REPORT

Tonkin+Taylor

Harania Flood Resilience Works – Tennessee Bridge

Geotechnical resource consent assessment report

Prepared for
Auckland Council
Prepared by
Tonkin & Taylor Ltd
Date
October 2024
Job Number
1017033.2002 v1

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Document control

Title: Harania Flood Resilience Works – Tennessee Bridge					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
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Distribution:

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1 Introduction

1.1 Background

The January 2023 floods, followed soon after by Cyclone Gabrielle, marked a period of unprecedented weather challenges for Auckland. Auckland Council is carrying out flood resilience projects with the aim of mitigating flood risk to property through a series of blue-green networks, addressing critical flood-prone areas with sustainable stormwater solutions. The Harania catchment was one of the worst affect areas of Auckland following the January 2023 floods. Healthy Waters identified significant flooding, causing risk to life, and widespread flood damage to homes. This occurred due to poor flood conveyance at the location of the current Tennessee Avenue embankment dam.

1.2 Project description

A detailed description of the full project works can be found in the Assessment of Effects on the Environment (AEE) report[1].

The Tennessee Bridge project involves removing the current embankment which carries the existing Eastern Interceptor (EI), an approximately 2.6 m diameter reinforced concrete wastewater pipe. The replacement will comprise a new pipe and pipe bridge in the coastal marine area (CMA) to open up the waterway capacity to allow increased flood conveyance. Diversion chambers are required at either end of the new pipe, connecting it to the existing pipe to facilitate the change over from the old pipe to the new pipe bridge diversion.

1.3 Scope of works

Tonkin & Taylor Ltd (T+T) has been engaged by Auckland Council's Healthy Waters to provide the following, related to the proposed Tennessee Bridge upgrade works (the Project):

- Provide an assessment of the geotechnical and groundwater conditions.
- Provide an assessment of geotechnical effects resulting from the proposed Tennessee Bridge works including consideration of land subject to instability hazards, soil stability and safety.

This report has been prepared to accompany a resource consent application for the Tennessee Bridge project under the Severe Weather Emergency Recovery (Auckland Flood Resilience Works) Order 2024. The purpose of this report is to consider the potential effects associated with the following works:

- Installation of the two chambers with screw-piled foundations at either end of the existing embankment including temporary excavations.
- Installation of screw-piled foundations for the bridge piers within the existing stream, including temporary excavations for pile cap construction.
- Removal of the existing Tennessee embankment, and the forming of final stream batters at a 2.5 (H) : 1 (V) slope, within natural ground.

Other temporary works elements are addressed by others.

[1] *Harania Flood Resilience Works – Tennessee Bridge Assessment of Effects on the Environment*, Beca Limited, November 2024.

2 Site conditions

2.1 Summary of geological conditions

The Site is underlain by Pliocene to Holocene Takaanini Formation with a dense sand layer (approximately 4 m thick) at about 8 m deep, underlain by East Coast Bays Formation (ECBF) at about 18 – 20 m deep. The ECBF is identified as a suitable pile founding layer.

The geological profile is consistent with published geological information, nearby previous investigations, and has been confirmed with site specific geotechnical investigations. The geotechnical investigations undertaken at the Site are shown on Figure 2.1, and comprised 3 cone penetrometer tests (CPTs), 3 hand augered boreholes (HAs) and 2 machine drilled boreholes (BHs). Laboratory soil characterisation testing of core samples from the BHs has also been completed, as well as down-hole shear wave velocity testing within one of the BHs.

Figure 2.1: Investigation locations

More information on investigations is presented in Appendix A, and investigation outputs are presented in Appendix B. A simplified geotechnical model is presented in Table 2.1.

Table 2.1: Summary of subsurface ground conditions around and beneath the Tennessee embankment

Geological unit	Soil description	Typical elevation of surface of layer (mRL)	Typical depth to surface of layer (mbgl)	Typical layer thickness (m)
Topsoil	Dark brown firm silt	-	0	0.15 – 0.3
Fill[1]	Dark brown firm clayey SILT	-	0.15	3.65
Takaanini Formation (alluvium)	Orange brown stiff silty CLAY	3.2 – 3.9	0.15 – 3.8	0.6 – 2.5

Geological unit	Soil description	Typical elevation of surface of layer (mRL)	Typical depth to surface of layer (mbgl)	Typical layer thickness (m)
Takaanini Formation (Hobsonville Member)	Grey interbedded clayey SILT (stiff) and fine to medium SAND (loose, pumiceous)	1.4 – 2.6	2.8 – 4.4	2.6 - 6
Takaanini Formation (Hobsonville Member)	Dark grey SAND	-1.2 – -3.8	7.9 – 8.1	4 – 6
Takaanini Formation	Greenish grey very stiff clayey SILT	-7.2 – -7.8	12 – 14.2	5.4 – 5.7
East Coast Bays Formation	Dark green to greyish brown, SILTSTONE	-12.6 – -13.5	17.7 – 19.6	5.5 – 6.3
	Dark grey SILTSTONE with some isolated SANDSTONE layers.	-18.1 – -19.8	24 - 25	0.4+ – 6+

[1] Fill was only identified in BH01/CPT01 (Appendix B)

[2] CPT data terminate at 22.96 mbgl for CPT01 and 26.15 mbgl for CPT02. (Appendix B)

2.2 Groundwater

Groundwater levels (GWL) were measured with a dip-meter following the CPT investigations as well within the HA investigations. The groundwater measurements within both CPT-24-1/HA-01 and CPT-24-2/HA-02 were both within a sand layer, and we therefore consider them to be representative measurements. Therefore, no standpipe piezometer has been installed as the information is sufficient to confirm current groundwater levels. A summary of GWL measurements is shown in Table 2.2. Note that only measurements related to the Tennessee embankment are included (CPT-24-3/HA-03 is excluded as it is over 100 m away and in a different stream environment).

GWL measurements were also undertaken following the BH excavations, however since drilling fluid was used to aid the borehole excavations, these readings are not reliable, and are included for information only.

Table 2.2: Summary of recorded groundwater levels at the Site

Investigation	Ground water level [mbgl]	Ground water [mRL]	Investigation termination depth [m]	Date of measurement	Comment on level of confidence in GWL measurement
CPT-24-1	5.00	~2.00	22.96	14th of June, 2024	High
CPT-24-2	3.05	~1.15	26.15	14th of June, 2024	High
HA-01	*Not encountered (> 4.0)*	*Not encountered* < 3	4.00	21st of June, 2024	High

Investigation	Ground water level [mbgl]	Ground water [mRL]	Investigation termination depth [m]	Date of measurement	Comment on level of confidence in GWL measurement
HA-02	2.95	~1.25	4.00	21st of June, 2024	High
BH-01	*4.2*[1]	*~2.8*	*25*	*13st of August, 2024*	*Low (water used during drilling)*
BH-02	*1.1*[1]	*~3.1*	*30*	*13th of August, 2024*	*Low (water used during drilling)*

[1] Groundwater levels were measured after drilling with water used as drilling fluid.

The stream water level within the adjacent stream has been observed to be at around +1 to +2 mRL, varying with tidal fluctuations. Based on groundwater measurements at the Site, and the water level of the adjacent stream, the groundwater level surrounding the Tennessee embankment is similar to the stream level. Therefore, for design and assessment purposes, a groundwater level of + 2 mRL is adopted. This represents a typical winter high level.

Figure 2.2 presents a section of the proposed works at the eastern stream bank and includes the adopted groundwater level.

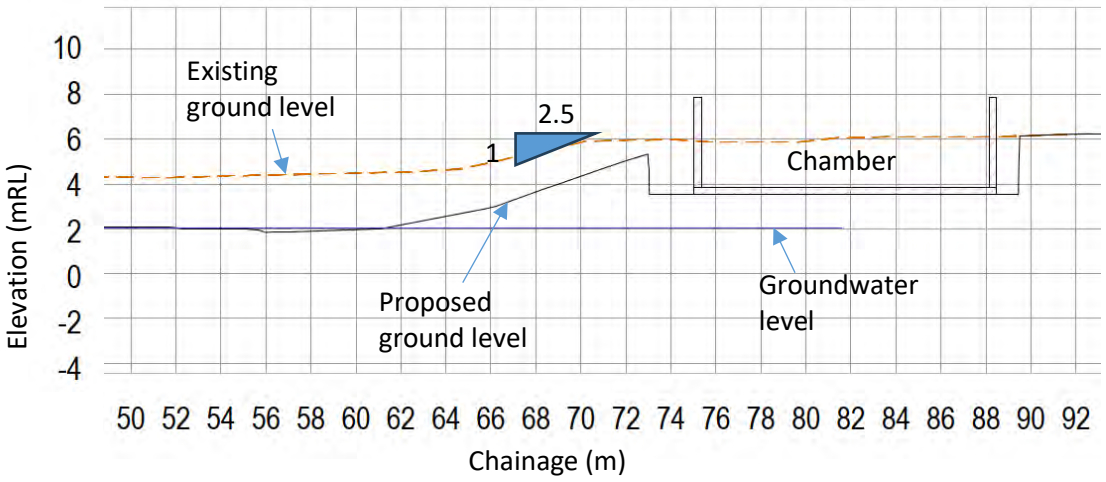


Figure 2.2: Section of proposed works at eastern stream bank

The chambers are to be founded at an elevation of 3.1 mRL. Allowing 0.5 m for over-excavation (expected to be less) means a maximum dig depth of 2.6 mRL. Based on this, we do not assess the proposed chamber excavations to encounter winter groundwater levels. With no groundwater interaction with the chambers and pipe works on the shore, no take, using, damming or diversion of groundwater will occur.

2.3 Land subject to instability

Chapter J1 of the Auckland Unitary Plan (AUP) defines land as being subject to instability if ground comprising Holocene or Pleistocene sediments are at a slope of 4 (H) : 1 (V) or steeper. The existing slopes trigger both elements, and therefore the stream banks are identified to potentially be subject to instability.

3 Effects assessment

3.1 Soil stability and safety

An assessment of potential effects of works on land subject to instability has been carried out and is presented below.

The completed slopes from the embankment removal will be formed to 2.5 (H) : 1 (V) from cut batters within natural soils, approximately 30 m long on each bank. The slopes will not be supporting any structure since the new chambers will be founded on piles.

A limit state equilibrium analysis has been carried out. Material parameters for the stability analysis are adopted based on observed materials and back-analysis of the existing slopes. The slope stability analysis used Geostudio's limit equilibrium software, Slope/W 2023 1.1. The selected section for analysis is representative of the final stream after removal of the Tennessee embankment has been completed. The final stream batter slope has been modelled as 2.5 (H) : 1 (V). The chambers impose no load on the slope as they will be founded on piles and therefore are not considered in the stability modelling. Further details of the material parameters, sections analysed, and model outputs are included in Appendix C.

The load cases and target factors of safety outlined in Chapter 2 of the Auckland Code of Practice for Land Development and Subdivision were considered, as follows:

- Factor of safety of 1.5 for normal groundwater conditions.
- Factor of safety of 1.3 for the worst credible groundwater condition.
- Factor of safety of 1.0 for the pseudo-static seismic loading using ULS PGA.

A summary of the results is presented in Table 3.1.

Table 3.1: Summary of slope stability modelling outputs

Design scenario	Factor of safety – west stream bank	Factor of safety – east stream bank	Factor of safety requirement
Long-term static	1.66	2.16	1.5
Worst credible groundwater level	1.41	1.57	1.3
Pseudo-static seismic (undrained)	1.41	1.41	1.0

Each of the model scenarios meet the target factors of safety. We have checked the stability presuming drained (long term) soil strengths combined with full earthquake loading. In this case some yield is indicated, although deformations less than 10 mm area assessed (based on Jibson, 2007). We note we do not consider this to be a likely scenario as we interpret the silty sands to behave in an undrained manner during seismic loading (and present this analysis in Table 3.1). This scenario is discussed here for completeness.

During construction, temporary excavations will be undertaken to install the chambers, which are expected to be up to 3.4 m deep, approximately 1.2 m away from the nearest property boundary. Temporary excavation of this magnitude is common practice, and it is expected that the contractor will undertake appropriate steps (which could include retention, benching or battering) to mitigate the risk of instability of temporary excavations. Measures to ensure stability of proposed excavations will be addressed in the Construction Environmental Management Plan (CEMP)[2] prepared for the application prior to construction.

[2] *Harania – Tennessee Bridge Draft Construction Environmental Management Plan*, Fulton Hogan, October 2024.

The current earthworks design includes the placement of buttress fill against the sides of the new chamber, at a slope of 1.5(H):1(V). We assess these slopes to be at risk of instability; however, several options are to be considered detailed design (such as soil reinforcement, slope easing, or increasing the exposure of the chamber walls) to provide a slope that meets minimum stability criteria outlined in Chapter 2 of the Auckland Code of Practice for Land Development and Subdivision.

Based on the analysis and our site observations, we consider the land to be sufficiently stable to meet normally accepted performance levels. We consider there to be no consequential risk to people, property or the environment from works on land subject to instability and proposed landform modifications as a result of the flood resilience works or associated temporary works.

3.2 Hazard risk assessment – Land subject to instability

A hazard risk assessment of the proposed work on land subject to instability is provided below.

Table 3.2: Hazard risk assessment summary – land subject to instability

Matter	Comment
the type, frequency and scale of the natural hazard and whether adverse effects on the development will be temporary or permanent	• Land subject to instability is identified (section 2.3) to exist at both stream banks. We assess it to have no adverse temporary or permanent effect on the development (section 3.1).
the type of activity being undertaken and its vulnerability to natural hazard events	The activity includes structures, temporary works and permanent batters. • Structures The design of the structures will mitigate any vulnerability to natural hazards. • Temporary works Provided the contactor undertakes appropriate measures during construction (ie temporary retention or slope easing), the activities are not vulnerable to land subject to instability (section 3.1). • Permanent earthworks batters Final slopes are to be formed at 2.5 (H) : 1 (V) which has been assessed to not be vulnerable to high groundwater events.
the consequences of a natural hazard event in relation to the proposed activity and the people likely to be involved in that activity	No adverse consequences are assessed in relation to the proposed works provided normal design and construction approaches are adopted.
the potential effects on public safety and other property	As discussed in section 3.3, no potential adverse effects on other properties are assessed. Therefore, there are no geotechnical public safety effects.
any exacerbation of an existing natural hazard risks or creation of a new natural hazard risks	As assessed in Appendix C and summarised in section 3.1, the final slopes are as stable or more stable than the existing slopes. Therefore, there is no exacerbation of the existing natural hazard, nor the creation of a new hazard.
whether any building, structure or activity located on land subject to natural hazards near the coast can be relocated in the event of severe coastal	The proposed structures cannot be readily relocated in the event of severe coastal erosion. However, the structures will be founded on piles so are resilient in

Matter	Comment
erosion, coastal storm inundation or shoreline retreat	such an event. Refer to the coastal report[3] for further information on the coastal erosion assessment.
the ability to use of non-structural solutions, such as planting or the retention or enhancement of natural landform buffers to avoid, remedy or mitigate the hazard, rather than hard engineering solutions or protection structures	The final slopes will be formed in natural soils, which can be readily topsoiled and planted or otherwise to enhance the resilience against land subject to instability. Refer to the Landscape and Visual Assessment report[3]. No hard engineering is proposed on the slopes and the chambers will be buried. Non-structural solutions are not feasible for the structural elements of this asset.
the design and construction of buildings and structures to mitigate the effects of natural hazards	The chambers located at the top of each stream bank will be founded on piles, which will provide a net positive effect on land stability.
the effect of structures used to mitigate hazards on landscape values and public access	Not applicable, refer to the Landscape and Visual Assessment report[4].
site layout and management to avoid or mitigate the adverse effects of natural hazards, including access and exit during a natural hazard event	Not applicable to geotechnical elements.
the duration of consent and how this may limit the exposure for more or less vulnerable activities to the effects of natural hazards including the effects of climate change	The duration of the consent will not have an effect on the exposure of the proposed activities to the natural hazard. As assessed in Appendix C and summarised in section 3.1, slope stability with elevated ground water has been assessed as meeting the required factors of safety.
any measures and/ or plans proposed to mitigate the natural hazard or the effects of the natural hazard	Appropriate mitigations will be undertaken by the Contractor's during normal construction methodology to mitigate natural hazard effects related to temporary works. These measures will be addressed in the CEMP[3]. No other mitigations are necessary.

3.3 Settlement

The existing EI has been in place for approximately 60 years, and therefore any residual settlement of the existing pipe is assessed to be negligible.

The weight of the proposed structures are expected to be higher than the weight of the soil being replaced, resulting in a net load increase. However, the chambers are proposed to be founded on piled foundations. The piles will carry loads to a strong underlying layer, and there is therefore no increase in load on the soils. No consolidation settlement is assessed to occur as a result of the chamber construction.

It is therefore assessed that there is no risk of adverse effects to the existing interceptor as a result ground settlement induced by the proposed works.

[3] *Harania Flood Resilience Works – Coastal and fluvial geomorphic effects assessment - Harania Creek Catchment*, Tonkin + Taylor, October 2024.
[4] *Harania Flood Resilience Works – Tennessee Bridge Landscape and Natural Character Effects Assessment report*, Boffa Miskell, October 2024.

It is recommended that measures be included in the CEMP prepared for the project to avoid applying significant temporary load to the ground within the zone of influence of the existing EI (approximately 3 m offset from the EI centreline).

Excavations during construction can also cause mechanical settlement of adjacent ground. We have considered the potential effect on nearby structures. The nearest existing structure to the proposed chamber excavations is a residential garage at 91 Blake Road (south-east of project works). The garage is situated at approximate 6 mRL, around 3 m higher than the base of the proposed excavation. The horizontal distance between the excavation and structure is around 4 m (refer Figure 3.1 below). The nearest existing structure to the proposed chamber at the western end of the project (which has a 3 m deep excavation) is approximately 12 m away.

With a horizontal distance at least that of the depth of excavation, we consider there to be negligible risk of the proposed excavations effecting the nearby existing garage structure.

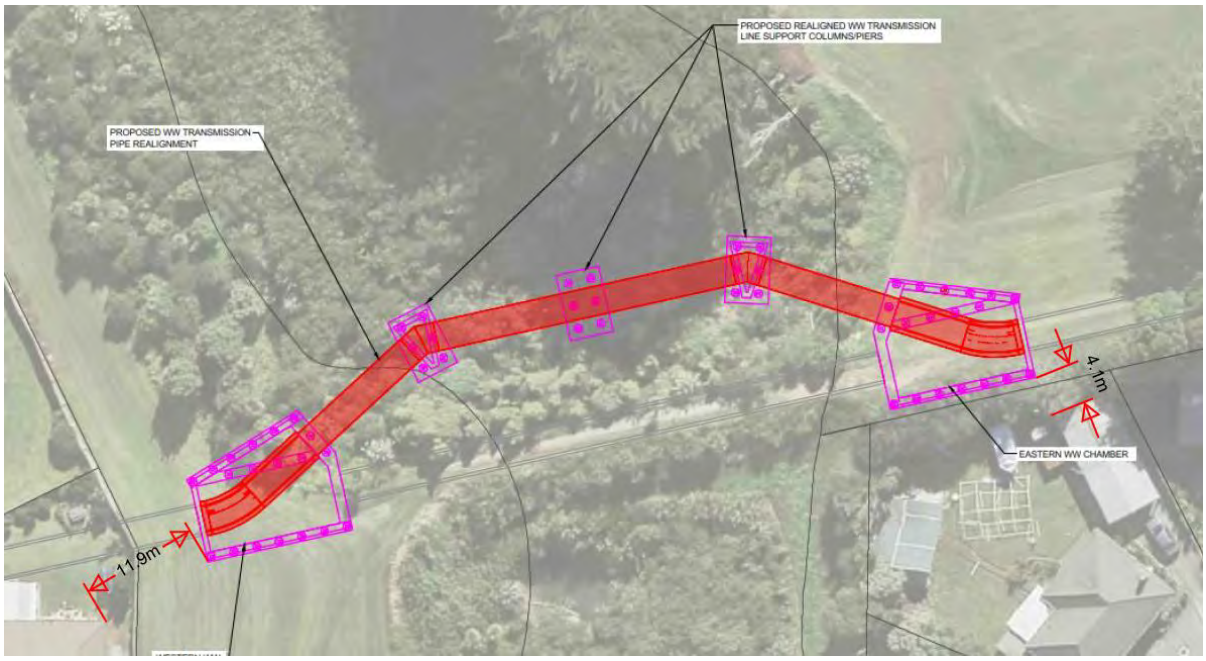


Figure 3.1: Proposed chamber locations and nearby existing structures

3.4 Liquefaction

Soil layers existing from 3 to 8 mbgl beneath the Site are assessed to be at risk of liquefaction during a ULS earthquake (1:2500 return period for IL4 structures like this). The potential effects that liquefied soil could have on the proposed pipe bridge are listed below:

- Deformation (settlement) of the ground around and beneath the chambers.
- Negative skin friction acting on the screw piles.
- Reduction in lateral capacity (particularly of the screw piles).
- Possible lateral spread effects.

The proposed works do not exacerbate the liquefaction hazard that already exists at the site, and any effects of hazard on the works can and will be mitigated through design using normal design approaches.

4 Conclusions

The following conclusions summarise potential effects as assessed in the report.

- Groundwater is assessed to be sufficiently deep that the proposed chamber excavations or pipe works on the shore will not encounter groundwater. Therefore, no take, use, damming or diversion of groundwater will occur.
- The existing and proposed final stream banks are identified to potentially be subject to instability in terms of Chapter J1 of the Auckland Unitary Plan. However, our analysis demonstrates that they meet Auckland Council factors of safety.
- We consider there to is no consequential risk to people, property or the environment from works on land subject to instability and proposed landform modifications as a result of the Tennessee Bridge works or associated temporary works.
- We assess that there is no risk of adverse effects to the existing interceptor pipeline as a result of ground settlement induced by the proposed works.

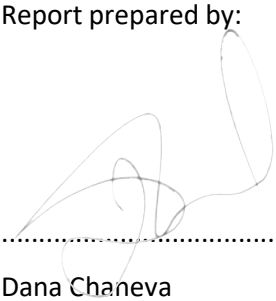
5 Applicability

This report has been prepared for the exclusive use of our client Auckland Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Recommendations and opinions in this report are based on data from discrete investigation locations. The nature and continuity of subsoil away from these locations are inferred but it must be appreciated that actual conditions could vary from the assumed model.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:



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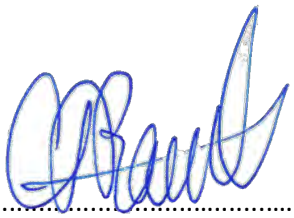
Dana Chaneva
Geotechnical Engineer

Authorised for Tonkin & Taylor Ltd by:



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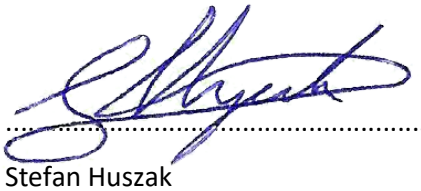
Chris Bauld
Project Director



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Stefan Huszak
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Appendix A Geotechnical investigation commentary

A1 Published geology

The published geology presented on the map in Figure Appendix A.1 shows that Site is underlain by Pliocene to Holocene undifferentiated Takanini Formation, described as pumiceous mud, sand and gravel river deposits with peat and lignite.

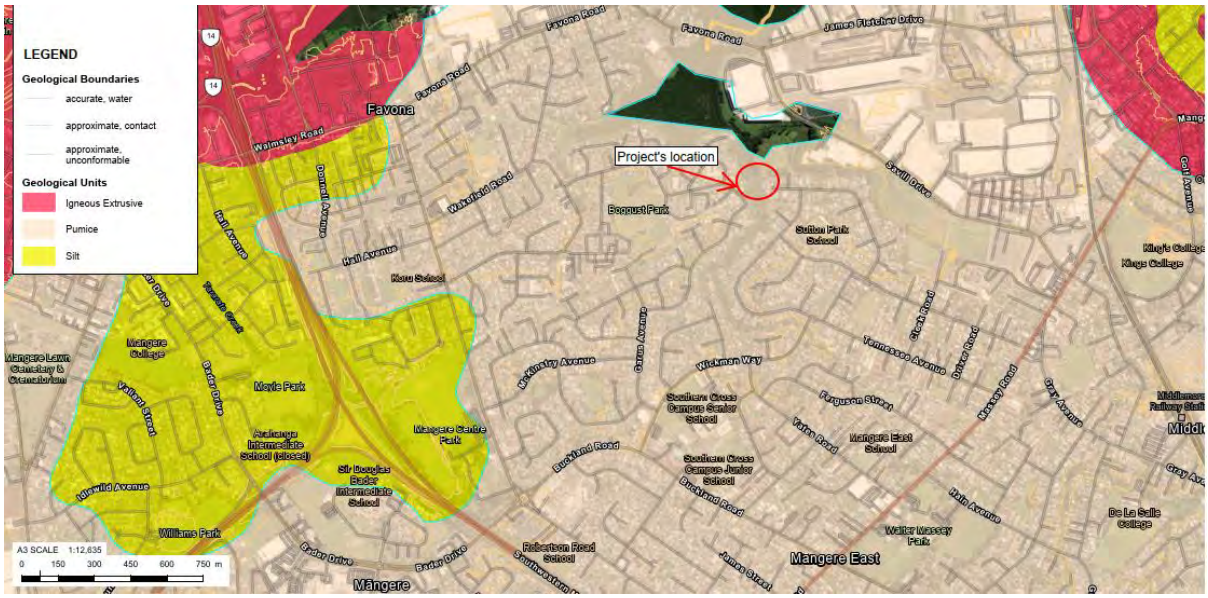

Figure Appendix A.1: Published geology for the area surrounding the project's location

A2 Previous geotechnical investigations

A review of the T+T and New Zealand Geotechnical Database (NZGD) identified geotechnical investigations undertaken near the Site. 18 investigations within a 400 m radius of the project's location have been considered to better understand the regional subsurface conditions. Investigation locations are shown on the Site plan (in Appendix B). The historical investigations comprise:

- Four (4) CPT investigations (depths of investigations ~25 mbgl);
- Three (3) Borehole investigations (including one undertaken within the overall project extents through the Blake embankment), with depths typically ranging between 19 and 26 mbgl; and
- Eleven (11) HA investigations.

In 2015, AECOM drilled a borehole at the Blake embankment to 15 m depth. The borehole lost core in the gravel embankment fill and did not encounter rock.

A2.1 Current geotechnical investigations

Recent geotechnical investigations were undertaken by T+T at the Site, comprising cone penetrometer tests (CPTs), hand augered boreholes (HAs) and machine drilled boreholes (BHs).

The scope of geotechnical investigations undertaken include:

- Three (3) CPTs to a maximum depth of 26 metres below ground level (mbgl).
- Three (3) HAs investigations to a maximum depth of 4.0 mbgl.
- Two (2) BHs to a maximum depth of 30 mbgl.
- One (1) down-hole geophysical measurement of shear wave velocity.

- A series of laboratory soil characterisation tests on machine drilled borehole samples.

Investigation locations are shown in Figure Appendix A.2. The recovered drill core from all borehole investigations were photographed and logged in general accordance with NZGS 'Field Description of Soil and Rock' guidelines. Summary CPT results, hand auger and machine drilled borehole logs, and core photographs are presented in Appendix B.

Figure Appendix A.2: Investigaton locations

Cone Penetrometer Tests

Three CPTs were carried out at both Tennessee and Blake embankments by Ground Investigations Ltd on 14th June 2024 (refer Appendix B). The tests were undertaken to "refusal", at locations offset 10 m from the East Interceptor (EI) situated within natural ground. CPT-24-01 achieved a depth of 23 mbgl, CPT-24-02 achieved a depth of 26 mbgl, and CPT-24-03 achieved a depth of 22 mbgl.

Hand augured boreholes

Hand Augered (HA) investigations were carried out by T+T adjacent to the CPT test locations, on 21st June 2024 (refer Appendix B). The purpose of these investigations was to view the subsurface conditions and assess the presence or absence of groundwater in the three locations. Particular attention was given to moisture contents of the recovered material. The target depth of 4 m was achieved for all three HA. Within HA-01 and HA-03, no moisture increase was observed, and no groundwater was encountered at this depth. Ground water (standing water and saturated soil) was encountered in HA-02 at a depth of 2.95 mbgl. The inflows were observed from a saturated sand layer that collapsed during hand augering.

Machine drilled boreholes

Two machine drilled boreholes were undertaken by McMillan Drilling (NI) Ltd. on the 12th and 13th August (refer Appendix B), adjacent to CPTs 24-01 and 24-02 at the Tennessee embankment. The BHs were undertaken to log the soil profile, provide the means for shear wave velocity testing, and to recover samples for soil characterisation via laboratory testing. BH-01 extended to a depth of 25 m, and BH-02 extended to 30 m. BH-01 was backfilled on completion of drilling, and BH-02 had a PVC pipe grouted in place for shear wave velocity testing.

Shear wave velocity testing

Down-hole shear wave velocity testing was carried out by Resource Development Contractors Ltd (RDCL) on 20th August within the machine drilled BH-02. The down-hole investigations were carried out to assist is determining the Site subsoil class, and assessment of the liquefaction potential. The outputs of this testing will be used for detailed design. The results are available on request.

Laboratory testing

A suite of soil characterisation testing was performed on samples retrieved from both of the BH core (BH-01 and BH-02) to assess the liquefaction susceptibility of soils underlying the Site. Soil characterisation tests were undertaken by Geotechnics Ltd., and comprised:

- Ten (10) Atterberg limit tests; and
- Six (6) Solid particle density tests.

The results are available on request.

A2.2 Geotechnical model

Based on published geological information and geotechnical investigations undertaken at and near the Site, subsurface ground conditions have been summarised in Table Appendix A.1 representing the area around and beneath the Tennessee embankment. The summary does not include the fill material itself.

Table Appendix A.1 : Summary of subsurface ground conditions around and beneath the Tennessee embankment

Geological unit	Soil description	Typical elevation of surface of layer (mRL)	Typical depth to surface of layer (mbgl)	Typical layer thickness (m)	Undrained shear strength (kPa)	CPT q_c (MPa)
Topsoil	Silt, minor clay; dark brown. Firm, moist, low plasticity.	-	0	0.15 – 0.3	25 – 50	0.5 – 1
Fill[1]	Clayey SILT, trace sand; dark brown. Stiff to very stiff, moist to wet, medium plasticity.	-	0.15	3.65	50 – 100	0.5 – 2
Takaanini Formation (alluvium)	Silty CLAY; orange brown trace grey. Stiff, moist, medium plasticity.	3.2 – 3.9	0.15 – 3.8	0.6 – 2.5	50 - 150	1 - 2
Takaanini Formation (Hobsonville Member)	Interbedded clayey SILT (stiff) and fine to medium SAND (loose, pumiceous); grey. moist.	1.4 – 2.6	2.8 – 4.4	2.6 - 6	~50 – 100	1 – 8
Takaanini Formation (Hobsonville Member)	Fine to medium SAND, trace silt; dark grey. Loose to dense, moist to wet. Sand, pumiceous.	-1.2 – -3.8	7.9 – 8.1	4 – 6	N/A	10 – 27

Geological unit	Soil description	Typical elevation of surface of layer (mRL)	Typical depth to surface of layer (mbgl)	Typical layer thickness (m)	Undrained shear strength (kPa)	CPT q_c (MPa)
Takaanini Formation	Clayey SILT, trace sand; greenish grey. Very stiff, moist medium plasticity.	-7.2 – -7.8	12 – 14.2	5.4 – 5.7	~100 – 200	2 – 3
East Coast Bays Formation	Completely weathered to moderately weathered, dark green to greyish brown, SILTSTONE. Extremely weak to very weak	-12.6 – -13.5	17.7 – 19.6	5.5 – 6.3	N/A	5 – 18[2]
	Slightly weathered, dark grey, SILTSTONE. Weak, fine to coarse grained. Some isolated SANDSTONE layers.	-18.1 – -19.8	24 - 25	0.4+ – 6+	N/A	N/A

[1] Fill was only identified in BH01/CPT01

[2] CPT data terminate at 22.96 mbgl for CPT01 and 26.15 mbgl for CPT02.

A2.3 Seismic hazard

The seismic hazard has been discussed with the structural engineer and have agreed to adopt an ultimate limit state (ULS) earthquake with return period of 2500 years, i.e. Earthquake Magnitude 5.9 and peak ground acceleration PGA = 0.28g for the purposes of this report.

Geotechnical investigations and soil characterisation tests undertaken at the Site indicate that potentially liquefiable soils exist at the Site.

Appendix B Geotechnical Investigation data

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NOTES:

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LOCATION PLAN		APPROVED	DATE
PROJECT No.	1017033.2002		
DESIGNED	STHU		SEP.24
DRAWN	-WEB-		SEP.24
CHECKED			

CLIENT **AUCKLAND COUNCIL**

PROJECT **HARANIA BLUE GREEN NETWORKS STAGE 2**

TITLE PREVIOUS GEOTECHNICAL INVESTIGATIONS

SCALE (A3) 1:4,588 FIG No. FIGURE B.1. REV A

GROUND INVESTIGATION

Measured CPT Log

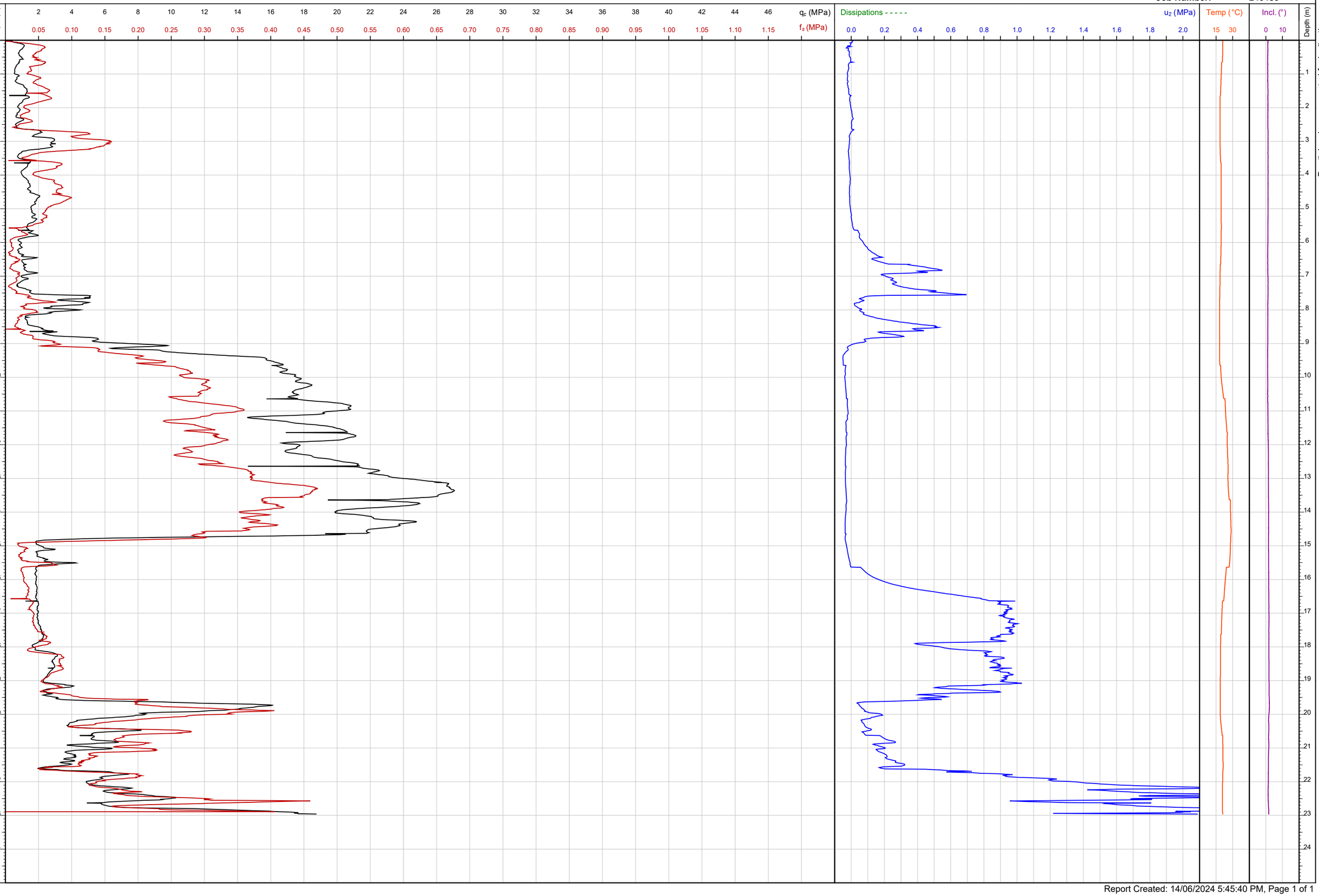
Client: Tonkin + Taylor
Project: Blake Road Reserve
Remarks:

Depth (m): 22.96
Termination: Limit of reaction force

Standard: ISO 22476-1:2012 CETANZ TG6
Date: 14/06/2024
Cone Ref: 000865

Test Name: CPT-24-1
Job Number: 240486

Depth has been corrected for inclination



Depth has been corrected for inclination

GROUND INVESTIGATION

Calculated CPT Log

Date: 14/06/2024

Project: Blake Road Reserve

1	Sensitive fine-grained	4	Silt mixtures: clayey silt & silty clay	7	Dense sand to gravelly sand	**Test Name:**	**CPT-24-1**
2	Clay - organic soil	5	Sand mixtures: silty sand to sandy silt	8	Stiff sand to clayey sand		
3	Clays: clay to silty clay	6	Sands: clean sands to silty sands	9	Stiff fine-grained	**Job Number:**	240486

Depth has been corrected for inclination

Depth (m)

q_t (MPa) / f_s (MPa)

u_0 - - - u_2 (MPa)

R_f (%)

SBT I_c

SBTn I_{cn}

Q_{tn}

B_q

γ (kg/m^3)

D_r (%) / S_u (kPa)

N_{kt} 15

Φ'

V_s (m/s)

G_0 (MPa)

M (MPa)

E (MPa)

N60

CPT Details

General Information

Project:	Blake Road Reserve	**Location:**	89 Blake Road, Mangere East, Auckland 2024
Contractor:	Ground Investigation	**Rig details:**	
WGS84 (deg):	-36.954527, 174.818757	**Location method:**	Handheld GPS
Elevation (m):	Unknown	**Elevation datum:**	
Date:		**Start time:**	

Test Setup

Standard:	ISO 22476-1:2012
Test type:	
Pre-Drill (m):	0.00
Start length (m):	0
Cone ID:	000865
Cone type:	10cm2 Compression
Cone class:	
Manufacturer:	
Calibration date:	
Cone area ratio:	0.8
Sleeve area ratio:	0
Sleeve offset:	0.07
Filter type:	U2 Stainless steel
Saturation method:	Funnel
Rig setup variation:	

Test Result

Termination reason:	
Termination depth:	22.96
Ground water level:	5
Water level origin:	Measured
Backfill:	
Observations and materials encountered:	
Deviations and interuptions:	Deviations: Interuptions:
Corrections applied:	
Test catagory:	
Operator name:	Alyssa Malamatenios
Manager name:	

CPT Formulas

Test Name: CPT-24-1

Job Number: 240486

Corrected cone resistance: $q_t = q_c + u_2 \bullet (1 - a)$

Friction ratio: $R_f = \frac{f_s}{q_c} \bullet 100$

Non-normalised soil behaviour type (SBT): Calculated using q_{net} and R_f for the Robertson's 2010 non-normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

Soil behaviour type index, (used for non-normalised SBT) : $I_c = \left((3.47 - \log(q_t))^2 + (\log(R_f) + 1.22)^2\right)^{0.5}$

Friction ratio: $F_r = \frac{f_s}{q_t - \sigma_{v0}} \bullet 100$

Refined normalised cone resistance: $Q_{tn} = \frac{(q_t - \sigma_{v0}) / \sigma_{atm}}{(\sigma'_{v0} / \sigma_{atm})^n}$ where $n = 0.381 \bullet I_c + 0.05 \bullet (\sigma'_{v0} / \sigma_{atm}) - 0.05 \leq 1.0$

Normalised soil behaviour type index: $I_c = \left((3.47 - \log(Q_{tn}))^2 + (\log(F_r) + 1.22)^2\right)^{0.5}$

Normalised pore pressure: $B_q = \frac{\Delta u}{q_t - \sigma_{v0}}$

Normalised soil behaviour type (SBTn): Calculated using Q_{tn} and F_r for the Robertson's 2010 normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

Undrained shear strength (s_u): $s_u = \frac{q_t - \sigma_{v0}}{N_{kt}}$

Relative density (D_r): $D_r = 100 \bullet \sqrt{\frac{Q_{tn}}{350}}$

Friction angle (Φ'): $\Phi' = 17.60 + 11 \bullet \log(Q_{tn})$

Small strain shear modulus (G_0): $G_0 = (qt - \sigma_{v0}) \bullet \left(0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$

Estimated shear wave velocity (V_s): $V_S = \sqrt{\frac{G_0}{\rho}}$ where $\rho = \frac{\gamma}{\gamma_w}$

Constrained modulus (M):

$M = \alpha_M (q_t - \sigma_{v0})$

when $I_c > 2.2$

$\alpha_M = Q_t$ when $Q_t < 14$

$\alpha_M = 14$ when $Q_t > 14$

when $I_c < 2.2$

$\alpha_M = 0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}$

Youngs modulus (E_s): $E_s = (qt - \sigma_{v0}) \bullet \left(0.015 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$

Estimated SPT N_{60}: $N_{60} = \frac{q_t / p_a}{8.5 \bullet \left(1 - \frac{I_c}{4.6}\right)}$

Zero Readings

kPa	Initial zeros	Final zeros	Final difference	Clean zeros	Clean difference
Cone resistance	22675.2	22703	27.81	0	0
Sleeve friction	268.40002	268.3	-0.1	0	0
Pore pressure	2988.5	2987.7998	-0.75	0	0

Measured CPT Log

Client: Tonkin + Taylor
Project: Blake Road Reserve
Remarks:

Depth (m): 26.15
Termination: High total load

Standard: ISO 22476-1:2012 CETANZ TG6
Date: 13/06/2024
Cone Ref: 000300

Test Name: CPT-24-2
Job Number: 240486

Depth has been corrected for inclination

q_c (MPa) 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46

f_s (MPa) 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00 1.05 1.10 1.15

Dissipations - - - - -

u_2 (MPa) 0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

Temp (°C) 15 30

Incl. (°) 0 10

Depth (m) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Depth has been corrected for inclination

Measured CPT Log

Client: Tonkin + Taylor
Project: Blake Road Reserve
Remarks:

Depth (m): 26.15
Termination: High total load

Standard: ISO 22476-1:2012 CETANZ TG6
Date: 13/06/2024
Cone Ref: 000300

Test Name: CPT-24-2
Job Number: 240486

Depth has been corrected for inclination

Depth (m)

q_c (MPa)

f_s (MPa)

Dissipations - - - - -

u_2 (MPa)

Temp (°C)

Incl. (°)

Calculated CPT Log

Date: 13/06/2024

Project: Blake Road Reserve

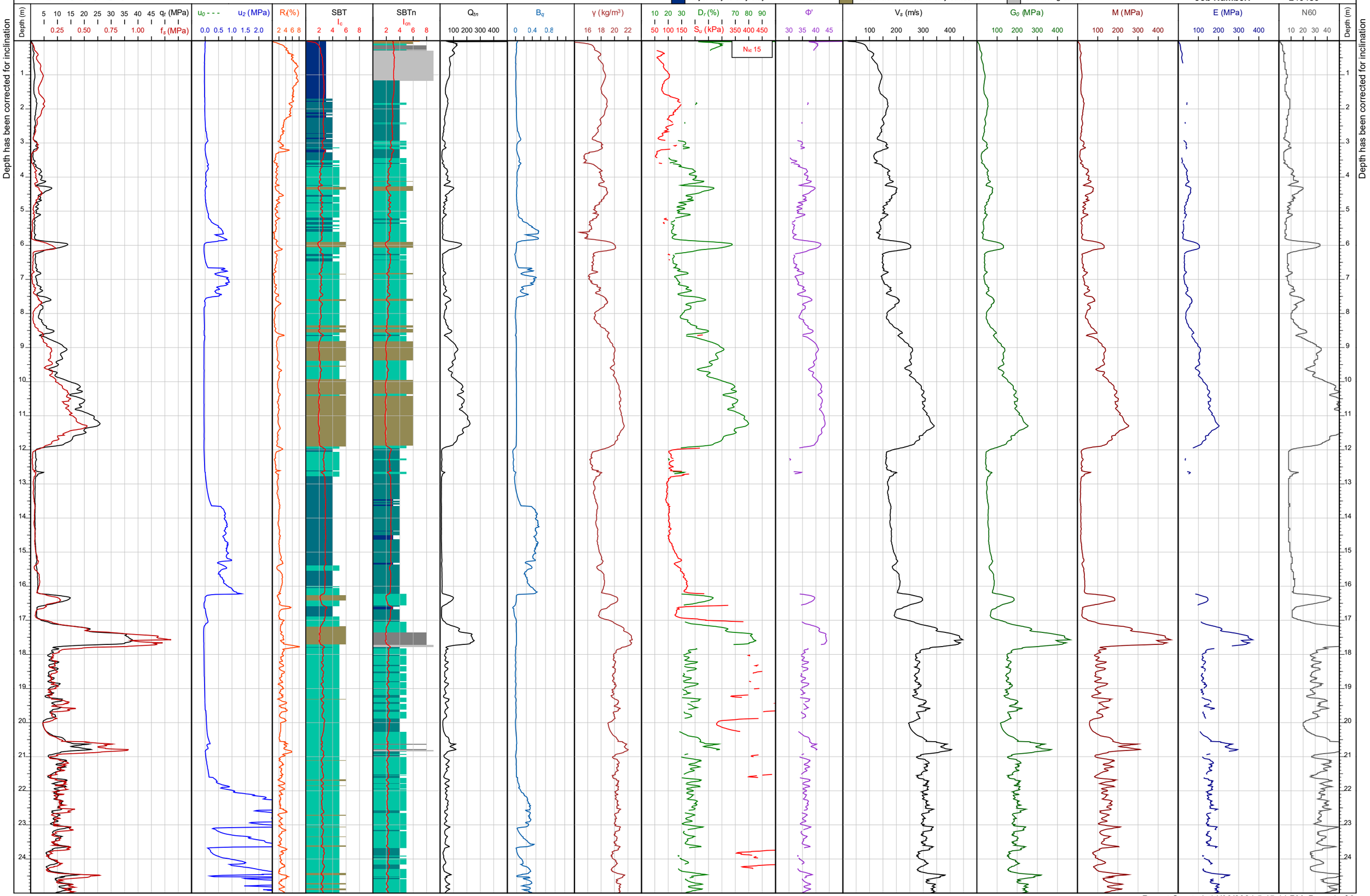
1 Sensitive fine-grained	4 Silt mixtures: clayey silt & silty clay	7 Dense sand to gravelly sand	
2 Clay - organic soil	5 Sand mixtures: silty sand to sandy silt	8 Stiff sand to clayey sand	
3 Clays: clay to silty clay	6 Sands: clean sands to silty sands	9 Stiff fine-grained	

Test Name: CPT-24-2

Job Number: 240486

Depth has been corrected for inclination

Depth has been corrected for inclination



Calculated CPT Log

Date: 13/06/2024

Project: Blake Road Reserve

1 Sensitive fine-grained	4 Silt mixtures: clayey silt & silty clay	7 Dense sand to gravelly sand	
2 Clay - organic soil	5 Sand mixtures: silty sand to sandy silt	8 Stiff sand to clayey sand	
3 Clays: clay to silty clay	6 Sands: clean sands to silty sands	9 Stiff fine-grained	

Test Name: CPT-24-2

Job Number: 240486

Depth has been corrected for inclination

Depth (m)

q_t (MPa) / f_s (MPa)

u_0 - - - u_2 (MPa)

R_f (%)

SBT I_c

SBTn I_{cn}

Q_{tn}

B_q

γ (kg/m^3)

D_r (%) / S_u (kPa)

Φ'

V_s (m/s)

G_0 (MPa)

M (MPa)

E (MPa)

N60

CPT Details

General Information

Project:	Blake Road Reserve	**Location:**	89 Blake Road, Mangere East, Auckland 2024
Contractor:	Ground Investigation	**Rig details:**	
WGS84 (deg):	-36.954215, 174.819309	**Location method:**	Handheld GPS
Elevation (m):	Unknown	**Elevation datum:**	
Date:		**Start time:**	

Test Setup

Standard:	ISO 22476-1:2012
Test type:	
Pre-Drill (m):	0.00
Start length (m):	0
Cone ID:	000300
Cone type:	10cm2 Compression
Cone class:	
Manufacturer:	
Calibration date:	
Cone area ratio:	0.79
Sleeve area ratio:	0
Sleeve offset:	0.07
Filter type:	U2 Stainless steel
Saturation method:	Funnel
Rig setup variation:	

Test Result

Termination reason:	
Termination depth:	26.15
Ground water level:	3.05
Water level origin:	Measured
Backfill:	
Observations and materials encountered:	Unknown ADDING RODS
Deviations and interuptions:	Deviations: Interuptions:
Corrections applied:	
Test catagory:	
Operator name:	Alyssa Malamatenios
Manager name:	

CPT Formulas

Test Name: CPT-24-2

Job Number: 240486

Corrected cone resistance:

$$q_t = q_c + u_2 \bullet (1 - a)$$

Friction ratio:

$$R_f = \frac{f_s}{q_c} \bullet 100$$

Non-normalised soil behaviour type (SBT):

Calculated using q_{net} and R_f for the Robertson's 2010 non-normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

Soil behaviour type index, (used for non-normalised SBT) :

$$I_c = \left((3.47 - \log(q_t))^2 + (\log(R_f) + 1.22)^2\right)^{0.5}$$

Friction ratio:

$$F_r = \frac{f_s}{q_t - \sigma_{v0}} \bullet 100$$

Refined normalised cone resistance:

$$Q_{tn} = \frac{(q_t - \sigma_{v0}) \,/\, \sigma_{atm}}{\left(\sigma'_{v0} \,/\, \sigma_{atm}\right)^n} \quad \text{where} \quad n = 0.381 \bullet I_c + 0.05 \bullet \left(\sigma'_{v0} \,/\, \sigma_{atm}\right) - 0.05 \leq 1.0$$

Normalised soil behaviour type index:

$$I_c = \left((3.47 - \log(Q_{tn}))^2 + (\log(F_r) + 1.22)^2\right)^{0.5}$$

Normalised pore pressure:

$$B_q = \frac{\Delta u}{q_t - \sigma_{v0}}$$

Normalised soil behaviour type (SBTn):

Calculated using Q_{tn} and F_r for the Robertson's 2010 normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

Undrained shear strength (s_u):

$$s_u = \frac{q_t - \sigma_{v0}}{N_{kt}}$$

Relative density (D_r):

$$D_r = 100 \bullet \sqrt{\frac{Q_{tn}}{350}}$$

Friction angle (Φ'):

$$\Phi' = 17.60 + 11 \bullet \log(Q_{tn})$$

Small strain shear modulus (G_0):

$$G_0 = (qt - \sigma_{v0}) \bullet \left(0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

Estimated shear wave velocity (V_s):

$$V_S = \sqrt{\frac{G_0}{\rho}} \quad \text{where} \quad \rho = \frac{\gamma}{\gamma_w}$$

Constrained modulus (M):

$$M = \alpha_M (q_t - \sigma_{v0})$$

when $I_c > 2.2$

$\alpha_M = Q_t$ when $Q_t < 14$

$\alpha_M = 14$ when $Q_t > 14$

when $I_c < 2.2$

$$\alpha_M = 0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}$$

Youngs modulus (E_s):

$$E_s = (qt - \sigma_{v0}) \bullet \left(0.015 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

Estimated SPT N_{60}:

$$N_{60} = \frac{q_t \,/\, p_a}{8.5 \bullet \left(1 - \frac{I_c}{4.6}\right)}$$

Zero Readings

kPa	Initial zeros	Final zeros	Final difference	Clean zeros	Clean difference
Cone resistance	21011.5	20995.898	-15.52	0	0
Sleeve friction	272.7	273.8	1.13	0	0
Pore pressure	2826.1	2826.1	0.09	0	0

Measured CPT Log

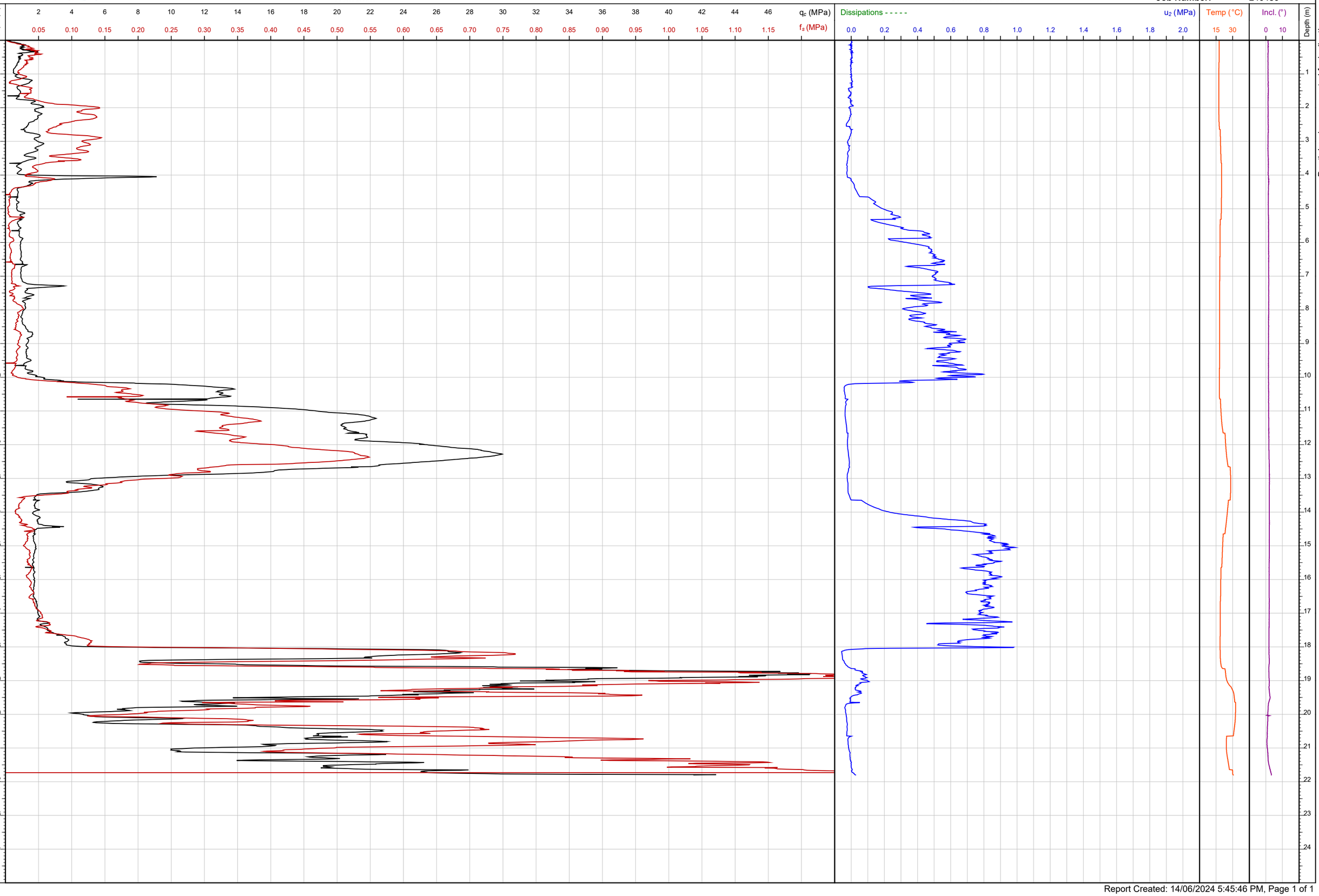
Client: Tonkin + Taylor
Project: Blake Road Reserve
Remarks:

Depth (m): 21.80
Termination: Limit of reaction force

Standard: ISO 22476-1:2012 CETANZ TG6
Date: 13/06/2024
Cone Ref: 000865

Test Name: CPT-24-3
Job Number: 240486

Depth has been corrected for inclination



Depth has been corrected for inclination

Calculated CPT Log

Date: 13/06/2024
Project: Blake Road Reserve

1 Sensitive fine-grained	4 Silt mixtures: clayey silt & silty clay	7 Dense sand to gravelly sand
2 Clay - organic soil	5 Sand mixtures: silty sand to sandy silt	8 Stiff sand to clayey sand
3 Clays: clay to silty clay	6 Sands: clean sands to silty sands	9 Stiff fine-grained

Test Name: CPT-24-3
Job Number: 240486

Depth has been corrected for inclination

Depth (m)

q_t (MPa) / f_s (MPa)

u_0 - - - u_2 (MPa)

R_f (%)

SBT I_c

SBTn I_{cn}

Q_{tn}

B_q

γ (kg/m^3)

D_r (%) / S_u (kPa)

N_{kt} 15

Φ'

V_s (m/s)

G_0 (MPa)

M (MPa)

E (MPa)

N60

CPT Details

General Information

Project:	Blake Road Reserve	**Location:**	89 Blake Road, Mangere East, Auckland 2024
Contractor:	Ground Investigation	**Rig details:**	
WGS84 (deg):	-36.953778, 174.82058	**Location method:**	Handheld GPS
Elevation (m):	Unknown	**Elevation datum:**	
Date:		**Start time:**	

Test Setup

Standard:	ISO 22476-1:2012
Test type:	
Pre-Drill (m):	0.00
Start length (m):	0
Cone ID:	000865
Cone type:	10cm2 Compression
Cone class:	
Manufacturer:	
Calibration date:	
Cone area ratio:	0.8
Sleeve area ratio:	0
Sleeve offset:	0.07
Filter type:	U2 Stainless steel
Saturation method:	Funnel
Rig setup variation:	

Test Result

Termination reason:	
Termination depth:	21.8
Ground water level:	4.05
Water level origin:	Estimated
Backfill:	
Observations and materials encountered:	Unknown ADDING MORE RODS
Deviations and interuptions:	Deviations: Interuptions:
Corrections applied:	
Test catagory:	
Operator name:	Alyssa Malamatenios
Manager name:	

CPT Formulas

Test Name: CPT-24-3

Job Number: 240486

Corrected cone resistance:

$$q_t = q_c + u_2 \bullet (1 - a)$$

Friction ratio:

$$R_f = \frac{f_s}{q_c} \bullet 100$$

Non-normalised soil behaviour type (SBT):

Calculated using q_{net} and R_f for the Robertson's 2010 non-normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

Soil behaviour type index, (used for non-normalised SBT) :

$$I_c = \left((3.47 - \log(q_t))^2 + (\log(R_f) + 1.22)^2\right)^{0.5}$$

Friction ratio:

$$F_r = \frac{f_s}{q_t - \sigma_{v0}} \bullet 100$$

Refined normalised cone resistance:

$$Q_{tn} = \frac{(q_t - \sigma_{v0}) \,/\, \sigma_{atm}}{\left(\sigma'_{v0} \,/\, \sigma_{atm}\right)^n} \quad \text{where} \quad n = 0.381 \bullet I_c + 0.05 \bullet \left(\sigma'_{v0} \,/\, \sigma_{atm}\right) - 0.05 \leq 1.0$$

Normalised soil behaviour type index:

$$I_c = \left((3.47 - \log(Q_{tn}))^2 + (\log(F_r) + 1.22)^2\right)^{0.5}$$

Normalised pore pressure:

$$B_q = \frac{\Delta u}{q_t - \sigma_{v0}}$$

Normalised soil behaviour type (SBTn):

Calculated using Q_{tn} and F_r for the Robertson's 2010 normalised CPT soil behaviour chart using zone equations defined by P.W. Mayne in "Evaluating effective stress parameters and undrained shear strength of soft-firm clays from CPT and DMT" 2016

Undrained shear strength (s_u):

$$s_u = \frac{q_t - \sigma_{v0}}{N_{kt}}$$

Relative density (D_r):

$$D_r = 100 \bullet \sqrt{\frac{Q_{tn}}{350}}$$

Friction angle (Φ'):

$$\Phi' = 17.60 + 11 \bullet \log(Q_{tn})$$

Small strain shear modulus (G_0):

$$G_0 = (qt - \sigma_{v0}) \bullet \left(0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

Estimated shear wave velocity (V_s):

$$V_S = \sqrt{\frac{G_0}{\rho}} \quad \text{where} \quad \rho = \frac{\gamma}{\gamma_w}$$

Constrained modulus (M):

$$M = \alpha_M (q_t - \sigma_{v0})$$

when $I_c > 2.2$

$\alpha_M = Q_t$ when $Q_t < 14$

$\alpha_M = 14$ when $Q_t > 14$

when $I_c < 2.2$

$$\alpha_M = 0.0188 \bullet 10^{(0.55 \bullet I_c + 1.68)}$$

Youngs modulus (E_s):

$$E_s = (qt - \sigma_{v0}) \bullet \left(0.015 \bullet 10^{(0.55 \bullet I_c + 1.68)}\right)$$

Estimated SPT N_{60}:

$$N_{60} = \frac{q_t \,/\, p_a}{8.5 \bullet \left(1 - \frac{I_c}{4.6}\right)}$$

Zero Readings

kPa	Initial zeros	Final zeros	Final difference	Clean zeros	Clean difference
Cone resistance	22703	22697.398	-5.56	0	0
Sleeve friction	267.5	268.5	0.92	0	0
Pore pressure	2987.7	2988	0.28	0	0

HAND AUGER

Tonkin+Taylor

Hand Auger No. HA01

Sheet: 1 of 1

Project: Harania
Project No: 1017033
Location: HA01

Coordinates: 5908627.53 mN - 1761926.88 mE
Drill Type: 50mm Hand Auger
Drill Method: HA

RL Ground: 7m
Datum: NZTM2000
Survey: GPS

RL (m) / Length (m)	Water Level (m)	Sampling Method	Recovery (%)	Tests (Scala Penetrometer and Shear Vanes)	Strength	Moisture	Geological Unit	Graphic Log	Material Description	Lab Testing	Installation	Core Box No.
7 / 0		HA	100	83/20			Fill		0-0.6m: Organic SILT, some clay; dark brown. Stiff, saturated, low to medium plasticity, sensitive			Box: 0-3m
0.5				83/20					0.6-1.5m: Silty CLAY; dark brown. Stiff, dry to moist, low to medium plasticity			
6 / 1				80/18								
				80/24					*1.4m: Metal rod.*			
1.5				115/18					1.5-2.4m: Clayey SILT, trace sand; dark brown. Stiff to very stiff, moist, medium plasticity			
				189/20								
5 / 2				80/20								
				107/38					2.4-2.7m: Silty CLAY; dark grey black. Very stiff, moist, medium to high plasticity			
2.5				163/44					2.7-3m: Silty CLAY; greenish grey dark purple. Very stiff, moist, high plasticity			
4 / 3				208/50					3-3.5m: Sandy SILT, some clay; greenish. Very stiff, moist, low to medium plasticity; sand, fine to medium			Box: 3-4m
				144/38								
3.5				83/34					3.5-3.8m: Clayey SILT, some sand; brownish. Stiff to very stiff, moist, medium to high plasticity			
				112/45			Kaiparoro Formation		3.8-4m: Silty CLAY; orange brown, trace grey. Very stiff, moist, medium plasticity			
3 / 4									Target depth (TD) - 4m			
4.5												

Tests (Scala Penetrometer and Shear Vanes)
Peak undrained shear strength (kPa)
30 50 80 100 130 150 180 200 230
Blows/50mm
0 2 4 6 8 10 12 14 16

Strength: VS S F St VSt H VH
Moisture: D M W S

Hole Depth 4m

Comments: Hand auger investigations undertaken to determine shallow subsurface geology and confirming water table.

Driller:
Logged by: DCHA
Date: 19/06/2024

Contractor:
Checked by: bewe

Produced on Logger by InfinityStudio.ai

Tonkin+Taylor

CORE IMAGES

Hand Auger No. HA01

Project: Harania	Coordinates: 5908627.53 mN - 1761926.88 mE	RL Ground: 7m
Project No: 1017033	Drill Type: 50mm Hand Auger	Datum: NZTM2000
Location: HA01	Drill Method: HA	Survey: GPS

0-3m

3-4m

Tonkin+Taylor

HAND AUGER

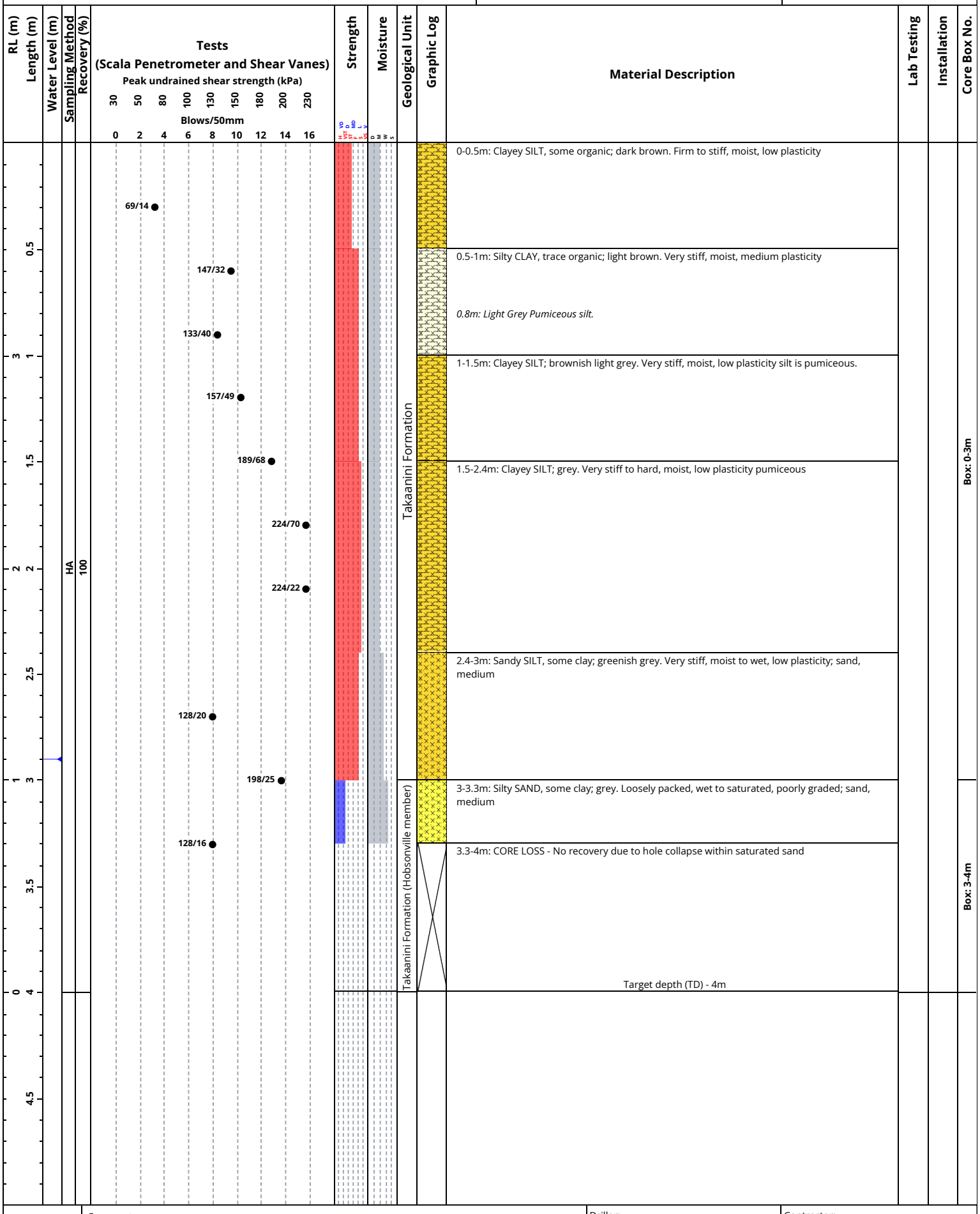
Hand Auger No. HA02

Sheet: 1 of 1

Project: Harania
Project No: 1017033
Location: HA02

Coordinates: 5908667.39 mN - 1761981.7 mE
Drill Type: 50mm Hand Auger
Drill Method: HA

RL Ground: 4m
Datum: NZTM2000
Survey: GPS



Hole Depth
4m

Comments: Hand auger investigations undertaken to determine shallow subsurface geology and confirming water table.

Driller:
Logged by: DCHA
Date: 19/06/2024

Contractor:
Checked by: bewe

Produced on Logger by InfinityStudio.ai

Tonkin+Taylor

CORE IMAGES

Hand Auger No. HA02

Project: Harania	Coordinates: 5908667.39 mN - 1761981.7 mE	RL Ground: 4m
Project No: 1017033	Drill Type: 50mm Hand Auger	Datum: NZTM2000
Location: HA02	Drill Method: HA	Survey: GPS

0-3m

3-4m

Tonkin+Taylor

HAND AUGER

Hand Auger No. HA03

Sheet: 1 of 1

Project: Harania
Project No: 1017033
Location: HA03

Coordinates: 5908705.676 mN - 1762093.554 mE
Drill Type: 50mm Hand Auger
Drill Method: HA

RL Ground: 7m
Datum: NZTM2000
Survey: GPS

RL (m) / Length (m)	Water Level (m)	Sampling Method	Recovery (%)	Tests (Scala Penetrometer and Shear Vanes)	Strength	Moisture	Geological Unit	Graphic Log	Material Description	Lab Testing	Installation	Core Box No.
7 / 0		HA	100	93/16			Takaanini Formation		0-0.4m: Clayey SILT, some organic; dark brown. Firm to stiff, moist, medium plasticity			Box: 0-3m
6.5 / 0.5				80/16					0.4-1.2m: Silty CLAY, trace gravel; brownish. Stiff, moist, medium to high plasticity			
6 / 1				77/15								
5.5 / 1.5				99/30					1.2-1.5m: Gravelly SILT, some clay; light brown. Stiff, moist, low plasticity loosely packed			
5 / 2				131/20					1.5-2m: Silty CLAY; light brown. Stiff to very stiff, wet, medium plasticity			
				144/30					2-2.4m: Silty CLAY, some sand; light brown purple, some speckled white. Very stiff, moist, medium to high plasticity; sand, fine to medium			
4.5 / 2.5				163/48					2.4-2.8m: Silty CLAY; white yellowish light grey. Very stiff to hard, moist, high plasticity			
				224/54								
4 / 3									2.8-3.7m: Silty CLAY; white light grey. Very stiff, moist, medium to high plasticity			Box: 3-4m
3.5 / 3.5				157/44								
3 / 4							Takaanini Formation (Wiltondale member)		3.7-4m: Sandy SILT, some clay; grey white light grey. Very stiff to hard, moist, low plasticity Target depth (TD) - 4m			
2.5 / 4.5												

Tests (Scala Penetrometer and Shear Vanes)
Peak undrained shear strength (kPa)
30 50 80 100 130 150 180 200 230
Blows/50mm
0 2 4 6 8 10 12 14 16

Strength: VS S F St VSt H
Moisture: D M W S

Hole Depth 4m

Comments: Hand auger investigations undertaken to determine shallow subsurface geology and confirming water table.

Driller:
Logged by: DCHA
Date: 19/06/2024

Contractor:
Checked by: bewe

Produced on Logger by InfinityStudio.ai

Tonkin+Taylor

CORE IMAGES

Hand Auger No. HA03

Project: Harania	Coordinates: 5908705.676 mN - 1762093.554 mE	RL Ground: 7m
Project No: 1017033	Drill Type: 50mm Hand Auger	Datum: NZTM2000
Location: HA03	Drill Method: HA	Survey: GPS

0-3m

3-4m

BOREHOLE LOG

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

SHEET: 1 OF 5

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908627.53 mN 1761926.88 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 12/08/2024
R.L.:	6.97m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS															ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%) 25 50 75	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) VS 12 25 50 100 200 VS+ F St VSt H	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa) EW 1 VW 5 W 20 MS 50 S 100	DEFECT SPACING (mm) 20 60 200 600 2000	DESCRIPTION
Topsoil									TS		M	F				*0.00m:* SILT, some rootlets, trace clay; dark brown. Firm, moist, low plasticity.
Fill				100	HA		6	1								*0.15m:* SILT, minor clay, trace rootlets; dark brown mixed with orange. Firm, moist, low plasticity. *0.60m:* Rootlets absent
				70	RC		5	2								*1.80m:* PARTIAL CORE LOSS - Suspect soft material washed out.
											W	F				*2.25m:* Clayey SILT; dark brown. Firm, wet, medium plasticity. *3.15m:* Grey mixed with dark brown and orange.
				73	RC		4	3								*3.40m:* PARTIAL CORE LOSS - Suspect soft material washed out.
Takaanini Formation							3	4			M	St				*3.80m:* Silty CLAY; orange brown trace grey. Stiff, moist, medium plasticity.
				100	RC											*4.40m:* Silty CLAY; orange-ish grey with trace brown. Stiff, moist, medium plasticity.
Takaanini Fm (Hobsonville member)						BH01-S1 @ 5.00m	2	5				L				*4.75m:* Silty fine to medium SAND; grey with trace brown. Loose, moist. Sand, rounded, pumiceous.

COMMENTS:

Hole Depth 25.5m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:58:07 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

SHEET: 2 OF 5

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908627.53 mN 1761926.88 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 12/08/2024
R.L.:	6.97m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS															ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%)	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa)	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa)	DEFECT SPACING (mm)	DESCRIPTION
Takaanini Fm (Hobsonville member)				100	RC		1	6			M	L				[CONT] *4.75m:* Silty fine to medium SAND; grey with trace brown. Loose, moist. Sand, rounded, pumiceous.
											W					*5.20 - 5.70m:* Trace clay.
																5.70 - 6.00m: Wet.
						BH01-S2 @ 6.00m					M	St				*6.00m:* SILT, minor sand, trace clay; grey. Stiff, moist, low plasticity. Sand, fine to medium.
				100	RC							L				*6.75m:* Sandy fine to medium GRAVEL; greyish black. Loose, moist. Gravel, sub-rounded.
												St				*6.85m:* SILT, minor sand, trace clay; grey. Stiff, moist, low plasticity. Sand, fine to medium.
						BH01-S3 @ 7.00m	0	7				L				*7.00m:* Sandy fine to medium GRAVEL; greyish black. Loose, moist. Gravel, sub-rounded.
																7.20m: Silty fine to medium SAND; grey with trace brown. Loose, moist. Sand, rounded, pumiceous.
							-1	8				St				*7.85m:* SILT, minor sand, trace clay; grey. Stiff, moist, low plasticity. Sand, fine to medium.
				100	RC	BH01-S4 @ 8.20m						MD				*8.10m:* Silty fine to medium SAND; grey with trace brown. Medium dense, moist. Sand, rounded, pumiceous.
							-2	9								*9.00m:* CORE LOSS - Suspect washed out.
				57	RC		-3	10			W	MD				*9.60m:* Fine to medium SAND; grey with trace brown. Medium dense, wet. Sand, rounded, pumiceous.

COMMENTS:

Hole Depth 25.5m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

SHEET: 3 OF 5

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908627.53 mN 1761926.88 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 12/08/2024
R.L.:	6.97m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS																ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%)	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa)	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa)	DEFECT SPACING (mm)		DESCRIPTION
				57	RC						W	MD					[CONT] *9.60m:* Fine to medium SAND; grey with trace brown. Medium dense, wet. Sand, rounded, pumiceous.
				80	RC		-4	11									
																	11.70m: CORE LOSS - Suspect washed out.
							-5	12			M	D					*12.00m:* Fine to medium SAND, trace silt; grey with trace brown. Dense, moist. Sand, rounded, pumiceous.
Takaanini Fm (Hobsonville member)				100	RC												
							-6	13									
							-7	14									
				100	RC							VSt					*14.20m:* Clayey SILT, trace sand; greenish grey. Very stiff, moist, medium plasticity. Sand, fine.
Takaanini Formation																	
							-8	15									
				100	RC												

COMMENTS:

Hole Depth 25.5m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

SHEET: 4 OF 5

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908627.53 mN 1761926.88 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 12/08/2024
R.L.:	6.97m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS															ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%)	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa)	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa)	DEFECT SPACING (mm)	DESCRIPTION
Takaanini Formation				100	RC		-9	16			M	VSt				[CONT] *14.20m:* Clayey SILT, trace sand; greenish grey. Very stiff, moist, medium plasticity. Sand, fine.
				87	RC		-10	17				F				*17.20m:* Silty PEAT, trace clay; black. Firm, moist.
												VSt				*17.40m:* Clayey SILT, trace sand; greenish grey. Very stiff, moist, medium plasticity. Sand, fine.
							-11	18								*17.70m:* CORE LOSS.
											M	VSt				*18.00m:* Clayey SILT, trace sand; greenish grey. Very stiff, moist, medium plasticity. Sand, fine.
Takaanini Fm (Hobsonville member)				100	RC		-12	19				D				*18.60m:* Silty fine to coarse SAND; greenish grey. Dense, moist. Sand, pumiceous. *19.20m:* Minor silt.
East Coast Bays Formation				100	RC		-13	20		CW		EW				*19.60m:* Completely weathered, dark green, SILTSTONE. Extremely weak. Recovered as SILT, minor clay, moist, low plasticity.

COMMENTS:

Hole Depth 25.5m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

SHEET: 5 OF 5

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908627.53 mN 1761926.88 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 12/08/2024
R.L.:	6.97m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS															ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%) 25 50 75	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) VS 12 25 50 F St 100 VSt 200 HS	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa) EW 1 VW 5 W 20 MS 50 S 100 VS+	DEFECT SPACING (mm) 20 60 200 600 2000	DESCRIPTION
East Coast Bays Formation				100	RC		-14	21		CW		EW				[CONT] *19.60m:* Completely weathered, dark green, SILTSTONE. Extremely weak. Recovered as SILT, minor clay, moist, low plasticity.
				83	RC		-15	22		MW						*21.50 - 25.00m:* Moderately weathered.
				100	RC		-16	23								
				80	RC		-17	24								
							-18	25								*24.80m:* CORE LOSS.
										SW		VW				*25.00m:* Slightly weathered, grey with some dark green, SANDSTONE. Very weak.
																25.5m: Target depth

COMMENTS:

Hole Depth 25.5m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

PROJECT: Harania Pipe Bridge	LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: 5908627.53 mN (NZTM2000) 1761926.88 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
R.L.: 6.97m	METHOD: Rotary cored	HOLE FINISHED: 12/08/2024
DATUM: NZVD2016	DRILL FLUID: WATER	DRILLED BY: McMillan Drilling
		LOGGED BY: JBER CHECKED: BEWE

0.00-3.00m

3.00-6.00m

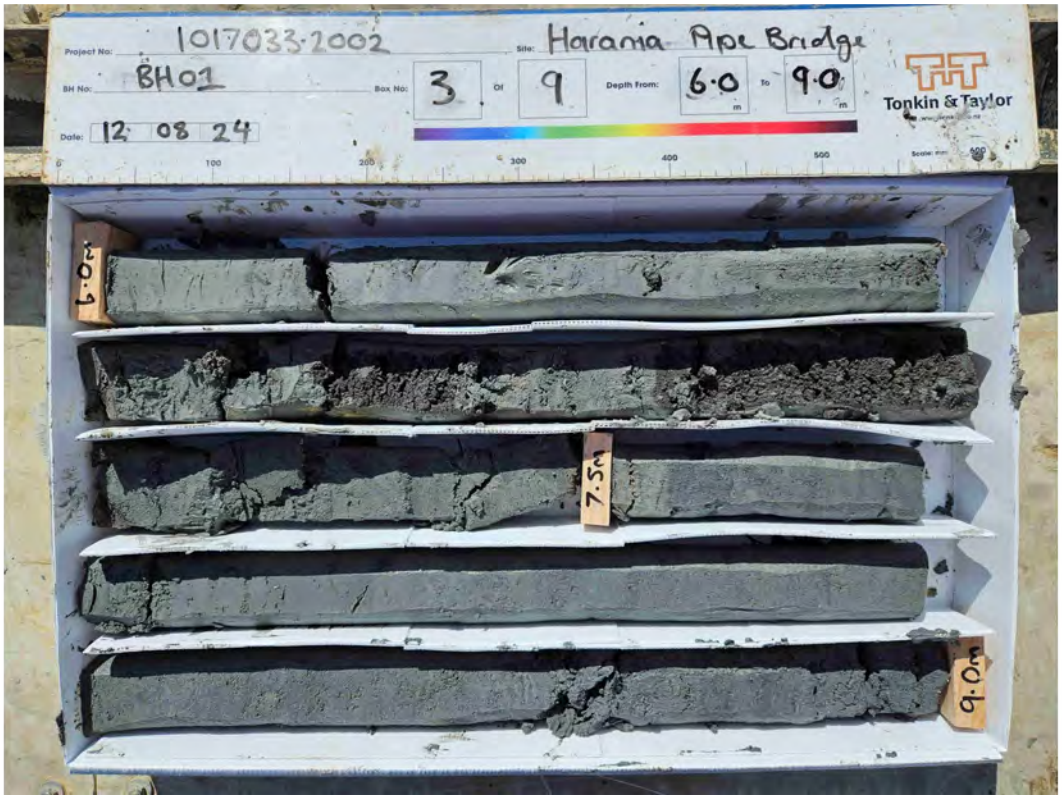
TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

PROJECT: Harania Pipe Bridge	LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: 5908627.53 mN (NZTM2000) 1761926.88 mE R.L.: 6.97m DATUM: NZVD2016	DRILL TYPE: MM3 METHOD: Rotary cored DRILL FLUID: WATER	HOLE STARTED: 12/08/2024 HOLE FINISHED: 12/08/2024 DRILLED BY: McMillan Drilling LOGGED BY: JBER CHECKED: BEWE



6.00-9.00m

9.00-12.00m

TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

PROJECT: Harania Pipe Bridge	LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: 5908627.53 mN (NZTM2000) 1761926.88 mE R.L.: 6.97m DATUM: NZVD2016	DRILL TYPE: MM3 METHOD: Rotary cored DRILL FLUID: WATER	HOLE STARTED: 12/08/2024 HOLE FINISHED: 12/08/2024 DRILLED BY: McMillan Drilling LOGGED BY: JBER CHECKED: BEWE

12.00-15.00m

15.00-18.00m

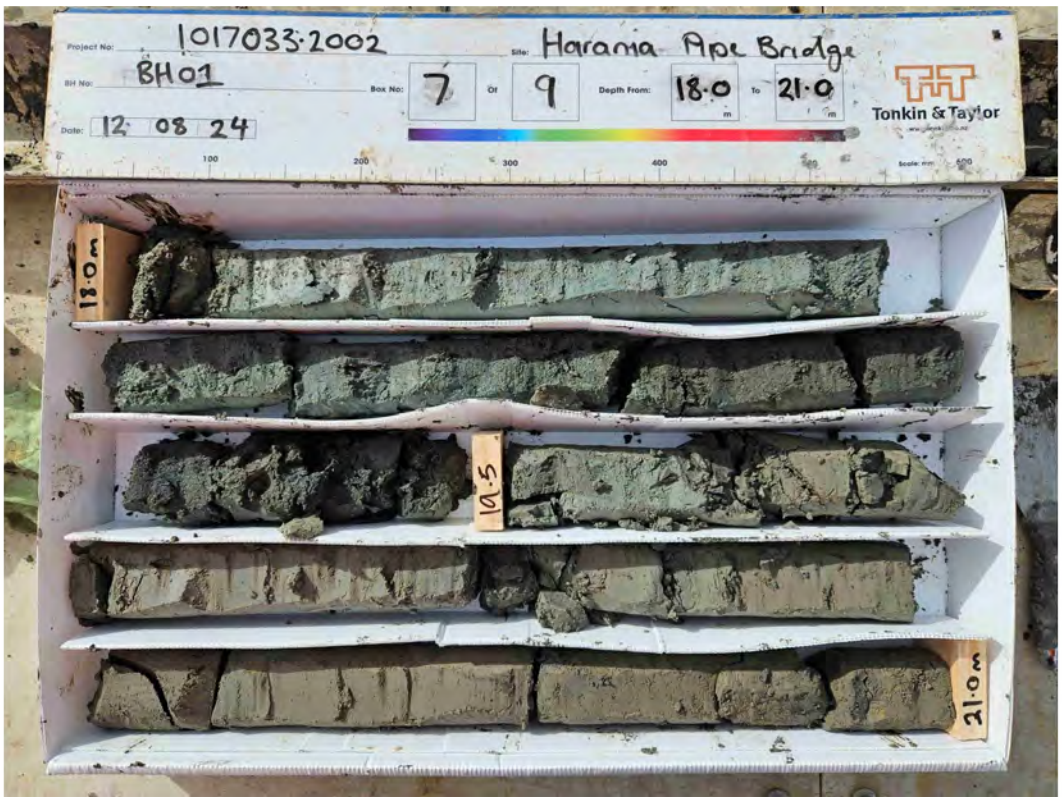
TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908627.53 mN 1761926.88 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 12/08/2024
R.L.:	6.97m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE



18.00-21.00m

21.00-24.00m

TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **BH01**

Hole Location: South-west of the pipe bridge

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908627.53 mN 1761926.88 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 12/08/2024
R.L.:	6.97m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

24.00-25.50m

TTNZ_20240902 - BoreLog - 9/09/2024 1:58:08 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

SHEET: 1 OF 6

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908667.39 mN 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024 HOLE FINISHED: 13/08/2024
R.L.:	4.17m	METHOD: Rotary cored	DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS														ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%)	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa)	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa)	DEFECT SPACING (mm)	DESCRIPTION
Topsoil				100	HA		4		TS		M	F				*0.00m:* SILT, minor clay; dark brown. Firm, moist, low plasticity.
Takaanini Formation								1				St				*0.30m:* Silty CLAY, trace rootlets and trace sand; orange brown with grey. Firm, moist, medium plasticity. Sand, fine. *0.60 - 1.50m:* Stiff.
				100	RC		3					VSt				*1.50m:* Silty CLAY, trace rootlets and trace sand; light grey mottled orange. Very stiff, moist, medium plasticity. Sand, fine.
								2								*1.90m:* Clayey sandy SILT; light grey mottled orange. Very stiff, moist, medium plasticity. Sand, fine.
							2					L				*2.80m:* Silty fine to medium SAND; light grey mottled orange. Loose, moist.
Takaanini Fm (Hobsonville member)				53	RC		1	3								*3.00m:* CORE LOSS - Suspect washed out.
											M	VSt				*3.70m:* Clayey SILT, trace rootlets and trace sand; greenish grey mottled orange. Very stiff, moist, medium plasticity. Sand, fine.
						BH02-S1 @ 4.20m	0	4								
												L				*4.40m:* Fine to medium SAND, trace silt; grey speckled white. Loose, moist. Sand, pumiceous.
				100	RC	BH02-S2 @ 4.80m						VSt				*4.70m:* SILT, some clay, trace sand; grey. Very stiff, moist, low to medium plasticity. Sand, fine.
								5								

COMMENTS:

Hole Depth 30m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

SHEET: 2 OF 6

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908667.39 mN 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024 HOLE FINISHED: 13/08/2024
R.L.:	4.17m	METHOD: Rotary cored	DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS															ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%)	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa)	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa)	DEFECT SPACING (mm)	DESCRIPTION
Takaanini Fm (Hobsonville member)				100	RC	BH02-S3 @ 5.60m	-1				M	VSt				[CONT] *4.70m:* SILT, some clay, trace sand; grey. Very stiff, moist, low to medium plasticity. Sand, fine.
								6				L				*5.90m:* Fine to medium SAND, trace silt; grey speckled white. Loose, moist. Sand, pumiceous.
							-2					F-St				*6.10m:* SILT, some clay, trace sand; grey. Firm to stiff, moist, low to medium plasticity. Sand, fine, pumiceous.
				100	RC	BH02-S4 @ 6.50m						L				*6.60m:* Fine to medium SAND, trace silt; grey speckled white. Loose, moist. Sand, pumiceous.
												St				*6.75m:* SILT, some clay, trace sand; grey. Stiff, moist, low to medium plasticity. Sand, fine, pumiceous.
								7				L				*7.10m:* Fine to medium SAND, trace silt; grey. Loose, moist. Sand, pumiceous.
							-3					St				*7.30m:* Sandy SILT, trace clay; dark grey. Stiff, moist, low plasticity. Sand, fine, pumiceous.
				63	RC	BH02-S5 @ 7.50m						L				*7.90m:* Fine to medium SAND, trace silt; dark grey. Loose, moist. Sand, pumiceous.
								8								*8.45m:* CORE LOSS - Suspect washed out.
						BH02-S6 @ 8.20m	-4									
								9			M	L				*9.00m:* Fine to medium SAND, trace silt; dark grey. Loose, moist. Sand, pumiceous.
				53	RC		-5									
								10								*9.80m:* CORE LOSS - Suspect washed out.

COMMENTS:

Hole Depth 30m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

SHEET: 3 OF 6

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908667.39 mN 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 13/08/2024
R.L.:	4.17m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS								ENGINEERING DESCRIPTION							
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%)	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa)	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa)	DEFECT SPACING (mm)	DESCRIPTION
Takaanini Fm (Hobsonville member)				53	RC			11			M	L				[CONT] *9.80m:* CORE LOSS - Suspect washed out.
				80	RC		-7				M	L				*10.50m:* Fine to medium SAND, some silt; dark grey. Loose, moist. Sand, pumiceous. *10.80 - 11.40m:* Trace silt.
								12								*11.70m:* CORE LOSS - Suspect washed out.
Takaanini Formation				100	RC		-8				M	VSt				*12.00m:* Clayey SILT; greenish grey. Very stiff, moist, medium plasticity.
				100	RC		-9	13								
				100	RC		-10	14								
				100	RC		-11	15				St				*15.20m:* Silty PEAT; black. Stiff, moist.

COMMENTS:

Hole Depth 30m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

SHEET: 4 OF 6

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908667.39 mN 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 13/08/2024
R.L.:	4.17m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS															ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%) 25 50 75	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa) VS 12 25 50 F St 100 VSt 200 H	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa) EW 1 VW 5 W 20 MS 50 S 100 VS+	DEFECT SPACING (mm) 20 60 200 600 2000	DESCRIPTION
Takaanini Formation				100	RC			16			M	VSt				*15.30m:* Clayey SILT; greenish grey. Very stiff, moist, medium plasticity.
				100	RC		-12	17								*17.20m:* Sandy SILT, trace clay; greenish grey. Very stiff, moist, low plasticity. Sand, fine to medium.
East Coast Bays Formation				100	RC		-13	18		CW		EW				*17.70m:* Completely weathered, greyish brown, SILTSTONE. Extremely weak. Recovered as SILT, trace clay; greyish brown. Hard, moist, low plasticity.
				100	RC		-14	19								
							-15									
							-16	20								

COMMENTS:

Hole Depth 30m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc v4.0.01

BOREHOLE LOG

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908667.39 mN 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024 HOLE FINISHED: 13/08/2024
R.L.:	4.17m	METHOD: Rotary cored	DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS															ENGINEERING DESCRIPTION
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%)	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m)	DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa)	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa)	DEFECT SPACING (mm)	DESCRIPTION
East Coast Bays Formation	25 50 75			100	RC		17	21		CW		EW	VS F St VSt H	EW VW W MS S VS+	20 60 200 600 2000	[CONT] *17.70m:* Completely weathered, greyish brown, SILTSTONE. Extremely weak. Recovered as SILT, trace clay; greyish brown. Hard, moist, low plasticity.
				100	RC		18	22		MW						*21.00m:* Moderately weathered, greyish brown, SILTSTONE. Extremely weak. Recovered as SILT, trace clay; greyish brown. Hard, moist, low plasticity.
				100	RC		19	23								
				100	RC		20	24		SW						*24.00m:* Slightly weathered, greyish brown, SILTSTONE. Extremely weak. Recovered as SILT, trace clay; greyish brown. Hard, moist, low plasticity.
							21	25								

COMMENTS:

Hole Depth 30m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

SHEET: 6 OF 6

PROJECT: Harania Pipe Bridge	LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: 5908667.39 mN (NZTM2000) 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
	METHOD: Rotary cored	HOLE FINISHED: 13/08/2024
R.L.: 4.17m		DRILLED BY: McMillan Drilling
DATUM: NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

GEOLOGICAL	METHOD OBSERVATIONS							ENGINEERING DESCRIPTION							
GEOLOGICAL UNIT/ ADDITIONAL OBSERVATIONS	FLUID LOSS (%)	WATER	CASING	CORE RECOVERY (%)	METHOD	TESTS	RL (m) / DEPTH (m)	GRAPHIC LOG	WEATHERING CLASSIFICATION	MOISTURE CLASSIFICATION	CONSISTENCY / DENSITY CLASSIFICATION	ESTIMATED SOIL SHEAR STRENGTH (Su, kPa)	ESTIMATED ROCK COMPRESSIVE STRENGTH (qu, MPa)	DEFECT SPACING (mm)	DESCRIPTION
East Coast Bays Formation				100	RC		22 / 26		SW		EW				[CONT] *24.00m:* Slightly weathered, greyish brown, SILTSTONE. Extremely weak. Recovered as SILT, trace clay; greyish brown. Hard, moist, low plasticity.
				100	RC		23 / 27								
							24 / 28				W				*28.50m:* Slightly weathered, dark grey, SANDSTONE. Weak, fine to coarse grained.
				100	RC		25 / 29				VW				*28.85m:* Slightly weathered, grey, SILTSTONE. Very weak.
							26 / 30								30m: Target depth

COMMENTS:

Hole Depth 30m

Scale 1:26

Rev.: A

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

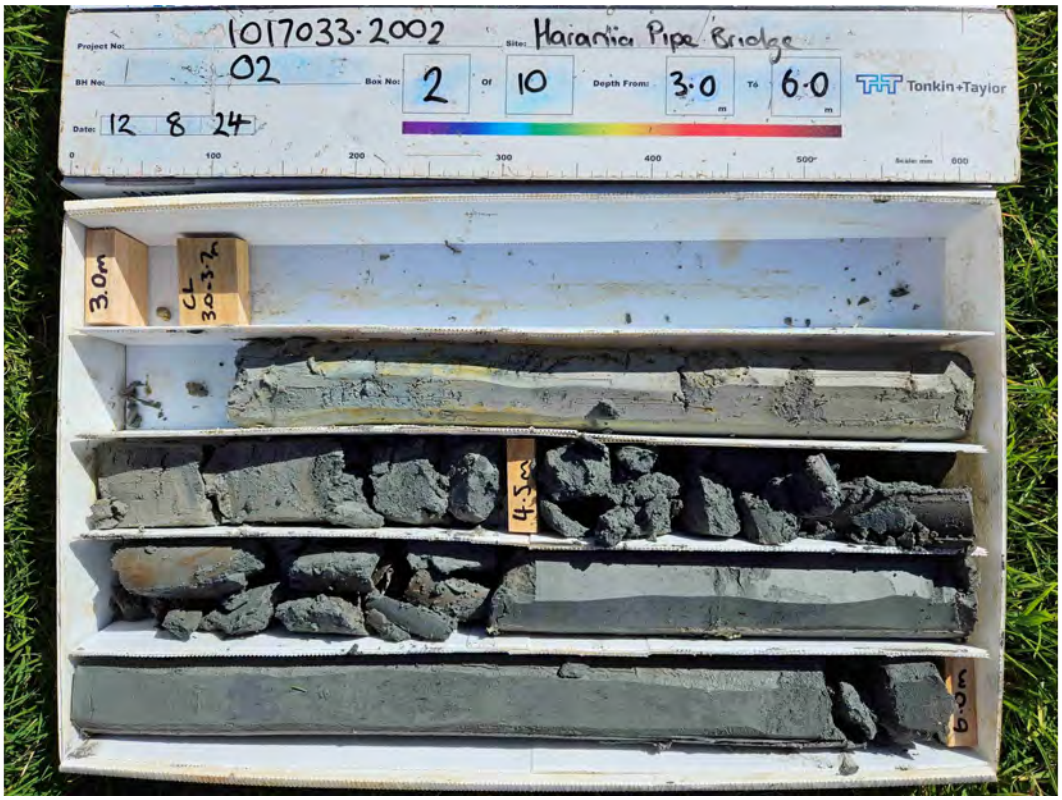
CORE PHOTOS

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908667.39 mN 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 13/08/2024
R.L.:	4.17m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

0.00-3.00m



3.00-6.00m

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

PROJECT: Harania Pipe Bridge	LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: 5908667.39 mN (NZTM2000) 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
R.L.: 4.17m	METHOD: Rotary cored	HOLE FINISHED: 13/08/2024
DATUM: NZVD2016	DRILL FLUID: WATER	DRILLED BY: McMillan Drilling
		LOGGED BY: JBER CHECKED: BEWE

6.00-9.00m

9.00-12.00m

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

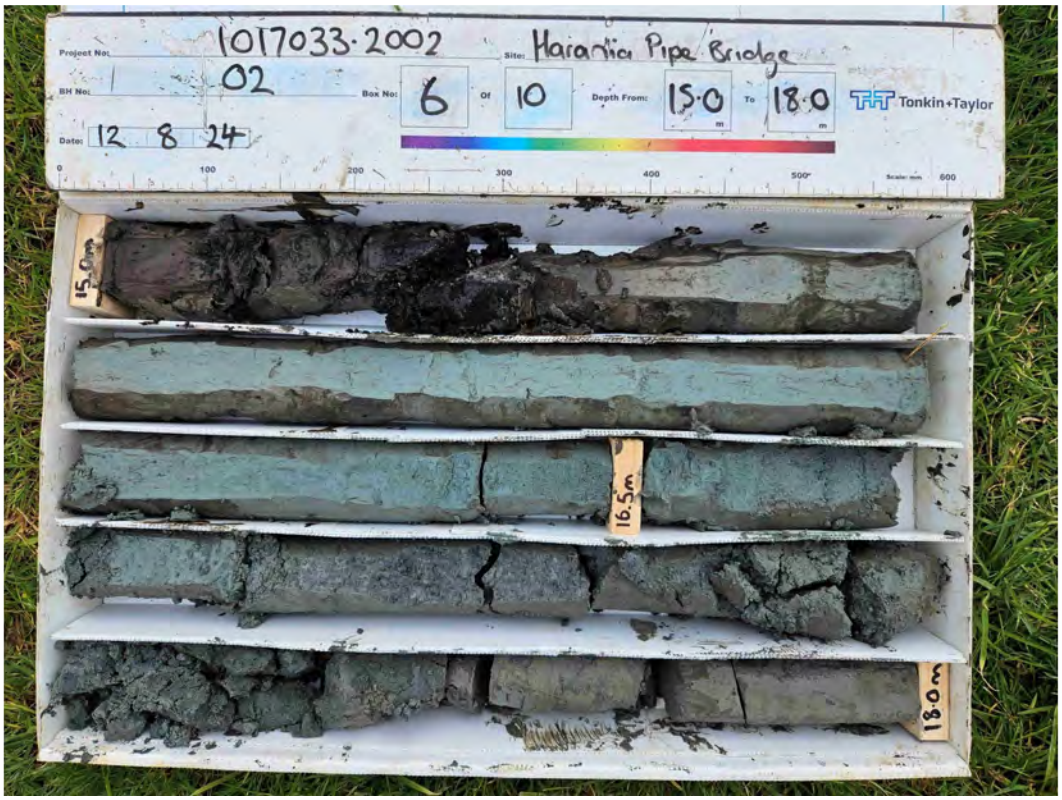
CORE PHOTOS

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

PROJECT: Harania Pipe Bridge		LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: (NZTM2000)	5908667.39 mN 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
		METHOD: Rotary cored	HOLE FINISHED: 13/08/2024
R.L.:	4.17m		DRILLED BY: McMillan Drilling
DATUM:	NZVD2016	DRILL FLUID: WATER	LOGGED BY: JBER CHECKED: BEWE

12.00-15.00m



15.00-18.00m

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

PROJECT: Harania Pipe Bridge	LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: 5908667.39 mN (NZTM2000) 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
R.L.: 4.17m	METHOD: Rotary cored	HOLE FINISHED: 13/08/2024
DATUM: NZVD2016	DRILL FLUID: WATER	DRILLED BY: McMillan Drilling
		LOGGED BY: JBER CHECKED: BEWE

18.00-21.00m

21.00-24.00m

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **BH02**

Hole Location: North-east of the pipe bridge

PROJECT: Harania Pipe Bridge	LOCATION: Blake Road Reserve	JOB No.: 1017033.2002
CO-ORDINATES: 5908667.39 mN (NZTM2000) 1761981.70 mE	DRILL TYPE: MM3	HOLE STARTED: 12/08/2024
R.L.: 4.17m	METHOD: Rotary cored	HOLE FINISHED: 13/08/2024
DATUM: NZVD2016	DRILL FLUID: WATER	DRILLED BY: McMillan Drilling
		LOGGED BY: JBER CHECKED: BEWE

24.00-27.00m

27.00-30.00m

TTNZ_20240902 - BoreLog - 9/09/2024 1:59:14 pm - Produced with Core-GS by GeRoc

Appendix C Assessment of land subject to instability

C1 Design purpose

The presented analyses in this document relate to the construction of a new pipe bridge and associated chambers to support the Eastern Interceptor as it spans over a stream in the Tennessee catchment in Mangere, Auckland. This calculation summary is intended to be appended to the geotechnical resource consent assessment report.

The presented design calculations include slope stability analyses that serve the purpose of assessing land subject to instability as defined within Chapter J1 of the Auckland Unitary Plan (AUP). The assessment has been completed in accordance with Chapter E36.9 of the AUP, to support resource consent application.

C2 Design objective

The design objectives are:

- Perform slope stability analysis on the existing slope to confirm the adopted design soil parameters (i.e. soil cohesion and friction angle); and
- Use the adopted soil parameters to assess slope stability in line with council requirements (as outlined in Chapter 2 of the Auckland Code of Practice for Land Development and Subdivision); including:
  - Factor of safety of 1.5 for normal groundwater conditions.
  - Factor of safety of 1.3 for the worst credible groundwater condition.
  - Factor of safety of 1.0 for the pseudo-static seismic loading using ULS PGA.

C3 Design method, input parameters and assumptions

In terms of slope geometry for the existing slopes, the most unfavourable (i.e. steepest and highest) slope around the project location was selected (refer to SECTION D-D within the attached plan and sections).

For assessment of the final slopes to be constructed by the project works, sections at the chamber locations were considered (refer to SECTION C-C within the attached plan and sections). Both the western and eastern stream banks were analysed due to differences in underlying ground conditions. The chambers themselves were excluded from analysis since they will be supported by piled foundations; thus, only stability of the slope itself was considered.

The material parameters were selected from consideration of the CPT traces, machine drilled and hand augered borehole logs, and soil characterisation tests. The adopted parameters were confirmed via back analysis and are displayed in Table Appendix C.1.

Table Appendix C.1 : Material parameters adopted

Material	Unit weight (kN/m^3)	Depth (mbgl)	Cohesion (kPa)	Friction angle (°)	Undrained shear strength (kPa)
Chamber (modelled as high strength)	25[1]	N/A	N/A	N/A	N/A
Takaanini Formation – clayey SILT/silty CLAY interbedded with silty SAND	18	0 to 10 (east) 0 to 8 (west)	3	28	60

Material	Unit weight (kN/m³)	Depth (mbgl)	Cohesion (kPa)	Friction angle (°)	Undrained shear strength (kPa)
Takaanini Formation – silty SAND	18	10 to 13 (east) 8 to 13 (west)	1	35	N/A
Takaanini Formation – liquefied material post-earthquake	18	4 to 10 (east) 4 to 8 (west)	N/A	N/A	5

[1] The area of the chamber has been modelled such that the total weight is representative of dead loads provided by the structural engineer (ACH) of 13,866 kN

A peak ground acceleration (PGA) of 0.28g (and magnitude 5.9) was adopted for pseudo-static seismic loading in accordance with NZGS Module 1 Table A1, corresponding to a 2500-year return period event in Auckland.

The existing analysis (refer to the attached output) resulted in a factor of safety of 1.64. This is perhaps higher than would be expected of a naturally formed slope; however given this is a stream slope that is likely formed by stream erosion, this is considered feasible.

C4 Results

The resulting factors of safety from the slope stability analyses are presented in Table Appendix C.2.

Table Appendix C.2 : Summary of slope stability modelling outputs

Design scenario	Factor of safety – west stream bank	Factor of safety – east stream bank	Factor of safety requirement
Long-term static	1.65	2.16	1.5
Worst credible groundwater level	1.49	1.76	1.3
Pseudo-static seismic	1.41	1.40	1.0

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P:\1017033\1017033.2002\WorkingMaterial\04 CAD\1017033.2002-030 GEO SECTIONS.dwg 2024-Aug-28 11:10:24 am Plotted By: PATRICK PEREIRA

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. COORDINATE DATUM: NZGD2000, NZTM COORDINATES.
3. LEVEL DATUM: NZVD 2016
4. AERIAL PHOTO SHOWN HAS BEEN SOURCED FROM THE AUCKLAND COUNCIL GIS GEO MAPS.
5. LOCATION OF ALL EXISTING SERVICES HAVE BEEN SOURCED FROM TOPOGRAPHICAL SURVEY PROVIDED BY THE CONTRACTOR AND FROM THE AUCKLAND COUNCIL GIS GEO MAPS.
6. EXISTING CONTOURS HAVE BEEN SOURCED FROM TOPOGRAPHICAL SURVEY PROVIDED BY THE CONTRACTOR AND FROM THE AUCKLAND COUNCIL GIS GEO MAPS.
7. LOCATION, SIZE AND ALIGNMENT OF THE PROPOSED WW TRANSMISSION LINE, SUPPORT COLUMNS/PIERS AND CHAMBERS PROVIDED BY ACH CONSULTANTS VIA IFC FILE.
8. LOCATION AND EXISTING ALIGNMENT OF THE WW TRANSMISSION LINE WERE SOURCED FROM TOPOGRAPHICAL SURVEY PROVIDED BY THE CONTRACTOR AND FROM THE AUCKLAND COUNCIL GIS GEO MAPS.
9. EXISTING WW TRANSMISSION LINE INVERTS AND LEVELS HAVE BEEN SOURCED FROM THE AUCKLAND COUNCIL GIS GEO MAPS.
10. LOCATIONS OF EXISTING SERVICES MAY VARY FROM THAT SHOWN AND SHOULD BE CHECKED ON SITE.

LEGEND:

PROPOSED MAJOR CONTOUR (1m)

PROPOSED MINOR CONTOUR (0.2m)

PROPOSED REALIGNED WW TRANSMISSION LINE SUPPORT COLUMNS/PIERS

SECTION A

SECTION B

SECTION C

SECTION D

SECTION E

PROPOSED WW TRANSMISSION PIPE REALIGNMENT

EASTERN WW CHAMBER

WESTERN WW CHAMBER

EX.PUBLIC 2550mmØ SS TRANSMISSION LINE (SCALED FROM COUNCIL GEOMAP)

LOT 73 DP 206462 522

LOT 72 DP 206462 868

LOT 74 DP 206463

LOT 75 DP 206463 631

LOT 104 DP 206463 2685

LOT 77 DP 206463 485

LOT 106 DP 206463 116

LOT 59 DP 47191 701

LOT 58 DP 47191 756

LOT 60 DP 47191 933

LOT 61 DP 47191 696

LOT 62 DP 47191 635

LOT 63 DP 47191 721

LOT 64 DP 47191 698

A3 SCALE 1:500
0 5 10 15 20 25 (m)

ORIGINAL IN COLOUR

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REV	DESCRIPTION	CAD	CHK	DATE	APPROVED	DATE
A	ISSUED FOR INFORMATION	PP				

DESIGNED	PP	Jun.24	DRAWING STATUS
DRAWN	PP	Jun.24	
DESIGN CHECKED			
DRAWING CHECKED			

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CLIENT **HEALTHY WATERS**

PROJECT **HARANIA INFRASTRUCTURE UPGRADE**

TITLE DESIGN CONTOUR PLANS
TENNESSEE AVENUE LAYOUT PLAN

FOR CONSENT REVISION

SCALE (A3) 1:500 DWG No. 1017033.2002-031G REV A

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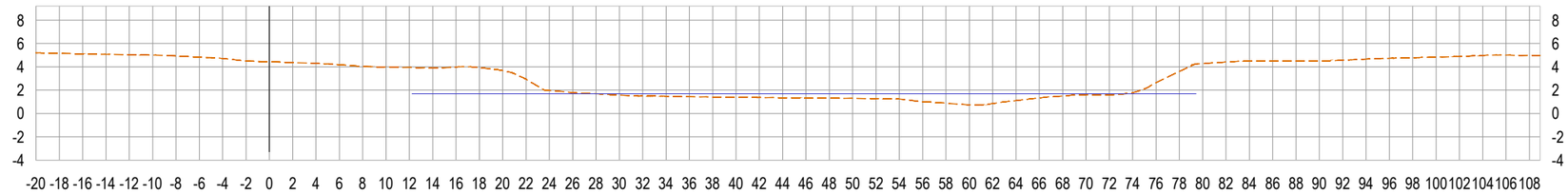
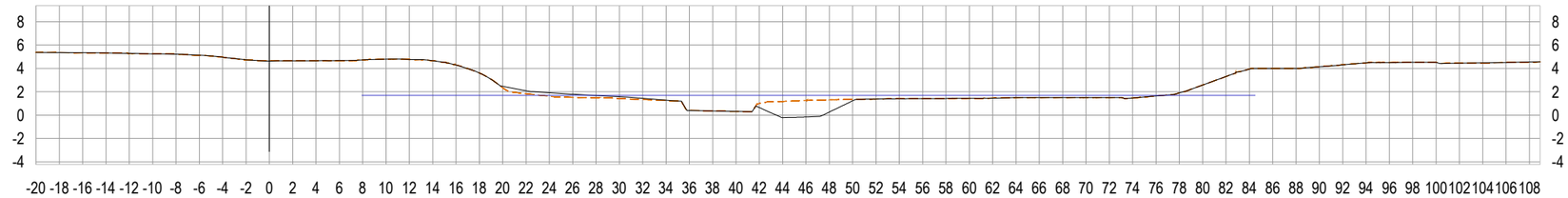
DESIGN SURFACE
EXISTING SURFACE
MHWS



SECTION A



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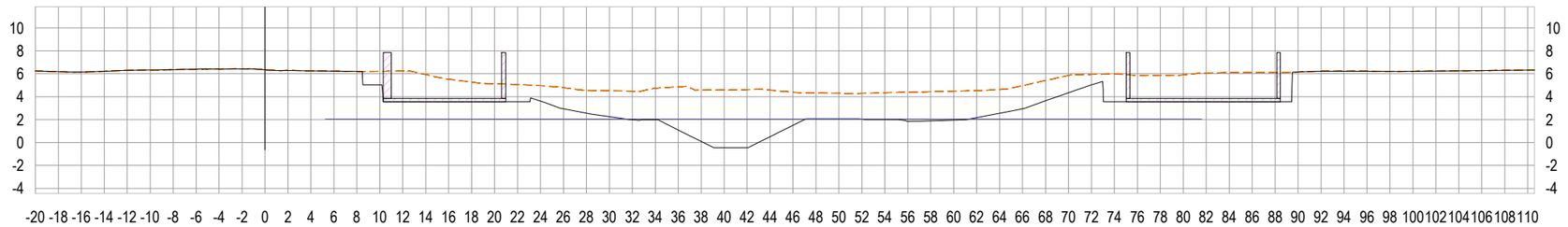

SECTION C

A3 SCALE 1:500
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ORIGINAL IN COLOUR

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REV	DESCRIPTION	CAD	CHK	DATE
A	ISSUED FOR INFORMATION	PP		

DESIGNED	PP	Jun.24	DRAWING STATUS
DRAWN	PP	Jun.24	
DESIGN CHECKED			
DRAWING CHECKED			

APPROVED _____ DATE _____

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CLIENT **HEALTHY WATERS**
PROJECT **HARANIA INFRASTRUCTURE UPGRADE**
TITLE DAM EMBANKMENT CROSS SECTIONS
TENNESSEE AVE GEO SECTIONS SHEET 1

UNDER REVISION

SCALE (A3) 1:500 DWG No. 1017033.2002-027 REV A

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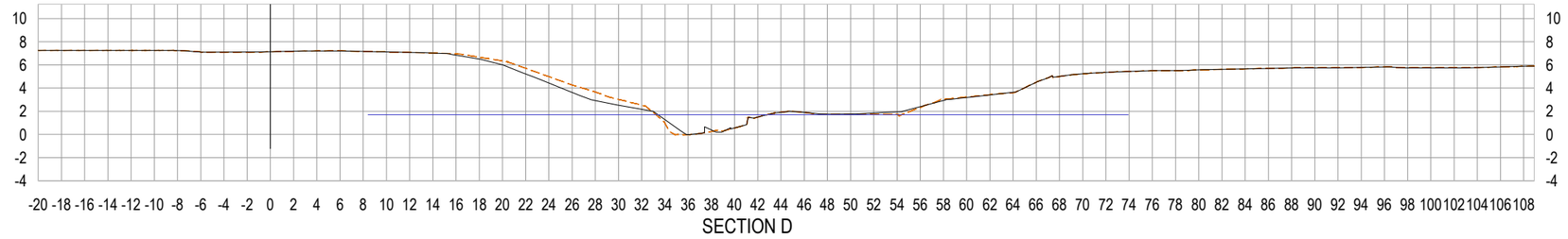
DESIGN SURFACE
EXISTING SURFACE
MHWS



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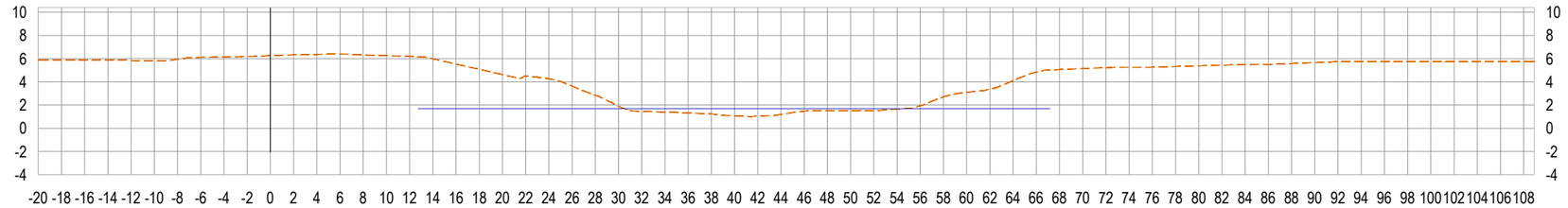

SECTION E

A3 SCALE 1:500
0 5 10 15 20 25 (m)

ORIGINAL IN COLOUR

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REV	DESCRIPTION	CAD	CHK	DATE
A	ISSUED FOR INFORMATION	PP		

DESIGNED	PP	Jun.24	DRAWING STATUS
DRAWN	PP	Jun.24	
DESIGN CHECKED			
DRAWING CHECKED			

APPROVED _____ DATE _____

THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED AS APPROVED

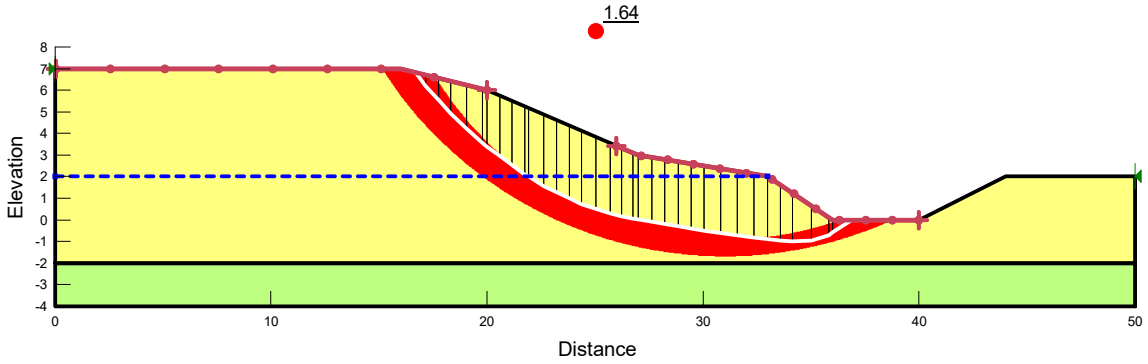
CLIENT **HEALTHY WATERS**
PROJECT **HARANIA INFRASTRUCTURE UPGRADE**
TITLE DAM EMBANKMENT CROSS SECTIONS
TENNESSEE AVE GEO SECTIONS SHEET 2

INNER REVISION

SCALE (A3) 1:500 DWG No. 1017033.2002-028 REV A

Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Silt (with clay)	Mohr-Coulomb	18	3	28	0	1
	Silty Sand	Mohr-Coulomb	18	0	35	0	1



Tonkin+Taylor

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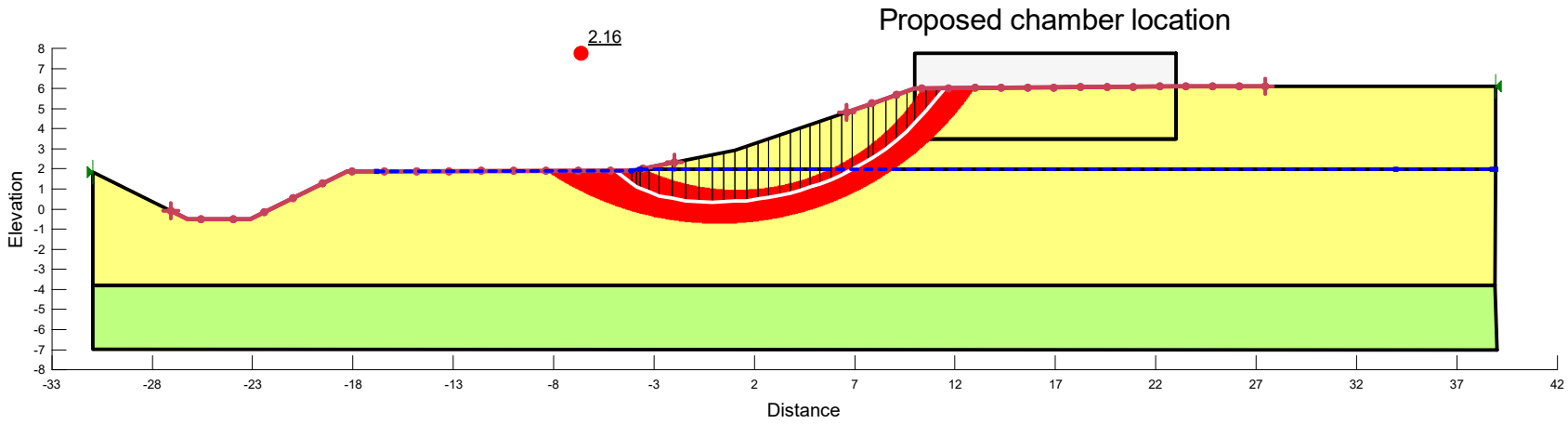
Analysis: Existing slope		Analysed by: STHU/DCHA
Comments:	Scale: 1:350 @ A4	Checked by: ABL

Directory: P:\1017033\1017033.2002\WorkingMaterial\09 Geotechnical\6. RC - Geotechnical Assessment\Final version\Slope Stability\

Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Silt (with clay)	Mohr-Coulomb	18	3	28	0	1
	Silty Sand	Mohr-Coulomb	18	0	35	0	1



Tonkin+Taylor

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Analysis: 1. Long term static - East		Analysed by: STHU/DCHA
Comments:	Scale: 1:350 @ A4	Checked by: ABL

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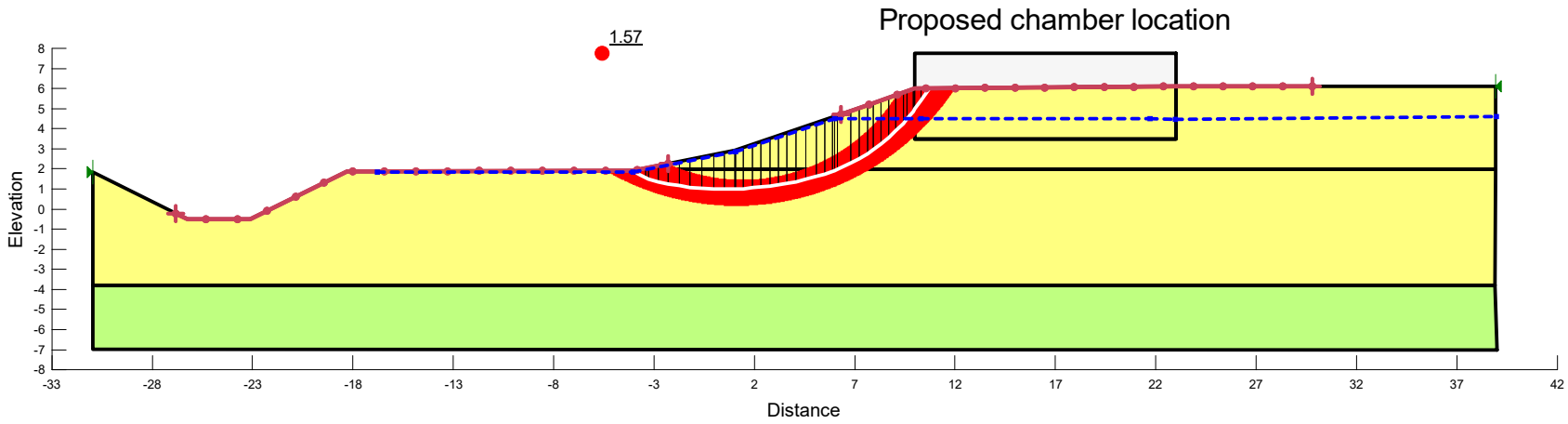
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Silt (with clay)	Mohr-Coulomb	18	3	28	0	1
	Silty Sand	Mohr-Coulomb	18	0	35	0	1



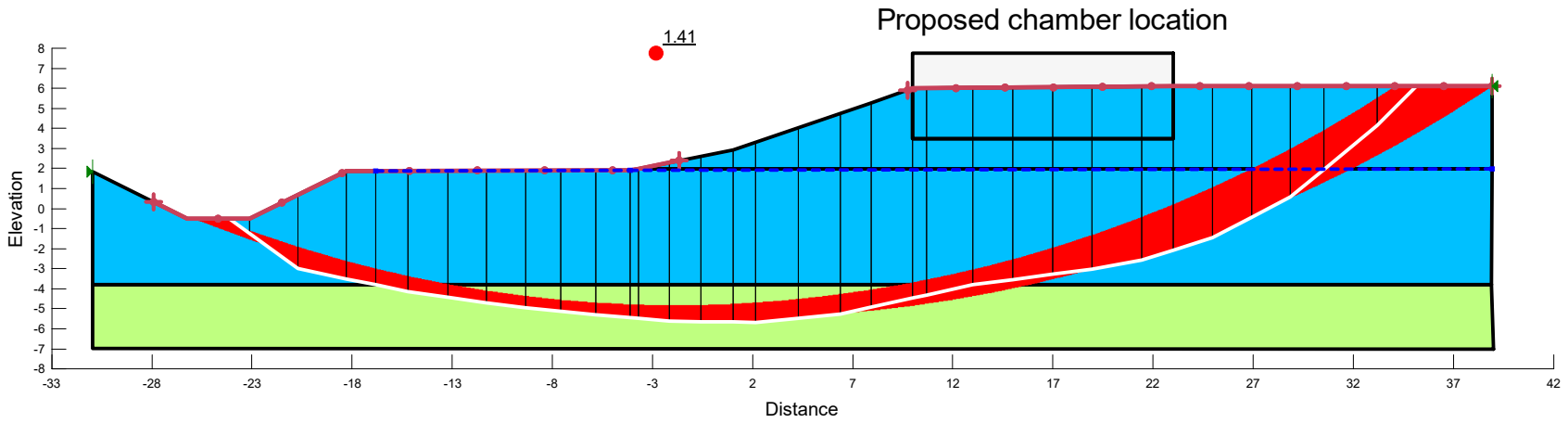
Tonkin+Taylor

Title: Harania-Tennessee Embankment slopes_ABL Review Copy.gsz		Job Number: 1017033.2002
Analysis: 2. High Groundwater - East		Analysed by: STHU/DCHA
Comments:	Scale: 1:350 @ A4	Checked by: ABL

Directory: P:\1017033\1017033.2002\WorkingMaterial\09 Geotechnical\6. RC - Geotechnical Assessment\Final version\Slope Stability\

Horz Seismic Coef.: 0.28

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	Total Cohesion (kPa)
	Silt (with clay) undrained	Undrained (Phi=0)	18					60
	Silty Sand	Mohr-Coulomb	18	0	35	0	1	



Tonkin+Taylor

Title: Harania-Tennessee Embankment slopes_ABL Review Copy.gsz		Job Number: 1017033.2002
Analysis: 3. Psuedo-static seismic - East		Analysed by: STHU/DCHA
Comments:	Scale: 1:350 @ A4	Checked by: ABL

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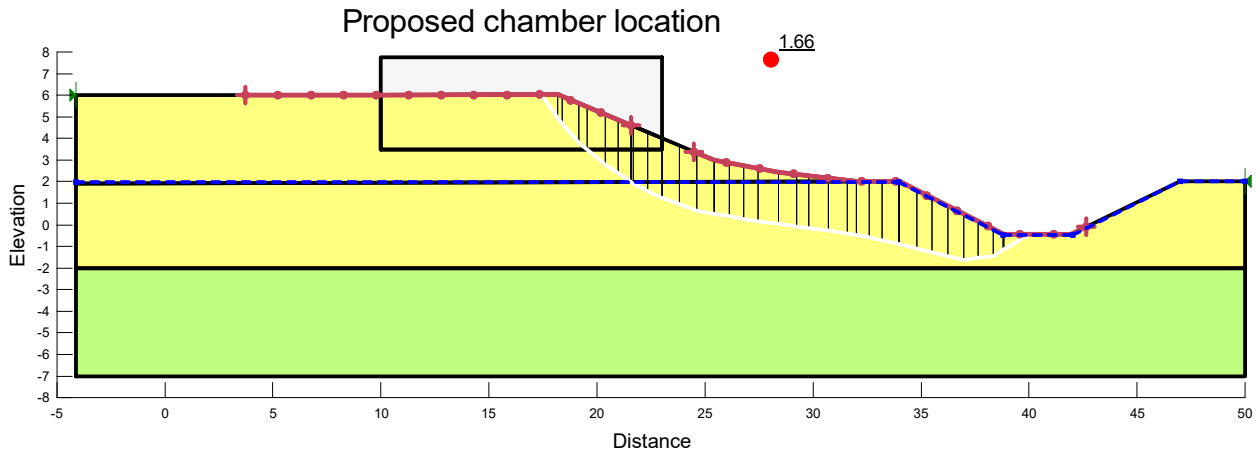
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Silt (with clay)	Mohr-Coulomb	18	3	28	0	1
	Silty Sand	Mohr-Coulomb	18	0	35	0	1



Tonkin+Taylor

Title: Harania-Tennessee Embankment slopes_ABL Review Copy.gsz		Job Number: 1017033.2002
Analysis: 1. Long term static - west		Analysed by: STHU/DCHA
Comments:	Scale: 1:350 @ A4	Checked by: ABL

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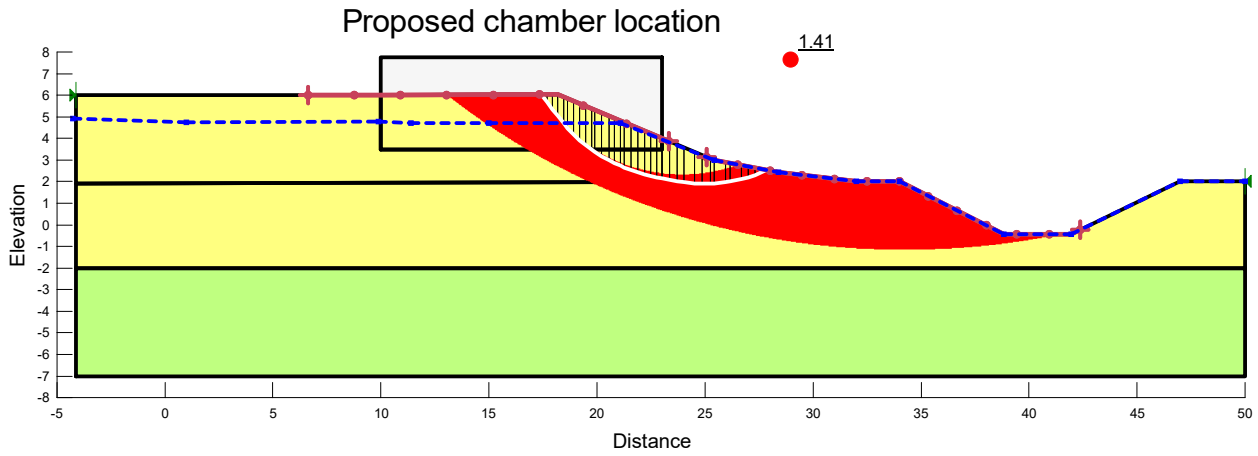
Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface
	Silt (with clay)	Mohr-Coulomb	18	3	28	0	1
	Silty Sand	Mohr-Coulomb	18	0	35	0	1



Tonkin+Taylor

Title: Harania-Tennessee Embankment slopes_ABL Review Copy.gsz		Job Number: 1017033.2002
Analysis: 2. High Groundwater - west		Analysed by: STHU/DCHA
Comments:	Scale: 1:350 @ A4	Checked by: ABL

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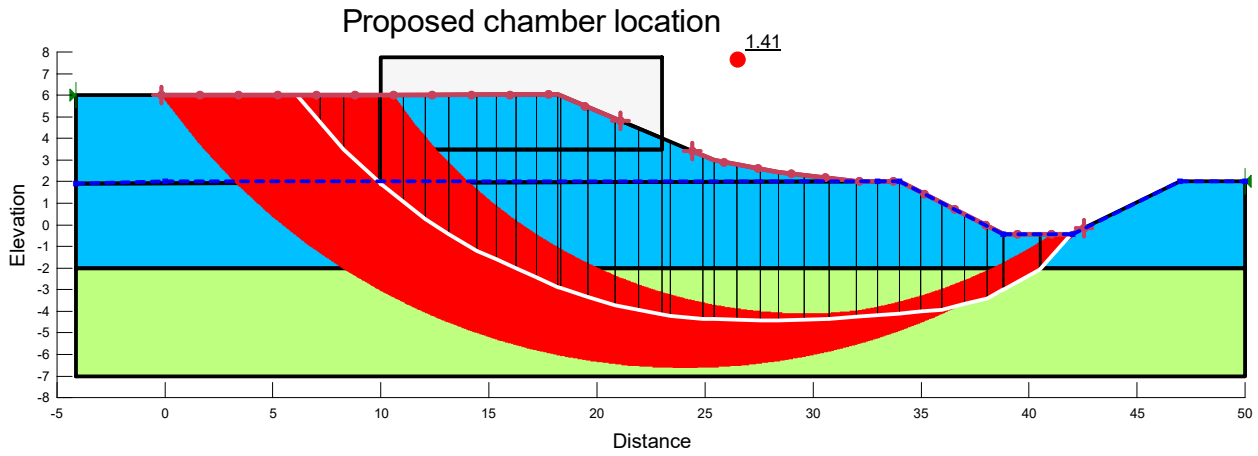
Horz Seismic Coef.: 0.28

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	Total Cohesion (kPa)
	Silt (with clay) undrained	Undrained (Phi=0)	18					60
	Silty Sand	Mohr-Coulomb	18	0	35	0	1	



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Title: Harania-Tennessee Embankment slopes_ABL Review Copy.gsz		Job Number: 1017033.2002
Analysis: 3. Pseudo-static seismic - west		Analysed by: STHU/DCHA
Comments:	Scale: 1:350 @ A4	Checked by: ABL

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