

GEOTECHNICAL INVESTIGATION REPORT MURIWAI DOWNS RESERVOIR MURIWAI VALLEY

Engineers and Geologists

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1.0 Introduction

Riley Consultants Ltd (RILEY) has been engaged by The Bears Home Project Management Limited (BHPM) to undertake a geotechnical investigation and assessment of a proposed water storage reservoir in Muriwai Valley, Auckland.

Preliminary design drawings by McKenzie & Co indicate the reservoir will be excavated several meters into the existing slope, with a small ring embankment up to 3m high on the northern, eastern, and western sides. The southern slope will be cut into the hillside and excess fill materials placed in a nominated disposal area upslope to the south.

The primary objectives of the investigation were to:

- Specify the geological context of the reservoir site, and how this could influence structural safety, water retention, and reservoir slope integrity.
- Determine if any prohibitive geological or geotechnical conditions exist that could prohibit safe and cost-effective construction and operation.
- Support a package of work for a resource consent application to Auckland Council (Council).

We expect this report will accompany others being prepared by WWLA and Mckenzie & Co.

2.0 Site Description

The proposed reservoir site is located on a very gentle (<5°) north facing slope approximately 9km south-west of Kumeu, Auckland. It is bordered by Muriwai Road to the north, an ephemeral stream to the west and perennial stream to the east. Access to the site from the north is via the neighbouring sand quarry at 555 Muriwai Road. Additionally, a private farm track extends from the north-eastern corner of the site through the middle of the site.

The site is currently in pasture with livestock grazing. The steep slopes down to the stream and gully are also in pasture with the immediate stream banks well vegetated with occasional large shrubs and trees.

A quarry 2.5ha in plan area and up to 25m deep is located approximately 300m west of the proposed reservoir (Muriwai Sandstone Quarry).

3.0 Desktop Review

A desktop review of available geotechnical information on regional and local geology, geomorphology, seismicity, and historic geotechnical investigation data was undertaken prior to undertaking site investigations. The review enabled development of a preliminary geological model for the site, which was then used to develop the site investigation programme. Results of the desktop review are presented below.



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3.1 Geological Setting

The GNS Science 1:250,000-scale QMAP and accompanying bulletin for the area (Map 3 'Auckland', 2001) indicates the site is underlain by Late Pliocene-age Awhitu Group Dunes (Pad) comprising unconsolidated bedded dune sands with intercalated paleosols, lignite and carbonaceous mudstone and some extremely weak, sub-horizontally bedded sandstone 1.8 to 3.6 million years old – Figure 1. Due to the predominant westerly winds the dune sands create gentle westerly (windward) facing slopes and steeper easterly (leeward) slopes.

The site is located adjacent to a perennial stream along the south-eastern boundary. The stream approximately defines the geological boundary between recent alluvial/colluvial deposits of the Tauranga Group (Qa1) and the older Nihotupu Formation (Mtn) submarine volcaniclastic sandstones and siltstones of the Manukau Group. The Nihotupu Formation likely underlies the Awhitu Group dunes at depth beneath the site.

An inferred basalt sill of the Waiatarua Formation (Mtw) is mapped to the north of the site. Its possible extent beneath the site is uncertain, however, it was not encountered in any subsurface investigations at the site.

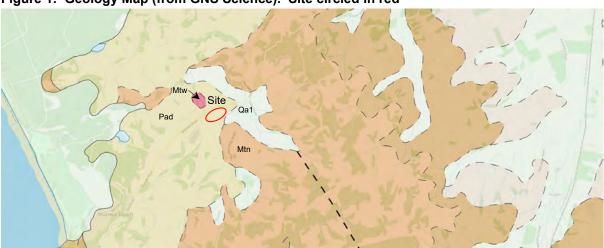


Figure 1: Geology Map (from GNS Science). Site circled in red

3.2 *Review of Aerial Imagery*

Ground elevation contours generated from 1m LiDAR flown in 2016 indicates the reservoir footprint generally sits within the existing contours on a terrace feature at the base of gentle (< 5°) northerly facing slopes. At the south-eastern extents of the reservoir and fill area, the slopes down to the stream increase steeply to between 15° and 30°. Slopes down to the western gully are gentle to moderate (~12°).

The aerial imagery indicates the site has been used for pasture since the 1980s. A dairy effluent disposal field was installed on the site within the reservoir footprint in early 2019.

4.0 Geotechnical Site Investigations

A geotechnical investigation was undertaken at the reservoir site and fill disposal area, involving:

- 1. Desktop review of available geotechnical information.
- 2. Walkover inspection and field mapping of the site and surrounds.

- 3. Inspection of the existing quarry (Muriwai Sandstone Quarry) to the immediate west of the site.
- 4. Subsurface investigations comprising:
 - a. 12 no. machine excavated test pits.
 - b. Retrieval of bulk soil samples from test pits for laboratory testing.
 - c. 3 no. machine boreholes with standard penetration tests (SPTs).
 - d. Installation of standpipe piezometers in each machine borehole.
 - e. 12 no. cone penetrometer tests (CPTs).
 - f. 4 no. Seismic Dilatometer tests (sDMTs).

Test locations and depths were selected based on the preliminary design provided by McKenzie and Co. with the aim of achieving suitable coverage across the site, and characterising soils for conceptual borrow/cut areas and embankment locations and heights.

Site investigations were undertaken between 4 August 2021 and 12 August 2021. Some of the proposed test locations were moved due to practical constraints. Final test locations are shown on the appended Site Plan, RILEY Dwg: 210339-1 (Appendix H).

Materials were logged by a RILEY engineer/geologist in accordance with the New Zealand Geotechnical Society, Field Description of Soil and Rock Guidelines (2005).

4.1 Geomorphological Site Assessment

A walkover was undertaken by a senior engineering geologist from RILEY to undertake preliminary geological mapping.

The following comments can be made:

- The general site geomorphology comprises dunes with generally gentler western slopes and steeper eastern slopes, likely representative of the prevailing wind directions during formation of the sand deposits.
- Exposures at the nearby quarry indicate the complexity of dune deposits with younger dunes overlying older dunes and filling of previous channels/depressions with further sand deposits and fine-grained soils (Photos 1 and 2).
- Cementation of the sand deposits with limonite (iron oxide) and clay minerals varies vertically and laterally across the site (i.e., does not appear consistent). A hardpan (typically a 0.2m to 1.0m thick limonite cemented sand layer running approximately coincident with ground surface) has been encountered within 3m of ground surface across portions of the site. It would appear from exposures, geomorphic expression and subsurface investigations, that this layer is not present across the entire site.
- The dune deposits have been subsequently incised by two north draining streams near the investigated site, with the eastern stream bordered by degraded alluvial terraces.

- Erosion associated with incision of these streams has exposed an apparent more resistant and stronger cemented sand horizon around the perimeter of the ridge upon which the reservoir is proposed (Photo 3). This layer, which appears to be dipping gently to the west, often presents on-site as outcrops and steeper slopes. It also appears to be associated with water springs. The cementation of this horizon does appear to vary across the site. Near the eastern corner of the proposed reservoir the strength of this layer appears to be significantly less than other locations as evidenced by lack of steeper slope definition and greater gully headward erosion (Figure 2). This is also supported by subsurface investigation at the location.
- The springs are noted to be associated with gully headward erosion near the proposed development, likely as a result of saturation of the soil deposits and possible degradation of cementation (Figure 3). The springs appear to emerge beneath the weakly cemented sand layer and with preferential erosion undermining the cemented sand layer.
- No obvious sinkhole or 'tomo' features were observed in the walkover or encountered in the subsurface investigation.
- On the eastern steeper slopes, shallow type ground movement (known as 'sheep tracks' or terracetting) was noted on slopes of 27° (1V:2H) or steeper. Natural slopes of any significant size did not seem to exceed an angle of about 34°.

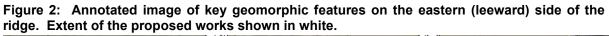


Photo 1: Natural filling of depression with later dune deposits in Awhitu Group exposed at the Muriwai Sandstone Quarry. Boundaries of the depression are arrowed. Within the depression fill is cross bedding and an unconformity.



Photo 2: Weakly cemented sand material overlying clayey silt exposed in the quarry. The clayey silt has been subject to preferential erosion compared to the sand above most likely due to frittering on stress relief joints. This fine-grained material, including some organics, filled a small depression under the weakly cemented sand. This preferential erosion of layers is also seen near the subject site.

• On the eastern (leeward) side of the ridge are mid-slope terraces. These are inferred to be primarily a combination of elevated degraded terraces and debris from headward gully erosion. This is illustrated in Figure 2.



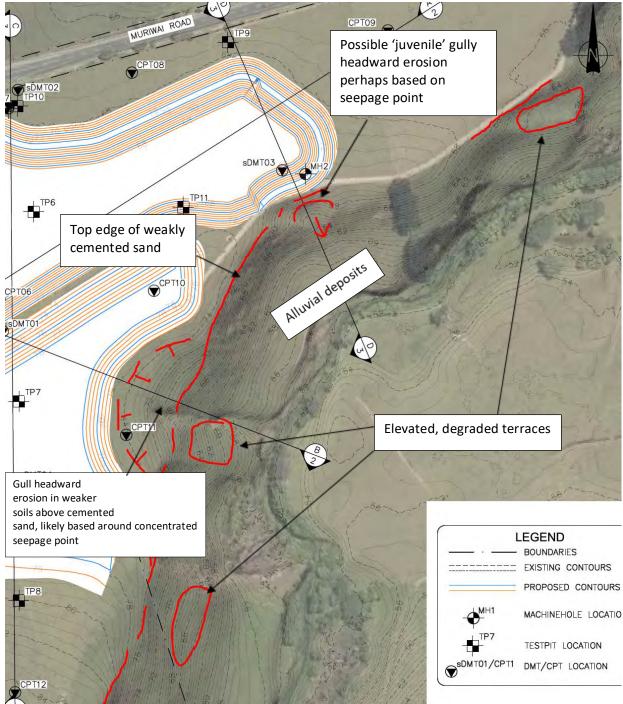




Photo 3: Weakly cemented sand horizon underlain by interlayered silts and sands. The weakly cemented sand is relatively resistant to erosion whereas the weaker interlayered beds beneath have been preferentially weathered. Although the strength of the weakly cemented sand horizon does vary across the site, this stratification is believed to underlie much of the ridge the proposed works are to be undertaken.

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Figure 3: Image from Google Earth (date July 2015). Solid red lines illustrate inferred extent of weakly cemented resistant sand layer as exposed at the surface. Dashed lines signify where the sand layer is possibly less cemented and subject to headward gully erosion. Evident is the water springs which appear to align with the cemented sand horizon.



4.2 Test Pits

A total of 12 test pits were excavated with a 13-tonne excavator operated by Burnetts Transport and Earthmoving between 4 August 2021 and 5 August 2021, to depths between 4.4m and 4.8m (target depth extent of excavator reach).

Four were undertaken within the reservoir footprint as part of the reservoir basin and borrow area investigation (TP2, TP4, TP6, and TP11); four as part of the dam embankment foundation assessment (TP3, TP5, TP9, and TP10); and four at the margins of the fill disposal area (TP1, TP7, TP8, and TP12).

Following logging and sampling, pits were backfilled with the arisings and tracked over to match the previous ground surface.

Test pit logs are presented in Appendix A.

4.2.1 Laboratory Tests

Bulk soil samples were collected from selected locations within the test pits for laboratory testing by WSP Ltd (WSP), an IANZ accredited soil laboratory.

A suite of tests was performed including particle size, plasticity, compaction, and material behaviour tests as summarised in Table 1. This information will be used to inform detailed design of the reservoir including material suitability for dam embankment construction, strength parameters, and construction processes.

				Particle Size							
Test Pit ID	Sample Depth (mbgl)	Sample Description		Atterberg Limits	Wet Sieve	Hydro	Fines content (75 µm split)	Standard Compact. Test		Emerson Crumb	
TP2	1.8	Silty CLAY	1	1		1		1	1	1	
TP2	2.0	Silty sandy CLAY			1						
TP2	3.4	Cemented SAND			1						
TP4	2.4	Silty SAND			1						
TP6	2.1	Sandy SILT	1	1		1		1		1	
TP6	2.9	SAND			1						
TP8	1.7	Silty SAND					1				
TP10	1.8	Silty CLAY		1		1	1			1	
TP11	1.7	Sandy SILT				1					
TP11	2.0	Silty SAND			1						
		Total	2	3	5	4	2	2	1	3	

 Table 1: Bulk Samples Collected for Soil Testing and Tests Undertaken

Note: 1. Meters below ground level (mbgl).

4.3 Machine Boreholes

Machine boreholes were drilled by Drill Force Ltd between 9 August 2021 and 11 August 2021 using a Hydra Power Trekker TK060 track-mounted rotary drill rig, to depths ranging 11m to 14m.

Sample recovery was generally good with greater than 75% recovery in all boreholes except for MH02, which experienced 100% core loss between 5.5m to 6.0m. This is attributed to the presence of saturated, loose to medium dense sand that appears to have liquefied by the drilling process.

Standard Penetration Tests (SPT) tests were undertaken at 1.5m intervals using a split spoon driven by a safety auto trip hammer. Due to COVID-19 Level 4 restrictions it is unknown which hammer is on the rig used. The measured energy transfer ratio (efficiency) across all 12 hammers owned by Drill Force ranges from 72% to 82%, with an average of 77%. We have conservatively adopted a value of 80% for the purposes of our assessment.

Core samples were retrieved and placed in boxes and photographed on-site. Borehole logs, core photographs, and the SPT hammer efficiency certificate can be found in Appendices B, C, and D, respectively.

4.3.1 **Piezometer Installations**

Standpipe piezometers were installed in each of the machine boreholes upon completion of drilling. These comprised machine-slotted internally threaded 32mm PVC pipe with screens of various lengths (see Table 2). Approximately 0.5m high upstands were protected by lockable steel 'toby boxes' and cemented in place. Backfill materials comprised a blinding sand and filter sand around the slotted sections, and hydrated bentonite pellets for seals. Boreholes were flushed with clean water prior to installation.

Machine Hole ID	Screen Interval (m bgl)	Screen Length (m)	Geology
MH1	10.5m to 13.5m	3.0	Slightly cemented SAND
MH2	4.5 to 6m 7.5 to 9m	1.5 1.5	Slightly cemented SAND
MH3	3.5 to 6m	2.5	Loose SAND

Table 2: Borehole Piezometer Screen Installation	۱
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4.4 Cone Penetrometer Tests

Cone Penetrometer Testing (CPT) was undertaken by Drill Force Ltd on 10 August 2021 using an 18T Geomil Panther capable of pushing 170kN and up to 40m depth. CPTs were advanced to a target depth of 15m or earlier refusal.

4.5 Seismic Dilatometer Testing

Drill Force Ltd also conducted down-hole seismic dilatometer testing across four locations on 12 August 2021 using the same 18T Geomil Panther rig. Testing was carried out between 2m and 11.5m below ground level (bgl) and was conducted in accordance with ASTM and Eurocode standards. The sDMT is a flat dilatometer, which measures the shear wave velocity between two receivers located at 0.5 m apart. When a shear wave is generated at surface, involving striking a timber beam with a sledgehammer, to produce a shear-wave signal, it reaches first the upper receiver, then, after a delay, the lower receiver. The sDMT test results are presented in Appendix E.

5.0 Investigation Findings

5.1 Stratigraphy/Geological Model

Test pitting allowed visual observation of material characteristics to 4.8m depth, while CPT/sDMT and Machine boreholes provided information on soil types and properties (e.g., strength and groundwater depth) to 14m depth. Inspection of the adjacent quarry enabled visual appraisal of the quarry faces up to c.25m depth.

Within the quarry faces, the Awhitu Group deposits were observed as moderately weathered, very weak to extremely weak sand with some thick bedding and cross bedding and occasional discontinuous cemented hardpan layers.

In general accordance with the GNS Science QMAP map for the area, the materials encountered in the RILEY site investigations comprised Awhitu Group Dune deposits which were observed in all investigation locations and were generally described as medium dense, fine-grained sand and silty fine-grained sand becoming dense with depth and with slightly cemented layers. Awhitu Group sands vary in density with depth (as is common with sand dune deposits). The level of cementation of the dune sand is also variable, which is reflected in the machine borehole logs and CPT results.

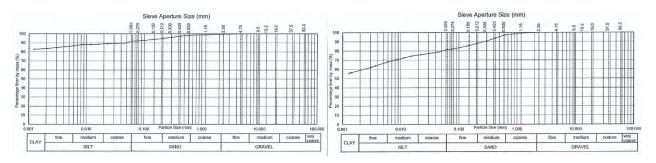
5.2 Lab Results

Eight samples of Awhitu Group materials were tested for a range of parameters. These are summarised in Table 3 and Figures 3 and 4. A full set of results is attached in Appendix H.

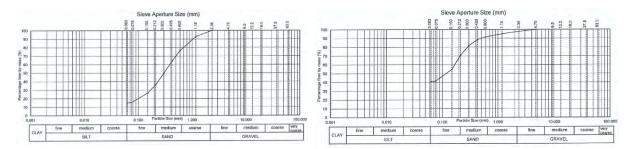
-	-	•				
Test	Unit	No. of Tests	Minimum	Maximum		
Natural Moisture Content	%	5	59.2	67.2		
Liquid Limit	%	3	105	136		
Plastic Limit	%	3	46	64		
Plasticity Index		3	41	87		
Solid Density	t/m³	1	2.86	-		
Maximum Dry Density	t/m³	2	1.05	1.06		
Optimum Moisture Content	%	2	54	56		
Emerson Crumb	Grading	3	Grade 1 – Non-dispersive			

 Table 3: Laboratory Test Result Summary for Awhitu Group

Figure 3: Typical Particle Size Distribution of Awhitu Group Clay (TP2 1.8m) and Silty Clay (TP6 2.1m)







Based on the grading and plasticity of the surficial clay a low to very low permeability could be expected if well compacted with low air voids.

5.3 Groundwater

The static groundwater table was not encountered by any of the test pits.

Rapid inflows were encountered in TP2 at 1m and 1.8m bgl, and slow seeps were encountered in TP4, TP6, and TP10 between depths of 1.2m and 2m. These inflows are interpreted to be perched groundwater seeping along discontinuous hardpans or other permeability contrasts within the stratigraphy.

Depth to the regional groundwater table is not discernible during drilling due to the method introducing fluid into the surrounding ground. Soils were logged by RILEY as wet to saturated from 2.4m bgl and 2.7m bgl in MH01 and MH03, respectively. Initial piezometer readings, taken the day after drilling was completed, show groundwater at 11.9m, 8.6m, and 4.8m bgl in MH01, MH02, and MH03, respectively (refer Table 3). Ongoing monitoring of piezometers is recommended to measure the static groundwater table and understand episodic and seasonal fluctuation thereof.

Based on investigation and monitoring results to-date, groundwater appears to comprise a two layered groundwater system:

- 1. An upper water surface, which may be perched either on a discontinuous hardpan (therefore creating a discontinuous perched water table), or on the finer grained interlayered soils beneath the weakly cemented sand. This perched water is likely transient and only partially saturates the upper soils.
- 2. Lower regional groundwater table some 9m to 12m bgl. This is possibly extensive and controlled by the streams on either side.

Barahala	Collar	Screen Depth	Water Depth (bgl)										
Borehole	RL	(m)	10/08/2021	11/08/2021	12/08/2021								
MH01	73.2	10.5 - 13.5	-	11.8	12.4								
MHOO	70.7	4.5 - 6.0	E 1		0.1								
MH02	70.7	7.5 - 9.0	5.1	-	9.1								
MH03	68.3	3.5 - 6.0	-	3.23	5.3								

Table 4: Groundwater Monitoring Levels

6.0 Natural Hazards

6.1 Seismicity and Site Classification

The seismic hazard at the site is considered low in the New Zealand context, with no recorded large earthquakes since records began (c. 1840). There are no active faults mapped nearby (the nearest is approximately 48km away in the Hunua Ranges). An inactive fault is mapped approximately 2.8km to the south-east associated with the Nihotupu Formation and is noted to transverse through the Waitakere Ranges area. This fault is not currently considered to present a seismic risk to the site.

The seismic loading induced on the dam embankment will depend on, amongst other factors, the natural period of the structure and stiffness of the underlying soil/rock which affect the ground motion input to the structure. Sites with low strength, deep soils can amplify ground accelerations, requiring the structures built on them to resist a higher seismic coefficient. The New Zealand Structural Design code, NZS 1170.5:2004: Earthquake Actions, contains response spectra for structural design. Sites are categorised into five classes (Class A to E) ranging from rock sites, Class A and B to very soft or deep soil sites, Class D and E. Class C is transitional between B and D for shallow soil sites, which results in the largest peak ground acceleration.

The sDMT data indicates an average shear wave velocity of 540m/s over the tested depth of around 10m. This suggests a natural period of around T=0.17s for the upper 30m assuming Vs₃₀=540m/s. Despite being underlain by a considerable thickness of sediment, the site is reasonable stiff in a seismic response sense i.e., Vs₃₀ is greater than the minimum Vs₃₀=360m/s for Site Class B (Rock) in NZS 1170.5:2004.

Calculations indicate the depth to bedrock would need to be at least 80m deep for the site to be classed as subsoil Class D (T>0.6s) assuming shear wave velocities do not increase. Based on present understanding of the local geology, this is considered unlikely.

On balance, the site has been classified as **Site Class C (shallow soil sites)** which results in the most conservative input ground motions.

In accordance with the New Zealand Society on Large Dams (NZSOLD) Dam Safety Guidelines (2015), two levels of ground shaking have been considered, with ground motions derived using MBIE guidance (2016), MBIE Module 1: Method 1/NZTA Bridge Manual Addendum 6A/:

- Operating Basis Earthquake (OBE) based on 150-year return period shaking:
 - o PGA=0.09g, M_{eff}=5.9
- Safety Evaluation Earthquake (SEE) based on 1,000-year return period shaking:
 - o PGA=0.2g, M_{eff}=5.9

6.2 Design Seismicity

The reservoir has been assigned a 'Low' Potential Impact Classification (RILEY Ref: 210339-B) in accordance with the NZSOLD Guidelines (2015). Due to the long recurrence intervals, seismic parameters for design are normally established by a site-specific seismic hazard assessment by a technical specialist, using both probabilistic and deterministic methods.

This involves evaluation of the following scenarios:

- Operating Basis Earthquake (OBE) The earthquake for which a dam, appurtenant structure, and gate/valve system that fulfils a dam safety function is designed to remain operational, with any damage being minor and readily repairable following the event. It is considered that an annual exceedance probability (AEP) of 1 in 150 is appropriate for the OBE.
- Safety Evaluation Earthquake (SEE) The earthquake that would result in the most severe ground motion, which a dam structure must be able to endure without uncontrolled release of the reservoir. Ground motion parameters should be estimated for the 50th percentile Controlling Maximum Earthquake (CME) or 1 in 1,000 AEP developed by a probabilistic approach.

6.3 Liquefaction Potential

Liquefaction can occur in saturated, loose to medium dense, cohesionless deposits (sands and non-plastic silts) under moderate to severe ground shaking. Geologically recent materials or very weak manmade fills are typically the most susceptible soils. Effects on dam structures can include settlement/differential settlement resulting in cracking and loss of freeboard or internal erosion through cracks, lateral spreading of the abutments into the dam, and/or foundation bearing failure.

We have undertaken an initial liquefaction susceptibility assessment using both qualitative and quantitative methods:

- A qualitative visual assessment was carried out to identify materials potentially susceptible to liquefaction based on soil description in test pit and drillhole logs.
- A quantitative analytical assessment was carried out on sDMT, CPT, and SPT data using the following methods (in order considered most to least reliable in cemented dune sands):
 - Seismic dilatometer sDMT test results against threshold values of Vs for liquefaction occurrence, i.e., using Cliq v. 3.3.2.9 by GeoLogismiki.
 - CPT-based triggering assessment using the Boulanger & Idriss (2014) method in Cliq v. 3.3.2.9 by GeoLogismiki.
 - SPT-based triggering method from Idriss and Boullanger (2014).
- The methods are based on the latest methodology from the NZGS and Ministry of Business, Innovation and Employment (MBIE) Guidelines, developed after the Canterbury earthquake sequence, with the most up to date guidance published in 2016.
- For the purposes of the liquefaction analyses presented in this report, a depth to groundwater of 1.0m bgl has been used which is likely very conservative (Section 5.3).

6.3.1 Results

A quantitative assessment of each individual investigation point has been made in terms of liquefaction susceptibility. Potentially liquefiable materials were identified within the upper 10.0m of the soil profile, comprising interbedded layers of cohesionless, loose to medium dense sands and silty sands of the Awhitu Group.

Soils become more resistant to liquefaction as they become older due to densification and various weathering and chemical cementation processes. The Awhitu Group dune sand deposits are assigned to the Late Pliocene-age (1.8M to 3.6M-years old).

There is evidence of cementation of sand grains and "hardpan" features in weathered outcrops around the site, which have a strength consistent with "extremely weak rock" in terms of the NZGS field description guidelines (Photo 4).



Photo 4: Outcrop of weathered Awhitu Group dune sands exhibiting weak cementation in the upper portion and assessed not susceptible to liquefaction.

Published guidance from Youd & Perkins (1978) indicates that dune sands of this age are "very unlikely" to be susceptible to liquefaction. This conclusion is reinforced by the observation that almost all liquefaction case history data are from Holocene-age deposits or constructed fills (Idris & Boulanger 2008). However, soil aging effects are difficult to quantify and are not typically included in design procedures.

Assessment of the sDMT data indicates:

- Shear-wave velocities ranging from 130m/s at 2m depth increasing to 500 to 600m/s at 10m depth. The case history data shows no liquefaction above an overburden stress-corrected Vs₁>210m/s, i.e., limiting upper value in sandy soils.
- No liquefaction is predicted for either the OBE nor SEE events while assessing the sDMT data using the Kayen et. al (2013) method. Note that the sDMT assessment was carried out in Cliq developed by GeoLogismiki, which also plots CRR for a nearby CPT as a comparison but is not associated with the sDMT data or assessment.

Assessment of the CPT data indicates:

- OBE: Very low LSNs consistent with little to no expression of liquefaction and negligible settlements were predicted.
- SEE: Liquefaction Severity Numbers (LSN) up to 17, which is consistent with little to minor expression of liquefaction and free-field settlements between 5mm to 80mm predicted.
- Overall, the thickness of liquefied soils for the OBE event is negligible, and several metres typically between 3m and 8m bgl for the SEE event. CPT analysis shows this material could be susceptible to liquefaction if it were in a saturated state during strong seismic shaking.

It should be acknowledged that advancing the CPT cone in weakly cemented material can disturb or break down the cementitious bonds resulting in underprediction of the soils resistance to liquefaction. For this reason, and the less soil disturbance caused by advancing the dilatometer blade, the sDMT data is considered more reliable in these soil types.

Assessment of the SPT data indicates:

- OBE: No liquefaction is predicted for the OBE event.
- SEE: No liquefaction is predicted at MH01, and very low LSNs consistent with little to no expression of liquefaction and free-field settlements less than 10mm and 25mm in MH02 and MH03.

Results from the liquefaction assessment are attached in Appendix F.

Location A in the central portion of the site between the proposed cut batter for the reservoir and fill areas comprises a cluster of investigation locations, MH01, CPT6, and sDMT1. Location B in the northern portion of the site downslope of the proposed reservoir comprises a cluster of investigation locations, MH03, CPT7, and sDMT2. A comparison of these test locations and liquefaction susceptibility methods are presented in Table 5 under a SEE event.

Investigation Type	Location A	Location B						
sDMT Kayen et. al (2013)	No Liquefaction.	No Liquefaction.						
CPT Idriss and Boullanger (2014)	Liquefaction between 3.2m to 5.5m with 77mm free-field settlement.	Liquefaction between 3.8m to 5.8m, 13mm free-field settlement.						
SPT Idriss and Boullanger (2014)	No Liquefaction.	Liquefaction between 1m to 6m, SPT N=5 to 11, 22mm free-field settlement.						

Table 5: Comparison of Testing Methods for SEE Ground Motions

Overall, the age of the depositions, soil compositions, and sDMT data indicate the soil is not susceptible to liquefaction. Conversely, CPT and SPT based method predict little to minor expression of liquefaction, but this may be conservative in view of the methods disturbing or breaking down the cementitious bonds formed in the sand over time.

Further, the groundwater table has generally been measured below potentially susceptible units meaning they may only be partially saturated. Modification to the drainage characteristics of the site is expected to significantly reduce the potential for soils to be saturated. Additional factors that could lead to a reduction in soil moisture beneath the reservoir includes the provision of a geomembrane liner, which will largely prevent infiltration of surface-water. Drainage of soils will also be aided by inclusion of under-liner drains if seepage horizons are noted within the excavation.

There is the potential that hardpan layers within the sand could impede vertical drainage. If this is observed to have a significant influence on seepage patterns within the reservoir excavation during construction, mechanical puncturing of hardpan layers may be appropriate.

As part of the construction of the dam, three piezometers have been installed to allow ongoing monitoring of groundwater levels in the vicinity of the reservoir. A design verification hold-point is envisaged to confirm the assumed groundwater model.

On this basis, and the results of our assessment, liquefaction is not considered to present a significant risk to the reservoir.

6.4 Slope Stability

Slope stability analyses were carried out for Cross Sections A through to D, to assess the available Factor of Safety (FoS) against instability for the existing ground profiles modified for the proposed development. Section A assesses the existing western slope with the proposed dam and the cut slope (3H:1V) of the reservoir. Section B assesses the existing south-eastern slope with the proposed fill batter (5H:1V) and the cut slope (3H:1V) of the reservoir. Section C assesses the proposed fill batter (5H:1V) with the cut slope (3H:1V) of the reservoir. Section D assesses the existing south facing slope at the eastern extent of the proposed reservoir with the proposed dam and the cut slope (3H:1V) of the reservoir. The proposed embankment slopes (3H:1V) are acceptably stable on a firm foundation subject to final design checks as part of the preliminary design. Our modelling utilised the effective stress parameters outlined in Table 5, using the Morgenstern-Price method of limit equilibrium analysis, and non-circular optimised Cuckoo failure modes.

Geotechnical parameters were developed from the subsurface testing information and terrain analysis/back-analysis of existing slopes. Back analysis of the steeper eastern slopes of approximately 27° that displayed evidence of shallow instability (i.e., marginal stability) was carried out to assess the typical soil shear strength parameters. The adopted effective stress parameters are considered reasonable based on our back analysis, as well as our experience and understanding of the behaviour of soils in the area. The selected effective stress parameters are presented in Table 5.

Existing groundwater conditions were modelled at approximately 3m to 9m depth depending on location on-site and elevated groundwater conditions were modelled between 2m and 2.9m depth, based on RILEY site observations and investigation locations. Sensitivity analyses for surface saturation were also undertaken, to model a short-term high intensity storm event.

	-		
Description	γ (kN/m³)	c' (kPa)	φ' (degrees)
Clayey SILT/Sandy Silt	18	5	30
Hardpan	20	15	35
Medium Dense to Dense SAND	18	4	35
Interbedded Dense/V.Stiff Material	18	3	32
Colluvium	18	3	28
FILL	18	5	32

Table 6: RILEY Adopted Effective Stress Strength Soil Parameters

A FoS of 1.0 indicates the forces driving and resisting instability are in equilibrium, and a FoS of less than 1.0 indicates theoretical failure. In accordance with NZSOLD Dam Safety Guidelines (2015), we have adopted a target a FoS of 1.5 or greater for normal groundwater conditions, and 1.3 or greater for worst-case, short-term/transient groundwater conditions.

Under OBE seismic conditions, a FoS greater than 1.0 is required for pseudo-static methods; under SEE seismic conditions, deformations are acceptable provided they do not lead to an uncontrolled release of the impounded contents. Ground motion input parameters for these events are outlined in Section 6.1.

Stability analysis shows that the minimum FoS targets are met for all scenarios with the exception of Section C under SEE ground motions. Additionally, initial stability analysis were carried on the reservoir (southern) cut slope to determine the maximum gradient available before instability is predicted. A 3H:1V, the cut meets minimum FoS requirements whether a hardpan layer is present or not. Table 6 shows the target and achieved FoS. Selected slope stability outputs are presented in Appendix G.

For the SEE case, displacements were estimated using sliding-block analysis methods (Jibson, 2007). Because the yield acceleration of the slope is very similar to the input ground motions, only minor displacements (<10mm) are predicted. These are considered unlikely to result in uncontrolled release of the reservoir contents and are therefore acceptable. It should be noted adopting the PGA as the input seismic coefficient and pseudo-static analyses are conservative due to the varying response of the slope and reversing nature of seismic ground motions. When assessing the full slope under pseudo-static conditions, a reduction factor of 0.65 to the PGA is commonly applied (per NZTA Report 613 Seismic Design of High Cut Slopes, 2018) but has been conservatively ignored in our assessment.

In all cases, the reservoir excavation, dam embankments, and fill disposal areas have been offset a minimum distance of $\frac{1}{2}$ the slope height away from the crest of the slope, as a precaution against slope instability.

Cross		Target	Minii	mum FoS	
Section	Case	FoS	Existing Slope	Cut Embankment	Comments
	Normal Groundwater Levels	1.5	2.5	2.6	ОК
Section A	High Groundwater Levels	1.3	2.1	-	OK
Section A	Saturated Sensitivity	1.3	1.7	1.5	ОК
	SEE earthquake	-	1.1	1.3	OK
	Normal Groundwater Levels	1.5	1.5	2.0	OK
	High Groundwater Levels	1.3	1.4	1.6	OK
Section B	Saturated Sensitivity	1.3	0.9*	1.5	*>1.3 for proposed Fill disposal area
	SEE earthquake	-	0.9*	1.1	*>1.0 for proposed Fill disposal area
	Normal Groundwater Levels	1.5	-	1.7	OK
Section C	High Groundwater Levels	1.3	-	2.3	OK
Section C	Saturated Sensitivity	1.3	-	1.4	OK
	SEE earthquake	-	-	~1.0	Displacements <5mm
	Normal Groundwater Levels	1.5	1.8	2.9	ОК
	High Groundwater Levels	1.3	1.7	2.0	ОК
Section D	Saturated Sensitivity	1.3	1.4	1.5	ОК
	SEE earthquake	-	~1.0	1.7	OK. Seismic slip surface well clear of proposed pond

Table 6: Slope Stability Results

7.0 Design Implications

7.1 Introduction

The present design concept is for a geomembrane-lined, homogeneous embankment dam in keeping with other large water storage reservoirs in similar ground conditions.

Based on the investigations undertaken to-date, the critical geotechnical considerations are the potential for slope instability, foundation seepage and surficial or internal erosion.

7.2 Construction Materials and Zoning

Construction will largely be conducted using site derived materials. Key materials to be transported to site include filter compatible drainage aggregate, geomembrane, and geosynthetics.

Bulk fill for dam construction is likely to comprise a mixture of fine to medium sands and stiff to very stiff silts identified within the borrow area/reservoir footprint. Sand dominated earth fills tend to require the addition of significant moisture to achieve an acceptable degree of compaction. This will necessitate access to a locally derived water source. We anticipate the contractor will require less than 200m³/day on average, and no more than 500m³/day based on experience.

The compacted sand fill is likely to be relatively free draining but may be subject to internal erosion (piping) under seepage flows or external erosion due to water flow for example from rainfall on dam batters during construction.

Based on the anticipated moderate permeability of the sand, the primary water retaining element will be a liner. The investigations have identified a potential low permeability cohesive material typically at least 1m thick that could be contemplated as a liner. This could be used as part of a composite lining system (i.e., beneath the HDPE for improved performance), or alternatively as an upstream zone within the dam embankment. There are some challenges with the use of such a material however, such as being prone to shrinkage. As a conservative approach synthetic lining, say with HDPE or a geosynthetic clay liner (GCL) is therefore envisaged. The persistent depth of sands within the reservoir floor means that lining of the reservoir is also likely to be required. As recommended in Section 6.3.1 under-liner drainage will be considered in the detail design phase , noting the potential for seepage loss from the drains themselves if the subgrade is very permeable (requiring deign mitigation such as lining to the drains themselves). This philosophy is in keeping with other dams of a similar geological setting.

Preliminary analyses were undertaken to assess possible leakage rates of water through the geomembrane liner using the method outlined by Giroud and Bonaparte (1989). Observations of in-service reservoirs suggest that leaks most commonly occur as either seam defects or larger holes from accidental puncture. A summary of typical installation defect frequencies is available in Design Standard-13 Embankment Dams, Chapter 20: Geomembranes (USBR, 2018). These range from less than one defect per acre for excellent installation quality up to 10 to 20 defects per acre for poor installation quality. Defect sizes typically range from a small hole with a surface area of about 3.1mm² (representing seam defects), up to large holes with a surface area of about 1cm² representing accidental punctures.

Combined leakage rate estimates across the entire floor are estimated to be 0.2L/s assuming excellent installation quality and seam defects, up to 0.4L/s for fair installation quality and small holes. We recommend these estimates be compared with observations of in-service performance of similar reservoirs. Extreme leakage rates would be considered unacceptable and would require drawdown of the reservoir for inspection and repairs to affected areas.

Based on the preliminary analysis it is reasonable to conclude that water table mounding under the pond, caused by leakage from the reservoir to the underlying subgrade, will be localised and unlikely to result in any significant effects. Leakage would either seep vertically, or along bedding horizons in the sand and outlet to the slopes to the west and east. Further assessment on leakage rates and requirements for piezometers and basal drainage will be undertaken during detailed design.

The disposal fill area is necessary to accommodate the excess cut material. It is proposed to be up to 5m deep and slopes at approximately 5H:1V. This material is likely to be compacted in lifts however, it is not necessary to achieve equivalent compaction as the fill dam embankment, assuming that no future building is proposed within the fill disposal area.

A greater quantity of cut earthworks, compared to embankment fill, will likely be required to account for material compaction and unsuitable materials. Estimates of loss factors will vary across the pond footprint both in plan and with depth, and this will need be considered alongside material bulking factors etc. during earthworks balancing. Once lab test results are available, following COVID-19 Level 4 lockdown, these would assist in determining actual loss factors and would also be helpful in evaluating different material handling and placement methods.

7.3 Foundation and Reservoir Floor Treatment

Awhitu Group deposits observed in borrow areas, depending on the results of the awaiting lab testing, are expected to be generally suitable for reuse in dam construction in combination with a synthetic liner, subject to further assessment. Layers containing higher proportions of silt and clay could be suitable as low permeability fill, whilst sandy silt and silty sand layers could be utilised as general fill. The selection of either an internally zoned or homogeneous dam embankment will be made during detailed design but due to the modest fill heights a homogeneous section is preferable.

The generally dense sandy soils underlying the site are considered sufficiently strong to support the embankments proposed notwithstanding further detailed assessment. While it is not envisaged that any considerable depth of undercut will be required as part of the foundation preparation or liquefaction mitigation, the variable and permeable nature of the foundation warrants further assessment as part of detailed design. Settlement effects, and the implications for the lining system, will also need to be evaluated in detail.

The requirement for, an extent of, any underdrainage system within the reservoir floor to avoid uplift of the liner will depend on long-term groundwater trends and the final reservoir floor elevation, to be confirmed during detailed design. The current proposed dam floor consists of a flat base at RL 67.5m, which is above the maximum recorded groundwater table to date and as such, sustained groundwater is not considered a significant risk for construction.

Prevention of wind uplift of the liner during low reservoir levels will also need to be considered.

7.4 Liquefaction

sDMT, CPT, and SPT data have been evaluated using the methods outlined in Section 6.3. No liquefaction is predicted at OBE ground motions and only minor at SEE. No specific mitigation options are considered warranted based on present information.

7.5 Reservoir Slope Stability

The dunes generally have gently rounded to flat ridge crests, flanked by moderate to steep slopes. The steeper slopes (24° to 34°) typically show signs of colluvium accumulation at their base and may be subject to soil creep. Exposed sand soils have limited resistance to erosion, and incised gully features are present where overland flow paths concentrate near the valley floor.

Generally, slope instability on the reservoir margins is expected to be minor in nature and unlikely to represent a hazard for the dam, pond slopes and stockpile. Initial stability analysis of the cut reservoir embankments indicate that cuts no steeper than 3H:1V meet the minimum FoS requirements. Maintenance of grass and vegetative cover in the slopes above reservoir level is recommended to further minimise the potential for shallow slumping or erosion. Perched groundwater in the upper soil horizons, e.g., above the hardpan where present, may lead to localised surficial saturation. Although not considered to pose an obvious risk to instability at a recommended batter of 3H:1V, the incorporation of regularly spaced counterfort drains extending 5m back from the face to a depth of 3m is considered prudent and will minimise the risk of this occurring and consequential effects on the lining system.

7.6 Spillway Cut

Hydraulic Design of the spillway is covered in RILEY report (Ref: 210339-B). Geotechnical considerations relevant to the spillway relate largely to protection of the underlying Awhitu Group sands from erosion. If disturbed, the fine sand making up the invert and side slopes of the channel are likely to be erodible under surface flows. In addition, careful detailing for seepage control is required where hardpan materials are used such as concrete linings or nib walls, as water tracking beneath such interfaces could cause internal erosion.

We understand that the proposed spillway is located at the western end of the reservoir close to a scarp feature observed during geological mapping. Should this spillway location be progressed to detailed design, further detailed investigations of this area will be required to get a better understanding of the behaviour of materials and the implications on the design.

In cases where specific erosion protection such as concrete or riprap is not warranted, the surfaces should be re-topsoiled and grassed.

7.7 Construction Considerations

The dam is likely to be constructed using conventional earthmoving equipment. The supplied 14 tonne excavator was found to be satisfactory for excavating to depths up to ~4.5m, i.e., similar to the likely maximum borrow area/reservoir cut.

The contractor should consider suitable excavation, placement, and compaction methodologies to ensure that design requirements are met.

As outlined earlier, the prevailing sandy soils are narrowly graded and would be potentially susceptible to piping failure in a concentrated leak scenario (i.e., complete rupture of the liner). Accordingly, sound commissioning and long-term monitoring procedures are recommended.

Construction dewatering is unlikely to be required, albeit minor perched water tables and seepages are possible locally and should be planned for in construction activities. Regularly spaced subsurface drains through the cut face of the pond will control this in the longer term.

Surface water management during construction will need to be considered and an appropriate methodology developed when planning the works. Standard erosion and sediment control works that are designed and implemented in accordance with Auckland Council Guidelines, are likely to be sufficient during construction.

8.0 Conclusions and Recommendations

RILEY has carried out detailed geological mapping of the site along with an intrusive geotechnical investigation comprising test pits, machine boreholes, CPTs, and sDMTs. The site is underlain by Awhitu Group dune sand deposits of the Late Pliocene-age (1.8M to 3.6M-years old) and there is evidence of cementation of sand grains and 'hardpan' features in weathered outcrops around the site, which have a strength consistent with 'extremely weak' rock.

Liquefaction and slope stability analyses have been carried out using the data acquired from the geotechnical investigations and has assisted the design implications and recommendations for this project. Key points are listed below:

- No liquefaction triggering is indicated for the OBE ground motions.
- For the SEE design case, no liquefaction is indicated for the sDMT data and little to minor liquefaction is indicated for the CPT and SPT data. It is noted that CPT and SPT based methods may overpredict the susceptibility of these soils due to breaking of the cementitious bonds during testing. On balance, based on the soils age, sDMT results, and groundwater monitoring to-date, liquefaction is not considered to present a credible risk to the reservoir.
- Slope stability analyses were carried out for several cross sections under various groundwater scenarios as well as under a seismic event. All results except for one location during the SEE achieve the minimum FoS requirements. Deformation is predicted to be small (<5mm), which is considered acceptably low.
- The construction of the reservoir is likely to comprise material from the borrow area as well as a synthetic liner.
- Counterfort drains are recommended along the rear cut of the reservoir to minimise the risk of surficial saturation.
- The current spillway location will require further investigation and analysis due to the presence of geological features in this location.

9.0 Limitation

This report has been prepared solely for the benefit of The Bears Home Project Management Limited as our client with respect to the brief and Auckland Council in processing the consent(s). The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Recommendations and opinions in this report are based on data from limited test positions. The nature and continuity of subsoil conditions away from the test positions are inferred, and it must be appreciated that actual conditions could vary considerably from the assumed model.

During excavation and construction, the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation and the modification of the design based upon this report. Riley Consultants Ltd would be pleased to provide this service to The Bears Home Project Management Limited and believes the project would benefit from such continuity. In any event, it is essential Riley Consultants Ltd is contacted if there is any variation in subsoil conditions from those described in the report as it may affect the design parameters recommended in the report.

APPENDIX A

Test Pit Logs (TP1 to TP12)

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(m)	Depth (m)	Geological Unit		Geological Desc er to separate Geotechnic Information sheet for furth	al and Geo		Legend	Unified Symbol		near St (kPa) 100 150			Penetron ws / 50 m 6 9		Groundwater	Soil Moisture	Samples		Tests
+71.50	- - 0.25	Topsoil	TOPSOIL				111									м			
	-		Silty CLA moist to v GROUP].	Y with trace sand; light or wet; moderately plastic; sa	ange brown and, fine [AV	n. very stiff; WHITU				 × 						MW			√ V= 125 R= 45
+70.85	0.90 1 		trace light	ILT with some sand, trace t grey and dark orange m	ottles. Very	inge with stiff; slight	y × ×	-		 x 									∨ V= 122 R= 43
	-		to modera	ately plastic; sand, fine; gi	ravei, fine.		×_× × × * *				*								✓ V= 199+
							× × × ×			x 					5/08/2021				√ V= 128 R= 43
+69.45	2.30	Broup	2.20 m G	rades to minor light grey r	nottles.		× × × ×		↑ 		* 								✓ V= 198 R= 51
+69.15	- 2.60	— Awhitu Group		to medium SAND with mir nge mottles. Loose; moist ıs.			× · . · × · .	> - -			+ + -					мw м	25025		√ V= 199+
	- 		orange m	edium SAND with minor s nottles. Loose; moist. rades to minor black limor				- - - - - - - - - -											-
+68.25	3.50 - - - 3.90		minor dar moist; slig	edium SAND with trace si rk limonite inclusions. Mec phtly cemented; sand, mic ation than above.	dium dense	to dense;	nt	• • • • • • •								м			
	-		brown wit Tightly pa	edium SAND with trace g th light grey mottles and b acked; moist; slightly ceme istant to excavation than a	lack limonite ented; sand	e inclusion		•											
+67.25	- -		4.10 m - 4 inclusions		ey with black	k limonite													
+67.25	- - 		Long																-
	-																		
Exp	lanatio				Scala	Penetrom	eter - blow	 s/50m	ım GF		WATEF	<u> </u>					R	emark	(S
weath comp Relat firm/n	Rock Mass Weathering - unweathered, slightly Permeability Test None weathered, moderately weathered, moderately weathered Schmidt Hammer None Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense Insitu Vane Shear Strength (kPa) Slow Seep (depth 2.0 m) • Small Disturbed Sample Image: Mathematical Strength (st, 2nd) Image: Mathematical Sample Image: Mathematical Sample Image: Large Disturbed Sample Image: Mathematical Sample Image: Mathematical Sample Image: Mathematical Sample																		
		ons	in metre			Time (minu 3 tonne)	utes)					5	Shear Va 2945	ane N	0.	L	.ogged GB		Checked by: SLP

2			4 Fr Auc	ey Consultants I red Thomas Drive, Takapu kland, 0622 +649-489-7872									T	ES	T F	J.	T L	OG	Ì
Proje 710 M Job N	∕luriwa lo.:	i Ro 0339		Start Date: 05-0	08-21	ai Down	d Level	(m)	:	Refe	dinates	EY dw s (NZT							o.: ?05
Clien	ıt:			Finish Date: 05-(67 Hole D 4.40 n	•	:		E 1,73	30,395	N 5,92	5,743			Shee		of 1
								-							ter	PILE	s		
²⁰⁹⁺ Elevation (m)	Depth (m)	Geological Unit	(refer to	Geological Desci o separate Geotechnic rmation sheet for furthe	al and Geo		Legend	Unified Symbol		hear S (kPa)	Ū		a Penetro ows / 50 r	nm)	വ Groundwater	Z Soil Moisture	Samples		Tests
+66.50	- - 0.25	Topsoil	TOPSOIL.				$\underline{11}$								 				
+65.95	- - - - 0.80		Silty CLAY w orange mottle fine [AWHITL	ith some sand; orange es. Very stiff; moist; mo U GROUP].	e brown with oderately p	h trace darl lastic; sanc					× 								✓ V= 179 R= 30
+65.65	- - 1 1.10		Sandy SILT with dark ora gravel, fine to	with some clay, minor g inge mottles. Very stiff; o coarse.	gravel; orar ; moist; san	nge brown nd, fine;	× × × × × ×			 × 						м			✓ V= 122 R= 48
+65.45	Fine to medium SAND with minor silt; light orange bro with minor black limonite inclusions. Medium dense; n slightly cemented; sand, micaceous.															DM			- - -
	- - - - - - -	Group	black limonite mottles. Med	se SAND with minor sill e inclusions, trace light lium dense to dense; d and, micaceous; more	t orange an Iry to moist;	nd light grey ; slightly													-
	- - - - - - - - - - -	Awhitu Group	2.60 m Grad limonite inclu	es to light orange with isions; slightly cemente	minor dark ed.	: brown													-
+62.35	- - - - - - - - - - - - - - - - - - -							· · · · · · · ·											_
	-		Difficult to ex	cavate with 13 tonne n	nachine.														
	- - 5		EOH @ 4.40) m															- - -
+62.35	- - - -																		
	-																		
Rock weath compl Relati firm/m	Explanations: Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense ● Small Disturbed Sample U100 Undisturbed Sample U100 Undisturbed Sample									Rapio	e Seep (i I Inflow RMINAT	(depth) w (depth) ATED DUE TO:					Remarks		
į		ons	in metres	Rig Type: Machine Excav	-		nes)										Logged by: Checked by: GB SLP		

2	RI CONS Engineers		ANTS	Riley Consultants I 4 Fred Thomas Drive, Takapu Auckland, 0622 Tel: +649-489-7872									I	TES	T I	Ы.	ΤL	OG
Proj 710	ect: Muriwa	i Ro	bad		Locatio	on: ai Downs	s				le posit efer to		Y dwg: 21	0339-1				No.:
Job	No.:)339		Start Date: 04-0 Finish Date: 04-0)8-21	Ground		(m):			-Ordina	ates (I	NZTM):	,925,829				TP06
Clie	nt:						Hole De	•	:			,730,0	009 14 3	,923,029			Shee	
			ome Pro	iject Management L	lmited		4.50 n								-			1 of 1
(m)		Geological Unit		Geological Descr er to separate Geotechnica information sheet for furthe	al and Geo		Legend	Unified Symbol	Soil :	(k	ar Stren Pa) <u>150_20</u>	gui	Scala Pen (blows /	50 mm)	ज Groundwater	Soil Moisture	Samples	Tests
+69.25	- - 0.25	Topsoil	TOPSOIL													M		No. 1 0, 1, 1, 2, 2, 2, 1, 2, 1,
	-		Silty CLA wet; mode GROUP].	Y with trace sand; brown o erately to highly plastic; sa	range. Stif nd, fine [A'	f; moist to WHITU				×		6 6 7		0.9m	4/08/2021			2, 2, 1, 2, 2, 1, 2, 1, 2 ∨ R= 85 R= 31
+68.20	- - - - -			LT with minor sand; brown			×	-		× × 					1	w		✓ R= 40 ✓ V= 80 R= 31
+67.50	- - - - 2.00			, micaceous.			× × × × * *	-	 ↑ ↑		 					DM		 ✓ UTP ✓ V= 134 R= 51
+66.60	- - - - - - - 2.90	Awhitu Group	trace light	LT with minor clay, minor g t grey and dark orange mo ist; sand, fine.	ravel; orar ttles. Hard	nge with to very stiff	f; × ·× · × ·× · × ·× · × ·× · · × · · × ·											
+65.90			white spe gravel, fir Fine to m	to medium SAND with min cks. Loose; dry to moist; s le to medium.	and, micad	nge with	× .									DM		
+65.00	- 	V	4.10 m G	I white specks. Medium de phty cemented; sand, mica tition than above. rades to minor to some bla 4.50 m Grades to dark bro arge amount of micaceous	aceous; mo ack limonite wn with ligl	ore resistant e inclusions												
1100101	- - - - 5 -		EOH @ 4	1.50 m														-
	-																	
Relation firm/	thered, mo pletely wea tive soil St medium de Small Dis Large Dis U100 Und	ather derate there rengtl ense, turbe turbe	ely weathere ed, residually h - very soft/ stiff/dense, d Sample	/very loose, soft/loose, very stiff/very dense	 Perm ▼ Schm ∨ Insitu ∨=Pe to per Wate 1 √ 	Penetrome eability Test idt Hammer Vane Sheai ak, R=Resic netrate r Strike (1st r Rise (1st, Time (minut	r Strength dual, UTP= t, 2nd) 2nd) ar	(kPa) =Unab	le [X S	apid Infl	p (der ow (de NATEI	D DUE TC		2.3	3m bộ	samples	temarks s taken at 2.1m bgl to 9m bgl to 3.1m bgl.

2			ANTS	Riley Consultants li Fred Thomas Drive, Takapu wuckland, 0622 rel: +649-489-7872									TES	ΤI	Ы.	T L	OG	
Projec	ct: /luriwa	Ro	ad		Locatio	on: ai Down	IS			Hole posit Refer to		' dwa: 2'	10339-1				No.:	
Job N				Start Date: 05-0 Finish Date: 05-0	08-21		d Level 76	(m):		Co-Ordin	ates (N	NZTM):	5,925,693	2			TP07	
Clien	t:						Hole De	•		E	1,730,0	090 N 0	0,920,093)		Shee		
			ome Pro	ect Management I	_imited		4.60 n							-	0		1 of 1	
Elevation (m)	Depth (m)	Geological Unit		Geological Descr r to separate Geotechnic formation sheet for furthe	al and Geo		Legend	Unified Symbol	Soil S	hear Strer (kPa) 100 150 20		Scala Per (blows / 3 6	,	5 Groundwater	Soil Moisture	Samples	Tests	
+75.30	0.20	Topsoi	TOPSOIL))) 								М			-
+74.80	- - - 0.70	Ī	moist; slig GROUP].	T with some sand; orang htly to moderately plastic;	sand, fine	ery stiff; [AWHITU	× × × × × ×								DM		∨ V= 1 R= 3	51 - 4 - -
+74.50	- - <u>1 1.00</u> -		Silty fine to black limo	anged to toothed bucket. o medium SAND; light ora nite inclusions. Loose; dry	ange brown y to moist;		X .											-
	-		some darl to moist; s	edium SAND with minor si brown limonite inclusion: lightly cemented; sand, m o excavation than above.	s. medium	dense; dry	· · · · · · · · · · · · · · · · · · ·											-
	- 2 - -	Group																-
+72.80	- - - 2.70 -	Awhitu Group			— — — -										DM			-
	- - - - - - - -		trace white slightly ce	e specks. Medium dense mented; sand, micaceous n than above.	to dense; d	Iry to moist	t;											
+70.90	4 4.60																	-
4	- - - 5 -		EOH @ 4	60 m														-
	- - - -																	-
	anatio				Scala	Penetrom	eter - blows	/50mr	m G	ROUNDWA						R	emarks	
Rock I weath comple Relativ firm/m	Mass We ered, mo etely wea ve soil Str redium de Gmall Dist arge Dis	ather deration there rengtion nse, urbe turbe	ely weathere ed, residually h - very soft/	hered, slightly d, highly weathered, weathered /ery loose, soft/loose, rery stiff/very dense	Perme Perme Schm V=Pea to per Wates Wates Wates	eability Tes idt Hamme Vane Shea ak, R=Res netrate r Strike (1s	st r ar Strength idual, UTP= st, 2nd) , 2nd) ar	(kPa) =Unab	le	_	ep (dep ilow (de INATED	epth)):					
		ons	in metre	Rig Type: Machine Excav	-				I				ar Vane 945	No.	L	ogged. GB	by: Checkee SLF	

2	RI CONS Engineers		EY	Riley Consultants 4 Fred Thomas Drive, Takap Auckland, 0622 Tel: +649-489-7872										Т	ES	T F	Ы.	T L	OG	ì
Proje 710 M Job N	/luriwa lo.:	i Ro 033		Start Date: 05- Finish Date: 05-	08-21	ai Dowr	d Level	(m)	:	Ref	e positi fer to f Ordina	RILEN ates (I	NZTM):						o.: ?08
Clien	t:			pject Management			80 Hole D 4.70 n		:		El	,730,5	594	N 5,92	25,554			Shee		of 1
Elevation (m)	Depth (m)	Geological Unit	(ref	Geological Desc er to separate Geotechnic Information sheet for furth	ription		Legend	Unified Symbol	Soil \$	Shear (kPa	Streng a)	gth	Scala I (blov	Penetro vs / 50		Groundwater	Soil Moisture	Samples		Tests
+80.00	-	opsoil	TOPSOIL				111))	50	100	<u>150 200</u> 	0	3	69 	<u>12</u> 1	5	M			
+79.70	0.30 - - -			Y with minor sand; orange by plastic; sand, fine [AWI						×										∨ V= 97 R= 23
+78.80	- - 1 - 1.20		1.00 m - orange.	1.20 m Grades to trace fir	e gravel;			 <u> </u> 								MW			 ✓ V= 99 R= 45 ✓ V= 199+ 	
+78.30	- - - 1.70		orange w	to medium SAND with mir ith trace light grey mottles and, micaceous; gravel, fir	. Medium d	lense; moi	st	>									м			∨ UTP
+77.80	- - 2 - 2.20			edium SAND with some s dense; moist; sand, micac	nge brown	L	· · · ·												-	
+77.40	- - - 2.60	Awhitu Group	with mind dense; m	edium SAND with minor s or black limonite inclusions loist; slightly cemented; sa 2.80 m Grades to brown v d SAND.	and, micace	lense to eous.		· · · · ·									w			
	- - 3 -		orange lig Medium o	nedium SAND with minor s ght grey with some dark b dense; wet; slightly cemer on than above.	rown limoni	ite inclusio		•												-
+76.40	- - - - - 3.90		Sandy SI light red r	LT with some clay, minor mixed; very stiff; slightly pl	gravel; light astic; sand,	t grey and , fine.	× × × × ×	· · · ·			 x 									∨ ^{V= 185} R= 43
+75.30	4 		orange b	edium SAND with minor s rown with minor black limo dense; wet; slightly ceme	onite inclusi	ions. Mediu											w			
+75.30	- - - - -	V	EOH @ 4	4.70 m																
	-																			
Expl Rock weath compl Relati firm/m	Explanations: Scala Penetrometer - blows/50mm GROUNDWATER Remarks Rock Mass Weathering - unweathered, highly weathered, moderately weathered, negicially weathered Scala Penetrometer - blows/50mm X None Completely weathered, residually weathered Schmidt Hammer Schmidt Hammer None 1. Bulk sample taken at 1.7m bgl to None Slow Seep (depth) Slow Seep (depth) I. Bulk sample taken at 1.7m bgl to * Small Disturbed Sample Water Strike (1st, 2nd) Water Rise (1st, 2nd) and HOLE TERMINATED DUE TO:																			
_ _ (J100 Un	distur	in metre		∑ Rise	Time (minu	utes)			Targe	et Dept	h	S	hear 294	Vane N 5	 10.	L	.ogged GB		Checked by: SLP

2	RI CONS Engineers		EY	Riley Consultants 4 Fred Thomas Drive, Takap Auckland, 0622 Tel: +649-489-7872									Т	EST	r f	Эľ.	ΤL	OG	ì
Proje	ct: ⁄luriwa	i Ro	ad		Locatio Muriwa	on: ai Downs	s			Hole pos Refer t		Y dwr	1: 2103	39-1				N	0.:
Job N	No.:)339		Start Date: 04- Finish Date: 04-	08-21	Ground	d Level	(m)	:	Co-Ordi	inates	(NZTN	И):					TF	P 09
Clien	nt:						68 Hole De	•	:		: 1,730	9,741	N 5,92	5,945			Shee		
			ome Pro	ject Management	Limited		4.50 n		1						<u> </u>			1	of 1
(m)	Depth (m)	Geological Unit		Geological Desc er to separate Geotechnic nformation sheet for furth	al and Geo		Legend	Unified Symbol		hear Stre (kPa) 100 150			Penetro ws / 50 i		জ Groundwater	Soil Moisture	Samples		Tests
+67.30	0.20	Topsoil	TOPSOIL													м мw		No. 0, 1, 1, 2,	0, 1,
+66.80	- - - - 0.70		Silty CLA' moist; mo	Y with minor sand; orange derately plastic; sand, fin	e. Stiff to ve e [AWHITU	ry stiff; GROUP].		-		· · · · · · · · · · · · · · · · · · ·								2, 2, 2, 1, 1, 1, 1, 2, 6	2, 1,
	- - 1			LT with minor sandstone g ist; sand, fine; gravel, fine		orange.	× × × × × × × × × ×						• • • • • • • • • • • • • • • • • • •	 	- - - -	м		V	∽ UTP
+65.90	- - - 1.60						× · · · · · · · · · · · · · · · · · · ·									DM			
	- - 2 -	Group	light orang	edium SAND with trace si ge mottles. Medium dens aceous; more resistant to	e to dense;	dry to mois	t;												
	- - - - - - - - - - - - - - -	Awhitu Group	2.60 m - 4 limonite ir	4.20 m Grades to light ora clusions and trace white	nge with m specks.	inor black													
	- - - - - - - - -																		
+63.30	4.20 - - 4.50	V	Fine to me light orang micaceou	edium SAND with trace si ge mottles. Dense; dry to is; more resistant to excav	It; light grey moist; sand vation than	/ with trace d, above.										DM			
	-		4.40 m Gi EOH @ 4	rades to dark orange and .50 m	grey SANE)													
	- - -																		
Rock weath compl Relati firm/m	nered, mo letely wea ive soil St nedium de Small Dis _arge Dis	atheri derate athere rength ense, s turbee turbe	ely weathere ed, residually h - very soft/ stiff/dense, d Sample d Sample	very loose, soft/loose, very stiff/very dense	Perma ▼ Schm ∨ Insitu V=Pe to per ₩ate 1 Wate	Penetrome eability Test idt Hammer Vane Shea ak, R=Resid netrate r Strike (1st r Rise (1st,	r Strength dual, UTP= t, 2nd) 2nd) ar	(kPa) =Unat		Slow S	eep (de nflow (d MINATE	depth					R	emarl	s
		ons	in metre		-	Time (minut	tes)						Shear \ 294		lo.	L	.oggeo GB		Checked by SLP

+67.75 0 - - - 50 100 150 200 3 6 9 12 15 +67.50 0.25 -<						
Job No.: 210339 Start Date: 04-08-21 Ground Level (m): Co-Ordinates (NZTM): Client: The Bears Home Project Management Limited Hole Depth: 4.50 m Visiting CE E F Scala Penetrometer (blows / 50 mm) Visiting CE E F F Geological Description F F F Visiting CE F F F Hole Depth: F F Hole Depth						No.:
Client: The Bears Home Project Management Limited Hole Depth: 4.50 m 0 <td< td=""><td></td><td></td><td></td><td></td><td></td><td>TP10</td></td<>						TP10
Image: Second problem Image: Second problem Image: Second problem Image: Second problem Second				S	Shee	t: 1 of 1
+67.75 L O So 100 150 200 3 6 9 12 15 +67.50 0.25	er	er	e	0	s	
+65.75 2.2.00 Sandy SILT with minor clay; light orange with light grey motiles. So iff the very stiff; wet; non to slightly plastic; trace X		Groundwat			Samples	Tests
			M			No. 1 0, 1, 1, 2, 1, 2,
-1 Δ X Δ X 1 </td <td>M</td> <td></td> <td>MV</td> <td>W</td> <td></td> <td>1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 1, 2, V= 65 R= 20</td>	M		MV	W		1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 1, 2, V= 65 R= 20
+65.75 2.2.00 +65.75 2.2.00 - -	4/08/2021	08/2021				V= 60 R= 23 −
+65.75 2.00 - <	₹ ₹	4	<u>_</u>			∨ ^{V= 80} R= 31
+65.25 2.50 2.50 - -	v		w	v	25225	∨ V= 125 R= 40
Silty SAND with minor clay, light grey with light grey , <td< td=""><td></td><td></td><td></td><td></td><td></td><td>✓ V= 188 R= 31</td></td<>						✓ V= 188 R= 31
+64.75 <u>3</u> 3.00						
Fine to medium SAND with some silt, trace clay; light orange with dark orange and light grey mottles. Medium dense to dense; moist to wet; sand. micaceous slightly cemented.	M		MV	W		-
4 3.80 m - 4.20 m Grades to trace white specks. 3.90 m - 4.50 m Grades to some dark orange and trace light orange mottles.						-
+63.25 4.50 ♥ · · · · · · · · · · · · · · · · · ·						
weathered, moderately weathered, night weathered, Schmidt Hammer Itone completely weathered, residually weathered Insitu Vane Shear Strength (kPa) X Slow Seep (depth 1.4 m) Relative soil Strength - very soft/very loose, soft/loose, V=Peak, R=Residual, UTP=Unable X Slow Seep (depth 1.4 m) to penetrate to penetrate To penetrate Rapid Inflow (depth)	1. Bu 2.0m				ample t	emarks aken at 1.8m bgl to
● Small Disturbed Sample ▼ Water Strike (1st, 2nd) HOLE TERMINATED DUE TO: I Large Disturbed Sample ▼ Water Rise (1st, 2nd) and Target Depth I U100 Undisturbed Sample ▼ Water Rise (minutes) HOLE TERMINATED DUE TO: All dimensions in metres Rig Type: Shear Vane No.						

2					Riley Consultants Fred Thomas Drive, Takapuckland, 0622 el: +649-489-7872											TI	ES	r f	J.	T L	OG	
Proj 710	ect: Muri	wa	Ro	ad		Locatio Muriwa	on: ai Down	IS					osition to RIL		dwg:	2103	39-1				N	lo.:
Job	No.:	210)339)	Start Date: 04- Finish Date: 04-		Groun	d Level 74	(m):		C		dinate E 1,73				5,828				TF	P11
Clie T		ear	s Ho	ome Proj	ect Management	Limited		Hole De 4.50 n	•											Shee		of 1
(m)	Jer L		Geological Unit		Geological Desc r to separate Geotechnic formation sheet for furth	al and Geo		Legend	Unified Symbol		(ear St (kPa)	rength	h s		enetro s / 50 r 9		വ Groundwater	Soil Moisture	Samples		Tests
+73.2	-	.25	Topsoil	TOPSOIL.				111					Î	K					М		No. 1, 0, 1, 2, 1, 1,	1, - 1, -
+72.3	- - - - - - - - - - - - - - - - - - -	.20		Silty CLAY moderately GROUP].	with trace sand; orange plastic; sand, fine, mica	. Very stiff; aceous [AW	moist; /HITU				 ▲ 						 1.0m				1, 1, 3, 1, 2, 3, 3, 2, 4	3, 3, V= 156
+12.0	- - - - -	.20		Sandy SIL fine, micac	T; orange brown. Hard; r eous.	moist; non p	plastic; san	id, × ·· × ·· × ·· × ·· × ·· × ·· · · ·											Μ	25252		- TAN -
+71.5	0 22	.00	- Awhitu Group		e medium SAND: yellow le mottles. Loose; moist;			× · · · · ·	>											(? -);??;??		-
+70.70	0 2	.80		with minor dense; dry	dium SAND with minor s black limonite inclusions to moist; sand, micaceo ades to minor black limor	. Medium d ous; slightly	lense to cemented.												DM			-
+69.00	-4	.50	V																			
0.099.01	- - - - - - - - - -			EOH @ 4.	50 m																	
	-										 											-
Ex Roc wea corr Rela firm ●	athered, npletely ative so /mediur Small Large	We mo wea il Sti n de Dist	atheri derate theree rength nse, s urbec	ly weathered d, residually - very soft/v	ery loose, soft/loose, ery stiff/very dense	Perm ▼ Schm ∨ Insitu V=Pe to per Wate	a Penetrome eability Tes hidt Hamme Vane Shea eak, R=Resi netrate er Strike (1st, Time (minu	st ar Strength idual, UTP= st, 2nd) , 2nd) ar	(kPa) =Unab	le		None Slow Rapid	Seep(I Inflow RMINA [·]	(dept v (dej	oth) DUE			1.9	im bộ	samples gl and 2.0	Om bgl	KS at 1.7m bgl to to 2.2m bgl.
All			ons e 1:	in metres 34	Rig Type: Machine Exca	vator (13	3 tonne)								Sł	near \ 2945	/ane N 5	lo.	L	ogged. GB		Checked by: SLP

2	RI CONS Engineers		ANTS	Riley Consultants If 4 Fred Thomas Drive, Takapu Auckland, 0622 Tel: +649-489-7872									TES	T I	Ы.	T L(C	
Proje	ct: /luriwa	i Ro	ad		Locatio	on: ai Downs	<u> </u>			Hole pos		(dwg: 21	0339-1				No	D.:
Job N				Start Date: 05-0	08-21	Ground	Level	(m):		Co-Ordi	inates (l	NZTM):					ΤР	12
Clien			5	Finish Date: 05-0	JO-2 I	 	77 Hole De	epth	:	E	: 1,730,6	664 N 5	,925,606	•		Shee	t:	
	e Bea		lome Pro	ject Management L	imited		4.80 n										1 c	of 1
Elevation (m)	Depth (m)	Geological Unit		Geological Descr er to separate Geotechnica nformation sheet for furthe	al and Geo		Legend	Unified Symbol	Soil S	hear Stre (kPa) 100 150	Jingur	Scala Pen (blows / 3 6	50 mm)	5 Groundwater	Soil Moisture	Samples		Tests
+76.25	- - 0.25	Topsoil	TOPSOIL				111	Ň							М			-
	- - - - -		Clayey SI moist; slig GROUP].	LT with some sand; orang htly to moderately plastic;	e. Very stif sand, fine	f to hard; [AWHITU	× × × × × × × × × × × × × ×			 x 					M			✓ V= 134 ✓ R= 40 - - - - - - - - - - - - -
+75.40	- 1 - - - - - -		with black	edium SAND with minor si limonite inclusions. Mediu sand, micaceous; slightly c	um dense t		/	· • • • • • • • • • • • • • •							DM			
+74.20	- - 2 - 2.30 - - -	Awhitu Group	light grey	T with some clay, some g mottles. Stiff; wet; slightly s ; gravel, fine to medium.	plastic; sar	red with Id, fine,	× × × × × × × × × × × × × × × × × × ×	· · · ·		 X 					w			- - - - - - - - - - - - - - -
+73.70	2.80 3 		with mino	o medium SAND with trac r black and trace light red moist to wet; sand, micaco l.	mottles. Me	edium dense	×	>							MW			
+72.60	- - - 3.90		3.60 m G	rades to some black limon	ite inclusio	ns.	· · · · · · · · · · · · · · · · · · ·	> >						i I I				-
	- 4 - - -		brown wit	o medium SAND with min- h trace black limonite inclu wet; slightly cemented.	or clay; ligh isions. Meo	nt orange dium dense	× . × . × .	>							W			
+72.00	4.50 - 4.80	V	light grey	T with minor clay; brown v mottles. Hard; wet; sand, t I.80 m Grades to light orai	fine to med	lium.	× × × × ·×	>										-
	- 		Light grey	mottles and trace black lin	nonite inclu	<u>usions.</u>												
Rock I weath compl Relati firm/m • s	ered, mo etely wea ve soil St redium de Small Dis arge Dis J100 Und	ather derat there rengt nse, urbe turbe listur	ely weathere ed, residually th - very soft/ stiff/dense, ed Sample ed Sample bed Sample	very loose, soft/loose, very stiff/very dense	 Perme ▼ Schm ∨ Insitu ∨=Pe to per Wate 1 Wate 	Penetromet eability Test idt Hammer Vane Shear ak, R=Resid netrate r Strike (1st, r Rise (1st, Time (minute	⁻ Strength ual, UTP [;] , 2nd) 2nd) ar	ı (kPa) =Unab		-	eep (der nflow (de MINATEI	epth) D DUE TC					emark	
All di	mensi Sca		in metre :34	s Rig Type: Machine Excav	ator (13	3 tonne)							ar Vane I 945	NU.	Ĺ	ogged. GB	by:	Checked by: SLP

APPENDIX B

Machine Logs (MH1 to MH3)

RILEY CONSULTANTS Engineers and Geologists	Riley Consultants Itd 4 Fred Thomas Drive, Takapuna Auckland, 0622 Tel: +649-489-7872
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MACHINE HOLE LOG

Proje 710		iwai	Road		Locat Muriv	tion: wai Down	S			ole pos Refer to			lwg: 210339	-1		No.: H01	
Job Clie	nt:	2103		Start Date: 09- Finish Date: 09-	08-21		d Level (r 73 Hole Dep 13.95 m	oth:	C	o-Ordin E			TM): 3 N 5,925,7	38	Sheet:	of 2	
				ject Management	Linited		13.95 11									01 2	
Elevation (m)	Depth (m)	Geological Unit		Geological E	escript	tion		Legend	Weathering	Rock Field Strength	Drilling Method	RQD (%)	Core Loss (%) 25 50 75 	Field Testi	ng (type, orient roughness api	escription tation, spacing, s, persistence erture, ing etc)	
72.50	-	opsoil	TOPSOIL					111	NAMES OF CONTRACT OF CONTRACT.								_
	- - - - - - - - - - - - - - - - - - -	境		minor sand; brownish ora plastic; sand, fine [AWHI							Н03						
71.30	- - - - - - - - - - - -		moderately 1.95 m Gra	clay, some sand; light or plastic. Sand, fine. des to very stiff (PP = 3.0 ⁻ , some sand, some clay;	kg/cm^2)	-					HQ3 - SPT			SPT 1.50 2, 3, 1 4, 6, Nc=1	3,		
9.45			plastic. San Silty clayey cemented.	d, fine.				× × × × × `· · ·			SPT A HO			SPT 3.00 1, 1, 3, 3, Nc=1	2,		
8.75	- - - - - - - - - - - - - - - - - - -	Awhitu Group	4.00 m Gra dense; dark slightly cem SAND, som	des to some Silt. des to SAND, some silt, s orange brown mottles, d ented. e silt, some clay limonite; es, dark yellow. Core bro	ark yellow medium o	/. Core broke dense; dark o	n up; orange				HQ3 HQ3 PT A HQ3			SPT 4.50 3, 3, 3, 3, 3, Nc=1	4,		
	- - - - - - - - - - - - - - - - - - -										HQ3 - SPT A- H			SPT 6.00 2, 2, 3 2, 3, Nc=1	3,		
	-		7.20 m Gra	des to speckled black; me	edium den	ise.					- SPT			SPT 7.50 2, 2, 3 3, 3, 1 Nc=1	3,] 3;]		
FCR - SCR - RQD - N - Nc -	- Solid - Rock SPT S SPT S le of di	Core I Core Quali poon olid C	Recovery Recovery ty Designation	ed as Dip/Dip	Large Dis U100 Un Lugeon T Water St Water Ri	sturbed Sam sturbed Sam ndisturbed Sa Test - Flow T trike (1st, 2nd ise (1st, 2nd ie (minutes)	iple ample ype/Adopted d)	Value	Geolog "Field D Rock", I (2005) Shear \ "Guidel	ine for Ha est", NZ G	ption: is of S chnica nd He	Soil and al Socie eld Shea	ety - Cap riser f - Bentonite - Blinding sa - Screened ar - Blinding sa - Bentonite - Filter sand	details: meter low pre: rom 0.0m bgl backfill from 0 nd from 10.0 pipe with filter and from 13.5 backfill from 1 from 13.85 n	ssure PVC to 0.2m bgl. 1.2m bgl to 10m bg m bgl to 10.5m bg sand from 10.5m m bgl to 13.7m bg 3.7m bgl to 13.85 n bgl to 13.95m bg	l. bgl to 13.5m b l. m bgl.	- -
All c			ns in metre 1:50	s Driller: DRILL FORC	_	Rig Typ Wirelii	e:	D	rilling F	luid:			2. PP = Pocke Shear Van		Logged by: AWT	Checked	

2	R	NSU Rets an	EY	Riley Consultants 4 Fred Thomas Drive, Takap Auckland, 0622 Tel: +649-489-7872									N	ΛA	CH	INE	Н	OLE I	.0G	
Proj 710		iwai	Road		Locat Muriv	ion: vai Dow	'ns					ition:		wg: 21	0339	-1			lo.:	
	No.:	2103		Start Date: 09- Finish Date: 09-	08-21		nd Level (i 73	m):			rdin	ates	(NZT	ГМ):				M	H01	
Clie	ent:			ject Management			73 Hole Dep 13.95 m				E	1,730	,573	N 5,	920,7	30		Sheet: 2	of 2	
Elevation (m)	Depth (m)	Geological Unit		Geological E)escript	ion		Legend	Rs HWW WWW Weathering		Strength	Drilling Method	RQD (%)	Core L (% 25 50 	_oss) 75 	Field Te	esting	roughness, ape	escription tion, spacing, persistence ture, ig etc)	Piezometer
			SAND, som brown mottle (continued	e can be broken with thur	medium c ken up; sli	dense; darl ightly ceme	k orange ented.					наз — врт 🛧 наз —				9 3 4	:PT			
	- - - - - - - - - - - - - - - - - - -	Awhitu Group										HQ3 SPT				S 1 ¹ 1. 3 N	- 			
												HQ3 SPT				1 2 5				
+58.80	-		EOH @ 13.	95 m								- SPT				1 2 3				
19/10/2000 1 / M/B (n propring) 1 / 4-58.80	- 15																			
	plana			•	Small Die	sturbed Sa	mple		Tes	t Met	hod	s		Ren	narks	<u> </u>		1		
SCR RQD N - Nc - Attitud	- Solid - Rock SPT S SPT S de of di	Core Quali poon olid C iscont	Recovery Recovery ty Designation one inuities displaye nd/Plunge	े ed as Dip/Dip मू पू	Large Dis U100 Un Lugeon T Water St Water Ris	sturbed Sa idisturbed \$	mple Sample Type/Adopted nd) d) and	l Value	"Field Rock (2005 Shea "Guid Vane	", NZ (5) r Vane eline fo	iption Seoteo : or Har NZ G	ption: s of So chnical nd Held eotech	Societ d Shea	- 32 - Ca - Be - Bli - So r - Bli - Be - Fil	mm dian p riser f nding sa reened nding sa ntonite ter sand	and from 1 pipe with 1 and from 1 backfill fro	bgl to 0 om 0.2m 10.0m b filter sau 13.5m b om 13.7 35 m bg	re PVC).2m bgl. h bgl to 10m bg igl to 10.5m bgl nd from 10.5m igl to 13.7m bgl m bgl to 13.85r bgl to 13.95m bgl	bgl to 13.5m n bgl.	bgl.
, <u> </u>			ns in metre 1:50	s Driller: DRILL FORC	E	Rig Ty Wire		D	rilling	Flui	d:			Shea	ır Van	ie No.:	Lo	ogged by: AWT	Checked SLP	

	F
	4
CONSULTANTS	A
Engineers and Geologists	

Riley Consultants Itd 4 Fred Thomas Drive, Takapuna Auckland, 0622 Tel: +649-489-7872

MACHINE HOLE LOG

Proje 710		wai	Road		Locati Muriw	on: /ai Downs			lole pos Refer to			wg: 210339)-1	No.:	
Job I		2103	39	Start Date: Finish Date:		Ground L	evel (m): 70	C	o-Ordir E			⁻ M): N 5,925,8	352	MH02	
Clier Tł		ears	Home Pro	oject Managemo	ent Limited		le Depth:).95 m			.,				Sheet: 1 of 2	
Elevation (m)	Depth (m)	Geological Unit		Geologic	al Descripti	on	Legend	s WW Weathering	Me Ms Strength	Drilling	RQD (%)	Core Loss (%) 25 50 75 	Field Testing	Defect Description (type, orientation, spacing, roughness, persistence aperture, infilling etc)	
70.00	-	H opsoil	TOPSOIL	T, minor sand; orang	e brown with rea	d mottles. Verv S		<u>XOIS0</u>	<u> </u>					- - - - -	
67.95			slight to me	oderately plastic; San	d, fine (AWHIT)	GROUP].	ĸı × ı × × × × × × × × × × × × × × × × ×			P SPT A HQ3			SPT 1.50 m 1, 2, 2, 4, 5, 6; Nc=17		
7.55 6.80		Group	dilatant; sa 2.30 m - 2. slightly pla: SAND, sor medium de 3.00 m Gra orange with SAND, trac	T, minor clay; orange. Ind, fine; micaceous. 70 m Sandy SILT, mi stic; dilatant; sand, fin me silt; light greyish bl ense; Sand, fine to me ades to very close spa h dark brown mottles. De clay, trace silt; orar hty cemented. Black	nor clay; orange e; micaceous. ack with light or edium. aced, very thin; manganese ox age with black s	e. Very stiff; non ange mottles; Lo Limonite; light gr ide bands. pecks; medium	to			наз — 🚩 spт 🛧 наз			SPT 3.00 m 2, 3, 4, 3, 6, 5; Nc=18		
4.75	- 5	Awhitu G	3.70 m Gra 4.30 m Gra Loose to m oxide stain 5.20 m - 5.	ades to medium to co ades to fine to mediun nedium dense. Slightly	arse SAND. n SAND, no silt, v cemented limo	d as saturated, lo	inese			HQ3 PT A H			SPT 4.50 m 2, 2, 3, 2, 3, 2; Nc=10		
-			CORELOS SAND, trac dense; slig	SS ce clay, trace silt; orar htty cemented. Black	ige with black s specks are mai	pecks; medium nganese oxide.				HQ3 - SPT A- HQ			SPT 6.00 m 2, 2, 3, 2, 4, 4; Nc=13		
-	-									SPT			SPT 7.50 m 2, 3, 4, 3, 4, 4; Nc=15		
FCR - SCR - RQD - N - S Nc - S Attitude	xplanations: - Total Core Recovery - Solid Core Recovery - Solid Core Recovery - SPT Spoon - SPT Spoon - SPT Spidi Cone ude of discontinuities displayed as Dip/Dip ction and Trend/Plunge - Rise Time (minutes) - Rise Ti										r details: meter low pressu backfill from 0.01 d from 4.4m bgl t pipe with filter se and from 6.0m b backfill from 6.21 and from 7.3m b pipe with filter se and from 9.0m b backfill from 9.21	m bgl to 4.3m bgl. o 4.5m bgl. and from 4.5m bgl to 6.0m bg gl to 6.2m bgl. m bgl to 7.3m bgl. gl to 7.5m bgl. and from 7.5m bgl to 9.0m bg			
All d			ns in metro 1:50	es Driller: DRILL FO		Rig Type: Wireline	D	rilling	Fluid:			Shear Var	et Penetrometer	ogged by: Checked AWT SLF	

	20	R	ISUL ers and	EY TANTS Geologists	Riley Consultants 4 Fred Thomas Drive, Takap Auckland, 0622 Tel: +649-489-7872	ltd ouna									MACH	IINE	H	OLE I	_OG	
	roject 10 M		wai	Road			ation: riwai Dow	/ns				ole pos Refer te			dwg: 21033	9-1			lo.: H02	
J	ob No		103	39	Start Date: 09- Finish Date: 09-			nd Level (r 70	n):		Сс	o-Ordii E			TM): 5 N 5,925	852		IVII	102	
0	Client: The		ars	Home Pro	oject Management	Limite	ed	Hole Dep 10.95 m										Sheet: 2	of 2	
ī	Elevation (m)	nepun (m)	Geological Unit		Geological E	Descrij	ption		Legend	CR CW Weathering		Hite Rock Field	» Drilling Method	RQD (%)	Core Loss (%) 25 50 75 	Field T	esting	(type, orienta roughness, ape	escription ation, spacing, persistence rture, ng etc)	Piezometer
	- 9	0	Awhitu Group	SAND, trac dense; slig (continue	e clay, trace silt; orange v htly cemented. Black spec d)	vith blac cks are r	k specks; me manganese o	edium oxide.					HQ3			9 4 5	;PT .00 m , 4, 5, , 5, 6; lc=21			
+59	9.30 - - - - - - - -		v	10.50 m Be tight.	edding Joint; 30deg dip; p	lanar, ro	ough, <2mm a	aperture,					SPT			1 2 3	PT 0.50 m , 2, 3, , 3, 4; lc=13 _	- - - - -		
) 21033B.MH LOGS.GPJ < <drawingfile>> 17.092021 13:41 Produced by gINT Professional</drawingfile>	- 1	2 3 4 5		EOH @ 10	.95 m															
120 TOC 1-1	CR - So	tal C olid C	ore F Core F	Recovery Recovery	● ⊥	Large	Disturbed Sa Disturbed Sa Jndisturbed \$	imple		Geo "Fie	ologio eld De	Aethoo cal descr escription	ription: ns of S	Soil and		er details: ameter low	pressu	Ire PVC		
N HW (B) N	- SP ⁻ c - SP ttitude o	T Sp T So of dis	ioon lid Co conti		yed as Dip/Dip ↓	Lugeor Water Water		rType/Adopted 2nd) id) and	Value	(20 She "Gu Var	05) ear V iidelir ne Te	VZ Geote ane: ne for Ha est", NZ ((2001)	and He	eld She	ety - Bentonit - Filter sa - Screene - Blinding - Bentonit - Blinding - Screene - Blinding	e backfill from ad from 4.4r sand from 6 e backfill fro sand from 7 d pipe with sand from 9 e backfill fro	om 0.0n m bgl to filter sa 6.0m bg om 6.2n 7.3m bg filter sa 9.0m bg om 9.2n	n bgl to 4.3m bg	gl to 6.0m bg gl. gl to 9.0m bg	
	All dim			ns in metro 1:50	es Driller: DRILL FORC	E	Rig Ty Wire		D	rillin	ıg F	luid:			Shear Va			ogged by: AWT	Checked SLF	

2	R	NSU Rets an	LEY 4 Fri Auch	ey Consultants ed Thomas Drive, Takap kland, 0622 +649-489-7872									R	ЛАС	HIN	ΕH	OLE I	_OG	
Proj 710		iwai	Road		Locat Muriv	ion: vai Dow	ns			Hole Refe				wg: 210	339-1			lo.: H03	
Job		2103		Start Date: 11-		Grou	nd Level (r 68	n):		Co-Oi			•	TM): 7 N 5,92	25,898		1411	105	
Clie T		ears	Home Projec	t Management	Limited	1	Hole Dep 10.95 m										Sheet: 1	of 2	
Elevation (m)	Depth (m)	Geological Unit		Geological D	escript	ion		Legend	Weathering	e Rock Field		Drilling Method	RQD (%)	Core Los (%) 25 50 1 	ss Fiel 75 	d Testing	(type, orient roughness ape	escription ation, spacing, persistence rture, rg etc)	Piezometer
+67.90	-	P psoil	TOPSOIL						803388		2000 2005 100						-		
	- - - - - - - - - - - -		fine [AWHITU C	e sand; dark yellow. \ GROUP]. to orange, trace fine g		• • •						Н03				-	- - - - - - - - - - - - - - -		
+66.00	- - - - - 2		medium grained	to light grey with light d sand. SAND; light brownish								SPT A				SPT 1.50 m 1, 0, 1, 1, 2, 1; Nc=5	- - - - - - -		
			mottles. Loose;	a SAND is non cemen		-	-					SPT 🔶 HQ3			 	SPT	- - - - - - - - - - - - - - - - - - -		
+64.65	-		`	n Limonite pan, orang			/				 _ 	5				1, 1, 2, 2, 3, 3; Nc=10	-		
	-4-4	Awhitu Group	sand; light yello laminar limonite	to medium to coarse	ge mottles	s. Very clos	e spaced					— наз –			 	-	-		
+63.40	Ę			medium pumiceous S.		•						SPT				SPT 4.50 m 2, 1, 1, 2, 1, 1; Nc=5			
+63.40	5 		yellowish brown	and orange mottles.	Loose.		-					НОЗ				-			
			orange mottles, 5.70 m Grades brownish red.	SAND, trace silt, trac speckled black. Loos to minor Silt, slightly c	e. emented;	; orange to	light				 	SPT				SPT 6.00 m 2, 2, 2,	-		
	- - - - - - 7		manganese oxi	to light brownish red, de staining; Medium c to moderately cement	lense.	a, trace lime	onite with				 	HQ3				3, 3, 3; Nc=11	- - - - - -		
+60.80	-			, some silt, trace grave ed; gravels, fine; distu			Loose;	0.			 	SPT				SPT 7.50 m 1, 2, 3, 3, 4, 4;	-		
Ex TCR - SCR - RQD N - Nc - Attitud	- Solid - Rock SPT S SPT S le of di	Core I Core Quali poon olid C	Recovery Recovery ty Designation		Large Dis U100 Un Lugeon T Water St Water Ri	sturbed Sar sturbed Sar idisturbed S Test - Flow trike (1st, 2n ise (1st, 2n e (minutes)	mple Sample Type/Adopted nd) d) and	l [`] [`] . Value	Geolo "Field Rock (2005 Shea "Guid Vane	t Meth ogical de Descrij ", NZ Ge) r Vane: eline fo Test", h ty (2001	escrip ptions eotecl r Han NZ Ge	otion: s of So hnica d Hel	l Socie d Shea	ty - 32m - Cap - Bent - Blinc - Scre ar - Blinc - Bent - Filte 2. NOTE	meter detai m diameter riser from (tonite backl ding sand fr eened pipe ding sand fr tonite backl r sand from E: Where po	Nc=14 ils: r low press 0.0m bgl to fill from 0.2 rom 2.5m b with filter s rom 6.0m b fill from 6.5 ill from 6.1 n 7.0m bgl 1 ocket pene	ure PVC. 0.2m bgl. m bgl to 2.5m b gl to 3.0m bgl. and from 3.0m igl to to 6.5m bg m bgl to 7.0m b o 10.95m bgl. to 10.95m bgl. or eat 10.95m	bgl to 6.0m bg ll. gl	
			ns in metres 1:50	Driller: DRILL FORC	E	Rig Ty Wire	•	D	rilling	Fluid	:			Shear	Vane N	o.: Lo	ogged by: AWT	Checke	

			LTANTS nd Geologists	Riley Consultants 4 Fred Thomas Drive, Taka Auckland, 0622 Tel: +649-489-7872										N	NA (CHI	INE	Н	OLE I	_OG	
	oject: 10 Mui	riwai	Road			ation: riwai Dow	ns						ition RIL		wg: 21	0339	-1			lo.: H03	
Jo	b No.:	210	339	Start Date: 11 Finish Date: 11			nd Level (i 68	n):		C	0-01			s (NZ 0,587	TM): 7 N 5,	925,8	98		IVI	103	
С	lient: The E	Bears	B Home Pro	oject Managemen	t Limite	ed	Hole Dep 10.95 m												Sheet: 2	of 2	
Elevation (m)	Depth (m)	Geological Unit		Geological	Descrij	ption		Legend		Weathering	Rock Field		Drilling Method	RQD (%)	Core L (%) 25 50 		Field Te	esting	roughness, ape	escription ation, spacing, persistence rture, rg etc)	Piezometer
	9	Awhitu Group	slightly cen (continue 8.00 m Gra mottles, ye moderately	AND, some silt, trace gra nented; gravels, fine; dis d) ides to fine to medium, tr llowish brown, brownish cemented; blackish ora thick, faint bedding.	turbed by race silt; li orange. N	drilling. ight orange v Aedium dens	with black ;e;						– наз – у SPT 🔶 наз –				9 2 4	PT			
+57.	15 - - - - - - - 11 ⁻		10.45 m "J manganes EOH @ 10	oint", 45deg dip; planar r e oxide coating - same a .95 m	rough; 2m is bedding	nm-3mm ape g; inferred be	rture; edding joint.		<pre> </pre>				SPT				1 1 3	PT - 0.50 m , 2, 2, - , 5, 5; - c=15 _ - -			
ssional	- - - - - - - - - - - - - - - -																				
1 Produced by gint Prov	- 																				
II//09/2021 13:4	- 14 - - - - - -																	-			
ziooosami coosasa seaamigniese iriosizazi iosti rioaasa oy gini molessona	- - - - - - - - - - - - - - - - - - -																				
	+ Explana	atior	IS:		0					est I			S		Rem	narks					
TC SC RC N NC Atti	R - Total R - Solid D - Rock - SPT S - SPT S tude of c	l Core l Core k Qual Spoor Solid (discon	Recovery Recovery ity Designatior		Large U100 U Lugeon Water Water	Disturbed Sa Disturbed Sa Jndisturbed I n Test - Flow Strike (1st, 2 Rise (1st, 2r ime (minutes	mple Sample Type/Adopted and) ad) and	Value	"F Ro (2) Sh "G Va	ock", i 005) near V Guideli	VZ Ge VZ Ge /ane: ine foi est", N	ption eoteo r Har NZ G	s of S chnica nd He	ioil and al Socie Id Shea hnical	1. Pie. - 32 - Ca - Bi - Bi - So ar - Bi - Bi - Bi - So - Fii 2. NO	zometer 2mm dia ap riser entonite inding s creened inding s entonite ter sanc TE: Wh	and from pipe with and from backfill fro d from 7.0 ere pocke	n bgl to om 0.2r 2.5m bg filter sa 6.0m bg om 6.5r m bgl to t peneti	re PVC. 0.2m bgl. n bgl to 2.5m b gl to 3.0m bgl. ind from 3.0m l gl to to 6.5m bg n bgl to 7.0m b o 10.95m bgl. rometer (PP) va re at 10.95m	ogl to 6.0m by Il. gl	
			ns in metro e 1:50	es Driller: DRILL FOR	CE	Rig Ty Wire		D	Drilli	ng F	luid	:			Shea	r Van	e No.:	Lo	gged by: AWT	Checke SLF	

APPENDIX C

Borehole Core Photographs

Machine Borehole 2 Photographs



Photo 1: MH2 from surface to 3m bgl



Photo 2: MH2 from 3m to 6m bgl



Photo 3: MH2 from 6m to 9.45m bgl



Photo 4: MH2 from 9.45m to 10.95m bgl

APPENDIX D

SPT Hammer Efficiency Certificate

Table 1. Summary of SPT Hammer Energy Transfer Measurements

The maximum, minimum, and standard deviation in energy transfer for each SPT sample over the SPT N value increment are included in Appendix B.

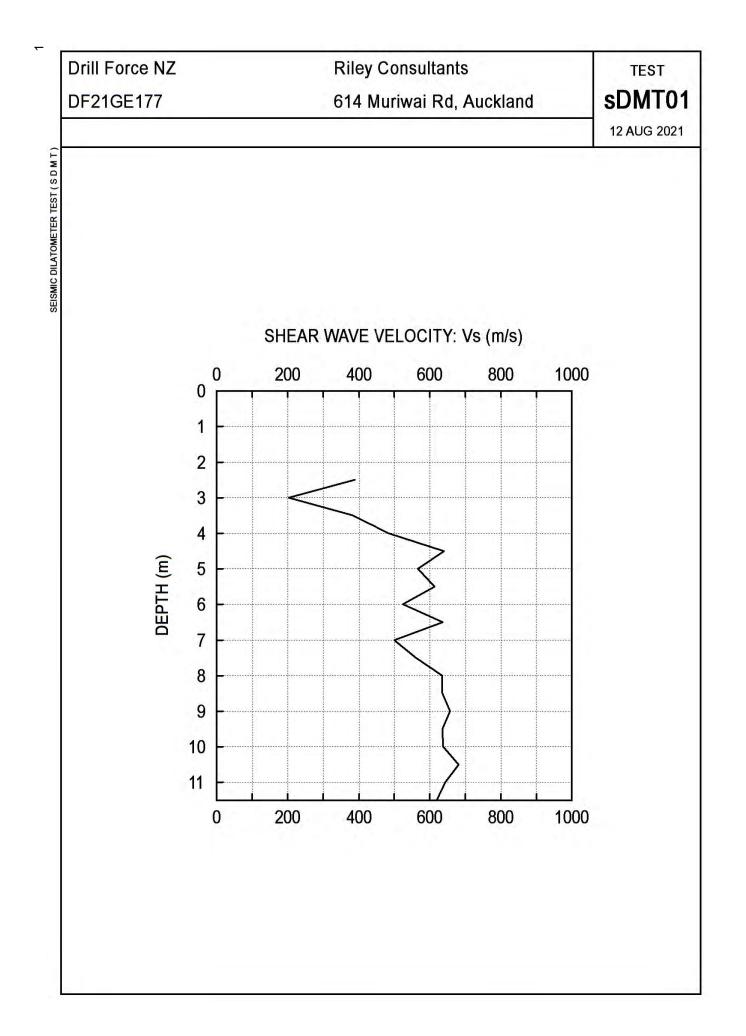
Hammer No.	Calibrated with Drill	Number of Valid Test	Average Transferred	Average Energy	Range in Transferred	Range in Energy
NO.	Rig No.	Samples	Energy	Transfer Ratio	Energy	Transfer Ratio
DFSH001	79	3	0.369kNm	77.7%	0.361kNm to 0.383kNm	76.0% to 80.5%
DFSH002	79	3	0.366kNm	77.1%	0.358kNm to 0.373kNm	75.3% to 78.5%
DFSH003	86	3	0.364kNm	76.5%	0.358kNm to 0.373kNm	75.3% to 78.5%
DFSH004	89	3	0.369kNm	77.6%	0.364kNm to 0.376kNm	76.7% to 79.1%
DFSH005	81	3	0.343kNm	72.3%	0.322kNm to 0.354kNm	67.8% to 74.6%
DFSH006	79	3	0.381kNm	80.2%	0.338kNm to 0.409kNm	71.2% to 86.1%
DFSH007	81	3	0.371kNm	78.1%	0.359kNm to 0.390kNm	75.6% to 82.1%
DFSH008	81	3	0.352kNm	74.2%	0.341kNm to 0.361kNm	71.9% to 76.0%
DFSH009	86	3	0.344kNm	72.4%	0.336kNm to 0.353kNm	70.8% to 74.4%
DFSH010	79	3	0.370kNm	77.8%	0.365kNm to 0.372kNm	76.8% to 78.4%
DFSH011	86	3	0.374kNm	78.8%	0.363kNm to 0.390kNm	76.5% to 82.1%
DFSH012	79	3	0.387kNm	81.5%	0.372kNm to 0.400kNm	78.4% to 84.2%

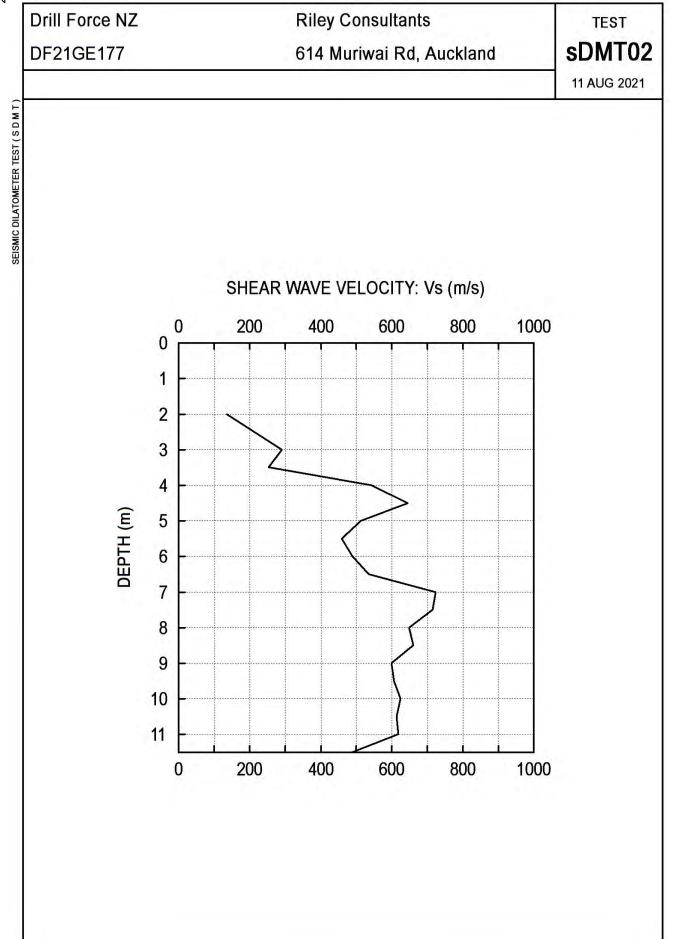
5

Average
Blow Rate
(blows
(010 WS
14
14
14
14
14
14
16
10
12
12
10
10
19
19
16
10
12
12
16
10
9
,
13
15

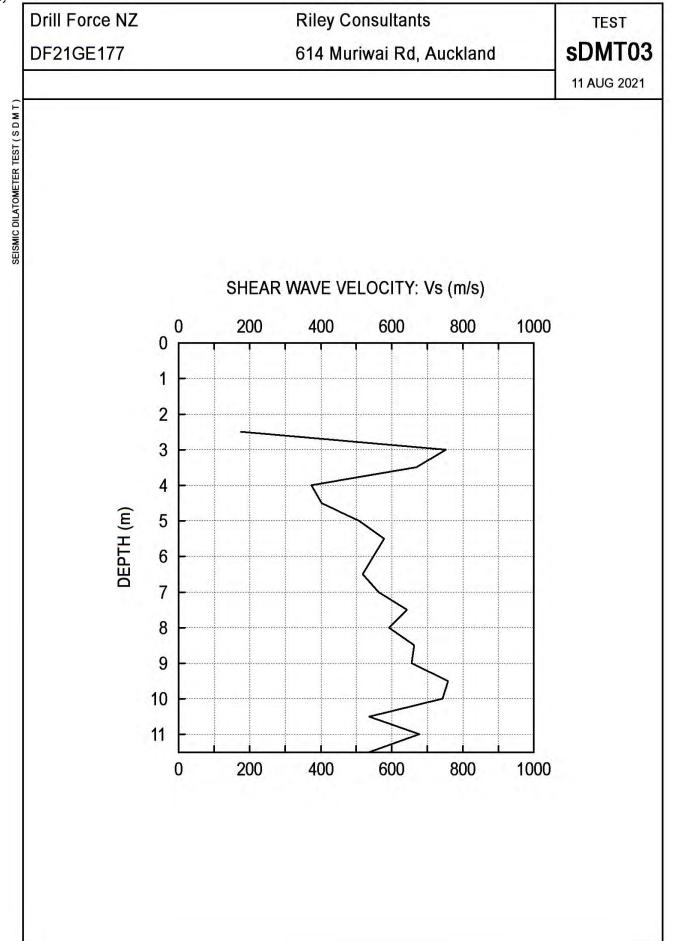
APPENDIX E

Seismic Dilatometer Test Results

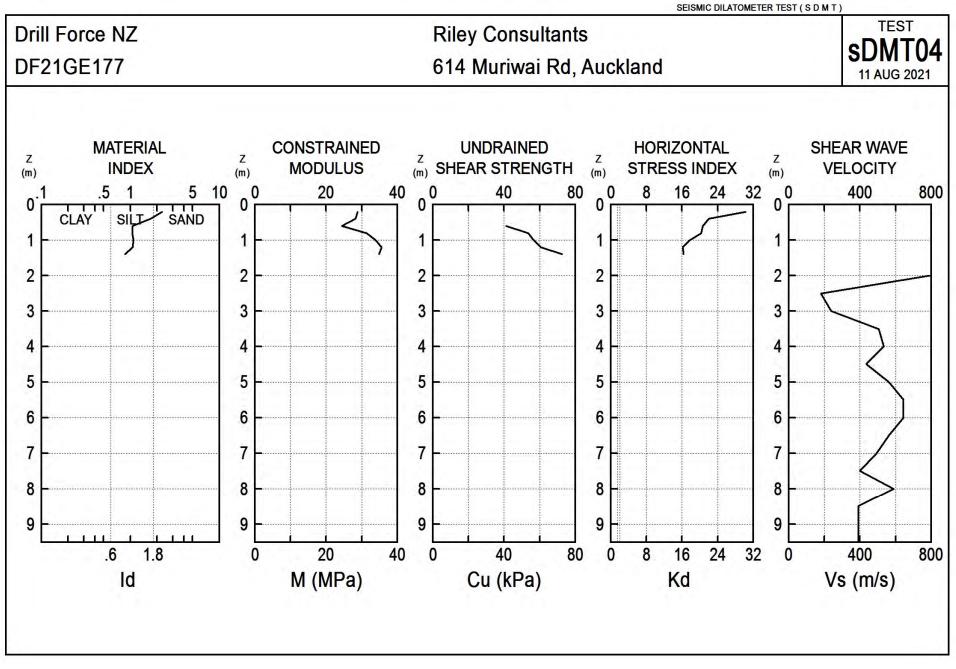


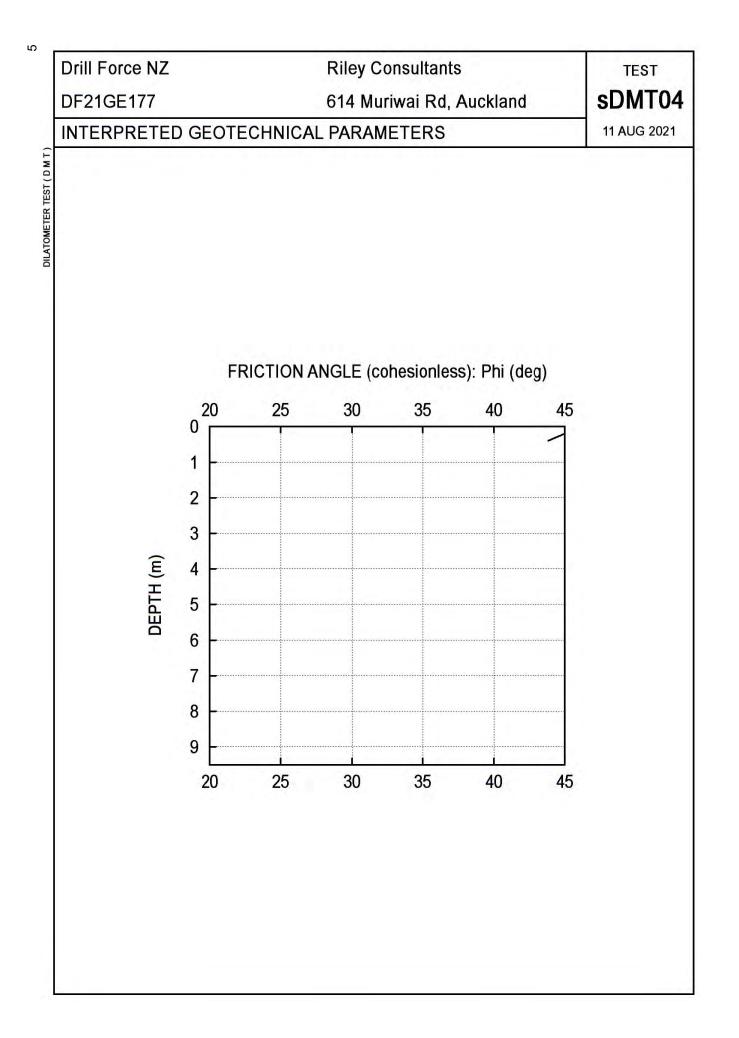


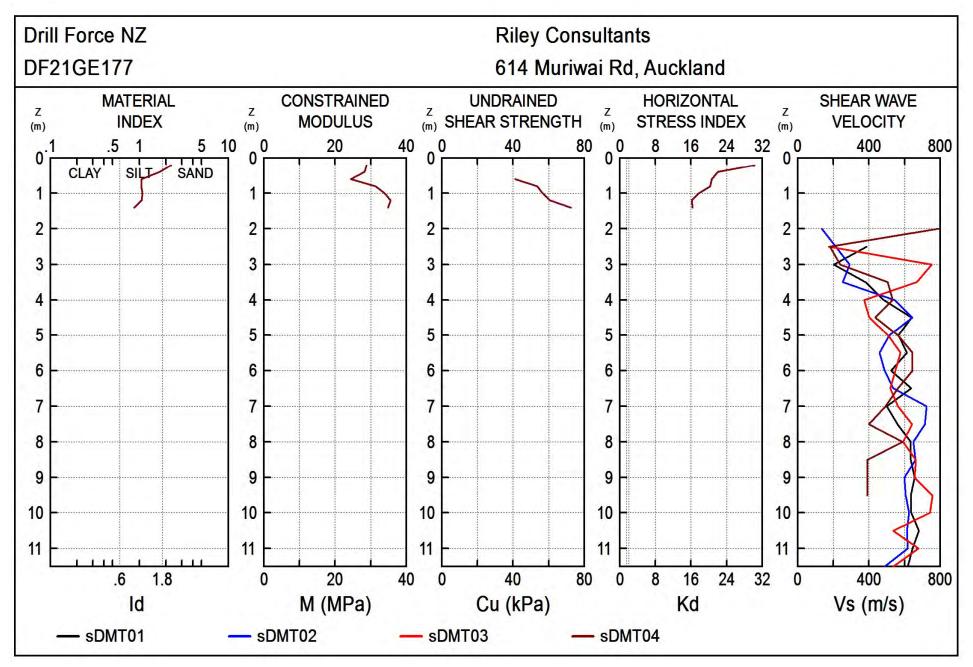
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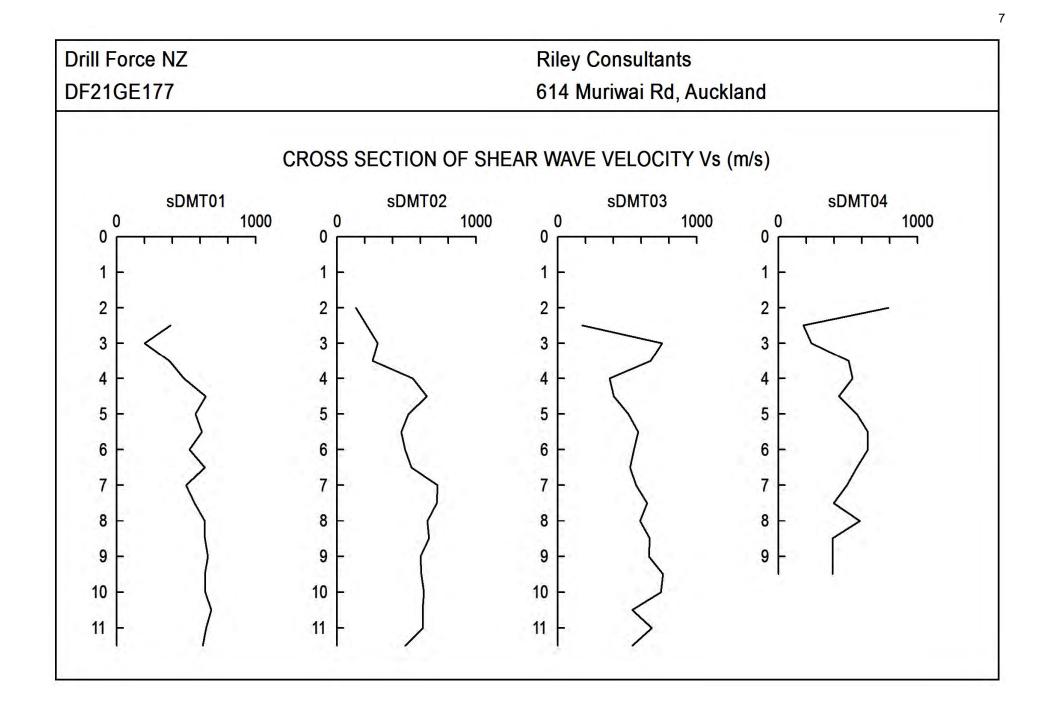


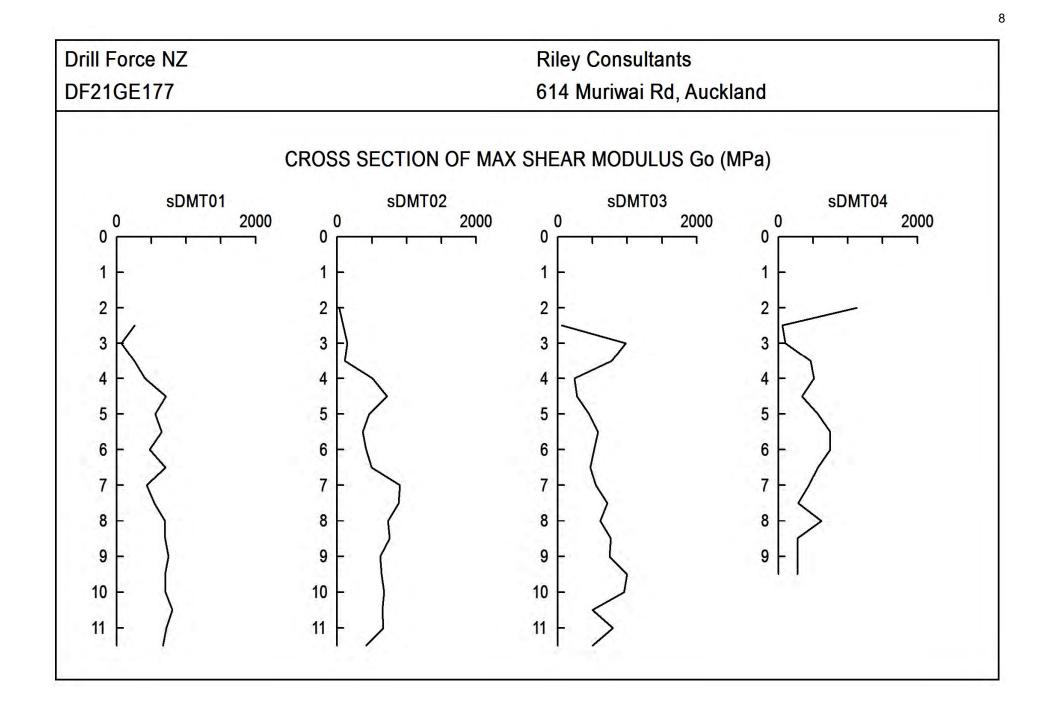
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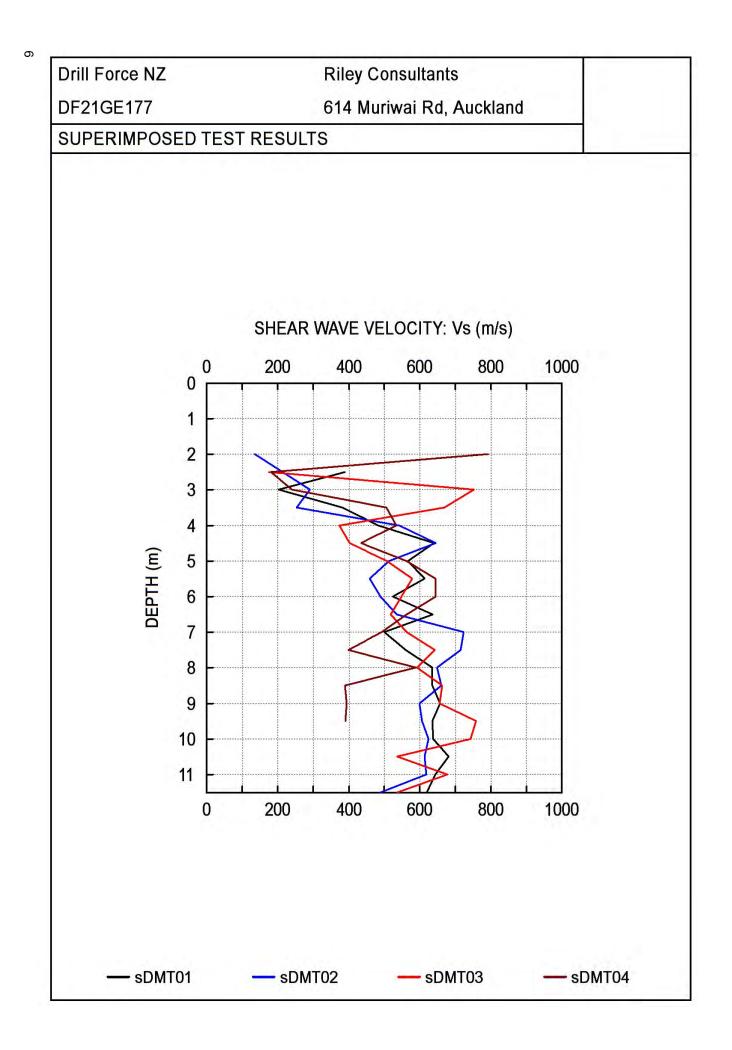


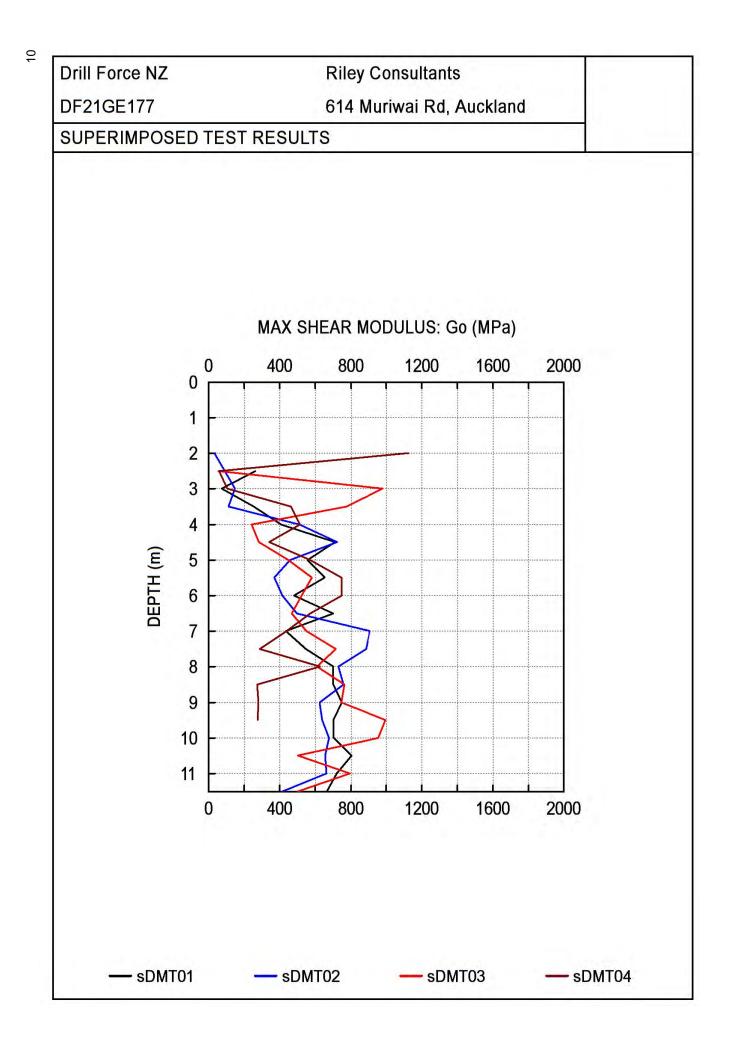












APPENDIX F

Liquefaction Results

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http://www.geologismiki.gr

Vs BASED LIQUEFACTION ANALYSIS REPORT (Kayen et al. 2013)

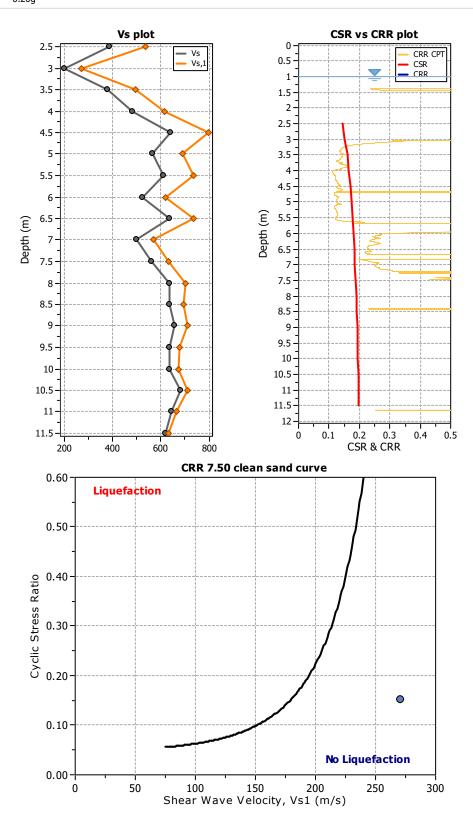
Project title : 210339 - Muriwai Downs

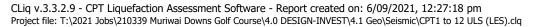
Software

Location : 710 Muriwai Road

CPT file : CPT-06

Calculation method: G.W.T. (in-situ):	Kayen et. al (2013) 1.00 m
G.W.T. (earthq.):	1.00 m
Earthquake magnitude M:	5.90
Peak ground acceleration.	0.20a





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Vs BASED LIQUEFACTION ANALYSIS REPORT (Kayen et al. 2013)

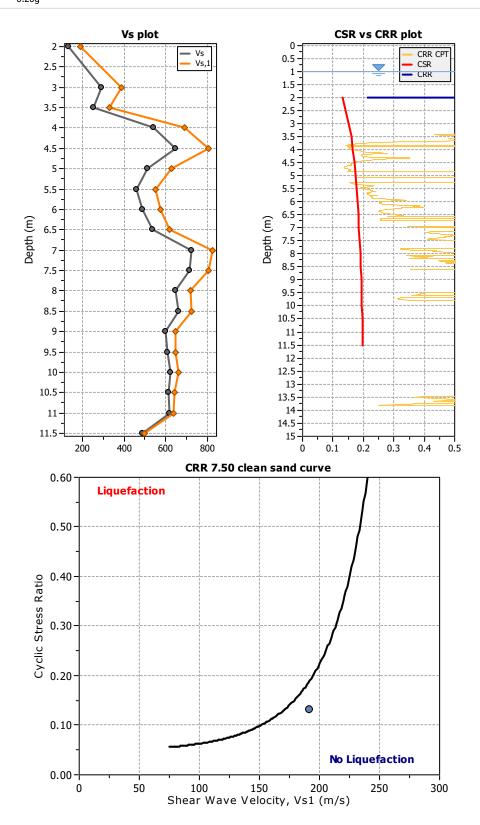
Project title : 210339 - Muriwai Downs

Software

Location : 710 Muriwai Road

CPT file : CPT-07

Calculation method: G.W.T. (in-situ):	Kayen et. al (2013) 1.00 m
G.W.T. (earthq.):	1.00 m
Earthquake magnitude M:	5.90
Peak ground acceleration.	0.20a



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Vs BASED LIQUEFACTION ANALYSIS REPORT (Kayen et al. 2013)

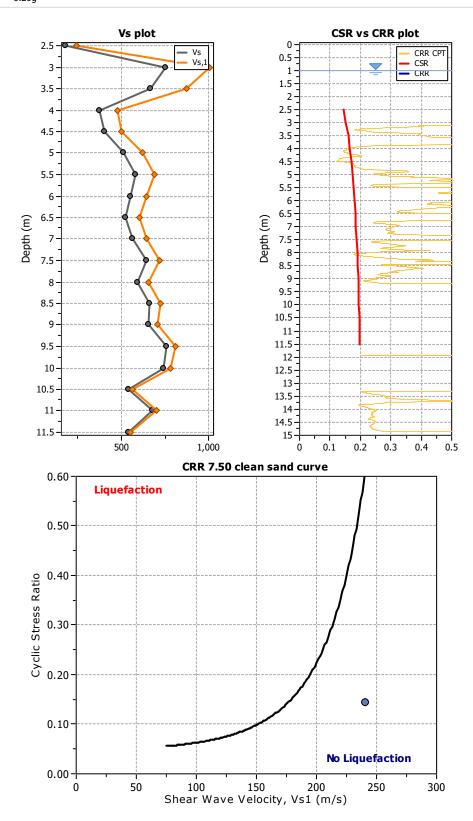
Project title : 210339 - Muriwai Downs

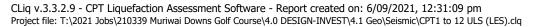
Software

Location : 710 Muriwai Road

CPT file : CPT-09

Calculation method:	Kayen et. al (2013)
G.W.T. (in-situ):	1.00 m
G.W.T. (earthq.):	1.00 m
Earthquake magnitude M:	5.90
Peak ground acceleration.	0 20a





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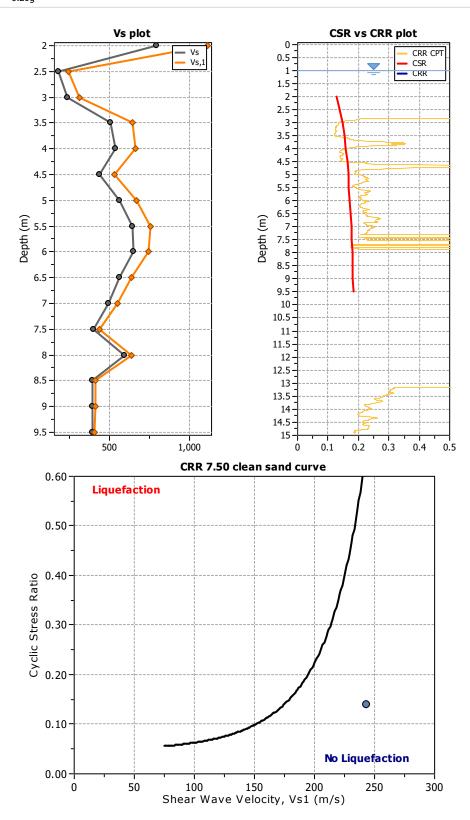
Vs BASED LIQUEFACTION ANALYSIS REPORT (Kayen et al. 2013)

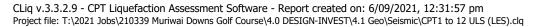
Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road

CPT file : CPT-02

Calculation method: G.W.T. (in-situ):	Kayen et. al (2013) 1.00 m
G.W.T. (earthq.):	1.00 m
Earthquake magnitude M:	5.90
Peak ground acceleration.	0.20a







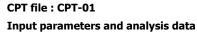
Geotechnical Engineers Merarhias 56

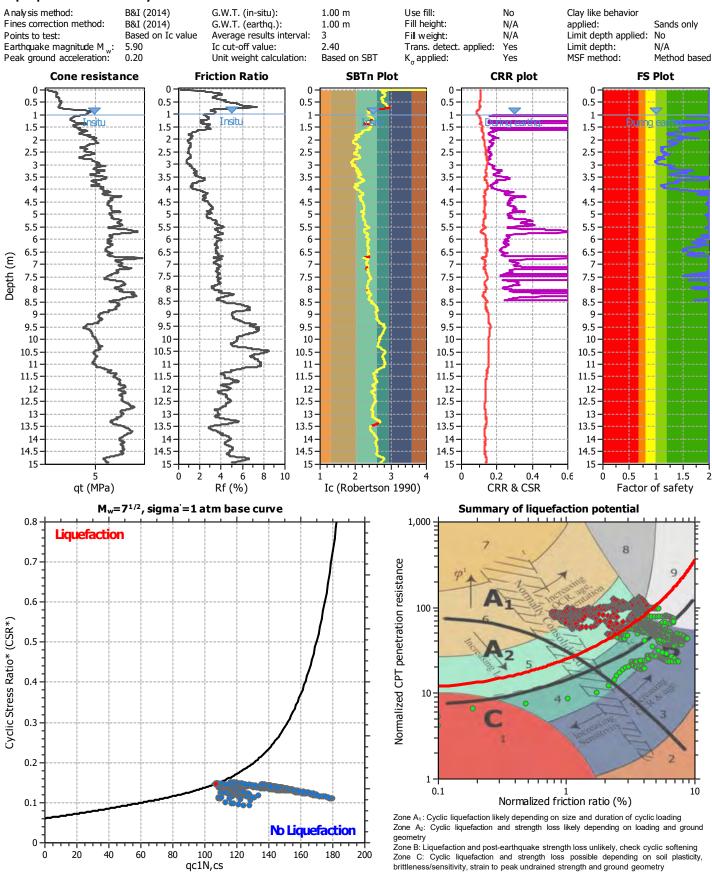
http://www.geologismiki.gr

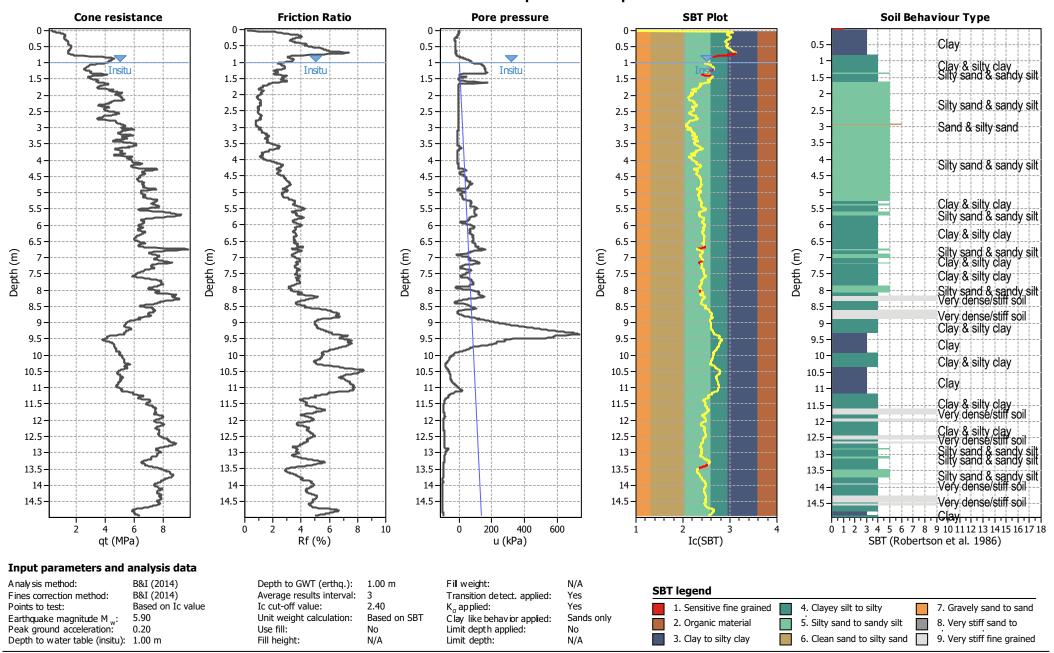
LIQUEFACTION ANALYSIS REPORT

Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road

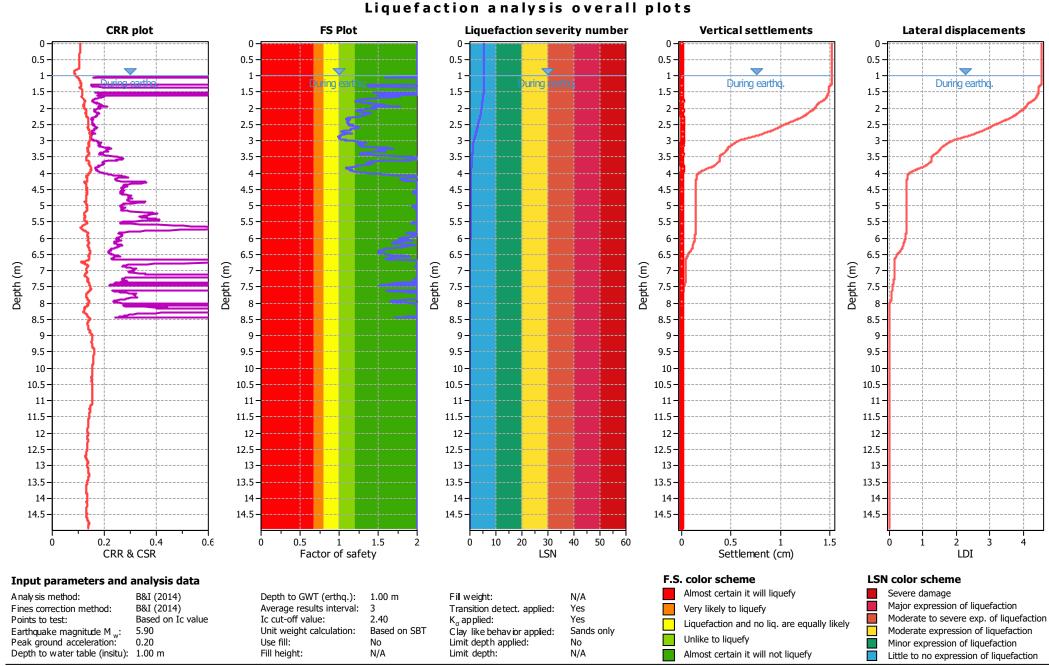






CPT basic interpretation plots

CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 11:48:13 am Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 11:48:13 am Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



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G.W.T. (in-situ):

G.W.T. (earthq.):

http://www.geologismiki.gr

LIQUEFACTION ANALYSIS REPORT

1.00 m

1.00 m

Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road

Use fill:

Fill height:

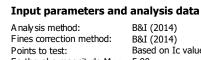
No

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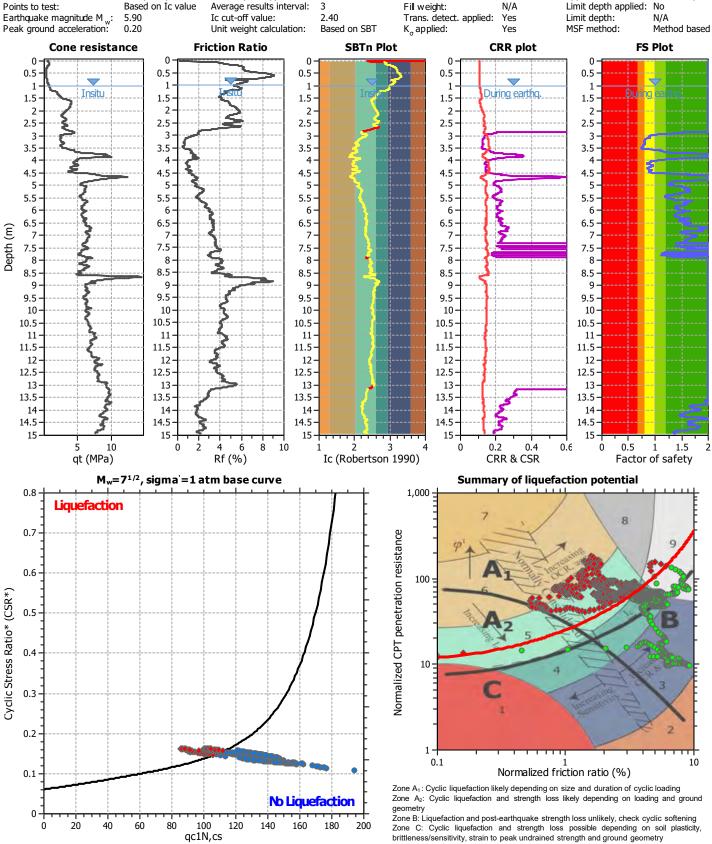
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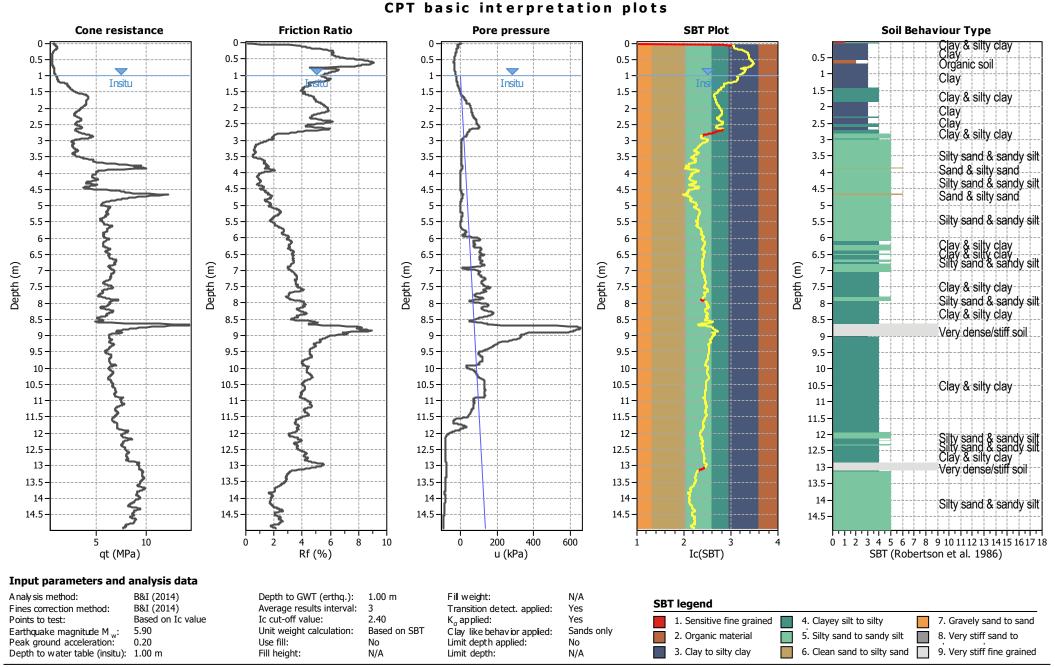
Sands only

applied:

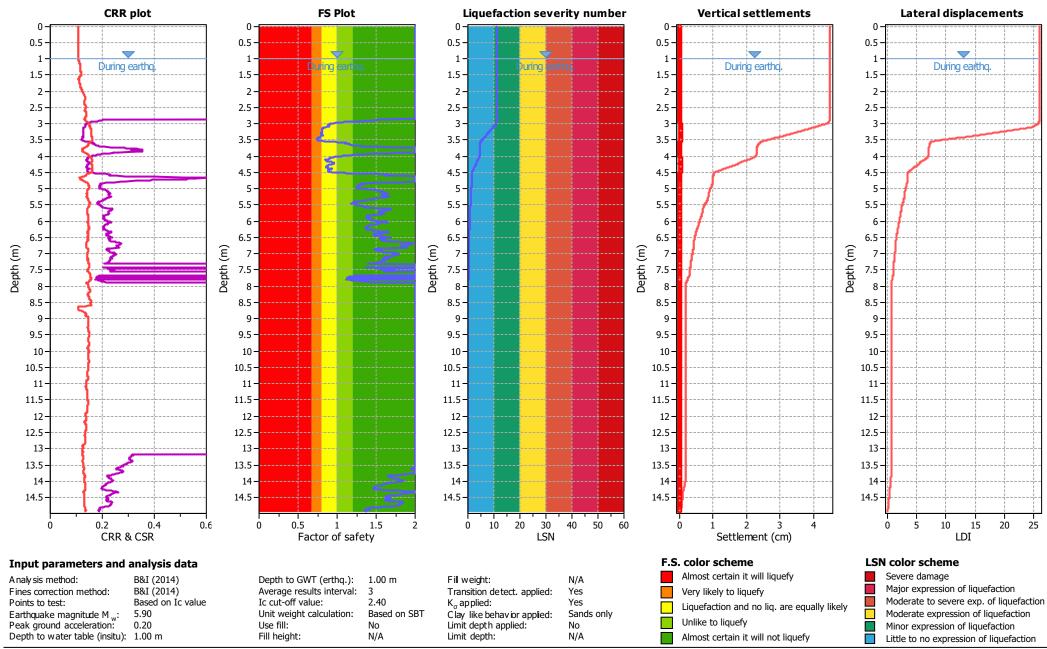


CPT file : CPT-02





CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:17:57 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



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G.W.T. (in-situ):

G.W.T. (earthq.):

http://www.geologismiki.gr

LIQUEFACTION ANALYSIS REPORT

1.00 m

1.00 m

3

Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road

Use fill:

Fill height:

No

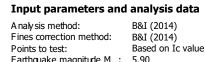
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Clay like behavior

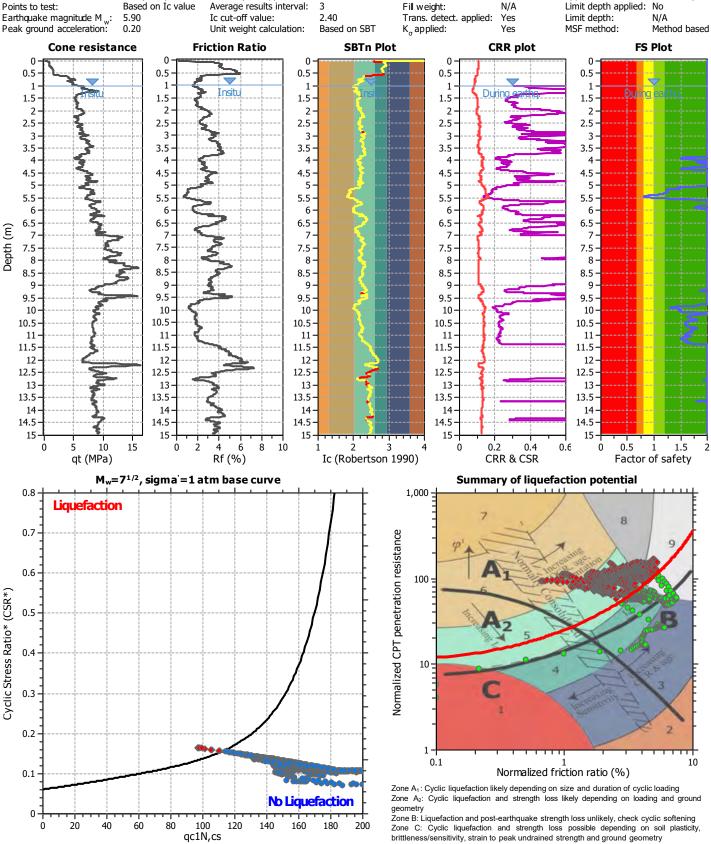
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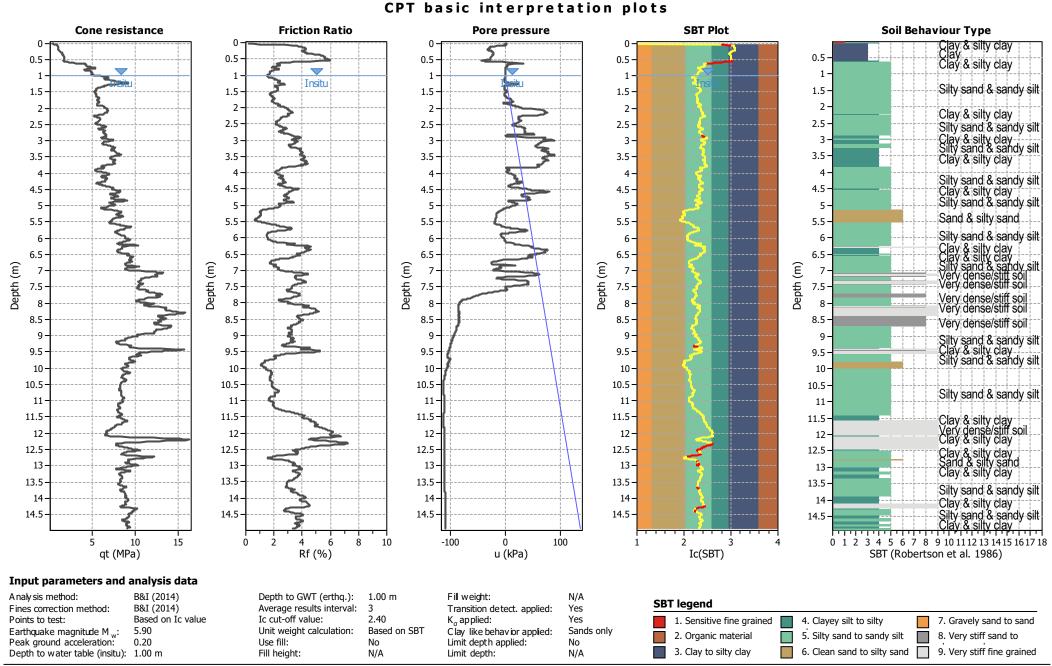
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applied:

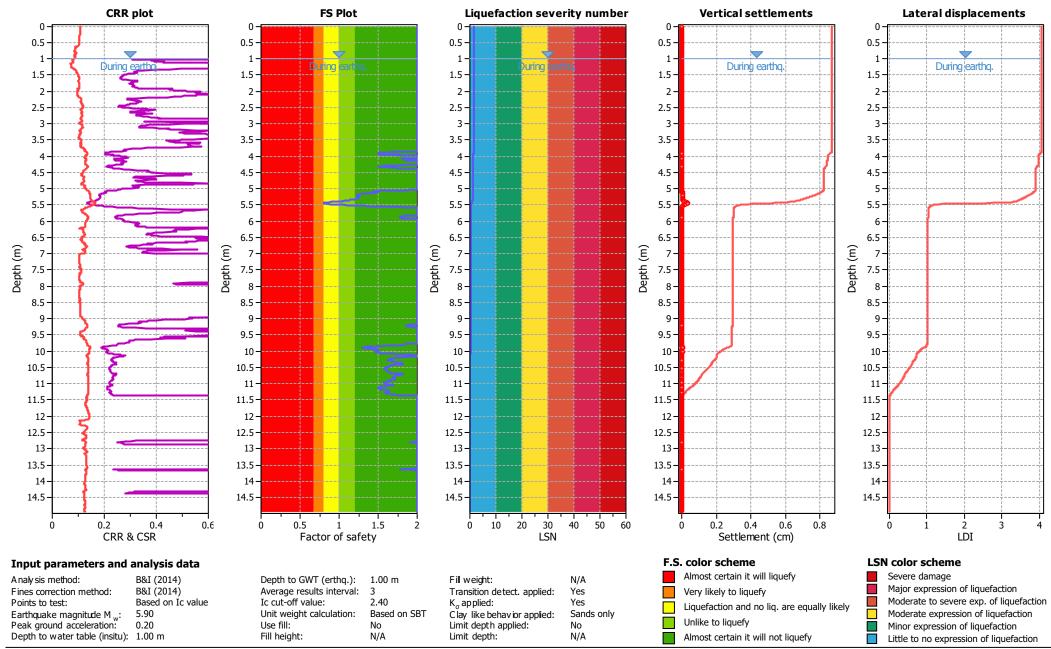


CPT file : CPT-03





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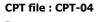
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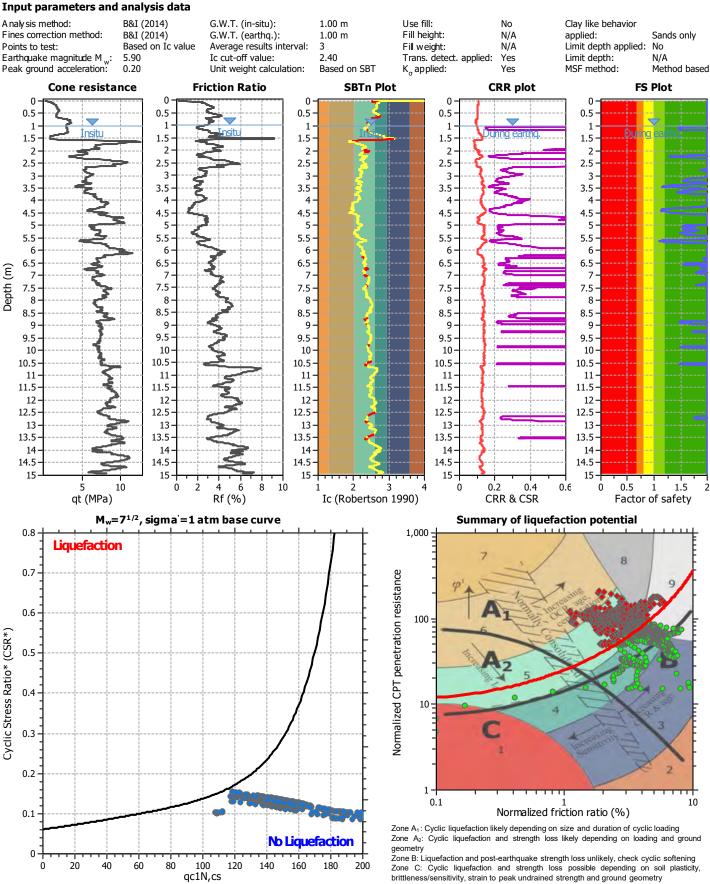
http://www.geologismiki.gr

LIQUEFACTION ANALYSIS REPORT

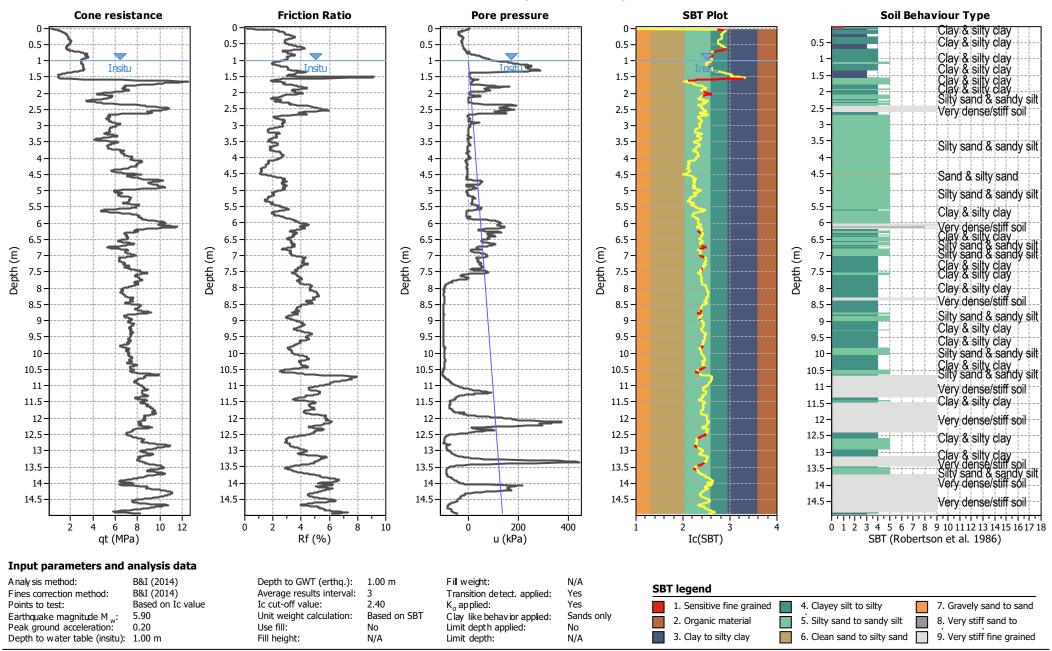
Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road



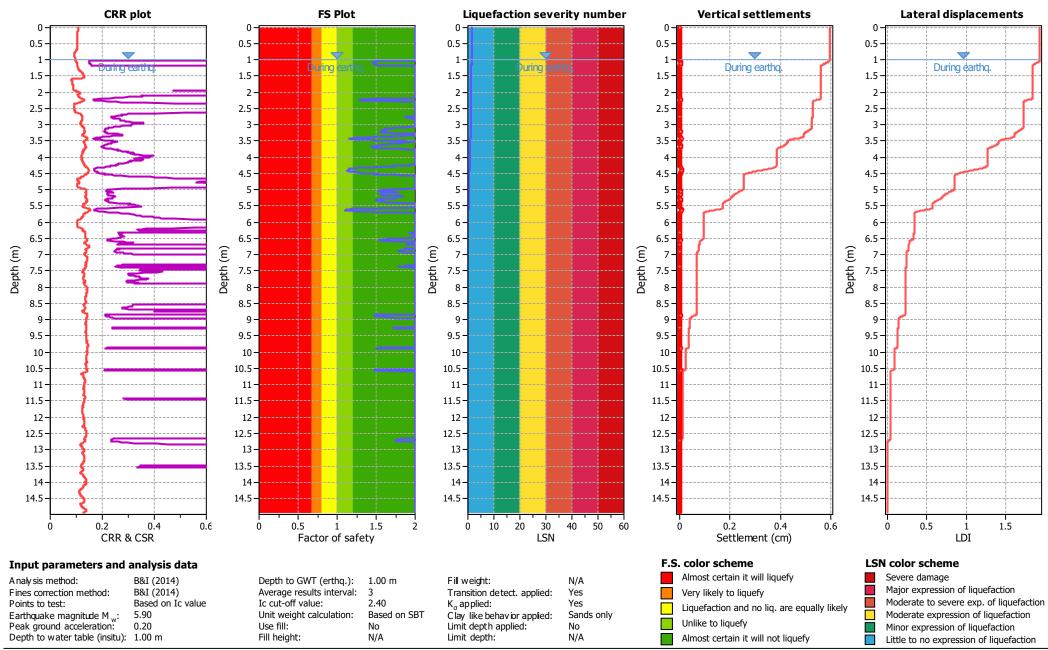


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CPT basic interpretation plots

CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:22:01 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



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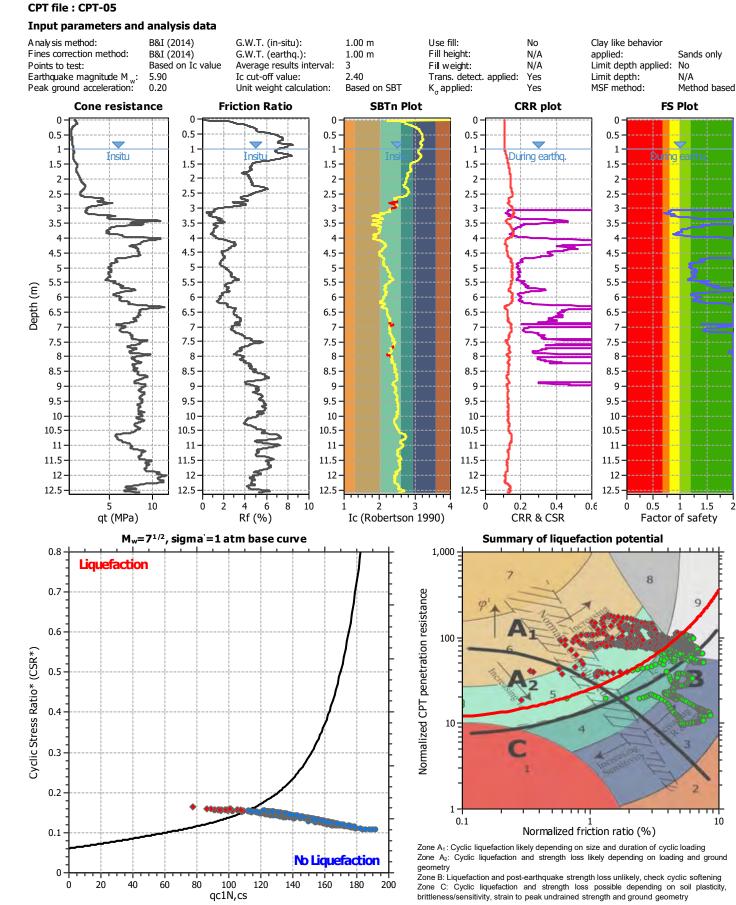
Geotechnical Engineers Merarhias 56

http://www.geologismiki.gr

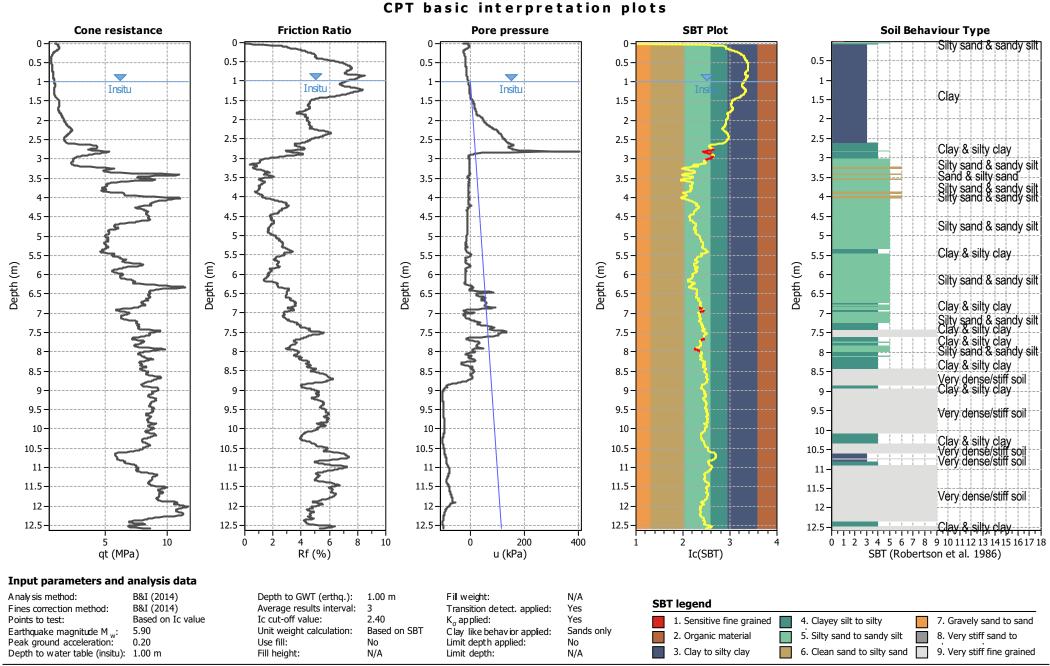
LIQUEFACTION ANALYSIS REPORT

Project title : 210339 - Muriwai Downs

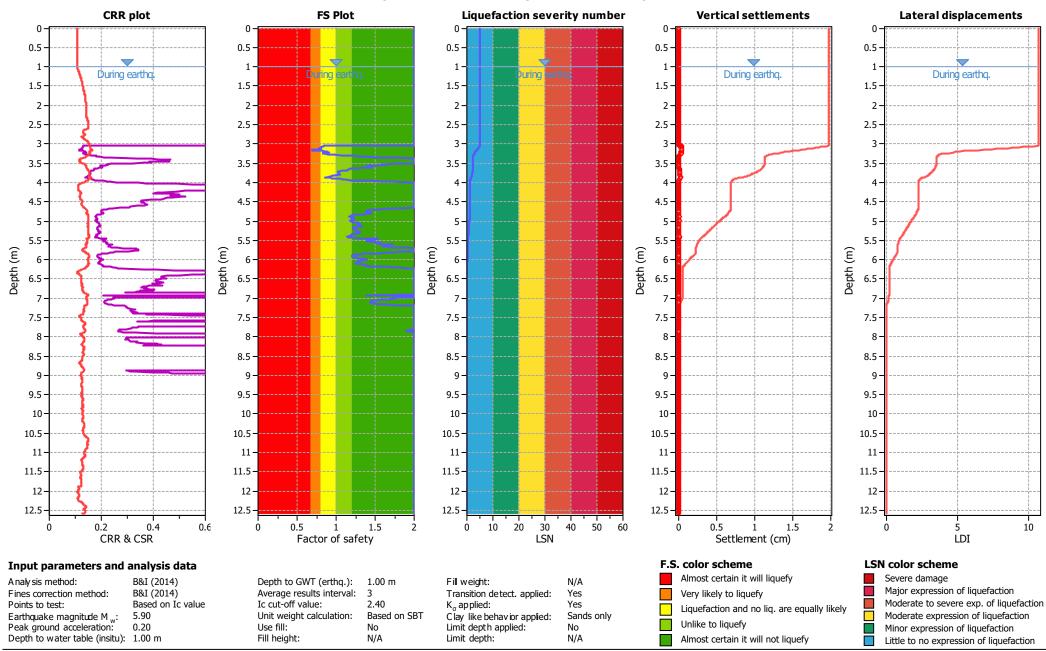
Location : 710 Muriwai Road



2



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CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:22:22 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



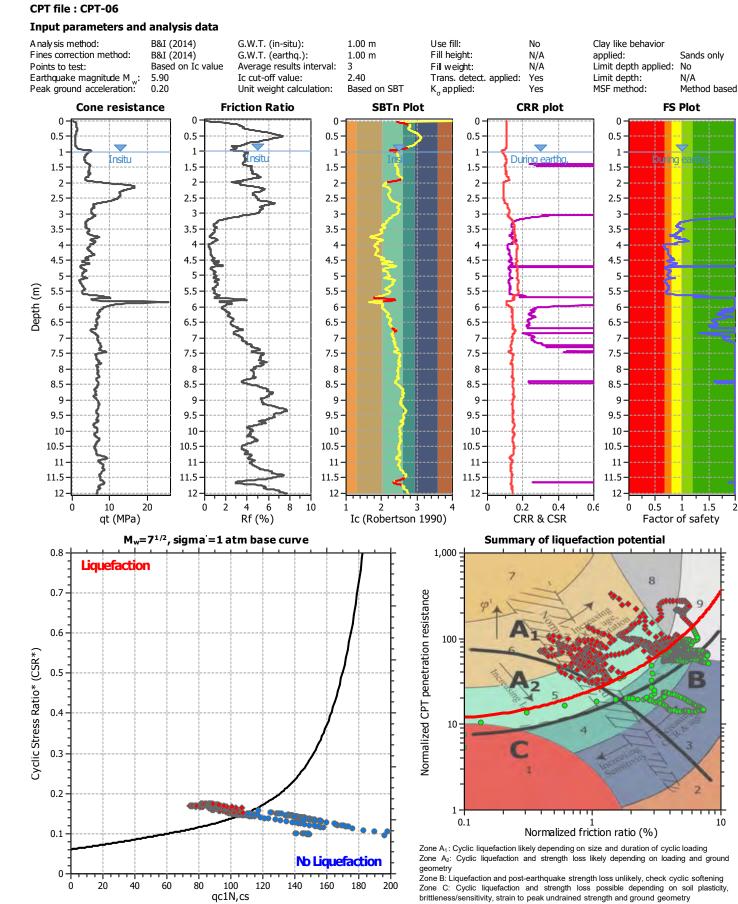
Geotechnical Engineers Merarhias 56

http://www.geologismiki.gr

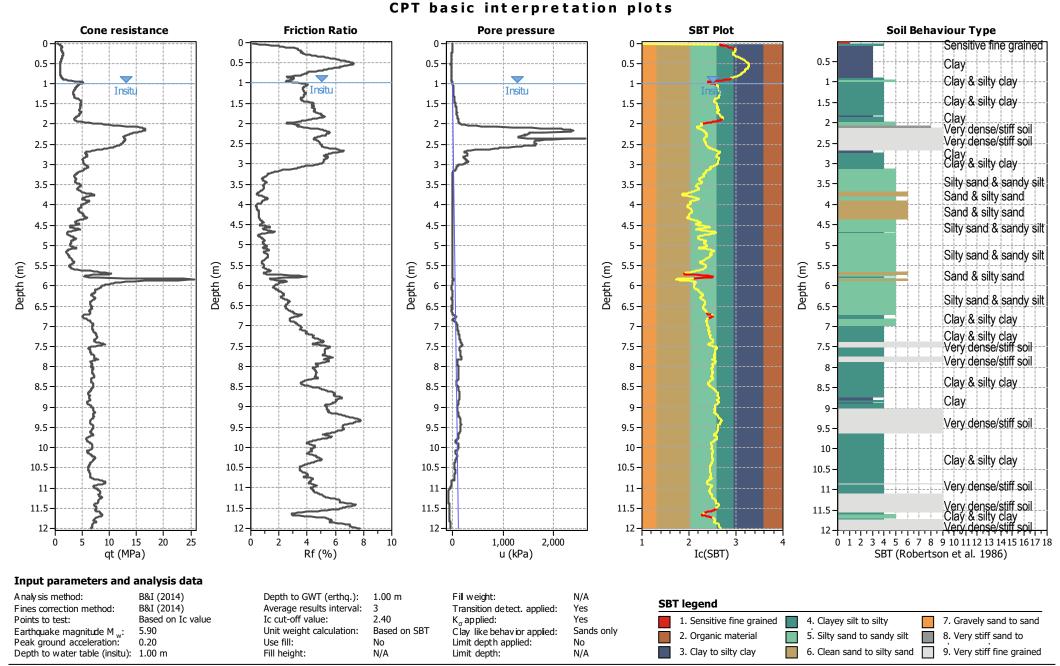
LIQUEFACTION ANALYSIS REPORT

Project title : 210339 - Muriwai Downs

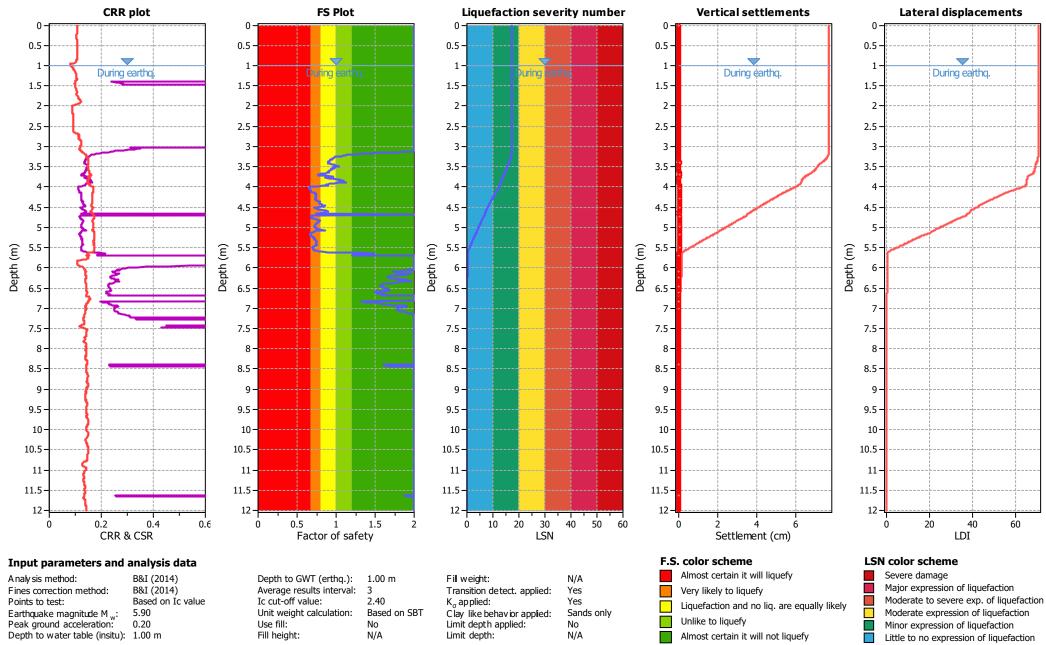
Location : 710 Muriwai Road



CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:22:40 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq 2



CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:22:40 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:22:40 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



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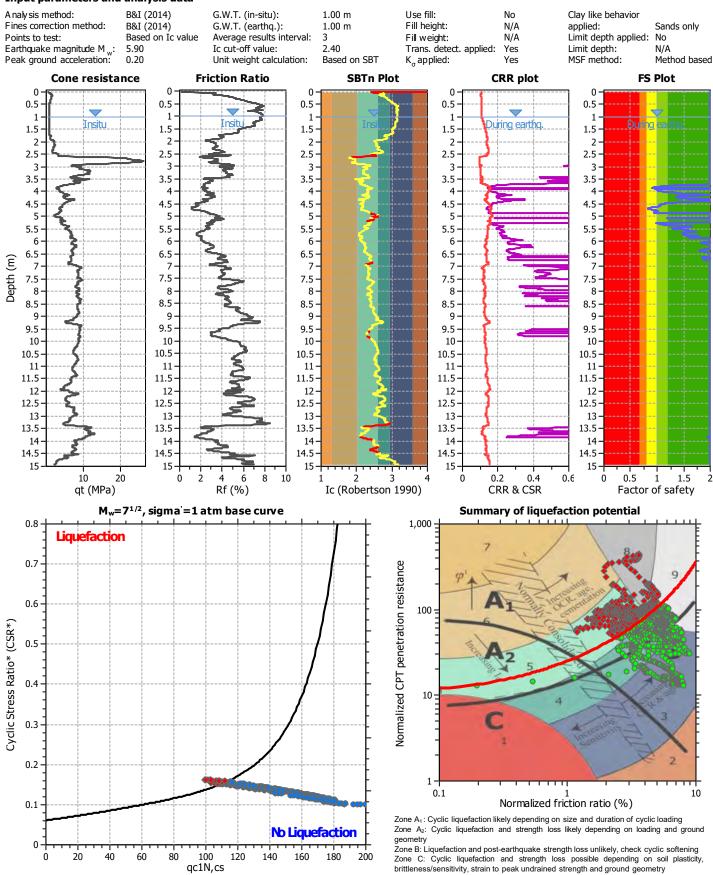
LIQUEFACTION ANALYSIS REPORT

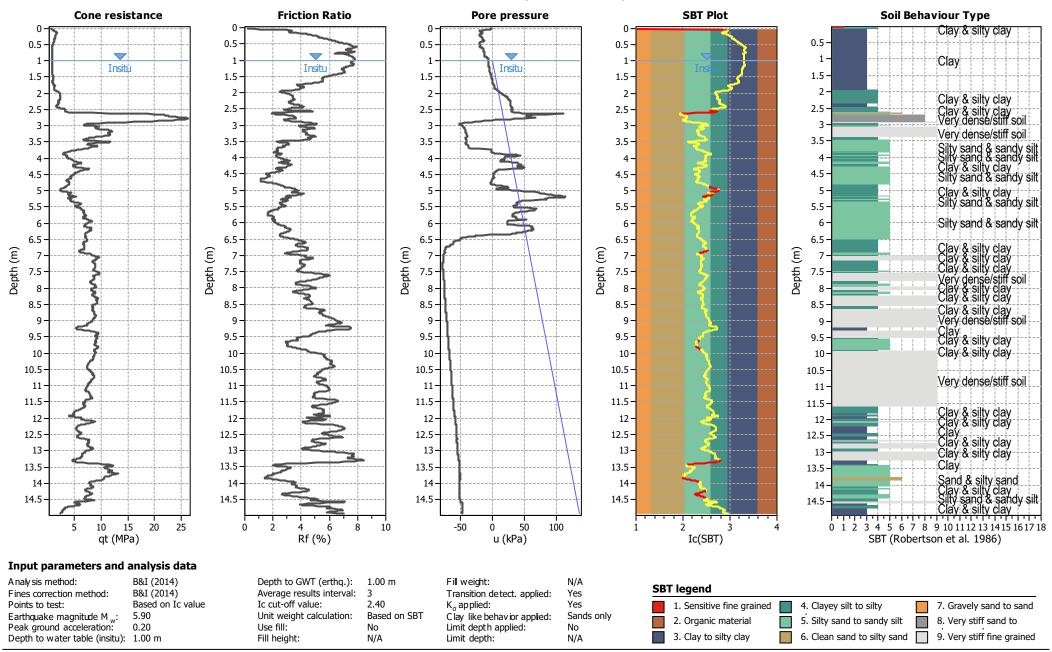
Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road



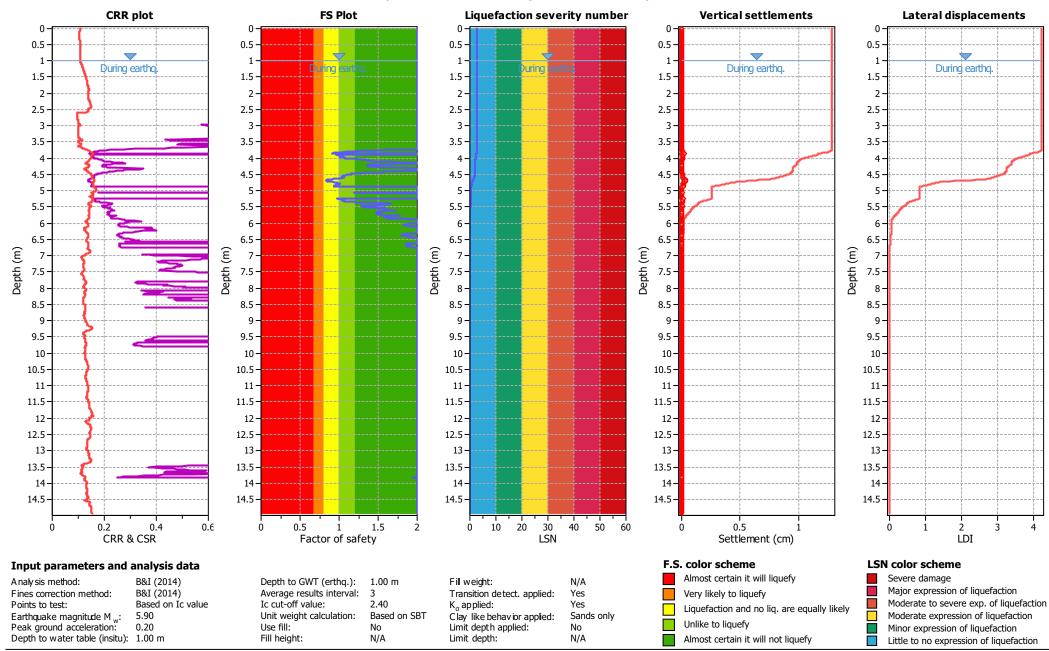
Input parameters and analysis data





CPT basic interpretation plots

CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:22:56 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq 2



CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:22:56 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



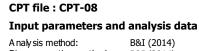
Geotechnical Engineers Merarhias 56

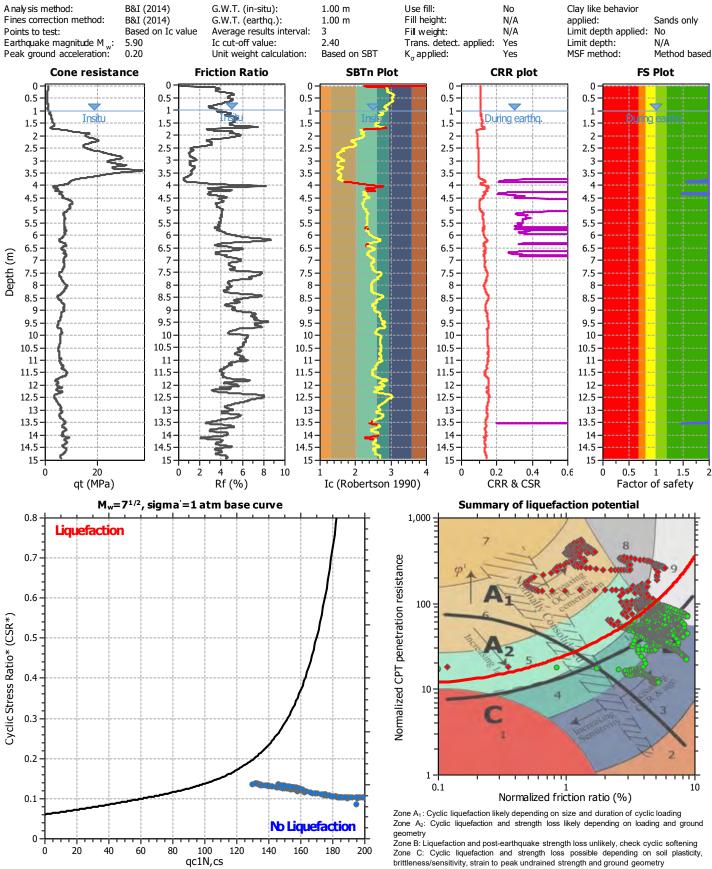
http://www.geologismiki.gr

LIQUEFACTION ANALYSIS REPORT

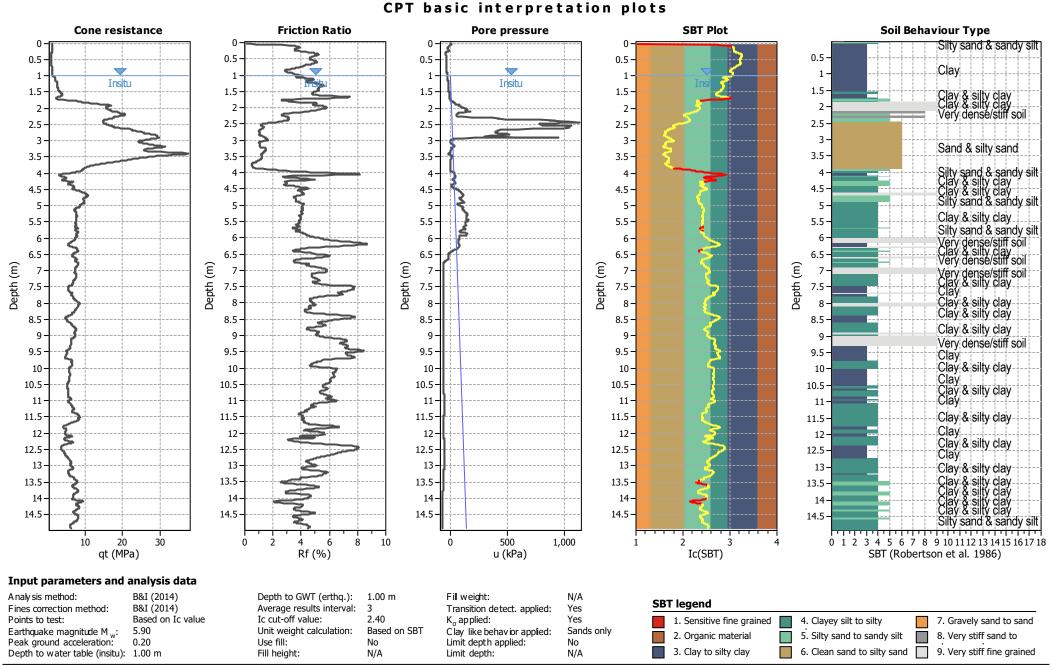
Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road

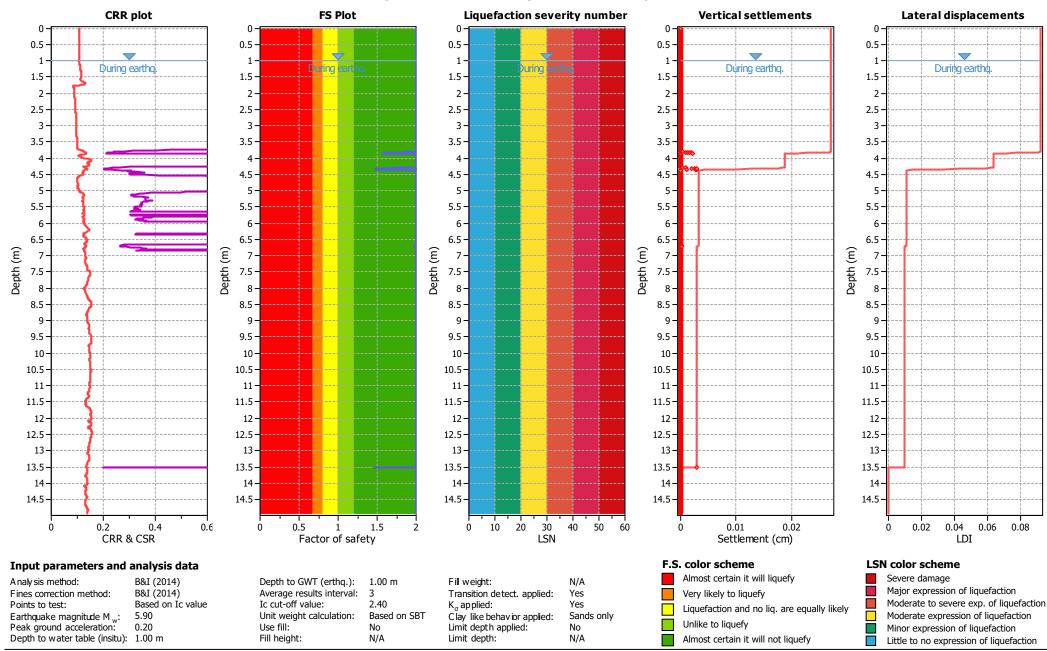




CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:23:15 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:23:15 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:23:15 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



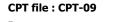
Geotechnical Engineers Merarhias 56

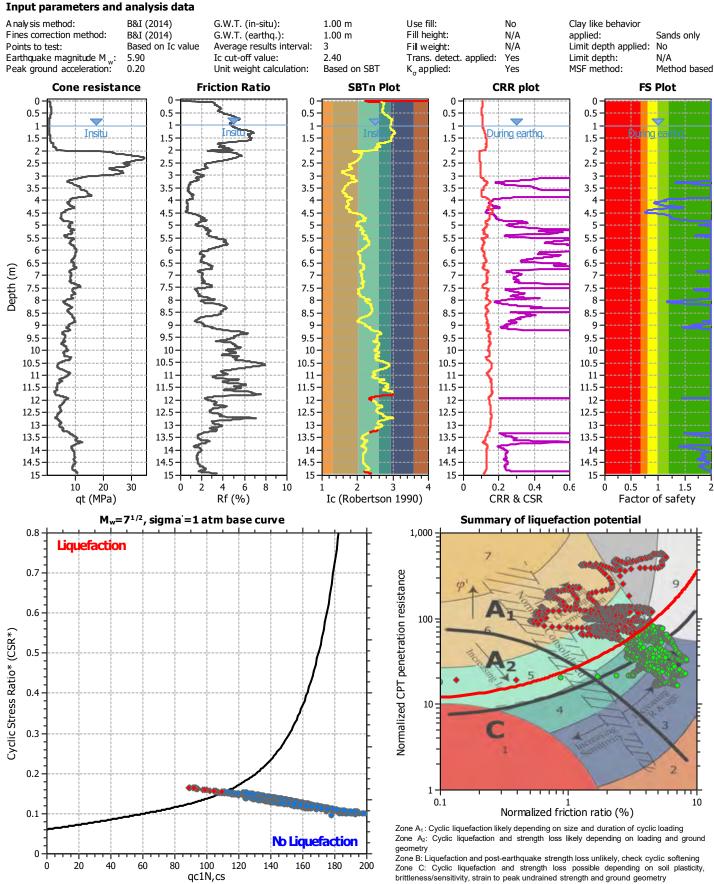
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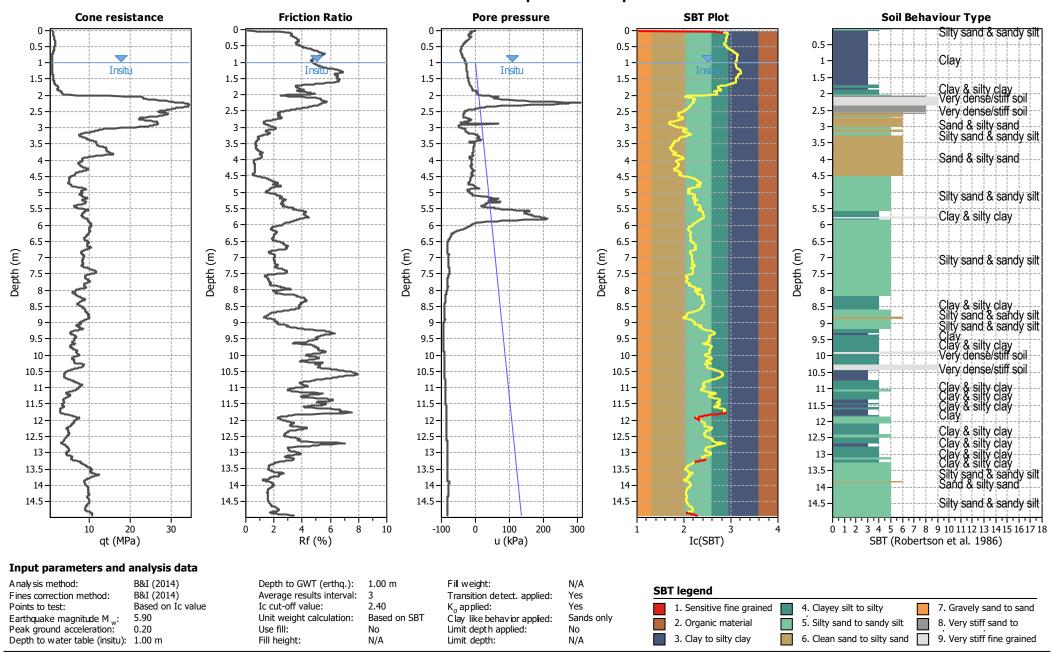
LIQUEFACTION ANALYSIS REPORT

Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road

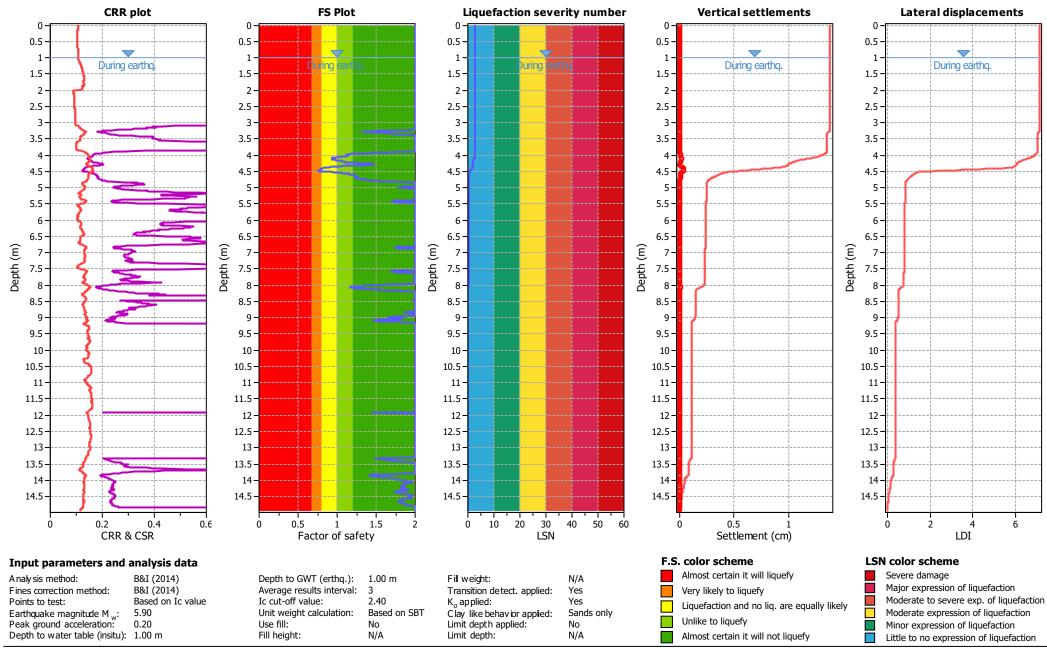






CPT basic interpretation plots

CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:23:33 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:23:33 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



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LIQUEFACTION ANALYSIS REPORT

Project title : 210339 - Muriwai Downs Location : 710 Muriwai Road CPT file : CPT-10 Input parameters and analysis data Clay like behavior A naly sis method: B&I (2014) 1.00 m Use fill: G.W.T. (in-situ): No Fill height: Fines correction method: B&I (2014) G.W.T. (earthq.): 1.00 m N/A applied: Sands only Points to test: Based on Ic value Average results interval: 3 Fill weight: N/A Limit depth applied: No Earthquake magnitude M 5.90 Ic cut-off value: 2.40 Trans. detect. applied: Yes Limit depth: N/A K_{σ} applied: Peak ground acceleration: 0.20 Unit weight calculation: Based on SBT Yes MSF method: Method based **Friction Ratio** SBTn Plot **CRR** plot FS Plot **Cone resistance** 0 0 0 0 0 0.5 0.5 0.5 0.5 0.5 -1 1 1 1 1 Insitu During earthq Dun ŋq 1.5 1.5 1.5 1.5 1.5 2 2 2 2 2 2.5 2.5 2.5 2.5 2.5 3 3 3 3 3 3.5 3.5 3.5 3.5 3.5 -4 4 4 4 4 4.5 4.5 4.5 4.5 4.5 5 5 5 5 5 5.5 5.5 5.5 5.5 5.5 6 6 6 6 6 6.5 6.5 6.5 6.5 6.5 -Depth (m) 7 7 7 7 7 7.5 7.5 7.5 7.5 7.5 8 8 8 8 8 8.5 8.5 8.5 8.5 8.5 9 9 9 9 9 9.5 9.5 9.5 9.5 9.5 10 10 10 10 10 10.5 10.5 10.5 10.5 10.5 11 11 11 11 11. 11.5 11.5 11.5 11.5 11.5 12 12 12 12 12 12.5 12.5 12.5 12.5 12.5 13 13 13 13 13 13.5 13.5 13.5 13.5 13.5 14 14 14 14 14. 14.5 14.5 14.5 14.5 14.5 15 15 15 15 15 0.5 5 10 0 6 8 10 2 3 0 0.2 0.4 0.6 0 1 4 qt (MPa) Rf Ic (Robertson 1990) CRR & CSR %) Factor of safety $M_w = 7^{1/2}$, sigma'=1 atm base curve Summary of liquefaction potential 0.8 1,000 Liquefaction 8 0.7 Normalized CPT penetration resistance 0.6 100 Cyclic Stress Ratio* (CSR*) 0.5 0.4 10 0.3 0.2 1 -0.1 1 Normalized friction ratio (%) 0.1

Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading Zone A_2 : Cyclic liquefaction and strength loss likely depending on loading and ground geometry

Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

140

120

100

qc1N,cs

0

0

20

40

60

80

No Liquefaction

180

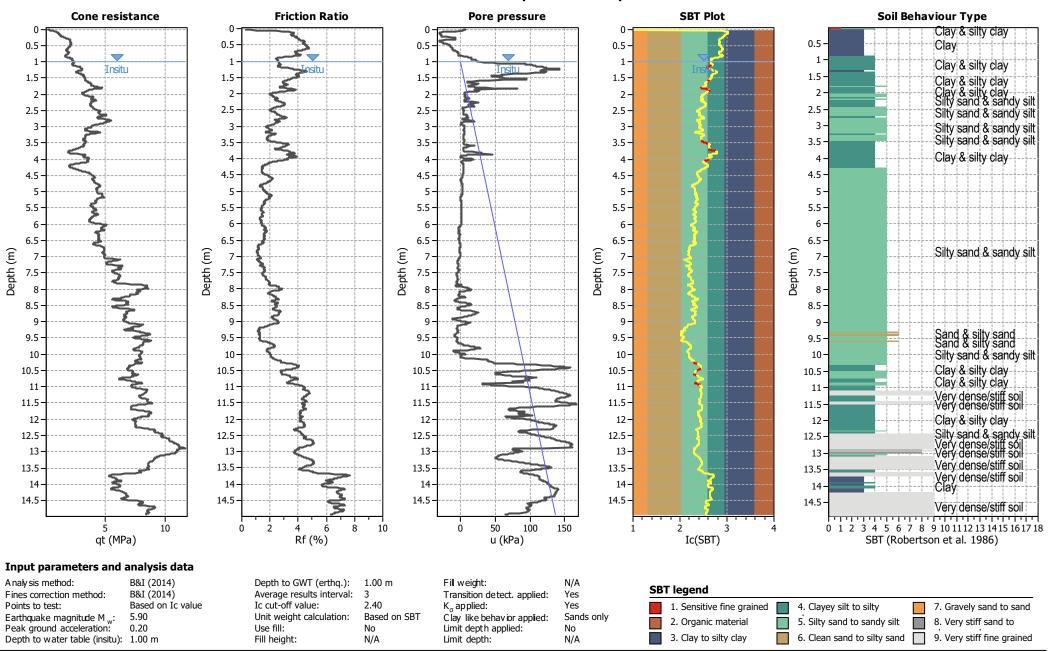
200

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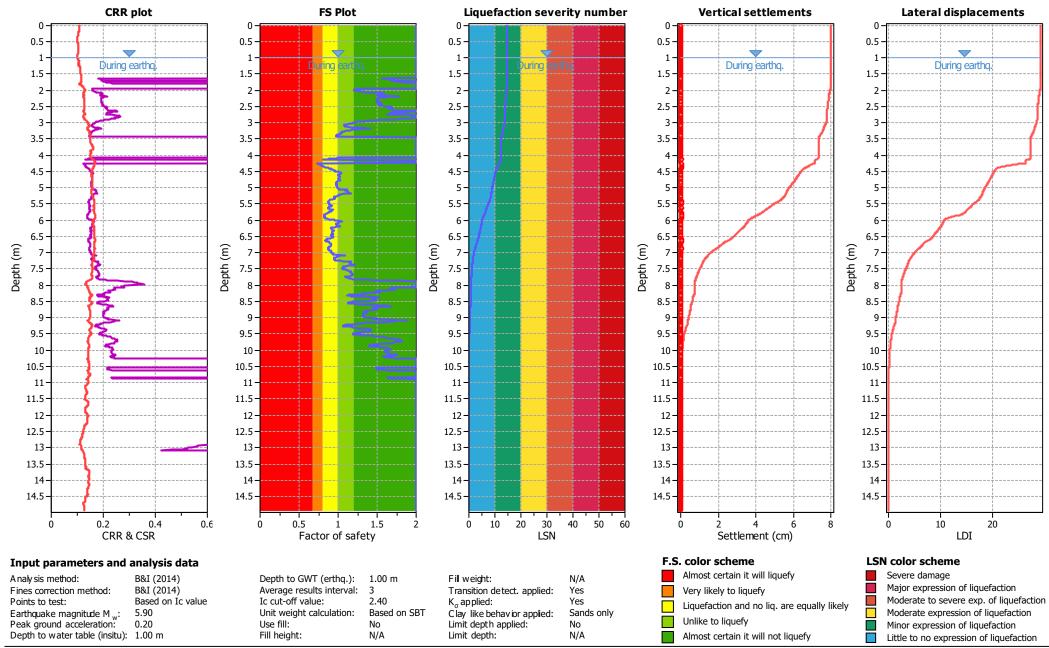
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2



CPT basic interpretation plots

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CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:23:57 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



0.2

0.1

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20

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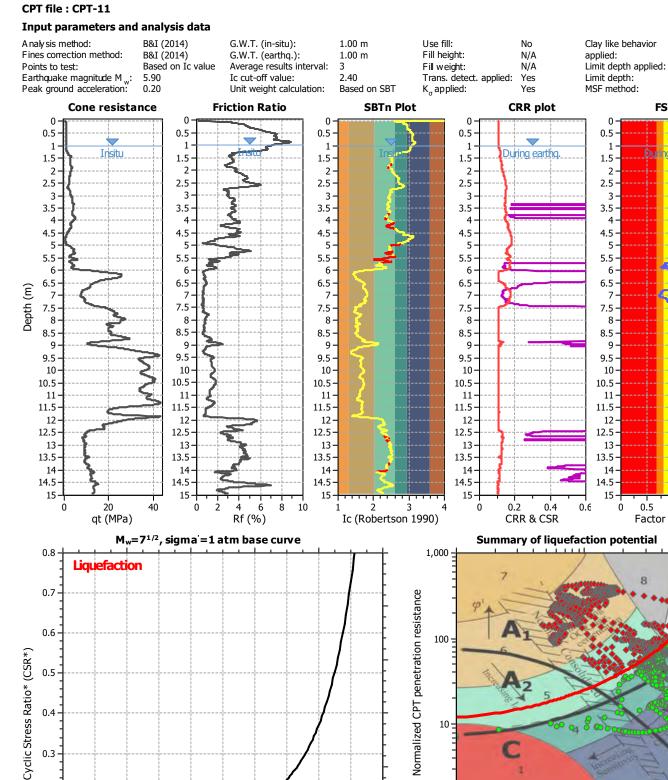
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LIQUEFACTION ANALYSIS REPORT

Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road



0.1 1 Normalized friction ratio (%) 10 Zone A1: Cyclic liquefaction likely depending on size and duration of cyclic loading

1 -

Zone A_2 : Cyclic liquefaction and strength loss likely depending on loading and ground geometry

Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

140

120

100

qc1N,cs

No Liquefaction

180

200

160

Sands only

Method based

No

FS Plot

Duri ng

0.5

8

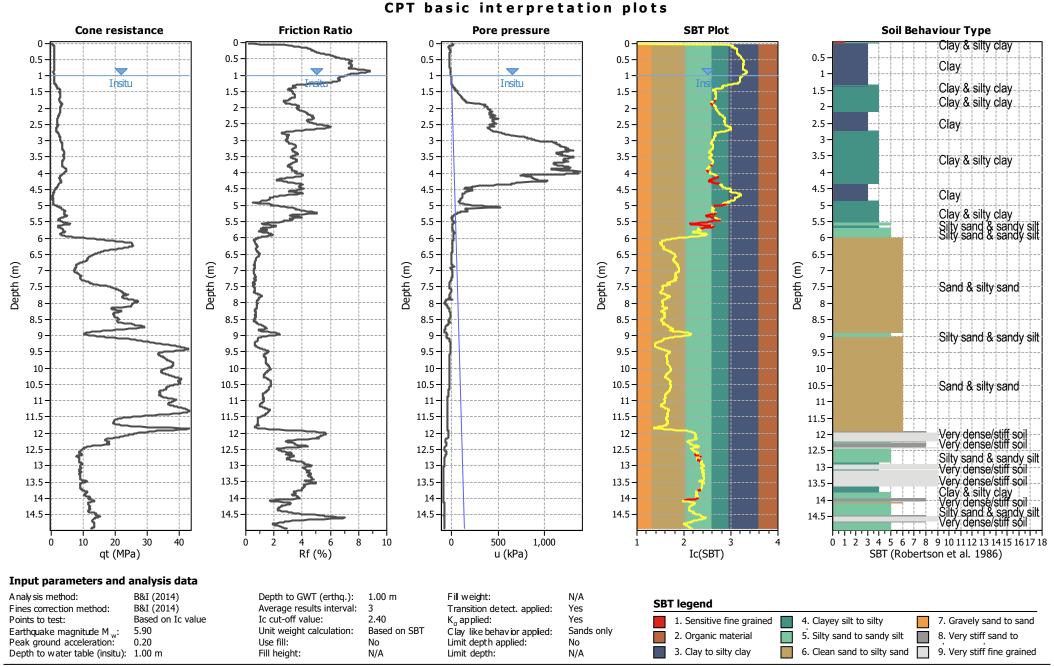
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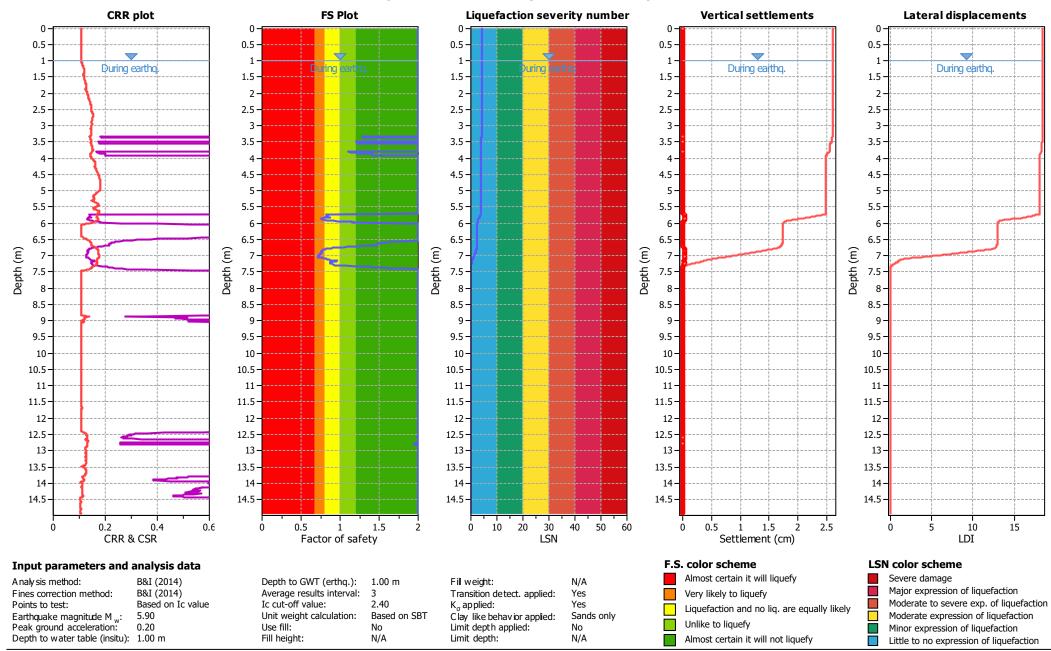
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Factor of safety

N/A



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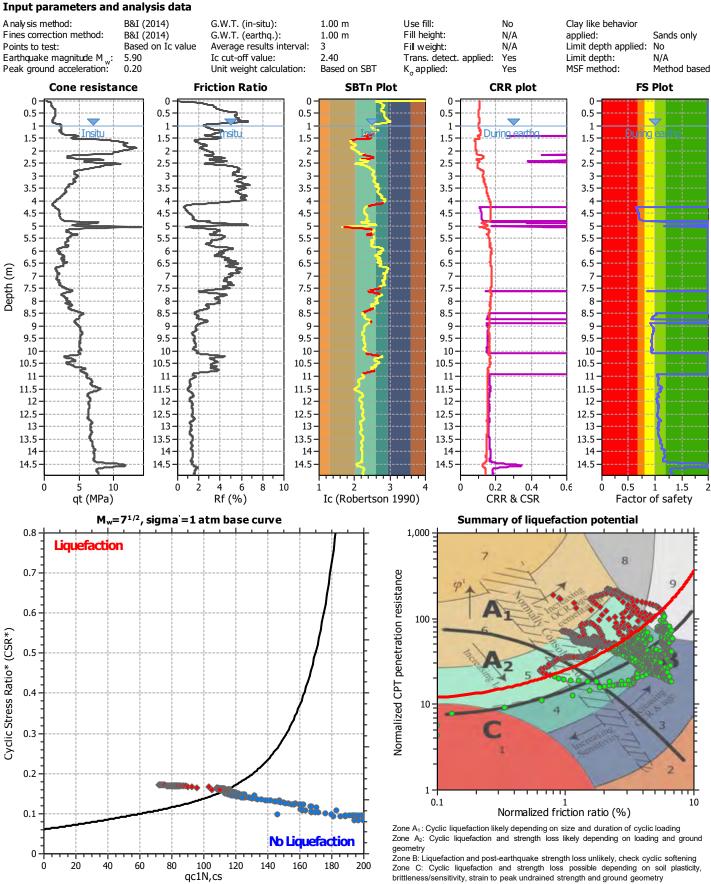
LIQUEFACTION ANALYSIS REPORT

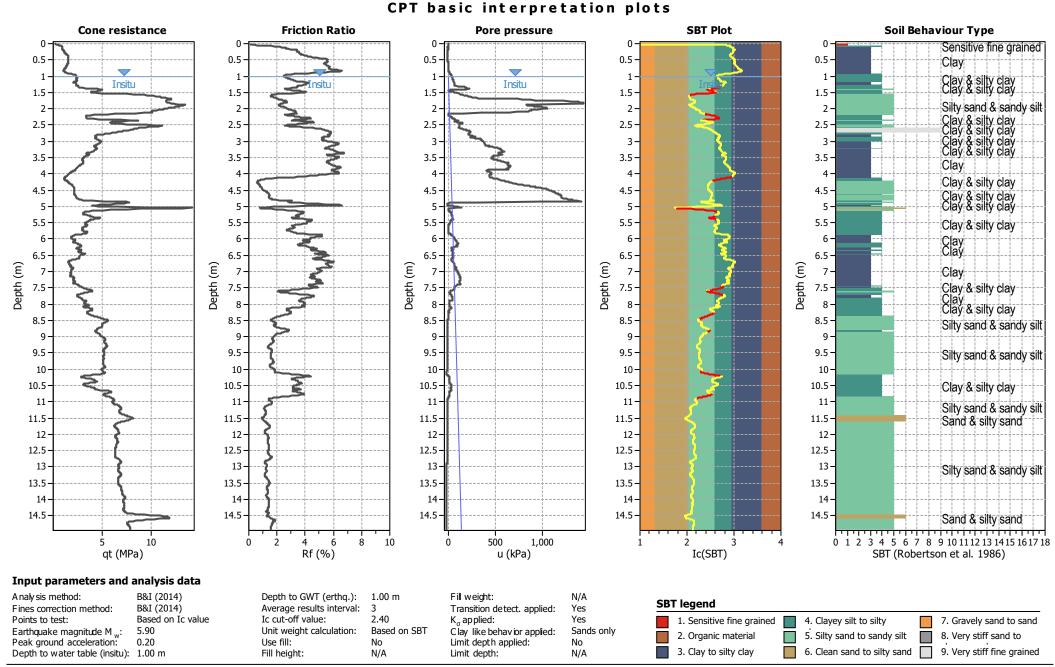
Project title : 210339 - Muriwai Downs

Location : 710 Muriwai Road

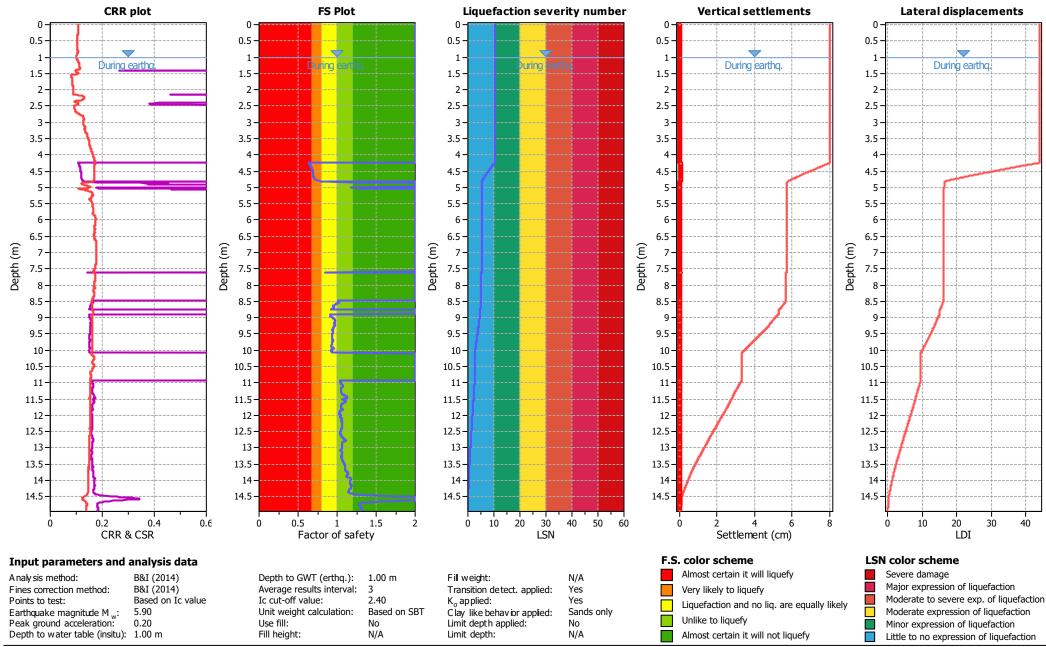


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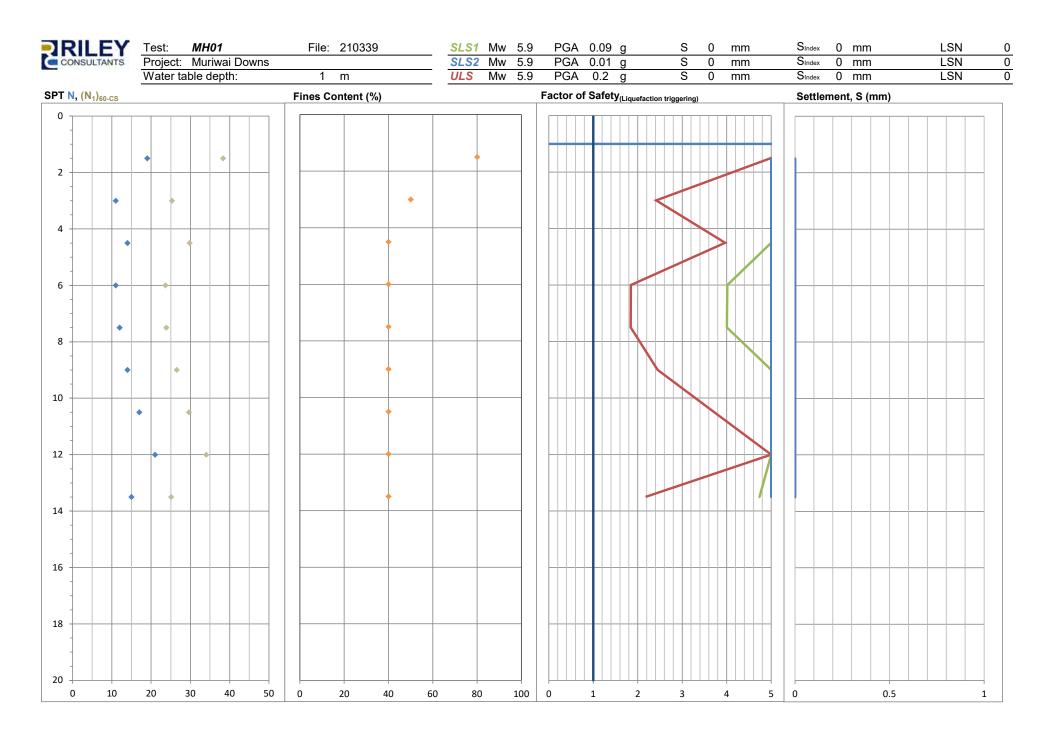


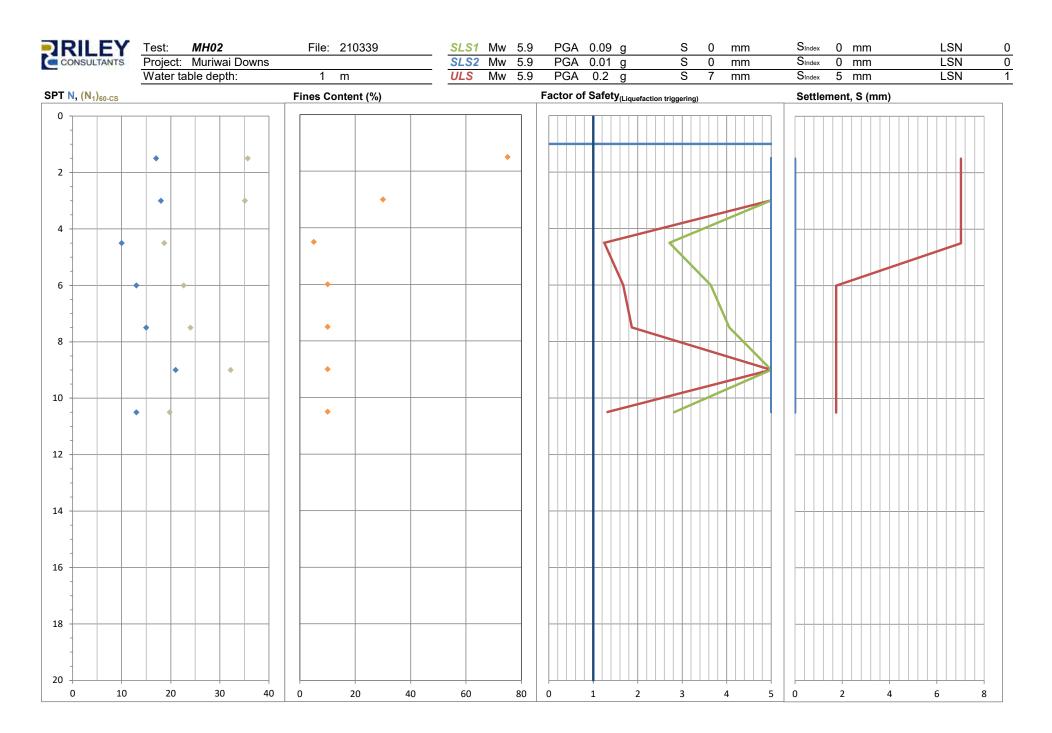


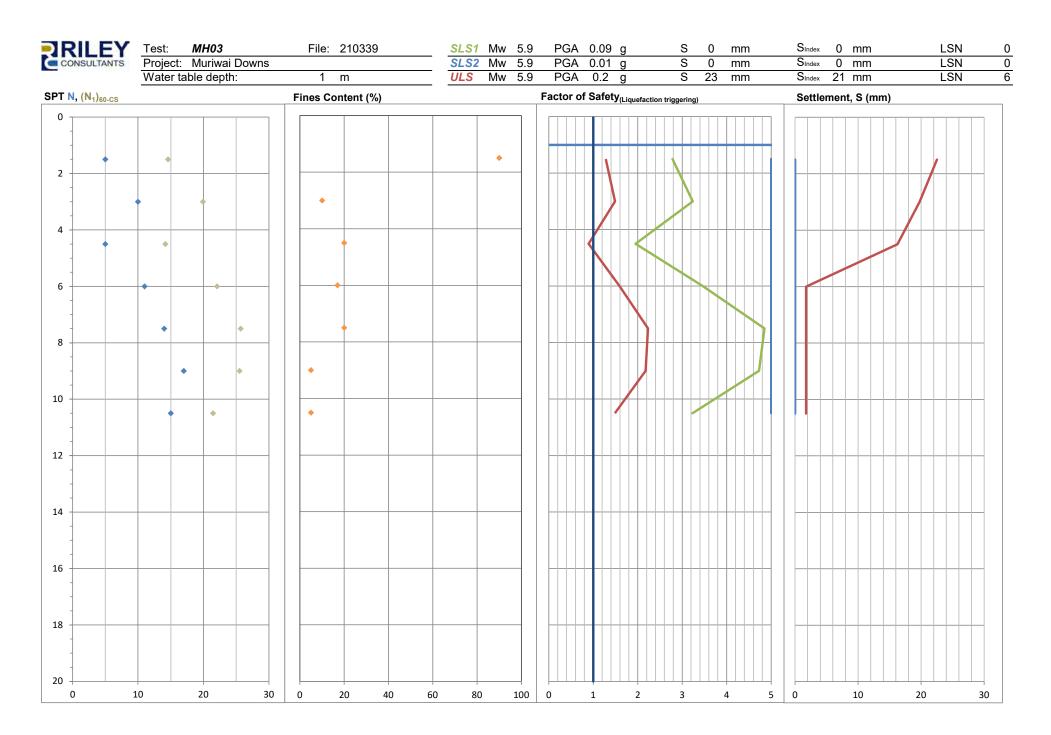
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CLiq v.3.3.2.9 - CPT Liquefaction Assessment Software - Report created on: 6/09/2021, 12:24:44 pm Project file: T:\2021 Jobs\210339 Muriwai Downs Golf Course\4.0 DESIGN-INVEST\4.1 Geo\Seismic\CPT1 to 12 ULS (LES).clq



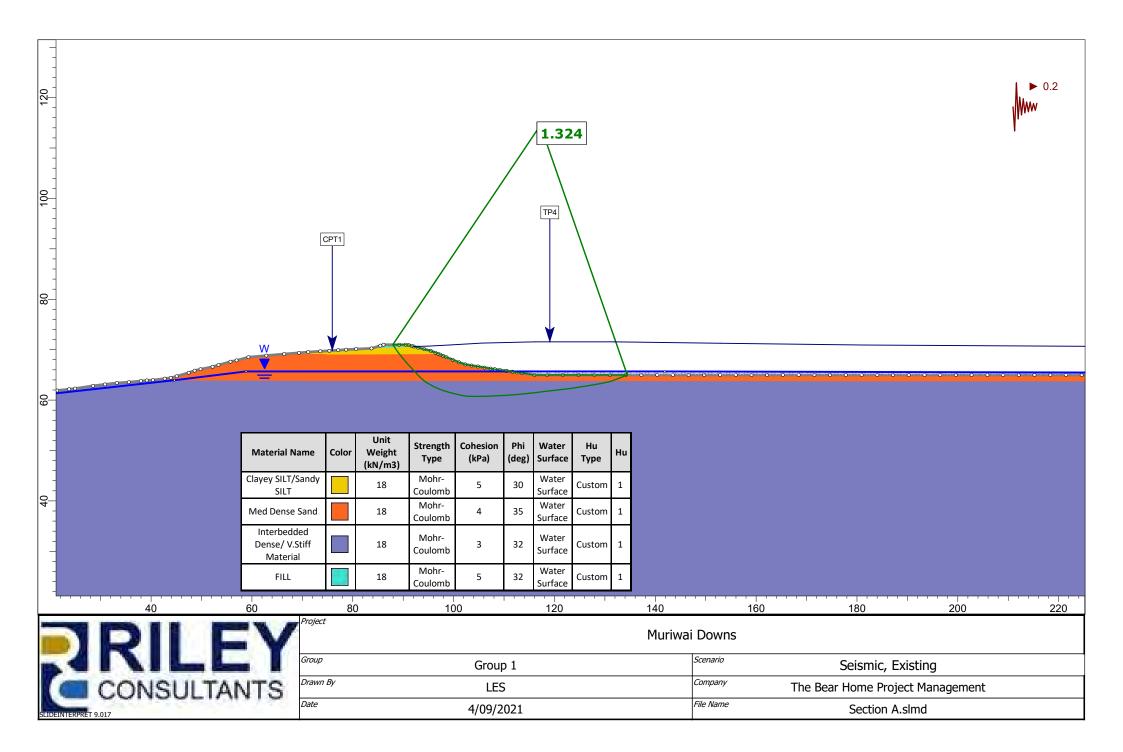




APPENDIX G

Slope Stability Outputs

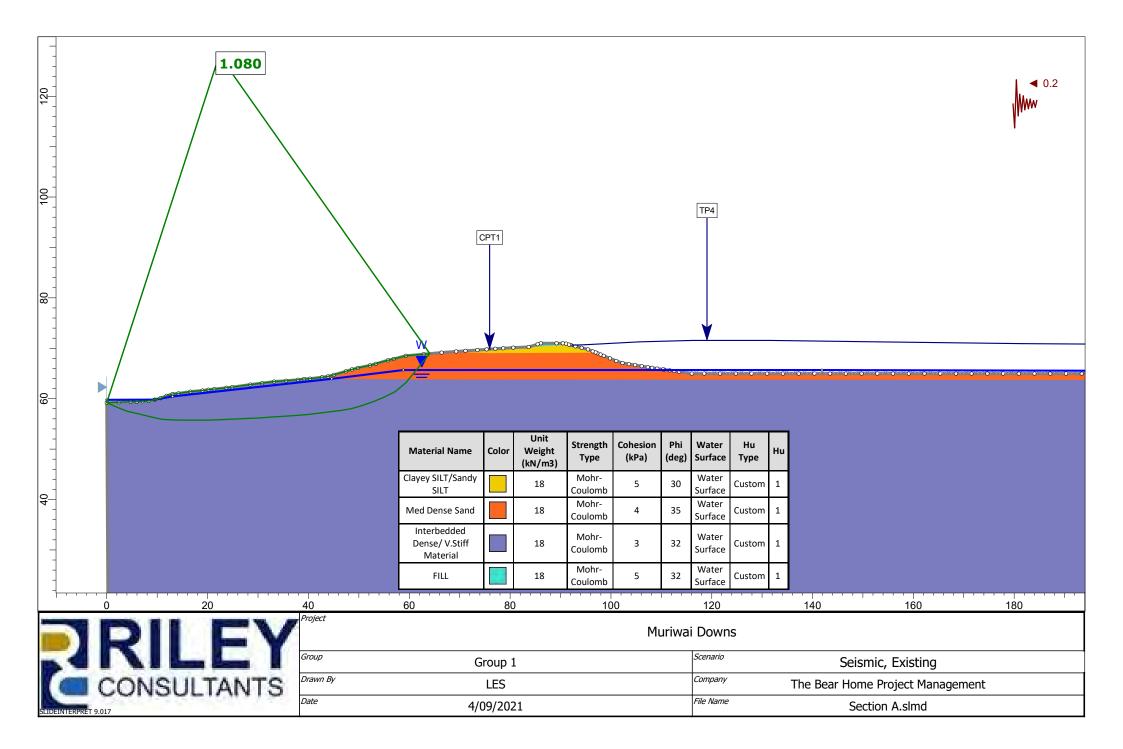
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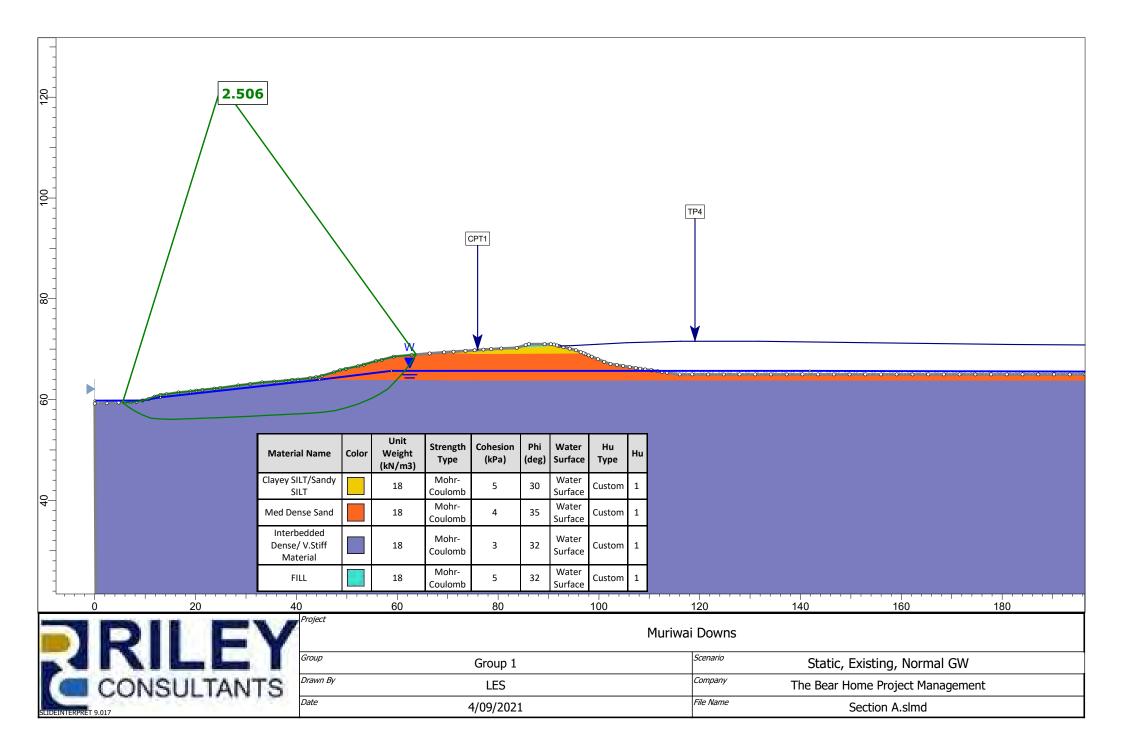


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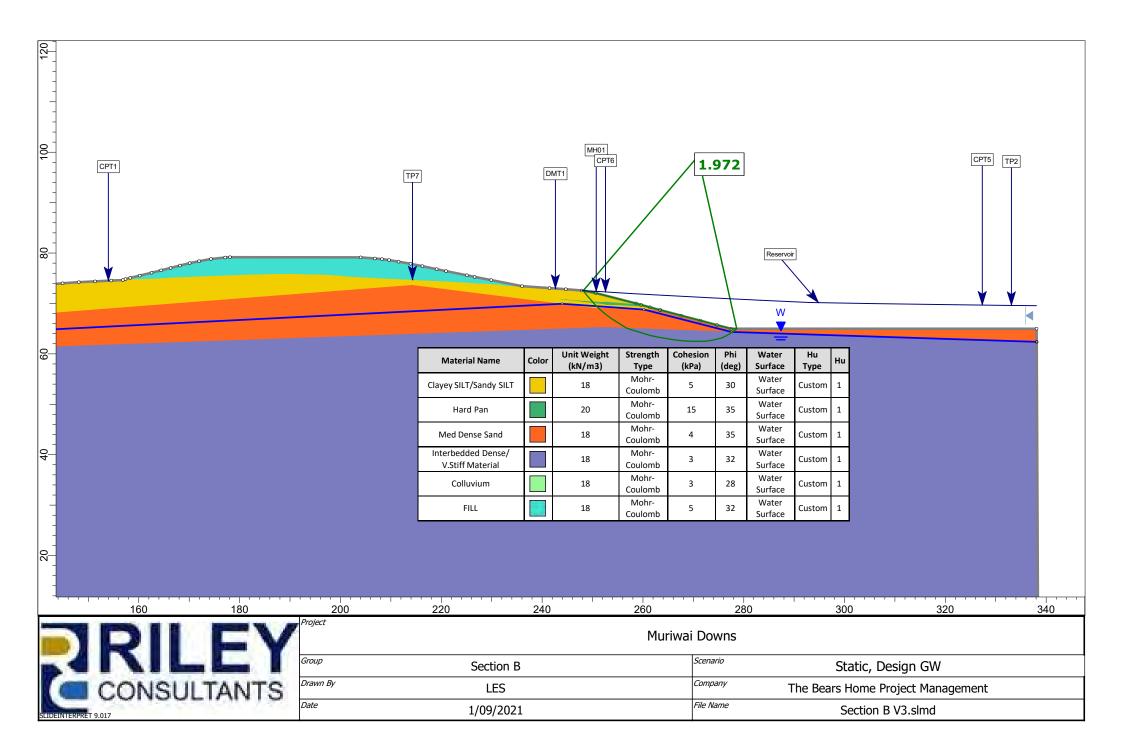
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		Med Dense Sand		18	Mohr- Coulomb	4	35	Water Surface	Custom	1			
		Interbedded Dense/ V.Stiff Material		18	Mohr- Coulomb	3	32	Water Surface	Custom	1			
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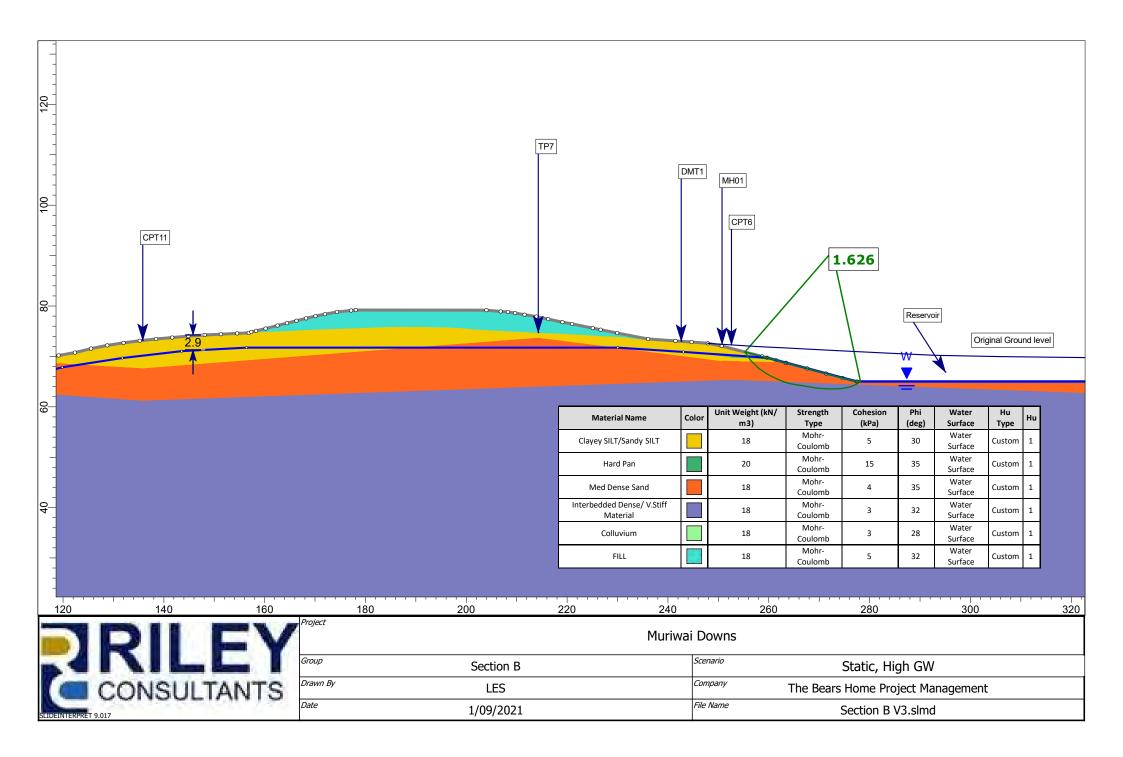


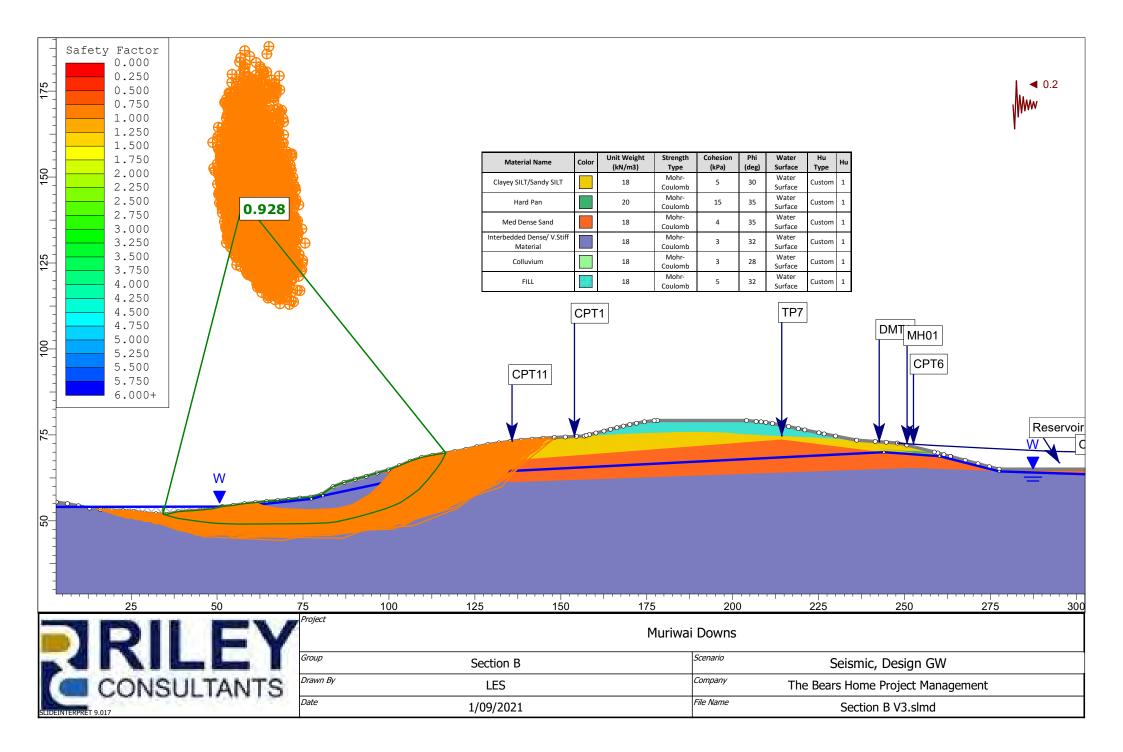


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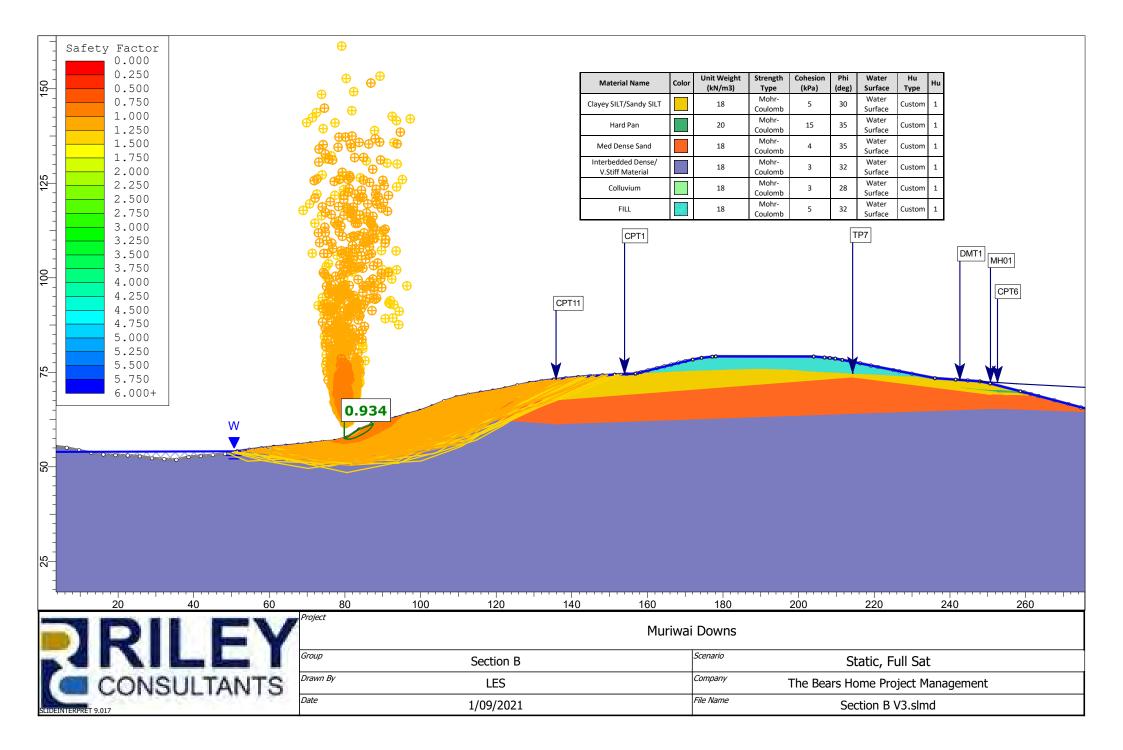


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	Material NameColom3)Type(kPa)(deg)SurfaceTypeNuClayey SILT/Sandy SILT18Mohr- Coulomb530Water SurfaceCustom1Hard Pan20Mohr- Coulomb1535Water SurfaceCustom1Med Dense Sand18Mohr- Coulomb435Water SurfaceCustom1Interbedded Dense/ V.Stiff Material18Mohr- Coulomb332Water SurfaceCustom1Colluvium18Mohr- Coulomb328Water SurfaceCustom1FILL18Mohr- Coulomb328Water SurfaceCustom1Fill18Mohr- Coulomb328Water SurfaceCustom1Fill18Mohr- Coulomb328Water SurfaceCustom1	
	Material NameColorm3)Type(kPa)(deg)SurfaceTypeNuClayey SILT/Sandy SILT18Mohr- Coulomb530Water SurfaceCustom1Hard Pan20Mohr- Coulomb1535Water SurfaceCustom1Med Dense Sand18Mohr- Coulomb435Water SurfaceCustom1Interbedded Dense/ V.Stiff Material18Mohr- Coulomb332Water SurfaceCustom1Colluvium18Mohr- Coulomb328Water SurfaceCustom1FILL18Mohr- Coulomb328Water Surface1FILL18Mohr- Coulomb328Water SurfaceCustom1	, , , , , , , , , , , , , , , , , , ,
Project ORILEY Group	Material ValueColom3)Type(kPa)(deg)SurfaceTypeHaClayey SILT/Sandy SILT18Mohr- Coulomb530Water SurfaceCustom1Hard Pan20Mohr- Coulomb1535SurfaceCustom1Med Dense Sand18Mohr- Coulomb435Water SurfaceCustom1Interbedded Dense/ V.Stiff Material18Mohr- Coulomb332Water SurfaceCustom1Collowium18Mohr- Coulomb328SurfaceCustom1FILL18Mohr- Coulomb328SurfaceCustom1Fill20260280300320320	, , , , , , , , , , , , , , , , , , ,
	Indectal Name Cold m3) Type (kPa) (deg) Surface Type Nu Clayey SILT/Sandy SILT 18 Mohr- Coulomb 5 30 Water Surface Custom 1 Hard Pan 20 Mohr- Coulomb 15 35 Water Surface Custom 1 Med Dense Sand 18 Mohr- Coulomb 4 35 Water Surface Custom 1 Interbedded Dense/ V.Stiff Material 18 Mohr- Coulomb 3 32 Water Surface Custom 1 Colluvium 18 Mohr- Coulomb 3 28 Water Surface Custom 1 FILL 18 Mohr- Coulomb 3 28 Water Surface Custom 1 FILL 18 Mohr- Coulomb 5 32 Water Surface Custom 1 Muriwai Downs 220 240 260 280 300 320 320	- - - - - - - - - - - - - - - - - - -

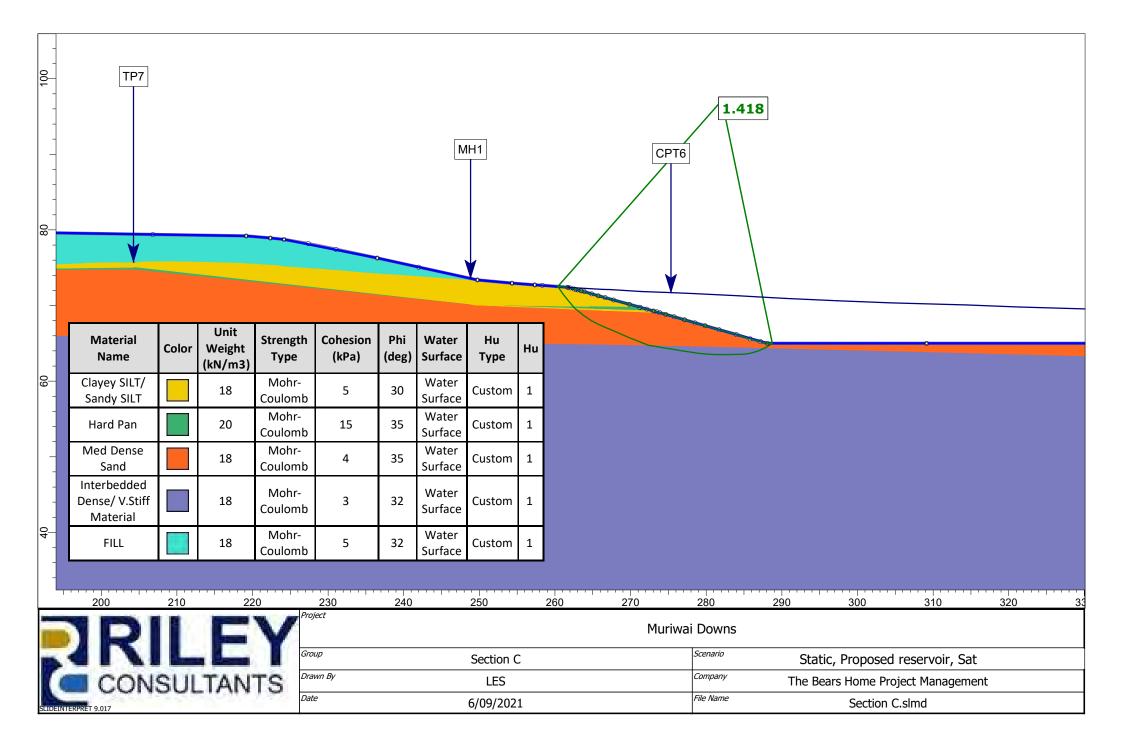




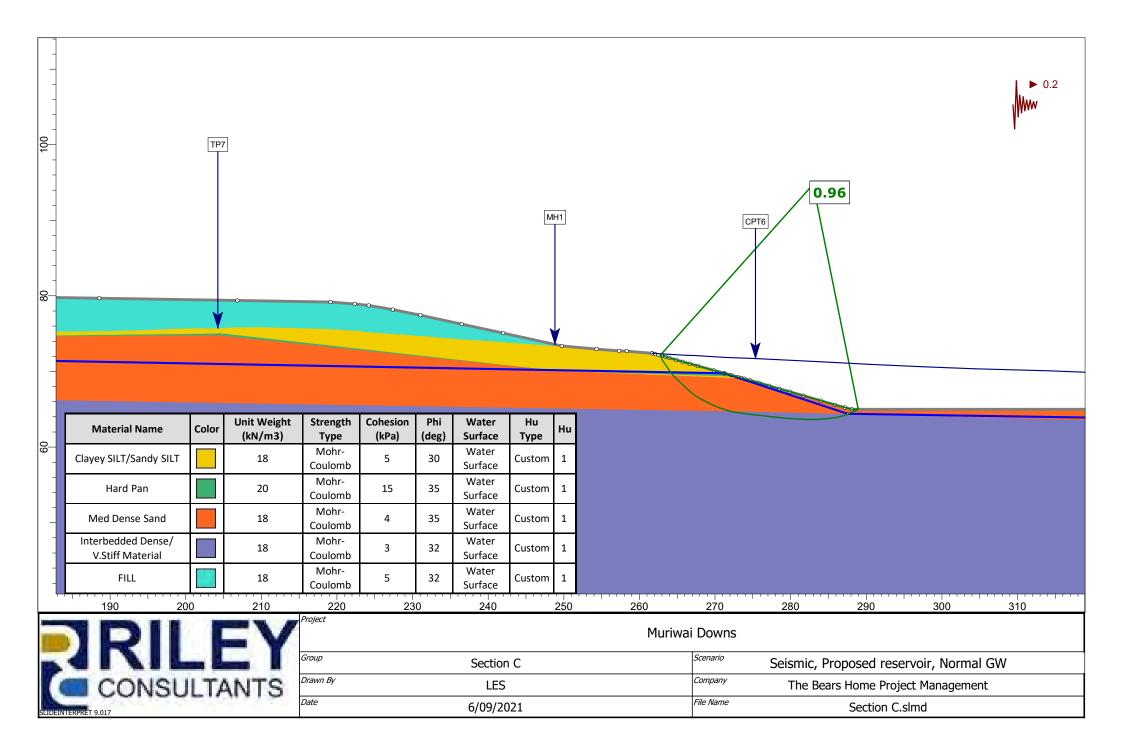
		CPT11	_	CPT1	0000	•••				
	Material Name	Color	Unit Weight	Strength	Cohesion	Phi (deg)	Water	Hu	Hu]
-	Clayey SILT/Sandy SILT		(kN/m3) 18	Type Mohr- Coulomb	(kPa) 5	(deg) 30	Surface Water Surface	Type Custom	1	
	Hard Pan		20	Mohr- Coulomb	15	35	Water Surface	Custom	1	
0- -	Med Dense Sand		18	Mohr- Coulomb	4	35	Water Surface	Custom	1	
	Interbedded Dense/ V.Stiff Material		18	Mohr- Coulomb	3	32	Water Surface	Custom	1	
			18	Mohr-	3	28	Water	Custom	1	
-	Colluvium		10	Coulomb	-		Surface			
	FILL		18	Coulomb Mohr- Coulomb	5	32	Surface Water Surface	Custom	1	
 	FILL 120			Mohr-	5		Water	-	1	200 220 240 260
<u>80 100</u>	FILL		18	Mohr- Coulomb	5		Water Surface 180	-	1 1	200 220 240 260
	FILL 120		18 140	Mohr- Coulomb	5		Water Surface 180	Custom	1 1	200 220 240 260 wns
	FILL 120 Project		18 140 See	Mohr- Coulomb	5		Water Surface 180	Custom	Dow	200 220 240 260 wns rio Static, Filled, Design GW, SE Slope

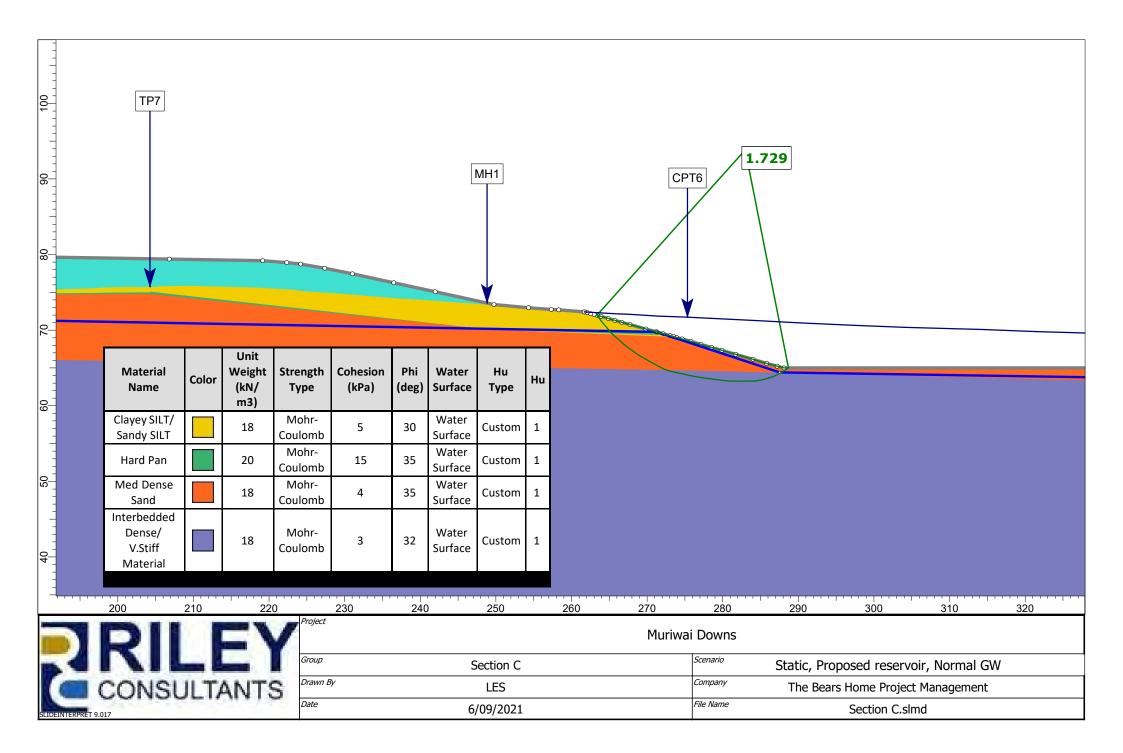


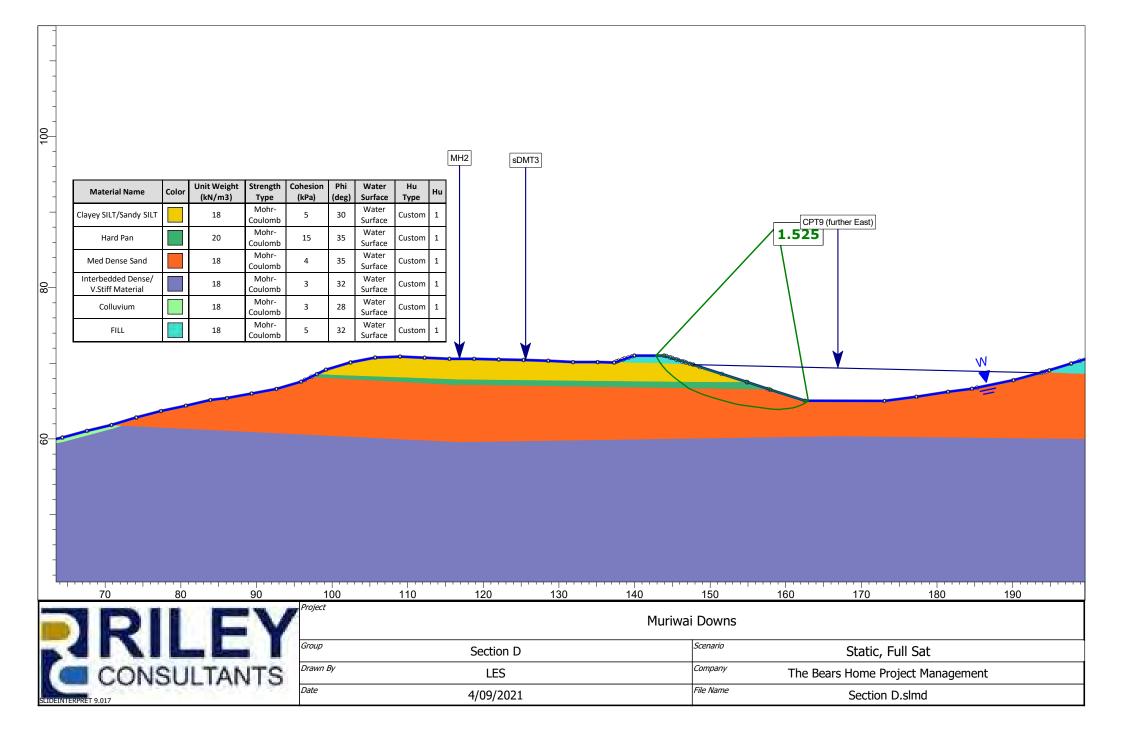
-													
												TP7	
-00-00-00-00-00-00-00-00-00-00-00-00-00													
				CPT11]								
					Ļ	- 0	0 0 0 0	0 0 0 00			0 0 0		
			0 0	0 0 0 0	2.9	0 0 00 0							
	417				T								
- 6-	2°°	0											
		Material Name	Color	Unit Weight (kN/ m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu			
		Clayey SILT/Sandy SILT		18	Mohr- Coulomb	5	30	Water Surface	Custom	1			
		Hard Pan		20	Mohr- Coulomb	15	35	Water Surface	Custom	1			
-	_	Med Dense Sand		18	Mohr- Coulomb	4	35	Water Surface	Custom	1			
	_	Interbedded Dense/ V.Stiff Material		18	Mohr- Coulomb Mohr-	3	32	Water Surface Water	Custom	1			
	-	Colluvium		18	Coulomb Mohr-	3	28	Surface Water	Custom	1			
	L	FILL		18	Coulomb	5	32	Surface	Custom	1			
			- T - T		10	160		1	80		200	220	
40 60 8	30	100	120	14	10	100			00		200		
	30 Project	100	120	14		luriwai Do			00		200		
RILEY	Project Group		120 tion B				owns			Filled	, High GW, SE		
A0 60 E	Project	Sect				luriwai Do	OWNS ario	9	itatic, f			Slope	



	MH1	2.321 CPT6	T
Material Name Color Unit (kN/m3) Unit Unit Weight (kN/m3)	Cohesion Phi Water (kPa) (deg) Surface		
Clayey SILT/ Sandy SILT 18 Mohr- Coulomb	5 30 Water Surface		
Hard Pan 20 Mohr- Coulomb	15 35 Water Surface		
Med Dense Sand 18 Mohr- Coulomb	4 35 Water Surface		
Interbedded Dense/ V.Stiff Material 18 Mohr- Coulomb	3 32 Water Surface		
FILL 18 Mohr- Coulomb	5 32 Water Surface		
210 220 230 2 ⁴	240 250	260 270 280 2 ⁱ	90 300 310 320 330
	Project	Muriv	vai Downs
IRILEY	Group Drawn By	Section C LES	Scenario Static, Proposed reservoir, High GW Company The Bears Home Project Management

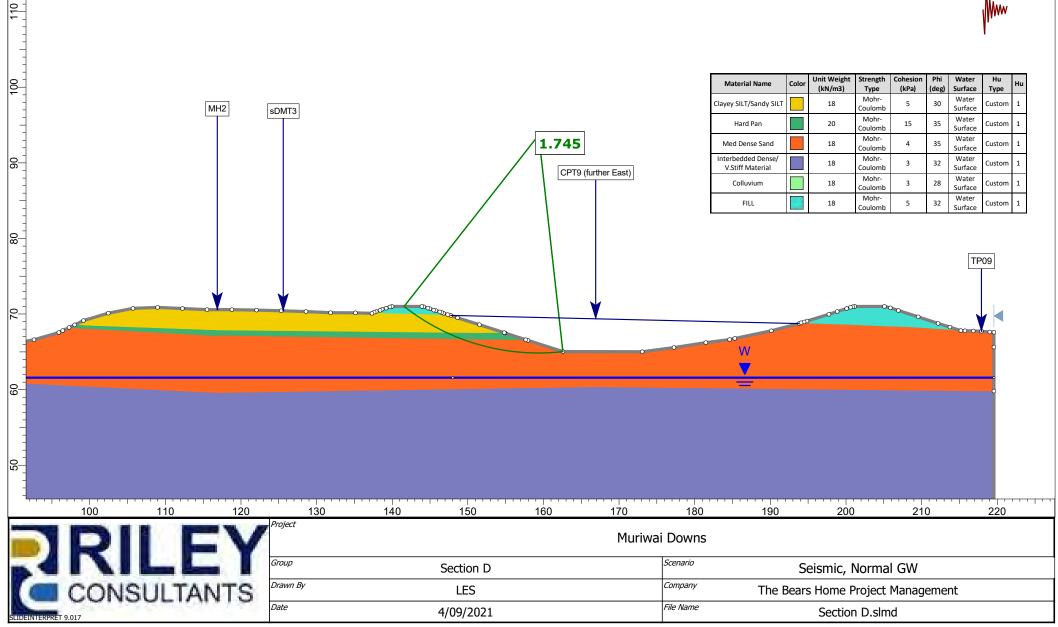


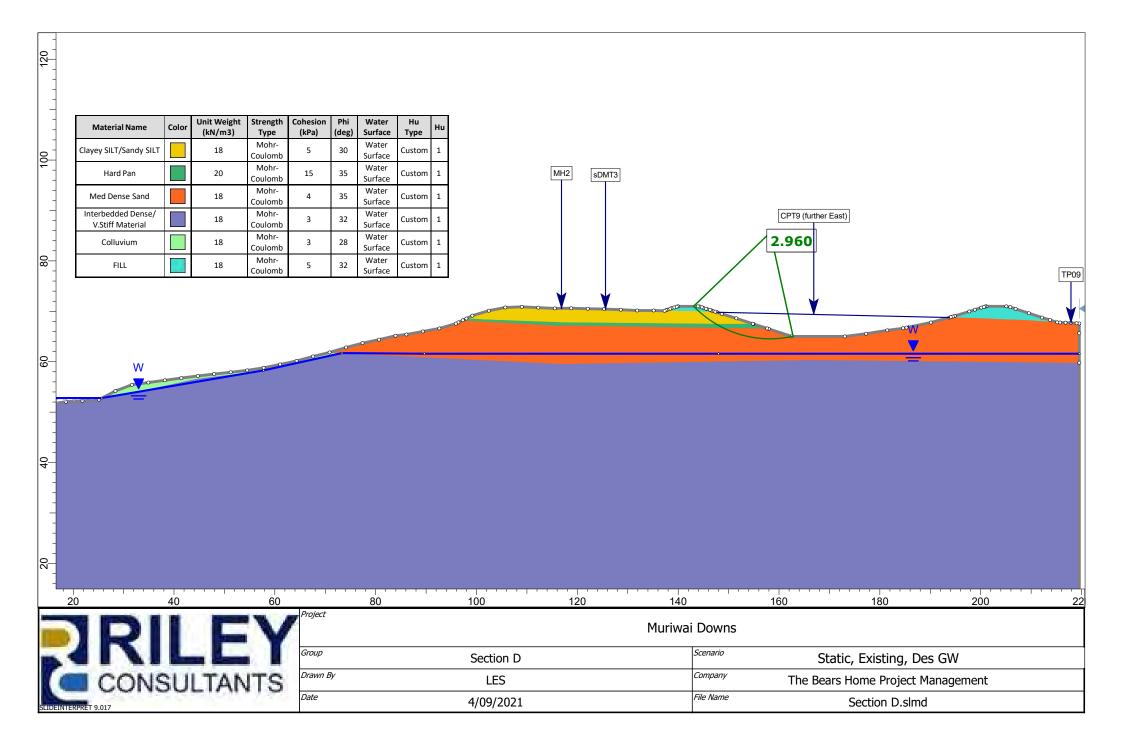


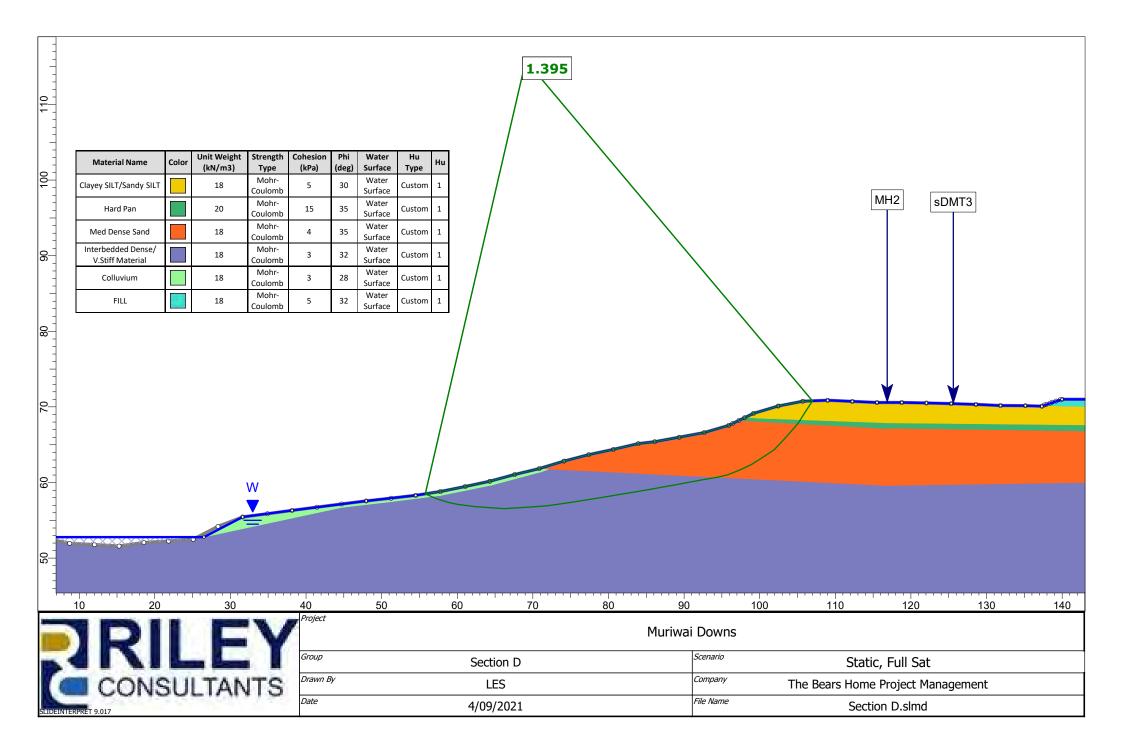


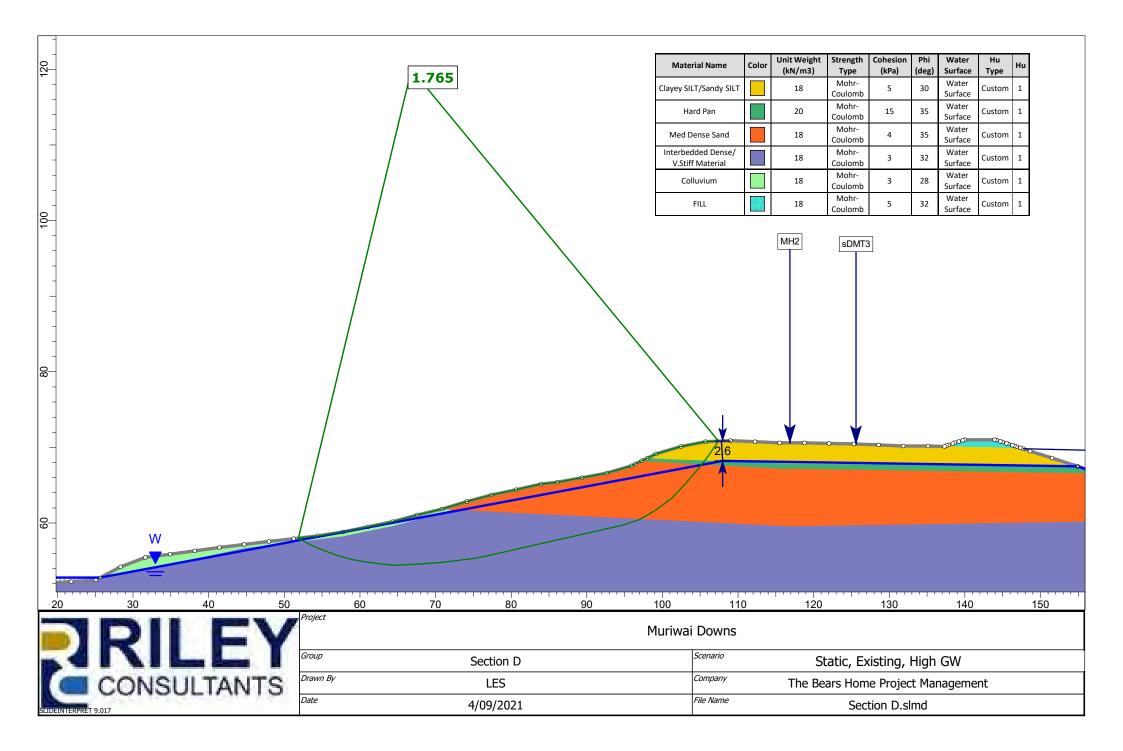
	MH2	2	SDMT3	3							CPT9 2.011	(further East)	
	2 6 Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	مرم Phi (deg)	o O Water Surface	Hu Type	Poo o			•	••••••••••••••••••••••••••••••••••••••
9 -	Clayey SILT/Sandy SIL	г	18	Mohr- Coulomb	5	30	Water Surface	Custom	1				
	Hard Pan		20	Mohr- Coulomb	15	35	Water Surface	Custom	1				
	Med Dense Sand		18	Mohr- Coulomb	4	35	Water Surface	Custom	1				
	Interbedded Dense/ V.Stiff Material		18	Mohr- Coulomb	3	32	Water Surface	Custom	1				
	Colluvium		18	Mohr- Coulomb	3	28	Water Surface	Custom	1				
	FILL		18	Mohr- Coulomb	5	32	Water Surface	Custom	1				
	110	120		130			140			150 16	0	170	180
	Project						Mu	riwai l					
	Group		Section [D					cenario	51	atic, Ex	kisting, High GW	
CONSULTANTS	Drawn By		LES						ompan	THE DE		ne Project Manager	nent
SLIDEINTERPRET 9.017	Date		4/09/202	21				Fi	ile Nan	е	Sec	tion D.slmd	

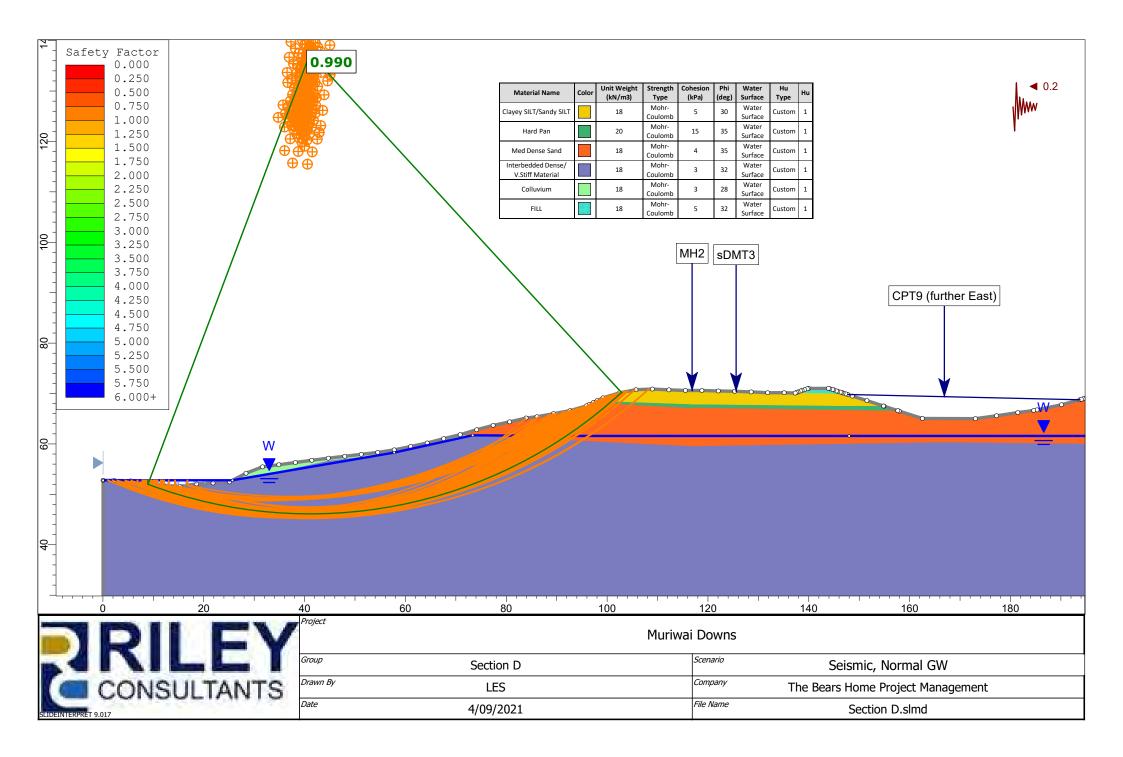
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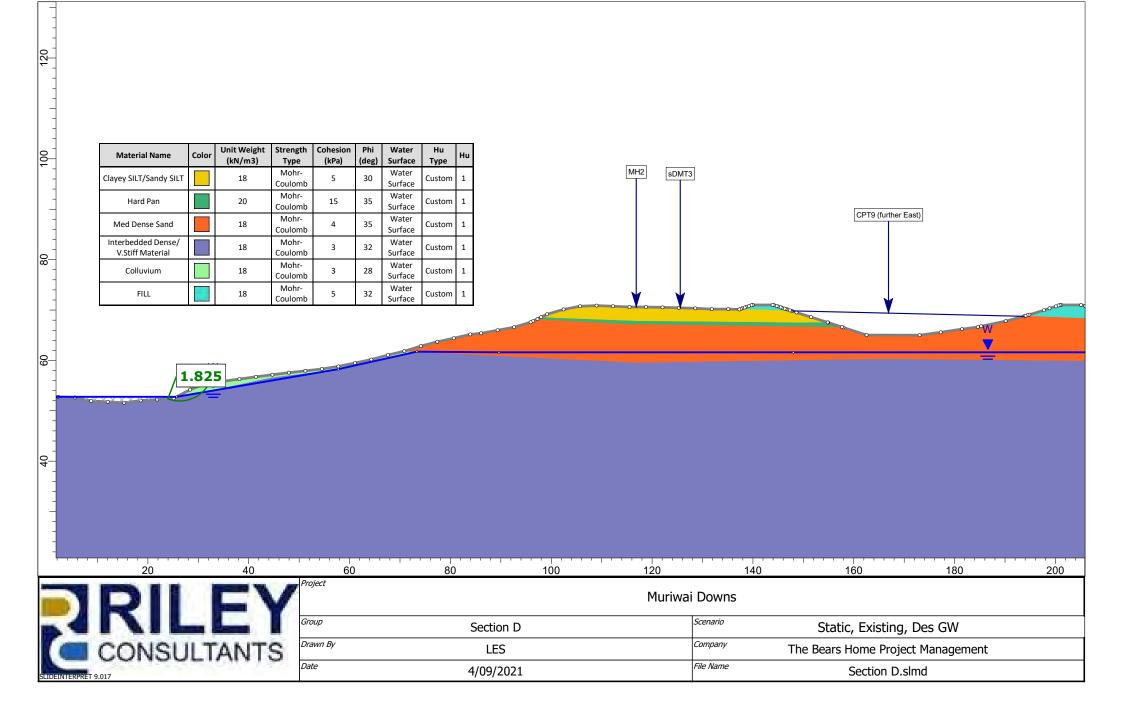












APPENDIX H

Laboratory Test Results PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT

						_			
Project :		Muriwai Do							
Location :		710 Muriwai							
Client :		Riley Consu	ltants Ltd c,	/o The Bears	s Home Pro	ject Manager	ment Limite	d	
Client Ref :		210339							
Contractor :		Not Stated							
Borehole No:		TP2	Depth:	1.80 metre	S				
Sampled by :		GB							
Date received :		10/08/21							
Sampling meth	nod :	Bulk sample	es						
Sample conditi	on:	As received					Project No:	1-LA614.00	
Sample descrip	tion :	CLAY with r	ninor sand a	and silt			Lab Ref No:	AL6732/1	
Solid Particle D	ensity (t/r	m ³):	2.86	Tested			Client Ref:	210339	
Water Content			65.9	%					
		Sieve An	alysis				Hydromete	er Analysis	All stars
Sieve Size	Passing	Sieve Size	Passing	Sieve Size	Passing	Particle Size	Passing	Particle Size	Passing
(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)
63.0		4.75	100	0.300	96	0.0460	90	0.0060	87
37.5		2.36	100 99	0.212	95	0.0325	90 89	0.0042	86 85
13.2		0.600	99	0.075	94	0.0231	89	0.0030	84
9.5		0.425	97	0.063	92	0.0119	88	0.0012	83
Note: "'	denotes si	eve not used and	d/or hydrome	ter analysis no	ot tested	0.0084	88		
100 90 80 (%) 70 50 40 40 40 40 40 40 40 40 40 40 40 40 40	fine	0.010 Medium 0	Coarse	fine m	St. 88 I I	€ 8 1 1 1 1 1 1 1 1 1 1 1 1 1	No. No. <th>m coarse</th> <th>2 2 2 2 2 2 2 2 2 2 2 2 2 2</th>	m coarse	2 2 2 2 2 2 2 2 2 2 2 2 2 2
Fest Methods				and the second		Notes			
Particle Size Analysis:	NZS 4402:198	36: Test 2.8.4 (Wash	ed Grading & Hy	ydrometer Meth	od)	pH of suspension Refer to report AL All information se	.6732/5 for solid p	particle density tes	st
Date Tested: 29, Date Reported:	/09/21 - 04			ot covered by ay only be repi		tation. Results a	pply only to sa		d as not

IANZ Approved Signatory

Designation : Date : ory Thirushen Pillay Senior Civil Engineering Technician 19/10/21



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

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Page 1 of 1

Website www.wsp.com/nz

PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) **TEST REPORT**

Project :		Muriwai Do	owns						
Location :		710 Muriwa	i Road						
Client :		Riley Cons	ultants Ltd	c/o The Bea	ars Home Pro	oject Manage	ement Limit	ed	
Client Ref :		210339							
Contractor :		Not Stated							
Borehole No	:	TP6	Dept	h: 2.10 metr	es				
Sampled by		GB						o: AL6732/2	
Date receive		10/08/21							
Sampling me		Bulk samp	les						
Sample conc		As received					Project No:	1-LA614.00	
Sample desc		silty CLAY		sand			Lab Ref No:	AL6732/2	
Solid Particle			2.74	Assumed	í.		Client Ref:	210339	
Water Conte			59.2	%					
		Sieve A		70			Hydromet	er Analysis	
Sieve Size	Passing	Sieve Size	Passing	Sieve Size	Passing	Particle Size	Passing	Particle Size	Passing
(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)
63.0		4.75	100	0.300	91	0.0432	79	0.0059	68
37.5		2.36	100	0.212	88	0.0308	77	0.0037	64
19.0		1.18	99	0.150	86	0.0219	76	0.0031	62
13.2		0.600	97 94	0.075	82	0.0156	75	0.0014	57 56
9.5 Note:		eve not used ar		11		0.0083	73	0.0013	
100 90 80 (%) sset 60 50 40 50 40 40 50 40 50 40 50 40 50 80 80 80 80 80 80 80 80 80 80 80 80 80	fine	0.010 medium SILT		0.100 Partic		900 000	10.000 10.000 10.000 10.000 10.000 10.000 10.000 10.000	Jm coarse	100.000
Test Methods						Notes	S. 8. 1992		
Particle Size Analy	rsis: NZS 4402:19	86: Test 2.8.4 (Wa				All information	n : 8.9 (Electrom supplied by Clie	nt	
Date Tested:	27/09/21 - 0	4/10/21		not covered b may only be re		tation. Results a II	apply only to sa	imple tested.	

Date Reported:

18/10/21

IANZ Approved Signatory Designation : Date :

Thirushen Pillay Senior Civil Engineering Technician 19/10/21



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PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) **TEST REPORT**

Project :		Muriwai Do	wns						
Location :	ocation : 710 Muriwai Road								
Client :	Client : Riley Consultants Ltd c/o The Bears Home Proje				oject Manage	ment Limit	ed		
Client Ref:		210339							
Contractor :		Not Stated							
Borehole No):	TP10	Depth	: 1.80 metre	es				
Sampled by	:	GB							
Date receive		10/08/21							
Sampling m		Bulk sample	95						
Sample cond		As received					Project No:	1-LA614.00	
Sample desc		CLAY with n	ninor sand	and silt			Lab Ref No:	AL6732/3	
			2.74	Assumed			Client Ref.	210339	
Solid Particle							Client Rei.	210333	
Water Conte	ent (as recei		65.5	%		11			
	and the second	Sieve An	alysis				Hydromete		
Sieve Size	Passing	Sieve Size	Passing	Sieve Size	Passing	Particle Size	Passing	Particle Size	Passing
(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)
63.0		4.75	100	0.300	94	0.0476	86	0.0062	83
37.5		2.36	100	0.212	93	0.0338	85	0.0044	83
19.0		1.18	99	0.150	92	0.0239	85	0.0031	83
13.2		0.600	98	0.075	90	0.0169	84	0.0014	82
9.5		0.425	96	0.063	90	0.0124	84	0.0013	82
Note:	"" denotes sie	eve not used and	1/or hydrome	ter analysis not	t tested	0.0088	84		
			ი ო	Sieve Apert					
			0.063	0.150 0.212 0.300	0.425 0.600	1.18	4.75 9.5 13.2	37.5	03.0
100 F									
ם וי									
90									
90 80 (%) 70									

Test Methods

fine

10 0

0.001

CLAY

Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)

coarse

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1.000

coarse

Notes

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0.100

fine

Date Tested: 01-05/10/21

18/10/21

19/10/21

0.010

medium

SILT

Particle Size (mm)

medium

SAND

Date Reported:

IANZ Approved Signatory Designation : Date :

Thirushen Pillay Senior Civil Engineering Technician



fine

All information supplied by Client

10.000

pH of suspension : 9.5 (Electrometric Method)

medium

GRAVEL

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coarse

100.000 very

coarse

112

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PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST DEPOPT

			CFORI	1.1					
oject :		Muriwai D	owns						
ocation :		710 Muriw	ai Road						
ient :		Rilev Cons	sultants Ltd o	c/o The Bear	s Home Pr	oject Manage	ement Limit	ed	
ent Ref:		210339				,			
ontractor:		Not Stated	4						
				170 motr					
orehole Nc		TPII	Depth	: 1.70 metre	25				
mpled by		GB							
ate receive		10/08/21							
mpling m	ethod :	Bulk samp	oles						
mple cond	dition :	As receive	d				Project No:	1-LA614.00	
mple desc	cription :	silty CLAY	with some s	and			Lab Ref No:	AL6732/4	
lid Particle	e Density (t/	′m³):	2.74	Assumed		1	Client Ref:	210339	
	ent (as rece		52.0	%					
			Analysis				Hydromet	er Analysis	
Sieve Size	Passing	Sieve Size	Passing	Sieve Size	Passing	Particle Size	Passing	Particle Size	Passin
(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)	(mm)	(%)
63.0		4.75	100	0.300	95	0.0406	82	0.0057	70
37.5		2.36	100	0.212	93	0.0290	81	0.0041	66
19.0		1.18	100	0.150	90	0.0206	81	0.0030	61 56
13.2 9.5		0.600	99	0.075	84 84	0.0147	79	0.0021	52
9.5 Note:			and/or hydrome	1		0.0078	76	0.0015	02
				Sieve Aper	ture Size (n	nm)			
			0.063	0.150 0.212	0.425	1.18	4.75 9.5 13.2	37.5	63.0
100 E					FITT				
90									
80									
§ 70									
tage tiner by mass (%) 09 00 09 00 09 00 09									$\left\ \cdot \right\ $
50									
± 40 ±									
30									
30 20 20									
-									
10									
E				0.100 Particle	e Size (mm) 1.0	000	10.000		100.000
0.001		0.010						um coarse	very
0.001	fine	0.010 medium	coarse	fine n	nedium c	oarse fi	ne medii	un course	I coarse I
	fine				nedium c SAND	oarse fi	GRAV		coarse
0.001	fine	medium							Coarse
0.001 CLAY		medium SILT	coarse	5	SAND	Notes	GRAV	EL	Coarse
0.001 CLAY st Methods		medium SILT		5	SAND	Notes pH of suspensic		EL netric Method)	

18/10/21

Date Reported:

IANZ Approved Signatory Designation : Date :

Thirushen Pillay Senior Civil Engineering Technician 19/10/21



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SOLID DENSITY FOR FINE TO MEDIUM SOILS **TEST REPORT**



-

Project: Location: Client: Contractor: Sampled by: Sampling method: Sample description: Sample condition: Sample reference: Sample depth:

Muriwai Downs 710 Muriwai Road The Bears Home Project Management Limited c/o Riley Consultants Ltd Not Stated Date sampled: 04-05/08/21 GB **Bulk samples** CLAY with minor sand and silt Project number: 1-LA614.00 As Received AL6732/5 TP2 Lab ref number: Client ref number: 210339 1.80m Folder number:

Test Results

Solid Density (t/m³): 2.86

Test Methods		Notes
Solid Density:	NZS 4402 : 1986 : Test 2.7.2	Sample descriptions are not covered by IANZ accreditation
		Test performed on: Fraction Passing 19mm Test sieve
		History: Unknown
		All information supplied by Client

Date tested : 1/10/21 Date reported : 18/10/21

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Designation : Date:

Thirushen Pillay Senior Civil Engineering Technician 19/10/2021



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LAF-105 (06/18)

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Page 1 of 1

PLASTICITY INDEX FOR SOILS TEST REPORT



Project : Location : Client : Contractor : Sampled by : Date sampled : Sampling method : Sample description : Sample condition : Sample reference: Sample depth:	Muriwai Downs 710 Muriwai Road Riley Consultants Ltd c/o The Bears Not Stated GB 04-05/08/21 Bulk samples CLAY with minor sand and silt As Received TP2 1.80m	Home Project Manag Project No : Lab Ref No : Client Ref No : Folder number:	ement Limited 1-LA614.00 AL6732/6 210339 -
	Test Results		
Liquid Limit :	124		
Plastic Limit :	46		
Plasticity Index :	78		
Natural Water Content :	65.9		
	-		
	_		

Test Methods		Notes	
Liquid Limit	NZS 4402 : 1986, Test 2.2	Materials used: Passing 425um sieve	
Plastic Limit	NZS 4402 : 1986, Test 2.3		
Plasticity Index	NZS 4402 : 1986, Test 2.4	for the first sector of the se	
Water Content	NZS 4402 : 1986, Test 2.1	All information supplied by Client	

NAM

Date tested : 01/10/21 Date reported : 18/10/21

PF-LAB-101 (14/05/2021)

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Thirushen PillayDesignation :Senior Civil Engineering TechnicianDate :19/10/21



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PLASTICITY INDEX FOR SOILS TEST REPORT



Project : Location : Client : Contractor : Sampled by : Date sampled : Sampling method : Sample description : Sample condition : Sample reference: Sample depth:	Muriwai Downs 710 Muriwai Road Riley Consultants Ltd c/o The Bears Not Stated GB 04-05/08/21 Bulk samples silty CLAY with some sand As Received TP6 2.10m	Home Project Manag Project No : Lab Ref No : Client Ref No : Folder number:	ement Limited 1-LA614.00 AL6732/7 210339 -
	Test Results		
Liquid Limit :	105		
Plastic Limit :	64		
Plasticity Index :	41		
Natural Water Content :	59.2		
	2		

Test Methods		Notes	100.00
Liquid Limit	NZS 4402 : 1986, Test 2.2	Materials used: Passing 425um sieve	
Plastic Limit	NZS 4402 : 1986, Test 2.3		
Plasticity Index	NZS 4402 : 1986, Test 2.4		
Water Content	NZS 4402 : 1986, Test 2.1	All information supplied by Client	

Date tested : 01/10/21 Date reported : 18/10/21

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PF-LAB-101 (14/05/2021)

Designation :

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Date :

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19/10/21

Thirushen Pillay

Senior Civil Engineering Technician

7A Ride Way, Albany Private Bag 101982, NS Mail Centre, North Shore City, 0745, Auckland, New Zealand

PLASTICITY INDEX FOR SOILS TEST REPORT



Project : Location : Client : Contractor : Sampled by : Date sampled : Sampling method : Sample description : Sample condition : Sample reference: Sample depth:	Muriwai Downs 710 Muriwai Road Riley Consultants Ltd c/o The Bears H Not Stated GB 04-05/08/21 Bulk samples CLAY with minor sand and silt As Received TP10 1.80m	Home Project Manag Project No : Lab Ref No : Client Ref No : Folder number:	ement Limited 1-LA614.00 AL6732/8 210339 -
	Test Results		
Liquid Limit :	136		
Plastic Limit :	49		44.
Plasticity Index :	87		
Natural Water Content :	65.5		

Test Methods		Notes
Liquid Limit	NZS 4402 : 1986, Test 2.2	Materials used: Passing 425um sieve
Plastic Limit	NZS 4402 : 1986, Test 2.3	
Plasticity Index	NZS 4402 : 1986, Test 2.4	and a second
Water Content	NZS 4402 : 1986, Test 2.1	All information supplied by Client

Date tested : 01/10/21 Date reported : 18/10/21 Sampling is not covered by IANZ Accreditation. Results apply only to sample tested. This report may only be reproduced in full

IANZ Approved Signatory

Thirushen PillayDesignation :Senior Civil Engineering TechnicianDate :19/10/21



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PF-LAB-101 (14/05/2021)

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PARTICLE SIZE ANALYSIS (WET SIEVE ME	THOD)
TEST REPORT	

Project :	Muriwai Downs					
Location :	710 Muriwai Road					
Client:	Riley Consultants Ltd c/o The Bea	rs Home Pro	ject Manage	ment Limit	ed	
Client Ref:	210339					
Contractor :	Not Stated					
Borehole No:	TP2 Depth: 2.00 met	es				
Sampled by :	GB					
Date received :	10/08/21					
Sampling method :	Bulk samples					
Sample condition :	As received			Project No:	1-LA614.00	
Sample description :	sandy SILT/CLAY			Lab Ref No:	AL6732/9	
Solid Particle Density (t	/m³): -			Client Ref:	210339	
Water Content (as rece	eived): 69.8 %					
	Sieve Analysis			Hydromet	er Analysis	
Siovo Sizo Dassing	Sieve Size Dassing Sieve Size	Passing	Particle Size	Passing	Particle Size	Passing

Sieve Size Passing Sieve Size Passing Sieve Size Passing Particle Size Passing Particle Size Passing (%) (mm) (%) (mm) (%) (mm) (%) (mm)(%) (mm) 4.75 100 0.300 91 ------------63.0 2.36 100 0.212 88 ------------37.5 99 0.150 83 ---1.18 --------19.0 ---79 ---0.600 97 0.075 --------13.2 --------95 0.063 78 -----0.425 9.5 ---"--" denotes sieve not used and/or hydrometer analysis not tested ------Note: Sieve Aperture Size (mm) 0.063 0.075 .212 425 63.0 50 300 600 37.5 19.0 8 2.36 13.2 9.5 100 90 80 (%) 70 mass 60 Percentage finer by 05 05 05 05 ł 10 0 Particle Size (mm) 0.010 0.100 1.000 10.000 100.000 0.001 very fine medium coarse fine medium coarse fine medium coarse coarse CLAY SAND GRAVEL SILT Notes Test Methods Particle Size Analysis: NZS 4402:1986: Test 2.8.1 (Wet Sieve Method) All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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Date Tested: 05/10/21

18/10/21

19/10/21

Date Reported:

IANZ Approved Signatory

Thirushen Pillay Senior Civil Engineering Technician



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PF-LAB-100 (11/07/2020)

Designation :

WSP

Date :

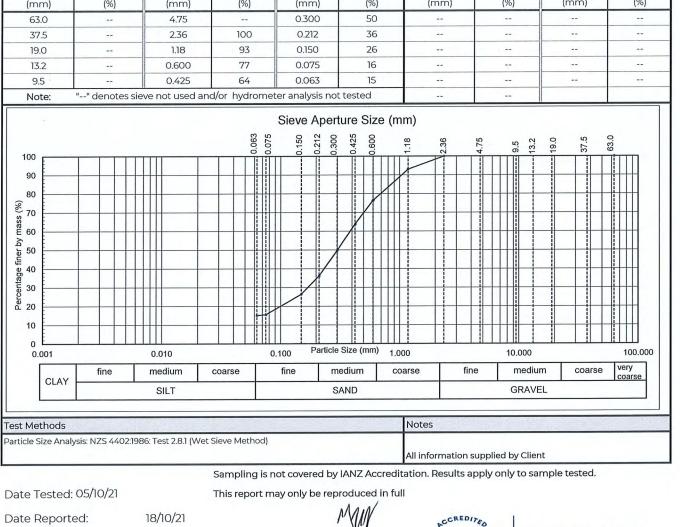
Auckland (Ride Way) Quality Management Systems Certified to ISO 9001

7A Ride Way, Albany Private Bag 101982, NS Mail Centre, North Shore City, 0745, Auckland, New Zealand

Page 1 of 1

PARTICLE SIZE ANALYSIS (WET SIEVE METHOD))
TEST REPORT	

	PARTICLE S	IZE ANALYSIS	OVEI SIEV	E METHOD)					
		TEST RE	PORT						11
Project :		Muriwai Do	wns						
Location :		710 Muriwa							
Client :				o The Bear	s Home Pro	oject Manage	ement Limit	ed	
Client Ref:		210339							
Contractor :		Not Stated							
Borehole No):	TP2	Depth	3.40 metre	es				
Sampled by	:	GB							
Date receive	ed :	10/08/21							
Sampling m	ethod :	Bulk sampl	es						
Sample con	dition :	As received					Project No:	1-LA614.00	
Sample desc	cription :	SAND with	minor silt a	nd clay			Lab Ref No:	AL6732/10	
Solid Particle	e Density (t/	′m³):	-				Client Ref:	210339	
Water Conte	ent (as rece	ived):	38.8	%					
2		Sieve Ar	nalysis				Hydromete	er Analysis	
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)



IANZ Approved Signatory Designation :

Thirushen Pillay Senior Civil Engineering Technician



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

PF-LAB-100 (11/07/2020)

Date :

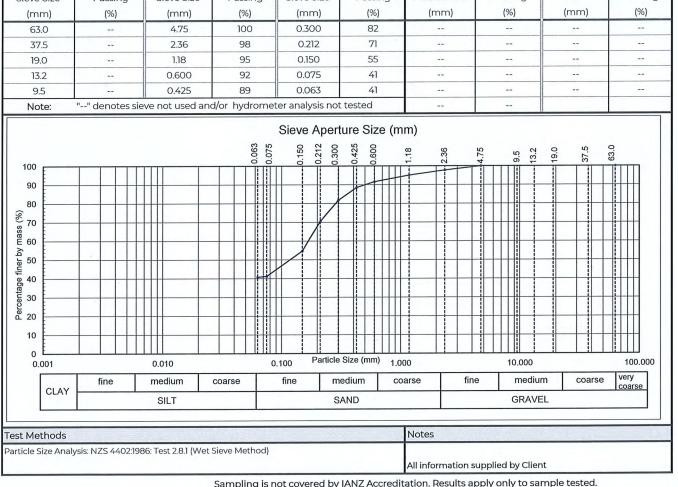
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Page 1 of 1

PARTICLE SIZE ANALYSIS (WET SIEVE METHOD)
TEST REPORT

Project :		Muriwai Do	wns						
Location :		710 Muriwa	i Road						
Client :		Riley Consu	ltants Ltd o	o The Bear	s Home Pro	ject Manage	ment Limit	ed	
Client Ref:		210339							
Contractor :		Not Stated							
Borehole No	:	TP4	Depth	2.40 metre	es				
Sampled by	:	GB							
Date receive	d:	10/08/21							
Sampling m	ethod :	Bulk sampl	es						
Sample cond	dition :	As received					Project No:	1-LA614.00	
Sample desc	cription :	clayey silty s	SAND with	traces of gra	avel		Lab Ref No:	AL6732/11	
Solid Particle	e Density (t/n	n ³):	-				Client Ref:	210339	
Water Conte	ent (as receiv	ved):	34.0	%					
	See See	Sieve Ar	alysis	Se La mais			Hydromet	er Analysis	
Sieve Size	Passing	Sieve Size	Passing	Sieve Size	Passing	Particle Size	Passing	Particle Size	Passing



Date Tested: 05/10/21

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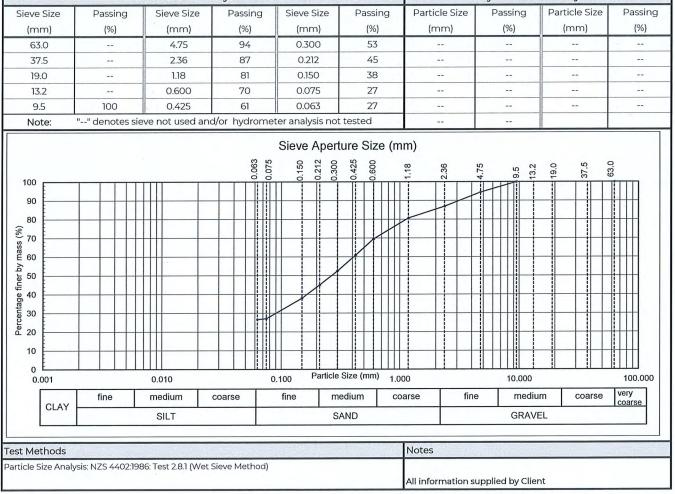
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PARTICLE SIZE ANALYSIS (WET SIEVE METHOD)
TEST REPORT

Project :	Muriwai Downs	
Location :	710 Muriwai Road	
Client :	Riley Consultants Ltd c/o The Bears Home Projec	ct Management Limited
Client Ref:	210339	
Contractor :	Not Stated	
Borehole No:	TP6 Depth: 2.90 metres	
Sampled by :	GB	
Date received :	10/08/21	
Sampling method :	Bulk samples	
Sample condition :	As received	Project No: 1-LA614.00
Sample description :	clayey silty SAND with some gravel	Lab Ref No: AL6732/12
Solid Particle Density (t	:/m³): -	Client Ref. 210339
Water Content (as rece	eived): 37.7 %	
1	Sieve Analysis	Hydrometer Analysis



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Date Tested: 05/10/21

Date Reported:

18/10/21

19/10/21

IANZ Approved Signatory Designation : Date :

Thirushen Pillay Senior Civil Engineering Technician



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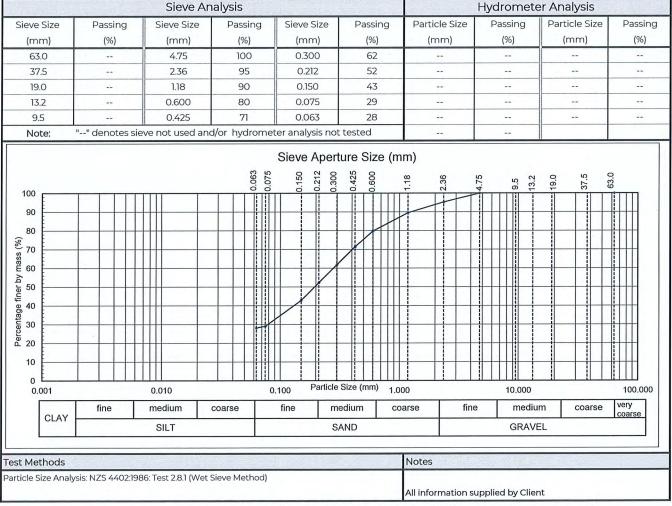
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PARTICLE SIZE ANALYSIS (WET SIEVE METHOD) TEST REPORT

Project :	Muriwai Dov	wns	
Location :	710 Muriwai	Road	
Client :	Riley Consul	tants Ltd c/o The Bears Home Project	t Management Limited
Client Ref:	210339		
Contractor :	Not Stated		
Borehole No:	TPII	Depth: 2.00 metres	
Sampled by :	GB		
Date received :	10/08/21		
Sampling method :	Bulk sample	es	
Sample condition :	As received		Project No: 1-LA614.00
Sample description :	clayey silty S	AND with minor gravel	Lab Ref No: AL6732/13
Solid Particle Density (t	/m³):	-	Client Ref. 210339
Water Content (as rece	eived):	45.1 %	



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Date Tested: 05/10/21

18/10/21

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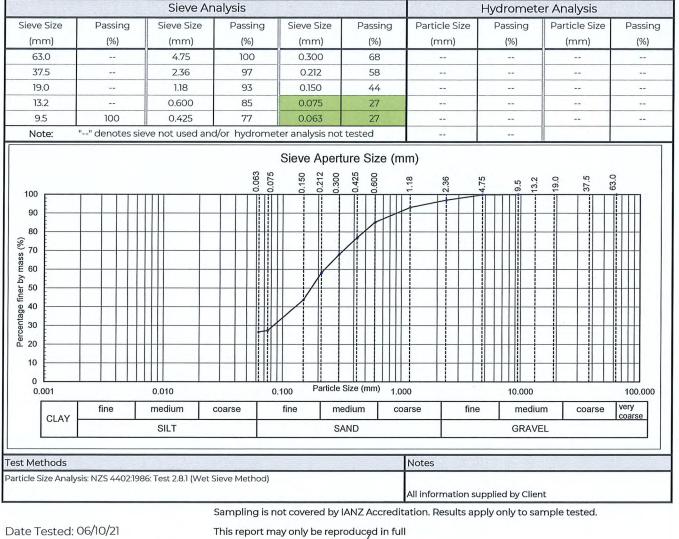
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PARTICLE SIZE ANALYSIS (WET SIEVE METHOD) **TEST REPORT**

11	5	

Project :	Muriwai Dowr	ns			
Location :	710 Muriwai R	load			
Client :	The Bears Hor	me Project Management Limited c/o Riley (Consultants	Ltd	
Client Ref:	210339				
Contractor :	Not Stated				
Borehole No:	TP8	Depth: 2.50 metres			
Sampled by :	GB				
Date received :	10/08/21				
Sampling method :	Bulk samples				
Sample condition :	As received		Project No:	1-LA614.00	
Sample description :	clayey silty SA	ND with traces of gravel	Lab Ref No:	AL6732/14	
Solid Particle Density (t,	/m³):	-	Client Ref:	210339	
Water Content (as rece	eived):	40.7 %			



Date Reported:

18/10/21

IANZ Approved Signatory Designation : Date :

Thirushen Pillay Senior Civil Engineering Technician 19/10/21



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Page 1 of 1

PARTICLE SIZE ANALYSIS (WET SIEVE METHOD) TEST REPORT

Project :		Muriwai Do	owns							
Location :		710 Muriwa	i Road							
Client :		The Bears I	Home Proje	ect Manage	ment Limit	ed c/o R	iley Co	onsultants Li	td	
Client Ref :		210339								
Contractor :		Not Stated								
Borehole No		TP10	Depth	n: 3.40 met	res					
Sampled by		GB	Dopti							
Date receive		10/08/21								
Sampling m		Bulk samp								
Sample cond		As received						Project No:	1-LA614.00	
Sample desc		SAND with		alay and are	wol			Lab Ref No:	AL6732/15	
			THINOT SIL,	siay and gra				Client Ref.	210339	
Solid Particle			-	0/				Client Rei.	210555	
Water Conte	nt (as receiv		30.6	%		1		1.1	. A sa a b sa ta	
Sieve Size	Dessing	Sieve Ar		Sieve Size	Passing	Particl	o Cizo	Hydromete Passing	Particle Size	Passing
(mm)	Passing (%)	Sieve Size (mm)	Passing (%)	(mm)	(%)	(m		(%)	(mm)	(%)
63.0		4.75	99	0.300	40					
37.5		2.36	94	0.212	27		-			
19.0		1.18	91	0.150	19 .		-			
13.2		0.600	80	0.075	13					
9.5 Note:	100 " " dopotos sis	0.425 eve not used an	59	0.063	13 ot tostod					
100 90 90 80 70 80 40 40 40 40 10 0 0 0001	fine	0.010		0.100 Partic			fine	22.49 66.61 10.000 medium		22222222222222222222222222222222222222
CLAY		SILT			SAND			GRAVE		coarse
		SILT			SAND			OIXAVE		
Test Methods						Notes				a siptist
Particle Size Analy	sis: NZS 4402:198	36: Test 2.8.1 (Wet	Sieve Method)							
						All inform	nation su	upplied by Clien	t	
Date Tested: Date Reporte		18/10/21			y IANZ Accred produced in fu	וונ	esults ap		mple tested. t results indicated	d as not

IANZ Approved SignatoryDesignation :SerDate :19/1

ory Thirushen Pillay Senior Civil Engineering Technician



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PF-LAB-100 (11/07/2020)

19/10/21

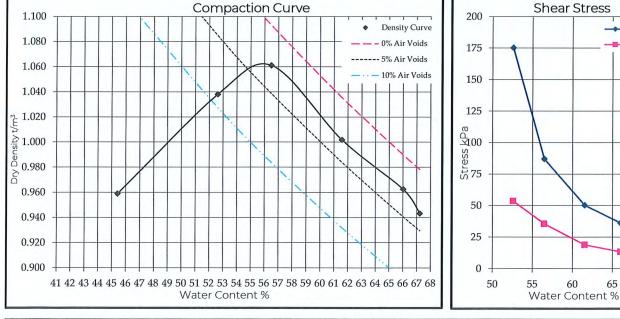
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DRY DENSITY / WATER CONTENT RELATIONSHIP STANDARD COMPACTION



			Test Results
Maximum dry density	1.06	t/m³	Natural water content 67.2 %
Optimum water content	56	%	Fraction tested Passing 19mm test sieve

Sample ID		A	В	С	D	E	Nat	
Bulk density	t/m³	1.394	1.584	1.661	1.619	1.598	1.577	
Water content	%	45.4	52.6	56.5	61.6	66.0	67.2	
Dry density	t/m ³	0.959	1.038	1.061	1.002	0.963	0.943	
Sample condition		Moist-	Moist-	Moist-	Moist-	Sat	Sat	
		Dry	Dry	Wet	Sat			
Peak stress	kPa	UTP	175	87	50	36	28	
Remoulded stress	kPa	-	54	36	19	14	10	



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	Sample description is not IANZ accredited
		Refer to report AL6732/5 for solid particle density test
Shear Strength us	ing a Hand Held Shear Vane, NZ Geotechnical Soc Inc 8/2001	All information supplied by Client

Date tested : 17/08/21 - 23/09/21 Date reported : 18/10/2021

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Thirushen Pillay Senior Civil Engineering Technician Designation : Date : 01/11/21



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PF-LAB-025 (10/07/20)

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Page 1 of 1

- Peak

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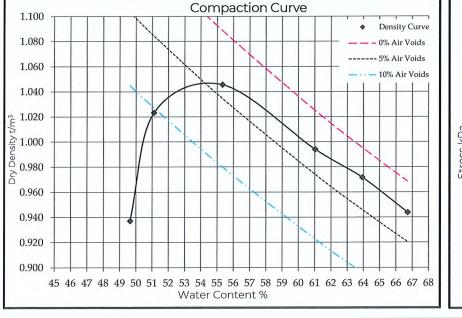
DRY DENSITY / WATER CONTENT RELATIONSHIP STANDARD COMPACTION

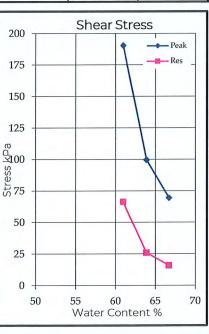


Project :	Muriwai Downs						
Location :	710 Muriwai Road						
Client :	Riley Consultants Ltd c/o The Bears Home Project Management Limited						
Contractor :	Not Stated						
Sampled by :	GB						
Date sampled :	04-05/8/21						
Sampling method :	Bulk samples						
Sample description :	silty CLAY with some sand						
Sample condition :	As received Project No : 1-LA614.00						
Solid density :	2.74 t/m ³ (Assumed)	Lab Ref No :	AL6732/17				
Source:	TP6 2.10m	Client Ref No :	210339				

	- 1- 2		Test Results
Maximum dry density	1.05	t/m³	Natural water content 61.0 %
Optimum water content	54	%	Fraction tested Passing 19mm test sieve

Sample ID		A	В	С	Nat	D	E	
Bulk density	t/m³	1.402	1.546	1.624	1.601	1.593	1.573	
Water content	%	49.6	51.1	55.3	61.0	63.9	66.7	
Dry density	t/m³	0.937	1.023	1.046	0.994	0.972	0.944	
Sample condition	٦	Dry	Dry-	Moist-	Moist	Moist-	Moist-	
			Moist	Dry		Wet	Wet	
Peak stress	kPa	UTP	UTP	140+	190	100	70	
Remoulded stres	s kPa	-	-	-	66	26	16	





Test Methods

Date tested :

Compaction NZS 4402 : 1986 Test 4.1.1 (Standard) Shear Strength using a Hand Held Shear Vane, NZ Geotechnical Soc Inc 8/2001

29/09/21-04/10/21

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested. This report may only be reproduced in full

All information supplied by client

Sample description is not IANZ accredited

Notes

Date reported : 18/10/2021

IANZ Approved Signatory Thirushen Pillay Designation : Senior Civil Engineering Technician Date : 01/11/21



Test results indicated as not accredited are outside the scope of the laboratory's accreditation

PF-LAB-025 (10/07/20)

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CRUMB TEST FOR DISPERSIBILITY OF SOILS **TEST REPORT**



210339

Project :	Muriwai Downs		
Location :	710 Muriwai Road		
Client :	Riley Consultants Ltd c/o The Bea	rs Home Project Mar	nagement Limited
Contractor :	-		
Sampled by :	GB		
Date sampled :	Not stated		
Date received :	10/08/21		
Sampling method :	Bulk samples		
Sample condition :	As received	Project No :	1-LA614.00
		Lab Ref No :	AL6732/18-20

Client Ref No :

Sample Lab Ref No :	AL6732/18	AL6732/19	AL6732/20
Location ID :	TP2	TP6	TP10
Depth (m) :	1.80	2.10	1.80
Description :	CLAY with minor sand and silt	Silty CLAY with some sand	CLAY with minor sand and silt
Grade :	1	1	1
Water Content as rec'd (%) :	66.9	59.0	65.2
Water Content as tested (%) :	66.9	59.0	65.2

Grade 1: Nondispersive : No reaction - no turbid water created by colloids

Grade 2: Intermediate : Slight reaction - faint , barely visible colloidal suspension

Grade 3: Dispersive : Moderate reaction - easily visible cloud of suspended clay colloids around crumb surface

Grade 4: Highly Dispersive : Strong reaction - dense profuse cloud of suspended clay colloids around bottom of dish

Test Methods	Notes	
Crumb Test : ASTM D6572 - 13	1) Whole soil tested.	
Water Content : NZS 4402 : 1986 Test 2.1	2) Samples were tested at natural water conter	
	3) Samples tested were natural crumbs.	

Date tested : Date reported : 21/10/21

12/10/21 DevHes

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Approved



All information supplied by Client

Designation : Date :

21/10/21

LHF 2424 (08/20)

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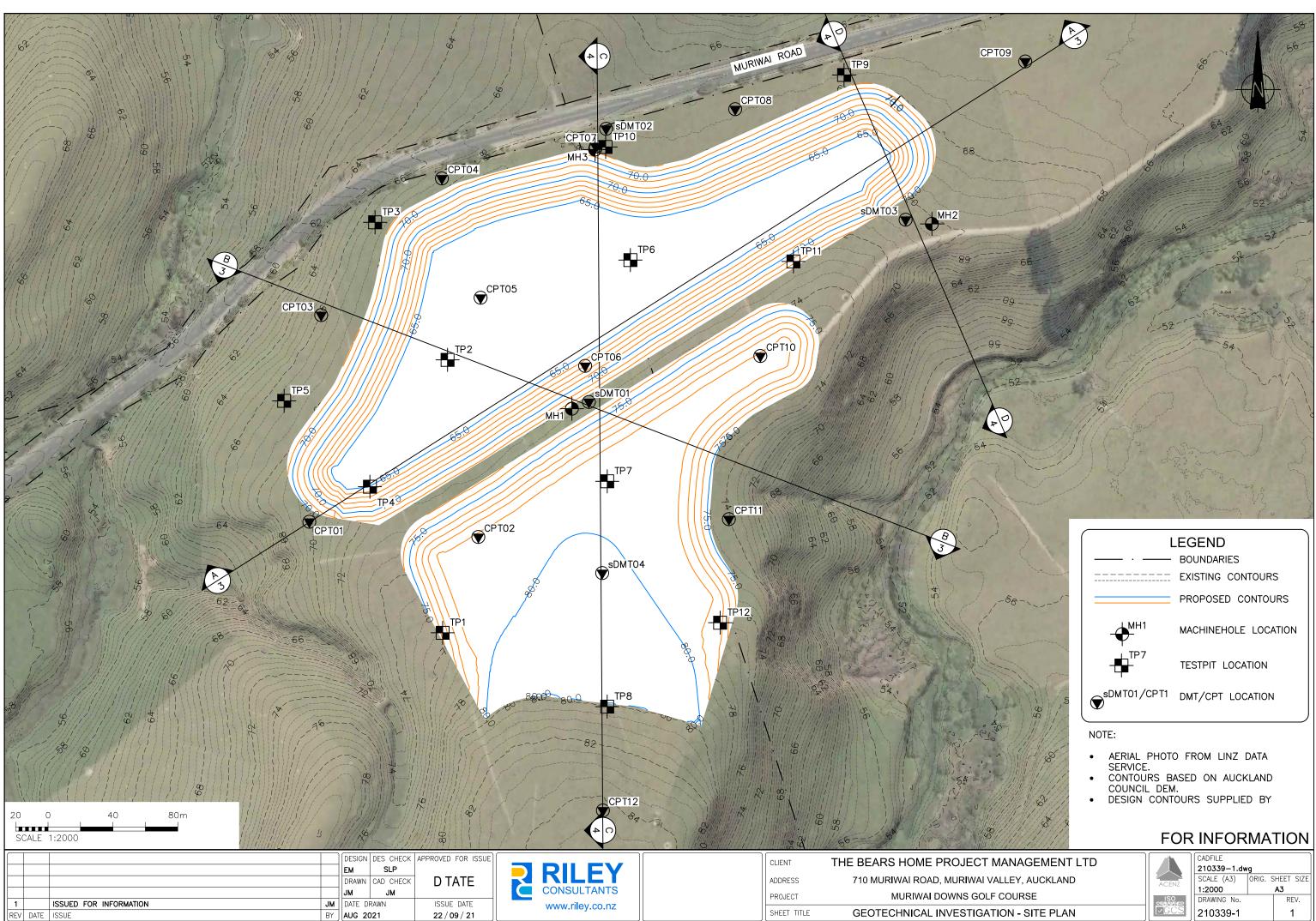
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Page 1 of 1

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APPENDIX I

RILEY Dwgs: 210339-1 to -4



	60			66 MURIWAI F	ECAD 68
	89-98		200		
		-72			
	DESIGN DES CHECK AN		80		
1 ISSUED FOR INFORMATION REV DATE	JM JM BY AUG	D TATE ISSUE DATE 22 / 09 / 21	RILEY CONSULTANTS www.riley.co.nz	PRC	THE BEARS HOME PROJECT MANAGERESS THE BEARS HOME PROJECT MANAGERESS RESS 710 MURIWAI ROAD, MURIWAI VALLEY, NECT MURIWAI DOWNS GOLF COURS TITLE GEOMORPHIC PLAN



