RILEY CONSULTANTS

GEOTECHNICAL INVESTIGATION

STABILITY OF KITEWAO PUMP STATION AND SURROUNDS

KITEWAO PUMP STATION AND AWATAHA MARAE, NORTHCOTE

Engineers and Geologists

GEOTECHNICAL INVESTIGATION
STABILITY OF KITEWAO PUMP STATION AND SURROUNDS
KITEWAO PUMP STATION AND AWATAHA MARAE, NORTHCOTE

Report prepared for: North Shore City Council

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1.0 Introduction

As requested, Riley Consultants Ltd (RILEY) has undertaken a geotechnical investigation at the above site. From the mid 1990s onwards, tilting of the pump station building has been noted. In addition, CCTV inspection of stormwater and sewer lines in the vicinity of the pump station has noted several breaks.

RILEY has previously undertaken a geotechnical investigation and assessment, as well as associated reporting, with respect to the pump station. Findings of a site investigation were presented in a report dated 29 May 1998 (RILEY Ref: 98191-A). A further geotechnical assessment was carried out more recently, providing advice to North Shore City Council (NSCC) on existing and likely future stability, and possible protection measures, with the investigation extending southward into the neighbouring marae land. A detailed report was prepared (RILEY Ref: 98191/1-B, dated 6 November 2007).

This current investigation has been undertaken to provide NSCC with further detail on the extent and depth of land movement and contributing factors. Recommendations have also been provided for the design of an in-ground (Palisade) wall around the pump station.

2.0 Site Description and Background

The pump station is located on a small platform above a tidal stream, immediately west of the northern motorway. Access to the facilities is via a concrete driveway from the end of Kitewao Street, Northcote. The facilities include a control house, which is a simple structure about 3m², with concrete block walls supported on a pad foundation. The adjacent wet well is about 3m in depth on the eastern side.

We understand these facilities have been in place for some considerable time. Concerns have arisen because the control house is tilting. Measurements detected a considerable worsening of the tilt between November 1997 and April 1998. Visual appraisal indicates that the tilting has worsened to the present day. There is also considerable evidence of associated ground movement and settlement, with cracking and settlement evident in the concrete slab accessway and block work fence adjacent to the pump station.

CCTV inspection of both stormwater and sanitary sewer lines indicate several areas of pipe damage. This includes the recent severance of a sanitary sewer line some 40m south of the pump station within the neighbouring Awataha Marae, at a depth of between 1m and 1.5m. Past investigations have concluded that the sewer line breakage was the possible result of ancient land slippage reactivation. Within the marae grounds is a significant scarp feature, with a vertical offset of up to 600mm, which coincides approximately with the severed pipe work. This scarp feature continues for a distance of approximately 110m through the marae land, sub-parallel with the nearby motorway.

A pond has been created at the toe of the instability, circa 2007, associated with the 'Busway' development. We understand marae staff are concerned the works associated with the 'Busway' may have contributed to further ground movement.

A plan and aerial photo showing the investigated area are shown on the attached RILEY Dwg: 98191/1-10.

On the information gathered to date, it would appear that the Kitewao Pump Station is being affected by ground movement. The station is at the northern margin of the slip, the vast body of which is within the Awataha Marae to the immediate south. The slip is inferred to be occurring on a weak horizon in the underlying alluvium at about 3.7m to 6.5m depth.

The current investigation has been undertaken to confirm this depth, along with the extent of movement and likely contributing factors.

3.0 Site Investigation

A subsurface investigation comprising the drilling of three machine boreholes (MH1 to MH3) to a maximum depth of 18.45m, and the excavation of two test pits (TP2 and TP3) to a maximum depth of 4.4m, was carried out on 3 and 4 April 2009. The drilling was undertaken by ProDrill and the recovered core was logged by an engineering geologist from RILEY. A site plan showing the location of the boreholes and test pits is attached (RILEY Dwg: 98191/1-10).

The test pits were logged by an engineering geologist and engineering technician from this office.

Two cross sections were measured with tape and clinometer through the slopes below the marae car park. Cross sections are appended as RILEY Dwgs: 98191/1-11 and 98191/1-12.

Following completion of the investigation, a single 'stand pipe' piezometer was installed in MH1 and a multiport piezometer was installed in MH3 to monitor groundwater levels. An inclinometer was installed in MH2 to measure possible lateral deformation of the soils and to give an indication of rate and direction of ground movement if it occurs.

4.0 Geology

The 1:25,000 Industrial Series geological map (Sheet N42/2 – Devonport) indicates the subject site is underlain by alluvial deposits. However, the later 1:50,000 Auckland Urban Area geological map (Sheet R11) indicates the site to be underlain by volcanic tuff deposits.

5.0 Subsurface Conditions

Subsurface investigation indicates the site is underlain by alluvial deposits incorporating bands of volcanic deposits and a variable depth veneer of surficial fill. Key points are summarised below:

- Fill was encountered in each of the machine holes and test pits, to a maximum depth of 4.95m in MH3. This typically comprised of silt with varying amounts of clay, sand and gravel. In MH3 scoria and tuff material were included in the fill. Shear strengths in the fill ranges from soft (13kPa) to hard (218+kPa) consistency. Much of this fill is believed to be derived from reworking of tuff deposits.
- Alluvial soils intermixed with varying amounts of tuff were encountered beneath the fill. The alluvial material comprised mostly silt, with varying amounts of sand, clay and gravel, and locally pumiceous sand. Layers of organic clay were encountered throughout. Shear strengths of the alluvial soils were highly variable ranging from firm (29kPa) to hard (225+kPa) consistency. Values from SPT tests within the machine holes generally range from firm to very stiff. Between 13m and 14m in MH1, SPT values exceeding 50 blows were recorded, corresponding with a layer of very dense fine and medium sand. Local tuff layers were recovered as silt with sand and gravel (comprising scoria).
- A potential failure surface was encountered in MH3 at 8m in an SPT sample. The shiny surface and parallel striation marks indicate movement has likely occurred along this interface (Photo 1) at some time. The failure surface was also exposed in TP1, TP2 and TP3, extending to the base of all pits in the shape of a curve. The inferred failure surface profile is shown on attached cross sections (RILEY Dwgs: 98191/1-11 and 98191/1-12).

Photo 1: Polished surface and striation marks on core (MH3 8m depth)

- Competent material was not encountered. The deepest machine hole (MH1), to a depth of 18.45m, ended in very stiff silts. Anecdotal evidence indicates Waitemata Group weak rock has been encountered at a depth of 28m beneath the nearby motorway.
- Groundwater was encountered in each of the machine holes and TP1, but not in TP2 or TP3. Water levels from monitoring visits are presented in the section below. Groundwater is generally near ground surface (within 2m), with the exception of the higher ground at the southern slip extent, where groundwater is recorded at between 3.9m and 5m depth (MH3). Groundwater level monitoring data is presented in the following section.

6.0 Review of Monitoring Devices and Data

6.1 Piezometers

Groundwater levels within the machine boreholes have been regularly recorded by RILEY since April 2009. Table 1 below summarises results.

Table 1: Piezometer Data

Date	Water Depth (mbgl)			
	MH1	MH2	MH3 P1	MH3 P2
	Screen Depth 1m to 5m		Screen Depth 6.5m to 9.5m	Screen Depth 2m to 5m
14 April 2009	1.60	2.14	4.78	4.83
5 May 2009	1.52	2.56	4.44	4.49
18 May 2009	1.31	2.00	4.40	4.27
8 June 2009	1.55	1.90	4.42	4.31
24 June 2009	1.52	-	3.93	3.91
9 July 2009	1.13	-	3.40	3.11
27 July 2009	1.35	-	3.41	2.76
10 August 2009	1.53	-	3.88	3.81
27 August 2009	1.23	-	3.72	3.29

The groundwater data gathered to date displays relatively small variation in groundwater level with time. All piezometers display an increase in average water level through winter months. However, at the time of monitoring no piezometers have had groundwater recorded at or just below ground surface. It is considered likely the shallow piezometers will have a rapid response to rainfall, and monitoring of a higher frequency may detect groundwater levels higher than those measured.

Groundwater within shallow hand augers drilled in 2007 (HA1 and HA2) was within 1.5m of the surface. As the measurements were made in early autumn these levels were considered to reflect typical lower levels.

The quality of collected piezometric data could be improved with the installation of divers within the boreholes, which continually monitor groundwater head. Such monitoring could record temporary spikes in groundwater level when ground movement may occur.

6.2 Inclinometer

Inclinometer tubing was installed into MH2 immediately following drilling on 4 April 2009. A baseline survey of the inclinometer was undertaken by Opus International Consultants Ltd (Opus) on 15 April 2004.

Since that time a further inclinometer survey was undertaken by Opus on 1 July 2009. This later survey detected some movement of the inclinometer tube downslope (Axis A), down to a depth of approximately 6.5m.

A copy of the graph showing cumulative displacement is displayed as Figure 1 below. All inclinometer plots are attached as Appendix B.

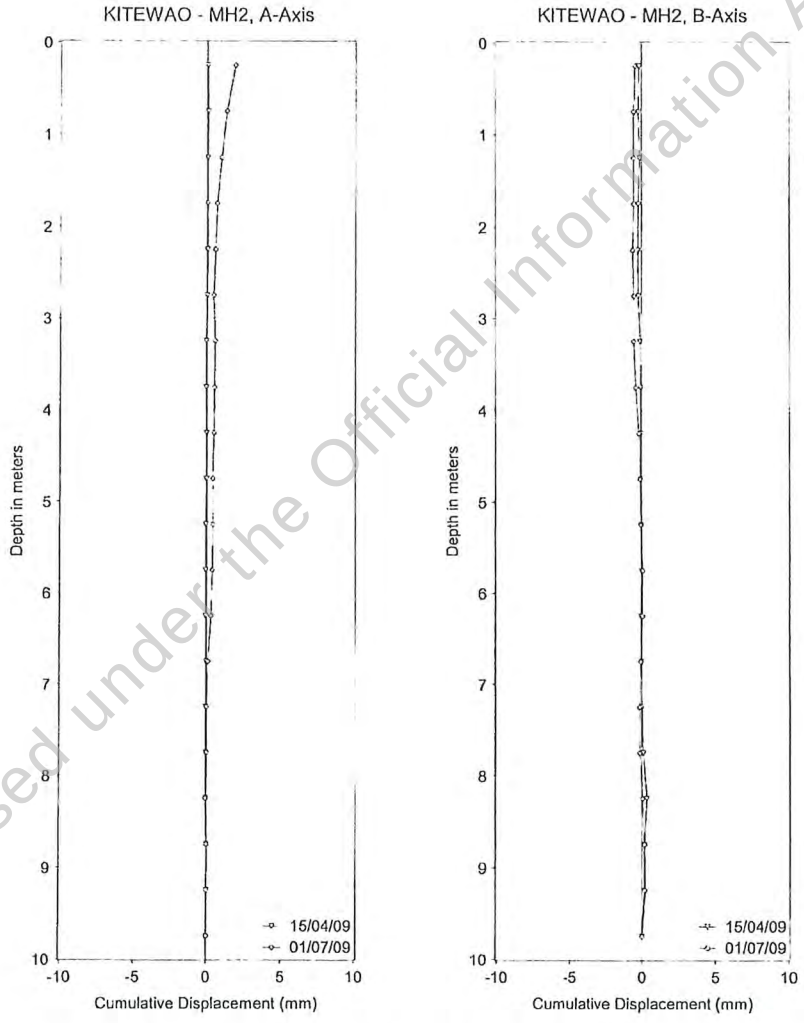


Figure 1: Inclinometer monitoring results up to 1 July 2009. Deflection is observed on the A axis, i.e. downslope to a depth of approximately 6.5m

7.0 Discussion

A large-scale slip feature has been defined within the eastern portion of the Awataha Marae adjacent to the northern motorway. This feature is in the order of 130m in width and up to 50m in length. This feature encompasses the Kitewao Pump Station at its northern extent. The recent investigations have largely confirmed initial findings of our 2007 investigation and reporting. These recent investigations have also provided:

- further definition of the extent of past slope movement;
- a more accurate assessment of failure depth;
- deep soil information below the inferred failure plane; and
- deep groundwater information.

7.1 Causes of Pump Station Tilting

The cause of the pump station tilting is inferred to be a combination of:

- primarily slope instability – this is associated with the large slip within the Awataha Marae;
- seasonal soil shrink-swell movement beneath the station's pad; and
- possibly a component of soil bearing capacity failure beneath the station foundation.

Within our report of November 2007 several options were presented to improve stability of the pump station, including fill replacement, drainage, buttressing and Palisade wall.

Council has indicated a Palisade wall is the preferred stability improvement option as it offers the greatest security to the asset. Design recommendations for the Palisade wall are presented in Section 8.0 below.

7.2 Slope Stability

As previously outlined, the eastern portion of the Awataha Marae has been affected by mass instability. This instability encompasses the Kitewao Pump Station (which is located on public reserve), and its approximate extent is shown on the attached RILEY Dwg: 98191/1-10.

Movement of the slip would appear to be largely creep-type movement, with small, slow episodic progress. The slip is probably moving at differing rates across the feature and in a complex manner.

It is considered likely the slip is an ancient feature. Locally, slips within similar terrain and geology have been noted by RILEY; for example, near the intersection of Northcote and Kitewao Roads and also near the YMCA on Northcote Road.

Our previous investigation of 2007 inferred failure depths in the order of 3.7m to 5m below ground surface. The current investigation has identified the failure depth at between 3m and 8m below ground surface (based on soil recovered from the boreholes and inclinometer records). It should be noted the failure surface would appear to increase in depth to the south as the ground level climbs, so the failure surface would appear to be roughly level at approximately RL 0m, leading to the depth of failure varying beneath the slip.

We do note the inclinometer reading showing deflection to approximately 6.5m depth is only a single reading and the deflection measured over the majority of length is slight, at less than 1mm; however, the deflection does exceed the measuring tolerance for the inclinometer probe (at 0.02mm). Further monitoring of this inclinometer is required and at this time a third reading is programmed for September 2009.

We have also attempted to evaluate the failure plane depth by the use of balanced cross sections. This method requires reconstruction of the slope prior to failure and an estimate of downslope deflection so an estimate of failure depth can be made. Using this method for section A, we estimate a failure depth of 6.25m at the position of MH2. This is in close agreement with the recent inclinometer result.

On all cross sections the inferred failure surface is relatively flat, e.g. on section A (RILEY Dwg: 98191/1-11) the basal failure plane is inclined at 3° to 4° downslope. For failure to be occurring on such a flat surface, in addition to a relatively gentle slope, the soil strength parameters along the failure plane are likely to be extremely low. However, the flat nature of the failure plane likely restricts the movement to slow creep. Such a flat surface will be highly sensitive to groundwater pressures, thus a moderate reduction in groundwater pressures will likely result in a significant increase in stability.

Stability analyses, as further discussed in the following section, indicate strength parameters on the failure plane typically expected for residual values, i.e. the soil has previously failed and is in a weakened state. This is consistent with an old slip which is subject to periodic movement. The test pit observations, which including warping of an organic silt horizon upslope of the failure plane (TP1) indicate the slip to be old. In addition, fill profiles within TP2 also indicate a previous failure through fill and then re-application of further fill to the headscarp. The age of the fill placement is unknown.

The piezometer monitoring undertaken in the deep machine boreholes has not recorded groundwater levels at or near ground surface, although within 2m over the northern portion of the slip feature. However, based on the inclinometer reading it would appear some creep movement of the slip has occurred. It is uncertain as to whether the creep occurred under prevailing groundwater conditions, or whether this movement occurred during a peak in groundwater levels, possibly following a recent storm event.

It is, however, considered likely the affected slope has a Factor of Safety (FoS) against instability of approximately 1.0 when groundwater is at the surface, i.e. ground saturation. (Note: the FoS is a ratio of forces resisting instability over those driving. A FoS of 1.0 indicated imminent failure. A FoS>1.5 is typically considered acceptable for long term stability.)

7.3 Contributing Factors of Instability

Based on our investigations to date and subsequent stability analyses, we consider the following factors as being contributory to the observed instability. We have attempted to list the factors in order of importance.

1. Weak soils to significant depth.
2. High groundwater levels.
3. Fill surcharge, both on the marae land and around the pump station.
4. Toe excavation, either through natural erosion of the stream channel or creation of the stormwater treatment pond.

Other contributing factors, which are difficult to quantify their importance, include stormwater discharge and leakage into the slope from both private and public lines, along with leakage from previous damaged sanitary sewer lines.

With respect to sewer lines, a section has been re-diverted in 2007 clear of the main inferred movement zone and an existing line abandoned. However, the inclinometer indicates movement since that time. Thus, the sewer leakage may not be a significant contributing factor.

Stormwater discharge into the affected area may be a significant factor. In particular, stormwater runoff from the sealed car park within the marae, which appears to be discharged to a soakage type pit downslope within the slip area. As this area downslope of the car park is an existing low point, it is possible high groundwater levels would exist without the car park discharge following storm events.

A possible contributing factor to the damaged pump station is the weight of the station itself applying surcharge loading to the slope below.

7.4 Stability Analyses

A series of stability analyses have been undertaken to assess current stability and also quantitatively assess the relative impact of the major contributing factors.

Analyses have been undertaken along section A (RILEY Dwg: 98191/1-11) through the area of noted recent movement. Similar analyses were undertaken in 2007; however, the model has been updated with the latest subsurface investigation, with the most significant difference being a remodelling of the inferred failure plane, which is flatter than previously modelled.

A summary of results for analyses along section A is summarised in Table 2 below.

Table 2: Summary of Stability Analyses along Section A

Section	Groundwater	Comment	FoS
A	Saturation	Inferred original slope prior to fill placement and pond formation	1.29
A	Saturation	Following placement of fill, but prior to pond formation.	1.09
A	Saturation	Existing ground profile with pond.	1.03
A	At 1.0m below ground surface	Sensitivity analyses with respect to lowering groundwater level	1.31
A	Saturation	Failure plane friction angle reduced from 14° to 13°	0.99

Printouts from the stability analyses are provided in Appendix A.

Despite a revised subsurface profile the analysis results are still similar to those obtained using the 2007 model. The most significant difference is the 2009 model is more sensitive to fill placement than the 2007 model.

The relative quantitative effect of the main contributing factors to instability are summarised below:

- groundwater rising 1m to surface -21% to calculated FoS;
- placement of existing fill surcharge -16%;
- excavation of pond at slope toe -6%; and
- decrease failure plane friction angle by 1° gives -4% to calculated FoS.

The analyses indicate the stormwater treatment pond formation lowered the calculated FoS. It should be noted the existing pond does not extend the full width of the slip feature; thus, its destabilising influence may be restricted to approximately the centre third of the slip width. It is also noted the ground was likely moving episodically prior to the pond formation and this structure has only had a minor influence over ground movement in the recent past.

The results indicate ground creep is likely with groundwater near surface, which is consistent with observations of the slope to date.

Without remedial options it is considered likely the slip feature across the Awataha Marae, incorporating the Kitewao Pump Station, will continue to undergo episodic creep movement. Following this, it is likely further damage to underground surfaces spanning the feature will continue and the pump station control building (and immediate surrounds) will continue to suffer damage.

8.0 Remedial Options

Following our reporting in 2007 we summarise below the options considered most practical for improvement of stability and protection against further damage.

8.1 Pump Station

The protection option preferred by Council for the pump station is construction of a Palisade wall isolating the structure from the surrounding slip.

A possible wall alignment is shown on attached RILEY Dwg: 98191/1-13.

For design of the wall we make the following recommendations:

- piles be bored and cast in-situ;
- groundwater may seep into the hole and soil collapse was noted in RILEY hand augers, thus, casing should be allowed for;
- all piles should be tied together by a capping beam;
- piles should be designed for an in-ground retained height of 4m and at rest earth pressures (Ko) assuming a friction angle (Φ') of 24°;
- a soil unit weight (γ) of 17kN/m^3 can be assumed;
- for embedment a friction angle of 25° can be assumed, or alternatively, if using Brom's solution, an un-drained shear strength of 50kPa;
- the alignment should minimise risk to existing services; and
- allowance for reduction in passive resistance due to a close pile spacing.

Stability analysis on section B (as attached) indicates a wall as designed will locally improve the FoS against slope movement to in excess of 1.5 for the pump station.

It is recommended wall construction be undertaken in summer, when groundwater levels are lowest. Regardless, provision should be made for placing concrete underwater, as pumping the holes dry may promote hole collapse, or in a worst case scenario, ground settlement.

There is likely to be practical difficulties in construction of the palisade wall in close proximity to the pump station and wet well due to the pipe network.

It would be expected in these ground conditions the piles should extend to a depth of at least 10m below existing ground surface.

Following construction of a Palisade wall some ground movement affecting the station can be expected to continue as a result of seasonal soil shrink-swell in combination with the station's shallow foundation pad; but a catastrophic slope failure is prevented and, in addition, slope creep should be arrested.

8.2 Slip in Awataha Marae

The most practical option for a significant improvement in stability of the affected marae land is a combination of preventing water discharge to the slope and installation of subsurface drainage.

It is recommended all lines in the vicinity of the slip feature be checked for possible rupture and/or leakage. Any damaged lines should be repaired. Stormwater runoff from surfaces should be collected and discharged to a safe point clear of the slip, such as the existing pond.

Stability analyses demonstrate the slip is highly sensitive and a significant improvement in stability can be achieved with a modest reduction in groundwater level. However, this is largely reliant on relieving groundwater pressures on the failure plane. As the inferred failure plane is typically lower than the slope toe, simple gravity drainage from a trench will not likely be entirely effective. It may be possible to extend wells from the trench base into the failure zone. This can be done by a suitable excavator with an auger.

There is a risk that subsurface drainage in the pump station vicinity will cause soil consolidation, exacerbating existing station tilt. It is recommended any drainage be set back from the station. With the station protected by a Palisade wall, subsurface drainage in close proximity to the station is not considered necessary and thus, a setback can be achieved.

The slope is largely covered in grass and suitable for drainage works. There are some areas of more intense tree growth and the counterfort drains will need to be aligned to minimise impact on these areas.

Assuming eight counterfort drains, each 30m long at 10m spacing across the slip within the marae, to depths of up to 5m and with wells off the base, the construction cost is estimated at between $80,000 and $100,000 (excluding GST).

9.0 Conclusions

On the information collected to date, the Kitewao Pump Station and adjacent eastern portion of the Awataha Marae is being affected be relatively deep-seated ground movement. The station would appear to be at the northern margin of the slip. This movement is inferred to be occurring on a weak horizon in the underlying alluvium, at about 3m to 8m in depth. The failure plane is very gently dipping east and is at about RL 0m.

The slip is inferred to be ancient in origin. However, stability of the feature has been detrimentally affected by human activities such as filling, toe excavation and discharge of collected stormwater/wastewater into the affected area.

Due to the flat slope and failure plane gradient, along with the past history, rapid large-scale movement is considered unlikely and not an obvious risk. Continuing creep movement is considered most likely. It would appear the central portion of the slip has been affected by creep movement during the period of the current study.

At the present time, the major contributing factors to continuing instability are considered to be, in order of importance:

1. High groundwater (possibly influenced by stormwater infiltration).
2. Fill surcharge (weight of fill previously placed on the slope).
3. Toe excavation (stormwater treatment pond).

As the slope and failure plane are relatively flat, stability of the slip is likely to be highly sensitive to groundwater level change, and this is reflected in the stability analyses results. As first priority, public and private stormwater lines and systems should be checked and efforts made to reduce infiltration. To further significantly improve stability of the slopes within the marae land, subsurface drainage, in the form of counterfort drains, is recommended. To adequately drain the affected area within the marae could be in the order of $80,000 to $100,000 (excluding GST).

The risk of catastrophic loss of the pump station is considered low in the medium term; however, its stability under extreme events (e.g. significant storms or earthquake) could be marginal. It is recommended the structure be protected by a Palisade wall, effectively isolating the ground beneath the station from the surrounding slip. Design recommendations based on the recent investigation are given in the report. Following construction of a Palisade wall, some ground movement affecting the station can be expected to continue as a result of seasonal soil shrink-swell, in combination with the station's shallow foundation pad, but a catastrophic slope failure is prevented and, in addition, slope creep should be arrested.

Alternatively, as the risk of catastrophic failure is considered low in the medium term, the continuation of monitoring could be implemented to assess whether the slip is accelerating or otherwise.

10.0 Limitation

This report has been prepared solely for the benefit of North Shore City Council as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

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

During excavation and construction the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation and the modification of the design is based upon this report.

Riley Consultants Ltd would be pleased to provide this service to North Shore City Council and believes that the project would benefit from such continuity. In any event, it is essential that Riley Consultants Ltd is contacted if there is any variation in subsoil conditions from those described in the report as it may affect the design parameters recommended in the report.

APPENDIX A

Stability Analyses

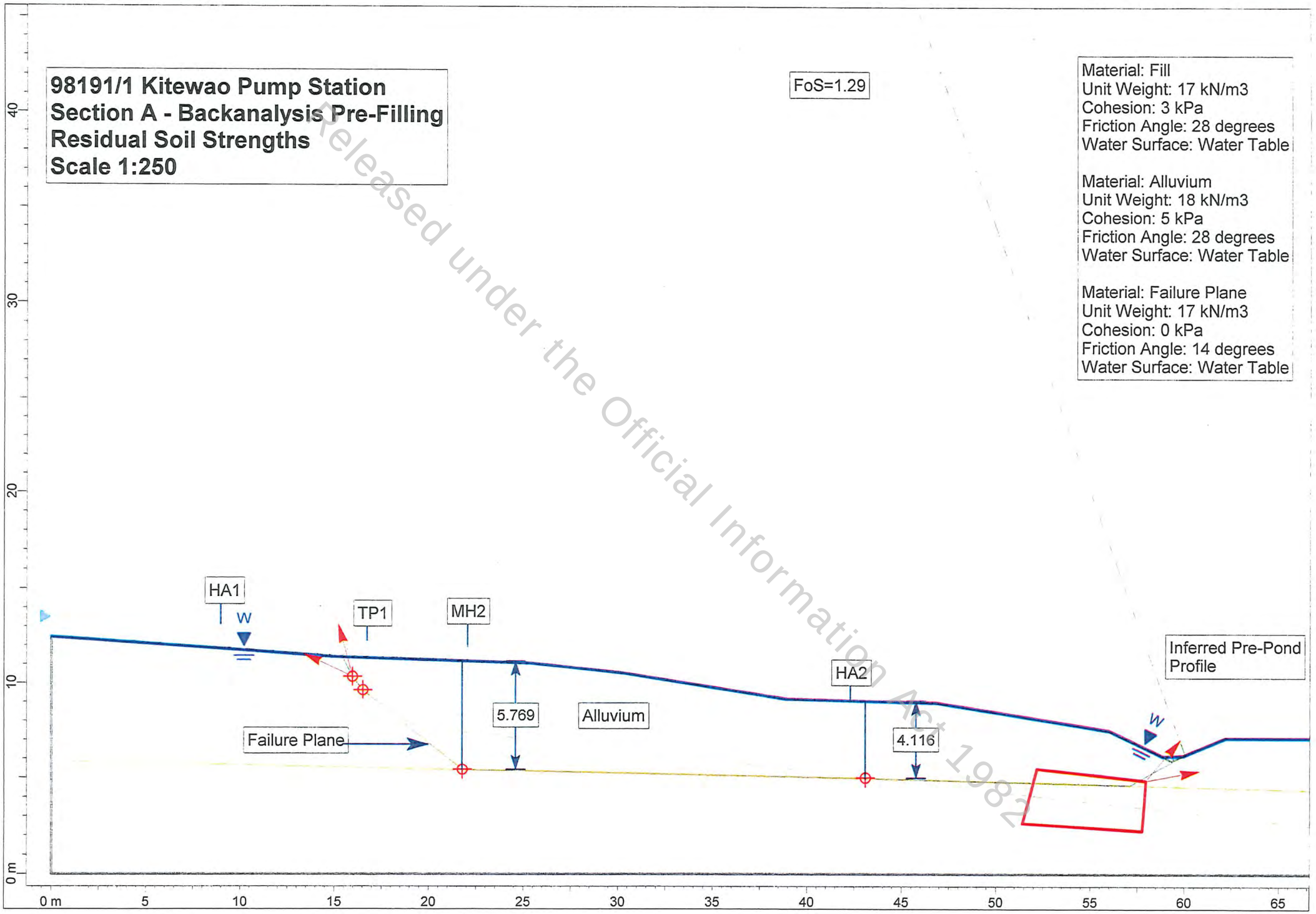
98191/1 Kitewao Pump Station
Section A - Backanalysis Pre-Filling
Residual Soil Strengths
Scale 1:250

FoS=1.29

Material: Fill
Unit Weight: 17 kN/m3
Cohesion: 3 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

Material: Alluvium
Unit Weight: 18 kN/m3
Cohesion: 5 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

Material: Failure Plane
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 14 degrees
Water Surface: Water Table



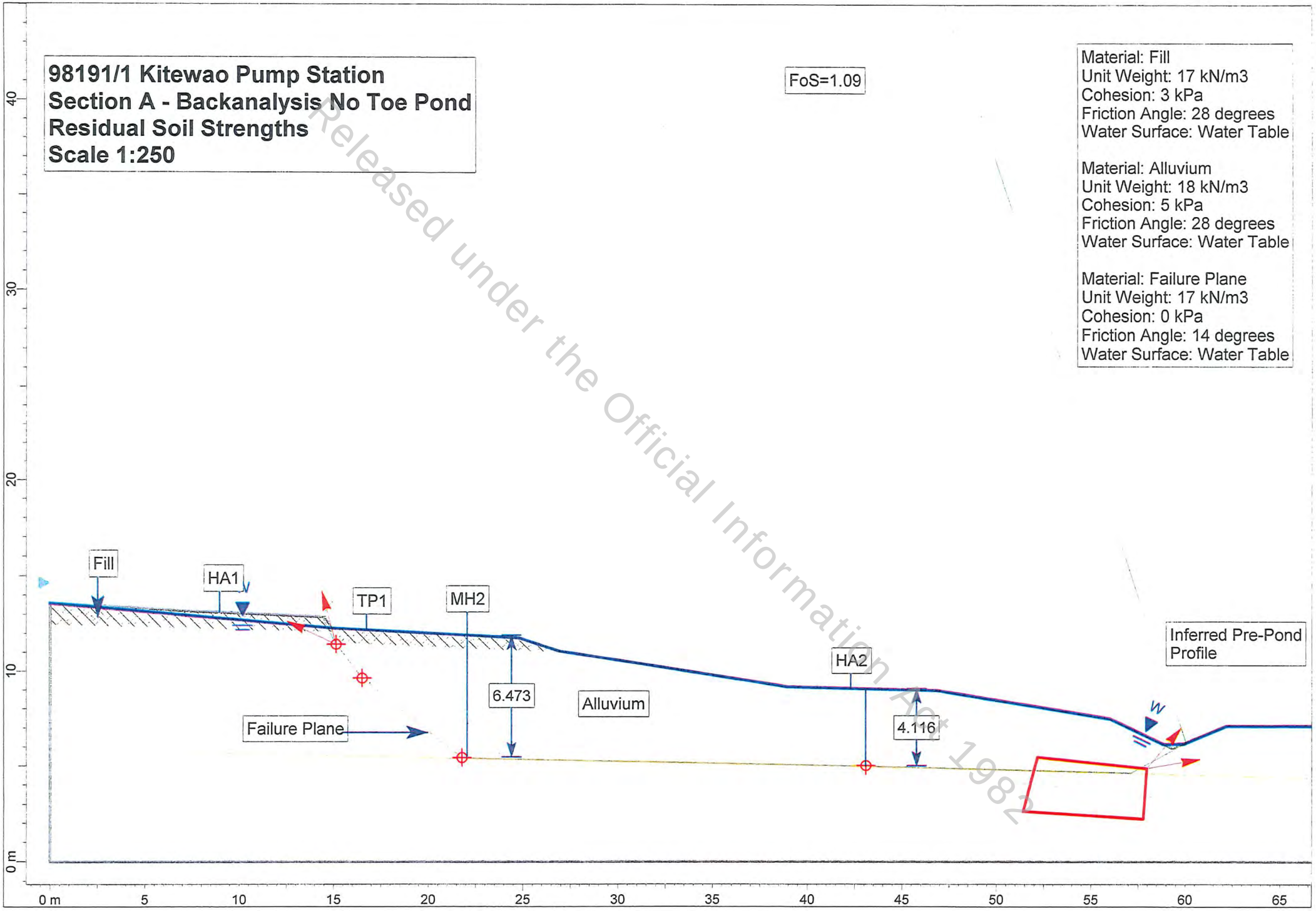
98191/1 Kitewao Pump Station
Section A - Backanalysis No Toe Pond
Residual Soil Strengths
Scale 1:250

FoS=1.09

Material: Fill
Unit Weight: 17 kN/m3
Cohesion: 3 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

Material: Alluvium
Unit Weight: 18 kN/m3
Cohesion: 5 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

Material: Failure Plane
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 14 degrees
Water Surface: Water Table



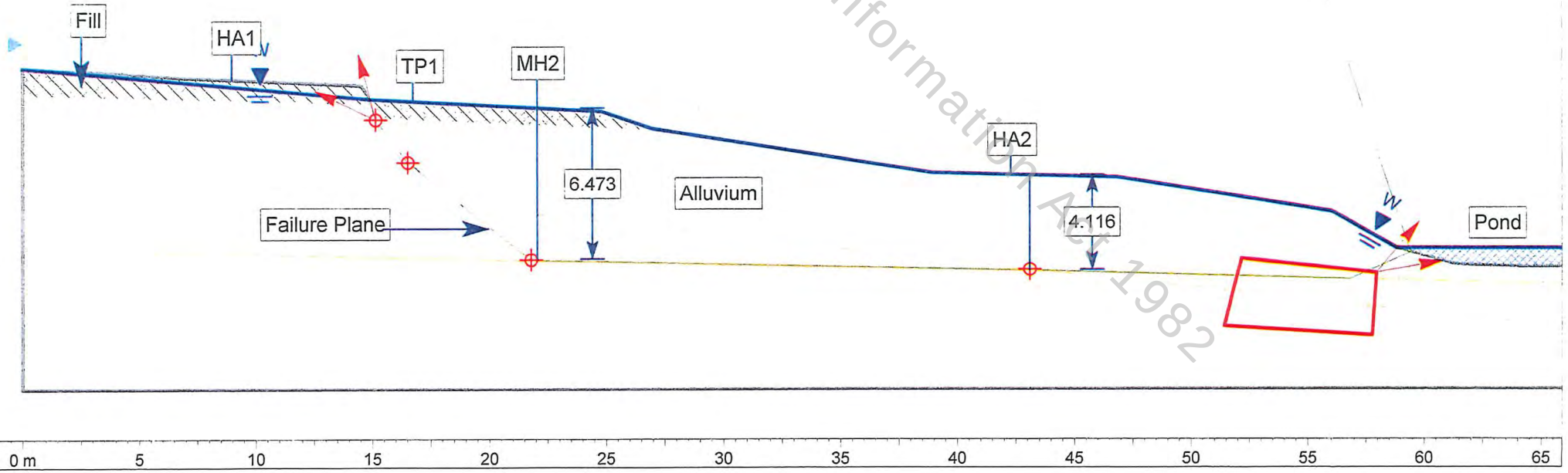
98191/1 Kitewao Pump Station
Section A - Backanalysis Current Profile
Residual Soil Strengths
Scale 1:250

FoS = 1.03

Material: Fill
Unit Weight: 17 kN/m3
Cohesion: 3 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

Material: Alluvium
Unit Weight: 18 kN/m3
Cohesion: 5 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

Material: Failure Plane
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 14 degrees
Water Surface: Water Table



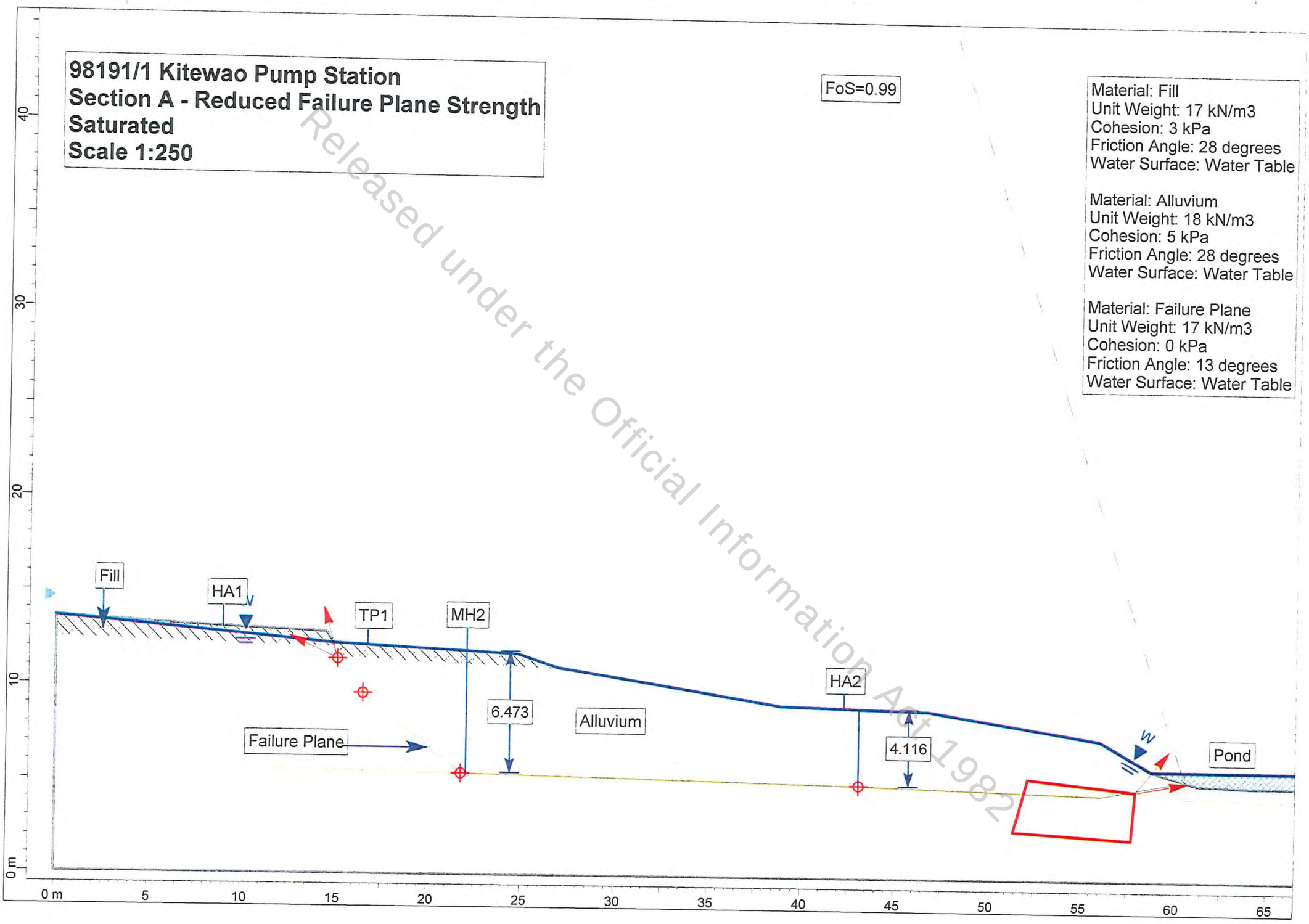
98191/1 Kitewao Pump Station
Section A - Reduced Failure Plane Strength
Saturated
Scale 1:250

FoS=0.99

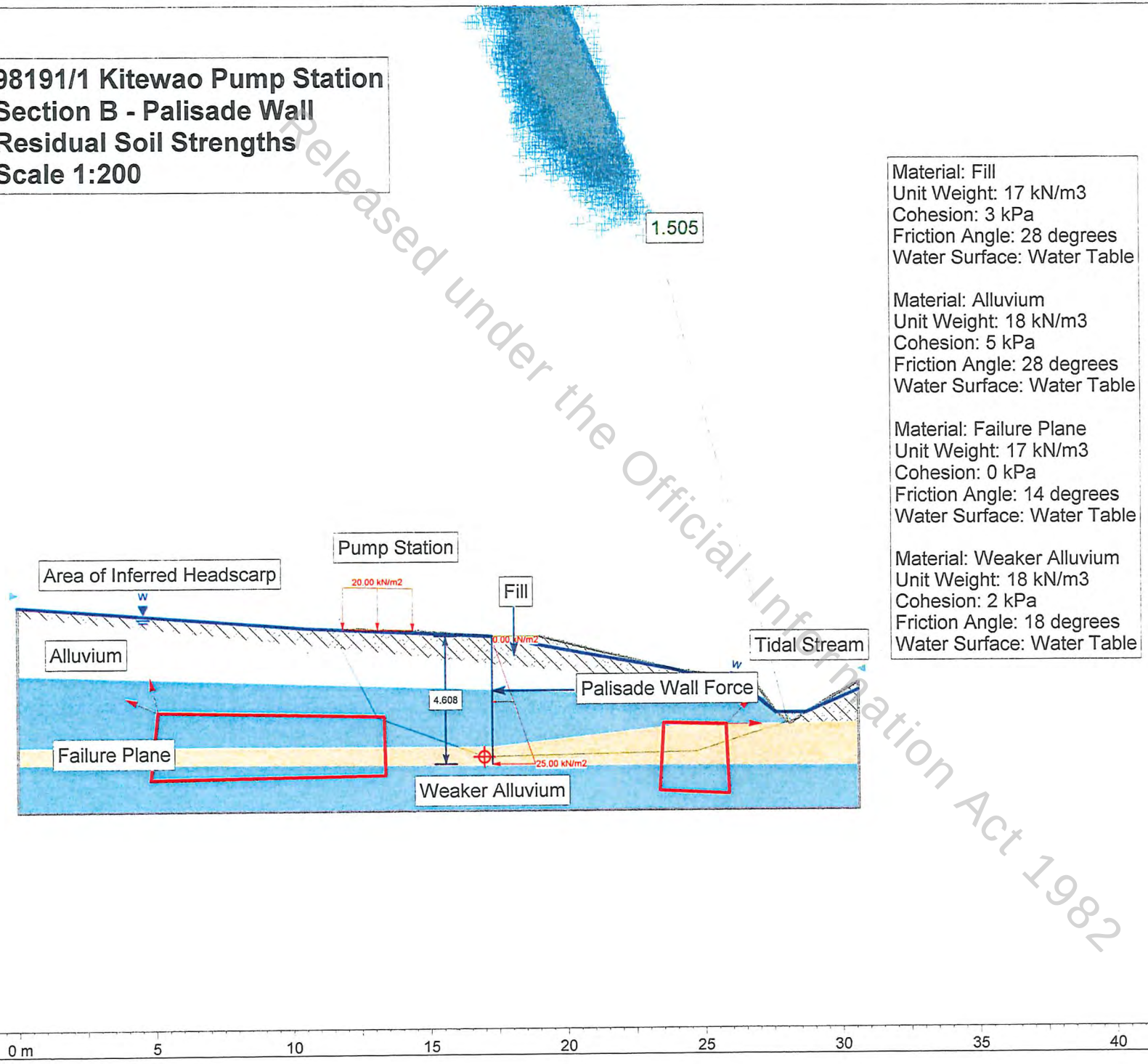
Material: Fill
Unit Weight: 17 kN/m3
Cohesion: 3 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

Material: Alluvium
Unit Weight: 18 kN/m3
Cohesion: 5 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

Material: Failure Plane
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 13 degrees
Water Surface: Water Table



98191/1 Kitewao Pump Station
Section B - Palisade Wall
Residual Soil Strengths
Scale 1:200



Material: Fill
Unit Weight: 17 kN/m3
Cohesion: 3 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

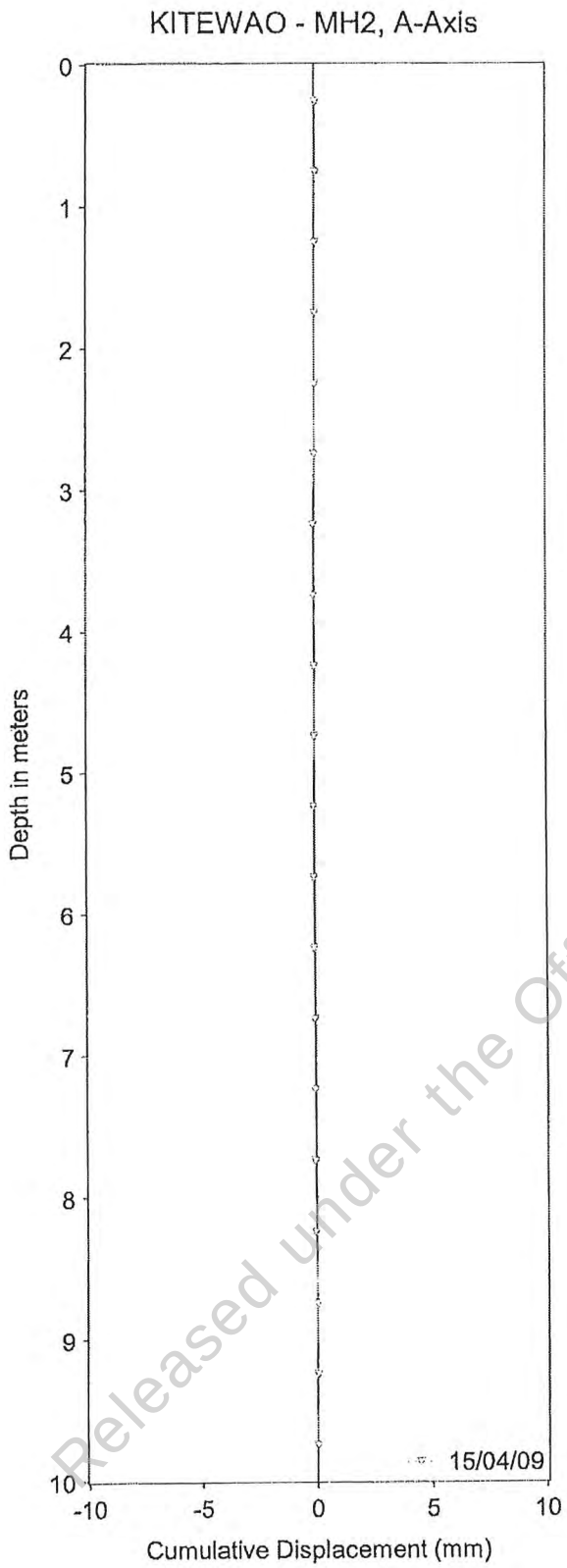
Material: Alluvium
Unit Weight: 18 kN/m3
Cohesion: 5 kPa
Friction Angle: 28 degrees
Water Surface: Water Table

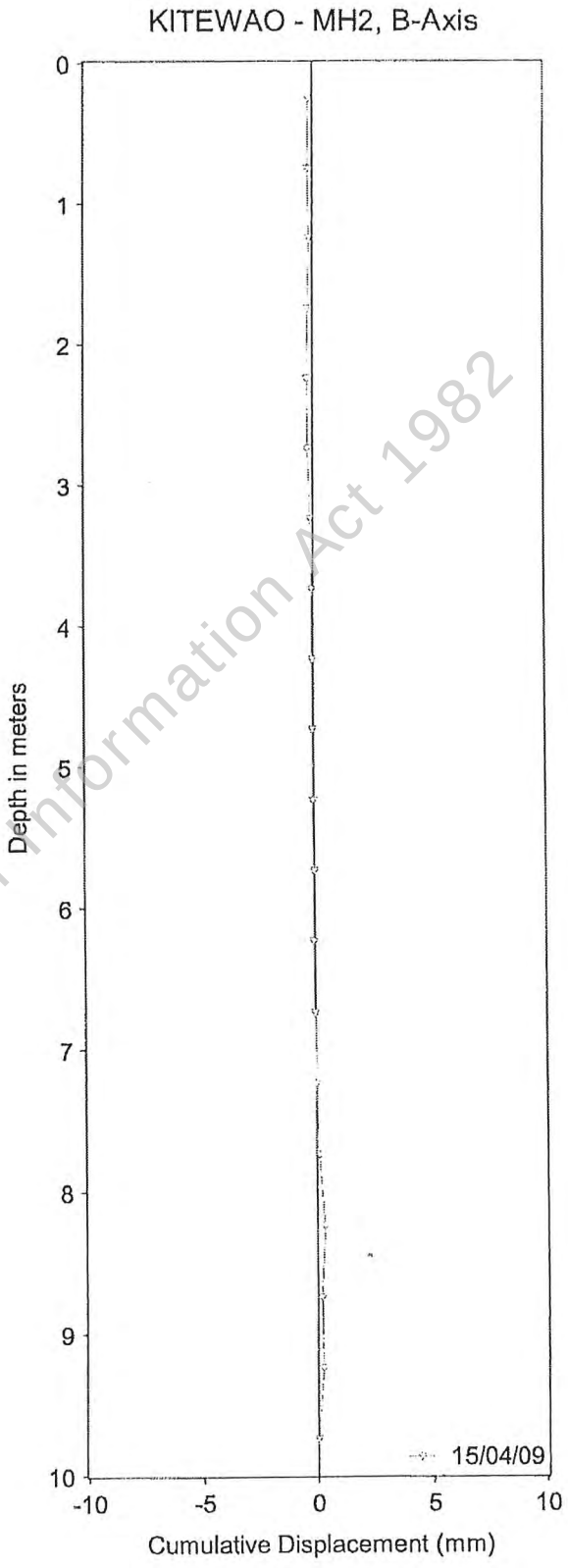
Material: Failure Plane
Unit Weight: 17 kN/m3
Cohesion: 0 kPa
Friction Angle: 14 degrees
Water Surface: Water Table

Material: Weaker Alluvium
Unit Weight: 18 kN/m3
Cohesion: 2 kPa
Friction Angle: 18 degrees
Water Surface: Water Table

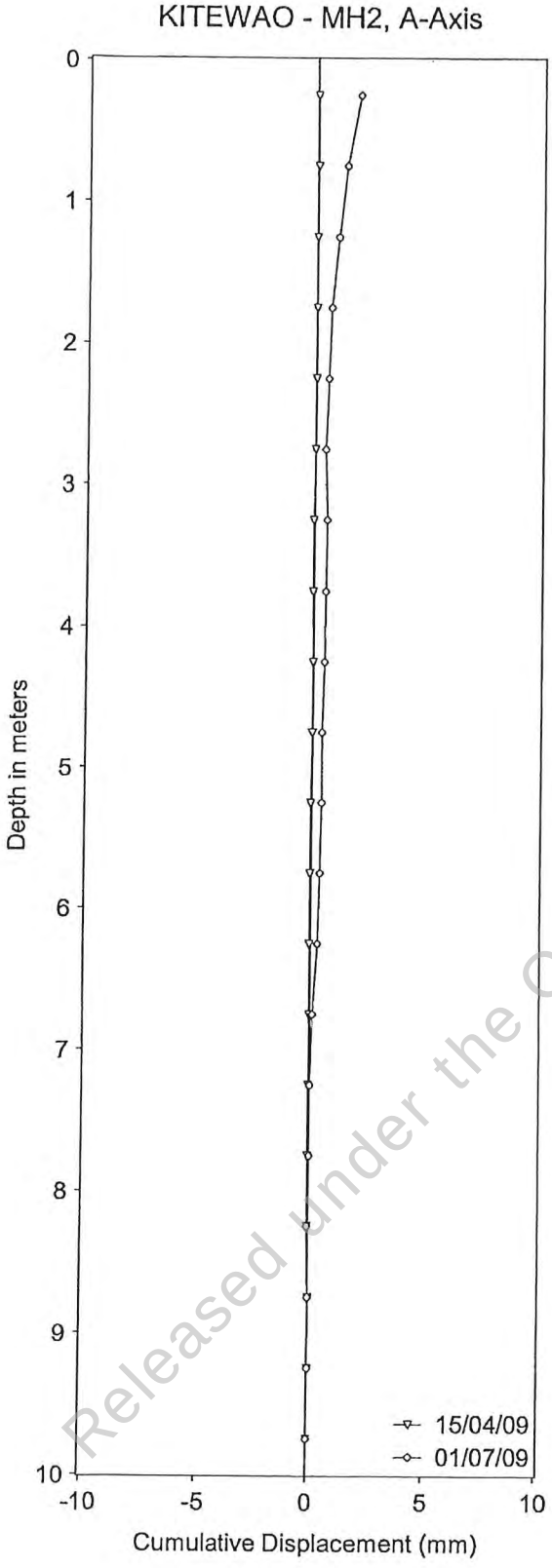
APPENDIX B

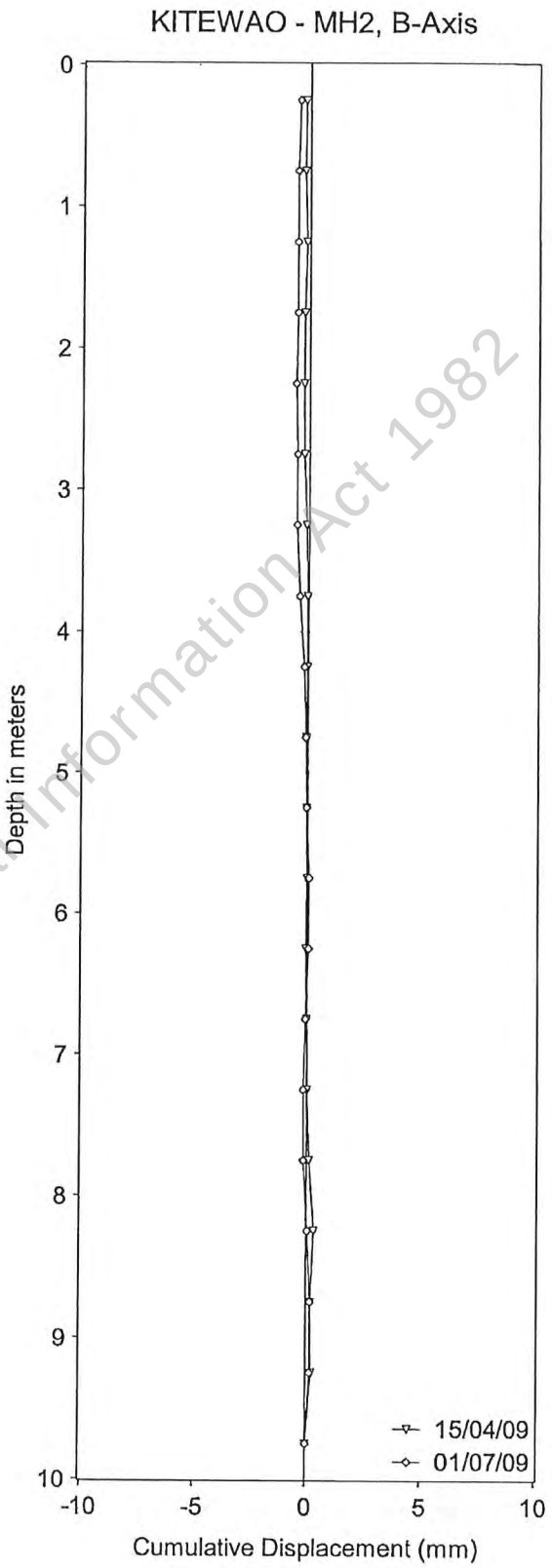
Inclinometer Results





Opus international Consultants	North Shore City Council
Auckland Laboratory	Kitewao Pump Station Stability
7A Ride Way	Lab Ref: 1-L0090.99 Test No. 058/09
North Harbour Industrial estate	Initial Data Set 15/04/09





Opus international Consultants	North Shore City Council
Auckland Laboratory	Kitewao Pump Station Stability
7A Ride Way	Lab Ref: 1-L0090.99 Test No. 076/09
North Harbour Industrial estate	Initial Data Set 15/04/09

APPENDIX C

Borehole and Test Pit Logs

RILEY CONSULTANTS
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DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Pump Station	MH1

Job No.:	Start Date: 02-04-09 Finish Date: 02-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	18.45 m			1 of 5

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)
	1	Fill	FILL; silt, minor clay, minor sand, trace gravel, firm, becoming stiff, gravel is sub angular to sub rounded, fine and medium, including scoria
	1.10	Auckland Volcanic Field	TUFF; clay with minor sand, minor gravel, bands of clay, gravel is angular to rounded, fine and medium, soft, slightly plastic, becomes wet
	2		
	2.00	Pleistocene Alluvium / Colluvium and Fan Deposits	SILT; minor clay, bands of some gravel(basaltic), light orangish brown to greyish brown
	2.50		
	2.60		organic(plant), fragments (50mm band)
			some clay, light grey, highly plastic
	2.90		minor sand (pumiceous)
	3		
	3.40		
	3.50		organic SILT; trace clay, black, non plastic
			SILT; some clay, light grey, highly plastic

Legend

Unified Symbol

Soil Shear Strength (kPa): 50 100 150 200

Drilling Method: HA; HQ OPEN BARREL

Core Recovery (%): 25 50 75

RQD (%)

Piezometer

Soil Moisture: M; MW; M

Groundwater

Samples

Lab Testing: Water Content(%); Density (Mg/m3); Uniaxial Comp Strength (kPa); Lab Comments

Field Testing: SPT 2.00 m 0, 0, 0; N=0; V= 88 R= 31 SPT 3.00 m 0, 0, 1; N=1; V= 49 R= 18

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP: 0 m; 25 m; 1:2,500; 50 m

Remarks

Piezo Installed
1.00 to 5.10 m: Backfill - Screen

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

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RILEY CONSULTANTS
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Riley Consultants Ltd
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Takapuna, AKL
Tel: 09 4897872
Fax: 09 4897873

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Pump Station	MH1

Job No.:	Start Date: 02-04-09 Finish Date: 02-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	18.45 m			2 of 5

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Water Content(%)	Lab Testing: Density (Mg/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Lab Comments	Field Testing
			SILT; some clay, light grey, highly plastic *(continued)*				HQ OPEN BARREL											
	4.50		organic CLAY; some silt, black, highly plastic															V= 42 R= 16
	4.90		SILT; some clay, highly plastic, firm, light grey brown with fine gravel sized pockets of black organic clay															SPT 5.00 m 0, 0, 0; N=0
	5																	V= 52 R= 16
	6																	V= 62 R= 23 SPT 6.00 m 0, 1, 2; N=3
	6.15		organic CLAY; black, soft, highly plastic with occasional fine gravels including scoria															
	6.45	Pleistocene Alluvium / Colluvium and Fan Deposits	SILT; some clay, grey, moderately plastic, firm to stiff, rare pockets, dark brown organic clay and fragments(wood/roots)															
	7																	V= 163 R= 11
	7.50		SILT; minor sand, green grey, stiff, non plastic															V= 225+ SPT 7.50 m 4, 7, 9; N=16
	7.95																	

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

- Scala Penetrometer - blows/50mm
- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Lugeon Test - Flow Type/Adopted Value
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP
0 m
25 m
1:2,500
50 m

Remarks

Piezo Installed
1.00 to 5.10 m: Backfill - Screen

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

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RILEY CONSULTANTS Engineers and Geologists
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DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Pump Station	MH1

Job No.:	Start Date: 02-04-09 Finish Date: 02-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	18.45 m			3 of 5

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Water Content(%)	Lab Testing: Density (Mg/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Lab Comments	Field Testing
		Pleistocene Alluvium / Colluvium and Fan Deposits	SILT; some clay, green grey, slightly plastic, firm to stiff *(continued)*				HQ OPEN BARREL											V= 85 R= 16
	8.90		becomes grey brown															V= 131 R= 24 SPT 9.00 m 0, 0, 2; N=2
	9 9.00 9.05		with scoria gravel, fine to coarse subangular															
	9.40		organic CLAY; dark brown, firm, highly plastic															
	9.50		organic SILT/CLAY; firm, friable, non plastic (like peat)								M							
	9.95		CLAY/SILT; grey brown, highly plastic, firm, occasional organic fragments (wood/roots) + organic clay															
	10		SILT; some clay, green grey, firm, moderately plastic becoming slightly plastic within SPT - 1-2mm black roots (10.5-10.95m)															V= 114 R= 16
	10.95																	V= 196 R= 33 SPT 10.50 m 4, 4, 6; N=10
	11 11.20		SILT; some clay, occasional gravel, moderatley plastic, firm, grey brown, gravel is fine to coarse sub angular to sub rounded including scoria, rare pockets of dark brown organic material															
			SILT; minor clay, trace sand, slightly plastic, grey brown, firm 11.45 m - 11.60 m band of sandy SILT; grey, non plastic, friable															V= 196 R= 33 V= 98

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP
0 m
25 m
1:2,500
50 m

Remarks

Piezo Installed
1.00 to 5.10 m: Backfill - Screen

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

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RILEY CONSULTANTS Engineers and Geologists
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Fax: 09 4897873

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Pump Station	MH1

Job No.:	Start Date: 02-04-09 Finish Date: 02-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	18.45 m			4 of 5

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Water Content(%)	Lab Testing: Density (Mg/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Lab Comments	Field Testing
	12.20																	R=20 SPT 12.00 m 2, 4, 9; N=13
		Pleistocene Alluvium / Colluvium and Fan Deposits	SILT; minor sand, friable, stiff, grey with occasional green blue mottles, non plastic with pockets of fine to minor sand with occasional rootlets preserved clasts of hard, friable fine sandstone/siltstone				HQ OPEN BARREL											
	13																	V= 225+
			13.50 m - 13.95 m SPT recovered as dense, fine to medium sand, green grey															SPT 13.50 m 11, 21, 29/145mm; N=50+
	14		13.95 m - 15.30 m no recovery in SPT															
	15																	SPT 15.00 m 15, 8, 8; N=16
	15.30		SILT; with trace sand, minor clay, grey brown, moderately plastic, firm															
	15.35		recovered as dense, fine to medium sand, grey in colour															
	15.95																	V= 131

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP
0 m
25 m
1:2,500
50 m

Remarks

Piezo Installed
1.00 to 5.10 m: Backfill - Screen

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

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DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Pump Station	MH1

Job No.:	Start Date: 02-04-09 Finish Date: 02-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	18.45 m			5 of 5

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Water Content(%)	Lab Testing: Density (Mg/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Lab Comments	Field Testing
		Pleistocene Alluvium / Colluvium and Fan Deposits	SILT; with trace clay, trace sand, green grey, slightly plastic, stiff, clasts/pockets of friable sandy silt/silty sand (hard) *(continued)*				HQ OPEN BARREL											R= 20 N= 180 R= 49 SPT 16.50 m 2, 4, 4; N=8
	16.90																	
	17		SILT; some clay, moderately plastic, stiff, green grey															N= 147 R= 36
	18		18.00 m - 18.10 m with abundant clasts, green grey sandstone/siltstone															N= 121 R= 49 SPT 18.00 m 3, 5, 7; N=12
	18.45																	
			EOH @ 18.45 m															
	19																	

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and
Rise Time (minutes)

MAP
0 m
25 m
1:2,500
50 m

Remarks

Piezo Installed
1.00 to 5.10 m: Backfill - Screen

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

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RILEY CONSULTANTS
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DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Awataha Marae	MH2

Job No.:	Start Date: 03-04-09 Finish Date: 03-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	10.45 m	90°		1 of 3

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Water Content(%)	Lab Testing: Density (Mg/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Lab Comments	Field Testing
	1	Fill	FILL; silt, minor clay, minor sand, trace gravel, firm, becoming stiff, gravel is sub angular to sub rounded, fine and medium, including scoria				HA				M							V= 114 R= 24 V= 16 R= 0
	1.60																	
	2		SILT; minor clay, grey brown, slightly to moderately plastic, soft to firm, organic odour, becoming dark grey, occasional fine to medium sized scoria gravels															
	2.00																	V= 65 R= 29 SPT 2.00 m 0, 0, 2; N=2
	3	Tauranga Group	organic SILT; some clay, trace sand, brown grey, highly plastic, soft, occasional fine to medium sub angular gravel - scoria				HQ OPEN BARREL											V= 33 R= 13 SPT 3.00 m 0, 0, 0; N=0
	3.20										MW							
			SILT; some clay, trace sand, highly plastic, soft, blue grey in colour with streaks/pockets of brown possible organic sand and clay with rootlets															V= 29

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP
0 m
25 m
1:2,500
50 m

Remarks

Inclinometer tube installed to 10.0m depth

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

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RILEY CONSULTANTS Engineers and Geologists
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Fax: 09 4897873

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Awataha Marae	MH2

Job No.:	Start Date: 03-04-09 Finish Date: 03-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	10.45 m	90°		2 of 3

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Water Content(%)	Lab Testing: Density (Mg/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Lab Comments	Field Testing
	4.30	Tauranga Group	SILT; minor clay, minor sand, highly plastic, very soft, dark grey with pocekts of brown and grey sub angular scoria				HQ OPEN BARREL				M							R= 8 V= 29 R= 8 SPT 4.50 m 0, 0, 0; N=0
	5.45	Auckland Volcanic Field	TUFF; sandy silt; some gravel, dark grey, non plastic soft, gravel is fine to medium scoria, some hard/dense areas								W							gravels
	6.20		organic CLAY; some silt, highly plastic, soft with pockets of grey tuff including scoria and fine sub angular orange brown gravel below 6.45 - becomes dense brown/black organic								M							SPT 6.00 m 0, 0, 0; N=0
	6.60		CLAY; some silt, highly plastic, firm, grey															
	7.00	Tauranga Group	CLAY; some silt, highly plastic, firm, moist, possible organic - brown with rare lignite/coal fragments															V= 73 R= 24
	7.30		silty fine SAND; light grey and brown mottled, crumbly															
	7.50 7.55		GRAVEL; grey, sub angular scoria								W							UTP SPT 7.50 m 1, 0, 2; N=2
			organic CLAY/SILT; highly plastic, soft to firm, dark brown becoming dark grey/black with occasional organic matter (roots, etc - peat like)															

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP 0 m 25 m 1:2,500 50 m

Remarks

Inclinometer tube installed to 10.0m depth

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

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RILEY CONSULTANTS Engineers and Geologists
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Tel: 09 4897872
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DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Awataha Marae	MH2

Job No.:	Start Date: 03-04-09 Finish Date: 03-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	10.45 m	90°		3 of 3

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Water Content(%)	Lab Testing: Density (Mg/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Lab Comments	Field Testing
			organic CLAY/SILT; highly plastic, soft to firm, dark brown becoming dark grey/black with occasional organic matter (roots, etc - peat like) *(continued)*															
			becomes brown															V= 62 R= 13
	9	Tauranga Group					HQ OPEN BARREL											V= 73 R= 29 SPT 9.00 m 2, 3, 3; N=6
	9.60		CLAY; some silt, highly plastic, firm, grey/blue grey with fragments/pockets, dark brown organic material															
	10																	V= 82 R= 29 SPT 10.00 m 2, 4, 5; N=9
	10.45		EOH @ 10.45 m															
	11																	

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP
0 m
25 m
1:2,500
50 m

Remarks

Inclinometer tube installed to 10.0m depth

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

RILEYAKL.GLB Log RILEY MH/DH (AKL) 98191-1.GPJ <<DrawingFile>> 15/07/2009 14:29 Produced by gINT Professional

RILEY CONSULTANTS Engineers and Geologists
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DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Awataha Marae	MH3

Job No.:	Start Date: 03-04-09 Finish Date: 03-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	10.00 m			1 of 3

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Water Content(%)	Lab Testing: Density (Mg/m3)	Lab Testing: Unlaxial Comp Strength (kPa)	Lab Testing: Lab Comments	Field Testing
	1	Fill	FILL; silt, minor clay, minor sand, with occasional gravel, bands of orange brown/grey clay, gravel is sub angular, fine to medium of scoria				HA				D							
	1.10		FILL; weathered TUFF; silt with trace clay, trace sand, thinly laminated, firm, non plastic occasional rootlets, ocasional fine to medium SA scoria								DM							
	1.60		FILL; layers of topsoil															
	1.80		FILL; scoria gravels sub angular, abundant fine to coarse sized - tuff															
	2 2.00		FILL; silt, minor clay, trace sand, slightly plastic, firm, orange brown/grey															SPT 2.00 m 1, 1, 2; N=3
	2.40		2.45m - scoria gravel (blocked SPT so only 100mm recovered) below 2.45m red and grey streaks and occasional fine to medium sub angular gravels of scoria, becoming highly plastic				HQ OPEN BARREL											V= 33 R= 8 SPT 3.00 m 0, 1, 2; N=3
	3 3.20		FILL; silt with some clay and trace sand, highly plastic, soft with occasional fine to medium sub angular scoria gravel, grey brown, possible organic, organic odour															V= 13
	4.00																	

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP 0 m 25 m 1:2,500 50 m

Remarks

Multi-peizometer installed

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

RILEYAKL.GLB Log RILEY MH/DH (AKL) 98191-1.GPJ <<DrawingFile>> 15/07/2009 14:29 Produced by gINT Professional

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Tel: 09 4897872
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DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Awataha Marae	MH3

Job No.:	Start Date: 03-04-09 Finish Date: 03-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	10.00 m			2 of 3

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)
	4.45	Fill	FILL; silt, minor clay, minor sand, highly plastic, firm, grey brown, organic odour, occasional, locally abundant scoria
	4.90	Fill	4.45m - fragment of wood
	4.95	Fill	4.9m - piece of wire
5	5.05	Tauranga Group	SILT; some clay, highly plastic, firm, orange brown, slightly mottled light grey and red
	5.50	Tauranga Group	sandy SILT; occasional gravel, slightly plastic, soft to firm, green grey, gravel is fine sub angular possible scoria
	5.70	Tauranga Group	SILT; minor sand, trace clay, highly plastic, firm, purple brown
6	6.00	Tauranga Group	silty SAND; dense, purple brown colour with lenses/pockets of organic silt/clay or peat
		Tauranga Group	with lenses of brown, highly plastic organic clay
		Tauranga Group	becomes dark brown in colour
	6.60	Tauranga Group	
	6.70	Tauranga Group	6.6m - layer of peat, firm, fibrous, dark brown
	6.75	Tauranga Group	pumiceous sand
7	7.05	Tauranga Group	PEAT - dark brown, clayey, firm, slgihtly fibrous, mostly amphorous
		Tauranga Group	silty SAND; banded grey (pumiceous) and brown (possible organic), fine grained
	7.50	Tauranga Group	CLAY; some silt, highly plastic, firm, grey

Soil Shear Strength (kPa): 50 100 150 200
Core Recovery (%): 25 50 75
Drilling Method: HQ OPEN BARREL

Lab Testing: Water Content(%); Density (Mg/m3); Uniaxial Comp Strength (kPa); Lab Comments

Field Testing:
R= 0
V= 95 R= 41 SPT 4.50 m 2, 3, 4; N=7
SPT 6.30 m 1, 2, 10; N=12
V= 82 R= 20 SPT 7.80 m 1, 2, 2; N=4

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

- Scala Penetrometer - blows/50mm
- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Lugeon Test - Flow Type/Adopted Value
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP: 0 m, 25 m, 50 m, 1:2,500

Remarks
Multi-peizometer installed

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

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DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote	Awataha Marae	MH3

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
98191/1	03-04-09 / 03-04-09		

Client:	Hole Depth:	Angle from Horiz.:	Direction:	Sheet:
North Shore City Council	10.00 m			3 of 3

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)
	8.10		
			becomes brown
	8.40		
	8.50		silty SAND; pumiceous, grey brown, dense, light grey
		Tauranga Group	CLAY; minor silt, highly plastic, firm, dark brown/black - organic
	9		
	9.40		becomes lighter brown in colour
	10.00		
	10		EOH @ 10.00 m
	11		

Legend | Unified Symbol | Soil Shear Strength (kPa) 50 100 150 200 | Drilling Method: HQ OPEN BARREL | Core Recovery (%) 25 50 75 | RQD (%) | Piezometer | Soil Moisture | Groundwater | Samples

Lab Testing: Water Content(%) | Density (Mg/m3) | Uniaxial Comp Strength (kPa) | Lab Comments

Field Testing: V= 49 R= 8; V= 65 R= 16; V= 82 R= 29 SPT 9.50 m 0, 2, 2; N=4

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP 0 m 25 m 50 m 1:2,500

Remarks

Multi-peizometer installed

All dimensions in metres Scale 1:23	Driller: Pro-Drill	Rig Type: Wireline		Shear Vane No.: 4840	Logged by: LMB	Checked by: SLP

Job No.	98191/1
Project	KITEWAO
Borehole Location	HEAD SCARP
Surface Elevation	
Surface Conditions	GRASS

LOG OF TEST PIT TP 1

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
FILL/TUFF?	SILT; trace clay, orange, slightly plastic.		ML			M					
	SILT; trace clay, trace sand, grey, orange staining.				St			V79 R24			
				1	F			V35 R29			
ALLUVIUM	SILT; minor–some sand, predominantly brownish grey.		ML								
	Organic SILT; black, slightly plastic.		OL		St			V95 R35			
	SILT; some clay, brown, slightly–moderately plastic.		ML	2				V64 R17			groundwater entering under upper organic silt horizon.(estimated flow 1l/2min)
	SILT; minor–some sand, very light grey, non plastic.										
	Organic SILT; minor–some clay, slightly–moderately plastic, black.		OL	3							
	Sandy SILT; pumiceous, light grey, non plastic.		ML		H			UTP			
	Organic SILT; minor–some clay, slightly–moderately plastic, black.		OL	4	St			V62 R24			
	clayey SILT; medium brown, trace organic fragments, moderately plastic.		ML					V62 R24			
	E.O.T.P @ 5.5m			5				V60 R22			

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Near Refusal
- ☐ Refusal
- ☐ Flooding

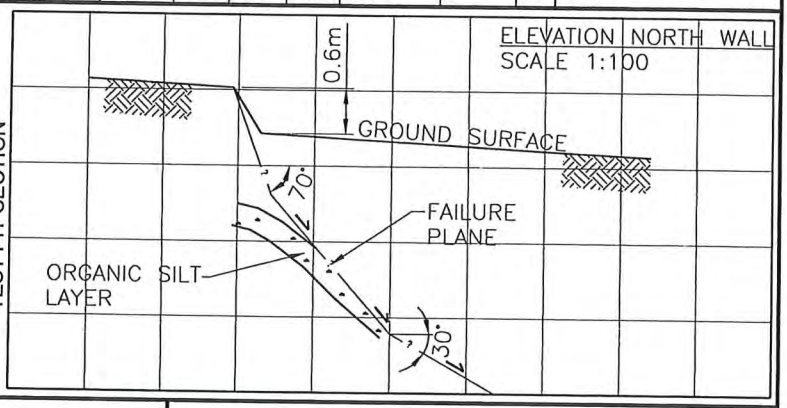
SAMPLE TYPE:

- B Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

TEST PIT SECTION



Date Logged	28/9/07
Logged By	MJB
Shear Vane No.	4840
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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TEST PIT LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote		TP2

Job No.:	Start Date: 03-04-09 Finish Date: 03-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Sheet:
North Shore City Council	4.40 m	1 of 1

Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Soil Moisture	Samples	Tests
	Fill	SILT; trace clay, non plastic, orange, light brown and grey.	D		
0.40	Fill	TOPSOIL; SILT; dark brown, non plastic.	D		
0.80	Fill	SILT; trace-minor clay, trace fine sand, light grey and orange.	M		V94
1.60	Taurnga Group	Clayey SILT.			V47
	Taurnga Group				V62
	Taurnga Group	Clayey, gravelly SILT; grey, free water.	S		
4.10	Taurnga Group				
4.30	Taurnga Group				
4.40	Taurnga Group	SILT; some clay, trace fine sand, medium grey, orange streaks, slightly-moderately plastic.	W		
		EOH @ 4.40 m			

Soil Shear Strength (kPa): 50 100 150 200
Scala Penetrometer (blows / 50 mm): 3 6 9 12 15
Groundwater

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER
- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO:
- ☐ Target depth
- ☐ Refusal

Remarks

All dimensions in metres Scale 1:27		Shear Vane No. 491	Logged by: MJB	Checked by:

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TEST PIT LOG

Project:	Location:	Hole position:	No.:
Kitewao Pump Station	Northcote		TP3

Job No.:	Start Date: 03-04-09 Finish Date: 03-04-09	Ground Level (m):	Co-Ordinates ():
98191/1			

Client:	Hole Depth:	Sheet:
North Shore City Council	4.15 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			SILT; trace clay, orange, brown, grey, non plastic.						D		
	0.30		TOPSOIL; SILT; dark brown, trace rootlets, non plastic.								
	0.70	Fill	SILT; minor clay, trace fine sand, light brownish grey, orange staining and topsoil staining/pockets.						M		V218+
	1										V164
	1.75		SILT; trace-minor clay, dark brown organic staining, occasional basalt gravel inclusions.								
	2										
	2.40		SILT; trace-minor clay, minor fine sand, light grey with blue tinge.								
	2.70	Tauranga Group	SILT; some clay, light grey, orange staining.						MW		V117
	3										
	3.80		SILT; minor-some clay, minor sand, grey.								
	4										
	4.00		SILT; minor clay, light grey, orange staining.								V80
	4.15		EOH @ 4.15 m								

Explanations:
Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER
- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO:
- ☐ Target depth
- ☐ Refusal

Remarks

All dimensions in metres Scale 1:27		Shear Vane No. 491	Logged by: MJB	Checked by:

RILEYAKL.GLB Log RILEY TP (AKL) 98191-1.GPJ <<DrawingFile>> 15/07/2009 14:27 Produced by gINT Professional

Job No.	07106
Project	AKORANGA DR SS REALIGNMENT
Borehole Location	2M OFF CARPARK
Surface Elevation	Elevation
Surface Conditions	Surface

LOG OF BOREHOLE HA1

(70mm ø HAND AUGER)

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
FILL	[TOPSOIL] SILT; dark brown, rootlets, non-plastic friable.					M					
	SILT; dark brown with dark red mottles, non-plastic friable.				H			V219+			
	SILT, trace clay; mixed orange and grey, non-plastic, rootlets.			1	VSt			V194 R59			
	SILT, some clay, trace fine sand; mixed grey, orange and dark reddish orange, dark angular gravels, moderately plastic.				St	M/W		V83 R24		AS MEASURED 16/3/07	
ALLUVIUM	SILT, minor clay; medium grey with orange staining, white and dark brown clasts, slightly plastic, rootlets.			2	VSt	W		V199 R19			
	silty SAND; dark brown, non-plastic.										
	SILT, minor clay, trace sand; dark grey, clasts <3mmø, non-slightly plastic.				St			V79 R43			
	hard cemented clasts <20mmø.										
	SILT, some clay, some gravel/grit/coarse sand; dark greenish grey, non-plastic.					S					
	SILT, minor to some gravels <15ø, minor fine sand; dark grey and grey, non-plastic.			3	H			UTP			
	E.O.B.H. @ 3.90m			4							
				5							

Date Logged	15/3/06
Logged By	JW/GJ
Shear Vane No.	4840
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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Job No.	98191/1
Project	KITEWAO
Borehole Location	7m NE OF SS MANHOLE
Surface Elevation	
Surface Conditions	GRASS

LOG OF BOREHOLE HA2

(70mm ø HAND AUGER)

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
	TOPSOIL.		OL			M					
	SILT; some clay, slightly–moderately plastic, orange with light grey staining.		ML		F			V47			
	light grey, minor gravels < 5mmø, limonite staining.			1	VSt			V158 R16		17/10/07	
	SILT; some clay, moderatley plastic, light grey.					W		V109 R16			Free Water
	Sandy SILT; pumiceous, very light grey, non plastic.			2				V158 R19			
	Organic SILT; minor–some clay, black.		OL		H			V218+			
	SILT; some sand, medium brown, non plastic.		ML	3	VSt			V140 R37			
	Organic SILT; some clay, minor wood fragments.		OL		St			V78 R62			
	SILT; some fine sand, whitish grey.		ML								
	Clayey SILT; moderatley plastic, very light grey, poor recovery.			4	F			V44 R11			
	E.O.B @ 4.1m No Recovery			5							

Date Logged	28/9/07
Logged By	MB/JM
Shear Vane No.	491
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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Job No.	No.
Project	AKORANGA DR SS REALIGNMENT
Test Location	2M OFF CARPARK
Logged By	GJ/JW
Date	15/3/07

SCALA PENETROMETER TEST RESULTS

BOREHOLE NUMBER	TABLE OF BLOWS PER 50mm INCREMENT							
	HA1	HA1	HA2					
Start Depth (m)	2.90m.	4.90m.	4.10m					
50	5	1	OWN					
100	2	1	WEIGHT					
150	1	2	1					
200	1	2	1					
250	2	2	2					
300	2	2	1					
350	1	2	2					
400	1	1	2					
450	2	2	2					
500	2	2	3					
550	2	2	3					
600	4	2	3					
650	3	3	3					
700	4	2	3					
750	3	3	2					
800	4	2	2					
850	4	3	2					
900	2	3	2					
950	2	2	3					
1000	1	2	3					
1050	1	2	2					
1100	1		2					
1150	1		2					
1200	↓		3					
1250	↓		2					
1300	↓ 1		3					
1350	1		2					
1400	1		4					
1450	1		3					
1500	2		5					
1550	4		5					
1600	5		5					
1650	5		5					
1700	5		4					
1750	4		5					
1800	2		5					
1850	3		6					
1900	2		6					
1950			7					
2000								
Finish Depth (m)	4.80m	4.95m	5.05m					

COMMENTS :

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APPENDIX D

Drawings

LEGEND

HA1 HAND AUGER LOCATION RILEY 2007

TP1 TEST PIT LOCATION RILEY 2007 & 2009

BH2 BOREHOLE LOCATION RILEY 1998

MH1 MACHINE BOREHOLE LOCATION RILEY 2009

SCARP

SANITARY SEWER PUMP STATION

STORMWATER TREATMENT POND

AUCKLAND – NORTHERN MOTORWAY

No. 25 KITEWAO STREET

No. 27 KITEWAO STREET

No. 22 KITEWAO STREET

PARKING AREA

MARAE BOUNDARY

EXISTING BUILDING

EXISTING BUILDING

EXISTING BUILDING

CONCRETE AREA

SCALE 1:500

0 5 10 15 20 30 (m)

0	FIRST ISSUE			DESIGN SLP	CHECKED	APPROVED FOR ISSUE:	
REV	DESCRIPTION	BY	DATE	DRAWN MB	CHECKED MJ	DATE: 11/9/09	
				DATE DRAWN JULY 2009			

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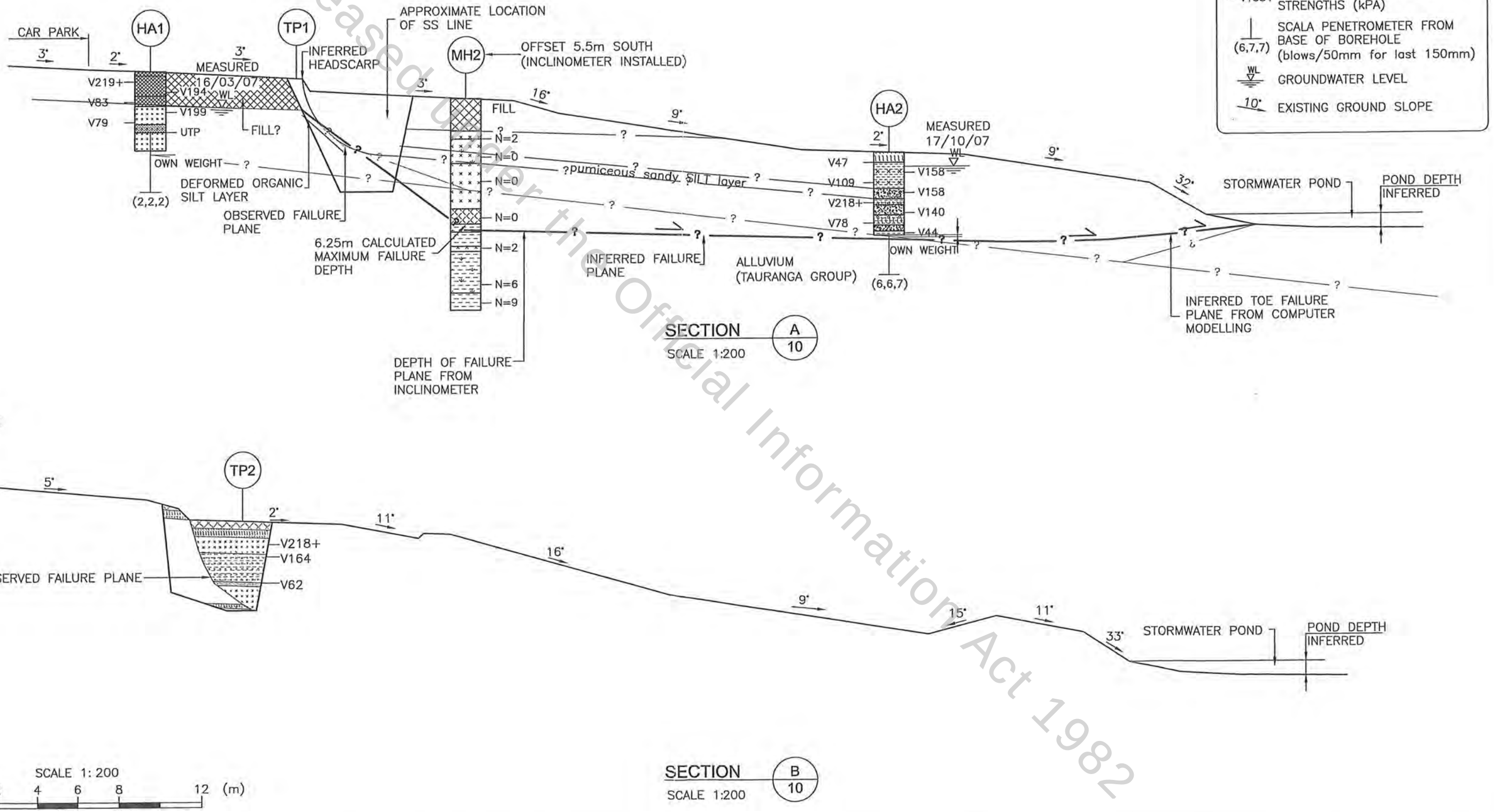
TITLE

NORTH SHORE CITY COUNCIL

KITEWAO PUMP STATION STABILITY, NORTHCOTE

GEOTECHNICAL INVESTIGATION - SITE PLAN

CADFILE 98191_1-10
SCALES (A3) 1:500
ACENZ
DRAWING No. 98191/1-10
REV. 0



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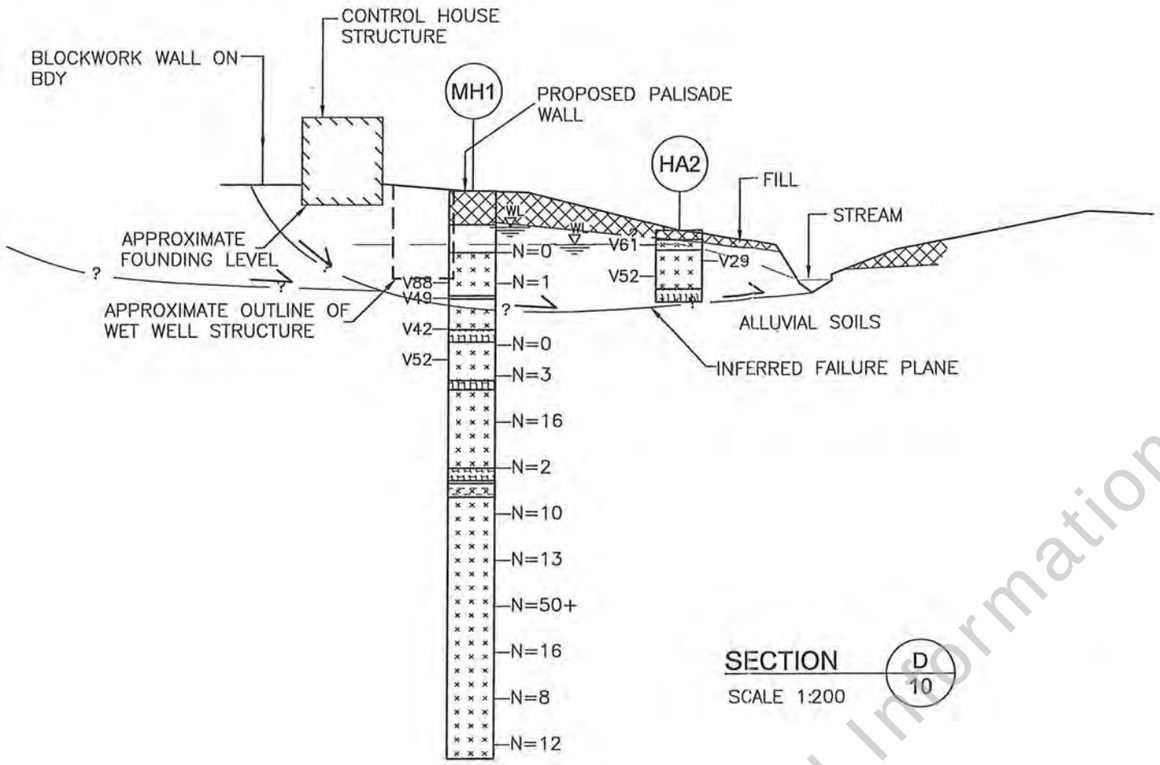
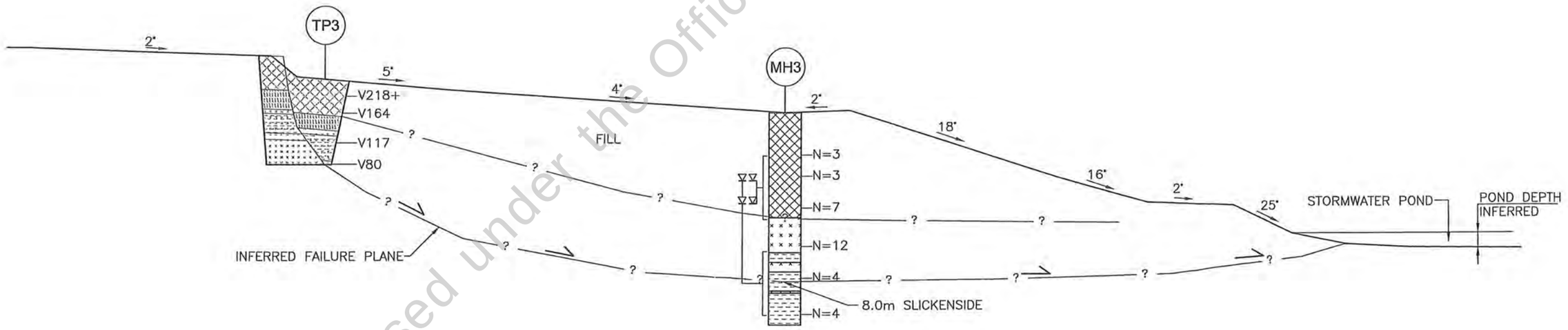
		DRAWN MJB	CHECKED MJ		P.O.BOX 100 253 N.S.M.C. AUCKLAND TEL. 09-4897872 FAX. 09-4897873	NORTH SHORE CITY COUNCIL KITEWAO PUMP STATION STABILITY, NORTHCOTE GEOTECHNICAL INVESTIGATION - CROSS SECTIONS A & B	SCALES (A3) 1:200
0	FIRST ISSUE			DATE: 11/9/09			ACENZ DRAWING No. 98191/1-11 REV. 0
REV	DESCRIPTION	BY	DATE	DATE DRAWN JULY 2009			



SECTION D / 10

SCALE 1:200



SECTION C / 10

SCALE 1:200

SCALE 1: 200

0 2 4 6 8 12 (m)

LEGEND

- HA1 — HAND AUGER LOCATION
- FILL
- CLAY
- SILT
- v188+ — INSITU UNDRAINED SHEAR STRENGTHS (kPA)
- (6,7,7) — SCALA PENETROMETER FROM BASE OF BOREHOLE (blows/50mm for last 150mm)
- GROUNDWATER LEVEL
- 10° — EXISTING GROUND SLOPE

REV	DESCRIPTION	BY	DATE
0	FIRST ISSUE		

DESIGN: SLP | CHECKED:
DRAWN: MJB | CHECKED: nd
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TITLE

NORTH SHORE CITY COUNCIL

KITEWAO PUMP STATION STABILITY, NORTHCOTE

GEOTECHNICAL INVESTIGATION - CROSS SECTIONS C & D

CADFILE: 98191_1-11&12
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