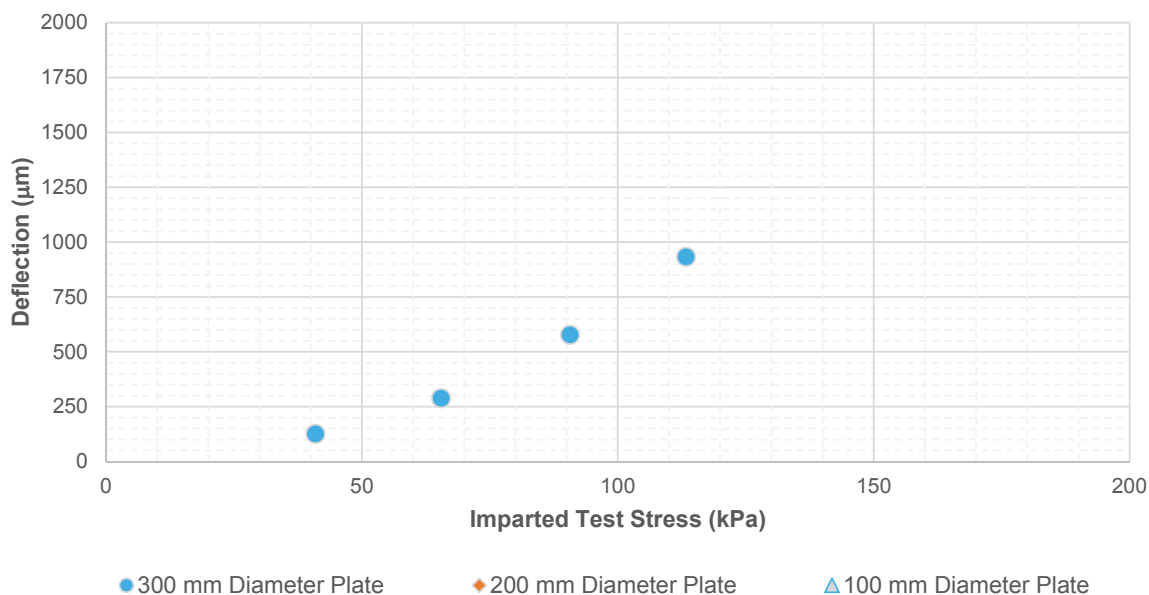
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 12/03/2019
Location: Site 24-5 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	41	124.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	65	287.5						
8	91	576.6						
7	113	931.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	73.6
			100	37.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-5A

Certificate Reference: 2091-LFWD-PRIMA-Site 24-5A

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

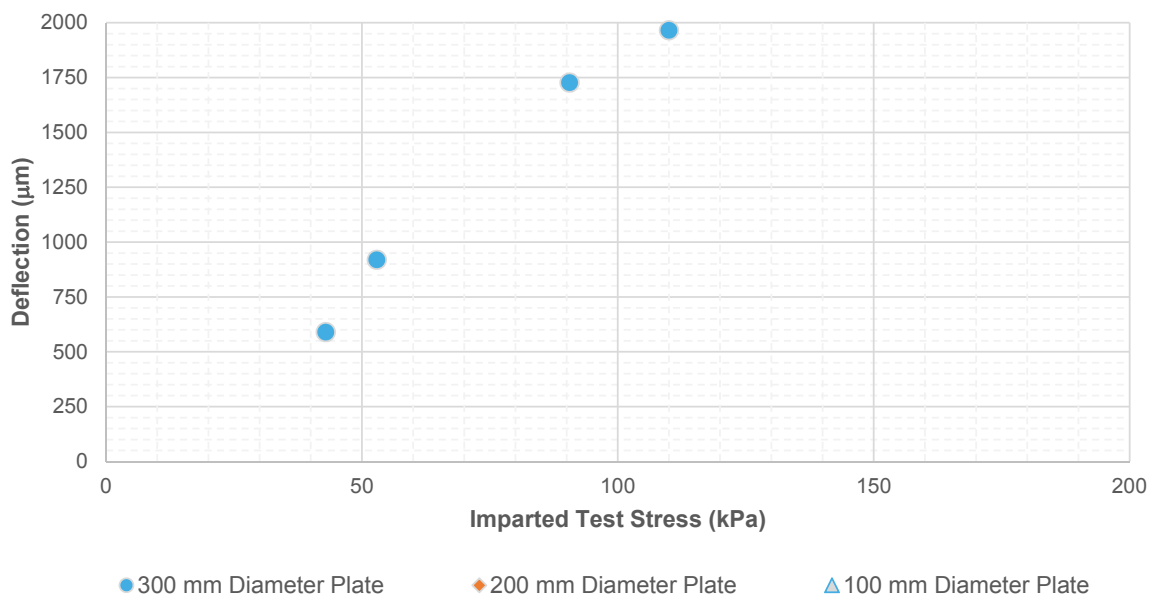
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	43	589.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	53	918.5						
3	91	1726.7						
6	110	1964.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	18.3
			100	14.5
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-5B

Certificate Reference: 2091-LFWD-PRIMA-Site 24-5B

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

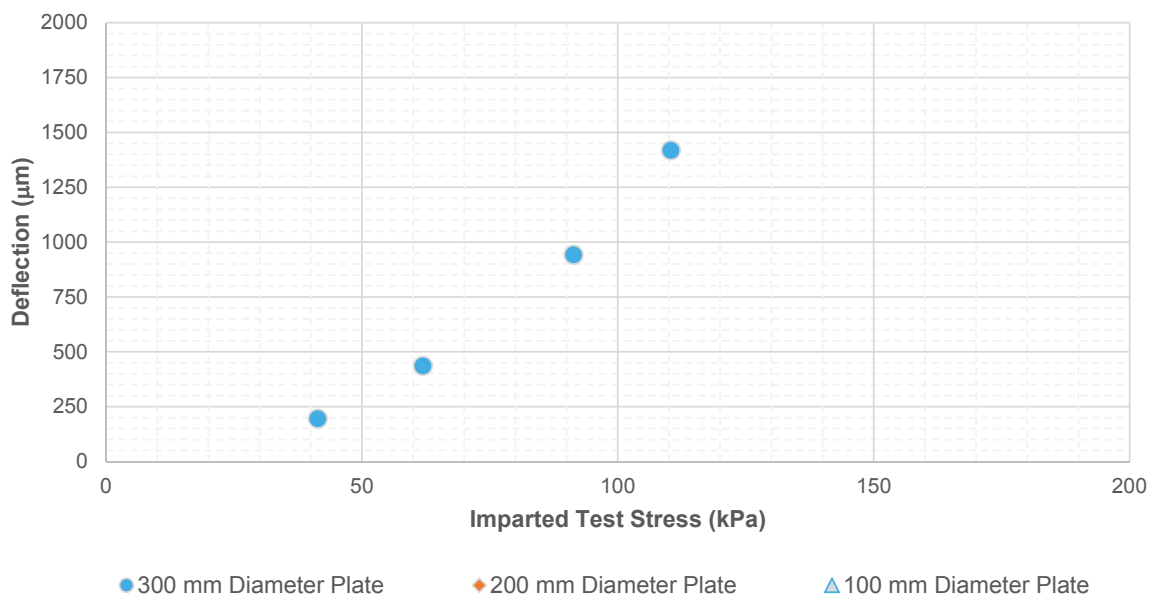
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	41	194.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	62	435.2						
6	91	941.1						
7	110	1417.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	46.5
			100	23.0
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-6

Certificate Reference: 2091-LFWD-PRIMA-Site 24-6

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-6 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

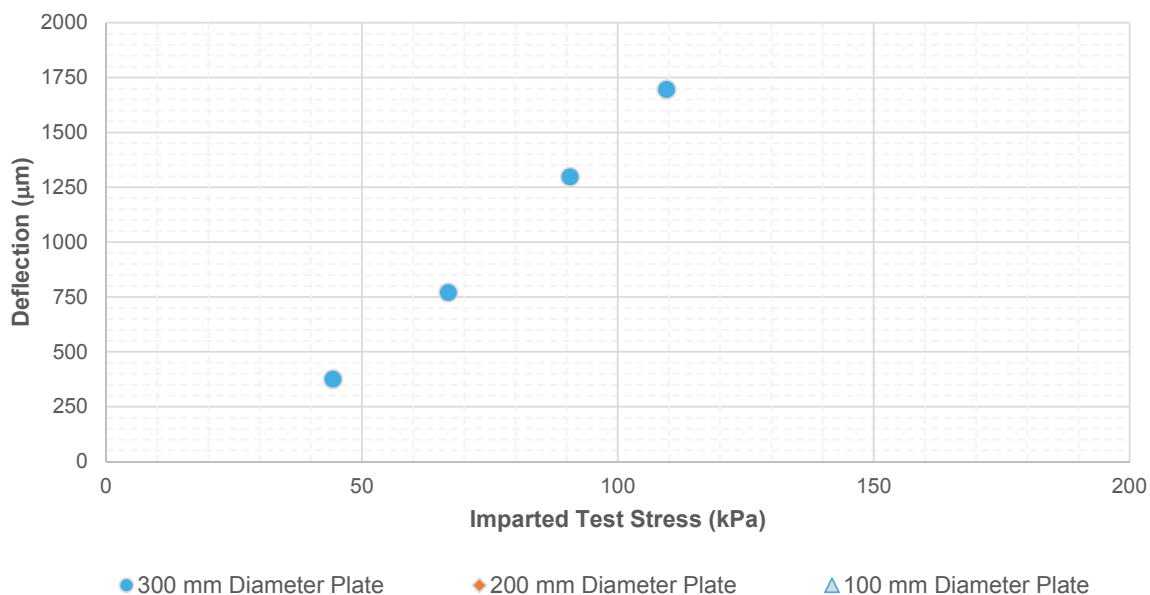
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	44	374.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	67	768.9						
8	91	1296.2						
3	110	1695.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	28.4
			100	17.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-6 (Retest, < 24 hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 24-6-R **Sheet:** 1 of 1

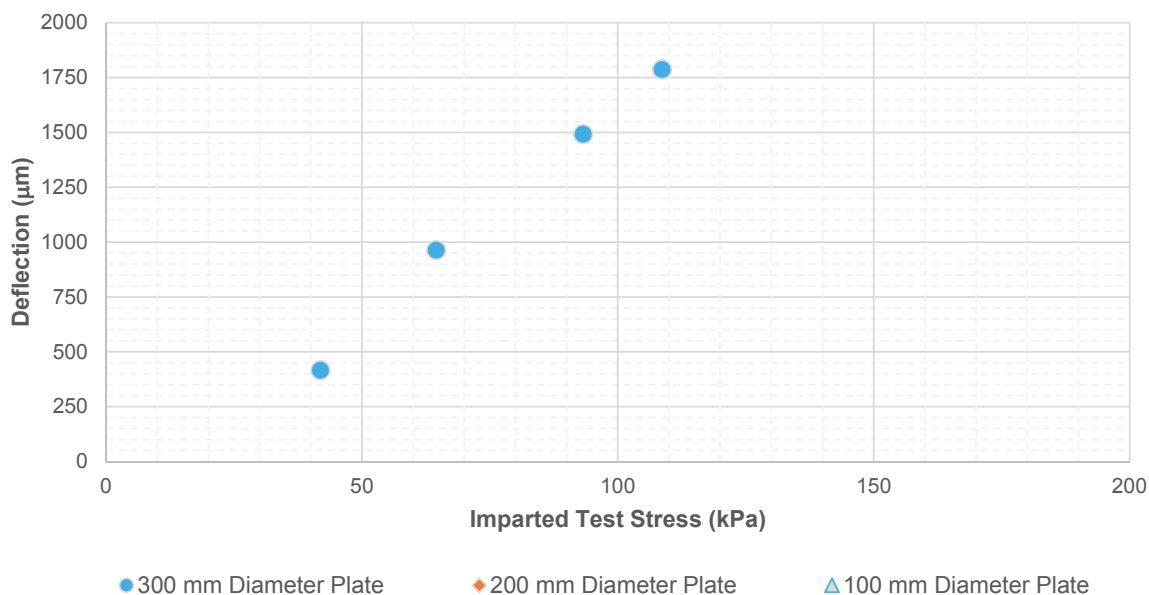
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 12/03/2019
Location: Site 24-6 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (v): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
4	42	415.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
10	65	962.8						
7	93	1491.7						
6	109	1786.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	18.2
			100	16.3
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-6 (Retest, > 24 hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 24-6-R2 **Sheet:** 1 of 1

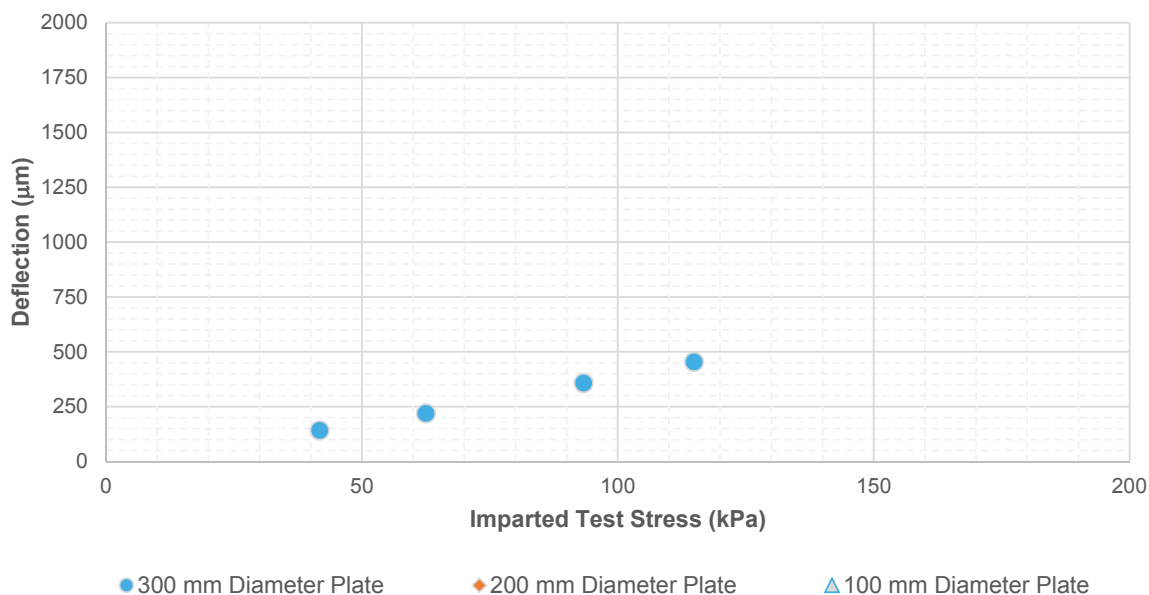
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 13/03/2019
Location: Site 24-6 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	42	141.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	63	218.4						
6	93	356.7						
7	115	452.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	76.8
			100	68.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-6A

Certificate Reference: 2091-LFWD-PRIMA-Site 24-6A

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-6 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

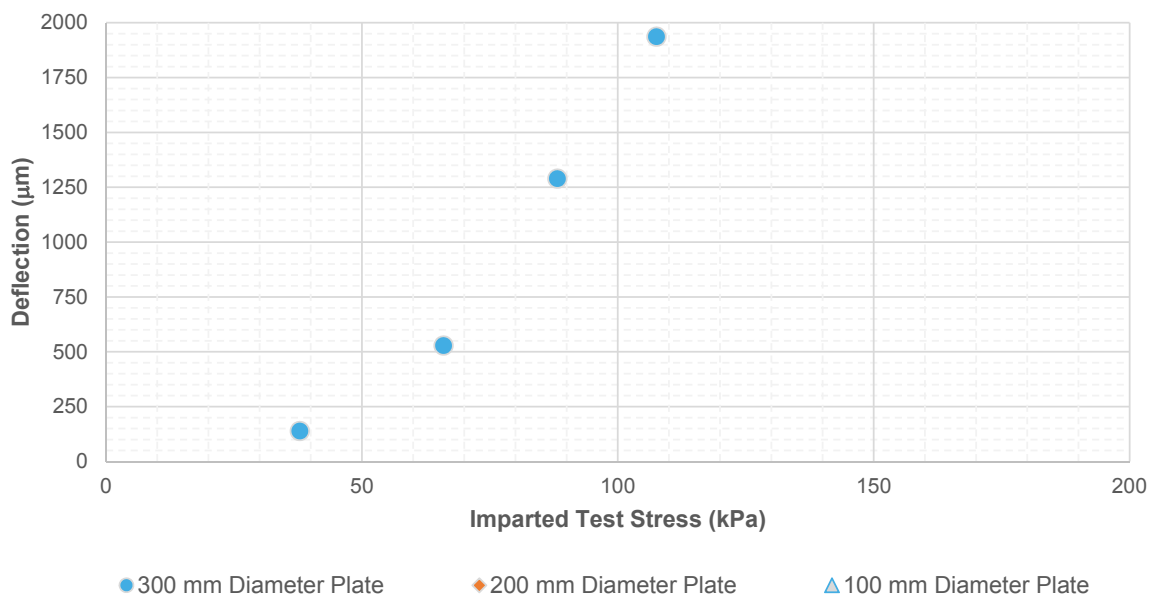
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	38	137.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	66	527.3						
5	88	1288.3						
5	108	1935.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	59.6
			100	15.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 24-6A (Retest, < 24 hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 24-6A-R **Sheet:** 1 of 1

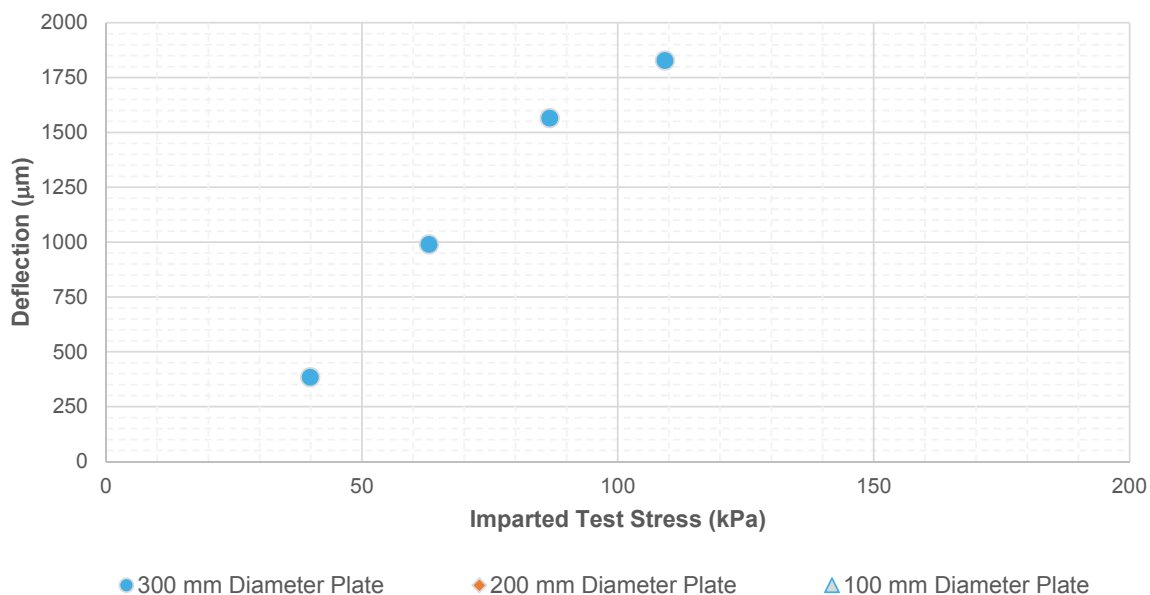
Client: ARRB Project: Best Practice in Compaction QA Location: Site 24-6 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (ν): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 12/03/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
--	--

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	40	383.0	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	63	988.7						
3	87	1564.0						
6	109	1827.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	16.6
			100	15.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 24-6A (Retest, > 24 hrs)

Certificate Reference: 2091-LFWD-PRIMA-Site 24-6A-R2 Sheet: 1 of 1

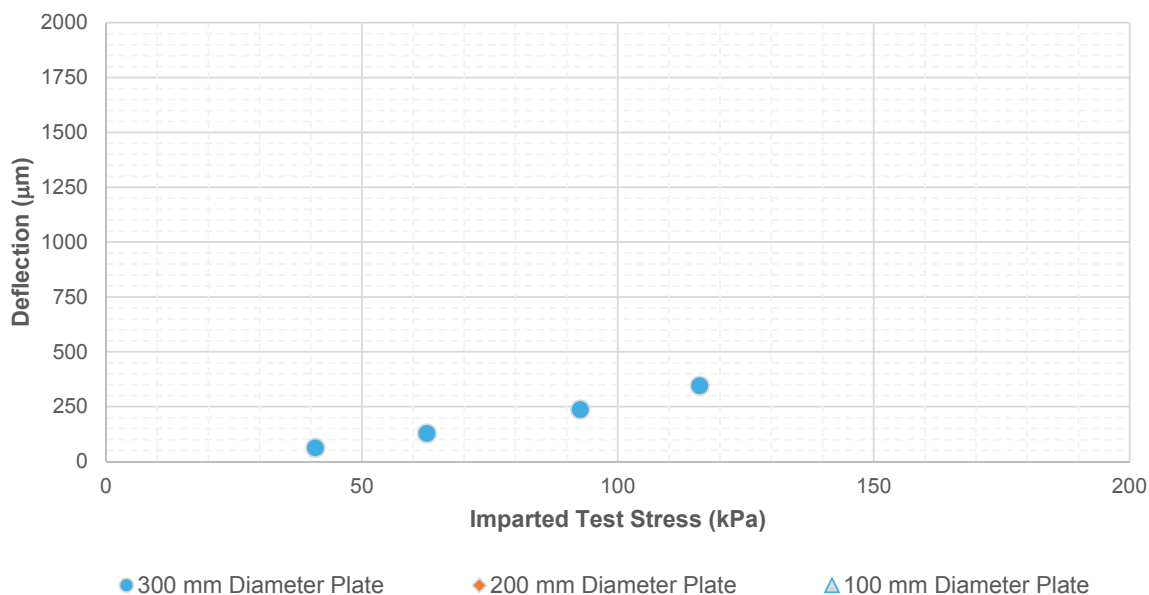
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 13/03/2019
 Location: Site 24-6 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	41	61.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	63	127.4						
7	93	235.6						
8	116	344.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	153
			100	97.7
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-7

Certificate Reference: 2091-LFWD-PRIMA-Site 24-7

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-7 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

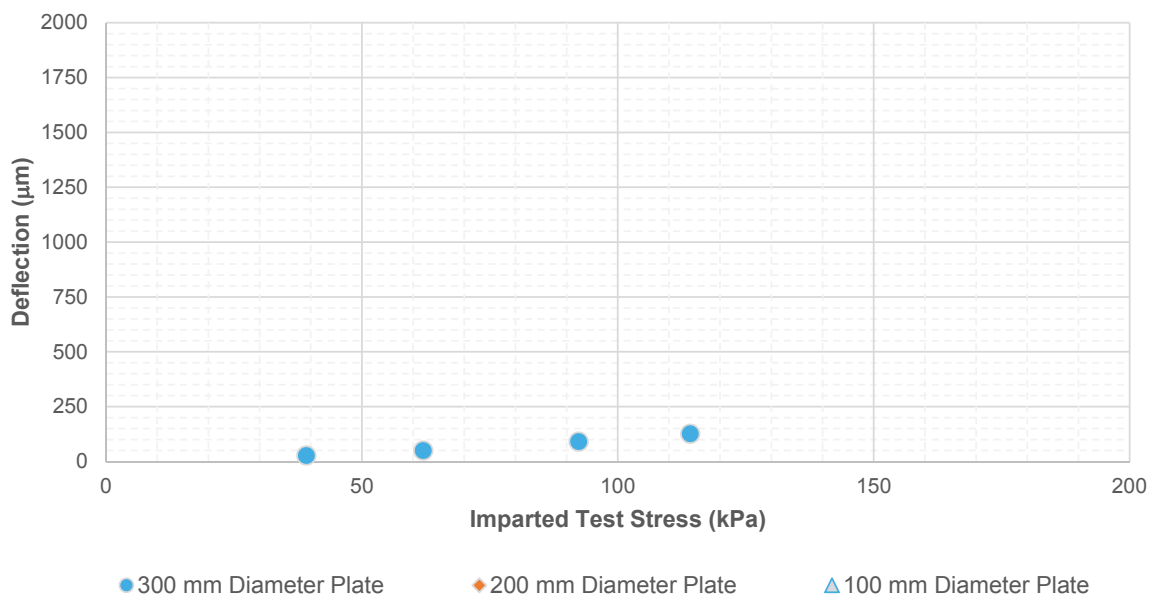
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	39	26.0 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	62	48.7 ⁺						
6	92	89.9						
8	114	125.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	367 ⁺
			100	262
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-8

Certificate Reference: 2091-LFWD-PRIMA-Site 24-8

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-8 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

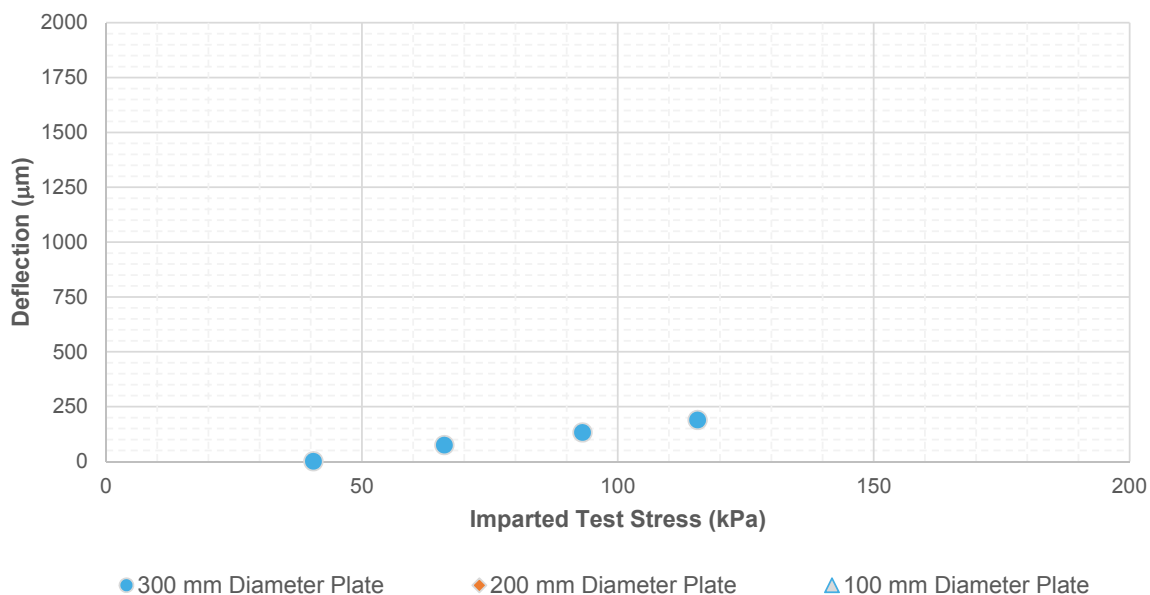
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	33.6 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	66	73.6						
4	93	131.3						
7	116	188.1						

⁺Material considered to have yielded at applied stress state

⁺Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	280 ⁺
			100	179
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-9

Certificate Reference: 2091-LFWD-PRIMA-Site 24-9

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-9 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

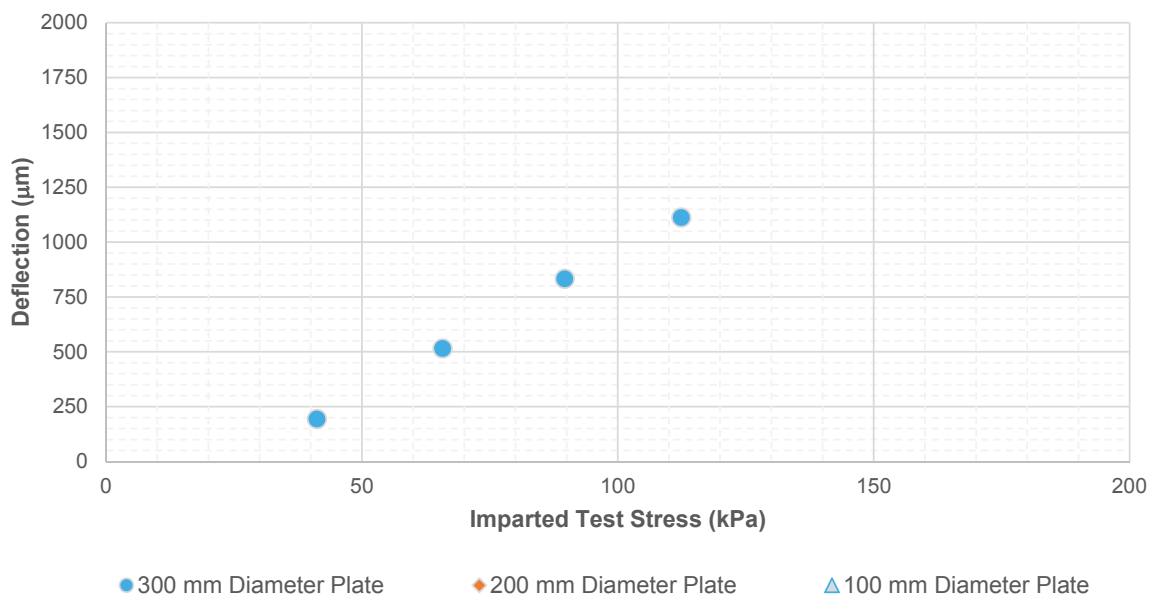
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	192.5	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	66	514.6						
5	90	831.9						
6	112	1110.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	35.5
			100	27.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-10

Certificate Reference: 2091-LFWD-PRIMA-Site 24-10 **Sheet:** 1 of 1

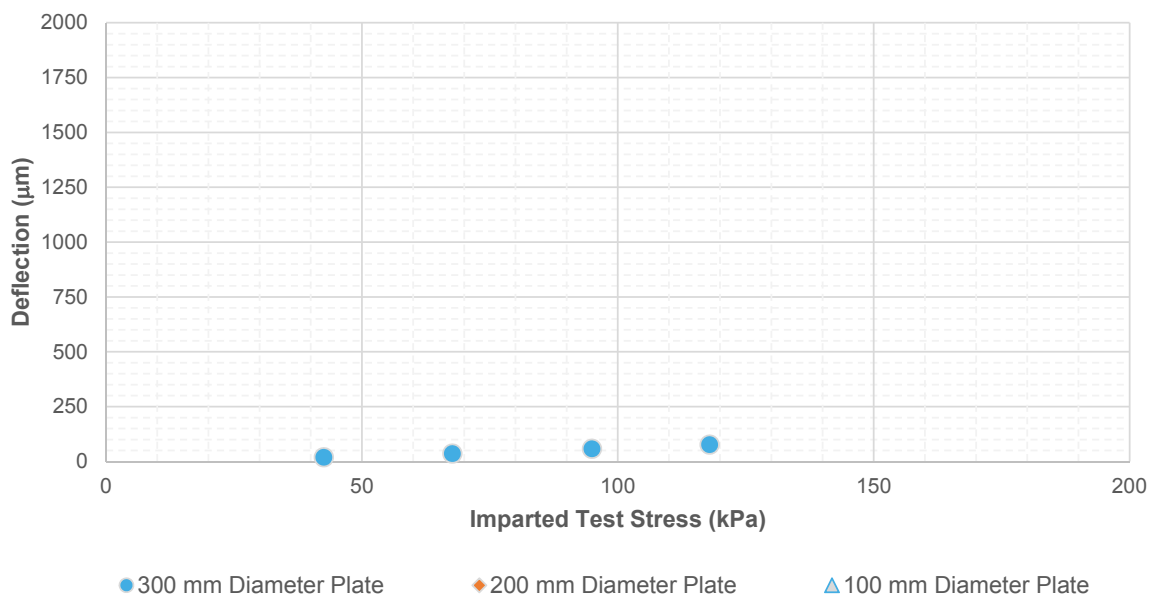
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 12/03/2019
Location: Site 24-10 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	43	18.1 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
10	68	34.9 ⁺						
12	95	56.8						
8	118	76.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	579 ⁺
			100	435.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-11

Certificate Reference: 2091-LFWD-PRIMA-Site 24-11

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-11 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

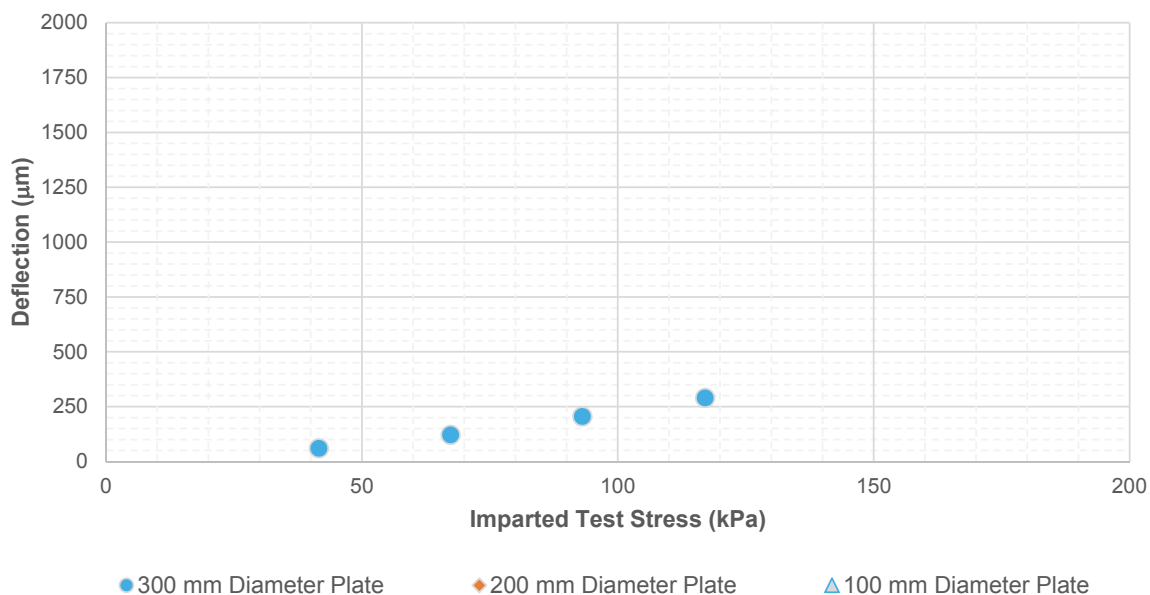
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	42	58.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	67	120.3						
7	93	204.3						
6	117	288.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	170
			100	116
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 24-12

Certificate Reference: 2091-LFWD-PRIMA-Site 24-12

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 12/03/2019

Location: Site 24-12 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

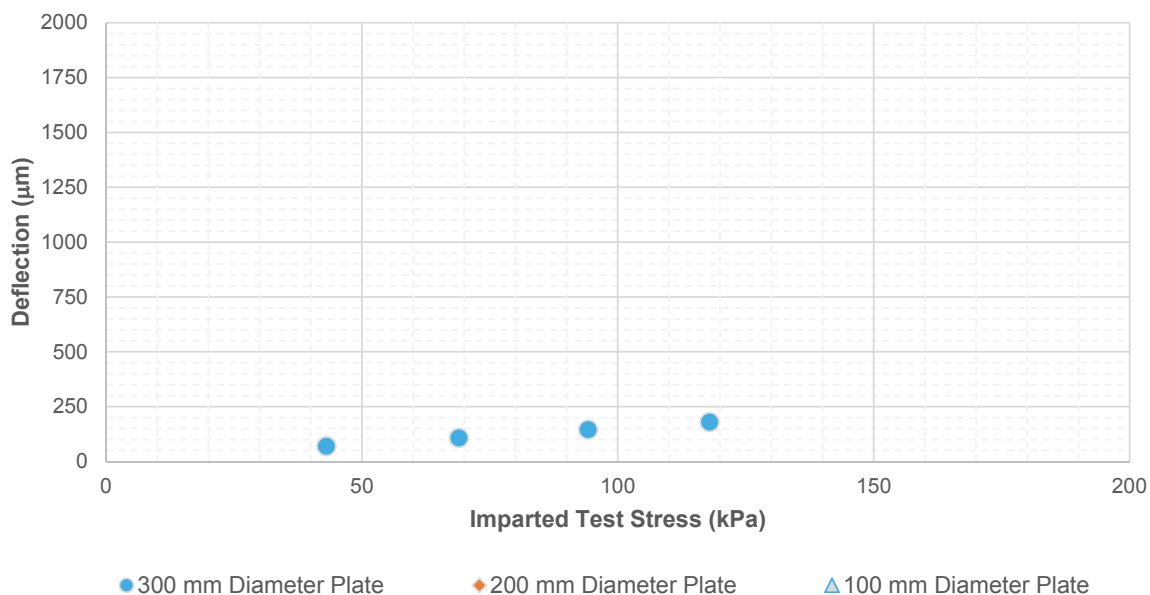
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	43	68.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	69	106.7						
6	94	144.6						
6	118	179.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	167
			100	172
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 25-1

Certificate Reference: 2091-LFWD-PRIMA-Site 25-1 Sheet: 1 of 1

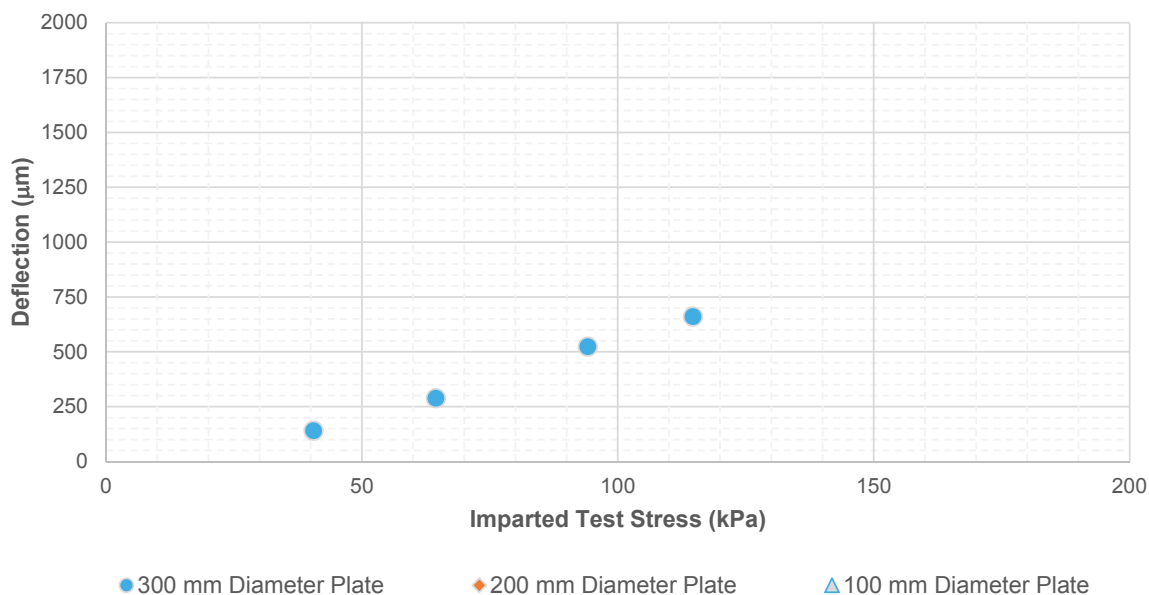
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 6/03/2019
 Location: Site 25-1 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	41	139.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	64	287.9						
10	94	522.3						
7	115	659.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	68.0
			100	47.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 25-2

Certificate Reference: 2091-LFWD-PRIMA-Site 25-2 Sheet: 1 of 1

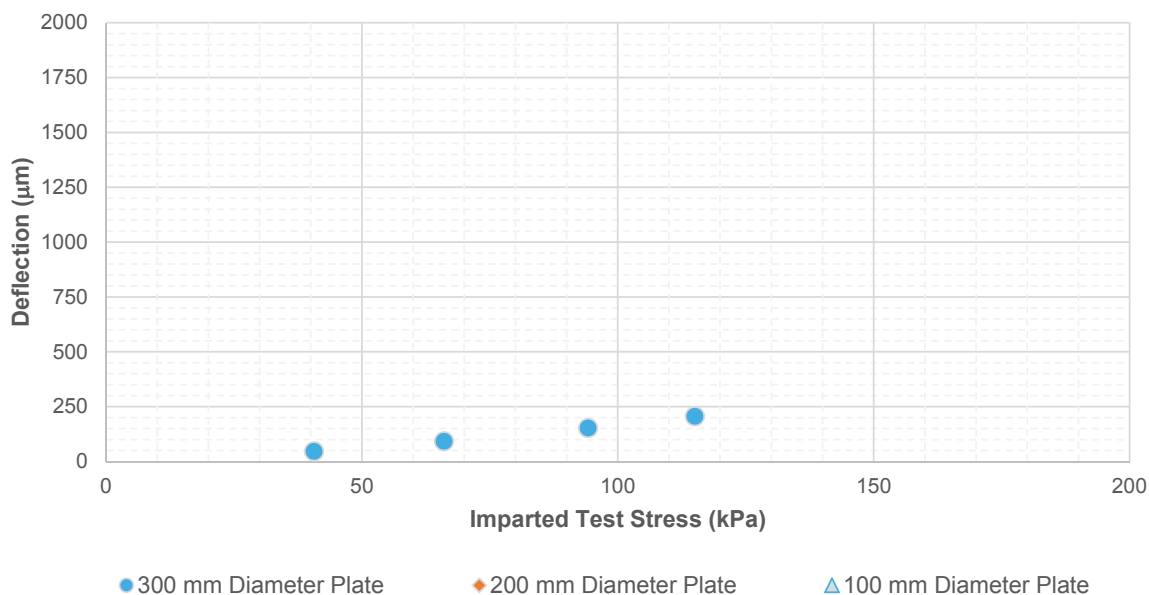
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 6/03/2019
 Location: Site 25-2 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	45.1 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	66	91.3						
8	94	151.9						
3	115	204.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	204
			100	160
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 25-3

Certificate Reference: 2091-LFWD-PRIMA-Site 25-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 25-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

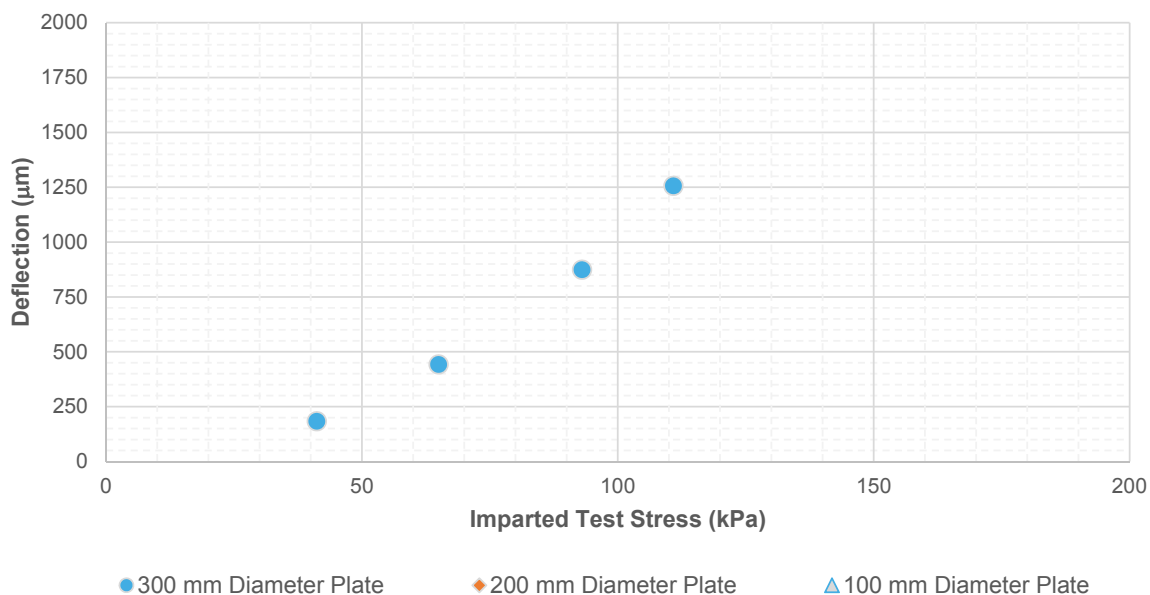
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	182.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	65	441.7						
6	93	873.2						
7	111	1255.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	43.5
			100	26.5
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 25-4

Certificate Reference: 2091-LFWD-PRIMA-Site 25-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 25-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

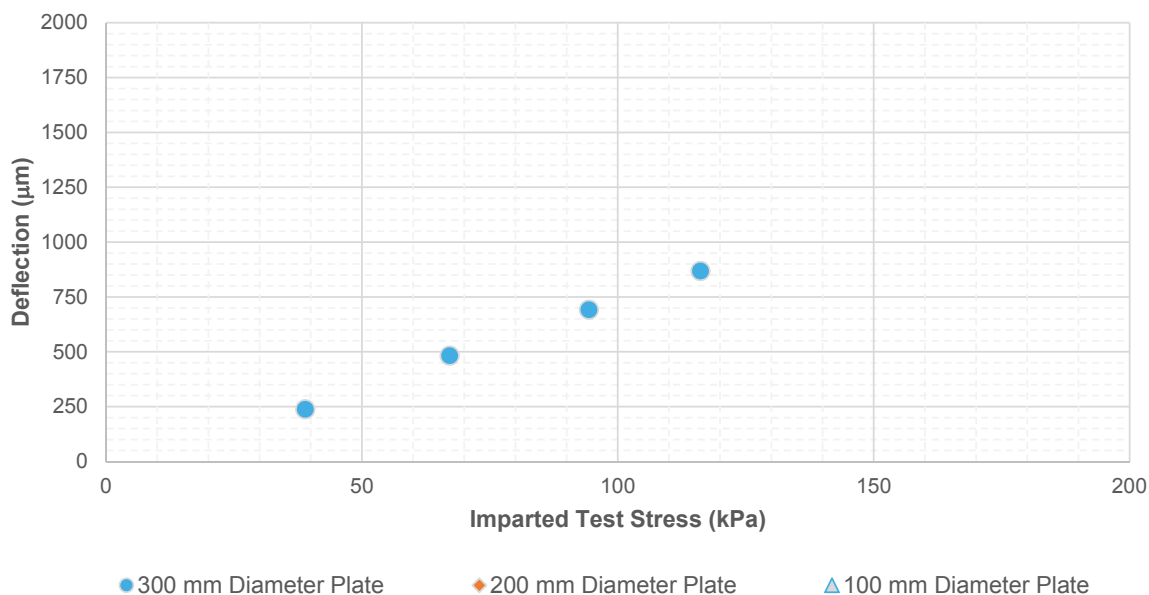
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	39	237.3	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
10	67	481.4						
4	94	690.7						
5	116	867.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	37.3
			100	35.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 25-5

Certificate Reference: 2091-LFWD-PRIMA-Site 25-5

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 25-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

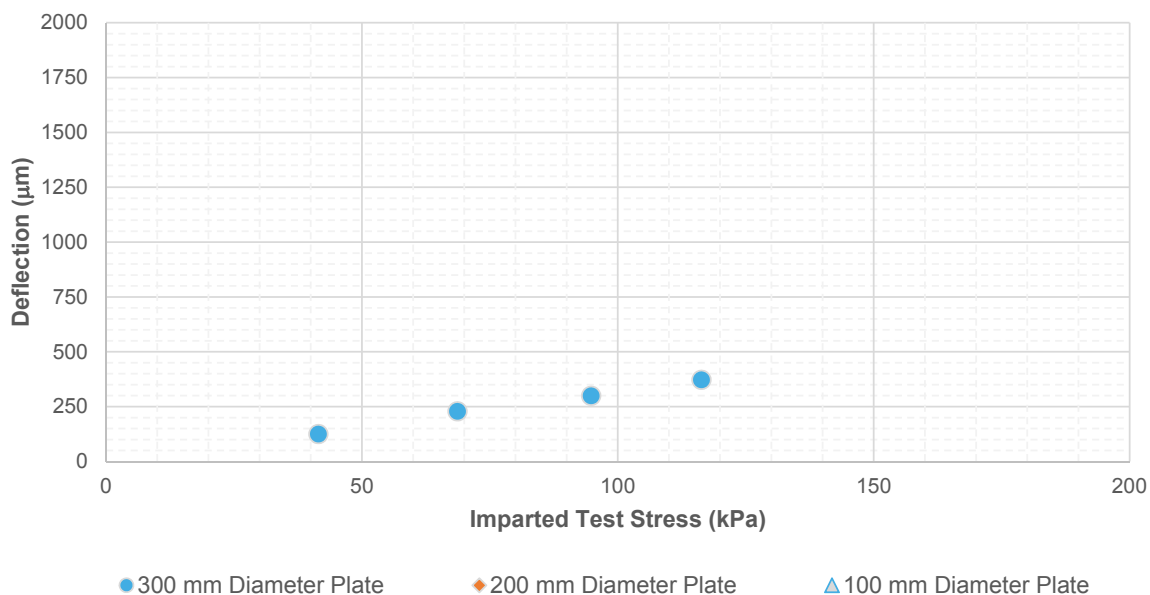
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	124.5	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	69	228.1						
5	95	298.4						
5	116	371.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	78.8
			100	82.2
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 25-6

Certificate Reference: 2091-LFWD-PRIMA-Site 25-6 Sheet: 1 of 1

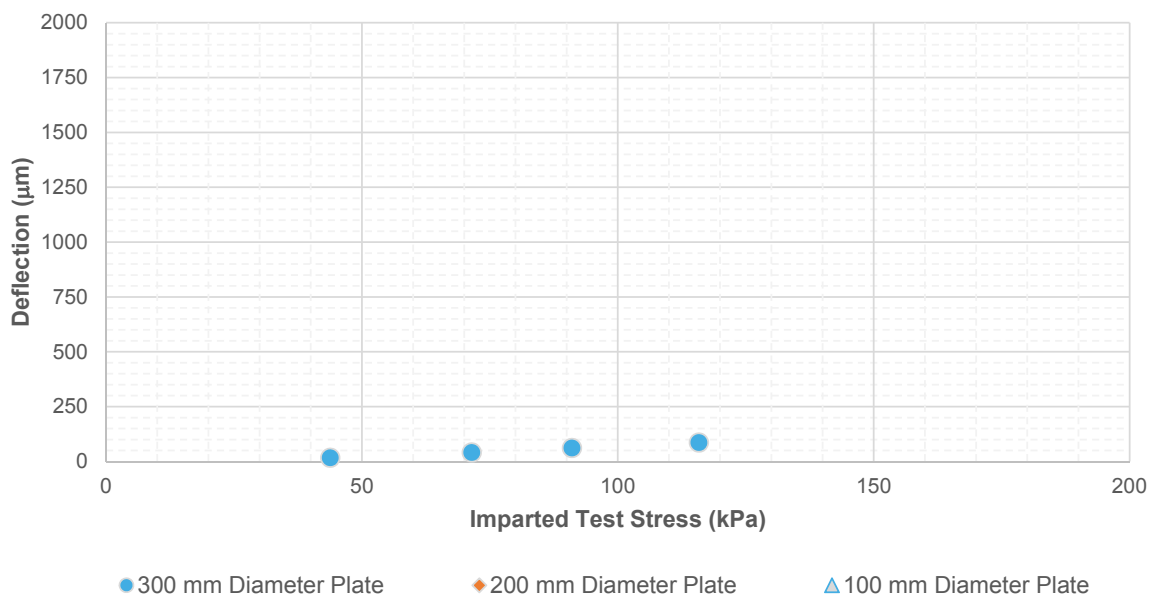
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 7/03/2019
 Location: Site 25-6 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	44	16.4 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	71	40.0 ⁺						
4	91	60.5						
6	116	85.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	519 ⁺
			100	391
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 25-7

Certificate Reference: 2091-LFWD-PRIMA-Site 25-7

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 25-7 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

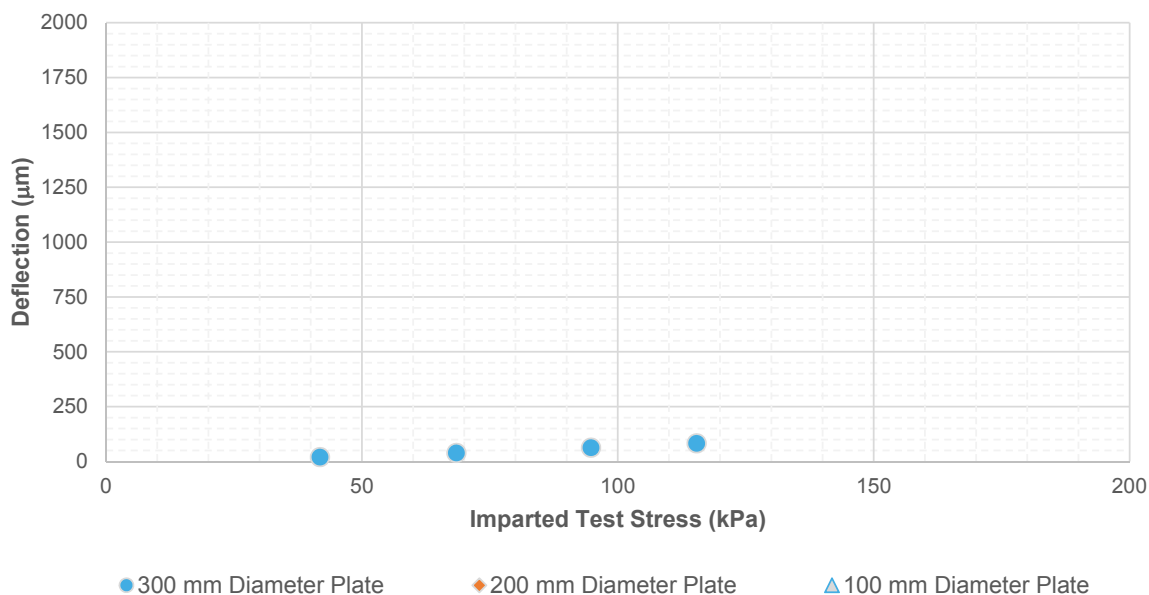
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	42	19.0 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	68	38.4 ⁺						
5	95	62.4						
8	115	81.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	504 ⁺
			100	399
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 25-8

Certificate Reference: 2091-LFWD-PRIMA-Site 25-8 Sheet: 1 of 1

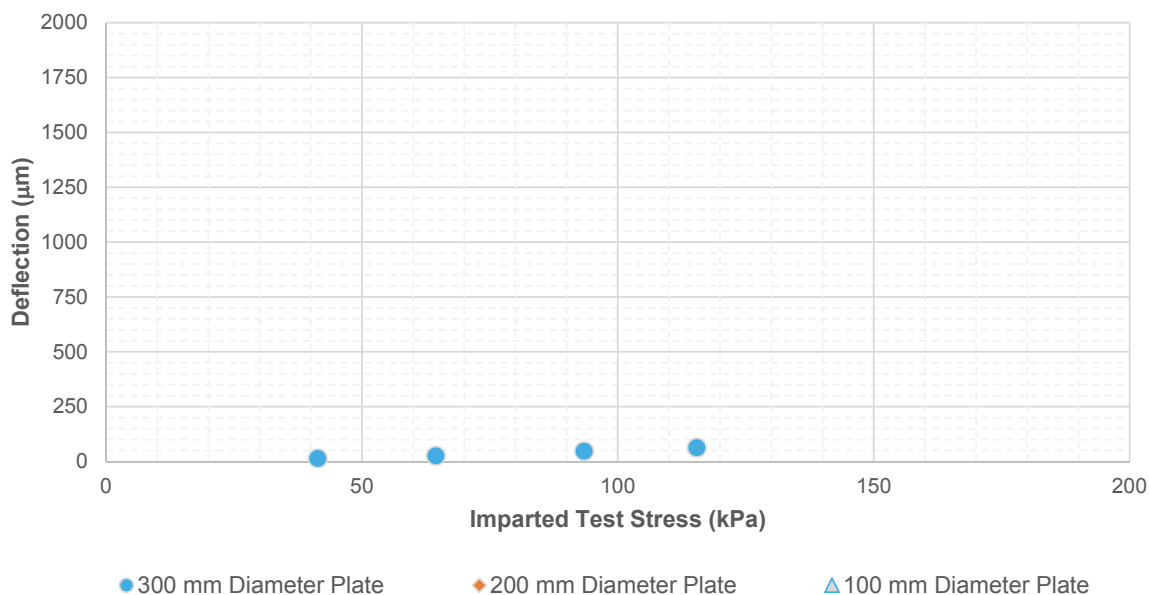
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 7/03/2019
 Location: Site 25-8 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	41	13.0 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	64	24.8 ⁺						
9	93	46.2 ⁺						
7	115	62.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	730 ⁺
			100	533
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 25-9

Certificate Reference: 2091-LFWD-PRIMA-Site 25-9

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 25-9 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

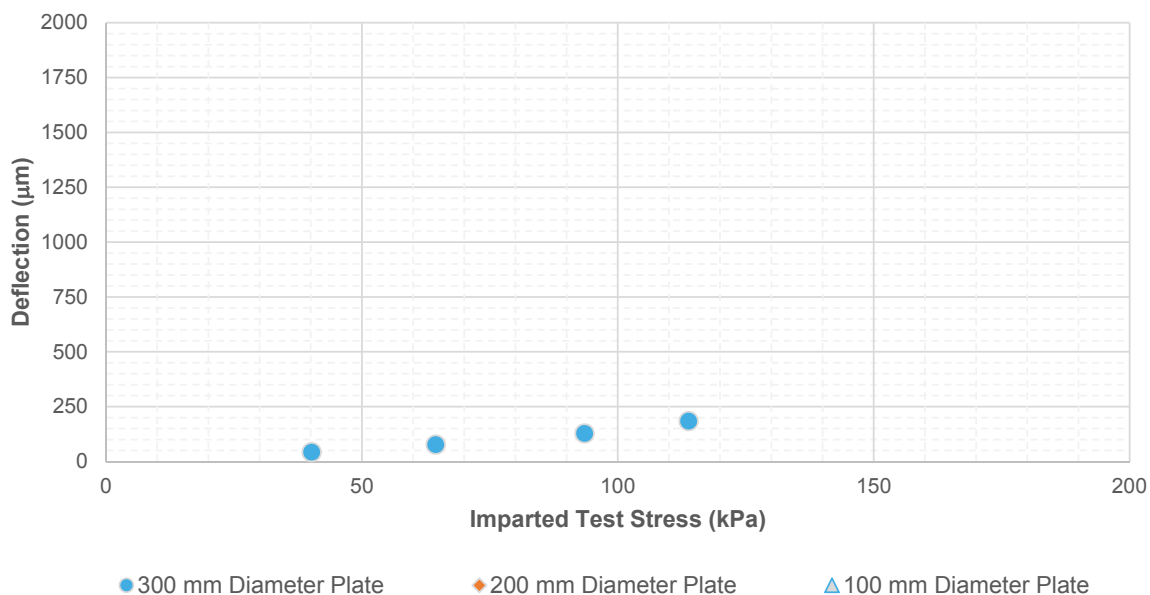
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	40	41.8 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	64	76.1						
4	94	127.2						
8	114	183.4						

⁺Material considered to have yielded at applied stress state

⁺Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	242
			100	182
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 25-10

Certificate Reference: 2091-LFWD-PRIMA-Site 25-10

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 25-10 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

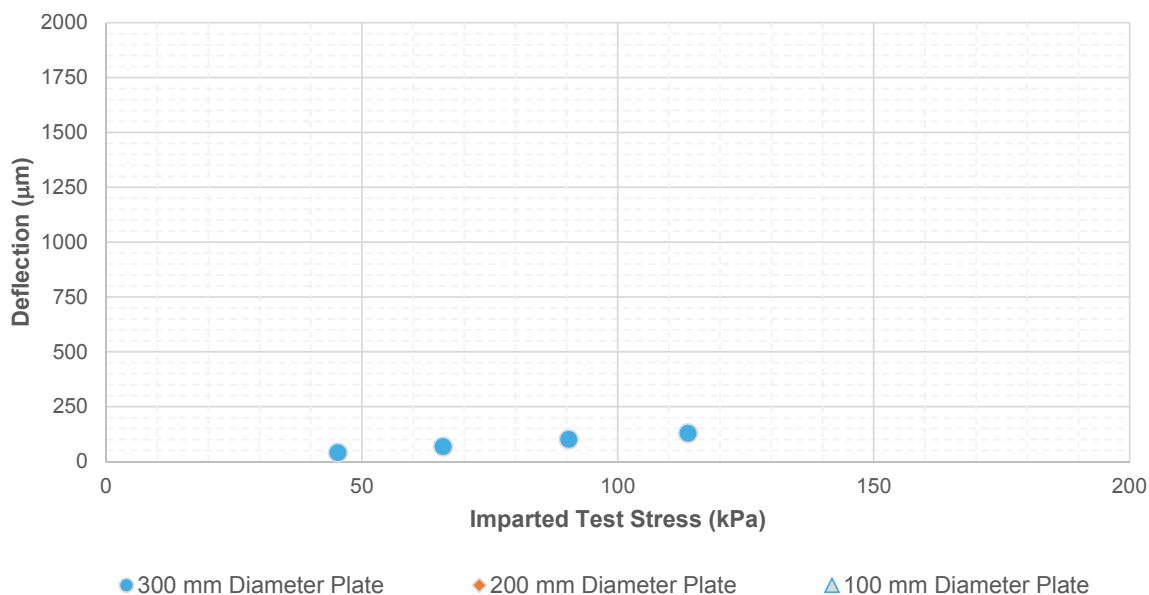
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	45	39.4 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	66	67.3						
7	90	100.1						
6	114	128.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	264 ⁺
			100	238
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 25-11

Certificate Reference: 2091-LFWD-PRIMA-Site 25-11

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 25-11 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

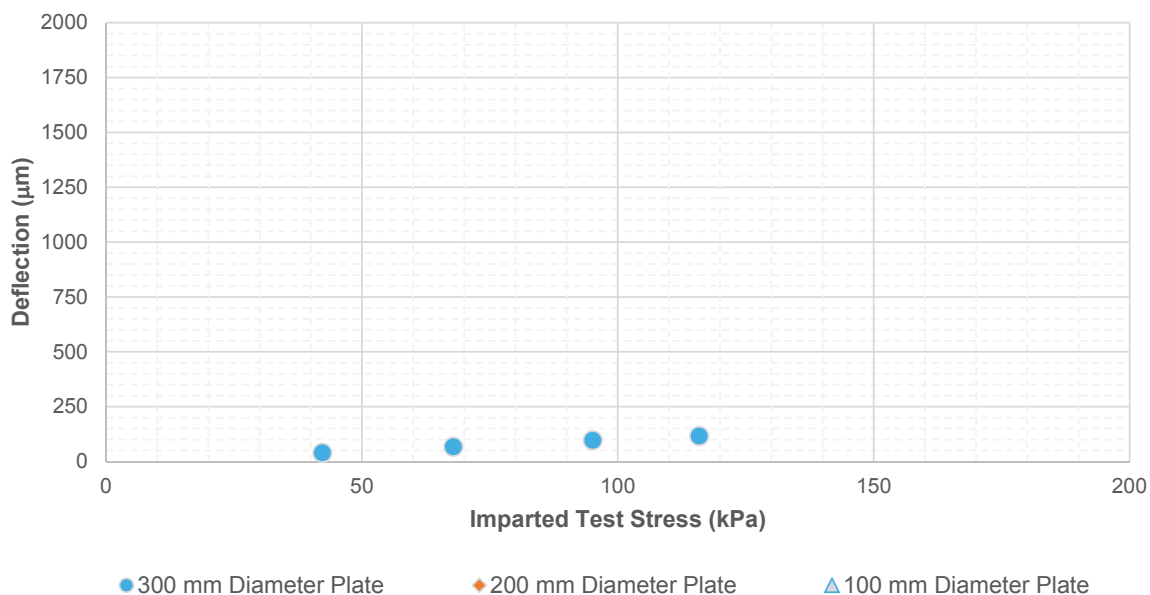
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	42	39.0 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	68	66.6						
8	95	95.8						
8	116	115.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	279 ⁺
			100	264
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 25-12

Certificate Reference: 2091-LFWD-PRIMA-Site 25-12

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 25-12 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

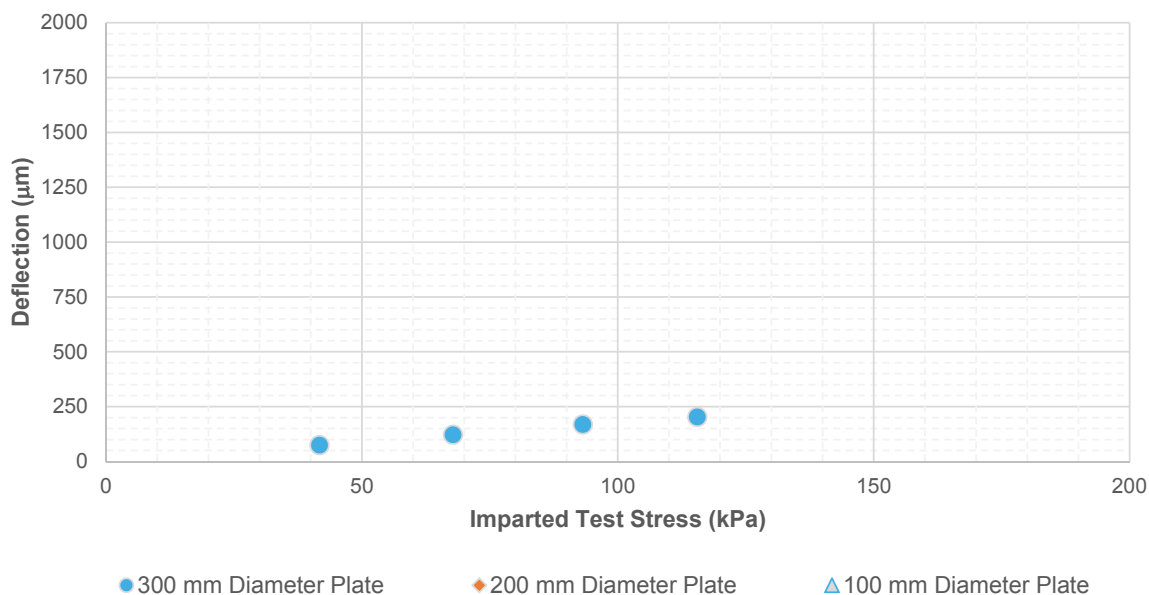
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	42	74.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	68	121.6						
8	93	168.2						
6	116	202.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	148
			100	146
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 26-1

Certificate Reference: 2091-LFWD-PRIMA-Site 26-1 Sheet: 1 of 1

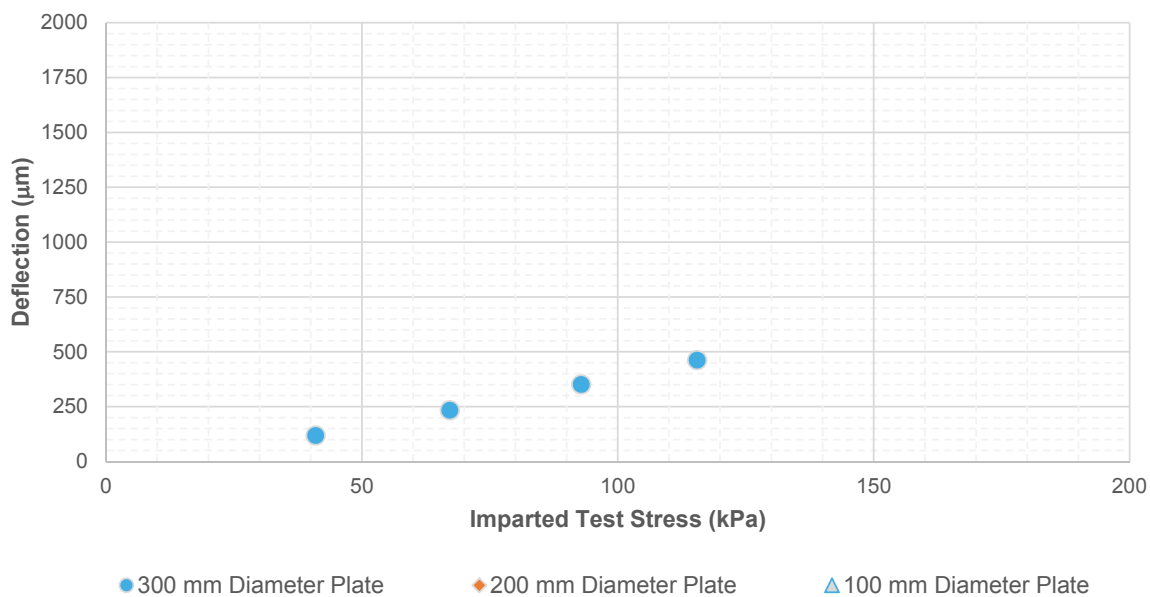
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 6/03/2019
 Location: Site 26-1 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	41	117.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	67	232.7						
6	93	350.5						
6	116	461.2						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	85.1
			100	68.3
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 26-2

Certificate Reference: 2091-LFWD-PRIMA-Site 26-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 26-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

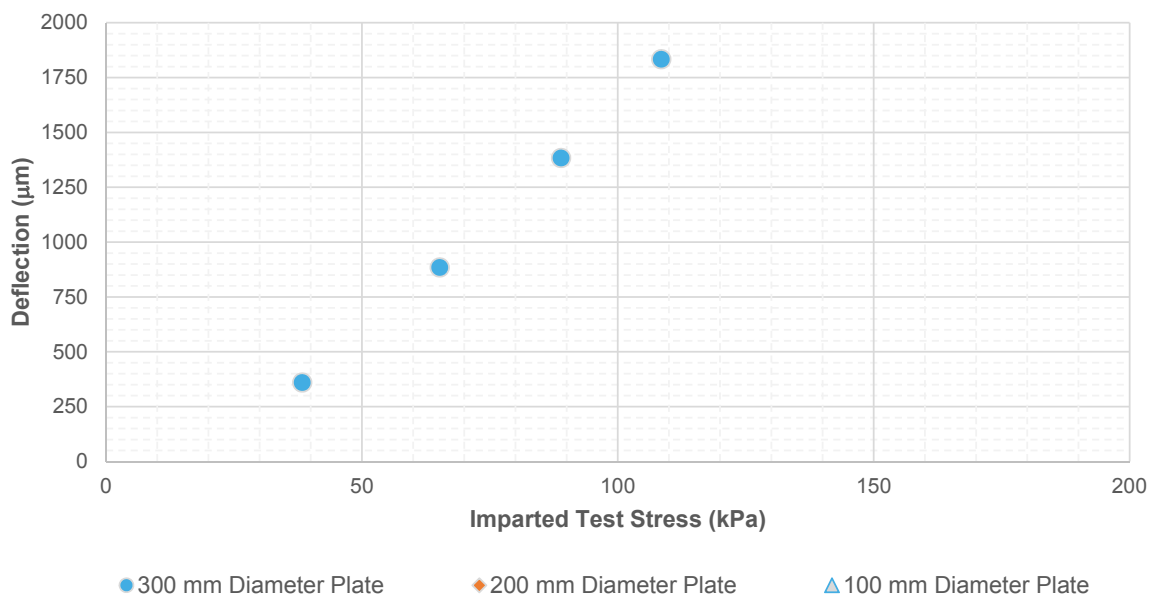
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	38	359.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	65	883.8						
7	89	1383.0						
6	109	1832.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	23.7
			100	15.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 26-2A

Certificate Reference: 2091-LFWD-PRIMA-Site 26-2A **Sheet:** 1 of 1

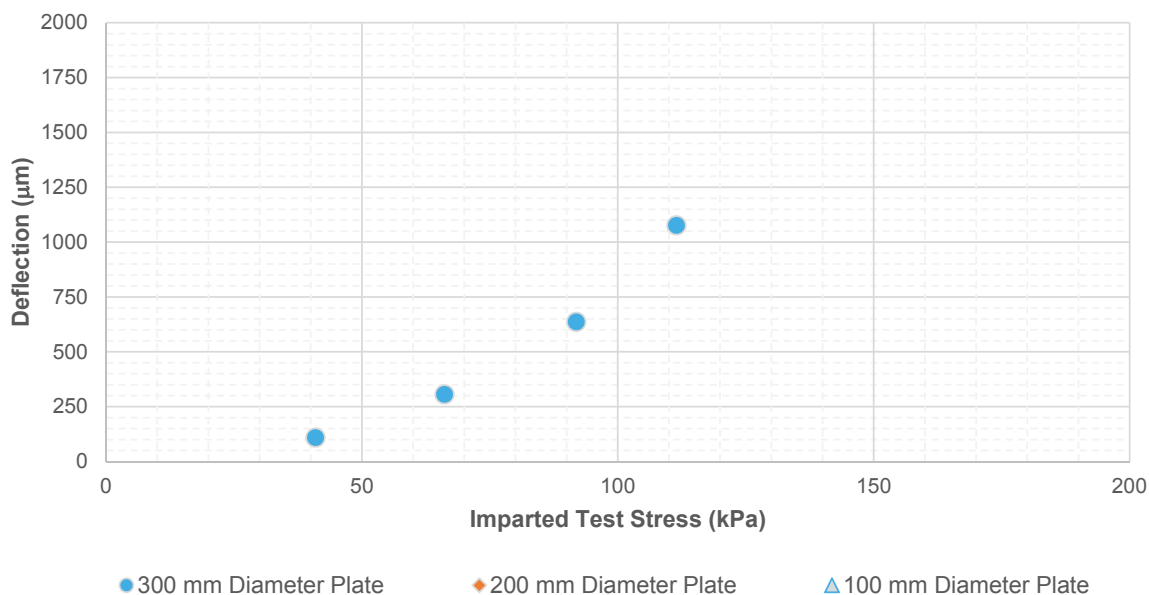
Client: ARRB **Project No.:** 2091
Project: Best Practice in Compaction QA **Test Date:** 6/03/2019
Location: Site 26-2 (Smithfield Bypass - Trial Embankment) **Tested By:** RM
Adopted Poisson's Ratio (ν): 0.35 **Checked By:** DWL
Adopted Stress Reduction Factor: 2 **Test Method:** ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	41	108.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	66	305.4						
4	92	635.9						
8	111	1075.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	79.1
			100	32.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 26-3

Certificate Reference: 2091-LFWD-PRIMA-Site 26-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 26-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

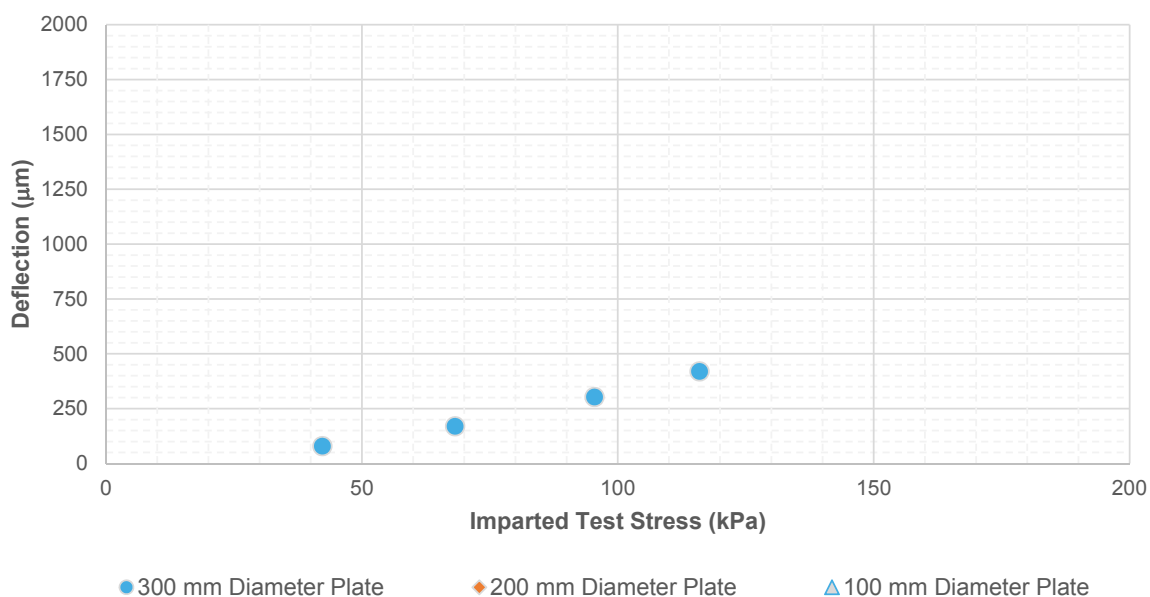
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	42	78.0	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	68	168.6						
4	95	302.2						
8	116	419.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	129
			100	80.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 26-4

Certificate Reference: 2091-LFWD-PRIMA-Site 26-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 26-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

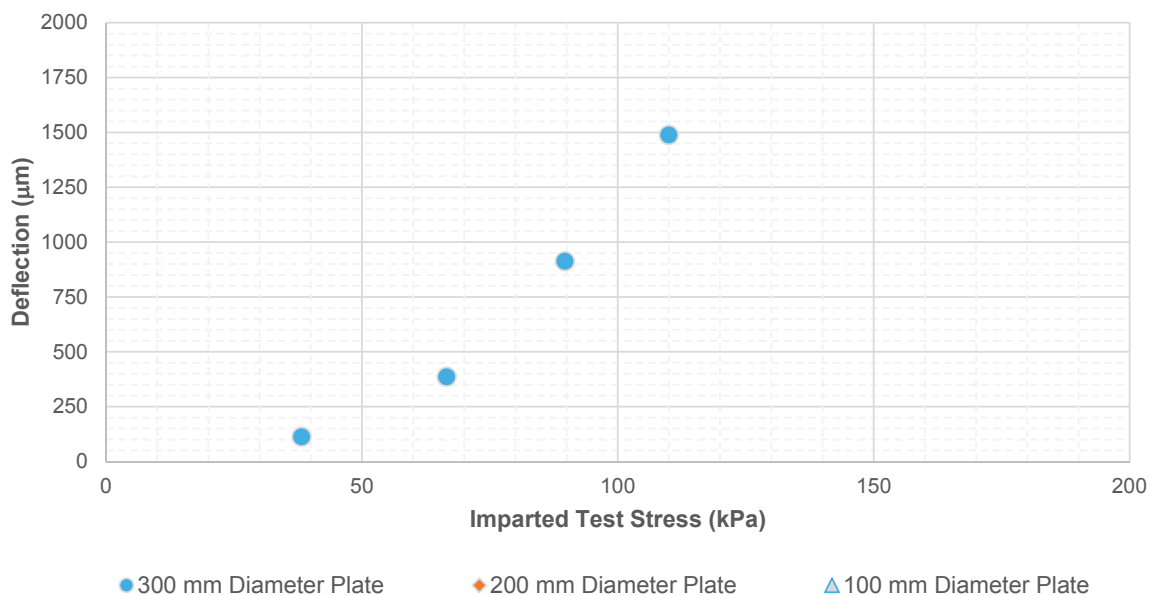
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
10	38	111.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	67	385.0						
6	90	912.0						
6	110	1487.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	63.1
			100	22.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 26-5

Certificate Reference: 2091-LFWD-PRIMA-Site 26-5 Sheet: 1 of 1

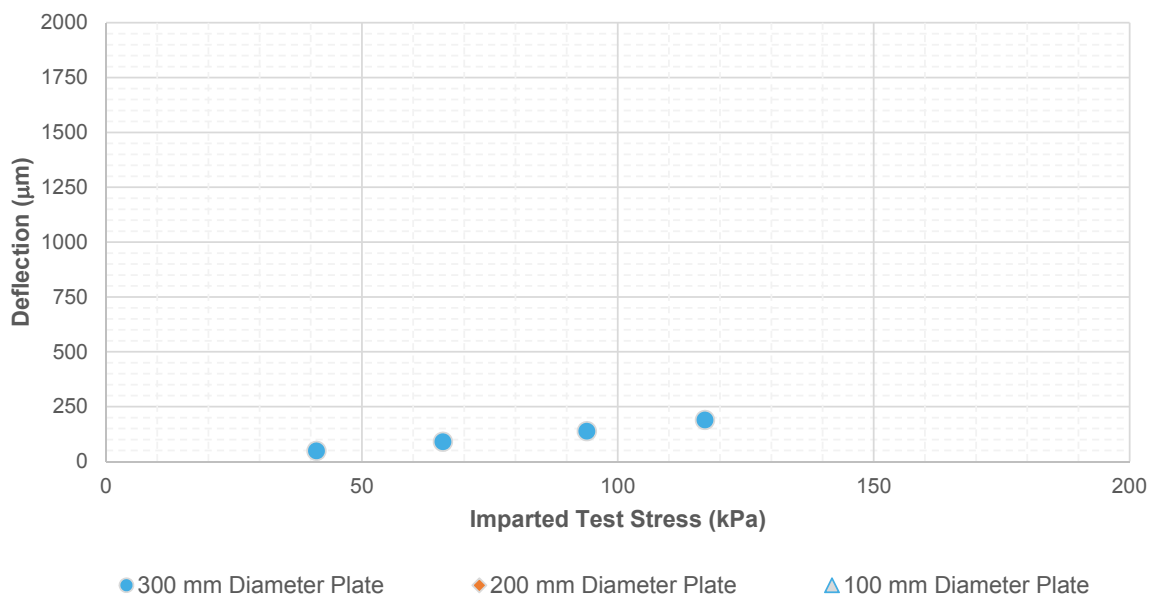
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 6/03/2019
 Location: Site 26-5 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	41	47.8 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	66	89.4						
5	94	137.4						
4	117	188.2						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	214
			100	174
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 26-6

Certificate Reference: 2091-LFWD-PRIMA-Site 26-6

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 26-6 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

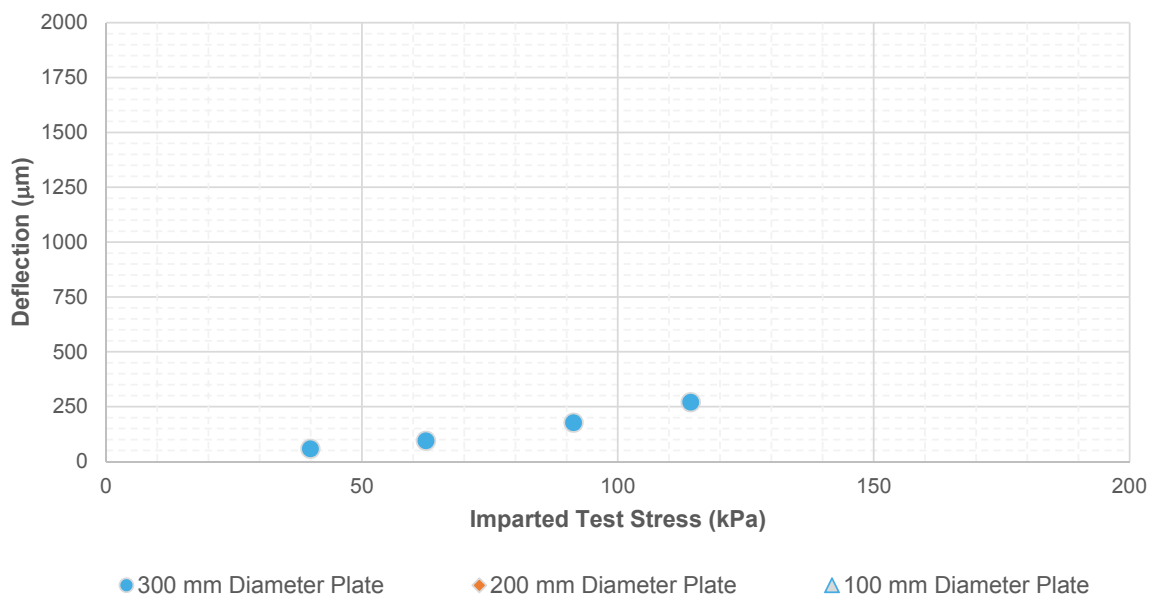
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
10	40	56.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
11	63	93.2						
9	91	176.3						
7	114	269.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	182
			100	129
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 26-7

Certificate Reference: 2091-LFWD-PRIMA-Site 26-7

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 26-7 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

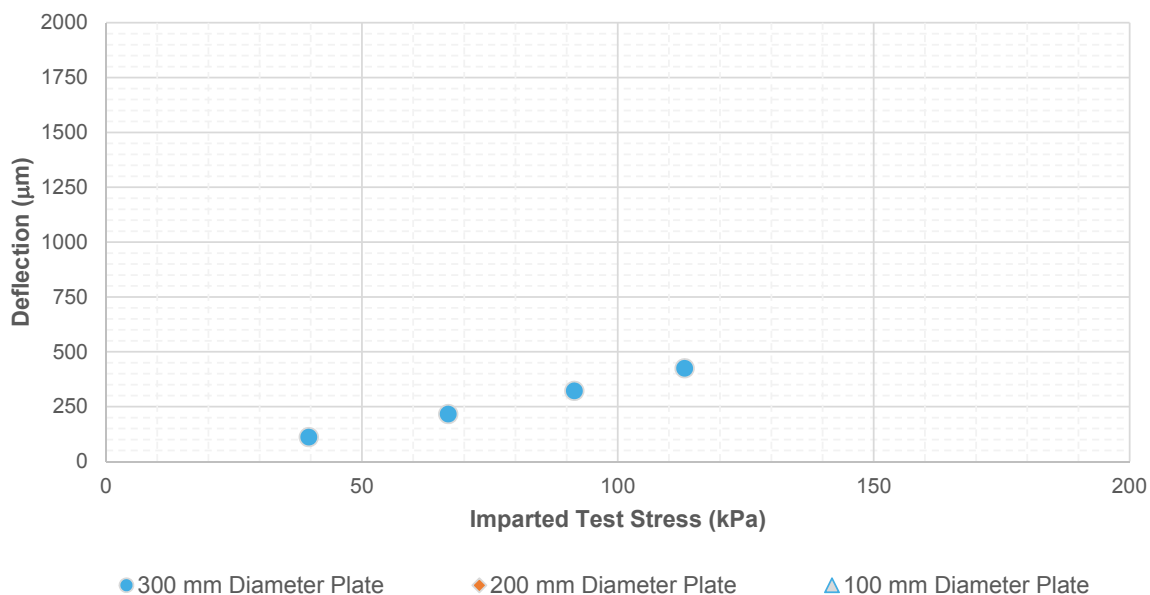
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	40	110.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	67	215.0						
5	92	321.4						
7	113	424.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	89.7
			100	73.1
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 26-8

Certificate Reference: 2091-LFWD-PRIMA-Site 26-8

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 26-8 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

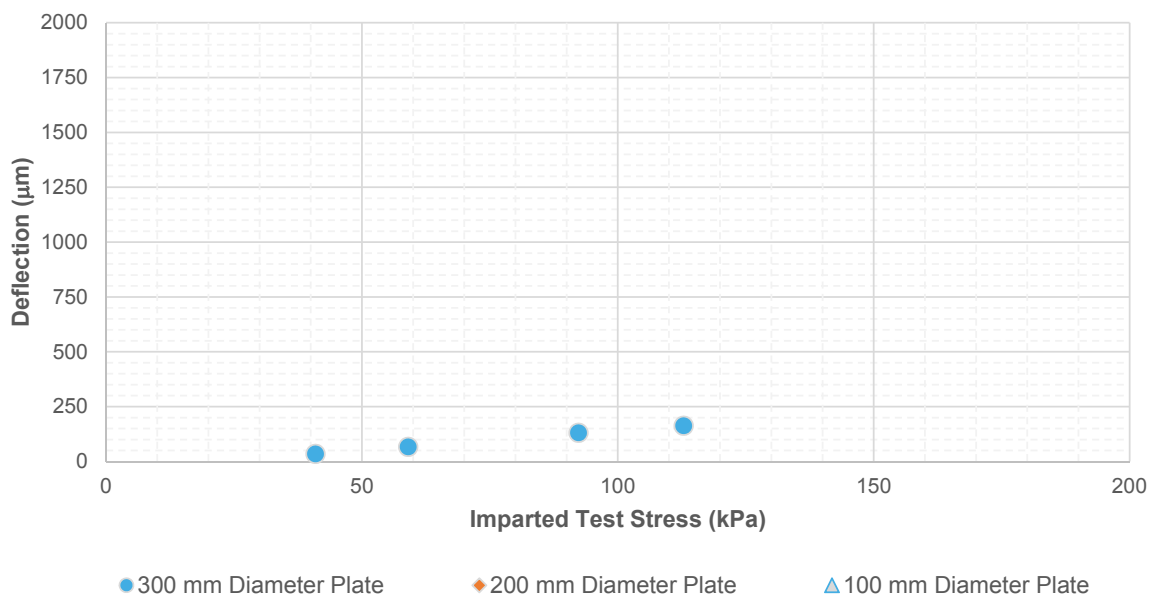
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	41	33.9 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	59	65.5						
8	92	129.9						
6	113	161.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	275 ⁺
			100	187
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 26-9

Certificate Reference: 2091-LFWD-PRIMA-Site 26-9

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 26-9 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

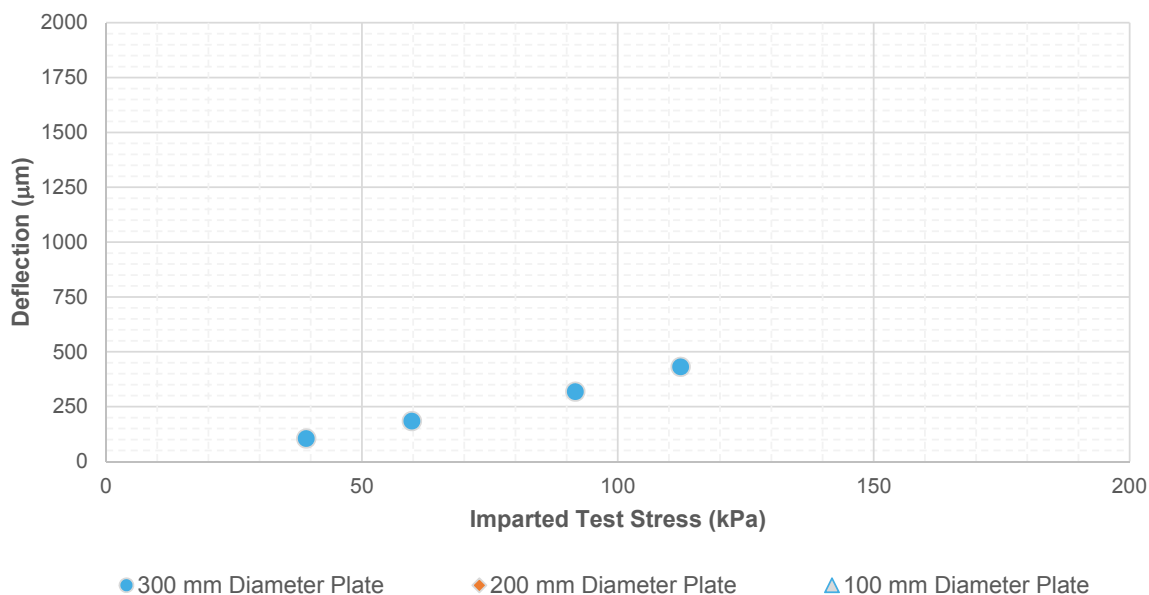
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
9	39	103.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	60	183.4						
7	92	317.4						
11	112	430.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	93.1
			100	72.7
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 26-11

Certificate Reference: 2091-LFWD-PRIMA-Site 26-11

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 26-11 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

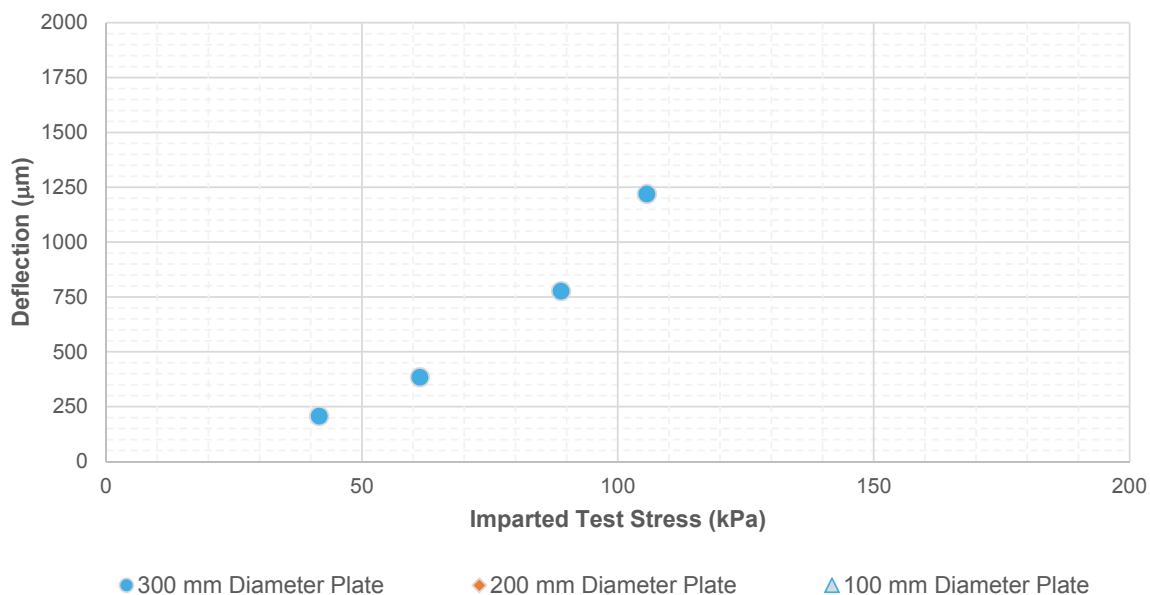
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	42	206.0	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	61	383.2						
9	89	776.0						
8	106	1218.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	48.6
			100	25.1
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 26-12

Certificate Reference: 2091-LFWD-PRIMA-Site 26-12 Sheet: 1 of 1

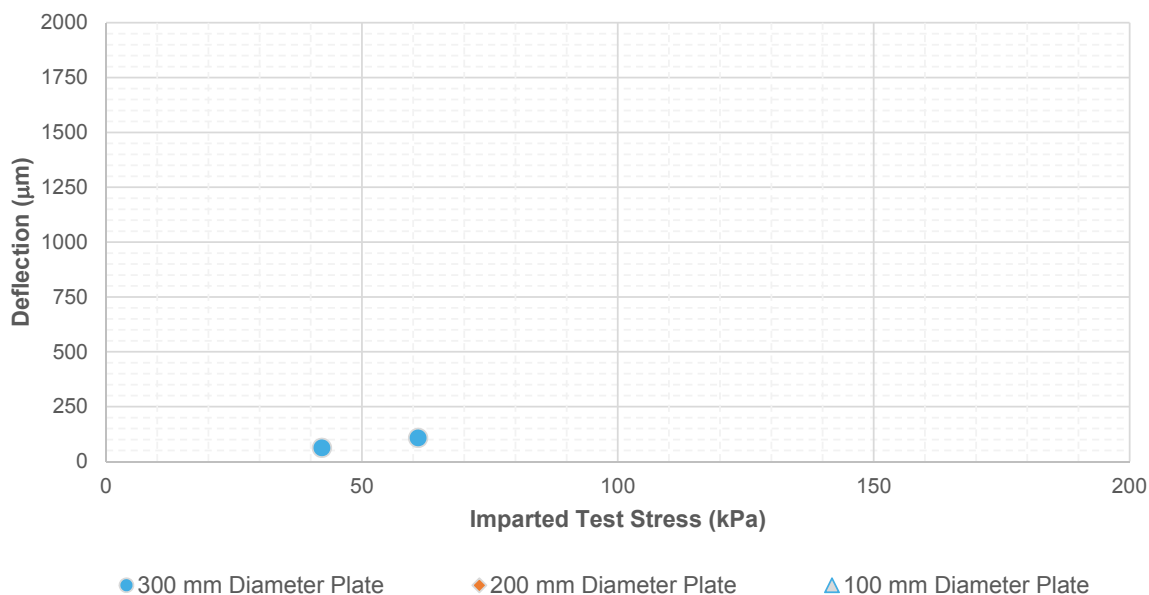
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 6/03/2019
 Location: Site 26-12 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	42	61.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
3	61	106.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	168
			100	
			500	
	100 to 300 mm Diameter:	N/A	750	Beyond Test Stress Range Applied
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site assessed with 2 no. ascending test stresses only

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 27-1

Certificate Reference: 2091-LFWD-PRIMA-Site 27-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 27-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

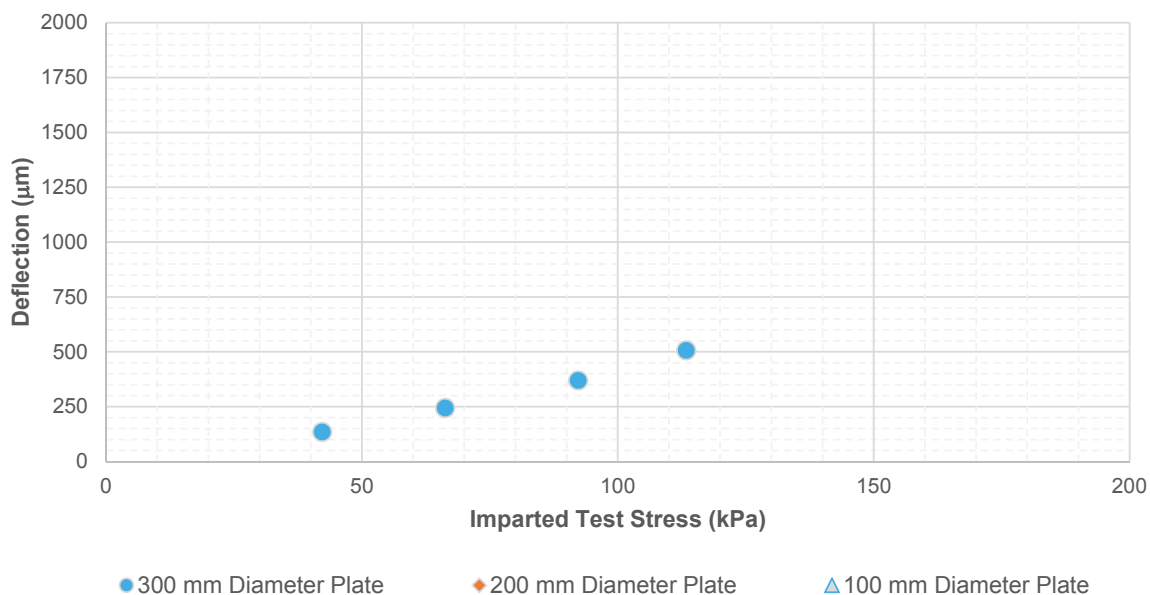
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	42	133.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
12	66	243.2						
5	92	368.6						
8	113	505.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	79.4
			100	63.0
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 27-2

Certificate Reference: 2091-LFWD-PRIMA-Site 27-2 Sheet: 1 of 1

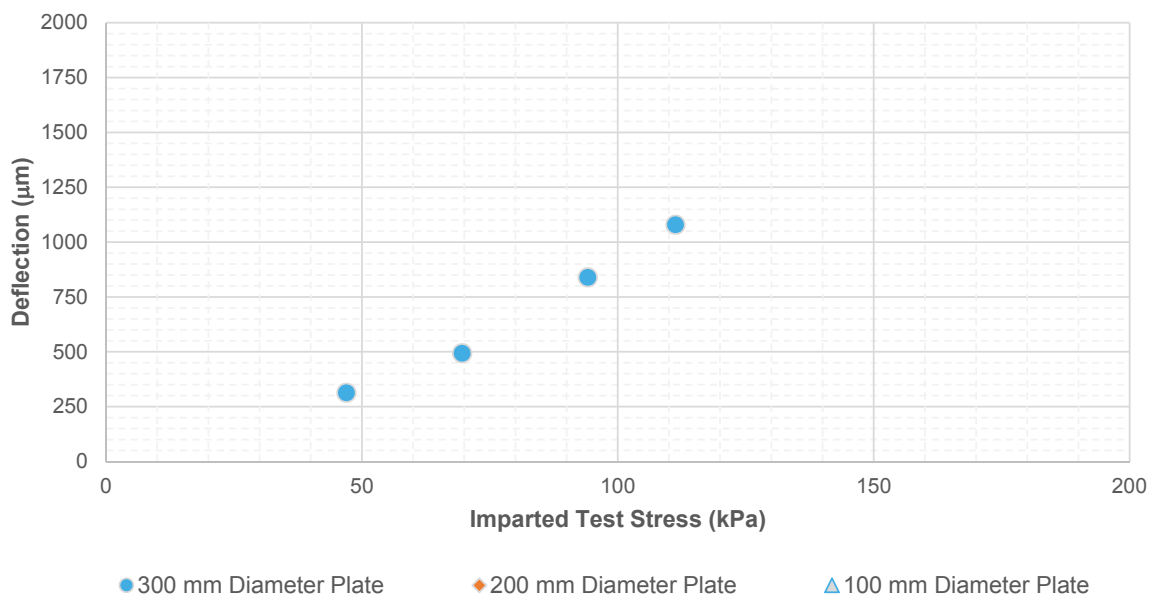
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 6/03/2019
 Location: Site 27-2 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	47	312.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
4	70	492.6						
4	94	838.6						
6	111	1078.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	39.7
			100	29.3
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 27-3

Certificate Reference: 2091-LFWD-PRIMA-Site 27-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 27-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

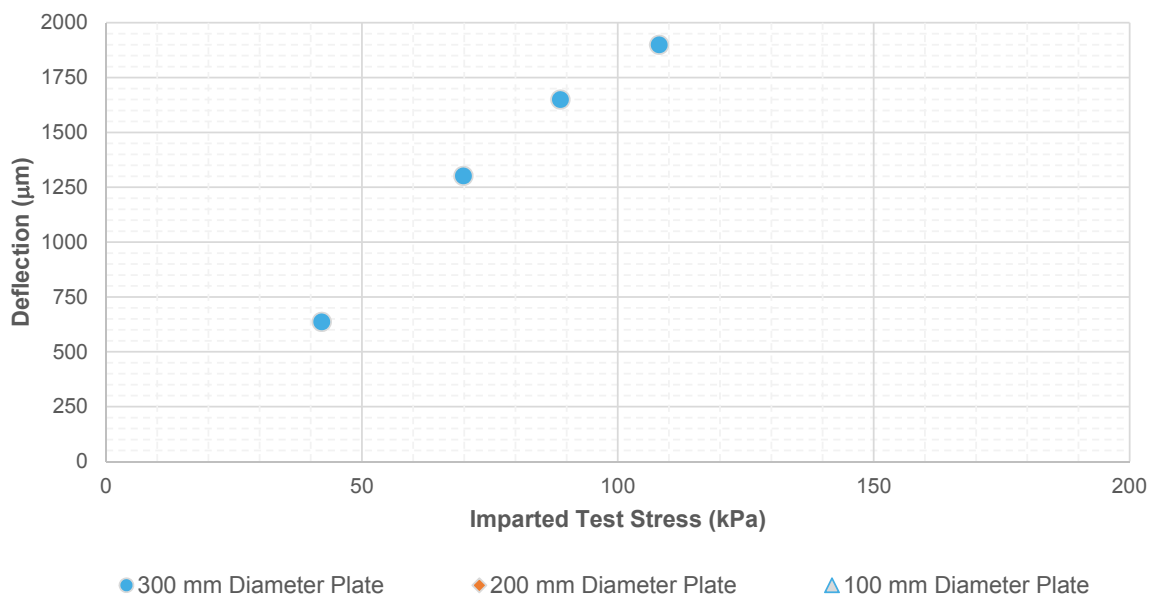
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	42	635.9	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	70	1300.9						
6	89	1648.8						
9	108	1898.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	16.5
			100	12.8
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 27-4

Certificate Reference: 2091-LFWD-PRIMA-Site 27-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 6/03/2019

Location: Site 27-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

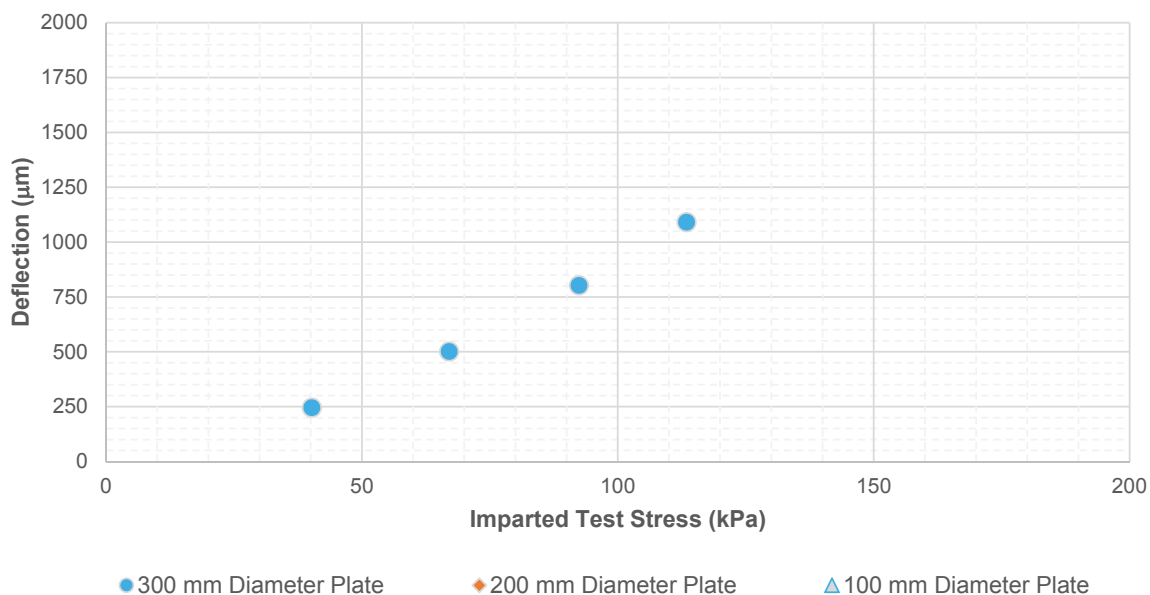
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	40	244.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	67	500.5						
10	92	801.8						
8	113	1090.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	40.3
			100	29.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 27-5

Certificate Reference: 2091-LFWD-PRIMA-Site 27-5 **Sheet:** 1 of 1

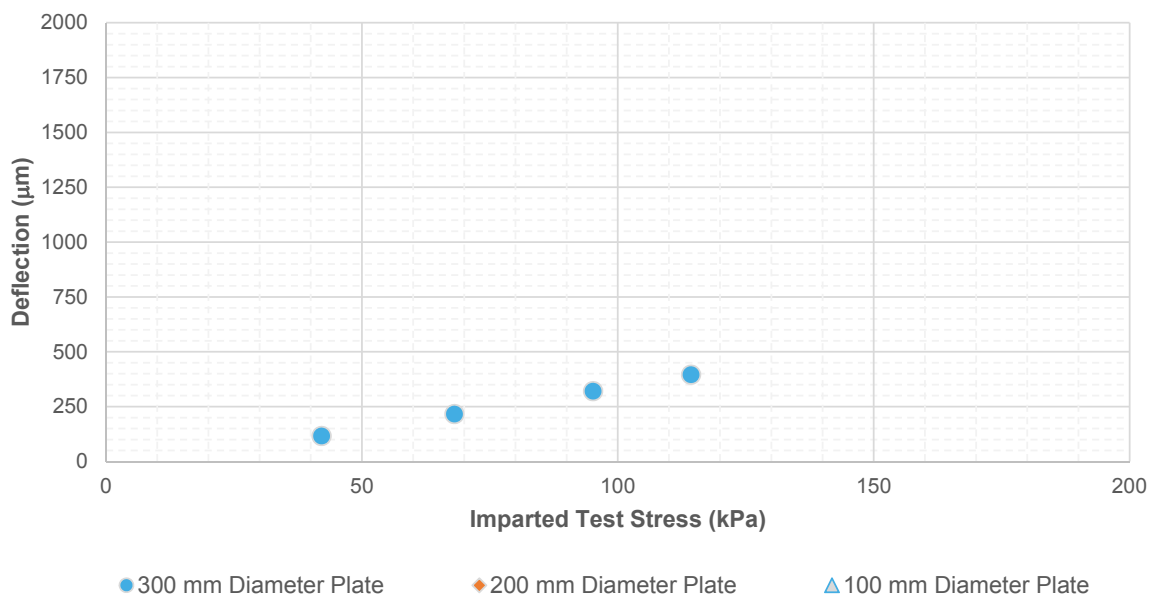
Client: ARRB Project: Best Practice in Compaction QA Location: Site 27-5 (Smithfield Bypass - Trial Embankment) Adopted Poisson's Ratio (v): 0.35 Adopted Stress Reduction Factor: 2	Project No.: 2091 Test Date: 6/03/2019 Tested By: RM Checked By: DWL Test Method: ASTM - E2583-07 (2011)
---	---

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (µm)
6	42	115.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	68	215.2						
9	95	319.3						
6	114	394.9						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	91.2
			100	77.7
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 28-1

Certificate Reference: 2091-LFWD-PRIMA-Site 28-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 28-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

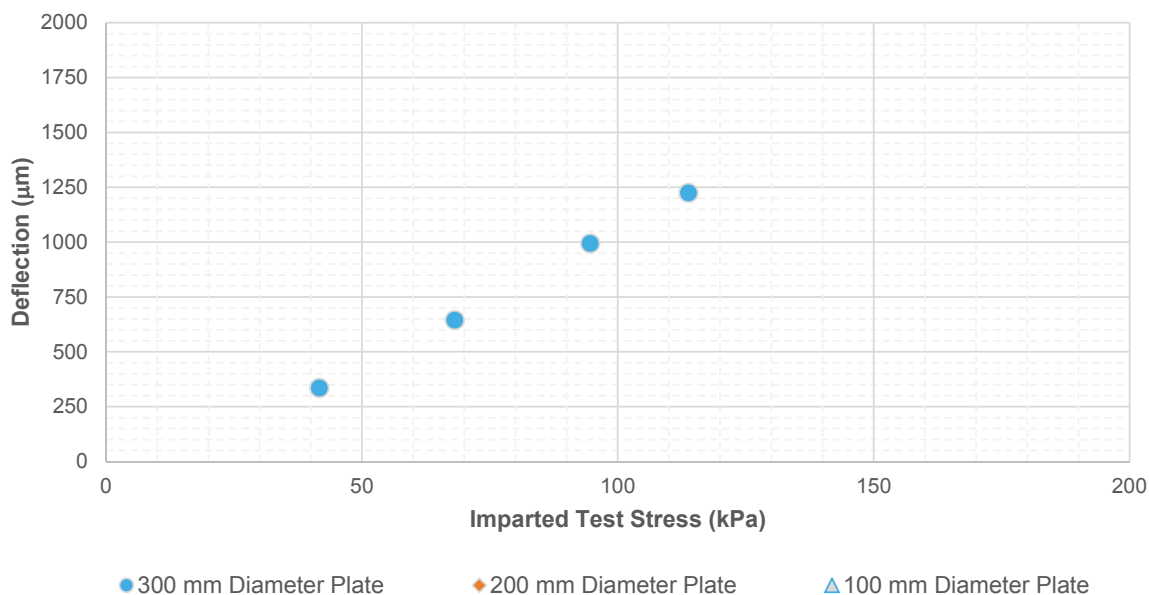
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	42	334.2	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	68	643.7						
6	95	993.0						
4	114	1223.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	30.9
			100	25.0
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 28-2

Certificate Reference: 2091-LFWD-PRIMA-Site 28-2 Sheet: 1 of 1

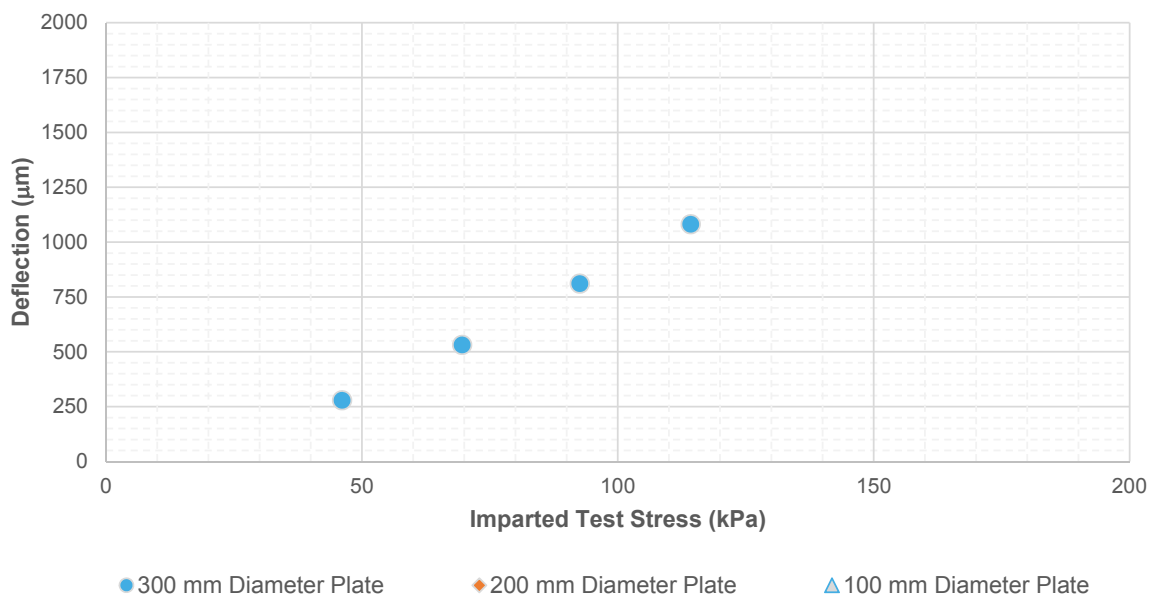
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 7/03/2019
 Location: Site 28-2 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	46	277.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	70	530.5						
4	93	810.2						
5	114	1080.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	41.5
			100	29.3
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 28-3

Certificate Reference: 2091-LFWD-PRIMA-Site 28-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 28-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

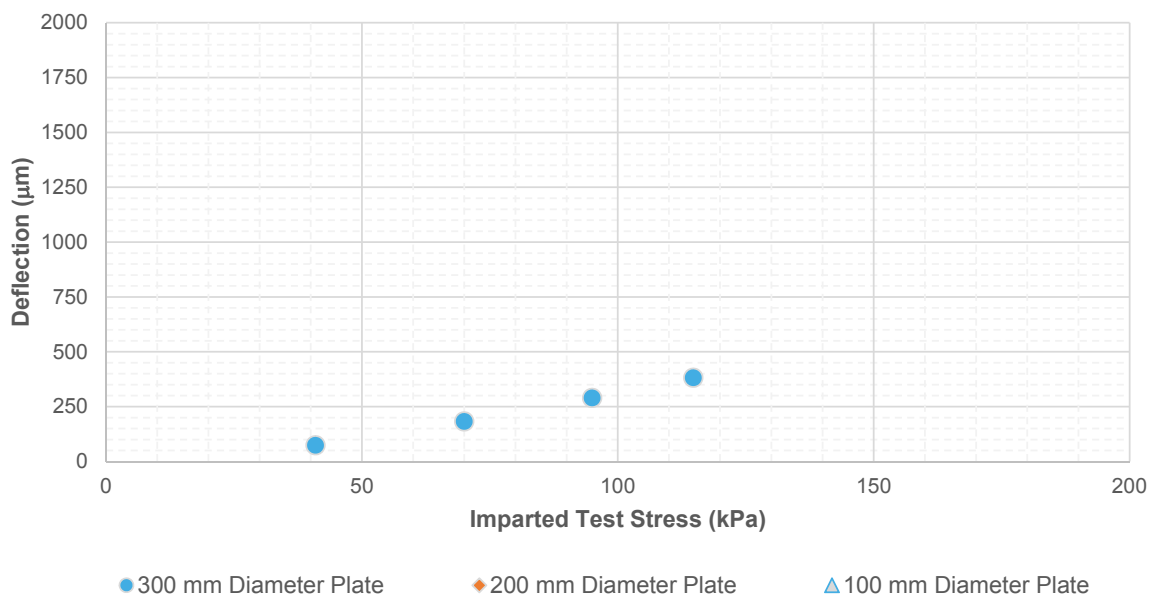
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
8	41	73.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	70	181.7						
5	95	289.0						
11	115	381.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	128
			100	84.4
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 28-4

Certificate Reference: 2091-LFWD-PRIMA-Site 28-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 28-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

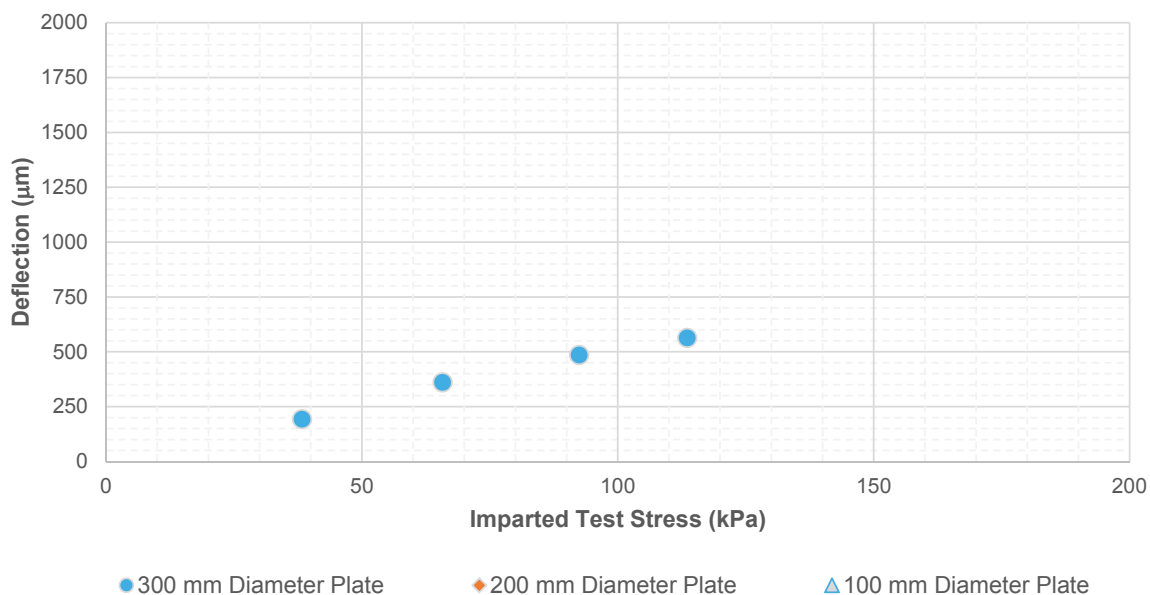
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
4	38	191.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	66	360.0						
8	92	484.8						
10	114	562.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	46.4
			100	51.5
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 28-5

Certificate Reference: 2091-LFWD-PRIMA-Site 28-5 Sheet: 1 of 1

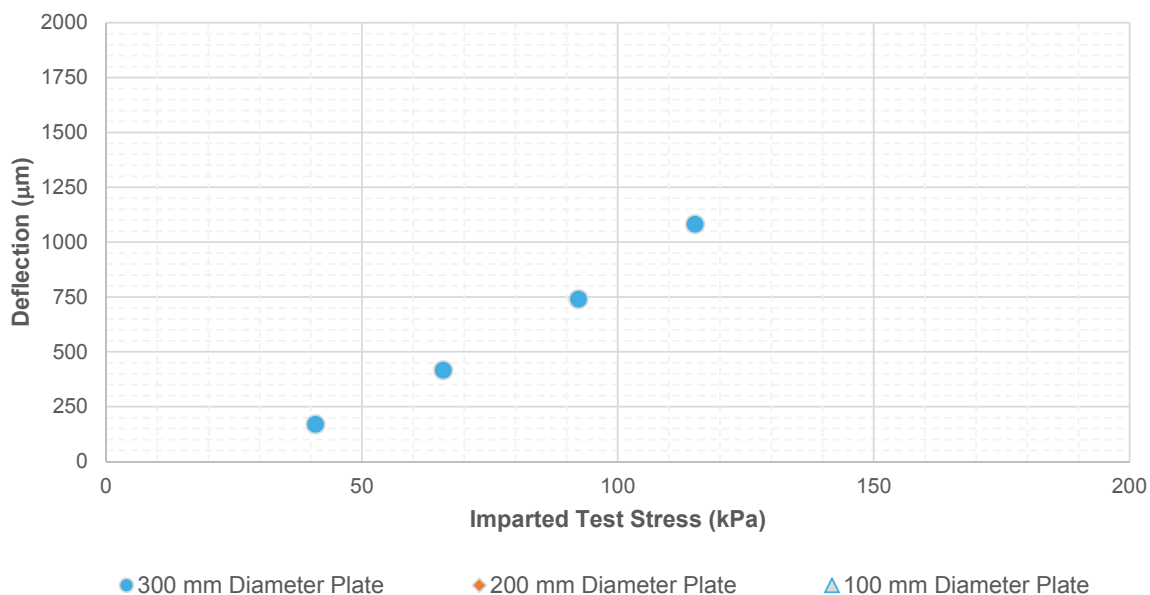
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 7/03/2019
 Location: Site 28-5 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	41	168.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
12	66	415.2						
6	92	739.5						
6	115	1080.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	53.7
			100	30.9
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 29-1

Certificate Reference: 2091-LFWD-PRIMA-Site 29-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 29-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

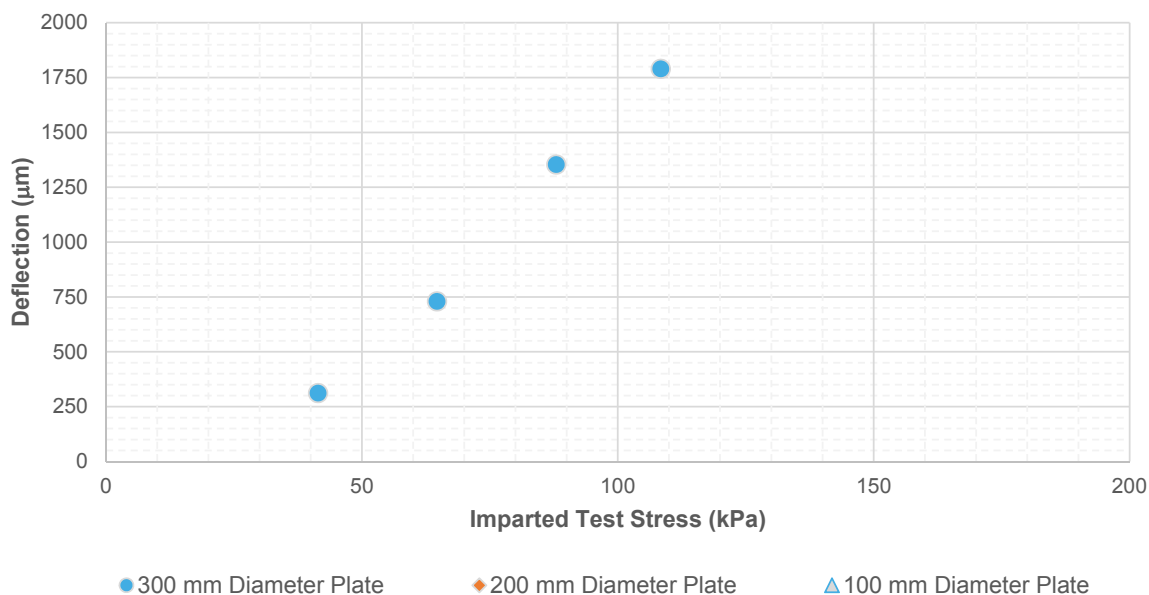
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	310.7	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	65	729.3						
6	88	1352.8						
6	108	1789.0						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	29.4
			100	16.3
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 29-2

Certificate Reference: 2091-LFWD-PRIMA-Site 29-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 29-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

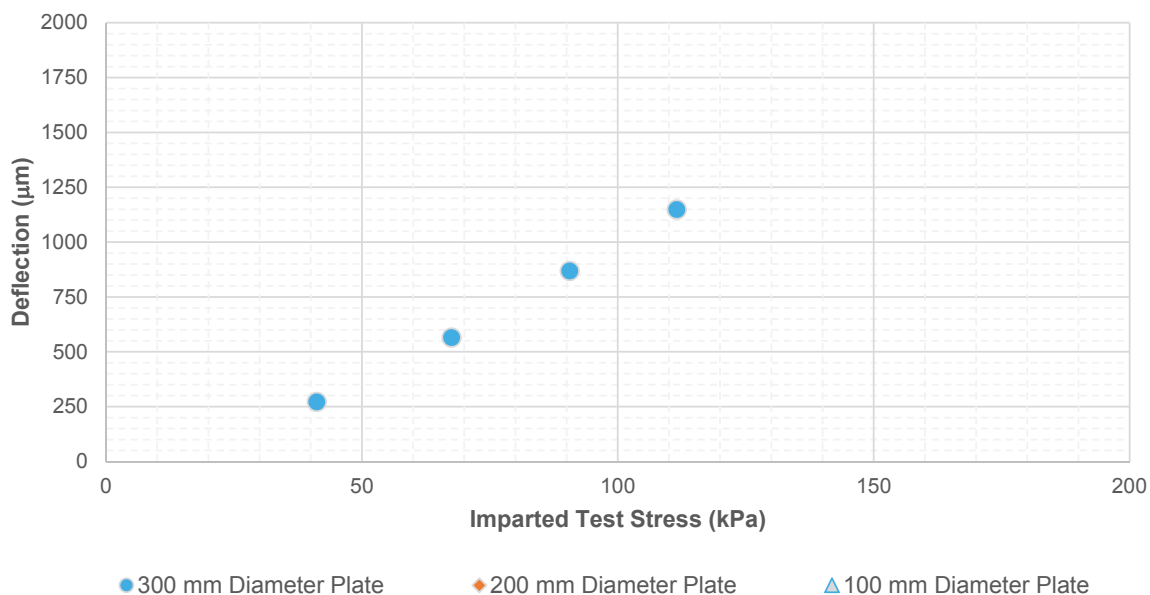
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	270.6	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
6	68	564.4						
4	91	867.3						
6	112	1148.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	36.4
			100	26.6
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 29-3

Certificate Reference: 2091-LFWD-PRIMA-Site 29-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 29-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

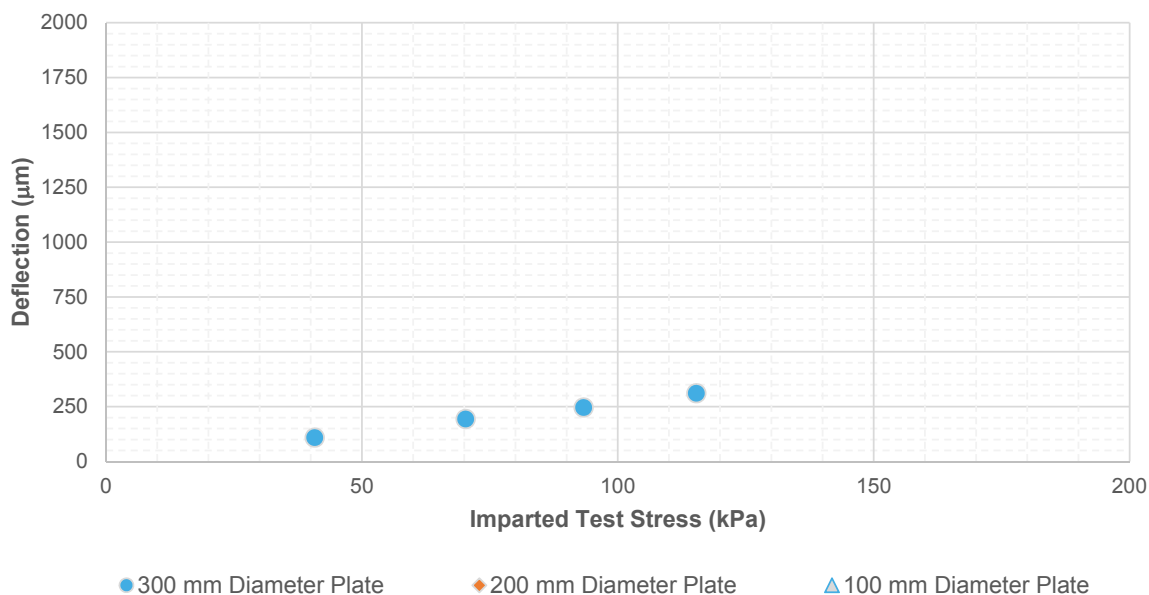
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	41	108.1	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
18	70	193.0						
7	93	245.2						
11	115	310.1						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	98.4
			100	98.3
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 29-4

Certificate Reference: 2091-LFWD-PRIMA-Site 29-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 7/03/2019

Location: Site 29-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

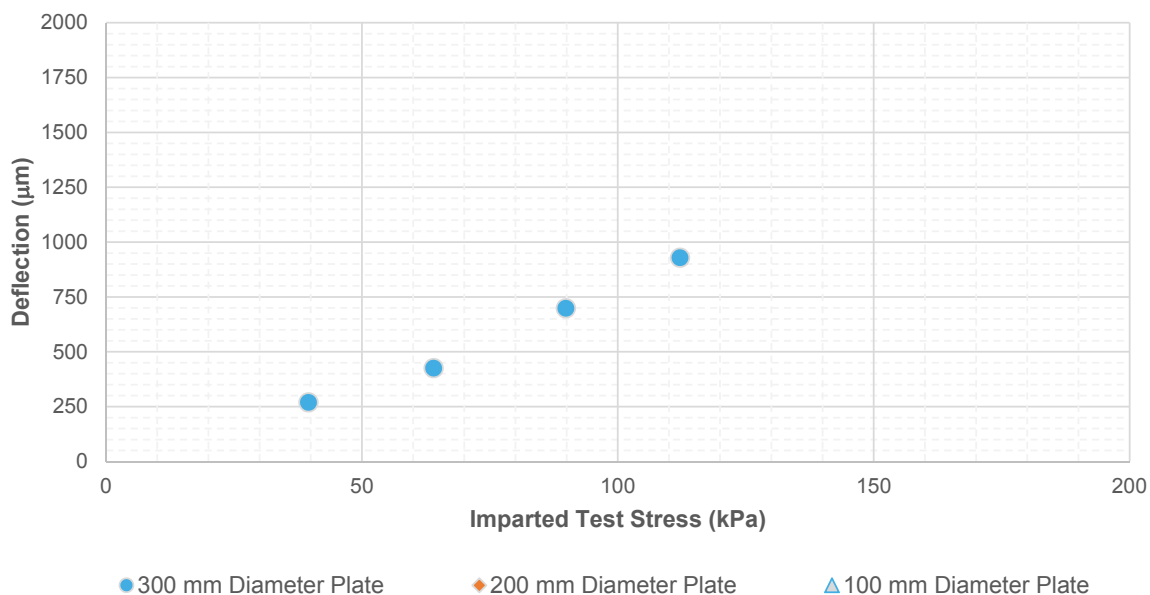
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	40	268.8	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	64	425.1						
10	90	698.0						
7	112	927.8						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	37.8
			100	33.0
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 29-5

Certificate Reference: 2091-LFWD-PRIMA-Site 29-5 Sheet: 1 of 1

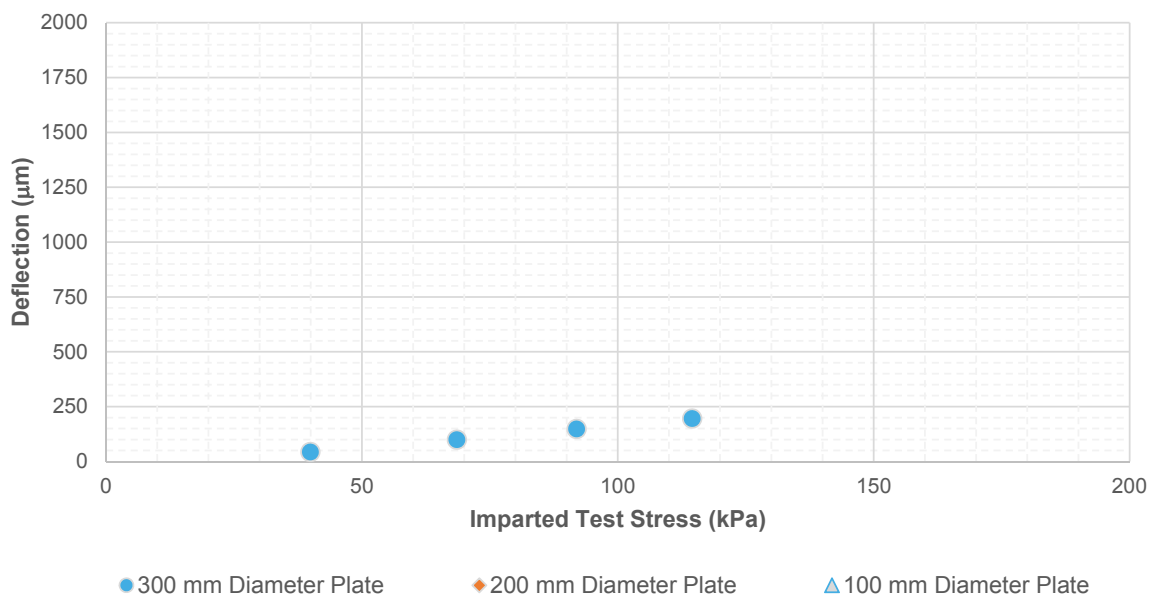
Client: ARRB Project No.: 2091
 Project: Best Practice in Compaction QA Test Date: 7/03/2019
 Location: Site 29-5 (Smithfield Bypass - Trial Embankment) Tested By: RM
 Adopted Poisson's Ratio (ν): 0.35 Checked By: DWL
 Adopted Stress Reduction Factor: 2 Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	40	42.2 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
8	69	98.8						
9	92	147.4						
11	115	195.0						

⁺Material considered to have yielded at applied stress state

⁺Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	192.7
			100	162.1
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
 Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 30-1

Certificate Reference: 2091-LFWD-PRIMA-Site 30-1

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/03/2019

Location: Site 30-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

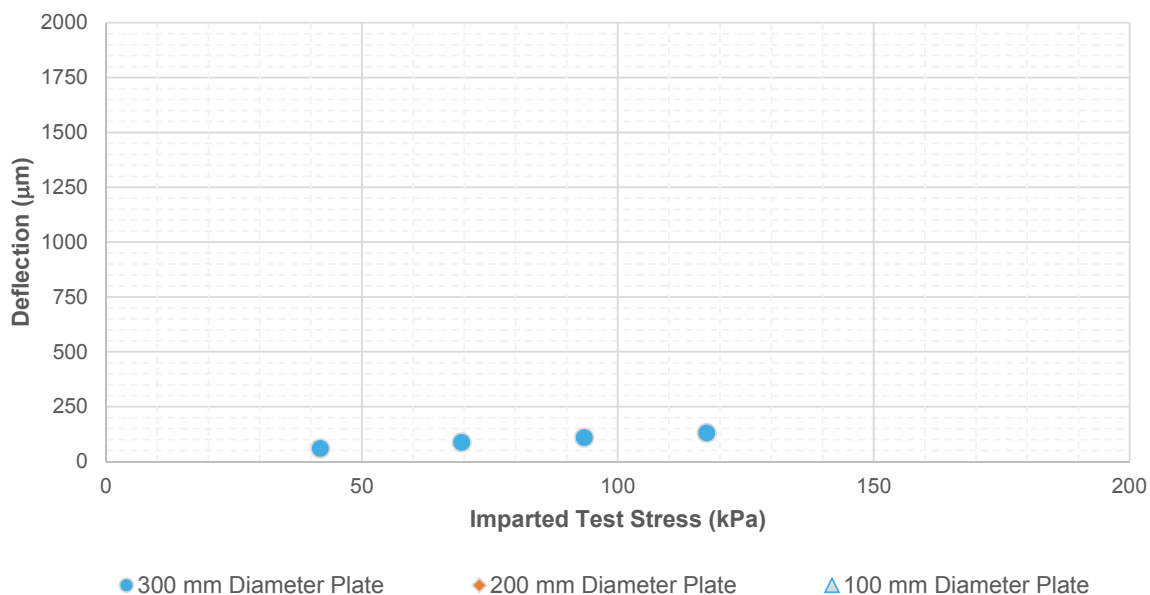
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
3	42	58.4	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
5	69	86.1						
7	93	108.1						
5	117	129.4						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	197
			100	231
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.
Test site fully assessed with ascending test stresses

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 30-2

Certificate Reference: 2091-LFWD-PRIMA-Site 30-2

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/03/2019

Location: Site 30-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

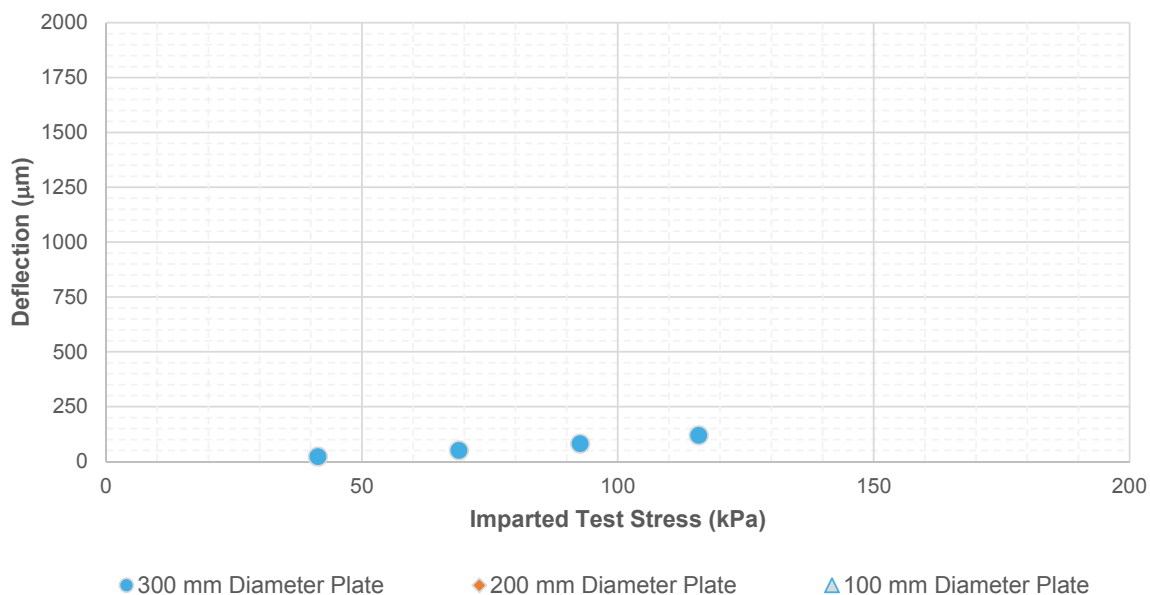
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	41	21.2 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	69	49.5 ⁺						
6	93	80.4						
3	116	118.5						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	454 ⁺
			100	286
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 30-3

Certificate Reference: 2091-LFWD-PRIMA-Site 30-3

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/03/2019

Location: Site 30-3 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

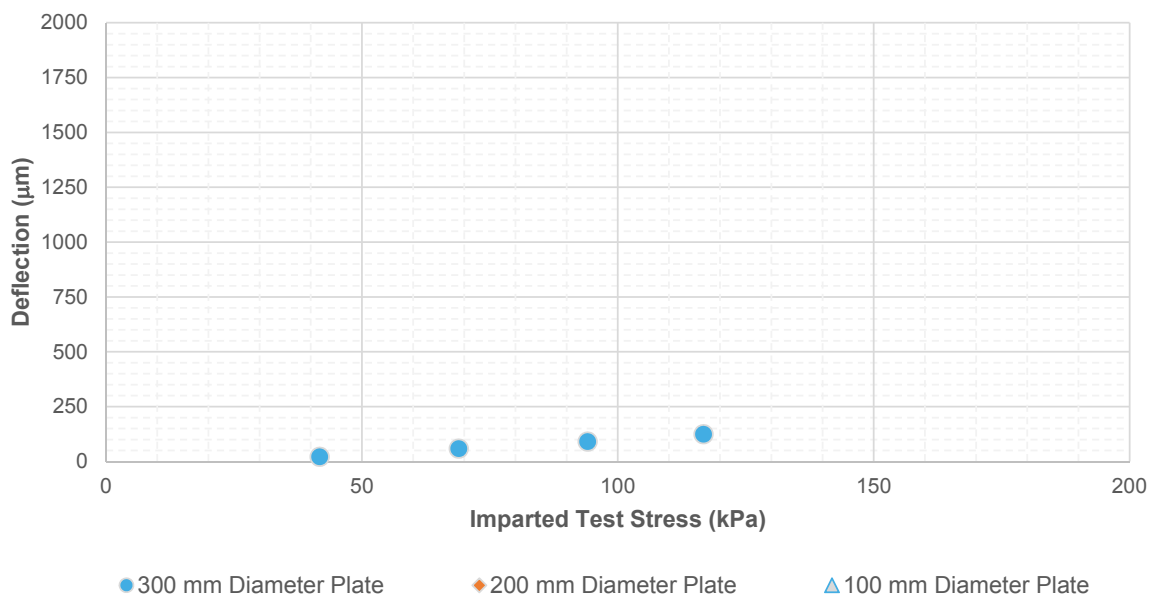
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
7	42	20.4 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
7	69	57.5						
8	94	90.2						
10	117	123.3						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	340 ⁺
			100	271
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

**Light Falling-Weight Deflectometer (LFWD) -
PRIMA 100**

Site 30-4

Certificate Reference: 2091-LFWD-PRIMA-Site 30-4

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/03/2019

Location: Site 30-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

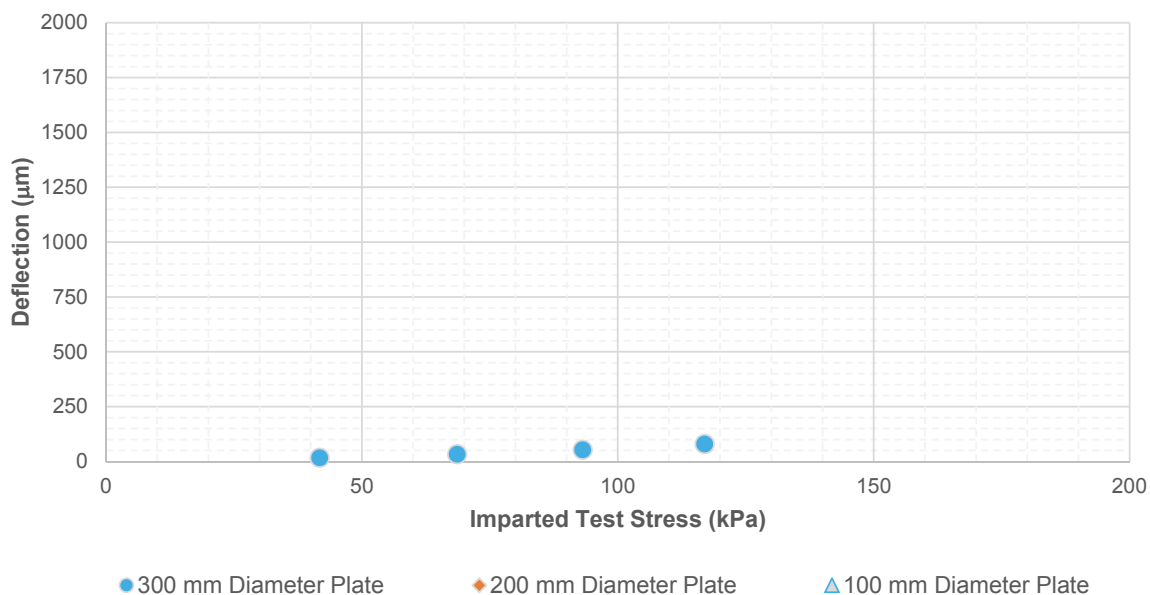
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
5	42	16.2 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
12	69	32.5 ⁺						
8	93	52.4						
12	117	78.6						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	639 ⁺
			100	448
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)

Light Falling-Weight Deflectometer (LFWD) - PRIMA 100

Site 30-5

Certificate Reference: 2091-LFWD-PRIMA-Site 30-5

Sheet: 1 of 1

Client: ARRB

Project No.: 2091

Project: Best Practice in Compaction QA

Test Date: 18/03/2019

Location: Site 30-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Adopted Poisson's Ratio (ν): 0.35

Checked By: DWL

Adopted Stress Reduction Factor: 2

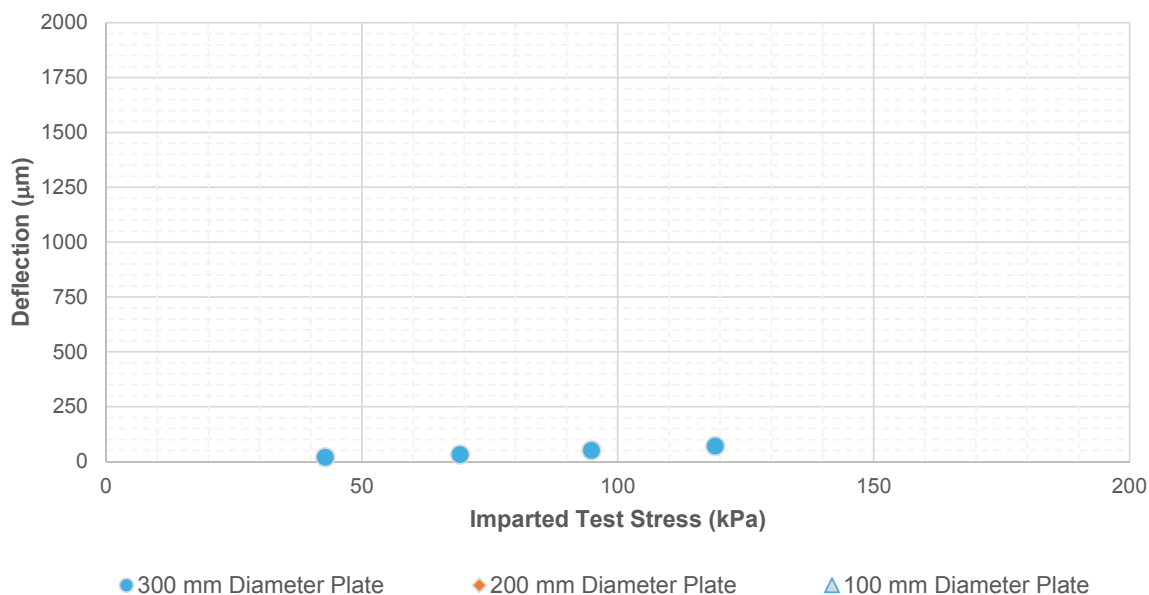
Test Method: ASTM - E2583-07 (2011)

Summary of LOAD vs. DEFLECTION Datapoints								
300 mm Diameter Plate			200 mm Diameter Plate			100 mm Diameter Plate		
No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)	No. Valid Hammer Drops	Average Stress (kPa)	Average Deflection (μm)
6	43	18.1 ⁺	Site Not Tested with 200 mm Diameter Plate			Site Not Tested with 100 mm Diameter Plate		
9	69	30.6 ⁺						
8	95	49.7 ⁺						
4	119	69.7						

*Material considered to have yielded at applied stress state

*Deflection magnitude below calibrated range of Equipment

Standardised <i>Insitu</i> Modulus (E_{LFWD})				
Standardised Plate Diameter (mm)	Fitted Plate Factors		Standardised Test Pressure (kPa)	<i>Insitu</i> Young's Modulus (MPa) - E_{LFWD}
300	200 to 300 mm Diameter:	N/A	50	647 ⁺
			100	500
			500	Beyond Test Stress Range Applied
	100 to 300 mm Diameter:	N/A	750	
			1000	



Comments / Remarks:

300 mm Diameter Plate utilised at a single location. Test site fully assessed with ascending test stresses.

Stiffness Parameter (E_{LFWD}) derived for 50kPa standardised test stress noted to exceed the calibrated equipment range due to measurement of limited plate deflections ($\delta < 50 \mu\text{m}$)



Appendix E

Terratest 5000 (Terratest), Light Falling weight Deflectometer (LWD) – Test Certificates

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-1

Certificate Reference: 2091-LFWD-TERRA-Site 21-1

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 21-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

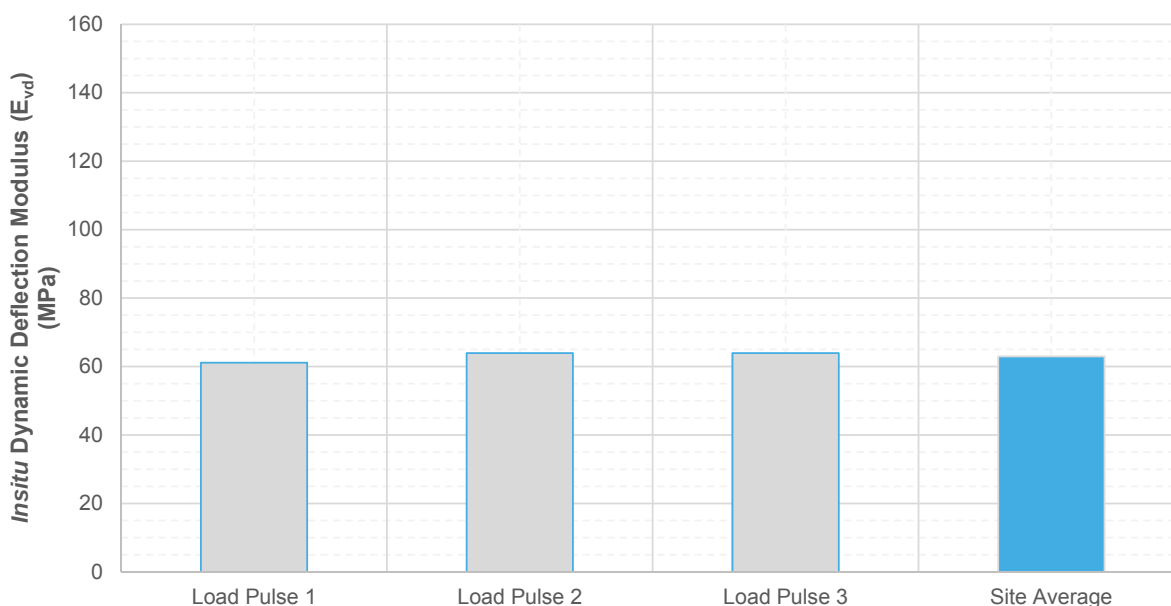
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	155.7	368	61.1
Weight Mass:	10 kg	2	(assumed - not measured)	149.2	352	63.9
Drop Height:	720 mm	3		150.4	352	63.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	151.8 (CoV = 2.3%)	357 (CoV = 2.6%)	63.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-2

Certificate Reference: 2091-LFWD-TERRA-Site 21-2 Sheet: 1 of 1

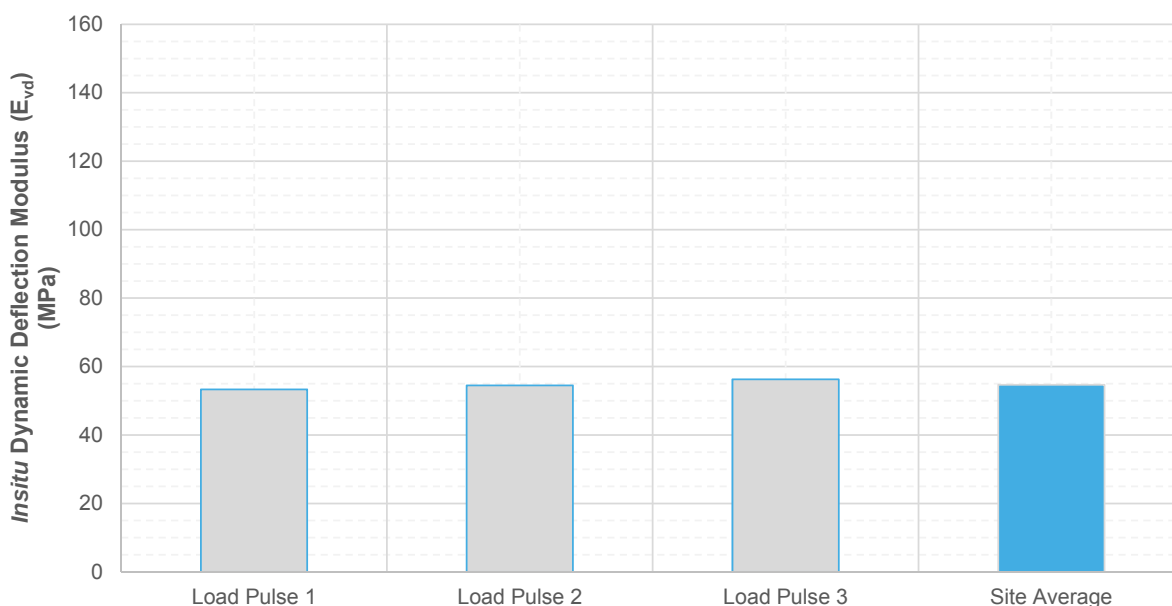
Client: ARRB Test Date: 1/03/2019
Project: Best Practice in Compaction QA Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)
Project No.: 2091 Adopted Stress Reduction Factor: 2 (Equipment Value)
Location: Site 21-2 (Smithfield Bypass - Trial Embankment) Tested By: RM
Test method: ASTM - E2835-11 (2011) Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	165.4	422	53.3
Weight Mass:	10 kg	2	(assumed - not measured)	162.4	413	54.5
Drop Height:	720 mm	3		160.1	400	56.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	162.6 (CoV = 1.6%)	412 (CoV = 2.7%)	54.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 21-3

Certificate Reference: 2091-LFWD-TERRA-Site 21-3

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

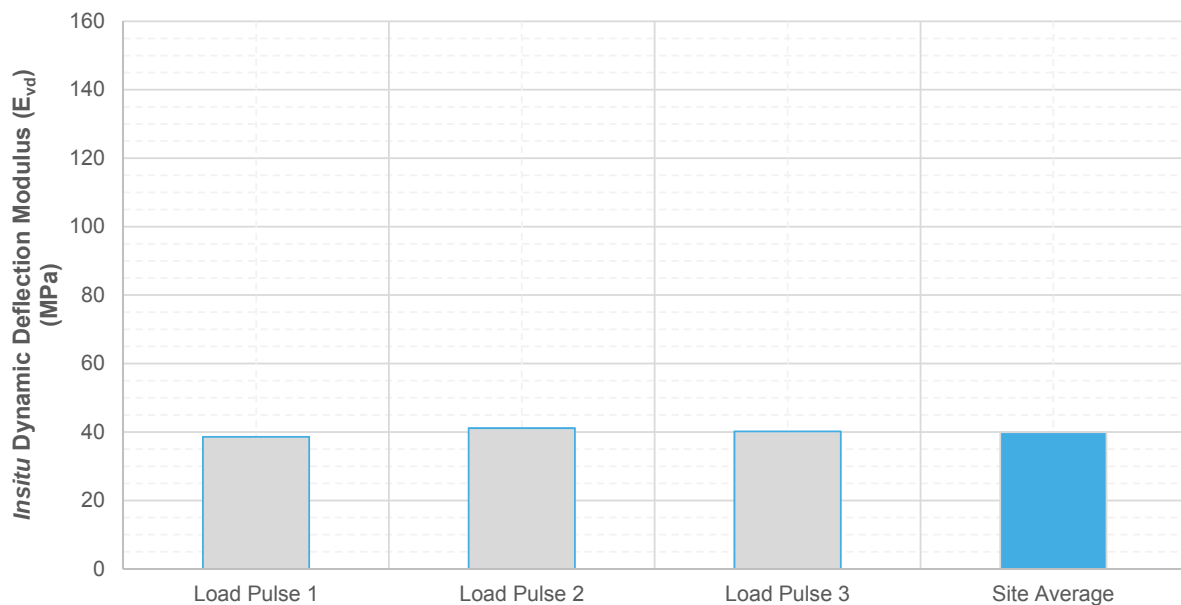
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	145.3	583	38.6
Weight Mass:	10 kg	2	(assumed - not measured)	134.4	547	41.1
Drop Height:	720 mm	3		137.8	560	40.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	139.2 (CoV = 4%)	563 (CoV = 3.2%)	39.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-4A

Certificate Reference: 2091-LFWD-TERRA-Site 21-4A

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 21-4A (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

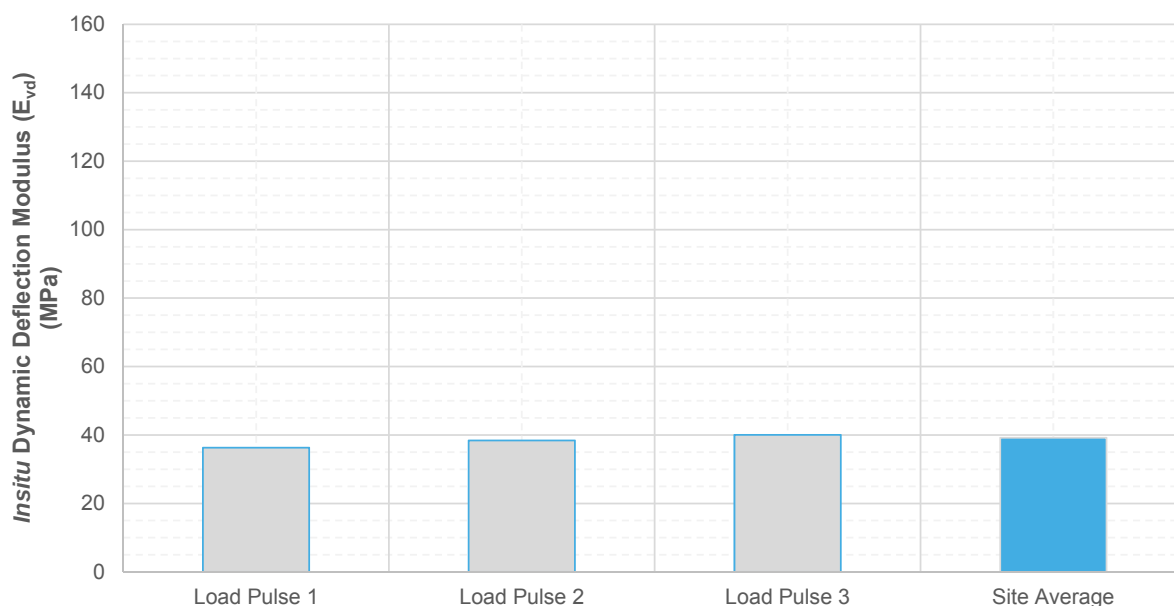
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	207.0	620 (Outlier)	36.3
Weight Mass:	10 kg	2	(assumed - not measured)	199.2	586	38.4
Drop Height:	720 mm	3		199.2	562	40.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	199.2 (CoV = 2.3%)	574 (CoV = 3%)	39.2



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 21-4B

Certificate Reference: 2091-LFWD-TERRA-Site 21-4B

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-4B (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

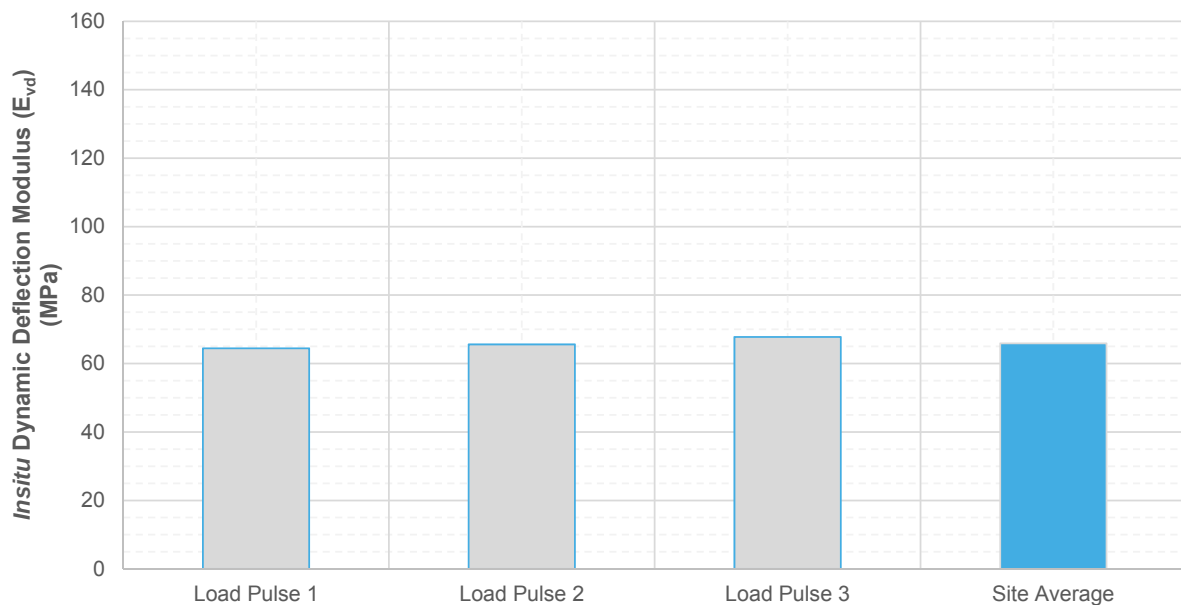
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	150.7	349	64.5
Weight Mass:	10 kg	2	(assumed - not measured)	152.7	343	65.6
Drop Height:	720 mm	3		148.2	332	67.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	150.5 (CoV = 1.5%)	341 (CoV = 2.5%)	65.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-5

Certificate Reference: 2091-LFWD-TERRA-Site 21-5

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-5 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

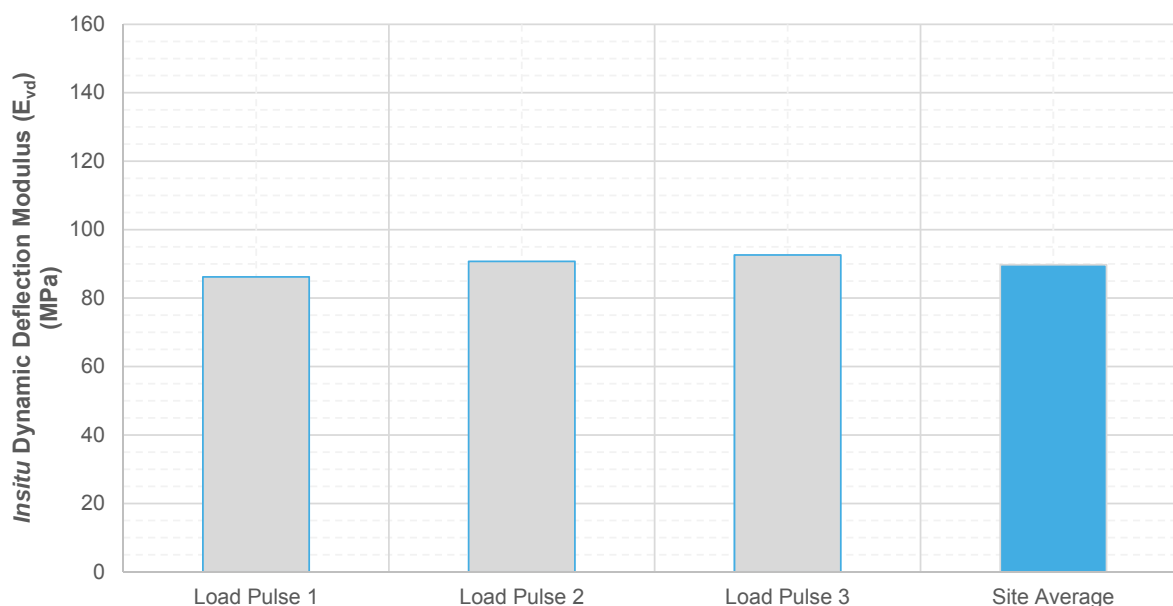
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	121.8	261	86.2
Weight Mass:	10 kg	2	(assumed - not measured)	117.0	248	90.7
Drop Height:	720 mm	3		113.0	243	92.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	117.3 (CoV = 3.8%)	251 (CoV = 3.7%)	89.8



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-6

Certificate Reference: 2091-LFWD-TERRA-Site 21-6

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-6 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

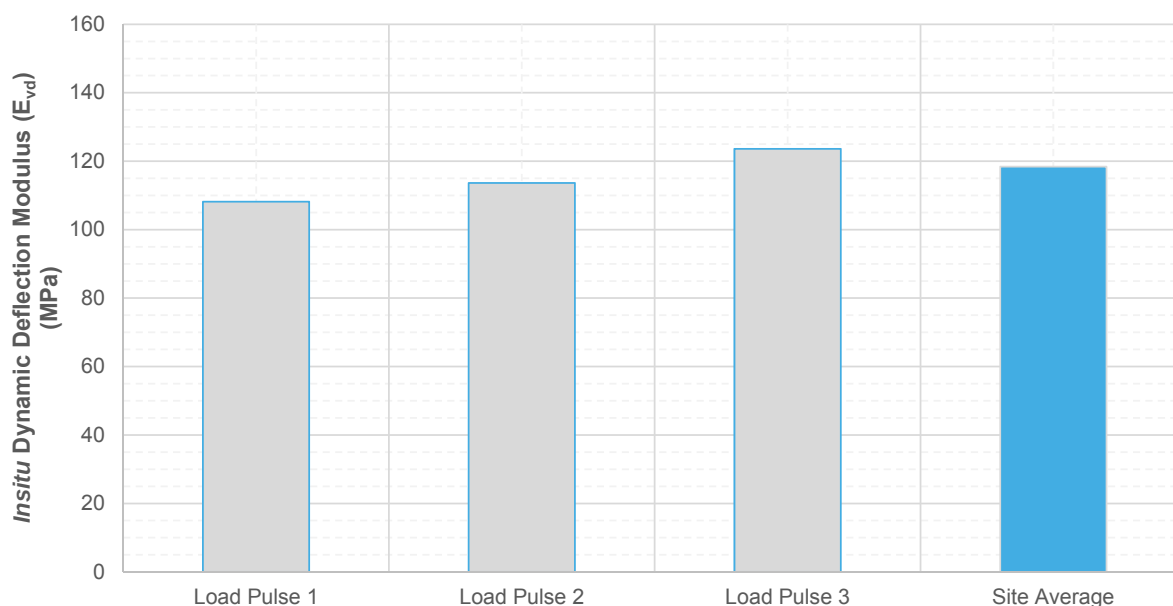
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm)*	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	100.9 (Outlier)	208 (Outlier)	108.2
Weight Mass:	10 kg	2		93.3	198	113.6
Drop Height:	720 mm	3		91.9	182	123.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	92.6 (CoV = 1.1%)	190 (CoV = 6%)	118.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 21-7

Certificate Reference: 2091-LFWD-TERRA-Site 21-7

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-7 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

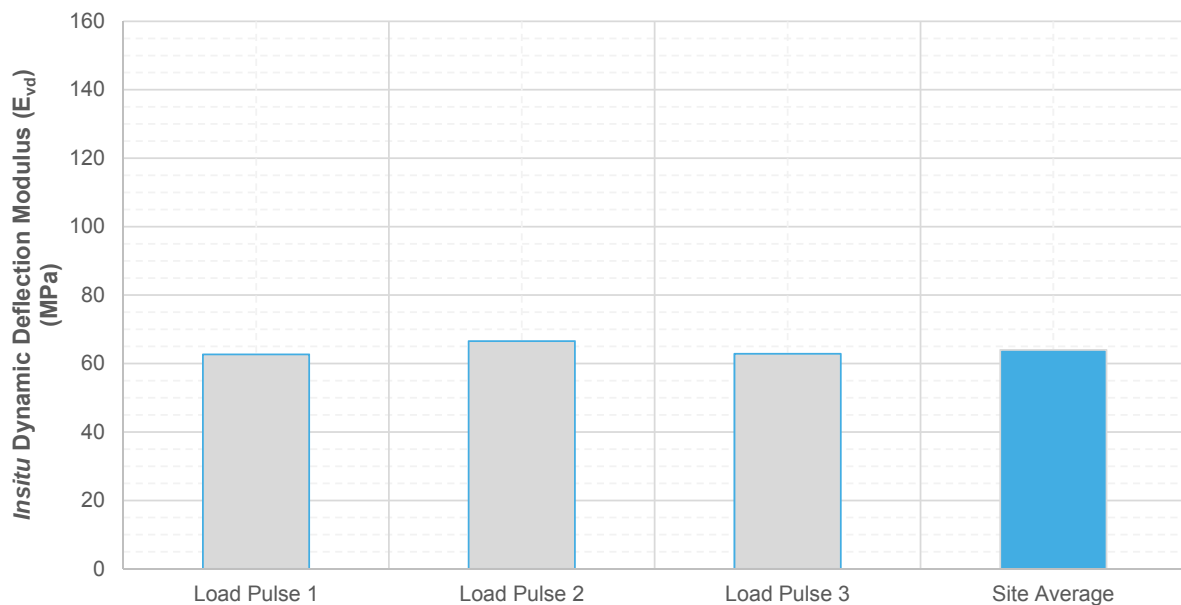
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	150.0	359	62.7
Weight Mass:	10 kg	2	(assumed - not measured)	143.4	338	66.6
Drop Height:	720 mm	3		148.8	358	62.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	147.4 (CoV = 2.4%)	352 (CoV = 3.4%)	64.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 21-8

Certificate Reference: 2091-LFWD-TERRA-Site 21-8

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-8 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

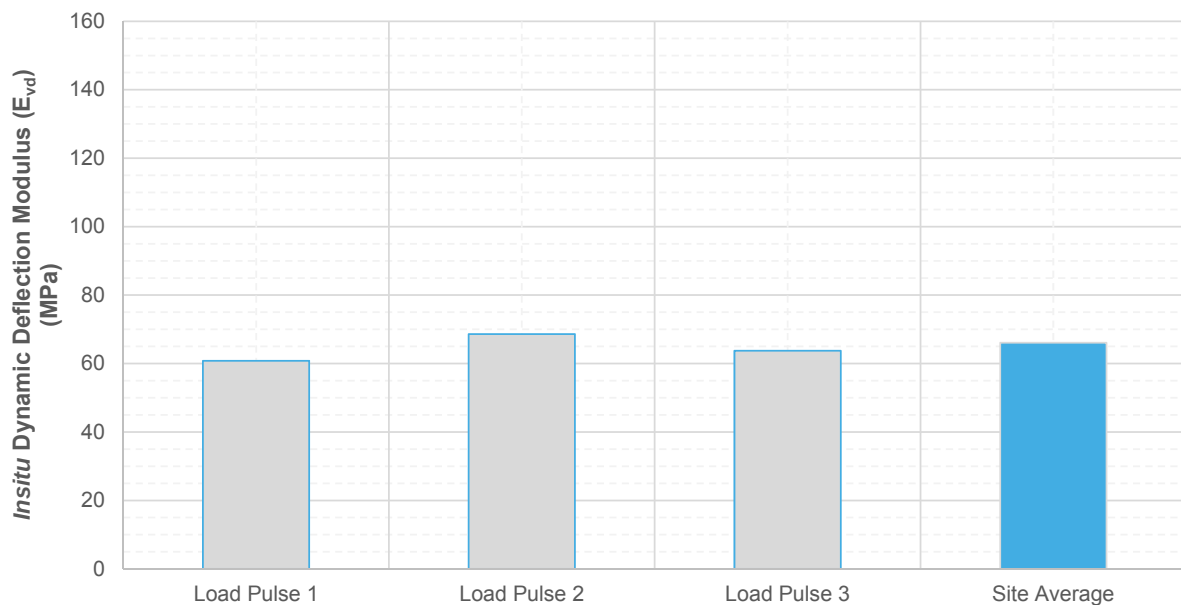
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	142.4 (<i>Outlier</i>)	370 (<i>Outlier</i>)	60.8
Weight Mass:	10 kg	2	(assumed - not measured)	127.9	328	68.6
Drop Height:	720 mm	3		133.1	353	63.7
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	130.5 (CoV = 2.8%)	341 (CoV = 5.2%)	66.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-9

Certificate Reference: 2091-LFWD-TERRA-Site 21-9

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 21-9 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

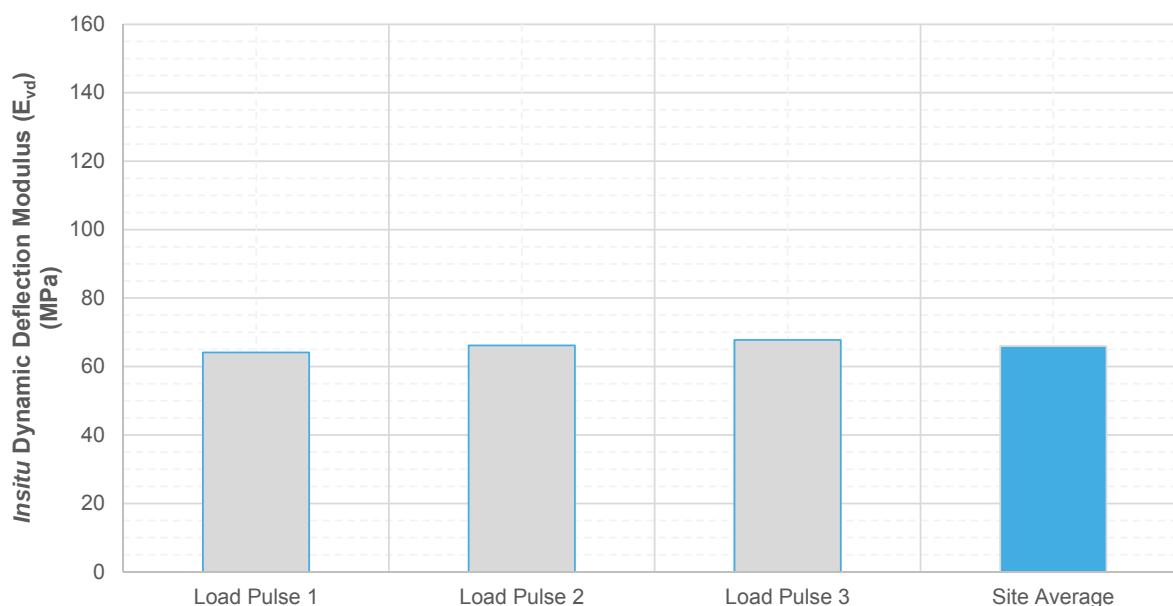
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	129.1	351	64.1
Weight Mass:	10 kg	2	(assumed - not measured)	127.2	340	66.2
Drop Height:	720 mm	3		126.6	332	67.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	127.6 (CoV = 1%)	341 (CoV = 2.8%)	66.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-10

Certificate Reference: 2091-LFWD-TERRA-Site 21-10

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 21-10 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

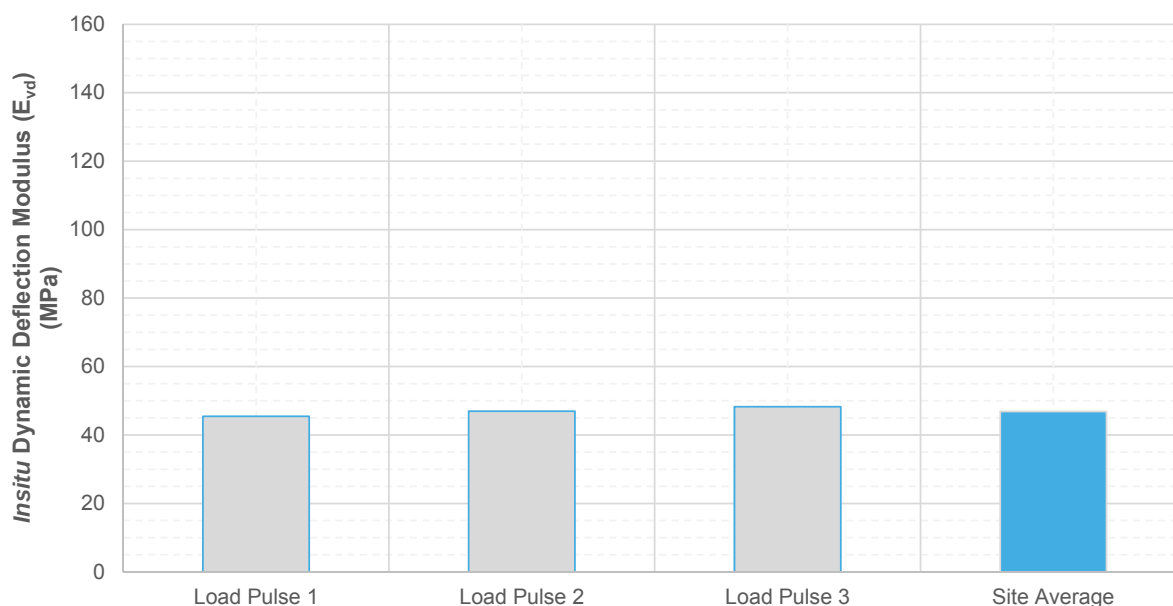
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	176.9	495	45.5
Weight Mass:	10 kg	2	(assumed - not measured)	174.6	479	47.0
Drop Height:	720 mm	3		172.9	466	48.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	174.8 (CoV = 1.1%)	480 (CoV = 3%)	46.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-11

Certificate Reference: 2091-LFWD-TERRA-Site 21-11

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-11 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

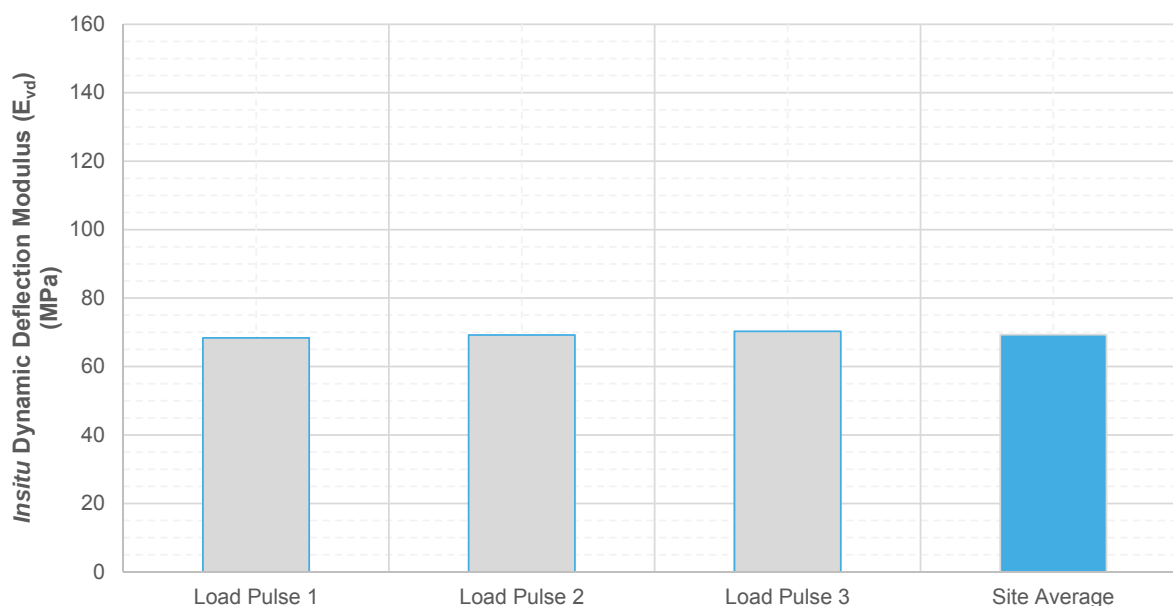
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	126.6	329	68.4
Weight Mass:	10 kg	2	(assumed - not measured)	129.7	325	69.2
Drop Height:	720 mm	3		127.3	320	70.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	127.9 (CoV = 1.3%)	325 (CoV = 1.4%)	69.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 21-12

Certificate Reference: 2091-LFWD-TERRA-Site 21-12

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 21-12 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

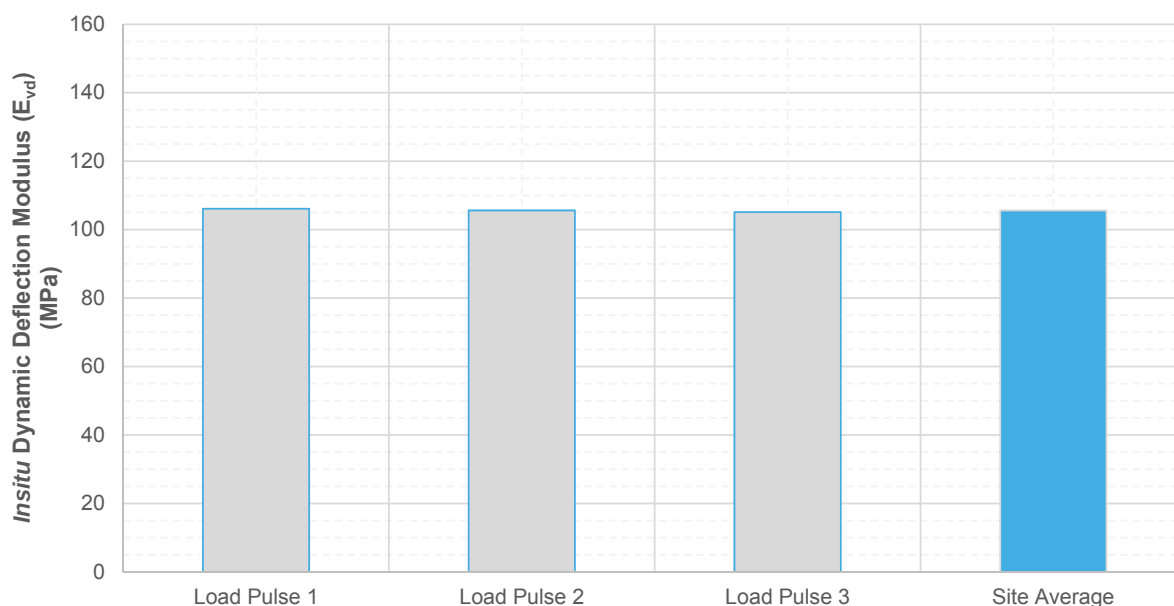
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	95.0	212	106.1
Weight Mass:	10 kg	2	(assumed - not measured)	93.3	213	105.6
Drop Height:	720 mm	3		92.0	214	105.1
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	93.4 (CoV = 1.6%)	213 (CoV = 0.5%)	105.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 21-13

Certificate Reference: 2091-LFWD-TERRA-Site 21-13

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-13 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

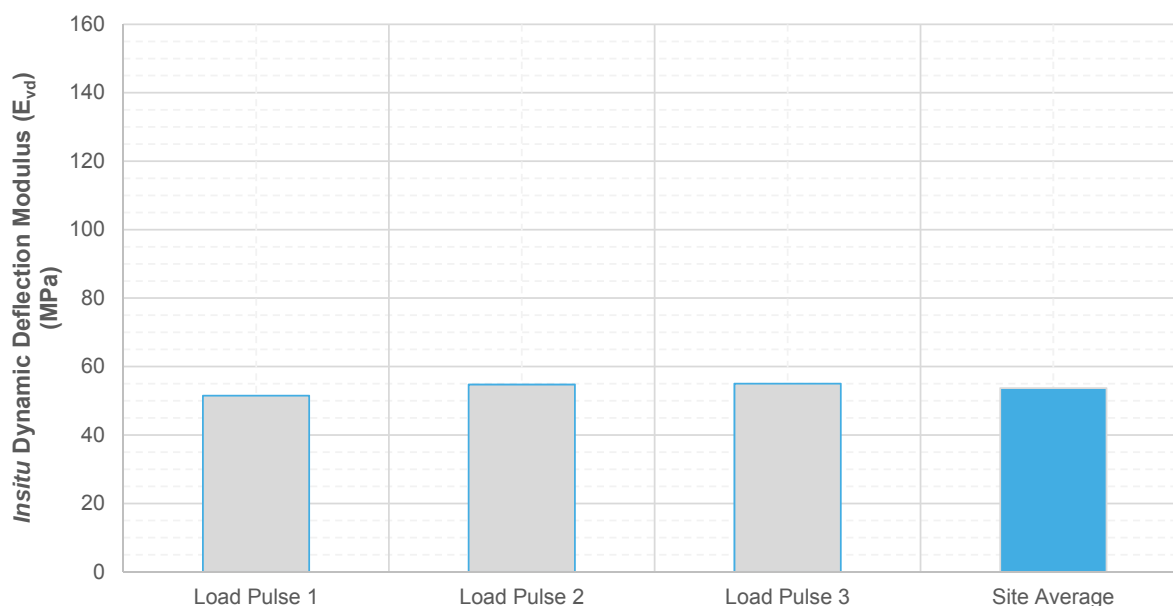
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm)*	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	173.9	437	51.5
Weight Mass:	10 kg	2		169.4	411	54.7
Drop Height:	720 mm	3		160.4	409	55.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	167.9 (CoV = 4.1%)	419 (CoV = 3.7%)	53.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 21-14

Certificate Reference: 2091-LFWD-TERRA-Site 21-14

Sheet: 1 of 1

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 21-14 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

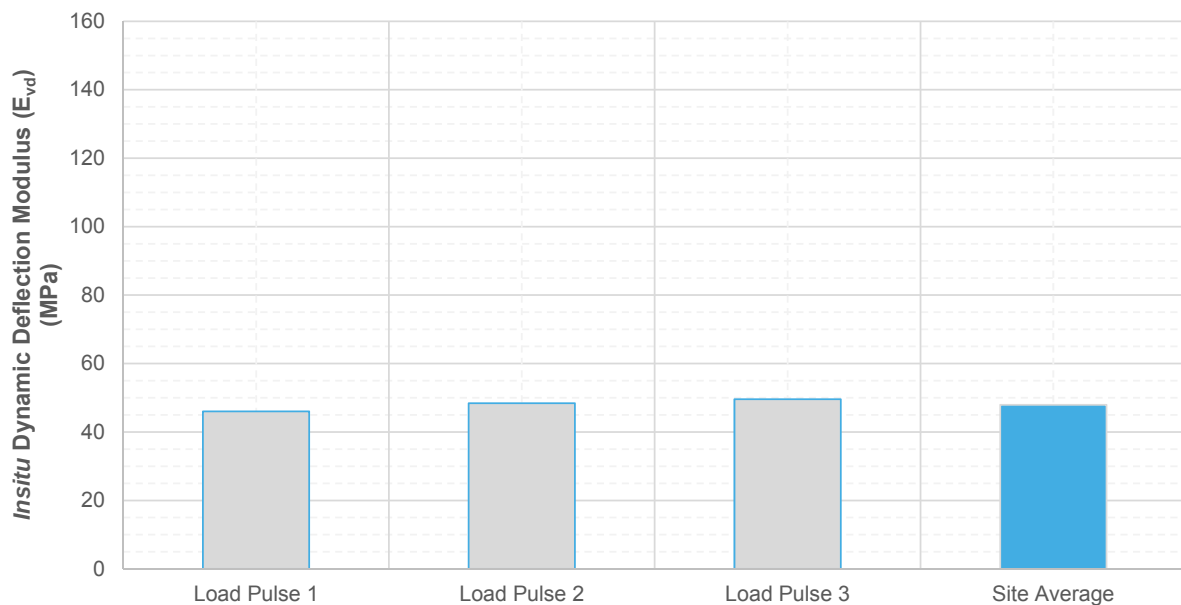
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	187.1	489	46.0
Weight Mass:	10 kg	2	(assumed - not measured)	181.1	465	48.4
Drop Height:	720 mm	3		171.4	454	49.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	179.9 (CoV = 4.4%)	469 (CoV = 3.8%)	47.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 22-1

Certificate Reference: 2091-LFWD-TERRA-Site 22-1

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 22-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

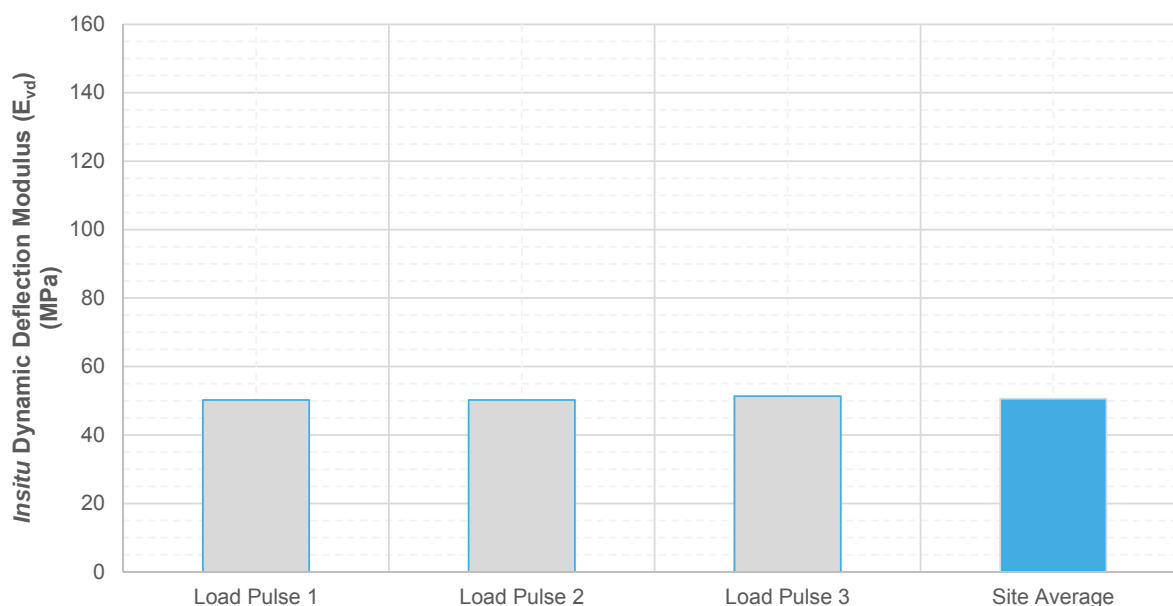
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa	156.4	448	50.2
Weight Mass:	10 kg	2	(assumed - not measured)	152.2	448	50.2
Drop Height:	720 mm	3		151.9	438	51.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	153.5 (CoV = 1.6%)	445 (CoV = 1.3%)	50.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 22-2

Certificate Reference: 2091-LFWD-TERRA-Site 22-2 Sheet: 1 of 1

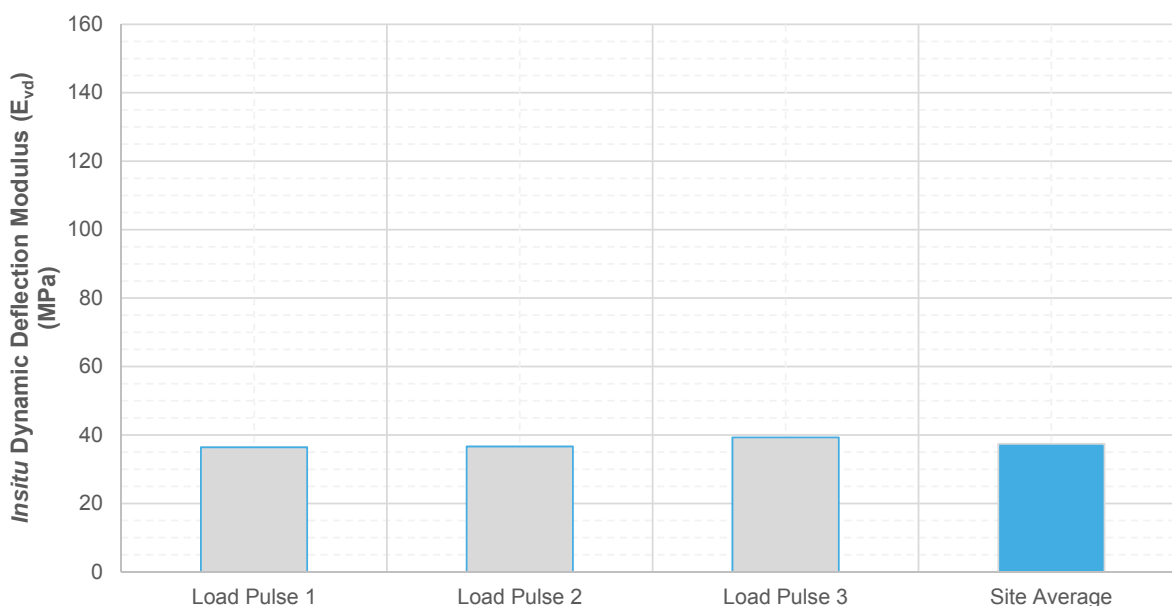
Client: ARRB Test Date: 28/02/2019
Project: Best Practice in Compaction QA Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)
Project No.: 2091 Adopted Stress Reduction Factor: 2 (Equipment Value)
Location: Site 22-2 (Smithfield Bypass - Trial Embankment) Tested By: RM
Test method: ASTM - E2835-11 (2011) Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	222.5	618	36.4
Weight Mass:	10 kg	2	(assumed - not measured)	220.1	614	36.6
Drop Height:	720 mm	3		213.8	573	39.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	218.8 (CoV = 2.1%)	602 (CoV = 4.1%)	37.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 22-2A

Certificate Reference: 2091-LFWD-TERRA-Site 22-2A

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-2A (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

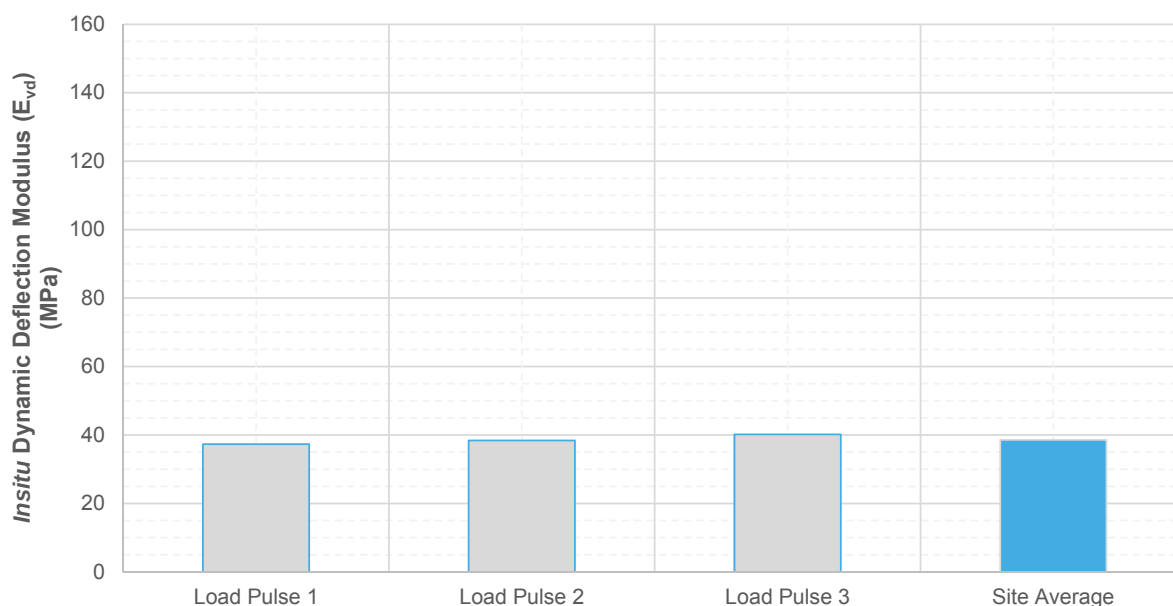
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa	232.8	603	37.3
Weight Mass:	10 kg	2	(assumed - not measured)	229.6	586	38.4
Drop Height:	720 mm	3		226.7	560	40.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	229.7 (CoV = 1.3%)	583 (CoV = 3.7%)	38.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 22-3

Certificate Reference: 2091-LFWD-TERRA-Site 22-3

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

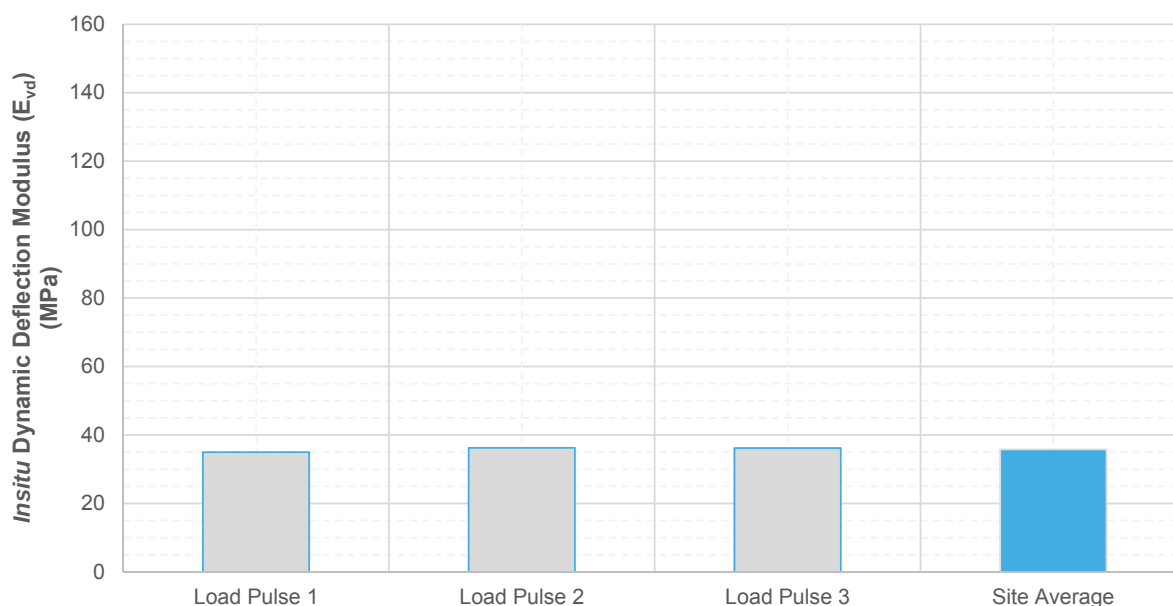
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	237.6	643	35.0
Weight Mass:	10 kg	2		231.8	621	36.2
Drop Height:	720 mm	3		231.3	622	36.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	233.6 (CoV = 1.5%)	629 (CoV = 2%)	35.8



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 22-4

Certificate Reference: 2091-LFWD-TERRA-Site 22-4

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 22-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

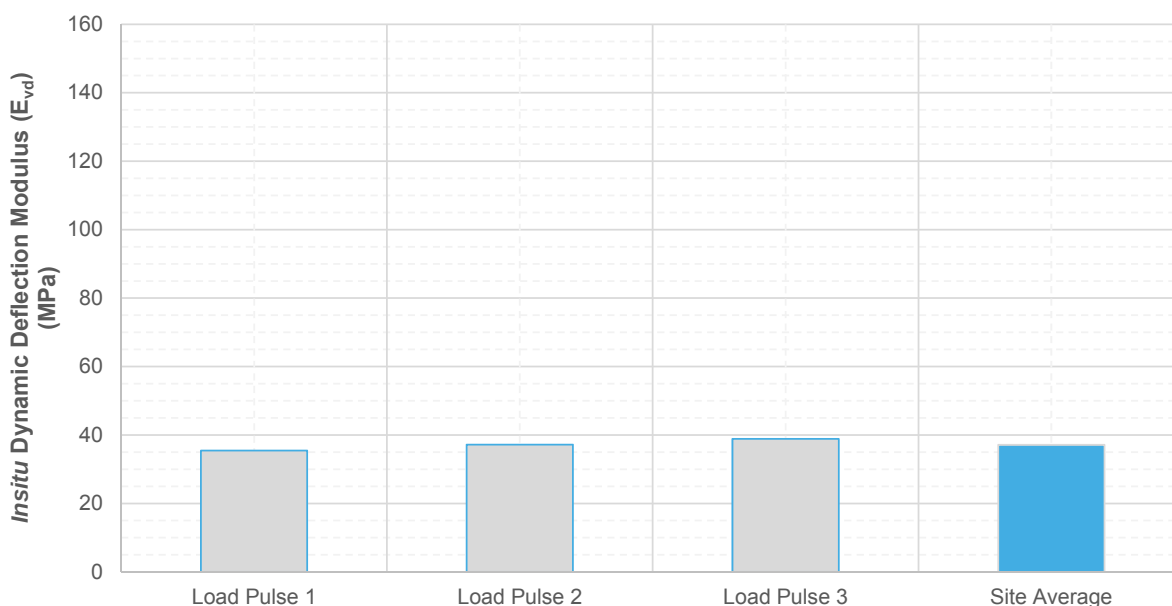
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	225.7	635	35.4
Weight Mass:	10 kg	2	(assumed - not measured)	216.1	605	37.2
Drop Height:	720 mm	3		209.9	579	38.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	217.2 (CoV = 3.7%)	606 (CoV = 4.6%)	37.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 22-5

Certificate Reference: 2091-LFWD-TERRA-Site 22-5

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 22-5 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

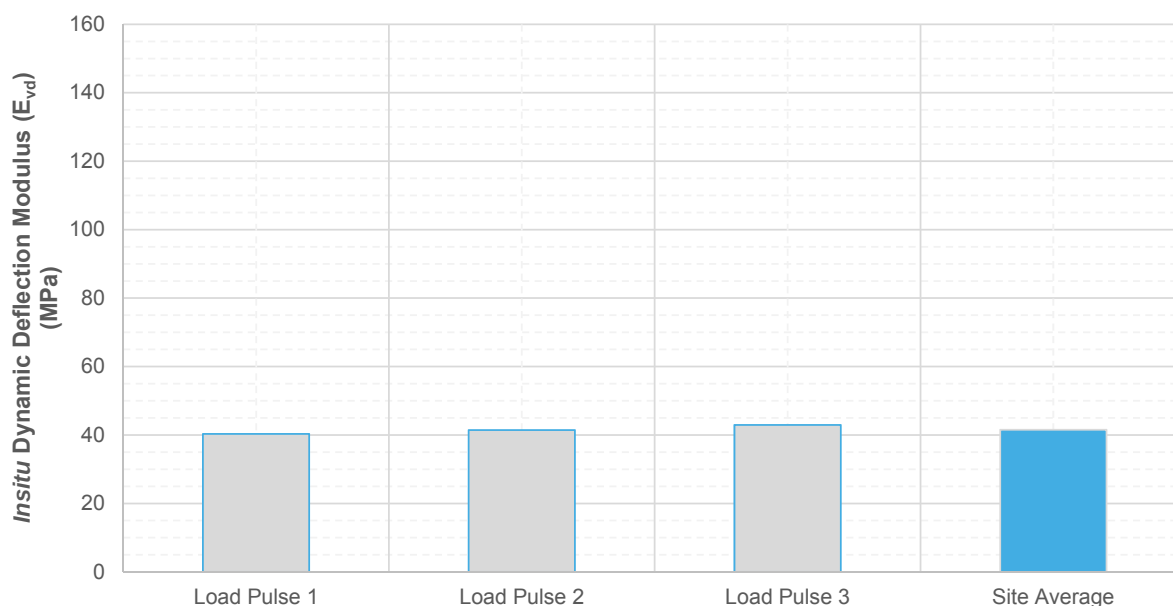
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	206.1	558	40.3
Weight Mass:	10 kg	2	(assumed - not measured)	202.1	543	41.4
Drop Height:	720 mm	3		198.4	524	42.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised Insitu Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average Insitu Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	202.2 (CoV = 1.9%)	542 (CoV = 3.1%)	41.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 22-6

Certificate Reference: 2091-LFWD-TERRA-Site 22-6

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-6 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

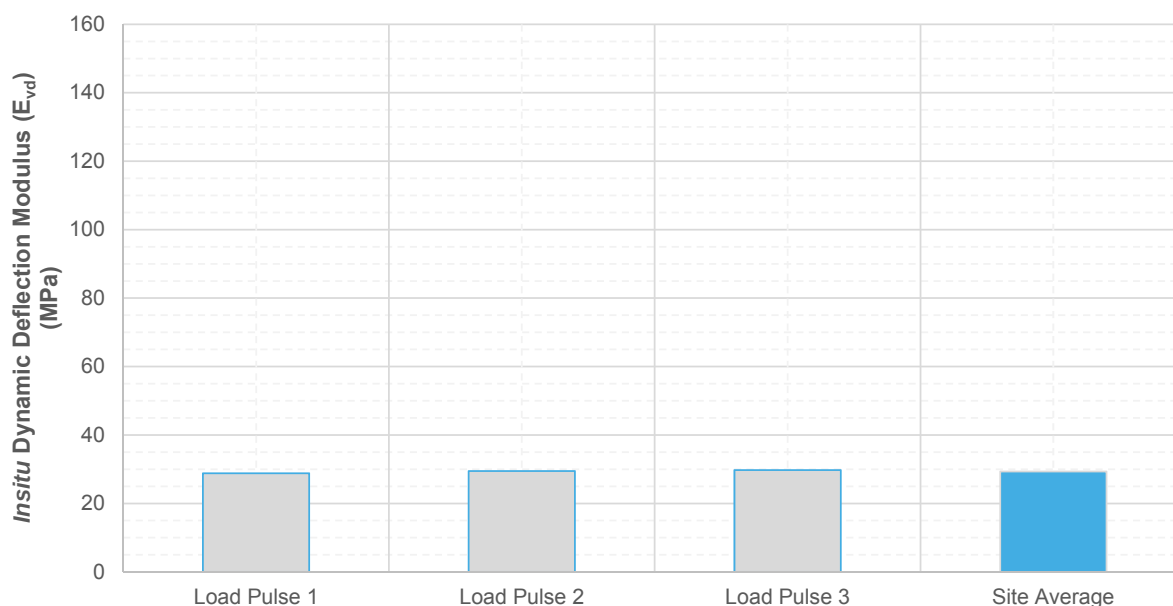
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	177.5	781	28.8
Weight Mass:	10 kg	2		172.1	764	29.5
Drop Height:	720 mm	3		170.5	756	29.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	173.4 (CoV = 2.1%)	767 (CoV = 1.7%)	29.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 22-6A

Certificate Reference: 2091-LFWD-TERRA-Site 22-6A

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-6A (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

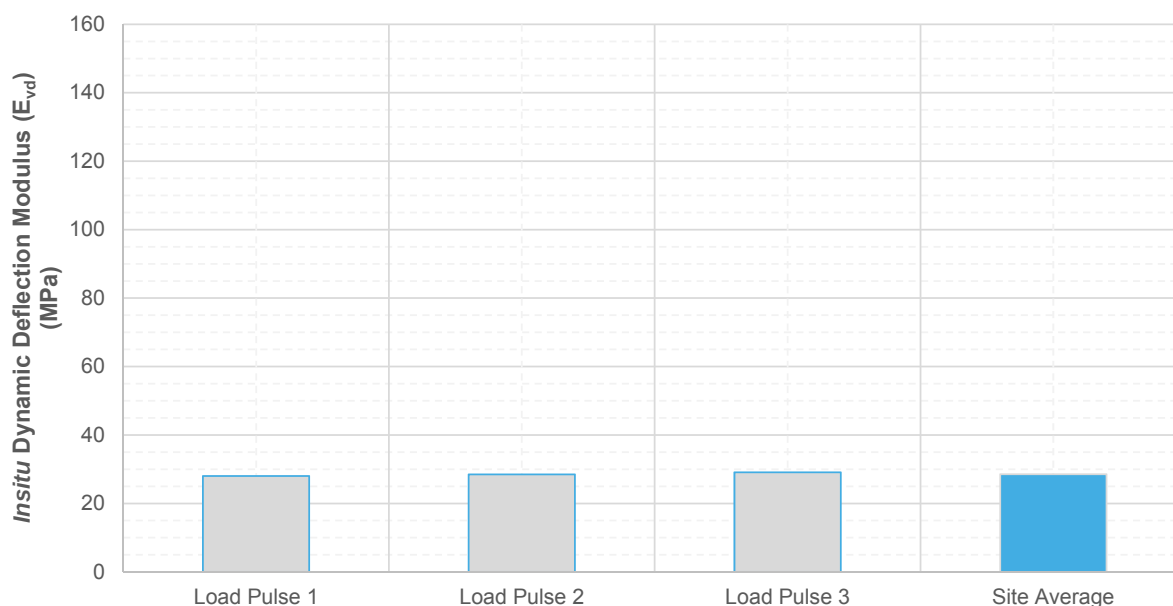
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	206.0	803	28.0
Weight Mass:	10 kg	2	(assumed - not measured)	202.6	790	28.5
Drop Height:	720 mm	3		195.8	773	29.1
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	201.5 (CoV = 2.6%)	789 (CoV = 1.9%)	28.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 22-7

Certificate Reference: 2091-LFWD-TERRA-Site 22-7

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-7 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

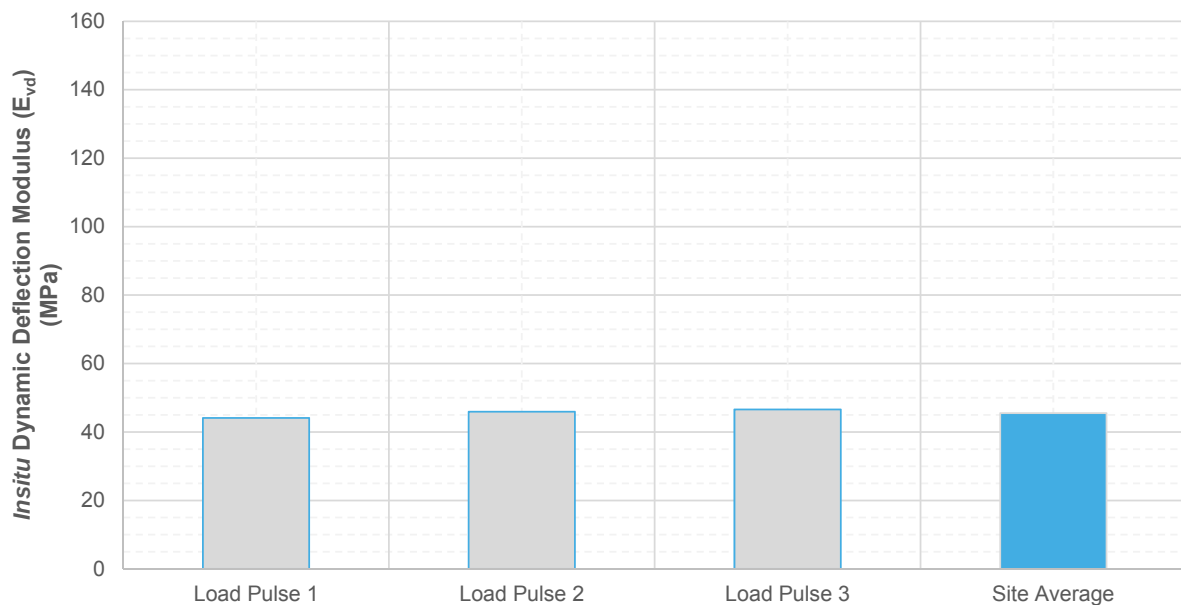
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	196.2	510	44.1
Weight Mass:	10 kg	2	(assumed - not measured)	191.3	490	45.9
Drop Height:	720 mm	3		188.0	483	46.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	191.8 (CoV = 2.2%)	494 (CoV = 2.8%)	45.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 22-8

Certificate Reference: 2091-LFWD-TERRA-Site 22-8

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 22-8 (Smithfield Bypass - Trial Embankment)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

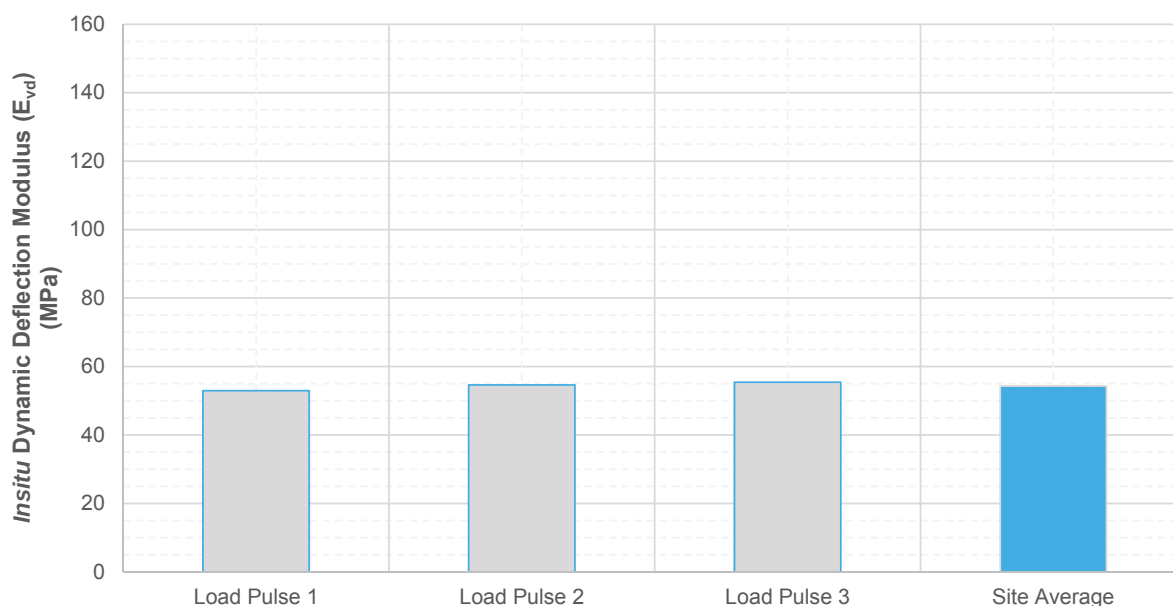
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	161.8	425	52.9
Weight Mass:	10 kg	2		156.4	412	54.6
Drop Height:	720 mm	3		154.1	406	55.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	157.4 (CoV = 2.5%)	414 (CoV = 2.3%)	54.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 22-9

Certificate Reference: 2091-LFWD-TERRA-Site 22-9

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-9 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

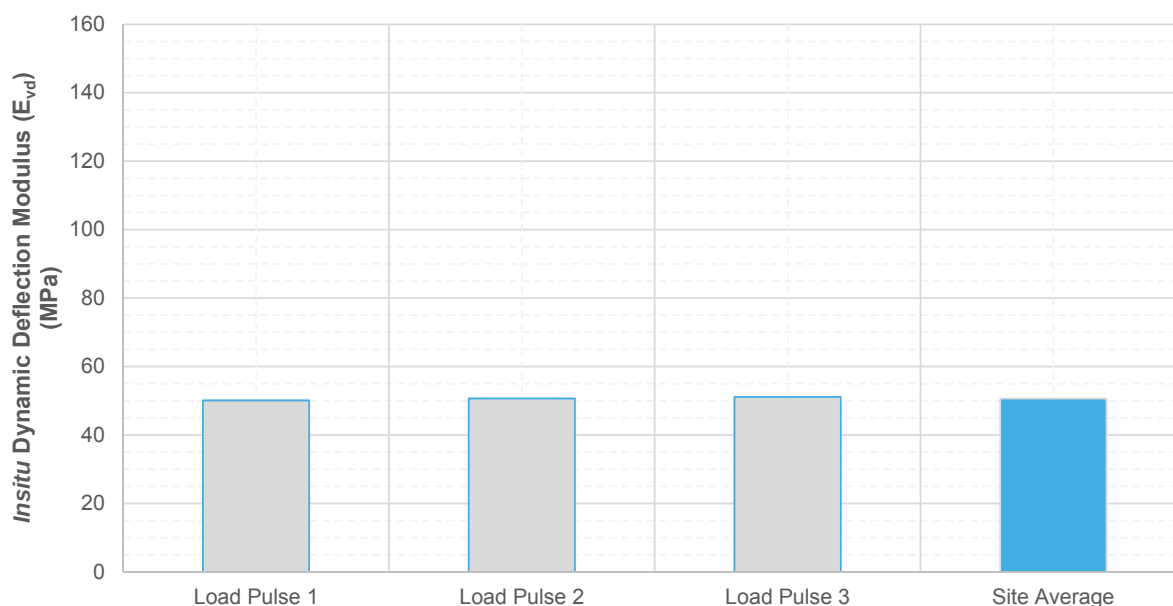
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	157.3	449	50.1
Weight Mass:	10 kg	2	(assumed - not measured)	156.9	444	50.7
Drop Height:	720 mm	3		157.1	440	51.1
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	157.1 (CoV = 0.1%)	444 (CoV = 1%)	50.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 22-10

Certificate Reference: 2091-LFWD-TERRA-Site 22-10

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-10 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

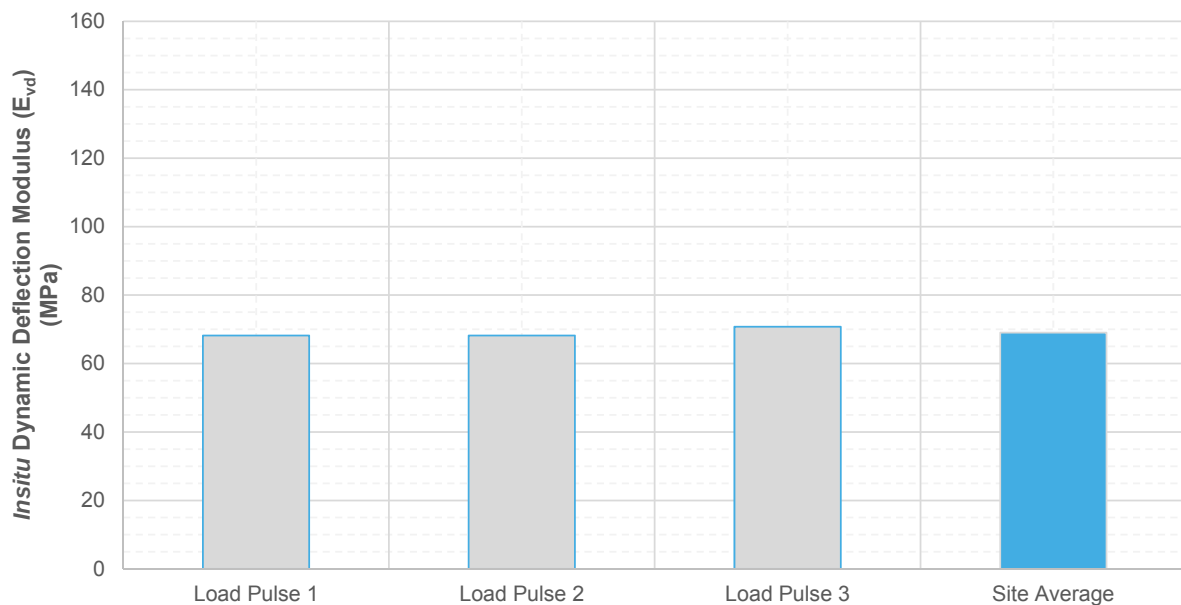
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	139.5	330	68.2
Weight Mass:	10 kg	2	(assumed - not measured)	138.4	330	68.2
Drop Height:	720 mm	3		135.0	318	70.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	137.6 (CoV = 1.7%)	326 (CoV = 2.1%)	69.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 22-11

Certificate Reference: 2091-LFWD-TERRA-Site 22-11

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-11 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

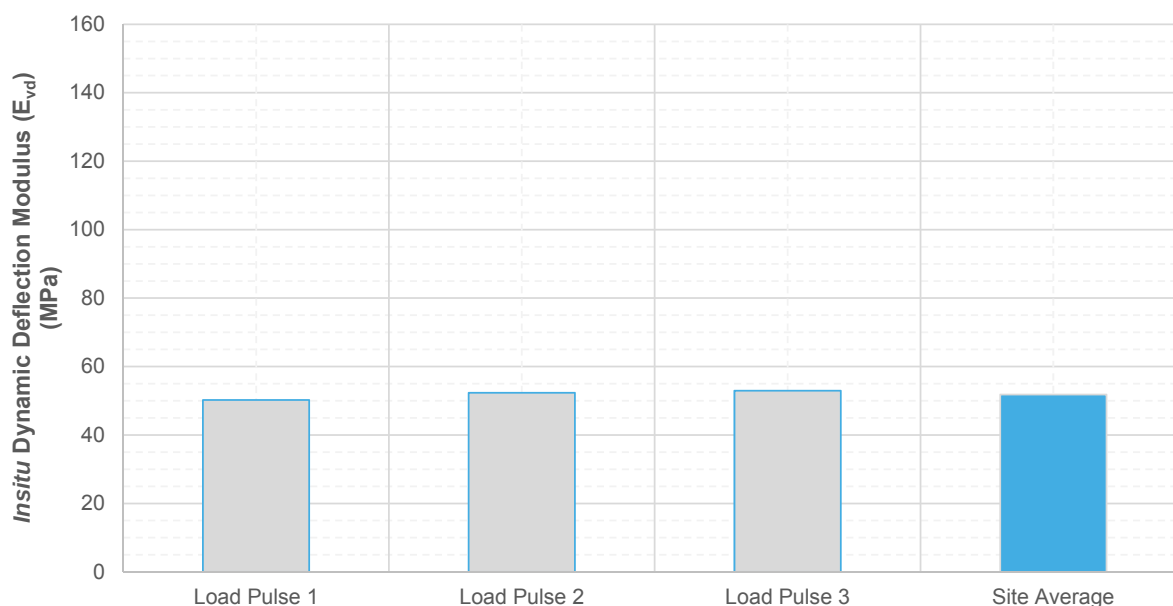
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm)*	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa	155.0	448	50.2
Weight Mass:	10 kg	2	(assumed - not measured)	153.6	430	52.3
Drop Height:	720 mm	3		150.2	425	52.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	152.9 (CoV = 1.6%)	434 (CoV = 2.8%)	51.8



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 22-12

Certificate Reference: 2091-LFWD-TERRA-Site 22-12

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-12 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

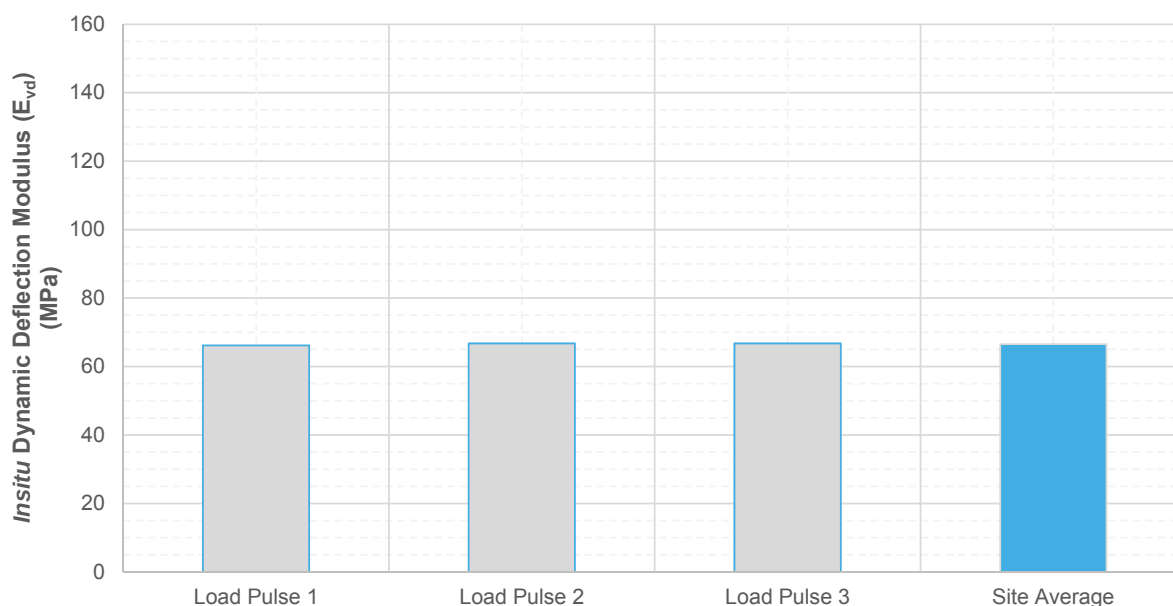
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	136.4	340	66.2
Weight Mass:	10 kg	2	(assumed - not measured)	135.7	337	66.8
Drop Height:	720 mm	3		132.9	337	66.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	135.0 (CoV = 1.4%)	338 (CoV = 0.5%)	66.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 22-13

Certificate Reference: 2091-LFWD-TERRA-Site 22-13

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-13 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

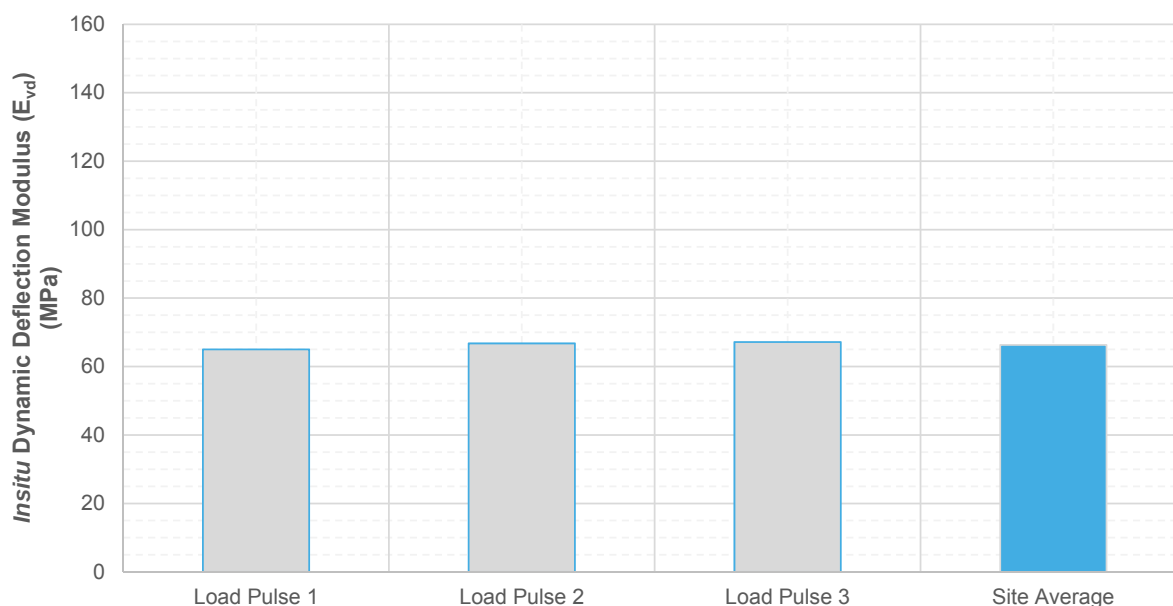
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	135.6	346	65.0
Weight Mass:	10 kg	2	(assumed - not measured)	131.8	337	66.8
Drop Height:	720 mm	3		128.9	335	67.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	132.1 (CoV = 2.5%)	339 (CoV = 1.7%)	66.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 22-14

Certificate Reference: 2091-LFWD-TERRA-Site 22-14

Sheet: 1 of 1

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 22-14 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM

Test method: ASTM - E2835-11 (2011)

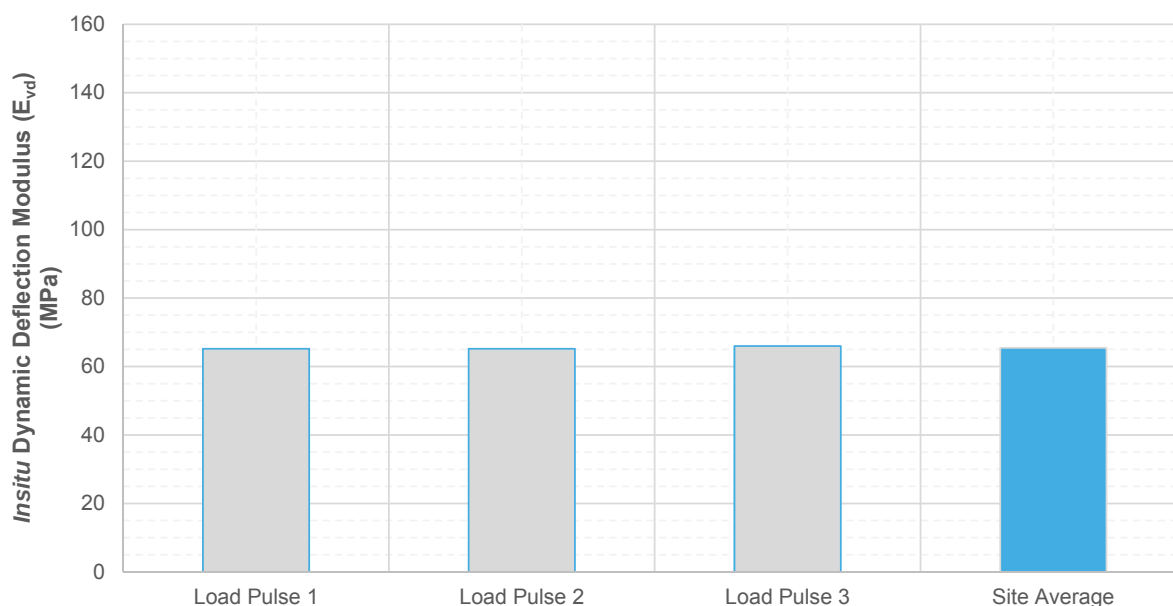
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	116.4	345	65.2
Weight Mass:	10 kg	2	(assumed - not measured)	116.2	345	65.2
Drop Height:	720 mm	3		114.6	341	66.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	115.7 (CoV = 0.9%)	344 (CoV = 0.7%)	65.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 23-1

Certificate Reference: 2091-LFWD-TERRA-Site 23-1

Sheet: 1 of 1

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 23-1 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

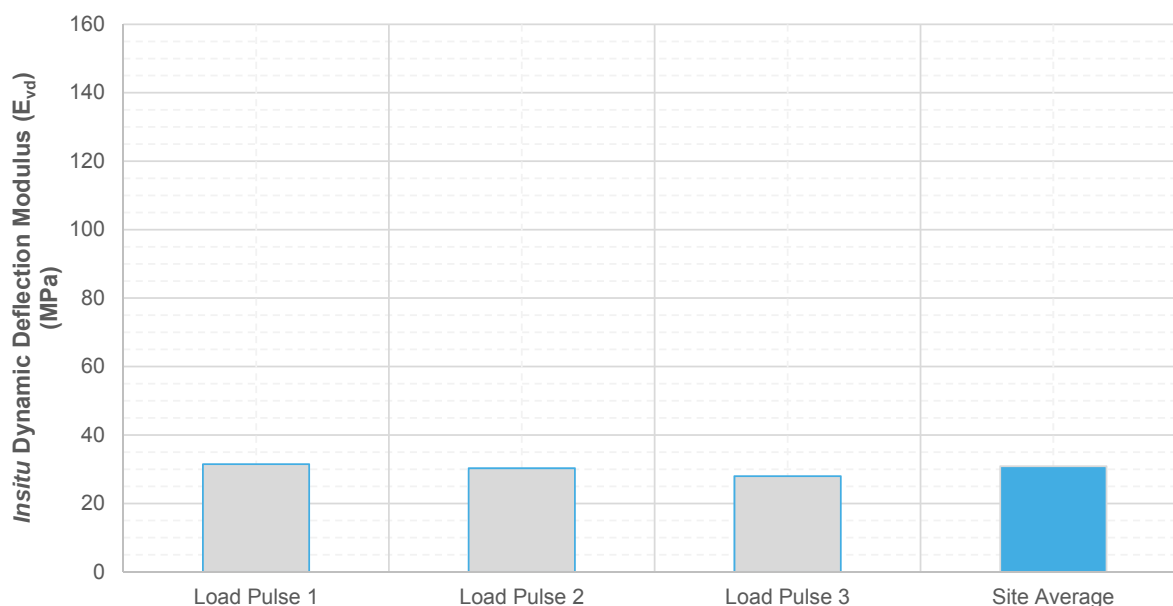
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) [†]	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	264.1	715	31.5
Weight Mass:	10 kg	2	(assumed - not measured)	274.4	743	30.3
Drop Height:	720 mm	3		292.4 (<i>Outlier</i>)	804 (<i>Outlier</i>)	28.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			†Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	269.3 (CoV = 2.7%)	729 (CoV = 2.7%)	30.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 23-2

Certificate Reference: 2091-LFWD-TERRA-Site 23-2

Sheet: 1 of 1

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 23-2 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

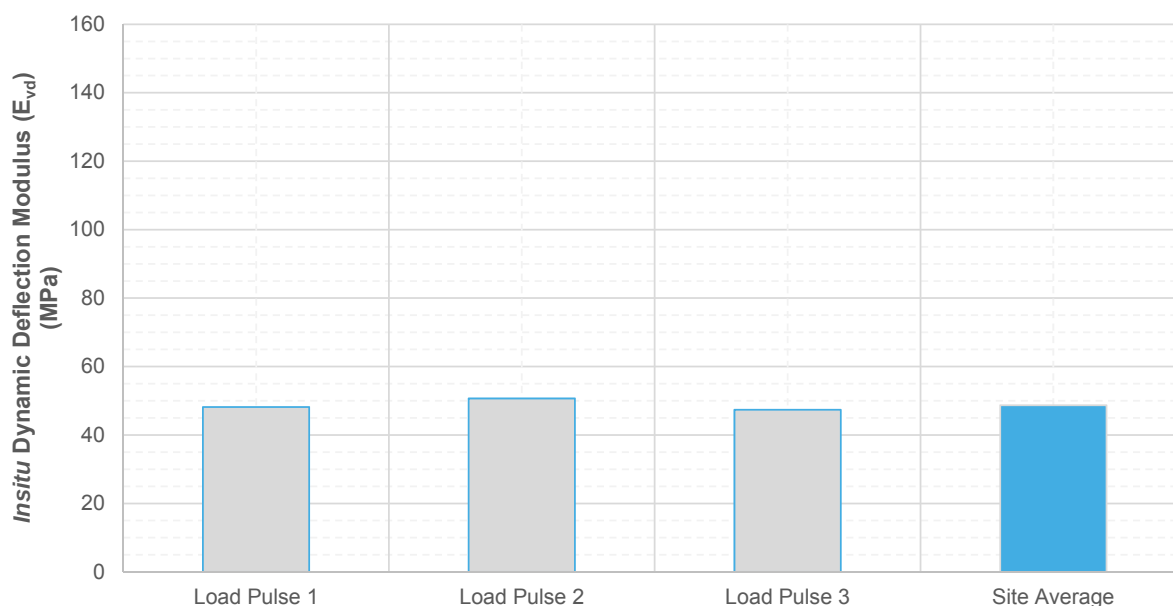
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa	204.1	467	48.2
Weight Mass:	10 kg	2	(assumed - not measured)	200.5	444	50.7
Drop Height:	720 mm	3		207.0	475	47.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	203.9 (CoV = 1.6%)	462 (CoV = 3.5%)	48.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 23-3

Certificate Reference: 2091-LFWD-TERRA-Site 23-3

Sheet: 1 of 1

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 23-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

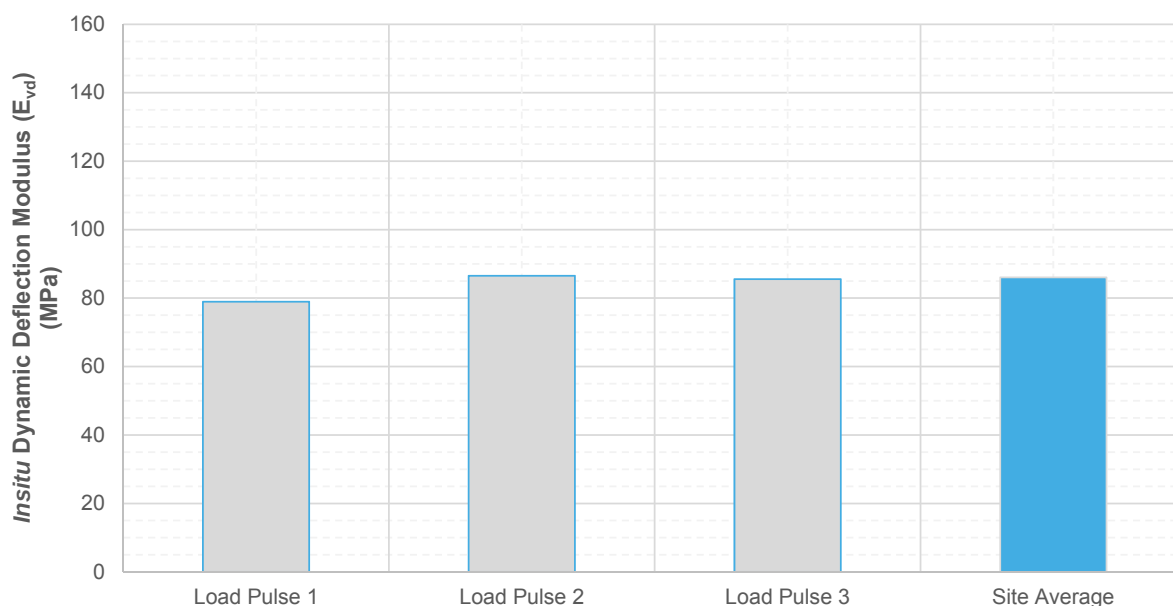
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) [†]	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	119.7 (<i>Outlier</i>)	285 (<i>Outlier</i>)	78.9
Weight Mass:	10 kg	2	(assumed - not measured)	114.0	260	86.5
Drop Height:	720 mm	3		113.1	263	85.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			†Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	113.6 (CoV = 0.6%)	262 (CoV = 0.8%)	86.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 23-4

Certificate Reference: 2091-LFWD-TERRA-Site 23-4

Sheet: 1 of 1

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 23-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

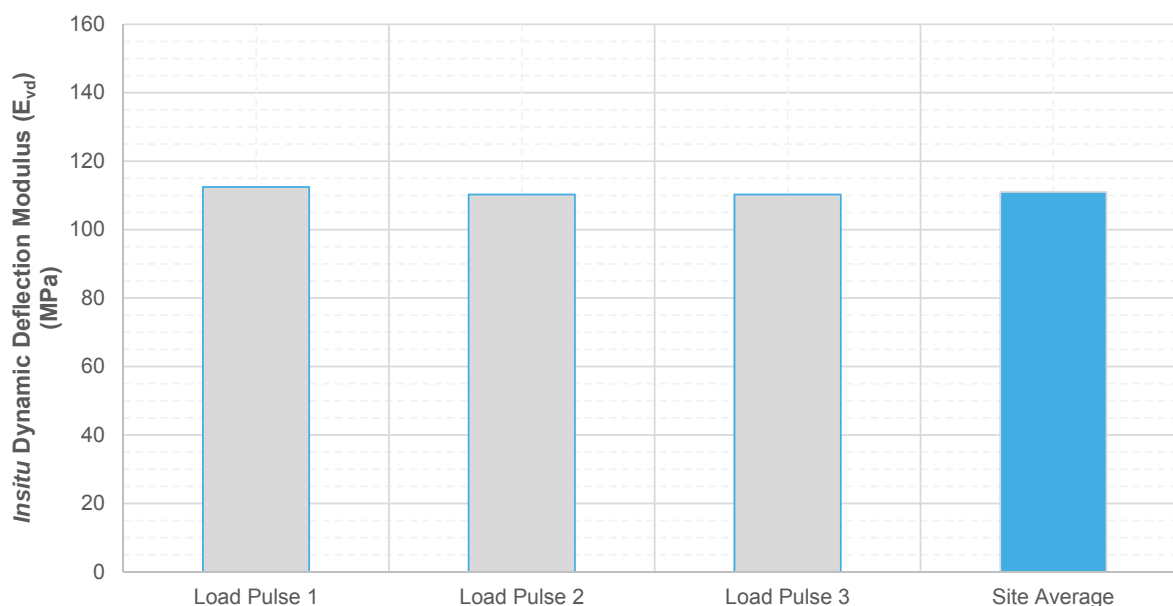
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	109.0	200	112.5
Weight Mass:	10 kg	2	(assumed - not measured)	108.9	204	110.3
Drop Height:	720 mm	3		109.4	204	110.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	109.1 (CoV = 0.2%)	203 (CoV = 1.1%)	111.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 23-5

Certificate Reference: 2091-LFWD-TERRA-Site 23-5

Sheet: 1 of 1

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 23-5 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

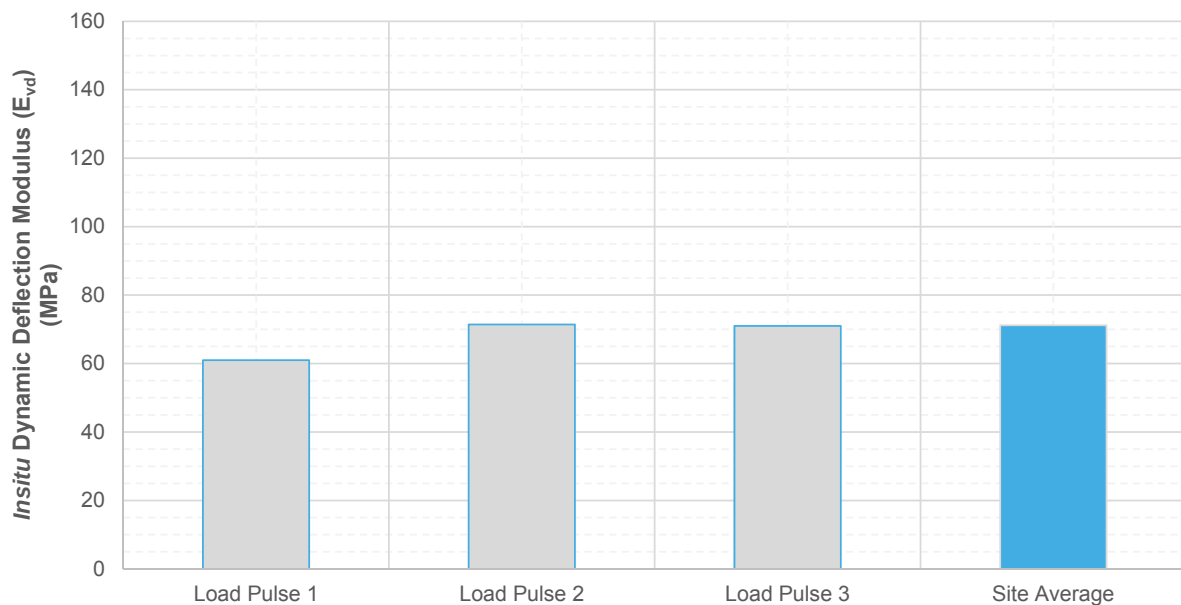
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	146.8 (<i>Outlier</i>)	369 (<i>Outlier</i>)	61.0
Weight Mass:	10 kg	2	(assumed - not measured)	133.5	315	71.4
Drop Height:	720 mm	3		135.9	317	71.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	134.7 (CoV = 1.3%)	316 (CoV = 0.4%)	71.2



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 23-6

Certificate Reference: 2091-LFWD-TERRA-Site 23-6

Sheet: 1 of 1

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 23-6 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

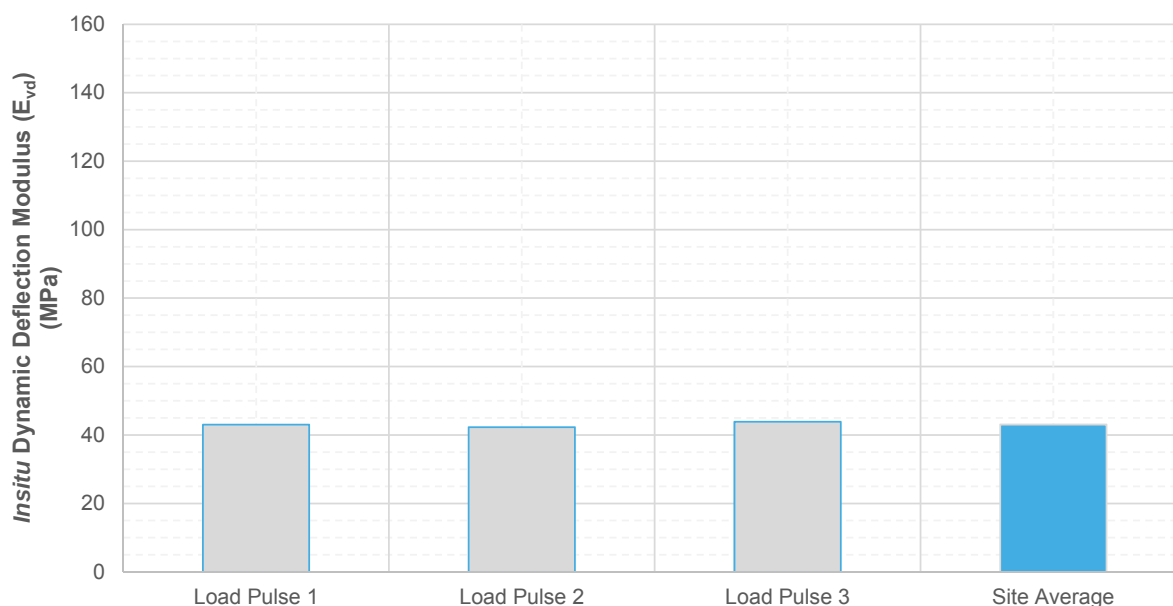
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	191.7	523	43.0
Weight Mass:	10 kg	2	(assumed - not measured)	195.4	532	42.3
Drop Height:	720 mm	3		193.5	513	43.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised Insitu Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average Insitu Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	193.5 (CoV = 1%)	523 (CoV = 1.8%)	43.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 24-1

Certificate Reference: 2091-LFWD-TERRA-Site 24-1

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-1 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

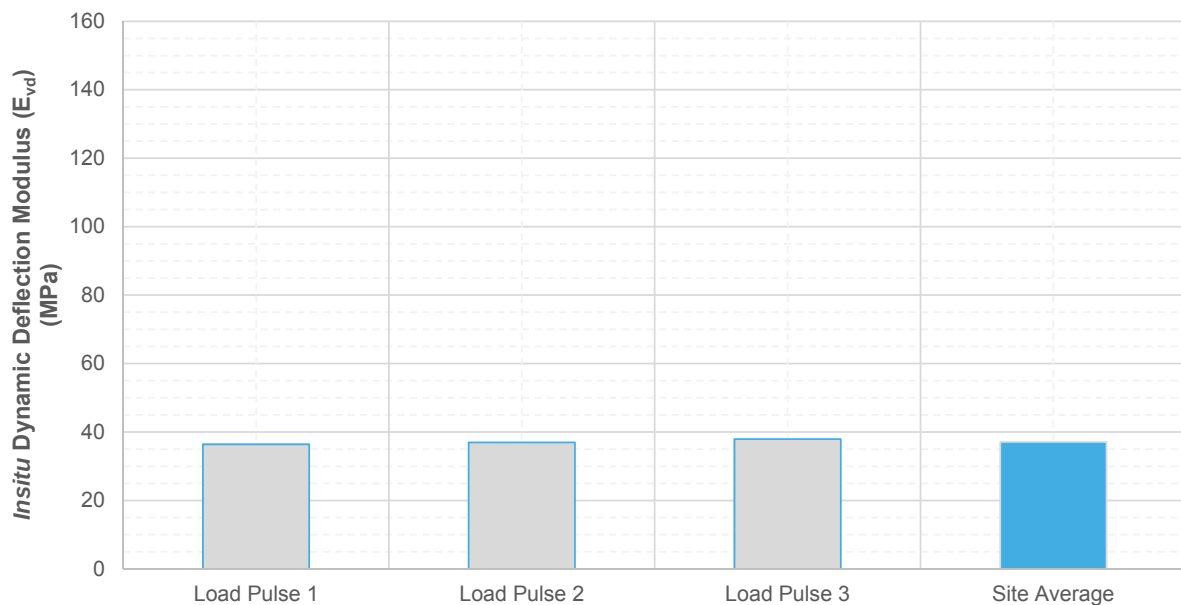
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	136.3	618	36.4
Weight Mass:	10 kg	2	(assumed - not measured)	136.0	609	36.9
Drop Height:	720 mm	3		131.5	593	37.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	134.6 (CoV = 2%)	607 (CoV = 2.1%)	37.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 24-2

Certificate Reference: 2091-LFWD-TERRA-Site 24-2 Sheet: 1 of 1

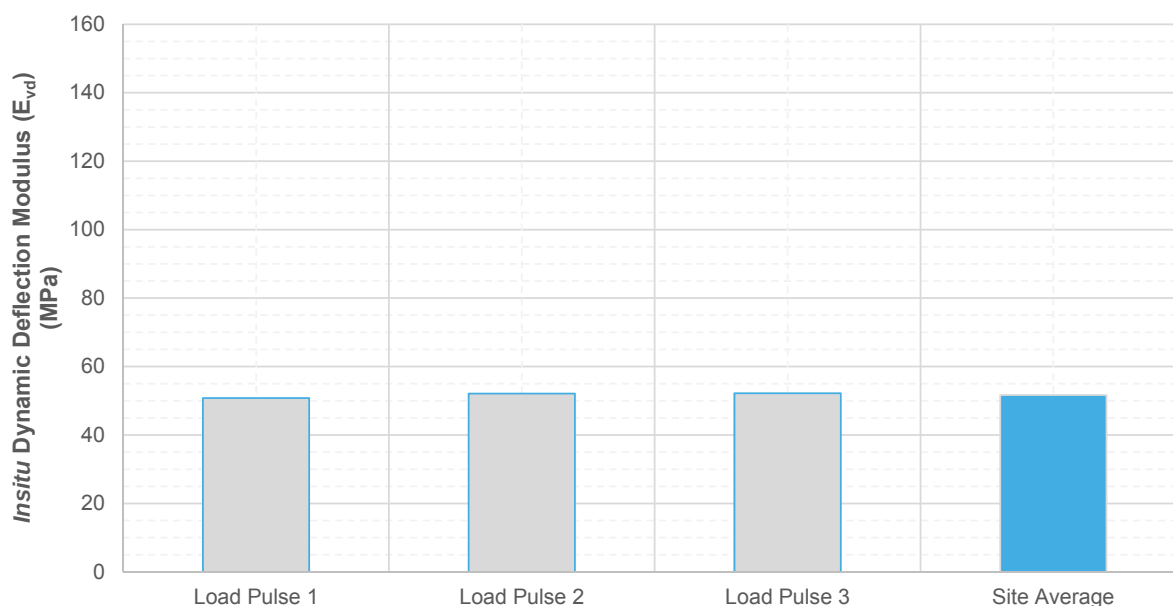
Client: ARRB Test Date: 12/03/2019
Project: Best Practice in Compaction QA Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)
Project No.: 2091 Adopted Stress Reduction Factor: 2 (Equipment Value)
Location: Site 24-2 (Smithfield Bypass - Trial Embankment) Tested By: RM / JH
Test method: ASTM - E2835-11 (2011) Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	120.1	443	50.8
Weight Mass:	10 kg	2	(assumed - not measured)	119.9	432	52.1
Drop Height:	720 mm	3		117.8	431	52.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	119.3 (CoV = 1.1%)	435 (CoV = 1.5%)	51.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 24-3

Certificate Reference: 2091-LFWD-TERRA-Site 24-3

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-3 (*Smithfield Bypass - Trial Embankment*)

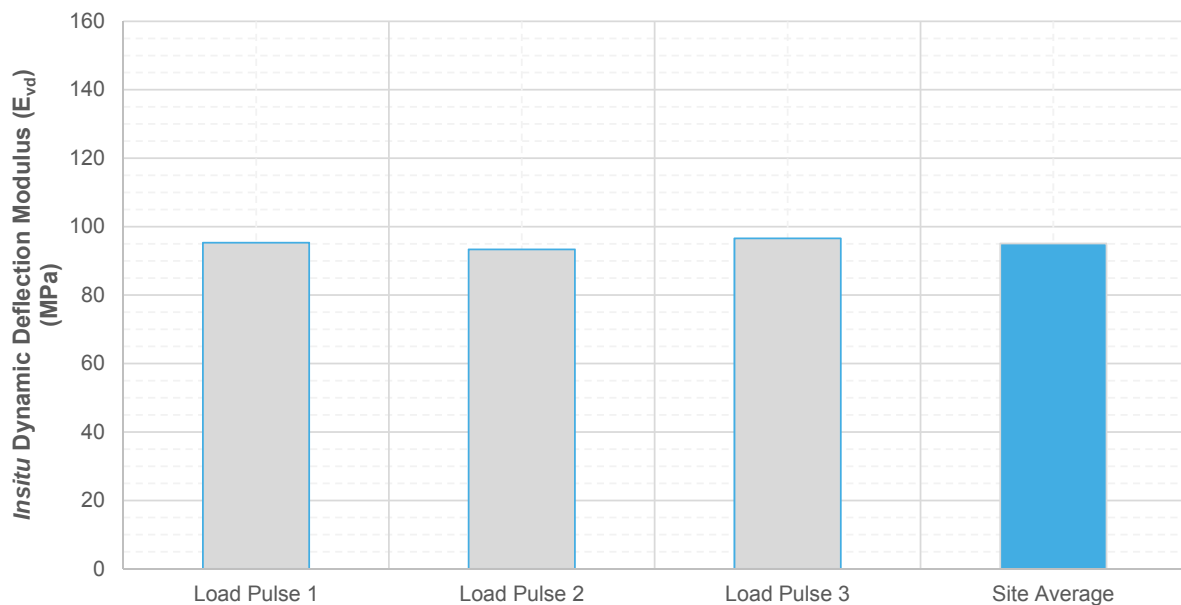
Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	72.4	236	95.3
Weight Mass:	10 kg	2	(assumed - not measured)	70.4	241	93.4
Drop Height:	720 mm	3		68.2	233	96.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})				
Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	70.3 (CoV = 3%)	237 (CoV = 1.7%)	95.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 24-4

Certificate Reference: 2091-LFWD-TERRA-Site 24-4

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

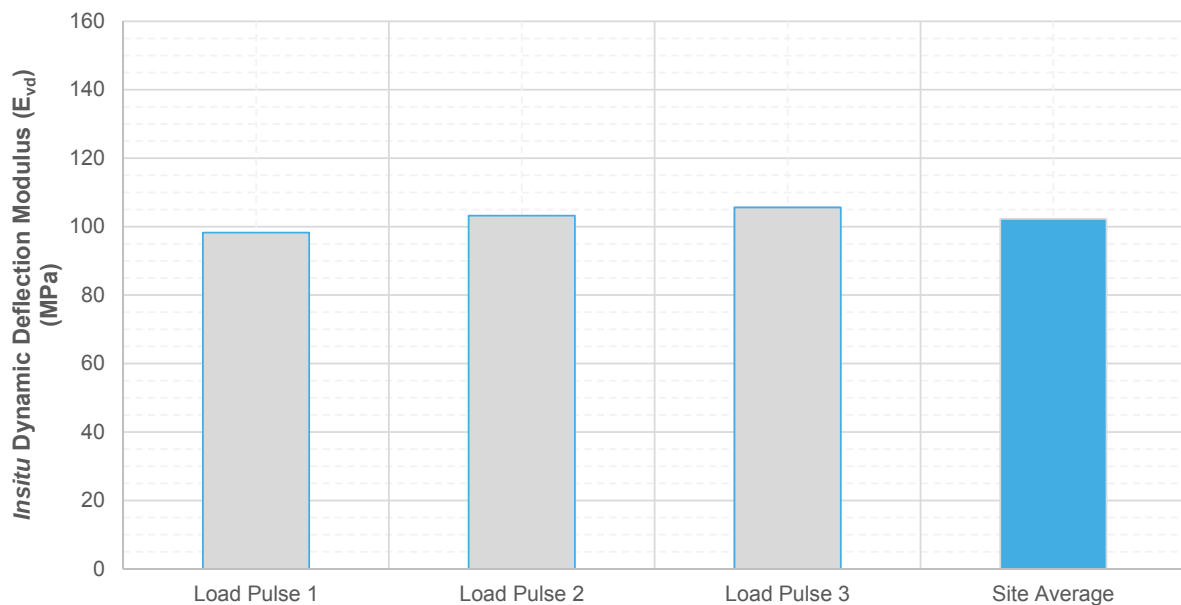
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (<i>E_{vd}</i>)
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	84.9	229	98.3
Weight Mass:	10 kg	2		82.7	218	103.2
Drop Height:	720 mm	3		82.1	213	105.6
Inferred Test Load:	7.07 kN	*After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	83.2 (CoV = 1.8%)	220 (CoV = 3.7%)	102.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 24-5

Certificate Reference: 2091-LFWD-TERRA-Site 24-5

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-5 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

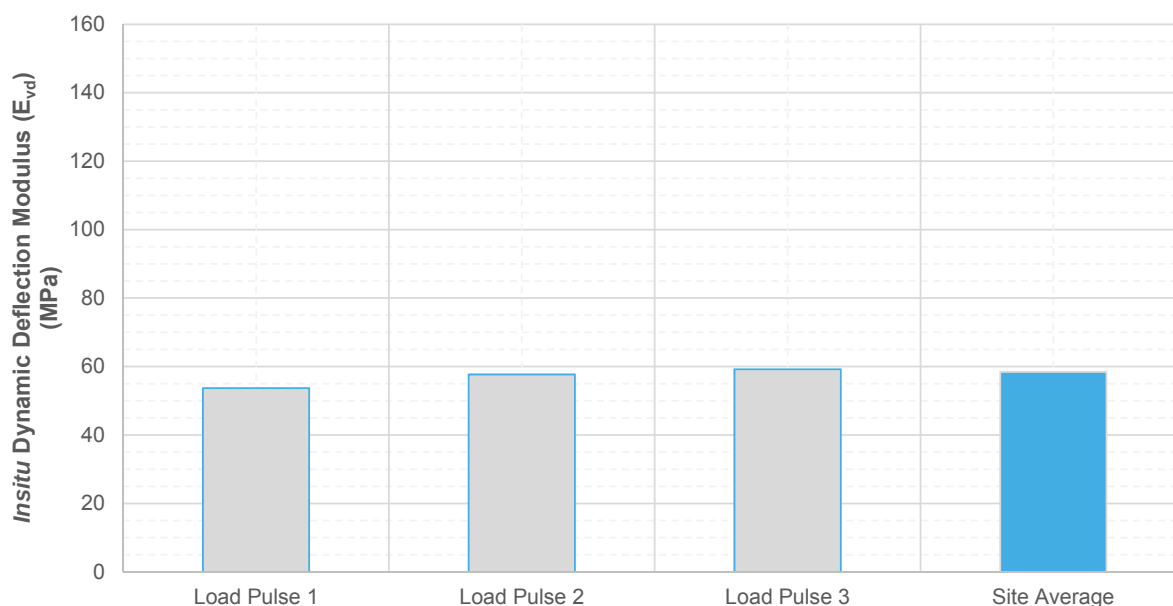
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	148.3 (<i>Outlier</i>)	419 (<i>Outlier</i>)	53.7
Weight Mass:	10 kg	2	(assumed - not measured)	135.1	390	57.7
Drop Height:	720 mm	3		133.7	380	59.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	134.4 (CoV = 0.7%)	385 (CoV = 1.8%)	58.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 24-5A

Certificate Reference: 2091-LFWD-TERRA-Site 24-5A

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-5A (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

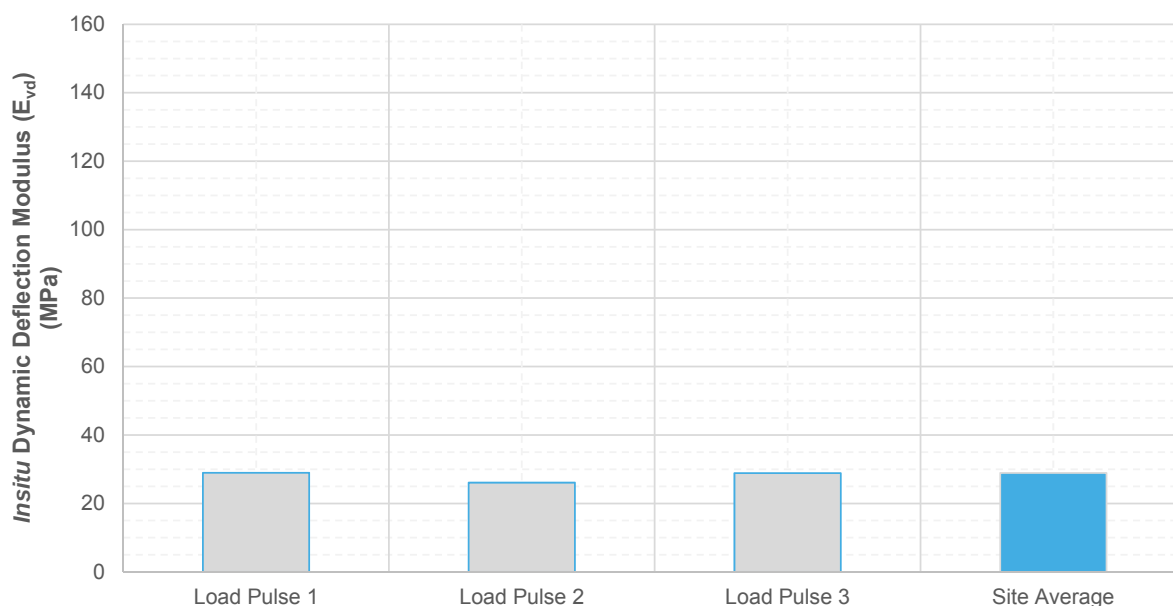
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	136.1	777	29.0
Weight Mass:	10 kg	2	(assumed - not measured)	144 (<i>Outlier</i>)	863 (<i>Outlier</i>)	26.1
Drop Height:	720 mm	3		135.5	780	28.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	135.8 (CoV = 0.3%)	779 (CoV = 0.3%)	28.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 24-6

Certificate Reference: 2091-LFWD-TERRA-Site 24-6

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-6 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) [†]	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	353.7	2404	9.4
Weight Mass:	10 kg	2	(assumed - not measured)	342.1	2417	9.3
Drop Height:	720 mm	3		347.9	2400	9.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			†Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	347.9 (CoV = 1.7%)	2407 (CoV = 0.4%)	9.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to breach the calibrated equipment range ($E_{vd} < 15 \text{ MPa}$) due to measurement of significant plate deflections ($\delta > 1,500 \mu\text{m}$) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 24-6A

Certificate Reference: 2091-LFWD-TERRA-Site 24-6A

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-6A (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

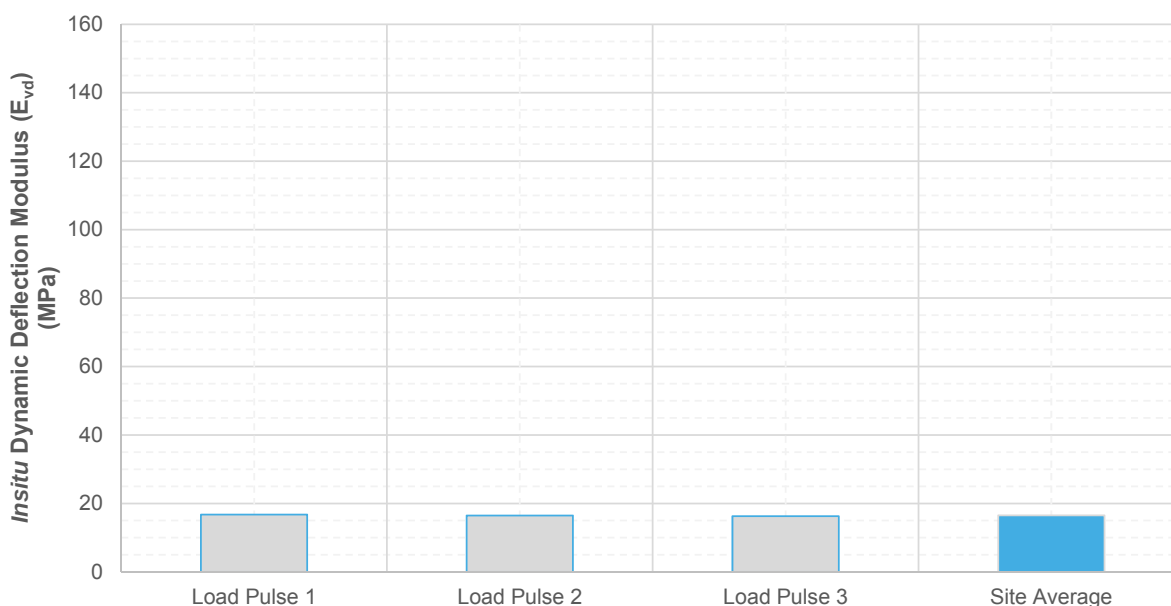
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	179.6	1345	16.7
Weight Mass:	10 kg	2	(assumed - not measured)	181.5	1366	16.5
Drop Height:	720 mm	3		182.7	1383	16.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	181.3 (CoV = 0.9%)	1365 (CoV = 1.4%)	16.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 24-7

Certificate Reference: 2091-LFWD-TERRA-Site 24-7

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-7 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

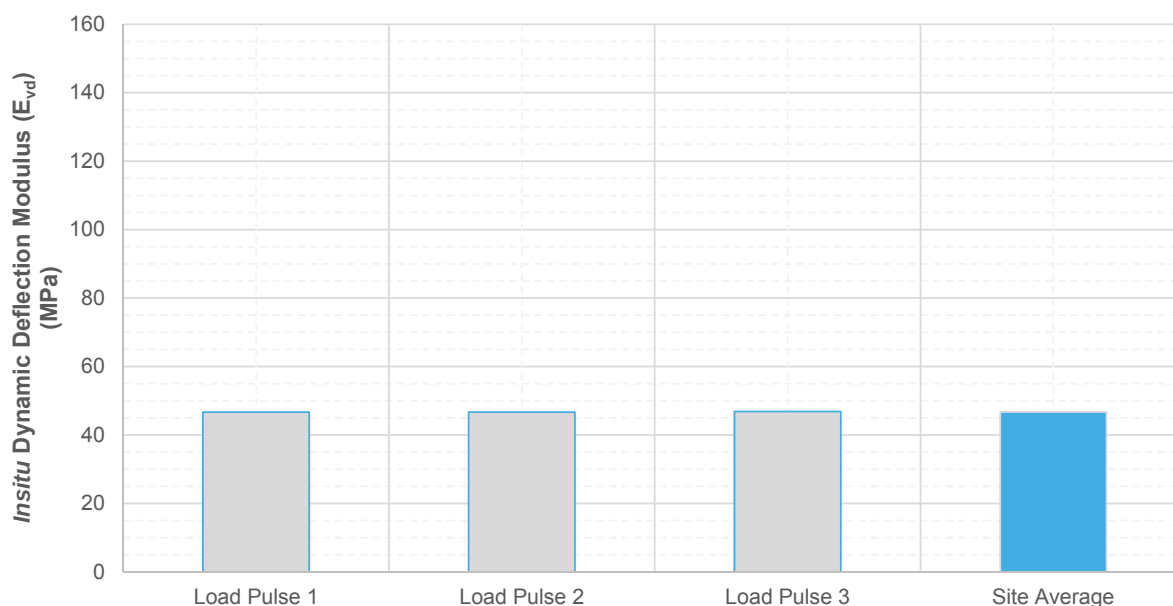
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	188.9	482	46.7
Weight Mass:	10 kg	2	(assumed - not measured)	187.8	482	46.7
Drop Height:	720 mm	3		187.0	480	46.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	187.9 (CoV = 0.5%)	481 (CoV = 0.2%)	46.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 24-8

Certificate Reference: 2091-LFWD-TERRA-Site 24-8

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-8 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

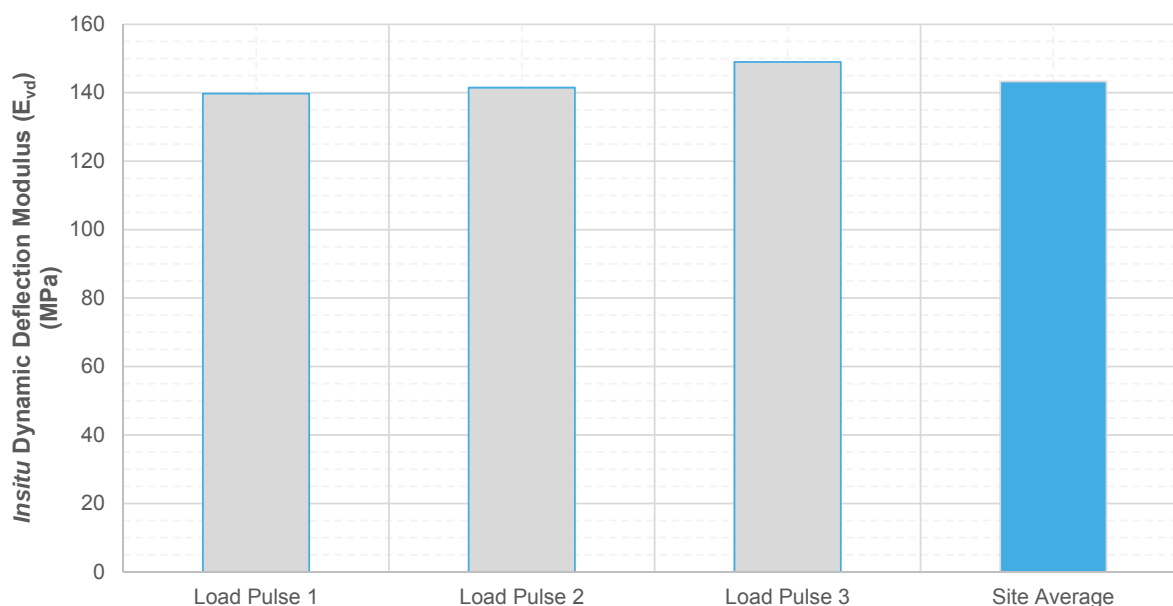
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	58.9	161	139.8
Weight Mass:	10 kg	2	(assumed - not measured)	57.8	159	141.5
Drop Height:	720 mm	3		58.1	151	149.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	58.3 (CoV = 1%)	157 (CoV = 3.4%)	143.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 24-9

Certificate Reference: 2091-LFWD-TERRA-Site 24-9

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 24-9 (Smithfield Bypass - Trial Embankment)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

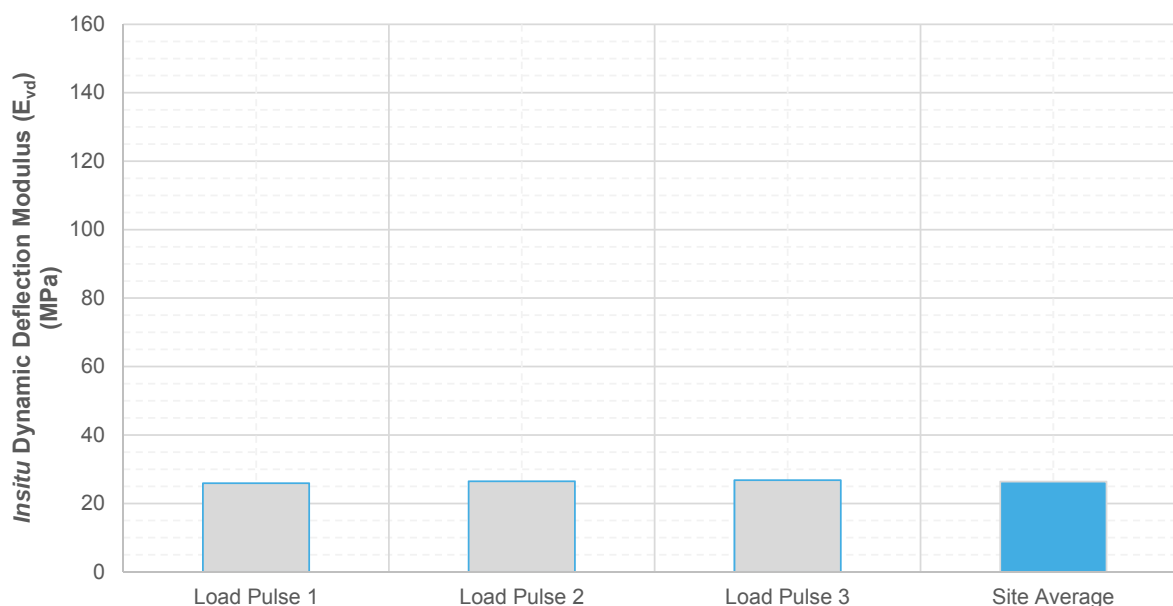
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	164.3	869	25.9
Weight Mass:	10 kg	2	(assumed - not measured)	160.7	850	26.5
Drop Height:	720 mm	3		158.6	840	26.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	161.2 (CoV = 1.8%)	853 (CoV = 1.7%)	26.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 24-10

Certificate Reference: 2091-LFWD-TERRA-Site 24-10

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-10 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

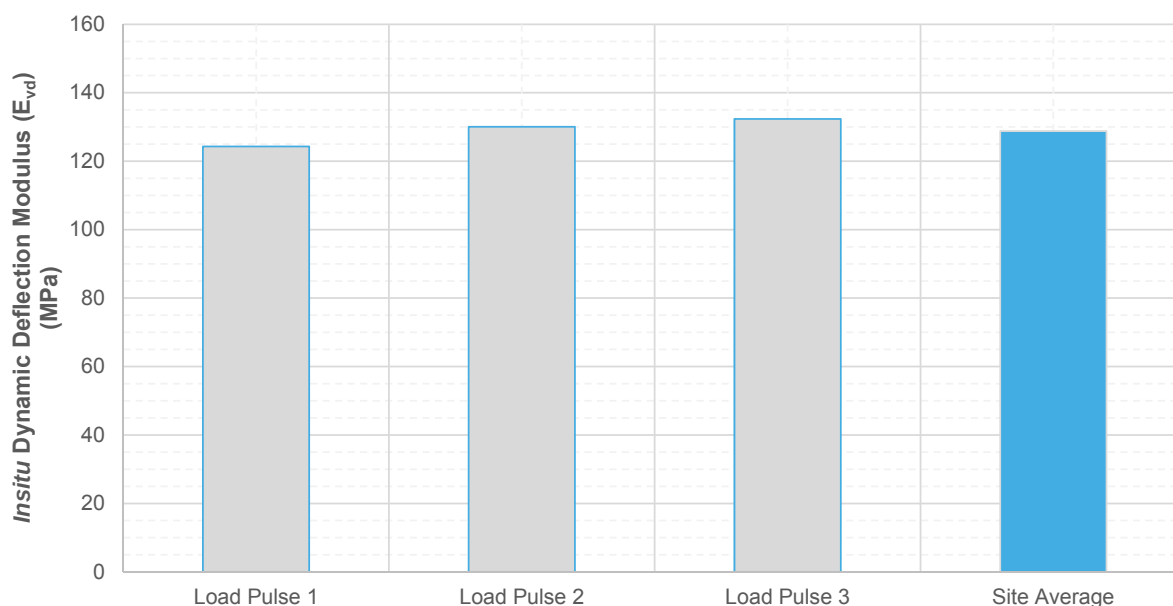
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	93.9	181	124.3
Weight Mass:	10 kg	2	(assumed - not measured)	93.3	173	130.1
Drop Height:	720 mm	3		90.7	170	132.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	92.6 (CoV = 1.8%)	175 (CoV = 3.3%)	128.8



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 24-11

Certificate Reference: 2091-LFWD-TERRA-Site 24-11

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-11 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

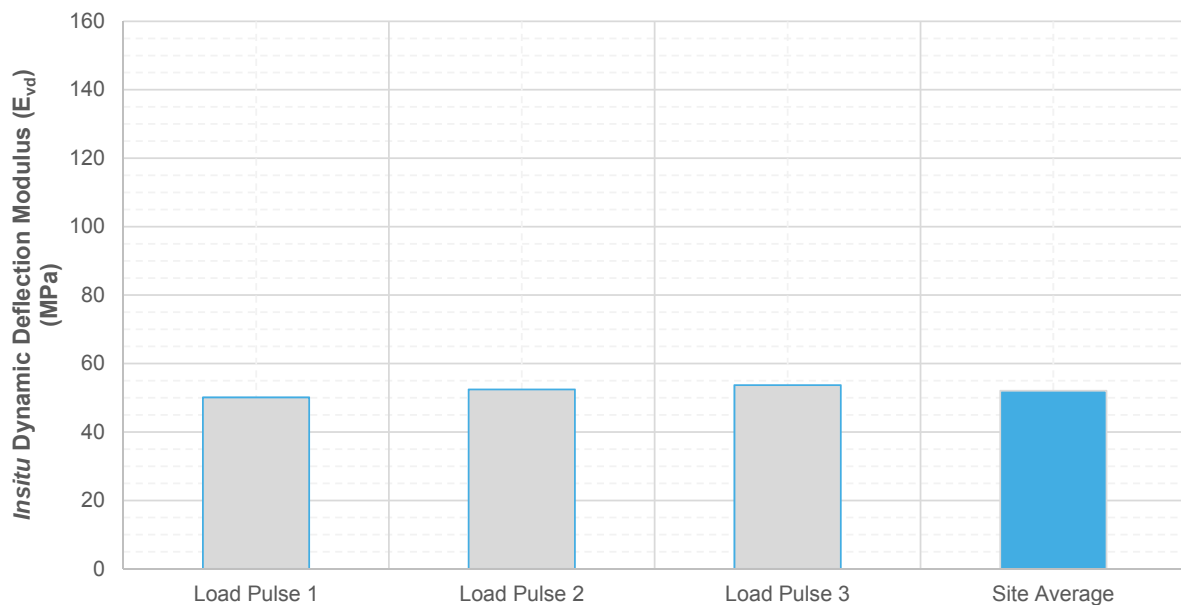
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	143.2	449	50.1
Weight Mass:	10 kg	2	(assumed - not measured)	140.4	429	52.4
Drop Height:	720 mm	3		140.2	419	53.7
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	141.3 (CoV = 1.2%)	432 (CoV = 3.5%)	52.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 24-11A

Certificate Reference: 2091-LFWD-TERRA-Site 24-11A

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 24-11A (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

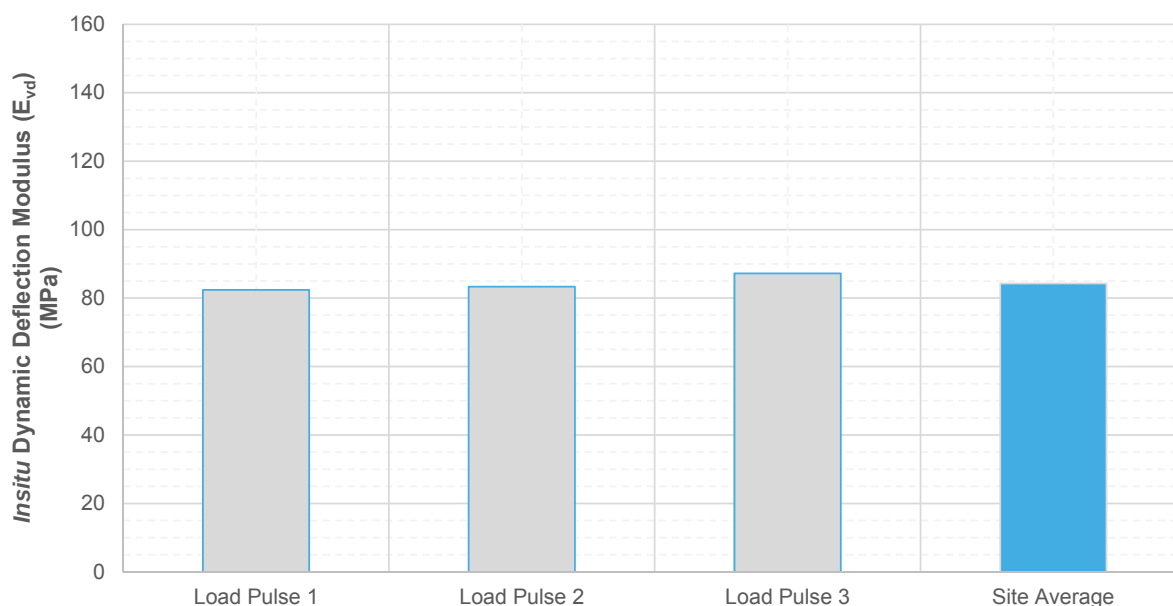
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	138.3	273	82.4
Weight Mass:	10 kg	2	(assumed - not measured)	128.0	270	83.3
Drop Height:	720 mm	3		134.3	258	87.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	133.5 (CoV = 3.9%)	267 (CoV = 3%)	84.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 24-12

Certificate Reference: 2091-LFWD-TERRA-Site 24-12

Sheet: 1 of 1

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 24-12 (Smithfield Bypass - Trial Embankment)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

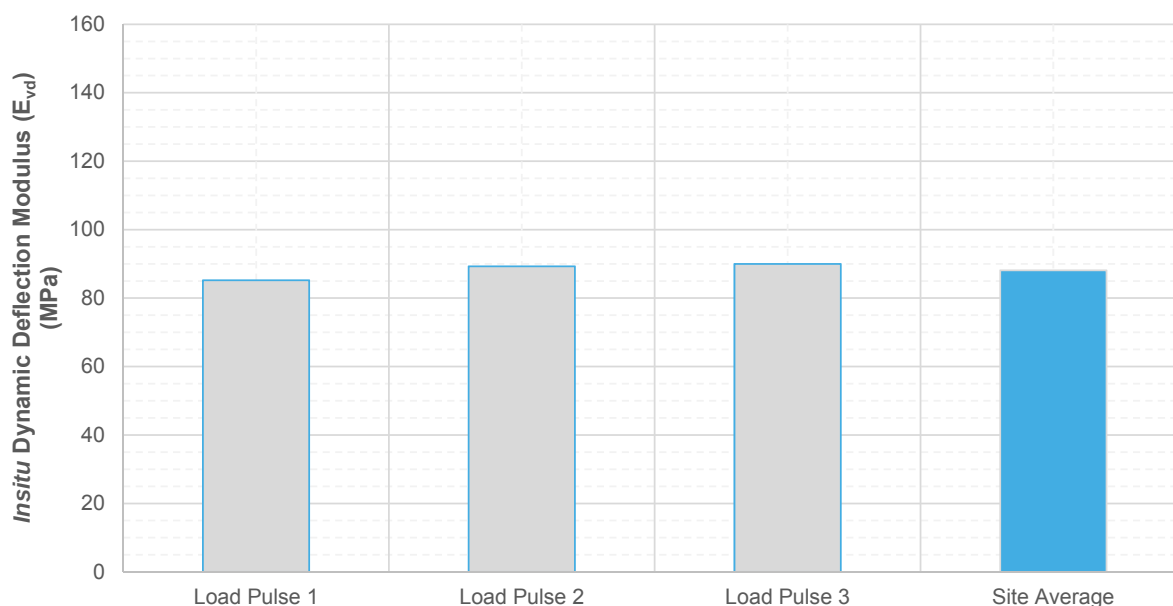
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	133.9	264	85.2
Weight Mass:	10 kg	2	(assumed - not measured)	130.6	252	89.3
Drop Height:	720 mm	3		129.9	250	90.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	131.5 (CoV = 1.6%)	255 (CoV = 3%)	88.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 25-1

Certificate Reference: 2091-LFWD-TERRA-Site 25-1

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 25-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

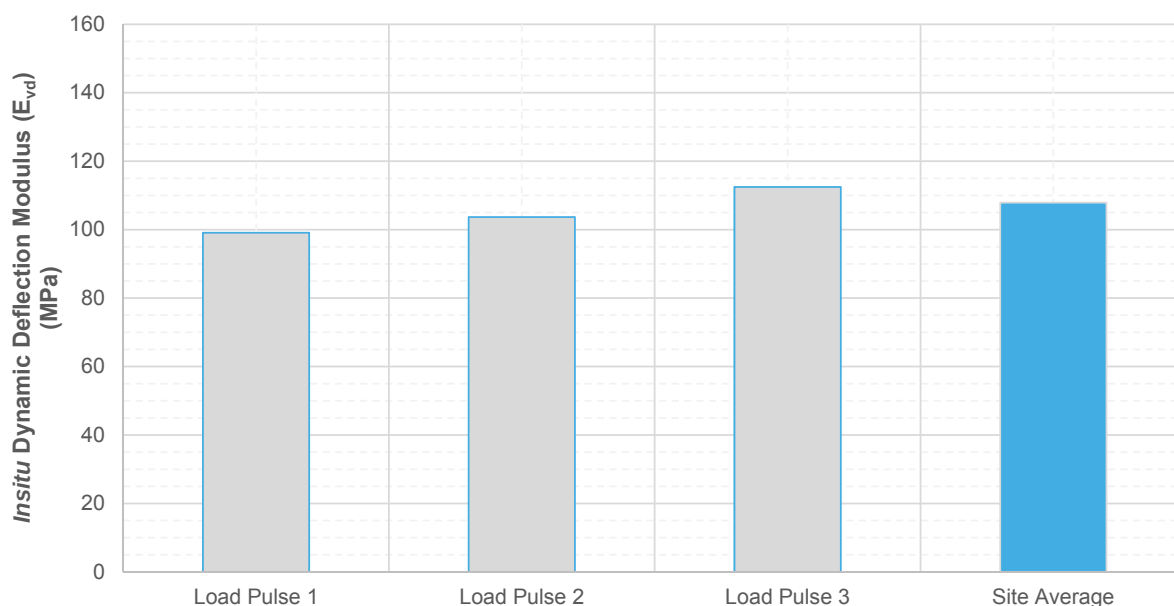
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	96.2 (Outlier)	227 (Outlier)	99.1
Weight Mass:	10 kg	2	(assumed - not measured)	88.4	217	103.7
Drop Height:	720 mm	3		86.0	200	112.5
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	87.2 (CoV = 1.9%)	209 (CoV = 5.8%)	107.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-2

Certificate Reference: 2091-LFWD-TERRA-Site 25-2

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-2 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

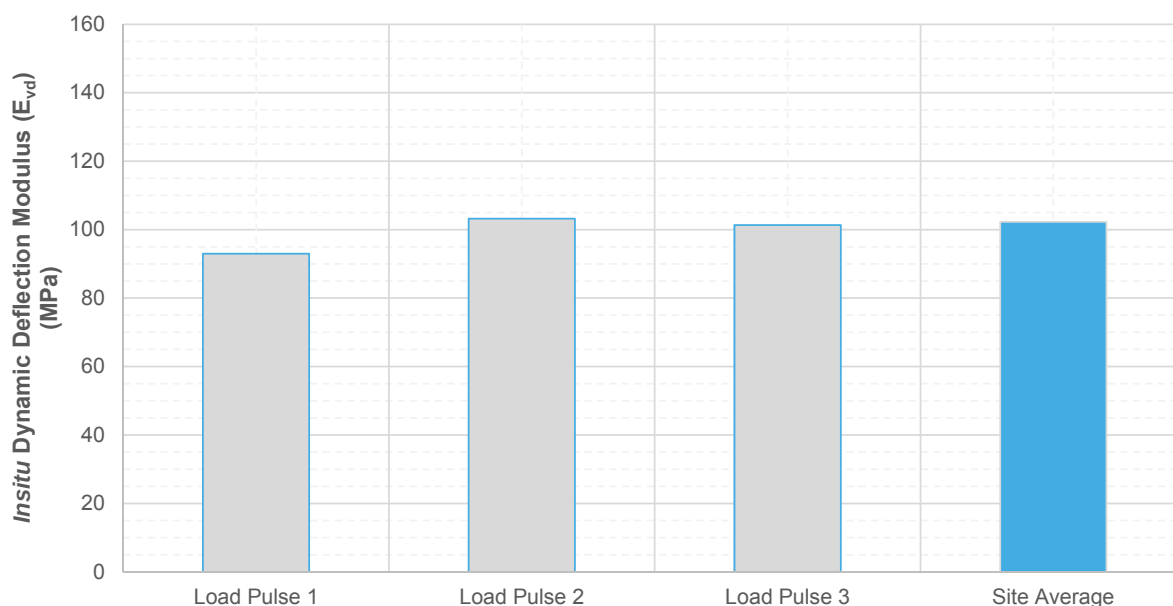
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm)*	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	86.7 (Outlier)	242 (Outlier)	93.0
Weight Mass:	10 kg	2		78.4	218	103.2
Drop Height:	720 mm	3		75.6	222	101.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	77.0 (CoV = 2.6%)	220 (CoV = 1.3%)	102.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 25-2A

Certificate Reference: 2091-LFWD-TERRA-Site 25-2A

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-2A (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

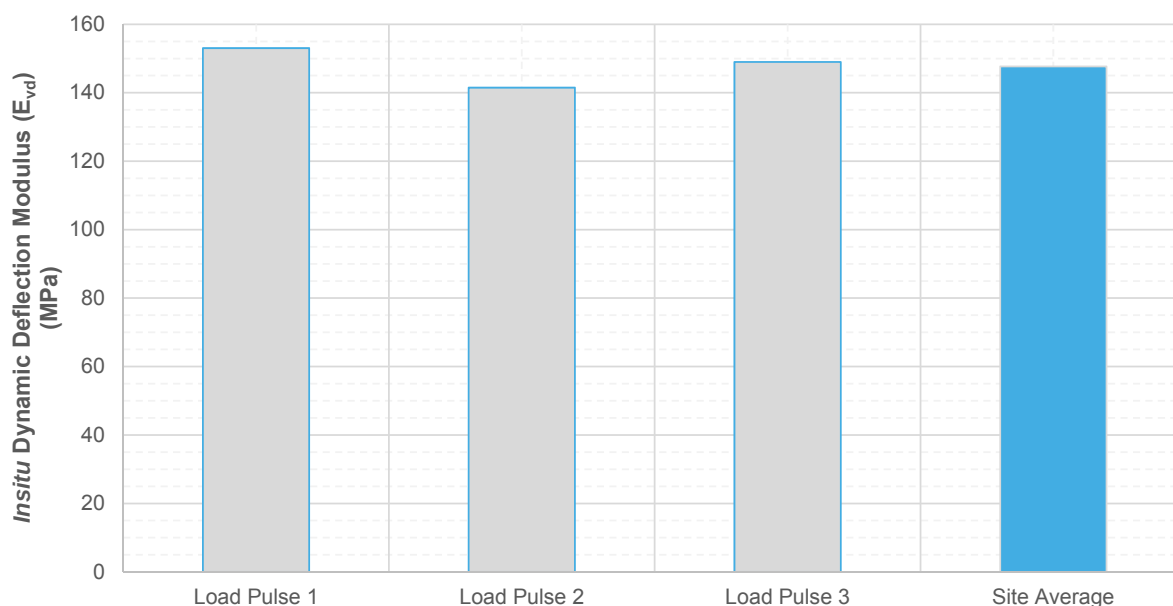
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	59.1	147	153.1
Weight Mass:	10 kg	2	(assumed - not measured)	60.8	159	141.5
Drop Height:	720 mm	3		58.7	151	149.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	59.5 (CoV = 1.9%)	152 (CoV = 4%)	147.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-3

Certificate Reference: 2091-LFWD-TERRA-Site 25-3

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

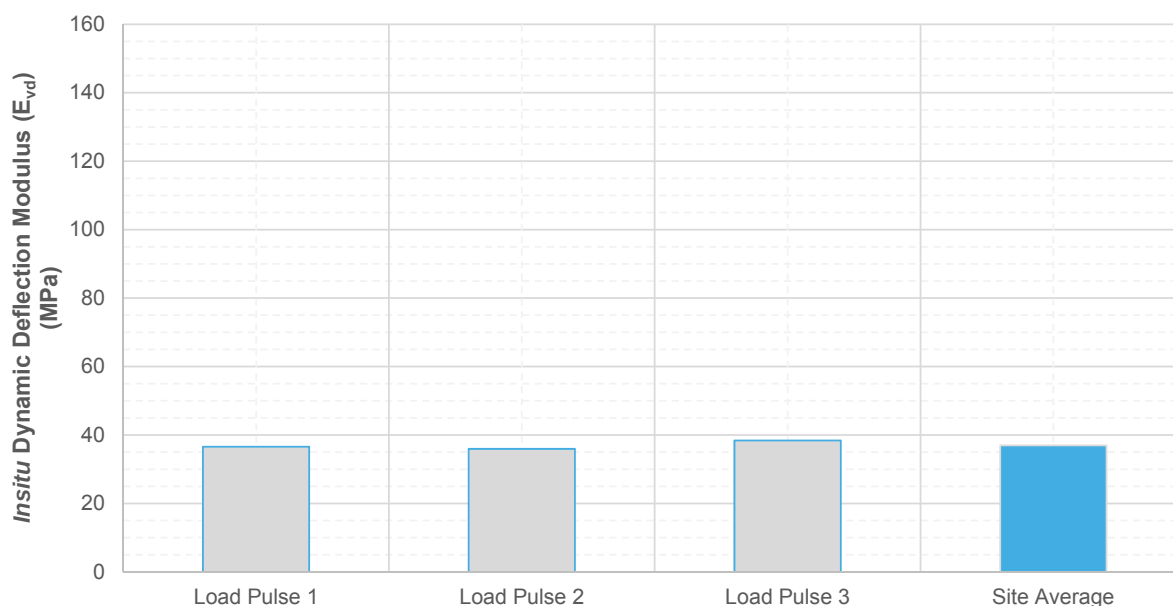
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	146.3	615	36.6
Weight Mass:	10 kg	2	(assumed - not measured)	146.9	626	35.9
Drop Height:	720 mm	3		137.7	586	38.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	143.6 (CoV = 3.6%)	609 (CoV = 3.4%)	36.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 25-4

Certificate Reference: 2091-LFWD-TERRA-Site 25-4

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 25-4 (Smithfield Bypass - Trial Embankment)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

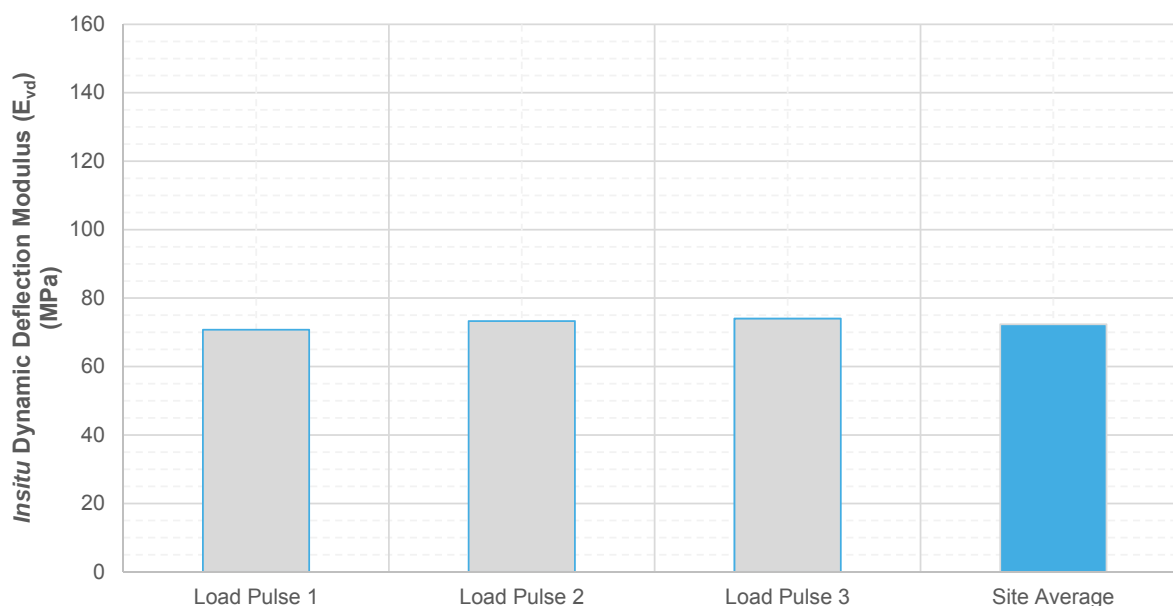
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	133.2	318	70.8
Weight Mass:	10 kg	2	(assumed - not measured)	142.4 (Outlier)	307	73.3
Drop Height:	720 mm	3		128.6	304	74.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	130.9 (CoV = 2.5%)	311 (CoV = 2.4%)	72.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 25-5

Certificate Reference: 2091-LFWD-TERRA-Site 25-5

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-5 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

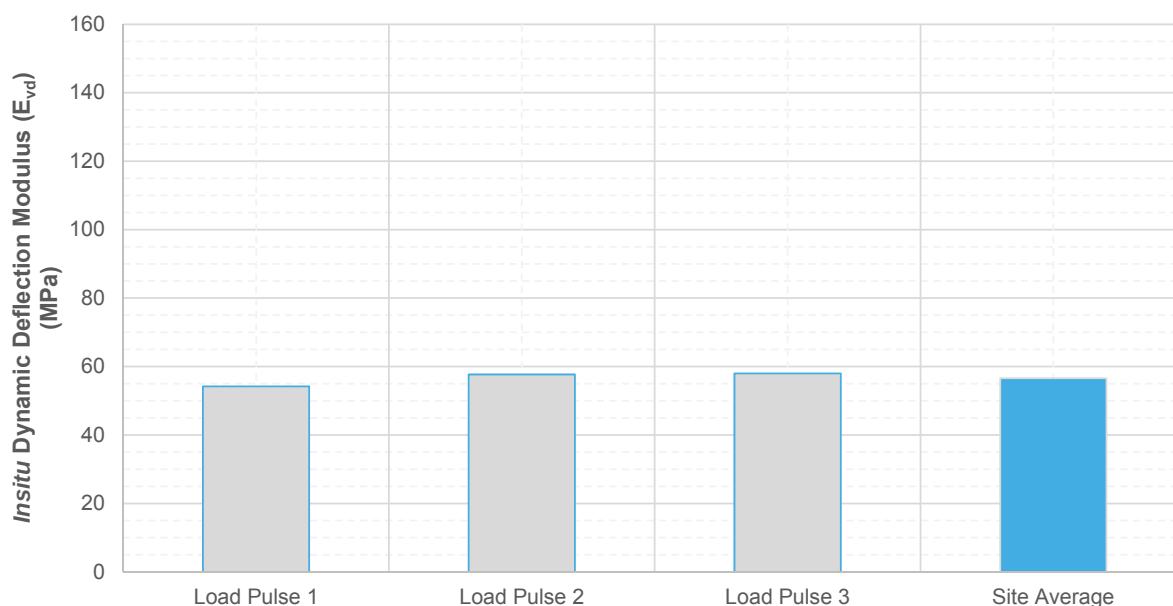
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	152.1	415	54.2
Weight Mass:	10 kg	2	(assumed - not measured)	146.3	390	57.7
Drop Height:	720 mm	3		144.0	388	58.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	147.5 (CoV = 2.8%)	398 (CoV = 3.8%)	56.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 25-6

Certificate Reference: 2091-LFWD-TERRA-Site 25-6

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-6 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

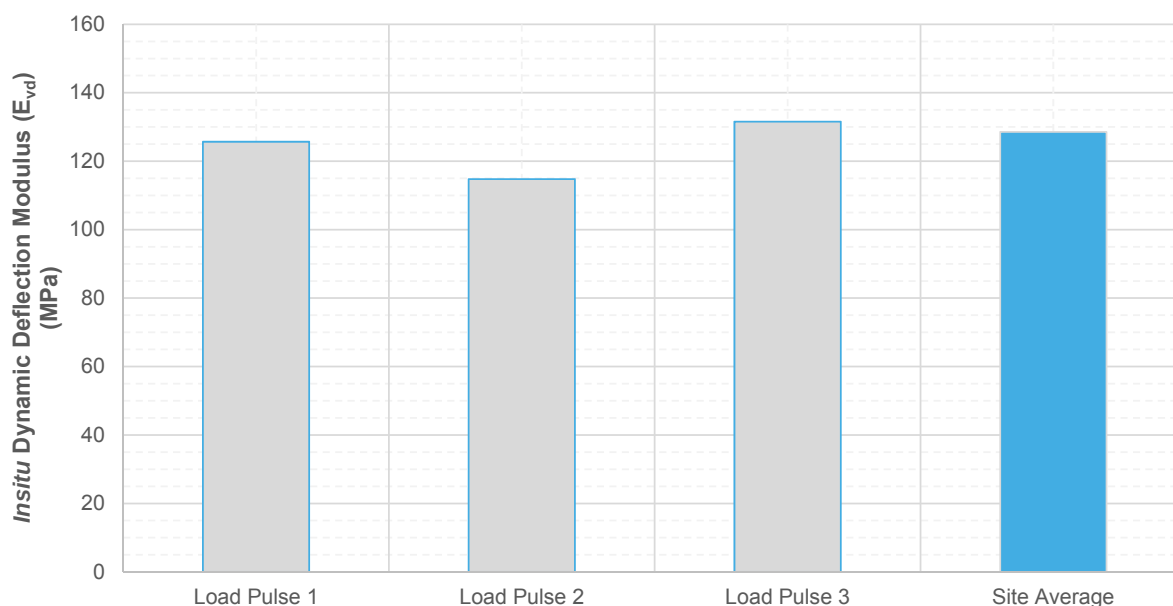
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	77.9	179	125.7
Weight Mass:	10 kg	2	(assumed - not measured)	76.2	196 (<i>Outlier</i>)	114.8
Drop Height:	720 mm	3		74.7	171	131.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	76.3 (CoV = 2.1%)	175 (CoV = 3.2%)	128.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-6A

Certificate Reference: 2091-LFWD-TERRA-Site 25-6A

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-6A (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

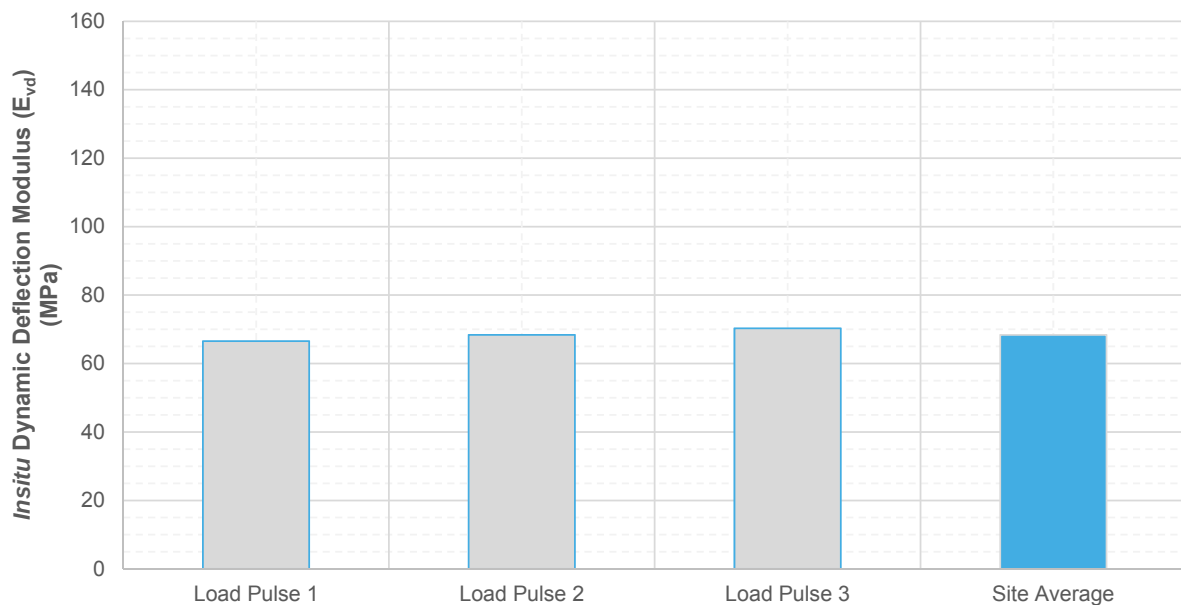
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	148.5	338	66.6
Weight Mass:	10 kg	2	(assumed - not measured)	145.5	329	68.4
Drop Height:	720 mm	3		143.9	320	70.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	146.0 (CoV = 1.6%)	329 (CoV = 2.7%)	68.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-7

Certificate Reference: 2091-LFWD-TERRA-Site 25-7

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-7 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

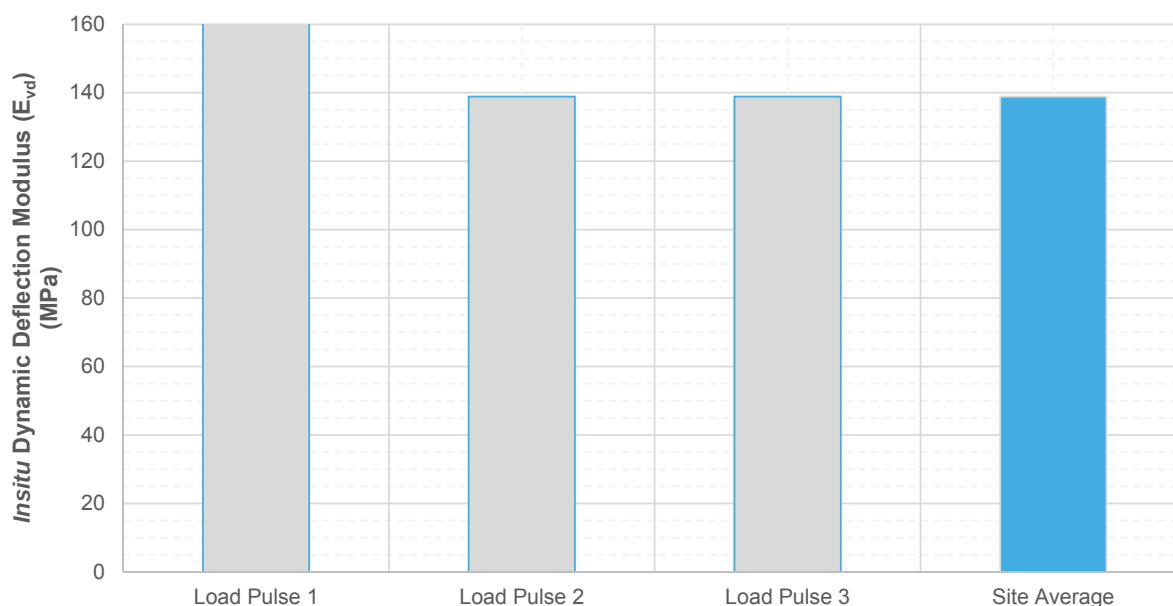
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	45.9 (<i>Outlier</i>)	140 (<i>Outlier</i>)	160.7
Weight Mass:	10 kg	2	(assumed - not measured)	66.5	162	138.9
Drop Height:	720 mm	3		62.4	162	138.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	64.5 (CoV = 4.5%)	162 (CoV = 0%)	138.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-7A

Certificate Reference: 2091-LFWD-TERRA-Site 25-7A

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-7A (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

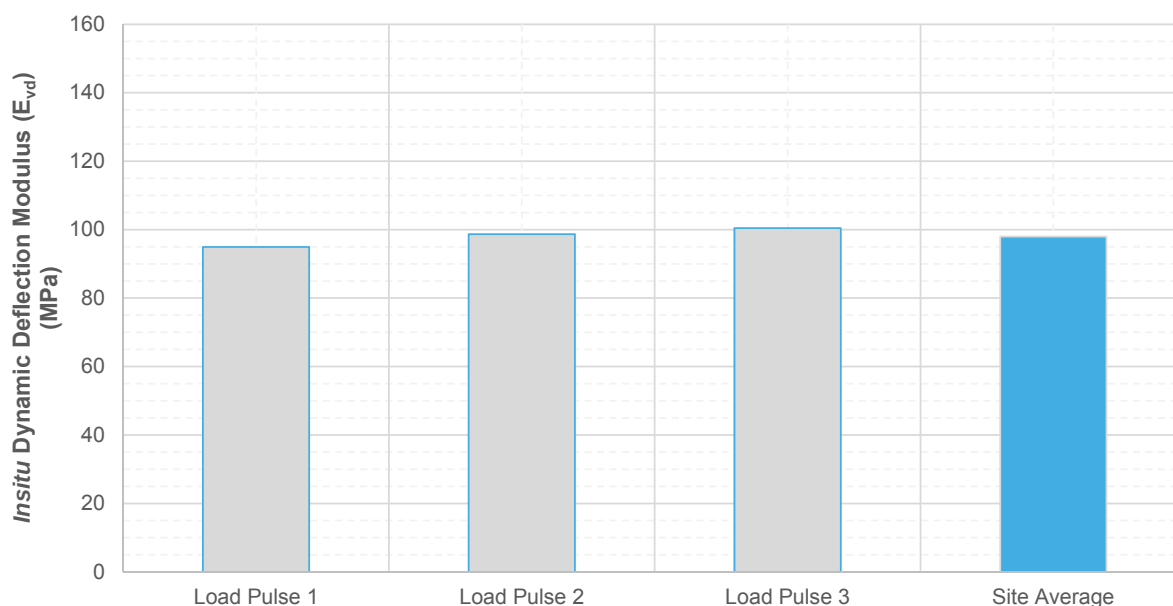
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	107.5	237	94.9
Weight Mass:	10 kg	2	(assumed - not measured)	104.7	228	98.7
Drop Height:	720 mm	3		102.2	224	100.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	104.8 (CoV = 2.5%)	230 (CoV = 2.9%)	98.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-8

Certificate Reference: 2091-LFWD-TERRA-Site 25-8

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-8 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

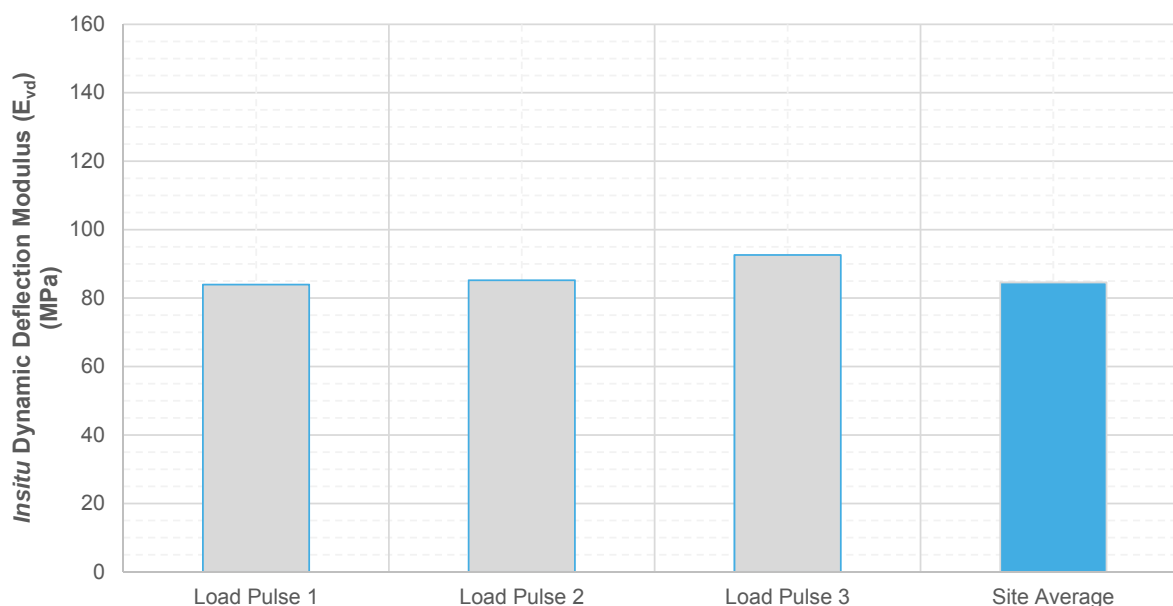
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	128.0	268	84.0
Weight Mass:	10 kg	2	(assumed - not measured)	126.4	264	85.2
Drop Height:	720 mm	3		118.4 (<i>Outlier</i>)	243 (<i>Outlier</i>)	92.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	127.2 (CoV = 0.9%)	266 (CoV = 1.1%)	84.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-9

Certificate Reference: 2091-LFWD-TERRA-Site 25-9

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-9 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

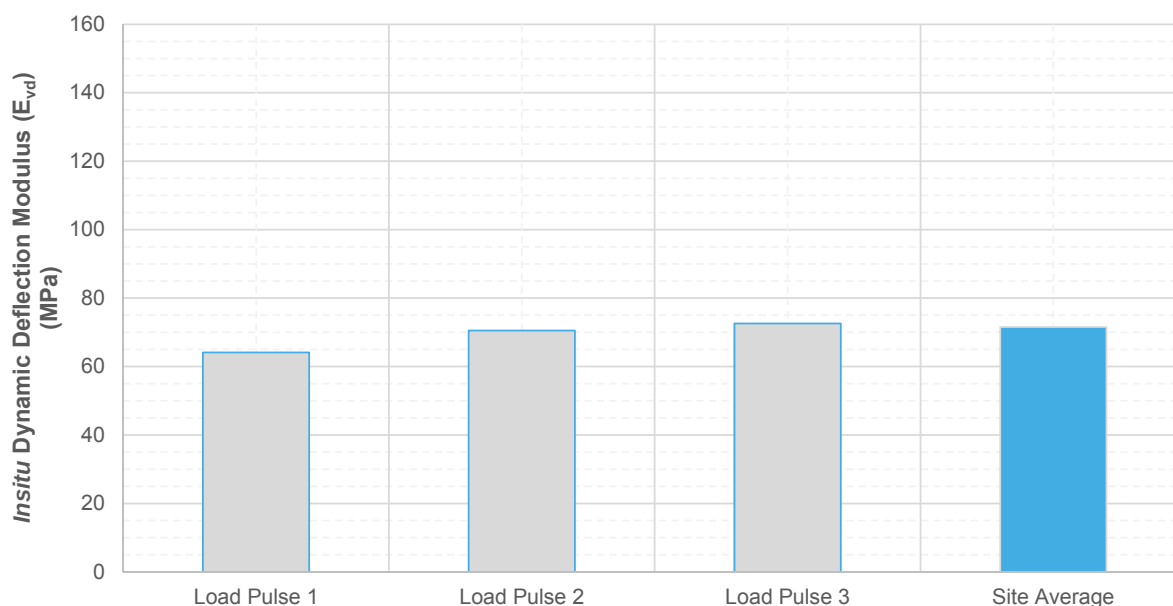
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	117.1	351 (<i>Outlier</i>)	64.1
Weight Mass:	10 kg	2	(assumed - not measured)	113.1	319	70.5
Drop Height:	720 mm	3		116.8	310	72.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	115.0 (CoV = 1.9%)	315 (CoV = 2%)	71.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-10

Certificate Reference: 2091-LFWD-TERRA-Site 25-10

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-10 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

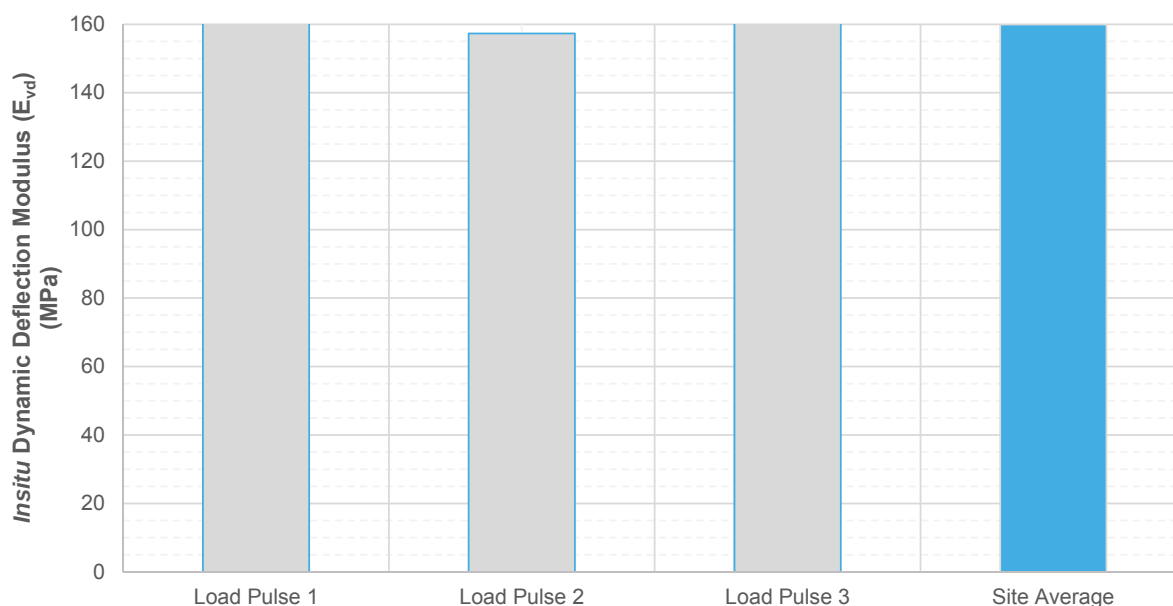
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	57.1	140	160.7
Weight Mass:	10 kg	2	(assumed - not measured)	56.9	143	157.3
Drop Height:	720 mm	3		56.4	139	161.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	56.8 (CoV = 0.6%)	141 (CoV = 1.5%)	160.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 25-11

Certificate Reference: 2091-LFWD-TERRA-Site 25-11

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 25-11 (Smithfield Bypass - Trial Embankment)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

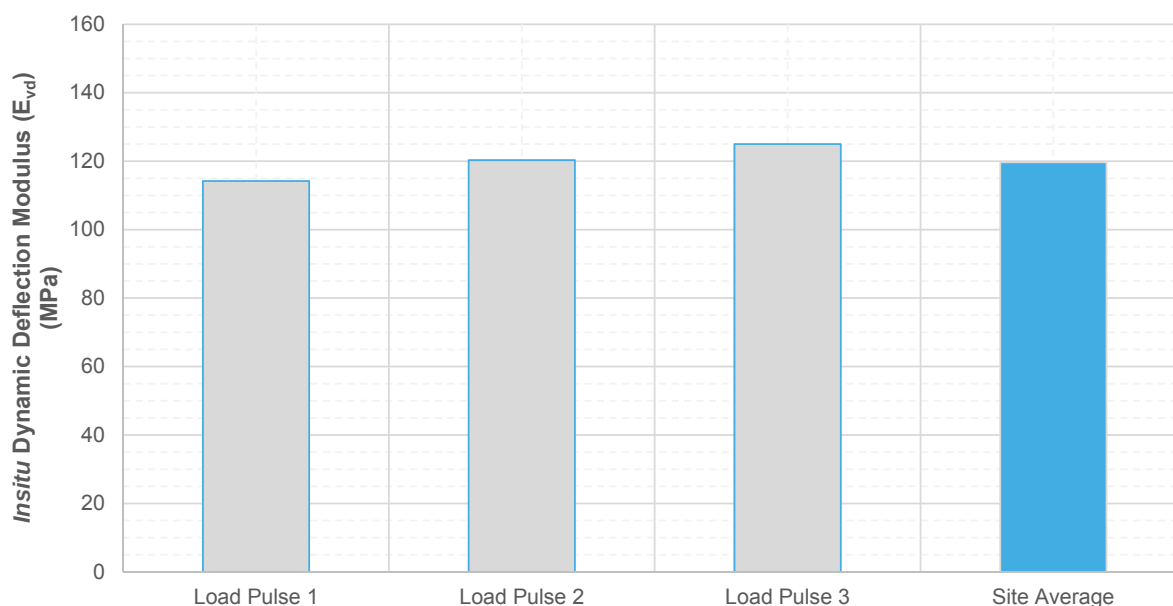
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	91.0	197	114.2
Weight Mass:	10 kg	2	(assumed - not measured)	85.8	187	120.3
Drop Height:	720 mm	3		83.6	180	125.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	86.8 (CoV = 4.4%)	188 (CoV = 4.5%)	119.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 25-12

Certificate Reference: 2091-LFWD-TERRA-Site 25-12

Sheet: 1 of 1

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 25-12 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

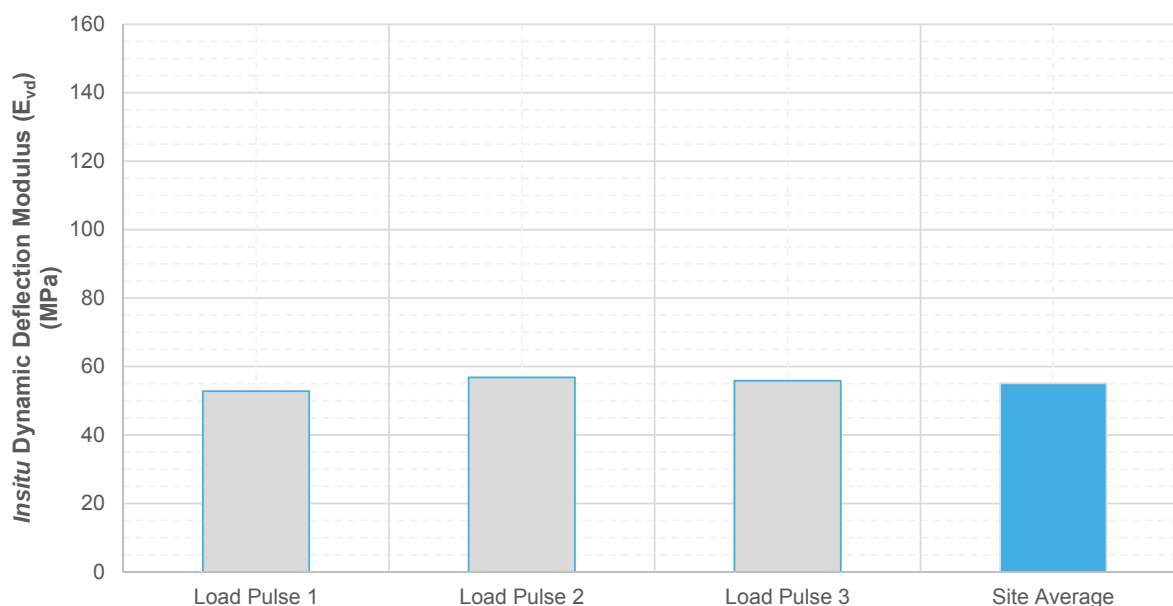
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	131.6	426	52.8
Weight Mass:	10 kg	2	(assumed - not measured)	126.0	396	56.8
Drop Height:	720 mm	3		127.2	403	55.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	128.3 (CoV = 2.3%)	408 (CoV = 3.8%)	55.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 26-1

Certificate Reference: 2091-LFWD-TERRA-Site 26-1

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 26-1 (Smithfield Bypass - Trial Embankment)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

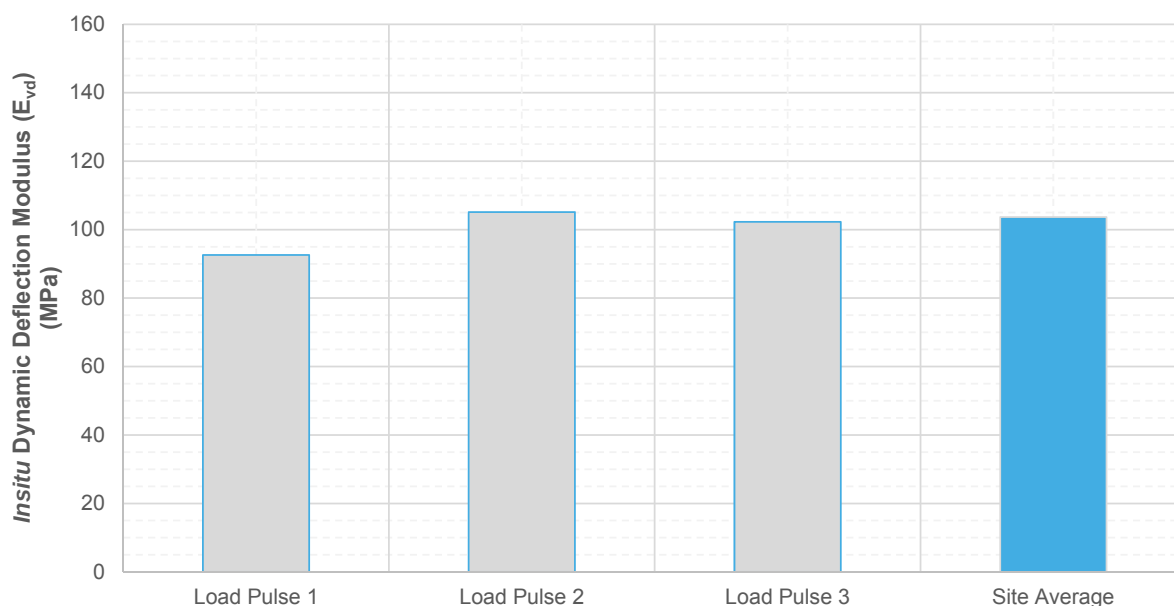
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	115.3	243 (Outlier)	92.6
Weight Mass:	10 kg	2	(assumed - not measured)	110.1	214	105.1
Drop Height:	720 mm	3		109.3	220	102.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	109.7 (CoV = 3%)	217 (CoV = 2%)	103.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 26-2

Certificate Reference: 2091-LFWD-TERRA-Site 26-2

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 26-2 (Smithfield Bypass - Trial Embankment)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	262.5 (Outlier)	1718 (Outlier)	13.1
Weight Mass:	10 kg	2	(assumed - not measured)	278.2	1833	12.3
Drop Height:	720 mm	3		295.9	1889	11.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	287.1 (CoV = 4.4%)	1861 (CoV = 2.1%)	12.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to breach the calibrated equipment range ($E_{vd} < 15 \text{ MPa}$) due to measurement of significant plate deflections ($\delta > 1,500 \mu\text{m}$) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 26-3

Certificate Reference: 2091-LFWD-TERRA-Site 26-3

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

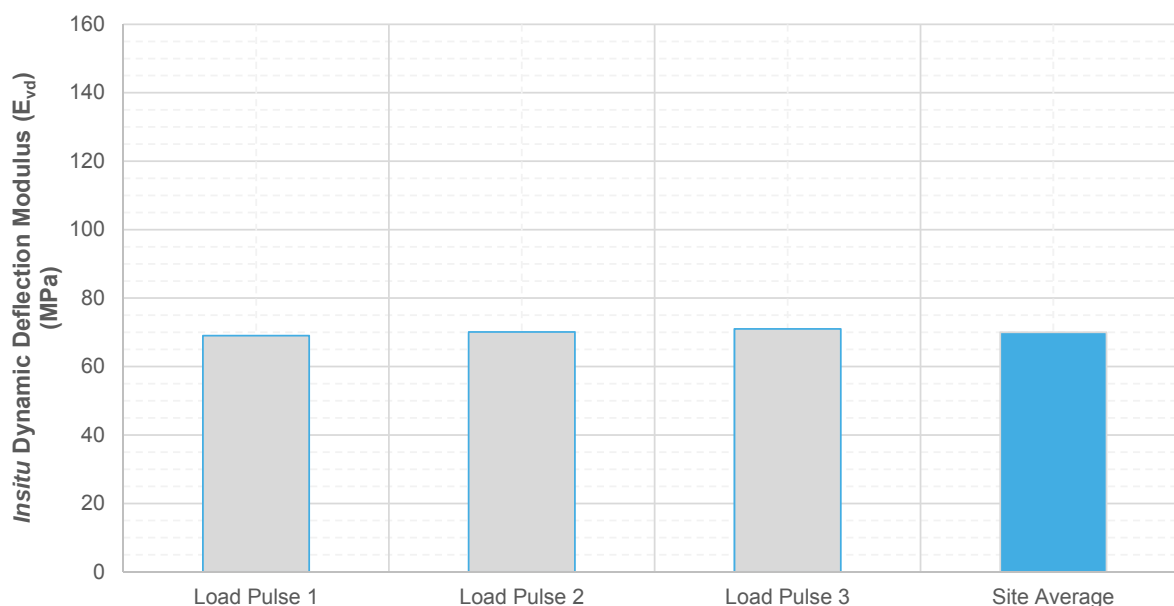
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	125.7	326	69.0
Weight Mass:	10 kg	2	(assumed - not measured)	121.5	321	70.1
Drop Height:	720 mm	3		120.8	317	71.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	122.7 (CoV = 2.2%)	321 (CoV = 1.4%)	70.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 26-4

Certificate Reference: 2091-LFWD-TERRA-Site 26-4

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

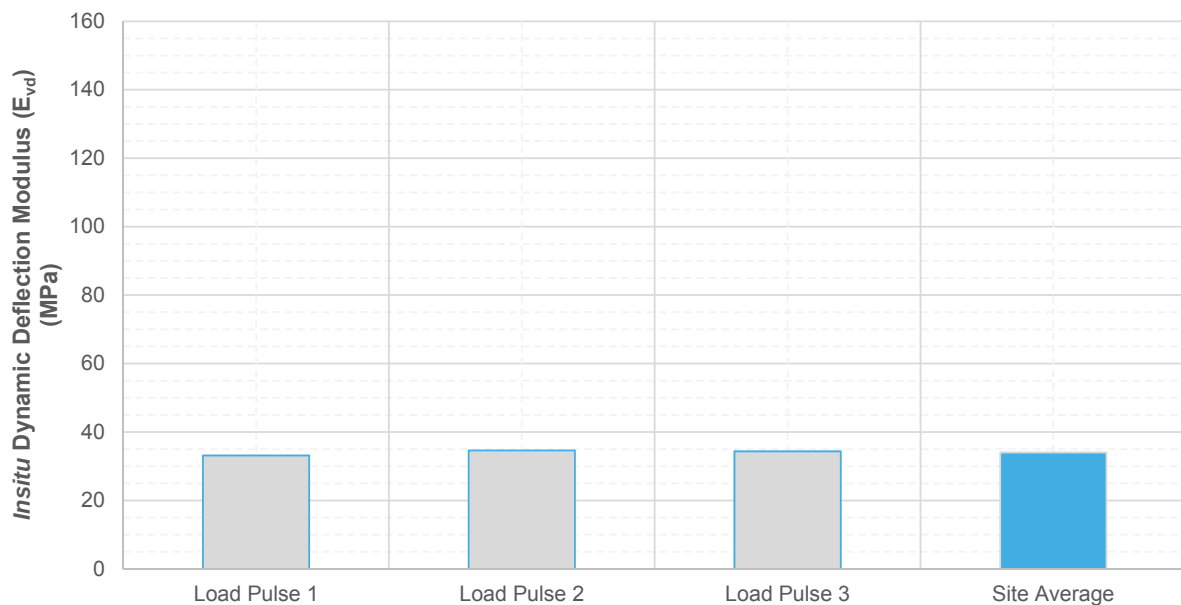
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	178.5	679	33.1
Weight Mass:	10 kg	2	(assumed - not measured)	172.8	650	34.6
Drop Height:	720 mm	3		170.6	655	34.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	174.0 (CoV = 2.3%)	661 (CoV = 2.3%)	34.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 26-5

Certificate Reference: 2091-LFWD-TERRA-Site 26-5

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-5 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

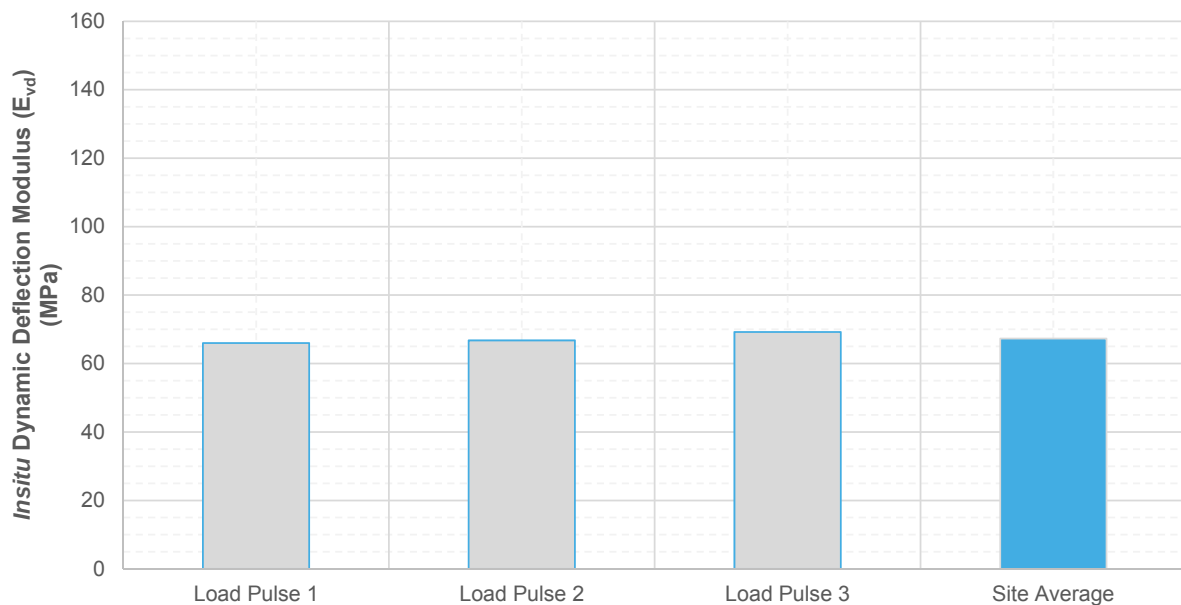
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	155.8	341	66.0
Weight Mass:	10 kg	2	(assumed - not measured)	153.0	337	66.8
Drop Height:	720 mm	3		150.9	325	69.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	153.2 (CoV = 1.6%)	334 (CoV = 2.5%)	67.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 26-6

Certificate Reference: 2091-LFWD-TERRA-Site 26-6

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-6 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

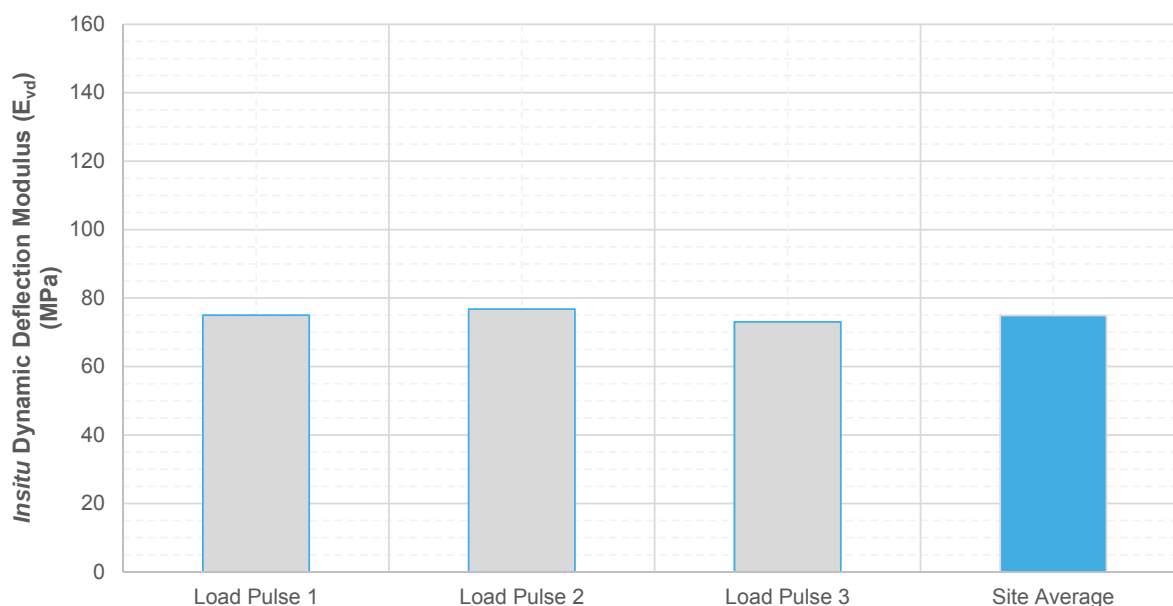
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses						
Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	125.0	300	75.0
Weight Mass:	10 kg	2		120.6	293	76.8
Drop Height:	720 mm	3		129.3	308	73.1
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	125.0 (CoV = 3.5%)	300 (CoV = 2.5%)	74.9



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 26-7

Certificate Reference: 2091-LFWD-TERRA-Site 26-7

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-7 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

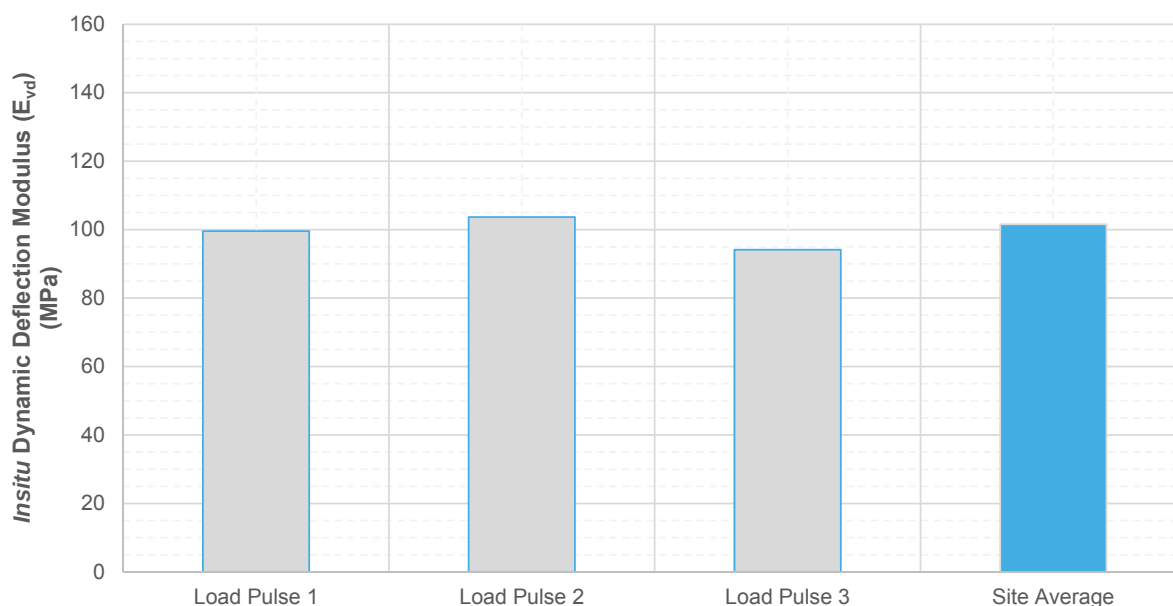
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	76.8	226	99.6
Weight Mass:	10 kg	2	(assumed - not measured)	77.6	217	103.7
Drop Height:	720 mm	3		76.4	239 (<i>Outlier</i>)	94.1
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	77.2 (CoV = 0.8%)	222 (CoV = 2.9%)	101.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 26-8

Certificate Reference: 2091-LFWD-TERRA-Site 26-8

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-8 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

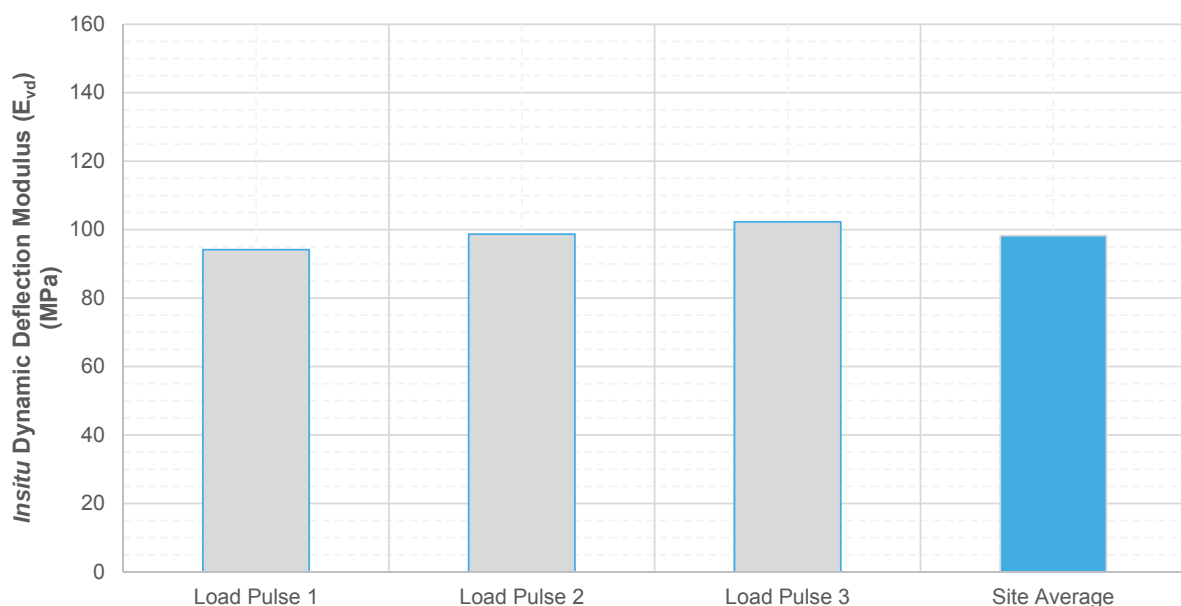
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	129.1	239	94.1
Weight Mass:	10 kg	2	(assumed - not measured)	128.1	228	98.7
Drop Height:	720 mm	3		121.9	220	102.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	126.4 (CoV = 3.1%)	229 (CoV = 4.2%)	98.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 26-9

Certificate Reference: 2091-LFWD-TERRA-Site 26-9

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-9 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

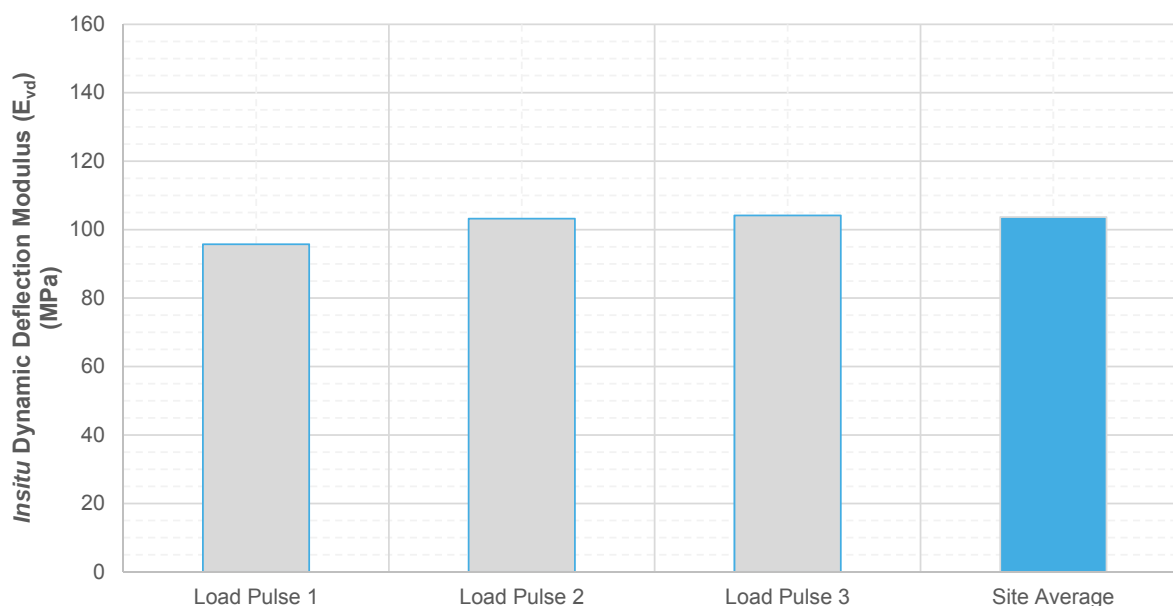
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) [†]	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	80.3	235 (<i>Outlier</i>)	95.7
Weight Mass:	10 kg	2	(assumed - not measured)	76.0	218	103.2
Drop Height:	720 mm	3		76.1	216	104.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			†Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	76.1 (CoV = 3.2%)	217 (CoV = 0.7%)	103.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 26-10

Certificate Reference: 2091-LFWD-TERRA-Site 26-10

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-10 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

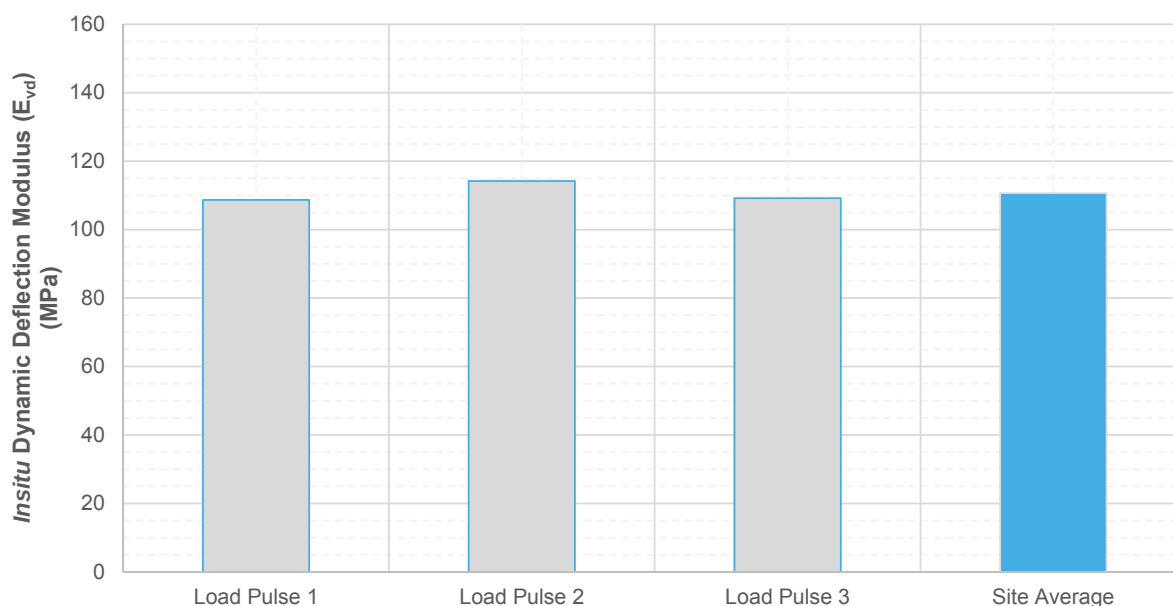
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	92.3	207	108.7
Weight Mass:	10 kg	2	(assumed - not measured)	88.3	197	114.2
Drop Height:	720 mm	3		85.9	206	109.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	88.8 (CoV = 3.6%)	203 (CoV = 2.7%)	110.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 26-11

Certificate Reference: 2091-LFWD-TERRA-Site 26-11

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-11 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

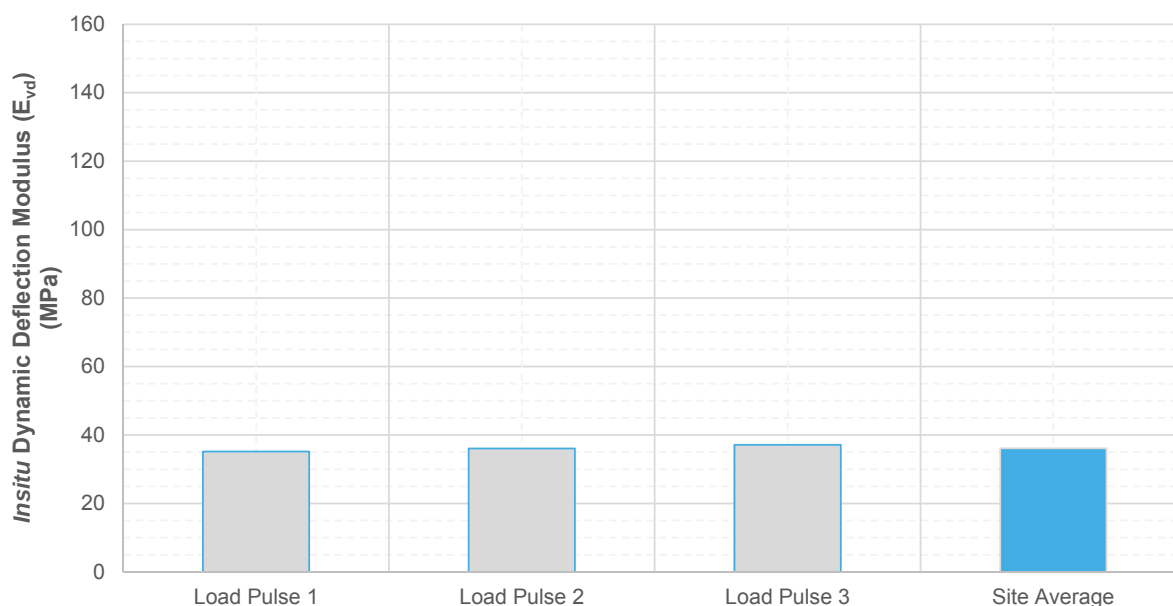
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	192.4	640	35.2
Weight Mass:	10 kg	2	(assumed - not measured)	185.3	624	36.1
Drop Height:	720 mm	3		176.0	606	37.1
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	184.6 (CoV = 4.5%)	623 (CoV = 2.7%)	36.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 26-12

Certificate Reference: 2091-LFWD-TERRA-Site 26-12

Sheet: 1 of 1

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 26-12 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

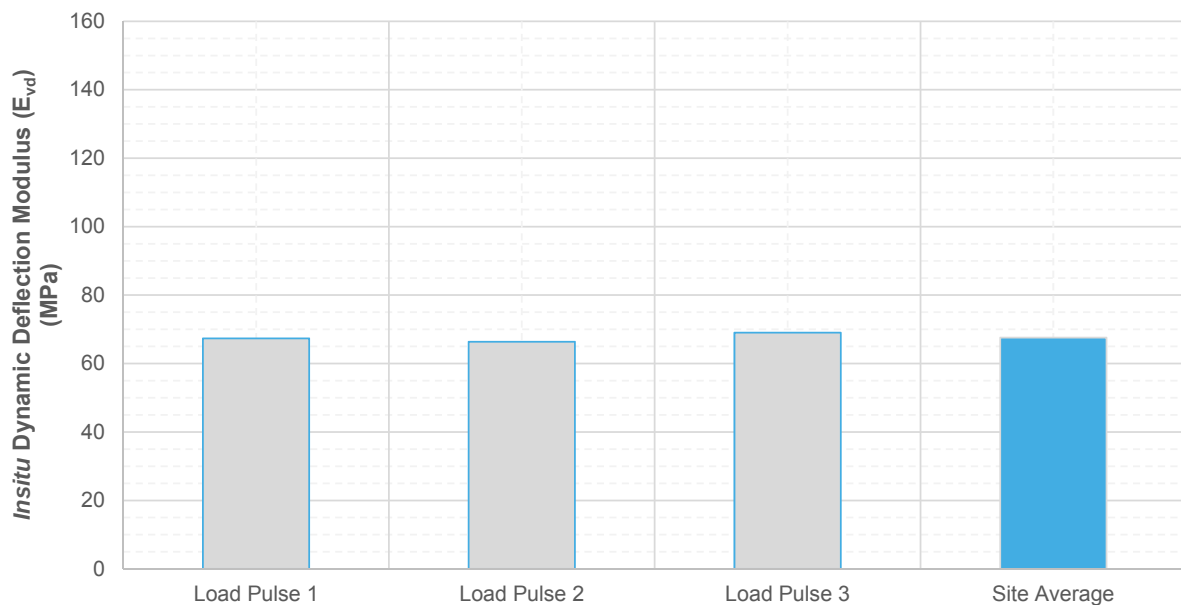
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	105.5	334	67.4
Weight Mass:	10 kg	2	(assumed - not measured)	103.3	339	66.4
Drop Height:	720 mm	3		103.0	326	69.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	103.9 (CoV = 1.3%)	333 (CoV = 2%)	67.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 30-1

Certificate Reference: 2091-LFWD-TERRA-Site 30-1

Sheet: 1 of 1

Client: ARRB

Test Date: 28/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 30-1 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

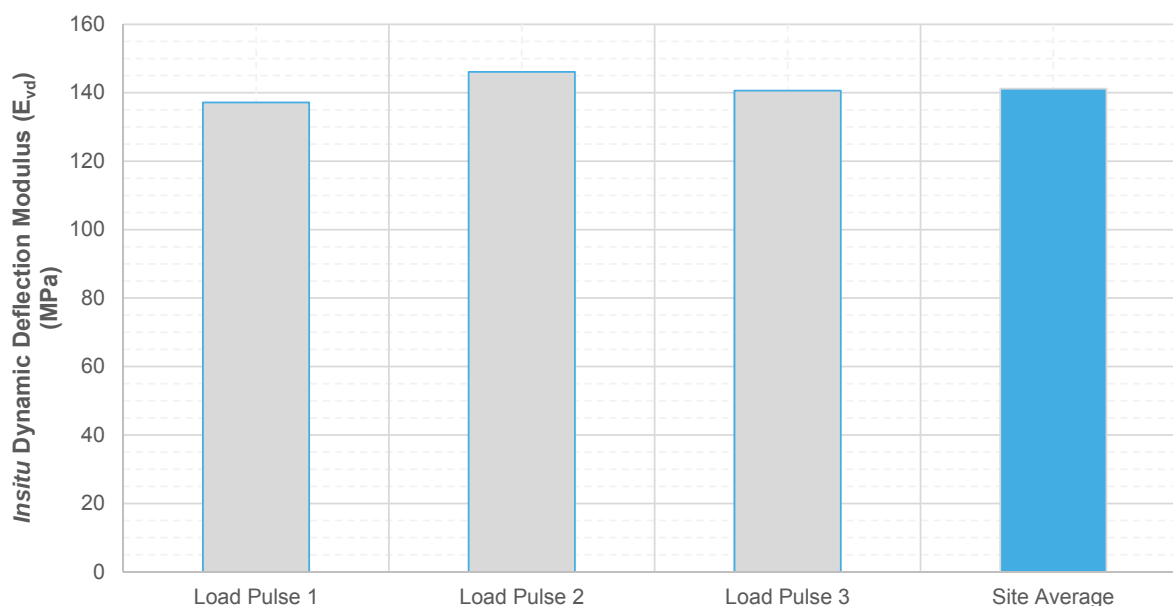
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	80.0	164	137.2
Weight Mass:	10 kg	2	(assumed - not measured)	76.8	154	146.1
Drop Height:	720 mm	3		75.8	160	140.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	77.5 (CoV = 2.8%)	159 (CoV = 3.2%)	141.2



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 30-2

Certificate Reference: 2091-LFWD-TERRA-Site 30-2

Sheet: 1 of 1

Client: ARRB

Test Date: 28/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 30-2 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

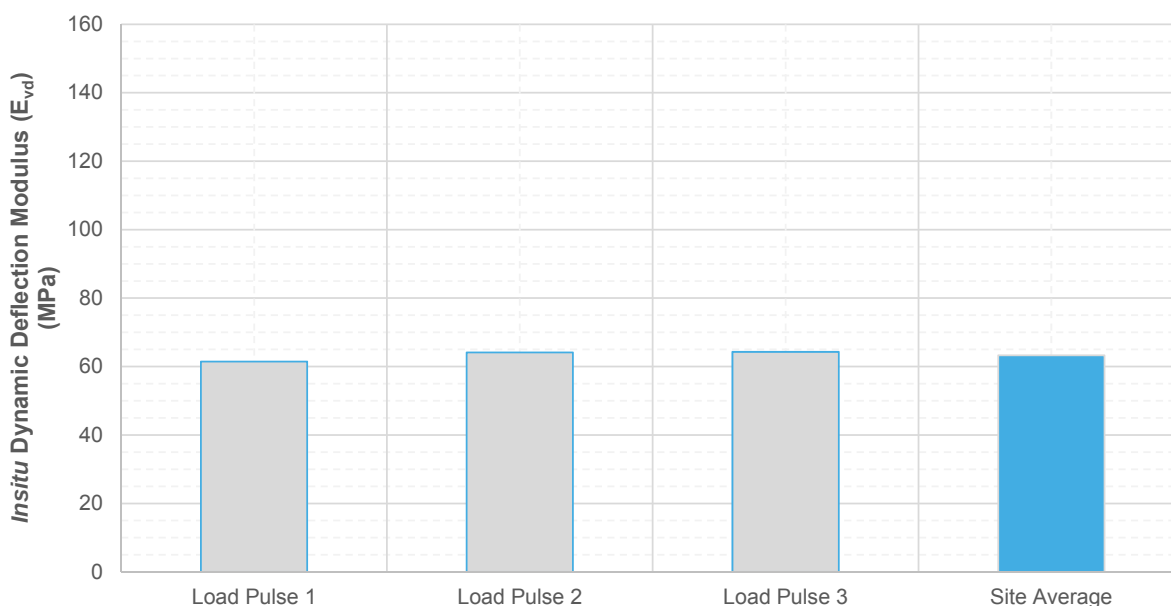
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	143.8	366	61.5
Weight Mass:	10 kg	2	(assumed - not measured)	140.2	351	64.1
Drop Height:	720 mm	3		137.3	350	64.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	140.4 (CoV = 2.3%)	356 (CoV = 2.5%)	63.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 30-3

Certificate Reference: 2091-LFWD-TERRA-Site 30-3

Sheet: 1 of 1

Client: ARRB

Test Date: 28/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 30-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

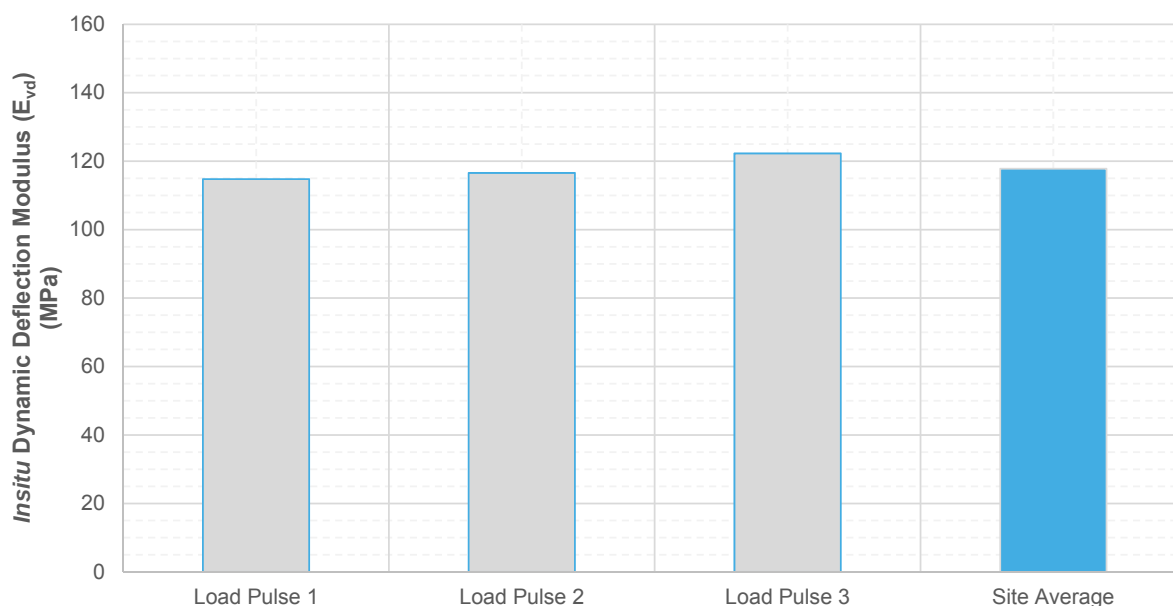
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	81.4	196	114.8
Weight Mass:	10 kg	2	(assumed - not measured)	80.0	193	116.6
Drop Height:	720 mm	3		77.8	184	122.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	79.7 (CoV = 2.3%)	191 (CoV = 3.3%)	117.8



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 30-4

Certificate Reference: 2091-LFWD-TERRA-Site 30-4

Sheet: 1 of 1

Client: ARRB

Test Date: 28/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 30-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

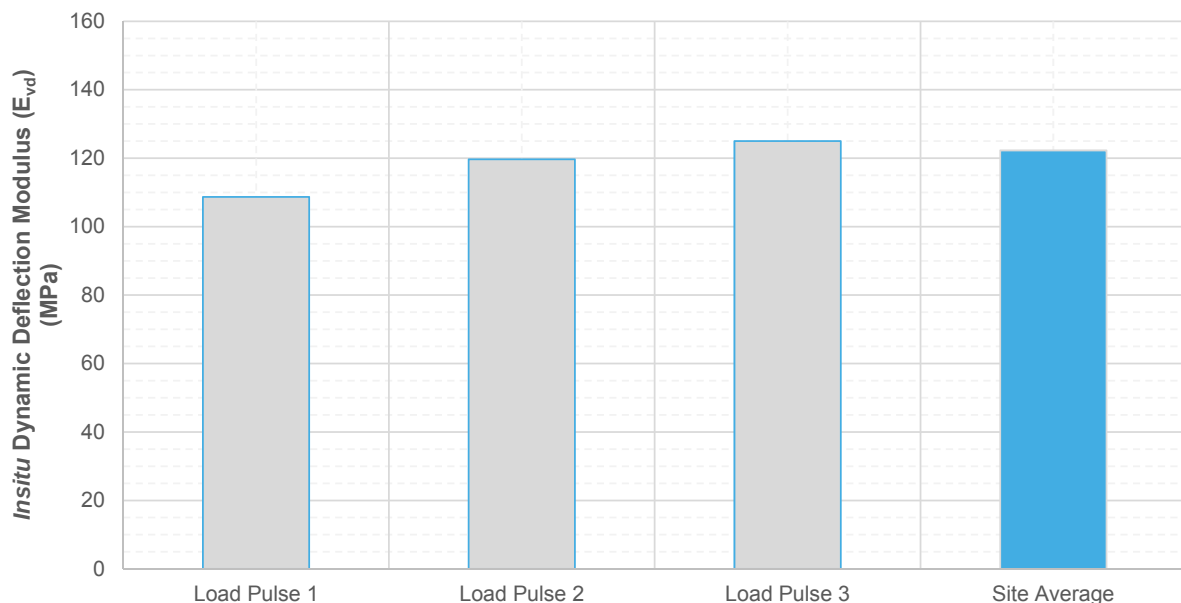
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	90.7 (Outlier)	207 (Outlier)	108.7
Weight Mass:	10 kg	2		85.1	188	119.7
Drop Height:	720 mm	3		82.3	180	125.0
Inferred Test Load:	7.07 kN	*After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	83.7 (CoV = 2.4%)	184 (CoV = 3.1%)	122.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 30-5

Certificate Reference: 2091-LFWD-TERRA-Site 30-5

Sheet: 1 of 1

Client: ARRB

Test Date: 28/03/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 30-5 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

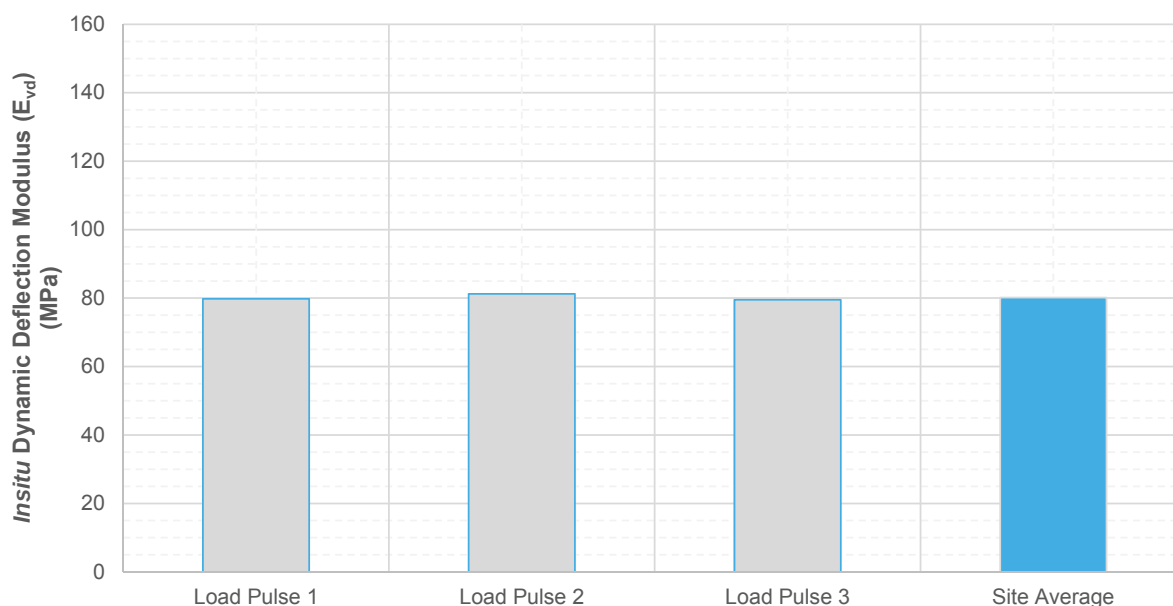
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	120.3	282	79.8
Weight Mass:	10 kg	2	(assumed - not measured)	119.2	277	81.2
Drop Height:	720 mm	3		120.0	283	79.5
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	119.8 (CoV = 0.5%)	281 (CoV = 1.1%)	80.2



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 31-1

Certificate Reference: 2091-LFWD-TERRA-Site 31-1

Sheet: 1 of 1

Client: ARRB

Test Date: 10/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 31-1 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

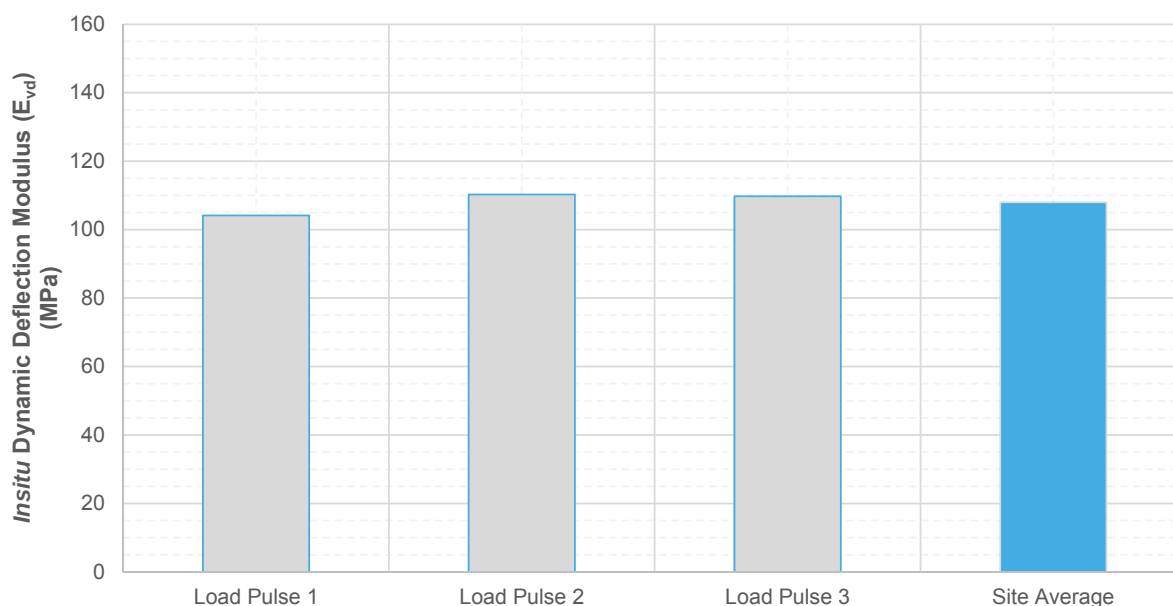
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	109.7	216	104.2
Weight Mass:	10 kg	2	(assumed - not measured)	105.2	204	110.3
Drop Height:	720 mm	3		110.1	205	109.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	108.3 (CoV = 2.5%)	208 (CoV = 3.2%)	108.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 31-2

Certificate Reference: 2091-LFWD-TERRA-Site 31-2

Sheet: 1 of 1

Client: ARRB

Test Date: 10/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 31-2 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

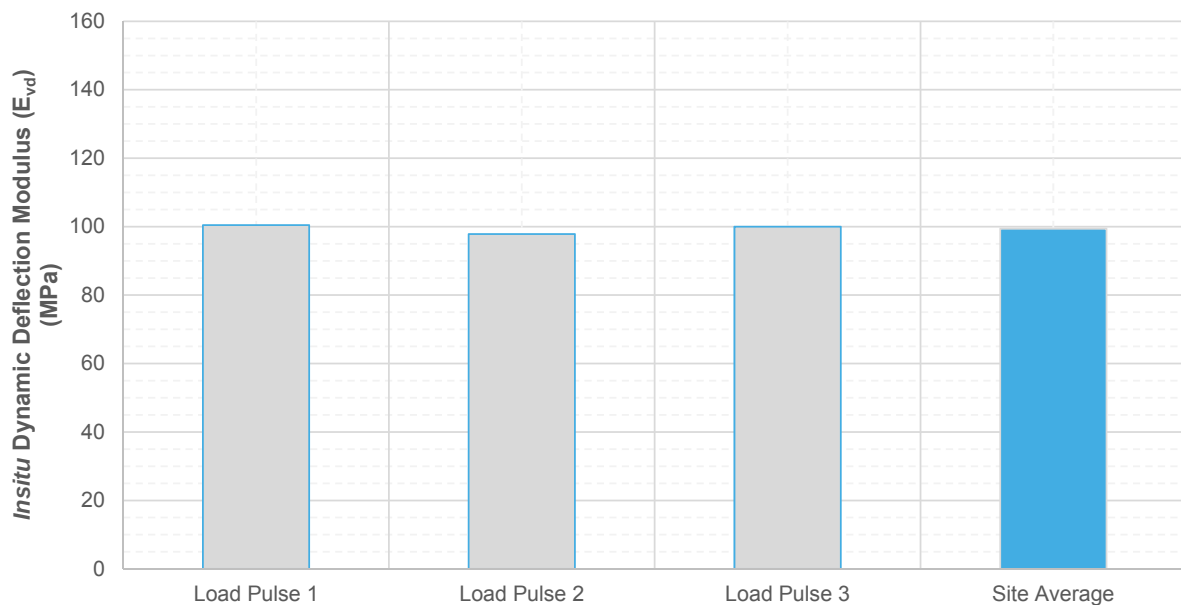
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	109.4	224	100.4
Weight Mass:	10 kg	2	(assumed - not measured)	106.6	230	97.8
Drop Height:	720 mm	3		104.1	225	100.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	106.7 (CoV = 2.5%)	226 (CoV = 1.4%)	99.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 31-3

Certificate Reference: 2091-LFWD-TERRA-Site 31-3

Sheet: 1 of 1

Client: ARRB

Test Date: 10/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 31-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

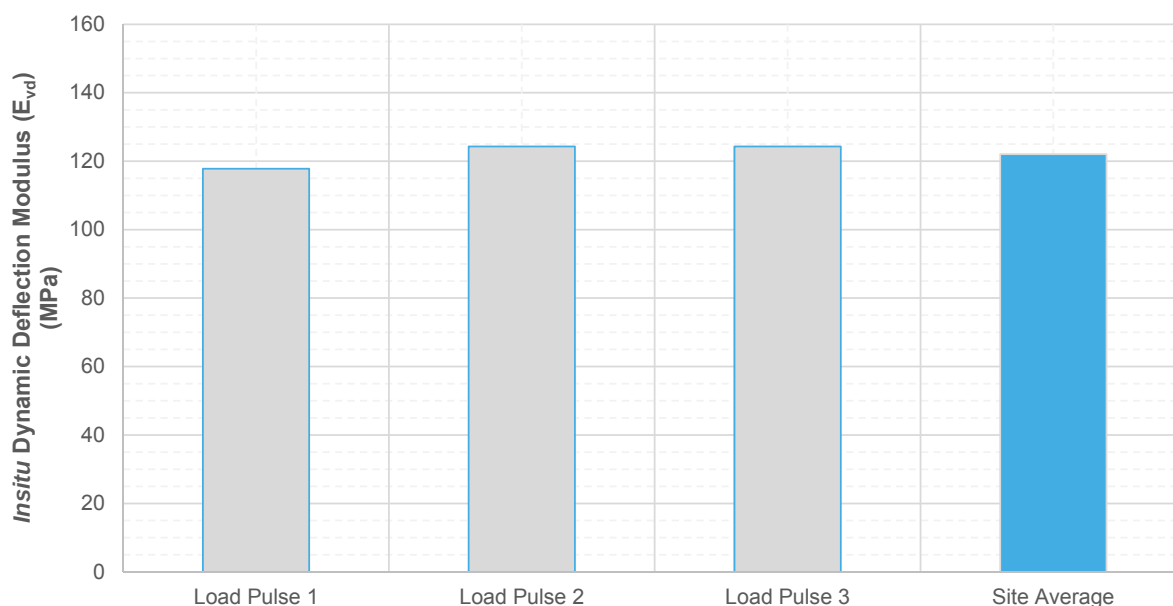
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	95.9	191	117.8
Weight Mass:	10 kg	2	(assumed - not measured)	94.1	181	124.3
Drop Height:	720 mm	3		93.6	181	124.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	94.5 (CoV = 1.3%)	184 (CoV = 3.1%)	122.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 31-4

Certificate Reference: 2091-LFWD-TERRA-Site 31-4

Sheet: 1 of 1

Client: ARRB

Test Date: 10/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 31-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

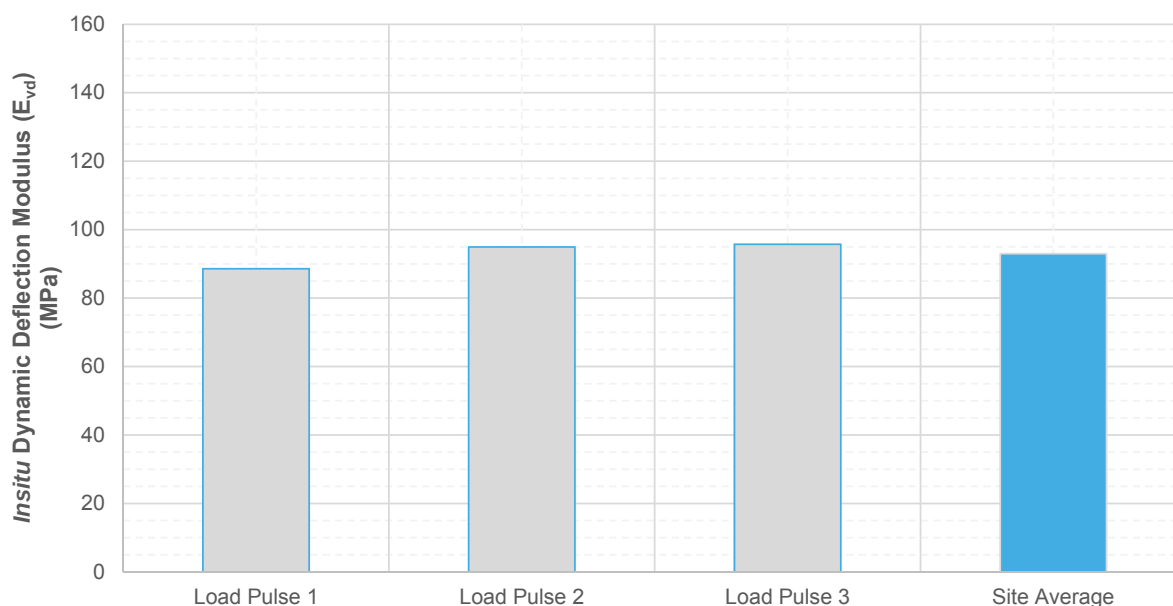
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	123.2	254	88.6
Weight Mass:	10 kg	2	(assumed - not measured)	118.3	237	94.9
Drop Height:	720 mm	3		118.2	235	95.7
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	119.9 (CoV = 2.4%)	242 (CoV = 4.3%)	93.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 32-1

Certificate Reference: 2091-LFWD-TERRA-Site 32-1

Sheet: 1 of 1

Client: ARRB

Test Date: 12/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 32-1 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

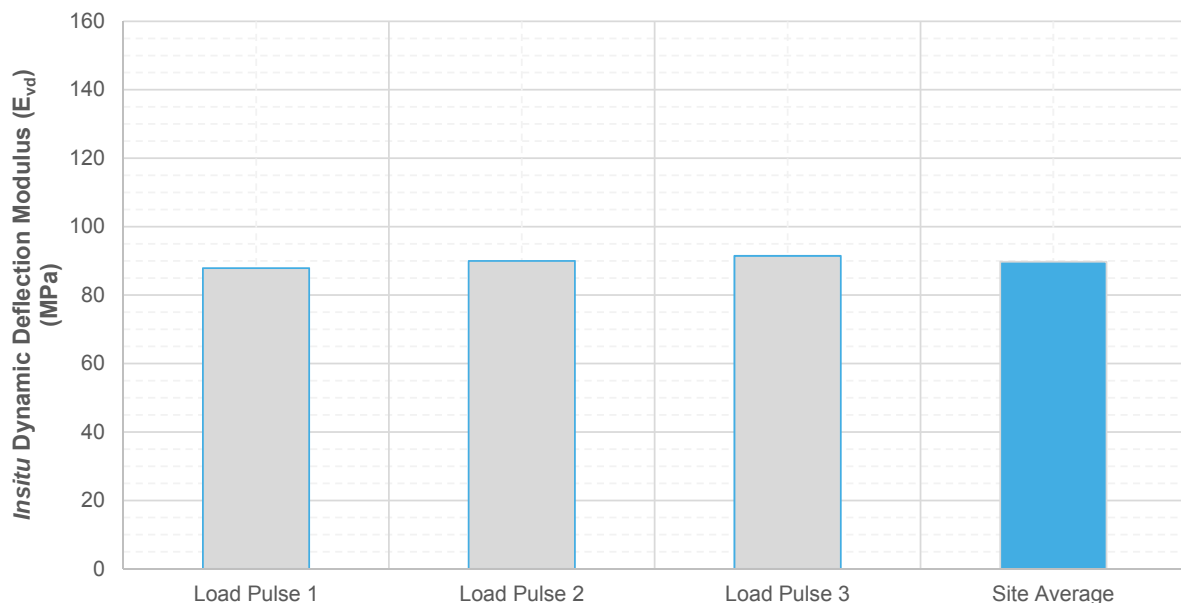
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	Insitu Dynamic Deflection Modulus (E _{vd})
Plate Diameter:	300 mm	1	100 kPa (assumed - not measured)	129.0	256	87.9
Weight Mass:	10 kg	2		126.8	250	90.0
Drop Height:	720 mm	3		126.4	246	91.5
Inferred Test Load:	7.07 kN	*After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	127.4 (CoV = 1.1%)	251 (CoV = 2%)	89.8



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 32-2

Certificate Reference: 2091-LFWD-TERRA-Site 32-2

Sheet: 1 of 1

Client: ARRB

Test Date: 12/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 32-2 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

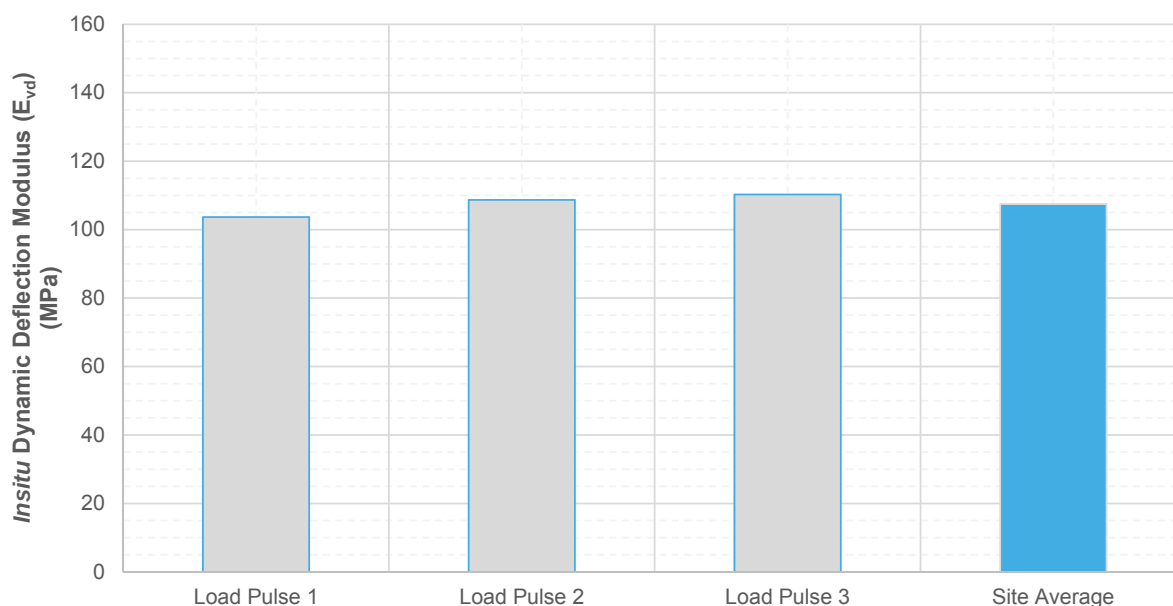
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	92.7	217	103.7
Weight Mass:	10 kg	2	(assumed - not measured)	95.1	207	108.7
Drop Height:	720 mm	3		92.4	204	110.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	93.4 (CoV = 1.6%)	209 (CoV = 3.3%)	107.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 32-3

Certificate Reference: 2091-LFWD-TERRA-Site 32-3

Sheet: 1 of 1

Client: ARRB

Test Date: 12/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 32-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

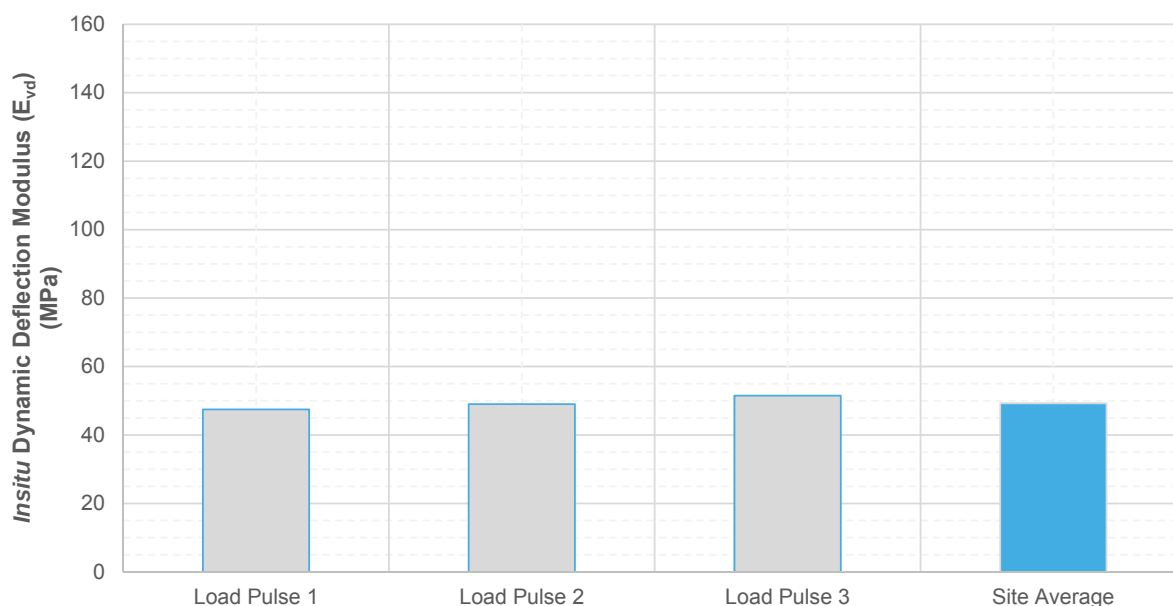
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	217.6	474	47.5
Weight Mass:	10 kg	2	(assumed - not measured)	213.3	459	49.0
Drop Height:	720 mm	3		204.3	437	51.5
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	211.7 (CoV = 3.2%)	457 (CoV = 4.1%)	49.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 32-4

Certificate Reference: 2091-LFWD-TERRA-Site 32-4

Sheet: 1 of 1

Client: ARRB

Test Date: 12/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 32-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: RM / JH

Test method: ASTM - E2835-11 (2011)

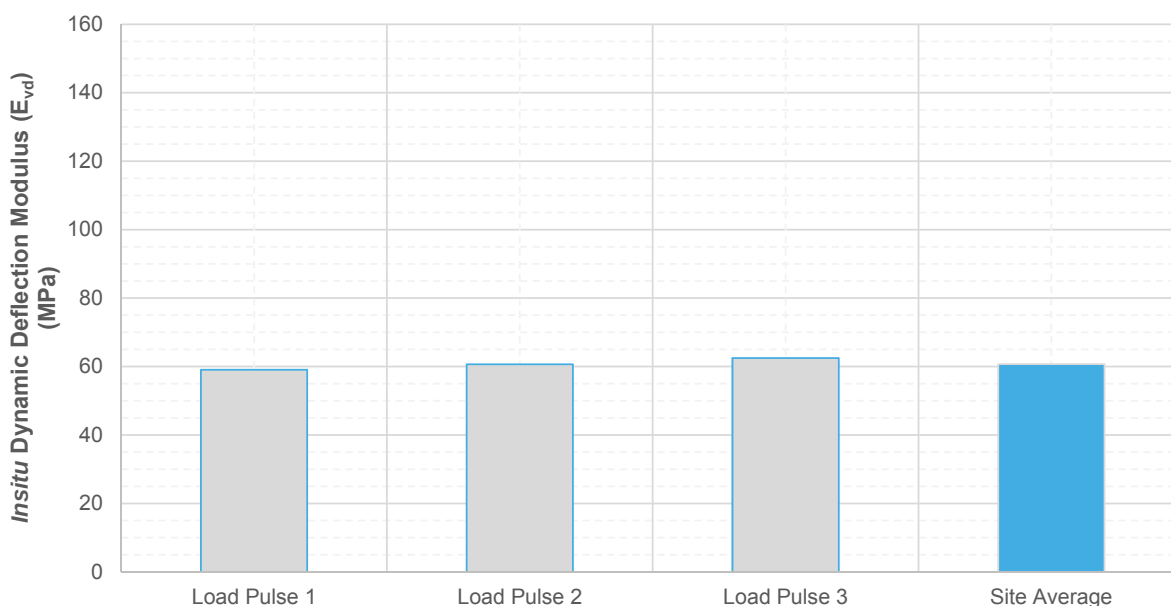
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	151.9	381	59.1
Weight Mass:	10 kg	2	(assumed - not measured)	151.1	371	60.6
Drop Height:	720 mm	3		143.5	360	62.5
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	148.8 (CoV = 3.1%)	371 (CoV = 2.8%)	60.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 33-1

Certificate Reference: 2091-LFWD-TERRA-Site 33-1

Sheet: 1 of 1

Client: ARRB

Test Date: 16/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 33-1 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

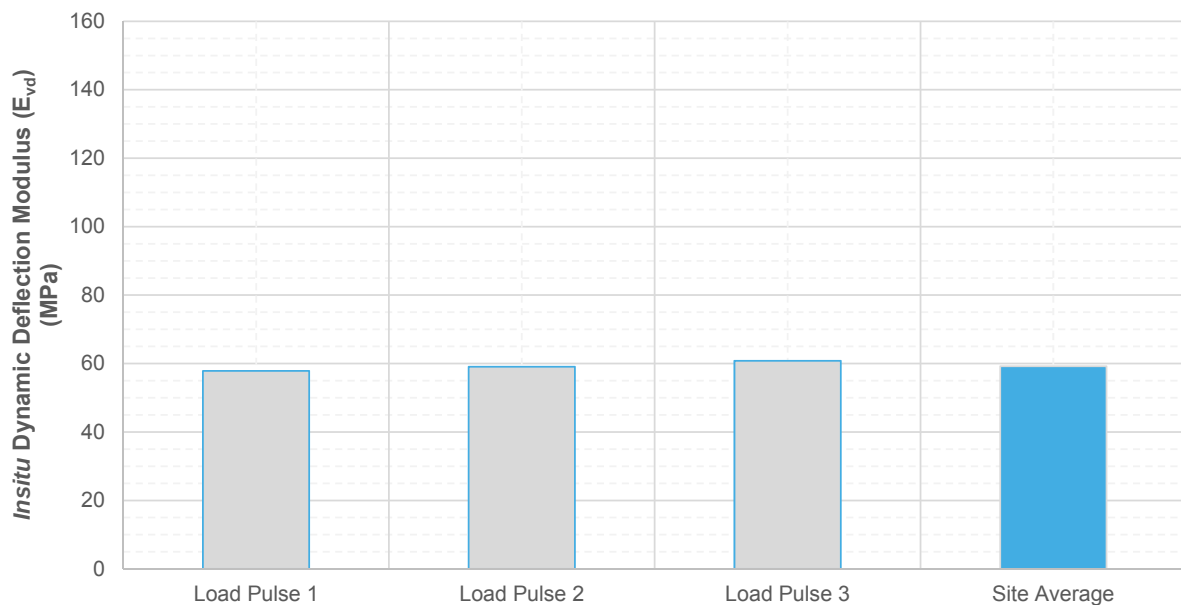
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	172.1	389	57.8
Weight Mass:	10 kg	2	(assumed - not measured)	167.9	381	59.1
Drop Height:	720 mm	3		163.0	370	60.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	167.7 (CoV = 2.7%)	380 (CoV = 2.5%)	59.2



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 33-2

Certificate Reference: 2091-LFWD-TERRA-Site 33-2

Sheet: 1 of 1

Client: ARRB

Test Date: 16/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 33-2 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

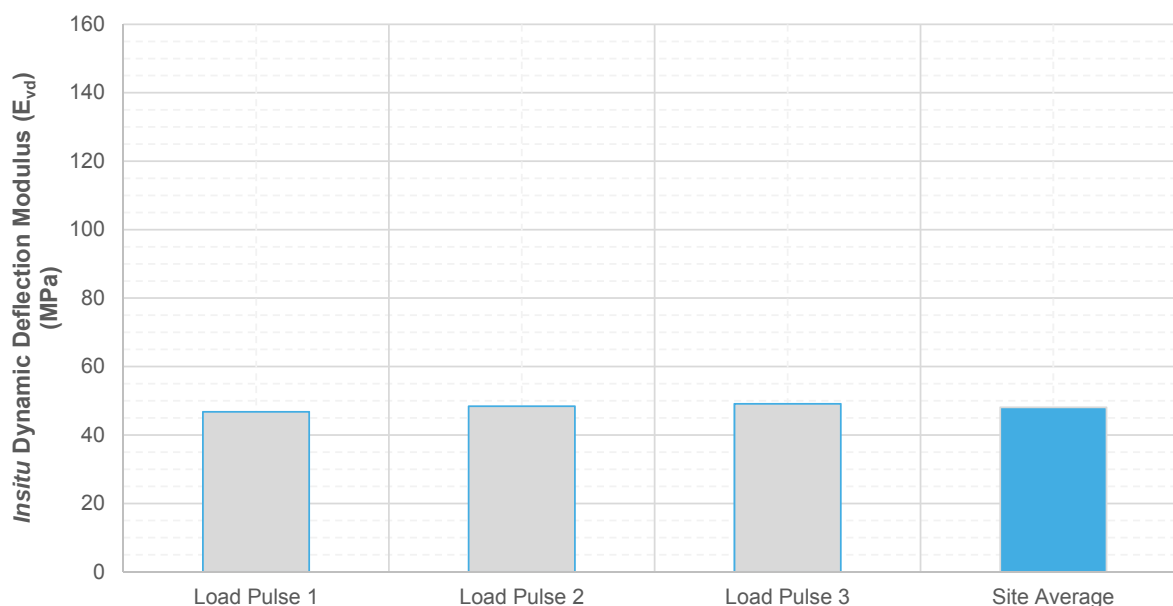
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	176.0	481	46.8
Weight Mass:	10 kg	2	(assumed - not measured)	168.7	465	48.4
Drop Height:	720 mm	3		166.7	458	49.1
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	170.5 (CoV = 2.9%)	468 (CoV = 2.5%)	48.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 33-3

Certificate Reference: 2091-LFWD-TERRA-Site 33-3

Sheet: 1 of 1

Client: ARRB

Test Date: 16/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 33-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

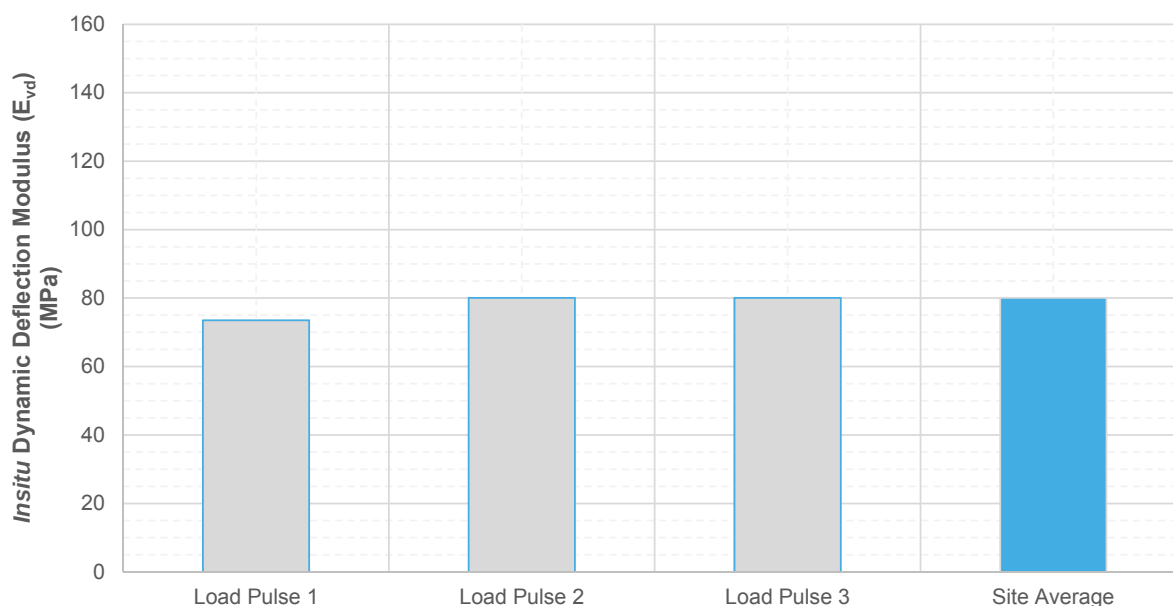
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) [†]	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	135.7	306 (<i>Outlier</i>)	73.5
Weight Mass:	10 kg	2	(assumed - not measured)	130.1	281	80.1
Drop Height:	720 mm	3		129.0	281	80.1
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			†Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	129.6 (CoV = 2.8%)	281 (CoV = 0%)	80.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 33-4

Certificate Reference: 2091-LFWD-TERRA-Site 33-4

Sheet: 1 of 1

Client: ARRB

Test Date: 16/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 33-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

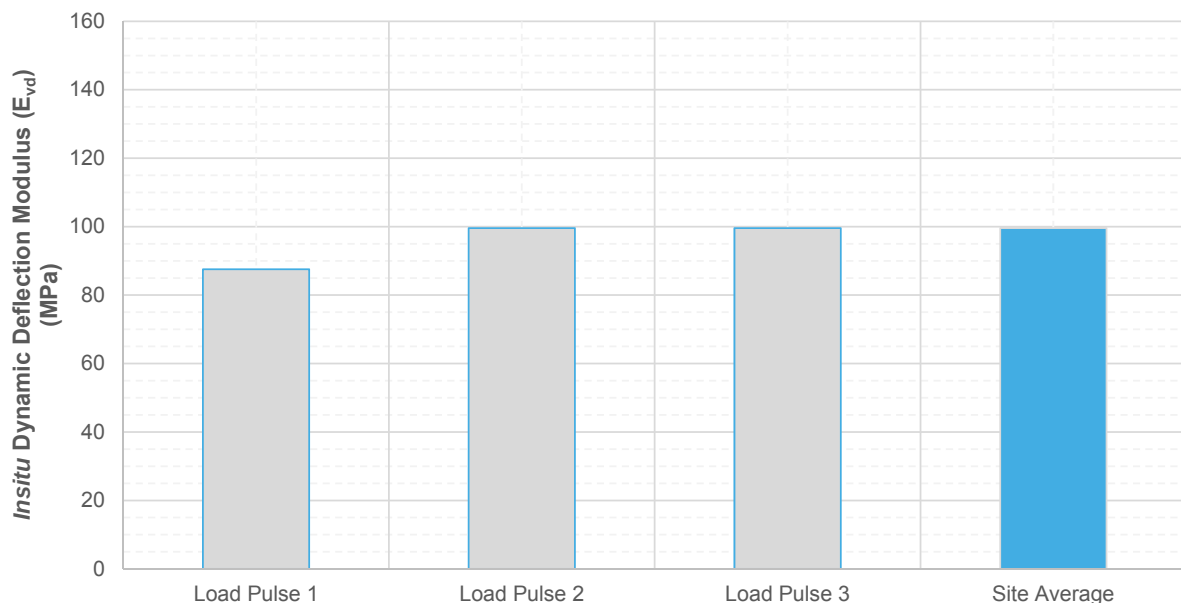
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	128.1 (<i>Outlier</i>)	257 (<i>Outlier</i>)	87.5
Weight Mass:	10 kg	2	(assumed - not measured)	130.1	226	99.6
Drop Height:	720 mm	3		129.0	226	99.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	129.6 (CoV = 0.6%)	226 (CoV = 0%)	99.6



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75 \text{ MPa}$) due to measurement of limited plate deflections ($\delta < 300 \mu\text{m}$) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 34-1

Certificate Reference: 2091-LFWD-TERRA-Site 34-1

Sheet: 1 of 1

Client: ARRB

Test Date: 17/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 34-1 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

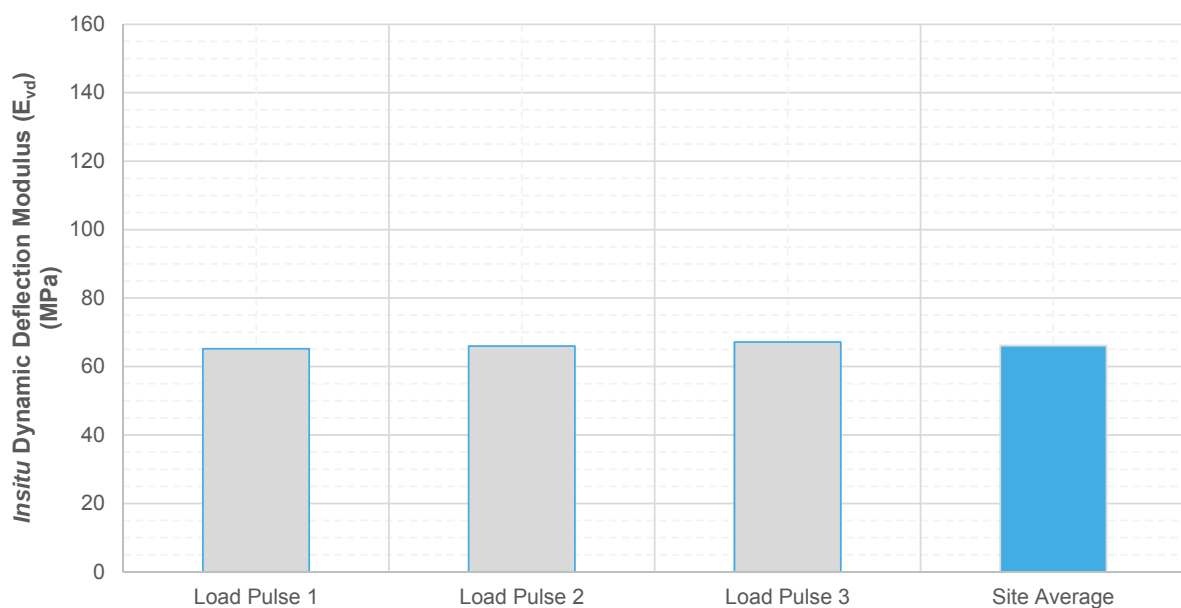
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	169.9	345	65.2
Weight Mass:	10 kg	2	(assumed - not measured)	168.8	341	66.0
Drop Height:	720 mm	3		166.0	335	67.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	168.2 (CoV = 1.2%)	340 (CoV = 1.5%)	66.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 34-2

Certificate Reference: 2091-LFWD-TERRA-Site 34-2

Sheet: 1 of 1

Client: ARRB

Test Date: 17/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 34-2 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

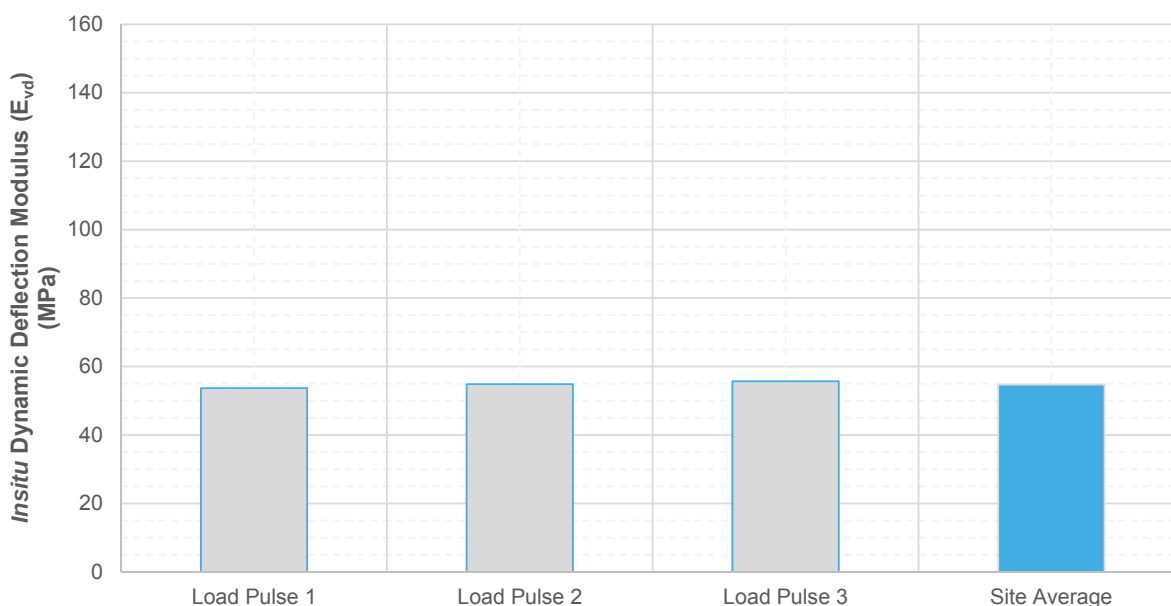
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	177.7	419	53.7
Weight Mass:	10 kg	2	(assumed - not measured)	174.1	410	54.9
Drop Height:	720 mm	3		173.1	404	55.7
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	175.0 (CoV = 1.4%)	411 (CoV = 1.8%)	54.7



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 34-3

Certificate Reference: 2091-LFWD-TERRA-Site 34-3

Sheet: 1 of 1

Client: ARRB

Test Date: 17/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 34-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

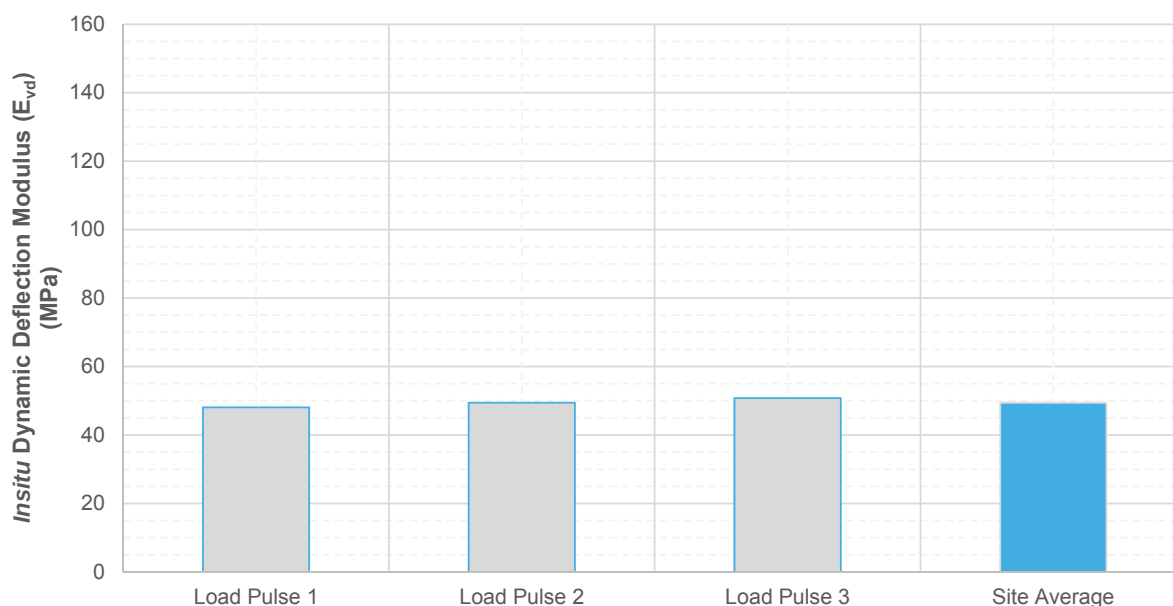
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	221.6	468	48.1
Weight Mass:	10 kg	2	(assumed - not measured)	217.0	455	49.5
Drop Height:	720 mm	3		213.6	443	50.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	217.4 (CoV = 1.8%)	455 (CoV = 2.7%)	49.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 34-4

Certificate Reference: 2091-LFWD-TERRA-Site 34-4

Sheet: 1 of 1

Client: ARRB

Test Date: 17/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 34-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

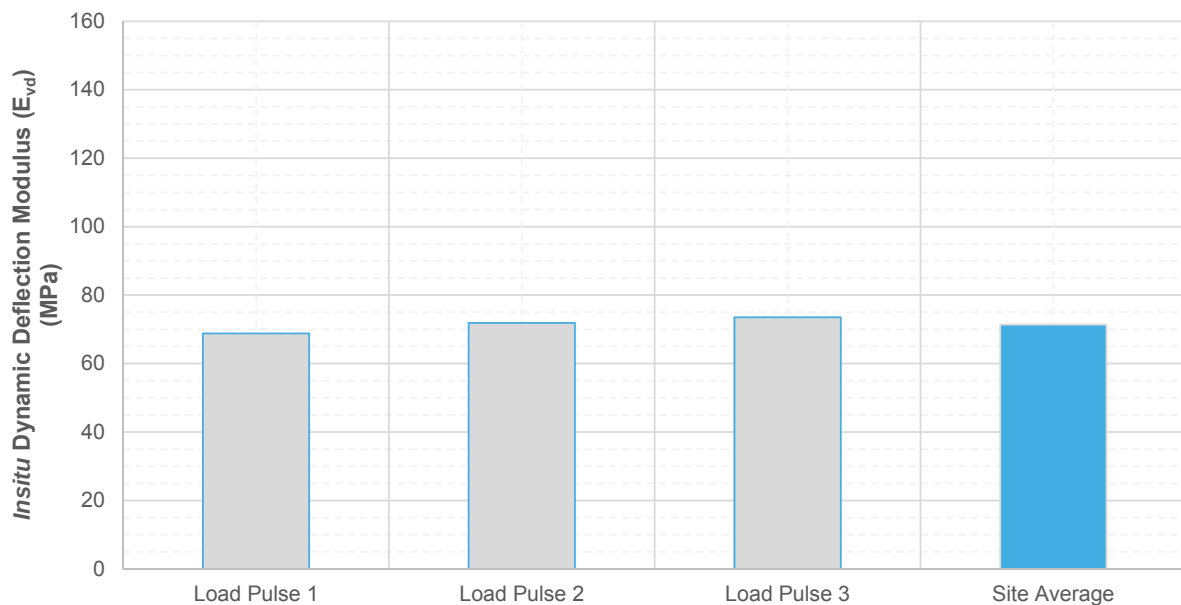
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	163.8	327	68.8
Weight Mass:	10 kg	2	(assumed - not measured)	157.8	313	71.9
Drop Height:	720 mm	3		155.7	306	73.5
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	159.1 (CoV = 2.6%)	315 (CoV = 3.4%)	71.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75 \text{ MPa}$) due to measurement of limited plate deflections ($\delta < 300 \mu\text{m}$) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 35-1

Certificate Reference: 2091-LFWD-TERRA-Site 35-1

Sheet: 1 of 1

Client: ARRB

Test Date: 18/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 35-1 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

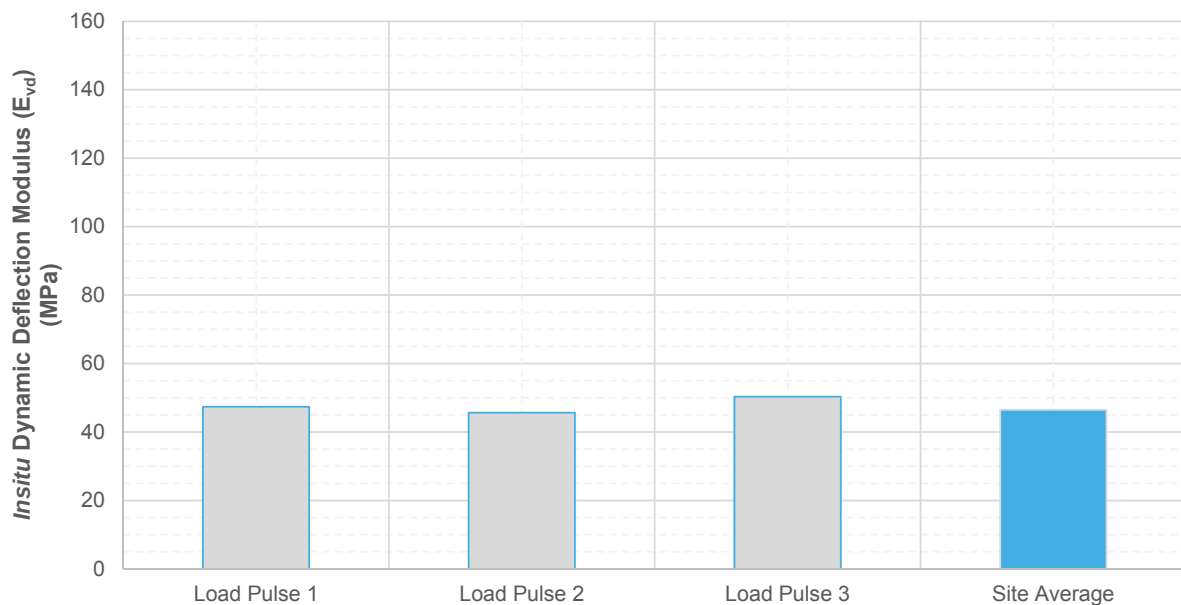
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	<i>In situ</i> Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	188.6	475	47.4
Weight Mass:	10 kg	2	(assumed - not measured)	192.7	493	45.6
Drop Height:	720 mm	3		181.1	447 (<i>Outlier</i>)	50.3
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised *In situ* Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average <i>In situ</i> Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	187.5 (CoV = 3.1%)	484 (CoV = 2.6%)	46.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 35-2

Certificate Reference: 2091-LFWD-TERRA-Site 35-2

Sheet: 1 of 1

Client: ARRB

Test Date: 18/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 35-2 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

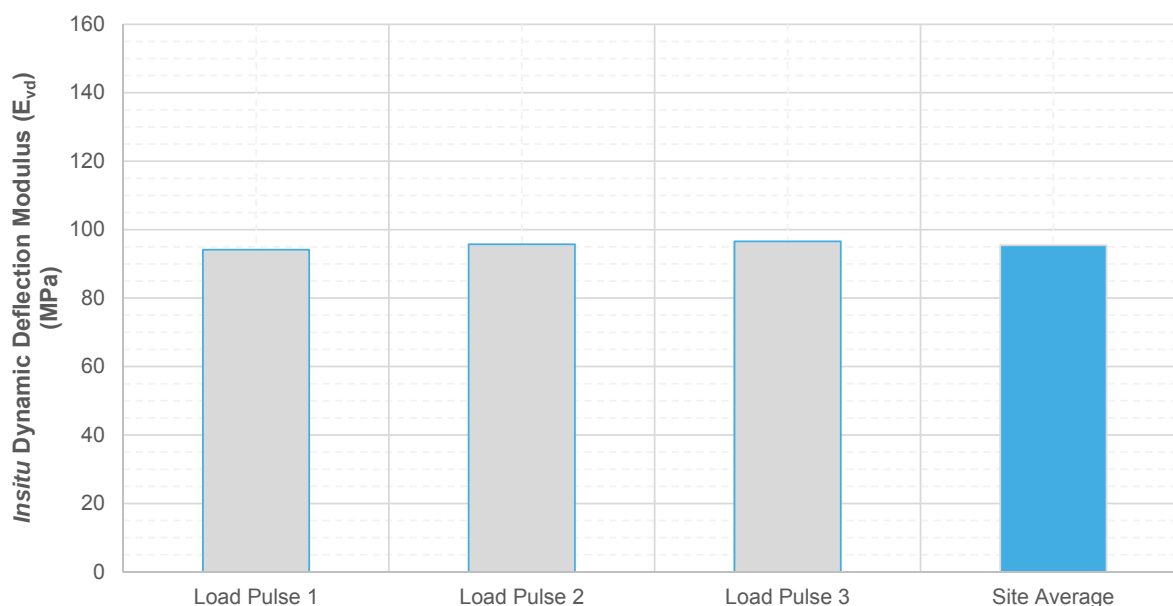
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) [†]	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	112.6	239	94.1
Weight Mass:	10 kg	2	(assumed - not measured)	110.7	235	95.7
Drop Height:	720 mm	3		107.4	233	96.6
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			†Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	110.2 (CoV = 2.4%)	236 (CoV = 1.3%)	95.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 35-3

Certificate Reference: 2091-LFWD-TERRA-Site 35-3

Sheet: 1 of 1

Client: ARRB

Test Date: 18/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 35-3 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

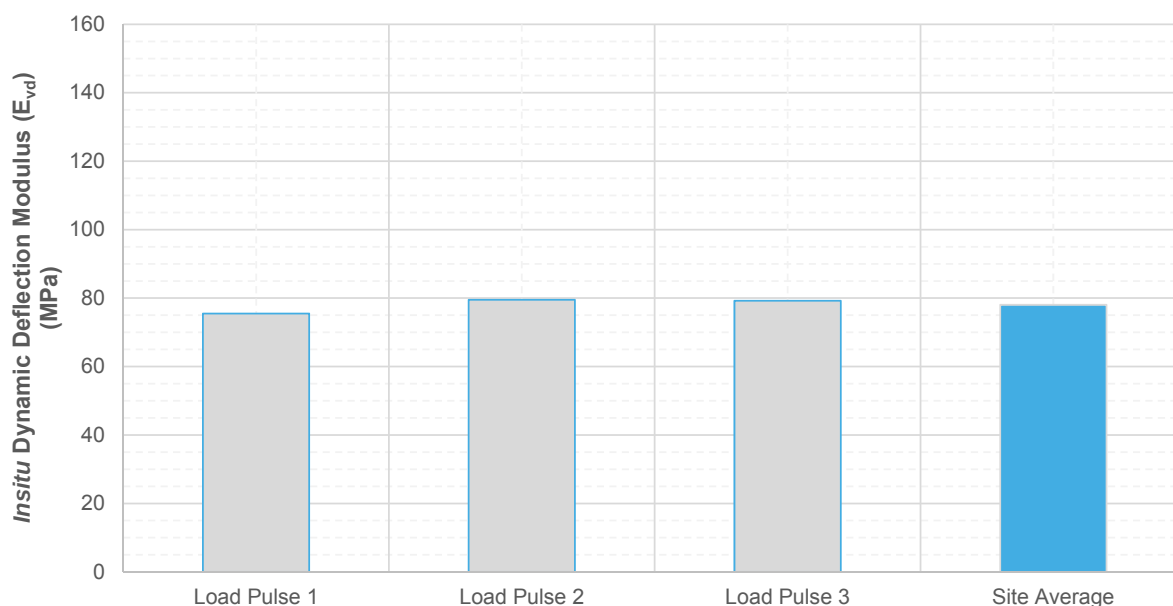
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	140.2	298	75.5
Weight Mass:	10 kg	2	(assumed - not measured)	135.8	283	79.5
Drop Height:	720 mm	3		136.2	284	79.2
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	137.4 (CoV = 1.8%)	288 (CoV = 2.9%)	78.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 35-4

Certificate Reference: 2091-LFWD-TERRA-Site 35-4

Sheet: 1 of 1

Client: ARRB

Test Date: 18/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 35-4 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

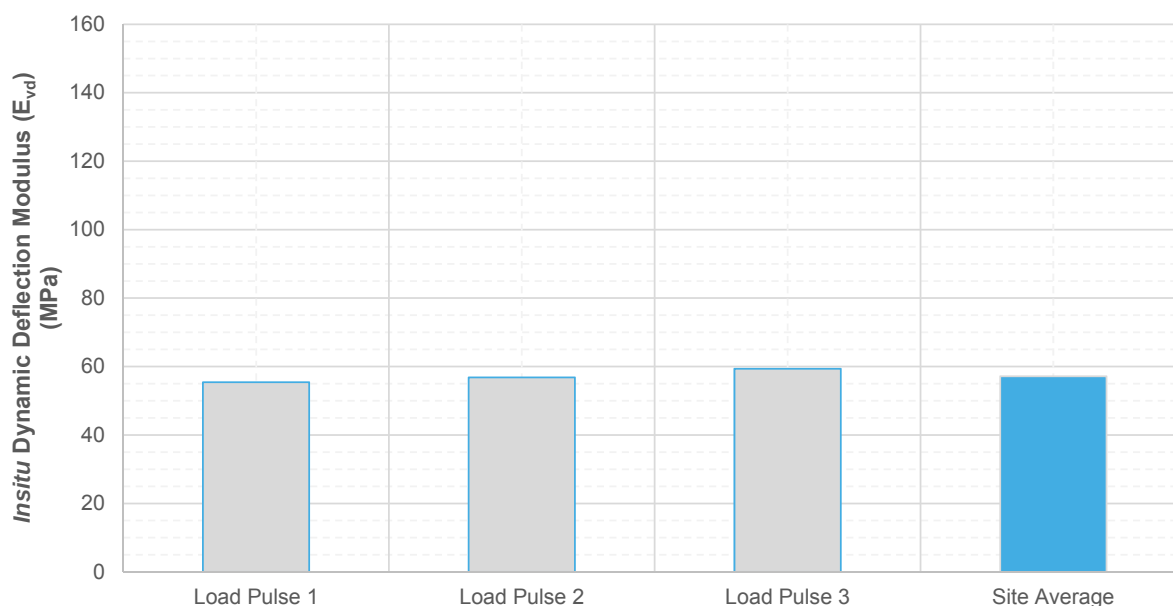
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	160.7	406	55.4
Weight Mass:	10 kg	2	(assumed - not measured)	159.3	396	56.8
Drop Height:	720 mm	3		152.9	379	59.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	157.6 (CoV = 2.6%)	394 (CoV = 3.5%)	57.2



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 36-1

Certificate Reference: 2091-LFWD-TERRA-Site 36-1

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 36-1 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

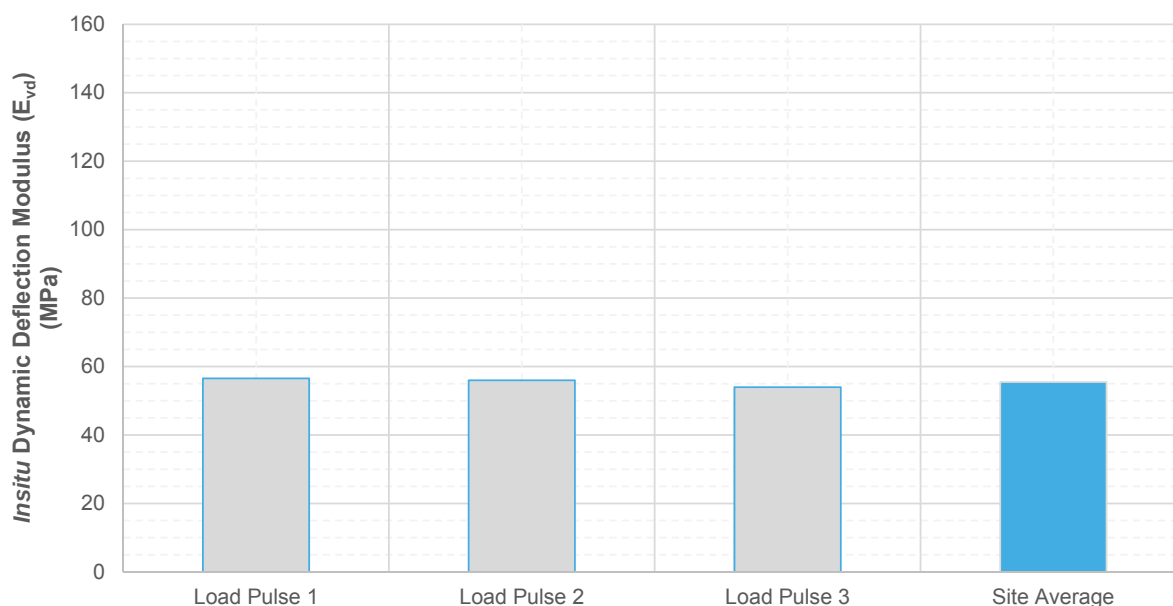
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	206.7	398	56.5
Weight Mass:	10 kg	2	(assumed - not measured)	213.0	402	56.0
Drop Height:	720 mm	3		219.6	417	54.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	213.1 (CoV = 3%)	406 (CoV = 2.5%)	55.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 36-2

Certificate Reference: 2091-LFWD-TERRA-Site 36-2

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 36-2 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

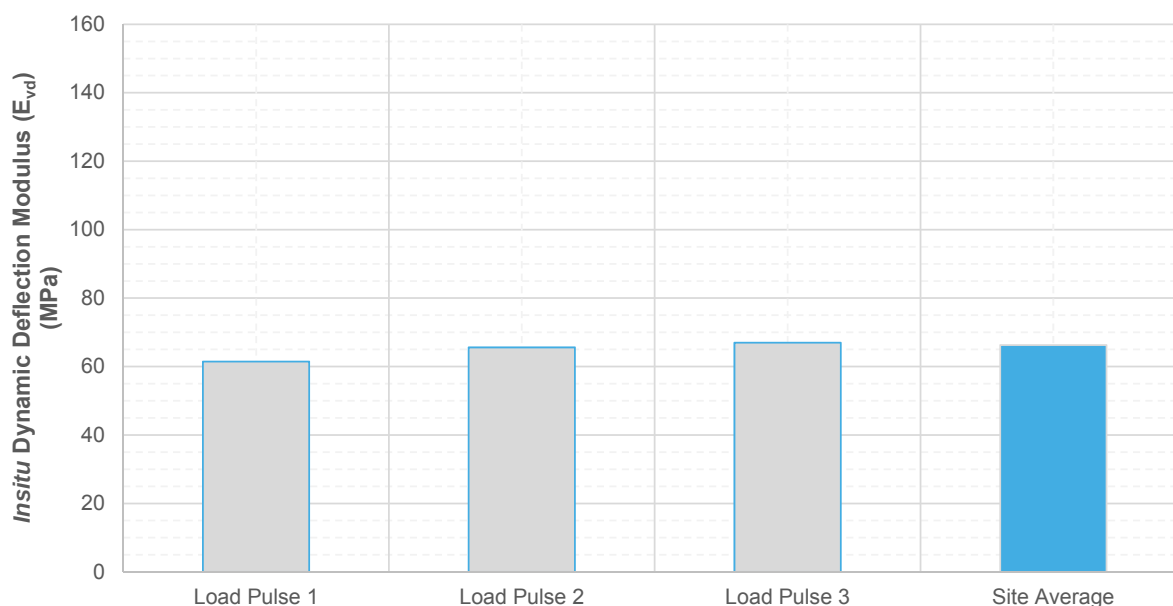
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	173.8	366 (Outlier)	61.5
Weight Mass:	10 kg	2	(assumed - not measured)	165.5	343	65.6
Drop Height:	720 mm	3		163.5	336	67.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	164.5 (CoV = 3.3%)	340 (CoV = 1.5%)	66.3



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 36-3

Certificate Reference: 2091-LFWD-TERRA-Site 36-3

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 36-3 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

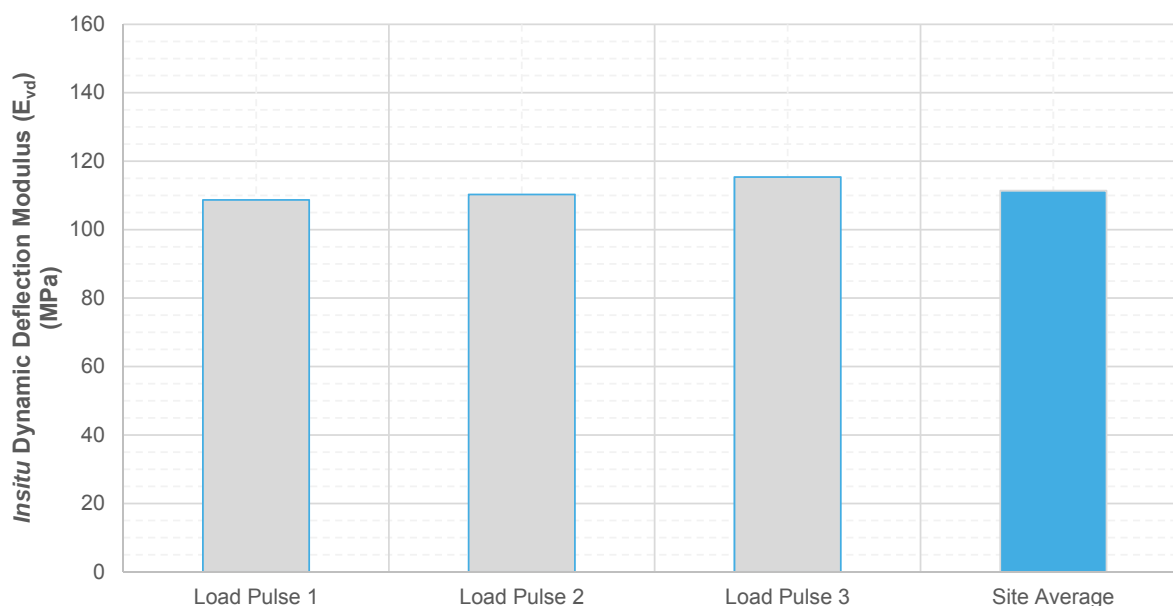
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	105.8	207	108.7
Weight Mass:	10 kg	2	(assumed - not measured)	104.1	204	110.3
Drop Height:	720 mm	3		102.9	195	115.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	104.3 (CoV = 1.4%)	202 (CoV = 3.1%)	111.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 36-4

Certificate Reference: 2091-LFWD-TERRA-Site 36-4

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 36-4 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

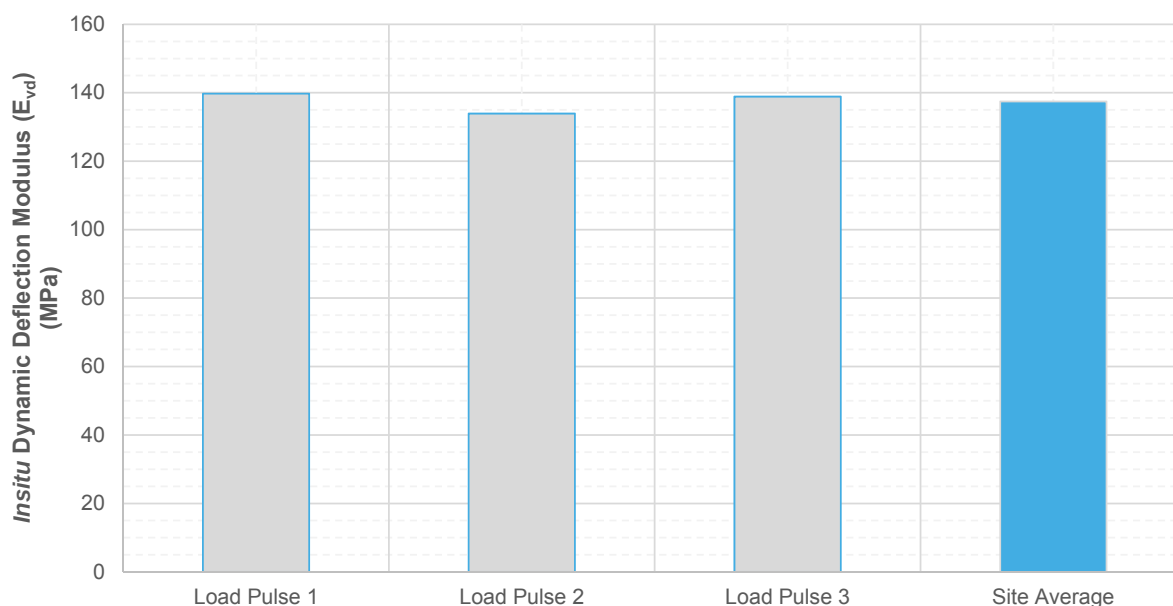
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	77.3	161	139.8
Weight Mass:	10 kg	2	(assumed - not measured)	78.4	168	133.9
Drop Height:	720 mm	3		76.0	162	138.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	77.2 (CoV = 1.6%)	164 (CoV = 2.3%)	137.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 37-1

Certificate Reference: 2091-LFWD-TERRA-Site 37-1

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 37-1 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

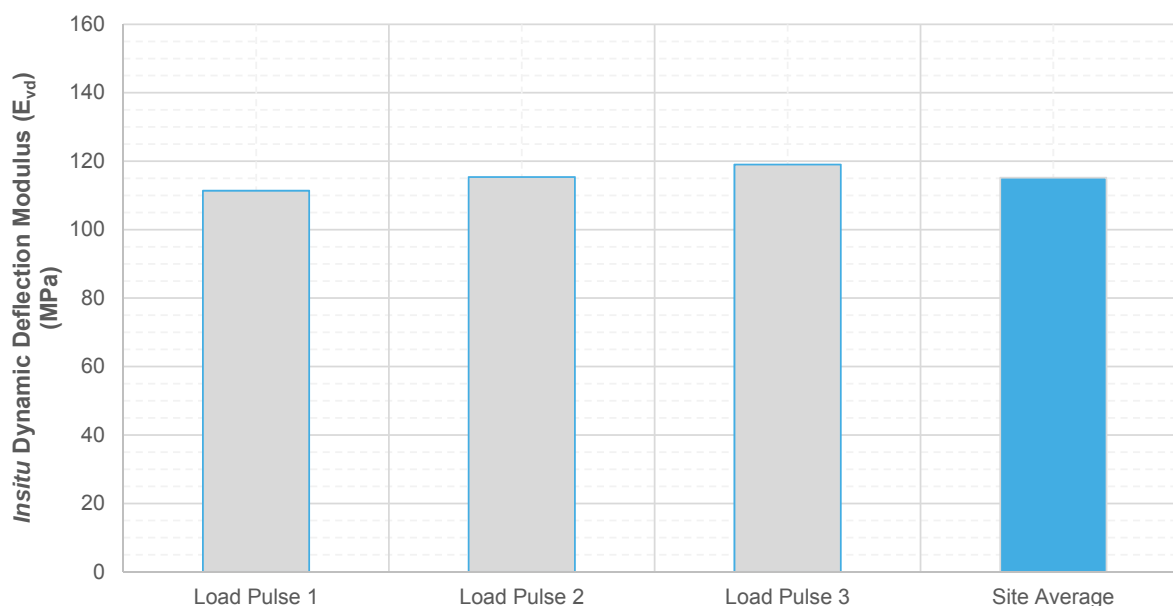
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	103.0	202	111.4
Weight Mass:	10 kg	2	(assumed - not measured)	99.8	195	115.4
Drop Height:	720 mm	3		99.1	189	119.0
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	100.6 (CoV = 2.1%)	195 (CoV = 3.3%)	115.2



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 37-2

Certificate Reference: 2091-LFWD-TERRA-Site 37-2

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 37-2 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

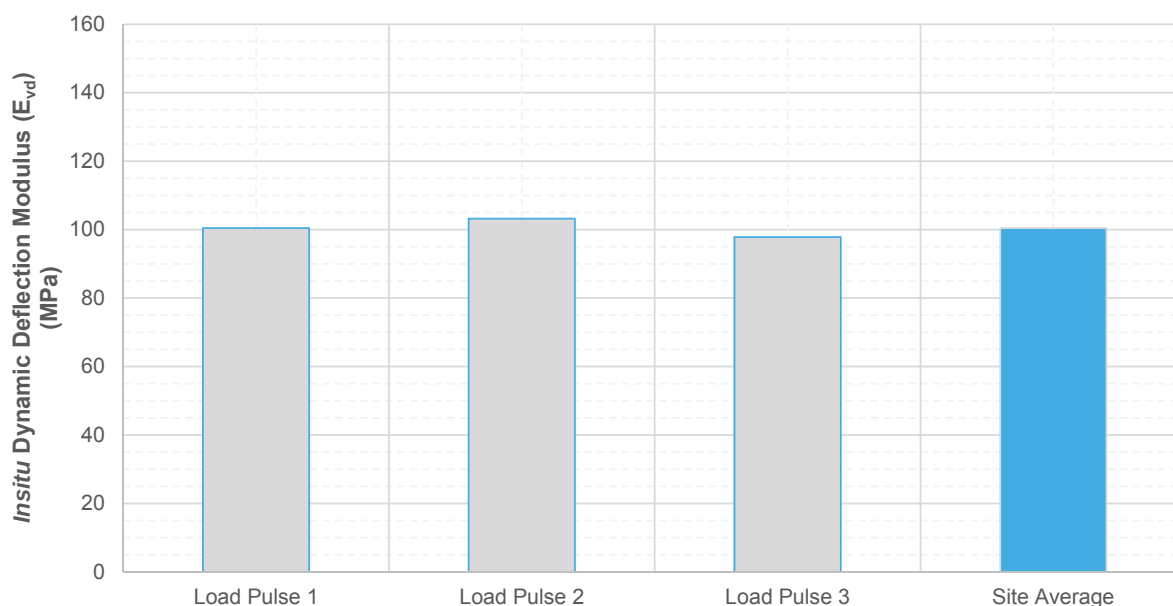
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	111.0	224	100.4
Weight Mass:	10 kg	2	(assumed - not measured)	112.0	218	103.2
Drop Height:	720 mm	3		110.0	230	97.8
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	111.0 (CoV = 0.9%)	224 (CoV = 2.7%)	100.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 37-3

Certificate Reference: 2091-LFWD-TERRA-Site 37-3

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 37-3 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

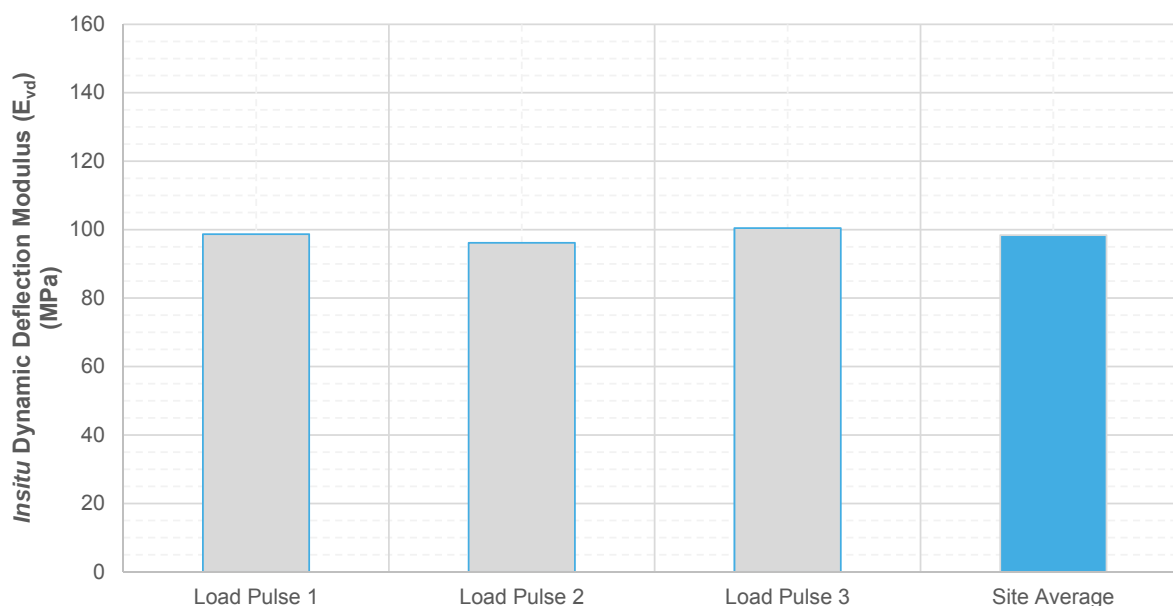
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	126.6	228	98.7
Weight Mass:	10 kg	2	(assumed - not measured)	124.2	234	96.2
Drop Height:	720 mm	3		118.7	224	100.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	123.2 (CoV = 3.3%)	229 (CoV = 2.2%)	98.4



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 37-4

Certificate Reference: 2091-LFWD-TERRA-Site 37-4

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 37-4 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

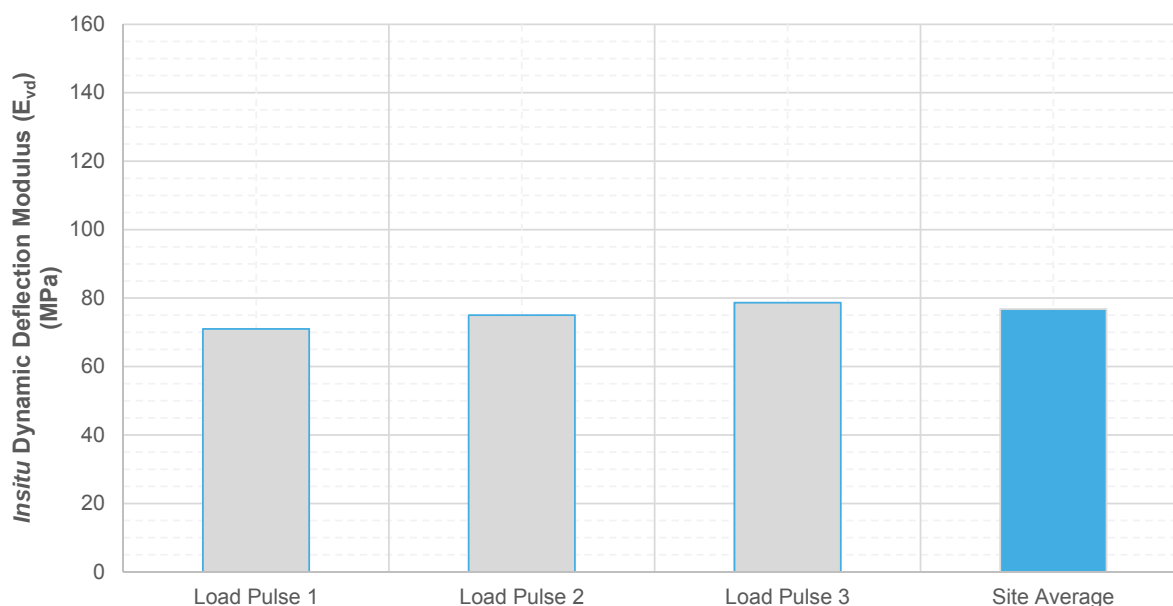
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	158.6	317 (<i>Outlier</i>)	71.0
Weight Mass:	10 kg	2	(assumed - not measured)	149.4	300	75.0
Drop Height:	720 mm	3		146.0	286	78.7
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	147.7 (CoV = 4.4%)	293 (CoV = 3.4%)	76.8



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 38-1

Certificate Reference: 2091-LFWD-TERRA-Site 38-1

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 38-1 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

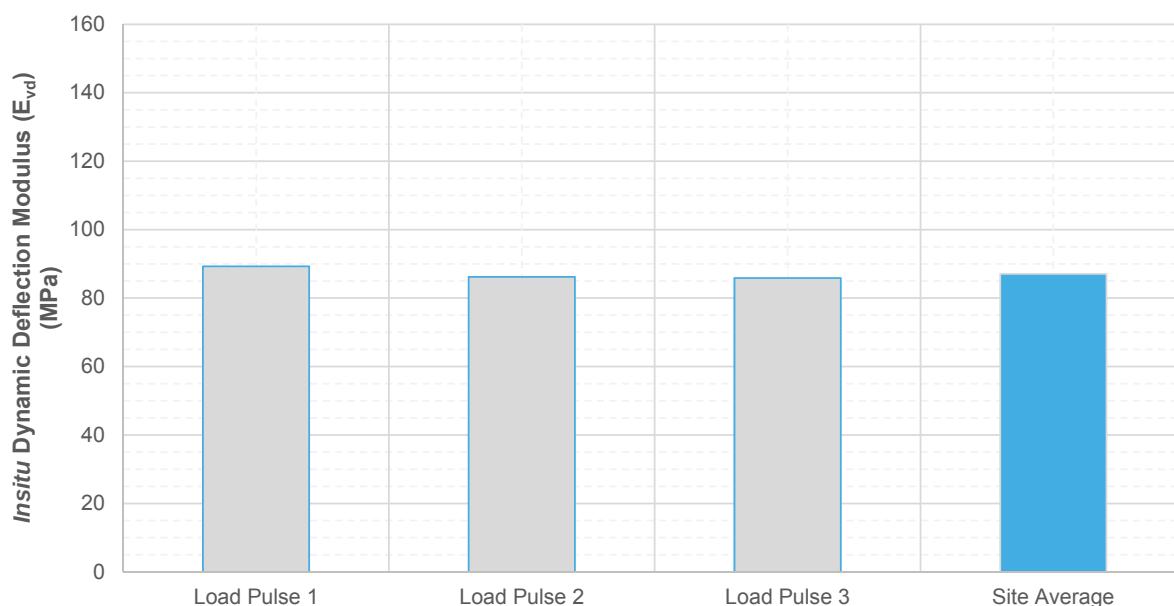
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	119.9	252	89.3
Weight Mass:	10 kg	2	(assumed - not measured)	117.1	261	86.2
Drop Height:	720 mm	3		121.1	262	85.9
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	119.4 (CoV = 1.7%)	258 (CoV = 2.1%)	87.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 38-2

Certificate Reference: 2091-LFWD-TERRA-Site 38-2

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (*Equipment Value*)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (*Equipment Value*)

Location: Site 38-2 (*Smithfield Bypass - Trial Embankment*)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

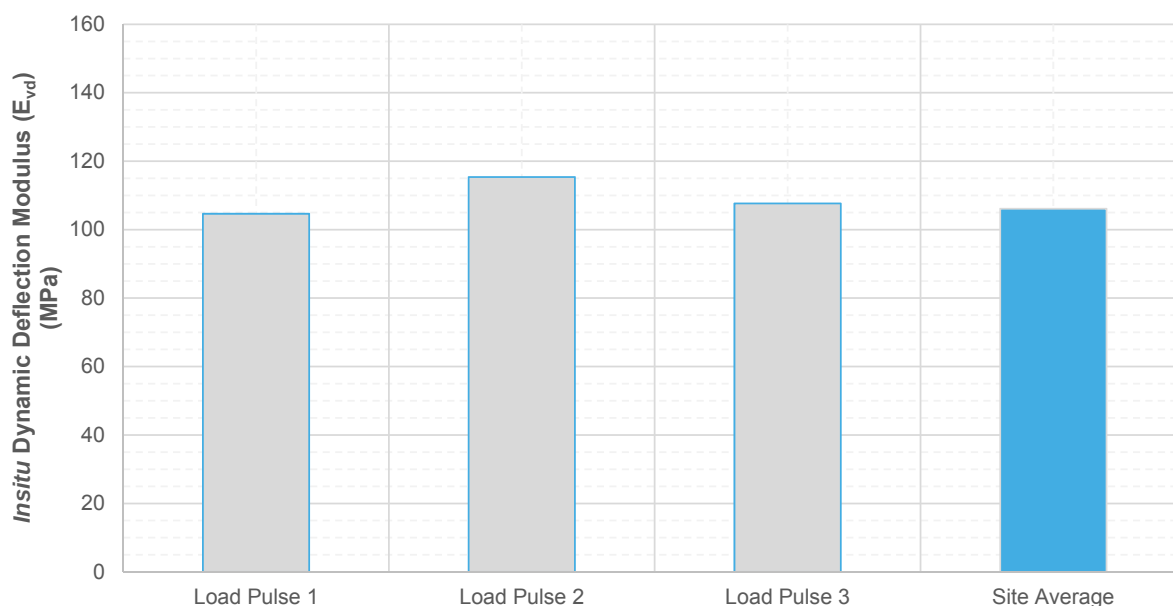
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) [†]	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	~100	215	104.7
Weight Mass:	10 kg	2	(assumed - not measured)	~90	195 (<i>Outlier</i>)	115.4
Drop Height:	720 mm	3		~90	209	107.7
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			†Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	~95.0 (CoV = ~6.2%)	212 (CoV = 2%)	106.1



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress

**Light Falling-Weight Deflectometer (LFWD) -
Terratest 5000**

Site 38-3

Certificate Reference: 2091-LFWD-TERRA-Site 38-3

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 38-3 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

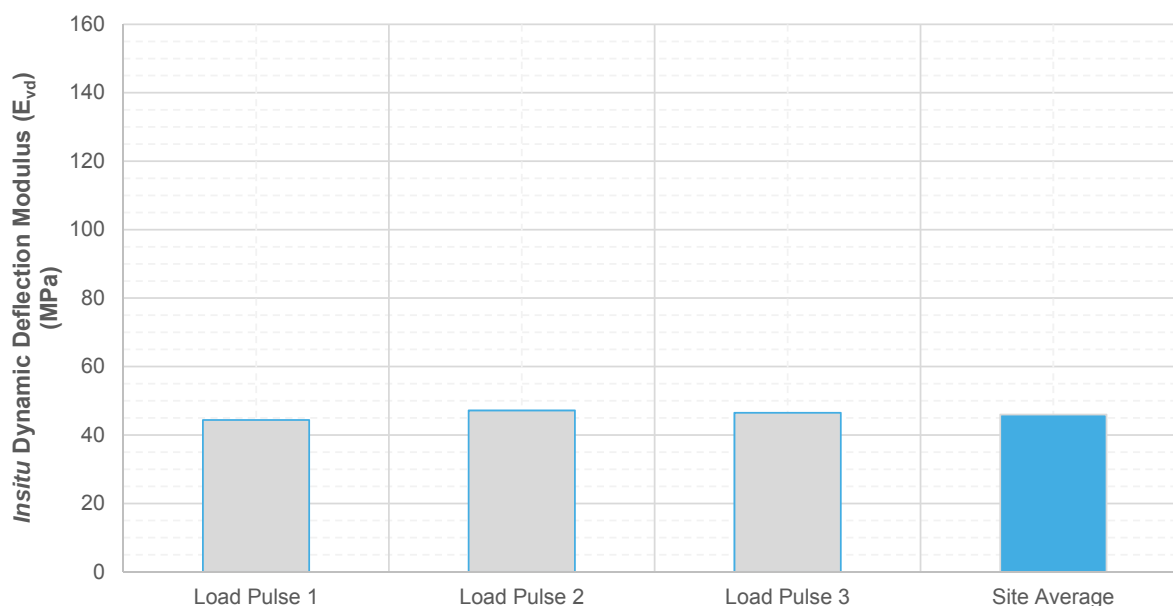
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	209.7	507	44.4
Weight Mass:	10 kg	2	(assumed - not measured)	201.4	477	47.2
Drop Height:	720 mm	3		205.1	484	46.5
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	205.4 (CoV = 2%)	489 (CoV = 3.2%)	46.0



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Light Falling-Weight Deflectometer (LFWD) - Terratest 5000

Site 38-4

Certificate Reference: 2091-LFWD-TERRA-Site 38-4

Sheet: 1 of 1

Client: ARRB

Test Date: 26/04/2019

Project: Best Practice in Compaction QA

Adopted Poisson's Ratio (ν): 0.5 (Equipment Value)

Project No.: 2091

Adopted Stress Reduction Factor: 2 (Equipment Value)

Location: Site 38-4 (Smithfield Bypass - Trial Embankment)

Tested By: ETS

Test method: ASTM - E2835-11 (2011)

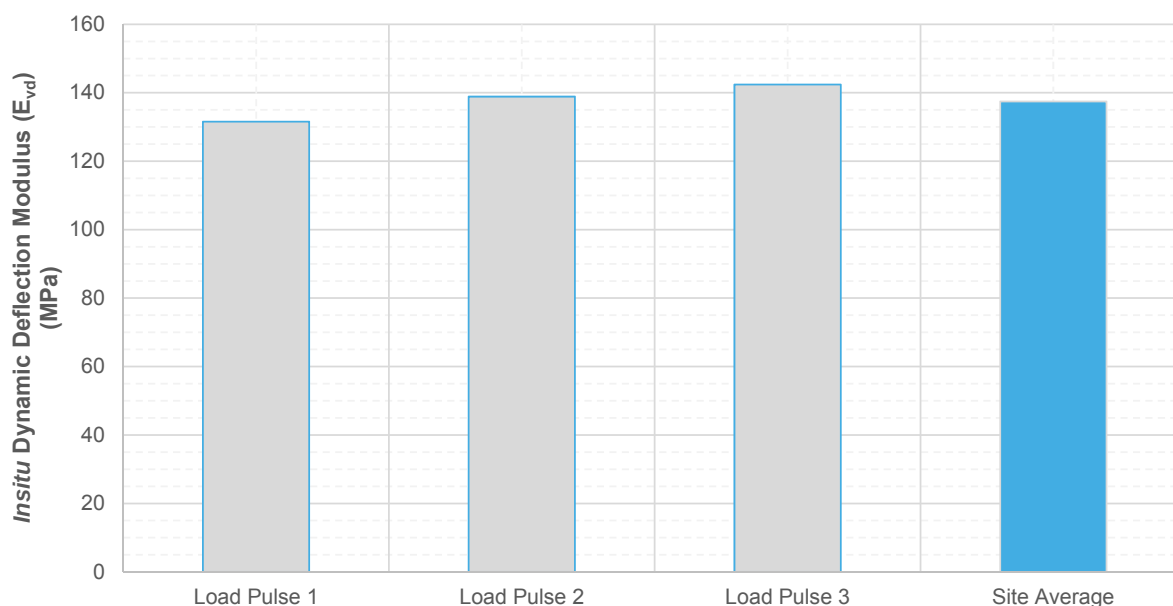
Checked By: DWL

LOAD vs. DEFLECTION Datapoints - Individual Load Pulses

Equipment Configuration		Accelerometer Readings			Results of Individual Load Pulse	
Device ID:	Terratest 5000 (Serial 161954)	Load Pulse ID*	Test Stress (kPa)	Peak Measured Velocity (mm/s)	Peak Deflection (μm) ⁺	In situ Dynamic Deflection Modulus (E_{vd})
Plate Diameter:	300 mm	1	100 kPa	81.1	171	131.6
Weight Mass:	10 kg	2	(assumed - not measured)	79.7	162	138.9
Drop Height:	720 mm	3		76.4	158	142.4
Inferred Test Load:	7.07 kN	After Removal of Seating Blows (3 no.)			*Determined by double integration of peak velocity measurement	

Standardised In situ Dynamic Deflection Modulus (E_{vd})

Standardised Plate Diameter (mm)	Standardised Test Pressure (kPa)	Average Peak Measured Velocity (mm/s)	Average Deflection (μm)	Average In situ Dynamic Deflection Modulus (E_{vd}) (MPa)
300 mm	100 kPa (assumed)	79.1 (CoV = 3.1%)	164 (CoV = 4.1%)	137.5



Comments / Remarks:

300 mm Diameter Plate utilised at a single location.

Stiffness Parameter (E_{vd}) noted to exceed the calibrated equipment range ($E_{vd} > 75$ MPa) due to measurement of limited plate deflections ($\delta < 300$ μm) under standardised test stress



Appendix F

Clegg Hammer – Test Certificates

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 19 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 1 / 3
Test Date: 26/02/2019
Tested By: ZN
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
19-1	0.076	86	90	118	111
	0.152	159	85	162	185
	0.305	242	240	210	252
	0.457	308	316	316	278
	0.610	381	360	341	404
19-2	0.076	31	44	52	53
	0.152	74	81	82	85
	0.305	117	124	122	132
	0.457	164	167	174	181
	0.610	200	211	200	201
19-3	0.076	55	83	96	90
	0.152	132	133	135	131
	0.305	188	156	181	205 / 206
	0.457	243	267	262	203 / 244
	0.610	290	276	295	262 / 254
19-4	0.076	49	60	65	72
	0.152	85	112	117	104 / 104
	0.305	158	159	162	167
	0.457	201	191	176	195 / 195
	0.610	238	221	238	243
19-5	0.076	36	47	60	62 / 53
	0.152	87	90	78	92
	0.305	134	140	143	155
	0.457	177	189	196	212
	0.610	205	286	235	222
19-6	0.076	56	63	72	76
	0.152	96	119	126	119
	0.305	157	168	183	192
	0.457	218	212	228	245 / 235
	0.610	208	228	292	271

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 19 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 2 / 3
Test Date: 26/02/2019
Tested By: ZN
Checked By: DL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
19-7	0.076	49	59	68	70
	0.152	92	92	111	115 / 113
	0.305	149	162	156	161
	0.457	205	189	161	161 / 176
	0.610	218	253	193	221 / 230
19-8	0.076	38	50	47	55
	0.152	79	80	89	87
	0.305	124	136	123	126
	0.457	158	152	180	178
	0.610	188	206	208	227 / 222
19-9	0.076	33	48	47	58 / 61
	0.152	77	84	93	100
	0.305	141	143	132	144
	0.457	178	186	197	207 / 208
	0.610	223	236	241	219
19-10	0.076	67	64	89	94
	0.152	119	126	130	135
	0.305	177	176	188	188
	0.457	187	225	237	234 / 229
	0.610	269	276	261	264
19-11	0.076	48	67	74	78
	0.152	113	126	134	116
	0.305	175	195	208	204
	0.457	256	245	241	258
	0.610	296	305	332 / 304	342 / 342
19-12	0.076	75	93	104	91
	0.152	158	140	184	167 / 168
	0.305	258	289	242	257
	0.457	276	288	319	334 / 338
	0.610	342	389	398	381 / 396

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 19 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 3 / 3
Test Date: 26/02/2019
Tested By: ZN
Checked By: DL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
19-13	0.076	40	46	61	51
	0.152	93	81	92	95
	0.305	141	149	156	156
	0.457	180	190	199	213 / 195
	0.610	248	243	251	255
19-14	0.076	50	73	82	90
	0.152	128	133	146	154
	0.305	218	210	208	243 / 238
	0.457	273	299	320	242 / 313
	0.610	350	376	372	305 / 335

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 21 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 1 / 3
Test Date: 1/03/2019
Tested By: RM / PP
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
21-1	0.076	13	18	18	17
	0.152	20	21	22	21
	0.305	45	40	34	48
	0.457	35	59	50	35
	0.610	263	257	226	254
21-2	0.076	64	86	71	81
	0.152	131	129	123	134
	0.305	187	222	191	241
	0.457	284	298	261	293
	0.610	269	265	291	274
21-3	0.076	39	30	40	40
	0.152	60	61	63	64
	0.305	63	109	100	105
	0.457	139	154	156	140
	0.610	156	154	167	162
21-4	0.076	45	60	66	79
	0.152	104	111	131	127
	0.305	164	167	176	174
	0.457	257	255	239	236 / 238
	0.610	269	266	250	262
21-5	0.076	75	75	77	85
	0.152	140	146	155	161
	0.305	227	203	197	227
	0.457	267	248	263	291 / 294
	0.610	281	315	340	334
21-6	0.076	60	69	76	82
	0.152	139	147	156	149
	0.305	186	189	186	197
	0.457	269	308	274	288
	0.610	309	297	332	345

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 21 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 2 / 3
Test Date: 1/03/2019
Tested By: RM / PP
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
21-7	0.076	50	77	63	82
	0.152	126	105	127	122
	0.305	215	185	184	218
	0.457	252	314	251	306
	0.610	277	334	329	297
21-8	0.076	73	87	82	83
	0.152	135	128	110	140
	0.305	236	173	203	215
	0.457	245	245	251	278
	0.610	272	314	280	261
21-9	0.076	40	61	77	61
	0.152	105	112	121	131
	0.305	167	175	199	200
	0.457	202	307	246	230
	0.610	270	270	234	249
21-10	0.076	33	50	57	64
	0.152	89	105	106	106
	0.305	165	159	174	181
	0.457	214	190	226	220
	0.610	253	254	259	256
21-11	0.076	75	89	96	86
	0.152	146	142	159	172
	0.305	208	244	233	245
	0.457	337	398	320	369
	0.610	467	401	432	396
21-12	0.076	59	60	65	73
	0.152	100	116	126	118
	0.305	174	179	167	185
	0.457	201	226	234	230
	0.610	267	298	261	290

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 21 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 3 / 3
Test Date: 1/03/2019
Tested By: RM / PP
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
21-13	0.076	44	59	75	90
	0.152	123	128	143	152
	0.305	200	204	205	189
	0.457	250	283	244	237
	0.610	275	294	306	309
21-14	0.076	70	79	92	93
	0.152	171	143	161	212
	0.305	280	260	256	257
	0.457	288	310	320	314 / 338
	0.610	377	350	385	349 / 372

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 22 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 1 / 3
Test Date: 28/02/2019
Tested By: ZN
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
22-1	0.076	11	14	15	13
	0.152	23	21	21	21
	0.305	36	35	38	30
	0.457	34	38	33	38
	0.610	37	36	40	39 / 40
22-2	0.076	8	7	12	7 / 10
	0.152	14	15	17	14
	0.305	22	24	24	25
	0.457	31	30	31	31
	0.610	28	28	30	27 / 29
22-3	0.076	6	11	11	11 / 10
	0.152	16	17	16	16
	0.305	21	23	23	21
	0.457	29	28	29	30
	0.610	26	28	31	30
22-4	0.076	13	8	8	14
	0.152	11	12	12	12
	0.305	15	21	20	14 / 22
	0.457	25	23	23	23
	0.610	29	23	27	31
22-5	0.076	10	13	12	13
	0.152	17	13	26	21
	0.305	24	19	24	24
	0.457	29	27	29	29
	0.610	33	30	37	31 / 32
22-6	0.076	15	19	12	13
	0.152	14	18	16	14
	0.305	19	22	22	21
	0.457	30	35	31	33
	0.610	30	38	33	33

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 22 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 2 / 3
Test Date: 28/02/2019
Tested By: ZN
Checked By: DL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
22-7	0.076	10	10	13	11
	0.152	13	15	14	14
	0.305	24	23	19	22
	0.457	27	30	30	31
	0.610	37	45	36	35
22-8	0.076	15	17	17	16
	0.152	21	21	21	22
	0.305	25	29	26	30
	0.457	31	33	35	39
	0.610	38	41	40	41
22-9	0.076	15	13	20	16
	0.152	18	19	17	22
	0.305	24	27	28	26
	0.457	33	31	28	30
	0.610	46	41	35	41
22-10	0.076	14	15	11	11
	0.152	17	16	19	18
	0.305	25	31	23	22
	0.457	28	26	38	28
	0.610	38	36	42	37
22-11	0.076	16	14	10	14
	0.152	20	16	21	20
	0.305	23	24	30	24
	0.457	34	38	28	28 / 30
	0.610	35	35	36	35
22-12	0.076	12	15	12	16
	0.152	21	18	21	21
	0.305	25	26	25	26
	0.457	41	32	31	30 / 31
	0.610	42	34	32	40 / 38

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 22 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 3 / 3
Test Date: 28/02/2019
Tested By: ZN
Checked By: DL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
22-13	0.076	14	12	11	14
	0.152	17	19	14	19
	0.305	25	25	23	26
	0.457	30	27	34	30
	0.610	39	36	44	41
22-14	0.076	13	14	15	19
	0.152	28	26	25	22
	0.305	23	24	28	34
	0.457	36	33	46	56
	0.610	66	54	37	50 / 56

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 23 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 1 / 2
Test Date: 13/03/2019
Tested By: JH
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
23-1	0.076	31	36	36	32
	0.152	43	36	48 / 49	54 / 45
	0.305	66	59	55	-
	0.457	Not Tested			
	0.610				
23-1A	0.076	22	22	21	23
	0.152	22	23	23	21
	0.305	32	36	31	31
	0.457	37	35	34	34
	0.610	38	38	45	35 / 34
23-2	0.076	17	14	11 / 16	12 / 17 / 21
	0.152	18	17	17	16
	0.305	28	43	36	32 / 50
	0.457	44	27	25 / 32	34 / 44 / 41
	0.610	30	32	30 / 37	41 / 59 / 50
23-3	0.076	24	22	27	35
	0.152	24	20	25	22 / 27
	0.305	39	32	32 / 38	35 / 36
	0.457	38	36	41	40 / 43
	0.610	38	28	34 / 33	31 / 34
23-4	0.076	27	23	35	28 / 33
	0.152	39	36	40 / 37	48 / 32
	0.305	43	45	30	27 / 35
	0.457	39	39	33	34 / 37
	0.610	32	36	39 / 30	37 / 30 / 36
23-5	0.076	16	18	22	20
	0.152	32	31	27 / 24	26 / 27
	0.305	39	33	29	27 / 33
	0.457	38	34	35 / 31 / 36	32 / 33 / 34
	0.610	43	40	41	35 / 38

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 23 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 2 / 2
Test Date: 13/03/2019
Tested By: JH
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
23-6	0.076	17	18	21	15
	0.152	18	20	22	22 / 18
	0.305	35	26	36 / 43	32 / 32
	0.457	39	33	33 / 33	31 / 29
	0.610	34	29	38 / 32	31 / 38 / 34

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 24 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 1 / 3
Test Date: 12/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
24-1	0.076	25	21	22	22
	0.152	22	21	23 / 23	23 / 23
	0.305	22	21	20	21
	0.457	Not Tested			
	0.610				
24-1A	0.076	21	21	18	20
	0.152	23	23	27	21 / 22
	0.305	28	35	28	26 / 32
	0.457	36	28	34	43
	0.610	34	37	31	38 / 37
24-1B	0.076	20	16	18 / 20	23 / 20
	0.152	22	19	22	23 / 20
	0.305	24	22	23	22 / 23
	0.457	29	22	29	29
	0.610	27	25	24	29
24-2	0.076	29	29	28 / 22	32 / 35 / 40
	0.152	50	51	48	51
	0.305	40	60	55 / 52	51 / 59
	0.457	70	73	76	74
	0.610	54	67	67 / 62	65 / 67
24-3	0.076	21	21	24	26 / 20
	0.152	31	44	32	30
	0.305	41	48	51 / 56	47 / 59
	0.457	59	51	55	70 / 68
	0.610	58	58	72 / 67	69 / 73 / 73
24-4	0.076	31	19	24 / 18	25 / 22
	0.152	31	33	35	38 / 34
	0.305	42	38	40 / 39	44 / 49
	0.457	47	58	61	65
	0.610	68	69	65	75 / 59

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 24 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 2 / 3
Test Date: 12/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
24-5	0.076	25	29	30	32 / 30
	0.152	26	25	21 / 21	31 / 31
	0.305	26	22	24 / 26 / 25	22 / 31 / 21 / 23
	0.457	35	35	32	26
	0.610	56	39	38 / 32	25 / 36
24-6	0.076	19	22	18	17
	0.152	15	15	19	16 / 18
	0.305	23	20	26	19 / 36
	0.457	37	33	27 / 35	37 / 56
	0.610	25	22	29 / 26	29 / 26 / 34
24-7	0.076	21	24	22	26
	0.152	26	26	25	26 / 27
	0.305	34	49	31 / 29	25 / 29
	0.457	46	38	46 / 49	61 / 57
	0.610	43	39	39 / 39	41 / 31
24-8	0.076	26	22	20	20 / 24
	0.152	28	27	32 / 37	27 / 32
	0.305	41	41	58 / 44	49 / 42 / 63
	0.457	46	57	48	55 / 49
	0.610	40	47	40 / 50 / 45	49 / 57 / 49
24-9	0.076	21	29	28	22
	0.152	26	29	26	30
	0.305	32	32	37	37 / 33
	0.457	27	36	45 / 51	37 / 46
	0.610	60	46	38 / 46	39 / 35 / 34
24-10	0.076	40	42	42	45
	0.152	48	52	52	47
	0.305	75	72	67	74
	0.457	77	74	79	84
	0.610	85	84	93	86 / 87

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 24 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 3 / 3
Test Date: 12/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
24-11	0.076	53	60	58	57
	0.152	73	67	69	82 / 64
	0.305	81	80	78 / 81	79 / 86
	0.457	99	96	112	113 / 109
	0.610	101	105	98	100 / 105
24-11A	0.076	37	25	28	29
	0.152	30	28	27	26 / 30
	0.305	28	40	38 / 38	39 / 40
	0.457	49	37	57 / 56	46 / 53
	0.610	49	46	42 / 41	58 / 42 / 39
24-12	0.076	16	18	26	24 / 25
	0.152	32	26	26	32 / 38
	0.305	37	44	46 / 58	37 / 40 / 44
	0.457	47	43	68	46 / 45
	0.610	60	50	59	68 / 60

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 25 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 1 / 3
Test Date: 7/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
25-1	0.076	17	18	20 / 17 / 18	18 / 20 / 19
	0.152	20	22	22 / 20 / 25	24 / 25 / 29
	0.305	35	29	44 / 32	37 / 39 / 41
	0.457	45	37	37 / 40 / 51	40 / 36 / 36
	0.610	43	38	37 / 44 / 36	53 / 53 / 57
25-2	0.076	18	24	19	25 / 20
	0.152	31	25	26	26 / 26
	0.305	42	38	43 / 44	45 / 51 / 45
	0.457	65	52	58 / 52 / 46	50 / 66 / 57
	0.610	65	55	54	53 / 66
25-3	0.076	18	18	21 / 20	19 / 22
	0.152	26	22	19 / 18	26 / 31
	0.305	31	28	35	35 / 32
	0.457	33	44	34 / 44	59 / 48 / 43
	0.610	46	40	52 / 54	62 / 75 / 66
25-4	0.076	14	21	20	17 / 19
	0.152	27	24	22	25
	0.305	28	30	38	40 / 40
	0.457	48	48	48	53 / 46
	0.610	67	62	58	47 / 52
25-5	0.076	18	22	22	20
	0.152	28	27	32	30
	0.305	32	40	40	35 / 38
	0.457	48	43	41	42
	0.610	52	46	52	50
25-6	0.076	21	19	19 / 24	17 / 23
	0.152	25	26	24 / 32	23 / 27
	0.305	37	38	36 / 35	39 / 38
	0.457	45	53	42 / 38	50 / 50
	0.610	44	49	46 / 53	57 / 51 / 51

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 25 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 2 / 3
Test Date: 7/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
25-7	0.076	18	13	18	20 / 18
	0.152	23	23	20	20 / 20
	0.305	35	27	42 / 26	40 / 45
	0.457	49	31	45 / 34	48 / 50 / 49
	0.610	46	38	37 / 34	35 / 30 / 29
25-7A	0.076	17	17	19	23
	0.152	21	21	22 / 24	21 / 21
	0.305	29	33	29 / 37 / 34	33 / 36 / 36
	0.457	61	47	54 / 47 / 53	50 / 43 / 42
	0.610	36	37	44 / 46 / 41	46 / 48 / 43 / 41
25-8	0.076	23	22	24	24 / 20
	0.152	26	25	29	27
	0.305	36	45	38 / 36	41 / 45
	0.457	43	44	38 / 43	51 / 45
	0.610	72	49	52 / 57 / 49	48 / 70 / 65
25-9	0.076	15	17	15	20 / 17
	0.152	24	25	28 / 23	25 / 24
	0.305	36	37	28 / 30	36 / 40 / 44
	0.457	51	53	46 / 42	42 / 46
	0.610	38	39	44 / 38	39 / 77 / 51
25-10	0.076	22	24	28	23 / 21
	0.152	26	28	30	35 / 31
	0.305	38	42	46 / 39	47 / 46
	0.457	44	43	54	63 / 61
	0.610	56	64	66 / 83	72 / 67 / 68
25-11	0.076	16	17	20	21 / 20
	0.152	28	24	20 / 29	29 / 30
	0.305	39	37	37	40 / 39
	0.457	43	41	39	48 / 47
	0.610	57	48	44 / 64	58 / 51

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 25 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 3 / 3
Test Date: 7/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
25-12	0.076	17	19	20	17 / 21
	0.152	28	29	25 / 24	26 / 30
	0.305	41	37	38 / 35	29 / 35
	0.457	43	50	45	49
	0.610	47	47	46	58 / 52

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 26 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 1 / 3
Test Date: 6 & 7/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
26-1	0.076	18	19	22	25 / 21
	0.152	22	26	19	28 / 28
	0.305	37	35	35	33
	0.457	45	42	37	41
	0.610	52	52	48	57
26-2	0.076	13	16	17	17 / 17
	0.152	21	21	17	19
	0.305	28	28	28	28
	0.457	29	39	40	46 / 42
	0.610	32	45	38 / 32	39 / 35 / 33
26-3 (06/03/2019)	0.076	14	11	18	17 / 17
	0.152	19	22	16	24 / 22
	0.305	28	28	37	30 / 29
	0.457	55	35	32	38 / 34
	0.610	Not Tested			
26-3A (07/03/2019)	0.076	21	19	20	18
	0.152	26	23	23	23 / 23
	0.305	30	32	38	38 / 40
	0.457	35	35	35	43 / 38
	0.610	39	41	58	46 / 45
26-4	0.076	17	12	14	13 / 14
	0.152	18	16	16	15
	0.305	19	32	42	35 / 31
	0.457	39	31	42	34 / 36
	0.610	32	47	33	51 / 49
26-5	0.076	19	21	16	16
	0.152	18	18	18	20
	0.305	42	42	34	39 / 41
	0.457	40	36	33	34 / 46
	0.610	41	44	44	43

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 26 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 2 / 3
Test Date: 6 & 7/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
26-6	0.076	24	15	19	19 / 18
	0.152	26	23	24	23
	0.305	26	27	28	33 / 26
	0.457	33	34	39	37
	0.610	42	49	43	42
26-7	0.076	17	17	19	26 / 16
	0.152	20	19	22	26 / 24
	0.305	39	41	35	43 / 41
	0.457	48	37	39	42 / 41
	0.610	48	43	46	50 / 49
26-8	0.076	18	20	21	27 / 25
	0.152	31	35	29	34 / 30
	0.305	33	40	41 / 32	38 / 44
	0.457	46	52	55 / 47	49 / 63
	0.610	56	52	49 / 50	57 / 64
26-9	0.076	21	18	21	17 / 18
	0.152	20	19	23	22
	0.305	28	32	32	32 / 31
	0.457	29	29	42	48 / 52
	0.610	40	37	36 / 44	42 / 46
26-10	0.076	14	19	17	23 / 17
	0.152	25	24	25	25 / 27
	0.305	31	35	37	33 / 32
	0.457	40	41	46	40 / 42
	0.610	47	45	44	50 / 42
26-11	0.076	35	37	15 / 14	20 / 15
	0.152	15	19	21	21 / 16
	0.305	30	26	28	22 / 29
	0.457	32	31	37	35 / 43
	0.610	31	36	41	34 / 38

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing

Clegg Hammer Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Site 26 (Smithfield Bypass – Trial Embankment)
Test Method: AS 1289.6.9.1: Methods for testing soils for engineering purposes- Method 6.9.1: Soil Strength and Consolidation test - Determination of stiffness of soil - Clegg Impact Value (CIV)

Sheet: 3 / 3
Test Date: 6 & 7/03/2019
Tested By: RM
Checked By: DWL

Test Details		Clegg Impact Value (CIV) - Reading from Hammer			
Site ID	Drop Height (m)	Seating Blows		Valid Test Blows	
		Drop 1	Drop 2	Drop 3	Drop 4 / 5
26-12	0.076	13	13	15	13
	0.152	25	29	26	26
	0.305	37	36	39	35
	0.457	48	47	44	45
	0.610	45	65	43	75 / 54

*9.1kg Variable Drop Height Version of Clegg Hammer used for all site testing



Appendix G

Dynamic Cone Penetrometer (DCP) – Test Certificates

Dynamic Cone Penetrometer Test

Sheet: 1 of 1

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 9 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 14/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 9-5	Site 9-6	Site 9-7	Site 9-8				
0 – 50	5	7	6	8				
50 – 100	5	10	13	5				
100 – 150	5	8	8	10				
150 – 200	10	9	10	7				
200 – 250	8	6	7	10				
250 – 300	5	8	8	9				
300 – 350								
350 – 400								
400 – 450								
450 – 500								
500 – 550								
550 – 600								
600 – 650								
650 – 700								
700 – 750								
750 – 800								
800 – 850								
850 – 900								

Test Depth (mm)								
0 – 50								
50 – 100								
100 – 150								
150 – 200								
200 – 250								
250 – 300								
300 – 350								
350 – 400								
400 – 450								
450 – 500								
500 – 550								
550 – 600								
600 – 650								
650 – 700								
700 – 750								
750 – 800								
800 – 850								
850 – 900								

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 10 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 14/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 10-1	Site 10-2	Site 10-3	Site 10-4				
0 – 50	4	4	7	8				
50 – 100	3	2	11	15				
100 – 150	5	2	14	10				
150 – 200	3	2	20	10				
200 – 250	4	4	7	7				
250 – 300	6	10	7	16				
300 – 350								
350 – 400								
400 – 450								
450 – 500								
500 – 550								
550 – 600								
600 – 650								
650 – 700								
700 – 750								
750 – 800								
800 – 850								
850 – 900								

Test Depth (mm)								
0 – 50								
50 – 100								
100 – 150								
150 – 200								
200 – 250								
250 – 300								
300 – 350								
350 – 400								
400 – 450								
450 – 500								
500 – 550								
550 – 600								
600 – 650								
650 – 700								
700 – 750								
750 – 800								
800 – 850								
850 – 900								

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 11 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 15/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 11-1	Site 11-1A	Site 11-2	Site 11-3	Site 11-3A	Site 11-4	Site 11-4A	
0 – 50	7	9	6	11	> 12	6	> 12	
50 – 100	7	> 18	5	13		9		
100 – 150	10		5	10		10		
150 – 200	8		7	11		12		
200 – 250	10		9	13		11		
250 – 300	12		7	10		20		
300 – 350	12		15	17		20		
350 – 400								
400 – 450								
450 – 500								
500 – 550								
550 – 600								
600 – 650								
650 – 700								
700 – 750								
750 – 800								
800 – 850								
850 – 900								

Test Depth (mm)								
0 – 50								
50 – 100								
100 – 150								
150 – 200								
200 – 250								
250 – 300								
300 – 350								
350 – 400								
400 – 450								
450 – 500								
500 – 550								
550 – 600								
600 – 650								
650 – 700								
700 – 750								
750 – 800								
800 – 850								
850 – 900								

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 12 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 15/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 12-1	Site 12-1A	Site 12-2	Site 12-3	Site 12-3A	Site 12-4	
0 – 50	10	10	7	6	7	7	
50 – 100	11	12	5	4	7	7	
100 – 150	10 / 40 mm	10 / 40 mm	6	10 / 25 mm	6	10	
150 – 200			4		6	10	
200 – 250			4		7	9	
250 – 300			8		6	9	
300 – 350			10		10 / 25 mm	10	
350 – 400			10 / 25 mm				
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 13 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 18/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 13-1	Site 13-2	Site 13-2A	Site 13-2B	Site 13-3	Site 13-3A	Site 13-4
0 – 50	3	8	10	6	5	9	6
50 – 100	7	10 / 40 mm	20	10	10	11	9
100 – 150	15			10 / 10 mm	16 / 20 mm	16 / 40 mm	12
150 – 200	20						12 / 40 mm
200 – 250	12						
250 – 300	12						
300 – 350	15						
350 – 400	10						
400 – 450	20 / 20 mm						
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 13-4A						
0 – 50	11						
50 – 100	13						
100 – 150	10 / 10 mm						
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 14 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 18/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 14-1	Site 14-2	Site 14-2A	Site 14-3	Site 14-3A	Site 14-4	
0 – 50	5	7	10	10 / 40 mm	9	7	
50 – 100	4	8	10		8	7	
100 – 150	6	7	10 / 40 mm		9	5	
150 – 200	7	6			10	4	
200 – 250	7	10 / 20 mm			13	6	
250 – 300	9				13	8	
300 – 350	10				8	6	
350 – 400	9				8	6	
400 – 450	6				7	10	
450 – 500	8				18	9	
500 – 550	8					9	
550 – 600	14					15	
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 15 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 19/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 15-1	Site 15-1A	Site 15-1B	Site 15-2	Site 15-2A	Site 15-3	Site 15-4
0 – 50	12	8	6	7	5	7	8
50 – 100	4	16	14	7	10	9	4
100 – 150	13	10 / 20 mm	10 / 10 mm	12	7	9	5
150 – 200	10 / 20 mm			10	10	7	5
200 – 250				10 / 20 mm	12	12	5
250 – 300					15	17	15
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 16 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 21/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 16-1	Site 16-1A	Site 16-2	Site 16-2A	Site 16-3	Site 16-3A	Site 16-4
0 – 50	10	7	7	6	7	10	8
50 – 100	20 / 40 mm	10	10	7	10	10	10
100 – 150		10	11	7	13	15	20
150 – 200		12	11	11	15	8	
200 – 250		14	15 / 30 mm	11		6	
250 – 300		6		6		10	
300 – 350		7		8		6	
350 – 400		8		12		6	
400 – 450		10 / 25 mm		20		5	
450 – 500						15	
500 – 550						20	
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 16-4A						
0 – 50	12						
50 – 100	10						
100 – 150	18						
150 – 200	12						
200 – 250	12						
250 – 300	11						
300 – 350	12						
350 – 400	> 20						
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 17 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 21/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 17-1	Site 17-2	Site 17-3	Site 17-4			
0 – 50	9	4	12	4			
50 – 100	10	5	10	3			
100 – 150	10	8	15	1			
150 – 200	20	10	14	2			
200 – 250	12	12	9	2			
250 – 300	12	11	7	3			
300 – 350	7	15	6	7			
350 – 400	10		6	5			
400 – 450	20		18	5			
450 – 500				6			
500 – 550				10			
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 18 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 22/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 18-1	Site 18-2	Site 18-2A	Site 18-3	Site 18-4	Site 18-4A	
0 – 50	7	10	–	9	8	7	
50 – 100	10	12	–	8	10	8	
100 – 150	9	10	–	10	12	10	
150 – 200	10	8	–	7	17	7	
200 – 250	12	13	8	11	20	10	
250 – 300	11	20	8	11		10	
300 – 350	14		9	13		9	
350 – 400			8			15	
400 – 450			15			16 / 30 mm	
450 – 500			15				
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 19 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 25 & 26/02/2019

Tested By: RM / PP

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 19-1	Site 19-1A	Site 19-1B	Site 19-2	Site 19-3	Site 19-4	Site 19-5
0 – 50	3	5	5	3	4	4	5
50 – 100	6	9	5	3	8	8	7
100 – 150	15 / 20 mm	10	10	5	12	8	7
150 – 200		10	10	6	6	8	11
200 – 250			10	6	8	8	16
250 – 300			13	7	5	10	20
300 – 350				12	6	9	15
350 – 400					9	4	
400 – 450					6	6	
450 – 500					9	8	
500 – 550					22	10	
550 – 600						11	
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 19-6	Site 19-6A	Site 19-7	Site 19-8	Site 19-9	Site 19-10	Site 19-11
0 – 50	6	6	4	3	4	7	5
50 – 100	6	12	5	7	8	5	8
100 – 150	10 / 10 mm	7	9	7	10	10	10
150 – 200		10	8	13	8	9	15
200 – 250		6	8	10	6	12	12
250 – 300		5	10	12	7	10	12
300 – 350		5	9	8	8	7	11
350 – 400		11	10	14	6	6	8
400 – 450					10	5	9
450 – 500						7	9
500 – 550						12	8
550 – 600							4
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 19 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 25 & 26/02/2019

Tested By: RM / PP

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 19-12	Site 19-12A	Site 19-13	Site 19-14			
0 – 50	10	8	4	7			
50 – 100	13	12	6	8			
100 – 150	12	14	10	8			
150 – 200	8 / 10 mm	10	4	6			
200 – 250		7	4	5			
250 – 300		13	10	7			
300 – 350		10	8	7			
350 – 400			9	10 / 40 mm			
400 – 450			5				
450 – 500			10				
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 21 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 27/02 – 01/03/19

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 21-1 (27/02/2019)	Site 21-1 (01/03/2019)	Site 21-1A (27/02/2019)	Site 21-1A (01/03/2019)	Site 21-2 (27/02/2019)	Site 21-2 (01/03/2019)	Site 21-2A
0 – 50	5	6	6	6	3	7	6
50 – 100	7	5	8	6	7	7	6
100 – 150	7	11	7	10	8	11	7
150 – 200	15	17	15	14	8	15	10 / 20 mm
200 – 250		8 / 20 mm	15		10	20	
250 – 300			15		10		
300 – 350			10		10		
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 21-3 (27/02/2019)	Site 21-3 (01/03/2019)	Site 21-4 (27/02/2019)	Site 21-4 (01/03/2019)	Site 21-4A (27/02/2019)	Site 21-5 (01/03/2019)	Site 21-5A
0 – 50	6	8	3	5	2	9	6
50 – 100	7	9	3	8	4	12	10
100 – 150	8	11	3	7	8	10 / 15 mm	10
150 – 200	7	7	5	6	4		10 / 20 mm
200 – 250	7	9		6	3		
250 – 300	8	10		7	4		
300 – 350	7	14		7	5		
350 – 400	11			5	4		
400 – 450				10	5		
450 – 500					7		
500 – 550					12		
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 21 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 01/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 21-6	Site 21-6A	Site 21-7	Site 21-8	Site 21-9	Site 21-10	Site 21-10A
0 – 50	7	9	4	5	6	5	5
50 – 100	11	10	4	5	7	4	6
100 – 150	10	10	10	9	7	8	7
150 – 200		10 / 20 mm	8	8	9	14	9
200 – 250			10	10	10		11
250 – 300			10	7	12		10
300 – 350			23	15	15		11
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 21-11	Site 21-12	Site 21-12A	Site 21-13	Site 21-14		
0 – 50	10	6	7	4	7		
50 – 100	7	7	14	7	7		
100 – 150	10	10	15	7	10		
150 – 200	7		20	6	7		
200 – 250	10			12	8		
250 – 300	9			9	8		
300 – 350	12			10	6		
350 – 400					6		
400 – 450					6		
450 – 500					5		
500 – 550					8		
550 – 600					12		
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 22 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 27/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 22-1	Site 22-2	Site 22-2A	Site 22-3	Site 22-4	Site 22-4A	Site 22-5
0 – 50	5	5	5	4	7	8	5
50 – 100	8	7	8	10	7	12	7
100 – 150	10	9	10	12	15	11	9
150 – 200	7	10	10	10		12	12
200 – 250	5	17	10	9		13	18
250 – 300	8		12	5		15 / 30 mm	
300 – 350	4		8	8			
350 – 400	4		10	10			
400 – 450	4						
450 – 500	15						
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 22-5A	Site 22-6	Site 22-6A	Site 22-7	Site 22-7A	Site 22-8	Site 22-8A
0 – 50	3	3	3	3	3	6	4
50 – 100	5	5	5	7	6	10 / 25 mm	10
100 – 150	8	10	8	10	13		10
150 – 200	8	7	8				9
200 – 250	15 / 30 mm	12 / 40 mm	13				7
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 22 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 27/02/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 22-9	Site 22-9A	Site 22-10	Site 22-11	Site 22-12	Site 22-13	Site 22-13A
0 – 50	5	3	4	5	5	5	4
50 – 100	12	12	8	8	8	10	10
100 – 150			14	12	10	11	13
150 – 200			9	14	7		
200 – 250			10	10	6		
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 22-14						
0 – 50	7						
50 – 100	11						
100 – 150	10						
150 – 200	11						
200 – 250	15						
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 23 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 13/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 23-1	Site 23-2	Site 23-2A	Site 23-3	Site 23-3A	Site 23-4	Site 23-4A
0 – 50	4	6	7	10	9	7	10
50 – 100	10	13	7	15	9	10	14
100 – 150	10		8		8		15
150 – 200	11		7		13		8 / 20 mm
200 – 250	6		6				
250 – 300	10		7				
300 – 350	6		6				
350 – 400	7		10				
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 23-5	Site 23-6	Site 23-6A				
0 – 50	9	5	4				
50 – 100	10	9	7				
100 – 150	10	9	10				
150 – 200	8	10	15				
200 – 250	8		10				
250 – 300	11		11				
300 – 350	10 / 30 mm		10				
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 24 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 12/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 24-1	Site 24-2	Site 24-3	Site 24-3A	Site 24-4	Site 24-5	Site 24-6
0 – 50	5	9	17	12	13	7	8
50 – 100	6	18	8 / 20 mm		10	7	5
100 – 150	8	12			7	7	3
150 – 200	12	12			10	11	11
200 – 250	10	8			9	10	
250 – 300	6	9			4	7	
300 – 350	7	6			6	7	
350 – 400	4	10			16	11	
400 – 450	8 / 20 mm						
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 24-6A	Site 24-7	Site 24-7A	Site 24-8	Site 24-9	Site 24-10	Site 24-11
0 – 50	6	8	10	8	6	13	9
50 – 100	6	10	8	9	7	10	18
100 – 150	5		9	8	6	6	8
150 – 200	8		12	10	6	11	12
200 – 250	6			12	6	6	12
250 – 300	7			12	14	6	9
300 – 350	5			7	7	6	5
350 – 400	12			14	8	9	19
400 – 450					8	11	
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 24 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 12/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 24-12						
0 – 50	13						
50 – 100	11						
100 – 150	8						
150 – 200	8						
200 – 250	7						
250 – 300	8						
300 – 350	7						
350 – 400	13						
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 25 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 07/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 25-1	Site 25-2	Site 25-2A	Site 25-3	Site 25-4	Site 25-5	Site 25-6
0 – 50	8	8	10	9	6	7	6
50 – 100	12	14	10	5	8	6	7
100 – 150	8		15	6	9	8	7
150 – 200	7		14	3	8	9	6
200 – 250	3			8	7	10	4
250 – 300	4			11	5	7	6
300 – 350	8			7	5	10	18
350 – 400	16			4	7		
400 – 450				3	6		
450 – 500				7	7		
500 – 550				7	7		
550 – 600				7	4		
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 25-7	Site 25-8	Site 25-9	Site 25-9A	Site 25-10	Site 25-11	Site 25-11A
0 – 50	11	11	10	8	11	13	10
50 – 100	8	10	7	8	9	15 / 25 mm	16
100 – 150	8	9	11	8	8		11
150 – 200	7	14	14 / 30 mm	14	10		18
200 – 250	7	11		13	7		10
250 – 300	12	7		11	6		9
300 – 350	6	10		6	5		7
350 – 400	8	14		8	4		6
400 – 450	13			10	4		5
450 – 500				14	6		12 / 25 mm
500 – 550					8		
550 – 600					14		
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 25 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 07/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 25-12						
0 – 50	8						
50 – 100	7						
100 – 150	12						
150 – 200	13						
200 – 250	14						
250 – 300	8						
300 – 350	10						
350 – 400	8						
400 – 450	12						
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 26 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 06/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 26-1	Site 26-1A	Site 26-2	Site 26-2A	Site 26-3	Site 26-4	Site 26-5
0 – 50	13	7	3	5	7	5	5
50 – 100	8	13	5	7	5	2	5
100 – 150	9	14	8	6	8	2	5
150 – 200	10		2	4	8	2	5
200 – 250	10		5	8	5	2	4
250 – 300	14		10	6	3	6	12
300 – 350				1	2	9	13 / 25 mm
350 – 400				5	5	13	
400 – 450				13	9		
450 – 500					15		
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)	Site 26-6	Site 26-6A	Site 26-7	Site 26-8	Site 26-8A	Site 26-9	Site 26-10
0 – 50	6	8	8	17	13	8	8
50 – 100	14	10	9		8	6	8
100 – 150		10	8		13	5	8
150 – 200		10	8		12	7	14 / 30 mm
200 – 250		9	7		12 / 40 mm	6	
250 – 300		18	3			7	
300 – 350			8			9	
350 – 400			16			10	
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 26 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 06/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 26-10A	Site 26-11	Site 26-12	Site 26-12A			
0 – 50	10	4	10	10			
50 – 100	8	7	10	14			
100 – 150	12	7	16	10			
150 – 200	9	7		10			
200 – 250	11	16		10			
250 – 300	15	7		9			
300 – 350		4		10 / 25 mm			
350 – 400		8					
400 – 450		9					
450 – 500		14					
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 27 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 06/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 27-1	Site 27-2	Site 27-3	Site 27-3A	Site 27-4	Site 27-5	
0 – 50	5	5	6	6	3	7	
50 – 100	7	5	5	6	5	10	
100 – 150	5	4		7	7	10	
150 – 200	5	5		7	4	10	
200 – 250	5	5		4	4	12	
250 – 300	7	6		4	11	14	
300 – 350	8	9		11	12	20	
350 – 400	14	13					
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 28 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 07/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 28-1	Site 28-2	Site 28-3	Site 28-4	Site 28-5		
0 – 50	4	6	6	4	7		
50 – 100	4	7	7	6	7		
100 – 150	5	8	8	5	10		
150 – 200	6	7	9	5	5		
200 – 250	5	7	6	8	5		
250 – 300	4	9	5	14	5		
300 – 350	3	12	8	20 / 30 mm	7		
350 – 400	4		16		12		
400 – 450	3						
450 – 500	6						
500 – 550	7						
550 – 600	6						
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:

Client: ARRB

Project: Best Practice in Compaction QA

Job No: 2091

Location: Site 29 (Smithfield Bypass – Trial Embankment)

Test Method: AS 1289.6.3.2. - 1997 *Methods of Testing Soils for Engineering Purposes - 9 kg Dynamic Cone Penetrometer Test*

Test Date: 07/03/2019

Tested By: RM

Checked: DWL

Drop Height: 510 mm

Hammer Mass: 9 kg

Tip Type: Conical

Test Depth (mm)	Site 29-1	Site 29-2	Site 29-3	Site 29-4	Site 29-5		
0 – 50	4	3	9	8	10		
50 – 100	4	3	8	5	11		
100 – 150	7	3	8	6	8		
150 – 200	3	3	14	4	12		
200 – 250	5	4	11	9	11		
250 – 300	3	2	19	7	15		
300 – 350	6	6	9	8	17 / 25 mm		
350 – 400	6	8	14	9			
400 – 450	12	8		9			
450 – 500		10		5			
500 – 550		10		8			
550 – 600		10		9			
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Test Depth (mm)							
0 – 50							
50 – 100							
100 – 150							
150 – 200							
200 – 250							
250 – 300							
300 – 350							
350 – 400							
400 – 450							
450 – 500							
500 – 550							
550 – 600							
600 – 650							
650 – 700							
700 – 750							
750 – 800							
800 – 850							
850 – 900							

Remarks:



Appendix H

Variable Energy Dynamic Cone Penetrometer (PANDA Probe)

– Test Certificates

PANDA Probe - Test Report

Site 7-1

Certificate Reference:

2091-PND-Site 7-1

Sheet:

1 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 7-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	5.31	41	5	15.58			
2	5	12.09	42	3	30.66			
3	5	16.44	43	2	33.34			
4	6	12.42	44	3	21.65			
5	5	25.89	45	3	16.63			
6	4	27.92	46	3	24.44			
7	4	22.94	47	3	16.06			
8	4	31.77	48	2	19.19			
9	2	36.81	49	3	17.64			
10	3	36.84	50	3	16.74			
11	3	39.42	51	3	15.54			
12	5	27.66	52	3	22.00			
13	5	31.11	53	3	25.18			
14	2	48.96	54	1	52.72			
15	5	30.67	55	2	37.99			
16	2	53.18	56	2	46.41			
17	3	38.71	57	3	31.91			
18	3	51.06	58	2	36.43			
19	3	42.79	59	2	40.25			
20	2	57.54	60	2	31.47			
21	2	101.66	61	2	26.50			
22	2	58.31	62	2	40.29			
23	5	37.62	63	2	33.11			
24	5	26.86	64	2	53.50			
25	4	38.12	End of Test Record					
26	4	34.35						
27	2	47.40						
28	4	19.19						
29	4	35.69						
30	4	35.13						
31	4	26.69						
32	4	25.73						
33	4	28.77						
34	4	33.22						
35	3	39.73						
36	3	20.70						
37	5	24.15						
38	4	22.48						
39	4	28.19						
40	4	24.67						

PANDA Probe - Test Report

Site 7-1

Certificate Reference:

2091-PND-Site 7-1

Sheet:

2 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

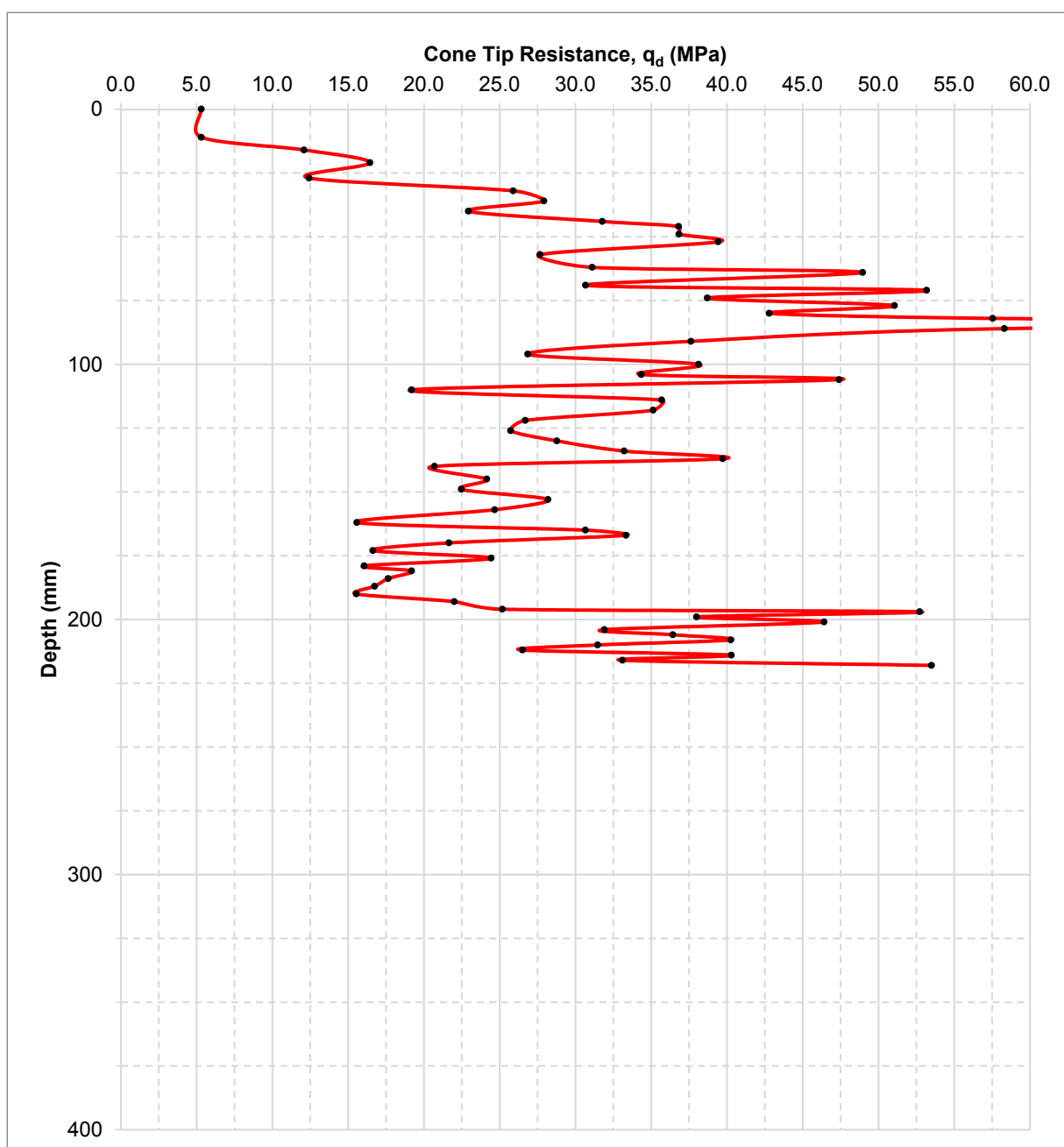
Project No.: 2091

Checked By: DWL

Location: Site 7-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 7-2

Certificate Reference:

2091-PND-Site 7-2

Sheet:

2 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

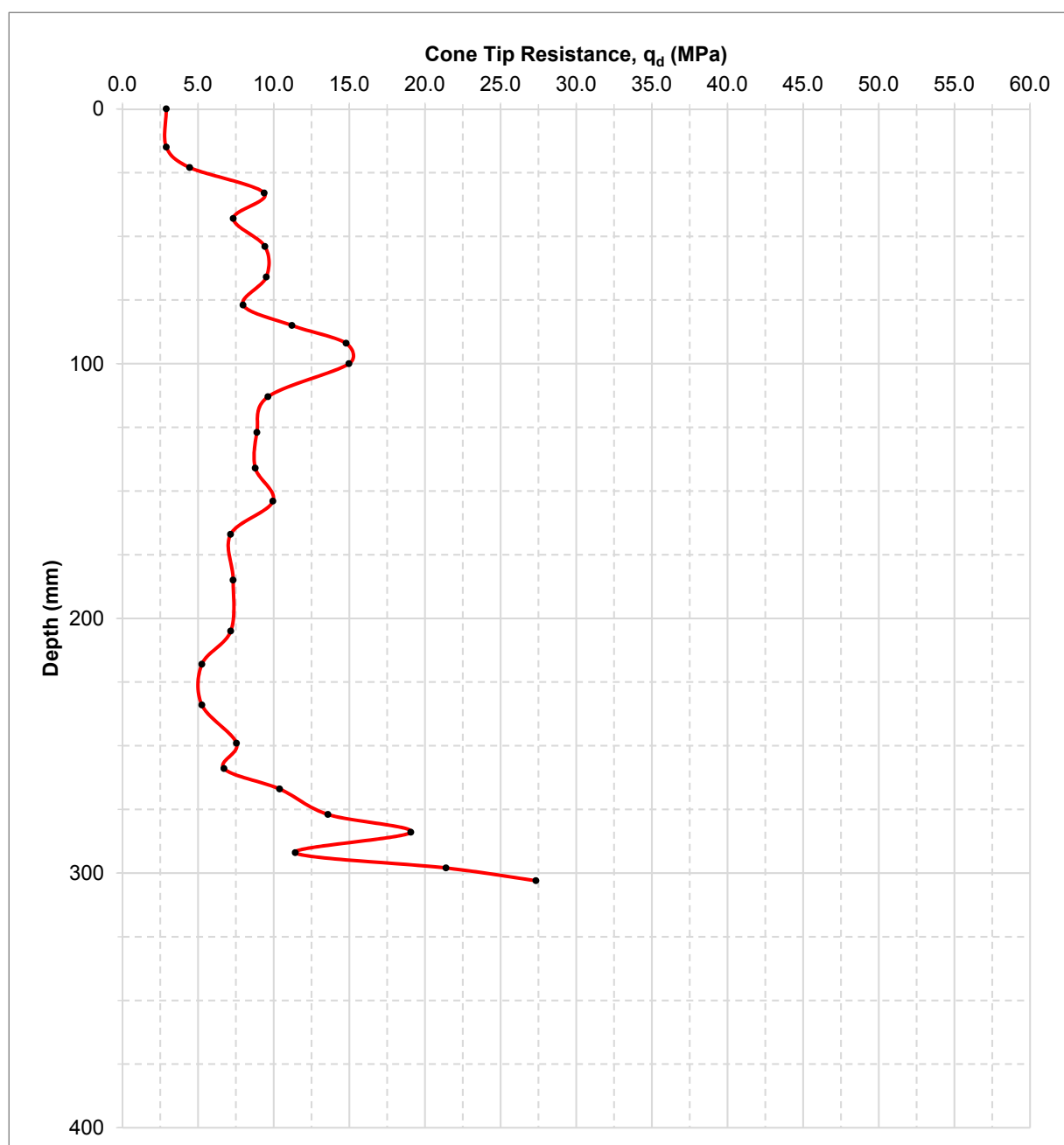
Project No.: 2091

Checked By: DWL

Location: Site 7-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 7-3

Certificate Reference:

2091-PND-Site 7-3

Sheet:

1 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 7-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	16	2.62	41	9	14.13			
2	6	9.23	42	6	23.25			
3	6	12.80	43	3	36.31			
4	5	12.84	End of Test Record					
5	4	21.14						
6	4	16.32						
7	2	103.78						
8	2	76.49						
9	3	41.16						
10	2	69.74						
11	2	40.98						
12	3	65.02						
13	5	31.81						
14	5	29.54						
15	5	36.26						
16	3	55.27						
17	7	23.41						
18	5	30.60						
19	5	24.97						
20	5	30.25						
21	5	26.02						
22	3	44.98						
23	6	31.90						
24	7	22.66						
25	10	16.29						
26	16	6.16						
27	23	7.26						
28	14	11.19						
29	7	18.99						
30	6	22.56						
31	8	11.87						
32	8	14.85						
33	8	17.03						
34	7	18.76						
35	5	21.92						
36	6	24.33						
37	12	12.85						
38	14	6.84						
39	14	10.95						
40	11	10.33						

PANDA Probe - Test Report

Site 7-3

Certificate Reference:

2091-PND-Site 7-3

Sheet:

2 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

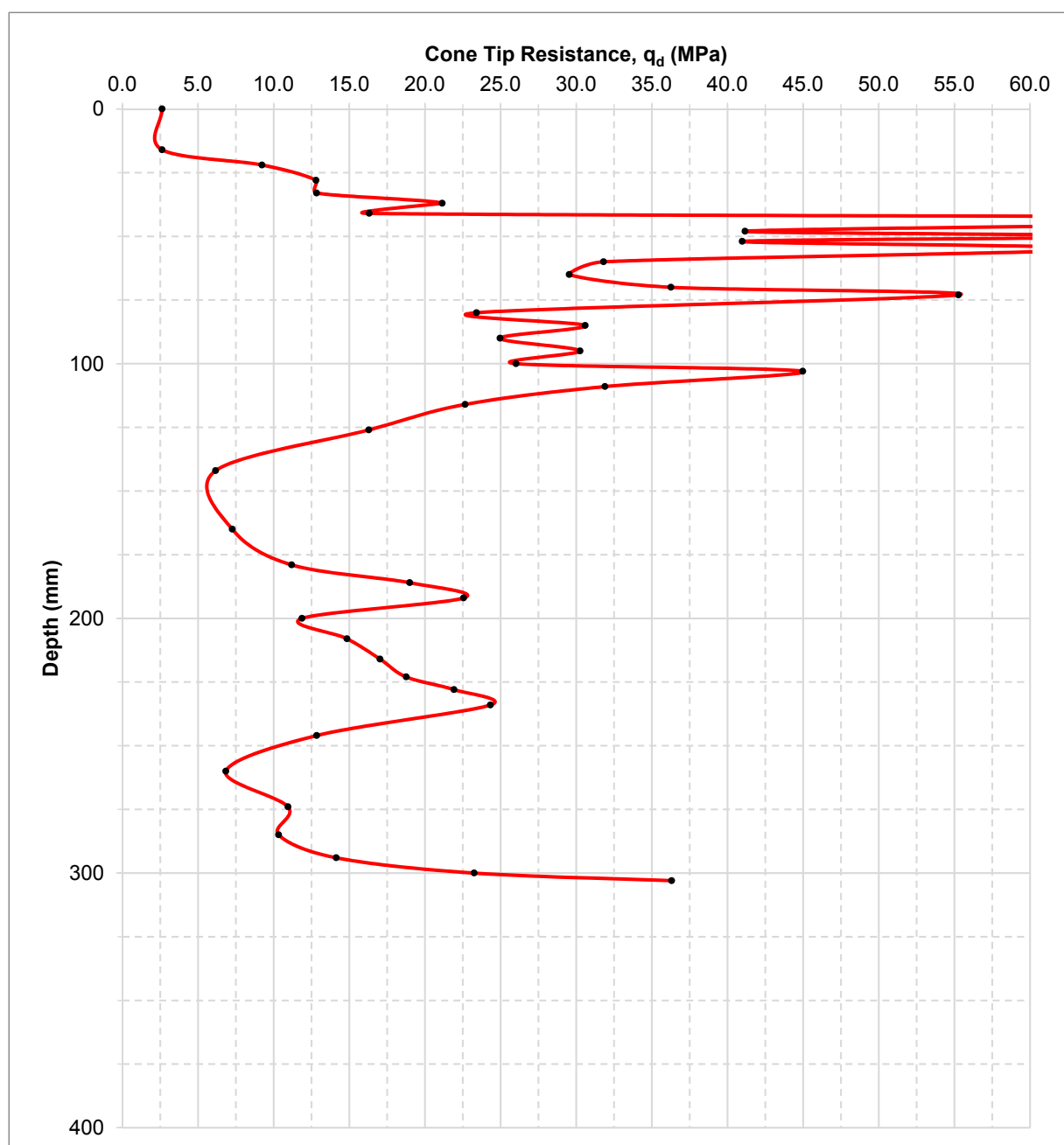
Project No.: 2091

Checked By: DWL

Location: Site 7-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 7-4

Certificate Reference:

2091-PND-Site 7-4

Sheet:

2 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

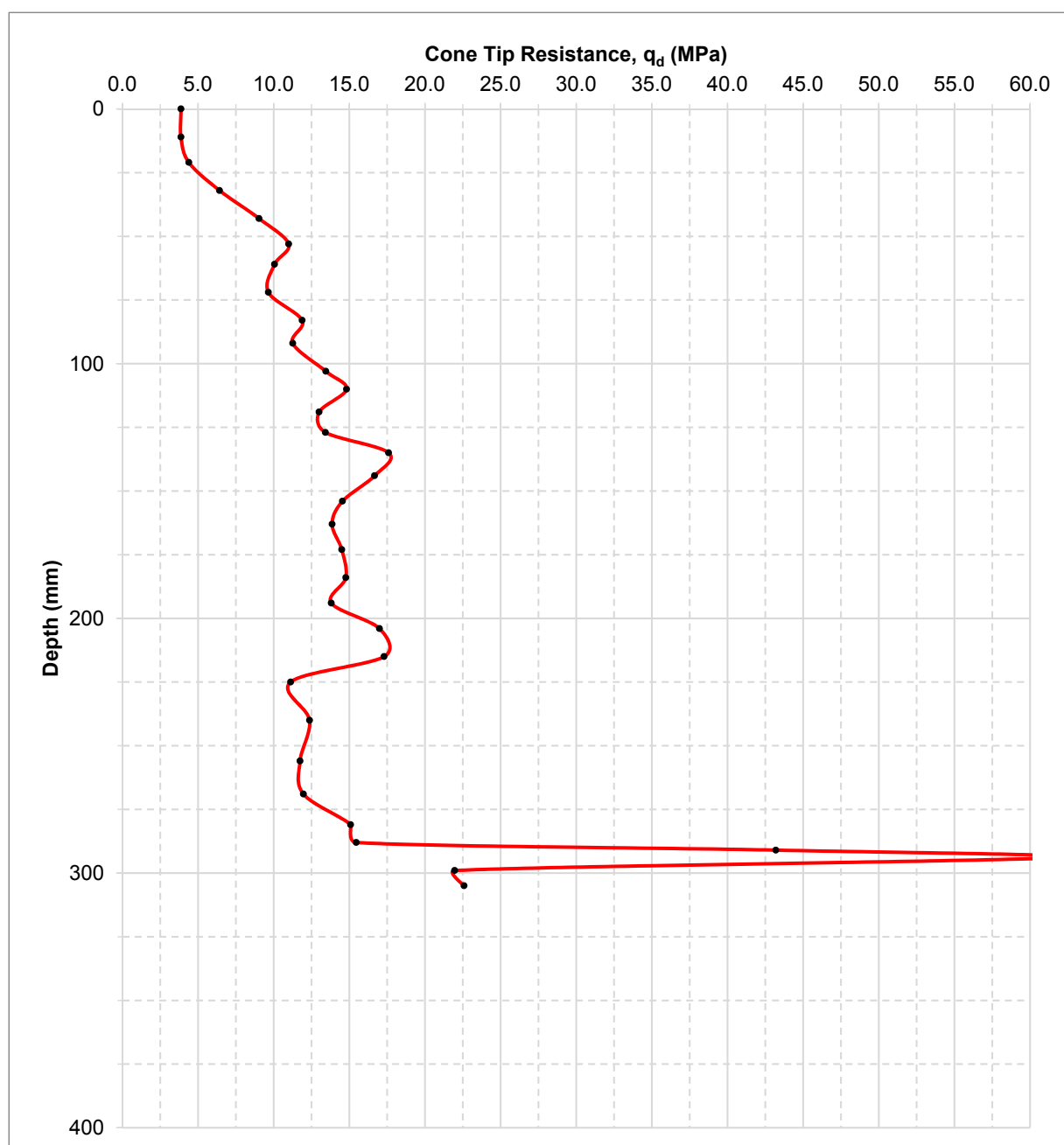
Project No.: 2091

Checked By: DWL

Location: Site 7-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 8-1

Certificate Reference:

2091-PND-Site 8-1

Sheet:

1 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 8-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	3.66	End of Test Record					
2	11	8.07						
3	12	8.05						
4	12	7.72						
5	10	10.04						
6	8	13.56						
7	9	12.28						
8	16	8.37						
9	12	8.49						
10	13	9.66						
11	13	11.42						
12	9	11.62						
13	12	11.82						
14	9	11.50						
15	8	14.23						
16	8	14.69						
17	7	13.66						
18	9	9.58						
19	9	10.33						
20	8	12.28						
21	7	13.67						
22	7	19.75						
23	7	17.56						
24	8	18.32						
25	7	20.38						
26	6	17.88						
27	7	20.68						
28	6	21.34						
29	7	19.53						
30	7	21.31						
31	5	25.46						
32	5	32.73						
33	5	25.91						
34	4	31.63						
35	3	31.22						
36	2	45.35						
37	4	24.19						
38	2	49.43						
39	4	27.58						
40	3	36.32						

PANDA Probe - Test Report

Site 8-1

Certificate Reference:

2091-PND-Site 8-1

Sheet:

2 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

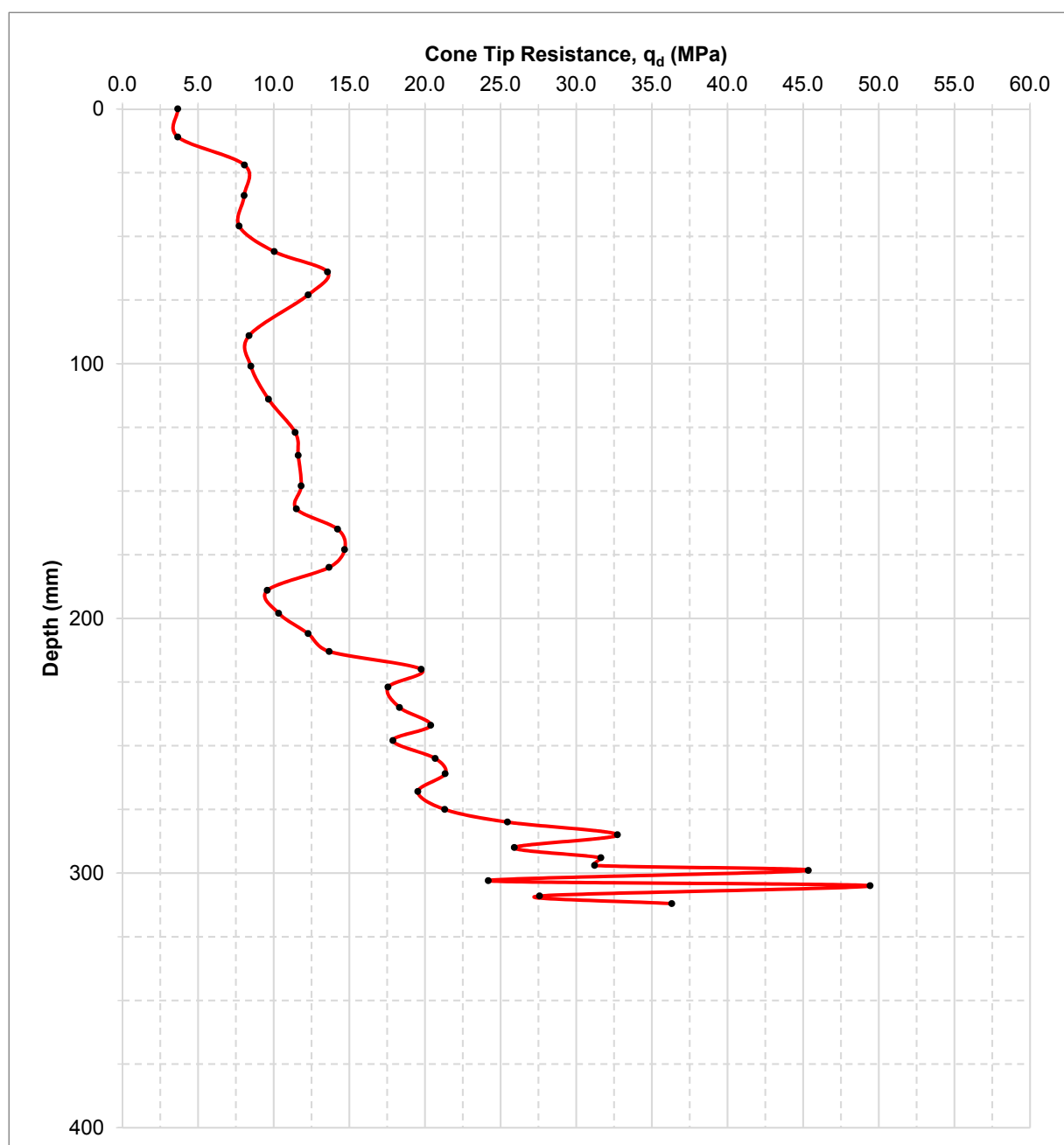
Project No.: 2091

Checked By: DWL

Location: Site 8-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 8-2

Certificate Reference:

2091-PND-Site 8-2

Sheet:

1 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 8-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	2	2.11	41	3	49.07			
2	4	4.79	42	1	64.67			
3	4	6.70	43	3	38.30			
4	6	6.03	44	2	78.38			
5	6	6.01	45	2	41.58			
6	6	8.70	46	1	79.89			
7	5	8.12	47	2	64.78			
8	4	11.39	End of Test Record					
9	6	7.83						
10	8	10.68						
11	5	19.97						
12	4	25.95						
13	4	23.89						
14	5	26.27						
15	6	21.28						
16	6	23.64						
17	5	22.51						
18	4	26.09						
19	3	29.42						
20	4	29.57						
21	3	38.05						
22	1	77.09						
23	4	24.41						
24	4	22.30						
25	7	21.73						
26	6	17.60						
27	5	23.21						
28	5	16.63						
29	5	21.02						
30	8	18.83						
31	6	17.66						
32	6	17.27						
33	7	18.34						
34	7	13.40						
35	8	14.19						
36	6	11.14						
37	7	16.54						
38	7	18.10						
39	3	27.22						
40	1	46.94						

PANDA Probe - Test Report

Site 8-2

Certificate Reference:

2091-PND-Site 8-2

Sheet:

2 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

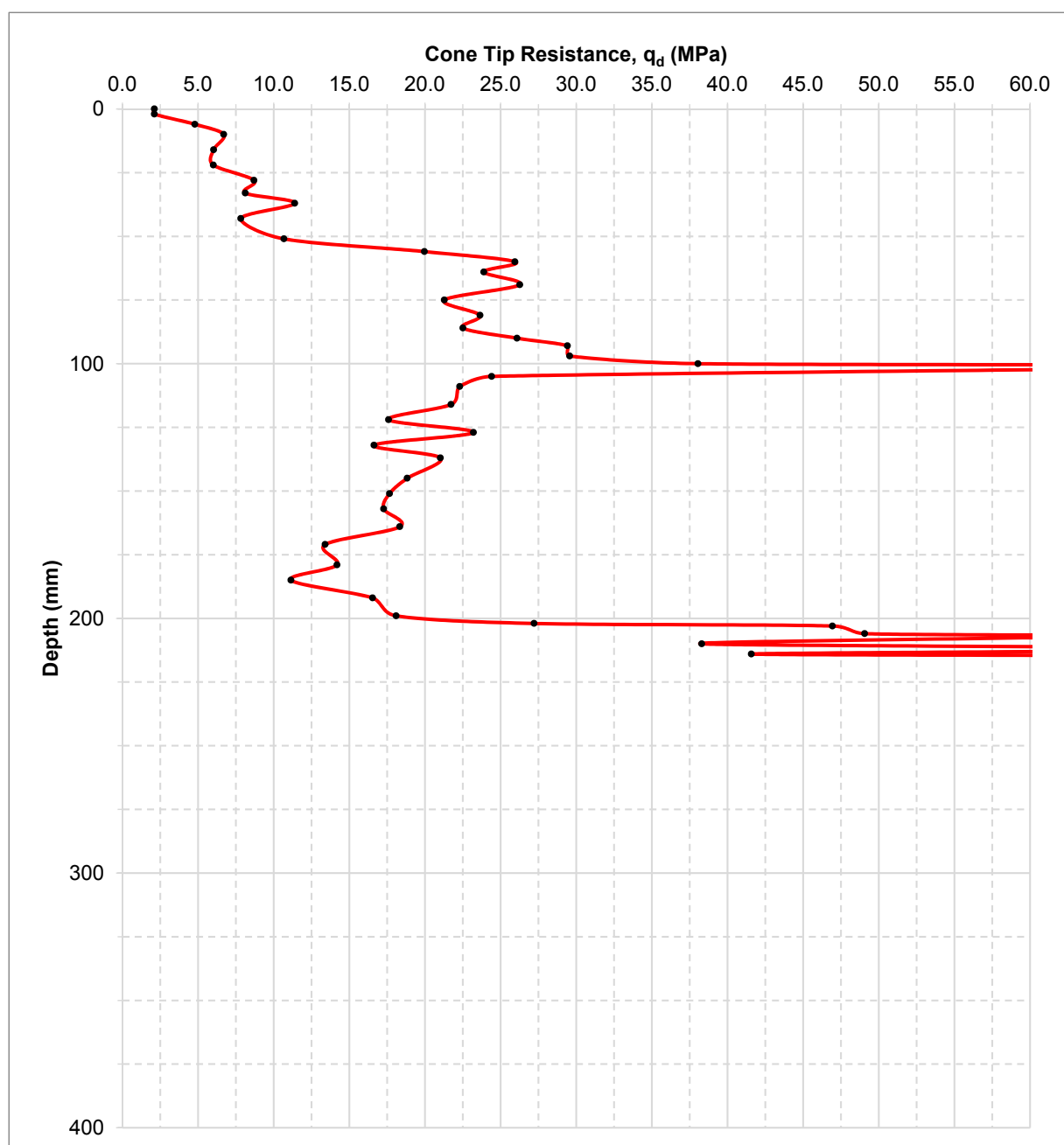
Project No.: 2091

Checked By: DWL

Location: Site 8-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 8-3

Certificate Reference:

2091-PND-Site 8-3

Sheet:

1 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 8-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.89	41	5	28.19			
2	5	6.91	42	5	28.44			
3	10	8.77	43	6	21.86			
4	8	7.49	44	3	26.41			
5	9	10.42	45	4	18.17			
6	11	10.97	46	3	23.15			
7	8	12.13	47	3	17.05			
8	6	10.47	48	3	26.76			
9	5	19.88	49	3	25.16			
10	6	17.14	End of Test Record					
11	8	14.24						
12	9	9.53						
13	5	15.16						
14	7	16.52						
15	5	20.23						
16	5	18.24						
17	5	20.53						
18	9	16.14						
19	8	12.93						
20	8	9.92						
21	8	13.92						
22	8	15.03						
23	9	17.23						
24	10	13.04						
25	8	15.09						
26	8	15.98						
27	9	10.52						
28	10	14.03						
29	8	12.32						
30	9	14.86						
31	8	12.87						
32	7	15.32						
33	6	15.34						
34	8	16.67						
35	5	17.21						
36	5	24.61						
37	6	24.28						
38	4	20.70						
39	3	37.56						
40	5	26.82						

PANDA Probe - Test Report

Site 8-3

Certificate Reference:

2091-PND-Site 8-3

Sheet:

2 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

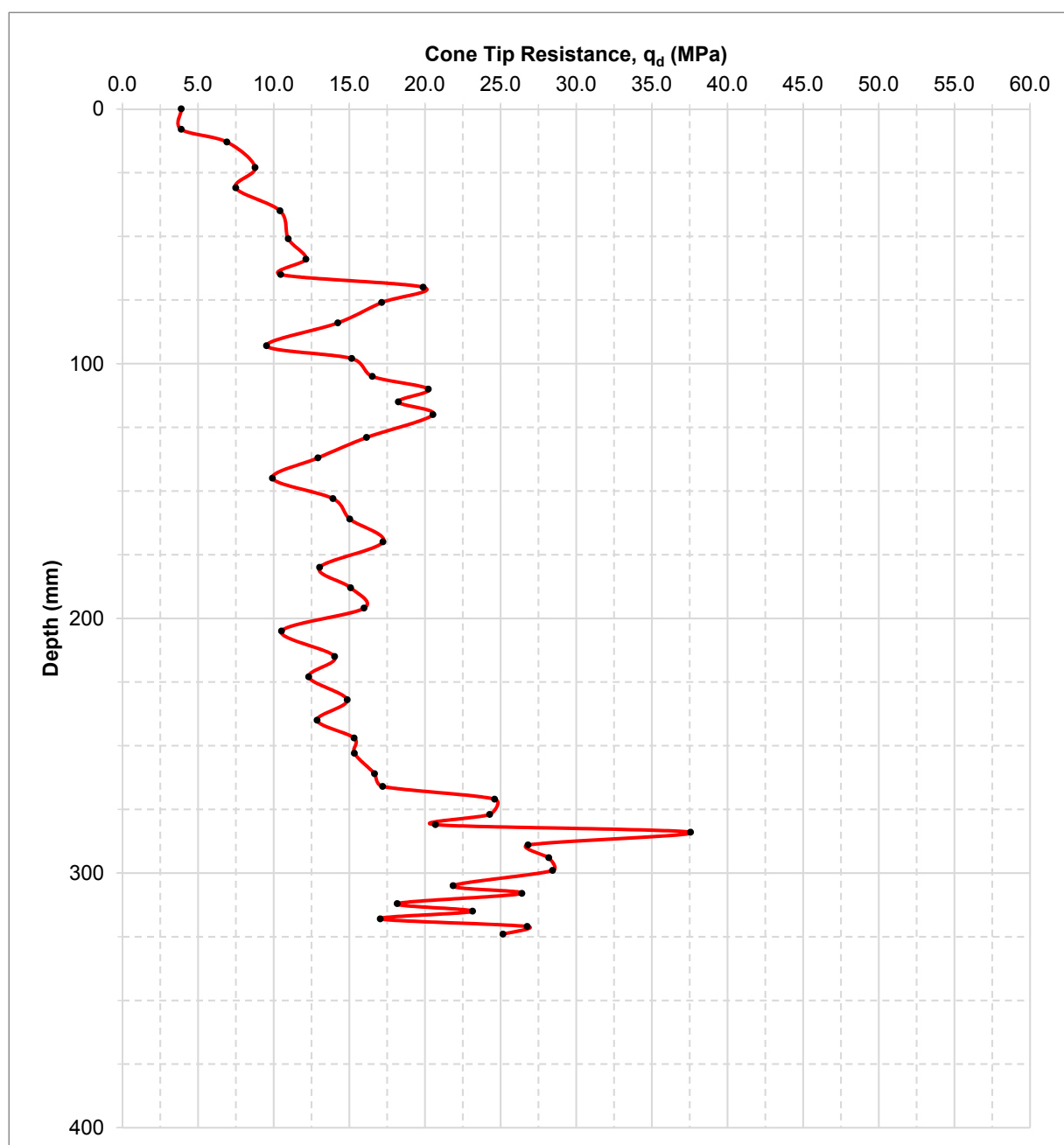
Project No.: 2091

Checked By: DWL

Location: Site 8-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 8-4

Certificate Reference:

2091-PND-Site 8-4

Sheet:

1 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 8-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	3.61	41	3	33.95			
2	9	3.50	End of Test Record					
3	9	4.80						
4	6	7.29						
5	7	7.57						
6	8	10.62						
7	8	6.72						
8	7	11.33						
9	8	11.47						
10	7	9.66						
11	7	14.22						
12	8	13.36						
13	7	14.48						
14	6	12.41						
15	5	16.93						
16	8	16.93						
17	5	14.55						
18	8	14.28						
19	6	12.16						
20	6	12.65						
21	7	16.09						
22	6	15.55						
23	6	15.57						
24	5	19.22						
25	6	17.50						
26	5	16.79						
27	2	17.16						
28	3	26.00						
29	2	35.16						
30	2	43.32						
31	3	27.95						
32	1	63.58						
33	4	28.29						
34	2	51.35						
35	5	31.45						
36	3	38.00						
37	5	34.05						
38	4	27.00						
39	3	47.64						
40	4	39.85						

PANDA Probe - Test Report

Site 8-4

Certificate Reference:

2091-PND-Site 8-4

Sheet:

2 of 2

Client: ARRB

Test Date: 13/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

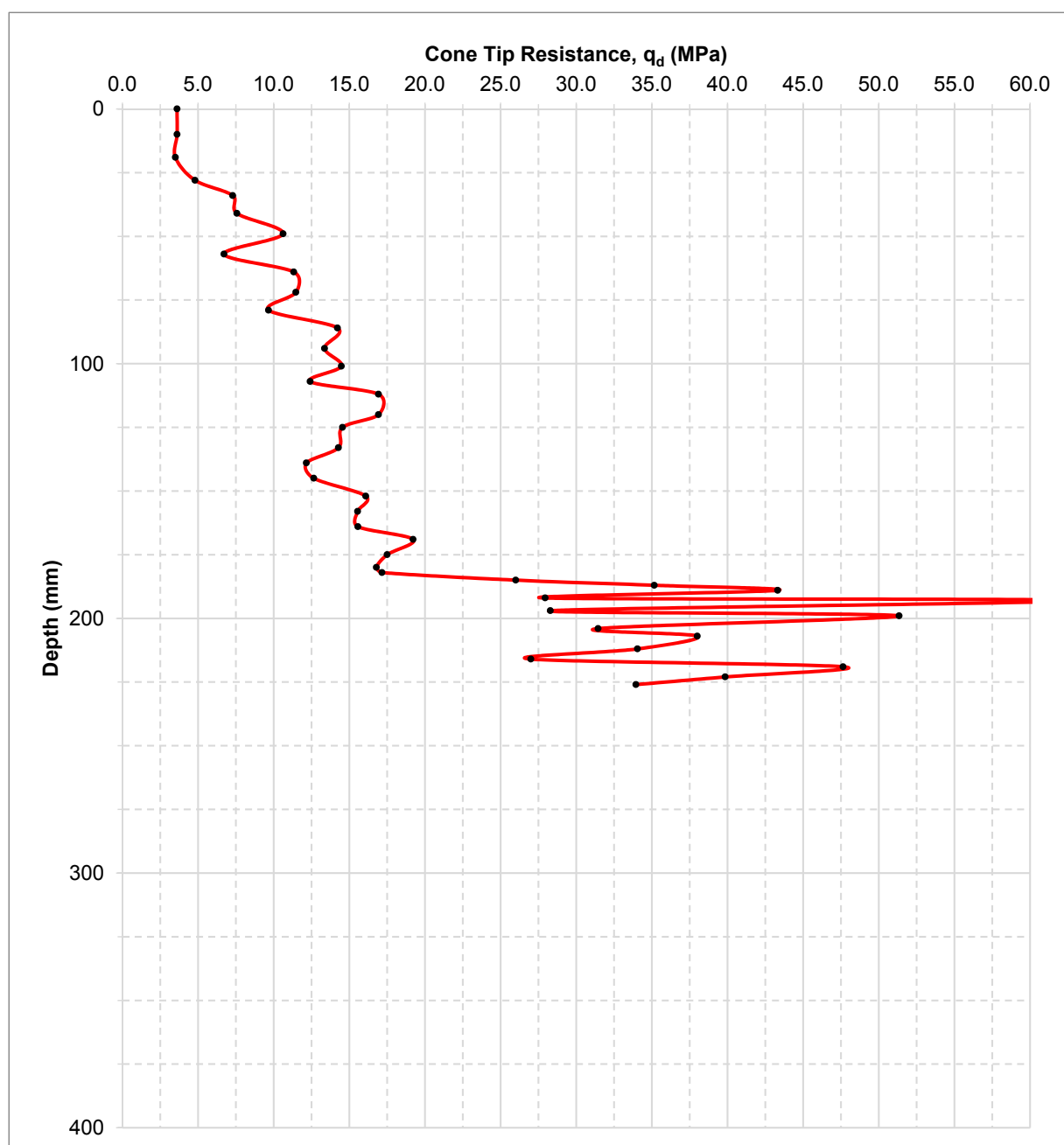
Project No.: 2091

Checked By: DWL

Location: Site 8-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 9-1

Certificate Reference:

2091-PND-Site 9-1

Sheet:

1 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 9-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.88	41	3	43.49			
2	7	7.35	42	4	29.18			
3	9	9.52	43	5	31.31			
4	9	10.37	44	5	25.29			
5	7	7.34	45	4	25.41			
6	10	7.55	46	3	22.86			
7	12	9.20	47	5	25.76			
8	9	9.19	48	4	22.48			
9	9	10.50	49	6	19.86			
10	7	11.38	50	4	21.52			
11	6	16.07	51	3	28.32			
12	7	17.82	52	3	27.50			
13	6	18.32	End of Test Record					
14	5	13.24						
15	6	18.73						
16	5	16.46						
17	7	12.51						
18	6	13.88						
19	4	16.23						
20	7	16.64						
21	6	12.40						
22	6	18.51						
23	6	14.52						
24	6	17.16						
25	6	18.12						
26	6	20.85						
27	5	26.25						
28	4	26.49						
29	5	17.07						
30	4	26.45						
31	4	26.73						
32	5	23.41						
33	3	30.66						
34	5	21.26						
35	5	22.65						
36	6	22.64						
37	5	22.42						
38	5	23.88						
39	5	23.42						
40	4	21.69						

PANDA Probe - Test Report

Site 9-1

Certificate Reference:

2091-PND-Site 9-1

Sheet:

2 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

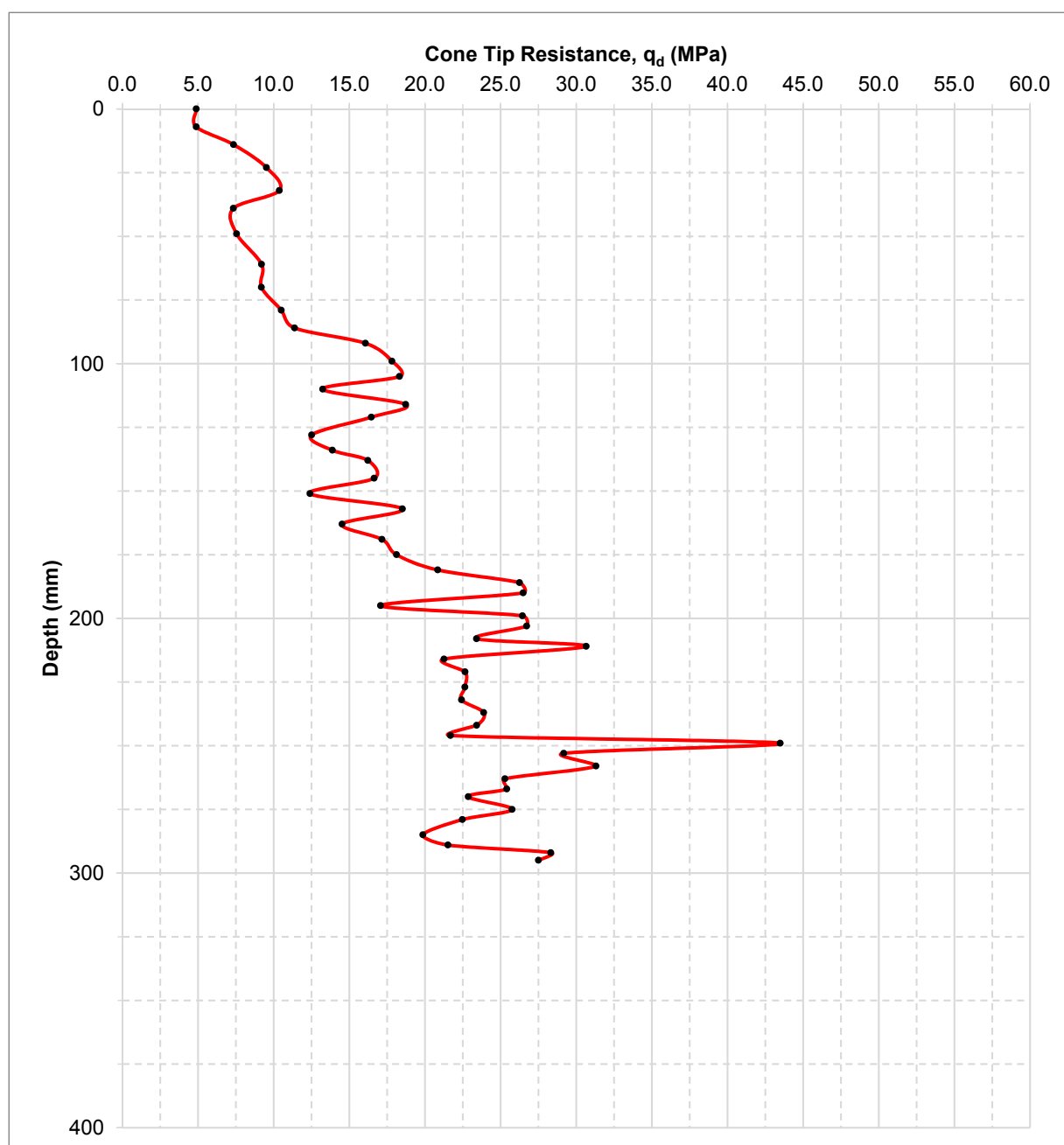
Project No.: 2091

Checked By: DWL

Location: Site 9-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 9-2

Certificate Reference:

2091-PND-Site 9-2

Sheet:

1 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 9-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	10.16	41	8	19.08			
2	6	9.32	42	7	21.87			
3	8	11.77	43	7	17.96			
4	7	10.90	44	8	13.40			
5	7	12.60	45	6	19.58			
6	6	16.87	46	6	21.15			
7	6	13.60	47	4	23.26			
8	7	17.01	End of Test Record					
9	7	17.56						
10	6	15.34						
11	7	15.29						
12	5	21.11						
13	5	25.21						
14	5	22.76						
15	4	19.04						
16	6	21.52						
17	6	21.79						
18	7	17.30						
19	8	21.07						
20	6	22.02						
21	4	23.19						
22	6	25.02						
23	5	27.22						
24	8	23.86						
25	7	17.05						
26	7	19.19						
27	8	18.49						
28	5	24.76						
29	9	21.82						
30	6	17.71						
31	7	19.99						
32	5	21.47						
33	6	17.20						
34	6	23.99						
35	6	21.62						
36	6	19.69						
37	7	19.58						
38	6	17.43						
39	7	19.80						
40	7	19.96						

PANDA Probe - Test Report

Site 9-2

Certificate Reference:

2091-PND-Site 9-2

Sheet:

2 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

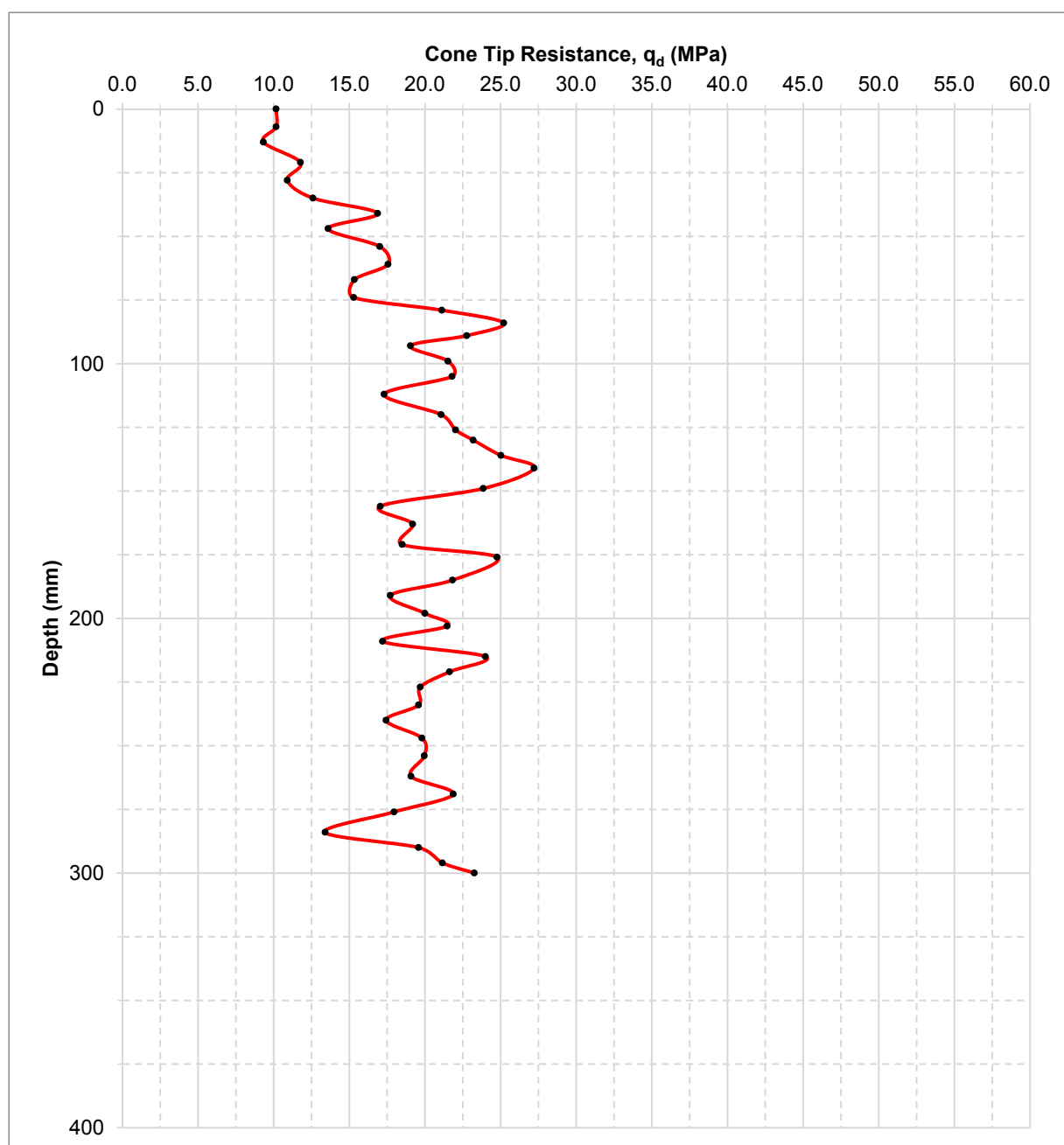
Project No.: 2091

Checked By: DWL

Location: Site 9-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 9-3

Certificate Reference:

2091-PND-Site 9-3

Sheet:

1 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 9-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	7.17	41	5	25.12			
2	9	7.16	42	5	23.38			
3	9	8.78	43	5	25.63			
4	6	10.27	44	4	17.04			
5	6	14.39	45	6	16.56			
6	9	10.54	46	6	16.24			
7	6	10.97	47	7	17.91			
8	8	17.01	48	7	16.68			
9	7	16.36	49	7	15.02			
10	7	16.76	50	7	13.14			
11	7	20.57	End of Test Record					
12	6	18.90						
13	6	17.43						
14	7	16.65						
15	4	24.53						
16	6	18.20						
17	5	19.07						
18	6	14.96						
19	6	16.03						
20	6	16.54						
21	7	17.23						
22	7	12.70						
23	8	16.46						
24	7	18.68						
25	5	25.80						
26	7	20.26						
27	7	20.44						
28	7	20.70						
29	6	21.75						
30	5	20.91						
31	4	24.50						
32	6	18.98						
33	4	25.02						
34	4	17.96						
35	4	21.61						
36	5	20.84						
37	5	23.42						
38	5	21.04						
39	4	19.32						
40	5	26.02						

PANDA Probe - Test Report

Site 9-3

Certificate Reference:

2091-PND-Site 9-3

Sheet:

2 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

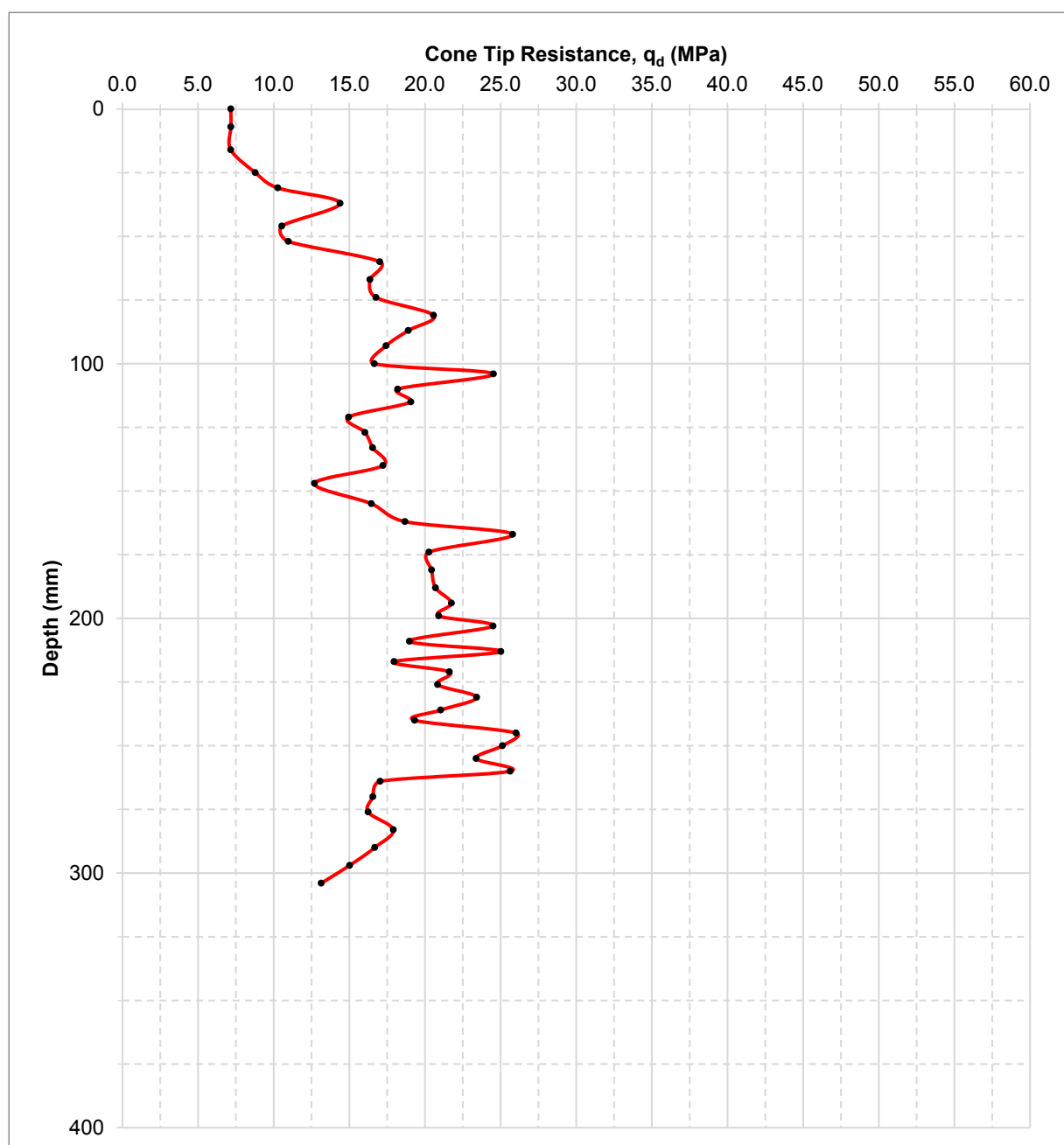
Project No.: 2091

Checked By: DWL

Location: Site 9-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 9-4

Certificate Reference:

2091-PND-Site 9-4

Sheet:

1 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 9-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	13	4.67	41	5	11.58			
2	8	7.26	42	3	19.68			
3	10	7.95	43	3	16.81			
4	8	9.92	End of Test Record					
5	7	14.47						
6	13	9.06						
7	15	7.37						
8	11	9.36						
9	14	8.92						
10	13	10.03						
11	9	14.62						
12	6	19.31						
13	9	19.91						
14	7	21.88						
15	7	19.58						
16	7	20.94						
17	5	24.72						
18	8	17.88						
19	8	17.71						
20	6	22.98						
21	5	24.59						
22	7	19.43						
23	7	16.83						
24	6	14.40						
25	8	21.65						
26	4	29.38						
27	3	36.29						
28	4	34.01						
29	3	39.08						
30	5	23.29						
31	6	23.05						
32	6	22.24						
33	6	17.67						
34	6	21.71						
35	4	22.68						
36	5	20.42						
37	4	23.01						
38	6	17.14						
39	5	16.93						
40	5	21.75						

PANDA Probe - Test Report

Site 9-4

Certificate Reference:

2091-PND-Site 9-4

Sheet:

2 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

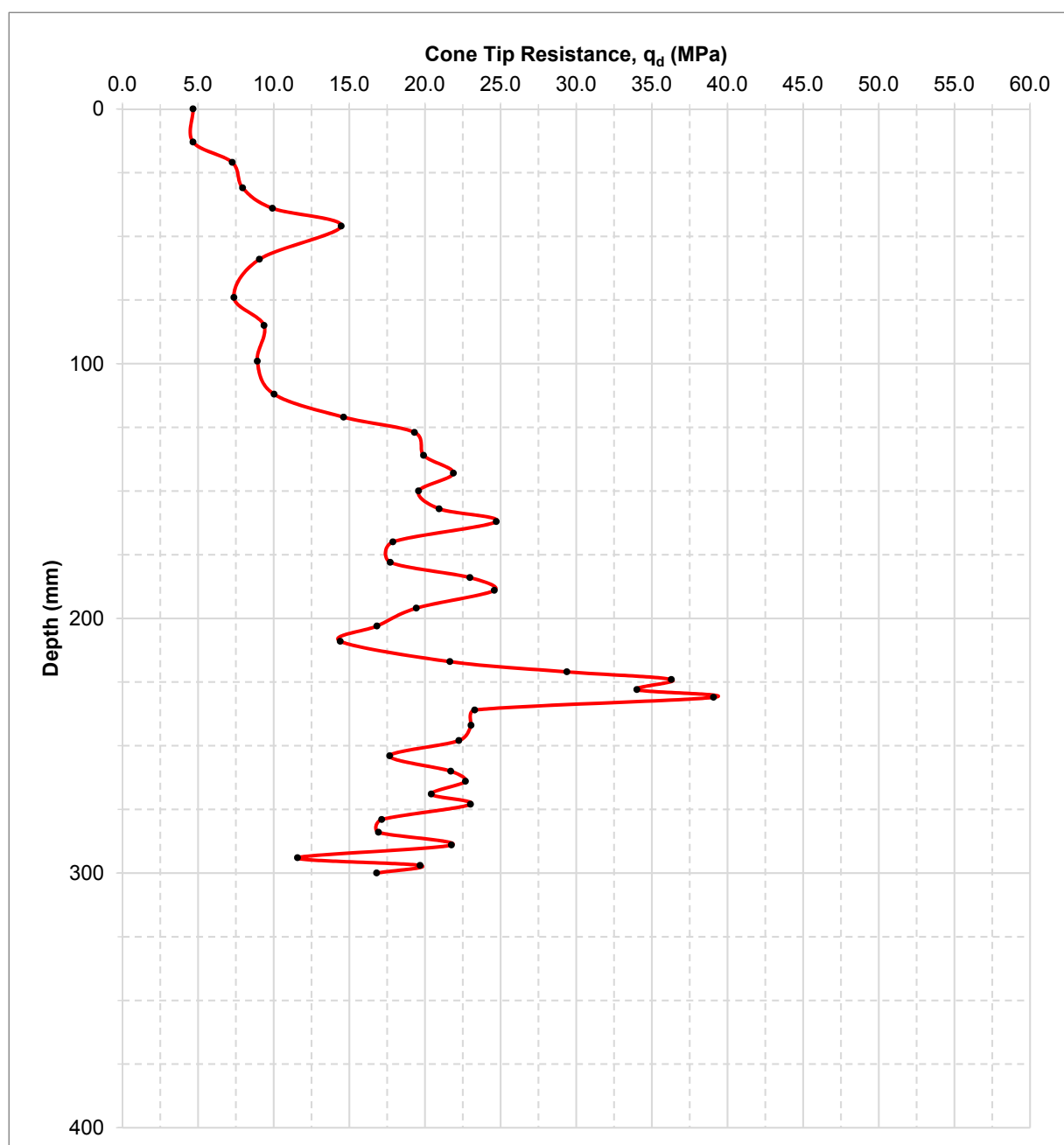
Project No.: 2091

Checked By: DWL

Location: Site 9-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 10-1

Certificate Reference:

2091-PND-Site 10-1

Sheet:

1 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 10-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	4.36						
2	14	4.84						
3	15	5.36						
4	8	8.22						
5	12	11.49						
6	10	11.14						
7	12	11.27						
8	4	18.72						
9	3	39.63						
10	3	53.43						
11	2	58.63						
12	4	36.06						
13	5	24.81						
14	4	34.36						
15	7	21.11						
16	12	12.35						
17	13	13.73						
18	14	11.65						
19	12	8.80						
20	14	12.59						
21	9	17.72						
22	4	30.62						
23	6	31.90						
24	3	41.54						
25	5	31.30						
26	4	36.77						
27	6	27.95						
28	5	24.52						
29	4	32.62						
30	7	23.52						
31	7	22.58						
32	9	18.40						
33	8	16.77						
34	10	14.06						
35	8	17.29						
36	8	17.47						
37	7	15.17						
38	8	16.83						
39	7	17.27						
End of Test Record								

PANDA Probe - Test Report

Site 10-1

Certificate Reference:

2091-PND-Site 10-1

Sheet:

2 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

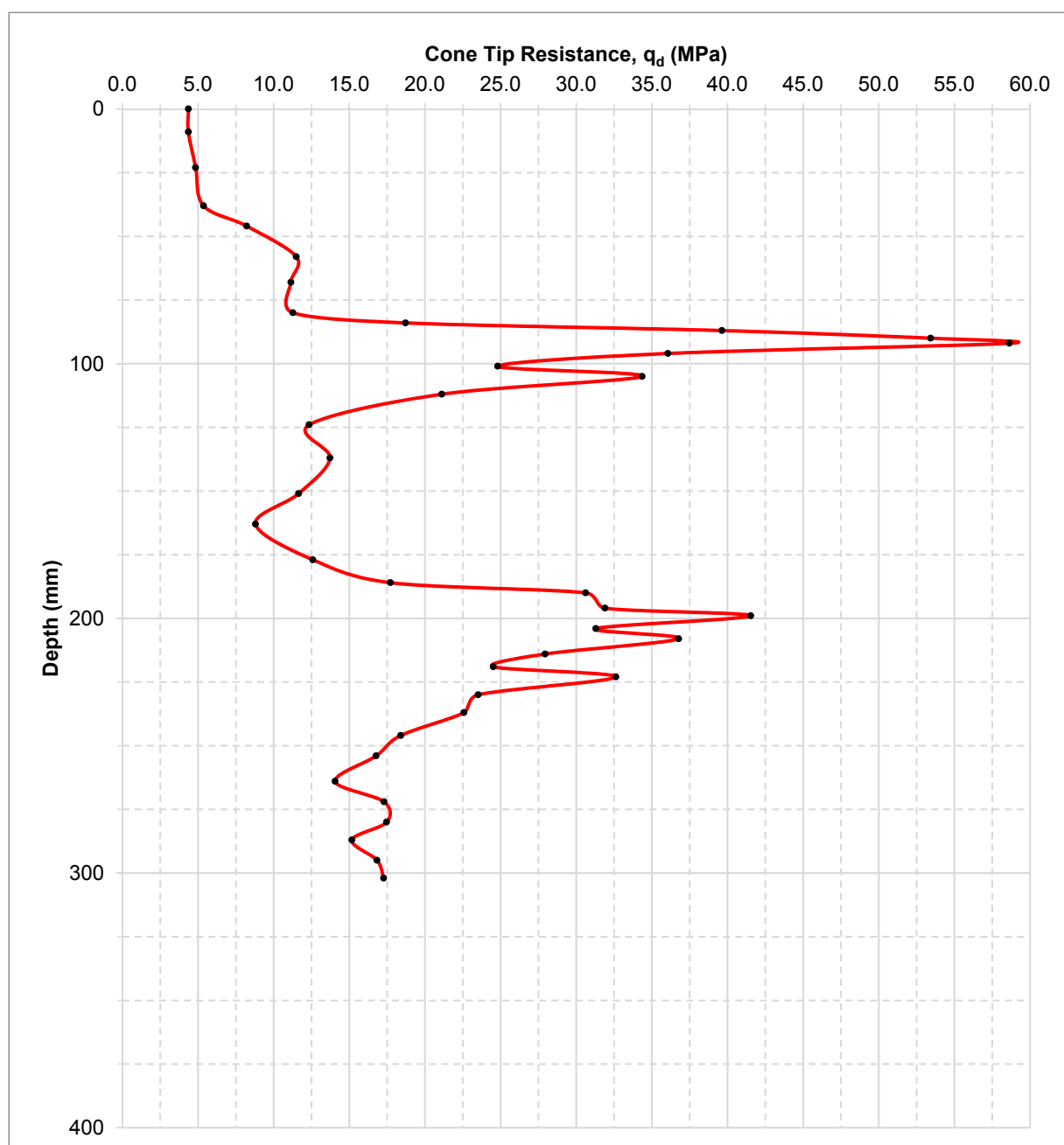
Project No.: 2091

Checked By: DWL

Location: Site 10-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 10-2

Certificate Reference:

2091-PND-Site 10-2

Sheet:

2 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

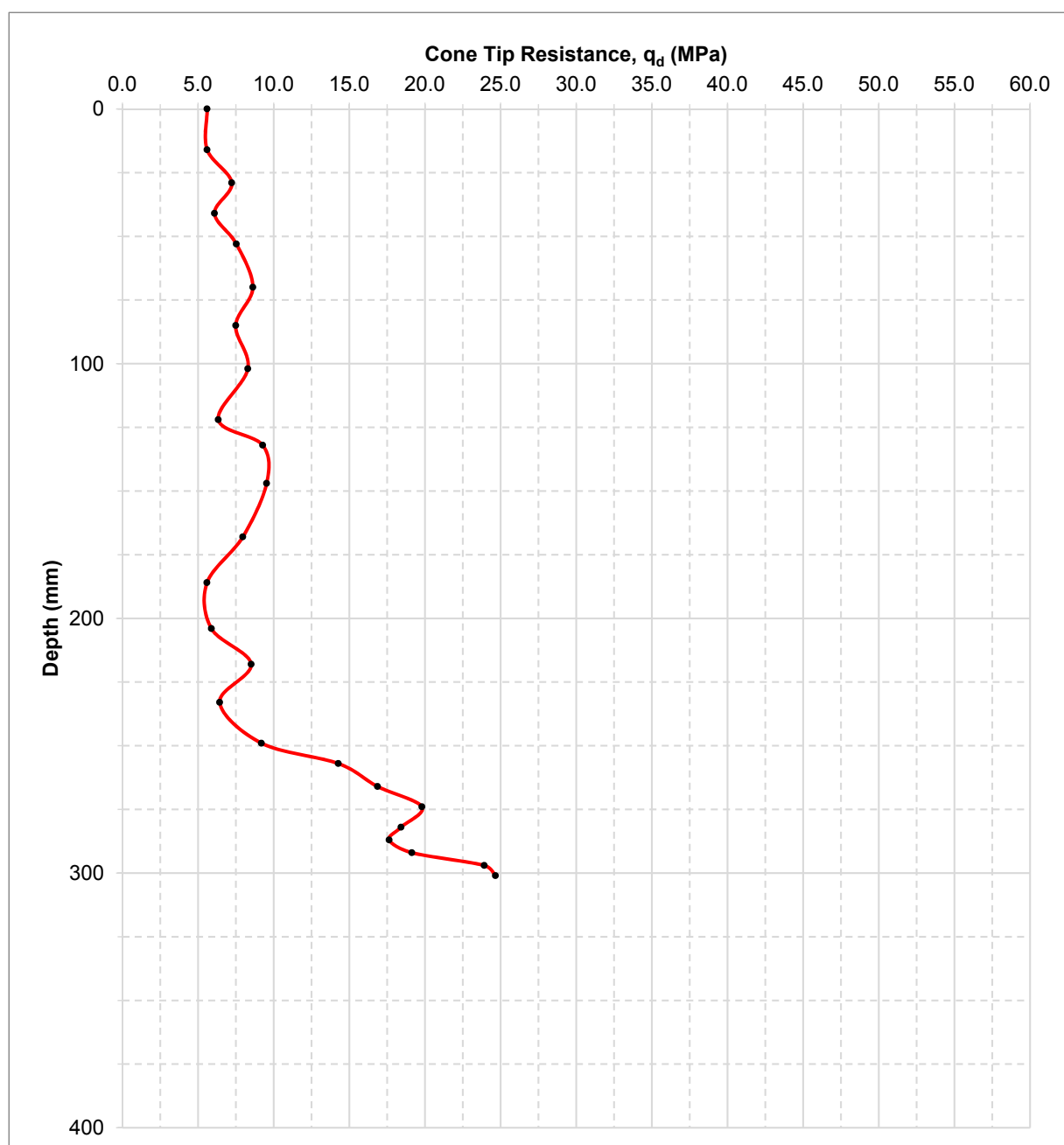
Project No.: 2091

Checked By: DWL

Location: Site 10-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 10-3

Certificate Reference:

2091-PND-Site 10-3

Sheet:

1 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 10-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	9.32	41	6	19.91			
2	11	10.08	42	5	21.69			
3	9	15.56	43	4	29.42			
4	8	15.69	44	4	32.52			
5	9	18.79	45	5	20.54			
6	10	17.93	46	4	29.63			
7	7	13.82	47	3	40.30			
8	3	35.46	48	2	43.62			
9	4	32.59	49	3	54.35			
10	4	34.18	50	2	48.04			
11	5	30.40	51	3	51.90			
12	5	27.27	52	3	51.37			
13	7	24.41	53	3	39.57			
14	6	22.20	54	4	38.10			
15	4	25.47	55	4	33.88			
16	6	24.37	56	5	27.25			
17	7	19.58	End of Test Record					
18	5	22.43						
19	6	19.65						
20	6	22.57						
21	7	22.71						
22	6	22.67						
23	7	21.29						
24	7	22.02						
25	7	24.07						
26	6	18.42						
27	7	19.78						
28	5	21.15						
29	7	24.51						
30	5	17.70						
31	6	21.06						
32	5	24.49						
33	6	21.57						
34	6	23.97						
35	4	34.64						
36	3	28.93						
37	4	32.32						
38	3	27.34						
39	4	21.13						
40	3	28.26						

PANDA Probe - Test Report

Site 10-3

Certificate Reference:

2091-PND-Site 10-3

Sheet:

2 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

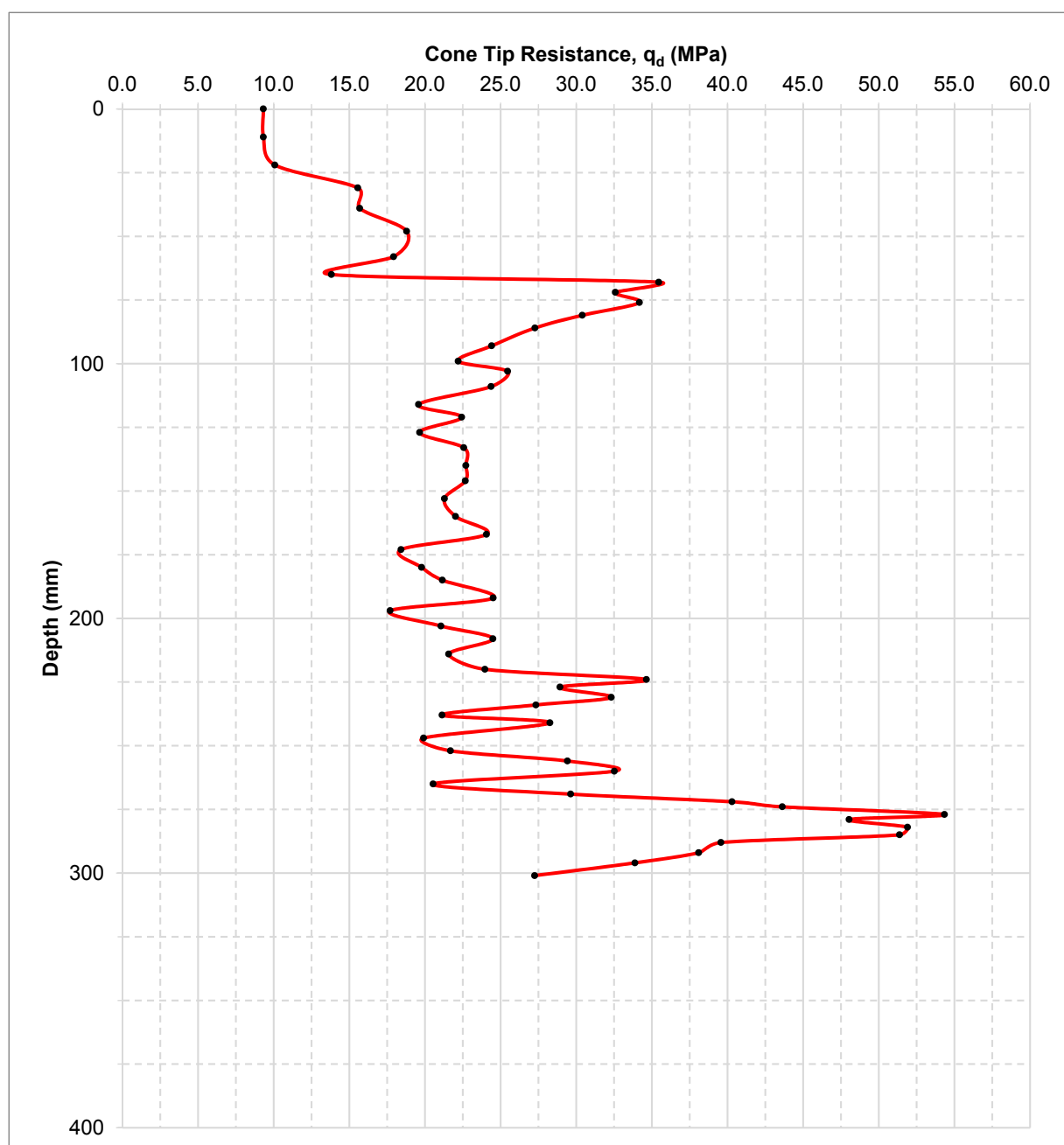
Project No.: 2091

Checked By: DWL

Location: Site 10-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 10-4

Certificate Reference:

2091-PND-Site 10-4

Sheet:

1 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 10-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	5.25	41	6	19.41			
2	7	6.86	42	4	27.88			
3	11	9.76	43	3	40.69			
4	14	10.15	44	6	20.22			
5	12	10.24	45	5	19.07			
6	7	17.03	46	7	23.28			
7	5	25.64	47	5	26.58			
8	6	14.50	48	3	26.84			
9	7	19.73	49	4	38.64			
10	3	48.70	50	2	31.99			
11	2	55.55	51	5	23.44			
12	3	49.41	52	7	16.91			
13	3	42.12	53	9	13.02			
14	4	30.51	54	8	10.81			
15	4	37.18	55	8	11.46			
16	2	14.68	56	8	13.02			
17	3	36.46	57	5	19.49			
18	3	50.11	58	5	16.38			
19	2	61.20	59	3	31.42			
20	1	96.25	End of Test Record					
21	2	58.76						
22	4	30.40						
23	4	40.41						
24	3	52.19						
25	2	54.39						
26	4	51.83						
27	3	50.68						
28	5	35.18						
29	3	46.62						
30	4	33.91						
31	5	28.44						
32	5	26.22						
33	5	29.42						
34	8	24.22						
35	5	17.88						
36	5	23.74						
37	6	21.53						
38	6	16.09						
39	9	17.88						
40	5	17.60						

PANDA Probe - Test Report

Site 10-4

Certificate Reference:

2091-PND-Site 10-4

Sheet:

2 of 2

Client: ARRB

Test Date: 14/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

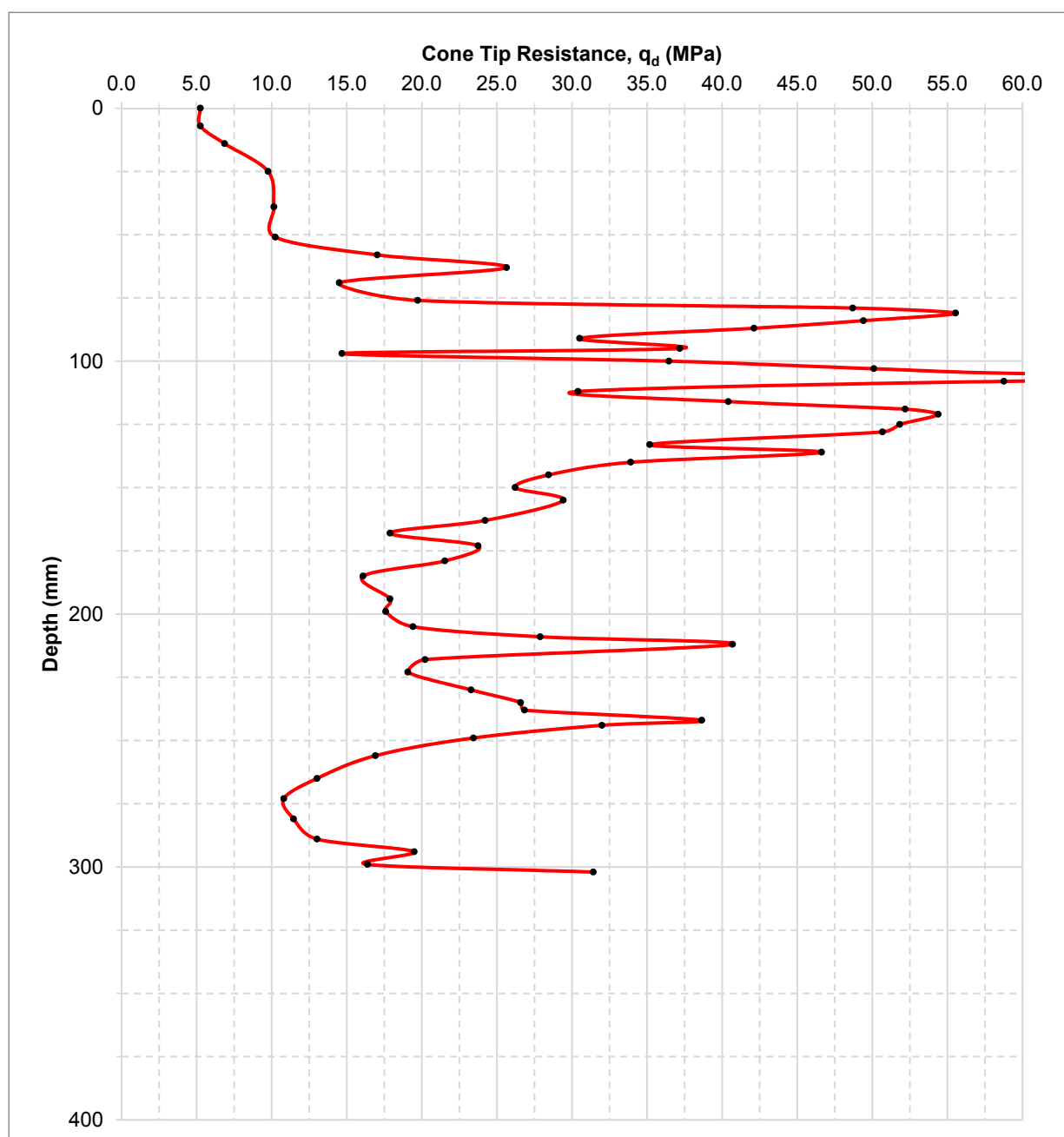
Project No.: 2091

Checked By: DWL

Location: Site 10-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 11-1

Certificate Reference:

2091-PND-Site 11-1

Sheet:

1 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 11-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	7.69	41	5	36.79			
2	14	5.46	42	4	38.41			
3	4	11.88	43	3	38.68			
4	12	9.47	44	2	53.20			
5	11	11.89	End of Test Record					
6	18	7.83						
7	10	10.77						
8	15	8.71						
9	11	12.33						
10	12	12.27						
11	13	10.66						
12	4	27.31						
13	12	12.49						
14	4	21.81						
15	15	9.96						
16	8	15.05						
17	12	14.70						
18	14	10.04						
19	10	13.63						
20	10	15.10						
21	14	10.99						
22	8	15.45						
23	12	7.37						
24	9	16.81						
25	10	10.35						
26	11	18.11						
27	9	15.89						
28	5	34.28						
29	8	17.50						
30	5	34.41						
31	3	64.58						
32	7	15.51						
33	6	24.83						
34	5	30.81						
35	6	23.46						
36	3	41.30						
37	5	25.53						
38	4	32.85						
39	4	30.57						
40	5	36.84						

PANDA Probe - Test Report

Site 11-1

Certificate Reference:

2091-PND-Site 11-1

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

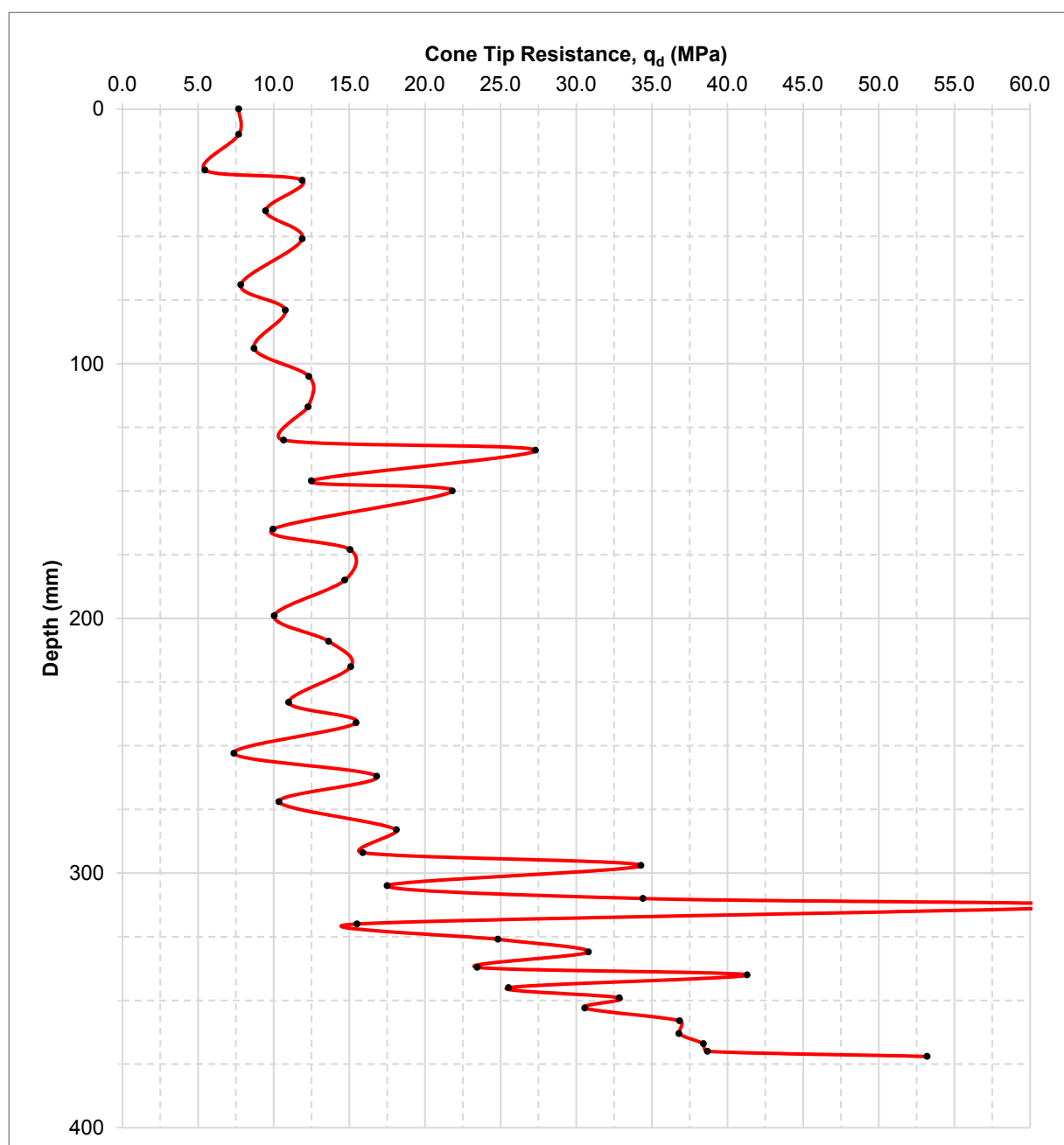
Project No.: 2091

Checked By: DWL

Location: Site 11-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 11-2

Certificate Reference:

2091-PND-Site 11-2

Sheet:

1 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 11-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	3.52	41	6	23.03			
2	7	4.82	42	3	63.26			
3	5	7.21	43	7	17.58			
4	7	9.55	44	6	23.75			
5	11	7.85	45	9	14.22			
6	8	7.19	46	3	34.32			
7	10	7.69	47	2	62.52			
8	8	13.09	48	6	19.11			
9	9	10.94	49	2	54.23			
10	8	11.95	50	6	20.55			
11	6	18.97	51	4	28.12			
12	18	7.20	52	5	21.10			
13	12	9.33	53	3	37.79			
14	16	7.67	54	4	28.86			
15	3	28.84	55	4	32.62			
16	10	11.02	56	4	25.39			
17	8	17.62	57	2	50.71			
18	10	11.83	58	6	19.35			
19	7	16.26	59	5	23.23			
20	10	13.81	60	1	102.49			
21	4	32.87	61	7	16.26			
22	11	8.79	62	2	52.78			
23	6	18.10	63	3	23.56			
24	3	32.05	64	3	43.27			
25	10	12.88	65	1	76.94			
26	3	39.71	66	2	27.74			
27	10	11.29	67	3	49.28			
28	4	24.92	68	2	51.32			
29	2	59.89	69	1	101.78			
30	9	15.61	70	2	35.74			
31	2	69.56	71	3	36.45			
32	7	18.55	End of Test Record					
33	2	54.89						
34	6	20.64						
35	3	42.76						
36	4	34.46						
37	5	32.22						
38	9	17.94						
39	4	36.66						
40	7	23.43						

PANDA Probe - Test Report

Site 11-2

Certificate Reference:

2091-PND-Site 11-2

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

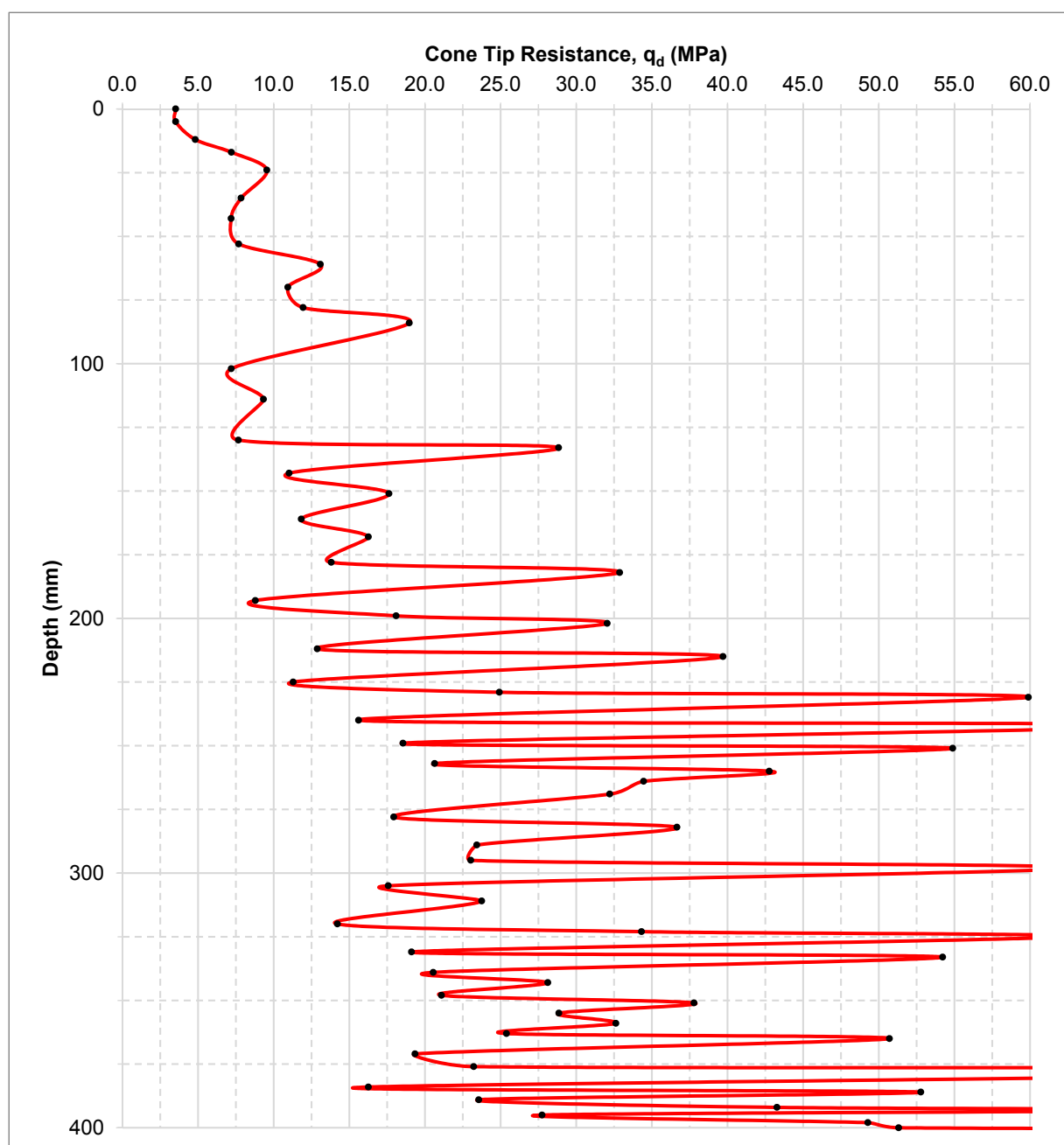
Project No.: 2091

Checked By: DWL

Location: Site 11-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 11-3

Certificate Reference:

2091-PND-Site 11-3

Sheet:

1 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 11-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	6.52	41	4	26.37			
2	10	12.29	42	4	18.86			
3	8	12.33	43	3	34.41			
4	9	12.38	44	4	35.32			
5	7	18.12	45	5	37.63			
6	5	22.84	46	8	27.57			
7	4	25.79	47	7	28.02			
8	5	17.68	48	4	35.62			
9	3	39.00	49	5	34.81			
10	4	33.35	50	5	36.45			
11	4	39.20	51	4	32.82			
12	2	57.41	52	4	38.90			
13	3	47.47	53	4	33.98			
14	3	39.76	54	4	36.05			
15	3	47.59	55	4	46.15			
16	4	36.52	56	1	82.07			
17	3	37.79	57	2	74.25			
18	4	51.48	58	3	47.50			
19	3	41.59	59	2	59.54			
20	4	36.69	60	1	84.21			
21	5	38.23	61	3	34.88			
22	4	43.43	End of Test Record					
23	4	46.98						
24	6	23.73						
25	2	47.01						
26	5	37.27						
27	4	27.25						
28	4	42.08						
29	5	34.53						
30	4	40.04						
31	5	36.66						
32	4	37.19						
33	6	31.98						
34	6	31.25						
35	6	23.71						
36	5	31.67						
37	5	28.25						
38	4	33.65						
39	4	30.89						
40	3	25.46						

PANDA Probe - Test Report

Site 11-3

Certificate Reference:

2091-PND-Site 11-3

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

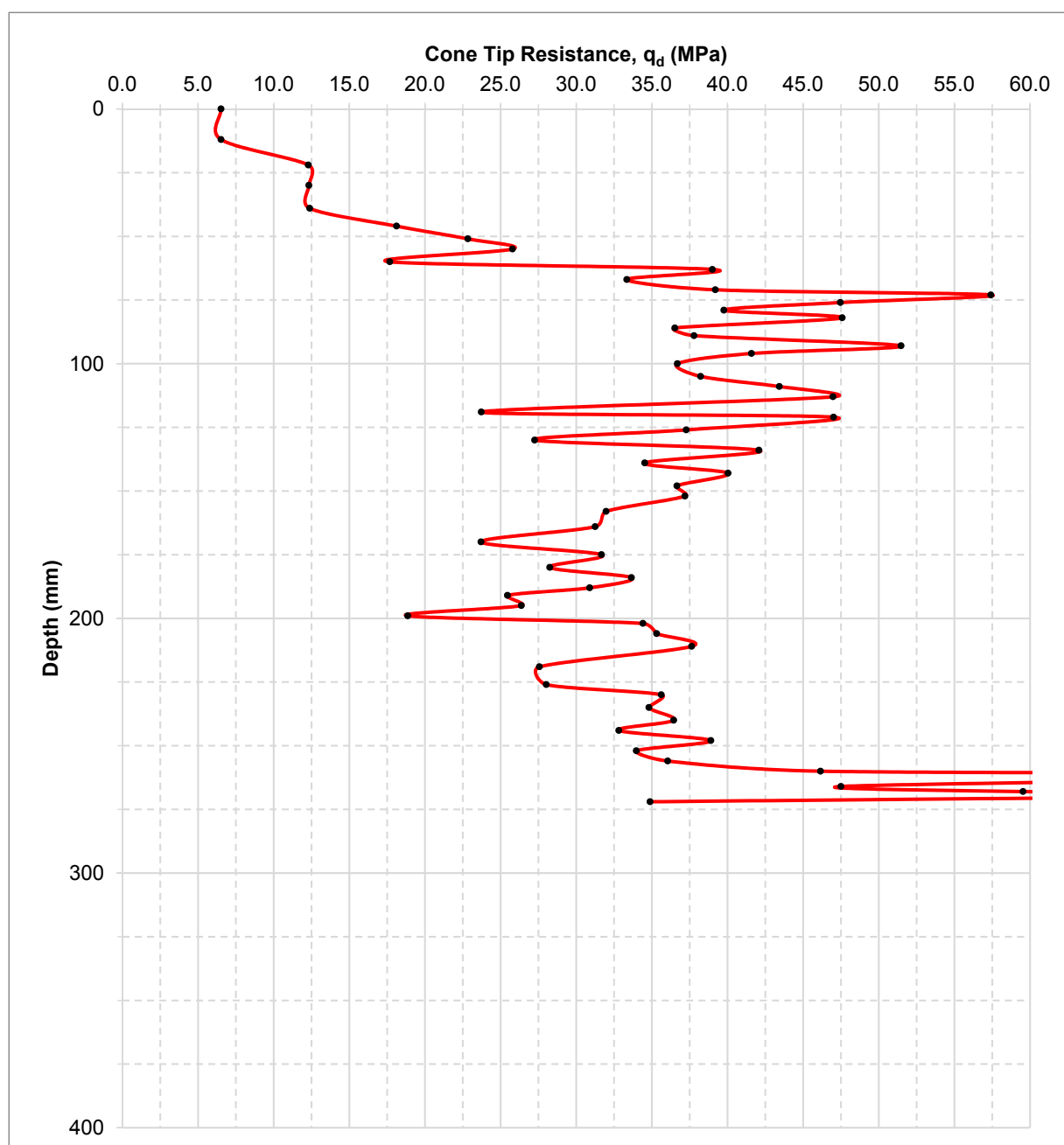
Project No.: 2091

Checked By: DWL

Location: Site 11-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 11-4

Certificate Reference:

2091-PND-Site 11-4

Sheet:

1 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 11-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	5.96	41	4	25.54			
2	9	8.26	42	3	26.19			
3	9	8.66	43	4	22.90			
4	9	7.41	44	3	28.84			
5	9	7.07	45	4	28.64			
6	7	9.14	46	4	25.74			
7	12	10.24	47	4	27.01			
8	8	11.17	48	4	26.93			
9	9	12.08	49	4	25.57			
10	6	10.97	50	4	31.53			
11	4	28.89	51	4	21.98			
12	3	28.78	52	4	20.46			
13	3	29.56	53	4	25.34			
14	5	26.26	54	3	22.50			
15	4	22.21	55	5	24.62			
16	5	21.63	56	4	27.63			
17	6	12.78	57	5	25.01			
18	5	15.23	58	3	28.94			
19	7	16.59	59	5	23.55			
20	5	17.51	60	4	23.59			
21	5	22.43	61	5	20.33			
22	4	21.67	62	4	21.37			
23	4	23.46	63	3	27.79			
24	4	24.66	64	4	22.55			
25	4	21.97	65	3	22.60			
26	5	22.58	66	4	26.07			
27	3	36.43	67	3	30.79			
28	3	37.50	68	2	20.85			
29	3	32.63	69	3	24.27			
30	1	50.11	70	3	32.21			
31	3	29.73	71	2	31.55			
32	3	25.60	72	3	25.08			
33	3	25.09	73	2	41.94			
34	3	27.79	74	2	47.04			
35	4	25.39	75	1	45.83			
36	4	22.58	76	2	41.48			
37	4	18.78	77	1	46.37			
38	5	25.26	78	2	33.10			
39	4	23.00	End of Test Record					
40	4	22.41						

PANDA Probe - Test Report

Site 11-4

Certificate Reference:

2091-PND-Site 11-4

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

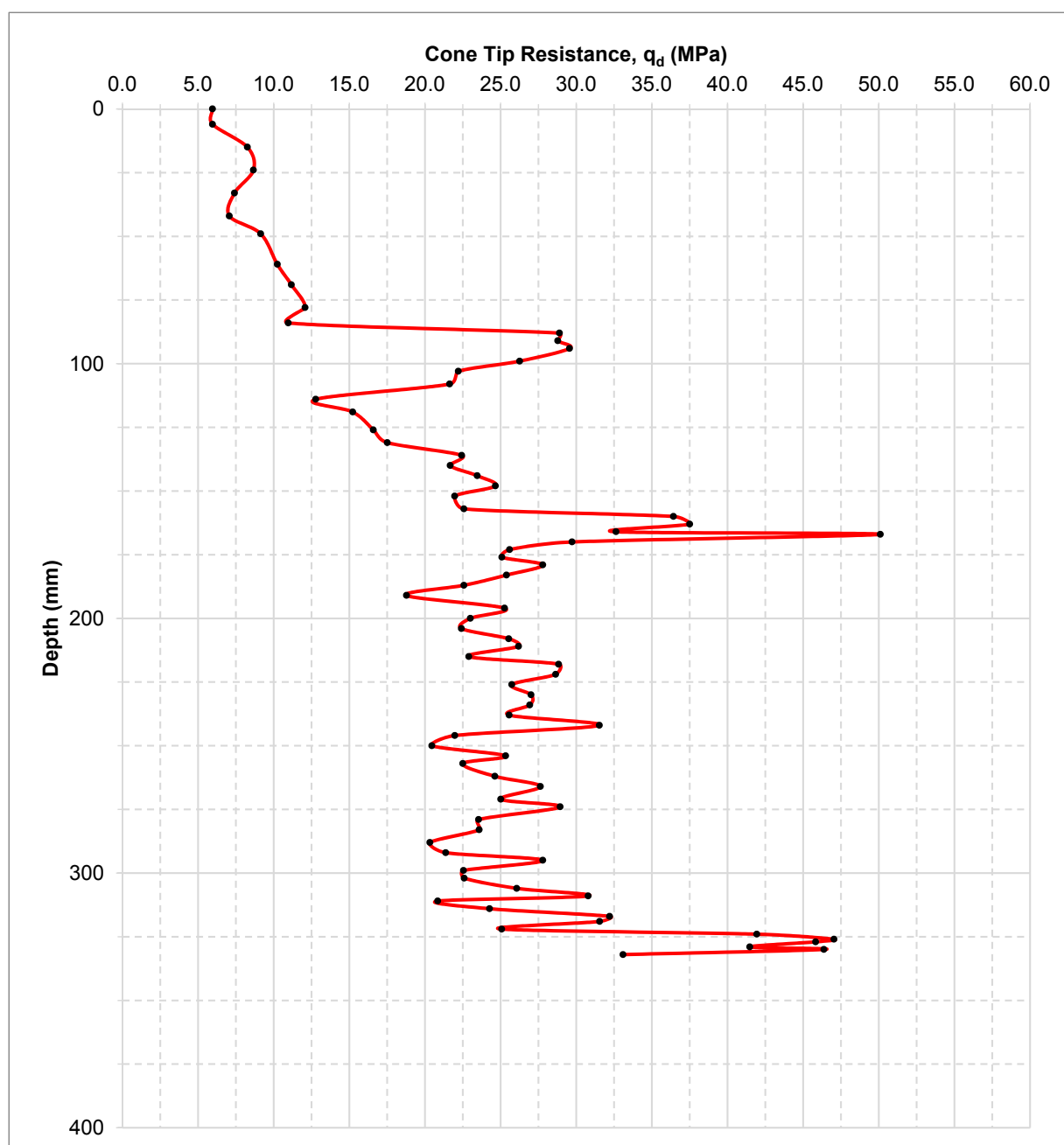
Project No.: 2091

Checked By: DWL

Location: Site 11-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 12-1

Certificate Reference:

2091-PND-Site 12-1

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

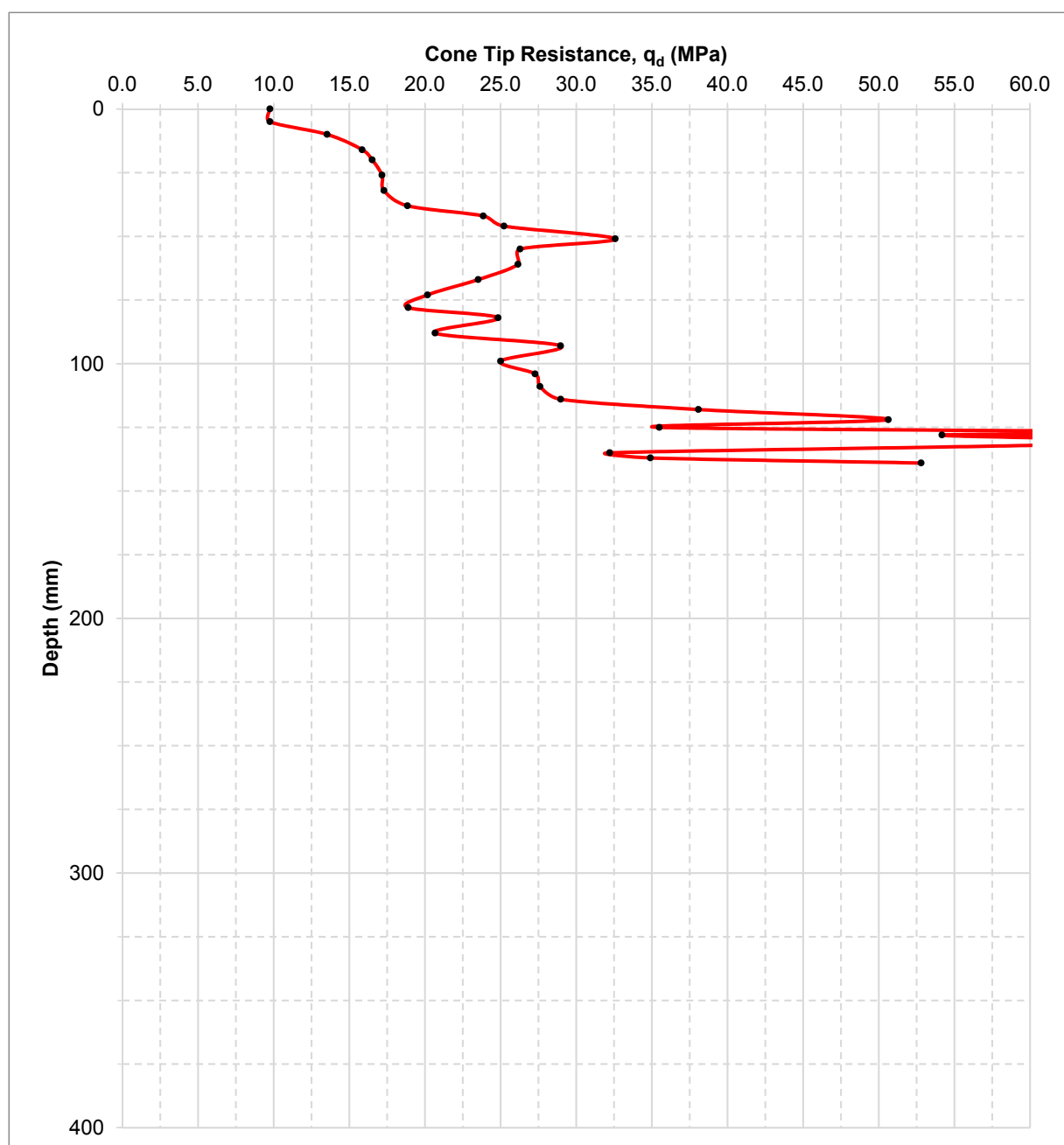
Project No.: 2091

Checked By: DWL

Location: Site 12-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 12-1A

Certificate Reference:

2091-PND-Site 12-1A

Sheet:

1 of 3

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 12-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	11.71	41	5	25.64	81	4	14.21
2	4	21.03	42	5	21.78	82	4	14.72
3	7	13.61	43	5	23.85	83	6	17.13
4	7	9.44	44	6	22.18	84	6	12.86
5	4	17.44	45	5	26.21	85	5	18.07
6	6	17.09	46	5	19.72	86	7	12.96
7	6	20.35	47	5	23.28	87	5	19.74
8	5	16.80	48	4	27.11	88	6	18.17
9	5	20.25	49	5	22.52	89	4	23.80
10	5	23.70	50	3	28.97	90	4	20.43
11	4	19.26	51	5	20.86	91	4	24.28
12	4	23.48	52	4	21.44	92	5	15.94
13	3	34.53	53	4	17.77	93	4	29.98
14	3	36.46	54	5	21.33	94	3	24.64
15	2	40.23	55	6	19.96	95	4	24.41
16	4	29.39	56	7	16.31	96	3	27.43
17	4	26.24	57	6	19.16	97	2	29.52
18	4	25.54	58	6	19.62	98	3	28.07
19	6	26.26	59	6	28.39	99	1	29.15
20	5	22.97	60	6	25.98	100	2	24.00
21	3	22.31	61	2	36.80	101	2	28.36
22	3	36.68	62	4	21.32	102	1	31.27
23	4	25.74	63	3	28.32	103	4	19.68
24	3	32.07	64	2	25.42	104	1	39.00
25	4	26.82	65	1	20.76	105	2	32.49
26	4	30.60	66	2	25.03	106	1	39.79
27	4	28.17	67	2	18.09	107	2	38.56
28	5	24.00	68	5	20.35	108	2	21.14
29	4	23.85	69	4	22.27	109	2	24.53
30	4	17.72	70	5	20.02	110	1	42.87
31	5	21.26	71	4	18.56	111	2	32.18
32	4	22.45	72	4	20.83	112	2	34.62
33	6	27.15	73	4	17.21	113	1	28.45
34	6	23.65	74	5	17.14	114	1	30.67
35	6	22.78	75	5	18.39	115	2	32.17
36	6	21.24	76	5	20.76	116	4	27.18
37	6	17.00	77	4	19.08	117	2	37.44
38	7	19.68	78	4	14.78	118	3	31.67
39	6	18.31	79	5	19.46	119	1	25.04
40	6	22.31	80	5	19.43	120	2	38.62

PANDA Probe - Test Report

Site 12-1A

Certificate Reference:

2091-PND-Site 12-1A

Sheet:

2 of 3

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 12-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	3	29.93						
122	2	30.26						
123	3	23.53						
124	2	23.11						
125	2	34.87						
126	1	20.89						
127	2	20.82						
128	4	18.85						
129	2	23.59						
130	2	20.23						
131	3	18.80						
132	2	18.20						
133	5	20.40						
134	5	25.59						
135	4	21.03						
136	4	27.96						
137	4	28.21						
138	3	35.05						
139	3	24.27						
140	2	13.41						
141	4	22.49						
142	4	22.26						
143	6	22.11						
144	6	19.96						
145	3	28.94						
146	5	20.16						
147	4	27.58						
148	3	26.97						
149	4	33.87						
150	4	27.20						
151	3	26.40						
152	3	31.70						
153	3	26.68						
154	2	28.40						
End of Test Record								

PANDA Probe - Test Report

Site 12-1A

Certificate Reference:

2091-PND-Site 12-1A

Sheet:

3 of 3

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

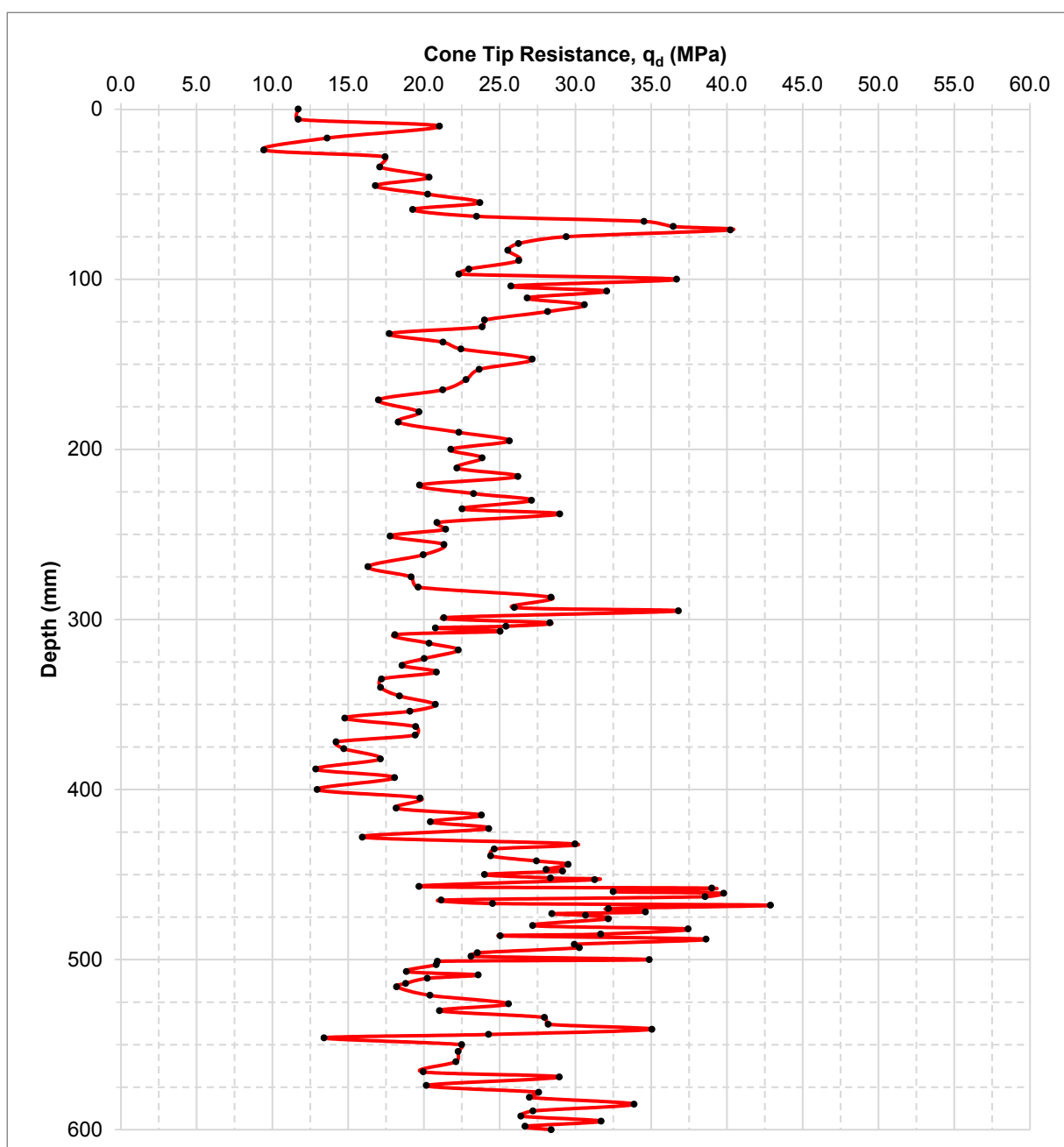
Project No.: 2091

Checked By: DWL

Location: Site 12-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 12-2

Certificate Reference:

2091-PND-Site 12-2

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

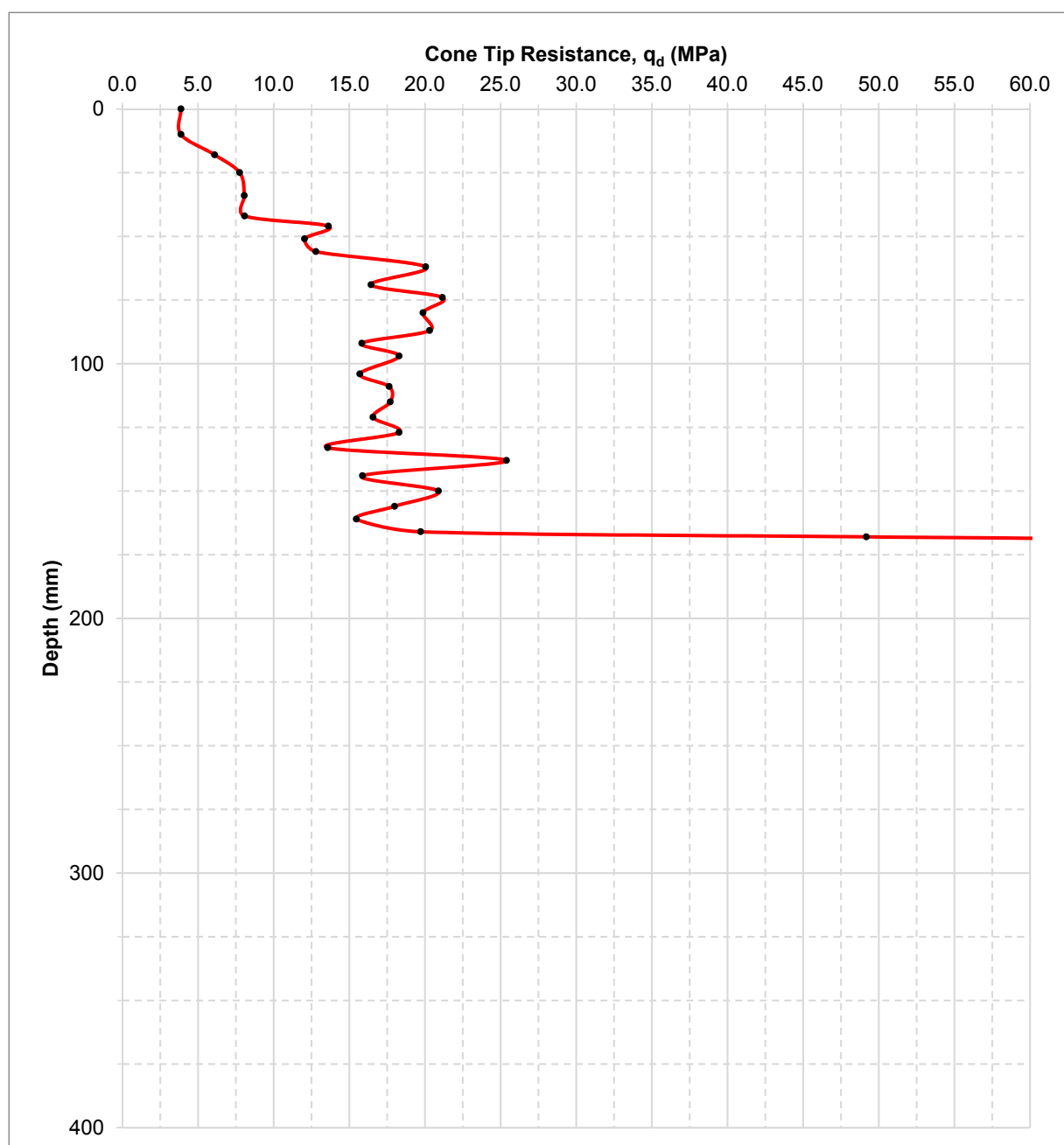
Project No.: 2091

Checked By: DWL

Location: Site 12-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 12-2A

Certificate Reference:

2091-PND-Site 12-2A

Sheet:

1 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 12-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	6.85	41	5	25.60	81	3	31.43
2	10	9.32	42	4	29.85	82	2	33.78
3	9	9.61	43	5	25.61	83	2	34.34
4	8	15.22	44	4	28.73	84	1	39.10
5	8	9.01	45	4	30.05	85	2	38.43
6	7	10.38	46	4	29.41	86	2	25.18
7	7	18.39	47	2	25.49	87	1	43.54
8	5	19.16	48	2	45.12	88	1	28.88
9	5	18.62	49	3	28.98	89	3	33.43
10	7	16.54	50	2	37.23	90	3	42.90
11	7	14.15	51	1	35.38	91	3	39.10
12	8	18.01	52	2	29.31	92	1	51.85
13	7	12.99	53	1	32.63	93	1	39.11
14	8	18.36	54	2	34.41	94	4	46.14
15	6	15.40	55	1	30.47	95	2	78.74
16	6	19.34	56	2	30.45	End of Test Record		
17	5	23.99	57	2	26.05			
18	6	17.94	58	2	25.21			
19	4	27.88	59	3	25.25			
20	3	55.47	60	1	25.38			
21	4	31.46	61	2	27.39			
22	4	30.17	62	2	27.70			
23	3	24.84	63	1	34.80			
24	4	33.83	64	3	23.26			
25	4	24.48	65	2	21.08			
26	5	22.61	66	2	22.32			
27	4	19.57	67	5	20.28			
28	4	33.11	68	4	17.99			
29	4	29.81	69	5	21.59			
30	6	25.72	70	6	21.57			
31	6	24.03	71	6	23.16			
32	6	20.29	72	5	22.70			
33	6	20.95	73	6	24.53			
34	5	22.26	74	7	18.54			
35	6	19.84	75	4	20.13			
36	6	17.68	76	4	24.74			
37	7	15.62	77	5	25.35			
38	7	18.87	78	1	37.41			
39	7	20.81	79	3	30.97			
40	5	14.14	80	2	24.63			

PANDA Probe - Test Report

Site 12-2A

Certificate Reference:

2091-PND-Site 12-2A

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

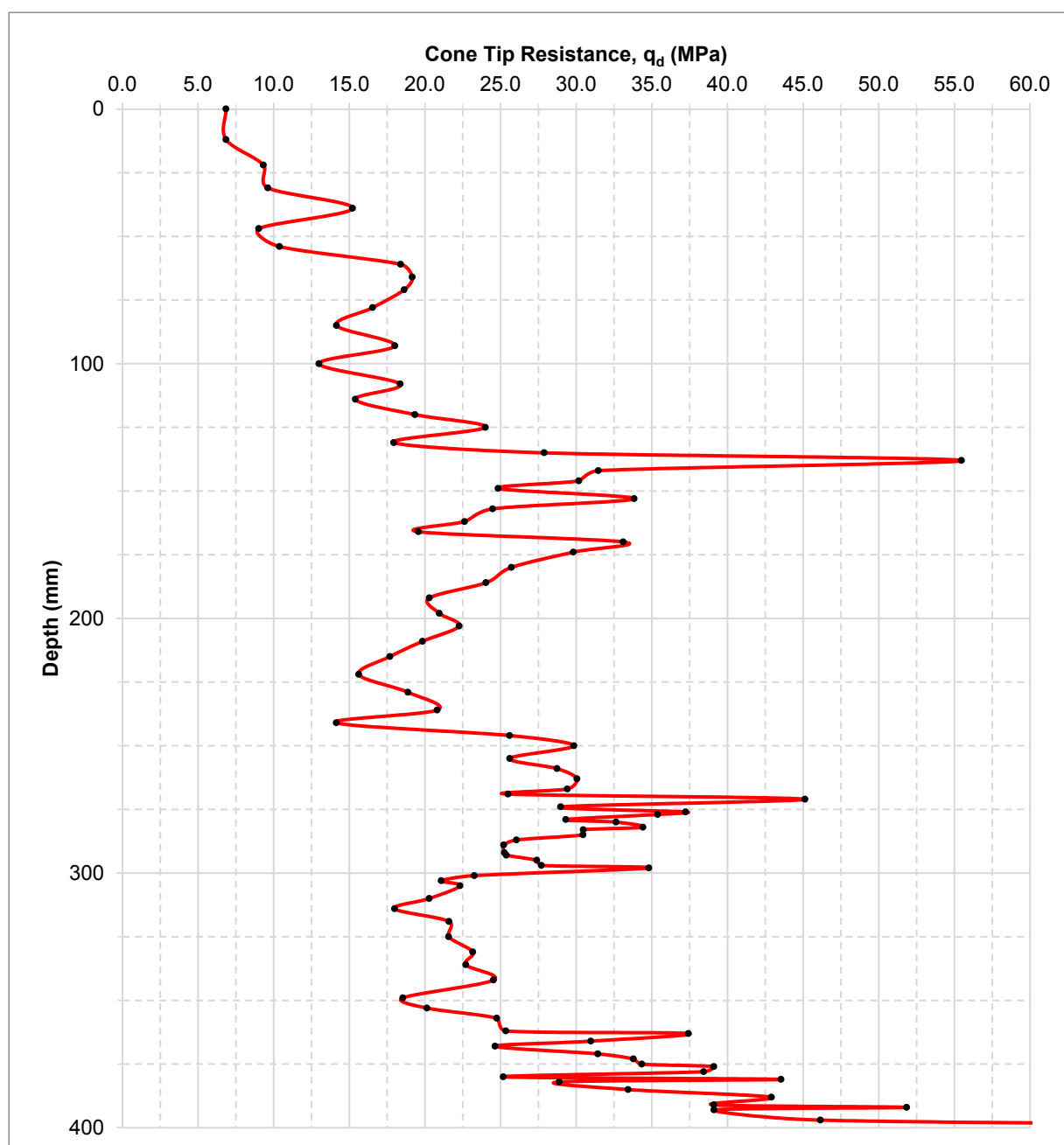
Project No.: 2091

Checked By: DWL

Location: Site 12-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 12-3

Certificate Reference:

2091-PND-Site 12-3

Sheet:

1 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 12-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	5.02	41	7	18.76			
2	8	12.97	42	7	18.74			
3	8	15.49	43	6	19.67			
4	11	11.24	44	5	19.50			
5	11	9.43	45	2	39.57			
6	8	15.23	46	4	39.34			
7	10	14.05	47	3	50.21			
8	6	17.72	48	4	33.33			
9	7	16.59	49	2	55.78			
10	9	16.13	50	3	37.74			
11	13	12.45	51	3	49.61			
12	14	11.25	52	2	53.25			
13	9	9.88	End of Test Record					
14	12	8.57						
15	12	8.72						
16	14	6.96						
17	15	5.65						
18	7	11.15						
19	5	23.97						
20	6	21.87						
21	6	29.85						
22	5	27.68						
23	8	20.99						
24	11	16.50						
25	17	7.56						
26	20	5.68						
27	20	6.30						
28	20	7.02						
29	13	9.47						
30	13	9.13						
31	9	13.53						
32	9	16.73						
33	10	14.52						
34	10	13.64						
35	11	12.74						
36	9	12.93						
37	10	13.12						
38	4	3.10						
39	4	23.07						
40	5	21.92						

Certificate Reference:

2091-PND-Site 12-3

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

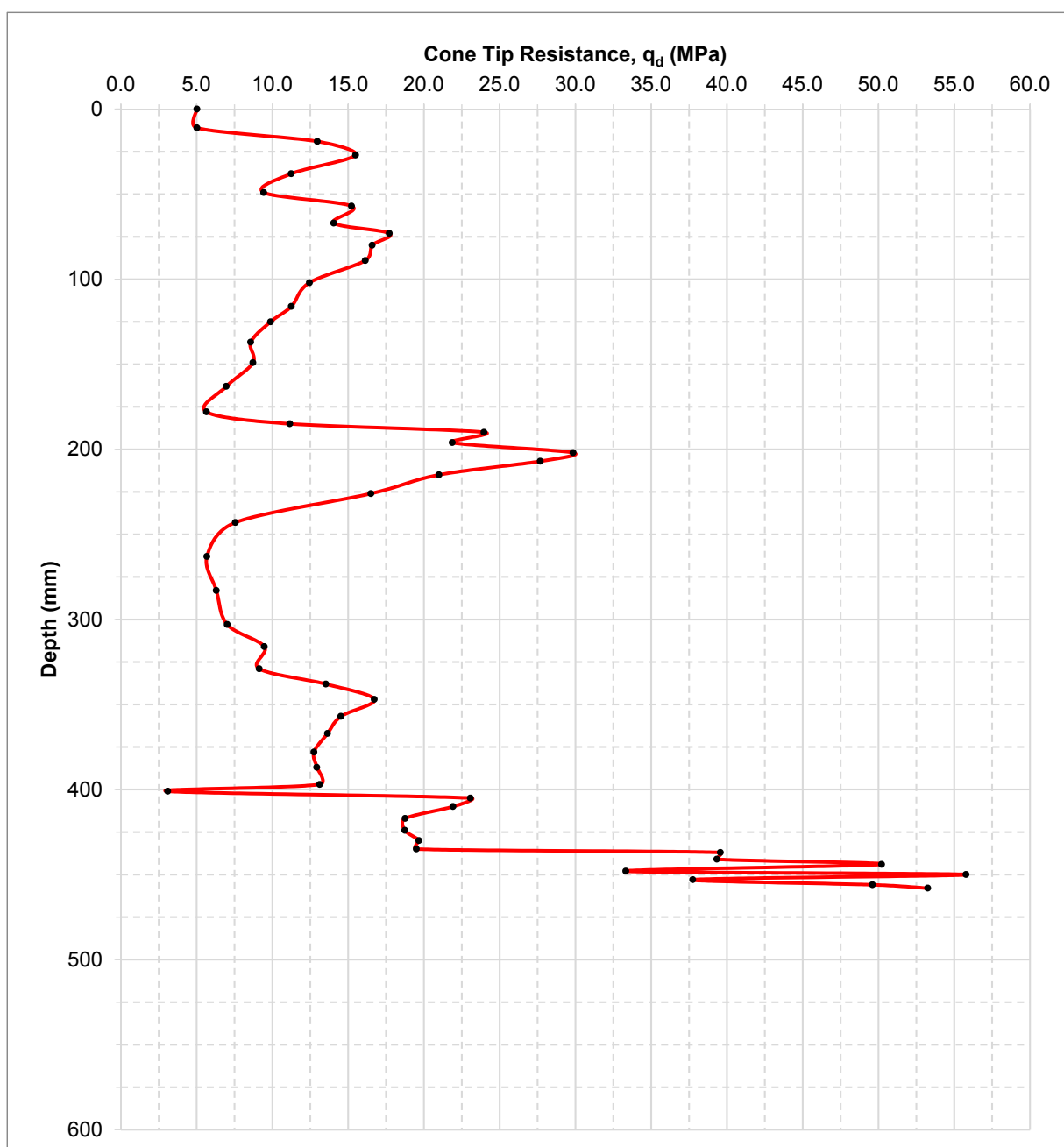
Project No.: 2091

Checked By: DWL

Location: Site 12-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 12-4

Certificate Reference:

2091-PND-Site 12-4

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

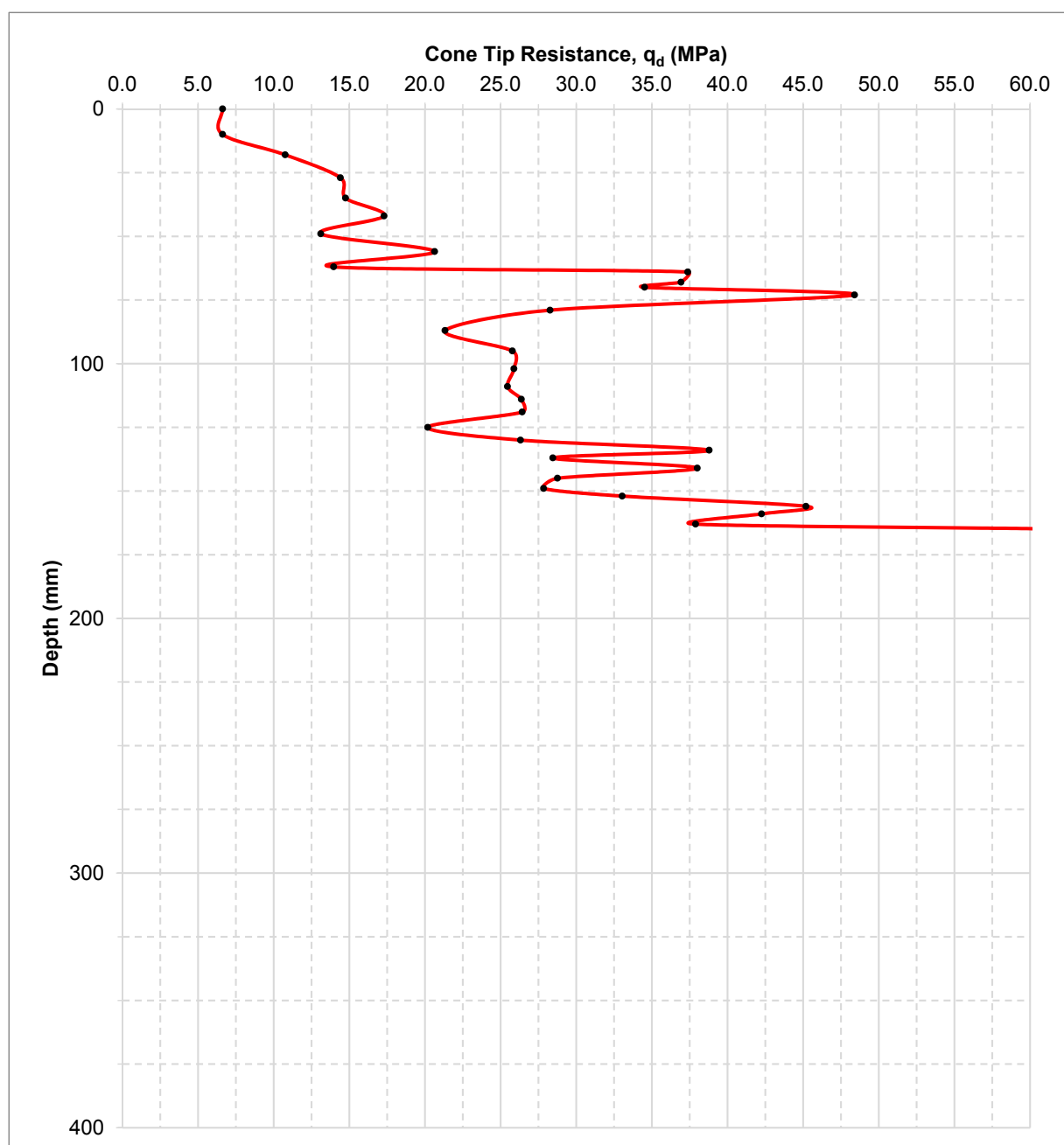
Project No.: 2091

Checked By: DWL

Location: Site 12-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 12-4A

Certificate Reference:

2091-PND-Site 12-4A

Sheet:

1 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 12-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	9.08	41	3	30.66			
2	7	18.57	42	4	25.23			
3	8	18.08	43	2	22.40			
4	8	21.46	44	2	24.60			
5	8	18.97	45	2	18.63			
6	6	21.57	46	2	31.15			
7	4	34.04	47	2	20.89			
8	5	26.75	48	2	19.38			
9	5	34.02	49	1	26.70			
10	4	22.22	50	4	26.56			
11	6	22.87	51	4	22.94			
12	5	20.63	52	4	28.65			
13	8	21.24	53	3	26.88			
14	6	22.80	54	2	37.17			
15	5	20.89	55	1	43.40			
16	5	21.36	56	2	31.48			
17	5	33.17	57	3	41.58			
18	6	29.84	58	2	61.72			
19	4	22.50	59	2	46.45			
20	6	23.57	End of Test Record					
21	5	29.45						
22	6	26.71						
23	6	23.64						
24	5	32.99						
25	5	23.37						
26	5	29.87						
27	4	33.62						
28	3	41.72						
29	3	57.42						
30	4	41.78						
31	4	33.16						
32	5	29.23						
33	4	38.50						
34	5	30.54						
35	4	31.80						
36	5	23.74						
37	4	33.08						
38	5	28.12						
39	5	22.92						
40	4	30.20						

PANDA Probe - Test Report

Site 12-4A

Certificate Reference:

2091-PND-Site 12-4A

Sheet:

2 of 2

Client: ARRB

Test Date: 15/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

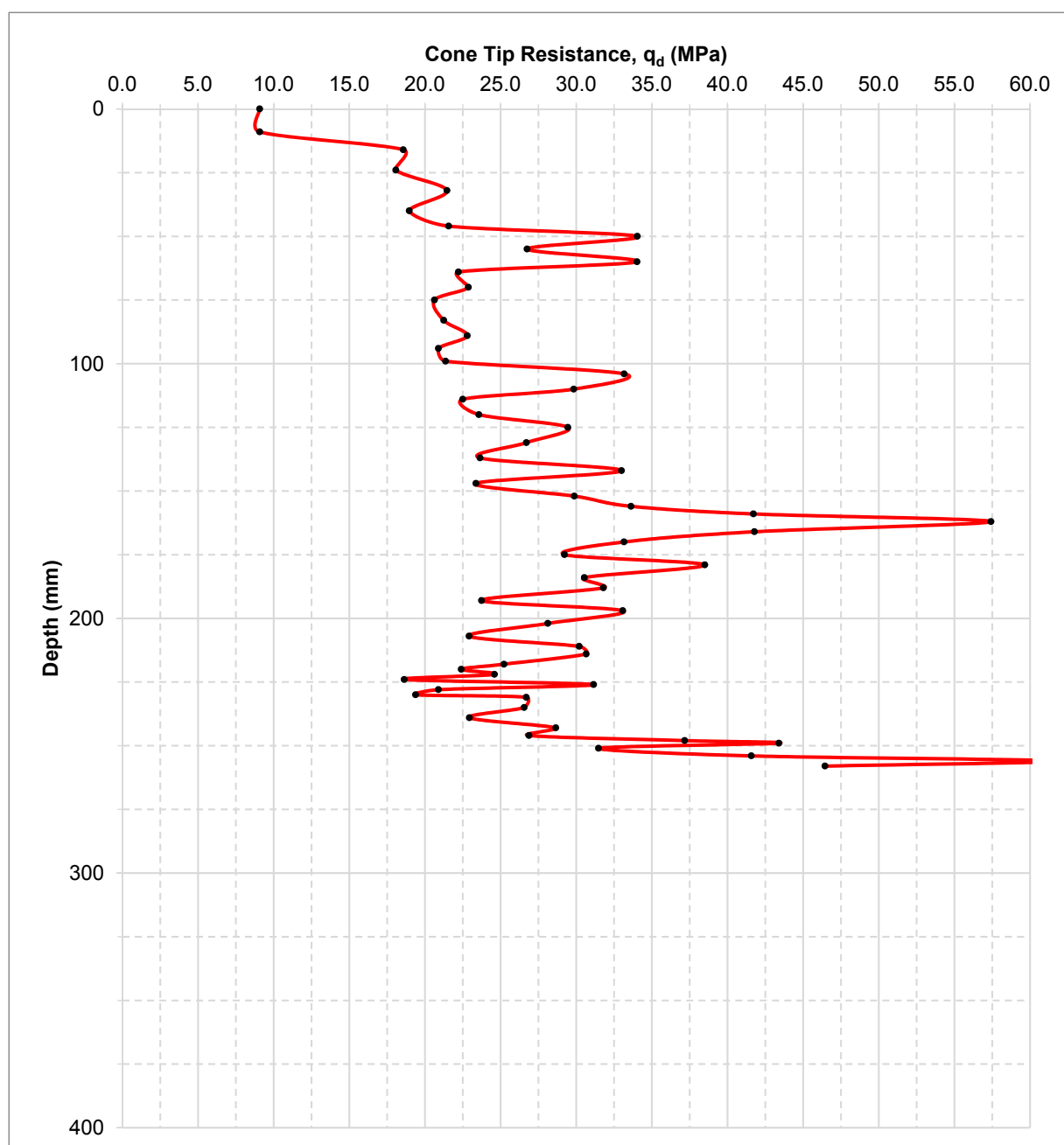
Project No.: 2091

Checked By: DWL

Location: Site 12-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 13-1

Certificate Reference:

2091-PND-Site 13-1

Sheet:

1 of 3

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 13-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	5.35	41	7	12.25	81	5	24.14
2	6	8.37	42	8	15.91	82	4	36.00
3	5	12.72	43	5	15.25	83	8	26.60
4	6	9.38	44	6	13.83	84	5	32.23
5	6	10.23	45	6	18.36	85	5	28.71
6	6	9.23	46	6	16.64	86	6	24.57
7	6	12.77	47	6	17.77	87	4	26.82
8	5	16.93	48	6	16.46	88	5	33.26
9	6	16.80	49	5	19.43	89	6	27.35
10	4	13.71	50	6	20.82	90	5	31.79
11	4	12.85	51	5	23.13	91	5	26.72
12	8	10.04	52	6	20.23	92	4	32.48
13	6	7.54	53	6	25.09	93	3	27.00
14	6	12.40	54	5	22.18	94	4	38.32
15	5	10.11	55	5	25.41	95	3	30.04
16	5	14.41	56	5	27.81	96	3	28.67
17	4	15.92	57	4	31.84	97	3	43.29
18	3	16.04	58	5	28.41	98	1	33.45
19	4	21.87	59	5	22.65	99	3	31.84
20	2	18.80	60	4	30.45	100	2	23.64
21	4	19.67	61	4	21.08	101	2	33.03
22	4	16.59	62	4	26.60	102	2	31.30
23	4	16.96	63	4	21.67	103	1	25.99
24	3	14.15	64	4	26.09	104	3	27.40
25	4	18.77	65	4	38.71	105	3	16.98
26	3	18.63	66	7	30.11	106	3	27.87
27	5	17.47	67	5	28.43	107	5	21.71
28	3	17.63	68	4	36.48	108	6	24.83
29	4	15.07	69	6	23.78	109	5	21.17
30	4	16.31	70	3	37.48	110	6	20.26
31	4	11.85	71	4	33.52	111	6	18.57
32	1	12.79	72	5	28.71	112	6	20.26
33	6	12.15	73	3	35.97	113	4	20.00
34	5	16.95	74	5	29.37	114	5	21.60
35	6	12.23	75	4	28.95	115	3	26.42
36	10	8.46	76	5	23.21	116	4	24.91
37	13	7.98	77	5	22.58	117	3	28.83
38	9	7.98	78	6	26.28	118	3	26.50
39	10	9.71	79	5	25.25	119	3	33.46
40	7	10.62	80	5	26.92	120	3	26.40

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	3	29.10
122	3	30.93
123	1	32.20
124	2	40.24
125	2	26.57
126	3	21.54
127	1	49.51
128	1	35.61
129	2	41.08
130	3	37.22
131	3	46.74
End of Test Record		

PANDA Probe - Test Report

Site 13-1

Certificate Reference:

2091-PND-Site 13-1

Sheet:

3 of 3

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

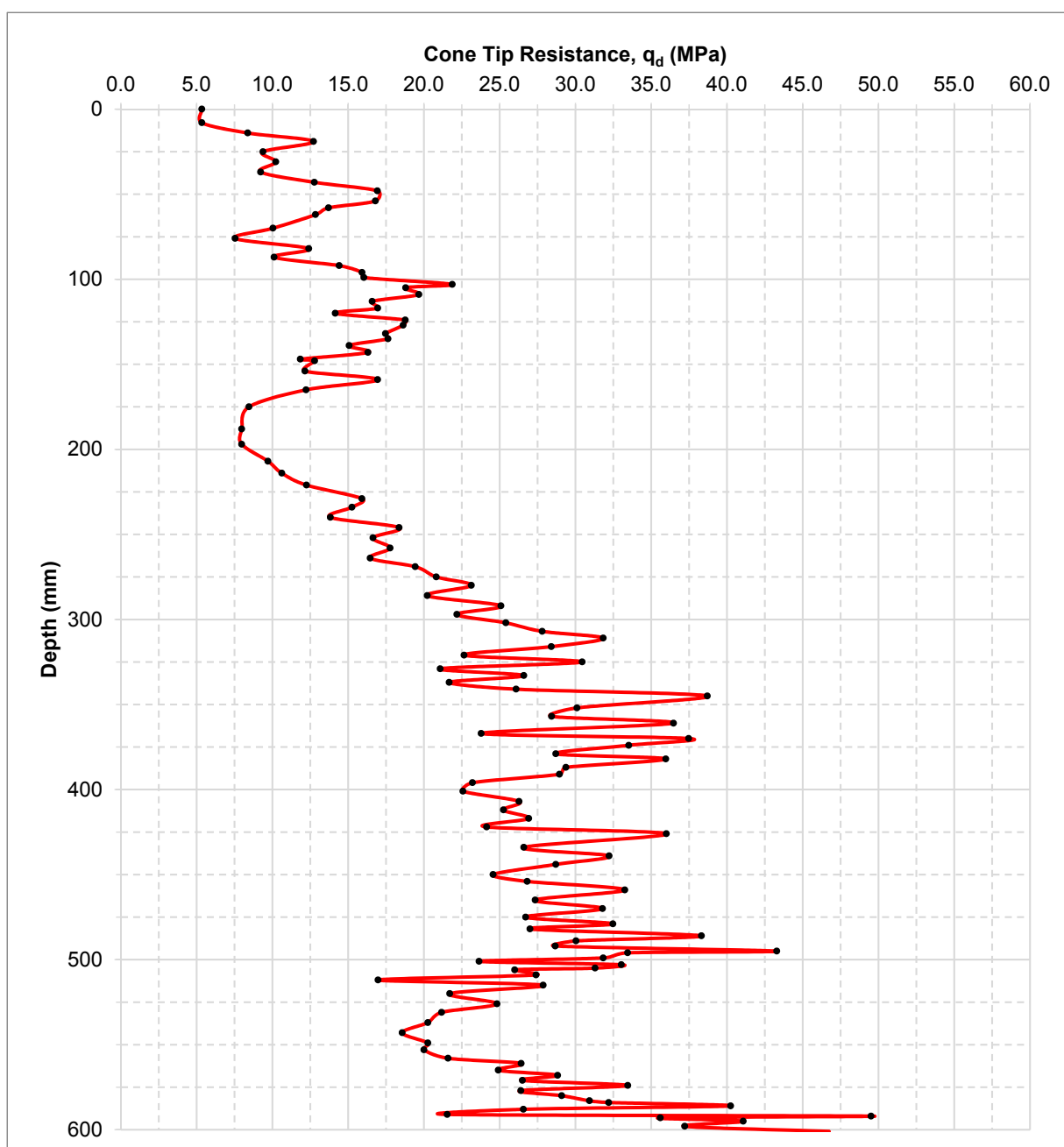
Project No.: 2091

Checked By: DWL

Location: Site 13-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 13-2

Certificate Reference:

2091-PND-Site 13-2

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 13-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	4.80	41	1	29.77			
2	3	8.05	42	2	30.42			
3	4	9.64	43	2	33.29			
4	1	7.69	44	1	34.61			
5	6	11.38	45	1	33.08			
6	4	14.95	46	1	48.61			
7	2	12.05	47	3	40.70			
8	5	6.58	End of Test Record					
9	2	18.67						
10	3	16.55						
11	2	9.20						
12	3	13.10						
13	3	14.60						
14	4	15.86						
15	2	11.23						
16	2	10.23						
17	3	14.86						
18	2	11.31						
19	3	13.45						
20	2	13.28						
21	2	17.05						
22	2	9.33						
23	3	16.07						
24	2	15.72						
25	2	16.49						
26	1	16.44						
27	2	16.65						
28	1	20.35						
29	2	15.72						
30	2	23.08						
31	2	21.18						
32	1	23.90						
33	2	20.37						
34	1	21.04						
35	3	21.27						
36	2	25.67						
37	3	22.26						
38	3	24.47						
39	1	29.31						
40	2	29.53						

PANDA Probe - Test Report

Site 13-2

Certificate Reference:

2091-PND-Site 13-2

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

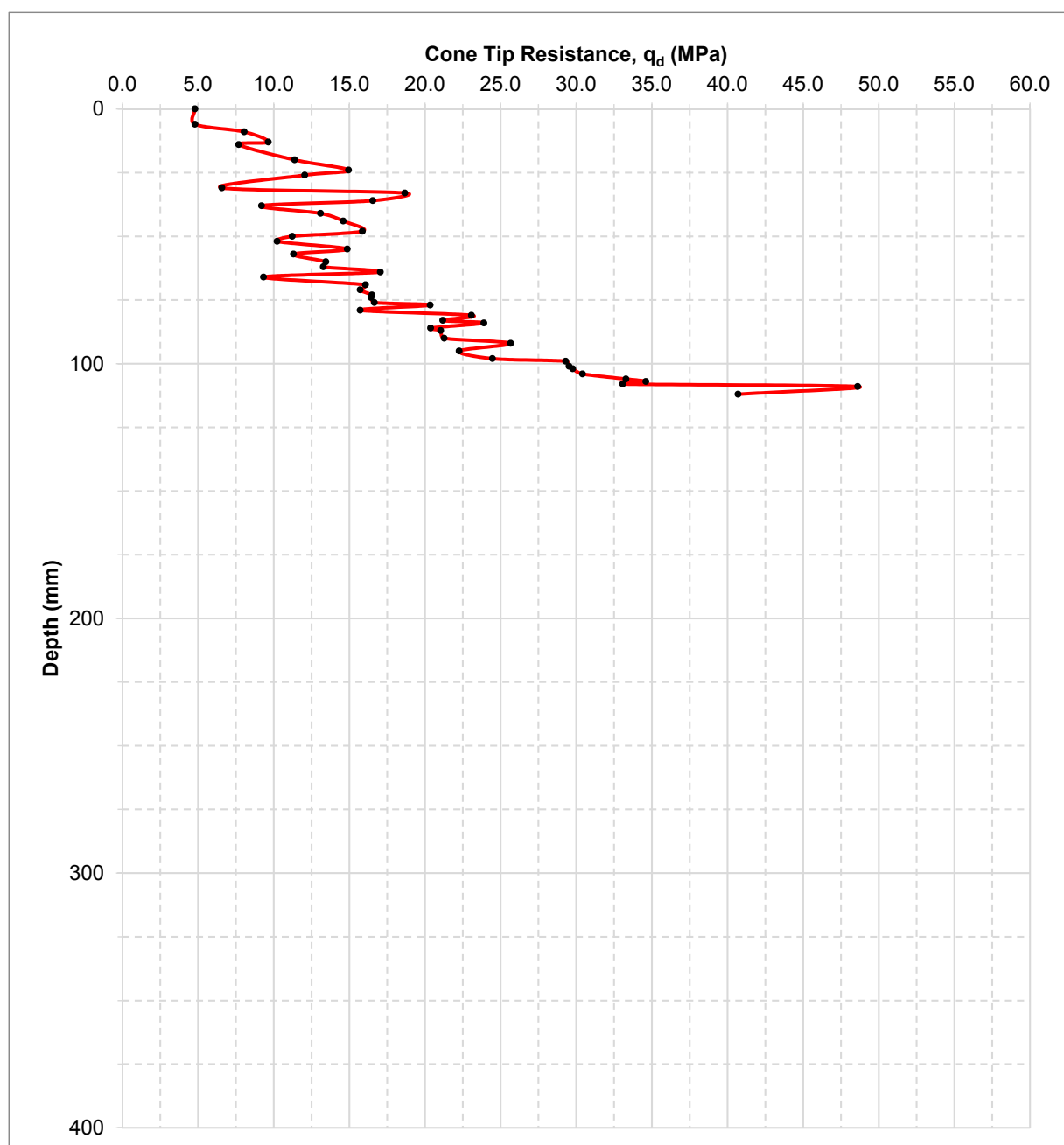
Project No.: 2091

Checked By: DWL

Location: Site 13-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 13-2A

Certificate Reference:

2091-PND-Site 13-2A

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 13-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	3.76	41	3	30.01			
2	3	6.62	42	4	21.58			
3	4	8.87	43	4	29.27			
4	5	6.30	44	3	27.36			
5	3	12.36	45	4	22.82			
6	3	11.32	46	4	24.77			
7	4	8.57	47	3	35.60			
8	4	12.29	48	3	855.86			
9	4	13.32	49	2	32.85			
10	3	11.85	50	3	31.04			
11	3	13.97	51	1	45.93			
12	4	12.84	52	2	44.49			
13	3	10.41	53	2	37.84			
14	2	22.36	54	1	45.12			
15	3	15.02	End of Test Record					
16	3	17.20						
17	3	11.09						
18	3	11.21						
19	1	18.89						
20	3	17.76						
21	1	20.34						
22	2	26.25						
23	1	32.36						
24	4	30.51						
25	1	29.27						
26	2	34.52						
27	1	33.85						
28	2	24.08						
29	2	28.59						
30	2	21.47						
31	1	33.52						
32	3	30.61						
33	4	38.18						
34	2	33.08						
35	4	32.95						
36	2	47.94						
37	3	30.91						
38	4	32.00						
39	4	31.65						
40	3	36.94						

PANDA Probe - Test Report

Site 13-2A

Certificate Reference:

2091-PND-Site 13-2A

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

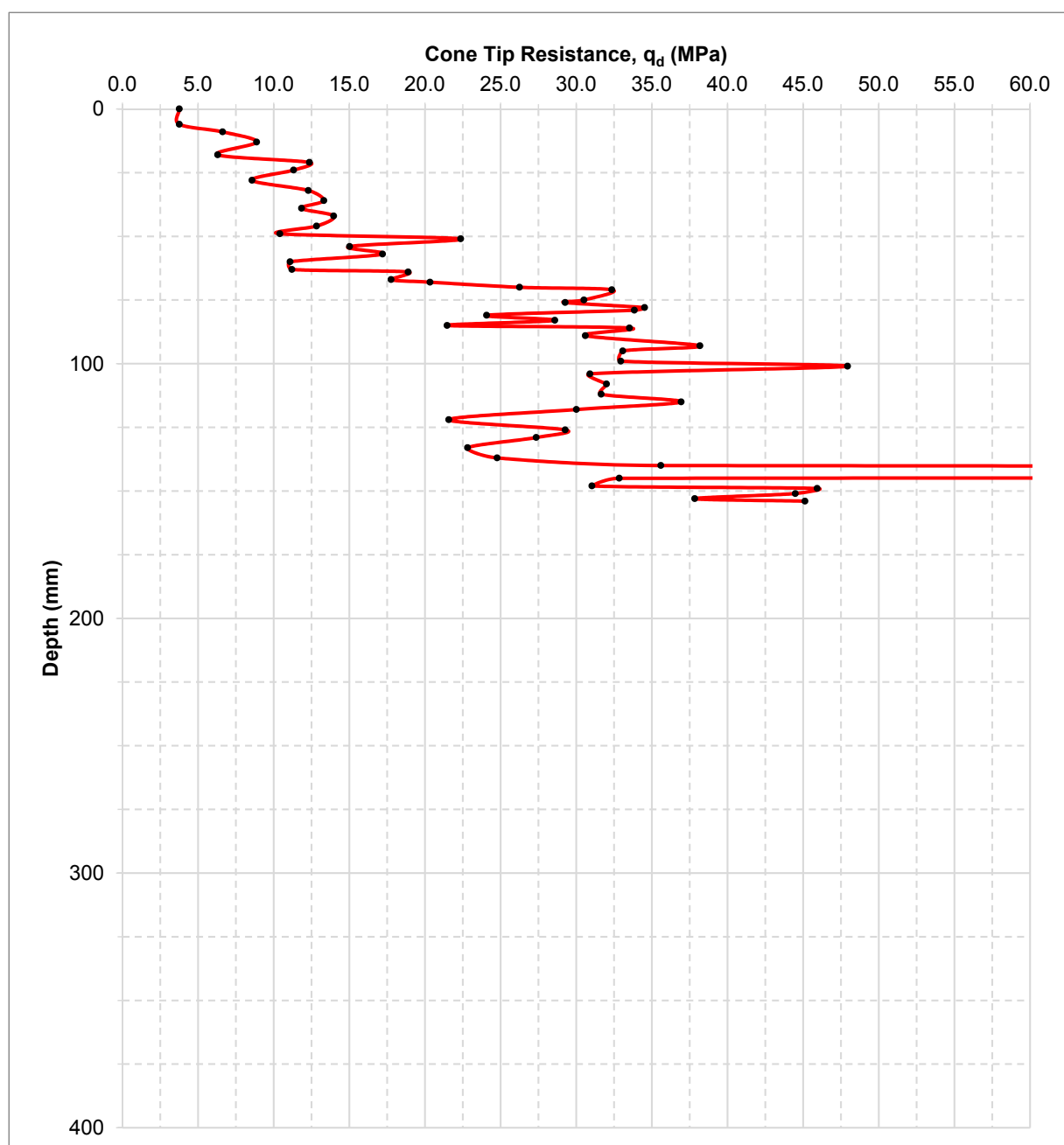
Project No.: 2091

Checked By: DWL

Location: Site 13-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 13-3

Certificate Reference:

2091-PND-Site 13-3

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 13-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	5.39						
2	6	8.07						
3	5	7.38						
4	4	8.77						
5	5	11.34						
6	4	11.24						
7	5	11.45						
8	5	12.81						
9	4	13.09						
10	4	13.13						
11	4	12.29						
12	4	14.36						
13	5	13.28						
14	4	13.82						
15	4	18.39						
16	4	16.64						
17	4	17.57						
18	2	11.92						
19	3	17.91						
20	4	16.73						
21	3	17.88						
22	3	20.15						
23	3	24.37						
24	3	23.46						
25	1	43.56						
26	2	28.64						
27	1	61.18						
28	2	40.13						
29	1	60.81						
30	2	61.05						
31	1	51.03						
32	1	48.72						
33	1	41.21						
34	1	52.09						
End of Test Record								

PANDA Probe - Test Report

Site 13-3

Certificate Reference:

2091-PND-Site 13-3

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

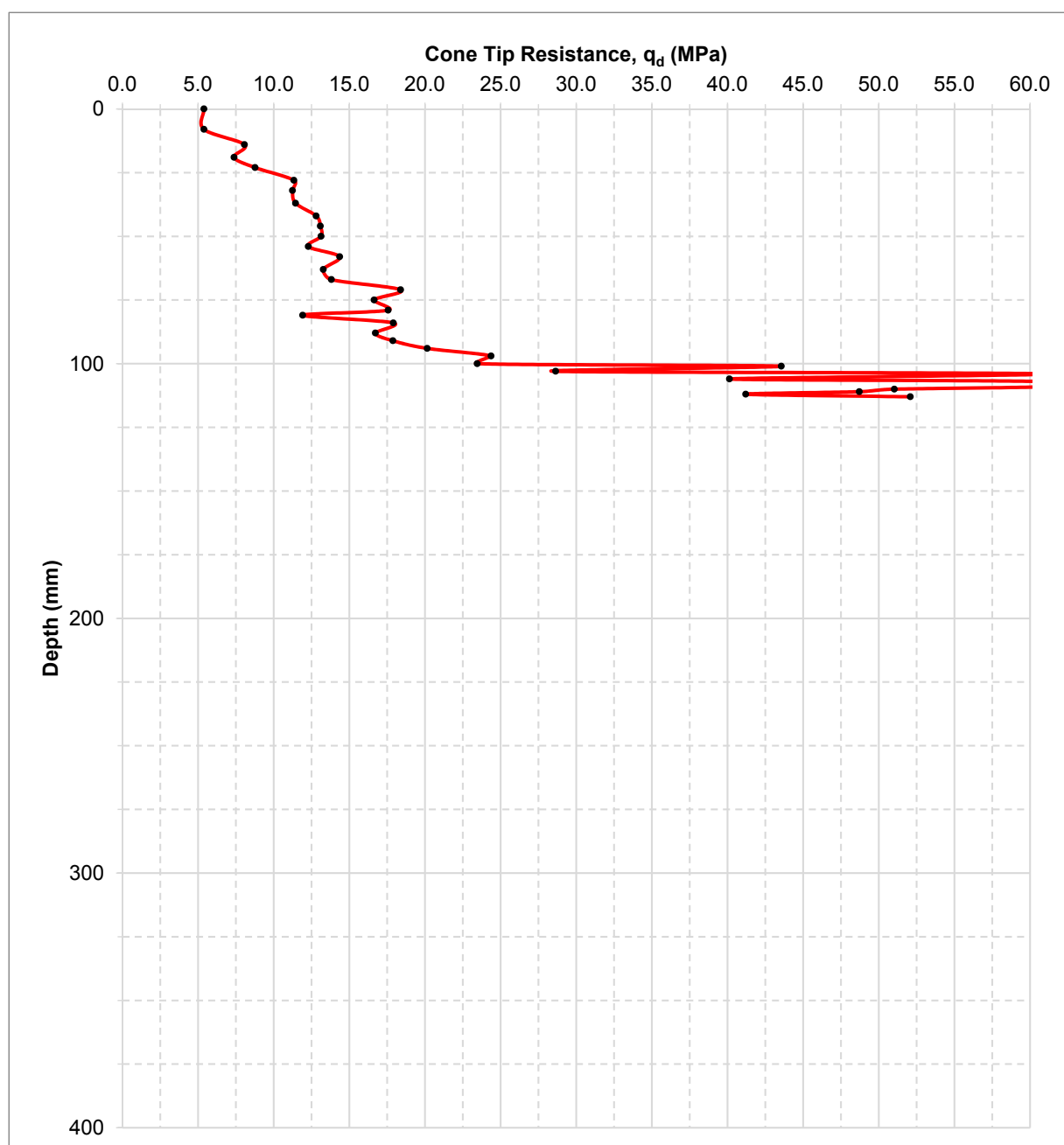
Project No.: 2091

Checked By: DWL

Location: Site 13-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 13-3A

Certificate Reference:

2091-PND-Site 13-3A

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 13-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	6.29	41	2	34.19			
2	5	12.50	42	1	35.61			
3	3	15.03	43	3	33.10			
4	3	15.69	44	1	42.37			
5	4	15.06	45	1	54.76			
6	4	11.18	46	1	54.09			
7	5	17.10	47	4	31.30			
8	3	18.22	48	3	39.79			
9	3	16.62	49	2	37.48			
10	3	21.17	50	2	48.50			
11	2	21.83	51	4	25.67			
12	2	37.18	52	2	35.97			
13	2	33.90	53	3	31.22			
14	1	44.23	54	3	38.35			
15	2	26.65	55	3	36.14			
16	3	46.93	56	3	33.82			
17	4	39.20	57	2	40.34			
18	1	29.52	58	2	48.58			
19	2	23.30	59	3	29.69			
20	2	18.28	60	2	41.44			
21	3	17.68	61	2	35.08			
22	4	13.48	62	3	40.07			
23	3	17.35	63	1	53.75			
24	4	15.75	64	2	29.78			
25	3	14.00	65	2	52.96			
26	3	13.83	66	2	22.59			
27	3	14.47	67	1	73.92			
28	2	12.64	68	3	34.87			
29	3	14.01	69	2	41.48			
30	3	17.67	70	1	39.89			
31	2	18.88	71	2	36.46			
32	4	22.85	72	1	43.48			
33	2	18.54	End of Test Record					
34	2	28.98						
35	2	24.58						
36	3	25.07						
37	3	28.19						
38	2	28.99						
39	2	26.80						
40	2	39.08						

PANDA Probe - Test Report

Site 13-3A

Certificate Reference:

2091-PND-Site 13-3A

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

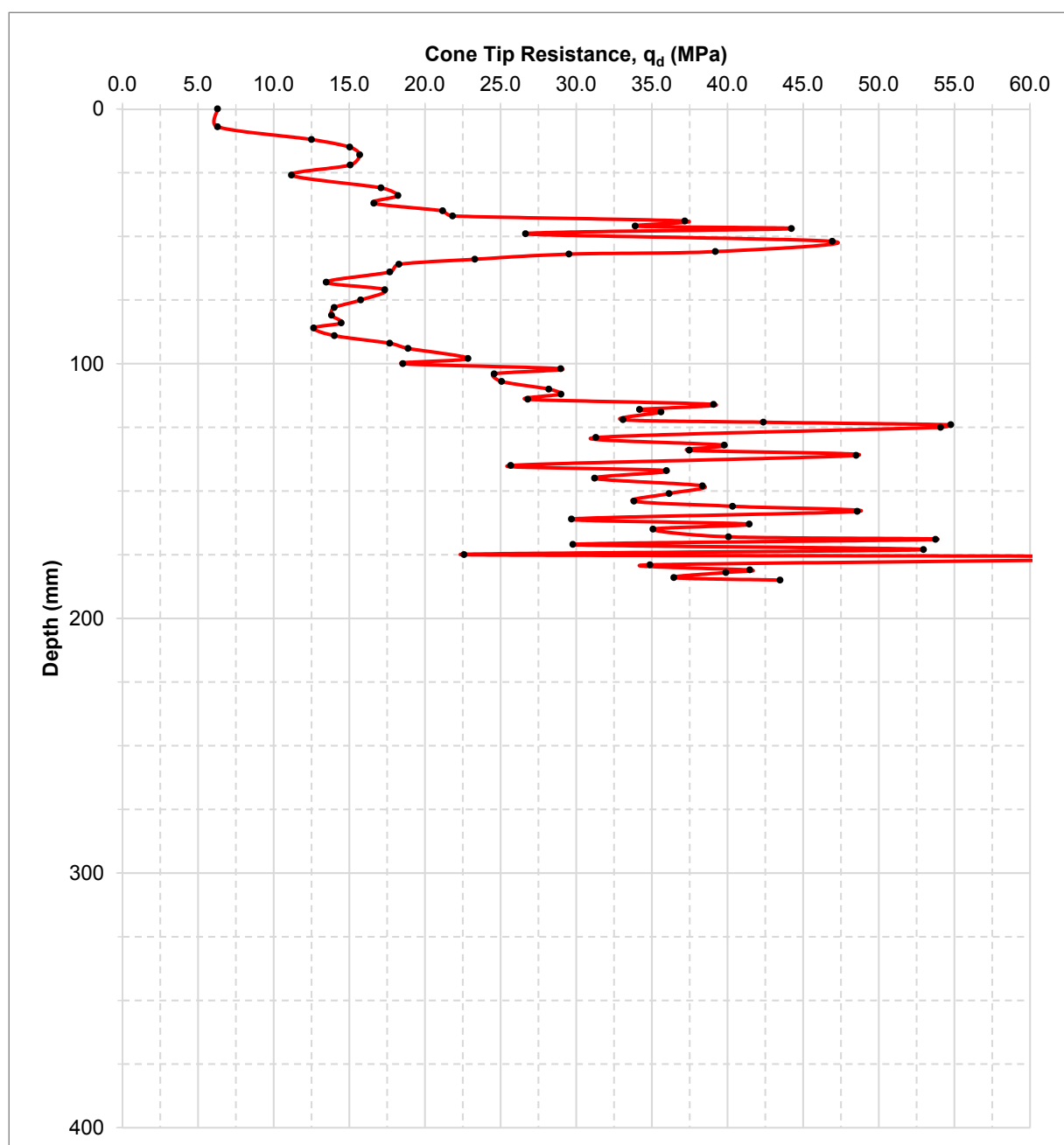
Project No.: 2091

Checked By: DWL

Location: Site 13-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 13-4

Certificate Reference:

2091-PND-Site 13-4

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 13-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	3	2.31						
2	4	4.80						
3	1	8.98						
4	3	7.06						
5	10	9.52						
6	9	10.35						
7	5	13.65						
8	6	9.23						
9	8	14.70						
10	7	9.92						
11	9	14.71						
12	7	11.16						
13	7	10.63						
14	4	27.77						
15	7	13.89						
16	4	24.42						
17	4	22.46						
18	6	17.83						
19	5	17.70						
20	5	24.68						
21	4	28.84						
22	6	26.00						
23	5	20.61						
24	4	27.99						
25	5	30.46						
26	5	26.43						
27	3	36.46						
28	1	20.94						
29	2	30.12						
30	1	46.89						
31	2	40.23						
32	2	39.65						
33	2	25.70						
34	1	44.93						
35	2	33.63						
End of Test Record								

Certificate Reference:

2091-PND-Site 13-4

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

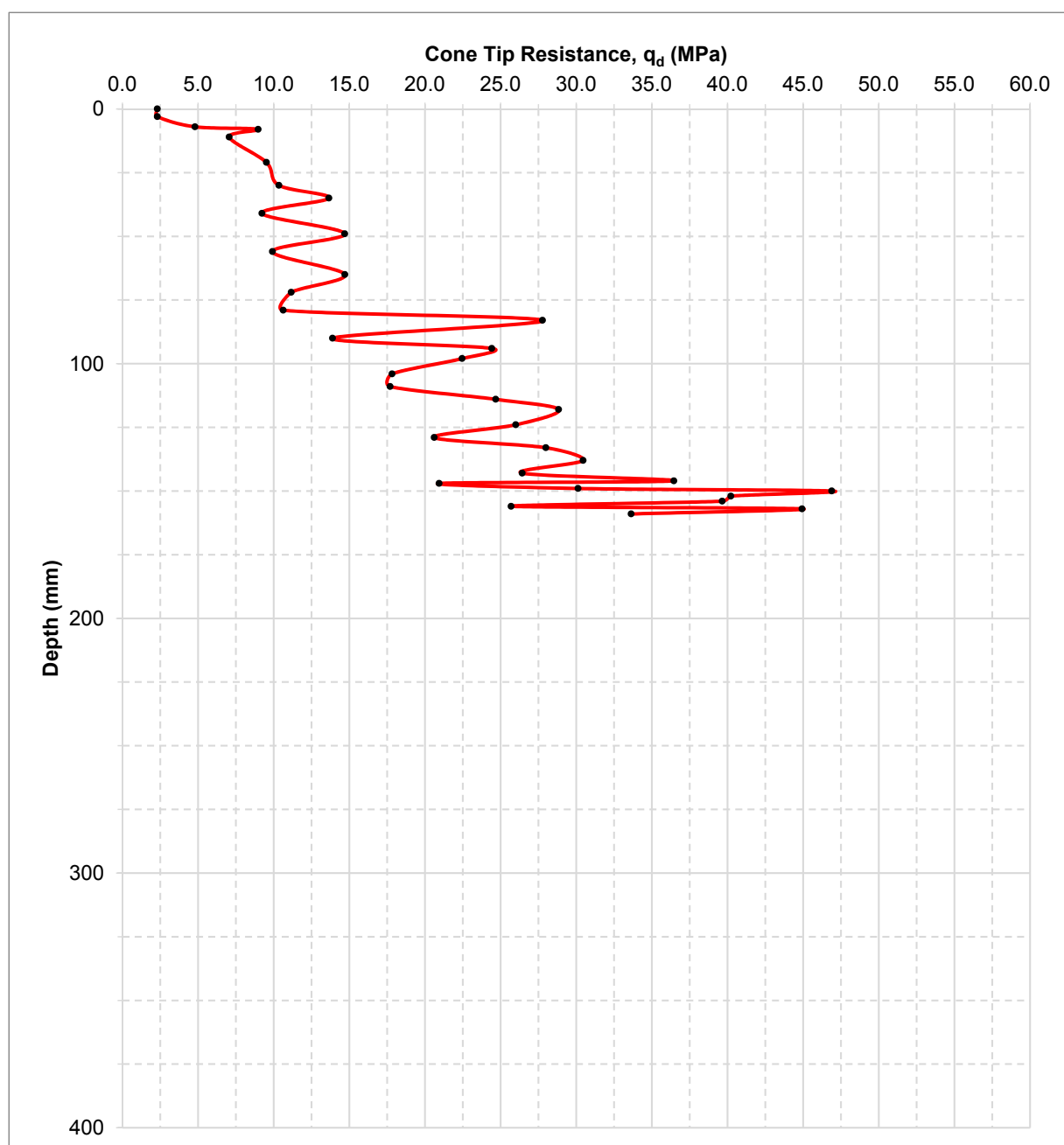
Project No.: 2091

Checked By: DWL

Location: Site 13-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 13-4A

Certificate Reference:

2091-PND-Site 13-4A

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 13-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	6.37	41	2	36.01	81	4	32.73
2	8	9.88	42	1	47.17	82	5	32.62
3	7	8.67	43	2	17.90	83	3	35.23
4	7	11.16	44	2	40.20	84	4	27.59
5	5	19.24	45	1	37.34	85	3	34.43
6	9	14.33	46	2	28.62	86	2	35.52
7	7	14.63	47	2	18.29	87	2	46.62
8	6	15.03	48	1	43.26	88	2	45.66
9	7	21.48	49	2	27.20	89	2	50.72
10	6	17.66	50	1	55.06	90	3	61.94
11	5	24.46	51	4	23.85	91	2	39.81
12	7	14.52	52	3	22.75	92	2	69.80
13	4	30.60	53	3	27.75	93	1	72.72
14	3	15.57	54	1	70.79	94	1	74.70
15	2	21.69	55	3	18.10	95	2	70.83
16	2	25.59	56	2	35.07	96	1	83.55
17	2	25.55	57	2	32.96	97	2	52.45
18	1	34.31	58	2	45.71	98	1	58.40
19	3	26.20	59	2	33.22	99	2	55.06
20	3	21.97	60	1	56.28	100	2	38.44
21	3	18.79	61	3	25.07	End of Test Record		
22	2	32.16	62	2	45.37			
23	1	30.64	63	2	35.59			
24	2	55.72	64	1	46.43			
25	2	19.90	65	3	29.38			
26	2	45.64	66	2	41.65			
27	2	28.77	67	3	35.88			
28	1	58.09	68	2	33.44			
29	2	43.93	69	2	31.80			
30	5	22.31	70	3	37.19			
31	1	39.48	71	2	36.70			
32	2	50.33	72	4	34.73			
33	1	42.71	73	4	43.73			
34	2	46.61	74	3	44.56			
35	1	28.67	75	4	37.40			
36	2	49.69	76	3	38.98			
37	3	28.99	77	4	34.70			
38	1	32.74	78	5	30.90			
39	2	44.04	79	4	33.12			
40	2	27.18	80	4	32.27			

PANDA Probe - Test Report

Site 13-4A

Certificate Reference:

2091-PND-Site 13-4A

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

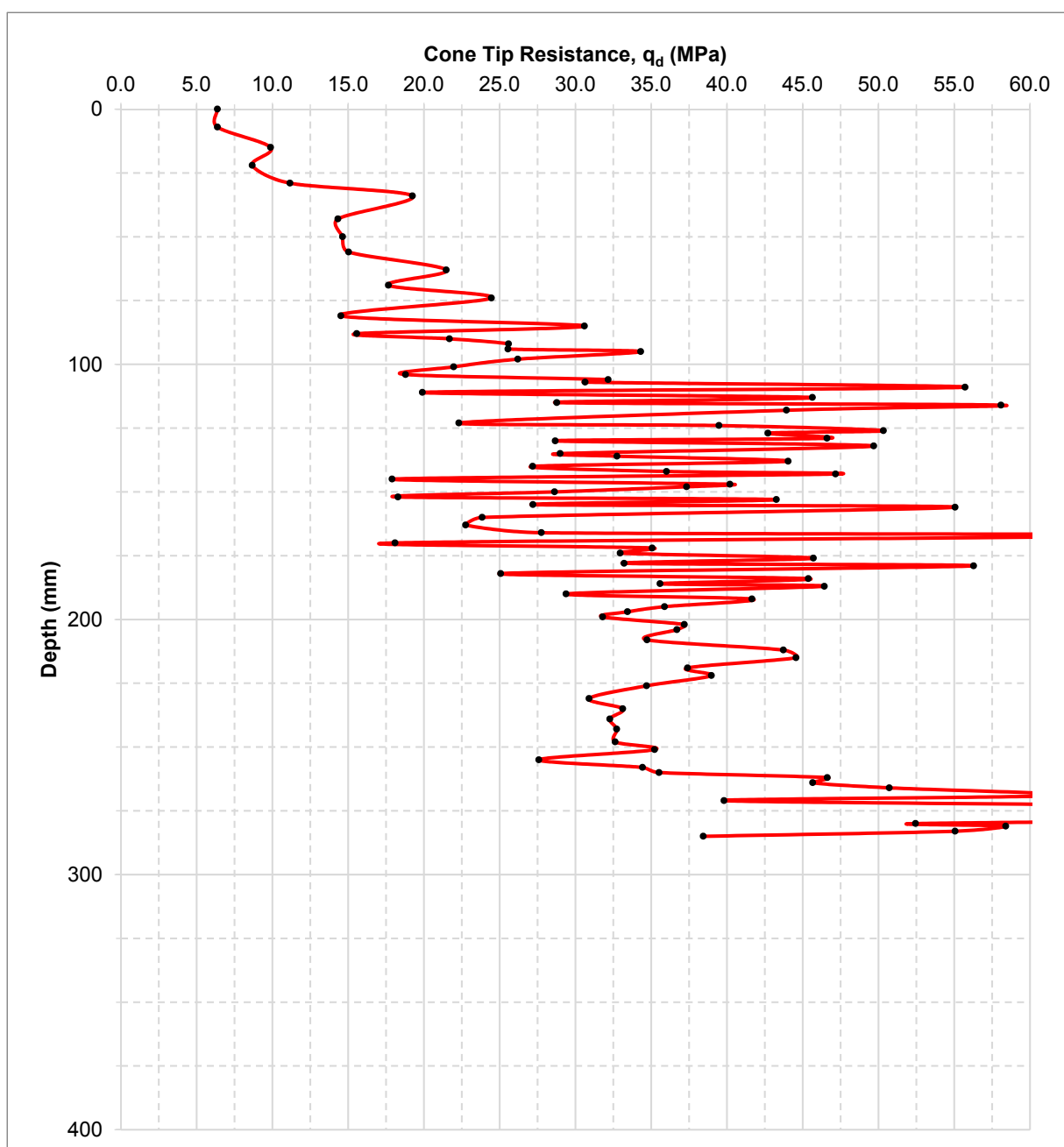
Project No.: 2091

Checked By: DWL

Location: Site 13-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 14-1

Certificate Reference:

2091-PND-Site 14-1

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 14-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	20	2.94	41	11	11.72			
2	13	5.10	42	12	9.44			
3	14	8.69	43	10	11.44			
4	9	8.12	44	9	12.60			
5	8	14.46	45	6	23.20			
6	7	12.21	46	5	29.84			
7	6	14.63	47	4	33.12			
8	9	11.67	48	5	32.48			
9	8	11.46	49	6	27.55			
10	9	13.36	50	4	24.52			
11	8	10.25	51	6	24.72			
12	9	12.86	52	6	22.69			
13	9	13.38	53	7	20.22			
14	7	15.30	54	7	18.43			
15	8	15.10	55	7	18.93			
16	10	14.25	56	7	17.71			
17	12	13.58	57	7	19.67			
18	8	16.15	58	5	23.12			
19	6	14.59	59	6	21.82			
20	8	14.19	60	6	23.35			
21	9	16.10	61	7	20.63			
22	11	14.18	62	6	17.13			
23	11	12.24	63	5	30.34			
24	10	8.62	64	5	25.52			
25	10	13.49	65	2	56.09			
26	11	16.73	66	2	76.76			
27	11	14.17	67	2	93.09			
28	13	10.65	68	2	108.31			
29	15	8.99	End of Test Record					
30	9	13.77						
31	7	17.27						
32	8	16.79						
33	7	18.19						
34	6	22.17						
35	5	25.60						
36	6	18.92						
37	8	13.28						
38	8	14.56						
39	10	15.31						
40	10	11.08						

PANDA Probe - Test Report

Site 14-1

Certificate Reference:

2091-PND-Site 14-1

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

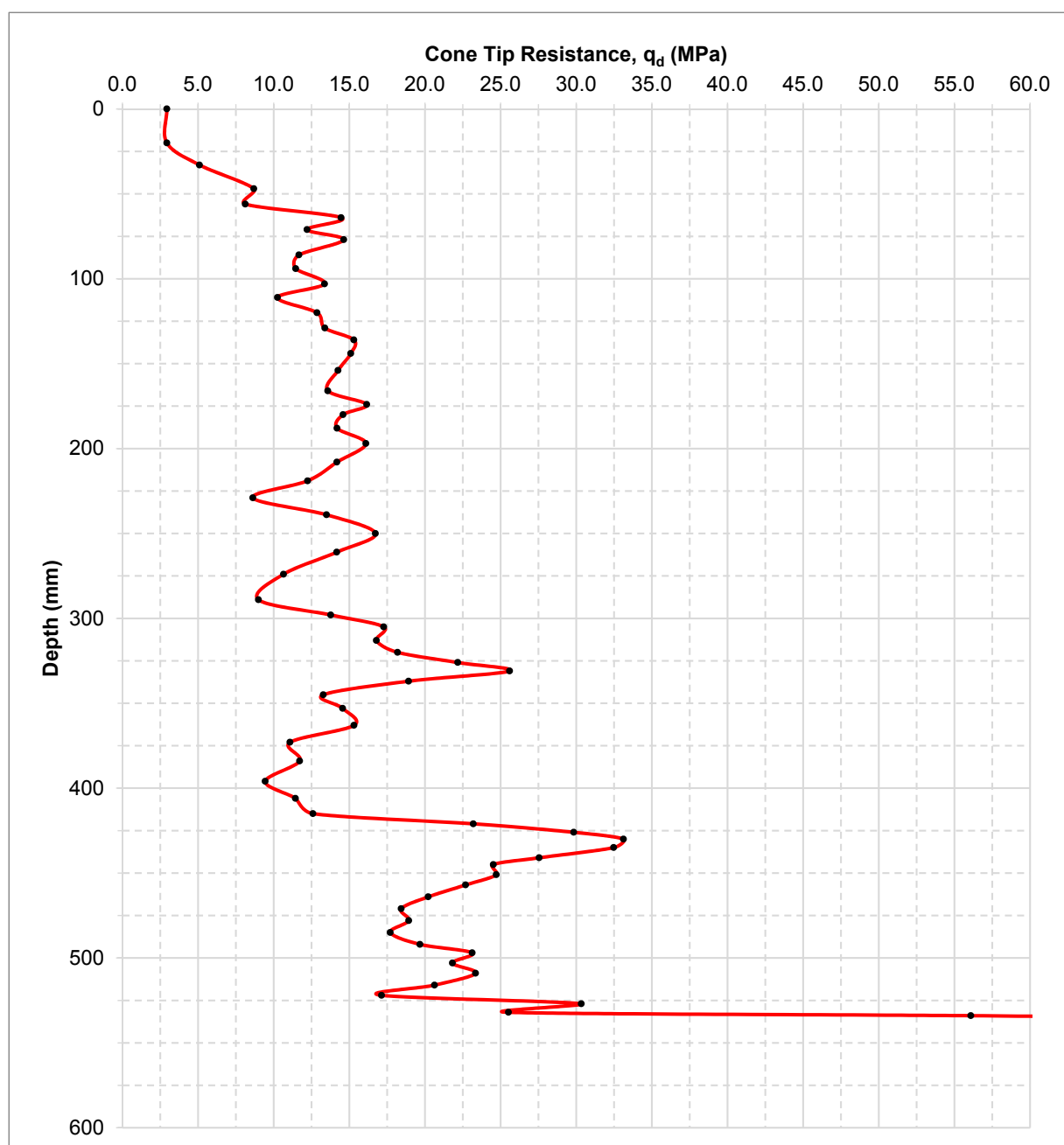
Project No.: 2091

Checked By: DWL

Location: Site 14-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 14-2

Certificate Reference:

2091-PND-Site 14-2

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 14-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	3.43	41	11	8.42			
2	8	6.35	42	10	11.69			
3	5	10.64	43	10	12.90			
4	7	10.69	44	9	11.64			
5	9	10.96	45	7	15.40			
6	10	10.49	46	10	10.71			
7	9	7.03	47	8	13.44			
8	9	9.38	48	7	13.11			
9	9	11.23	49	9	14.90			
10	10	12.81	50	6	17.62			
11	11	11.63	51	5	23.63			
12	15	8.48	52	4	31.85			
13	11	9.68	53	5	24.43			
14	8	14.30	54	6	23.48			
15	9	11.04	55	4	35.68			
16	14	8.90	56	5	31.20			
17	15	7.09	57	4	26.88			
18	17	7.50	58	6	29.47			
19	14	9.02	59	5	27.94			
20	13	9.31	60	5	26.01			
21	10	9.81	61	4	26.69			
22	7	9.18	62	4	26.17			
23	8	13.66	63	4	40.03			
24	4	23.60	64	4	33.14			
25	4	24.60	65	4	30.27			
26	5	19.84	66	4	35.42			
27	6	19.30	67	5	27.71			
28	6	18.53	68	4	29.47			
29	6	20.31	69	4	35.45			
30	7	23.12	70	2	48.78			
31	8	18.06	71	4	31.47			
32	8	15.05	72	1	65.63			
33	7	17.60	73	3	33.97			
34	9	15.06	74	2	34.32			
35	8	14.55	End of Test Record					
36	8	14.95						
37	10	12.74						
38	10	11.87						
39	11	10.08						
40	12	10.91						

PANDA Probe - Test Report

Site 14-2

Certificate Reference:

2091-PND-Site 14-2

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

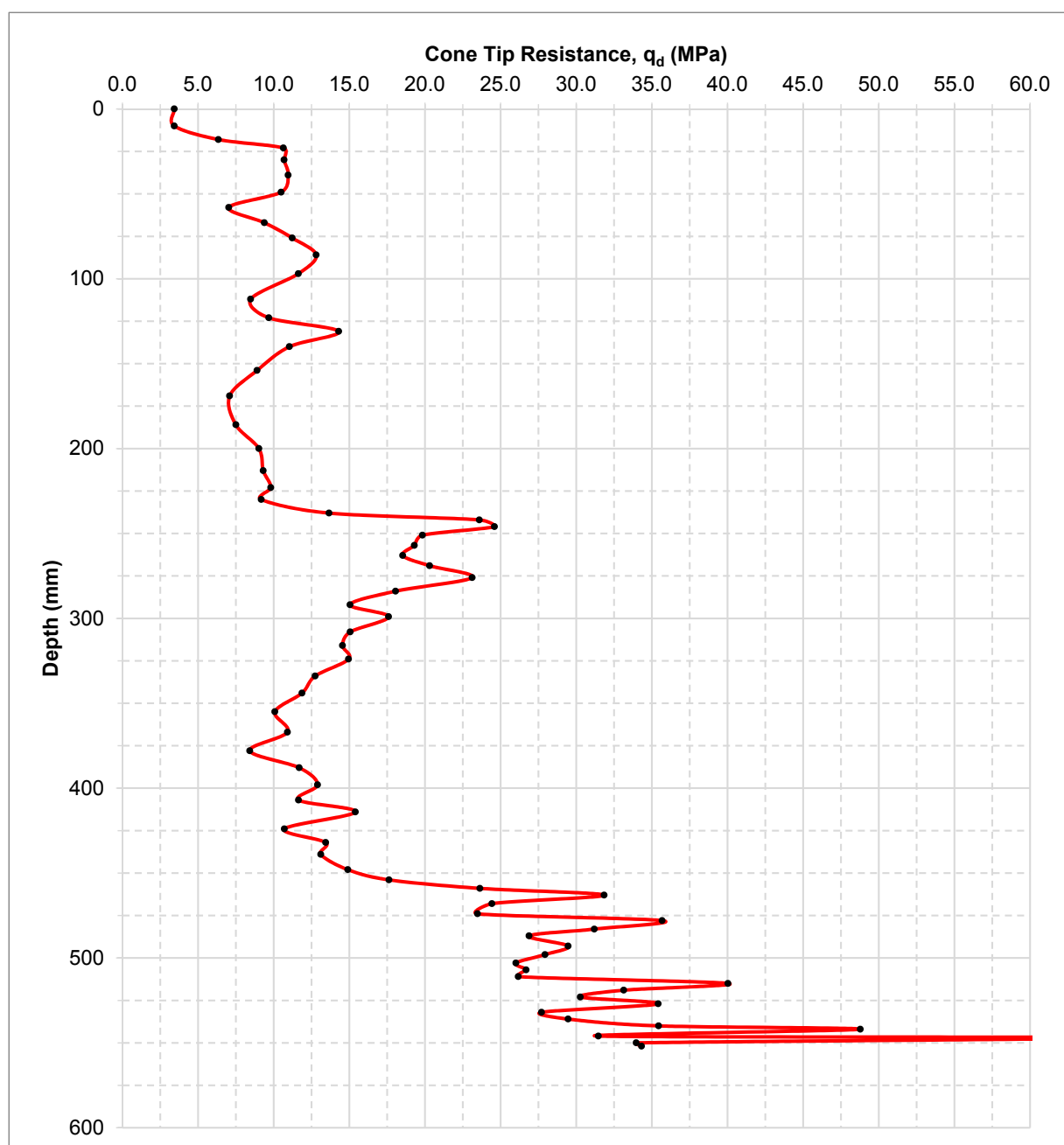
Project No.: 2091

Checked By: DWL

Location: Site 14-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 14-3

Certificate Reference:

2091-PND-Site 14-3

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 14-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	19	3.49	41	2	80.64			
2	10	5.81	End of Test Record					
3	8	7.95						
4	9	11.16						
5	9	9.91						
6	5	20.08						
7	4	26.85						
8	3	29.94						
9	3	26.63						
10	3	37.26						
11	4	21.95						
12	8	13.77						
13	6	14.25						
14	7	13.27						
15	7	15.66						
16	6	12.27						
17	9	15.72						
18	8	17.06						
19	8	15.87						
20	7	18.07						
21	8	22.17						
22	7	17.79						
23	7	16.18						
24	7	15.68						
25	5	19.00						
26	5	20.30						
27	6	19.24						
28	5	17.09						
29	5	22.90						
30	5	30.18						
31	5	29.46						
32	5	23.35						
33	5	25.81						
34	5	25.09						
35	5	26.35						
36	6	22.13						
37	5	22.54						
38	5	26.57						
39	3	47.84						
40	1	92.86						

PANDA Probe - Test Report

Site 14-3

Certificate Reference:

2091-PND-Site 14-3

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

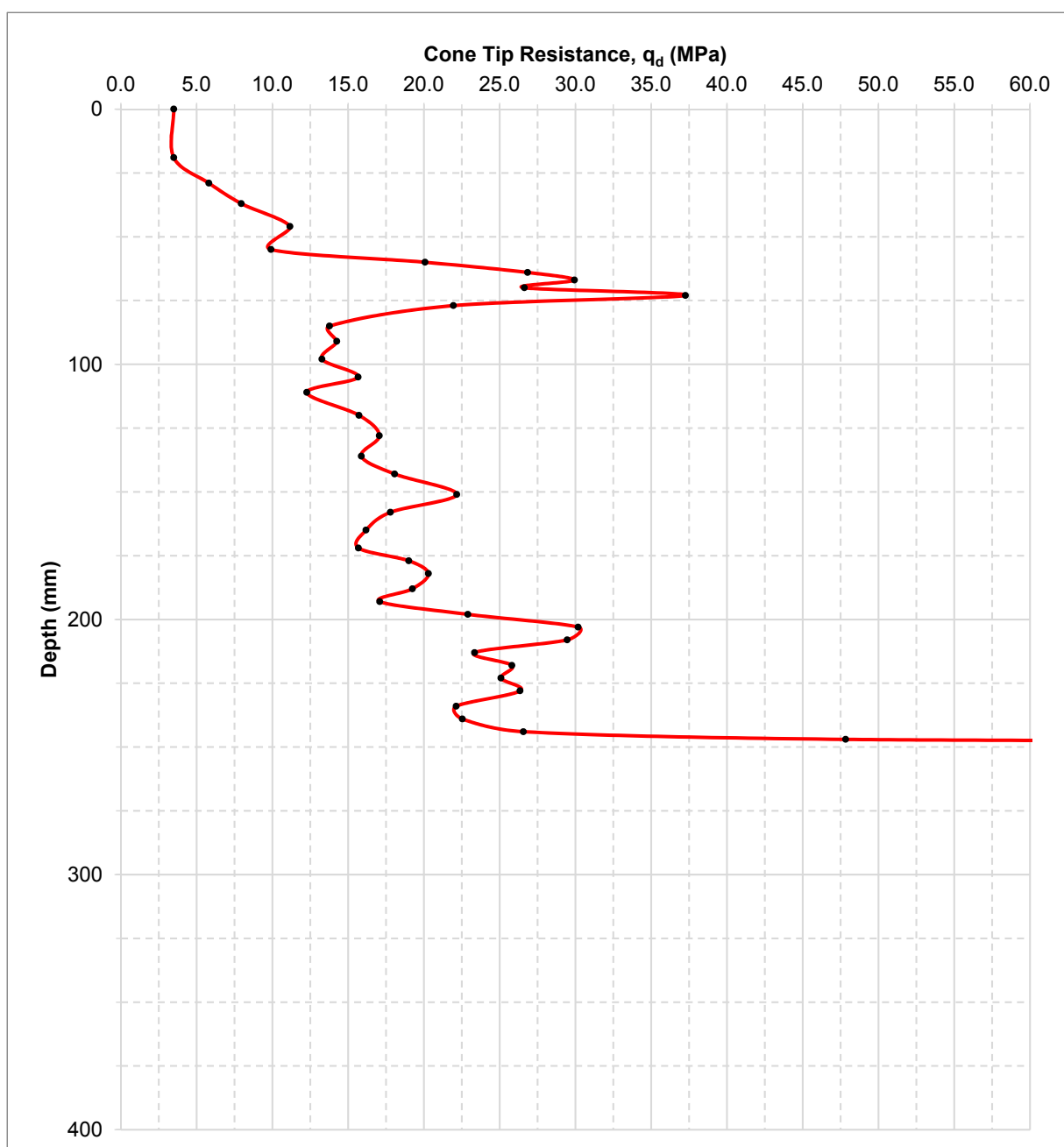
Project No.: 2091

Checked By: DWL

Location: Site 14-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 14-3A

Certificate Reference:

2091-PND-Site 14-3A

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 14-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	13	5.40	41	6	19.90			
2	7	10.11	42	5	19.61			
3	10	10.68	43	5	22.34			
4	10	11.41	44	6	19.09			
5	8	10.29	45	5	15.80			
6	9	14.51	46	4	23.29			
7	7	11.55	47	5	21.16			
8	7	19.78	48	3	23.87			
9	6	16.79	49	4	25.45			
10	8	17.87	50	3	39.76			
11	7	17.09	51	4	36.10			
12	6	20.51	52	1	61.92			
13	2	39.44	53	3	31.68			
14	2	96.17	54	3	40.82			
15	3	53.61	55	3	30.12			
16	3	41.17	56	3	35.96			
17	3	51.76	57	3	31.41			
18	1	42.88	58	3	36.65			
19	4	34.50	59	2	44.88			
20	6	26.26	60	3	35.64			
21	4	22.99	61	3	43.69			
22	6	20.27	62	1	31.75			
23	7	22.20	63	3	43.57			
24	5	23.80	End of Test Record					
25	7	21.78						
26	6	26.65						
27	5	20.33						
28	5	26.55						
29	2	24.14						
30	5	25.15						
31	6	21.61						
32	4	27.11						
33	4	33.37						
34	4	34.41						
35	5	30.27						
36	3	30.39						
37	5	22.89						
38	5	25.79						
39	5	29.42						
40	5	23.62						

PANDA Probe - Test Report

Site 14-3A

Certificate Reference:

2091-PND-Site 14-3A

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

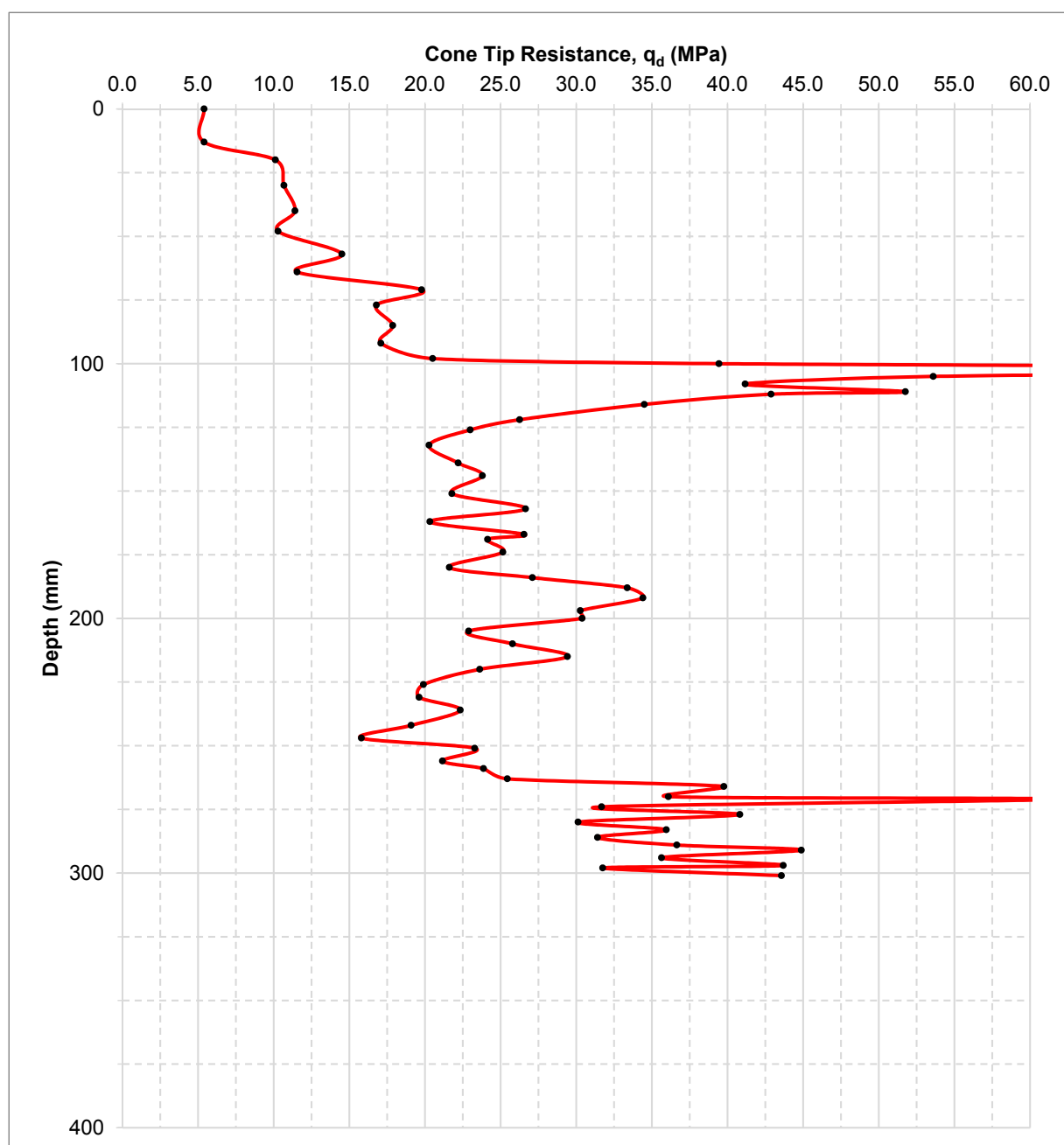
Project No.: 2091

Checked By: DWL

Location: Site 14-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 14-4

Certificate Reference:

2091-PND-Site 14-4

Sheet:

1 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 14-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	4.15	41	6	16.63	81	3	39.44
2	10	5.84	42	6	15.02	82	4	21.15
3	7	8.80	43	4	16.85	End of Test Record		
4	11	9.05	44	7	12.69			
5	8	10.25	45	8	11.72			
6	9	8.54	46	8	12.16			
7	8	10.04	47	6	15.13			
8	8	9.50	48	5	19.59			
9	9	10.10	49	6	17.64			
10	9	10.20	50	5	16.20			
11	6	12.77	51	8	17.53			
12	6	18.64	52	7	17.89			
13	4	26.95	53	6	16.78			
14	5	22.78	54	7	17.87			
15	6	20.61	55	5	15.64			
16	7	17.13	56	8	14.63			
17	10	10.42	57	10	13.49			
18	11	11.36	58	9	12.07			
19	14	9.72	59	13	10.32			
20	15	7.60	60	14	10.02			
21	11	7.86	61	14	11.19			
22	16	6.74	62	13	9.66			
23	14	6.48	63	12	9.79			
24	12	7.43	64	11	10.98			
25	13	7.96	65	5	21.14			
26	10	8.39	66	4	35.35			
27	10	10.98	67	5	21.08			
28	11	10.40	68	5	30.87			
29	10	12.26	69	3	37.15			
30	11	10.52	70	5	19.40			
31	7	13.83	71	4	33.71			
32	5	26.54	72	4	30.40			
33	4	25.60	73	3	40.63			
34	4	23.11	74	4	32.67			
35	5	21.90	75	2	48.23			
36	6	18.17	76	3	45.14			
37	4	14.94	77	4	31.74			
38	6	16.68	78	2	50.80			
39	6	18.51	79	3	35.04			
40	5	15.27	80	3	30.75			

PANDA Probe - Test Report

Site 14-4

Certificate Reference:

2091-PND-Site 14-4

Sheet:

2 of 2

Client: ARRB

Test Date: 18/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

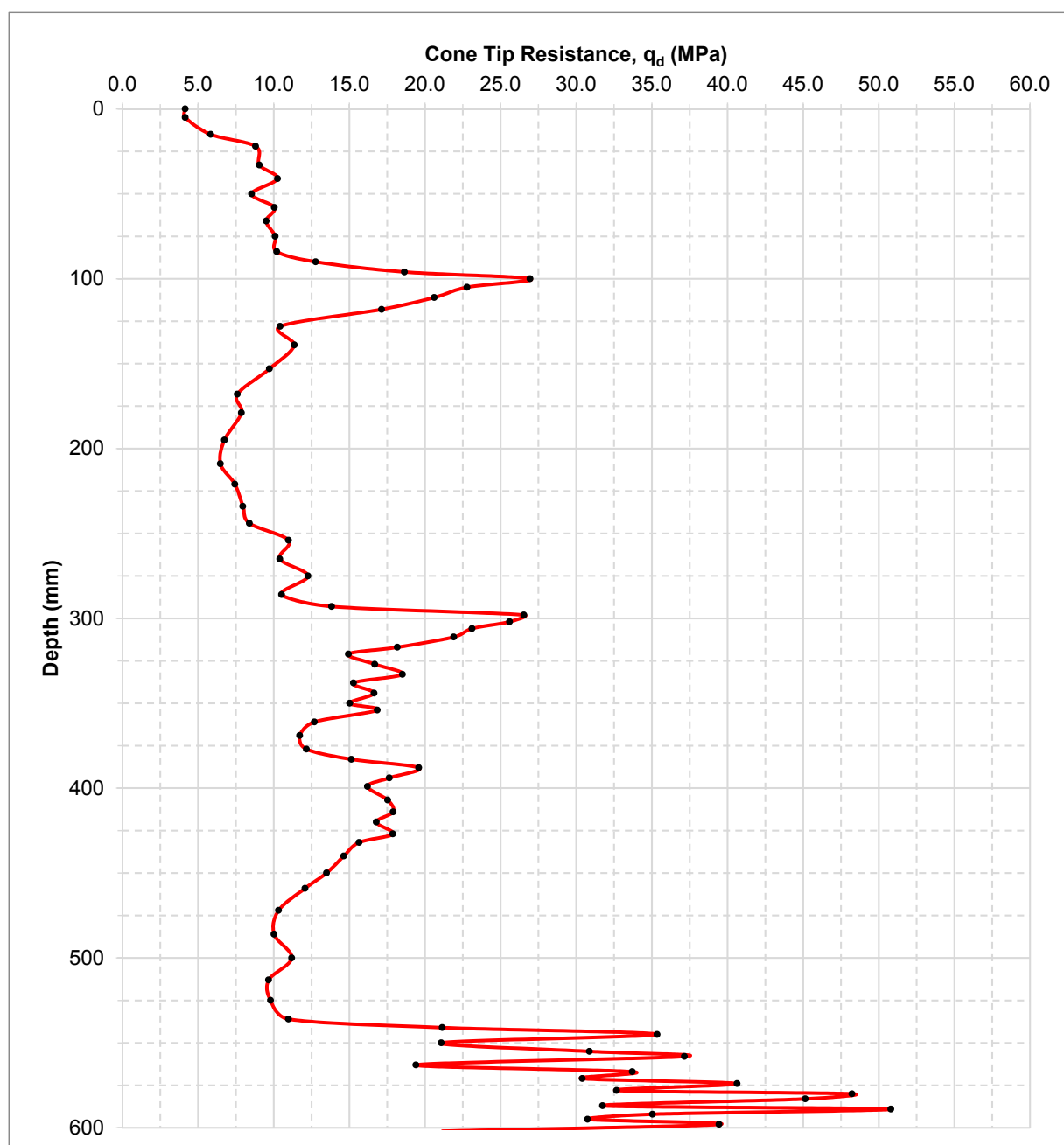
Project No.: 2091

Checked By: DWL

Location: Site 14-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 15-1

Certificate Reference:

2091-PND-Site 15-1

Sheet:

1 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 15-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.42	41	3	29.31			
2	9	5.74	42	2	31.14			
3	5	10.72	43	3	28.19			
4	6	9.92	44	2	34.27			
5	7	7.94	45	3	21.26			
6	5	8.76	46	3	23.14			
7	6	9.10	47	2	27.05			
8	6	11.12	48	3	25.41			
9	6	9.97	49	2	34.12			
10	5	12.59	50	2	26.72			
11	4	14.06	51	2	36.78			
12	5	13.99	52	2	38.15			
13	3	12.80	53	2	41.43			
14	3	18.17	54	1	36.52			
15	4	18.10	55	2	51.16			
16	3	25.71	End of Test Record					
17	3	18.33						
18	4	17.81						
19	4	20.30						
20	3	22.34						
21	3	22.47						
22	3	22.21						
23	3	25.31						
24	2	25.89						
25	3	18.75						
26	3	21.11						
27	3	25.94						
28	3	15.42						
29	4	16.24						
30	4	21.90						
31	4	21.09						
32	3	14.31						
33	4	17.62						
34	3	19.20						
35	2	22.27						
36	3	27.60						
37	2	20.55						
38	2	23.83						
39	3	23.92						
40	2	27.93						

PANDA Probe - Test Report

Site 15-1

Certificate Reference:

2091-PND-Site 15-1

Sheet:

2 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

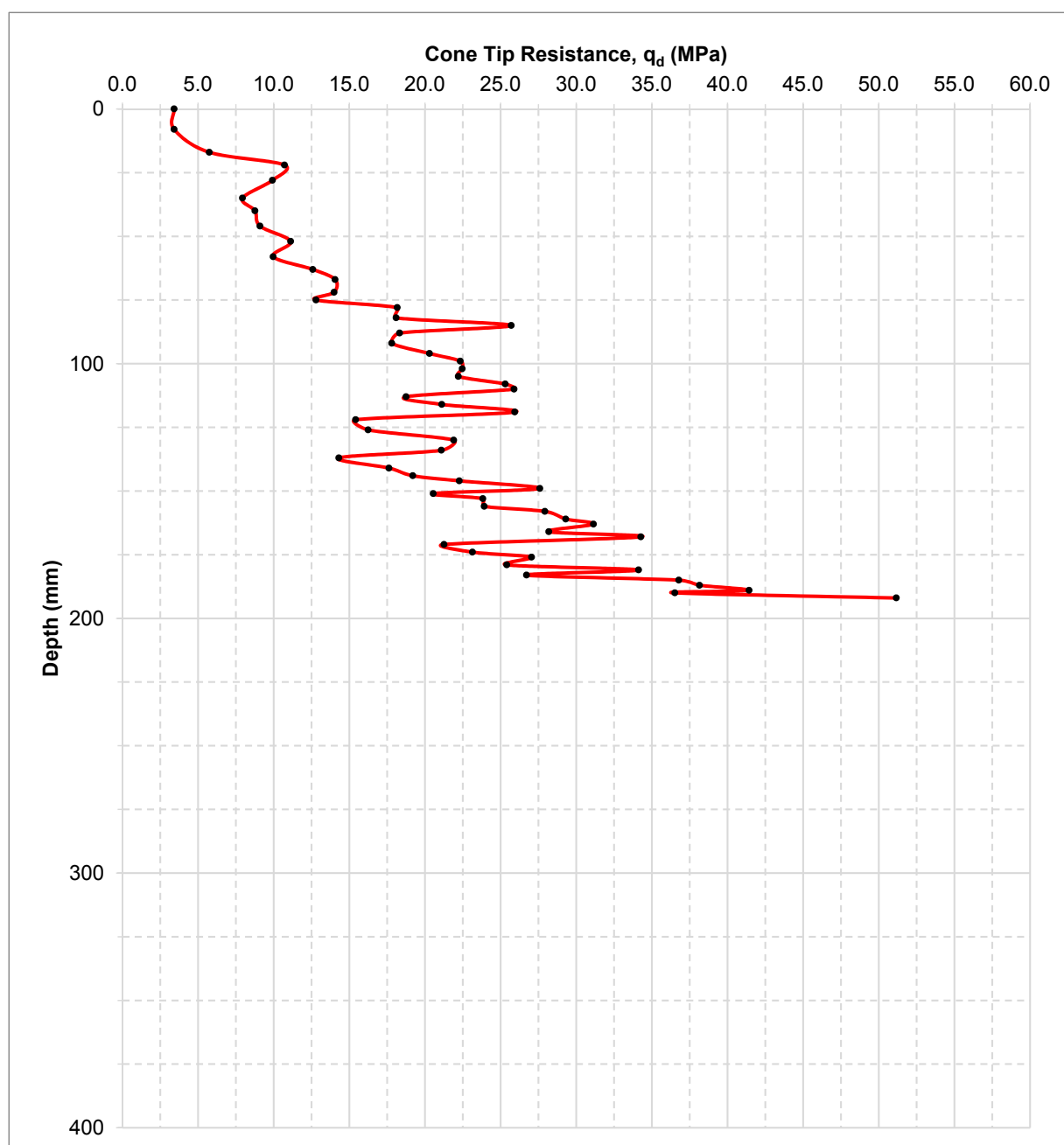
Project No.: 2091

Checked By: DWL

Location: Site 15-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 15-1A

Certificate Reference:

2091-PND-Site 15-1A

Sheet:

1 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 15-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	4.23	41	3	31.21	81	2	30.31
2	6	8.82	42	4	24.89	82	3	18.94
3	3	8.64	43	4	22.86	83	3	19.66
4	7	7.59	44	5	29.79	84	2	25.91
5	7	7.22	45	4	26.65	85	3	22.68
6	5	11.17	46	4	28.09	86	2	20.99
7	6	11.98	47	4	27.62	87	2	37.53
8	5	13.95	48	3	24.73	88	3	26.55
9	5	9.09	49	6	24.14	89	1	34.62
10	4	9.56	50	4	27.79	90	2	27.16
11	6	13.82	51	4	34.95	91	2	29.85
12	6	11.77	52	5	25.62	92	3	24.89
13	7	13.31	53	6	21.76	93	2	43.72
14	6	15.87	54	7	23.20	94	2	28.98
15	6	17.58	55	5	24.61	95	2	35.81
16	5	16.12	56	5	30.06	96	3	34.58
17	4	20.13	57	6	20.71	97	4	27.05
18	5	15.67	58	8	23.46	98	1	56.16
19	5	21.97	59	10	13.73	99	1	39.94
20	6	18.55	60	8	19.17	100	2	37.97
21	4	22.04	61	8	18.45	101	2	28.79
22	4	23.14	62	10	16.48	102	2	56.02
23	4	25.93	63	5	28.68	103	2	23.50
24	3	30.68	64	5	26.24	104	2	40.19
25	3	33.91	65	4	41.41	105	2	32.08
26	3	25.63	66	5	35.53	106	2	36.60
27	4	19.69	67	4	38.08	107	2	52.13
28	2	29.26	68	7	25.97	108	2	40.72
29	5	21.85	69	6	28.09	109	3	47.49
30	3	19.73	70	8	24.50	End of Test Record		
31	4	26.32	71	7	18.43			
32	4	22.17	72	5	24.85			
33	4	24.21	73	5	20.27			
34	4	25.35	74	3	21.66			
35	4	23.41	75	2	29.32			
36	3	28.77	76	5	17.64			
37	3	19.64	77	5	22.57			
38	3	28.52	78	4	34.05			
39	2	26.42	79	3	21.84			
40	4	24.89	80	3	25.46			

PANDA Probe - Test Report

Site 15-1A

Certificate Reference:

2091-PND-Site 15-1A

Sheet:

2 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

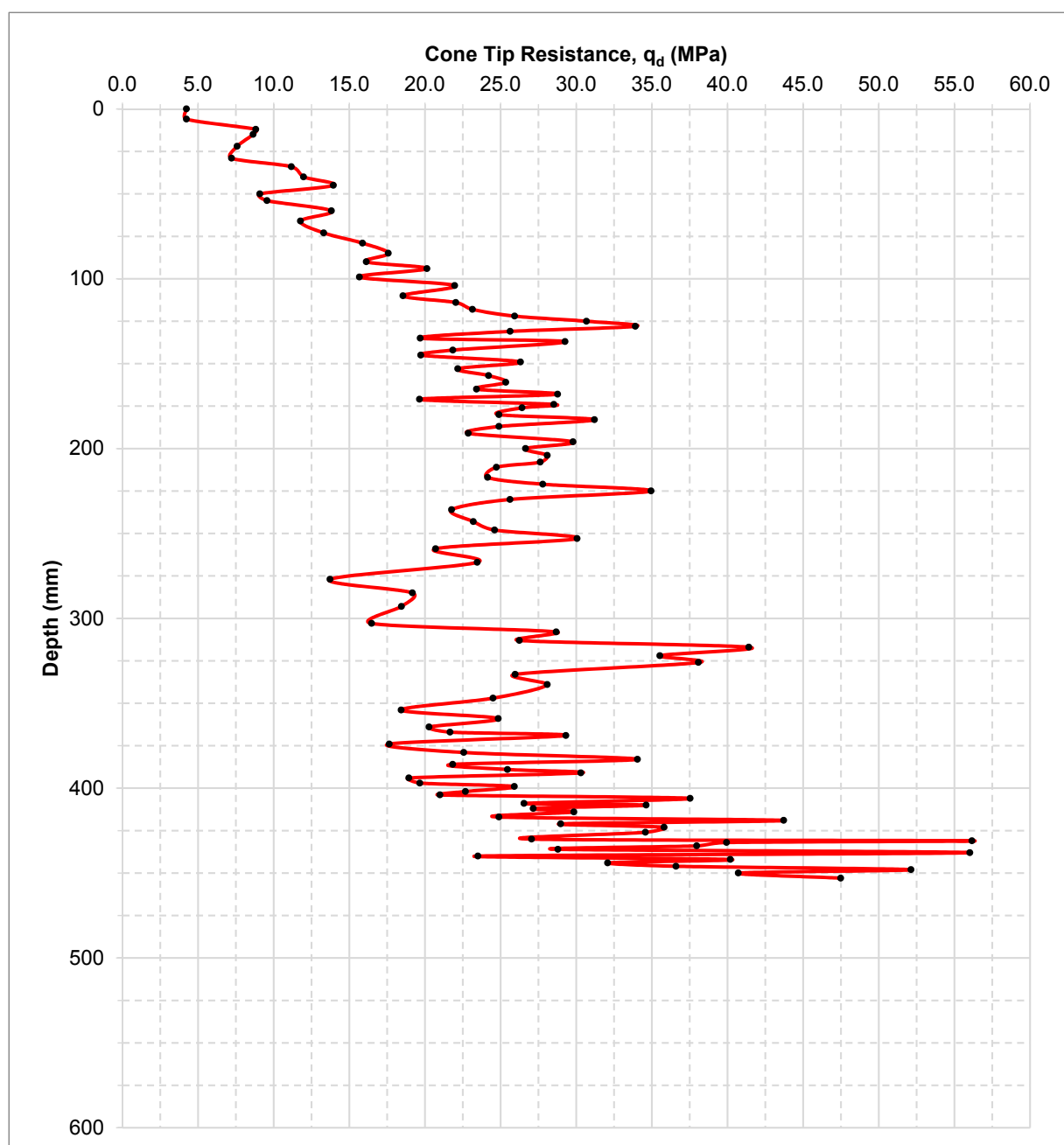
Project No.: 2091

Checked By: DWL

Location: Site 15-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 15-2

Certificate Reference:

2091-PND-Site 15-2

Sheet:

2 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

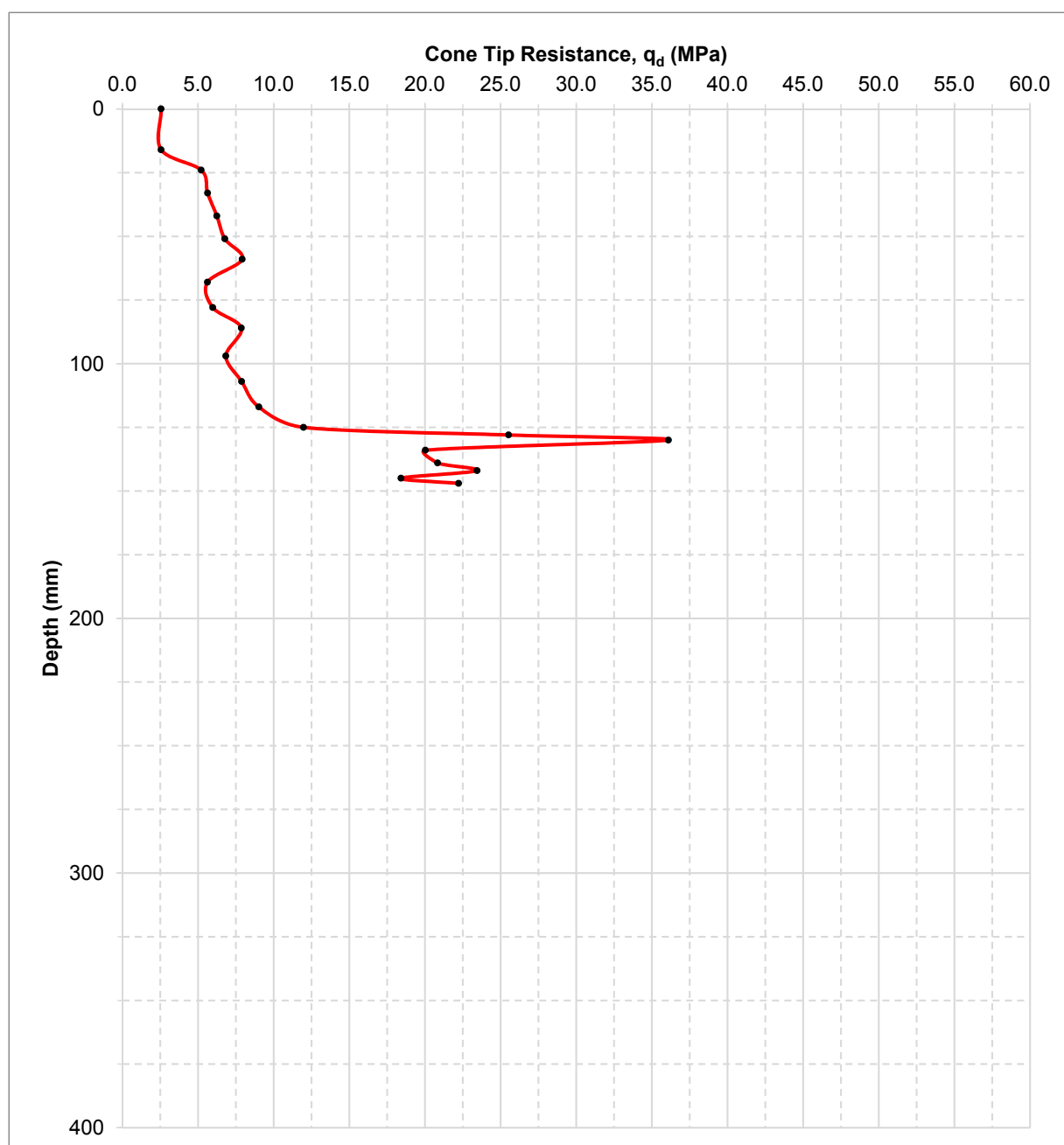
Project No.: 2091

Checked By: DWL

Location: Site 15-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 15-2A

Certificate Reference:

2091-PND-Site 15-2A

Sheet:

2 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

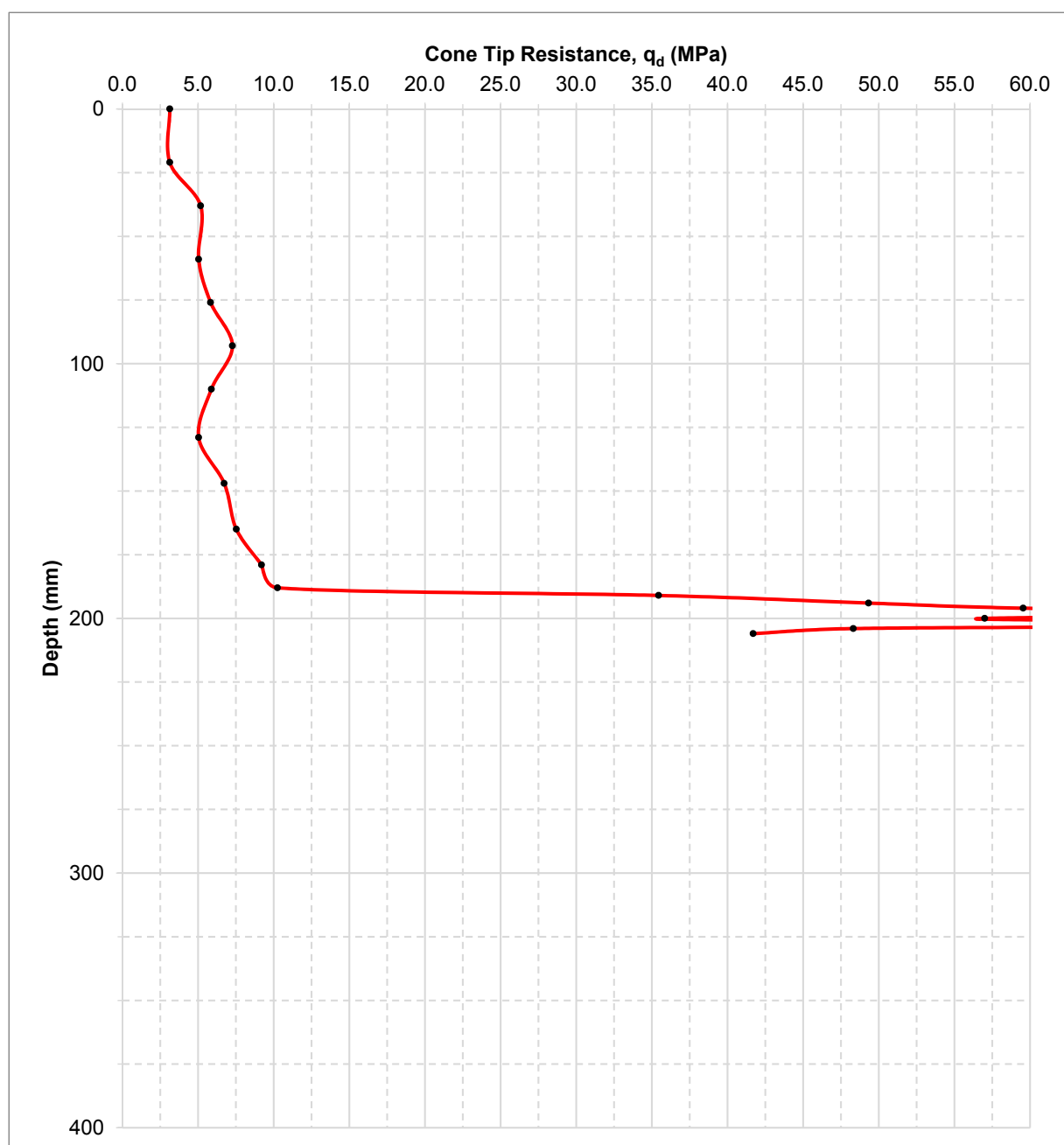
Project No.: 2091

Checked By: DWL

Location: Site 15-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 15-2B

Certificate Reference:

2091-PND-Site 15-2B

Sheet:

1 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 15-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	13	4.60	41	1	27.87			
2	6	10.62	42	2	29.20			
3	9	11.73	43	3	25.92			
4	12	9.08	44	2	43.41			
5	12	8.60	45	2	53.87			
6	11	11.02	46	2	58.32			
7	16	7.03	47	1	53.81			
8	7	8.57	48	1	46.93			
9	11	10.17	49	2	27.04			
10	16	6.58	50	1	51.60			
11	18	7.82	End of Test Record					
12	17	6.18						
13	13	9.78						
14	13	10.79						
15	10	14.11						
16	9	15.31						
17	6	17.06						
18	7	17.25						
19	6	23.03						
20	7	19.81						
21	8	18.00						
22	8	14.47						
23	6	17.50						
24	7	13.60						
25	9	15.11						
26	9	16.27						
27	10	15.82						
28	9	16.10						
29	7	16.66						
30	7	21.59						
31	7	22.32						
32	6	25.63						
33	5	22.10						
34	3	19.40						
35	1	25.92						
36	1	22.64						
37	2	18.60						
38	2	20.51						
39	3	39.95						
40	2	35.76						

PANDA Probe - Test Report

Site 15-2B

Certificate Reference:

2091-PND-Site 15-2B

Sheet:

2 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

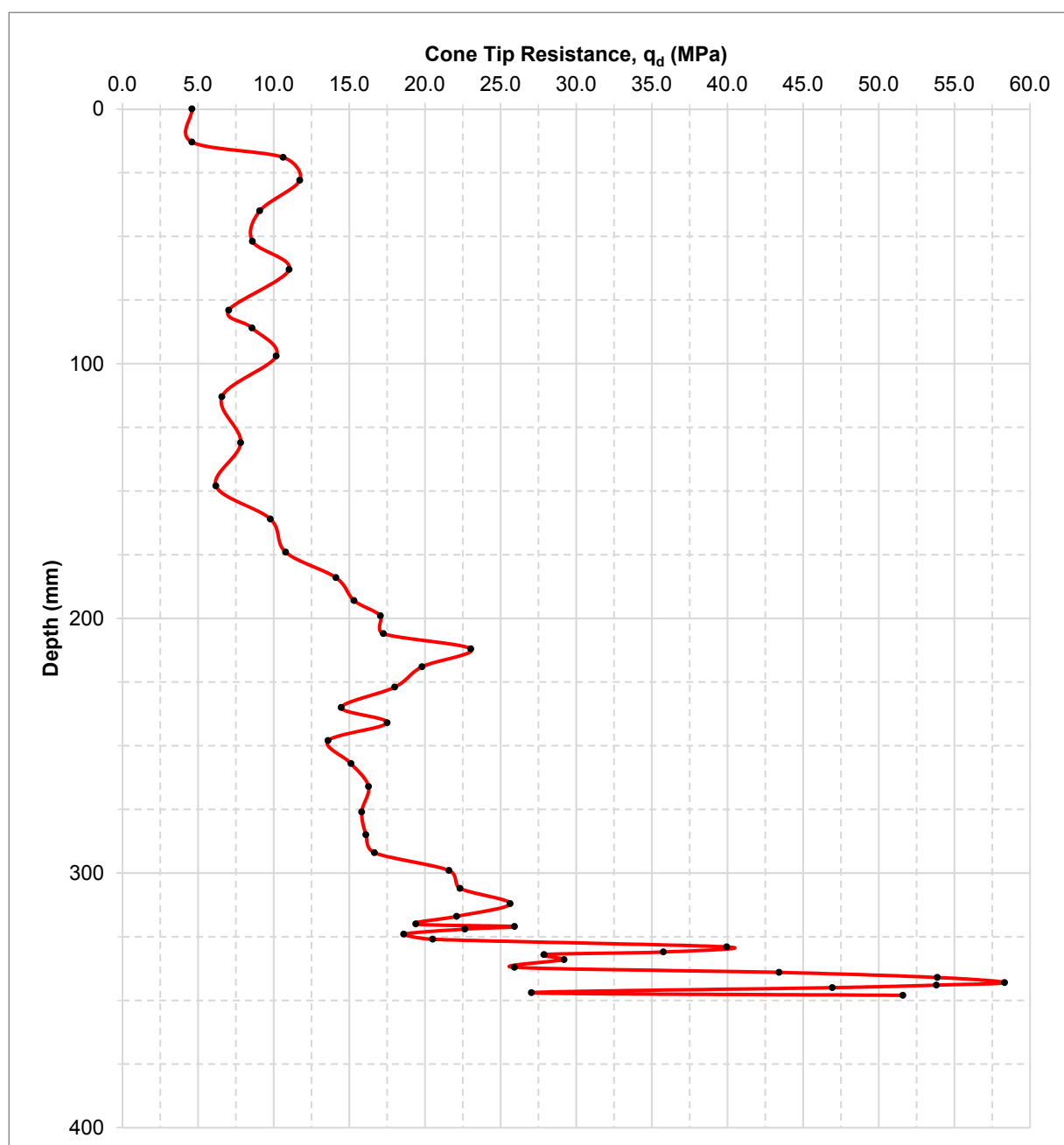
Project No.: 2091

Checked By: DWL

Location: Site 15-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 15-3

Certificate Reference:

2091-PND-Site 15-3

Sheet:

1 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 15-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.28	41	4	38.22			
2	5	6.78	42	3	45.32			
3	5	4.15	43	2	70.31			
4	8	5.47	End of Test Record					
5	8	7.04						
6	8	7.75						
7	9	6.88						
8	10	7.45						
9	5	11.49						
10	6	15.33						
11	3	17.55						
12	6	19.07						
13	7	17.24						
14	5	16.90						
15	4	23.17						
16	4	22.37						
17	4	28.53						
18	4	29.82						
19	2	29.49						
20	4	24.68						
21	2	23.16						
22	3	23.90						
23	3	20.16						
24	4	20.14						
25	7	18.17						
26	5	22.73						
27	6	20.73						
28	7	19.21						
29	6	25.76						
30	6	23.83						
31	5	25.23						
32	7	19.49						
33	5	17.54						
34	8	17.31						
35	8	15.14						
36	8	14.56						
37	7	16.37						
38	7	19.17						
39	6	22.84						
40	4	30.38						

PANDA Probe - Test Report

Site 15-3

Certificate Reference:

2091-PND-Site 15-3

Sheet:

2 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

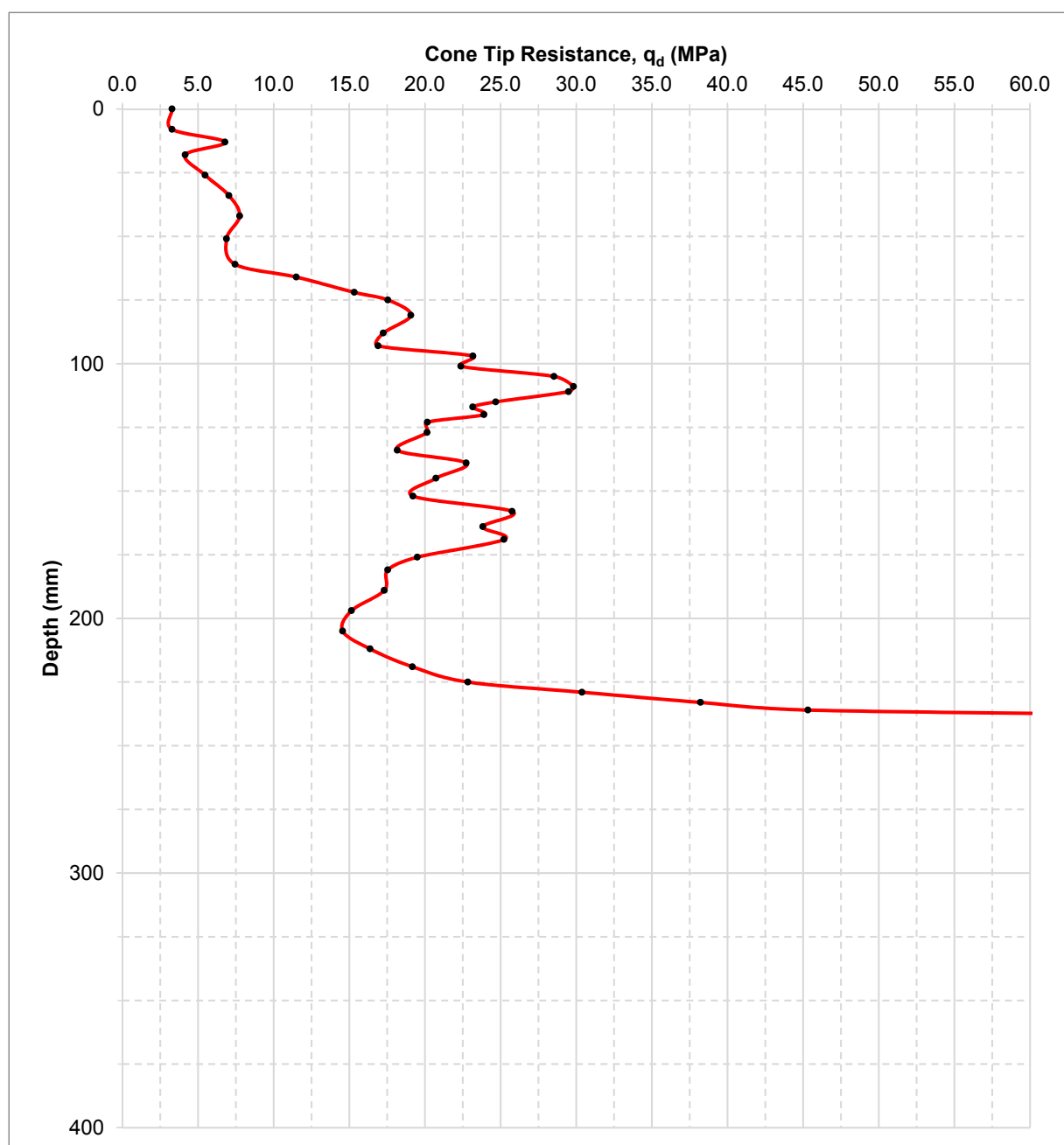
Project No.: 2091

Checked By: DWL

Location: Site 15-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 15-3A

Certificate Reference:

2091-PND-Site 15-3A

Sheet:

1 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 15-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	6.45	41	5	13.04			
2	6	18.01	42	5	16.27			
3	10	9.83	43	8	16.74			
4	8	9.63	44	7	13.82			
5	7	12.03	45	4	16.36			
6	6	15.23	46	6	14.72			
7	5	15.51	47	6	14.90			
8	7	14.98	48	7	13.39			
9	7	14.68	49	7	10.69			
10	6	14.02	50	5	14.53			
11	6	14.58	51	4	22.23			
12	4	20.63	52	5	18.34			
13	5	23.32	53	4	22.82			
14	6	22.38	54	4	17.13			
15	5	22.11	55	5	17.06			
16	6	20.53	56	5	18.85			
17	5	25.20	57	6	14.85			
18	7	15.47	58	5	20.75			
19	7	21.07	59	5	16.87			
20	7	12.93	60	3	22.73			
21	7	19.61	61	5	22.05			
22	6	20.33	62	5	24.04			
23	7	16.48	63	4	26.21			
24	3	13.62	64	5	25.38			
25	5	18.89	65	2	38.65			
26	6	20.70	66	2	27.01			
27	5	21.16	67	2	50.58			
28	4	18.33	68	1	39.88			
29	3	20.42	69	2	34.51			
30	3	21.08	70	1	37.92			
31	3	22.98	End of Test Record					
32	3	28.03						
33	4	22.39						
34	3	26.93						
35	5	20.79						
36	6	18.81						
37	6	15.29						
38	5	15.39						
39	6	12.42						
40	5	13.92						

PANDA Probe - Test Report

Site 15-3A

Certificate Reference:

2091-PND-Site 15-3A

Sheet:

2 of 2

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

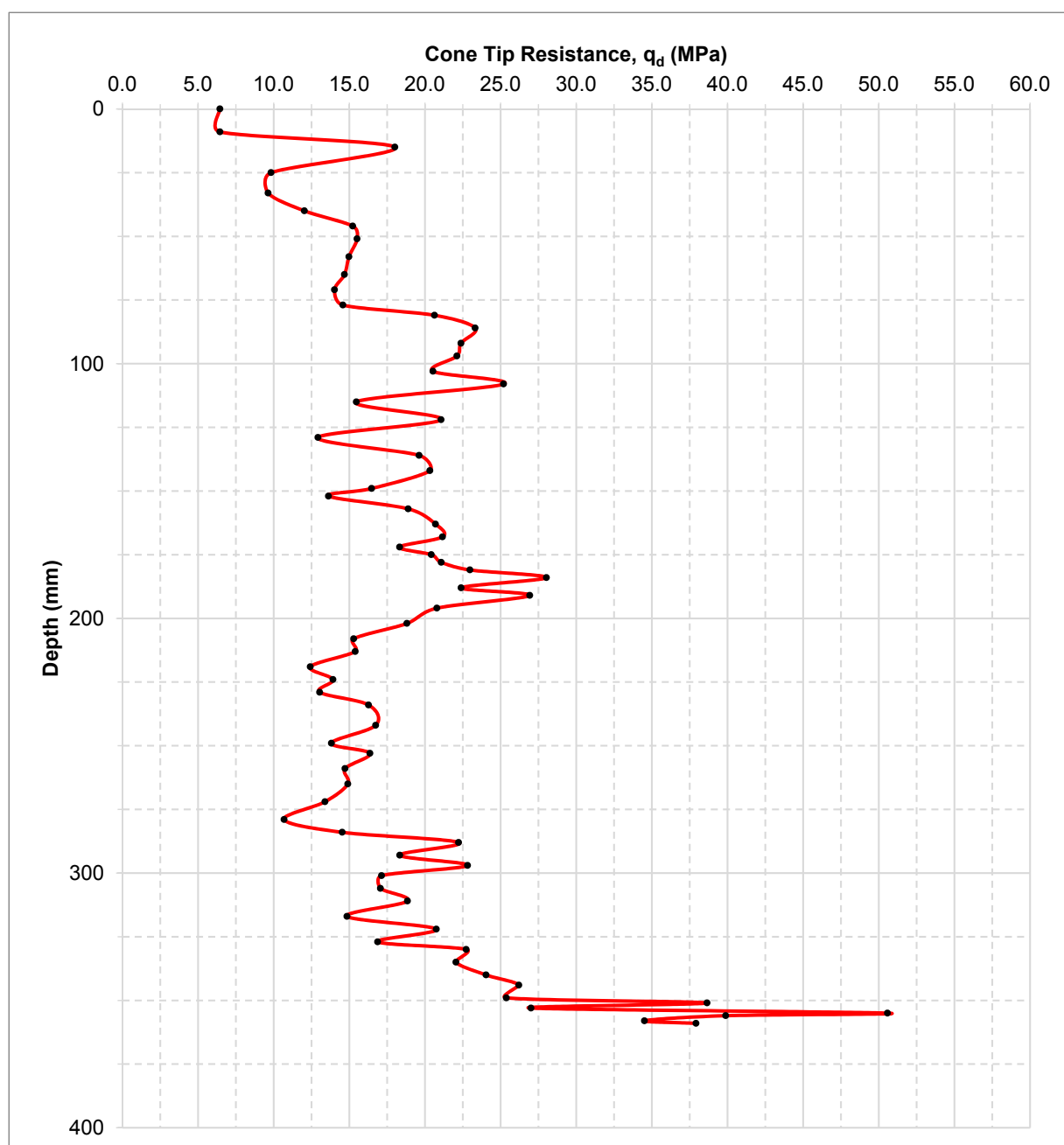
Project No.: 2091

Checked By: DWL

Location: Site 15-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 15-4

Certificate Reference:

2091-PND-Site 15-4

Sheet:

1 of 3

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 15-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.57	41	7	13.84	81	6	10.44
2	4	6.73	42	8	14.46	82	5	10.94
3	5	7.44	43	9	13.39	83	5	11.86
4	7	9.77	44	7	16.45	84	6	12.56
5	7	10.50	45	7	18.20	85	4	12.45
6	7	8.76	46	5	20.00	86	4	15.63
7	6	13.47	47	6	22.37	87	4	15.76
8	4	18.57	48	4	20.83	88	5	17.35
9	6	15.43	49	3	27.49	89	4	18.68
10	7	16.18	50	3	36.90	90	2	17.74
11	6	18.02	51	3	38.06	91	4	17.64
12	5	17.04	52	4	33.45	92	1	49.26
13	7	13.14	53	4	32.41	93	4	30.30
14	8	12.34	54	4	35.78	94	1	30.92
15	3	20.07	55	3	27.21	95	2	32.73
16	4	29.67	56	5	25.58	96	1	27.35
17	3	24.69	57	4	20.22	97	2	33.24
18	4	30.49	58	6	21.89	98	2	27.16
19	4	23.85	59	5	19.32	99	1	38.35
20	4	21.01	60	4	16.51	100	3	31.33
21	5	20.13	61	3	17.60	101	1	32.19
22	4	18.97	62	2	14.73	102	2	21.74
23	7	11.29	63	4	16.52	103	2	38.74
24	7	9.47	64	3	15.41	104	1	35.96
25	7	11.44	65	4	16.15	105	2	39.82
26	8	10.54	66	4	15.64	106	4	20.03
27	7	12.22	67	4	15.00	107	2	42.03
28	8	13.12	68	4	12.69	108	1	31.14
29	6	11.98	69	5	19.96	109	2	26.77
30	6	14.32	70	7	16.31	110	1	38.00
31	5	16.67	71	5	19.54	111	4	31.55
32	6	17.55	72	4	16.87	112	4	32.33
33	7	17.91	73	6	14.36	113	4	33.04
34	8	11.59	74	5	11.39	114	4	34.27
35	10	11.20	75	6	12.93	115	4	27.04
36	10	9.62	76	5	13.63	116	3	32.68
37	12	8.07	77	6	13.95	117	3	30.39
38	11	6.49	78	5	11.69	118	4	27.63
39	12	9.44	79	5	9.43	119	4	28.39
40	7	11.50	80	6	11.81	120	5	31.82

[illegible]

Certificate Reference:

2091-PND-Site 15-4

Sheet:

3 of 3

Client: ARRB

Test Date: 19/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

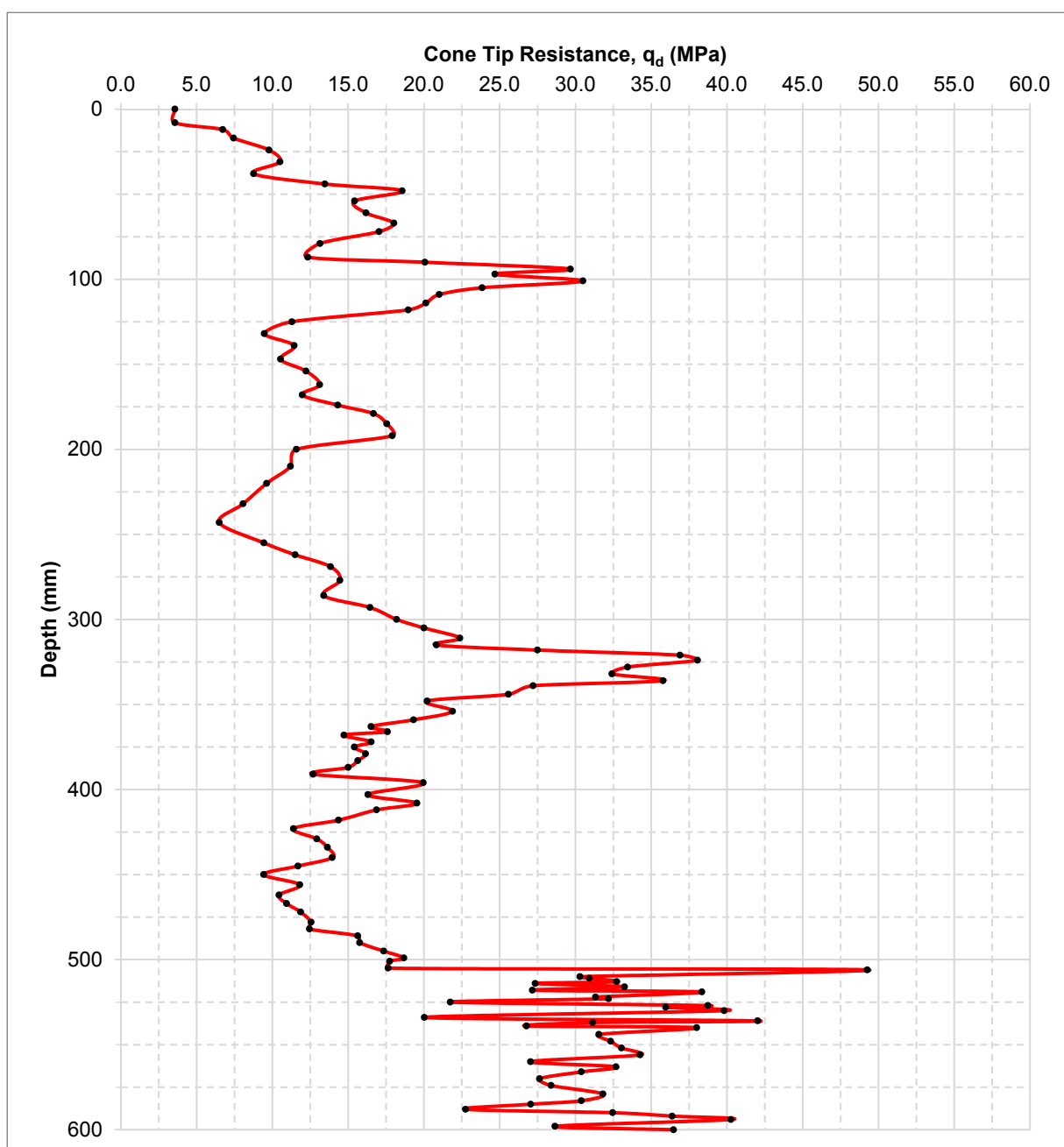
Project No.: 2091

Checked By: DWL

Location: Site 15-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 16-1

Certificate Reference:

2091-PND-Site 16-1

Sheet:

1 of 3

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 16-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	7.85	41	3	20.29	81	2	32.62
2	4	16.04	42	2	18.63	82	2	28.01
3	4	14.28	43	2	20.13	83	3	29.39
4	2	49.60	44	1	29.82	84	2	35.81
5	2	25.85	45	2	19.85	85	2	32.92
6	3	19.18	46	2	27.89	86	3	23.34
7	2	36.33	47	3	19.50	87	1	35.63
8	2	22.79	48	3	24.52	88	2	28.34
9	2	35.64	49	2	28.79	89	2	24.59
10	3	29.04	50	3	24.97	90	3	28.99
11	3	17.40	51	2	23.76	91	2	27.07
12	3	29.09	52	2	22.53	92	3	32.55
13	3	24.08	53	3	21.35	93	1	25.74
14	4	22.81	54	2	19.92	94	2	20.19
15	5	19.79	55	2	24.35	95	3	20.87
16	3	15.31	56	3	21.45	96	2	28.14
17	1	6.98	57	2	22.00	97	3	31.47
18	4	21.07	58	2	18.17	98	2	36.67
19	3	12.86	59	2	25.06	99	4	29.48
20	4	20.35	60	1	27.26	100	3	36.20
21	2	27.64	61	2	25.03	101	3	30.18
22	4	19.24	62	3	17.99	102	3	33.01
23	3	26.94	63	1	20.43	103	2	21.04
24	3	23.09	64	2	29.35	104	4	35.28
25	3	26.92	65	2	25.80	105	3	27.27
26	2	27.35	66	1	26.84	106	3	28.29
27	4	20.60	67	2	23.81	107	4	27.94
28	4	18.00	68	3	24.19	108	3	25.52
29	3	15.97	69	1	27.96	109	6	22.97
30	2	29.67	70	2	29.16	110	3	28.34
31	2	23.95	71	2	31.20	111	5	15.49
32	2	24.99	72	2	30.62	112	3	21.87
33	3	22.16	73	2	29.90	113	4	20.38
34	3	29.20	74	2	33.39	114	3	24.65
35	2	21.64	75	2	31.69	115	7	19.00
36	3	24.25	76	3	25.46	116	6	17.47
37	3	18.83	77	3	26.33	117	6	11.04
38	3	27.93	78	1	27.81	118	6	19.29
39	4	23.94	79	2	26.13	119	4	13.96
40	2	26.04	80	3	22.26	120	5	17.48

[illegible]

PANDA Probe - Test Report

Site 16-1

Certificate Reference:

2091-PND-Site 16-1

Sheet:

3 of 3

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

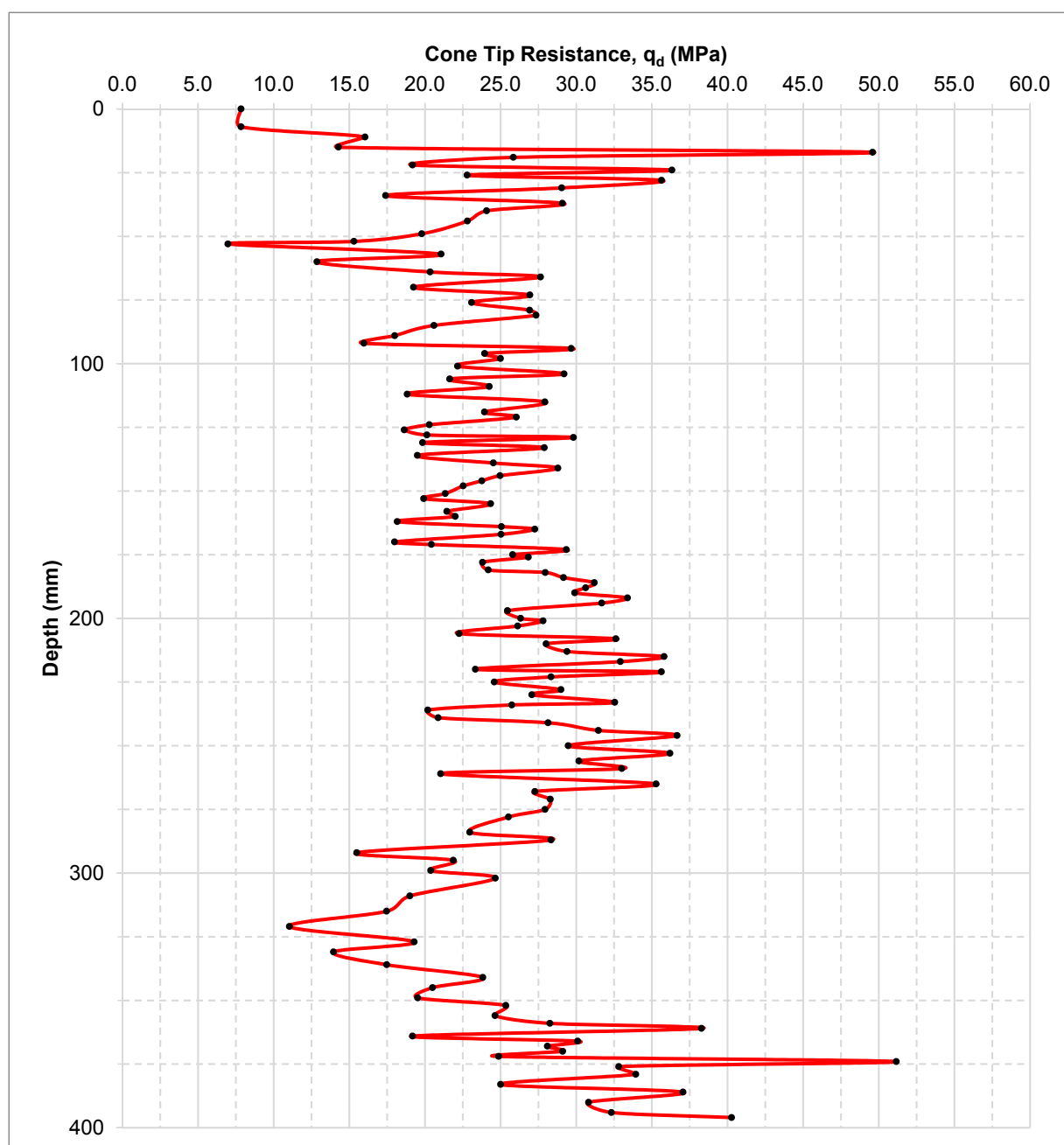
Project No.: 2091

Checked By: DWL

Location: Site 16-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 16-2

Certificate Reference:

2091-PND-Site 16-2

Sheet:

1 of 3

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 16-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	4.08	41	3	34.01	81	1	14.92
2	4	7.97	42	2	54.10	82	2	19.43
3	6	8.64	43	2	44.08	83	1	24.22
4	6	7.26	44	2	49.03	84	2	24.78
5	4	10.91	45	3	46.84	85	3	34.32
6	3	17.74	46	3	35.13	86	1	30.30
7	5	9.07	47	2	34.11	87	2	29.50
8	3	11.56	48	3	41.87	88	1	25.18
9	3	13.31	49	3	33.64	89	3	23.04
10	3	15.10	50	2	39.33	90	2	27.10
11	3	11.94	51	3	43.52	91	2	19.56
12	3	17.33	52	2	33.06	92	2	32.78
13	4	14.85	53	3	42.96	93	2	22.49
14	4	13.22	54	2	41.77	94	2	26.21
15	3	11.02	55	3	32.66	95	3	18.37
16	4	8.23	56	3	32.28	96	3	18.92
17	3	12.07	57	3	34.72	97	2	16.63
18	4	11.00	58	5	22.54	98	3	16.16
19	3	13.69	59	2	35.88	99	3	14.98
20	4	12.85	60	4	20.23	100	2	10.85
21	5	13.40	61	3	33.76	101	3	10.28
22	3	13.40	62	2	33.25	102	3	10.66
23	4	12.72	63	2	20.42	103	3	11.54
24	3	13.61	64	2	30.23	104	3	9.98
25	4	15.83	65	1	20.52	105	3	9.11
26	3	14.10	66	2	20.54	106	3	15.61
27	3	12.47	67	2	22.20	107	4	17.94
28	3	17.96	68	2	23.23	108	7	14.88
29	4	17.08	69	2	23.90	109	6	13.77
30	5	23.55	70	2	21.48	110	5	13.35
31	6	14.86	71	2	22.42	111	6	13.58
32	2	24.58	72	2	21.76	112	6	15.08
33	5	25.18	73	2	22.37	113	5	16.98
34	3	29.66	74	1	21.14	114	3	35.87
35	4	29.90	75	2	21.03	115	4	19.80
36	3	23.98	76	2	23.06	116	3	31.62
37	3	24.32	77	2	17.26	117	2	31.00
38	3	25.62	78	2	18.83	118	4	30.55
39	3	33.07	79	2	23.48	119	3	25.88
40	2	44.86	80	2	26.48	120	3	26.18

[illegible]

Certificate Reference:

2091-PND-Site 16-2

Sheet:

3 of 3

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

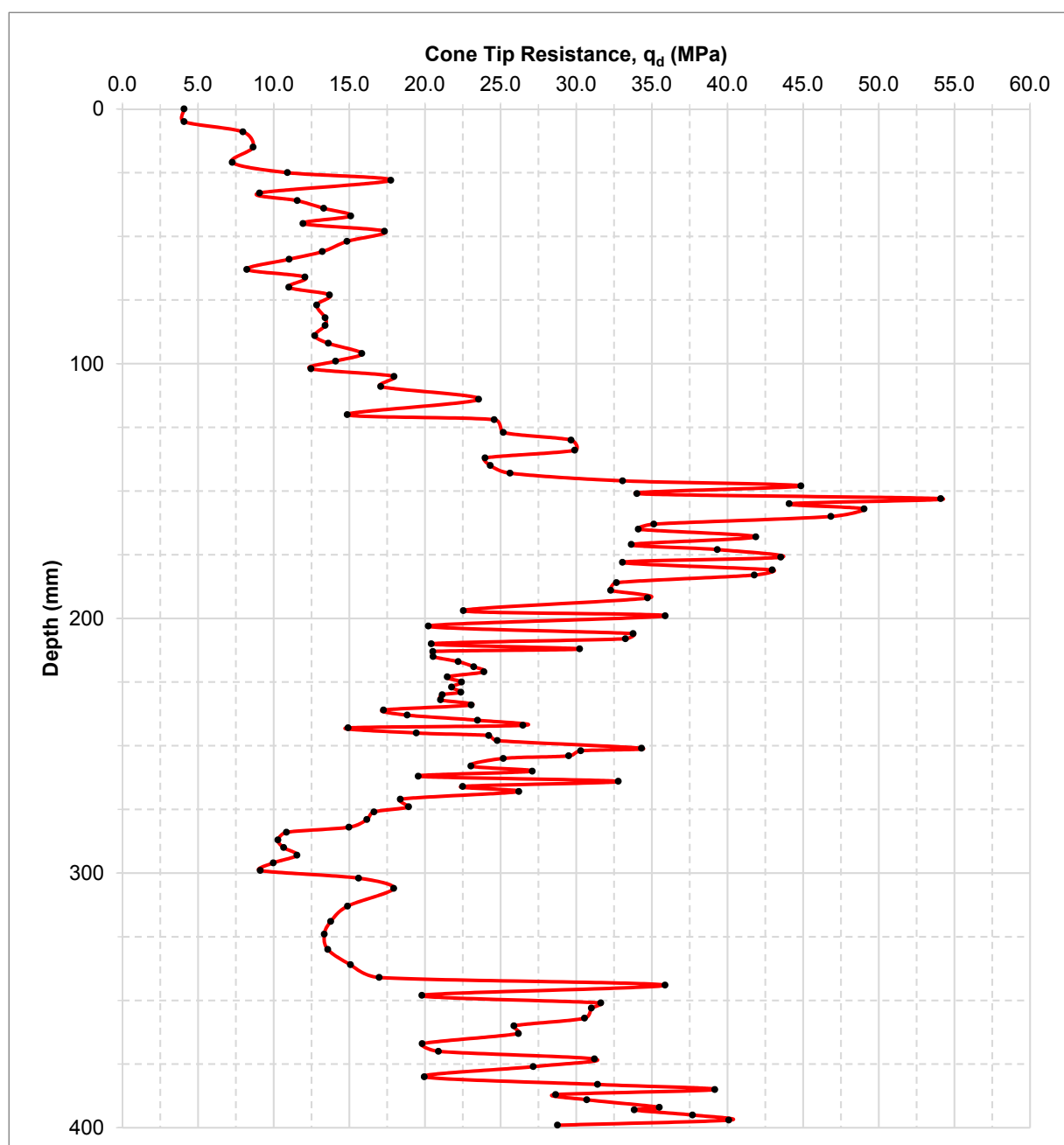
Project No.: 2091

Checked By: DWL

Location: Site 16-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 16-3

Certificate Reference:

2091-PND-Site 16-3

Sheet:

1 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 16-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	7.01	41	4	20.73	81	2	66.63
2	2	8.83	42	4	19.62	82	1	58.20
3	2	22.36	43	4	17.54	83	2	90.23
4	1	13.76	44	4	19.05	84	2	65.70
5	2	27.57	45	4	22.58	85	3	47.68
6	2	15.91	46	4	15.89	86	1	63.37
7	2	19.98	47	4	23.40	87	2	57.03
8	3	13.03	48	3	24.35	88	1	76.68
9	2	14.09	49	4	27.97	89	1	61.17
10	2	12.81	50	2	37.82	90	1	59.69
11	3	9.98	51	4	24.18	91	2	45.97
12	2	12.92	52	4	29.00	End of Test Record		
13	4	10.24	53	3	35.55			
14	4	9.53	54	3	29.97			
15	4	9.65	55	3	34.21			
16	3	7.46	56	3	26.83			
17	4	7.95	57	4	24.80			
18	3	9.87	58	4	23.47			
19	3	14.00	59	4	27.86			
20	3	10.65	60	3	28.35			
21	2	9.33	61	3	24.27			
22	2	10.32	62	4	18.98			
23	3	13.75	63	3	26.39			
24	3	12.11	64	4	20.95			
25	3	10.93	65	2	27.96			
26	2	13.56	66	3	22.13			
27	2	12.69	67	2	24.35			
28	2	8.27	68	3	27.55			
29	1	14.68	69	4	27.03			
30	2	19.00	70	3	34.71			
31	2	11.56	71	3	30.96			
32	3	13.67	72	3	28.03			
33	2	12.84	73	3	27.10			
34	2	12.85	74	3	34.92			
35	4	10.93	75	2	31.90			
36	1	14.48	76	3	38.24			
37	2	16.26	77	2	51.21			
38	3	18.23	78	2	50.17			
39	3	12.54	79	1	71.16			
40	2	15.36	80	1	86.98			

PANDA Probe - Test Report

Site 16-3

Certificate Reference:

2091-PND-Site 16-3

Sheet:

2 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

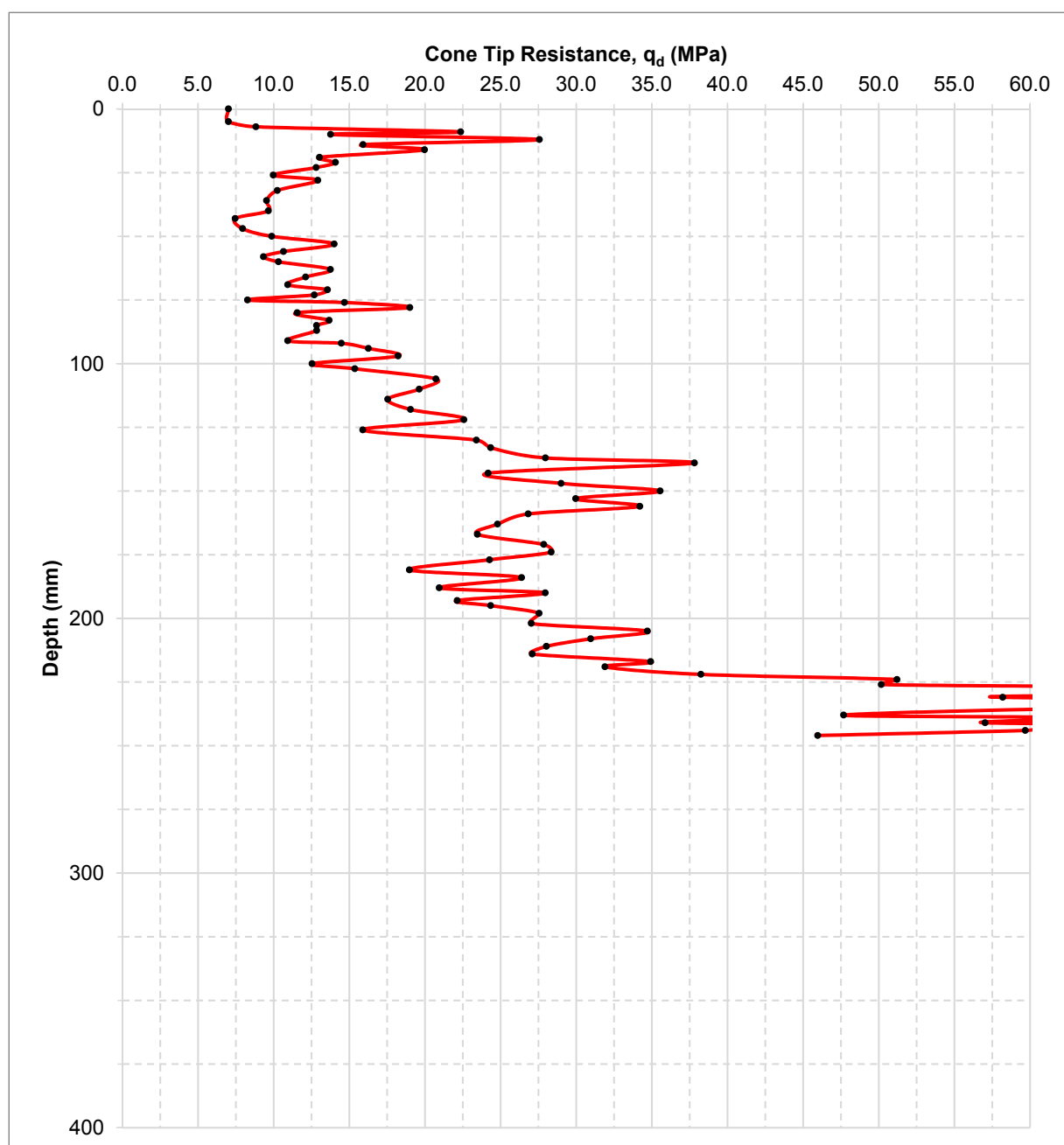
Project No.: 2091

Checked By: DWL

Location: Site 16-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 16-3A

Certificate Reference:

2091-PND-Site 16-3A

Sheet:

1 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 16-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	6.30	41	4	21.45			
2	5	10.03	42	1	37.75			
3	4	14.91	43	2	24.45			
4	5	14.99	44	2	47.08			
5	5	14.55	45	2	23.65			
6	5	12.60	46	2	22.63			
7	6	10.12	47	3	23.79			
8	7	8.80	48	2	21.98			
9	7	12.96	49	2	20.00			
10	5	11.25	50	2	29.51			
11	7	11.31	51	1	35.38			
12	7	15.39	52	2	26.95			
13	6	12.59	53	2	19.62			
14	5	10.36	54	2	20.78			
15	7	14.13	55	1	29.91			
16	5	16.13	56	3	18.33			
17	6	19.10	57	2	22.93			
18	4	26.65	58	2	15.39			
19	5	28.64	59	2	24.63			
20	2	26.00	60	2	24.24			
21	3	24.70	61	2	24.89			
22	4	22.19	62	2	20.81			
23	4	21.47	63	1	29.06			
24	4	24.12	64	2	18.38			
25	3	20.42	65	1	27.70			
26	2	22.81	66	1	40.83			
27	3	26.32	67	2	39.70			
28	3	24.81	68	1	30.17			
29	3	31.97	69	2	56.60			
30	3	34.24	70	3	69.28			
31	2	21.88	71	1	62.79			
32	2	45.11	72	2	76.00			
33	2	37.73	73	2	68.44			
34	2	39.79	74	2	70.78			
35	2	36.71	75	3	68.24			
36	2	21.41	End of Test Record					
37	1	31.38						
38	2	37.34						
39	1	30.86						
40	2	25.79						

Certificate Reference:

2091-PND-Site 16-3A

Sheet:

2 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

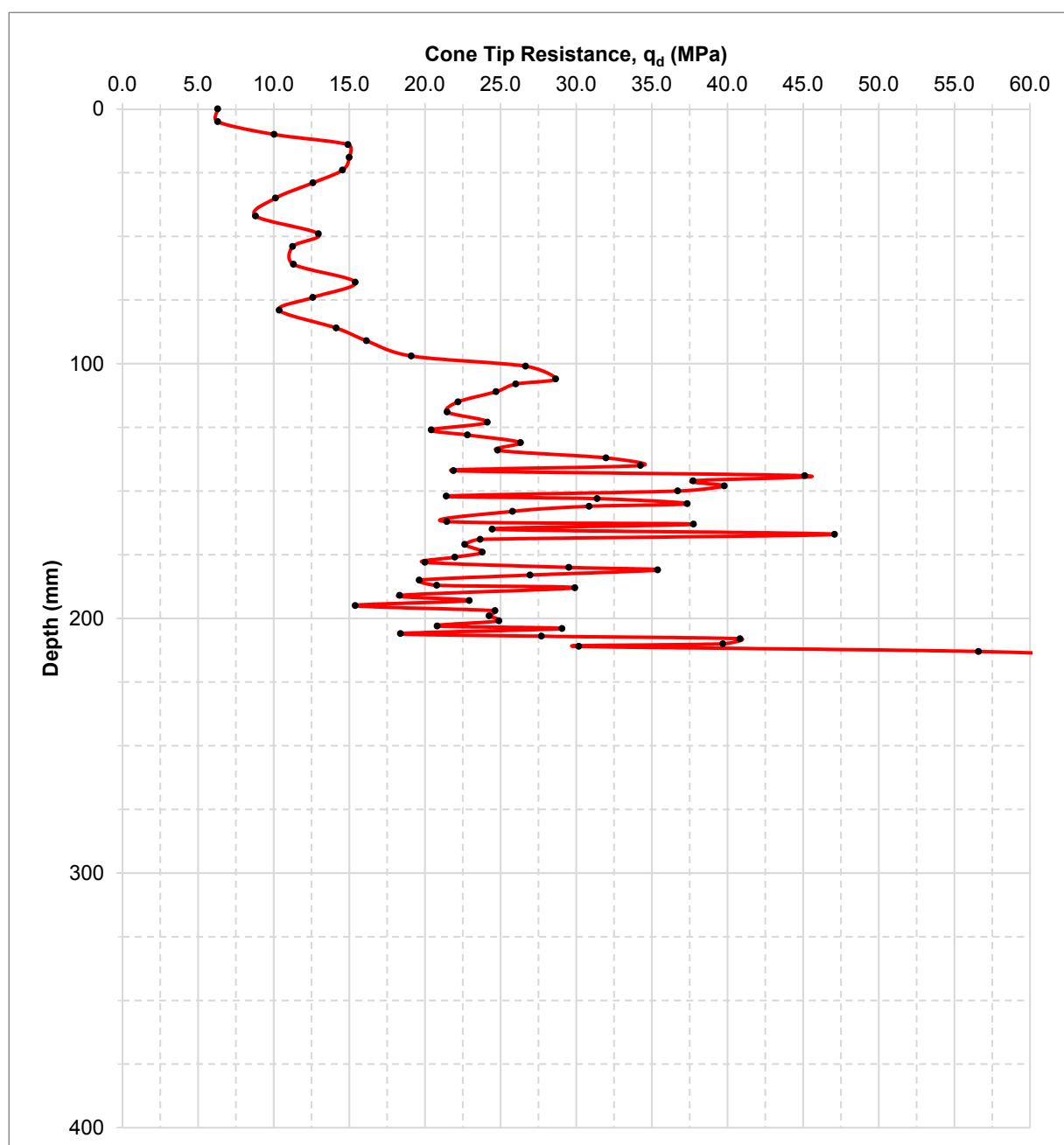
Project No.: 2091

Checked By: DWL

Location: Site 16-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 16-4

Certificate Reference:

2091-PND-Site 16-4

Sheet:

1 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 16-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	7.03	41	2	14.27			
2	8	10.30	42	3	14.67			
3	7	14.58	43	2	16.66			
4	7	12.19	44	3	21.49			
5	7	13.00	45	2	20.39			
6	5	15.38	46	3	24.52			
7	6	14.69	47	2	19.01			
8	5	18.28	48	2	20.81			
9	5	19.12	49	3	16.54			
10	3	21.65	50	1	17.70			
11	4	19.34	51	2	18.84			
12	4	21.06	52	2	17.24			
13	4	17.79	53	3	18.18			
14	3	20.35	54	2	17.41			
15	4	21.80	55	1	15.05			
16	5	22.91	56	3	12.87			
17	6	17.06	57	2	19.93			
18	5	23.29	58	2	18.13			
19	4	25.17	59	2	28.66			
20	3	36.52	60	2	21.09			
21	3	31.64	61	3	17.78			
22	3	45.25	62	1	36.51			
23	3	32.63	63	2	16.71			
24	4	16.86	64	1	24.24			
25	3	32.34	65	2	22.07			
26	3	25.47	66	3	27.44			
27	6	22.49	67	2	25.03			
28	4	23.42	68	2	29.28			
29	4	23.62	End of Test Record					
30	4	25.74						
31	4	17.49						
32	3	24.10						
33	2	14.87						
34	3	12.34						
35	2	13.97						
36	1	28.01						
37	2	22.23						
38	2	21.29						
39	3	15.85						
40	3	18.40						

PANDA Probe - Test Report

Site 16-4

Certificate Reference:

2091-PND-Site 16-4

Sheet:

2 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

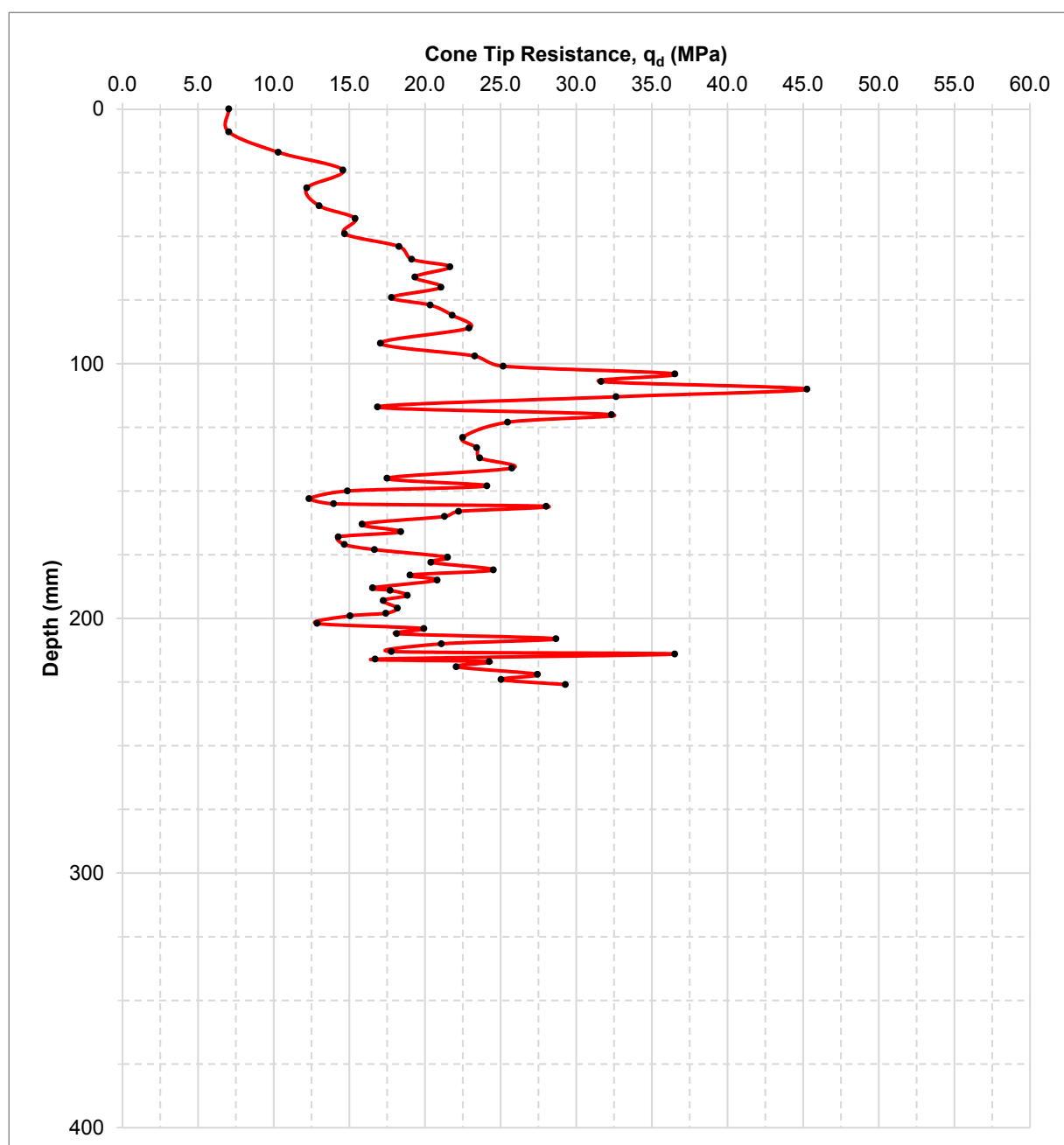
Project No.: 2091

Checked By: DWL

Location: Site 16-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 16-4A

Certificate Reference:

2091-PND-Site 16-4A

Sheet:

1 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 16-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.90	41	2	52.93			
2	6	11.66	42	1	46.37			
3	6	17.89	43	1	45.95			
4	4	18.20	44	1	41.03			
5	5	18.94	45	3	36.44			
6	5	13.57	46	3	31.21			
7	4	14.78	47	2	34.55			
8	5	16.48	48	1	39.00			
9	4	15.19	49	2	24.33			
10	5	19.78	50	1	46.18			
11	4	29.65	End of Test Record					
12	5	21.44						
13	4	24.29						
14	3	25.38						
15	5	25.16						
16	4	23.49						
17	4	29.34						
18	5	27.27						
19	3	32.97						
20	5	18.05						
21	3	25.91						
22	4	27.00						
23	3	18.72						
24	3	19.58						
25	3	25.06						
26	3	17.98						
27	4	25.32						
28	4	28.74						
29	4	22.79						
30	4	28.83						
31	3	24.44						
32	2	41.64						
33	3	43.69						
34	1	52.07						
35	1	40.38						
36	1	46.30						
37	2	19.83						
38	1	21.39						
39	1	27.66						
40	2	30.67						

PANDA Probe - Test Report

Site 16-4A

Certificate Reference:

2091-PND-Site 16-4A

Sheet:

2 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

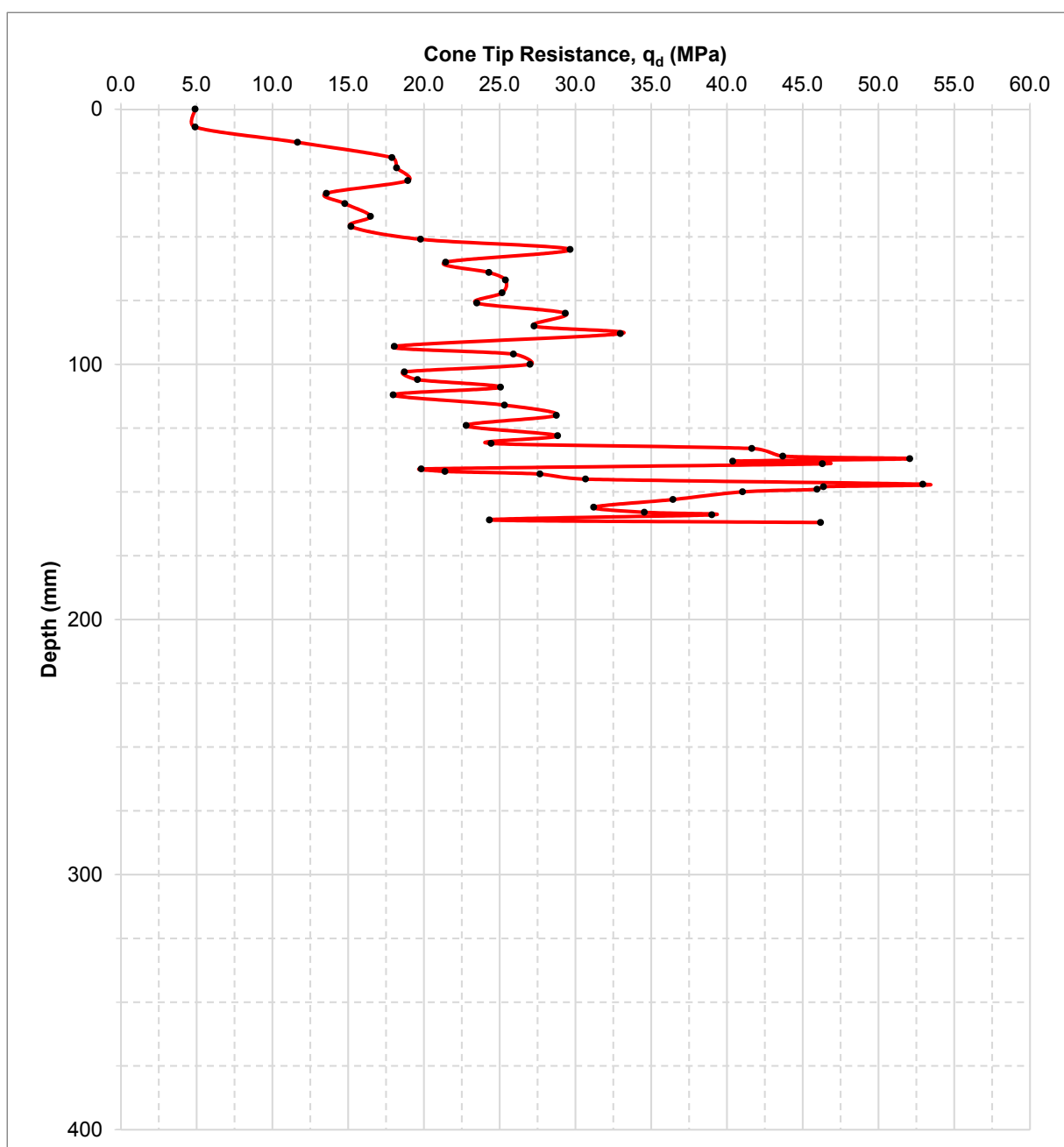
Project No.: 2091

Checked By: DWL

Location: Site 16-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 17-1

Certificate Reference:

2091-PND-Site 17-1

Sheet:

1 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 17-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	8.24	41	1	85.30			
2	8	14.69	42	2	68.03			
3	8	15.36	43	2	69.02			
4	9	16.91	44	2	81.02			
5	8	20.14	45	2	80.97			
6	7	18.14	46	1	105.34			
7	6	22.63	47	1	87.02			
8	7	22.23	48	3	87.45			
9	8	21.12	49	2	104.55			
10	7	21.67	50	2	72.15			
11	7	26.26	End of Test Record					
12	5	25.79						
13	5	24.96						
14	7	21.44						
15	5	25.35						
16	7	26.05						
17	6	21.49						
18	5	19.72						
19	7	23.80						
20	8	22.33						
21	8	22.02						
22	7	19.96						
23	6	32.74						
24	5	25.77						
25	6	21.94						
26	5	23.66						
27	8	22.29						
28	7	26.85						
29	5	18.56						
30	7	23.40						
31	6	21.05						
32	6	20.51						
33	5	18.50						
34	4	17.12						
35	7	19.78						
36	6	19.22						
37	3	18.64						
38	5	19.70						
39	4	27.05						
40	3	40.08						

PANDA Probe - Test Report

Site 17-1

Certificate Reference:

2091-PND-Site 17-1

Sheet:

2 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

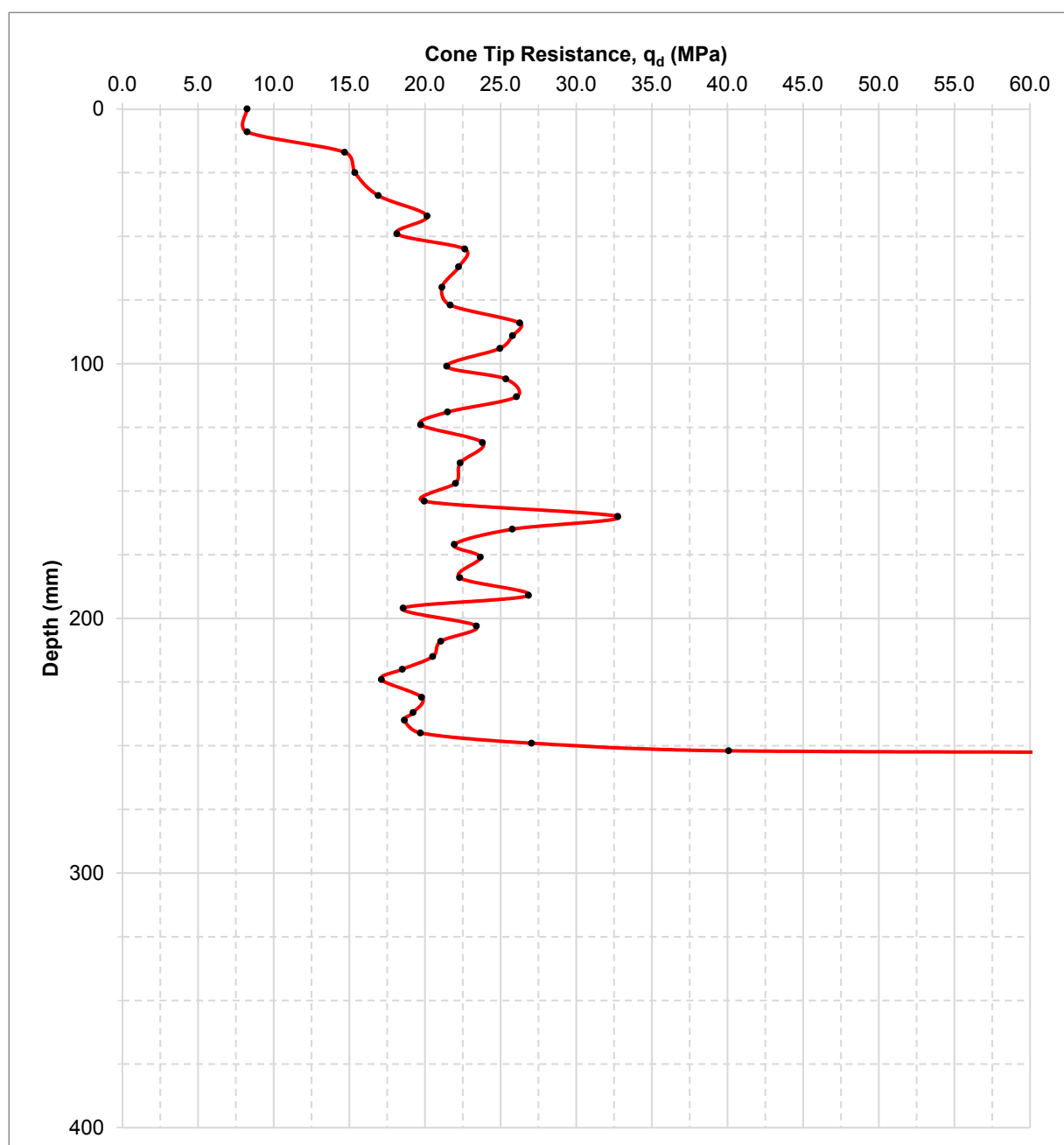
Project No.: 2091

Checked By: DWL

Location: Site 17-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 17-1A

Certificate Reference:

2091-PND-Site 17-1A

Sheet:

1 of 3

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 17-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	6.70	41	4	28.07	81	5	5.29
2	7	9.29	42	4	22.85	82	4	7.78
3	6	10.64	43	6	25.33	83	3	10.69
4	5	12.23	44	4	26.43	84	4	10.66
5	4	8.35	45	5	23.01	85	2	14.21
6	4	9.75	46	5	23.91	86	4	16.42
7	5	10.13	47	4	19.52	87	2	15.38
8	5	5.62	48	3	25.31	88	3	18.43
9	4	10.95	49	4	17.17	89	2	16.11
10	5	11.54	50	5	17.37	90	3	12.66
11	5	11.20	51	5	15.05	91	3	17.10
12	5	10.89	52	6	14.44	92	3	11.43
13	4	13.14	53	5	16.09	93	3	11.52
14	3	10.98	54	7	15.87	94	3	7.74
15	4	10.57	55	7	13.40	95	6	7.69
16	3	14.44	56	7	12.98	96	4	6.21
17	2	12.44	57	8	13.61	97	6	8.19
18	2	14.02	58	9	12.85	98	7	8.45
19	3	12.66	59	6	14.39	99	5	6.44
20	3	18.94	60	8	13.92	100	5	7.07
21	2	18.79	61	7	11.99	101	4	7.30
22	2	18.93	62	5	9.96	102	4	6.90
23	2	4.68	63	3	5.64	103	4	9.88
24	1	20.57	64	6	8.12	104	4	10.61
25	2	14.42	65	5	5.50	105	6	6.69
26	2	16.76	66	5	8.54	106	6	9.08
27	2	18.70	67	4	9.18	107	5	8.96
28	2	16.36	68	5	9.55	108	5	8.63
29	2	15.28	69	5	9.89	109	3	6.31
30	2	18.54	70	4	6.20	110	3	9.85
31	3	22.08	71	4	6.48	111	2	14.34
32	5	24.31	72	5	6.81	112	3	9.53
33	5	21.77	73	4	7.22	113	2	11.81
34	5	23.15	74	4	8.23	114	3	19.01
35	4	21.42	75	5	8.08	115	3	9.77
36	5	21.70	76	4	8.13	116	3	17.06
37	5	26.04	77	3	10.18	117	2	18.38
38	4	27.46	78	5	8.50	118	2	56.29
39	5	21.37	79	6	8.61	119	3	38.00
40	4	27.53	80	6	8.21	120	1	59.67

[illegible]

Certificate Reference:

2091-PND-Site 17-1A

Sheet:

3 of 3

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

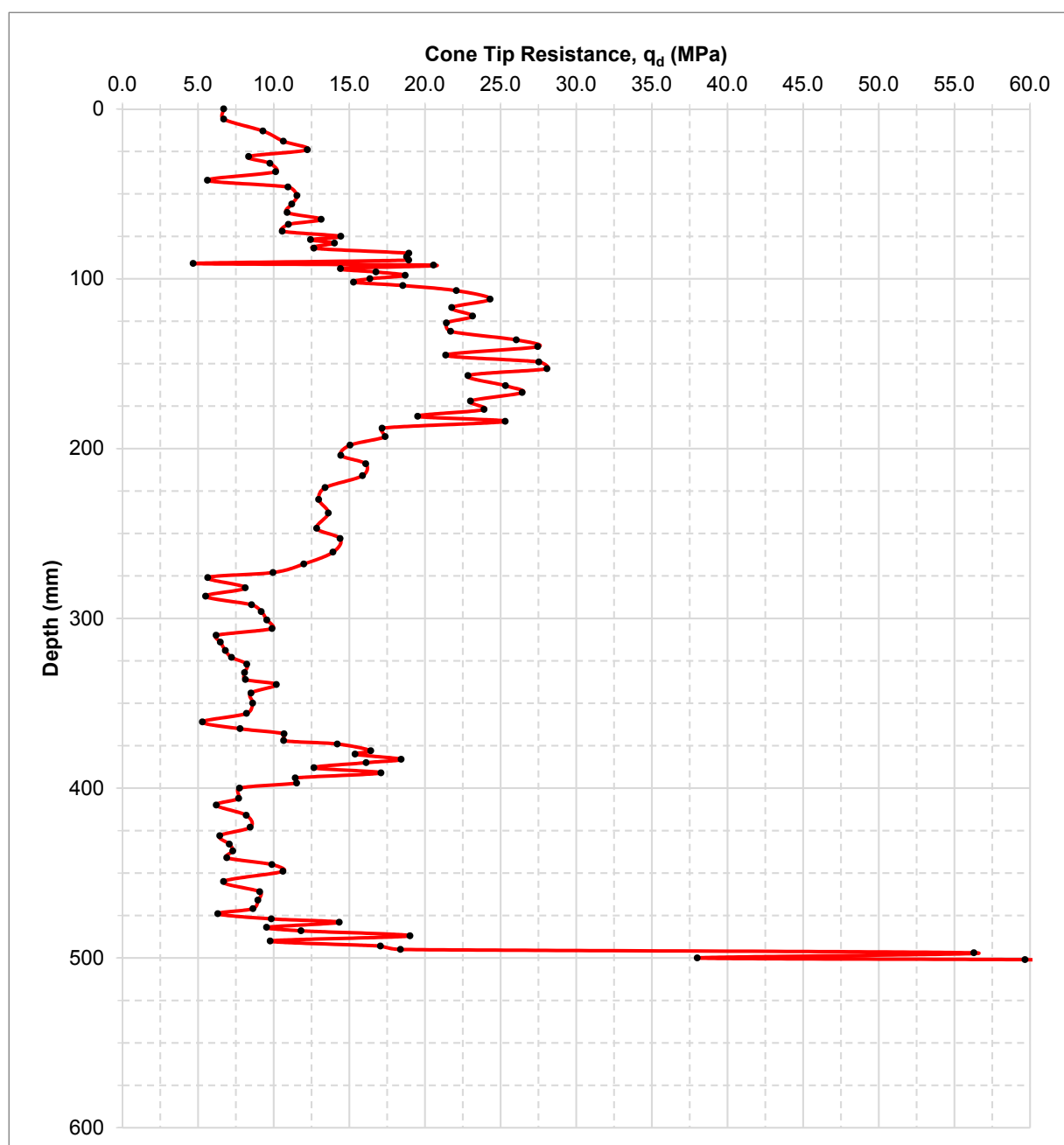
Project No.: 2091

Checked By: DWL

Location: Site 17-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 17-2

Certificate Reference:

2091-PND-Site 17-2

Sheet:

1 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 17-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	2.00	41	2	18.62	81	3	20.35
2	16	3.27	42	3	13.82	82	3	16.88
3	9	7.11	43	3	23.08	83	2	21.56
4	6	9.76	44	2	30.55	84	2	20.37
5	6	10.21	45	3	14.90	85	2	15.16
6	5	13.16	46	1	24.42	86	2	20.71
7	6	13.28	47	2	25.17	87	3	17.60
8	6	12.42	48	3	12.78	88	2	21.79
9	6	10.87	49	2	14.14	89	2	18.69
10	7	12.12	50	2	19.55	90	2	20.14
11	7	13.93	51	3	21.73	91	2	22.31
12	5	13.67	52	2	19.94	92	2	29.64
13	5	9.14	53	2	22.35	93	2	24.12
14	7	18.73	54	2	23.02	94	3	35.48
15	5	12.19	55	2	19.75	95	2	39.31
16	3	11.84	56	3	18.53	96	1	63.55
17	3	15.27	57	2	24.75	97	3	28.29
18	6	14.71	58	2	18.43	98	4	27.77
19	4	14.34	59	1	30.21	99	4	27.56
20	5	16.21	60	2	32.01	100	5	28.93
21	5	16.95	61	1	50.67	101	3	28.18
22	5	16.96	62	2	26.72	102	2	27.84
23	4	13.39	63	1	47.60	103	3	26.66
24	4	19.44	64	1	35.87	104	2	31.53
25	3	20.24	65	1	29.39	105	3	31.06
26	5	15.17	66	2	30.60	106	2	45.42
27	4	17.43	67	1	28.45	107	3	26.05
28	4	15.17	68	2	36.47	108	3	37.69
29	4	17.00	69	1	26.70	109	1	33.82
30	4	10.26	70	1	37.78	110	2	40.62
31	5	15.45	71	2	28.21	End of Test Record		
32	3	16.01	72	2	28.52			
33	3	17.76	73	2	16.90			
34	5	13.03	74	2	18.81			
35	3	20.84	75	2	21.14			
36	3	21.46	76	3	20.30			
37	4	23.86	77	2	23.00			
38	2	28.96	78	1	20.94			
39	4	21.15	79	3	23.49			
40	4	19.53	80	1	11.36			

PANDA Probe - Test Report

Site 17-2

Certificate Reference:

2091-PND-Site 17-2

Sheet:

2 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

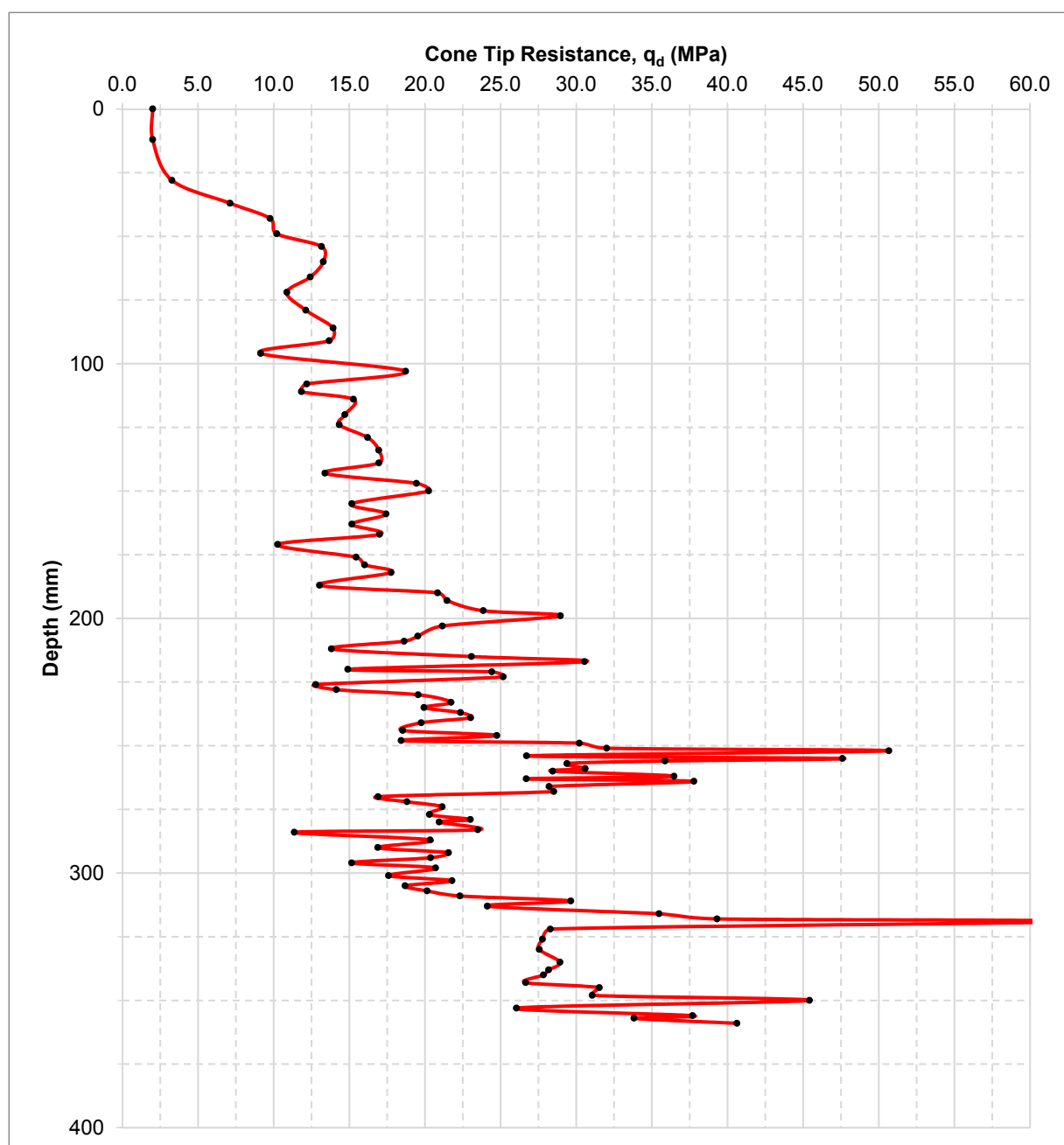
Project No.: 2091

Checked By: DWL

Location: Site 17-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 17-3

Certificate Reference:

2091-PND-Site 17-3

Sheet:

1 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 17-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	4.12	41	2	38.96	81	1	45.41
2	5	6.20	42	2	43.72	82	2	37.87
3	4	9.75	43	2	41.49	83	2	31.38
4	3	12.53	44	2	35.61	84	1	26.13
5	4	11.81	45	4	35.81	85	3	26.24
6	5	12.28	46	3	22.89	86	3	25.86
7	6	10.45	47	2	29.85	87	2	17.79
8	5	13.00	48	4	29.85	88	1	19.01
9	5	9.59	49	2	26.61	89	2	21.76
10	3	17.37	50	2	18.99	90	1	28.54
11	5	13.77	51	3	21.73	91	2	16.65
12	4	11.38	52	2	23.88	92	1	23.20
13	5	12.95	53	3	33.94	93	2	21.37
14	4	14.53	54	3	18.23	94	2	20.85
15	5	14.94	55	4	27.01	95	2	20.97
16	4	18.52	56	1	30.74	96	1	20.45
17	4	17.01	57	3	24.38	97	2	16.85
18	2	15.16	58	2	29.57	98	3	16.13
19	3	18.17	59	2	32.13	99	1	20.19
20	4	16.35	60	2	33.93	100	3	18.94
21	4	17.74	61	2	25.81	101	2	17.09
22	3	17.89	62	2	27.18	102	2	19.29
23	3	17.83	63	1	28.23	103	4	41.66
24	3	19.13	64	2	48.71	104	3	22.29
25	3	21.31	65	2	32.33	105	1	39.97
26	3	15.29	66	1	27.99	106	2	49.91
27	3	17.15	67	3	16.82	107	4	74.87
28	3	18.97	68	2	26.95	108	1	98.45
29	1	25.29	69	1	22.98	109	1	80.63
30	2	27.71	70	4	23.33	110	3	52.73
31	2	27.92	71	2	27.44	111	2	50.20
32	2	28.87	72	2	28.95	112	3	40.56
33	2	37.94	73	2	27.10	113	3	37.45
34	1	38.01	74	2	25.09	114	3	31.41
35	2	47.62	75	2	26.79	115	3	40.26
36	2	38.91	76	2	29.11	116	3	29.32
37	2	35.51	77	2	24.93	117	4	27.30
38	2	41.34	78	2	25.59	End of Test Record		
39	2	42.15	79	2	23.79			
40	2	52.93	80	2	25.85			

PANDA Probe - Test Report

Site 17-3

Certificate Reference:

2091-PND-Site 17-3

Sheet:

2 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

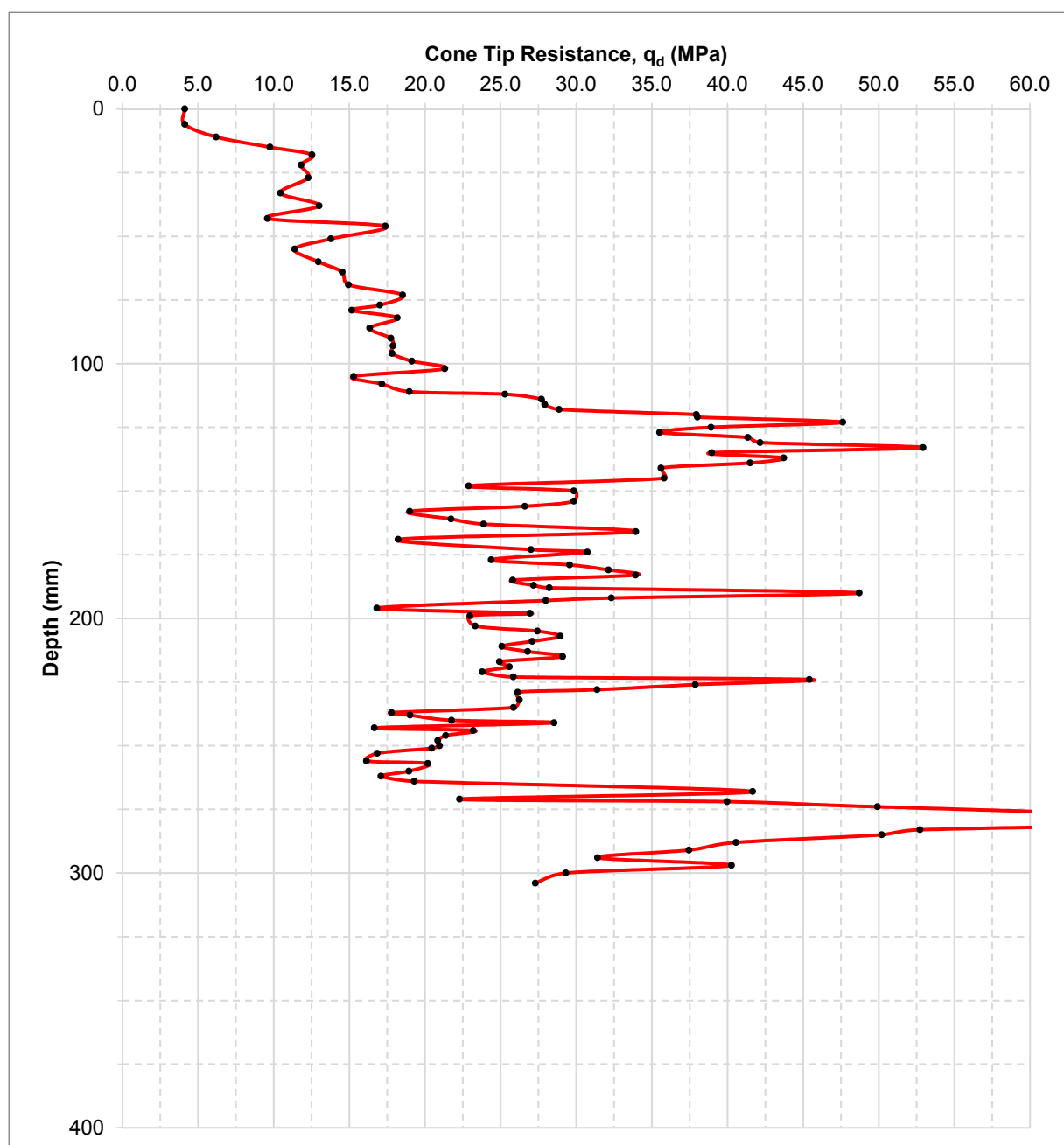
Project No.: 2091

Checked By: DWL

Location: Site 17-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 17-4

Certificate Reference:

2091-PND-Site 17-4

Sheet:

1 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 17-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.28	41	4	11.34	81	1	34.94
2	6	4.42	42	3	10.70	82	2	29.60
3	8	6.32	43	3	12.43	83	3	13.53
4	9	8.98	44	3	13.71	84	1	29.17
5	4	9.87	45	5	10.88	85	5	25.64
6	6	11.28	46	3	13.52	86	3	22.88
7	4	17.04	47	2	13.67	87	3	24.32
8	5	20.30	48	4	12.54	88	2	33.75
9	6	12.21	49	3	11.36	89	1	39.97
10	6	13.49	50	4	12.32	90	1	34.58
11	7	14.19	51	4	10.31	91	2	37.74
12	7	12.15	52	3	10.20	92	2	35.54
13	8	8.60	53	2	13.48	93	1	29.50
14	11	6.63	54	4	10.31	94	2	32.35
15	15	6.69	55	5	10.26	95	1	27.31
16	16	6.00	56	4	8.96	96	2	38.29
17	11	5.75	57	5	9.89	97	1	28.88
18	9	9.69	58	4	11.34	98	1	36.18
19	6	10.83	59	4	10.49	99	1	37.10
20	5	13.24	60	4	9.12	100	2	23.66
21	7	13.87	61	5	12.13	101	2	31.78
22	7	11.37	62	3	6.98	102	2	30.27
23	6	11.34	63	4	8.15	103	1	50.58
24	6	8.71	64	4	13.48	104	1	40.16
25	7	8.00	65	2	21.15	105	1	33.42
26	9	6.63	66	1	20.65	106	1	24.37
27	9	8.29	67	2	16.05	107	2	26.77
28	9	6.36	68	2	22.04	108	2	33.19
29	11	7.38	69	4	14.94	109	3	48.14
30	10	7.01	70	2	26.35	110	4	38.49
31	8	8.34	71	2	22.20	111	3	40.44
32	7	5.85	72	3	20.07	112	3	39.45
33	7	8.44	73	4	14.93	113	4	33.44
34	6	10.13	74	1	39.64	114	3	41.81
35	6	12.00	75	2	22.27	115	2	41.15
36	5	11.96	76	2	24.29	End of Test Record		
37	3	10.75	77	2	29.58			
38	4	10.87	78	3	16.12			
39	3	8.88	79	3	29.96			
40	2	10.25	80	1	32.26			

PANDA Probe - Test Report

Site 17-4

Certificate Reference:

2091-PND-Site 17-4

Sheet:

2 of 2

Client: ARRB

Test Date: 21/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

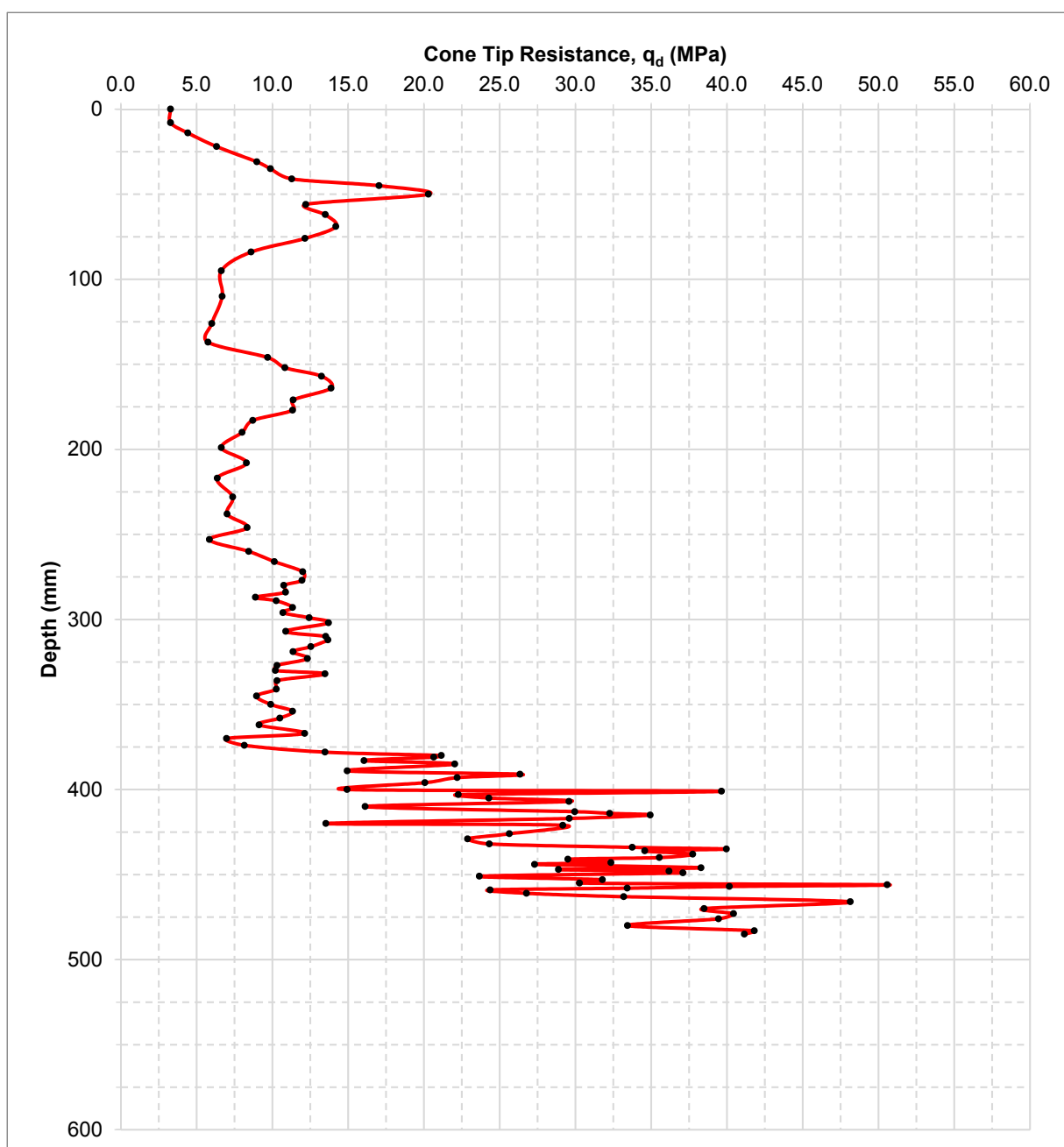
Project No.: 2091

Checked By: DWL

Location: Site 17-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 18-1

Certificate Reference:

2091-PND-Site 18-1

Sheet:

1 of 3

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 18-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	3.41	41	1	26.16	81	6	12.73
2	8	6.49	42	3	20.87	82	5	13.21
3	7	8.86	43	2	24.94	83	5	12.48
4	6	8.48	44	2	18.86	84	5	14.34
5	4	10.80	45	2	19.47	85	5	14.76
6	4	13.86	46	3	21.35	86	4	12.72
7	5	11.82	47	3	20.29	87	4	16.99
8	5	13.38	48	3	18.95	88	2	22.31
9	4	14.19	49	5	19.04	89	5	14.47
10	4	16.87	50	4	17.09	90	4	19.96
11	3	18.51	51	4	18.81	91	4	16.69
12	4	18.81	52	2	11.35	92	2	11.64
13	3	15.49	53	3	12.94	93	3	11.65
14	4	20.16	54	5	16.61	94	3	18.00
15	3	26.51	55	3	15.49	95	3	21.56
16	4	20.55	56	4	13.92	96	3	14.21
17	2	18.28	57	3	14.18	97	2	16.95
18	3	22.36	58	4	18.30	98	1	24.48
19	4	20.17	59	4	17.07	99	3	25.90
20	3	19.73	60	5	16.23	100	2	28.01
21	4	19.95	61	5	15.54	101	3	24.87
22	5	16.99	62	5	11.53	102	2	21.74
23	2	13.47	63	4	13.73	103	3	20.73
24	2	16.02	64	4	12.17	104	3	17.93
25	3	18.30	65	4	13.52	105	2	27.35
26	2	18.16	66	5	16.26	106	3	20.11
27	2	18.13	67	4	16.10	107	2	17.84
28	2	21.94	68	5	10.36	108	2	16.68
29	2	13.58	69	4	12.42	109	2	22.02
30	2	10.02	70	3	13.32	110	3	19.79
31	2	24.09	71	4	15.76	111	3	21.83
32	3	20.36	72	6	16.63	112	2	26.36
33	1	21.55	73	7	14.15	113	2	24.81
34	3	21.53	74	6	15.50	114	3	19.81
35	2	23.27	75	5	20.12	115	1	30.42
36	2	19.37	76	5	16.49	116	2	29.23
37	2	12.90	77	4	11.03	117	2	30.92
38	2	24.44	78	5	11.44	118	2	32.37
39	1	20.04	79	5	14.01	119	1	42.92
40	2	25.14	80	4	15.15	120	2	39.96

[illegible]

PANDA Probe - Test Report

Site 18-1

Certificate Reference:

2091-PND-Site 18-1

Sheet:

3 of 3

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

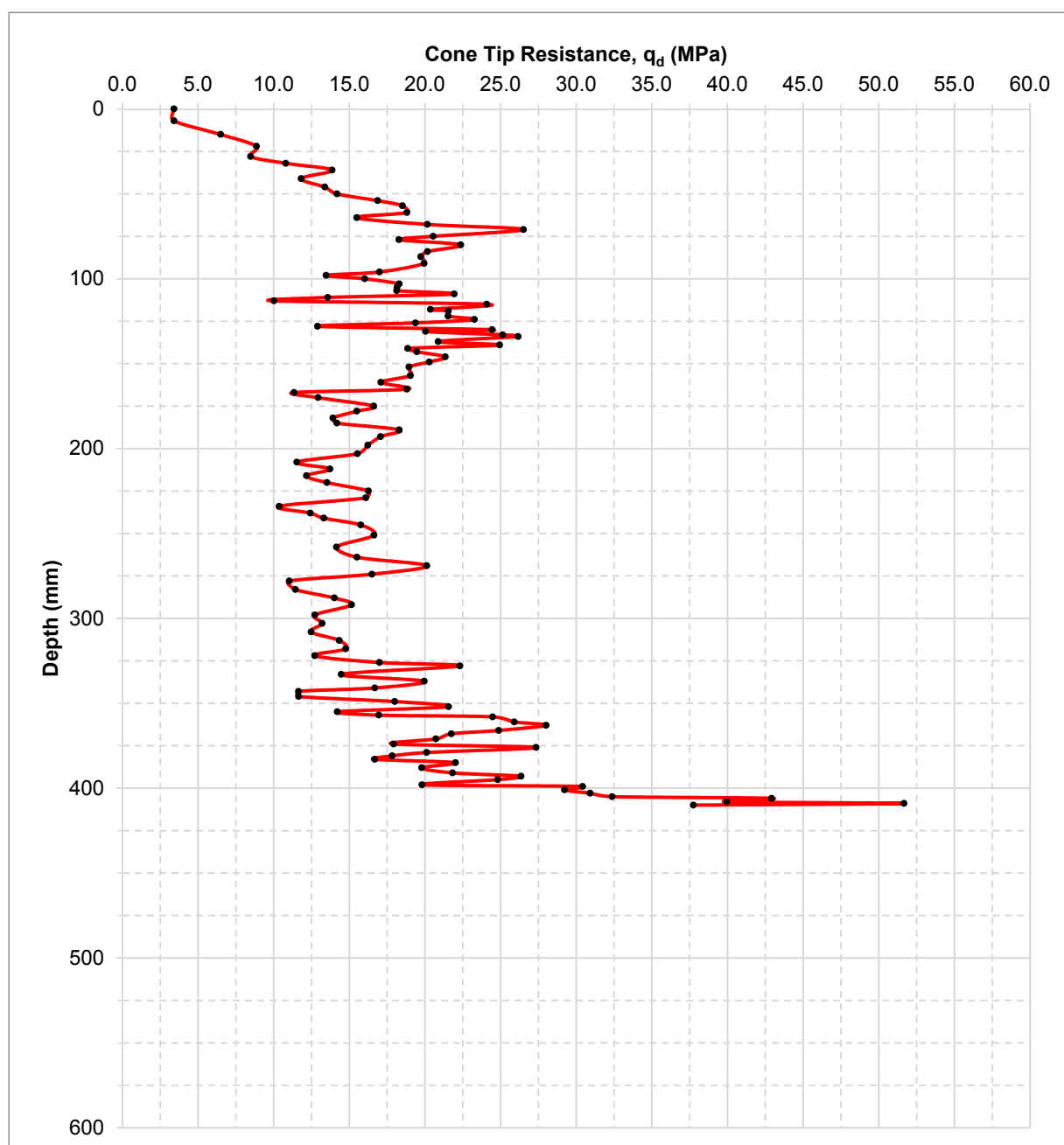
Project No.: 2091

Checked By: DWL

Location: Site 18-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 18-2

Certificate Reference:

2091-PND-Site 18-2

Sheet:

1 of 3

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 18-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.09	41	2	16.31	81	4	14.41
2	6	7.24	42	3	17.54	82	3	19.94
3	5	5.84	43	3	20.45	83	3	14.80
4	5	9.22	44	3	16.07	84	3	21.31
5	5	10.17	45	3	23.76	85	3	19.00
6	3	11.15	46	2	20.33	86	3	15.74
7	3	9.35	47	2	24.24	87	3	20.38
8	3	13.44	48	3	21.81	88	3	17.92
9	3	16.43	49	2	29.26	89	3	16.84
10	2	10.74	50	2	20.22	90	3	20.74
11	2	22.68	51	2	23.50	91	3	20.86
12	3	13.95	52	2	20.14	92	4	21.88
13	4	13.10	53	1	34.41	93	3	17.98
14	2	21.04	54	3	21.69	94	2	17.14
15	3	13.94	55	3	27.03	95	3	16.89
16	4	15.16	56	2	23.26	96	3	18.01
17	2	18.02	57	3	18.02	97	4	21.06
18	3	14.75	58	3	17.62	98	5	21.00
19	3	13.48	59	3	19.12	99	3	22.06
20	4	18.31	60	3	20.73	100	3	19.08
21	4	20.21	61	3	20.50	101	3	14.21
22	3	18.17	62	3	17.78	102	2	21.30
23	4	13.75	63	2	32.28	103	3	28.31
24	3	18.23	64	3	19.86	104	2	20.73
25	4	15.15	65	3	23.26	105	2	21.46
26	3	18.05	66	3	24.82	106	2	16.13
27	5	13.00	67	4	21.71	107	2	13.42
28	8	10.34	68	3	22.22	108	3	22.36
29	4	12.15	69	2	21.14	109	2	18.03
30	5	14.36	70	3	20.88	110	4	21.36
31	4	16.82	71	2	21.64	111	4	17.68
32	4	15.29	72	3	26.76	112	3	20.15
33	3	15.41	73	3	23.45	113	3	20.50
34	2	22.37	74	3	21.37	114	4	17.96
35	3	17.98	75	3	21.17	115	3	21.80
36	3	16.90	76	4	15.11	116	4	18.22
37	3	20.65	77	3	21.97	117	4	20.06
38	3	21.40	78	5	18.21	118	2	23.57
39	3	15.95	79	4	20.02	119	1	25.59
40	3	17.81	80	4	20.38	120	3	16.10

[illegible]

PANDA Probe - Test Report

Site 18-2

Certificate Reference:

2091-PND-Site 18-2

Sheet:

3 of 3

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

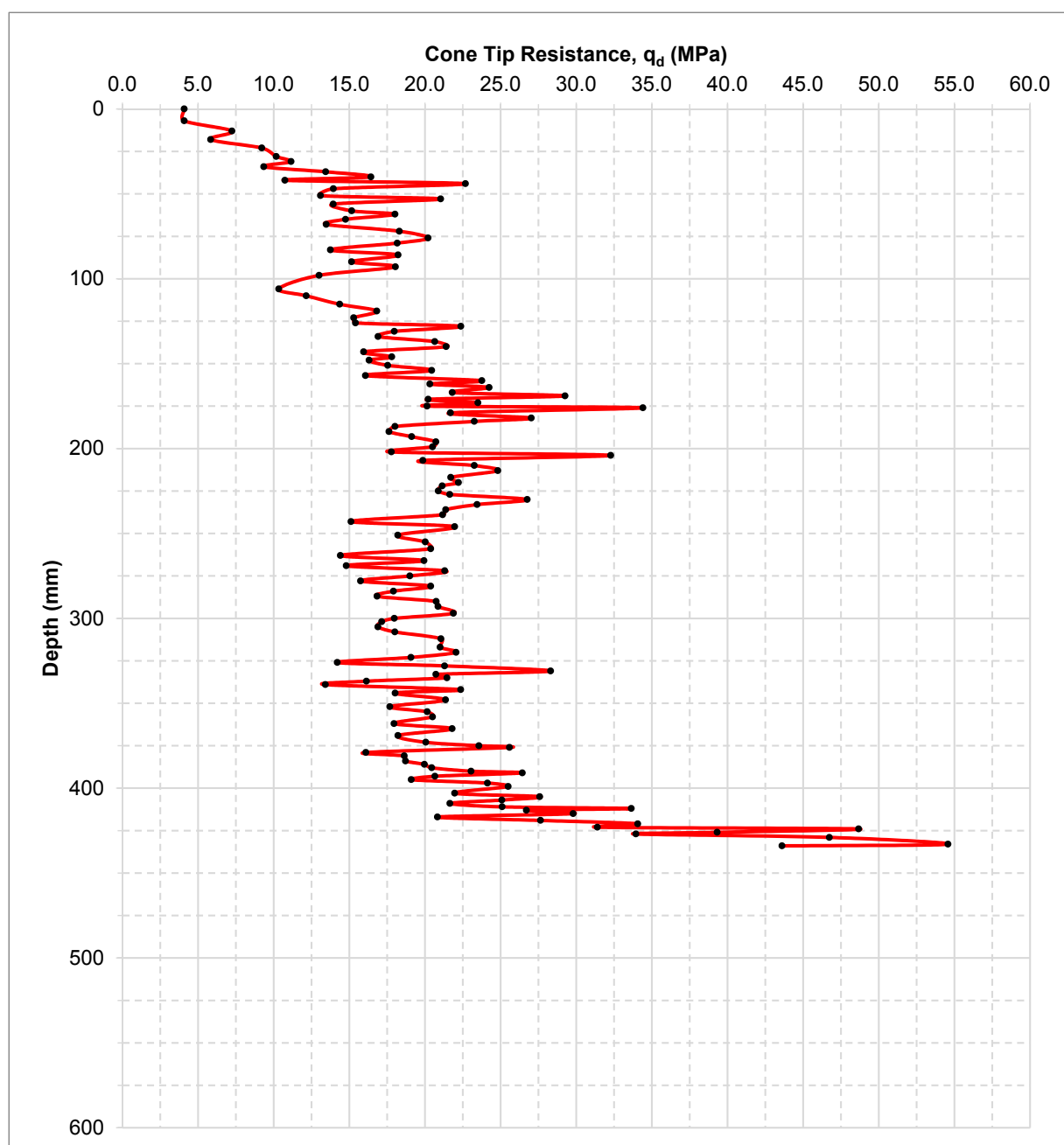
Project No.: 2091

Checked By: DWL

Location: Site 18-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 18-3

Certificate Reference:

2091-PND-Site 18-3

Sheet:

1 of 2

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 18-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	4.06	41	10	13.73			
2	2	5.63	42	10	14.99			
3	1	7.18	43	7	13.23			
4	6	5.82	44	8	16.48			
5	3	8.59	45	7	23.07			
6	5	7.28	46	6	24.39			
7	4	8.35	47	8	17.85			
8	2	13.73	48	7	21.38			
9	4	8.52	49	5	22.58			
10	5	7.36	50	4	17.11			
11	5	10.54	51	4	18.51			
12	4	11.11	52	4	19.22			
13	4	9.81	53	4	20.89			
14	5	9.82	54	3	17.24			
15	5	10.95	55	5	19.76			
16	4	12.80	56	3	29.04			
17	5	17.11	57	3	38.61			
18	7	13.40	58	3	30.81			
19	8	15.68	59	2	32.03			
20	9	13.51	60	2	35.31			
21	8	14.34	61	2	25.61			
22	7	16.70	62	3	32.52			
23	10	14.20	63	2	30.73			
24	6	13.45	64	3	28.09			
25	6	13.60	65	3	28.19			
26	6	16.29	66	3	28.93			
27	7	20.49	67	2	31.62			
28	6	24.79	68	3	44.03			
29	7	24.80	End of Test Record					
30	7	19.80						
31	9	17.08						
32	9	19.83						
33	9	19.52						
34	8	20.24						
35	8	20.65						
36	7	20.74						
37	7	19.44						
38	11	14.20						
39	8	16.86						
40	9	16.58						

PANDA Probe - Test Report

Site 18-3

Certificate Reference:

2091-PND-Site 18-3

Sheet:

2 of 2

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

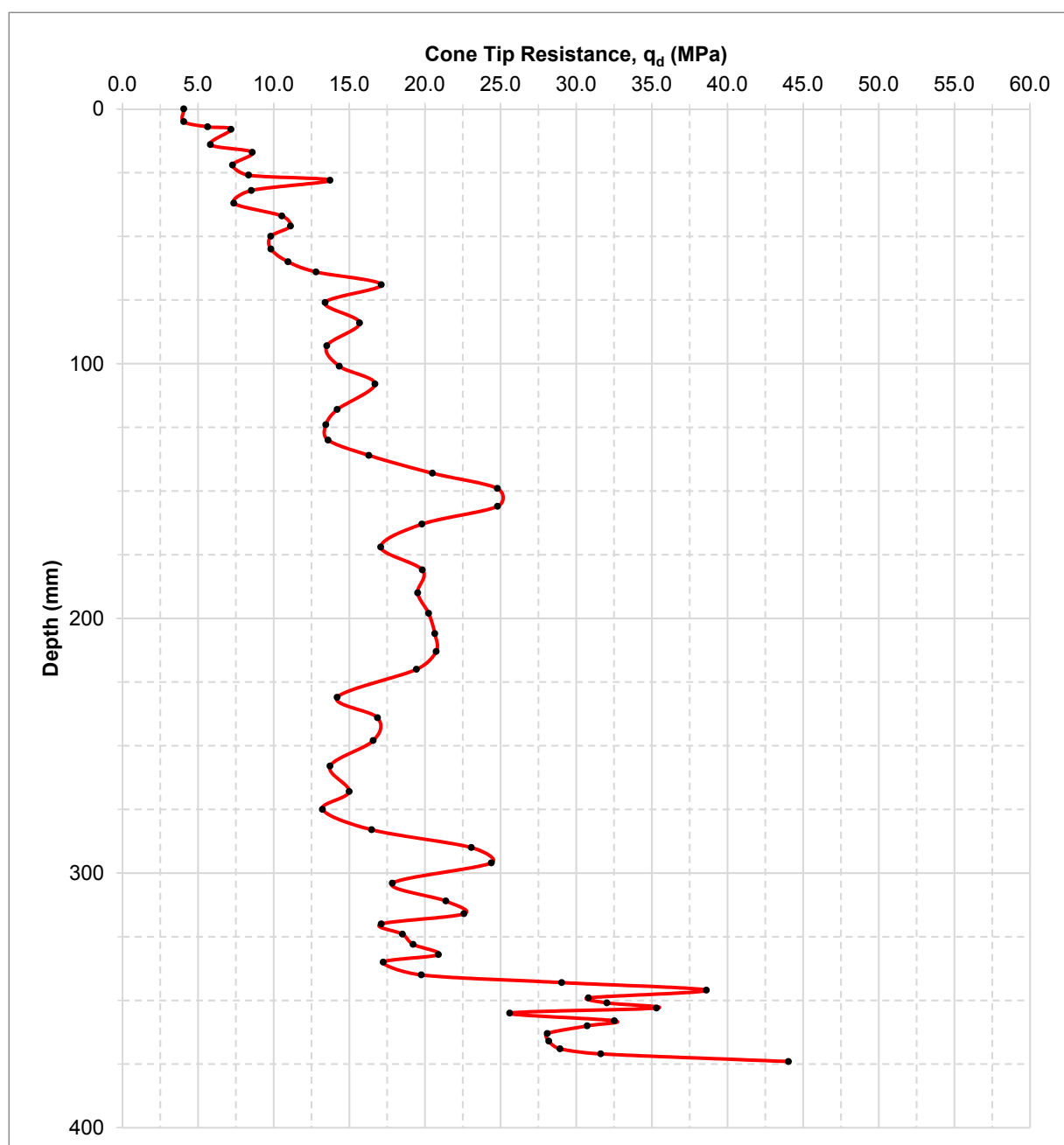
Project No.: 2091

Checked By: DWL

Location: Site 18-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 18-4

Certificate Reference:

2091-PND-Site 18-4

Sheet:

1 of 2

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 18-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	3.73	41	3	18.79			
2	6	5.69	42	5	18.58			
3	5	9.37	43	3	20.38			
4	2	24.73	44	4	20.78			
5	1	16.11	45	4	19.96			
6	2	18.29	46	3	20.34			
7	4	15.45	47	3	21.77			
8	3	21.77	48	3	27.39			
9	2	29.19	49	3	27.21			
10	2	27.84	50	3	25.63			
11	3	22.48	51	4	18.14			
12	2	23.24	52	3	21.49			
13	2	33.08	53	3	21.61			
14	1	33.11	54	3	25.19			
15	2	24.10	55	3	25.40			
16	2	19.41	56	3	30.55			
17	3	33.16	57	3	25.19			
18	2	26.94	58	2	43.04			
19	3	22.67	59	2	29.87			
20	2	19.85	60	1	34.85			
21	3	18.43	61	2	39.15			
22	2	21.55	62	2	36.03			
23	3	16.17	63	3	37.08			
24	3	14.44	64	2	40.77			
25	1	20.54	65	2	36.59			
26	1	28.09	66	1	41.82			
27	3	26.54	67	1	59.71			
28	2	24.93	68	2	72.61			
29	2	24.91	End of Test Record					
30	3	15.89						
31	3	18.35						
32	2	19.84						
33	2	12.67						
34	4	15.57						
35	4	17.48						
36	3	16.81						
37	2	12.96						
38	4	20.16						
39	5	17.26						
40	4	18.18						

PANDA Probe - Test Report

Site 18-4

Certificate Reference:

2091-PND-Site 18-4

Sheet:

2 of 2

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

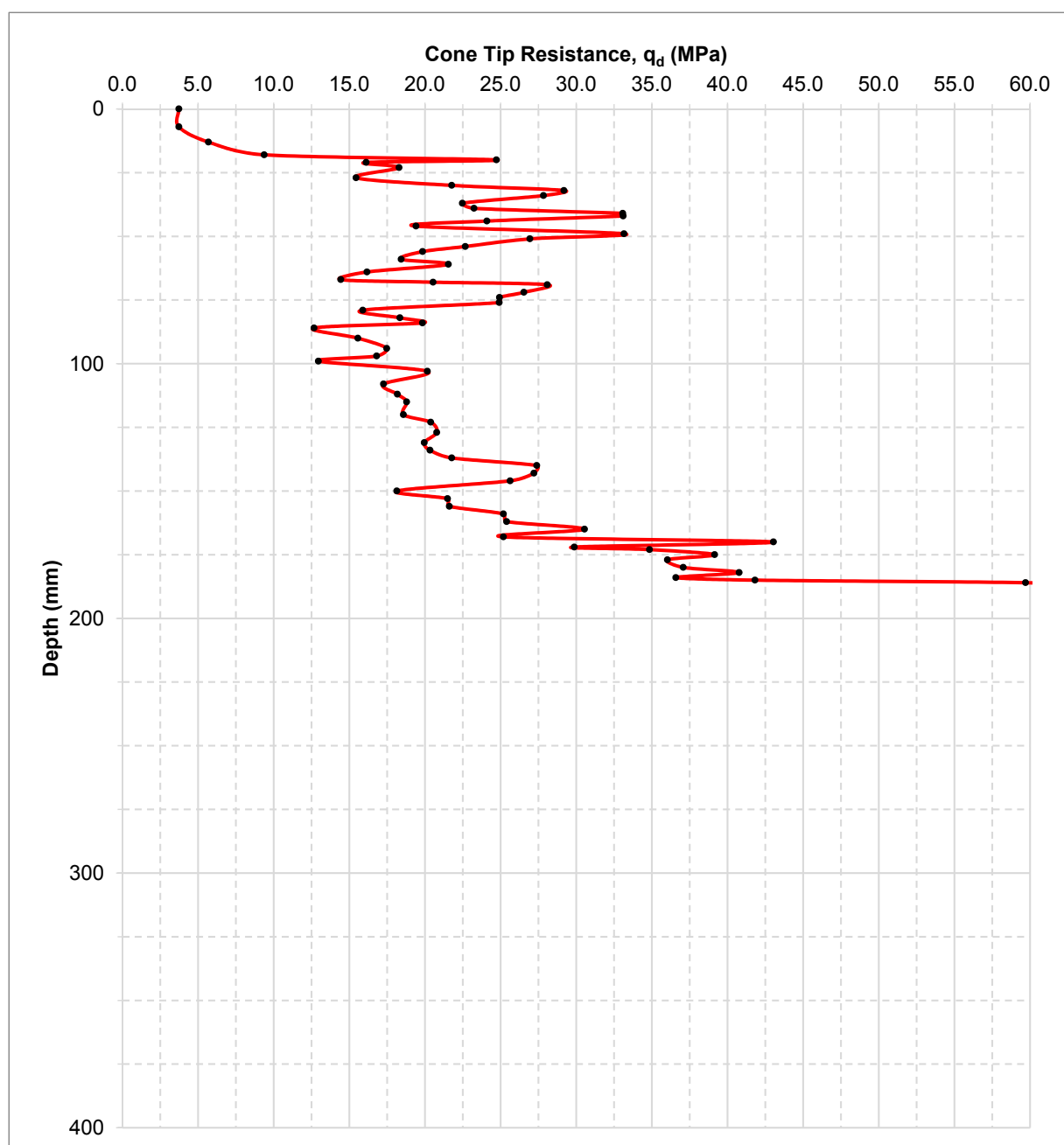
Project No.: 2091

Checked By: DWL

Location: Site 18-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 18-4A

Certificate Reference:

2091-PND-Site 18-4A

Sheet:

1 of 2

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 18-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	4.07	41	4	19.19	End of Test Record		
2	3	3.95	42	6	18.99			
3	8	7.86	43	7	15.08			
4	6	8.00	44	7	18.71			
5	5	8.90	45	9	12.41			
6	7	10.20	46	7	11.57			
7	4	11.20	47	8	13.36			
8	4	9.36	48	7	14.66			
9	5	10.15	49	8	9.38			
10	4	12.46	50	5	14.23			
11	8	13.01	51	7	11.96			
12	8	15.29	52	6	13.59			
13	7	15.57	53	6	17.75			
14	4	23.47	54	6	14.78			
15	3	24.82	55	5	15.27			
16	4	33.46	56	5	15.04			
17	4	33.32	57	6	16.05			
18	2	42.41	58	5	19.28			
19	4	25.16	59	6	15.90			
20	3	19.74	60	7	17.70			
21	5	18.99	61	4	19.01			
22	6	15.66	62	4	16.56			
23	7	14.29	63	3	13.17			
24	7	13.53	64	5	16.38			
25	7	10.85	65	4	18.74			
26	7	14.14	66	4	17.98			
27	7	13.59	67	3	24.37			
28	7	12.11	68	3	28.79			
29	7	17.56	69	3	28.94			
30	8	15.63	70	3	29.61			
31	9	12.96	71	2	22.24			
32	6	15.31	72	2	38.55			
33	7	17.98	73	3	28.85			
34	5	16.20	74	2	36.58			
35	6	15.92	75	2	31.35			
36	5	24.73	76	2	37.05			
37	4	29.44	77	2	37.95			
38	4	22.80	78	2	40.93			
39	5	31.22	79	2	41.56			
40	5	24.03	80	2	36.74			

PANDA Probe - Test Report

Site 18-4A

Certificate Reference:

2091-PND-Site 18-4A

Sheet:

2 of 2

Client: ARRB

Test Date: 22/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

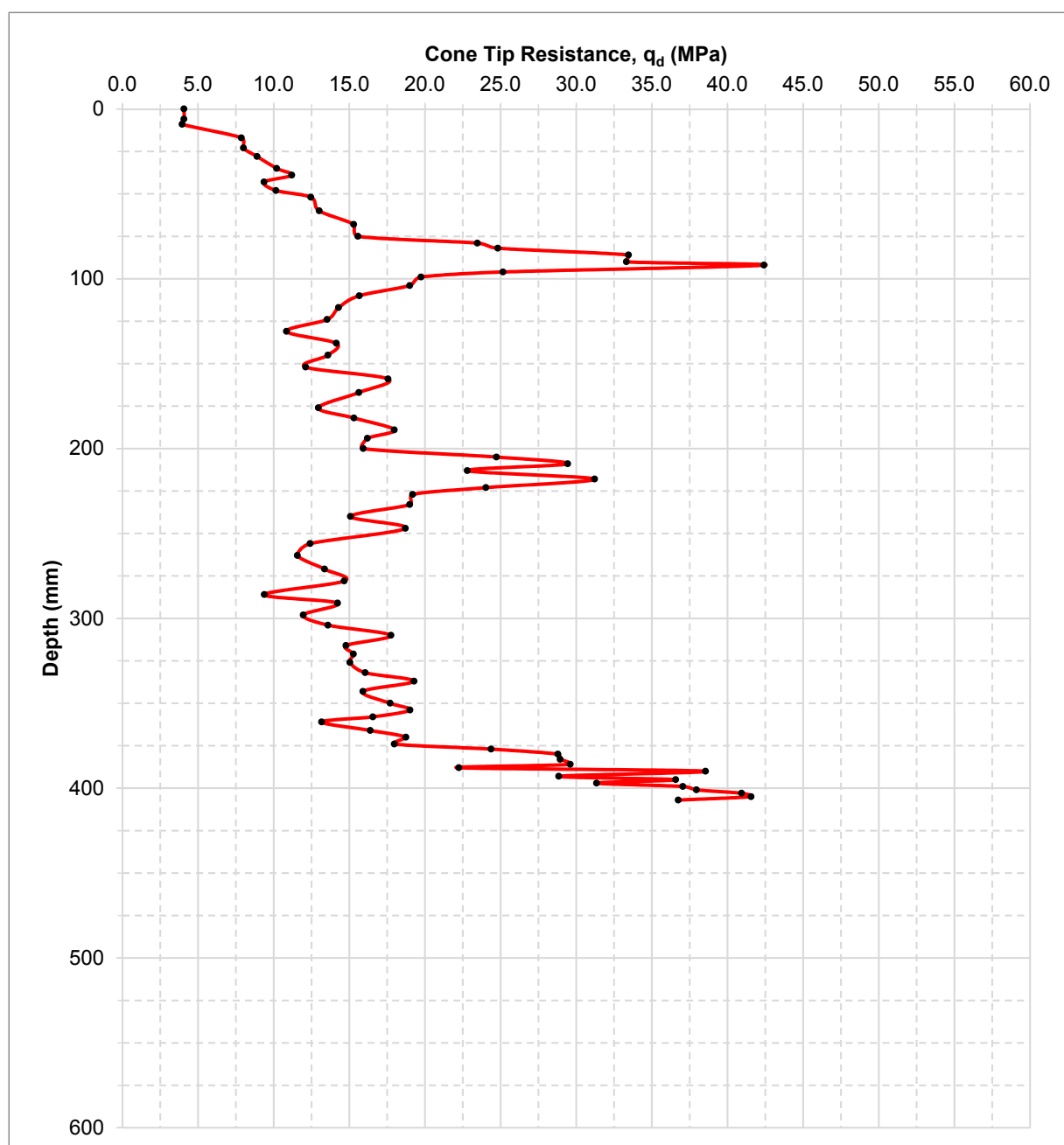
Project No.: 2091

Checked By: DWL

Location: Site 18-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-1

Certificate Reference:

2091-PND-Site 19-1

Sheet:

1 of 2

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	3.02	41	3	21.65	81	2	43.19
2	13	4.81	42	4	23.22	82	1	37.78
3	10	5.65	43	3	23.68	83	2	39.96
4	7	8.97	44	4	20.97	84	1	45.38
5	8	11.67	45	2	24.31	85	1	39.23
6	8	10.05	46	4	20.83	End of Test Record		
7	8	12.88	47	3	23.33			
8	9	9.24	48	4	23.15			
9	7	12.83	49	2	23.36			
10	9	11.09	50	2	31.38			
11	9	9.69	51	4	20.40			
12	8	11.74	52	3	21.27			
13	8	11.81	53	5	20.48			
14	10	9.78	54	3	22.43			
15	7	13.12	55	5	15.37			
16	7	12.86	56	3	26.16			
17	8	16.57	57	2	28.57			
18	6	15.69	58	3	17.06			
19	7	13.27	59	3	24.55			
20	7	16.11	60	3	23.06			
21	7	16.83	61	2	24.89			
22	6	15.51	62	3	24.55			
23	6	13.76	63	2	26.49			
24	6	14.81	64	2	26.71			
25	6	15.77	65	3	27.05			
26	7	13.07	66	1	36.66			
27	7	13.82	67	3	24.70			
28	5	15.58	68	2	25.27			
29	6	11.55	69	1	49.35			
30	6	15.27	70	2	46.31			
31	5	16.64	71	2	38.58			
32	5	17.79	72	2	28.75			
33	4	24.63	73	2	40.57			
34	3	18.44	74	2	51.66			
35	3	24.12	75	3	26.20			
36	2	31.73	76	1	59.85			
37	3	31.00	77	1	70.74			
38	3	28.27	78	2	65.91			
39	3	27.24	79	2	67.09			
40	3	22.90	80	3	38.25			

PANDA Probe - Test Report

Site 19-1

Certificate Reference:

2091-PND-Site 19-1

Sheet:

2 of 2

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

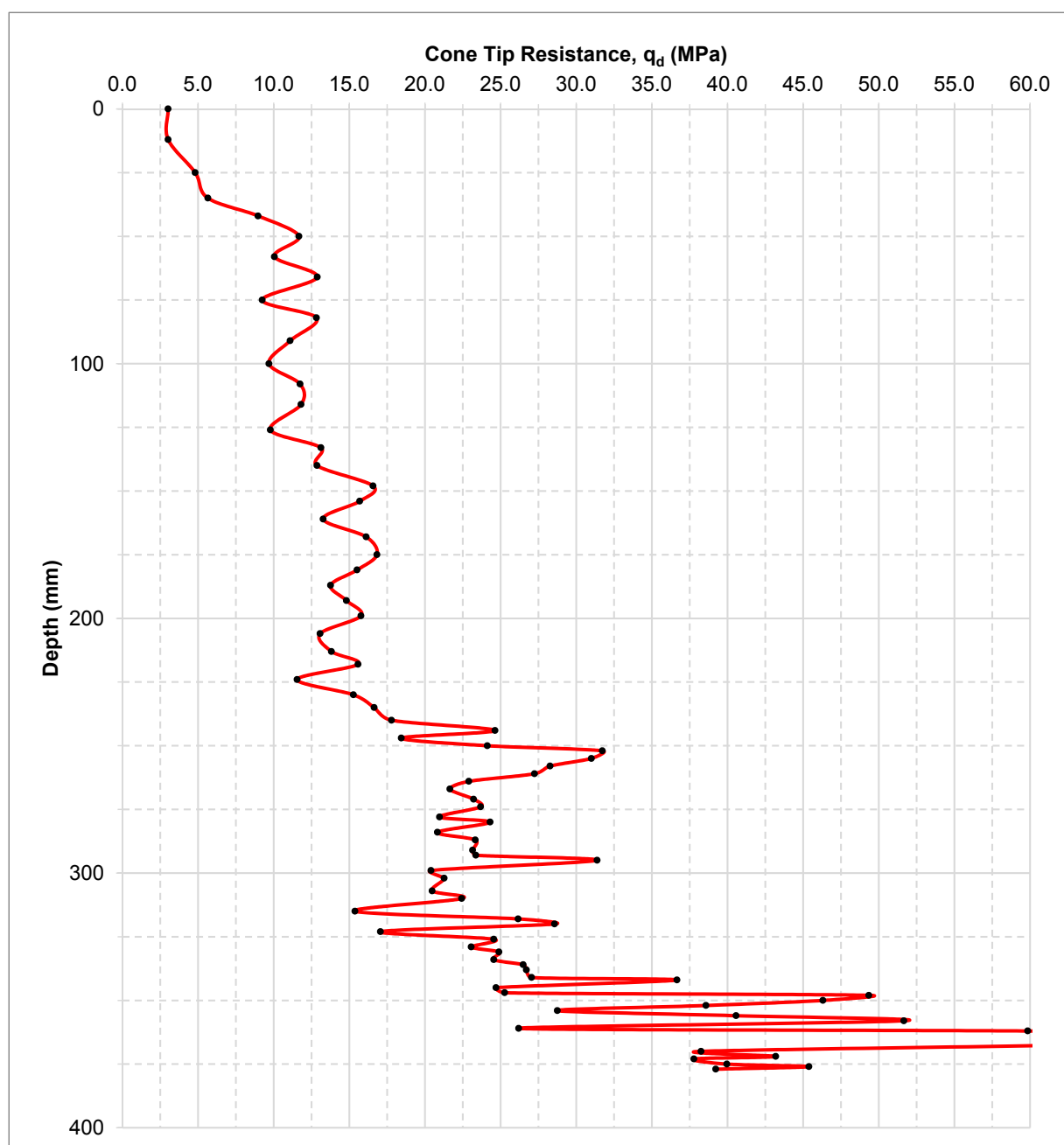
Project No.: 2091

Checked By: DWL

Location: Site 19-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-2

Certificate Reference:

2091-PND-Site 19-2

Sheet:

1 of 2

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	1.99	41	5	12.99	81	1	40.67
2	9	2.86	42	4	12.79	82	2	39.98
3	8	3.32	43	4	13.54	83	2	41.37
4	10	5.97	44	4	14.96	84	3	31.84
5	7	5.08	45	4	12.07	85	2	35.82
6	6	6.76	46	5	12.73	86	3	29.40
7	6	5.08	47	5	12.20	87	3	28.14
8	7	7.32	48	5	11.38	88	2	45.98
9	5	10.13	49	4	10.74	89	3	21.10
10	6	7.81	50	5	15.53	90	2	36.31
11	6	8.04	51	5	13.87	91	2	31.35
12	4	8.19	52	4	12.81	92	3	24.42
13	4	6.65	53	5	13.86	93	2	31.15
14	2	8.79	54	5	13.32	94	2	28.87
15	4	7.84	55	5	11.34	95	3	31.94
16	3	9.11	56	4	16.59	96	2	38.08
17	3	11.70	57	4	13.84	97	2	28.02
18	4	11.24	58	4	16.41	98	2	29.62
19	3	12.14	59	4	14.78	99	4	28.91
20	2	13.26	60	4	15.98	100	2	40.09
21	2	16.54	61	4	16.73	101	3	29.58
22	3	16.80	62	3	20.58	102	2	27.89
23	2	14.64	63	2	16.82	103	3	27.94
24	3	14.39	64	3	15.32	104	2	30.68
25	2	16.05	65	4	18.63	105	3	32.07
26	3	15.95	66	5	17.03	106	2	38.66
27	3	17.68	67	4	15.20	107	4	28.69
28	3	15.44	68	5	14.06	108	2	39.60
29	3	16.22	69	5	13.56	109	2	41.30
30	2	13.25	70	5	12.47	End of Test Record		
31	3	17.21	71	5	11.30			
32	3	16.80	72	5	13.66			
33	3	15.77	73	4	15.95			
34	4	13.67	74	5	12.56			
35	3	13.41	75	5	15.39			
36	4	16.50	76	3	16.88			
37	3	16.15	77	4	20.46			
38	3	13.29	78	3	25.46			
39	4	14.65	79	2	29.62			
40	3	14.37	80	2	36.86			

Certificate Reference:

2091-PND-Site 19-2

Sheet:

2 of 2

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

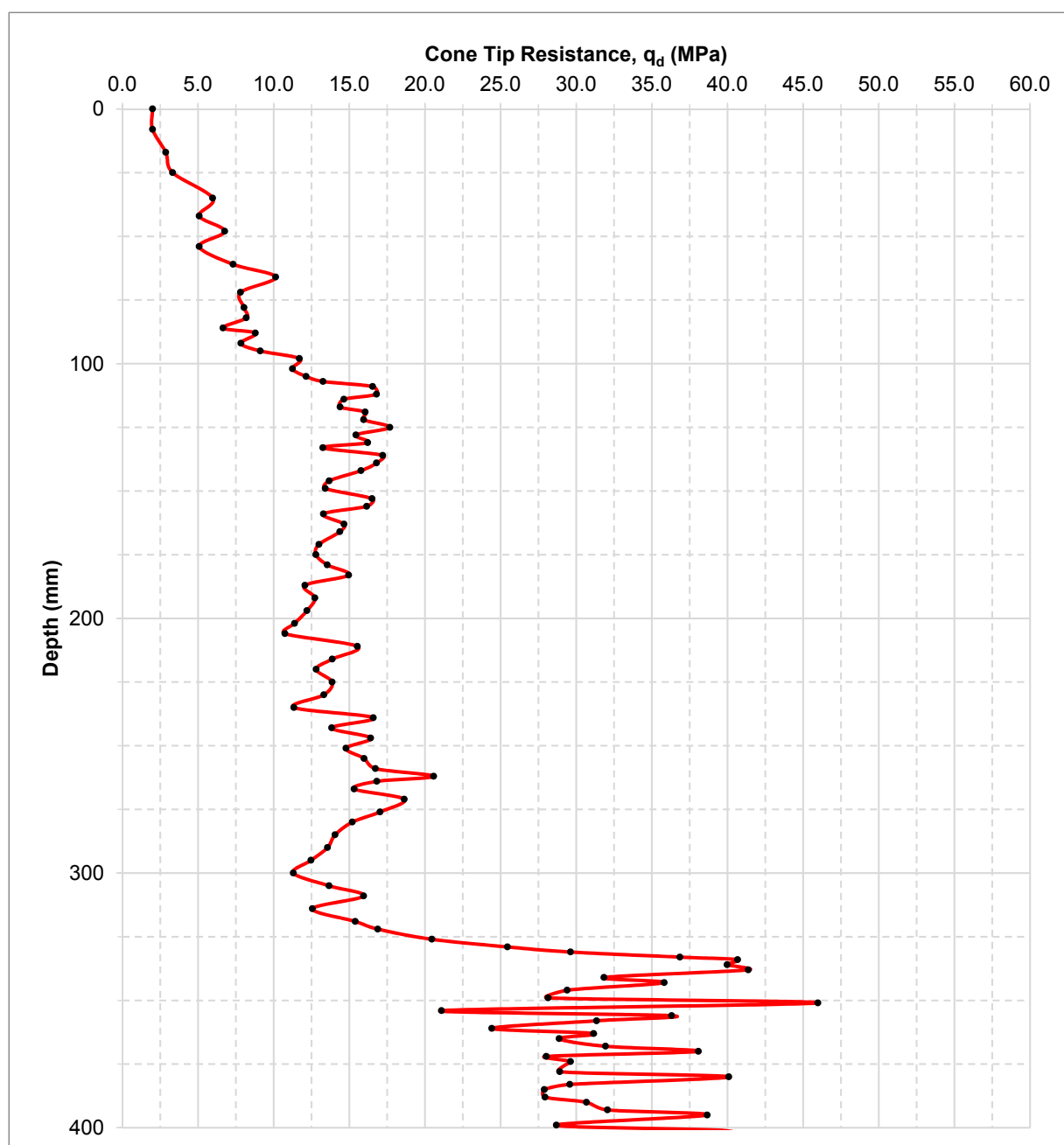
Project No.: 2091

Checked By: DWL

Location: Site 19-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-3

Certificate Reference:

2091-PND-Site 19-3

Sheet:

1 of 2

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	2.75	41	5	14.00	81	3	22.07
2	10	4.32	42	5	14.97	82	2	19.04
3	10	7.37	43	4	11.93	83	4	22.25
4	6	10.07	44	4	11.84	84	2	22.36
5	7	7.94	45	5	14.90	85	2	15.48
6	8	7.70	46	3	15.95	86	3	23.54
7	9	7.32	47	4	20.90	87	2	23.65
8	14	6.30	48	3	14.22	88	4	17.24
9	6	6.01	49	5	16.93	89	2	16.87
10	5	9.87	50	5	11.97	90	3	25.06
11	6	9.80	51	5	10.76	91	2	32.71
12	7	11.35	52	6	10.89	92	3	25.91
13	8	7.99	53	6	11.46	93	1	27.64
14	8	7.50	54	6	15.05	94	2	35.09
15	9	7.71	55	6	12.11	95	2	32.31
16	9	7.17	56	6	11.15	96	1	35.82
17	8	9.35	57	7	9.82	97	2	36.07
18	7	10.13	58	6	10.94	98	1	35.20
19	6	11.43	59	9	10.88	99	2	27.15
20	6	10.24	60	8	9.00	100	2	27.50
21	7	11.54	61	11	9.34	101	2	27.91
22	7	12.72	62	12	7.68	102	2	31.33
23	7	16.40	63	11	7.32	End of Test Record		
24	7	15.34	64	12	7.26			
25	7	15.17	65	10	7.38			
26	6	10.91	66	9	9.68			
27	6	16.33	67	9	9.50			
28	9	8.70	68	5	10.18			
29	9	10.85	69	6	13.53			
30	6	10.53	70	6	12.93			
31	4	14.78	71	6	16.29			
32	4	13.16	72	4	14.46			
33	4	16.08	73	3	15.53			
34	5	13.50	74	3	14.79			
35	5	14.96	75	2	14.72			
36	5	12.62	76	3	19.92			
37	4	8.39	77	4	17.87			
38	6	11.75	78	3	19.72			
39	7	13.40	79	3	22.17			
40	6	9.20	80	2	22.47			

PANDA Probe - Test Report

Site 19-3

Certificate Reference:

2091-PND-Site 19-3

Sheet:

2 of 2

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

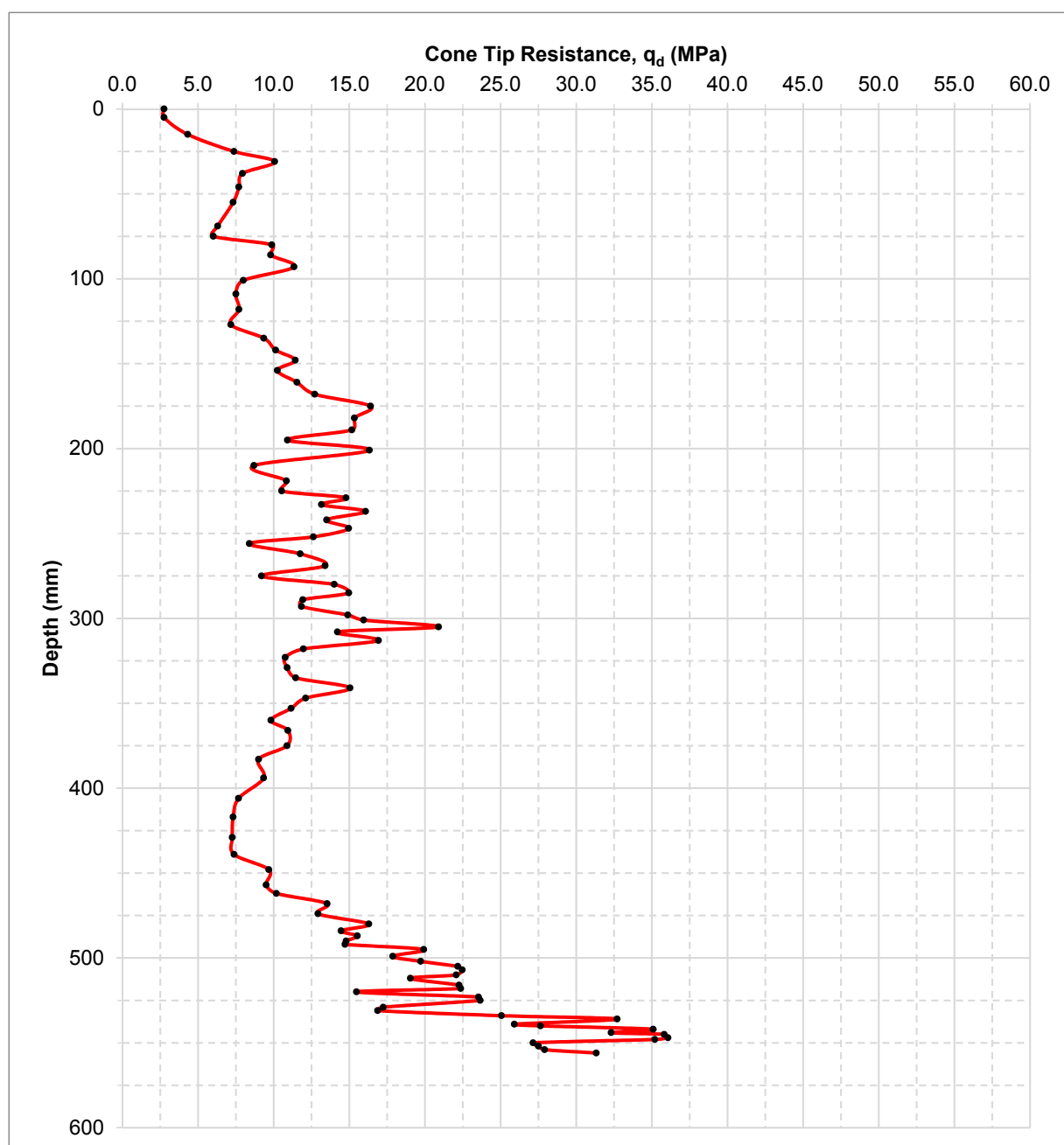
Project No.: 2091

Checked By: DWL

Location: Site 19-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-4

Certificate Reference:

2091-PND-Site 19-4

Sheet:

1 of 3

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	2.82	41	3	26.35	81	6	8.92
2	6	7.16	42	3	24.07	82	6	9.15
3	5	10.09	43	4	16.81	83	6	10.26
4	4	11.49	44	3	21.05	84	6	11.79
5	6	7.32	45	4	16.29	85	6	8.78
6	6	7.24	46	3	13.15	86	8	9.57
7	8	6.24	47	3	19.07	87	7	10.39
8	9	7.82	48	4	14.95	88	7	10.90
9	7	9.77	49	5	17.26	89	4	14.30
10	6	9.52	50	4	20.98	90	4	12.38
11	8	9.45	51	4	15.48	91	4	14.68
12	6	12.10	52	4	16.41	92	2	19.84
13	6	11.17	53	3	28.70	93	3	19.04
14	3	12.94	54	4	21.24	94	3	20.50
15	3	14.65	55	4	28.41	95	1	28.69
16	3	10.70	56	5	19.10	96	2	29.17
17	2	12.65	57	4	20.34	97	2	32.72
18	4	11.93	58	4	24.87	98	2	45.52
19	6	15.35	59	3	11.83	99	2	13.41
20	4	18.17	60	5	16.12	100	2	21.75
21	4	12.12	61	4	16.34	101	2	25.52
22	3	18.01	62	6	11.79	102	3	16.35
23	2	16.97	63	6	13.93	103	3	20.14
24	4	18.08	64	6	11.13	104	2	17.78
25	3	17.75	65	5	12.11	105	2	25.42
26	3	31.64	66	7	10.22	106	3	17.19
27	1	24.11	67	6	11.67	107	2	19.31
28	3	16.90	68	6	11.75	108	2	19.87
29	3	24.79	69	8	10.41	109	3	19.28
30	4	21.57	70	6	9.71	110	2	22.21
31	3	21.16	71	10	8.39	111	4	15.35
32	3	18.73	72	8	8.27	112	2	18.72
33	2	16.59	73	6	8.77	113	3	20.21
34	3	25.68	74	7	10.00	114	3	21.09
35	2	28.12	75	6	10.01	115	3	19.30
36	2	25.74	76	7	8.05	116	3	20.04
37	2	26.49	77	7	7.55	117	2	26.28
38	3	24.47	78	8	9.49	118	3	23.05
39	3	31.47	79	7	9.48	119	2	20.06
40	5	21.18	80	9	7.64	120	2	24.80

PANDA Probe - Test Report

Site 19-4

Certificate Reference:

2091-PND-Site 19-4

Sheet:

2 of 3

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	2	26.32						
122	3	22.02						
123	2	20.22						
124	2	19.51						
125	2	34.64						
126	3	20.15						
127	2	25.84						
128	3	18.06						
129	3	21.64						
130	2	25.85						
131	2	25.17						
132	4	20.16						
133	2	35.80						
134	2	28.53						
135	3	27.95						
136	2	24.69						
137	3	18.33						
138	2	31.17						
139	2	19.07						
140	1	21.98						
141	1	26.73						
142	3	27.76						
143	2	32.11						
144	2	27.25						
145	3	20.89						
146	2	20.52						
147	1	18.02						
148	3	18.05						
149	2	21.88						
150	2	30.46						
151	2	21.23						
152	4	18.64						
153	4	18.51						
154	1	20.12						
155	3	19.88						
156	2	18.62						
157	2	17.30						
158	3	16.54						
End of Test Record								

Certificate Reference:

2091-PND-Site 19-4

Sheet:

3 of 3

Client: ARRB

Test Date: 25/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

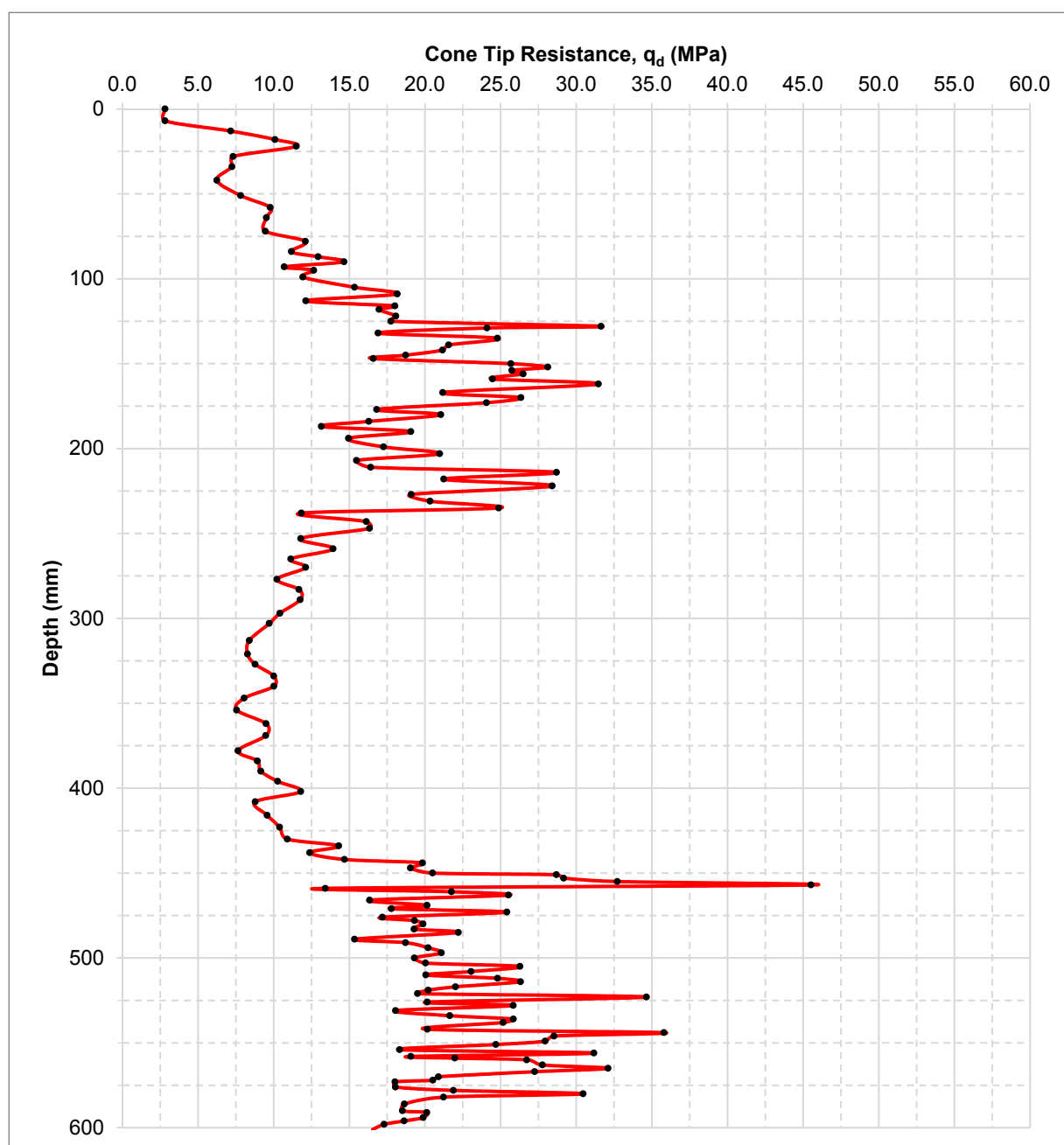
Project No.: 2091

Checked By: DWL

Location: Site 19-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-5

Certificate Reference:

2091-PND-Site 19-5

Sheet:

1 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.99	41	2	43.16	81	3	30.88
2	5	12.04	42	3	33.95	82	3	26.64
3	5	10.76	43	1	62.93	83	2	59.89
4	4	14.35	44	3	29.26	84	5	24.40
5	5	12.98	45	1	79.05	85	1	57.89
6	5	15.50	46	3	26.25	86	3	35.54
7	6	10.96	47	2	37.79	87	5	22.40
8	3	19.69	48	2	28.98	88	1	54.18
9	5	10.67	49	1	30.97	89	2	59.97
10	4	15.58	50	3	44.93	90	3	26.62
11	4	15.62	51	2	37.52	91	2	76.79
12	3	18.60	52	2	37.39	92	3	36.94
13	2	31.70	53	1	42.17	93	1	66.79
14	4	16.68	54	4	19.63	94	2	99.99
15	4	16.91	55	1	45.54	95	3	33.34
16	3	20.97	56	2	58.75	96	1	96.75
17	4	17.90	57	2	66.53	97	3	62.40
18	3	24.07	58	1	55.79	98	2	51.55
19	4	19.35	59	2	45.74	99	2	61.48
20	2	22.35	60	4	23.95	100	1	67.34
21	4	21.69	61	2	37.68	101	2	88.87
22	3	22.15	62	2	46.84	102	1	83.62
23	2	58.16	63	2	40.95	103	3	41.55
24	4	20.08	64	1	74.29	104	3	67.33
25	3	27.19	65	3	27.50	105	2	70.46
26	2	40.04	66	2	49.06	106	3	47.52
27	4	22.46	67	3	36.52	107	1	69.36
28	3	23.99	68	3	28.38	108	1	92.91
29	1	53.52	69	1	25.16	109	1	82.41
30	4	20.03	70	1	57.11	110	2	67.12
31	2	37.43	71	3	26.76	111	2	78.91
32	1	32.76	72	2	33.68	112	2	62.69
33	2	41.25	73	3	34.29	113	1	70.29
34	3	24.69	74	2	40.24	114	1	74.52
35	3	37.76	75	2	30.29	115	1	71.19
36	3	22.82	76	3	39.80	116	4	33.94
37	2	41.85	77	1	48.54	117	1	58.57
38	2	51.88	78	4	26.49	118	1	66.30
39	4	24.02	79	2	28.82	119	3	71.09
40	3	31.97	80	3	35.00	120	1	59.43

[illegible]

PANDA Probe - Test Report

Site 19-5

Certificate Reference:

2091-PND-Site 19-5

Sheet:

3 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

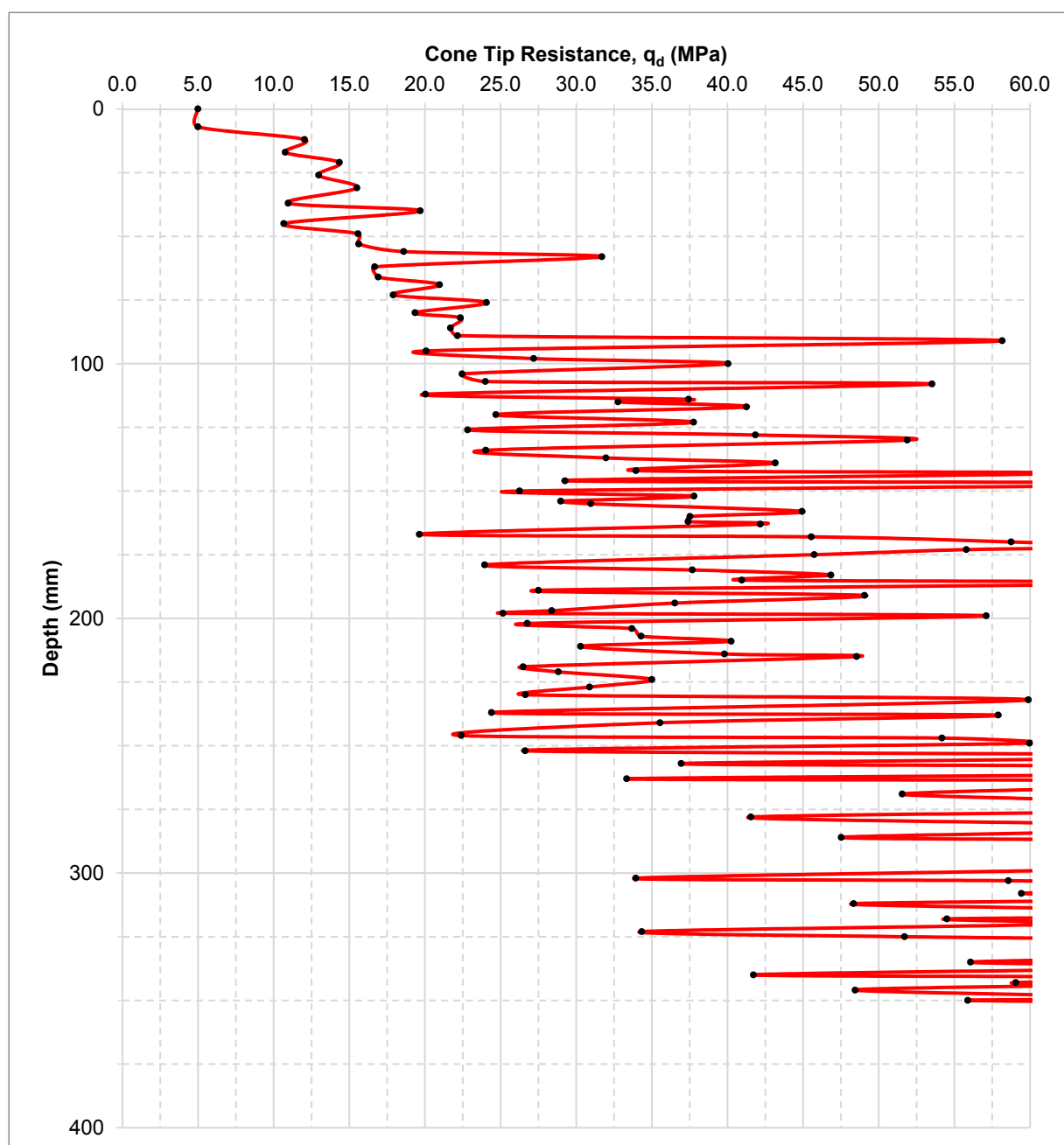
Project No.: 2091

Checked By: DWL

Location: Site 19-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 19-6

Certificate Reference:

2091-PND-Site 19-6

Sheet:

2 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

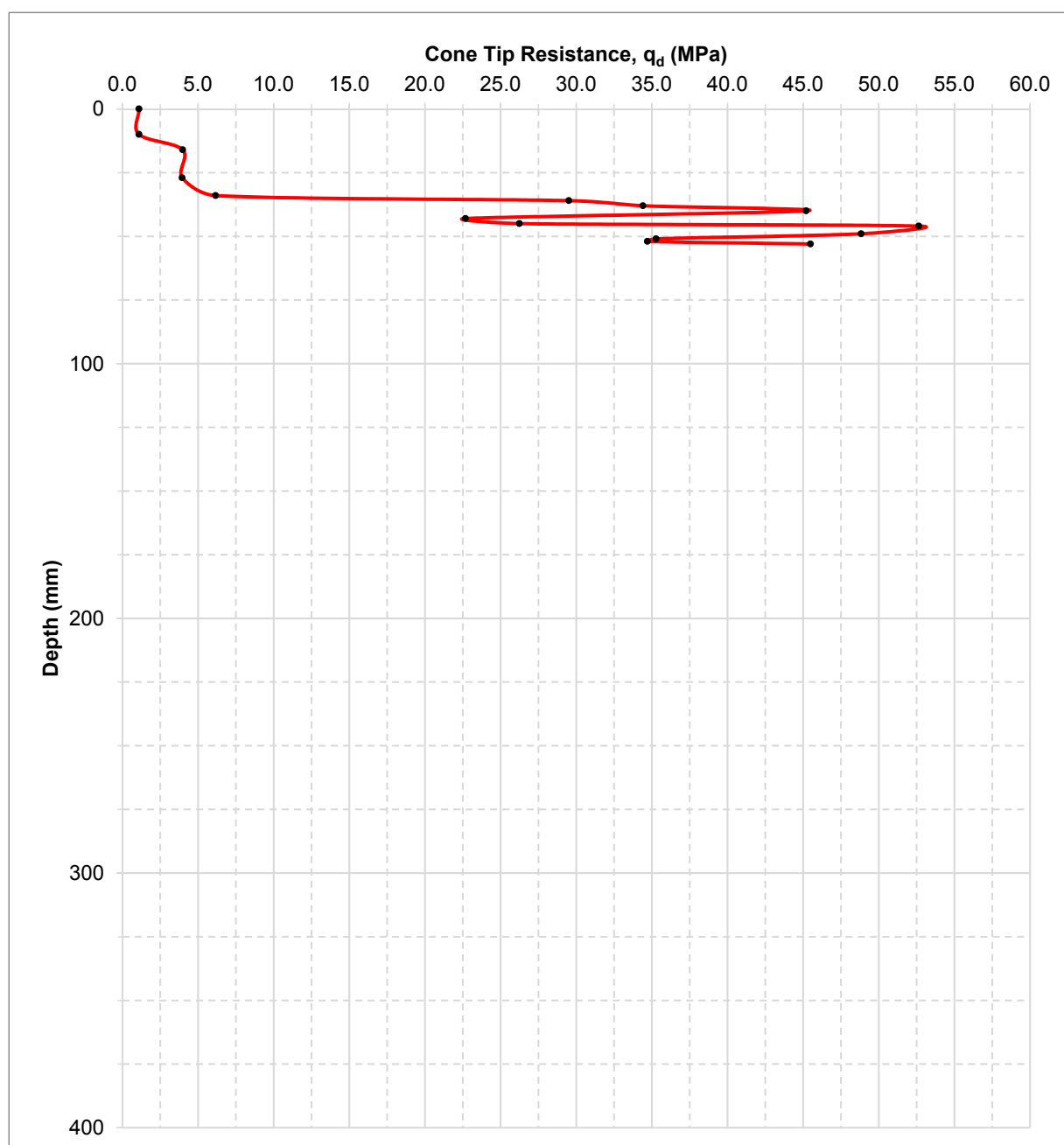
Project No.: 2091

Checked By: DWL

Location: Site 19-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-6A

Certificate Reference:

2091-PND-Site 19-6A

Sheet:

1 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	2.10	41	5	15.87	81	2	24.61
2	8	4.09	42	6	16.16	82	2	32.19
3	9	4.22	43	4	13.19	83	3	27.25
4	7	5.21	44	7	11.18	84	1	41.09
5	7	6.31	45	6	11.61	85	1	40.13
6	5	7.56	46	6	12.76	86	2	24.98
7	4	10.74	47	7	9.34	87	2	26.74
8	5	8.38	48	5	13.31	88	2	30.45
9	5	12.48	49	4	14.12	89	2	27.23
10	4	13.78	50	3	15.04	90	2	50.58
11	4	13.74	51	5	12.87	91	2	47.63
12	5	12.27	52	5	14.58	92	2	47.93
13	7	9.74	53	5	13.49	93	1	42.17
14	5	15.96	54	3	21.28	94	1	53.06
15	6	11.37	55	6	13.34	95	1	48.22
16	3	23.18	56	3	27.15	96	3	27.83
17	6	8.61	57	4	19.39	97	2	44.02
18	4	12.91	58	3	18.65	98	3	26.81
19	2	15.52	59	2	25.88	End of Test Record		
20	4	12.23	60	2	24.60			
21	5	11.59	61	4	19.32			
22	4	12.44	62	2	26.24			
23	5	14.45	63	4	22.83			
24	4	17.50	64	3	20.52			
25	6	11.24	65	3	21.31			
26	5	16.64	66	2	23.88			
27	7	10.52	67	2	35.42			
28	6	10.77	68	5	14.21			
29	5	12.08	69	2	26.40			
30	5	15.17	70	3	21.14			
31	5	14.50	71	3	20.09			
32	5	13.98	72	3	27.24			
33	6	11.92	73	2	24.32			
34	6	12.10	74	2	28.53			
35	6	11.59	75	3	20.89			
36	6	11.15	76	1	47.13			
37	6	10.80	77	2	27.90			
38	6	12.63	78	2	33.06			
39	7	9.39	79	3	28.05			
40	6	15.59	80	2	32.19			

Certificate Reference:

2091-PND-Site 19-6A

Sheet:

2 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

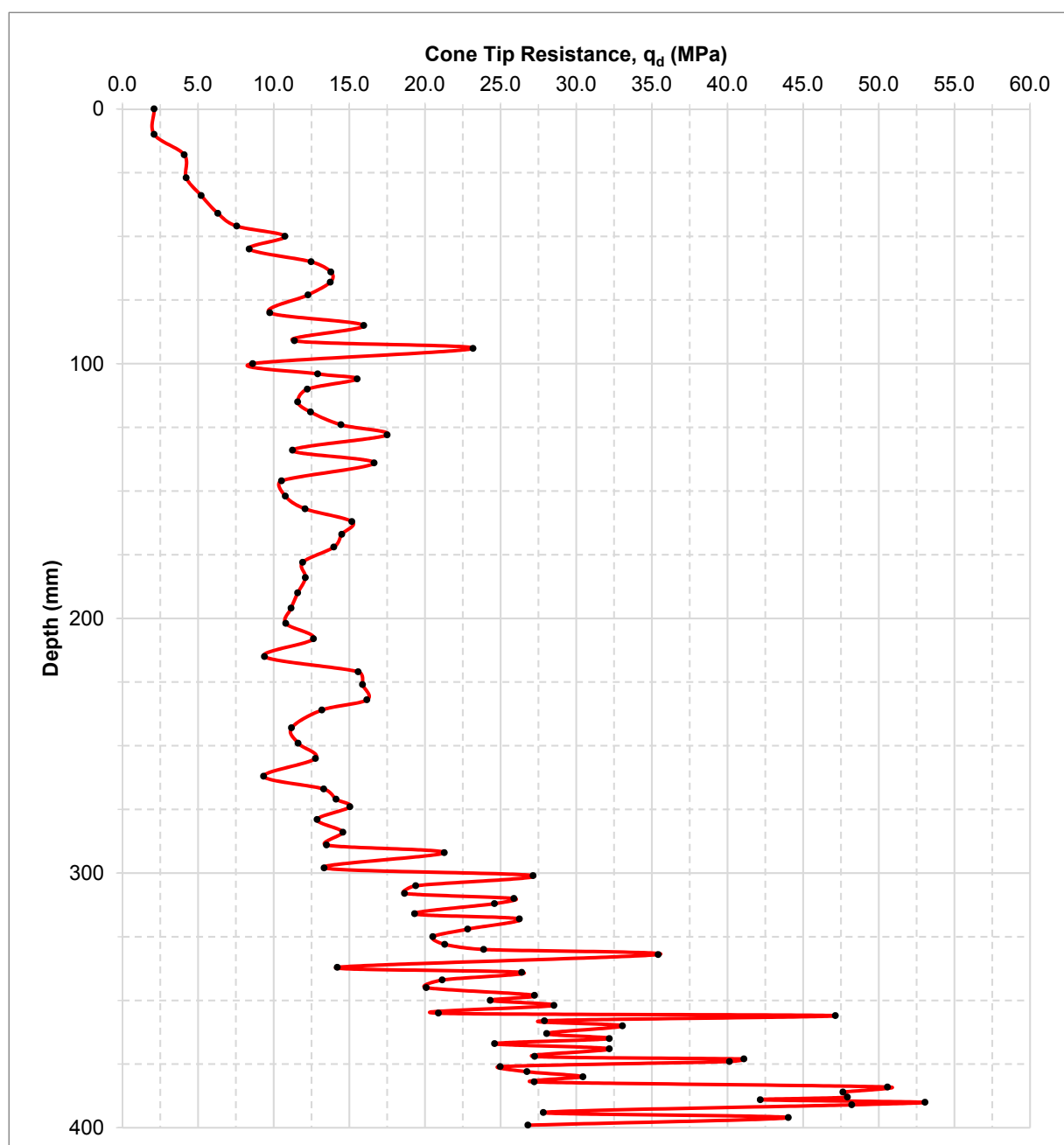
Project No.: 2091

Checked By: DWL

Location: Site 19-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-7

Certificate Reference:

2091-PND-Site 19-7

Sheet:

1 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	2.13	41	3	15.70	81	2	24.64
2	12	3.49	42	3	19.75	82	2	25.29
3	10	4.00	43	2	22.49	83	3	23.63
4	9	6.84	44	3	21.16	84	2	24.29
5	10	6.32	45	3	20.97	85	2	35.90
6	11	7.83	46	3	18.58	86	1	32.75
7	9	9.13	47	3	19.89	87	2	29.09
8	10	6.79	48	2	33.18	88	1	52.21
9	8	8.23	49	5	10.91	89	3	24.04
10	9	8.57	50	3	16.78	90	2	55.27
11	6	10.86	51	4	17.18	91	3	34.98
12	7	10.74	52	3	22.23	92	6	21.98
13	8	10.42	53	4	17.17	93	4	26.33
14	8	7.49	54	3	24.95	94	2	54.33
15	8	5.94	55	4	16.45	95	1	52.98
16	9	8.03	56	5	9.87	96	2	35.60
17	10	8.06	57	5	10.43	97	1	44.97
18	8	9.60	58	2	19.37	98	1	47.03
19	7	9.55	59	5	9.96	99	3	28.16
20	5	13.87	60	4	12.89	100	1	33.82
21	8	9.02	61	5	15.46	101	4	23.90
22	5	11.02	62	2	15.98	102	2	33.40
23	6	10.01	63	4	18.19	103	1	39.68
24	6	11.25	64	3	18.31	104	3	31.66
25	6	10.57	65	4	16.24	105	1	36.33
26	6	6.90	66	3	15.57	106	4	39.40
27	6	10.17	67	4	14.54	107	3	42.12
28	7	9.39	68	3	19.31	108	2	41.11
29	6	8.25	69	3	17.37	109	1	47.85
30	6	7.86	70	4	21.37	110	2	34.17
31	7	8.48	71	2	20.15	111	3	34.88
32	5	11.04	72	4	16.54	End of Test Record		
33	9	6.50	73	3	18.26			
34	7	9.06	74	2	19.61			
35	5	11.39	75	3	18.47			
36	4	15.17	76	3	21.26			
37	5	16.26	77	2	24.97			
38	2	16.77	78	3	16.63			
39	3	27.35	79	2	27.83			
40	5	11.07	80	1	39.37			

PANDA Probe - Test Report

Site 19-7

Certificate Reference:

2091-PND-Site 19-7

Sheet:

2 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

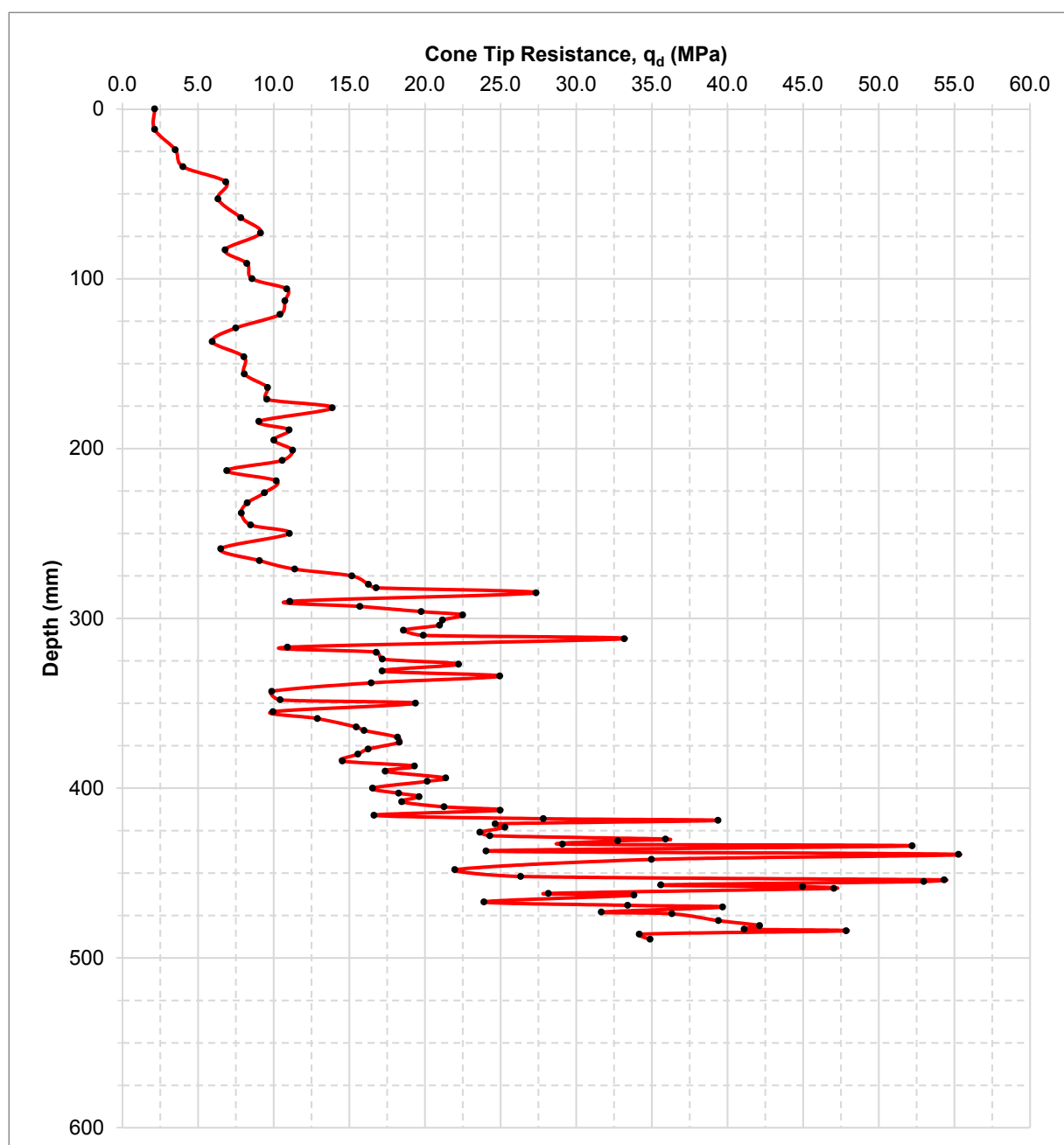
Project No.: 2091

Checked By: DWL

Location: Site 19-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-8

Certificate Reference:

2091-PND-Site 19-8

Sheet:

1 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	2.66	41	1	26.76	81	1	48.21
2	10	4.07	42	3	25.02	82	1	57.18
3	10	3.42	43	3	28.00	83	3	28.10
4	8	5.66	44	2	43.97	84	3	27.69
5	7	6.24	45	4	24.80	85	2	37.31
6	7	6.66	46	6	14.53	86	2	34.17
7	6	4.97	47	2	36.03	87	3	29.20
8	6	7.73	48	2	40.23	88	5	19.28
9	6	8.17	49	4	21.11	89	2	32.24
10	7	10.12	50	1	52.89	90	3	37.18
11	5	11.54	51	4	15.73	91	5	17.46
12	5	11.17	52	1	57.74	92	2	36.45
13	4	10.50	53	3	33.32	93	2	37.03
14	2	22.42	54	4	24.74	94	2	49.94
15	1	20.66	55	2	51.61	95	4	12.42
16	3	11.70	56	4	28.21	96	2	37.32
17	5	8.17	57	2	38.01	97	2	17.33
18	4	10.39	58	1	54.58	98	2	30.02
19	2	22.23	59	3	58.24	99	1	19.01
20	3	16.49	60	1	42.30	100	2	34.76
21	4	16.16	61	2	57.75	101	4	13.03
22	4	20.82	62	1	46.93	102	3	23.91
23	3	32.81	63	2	49.83	103	5	14.55
24	5	10.33	64	2	49.62	104	5	15.87
25	2	19.18	65	1	45.87	105	2	39.10
26	3	30.29	66	2	75.18	106	5	17.75
27	2	18.62	67	1	48.37	107	2	72.87
28	2	23.14	68	2	45.65	108	3	17.89
29	3	21.14	69	1	62.20	109	3	26.23
30	1	24.16	70	2	45.74	110	3	24.20
31	5	12.65	71	1	50.50	111	3	12.88
32	4	16.49	72	2	39.17	112	2	28.77
33	2	28.74	73	2	44.55	113	2	24.36
34	2	44.47	74	2	42.31	114	3	21.03
35	4	16.73	75	2	33.18	115	2	23.24
36	4	18.07	76	2	55.82	116	2	30.46
37	2	22.46	77	2	35.26	117	2	33.16
38	3	16.16	78	2	54.28	118	4	18.07
39	2	23.61	79	2	38.45	119	4	15.42
40	5	13.18	80	2	46.93	120	3	26.07

PANDA Probe - Test Report

Site 19-8

Certificate Reference:

2091-PND-Site 19-8

Sheet:

2 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	3	20.79	161	7	14.02			
122	3	21.31	162	9	12.42			
123	1	42.03	163	9	12.35			
124	4	21.03	164	7	10.45			
125	4	16.15	165	7	14.22			
126	3	23.72	166	8	13.93			
127	3	21.54	167	6	19.64			
128	3	17.06	168	8	15.77			
129	3	21.69	169	10	11.69			
130	2	45.22	170	7	22.09			
131	3	20.60	171	5	26.49			
132	2	24.06	172	5	19.55			
133	2	27.31	173	5	23.37			
134	2	39.71	174	5	30.79			
135	2	29.41	175	5	21.12			
136	3	20.44	176	5	25.89			
137	3	25.42	177	6	18.31			
138	2	26.83	178	6	16.23			
139	1	37.13	179	5	22.74			
140	4	20.30	End of Test Record					
141	2	37.39						
142	2	28.26						
143	1	36.85						
144	1	34.08						
145	2	28.98						
146	3	30.49						
147	2	22.36						
148	3	34.55						
149	2	30.44						
150	2	27.56						
151	2	26.70						
152	3	18.49						
153	3	24.52						
154	3	18.91						
155	3	19.39						
156	3	25.85						
157	3	16.30						
158	4	18.53						
159	5	17.69						
160	7	17.41						

PANDA Probe - Test Report

Site 19-8

Certificate Reference:

2091-PND-Site 19-8

Sheet:

3 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

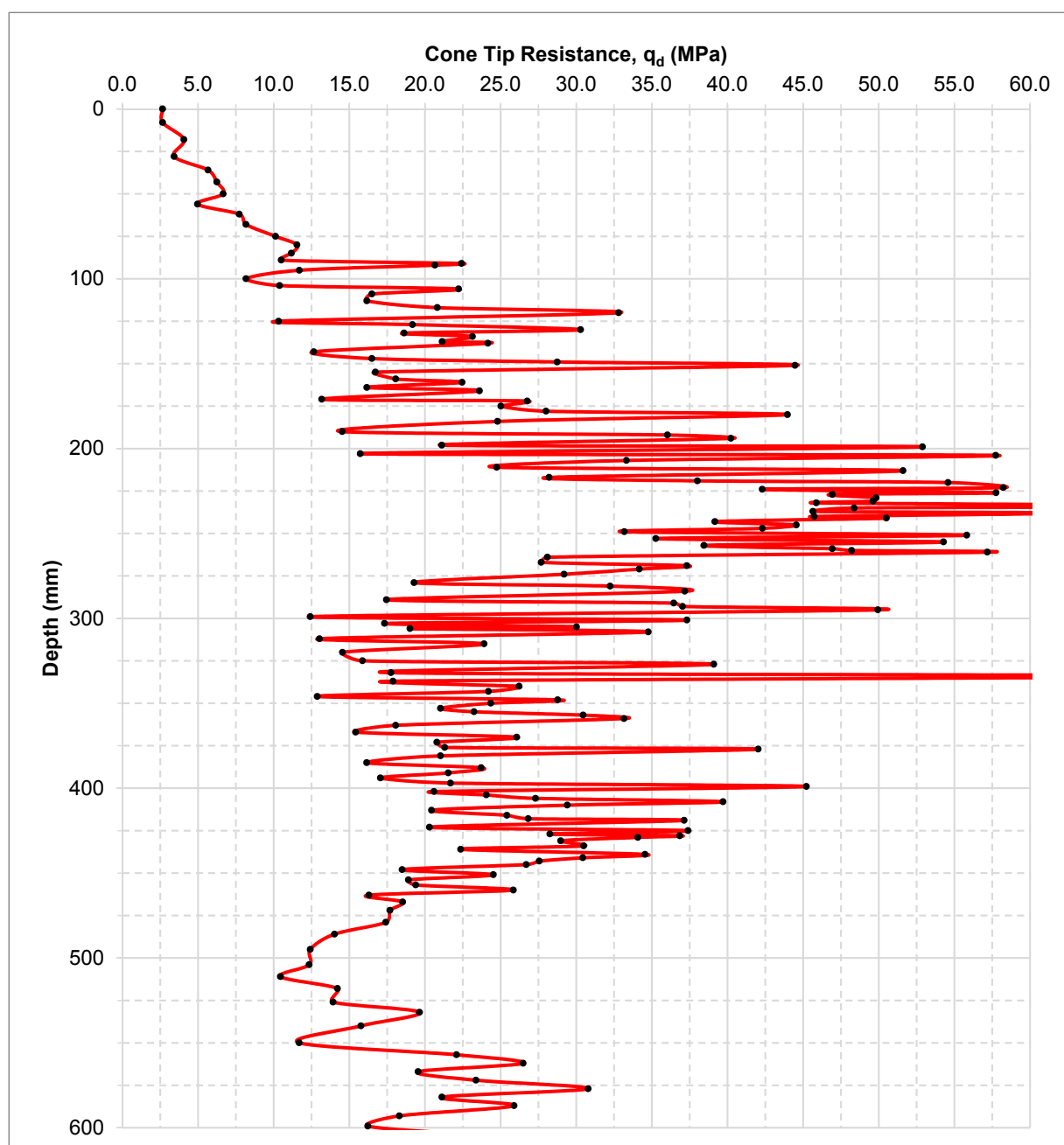
Project No.: 2091

Checked By: DWL

Location: Site 19-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-9

Certificate Reference:

2091-PND-Site 19-9

Sheet:

1 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	3	1.57	41	3	22.98	81	3	17.82
2	2	1.94	42	3	24.14	82	4	13.43
3	4	1.31	43	4	21.10	83	3	24.74
4	3	1.72	44	2	33.94	84	3	30.47
5	9	2.81	45	4	25.26	85	6	12.33
6	10	3.21	46	2	44.52	86	4	20.62
7	9	3.40	47	1	79.07	87	4	25.97
8	2	10.81	48	4	34.07	88	2	37.41
9	5	94.74	49	2	38.79	89	6	12.80
10	2	52.89	50	2	77.51	90	4	29.85
11	5	24.96	51	2	52.54	91	6	12.45
12	11	7.55	52	5	22.26	92	4	20.67
13	11	6.96	53	5	27.78	93	4	14.50
14	11	9.64	54	2	31.69	94	5	14.09
15	10	7.43	55	2	34.97	95	3	16.94
16	7	12.91	56	2	36.64	96	4	18.69
17	5	14.22	57	1	58.75	97	6	12.22
18	6	15.89	58	4	23.74	98	7	14.96
19	4	16.48	59	2	30.07	99	7	17.41
20	4	17.77	60	3	26.71	100	2	22.74
21	6	19.74	61	3	31.87	101	2	20.23
22	4	20.61	62	5	22.82	102	2	23.59
23	4	18.35	63	5	22.94	103	1	35.85
24	3	27.01	64	2	38.97	104	3	19.21
25	4	24.18	65	5	13.80	105	3	22.41
26	3	27.30	66	3	26.63	106	2	23.75
27	4	25.36	67	2	40.12	107	4	16.37
28	4	20.39	68	7	16.46	108	6	17.43
29	4	26.44	69	5	22.11	109	5	23.27
30	3	21.04	70	4	17.19	110	5	24.55
31	2	32.11	71	2	21.88	111	7	23.56
32	1	31.79	72	2	16.94	112	6	24.00
33	2	30.47	73	3	18.32	113	6	27.18
34	1	50.04	74	2	18.91	114	3	31.07
35	3	29.04	75	3	17.75	115	1	34.19
36	2	35.73	76	2	31.76	116	2	52.30
37	2	33.66	77	4	20.94	117	1	54.91
38	3	42.53	78	5	13.31	118	1	41.19
39	3	21.93	79	5	18.90	119	3	21.04
40	2	28.09	80	5	15.06	120	2	35.56

[illegible]

PANDA Probe - Test Report

Site 19-9

Certificate Reference:

2091-PND-Site 19-9

Sheet:

3 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

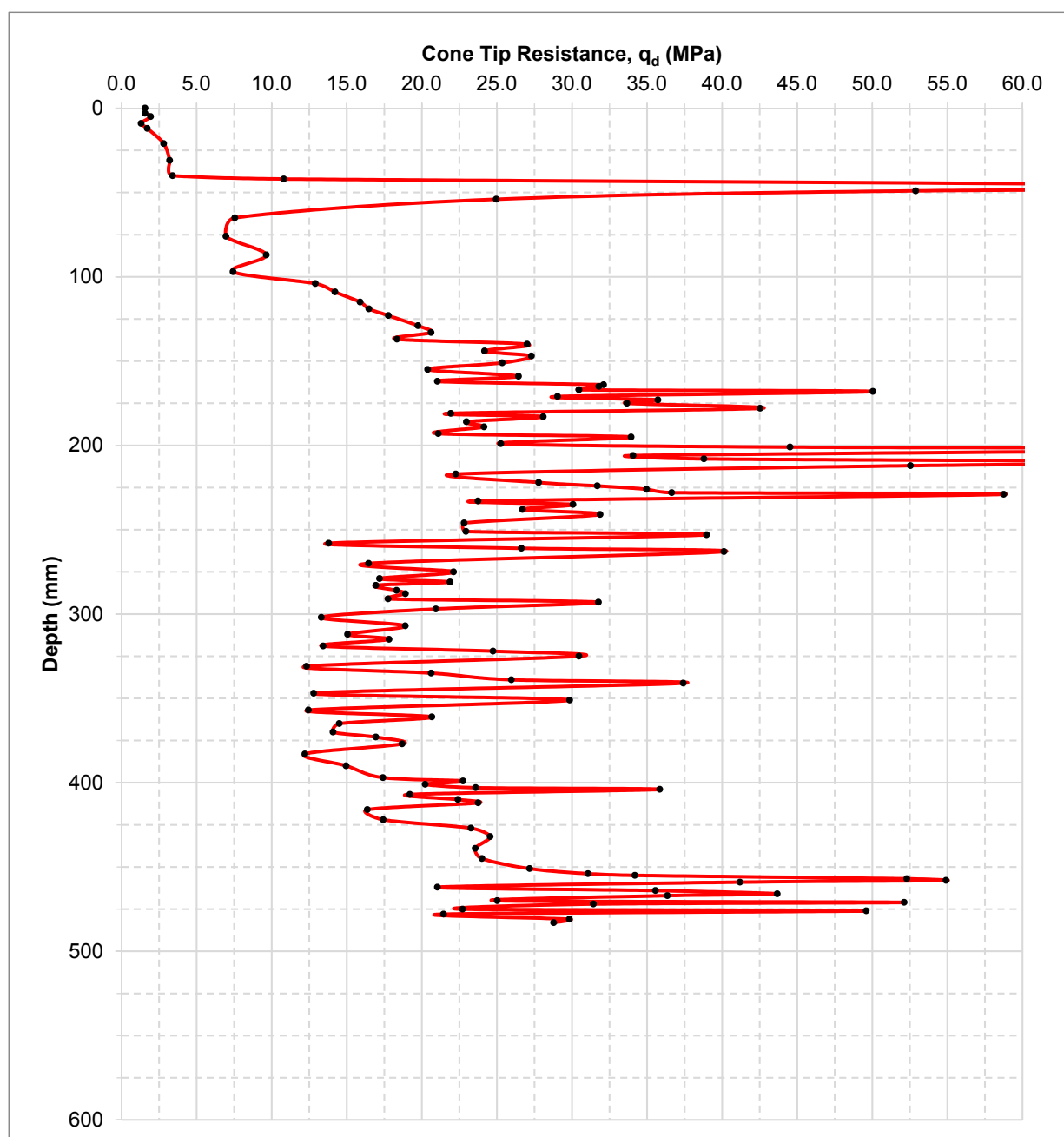
Project No.: 2091

Checked By: DWL

Location: Site 19-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-10

Certificate Reference:

2091-PND-Site 19-10

Sheet:

1 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	2.98	41	2	24.00			
2	6	6.03	42	4	20.71			
3	5	7.24	43	3	25.07			
4	5	4.42	44	2	26.57			
5	3	8.45	45	4	15.79			
6	3	7.86	46	3	28.94			
7	2	11.58	47	3	28.77			
8	3	7.69	48	3	20.52			
9	1	12.22	49	2	22.94			
10	4	10.38	50	2	28.12			
11	3	12.64	51	3	16.92			
12	5	7.15	52	2	19.15			
13	4	14.61	53	2	33.80			
14	4	15.70	54	1	47.91			
15	4	12.62	55	2	35.48			
16	5	12.43	56	1	32.44			
17	3	14.91	57	2	41.34			
18	4	11.64	58	2	43.39			
19	4	15.86	59	4	21.01			
20	3	19.10	60	2	32.00			
21	3	13.84	61	3	52.69			
22	2	17.91	62	1	49.57			
23	4	14.11	63	1	49.26			
24	3	20.54	64	3	32.75			
25	2	17.28	65	1	63.97			
26	4	15.62	66	2	38.64			
27	4	16.49	67	2	60.02			
28	4	16.80	68	2	48.73			
29	3	19.02	69	1	74.34			
30	4	14.10	70	1	45.35			
31	2	18.19	71	2	36.41			
32	3	23.86	72	2	54.25			
33	3	20.38	73	2	35.02			
34	3	22.51	74	2	60.35			
35	3	21.06	75	1	43.32			
36	3	19.18	76	2	33.62			
37	3	24.12	End of Test Record					
38	2	20.95						
39	5	14.64						
40	3	23.04						

PANDA Probe - Test Report

Site 19-10

Certificate Reference:

2091-PND-Site 19-10

Sheet:

2 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

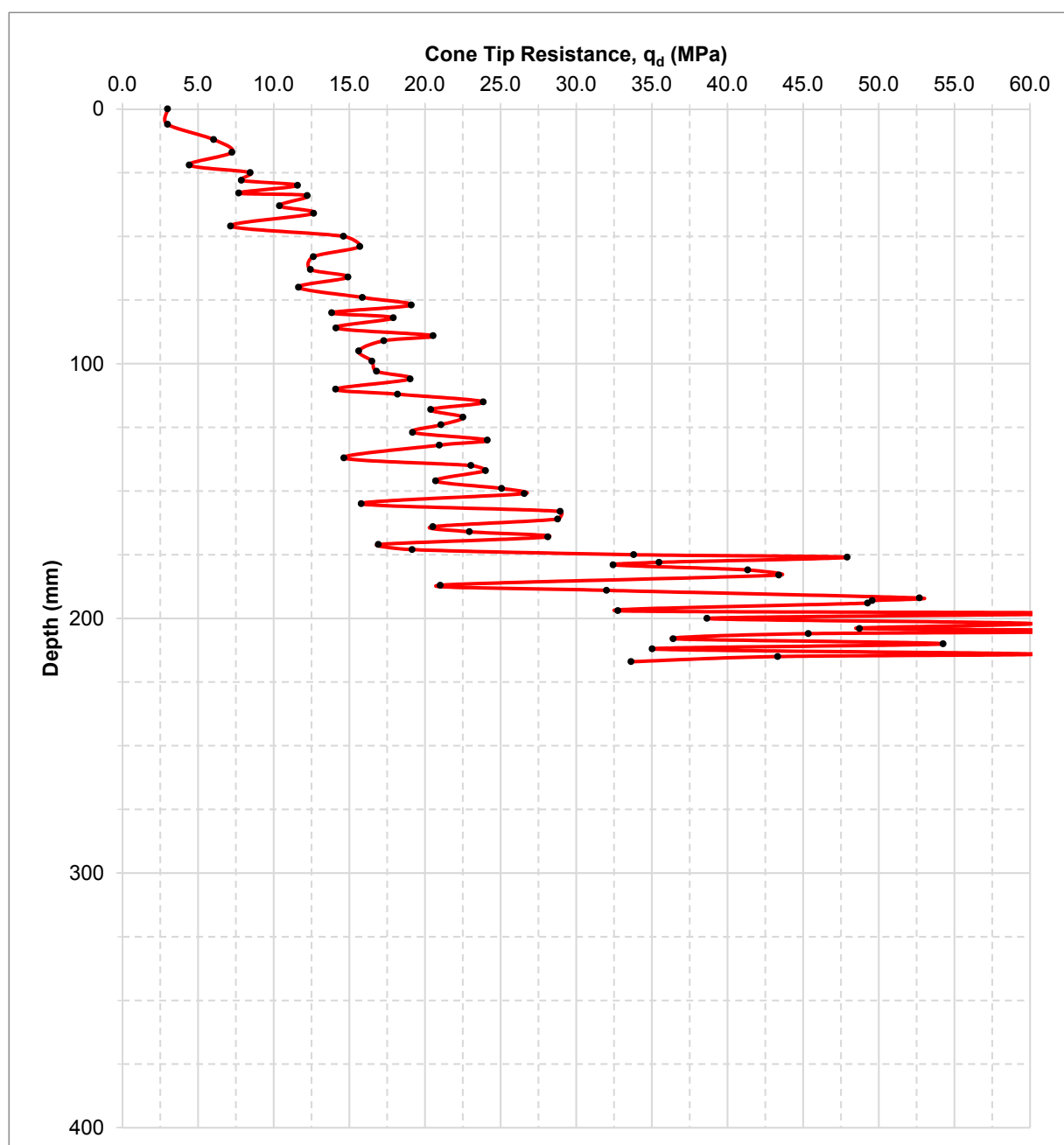
Project No.: 2091

Checked By: DWL

Location: Site 19-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-10A

Certificate Reference:

2091-PND-Site 19-10A

Sheet:

1 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	2.24	41	2	35.69	81	4	35.25
2	10	5.76	42	2	36.74	82	4	36.06
3	11	6.10	43	2	62.28	83	7	20.27
4	5	8.37	44	2	26.86	84	6	27.92
5	7	10.92	45	1	57.23	85	2	28.47
6	8	10.54	46	2	89.01	86	3	21.60
7	8	9.94	47	5	23.28	87	6	21.03
8	8	10.34	48	2	44.12	88	5	24.51
9	5	12.62	49	3	20.10	89	4	37.90
10	7	9.78	50	1	28.52	90	6	22.17
11	8	12.04	51	1	51.95	91	2	27.03
12	5	8.02	52	3	40.22	92	4	17.82
13	6	9.03	53	2	25.61	93	3	19.13
14	7	13.25	54	1	54.08	94	6	13.12
15	3	13.63	55	3	37.87	95	2	20.01
16	4	18.46	56	2	44.60	96	2	22.06
17	6	15.38	57	2	36.15	97	4	14.03
18	3	29.10	58	1	49.27	98	3	16.46
19	5	20.95	59	3	40.93	99	8	18.00
20	3	25.17	60	3	34.40	100	10	13.64
21	3	40.11	61	4	15.32	101	12	14.06
22	5	18.62	62	3	30.66	102	10	10.54
23	3	40.87	63	1	49.14	103	9	15.72
24	3	41.84	64	2	27.77	104	14	13.31
25	2	30.72	65	2	37.11	105	18	11.07
26	2	49.10	66	2	28.80	106	15	15.88
27	2	52.42	67	3	24.82	107	9	18.50
28	2	29.13	68	2	29.19	108	8	22.69
29	1	67.39	69	2	33.81	109	10	22.75
30	1	74.06	70	3	24.98	110	10	23.19
31	2	87.03	71	3	32.66	111	3	7.59
32	2	53.12	72	2	28.80	112	3	18.15
33	2	48.04	73	1	62.49	113	1	18.85
34	2	52.61	74	4	19.21	114	2	20.79
35	4	64.30	75	2	58.83	115	3	19.37
36	2	68.16	76	2	43.07	116	2	19.21
37	2	40.03	77	6	36.85	117	3	16.17
38	1	58.66	78	4	38.07	118	2	23.08
39	2	36.91	79	2	26.64	119	5	27.06
40	5	22.90	80	6	22.25	120	5	23.88

[illegible]

PANDA Probe - Test Report

Site 19-10A

Certificate Reference:

2091-PND-Site 19-10A

Sheet:

3 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

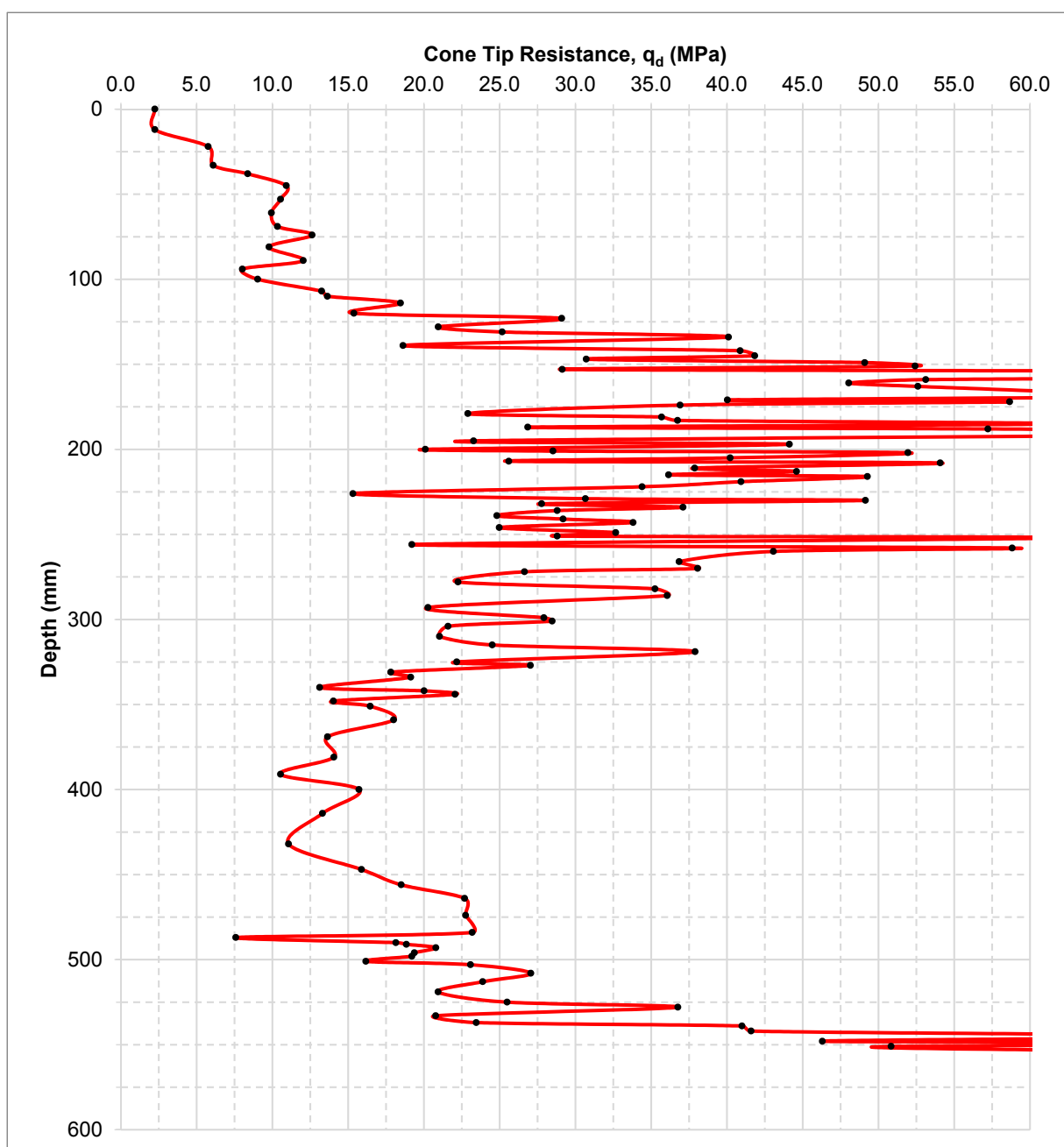
Project No.: 2091

Checked By: DWL

Location: Site 19-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-11

Certificate Reference:

2091-PND-Site 19-11

Sheet:

1 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	2.99	41	2	4.86	81	3	18.46
2	3	6.50	42	5	25.43	82	3	15.82
3	6	4.60	43	1	26.65	83	3	21.23
4	6	6.26	44	4	13.91	84	4	15.59
5	5	7.62	45	5	14.49	85	3	28.24
6	5	9.01	46	4	17.31	86	2	55.83
7	8	7.99	47	1	43.64	87	1	57.28
8	6	8.44	48	3	19.44	88	4	18.62
9	5	8.95	49	1	23.85	89	4	27.74
10	5	8.96	50	2	19.73	90	4	21.64
11	6	9.17	51	4	28.52	91	2	19.38
12	7	11.29	52	1	50.21	92	3	19.85
13	6	14.81	53	3	31.27	93	4	8.92
14	5	14.39	54	5	27.66	94	3	14.55
15	5	16.13	55	6	20.06	95	3	13.02
16	3	17.64	56	4	27.97	96	8	19.78
17	3	17.64	57	7	19.65	97	6	15.94
18	3	11.75	58	7	19.22	98	7	16.73
19	2	11.41	59	5	22.78	99	6	17.74
20	4	12.19	60	4	30.15	100	5	19.05
21	2	12.27	61	4	22.51	101	8	13.58
22	1	13.45	62	6	19.84	102	7	14.88
23	2	11.95	63	3	25.87	103	10	13.47
24	3	14.93	64	4	26.62	104	10	13.87
25	1	12.98	65	4	22.35	105	8	15.01
26	2	14.87	66	2	25.86	106	8	13.50
27	3	18.38	67	3	14.89	107	6	17.00
28	2	12.72	68	2	15.36	108	6	14.08
29	2	23.26	69	3	13.74	109	6	20.06
30	3	14.73	70	2	17.71	110	5	19.61
31	2	12.21	71	4	25.62	111	3	33.57
32	2	18.47	72	2	74.33	112	2	37.61
33	2	22.61	73	3	19.56	113	3	23.30
34	2	19.06	74	2	19.91	114	4	32.27
35	4	17.52	75	3	13.11	115	4	21.62
36	3	16.36	76	4	12.86	116	4	18.30
37	3	27.14	77	3	18.40	117	6	22.65
38	1	57.36	78	2	19.80	118	7	20.74
39	2	51.82	79	2	19.16	119	6	19.46
40	3	21.88	80	3	17.98	120	6	17.68

[illegible]

PANDA Probe - Test Report

Site 19-11

Certificate Reference:

2091-PND-Site 19-11

Sheet:

3 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

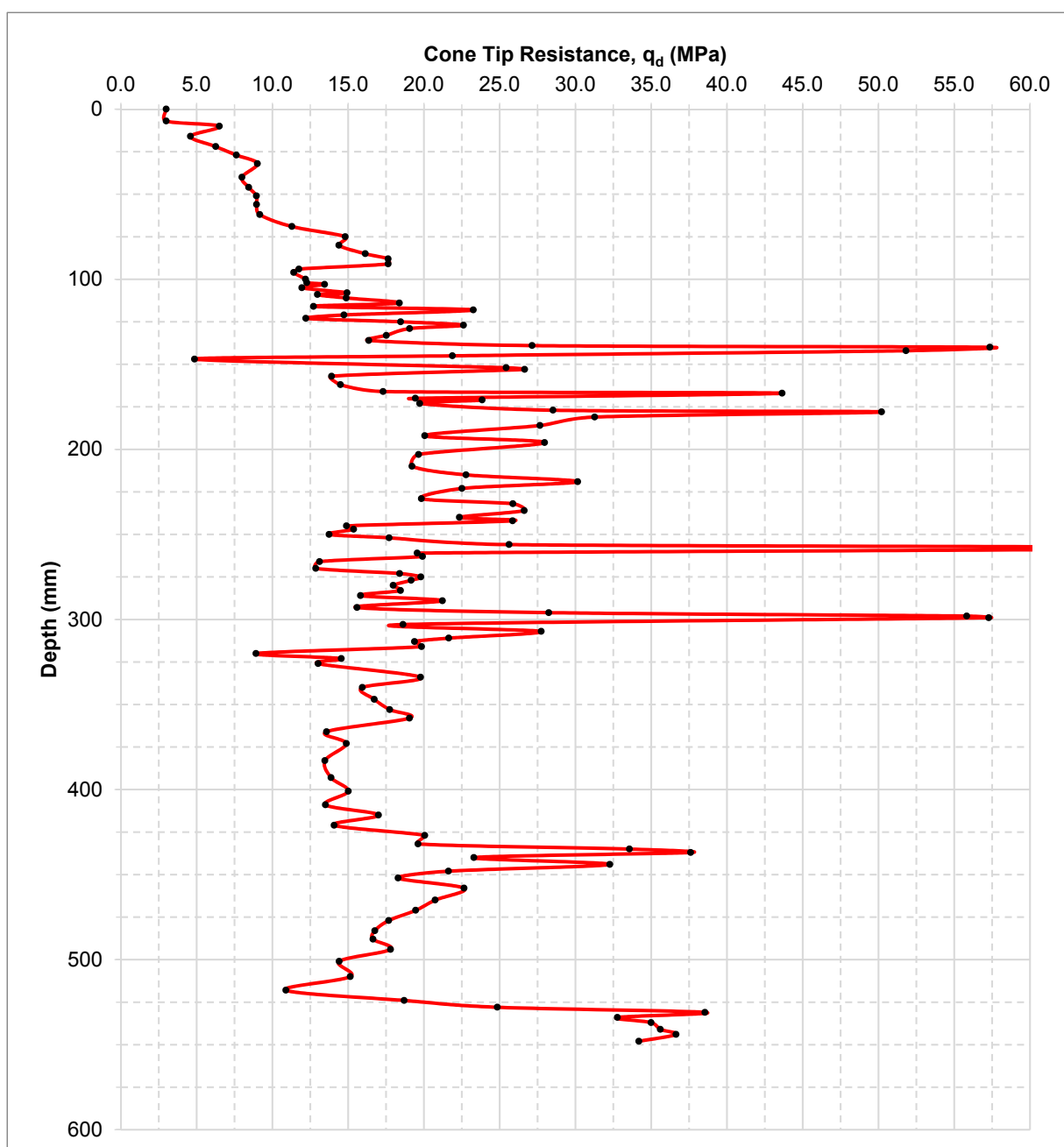
Project No.: 2091

Checked By: DWL

Location: Site 19-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-12

Certificate Reference:

2091-PND-Site 19-12

Sheet:

1 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	4	4.02	41	3	21.50	81	5	32.47
2	3	6.54	42	4	16.84	82	4	50.90
3	3	6.68	43	2	32.90	83	4	22.02
4	2	11.12	44	2	22.00	84	2	71.33
5	3	7.73	45	2	48.34	85	2	62.04
6	2	12.61	46	3	25.14	86	4	42.95
7	2	12.15	47	3	30.02	87	2	47.29
8	3	17.64	48	2	35.25	88	7	34.35
9	1	22.70	49	4	25.31	89	6	35.66
10	2	18.23	50	4	24.13	90	8	26.33
11	1	45.60	51	4	27.80	91	6	35.15
12	2	21.58	52	2	38.72	92	8	26.53
13	1	38.57	53	5	29.29	93	7	26.86
14	3	17.01	54	3	30.96	94	7	22.34
15	2	14.66	55	5	29.91	95	8	22.02
16	3	18.03	56	5	32.82	96	5	19.99
17	3	21.65	57	1	50.96	97	7	22.21
18	2	37.66	58	4	28.51	98	4	42.24
19	2	23.57	59	3	34.96	99	7	19.83
20	2	15.05	60	5	32.29	100	5	28.65
21	1	37.71	61	3	39.42	101	6	24.68
22	1	20.60	62	3	34.66	102	5	31.87
23	1	27.24	63	3	33.90	103	6	30.04
24	2	57.40	64	5	36.39	104	7	27.55
25	2	31.70	65	5	35.71	105	3	36.00
26	3	30.55	66	4	45.32	106	3	31.63
27	1	38.82	67	2	60.13	107	2	32.22
28	2	31.21	68	4	36.27	108	3	38.05
29	2	30.62	69	1	57.79	109	2	32.07
30	3	29.43	70	2	59.01	110	3	43.36
31	2	27.32	71	3	54.62	End of Test Record		
32	2	27.17	72	3	53.79			
33	4	21.13	73	4	48.07			
34	1	68.61	74	4	43.81			
35	4	24.82	75	3	76.88			
36	4	20.44	76	3	43.00			
37	4	30.97	77	5	24.87			
38	3	25.09	78	3	73.16			
39	2	29.06	79	2	63.22			
40	3	25.71	80	5	25.31			

PANDA Probe - Test Report

Site 19-12

Certificate Reference:

2091-PND-Site 19-12

Sheet:

2 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

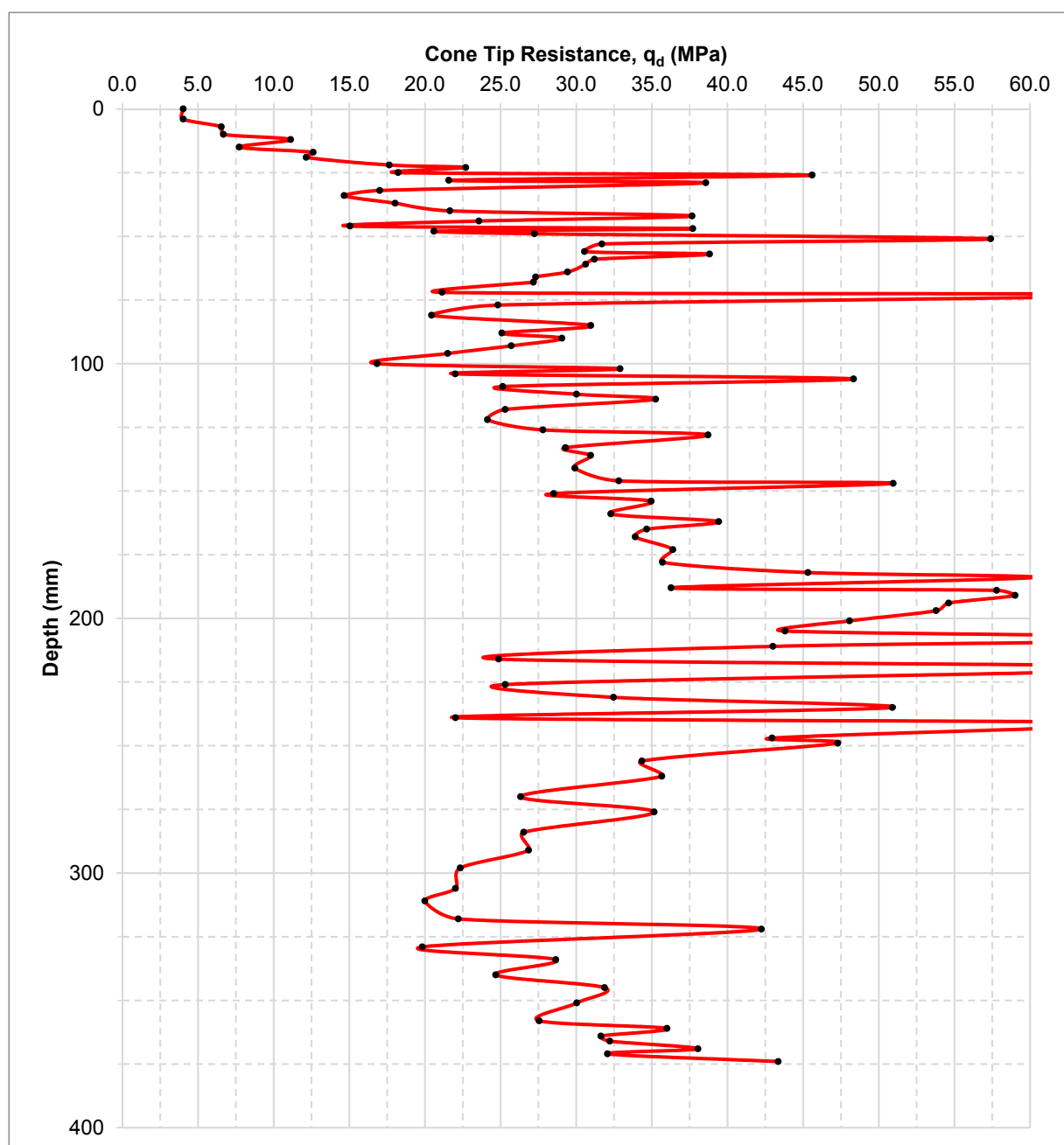
Project No.: 2091

Checked By: DWL

Location: Site 19-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-13

Certificate Reference:

2091-PND-Site 19-13

Sheet:

1 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	3.63	41	4	19.33	81	1	123.72
2	4	7.70	42	3	16.23	82	2	93.64
3	3	11.48	43	4	11.88	83	1	71.12
4	4	9.54	44	3	15.83	84	3	30.99
5	4	14.60	45	5	14.14	85	2	80.22
6	4	8.89	46	4	14.33	86	2	21.51
7	5	8.60	47	3	17.91	End of Test Record		
8	3	9.42	48	4	17.07			
9	4	7.62	49	2	25.25			
10	2	11.66	50	4	14.01			
11	1	23.17	51	3	20.75			
12	2	40.35	52	2	27.35			
13	2	27.98	53	3	36.17			
14	2	45.52	54	4	26.41			
15	2	51.28	55	10	12.50			
16	1	42.82	56	6	24.08			
17	2	36.90	57	5	10.25			
18	1	39.08	58	6	11.78			
19	2	44.22	59	5	13.13			
20	2	40.23	60	8	13.89			
21	2	28.10	61	9	12.05			
22	2	39.70	62	8	11.27			
23	2	37.69	63	9	15.46			
24	1	44.37	64	5	16.51			
25	2	41.49	65	5	13.77			
26	2	35.74	66	3	16.11			
27	3	21.72	67	5	17.43			
28	2	30.58	68	4	25.96			
29	2	29.96	69	3	19.82			
30	2	23.08	70	2	33.55			
31	2	27.40	71	2	102.76			
32	3	17.60	72	3	73.83			
33	2	21.37	73	0	134.23			
34	4	22.02	74	4	40.62			
35	4	12.90	75	3	45.30			
36	4	18.09	76	3	52.84			
37	4	14.08	77	3	56.55			
38	3	20.96	78	3	39.08			
39	4	17.91	79	2	44.46			
40	5	16.45	80	2	56.43			

PANDA Probe - Test Report

Site 19-13

Certificate Reference:

2091-PND-Site 19-13

Sheet:

2 of 2

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

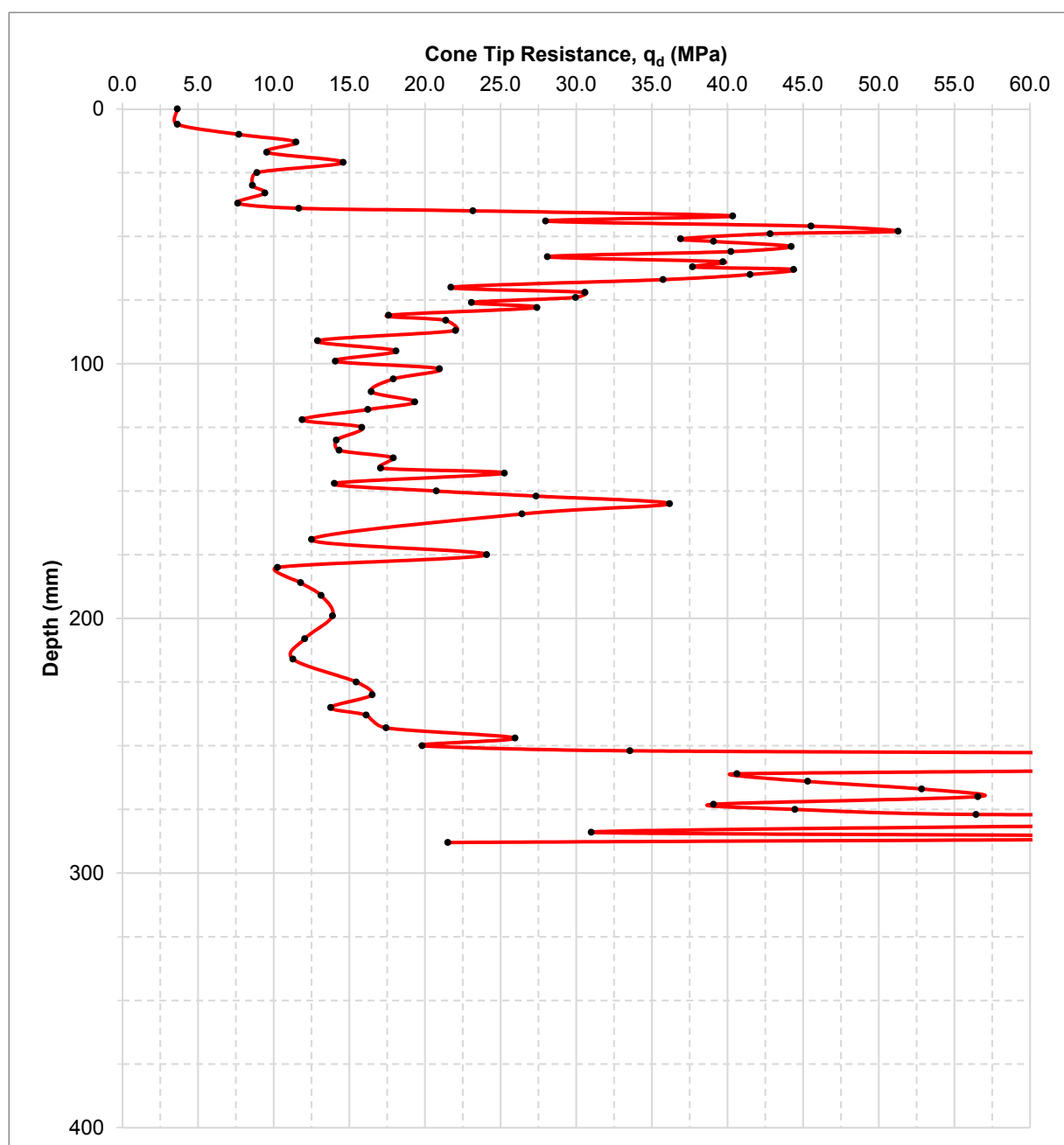
Project No.: 2091

Checked By: DWL

Location: Site 19-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-13A

Certificate Reference:

2091-PND-Site 19-13A

Sheet:

1 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.17	41	2	17.89	81	1	30.46
2	7	5.26	42	3	10.46	82	2	26.88
3	10	6.81	43	3	13.91	83	2	31.95
4	6	7.67	44	5	13.37	84	1	51.53
5	5	11.04	45	3	17.39	85	2	53.70
6	6	6.32	46	5	11.82	86	1	35.78
7	3	8.37	47	5	11.00	87	3	46.11
8	4	10.11	48	3	13.85	88	1	94.23
9	5	10.23	49	5	10.20	89	3	35.91
10	5	7.84	50	6	12.66	90	3	28.11
11	4	10.01	51	6	11.29	91	1	67.40
12	5	9.70	52	6	13.98	92	3	33.04
13	6	10.72	53	4	12.05	93	1	51.37
14	6	7.29	54	6	8.21	94	2	55.89
15	6	9.32	55	3	19.55	95	1	63.87
16	6	9.56	56	3	18.43	96	6	19.71
17	4	7.45	57	1	51.53	97	2	60.36
18	7	9.56	58	2	22.36	98	2	48.15
19	7	7.47	59	2	29.47	99	1	53.88
20	6	9.79	60	2	32.31	100	1	63.52
21	6	12.89	61	2	23.54	101	3	19.39
22	3	19.33	62	3	27.64	102	3	33.23
23	2	17.18	63	4	35.62	103	1	33.97
24	1	39.31	64	2	70.51	104	1	40.22
25	3	39.26	65	1	37.07	105	4	33.79
26	2	24.97	66	5	19.05	106	3	21.12
27	2	52.21	67	3	27.02	107	5	20.35
28	2	22.19	68	3	28.11	108	5	23.73
29	2	37.37	69	2	35.49	109	5	24.61
30	2	18.52	70	2	32.94	110	3	12.36
31	3	17.28	71	3	27.76	111	2	38.02
32	2	43.50	72	1	53.57	112	1	37.30
33	3	14.98	73	2	37.59	113	1	41.68
34	4	12.04	74	1	63.57	114	2	35.42
35	2	22.92	75	2	36.01	115	1	35.39
36	1	29.29	76	3	20.71	116	1	38.22
37	2	16.33	77	2	26.35	117	2	28.53
38	2	25.27	78	1	27.02	118	2	36.88
39	2	18.41	79	3	29.81	119	3	33.18
40	2	17.24	80	3	23.09	120	1	28.29

PANDA Probe - Test Report

Site 19-13A

Certificate Reference:

2091-PND-Site 19-13A

Sheet:

2 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	1	34.47						
122	1	31.47						
123	2	25.75						
124	1	34.04						
125	1	27.63						
126	3	26.40						
127	4	15.18						
128	3	19.38						
129	2	33.21						
130	3	17.97						
131	2	26.98						
132	3	16.83						
133	1	37.88						
134	2	20.44						
135	3	21.93						
136	3	16.69						
137	3	17.71						
138	3	19.35						
139	2	26.33						
140	2	20.04						
141	3	18.08						
142	3	18.66						
143	3	26.81						
144	1	46.47						
145	3	27.38						
146	2	61.39						
147	4	33.36						
148	1	56.36						
149	2	52.13						
150	2	48.90						
151	4	28.43						
152	2	76.74						
153	4	28.05						
154	2	80.09						
End of Test Record								

PANDA Probe - Test Report

Site 19-13A

Certificate Reference:

2091-PND-Site 19-13A

Sheet:

3 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

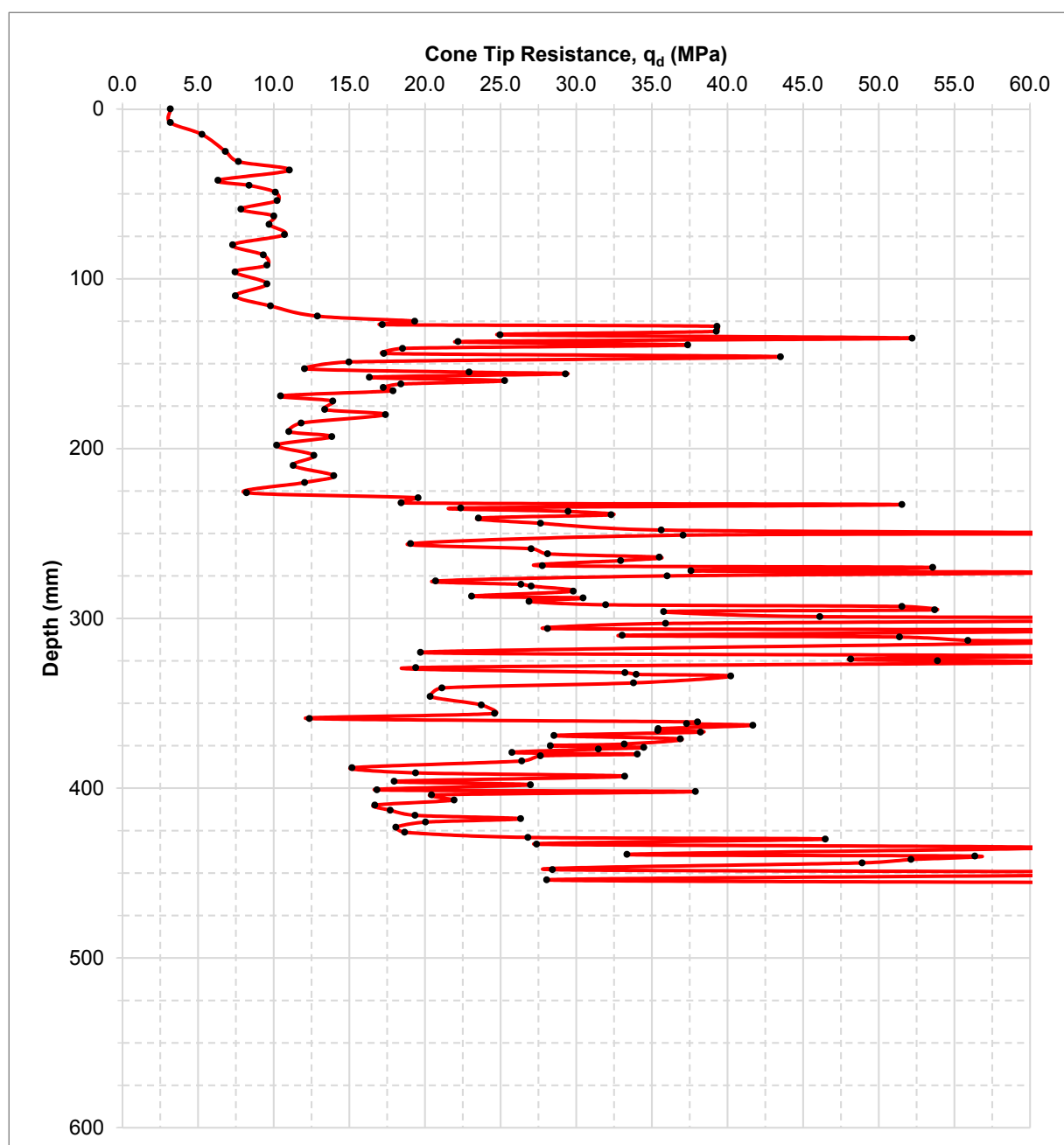
Project No.: 2091

Checked By: DWL

Location: Site 19-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 19-14

Certificate Reference:

2091-PND-Site 19-14

Sheet:

1 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-14 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	4	2.84	41	3	22.42	81	4	14.03
2	2	2.97	42	3	22.45	82	1	31.96
3	1	4.99	43	4	24.29	83	5	11.98
4	3	7.46	44	3	24.37	84	3	23.23
5	4	9.87	45	3	21.07	85	3	16.63
6	4	10.90	46	3	18.34	86	2	38.85
7	4	12.71	47	2	20.27	87	4	13.41
8	3	11.27	48	2	19.63	88	4	18.81
9	4	14.10	49	3	20.77	89	5	19.70
10	3	6.47	50	2	19.01	90	5	16.47
11	3	12.52	51	3	23.88	91	7	17.19
12	2	11.45	52	3	20.29	92	8	12.44
13	3	10.24	53	2	20.92	93	6	13.48
14	2	23.23	54	3	16.54	94	3	27.65
15	2	20.85	55	3	25.38	95	7	14.33
16	2	21.25	56	3	26.05	96	5	13.16
17	3	15.63	57	4	18.10	97	3	8.54
18	1	22.04	58	4	13.42	98	2	9.00
19	2	17.09	59	3	16.46	99	3	7.24
20	1	19.97	60	4	15.71	100	4	15.59
21	2	18.06	61	3	16.25	101	5	16.32
22	1	13.00	62	2	34.80	102	4	14.72
23	2	22.22	63	4	12.81	103	4	13.77
24	2	15.11	64	4	16.32	104	4	16.27
25	2	17.12	65	4	15.93	105	3	15.98
26	1	24.72	66	5	13.64	106	4	19.26
27	2	16.60	67	4	14.98	107	4	22.06
28	1	30.84	68	4	18.90	108	6	16.40
29	2	13.84	69	4	13.13	109	3	31.84
30	2	20.37	70	3	20.48	110	6	17.70
31	1	25.07	71	4	16.33	111	6	20.38
32	2	24.76	72	5	12.55	112	5	17.74
33	2	17.33	73	3	16.73	113	4	27.22
34	2	19.70	74	4	21.30	114	3	19.29
35	1	23.41	75	4	12.17	115	5	21.05
36	2	20.65	76	3	15.89	116	6	16.69
37	2	22.70	77	2	19.52	117	3	28.58
38	2	22.02	78	4	13.55	118	5	17.44
39	3	22.56	79	3	18.48	119	5	23.39
40	3	24.89	80	3	27.95	120	4	20.67

PANDA Probe - Test Report

Site 19-14

Certificate Reference:

2091-PND-Site 19-14

Sheet:

2 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 19-14 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	5	20.61	161	4	10.70			
122	4	27.29	162	2	30.11			
123	3	27.84	163	3	14.73			
124	3	22.16	164	2	23.59			
125	5	22.37	165	3	22.82			
126	5	21.27	166	3	26.06			
127	6	22.44	167	5	20.92			
128	3	31.35	168	1	73.78			
129	3	25.57	169	5	13.74			
130	5	21.87	170	2	40.50			
131	4	22.81	171	3	32.65			
132	4	16.08	172	4	18.19			
133	3	11.28	173	5	16.98			
134	2	19.28	174	1	57.40			
135	2	24.03	175	4	18.25			
136	3	19.11	176	4	27.41			
137	1	26.25	177	6	12.91			
138	2	15.80	178	3	24.70			
139	2	30.51	179	10	14.57			
140	2	17.69	180	5	21.47			
141	2	19.97	181	8	18.25			
142	1	31.71	End of Test Record					
143	3	14.65						
144	2	19.50						
145	2	12.72						
146	1	25.18						
147	2	12.56						
148	3	19.05						
149	5	18.08						
150	7	13.65						
151	9	18.42						
152	8	16.10						
153	11	16.40						
154	9	18.41						
155	2	21.13						
156	4	11.87						
157	2	20.83						
158	2	11.76						
159	3	17.10						
160	3	14.75						

Certificate Reference:

2091-PND-Site 19-14

Sheet:

3 of 3

Client: ARRB

Test Date: 26/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

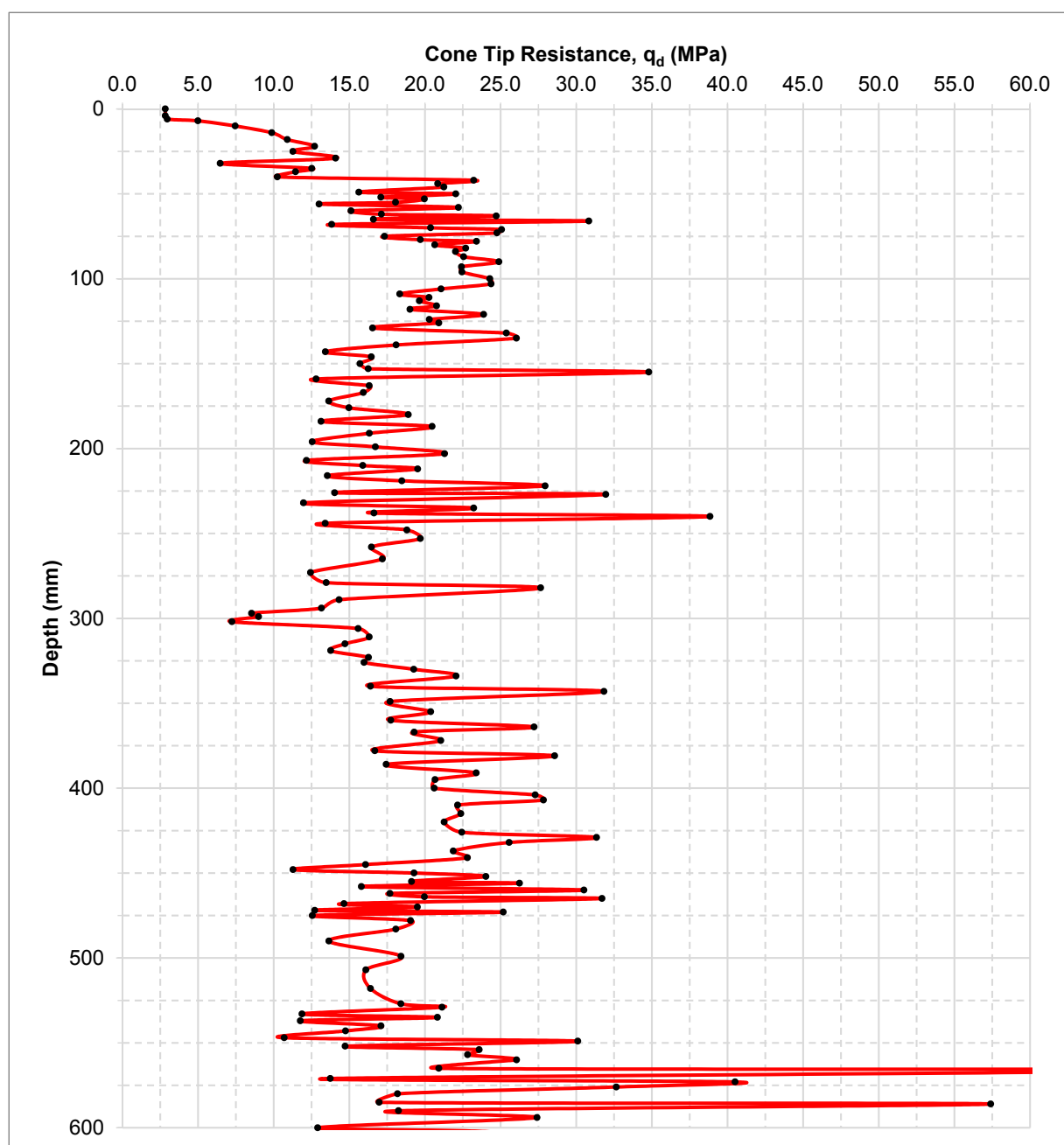
Project No.: 2091

Checked By: DWL

Location: Site 19-14 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-1

Certificate Reference:

2091-PND-Site 21-1

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	4.93	41	3	42.74			
2	9	5.15	42	2	54.60			
3	8	7.13	43	2	62.03			
4	8	6.73	End of Test Record					
5	7	7.56						
6	9	8.76						
7	8	12.23						
8	7	13.72						
9	6	14.29						
10	5	15.97						
11	5	16.07						
12	4	14.77						
13	6	17.38						
14	5	17.78						
15	4	18.79						
16	5	23.63						
17	5	20.60						
18	4	19.93						
19	5	22.14						
20	4	20.08						
21	4	22.63						
22	5	19.25						
23	5	19.78						
24	5	23.74						
25	4	19.69						
26	4	15.41						
27	4	21.40						
28	4	27.05						
29	4	20.75						
30	4	35.39						
31	4	30.54						
32	3	34.28						
33	4	34.88						
34	3	41.43						
35	4	37.73						
36	4	32.42						
37	4	36.19						
38	4	37.84						
39	3	37.01						
40	3	39.53						

PANDA Probe - Test Report

Site 21-1

Certificate Reference:

2091-PND-Site 21-1

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

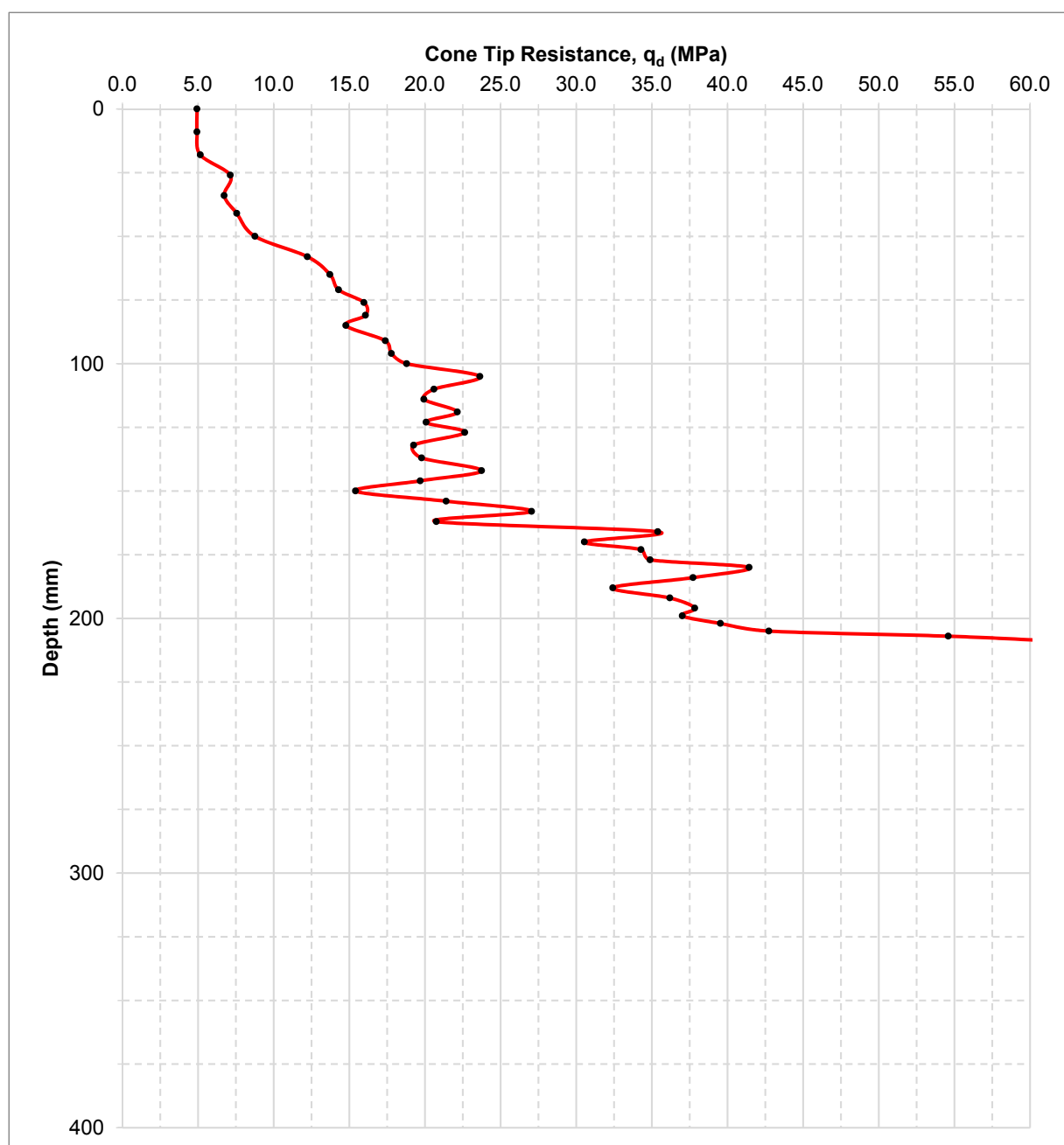
Project No.: 2091

Checked By: DWL

Location: Site 21-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-1A

Certificate Reference:

2091-PND-Site 21-1A

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	18	4.19	41	5	28.97			
2	10	4.91	42	4	32.68			
3	7	7.72	43	3	32.22			
4	8	10.09	44	3	23.97			
5	5	9.53	45	4	32.57			
6	6	7.50	46	3	29.39			
7	6	11.44	47	4	21.06			
8	5	12.52	48	3	28.04			
9	6	12.96	49	4	33.72			
10	8	12.30	50	4	29.29			
11	5	12.51	51	4	25.96			
12	6	12.95	52	4	24.62			
13	4	20.62	53	4	33.08			
14	2	47.19	54	3	27.64			
15	3	36.26	55	4	25.34			
16	2	47.67	56	2	27.01			
17	3	31.99	57	2	20.44			
18	4	27.15	58	3	27.99			
19	4	27.30	59	3	28.85			
20	3	24.69	60	2	30.94			
21	4	20.34	61	3	22.98			
22	6	19.06	62	4	22.89			
23	5	18.48	63	2	37.65			
24	6	20.93	64	2	26.57			
25	6	19.06	65	3	31.42			
26	6	19.41	66	3	28.11			
27	8	16.26	67	2	31.36			
28	7	18.29	68	3	33.84			
29	6	20.17	69	2	34.37			
30	7	17.24	70	1	41.09			
31	6	23.35	71	2	41.74			
32	5	26.48	72	2	30.43			
33	5	21.48	73	3	32.29			
34	6	20.76	End of Test Record					
35	5	28.63						
36	5	24.53						
37	6	22.08						
38	5	28.19						
39	5	28.89						
40	6	30.52						

PANDA Probe - Test Report

Site 21-1A

Certificate Reference:

2091-PND-Site 21-1A

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

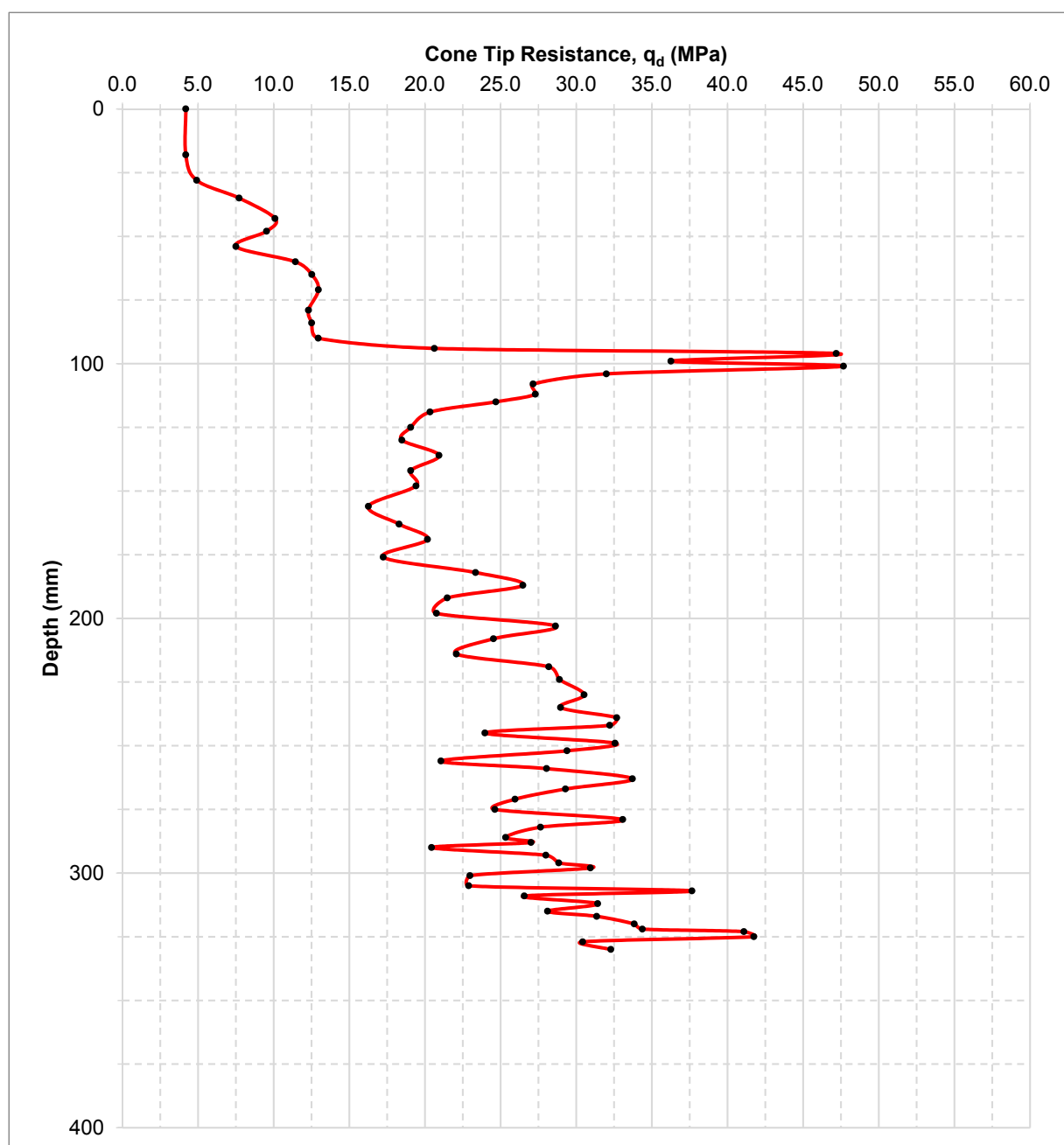
Project No.: 2091

Checked By: DWL

Location: Site 21-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-1 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 21-1-R

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	15	4.64	41	6	30.38			
2	14	4.53	42	3	45.12			
3	12	10.66	43	2	44.36			
4	14	7.41	44	3	56.58			
5	15	9.95	45	2	50.36			
6	10	12.61	46	2	58.55			
7	9	11.36	47	4	35.86			
8	7	13.60	48	2	30.11			
9	6	13.31	49	2	46.30			
10	7	12.71	End of Test Record					
11	9	14.25						
12	6	14.15						
13	7	13.54						
14	6	25.17						
15	8	19.99						
16	4	21.22						
17	7	20.23						
18	5	24.84						
19	5	25.80						
20	7	23.81						
21	5	26.45						
22	6	25.72						
23	5	25.91						
24	5	27.19						
25	7	24.94						
26	5	17.80						
27	6	27.27						
28	7	20.57						
29	4	30.46						
30	8	21.63						
31	6	19.53						
32	4	29.91						
33	6	25.48						
34	5	23.96						
35	3	35.23						
36	5	25.47						
37	2	32.31						
38	5	30.21						
39	5	28.45						
40	3	42.23						

PANDA Probe - Test Report

Site 21-1 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 21-1-R

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

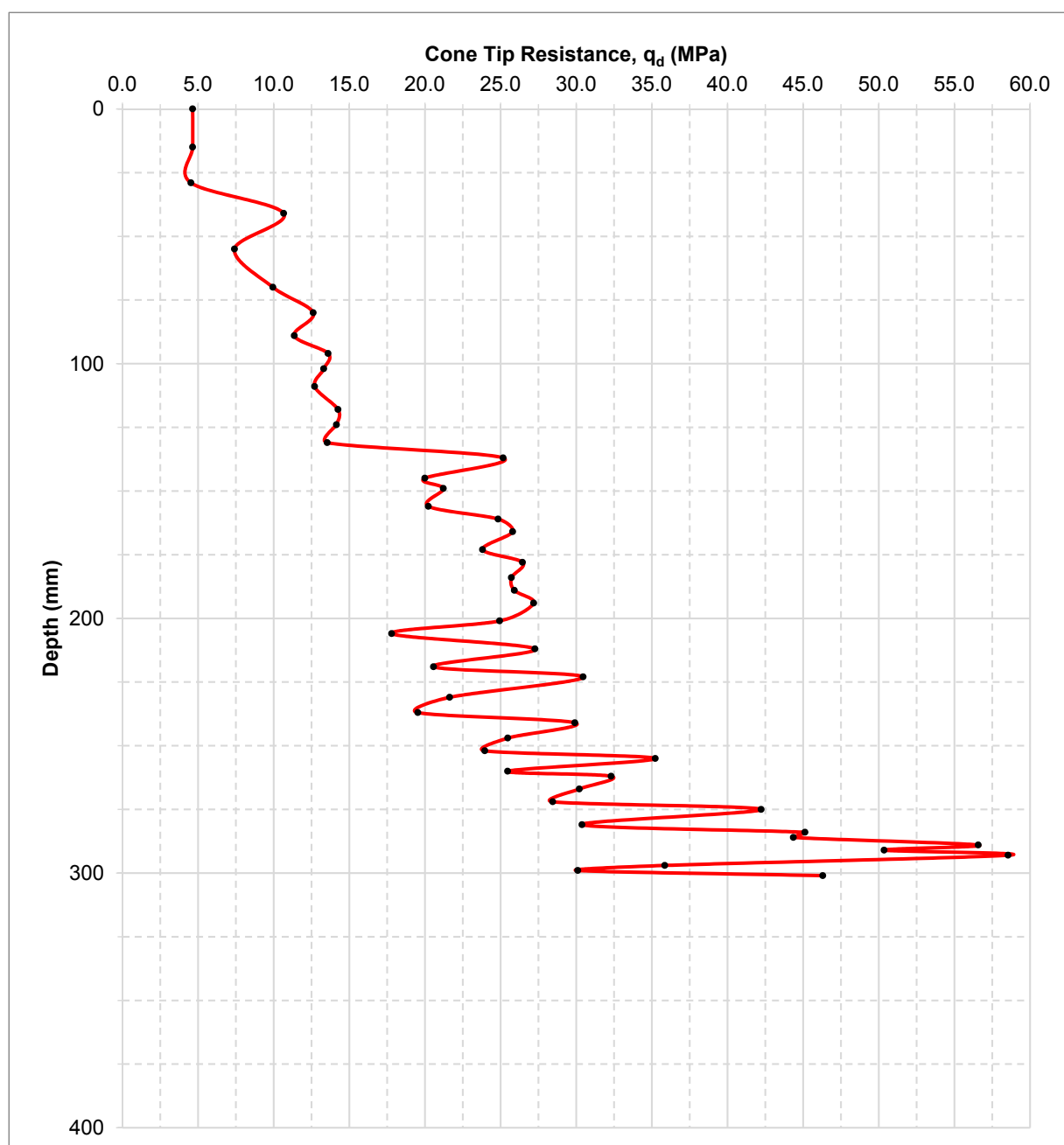
Project No.: 2091

Checked By: DWL

Location: Site 21-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-2

Certificate Reference:

2091-PND-Site 21-2

Sheet:

1 of 3

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	2.09	41	4	26.41	81	5	29.31
2	3	2.74	42	2	30.46	82	4	31.08
3	2	4.37	43	4	13.57	83	5	22.91
4	2	5.25	44	4	21.23	84	4	18.66
5	5	5.65	45	4	21.47	85	4	20.32
6	4	9.72	46	3	33.26	86	6	19.99
7	7	5.58	47	4	18.25	87	4	17.98
8	4	8.28	48	4	22.26	88	6	21.76
9	4	10.90	49	3	16.78	89	6	14.10
10	2	10.51	50	3	23.63	90	4	22.68
11	3	8.93	51	3	22.91	91	6	14.61
12	2	27.05	52	3	22.39	92	5	18.32
13	3	11.29	53	4	18.03	93	4	20.60
14	2	33.36	54	2	31.38	94	5	21.36
15	1	21.59	55	5	16.32	95	5	20.84
16	4	26.84	56	2	28.49	96	5	21.51
17	1	17.19	57	3	22.42	97	4	19.43
18	2	23.37	58	3	25.54	98	6	18.79
19	1	30.08	59	3	20.62	99	5	25.82
20	5	21.96	60	2	55.87	100	5	19.43
21	3	32.37	61	5	15.83	101	5	22.06
22	2	49.49	62	2	20.27	102	5	23.51
23	2	36.95	63	2	20.32	103	2	20.27
24	2	41.79	64	3	25.15	104	2	29.70
25	2	45.79	65	3	17.00	105	1	22.37
26	2	37.89	66	2	31.29	106	1	21.20
27	2	41.50	67	3	16.28	107	3	28.10
28	2	33.88	68	3	12.61	108	3	26.99
29	2	29.82	69	3	17.25	109	2	19.13
30	3	27.49	70	5	20.40	110	3	15.05
31	2	20.41	71	3	20.85	111	2	24.57
32	4	17.14	72	4	23.70	112	4	20.12
33	3	26.30	73	5	25.56	113	2	23.47
34	1	28.11	74	6	24.36	114	3	27.76
35	2	26.86	75	5	28.19	115	5	22.11
36	3	20.24	76	4	24.94	116	5	22.19
37	3	20.48	77	5	29.47	117	4	22.89
38	2	31.58	78	5	24.50	118	6	18.11
39	2	31.61	79	5	33.92	119	4	16.92
40	4	20.04	80	4	27.36	120	4	21.51

PANDA Probe - Test Report

Site 21-2

Certificate Reference:

2091-PND-Site 21-2

Sheet:

2 of 3

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	5	19.26	161	3	36.38			
122	5	18.19	162	6	30.44			
123	4	21.31	End of Test Record					
124	5	19.88						
125	5	19.77						
126	4	21.91						
127	6	20.41						
128	4	24.57						
129	4	25.82						
130	4	22.41						
131	4	23.92						
132	3	29.57						
133	2	31.38						
134	4	25.23						
135	3	30.38						
136	3	36.44						
137	3	20.88						
138	2	37.56						
139	4	23.35						
140	2	31.45						
141	3	31.32						
142	3	25.79						
143	3	26.66						
144	3	19.09						
145	4	31.06						
146	5	26.43						
147	5	27.45						
148	5	31.89						
149	6	33.02						
150	6	23.04						
151	5	23.26						
152	7	27.17						
153	6	28.73						
154	5	30.49						
155	6	29.80						
156	6	26.48						
157	6	24.42						
158	4	32.68						
159	6	30.81						
160	5	27.10						

PANDA Probe - Test Report

Site 21-2

Certificate Reference:

2091-PND-Site 21-2

Sheet:

3 of 3

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

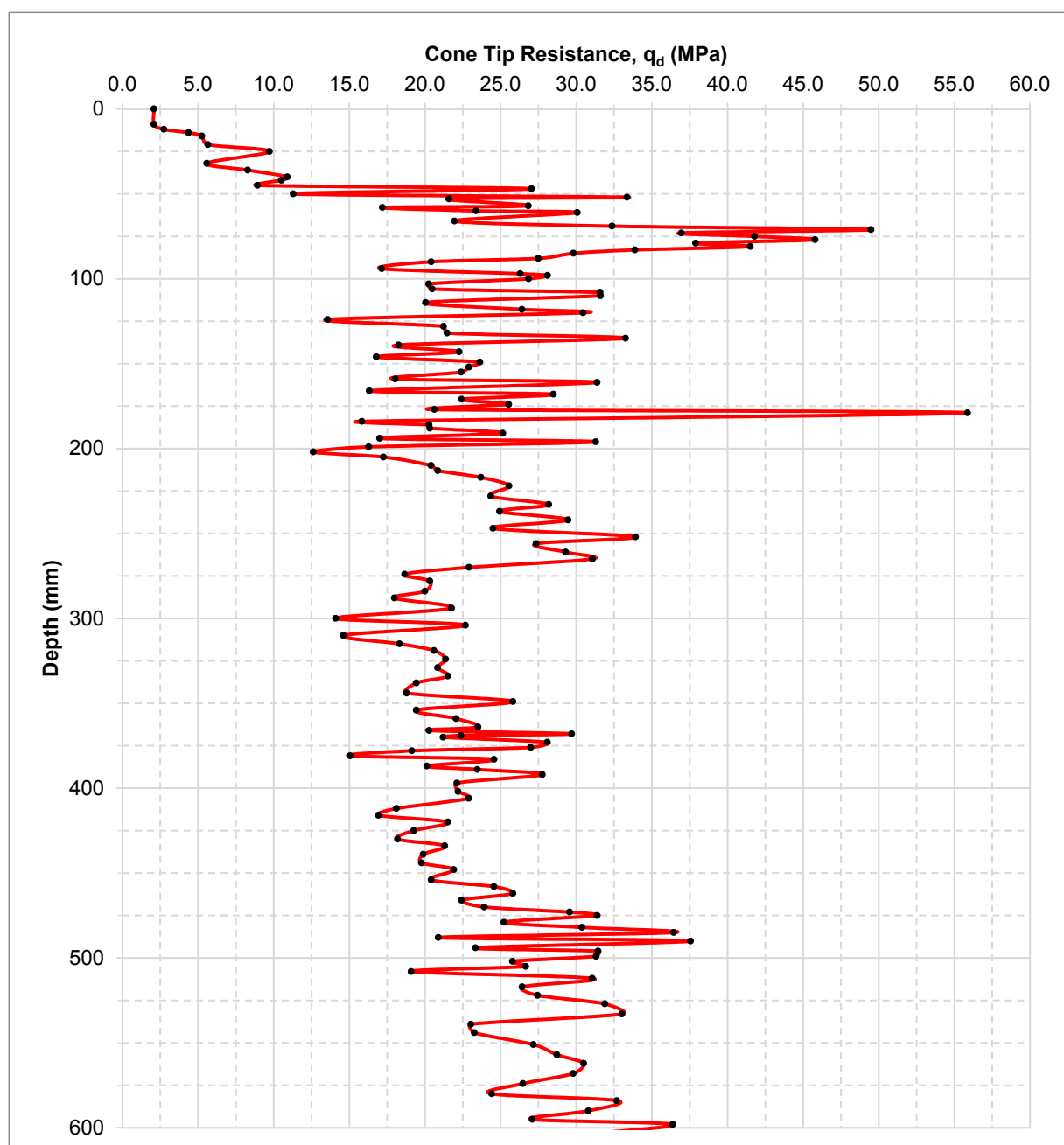
Project No.: 2091

Checked By: DWL

Location: Site 21-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 21-2 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 21-2-R

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

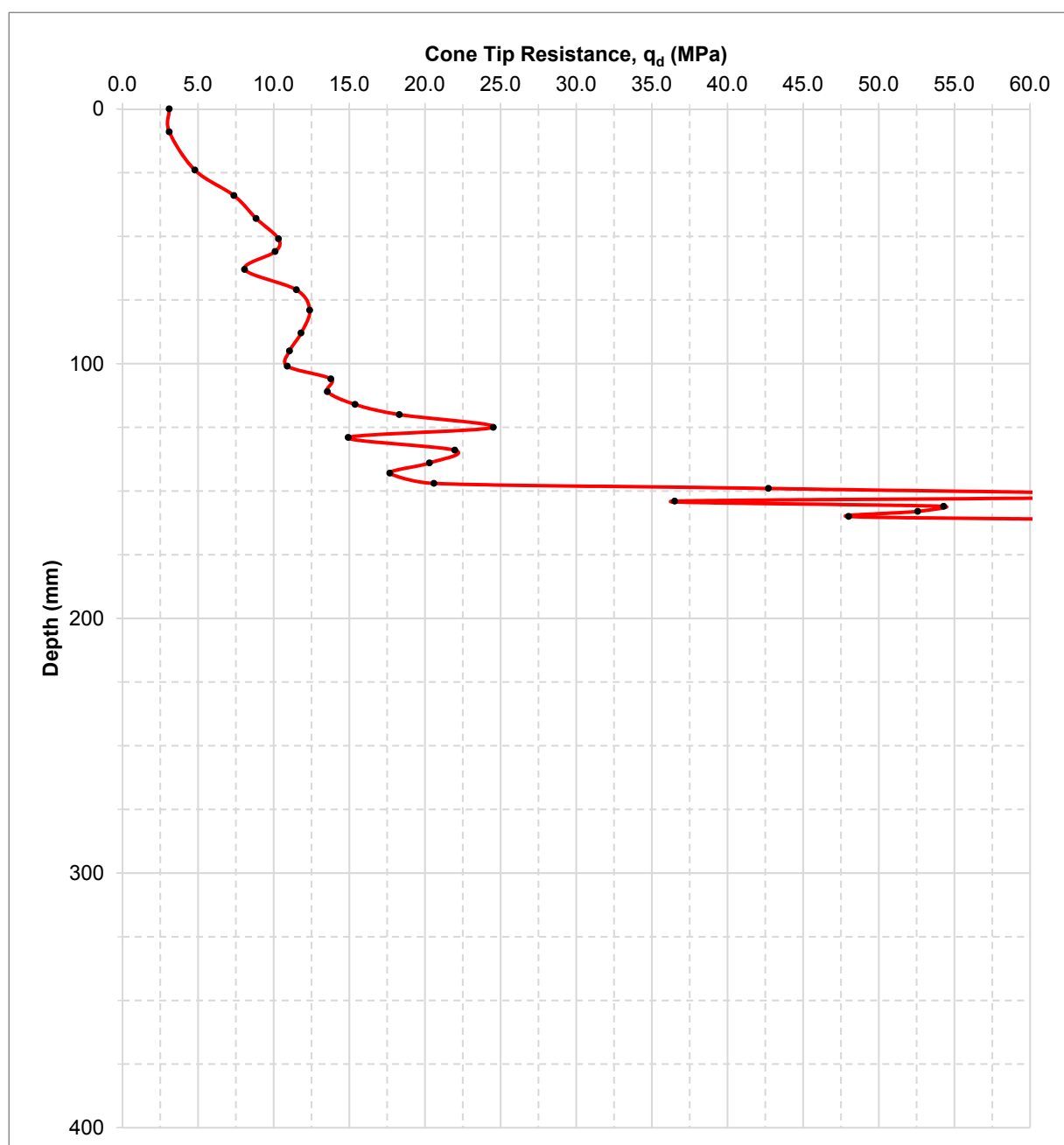
Project No.: 2091

Checked By: DWL

Location: Site 21-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-3

Certificate Reference:

2091-PND-Site 21-3

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	14	2.93	41	6	9.49	81	2	24.18
2	13	4.67	42	8	10.20	82	2	31.88
3	9	7.80	43	8	8.51	83	3	12.67
4	8	8.27	44	12	7.67	84	2	56.83
5	9	10.25	45	11	5.84	85	1	12.05
6	8	12.35	46	10	5.18	86	2	24.89
7	5	13.87	47	8	8.06	87	2	31.96
8	7	12.88	48	5	8.28	88	1	34.04
9	8	12.67	49	3	14.54	89	4	13.45
10	8	14.04	50	4	10.30	90	1	41.08
11	7	12.11	51	4	14.88	91	1	32.81
12	5	14.27	52	4	13.68	92	3	17.43
13	4	27.14	53	4	23.24	93	2	32.91
14	5	17.63	54	8	11.81	94	4	22.07
15	5	19.73	55	9	12.58	95	1	20.71
16	5	12.04	56	7	12.50	96	3	17.97
17	6	12.93	57	6	14.14	97	1	40.17
18	7	9.61	58	5	13.93	98	2	25.59
19	6	14.17	59	5	13.09	99	2	43.34
20	7	8.23	60	8	11.80	100	4	25.25
21	6	11.40	61	4	22.46	101	2	31.95
22	7	12.67	62	7	10.06	102	3	23.86
23	6	14.48	63	5	14.94	103	1	34.62
24	6	14.67	64	4	20.25	104	1	31.25
25	7	14.49	65	5	11.39	105	2	38.50
26	8	10.34	66	4	13.86	106	2	34.93
27	9	7.72	67	6	11.74	107	1	30.12
28	10	7.36	68	4	19.67	108	2	28.62
29	10	6.67	69	4	16.80	109	2	29.09
30	13	7.76	70	6	16.83	110	1	53.80
31	12	9.39	71	6	12.54	111	3	17.42
32	16	6.84	72	3	20.74	112	2	25.42
33	11	5.34	73	6	15.58	End of Test Record		
34	11	9.12	74	5	20.27			
35	10	5.39	75	6	18.59			
36	8	12.55	76	7	26.68			
37	5	14.16	77	1	31.99			
38	6	16.12	78	1	15.85			
39	3	12.44	79	3	21.68			
40	3	13.06	80	1	30.68			

Certificate Reference:

2091-PND-Site 21-3

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

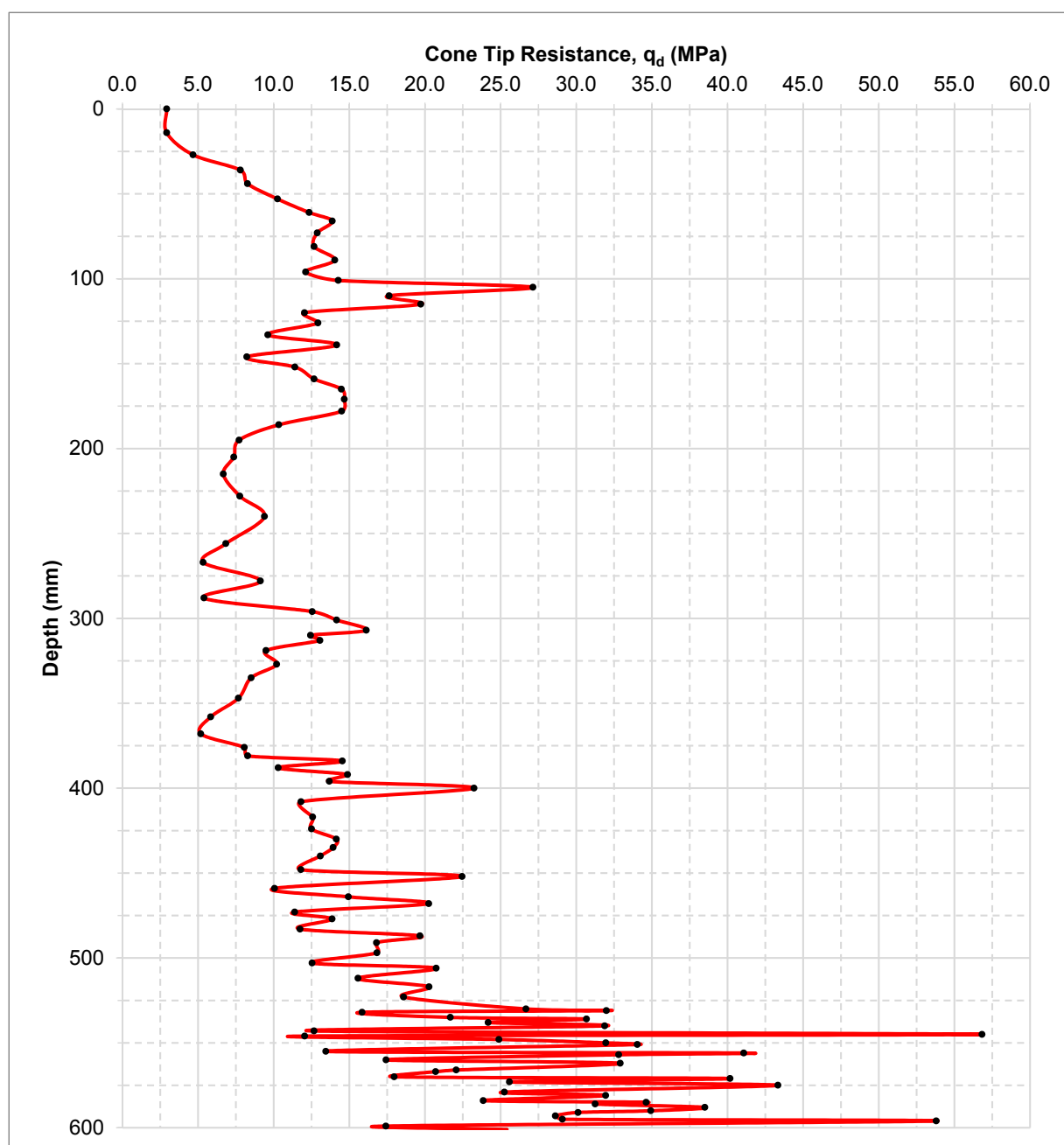
Project No.: 2091

Checked By: DWL

Location: Site 21-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-3 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 21-3-R

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	24	1.16	41	5	21.37			
2	7	3.26	42	6	10.07			
3	11	3.36	43	8	9.12			
4	6	4.17	44	3	31.95			
5	4	6.47	45	2	40.39			
6	5	6.65	46	1	60.10			
7	3	11.00	47	1	44.53			
8	2	7.92	48	2	40.27			
9	6	5.89	49	1	42.07			
10	4	7.11	End of Test Record					
11	6	7.01						
12	5	6.71						
13	6	7.61						
14	6	8.35						
15	7	8.16						
16	7	8.25						
17	6	9.69						
18	8	8.08						
19	7	12.38						
20	9	8.96						
21	8	9.61						
22	7	14.28						
23	6	14.20						
24	9	12.30						
25	8	13.49						
26	9	12.59						
27	6	13.27						
28	9	15.15						
29	9	9.39						
30	10	11.89						
31	10	12.08						
32	13	9.16						
33	8	11.87						
34	9	12.03						
35	6	12.58						
36	5	22.52						
37	6	14.65						
38	5	20.32						
39	4	19.54						
40	4	16.28						

PANDA Probe - Test Report

Site 21-3 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 21-3-R

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

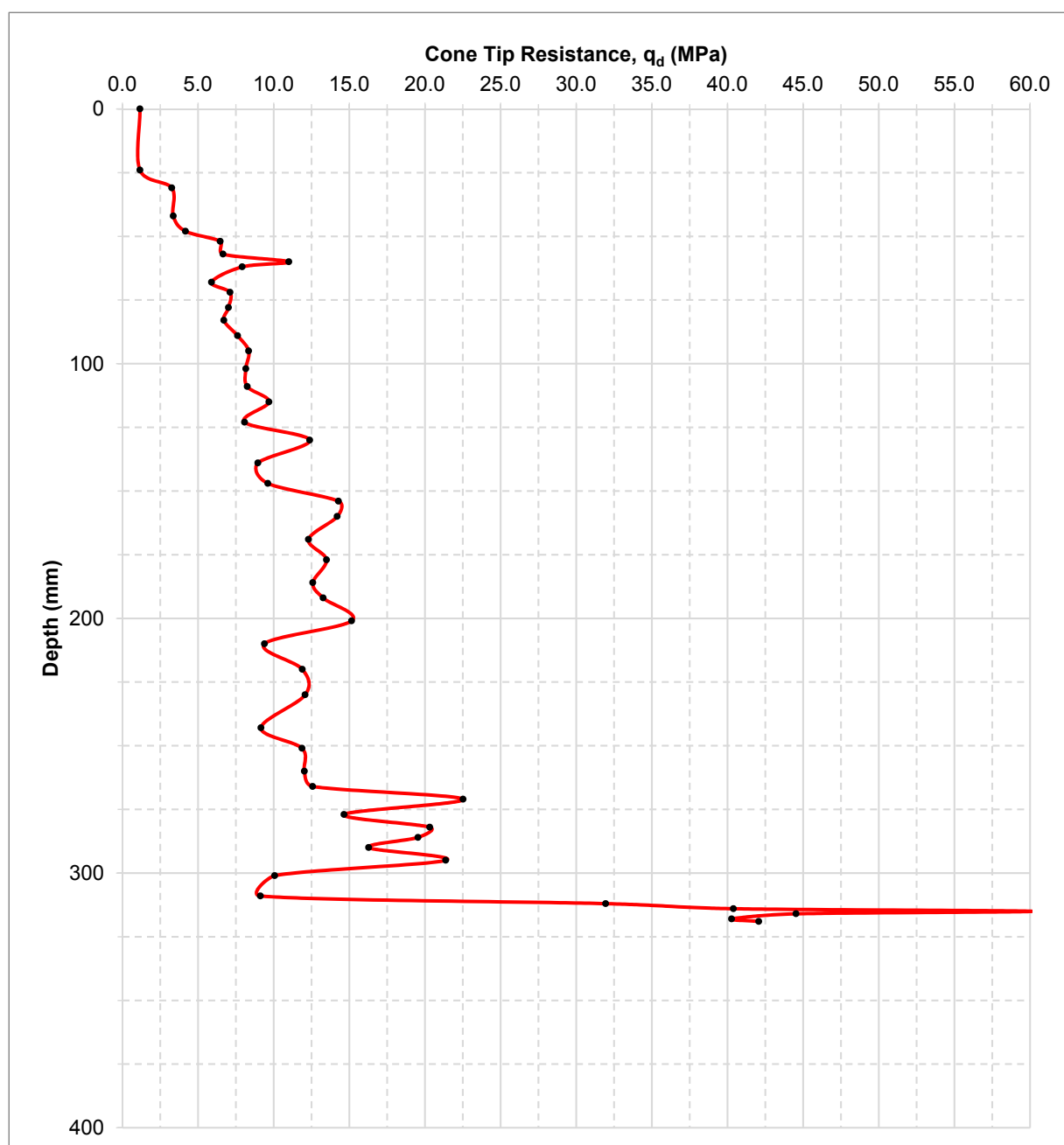
Project No.: 2091

Checked By: DWL

Location: Site 21-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-4

Certificate Reference:

2091-PND-Site 21-4

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	4.48	41	7	20.16			
2	9	4.76	42	7	20.62			
3	7	9.76	43	4	28.81			
4	5	7.74	44	3	46.91			
5	6	7.18	45	2	30.37			
6	2	12.38	46	3	41.27			
7	4	8.89	End of Test Record					
8	2	17.89						
9	2	6.66						
10	5	11.76						
11	6	11.64						
12	3	13.31						
13	3	17.07						
14	4	19.00						
15	5	21.77						
16	7	15.04						
17	4	15.91						
18	8	16.00						
19	9	17.83						
20	11	15.42						
21	9	13.00						
22	9	20.76						
23	6	13.52						
24	4	12.64						
25	5	11.98						
26	5	15.87						
27	6	15.85						
28	5	15.29						
29	6	17.09						
30	7	13.92						
31	6	14.70						
32	7	14.66						
33	8	12.18						
34	6	12.28						
35	8	11.73						
36	8	9.91						
37	9	12.62						
38	6	19.17						
39	6	17.49						
40	5	17.72						

PANDA Probe - Test Report

Site 21-4

Certificate Reference:

2091-PND-Site 21-4

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

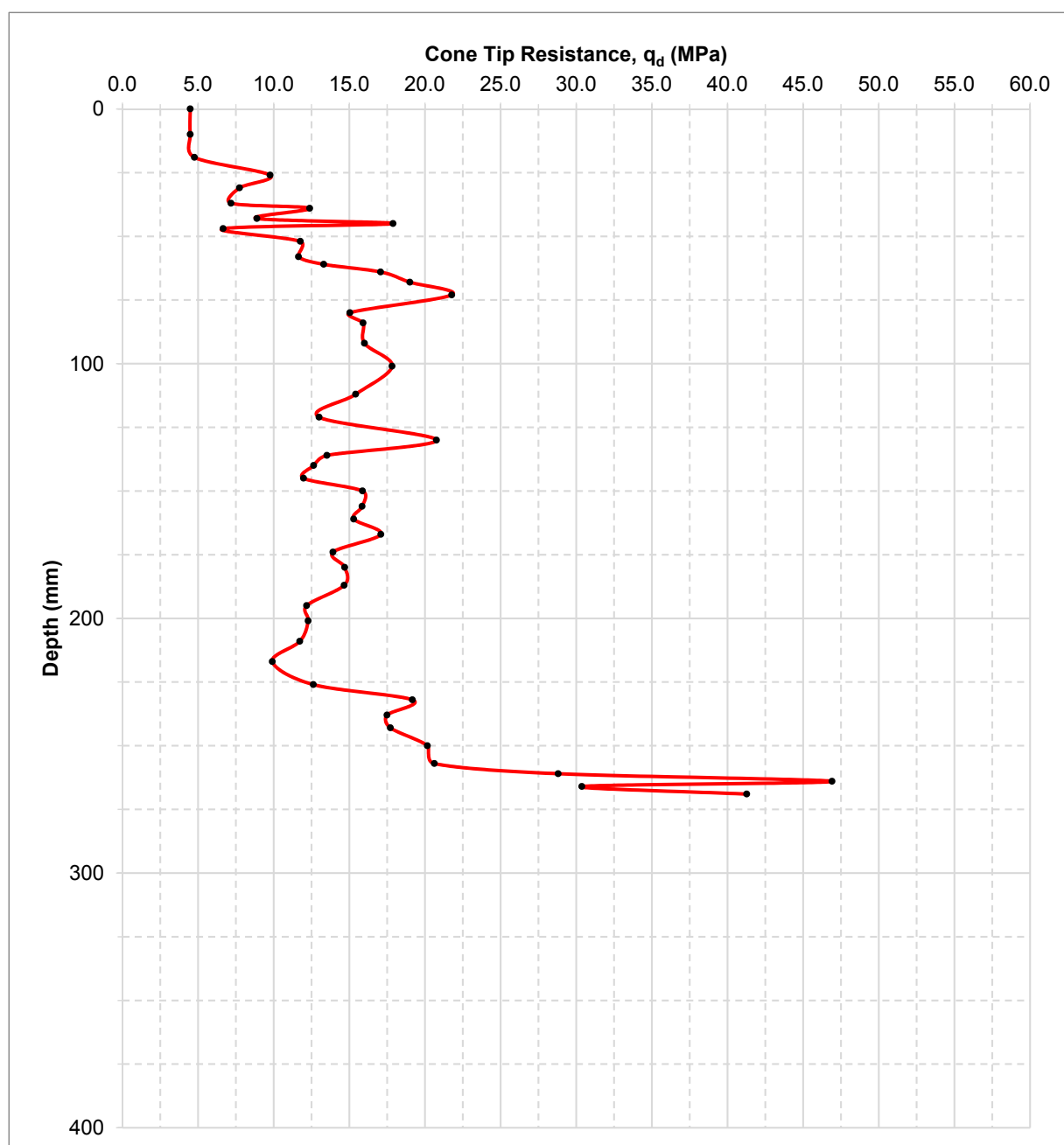
Project No.: 2091

Checked By: DWL

Location: Site 21-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-4A

Certificate Reference:

2091-PND-Site 21-4A

Sheet:

1 of 3

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	14	3.49	41	5	29.64	81	3	25.34
2	10	7.78	42	6	20.40	82	3	20.91
3	13	7.74	43	7	18.72	83	4	19.05
4	10	10.75	44	7	17.15	84	3	19.48
5	7	12.37	45	7	18.03	85	4	16.96
6	8	10.99	46	4	16.27	86	3	24.80
7	6	11.40	47	4	20.07	87	3	22.05
8	5	9.82	48	4	21.70	88	2	30.50
9	6	14.18	49	3	21.51	89	2	28.70
10	5	17.53	50	3	19.98	90	3	31.99
11	6	15.42	51	2	29.47	91	2	27.51
12	5	14.59	52	2	35.67	92	2	32.89
13	7	13.92	53	2	37.19	93	2	27.90
14	6	17.44	54	2	35.02	94	2	28.50
15	5	13.71	55	3	29.98	95	2	26.23
16	5	17.13	56	3	22.74	96	2	31.86
17	6	15.58	57	3	35.81	97	2	31.24
18	4	19.74	58	2	39.58	98	1	38.66
19	5	21.29	59	2	45.42	99	2	40.27
20	6	15.72	60	2	49.87	100	2	27.75
21	6	18.60	61	2	43.46	101	3	27.29
22	5	18.38	62	2	38.06	102	2	37.73
23	7	18.08	63	2	32.52	103	3	37.60
24	7	19.84	64	3	31.05	104	3	33.16
25	8	13.16	65	1	33.53	105	4	30.77
26	8	22.36	66	3	32.65	106	3	32.05
27	8	16.50	67	3	24.79	107	4	28.47
28	9	18.88	68	3	28.63	108	5	30.34
29	9	18.06	69	3	22.33	109	3	28.94
30	9	15.51	70	3	32.54	110	4	29.39
31	8	23.17	71	4	28.00	111	3	31.10
32	8	20.19	72	3	26.16	112	1	25.71
33	7	27.56	73	3	24.95	113	3	25.52
34	4	52.43	74	3	26.05	114	4	29.36
35	5	36.12	75	3	22.35	115	2	36.55
36	2	56.90	76	3	23.47	116	2	34.03
37	2	42.66	77	2	27.96	117	4	26.58
38	3	45.73	78	4	23.24	118	2	38.04
39	4	38.31	79	2	25.05	119	4	34.28
40	5	28.50	80	3	23.49	120	4	29.74

[illegible]

PANDA Probe - Test Report

Site 21-4A

Certificate Reference:

2091-PND-Site 21-4A

Sheet:

3 of 3

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

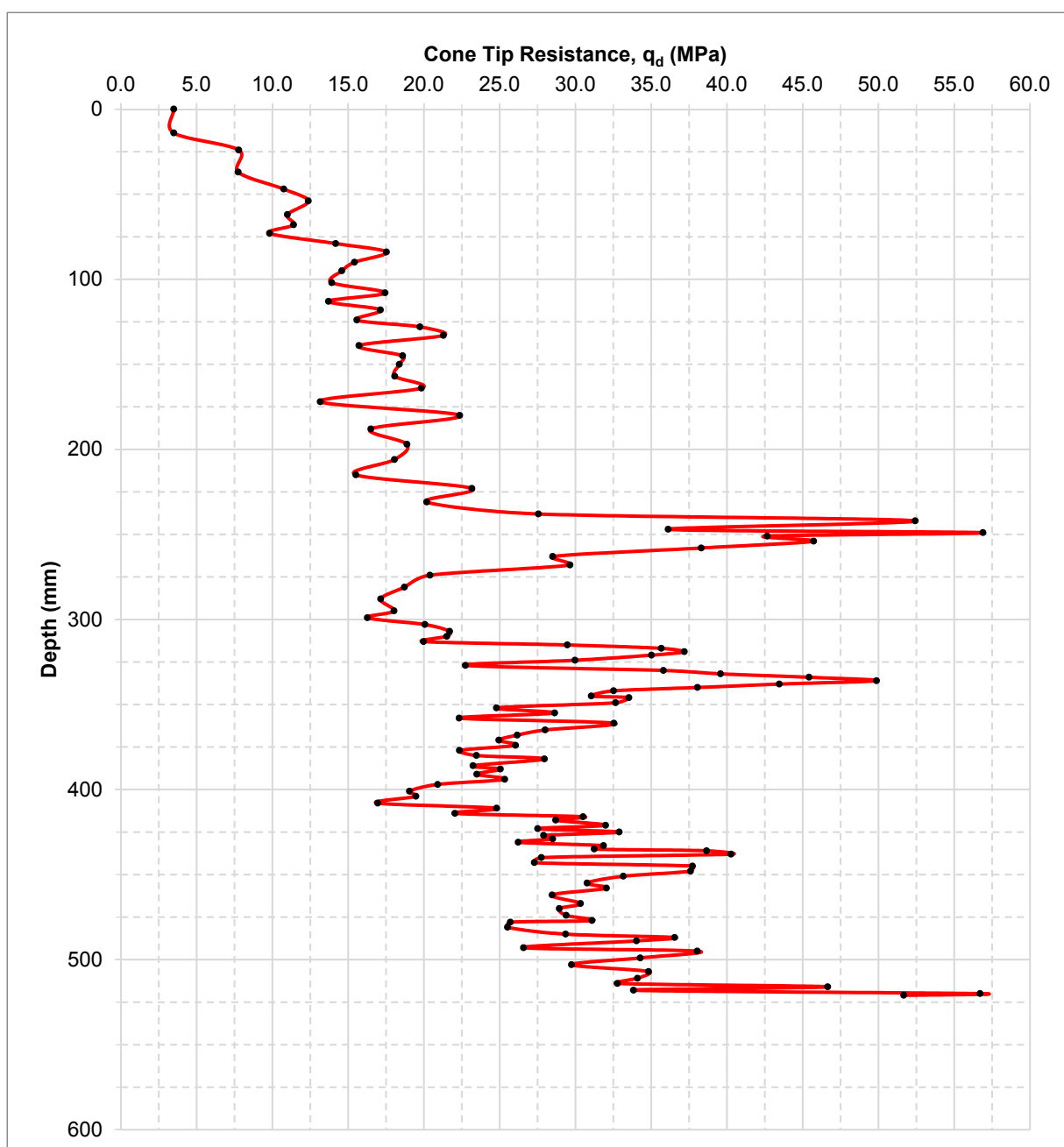
Project No.: 2091

Checked By: DWL

Location: Site 21-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-4 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 21-4-R

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	5.37	41	5	25.08			
2	7	7.42	42	7	21.65			
3	5	13.26	43	7	19.47			
4	6	13.24	44	7	17.58			
5	6	12.66	45	8	18.43			
6	5	9.29	46	8	20.31			
7	8	9.79	47	7	16.65			
8	6	12.36	48	8	15.80			
9	5	13.90	49	9	14.72			
10	7	12.05	50	7	11.61			
11	7	13.77	51	11	14.63			
12	7	14.26	52	8	12.82			
13	6	14.16	53	8	13.65			
14	8	14.11	54	4	21.56			
15	7	16.30	55	3	33.83			
16	7	18.47	56	3	52.90			
17	7	16.06	57	2	78.46			
18	6	15.71	58	1	92.70			
19	8	14.72	59	2	70.87			
20	7	14.91	End of Test Record					
21	8	13.26						
22	5	17.43						
23	9	15.87						
24	8	17.58						
25	6	22.00						
26	7	16.03						
27	6	22.36						
28	7	18.75						
29	6	21.94						
30	10	20.56						
31	9	21.65						
32	8	17.32						
33	7	15.39						
34	5	17.92						
35	5	18.07						
36	8	17.58						
37	5	23.56						
38	7	23.66						
39	9	19.37						
40	6	18.87						

PANDA Probe - Test Report

Site 21-4 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 21-4-R

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

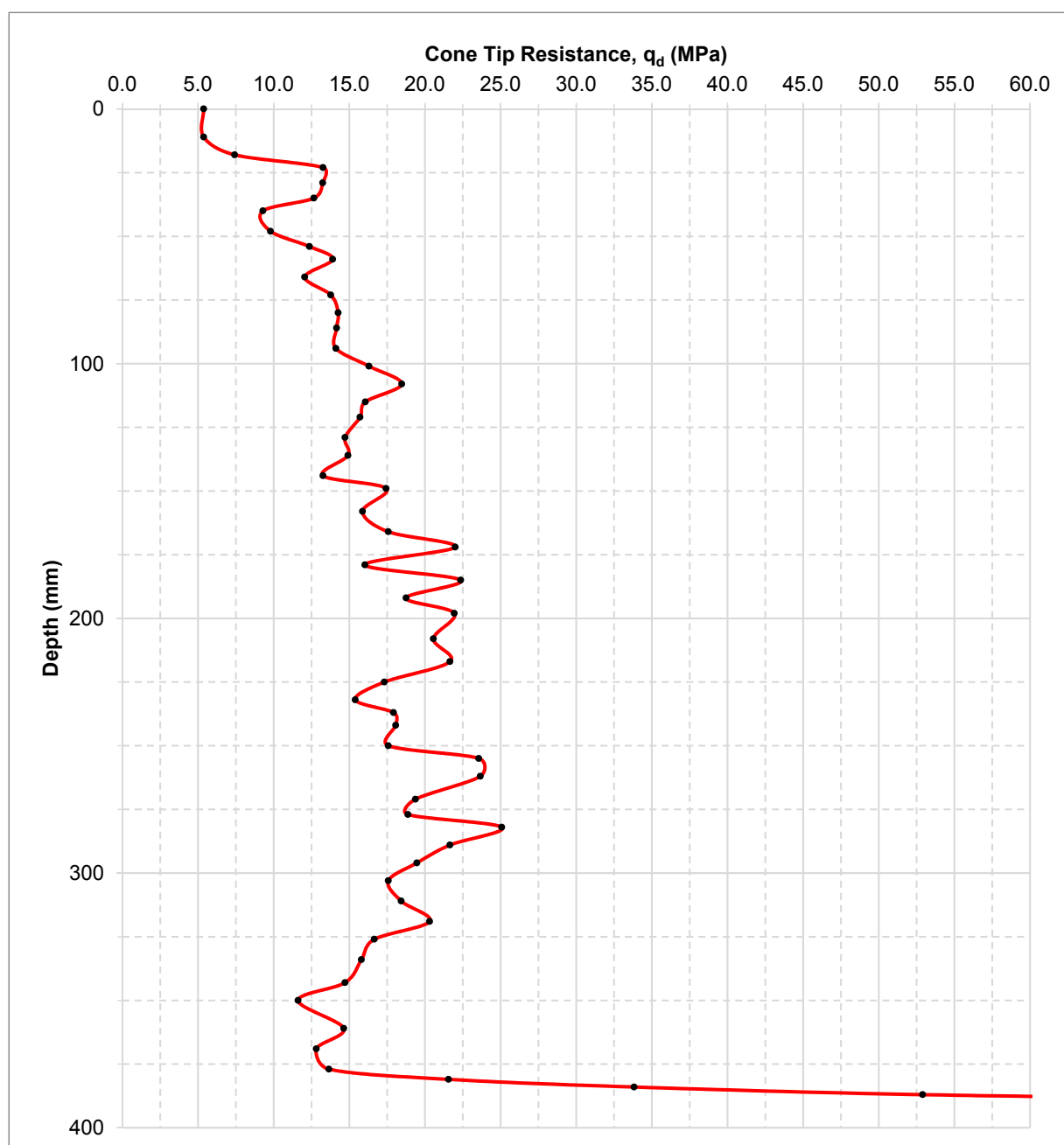
Project No.: 2091

Checked By: DWL

Location: Site 21-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-5

Certificate Reference:

2091-PND-Site 21-5

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	5.21	41	3	32.54	81	3	37.96
2	8	8.21	42	4	22.40	82	2	45.09
3	8	9.94	43	4	26.31	83	2	46.28
4	9	8.73	44	2	30.17	84	2	48.14
5	8	9.78	45	3	23.64	85	2	33.54
6	8	11.09	46	4	25.97	86	2	61.31
7	10	10.94	47	2	28.53	87	2	41.81
8	7	12.53	48	4	17.63	88	2	40.25
9	8	10.51	49	3	19.68	89	2	59.42
10	8	12.63	50	3	31.50	90	3	45.44
11	7	13.24	51	3	40.12	91	2	43.35
12	5	18.15	52	2	43.66	92	2	46.62
13	7	20.10	53	3	43.11	93	2	47.71
14	4	25.70	54	2	41.19	94	1	76.60
15	5	18.06	55	3	55.21	End of Test Record		
16	3	17.72	56	4	36.77			
17	5	18.76	57	3	35.50			
18	6	16.93	58	3	34.66			
19	3	32.54	59	2	33.69			
20	3	20.05	60	3	28.71			
21	3	24.49	61	3	33.38			
22	3	27.58	62	2	45.00			
23	4	24.73	63	3	34.45			
24	3	28.27	64	3	24.83			
25	4	28.56	65	3	32.62			
26	4	25.40	66	2	38.06			
27	3	38.67	67	4	47.99			
28	2	39.37	68	3	46.78			
29	2	33.06	69	4	27.41			
30	2	32.81	70	4	35.91			
31	2	29.54	71	4	47.50			
32	3	29.13	72	3	20.11			
33	4	22.56	73	4	20.56			
34	1	38.39	74	4	29.61			
35	2	31.00	75	3	39.93			
36	2	25.67	76	2	50.32			
37	1	36.50	77	3	35.01			
38	3	25.68	78	2	33.16			
39	3	25.36	79	2	22.24			
40	2	22.52	80	1	48.15			

PANDA Probe - Test Report

Site 21-5

Certificate Reference:

2091-PND-Site 21-5

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

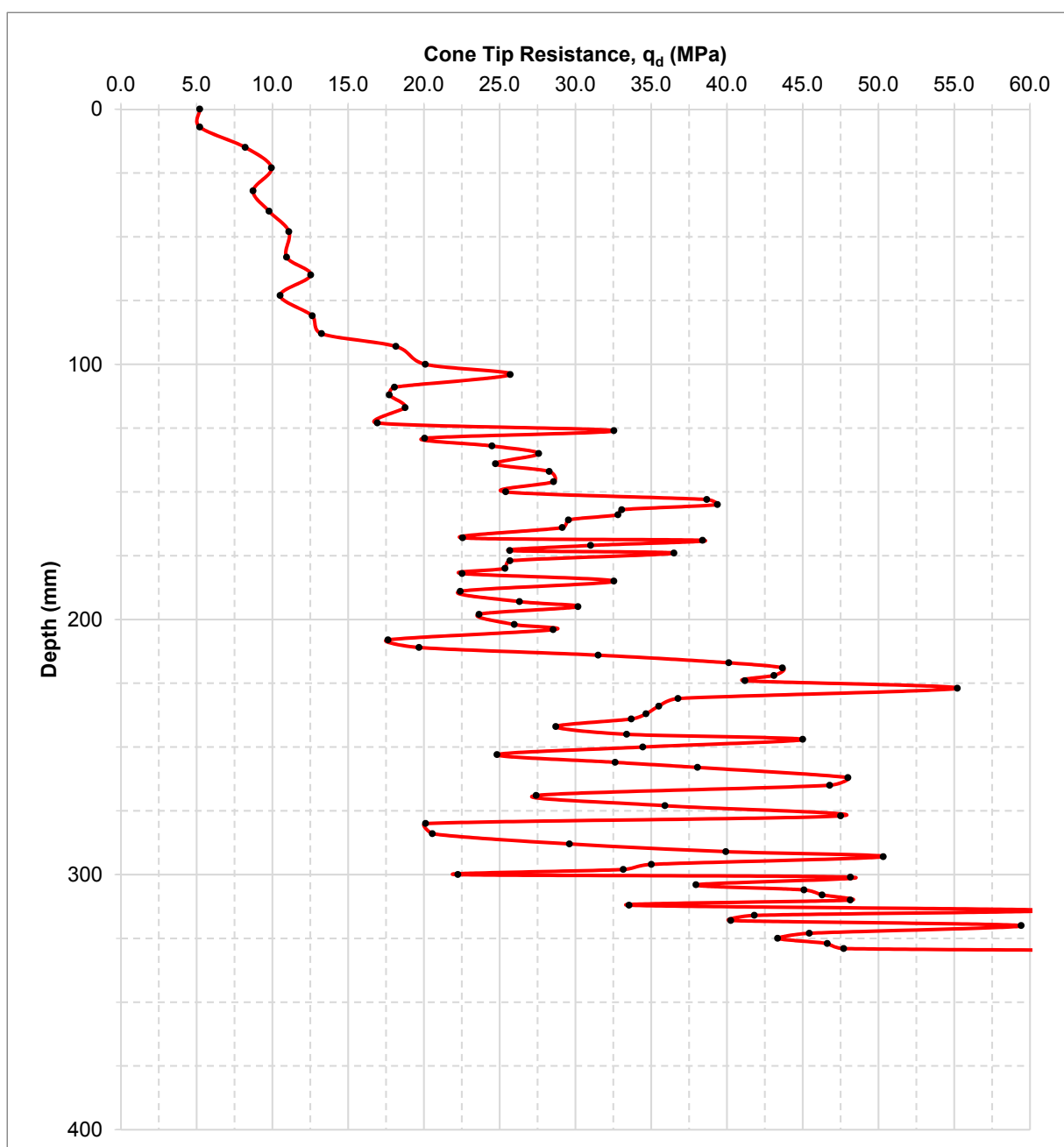
Project No.: 2091

Checked By: DWL

Location: Site 21-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-6

Certificate Reference:

2091-PND-Site 21-6

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	2.16	41	1	56.37	81	4	13.28
2	6	10.01	42	2	48.44	82	4	19.87
3	5	7.15	43	1	67.19	83	2	23.41
4	5	13.42	44	1	44.39	84	3	18.74
5	6	13.25	45	2	37.66	85	3	15.69
6	7	8.75	46	3	20.86	86	2	24.44
7	9	8.24	47	2	42.90	87	3	19.60
8	9	10.10	48	1	47.15	88	3	26.30
9	8	11.98	49	3	23.24	89	2	26.04
10	9	10.40	50	2	37.65	90	3	22.36
11	9	9.00	51	2	76.59	91	3	16.72
12	7	14.99	52	4	14.67	92	3	22.71
13	5	12.65	53	2	32.76	93	3	27.40
14	4	15.45	54	2	27.56	94	2	35.78
15	7	11.47	55	2	27.36	95	2	34.62
16	4	17.42	56	3	28.25	96	3	34.38
17	3	27.77	57	2	30.35	97	2	28.15
18	4	28.79	58	3	22.66	98	3	29.17
19	4	13.46	59	2	21.10	99	2	33.56
20	3	21.23	60	2	25.49	100	2	30.68
21	3	31.62	61	2	37.09	101	1	44.77
22	4	22.01	62	6	17.41	102	2	24.57
23	3	30.50	63	2	36.92	103	2	31.21
24	3	25.12	64	4	21.50	104	3	33.56
25	2	39.99	65	2	29.14	105	2	32.13
26	4	24.02	66	2	19.88	106	1	41.25
27	1	13.09	67	2	22.36	107	3	33.85
28	1	25.57	68	1	17.25	108	2	38.21
29	1	35.09	69	3	22.22	109	2	22.79
30	2	19.96	70	4	19.58	110	1	47.84
31	2	28.37	71	2	27.30	111	2	36.98
32	1	30.09	72	4	14.15	112	1	40.78
33	2	22.98	73	1	23.23	113	2	35.73
34	4	25.84	74	3	21.31	114	2	34.84
35	1	81.56	75	3	19.40	115	2	36.30
36	2	30.15	76	4	21.16	116	1	50.85
37	2	51.06	77	2	29.64	117	2	28.99
38	2	45.19	78	3	23.98	118	2	40.90
39	2	47.58	79	2	8.36	119	2	44.10
40	3	21.23	80	2	22.64	End of Test Record		

PANDA Probe - Test Report

Site 21-6

Certificate Reference:

2091-PND-Site 21-6

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

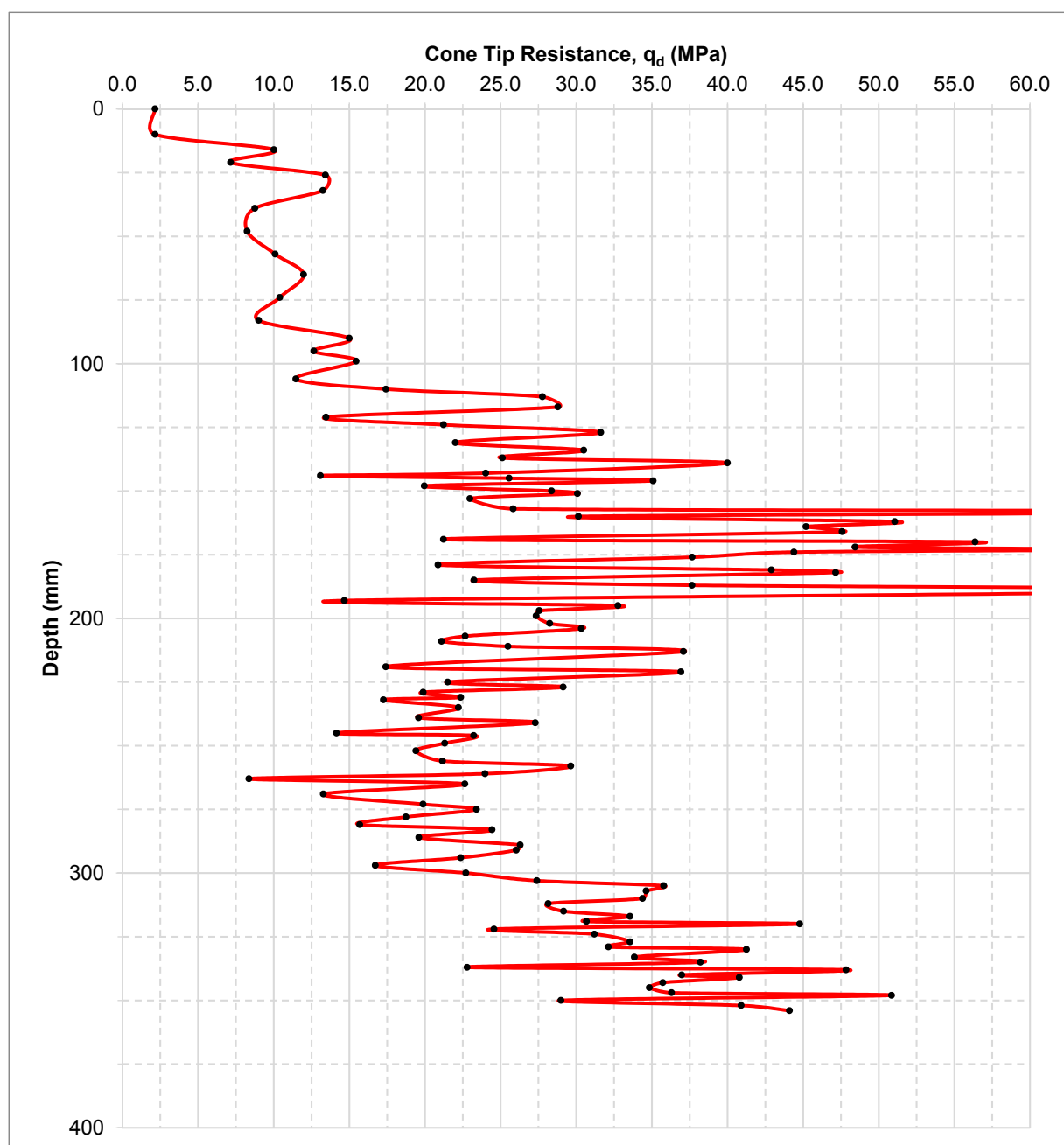
Project No.: 2091

Checked By: DWL

Location: Site 21-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 21-7

Certificate Reference:

2091-PND-Site 21-7

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

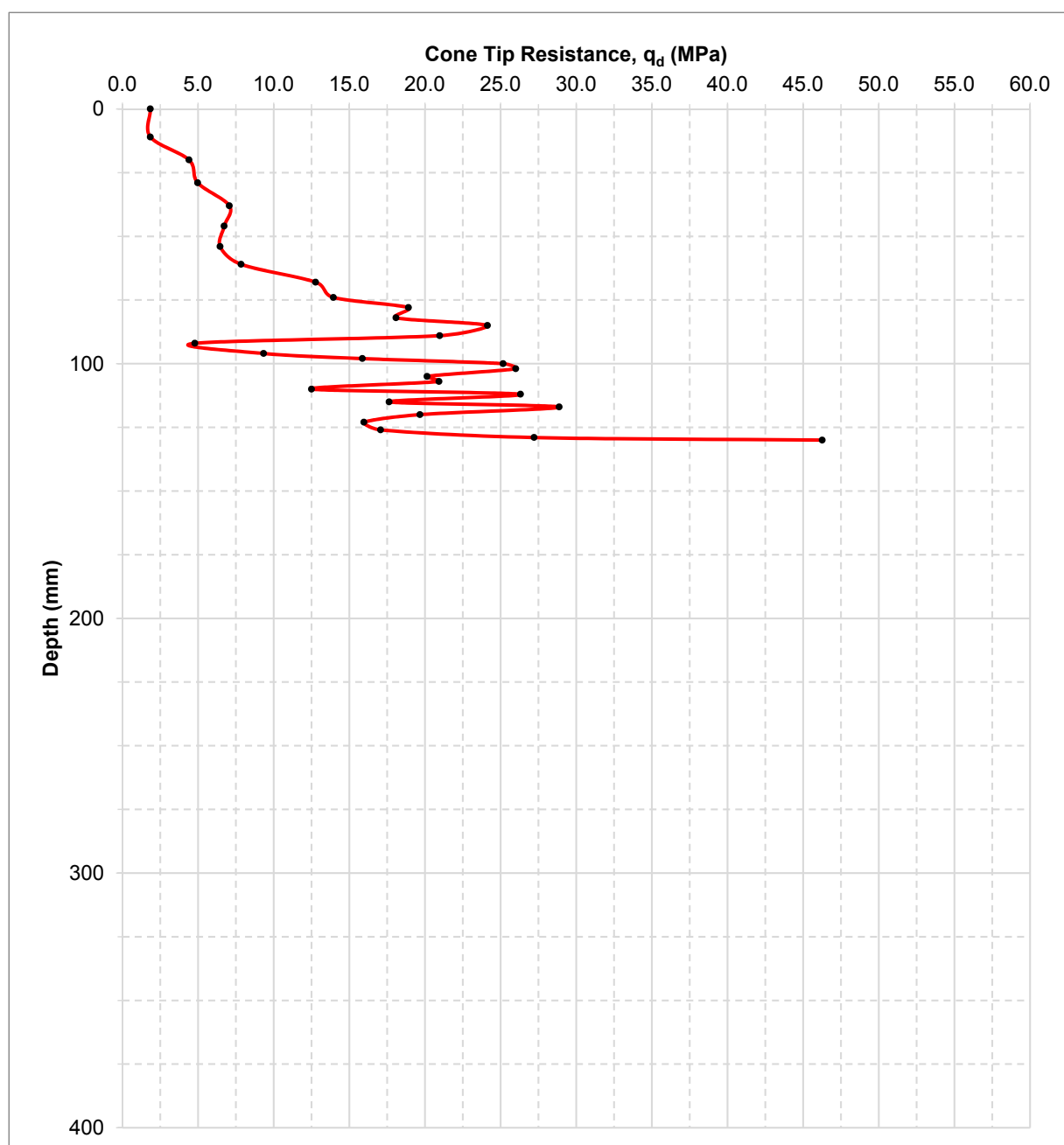
Project No.: 2091

Checked By: DWL

Location: Site 21-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-7A

Certificate Reference:

2091-PND-Site 21-7A

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	4.07	41	1	57.85			
2	9	4.72	42	2	46.38			
3	13	5.39	43	4	38.19			
4	8	7.14	44	3	29.72			
5	7	8.77	45	3	32.35			
6	6	7.83	46	2	45.23			
7	4	12.59	47	2	44.85			
8	5	12.42	48	2	59.49			
9	6	10.92	49	2	27.08			
10	6	12.96	50	1	59.47			
11	6	14.47	51	2	38.00			
12	5	12.31	52	1	42.49			
13	4	20.35	53	2	45.70			
14	5	18.43	54	2	35.36			
15	5	15.55	55	1	48.88			
16	5	20.58	End of Test Record					
17	4	22.93						
18	4	27.86						
19	4	24.02						
20	3	33.31						
21	5	12.17						
22	2	28.98						
23	2	29.97						
24	2	30.02						
25	2	33.40						
26	3	36.72						
27	3	35.12						
28	2	27.48						
29	2	39.90						
30	2	33.68						
31	3	40.00						
32	3	26.07						
33	1	42.60						
34	3	36.87						
35	4	30.21						
36	3	36.01						
37	3	42.43						
38	2	48.00						
39	2	59.78						
40	2	48.82						

PANDA Probe - Test Report

Site 21-7A

Certificate Reference:

2091-PND-Site 21-7A

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

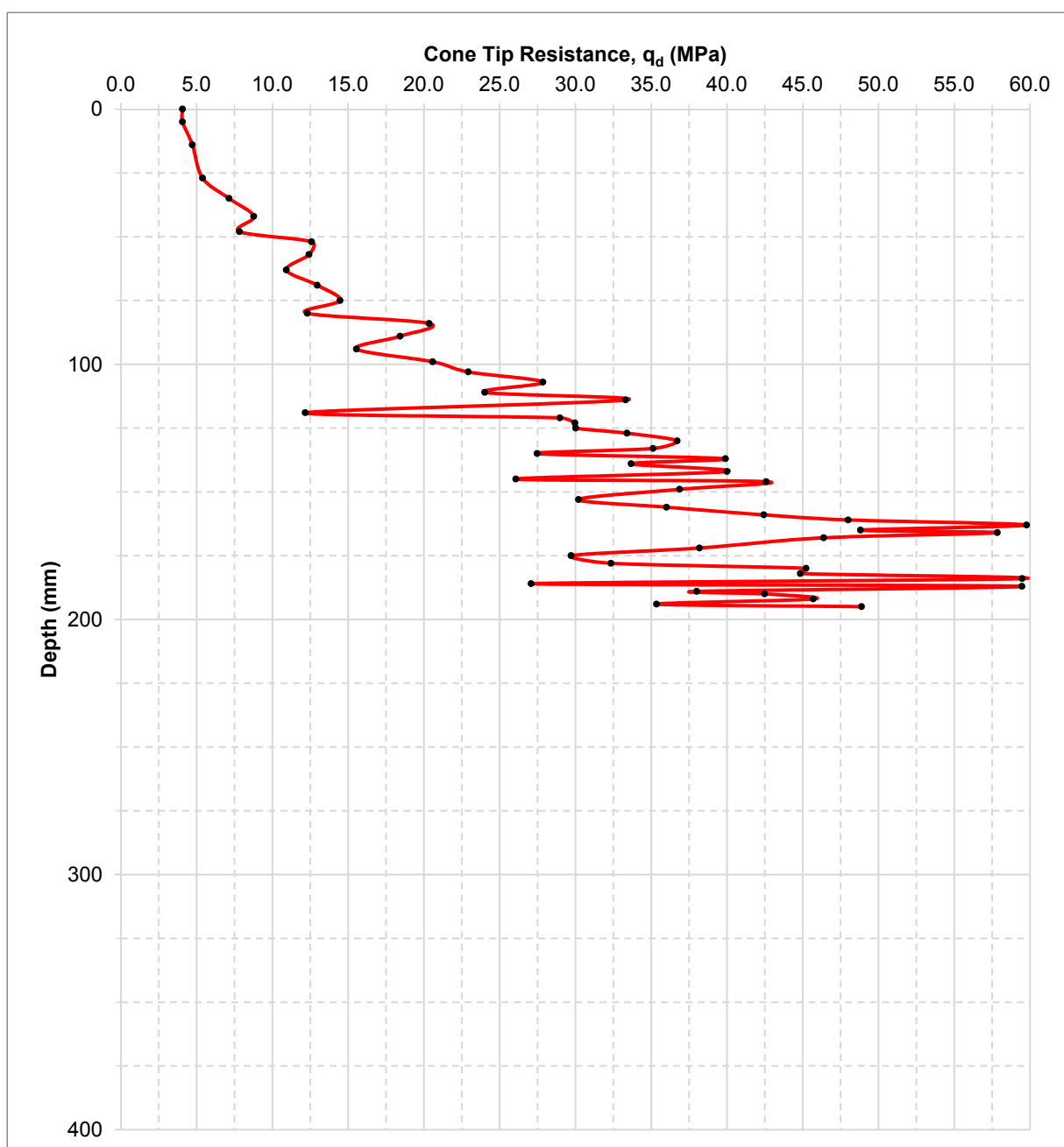
Project No.: 2091

Checked By: DWL

Location: Site 21-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-8

Certificate Reference:

2091-PND-Site 21-8

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	4.95	41	3	21.08			
2	4	9.14	42	3	15.33			
3	6	9.56	43	3	16.69			
4	6	10.75	44	4	20.66			
5	5	9.46	45	3	28.29			
6	5	7.16	46	4	16.34			
7	6	9.69	47	4	24.85			
8	5	9.61	48	5	21.78			
9	5	9.66	49	3	27.18			
10	5	10.45	50	5	21.55			
11	5	15.45	51	4	21.01			
12	5	10.95	52	4	19.74			
13	5	13.42	53	3	19.62			
14	5	17.58	54	3	28.19			
15	4	16.53	55	3	22.63			
16	5	14.20	56	2	21.47			
17	5	16.05	57	3	23.88			
18	4	15.17	58	4	23.03			
19	4	14.50	59	4	23.38			
20	4	19.09	60	3	26.03			
21	5	15.03	61	3	30.54			
22	5	17.75	62	3	14.19			
23	4	16.92	63	1	27.96			
24	5	14.21	64	3	25.24			
25	4	15.38	65	2	26.59			
26	5	19.61	66	3	23.35			
27	5	13.41	67	2	36.52			
28	4	16.63	68	2	56.73			
29	4	16.32	69	2	29.51			
30	3	19.16	70	2	39.42			
31	4	19.30	End of Test Record					
32	3	21.45						
33	4	19.12						
34	2	22.12						
35	5	12.31						
36	2	23.58						
37	5	18.39						
38	4	22.55						
39	3	20.20						
40	2	14.85						

PANDA Probe - Test Report

Site 21-8

Certificate Reference:

2091-PND-Site 21-8

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

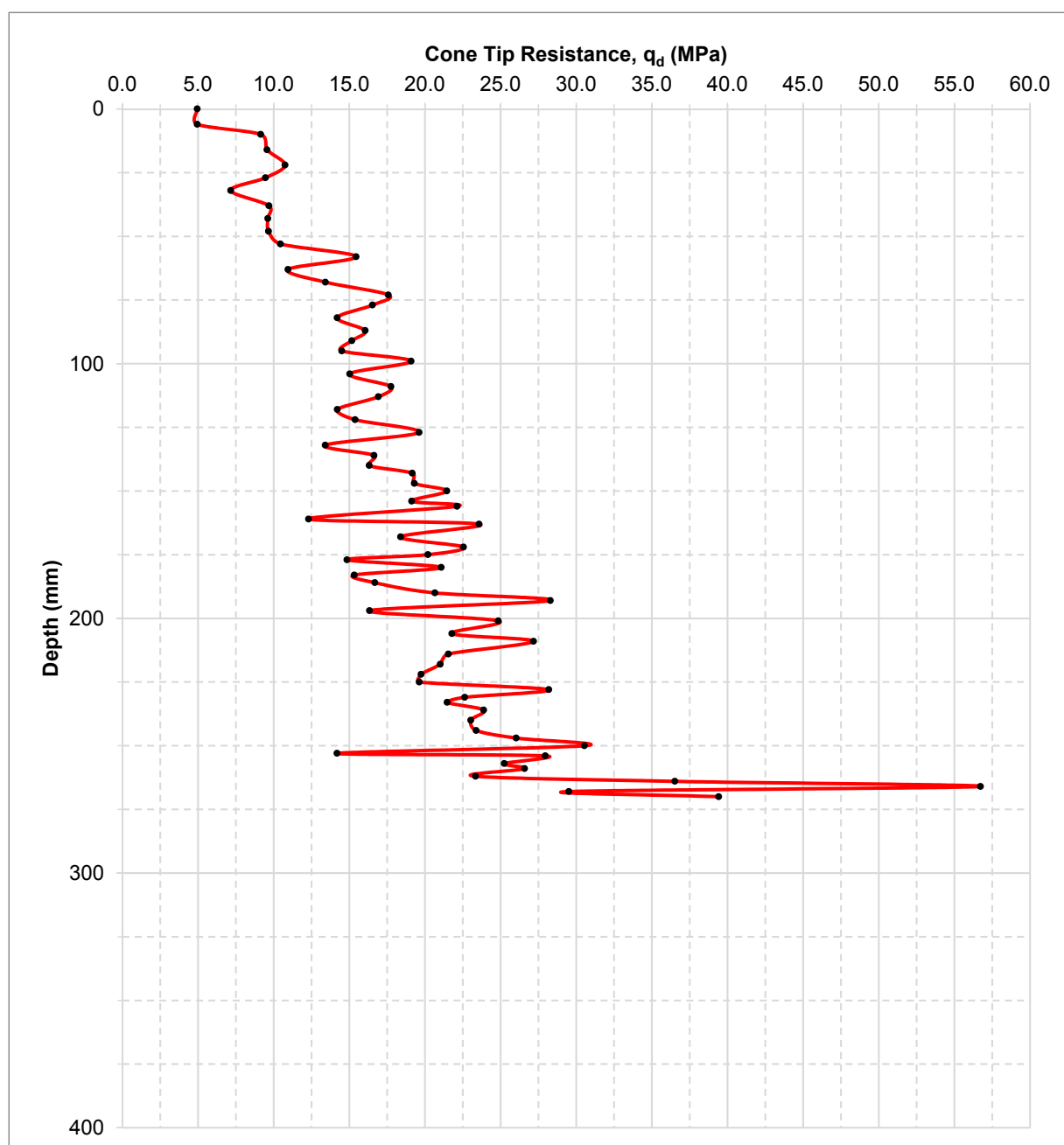
Project No.: 2091

Checked By: DWL

Location: Site 21-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-8A

Certificate Reference:

2091-PND-Site 21-8A

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	1.78	41	4	18.64			
2	4	3.91	42	2	17.65			
3	5	4.70	43	4	21.79			
4	5	6.53	44	5	26.76			
5	6	7.06	45	5	22.91			
6	6	5.45	46	5	22.57			
7	6	6.71	47	4	25.71			
8	4	8.19	48	5	24.80			
9	4	9.32	49	4	28.92			
10	6	9.62	50	3	29.16			
11	5	9.20	51	3	25.98			
12	5	10.28	52	4	25.43			
13	4	11.80	53	3	21.05			
14	3	13.20	54	3	24.63			
15	2	14.89	55	3	27.42			
16	3	19.85	56	4	27.97			
17	3	16.14	57	4	36.01			
18	3	22.48	58	3	25.51			
19	2	19.03	59	2	24.38			
20	1	20.93	60	3	25.30			
21	3	13.59	61	3	29.02			
22	3	15.99	62	2	34.29			
23	2	19.99	63	2	35.44			
24	3	17.13	64	3	38.59			
25	2	17.53	65	2	35.36			
26	4	17.83	66	2	40.22			
27	3	15.62	67	3	41.44			
28	2	14.73	68	2	39.34			
29	1	18.98	69	2	46.08			
30	3	17.83	70	3	32.17			
31	2	19.92	71	2	39.15			
32	6	15.85	72	1	55.76			
33	4	16.34	73	2	45.10			
34	4	19.90	74	2	50.02			
35	5	16.44	75	1	51.16			
36	5	16.11	End of Test Record					
37	4	17.27						
38	3	17.60						
39	4	18.32						
40	4	18.72						

PANDA Probe - Test Report

Site 21-8A

Certificate Reference:

2091-PND-Site 21-8A

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

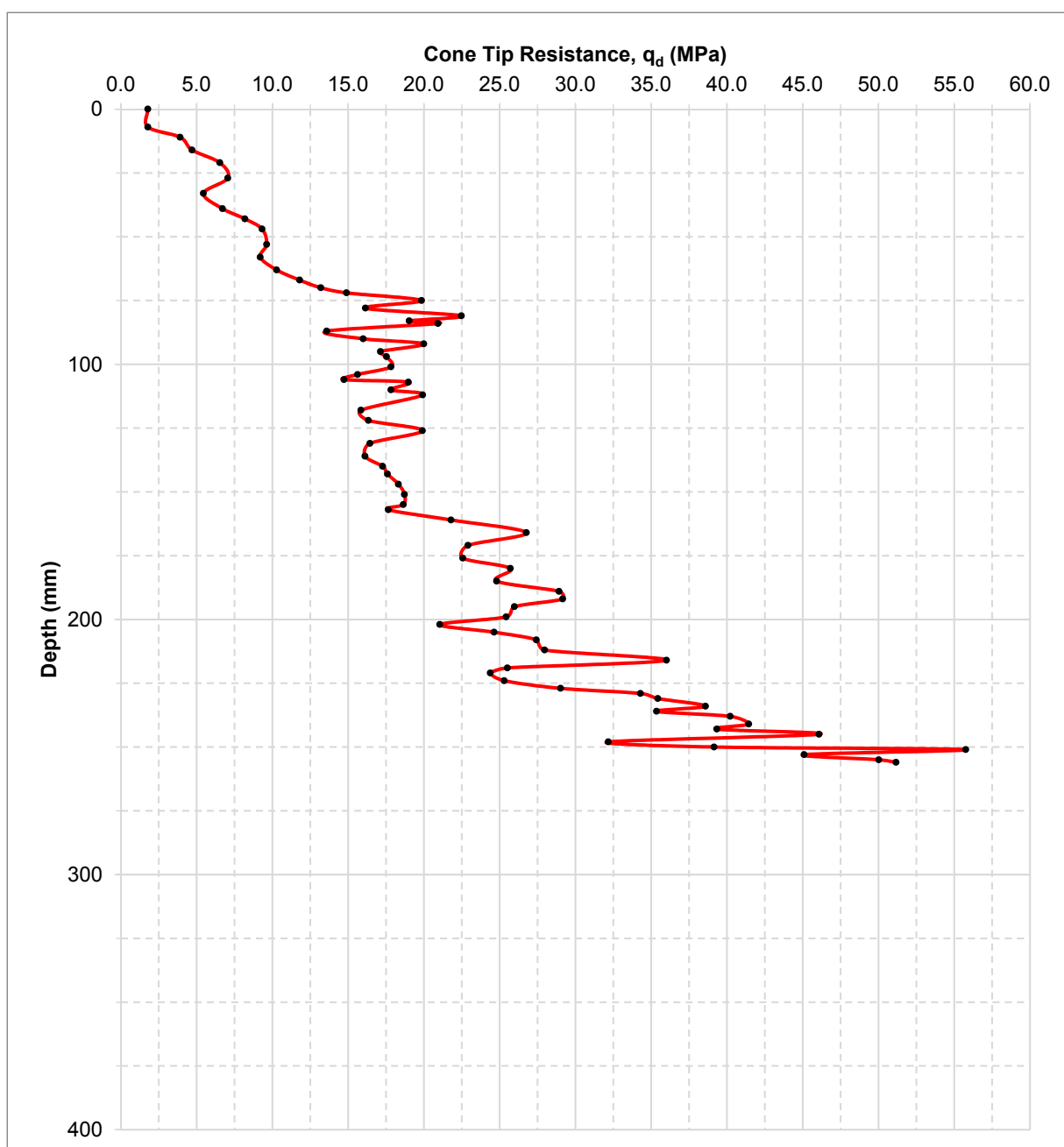
Project No.: 2091

Checked By: DWL

Location: Site 21-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 21-9

Certificate Reference:

2091-PND-Site 21-9

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

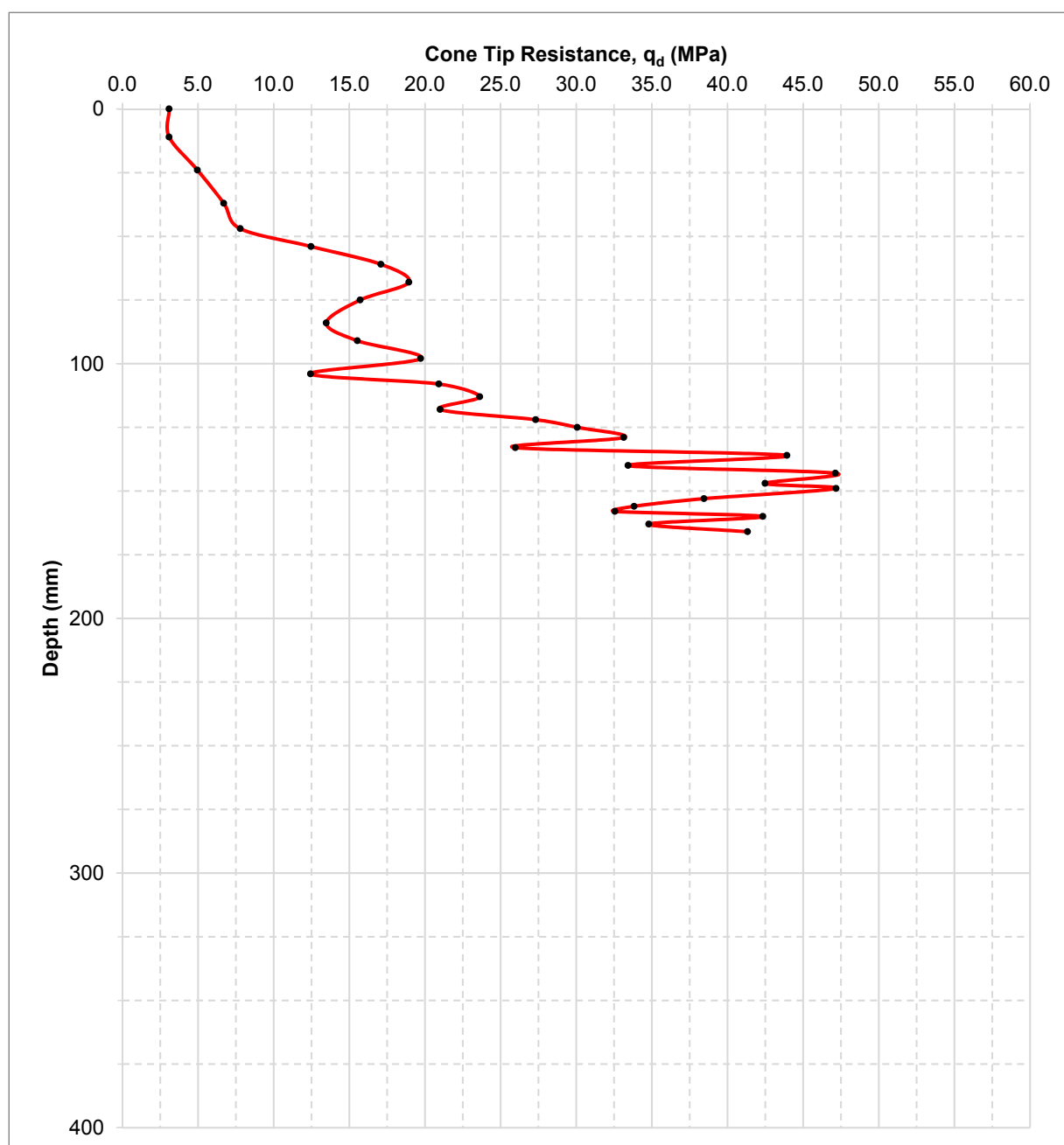
Project No.: 2091

Checked By: DWL

Location: Site 21-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-9A

Certificate Reference:

2091-PND-Site 21-9A

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	4.24	41	5	20.95			
2	13	6.09	42	5	22.53			
3	9	8.12	43	5	23.38			
4	8	7.21	44	6	19.54			
5	8	10.06	45	4	20.20			
6	7	10.41	46	5	25.85			
7	8	13.00	47	4	27.99			
8	6	14.07	48	5	19.00			
9	6	17.75	49	5	27.45			
10	6	13.93	50	3	37.62			
11	7	14.41	51	5	20.72			
12	7	20.71	52	3	34.05			
13	5	15.64	53	2	52.94			
14	6	16.41	54	4	36.48			
15	6	16.31	55	3	54.01			
16	5	13.84	56	3	38.37			
17	6	14.87	57	2	43.63			
18	5	15.52	58	2	36.74			
19	5	16.88	59	3	29.12			
20	5	17.22	60	3	30.62			
21	6	13.14	61	2	42.11			
22	3	12.86	62	3	30.86			
23	4	10.17	63	1	50.34			
24	3	17.81	64	3	28.38			
25	3	17.67	65	2	51.67			
26	4	19.97	66	2	29.40			
27	6	14.12	67	2	41.86			
28	4	21.61	68	3	32.96			
29	6	17.13	69	2	37.72			
30	5	19.36	70	2	27.56			
31	6	14.32	71	3	30.05			
32	5	19.37	72	3	30.41			
33	7	18.13	73	3	33.15			
34	7	16.83	74	2	34.82			
35	6	18.60	End of Test Record					
36	5	16.81						
37	6	10.55						
38	4	13.60						
39	5	20.88						
40	6	18.86						

PANDA Probe - Test Report

Site 21-9A

Certificate Reference:

2091-PND-Site 21-9A

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

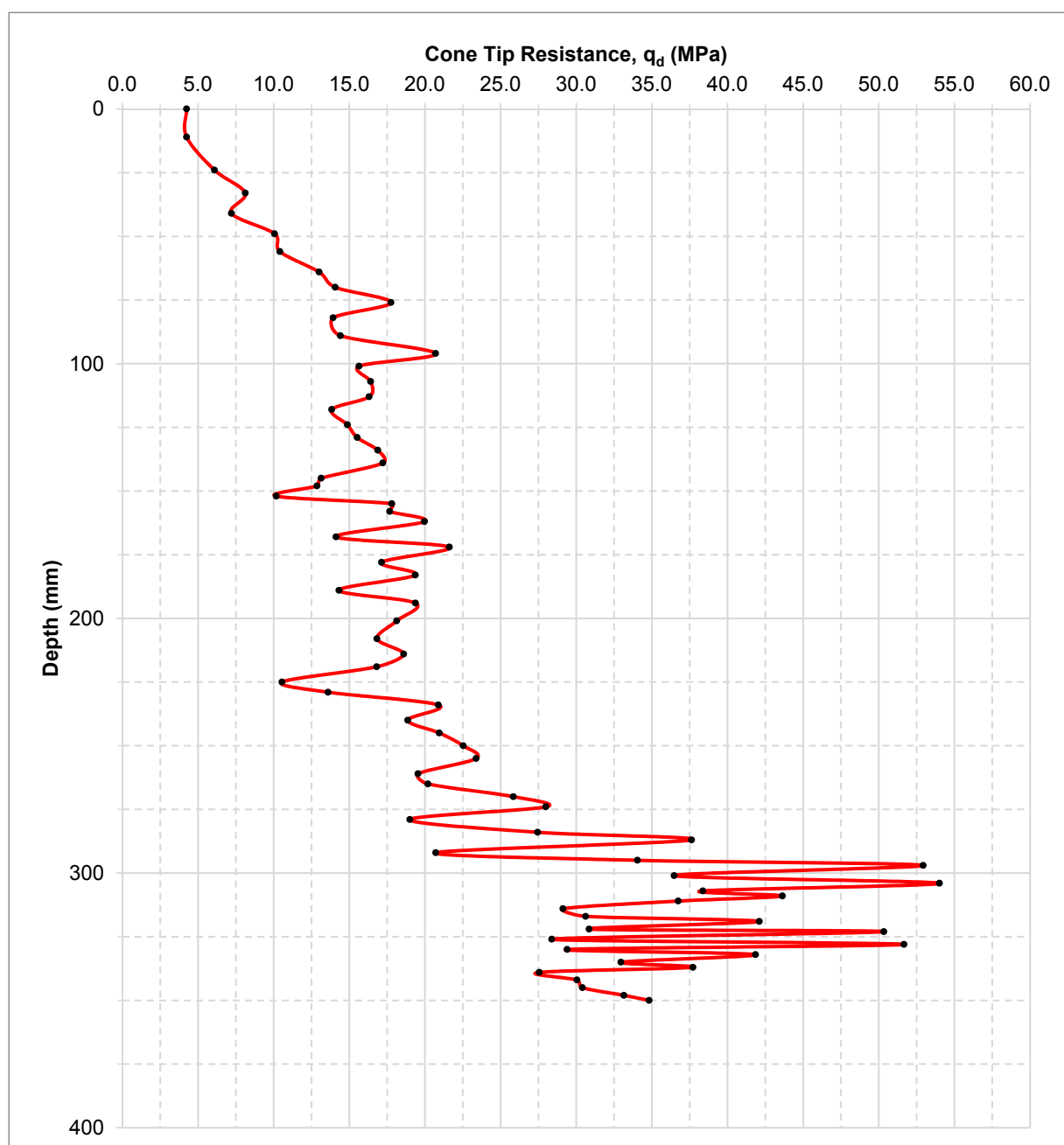
Project No.: 2091

Checked By: DWL

Location: Site 21-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-10

Certificate Reference:

2091-PND-Site 21-10

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	3.01						
2	9	3.92						
3	9	5.08						
4	11	6.71						
5	12	7.84						
6	12	9.72						
7	9	8.51						
8	6	11.93						
9	7	15.73						
10	6	18.61						
11	6	17.36						
12	6	13.34						
13	5	17.67						
14	7	15.17						
15	6	20.06						
16	6	13.96						
17	6	20.74						
18	6	19.46						
19	8	13.25						
20	5	16.22						
21	3	18.15						
22	4	19.56						
23	5	12.53						
24	5	19.18						
25	4	19.45						
26	3	19.52						
27	3	23.94						
28	4	28.73						
29	3	37.16						
30	2	48.03						
31	2	53.68						
32	1	65.39						
33	2	41.24						
34	3	35.45						
35	2	36.65						
36	2	37.47						
37	2	47.69						
38	1	47.89						
39	1	70.81						
End of Test Record								

PANDA Probe - Test Report

Site 21-10

Certificate Reference:

2091-PND-Site 21-10

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

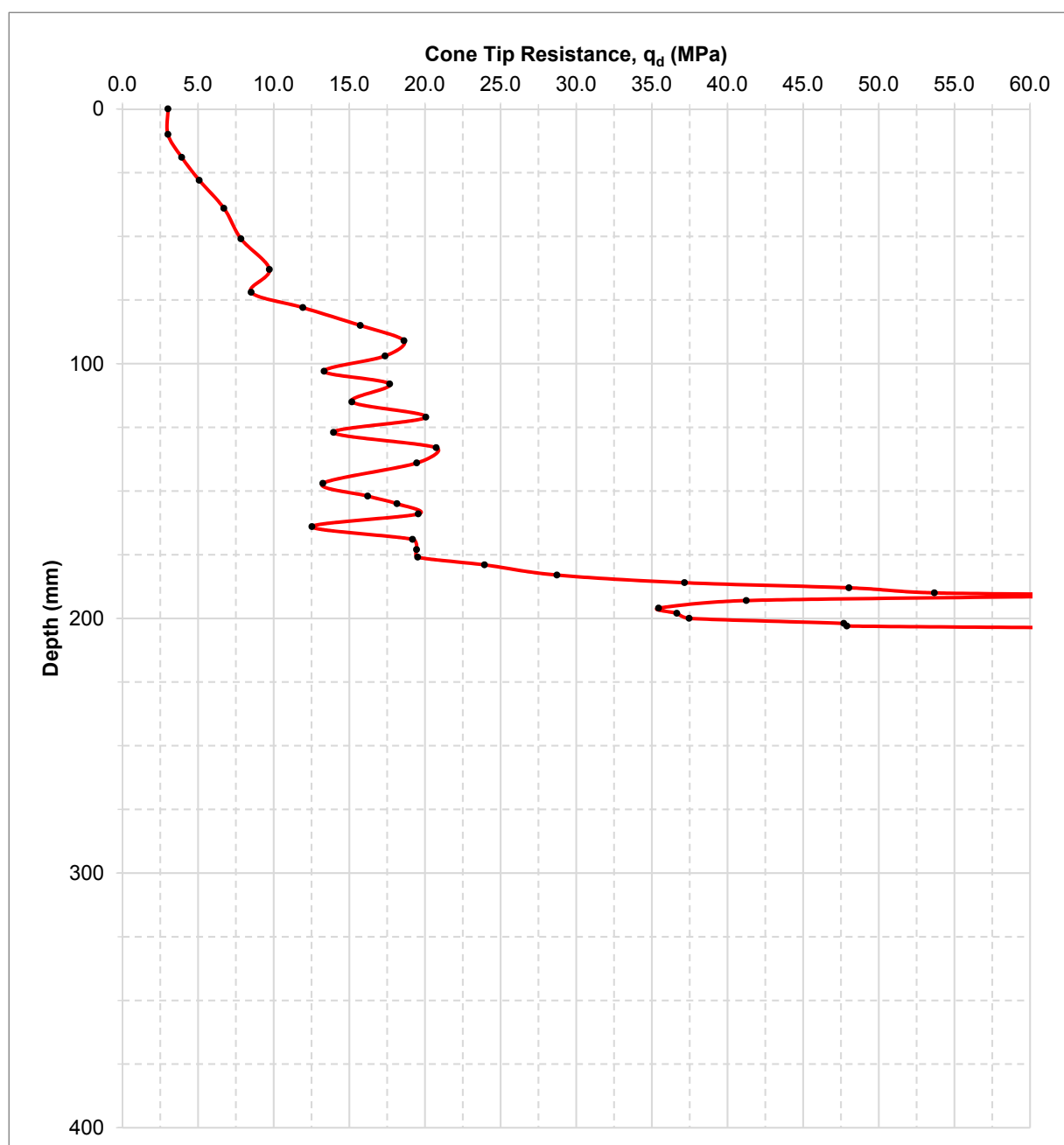
Project No.: 2091

Checked By: DWL

Location: Site 21-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-10A

Certificate Reference:

2091-PND-Site 21-10A

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	25	1.79	41	5	25.52			
2	18	3.20	42	4	21.72			
3	14	4.29	43	4	11.82			
4	21	5.47	44	3	24.43			
5	9	11.24	45	5	22.60			
6	12	10.40	46	3	26.10			
7	12	10.70	47	2	46.73			
8	6	12.09	48	2	59.93			
9	4	24.25	49	1	60.66			
10	5	17.76	50	2	65.79			
11	5	19.02	51	1	62.00			
12	9	15.57	52	2	43.87			
13	6	19.57	53	1	38.00			
14	11	13.54	54	2	38.14			
15	10	11.09	55	3	47.13			
16	9	11.97	End of Test Record					
17	10	12.48						
18	7	15.15						
19	5	21.94						
20	4	12.33						
21	3	17.14						
22	4	20.49						
23	5	22.10						
24	4	25.07						
25	4	23.41						
26	5	24.86						
27	5	27.26						
28	5	26.54						
29	5	22.89						
30	6	13.16						
31	4	30.32						
32	4	20.89						
33	6	18.73						
34	5	23.22						
35	5	20.64						
36	5	25.24						
37	5	17.53						
38	5	21.19						
39	5	16.32						
40	4	24.60						

PANDA Probe - Test Report

Site 21-10A

Certificate Reference:

2091-PND-Site 21-10A

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

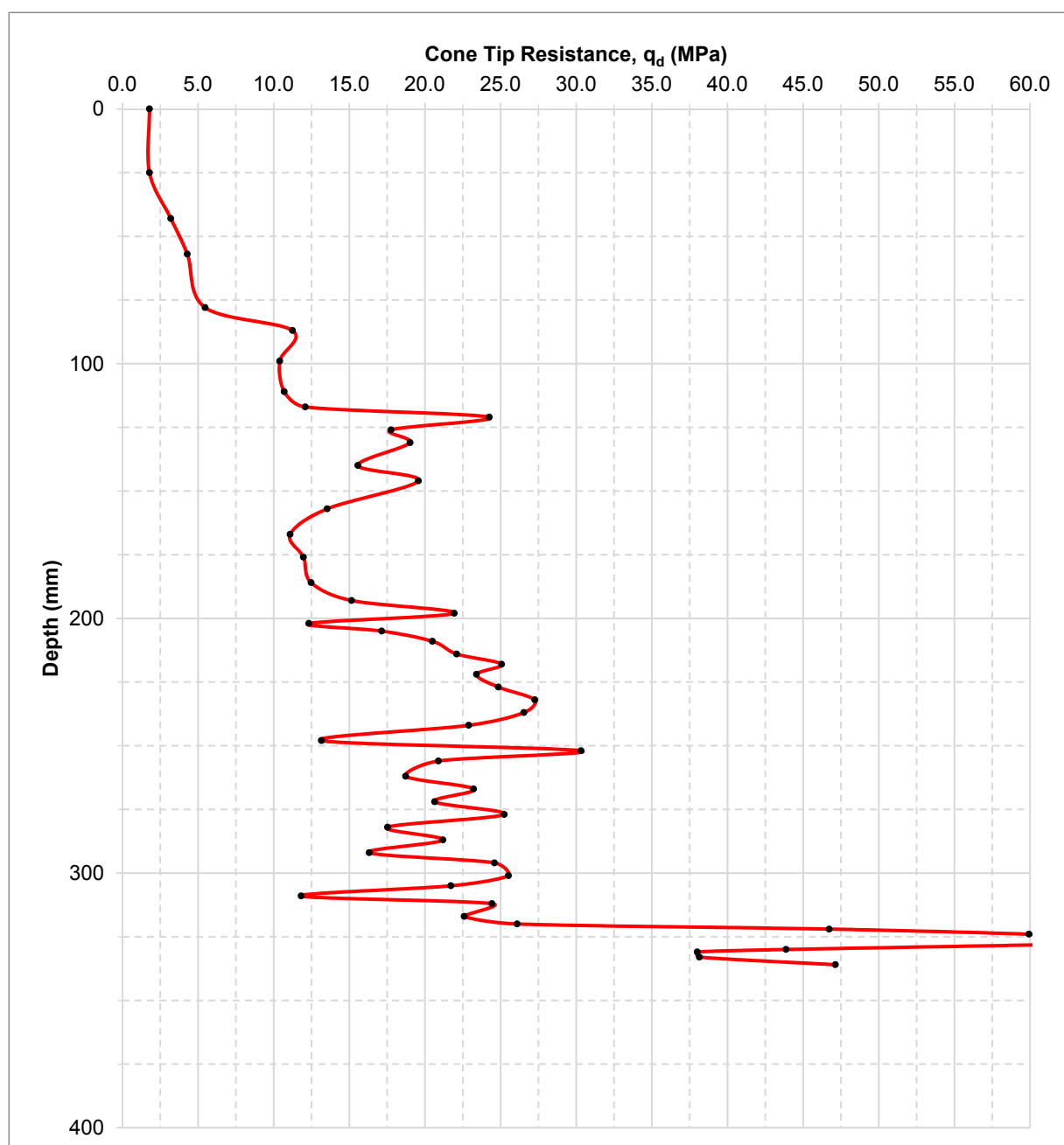
Project No.: 2091

Checked By: DWL

Location: Site 21-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-11

Certificate Reference:

2091-PND-Site 21-11

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	4.35						
2	5	7.24						
3	5	11.98						
4	4	11.60						
5	4	14.91						
6	3	16.66						
7	3	21.45						
8	4	19.00						
9	5	9.01						
10	2	25.29						
11	3	14.62						
12	3	18.33						
13	3	14.98						
14	3	12.26						
15	3	16.17						
16	2	21.00						
17	3	26.52						
18	3	21.89						
19	2	18.99						
20	2	22.47						
21	2	25.38						
22	2	21.18						
23	2	23.60						
24	2	24.04						
25	1	19.93						
26	2	25.79						
27	1	15.30						
28	2	25.92						
29	2	34.03						
30	2	40.03						
31	1	42.22						
32	1	41.56						
33	2	29.61						
34	2	53.84						
35	2	51.16						
36	2	47.32						
37	2	44.15						
End of Test Record								

PANDA Probe - Test Report

Site 21-11

Certificate Reference:

2091-PND-Site 21-11

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

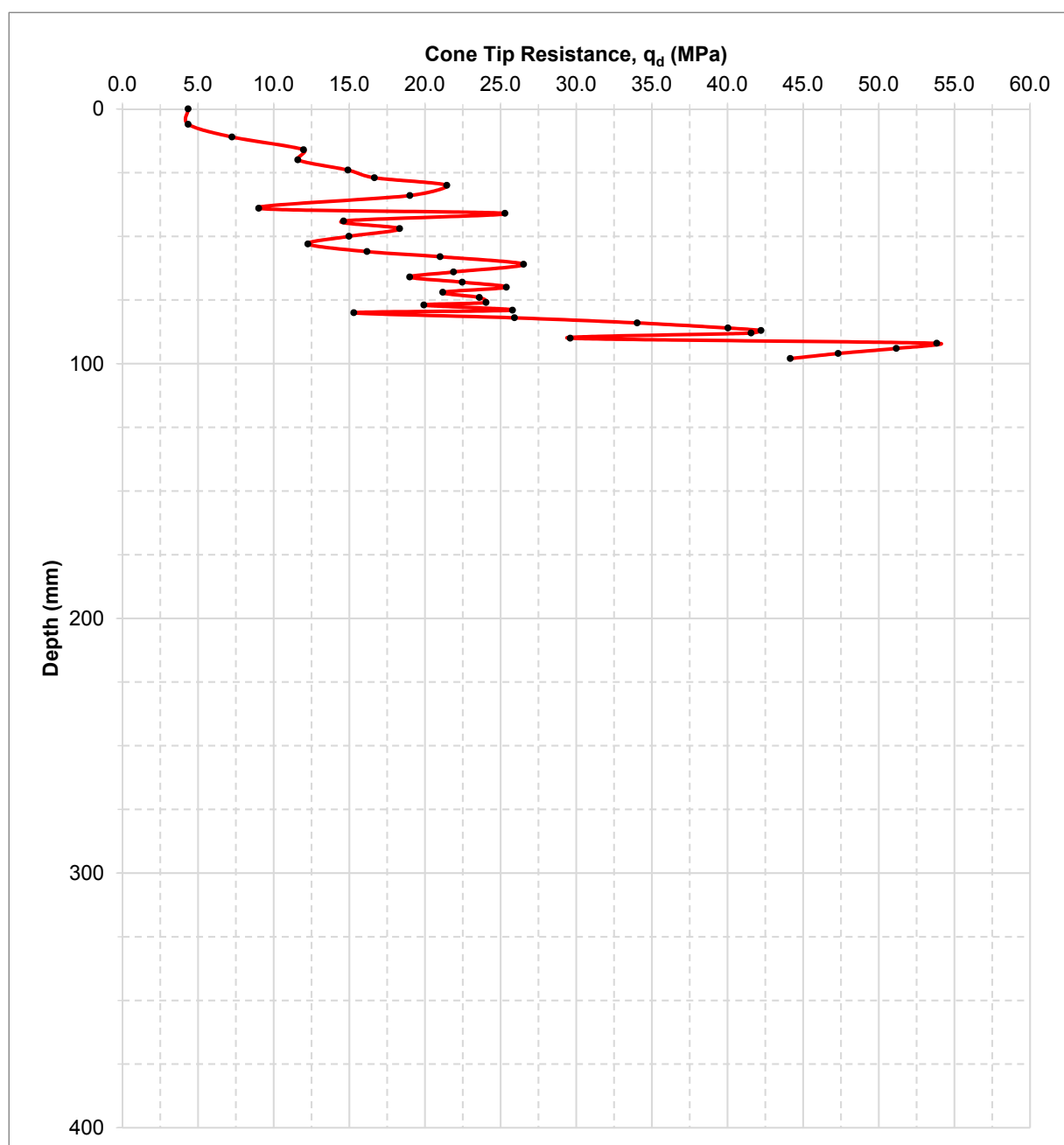
Project No.: 2091

Checked By: DWL

Location: Site 21-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-11A

Certificate Reference:

2091-PND-Site 21-11A

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	13	2.14	41	7	18.58	81	1	42.37
2	14	5.54	42	5	13.67	82	1	37.04
3	13	7.28	43	4	24.78	83	1	35.98
4	7	5.44	44	4	15.29	84	1	31.41
5	6	6.82	45	5	19.05	85	2	31.12
6	9	11.62	46	6	20.04	86	1	31.46
7	7	15.89	47	6	19.77	87	2	33.75
8	4	20.50	48	5	15.52	End of Test Record		
9	4	11.59	49	5	16.26			
10	3	21.18	50	4	12.82			
11	3	23.47	51	5	19.54			
12	2	23.97	52	5	17.77			
13	3	17.35	53	7	19.16			
14	3	23.00	54	6	18.39			
15	3	19.58	55	5	16.98			
16	3	22.99	56	4	20.20			
17	3	26.53	57	5	14.20			
18	4	19.77	58	4	19.58			
19	2	21.52	59	4	25.95			
20	3	18.87	60	3	15.53			
21	2	22.94	61	4	21.57			
22	4	20.19	62	3	28.19			
23	4	28.89	63	3	29.77			
24	4	25.20	64	4	23.51			
25	4	35.02	65	3	33.96			
26	4	19.52	66	4	17.58			
27	2	35.81	67	4	23.91			
28	2	33.70	68	4	24.58			
29	4	32.14	69	3	31.96			
30	4	23.13	70	5	23.24			
31	4	25.21	71	3	21.23			
32	5	14.51	72	1	24.57			
33	6	19.49	73	2	20.42			
34	4	20.95	74	2	28.08			
35	6	19.83	75	2	17.47			
36	6	16.34	76	1	33.95			
37	6	16.86	77	3	28.68			
38	6	17.25	78	2	32.36			
39	8	17.70	79	3	24.66			
40	6	19.58	80	1	36.37			

PANDA Probe - Test Report

Site 21-11A

Certificate Reference:

2091-PND-Site 21-11A

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

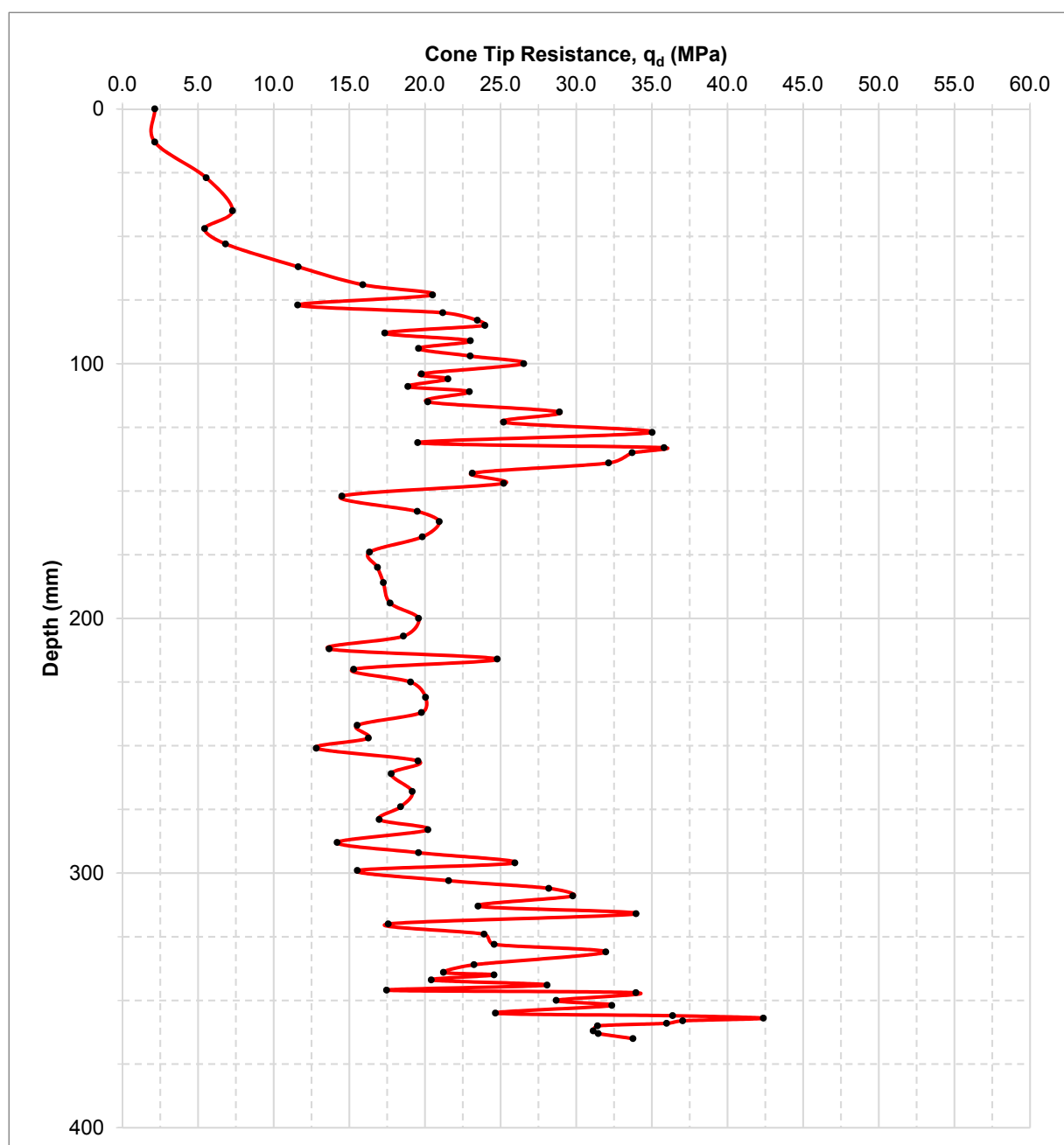
Project No.: 2091

Checked By: DWL

Location: Site 21-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 21-12

Certificate Reference:

2091-PND-Site 21-12

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

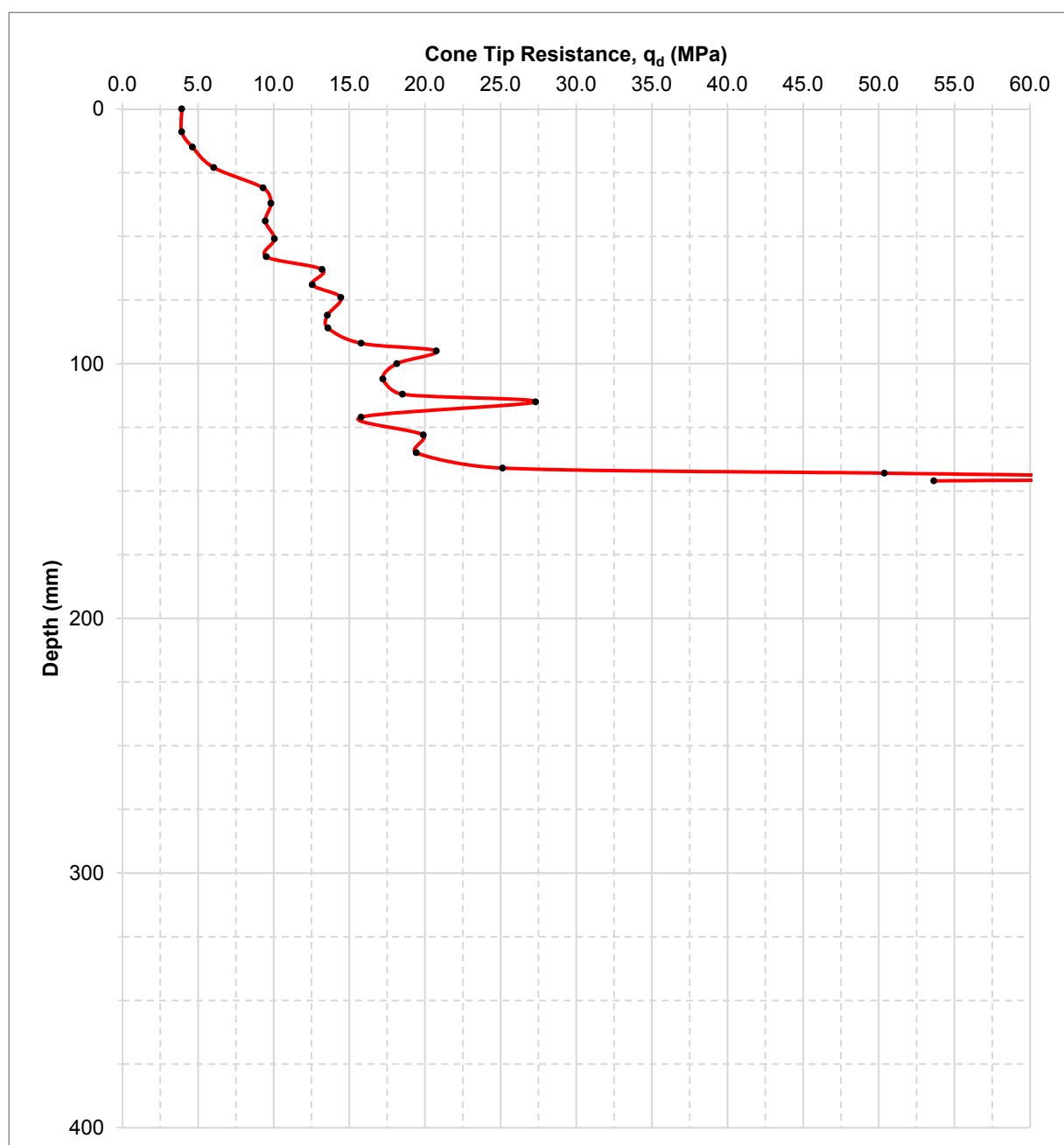
Project No.: 2091

Checked By: DWL

Location: Site 21-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-12A

Certificate Reference:

2091-PND-Site 21-12A

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	4.84	End of Test Record					
2	12	8.55						
3	7	11.23						
4	4	15.22						
5	5	13.74						
6	6	17.27						
7	8	10.99						
8	5	16.29						
9	6	12.54						
10	6	15.78						
11	7	13.61						
12	6	16.29						
13	5	19.13						
14	5	18.81						
15	8	14.13						
16	5	18.13						
17	7	16.07						
18	7	19.43						
19	6	15.42						
20	5	27.49						
21	7	19.26						
22	5	27.52						
23	7	22.18						
24	5	22.30						
25	7	19.64						
26	6	22.51						
27	5	24.30						
28	4	28.67						
29	3	47.46						
30	3	47.79						
31	2	59.90						
32	2	45.43						
33	1	57.37						
34	3	40.65						
35	1	64.43						
36	3	44.49						
37	2	45.19						
38	2	55.17						
39	1	45.95						
40	1	44.54						

Certificate Reference:

2091-PND-Site 21-12A

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

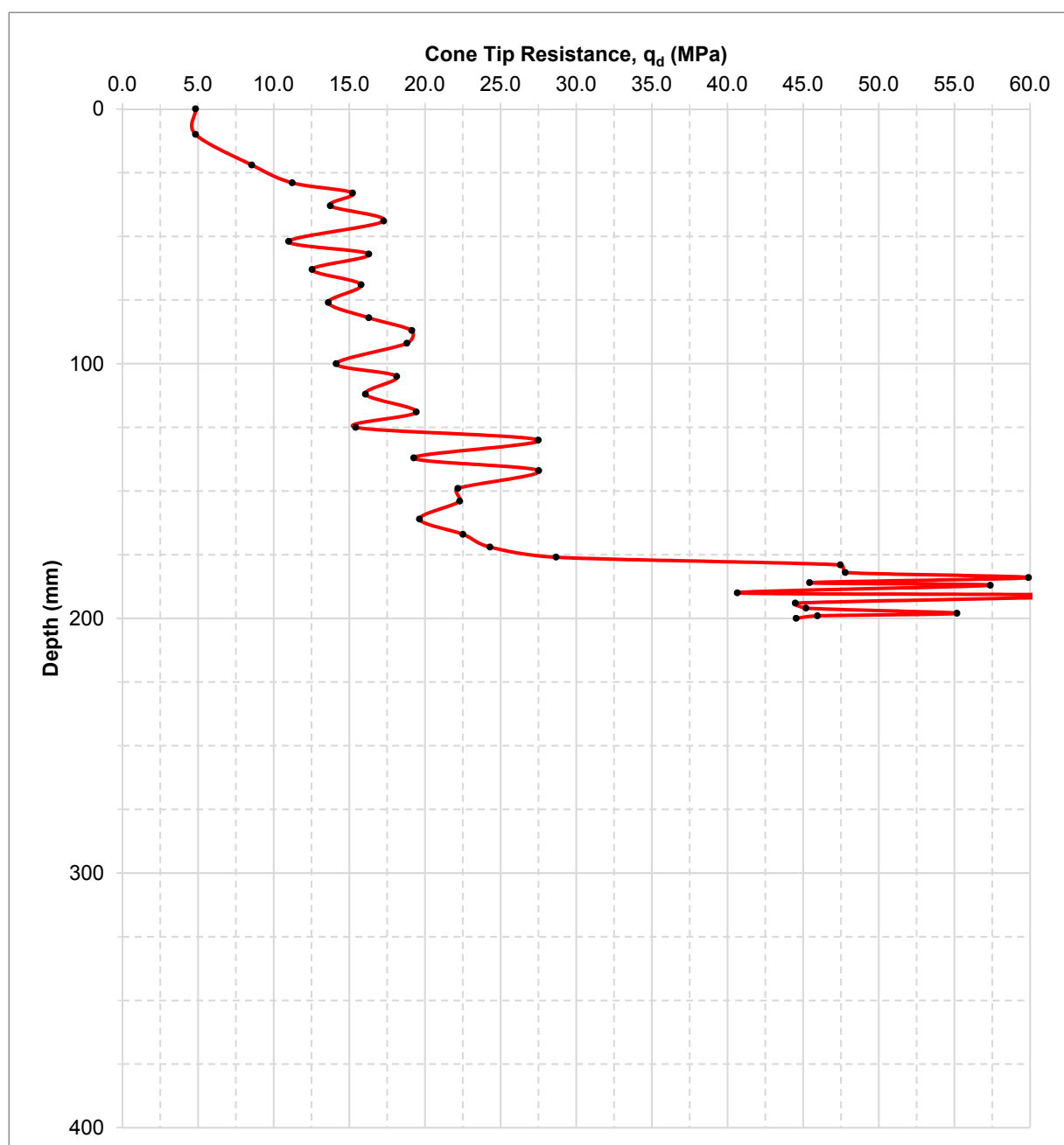
Project No.: 2091

Checked By: DWL

Location: Site 21-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-13

Certificate Reference:

2091-PND-Site 21-13

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	2.74	41	6	32.05			
2	9	5.08	42	4	30.58			
3	8	5.08	43	4	29.01			
4	5	8.39	44	5	29.13			
5	8	9.06	45	6	34.65			
6	6	10.44	46	4	31.12			
7	8	11.81	47	4	32.24			
8	6	12.14	48	4	38.50			
9	6	10.70	49	4	30.39			
10	7	16.91	50	4	46.93			
11	5	15.41	51	3	39.31			
12	8	13.56	52	3	41.71			
13	7	12.40	53	5	30.22			
14	8	14.97	54	4	33.56			
15	7	20.57	55	5	24.21			
16	8	16.51	56	6	30.63			
17	6	18.56	57	5	28.32			
18	8	14.55	58	5	34.03			
19	9	16.35	59	5	32.12			
20	7	17.99	60	4	35.48			
21	7	17.89	End of Test Record					
22	8	17.30						
23	7	21.72						
24	7	22.63						
25	5	25.01						
26	6	21.30						
27	5	22.84						
28	4	22.87						
29	6	22.11						
30	6	25.26						
31	6	21.47						
32	7	26.29						
33	6	27.00						
34	7	25.93						
35	5	27.12						
36	7	25.82						
37	6	24.40						
38	4	37.46						
39	5	29.47						
40	4	43.67						

PANDA Probe - Test Report

Site 21-13

Certificate Reference:

2091-PND-Site 21-13

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

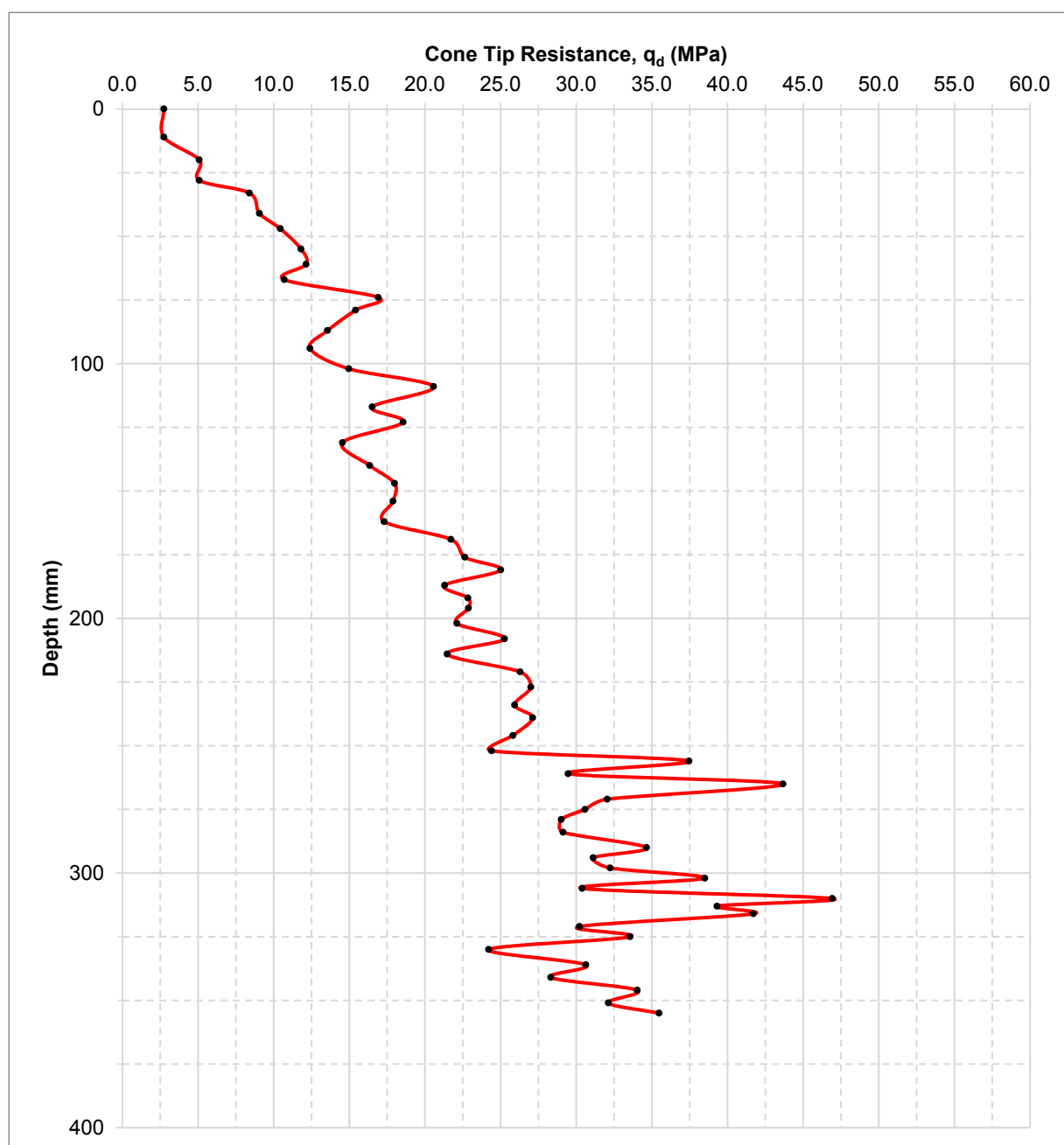
Project No.: 2091

Checked By: DWL

Location: Site 21-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 21-14

Certificate Reference:

2091-PND-Site 21-14

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

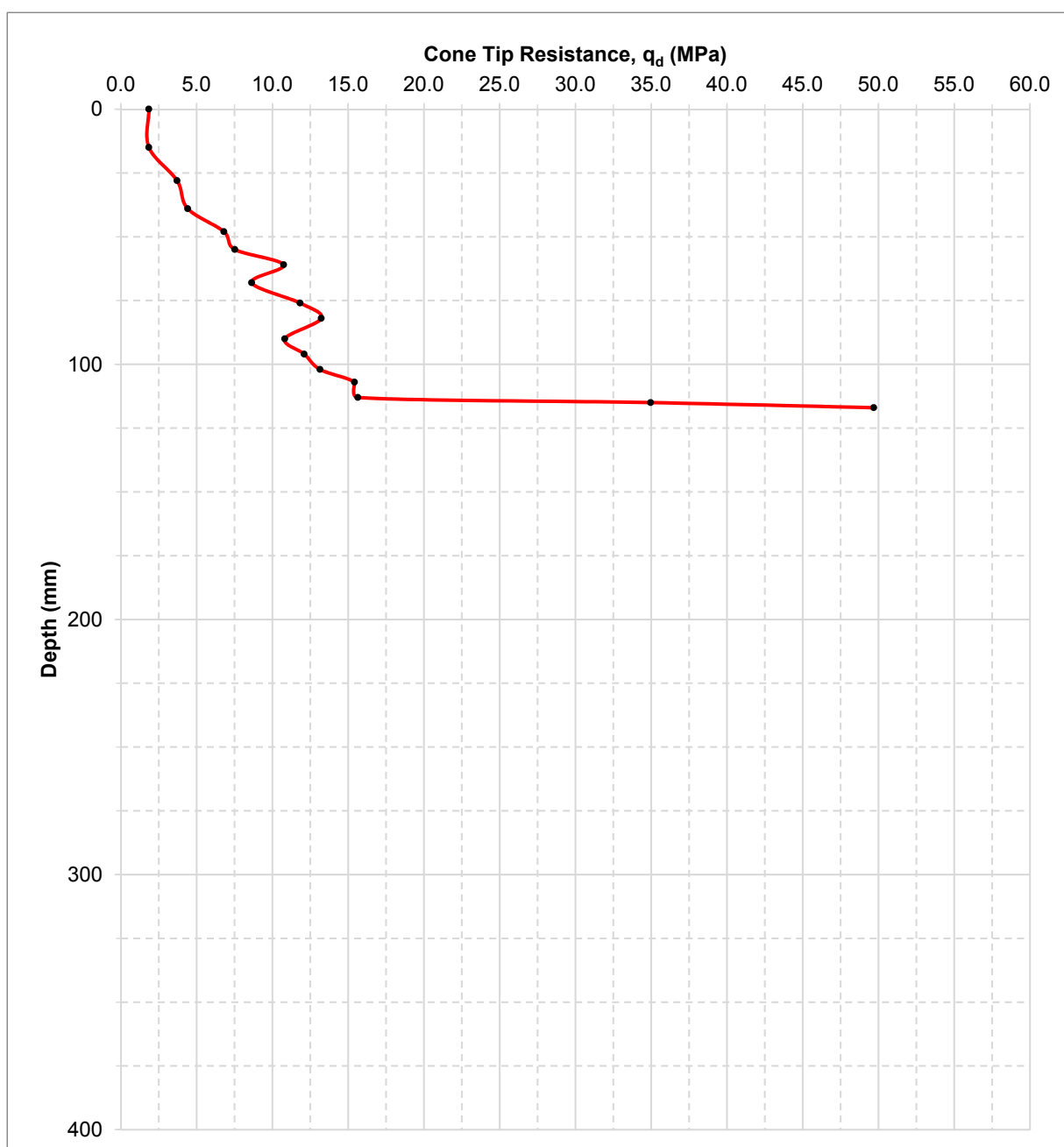
Project No.: 2091

Checked By: DWL

Location: Site 21-14 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 21-14A

Certificate Reference:

2091-PND-Site 21-14A

Sheet:

1 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 21-14 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	15	2.79	41	4	31.36			
2	9	4.40	42	4	25.36			
3	8	4.87	43	5	20.79			
4	9	5.98	44	2	29.62			
5	7	6.25	45	6	23.03			
6	6	6.67	46	5	25.61			
7	10	10.02	47	4	19.55			
8	6	11.86	48	5	24.19			
9	6	10.23	49	5	23.67			
10	8	10.77	50	5	28.02			
11	6	12.77	51	5	24.92			
12	8	11.16	52	6	21.69			
13	7	14.58	53	7	24.66			
14	7	12.38	54	9	15.53			
15	6	13.31	55	8	21.13			
16	5	12.29	56	9	22.54			
17	5	13.14	57	9	16.08			
18	3	17.96	58	8	18.07			
19	4	22.13	59	7	17.64			
20	4	16.83	60	7	21.10			
21	5	28.86	61	5	21.93			
22	4	32.52	62	4	20.91			
23	5	30.55	63	6	18.56			
24	4	27.71	64	4	17.75			
25	6	24.42	65	6	18.58			
26	6	19.83	66	7	14.49			
27	7	27.91	67	6	14.80			
28	6	21.28	68	8	13.76			
29	6	28.98	69	6	15.23			
30	4	34.44	70	2	37.02			
31	5	28.16	71	4	29.58			
32	6	21.66	72	1	38.15			
33	6	26.76	73	2	43.56			
34	5	24.13	74	1	45.08			
35	5	28.58	75	2	42.09			
36	6	26.17	76	2	41.36			
37	5	27.08	77	1	56.87			
38	5	27.13	78	1	41.55			
39	6	26.63	End of Test Record					
40	4	26.68						

PANDA Probe - Test Report

Site 21-14A

Certificate Reference:

2091-PND-Site 21-14A

Sheet:

2 of 2

Client: ARRB

Test Date: 1/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

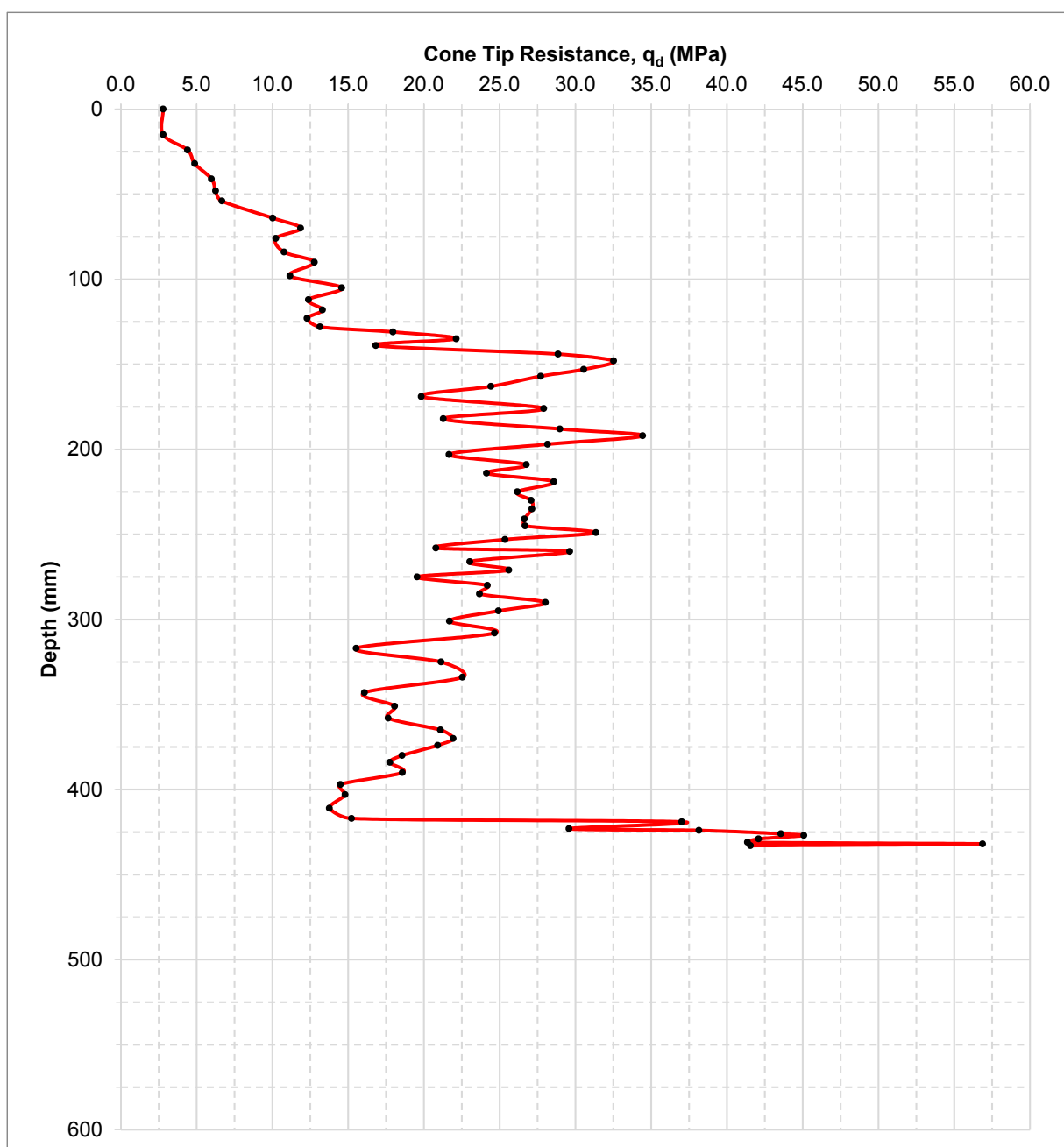
Project No.: 2091

Checked By: DWL

Location: Site 21-14 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-1

Certificate Reference:

2091-PND-Site 22-1

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	4.32	41	6	13.75	81	6	21.14
2	7	6.40	42	6	13.60	82	6	18.05
3	4	10.08	43	5	24.42	83	3	41.60
4	5	6.91	44	6	17.67	84	2	50.25
5	5	6.52	45	3	25.28	85	2	31.18
6	5	8.46	46	3	12.62	86	2	24.02
7	4	8.13	47	3	19.27	87	2	15.33
8	3	9.79	48	1	37.99	88	2	39.65
9	4	10.51	49	3	26.42	89	2	28.61
10	4	10.36	50	2	29.69	90	2	33.44
11	3	12.88	51	4	23.42	91	2	39.86
12	4	17.65	52	3	23.12	92	3	29.61
13	4	11.83	53	4	23.90	93	1	38.17
14	5	16.62	54	3	20.77	94	2	38.57
15	5	17.57	55	5	19.25	95	1	45.98
16	5	15.07	56	4	15.66	96	3	18.90
17	6	13.31	57	6	14.45	97	2	44.48
18	6	11.19	58	6	14.41	98	2	34.88
19	4	14.82	59	6	12.07	99	1	36.63
20	4	16.18	60	6	13.05	100	2	38.98
21	5	16.72	61	7	10.75	101	2	36.78
22	4	17.56	62	6	14.07	102	1	38.27
23	5	17.44	63	6	10.56	End of Test Record		
24	5	18.39	64	9	9.74			
25	5	17.96	65	9	11.48			
26	3	18.17	66	8	10.30			
27	3	25.01	67	7	13.38			
28	3	28.13	68	10	12.70			
29	4	24.69	69	11	11.75			
30	3	22.25	70	7	10.15			
31	2	18.64	71	8	10.28			
32	2	27.98	72	9	9.53			
33	3	15.06	73	9	9.45			
34	2	39.06	74	8	9.94			
35	5	17.68	75	9	9.52			
36	5	17.58	76	10	11.82			
37	7	15.23	77	6	7.35			
38	6	18.20	78	6	9.42			
39	6	15.95	79	7	13.09			
40	5	20.04	80	7	14.77			

PANDA Probe - Test Report

Site 22-1

Certificate Reference:

2091-PND-Site 22-1

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

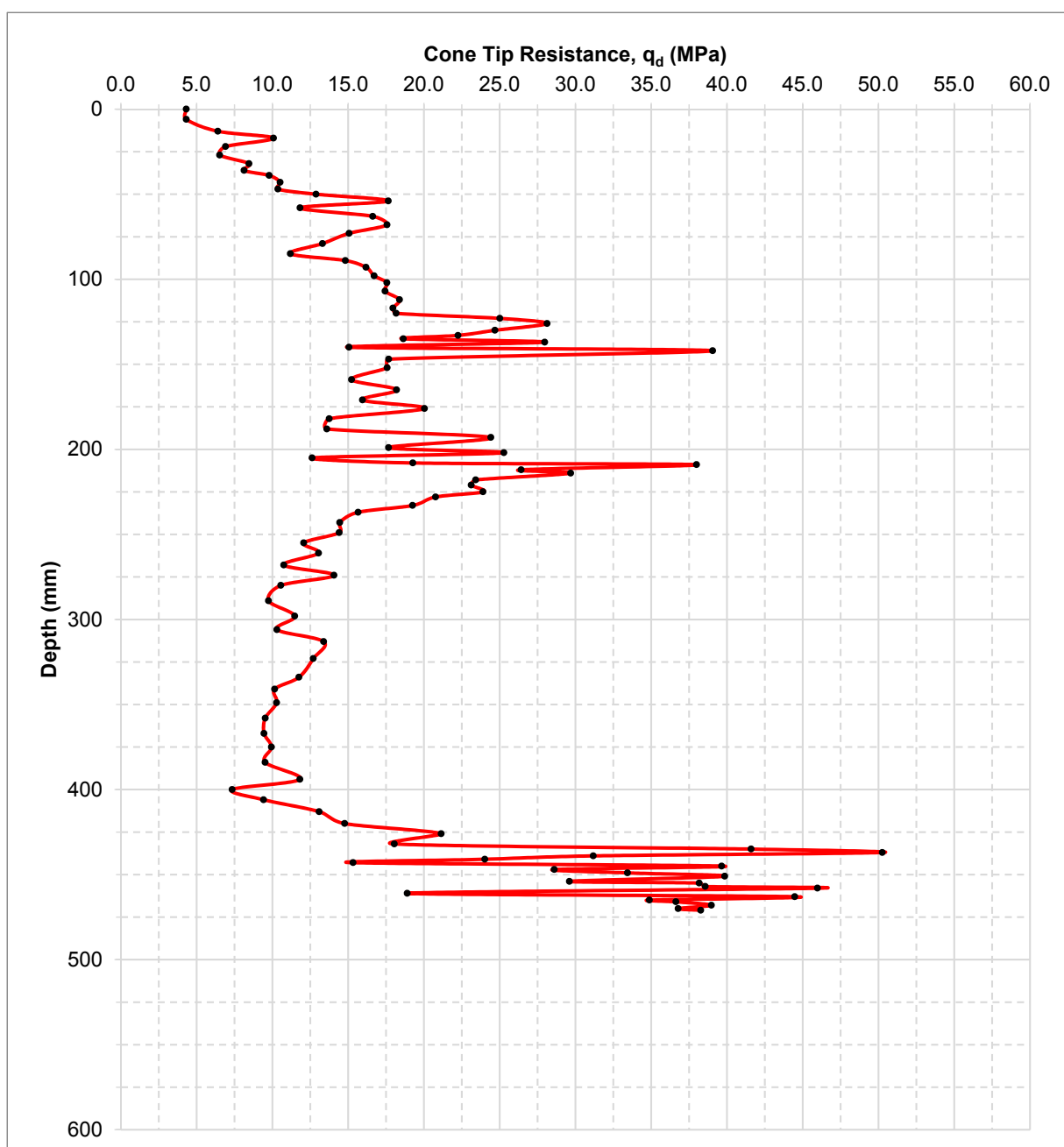
Project No.: 2091

Checked By: DWL

Location: Site 22-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-2

Certificate Reference:

2091-PND-Site 22-2

Sheet:

1 of 3

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	2.58	41	3	29.08	81	2	27.50
2	5	8.98	42	3	31.90	82	2	33.39
3	6	6.69	43	2	25.63	83	1	40.16
4	7	8.62	44	3	22.17	84	2	30.72
5	7	8.67	45	1	19.45	85	3	27.82
6	6	7.20	46	2	25.60	86	1	35.33
7	5	8.22	47	2	25.49	87	3	32.23
8	5	7.22	48	1	22.11	88	2	34.82
9	4	9.81	49	2	31.28	89	2	19.24
10	4	9.67	50	2	17.49	90	2	26.36
11	2	15.23	51	1	20.92	91	3	24.93
12	3	11.73	52	3	27.17	92	1	39.90
13	2	12.53	53	1	35.23	93	2	34.33
14	2	10.92	54	2	23.22	94	3	25.16
15	3	10.45	55	2	31.54	95	2	24.10
16	4	11.48	56	1	44.03	96	2	23.17
17	3	11.32	57	2	35.95	97	2	27.62
18	1	15.50	58	1	44.18	98	2	26.29
19	2	16.14	59	1	35.78	99	3	30.99
20	2	13.18	60	2	34.01	100	1	17.59
21	2	15.44	61	2	32.79	101	2	23.69
22	3	16.57	62	1	32.83	102	3	27.06
23	2	12.57	63	2	30.92	103	1	29.69
24	2	13.81	64	2	27.11	104	4	22.13
25	2	17.05	65	1	36.54	105	3	26.29
26	3	14.71	66	1	34.50	106	2	27.83
27	1	28.36	67	2	31.51	107	4	20.07
28	2	20.00	68	2	43.39	108	3	27.51
29	2	23.46	69	1	38.72	109	3	21.62
30	2	19.97	70	3	18.95	110	3	27.12
31	3	15.07	71	2	34.35	111	3	23.75
32	2	23.42	72	3	24.22	112	3	26.47
33	2	23.36	73	2	28.94	113	3	21.39
34	2	20.10	74	2	24.01	114	3	21.92
35	2	24.57	75	4	26.45	115	5	18.38
36	2	17.18	76	1	46.46	116	3	20.49
37	2	22.23	77	2	34.61	117	3	15.36
38	3	22.42	78	3	23.78	118	3	20.35
39	1	44.63	79	3	28.68	119	2	23.15
40	3	24.43	80	1	32.67	120	3	15.13

PANDA Probe - Test Report

Site 22-2

Certificate Reference:

2091-PND-Site 22-2

Sheet:

2 of 3

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	4	17.79						
122	5	17.60						
123	4	17.04						
124	2	12.84						
125	2	24.49						
126	1	14.49						
127	3	15.64						
128	4	12.32						
129	3	15.18						
130	3	10.70						
131	4	15.27						
132	4	12.60						
133	3	16.99						
134	3	13.44						
135	4	17.14						
136	3	17.81						
137	2	16.79						
138	3	20.59						
139	2	17.94						
140	2	19.94						
141	2	29.03						
142	2	32.40						
143	2	26.73						
144	2	35.33						
145	1	33.32						
146	1	47.35						
147	2	35.29						
148	4	27.78						
149	1	39.16						
150	3	28.16						
151	1	39.90						
152	1	34.74						
153	1	36.71						
154	2	42.78						
155	1	43.21						
156	1	32.51						
End of Test Record								

PANDA Probe - Test Report

Site 22-2

Certificate Reference:

2091-PND-Site 22-2

Sheet:

3 of 3

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

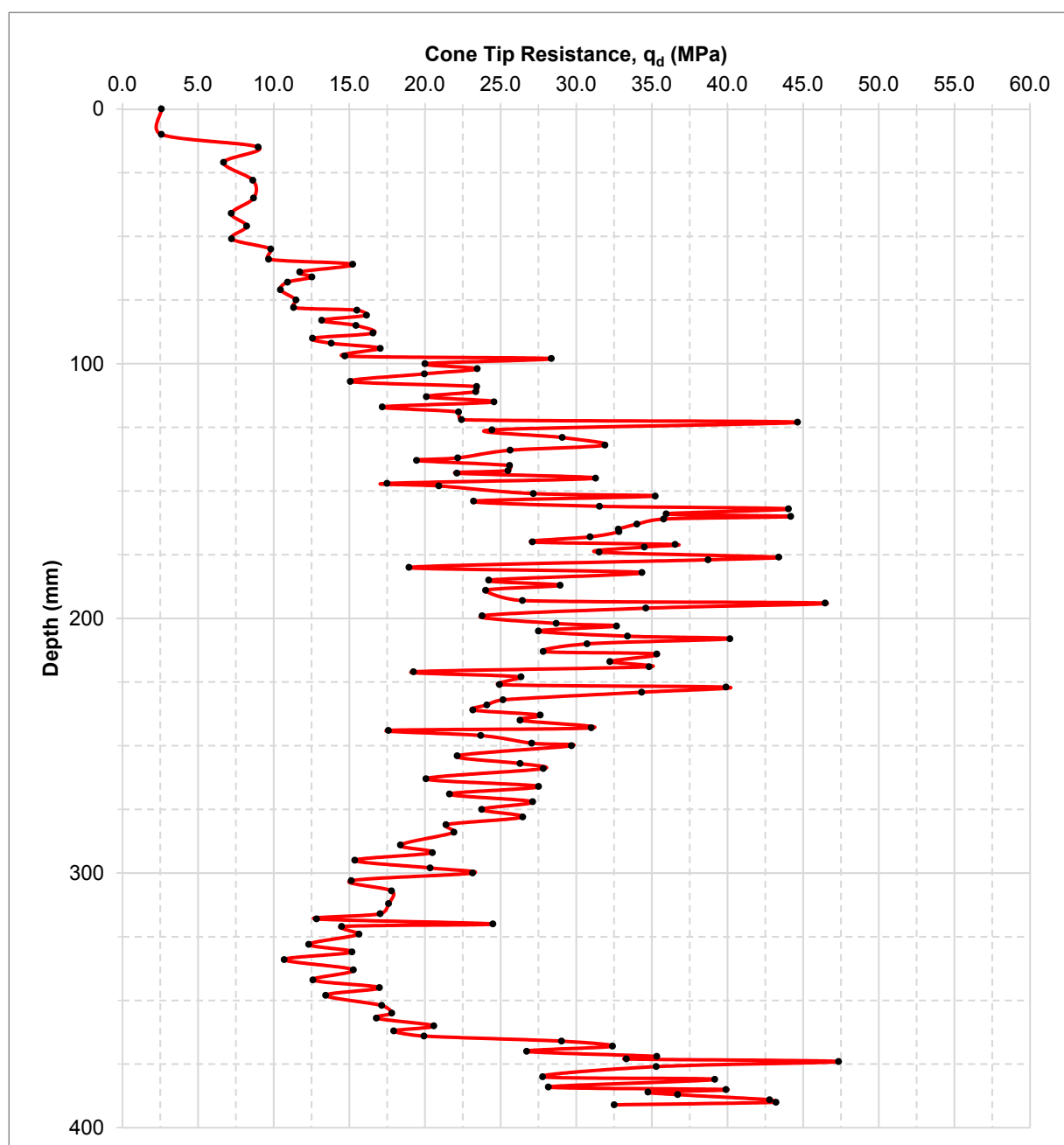
Project No.: 2091

Checked By: DWL

Location: Site 22-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-3

Certificate Reference:

2091-PND-Site 22-3

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	5.15	41	5	15.05	81	1	49.63
2	5	7.67	42	5	19.22	82	2	48.06
3	7	8.50	43	3	22.68	83	4	91.41
4	5	8.45	44	5	14.89	84	2	46.73
5	7	5.96	45	5	21.87	85	2	54.97
6	10	7.79	46	5	14.50	86	1	57.57
7	8	9.57	47	6	16.09	End of Test Record		
8	5	11.72	48	5	17.73			
9	5	18.28	49	6	15.27			
10	7	14.47	50	6	11.63			
11	6	14.98	51	5	11.61			
12	4	15.21	52	3	14.95			
13	5	15.20	53	5	12.74			
14	4	14.56	54	7	14.49			
15	3	15.58	55	4	16.55			
16	5	12.80	56	6	19.50			
17	5	12.16	57	3	16.11			
18	4	14.52	58	5	17.24			
19	5	19.94	59	6	8.78			
20	4	16.69	60	6	12.72			
21	4	20.38	61	6	11.43			
22	4	19.37	62	10	9.49			
23	3	19.28	63	10	11.01			
24	4	18.55	64	8	10.79			
25	5	16.18	65	6	12.74			
26	4	21.34	66	9	11.65			
27	5	17.37	67	6	12.02			
28	4	19.58	68	8	12.01			
29	4	18.60	69	9	14.73			
30	1	68.97	70	10	15.95			
31	4	20.25	71	8	14.78			
32	2	55.54	72	3	20.46			
33	4	23.22	73	4	19.73			
34	5	13.34	74	3	18.12			
35	3	16.79	75	2	21.82			
36	3	21.80	76	4	19.47			
37	3	17.61	77	2	30.87			
38	4	17.87	78	3	16.99			
39	5	20.34	79	2	32.23			
40	4	16.45	80	3	25.25			

PANDA Probe - Test Report

Site 22-3

Certificate Reference:

2091-PND-Site 22-3

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

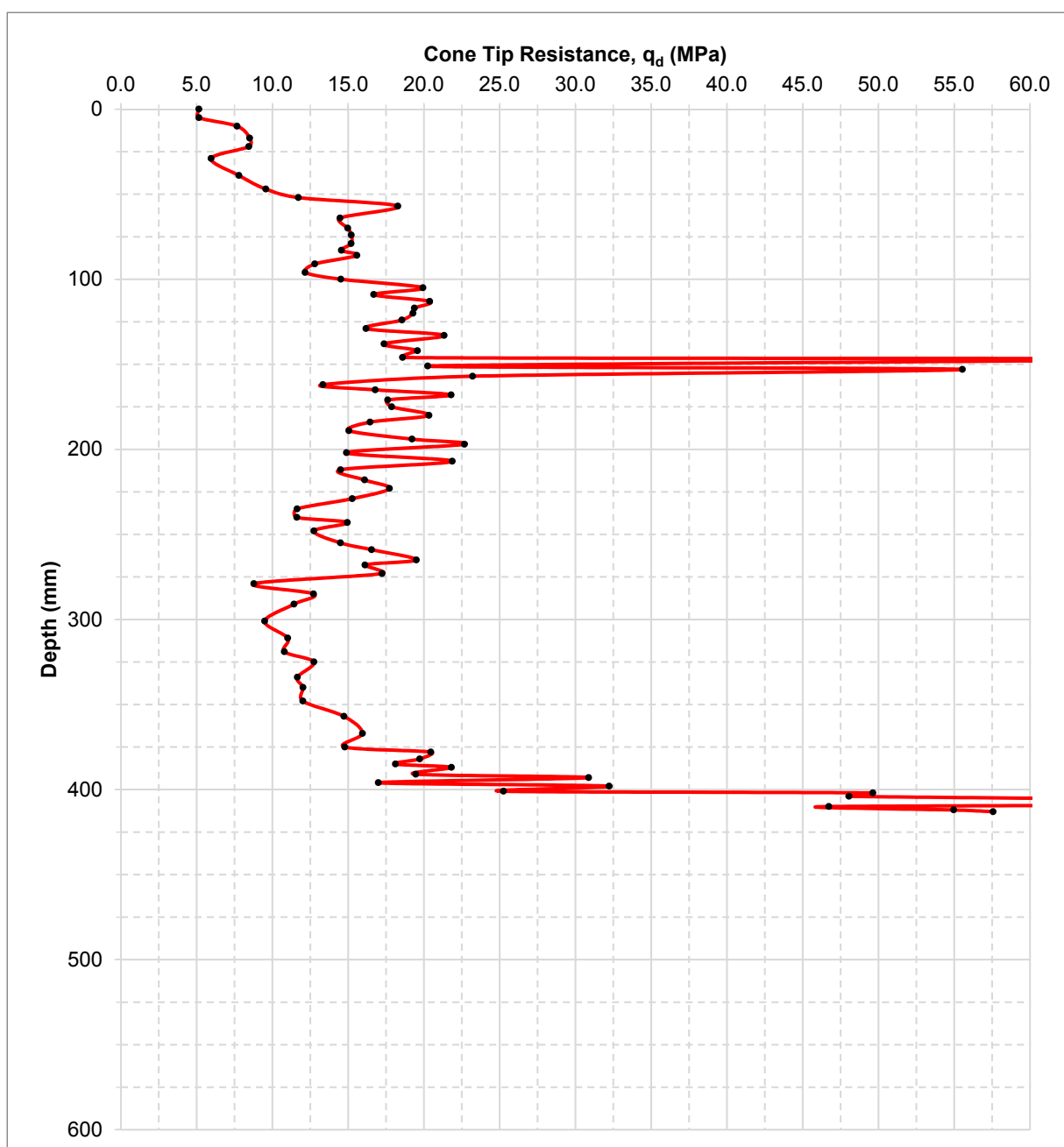
Project No.: 2091

Checked By: DWL

Location: Site 22-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-4

Certificate Reference:

2091-PND-Site 22-4

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.07	41	2	23.81			
2	7	7.21	42	3	24.76			
3	7	8.59	43	2	28.38			
4	8	8.30	44	4	21.61			
5	7	9.10	45	2	30.58			
6	7	10.48	46	3	33.89			
7	6	11.00	47	3	29.87			
8	6	14.01	48	3	20.20			
9	4	16.73	49	1	24.18			
10	5	13.50	50	3	34.54			
11	4	16.71	51	3	25.21			
12	5	19.00	52	2	30.23			
13	4	13.23	53	3	34.67			
14	3	21.19	54	3	32.75			
15	3	15.04	55	4	27.26			
16	3	16.95	56	3	31.17			
17	3	17.18	57	1	53.13			
18	3	26.97	58	2	55.42			
19	3	37.50	59	2	64.48			
20	3	21.95	60	1	63.78			
21	2	33.03	61	3	31.39			
22	2	37.14	62	1	43.81			
23	3	30.03	63	1	52.49			
24	3	34.45	64	2	56.35			
25	2	30.28	65	2	31.03			
26	3	21.09	66	2	56.67			
27	1	30.80	67	2	36.74			
28	3	27.05	68	2	30.49			
29	2	34.33	69	1	49.00			
30	3	25.71	70	2	34.14			
31	3	33.22	71	2	71.15			
32	3	26.73	72	1	37.37			
33	3	29.91	73	2	47.19			
34	3	28.08	74	1	59.84			
35	2	26.32	75	1	86.81			
36	3	24.47	76	3	34.42			
37	3	31.44	End of Test Record					
38	2	41.16						
39	3	26.60						
40	3	29.61						

PANDA Probe - Test Report

Site 22-4

Certificate Reference:

2091-PND-Site 22-4

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

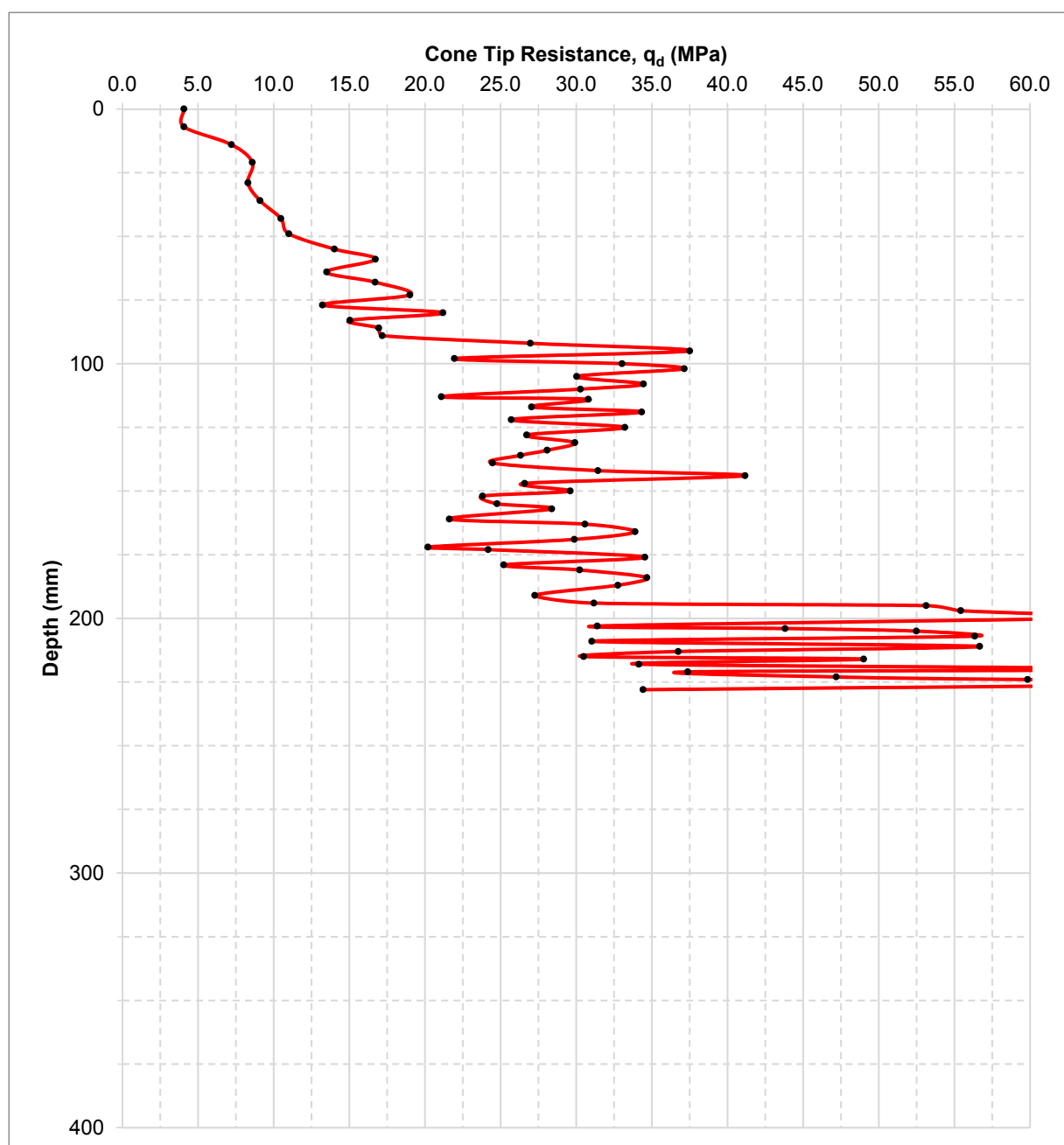
Project No.: 2091

Checked By: DWL

Location: Site 22-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-4A

Certificate Reference:

2091-PND-Site 22-4A

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	2.93	41	3	29.13			
2	6	6.33	42	1	30.15			
3	6	9.16	43	4	27.31			
4	5	8.81	44	4	30.18			
5	8	9.03	45	2	72.88			
6	5	9.64	46	1	32.78			
7	7	8.08	47	4	17.25			
8	5	6.46	48	3	51.66			
9	6	10.73	49	2	44.85			
10	6	11.47	50	1	65.33			
11	6	13.10	51	3	74.34			
12	7	10.96	52	1	45.74			
13	5	16.32	53	2	24.09			
14	5	13.31	54	3	63.77			
15	5	21.73	55	3	59.80			
16	4	24.07	56	1	45.17			
17	3	26.25	57	3	36.55			
18	2	32.22	58	1	47.58			
19	2	40.50	59	6	45.67			
20	2	37.62	End of Test Record					
21	1	41.71						
22	2	39.20						
23	1	44.82						
24	2	45.61						
25	2	41.99						
26	2	46.25						
27	1	41.80						
28	2	33.67						
29	2	42.17						
30	1	35.58						
31	2	38.83						
32	2	45.87						
33	2	46.60						
34	1	34.79						
35	2	38.77						
36	2	40.18						
37	1	62.31						
38	2	41.30						
39	1	27.24						
40	3	31.21						

PANDA Probe - Test Report

Site 22-4A

Certificate Reference:

2091-PND-Site 22-4A

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

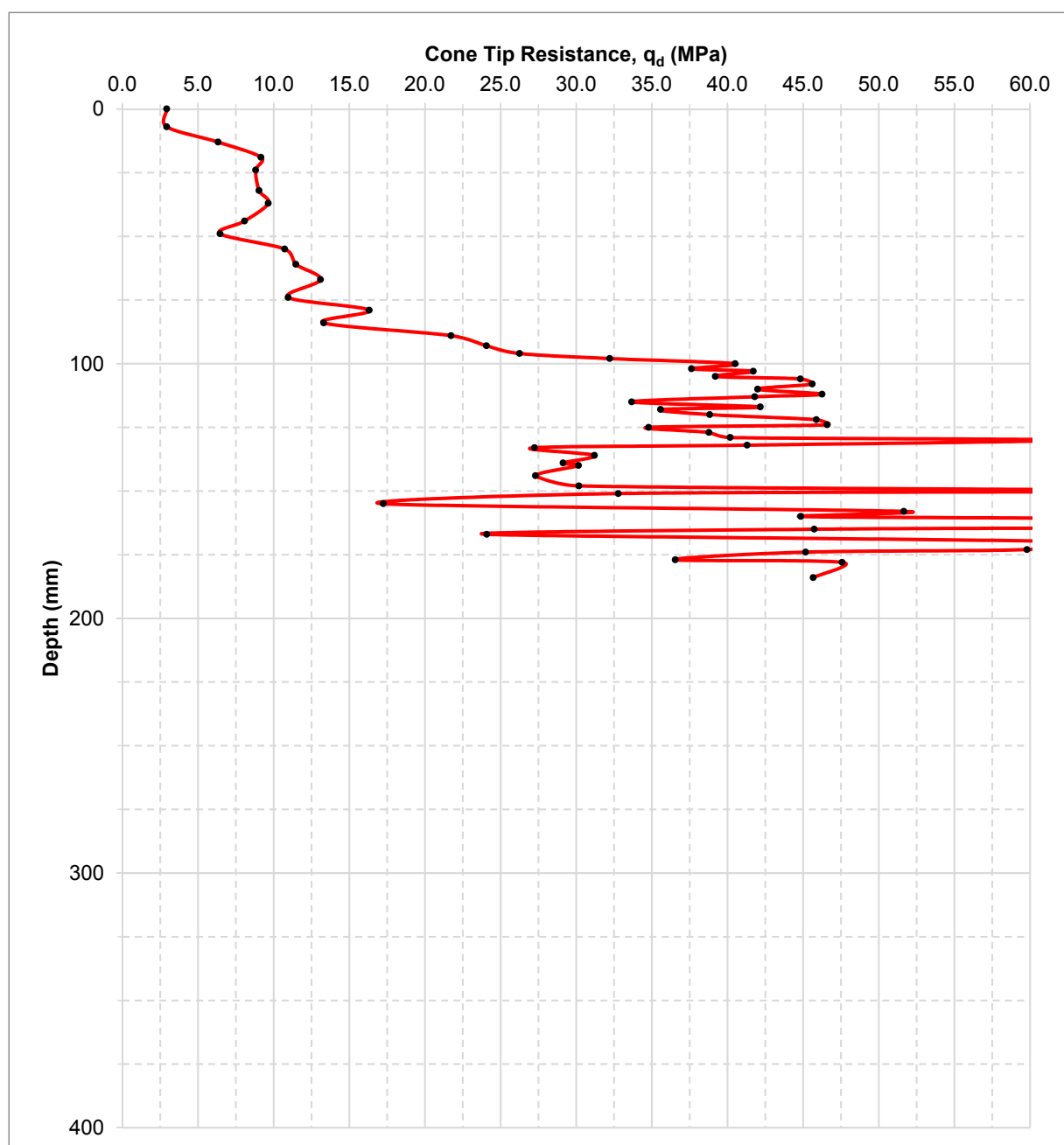
Project No.: 2091

Checked By: DWL

Location: Site 22-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-4B

Certificate Reference:

2091-PND-Site 22-4B

Sheet:

1 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	2.35	41	4	12.33	81	2	33.22
2	2	4.67	42	3	15.33	82	2	32.03
3	3	4.17	43	3	19.54	83	1	31.13
4	3	4.51	44	3	18.01	84	2	45.95
5	2	6.55	45	4	12.82	85	2	27.27
6	2	4.65	46	1	16.31	86	2	22.04
7	2	9.17	47	2	16.80	87	3	24.88
8	2	5.21	48	1	17.81	88	1	35.04
9	1	8.40	49	2	20.49	89	2	36.53
10	1	6.40	50	1	27.73	90	2	38.65
11	1	7.90	51	2	21.64	91	2	33.16
12	2	8.90	52	2	18.33	92	2	23.60
13	1	5.10	53	3	17.29	93	3	27.82
14	3	11.93	54	2	25.39	94	1	30.77
15	2	8.38	55	2	23.65	95	2	34.15
16	1	12.22	56	2	29.54	96	1	29.55
17	2	10.07	57	2	21.15	97	2	35.31
18	1	9.45	58	2	38.10	98	2	25.98
19	1	10.02	59	1	28.32	99	3	31.32
20	3	12.08	60	2	33.60	100	1	37.18
21	2	7.66	61	2	30.00	101	1	47.46
22	1	10.50	62	1	30.84	102	2	36.03
23	3	8.47	63	2	36.14	103	1	49.95
24	2	9.35	64	2	20.73	104	1	43.02
25	1	11.18	65	2	37.14	105	2	51.91
26	2	8.17	66	2	29.15	106	1	49.03
27	3	11.23	67	1	41.72	107	2	48.84
28	2	8.91	68	4	16.12	108	1	51.82
29	2	7.00	69	5	33.46	End of Test Record		
30	3	11.06	70	2	32.18			
31	2	12.27	71	1	44.83			
32	1	10.47	72	2	37.35			
33	1	10.76	73	1	32.73			
34	4	14.13	74	2	37.83			
35	3	16.06	75	2	27.49			
36	3	13.31	76	2	36.86			
37	3	12.58	77	2	27.18			
38	2	16.71	78	2	34.87			
39	3	11.35	79	1	34.95			
40	3	14.01	80	2	29.38			

PANDA Probe - Test Report

Site 22-4B

Certificate Reference:

2091-PND-Site 22-4B

Sheet:

2 of 2

Client: ARRB

Test Date: 27/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

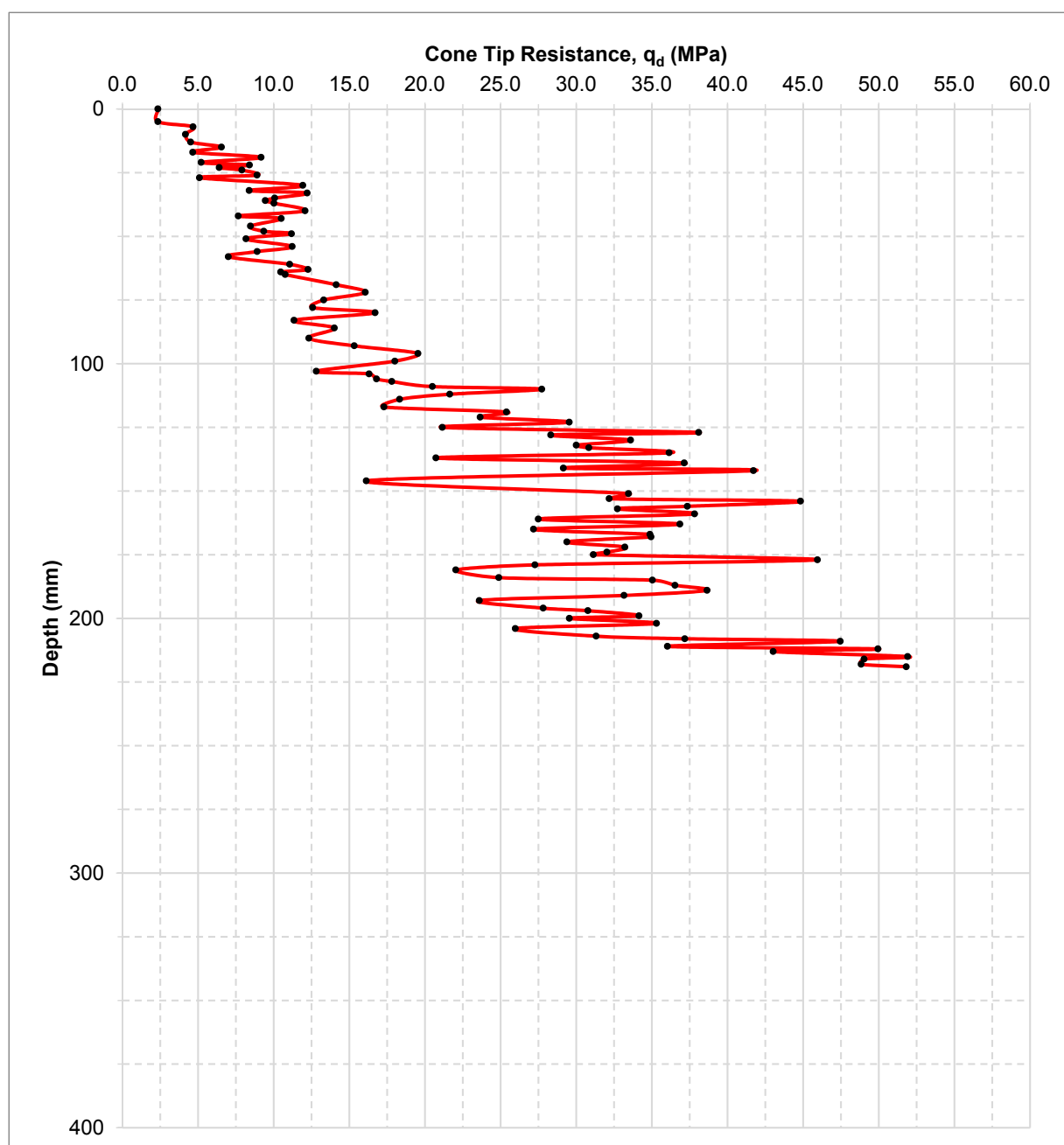
Project No.: 2091

Checked By: DWL

Location: Site 22-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-5

Certificate Reference:

2091-PND-Site 22-5

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	2.40	41	3	24.69			
2	9	5.96	42	3	17.19			
3	11	6.84	43	3	20.48			
4	9	5.96	44	3	18.99			
5	8	7.07	45	4	19.52			
6	8	8.61	46	4	13.18			
7	7	8.47	47	2	23.19			
8	5	8.90	48	3	16.47			
9	5	11.30	49	4	26.79			
10	5	12.57	50	3	24.44			
11	6	11.79	51	3	27.69			
12	5	15.95	52	2	25.47			
13	6	13.51	53	3	21.37			
14	5	14.87	54	2	34.90			
15	5	12.99	55	3	20.82			
16	5	18.87	56	3	19.55			
17	5	13.38	57	3	27.16			
18	4	14.53	58	4	17.52			
19	4	15.69	59	3	20.80			
20	5	18.52	End of Test Record					
21	5	27.44						
22	3	20.35						
23	5	16.79						
24	4	14.63						
25	2	27.26						
26	5	16.34						
27	4	19.73						
28	3	21.05						
29	4	21.52						
30	4	17.58						
31	5	12.23						
32	2	24.58						
33	4	18.67						
34	4	25.85						
35	3	20.08						
36	3	17.60						
37	2	12.81						
38	2	12.30						
39	3	13.60						
40	4	16.49						

PANDA Probe - Test Report

Site 22-5

Certificate Reference:

2091-PND-Site 22-5

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

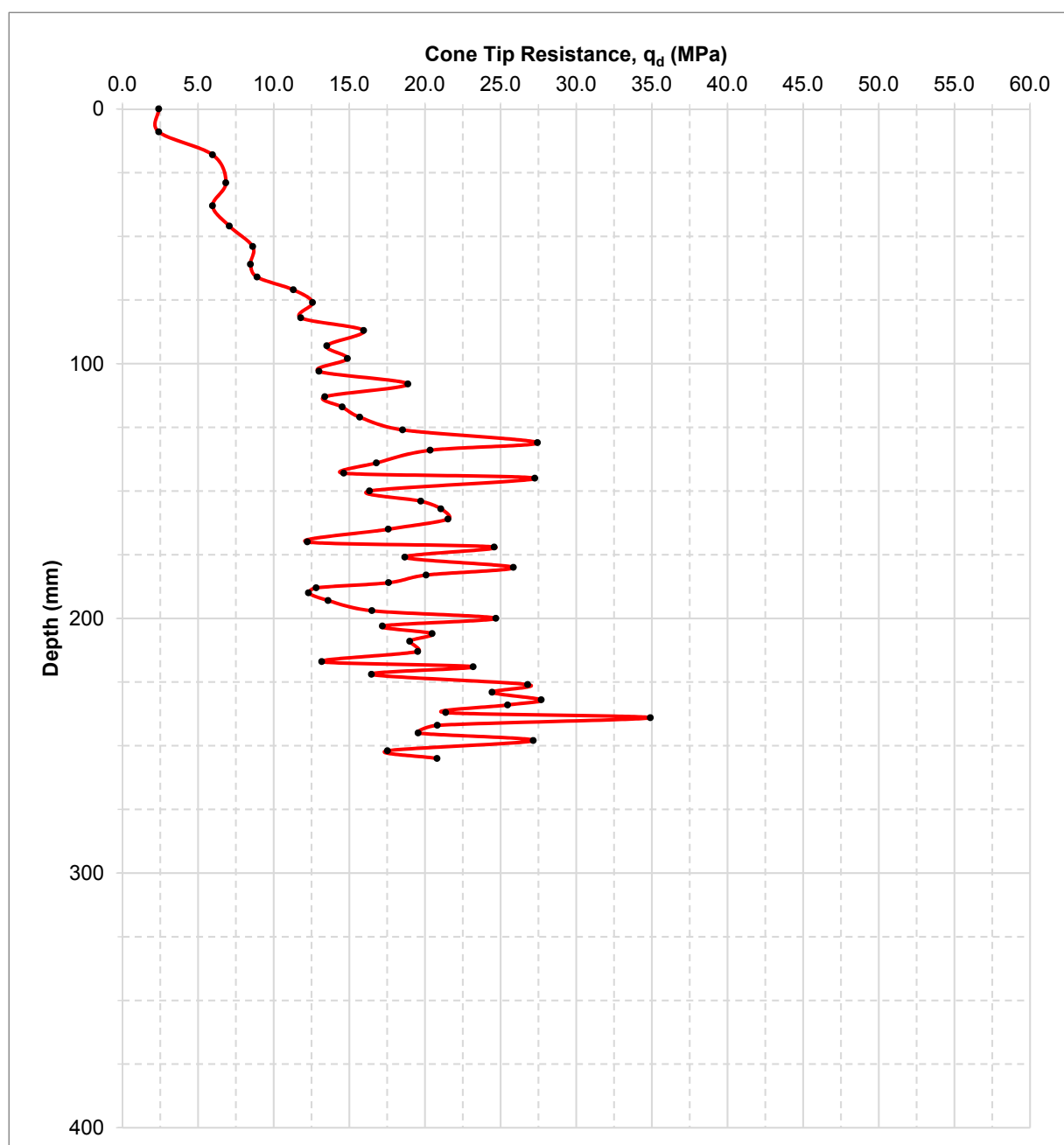
Project No.: 2091

Checked By: DWL

Location: Site 22-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-6

Certificate Reference:

2091-PND-Site 22-6

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	2.54	41	3	19.28			
2	9	5.13	42	4	20.99			
3	12	6.11	43	3	23.63			
4	11	5.87	44	2	21.01			
5	13	5.23	45	3	26.38			
6	10	7.46	46	2	29.57			
7	7	9.34	47	3	27.79			
8	5	9.93	48	4	25.55			
9	6	9.80	49	3	20.03			
10	6	13.26	50	4	18.87			
11	6	13.06	51	4	18.68			
12	5	13.22	52	1	24.07			
13	6	13.44	53	3	21.59			
14	5	10.39	54	2	28.63			
15	3	19.88	55	2	31.67			
16	4	16.82	End of Test Record					
17	4	19.31						
18	3	25.49						
19	4	22.45						
20	3	22.38						
21	4	19.13						
22	5	15.22						
23	4	20.66						
24	4	16.31						
25	4	15.26						
26	5	19.42						
27	4	20.13						
28	4	20.04						
29	4	17.98						
30	4	16.66						
31	4	19.62						
32	5	16.97						
33	4	16.57						
34	5	16.94						
35	5	16.72						
36	4	17.10						
37	3	13.81						
38	4	15.51						
39	3	15.03						
40	4	18.15						

PANDA Probe - Test Report

Site 22-6

Certificate Reference:

2091-PND-Site 22-6

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

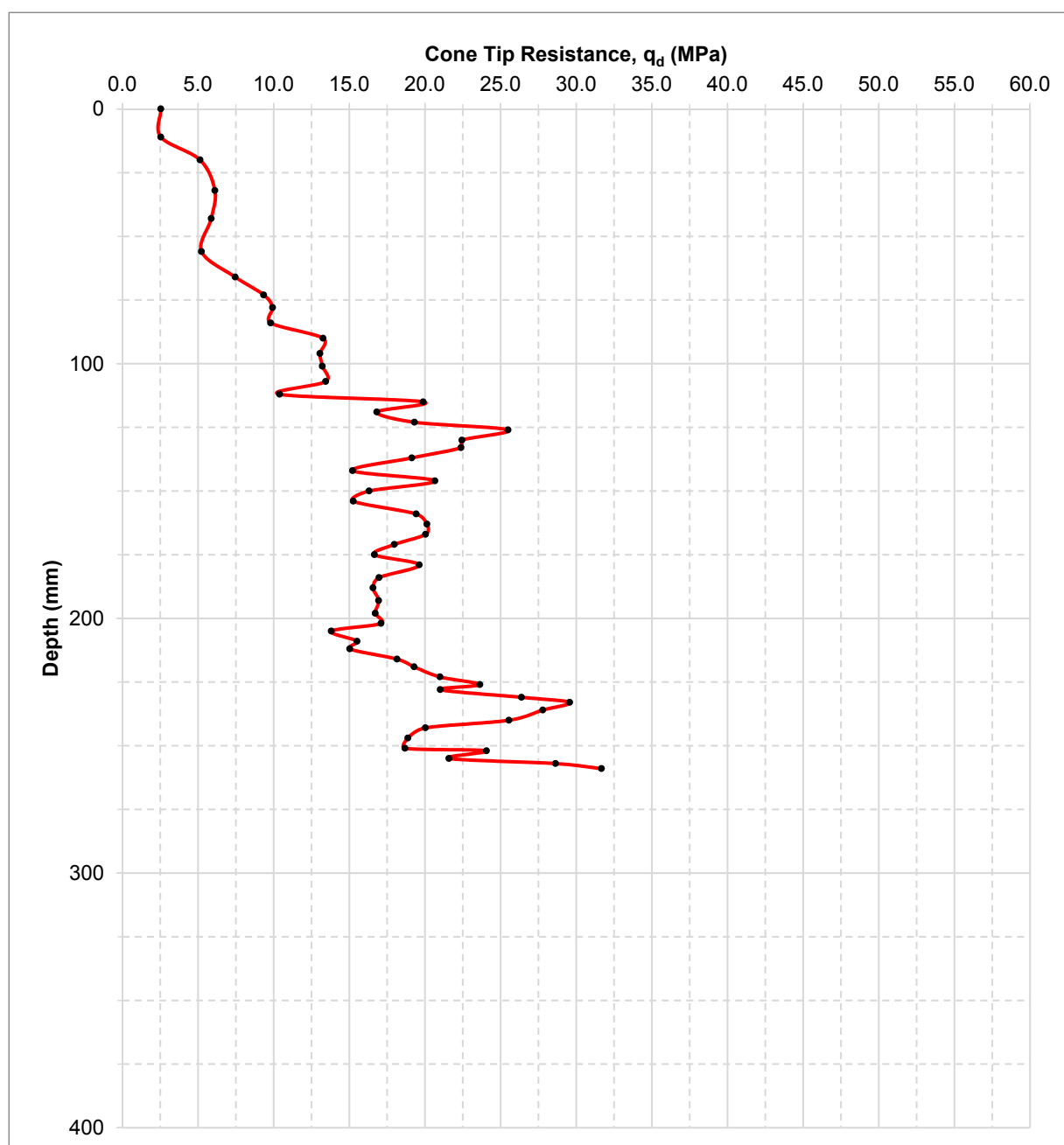
Project No.: 2091

Checked By: DWL

Location: Site 22-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-7

Certificate Reference:

2091-PND-Site 22-7

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	3.98	41	2	24.35			
2	5	4.37	42	2	47.69			
3	5	5.59	43	3	26.84			
4	6	6.07	44	1	41.05			
5	5	4.52	45	2	31.25			
6	5	4.50	46	1	32.77			
7	5	7.78	47	2	33.98			
8	6	7.97	48	3	28.57			
9	6	7.50	49	2	22.50			
10	4	8.60	50	2	27.74			
11	5	11.91	51	3	40.78			
12	6	10.10	52	1	33.60			
13	5	12.26	53	1	37.35			
14	6	10.55	54	2	36.95			
15	4	14.52	55	1	35.87			
16	5	14.08	56	2	41.47			
17	3	17.53	End of Test Record					
18	2	21.98						
19	2	20.21						
20	1	25.18						
21	2	26.37						
22	2	24.80						
23	3	15.24						
24	2	28.91						
25	2	20.42						
26	2	30.55						
27	3	19.04						
28	3	14.10						
29	2	17.55						
30	2	23.30						
31	5	17.28						
32	4	22.30						
33	3	17.21						
34	3	17.96						
35	2	32.77						
36	2	24.84						
37	3	20.30						
38	2	35.14						
39	2	28.49						
40	1	42.39						

PANDA Probe - Test Report

Site 22-7

Certificate Reference:

2091-PND-Site 22-7

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

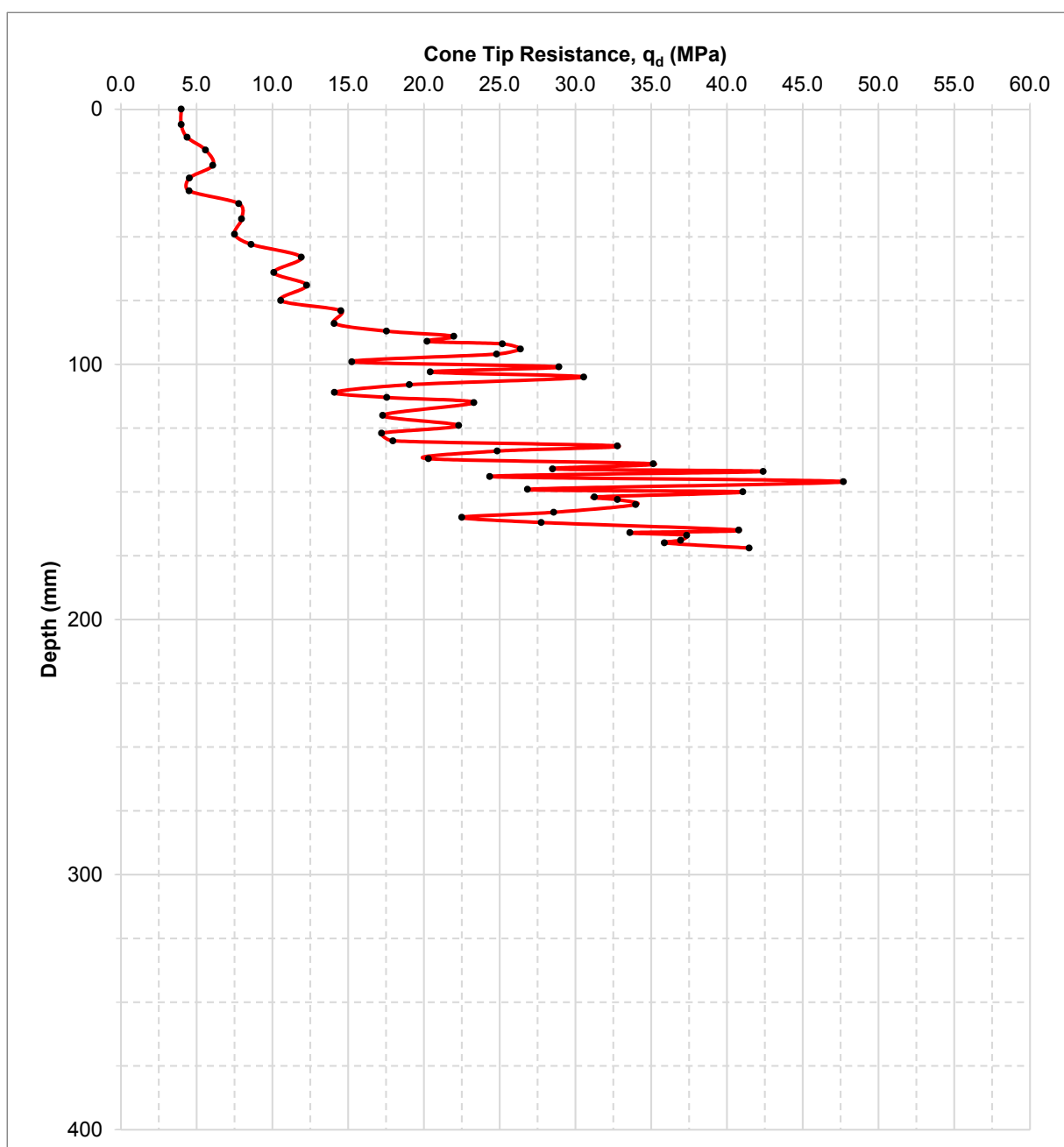
Project No.: 2091

Checked By: DWL

Location: Site 22-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-7A

Certificate Reference:

2091-PND-Site 22-7A

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	3.27	41	2	35.88			
2	12	4.20	42	2	33.44			
3	8	6.36	43	3	24.01			
4	9	5.47	44	2	33.68			
5	7	5.13	45	3	16.88			
6	6	8.39	46	1	42.65			
7	6	7.72	47	2	33.12			
8	5	8.34	48	1	34.07			
9	5	8.23	49	4	22.76			
10	7	8.53	50	1	51.28			
11	4	9.76	51	1	48.03			
12	4	13.32	52	2	41.55			
13	5	12.67	53	1	46.76			
14	3	16.75	54	2	27.72			
15	5	15.14	55	4	38.07			
16	4	16.28	56	2	38.87			
17	5	13.48	57	1	45.37			
18	4	14.64	58	1	44.83			
19	5	16.52	59	2	31.20			
20	1	36.86	60	3	26.81			
21	5	17.01	61	2	46.67			
22	2	19.38	62	1	52.93			
23	2	27.29	63	2	26.12			
24	2	26.24	64	3	23.14			
25	2	31.95	65	1	53.64			
26	2	50.70	66	2	29.20			
27	1	40.95	67	2	29.97			
28	4	35.03	68	1	32.05			
29	3	15.62	69	2	32.36			
30	2	19.97	70	1	29.05			
31	2	26.21	71	2	28.39			
32	2	31.82	72	1	35.97			
33	2	31.53	73	3	27.43			
34	1	42.60	End of Test Record					
35	2	25.43						
36	2	38.49						
37	1	31.70						
38	3	29.05						
39	2	27.55						
40	1	31.00						

PANDA Probe - Test Report

Site 22-7A

Certificate Reference:

2091-PND-Site 22-7A

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

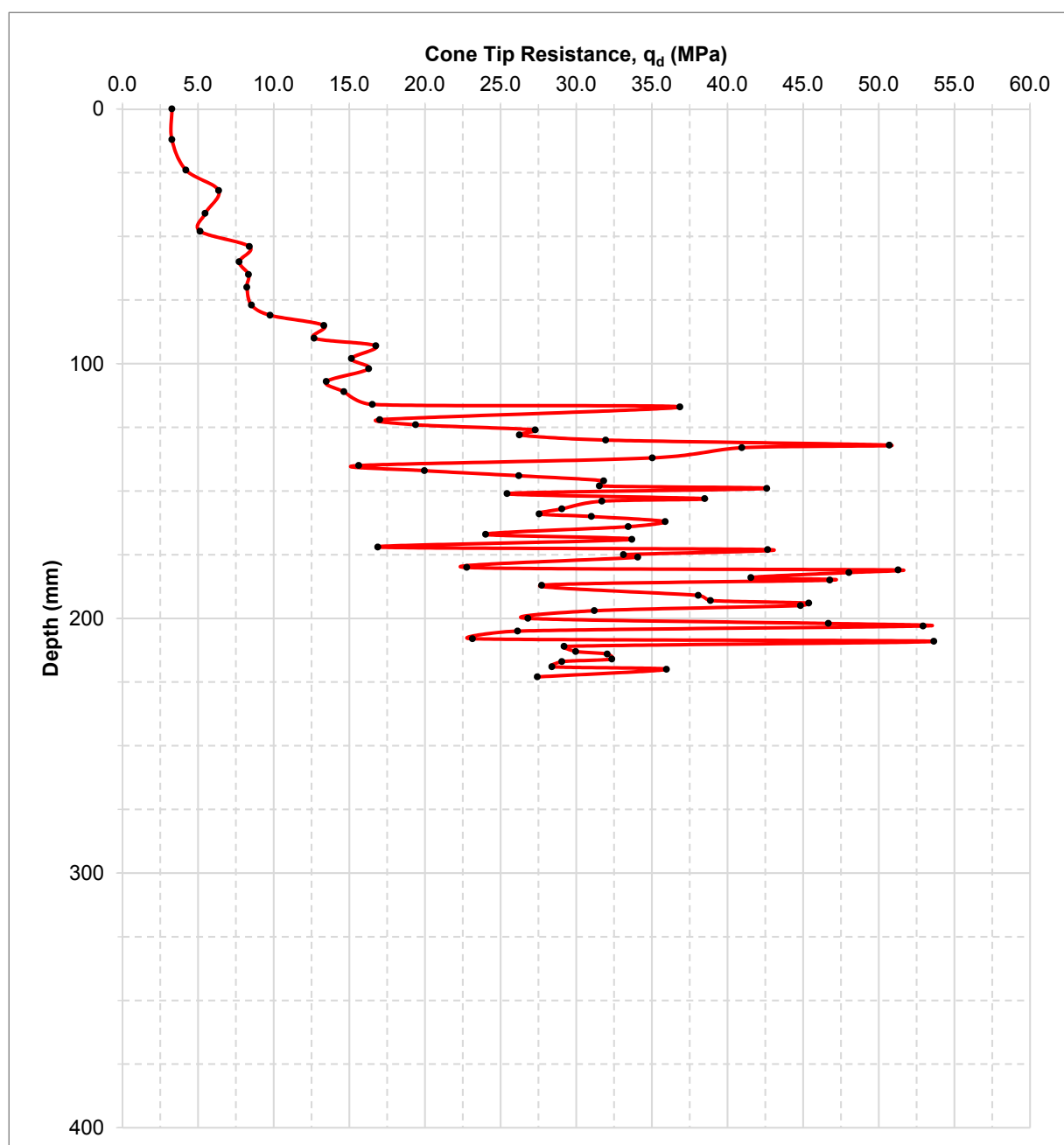
Project No.: 2091

Checked By: DWL

Location: Site 22-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-8

Certificate Reference:

2091-PND-Site 22-8

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	13	5.11	41	2	41.69			
2	2	43.26	42	2	41.07			
3	10	3.65	43	2	28.33			
4	10	5.34	44	2	37.25			
5	7	6.35	45	2	33.37			
6	7	5.10	46	2	32.92			
7	9	9.38	47	1	50.23			
8	8	8.10	48	2	39.06			
9	5	11.87	49	3	29.68			
10	5	16.30	50	2	54.33			
11	6	13.46	51	3	36.16			
12	4	20.73	52	2	38.16			
13	6	17.97	53	6	18.05			
14	3	25.23	54	2	45.71			
15	5	19.40	55	6	22.86			
16	4	25.35	56	4	23.03			
17	4	21.19	57	4	14.24			
18	2	44.36	58	2	61.90			
19	6	16.45	59	3	22.41			
20	4	24.98	60	4	24.36			
21	3	37.67	61	3	30.93			
22	4	21.69	62	2	32.31			
23	3	25.79	63	3	39.18			
24	2	51.92	64	2	30.83			
25	4	14.70	65	3	35.37			
26	3	23.97	66	1	58.30			
27	2	26.99	67	2	34.79			
28	3	27.79	68	2	59.55			
29	1	48.11	69	2	49.80			
30	2	21.46	70	1	46.49			
31	3	23.07	71	2	52.79			
32	2	32.23	End of Test Record					
33	2	42.67						
34	2	25.61						
35	2	40.81						
36	3	34.18						
37	2	29.86						
38	2	33.69						
39	3	33.08						
40	3	43.38						

PANDA Probe - Test Report

Site 22-8

Certificate Reference:

2091-PND-Site 22-8

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

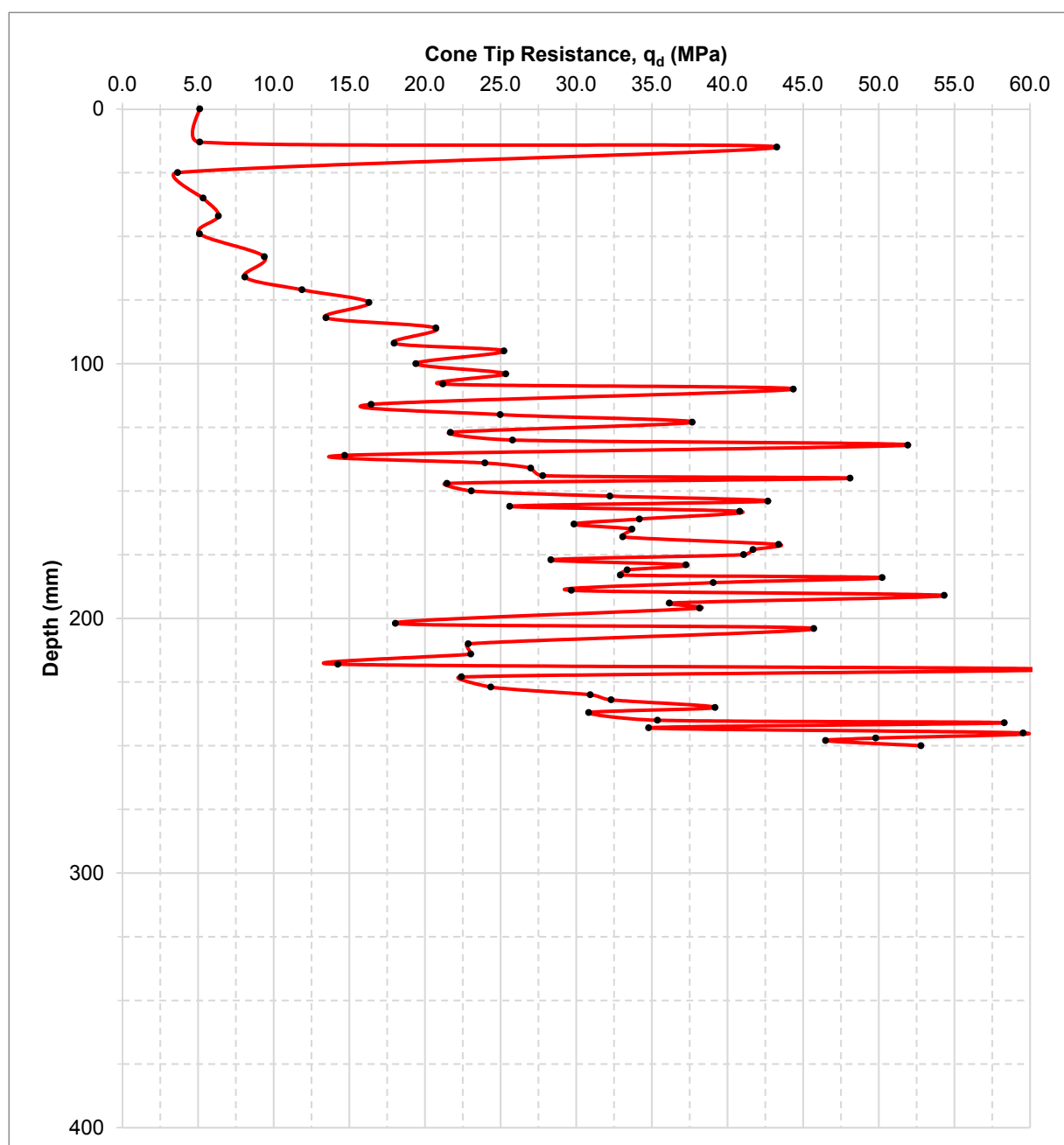
Project No.: 2091

Checked By: DWL

Location: Site 22-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-9

Certificate Reference:

2091-PND-Site 22-9

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	2.68	41	6	20.11			
2	7	5.38	42	7	16.24			
3	9	5.97	43	8	16.92			
4	8	5.63	44	9	15.70			
5	6	7.98	45	8	15.53			
6	8	7.44	46	9	12.89			
7	7	10.50	47	12	11.03			
8	7	10.92	48	9	8.55			
9	2	38.61	49	6	13.32			
10	3	38.19	50	6	11.50			
11	1	75.88	End of Test Record					
12	3	31.59						
13	3	31.32						
14	3	27.42						
15	3	28.74						
16	4	26.85						
17	5	22.11						
18	5	17.81						
19	5	18.87						
20	3	28.45						
21	5	22.07						
22	3	22.58						
23	3	38.25						
24	4	26.83						
25	4	27.37						
26	4	27.17						
27	3	21.82						
28	5	26.16						
29	4	29.38						
30	4	26.74						
31	4	27.98						
32	6	18.88						
33	5	28.63						
34	5	21.93						
35	5	23.78						
36	4	18.40						
37	5	22.30						
38	5	22.82						
39	5	22.43						
40	6	17.70						

PANDA Probe - Test Report

Site 22-9

Certificate Reference:

2091-PND-Site 22-9

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

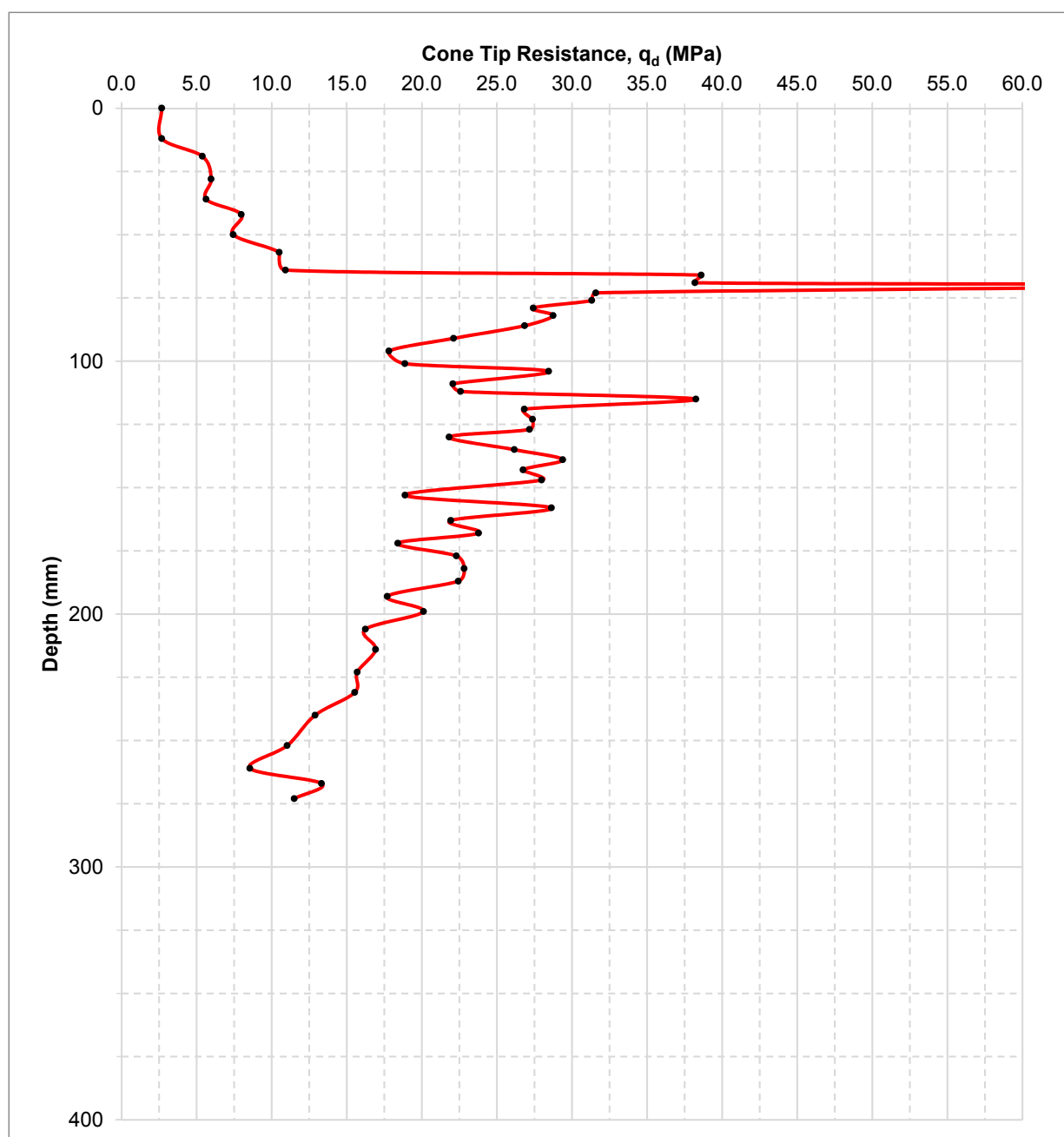
Project No.: 2091

Checked By: DWL

Location: Site 22-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 22-10

Certificate Reference:

2091-PND-Site 22-10

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

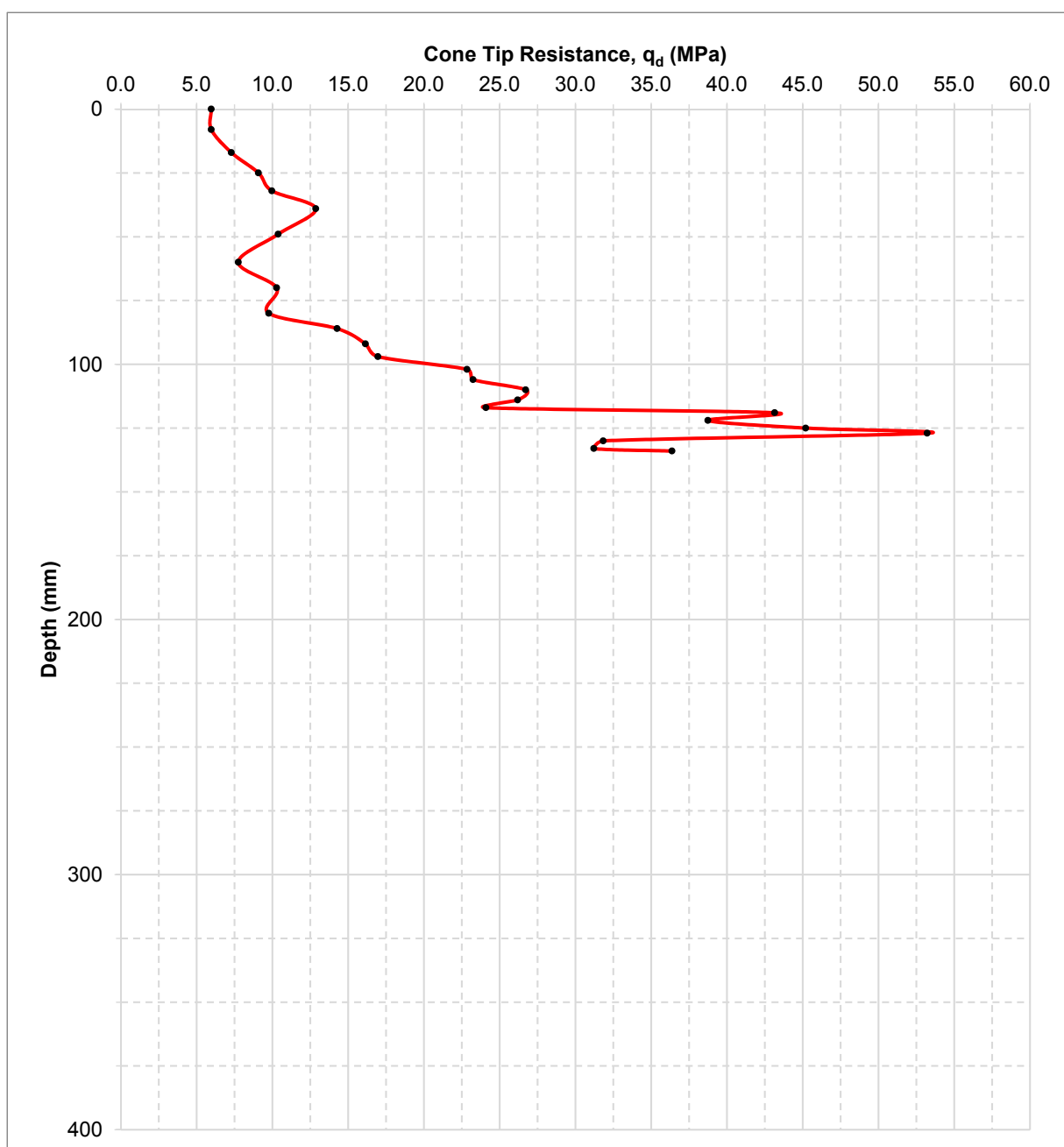
Project No.: 2091

Checked By: DWL

Location: Site 22-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q_d) (MPa)
1	15	4.06
2	11	6.55
3	10	6.26
4	15	7.25
5	11	8.20
6	8	8.64
7	7	10.42
8	7	10.14
9	5	14.26
10	6	16.87
11	4	21.76
12	5	24.75
13	4	27.74
14	4	23.11
15	4	26.29
16	4	27.78
17	4	32.08
18	3	28.96
19	5	29.19
20	5	34.81
21	4	26.99
22	3	32.63
23	3	42.43
24	3	52.06
25	1	98.83
End of Test Record		

PANDA Probe - Test Report

Site 22-10A

Certificate Reference:

2091-PND-Site 22-10A

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

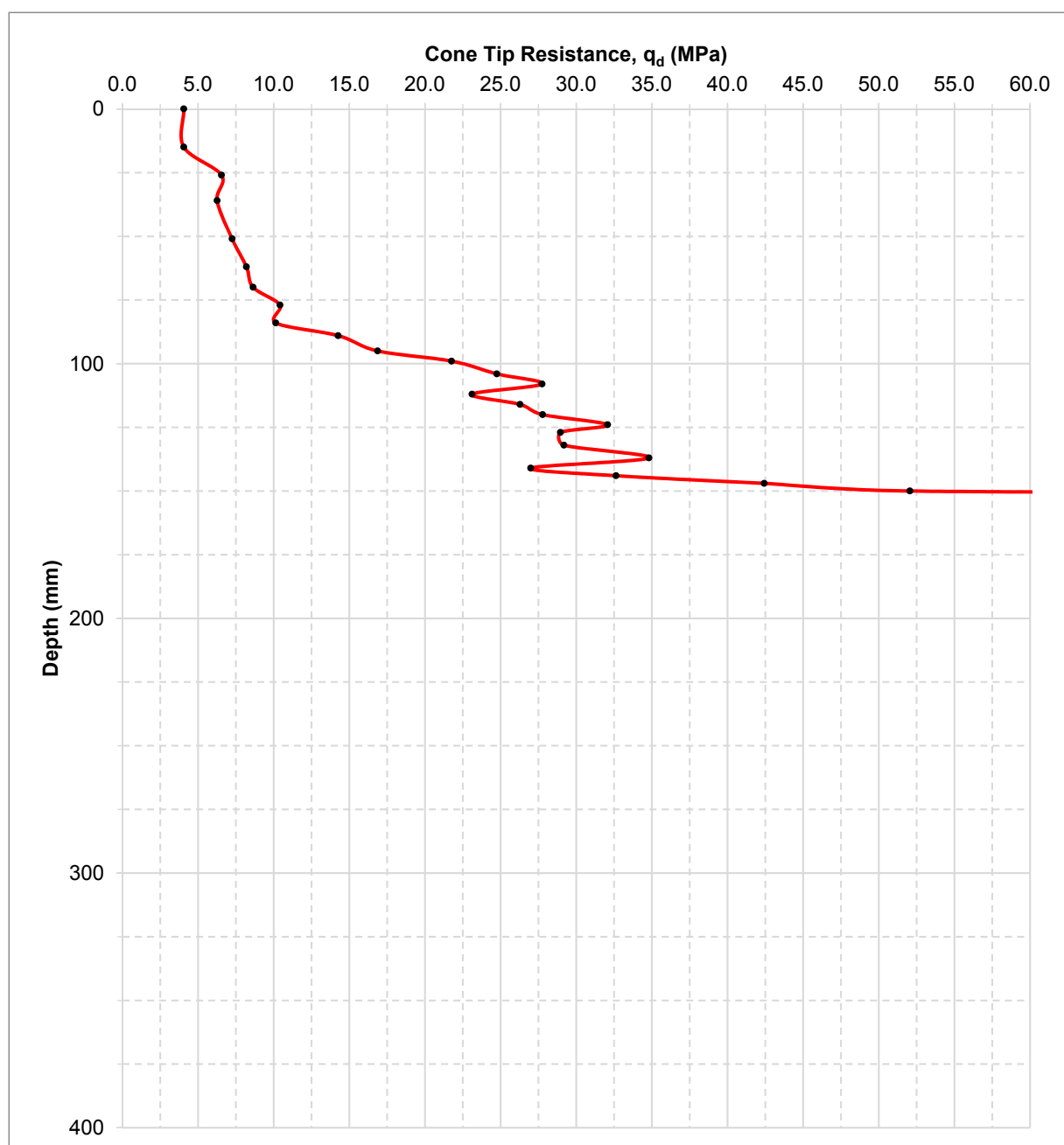
Project No.: 2091

Checked By: DWL

Location: Site 22-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-11

Certificate Reference:

2091-PND-Site 22-11

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	4.78	41	5	23.93			
2	10	8.74	42	5	32.06			
3	9	10.27	43	7	25.96			
4	8	7.87	44	5	22.72			
5	6	7.41	45	4	25.54			
6	6	12.46	46	5	16.53			
7	6	13.21	47	3	26.05			
8	5	14.66	48	5	19.09			
9	6	16.41	49	4	24.05			
10	5	13.75	50	2	22.16			
11	5	17.65	51	3	22.96			
12	5	16.27	52	3	25.60			
13	6	20.68	53	3	23.86			
14	2	30.07	54	3	19.87			
15	4	26.01	55	3	19.77			
16	3	30.60	56	5	19.20			
17	4	31.72	57	4	18.88			
18	3	19.95	58	3	22.29			
19	5	22.82	59	2	18.81			
20	4	22.68	60	1	21.48			
21	4	28.23	61	1	18.39			
22	5	29.01	62	3	13.16			
23	5	23.00	63	1	22.69			
24	3	33.22	End of Test Record					
25	5	26.92						
26	3	26.98						
27	4	31.29						
28	4	24.47						
29	3	35.28						
30	3	36.29						
31	3	30.29						
32	3	23.20						
33	2	30.62						
34	5	21.98						
35	5	32.28						
36	5	29.99						
37	4	25.16						
38	4	28.27						
39	3	41.37						
40	5	36.10						

PANDA Probe - Test Report

Site 22-11

Certificate Reference:

2091-PND-Site 22-11

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

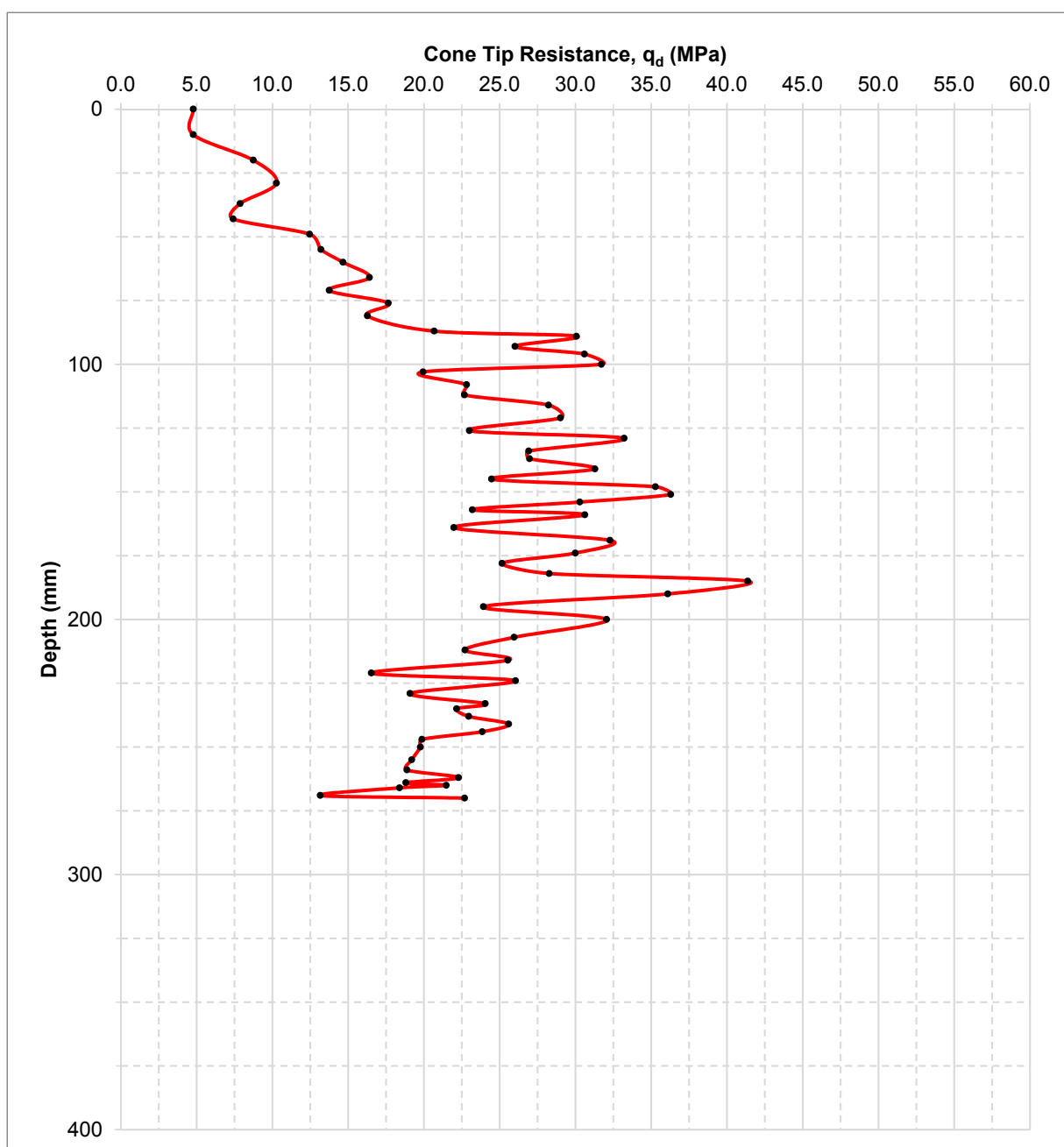
Project No.: 2091

Checked By: DWL

Location: Site 22-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 22-11A

Certificate Reference:

2091-PND-Site 22-11A

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

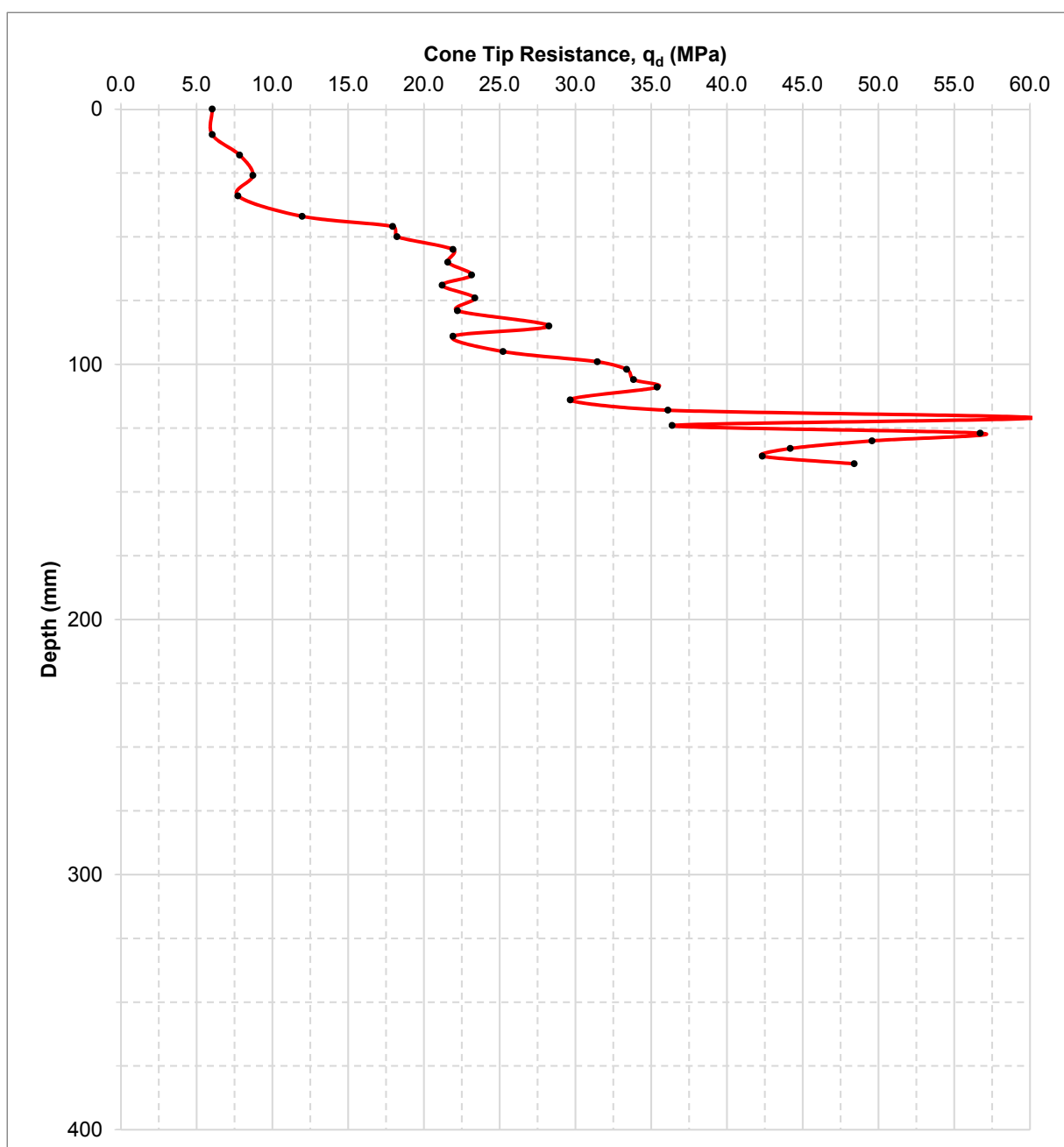
Project No.: 2091

Checked By: DWL

Location: Site 22-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 22-12

Certificate Reference:

2091-PND-Site 22-12

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

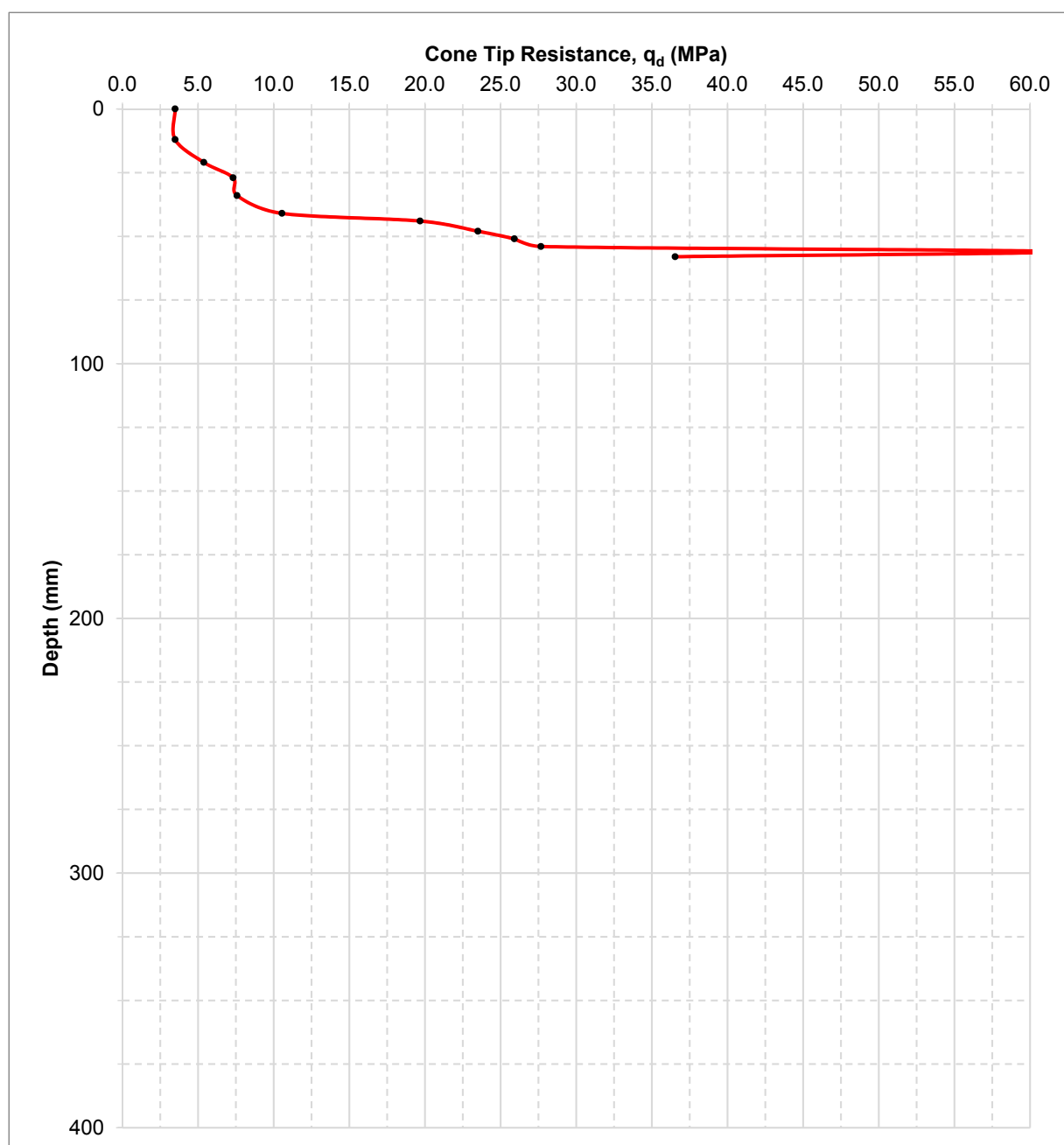
Project No.: 2091

Checked By: DWL

Location: Site 22-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 22-12A

Certificate Reference:

2091-PND-Site 22-12A

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

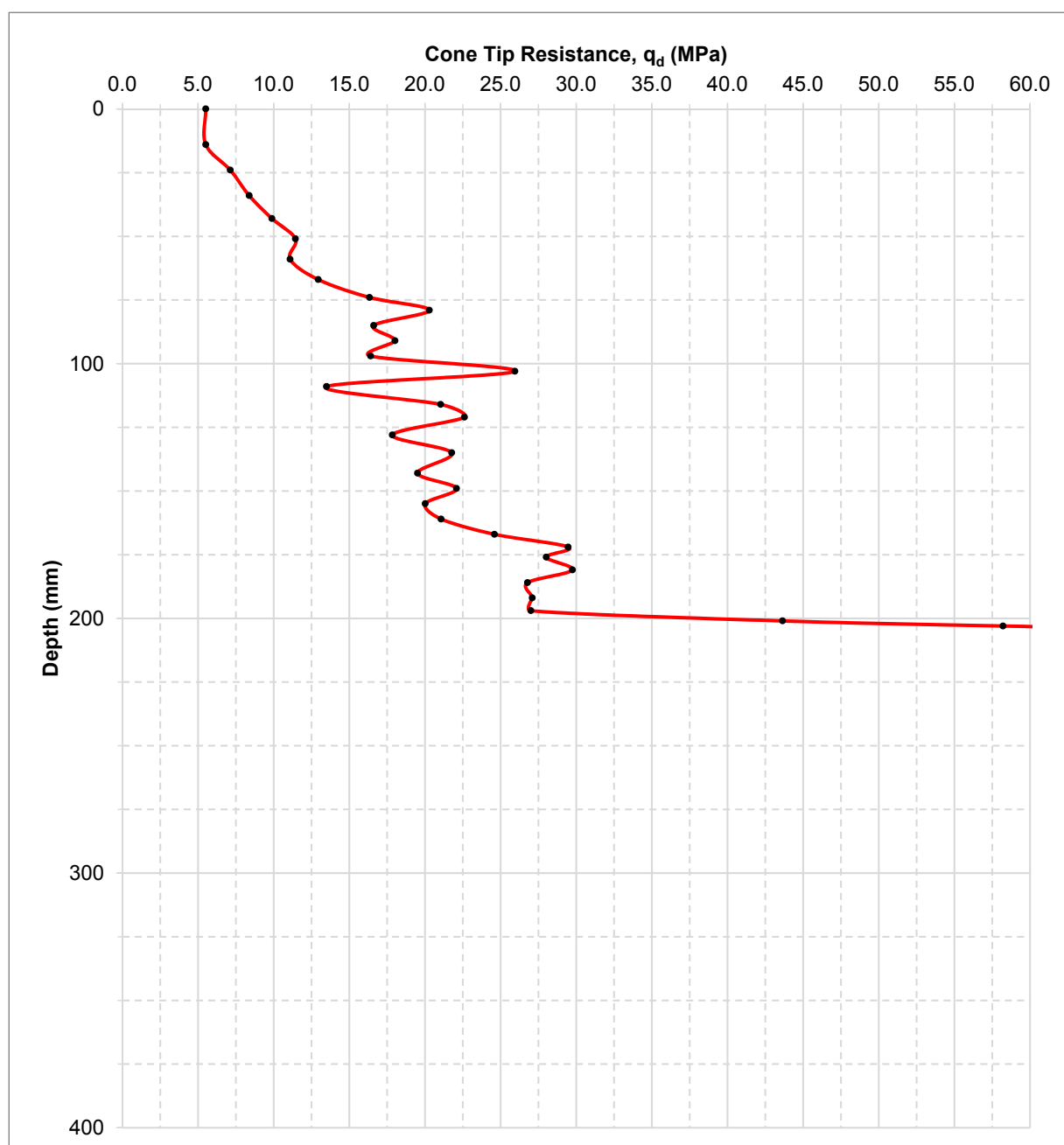
Project No.: 2091

Checked By: DWL

Location: Site 22-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-13

Certificate Reference:

2091-PND-Site 22-13

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	5.17	41	5	12.44			
2	4	8.43	End of Test Record					
3	7	10.47						
4	9	9.50						
5	8	9.99						
6	7	9.93						
7	8	10.58						
8	9	12.64						
9	6	15.02						
10	6	22.44						
11	6	19.84						
12	4	23.84						
13	5	19.77						
14	6	21.55						
15	4	24.54						
16	6	20.10						
17	6	26.48						
18	6	29.08						
19	6	28.10						
20	6	30.02						
21	7	28.45						
22	5	31.55						
23	6	29.40						
24	6	25.96						
25	7	22.60						
26	5	18.77						
27	5	22.51						
28	10	16.84						
29	7	17.19						
30	7	17.34						
31	8	16.84						
32	7	18.62						
33	7	17.33						
34	7	17.14						
35	7	14.55						
36	6	15.80						
37	6	15.30						
38	7	14.32						
39	7	17.60						
40	6	15.02						

PANDA Probe - Test Report

Site 22-13

Certificate Reference:

2091-PND-Site 22-13

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

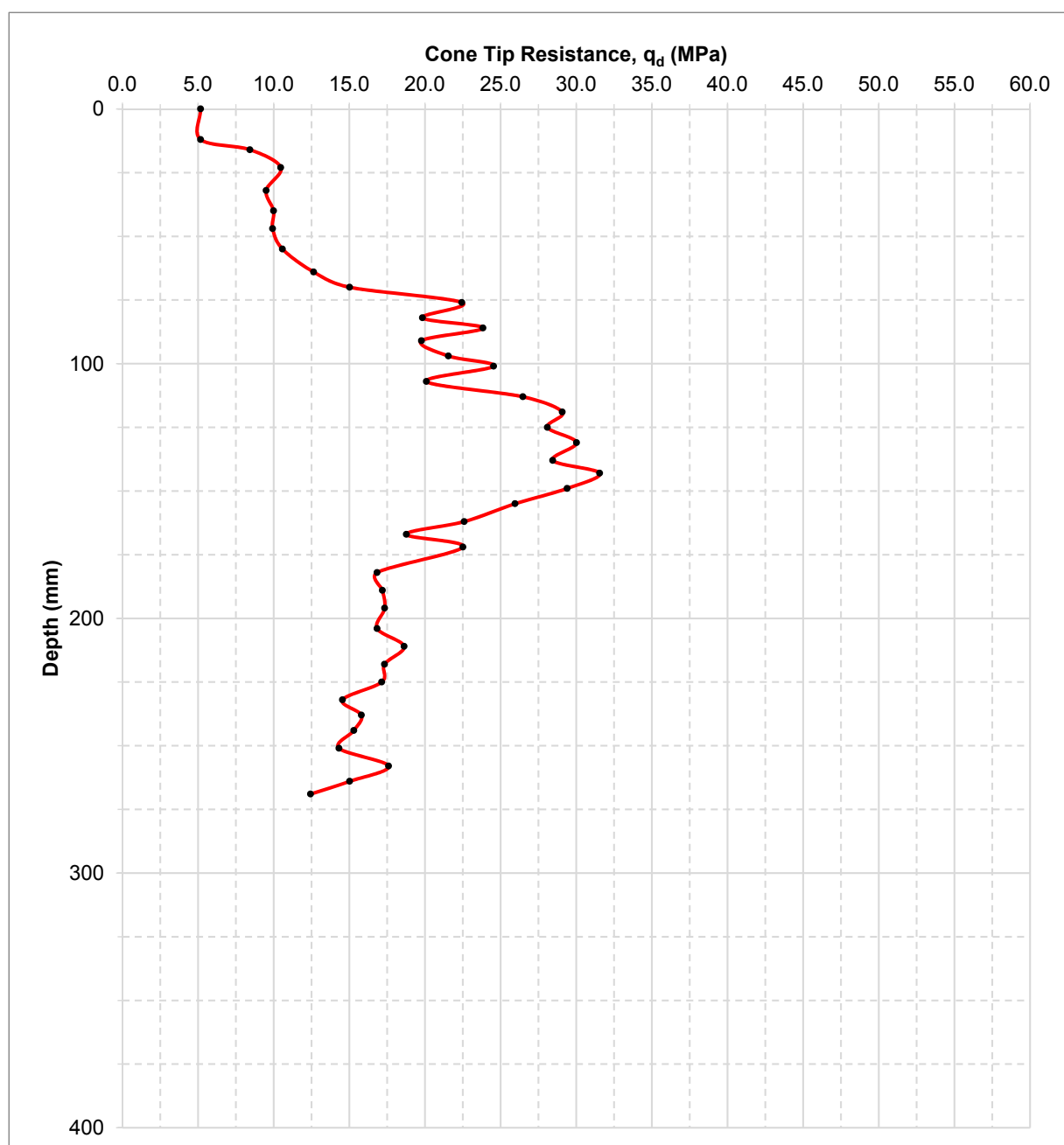
Project No.: 2091

Checked By: DWL

Location: Site 22-13 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 22-14

Certificate Reference:

2091-PND-Site 22-14

Sheet:

1 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 22-14 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	5.51						
2	9	12.96						
3	6	11.72						
4	6	14.55						
5	8	16.69						
6	6	13.90						
7	11	16.17						
8	10	14.13						
9	9	15.37						
10	9	16.25						
11	7	14.88						
12	8	17.46						
13	7	16.60						
14	9	15.32						
15	6	13.52						
16	9	15.80						
17	6	14.78						
18	7	18.58						
19	8	14.36						
20	8	13.59						
21	10	18.21						
22	9	15.33						
23	9	14.04						
24	9	16.71						
25	9	18.51						
26	7	18.86						
27	8	17.95						
28	6	30.52						
29	8	25.70						
30	5	34.12						
31	6	21.44						
32	4	35.69						
33	4	31.82						
34	6	29.96						
35	8	28.03						
36	5	33.56						
37	4	22.63						
End of Test Record								

PANDA Probe - Test Report

Site 22-14

Certificate Reference:

2091-PND-Site 22-14

Sheet:

2 of 2

Client: ARRB

Test Date: 28/02/2019

Project: Best Practice in Compaction QA

Tested By: RM

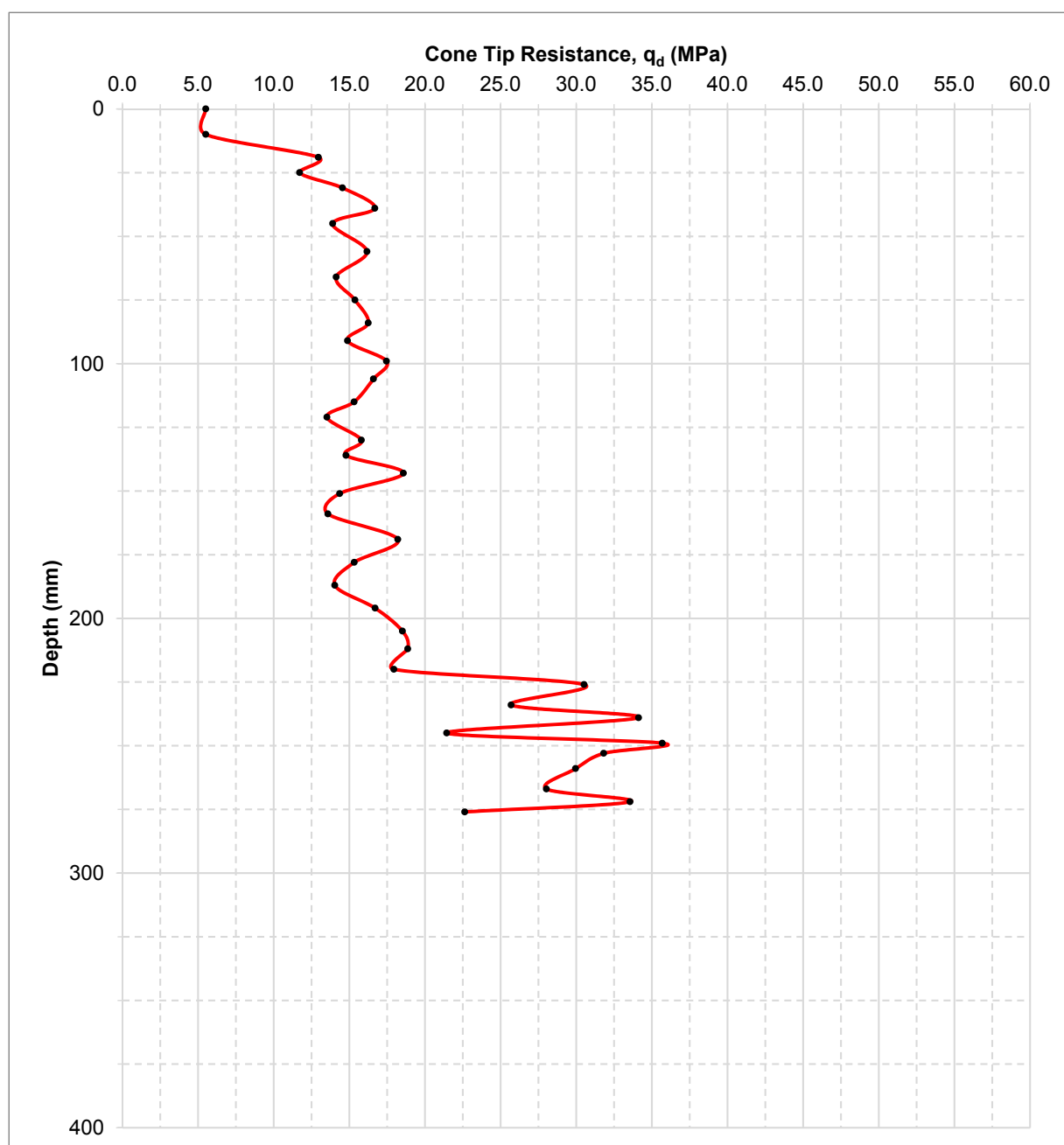
Project No.: 2091

Checked By: DWL

Location: Site 22-14 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 23-1

Certificate Reference:

2091-PND-Site 23-1

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

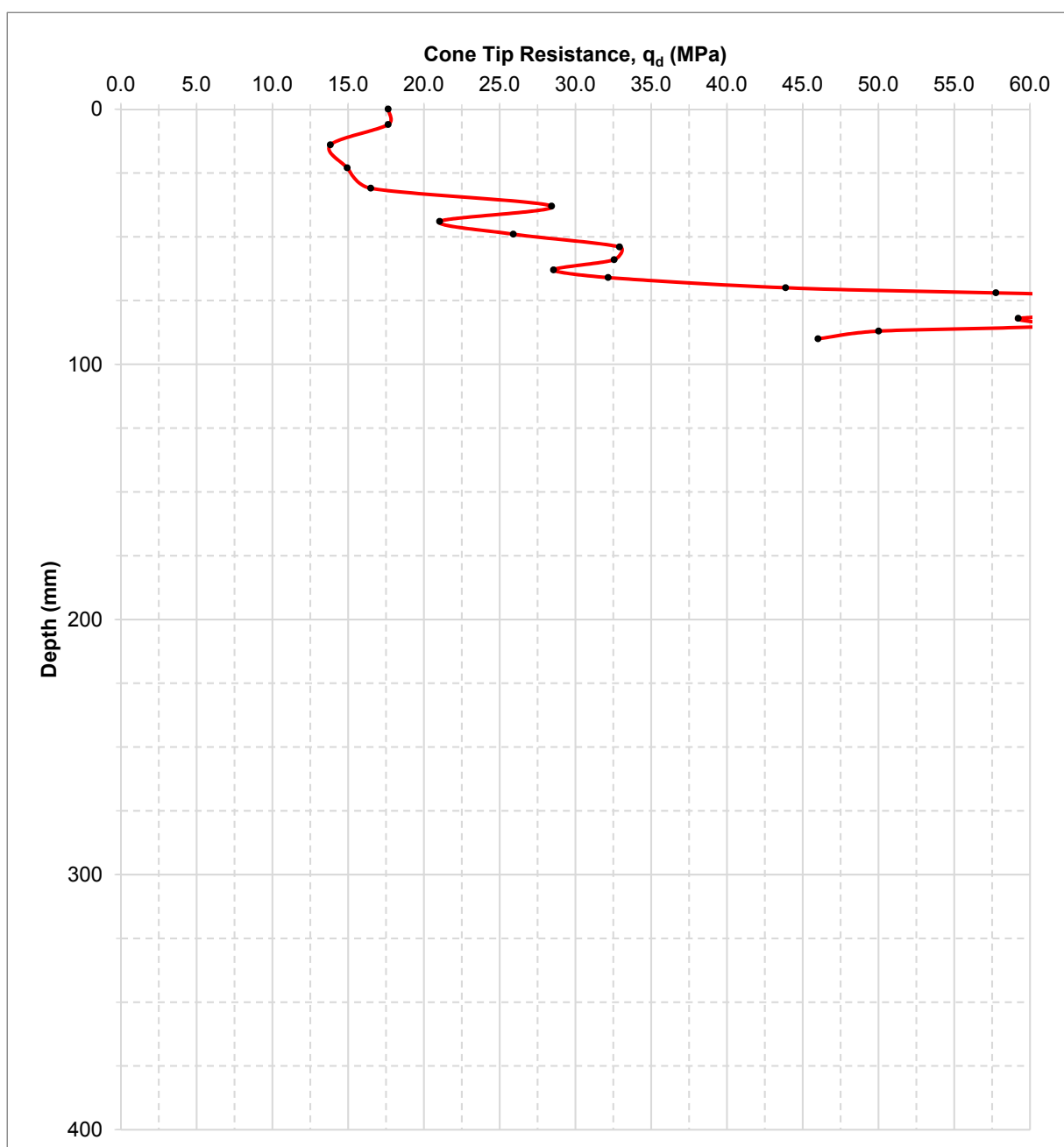
Project No.: 2091

Checked By: DWL

Location: Site 23-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 23-1A

Certificate Reference:

2091-PND-Site 23-1A

Sheet:

1 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 23-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	4.88	41	2	32.90	81	3	26.25
2	10	7.38	42	3	33.29	82	3	20.34
3	9	8.73	43	1	23.39	83	3	15.04
4	5	4.45	44	3	32.67	84	1	26.75
5	6	9.99	45	2	27.42	85	3	24.63
6	5	11.05	46	2	35.39	86	1	42.16
7	6	12.00	47	2	41.79	87	2	49.04
8	5	14.11	48	2	42.12	End of Test Record		
9	5	12.87	49	2	33.71			
10	6	13.98	50	3	31.91			
11	4	13.56	51	2	33.68			
12	4	15.69	52	3	37.82			
13	4	13.17	53	3	33.41			
14	3	18.83	54	4	25.25			
15	3	18.80	55	2	36.28			
16	4	21.95	56	4	28.40			
17	2	24.30	57	2	31.62			
18	4	24.53	58	4	27.08			
19	4	20.47	59	3	27.76			
20	3	20.68	60	3	26.40			
21	3	23.51	61	3	33.38			
22	3	26.56	62	3	27.85			
23	3	25.95	63	3	29.65			
24	4	21.75	64	4	28.97			
25	3	21.90	65	4	20.25			
26	2	28.67	66	4	27.26			
27	3	35.25	67	3	19.23			
28	3	24.19	68	4	20.10			
29	3	23.48	69	3	20.22			
30	3	35.44	70	4	19.79			
31	2	27.85	71	4	23.18			
32	3	36.25	72	4	24.23			
33	2	22.49	73	5	22.53			
34	3	23.15	74	5	22.21			
35	3	27.64	75	3	20.24			
36	2	31.53	76	4	23.50			
37	2	29.81	77	5	21.88			
38	3	28.79	78	3	21.09			
39	3	22.11	79	4	14.08			
40	2	32.90	80	4	21.14			

PANDA Probe - Test Report

Site 23-1A

Certificate Reference:

2091-PND-Site 23-1A

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

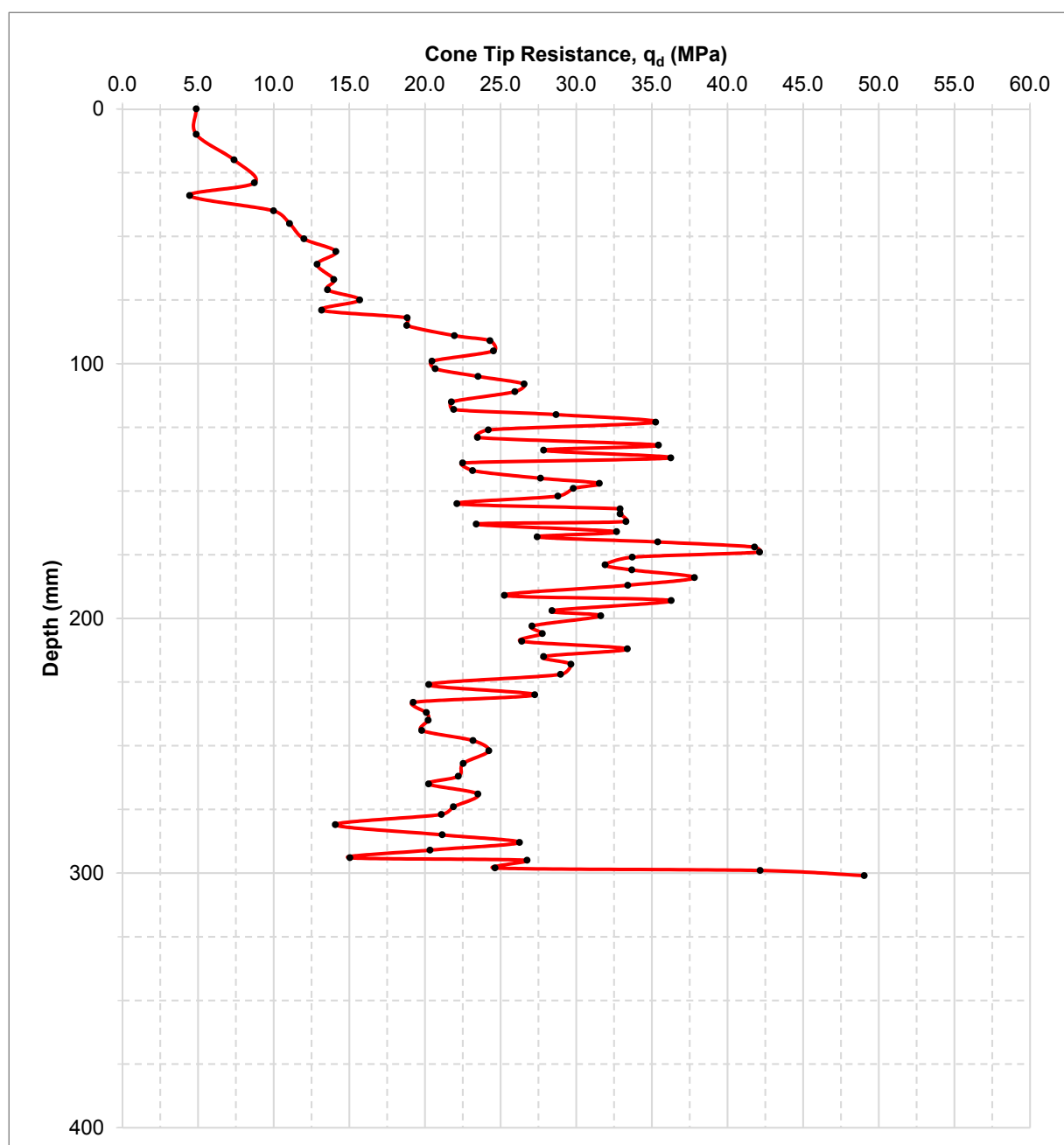
Project No.: 2091

Checked By: DWL

Location: Site 23-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 23-2

Certificate Reference:

2091-PND-Site 23-2

Sheet:

1 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 23-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	3.06	41	4	12.02	81	3	8.49
2	7	3.60	42	2	10.80	82	2	9.93
3	7	4.41	43	2	12.73	83	3	12.13
4	7	2.92	44	3	6.34	84	3	13.00
5	6	5.40	45	3	14.19	85	2	8.59
6	5	6.41	46	2	9.56	86	3	8.62
7	5	6.32	47	3	14.80	87	2	11.21
8	5	6.88	48	2	16.64	88	1	11.25
9	6	6.78	49	2	14.40	89	3	10.79
10	5	7.96	50	2	22.61	90	3	11.45
11	3	8.54	51	2	21.19	91	1	12.75
12	5	6.40	52	1	19.44	92	2	13.54
13	4	6.12	53	4	12.80	93	2	14.82
14	4	6.56	54	1	20.21	94	2	20.81
15	4	8.32	55	2	10.78	95	2	11.62
16	4	5.36	56	2	26.76	96	2	16.58
17	4	9.49	57	2	12.76	97	3	10.69
18	5	10.25	58	1	9.48	98	2	13.58
19	4	12.03	59	2	24.77	99	2	18.82
20	3	10.98	60	2	11.75	100	1	18.52
21	3	14.09	61	2	18.58	101	2	17.70
22	2	15.70	62	1	14.37	102	2	15.78
23	3	13.79	63	3	14.19	103	1	14.59
24	2	15.01	64	2	13.08	104	3	14.02
25	3	15.50	65	2	11.30	End of Test Record		
26	3	11.10	66	2	13.95			
27	3	11.84	67	3	14.29			
28	3	15.06	68	2	16.27			
29	3	9.78	69	3	14.06			
30	2	12.22	70	2	13.44			
31	3	11.35	71	2	11.98			
32	2	12.54	72	2	16.55			
33	3	13.95	73	3	9.57			
34	2	14.09	74	3	12.99			
35	3	15.72	75	3	10.66			
36	3	8.71	76	3	10.57			
37	2	8.88	77	3	12.45			
38	3	12.89	78	3	10.80			
39	3	6.71	79	2	12.50			
40	2	10.10	80	3	9.76			

Certificate Reference:

2091-PND-Site 23-2

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

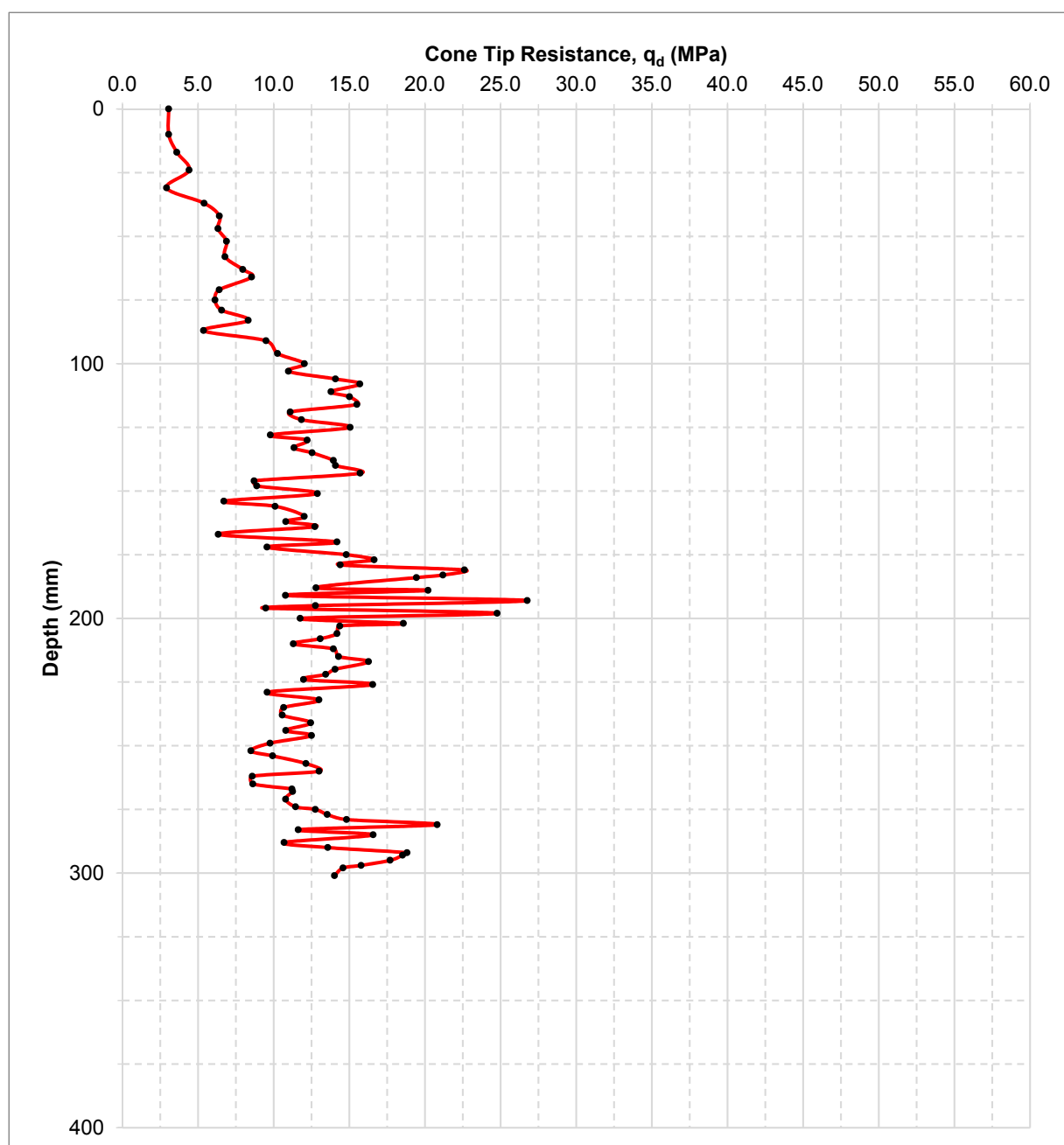
Project No.: 2091

Checked By: DWL

Location: Site 23-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 23-3

Certificate Reference:

2091-PND-Site 23-3

Sheet:

1 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 23-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	4.29	41	4	18.45			
2	9	4.94	42	5	16.20			
3	8	7.40	43	3	16.66			
4	7	7.76	44	4	18.55			
5	7	9.12	45	4	14.25			
6	7	9.63	46	3	19.02			
7	7	8.92	47	3	12.80			
8	5	6.00	48	2	45.16			
9	6	11.21	49	4	19.25			
10	6	13.21	50	3	19.30			
11	6	12.21	51	3	21.44			
12	7	9.63	52	5	17.44			
13	6	6.00	53	4	21.20			
14	8	8.59	54	5	12.73			
15	6	8.49	55	6	14.39			
16	6	12.12	56	5	9.28			
17	6	11.95	57	6	9.96			
18	7	14.68	58	6	9.75			
19	6	12.04	59	7	10.09			
20	6	12.21	End of Test Record					
21	6	13.97						
22	6	15.66						
23	4	16.40						
24	5	15.88						
25	4	18.05						
26	4	12.80						
27	3	16.01						
28	5	18.99						
29	4	18.30						
30	3	19.34						
31	5	14.70						
32	4	19.81						
33	4	16.88						
34	4	16.53						
35	3	17.74						
36	3	23.33						
37	4	16.58						
38	4	18.31						
39	3	25.21						
40	5	15.13						

PANDA Probe - Test Report

Site 23-3

Certificate Reference:

2091-PND-Site 23-3

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

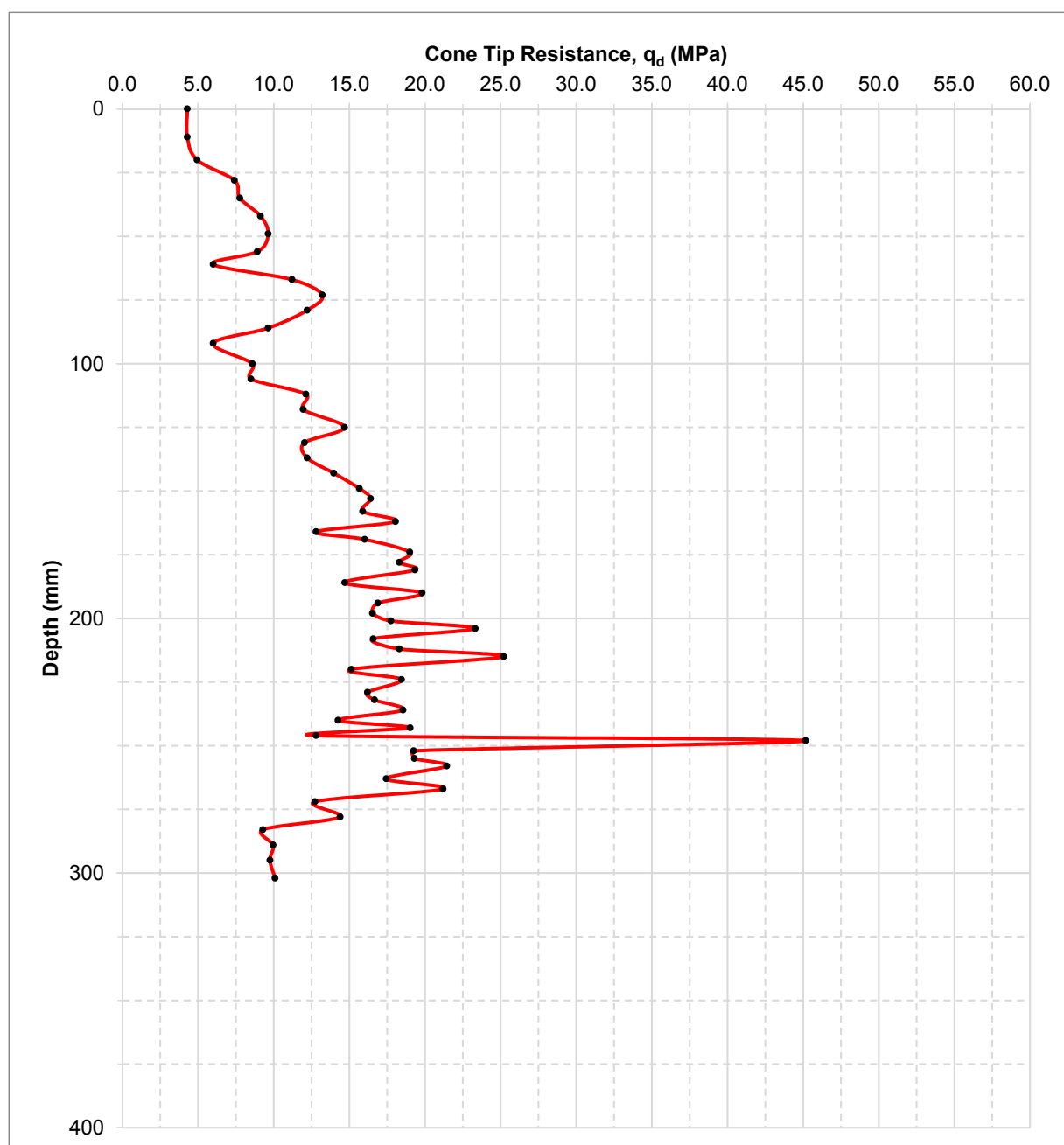
Project No.: 2091

Checked By: DWL

Location: Site 23-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 23-4

Certificate Reference:

2091-PND-Site 23-4

Sheet:

1 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 23-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	3.68	41	2	37.55			
2	8	4.27	42	3	33.62			
3	8	6.60	43	2	20.26			
4	7	7.74	44	1	34.48			
5	5	8.24	45	2	31.17			
6	4	19.26	46	2	29.85			
7	7	7.67	47	2	50.97			
8	6	9.83	48	2	34.58			
9	4	11.79	49	1	35.95			
10	4	14.44	50	2	7.84			
11	4	22.71	51	2	63.25			
12	4	17.27	52	1	17.67			
13	3	13.25	53	1	47.89			
14	3	19.50	54	2	53.62			
15	2	26.19	55	1	34.83			
16	3	31.26	End of Test Record					
17	2	26.60						
18	2	55.18						
19	4	25.40						
20	1	43.69						
21	4	15.47						
22	2	32.18						
23	4	18.40						
24	2	19.74						
25	3	25.71						
26	3	30.36						
27	1	43.38						
28	3	11.47						
29	2	28.30						
30	2	25.31						
31	3	25.62						
32	2	30.30						
33	3	26.29						
34	2	31.30						
35	2	33.72						
36	2	30.56						
37	2	41.82						
38	3	37.10						
39	2	26.38						
40	2	34.31						

PANDA Probe - Test Report

Site 23-4

Certificate Reference:

2091-PND-Site 23-4

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

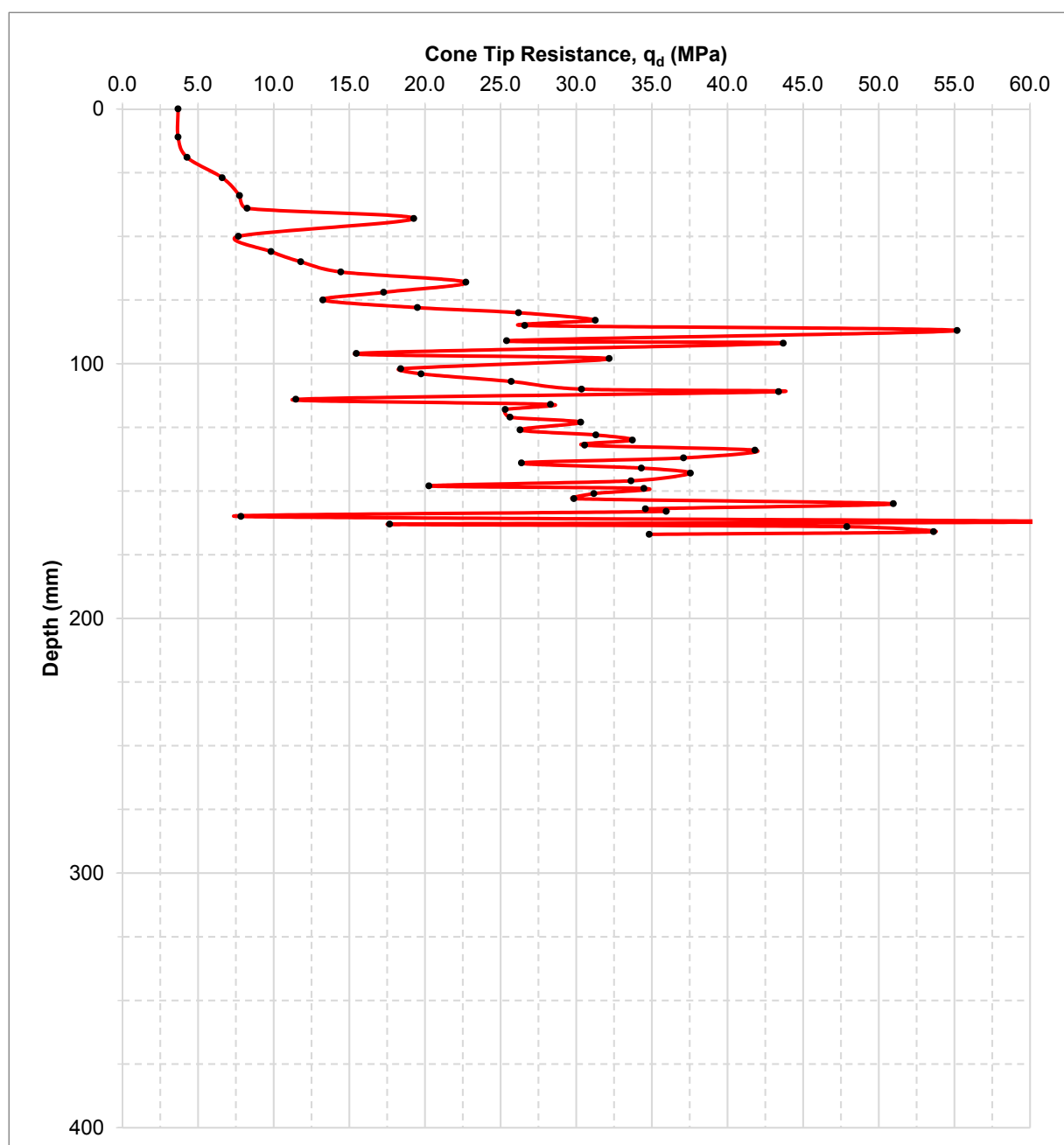
Project No.: 2091

Checked By: DWL

Location: Site 23-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 23-4A

Certificate Reference:

2091-PND-Site 23-4A

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

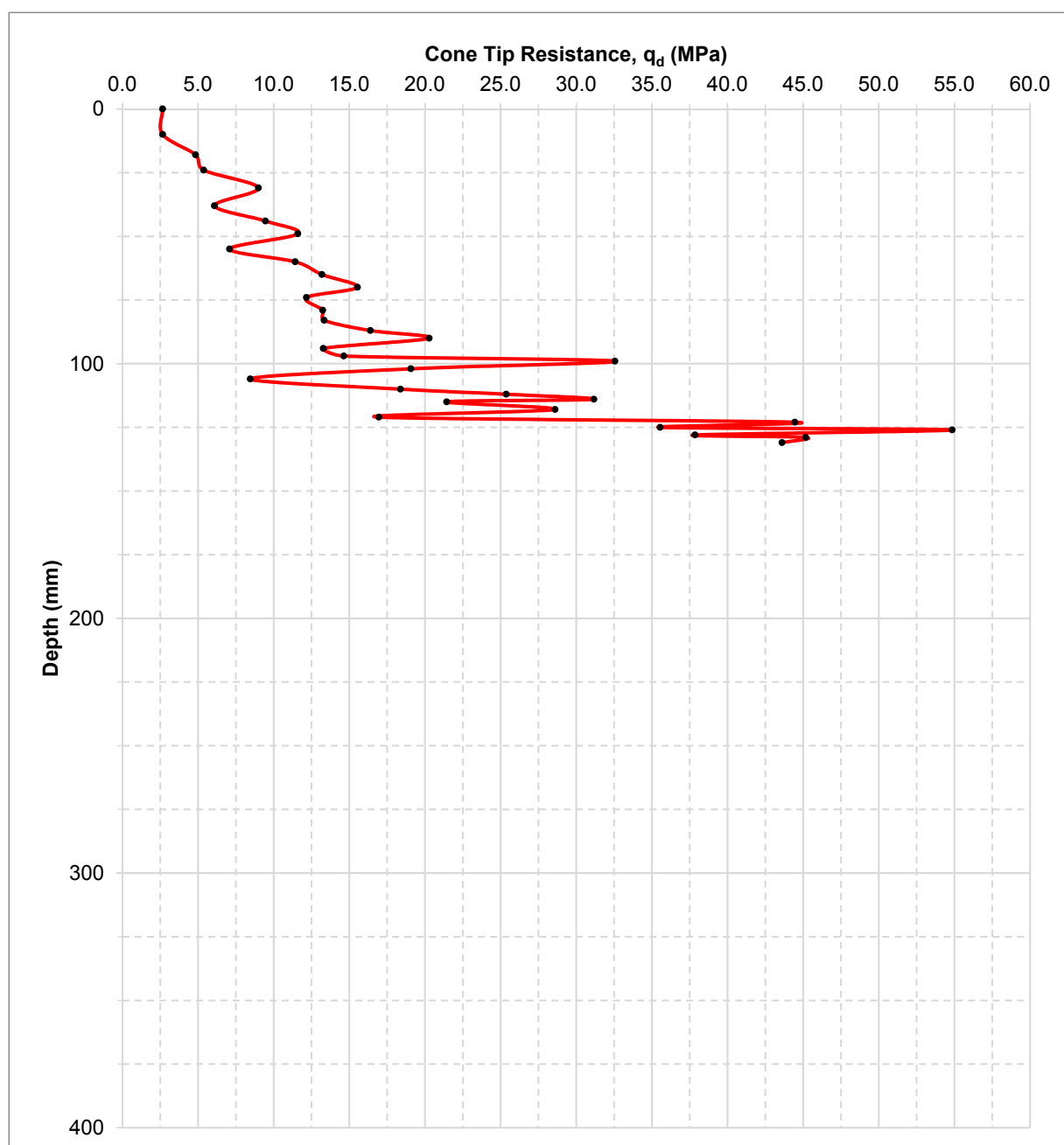
Project No.: 2091

Checked By: DWL

Location: Site 23-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 23-5

Certificate Reference:

2091-PND-Site 23-5

Sheet:

1 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 23-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	5.88	41	2	17.73	81	5	12.91
2	6	7.25	42	3	18.29	82	4	17.74
3	5	8.91	43	4	22.00	83	2	24.83
4	4	9.79	44	2	27.47	84	5	9.50
5	5	11.78	45	3	17.07	85	4	15.25
6	5	8.95	46	2	22.42	86	3	13.88
7	4	13.26	47	4	16.22	87	3	17.15
8	2	26.83	48	3	21.16	88	2	19.88
9	3	11.60	49	4	14.96	89	3	23.63
10	5	2.88	50	2	21.85	90	4	17.76
11	4	13.97	51	3	22.74	91	3	15.16
12	3	18.87	52	3	14.64	92	4	24.93
13	5	15.13	53	2	29.47	End of Test Record		
14	2	28.12	54	3	21.14			
15	5	10.52	55	2	23.35			
16	2	23.37	56	1	50.62			
17	5	10.52	57	5	23.12			
18	3	16.71	58	2	28.09			
19	4	18.58	59	4	18.81			
20	2	21.22	60	1	40.74			
21	3	18.92	61	5	17.84			
22	4	19.26	62	3	23.85			
23	4	16.91	63	4	15.59			
24	3	18.93	64	3	23.89			
25	3	22.81	65	3	18.96			
26	2	30.20	66	3	20.56			
27	2	28.42	67	3	19.64			
28	4	19.84	68	3	22.03			
29	3	19.35	69	3	20.16			
30	2	34.05	70	3	19.25			
31	3	20.44	71	3	14.73			
32	3	26.53	72	2	30.51			
33	3	26.12	73	6	11.55			
34	1	51.63	74	3	19.35			
35	4	14.66	75	3	11.97			
36	2	24.03	76	4	15.90			
37	3	26.01	77	3	21.90			
38	3	19.54	78	3	17.78			
39	2	36.48	79	4	16.66			
40	3	14.93	80	3	16.47			

PANDA Probe - Test Report

Site 23-5

Certificate Reference:

2091-PND-Site 23-5

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

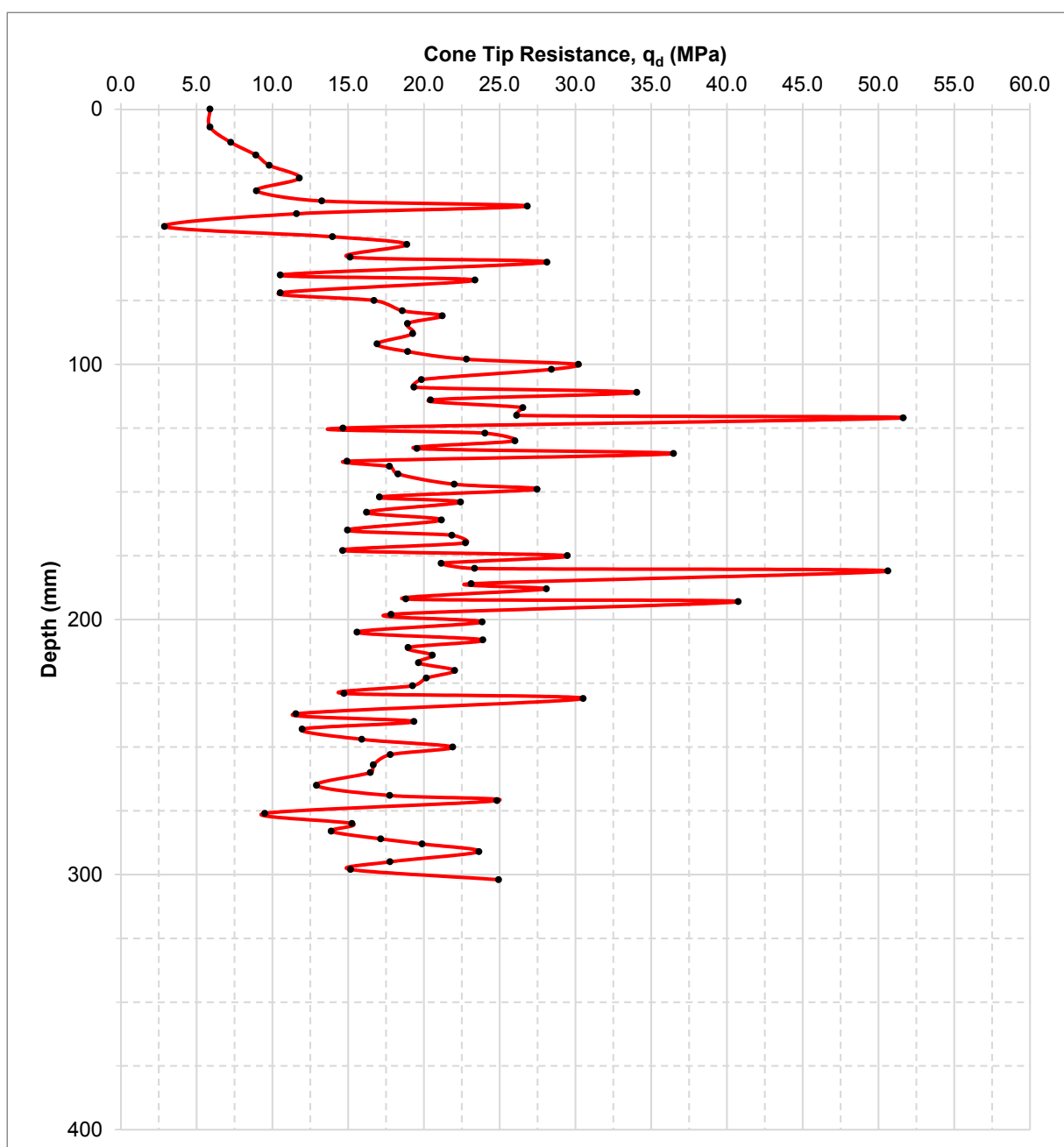
Project No.: 2091

Checked By: DWL

Location: Site 23-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 23-6

Certificate Reference:

2091-PND-Site 23-6

Sheet:

1 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 23-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	3.35	41	3	26.18			
2	8	6.65	42	2	23.53			
3	8	6.78	43	3	28.68			
4	4	14.79	44	3	17.95			
5	5	15.90	45	2	13.15			
6	4	13.42	46	2	17.92			
7	3	16.85	47	3	26.23			
8	3	26.71	48	3	32.49			
9	3	23.73	49	2	32.17			
10	5	10.78	50	2	39.06			
11	4	19.69	51	3	47.69			
12	5	6.69	52	1	35.43			
13	6	10.59	53	2	57.76			
14	6	7.46	54	1	55.92			
15	5	12.90	End of Test Record					
16	5	12.95						
17	5	10.47						
18	5	12.74						
19	6	11.80						
20	4	17.84						
21	4	13.44						
22	6	9.86						
23	3	14.32						
24	4	17.89						
25	4	17.46						
26	3	13.32						
27	3	15.70						
28	4	19.92						
29	4	20.64						
30	3	19.59						
31	4	18.57						
32	4	20.51						
33	3	15.50						
34	3	18.51						
35	3	20.96						
36	4	18.30						
37	3	20.83						
38	3	15.34						
39	3	26.31						
40	3	25.60						

PANDA Probe - Test Report

Site 23-6

Certificate Reference:

2091-PND-Site 23-6

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

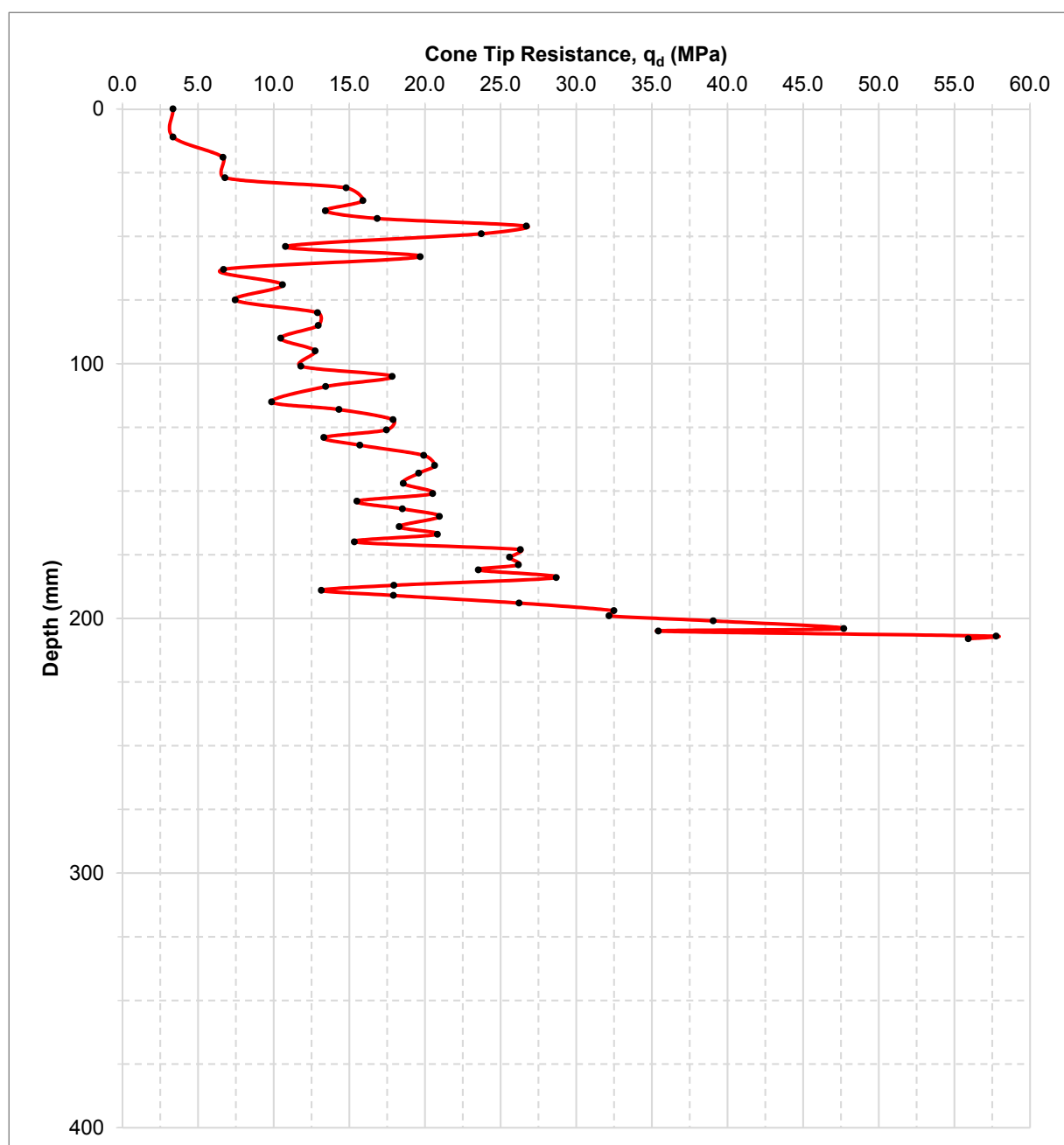
Project No.: 2091

Checked By: DWL

Location: Site 23-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 24-1

Certificate Reference:

2091-PND-Site 24-1

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

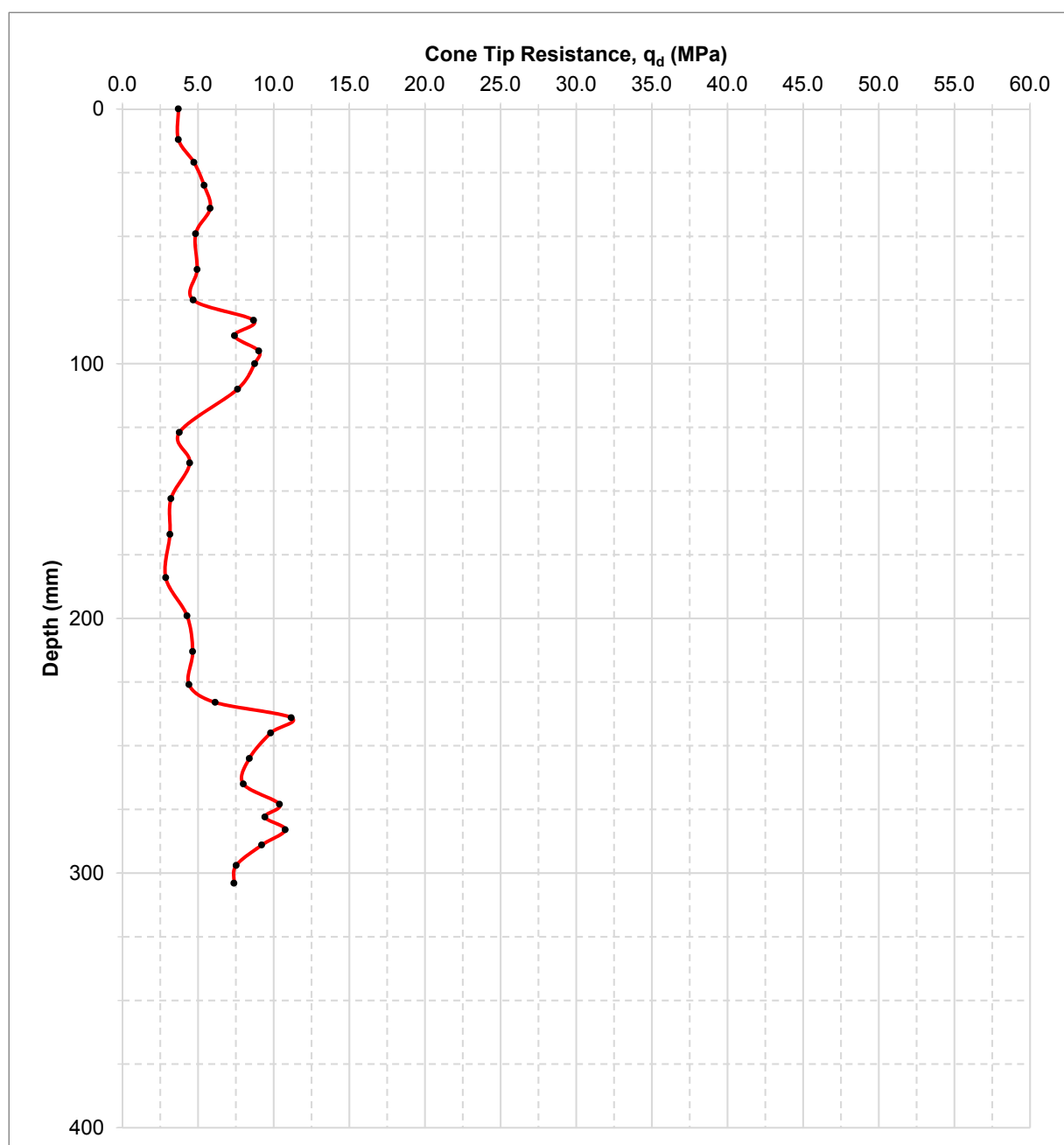
Project No.: 2091

Checked By: DWL

Location: Site 24-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-1 (Retest, < 24 hrs)

Certificate Reference:

2091-PND-Site 24-1-R

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	16	1.86	41	3	25.51			
2	10	3.09	42	3	20.27			
3	8	2.63	43	3	25.55			
4	7	4.77	44	3	25.06			
5	8	6.62	45	4	23.71			
6	6	8.47	46	1	29.72			
7	6	7.76	47	3	25.96			
8	4	7.20	48	3	27.68			
9	5	11.26	49	3	26.36			
10	5	10.55	50	2	25.51			
11	4	10.20	51	2	33.75			
12	5	5.75	52	2	26.10			
13	5	11.31	53	3	29.26			
14	6	10.28	54	2	31.03			
15	5	6.74	55	3	22.41			
16	4	13.03	56	2	29.70			
17	3	10.21	57	3	28.64			
18	5	10.81	58	3	28.56			
19	6	11.12	59	2	34.31			
20	4	13.07	60	2	29.26			
21	5	12.44	61	3	31.72			
22	5	10.33	62	3	31.72			
23	5	12.78	63	3	30.07			
24	5	11.17	64	3	21.91			
25	5	7.95	65	2	19.91			
26	5	10.70	66	3	21.38			
27	5	9.74	67	1	17.66			
28	6	7.68	68	4	18.61			
29	6	11.01	69	3	14.04			
30	5	9.67	70	5	16.18			
31	6	10.59	71	5	14.36			
32	4	11.93	72	4	17.12			
33	4	11.95	73	4	20.60			
34	4	16.73	End of Test Record					
35	2	19.98						
36	3	25.20						
37	2	16.41						
38	3	25.56						
39	2	29.26						
40	2	22.70						

PANDA Probe - Test Report

Site 24-1 (Retest, < 24 hrs)

Certificate Reference:

2091-PND-Site 24-1-R

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

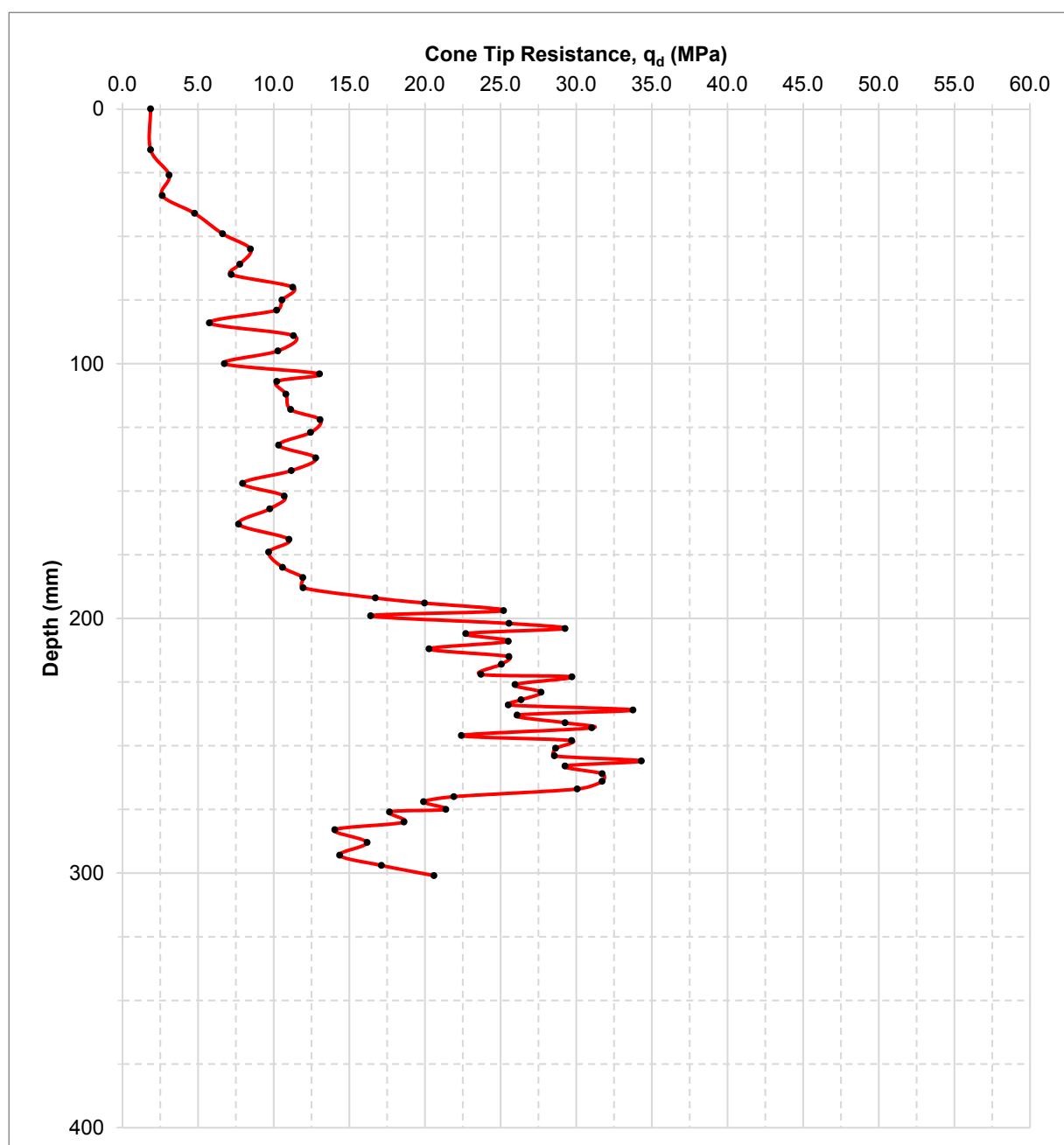
Project No.: 2091

Checked By: DWL

Location: Site 24-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 24-2

Certificate Reference:

2091-PND-Site 24-2

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

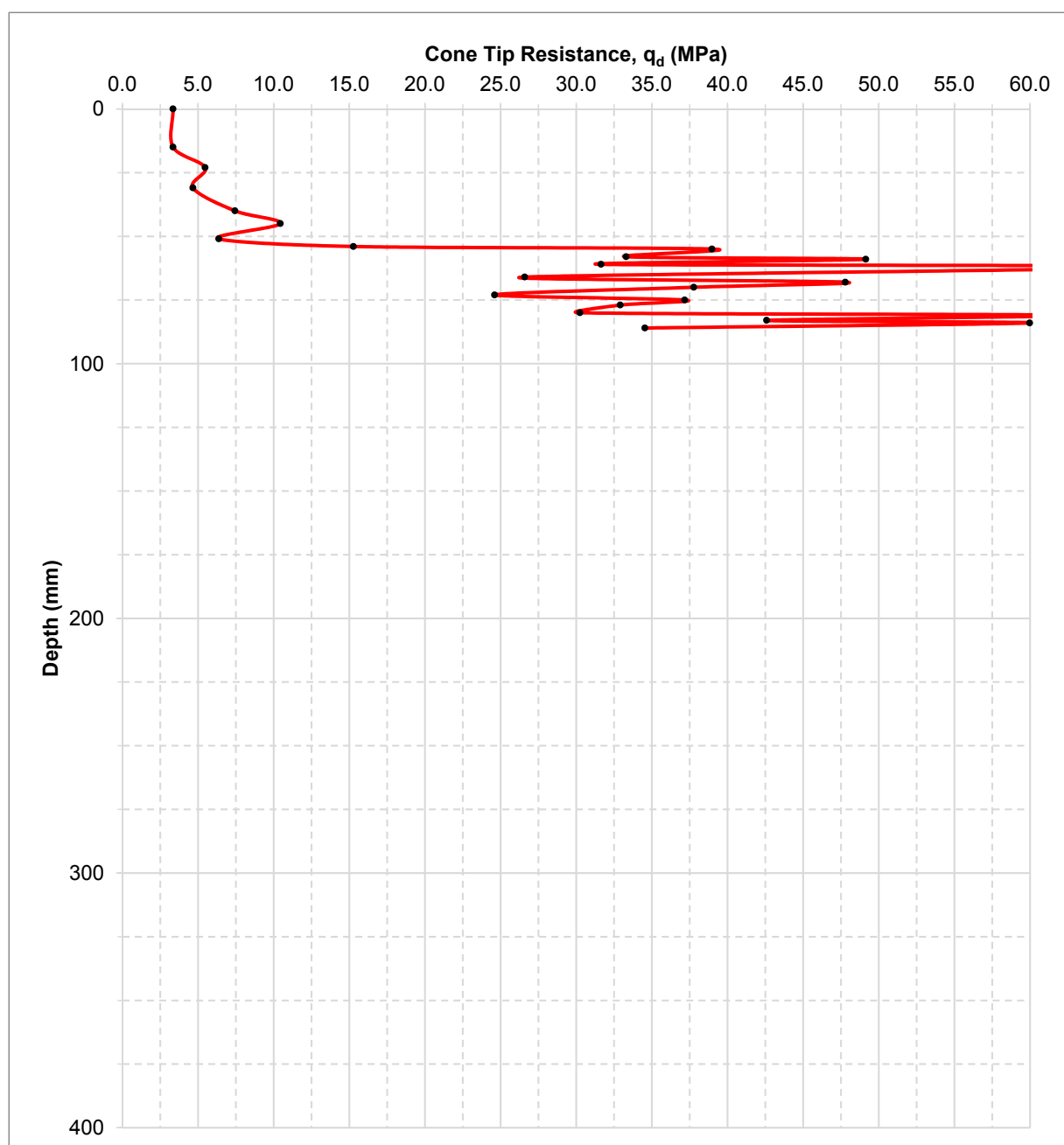
Project No.: 2091

Checked By: DWL

Location: Site 24-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-2A

Certificate Reference:

2091-PND-Site 24-2A

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	2.39	41	4	18.01			
2	8	4.80	42	4	14.23			
3	6	5.36	43	4	18.75			
4	6	7.85	44	1	37.83			
5	6	14.35	45	1	63.94			
6	5	11.04	46	1	68.61			
7	5	10.44	47	4	47.87			
8	7	9.43	48	1	62.52			
9	6	11.45	49	3	46.89			
10	6	9.80	50	3	42.72			
11	6	12.16	51	2	34.39			
12	7	11.35	52	2	32.92			
13	7	10.59	53	3	32.83			
14	6	9.38	54	1	35.95			
15	6	11.84	55	2	42.25			
16	5	11.06	56	2	46.14			
17	6	12.16	End of Test Record					
18	6	6.69						
19	8	7.27						
20	7	10.94						
21	9	9.50						
22	9	9.42						
23	7	11.01						
24	7	11.92						
25	5	6.90						
26	9	8.61						
27	8	8.04						
28	8	5.56						
29	10	5.93						
30	9	4.69						
31	8	7.71						
32	7	7.21						
33	2	14.41						
34	3	14.14						
35	3	12.76						
36	4	13.71						
37	6	12.30						
38	5	11.89						
39	5	12.04						
40	8	9.12						

PANDA Probe - Test Report

Site 24-2A

Certificate Reference:

2091-PND-Site 24-2A

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

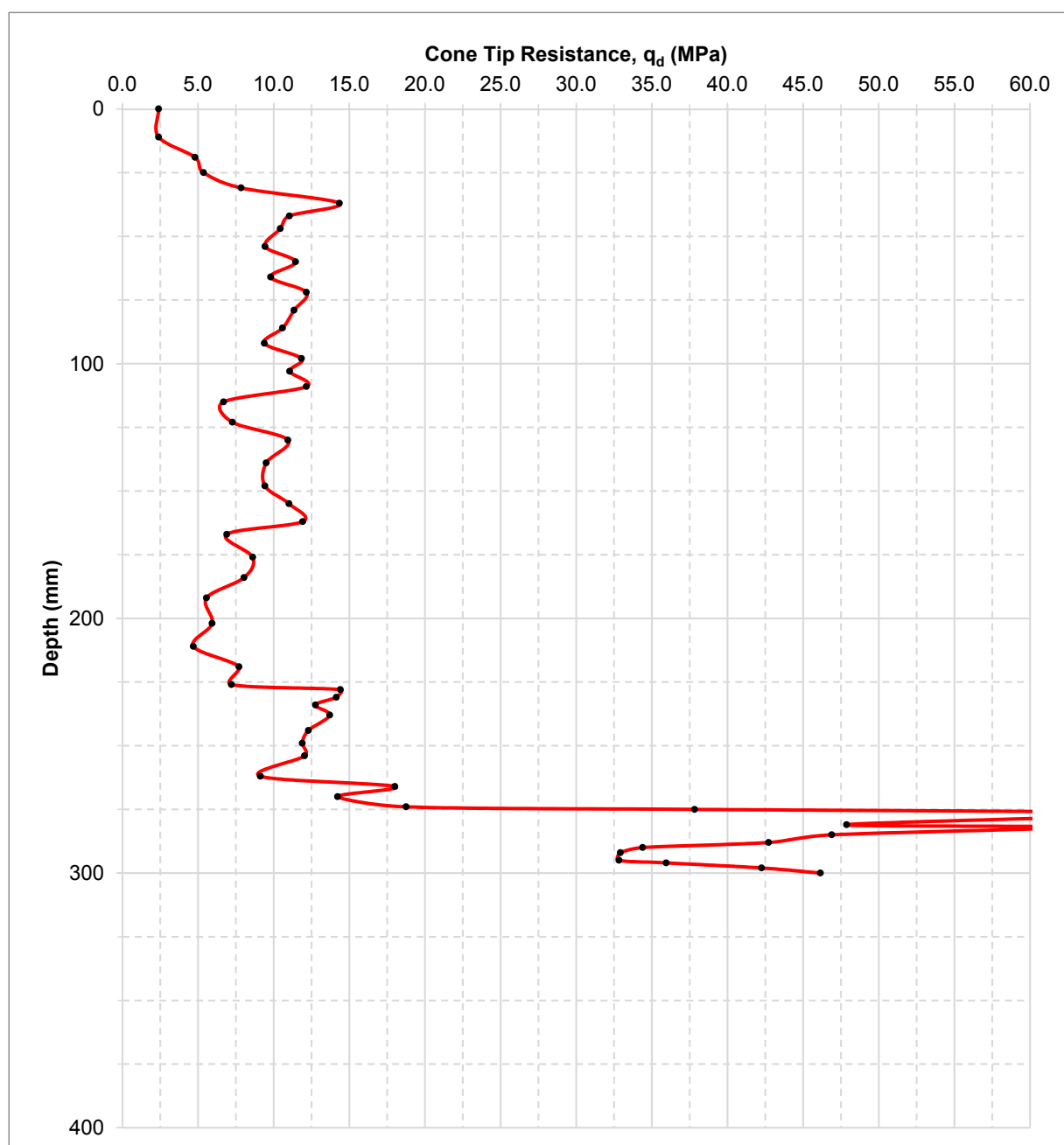
Project No.: 2091

Checked By: DWL

Location: Site 24-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 24-3

Certificate Reference:

2091-PND-Site 24-3

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

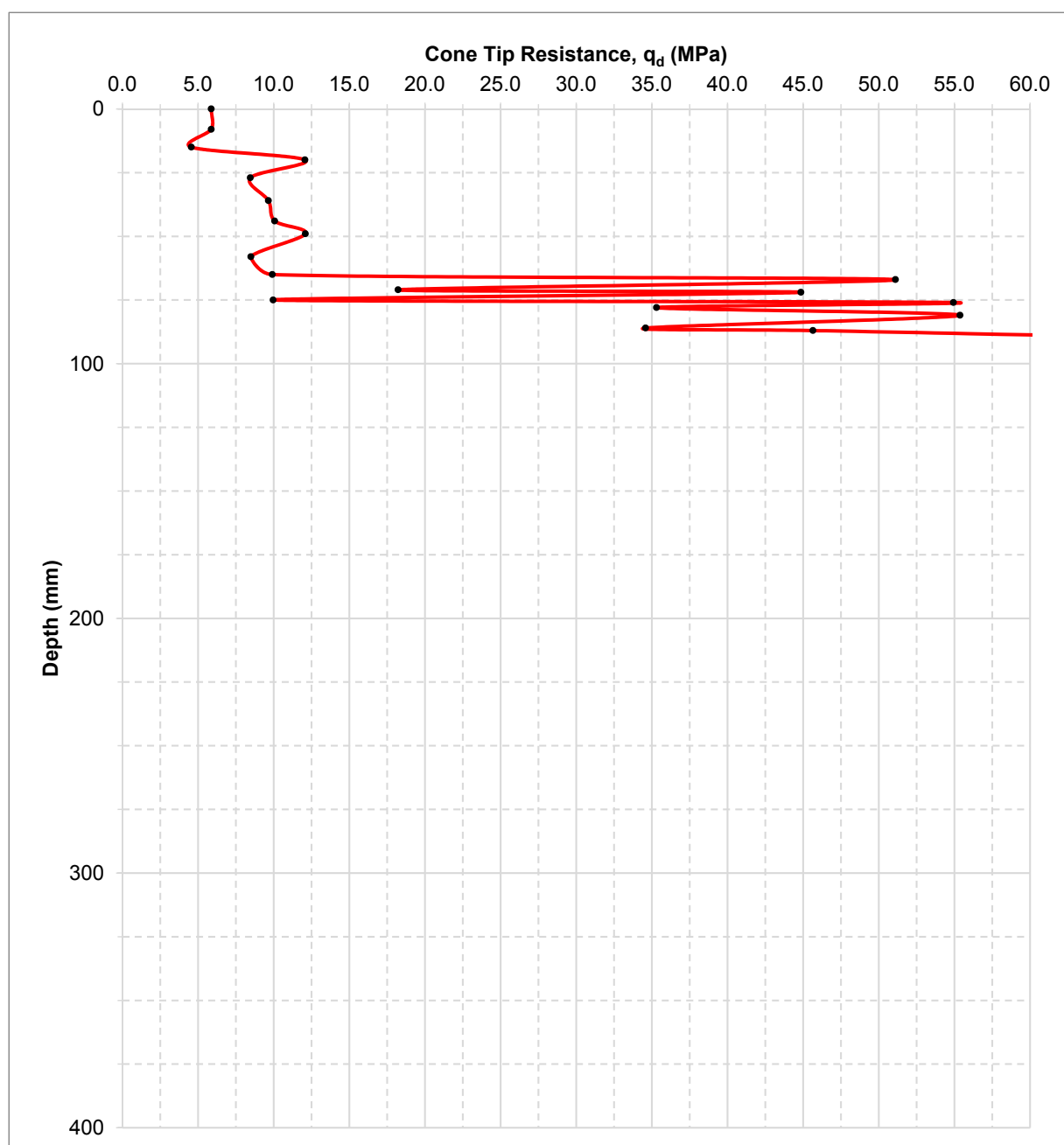
Project No.: 2091

Checked By: DWL

Location: Site 24-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-3A

Certificate Reference:

2091-PND-Site 24-3A

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	5.36	41	4	16.64			
2	5	12.85	42	3	27.00			
3	7	7.73	43	4	14.04			
4	5	8.43	44	3	20.01			
5	5	12.48	45	3	19.44			
6	6	12.37	46	4	21.62			
7	5	12.65	47	4	27.16			
8	5	10.45	48	4	21.39			
9	5	10.61	49	4	15.57			
10	5	13.27	50	3	20.89			
11	5	11.15	51	4	15.64			
12	6	11.92	52	2	26.03			
13	5	15.95	53	4	16.77			
14	5	14.26	54	3	21.31			
15	5	16.11	55	4	18.59			
16	4	15.29	56	3	17.28			
17	4	14.75	57	4	13.66			
18	3	28.59	58	5	14.52			
19	5	15.50	59	3	16.67			
20	3	14.77	60	3	17.24			
21	4	16.93	61	4	18.68			
22	4	19.69	62	4	10.30			
23	4	19.91	63	5	14.04			
24	3	19.34	64	4	13.63			
25	4	19.72	65	4	15.60			
26	4	20.35	66	6	13.88			
27	5	12.81	67	3	20.69			
28	3	19.12	68	2	37.69			
29	3	18.68	69	1	35.58			
30	1	25.96	70	3	37.67			
31	4	15.02	71	2	59.38			
32	2	22.25	72	1	65.65			
33	3	29.22	73	4	72.28			
34	3	21.08	74	3	43.40			
35	3	25.72	End of Test Record					
36	4	16.32						
37	3	24.77						
38	3	16.88						
39	2	27.59						
40	4	22.76						

PANDA Probe - Test Report

Site 24-3A

Certificate Reference:

2091-PND-Site 24-3A

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

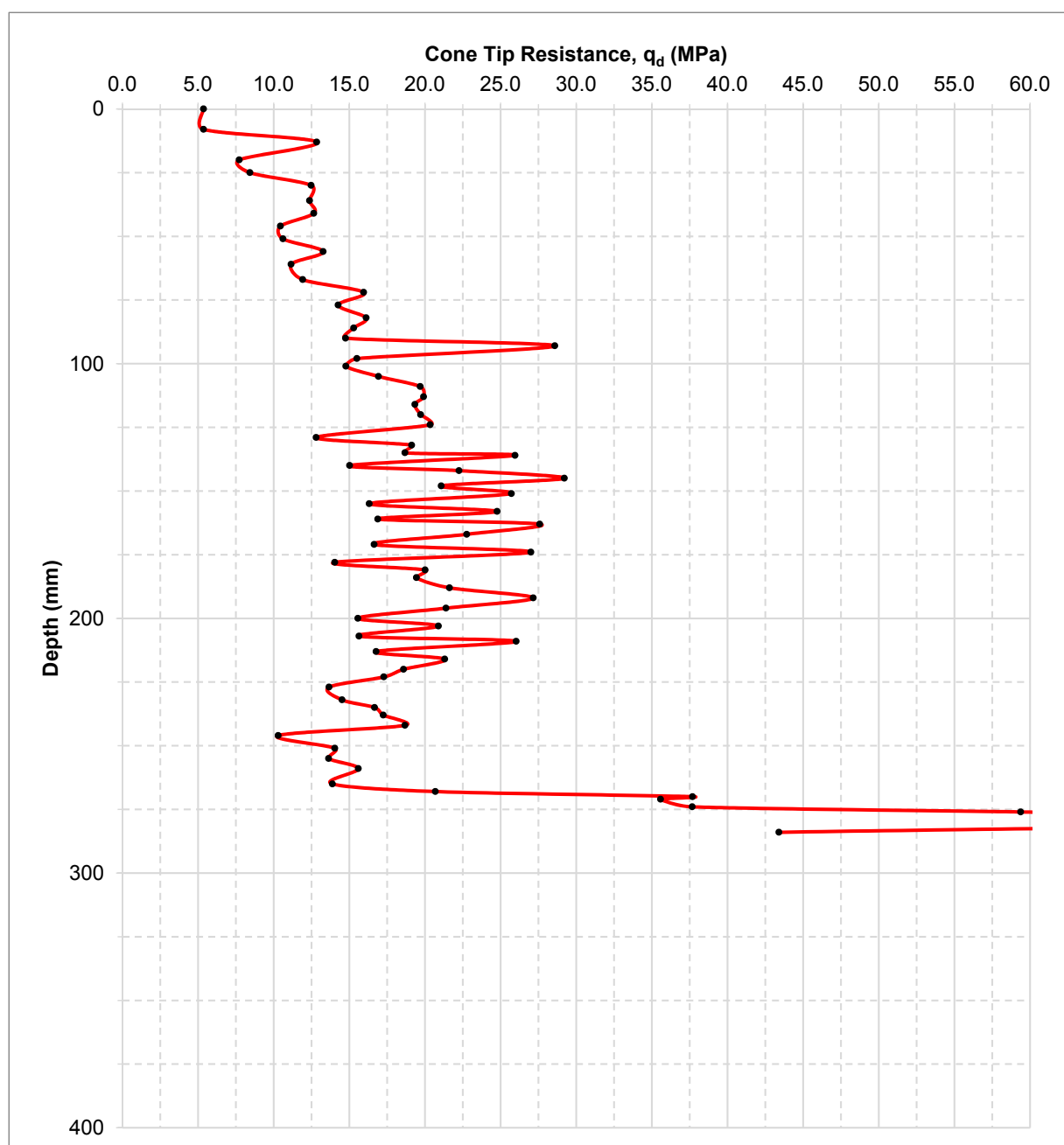
Project No.: 2091

Checked By: DWL

Location: Site 24-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-4

Certificate Reference:

2091-PND-Site 24-4

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.61	41	3	25.61	81	4	13.13
2	4	11.73	42	4	21.08	82	3	22.69
3	5	7.88	43	3	17.45	83	6	8.63
4	3	13.81	44	2	19.41	84	5	12.66
5	2	16.02	45	2	31.77	85	5	11.68
6	2	32.28	46	4	17.23	86	6	11.04
7	3	22.04	47	3	18.21	87	5	7.47
8	4	15.71	48	3	20.80	88	4	13.01
9	5	15.64	49	3	21.45	89	5	10.51
10	3	22.92	50	1	18.76	90	6	13.16
11	3	20.89	51	4	18.77	91	5	9.96
12	5	17.31	52	3	19.69	92	3	2.59
13	2	28.01	53	3	25.56	End of Test Record		
14	3	12.10	54	3	19.10			
15	2	37.37	55	3	16.36			
16	5	11.62	56	2	23.79			
17	2	21.63	57	4	21.67			
18	4	18.08	58	3	21.12			
19	2	26.80	59	3	20.93			
20	1	26.90	60	3	22.35			
21	3	21.31	61	2	30.72			
22	3	13.04	62	4	14.03			
23	2	20.25	63	3	11.61			
24	3	22.47	64	3	17.23			
25	3	30.57	65	3	16.05			
26	2	25.74	66	4	13.27			
27	1	48.41	67	3	21.30			
28	2	24.56	68	4	16.85			
29	1	50.10	69	4	19.02			
30	2	39.01	70	4	14.36			
31	2	29.73	71	4	11.39			
32	1	37.69	72	2	34.25			
33	1	64.56	73	6	9.57			
34	2	45.42	74	3	17.79			
35	3	32.75	75	5	10.31			
36	3	19.97	76	5	13.67			
37	2	42.37	77	5	13.40			
38	2	36.47	78	3	15.05			
39	4	19.36	79	5	14.61			
40	2	28.07	80	4	14.98			

PANDA Probe - Test Report

Site 24-4

Certificate Reference:

2091-PND-Site 24-4

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

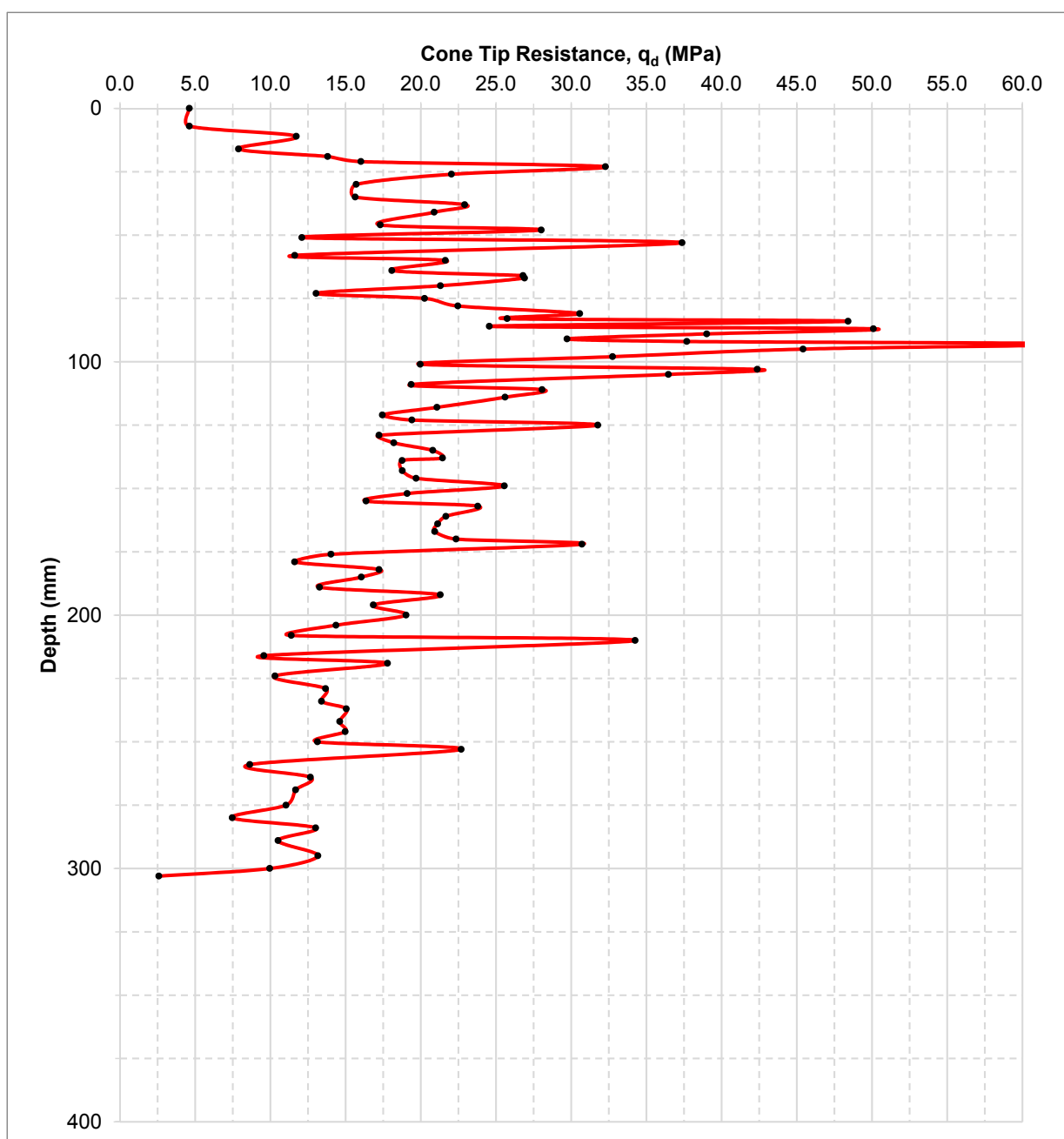
Project No.: 2091

Checked By: DWL

Location: Site 24-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-5

Certificate Reference:

2091-PND-Site 24-5

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	3.15	41	4	10.87			
2	6	5.69	42	4	16.33			
3	7	5.11	43	3	17.45			
4	6	5.11	44	3	24.57			
5	10	5.20	45	3	18.84			
6	7	6.01	46	3	18.02			
7	10	5.55	47	3	18.84			
8	9	6.34	48	3	19.54			
9	6	7.55	49	4	13.32			
10	7	5.71	50	3	12.90			
11	7	7.34	51	4	13.85			
12	8	7.58	52	3	14.17			
13	7	6.18	End of Test Record					
14	8	8.13						
15	8	6.52						
16	7	6.10						
17	7	6.76						
18	10	6.76						
19	11	7.02						
20	8	8.14						
21	8	7.87						
22	7	6.90						
23	7	8.29						
24	5	10.41						
25	6	8.68						
26	6	11.97						
27	5	6.75						
28	6	9.29						
29	6	9.70						
30	6	10.01						
31	6	8.74						
32	4	9.10						
33	3	11.33						
34	3	14.43						
35	4	16.45						
36	4	13.88						
37	5	12.38						
38	5	12.02						
39	5	13.46						
40	4	11.47						

PANDA Probe - Test Report

Site 24-5

Certificate Reference:

2091-PND-Site 24-5

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

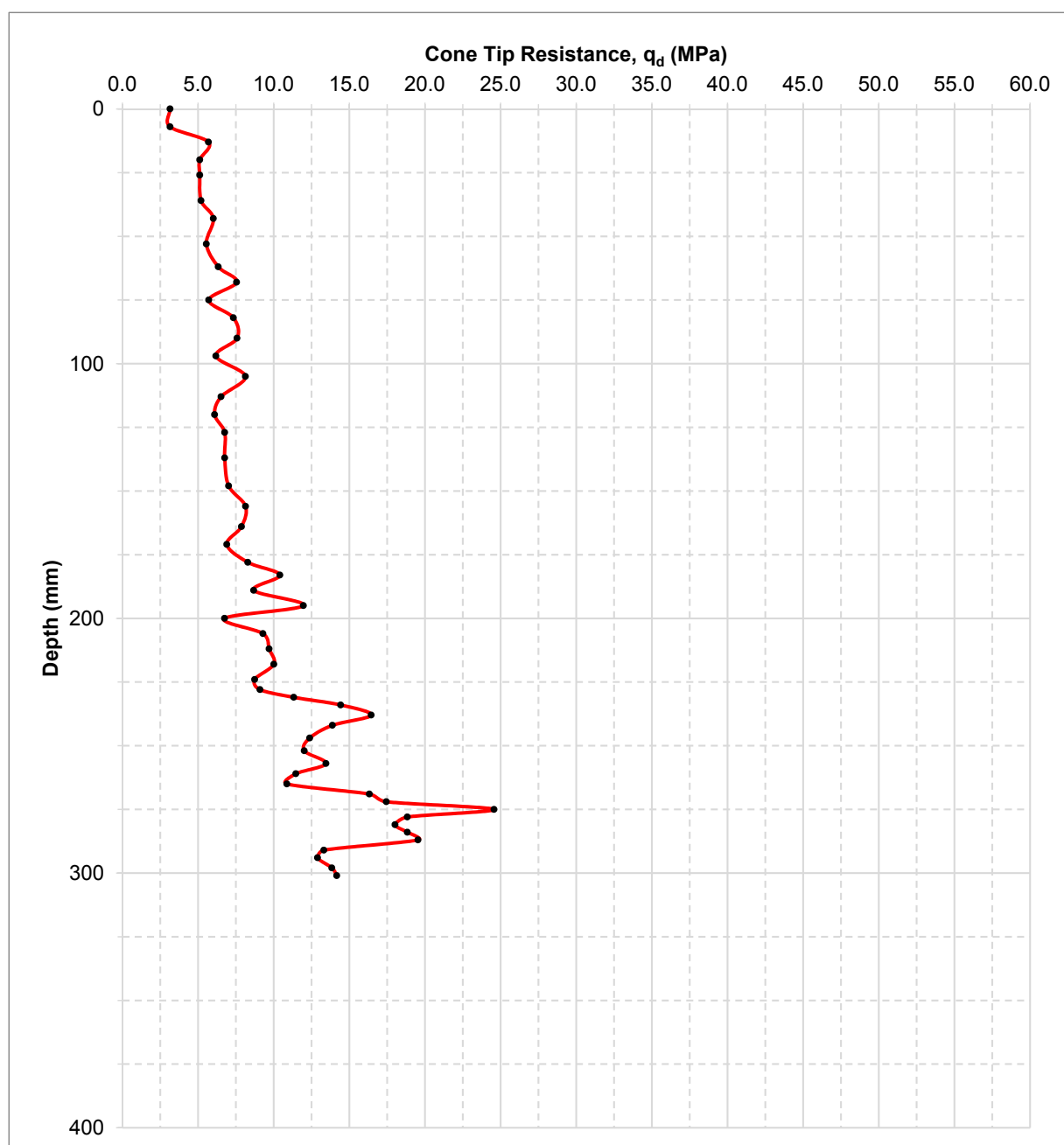
Project No.: 2091

Checked By: DWL

Location: Site 24-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-5 (Retest, < 24 hrs)

Certificate Reference:

2091-PND-Site 24-5-R

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	6.41	41	3	13.12			
2	5	6.47	42	4	15.46			
3	5	9.87	43	2	18.59			
4	5	9.17	44	3	19.30			
5	4	9.87	45	4	18.19			
6	6	10.22	46	3	24.29			
7	4	11.19	47	2	21.45			
8	5	8.48	48	3	21.47			
9	4	12.29	49	2	22.24			
10	6	9.80	50	3	16.39			
11	4	12.54	51	4	21.01			
12	5	8.26	52	3	23.73			
13	4	11.06	53	3	24.63			
14	3	17.49	54	3	18.19			
15	4	15.64	55	2	28.43			
16	4	10.58	56	2	18.28			
17	4	13.57	57	2	23.11			
18	3	7.58	58	3	21.51			
19	4	14.18	59	2	17.30			
20	3	13.89	60	3	24.12			
21	3	17.00	61	2	24.89			
22	2	17.46	62	2	33.16			
23	4	17.95	63	2	51.95			
24	4	13.22	64	1	62.52			
25	5	12.40	65	1	43.66			
26	4	10.89	66	1	39.19			
27	4	14.20	67	3	42.09			
28	3	8.68	End of Test Record					
29	4	8.74						
30	3	16.22						
31	3	11.29						
32	3	16.79						
33	4	13.83						
34	2	15.56						
35	3	10.16						
36	3	9.91						
37	3	18.10						
38	3	12.63						
39	4	16.06						
40	3	16.34						

PANDA Probe - Test Report

Site 24-5 (Retest, < 24 hrs)

Certificate Reference:

2091-PND-Site 24-5-R

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

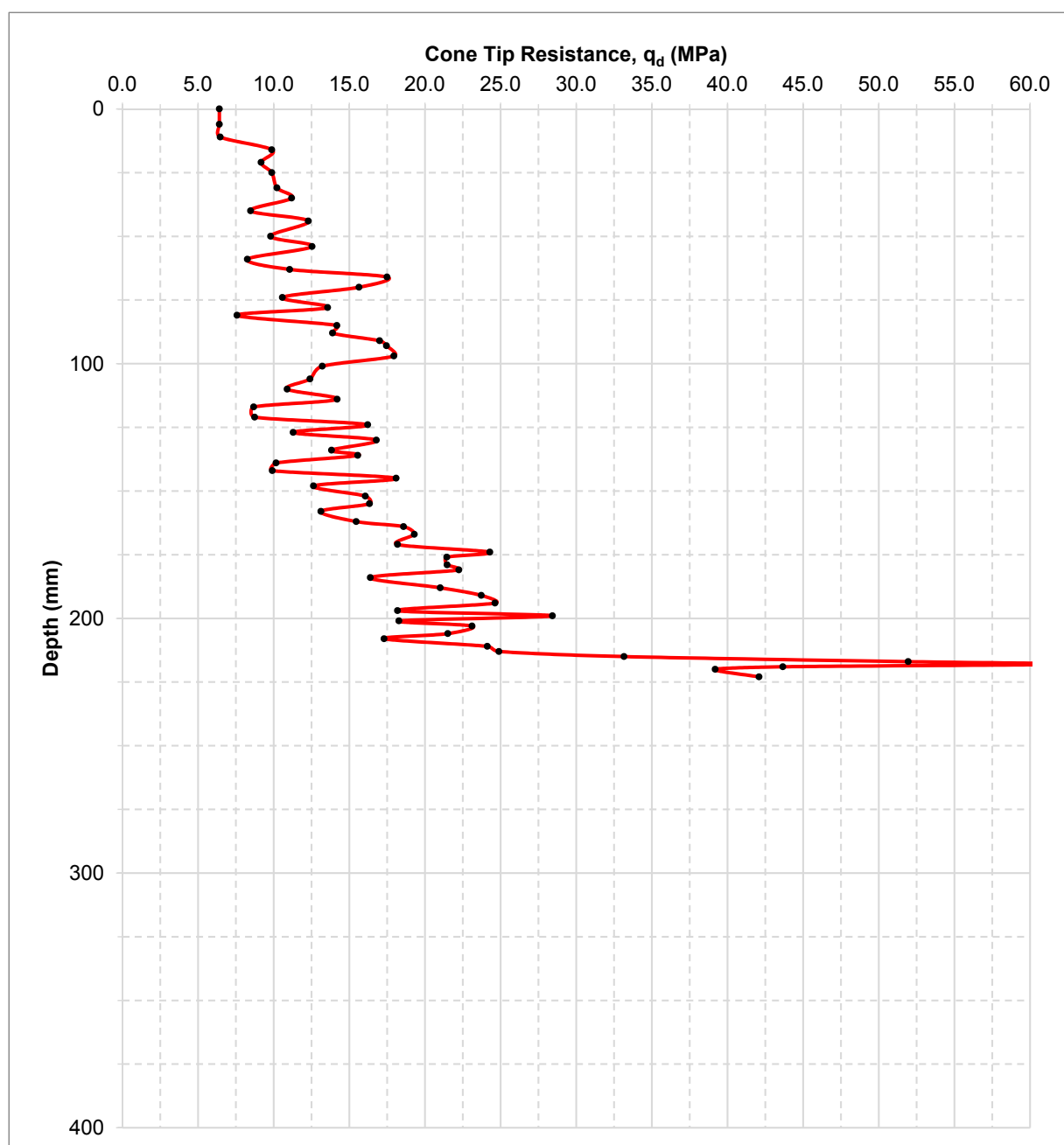
Project No.: 2091

Checked By: DWL

Location: Site 24-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-6

Certificate Reference:

2091-PND-Site 24-6

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	3.21	41	5	12.78			
2	7	3.72	42	4	19.74			
3	7	4.88	43	3	18.54			
4	2	17.09	44	4	16.99			
5	7	6.30	45	3	19.34			
6	4	10.50	46	2	26.82			
7	4	11.03	47	3	16.59			
8	5	9.92	48	2	19.31			
9	7	7.30	49	3	24.76			
10	6	8.87	50	3	20.78			
11	7	5.99	51	3	19.50			
12	5	9.28	52	3	28.69			
13	7	7.80	53	3	14.18			
14	6	10.08	54	4	14.75			
15	6	8.50	55	4	13.45			
16	9	5.38	56	4	14.51			
17	14	3.99	End of Test Record					
18	10	4.19						
19	9	3.93						
20	8	4.97						
21	9	6.66						
22	8	5.34						
23	9	6.52						
24	10	5.58						
25	5	11.24						
26	7	7.40						
27	7	9.13						
28	7	8.95						
29	6	10.42						
30	4	12.67						
31	3	14.44						
32	5	18.97						
33	2	17.34						
34	4	11.45						
35	4	13.89						
36	4	10.67						
37	4	12.69						
38	4	11.00						
39	4	12.34						
40	4	15.83						

PANDA Probe - Test Report

Site 24-6

Certificate Reference:

2091-PND-Site 24-6

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

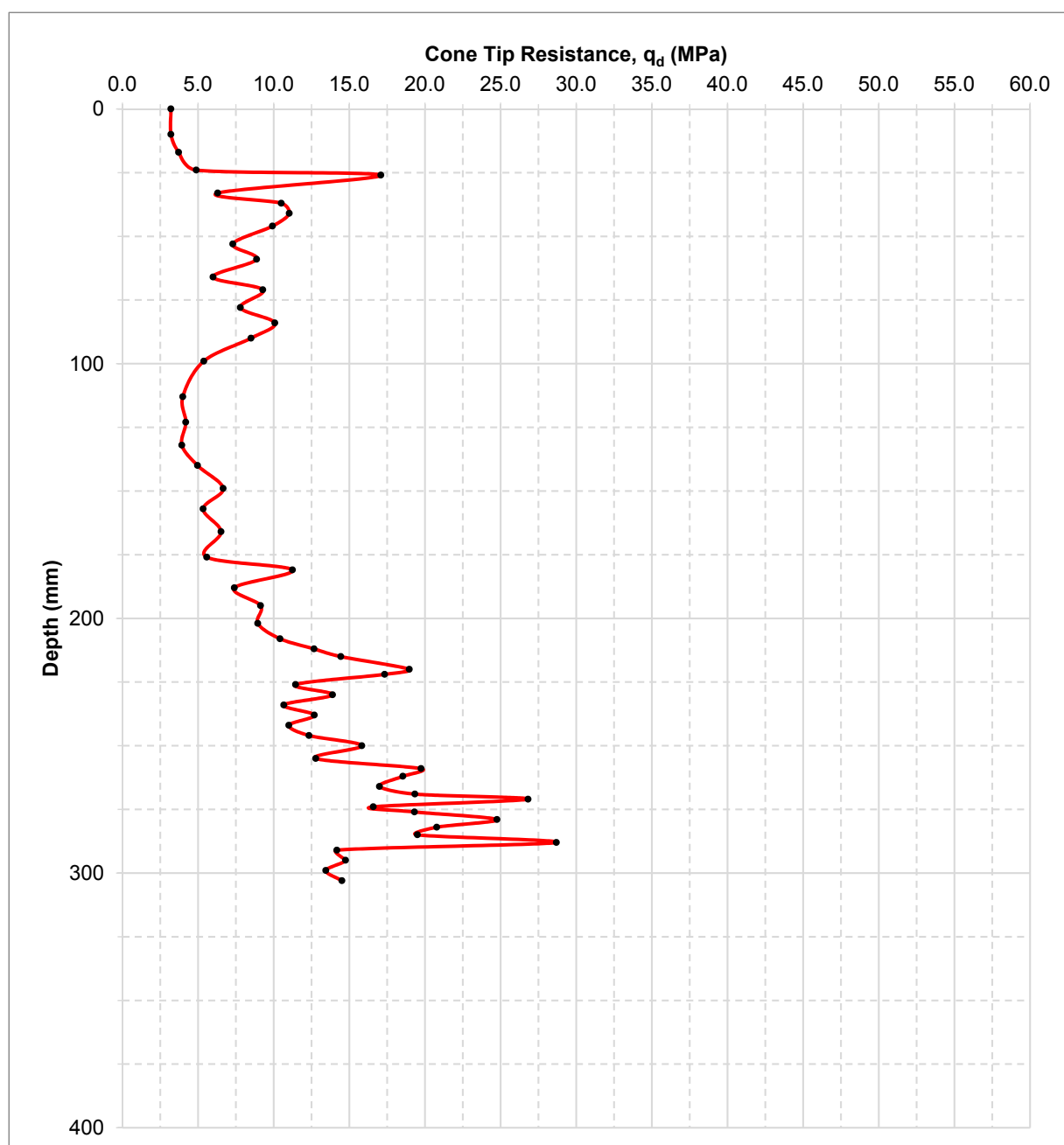
Project No.: 2091

Checked By: DWL

Location: Site 24-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-6 (Retest, < 24 hrs)

Certificate Reference:

2091-PND-Site 24-6-R

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	3.34	41	7	8.57			
2	4	5.53	42	9	7.15			
3	4	7.32	43	8	7.11			
4	4	5.88	44	6	5.15			
5	4	10.98	45	9	7.15			
6	4	10.60	46	7	8.27			
7	4	6.89	47	8	8.01			
8	4	6.93	48	6	7.17			
9	4	10.99	49	7	9.42			
10	4	8.97	50	5	6.90			
11	4	11.20	51	6	7.21			
12	4	10.82	52	8	7.24			
13	4	13.00	53	7	8.45			
14	4	6.23	54	6	8.60			
15	4	13.06	55	7	8.75			
16	3	13.36	56	8	7.85			
17	4	18.87	57	6	7.50			
18	3	9.33	End of Test Record					
19	4	14.36						
20	5	11.08						
21	4	9.99						
22	4	13.00						
23	4	9.21						
24	5	12.07						
25	5	9.64						
26	5	9.09						
27	4	10.17						
28	5	12.20						
29	2	7.62						
30	5	11.27						
31	4	8.60						
32	5	12.14						
33	4	10.82						
34	6	10.06						
35	6	7.47						
36	7	8.77						
37	8	7.95						
38	9	7.45						
39	6	11.60						
40	6	11.51						

PANDA Probe - Test Report

Site 24-6 (Retest, < 24 hrs)

Certificate Reference:

2091-PND-Site 24-6-R

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

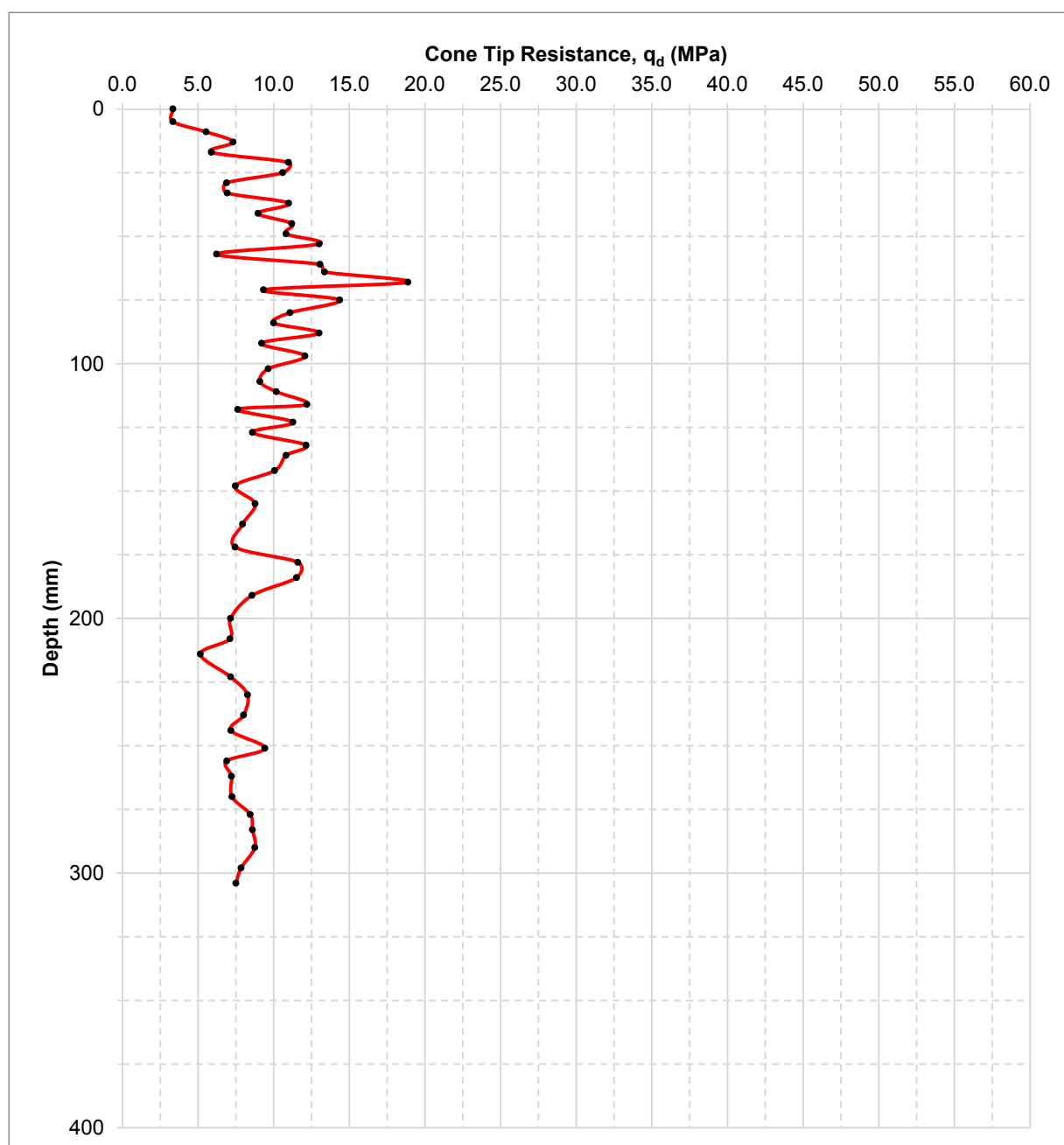
Project No.: 2091

Checked By: DWL

Location: Site 24-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-6 (Retest, ~24 hrs)

Certificate Reference:

2091-PND-Site 24-6-R2

Sheet:

1 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	3.25	41	4	10.70			
2	9	4.95	42	4	8.87			
3	6	7.48	43	5	13.42			
4	8	7.97	44	5	12.50			
5	6	7.23	45	4	12.51			
6	6	10.14	46	3	15.80			
7	6	7.96	47	3	12.56			
8	7	11.66	48	6	10.23			
9	5	13.32	49	6	9.12			
10	6	9.67	50	5	9.25			
11	3	12.85	51	5	10.01			
12	3	22.58	52	1	13.65			
13	2	30.59	53	3	26.62			
14	1	37.99	54	2	25.95			
15	2	37.52	55	1	27.83			
16	1	45.65	56	2	22.56			
17	1	26.53	57	1	24.47			
18	3	32.58	58	3	23.96			
19	2	34.47	59	1	20.07			
20	2	43.08	60	2	20.06			
21	2	53.97	61	3	18.49			
22	2	26.68	62	7	7.52			
23	1	51.98	63	7	7.54			
24	2	41.17	64	6	6.63			
25	2	37.52	65	6	7.20			
26	2	27.45	66	8	7.23			
27	2	31.42	67	5	8.52			
28	2	25.12	68	6	8.31			
29	2	20.77	69	6	8.82			
30	3	17.86	70	5	7.73			
31	3	15.31	71	8	5.71			
32	3	18.15	72	6	9.95			
33	2	26.85	73	4	15.25			
34	2	15.54	74	4	12.46			
35	3	18.88	75	6	9.00			
36	2	17.80	76	6	9.06			
37	3	11.74	77	7	7.67			
38	2	21.55	End of Test Record					
39	4	10.18						
40	2	10.12						

PANDA Probe - Test Report

Site 24-6 (Retest, ~24 hrs)

Certificate Reference:

2091-PND-Site 24-6-R2

Sheet:

2 of 2

Client: ARRB

Test Date: 13/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

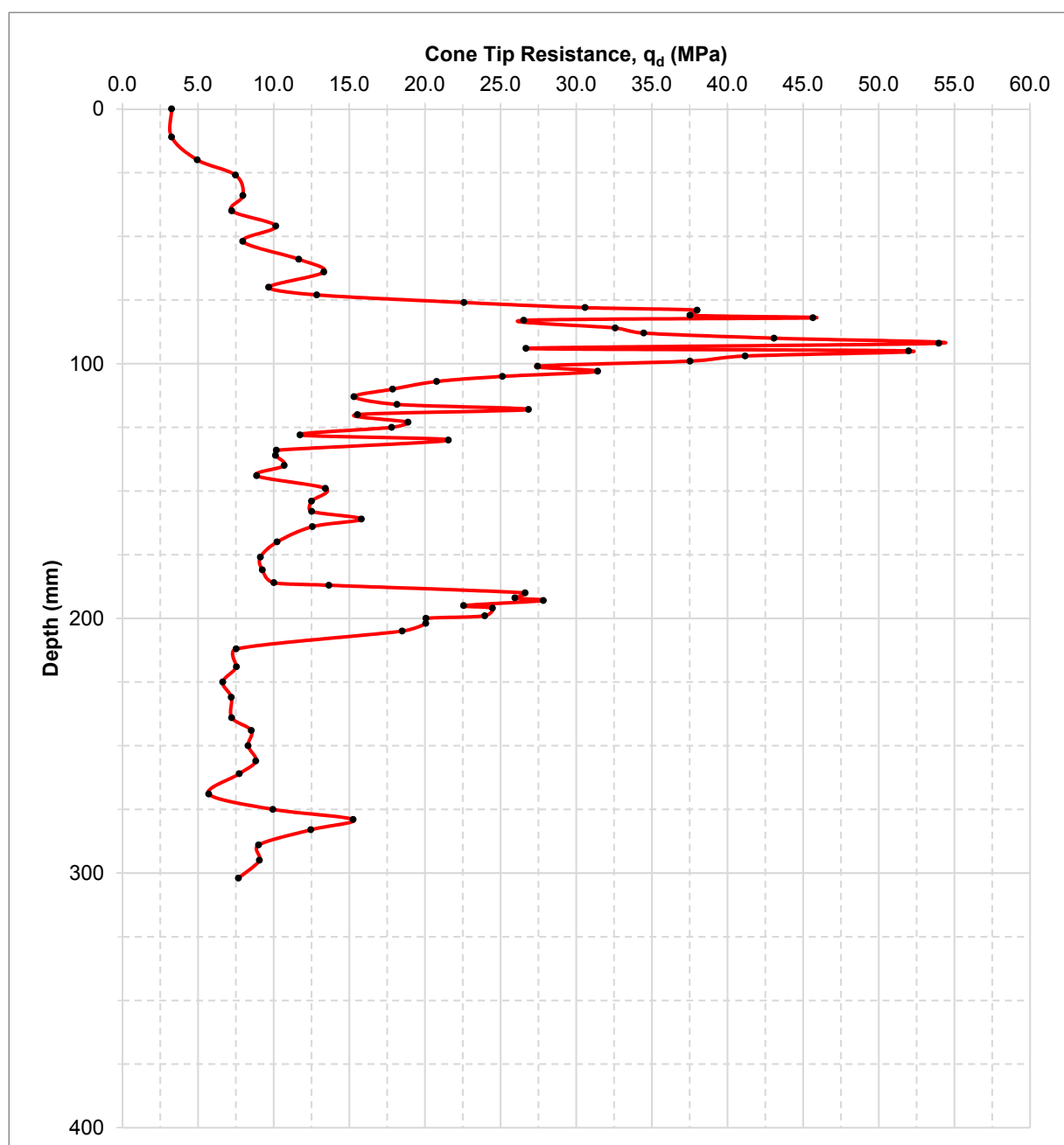
Project No.: 2091

Checked By: DWL

Location: Site 24-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-7

Certificate Reference:

2091-PND-Site 24-7

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	2.67	41	4	13.73			
2	7	11.03	42	4	17.31			
3	8	8.05	43	3	19.90			
4	7	7.50	44	4	17.79			
5	8	10.11	45	3	19.03			
6	5	13.56	46	3	21.50			
7	6	13.82	47	3	22.99			
8	6	11.77	48	4	23.62			
9	6	12.61	49	2	21.28			
10	5	12.77	50	3	19.42			
11	3	19.40	51	2	23.81			
12	7	9.76	52	3	23.59			
13	6	14.13	53	2	22.87			
14	5	9.36	54	3	24.89			
15	4	12.17	55	2	31.77			
16	5	10.48	56	3	28.01			
17	3	16.42	57	1	39.97			
18	4	20.58	58	3	28.58			
19	3	14.67	59	2	27.36			
20	3	14.54	60	3	34.81			
21	4	13.51	61	1	25.50			
22	4	15.90	62	4	20.00			
23	5	13.27	63	3	28.54			
24	4	14.26	64	4	18.30			
25	5	14.63	65	4	19.85			
26	4	13.44	66	3	16.85			
27	3	19.33	67	4	15.42			
28	3	15.74	68	5	14.15			
29	3	19.24	69	5	11.33			
30	4	15.11	70	6	13.86			
31	4	16.00	71	3	16.94			
32	4	15.50	72	5	16.93			
33	4	18.23	73	3	12.25			
34	2	23.74	74	6	13.60			
35	3	15.38	75	6	14.64			
36	4	14.65	76	5	14.01			
37	2	24.19	End of Test Record					
38	4	16.80						
39	2	18.95						
40	3	16.41						

PANDA Probe - Test Report

Site 24-7

Certificate Reference:

2091-PND-Site 24-7

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

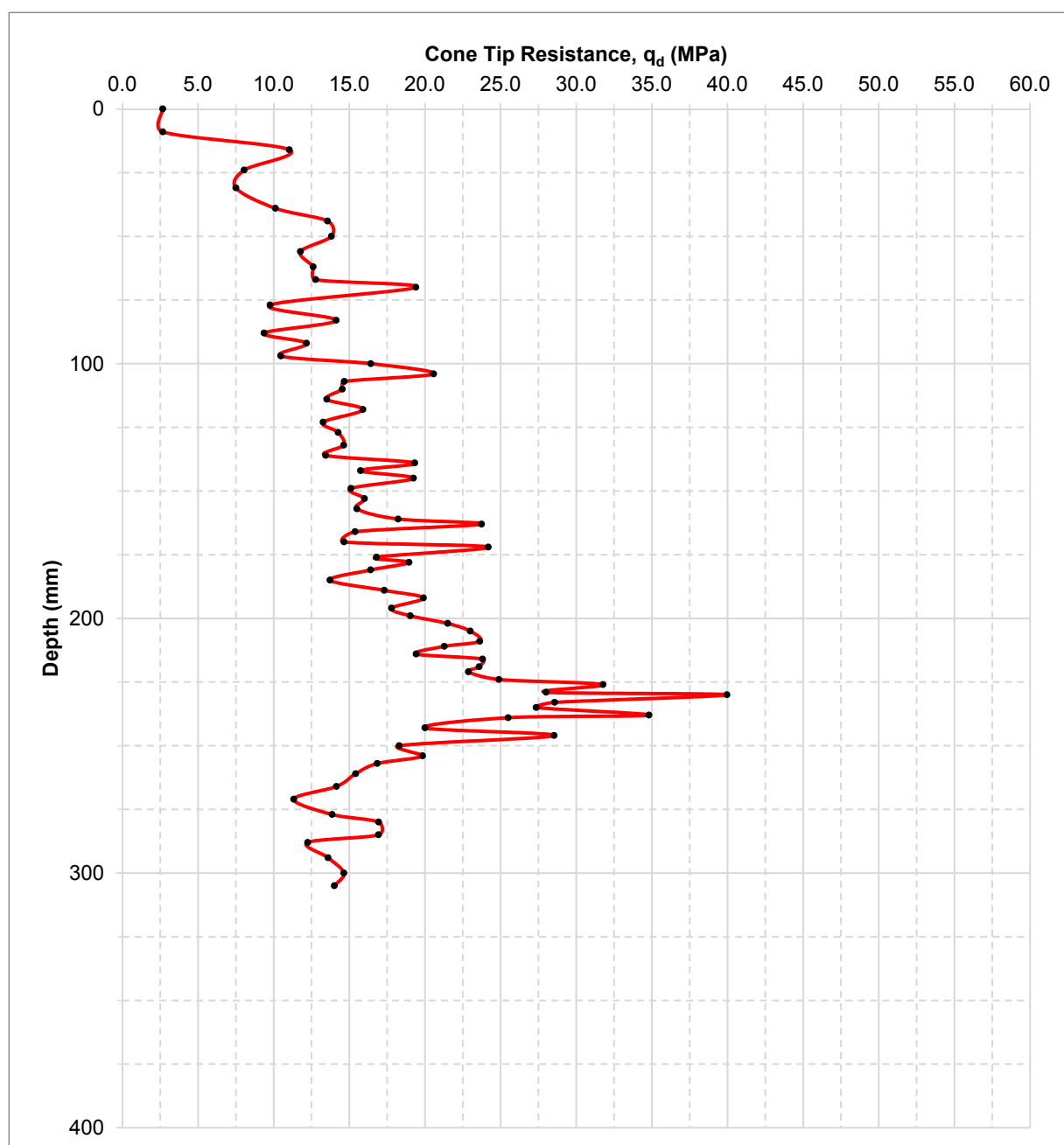
Project No.: 2091

Checked By: DWL

Location: Site 24-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-8

Certificate Reference:

2091-PND-Site 24-8

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	3.03	41	3	24.06			
2	7	9.15	42	3	18.43			
3	7	7.72	43	3	24.31			
4	5	5.42	44	3	23.69			
5	7	8.60	45	3	28.71			
6	5	16.35	46	2	23.28			
7	7	12.15	47	3	31.64			
8	8	8.12	48	2	21.24			
9	5	12.09	49	3	28.93			
10	6	16.75	50	3	26.40			
11	5	7.66	51	3	21.14			
12	5	13.92	52	2	27.29			
13	5	11.08	53	4	21.19			
14	6	16.23	54	3	19.85			
15	5	14.13	55	3	27.10			
16	5	12.43	56	3	30.84			
17	4	15.92	57	3	29.50			
18	5	17.34	58	4	17.20			
19	5	22.32	59	3	28.54			
20	3	20.77	60	4	21.16			
21	4	13.89	61	3	23.97			
22	4	17.74	62	3	18.82			
23	4	21.64	63	4	16.90			
24	2	17.95	64	4	17.39			
25	3	24.02	65	5	14.05			
26	4	21.14	66	5	12.63			
27	3	21.31	67	5	15.13			
28	3	20.65	68	5	14.56			
29	5	18.04	69	6	13.38			
30	5	15.94	70	5	9.52			
31	2	10.26	71	5	11.08			
32	5	13.05	72	6	12.20			
33	4	13.81	End of Test Record					
34	3	14.88						
35	4	16.46						
36	3	20.61						
37	3	14.58						
38	2	23.15						
39	2	20.89						
40	3	31.37						

PANDA Probe - Test Report

Site 24-8

Certificate Reference:

2091-PND-Site 24-8

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

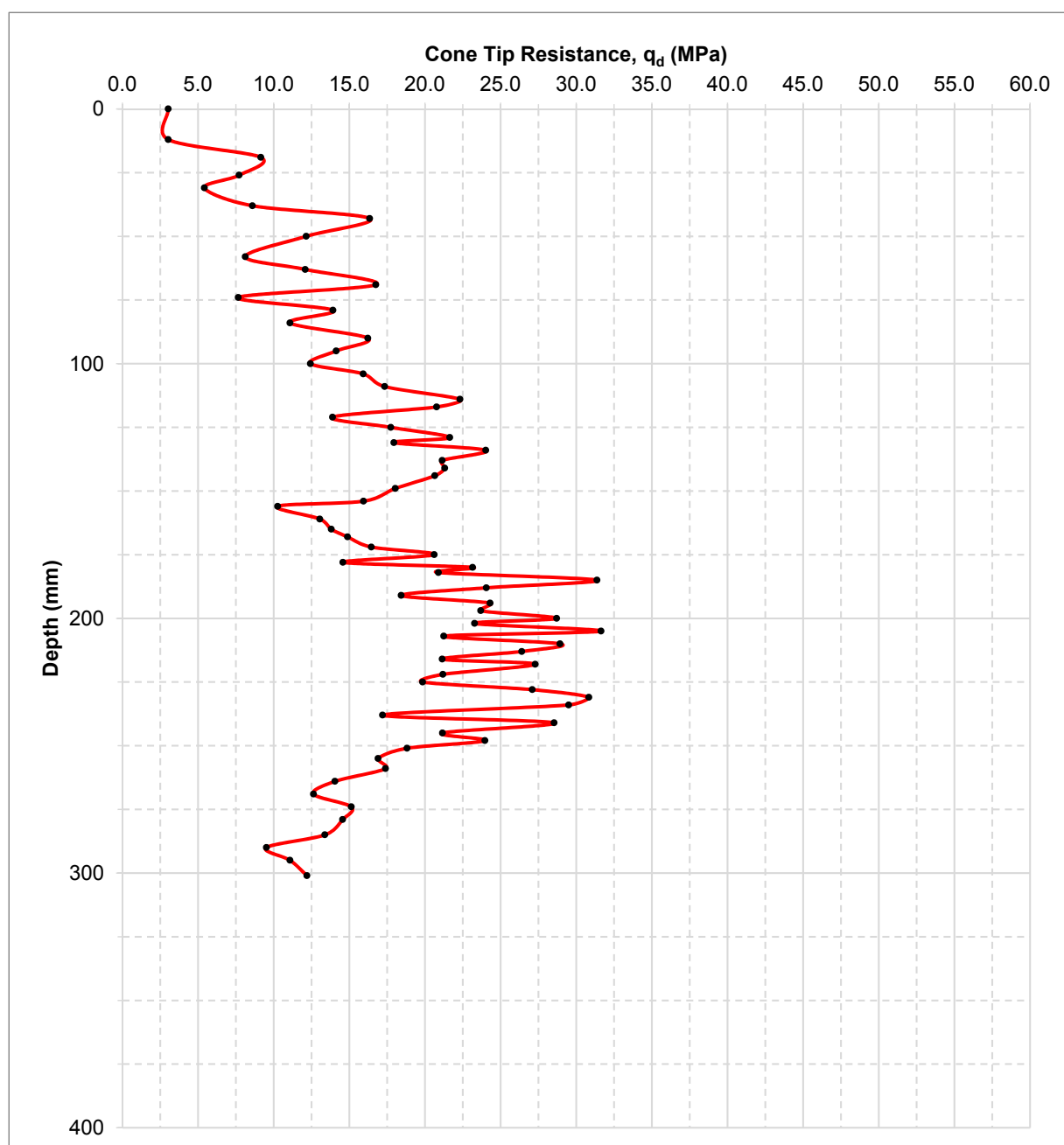
Project No.: 2091

Checked By: DWL

Location: Site 24-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-9

Certificate Reference:

2091-PND-Site 24-9

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	2.95	41	7	7.48			
2	5	7.30	42	8	6.05			
3	6	6.63	43	8	5.79			
4	5	6.79	44	8	6.49			
5	2	28.56	45	8	7.71			
6	1	46.36	46	6	11.68			
7	2	43.04	47	7	14.19			
8	2	34.33	48	7	9.22			
9	2	37.03	49	6	9.30			
10	3	30.62	50	8	8.72			
11	1	46.00	51	6	6.78			
12	4	19.74	52	9	9.61			
13	5	9.85	53	6	10.44			
14	4	16.26	54	9	9.75			
15	4	13.26	End of Test Record					
16	6	9.61						
17	7	11.04						
18	6	10.15						
19	4	11.65						
20	4	10.98						
21	4	16.38						
22	3	20.58						
23	3	12.54						
24	6	14.58						
25	5	11.08						
26	6	8.41						
27	6	11.39						
28	4	10.42						
29	6	8.03						
30	8	10.33						
31	7	7.86						
32	6	10.61						
33	6	10.14						
34	6	9.53						
35	6	11.51						
36	7	7.85						
37	7	6.68						
38	8	6.30						
39	8	7.34						
40	7	6.32						

PANDA Probe - Test Report

Site 24-9

Certificate Reference:

2091-PND-Site 24-9

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

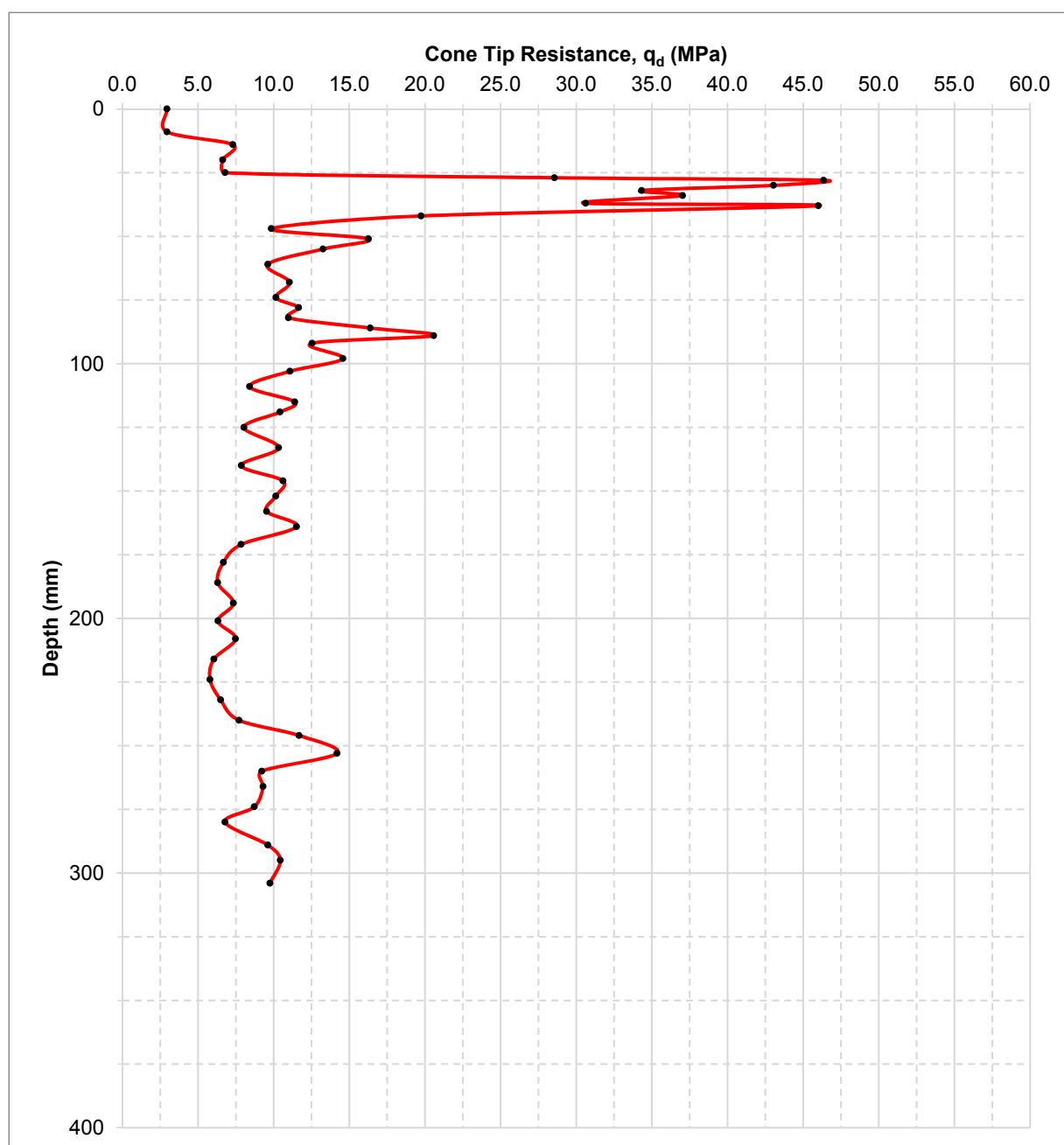
Project No.: 2091

Checked By: DWL

Location: Site 24-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-10

Certificate Reference:

2091-PND-Site 24-10

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	7.69	41	2	51.83			
2	4	11.75	42	1	56.84			
3	5	16.61	43	2	40.80			
4	5	17.82	44	1	35.92			
5	4	16.28	45	2	59.78			
6	4	15.88	End of Test Record					
7	3	16.46						
8	4	15.77						
9	3	14.30						
10	4	18.62						
11	4	19.14						
12	3	23.26						
13	3	21.85						
14	3	25.51						
15	3	21.07						
16	2	25.68						
17	4	25.74						
18	2	25.92						
19	2	27.74						
20	2	37.39						
21	2	27.34						
22	3	24.72						
23	2	25.57						
24	3	35.30						
25	2	36.33						
26	3	27.99						
27	2	29.89						
28	2	30.11						
29	2	20.56						
30	2	27.08						
31	2	27.99						
32	2	31.40						
33	2	39.22						
34	3	35.94						
35	3	22.84						
36	2	39.48						
37	2	28.98						
38	2	21.85						
39	2	39.22						
40	1	62.72						

PANDA Probe - Test Report

Site 24-10

Certificate Reference:

2091-PND-Site 24-10

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

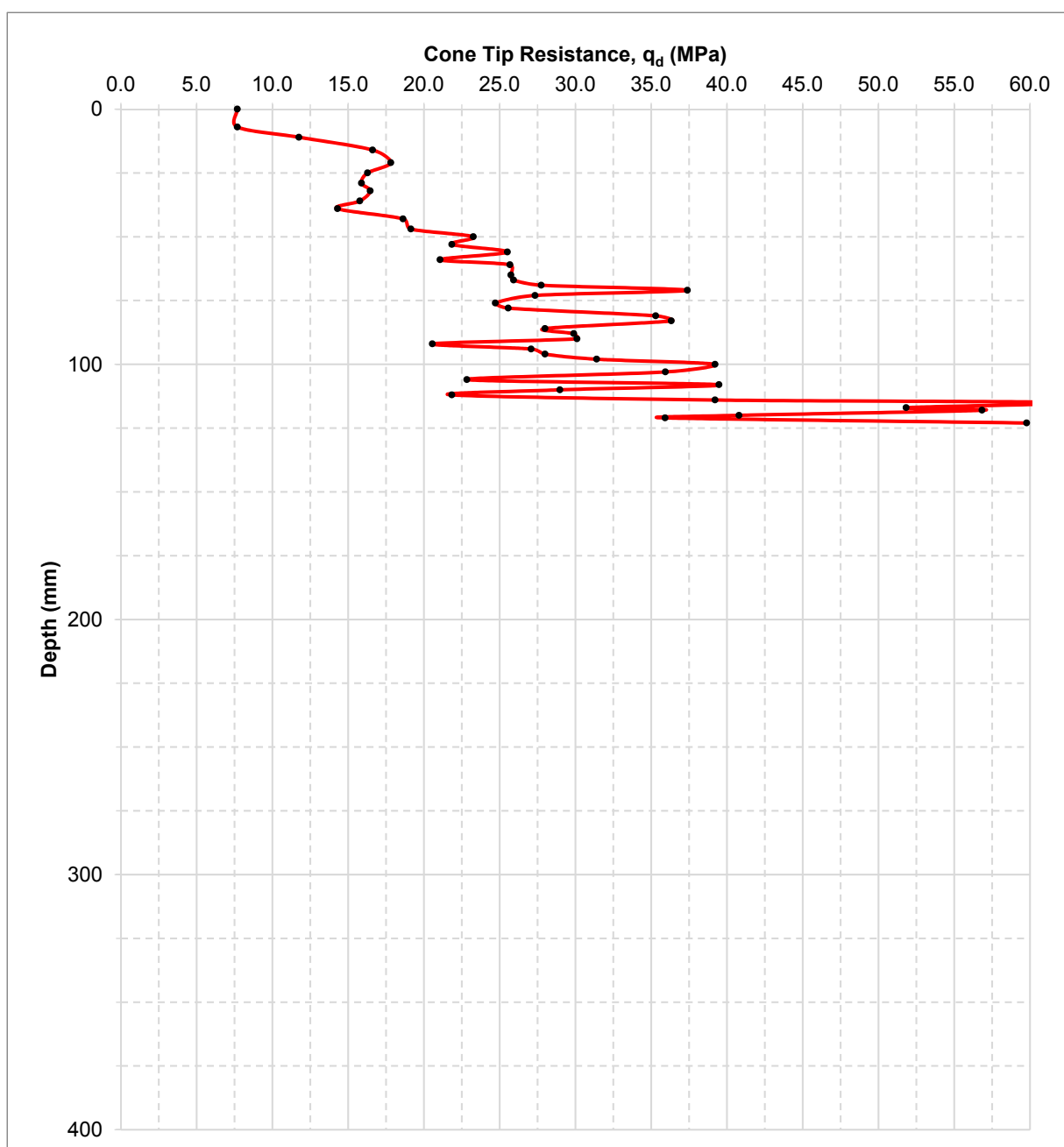
Project No.: 2091

Checked By: DWL

Location: Site 24-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-10A

Certificate Reference:

2091-PND-Site 24-10A

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	7.20	End of Test Record					
2	5	7.59						
3	5	10.03						
4	6	7.35						
5	5	9.40						
6	4	12.20						
7	4	17.83						
8	4	13.97						
9	3	24.02						
10	4	9.50						
11	3	17.87						
12	4	14.87						
13	3	14.84						
14	3	20.55						
15	2	42.04						
16	5	19.51						
17	2	22.98						
18	4	18.40						
19	3	21.35						
20	2	32.31						
21	1	43.01						
22	4	19.24						
23	2	28.42						
24	2	43.11						
25	3	32.28						
26	1	46.83						
27	2	36.23						
28	3	37.72						
29	2	38.73						
30	2	39.75						
31	2	44.24						
32	2	36.43						
33	3	45.20						
34	2	29.26						
35	2	51.01						
36	3	32.45						
37	1	41.80						
38	3	34.60						
39	2	31.32						
40	2	38.32						

PANDA Probe - Test Report

Site 24-10A

Certificate Reference:

2091-PND-Site 24-10A

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

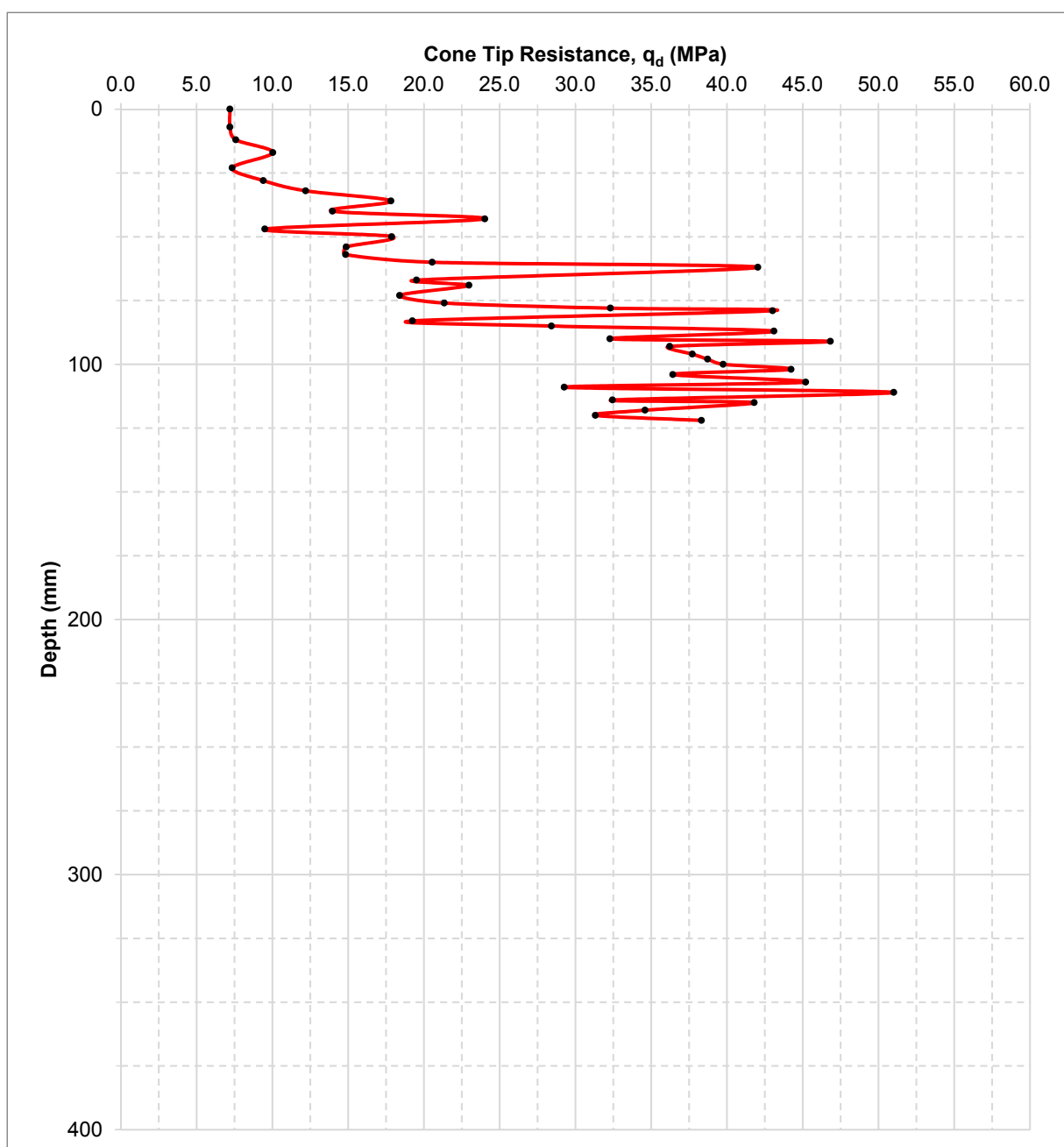
Project No.: 2091

Checked By: DWL

Location: Site 24-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-11

Certificate Reference:

2091-PND-Site 24-11

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	2.39	41	3	14.16			
2	6	4.48	42	2	13.31			
3	6	3.64	43	3	13.16			
4	4	5.20	44	2	12.62			
5	6	4.34	45	3	12.11			
6	5	5.19	46	2	17.52			
7	5	3.52	47	3	7.61			
8	1	13.41	48	3	11.84			
9	4	7.60	49	3	15.44			
10	3	6.70	50	2	11.19			
11	3	9.57	51	3	11.52			
12	3	9.28	52	3	13.60			
13	3	7.71	53	3	15.17			
14	3	9.02	54	1	13.79			
15	2	13.09	55	2	14.67			
16	4	10.08	56	3	10.94			
17	1	15.40	57	3	13.57			
18	2	13.42	58	2	19.17			
19	3	9.74	59	2	22.45			
20	4	6.91	60	2	18.94			
21	3	14.27	61	2	14.03			
22	2	11.18	62	2	21.37			
23	5	8.38	63	2	20.95			
24	5	10.32	64	2	17.61			
25	4	9.25	65	1	21.19			
26	2	11.76	66	2	22.52			
27	4	10.67	End of Test Record					
28	4	11.02						
29	2	9.32						
30	3	8.74						
31	3	8.44						
32	3	10.26						
33	3	9.72						
34	2	14.66						
35	3	10.34						
36	2	10.71						
37	2	13.28						
38	3	12.48						
39	3	14.51						
40	1	9.62						

PANDA Probe - Test Report

Site 24-11

Certificate Reference:

2091-PND-Site 24-11

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

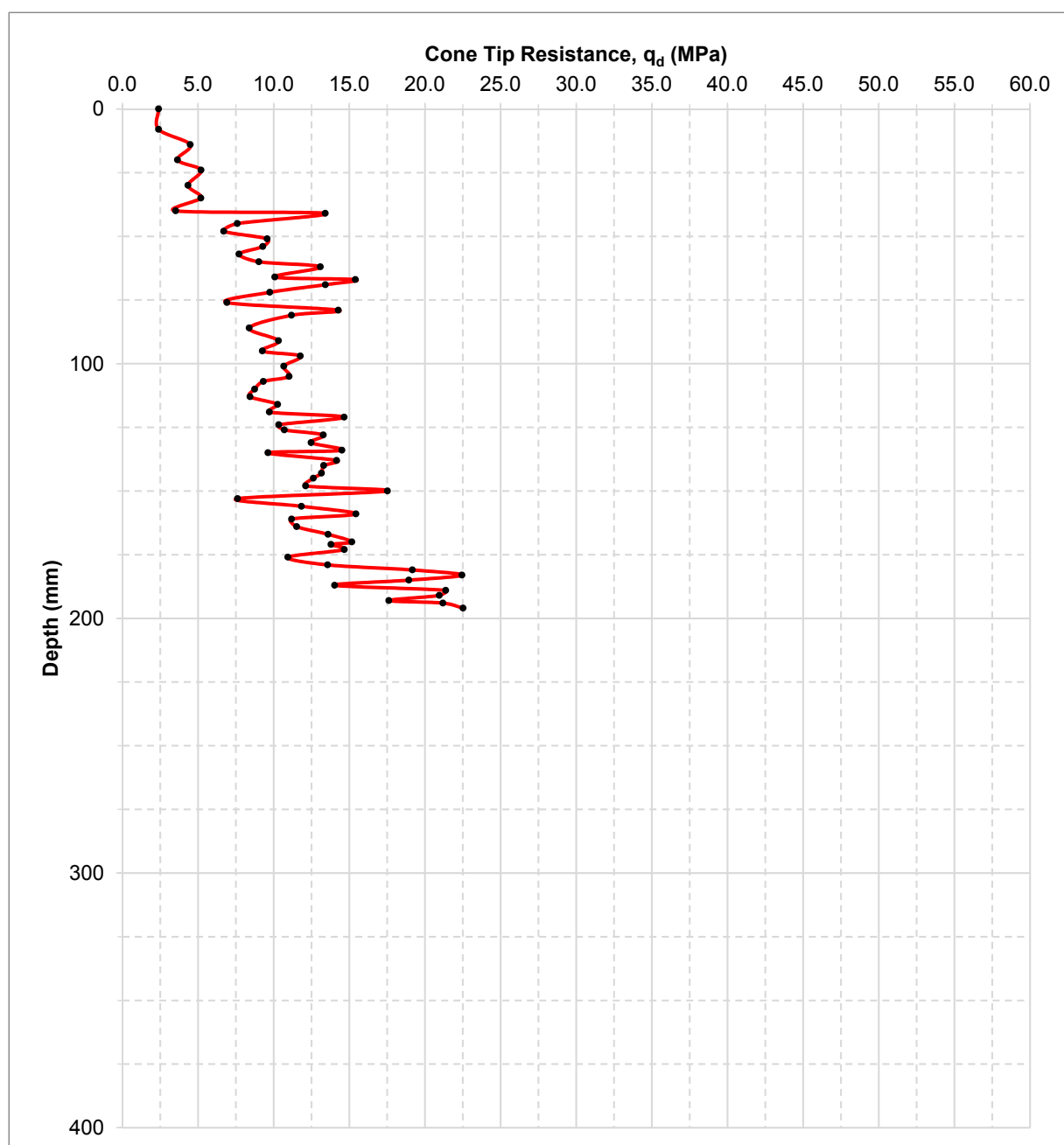
Project No.: 2091

Checked By: DWL

Location: Site 24-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-11A

Certificate Reference:

2091-PND-Site 24-11A

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	6.68	41	4	16.72	81	3	24.50
2	6	11.39	42	3	27.30	82	4	22.13
3	4	14.00	43	4	22.78	83	4	20.61
4	6	12.73	44	2	28.62	84	4	23.20
5	5	9.61	45	4	17.29	85	3	25.13
6	7	9.30	46	4	19.89	End of Test Record		
7	6	18.34	47	4	20.23			
8	5	15.57	48	3	21.81			
9	4	11.04	49	3	20.80			
10	5	13.08	50	4	20.97			
11	5	10.10	51	3	21.73			
12	5	16.34	52	3	25.57			
13	3	14.10	53	3	21.65			
14	4	15.68	54	4	24.24			
15	4	15.12	55	2	27.35			
16	3	19.09	56	5	18.83			
17	3	16.33	57	3	23.92			
18	3	10.26	58	4	20.82			
19	4	19.84	59	3	24.97			
20	4	15.72	60	4	21.12			
21	3	18.92	61	5	21.87			
22	3	21.95	62	3	24.18			
23	4	22.81	63	5	22.02			
24	3	22.48	64	3	25.04			
25	3	26.23	65	3	24.26			
26	3	27.13	66	3	26.74			
27	3	19.72	67	2	26.65			
28	2	28.98	68	3	30.69			
29	4	18.06	69	3	23.50			
30	3	28.92	70	2	30.55			
31	2	25.32	71	4	22.05			
32	4	19.62	72	4	23.15			
33	3	22.43	73	2	27.41			
34	3	21.80	74	2	27.07			
35	3	22.11	75	3	29.69			
36	3	24.78	76	4	29.75			
37	3	22.77	77	3	27.39			
38	3	28.14	78	3	26.34			
39	3	24.72	79	3	25.19			
40	2	17.24	80	3	29.75			

PANDA Probe - Test Report

Site 24-11A

Certificate Reference:

2091-PND-Site 24-11A

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

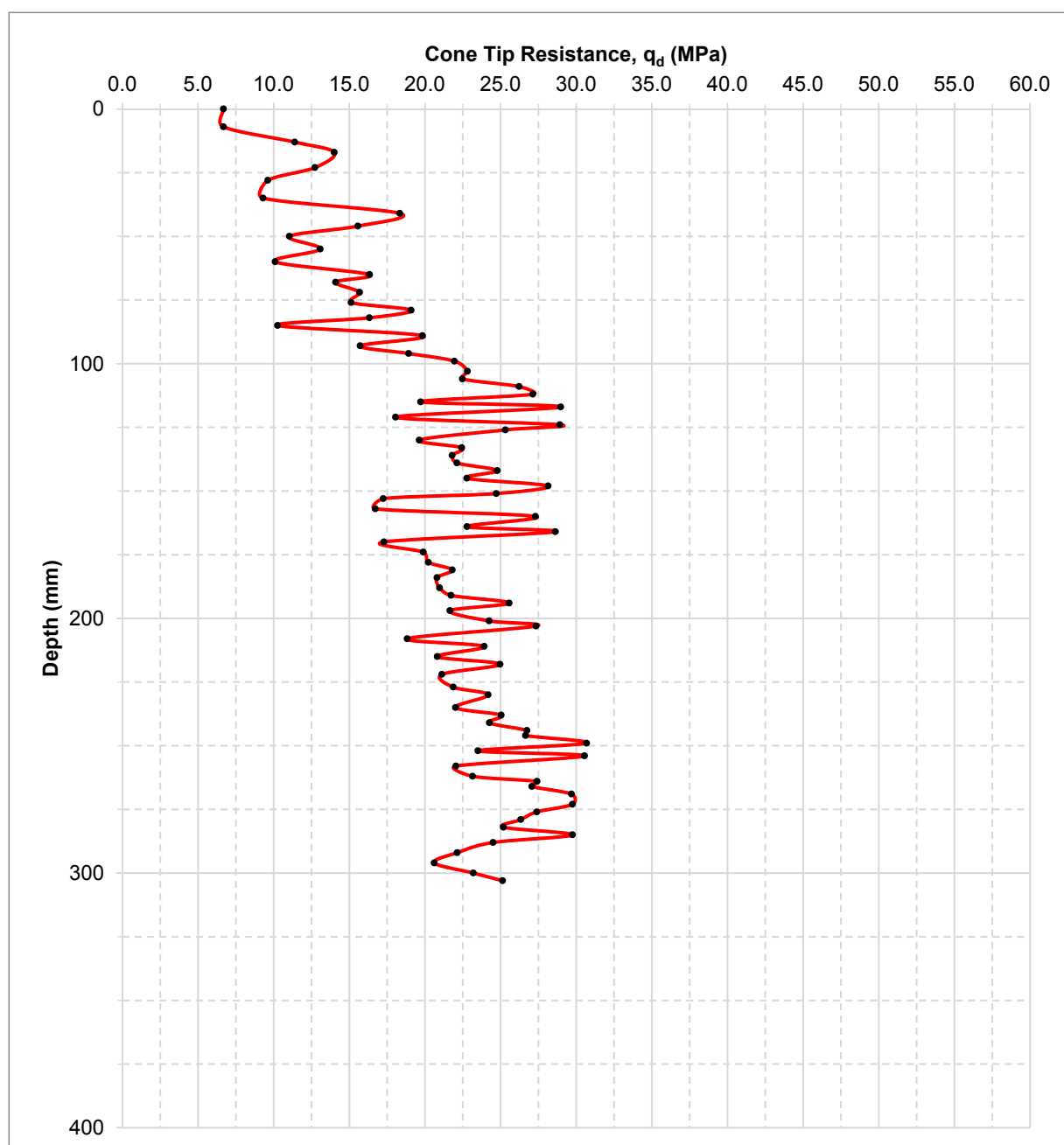
Project No.: 2091

Checked By: DWL

Location: Site 24-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 24-12

Certificate Reference:

2091-PND-Site 24-12

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

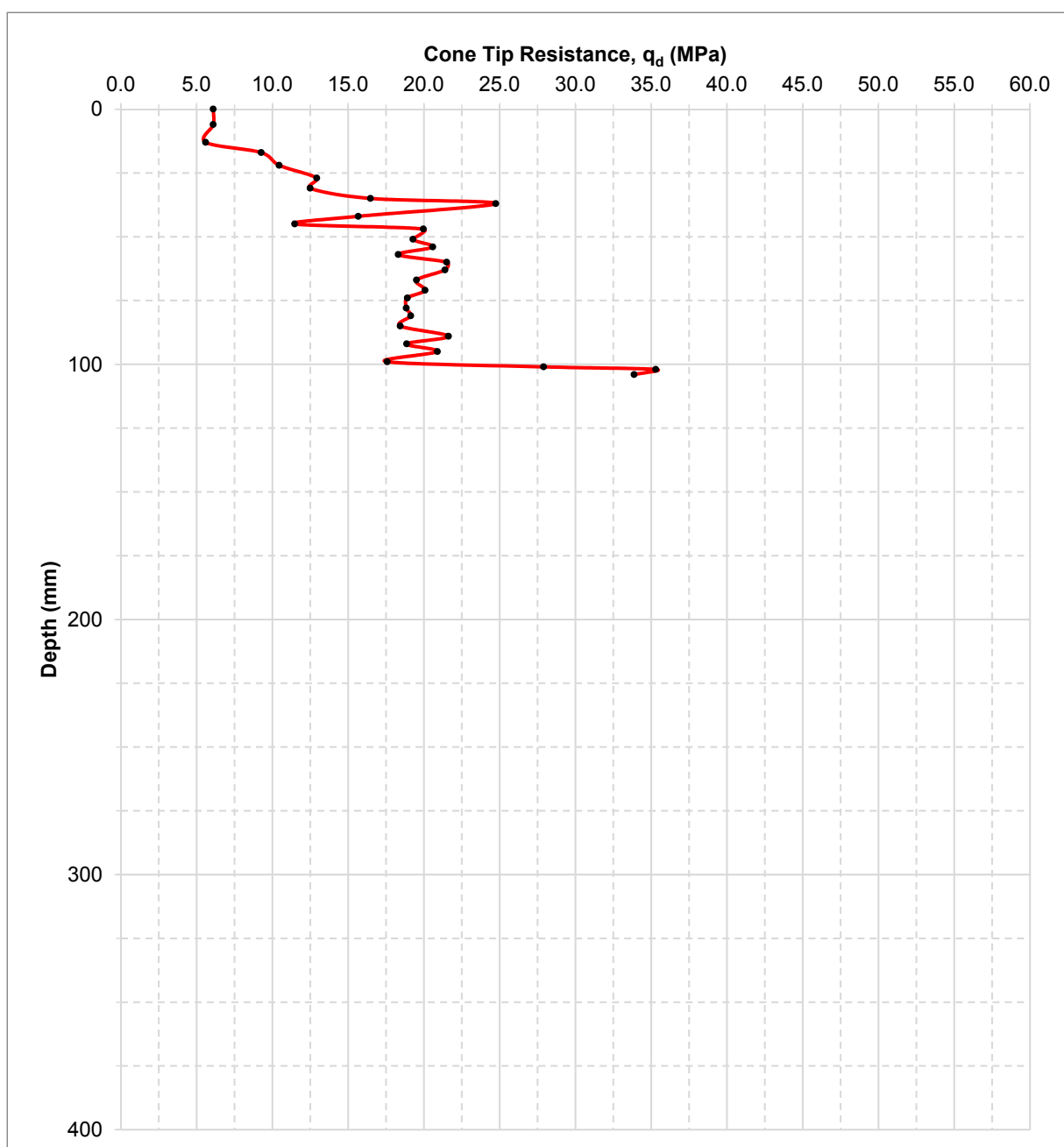
Project No.: 2091

Checked By: DWL

Location: Site 24-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 24-12A

Certificate Reference:

2091-PND-Site 24-12A

Sheet:

1 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 24-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	8.19	41	3	23.07			
2	5	7.49	42	4	18.19			
3	5	13.21	43	1	38.18			
4	5	12.82	44	2	30.87			
5	1	29.50	45	2	67.49			
6	4	18.23	46	1	42.19			
7	2	16.38	47	2	47.68			
8	4	14.87	48	3	37.97			
9	3	18.15	49	1	58.66			
10	4	15.00	50	2	41.87			
11	3	19.25	End of Test Record					
12	2	24.92						
13	3	34.52						
14	3	21.62						
15	3	18.91						
16	3	26.65						
17	2	14.99						
18	2	34.03						
19	3	18.64						
20	2	27.62						
21	3	25.23						
22	2	23.65						
23	2	28.56						
24	3	24.39						
25	2	20.96						
26	3	28.20						
27	2	34.91						
28	2	21.67						
29	3	31.94						
30	2	30.28						
31	2	26.65						
32	3	30.12						
33	2	26.74						
34	3	25.63						
35	2	23.48						
36	3	19.23						
37	3	25.91						
38	3	22.16						
39	3	30.39						
40	3	21.25						

PANDA Probe - Test Report

Site 24-12A

Certificate Reference:

2091-PND-Site 24-12A

Sheet:

2 of 2

Client: ARRB

Test Date: 12/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

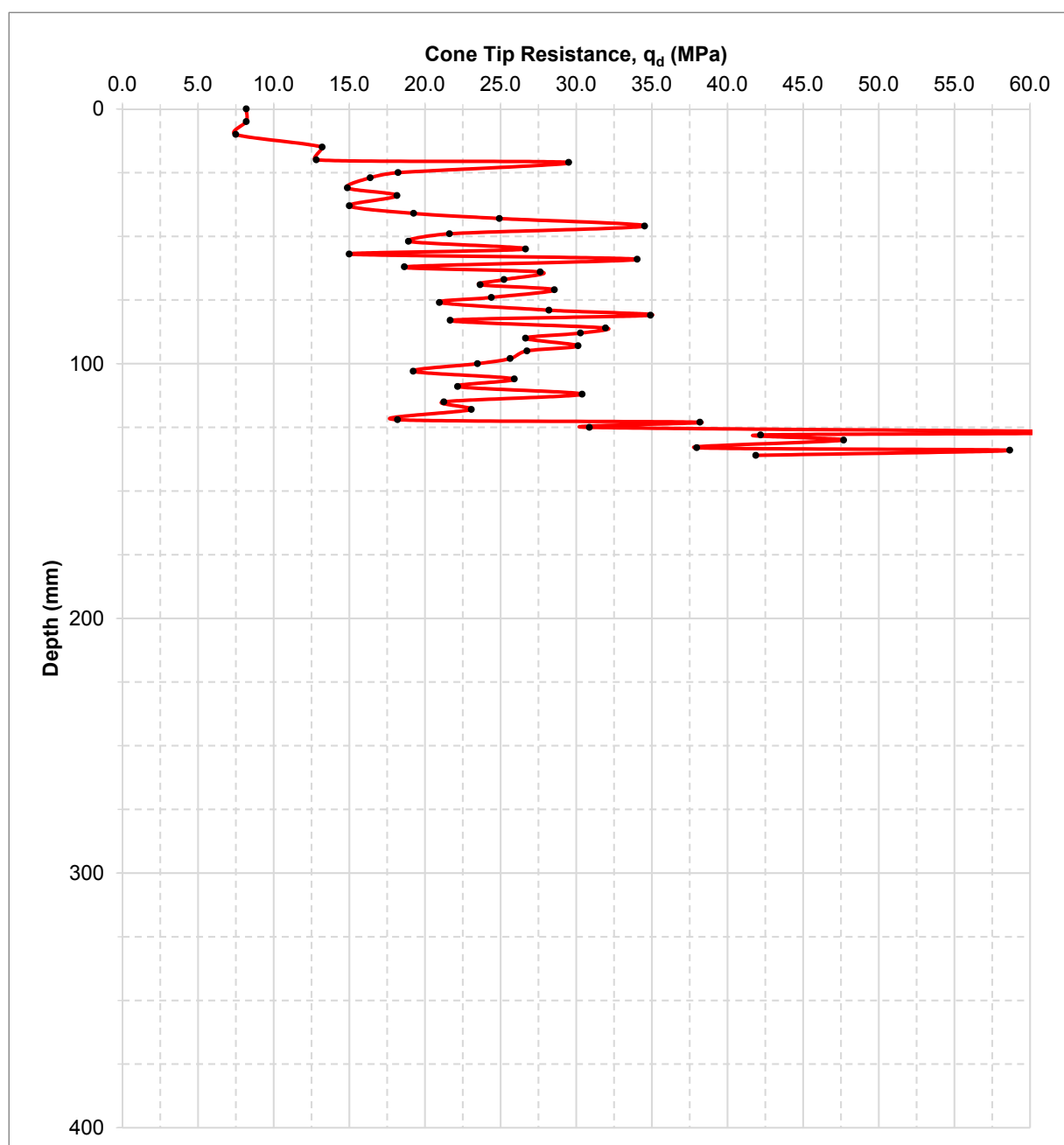
Project No.: 2091

Checked By: DWL

Location: Site 24-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 25-1

Certificate Reference:

2091-PND-Site 25-1

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

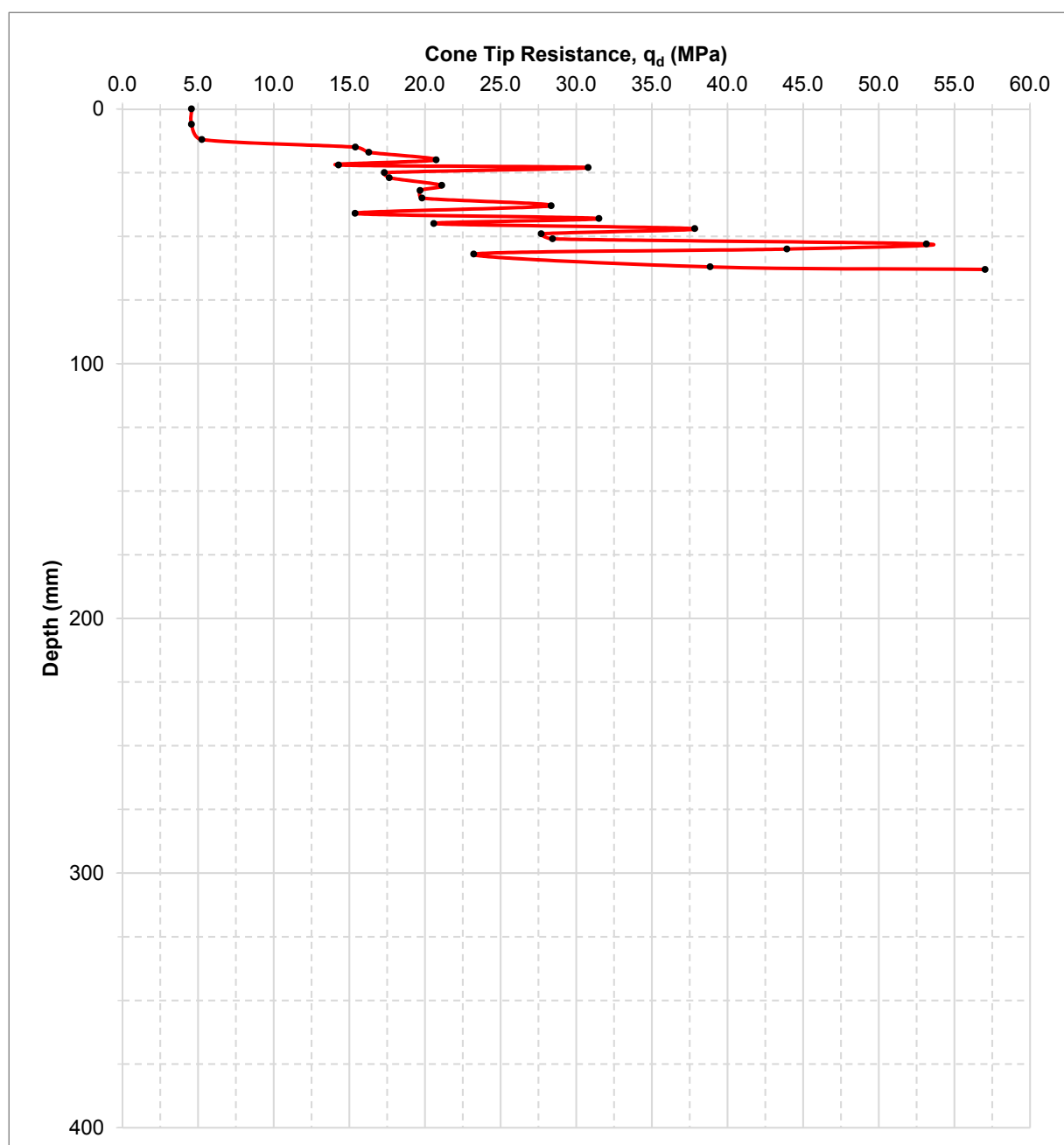
Project No.: 2091

Checked By: DWL

Location: Site 25-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-1A

Certificate Reference:

2091-PND-Site 25-1A

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.59	41	3	14.67	81	4	16.57
2	8	6.08	42	5	10.83	82	4	15.66
3	6	6.15	43	5	12.32	83	5	12.58
4	4	7.36	44	4	10.48	84	5	13.27
5	7	6.41	45	4	15.01	85	6	14.58
6	4	10.66	46	4	13.59	86	3	14.97
7	3	16.33	47	3	17.86	87	2	31.40
8	2	15.24	48	5	10.94	88	3	17.04
9	3	15.67	49	4	11.88	89	3	23.98
10	5	12.03	50	5	12.89	90	3	19.81
11	3	17.99	51	3	14.34	91	4	15.19
12	2	16.72	52	3	15.27	92	2	20.11
13	4	10.54	53	3	16.82	93	4	18.36
14	2	18.64	54	1	31.54	94	3	22.47
15	3	7.92	55	3	26.31	95	2	25.08
16	6	12.07	56	2	25.38	96	3	15.12
17	4	8.59	57	1	38.44	97	3	18.91
18	6	9.64	58	2	28.18	98	3	21.93
19	5	9.61	59	2	27.96	99	3	20.79
20	5	10.81	60	2	36.59	100	3	18.50
21	4	7.28	61	2	30.87	101	3	31.26
22	5	9.59	62	2	27.40	102	1	33.56
23	4	8.99	63	1	40.80	103	2	31.20
24	5	6.67	64	3	23.60	104	2	33.61
25	2	22.78	65	2	34.40	105	2	35.05
26	2	9.96	66	2	26.28	106	1	32.83
27	2	25.13	67	1	59.81	107	2	46.69
28	2	36.36	68	2	23.12	End of Test Record		
29	3	23.69	69	3	18.75			
30	3	20.11	70	4	14.95			
31	4	11.57	71	4	17.48			
32	2	22.16	72	2	18.43			
33	3	17.69	73	3	16.13			
34	3	16.32	74	4	15.16			
35	2	9.27	75	5	14.63			
36	3	14.86	76	5	13.16			
37	4	16.05	77	2	21.07			
38	4	13.68	78	6	13.05			
39	4	13.16	79	3	20.84			
40	3	10.41	80	6	14.54			

PANDA Probe - Test Report

Site 25-1A

Certificate Reference:

2091-PND-Site 25-1A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

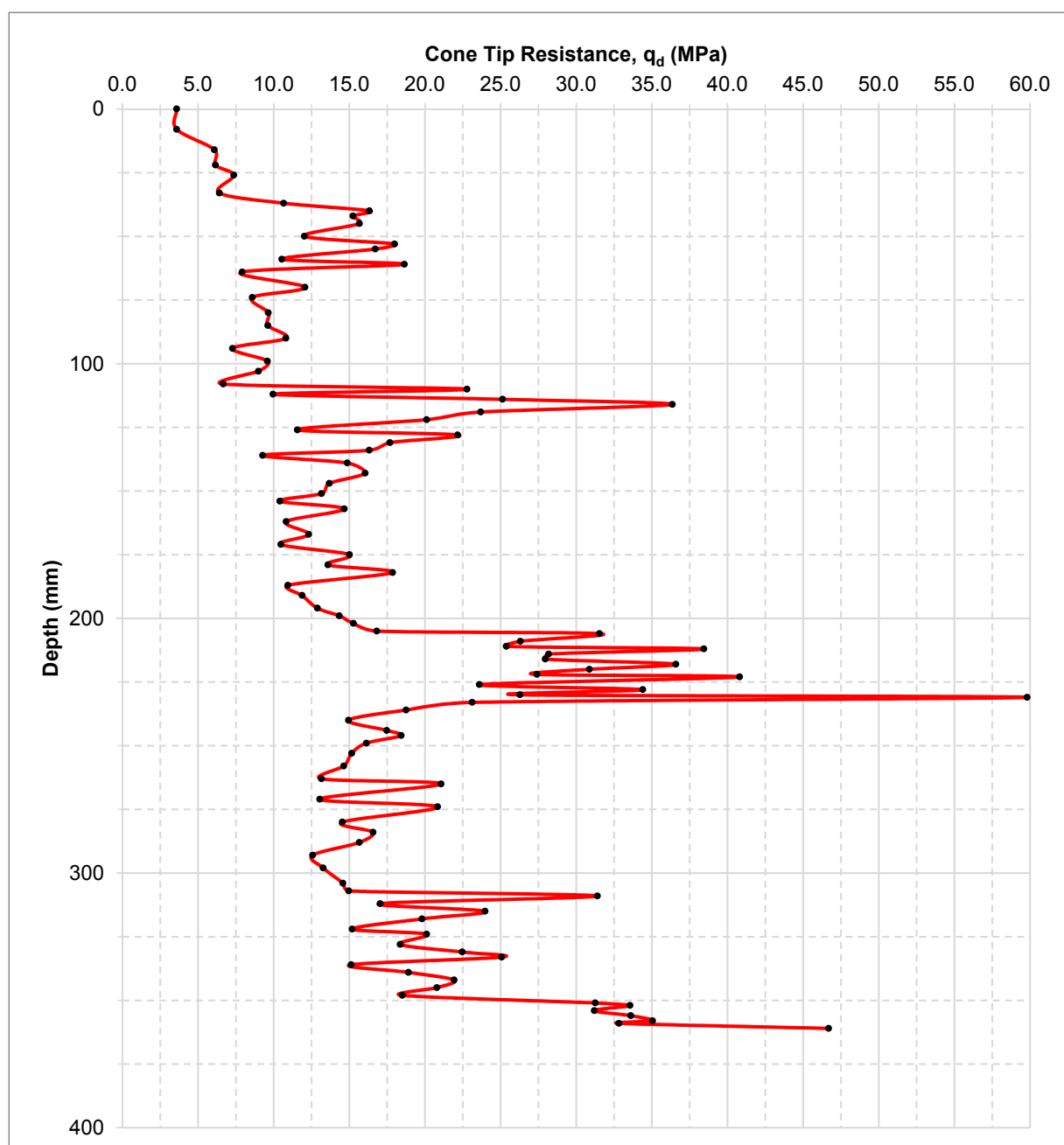
Project No.: 2091

Checked By: DWL

Location: Site 25-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 25-1A (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 25-1A-R

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

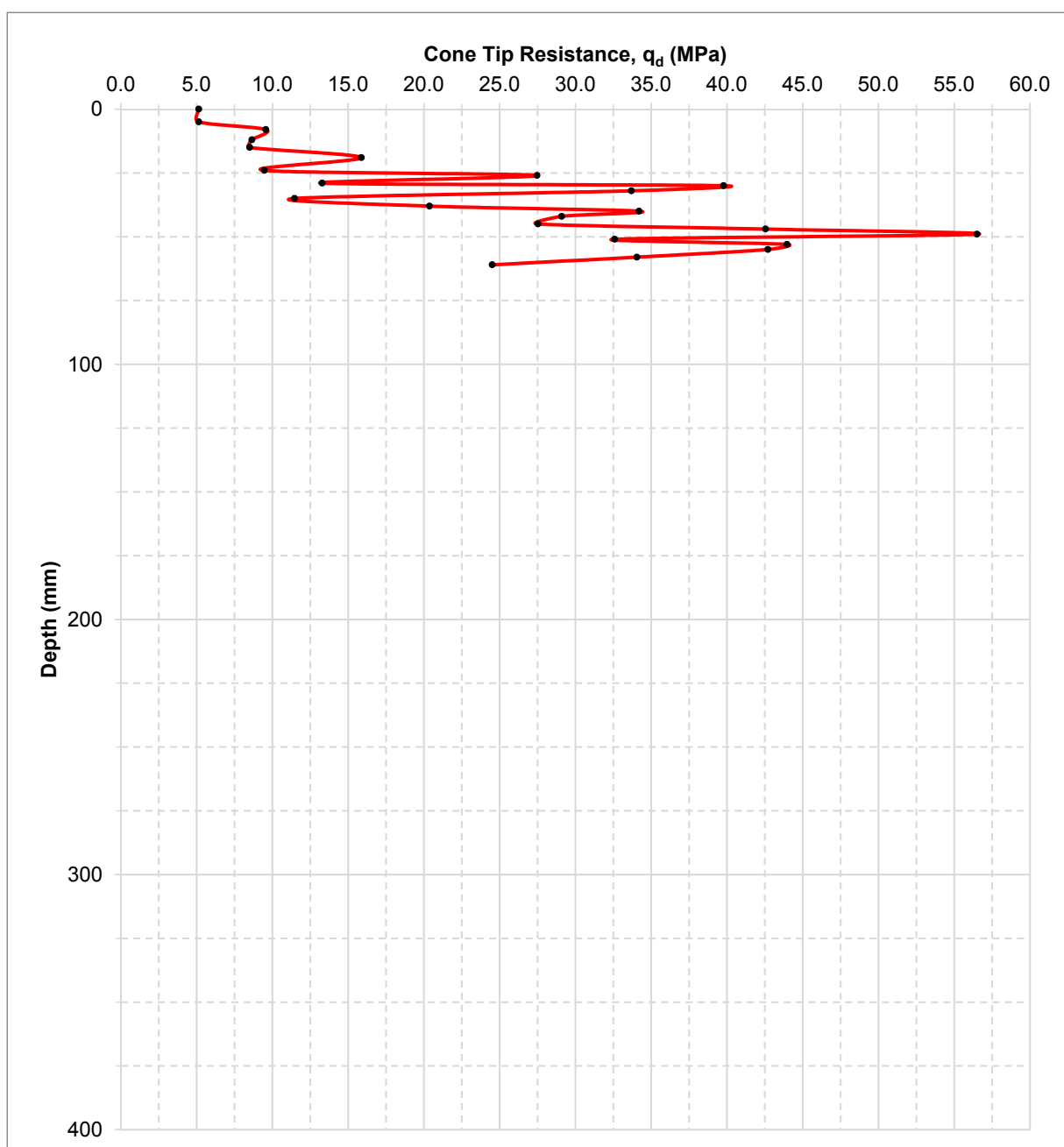
Project No.: 2091

Checked By: DWL

Location: Site 25-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 25-1B (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 25-1B-R

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

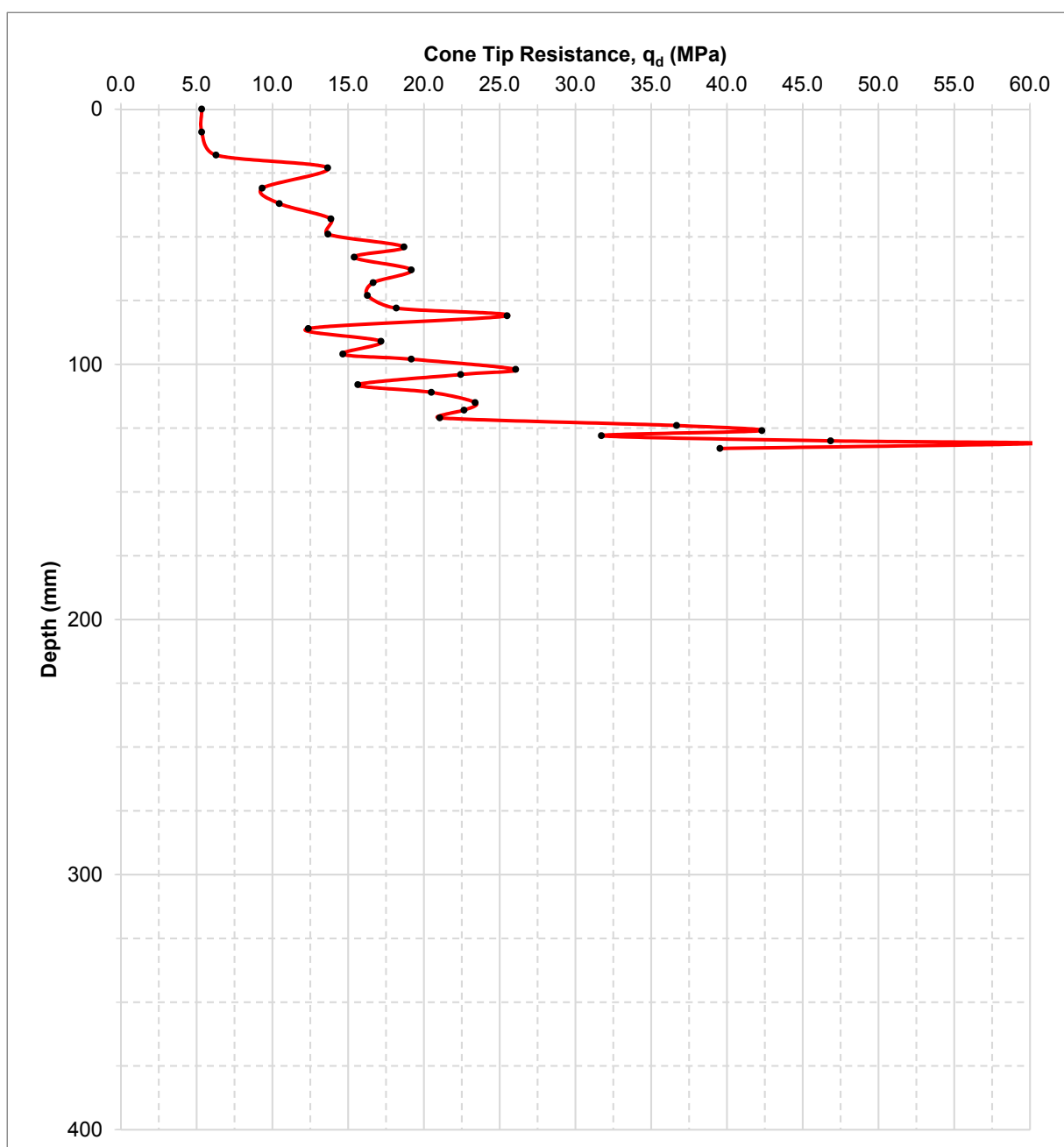
Project No.: 2091

Checked By: DWL

Location: Site 25-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-1 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 25-1-R

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.82	41	3	32.25			
2	5	7.12	42	3	37.37			
3	6	6.69	43	1	44.47			
4	3	12.51	44	1	52.19			
5	5	10.84	45	2	48.61			
6	5	9.87	End of Test Record					
7	5	12.33						
8	4	14.61						
9	5	9.10						
10	4	14.30						
11	3	13.42						
12	5	11.83						
13	3	19.24						
14	7	13.46						
15	4	13.71						
16	5	14.07						
17	1	52.03						
18	3	34.82						
19	3	6.68						
20	1	31.06						
21	3	27.11						
22	1	48.12						
23	2	25.69						
24	2	32.14						
25	3	16.83						
26	3	25.05						
27	2	44.52						
28	2	36.72						
29	4	23.21						
30	4	19.95						
31	2	17.16						
32	4	17.95						
33	3	18.59						
34	3	20.87						
35	2	32.17						
36	3	19.84						
37	2	28.55						
38	1	43.88						
39	2	27.76						
40	2	56.38						

PANDA Probe - Test Report

Site 25-1 (Retest, > 24 hrs)

Certificate Reference:

2091-PND-Site 25-1-R

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

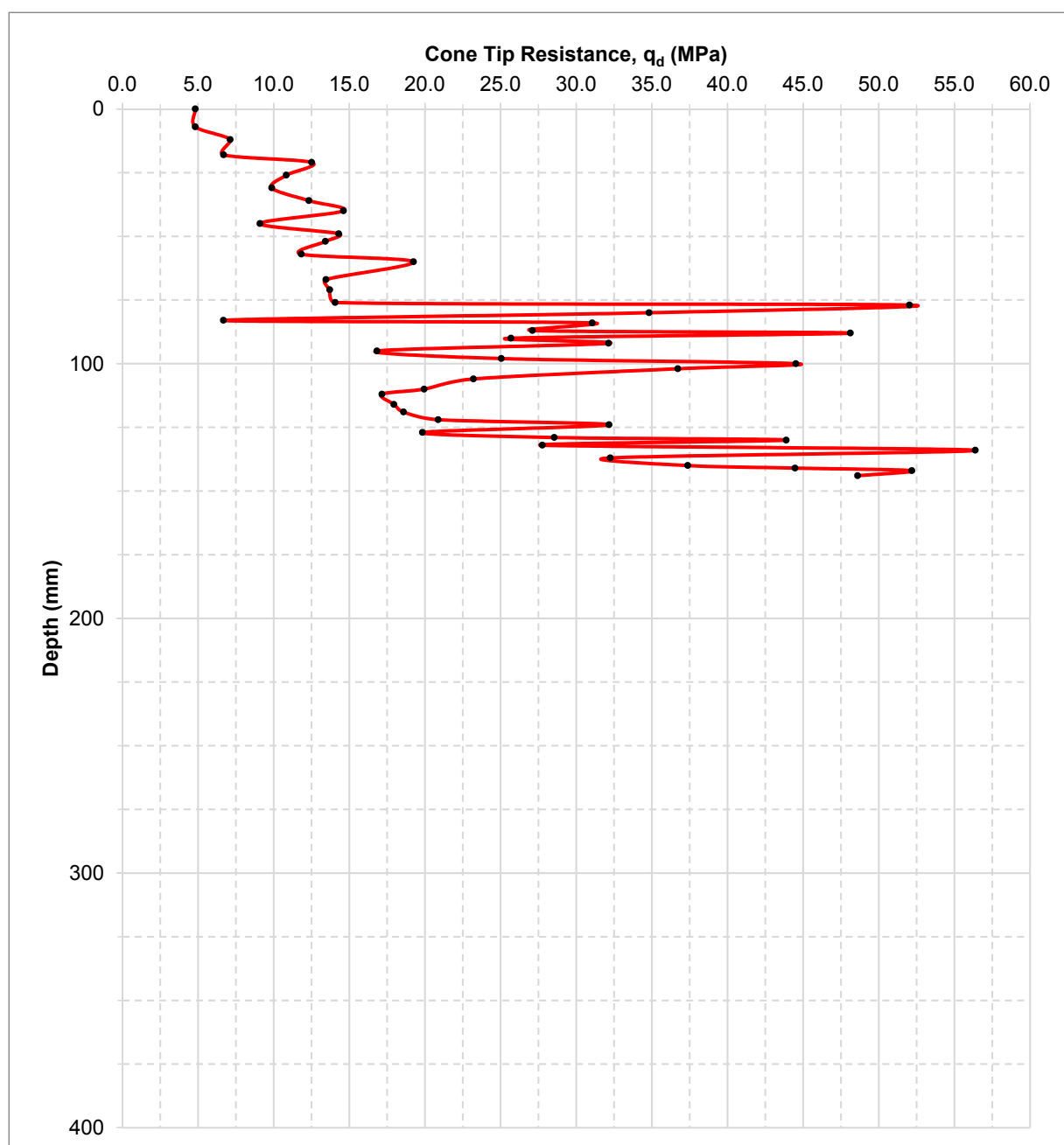
Project No.: 2091

Checked By: DWL

Location: Site 25-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-2

Certificate Reference:

2091-PND-Site 25-2

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	3.52	41	2	20.09	81	2	41.21
2	6	5.19	42	2	17.83	82	2	42.25
3	4	11.07	43	1	24.24	83	3	33.90
4	5	7.96	44	2	24.63	End of Test Record		
5	2	17.19	45	3	18.72			
6	3	12.07	46	2	19.30			
7	4	13.31	47	3	21.24			
8	4	12.00	48	1	18.30			
9	1	30.86	49	2	23.54			
10	4	12.97	50	3	23.32			
11	4	9.59	51	3	21.50			
12	3	17.68	52	2	21.27			
13	2	24.81	53	2	27.63			
14	6	6.98	54	3	19.38			
15	5	9.51	55	2	12.42			
16	3	16.57	56	3	23.89			
17	4	15.77	57	3	19.18			
18	3	14.58	58	3	20.18			
19	3	17.50	59	4	19.09			
20	4	10.81	60	4	17.08			
21	5	12.20	61	4	16.08			
22	3	26.76	62	4	12.35			
23	4	10.71	63	4	17.48			
24	2	36.22	64	3	18.11			
25	3	12.61	65	2	24.73			
26	2	25.78	66	4	13.32			
27	2	16.18	67	3	15.14			
28	4	16.99	68	3	17.10			
29	3	17.59	69	2	20.55			
30	3	12.12	70	4	11.36			
31	3	15.77	71	3	17.76			
32	3	16.40	72	5	16.48			
33	4	15.88	73	3	19.88			
34	3	13.98	74	2	25.67			
35	2	15.14	75	2	36.03			
36	4	8.65	76	4	16.09			
37	2	15.57	77	1	34.09			
38	3	25.13	78	3	39.23			
39	3	15.72	79	1	39.30			
40	3	15.48	80	2	42.83			

Certificate Reference:

2091-PND-Site 25-2

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

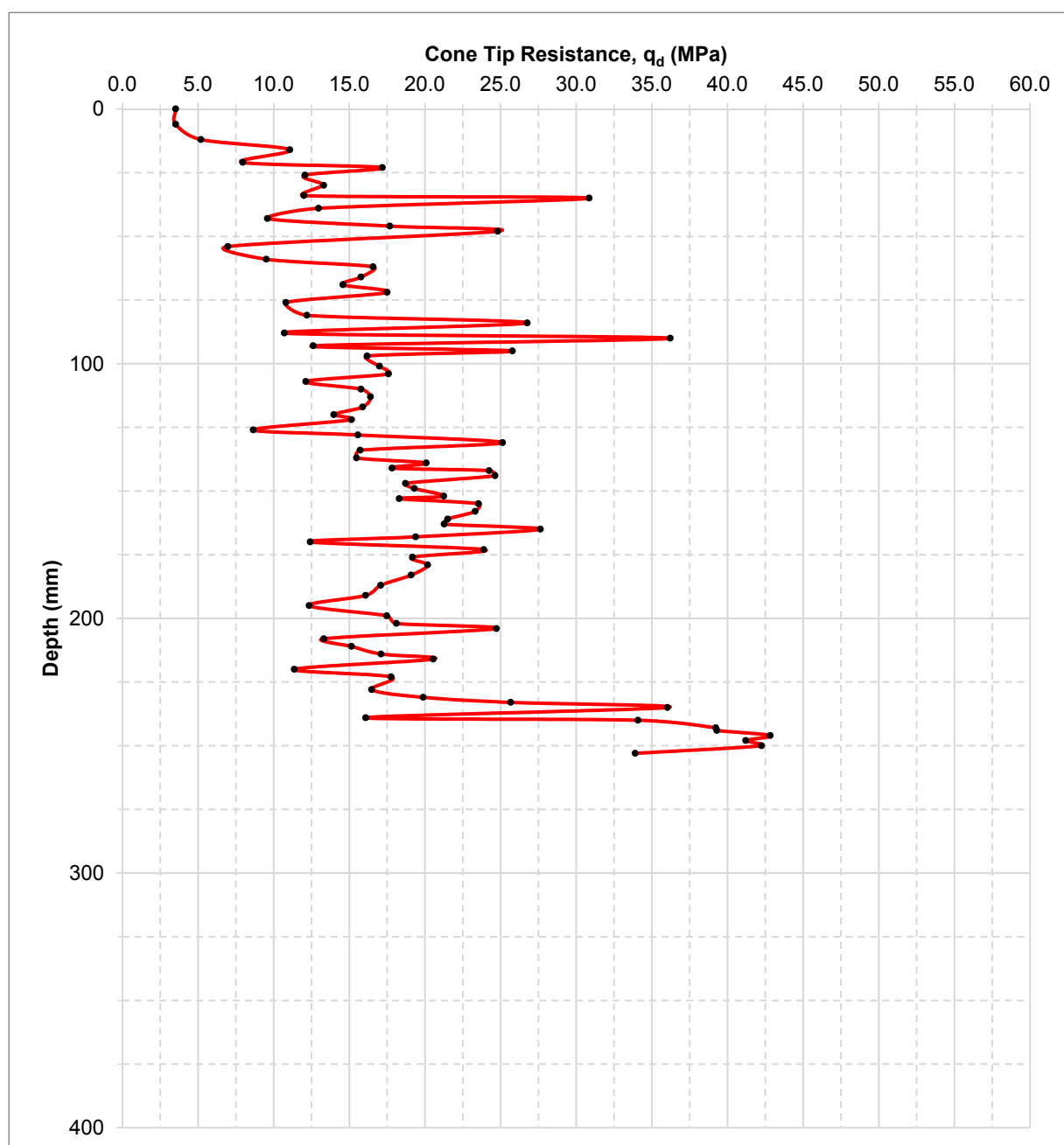
Project No.: 2091

Checked By: DWL

Location: Site 25-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-2A

Certificate Reference:

2091-PND-Site 25-2A

Sheet:

1 of 3

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	8.36	41	3	33.35	81	3	20.03
2	5	6.29	42	3	27.24	82	5	14.53
3	4	9.42	43	2	31.78	83	3	13.77
4	3	13.29	44	3	24.09	84	3	24.85
5	6	9.41	45	2	33.56	85	3	24.02
6	4	11.41	46	2	35.72	86	1	19.45
7	4	10.35	47	2	39.28	87	2	16.93
8	4	10.74	48	2	35.21	88	2	29.11
9	4	12.50	49	4	21.74	89	3	18.02
10	6	12.11	50	1	27.45	90	3	21.64
11	3	13.92	51	4	14.73	91	1	38.25
12	4	11.79	52	3	19.43	92	3	22.54
13	3	9.96	53	2	29.47	93	2	33.58
14	3	22.16	54	2	20.28	94	2	29.69
15	4	13.03	55	3	21.45	95	2	21.02
16	4	8.45	56	4	20.06	96	3	30.91
17	2	21.87	57	2	20.00	97	3	23.54
18	3	16.87	58	4	12.55	98	5	14.08
19	3	7.80	59	2	17.19	99	2	24.42
20	3	8.90	60	3	17.96	100	2	32.11
21	4	13.73	61	2	15.64	101	3	28.34
22	1	33.32	62	3	16.84	102	2	21.93
23	4	14.02	63	2	37.10	103	2	20.15
24	5	21.66	64	4	20.45	104	4	13.81
25	2	35.71	65	5	10.13	105	1	40.35
26	3	10.17	66	3	18.81	106	2	25.30
27	4	14.09	67	2	25.45	107	2	26.18
28	3	23.04	68	3	21.22	108	3	16.02
29	3	28.70	69	1	50.71	109	2	17.23
30	2	17.85	70	5	9.78	110	3	16.60
31	3	23.66	71	3	20.64	111	3	21.15
32	3	20.80	72	4	16.70	112	3	20.69
33	1	29.70	73	2	29.22	113	3	26.13
34	3	31.41	74	5	19.79	114	1	25.18
35	3	28.73	75	5	9.82	115	2	29.56
36	2	19.80	76	2	5.06	116	2	23.74
37	2	19.40	77	3	17.72	117	2	32.02
38	3	20.77	78	4	10.81	118	2	18.10
39	3	31.39	79	4	16.14	119	3	11.17
40	2	27.53	80	5	13.65	120	2	15.92

PANDA Probe - Test Report

Site 25-2A

Certificate Reference:

2091-PND-Site 25-2A

Sheet:

2 of 3

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	4	10.77	161	5	14.34			
122	4	12.84	162	5	12.18			
123	5	11.24	163	4	16.66			
124	4	16.75	164	3	23.46			
125	4	14.19	165	2	18.04			
126	2	18.18	166	5	12.39			
127	2	17.36	167	4	17.07			
128	3	11.30	168	2	33.18			
129	2	20.97	169	2	27.01			
130	2	19.58	170	4	16.85			
131	2	16.20	171	5	47.79			
132	2	21.02	172	3	42.03			
133	2	13.14	173	3	56.04			
134	2	18.00	174	4	34.49			
135	1	21.03	175	3	50.67			
136	2	13.28	176	3	36.39			
137	1	31.59	End of Test Record					
138	4	13.96						
139	3	14.42						
140	4	14.64						
141	1	9.44						
142	2	16.07						
143	2	21.04						
144	2	11.07						
145	2	11.64						
146	3	18.64						
147	2	18.19						
148	4	13.52						
149	4	12.17						
150	3	16.21						
151	3	12.73						
152	3	7.02						
153	1	14.88						
154	5	8.28						
155	4	16.73						
156	4	14.09						
157	4	10.23						
158	3	18.49						
159	4	11.46						
160	6	11.34						

PANDA Probe - Test Report

Site 25-2A

Certificate Reference:

2091-PND-Site 25-2A

Sheet:

3 of 3

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

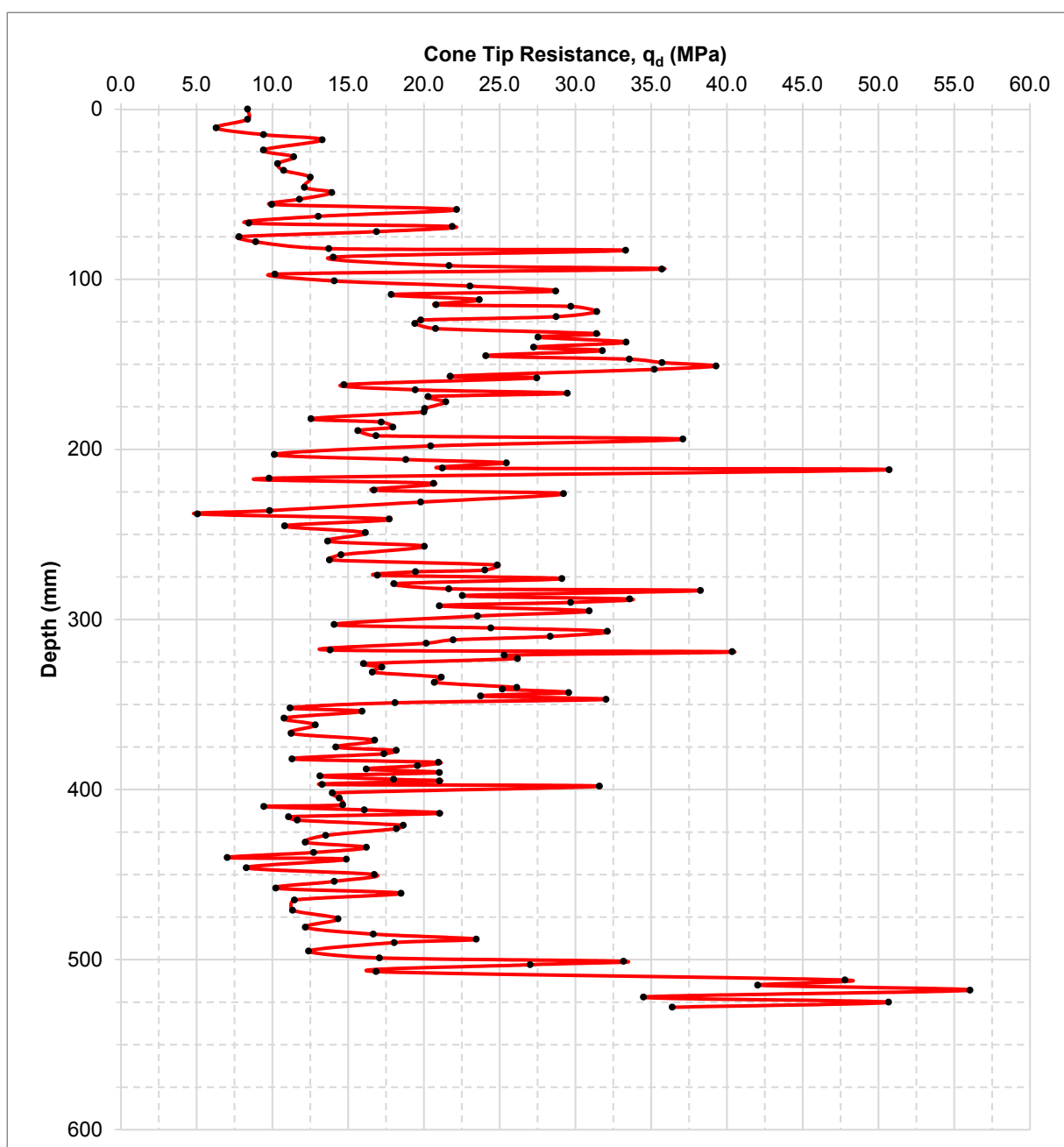
Project No.: 2091

Checked By: DWL

Location: Site 25-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-3

Certificate Reference:

2091-PND-Site 25-3

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	5.58	41	6	22.92			
2	5	8.65	42	4	24.44			
3	8	11.52	43	5	27.65			
4	7	14.98	44	7	17.73			
5	11	10.56	45	7	14.62			
6	10	13.39	46	7	15.56			
7	11	11.60	47	6	13.49			
8	12	11.57	48	5	12.60			
9	14	7.65	49	7	9.39			
10	15	9.41	50	13	12.80			
11	10	9.99	51	12	17.66			
12	7	7.15	52	8	22.72			
13	10	14.29	53	4	52.26			
14	11	11.67	54	3	50.73			
15	10	15.14	55	2	55.13			
16	9	15.61	56	3	57.28			
17	7	16.36	57	2	49.04			
18	7	21.37	58	2	45.33			
19	7	26.98	59	2	35.44			
20	6	24.67	End of Test Record					
21	7	26.68						
22	8	21.63						
23	10	18.22						
24	10	14.07						
25	10	17.37						
26	9	15.09						
27	9	17.07						
28	9	21.22						
29	9	16.85						
30	7	19.39						
31	7	25.93						
32	8	18.79						
33	7	28.79						
34	11	17.13						
35	8	12.46						
36	6	29.22						
37	8	20.22						
38	11	15.44						
39	6	33.06						
40	6	29.95						

PANDA Probe - Test Report

Site 25-3

Certificate Reference:

2091-PND-Site 25-3

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

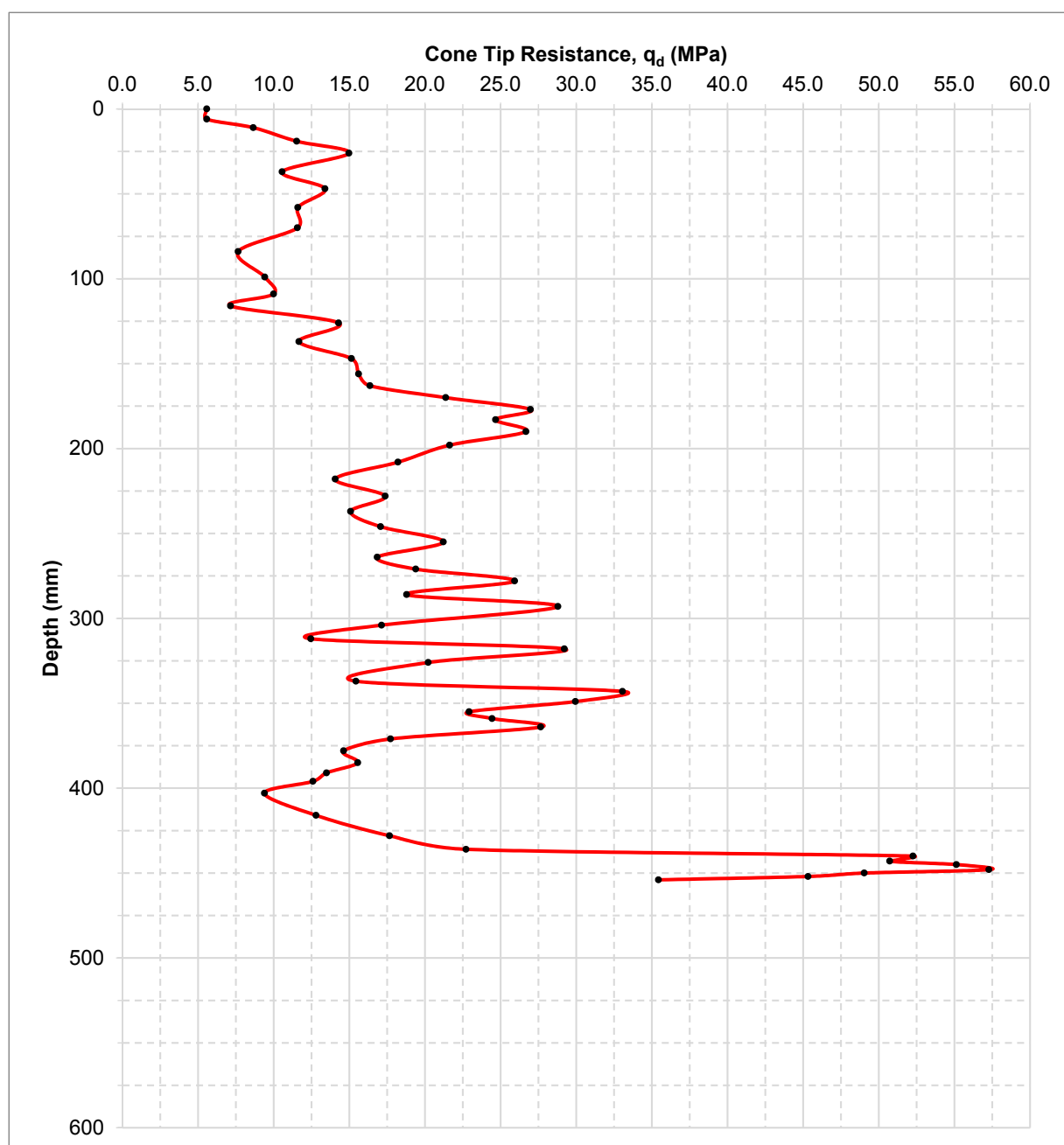
Project No.: 2091

Checked By: DWL

Location: Site 25-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-4

Certificate Reference:

2091-PND-Site 25-4

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	8.84	41	5	34.77	81	2	40.61
2	8	11.11	42	5	38.34	82	2	30.55
3	8	16.56	43	3	50.38	83	2	38.87
4	9	9.68	44	5	37.88	84	1	37.81
5	13	13.72	45	4	40.98	85	2	32.21
6	9	12.69	46	5	38.74	86	2	32.25
7	8	16.91	47	7	30.50	87	1	38.51
8	6	22.83	48	10	20.28	End of Test Record		
9	5	17.60	49	10	18.16			
10	7	16.92	50	7	19.76			
11	5	20.63	51	5	21.29			
12	6	29.34	52	6	21.45			
13	6	13.54	53	7	21.79			
14	8	16.85	54	7	19.87			
15	6	18.62	55	5	25.27			
16	7	15.59	56	5	25.48			
17	6	18.87	57	6	22.04			
18	5	18.45	58	5	26.57			
19	6	23.72	59	5	23.51			
20	7	18.12	60	4	21.51			
21	7	21.08	61	3	32.10			
22	8	21.24	62	3	22.80			
23	8	16.25	63	4	26.43			
24	6	19.27	64	3	19.56			
25	6	24.60	65	5	22.97			
26	7	19.06	66	6	27.31			
27	6	24.04	67	7	21.63			
28	7	23.27	68	3	25.51			
29	9	18.79	69	3	32.04			
30	6	23.92	70	3	24.34			
31	7	22.23	71	3	29.05			
32	7	24.37	72	4	23.16			
33	7	22.14	73	3	28.25			
34	6	25.57	74	4	28.00			
35	9	18.65	75	4	26.18			
36	9	17.09	76	5	24.61			
37	7	17.47	77	6	25.99			
38	5	25.88	78	4	30.65			
39	3	33.61	79	2	26.74			
40	5	30.97	80	2	27.36			

PANDA Probe - Test Report

Site 25-4

Certificate Reference:

2091-PND-Site 25-4

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

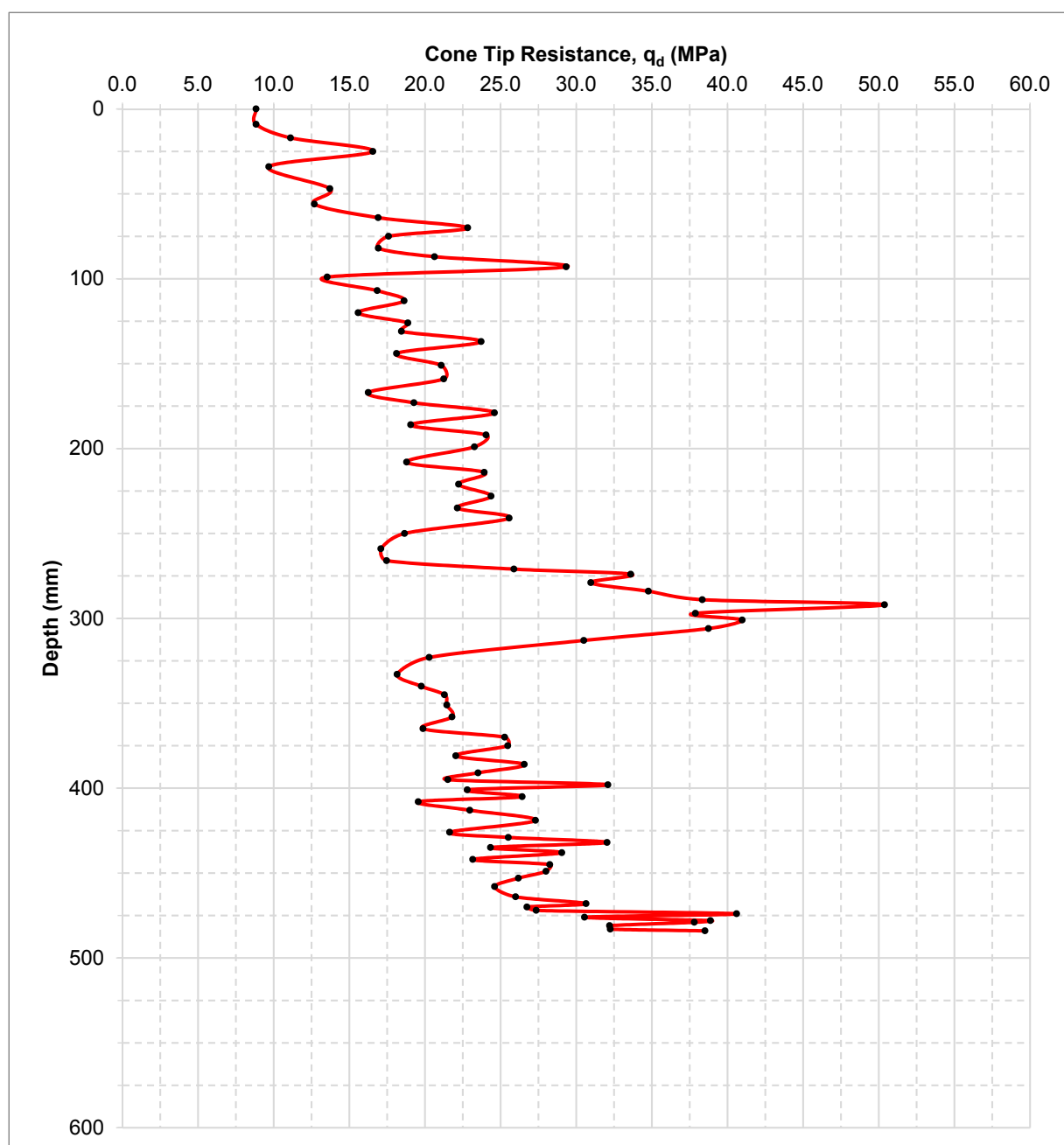
Project No.: 2091

Checked By: DWL

Location: Site 25-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-5

Certificate Reference:

2091-PND-Site 25-5

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	3.55	41	2	43.80			
2	10	6.01	42	2	39.92			
3	8	11.87	43	3	47.82			
4	10	13.70	44	2	39.60			
5	11	9.70	End of Test Record					
6	14	8.38						
7	11	14.19						
8	13	12.57						
9	8	18.22						
10	8	15.73						
11	12	15.50						
12	8	16.42						
13	8	20.65						
14	7	21.56						
15	11	17.78						
16	9	18.98						
17	8	16.69						
18	6	26.88						
19	6	30.26						
20	6	31.61						
21	10	17.42						
22	12	15.48						
23	10	14.15						
24	8	16.76						
25	10	12.98						
26	9	15.32						
27	8	13.93						
28	9	10.73						
29	9	13.34						
30	10	12.95						
31	7	13.86						
32	9	11.76						
33	9	14.68						
34	9	14.13						
35	6	16.92						
36	7	18.71						
37	6	17.65						
38	4	35.39						
39	4	32.77						
40	3	38.12						

PANDA Probe - Test Report

Site 25-5

Certificate Reference:

2091-PND-Site 25-5

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

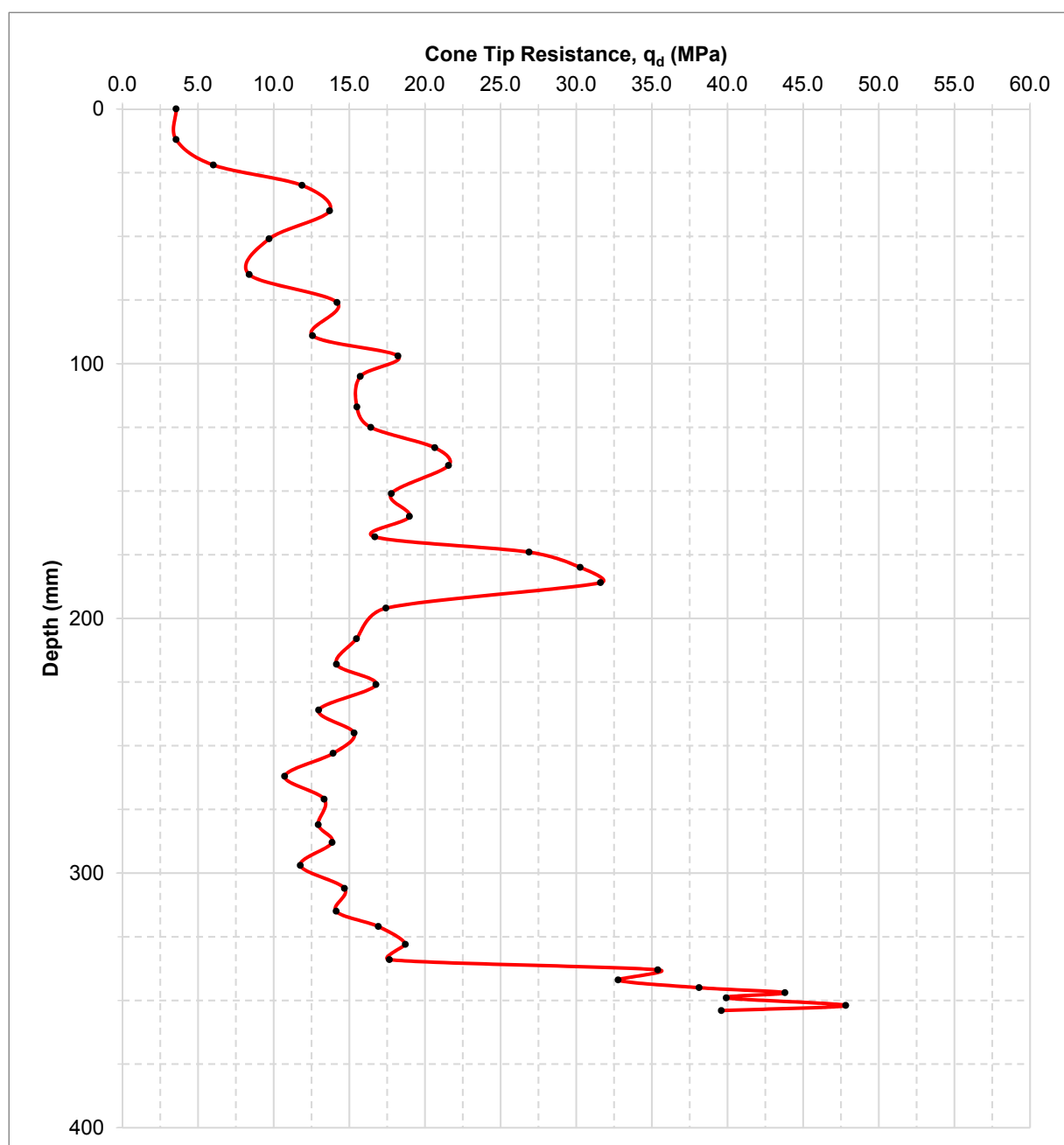
Project No.: 2091

Checked By: DWL

Location: Site 25-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-7

Certificate Reference:

2091-PND-Site 25-7

Sheet:

1 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	7.72	41	4	26.06	81	3	36.13
2	5	11.72	42	2	27.49	82	5	13.32
3	2	25.25	43	2	33.06	83	4	29.13
4	5	10.03	44	2	32.78	84	4	24.17
5	3	17.22	45	4	21.22	85	2	44.86
6	3	17.89	46	1	44.42	86	6	17.17
7	2	19.93	47	4	16.25	87	4	25.20
8	2	24.53	48	4	22.37	88	5	23.49
9	4	16.35	49	3	23.86	89	2	55.49
10	3	15.51	50	3	26.10	90	4	16.49
11	3	24.01	51	1	38.55	91	6	18.88
12	2	27.30	52	5	9.82	92	5	21.33
13	3	18.02	53	2	22.64	93	5	20.99
14	2	12.57	54	2	27.90	94	6	19.46
15	2	26.55	55	3	27.30	95	5	19.43
16	3	17.07	56	4	23.08	96	6	17.90
17	4	23.54	57	1	51.10	97	7	17.47
18	3	22.91	58	4	22.32	98	5	14.04
19	3	21.10	59	2	21.61	99	5	14.59
20	2	21.31	60	2	38.24	100	8	12.94
21	2	28.61	61	2	35.57	101	5	12.97
22	3	25.44	62	4	17.24	102	5	17.85
23	4	21.06	63	5	12.79	103	7	13.26
24	2	23.39	64	1	62.69	104	6	12.93
25	2	29.30	65	3	20.92	105	6	15.77
26	3	15.13	66	3	14.99	106	8	8.83
27	2	23.05	67	3	11.83	107	6	9.54
28	2	41.33	68	3	27.49	108	7	10.72
29	4	19.53	69	1	32.42	109	8	12.50
30	3	17.35	70	3	25.77	110	8	10.97
31	3	21.11	71	2	29.95	111	7	13.38
32	2	27.53	72	1	33.73	112	5	17.25
33	3	19.37	73	4	15.34	113	6	14.63
34	2	31.07	74	3	24.22	114	7	12.13
35	3	19.24	75	2	24.02	115	6	14.43
36	2	25.74	76	3	19.86	116	4	21.81
37	2	27.18	77	4	25.99	117	7	13.82
38	3	19.06	78	3	24.91	118	3	24.30
39	4	18.72	79	4	23.45	119	6	16.81
40	2	25.25	80	3	26.10	120	4	22.69

PANDA Probe - Test Report

Site 25-7

Certificate Reference:

2091-PND-Site 25-7

Sheet:

2 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	4	21.12	161	3	27.49			
122	4	21.56	162	3	24.94			
123	4	27.59	163	3	33.38			
124	5	15.68	164	3	25.11			
125	2	44.99	165	3	28.41			
126	4	22.92	166	2	37.47			
127	2	30.11	167	3	21.96			
128	5	15.41	168	3	30.01			
129	4	24.84	169	2	29.99			
130	2	34.37	170	3	28.24			
131	3	25.89	End of Test Record					
132	3	28.59						
133	5	18.72						
134	3	25.11						
135	2	37.35						
136	3	29.96						
137	4	22.50						
138	3	29.91						
139	3	23.12						
140	4	23.05						
141	3	29.42						
142	2	31.61						
143	3	32.37						
144	3	25.77						
145	3	49.14						
146	3	20.56						
147	3	29.29						
148	3	24.04						
149	3	29.27						
150	3	28.35						
151	2	42.92						
152	3	20.98						
153	3	22.27						
154	3	34.87						
155	3	29.38						
156	3	18.11						
157	3	42.29						
158	2	29.35						
159	3	27.88						
160	4	25.87						

PANDA Probe - Test Report

Site 25-7

Certificate Reference:

2091-PND-Site 25-7

Sheet:

3 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

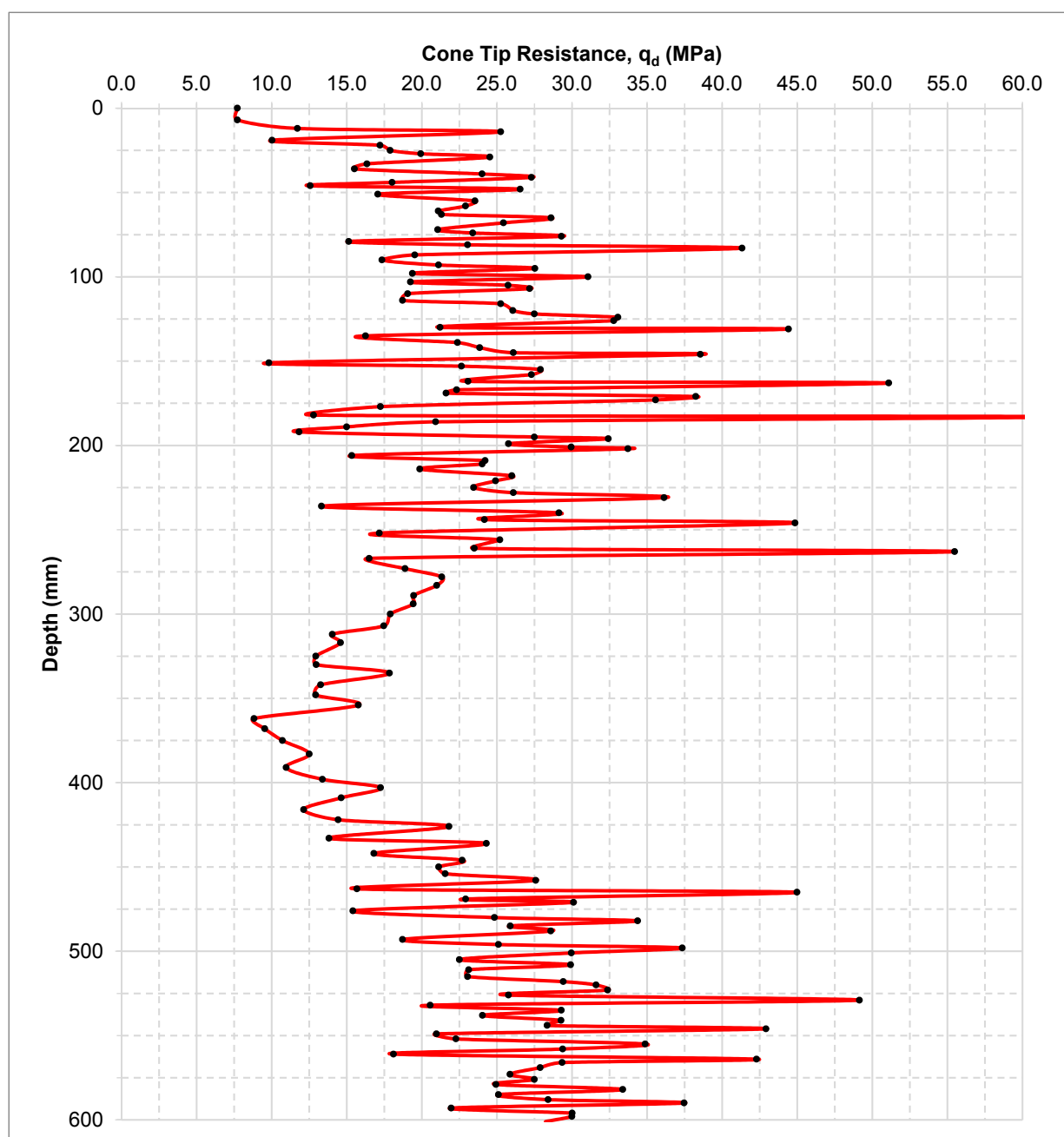
Project No.: 2091

Checked By: DWL

Location: Site 25-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 25-8

Certificate Reference:

2091-PND-Site 25-8

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

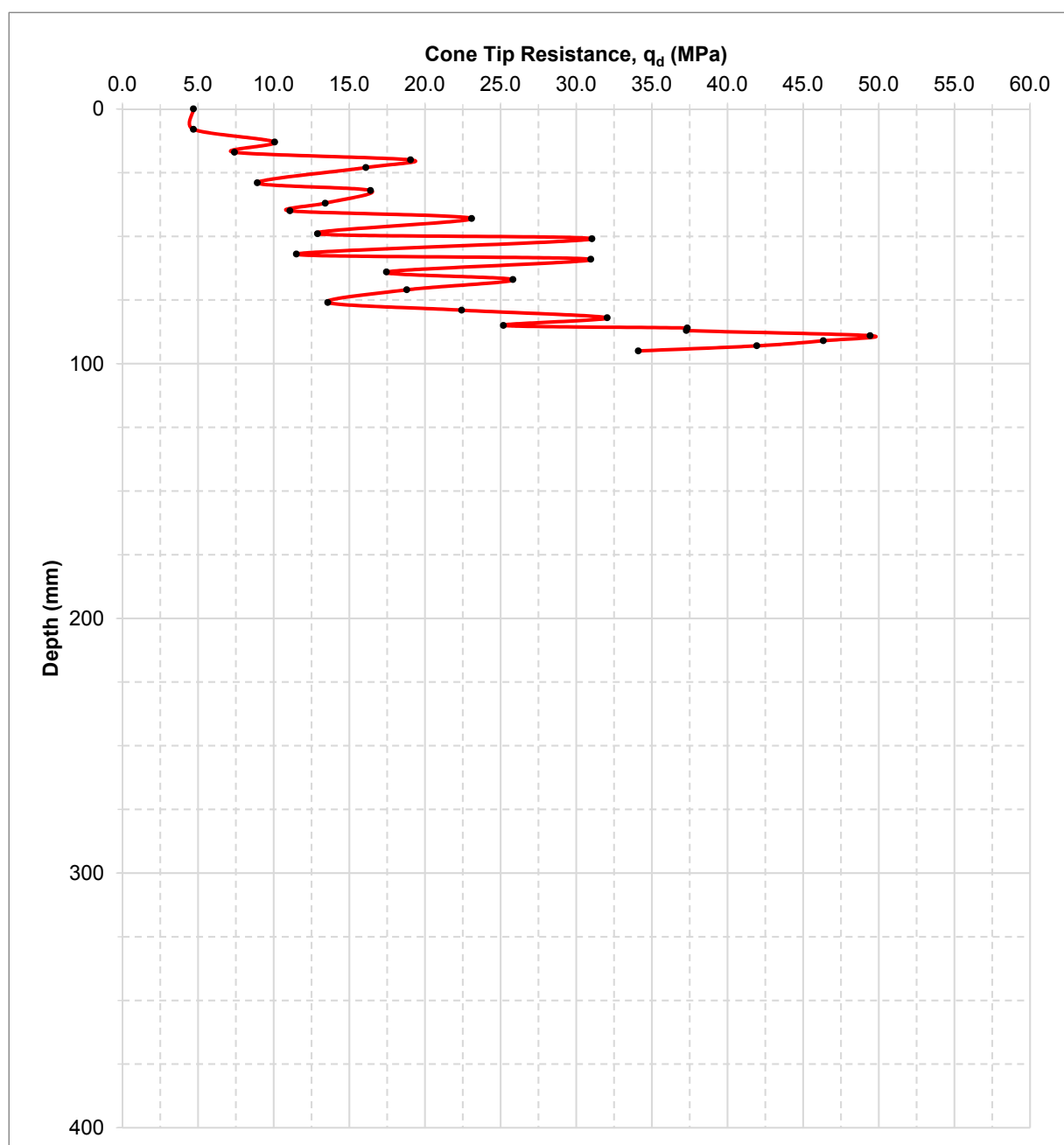
Project No.: 2091

Checked By: DWL

Location: Site 25-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-8A

Certificate Reference:

2091-PND-Site 25-8A

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	23	0.58	41	2	24.56	81	2	32.59
2	7	3.23	42	2	25.01	82	3	29.88
3	4	10.85	43	1	43.30	83	2	34.99
4	3	14.87	44	3	15.98	84	3	31.95
5	4	6.94	45	1	41.11	85	1	53.98
6	2	26.81	46	3	18.30	86	3	21.99
7	5	11.21	47	3	32.05	87	2	45.32
8	4	13.60	48	2	21.97	88	1	55.16
9	4	12.72	49	3	29.28	89	3	22.21
10	2	27.81	50	1	37.61	90	2	39.55
11	3	17.99	51	2	38.86	91	1	36.39
12	5	11.79	52	1	41.42	92	2	35.36
13	2	14.65	53	3	33.68	93	1	32.35
14	2	27.51	54	3	20.16	94	5	19.95
15	3	12.25	55	1	52.44	95	2	41.41
16	2	37.20	56	2	25.47	96	2	35.73
17	2	29.96	57	2	30.13	97	1	52.47
18	3	16.33	58	2	31.41	98	2	28.62
19	2	38.74	59	2	51.01	99	2	52.66
20	3	18.09	60	2	16.66	100	2	23.52
21	3	30.23	61	1	64.23	101	1	33.46
22	2	19.35	62	3	22.99	102	2	36.10
23	3	21.17	63	1	39.08	103	1	26.91
24	2	31.29	64	2	51.52	104	2	52.19
25	2	22.25	65	1	64.39	105	3	19.54
26	3	19.62	66	1	38.99	106	2	31.32
27	2	26.40	67	1	47.42	107	1	53.17
28	3	21.52	68	6	21.69	108	2	38.60
29	2	28.83	69	2	47.16	109	2	21.07
30	2	30.54	70	1	78.18	110	1	46.48
31	2	37.45	71	3	19.20	111	2	33.58
32	3	18.68	72	3	30.76	112	2	31.76
33	2	20.16	73	2	30.61	113	1	42.42
34	2	35.87	74	2	29.47	114	2	41.16
35	3	21.63	75	4	28.49	115	2	66.44
36	3	24.63	76	2	30.91	End of Test Record		
37	2	27.74	77	2	53.06			
38	2	20.59	78	3	19.43			
39	2	36.11	79	1	52.54			
40	3	15.91	80	4	23.25			

PANDA Probe - Test Report

Site 25-8A

Certificate Reference:

2091-PND-Site 25-8A

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

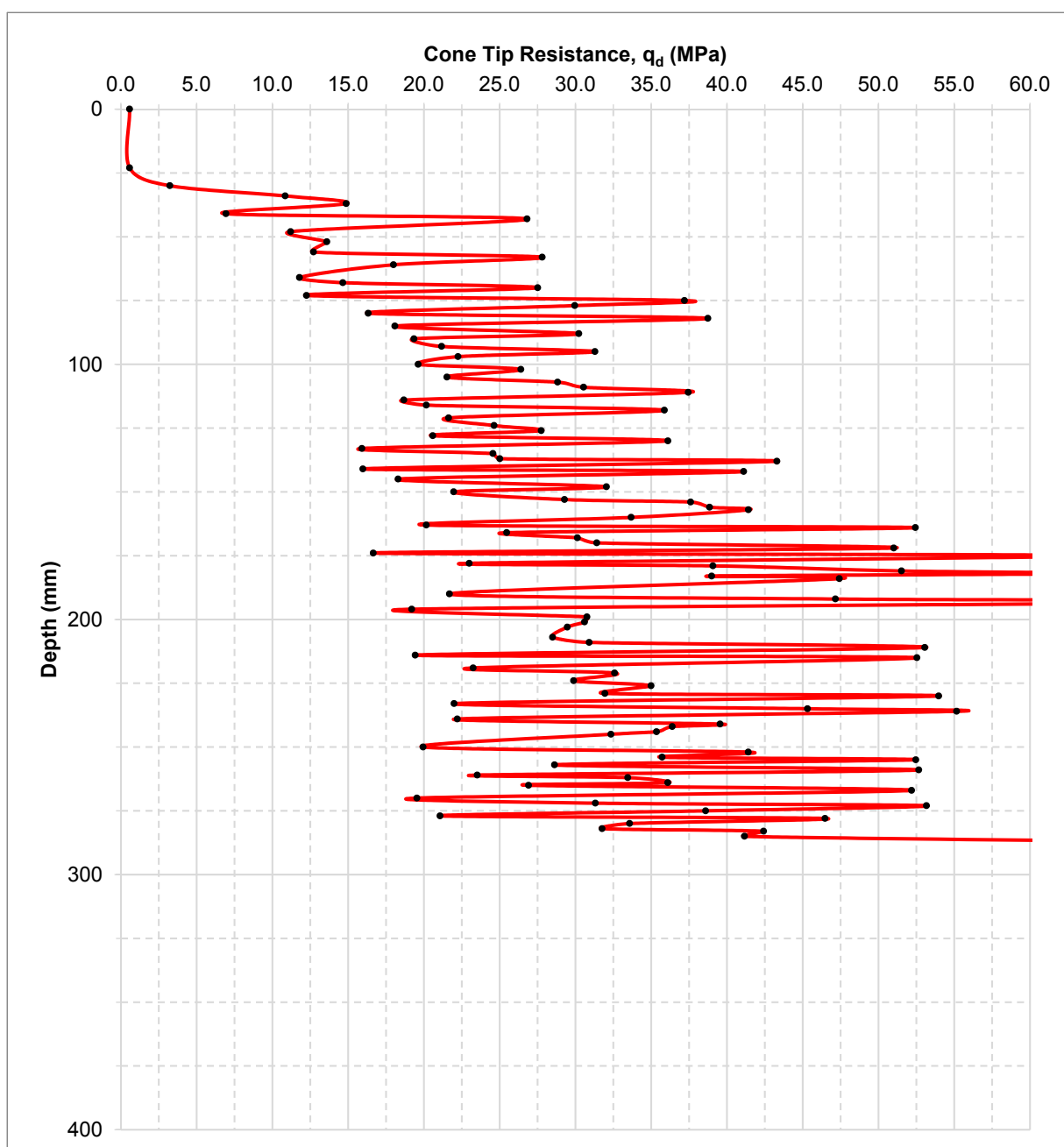
Project No.: 2091

Checked By: DWL

Location: Site 25-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-9

Certificate Reference:

2091-PND-Site 25-9

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	6.36	41	2	44.77			
2	3	12.35	42	2	18.43			
3	2	29.30	43	2	34.32			
4	4	11.80	44	3	48.74			
5	2	33.13	45	2	36.48			
6	3	15.63	46	1	44.15			
7	3	12.75	47	1	56.18			
8	2	43.76	48	3	28.19			
9	2	24.16	49	2	31.49			
10	4	9.75	50	2	29.90			
11	2	22.21	51	2	44.18			
12	3	11.64	52	1	42.92			
13	2	19.67	53	1	33.79			
14	5	11.50	54	2	25.89			
15	1	47.14	55	3	37.91			
16	3	17.44	56	1	49.49			
17	2	23.46	57	2	40.20			
18	1	41.67	58	2	33.75			
19	3	17.51	59	1	36.06			
20	2	35.36	60	2	32.17			
21	2	18.68	End of Test Record					
22	2	23.04						
23	4	19.05						
24	2	24.51						
25	2	36.19						
26	3	15.82						
27	2	25.57						
28	4	16.24						
29	1	40.12						
30	3	25.10						
31	3	14.78						
32	2	40.51						
33	1	43.00						
34	2	36.94						
35	3	17.59						
36	2	34.82						
37	1	40.41						
38	1	52.44						
39	3	17.68						
40	2	27.39						

PANDA Probe - Test Report

Site 25-9

Certificate Reference:

2091-PND-Site 25-9

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

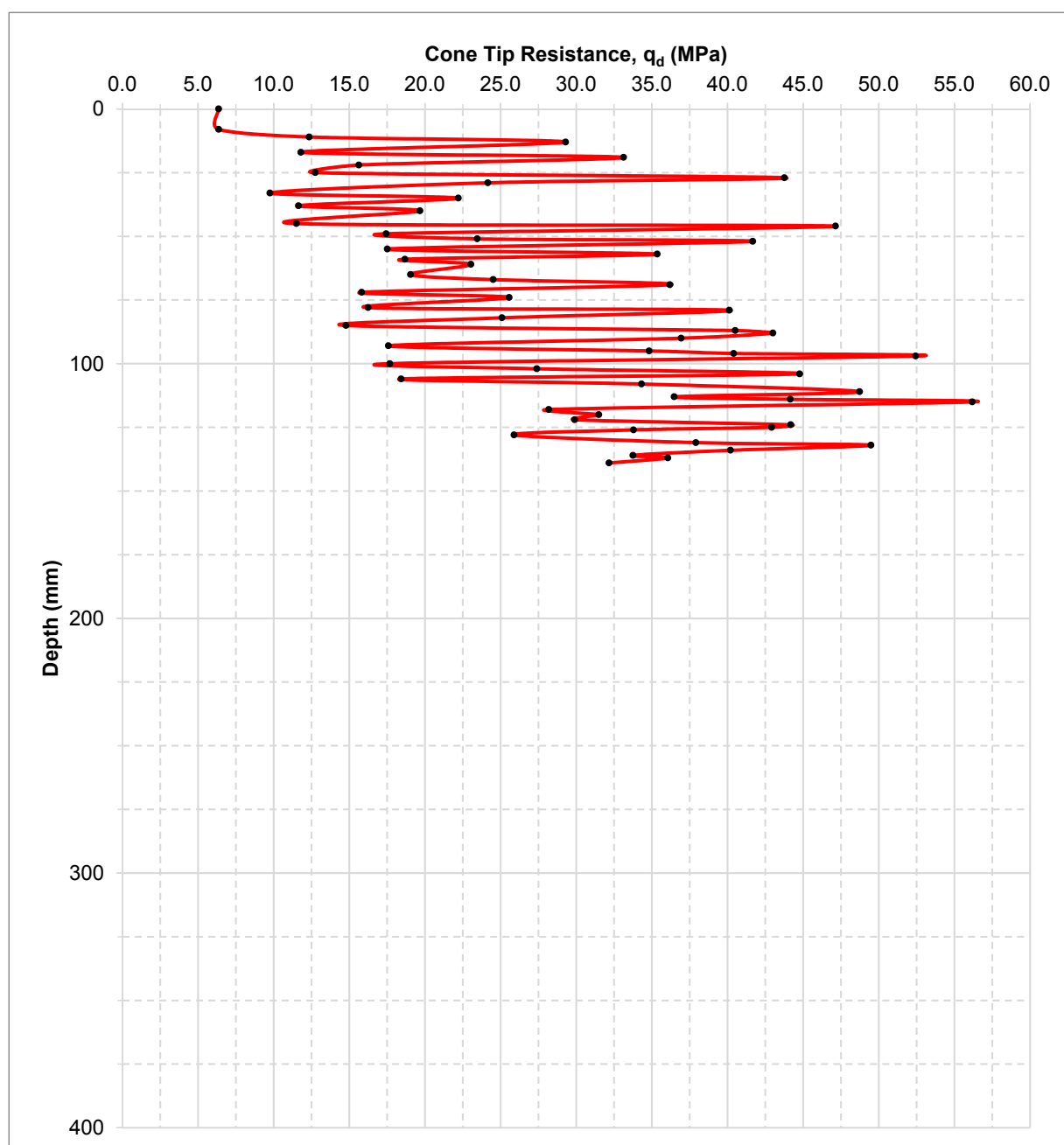
Project No.: 2091

Checked By: DWL

Location: Site 25-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-9A

Certificate Reference:

2091-PND-Site 25-9A

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	7.32	41	3	19.04			
2	7	8.93	42	1	53.02			
3	4	12.82	43	4	20.77			
4	4	9.78	44	1	46.97			
5	3	16.94	45	3	22.85			
6	4	15.76	46	2	39.31			
7	3	18.08	47	2	49.87			
8	4	17.24	48	4	20.12			
9	2	24.32	49	2	34.85			
10	5	11.21	50	2	28.19			
11	3	22.36	51	1	58.40			
12	1	47.76	52	2	32.68			
13	5	11.66	53	2	45.29			
14	3	16.82	54	3	17.28			
15	4	19.85	55	2	46.31			
16	1	25.29	56	1	50.02			
17	4	19.60	57	2	53.63			
18	3	20.75	58	2	28.93			
19	2	27.16	59	1	51.26			
20	3	19.08	60	2	33.98			
21	3	20.61	61	2	38.13			
22	2	35.52	62	1	59.12			
23	4	9.81	63	3	37.94			
24	3	20.51	64	1	57.04			
25	2	27.24	End of Test Record					
26	2	19.42						
27	3	21.88						
28	2	19.90						
29	2	36.33						
30	2	19.26						
31	3	25.63						
32	2	24.60						
33	2	21.84						
34	3	18.73						
35	2	21.95						
36	3	23.47						
37	2	31.93						
38	3	15.76						
39	1	43.56						
40	3	25.56						

PANDA Probe - Test Report

Site 25-9A

Certificate Reference:

2091-PND-Site 25-9A

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

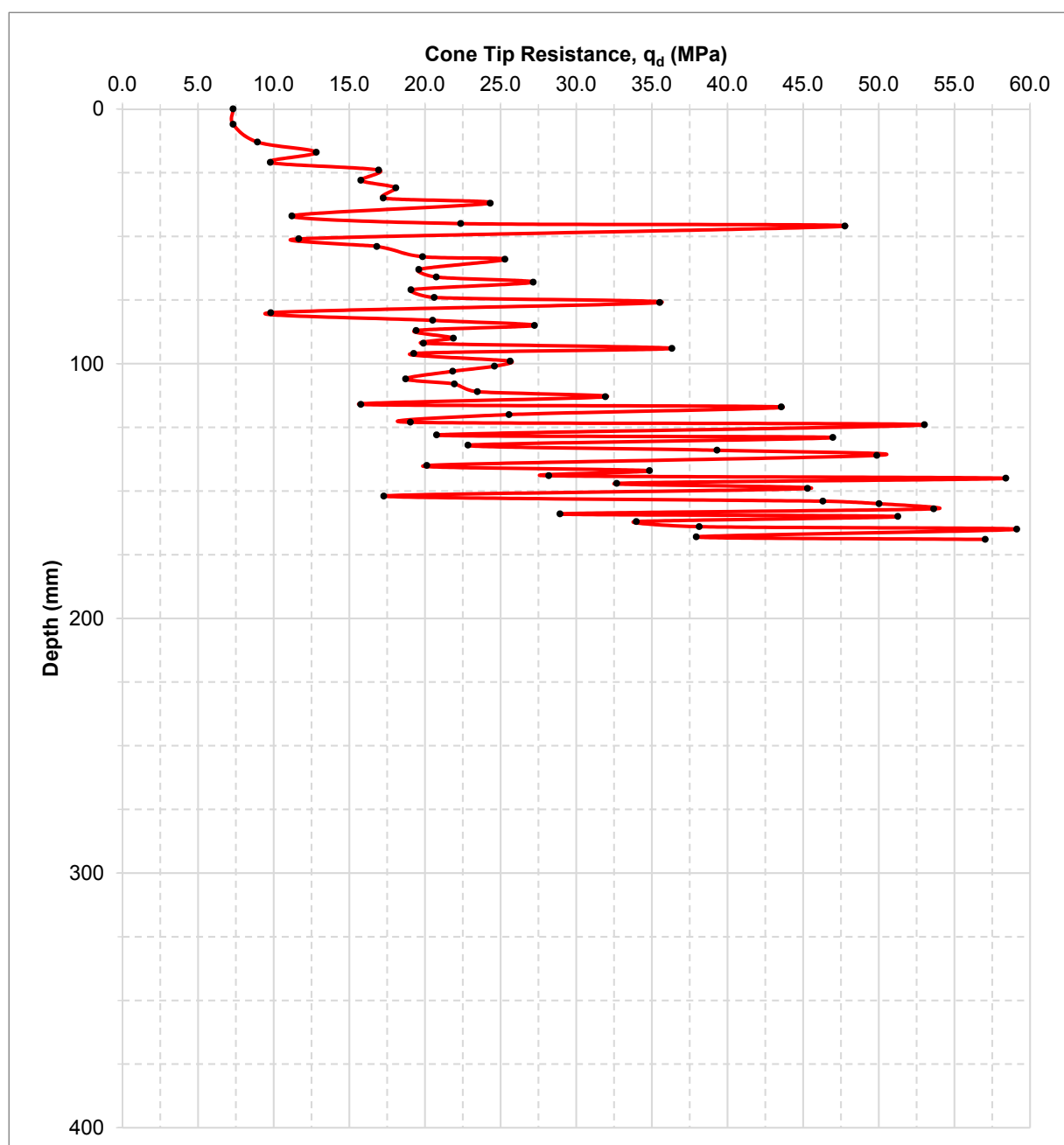
Project No.: 2091

Checked By: DWL

Location: Site 25-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-10

Certificate Reference:

2091-PND-Site 25-10

Sheet:

1 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	3.60	41	3	15.84	81	1	32.10
2	6	2.82	42	3	26.81	82	3	24.32
3	7	5.84	43	2	22.84	83	2	22.07
4	5	10.63	44	3	21.98	84	2	29.90
5	6	6.02	45	3	17.06	85	2	25.30
6	3	15.55	46	2	21.57	86	3	22.58
7	4	8.00	47	3	17.07	87	3	24.82
8	1	27.64	48	3	16.16	88	2	17.90
9	3	20.35	49	3	23.65	89	2	20.86
10	5	12.72	50	3	15.69	90	3	25.97
11	2	21.39	51	2	24.63	91	4	19.64
12	2	41.57	52	5	15.25	92	2	17.05
13	2	14.25	53	2	20.20	93	4	23.22
14	2	23.02	54	3	18.27	94	2	20.59
15	3	23.07	55	5	16.68	95	3	20.81
16	2	16.81	56	3	19.24	96	3	18.14
17	2	25.25	57	4	14.38	97	2	22.91
18	3	20.77	58	2	28.20	98	3	16.55
19	1	36.03	59	4	11.76	99	2	21.66
20	2	25.18	60	4	18.62	100	2	21.92
21	2	29.15	61	3	15.94	101	3	25.64
22	1	34.28	62	3	19.15	102	2	23.81
23	3	22.50	63	3	19.85	103	1	29.80
24	1	46.29	64	3	22.79	104	2	34.41
25	2	33.56	65	3	15.62	105	1	35.29
26	2	42.56	66	2	23.78	106	1	35.60
27	2	41.11	67	3	20.71	107	3	31.28
28	1	45.80	68	3	25.06	108	2	32.74
29	4	19.12	69	4	20.16	109	2	22.91
30	1	51.77	70	2	27.08	110	2	27.76
31	3	23.35	71	3	19.36	111	3	22.45
32	2	18.23	72	2	21.68	112	2	20.35
33	2	27.64	73	2	28.43	113	3	21.52
34	3	23.33	74	3	22.92	114	3	20.70
35	2	29.77	75	4	18.83	115	4	18.15
36	3	17.27	76	3	20.97	116	2	14.60
37	3	29.58	77	2	29.77	117	3	11.26
38	2	14.82	78	2	26.44	118	4	16.57
39	2	21.10	79	1	30.79	119	3	15.52
40	2	35.80	80	3	26.79	120	3	19.13

[illegible]

PANDA Probe - Test Report

Site 25-10

Certificate Reference:

2091-PND-Site 25-10

Sheet:

3 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

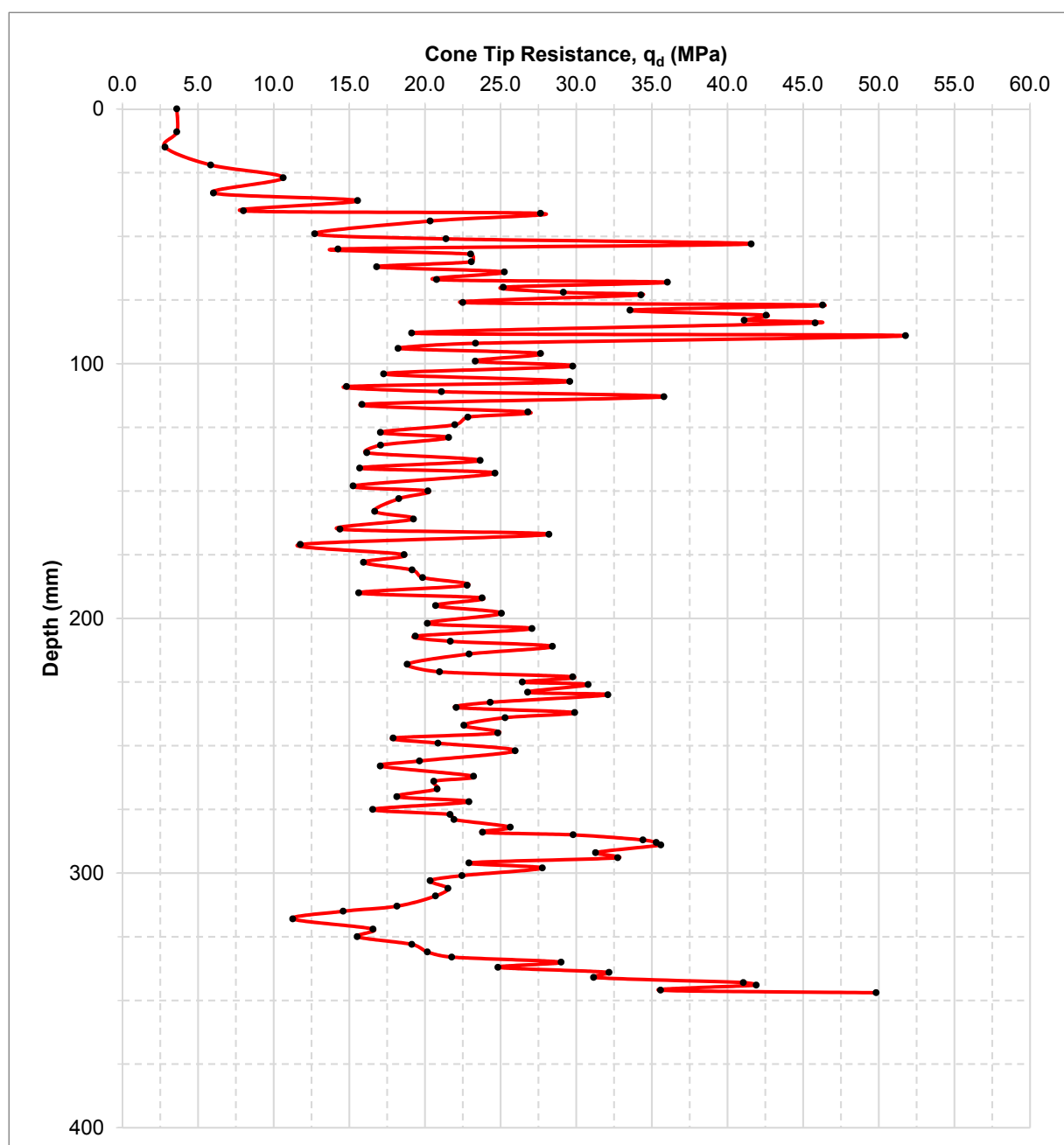
Project No.: 2091

Checked By: DWL

Location: Site 25-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-11

Certificate Reference:

2091-PND-Site 25-11

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	3	13.05	41	3	35.71			
2	2	24.89	42	2	31.38			
3	2	20.43	43	3	19.20			
4	4	14.85	44	1	59.97			
5	1	29.05	45	2	33.94			
6	4	11.98	46	1	46.32			
7	4	14.51	47	3	25.34			
8	3	18.45	48	3	21.92			
9	2	22.64	49	1	40.85			
10	3	18.62	50	1	45.54			
11	2	20.89	51	1	31.19			
12	3	23.62	52	3	27.30			
13	3	25.30	53	2	33.82			
14	2	19.04	54	4	14.06			
15	3	23.77	55	2	31.97			
16	4	14.04	56	1	32.88			
17	3	14.72	57	3	25.30			
18	2	17.79	58	1	30.60			
19	2	34.19	59	3	30.17			
20	3	17.70	60	2	37.60			
21	2	38.00	61	1	30.72			
22	3	16.47	62	1	51.05			
23	2	25.59	63	2	30.44			
24	1	54.81	64	2	32.54			
25	2	35.71	65	1	48.22			
26	2	32.75	End of Test Record					
27	3	20.30						
28	2	26.10						
29	1	31.53						
30	2	44.82						
31	2	17.94						
32	2	32.19						
33	2	23.98						
34	2	31.35						
35	2	36.24						
36	2	27.92						
37	2	27.25						
38	2	29.11						
39	1	26.21						
40	2	37.11						

PANDA Probe - Test Report

Site 25-11

Certificate Reference:

2091-PND-Site 25-11

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

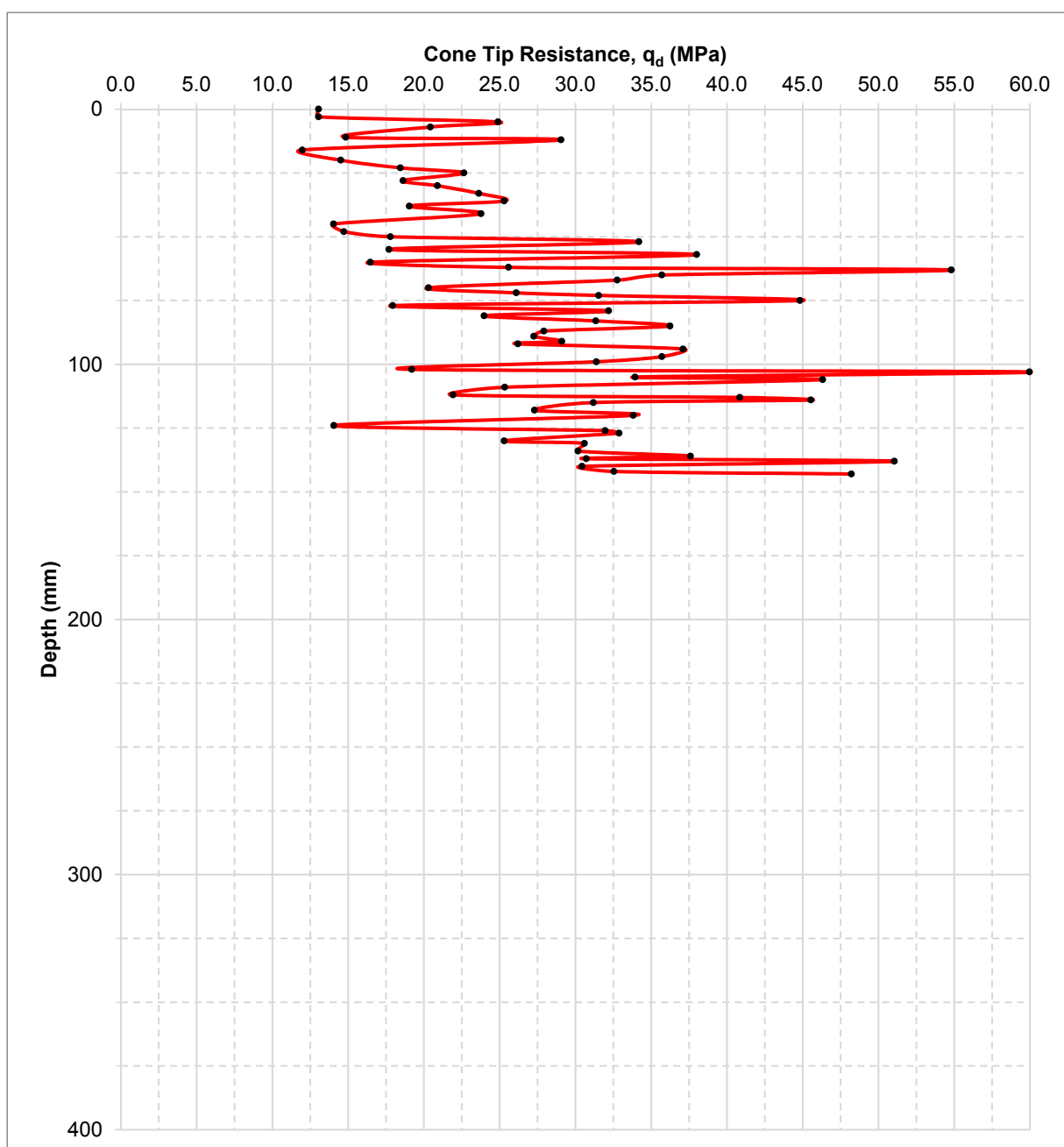
Project No.: 2091

Checked By: DWL

Location: Site 25-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 25-11A

Certificate Reference:

2091-PND-Site 25-11A

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

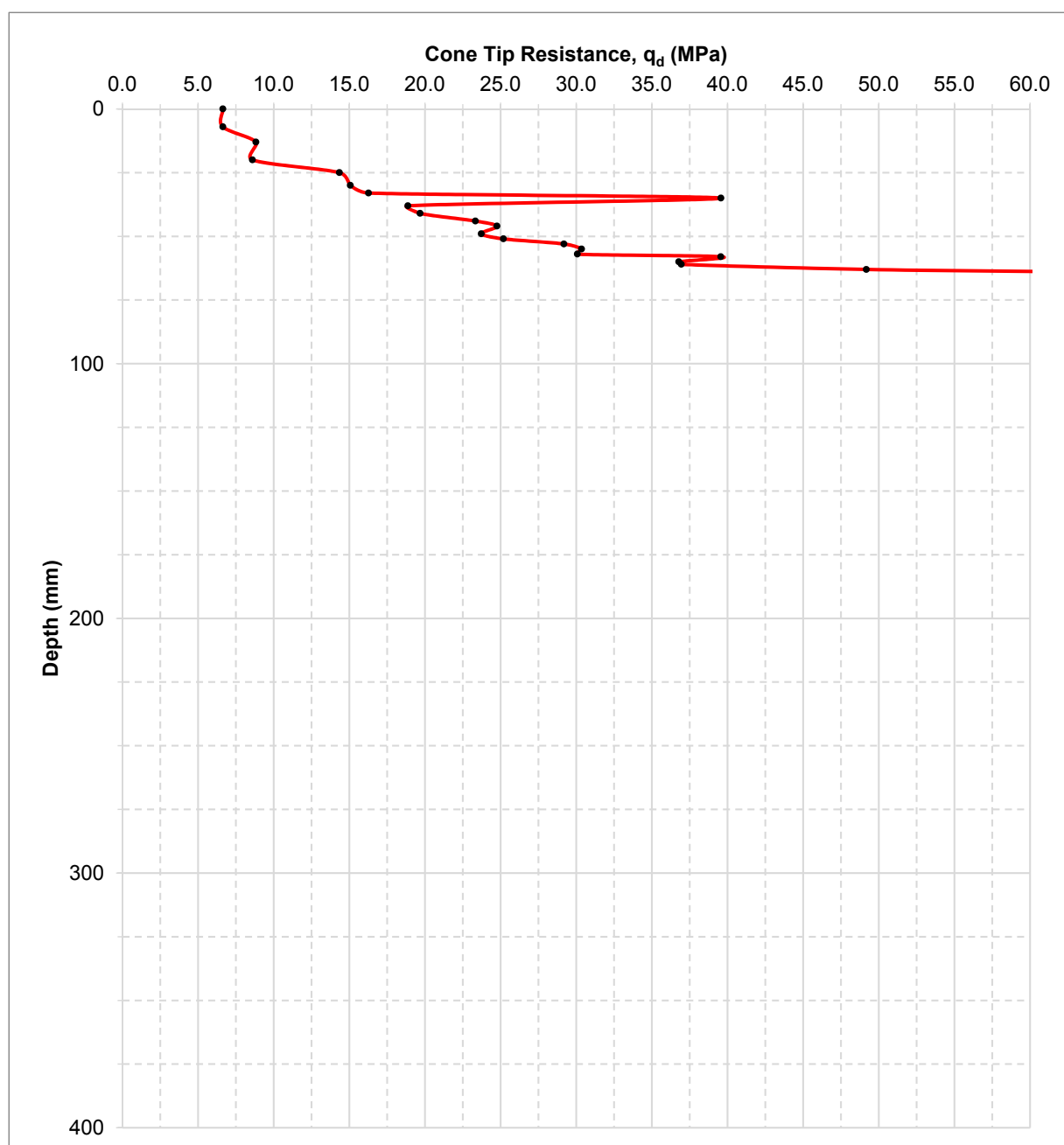
Project No.: 2091

Checked By: DWL

Location: Site 25-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-11B

Certificate Reference:

2091-PND-Site 25-11B

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	4	10.83	41	2	37.50			
2	7	7.99	42	1	40.72			
3	4	15.70	End of Test Record					
4	2	23.50						
5	5	9.22						
6	3	20.26						
7	4	19.21						
8	3	20.80						
9	2	18.43						
10	3	28.81						
11	2	48.02						
12	4	36.63						
13	3	40.50						
14	1	65.52						
15	2	20.31						
16	3	21.68						
17	1	43.02						
18	2	40.83						
19	1	37.75						
20	2	32.03						
21	3	25.53						
22	3	23.34						
23	2	42.27						
24	2	27.20						
25	2	29.62						
26	3	26.09						
27	1	41.56						
28	2	51.90						
29	2	21.60						
30	2	42.28						
31	2	26.02						
32	1	38.05						
33	3	27.59						
34	1	49.25						
35	1	39.84						
36	2	28.07						
37	2	34.12						
38	2	41.28						
39	1	32.92						
40	2	40.74						

PANDA Probe - Test Report

Site 25-11B

Certificate Reference:

2091-PND-Site 25-11B

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

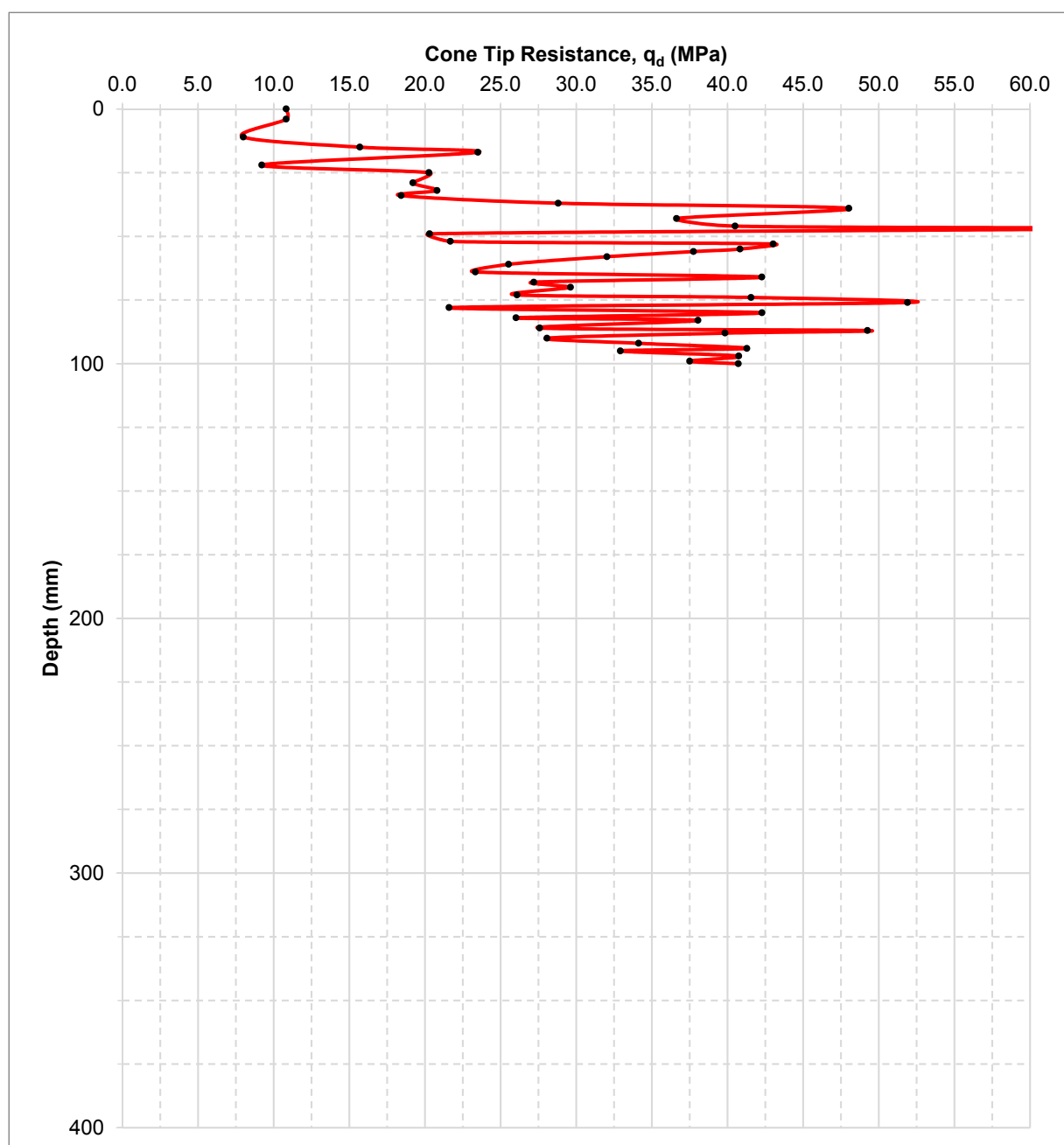
Project No.: 2091

Checked By: DWL

Location: Site 25-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-12

Certificate Reference:

2091-PND-Site 25-12

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.96	41	4	30.84			
2	6	6.73	42	2	34.07			
3	4	9.04	43	1	44.98			
4	4	13.38	44	2	46.36			
5	4	13.60	45	1	57.47			
6	3	13.90	46	2	45.41			
7	3	15.89	End of Test Record					
8	4	15.05						
9	4	14.91						
10	2	24.63						
11	4	16.92						
12	4	10.31						
13	3	28.64						
14	4	12.50						
15	2	28.19						
16	4	15.49						
17	2	33.14						
18	4	20.73						
19	2	24.05						
20	3	22.46						
21	5	14.29						
22	3	17.89						
23	4	16.06						
24	3	16.48						
25	3	24.58						
26	3	18.15						
27	3	19.57						
28	5	13.27						
29	2	25.52						
30	2	32.57						
31	2	19.38						
32	3	18.35						
33	2	25.89						
34	2	25.43						
35	3	15.79						
36	3	15.75						
37	3	20.20						
38	2	28.37						
39	3	25.06						
40	1	41.36						

PANDA Probe - Test Report

Site 25-12

Certificate Reference:

2091-PND-Site 25-12

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

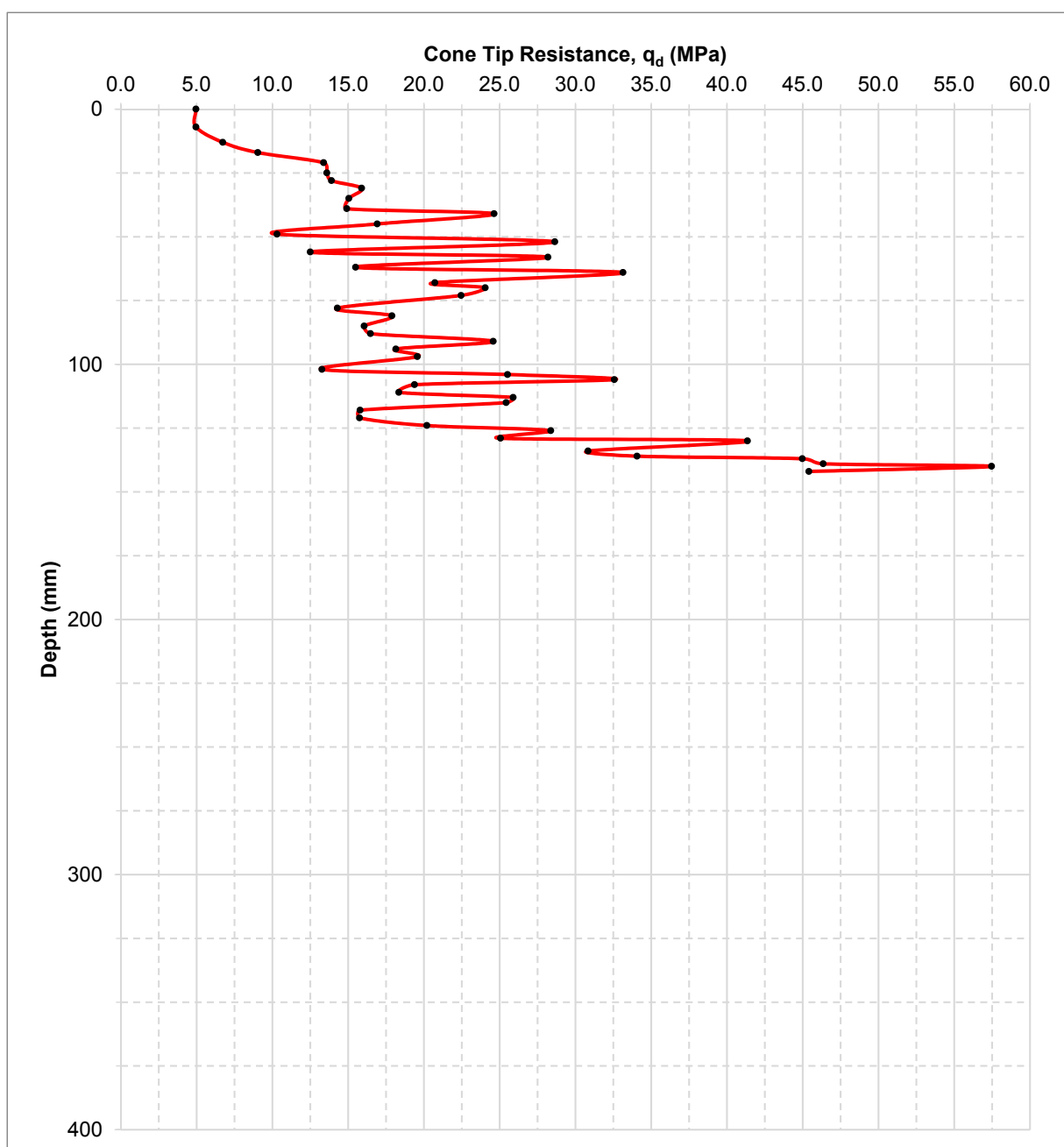
Project No.: 2091

Checked By: DWL

Location: Site 25-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 25-12A

Certificate Reference:

2091-PND-Site 25-12A

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 25-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	6.77						
2	6	8.60						
3	5	11.25						
4	5	14.21						
5	5	11.34						
6	5	14.02						
7	5	14.09						
8	3	27.38						
9	5	13.24						
10	3	29.12						
11	4	22.87						
12	4	18.70						
13	3	20.26						
14	5	17.69						
15	3	23.15						
16	4	16.27						
17	4	27.55						
18	5	16.85						
19	4	21.32						
20	2	22.45						
21	3	14.43						
22	3	29.02						
23	4	17.21						
24	3	21.14						
25	3	23.77						
26	3	28.64						
27	3	30.60						
28	2	39.39						
29	4	21.44						
30	2	39.27						
31	3	22.28						
32	1	66.29						
33	4	21.70						
34	1	34.11						
35	2	55.34						
36	2	30.61						
37	1	57.51						
38	1	44.54						
39	2	46.95						
End of Test Record								

PANDA Probe - Test Report

Site 25-12A

Certificate Reference:

2091-PND-Site 25-12A

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

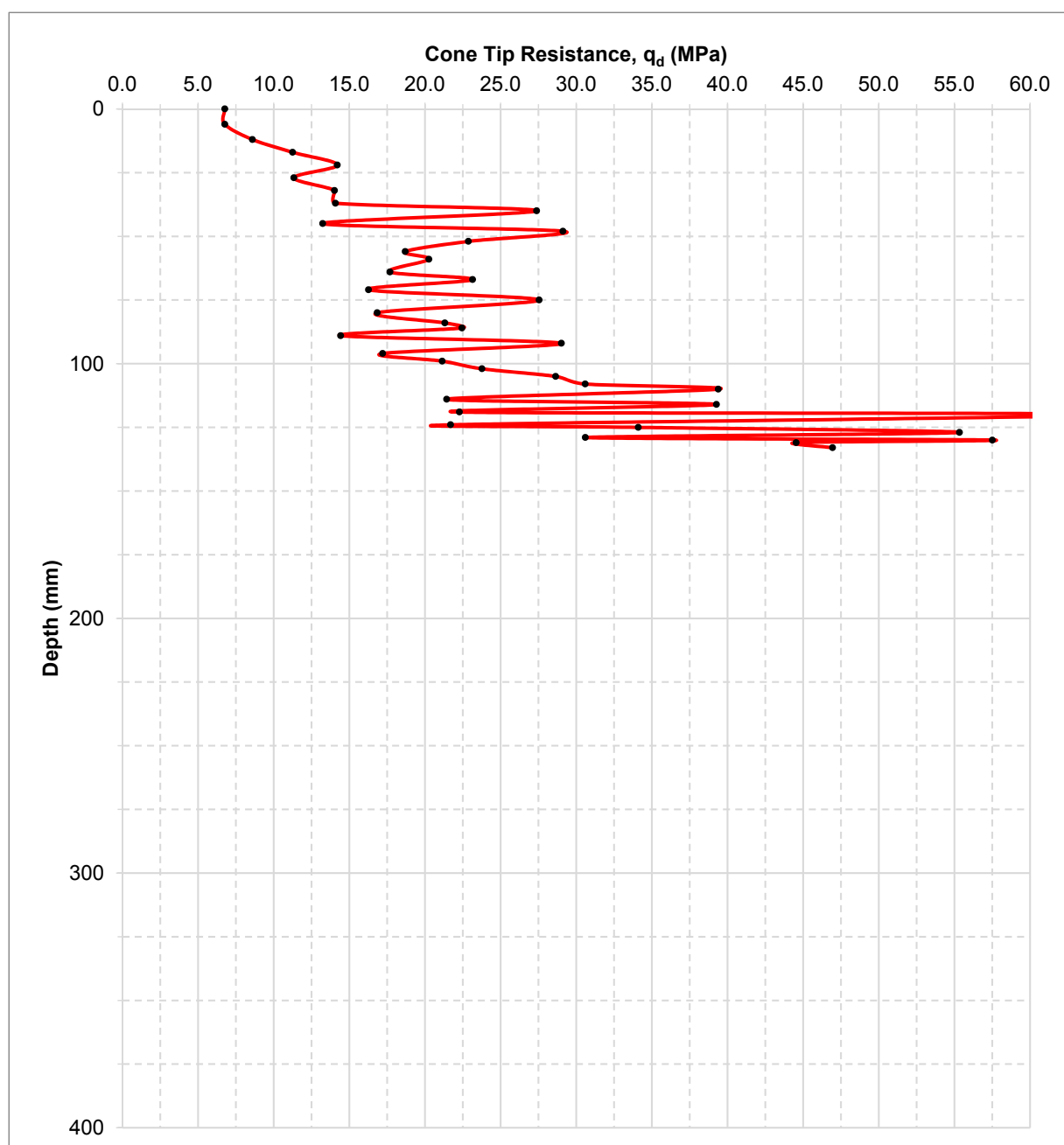
Project No.: 2091

Checked By: DWL

Location: Site 25-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-1

Certificate Reference:

2091-PND-Site 26-1

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	6.39	41	2	32.42	81	1	33.24
2	5	10.00	42	3	26.65	82	2	37.29
3	6	6.82	43	2	25.74	83	1	25.16
4	4	10.45	44	2	32.96	End of Test Record		
5	6	7.87	45	3	30.76			
6	3	14.78	46	3	20.81			
7	6	8.66	47	3	27.23			
8	4	14.54	48	3	22.89			
9	2	11.32	49	2	24.04			
10	3	12.99	50	2	24.76			
11	3	11.59	51	3	25.85			
12	3	15.69	52	2	23.45			
13	2	17.09	53	2	26.00			
14	3	13.23	54	3	27.39			
15	3	15.16	55	2	24.75			
16	3	13.37	56	2	25.16			
17	3	28.71	57	3	24.37			
18	3	14.95	58	3	32.34			
19	1	24.73	59	3	24.85			
20	4	17.05	60	3	24.67			
21	3	15.81	61	2	26.05			
22	2	24.07	62	1	24.65			
23	3	20.66	63	3	21.30			
24	3	17.70	64	2	24.36			
25	1	30.47	65	2	27.83			
26	2	36.38	66	3	32.06			
27	2	37.27	67	2	32.35			
28	2	38.30	68	2	34.55			
29	1	37.54	69	2	22.58			
30	3	27.83	70	2	42.53			
31	1	39.71	71	2	31.41			
32	2	46.62	72	1	43.41			
33	2	39.22	73	2	33.77			
34	1	43.17	74	2	39.63			
35	2	30.72	75	1	42.41			
36	2	24.23	76	2	28.63			
37	1	30.48	77	1	34.37			
38	2	26.39	78	2	27.63			
39	2	22.69	79	1	28.46			
40	2	24.27	80	2	28.84			

PANDA Probe - Test Report

Site 26-1

Certificate Reference:

2091-PND-Site 26-1

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

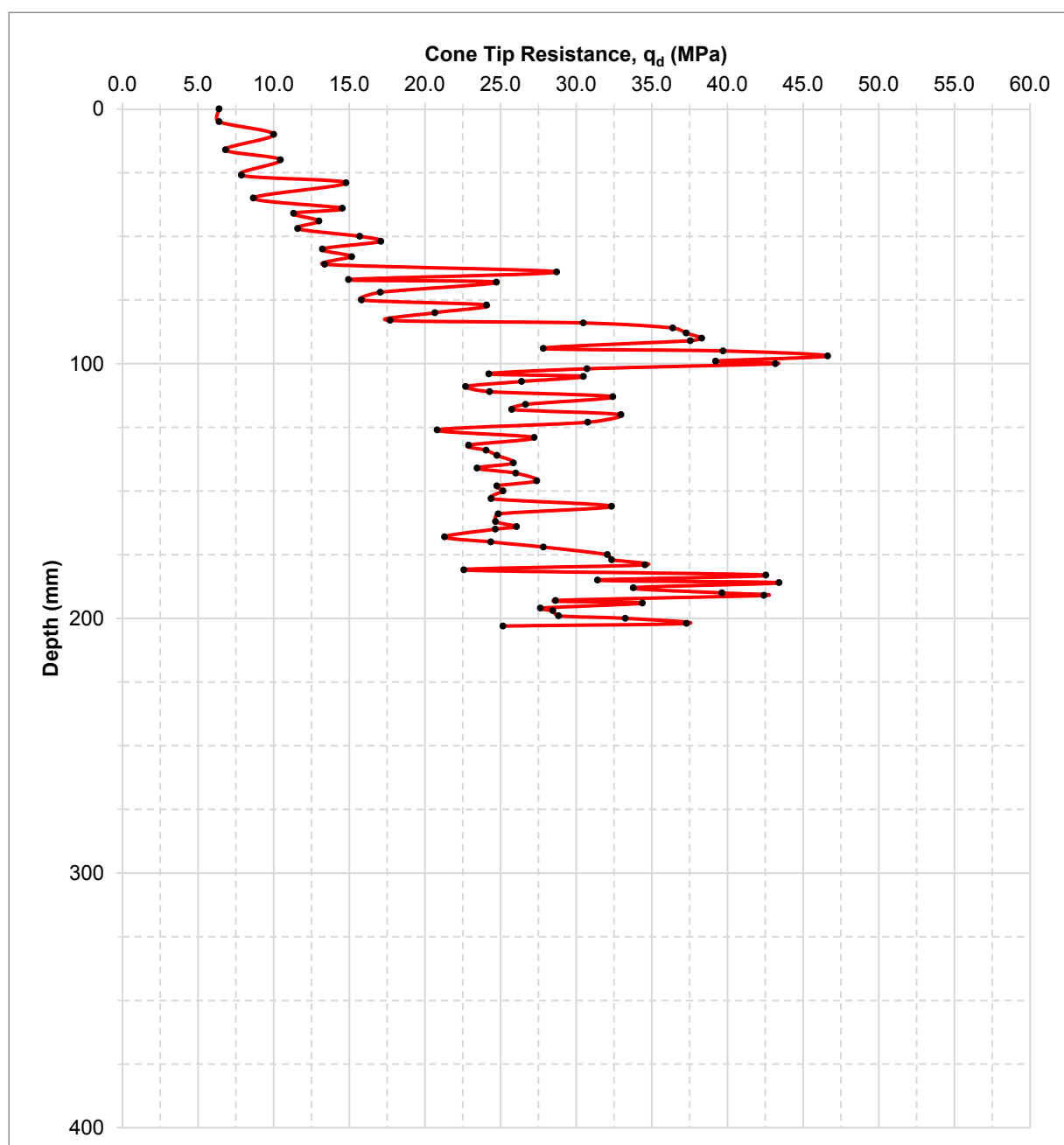
Project No.: 2091

Checked By: DWL

Location: Site 26-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-1A

Certificate Reference:

2091-PND-Site 26-1A

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	4.41	41	3	25.03			
2	4	9.06	42	3	19.49			
3	5	6.93	43	3	18.22			
4	5	9.67	44	2	18.15			
5	5	10.87	45	3	21.77			
6	5	10.70	46	5	17.49			
7	5	11.50	47	4	29.11			
8	4	14.78	48	3	20.00			
9	4	11.66	49	3	12.90			
10	3	15.10	50	3	23.65			
11	4	12.33	51	2	21.83			
12	5	13.52	52	3	13.00			
13	3	10.35	53	3	43.73			
14	3	23.95	54	2	30.57			
15	3	13.72	55	2	38.65			
16	4	13.55	56	1	46.99			
17	3	11.74	57	2	53.11			
18	3	15.94	58	1	46.98			
19	2	13.30	End of Test Record					
20	3	14.51						
21	3	17.12						
22	3	19.78						
23	2	25.19						
24	2	17.98						
25	2	23.33						
26	3	19.59						
27	3	16.49						
28	4	17.01						
29	2	25.36						
30	3	14.84						
31	4	18.97						
32	3	19.98						
33	2	20.13						
34	4	19.02						
35	2	18.96						
36	2	21.07						
37	2	15.71						
38	2	24.82						
39	4	21.19						
40	3	17.79						

PANDA Probe - Test Report

Site 26-1A

Certificate Reference:

2091-PND-Site 26-1A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

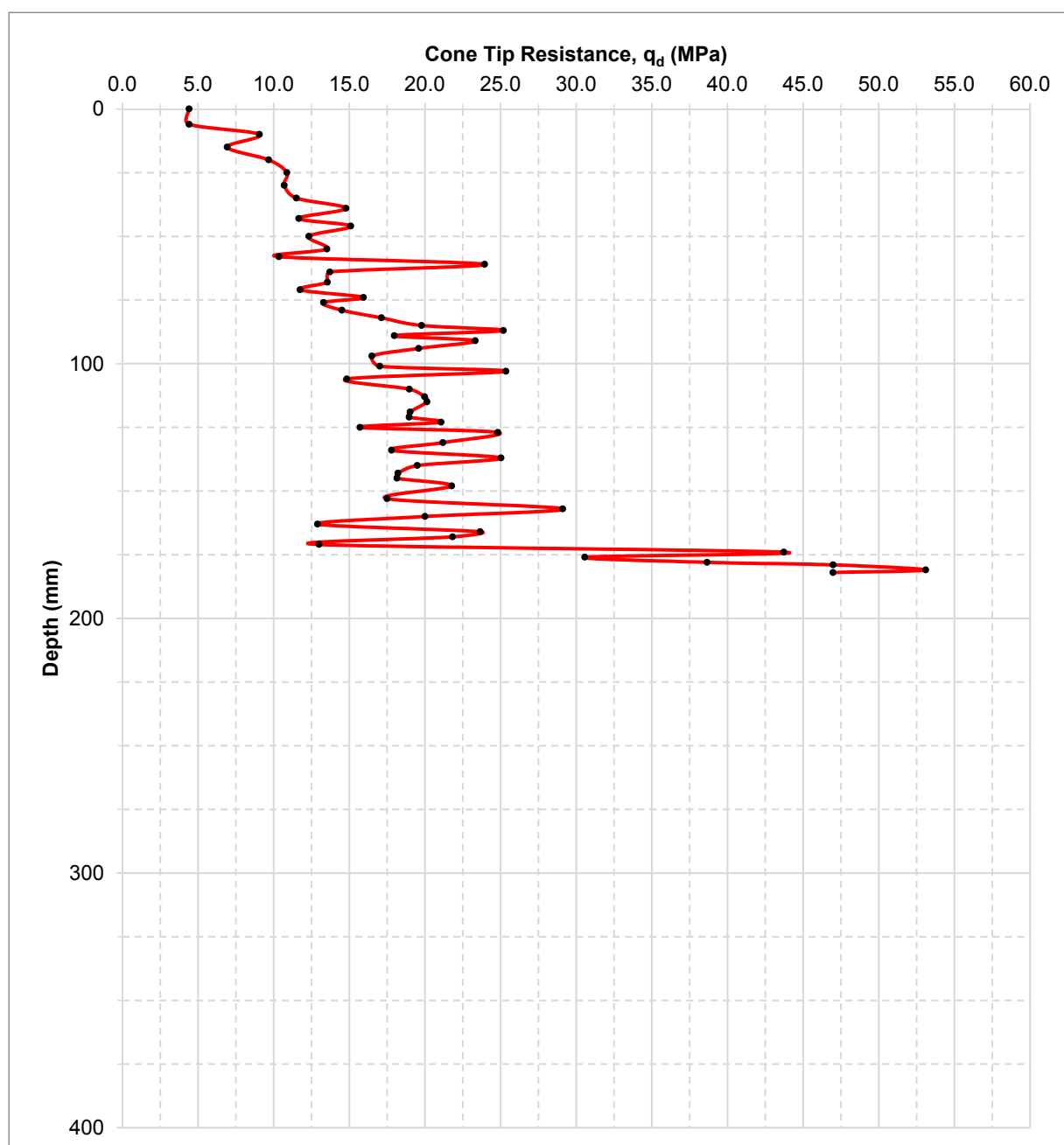
Project No.: 2091

Checked By: DWL

Location: Site 26-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-2

Certificate Reference:

2091-PND-Site 26-2

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	2.53	41	4	18.75	81	4	7.56
2	6	4.06	42	6	14.82	82	5	9.66
3	8	4.25	43	5	10.56	83	4	14.40
4	8	4.45	44	4	18.77	84	4	15.24
5	7	5.44	45	3	20.25	85	4	15.20
6	7	6.39	46	1	34.65	86	2	20.06
7	6	5.52	47	2	22.38	87	3	22.34
8	7	4.68	48	3	23.18	88	2	19.21
9	6	5.83	49	1	24.76	89	2	24.42
10	8	6.07	50	2	32.71	90	2	17.41
11	5	6.30	51	2	32.76	91	2	19.50
12	4	7.52	52	2	29.03	92	1	20.71
13	5	6.46	53	2	30.16	93	2	24.33
14	4	8.83	54	2	27.77	94	2	31.65
15	4	7.76	55	3	21.49	95	2	28.12
16	5	6.68	56	3	17.92	96	1	37.82
17	6	8.24	57	3	17.37	97	2	25.23
18	6	6.90	58	5	12.84	98	3	23.19
19	7	6.38	59	5	12.88	99	1	24.72
20	6	9.10	60	7	8.39	100	2	30.75
21	5	7.71	61	8	8.81	101	2	30.30
22	7	7.31	62	10	8.64	102	1	32.76
23	4	8.87	63	4	7.27	103	1	33.73
24	6	7.83	64	5	5.96	104	2	29.88
25	3	9.63	65	4	8.57	105	3	28.04
26	3	22.97	66	7	8.59	106	3	29.96
27	2	32.39	67	7	8.77	107	1	33.32
28	1	25.10	68	6	8.27	108	2	46.48
29	3	19.12	69	6	12.00	109	1	26.42
30	1	32.84	70	6	11.37	110	2	39.96
31	2	30.47	71	4	12.30	111	1	36.13
32	2	34.20	72	5	11.21	112	2	44.48
33	1	39.12	73	5	10.75	113	3	45.74
34	3	28.36	74	5	8.56	114	2	51.60
35	2	27.35	75	6	7.87	115	2	52.23
36	2	32.02	76	6	6.96	116	1	52.44
37	2	19.26	77	7	7.50	117	2	48.05
38	3	23.29	78	6	6.61	118	2	46.17
39	1	24.73	79	7	6.82	End of Test Record		
40	3	16.89	80	4	7.30			

PANDA Probe - Test Report

Site 26-2

Certificate Reference:

2091-PND-Site 26-2

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

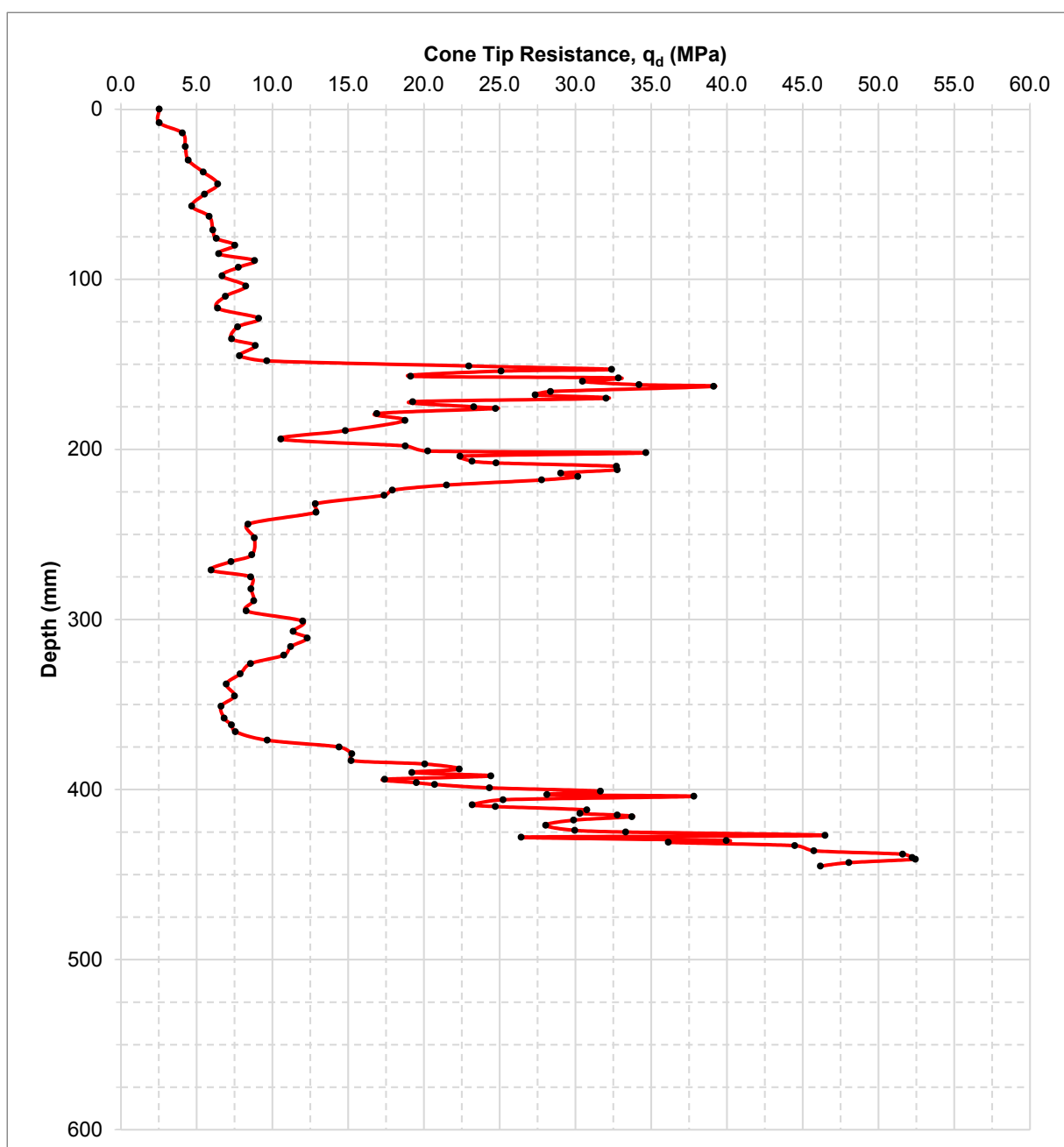
Project No.: 2091

Checked By: DWL

Location: Site 26-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-3

Certificate Reference:

2091-PND-Site 26-3

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	4.27	41	3	11.06	81	6	7.08
2	6	4.76	42	3	18.57	82	6	8.40
3	5	6.63	43	2	19.30	83	6	7.94
4	5	8.82	44	3	16.34	84	4	4.86
5	6	9.63	45	3	16.55	85	6	8.70
6	5	7.15	46	2	19.51	86	5	8.59
7	6	9.85	47	3	24.18	87	5	10.73
8	5	10.54	48	3	16.35	88	5	7.64
9	4	8.93	49	2	22.99	89	6	10.15
10	4	10.01	50	3	25.57	90	6	9.31
11	4	12.82	51	2	25.82	91	4	10.16
12	5	12.88	52	2	33.30	92	6	8.78
13	5	14.20	53	2	31.57	93	7	7.59
14	5	11.31	54	2	27.91	94	6	7.64
15	5	11.07	55	3	29.46	95	5	6.62
16	4	9.74	56	2	28.26	96	5	10.10
17	3	13.53	57	2	25.32	97	3	14.34
18	5	10.97	58	2	21.71	98	2	12.96
19	4	8.71	59	2	18.59	99	3	19.61
20	4	7.65	60	3	20.28	100	3	18.58
21	5	8.95	61	3	19.82	101	3	18.08
22	6	10.41	62	3	16.17	102	4	16.11
23	6	10.65	63	3	13.01	103	3	18.86
24	4	10.25	64	2	23.46	104	3	16.94
25	5	11.12	65	2	25.24	105	3	20.58
26	3	13.75	66	3	31.46	106	1	25.64
27	4	10.31	67	2	22.96	107	3	20.50
28	3	11.33	68	3	27.14	108	2	19.95
29	3	13.96	69	3	22.58	109	2	40.38
30	3	8.66	70	3	21.55	110	1	43.10
31	2	15.05	71	2	24.53	111	4	47.81
32	3	15.33	72	2	23.67	112	2	55.03
33	3	14.80	73	3	17.62	113	1	51.69
34	3	18.48	74	4	13.42	114	3	58.72
35	3	15.03	75	4	11.41	115	1	45.87
36	4	17.98	76	4	9.21	End of Test Record		
37	3	18.30	77	5	9.48			
38	4	16.15	78	6	8.90			
39	3	13.30	79	7	8.50			
40	4	16.83	80	6	9.37			

PANDA Probe - Test Report

Site 26-3

Certificate Reference:

2091-PND-Site 26-3

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

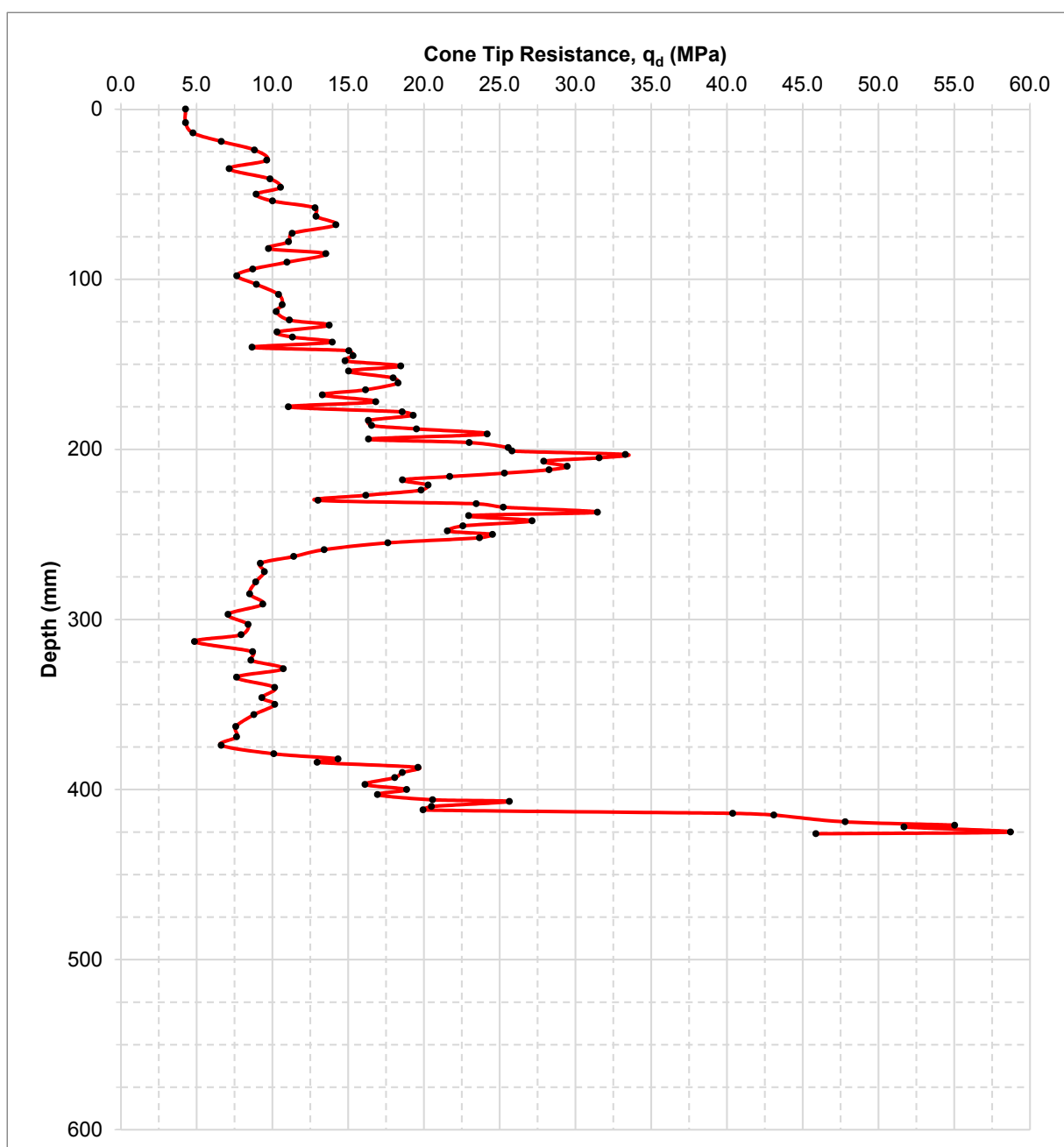
Project No.: 2091

Checked By: DWL

Location: Site 26-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-4

Certificate Reference:

2091-PND-Site 26-4

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	2.25	41	2	28.15	81	3	20.74
2	6	4.49	42	2	30.22	82	2	22.57
3	7	5.67	43	1	34.03	83	2	21.66
4	5	5.56	44	2	42.19	84	2	22.91
5	5	7.44	45	1	36.21	85	2	19.55
6	5	7.51	46	3	22.46	86	1	17.72
7	6	8.68	47	2	26.74	87	3	21.59
8	5	8.24	48	1	25.32	88	1	28.06
9	5	7.27	49	2	31.32	89	1	18.19
10	6	6.59	50	1	23.77	90	2	22.13
11	9	6.52	51	3	21.46	91	2	24.93
12	9	7.40	52	2	17.79	92	2	31.05
13	8	5.18	53	2	19.00	93	2	37.93
14	6	6.89	54	2	17.10	94	1	24.11
15	7	5.67	55	2	15.47	95	2	34.62
16	7	6.58	56	2	14.89	96	2	28.02
17	10	6.42	57	3	15.77	97	2	28.84
18	8	8.26	58	3	15.21	98	3	26.39
19	8	7.34	59	3	12.77	99	1	32.90
20	8	8.07	60	4	12.89	100	2	33.86
21	10	7.45	61	4	10.37	101	1	40.48
22	10	6.11	62	4	9.18	102	2	35.68
23	5	6.85	63	6	8.60	103	2	37.28
24	5	6.22	64	3	8.79	104	2	41.91
25	11	5.98	65	7	7.80	End of Test Record		
26	11	5.33	66	3	9.53			
27	8	6.18	67	5	9.47			
28	6	6.89	68	3	13.26			
29	3	13.64	69	4	13.45			
30	2	20.88	70	3	13.71			
31	3	22.11	71	2	18.31			
32	2	22.07	72	3	14.77			
33	3	23.69	73	3	17.43			
34	3	26.25	74	3	19.63			
35	1	26.36	75	2	15.98			
36	2	24.76	76	2	20.78			
37	2	37.92	77	1	21.86			
38	4	33.10	78	2	17.84			
39	2	43.25	79	2	17.75			
40	1	39.46	80	2	23.47			

PANDA Probe - Test Report

Site 26-4

Certificate Reference:

2091-PND-Site 26-4

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

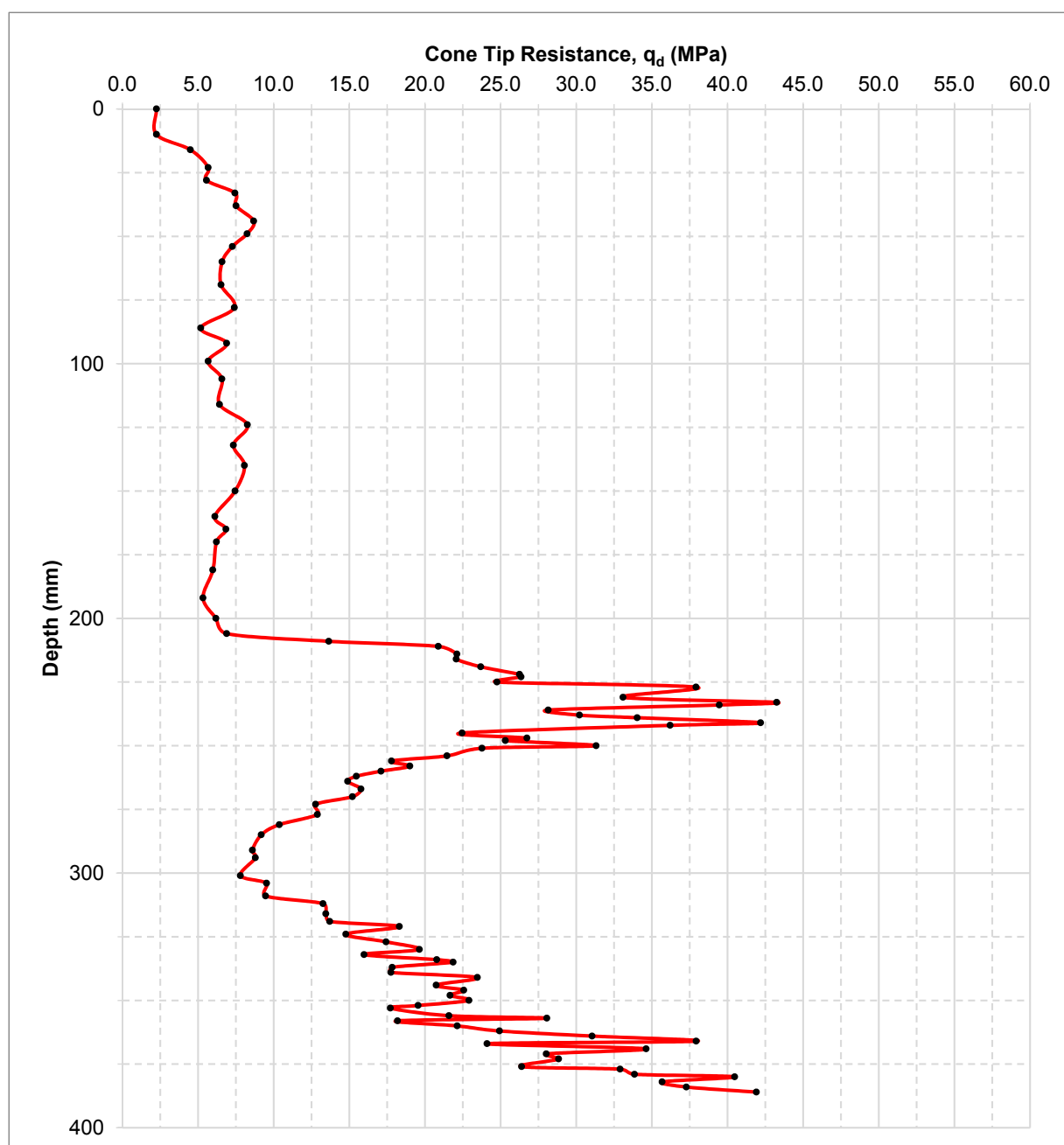
Project No.: 2091

Checked By: DWL

Location: Site 26-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-5

Certificate Reference:

2091-PND-Site 26-5

Sheet:

1 of 3

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.04	41	1	24.57	81	3	13.00
2	6	2.97	42	3	16.89	82	3	11.86
3	4	3.84	43	3	16.24	83	3	14.07
4	4	7.97	44	2	10.91	84	3	13.80
5	4	10.92	45	2	16.27	85	2	12.80
6	5	8.50	46	3	13.01	86	2	16.54
7	5	8.46	47	4	17.62	87	1	18.00
8	4	5.48	48	3	18.23	88	3	18.19
9	4	9.81	49	4	15.82	89	2	22.88
10	3	12.28	50	3	15.29	90	1	27.82
11	6	9.91	51	4	13.13	91	3	19.90
12	2	17.98	52	2	14.71	92	2	19.77
13	4	12.80	53	3	14.45	93	2	16.99
14	3	20.86	54	4	14.86	94	2	19.24
15	4	10.73	55	4	15.73	95	3	15.44
16	5	14.49	56	3	11.00	96	3	19.85
17	2	24.03	57	3	13.24	97	3	17.30
18	2	17.08	58	2	12.37	98	3	18.97
19	2	23.85	59	3	11.87	99	2	19.21
20	3	18.50	60	3	11.25	100	4	17.39
21	2	24.10	61	4	12.64	101	2	18.62
22	3	24.22	62	3	17.93	102	2	14.75
23	3	16.59	63	4	17.18	103	2	14.32
24	3	18.64	64	2	15.24	104	3	18.21
25	2	11.25	65	2	25.57	105	2	17.32
26	3	18.15	66	4	19.16	106	2	25.46
27	2	12.16	67	1	16.09	107	2	23.77
28	3	15.73	68	2	17.47	108	2	24.39
29	2	14.16	69	2	14.00	109	1	31.38
30	3	14.76	70	3	16.38	110	3	22.13
31	3	13.40	71	4	14.51	111	1	29.80
32	3	18.16	72	3	16.66	112	2	25.77
33	3	11.89	73	5	12.79	113	2	27.53
34	4	15.64	74	4	11.09	114	1	24.50
35	3	10.10	75	4	11.51	115	3	30.75
36	4	15.64	76	3	11.83	116	1	28.49
37	2	18.30	77	2	10.46	117	3	18.53
38	3	13.17	78	4	13.04	118	1	26.54
39	3	22.45	79	2	11.85	119	2	25.79
40	3	15.28	80	4	12.80	120	1	31.16

[illegible]

PANDA Probe - Test Report

Site 26-5

Certificate Reference:

2091-PND-Site 26-5

Sheet:

3 of 3

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

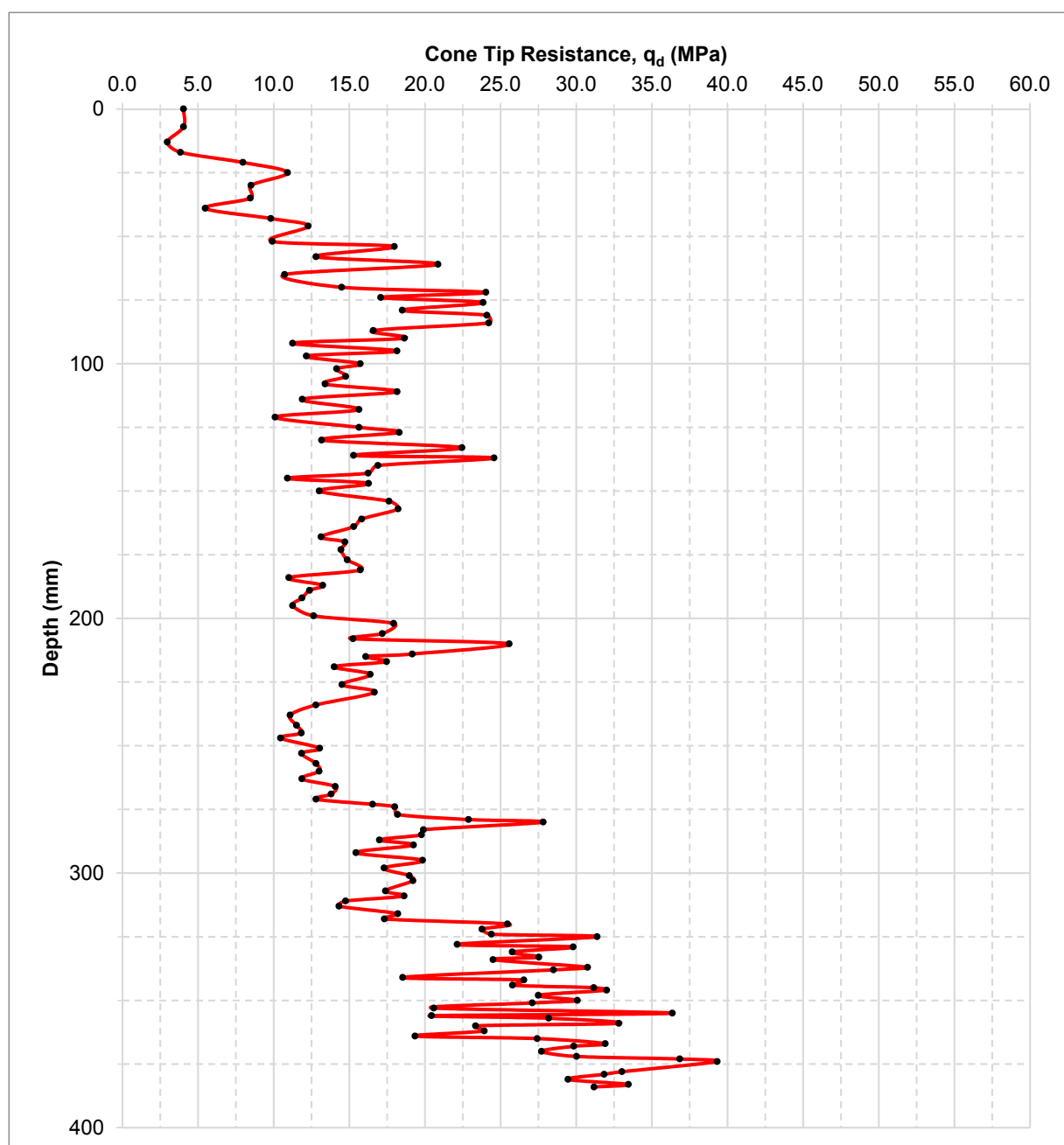
Project No.: 2091

Checked By: DWL

Location: Site 26-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction –Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-6

Certificate Reference:

2091-PND-Site 26-6

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	12.32	41	5	33.72			
2	6	15.26	42	6	28.63			
3	7	17.85	43	4	35.18			
4	7	21.58	44	4	33.13			
5	8	21.53	45	5	35.34			
6	7	20.75	46	6	28.52			
7	6	21.67	47	5	36.81			
8	5	23.35	48	5	38.85			
9	6	26.31	49	4	29.53			
10	4	45.24	50	3	50.01			
11	6	23.42	51	4	37.04			
12	5	23.50	52	3	44.66			
13	5	39.77	53	3	41.06			
14	3	28.29	54	3	43.43			
15	6	27.14	55	2	50.19			
16	6	24.21	56	4	51.57			
17	7	22.69	57	3	53.54			
18	6	26.88	58	3	50.88			
19	6	19.23	59	3	47.15			
20	7	19.98	End of Test Record					
21	6	19.15						
22	7	18.43						
23	6	19.61						
24	6	19.37						
25	7	20.42						
26	8	21.44						
27	8	22.76						
28	5	24.67						
29	8	25.22						
30	7	23.84						
31	4	20.16						
32	5	21.86						
33	5	23.04						
34	5	27.94						
35	5	24.08						
36	4	24.70						
37	5	25.78						
38	6	21.78						
39	5	21.38						
40	5	31.03						

PANDA Probe - Test Report

Site 26-6

Certificate Reference:

2091-PND-Site 26-6

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

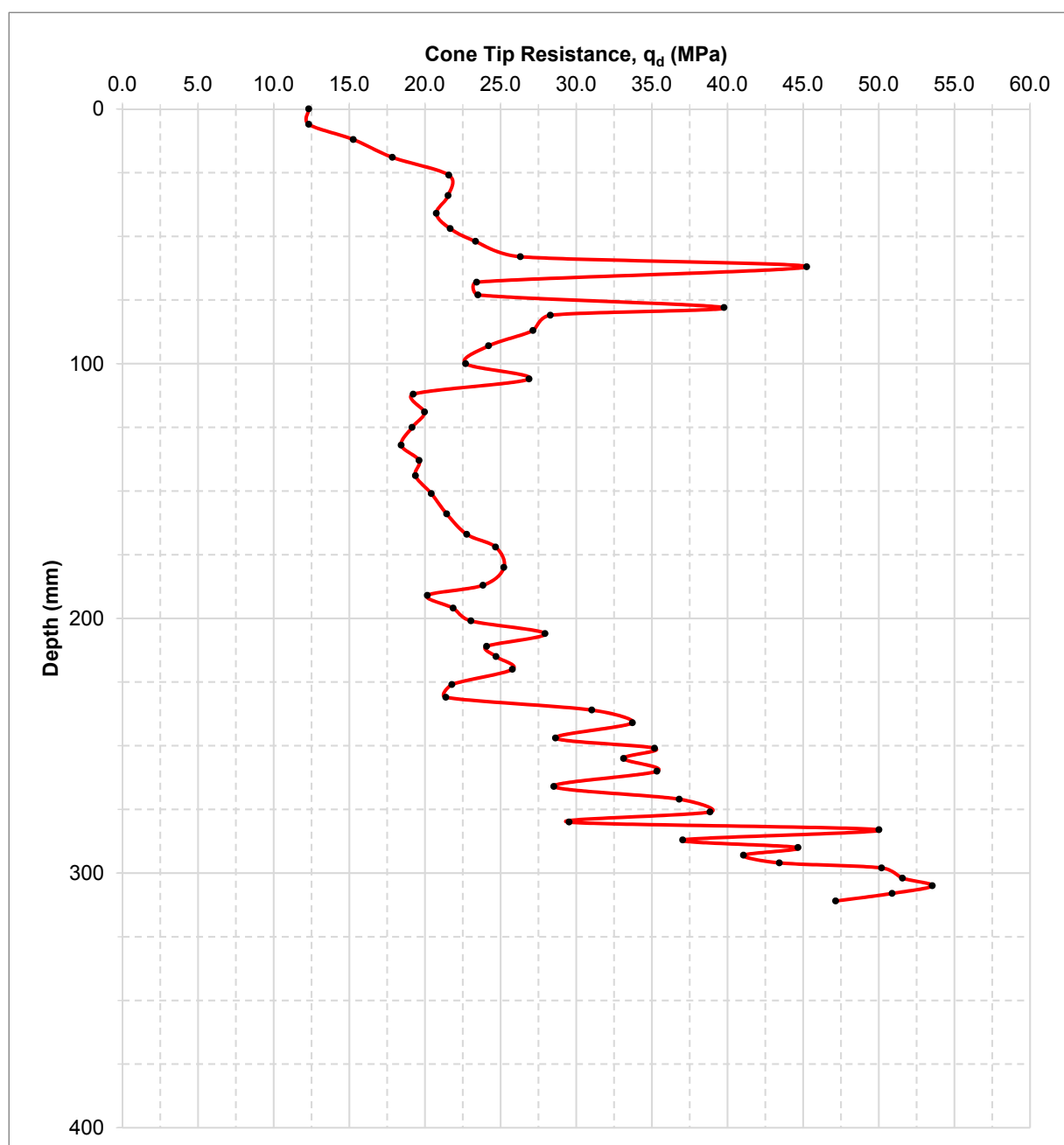
Project No.: 2091

Checked By: DWL

Location: Site 26-6 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-7

Certificate Reference:

2091-PND-Site 26-7

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	9.81	41	12	21.02			
2	6	14.61	42	9	14.80			
3	5	16.53	43	10	18.10			
4	6	12.93	44	10	19.41			
5	8	23.44	45	6	28.75			
6	6	28.26	46	5	36.42			
7	8	23.59	47	2	43.13			
8	6	18.13	48	2	71.40			
9	6	23.30	49	2	60.85			
10	7	16.94	50	2	51.20			
11	7	23.59	51	4	44.75			
12	6	23.28	52	2	54.15			
13	6	23.71	53	5	32.98			
14	4	19.29	54	3	47.62			
15	5	21.36	55	5	27.57			
16	5	22.27	56	2	65.99			
17	4	26.24	57	2	18.33			
18	5	26.15	58	2	45.71			
19	6	22.30	End of Test Record					
20	6	26.54						
21	6	18.39						
22	7	20.87						
23	6	24.08						
24	7	23.42						
25	5	18.90						
26	8	21.73						
27	7	16.48						
28	8	19.31						
29	6	19.03						
30	7	15.61						
31	8	17.90						
32	8	15.75						
33	6	16.41						
34	8	17.60						
35	9	22.16						
36	7	21.81						
37	10	17.27						
38	7	21.22						
39	5	18.85						
40	8	21.57						

PANDA Probe - Test Report

Site 26-7

Certificate Reference:

2091-PND-Site 26-7

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

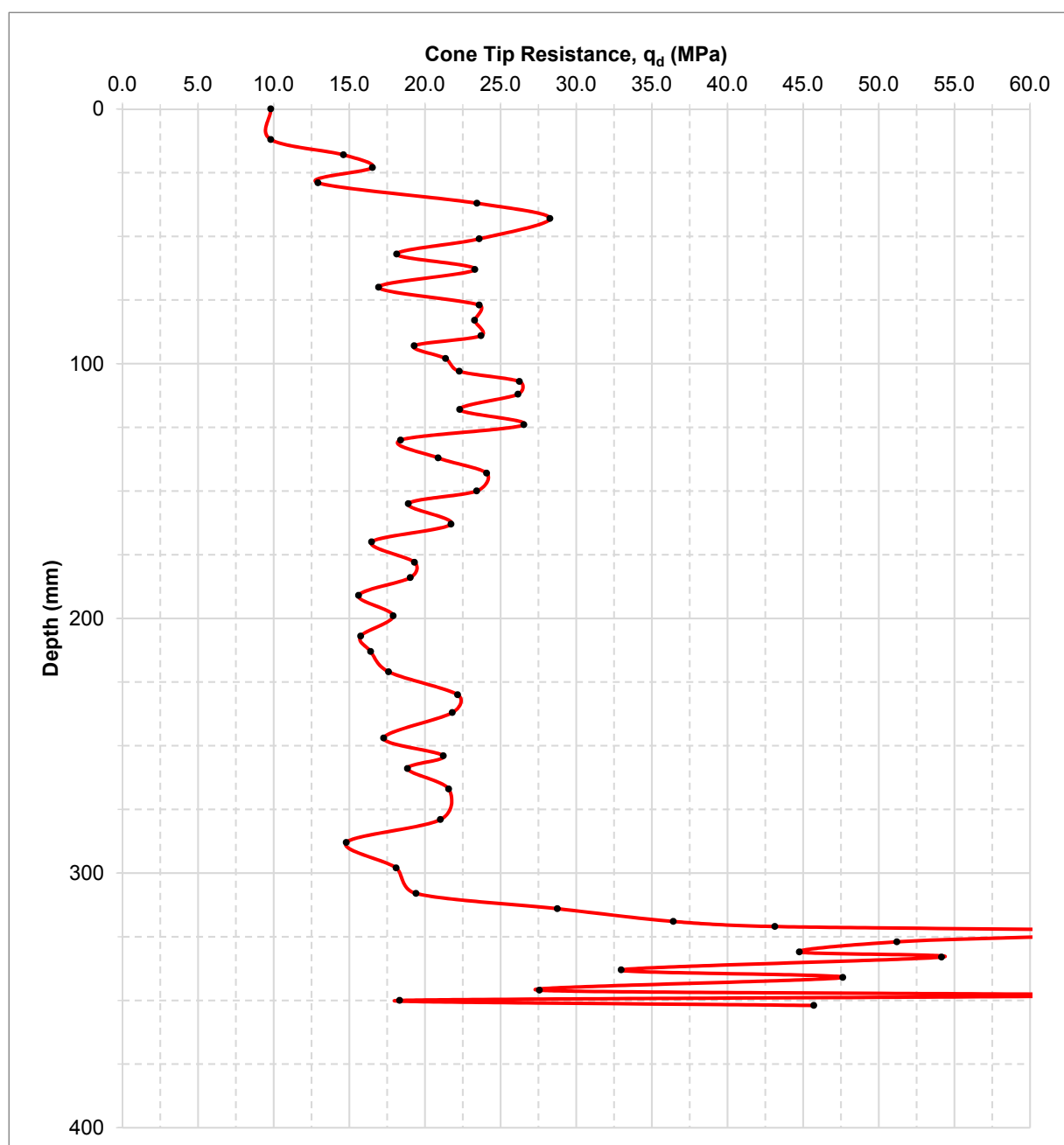
Project No.: 2091

Checked By: DWL

Location: Site 26-7 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 26-8

Certificate Reference:

2091-PND-Site 26-8

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

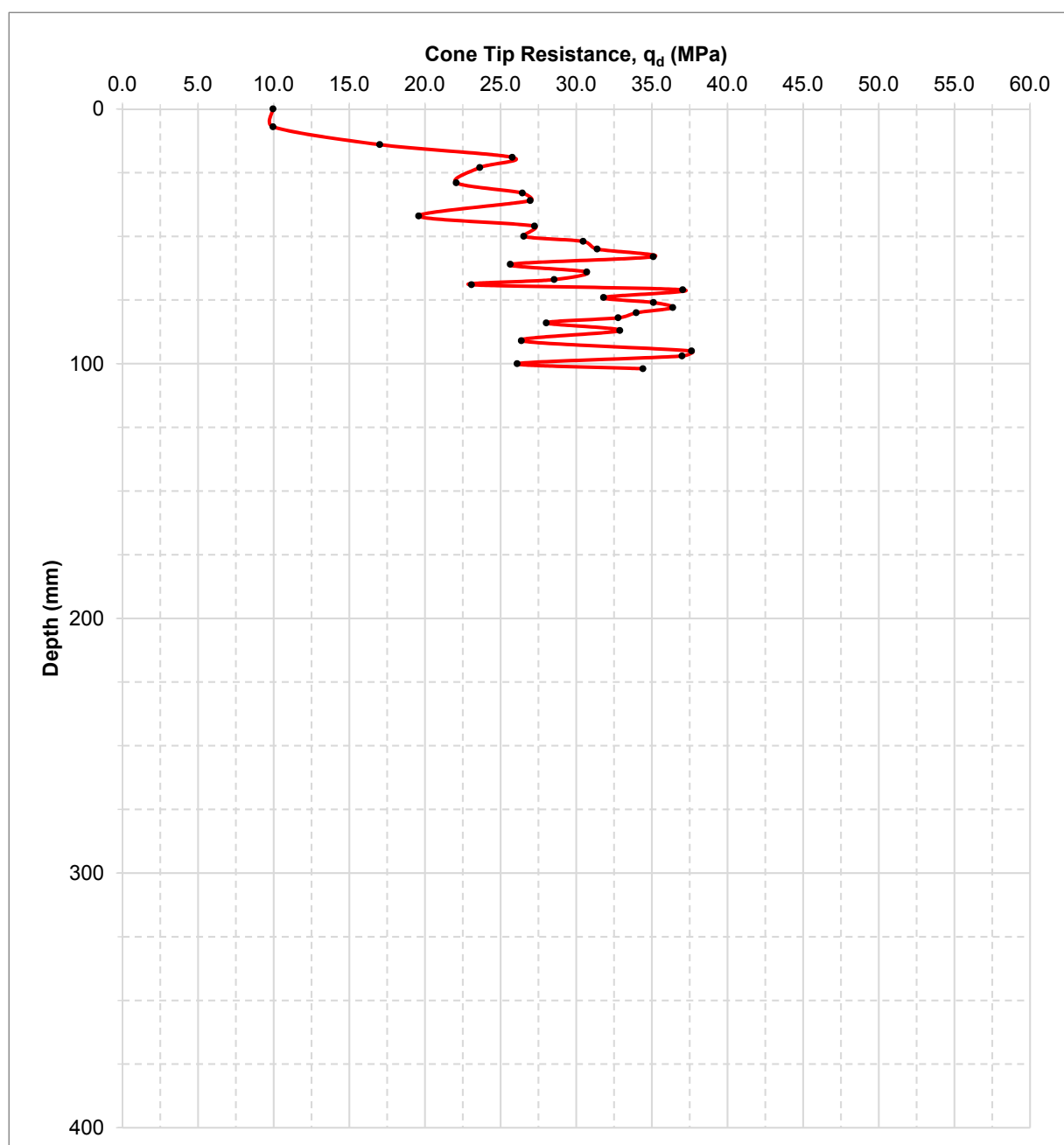
Project No.: 2091

Checked By: DWL

Location: Site 26-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



[illegible]

PANDA Probe - Test Report

Site 26-8A

Certificate Reference:

2091-PND-Site 26-8A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

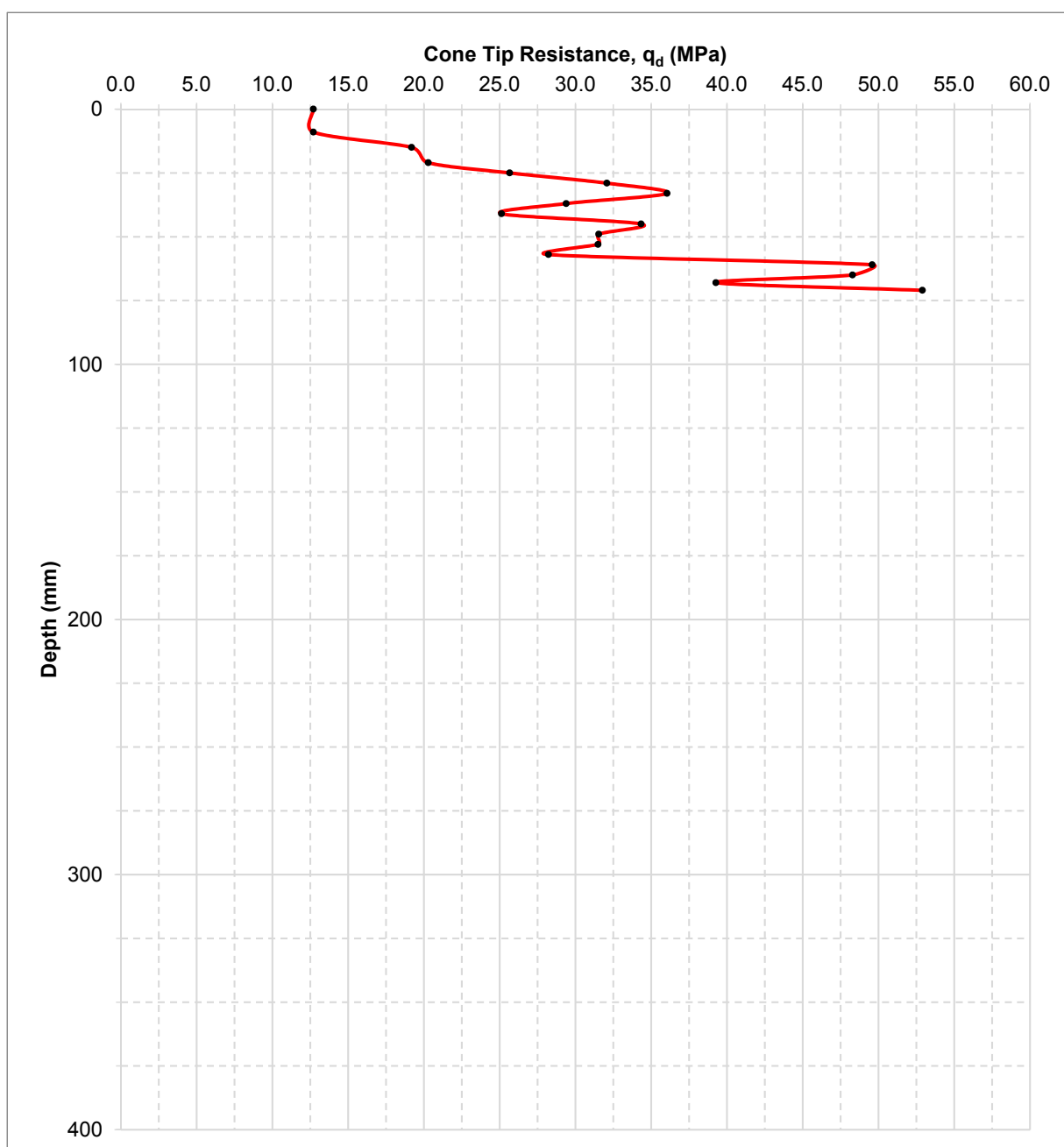
Project No.: 2091

Checked By: DWL

Location: Site 26-8 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-9

Certificate Reference:

2091-PND-Site 26-9

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	8.17	41	4	15.14	81	3	27.29
2	8	12.64	42	2	11.23	82	3	41.89
3	8	11.18	43	3	17.43	83	3	48.94
4	9	14.28	44	2	13.81	84	2	36.69
5	8	14.59	45	3	19.56	85	1	40.96
6	8	12.32	46	2	16.21	End of Test Record		
7	9	16.12	47	3	16.95			
8	11	12.97	48	2	19.97			
9	8	15.35	49	3	11.28			
10	8	13.77	50	3	15.86			
11	3	15.27	51	3	14.32			
12	4	14.86	52	2	19.95			
13	3	16.39	53	2	20.23			
14	2	15.53	54	2	20.72			
15	5	11.76	55	2	23.63			
16	4	11.56	56	3	19.22			
17	5	12.59	57	2	20.10			
18	5	9.49	58	3	17.05			
19	4	14.49	59	2	22.15			
20	4	13.08	60	1	26.58			
21	5	15.88	61	2	27.67			
22	4	13.35	62	1	23.17			
23	3	15.66	63	2	29.02			
24	5	11.91	64	3	26.27			
25	5	12.94	65	2	29.71			
26	5	12.34	66	1	52.82			
27	3	16.57	67	3	26.94			
28	5	11.91	68	1	31.90			
29	3	16.68	69	2	38.75			
30	4	13.96	70	2	31.66			
31	4	14.21	71	2	25.92			
32	4	13.43	72	2	25.80			
33	5	12.39	73	2	27.94			
34	4	11.71	74	2	23.53			
35	4	15.59	75	2	24.43			
36	4	10.17	76	2	26.78			
37	2	17.08	77	2	25.17			
38	5	14.63	78	2	24.47			
39	5	12.72	79	2	31.09			
40	3	15.30	80	3	29.16			

PANDA Probe - Test Report

Site 26-9

Certificate Reference:

2091-PND-Site 26-9

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

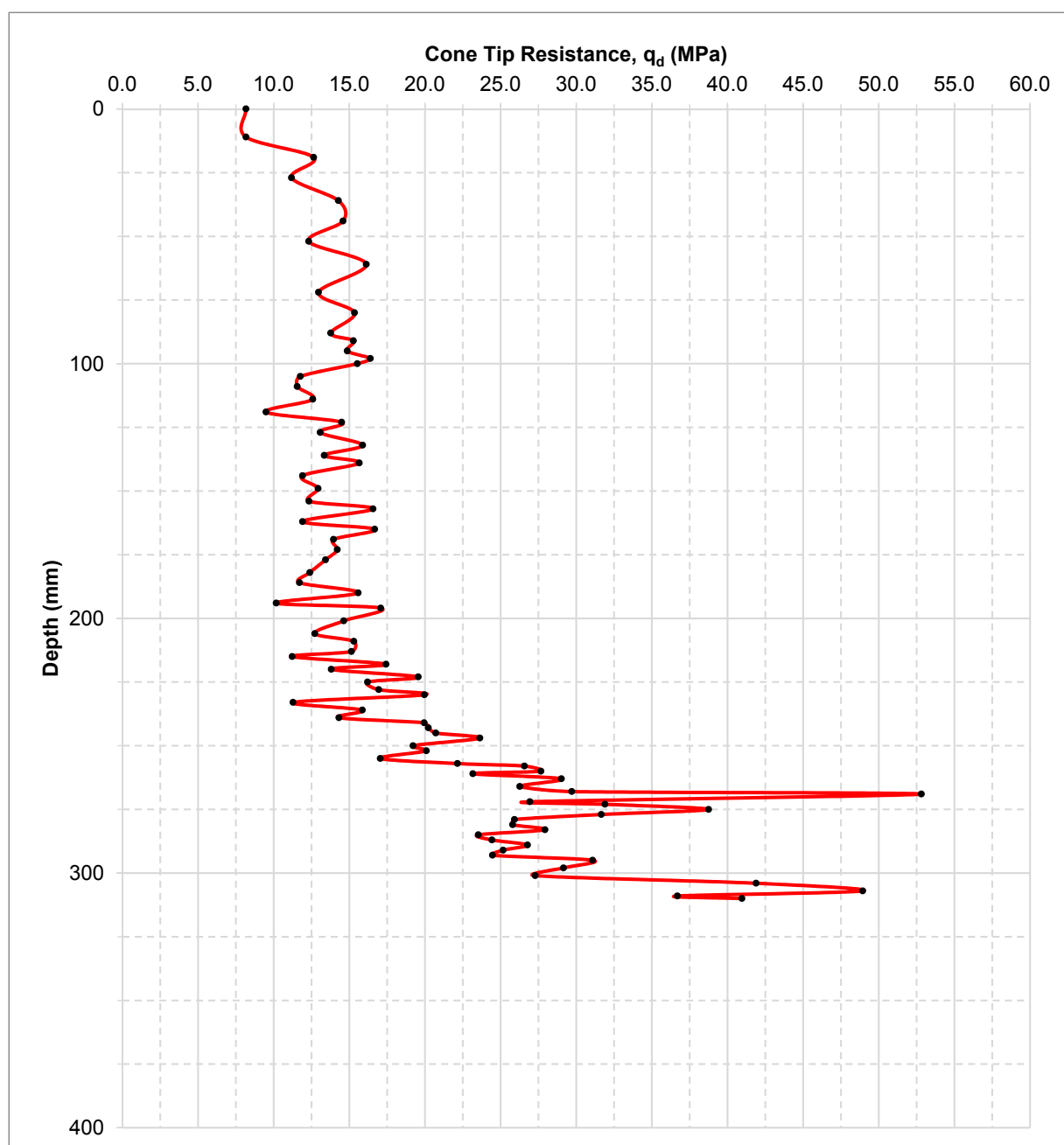
Project No.: 2091

Checked By: DWL

Location: Site 26-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-9A

Certificate Reference:

2091-PND-Site 26-9A

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	5.24	41	3	16.92	81	4	21.00
2	5	11.73	42	3	16.10	82	5	23.70
3	4	11.73	43	3	16.79	83	4	24.15
4	4	7.69	44	3	27.19	84	2	15.57
5	4	14.64	45	4	10.28	85	2	22.36
6	3	11.30	46	3	15.00	86	2	27.43
7	5	11.19	47	3	12.29	87	2	29.04
8	3	18.50	48	4	13.76	88	1	48.81
9	4	14.16	49	5	9.29	89	3	50.69
10	5	5.02	50	5	11.97	90	2	41.74
11	4	12.86	51	5	13.93	91	2	42.06
12	3	11.20	52	7	11.61	92	2	50.28
13	4	12.16	53	9	12.59	End of Test Record		
14	3	11.86	54	9	13.65			
15	3	12.81	55	11	14.03			
16	2	32.96	56	8	14.02			
17	2	33.37	57	8	17.41			
18	2	35.66	58	8	15.51			
19	3	24.52	59	7	16.73			
20	2	31.92	60	10	17.02			
21	2	22.01	61	6	21.79			
22	2	30.94	62	8	17.30			
23	2	21.13	63	8	17.86			
24	2	31.34	64	6	16.24			
25	2	26.25	65	7	15.39			
26	1	25.70	66	7	15.63			
27	2	30.03	67	7	14.32			
28	3	22.24	68	6	13.75			
29	2	22.45	69	8	13.57			
30	2	26.80	70	8	13.90			
31	2	17.94	71	10	16.37			
32	3	16.33	72	6	8.90			
33	2	19.80	73	7	11.82			
34	3	17.36	74	7	12.15			
35	4	17.68	75	8	12.38			
36	2	28.75	76	7	14.47			
37	2	30.29	77	6	16.20			
38	3	14.41	78	5	15.77			
39	3	23.80	79	6	18.57			
40	2	14.76	80	4	17.49			

PANDA Probe - Test Report

Site 26-9A

Certificate Reference:

2091-PND-Site 26-9A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

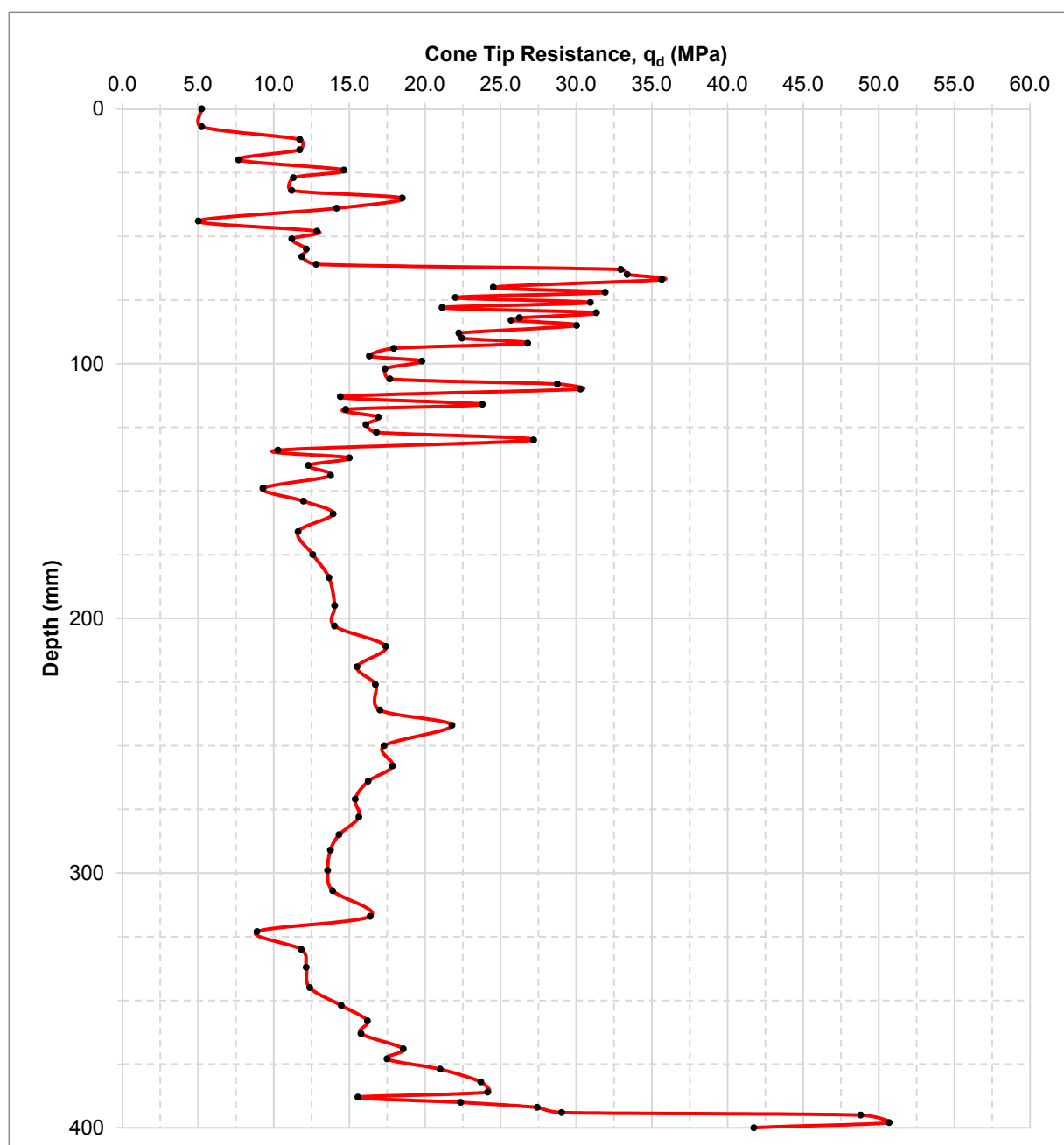
Project No.: 2091

Checked By: DWL

Location: Site 26-9 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-10

Certificate Reference:

2091-PND-Site 26-10

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	6.10						
2	5	8.18						
3	4	10.77						
4	4	12.00						
5	4	14.91						
6	4	15.31						
7	5	15.44						
8	3	18.67						
9	5	11.11						
10	3	20.23						
11	2	21.56						
12	3	11.18						
13	3	18.36						
14	2	24.12						
15	3	21.55						
16	1	31.48						
17	3	20.06						
18	2	27.24						
19	3	24.38						
20	3	14.75						
21	3	21.61						
22	3	20.22						
23	4	18.09						
24	3	26.84						
25	4	23.58						
26	2	23.09						
27	3	16.67						
28	2	20.93						
29	3	21.19						
30	4	22.45						
31	2	19.61						
32	2	25.97						
33	3	27.71						
34	2	31.00						
35	2	34.91						
36	2	40.88						
37	1	46.73						
38	2	40.44						
End of Test Record								

PANDA Probe - Test Report

Site 26-10

Certificate Reference:

2091-PND-Site 26-10

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

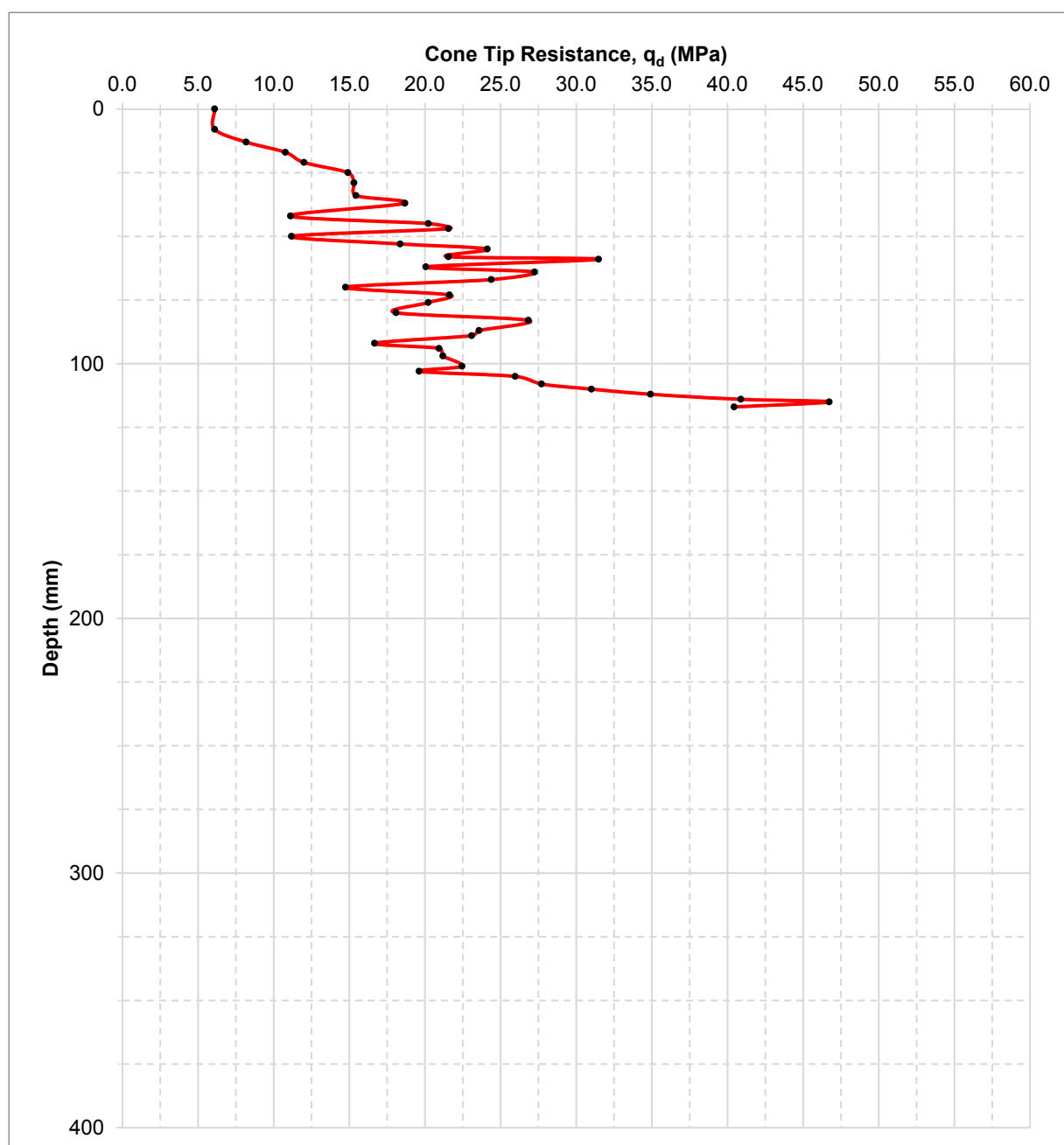
Project No.: 2091

Checked By: DWL

Location: Site 26-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-10A

Certificate Reference:

2091-PND-Site 26-10A

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	6.51						
2	5	10.95						
3	5	12.68						
4	3	22.73						
5	4	9.55						
6	3	12.69						
7	4	17.39						
8	4	11.74						
9	3	17.54						
10	3	16.58						
11	1	36.90						
12	2	27.03						
13	2	10.97						
14	2	15.30						
15	1	32.60						
16	2	26.90						
17	1	43.88						
18	2	27.58						
19	2	26.94						
20	1	40.31						
21	3	23.24						
22	1	27.64						
23	2	20.22						
24	1	34.53						
25	3	18.94						
26	4	21.71						
27	2	27.58						
28	2	16.60						
29	2	26.49						
30	2	13.99						
31	1	24.45						
32	2	16.70						
33	1	33.38						
34	2	49.68						
35	1	57.51						
36	1	41.89						
37	1	74.99						
38	2	65.57						
End of Test Record								

PANDA Probe - Test Report

Site 26-10A

Certificate Reference:

2091-PND-Site 26-10A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

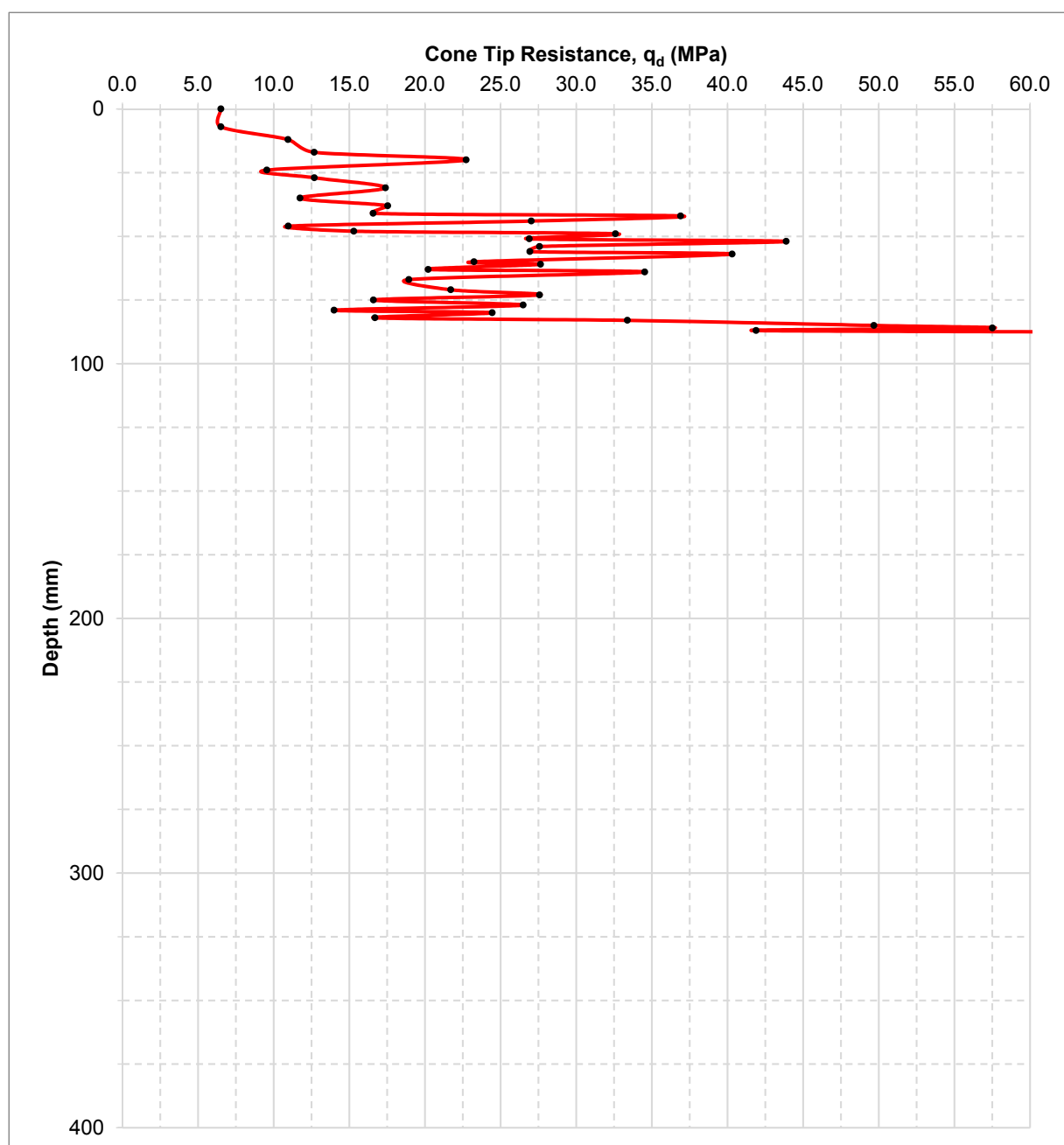
Project No.: 2091

Checked By: DWL

Location: Site 26-10 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-11

Certificate Reference:

2091-PND-Site 26-11

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.10	41	4	31.22			
2	7	4.90	42	2	33.12			
3	8	7.08	43	2	30.37			
4	8	6.85	44	2	37.68			
5	6	8.54	45	1	40.74			
6	8	9.41	46	2	53.30			
7	5	8.88	End of Test Record					
8	6	10.40						
9	5	10.17						
10	6	11.72						
11	3	8.88						
12	4	9.28						
13	4	11.13						
14	6	10.22						
15	5	11.01						
16	5	14.91						
17	6	8.06						
18	3	14.10						
19	6	11.52						
20	6	11.94						
21	7	12.56						
22	6	12.03						
23	5	11.31						
24	7	9.81						
25	6	12.01						
26	7	9.44						
27	6	10.96						
28	8	11.53						
29	5	10.92						
30	5	10.50						
31	5	14.37						
32	5	19.99						
33	3	14.85						
34	3	23.17						
35	3	39.41						
36	2	27.41						
37	2	22.28						
38	2	29.08						
39	3	20.99						
40	2	26.09						

PANDA Probe - Test Report

Site 26-11

Certificate Reference:

2091-PND-Site 26-11

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

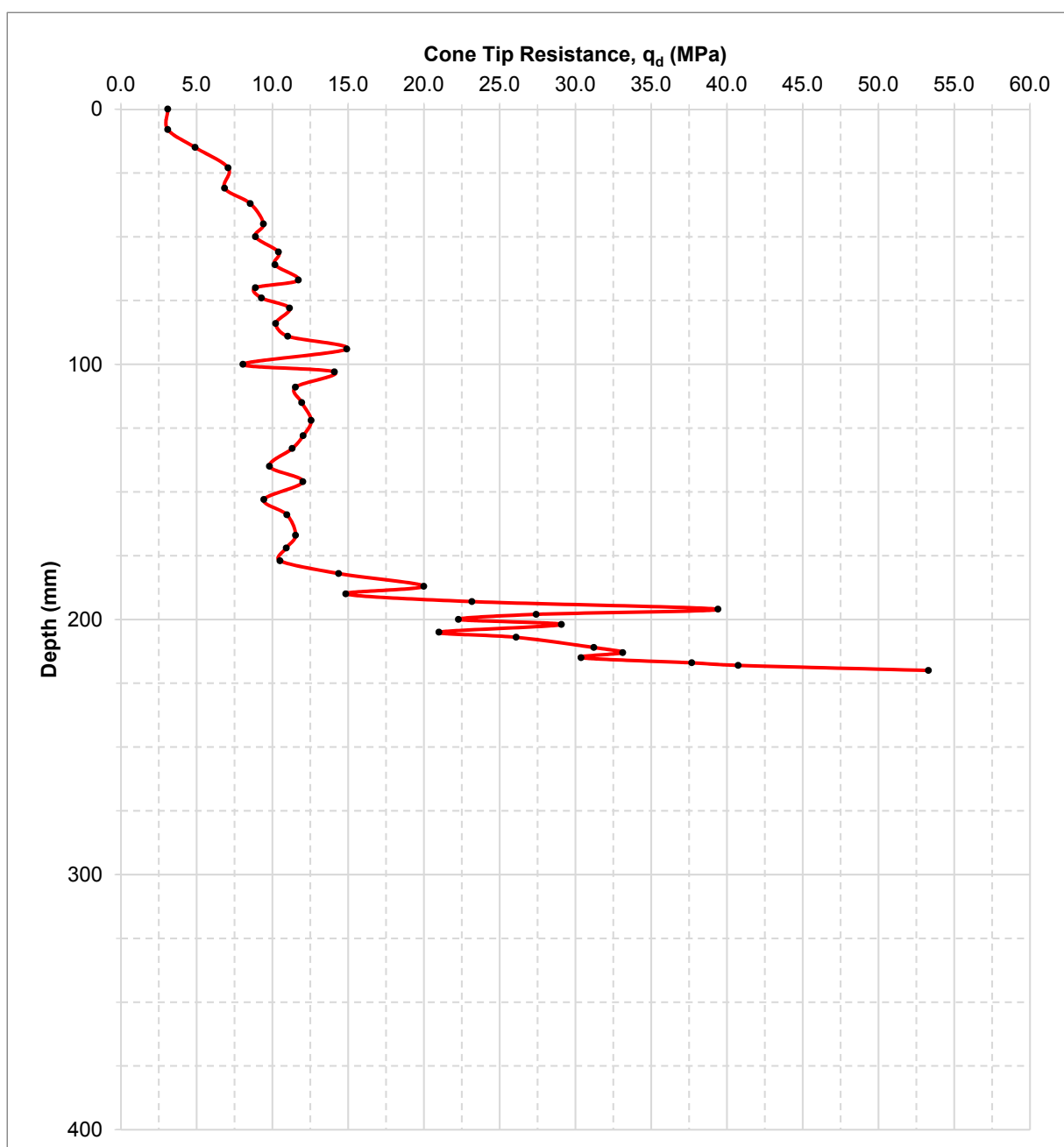
Project No.: 2091

Checked By: DWL

Location: Site 26-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-11A

Certificate Reference:

2091-PND-Site 26-11A

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	5	6.89	41	4	11.53	81	3	16.31
2	4	10.65	42	3	14.99	82	4	19.73
3	5	9.69	43	4	12.49	83	3	17.96
4	7	6.68	44	3	19.43	84	4	14.59
5	6	6.64	45	3	18.35	85	4	16.39
6	5	10.12	46	3	18.72	86	3	14.58
7	4	10.48	47	2	22.59	87	3	22.85
8	5	10.13	48	4	12.17	88	3	19.47
9	4	10.19	49	5	10.99	89	3	20.33
10	5	12.54	50	4	11.98	90	3	24.52
11	4	14.33	51	4	8.51	91	3	24.04
12	4	11.30	52	6	11.10	92	2	21.61
13	4	13.16	53	5	11.94	93	3	26.99
14	4	13.53	54	6	11.96	94	1	39.85
15	4	10.19	55	4	11.99	95	2	44.23
16	4	12.19	56	2	12.72	96	4	43.11
17	4	13.46	57	7	8.91	97	1	40.78
18	4	10.60	58	5	13.53	98	2	64.20
19	4	15.78	59	4	10.45	99	2	61.17
20	3	14.27	60	5	14.05	100	1	82.55
21	5	12.28	61	4	9.46	End of Test Record		
22	4	14.81	62	3	17.71			
23	4	12.85	63	3	14.60			
24	4	9.40	64	4	12.26			
25	4	16.99	65	4	7.81			
26	4	17.88	66	3	12.33			
27	4	12.04	67	4	13.05			
28	4	12.27	68	4	9.86			
29	4	15.25	69	6	11.96			
30	5	12.80	70	5	11.20			
31	4	15.31	71	5	8.94			
32	6	11.01	72	3	8.00			
33	5	13.96	73	5	14.05			
34	4	16.45	74	5	12.62			
35	3	24.47	75	6	11.51			
36	4	17.05	76	4	15.81			
37	2	13.31	77	5	10.70			
38	4	14.78	78	4	8.22			
39	4	11.20	79	6	14.39			
40	4	11.12	80	4	9.71			

PANDA Probe - Test Report

Site 26-11A

Certificate Reference:

2091-PND-Site 26-11A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

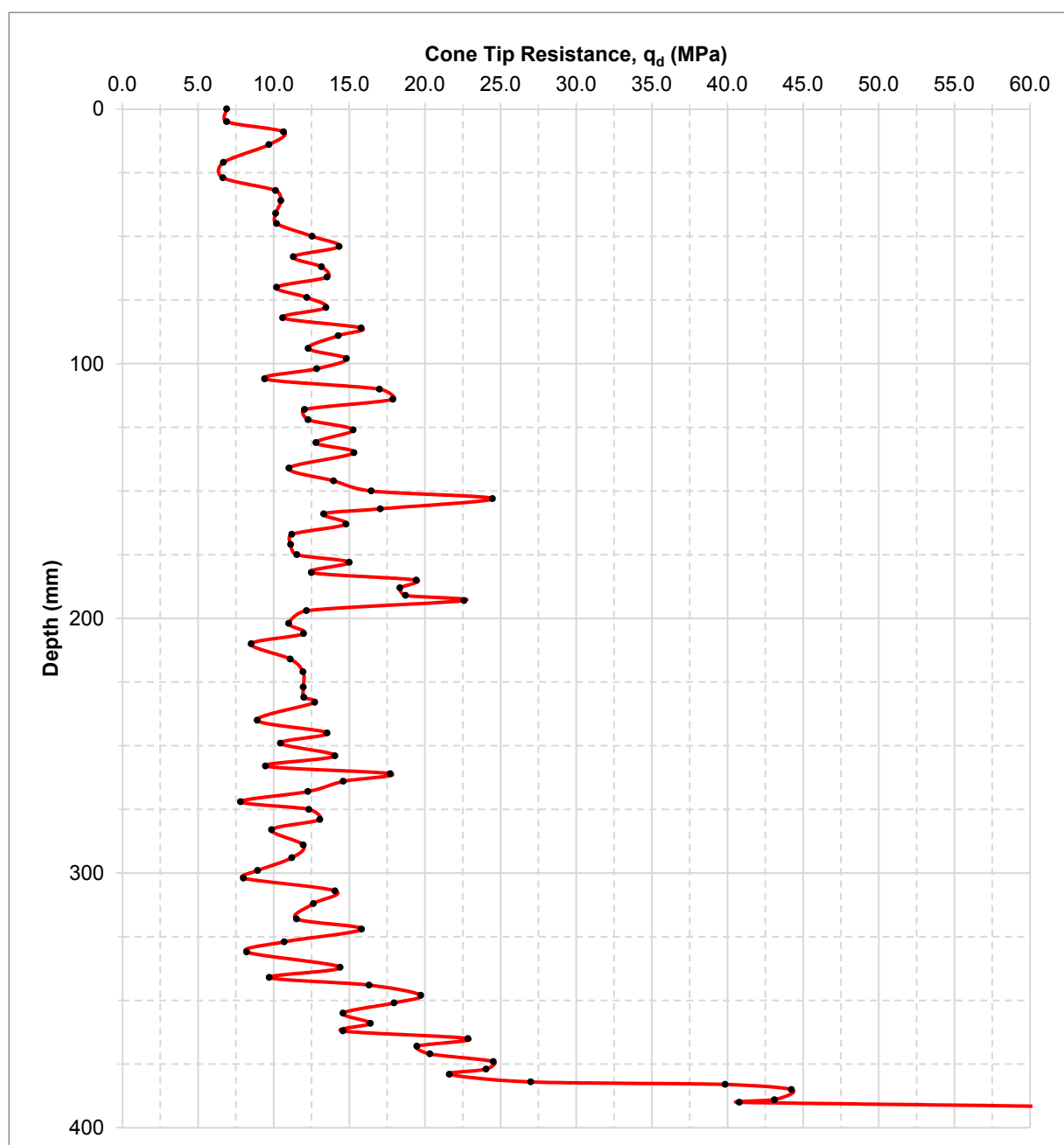
Project No.: 2091

Checked By: DWL

Location: Site 26-11 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-12

Certificate Reference:

2091-PND-Site 26-12

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	3	6.66	41	2	22.00	81	3	11.33
2	5	8.42	42	3	20.21	82	2	12.68
3	3	12.05	43	2	29.58	83	3	20.06
4	4	11.10	44	2	23.42	84	2	28.53
5	3	15.59	45	2	20.23	85	1	30.48
6	4	12.60	46	2	15.40	86	4	32.69
7	5	6.59	47	2	14.94	End of Test Record		
8	2	16.22	48	3	16.22			
9	3	14.27	49	5	12.59			
10	4	6.13	50	2	18.63			
11	2	11.46	51	3	18.51			
12	3	15.90	52	3	16.54			
13	1	22.23	53	4	16.67			
14	4	12.01	54	3	18.02			
15	2	20.07	55	3	12.88			
16	3	17.05	56	2	19.34			
17	3	14.93	57	3	17.72			
18	2	13.78	58	4	14.92			
19	2	16.99	59	3	9.73			
20	2	10.05	60	3	17.90			
21	3	19.61	61	2	15.03			
22	4	17.40	62	5	13.42			
23	2	20.91	63	3	15.55			
24	4	26.84	64	5	12.20			
25	3	18.96	65	4	15.05			
26	3	20.07	66	3	8.08			
27	2	27.50	67	4	12.26			
28	2	21.46	68	3	19.17			
29	1	21.61	69	3	13.39			
30	2	21.64	70	2	25.76			
31	3	21.45	71	3	11.38			
32	3	20.03	72	2	20.53			
33	4	16.68	73	2	16.12			
34	2	21.95	74	3	16.15			
35	3	20.02	75	3	13.78			
36	2	24.78	76	2	15.34			
37	3	18.99	77	2	21.31			
38	2	24.23	78	2	14.86			
39	2	16.59	79	2	20.68			
40	3	19.61	80	3	14.04			

PANDA Probe - Test Report

Site 26-12

Certificate Reference:

2091-PND-Site 26-12

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

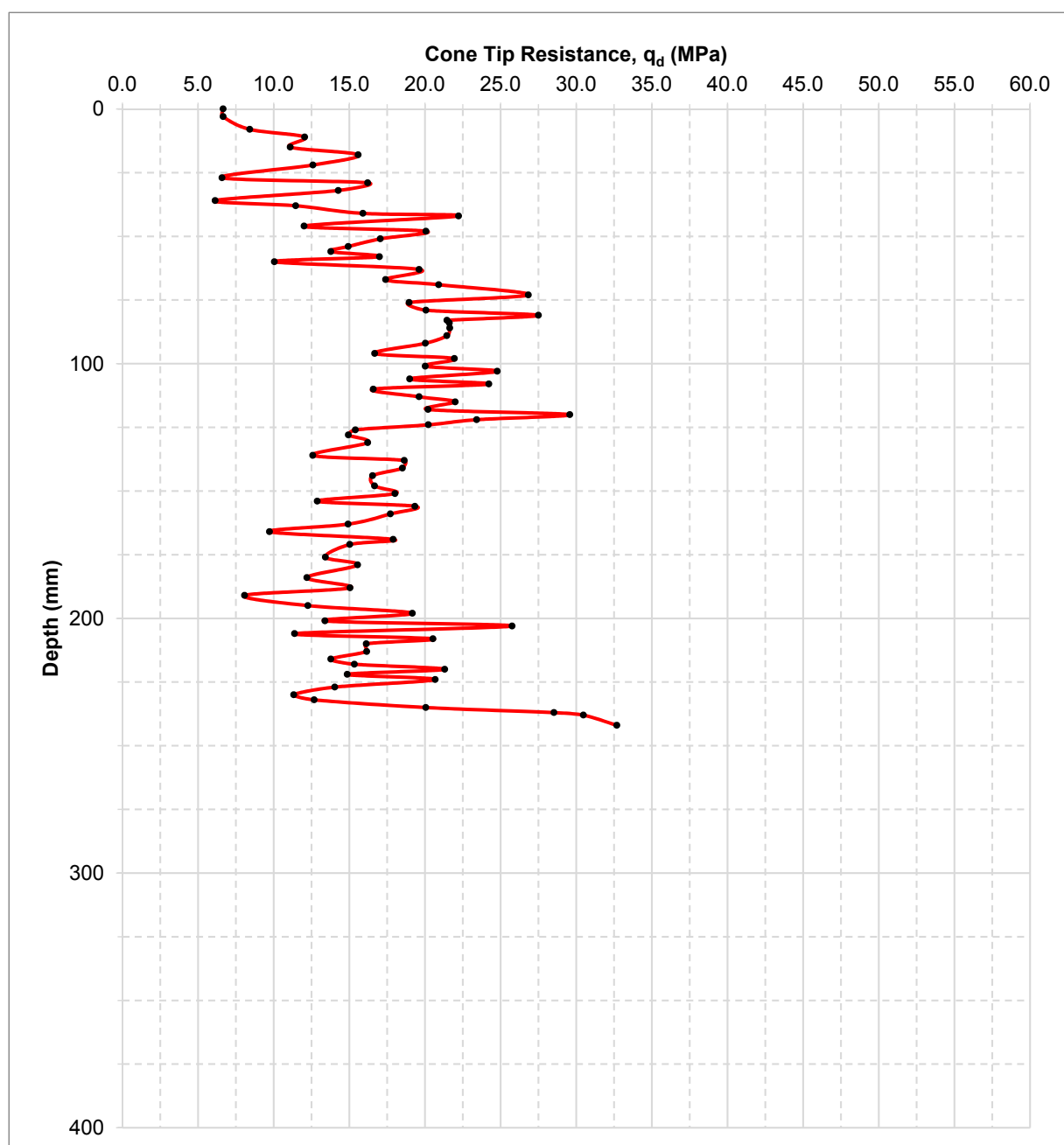
Project No.: 2091

Checked By: DWL

Location: Site 26-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 26-12A

Certificate Reference:

2091-PND-Site 26-12A

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 26-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	7.67	41	3	16.01	81	2	31.07
2	3	12.92	42	2	27.30	82	3	20.25
3	2	16.69	43	3	23.13	83	4	35.99
4	3	13.69	44	2	22.15	84	1	50.17
5	4	14.87	45	2	18.54	85	1	40.14
6	3	18.98	46	3	15.29	86	3	44.51
7	3	10.84	47	2	19.55	87	2	35.21
8	3	17.04	48	2	13.56	88	1	37.14
9	4	12.84	49	2	17.04	End of Test Record		
10	2	21.40	50	3	22.17			
11	3	13.68	51	4	16.37			
12	3	14.43	52	2	20.25			
13	2	16.30	53	3	17.99			
14	2	16.08	54	3	14.96			
15	2	22.91	55	2	24.14			
16	2	28.92	56	3	21.45			
17	4	5.85	57	3	19.59			
18	2	18.48	58	2	17.88			
19	3	21.87	59	3	18.73			
20	1	33.58	60	3	16.78			
21	2	15.98	61	3	19.36			
22	3	18.31	62	3	15.99			
23	1	28.21	63	2	21.30			
24	2	32.52	64	4	16.76			
25	2	15.03	65	2	23.46			
26	3	24.29	66	3	20.20			
27	1	28.00	67	2	20.60			
28	3	22.02	68	3	21.17			
29	1	65.39	69	2	20.45			
30	2	38.85	70	2	21.55			
31	5	16.48	71	2	16.46			
32	3	28.49	72	2	21.84			
33	3	21.22	73	2	19.61			
34	2	23.39	74	3	18.45			
35	3	18.09	75	3	18.30			
36	2	20.53	76	3	16.77			
37	2	18.57	77	2	25.01			
38	2	30.84	78	2	27.36			
39	3	15.77	79	1	24.58			
40	2	30.28	80	2	29.77			

PANDA Probe - Test Report

Site 26-12A

Certificate Reference:

2091-PND-Site 26-12A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

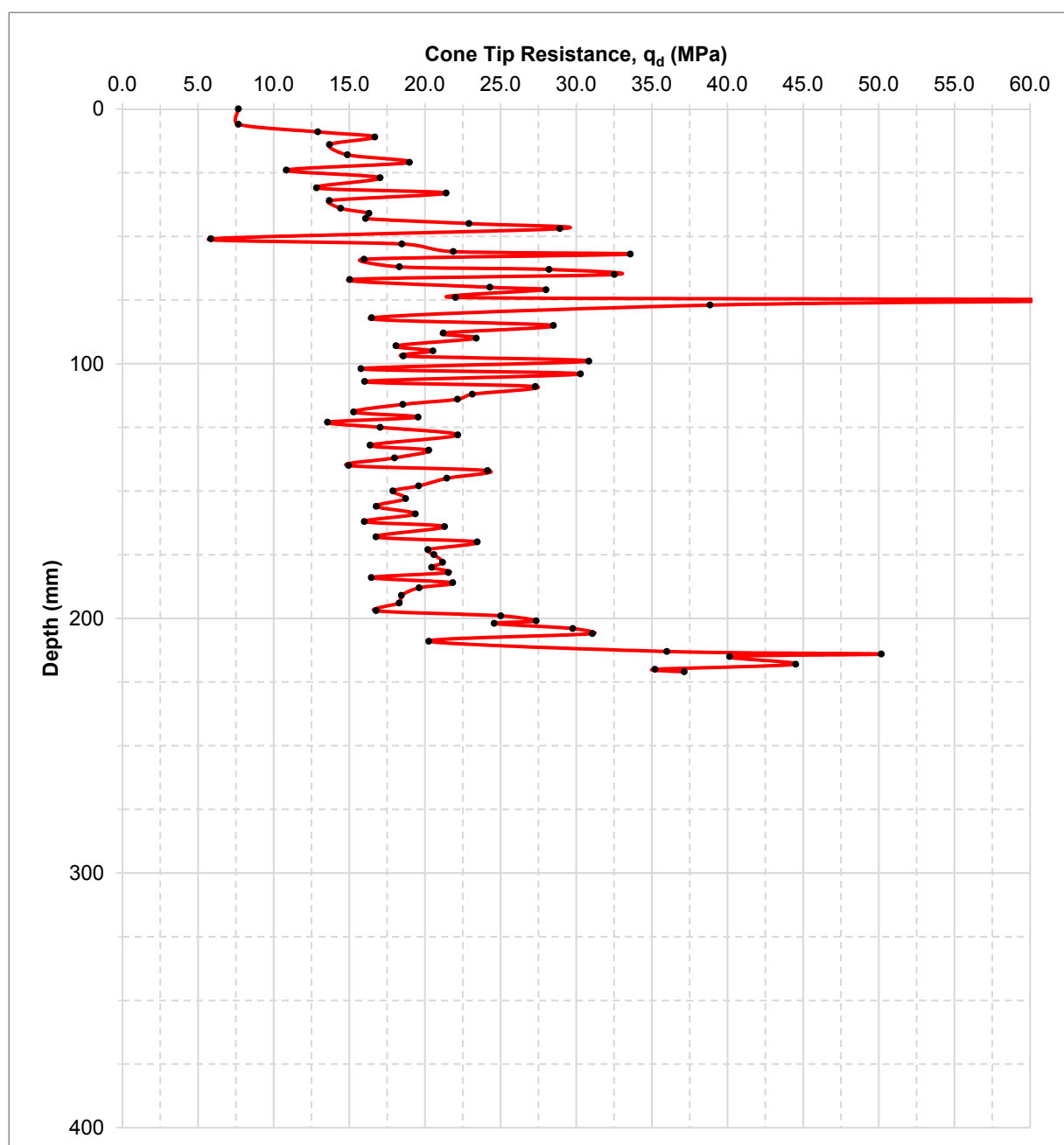
Project No.: 2091

Checked By: DWL

Location: Site 26-12 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 27-1

Certificate Reference:

2091-PND-Site 27-1

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 27-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	1.37	41	4	13.10	81	3	16.54
2	9	2.31	42	3	14.52	82	2	24.69
3	6	4.13	43	5	7.79	83	4	18.42
4	5	4.17	44	3	14.08	84	3	17.90
5	6	3.89	45	4	12.13	85	3	21.95
6	6	3.70	46	3	14.29	86	2	25.13
7	6	5.68	47	2	12.82	87	3	16.93
8	5	5.46	48	4	13.19	88	3	14.94
9	4	7.95	49	3	16.32	89	4	19.16
10	5	6.29	50	2	22.98	90	2	16.52
11	4	10.40	51	5	9.50	91	3	20.66
12	6	4.88	52	1	36.71	92	3	21.39
13	5	7.04	53	4	12.27	93	2	34.01
14	6	6.43	54	2	14.19	94	2	32.77
15	5	7.15	55	2	16.22	95	2	30.90
16	6	7.05	56	2	27.31	96	2	29.23
17	3	10.87	57	5	9.51	97	2	22.56
18	6	9.09	58	3	18.39	98	2	41.09
19	4	8.21	59	2	10.02	99	2	19.51
20	5	9.38	60	4	14.11	100	1	23.69
21	5	8.15	61	3	11.88	101	2	28.76
22	4	10.78	62	3	11.05	102	2	38.90
23	4	8.96	63	4	12.78	103	1	29.19
24	5	10.97	64	3	13.26	104	2	35.01
25	3	14.81	65	3	9.94	105	1	43.85
26	4	11.06	66	3	12.11	106	2	34.11
27	3	12.10	67	3	14.78	107	2	40.56
28	3	15.31	68	3	11.13	108	1	41.67
29	3	10.82	69	3	12.55	109	1	39.42
30	4	9.86	70	3	14.56	110	2	32.69
31	2	13.00	71	2	15.89	111	1	53.73
32	4	12.26	72	2	19.16	End of Test Record		
33	4	13.80	73	1	13.30			
34	4	9.81	74	5	12.19			
35	4	9.17	75	2	27.04			
36	4	10.42	76	3	6.71			
37	5	12.93	77	2	28.96			
38	2	17.86	78	5	10.28			
39	2	13.08	79	1	31.97			
40	2	7.78	80	5	12.96			

Certificate Reference:

2091-PND-Site 27-1

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

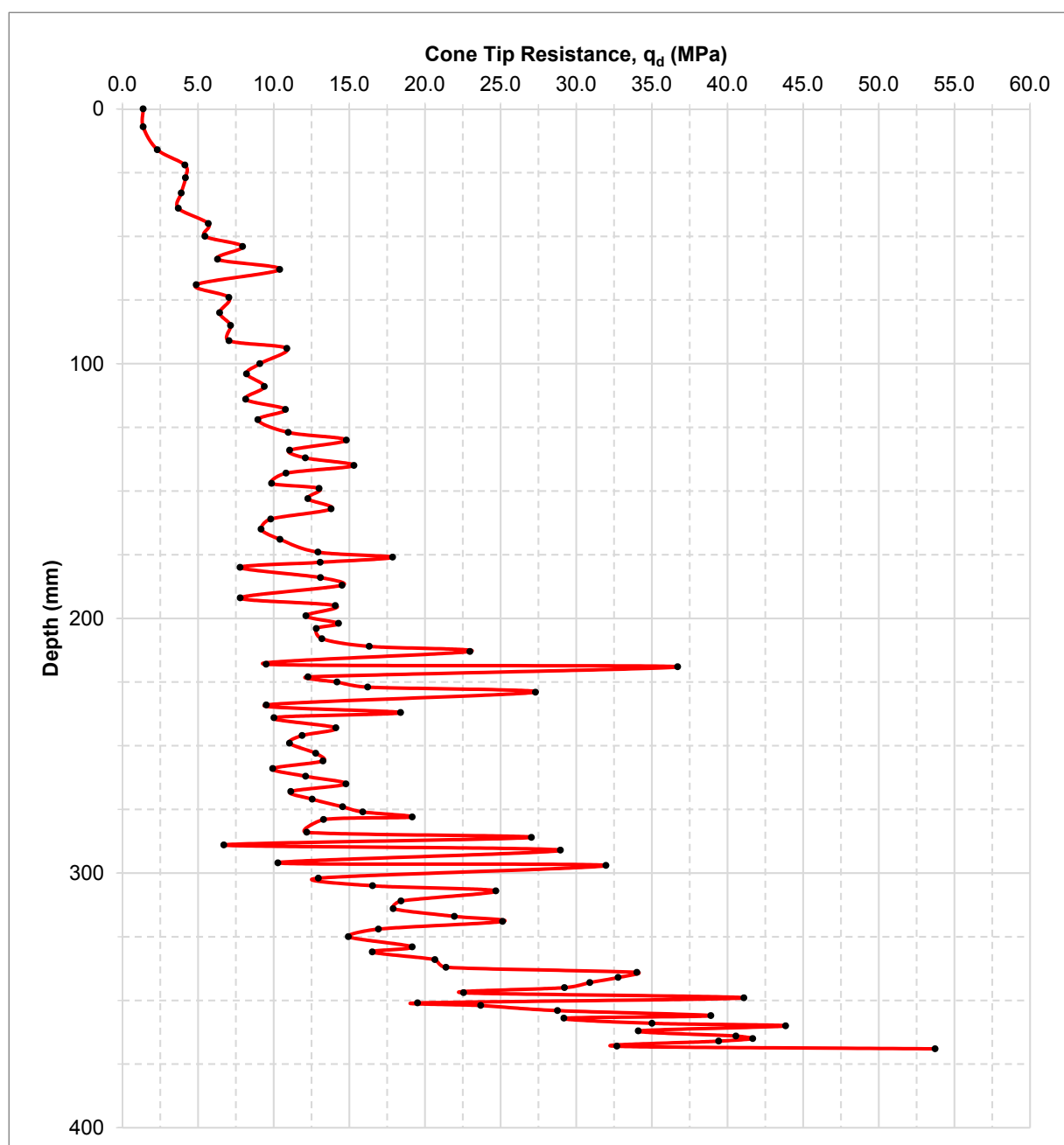
Project No.: 2091

Checked By: DWL

Location: Site 27-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 27-2

Certificate Reference:

2091-PND-Site 27-2

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 27-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.20	41	4	9.32	81	2	28.51
2	6	4.97	42	1	44.96	82	1	27.46
3	8	5.86	43	3	13.68	83	3	17.02
4	4	10.45	44	6	9.88	84	2	31.54
5	3	7.24	45	5	11.02	85	2	22.00
6	6	7.56	46	3	16.21	86	2	26.37
7	5	8.17	47	4	12.37	87	1	41.49
8	4	9.50	48	2	17.52	88	2	35.54
9	6	7.54	49	4	6.76	89	1	33.62
10	5	12.73	50	3	15.51	90	1	34.89
11	5	13.42	51	4	12.84	End of Test Record		
12	4	14.11	52	3	12.35			
13	5	11.34	53	3	18.74			
14	8	10.71	54	4	16.39			
15	9	9.64	55	4	16.55			
16	7	7.42	56	7	10.30			
17	9	8.58	57	3	17.01			
18	9	7.70	58	3	12.15			
19	8	8.64	59	1	26.55			
20	10	8.41	60	4	13.23			
21	7	10.10	61	5	18.72			
22	6	7.34	62	3	28.76			
23	5	6.95	63	4	21.40			
24	6	10.98	64	5	19.80			
25	5	8.73	65	4	13.55			
26	8	10.06	66	4	12.43			
27	8	7.62	67	2	28.13			
28	7	5.76	68	3	22.16			
29	10	5.70	69	2	29.80			
30	14	4.72	70	2	20.47			
31	8	6.62	71	3	12.17			
32	12	5.71	72	2	49.22			
33	8	7.23	73	3	17.73			
34	10	5.05	74	3	36.13			
35	7	5.62	75	2	19.80			
36	9	7.34	76	1	52.07			
37	7	6.82	77	2	42.72			
38	6	8.21	78	1	19.26			
39	7	8.21	79	2	36.21			
40	4	11.42	80	2	23.55			

PANDA Probe - Test Report

Site 27-2

Certificate Reference:

2091-PND-Site 27-2

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

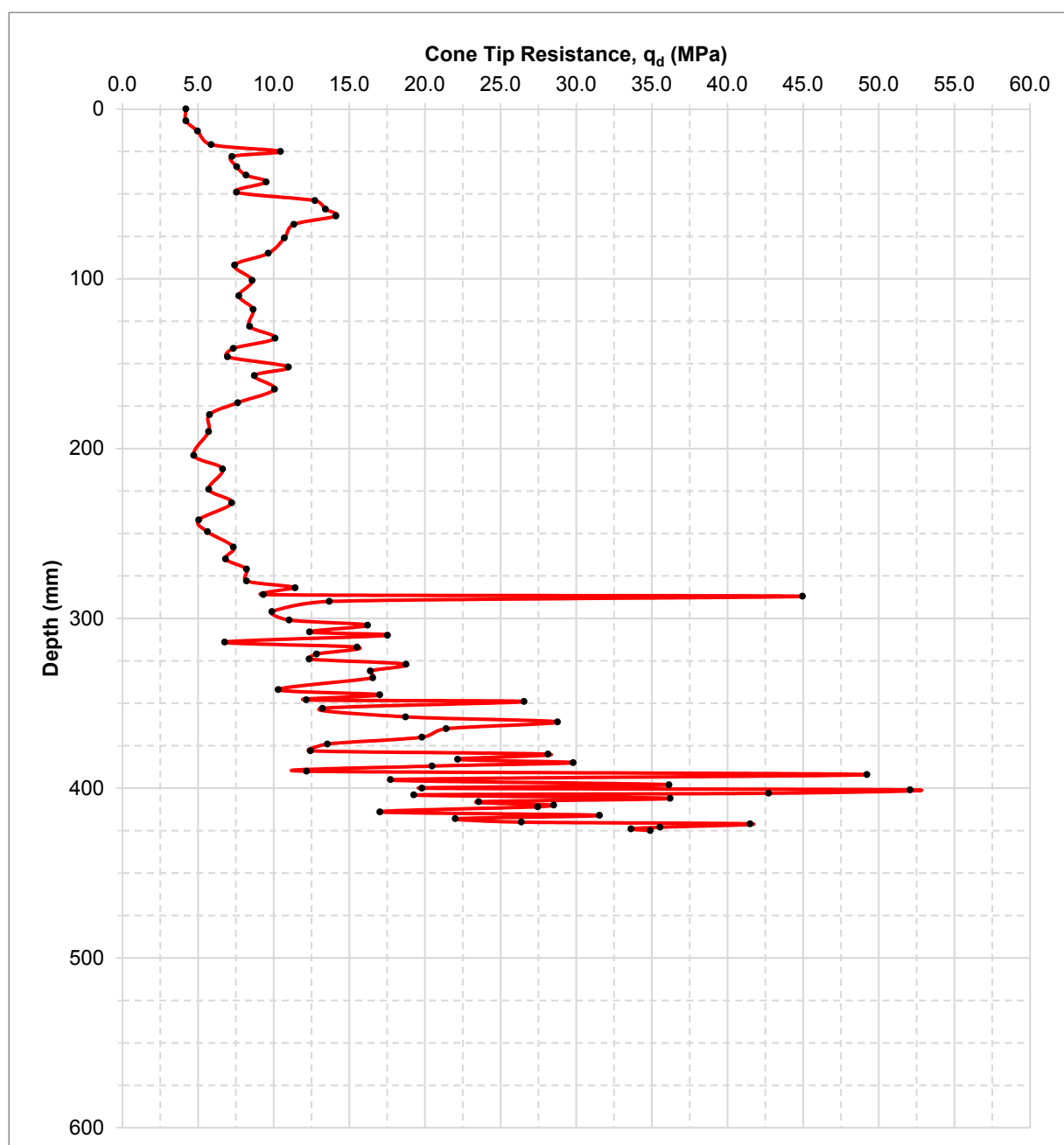
Project No.: 2091

Checked By: DWL

Location: Site 27-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 27-3

Certificate Reference:

2091-PND-Site 27-3

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 27-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	3.40	41	3	15.55			
2	5	8.97	42	4	14.51			
3	7	6.32	43	3	14.36			
4	3	9.69	44	4	17.67			
5	3	8.30	45	2	34.33			
6	6	6.13	46	1	40.25			
7	4	11.25	47	1	36.26			
8	6	7.32	48	2	28.24			
9	3	15.90	49	2	29.75			
10	4	6.01	50	2	32.59			
11	4	9.45	51	2	32.44			
12	4	11.42	52	3	33.49			
13	4	11.07	53	1	46.13			
14	3	12.48	54	1	64.02			
15	6	9.28	55	1	54.11			
16	4	11.93	End of Test Record					
17	3	12.36						
18	8	7.90						
19	4	10.02						
20	5	11.79						
21	4	11.35						
22	5	12.23						
23	4	13.69						
24	2	31.21						
25	2	22.60						
26	2	28.47						
27	2	18.07						
28	3	14.83						
29	2	19.37						
30	1	28.51						
31	3	9.91						
32	3	22.51						
33	2	29.29						
34	2	17.13						
35	3	21.26						
36	2	20.77						
37	3	19.05						
38	5	14.01						
39	2	17.48						
40	4	12.34						

PANDA Probe - Test Report

Site 27-3

Certificate Reference:

2091-PND-Site 27-3

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

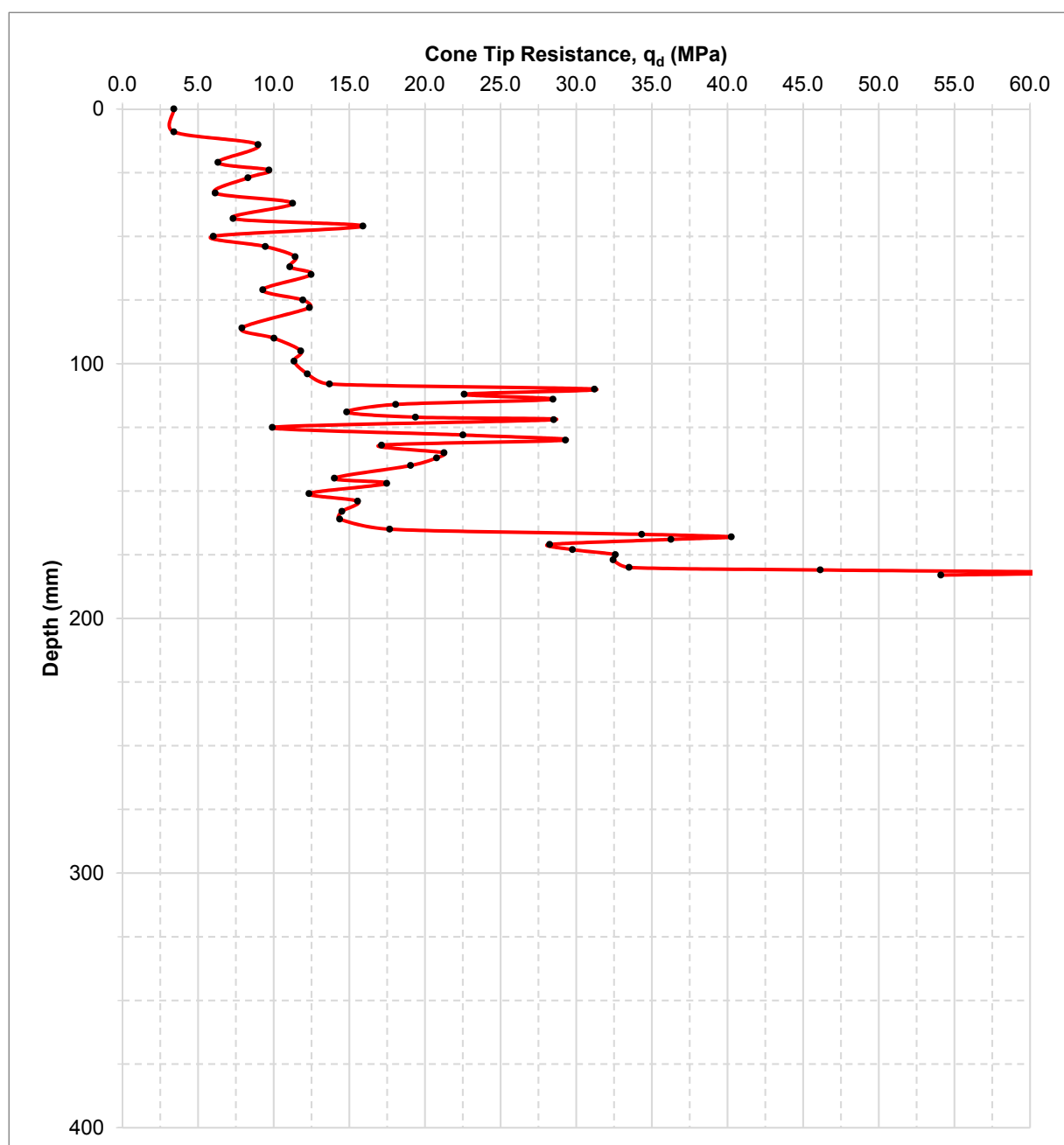
Project No.: 2091

Checked By: DWL

Location: Site 27-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 27-3A

Certificate Reference:

2091-PND-Site 27-3A

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 27-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	4.06	41	8	5.60	81	2	38.51
2	8	3.90	42	6	5.97	82	1	38.54
3	6	6.25	43	8	5.81	83	2	37.35
4	5	7.65	44	8	5.43	84	3	37.50
5	6	8.54	45	8	6.89	85	1	38.58
6	5	6.16	46	6	5.83	86	2	52.35
7	4	11.02	47	10	6.61	End of Test Record		
8	4	9.51	48	7	6.55			
9	5	9.15	49	7	5.90			
10	2	20.00	50	8	6.90			
11	6	8.38	51	7	7.29			
12	4	10.27	52	7	9.03			
13	5	4.12	53	5	10.63			
14	6	7.68	54	6	9.88			
15	6	6.79	55	4	10.73			
16	5	6.56	56	4	12.92			
17	5	8.58	57	3	16.52			
18	7	7.50	58	3	14.13			
19	6	7.23	59	2	31.34			
20	6	6.16	60	2	24.11			
21	3	12.26	61	2	18.95			
22	7	5.46	62	3	19.18			
23	7	8.29	63	3	23.65			
24	8	8.02	64	2	18.25			
25	6	6.72	65	3	17.81			
26	4	9.06	66	2	27.47			
27	6	9.43	67	3	22.72			
28	4	9.08	68	3	18.25			
29	15	3.90	69	2	31.55			
30	6	12.24	70	2	18.77			
31	4	10.98	71	3	24.69			
32	5	10.40	72	1	25.77			
33	5	10.71	73	3	29.11			
34	4	10.09	74	1	27.40			
35	5	11.42	75	2	22.91			
36	5	10.05	76	2	33.90			
37	6	9.57	77	2	29.90			
38	6	9.45	78	1	49.55			
39	6	7.07	79	3	22.46			
40	5	7.86	80	1	40.83			

PANDA Probe - Test Report

Site 27-3A

Certificate Reference:

2091-PND-Site 27-3A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

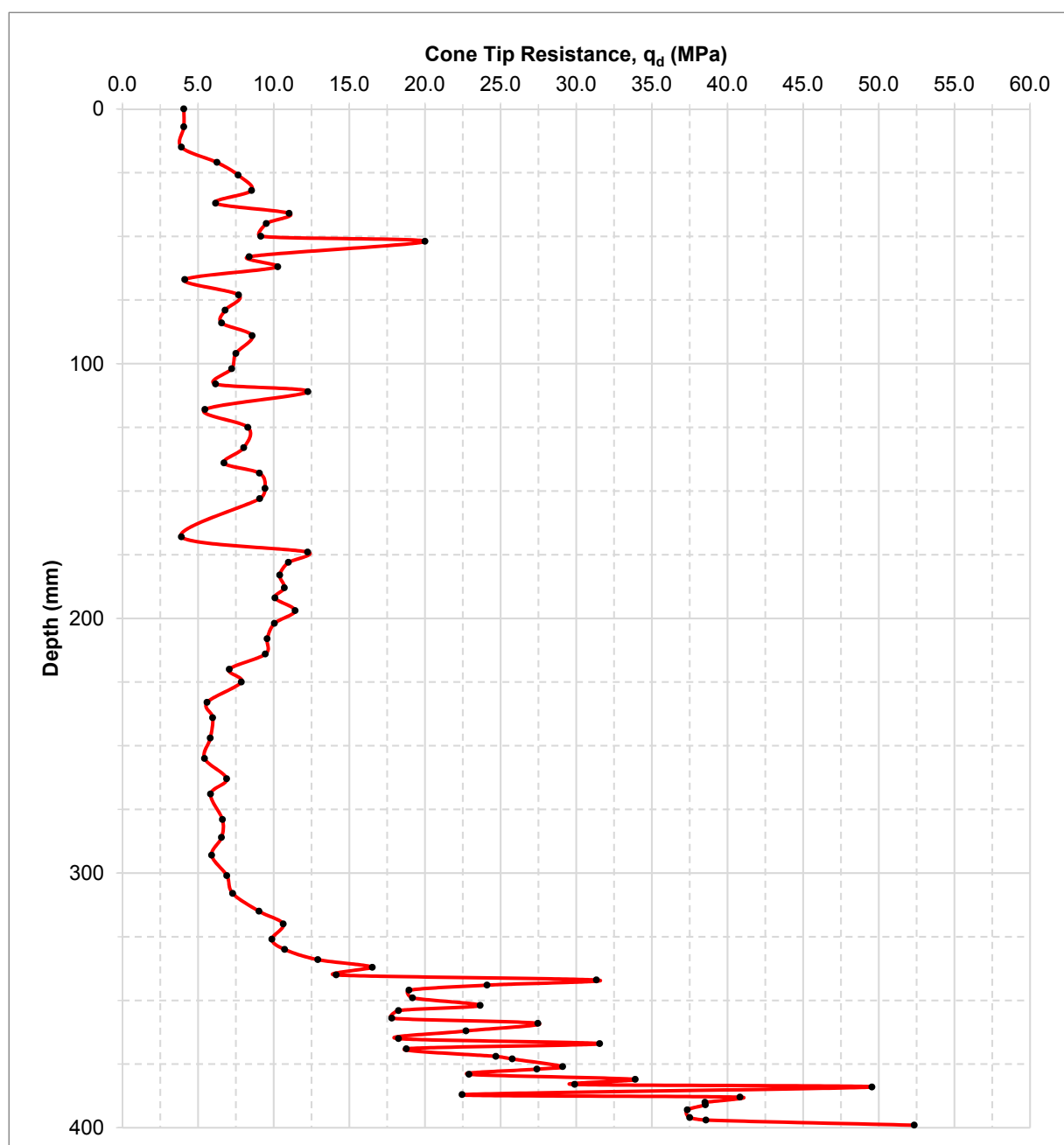
Project No.: 2091

Checked By: DWL

Location: Site 27-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 27-4

Certificate Reference:

2091-PND-Site 27-4

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 27-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	4.37	41	4	11.82	81	2	21.41
2	8	3.83	42	5	16.99	82	4	18.56
3	6	4.14	43	4	14.18	83	3	21.01
4	8	4.61	44	4	17.77	84	2	22.84
5	8	2.76	45	3	19.03	85	3	22.28
6	8	4.25	46	2	17.30	86	2	24.89
7	8	4.34	47	3	18.84	87	3	27.67
8	4	6.65	48	4	20.66	88	2	29.64
9	5	10.45	49	4	22.07	89	2	25.45
10	2	21.81	50	4	15.45	90	2	40.49
11	2	20.38	51	4	12.66	91	1	57.73
12	2	19.76	52	5	12.96	92	1	47.82
13	4	13.60	53	4	12.70	93	2	47.80
14	2	20.02	54	5	10.62	94	1	53.85
15	1	39.86	55	6	10.75	95	2	48.77
16	2	22.48	56	4	11.94	96	1	70.42
17	1	28.01	57	4	16.45	End of Test Record		
18	2	27.86	58	4	16.62			
19	2	22.15	59	5	15.31			
20	3	15.10	60	5	12.13			
21	2	18.21	61	4	19.62			
22	4	10.27	62	2	25.04			
23	6	7.53	63	2	14.83			
24	7	5.69	64	2	16.07			
25	6	6.03	65	3	17.26			
26	5	8.61	66	3	19.32			
27	5	8.19	67	2	19.02			
28	5	8.90	68	2	18.42			
29	4	15.52	69	2	22.94			
30	3	18.72	70	2	18.33			
31	3	16.91	71	3	23.18			
32	1	27.82	72	1	39.15			
33	3	23.07	73	2	23.71			
34	3	18.90	74	3	24.59			
35	3	15.50	75	1	25.05			
36	4	15.98	76	2	24.26			
37	4	14.96	77	3	21.49			
38	5	11.49	78	3	24.57			
39	3	12.35	79	3	17.10			
40	5	13.25	80	3	22.48			

PANDA Probe - Test Report

Site 27-4

Certificate Reference:

2091-PND-Site 27-4

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

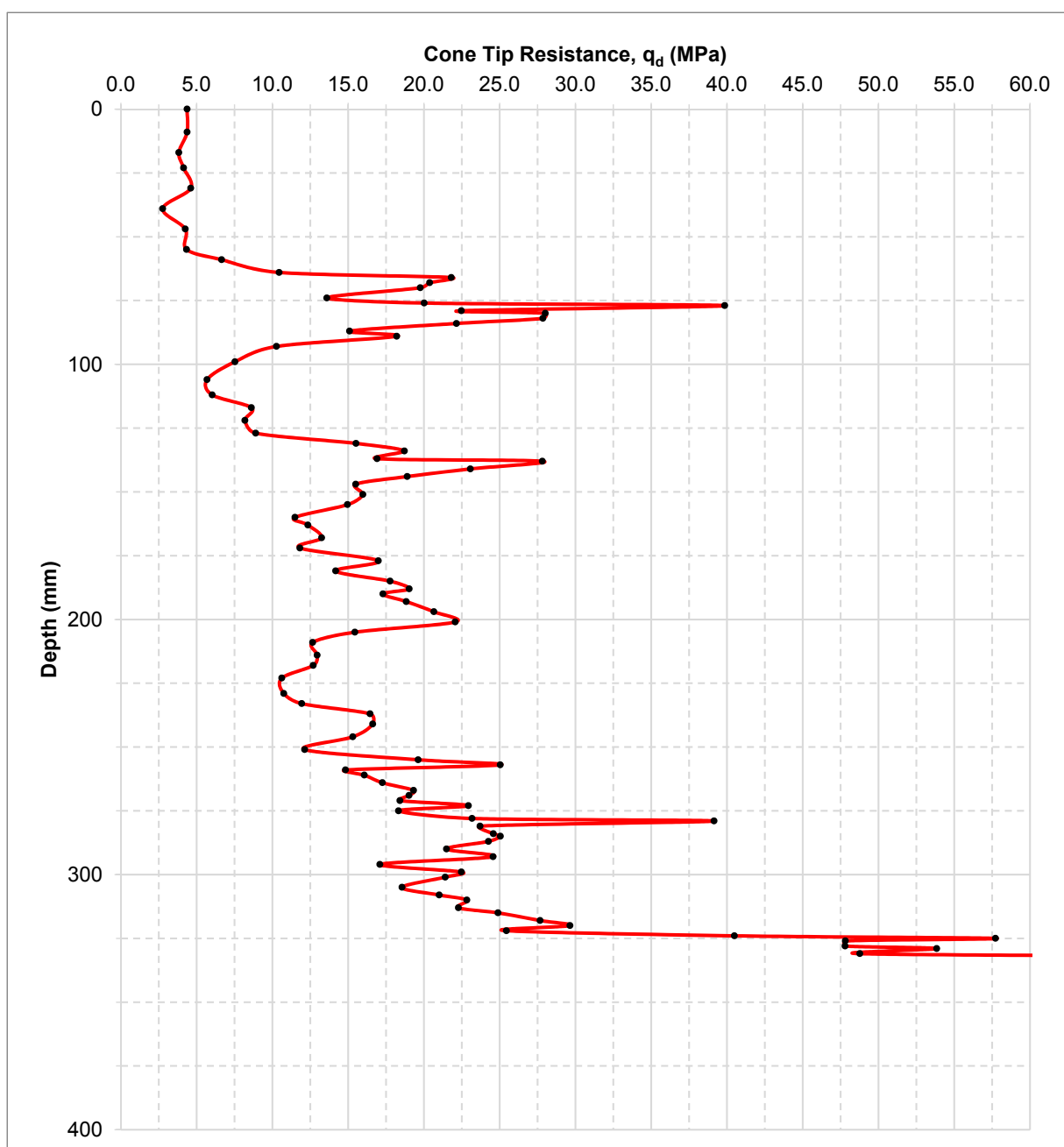
Project No.: 2091

Checked By: DWL

Location: Site 27-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 27-4A

Certificate Reference:

2091-PND-Site 27-4A

Sheet:

1 of 3

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 27-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	5.06	41	3	20.59	81	2	24.02
2	6	4.51	42	2	27.45	82	3	24.92
3	6	5.83	43	3	17.93	83	2	29.59
4	5	6.54	44	3	19.10	84	2	23.60
5	5	7.20	45	4	19.58	85	3	19.41
6	5	9.44	46	3	15.98	86	3	19.12
7	6	9.23	47	4	15.31	87	2	29.00
8	7	6.27	48	5	12.92	88	2	28.49
9	6	10.47	49	4	17.51	89	2	22.74
10	7	7.36	50	4	12.73	90	2	29.11
11	5	11.52	51	3	19.22	91	2	28.53
12	7	8.38	52	4	14.64	92	2	30.41
13	7	7.55	53	4	17.67	93	2	31.58
14	4	11.88	54	3	14.65	94	2	24.71
15	6	12.89	55	3	15.84	95	2	21.55
16	4	11.85	56	4	15.04	96	2	23.97
17	3	12.56	57	3	16.64	97	2	32.13
18	5	12.76	58	4	10.36	98	3	28.19
19	4	11.66	59	3	16.48	99	2	28.81
20	4	14.34	60	4	11.46	100	2	28.06
21	4	12.13	61	4	13.90	101	3	33.38
22	2	13.27	62	4	15.94	102	2	29.69
23	3	15.16	63	3	20.62	103	3	34.20
24	5	14.05	64	3	16.52	104	1	42.12
25	2	11.58	65	2	25.20	105	1	27.06
26	4	16.04	66	3	22.16	106	3	24.10
27	3	14.97	67	3	22.38	107	2	38.32
28	3	14.19	68	2	27.69	108	3	28.06
29	3	12.33	69	3	19.87	109	2	35.57
30	3	19.93	70	5	14.43	110	1	38.83
31	4	14.62	71	4	23.20	111	2	36.52
32	3	15.46	72	3	23.57	112	2	28.81
33	4	17.97	73	2	24.18	113	3	30.12
34	3	16.33	74	3	17.84	114	1	26.70
35	2	14.34	75	3	20.78	115	1	44.94
36	3	24.97	76	2	22.63	116	3	26.41
37	2	17.98	77	3	25.30	117	2	36.86
38	3	20.89	78	2	23.24	118	3	28.68
39	3	23.99	79	3	18.20	119	1	37.14
40	3	21.32	80	3	17.46	120	1	46.48

[illegible]

PANDA Probe - Test Report

Site 27-4A

Certificate Reference:

2091-PND-Site 27-4A

Sheet:

3 of 3

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

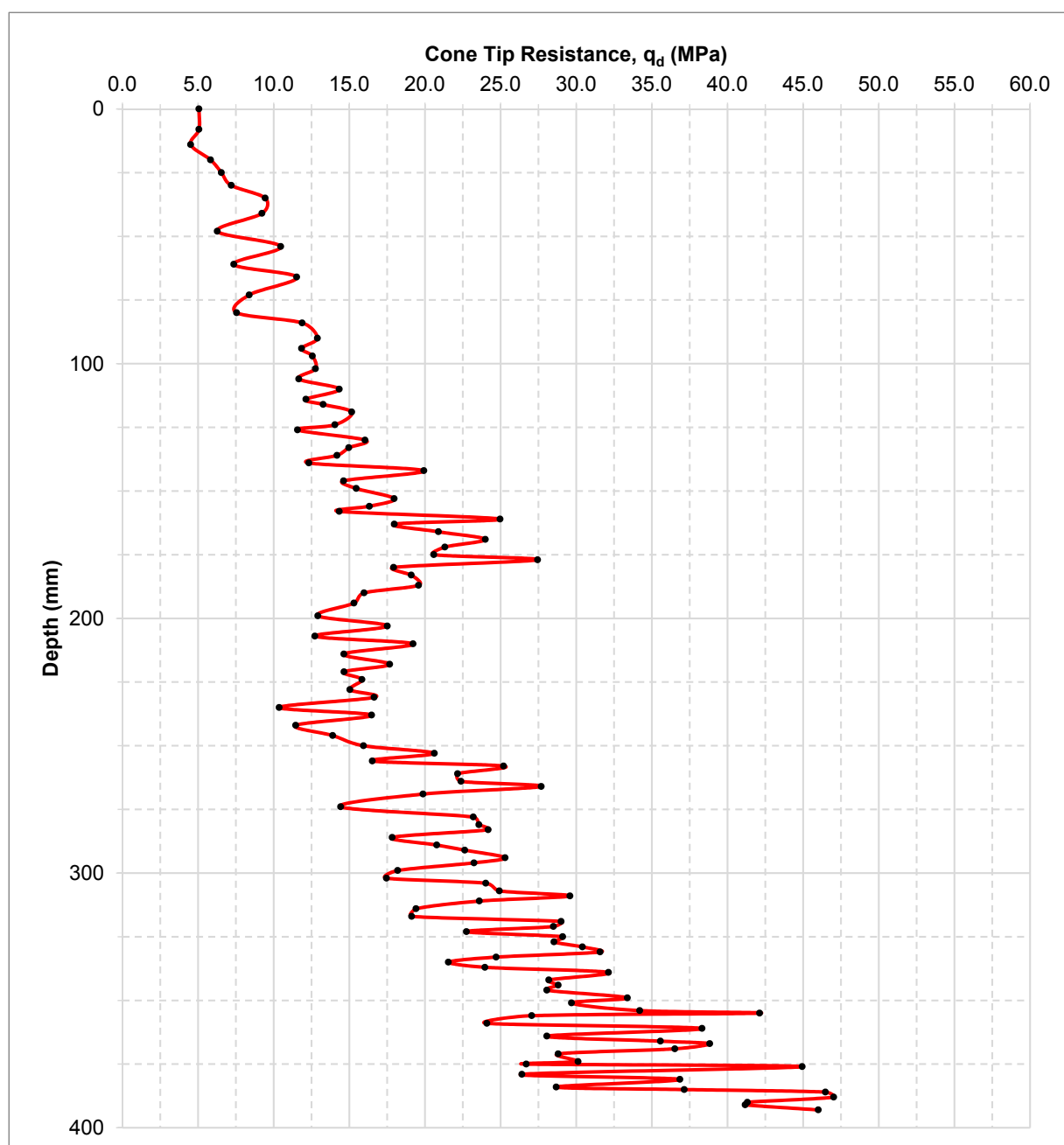
Project No.: 2091

Checked By: DWL

Location: Site 27-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 27-5

Certificate Reference:

2091-PND-Site 27-5

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 27-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	5.46	41	4	22.33	81	1	26.98
2	6	7.40	42	2	18.57	82	2	22.94
3	4	7.66	43	3	22.17	83	3	22.36
4	5	6.90	44	3	15.87	84	2	21.66
5	5	7.94	45	3	17.85	85	3	18.72
6	4	10.93	46	3	20.98	86	3	21.35
7	3	12.87	47	3	20.20	87	2	20.48
8	2	16.99	48	3	23.76	88	2	23.86
9	4	9.64	49	4	19.71	89	3	15.95
10	2	17.43	50	4	20.34	90	2	22.27
11	4	11.35	51	3	22.35	91	2	22.15
12	2	12.68	52	4	18.24	92	2	24.29
13	3	20.37	53	3	19.60	93	2	24.17
14	2	24.58	54	4	19.42	94	2	29.27
15	3	14.05	55	3	22.42	95	3	18.19
16	2	20.88	56	3	22.08	96	2	25.68
17	2	18.38	57	4	19.70	97	1	40.96
18	2	26.04	58	4	24.62	98	2	39.46
19	2	13.20	59	3	20.51	99	1	51.96
20	2	26.96	60	3	22.94	100	2	63.94
21	2	22.50	61	2	27.38	End of Test Record		
22	2	21.03	62	3	24.10			
23	3	20.86	63	3	24.09			
24	2	23.25	64	1	25.20			
25	2	20.70	65	2	28.02			
26	3	20.33	66	1	38.17			
27	3	22.69	67	2	39.86			
28	4	13.68	68	2	30.82			
29	4	15.67	69	3	31.95			
30	3	17.87	70	2	29.17			
31	3	22.35	71	2	31.83			
32	2	18.43	72	3	19.33			
33	3	23.73	73	2	27.14			
34	2	15.95	74	3	25.57			
35	2	13.99	75	2	24.93			
36	4	17.07	76	3	27.26			
37	2	18.12	77	2	26.51			
38	3	24.00	78	2	28.72			
39	3	20.46	79	2	21.21			
40	3	18.64	80	2	58.72			

PANDA Probe - Test Report

Site 27-5

Certificate Reference:

2091-PND-Site 27-5

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

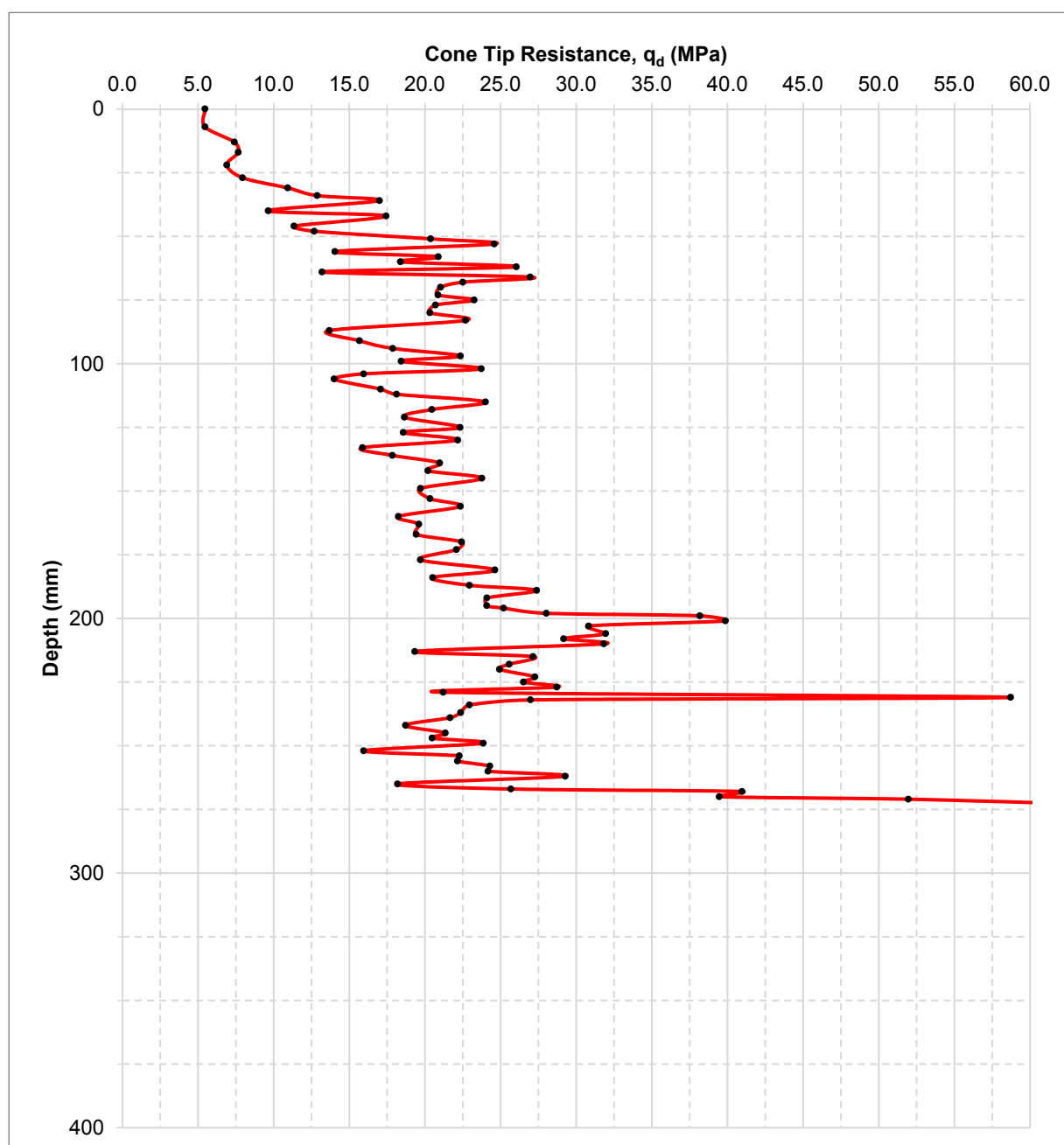
Project No.: 2091

Checked By: DWL

Location: Site 27-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 27-5A

Certificate Reference:

2091-PND-Site 27-5A

Sheet:

1 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 27-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	4.57	41	1	34.97			
2	5	5.98	42	2	38.95			
3	4	4.29	43	1	36.81			
4	4	7.24	End of Test Record					
5	5	7.96						
6	5	7.18						
7	4	6.10						
8	4	10.39						
9	2	13.04						
10	2	17.66						
11	2	14.59						
12	3	13.46						
13	1	27.13						
14	3	19.03						
15	3	13.48						
16	3	14.30						
17	2	14.63						
18	3	18.31						
19	3	15.06						
20	3	19.23						
21	2	24.51						
22	2	21.45						
23	2	26.78						
24	2	17.91						
25	2	33.89						
26	2	17.66						
27	3	19.35						
28	2	11.76						
29	3	16.44						
30	2	22.60						
31	2	13.17						
32	3	15.70						
33	3	15.00						
34	3	17.20						
35	2	19.00						
36	3	15.90						
37	1	35.64						
38	3	32.61						
39	2	46.15						
40	2	49.60						

PANDA Probe - Test Report

Site 27-5A

Certificate Reference:

2091-PND-Site 27-5A

Sheet:

2 of 2

Client: ARRB

Test Date: 6/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

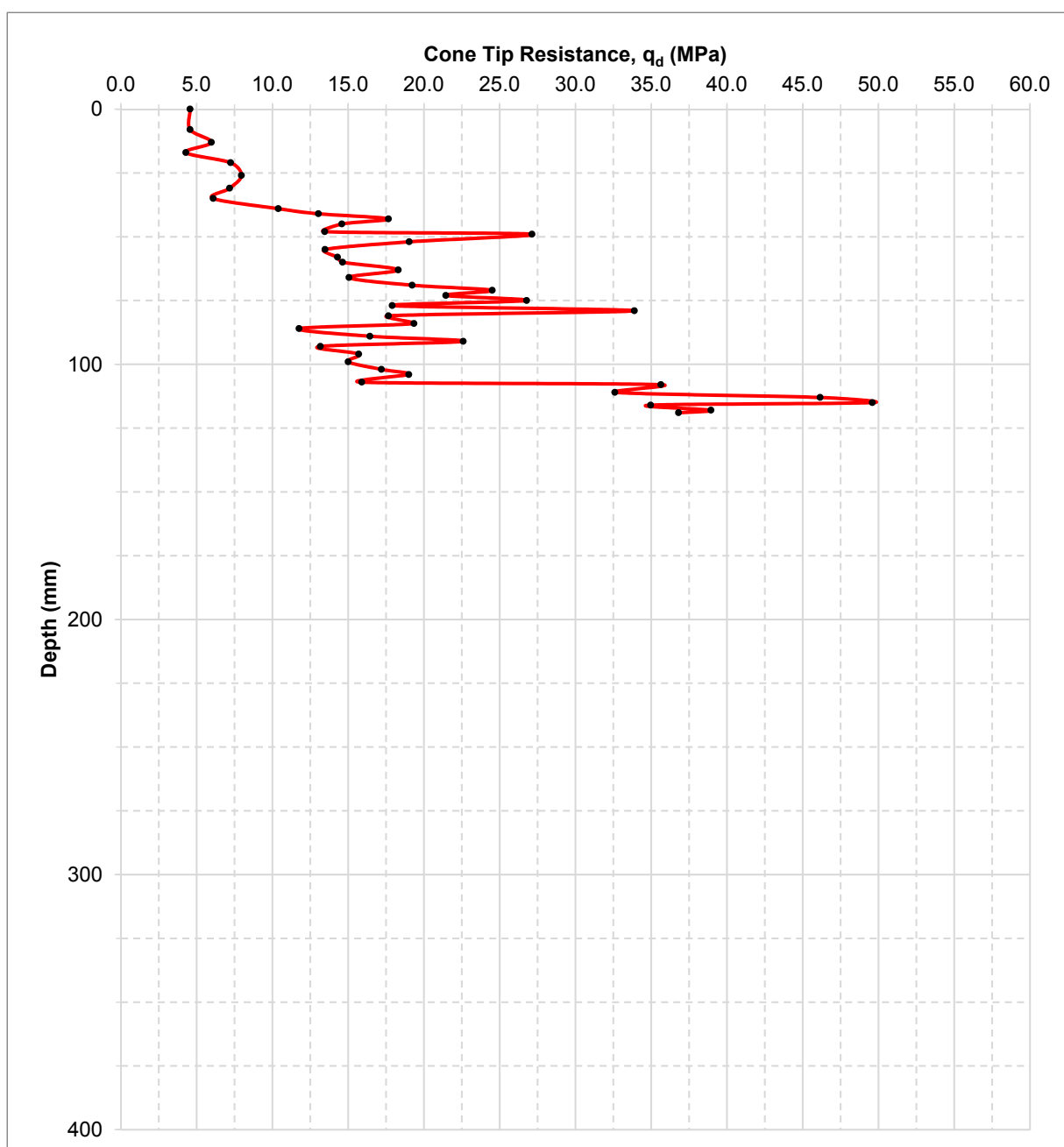
Project No.: 2091

Checked By: DWL

Location: Site 27-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 28-1

Certificate Reference:

2091-PND-Site 28-1

Sheet:

1 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 28-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	1.04	41	3	13.86	81	2	11.79
2	8	3.84	42	4	10.97	82	3	9.78
3	11	2.78	43	4	12.59	83	2	21.09
4	9	3.96	44	3	15.89	84	1	14.02
5	9	4.18	45	4	14.94	85	3	11.45
6	10	3.90	46	3	11.40	86	4	16.99
7	9	5.07	47	2	20.02	87	2	14.26
8	9	4.27	48	4	6.94	88	2	18.05
9	13	3.11	49	4	18.60	89	5	10.56
10	11	3.12	50	2	17.80	90	4	13.54
11	13	3.34	51	3	13.29	91	3	13.11
12	8	4.93	52	2	12.14	92	2	8.64
13	5	6.42	53	5	15.09	93	3	11.77
14	3	14.02	54	3	22.23	94	3	17.64
15	3	18.72	55	2	19.49	95	3	6.69
16	4	14.90	56	2	14.13	96	3	14.86
17	8	6.89	57	2	14.90	97	3	12.89
18	5	6.70	58	2	14.52	98	2	10.38
19	9	6.62	59	1	20.37	99	3	10.72
20	8	7.66	60	2	14.26	100	3	15.91
21	7	7.02	61	2	13.08	101	4	10.50
22	8	7.04	62	3	18.37	102	2	12.60
23	7	4.93	63	2	19.57	103	2	20.96
24	7	9.24	64	4	16.88	104	2	18.99
25	4	10.24	65	3	20.22	105	3	15.64
26	4	10.78	66	2	22.91	106	3	19.57
27	3	10.02	67	3	16.81	107	2	19.27
28	5	11.40	68	1	18.86	108	3	20.38
29	5	10.67	69	3	20.94	109	3	14.34
30	3	11.52	70	2	19.57	110	5	9.31
31	6	12.03	71	2	18.38	111	5	8.84
32	5	10.26	72	4	15.39	112	8	7.32
33	5	12.36	73	3	17.20	113	8	7.85
34	4	12.59	74	2	19.51	114	8	8.12
35	5	9.61	75	2	15.98	115	8	6.45
36	3	12.79	76	2	20.28	116	5	6.17
37	5	12.50	77	3	20.38	117	5	4.62
38	4	9.71	78	2	16.48	118	6	8.11
39	5	16.36	79	2	18.10	119	4	6.47
40	4	12.67	80	2	16.78	120	8	5.82

[illegible]

Certificate Reference:

2091-PND-Site 28-1

Sheet:

3 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

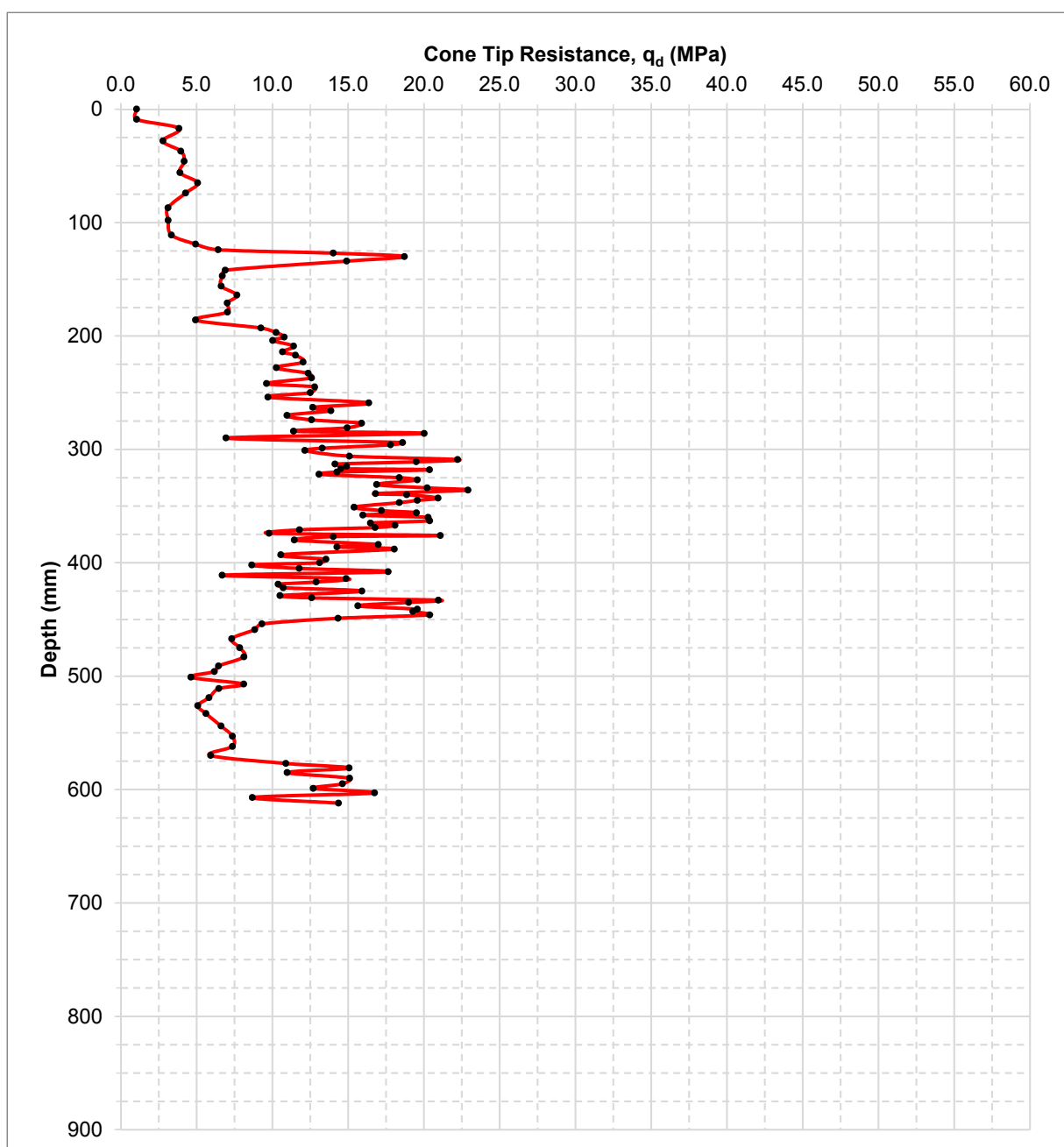
Project No.: 2091

Checked By: DWL

Location: Site 28-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 28-2

Certificate Reference:

2091-PND-Site 28-2

Sheet:

1 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 28-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	10	2.18	41	1	11.51	81	2	14.88
2	6	4.29	42	2	20.14	82	2	9.18
3	7	4.36	43	2	15.10	83	1	10.80
4	5	7.32	44	3	14.11	84	2	9.95
5	4	10.35	45	3	19.95	85	3	14.47
6	4	9.21	46	2	16.37	86	2	9.93
7	4	6.32	47	4	16.32	87	3	10.38
8	5	8.64	48	3	13.14	88	3	13.49
9	3	3.86	49	3	10.41	89	4	9.57
10	3	6.69	50	3	13.26	90	3	20.97
11	2	9.67	51	5	12.74	91	1	19.76
12	4	7.92	52	2	23.69	92	2	15.97
13	3	8.11	53	3	15.85	93	3	25.37
14	2	9.04	54	2	15.30	94	2	18.90
15	3	7.40	55	4	11.66	95	3	12.84
16	3	13.66	56	3	14.45	96	1	37.34
17	2	11.04	57	3	10.78	97	2	23.78
18	3	13.96	58	4	9.74	98	3	15.33
19	3	10.87	59	2	15.76	99	1	16.96
20	3	13.92	60	3	8.38	100	1	26.98
21	4	21.17	61	4	14.77	101	4	23.22
22	3	16.41	62	3	13.73	102	2	19.00
23	3	16.85	63	4	10.38	103	3	11.51
24	4	13.29	64	2	9.77	104	2	15.99
25	3	16.22	65	3	13.81	105	2	12.94
26	3	11.67	66	3	12.96	106	2	13.58
27	3	8.22	67	4	7.54	107	2	10.21
28	4	15.07	68	3	8.06	108	2	14.64
29	1	13.35	69	3	9.34	109	2	14.94
30	3	19.32	70	2	12.78	110	2	13.33
31	2	24.96	71	2	15.08	111	2	16.14
32	3	23.75	72	4	10.75	112	3	15.40
33	4	18.51	73	2	5.28	113	3	14.04
34	2	18.86	74	3	12.72	114	2	11.38
35	1	17.84	75	2	12.80	115	3	14.75
36	2	30.61	76	3	13.38	116	3	13.50
37	1	17.69	77	2	13.93	117	3	14.29
38	2	18.64	78	2	10.39	118	3	9.49
39	3	13.92	79	2	12.50	119	2	10.12
40	1	18.66	80	3	14.36	120	3	12.37

PANDA Probe - Test Report

Site 28-2

Certificate Reference:

2091-PND-Site 28-2

Sheet:

2 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 28-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
121	2	16.99	161	2	22.82	201	3	25.92
122	2	11.50	162	2	19.31	202	3	31.98
123	2	15.23	163	2	14.16	203	2	31.96
124	2	11.54	164	2	15.81	204	2	26.41
125	2	14.49	165	2	15.65	205	1	40.04
126	2	16.42	166	2	15.26	206	1	36.29
127	1	18.34	167	2	27.24	207	1	29.19
128	1	22.01	168	3	17.43	208	3	50.44
129	3	19.34	169	3	13.63	209	1	40.14
130	2	14.83	170	1	24.18	210	1	43.76
131	2	18.18	171	3	17.97	211	2	61.75
132	2	13.20	172	2	19.87	212	2	37.86
133	1	31.28	173	1	25.51	213	3	27.49
134	2	13.85	174	2	18.95	214	3	34.13
135	3	20.88	175	1	17.25	215	2	27.91
136	2	22.84	176	2	17.94	216	1	37.54
137	2	20.76	177	2	20.54	217	3	33.56
138	3	14.37	178	1	26.99	218	1	38.95
139	2	16.78	179	1	28.68	219	1	38.45
140	2	16.67	180	3	21.89	220	2	37.39
141	4	10.37	181	2	24.59	221	2	26.86
142	2	13.00	182	1	28.41	222	2	24.96
143	1	13.33	183	1	19.86	223	4	42.98
144	2	16.31	184	2	23.27	End of Test Record		
145	2	14.40	185	1	31.79			
146	2	16.09	186	2	22.24			
147	2	15.40	187	1	27.24			
148	2	18.21	188	4	24.69			
149	2	18.63	189	2	32.69			
150	2	14.45	190	2	35.52			
151	3	13.25	191	2	30.80			
152	3	15.61	192	2	27.93			
153	3	15.51	193	1	27.49			
154	1	30.37	194	2	29.70			
155	2	17.05	195	1	26.57			
156	2	16.62	196	2	27.16			
157	3	9.88	197	1	39.28			
158	2	18.48	198	2	27.07			
159	3	21.10	199	2	26.93			
160	3	21.79	200	2	23.25			

Certificate Reference:

2091-PND-Site 28-2

Sheet:

3 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

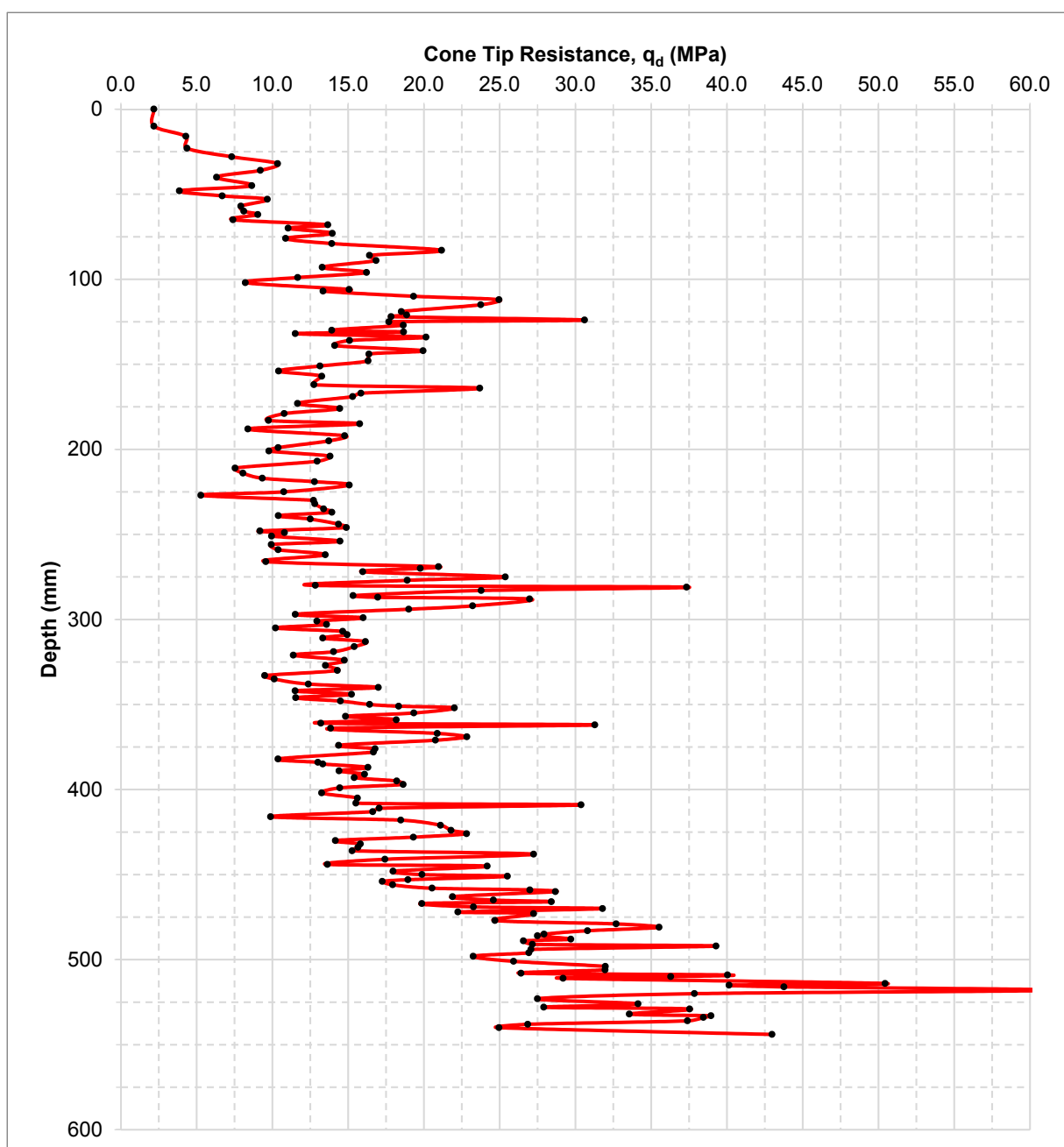
Project No.: 2091

Checked By: DWL

Location: Site 28-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 28-3

Certificate Reference:

2091-PND-Site 28-3

Sheet:

1 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 28-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	9	3.68	41	2	34.15	81	3	23.35
2	7	5.24	42	1	29.46	82	2	14.29
3	7	5.12	43	3	29.62	83	3	16.11
4	7	7.16	44	3	19.30	84	2	19.56
5	7	9.36	45	1	52.01	85	2	20.71
6	6	9.89	46	2	42.65	86	2	17.22
7	6	10.93	47	2	22.92	87	3	15.47
8	6	10.03	48	2	29.99	88	2	14.21
9	3	6.50	49	2	33.83	89	4	17.59
10	6	10.79	50	2	28.81	90	3	14.43
11	5	14.23	51	1	36.36	91	4	14.50
12	5	11.94	52	2	28.75	92	3	16.30
13	5	15.70	53	1	29.62	93	4	14.40
14	3	16.26	54	2	26.87	94	4	14.99
15	3	4.81	55	2	40.03	95	4	13.77
16	3	11.66	56	2	23.41	96	3	14.16
17	4	8.41	57	3	24.65	97	5	11.80
18	3	19.94	58	2	29.34	98	5	10.61
19	1	56.40	59	2	27.18	99	6	12.13
20	3	15.12	60	2	37.34	100	5	12.23
21	2	21.76	61	2	26.64	101	6	12.75
22	2	18.95	62	2	30.95	102	5	13.62
23	1	33.32	63	2	31.15	103	5	15.71
24	2	33.27	64	1	46.58	104	4	12.53
25	2	26.64	65	2	33.86	105	6	8.12
26	2	26.74	66	2	33.61	106	5	11.56
27	2	30.10	67	2	28.53	107	4	11.71
28	2	33.70	68	2	30.62	108	5	12.03
29	2	28.47	69	3	26.19	109	3	15.87
30	1	22.42	70	2	21.98	110	3	14.83
31	3	24.74	71	2	28.39	111	3	13.00
32	1	40.40	72	3	26.98	112	2	15.13
33	2	28.77	73	3	24.14	113	3	14.55
34	3	21.55	74	2	24.25	114	3	14.80
35	2	25.89	75	1	19.28	115	3	14.37
36	1	23.04	76	3	21.16	116	4	17.24
37	2	27.67	77	1	21.49	117	3	14.44
38	1	32.33	78	3	23.96	118	4	10.56
39	2	28.39	79	3	20.92	119	4	11.05
40	1	24.27	80	2	16.08	120	3	15.51

[illegible]

PANDA Probe - Test Report

Site 28-3

Certificate Reference:

2091-PND-Site 28-3

Sheet:

3 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

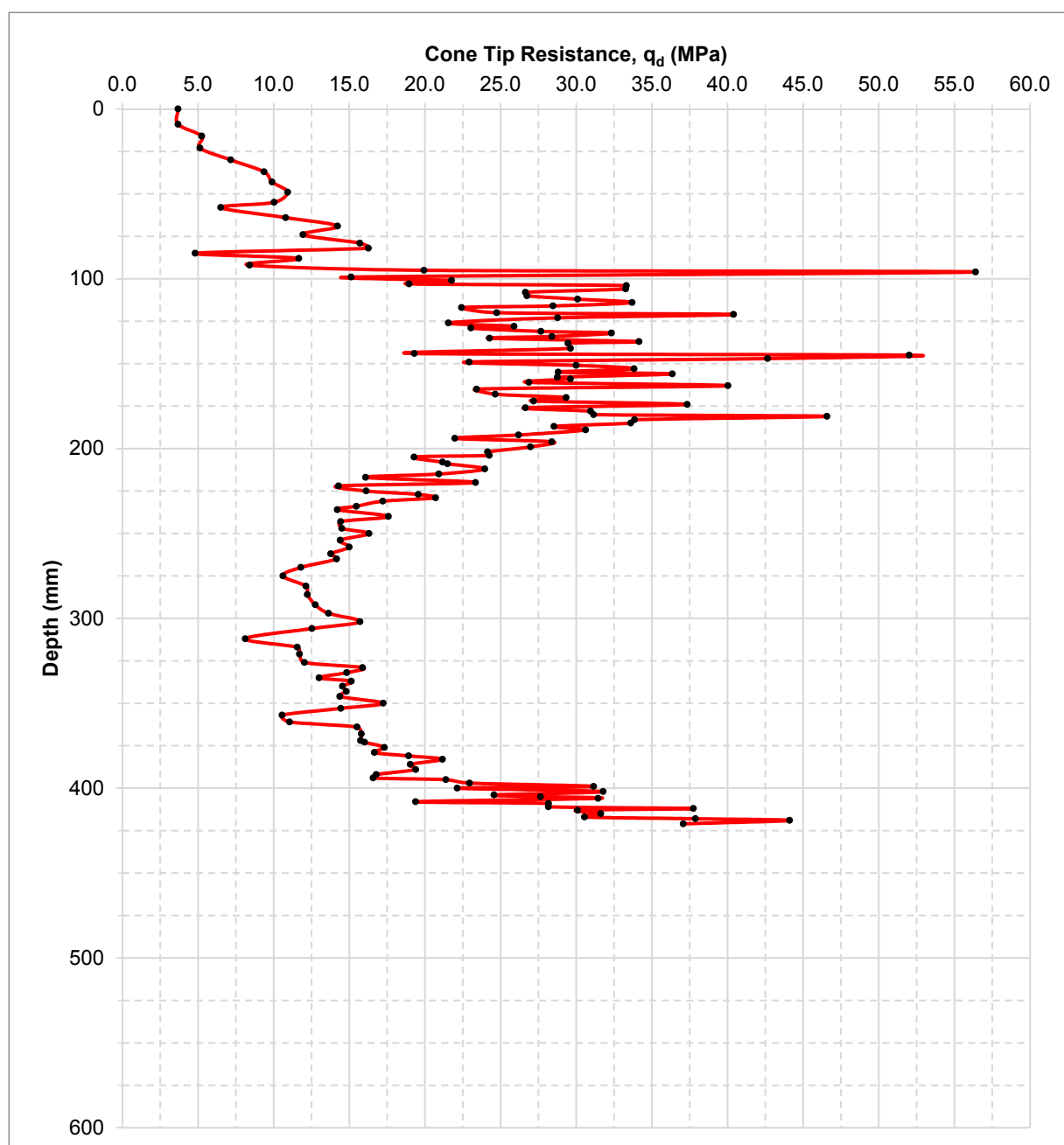
Project No.: 2091

Checked By: DWL

Location: Site 28-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 28-4

Certificate Reference:

2091-PND-Site 28-4

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 28-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	2.51	41	3	18.75			
2	6	4.89	42	3	15.94			
3	4	6.48	43	3	17.66			
4	6	6.28	44	2	23.67			
5	6	6.53	45	1	16.20			
6	7	6.76	46	2	14.30			
7	7	5.17	47	3	18.34			
8	8	6.40	48	1	20.72			
9	6	6.52	49	3	16.21			
10	6	4.86	50	2	18.31			
11	7	6.06	51	2	16.71			
12	5	5.45	52	2	24.73			
13	6	5.58	53	1	29.69			
14	5	7.36	54	5	30.43			
15	4	8.93	55	1	37.17			
16	3	11.31	56	1	40.86			
17	4	11.58	57	1	36.18			
18	4	11.39	58	2	39.09			
19	3	11.63	59	3	33.28			
20	5	8.46	End of Test Record					
21	5	6.74						
22	5	8.16						
23	4	9.24						
24	3	10.71						
25	3	9.77						
26	2	13.16						
27	3	15.17						
28	1	16.33						
29	3	14.19						
30	2	21.30						
31	2	18.79						
32	2	21.82						
33	2	15.75						
34	2	16.48						
35	2	15.45						
36	2	17.73						
37	4	12.66						
38	2	16.67						
39	3	16.64						
40	2	20.59						

PANDA Probe - Test Report

Site 28-4

Certificate Reference:

2091-PND-Site 28-4

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

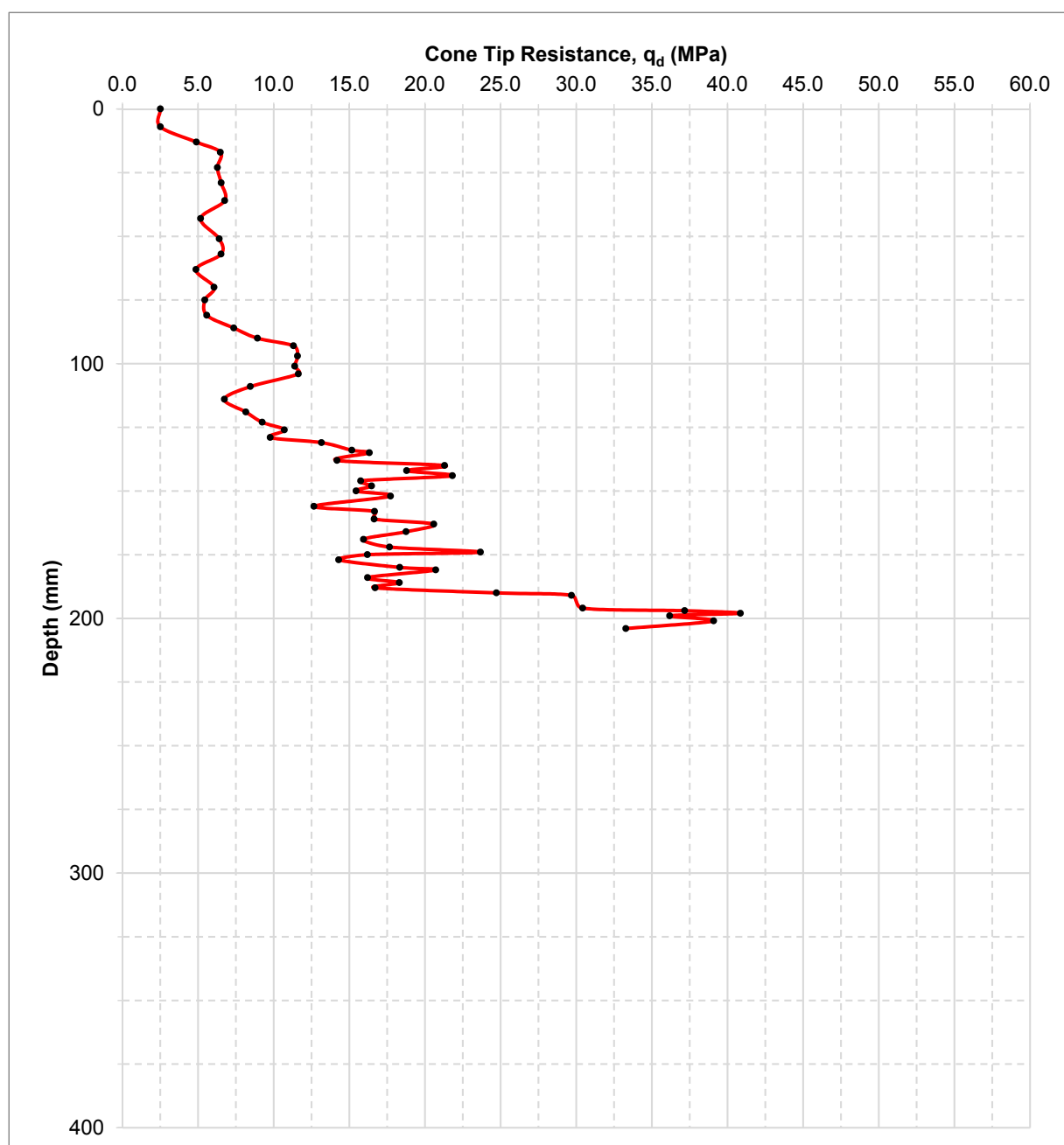
Project No.: 2091

Checked By: DWL

Location: Site 28-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 28-4A

Certificate Reference:

2091-PND-Site 28-4A

Sheet:

1 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 28-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.73	41	4	15.06	81	3	22.55
2	9	4.31	42	5	11.56	82	2	24.77
3	6	4.43	43	6	12.41	83	3	25.08
4	11	4.45	44	5	11.50	84	2	24.25
5	9	7.22	45	4	12.47	85	2	30.96
6	8	6.45	46	5	13.83	86	2	21.66
7	7	7.90	47	4	16.21	87	2	21.65
8	6	7.85	48	3	14.52	88	1	30.05
9	5	7.57	49	3	14.91	89	3	26.72
10	6	9.94	50	3	12.98	90	1	27.03
11	4	8.83	51	4	16.35	91	3	25.73
12	4	14.92	52	4	11.49	92	1	35.21
13	3	17.76	53	3	14.57	93	3	22.00
14	4	12.01	54	3	17.14	94	2	30.26
15	4	17.36	55	3	19.68	95	2	23.97
16	2	13.90	56	3	21.16	96	2	27.05
17	2	20.51	57	3	22.79	97	2	27.58
18	2	24.58	58	2	26.95	98	2	32.62
19	2	36.19	59	4	15.02	99	1	31.46
20	1	26.44	60	3	20.56	100	2	22.70
21	2	26.83	61	2	21.83	101	2	25.07
22	2	22.34	62	3	25.60	102	2	29.22
23	2	27.86	63	2	20.18	103	2	42.21
24	2	17.40	64	2	16.69	104	1	28.87
25	2	27.56	65	3	16.29	105	2	26.40
26	2	33.70	66	2	22.96	106	1	43.57
27	1	28.47	67	3	22.94	107	1	47.94
28	1	41.48	68	1	24.17	108	2	29.12
29	2	48.47	69	3	26.00	109	1	31.09
30	5	27.42	70	3	23.95	110	1	33.80
31	2	42.89	71	2	17.05	111	3	29.65
32	1	54.58	72	3	16.86	112	1	35.74
33	2	25.19	73	3	23.64	113	2	29.90
34	1	42.39	74	3	24.00	114	1	29.10
35	4	22.12	75	3	21.50	115	3	31.16
36	4	16.91	76	3	18.03	116	3	34.88
37	4	17.23	77	2	24.68	117	1	45.63
38	3	18.99	78	2	25.84	118	1	49.55
39	4	13.60	79	3	24.53	119	1	31.12
40	4	17.00	80	2	27.90	120	2	42.58

[illegible]

PANDA Probe - Test Report

Site 28-4A

Certificate Reference:

2091-PND-Site 28-4A

Sheet:

3 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

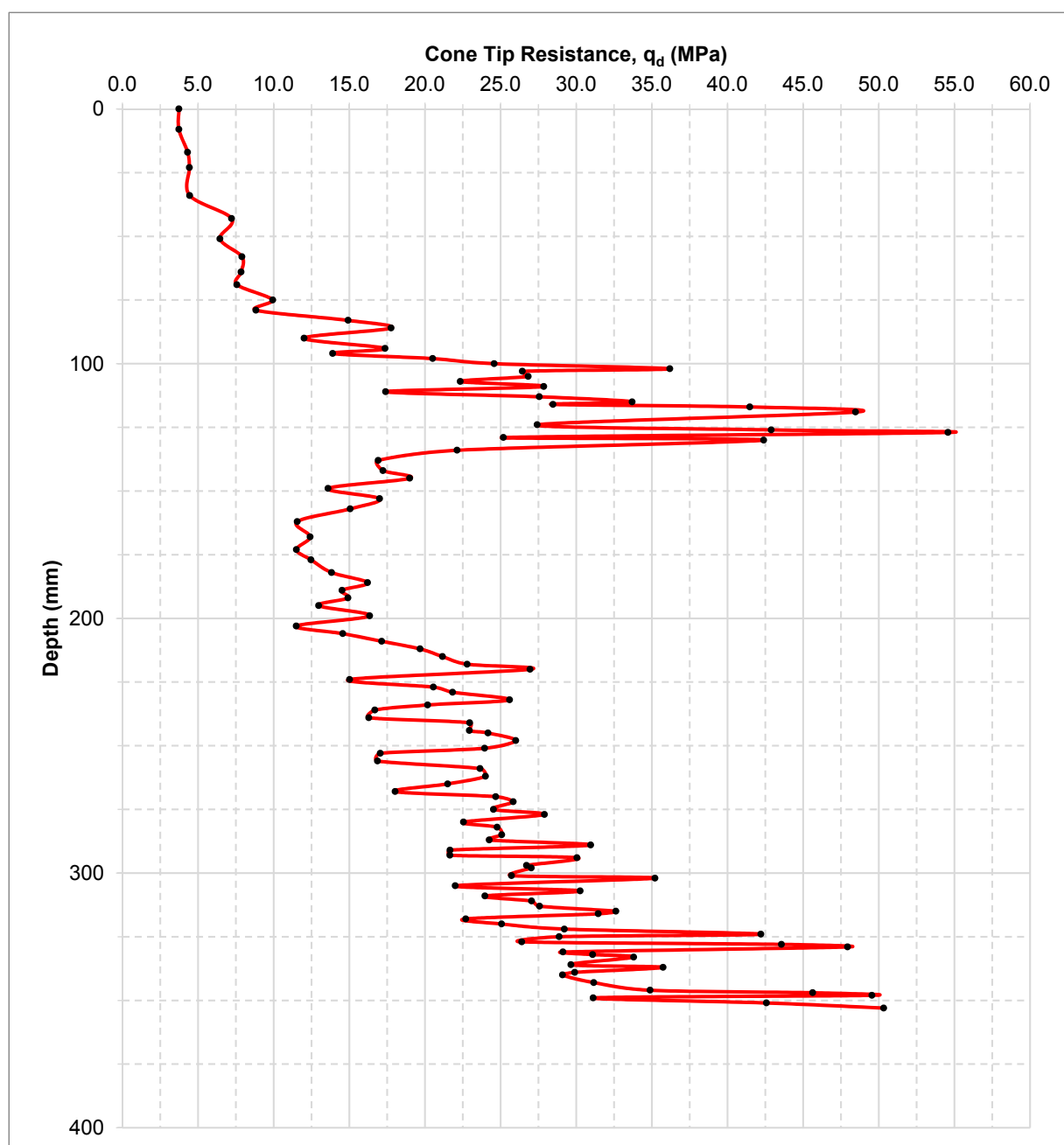
Project No.: 2091

Checked By: DWL

Location: Site 28-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 28-5

Certificate Reference:

2091-PND-Site 28-5

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 28-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	7	3.13	41	4	11.65	81	4	12.93
2	5	6.44	42	3	13.60	82	1	37.44
3	5	7.26	43	4	13.85	83	3	14.32
4	4	9.27	44	3	18.18	84	3	20.07
5	4	9.72	45	4	13.75	85	3	18.74
6	5	7.62	46	2	19.40	86	3	20.64
7	4	9.46	47	2	16.22	87	3	18.97
8	5	8.95	48	2	25.21	88	2	22.46
9	5	9.58	49	2	24.18	89	2	16.33
10	6	9.25	50	2	24.91	90	2	18.14
11	6	6.85	51	1	28.85	91	3	18.94
12	5	4.72	52	2	24.41	92	2	19.79
13	5	7.84	53	2	27.56	93	2	22.62
14	5	10.08	54	1	37.22	94	3	19.79
15	5	11.09	55	1	31.20	95	2	20.25
16	6	10.35	56	2	28.65	96	2	15.12
17	5	14.77	57	1	30.70	97	1	23.46
18	4	11.19	58	3	24.02	98	3	23.30
19	4	15.95	59	3	23.61	99	1	21.06
20	5	8.46	60	3	20.71	100	2	18.31
21	4	11.69	61	2	18.29	101	2	19.11
22	5	12.68	62	6	8.79	102	2	26.58
23	5	16.71	63	5	9.56	103	1	17.32
24	4	17.65	64	3	14.25	104	1	43.54
25	4	15.87	65	5	8.69	105	2	33.22
26	5	11.56	66	5	13.11	106	2	40.63
27	3	13.44	67	5	13.07	107	1	53.27
28	5	12.62	68	4	12.90	108	1	41.92
29	4	11.96	69	4	12.71	109	3	45.00
30	4	12.87	70	5	12.82	End of Test Record		
31	3	12.81	71	2	20.75			
32	4	16.42	72	4	10.93			
33	4	12.59	73	2	18.58			
34	3	13.89	74	3	13.20			
35	5	11.16	75	2	13.88			
36	3	16.55	76	4	12.58			
37	3	17.74	77	2	20.39			
38	3	15.03	78	4	10.88			
39	4	12.91	79	4	14.88			
40	4	13.76	80	2	25.63			

Certificate Reference:

2091-PND-Site 28-5

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

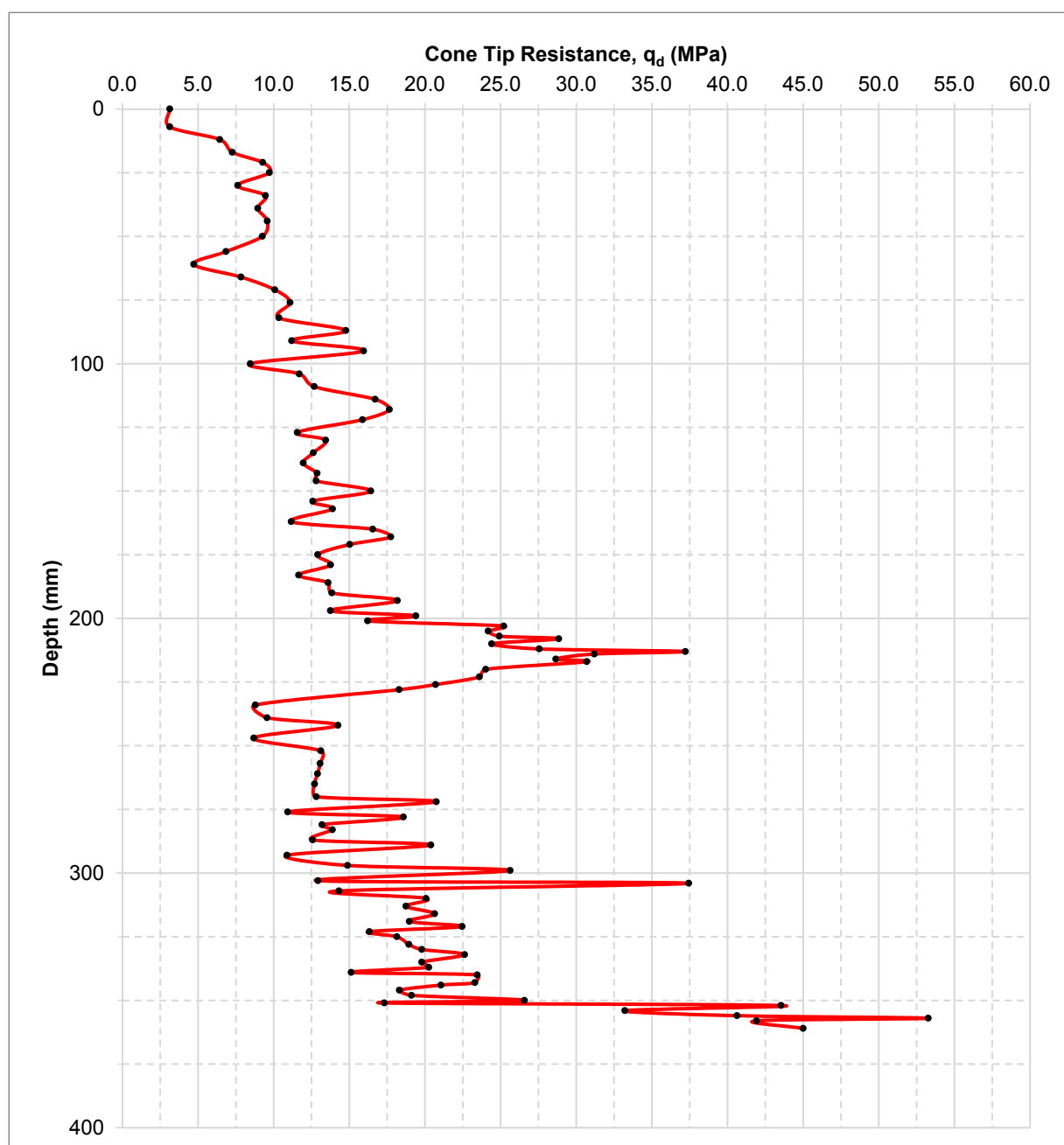
Project No.: 2091

Checked By: DWL

Location: Site 28-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 29-1

Certificate Reference:

2091-PND-Site 29-1

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 29-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	13	1.70	41	6	10.78	81	1	55.31
2	9	2.56	42	6	11.84	82	1	19.04
3	9	4.56	43	5	10.82	83	2	49.54
4	7	4.88	44	6	10.01	84	1	50.42
5	7	6.63	45	6	11.44	85	2	36.16
6	7	5.48	46	6	11.95	86	1	41.57
7	6	5.51	47	7	11.97	87	2	54.68
8	7	5.38	48	5	11.61	88	1	48.87
9	8	6.37	49	6	12.73	89	1	45.74
10	9	7.82	50	6	12.26	End of Test Record		
11	8	4.87	51	4	18.56			
12	6	5.91	52	3	18.09			
13	6	8.75	53	5	11.39			
14	4	11.73	54	4	16.33			
15	4	6.76	55	3	18.64			
16	7	8.48	56	3	15.03			
17	7	8.77	57	4	13.88			
18	10	6.41	58	3	13.79			
19	11	5.16	59	3	19.66			
20	12	3.01	60	4	20.91			
21	10	3.63	61	3	14.28			
22	12	3.56	62	4	18.74			
23	12	4.24	63	3	21.99			
24	15	4.01	64	4	20.25			
25	11	3.23	65	1	23.01			
26	10	3.99	66	2	25.63			
27	13	4.74	67	3	19.92			
28	8	6.92	68	2	20.57			
29	6	10.26	69	3	32.40			
30	7	9.38	70	2	31.58			
31	6	7.91	71	2	34.82			
32	5	14.82	72	2	28.80			
33	6	13.83	73	2	26.35			
34	6	13.50	74	1	42.94			
35	5	11.50	75	2	28.20			
36	6	10.10	76	2	38.79			
37	7	6.86	77	1	38.67			
38	13	6.15	78	2	31.60			
39	10	4.41	79	2	33.51			
40	10	6.45	80	1	47.67			

Site 29-1

Certificate Reference:

2091-PND-Site 29-1

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

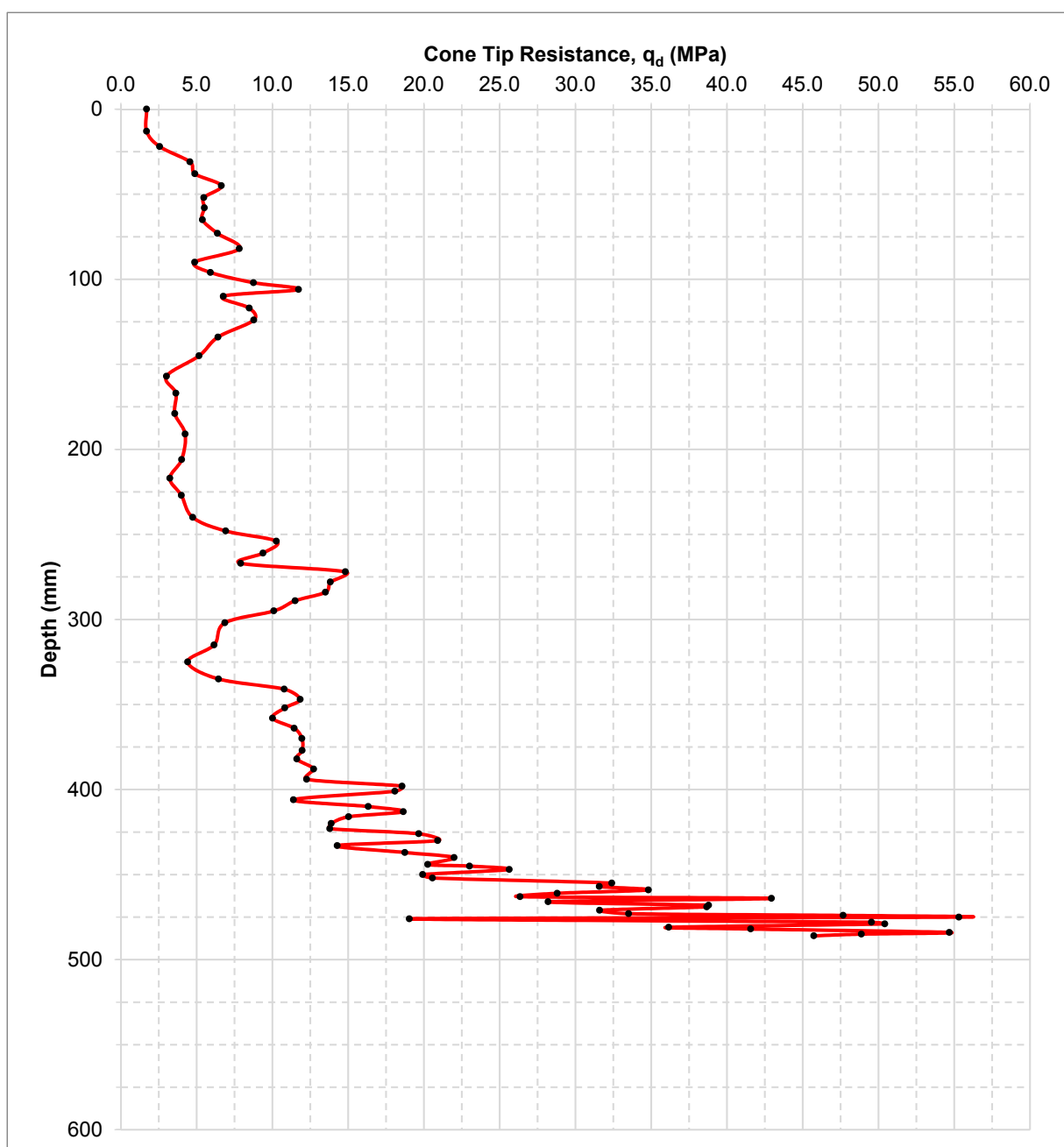
Project No.: 2091

Checked By: DWL

Location: Site 29-1 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 29-2

Certificate Reference:

2091-PND-Site 29-2

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 29-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	6	5.40	41	5	10.77			
2	7	3.85	42	7	7.64			
3	11	5.21	43	5	9.84			
4	10	4.90	44	4	8.64			
5	7	5.93	45	5	13.52			
6	4	14.75	46	4	9.75			
7	2	19.95	47	5	12.97			
8	4	12.95	48	3	16.55			
9	4	11.15	49	5	10.33			
10	5	10.60	50	4	10.08			
11	5	7.69	51	4	14.75			
12	5	7.46	52	2	23.46			
13	7	5.80	53	3	31.90			
14	9	5.70	54	2	38.63			
15	11	5.54	55	1	38.35			
16	10	5.62	56	1	33.71			
17	12	5.00	57	2	44.08			
18	10	4.61	58	2	51.48			
19	9	4.46	End of Test Record					
20	10	5.35						
21	9	5.29						
22	8	4.76						
23	9	5.99						
24	8	5.37						
25	9	6.03						
26	7	7.41						
27	8	5.75						
28	7	6.07						
29	8	7.16						
30	8	7.06						
31	5	6.70						
32	7	5.94						
33	5	7.26						
34	7	7.37						
35	5	9.80						
36	7	8.02						
37	3	8.29						
38	6	8.14						
39	6	9.84						
40	6	9.27						

PANDA Probe - Test Report

Site 29-2

Certificate Reference:

2091-PND-Site 29-2

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

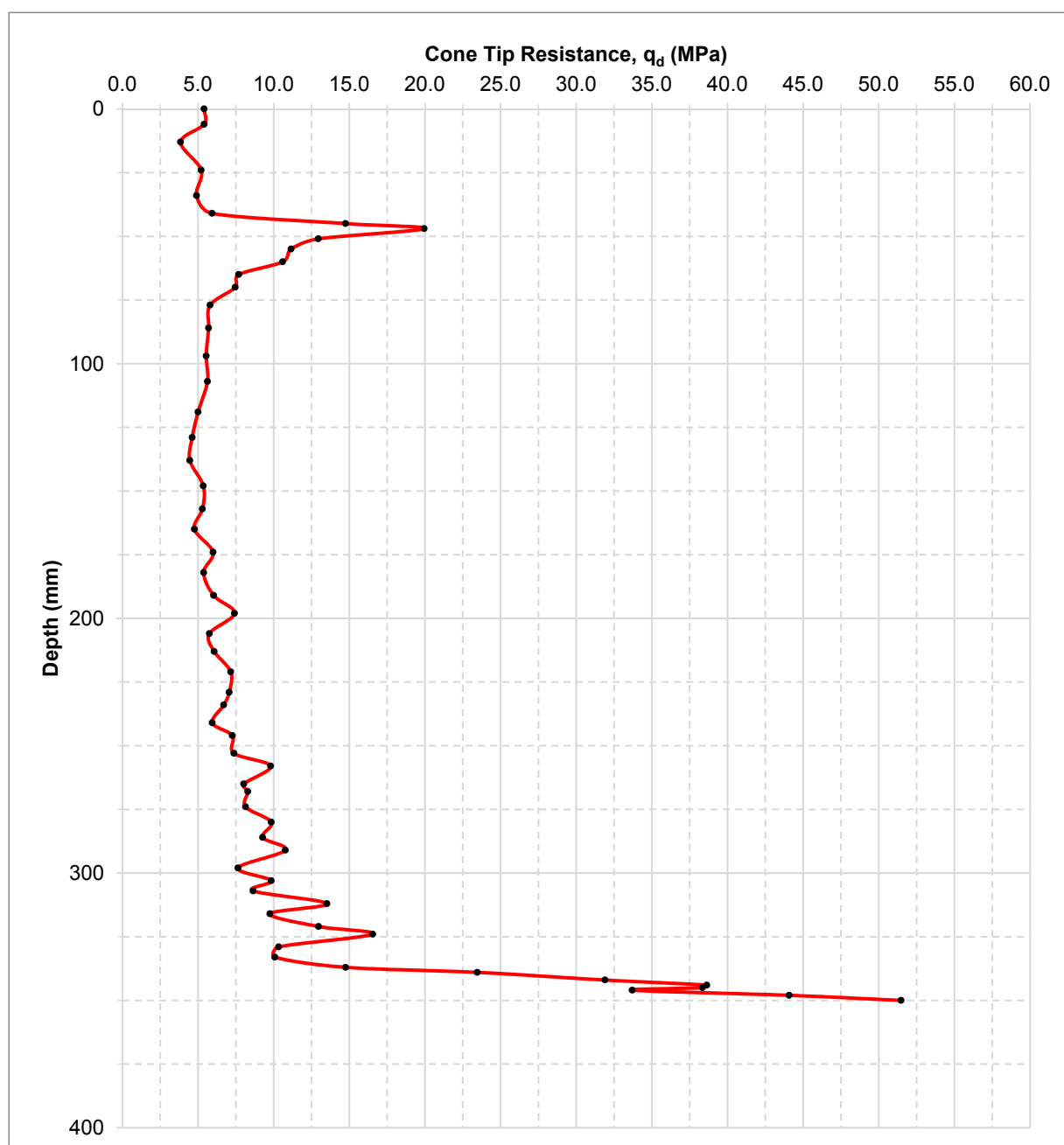
Project No.: 2091

Checked By: DWL

Location: Site 29-2 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 29-3

Certificate Reference:

2091-PND-Site 29-3

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 29-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	3.32	41	5	13.56			
2	7	5.39	42	6	9.84			
3	8	4.86	43	6	10.50			
4	8	7.97	44	5	11.65			
5	5	7.72	45	2	18.05			
6	4	13.50	46	5	15.45			
7	4	12.03	47	2	32.61			
8	4	12.07	48	2	47.60			
9	4	12.85	49	1	35.03			
10	3	11.05	50	1	52.88			
11	3	14.64	End of Test Record					
12	4	14.80						
13	2	22.33						
14	3	20.16						
15	4	9.27						
16	4	8.68						
17	5	13.10						
18	4	11.14						
19	4	8.77						
20	5	12.13						
21	5	11.94						
22	4	14.65						
23	5	12.66						
24	4	21.43						
25	3	18.98						
26	4	18.03						
27	2	35.10						
28	3	16.80						
29	3	21.45						
30	3	13.19						
31	5	16.18						
32	4	14.14						
33	4	12.48						
34	3	18.67						
35	3	17.05						
36	4	16.52						
37	3	13.93						
38	8	9.25						
39	6	11.26						
40	3	6.97						

PANDA Probe - Test Report

Site 29-3

Certificate Reference:

2091-PND-Site 29-3

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

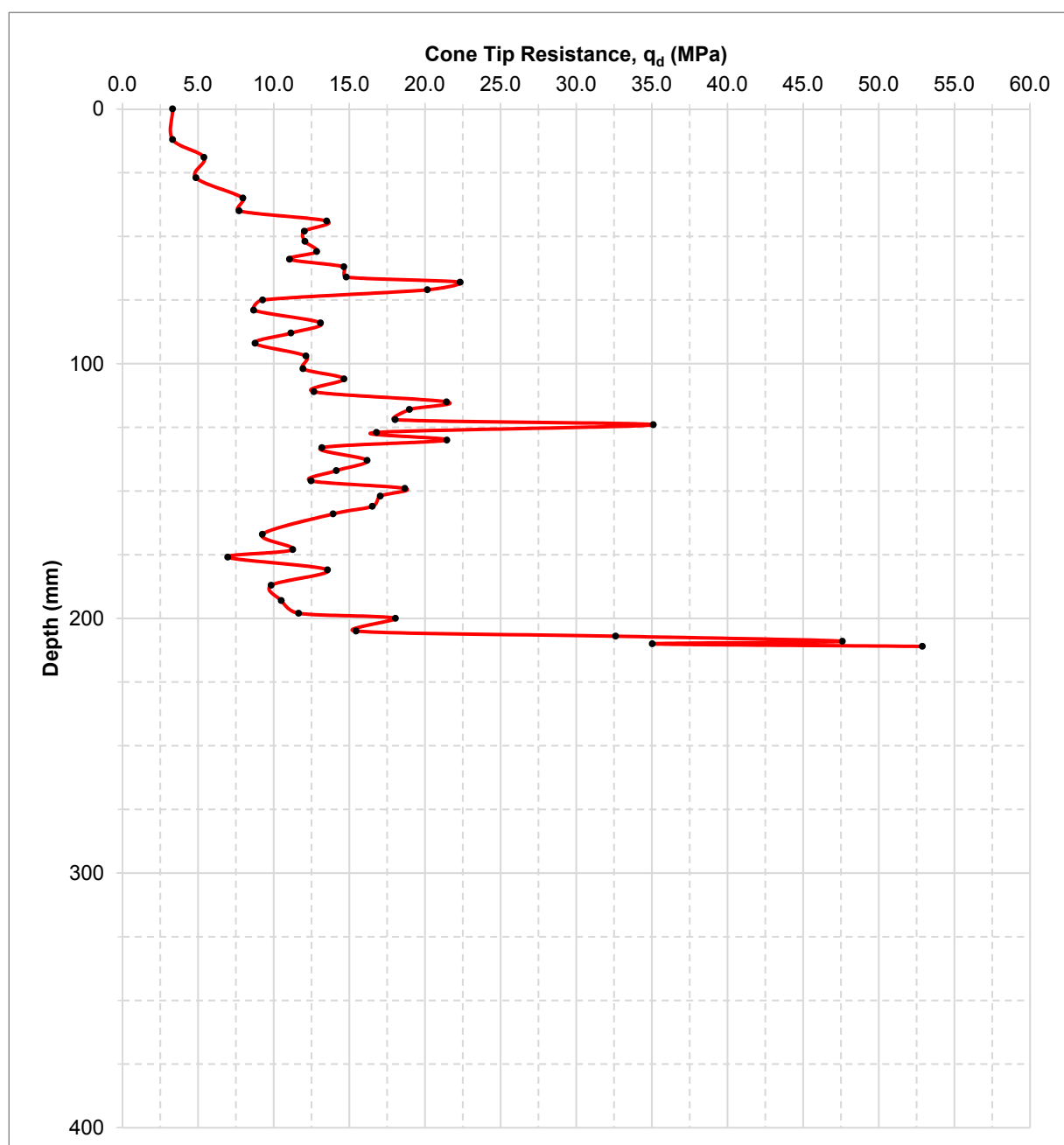
Project No.: 2091

Checked By: DWL

Location: Site 29-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 29-3A

Certificate Reference:

2091-PND-Site 29-3A

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 29-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	8	3.81	41	4	20.42			
2	9	5.64	42	3	18.50			
3	7	8.06	43	4	17.50			
4	8	10.23	44	3	16.93			
5	8	9.36	45	3	22.26			
6	5	10.09	46	3	23.24			
7	7	9.76	47	4	15.16			
8	5	9.08	48	2	15.74			
9	5	10.92	49	3	17.24			
10	6	11.21	50	3	19.24			
11	5	13.76	51	3	22.51			
12	5	10.09	52	3	23.14			
13	4	11.37	53	3	22.53			
14	4	13.40	54	1	31.41			
15	5	11.72	55	3	17.80			
16	5	11.68	56	1	31.81			
17	4	10.80	57	2	27.89			
18	3	9.63	58	2	42.07			
19	4	10.74	59	2	45.49			
20	4	12.53	60	4	31.22			
21	5	12.20	End of Test Record					
22	3	14.04						
23	3	15.43						
24	4	15.96						
25	4	13.48						
26	2	32.09						
27	4	11.64						
28	2	22.22						
29	1	56.16						
30	4	48.95						
31	1	53.25						
32	2	38.15						
33	2	27.88						
34	2	31.36						
35	2	23.52						
36	3	22.84						
37	3	26.47						
38	2	26.52						
39	2	28.38						
40	5	12.36						

PANDA Probe - Test Report

Site 29-3A

Certificate Reference:

2091-PND-Site 29-3A

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

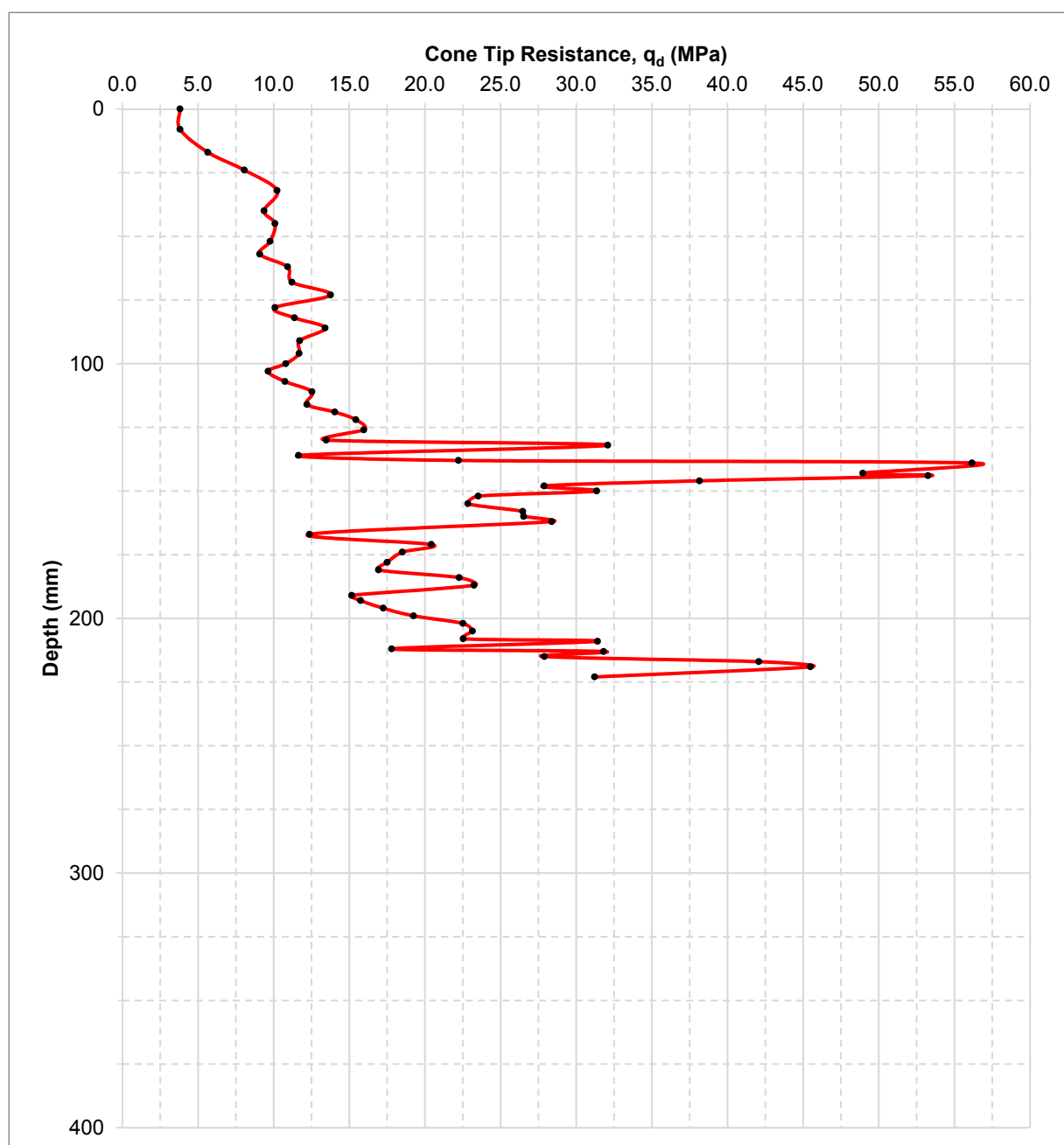
Project No.: 2091

Checked By: DWL

Location: Site 29-3 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 29-4

Certificate Reference:

2091-PND-Site 29-4

Sheet:

1 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 29-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	2.99	41	6	7.73	81	1	40.54
2	8	3.85	42	5	9.23	82	3	18.30
3	9	4.47	43	6	10.38	83	2	22.85
4	9	5.79	44	8	10.25	84	3	22.29
5	7	6.65	45	4	10.69	85	2	22.41
6	7	6.86	46	5	8.44	86	3	23.75
7	5	7.51	47	5	13.40	87	3	15.28
8	8	8.07	48	2	13.77	88	1	22.63
9	4	10.23	49	4	11.45	89	2	23.48
10	7	6.22	50	3	14.43	90	3	24.89
11	4	10.45	51	4	12.39	91	2	29.96
12	6	8.32	52	3	16.51	92	2	25.22
13	4	17.73	53	4	18.02	93	1	30.52
14	5	20.11	54	4	16.62	94	2	34.21
15	4	12.80	55	4	14.24	95	1	26.27
16	4	15.70	56	3	17.39	96	2	41.08
17	4	15.35	57	3	14.39	97	1	33.75
18	6	16.71	58	3	20.78	98	1	35.51
19	5	17.28	59	3	21.45	99	3	27.41
20	5	16.33	60	2	17.84	100	2	24.65
21	5	16.38	61	3	26.23	101	2	28.72
22	6	11.84	62	1	25.90	102	2	27.36
23	5	11.20	63	2	28.93	103	2	29.76
24	5	13.04	64	2	43.42	104	3	21.15
25	4	14.44	65	2	32.96	105	1	35.67
26	4	13.47	66	2	35.09	106	2	32.76
27	5	13.10	67	3	24.17	107	1	33.72
28	4	18.46	68	3	23.25	108	3	23.86
29	4	8.21	69	2	36.70	109	1	40.38
30	5	11.54	70	3	21.14	110	1	46.16
31	6	14.10	71	2	24.92	111	2	23.99
32	7	12.61	72	4	17.38	112	3	16.95
33	7	9.34	73	3	20.69	113	2	30.47
34	5	11.61	74	2	24.80	114	1	30.04
35	8	9.83	75	2	20.53	115	2	20.27
36	8	8.38	76	2	28.01	116	2	24.83
37	7	8.88	77	2	27.83	117	2	31.03
38	7	11.70	78	3	18.87	118	2	22.64
39	5	11.42	79	3	23.39	119	2	17.87
40	7	8.58	80	3	30.36	120	2	21.14

[illegible]

PANDA Probe - Test Report

Site 29-4

Certificate Reference:

2091-PND-Site 29-4

Sheet:

3 of 3

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

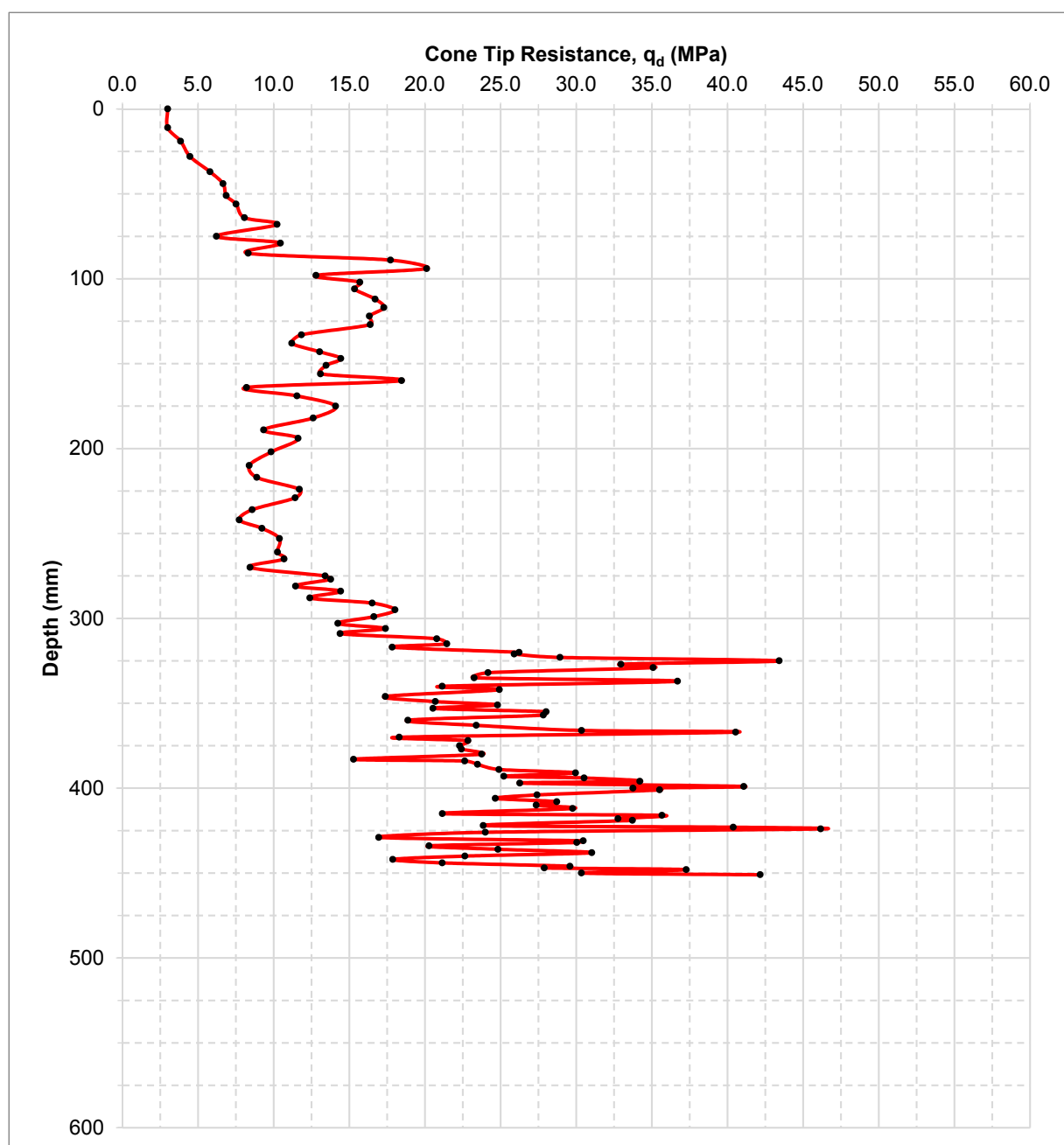
Project No.: 2091

Checked By: DWL

Location: Site 29-4 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 29-5

Certificate Reference:

2091-PND-Site 29-5

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 29-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	11	3.32	41	3	17.64			
2	11	2.80	42	4	18.28			
3	13	2.86	43	3	15.95			
4	11	2.97	44	3	19.07			
5	11	3.48	45	4	17.24			
6	15	2.13	46	3	13.85			
7	13	2.63	47	4	15.38			
8	11	3.80	48	3	14.82			
9	10	3.54	49	4	16.70			
10	8	5.76	50	3	14.13			
11	9	5.13	51	3	19.84			
12	8	6.14	52	2	21.09			
13	8	4.37	53	2	20.65			
14	5	7.76	54	2	27.74			
15	6	8.85	55	1	34.46			
16	7	8.73	56	2	35.06			
17	4	7.16	57	1	45.97			
18	7	9.65	58	2	33.98			
19	8	6.45	59	2	34.93			
20	6	7.65	60	2	39.09			
21	4	8.16	End of Test Record					
22	7	8.14						
23	4	11.06						
24	5	8.72						
25	5	12.27						
26	3	12.42						
27	3	16.45						
28	4	12.64						
29	2	17.88						
30	3	18.63						
31	5	10.92						
32	3	16.40						
33	2	16.90						
34	2	23.57						
35	3	21.16						
36	2	16.71						
37	2	26.02						
38	2	19.01						
39	2	19.80						
40	3	17.69						

PANDA Probe - Test Report

Site 29-5

Certificate Reference:

2091-PND-Site 29-5

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

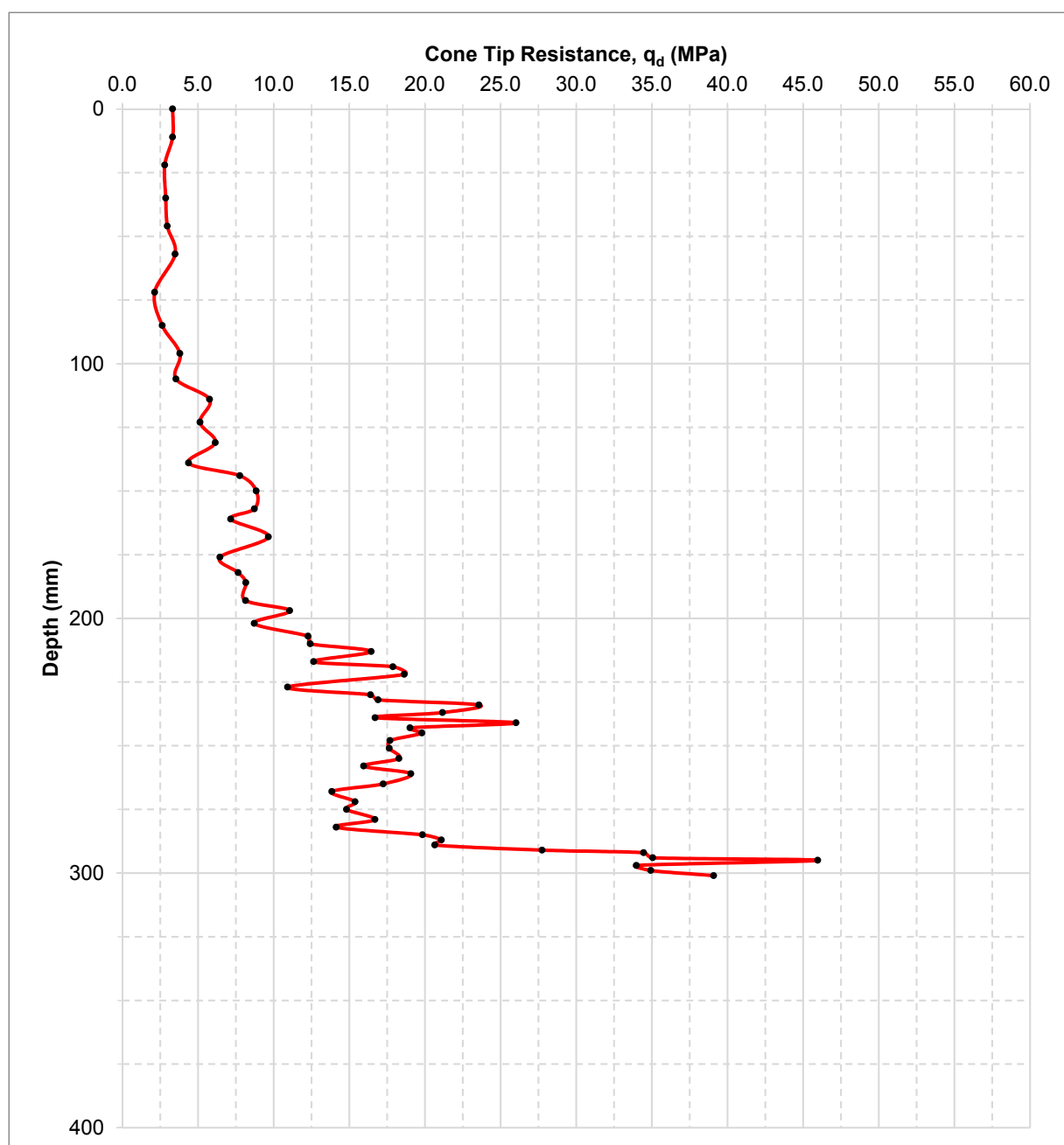
Project No.: 2091

Checked By: DWL

Location: Site 29-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)



PANDA Probe - Test Report

Site 29-5A

Certificate Reference:

2091-PND-Site 29-5A

Sheet:

1 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

Project No.: 2091

Checked By: DWL

Location: Site 29-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)

Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)	Blow ID	Penetration of Cone (mm)	Cone Tip Resistance (q _d) (MPa)
1	12	2.77	41	2	28.42			
2	13	2.57	42	1	38.46			
3	11	4.06	43	4	45.57			
4	7	7.04	44	4	46.83			
5	6	4.81	45	1	47.50			
6	8	4.88	46	2	38.21			
7	9	4.00	47	2	43.85			
8	12	3.67	48	1	53.50			
9	17	3.77	49	2	51.32			
10	12	3.12	End of Test Record					
11	11	3.50						
12	9	5.63						
13	9	6.08						
14	4	8.82						
15	5	7.91						
16	6	7.68						
17	5	11.20						
18	4	10.53						
19	5	10.10						
20	4	7.29						
21	5	9.47						
22	4	12.15						
23	5	10.53						
24	7	7.42						
25	5	11.69						
26	4	13.54						
27	6	8.68						
28	5	12.60						
29	4	12.82						
30	5	10.66						
31	3	14.17						
32	4	11.87						
33	4	15.24						
34	3	14.36						
35	2	16.31						
36	3	16.12						
37	3	14.94						
38	3	16.92						
39	2	26.27						
40	2	24.08						

PANDA Probe - Test Report

Site 29-5A

Certificate Reference:

2091-PND-Site 29-5A

Sheet:

2 of 2

Client: ARRB

Test Date: 7/03/2019

Project: Best Practice in Compaction QA

Tested By: RM

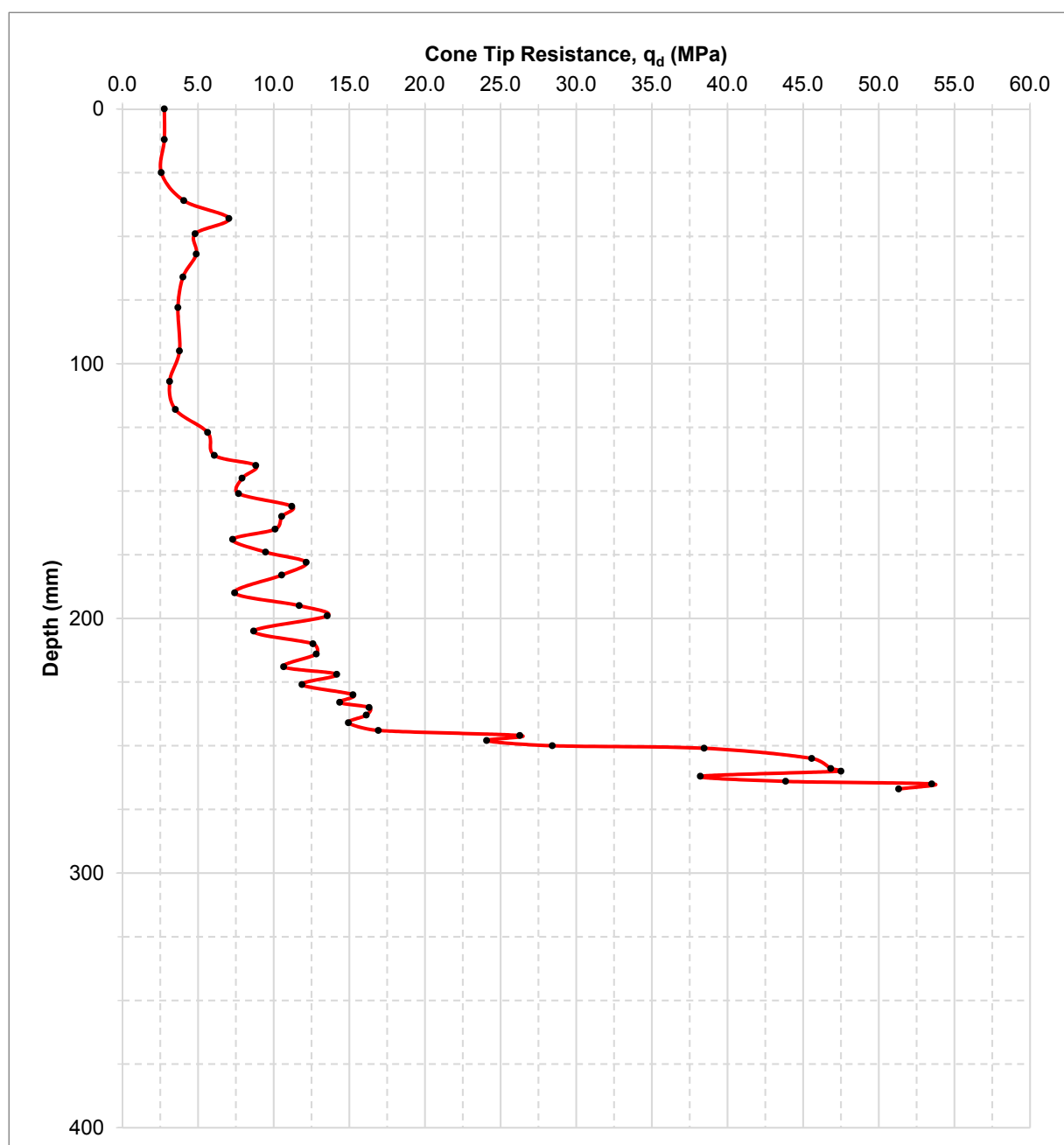
Project No.: 2091

Checked By: DWL

Location: Site 29-5 (Smithfield Bypass - Trial Embankment)

Cone Size: 2 cm²

Test method: French Standard, 2012 – NF P 94-105, Soils: Recognition and testing – Control of the quality of compaction – Dynamic penetrometer with variable energy method - Penetrometer calibration, principles and methodology – Interpretation of results (in French)





Appendix I

Field Assessment of Volumetric Moisture Content via TEROS 12 Sensor – Test Certificates

Field Moisture Content Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Various (Smithfield Bypass – Trial Embankment)
Equipment: *TEROS 12* - Field Measurement of Volumetric Water Content (VWC), Temperature and Electrical Conductivity (EC) in soil
 + Coupled with a *KD2 Pro Thermal Properties Analyser* (for data collection)

Sheet: 1 / 4
Test Date: Various
Tested By: RM
Checked By: DWL

Test Details			Insitu Testing of Soil Condition (at time of test)		
Site	Date of Test	Sub-site ID (Test Location)	Field Volumetric Water Content (m ³ /m ³ , %)	Soil Temperature (°C)	Bulk Electrical Conductivity (EC, dS/m)
Site 16	21/02/2019	16-1	10.05%	34.8	0.015
		16-2	2.55%	34.4	0.004
		16-3	3.42%	34.4	0.013
		16-4	3.51%	34.2	0.013
Site 17	21/02/2019	16-1	5.86%	36.5	0.009
		17-2	1.13%	39.8	0.003
		17-3	5.95%	38.7	0.011
		17-4	13.93%	39.4	0.022
Site 18	22/02/2019	18-1	6.56%	32.1	0.026
		18-2	4.69%	31.6	0.017
		18-3	8.54%	31.6	0.031
		18-4	2.20%	31.5	0.009
Site 19	25/02/2019	19-1	9.96%	33.7	0.019
		19-2	6.39%	33.1	0.018
		19-3	5.82%	32.7	0.008
		19-3A	11.35%	33.0	0.019
		19-4	8.65%	30.7	0.023
	26/02/2019	19-5	6.02%	31.9	0.006
		19-6	4.62%	31.7	0.028
		19-7	3.03%	31.5	0.021
		19-8	4.97%	31.5	0.021
		19-9	3.47%	31.6	0.018
		19-10	4.64%	31.9	0.020
		19-11	7.15%	32.2	0.024
		19-12	3.79%	32.3	0.008
		19-13	4.71%	32.3	0.006
		19-13A	4.75%	32.2	0.007
		19-14	3.92%	32.3	0.011
Site 21	27/02/2019	21-1	5.82%	33.5	0.007
	1/03/2019	21-1 (+24hrs)	14.12%	30.5	0.030

Field Moisture Content Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Various (Smithfield Bypass – Trial Embankment)
Test Method: *TEROS 12* - Field Measurement of Volumetric Water Content (VWC), Temperature and Electrical Conductivity (EC) in soil
 + Coupled with a *KD2 Pro Thermal Properties Analyser* (for data collection)

Sheet: 2 / 4
Test Date: Various
Tested By: RM
Checked By: DWL

Test Details			Insitu Testing of Soil Condition (at time of test)		
Site	Date of Test	Sub-site ID (Test Location)	Field Volumetric Water Content (m ³ /m ³ , %)	Soil Temperature (°C)	Bulk Electrical Conductivity (EC, dS/m)
Site 21 (Continued)	27/02/2019	21-2	13.27%	33.4	0.015
	1/03/2019	21-2 (+24hrs)	17.50%	30.5	0.035
	27/02/2019	21-3	13.01%	35.3	0.023
	1/03/2019	21-3 (+24hrs)	24.26%	30.6	0.081
	27/02/2019	21-4	4.25%	36.7	0.010
	1/03/2019	21-4 (+24hrs)	25.95%	31.5	0.037
	1/03/2019	21-5	11.94%	33.1	0.019
		21-6	12.71%	32.6	0.026
		21-7	24.87%	32.4	0.039
		21-8	9.70%	32.2	0.018
		21-9	22.08%	32.0	0.046
		21-10	21.68%	31.9	0.040
		21-11	10.66%	31.6	0.012
		21-12	23.12%	31.7	0.038
		21-13	22.69%	31.6	0.038
		21-14	23.01%	30.3	0.063
Site 22	27/02/2019	22-1	6.49%	34.4	0.007
		22-2	3.49%	33.8	0.004
		22-3	5.45%	33.9	0.010
		22-4	7.56%	33.7	0.030
	28/02/2019	22-5	9.94%	29.1	0.024
		22-6	14.95%	30.9	0.019
		22-7	5.45%	29.6	0.010
		22-8	14.17%	31.2	0.019
		22-8A	11.90%	30.4	0.015
		22-9	15.15%	30.1	0.029
		22-10	4.08%	31.0	0.019
		22-11	7.71%	31.7	0.014
		22-12	6.28%	32.3	0.012
		22-13	8.13%	32.5	0.013
		22-14	2.94%	32.9	0.017

Field Moisture Content Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Various (Smithfield Bypass – Trial Embankment)
Equipment: *TEROS 12 - Field Measurement of Volumetric Water Content (VWC), Temperature and Electrical Conductivity (EC) in soil*
+ Coupled with a KD2 Pro Thermal Properties Analyser (for data collection)

Sheet: 3 / 4
Test Date: Various
Tested By: RM
Checked By: DWL

Test Details			Insitu Testing of Soil Condition (at time of test)		
Site	Date of Test	Sub-site ID (Test Location)	Field Volumetric Water Content (m ³ /m ³ , %)	Soil Temperature (°C)	Bulk Electrical Conductivity (EC, dS/m)
Site 23	13/03/2019	23-1	2.03%	28.8	0.003
		23-2	3.18%	33.1	0.007
		23-3	1.33%	33.9	0.004
		23-4	1.44%	33.9	0.000
		23-5	1.40%	34.6	0.003
		23-6	1.61%	32.0	0.000
Site 24	12/03/2019	24-1	1.61%	35.1	0.005
		24-2	1.22%	34.9	0.002
		24-3	1.59%	35.1	0.004
		24-4	1.37%	35.3	0.004
		24-5	1.50%	35.1	0.000
		24-6	1.55%	35.3	0.004
		24-7	1.16%	35.0	0.000
		24-8	1.02%	34.9	0.002
		24-9	2.62%	34.6	0.009
		24-10	0.83%	34.3	0.003
		24-11	1.57%	34.0	0.004
		24-12	1.09%	33.8	0.003
Site 25	6/03/2019	25-1	3.29%	32.5	0.028
		25-2	2.01%	36.2	0.003
		25-3	2.01%	33.6	0.008
		25-4	1.85%	34.1	0.004
		25-5	3.29%	34.3	0.005
		25-6	1.26%	34.2	0.004
		25-7	1.37%	34.4	0.003
		25-8	1.24%	34.9	0.003
		25-9	1.18%	34.2	0.006
		25-10	1.22%	34.3	0.005
		25-11	1.53%	34.6	0.004
		25-12	1.22%	34.6	0.000

Field Moisture Content Report

Client: ARRB
Project: Best Practice in Compaction QA
Project No.: 2091
Location: Various (Smithfield Bypass – Trial Embankment)
Equipment: *TEROS 12* - Field Measurement of Volumetric Water Content (VWC), Temperature and Electrical Conductivity (EC) in soil
 + Coupled with a *KD2 Pro Thermal Properties Analyser* (for data collection)

Sheet: 4 / 4
Test Date: Various
Tested By: RM
Checked By: DWL

Test Details			Insitu Testing of Soil Condition (at time of test)		
Site	Date of Test	Sub-site ID (Test Location)	Field Volumetric Water Content (m ³ /m ³ , %)	Soil Temperature (°C)	Bulk Electrical Conductivity (EC, dS/m)
Site 26	6/03/2019	26-1	1.53%	34.9	0.000
		26-2	1.57%	34.7	0.000
		26-3	0.94%	34.0	0.000
		26-4	1.29%	33.0	0.000
		26-5	1.29%	33.1	0.009
		26-6	1.57%	34.6	0.000
		26-7	1.59%	34.5	0.002
		26-8	1.59%	34.1	0.003
		26-9	1.66%	33.6	0.005
		26-10	3.05%	33.4	0.003
		26-11	5.78%	33.1	0.006
		26-12	0.87%	33.3	0.000
Site 27	6/03/2019	27-1	6.34%	29.1	0.004
		27-2	16.95%	29.6	0.026
		27-3	12.49%	29.5	0.013
		27-4	14.56%	29.6	0.023
		27-5	11.42%	29.7	0.031
Site 28	7/03/2019	28-1	8.80%	47.5	0.024
		28-2	8.39%	45.5	0.011
		28-3	7.78%	42.9	0.020
		28-4	12.53%	41.0	0.023
		28-5	8.19%	40.4	0.008
Site 29	7/03/2019	29-1	3.57%	30.5	0.003
		29-1A	7.87%	31.4	0.006
		29-2	16.69%	30.9	0.044
		29-3	3.81%	33.2	0.005
		29-4	9.09%	34.5	0.008
		29-5	24.73%	34.4	0.075



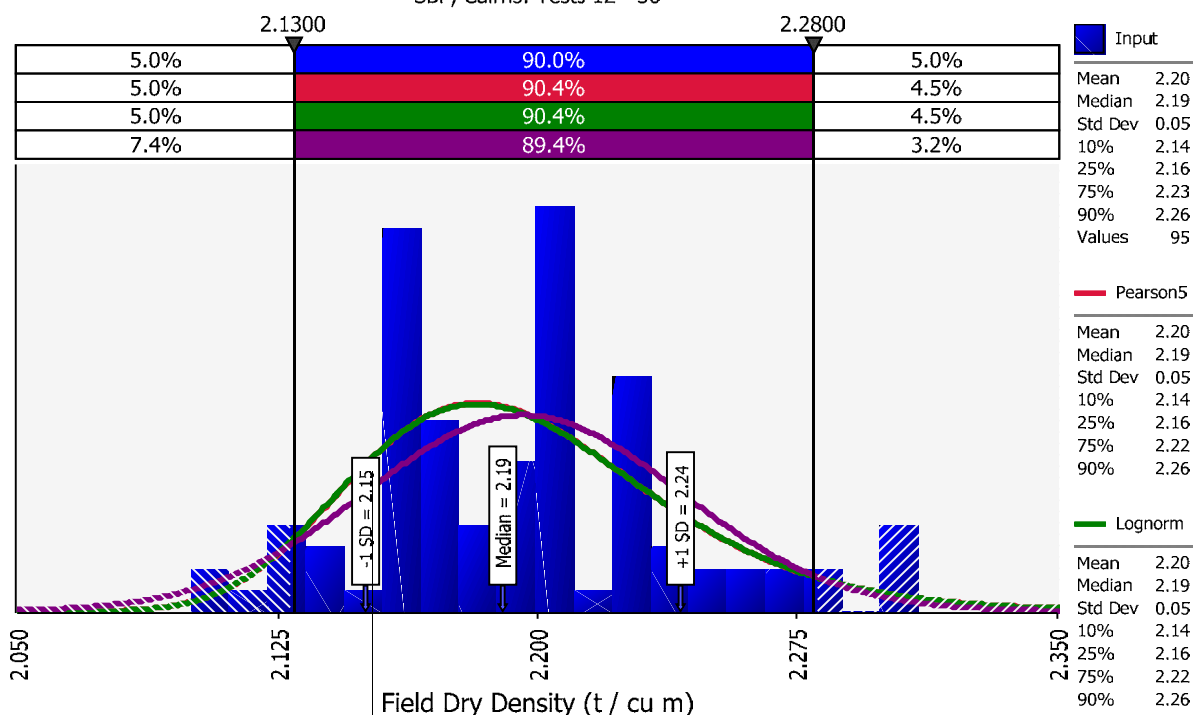
Appendix J

Probability Density Functions (PDFs)



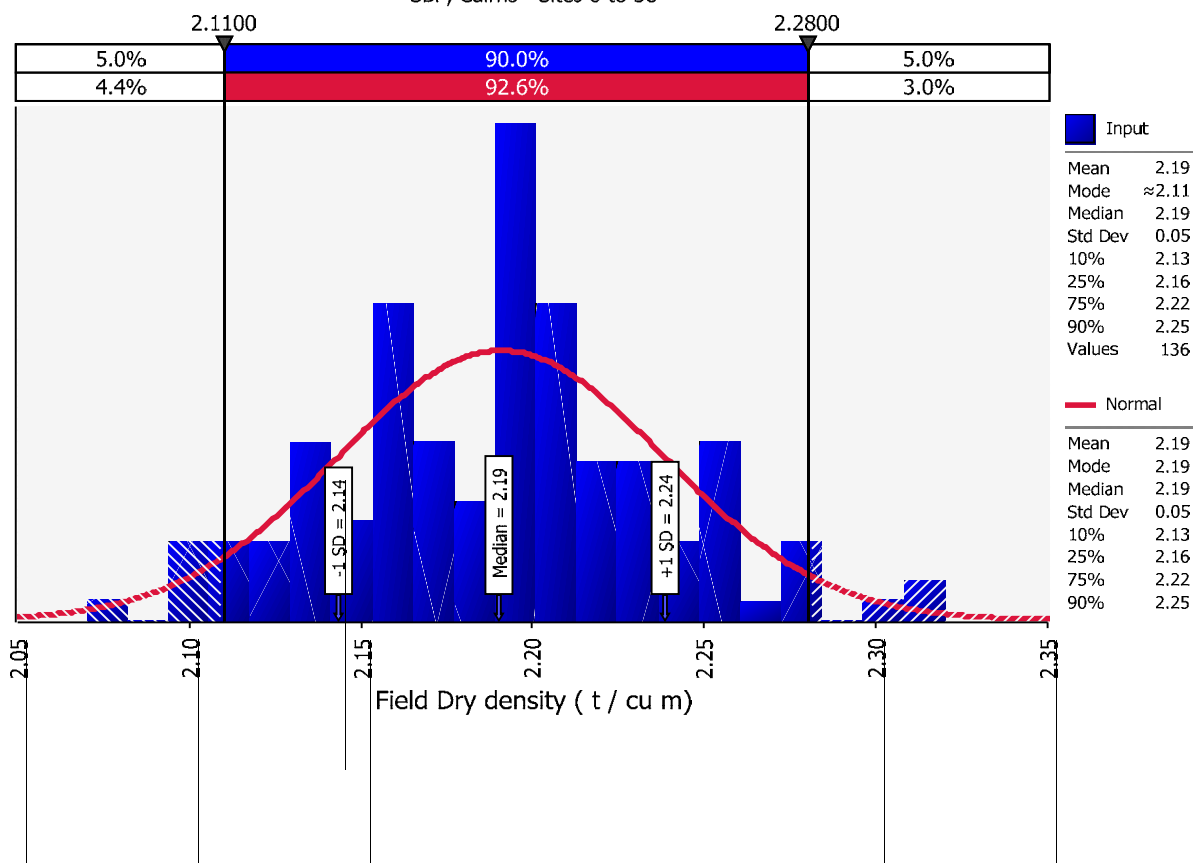
Fit Comparison for Field Dry Density (t/m³)

SBP, Cairns: Tests 12 - 30



Fit Comparison for Field Dry Density (t/m³)

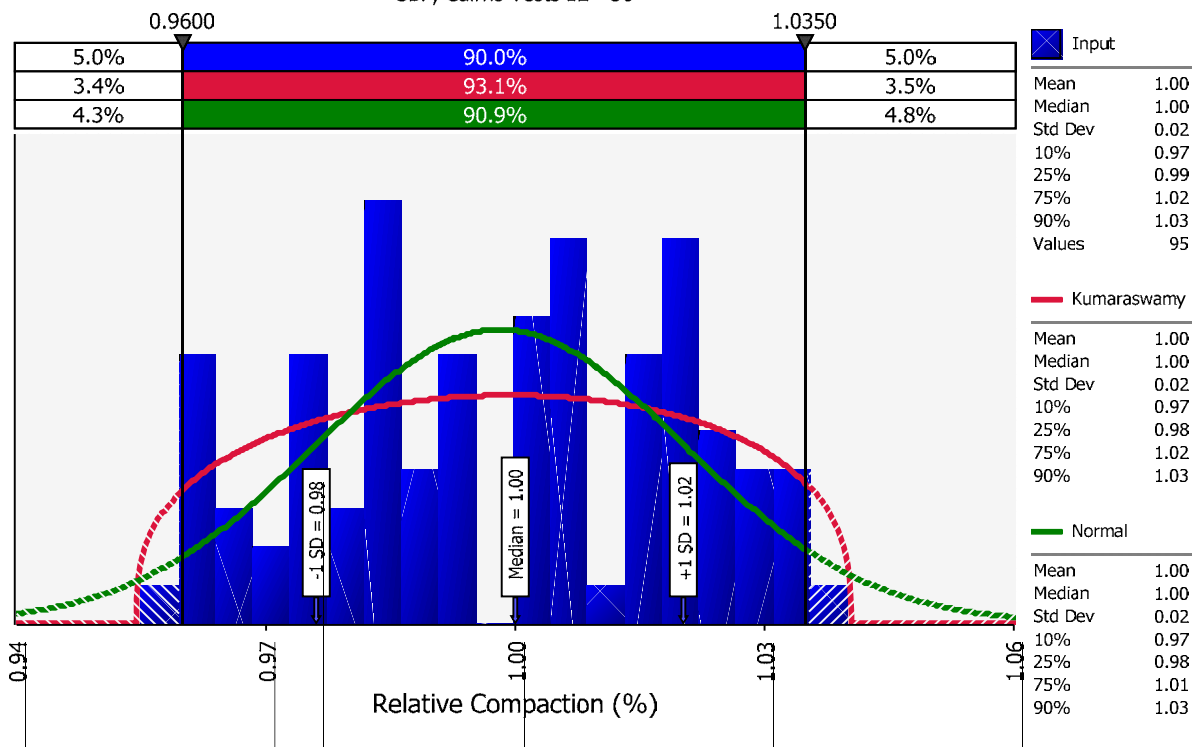
SBP, Cairns - Sites 6 to 38





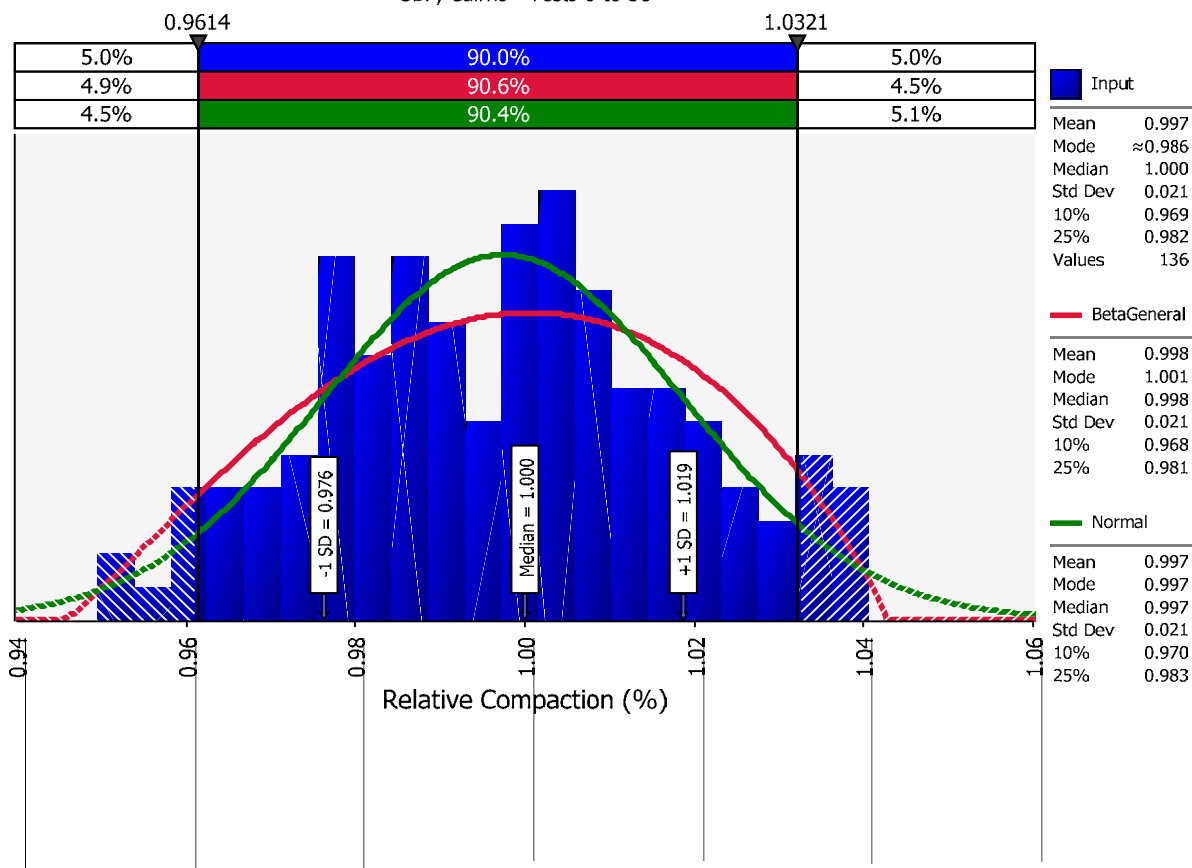
Fit Comparison for Relative Compaction (%)

SBP, Cairns Tests 12 - 30



Fit Comparison for Relative Compaction (%) - RDD

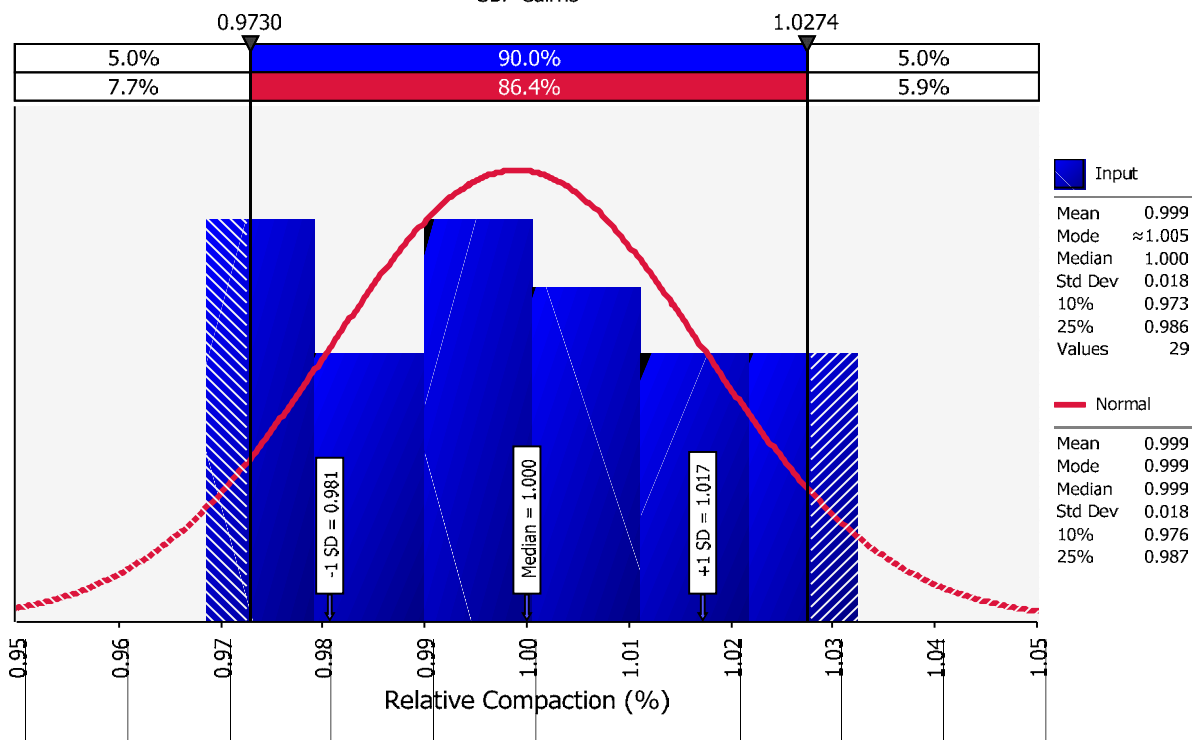
SBP, Cairns - Tests 6 to 38





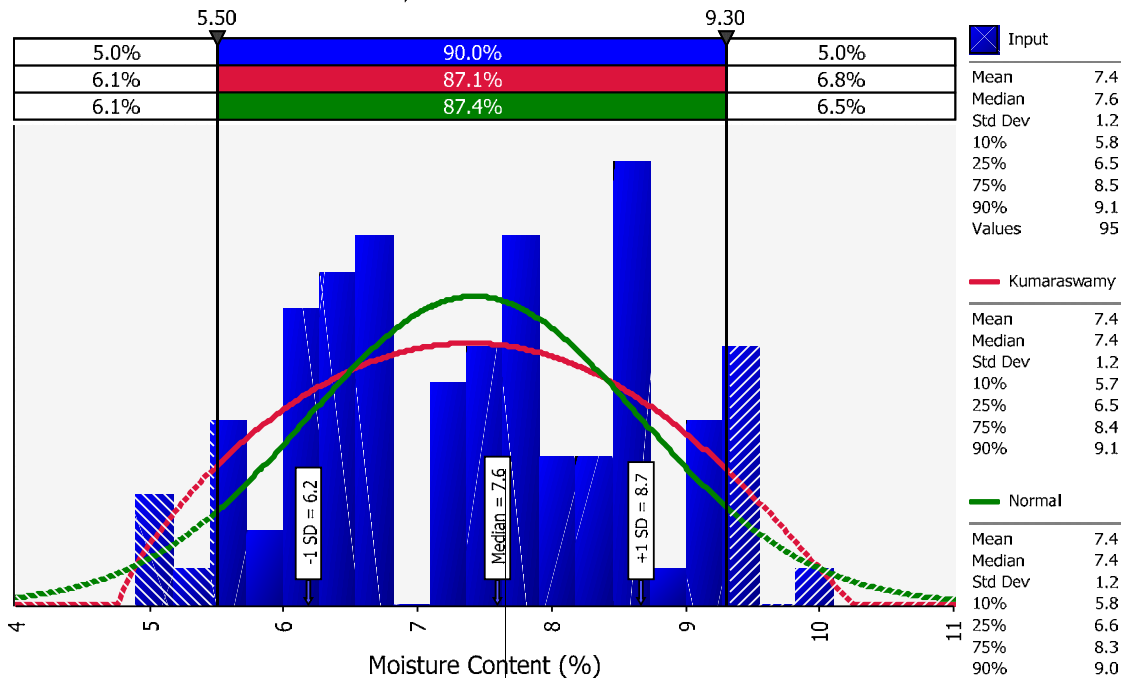
Fit Comparison for RDD - Tests 21 - 26

SBP Cairns



Fit Comparison for Field Moisture Content (%)

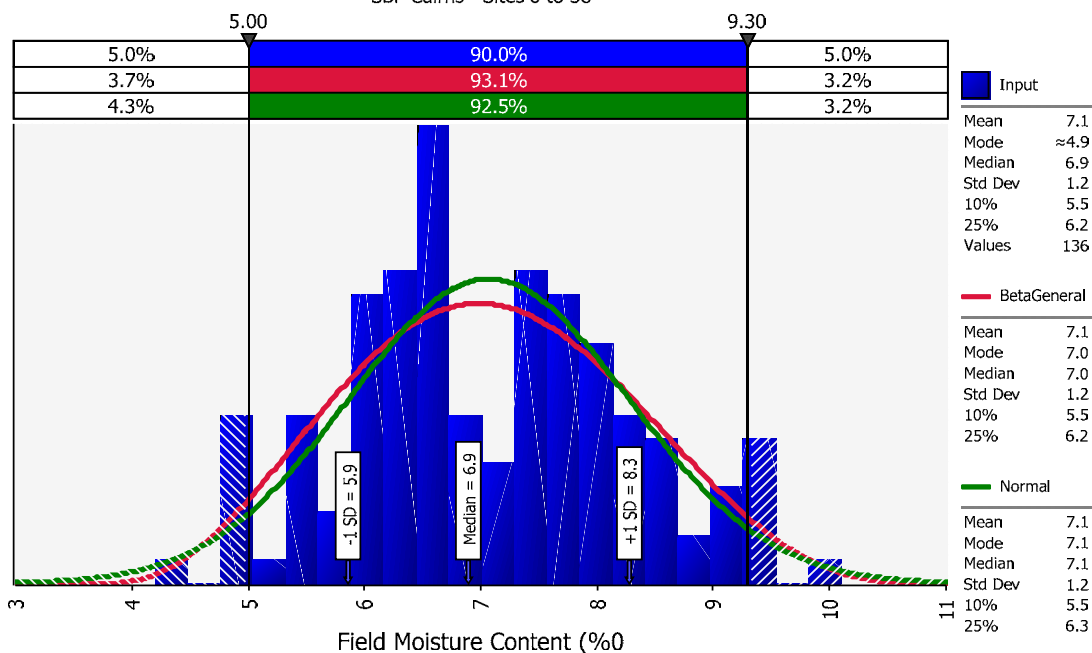
SBP, Cairns: Tests 12 - 30





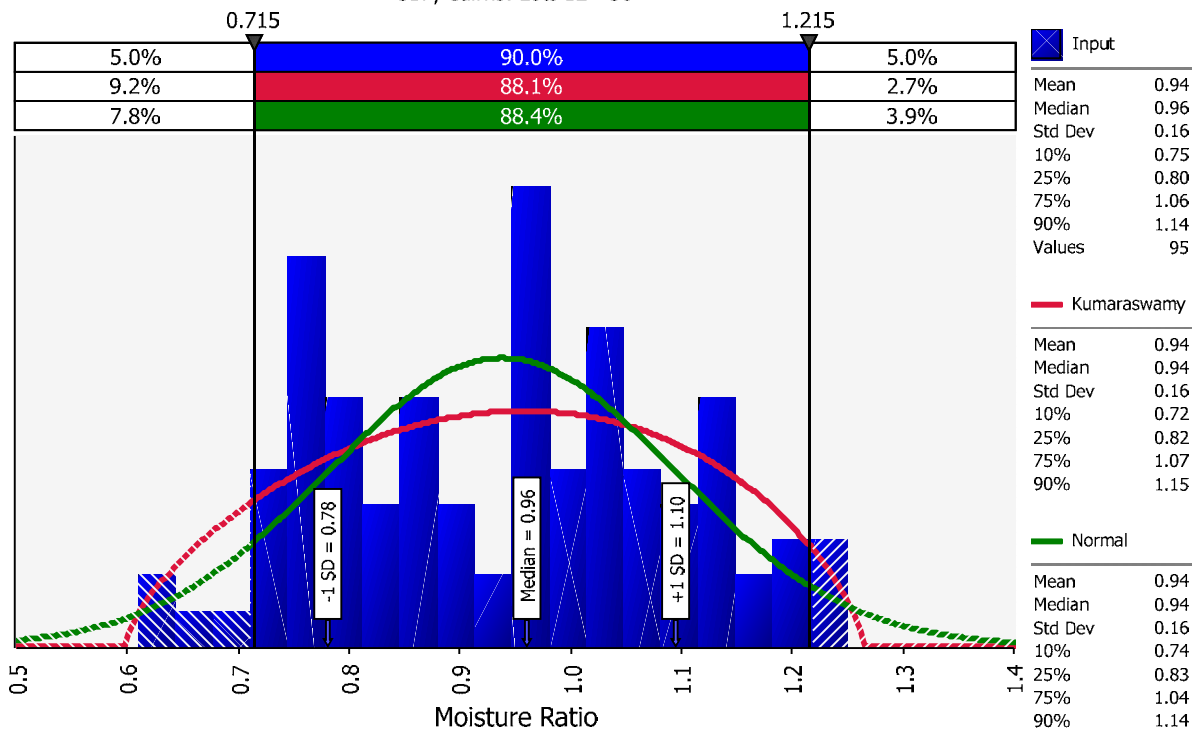
Fit Comparison for Field Moisture Content (%)

SBP Cairns - Sites 6 to 38



Fit Comparison for Moisture Ratio (%)

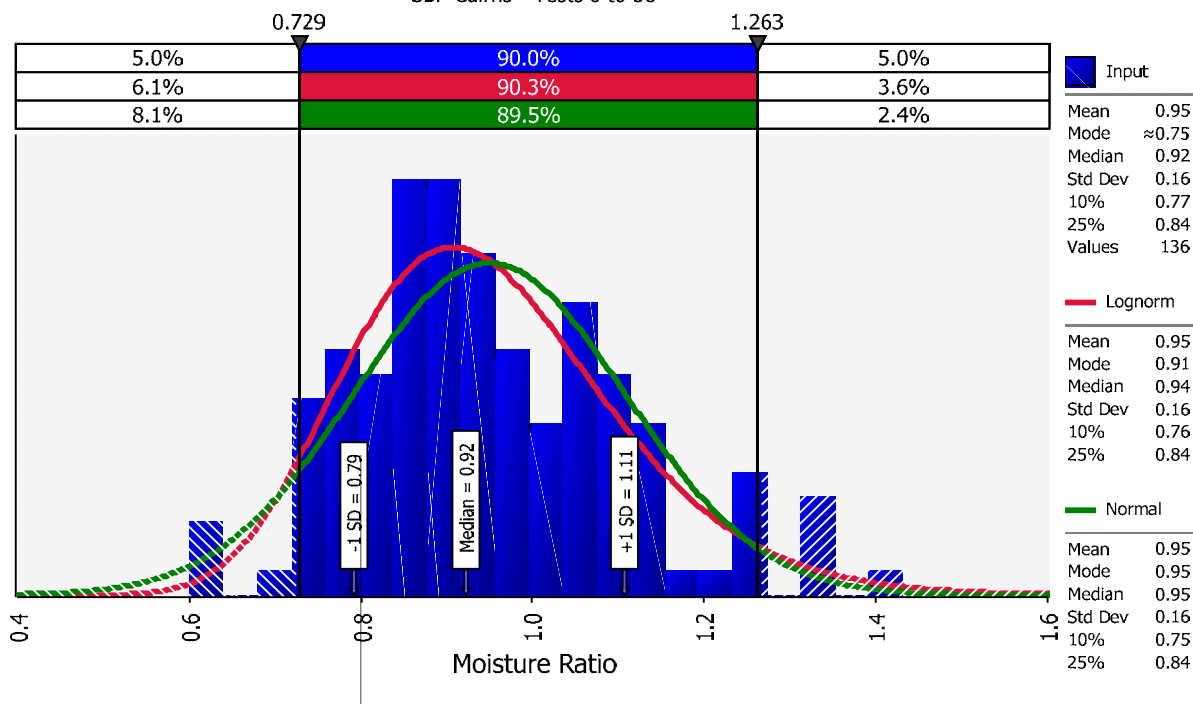
SBP, Cairns: Lots 12 - 30





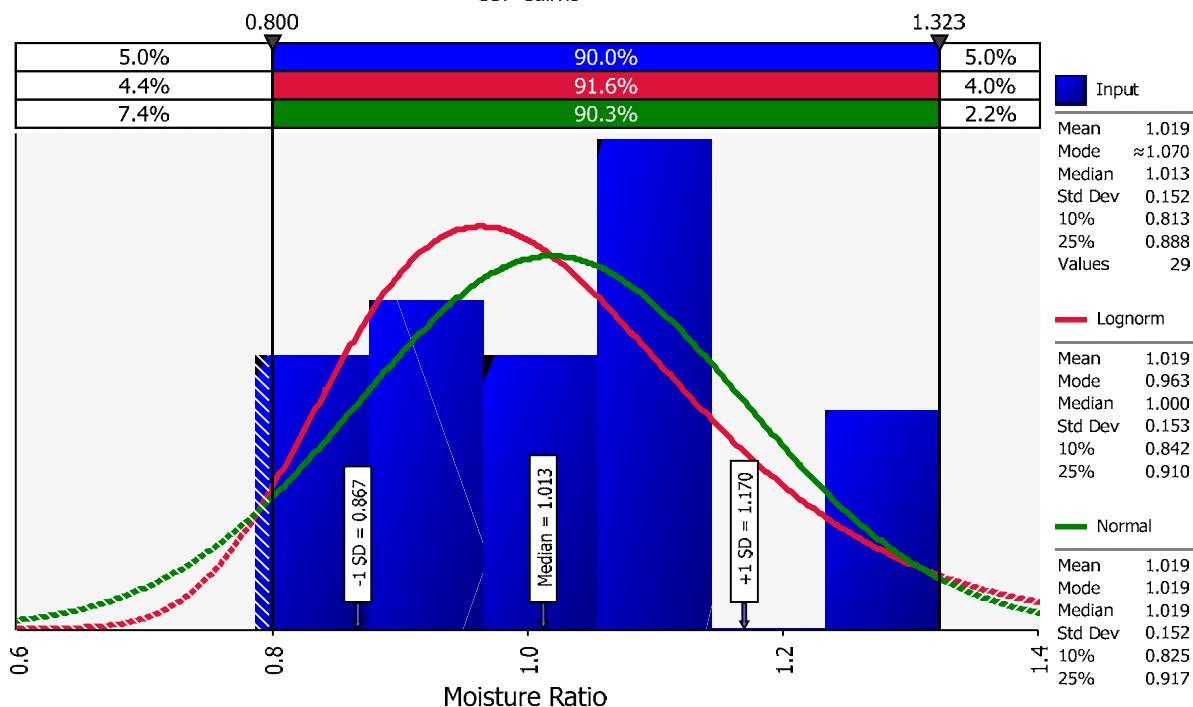
Fit Comparison for Moisture Ratio (%) - Recalculated (FMC / Adjusted OMC, %)

SBP Cairns - Tests 6 to 38



Fit Comparison for Moisture Ratio Tests 21 - 26

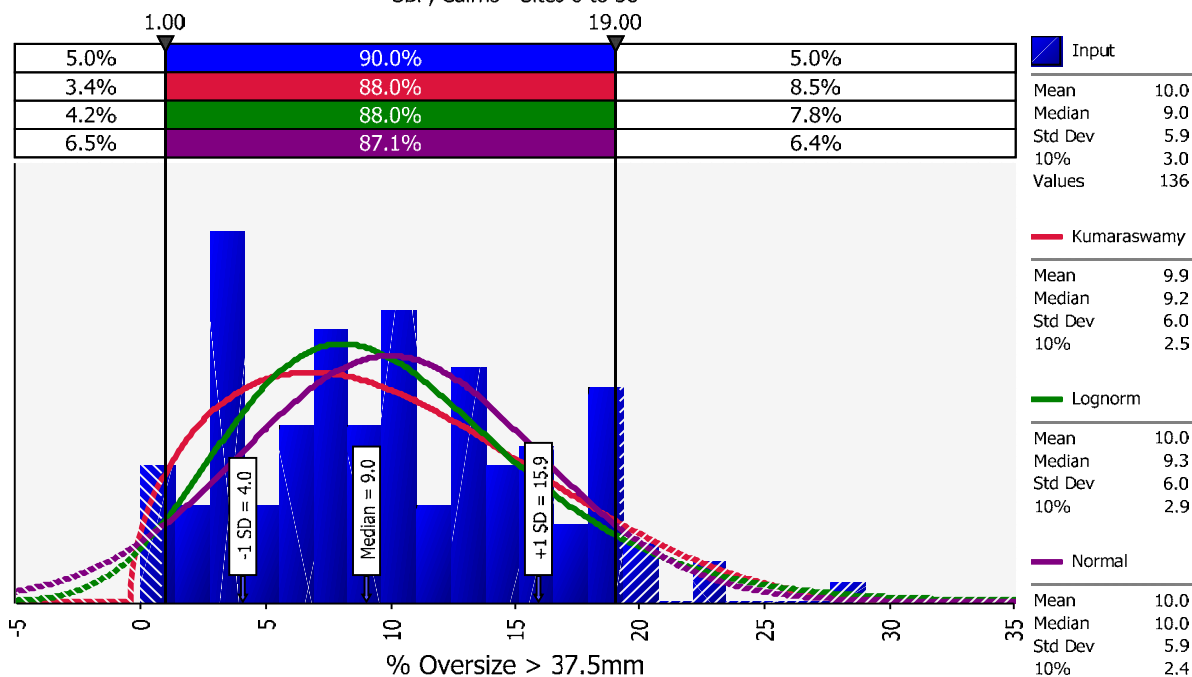
SBP Cairns





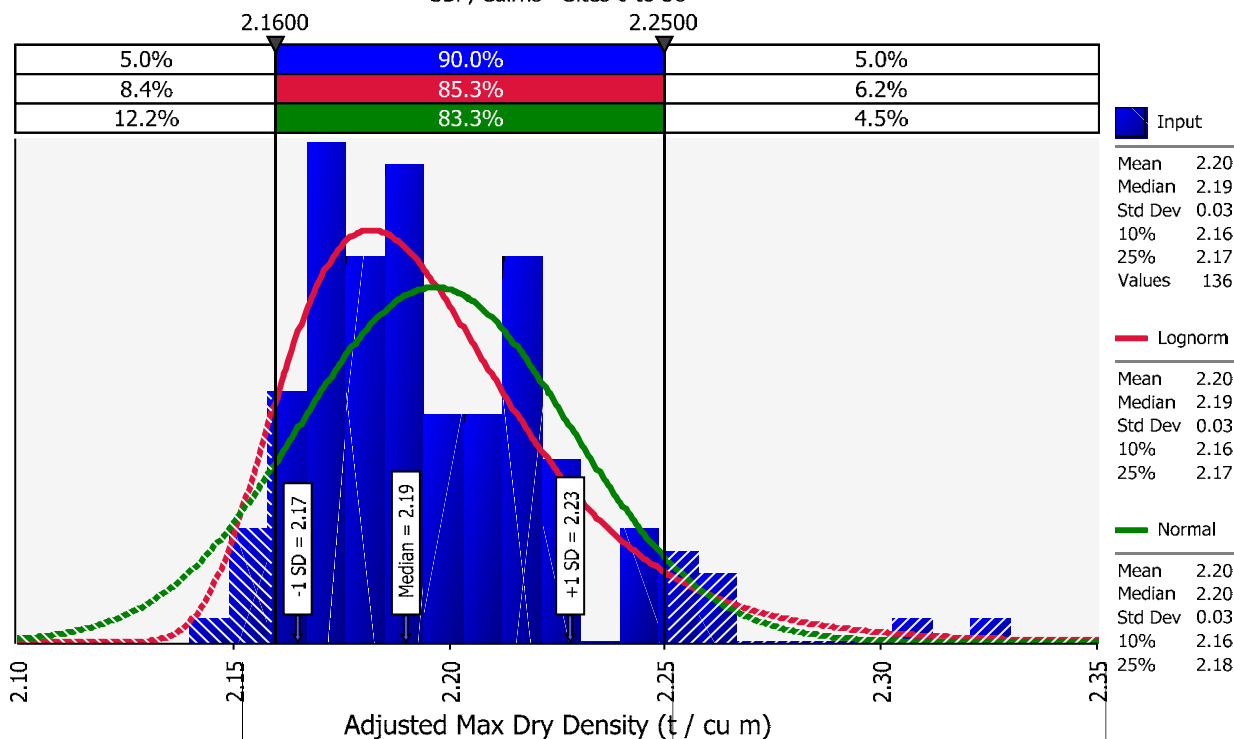
Fit Comparison for Oversize (%) - Dry (> 37.5 mm)

SBP, Cairns - Sites 6 to 38



Fit Comparison for Adjusted Max. Dry Density (t/m³)

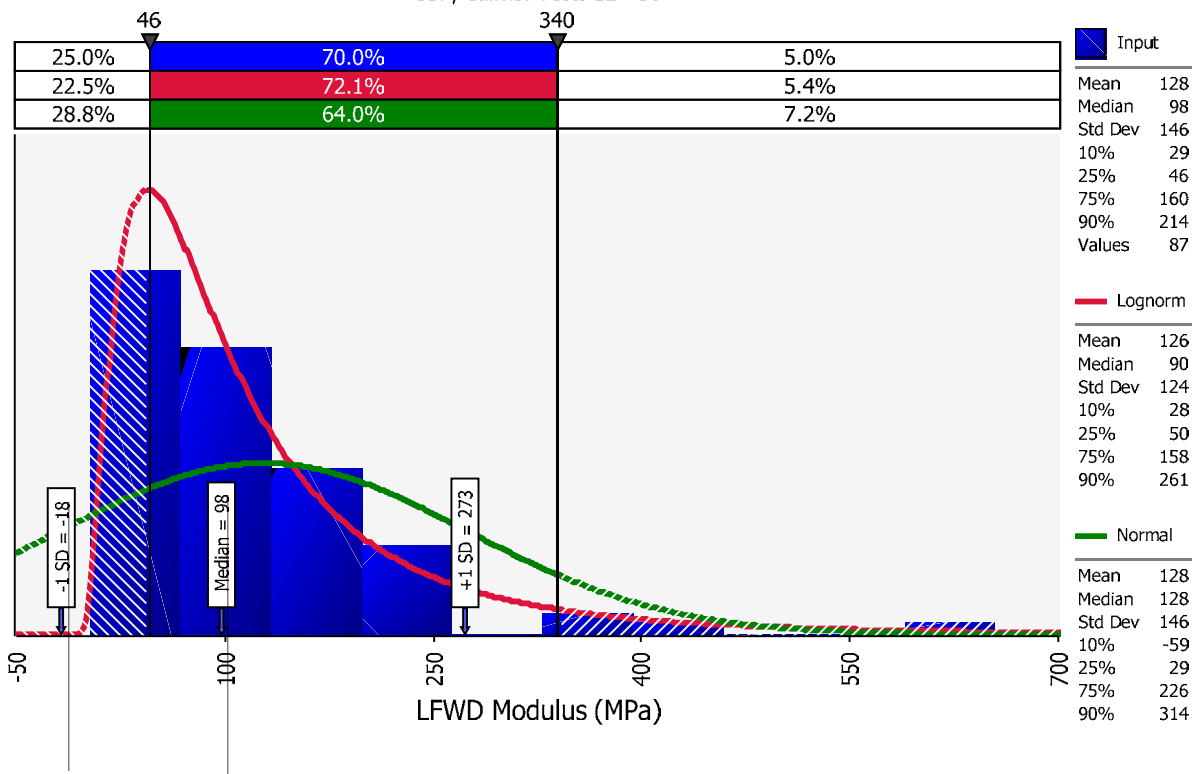
SBP, Cairns - Sites 6 to 38





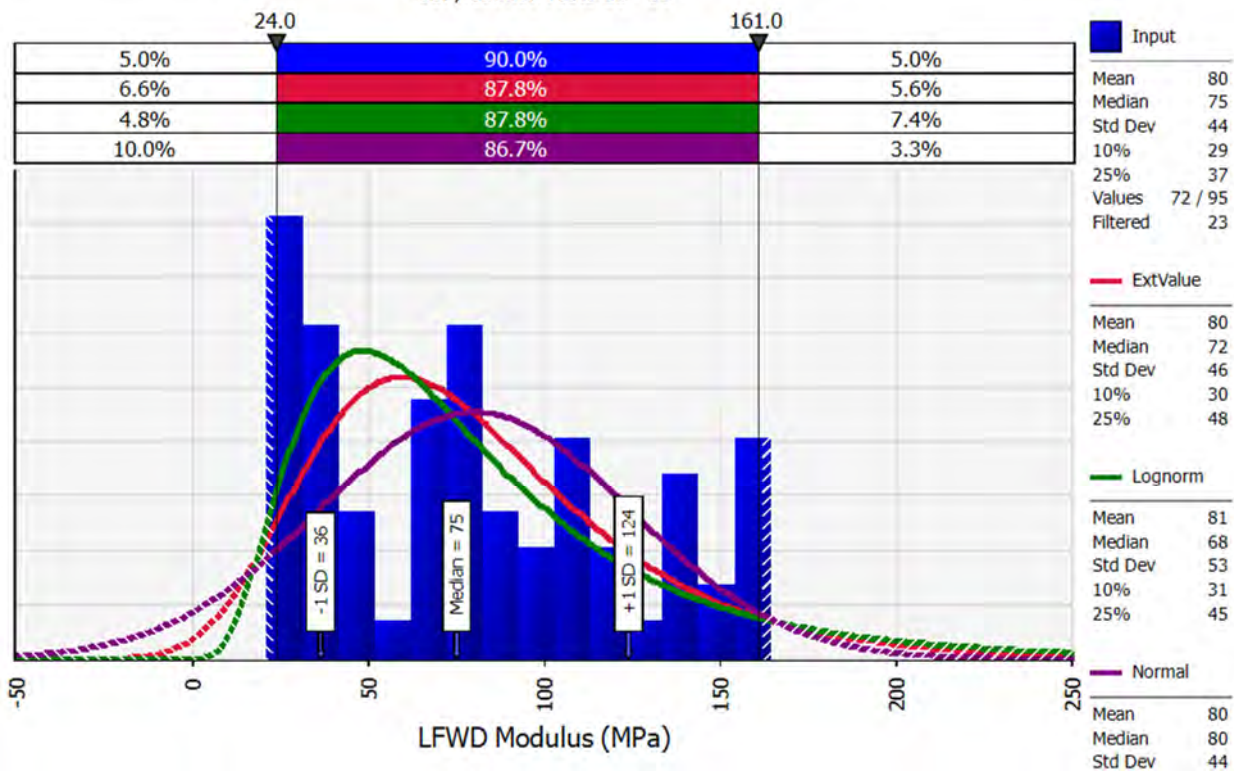
Fit Comparison for LFWD Modulus @ 50 kPa applied stress

SBP, Cairns: Tests 12 - 30

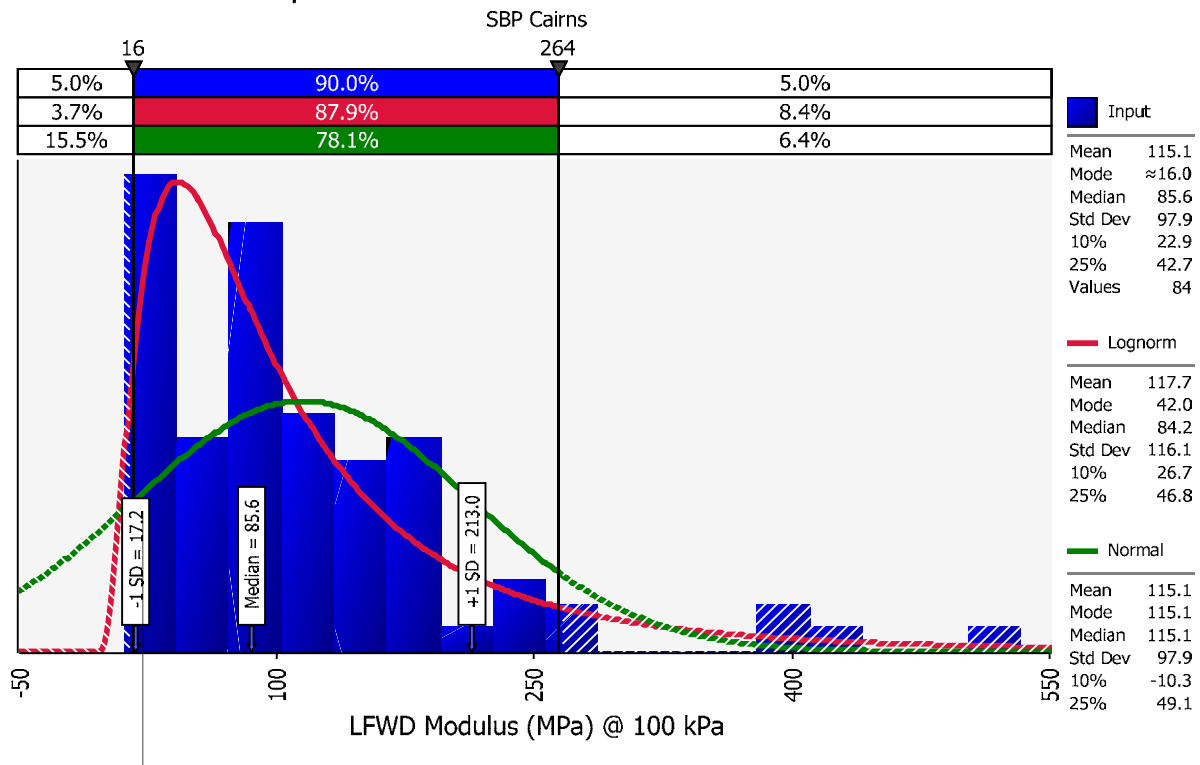


Fit Comparison for LFWD Modulus @ 100 kPa stress

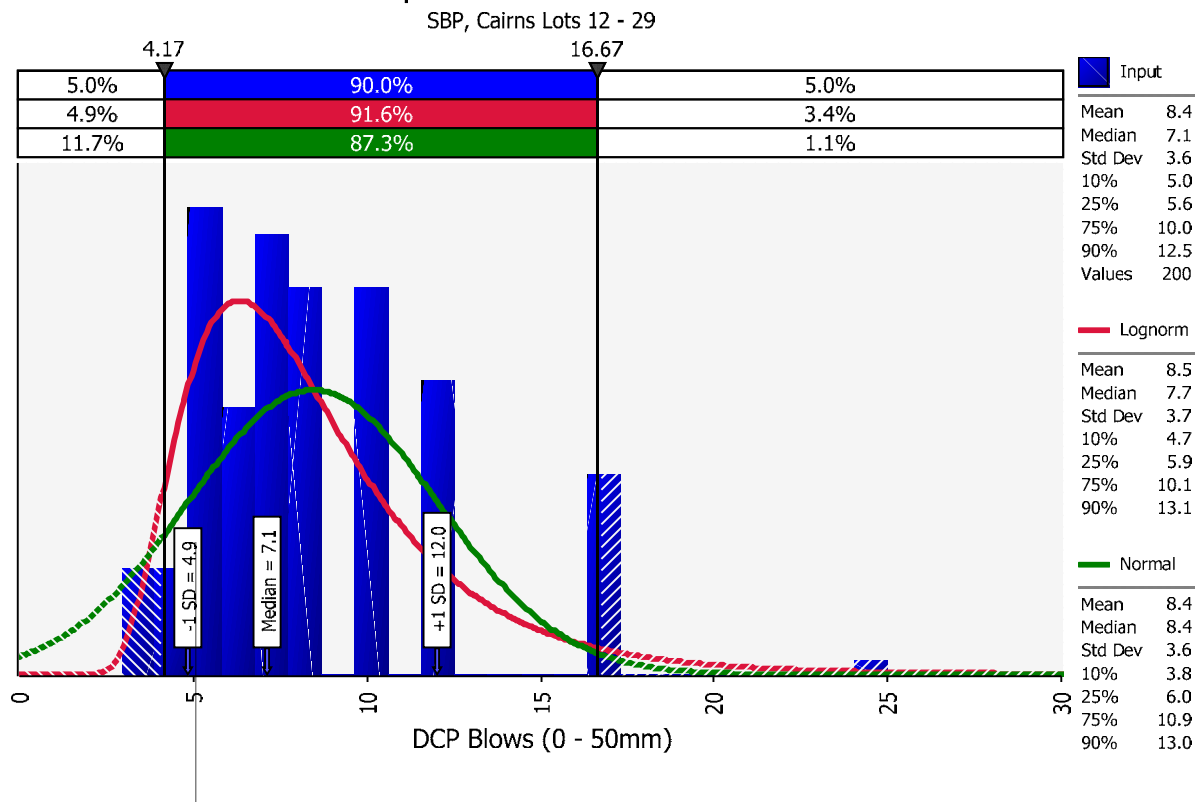
SBP, Cairns: Tests 12 - 30



Fit Comparison for LFWD -@100kPa - Tests 21 - 26



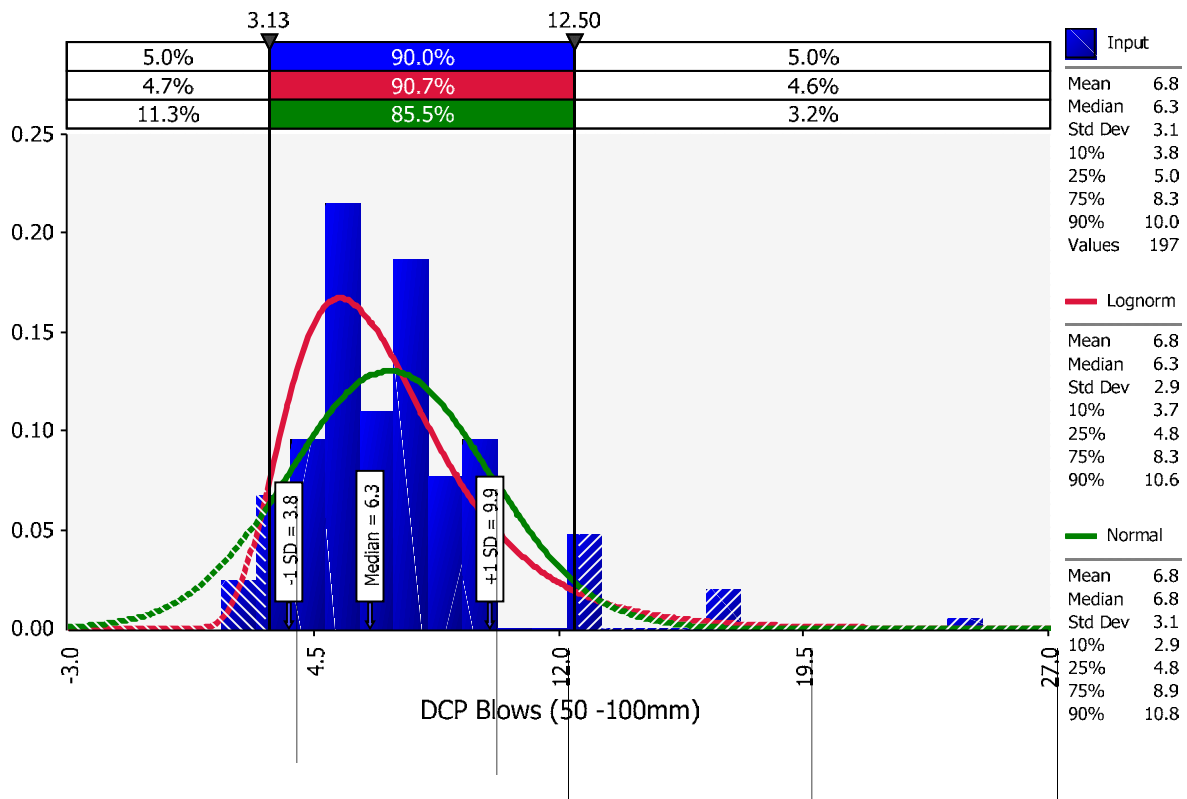
Fit Comparison for DCP: 0 – 50 mm





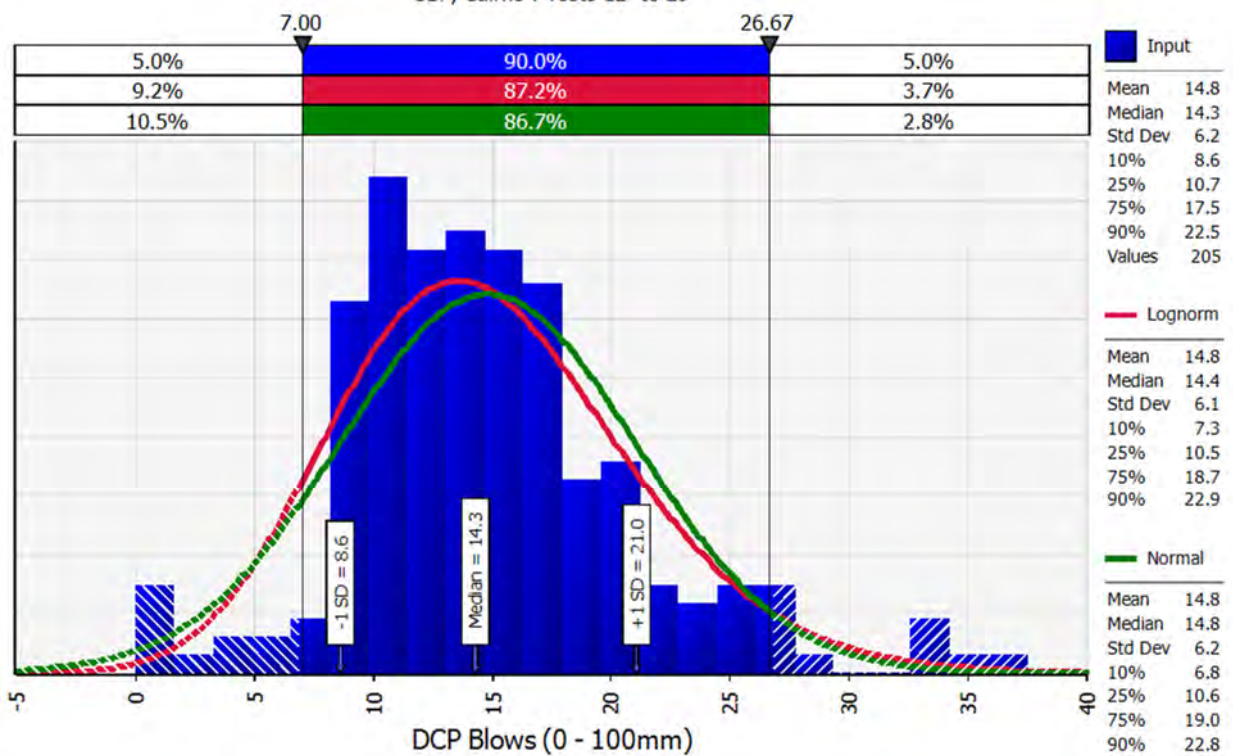
Fit Comparison for DCP : 50 – 100 mm

SBP : Tests 12 - 29



Fit Comparison for DCP : 0 - 100

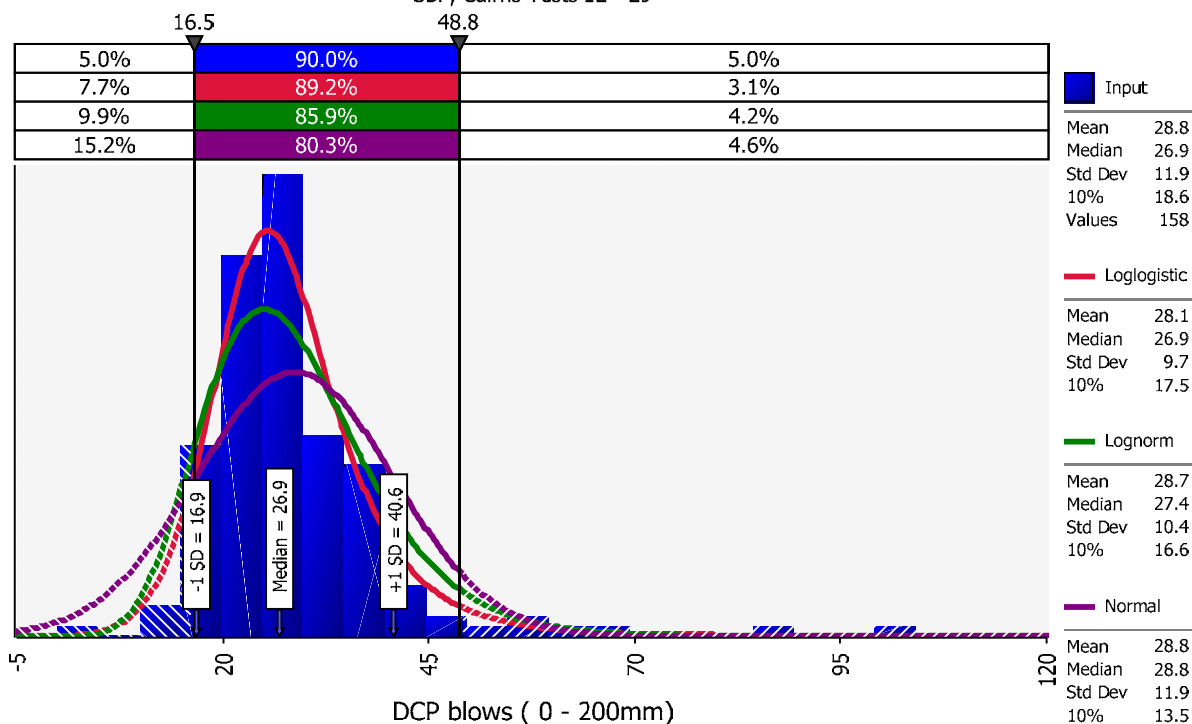
SBP, Cairns : Tssts 12 to 29





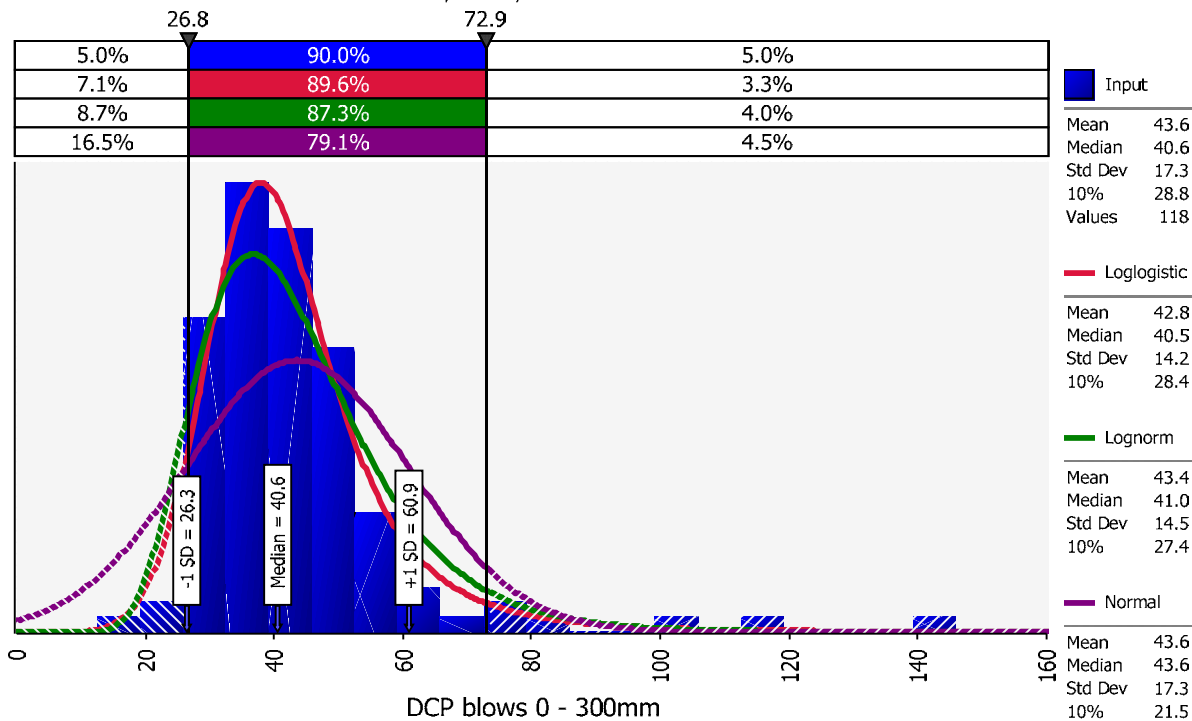
Fit Comparison for DCP 0 - 200 mm

SBP, Cairns Tests 12 - 29



Fit Comparison for DCP 0-300mm

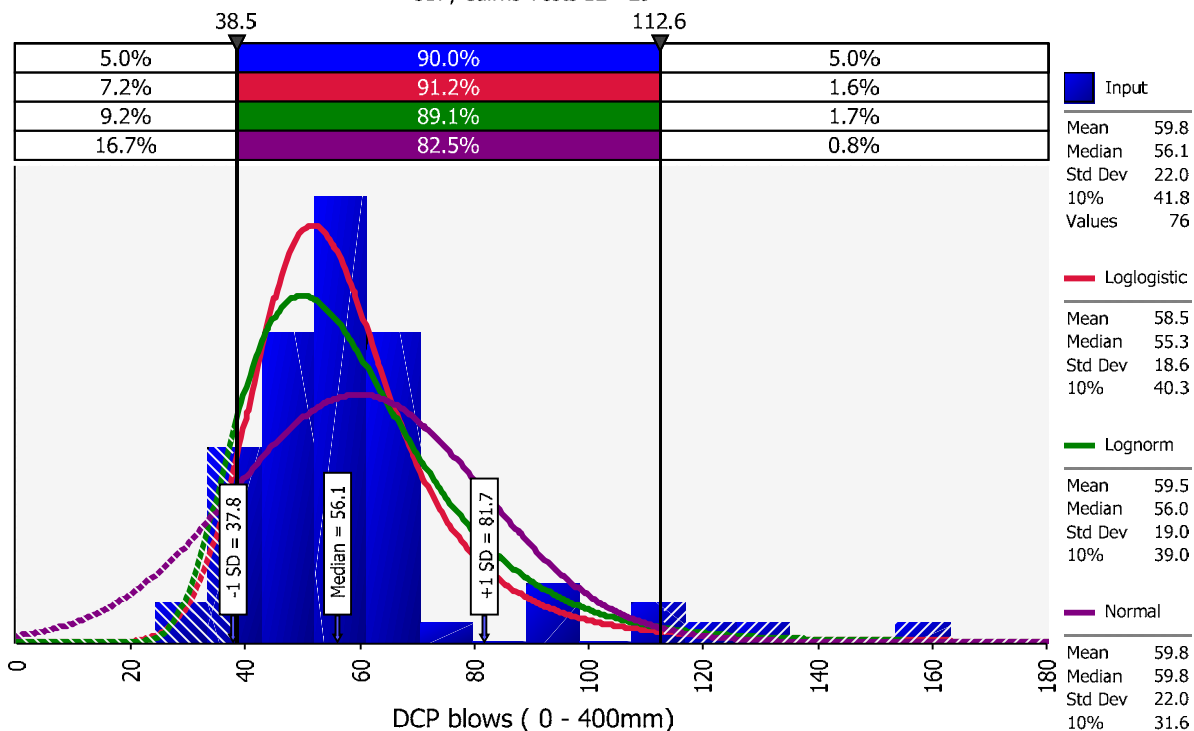
SBP, Cairns, Tests 12 - 29





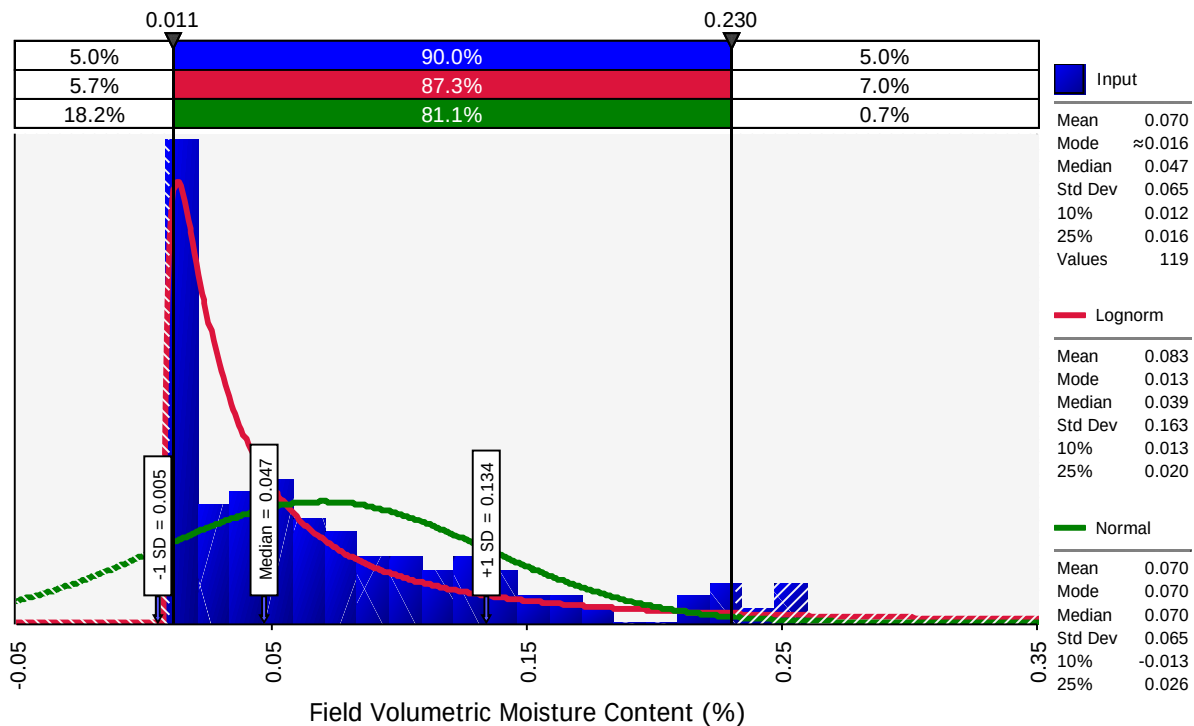
Fit Comparison for DCP 0-400mm

SBP, Cairns Tests 12 - 29



Fit Comparison for Field Volumetric Moisture Content

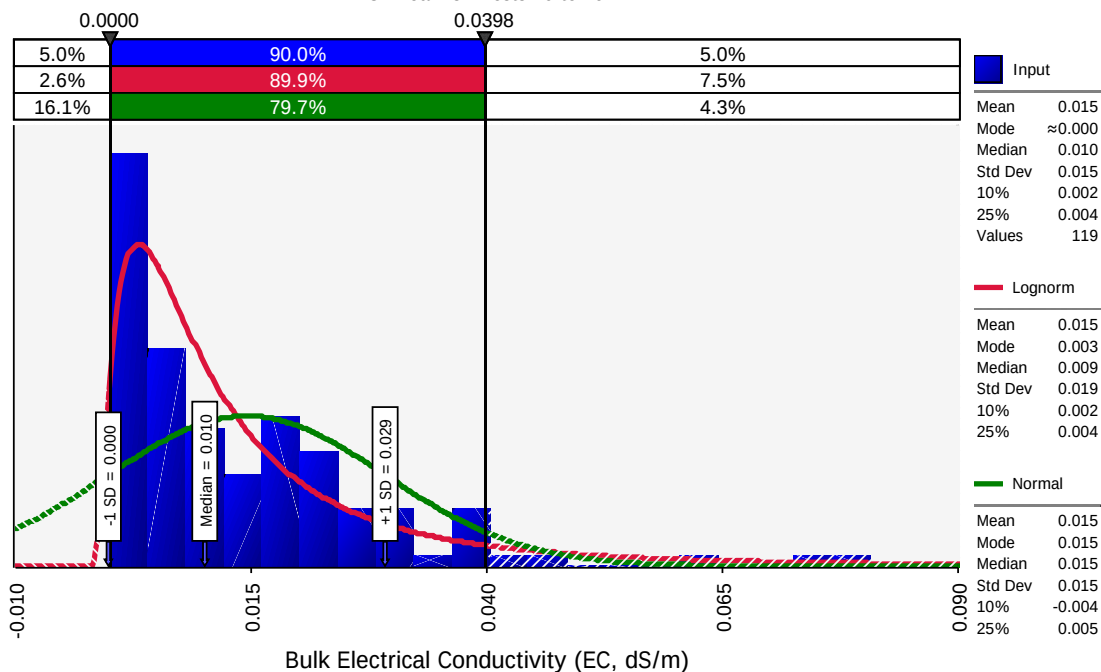
SBP Cairns - Tests 16 to 29





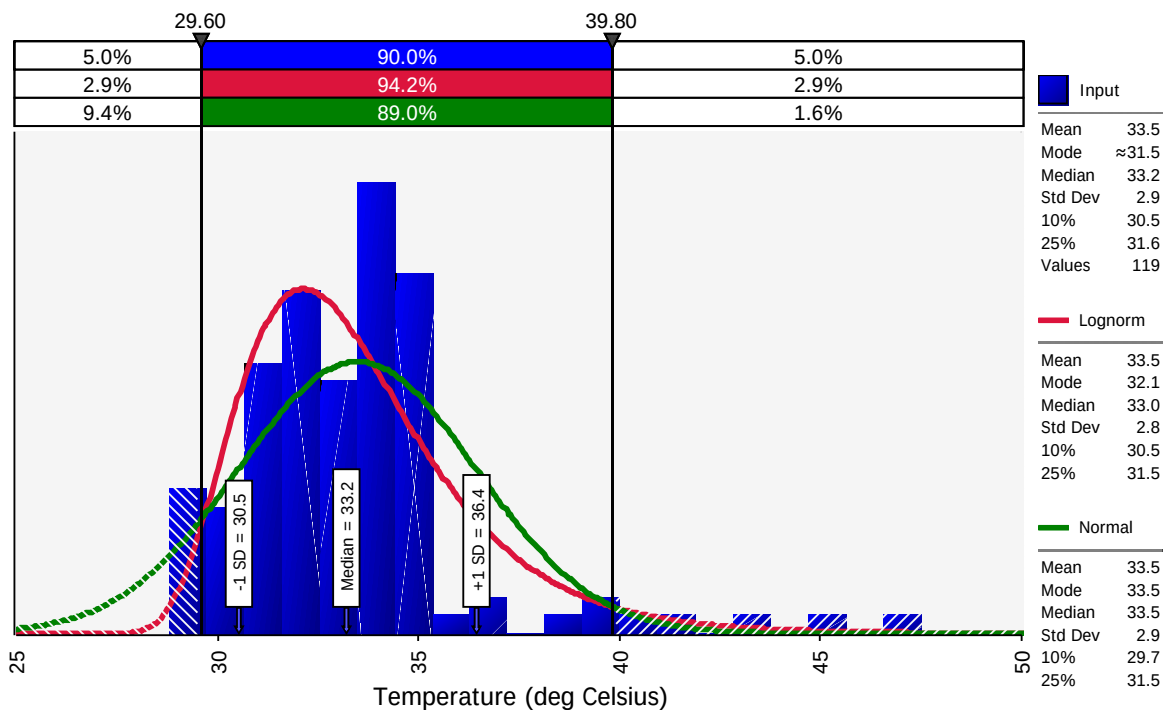
Fit Comparison for Bulk Electrical Conductivity

SBP Cairns - Tests 16 to 29



Fit Comparison for Soil Temperature

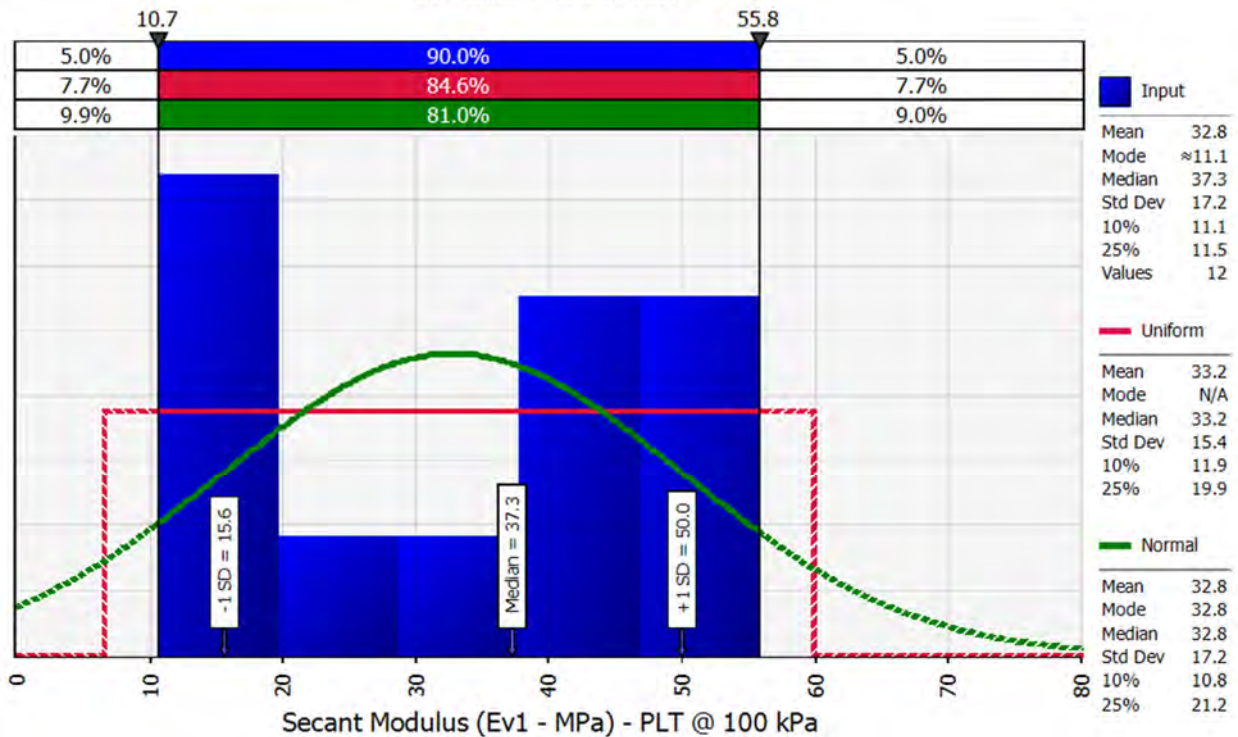
SBP Cairns - Tests 16 to 29





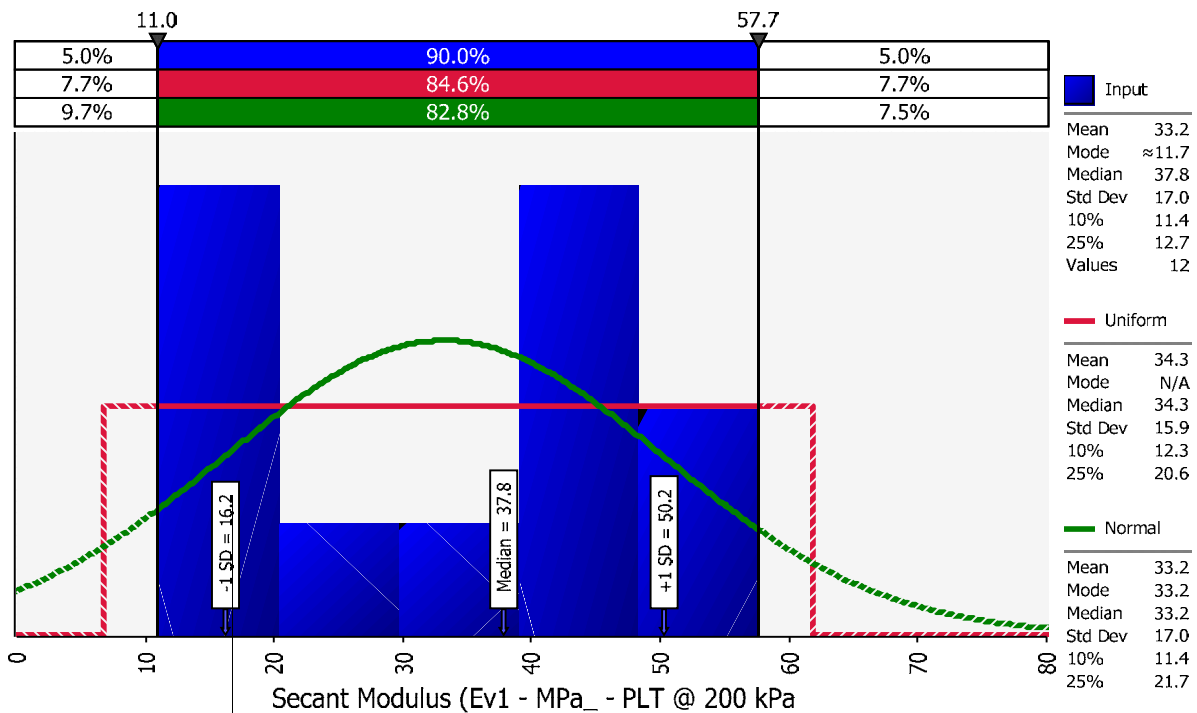
Fit Comparison for PLT Ev1 @ 100 kPa

SBP Cairns - Tests 21 to 26



Fit Comparison for PLT Ev1 @ 200 kPa

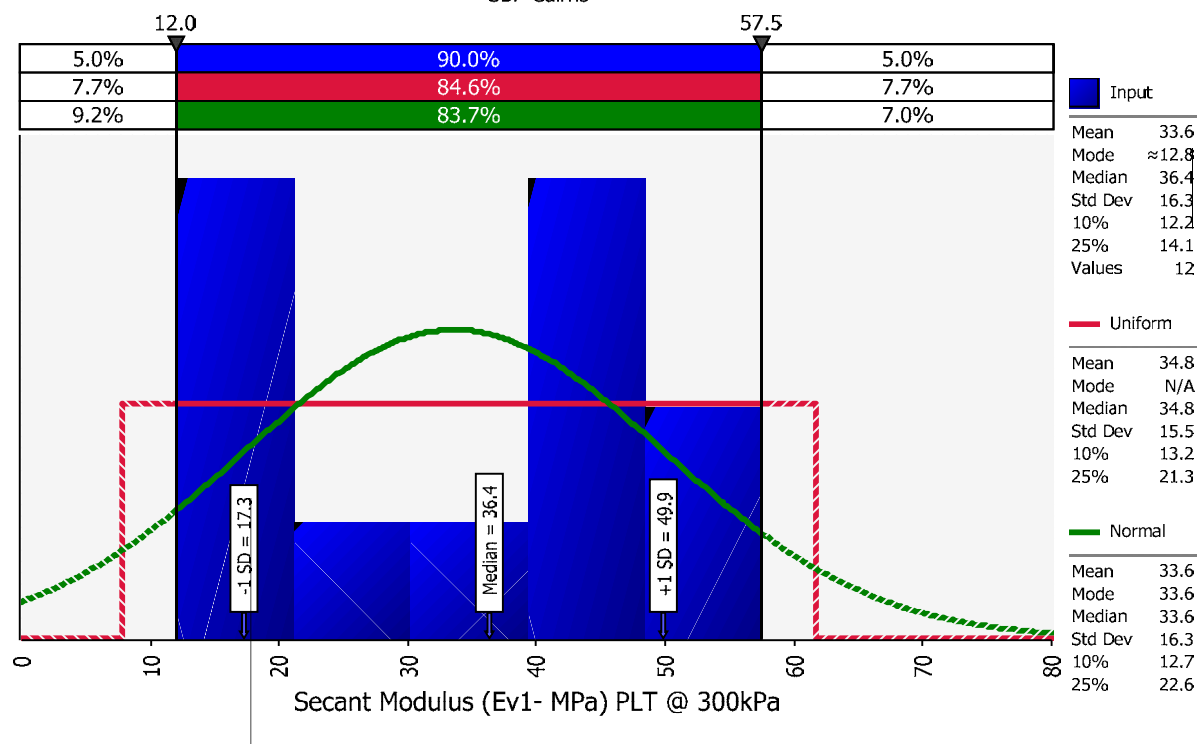
SBP Cairns





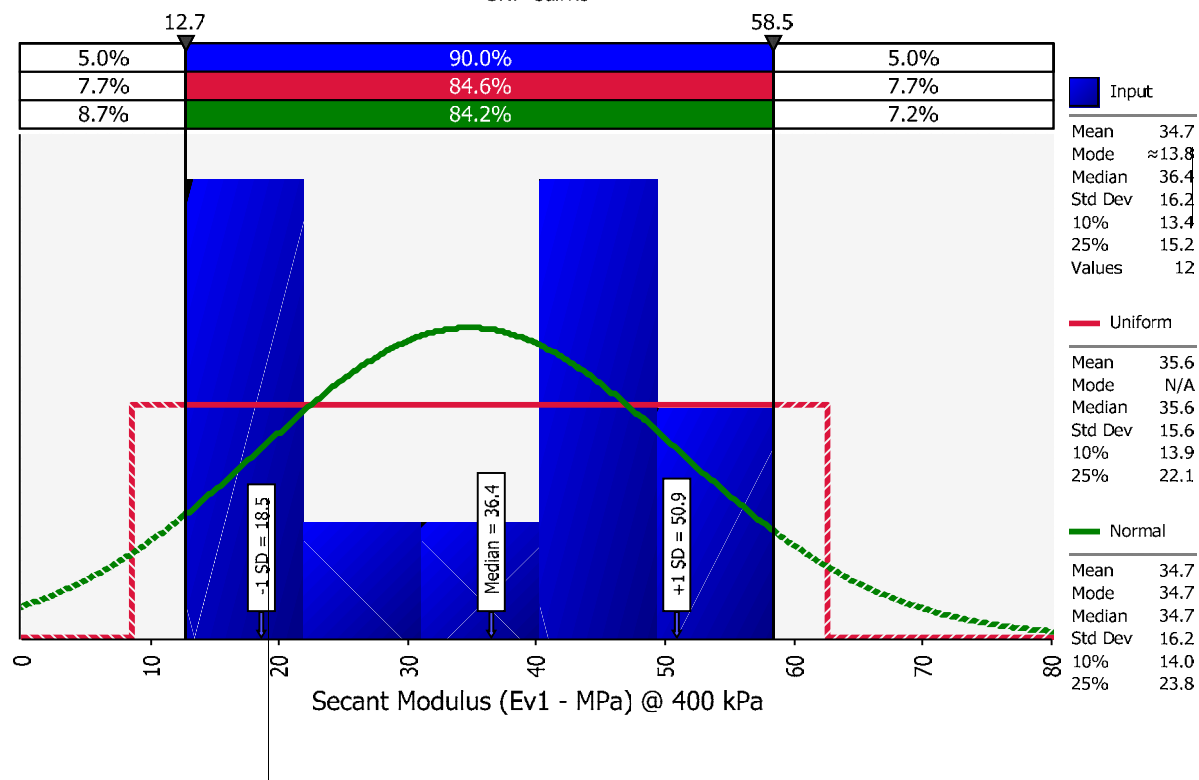
Fit Comparison for PLT Ev1 @ 300 kPa

SBP Cairns



Fit Comparison for PLT Ev1 @ 400 kPa

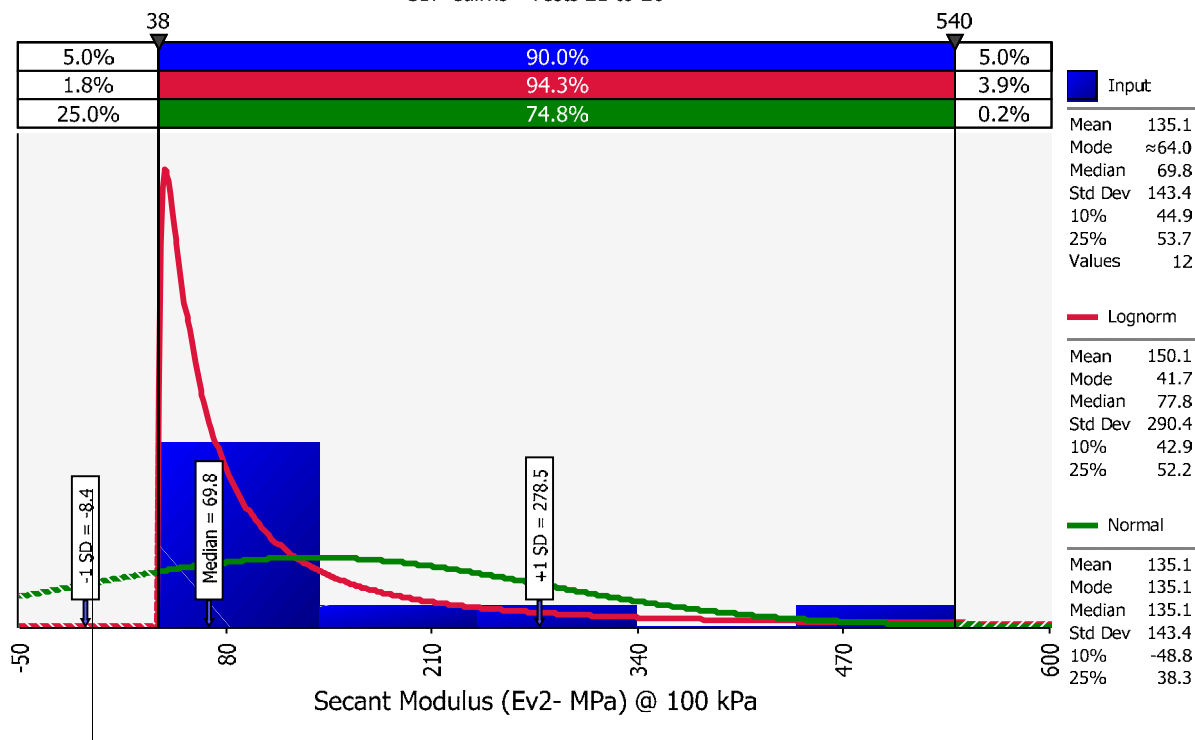
SNP Cairns





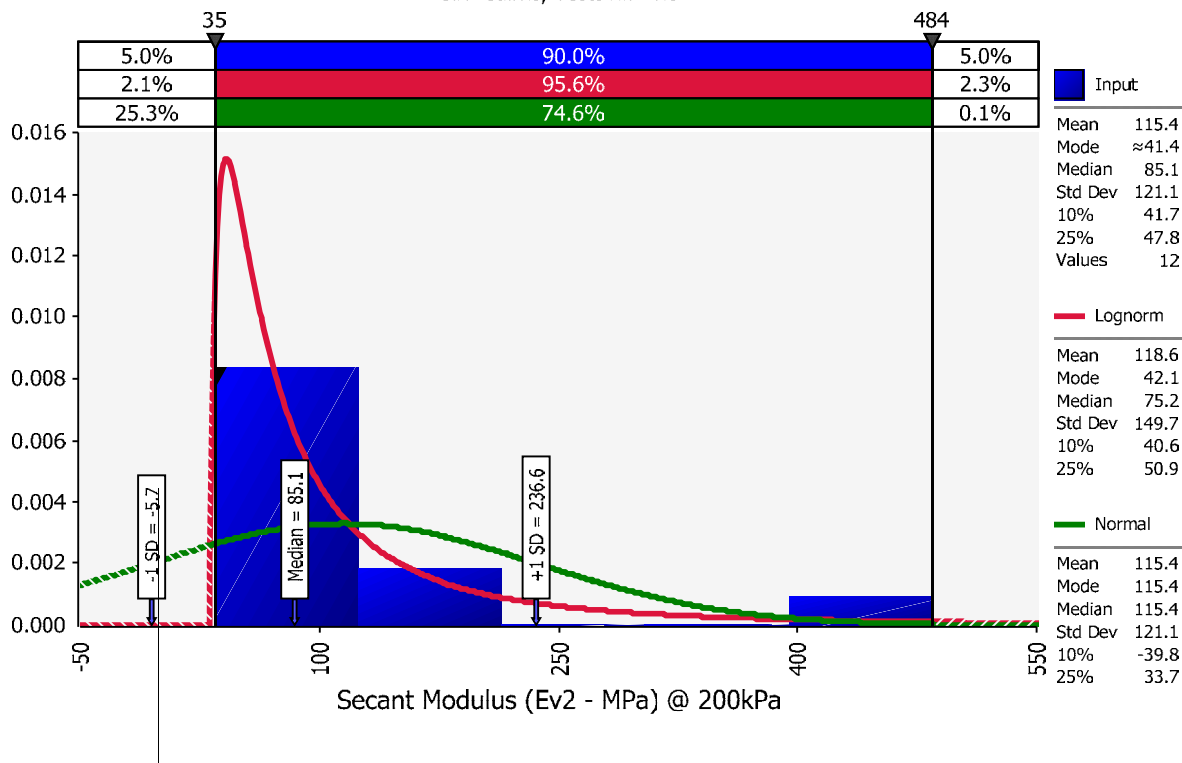
Fit Comparison for PLT Ev2 @ 100 kPa

SBP Cairns - Tests 21 to 26



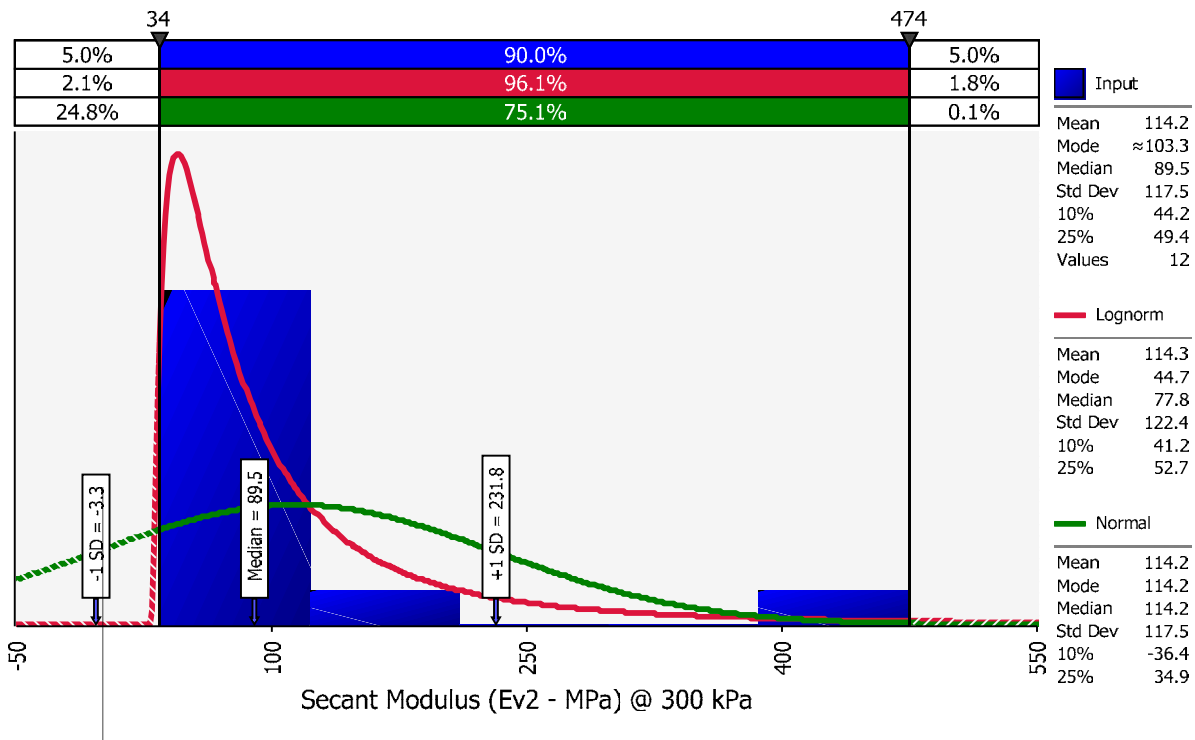
Fit Comparison for PLT Ev2 @ 200 kPa

SBP Cairns, Tests 21 - 26



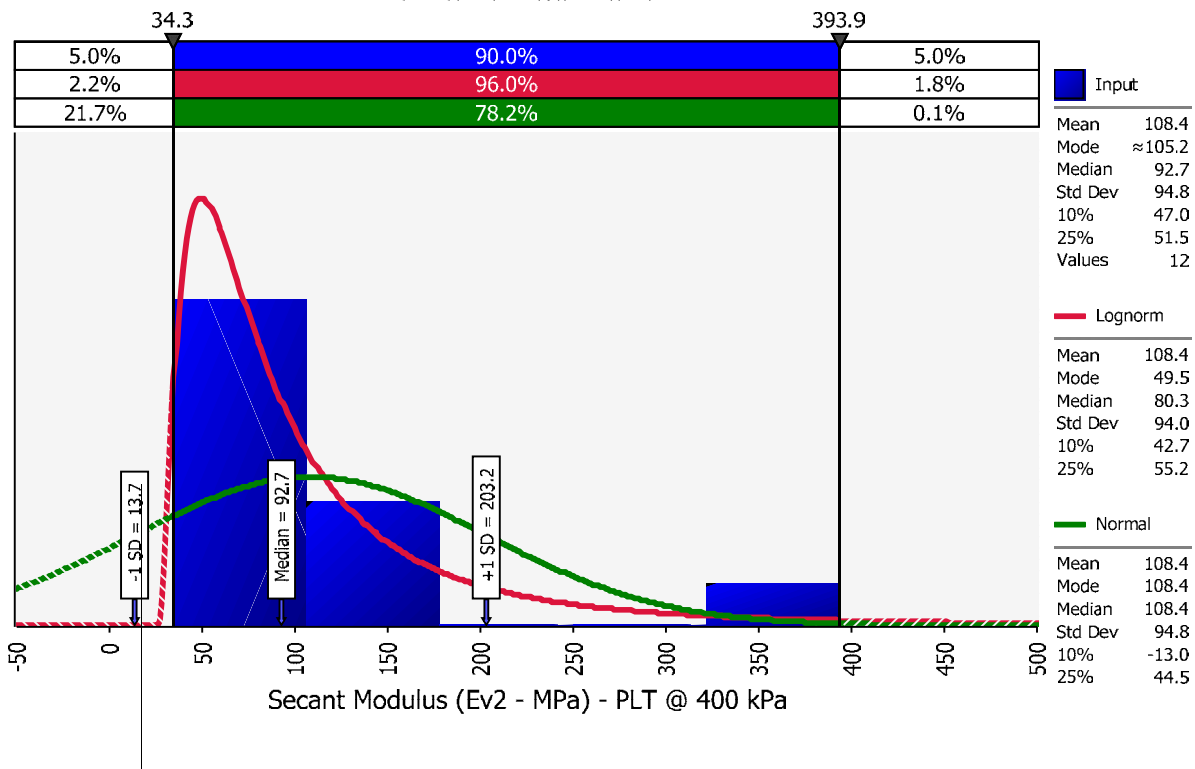
Fit Comparison for PLT Ev2 @ 300 kPa

SBP Cairns - Tests 21 - 26



Fit Comparison for PLT Ev2 @ 400 kPa

SBP Cairns - Tests 21 to 26





Appendix K

Correlation Matrix Summary



Field Dry Density

LFWD @ 100 kPa (0.27)
LFWD @ 50 kPa
DCP @ 0 - 300mm (0.20)
DCP @ 0 - 200mm (0.17)
Relative Compaction (0.15)
DCP @ 0 - 400mm
DCP @ 0 - 100mm
Moisture Ratio
DCP @ 50 - 100mm (0.10)
DCP @ 0 - 50mm
Field Moisture Content (0.07)

Relative Compaction

DCP @ 0 - 300mm (0.22)
DCP @ 0 - 400mm (0.19)
DCP @ 0 - 200mm
LFWD @ 100 kPa (0.18)
Field dry Density
LFWD @ 50 kPa
DCP @ 0 - 100mm (0.15)
DCP @ 50 - 100mm
Moisture Ratio (0.11)
DCP @ 0 - 50mm
Field Moisture Content (0.07)

Field Moisture Content

LFWD @ 100 kPa (0.44)
Moisture Ratio (0.37)
LFWD @ 50 kPa
DCP @ 0 - 200mm (0.3)
DCP @ 0 - 300mm
DCP @ 0 - 100mm (0.22)
DCP @ 0 - 400mm (0.19)
DCP @ 50 - 100mm
DCP @ 0 - 50mm (0.15)
Relative Compaction
Field Dry Density (0.07)

Moisture Ratio

LFWD @ 100 kPa (0.48)
LFWD @ 50 kPa (0.39)
Field Moisture Content
DCP @ 0 - 100mm (0.29)
DCP @ 0 - 200mm
DCP @ 50 - 100mm (0.24)
DCP @ 0 - 400mm
DCP @ 0 - 50mm (0.19)
DCP @ 0 - 300mm
Field Dry Density
Relative Compaction (0.11)

**LFWD
Modulus
@ 50 kPa**

Moisture Ratio (0.39)

LFWD @ 100 kPa

Field Moisture Content

DCP @ 0 - 100mm (0.27)

DCP @ 0 - 400mm

DCP @ 0 - 200mm

Field Dry Density (0.20)

DCP @ 0 - 300mm (0.15)

Relative Compaction

DCP @ 50 - 100mm

DCP @ 0 - 50mm (0.07)

**LFWD
Modulus
@ 100
kPa**

Field dry Density (0.46)

Field Moisture Content

Moisture Ratio (0.37)

LFWD @ 50 kPa (0.34)

DCP @ 0 - 200mm

DCP @ 0 - 100mm

Relative Compaction

DCP @ 0 - 400mm (0.24)

DCP @ 0 - 300mm

DCP @ 50 - 100mm (.20)

DCP @ 0 - 50mm (0.10)



DCP - (0 - 50 mm)

DCP @ 50 - 100mm (0.43)

DCP @ 0 - 100mm (0.31)

Moisture Ratio (0.16)

DCP @ 0 - 400mm

DCP @ 0 - 300mm

DCP @ 0 - 200mm

Field dry Density

LFWD @ 100 kPa (0.10)

LFWD @ 50 kPa

Field Moisture Content (0.07)

Relative Compaction (-0.12)

DCP - (50 - 100 mm)

DCP @ 0 - 50mm (0.43)

DCP @ 0 - 100mm

Field Moisture Content (0.26)

LFWD @ 100 kPa (0.20)

Moisture Ratio (0.19)

DCP @ 0 - 200mm

DCP @ 0 - 300mm

DCP @ 0 - 400mm

Field dry Density

LFWD @ 50 kPa (0.14)

Relative Compaction (0.09)

DCP - (0 - 100 mm)

DCP @ 50 - 100mm (0.42)

DCP @ 0 - 200mm

DCP @ 0 - 50mm

Moisture Ratio

LFWD @ 100 kPa (0.28)

LFWD @ 50 kPa

DCP @ 0 - 300mm

Field Moisture Content

DCP @ 0 - 400mm (0.21)

Relative Compaction (0.15)

Field Dry Density (0.14)

DCP - (0 - 200 mm)

DCP @ 50 - 100mm (0.38)

DCP @ 0 - 100mm

LFWD @ 100 kPa (0.34)

Field Moisture Content

DCP @ 0 - 300mm

DCP @ 0 - 400mm

Moisture Ratio

LFWD @ 50 kPa (0.24)

Relative Compaction (0.18)

DCP @ 0 - 50mm

Field Dry Density (0.14)

DCP - (0 - 300 mm)

DCP @ 0 - 400mm (0.27)

DCP @ 0 - 200mm

Field Moisture Content

DCP @ 0 - 100mm

Relative Compaction (0.22)

Field Dry Density (0.20)

DCP @ 50 - 100mm (0.19)

DCP @ 0 - 50mm

LFWD @ 100 kPa

Moisture Ratio

LFWD @ 50 kPa (0.15)

DCP - (0 - 400 mm)

DCP @ 0 - 300mm (0.27)

DCP @ 0 - 200mm

Moisture Ratio

LFWD @ 100 kPa

LFWD @ 50 kPa (0.24)

DCP @ 0 - 100mm (0.21)

Field Moisture Content (0.19)

Relative Compaction

Field Dry Density

DCP @ 50 - 100mm

DCP @ 0 - 50mm (0.15)



Field Dry Density	Relative Compaction (0.78)
	Adjusted Max Dry Density (0.33)
	% Oversize > 38mm (0.24)
	Assigned OMC (-0.27)
	Adjusted OMC (-0.31)
	Moisture Ratio Adjusted for oversize (-0.37)
	Moisture Ratio Reported (-0.41)
	Moisture Ratio Recalculated (-0.41)
Relative Compaction	Field Moisture Content (-0.47)
	Field Dry Density (0.78)
	Adjusted OMC (0.16)
	Assigned OMC (-0.07)
	% Oversize > 38mm (-0.20)
	Adjusted Max Dry Density (-0.26)
	Moisture Ratio Recalculated (-0.28)
	Field Moisture Content (-0.29)
Field Moisture Content	Moisture Ratio Reported (-0.30)
	Moisture Ratio Adjusted for oversize (-0.38)
	Moisture Ratio Recalculated (0.98)
	Moisture Ratio Reported (0.95)
	Moisture Ratio Adjusted for oversize (0.92)
	Adjusted OMC (0.35)
	Assigned OMC (0.07)
	Relative Compaction (-0.29)
Moisture Ratio Adjusted for oversize	Adjusted Max Dry Density (-0.30)
	% Oversize > 38mm (-0.33)
	Field Dry Density (-0.47)
	Moisture Ratio Reported (0.94)
	Moisture Ratio Recalculated (0.93)
	Field Moisture Content (0.92)
	Adjusted Max Dry Density (0.01)
	% Oversize > 38mm (0.00)
	Adjusted OMC (-0.01)
	Assigned OMC (-0.07)
	Field Dry Density (-0.37)
	Relative Compaction (-0.38)

Spearman rank coefficient shown with relative effect between the different tests

