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CITY COUNCIL
Te Kaunihera o Ahuriri

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STRATEGY AND INFRASTRUCTURE COMMITTEE

Open Attachments Under Separate Cover

Meeting Date:	Tuesday 19 March 2019
Time:	3pm
Venue:	Council Chambers Hawke's Bay Regional Council 159 Dalton Street Napier

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Onekawa Park Development Plan

Overview

Vision

- NCC have an opportunity with the relocation of the Aquatic Centre to transform Onekawa Park into a recreational space loved by residents and supporting our community to be more active.

Overview

Suburb:	Onekawa
Location:	48, 50 Flanders Avenue
Total area of reserve:	8.5766 ha

This area was set aside in 1946 when the first part of Onekawa was planned for residential sites. Parts of the park were used for a dump whilst the remainder was leased for grazing purposes. The legacy from the dumping areas is all too evident in the form of broken glass, bricks and stones and other rubbish in the surface soil. Onekawa Park was chosen as the site for the Olympic Pool and this swimming complex was completed and opened in December 1964. Later, 12 all weather tennis courts were constructed next to the pool and these were opened for play in December 1966.

The courts were extensively renovated in 1990. The courts are also used in winter for netball. In 1974 the indoor heated pool was opened. Exhibition courts for netball and tennis were constructed in 1983.

The predominant uses are swimming all year round, tennis in summer and netball in winter. The park is also used as a neighbourhood reserve and children’s play area. A kindergarten occupies part of the reserve.

High Level Consultation Plan

An Onekawa Park Development Working Group will be established at the outset of the project, which will coordinate consultation on the Park's development as part of its role. The composition of this group should include representation from council, council officers and members from within the community.

Several layers of consultation will be implemented to ensure there are appropriate and relevant opportunities for the community and key stakeholders to contribute to development of Onekawa Park following relocation of the Napier Aquatic Centre.

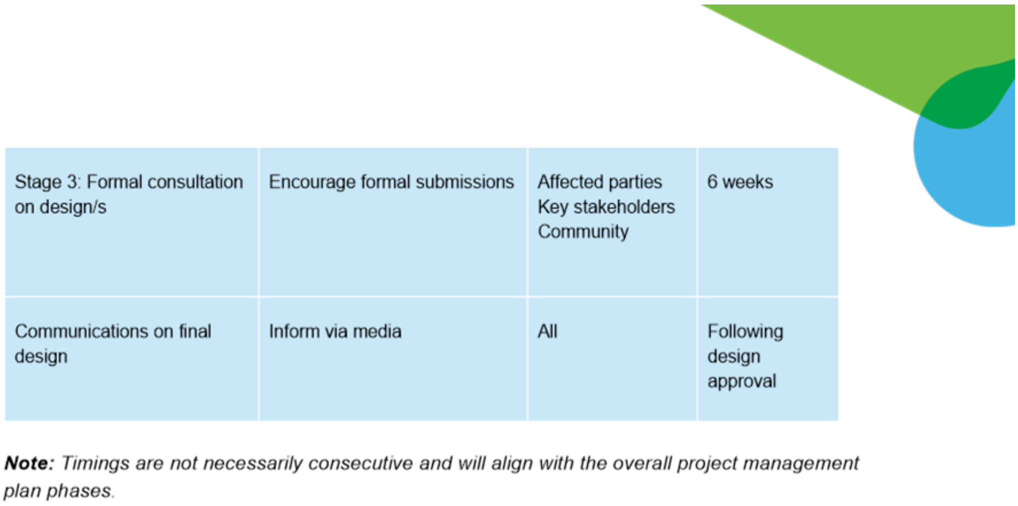
Key stakeholders to be engaged with during the masterplan development process include:

- Plunket
- Omni-gym
- Hawkes Bay Netball
- Onekawa Kindergarton
- Age Concern
- Cancer Society
- Disability Advisory Group
- Zeal
- Sport Hawke's Bay
- Local childcare centres
- Local schools (including Onekawa School, Saint Patrick's School, William Colenso College)
- Local businesses
- Local and neighbouring residents

It is anticipated there will be three stages of consultation – pre-engagement (informal), engagement (informal), and consultation (formal).

A detailed consultation plan will be required, which will identify the key stakeholder groups, specific timings and the tools to be used at each stage.

Consultation stage	**Focus**	**Audience**	**Timing**
Stage 1: Pre-engagement	Awareness raising Idea, theme generation	Working Group Key stakeholders Community	4-6 weeks
Stage 2: Engagement on concept/s	Awareness raising Feedback	Key stakeholders Community	4-6 weeks



Stage 3: Formal consultation on design/s	Encourage formal submissions	Affected parties Key stakeholders Community	6 weeks
Communications on final design	Inform via media	All	Following design approval

Note: *Timings are not necessarily consecutive and will align with the overall project management plan phases.*

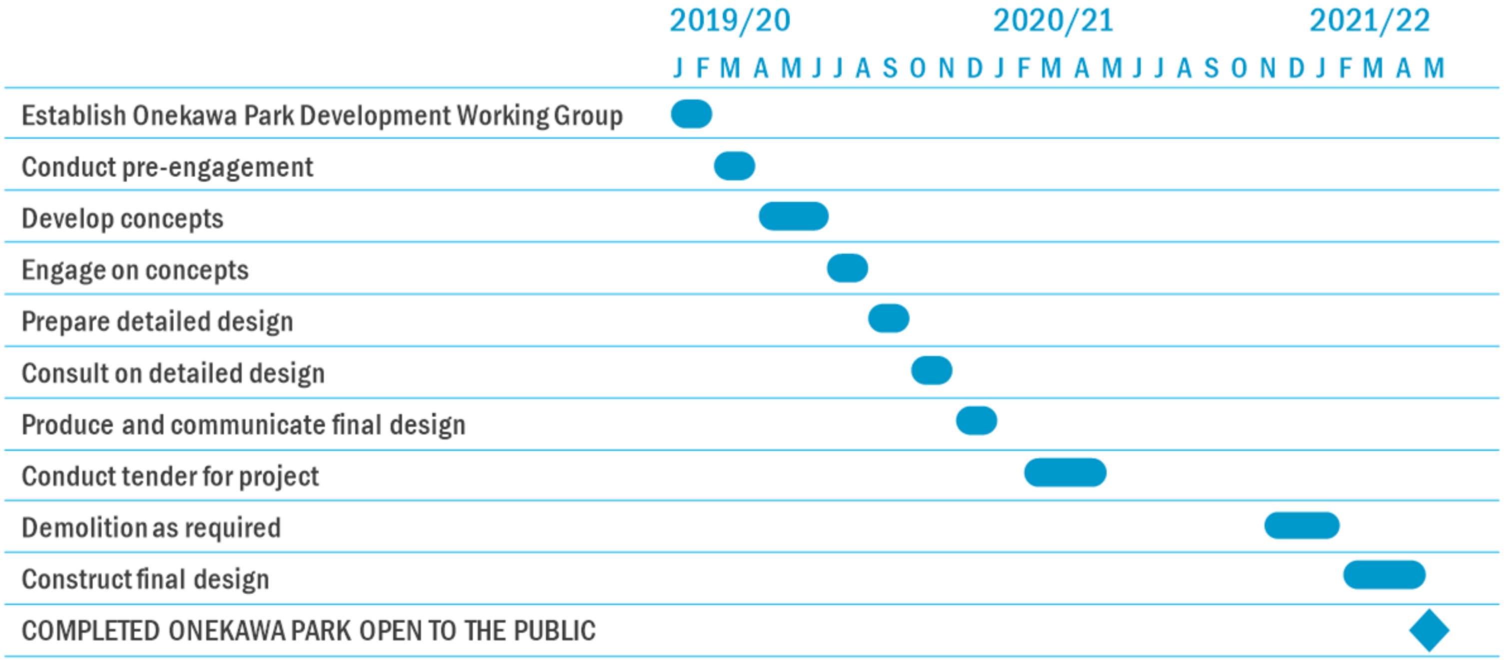
Project Funding

Included in the LTP budget is:

- $500,000 in the 2019/20 financial year for demolition of existing facility and returning the site to reserve. Project timeline delays will mean that this amount will need to be carried over to the following financial year when the completion of the new facility is now scheduled.
- $700,000 in 2023/24 financial year for implementation of the Master Plan for the reserve. It is intended to bring this forward to year one of the 2021/22 - 2031/32 Long Term Plan.
- Dependant on the master planning process, council vision for Onekawa and the community consultation, council will have the opportunity to review and allocate funding required.

Project Plan

ONEKAWA PARK DEVELOPMENT PLAN: Project Plan



Prepared March 2019

ONEKAWA PARK

What will stay?

A. Omni Gym
B. Kindergarten
C. Plunket
D. Netball courts
E. Carparking (enhanced)

Optional Enhancement

A. **Re-purpose Pool Buildings**
  - Indoor sport
  - Clubrooms
  - Education hub
  - Kapa haka
  - Community hall
  - Partnership opportunities
  - Other operators (i.e. ice rink)

B. Splash Pad (enhanced)

Other Opportunities

A. Children's / young adult play equipment
  - Playground
  - Skatebowl
  - Climbing structures

B. Improved Amenity / Greenspace
C. Passive & Active Recreation
  - Informal – walking, resting, biking, Tai chi, dog walking, scootering
  - Formal – Kī-O-Rahi, basketball, touch rugby, CrossFit.

WARREN AND MAHONEY®

NAPIER AQUATIC CENTRE

CONCEPT DESIGN

—

Revision 2.0

—

February 2019

DESIGN PRINCIPLES

WELLNESS

OPERATIONAL EFFICIENCY

→ A simple building arrangement allows separation of wet and dry components.

INTUITIVE & LEGIBLE

→ Hydroslides provide visual landmark for the facility from the main road.

→ Controlled glazing to the pool hall provides views to the park to the North West whilst controlling glare.

→ Fitness areas and studios are placed on display, activating outdoor space and providing visual beacon from State Highway 2

→ Visual connections provide passive surveillance of the shared green space and the car park and are a significant component of CPTED design for the facility

ACCESS

→ Public access provided from Tamatea Drive

→ Service access is to the South East of building

SOCIAL SPACE

→ A shared green / sporting space for the community to use

→ Park like nature, with grassed areas, picnic spaces, swing ball

SHELTER

→ External spaces are orientated to be protected from the prevailing nor-easterly wind

→ Afternoon sunshine is captured in west facing areas providing amenity for the cafe outdoor seating area and the shared green space

FUTURE FLEXIBILITY

→ Provision has been made to enable the construction of an additional pool to the east end of the pool hall in future.

SITE ANALYSIS

LOCATION PLAN

Not To Scale

DESIGN RESPONSE

SITE PLAN

Not To Scale

DESIGN RESPONSE

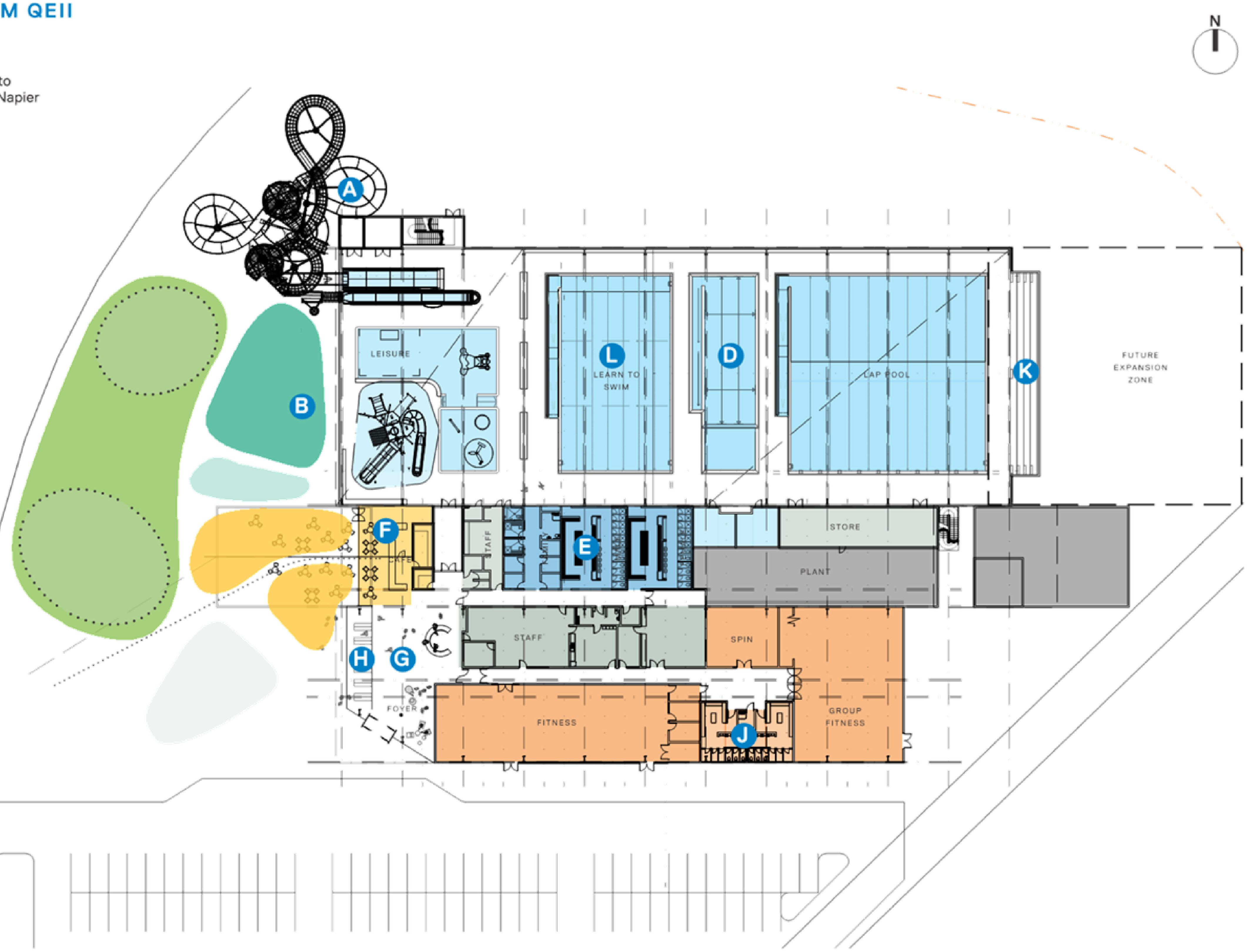
DESIGN CHANGES FROM QEII

1:500 @ A3

The following design changes and developments have been incorporated to respond to operator feedback and the Napier Aquatic Brief.

LEGEND:

- **A** SECOND BODY SLIDE ADDED TO PROVIDE A TOTAL OF TWO WATER SLIDES
- **B** FUTURE OUTDOOR AREA
- **C** DEEPER BODY OF WATER INCLUDED FOR BOMBING / AQUA CLIMBING IN MAIN POOL
- **D** WARM WATER POOL SPACES (WWP / SPA / SAUNA / STEAM) LOCATED CLOSER TO CHANGE ROOMS TO ALLOW SPACE FOR FUTURE POOL EXPANSION
- **E** CHANGING ROOMS ENLARGED AND WET / DRY SEPERATION ACHIEVED FOR BETTER OPERATIONAL OUTCOMES
- **F** CAFE WET LOUNGE CREATED ACCESSED FROM POOLSIDE
- **G** FOYER AND RECEPTION ADJUSTED TO RESPOND TO ENTRY FROM SOUTH.
- **H** RETAIL AREA CREATED ADJACENT TO THE FOYER SPACE FOR IMPROVED FLOW
- **J** DRY CHANGE ROOMS RE-PLANNED TO IMPROVE LAYOUT
- **K** SPECTATOR SEATING AREA INCREASED TO PROVIDE SEATING CAPACITY FOR APPROXIMATELY 250
- **L** ADDITIONAL TWO LANES ADDED TO LEARN TO SWIM POOL



DESIGN RESPONSE

OUTDOOR AREA: DRY SIDE ENTRY

The building entry faces the Tamatea Drive to the West and is immediately visible on approach creating a clear and legible entry sequence. This provides an opportunity to create an active civic address to the building which can be developed to provide a range of informal recreation opportunities.

The cafe location is designed to service the wet pool side and the dry side and will activate the main entrance by servicing a dry seating area adjacent to the foyer and an outdoor undercover seating area.

It is envisaged that the outdoor civic entry would be activated by integrating play, recreation and informal seating spaces into the landscape.

MAIN ENTRANCE

URBAN PLAY AREA

DRY SIDE CAFE

NATIVE PLANTING AND FENCING

SEATING PLATFORMS

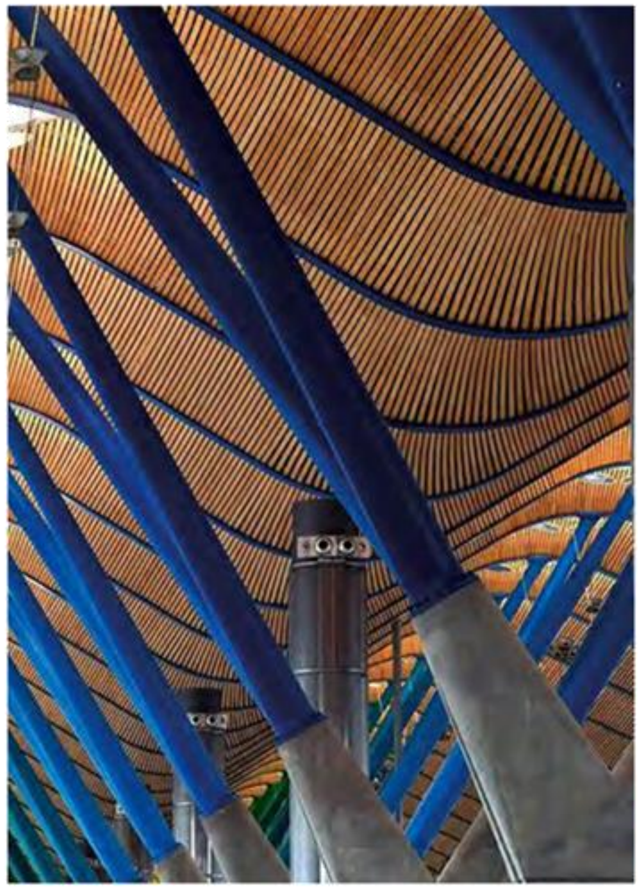
EXTERIOR MATERIALS

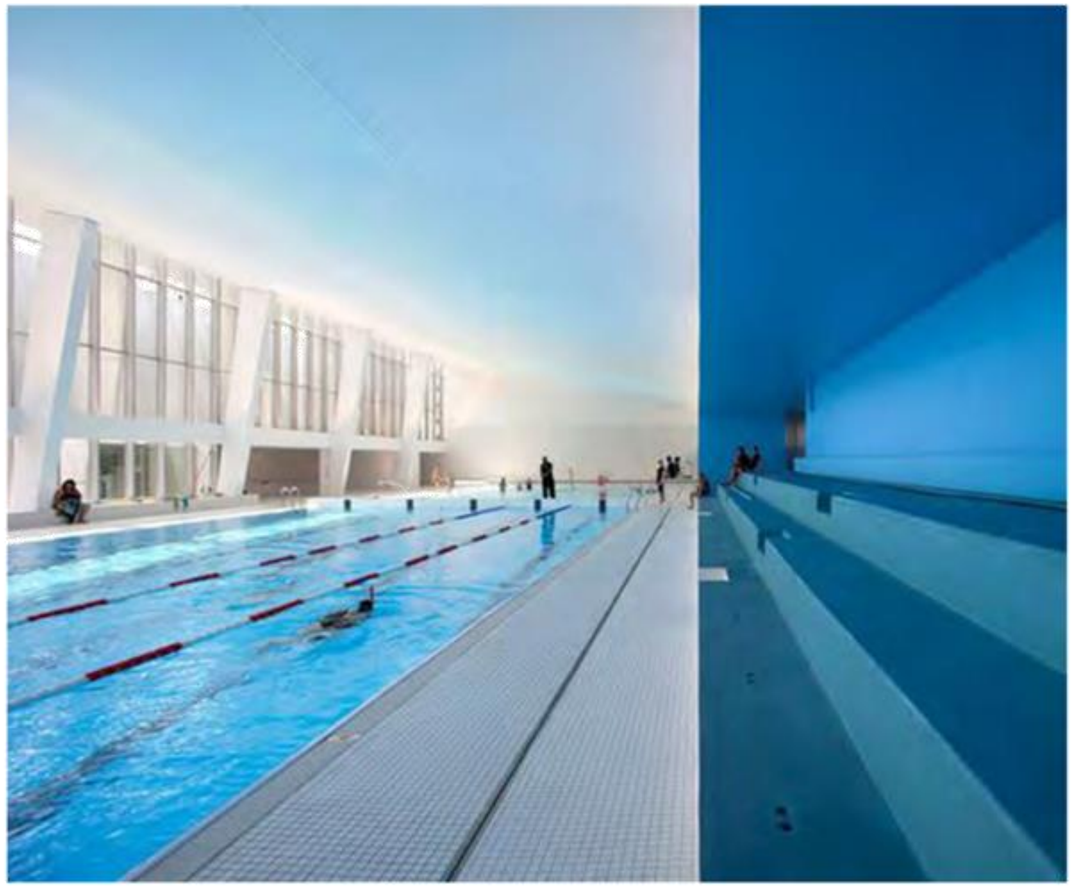
WHITE KINGSPAN PANEL

TRANSLUCENT POLYCARBONATE

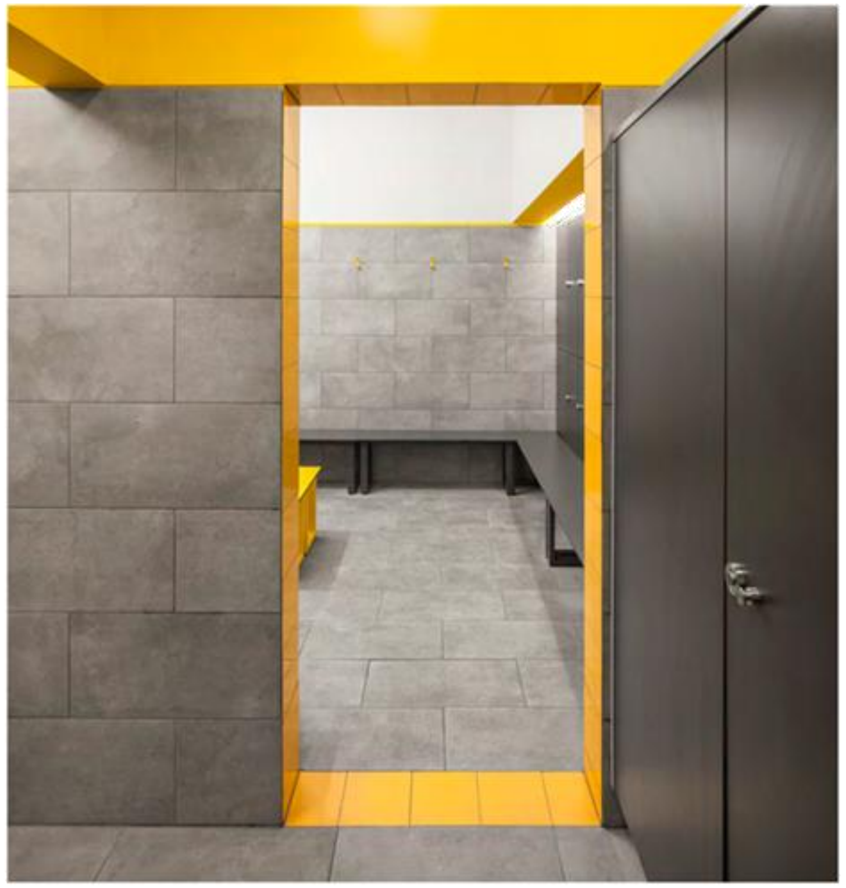
PRECAST CONCRETE

INTERIOR PRECEDENTS



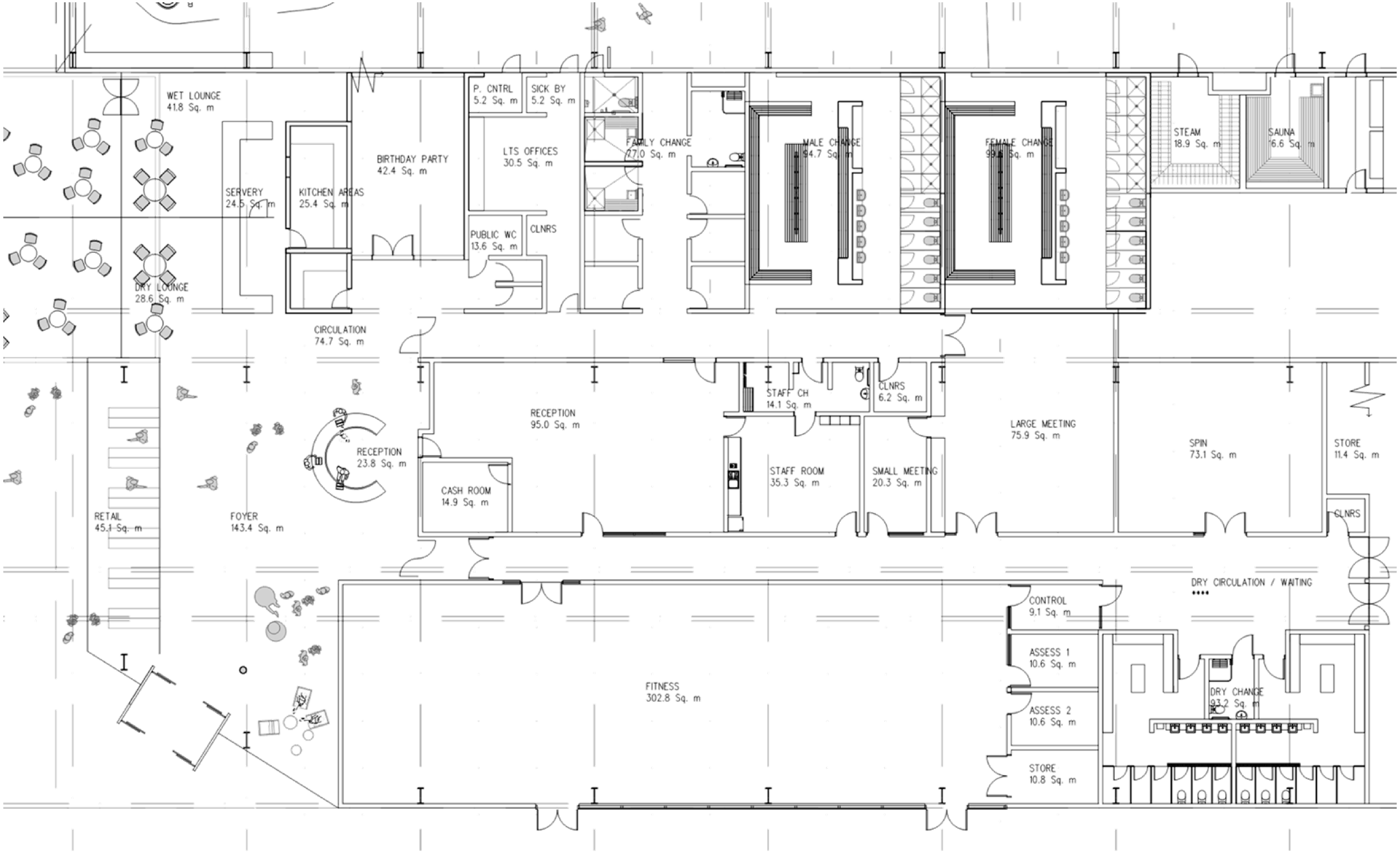


POOL HALL



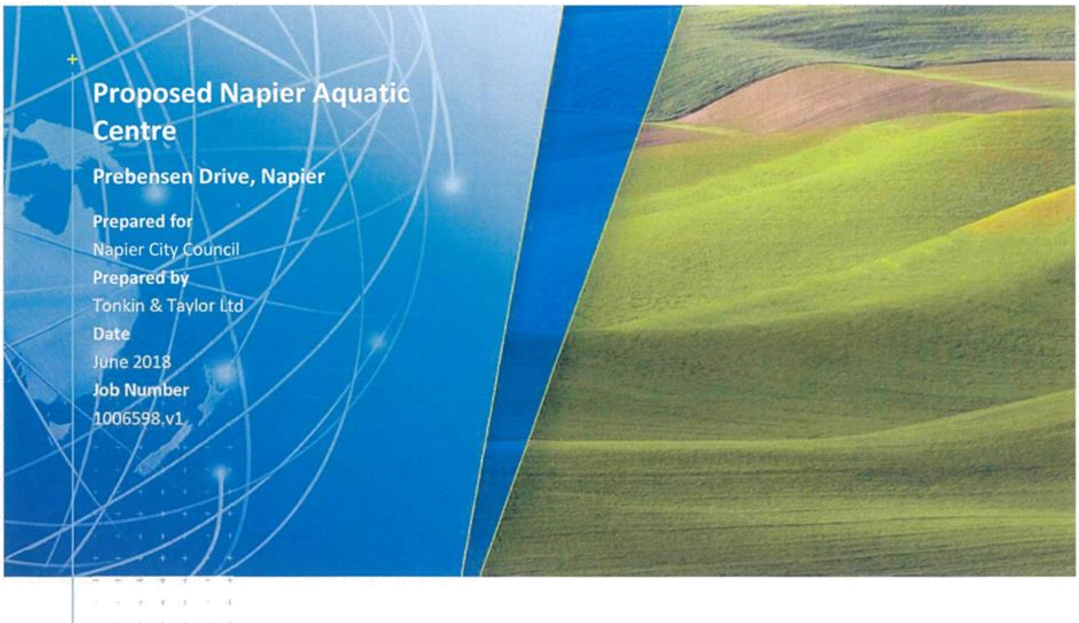
CHANGE BLOCK

MASSING


WET LOUNGE
41.8 Sq. m
SERVERY
24.5 Sq. m
KITCHEN AREAS
25.4 Sq. m
BIRTHDAY PARTY
42.4 Sq. m
P. CNTRL
5.2 Sq. m
SICK BY
5.2 Sq. m
LTS OFFICES
30.5 Sq. m
PUBLIC WC
13.6 Sq. m
CLNRS
FAMILY CHANGE
27.0 Sq. m
MALE CHANGE
94.7 Sq. m
FEMALE CHANGE
99.6 Sq. m
STEAM
18.9 Sq. m
SAUNA
6.6 Sq. m
DRY LOUNGE
28.6 Sq. m
CIRCULATION
74.7 Sq. m
RECEPTION
95.0 Sq. m
STAFF CH
14.1 Sq. m
CLNRS
6.2 Sq. m
LARGE MEETING
75.9 Sq. m
SPIN
73.1 Sq. m
STORE
11.4 Sq. m
RECEPTION
23.8 Sq. m
CASH ROOM
14.9 Sq. m
STAFF ROOM
35.3 Sq. m
SMALL MEETING
20.3 Sq. m
CLNRS
RETAIL
45.1 Sq. m
FOYER
143.4 Sq. m
DRY CIRCULATION / WAITING
CONTROL
9.1 Sq. m
ASSESS 1
10.6 Sq. m
FITNESS
302.8 Sq. m
ASSESS 2
10.6 Sq. m
DRY CHANGE
93.2 Sq. m
STORE
10.8 Sq. m

REPORT

Tonkin+Taylor



Proposed Napier Aquatic Centre

Prebensen Drive, Napier

Prepared for
Napier City Council
Prepared by
Tonkin & Taylor Ltd
Date
June 2018
Job Number
1006598.v1

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www.tonkintaylor.co.nz

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Appendix C :	**Laboratory Test Results**
Appendix D :	**Liquefaction Assessment Outputs**
Appendix E :	**Historical Aerial Photographs**

1 Introduction

1.1 General / Scope

Tonkin & Taylor Ltd (T+T) was engaged by Halcyon Project Management on behalf of Napier City Council (NCC) to undertake geotechnical investigations and provide a geotechnical interpretive report for the proposed Napier Aquatic Centre (NAC). The proposed NAC site is adjacent to the Prebensen Drive Roundabout between SH2B and Tamatea Drive.

The works have been undertaken in accordance with our proposal dated 13 April 2018[1], which was accepted by the client on 4th May 2018[2].

Our scope of works has included:

- Review of publically available information including historical aerial photography, available historical geotechnical investigations and information held in the T+T archives;
- Ground investigations at the preferred Prebensen Drive site comprising 3 No sonic machine boreholes and 9 No CPTs.
- Installation of a single Piezometer in one of the boreholes to monitor groundwater levels on site;
- Preparation of summary borehole logs, site investigation plans and geological cross sections;
- Laboratory testing schedule to assist in liquefaction and consolidation settlement estimates comprising;
  - 2 No Atterberg limits tests
  - 3 No Particle Size Distribution tests;
  - 1 No Consolidation test.
- Undertake a liquefaction assessment based on the CPT and laboratory testing;
- Assess foundation options for the chosen site and indicate likely ground improvements that may be required; and
- Preparation of this report outlining the results of the investigations and analyses undertaken, along with the geotechnical considerations that will need to be addressed during the detailed design of the proposed aquatic centre.

We understand this report is to support a design and build contract.

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[1] T+T, Offer of Geotechnical Services-Geotechnical Investigations and Assessment for land adjacent to the Cross-Country Drain in Napier, 22 November 2016, T+T ref: 1001268

[2] Signed acceptance, Rodney Howard (client Rep), 4 May 2017

1.2 Site Description

The site is legally described as "398 Prebensen Drive, Napier" Lot 2 DP 420058 with an area of approximately 12.2 Ha. The investigation was limited to the northern portion of site adjacent to the corner of Prebensen Drive and Tamatea Drive. The northern portion of the site was previously used for agricultural purposes and contained two residential dwellings which have since been demolished. A series of boardwalks (timber and steel) are currently being stored onsite within the area of the previously demolished residential dwellings.

The site is bounded by Tamatea Drive to the west, Prebensen Drive to the north, the SH50 Expressway to the east and undeveloped land to the south. The site is bounded by a drainage channel to the east with slopes up to 3m high at a grade of approximately 1V:2H.

Figure 1.1- Looking north towards Prebensen Dr, with the proposed site in the foreground.

Figure 1.2-Looking east from the site of the previously demolished residential dwellings.

1.3 Proposed development

We understand NCC intend to construct a new aquatic centre at the site including a 25m lane pool (with room for expansion to 50m) and associated gym and office facilities. At the time of writing this report, no development plans or architectural drawings were provided.

2 Desktop Review

2.1 Historical Aerial Photography

The earliest readily available aerial photograph from 1972 indicate the site was used as agricultural land with a small farmhouse still visible in the centre of the site. A series of farm tracks run in a north south and SW-NE direction that are still present on site.

The large drain on the eastern side of the site appears to run roughly north south along the site boundary.

A small ancillary shed is visible on the eastern portion of the site in the 1972 and 1980 aerial photos but appears to have been demolished by 1996.

Prior to 1988, a dog racing track was constructed just south of the proposed aquatic centre site with the development of a through road from Prebensen Drive towards Tamatea to the southwest.

Between 1996 and 2018 the site appears to have remained in roughly the same format. The old farmhouse building appears to have been partially demolished (circa 2012) with only the concrete block walls and foundations present on site.

Prebensen Drive was realigned between 2002-2003 and no longer passes through the site. This now forms Tamatea Drive to the west of the site.

The aerial photography review indicates that no significant filling operations appear to have taken place on site.

The relevant aerial photographs have been appended (Appendix E) to this report.

2.2 Published geology

Published geology[3] indicates the site is underlain by Holocene estuarine deposits (Q1a), comprising unconsolidated mud, sand and peat. The published geology is shown in Figure 2.1 below.

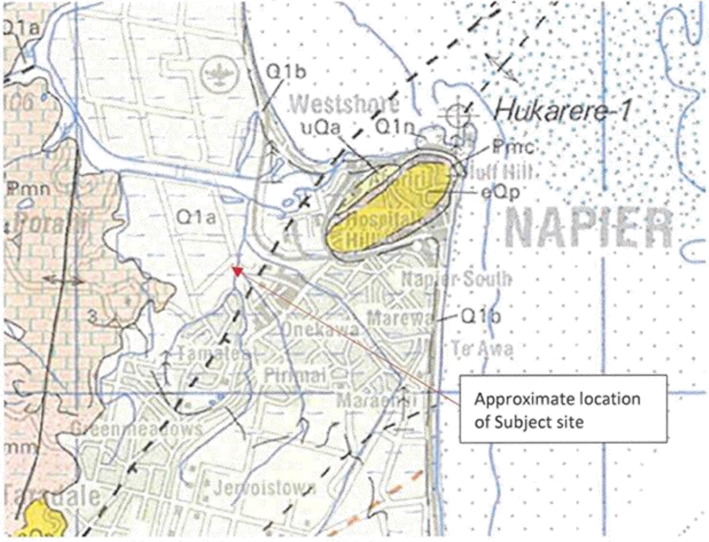

Figure 2.1-Published geology of the Napier area.

2.3 Historical Geotechnical Investigations

A number of historical CPT tests have been pushed on site or the adjacent site. These include:

- A series of CPTs pushed across the Prebensen Drive Roundabout in 1989, northeast of the site.
- One CPT pushed on the eastern boundary of the site by Works Consultancy Services (Now WSP OPUS in 1995) for the Airport to Taradale Road upgrade.
- One CPT pushed by T+T in 2015 on the northeast of the site for Napier City Council to provide additional investigations for region liquefaction hazard maps.

3 Geotechnical Investigations (T+T 2018)

3.1 Site Investigations

Site investigations were undertaken between May and June 2018 and comprised the following:

- 9 No. CPTs pushed to 25m depth or refusal; and
- 3 No. machine boreholes to approximately 15m depth.

Borehole and CPT investigations were carried out by Geotech Drilling Ltd using a sonic drilling rig and a truck mounted CPT rig.

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[3] Lee, J.M; Bland, K.J; Townshend, D.B; Kamp, P.J.J. (compilers) 2011, Geology of the Hawkes Bay area, Institute of Geological and Nuclear Sciences 1:250 000 geological map9.1 sheet +93 p. lower Hutt, New Zealand

The investigations outlined were supervised by an engineering geologist from T+T. In situ Standard Penetration Testing (SPT) was carried out at regular (1.5 m) intervals through the soil horizon as directed by the engineering geologist. The recovered drill core was photographed and logged to NZGS 'Field Description of Soil and Rock' guidelines.

On completion of the drilling one standpipe piezometer was installed in BH3 to monitor groundwater levels.

The investigation locations are shown on the investigation plan (Figure 1 in Appendix A) while the investigation logs are presented in Appendix B. Summary borehole details are presented in Table 3.1 below.

Table 3.1: Machine Borehole Summary

BH ID	Location (Hawkes Bay 2000)		Collar Elevation[1] RL (m)	Total Depth (m)
	Easting (m)	Northing (m)		
BH1	817054.7	417075.0	11.95	15.45
BH2	817061.8	416961.9	11.78	15.15
BH3	816996.6	417041.1	11.82	15.45

[1]Collar elevation surveyed by Civil Services (HB) Ltd (June 2018) and is in terms of Napier 1962 vertical datum.

3.2 Laboratory Testing

Select samples retrieved during the geotechnical investigation were tested by an IANZ accredited laboratory run by Opus International Consultants Ltd and Geotechnics Ltd. The purpose of the laboratory testing was to assist in characterising the subsoils encountered during the investigations and to assist in identifying the material susceptible to liquefaction and consolidation settlement.

The following tests were carried out:

- 1 No. 1 D consolidation settlement test;
- 2 No. PSD (Particle Size Distribution) tests;
- 2 No. Plasticity Index for Soils (Atterberg Limits) tests.

The results of laboratory testing is presented in Appendix C and discussed in subsequent sections.

4 Subsurface Conditions

4.1 Site Stratigraphy

The subsurface materials encountered during the investigations are generally consistent with the published geology. A summary of the materials encountered during the investigations are as follows:

- **Fill/Topsoil**

  A surficial layer ploughed topsoil material comprising sandy silt was encountered up to approximately 0.2 m thick. Uncontrolled fill material comprising sandy medium to coarse gravel was encountered in BH1 to 1.2 m depth.
- **Holocene Estuarine Deposits- Estuarine Interbedded Sand and Silt**

  Underlying the topsoil/fill are interbedded layers of sand and silt with fragments of shell. Cone tip resistances, q_c, ranges between 0.5 MPa and 20 MPa. SPT 'N' values range between 0 and 15 indicating this material is very loose/soft to medium dense/stiff. A layer of very soft to soft silt was encountered in the majority of the test locations at 2.5m that was 1.0-2.5m thick with qc values of less than 0.5MPa.

On the southern and eastern portion of the site the base of the interbedded sand and silt unit was unproven and this has been delineated on Figure 1 of Appendix A

- **Holocene Alluvial Deposits- Limestone Gravel/Dense Sand (Northwestern corner only)**

  In the northwestern portion of the site a unit of well graded sandy gravels, cobbles and sands was encountered. This unit appeared to comprise a significant amount of limestone and shells. The spatial extent of this unit was limited to the northwestern corner of the site only (CPT 3,7,8 and BH2).

  A number of the CPT's refused in this layer with tip resistances, q_c, generally exceeding 25 MPa. SPT 'N' values >50 indicating this material is dense to very dense.

The geological units expected across the site are summarised in Table 4.1. Geological cross sections through the site are presented on Figures 2-3 in Appendix A.

Table 4.1: General site profile

Unit	Depth to top of layer (m begl)	Cone Resistance (MPa)	SPT 'N' Value
Fill/Topsoil	0 – 1.2m	2 – 20	-
Estuarine Interbedded Sand and Silt	0.05 – 1.2m	0.5 - 14 (occasional lenses of greater than 20MPa material)	0 – 15
Limestone gravel	10.5- 12.6 (Portion of the site only- Refer Figure 1- Appendix A)	>25	>50

4.2 Groundwater

One standpipe piezometer was installed within BH3. Groundwater within the piezometer was measured at approximately 2.0 m below existing ground level (begl). Groundwater was also recorded between 2.2 and 2.3 m begl in BH1 and BH2 respectively following the completion of drilling.

We note some tidal and seasonal fluctuations are expected in the groundwater levels.

For the purposes of our analyses (outlined in subsequent sections) we have adopted a groundwater level of 1.5 m begl. This is based on the results of the site investigations and from our experience on adjacent sites.

A summary of groundwater levels measured following the installation of the piezometer is presented in Table 4.2 below.

Table 4.2: Piezometer details

ID	Collar RL (m)	Screen depth (m begl)	Min. – Max. water level in standpipe	Number of measurements	Geological Unit over screened depth
BH3	11.82	3.6 – 6.6	RL +9.82 (2.0 begl)	1	Interbedded fine to coarse SAND and SILT

5 Geotechnical Considerations

5.1 General

The recommendations and opinions in this report are based on data from machine borehole and CPT investigations, laboratory test results and review of published information. The nature and continuity of subsoil away from site investigations are inferred but it must be appreciated that actual conditions could vary from the assumed model.

5.2 Seismic shaking hazard

5.2.1 Seismic site subsoil class

While the CPTs and boreholes were terminated before bedrock was encountered; published geology indicates the estuarine deposits encountered could be hundreds of metres thick. Accordingly, based on the strengths of the materials encountered during the investigations we consider the site be classified as **Class D – Deep or Soft Soil** Site in accordance with NZS 1170.5:2004.

5.2.2 Ground shaking hazard

T+T's seismic assessment has been undertaken in accordance with the recommendations in the NZTA Bridge Manual and the New Zealand Code of Practice NZS 1170.5:2004 to represent the following design performance requirements:

- **Ultimate Limit State (ULS)** – to avoid collapse of the structural system, and
- **Serviceability Limit State (SLS)** – to avoid damage that would prevent the structure from being used as originally intended without repair.

In addition to the ULS and SLS cases above, a third design case has been assessed, being the 100 year recurrence interval (100y RI).

We have assumed structures associated with the proposed aquatic centre development are likely to be **Importance Level 3** in accordance with AS/NZS1170.0:2002, accordingly, the design earthquakes for serviceability and ultimate limit states have been adopted as 1 in 25 years and 1 in 1000 years respectively.

Table 5.1 presents the return periods for earthquakes with various 'unweighted' peak ground accelerations (PGA) with a corresponding earthquake magnitude.

Table 5.1: Ground seismic hazard

NZS 1170.5 Limit State	PGA (g)	Effective magnitude M_{eff}	Return period (years)
Ultimate limit state (ULS)	0.43	6.9	1000
100 Year Recurrence Interval (100y RI)	0.17	6.2	100
Serviceability limit state (SLS)	0.08	6.2	25

Note:

PGA and effective magnitude has been assessed based on Bridge Manual SP/M/022 Third Edition for the following:

Assumed design life of proposed structures	50 years
Assumed importance level of proposed structures	3 (NZS 1170.0:2004, Table 3.2)
Return period factor, Ru	1.3 for 1000yr; 0.5 for 100yr; and 0.25 for 25yr return period (NZS 1170.5:2004, Table 3.5)
Subsoil class	D (Deep soil) – refer Section 3.1

Return period PGA coefficient, $C_{0,1000}$	0.43 (Bridge Manual Table 6A.1)
Site subsoil class factor, f	1.0 (Bridge Manual Section 6.2)
PGA	$C_{0,1000}$ x Ru/1.3 x f x g (Bridge Manual Section 6.2)
Effective Magnitude, M_{eff}	6.9 for 1000yr and 6.2 for 100yr and 25yr return period (Bridge Manual Table 6A.1)

5.3 Liquefaction assessment

When loose, saturated, cohesionless soils are subjected to strong shaking they have a tendency to try to densify. This tendency to densify results in excess pore pressures being generated and the soil undergoing partial to near-complete loss of shear strength. Such a loss of shear strength can result in, bearing capacity yield or failure, and/or horizontal movement of the soil mass. Release of the pressure to the surface can cause sand boils and settlement.

The occurrence of liquefaction is dependent on several factors including: the intensity and duration of ground shaking, soil density, particle size distribution, and elevation of the groundwater table.

5.3.1 Liquefaction susceptibility

Liquefaction only occurs in some soils. Liquefaction susceptible soils are typically saturated and non-cohesive.

- Sands and low plasticity and non-plastic silts are most susceptible to liquefaction[4];
- Gravels can liquefy if they have a low permeability or are confined by less permeable layers. This is considered unlikely at the Prebensen Drive site;
- Some fine grained soils may be susceptible (typically low plasticity and high water content)[5,6]. Bray and Sancio (2006) indicated that soils with plasticity index (PI) greater than 12 are unlikely to liquefy (as they behave in a cohesive manner) under seismic loading; and
- Younger (Holocene) deposits (present in Napier) are likely to be more susceptible to liquefaction than older (Pleistocene) deposits of similar composition, i.e. the age of the deposits is important.

5.3.2 Liquefaction potential

Analyses have been undertaken on CPTs to assess the potential of the subsoils for earthquake induced liquefaction. Analyses have been performed using 'unweighted' PGA with a corresponding Magnitude (refer to Section 5.2.2). The results of the laboratory testing outlined in Section 3.2 were used to calibrate the CPT based analyses.

From the analyses, the liquefaction potential at the site is summarised as follows:

SLS, 1/25 Return Period	Liquefaction is not expected.
100y IR, 1/100 Return Period	Triggering of liquefaction is expected, with liquefaction of interbedded sand layers expected between 4-6m and below 7m depth.
ULS, 1/500 Return Period	Liquefaction of interbedded sand layers expected between 2-3m and below 5m depth.

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[4] Bray, K et al, 2014, "Liquefaction effects on buildings in Central Business District of Christchurch", Earthquake Spectra, 30 (1), 85-109.

[5] Bray J.D. and Sancio R.B., 2006, "Assessment of the liquefaction susceptibility of fine-graded soils", Journal of Geotechnical and Geoenvironmental Engineering, 132 (9), 1165–1177.

[6] Boulanger R.W. and Idriss I.M., 2006, "Liquefaction Susceptibility Criteria for Silts and Clays", Journal of Geotechnical and Geoenvironmental Engineering, 132 (11), 1412–1426.

5.3.3 Consequences of Liquefaction

Free field settlement:

Liquefaction induced, one dimensional vertical reconsolidation settlements have been estimated using the methodology developed by Zhang, Robertson and Brachman (2002) and are presented in Table 5.4 below

It should be noted that estimated settlements are total, "free-field" settlement estimations. This describes the liquefaction induced settlement of the ground surface ignoring soil-structure interaction, which is caused by a dissipation of excess pore water pressure generated during earthquake shaking. The settlement of the proposed structures may differ from the estimated ground settlement and is dependent on the interaction of the building and soil it is founded on.

LSN:

The Liquefaction Severity Number (LSN) is another indicator of the effects liquefaction can have on land and shallow foundations. LSN was developed from observations of residential damage from the Canterbury Earthquake Sequence and its calculation is presented below:

$$LSN = \int \frac{\varepsilon_v}{z} dz$$

Where ε_v is the calculated volumetric densification strain using Idriss and Boulanger (2014) and z is the depth to the layer of interest.

As the LSN increases, so does the risk of adverse ground level effects associated with liquefaction. Table 5.2 summarises correlations of LSN with land and residential building damage, as observed from the Canterbury Earthquake Sequence.

Table 5.2: LSN ranges and associated damage

LSN Range	Effects and Expression of Liquefaction on Structures and Land
0-5	Negligible to Minor: No major effects expected.
5-20	Minor: Generally consistent with acceptable performance under SLS conditions (i.e. little settlement or permanent dwelling damage). Some ejection of material can be expected at the ground surface, but likely to be localised in nature.
20-40	Moderate: Liquefaction evidence possible. Generally consistent with acceptable performance under ULS conditions (i.e. settlement).
>40	Severe: High risk of substantial damage to the site and/or building if on shallow foundations

5.3.4 Lateral Spreading

Lateral spread is the movement of ground down slope or toward a free edge (e.g. drainage channel) as a result of shearing of weak liquefied ground under seismic and/or gravity forces. Lateral spread could be expected to occur in a series of surface cracks and fissures extending back from the channel edge with the magnitude of total displacement reducing with distance from the reclamation edge. With increasing magnitude and acceleration of earthquakes, greater displacement and greater extent of lateral spread can be expected.

Generally, the risk of lateral spreading decreases with distance from the free face (L). The risk regions for lateral spread in relation to the development can be summarised as follows:

1. **L = 0 – 5H 'Edge failure Region'**, where H is the height of the free face. Significant ground cracking, large horizontal and vertical displacement displacements and ground failure can

occur. Building in this zone without significant ground improvements or suitably detailed piles is not recommended;

2. **L = 5 – 20H 'Block sliding Region'** - Block Slide zone here the lateral spreading displacement could be concentrated over one or two large cracks as large blocks of soil slide towards the stream. In this region, robust shallow foundations (stiffened raft type) should be detailed to resist the strains from the ground trying to "pull apart", possibly in combination with some ground improvements; and
3. **L > 20H 'Lateral stretch Region'** - here the lateral spreading displacement occurs over a large number of small cracks, gradually decreasing in width with increasing distance from the stream. These cracks generally have a minor influence on structural performance.

Estimated lateral spread displacements are presented in Sections 5.3.5 and 5.3.6 below. The above regions are independent of the risk zones shown in Figure 2, Appendix A.

5.3.5 Discussion

Our liquefaction assessment indicates that there is moderate risk of liquefaction under a ULS event and minor to moderate liquefaction risk in a 1 in 100 year event. A 1.5-1.8m crust of 'non-liquefiable materials' appears to be present at the site based on the CPTs, lab testing and groundwater measurements. There appears to be a negligible change in liquefaction risk between an IL2 and IL3 design level event.

Pool:

Assuming that the pool is to be constructed by excavating below existing ground level and in the western portion of the site (green zone on Figure 2 in Appendix A), an approximately 3m deep excavation would effectively remove the shallow potentially liquefiable material encountered on site. We expect the soft to firm plastic clayey silt later from 2.5-5.0m depth will provide an impermeable barrier from liquefaction at depths greater than 6m.

The pool would then found on the non-liquefiable silts underlying the upper liquefiable sands lenses. While analyses indicate the silts are note susceptible to liquefaction, they may be susceptible to cyclic softening (i.e. a temporary reduction in undrained shear strength as result of seismic loading). An assessment of the effects of temporary strength loss on structural performance should be undertaken during detailed design.

Building:

Building foundations along the perimeter of the site will need to be designed to prevent excessive liquefaction damage under 1 in 100 year and ULS events. Shallow ground improvements such as geogrid reinforced gravel rafts or in situ/ex situ cement stabilisation are likely to be appropriate liquefaction damage mitigation methods. In addition it is recommended foundations are tied together to prevent the structure "pulling apart" under seismic loading.

The liquefaction analysis will need to be reassessed during detailed design following confirmation of cut/fill levels.

The CPT based liquefaction assessment outputs are provided in Appendix of this report.

Non-uniform liquefaction damage is expected across the site. For reporting purposes, the site has been divided into three zones based on expected consequences of liquefaction of underlying soils and potential risk mitigation strategies. Figure 2 in Appendix A illustrates the spatial locations of each zone.

Results of the liquefaction assessment indicate the consequences of liquefaction and (as a result lateral spread) are expected to be greater in Zones 1 and 2 than those in Zone 3 (due to the presence of the open drain). Accordingly, it is recommended that the swimming pool is located in Zone 3 and Zones 1 and 2 used for carparking.

Table 5.3 summarises liquefaction consequences for each zone.

Table 5.3: Liquefaction consequences

Issue	Zone 1	Zone 2	Zone 3
Estimated free field settlement[1]	ULS event: 100-120mm 100y RI: 60-80mm	ULS event: 100-140mm 100y RI: 60-120mm	ULS event: 50-120mm 100y RI: 40-100mm
Sand boils[2]	ULS event: Expected 100y RI: Possible	ULS event: Expected 100y RI: Possible	ULS event: Expected 100y RI: Possible
Surface Damage, based on LSN[3]	ULS event: Moderate 100y RI: Moderate	ULS event: Minor-Moderate 100y RI: Minor- Moderate	ULS event: Minor- Moderate 100y RI: Minor
Lateral spread[4]	ULS event: Expected 100y RI: Expected	ULS event: Expected 100y RI: Possible	ULS event: Unlikely 100y RI: Unlikely
Lateral stretch[4]	ULS event: Expected 100y RI: Expected	ULS event: Expected 100y RI: Possible	ULS event: Unlikely 100y RI: Unlikely

Note:

1 Refer to Section5.3.3 above.
2 Sand boils occur when liquefied soils at depth break through to the ground surface through fissures, cracking and/or weak crustal soils.
3 LSN (Liquefaction Severity Number), refer to Section 5.3.3 above.
4 Refer to Section 5.3.6 below

Table 5.4 summarises predicted lateral spread within each "zone" for various levels of earthquake shaking, assuming existing, non-improved ground conditions.

Table 5.4: Expected lateral spread

Zone	Expected (Possible) Lateral Spread[1]	
	ULS	**100 year RI**
Zone 1 –Within 20m of the free face	Up to 2m	Up to 600mm
Zone 2 - (20 m – 40 m from free face) + CPT03	Up to 600 mm	Up to 300 mm
Zone 3 - (> 40 m – from free face)	This zone is not likely to be subject to large lateral spread displacements. However, small cracks decreasing in width (with increasing distance from the stream) may develop.	

Note:

The lateral spread estimations above are for the boundary closest to the drainage channel. The estimations are based on empirical analyses developed from historical observations. We would not expect actual lateral spread to fall outside the "possible" range but we cannot discount this.

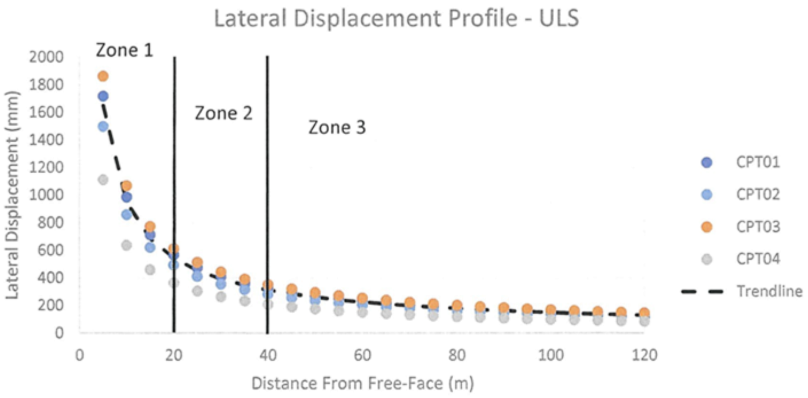

Figure 5.1: Lateral Displacement Profile –ULS case

Lateral stretch is defined as the difference in lateral spread (displacement) over a given length, perpendicular to the free face (drainage channel), effectively lateral strain within the ground. Lateral stretching of the ground is anticipated following an ULS earthquake event, with the majority of lateral stretch occurring within Zone 1 closest to the drain. Table 5.5 summarises predicted lateral stretch within each zone for various levels of earthquake shaking, being ULS and 100 year RI.

Table 5.5: Expected lateral stretch

Zone	Expected Lateral Stretch (mm)	
	ULS	100 year RI
Zone 1 – Within 20m of free face	Up to 1000mm	Up to 350mm
Zone 2 - (20 m – 40 m from free face) + CPT03	Up to 200 mm over 10m length	Up to 100 mm over 10m length
Zone 3 - (> 40 m – from free face)	Up to 50 mm over 10m length	Negligible

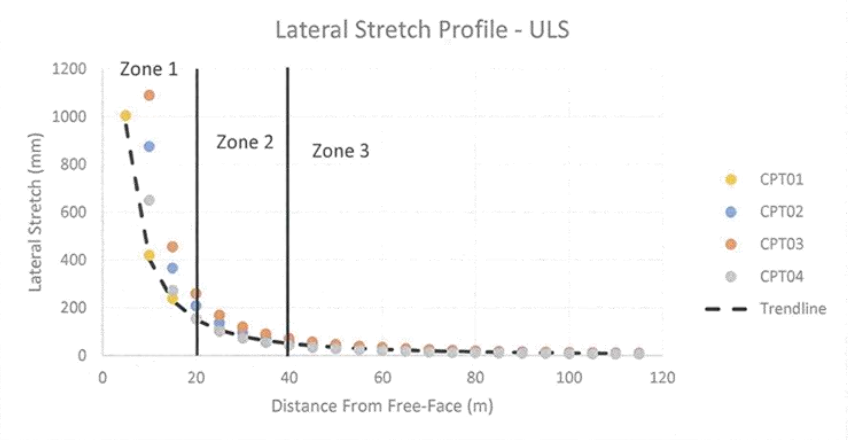

Figure 5.2: Lateral stretch profile-ULS case

5.4 Consolidation Settlement

Settlement calculations were performed on the results of CPT data using software program *Settle 3D.* The purpose of the calculations was to estimate primary consolidation settlements that may result from earthworks (filling) and future building and pavement loads.

The results of 1D consolidation tests were used to confirm the settlements derived from CPT data. Our assessment has been based on assumed loads and layouts as these were not available at the time of writing.

Based on our experience in the area we expect the majority of settlements to occur relatively quickly, due to the presence of interbedded sand layers which provide drainage pathways.

Estimated settlements based on a range of loads are provided in Table 5.6 below:

Table 5.6: Range of consolidation settlements based on loads

Applied Load	Estimated settlements
10kPa	20-40mm
20kPa	50-80mm
30kPa	50-120mm

We note that a pool excavation may "compensate" the loads from the pool by the removal of soil overburden. However this will need to be assessed following confirmation of excavation depths.

Differential settlement between the pad foundations will need to be reassessed during detailed design following confirmation of design loads and layout. If site levels are raised (to mitigate flooding etc.) this will impart additional surcharge on the ground and consolidation settlement, estimates should be reviewed on development of building and site plans.

If significant site filling is required, "pre loading" may be considered to mitigate the risk of consolidation settlements on future structures and services. "Pre loading" involves the placement of a surcharge load (typically additional fill) in order to simulate building loads and for the majority of expected consolidation settlement to occur prior to construction.

5.4.1 Settlement monitoring

Depending on the final cut/fill levels there may be a requirement to pre load the site and monitor the resulting settlements. This will need to be confirmed during detailed design.

Settlement of any new structural fill placed on site should be monitored for a period of at least 3 months to confirm the design assumptions regarding settlement magnitude and suitability for construction of structures/services, as mentioned in Section 5.5. We recommend that settlement plates are installed within any new fill placed on each Lot to monitor consolidation settlements.

Settlement monitoring results should be provided to T+T to determine if consolidation settlements have ceased. If settlements are ongoing the fill may require addition time to settle or could be surcharged with additional fill to increase the rate of settlement.

5.5 Foundation Considerations

5.5.1 Zone 1 Foundations

Analyses indicates that ground improvement would be required for structures and services constructed within Zone 1 to limit lateral spread/stretch risk. These options could comprise the following (subject to detailed design):

- Soil-cement mixed columns (DSM);
- Stone Columns (Vibroflot); and
- Rammed Aggregate Piers (RAPs)

Further details of these options will need to be following confirmation of preferred site layouts.

5.5.2 Zone 2 Ground Improvement and Foundations

For foundations within Zone 2 (i.e. within 40 m of the drain free edge) we recommend ground improvement measures are implemented to stiffen the founding ground to mitigate the effects of lateral spread within the zone and to allow the construction of shallow foundations. Ground improvement and foundation options in Zone 2 could comprise:

- 1.2 m thick geogrid reinforced gravel rafts, with stiffened rafts (as per Zone 3). This would involve placement and compaction of crushed, angular gravel in approximately 200 mm thick layers. The gravel should be reinforced with geogrid with 40kN/m minimum tensile strength at 5% elongation, with the grid placed 200 mm and 400 mm from the base of the raft. The grid should be lapped at joins as specified by the manufacturer; or
- Perimeter treatment (DSM, RAPs or Stone Columns) to a minimum depth twice the height of the free face. As per the recommendations for Zone 1 above, perimeter treatment details will need to be developed during detailed design if required.

5.5.3 Zone 3 Foundations

5.5.3.1 Shallow foundations

Foundations within Zone 3 are not considered to be at a major risk of lateral spread/stretch damage. However, foundations in this area will need to account for both consolidation and liquefaction induced settlements. Depending on acceptable risk and tolerances to consolidation and liquefaction induced settlements, ground improvements may be required.

We expect that foundations in Zone 3 could comprise shallow raft foundations with interconnected ground beams. A 0.8-1.0m thick engineered granular fill raft below foundation level could be constructed to support foundations in this zone to mitigate the effects of liquefaction induced settlements if the risk is considered unacceptable.

The gravel rafts should include at least 2 layers of high tensile geogrid to stiffen the raft. A layer of geofrabric (Bidum A19 or similar) should be placed at the base of any excavation to prevent punching failures during compaction and aid in separation of the engineered fill from the subgrade.

Alternatively, a 1.5m thick in situ cement stabilised raft could be constructed to form a stabilised crust under the perimeter of the building.

5.5.3.2 Pile Foundations

Due to the inconsistency of the dense limestone gravel layer across the site (refer highlighted area on Figure 1-Appendix A) a deep piled solution within the area where gravels were encountered (as indicated on Figure 1 in Appendix A) may be suitable. However, further investigation is recommended to prove the consistency of this layer.

5.5.4 Services

It is recommended that critical services be located outside the spread zone i.e. further than 40 m from the drain free face (unless ground improvements are undertaken). We note that a series of main trunk water mains run along the southern and eastern boundaries of the site.

Services in Zone 2-3 should be designed to be flexible to accommodate up to 100mm of vertical settlement during a 1 in 100 year seismic event.

5.6 Earthworks Considerations

5.6.1 General

The site should be cleared of vegetation and all existing fill (up to 1m deep) and topsoil should be stripped from the cut and fill areas. An inspection should be carried out of all stripped areas prior to filling or cutting operations commencing.

5.6.2 Structural Fill

Compaction of new fill material should be in accordance with the normal requirements of NZS 4404:2010 and should be the subject of engineering earthwork trials prior to bulk earthworks taking place.

We recommend that the compaction characteristics of any proposed fill material are obtained to ensure that they are suitable for use.

Typical performance specifications for granular fill and cohesive fill are outlined below, however should be reviewed once fill sources are confirmed:

Granular Fill

- Average of 95% Maximum Dry Density (MDD) – standard compaction;
- No result less than 92% MDD; and
- Clegg impact value – No result less than 20 CIV (or as determined from field trials).

Cohesive Fill

- Shear strengths (measured in situ with a hand held shear vane)- average of 140kPa;
- Shear strengths- No result less than 120kPa;
- Average 8% - maximum air voids; and
- No individual result greater than 10% air voids.

From experience on neighbouring sites the local "straight haul" gravels, mixed with local silts are likely to be suitable for use on site, provided they are compacted in accordance with the specifications above, and water content is well controlled. This would not be the case in Zone 2, where crushed angular gravels would be required for the construction of shallow gravel raft ground improvements.

6 Pavement Design

Our experience on the neighbouring sites indicates that the underlying sands and silt are predominantly of low strength. Based on our experience, a CBR of 2% would be appropriate for light weight pavements at the subject site.

During excavation of the pavement areas, the subgrade should be inspected by a geotechnical engineer to assess any areas that may require undercutting and replacement with compacted hardfill. Alternatively a cement stabilised subgrade could be adopted.

Following stripping of the topsoil, the trafficability of the site soils may be expected to deteriorate, especially following wet weather. It is imperative that the exposed surfaces are not disturbed and sensitive soils are not subject to remoulding. We recommend tracked vehicles only be allowed to pass over roading areas in these conditions, as wheeled vehicles may cause the subgrade to fail and hence require over-excavation, and (possibly removal of the subgrade to spoil or to stockpile for drying and re-working) to be required.

Following confirmation of site layouts a series of Scala penetrometer tests should be undertaken to confirm CBR values for design.

7 Retention Design and Groundwater Control

If an excavation is required for the swimming pool, the geotechnical parameters in Table 7.1 are considered suitable for use in preliminary retention design (sheet piling etc.). The earth pressure coefficients do not account for wall friction.

Table 7.1: Retention design parameters

Unit	Effective Friction Angle (ϕ')	Unit weight (γ), kN/m³	Effective Cohesion (kPa)	At rest earth pressure coefficient (k_0)	Active earth pressure coefficient (k_a)	Passive earth pressure coefficient (k_p)
Sand	30	18	0	0.50	0.33	3.00
Silt	26	17	2	0.56	0.39	2.56

Allowance should be made in the retaining wall design for groundwater pressures, surcharge loading of the retaining wall due to stockpiles and/or construction traffic and the potential liquefaction of bands of soil within the retained soil profile.

A geotechnical ultimate bearing capacity of 150kPa may be assumed for the design of any retaining wall footings bearing on soft alluvial silts. A strength reduction factor of 0.5 should be applied for the ULS design case.

An allowance for buoyancy pressures on the pool superstructure will need to be allowed for in design when the pool is emptied for periodic maintenance.

8 Conclusions and Recommendations

Geotechnical investigations and reporting have been completed for the proposed aquatic centre at Prebensen Drive, Parklands, Napier. The following points summarise the main conclusions of the investigation and results of engineering analysis.

1 A 25m lane pool complex is proposed on the vacant lot between Prebensen Drive, Tamatea Drive and the Hawkes Bay Expressway-At this time no site layouts and architectural plans are available;

2 Aerial photography indicates the site has previously been used as agricultural land with a former farmhouse present on the southern area of the site until 2012, the remnants of the dwelling foundations are still exposed on site. No evidence of site filling was evident from review of the aerial photographs;

3 The site is underlain by Holocene estuarine deposits comprising interbedded layers of sand and silt with fragments of shell. A soft silt layer is present at 2.5-5.0m depth. A dense gravel layer is present on a portion of the site only at 10-15m depth (shown on Figure 1);

4 We consider the site should be classified as Class D – Deep or Soft Soil Site in accordance with NZS 1170.5:2004;

5 The site is subject to the following geotechnical risks;

- Liquefaction during a 100 year RI (at which some liquefaction triggering occurs) and an ULS earthquake event;
- Lateral spreading following liquefaction, within the zones closest to the open drain to the east of the site (Zones 1 and 2 on Figure 2 in Appendix A);
- Consolidation settlement with ranges of estimated settlements presented in Section 5.4

6 For reporting purposes the site has been separated into 3 Zones (refer Figure 1 in Appendix A) based on expected performance with regard to liquefaction and lateral spread;

- Significant Ground improvements are recommended in Zones 1- 2 to limit the effects of lateral spreading on proposed structures.
- Zone 3 is not expected to be at significant risk of lateral spreading and only shallow ground improvements likely to facilitate development of shallow foundations. **Accordingly we recommend the pool be situated in this zone**.

7 A CBR of 2% is considered appropriate for pavement design on site, this should be confirmed with Scala penetrometer testing during detailed design;

8 Preliminary retention design parameters are presented in Section 7; and

9 Further geotechnical analyses will be required during detailed design once site layouts and levels have been confirmed.

9 Applicability

This report has been prepared for the exclusive use of our client Napier City Council Limited, 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.

The susceptibility analyses carried out are based on empirical methods derived from case histories/databases with limited information.Earthquakes are unique and impose different levels of shaking in different directions on different sites.The results of the liquefaction susceptibility analyses and the estimates of consequences presented within this document are based on regional seismic demand and published analysis methods, but it is important to understand that the actual performance may vary from that calculated.

During excavation and construction, the site should be examined by an engineer competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. We would be pleased to provide this service to you and believe your project would benefit from the continuity. However, it is important that we be contacted if there is any variation in subsoil conditions from those described in the report

Tonkin & Taylor Ltd

Report prepared by:	Reviewed for Tonkin & Taylor Ltd by:
....	....
Jamie Yule/John Martin Engineering Geologist/ Geotechnical Engineer	Nathan Hickman CPEng Geotechnical Engineer

Authorised for Tonkin & Taylor Ltd by:

....

for Grant Loney
Project Director

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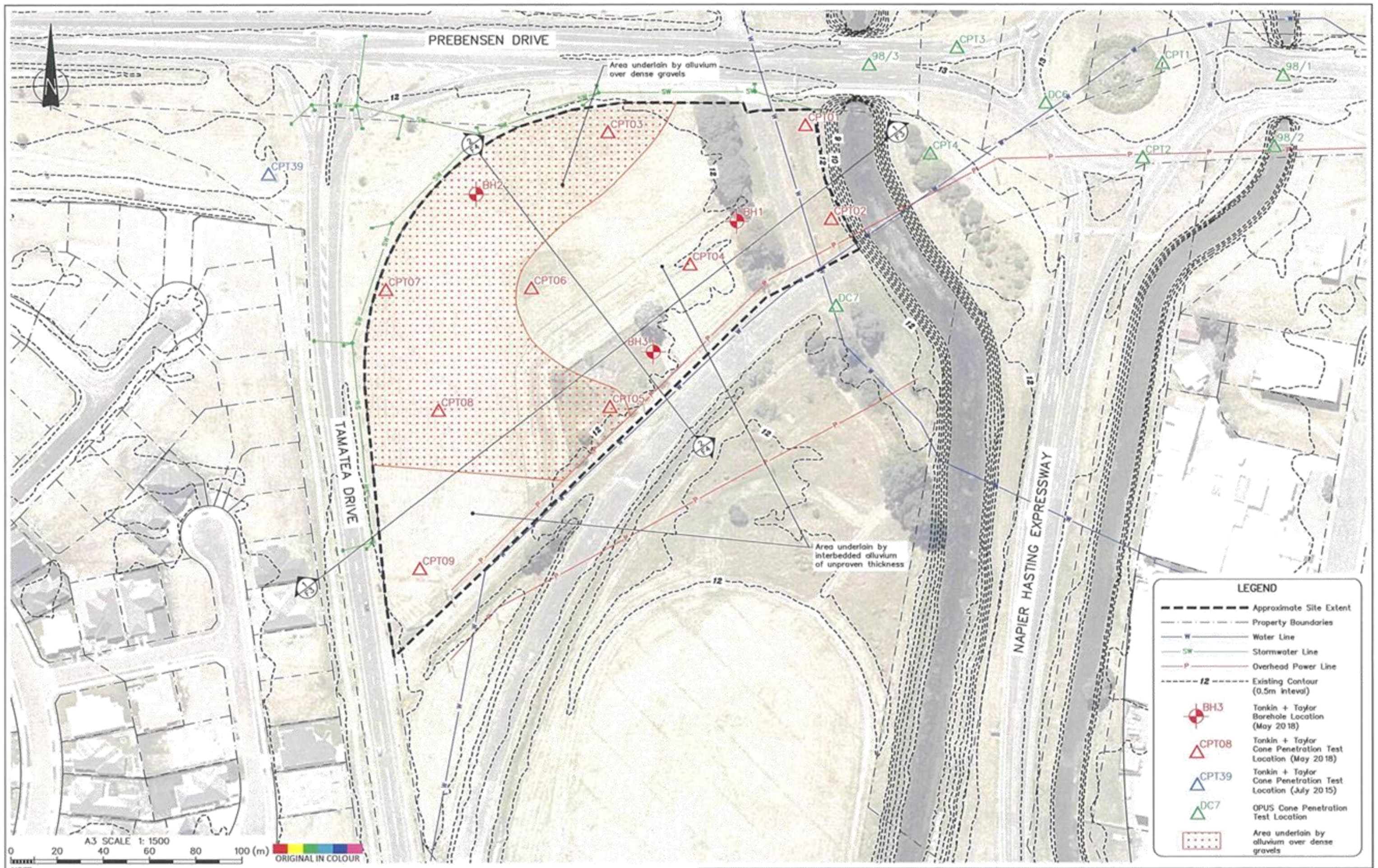
Appendix A: Figures

- **Figure 1 – Site Investigation Plan**
- **Figure 2- Liquefaction and Lateral Spread Hazard Plan**
- **Figures 3-4 – Geological Cross Sections**



NOTE:

1. All dimension are in millimetres unless noted otherwise.
2. Aerial photo sourced from Linz Data Service <https://data.linz.govt.nz/layer/53401-hawkes-bay-0.3m-rural-aerial-photos-2014-15/> , licensed by LINZ for re-use under the Creative Commons Attribution 4.0 New Zealand licence (CC BY 4.0)
3. Property boundaries sourced from Linz Data Service <https://data.linz.govt.nz/layer/50772-nz-primary-parcels> , licensed by LINZ for re-use under the Creative Commons Attribution 4.0 New Zealand licence (CC BY 4.0)
4. Contours and services are based on IntraMaps of Napier City Council <http://www.gis.napier.govt.nz/IntraMaps80>

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PROJECT No. 1006598		

NAPIER AQUATIC CENTRE
GEOTECHNICAL INVESTIGATION
PREBENSEN DRIVE, NAPIER
Site Investigation Plan

FIG. No. Figure 1

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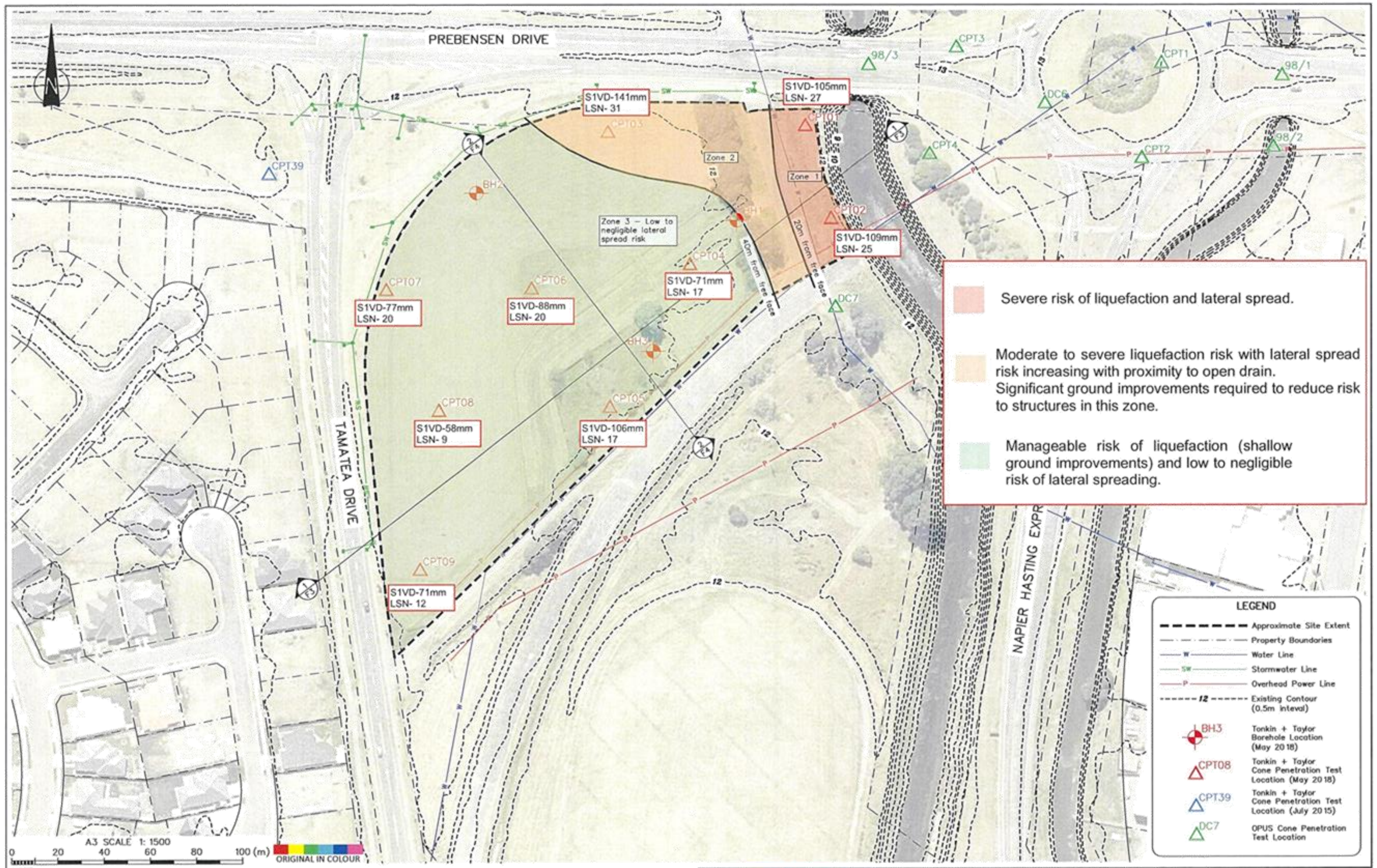

NOTE:

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NAPIER AQUATIC CENTRE
GEOTECHNICAL INVESTIGATION
PREBENSEN DRIVE, NAPIER
Liquefaction/Lateral Spread Hazard Plan

FIG. No. Figure 2
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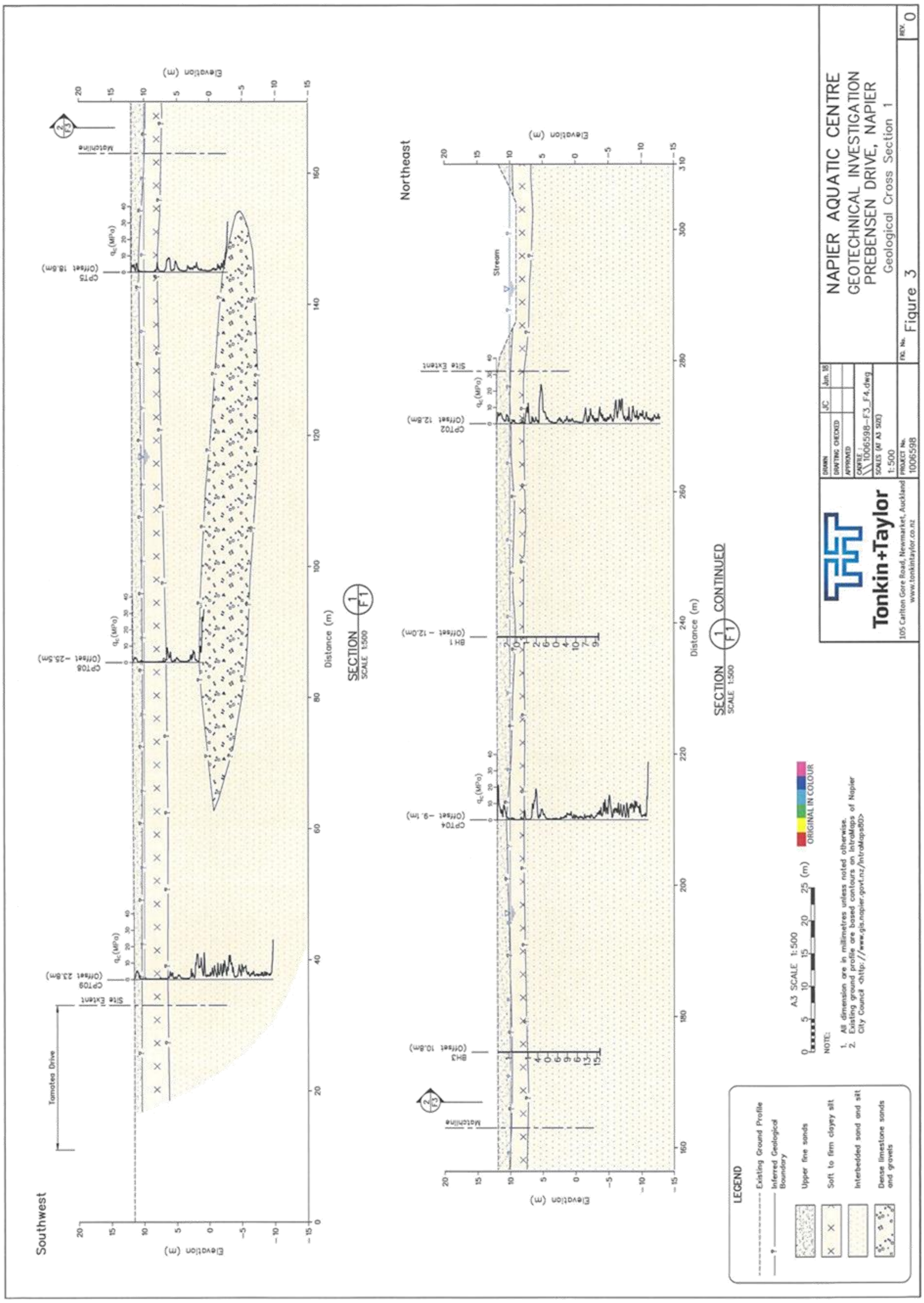

NAPIER AQUATIC CENTRE
GEOTECHNICAL INVESTIGATION
PREBENSEN DRIVE, NAPIER
Geological Cross Section 1

Figure 3

NOTE:

1. All dimension are in millimetres unless noted otherwise.
2. Existing ground profile are based contours on IntraMaps of Napier City Council <http://www.gis.napier.govt.nz/IntraMaps80>

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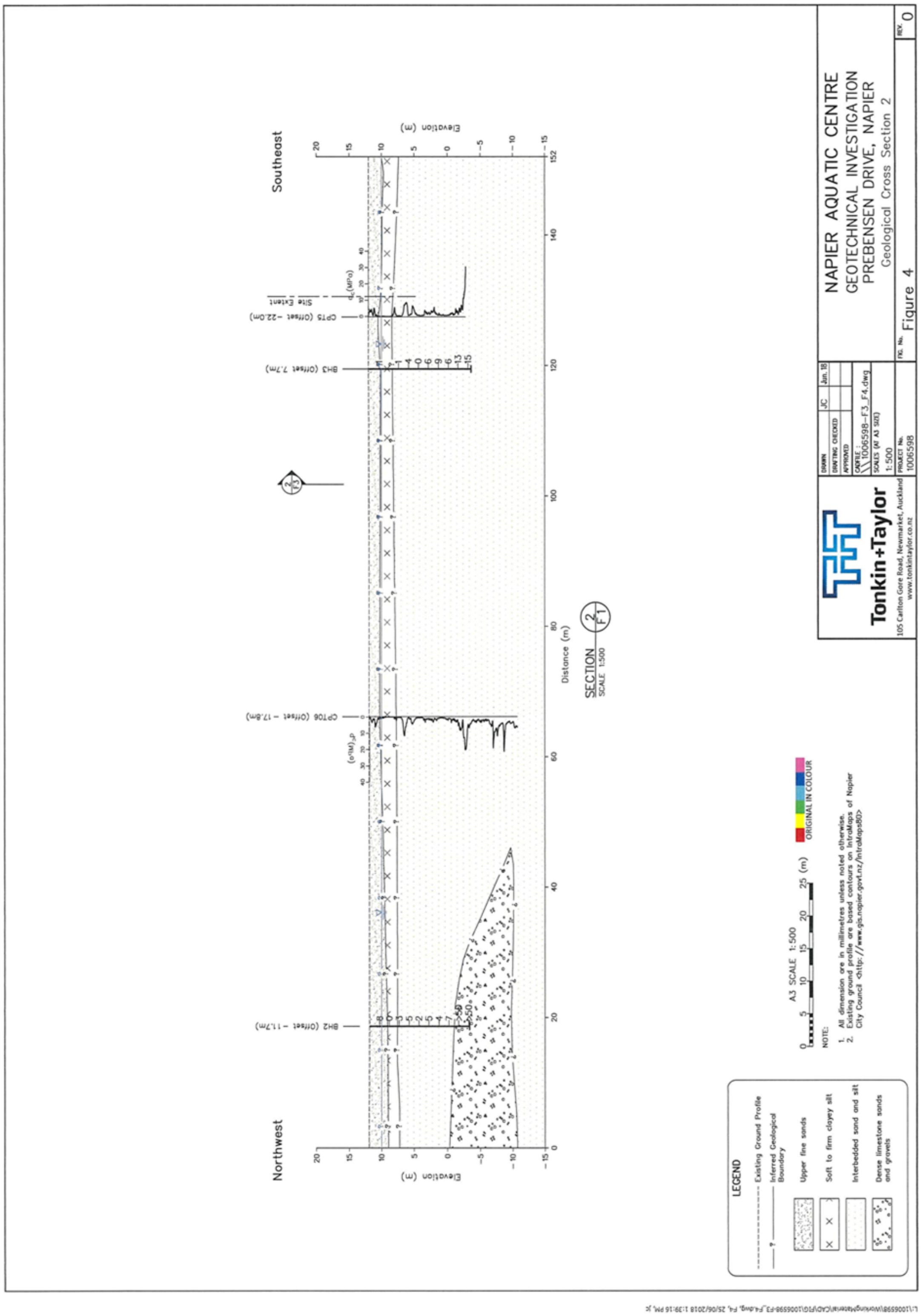
Northwest
Southeast
Elevation (m)
Distance (m)
0
20
40
60
80
100
120
140
152
20
15
10
5
0
-5
-10
-15
BH2 (Offset -11.7m)
CPT06 (Offset -17.8m)
BH3 (Offset 7.7m)
CPT5 (Offset -22.0m)
Site Extent
q_c (MPa)
SECTION
SCALE 1:500
2
F1
2
F3
LEGEND
Existing Ground Profile
Inferred Geological Boundary
Upper fine sands
Soft to firm clayey silt
Interbedded sand and silt
Dense limestone sands and gravels
A3 SCALE 1:500
0 5 10 15 20 25 (m)
ORIGINAL IN COLOUR
NOTE:
1. All dimension are in millimetres unless noted otherwise.
2. Existing ground profile are based contours on IntraMaps of Napier City Council <http://www.gis.napier.govt.nz/IntraMaps80>
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NAPIER AQUATIC CENTRE
GEOTECHNICAL INVESTIGATION
PREBENSEN DRIVE, NAPIER
Geological Cross Section 2
FIG. No. Figure 4
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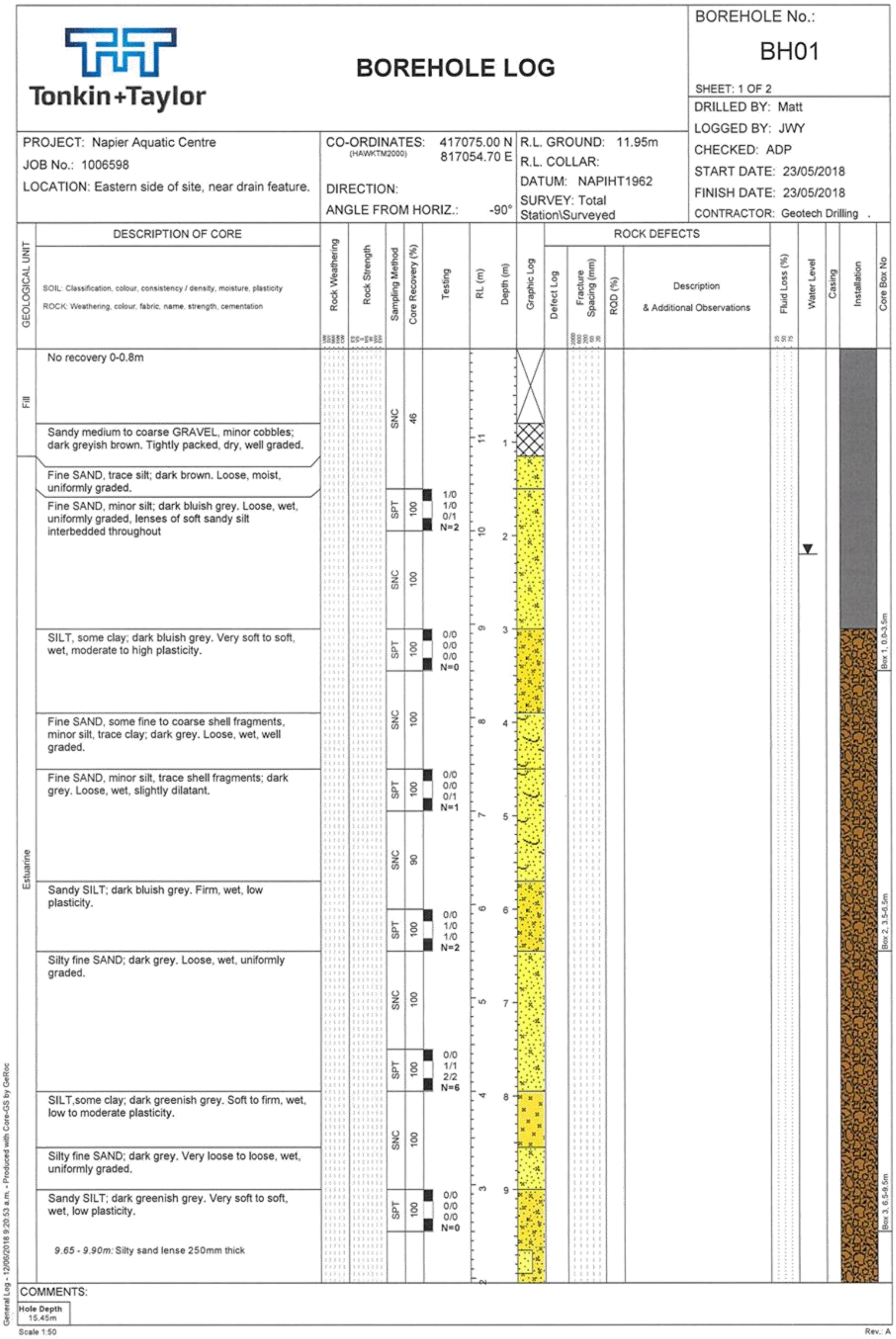
Appendix B: Investigation Logs

- **Borehole Logs**
- **CPT Logs**



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BOREHOLE LOG

BOREHOLE No.: BH01

SHEET: 1 OF 2

DRILLED BY: Matt
LOGGED BY: JWY
CHECKED: ADP
START DATE: 23/05/2018
FINISH DATE: 23/05/2018
CONTRACTOR: Geotech Drilling .

PROJECT: Napier Aquatic Centre
JOB No.: 1006598
LOCATION: Eastern side of site, near drain feature.

CO-ORDINATES: 417075.00 N
(HAWKTM2000) 817054.70 E
DIRECTION:
ANGLE FROM HORIZ.: -90°

R.L. GROUND: 11.95m
R.L. COLLAR:
DATUM: NAPIHT1962
SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation
Fill	No recovery 0-0.8m
	Sandy medium to coarse GRAVEL, minor cobbles; dark greyish brown. Tightly packed, dry, well graded.
Estuarine	Fine SAND, trace silt; dark brown. Loose, moist, uniformly graded.
	Fine SAND, minor silt; dark bluish grey. Loose, wet, uniformly graded, lenses of soft sandy silt interbedded throughout
	SILT, some clay; dark bluish grey. Very soft to soft, wet, moderate to high plasticity.
	Fine SAND, some fine to coarse shell fragments, minor silt, trace clay; dark grey. Loose, wet, well graded.
	Fine SAND, minor silt, trace shell fragments; dark grey. Loose, wet, slightly dilatant.
	Sandy SILT; dark bluish grey. Firm, wet, low plasticity.
	Silty fine SAND; dark grey. Loose, wet, uniformly graded.
	SILT,some clay; dark greenish grey. Soft to firm, wet, low to moderate plasticity.
	Silty fine SAND; dark grey. Very loose to loose, wet, uniformly graded.
	Sandy SILT; dark greenish grey. Very soft to soft, wet, low plasticity. *9.65 - 9.90m:* Silty sand lense 250mm thick

Sampling Method	Core Recovery (%)	Testing
SNC	46	
SPT	100	1/0 1/0 0/1 N=2
SNC	100	
SPT	100	0/0 0/0 0/0 N=0
SNC	100	
SPT	100	0/0 0/0 0/1 N=1
SNC	90	
SPT	100	0/0 1/0 1/0 N=2
SNC	100	
SPT	100	0/0 1/1 2/2 N=6
SNC	100	
SPT	100	0/0 0/0 0/0 N=0

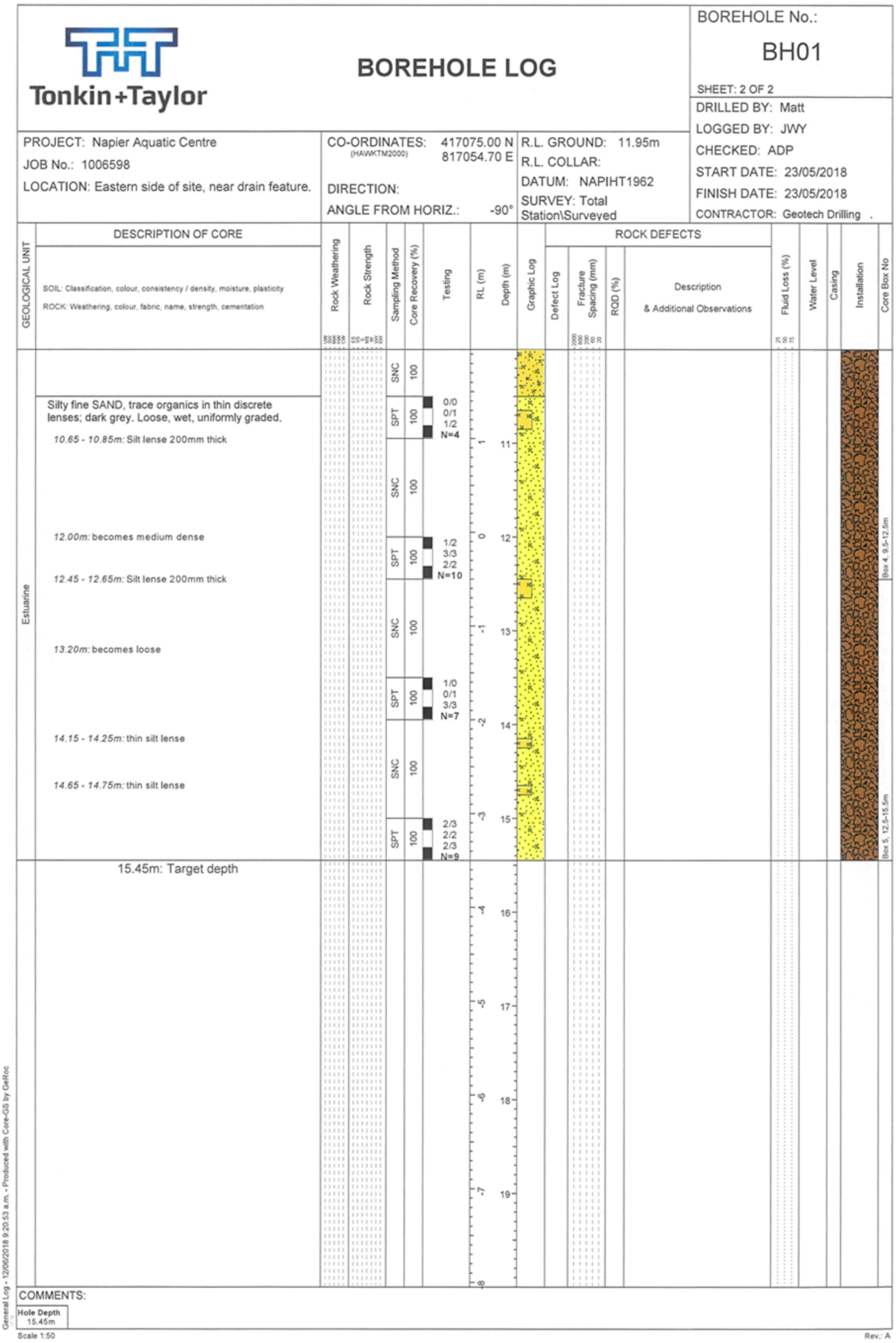
COMMENTS:

Hole Depth
15.45m

Scale 1:50

Rev.: A

General Log - 12/06/2018 9:20:53 a.m. - Produced with Core-GS by GeRoc



Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.:
BH01
SHEET: 2 OF 2

DRILLED BY: Matt
LOGGED BY: JWY
CHECKED: ADP
START DATE: 23/05/2018
FINISH DATE: 23/05/2018
CONTRACTOR: Geotech Drilling .

PROJECT: Napier Aquatic Centre
JOB No.: 1006598
LOCATION: Eastern side of site, near drain feature.

CO-ORDINATES: 417075.00 N
(HAWKTM2000) 817054.70 E
DIRECTION:
ANGLE FROM HORIZ.: -90°

R.L. GROUND: 11.95m
R.L. COLLAR:
DATUM: NAPIHT1962
SURVEY: Total Station\Surveyed

DESCRIPTION OF CORE

SOIL: Classification, colour, consistency / density, moisture, plasticity
ROCK: Weathering, colour, fabric, name, strength, cementation

GEOLOGICAL UNIT: Estuarine

Silty fine SAND, trace organics in thin discrete lenses; dark grey. Loose, wet, uniformly graded.

10.65 - 10.85m: Silt lense 200mm thick

12.00m: becomes medium dense

12.45 - 12.65m: Silt lense 200mm thick

13.20m: becomes loose

14.15 - 14.25m: thin silt lense

14.65 - 14.75m: thin silt lense

15.45m: Target depth

Sampling Method	Core Recovery (%)	Testing
SNC	100	
SPT	100	0/0 0/1 1/2 N=4
SNC	100	
SPT	100	1/2 3/3 2/2 N=10
SNC	100	
SPT	100	1/0 0/1 3/3 N=7
SNC	100	
SPT	100	2/3 2/2 2/3 N=9

RL (m)	Depth (m)
1	11
0	12
-1	13
-2	14
-3	15
-4	16
-5	17
-6	18
-7	19
-8	

Core Box No: Box 4, 9.5-12.5m; Box 5, 12.5-15.5m

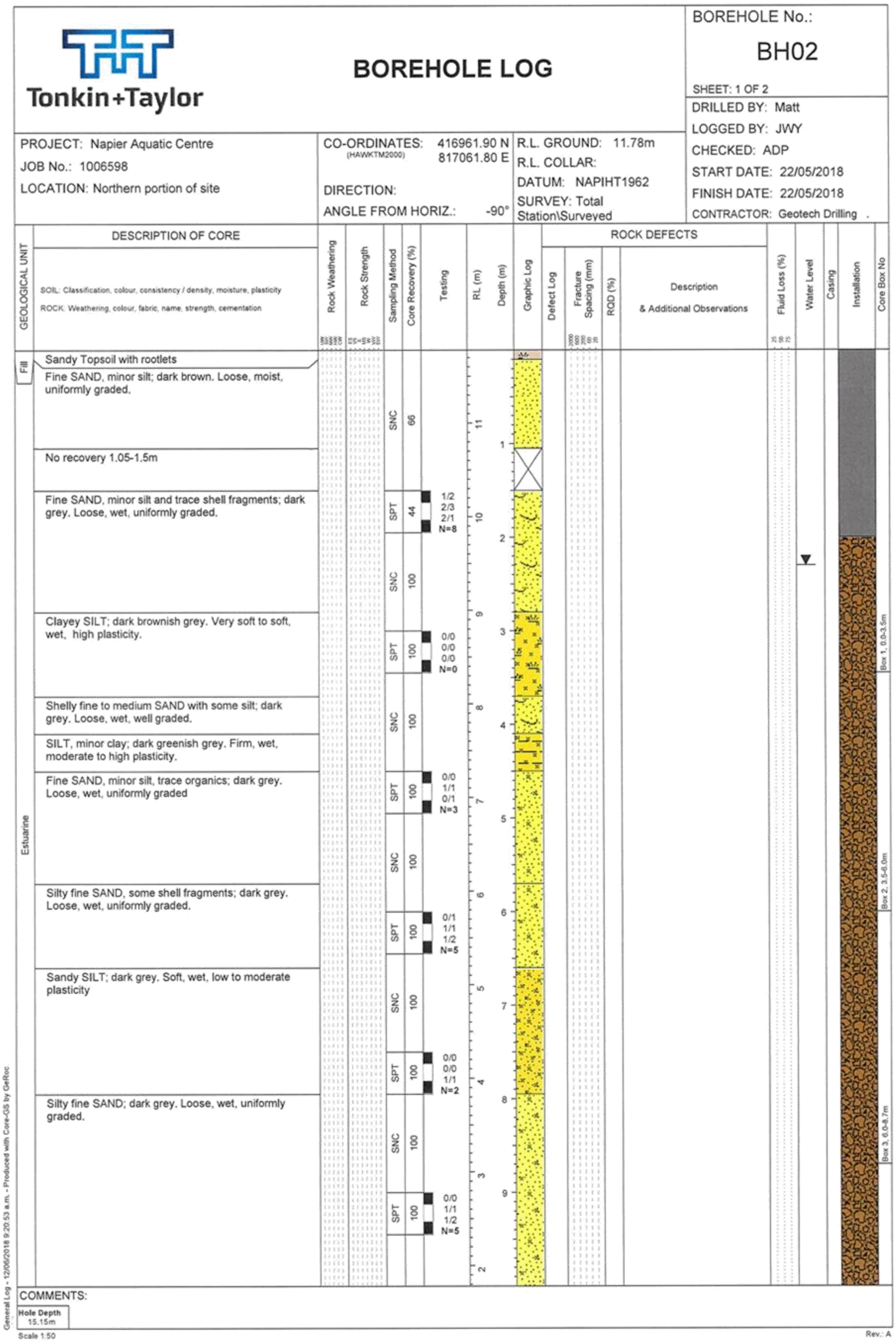
COMMENTS:

Hole Depth
15.45m

Scale 1:50

Rev.: A

General Log - 12/06/2018 9:20:53 a.m. - Produced with Core-GS by GeRoc



Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.:
BH02
SHEET: 1 OF 2

DRILLED BY: Matt
LOGGED BY: JWY
CHECKED: ADP
START DATE: 22/05/2018
FINISH DATE: 22/05/2018
CONTRACTOR: Geotech Drilling .

PROJECT: Napier Aquatic Centre
JOB No.: 1006598
LOCATION: Northern portion of site

CO-ORDINATES: (HAWKTM2000) 416961.90 N 817061.80 E
DIRECTION:
ANGLE FROM HORIZ.: -90°

R.L. GROUND: 11.78m
R.L. COLLAR:
DATUM: NAPIHT1962
SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation
Fill	Sandy Topsoil with rootlets
Estuarine	Fine SAND, minor silt; dark brown. Loose, moist, uniformly graded.
	No recovery 1.05-1.5m
	Fine SAND, minor silt and trace shell fragments; dark grey. Loose, wet, uniformly graded.
	Clayey SILT; dark brownish grey. Very soft to soft, wet, high plasticity.
	Shelly fine to medium SAND with some silt; dark grey. Loose, wet, well graded.
	SILT, minor clay; dark greenish grey. Firm, wet, moderate to high plasticity.
	Fine SAND, minor silt, trace organics; dark grey. Loose, wet, uniformly graded
	Silty fine SAND, some shell fragments; dark grey. Loose, wet, uniformly graded.
	Sandy SILT; dark grey. Soft, wet, low to moderate plasticity
	Silty fine SAND; dark grey. Loose, wet, uniformly graded.

Sampling Method	Core Recovery (%)	Testing
SNC	66	
SPT	44	1/2 2/3 2/1 N=8
SNC	100	
SPT	100	0/0 0/0 0/0 N=0
SNC	100	
SPT	100	0/0 1/1 0/1 N=3
SNC	100	
SPT	100	0/1 1/1 1/2 N=5
SNC	100	
SPT	100	0/0 0/0 1/1 N=2
SNC	100	
SPT	100	0/0 1/1 1/2 N=5

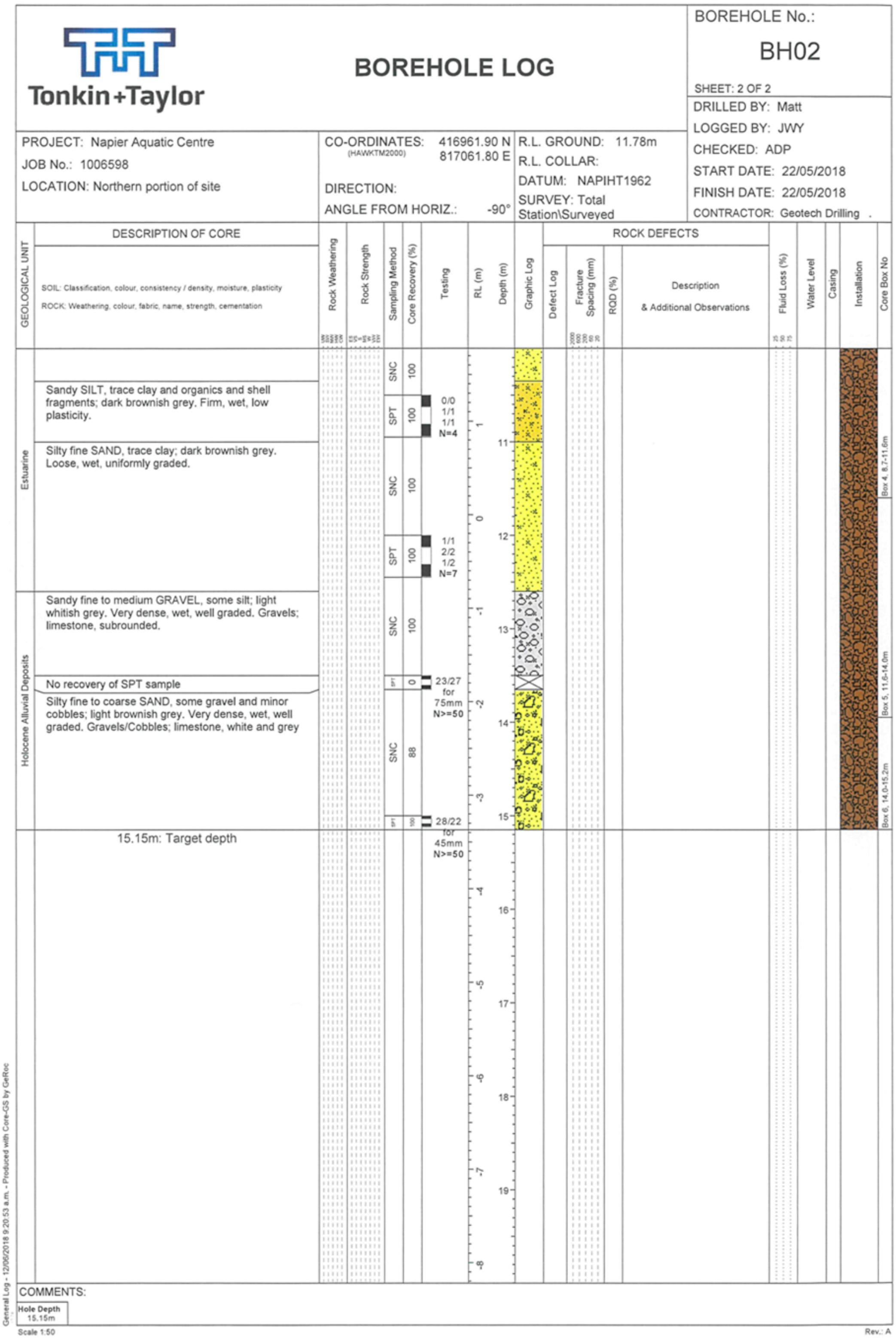
COMMENTS:

Hole Depth
15.15m

Scale 1:50

Rev.: A

General Log - 12/06/2018 9:20:53 a.m. - Produced with Core-GS by GeRoc



Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.:
BH02
SHEET: 2 OF 2

DRILLED BY: Matt
LOGGED BY: JWY
CHECKED: ADP
START DATE: 22/05/2018
FINISH DATE: 22/05/2018
CONTRACTOR: Geotech Drilling .

PROJECT: Napier Aquatic Centre
JOB No.: 1006598
LOCATION: Northern portion of site

CO-ORDINATES: 416961.90 N 817061.80 E
(HAWKTM2000)
DIRECTION:
ANGLE FROM HORIZ.: -90°

R.L. GROUND: 11.78m
R.L. COLLAR:
DATUM: NAPIHT1962
SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Sampling Method	Core Recovery (%)	Testing
Estuarine		SNC	100	
	Sandy SILT, trace clay and organics and shell fragments; dark brownish grey. Firm, wet, low plasticity.	SPT	100	0/0 1/1 1/1 N=4
	Silty fine SAND, trace clay; dark brownish grey. Loose, wet, uniformly graded.	SNC	100	
		SPT	100	1/1 2/2 1/2 N=7
Holocene Alluvial Deposits	Sandy fine to medium GRAVEL, some silt; light whitish grey. Very dense, wet, well graded. Gravels; limestone, subrounded.	SNC	100	
	No recovery of SPT sample	SPT	0	23/27 for 75mm N>=50
	Silty fine to coarse SAND, some gravel and minor cobbles; light brownish grey. Very dense, wet, well graded. Gravels/Cobbles; limestone, white and grey	SNC	88	
		SPT	100	28/22 for 45mm N>=50
	15.15m: Target depth			

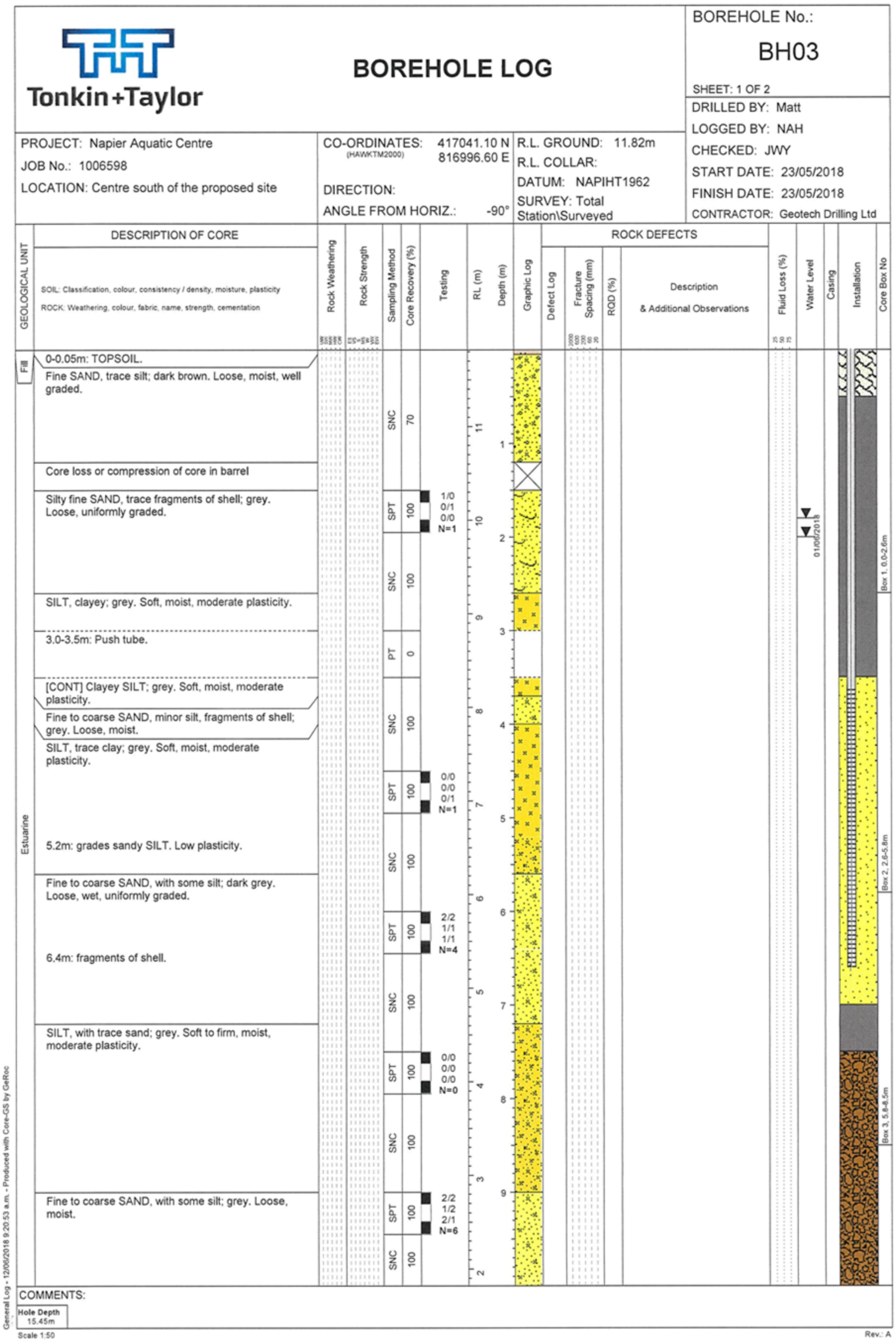
COMMENTS:

Hole Depth
15.15m

Scale 1:50

Rev.: A

General Log - 12/06/2018 9:20:53 a.m. - Produced with Core-GS by GeRoc



Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.:
BH03
SHEET: 1 OF 2

DRILLED BY: Matt
LOGGED BY: NAH
CHECKED: JWY
START DATE: 23/05/2018
FINISH DATE: 23/05/2018
CONTRACTOR: Geotech Drilling Ltd

PROJECT: Napier Aquatic Centre
JOB No.: 1006598
LOCATION: Centre south of the proposed site

CO-ORDINATES: 417041.10 N 816996.60 E
(HAWKTM2000)
DIRECTION:
ANGLE FROM HORIZ.: -90°

R.L. GROUND: 11.82m
R.L. COLLAR:
DATUM: NAPIHT1962
SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Sampling Method	Core Recovery (%)	Testing
Fill	0-0.05m: TOPSOIL. Fine SAND, trace silt; dark brown. Loose, moist, well graded.	SNC	70	
Estuarine	Core loss or compression of core in barrel			
	Silty fine SAND, trace fragments of shell; grey. Loose, uniformly graded.	SPT	100	1/0 0/1 0/0 N=1
		SNC	100	
	SILT, clayey; grey. Soft, moist, moderate plasticity.			
	3.0-3.5m: Push tube.	PT	0	
	[CONT] Clayey SILT; grey. Soft, moist, moderate plasticity.	SNC	100	
	Fine to coarse SAND, minor silt, fragments of shell; grey. Loose, moist.			
	SILT, trace clay; grey. Soft, moist, moderate plasticity.	SPT	100	0/0 0/0 0/1 N=1
	5.2m: grades sandy SILT. Low plasticity.	SNC	100	
	Fine to coarse SAND, with some silt; dark grey. Loose, wet, uniformly graded.	SPT	100	2/2 1/1 1/1 N=4
	6.4m: fragments of shell.	SNC	100	
	SILT, with trace sand; grey. Soft to firm, moist, moderate plasticity.	SPT	100	0/0 0/0 0/0 N=0
		SNC	100	
	Fine to coarse SAND, with some silt; grey. Loose, moist.	SPT	100	2/2 1/2 2/1 N=6
		SNC	100	

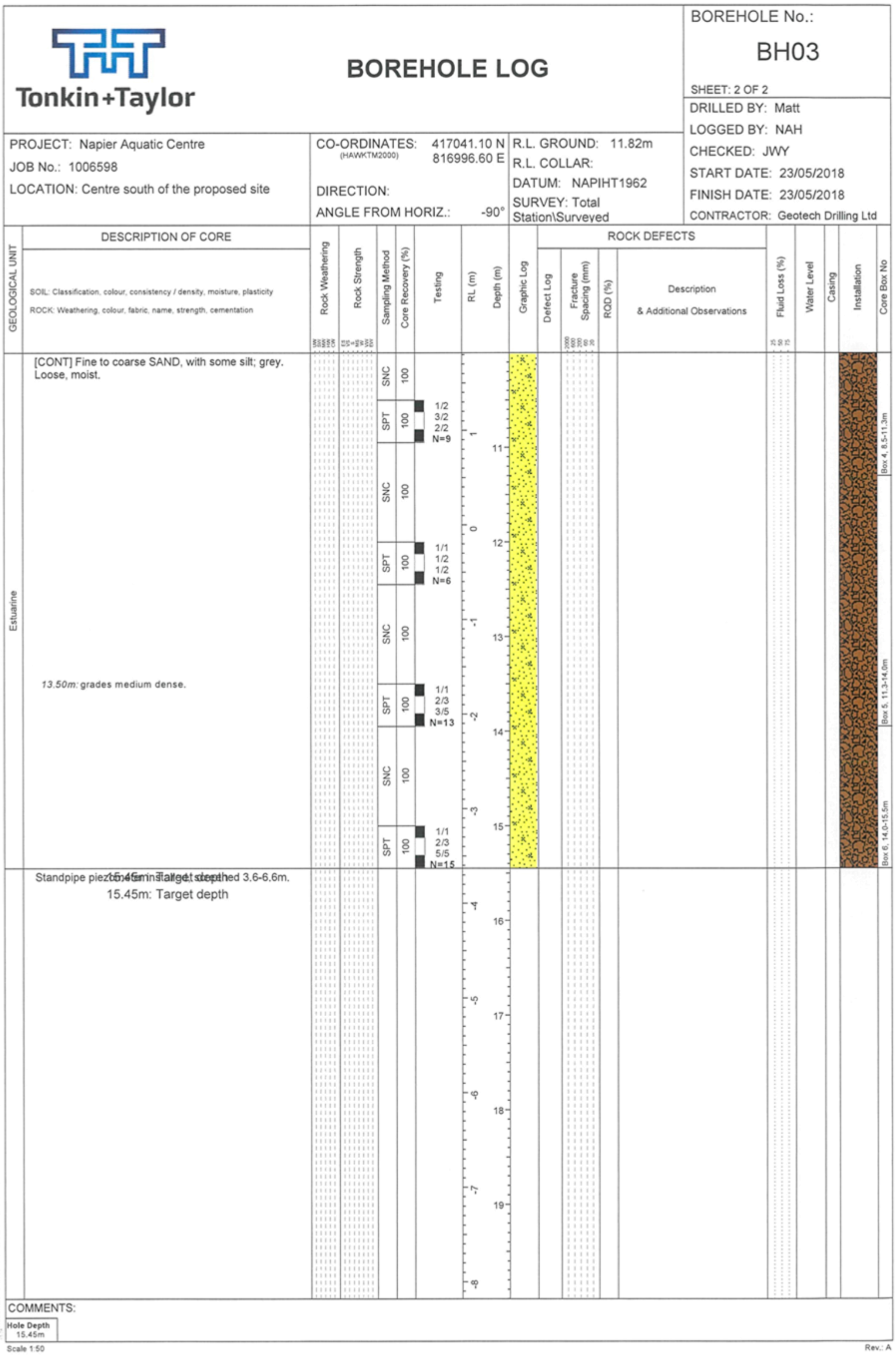
COMMENTS:

Hole Depth
15.45m

Scale 1:50

Rev.: A

General Log - 12/06/2018 9:20:53 a.m. - Produced with Core-GS by GeRoc



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BOREHOLE LOG

BOREHOLE No.:
BH03
SHEET: 2 OF 2

DRILLED BY: Matt
LOGGED BY: NAH
CHECKED: JWY
START DATE: 23/05/2018
FINISH DATE: 23/05/2018
CONTRACTOR: Geotech Drilling Ltd

PROJECT: Napier Aquatic Centre
JOB No.: 1006598
LOCATION: Centre south of the proposed site

CO-ORDINATES: 417041.10 N
(HAWKTM2000) 816996.60 E
DIRECTION:
ANGLE FROM HORIZ.: -90°

R.L. GROUND: 11.82m
R.L. COLLAR:
DATUM: NAPIHT1962
SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation
Estuarine	[CONT] Fine to coarse SAND, with some silt; grey. Loose, moist. *13.50m:* grades medium dense.
	Standpipe piezometer installed, screened 3.6-6.6m. 15.45m: Target depth

Sampling Method	Core Recovery (%)	Testing
SNC	100	
SPT	100	1/2 3/2 2/2 N=9
SNC	100	
SPT	100	1/1 1/2 1/2 N=6
SNC	100	
SPT	100	1/1 2/3 3/5 N=13
SNC	100	
SPT	100	1/1 2/3 5/5 N=15

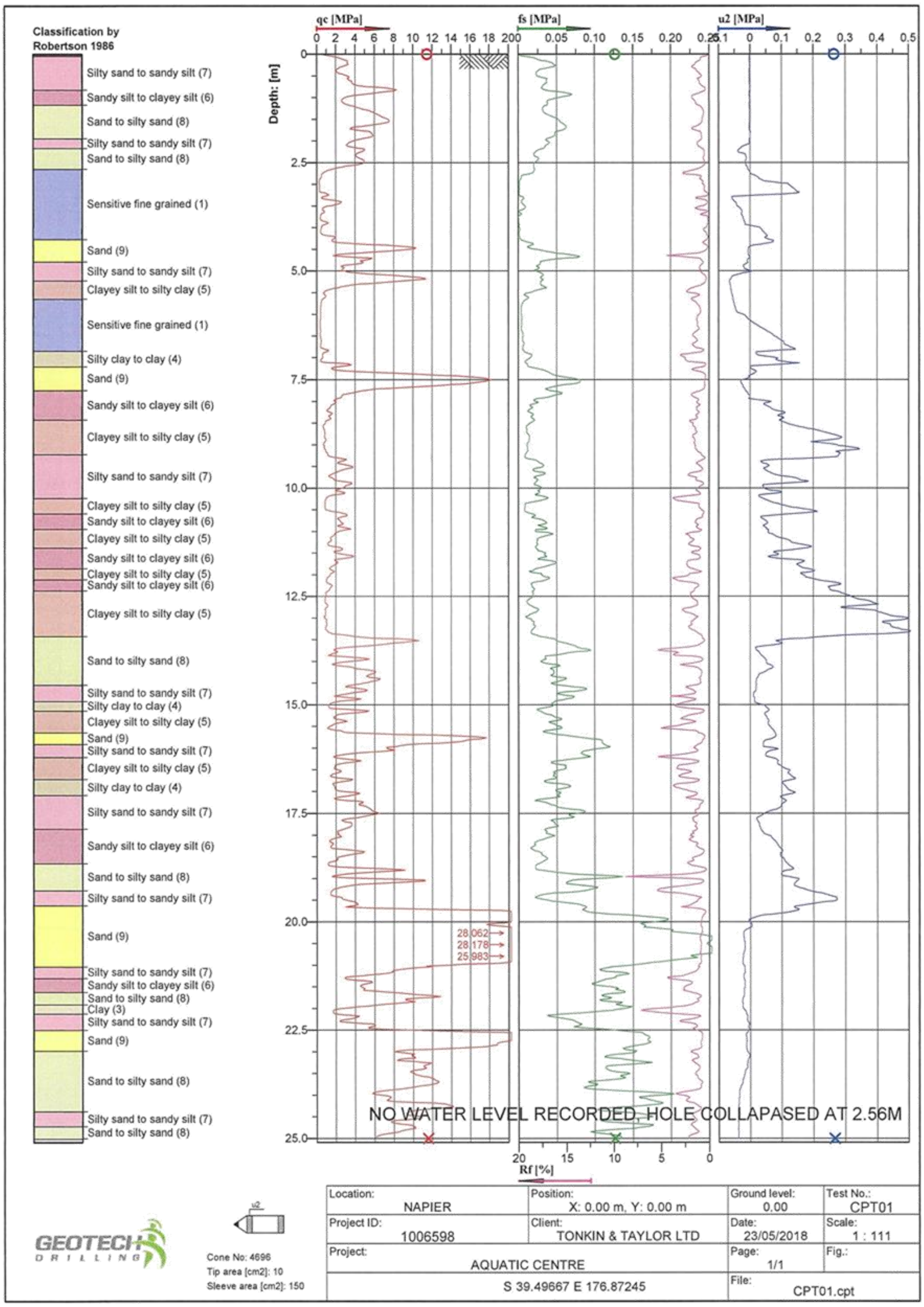
COMMENTS:

Hole Depth
15.45m

Scale 1:50

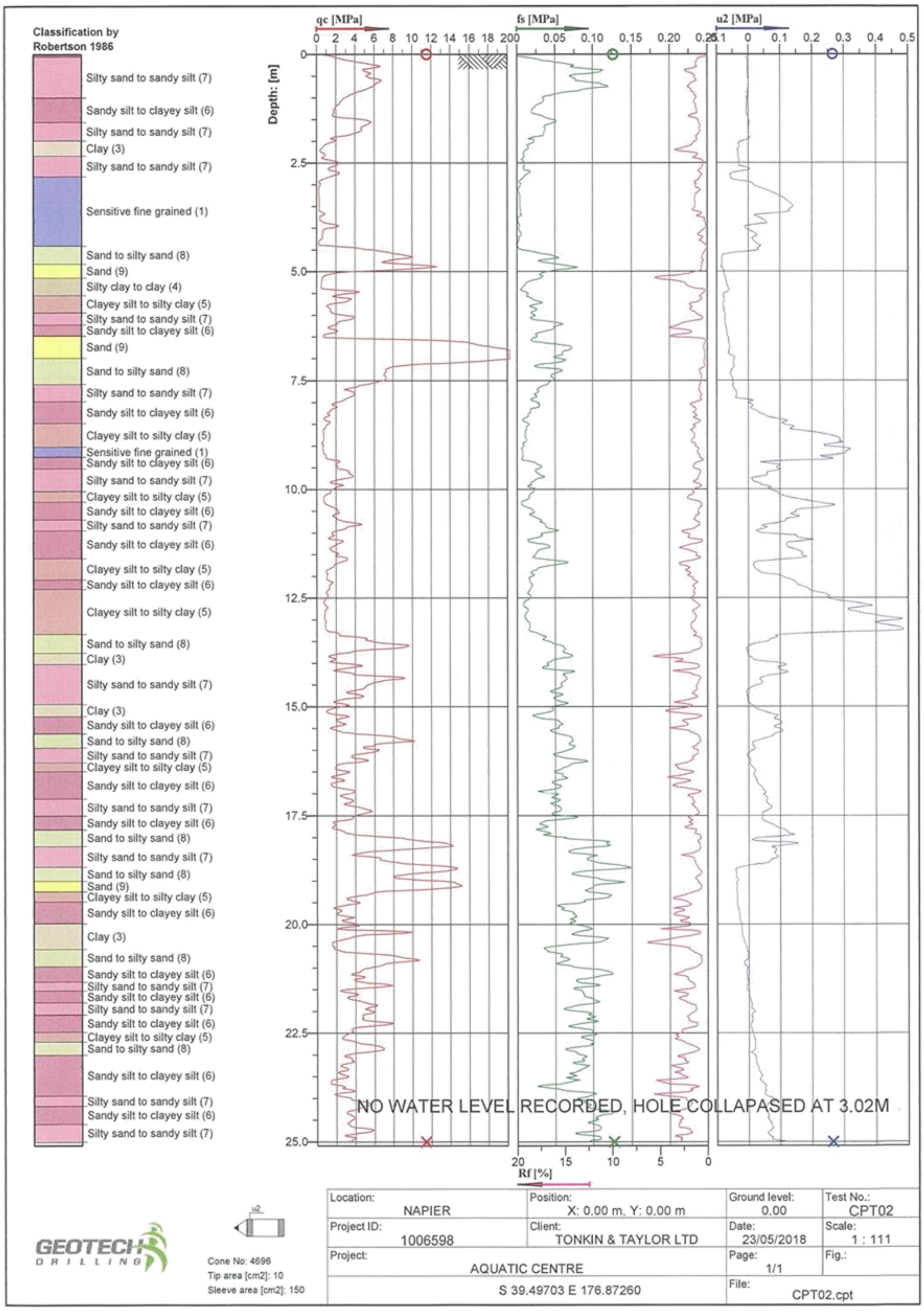
Rev.: A

General Log - 12/06/2018 9:20:53 a.m. - Produced with Core-GS by GeRoc

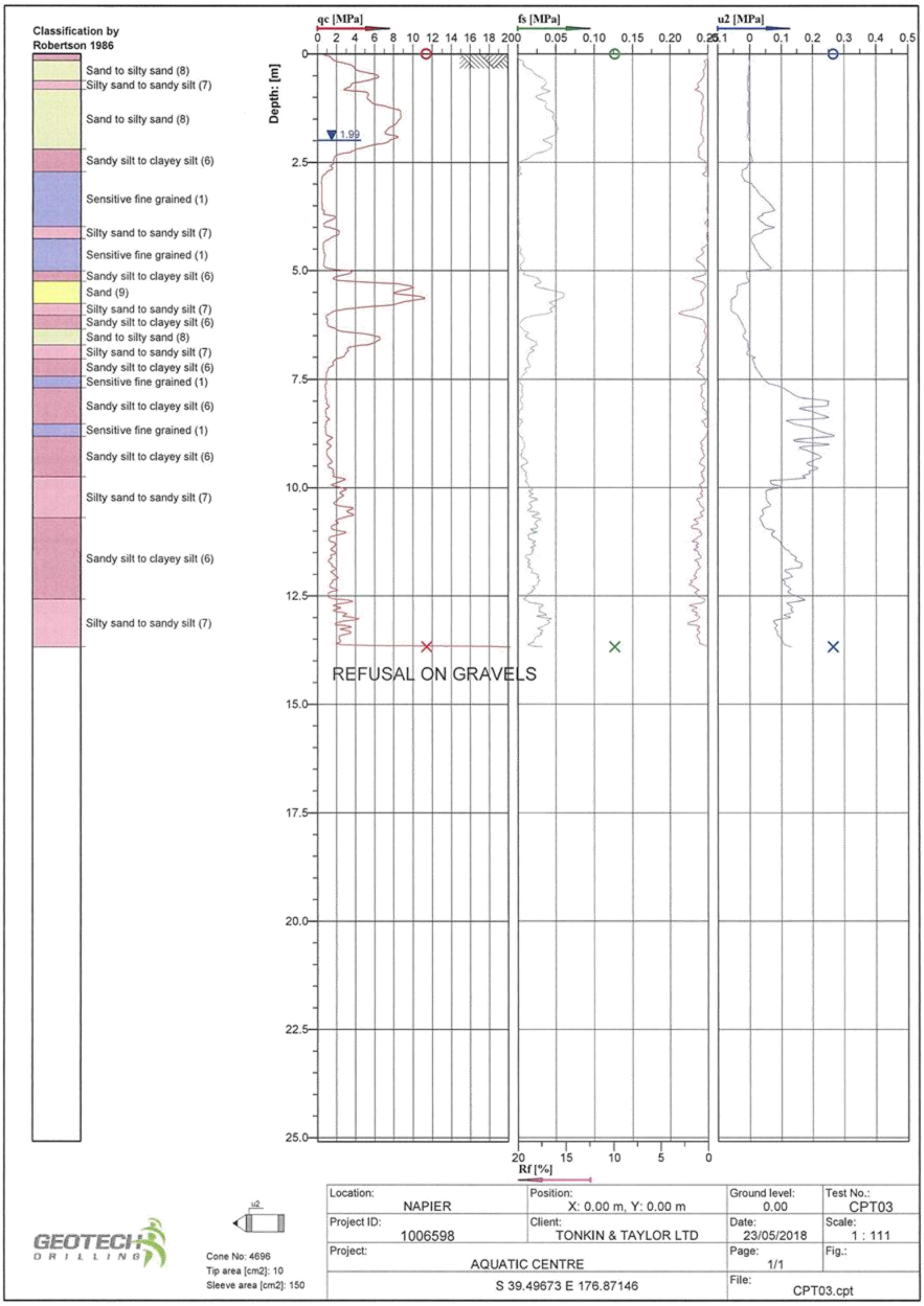


Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: NAPIER	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT01
Project ID: 1006598	Client: TONKIN & TAYLOR LTD	Date: 23/05/2018	Scale: 1 : 111
Project: AQUATIC CENTRE		Page: 1/1	Fig.:
S 39.49667 E 176.87245		File: CPT01.cpt	

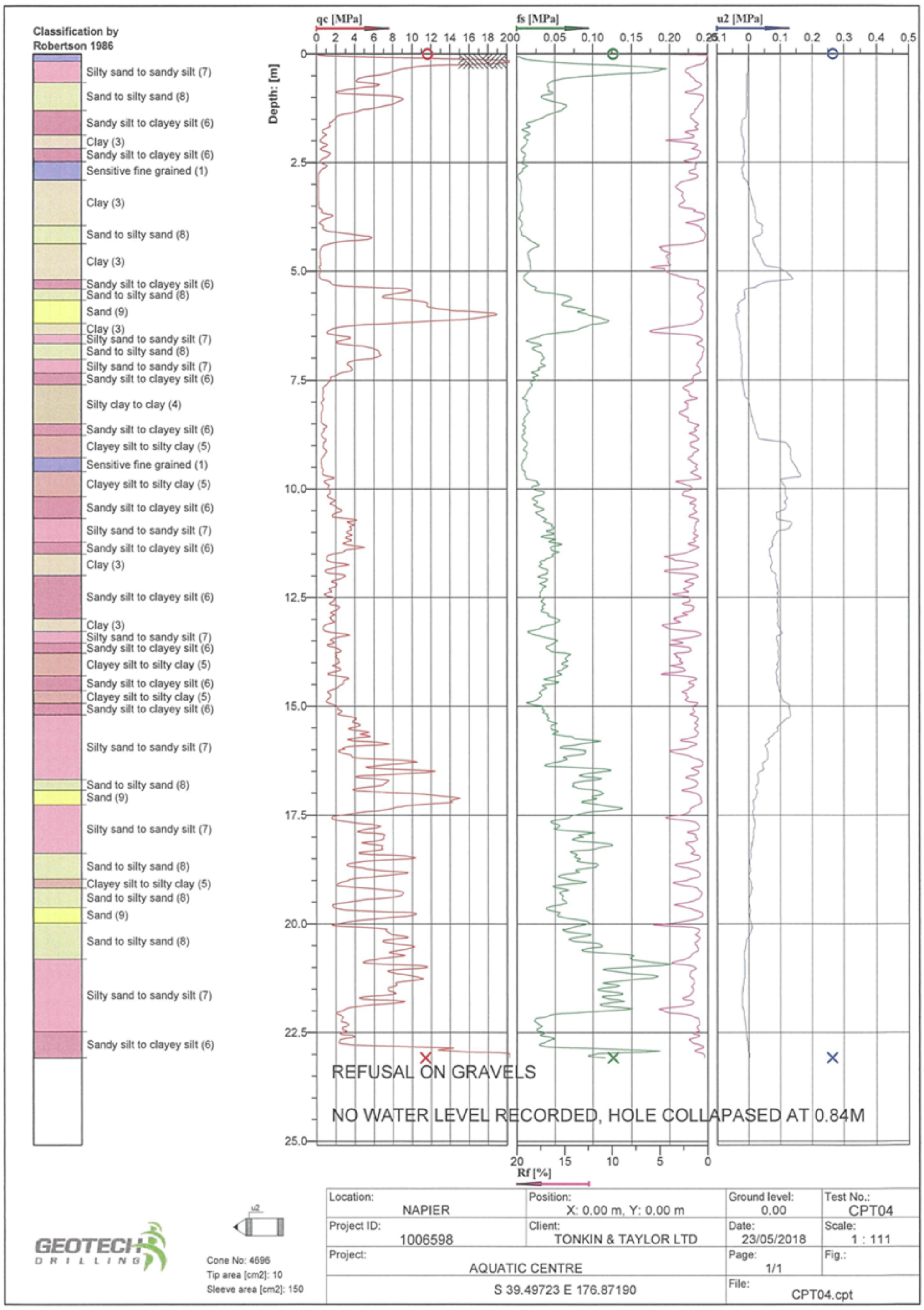


Location: NAPIER	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT02
Project ID: 1006598	Client: TONKIN & TAYLOR LTD	Date: 23/05/2018	Scale: 1 : 111
Project: AQUATIC CENTRE		Page: 1/1	Fig.:
S 39.49703 E 176.87260		File: CPT02.cpt	



Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: NAPIER
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT03
Project ID: 1006598
Client: TONKIN & TAYLOR LTD
Date: 23/05/2018
Scale: 1 : 111
Project: AQUATIC CENTRE
Page: 1/1
Fig.:
S 39.49673 E 176.87146
File: CPT03.cpt

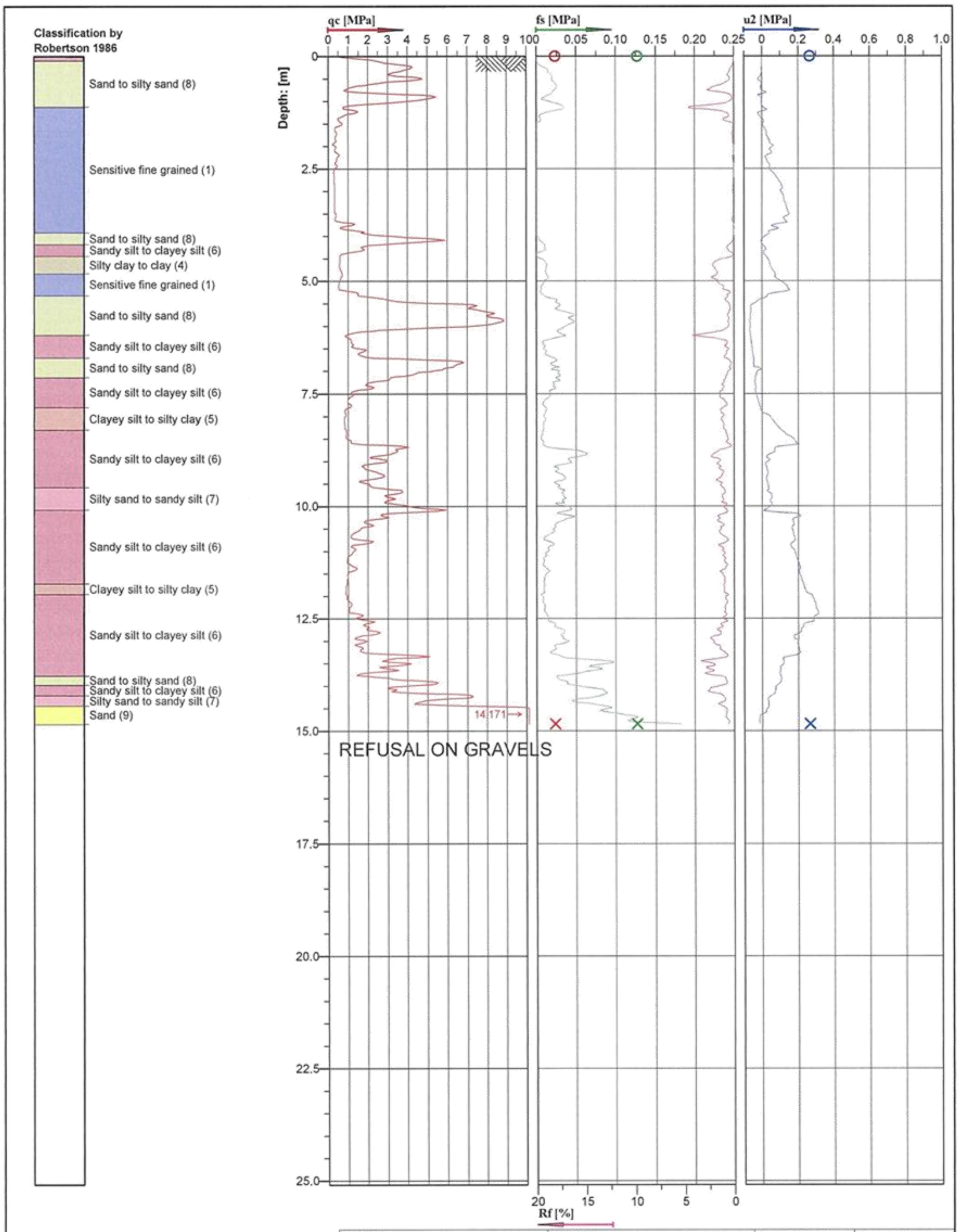


REFUSAL ON GRAVELS

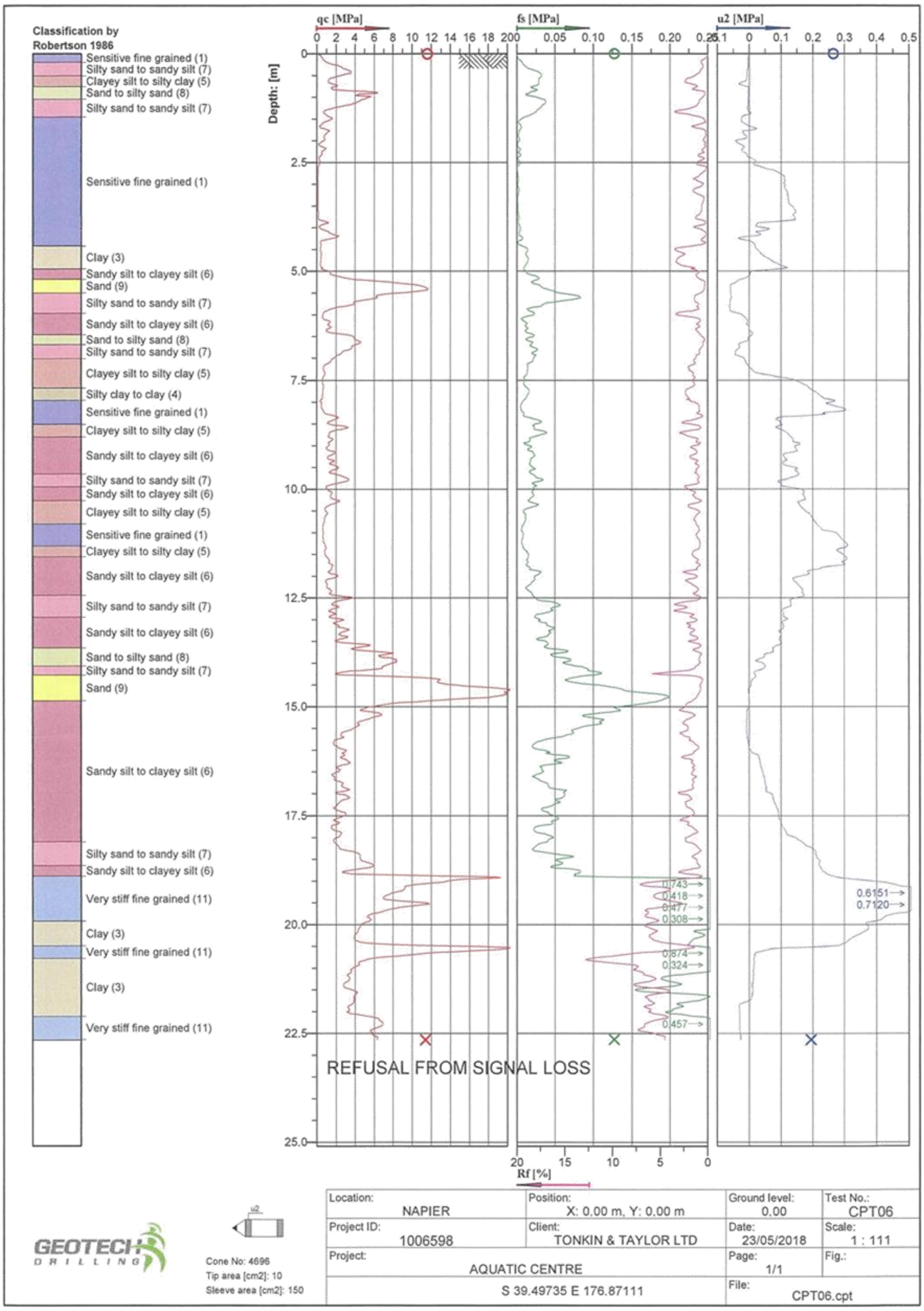
NO WATER LEVEL RECORDED, HOLE COLLAPASED AT 0.84M

Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

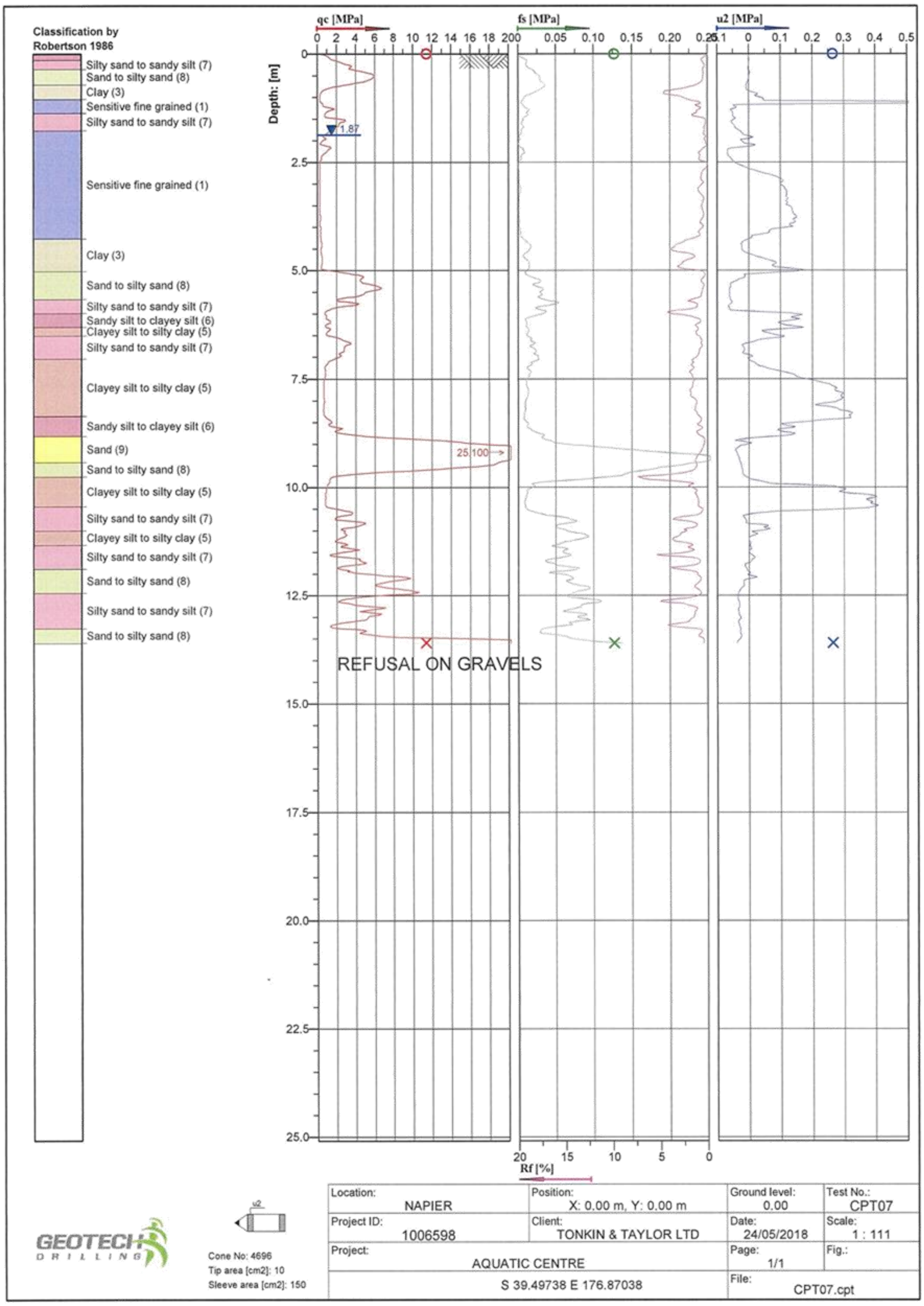
Location: NAPIER	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT04
Project ID: 1006598	Client: TONKIN & TAYLOR LTD	Date: 23/05/2018	Scale: 1 : 111
Project: AQUATIC CENTRE		Page: 1/1	Fig.:
S 39.49723 E 176.87190		File: CPT04.cpt	



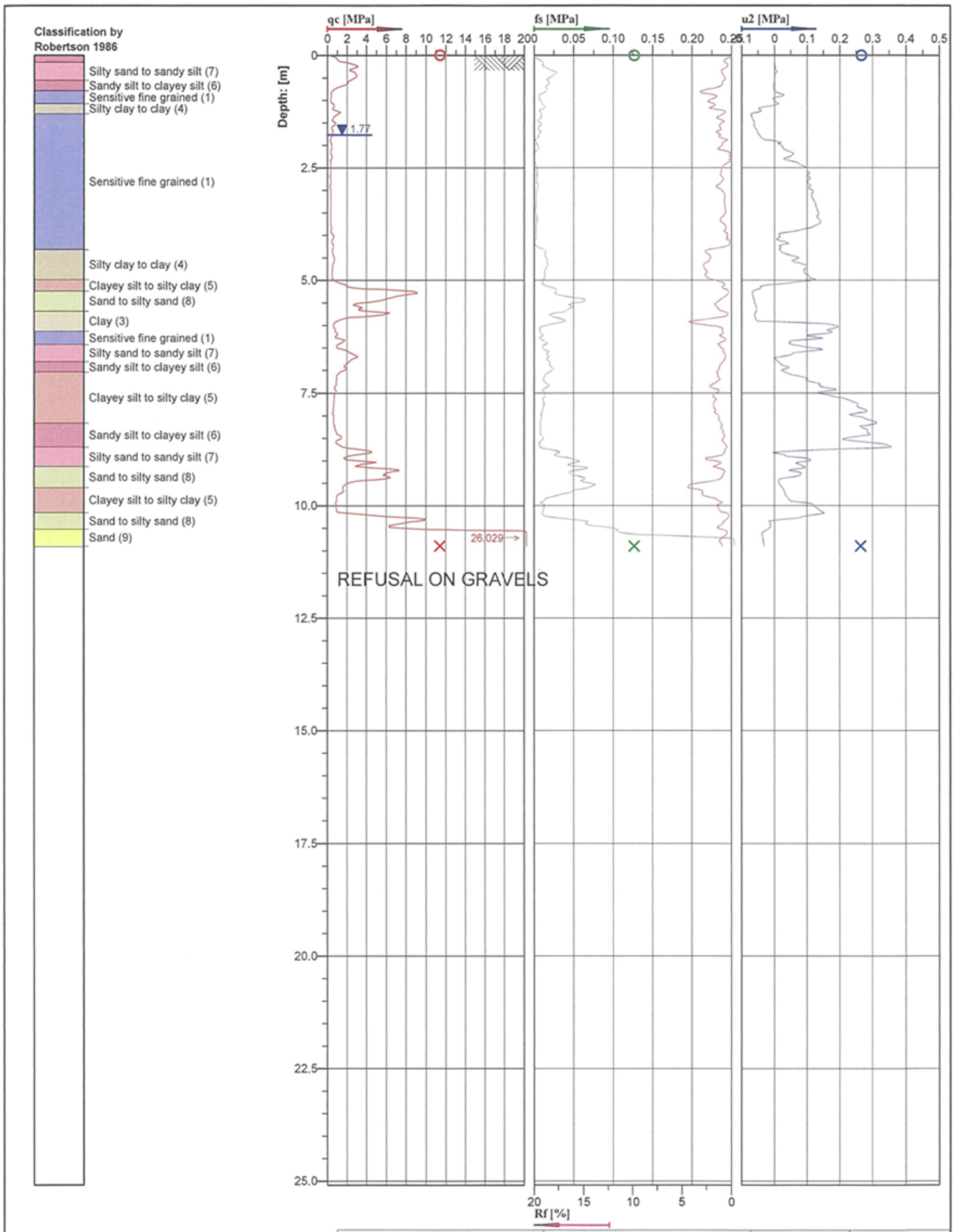
Location: NAPIER
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT05A
Project ID:
Client: TONKIN & TAYLOR LTD
Date: 6/06/2018
Scale: 1 : 111
Project: AQUATIC CENTRE SITE
Page: 1/1
Fig.:
S 39.49780 E 176.87152
File: CPT05.cpt



Location: NAPIER	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT06
Project ID: 1006598	Client: TONKIN & TAYLOR LTD	Date: 23/05/2018	Scale: 1 : 111
Project: AQUATIC CENTRE		Page: 1/1	Fig.:
S 39.49735 E 176.87111		File: CPT06.cpt	

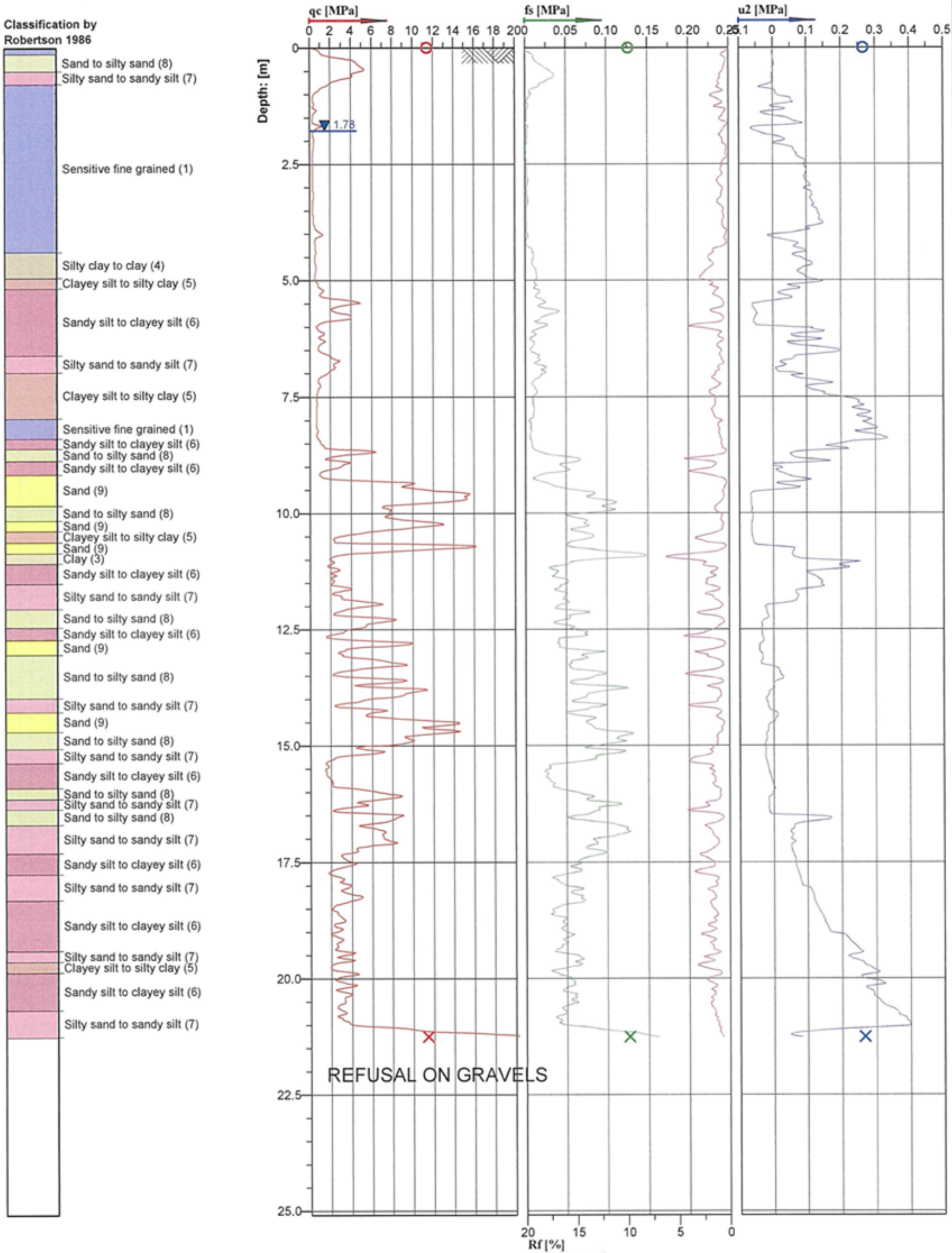


Location: NAPIER	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT07
Project ID: 1006598	Client: TONKIN & TAYLOR LTD	Date: 24/05/2018	Scale: 1 : 111
Project: AQUATIC CENTRE S 39.49738 E 176.87038		Page: 1/1	Fig.:
		File: CPT07.cpt	



Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: NAPIER	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT08
Project ID: 1006598	Client: TONKIN & TAYLOR LTD	Date: 24/05/2018	Scale: 1 : 111
Project: AQUATIC CENTRE		Page: 1/1	Fig.:
S 39.49784 E 176.87067		File: CPT08.cpt	

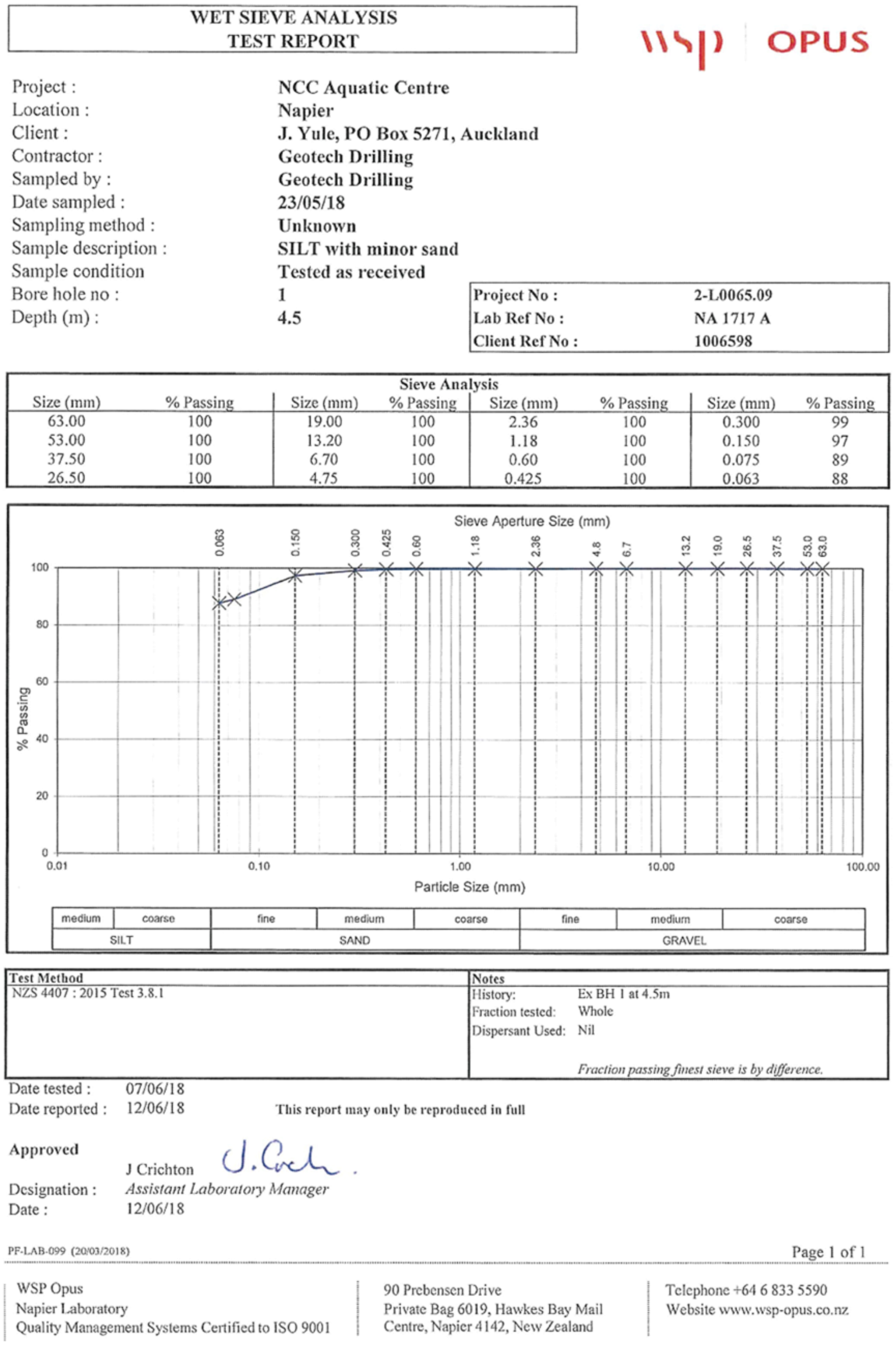


Cone No: 4696
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: NAPIER	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test No.: CPT09
Project ID: 1006598	Client: TONKIN & TAYLOR LTD	Date: 24/05/2018	Scale: 1 : 111
Project: AQUATIC CENTRE		Page: 1/1	Fig.:
S 39.49846 E 176.87061		File: CPT09.cpt	

Appendix C: Laboratory Test Results

- **1 D Consolidation Settlement Test**
- **Atterberg limit and particle size distribution test results**



WET SIEVE ANALYSIS
TEST REPORT

Project :	**NCC Aquatic Centre**
Location :	**Napier**
Client :	**J. Yule, PO Box 5271, Auckland**
Contractor :	**Geotech Drilling**
Sampled by :	**Geotech Drilling**
Date sampled :	**23/05/18**
Sampling method :	**Unknown**
Sample description :	**SILT with minor sand**
Sample condition	**Tested as received**
Bore hole no :	**1**
Depth (m) :	**4.5**

Project No :	**2-L0065.09**
Lab Ref No :	**NA 1717 A**
Client Ref No :	**1006598**

Sieve Analysis							
Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing
63.00	100	19.00	100	2.36	100	0.300	99
53.00	100	13.20	100	1.18	100	0.150	97
37.50	100	6.70	100	0.60	100	0.075	89
26.50	100	4.75	100	0.425	100	0.063	88

Test Method	Notes	
NZS 4407 : 2015 Test 3.8.1	History:	Ex BH 1 at 4.5m
	Fraction tested:	Whole
	Dispersant Used:	Nil
		Fraction passing finest sieve is by difference.

Date tested : 07/06/18
Date reported : 12/06/18

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Approved

J Crichton

Designation : *Assistant Laboratory Manager*
Date : 12/06/18

PF-LAB-099 (20/03/2018)

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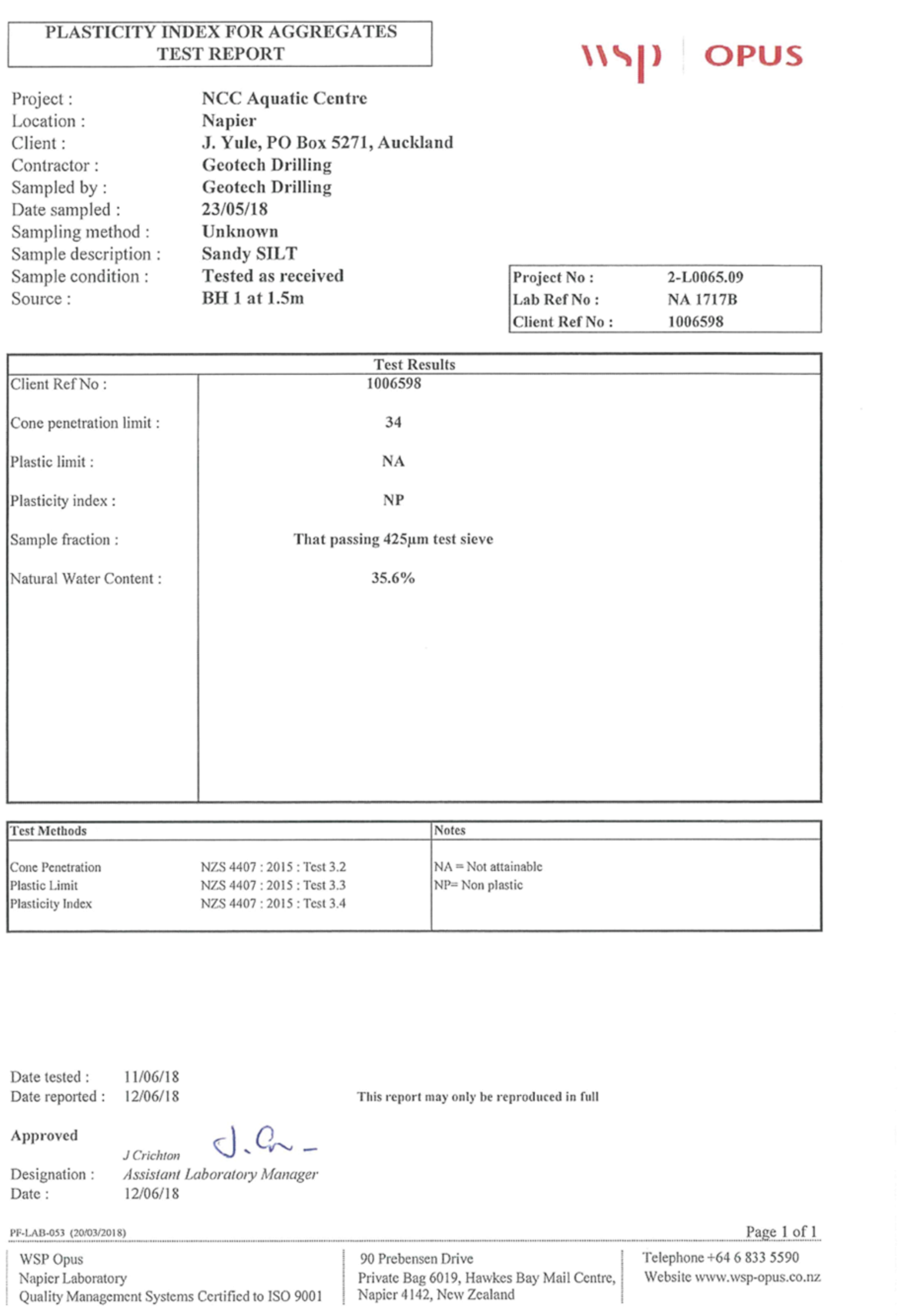
WSP Opus
Napier Laboratory
Quality Management Systems Certified to ISO 9001

90 Prebensen Drive
Private Bag 6019, Hawkes Bay Mail Centre, Napier 4142, New Zealand

Telephone +64 6 833 5590
Website www.wsp-opus.co.nz



PLASTICITY INDEX FOR AGGREGATES TEST REPORT

WSP | OPUS

Project : **NCC Aquatic Centre**
Location : **Napier**
Client : **J. Yule, PO Box 5271, Auckland**
Contractor : **Geotech Drilling**
Sampled by : **Geotech Drilling**
Date sampled : **23/05/18**
Sampling method : **Unknown**
Sample description : **Sandy SILT**
Sample condition : **Tested as received**
Source : **BH 1 at 1.5m**

Project No : **2-L0065.09**
Lab Ref No : **NA 1717B**
Client Ref No : **1006598**

	Test Results
Client Ref No :	**1006598**
Cone penetration limit :	**34**
Plastic limit :	**NA**
Plasticity index :	**NP**
Sample fraction :	**That passing 425µm test sieve**
Natural Water Content :	**35.6%**

Test Methods		**Notes**
Cone Penetration	NZS 4407 : 2015 : Test 3.2	NA = Not attainable
Plastic Limit	NZS 4407 : 2015 : Test 3.3	NP= Non plastic
Plasticity Index	NZS 4407 : 2015 : Test 3.4	

Date tested : 11/06/18
Date reported : 12/06/18

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Approved
J Crichton
Designation : *Assistant Laboratory Manager*
Date : 12/06/18

PF-LAB-053 (20/03/2018)

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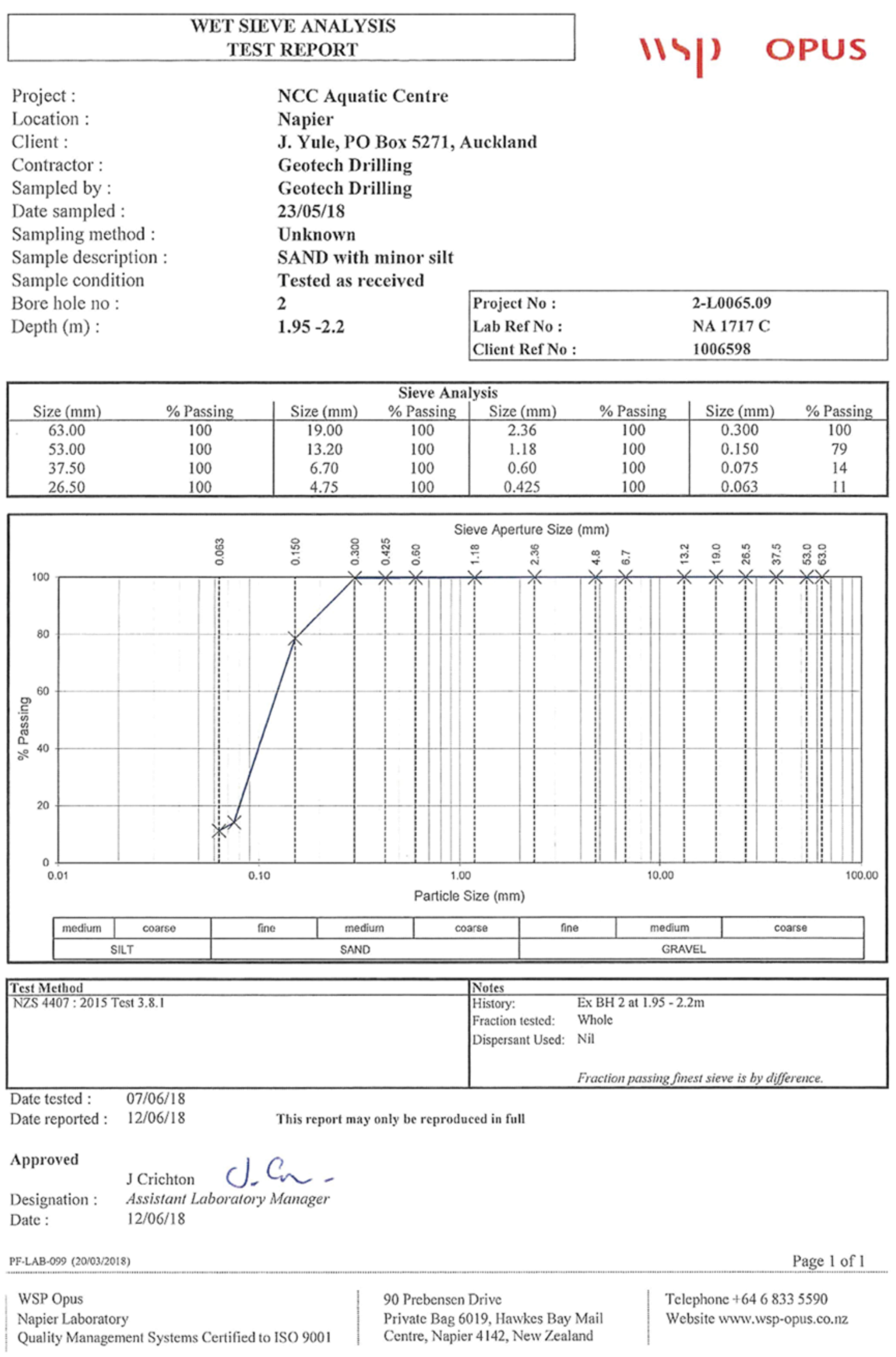
WSP Opus
Napier Laboratory
Quality Management Systems Certified to ISO 9001

90 Prebensen Drive
Private Bag 6019, Hawkes Bay Mail Centre,
Napier 4142, New Zealand

Telephone +64 6 833 5590
Website www.wsp-opus.co.nz



WET SIEVE ANALYSIS
TEST REPORT

Project :	**NCC Aquatic Centre**
Location :	**Napier**
Client :	**J. Yule, PO Box 5271, Auckland**
Contractor :	**Geotech Drilling**
Sampled by :	**Geotech Drilling**
Date sampled :	**23/05/18**
Sampling method :	**Unknown**
Sample description :	**SAND with minor silt**
Sample condition	**Tested as received**
Bore hole no :	**2**
Depth (m) :	**1.95 -2.2**

Project No :	**2-L0065.09**
Lab Ref No :	**NA 1717 C**
Client Ref No :	**1006598**

Sieve Analysis

Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing
63.00	100	19.00	100	2.36	100	0.300	100
53.00	100	13.20	100	1.18	100	0.150	79
37.50	100	6.70	100	0.60	100	0.075	14
26.50	100	4.75	100	0.425	100	0.063	11

Test Method	**Notes**	
NZS 4407 : 2015 Test 3.8.1	History:	Ex BH 2 at 1.95 - 2.2m
	Fraction tested:	Whole
	Dispersant Used:	Nil
		Fraction passing finest sieve is by difference.

Date tested : 07/06/18
Date reported : 12/06/18

This report may only be reproduced in full

Approved

J Crichton J. Cr
Designation : *Assistant Laboratory Manager*
Date : 12/06/18

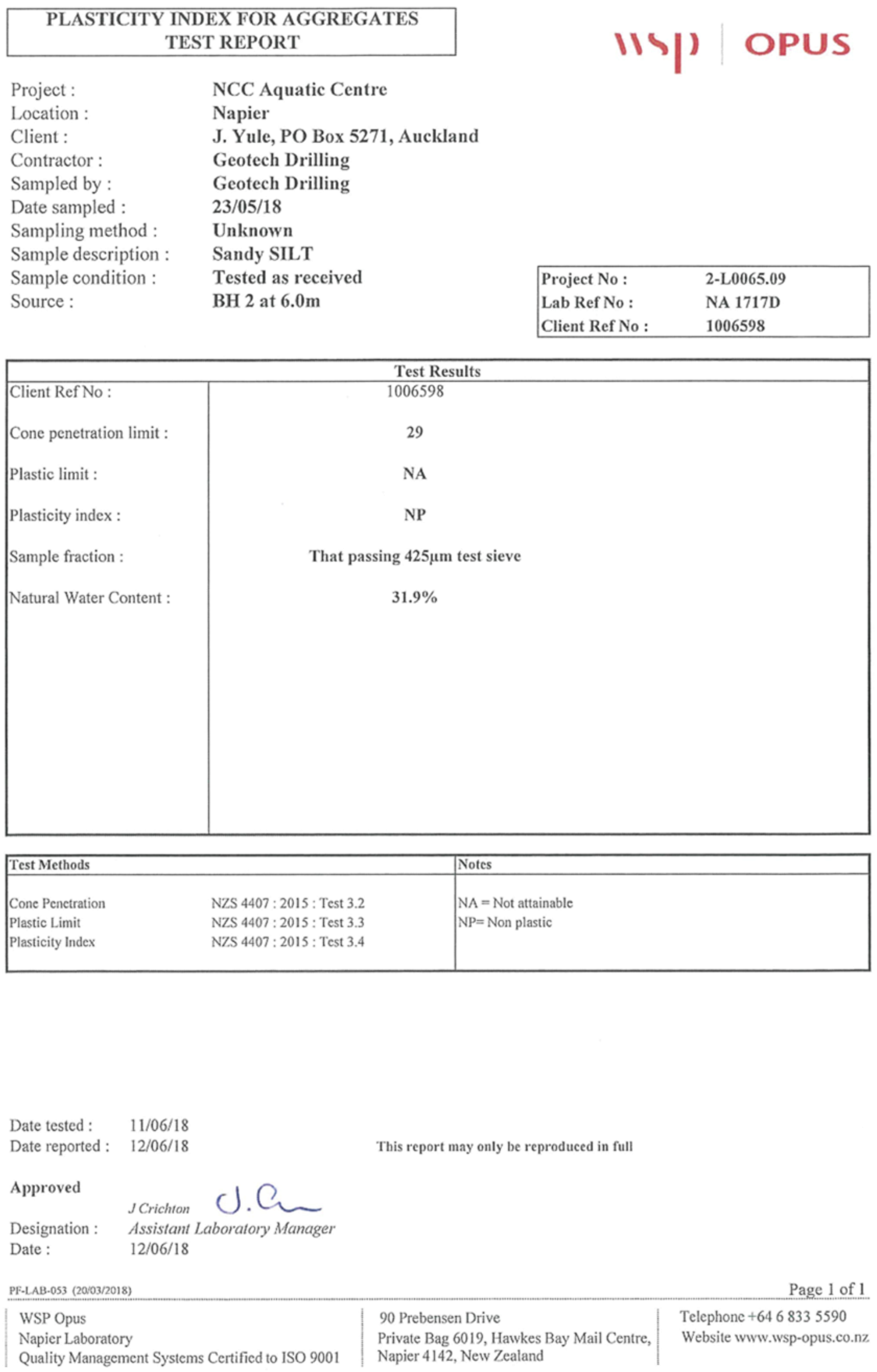
PF-LAB-099 (20/03/2018)

Page 1 of 1

WSP Opus
Napier Laboratory
Quality Management Systems Certified to ISO 9001

90 Prebensen Drive
Private Bag 6019, Hawkes Bay Mail Centre, Napier 4142, New Zealand

Telephone +64 6 833 5590
Website www.wsp-opus.co.nz



PLASTICITY INDEX FOR AGGREGATES TEST REPORT

WSP | OPUS

Project :	**NCC Aquatic Centre**
Location :	**Napier**
Client :	**J. Yule, PO Box 5271, Auckland**
Contractor :	**Geotech Drilling**
Sampled by :	**Geotech Drilling**
Date sampled :	**23/05/18**
Sampling method :	**Unknown**
Sample description :	**Sandy SILT**
Sample condition :	**Tested as received**
Source :	**BH 2 at 6.0m**

Project No :	**2-L0065.09**
Lab Ref No :	**NA 1717D**
Client Ref No :	**1006598**

	Test Results
Client Ref No :	1006598
Cone penetration limit :	29
Plastic limit :	NA
Plasticity index :	NP
Sample fraction :	That passing 425µm test sieve
Natural Water Content :	31.9%

Test Methods		**Notes**
Cone Penetration	NZS 4407 : 2015 : Test 3.2	NA = Not attainable
Plastic Limit	NZS 4407 : 2015 : Test 3.3	NP= Non plastic
Plasticity Index	NZS 4407 : 2015 : Test 3.4	

Date tested : 11/06/18
Date reported : 12/06/18

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Approved
J Crichton J.C
Designation : *Assistant Laboratory Manager*
Date : 12/06/18

PF-LAB-053 (20/03/2018)

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Napier 4142, New Zealand

Telephone +64 6 833 5590
Website www.wsp-opus.co.nz

WET SIEVE ANALYSIS
TEST REPORT

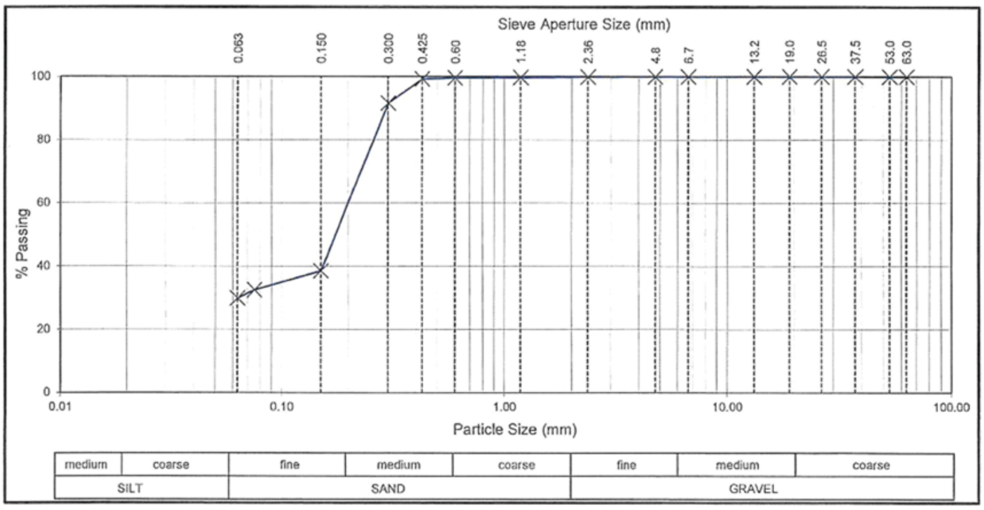
WSP OPUS

Project :	**NCC Aquatic Centre**
Location :	**Napier**
Client :	**J. Yule, PO Box 5271, Auckland**
Contractor :	**Geotech Drilling**
Sampled by :	**Geotech Drilling**
Date sampled :	**23/05/18**
Sampling method :	**Unknown**
Sample description :	**Silty SAND**
Sample condition	**Tested as received**
Bore hole no :	**3**
Depth (m) :	**6**

Project No :	**2-L0065.09**
Lab Ref No :	**NA 1717 E**
Client Ref No :	**1006598**

Sieve Analysis

Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing
63.00	100	19.00	100	2.36	100	0.300	92
53.00	100	13.20	100	1.18	100	0.150	39
37.50	100	6.70	100	0.60	100	0.075	32
26.50	100	4.75	100	0.425	99	0.063	30



Test Method	**Notes**
NZS 4407 : 2015 Test 3.8.1	History: Ex BH 3 at 6.0m Fraction tested: Whole Dispersant Used: Nil *Fraction passing finest sieve is by difference.*

Date tested : 07/06/18
Date reported : 12/06/18

This report may only be reproduced in full

Approved

J Crichton J.C

Designation : *Assistant Laboratory Manager*
Date : 12/06/18

PF-LAB-099 (20/03/2018)

Page 1 of 1

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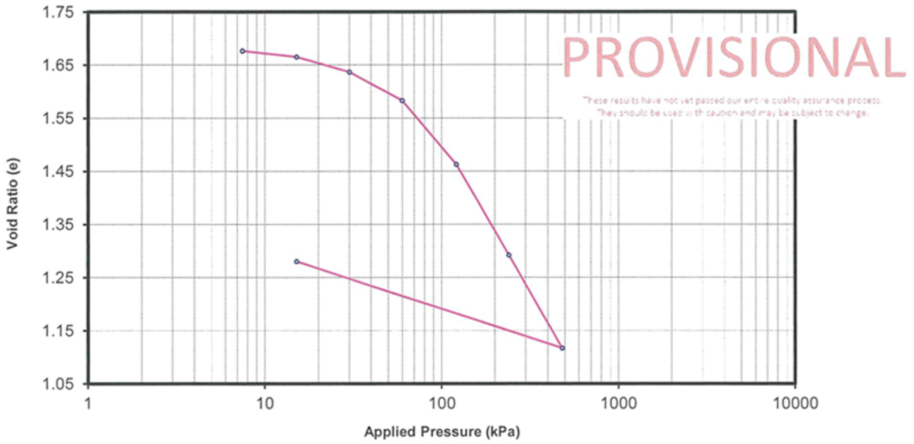
GEOTECHNICS
Ground Floor, 19 Morgan Street, Newmarket, Auckland 1023
PO Box 9360, Newmarket, Auckland 1149
p 64 9 356 3510
www.geotechnics.co.nz

Your Job No.: **1006598.0000**
Site: **Aquatic Centre, Napier** Our Job No.: **1007378.00000.0.0**
BH No.: **3** Sample ID.: **2** Depth: **3.30-3.35 (m)**
Test Method Used: NZS 4402:1986 Test 7.1 One-Dimensional Consolidation

ONE-DIMENSIONAL CONSOLIDATION TEST



PROVISIONAL

"These results have not yet passed our entire quality assurance process. They should be used with caution and may be subject to change.

Pressure (kPa)		Void Ratio (e)	Pressure Increment (kPa)	Coefficient of Consolidation Cv (m^2/yr)	Coefficient of Volume Compressibility Mv (m^2/MN)
As received	0	1.689			
Preload	7.5	1.677	0 to 7.5	NA	0.60
	15.1	1.666	7.5 to 15.1	9.0	0.54
	30.2	1.637	15.1 to 30.2	7.8	0.71
	60.3	1.584	30.2 to 60.3	6.3	0.67
	121	1.463	60.3 to 121	5.4	0.77
	241	1.293	121 to 241	4.6	0.58
	483	1.118	241 to 483	4.3	0.32
Unload	15.1	1.281	483 to 15.1	NA	NA

Sample History: Undisturbed core trimmed at NWC.
Description: SILT with minor clay and trace of sand, soft, grey to dark grey.

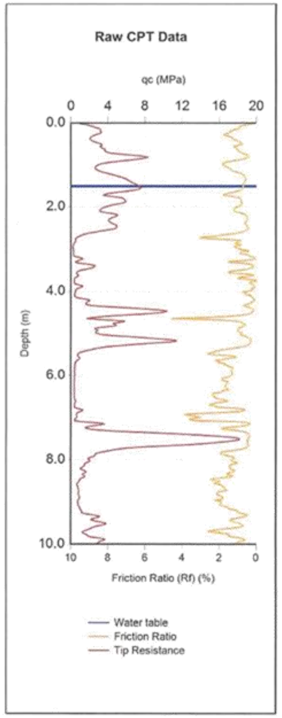
Initial Dry Density (t/m³): 0.99 Initial Water Content: 61.5%
Solid Density (t/m³): 2.65 (Assumed) Initial Saturation: 96%
Temperature During Testing: Max = 18 °C Min = 16 °C

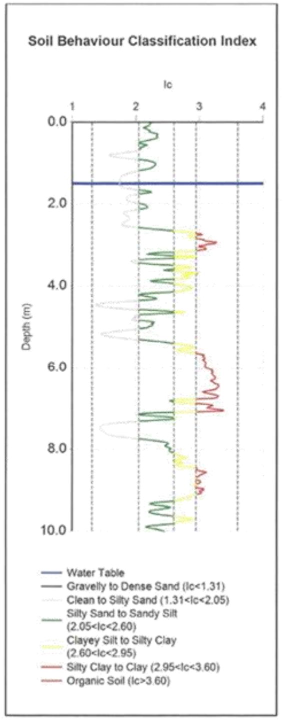
Remarks: SQR of time fitting method was used. We have assumed a standard value of 2.65 t/m³. The calculations of void ratio are affected by the solid density value.
The test results are IANZ accredited but the sample description is not IANZ accredited.

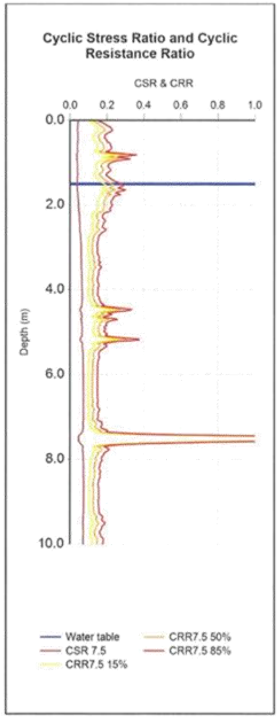
Entered by: Date: Checked by: Date:

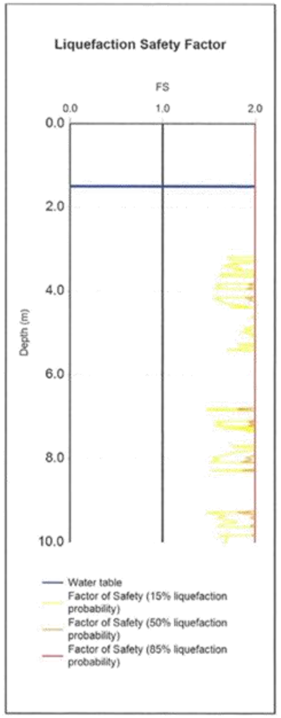
Appendix D : Liquefaction Assessment Outputs

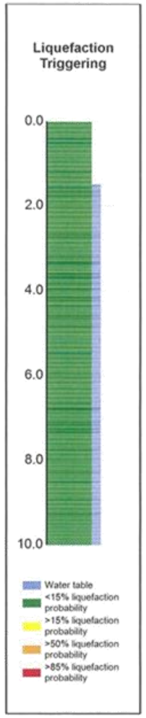
- **SLS Liquefaction Assessment**
- **100 Year Recurrence Interval Liquefaction Assessment**
- **ULS Liquefaction Assessment**











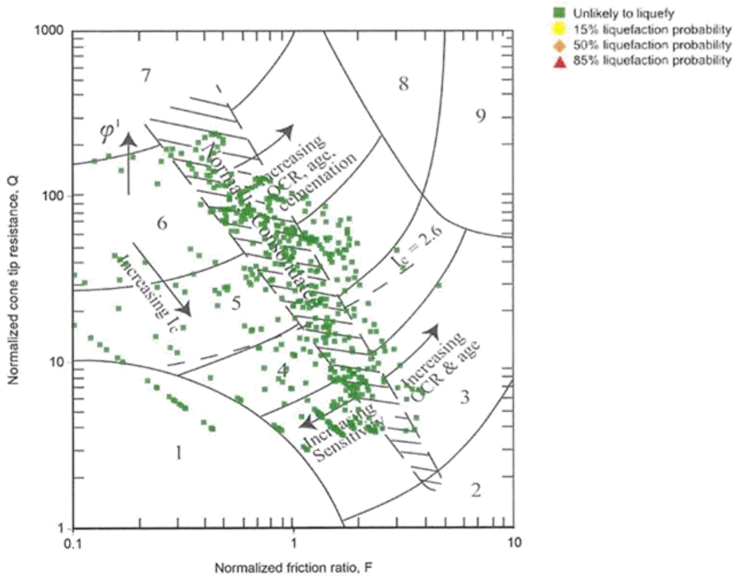
(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT01	112067	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish
OUTPUT	15%	3	0	0	1	10	0
	50%	0	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
		ANALYSED	joma
TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
		PAGE	1 of 11 pages

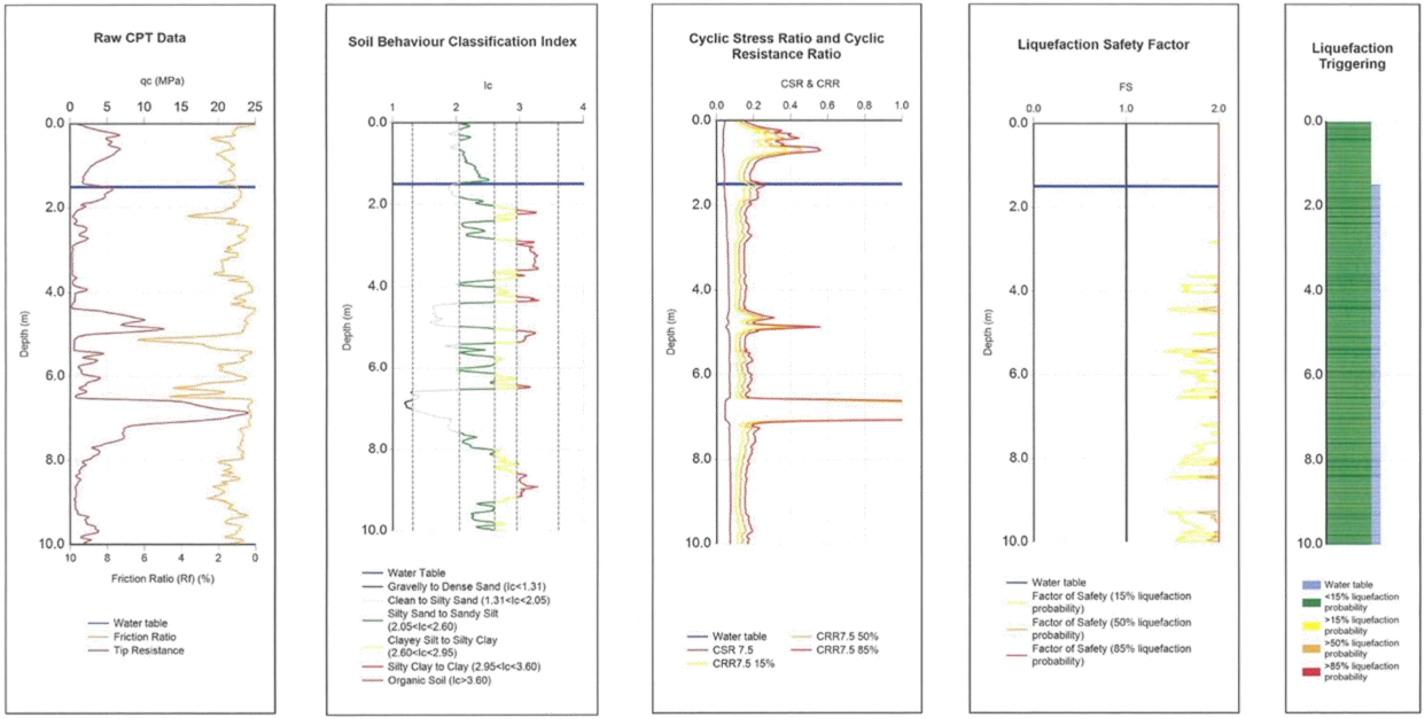


1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	2 of 11 pages



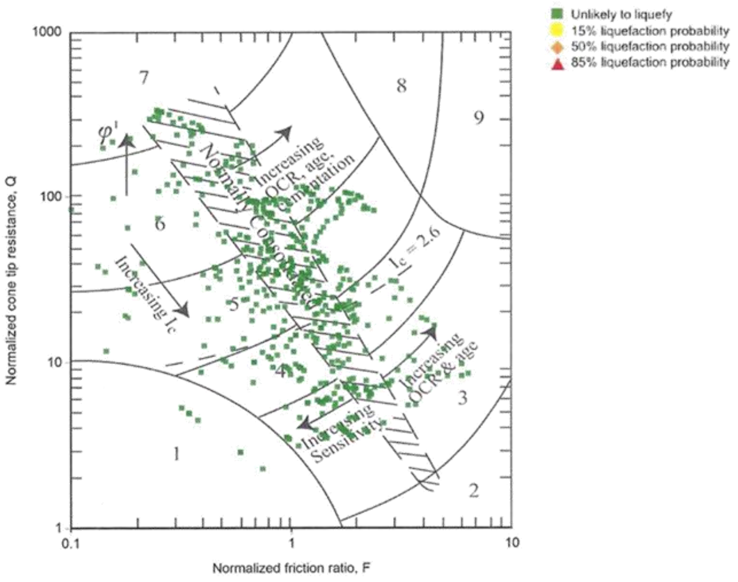
(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT02	112104	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	4	0	0	1	10	0
	50%	0	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
		ANALYSED	joma
TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
		PAGE	3 of 11 pages



1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
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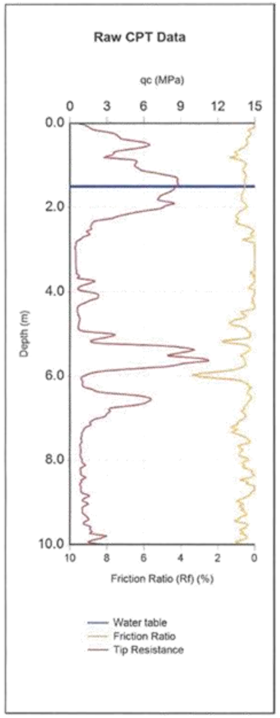
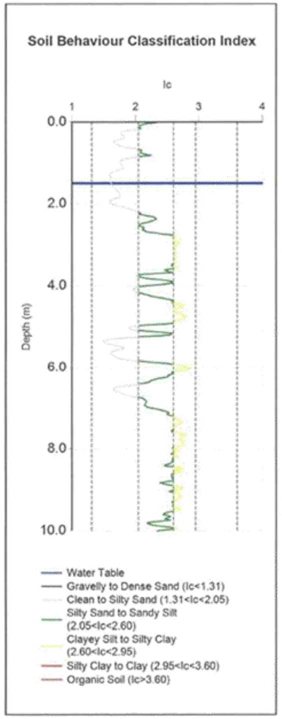
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

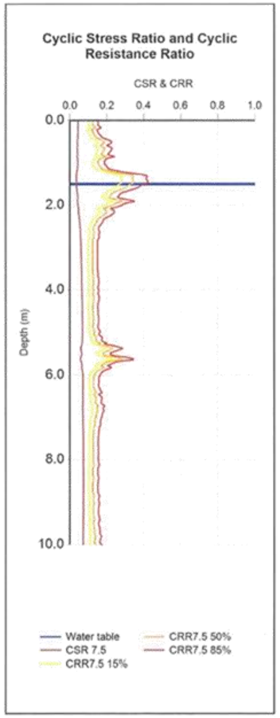
*Heavily overconsolidated or cemented

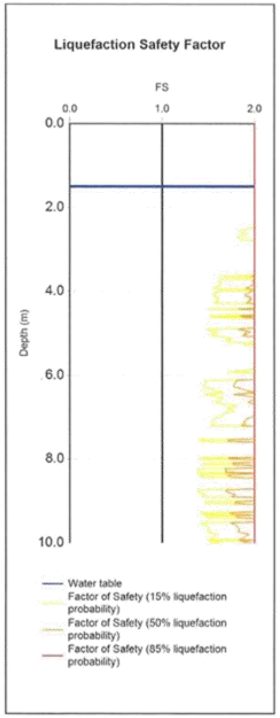
CPT-based soil behavior type classification chart by Robertson (1990)

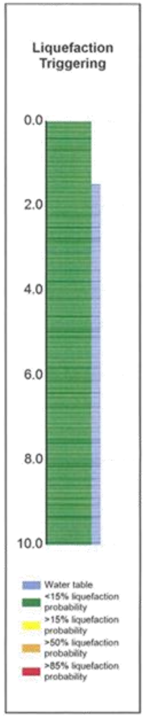
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED PAGE 4 of 11 pages











(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT03	112111	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	8	0	0	1	10	0
	50%	2	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor
Exceptional thinking together
V1.3

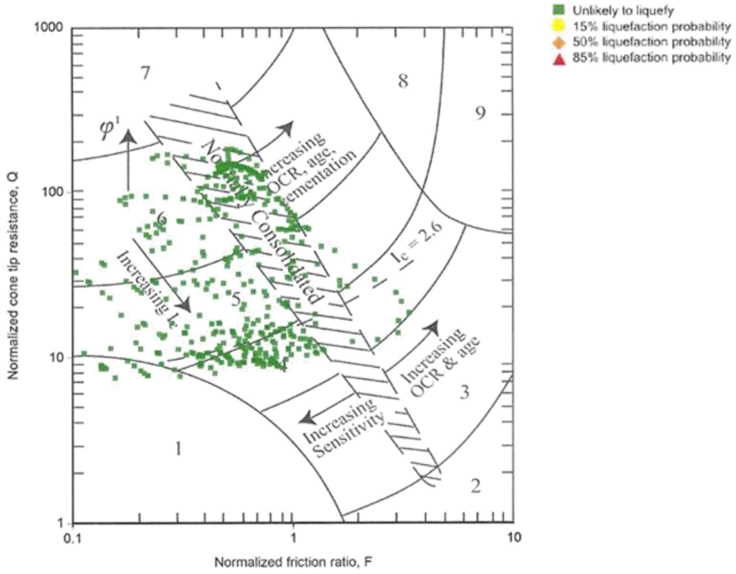
CLIENT, PROJECT
Napier City Council
Napier Aquatic Centre

TITLE
Liquefaction Analyses - SLS

LOCATION
Napier

JOB NUMBER
1006598

DATE	12/06/2018
ANALYSED	joma
CHECKED	
PAGE	5 of 11 pages



1. Sensitive, fine grained
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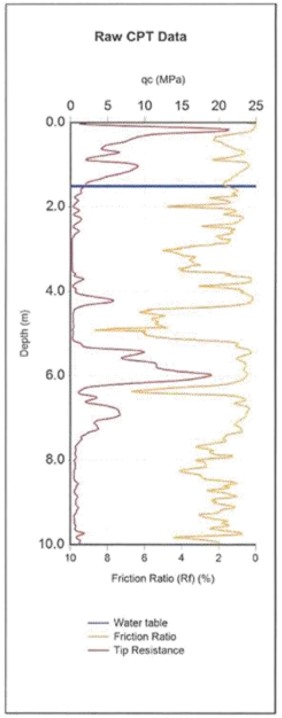
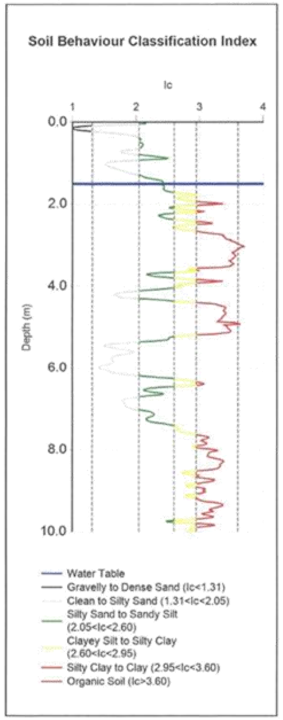
CPT-based soil behavior type classification chart by Robertson (1990)

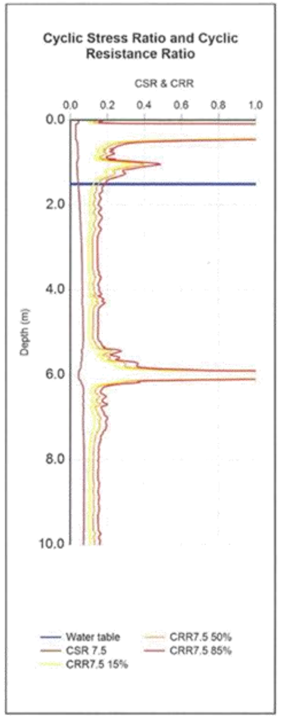
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	6 of 11 pages



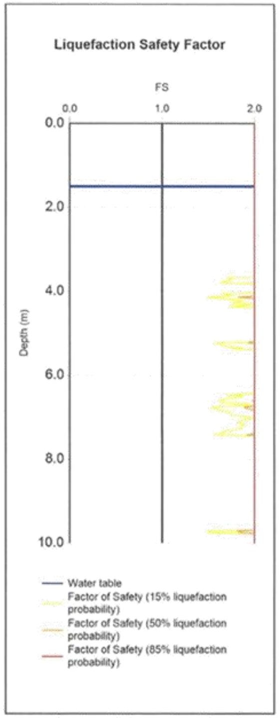
Raw CPT Data



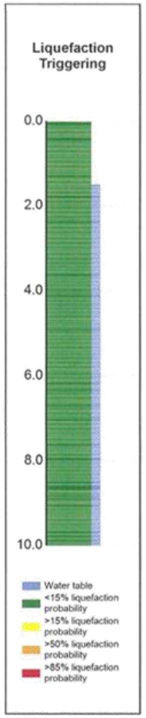
Soil Behaviour Classification Index



Cyclic Stress Ratio and Cyclic Resistance Ratio



Liquefaction Safety Factor



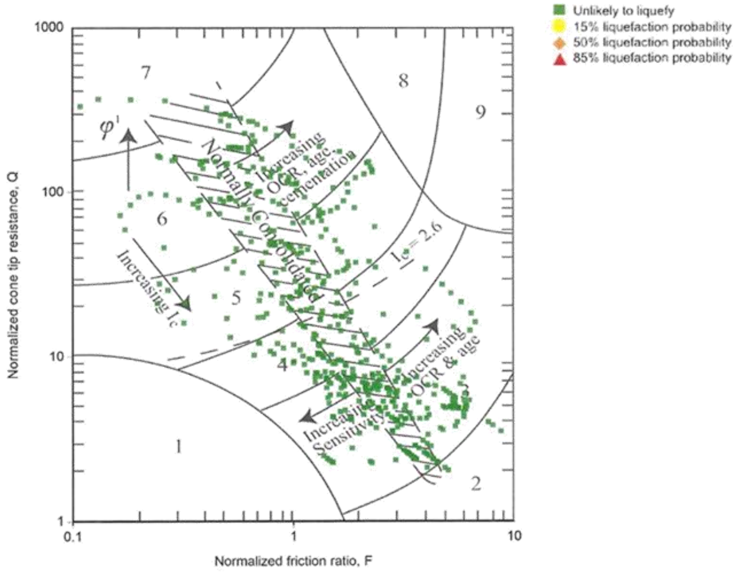
Liquefaction Triggering

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT04	112112	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	2	0	0	0	10	0
	50%	0	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	7 of 11 pages



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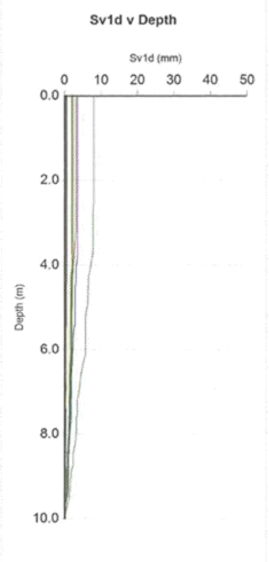
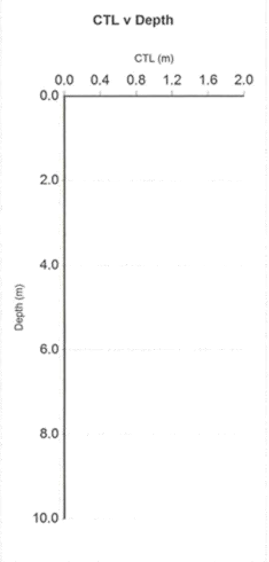
9. Very stiff, fine grained *

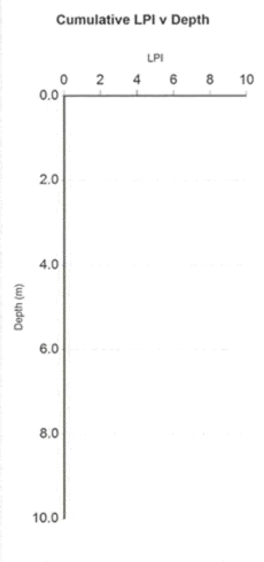
*Heavily overconsolidated or cemented

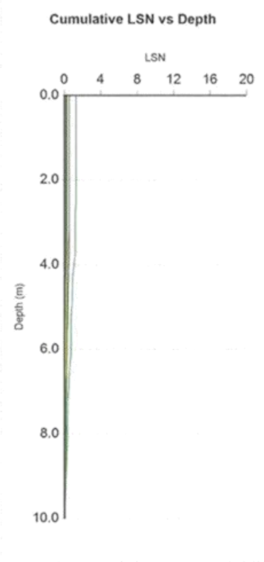
CPT-based soil behavior type classification chart by Robertson (1990)

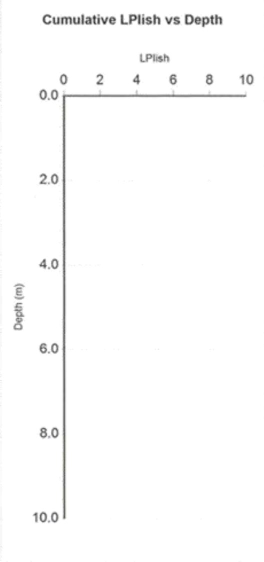
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	8 of 11 pages







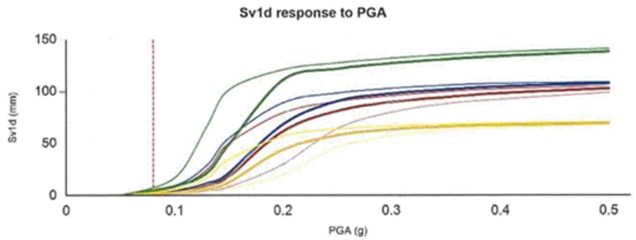


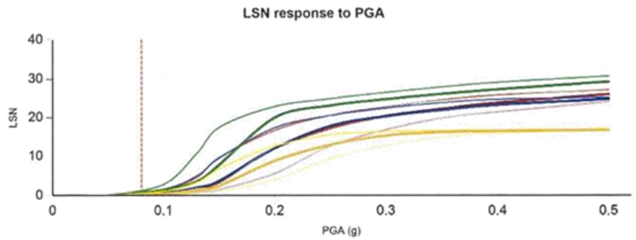


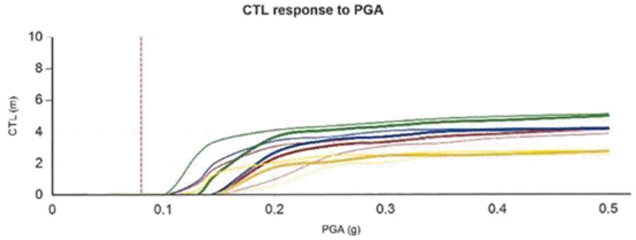
										(Assumed pre-drill values)			
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT01	112067	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT02	112104	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT03	112111	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT04	112112	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

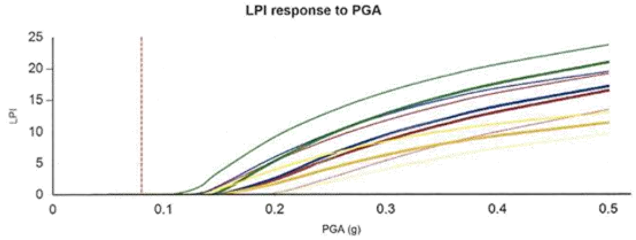
Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	9 of 11 pages


Sv1d response to PGA


LSN response to PGA


CTL response to PGA


LPI response to PGA

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

										(Assumed pre-drill values)			
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT01	112067	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT02	112104	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT03	112111	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT04	112112	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
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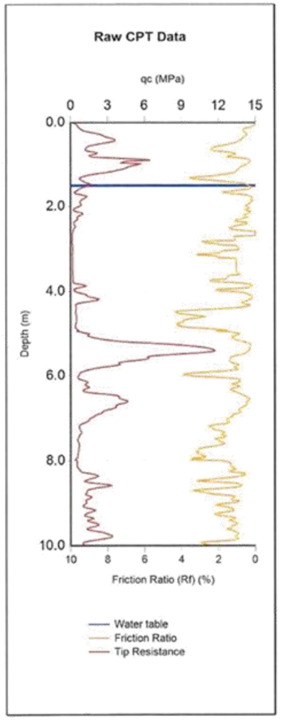
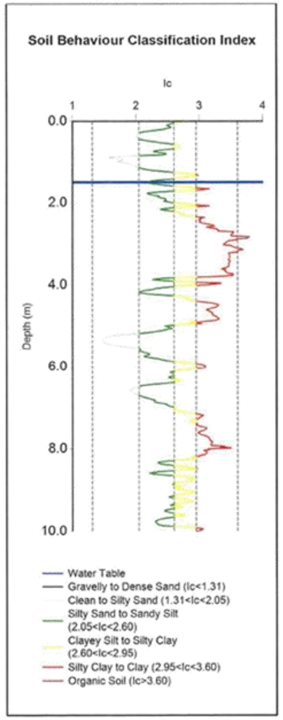
The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

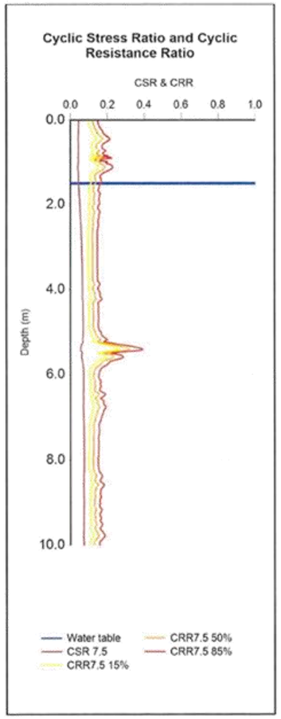
Table 1.1-1 Summary of inputs for liquefaction analysis

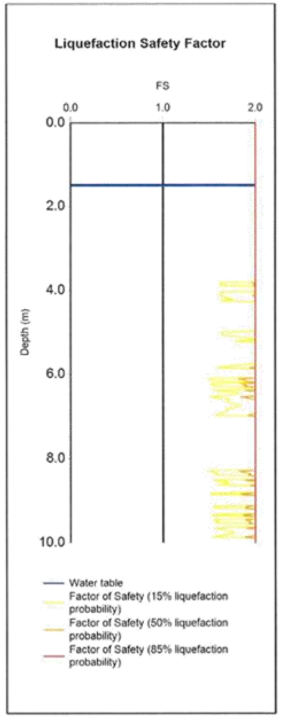
TTGD ID	112067	112104	112111	112112
CPT Name	CPT01	CPT02	CPT03	CPT04
PGA	0.08g	0.08g	0.08g	0.08g
Magnitude	6.2	6.2	6.2	6.2
Depth to groundwater	1.5m	1.5m	1.5m	1.5m
Predrill depth	0m	0m	0m	0.02m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	25m	25m	13.68m	23.08m
Maximum depth of analysis	10m	10m	10m	10m
RL	n/a	n/a	n/a	n/a

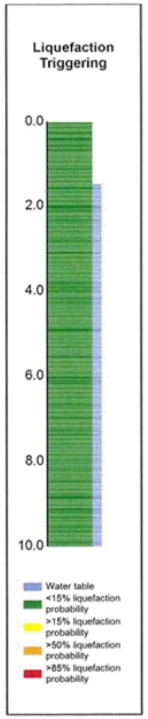
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	11 of 11 pages







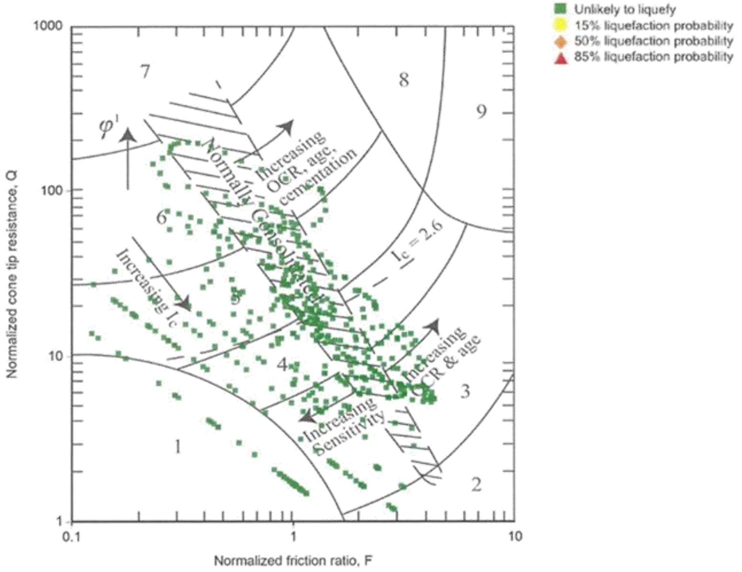




										(Assumed pre-drill values)			
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT06	112113	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	4	0	0	1	10	0
	50%	0	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	1 of 11 pages

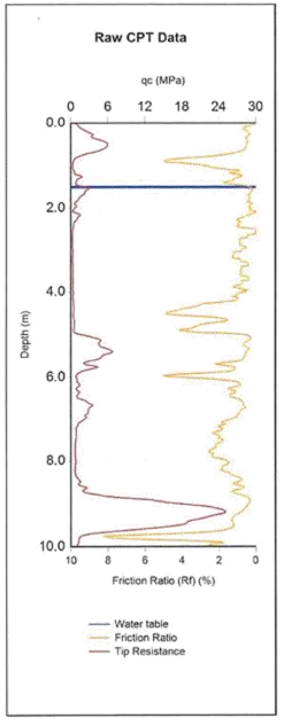


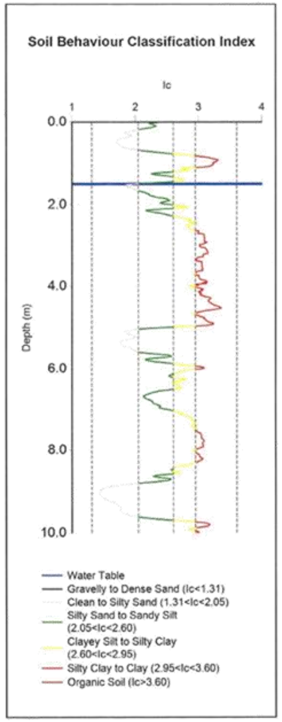
1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

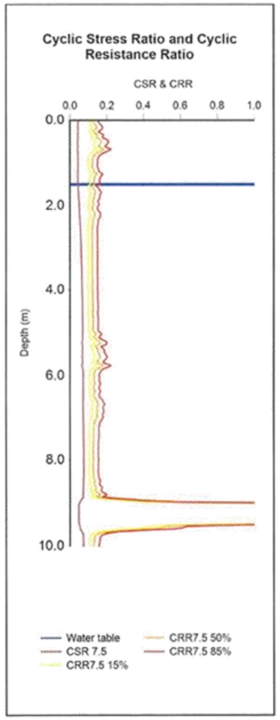
*Heavily overconsolidated or cemented

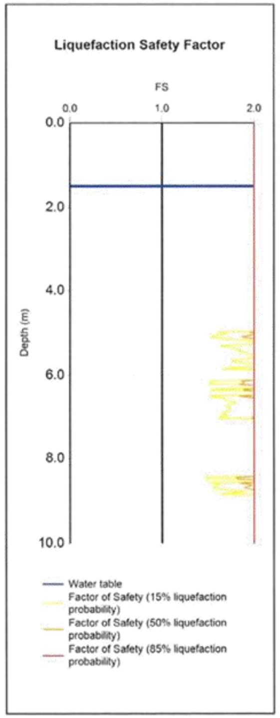
CPT-based soil behavior type classification chart by Robertson (1990)

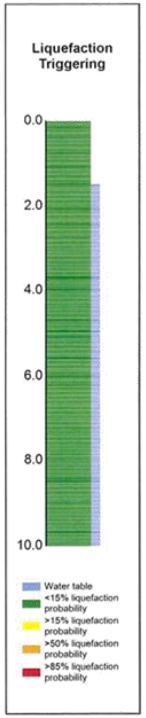
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Napier City Council Napier Aquatic Centre	LOCATION Napier	DATE 12/06/2018 ANALYSED joma
	TITLE Liquefaction Analyses - SLS	JOB NUMBER 1006598	CHECKED PAGE 2 of 11 pages









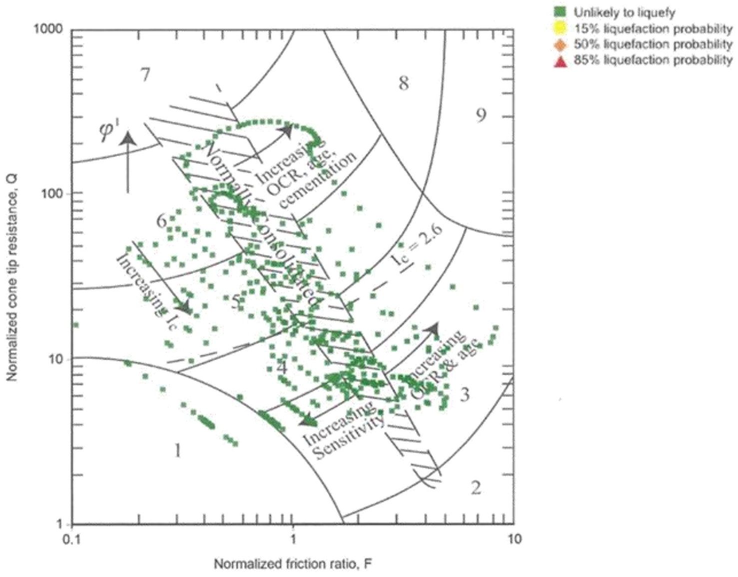


(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT07	112114	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	2	0	0	0	10	0
	50%	0	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED PAGE 3 of 11 pages

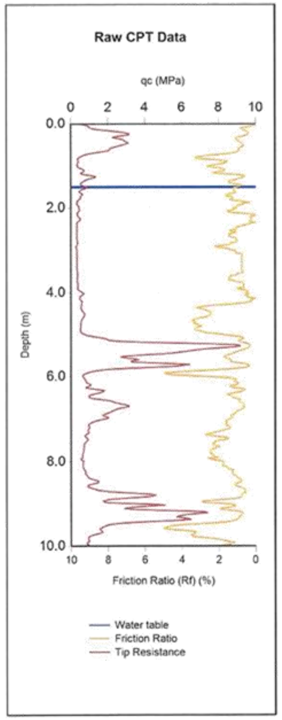


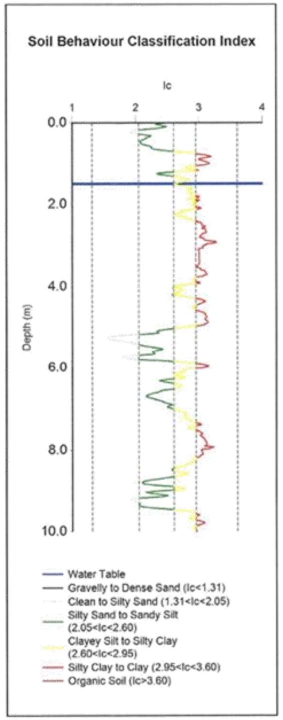
1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

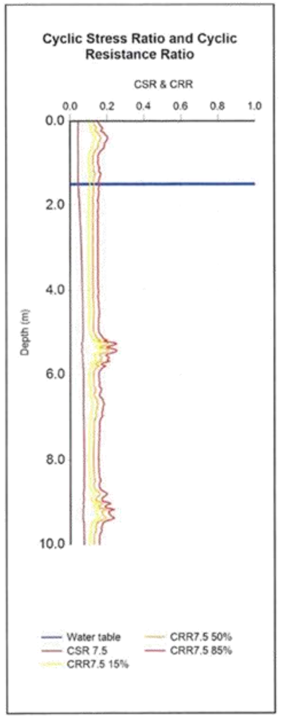
*Heavily overconsolidated or cemented

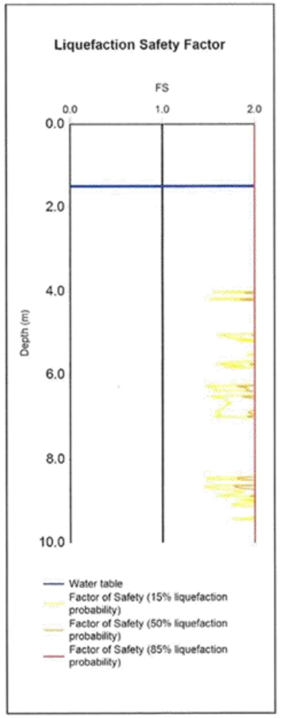
CPT-based soil behavior type classification chart by Robertson (1990)

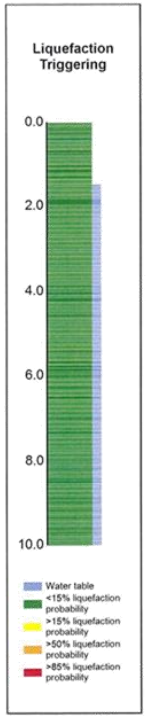
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
		JOB NUMBER **1006598**	CHECKED	
	TITLE **Liquefaction Analyses - SLS**		PAGE	4 of 11 pages











	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	(Assumed pre-drill values) qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT08	112115	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	2	0	0	0	10	0
	50%	0	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Napier City Council
Napier Aquatic Centre

TITLE
Liquefaction Analyses - SLS

LOCATION	Napier
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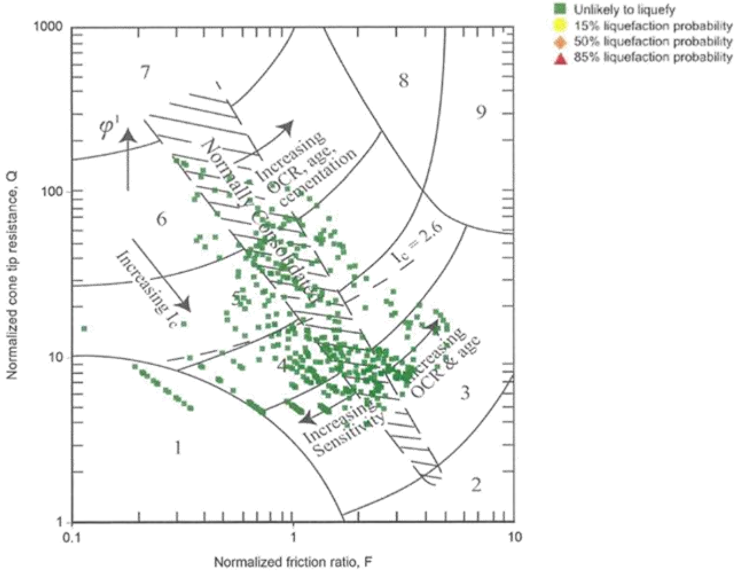

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
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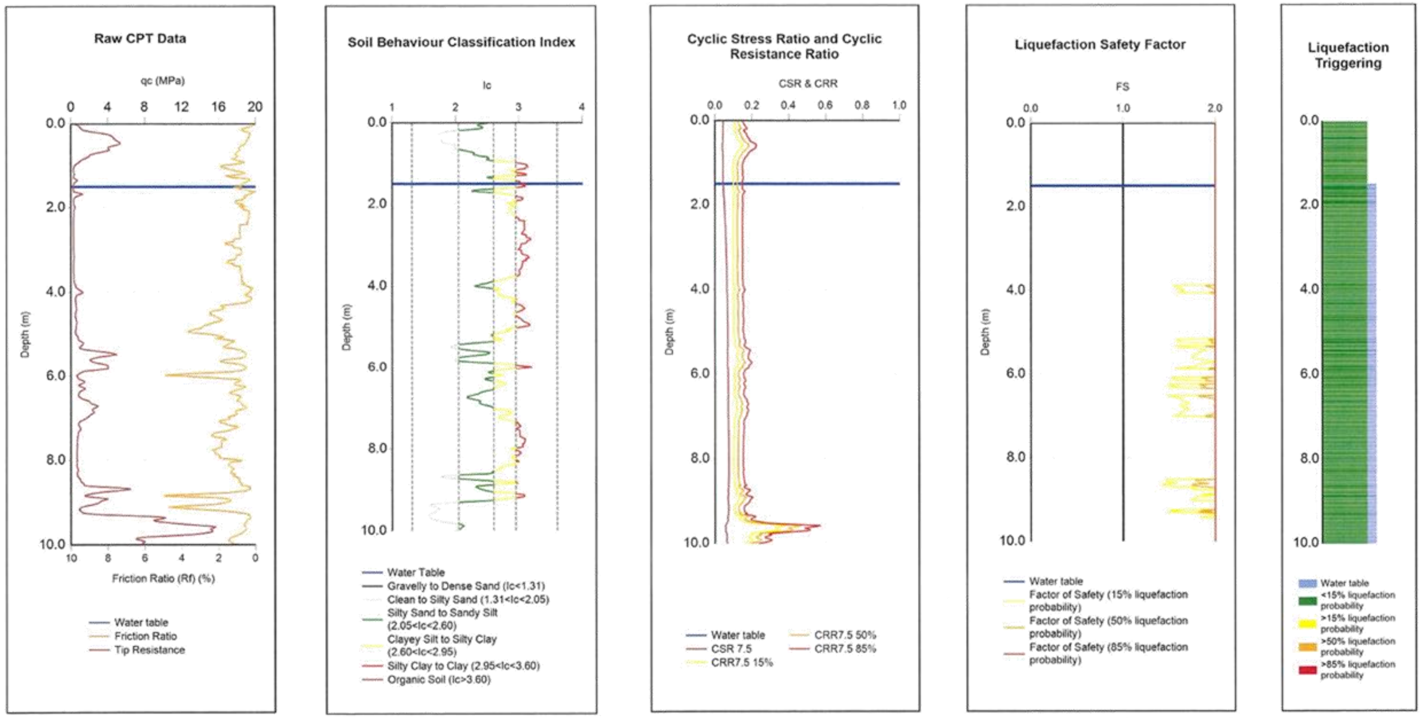
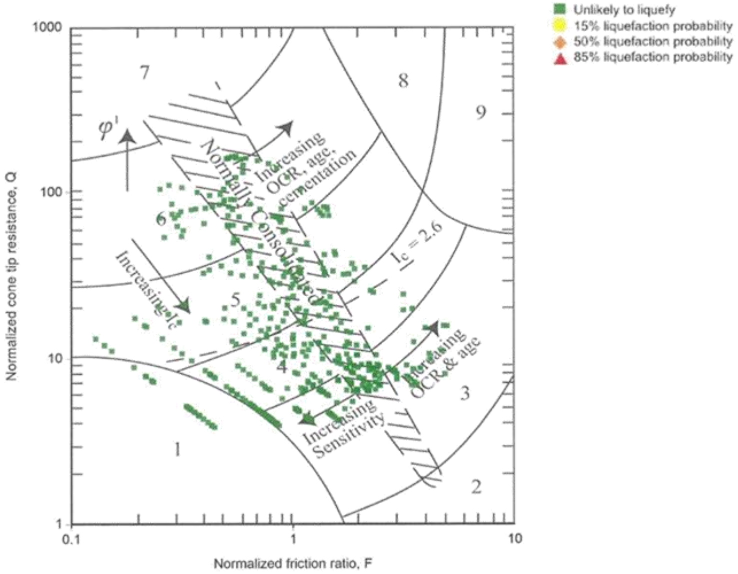


	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
											(Assumed pre-drill values)		
INPUT	CPT09	112116	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	3	0	0	1	10	0
	50%	0	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED PAGE 7 of 11 pages

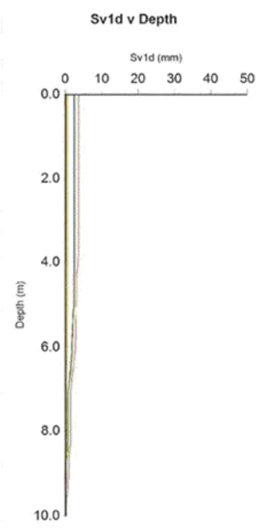


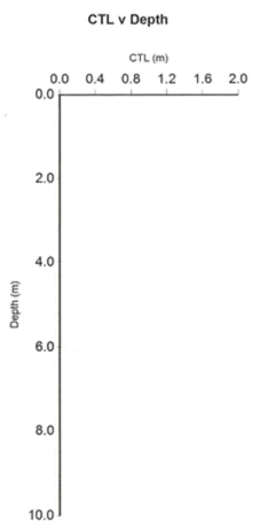
1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

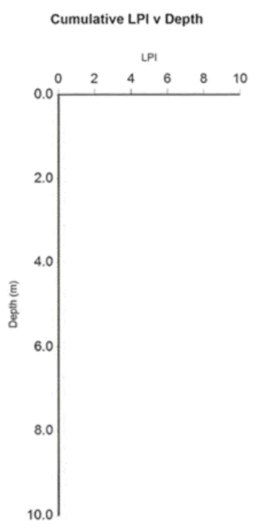
*Heavily overconsolidated or cemented

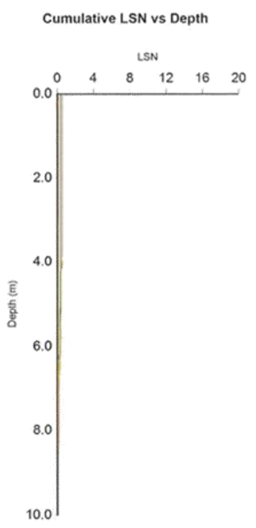
CPT-based soil behavior type classification chart by Robertson (1990)

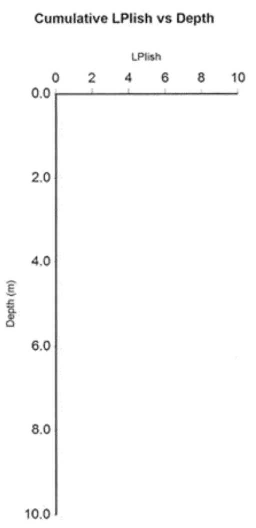
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma CHECKED
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	PAGE 8 of 11 pages











										(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥 CPT06	112113	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦 CPT07	112114	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩 CPT08	112115	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨 CPT09	112116	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma CHECKED
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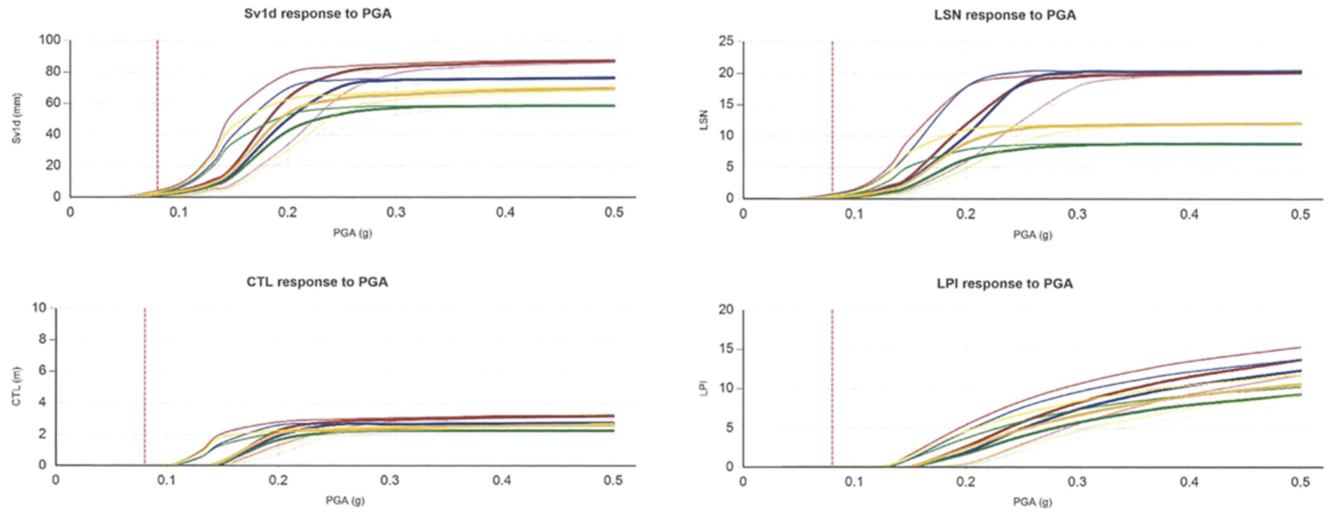

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

											(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT06	112113	23/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT07	112114	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT08	112115	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT09	112116	24/05/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
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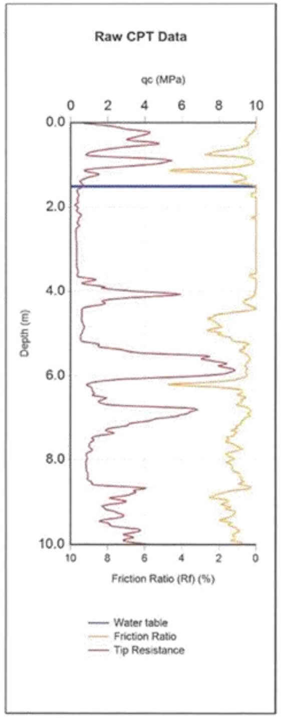
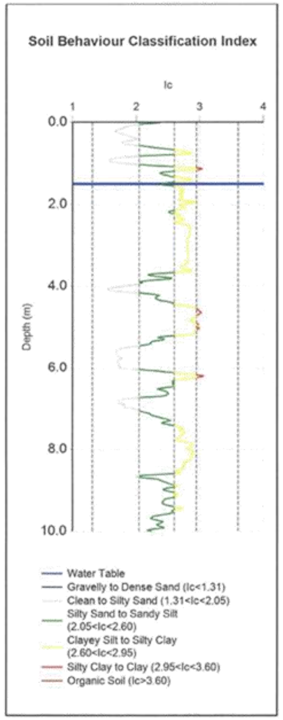
The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

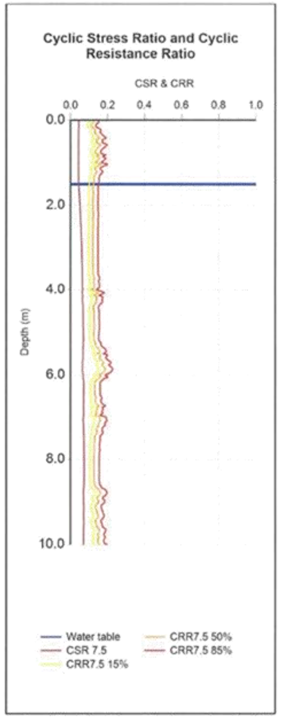
Table 1.1-1 Summary of inputs for liquefaction analysis

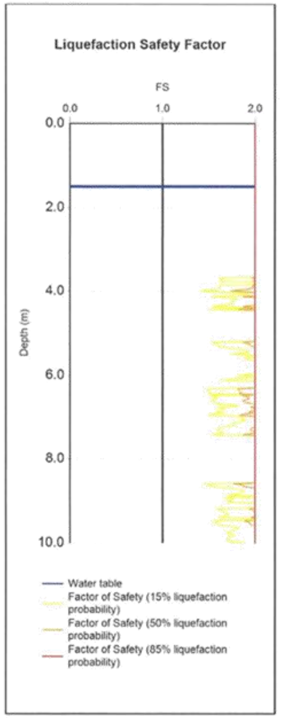
TTGD ID	112113	112114	112115	112116
CPT Name	CPT06	CPT07	CPT08	CPT09
PGA	0.08g	0.08g	0.08g	0.08g
Magnitude	6.2	6.2	6.2	6.2
Depth to groundwater	1.5m	1.5m	1.5m	1.5m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	22.64m	13.6m	10.9m	21.26m
Maximum depth of analysis	10m	10m	10m	10m
RL	n/a	n/a	n/a	n/a

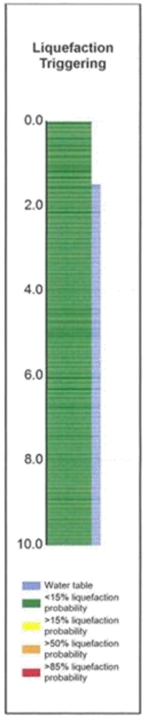
Tonkin + Taylor Exceptional thinking together	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
V1.3	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	11 of 11 pages







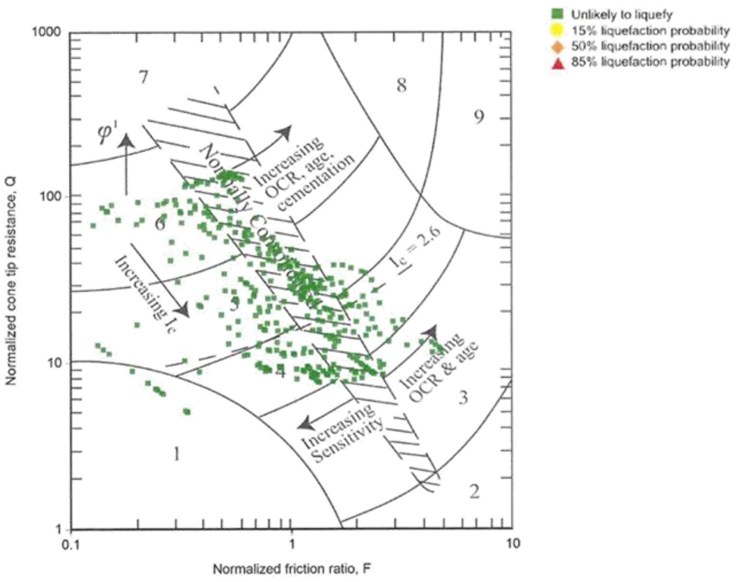




											(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT05	112335	6/06/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	5	0	0	1	10	0
	50%	1	0	0	0	10	0
	85%	0	0	0	0	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Napier City Council Napier Aquatic Centre	LOCATION Napier	DATE 12/06/2018 ANALYSED joma CHECKED
	TITLE Liquefaction Analyses - SLS	JOB NUMBER 1006598	PAGE 1 of 5 pages

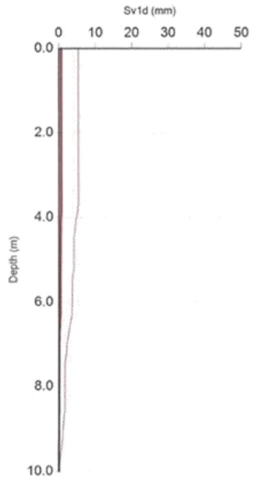


1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	2 of 5 pages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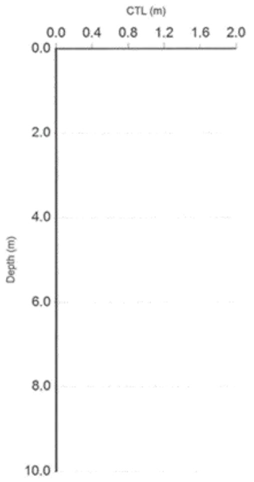
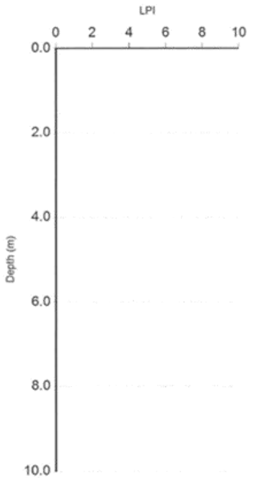
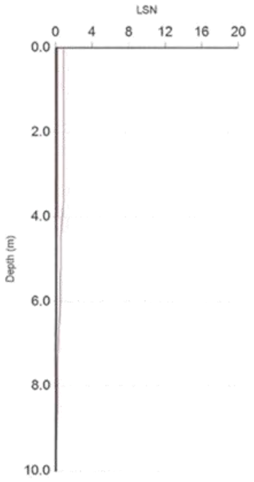
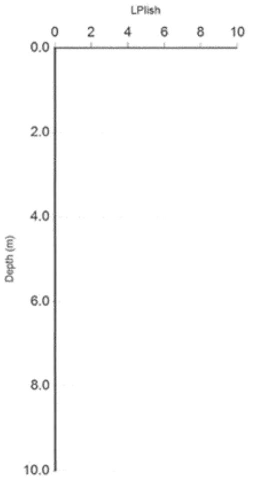

CTL v Depth


Cumulative LPI v Depth


Cumulative LSN vs Depth


Cumulative LPIish vs Depth

										(Assumed pre-drill values)			
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT05	112335	6/06/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
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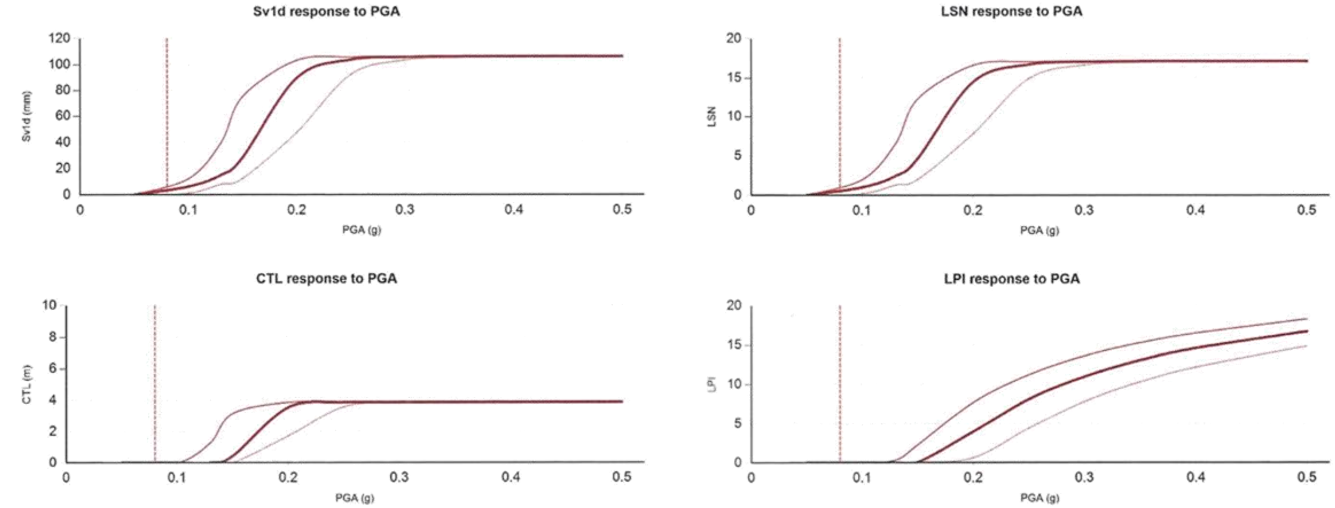

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

										(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥 CPT05	112335	6/06/2018	User Specified	6.2	0.08	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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V1.3	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	4 of 5 pages

The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	112335
CPT Name	CPT05
PGA	0.08g
Magnitude	6.2
Depth to groundwater	1.5m
Predrill depth	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)
CFC	0
Total depth of CPT	14.84m
Maximum depth of analysis	10m
RL	n/a

Tonkin + Taylor Exceptional thinking together	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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V1.3	TITLE **Liquefaction Analyses - SLS**	JOB NUMBER **1006598**	CHECKED	
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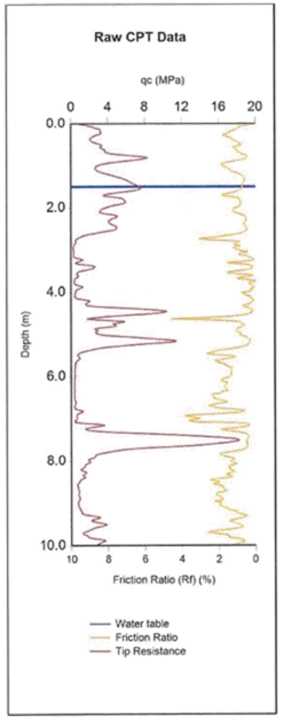
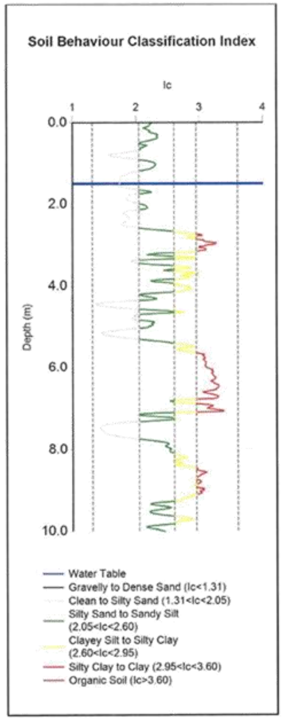
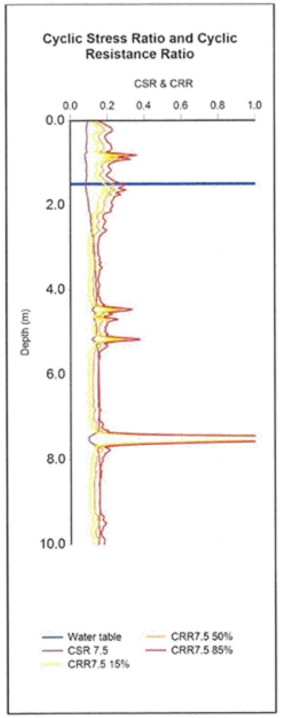
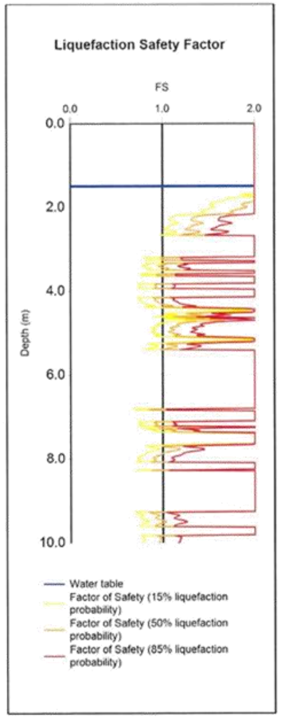
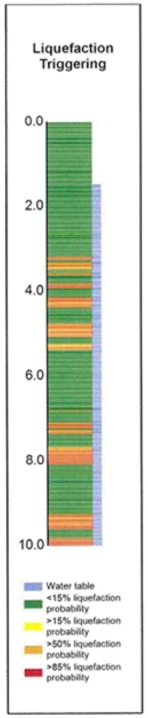








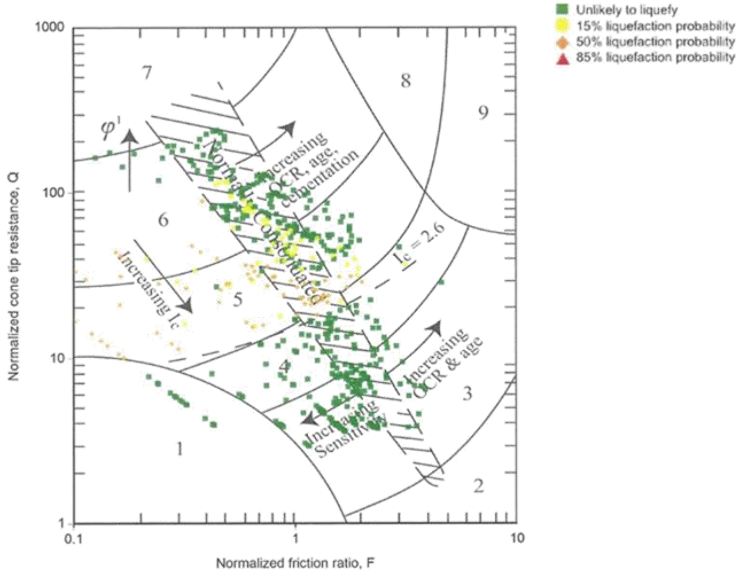


(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT01	112067	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	66	2.4	3	13	3.3	1
	50%	37	1.4	1	7	3.4	0
	85%	13	0	0	2	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
			PAGE	1 of 11 pages



1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
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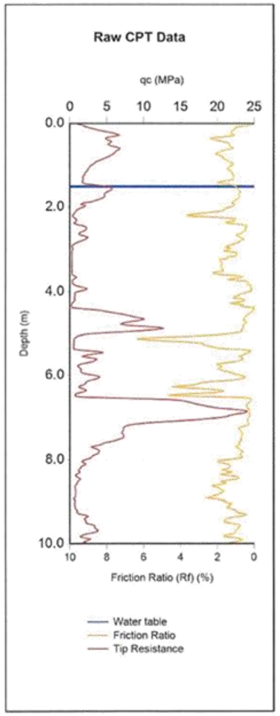
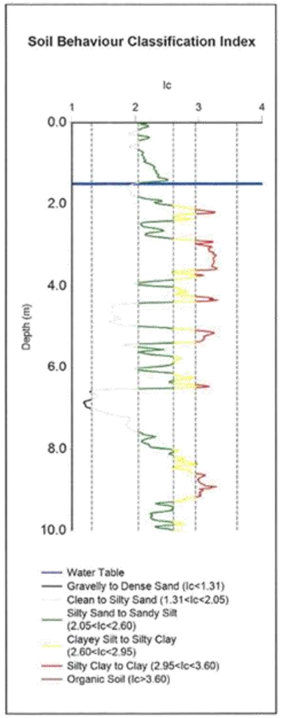
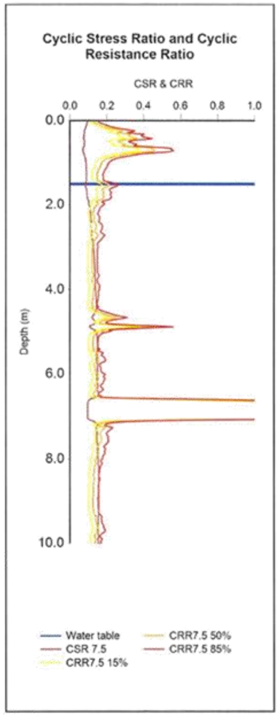
*Heavily overconsolidated or cemented

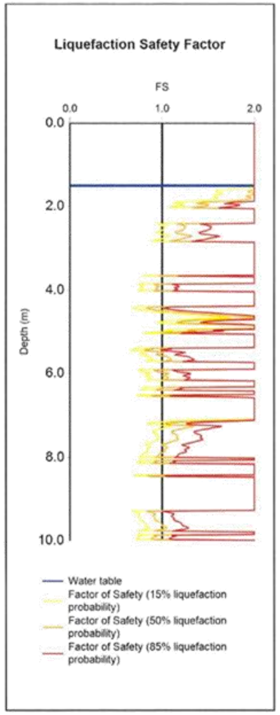
CPT-based soil behavior type classification chart by Robertson (1990)

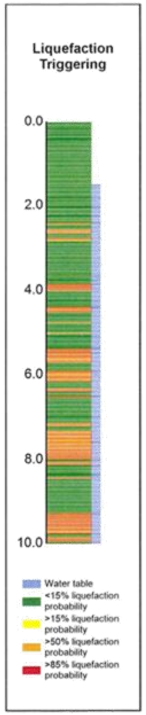
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
			PAGE	2 of 11 pages







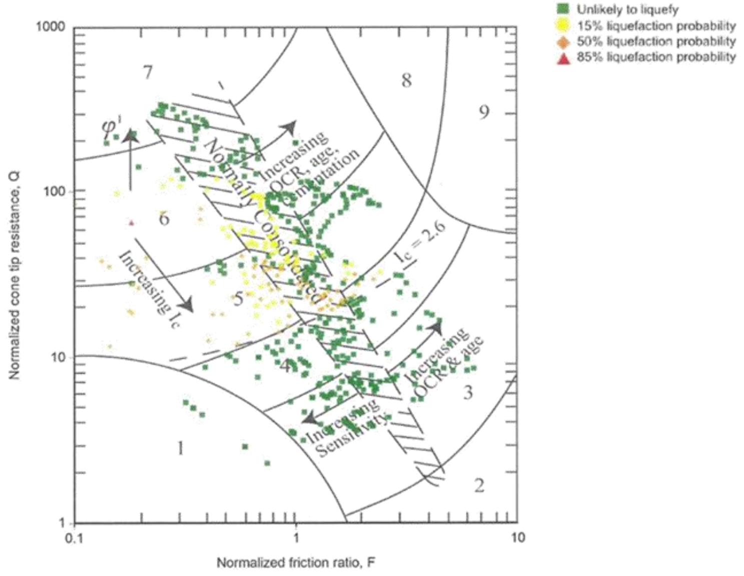




	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
											(Assumed pre-drill values)		
INPUT	CPT02	112104	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	73	2.9	3	13	2.6	2
	50%	41	1.5	1	7	3.9	0
	85%	15	0	0	3	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma CHECKED
	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	PAGE 3 of 11 pages



1. Sensitive, fine grained
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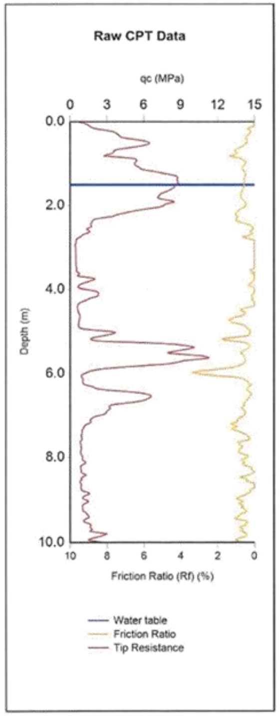
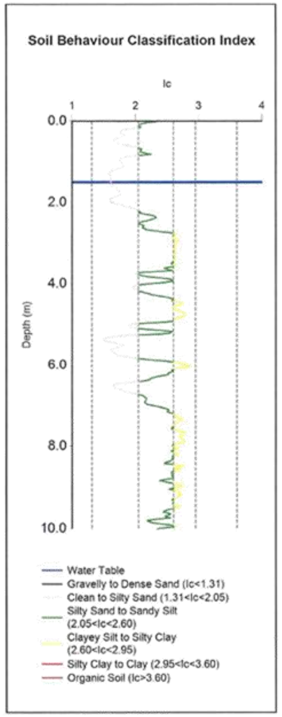
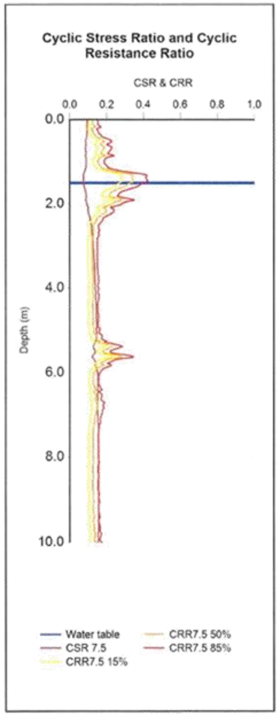
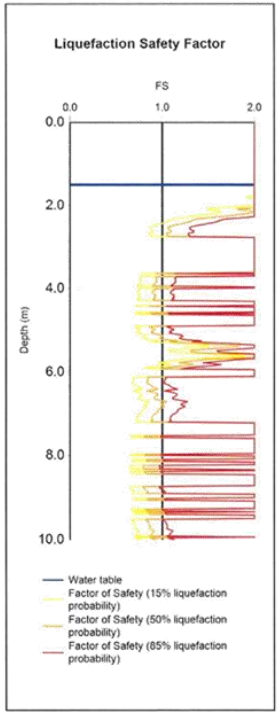
CPT-based soil behavior type classification chart by Robertson (1990)

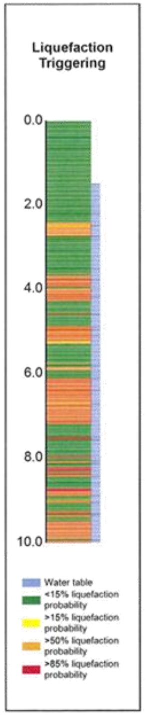
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma
	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED PAGE 4 of 11 pages


Raw CPT Data


Soil Behaviour Classification Index


Cyclic Stress Ratio and Cyclic Resistance Ratio


Liquefaction Safety Factor


Liquefaction Triggering

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT03	112111	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	114	3.7	6	21	2.5	3
	50%	87	3.1	2	15	3.8	0
	85%	30	0.4	0	5	8	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
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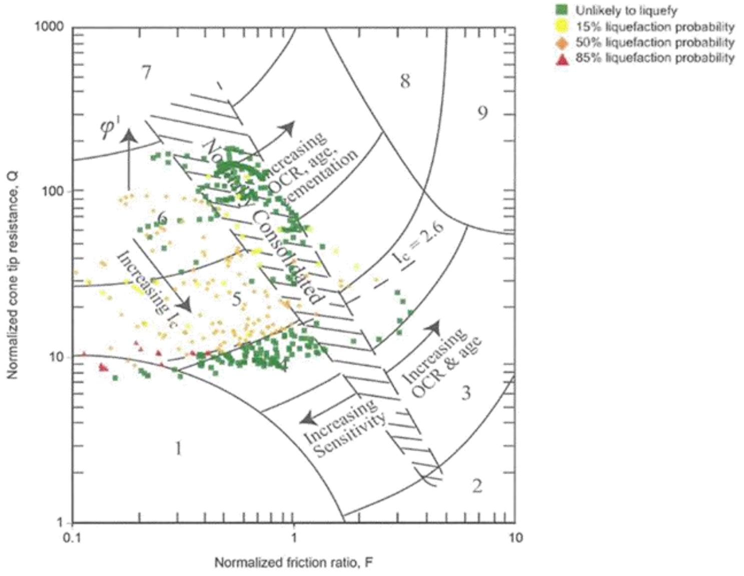

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CPT-based soil behavior type classification chart by Robertson (1990)

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			ANALYSED	joma
	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
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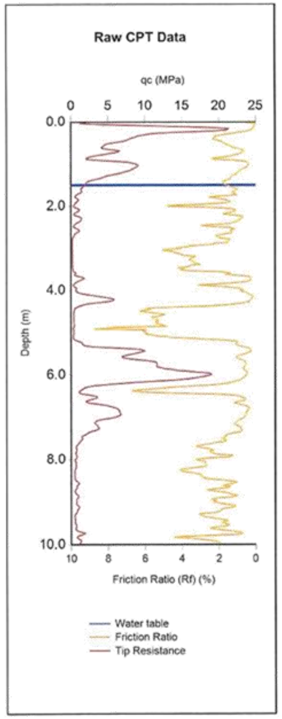

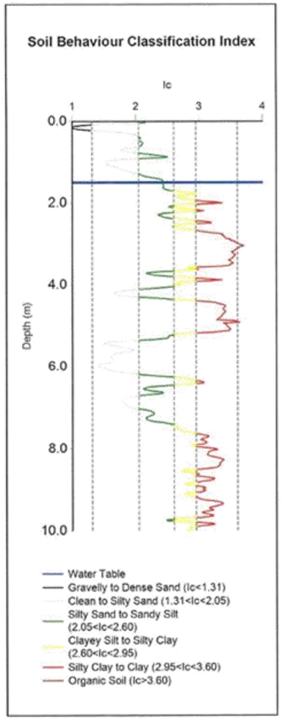

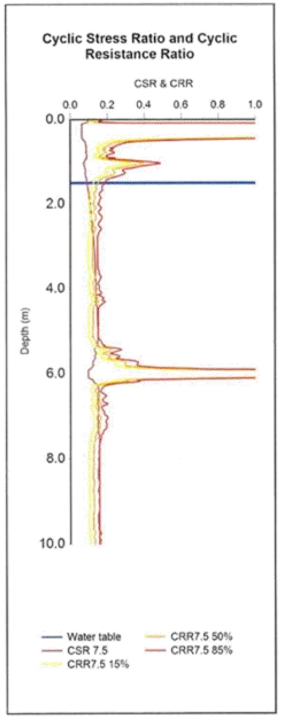

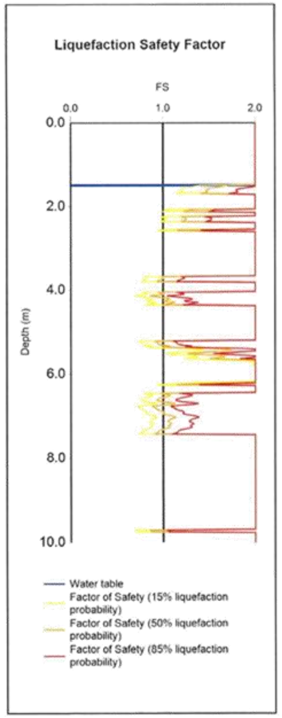

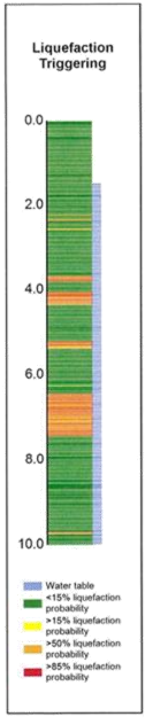

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT04	112112	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish
OUTPUT	15%	47	1.8	2	10	2.6	1
	50%	24	0.9	0	5	3.8	0
	85%	9	0	0	2	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
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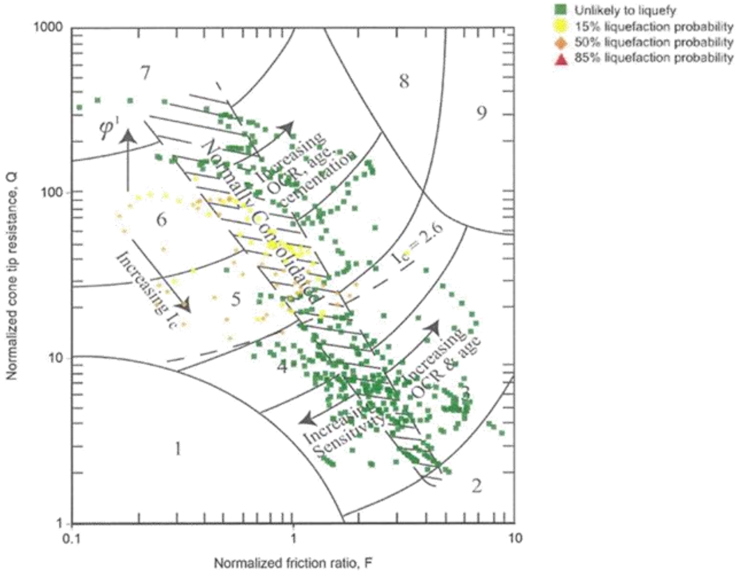

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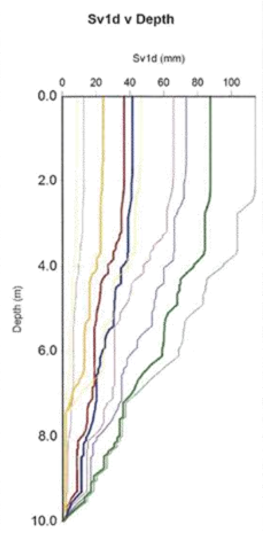
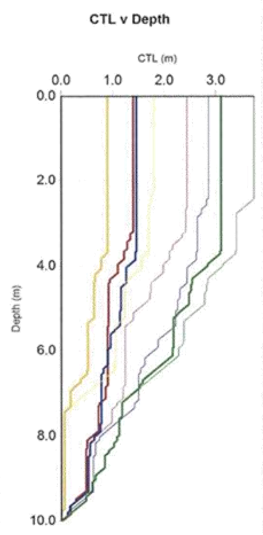
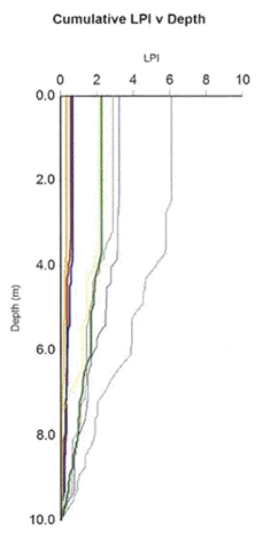
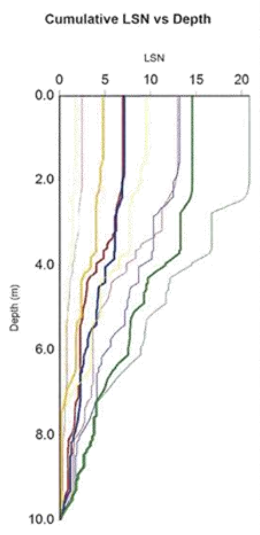
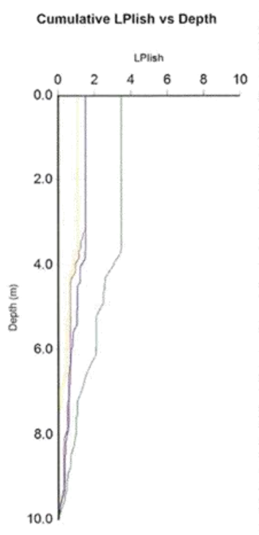








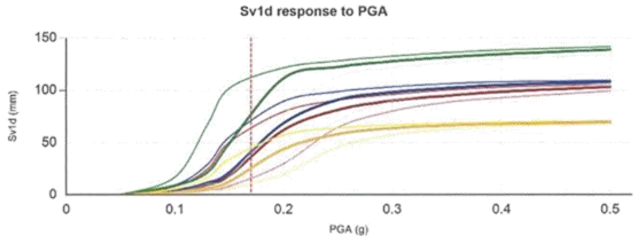


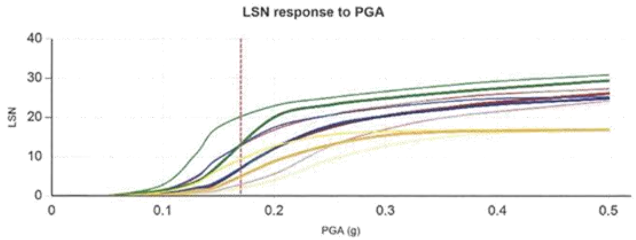
(Assumed pre-drill values)

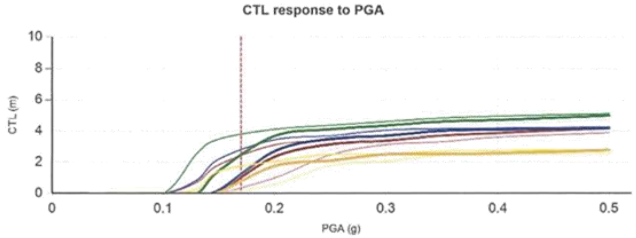
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT01	112067	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT02	112104	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT03	112111	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT04	112112	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

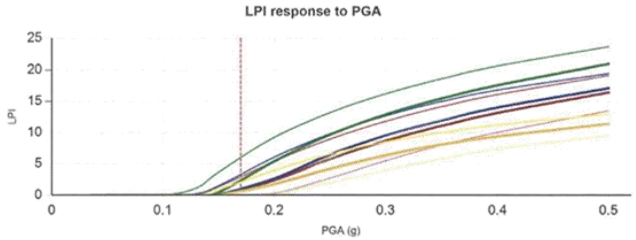
Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
			PAGE	9 of 11 pages


Sv1d response to PGA


LSN response to PGA


CTL response to PGA


LPI response to PGA

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

											(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT01	112067	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT02	112104	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT03	112111	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT04	112112	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma CHECKED
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The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	112067	112104	112111	112112
CPT Name	CPT01	CPT02	CPT03	CPT04
PGA	0.17g	0.17g	0.17g	0.17g
Magnitude	6.2	6.2	6.2	6.2
Depth to groundwater	1.5m	1.5m	1.5m	1.5m
Predrill depth	0m	0m	0m	0.02m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	25m	25m	13.68m	23.08m
Maximum depth of analysis	10m	10m	10m	10m
RL	n/a	n/a	n/a	n/a

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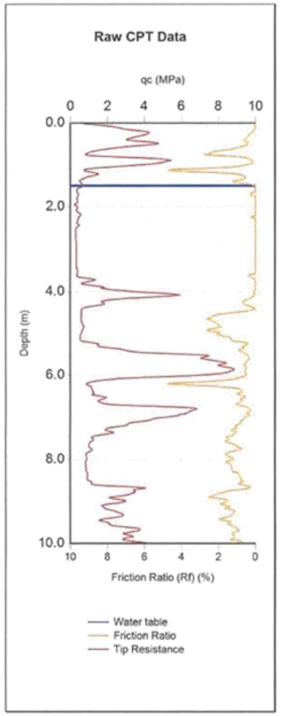

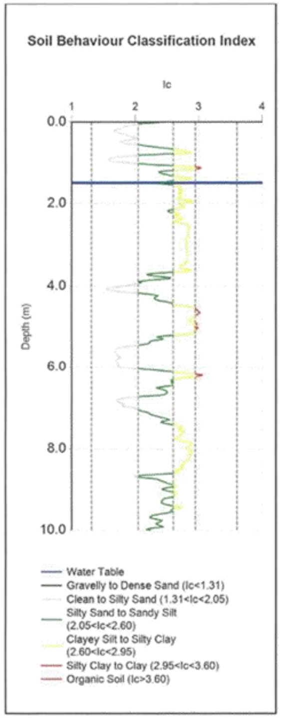

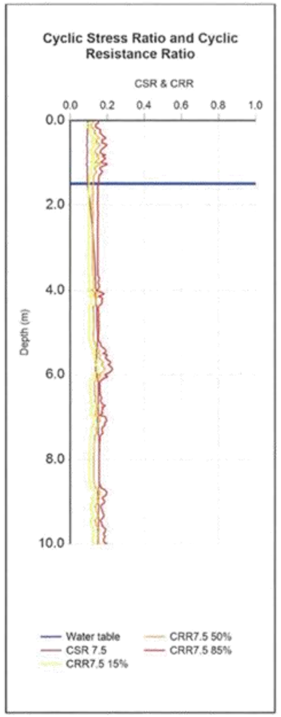

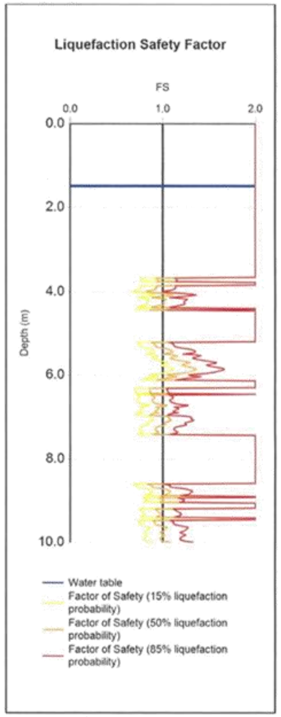

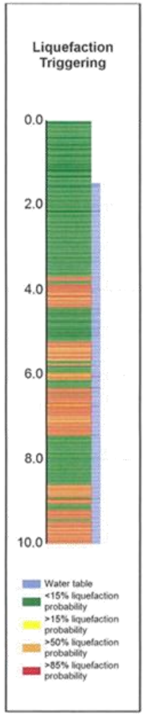

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
										(Assumed pre-drill values)			
INPUT	CPT05	112335	6/06/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	94	3.6	5	15	3.8	1
	50%	57	2.3	1	9	3.8	0
	85%	19	0	0	3	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Napier City Council Napier Aquatic Centre	LOCATION Napier	DATE 12/06/2018 ANALYSED joma CHECKED
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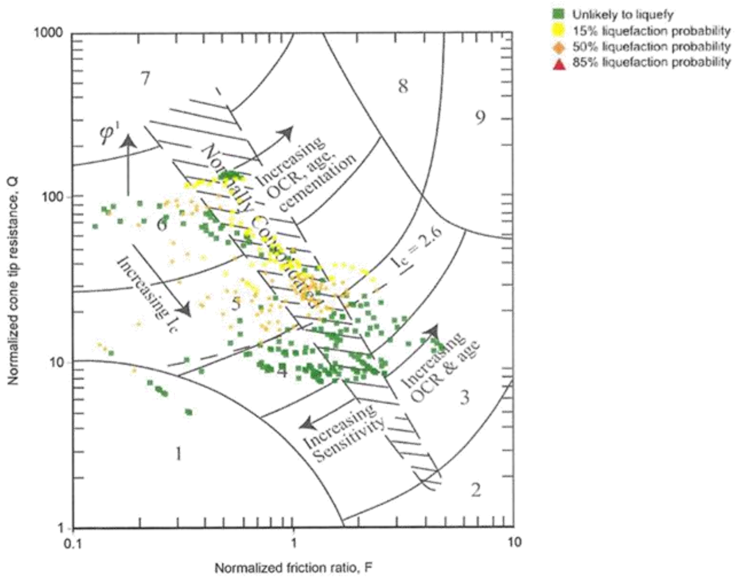

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
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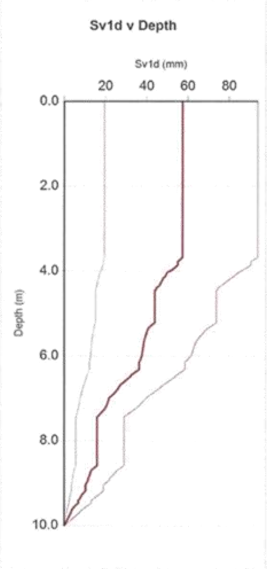

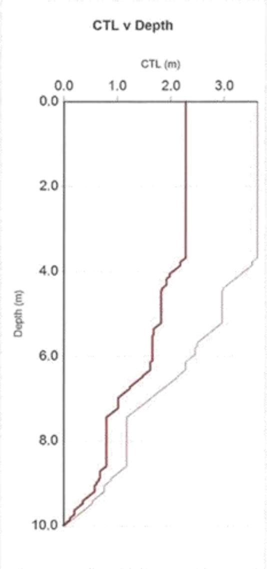

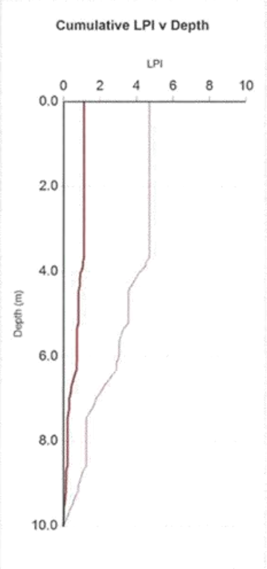

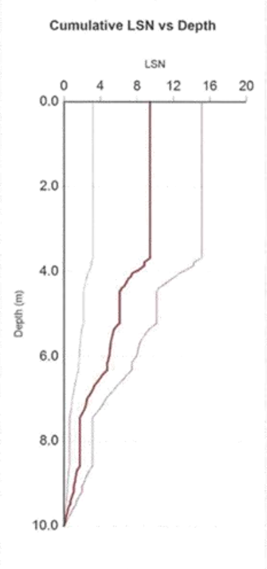

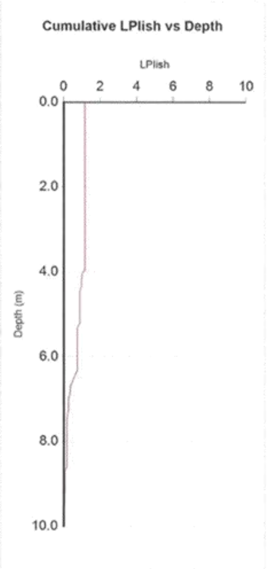

										(Assumed pre-drill values)			
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT05	112335	6/06/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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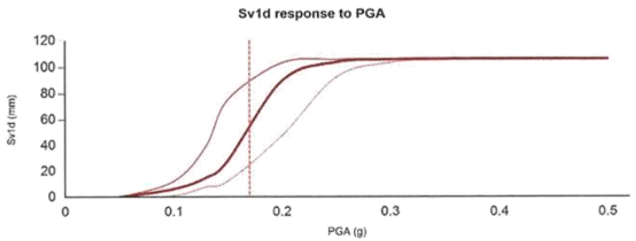
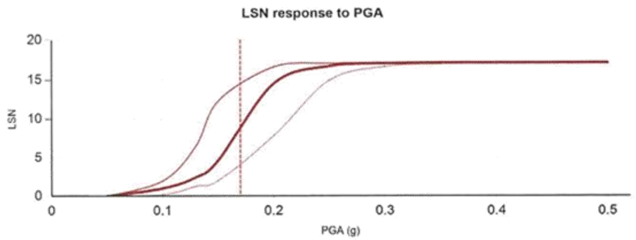
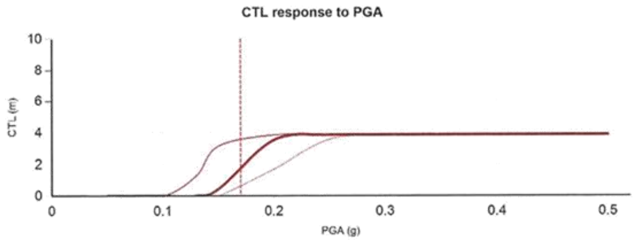
Sv1d response to PGA



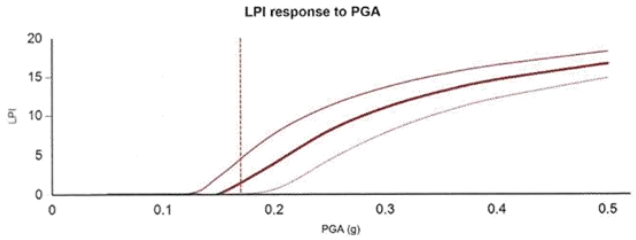
LSN response to PGA



CTL response to PGA



LPI response to PGA



Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

										(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥 CPT05	112335	6/06/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

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V1.3

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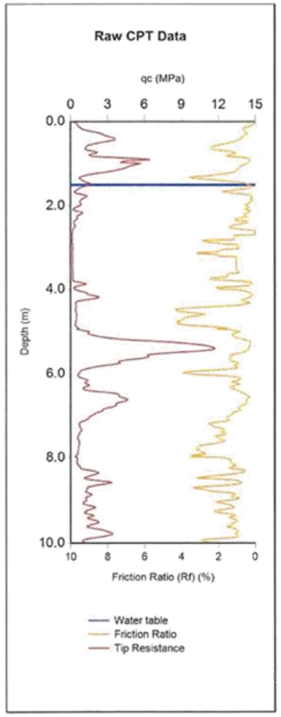
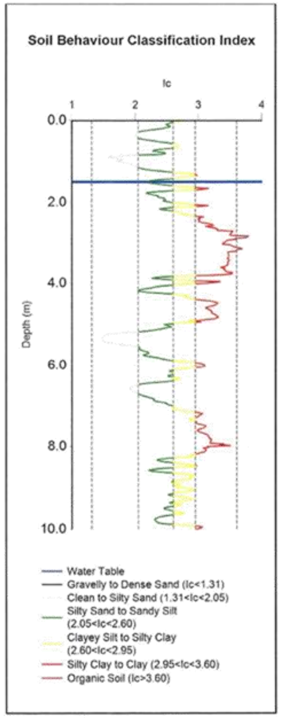
The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

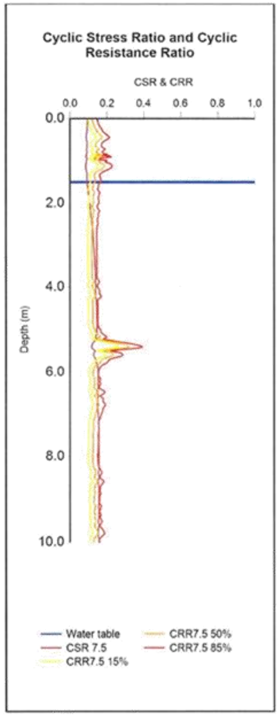
Table 1.1-1 Summary of inputs for liquefaction analysis

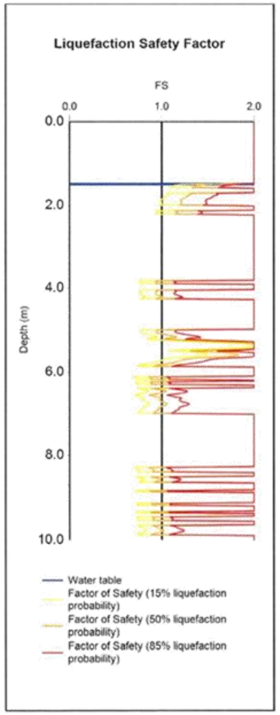
TTGD ID	112335
CPT Name	CPT05
PGA	0.17g
Magnitude	6.2
Depth to groundwater	1.5m
Predrill depth	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)
CFC	0
Total depth of CPT	14.84m
Maximum depth of analysis	10m
RL	n/a

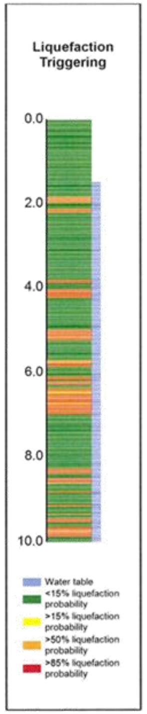
Tonkin + Taylor Exceptional thinking together	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma
V1.3	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED PAGE 5 of 5 pages











(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT06	112113	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	67	2.5	3	13	1.9	2
	50%	41	1.7	1	7	4.1	0
	85%	14	0	0	3	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
		JOB NUMBER **1006598**	CHECKED	
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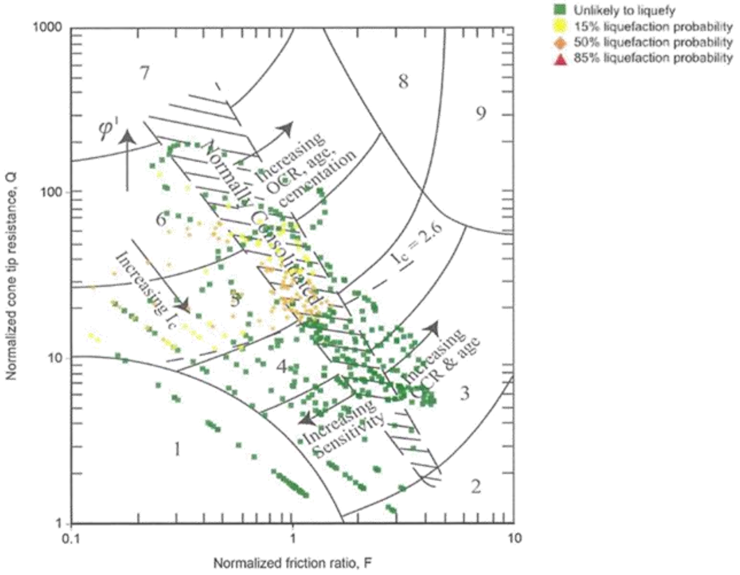

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
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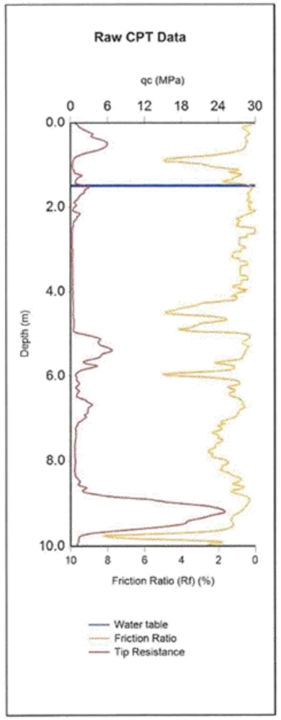

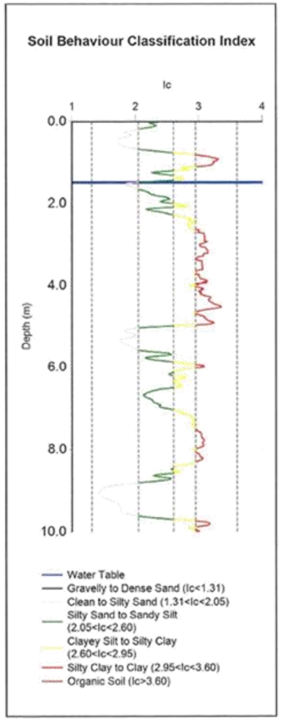

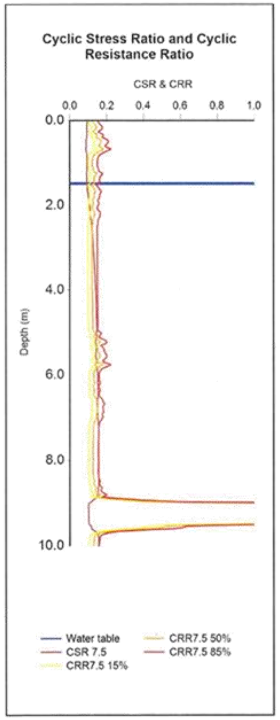

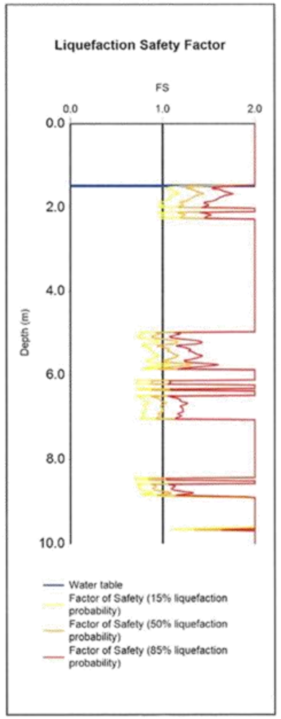

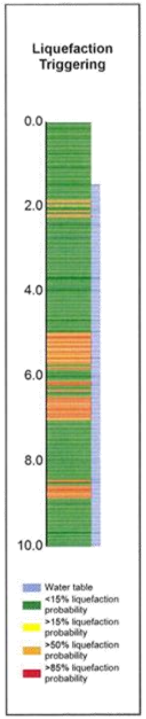

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT07	112114	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	54	2.1	2	11	2	1
	50%	30	1.1	0	6	5.1	0
	85%	11	0	0	2	10	0

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT	LOCATION	DATE	12/06/2018
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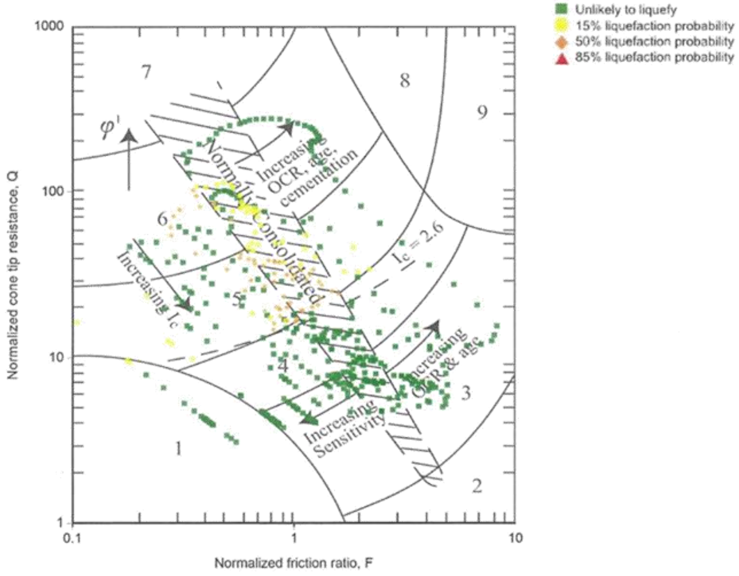

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
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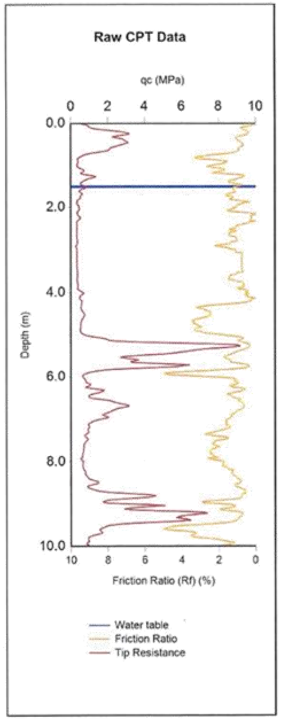

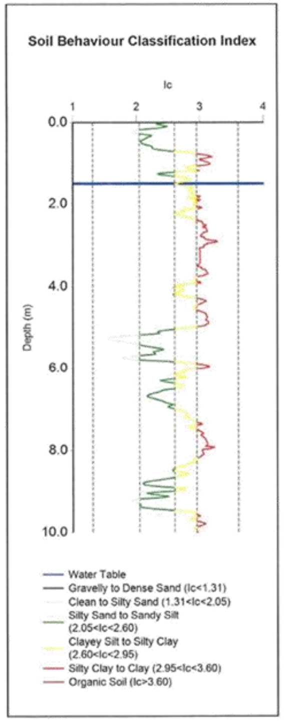

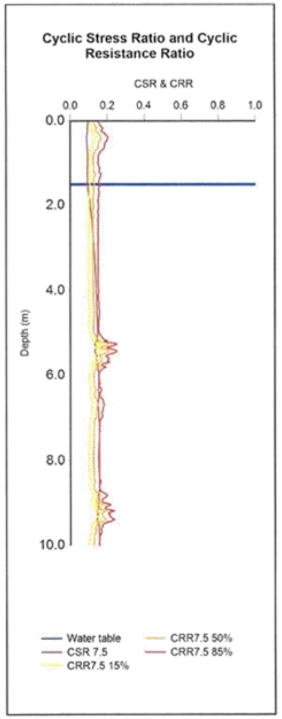

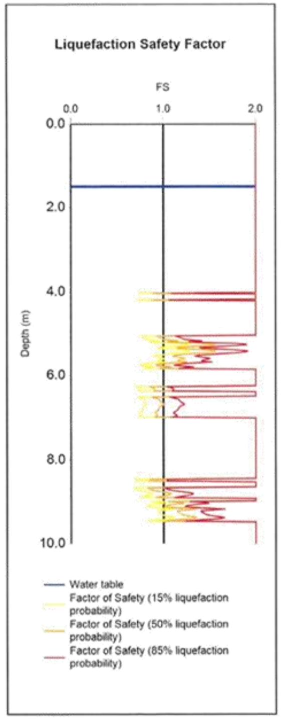

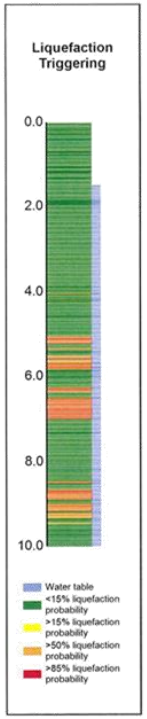

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT08	112115	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	45	1.8	2	7	5.1	0
	50%	27	1	0	4	5.1	0
	85%	9	0	0	1	10	0

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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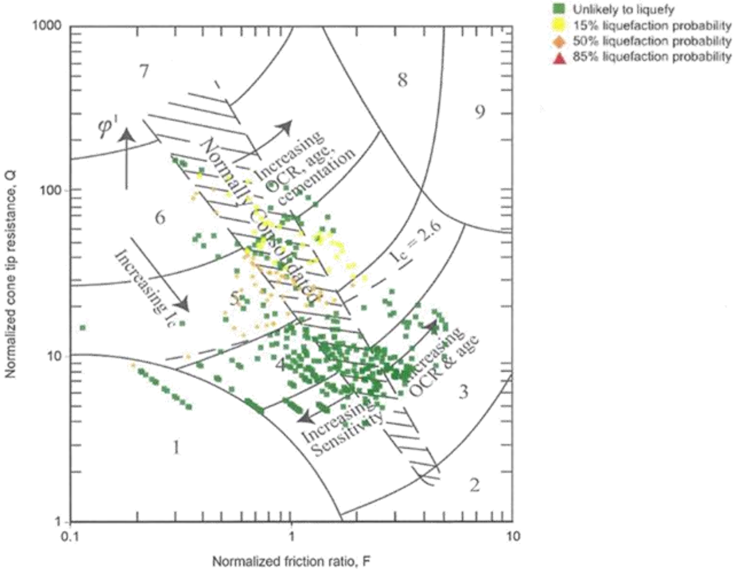

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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	TITLE **Liquefaction Analyses - 100yr**	JOB NUMBER **1006598**	CHECKED	
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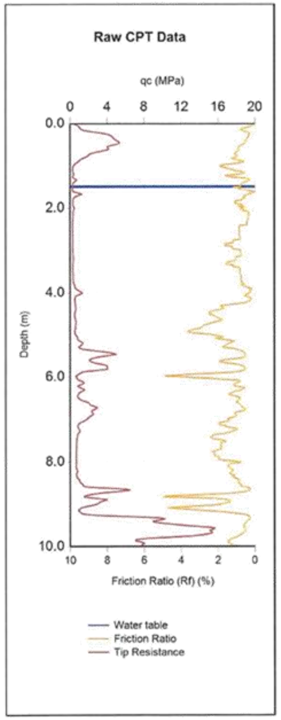
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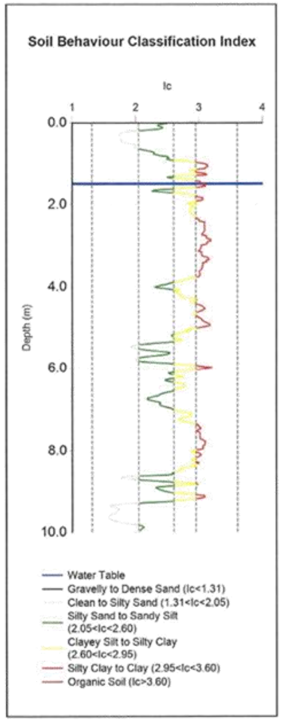
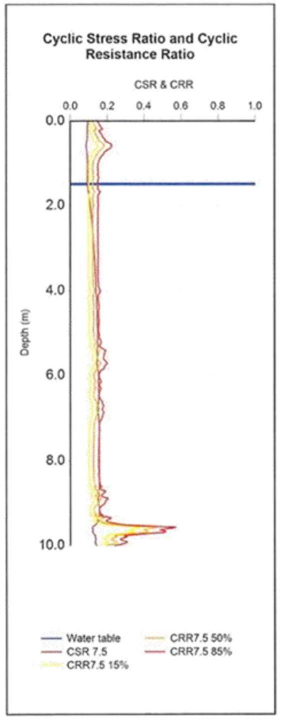
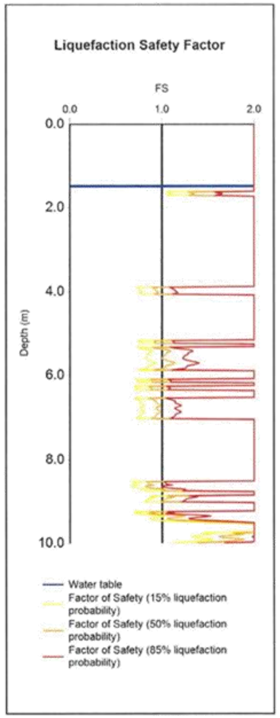
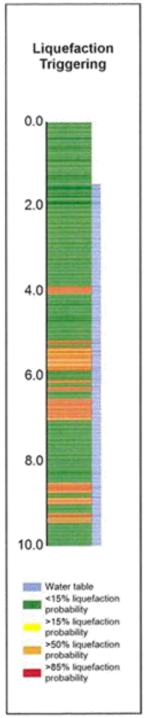

Soil Behaviour Classification Index


Cyclic Stress Ratio and Cyclic Resistance Ratio


Liquefaction Safety Factor


Liquefaction Triggering

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT09	112116	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	56	2.1	3	9	4	0
	50%	36	1.3	1	6	4	0
	85%	12	0	0	2	10	0

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Napier City Council Napier Aquatic Centre	LOCATION Napier	DATE	12/06/2018
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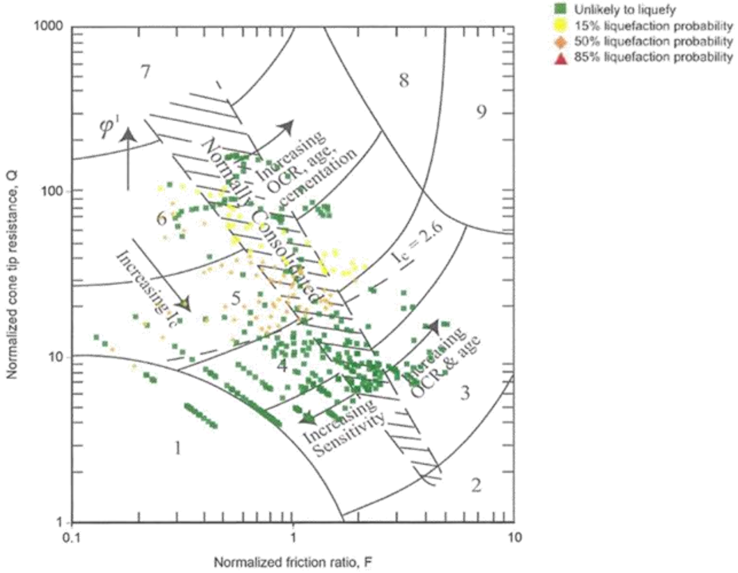

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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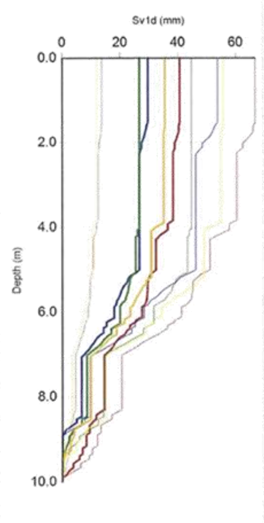
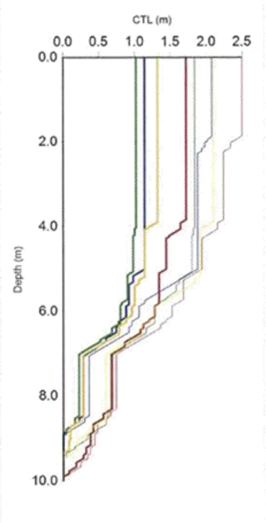
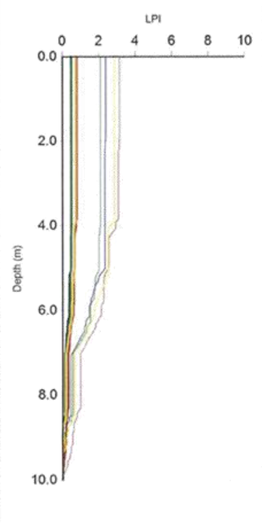
Sv1d v Depth



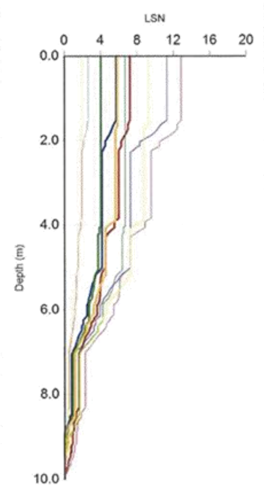
CTL v Depth



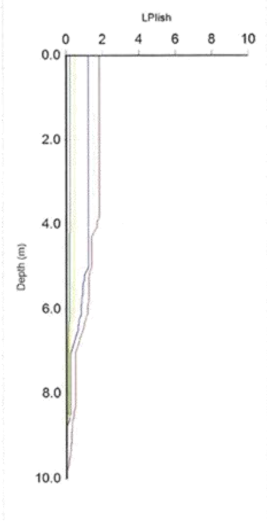
Cumulative LPI v Depth



Cumulative LSN vs Depth



Cumulative LPlish vs Depth



											(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT06	112113	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT07	112114	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT08	112115	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT09	112116	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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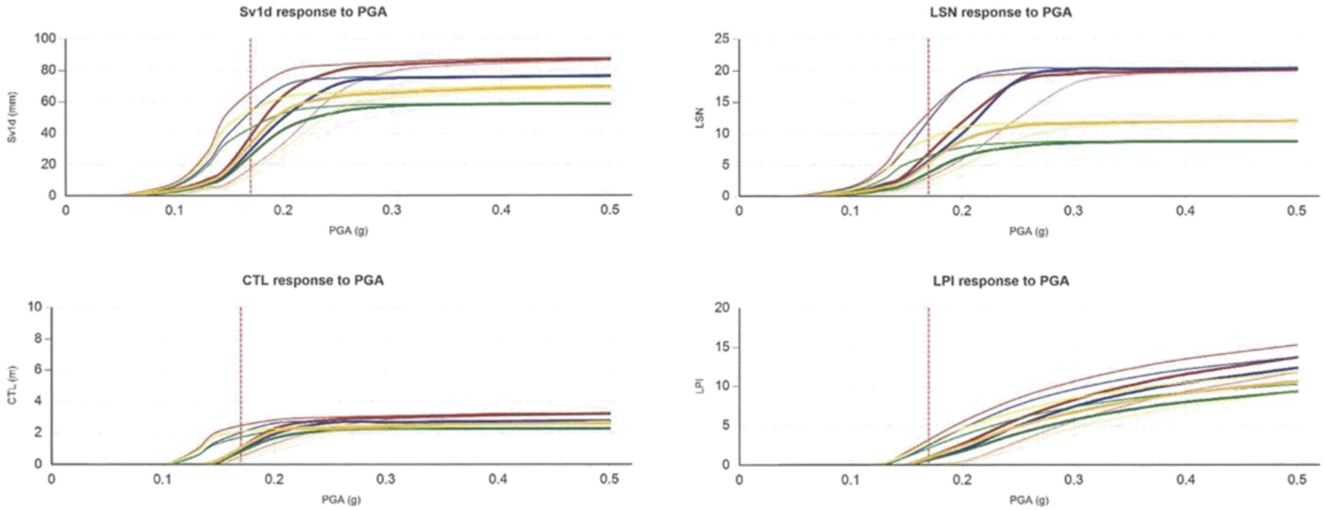

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

										(Assumed pre-drill values)		
CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥 CPT06	112113	23/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦 CPT07	112114	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩 CPT08	112115	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨 CPT09	112116	24/05/2018	User Specified	6.2	0.17	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
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Napier Aquatic Centre

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The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	112113	112114	112115	112116
CPT Name	CPT06	CPT07	CPT08	CPT09
PGA	0.17g	0.17g	0.17g	0.17g
Magnitude	6.2	6.2	6.2	6.2
Depth to groundwater	1.5m	1.5m	1.5m	1.5m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	22.64m	13.6m	10.9m	21.26m
Maximum depth of analysis	10m	10m	10m	10m
RL	n/a	n/a	n/a	n/a

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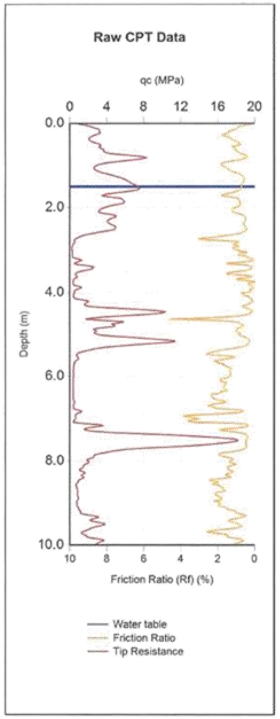

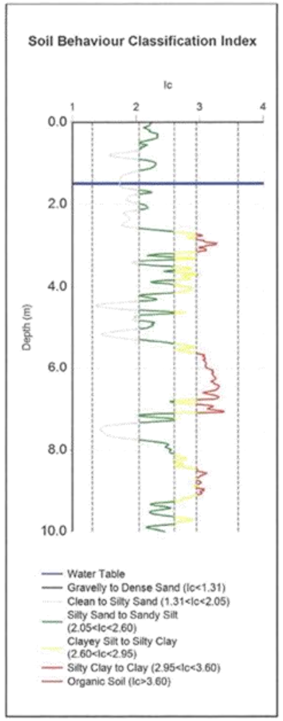

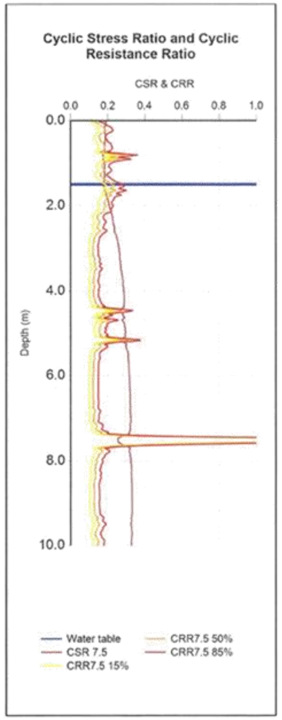

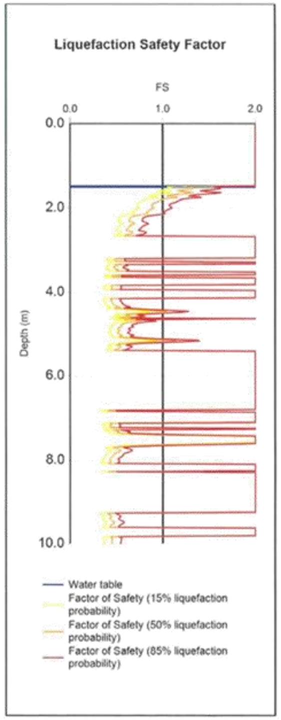

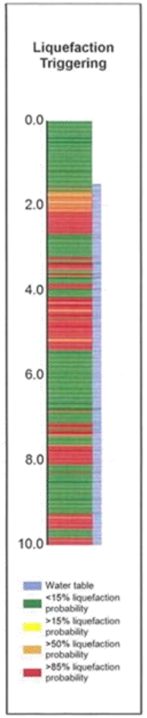

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT01	112067	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish
OUTPUT	15%	101	4	15	25	1.7	12
	50%	96	3.8	11	23	1.9	8
	85%	90	3.3	8	20	2.2	6

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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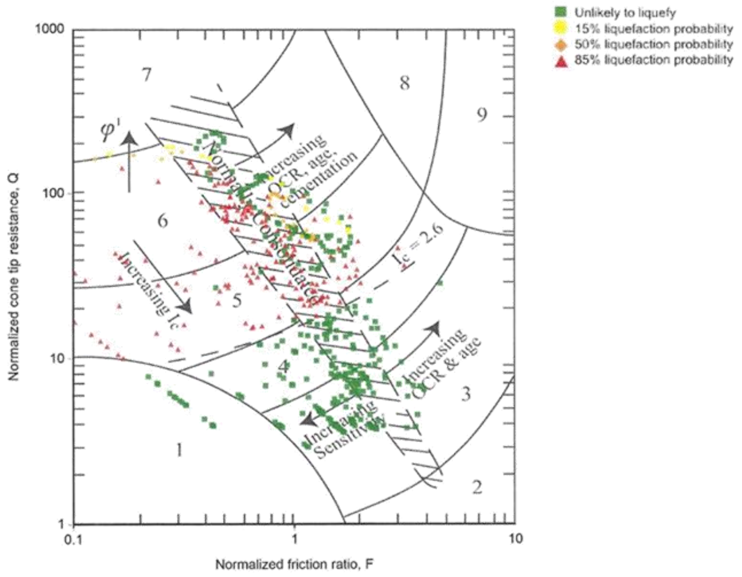

1. Sensitive, fine grained
2. Organic soils - peats
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5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
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CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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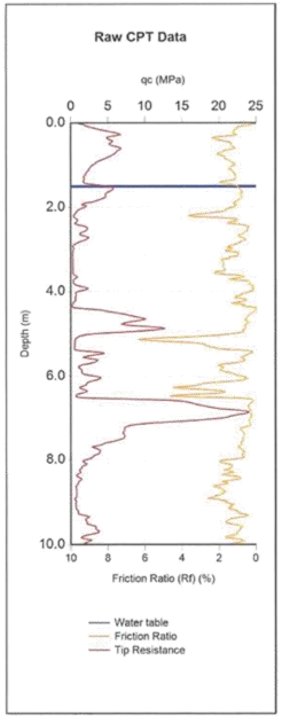

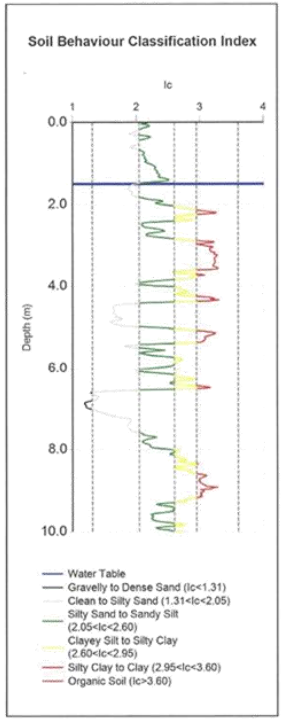

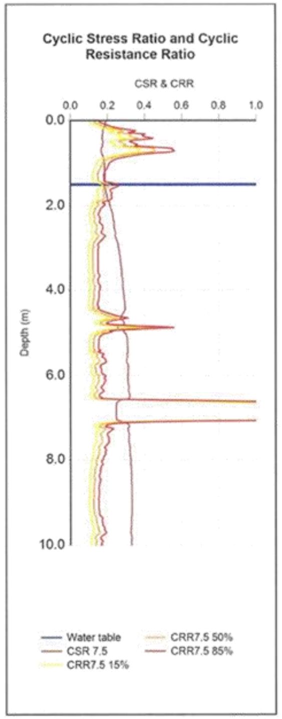

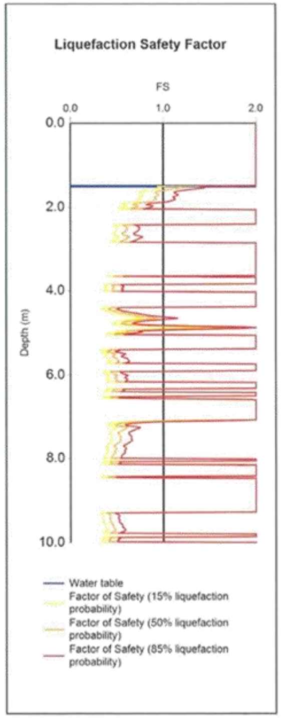

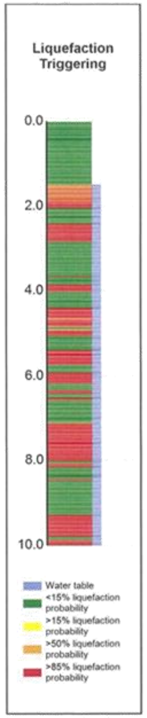

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT02	112104	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	107	4.2	15	24	1.6	12
	50%	103	4	12	22	1.7	9
	85%	98	3.7	9	20	2	6

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma
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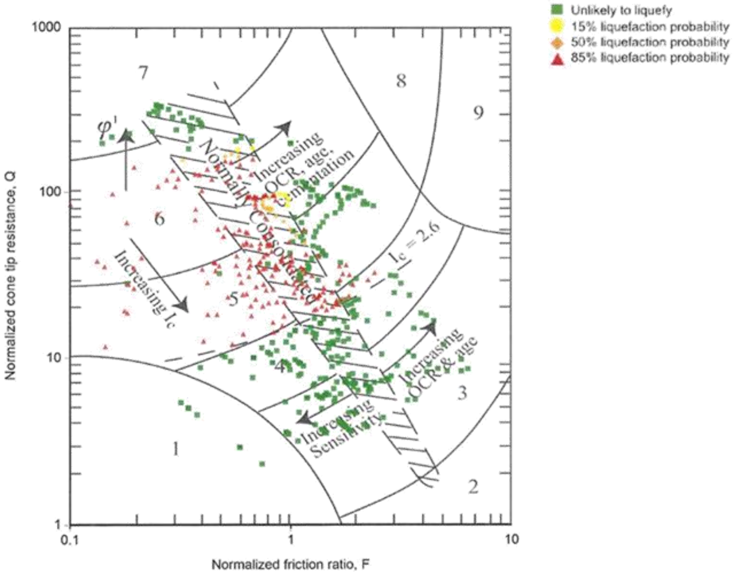

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CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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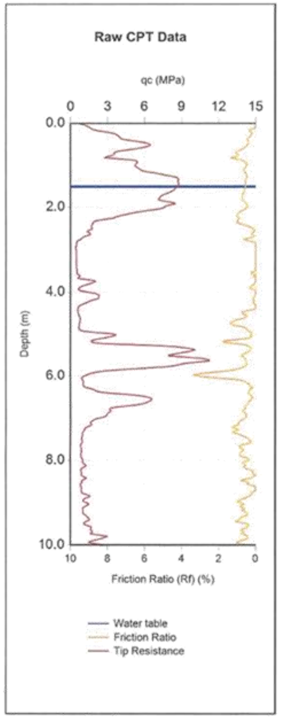

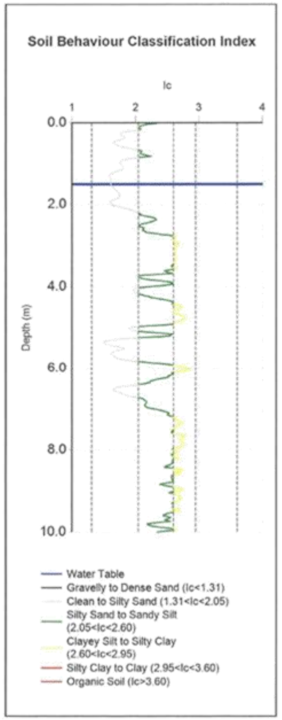

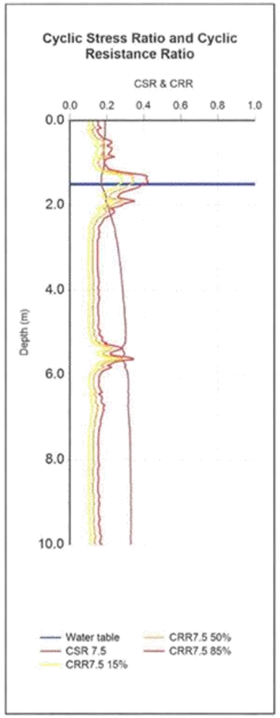

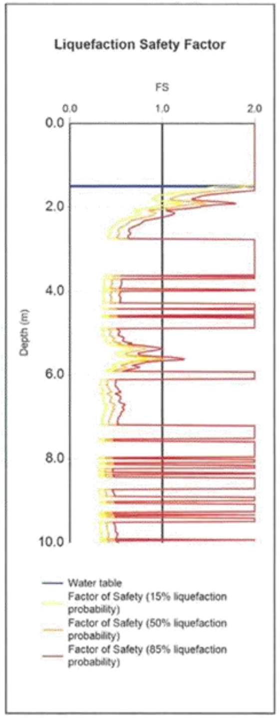

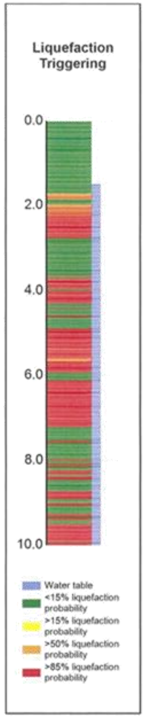

											(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT03	112111	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish
OUTPUT	15%	137	4.9	19	28	1.8	13
	50%	133	4.6	16	27	2.1	11
	85%	128	4.3	12	25	2.3	8

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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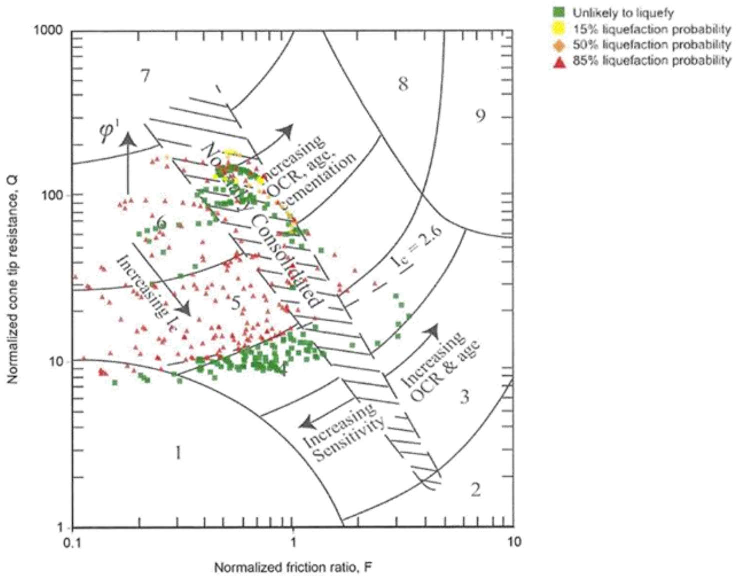

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CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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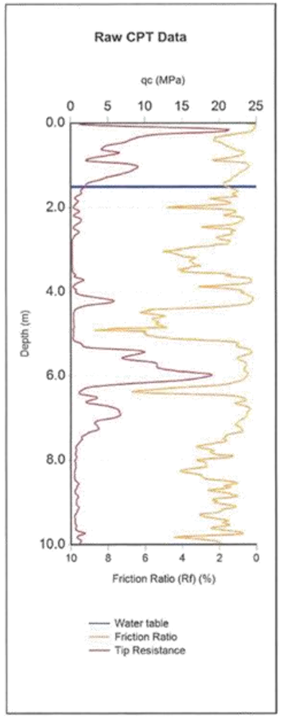

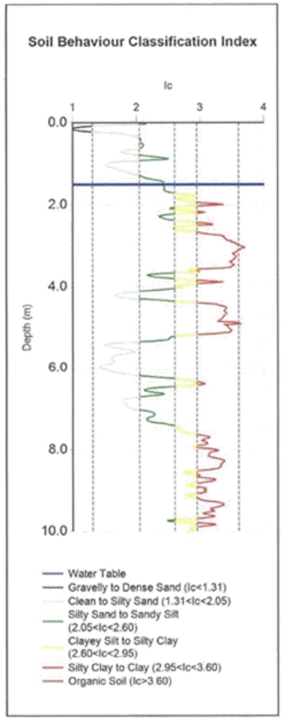

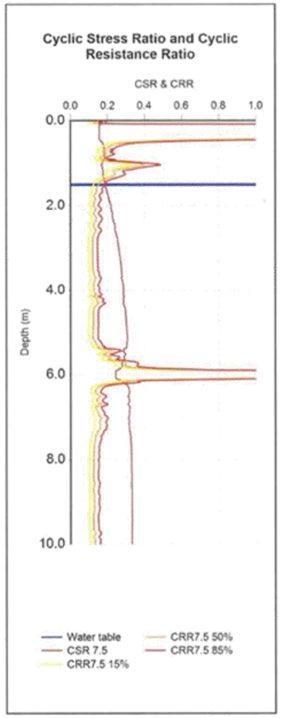

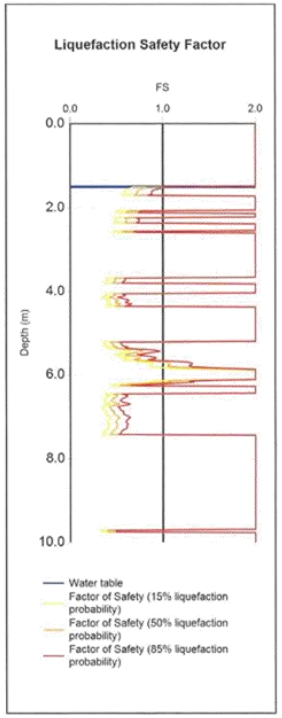

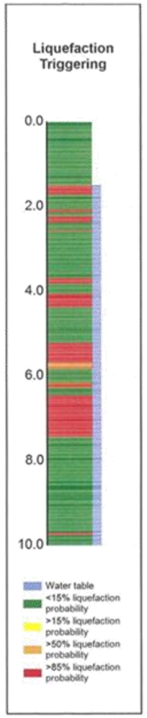

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT04	112112	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish
OUTPUT	15%	69	2.7	10	17	1.6	8
	50%	67	2.5	8	16	1.6	6
	85%	63	2.5	6	15	1.6	4

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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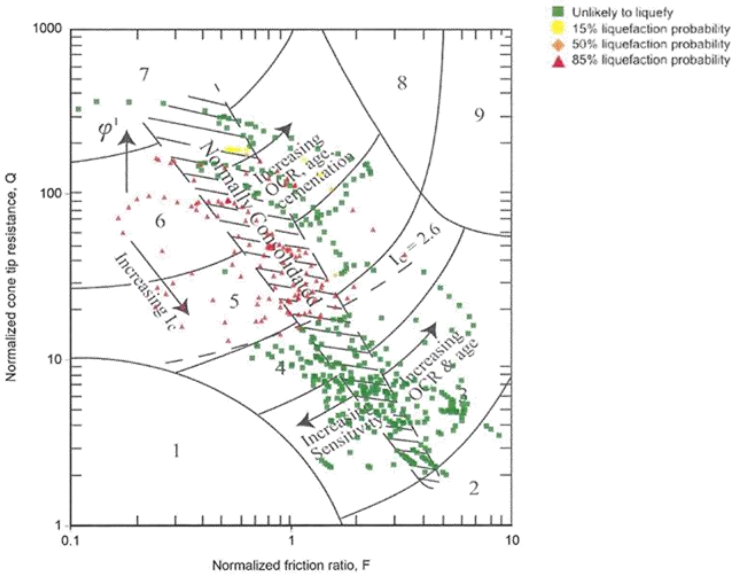

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CPT-based soil behavior type classification chart by Robertson (1990)

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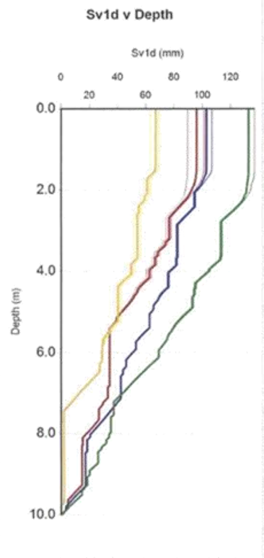
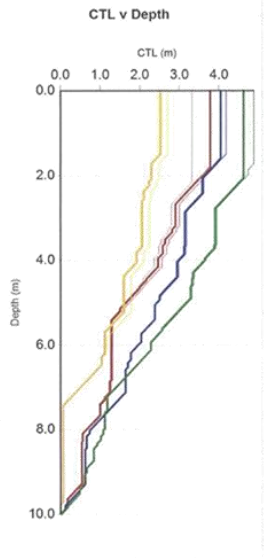
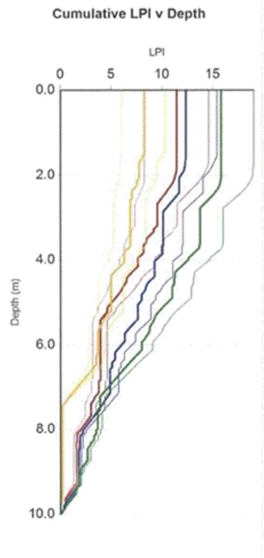
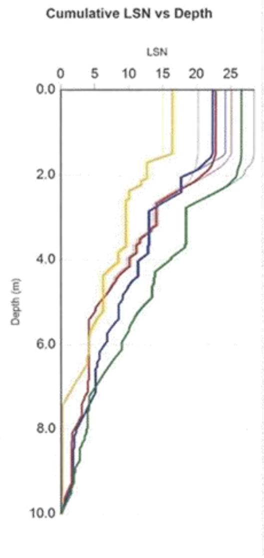
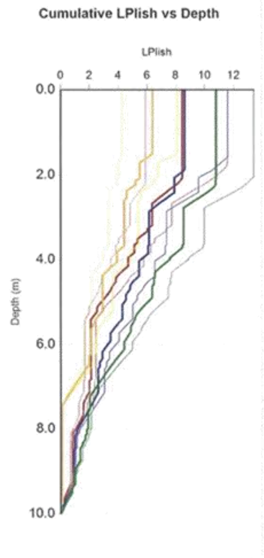

Sv1d v Depth


CTL v Depth


Cumulative LPI v Depth


Cumulative LSN vs Depth


Cumulative LPlish vs Depth

											(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT01	112067	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT02	112104	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT03	112111	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT04	112112	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
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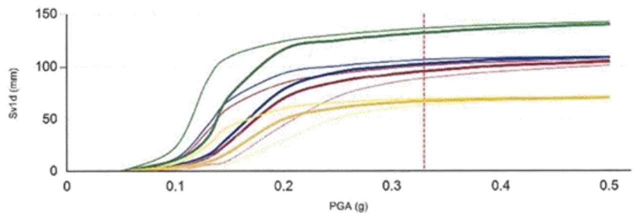
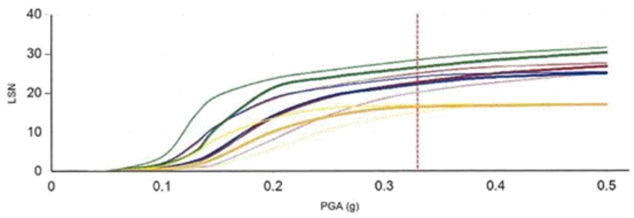
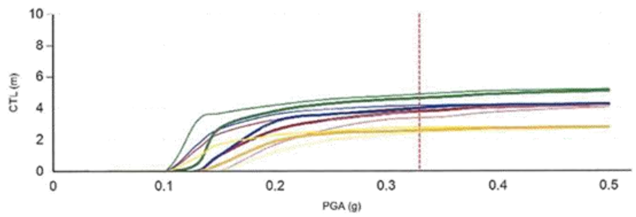
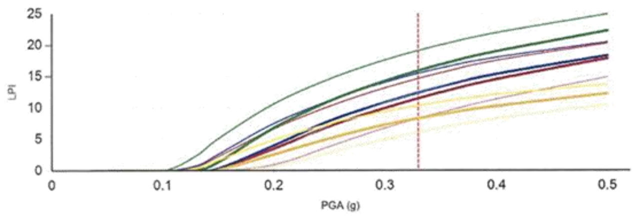
			PAGE	9 of 11 pages


Sv1d response to PGA


LSN response to PGA


CTL response to PGA


LPI response to PGA

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	(Assumed pre-drill values) qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT01	112067	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT02	112104	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT03	112111	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT04	112112	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	112067	112104	112111	112112
CPT Name	CPT01	CPT02	CPT03	CPT04
PGA	0.33g	0.33g	0.33g	0.33g
Magnitude	6.9	6.9	6.9	6.9
Depth to groundwater	1.5m	1.5m	1.5m	1.5m
Predrill depth	0m	0m	0m	0.02m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	25m	25m	13.68m	23.08m
Maximum depth of analysis	10m	10m	10m	10m
RL	n/a	n/a	n/a	n/a

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
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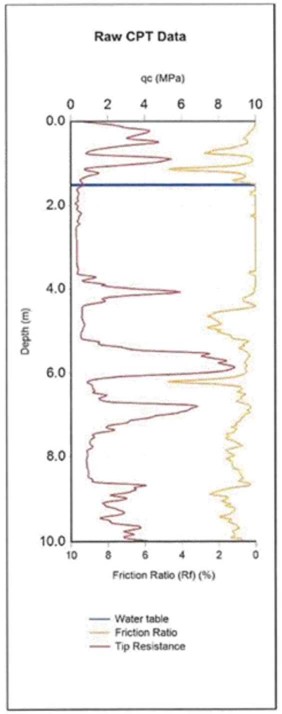
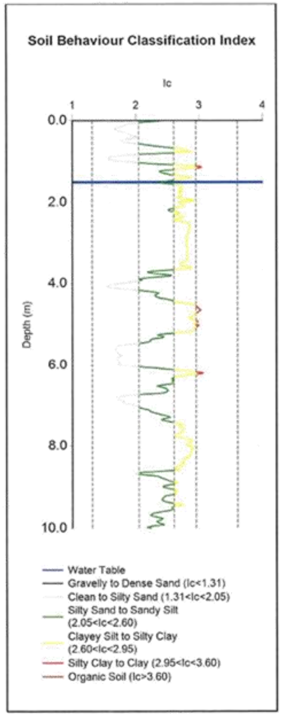
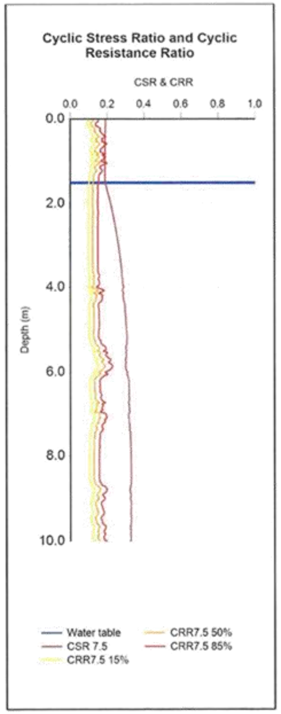
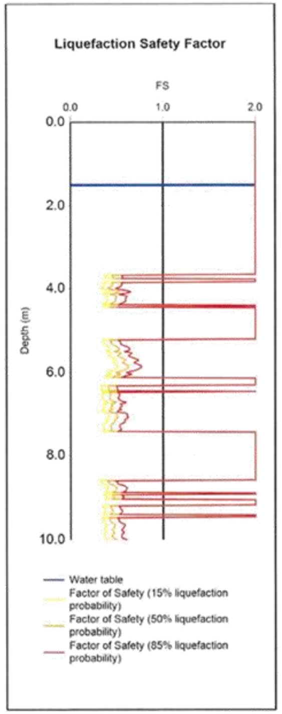
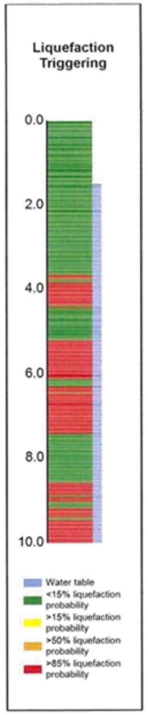

Raw CPT Data


Soil Behaviour Classification Index


Cyclic Stress Ratio and Cyclic Resistance Ratio


Liquefaction Safety Factor


Liquefaction Triggering

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT05	112335	6/06/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	106	3.9	16	17	3.8	10
	50%	106	3.9	13	17	3.8	8
	85%	106	3.9	11	17	3.8	7

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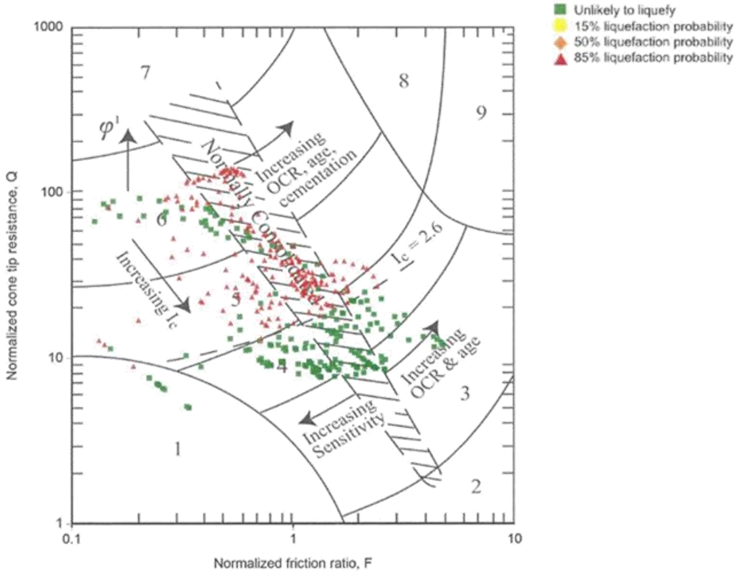

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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		JOB NUMBER **1006598**	CHECKED	
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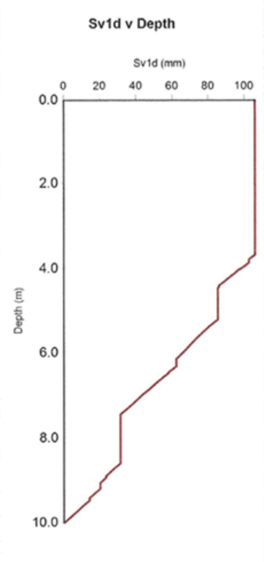

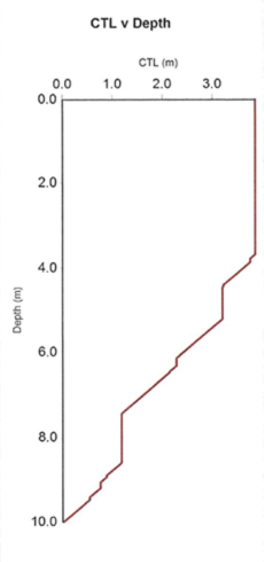

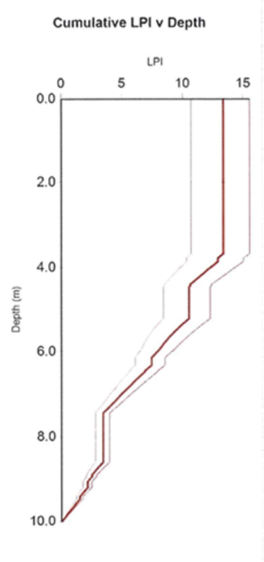

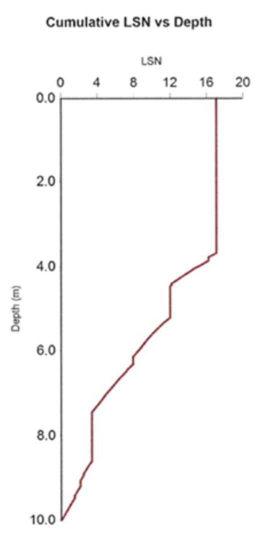

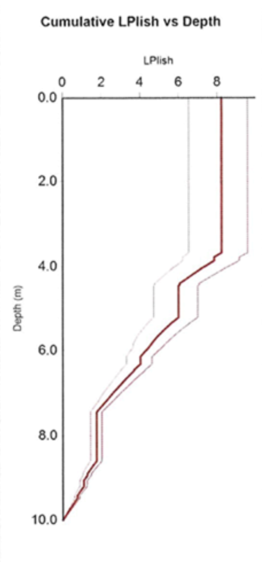

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT05	112335	6/06/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma CHECKED
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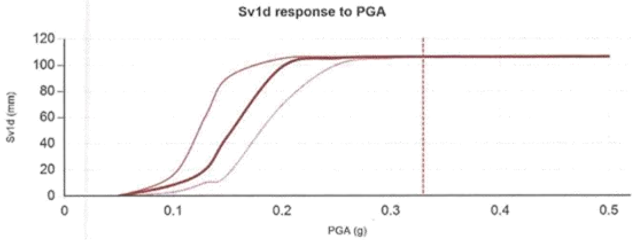

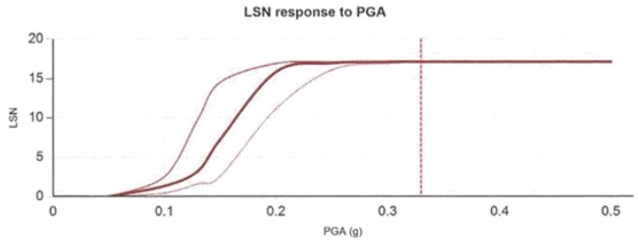

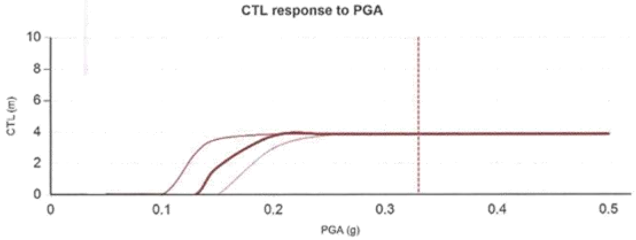

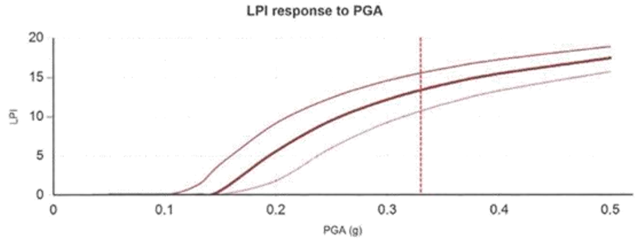

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

										(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT05	112335	6/06/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 12/06/2018 ANALYSED joma CHECKED
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The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	112335
CPT Name	CPT05
PGA	0.33g
Magnitude	6.9
Depth to groundwater	1.5m
Predrill depth	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)
CFC	0
Total depth of CPT	14.84m
Maximum depth of analysis	10m
RL	n/a

Tonkin + Taylor Exceptional thinking together	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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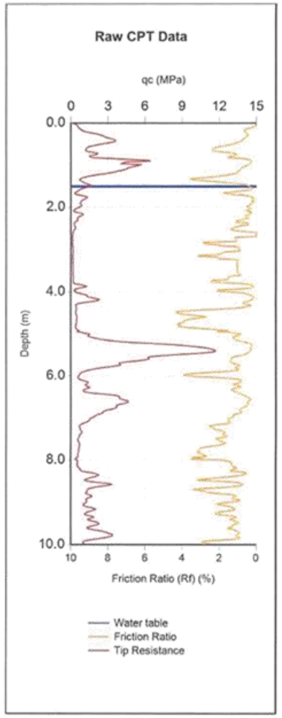

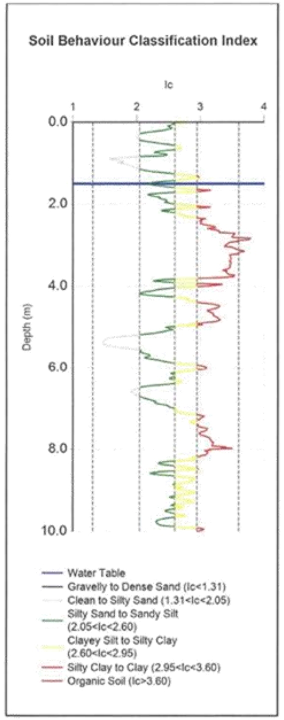

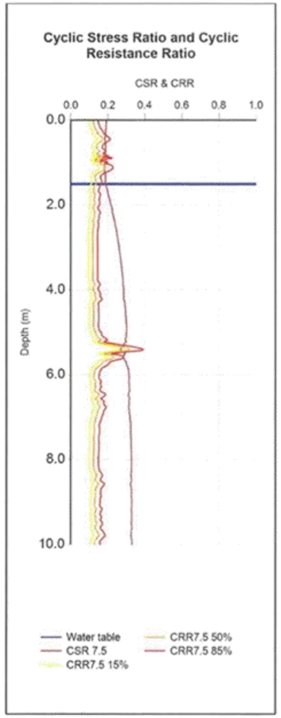

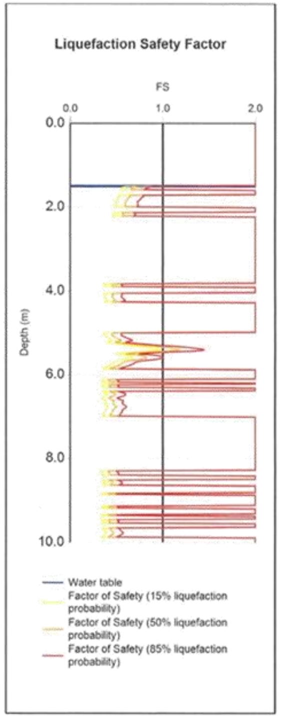

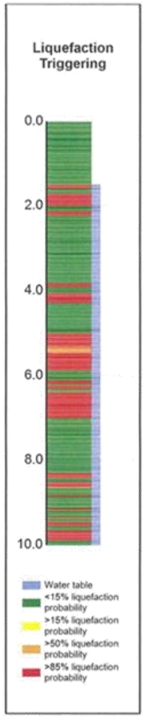

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT06	112113	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish
OUTPUT	15%	87	3.2	12	20	1.6	10
	50%	85	3.1	10	20	1.6	8
	85%	83	3	8	19	1.6	6

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Exceptional thinking together
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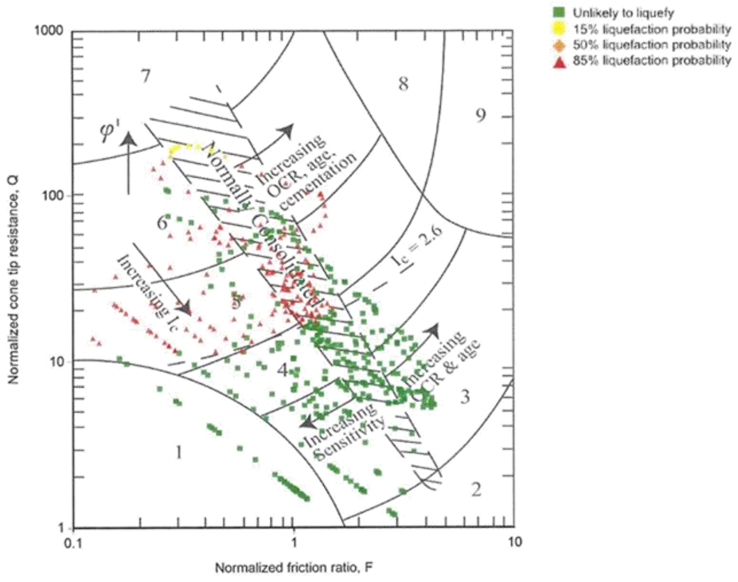

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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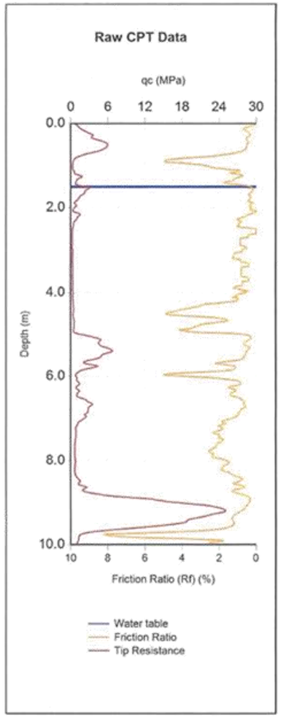

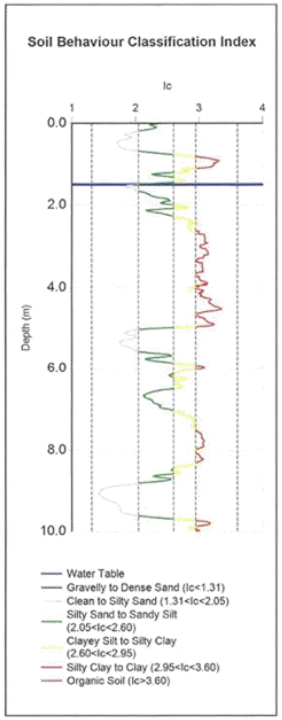

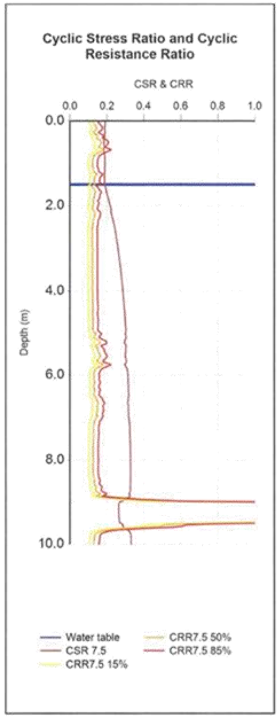

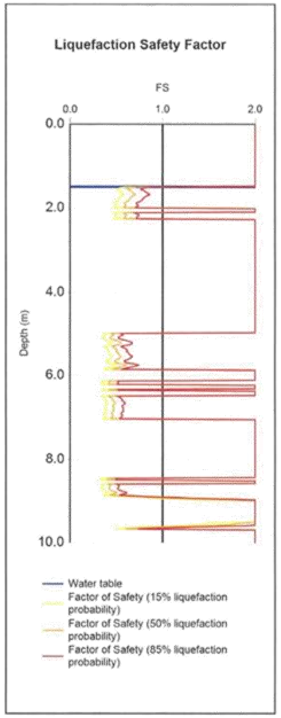

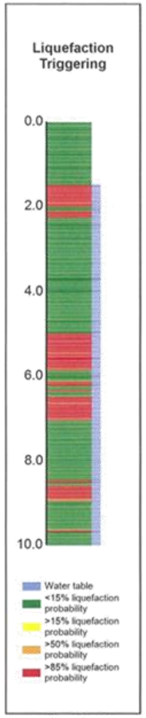

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT07	112114	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	76	2.7	11	20	1.6	10
	50%	76	2.7	9	20	1.6	8
	85%	75	2.7	7	20	1.6	5

Tonkin + Taylor
Exceptional thinking together
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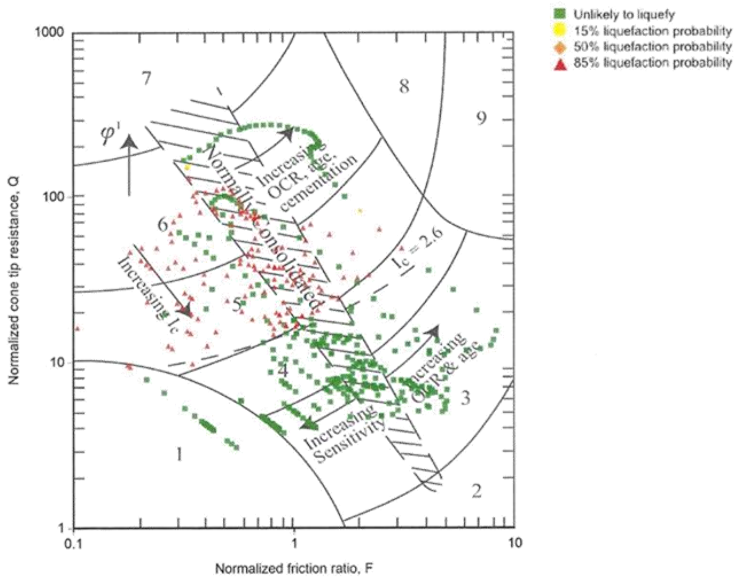

1. Sensitive, fine grained
2. Organic soils - peats
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6. Sands - clean sand to silty sand
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CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
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		JOB NUMBER	CHECKED	
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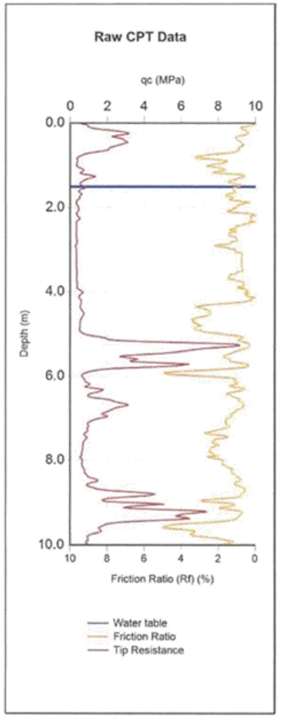
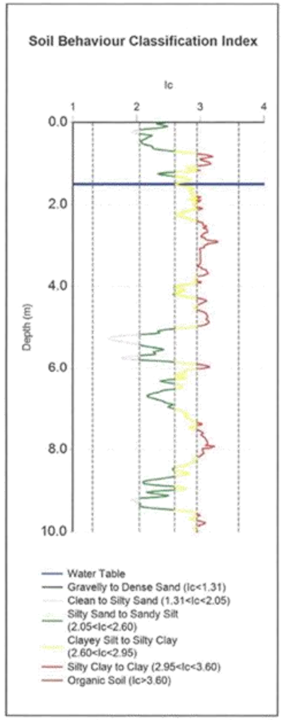
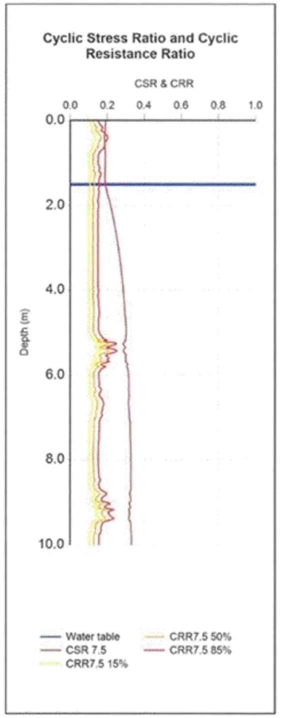
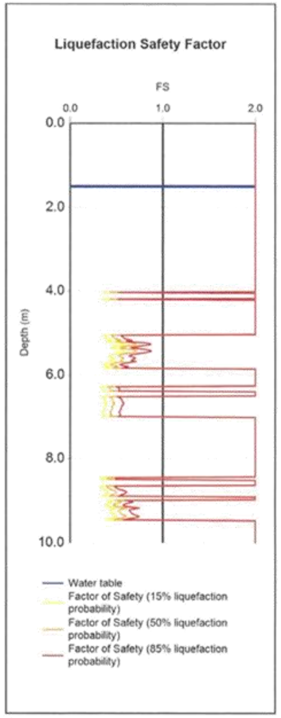
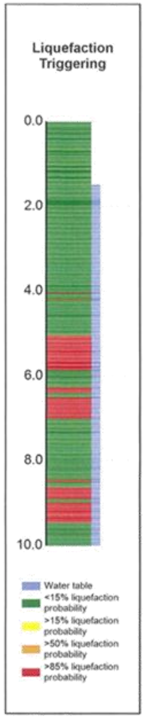








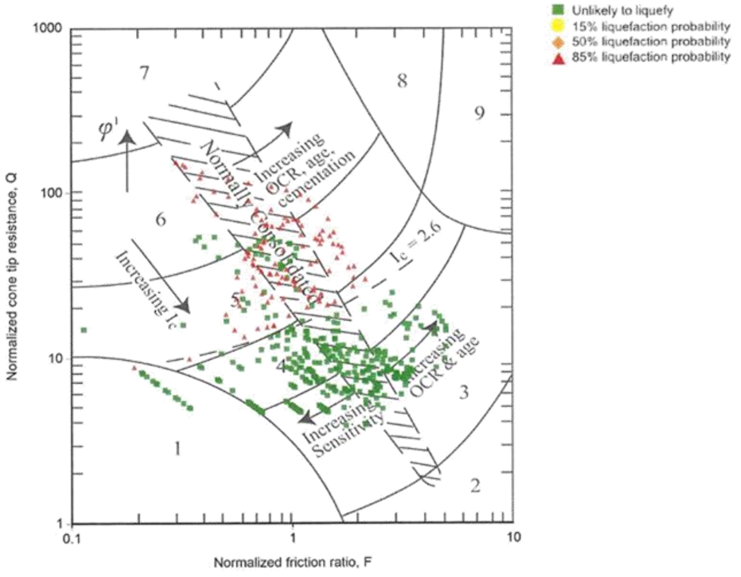


(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT08	112115	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	58	2.3	9	9	5.1	5
	50%	58	2.3	7	9	5.1	4
	85%	57	2.3	6	9	5.1	3

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Napier City Council Napier Aquatic Centre	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE Liquefaction Analyses - ULS	JOB NUMBER 1006598	CHECKED	
			PAGE	5 of 11 pages

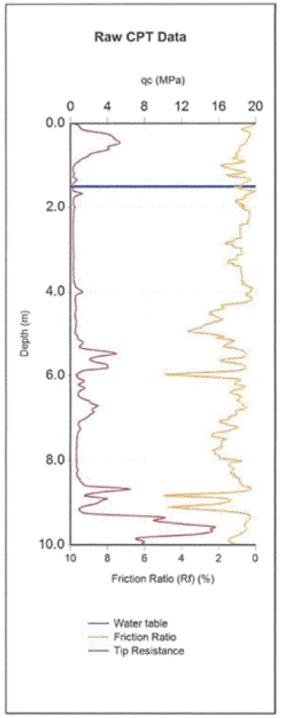


1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
V1.3	TITLE **Liquefaction Analyses - ULS**	JOB NUMBER **1006598**	CHECKED	
			PAGE	6 of 11 pages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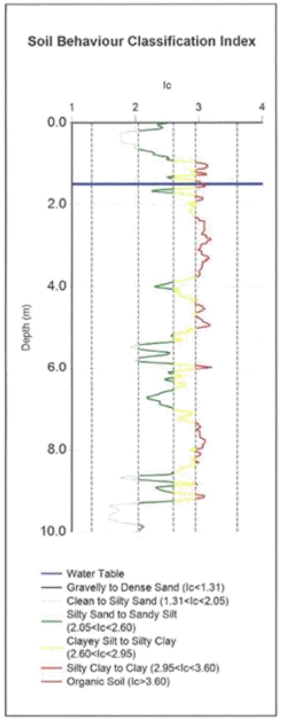
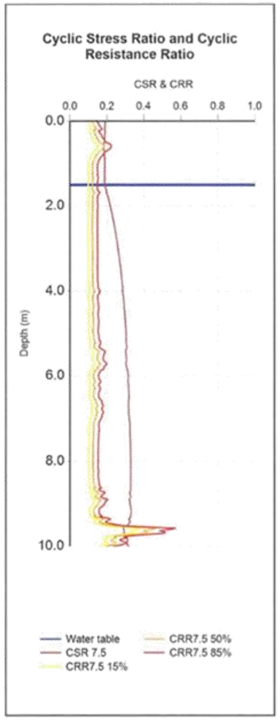
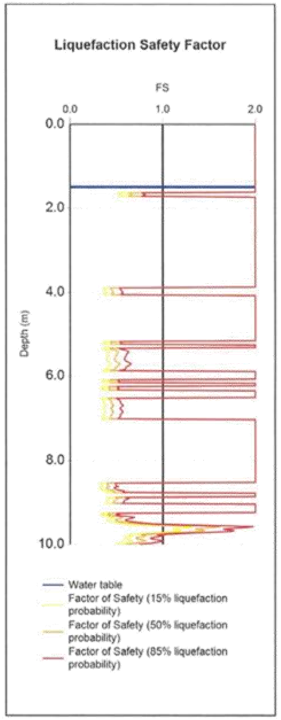

Soil Behaviour Classification Index


Cyclic Stress Ratio and Cyclic Resistance Ratio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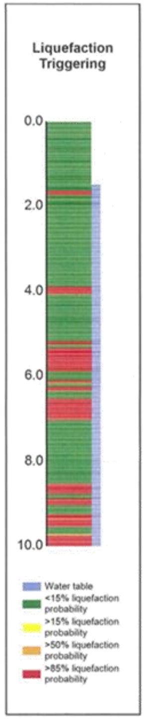

Liquefaction Triggering

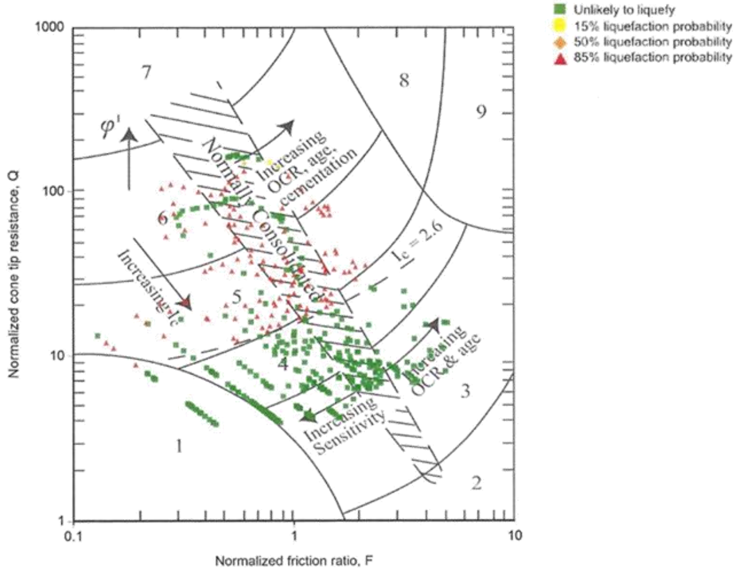
(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT09	112116	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	69	2.6	10	12	1.7	6
	50%	68	2.6	8	12	1.7	5
	85%	66	2.5	6	12	1.7	4

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT	LOCATION	DATE	12/06/2018
Napier City Council Napier Aquatic Centre	Napier	ANALYSED	joma
TITLE	JOB NUMBER	CHECKED	
Liquefaction Analyses - ULS	1006598	PAGE	7 of 11 pages



1. Sensitive, fine grained	6. Sands - clean sand to silty sand
2. Organic soils - peats	7. Gravelly sand to dense sand
3. Clays - silty clay to clay	8. Very stiff sand to clayey sand *
4. Silt mixtures - clayey silt to silty clay	9. Very stiff, fine grained *
5. Sand mixtures - silty sand to sandy silt	

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses - ULS**	JOB NUMBER **1006598**	CHECKED	
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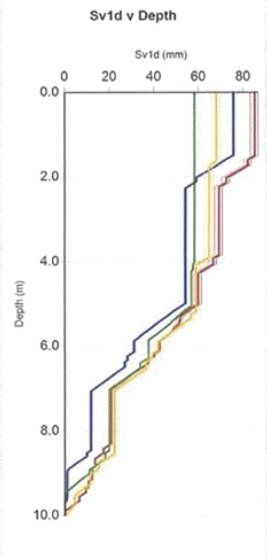
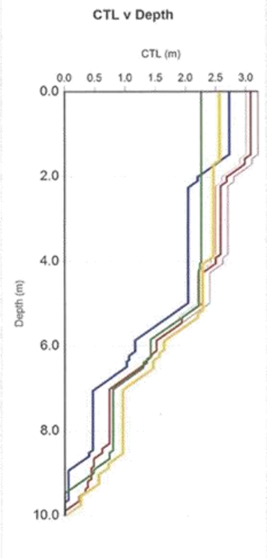
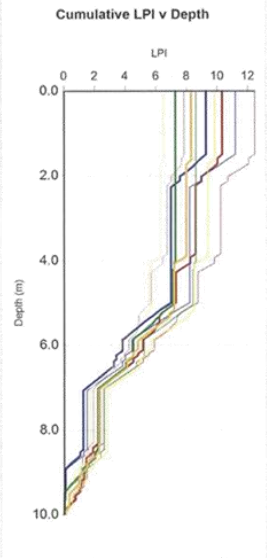
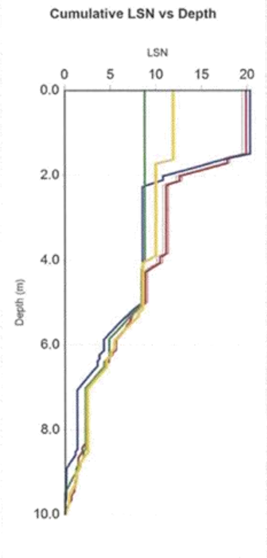
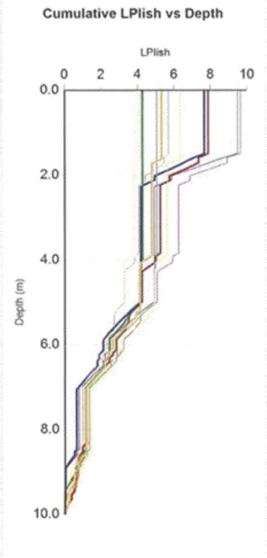

Sv1d v Depth


CTL v Depth


Cumulative LPI v Depth


Cumulative LSN vs Depth


Cumulative LPlish vs Depth

										(Assumed pre-drill values)			
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT06	112113	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT07	112114	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT08	112115	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT09	112116	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Napier City Council
Napier Aquatic Centre

TITLE
Liquefaction Analyses - ULS

LOCATION
Napier

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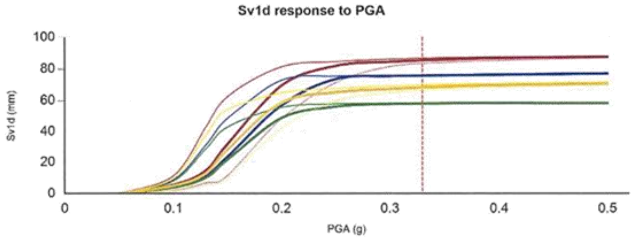
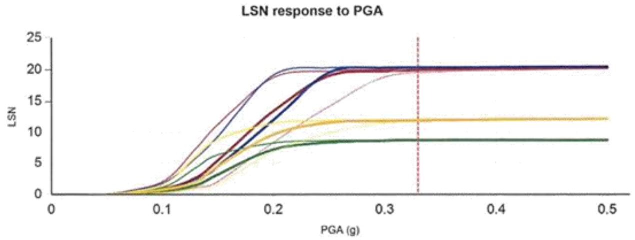
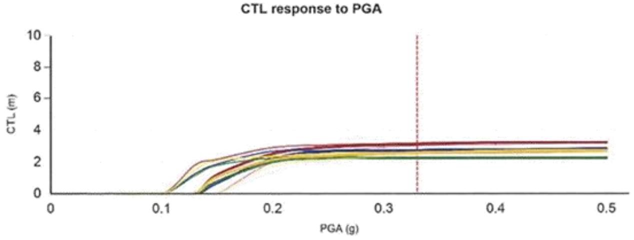
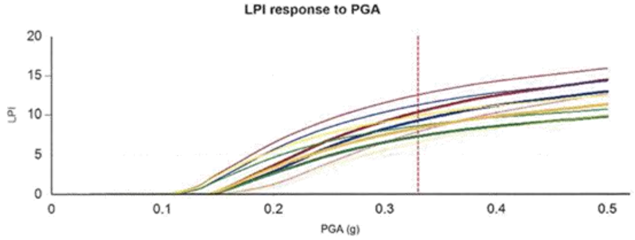

Sv1d response to PGA


LSN response to PGA


CTL response to PGA


LPI response to PGA

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

											(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT06	112113	23/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT07	112114	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT08	112115	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT09	112116	24/05/2018	User Specified	6.9	0.33	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT Napier City Council Napier Aquatic Centre	LOCATION Napier	DATE	12/06/2018
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The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	112113	112114	112115	112116
CPT Name	CPT06	CPT07	CPT08	CPT09
PGA	0.33g	0.33g	0.33g	0.33g
Magnitude	6.9	6.9	6.9	6.9
Depth to groundwater	1.5m	1.5m	1.5m	1.5m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	22.64m	13.6m	10.9m	21.26m
Maximum depth of analysis	10m	10m	10m	10m
RL	n/a	n/a	n/a	n/a

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	12/06/2018
			ANALYSED	joma
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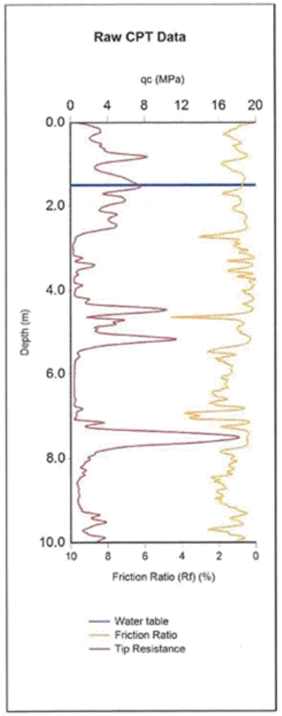

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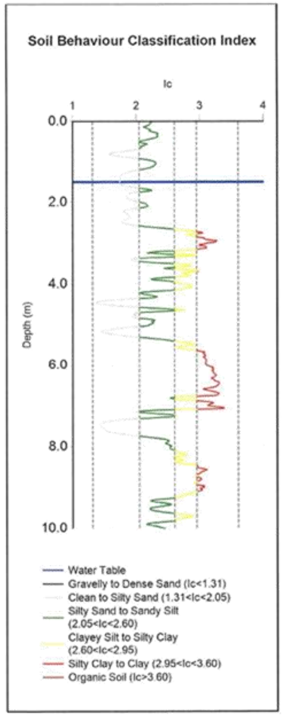
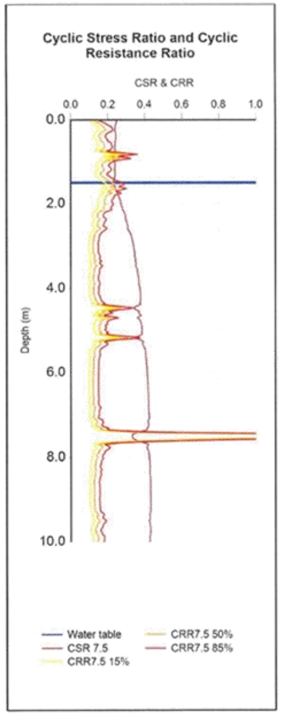
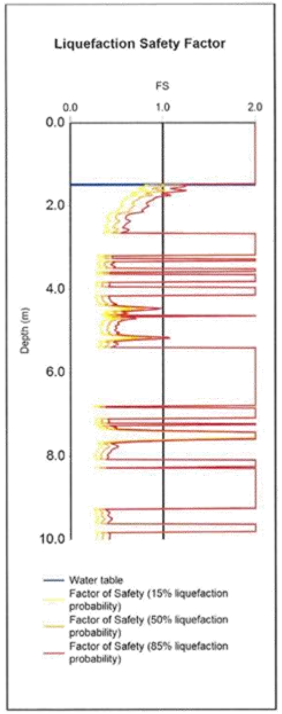


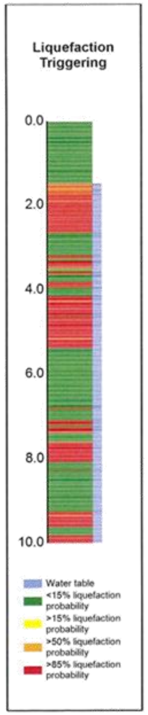
Soil Behaviour Classification Index



Cyclic Stress Ratio and Cyclic Resistance Ratio



Liquefaction Safety Factor



Liquefaction Triggering

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT01	112067	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	105	4.2	18	27	1.6	16
	50%	103	4.1	16	26	1.6	13
	85%	98	3.9	13	24	1.8	10

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
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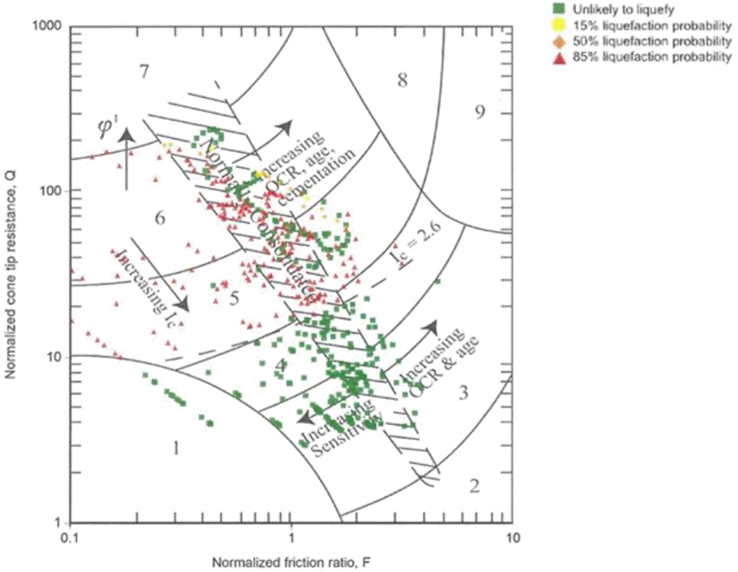

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
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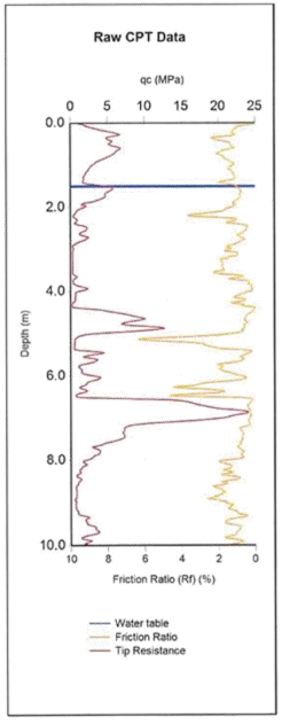
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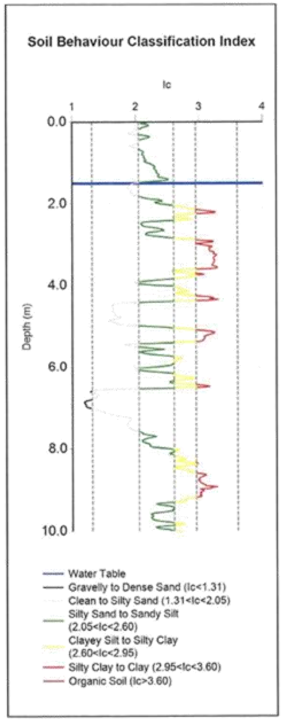
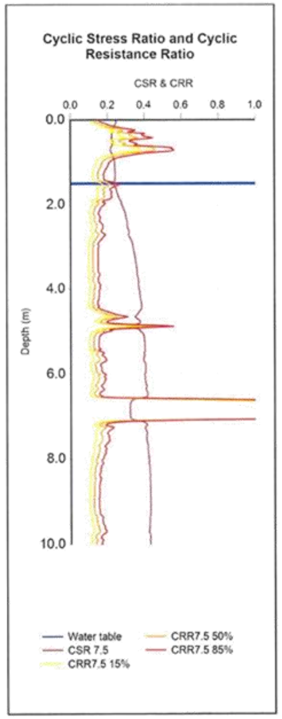
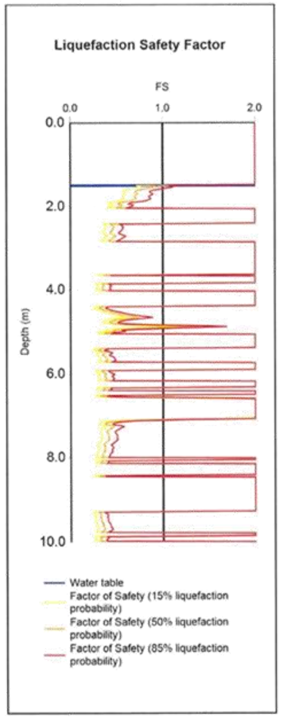
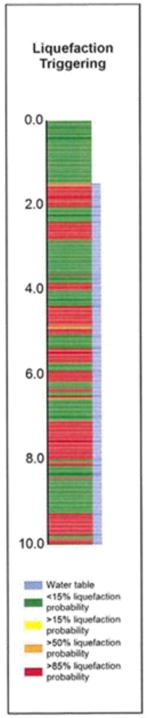

Soil Behaviour Classification Index


Cyclic Stress Ratio and Cyclic Resistance Ratio


Liquefaction Safety Factor


Liquefaction Triggering

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT02	112104	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	109	4.3	19	25	1.6	15
	50%	108	4.2	16	25	1.6	12
	85%	104	4.1	13	23	1.7	10

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
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	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
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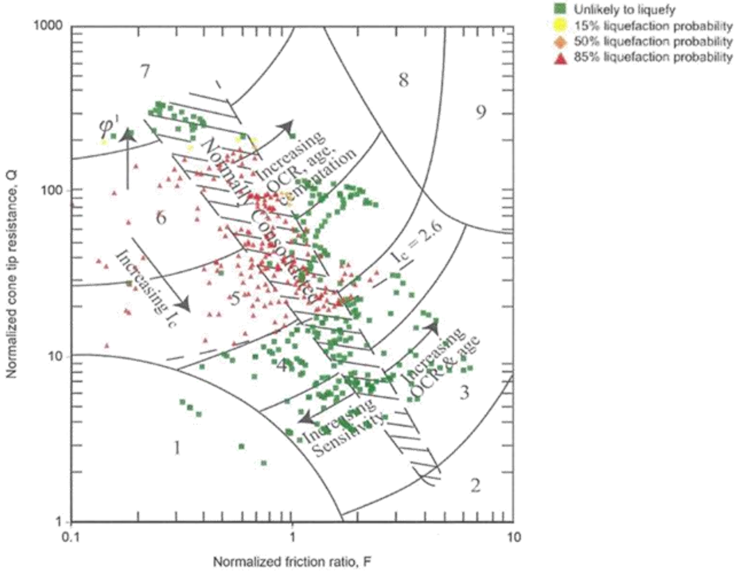

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
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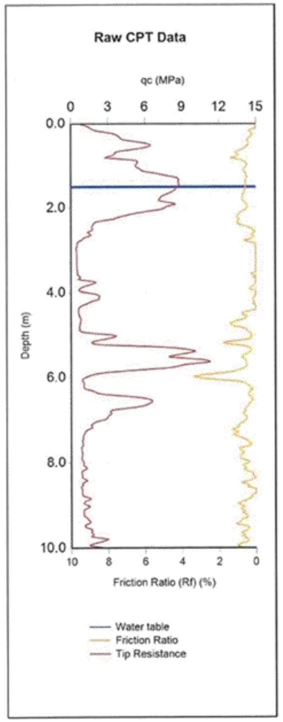
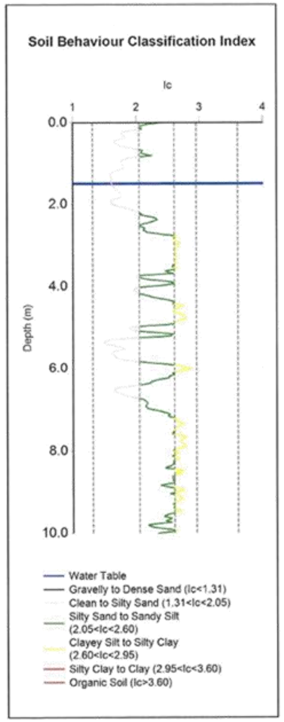
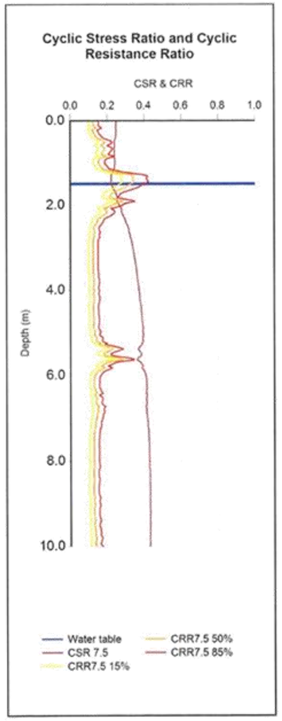
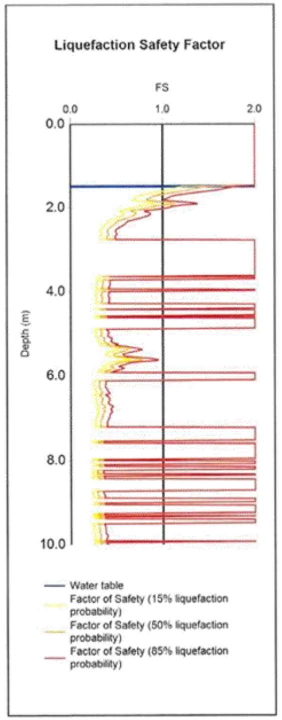
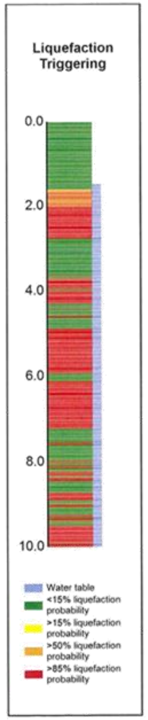








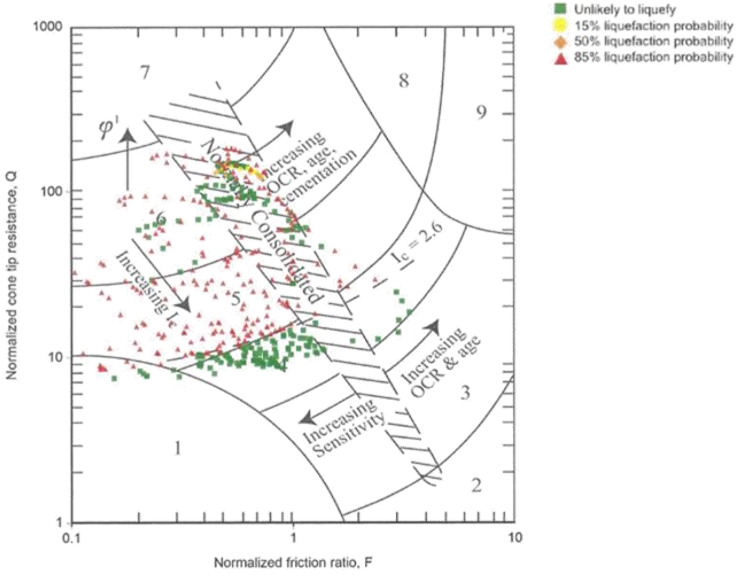


(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT03	112111	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	141	5.1	23	31	1.7	17
	50%	138	4.9	20	29	1.8	14
	85%	134	4.7	17	27	2.1	12

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
		JOB NUMBER **1006598**	CHECKED	
	TITLE **Liquefaction Analyses**		PAGE	5 of 11 pages



1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
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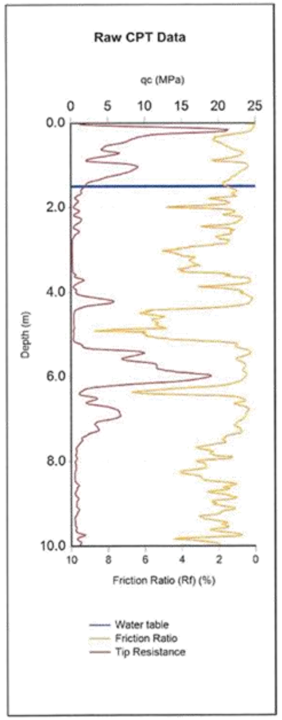

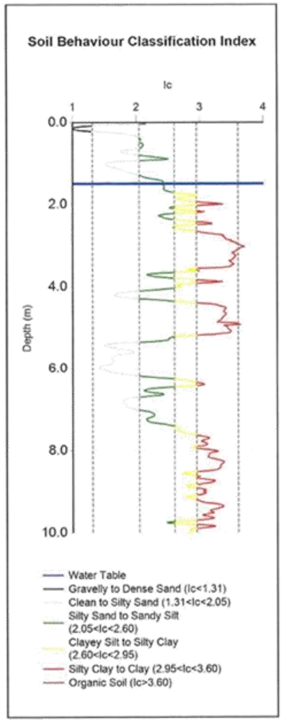

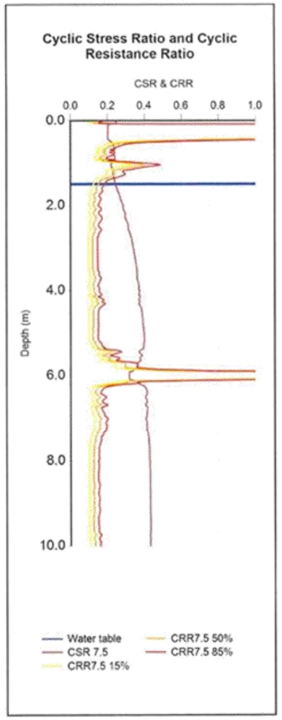

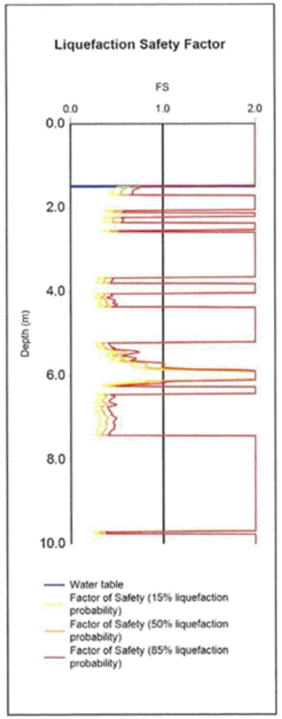

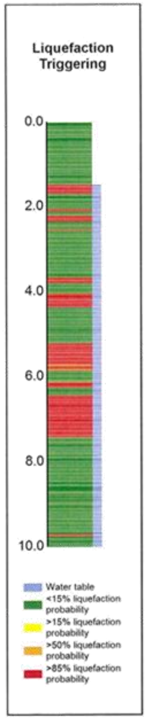

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT04	112112	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	71	2.8	13	17	1.6	10
	50%	69	2.7	11	17	1.6	9
	85%	68	2.6	9	17	1.6	7

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Napier City Council
Napier Aquatic Centre

TITLE
Liquefaction Analyses

LOCATION
Napier

JOB NUMBER
1006598

DATE	13/06/2018
ANALYSED	joma
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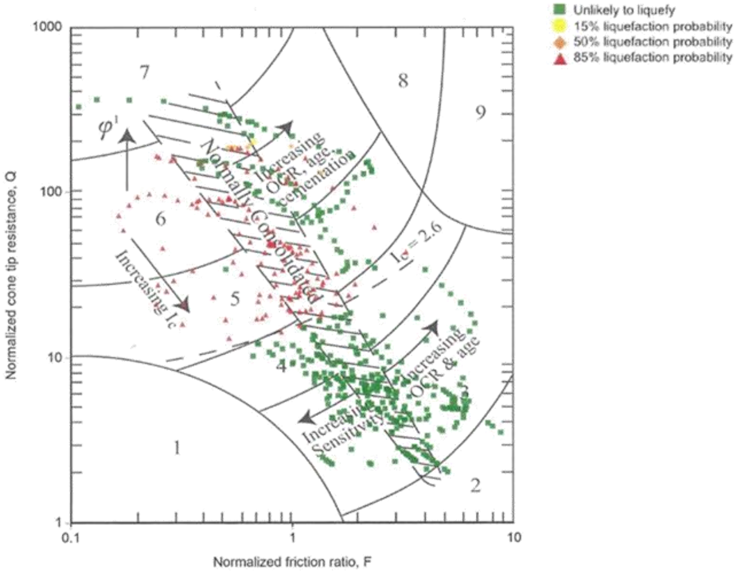

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
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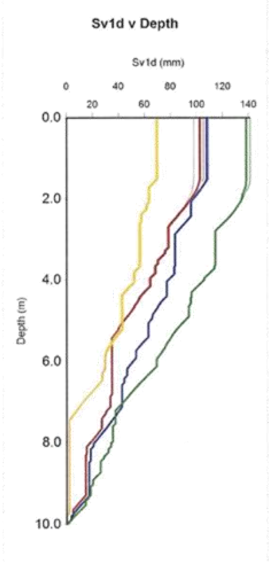
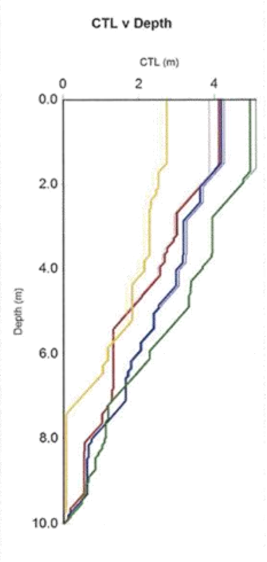
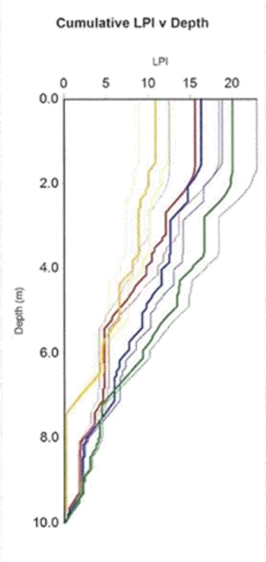
*Heavily overconsolidated or cemented

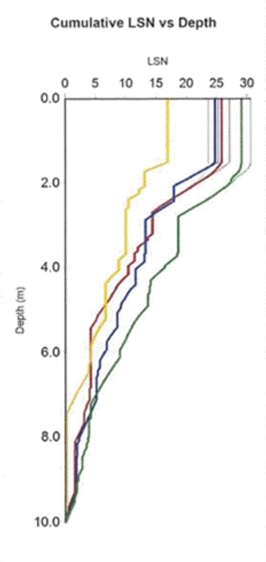
CPT-based soil behavior type classification chart by Robertson (1990)

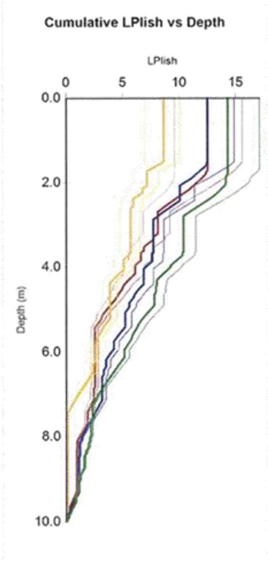
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT	**Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
				ANALYSED	joma
	TITLE	**Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
				PAGE	8 of 11 pages


Sv1d v Depth


CTL v Depth


Cumulative LPI v Depth


Cumulative LSN vs Depth

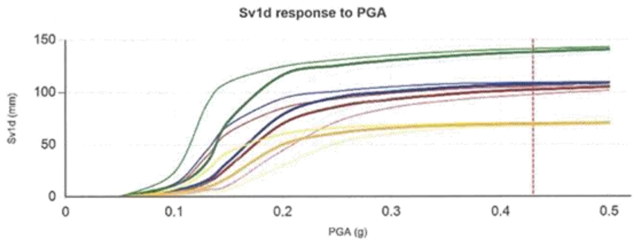

Cumulative LPIish vs Depth

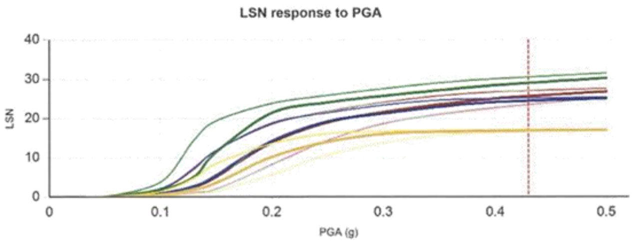
(Assumed pre-drill values)

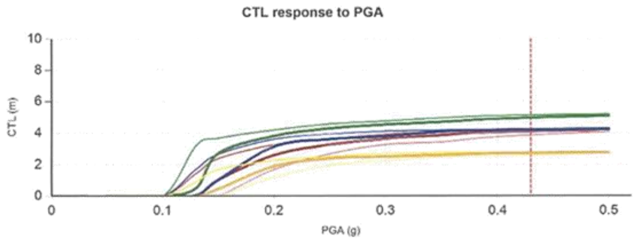
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT01	112067	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT02	112104	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT03	112111	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT04	112112	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

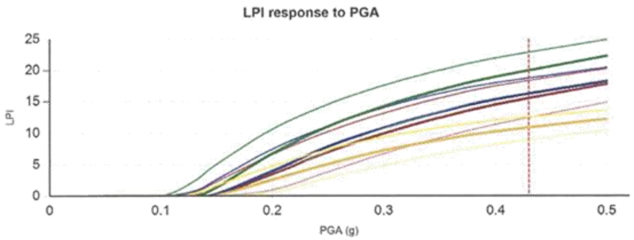
Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
			PAGE	9 of 11 pages


Sv1d response to PGA


LSN response to PGA


CTL response to PGA


LPI response to PGA

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

											(Assumed pre-drill values)		
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT01	112067	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT02	112104	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT03	112111	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT04	112112	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0.02	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

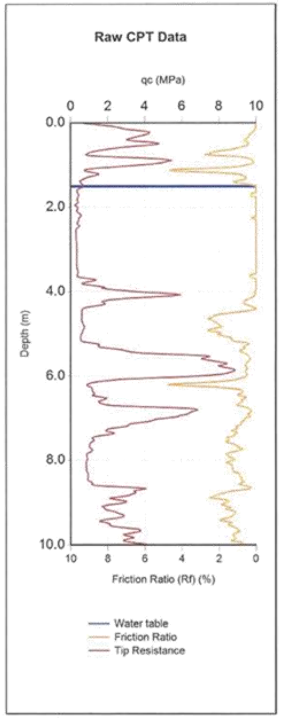
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 13/06/2018 ANALYSED joma CHECKED
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	PAGE 10 of 11 pages

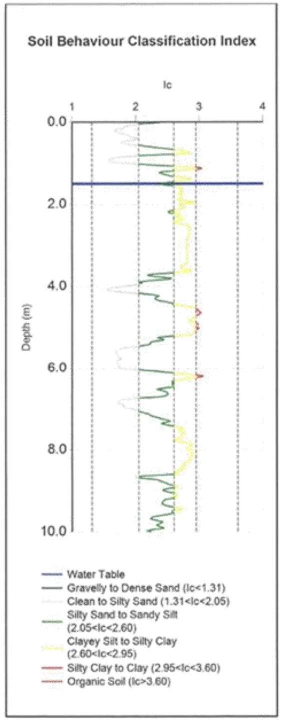
The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

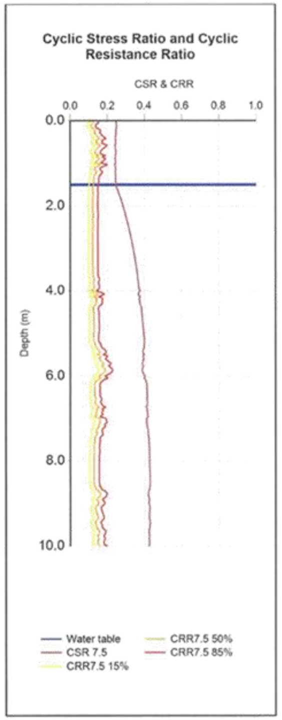
Table 1.1-1 Summary of inputs for liquefaction analysis

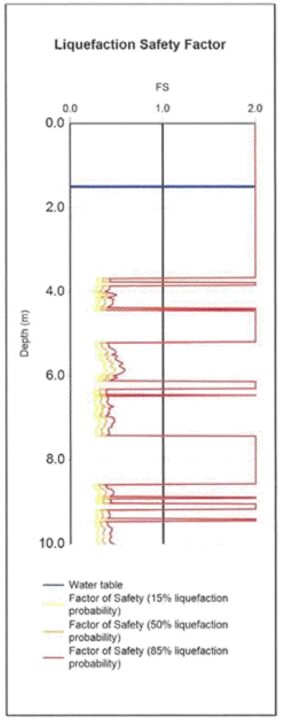
TTGD ID	112067	112104	112111	112112
CPT Name	CPT01	CPT02	CPT03	CPT04
PGA	0.43g	0.43g	0.43g	0.43g
Magnitude	6.9	6.9	6.9	6.9
Depth to groundwater	1.5m	1.5m	1.5m	1.5m
Predrill depth	0m	0m	0m	0.02m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	25m	25m	13.68m	23.08m
Maximum depth of analysis	10m	10m	10m	10m
RL	n/a	n/a	n/a	n/a

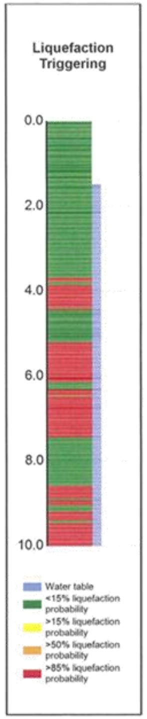
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 13/06/2018 ANALYSED joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED PAGE 11 of 11 pages











(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT05	112335	6/06/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPlish
OUTPUT	15%	106	3.9	18	17	3.8	11
	50%	106	3.9	16	17	3.8	10
	85%	106	3.9	14	17	3.8	9

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
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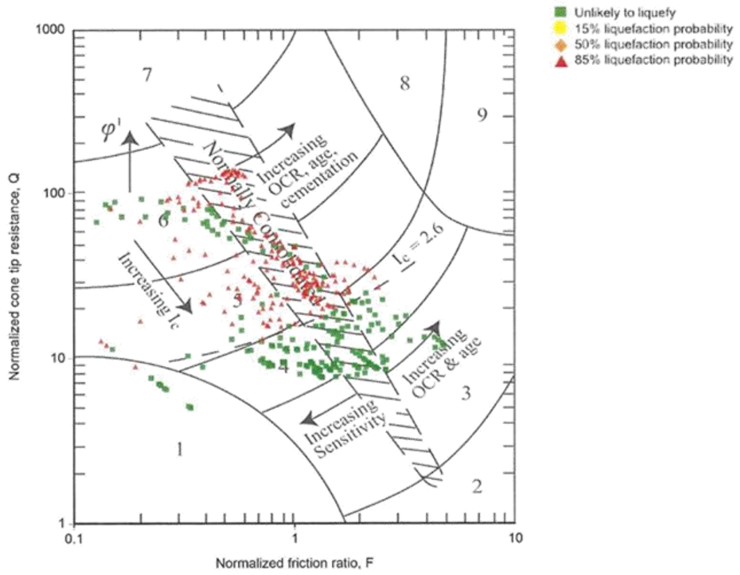

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
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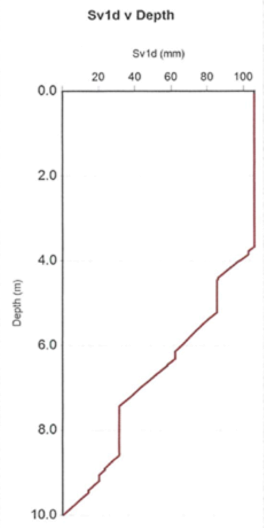
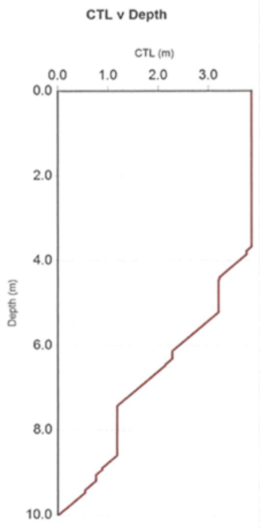
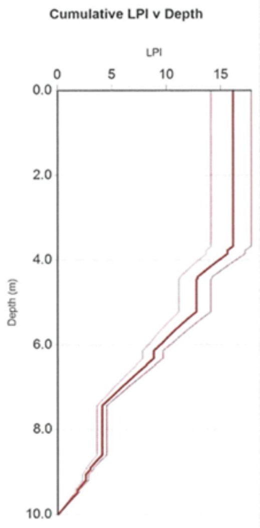
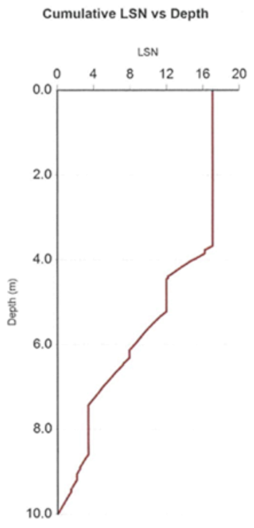
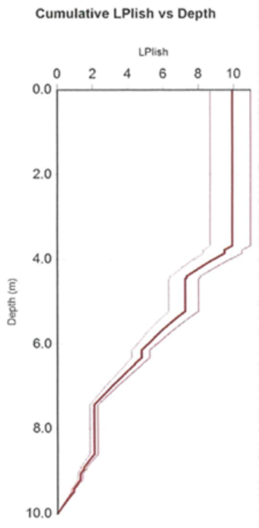

Sv1d v Depth


CTL v Depth


Cumulative LPI v Depth


Cumulative LSN vs Depth


Cumulative LPlish vs Depth

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT05	112335	6/06/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
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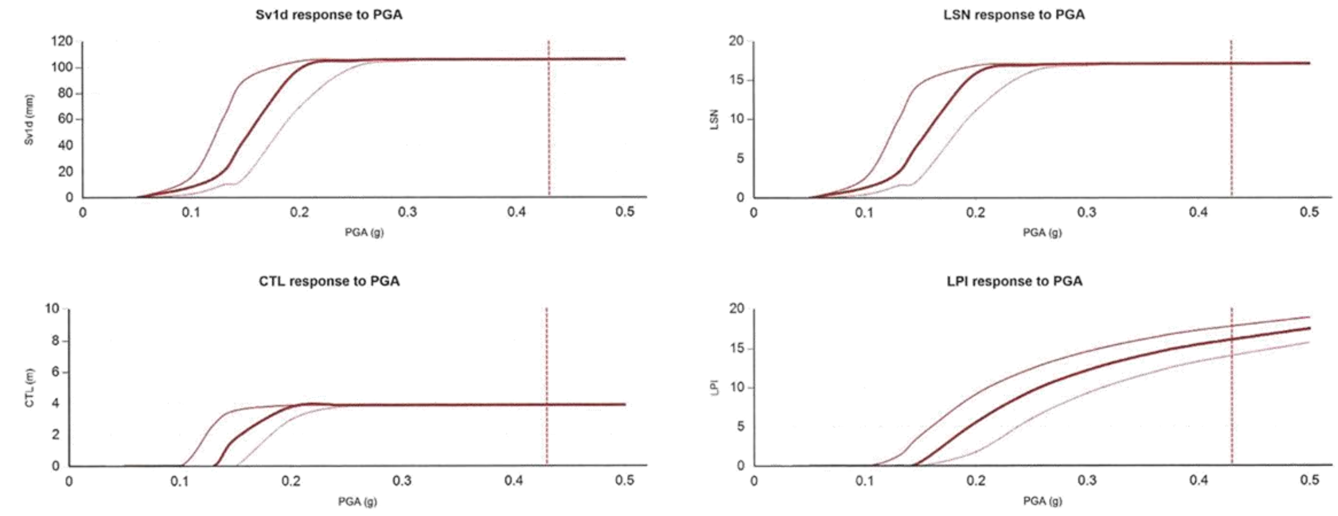

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	(Assumed pre-drill values) qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥 CPT05	112335	6/06/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
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TITLE
Liquefaction Analyses

LOCATION
Napier

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1006598

DATE	13/06/2018
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CHECKED	
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The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	112335
CPT Name	CPT05
PGA	0.43g
Magnitude	6.9
Depth to groundwater	1.5m
Predrill depth	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)
CFC	0
Total depth of CPT	14.84m
Maximum depth of analysis	10m
RL	n/a

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
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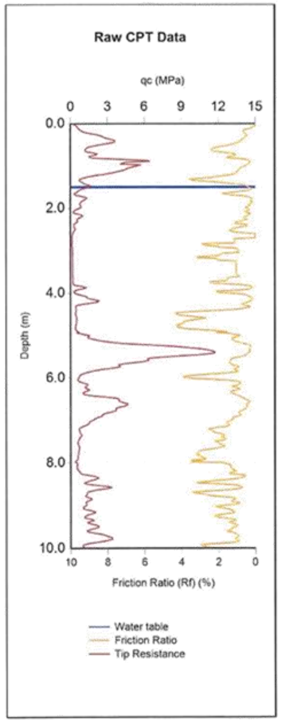

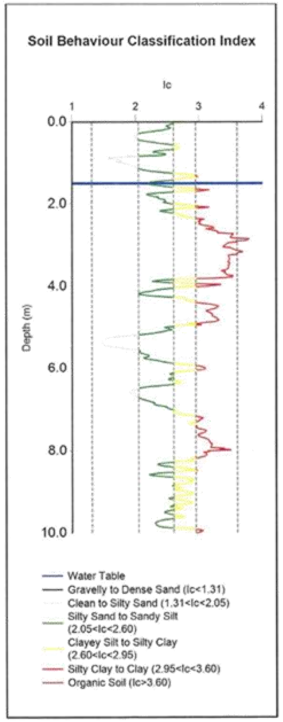

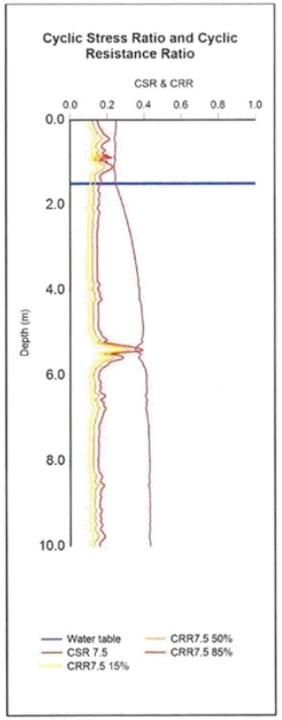

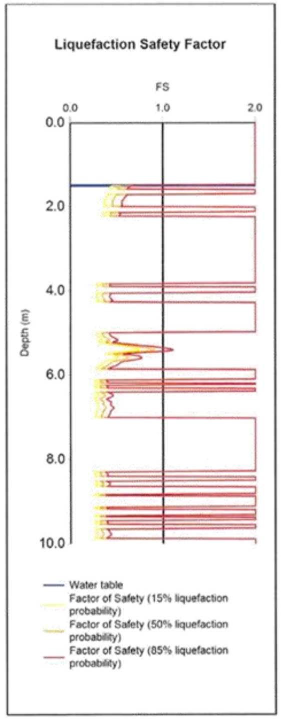

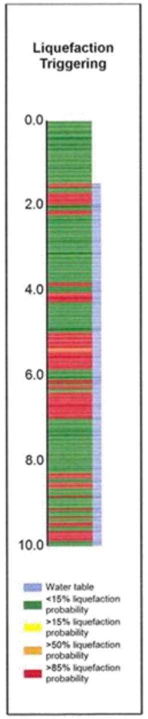

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT06	112113	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	88	3.2	15	20	1.6	12
	50%	87	3.2	13	20	1.6	10
	85%	86	3.1	11	20	1.6	8

Tonkin + Taylor
Exceptional thinking together
V1.3

CLIENT, PROJECT
Napier City Council
Napier Aquatic Centre

TITLE
Liquefaction Analyses

LOCATION
Napier

JOB NUMBER
1006598

DATE	13/06/2018
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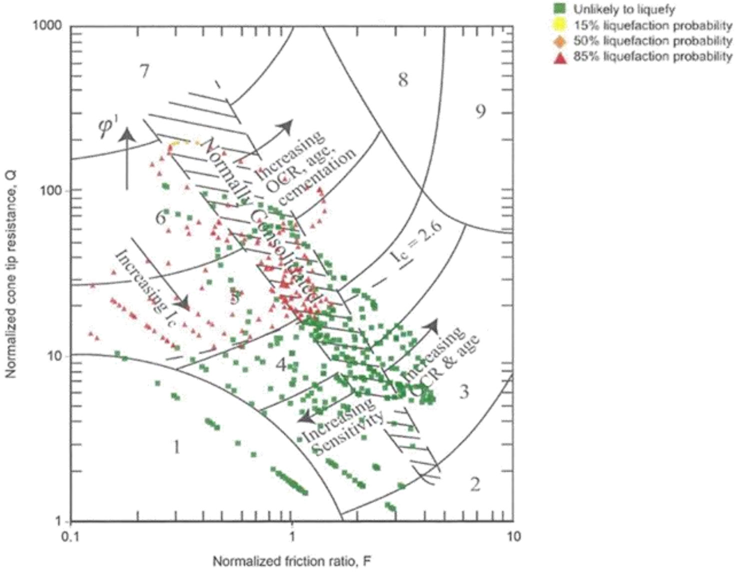
CHECKED	
PAGE	1 of 11 pages



1. Sensitive, fine grained
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5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
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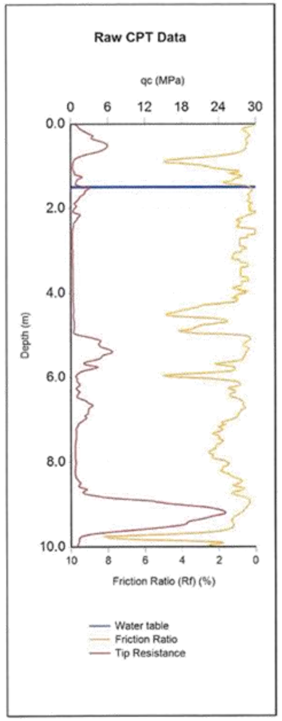
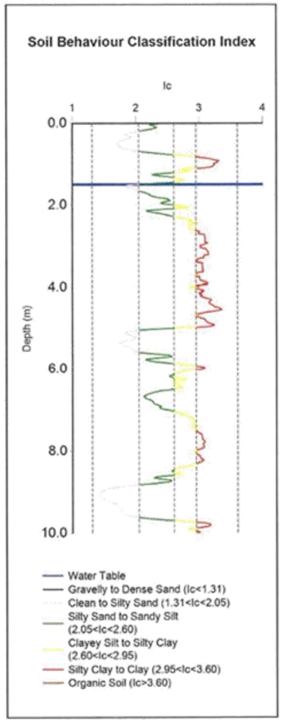
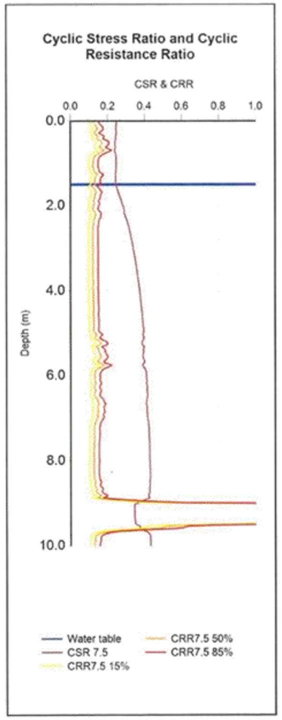
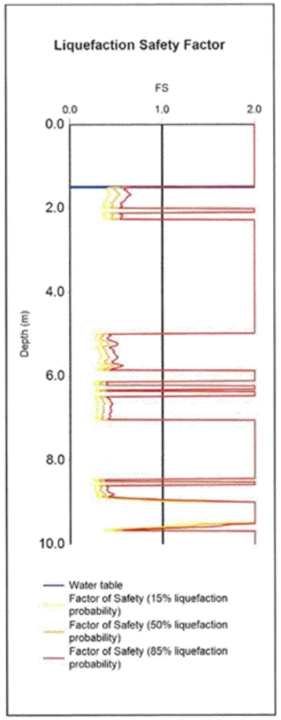
CPT-based soil behavior type classification chart by Robertson (1990)

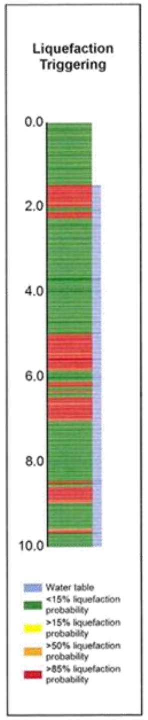
Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
	TITLE **Liquefaction Analyses**	JOB NUMBER **1006598**	CHECKED	
			PAGE	2 of 11 pages











(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT07	112114	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	77	2.8	13	20	1.6	11
	50%	76	2.8	12	20	1.6	10
	85%	76	2.7	10	20	1.6	8

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
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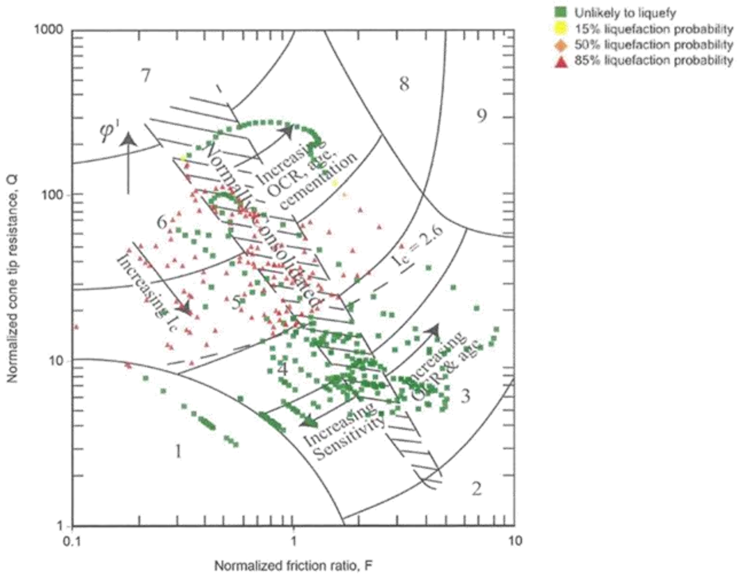

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
			ANALYSED	joma
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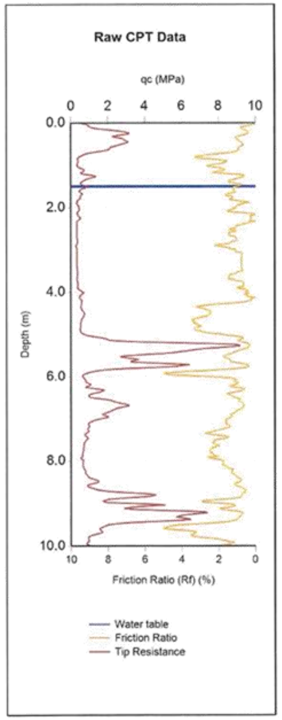

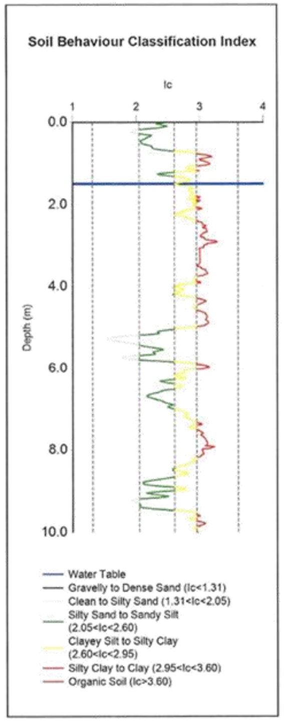

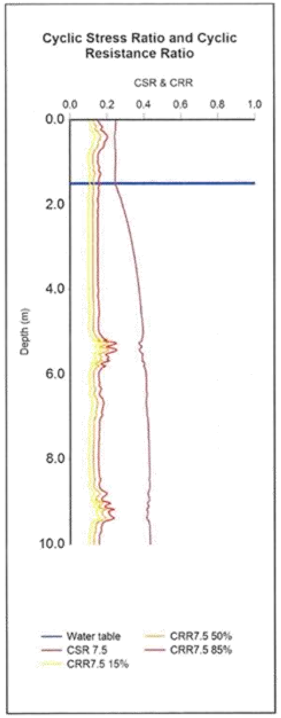

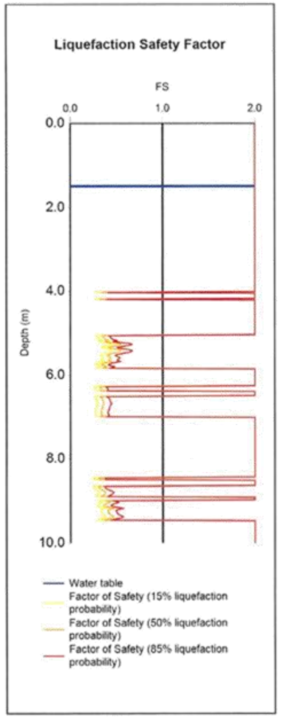

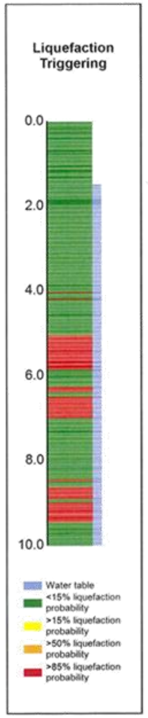

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT08	112115	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	58	2.3	10	9	5.1	6
	50%	58	2.3	9	9	5.1	5
	85%	58	2.3	8	9	5.1	5

Tonkin + Taylor
Exceptional thinking together
V1.3

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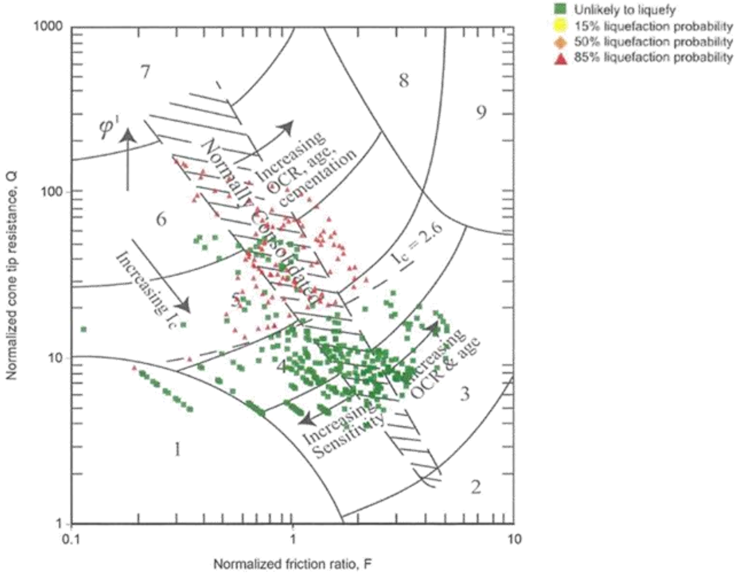

1. Sensitive, fine grained	6. Sands - clean sand to silty sand
2. Organic soils - peats	7. Gravelly sand to dense sand
3. Clays - silty clay to clay	8. Very stiff sand to clayey sand *
4. Silt mixtures - clayey silt to silty clay	9. Very stiff, fine grained *
5. Sand mixtures - silty sand to sandy silt	

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE 13/06/2018 ANALYSED joma CHECKED
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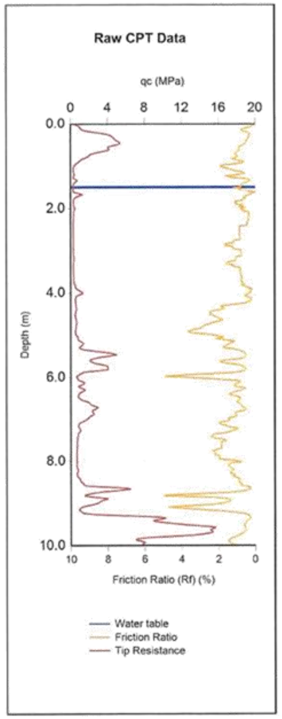
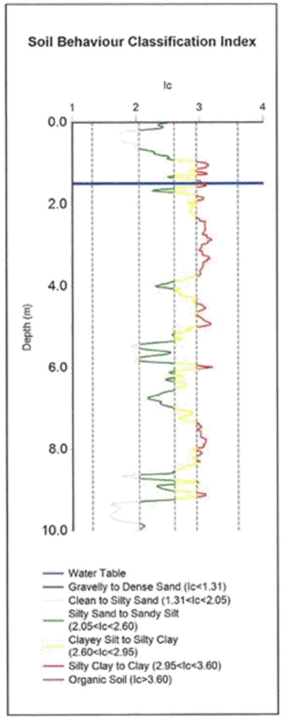
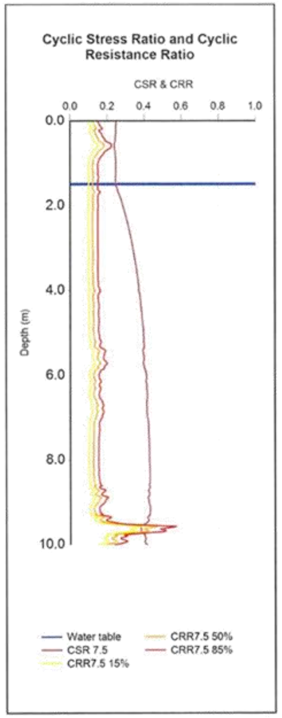
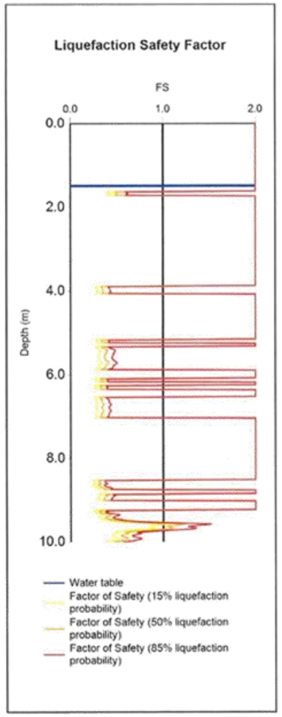
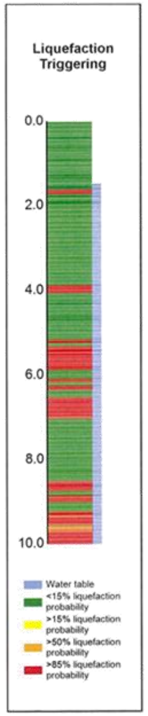

Raw CPT Data


Soil Behaviour Classification Index


Cyclic Stress Ratio and Cyclic Resistance Ratio


Liquefaction Safety Factor


Liquefaction Triggering

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
INPUT	CPT09	112116	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

	PL	Sv1d (mm)	CTL (m)	LPI	LSN	CT (m)	LPIish
OUTPUT	15%	71	2.7	12	12	1.7	7
	50%	70	2.6	10	12	1.7	7
	85%	69	2.6	9	12	1.7	6

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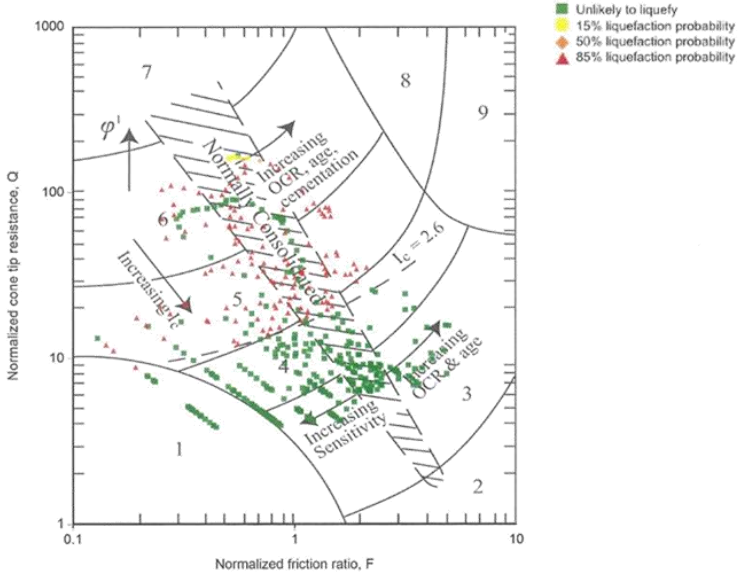

1. Sensitive, fine grained
2. Organic soils - peats
3. Clays - silty clay to clay
4. Silt mixtures - clayey silt to silty clay
5. Sand mixtures - silty sand to sandy silt
6. Sands - clean sand to silty sand
7. Gravelly sand to dense sand
8. Very stiff sand to clayey sand *
9. Very stiff, fine grained *

*Heavily overconsolidated or cemented

CPT-based soil behavior type classification chart by Robertson (1990)

Tonkin + Taylor Exceptional thinking together V1.3	CLIENT, PROJECT **Napier City Council** **Napier Aquatic Centre**	LOCATION Napier	DATE	13/06/2018
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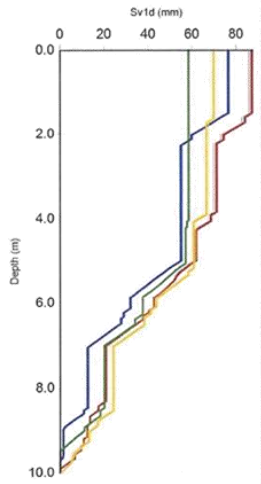
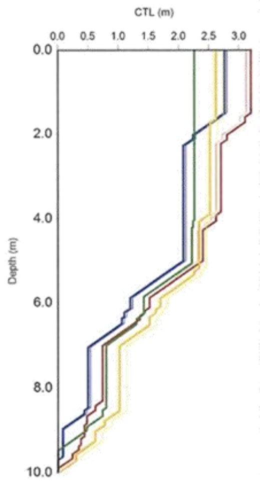
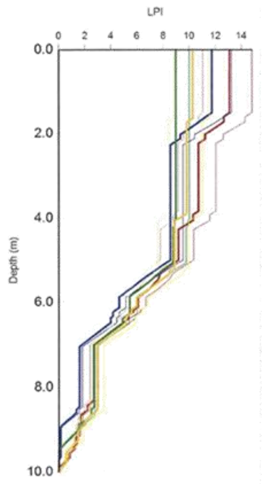
Sv1d v Depth



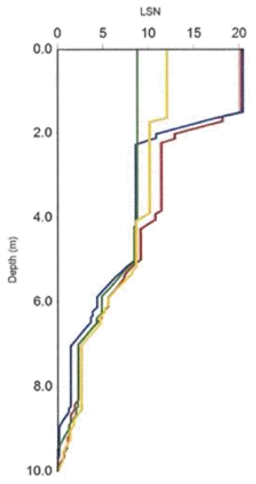
CTL v Depth



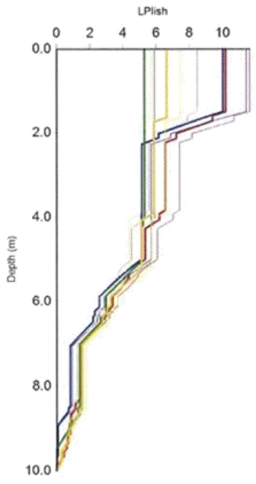
Cumulative LPI v Depth



Cumulative LSN vs Depth



Cumulative LPIish vs Depth



										(Assumed pre-drill values)			
	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT06	112113	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT07	112114	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT08	112115	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT09	112116	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the left and right of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

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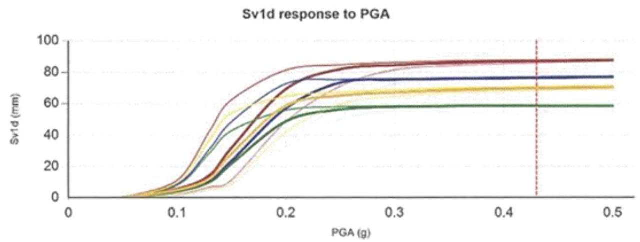

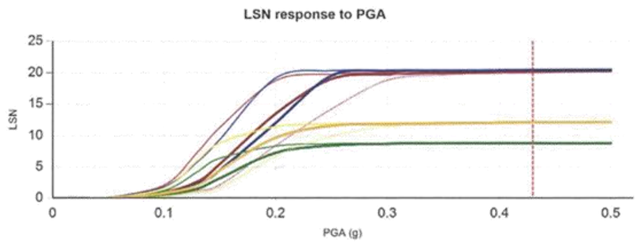

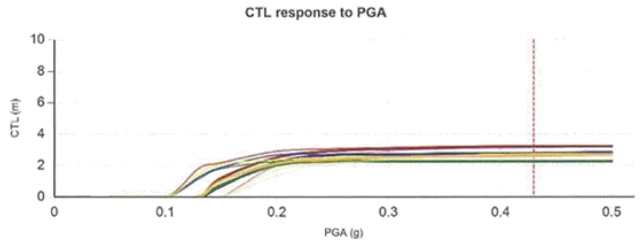

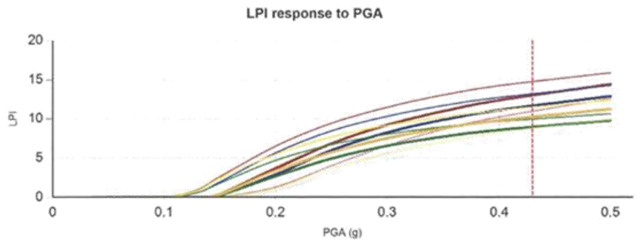

Vertical dotted line/s indicate user specified PGA at the CPT locations. (actual PGA)

(Assumed pre-drill values)

	CPT Name	TTGD ID	Investigation Date	Event and Model (PGA & GWD)	Magnitude	PGA (g)	GWD (m)	Trigger Method	Settlement Method	Pre-drill Depth (m)	qc (MPa)	Fs (MPa)	γ (kN/m³)
🟥	CPT06	112113	23/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟦	CPT07	112114	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟩	CPT08	112115	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18
🟨	CPT09	112116	24/05/2018	User Specified	6.9	0.43	1.5	BI-2014	ZRB-2002	0	2	0.01	18

Thicker lines represent the 50% probability of exceedence case and the thinner lines to the bottom and top of the thicker lines represent the 85% and 15% probability of exceedance cases respectively.

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The inputs listed in Table 1.1-1 below have been adopted for the liquefaction analysis.

Table 1.1-1 Summary of inputs for liquefaction analysis

TTGD ID	112113	112114	112115	112116
CPT Name	CPT06	CPT07	CPT08	CPT09
PGA	0.43g	0.43g	0.43g	0.43g
Magnitude	6.9	6.9	6.9	6.9
Depth to groundwater	1.5m	1.5m	1.5m	1.5m
Predrill depth	0m	0m	0m	0m
Assumed predrill tip resistance and skin friction	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa	qc= 2MPa & Fs= 0.01MPa
Trigger method	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)	Boulanger & Idriss (2014)
Settlement method	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)	Zhang, Robertson & Brachman (2002)
CFC	0	0	0	0
Total depth of CPT	22.64m	13.6m	10.9m	21.26m
Maximum depth of analysis	10m	10m	10m	10m
RL	n/a	n/a	n/a	n/a

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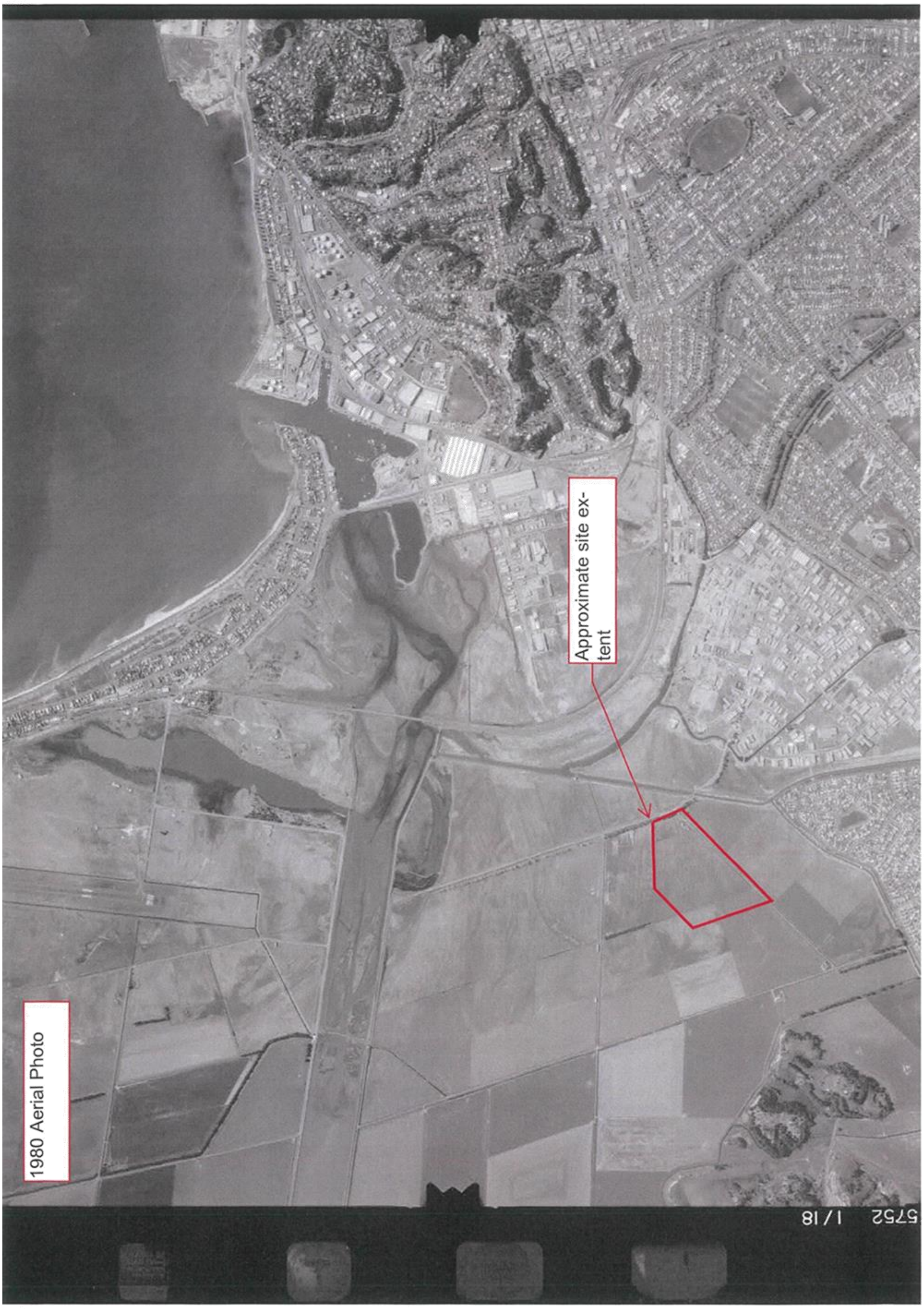
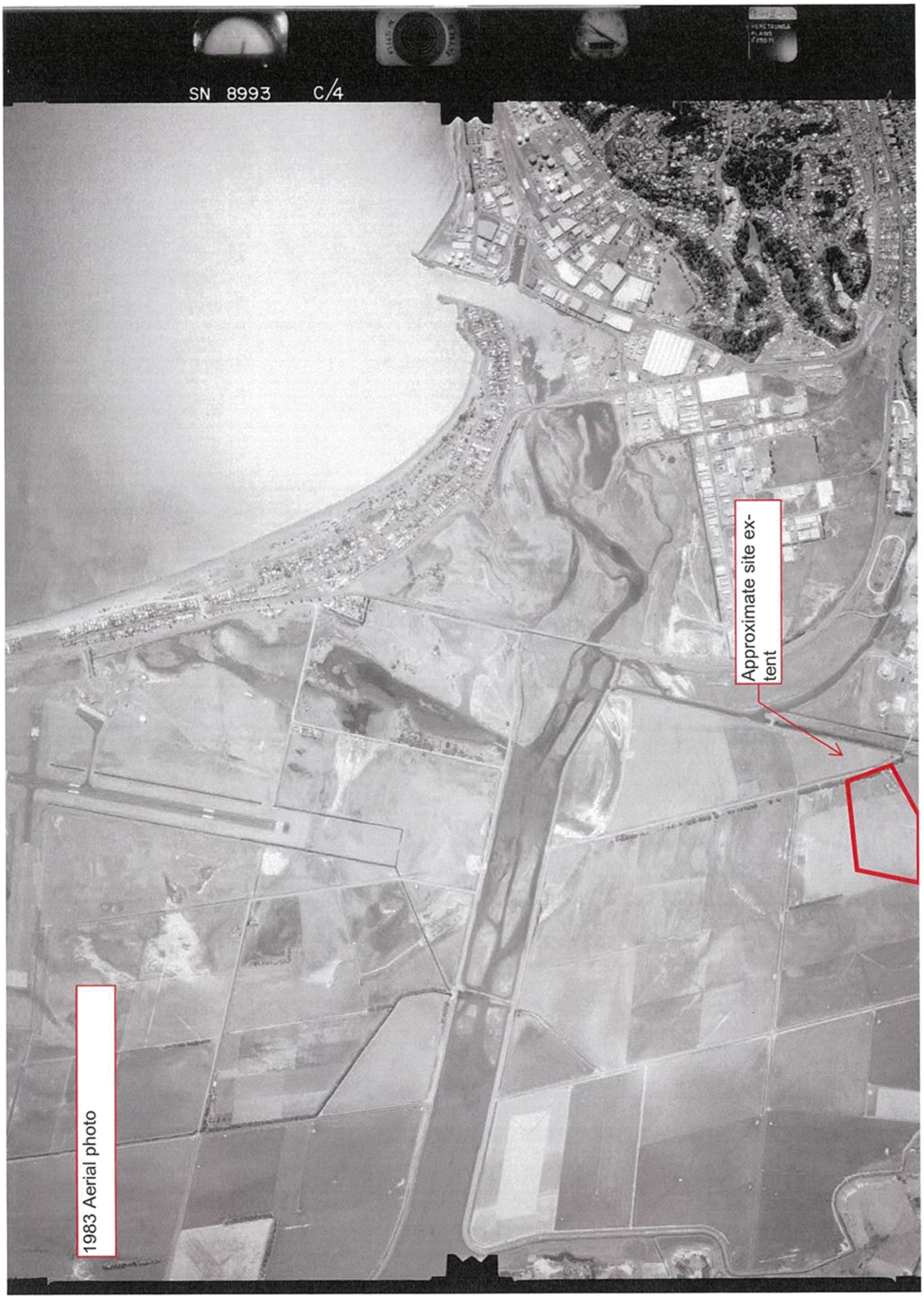
Appendix E : Historical Aerial Photographs


3611
A/2
1972 Aerial photo
Approximate site extent


Approximate site extent
1980 Aerial Photo
5752 1/18



Approximate site extent

1983 Aerial photo


Approximate site extent
1996 Aerial Photo
17/12/96
SN 9585 B/9

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Ashburton EA Networks Centre: Case Study

The EA Networks Centre in Ashburton is an 8,000m2 multi-discipline sports facility combining indoor courts, an aquatic centre and a gym. The facility was completed in 2015 at a cost of $30 million.

The current gym is 521m2 including small group fitness studio and spin room. Before construction the new (at the time) Sports Facilities Manager at Ashburton District Council expressed reservations around the size of the gym, but the construction budget at the time could not cater for any increases in footprint.

Upon opening, the gym had a goal of attracting 500-600 members in a town of 34,000 population. Membership reached 1,100 within the first year, meaning that the relatively small facility was at capacity almost straight away. This was within a town that was previously well catered for in terms of the number of commercial gyms.

Of the complaints that were received, by far the most common was the lack of space. This particularly affected group fitness classes that due to space constraints need to be capped to ensure safety and quality of experience, but meaning that many that wanted to participate were not able to be catered for.

A review of the fitness centre after three years of operation was completed, that revealed a net financial contribution of $125,000 per annum. It also revealed significant synergy between the dry and wet components of the centre, with a large percent of membership paying a premium fee to be able to use both the aquatic and dry fitness facilities.

To respond to the needs of the community and increase capacity and therefore revenue potential, a plan has been developed to increase the dry-side space by an additional 200m2 (bringing total area to 721m2) at a cost of approximately $500,000. This estimate is calculated on the cost of $2,500 per m2 . Due to additional plans to add to the number of indoor courts, the gym extension will be included in the same construction contract, with the work to be commenced in three years' time. The reason for this would be to get a cost saving due to it being part of a larger project