APPENDIX 6

GEOTECHNICAL ASSESSMENT

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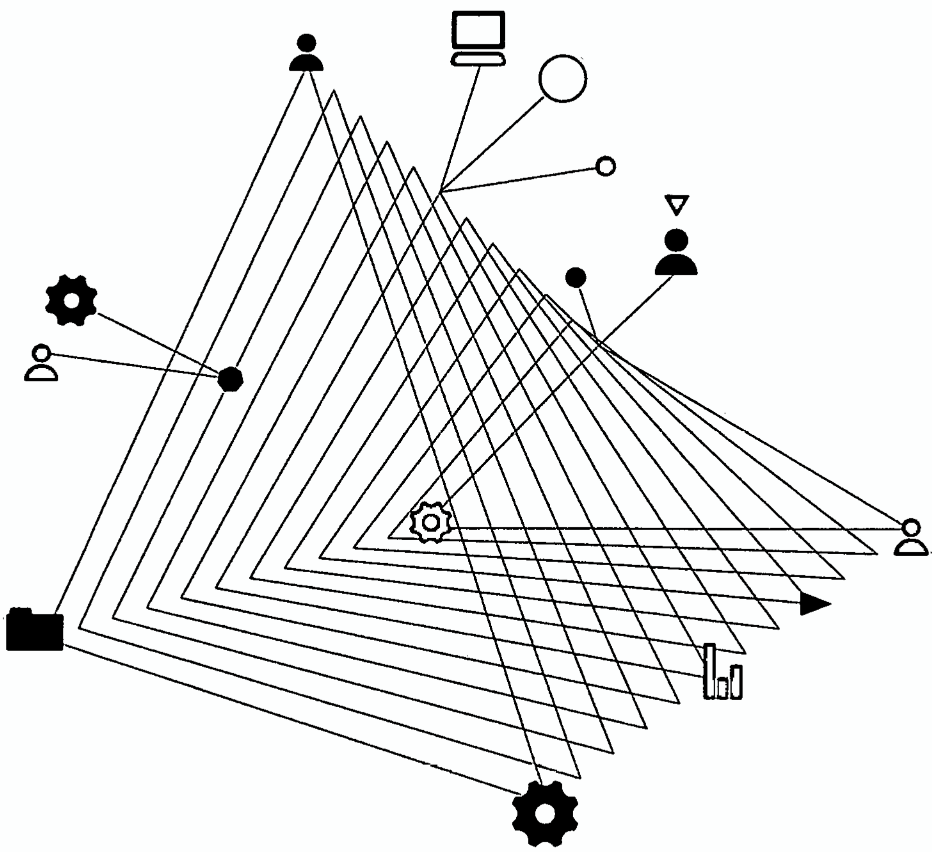
KSS Properties Ltd

57-59 Kingsford Smith Street

Preliminary Geotechnical Assessment



Experience
comes to life
when it is
powered by
expertise

13062017

57-59 Kingsford Smith Street

Prepared for
KSS Properties Ltd
8 Reese Jones Grove
Maungaraki, Lower Hutt

Prepared by
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16 May 2017

Document authorisation

Our ref: 773-WLGGE203610AA

For and on behalf of Coffey

NCSchumacher.

Nathan Schumacher
Senior Geotechnical Engineer

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
AA	Final	16 May 2017	A Hutchinson	KW Ho	N Schumacher

Distribution

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1. Introduction

KSS Properties Ltd commissioned Coffey Services (NZ) Ltd (Coffey) to undertake a geotechnical assessment of 57-59 Kingsford Smith Street, Lyall Bay. The proposed development consists of a five level mixed commercial and residential development with a basement car park.

Coffey has been provided with the concept architectural drawings by Reve Architecture Ltd dated May 2017.

This report presents the findings of a preliminary ground investigation and can be used as one of the supporting documents for resource consent submission.

For the detailed design stage and building consent, further ground investigations will be required, the scope of which can be advised once the concept layout and design is completed.

1.1. Scope of Work

Coffey's scope of work included the following:

1. Development of a preliminary ground model across the site.
2. Depth to groundwater and its effects on design and construction, particularly the basement.
3. Comments on seismic soil classification to NZS1170.5:2004.
4. Preliminary ultimate bearing capacities of the existing ground, and for shallow foundation design, such as ground beams.
5. Preliminary geotechnical design parameters for piles.
6. Preliminary liquefaction analysis and potential for liquefaction induced settlements.
7. Comments on geotechnical issues related to the construction of the basement.

2. Site Setting

The site is relatively flat and lies at an elevation of between RL4.73 – 5.22m according to the topographical survey by Adamson Shaw (2 May 2017). Lyall Parade runs south of the site with the beach sloping at around 5° to the sea beyond. The site is currently occupied by commercial and industrial premises.

A site location plan is provided in Appendix A Figure 1.

2.1. Published Geology

The geology is mapped as Holocene marginal marine sediments including sand according to GNS QMAP digital mapping. Photography from the early 1900s, prior to development, shows much of the Lyall Bay to Evans Bay isthmus to be covered by dune sands.

The Evans Bay Fault intersects Tirangi Road around 50m west of the site; however the nature of the fault is not well understood. According to the GNS active faults database the reoccurrence interval and single event displacement are not known.

2.2. Published Natural Hazards

According to Greater Wellington Regional Council hazard maps the hazard risks are:

1. Liquefaction potential – Low.
2. Slope failure hazard – Low.
3. Tsunami Zone - Class 2, orange, CDEM Evacuation Zone, up to 5.0m distant or regional source tsunami, up to 5.0m wave height.
4. Combined hazard – High.

2.3. Existing Geotechnical Information

A search of Wellington City Council (WCC) archives files found the following existing geotechnical information from neighbouring properties:

1. 7 McGregor Street – one hand auger to 3.3m and one Dynamic Cone Penetrometer (DCP) to 2.9m for design of a monopole tower at rear of property. Report by Beca (2005).
2. 70 Kingsford Smith Street – two DCPs to 3.3m and 3.4m at the front of the property for an extension to the building. Report by Spencer Holmes (2003).

The hand auger found granular hardfill to 0.3m followed by fine brown dune sand below with trace gravels from 2.8m. The DCPs indicate the sand is medium dense to 2.6-3.0m depth with DCP blows/100mm between 3 and10 with an average 5. Below 2.6-3.0m depth the material is dense with DCP blows/100mm between 8 and 20 with an average 12.

The New Zealand Geotechnical Database contains the records of a CPT penetrated to 9.9m depth approximately 120m southeast of the site. The geology is inferred to be predominantly sand and silty sand. The marine deposits are medium dense to 4.5m depth and dense below. Further discussion on the results of the CPT are provided in Section 5.5.2.

The locations of the existing investigations are shown in Figure 1 in Appendix A.

3. Site Investigation

The site investigation was undertaken between 28 April 2017 and 1 May 2017 and comprised of one machine drilled borehole to 20m depth. Standard Penetrometer Tests (SPT) were carried out at 1.0m intervals in the top 15m then at 1.5m intervals to 20m. A piezometer was installed to 10m depth within the borehole.

The material from the borehole was logged on-site by a Coffey Engineering Geologist in accordance with the Coffey Geotechnical Field Manual (March 2013).

The borehole log and piezometer installation specification are provided in Appendix B.

4. Ground Conditions

4.1. Summary of Ground Conditions

Results of the investigation and desktop study show that the site is underlain by sandy marine deposits which become relatively competent below 3.5m. The marine deposits are underlain by medium dense to very dense alluvial gravels below 15.0m depth.

Table 1 below provides a summary of the ground profile.

Table 1: Summary of materials encountered on site.

Unit	Top depth (mbgl)	Bottom depth (mbgl)	Geological Unit	Soil Description	Density	SPT Field N Range (Ave)	SPT N_{60} Ave
A	0.00	0.55	Fill	**SAND & GRAVEL,** brown-orange; angular	-	-	
B	0.55	3.50	Marine Deposits A	**SAND,** grey-brown; trace fine medium, angular to sub-angular gravel	loose	5 – 6 (5.5)	6
C	3.50	15.0	Marine Deposits B	**Sand,** grey-brown; some shell fragments	medium dense	17 – 39 (26)	36
D	15.0	20.0	Alluvial	**Sandy GRAVEL,** grey; rounded to sub-rounded	medium dense – very dense	13 – 50+ (30)	42

Note: mbgl - metres below ground level.

4.2. Groundwater

Groundwater measurements are summarised in Table 2 below. Groundwater is likely to be tidal influenced at the site and requires further monitoring to assess the variation in level.

Table 2: Groundwater Level Measurements

Date and Time	Tide level	GWT (mbgl)	RL (m)	Comments
1/05/2017	1hr before high tide	4.38	0.62	During drilling at hole depth 11.0m. Taken Monday morning after Friday's drilling
11/05/2017	1.5hrs before high tide of 1.5m	4.14	0.86	11 days after drilling completion

Note: GWT Ground Water Table

5. Geotechnical Assessment

5.1. Site Subsoil Class

Information on the depth to rock below the site could not be found as it appears that no deep boreholes have been drilled here. It is likely that given the sites location near the centre of the Lyall Bay isthmus that rock could be at over 40-60m depth. The site has therefore been conservatively assessed as being Site Subsoil Class D according to the definitions in NZ1170.5:2004. This site class should be adopted for the building's design although further investigations may be able to confirm whether the site is Class C.

5.2. Liquefaction Assessment

5.2.1. Seismic Loads

Peak Ground Accelerations (PGA) for use in the liquefaction assessment have been assessed as 0.35 and 0.09 under ULS and SLS design levels respectively.

The PGAs have been calculated according to the *NZTA Bridge Manual 2013 Third Edition* (May 2016) as recommended by NZGS, MBIE/NZGS *Geotechnical Guidance Module 1* (March 2016) and use of the following assumptions:

1. $C_{0,1000}$: 0.45 (Table 6A.1 Bridge Manual).
2. Importance Level (IL): 2 (AS/NZS1170.0).
3. Annual probability of exceedance: ULS 1/500, SLS 1/25 (Table 3.3 of NZS 1170.5).
4. Return Period Factor, R_u ULS = 1.0, R_u SLS = 0.25 (Table 3.5 of NZS 1170.5).
5. Effective earthquake magnitude, M_{eff}: ULS 7.1, SLS 6.2.
6. Site Subsoil Class Factor, f: 1.0 (for Site Subsoil Class D – Deep Soil Site).

$$\text{PGA} = C_{0,1000} \times \frac{Ru}{1.3} \times f$$

5.2.2. SPT Based Liquefaction Assessment Results

An SPT based liquefaction assessment has been completed using the results of the site investigation from BH1 completed during the site investigation works, has been carried out according to the method of Idriss and Boulanger (2014) and assuming a ground water level of 4.0mbgl.

Liquefaction is not predicted to occur under ULS or SLS seismic loading; however, strain softening is predicted at certain depths which is likely to cause minor amounts of settlement and lateral stretch toward the sea. The results of the assessment are presented in Table 3 below and graphical outputs are provided in Appendix C.

Table 3: Liquefaction Assessment Results

Depth (m)	Lateral Stretch (mm)	Free Field Settlement (mm)
06.50 – 07.50	10	20
12.50 – 13.50	<1	5
17.00 – 18.00	180	20
20.00 – 20.45	150	15
Cumulative	**341**	**60**

Note material at the base of the hole, where an anomalously low SPT was recorded (N=13), is not expected to be associated with any liquefaction given the lack of evidence in the literature for liquefaction occurring below 20.0m depth.

A liquefaction check was also carried out on the existing CPT located 120m southeast of the site assuming a water level of 4.0m consistent with water level at the site. The assessment was undertaken in CLiq software (Geologismiki, v. 1.7.6.49) using the Idriss and Boulanger (2014) method. The results are provided in Appendix D.

Under ULS seismic loading ground is predicted to liquefy between 4.0-4.5m and also at around 5.0 and 9.0m although layers here may be too thin to liquefy at only 0.03 and 0.07m thick, respectively. Liquefaction induced free field settlement is predicted to be in the order of 15mm and lateral displacement 360mm. Using the SPT based site investigation data at the site, a similar order of magnitude in values to the above were predicted.

Overall the site appears to have a low liquefaction risk consistent with the GWRC mapping.

5.3. Geotechnical Parameters

The adopted geotechnical design parameters for the soil units presented in Table 4 have been interpreted from the site investigation data and Coffey's experience in working with similar materials.

Table 4: Summary of Soil Geotechnical Parameters

Unit	Bulk Unit Weight, γ_b (kN/m³)	Effective Cohesion, c' (kPa)	Effective Friction Angle, φ' (°)	Young's Modulus vertical, E_v	Young's Modulus horizontal, E_h	Ultimate Bearing Capacity (kPa)
A - Fill	18	-	-	-	-	-
B - Marine A	17	0	30	6	4	300
C - Marine B	19	0	34	35	25	800
D - Alluvial	20	0	36	70	47	1,000

5.4. Foundation Design Parameters

5.4.1. Shallow Foundations

The existing fill which extends to 0.55m below the site is considered an unsuitable bearing strata and should be removed from the site. The natural marine sand below is medium dense and expected to have an ultimate bearing capacity of 300kPa.

We recommend a geotechnical strength reduction factor (Φ_g) value of 0.5 be used in the static design of foundations and a Φ_g of 0.6 be used in the seismic foundation design.

5.4.2. Deep Foundations

Table 5 presents assessed geotechnical strength parameters which can be used in the design of non-displacement end bearing piles (i.e. bored piles). The surficial fill material should be removed from site and so is ignored from offering any skin friction.

Table 5: Assessed Geotechnical Strength Parameters for Deep Foundation Design

Unit	Ultimate Skin Friction, f_s (kPa)	Ultimate Skin Friction in Tension, $f_{s,t}$ (kPa)	Ultimate End Bearing, f_b (kPa)
A - Fill	n/a	n/a	n/a
B - Marine A	16	11	1,000
C - Marine B	66	46	2,500
D - Alluvial	76	53	5,000

For piles, the ultimate geotechnical pile strength, $R_{d,ug}$ is defined as the total resistance developed by the (axially loaded) pile at which static equilibrium is lost or the supporting ground fails. Therefore the ultimate skin friction, f_s and ultimate end bearing, f_b, values should be multiplied by a geotechnical reduction factor, ϕ_{pc}, in the calculation of the design pile strength.

In line with New Zealand Building Code, B1/VM4 a ϕ_{pc} value of 0.5 has been assessed as being appropriate for a bored pile option.

5.5. Summary of Assessment

5.5.1. General

In summary the site lies on beach dune deposits which are loose in the top 3.5m but relatively competent below. Below 15m are medium dense to very dense gravelly alluvial deposits. Although liquefaction is not predicted in these sediments, lateral stretch of the ground around the site toward the ocean is likely with minor amounts of settlement predicted associated with strain softening during cyclic loading.

The foundation design should take into account the loose sand in the top 3.5m and can be optimised to take into account the uplift and compression load demands. Either a raft or piled raft is likely to be appropriate for the site (refer Section 6).

The excavation for the basement construction requires temporary shoring or otherwise the retaining can be incorporated into the permanent building design. Provision for pumping of water from the basement should be made in the event of flooding from storm surge or tsunami.

5.5.2. Natural Hazards

As per Section 71 of the Building Act and Section 106 of the Resource Management Act, an assessment of the land subjected to natural hazards is to be completed (for Resource Consent), to specifically address the effects of:

1. Erosion (including coastal erosion, bank erosion and sheet erosion).
2. Falling debris (including soil, rock, snow and ice).
3. Subsidence.
4. Inundation (including flooding, overland flow, storm surge, tidal effects and ponding).
5. Slippage.

Adequate provision is to be made to protect the land, building work, or other properties from the natural hazards outlined above.

The site lies over 3.0m above the Mean High Water Springs-10 (MHWS10) (refer Figure 2 Appendix A.) This is the mean high water spring tide exceeded 10 percent of the time. The level provides a reference point for infrastructure design works, and also for estimating extreme high (e.g. the 100-

year Average Recurrence Interval) storm tides. Although the site is above the MHWS10 the basement will still be subject to flooding from tsunamis and potentially from extreme storm events. Adequate provision should therefore be made for pumping of water from the basement should it flood.

In our opinion the site is not subject to falling debris, subsidence or slippage provided foundations are designed appropriately. Coastal erosion is not considered to be a risk due to the protection of the proposed building by the adjacent road and seawall. Subsidence will be managed through appropriate foundation design to limit settlements.

6. Foundation Options

Foundation options for the development include:

1. Raft – a reinforced concrete raft is able to spread building loads over a large area and even out differential settlement by holding the building together as one.
2. Deep Piles – Should building overturning/ uplift loads be large then deep piles may provide the uplift resistance.
3. Combination of raft-pile – the combination shares the building load demands where shorter piles are needed with the raft assisting in the uplift resistance. This is often a cost effective way of constructing building foundations on soft/ loose ground subject to differential settlements and lateral movement such as sites like this.

6.1. Basement Discussion

A single level basement is proposed for the development although the depth has not been decided at this stage. For a typical basement, a depth of approximately 3.0m can be assumed which would found the basement above the groundwater table based on water levels recorded during drilling.

The excavation for the basement will be through loose dune sand therefore the walls of the excavation will require shoring. The shoring can either be temporary for example, use of sheet piles or permanent by incorporating the retaining into the structure such as secant pile wall or precast concrete wall. The design requires appropriate assessment of local and global cut stability during the detailed design stage.

It is recommended that the groundwater is monitored for the detailed design of the building to assess seasonal fluctuations in groundwater level and the tidal variability.

7. Further Investigation Requirements

It is recommended that further site investigations including drilling of additional boreholes are undertaken for the detailed design of the buildings. The investigation will allow cross sections of the ground profile to be developed and increase confidence in the ground model whilst reducing any conservatism. The scope of the further investigation can be confirmed once the preliminary design is complete.

8. Conclusions

The following conclusions are made:

1. The site is underlain by sandy marine deposits which are loose in the top 3.5m although an ultimate bearing capacity of 300kPa is thought to be achievable in this material. The sandy marine deposits are medium dense from 3.5m to 15.0m and below 15.0m a medium dense to very dense alluvial sandy GRAVEL material is present.
2. The site is likely to be Site Class D. Rock depth could not be confirmed during the investigation.
3. Liquefaction is not expected to occur under either ULS or SLS seismic loading; however lateral stretch to the sea and minor amounts of settlement may occur.
4. Soil parameters for shallow and deep foundation design are provided in Table 2 and Table 3.
5. The walls of the excavation for the basement will require temporary shoring or otherwise retained using a permanent retaining system (secant pile wall, precast concrete wall) incorporated into the building design.
6. From a geotechnical engineering perspective there are no issues which would prohibit the development from taking place.
7. Possible foundation options are discussed in Section 6.

The following recommendations are made:

1. Further investigation of the site will be required to confirm the preliminary ground model provided in this report.
2. The depth to groundwater and any seasonal and tidal influence requires confirmation for detailed design of the basement. Further groundwater level monitoring is therefore recommended although at this stage it appears unlikely that groundwater will be at the level of the basement if we consider a typical basement depth to be 3.0m and groundwater level appears to be at around 4.0-4.5m depth.

9. Limitations

This report has been prepared solely for the use of our client, KSS Properties Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specific project described herein. No liability is accepted in respect of its use for any other purpose or by any other person or entity. All future owners of this property should seek professional geotechnical advice to satisfy themselves as to the on-going suitability for their intended use.

Please also refer to the enclosed *Important Information about Your Coffey Report*. If you have queries or you require any clarification on aspects of this report, please contact the author of this report.

Prepared by

Andrew Hutchinson
Project Engineering Geologist

Reviewed/ Authorised By:

Kah-Weng Ho
Senior Principal Geotechnical Engineer

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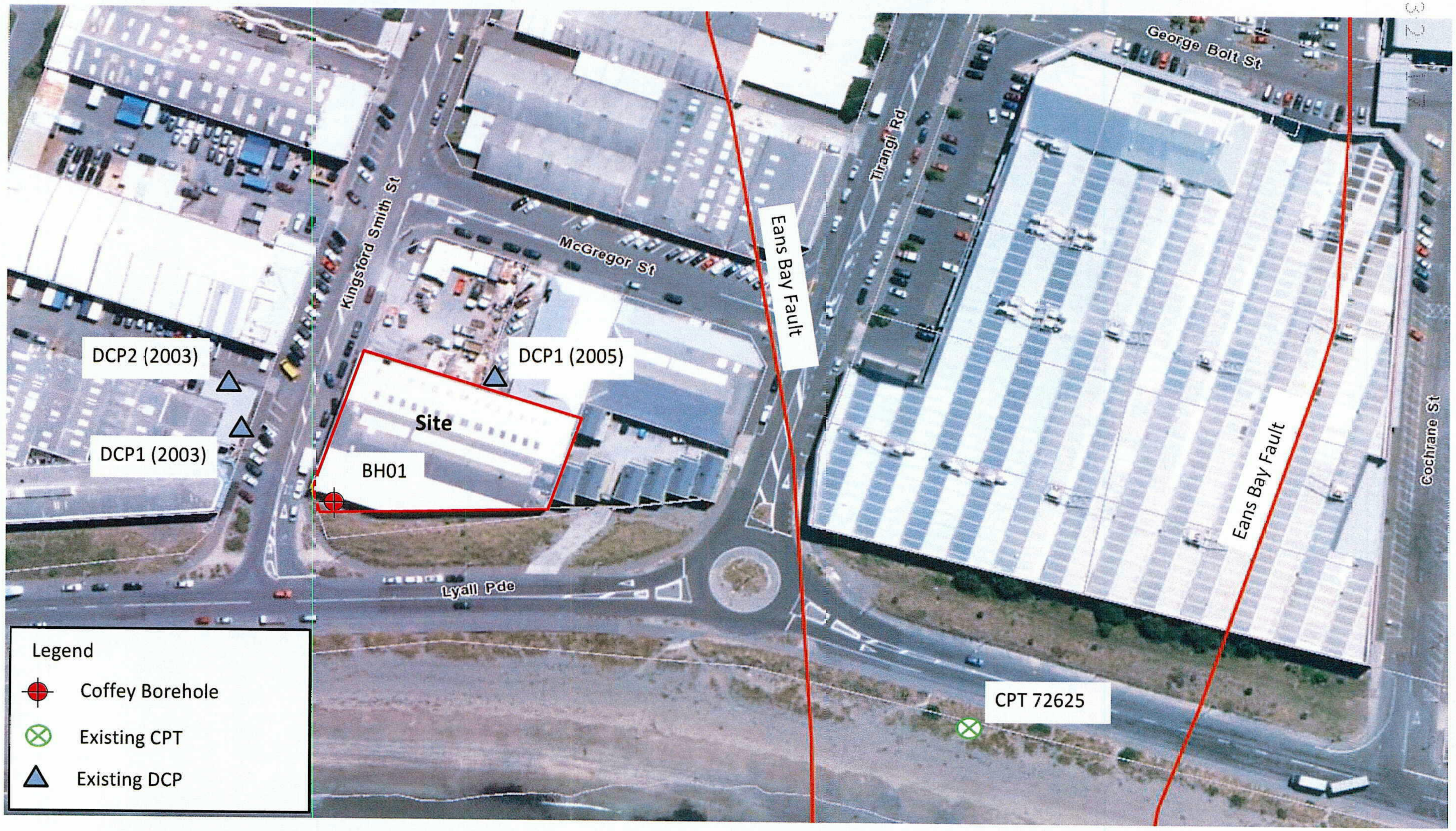
Appendix A - Figures



coffey A TETRA TECH COMPANY	CLIENT: KSS Properties Ltd	PROJECT:	773-WLGGE203610	DESIGNED:	AH	FIGURE TITLE:	Investigation Location Plan
		DATE:	12-05-2017	DRAWN:	AH	FIGURE NO:	A-1
	PROJECT TITLE: Kingsford Smith Street Feasibility	REVISION:	A	CHECKED:	KWH	NOTES:	
		SCALE:	n/a	STATUS:	Draft		

GWRC Web Map

May 9, 2017

Coastal Elevation in the Wellington Region - Coastal Elevation

25 cm relative to MHWS10
50 cm
100 cm
125 cm
150 cm
200 cm
250 cm
300 cm relative to MHWS10

1:1,128

0 0.0075 0.015 0.03 mi
0 0.015 0.03 0.06 km

GWRC/LINZ/Terralink International
GWRC, WAGGIS, LINZ, NZAM

GWRC Mapping Services
GWRC

Appendix B - Borehole Log

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are broadly described in accordance with the Unified Soil Classification System (UCS) as shown in the table on Sheet 2. However, there are some departures from this and reference should be made to the New Zealand Geotechnical Society 'Field Description of Soil and Rock' 2005 for clarification.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		60 mm to 200 mm
Gravel	coarse	20 mm to 60 mm
	medium	6 mm to 20 mm
	fine	2 mm to 6 mm
Sand	coarse	600 μm to 2 mm
	medium	200 μm to 600 μm
	fine	60 μm to 200 μm

MOISTURE CONDITION

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH S_u (kPa)	FIELD GUIDE
Very Soft	<12	Easily exudes between fingers when squeezed.
Soft	12 - 25	Easily indented by fingers.
Firm	25 - 50	Indented by strong finger pressure & can be indented by thumb pressure.
Stiff	50 - 100	Cannot be indented by thumb pressure.
Very Stiff	100 - 200	Can be indented by thumb nail.
Hard	200 - 500	Difficult to indent by thumb nail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)	SPT N-value (Blows / 300mm)
Very loose	Less than 15	Less than 4
Loose	15 - 35	4 - 10
Medium Dense	35 - 65	10 - 30
Dense	65 - 85	30 - 50
Very Dense	Greater than 85	Greater than 50

MINOR COMPONENTS

FRACTION	TERM	% OF SOIL MASS	EXAMPLE
Major	(...) [UPPER CASE]	≥ 50 [major constituent]	GRAVEL
Subordinate	(...)y [lower case]	20 - 50	Sandy
Minor	with some... with minor...	12 - 20 5 - 12	with some sand with minor sand
	with trace of (or slightly) ...	< 5	with trace of sand (slightly sandy)

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS	
Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS	
Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

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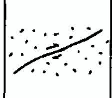
Soil Description Explanation Sheet (2 of 2)

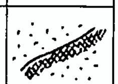
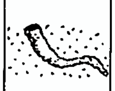
SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 60 mm is larger than 0.06 mm	(A 0.06 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 60 mm is smaller than 0.05 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
				DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
		SILTS & CLAYS Liquid limit less than 50		None to Low	Quick to slow	None	ML	SILT
				Medium to High	None	Medium	CL	CLAY
				Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50		Low to medium	Slow to very slow	Low to medium	MH	SILT
				High	None	High	CH	CLAY
				Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS				Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter.	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Engineering Log - Borehole

client:	*KSS Properties Ltd*	Borehole ID.	**BH01**
principal:		sheet:	1 of 2
project:	*57-59 Kingsford Smith Street*	project no.	*773-WLGGE203610*
location:	*Lyall Bay, Wellington*	date started:	*28 Apr 2017*
		date completed:	*01 May 2018*
		logged by:	*AH*
		checked by:	*MH*

position: Not Specified — surface elevation: 5.00 m (NZVD2009) — angle from horizontal: 90°

drill model: Sonic — drilling fluid: — hole diameter : 123 mm

method & support	samples & field tests	RL (m)	depth (m)	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	structure and additional observations
NDD		5	0.0	SP	**FILL: SAND**: fine to coarse grained, brown-orange.	M		**FILL** Core Run (0.0-1.5 m): 0% recovery
				GP	**FILL: GRAVEL**: medium to coarse grained, angular, orange, some fine to coarse sand and silt.			
		4	1.0	SP	**SAND**: fine to coarse grained, grey.		L	**MARINE DESPOSITS A**
SD	SPT 1, 2, 3 N*=5	3	2.0	SP	**SAND**: fine grained, grey-brown, trace fine to medium, angular to subangular gravel.			Core Run (1.5-2.5 m): 100% recovery
	SPT 1, 3, 3 N*=6	2	3.0					Core Run (2.5-3.5 m): 100% recovery
	SPT 3, 7, 10 N*=17	1	4.0	SP	**SAND**: fine to coarse grained, grey, some fine to medium, sub-rounded to rounded gravel. some shell fragments <2mm.	W	MD	**MARINE DESPOSITS B** Core Run (3.5-4.5 m): 100% recovery
	SPT 6, 11, 13 N*=24 (water: 01/05/17)	0	5.0					Core Run (4.5-5.5 m): 100% recovery
	SPT 4, 8, 11 N*=19	-1	6.0	SP	**SAND**: fine to medium grained, grey-brown, trace fine to medium, rounded gravel. minor shell fragments <10mm.			Core Run (5.5-6.5 m): 100% recovery
	SPT 5, 8, 10 N*=18	-2	7.0					Core Run (6.5-7.5 m): 100% recovery
	SPT 6, 11, 14 N*=25	-3	8.0	SP	**SAND**: fine grained, grey, trace shell fragments.			Core Run (7.5-8.5 m): 100% recovery
	SPT 6, 10, 13 N*=23	-4	9.0					Core Run (8.5-9.5 m): 100% recovery
	SPT 6, 15, 16 N*=31	-5	10.0				D	Core Run (9.5-10.5 m): 100% recovery

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method
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore
NDD non destructive drilling
SD sonic drilling
* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud — N nil
C casing

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Engineering Log - Borehole

Borehole ID.	**BH01**
sheet:	2 of 2
project no.	**773-WLGGE203610**
date started:	**28 Apr 2017**
date completed:	**01 May 2018**
logged by:	**AH**
checked by:	**MH**

client: **KSS Properties Ltd**

principal:

project: **57-59 Kingsford Smith Street**

location: **Lyall Bay, Wellington**

position: Not Specified | surface elevation: 5.00 m (NZVD2009) | angle from horizontal: 90°

drill model: Sonic | drilling fluid: | hole diameter : 123 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	vane shear (kPa)	structure and additional observations
SD			SPT 6, 14, 16 N*=30				SP	**SAND**: fine grained, grey, trace shell fragments. *(continued)*	W	D		Core Run (10.5-11.5 m): 100% recovery
				-6	11.0							
			SPT 8, 17, 16 N*=33									Core Run (11.5-12.5 m): 100% recovery
				-7	12.0							
			SPT 7, 10, 15 N*=25							MD		Core Run (12.5-13.5 m): 100% recovery
				-8	13.0							
			SPT 5, 11, 16 N*=27									Core Run (13.5-14.5 m): 100% recovery
				-9	14.0							
			SPT 10, 18, 21 N*=39							D		Core Run (14.5-15.5 m): 100% recovery
				-10	15.0		GW	**Sandy GRAVEL**: fine to medium grained, rounded to sub-rounded, grey. 15.25 m: grades to fine sand				**ALLUVIUM**
			SPT 13, 24, 26/120mm N*=R					**SILT**: low liquid limit, grey, trace fine sand.	M	St to VSt		HP 150 - 220 kPa; HP values are dial value times 100 for compressive strength
				-11	16.0		GP	**GRAVEL**: medium to coarse grained, rounded to sub-rounded, grey, some fine to coarse sand.	W	VD		Core Run (15.5-17.0 m): 100% recovery
				-12	17.0							
			SPT 2, 7, 10 N*=17							MD		Core Run (17.0-18.5 m): 100% recovery
				-13	18.0		GW	**Sandy GRAVEL**: fine to coarse grained, rounded to sub-rounded, grey.				
			SPT 6, 11, 30 N*=41							D		Core Run (18.5-20.0 m): 100% recovery
				-14	19.0							
				-15	20.0							
			SPT 2, 4, 9 N*=13							MD		
								Borehole BH01 terminated at 20.45 m Target depth				

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method
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore
NDD non destructive drilling
SD sonic drilling

* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud N nil
C casing

penetration
1 2 3
no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
S saturated
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

BH01 1.50 - 4.95 m - Core Box #1

BH01 4.95 - 8.95 m - Core Box #2

drawn	AH	coffey A TETRA TECH COMPANY	client:	KSS Properties Ltd
approved	KWH		project:	57-59 Kingsford Smith Street Lyall Bay, Wellington
date	5/05/2017		title:	CORE PHOTOGRAPH BH01
scale	N.T.S.			
original size	A4		project no. 773-WLGGE203610	fig no: PLATE 1 rev: A

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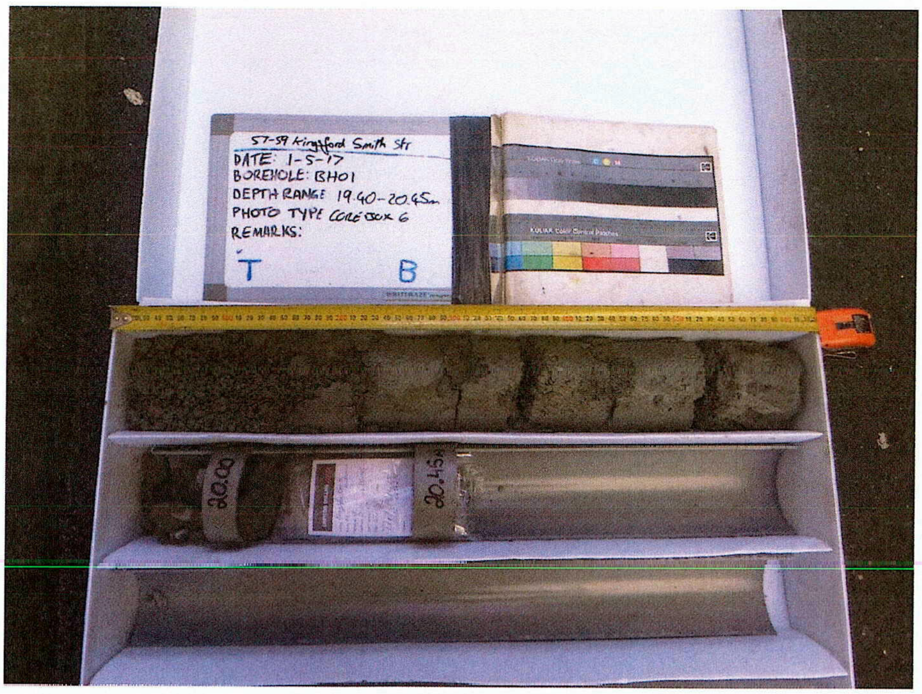
BH01 8.95 - 12.95 m - Core Box #3

BH01 12.95 - 16.40 m - Core Box #4

drawn	AH	coffey A TETRA TECH COMPANY	client:	KSS Properties Ltd
approved	KWH		project:	57-59 Kingsford Smith Street Lyall Bay, Wellington
date	5/05/2017		title:	**CORE PHOTOGRAPH BH01**
scale	N.T.S.		project no: 773-WLGGE203610	fig no: **PLATE 2** rev: A
original size	A4			

CDF_0_9_06_LIBRARY.GLB GrfcTbl COF PHOTO CORE PHOTO 2 PER PAGE 57-59 KINGSFORD SMITH STR LOGS.GPJ <<DrawingFile>> 16/05/2017 12:28

BH01 16.40 - 19.40 m - Core Box #5



BH01 19.40 - 20.45 m - Core Box #6

drawn	AH	coffey A TETRA TECH COMPANY	client:	KSS Properties Ltd
approved	KWH		project:	57-59 Kingsford Smith Street Lyall Bay, Wellington
date	5/05/2017		title:	CORE PHOTOGRAPH BH01
scale	N.T.S.		project no: 773-WLGGE203610	fig no: PLATE 3 rev: A
original size	A4			

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Piezometer Installation Log

Hole ID.	**BH01**
sheet:	1 of 1
project no.	*773-WLGGE203610*

client:	*KSS Properties Ltd*	date started:	*28 Apr 2017*
principal:		date completed:	*01 May 2018*
project:	*57-59 Kingsford Smith Street*	logged by:	*AH*
location:	*Lyall Bay, Wellington*	checked by:	*MH*

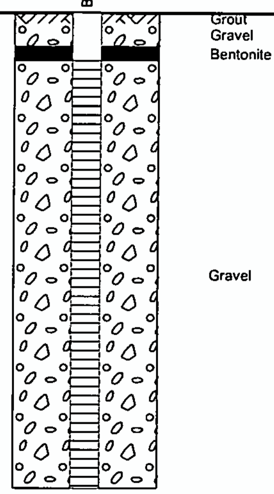
position: Not Specified	surface elevation: 5.00 m (NZVD2009)	angle from horizontal: 90°
equipment type: Sonic	drilling fluid:	hole diameter : 123 mm

drilling information | **material substance** | **piezometer construction details**

bore construction license:
drilling company: Griffiths
driller: Jack
driller's permit no.:

method & support	water	RL (m)	depth (m)	material name
NDD		4	0	FILL
				MARINE DESPOSITS A
			4	MARINE DESPOSITS B
	01/05/17	0		
		-4	8	
SD		-8	12	
				ALLUVIUM
		-12	16	
		-16	20	

1.00 m
1.00 m, 1.00 m NZVD2009



10.00 m

method & support	graphic log / core recovery
see engineering log for details	core recovered (graphic symbols indicate material)
water	no core recovered
10-Oct-12, water level on date shown	
water inflow	
complete drilling fluid loss	
partial drilling fluid loss	
25 water pressure test result (lugeons) for depth interval shown	

ID	type	installation date	stickup (m)	tip depth (m)	water level (m)	Relative Levels (NZVD2009) stickup	tip	water level
BH01	standpipe	01/05/2017	0.00 m	10.00 m		5.00	-5.00	

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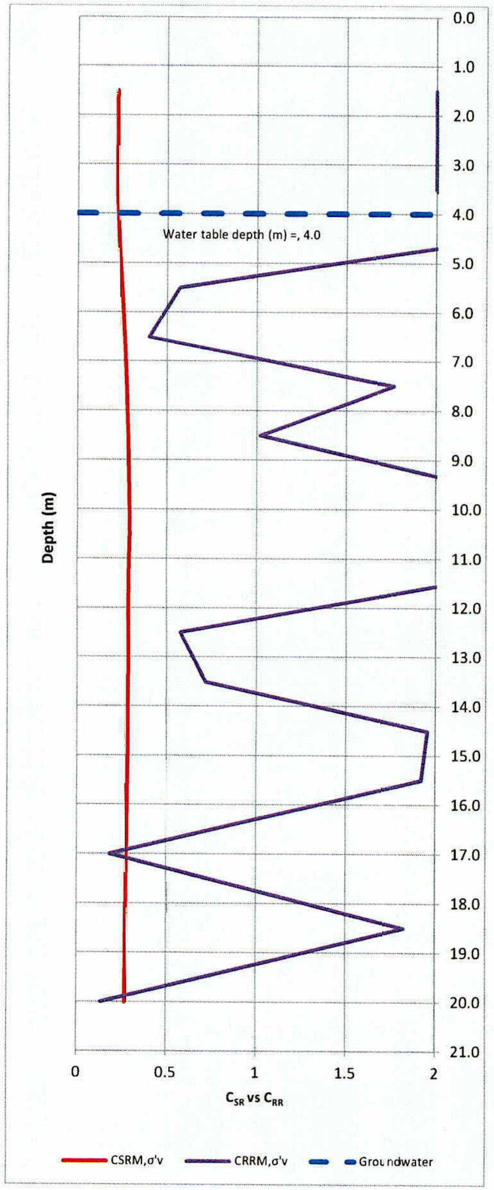
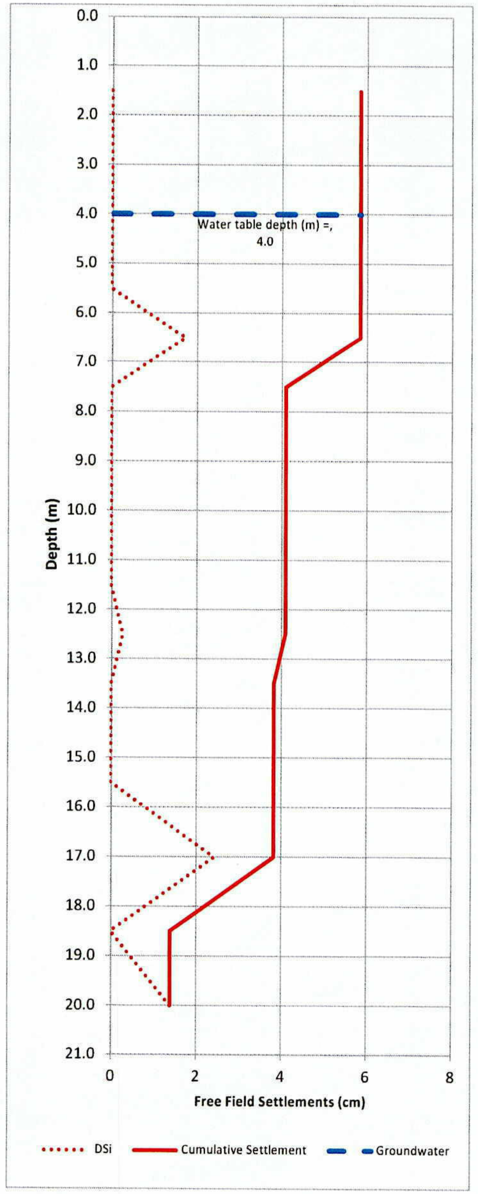
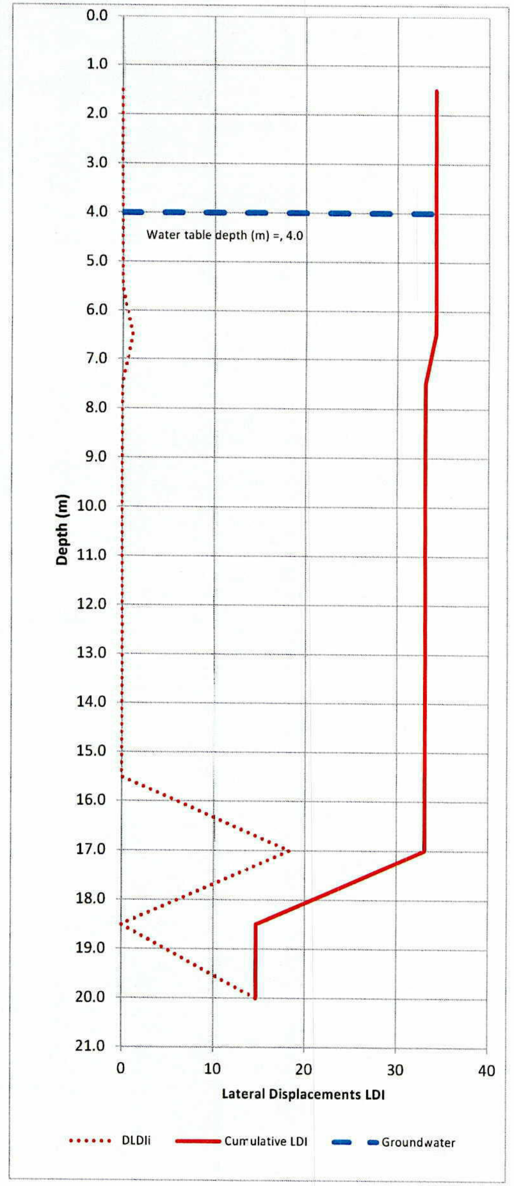
Appendix C - SPT Liquefaction Assessment Results







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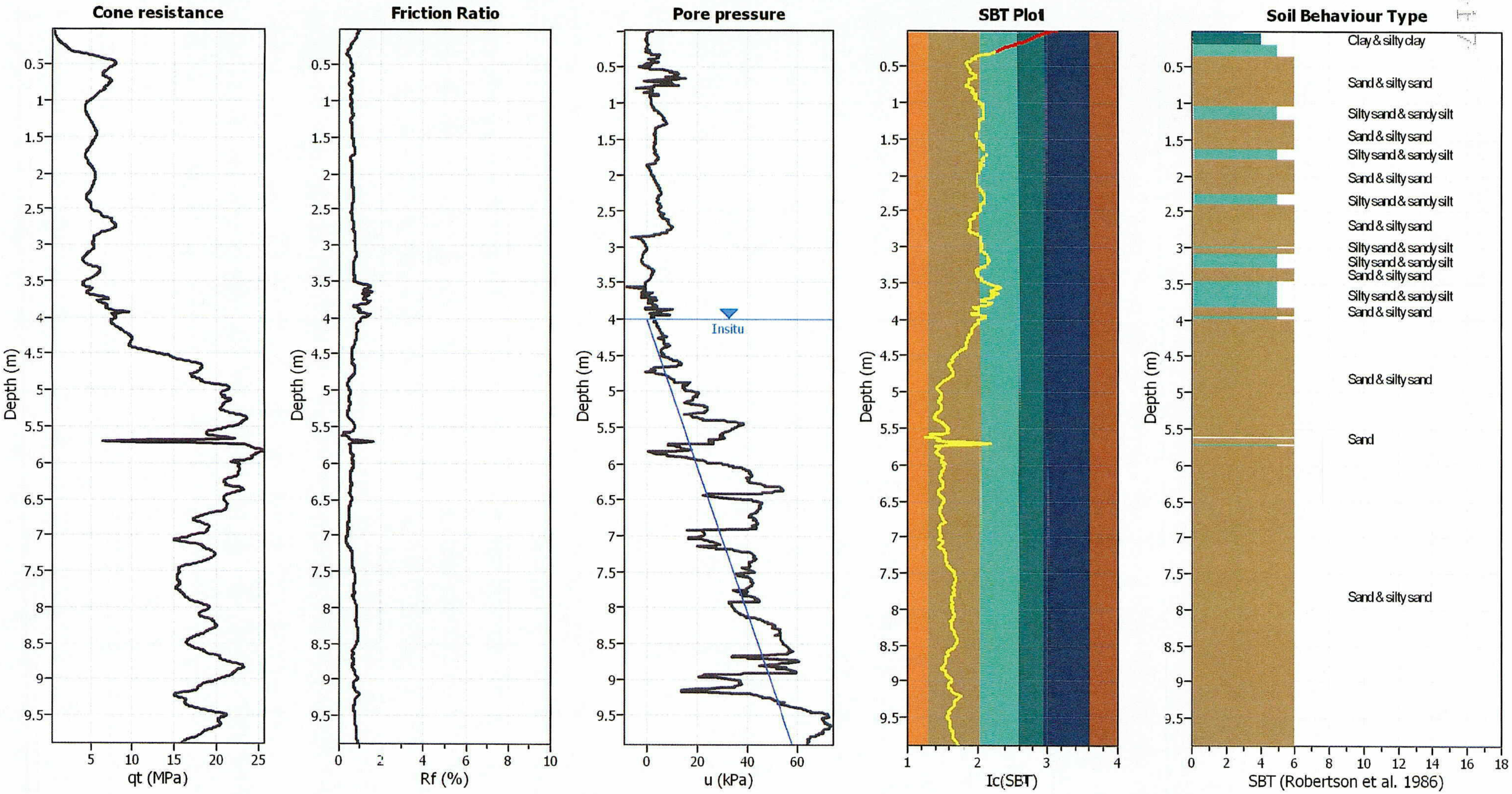
CLIENT: KSS Properties Ltd	PROJECT: 773-WLGGE203610	DESIGNED: AH	FIGURE TITLE: Liquefaction Assessment Results
PROJECT TITLE: 57-59 Kingsford Smith Street	DATE: 12-05-2017	DRAWN: AH	FIGURE NO: A-3
	REVISION: A	CHECKED: KWH	NOTES:
	SCALE: n/a	STATUS: Draft	

Appendix D - Neighbouring CPT Liquefaction Assessment Results

CPT basic interpretation plots



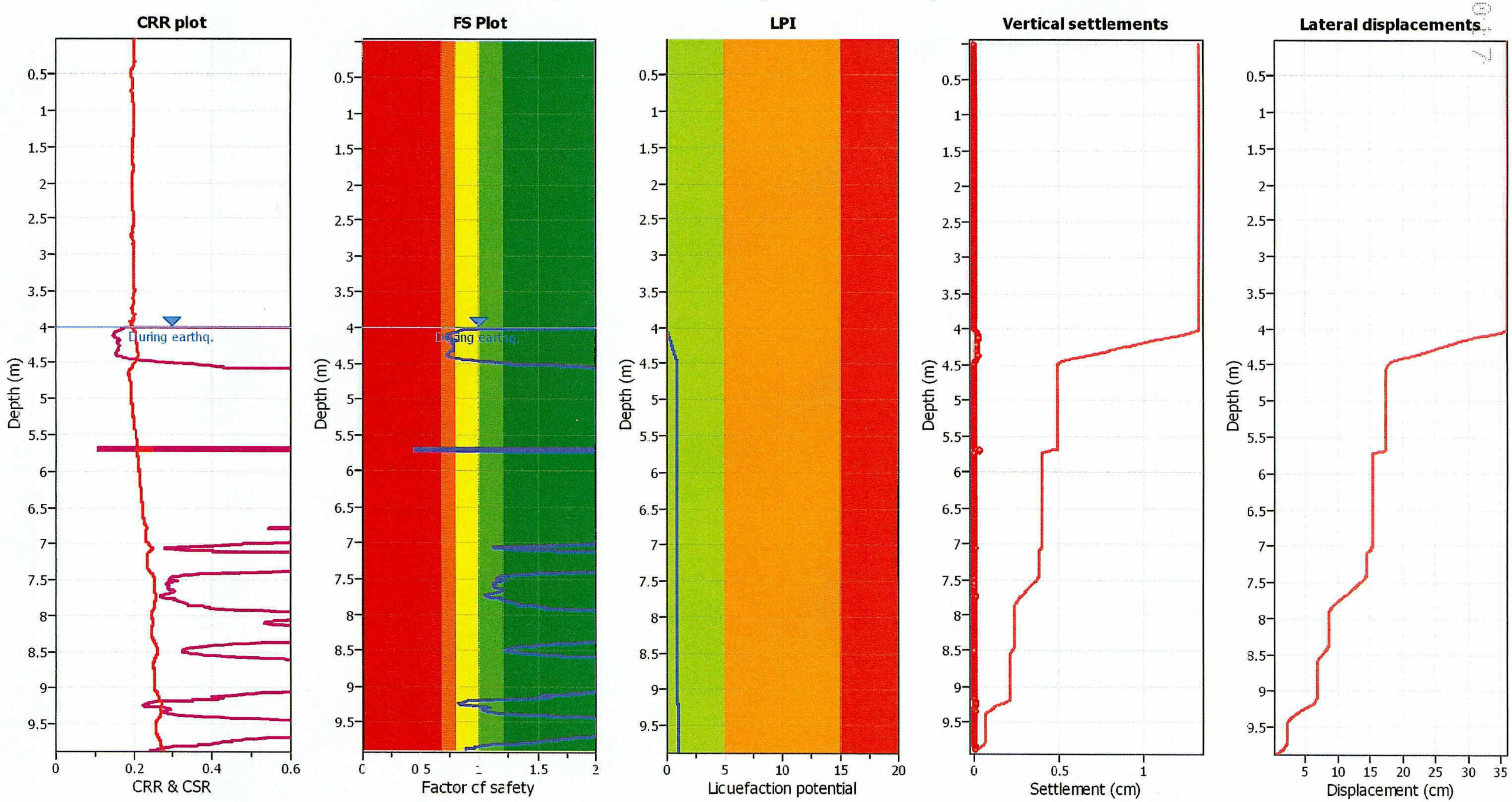
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 m	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	4.00 m	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.10	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sand & Clay
Peak ground acceleration:	0.35	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 m	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk