CHRISTCHURCH CITY COUNCIL
PRK_1507_BLDG_001 EQ2
South Hagley - Pavilion/Shelter (Polo)
Hagley Park, Christchurch Central

QUALITATIVE ASSESSMENT REPORT

FINAL

- Rev C
- 27 February 2013

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Contents

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1. Executive Summary

1.1. Background

A qualitative assessment was carried out on the building located in South Hagley Park near the Hagley Oval, in Christchurch Central. The building is single storey and is assumed to be currently utilised for storage. It is constructed from partially reinforced masonry walls and appears to have a timber-framed ceiling with a lightweight roof. An aerial photograph illustrating this area is shown below in Figure 1. Detailed descriptions outlining the buildings age and construction type is given in Section 5 of this report.

- Figure 1 Aerial Photograph of the Pavilion/Shelter (Polo) in South Hagley Park

The qualitative assessment includes a summary of the building damage as well as an initial assessment of the current seismic capacity compared with current seismic code loads using the Initial Evaluation Procedure (IEP).

This qualitative report for the building structure is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 and a visual inspection on 8 May 2012.

1.2. Key Damage Observed

No external structural damage was observed during our site inspection.

1.3. Critical Structural Weaknesses

No potential critical structural weaknesses have been identified for this building.

1.4. Indicative Building Strength (from IEP and CSW assessment)

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the buildings original capacity has been assessed to be in the order of 17% NBS. The damage observed during the site investigation was not significant, therefore the post earthquake capacity will not change as a result of earthquake damage.

The building has been assessed to have a seismic capacity less than 34% NBS and is therefore potentially earthquake prone.

Please note that structural strengthening is required by law for buildings that are confirmed to have a seismic capacity of less than 34% NBS.

1.5. Recommendations

It is recommended that:

a) A quantitative assessment of the building, supported by intrusive investigations if required, be undertaken to determine the seismic capacity and to develop potential strengthening concepts.
b) We consider that barriers around the building are not necessary.

2. Introduction

Sinclair Knight Merz was engaged by Christchurch City Council to prepare a qualitative assessment report for the building located near the Hagley Oval at South Hagley Park following the magnitude 6.3 earthquake which occurred in the afternoon of the 22nd of February 2011 and the subsequent aftershocks.

The Qualitative Assessment uses the methodology recommended in the Engineering Advisory Group draft document "Guidance on Detailed Engineering Evaluation of Earthquake affected Non-residential Buildings in Canterbury", issued 19 July 2011. The qualitative assessment includes a summary of the building damage as well as an initial assessment of the likely current Seismic Capacity compared with current seismic code requirements.

A qualitative assessment involves inspections of the building and a desktop review of existing structural and geotechnical information, including existing drawings and calculations, if available.

The purpose of the assessment is to determine the likely building performance and damage patterns, to identify any potential critical structural weaknesses or collapse hazards, and to make an initial assessment of the likely building strength in terms of percentage of new building standard (%NBS).

This report describes the structural damage observed during our inspection and indicates suggested remediation measures. The inspection was undertaken from floor levels and was a visual inspection only. Our report reflects the situation at the time of the inspection and does not take account of changes caused by any events following our inspection. A full description of the basis on which we have undertaken our visual inspection is set out in Section 7.

The NZ Society for Earthquake Engineering (NZSEE) Initial Evaluation Procedure (IEP) was used to assess the likely performance of the building in a seismic event relative to the New Building Standard (NBS). 100% NBS is equivalent to the strength of a building that fully complies with current codes. This includes a recent increase of the Christchurch seismic hazard factor from 0.22 to 0.3[1].

At the time of this report, no intrusive site investigation, detailed analysis, or modelling of the building structure had been carried out. The building description below is based on our visual inspections.

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[1] http://www.dbh.govt.nz/seismicity-info

3. Compliance

This section contains a brief summary of the requirements of the various statutes and authorities that control activities in relation to buildings in Christchurch at present.

3.1. Canterbury Earthquake Recovery Authority (CERA)

CERA was established on 28 March 2011 to take control of the recovery of Christchurch using powers established by the Canterbury Earthquake Recovery Act enacted on 18 April 2011. This act gives the Chief Executive Officer of CERA wide powers in relation to building safety, demolition and repair. Two relevant sections are:

Section 38 – Works

This section outlines a process in which the chief executive can give notice that a building is to be demolished and if the owner does not carry out the demolition, the chief executive can commission the demolition and recover the costs from the owner or by placing a charge on the owners' land.

Section 51 – Requiring Structural Survey

This section enables the chief executive to require a building owner, insurer or mortgagee carry out a full structural survey before the building is re-occupied.

We understand that CERA will require a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). It is anticipated that CERA will adopt the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

The qualitative assessment is a desk-top and site inspection assessment. It is based on a thorough visual inspection of the building coupled with a review of available documentation such as drawings and specifications. The quantitative assessment involves analytical calculation of the buildings strength and may require non-destructive or destructive material testing, geotechnical testing and intrusive investigation.

It is anticipated that factors determining the extent of evaluation and strengthening level required will include:

- The importance level and occupancy of the building
- The placard status and amount of damage
- The age and structural type of the building

- Consideration of any critical structural weaknesses
- The extent of any earthquake damage

3.2. Building Act

Several sections of the Building Act are relevant when considering structural requirements:

3.2.1. Section 112 – Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to any alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

3.2.2. Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) be satisfied that the building with a new use complies with the relevant sections of the Building Code ‘as near as is reasonably practicable’. Regarding seismic capacity ‘as near as reasonably practicable’ has previously been interpreted by CCC as achieving a minimum of 67%NBS however where practical achieving 100%NBS is desirable. The New Zealand Society for Earthquake Engineering (NZSEE) recommend a minimum of 67%NBS.

3.2.3. Section 121 – Dangerous Buildings

The definition of dangerous building in the Act was extended by the Canterbury Earthquake (Building Act) Order 2010, and it now defines a building as dangerous if:

- in the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
- in the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
- there is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a ‘moderate earthquake’ (refer to Section 122 below); or
- there is a risk that that other property could collapse or otherwise cause injury or death; or
- a territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

3.2.4. Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone if its ultimate capacity would be exceeded in a ‘moderate earthquake’ and it would be likely to collapse causing injury or death, or damage to other property. A moderate earthquake is defined by the building regulations as one that would generate ground shaking 33% of the shaking used to design an equivalent new building.

3.2.5. Section 124 – Powers of Territorial Authorities

This section gives the territorial authority the power to require strengthening work within specified timeframes or to close and prevent occupancy to any building defined as dangerous or earthquake prone.

3.2.6. Section 131 – Earthquake Prone Building Policy

This section requires the territorial authority to adopt a specific policy for earthquake prone, dangerous and insanitary buildings.

3.3. Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in 2006. This policy was amended immediately following the Darfield Earthquake of the 4th September 2010.

The 2010 amendment includes the following:

- A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- A strengthening target level of 67% of a new building for buildings that are Earthquake Prone. Council recognises that it may not be practicable for some repairs to meet that target. The council will work closely with building owners to achieve sensible, safe outcomes;
- A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- Repair works for buildings damaged by earthquakes will be required to comply with the above.

The council has stated their willingness to consider retrofit proposals on a case by case basis, considering the economic impact of such a retrofit.

We anticipate that any building with a capacity of less than 33%NBS (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67%NBS of new building standard as recommended by the Policy.

If strengthening works are undertaken, a building consent will be required. A requirement of the consent will require upgrade of the building to comply ‘as near as is reasonably practicable’ with:

- The accessibility requirements of the Building Code.

- The fire requirements of the Building Code. This is likely to require a fire report to be submitted with the building consent application.

3.4. Building Code

The building code outlines performance standards for buildings and the Building Act requires that all new buildings comply with this code. Compliance Documents published by The Department of Building and Housing can be used to demonstrate compliance with the Building Code.

After the February Earthquake, on 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

a) Hazard Factor increased from 0.22 to 0.3 (36% increase in the basic seismic design load)
b) Serviceability Return Period Factor increased from 0.25 to 0.33 (80% increase in the serviceability design loads when combined with the Hazard Factor increase)

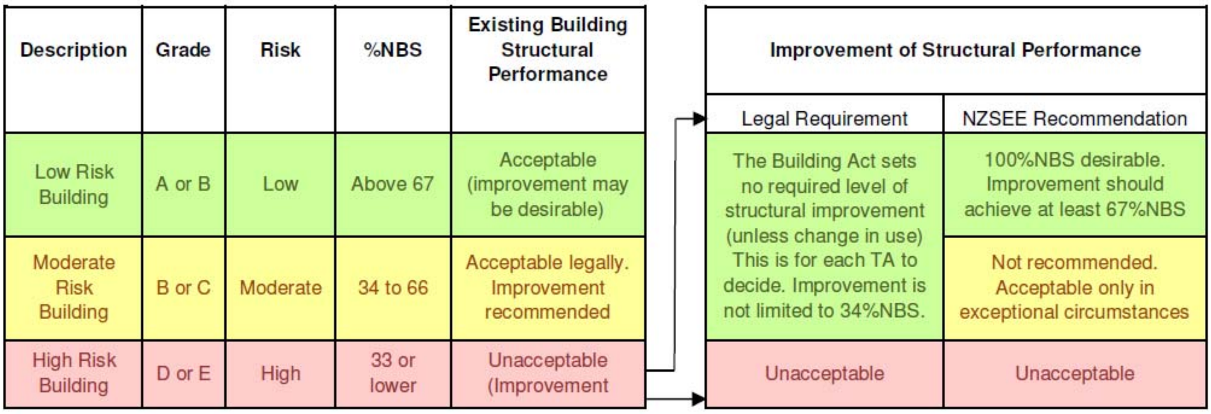
The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

4. Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The new building standard load requirements have been determined in accordance with the current earthquake loading standard (NZS 1170.5:2004 Structural design actions - Earthquake actions - New Zealand).

The likely capacity of this building has been derived in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' (AISPBE), 2006. These guidelines provide an Initial Evaluation Procedure that assesses a buildings capacity based on a comparison of loading codes from when the building was designed and currently. It is a quick high-level procedure that can be used when undertaking a Qualitative analysis of a building. The guidelines also provide guidance on calculating a modified Ultimate Limit State capacity of the building which is much more accurate and can be used when undertaking a Quantitative analysis.

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 2 below.

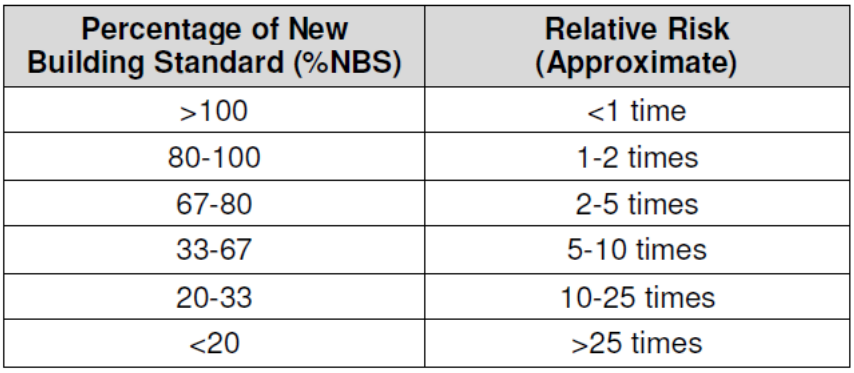


Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement	Unacceptable	Unacceptable

- **Figure 2: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines**

Table 1 below provides an indication of the risk of failure for an existing building with a given percentage NBS, relative to the risk of failure for a new building that has been designed to meet current Building Code criteria (the annual probability of exceedance specified by current earthquake design standards for a building of 'normal' importance is 1/500, or 0.2% in the next year, which is equivalent to 10% probability of exceedance in the next 50 years).

- **Table 1: %NBS compared to relative risk of failure**



Percentage of New Building Standard (%NBS)	Relative Risk (Approximate)
>100	<1 time
80-100	1-2 times
67-80	2-5 times
33-67	5-10 times
20-33	10-25 times
<20	>25 times

5. Building Details

5.1. Building description

The building is located near the Hagley Oval in South Hagley Park. There is only one building on this site. The building has one storey that appears to be currently utilised as a storage shed. The building is constructed from partially reinforced masonry walls and is believed to have a lightweight roof with timber framing. The masonry walls have vertical reinforcing present at the corners and at either side of openings. The ground floor appears to be supported on a concrete slab foundation. It is assumed the building was designed and constructed in the 1970s.

Our evaluation was based on the external visual inspection carried out on 8 May 2012 and a cover meter survey carried out on 14 May 2012. Internal inspection was not able to be carried out as the doors were locked at the time of the visual inspection. Drawings were not available to verify the foundation system and the date of construction.

5.2. Gravity Load Resisting system

It appears that the gravity loads are taken by the masonry block walls, with direct transfer into the concrete slab foundation below.

5.3. Seismic Load Resisting system

Lateral loads acting across and along the building will be resisted by the masonry walls in shear.

Note that for this building the ‘across direction’ has been taken as east-west and the ‘along direction’ has been taken as north-south.

5.4. Geotechnical Conditions

A geotechnical desktop study was carried out for this site. The main conclusions from this report are:

- In accordance with NZS1170.5 the site is likely to be seismic subsoil Class D (deep or soft soil) ground performance and properties.
- Liquefaction risk is expected to be low to moderate on this site.

If a quantitative assessment is to be performed for the structures on site, intrusive geotechnical investigations are required to provide a reliable estimate of shallow ground properties. Additional investigations recommended are:

- Two hand augers to a minimum depth of 3m near the building

6. Damage Summary

SKM undertook an inspection on 8 May 2012. The following areas of damage were observed during the time of inspection:

General

1) No visual evidence of settlement was noted at this site, therefore a level survey is not required at this stage of assessment.

Building Damage

1) Hairline shrinkage cracks in concrete footing under masonry walls throughout the building. This is not believed to be earthquake-related damage.
2) Spalling of the concrete footing was noted, but is not a result of earthquake damage. A likely cause would be the large aggregate size noted throughout.
3) Cracking and spalling in external concrete ground slab on the west side, exposing footing reinforcing. This is not believed to be earthquake-related damage.
4) Low quality pointing was noted, but is not a result of earthquake damage.
5) Warping of top timber roof facia member on the north side was noted, but due to the paintwork, this is believed to be existing and not as a result of earthquake damage.

Photos of the above damage can be found in Appendix 1 – Photos.

7. Initial Seismic Evaluation

7.1. The Initial Evaluation Procedure Process

This section covers the initial seismic evaluation of the building as detailed in the NZSEE 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes'. The IEP grades buildings according to their likely performance in a seismic event. The procedure is not yet recognised by the NZ Building Code but is widely used and recognised by the Christchurch City Council as the preferred method for preliminary seismic investigations of buildings[2].

The IEP is a coarse screening process designed to identify buildings that are likely to be earthquake prone. The IEP process ranks buildings according to how well they are likely to perform relative to a new building designed to current earthquake standards, as shown in Table 2. The building rank is indicated by the percent of the required New Building Standard (%NBS) strength that the building is considered to have. Earthquake prone buildings are defined as having less than 33% NBS strength which correlates to an increased risk of approximately 20 times that of 100% NBS[3]. Buildings that are identified to be earthquake prone are required by law to be followed up with a detailed assessment and strengthening work within 30 years of the owner being notified that the building is potentially earthquake prone[4].

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[2] http://resources.ccc.govt.nz/files/EarthquakeProneDangerousAndInsanitaryBuildingsPolicy2010.pdf

[3] NZSEE 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes,* p 2-2

[4] http://resources.ccc.govt.nz/files/EarthquakeProneDangerousAndInsanitaryBuildingsPolicy2010.pdf

Table 2: IEP Risk classifications

Description	Grade	Risk	%NBS	Structural performance
Low risk building	A+	Low	> 100	Acceptable. Improvement may be desirable.
	A		100 to 80	
	B		80 to 67	
Moderate risk building	C	Moderate	67 to 33	Acceptable legally. Improvement recommended.
High risk building	D	High	33 to 20	Unacceptable. Improvement required.
	E		< 20	

The IEP is a simple desktop study that is useful for risk management. No detailed calculations are done and so it relies on an inspection of the building and its plans to identify the structural members and describe the likely performance of the building in a seismic event. A review of the plans is also likely to identify any critical structural weaknesses. The IEP assumes that the building was properly designed and built according to the relevant codes at the time of construction. The IEP method rates buildings based on the code used at the time of construction and some more subjective parameters associated with how the building is detailed and so it is possible that %NBS derived from different engineers may differ.

This assessment describes only the likely seismic Ultimate Limit State (ULS) performance of the building. The ULS is the level of earthquake that can be resisted by the building without catastrophic failure. The IEP does not attempt to estimate Serviceability Limit State (SLS) performance of the building, or the level of earthquake that would start to cause damage to the building[5]. This assessment concentrates on matters relating to life safety as damage to the building is a secondary consideration. SLS performance of the building can be estimated by scaling the current code levels if required.

The NZ Building Code describes that the relevant codes for NBS are primarily:

- AS/NZS 1170 Structural Design Actions
- NZS 3101:2006 Concrete Structures Standard
- NZS 3404:1997 Steel Structures Standard

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[5] NZSEE 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes,* p2-9

7.2. Available Information, Assumptions and Limitations

Following our inspection on 8 May 2012, SKM carried out a preliminary structural review. The structural review was undertaken using the available information which was as follows:

- SKM site measurements, cover meter survey and external inspection findings of the building. Please note no intrusive investigations were undertaken.
- There were no drawings available to carry out our review.

The following assumptions and design criteria were used in this assessment:

- Standard design assumptions for typical office and factory buildings as described in AS/NZS1170.0:2002
  - 50 year design life, which is the default NZ Building Code design life.
  - Structure Importance Level 2. This level of importance is described as ‘normal’ with medium or considerable consequence of failure.
  - Ductility level of 1.25 in both directions, based on our assessment and code requirements at the time of design.
  - Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011

This IEP was based on our external visual inspection of the building. Since it is not a full design and construction review, it has the following limitations:

- It is not likely to pick up on any original design or construction errors (if they exist)
- Other possible issues that could affect the performance of the building such as corrosion and modifications to the building will not be identified
- The IEP deals only with the structural aspects of the building. Other aspects such as building services are not covered.

7.3. Critical Structural Weaknesses

No critical structural weaknesses have been identified in this building.

7.4. Qualitative Assessment Results

The building has had its capacity assessed using the Initial Evaluation Procedure based on the information available. The buildings capacity is expressed as a percentage of new building standard (%NBS) and are in the order of that shown below in Table 3. This capacity is subject to confirmation by a quantitative analysis.

Table 3: Qualitative Assessment Summary

Item	%NBS
Likely Seismic Capacity of Building	17

Our qualitative assessment found that the building is likely to be classed as potentially earthquake prone and probably a ‘High Risk Building’ (capacity less than 34% of NBS). The full IEP assessment form is detailed in Appendix 2 – IEP Reports.

Further investigation is required to confirm our initial findings and establish possible strengthening concepts.

The Council regulations state that if the %NBS of the building is less than 34%, this building is considered earthquake prone and is required to be strengthened.

The Engineering Advisory Group notes:

> *“For buildings with insignificant damage, but that have %NBS<33%, and buildings with significant damage, a quantitative assessment is required. Note that according to the extent of damage, it may be possible to complete a quantitative assessment for part only of the structure, with a qualitative analysis for the structure as a whole. This could be sufficient when there is highly localised severe damage but the building has otherwise suffered little or no damage.”*

8. Further Investigation

Due to the lack of structural drawings and the likely seismic capacity of the building being less than 34% NBS we recommend that a quantitative assessment is carried out due to the potential margin of errors that may be inherent in our initial assessment. This will allow us to confirm our findings and establish possible strengthening concepts.

If a quantitative assessment is carried out then intrusive investigations will be required to confirm the following structural details:

- Foundation layout and size of elements.
- Structural roof member sizes and layouts.
- Connections sizes and layouts.

9. Conclusion

A qualitative assessment was carried out on the building located near the Hagley Oval in South Hagley Park in Christchurch Central. The building has sustained no external structural damage. The building has been assessed to have a seismic capacity in the order of 17% NBS and is therefore potentially earthquake prone and is likely to be classified as a ‘High Risk Building’ (capacity less than 34% of NBS).

Further investigation is required to confirm our initial findings and to establish possible strengthening concepts. This investigation will require carrying out a quantitative assessment on the building to determine if there is enough capacity in the structural elements to resist the required earthquake demand.

It is recommended that:

a) A quantitative assessment of the building, supported by intrusive investigations if required, be undertaken to determine the seismic capacity and to develop potential strengthening concepts.
b) We consider that barriers around the building are not necessary.

10. Limitation Statement

This report has been prepared on behalf of, and for the exclusive use of, SKM's client, and is subject to, and issued in accordance with, the provisions of the contract between SKM and the Client. It is not possible to make a proper assessment of this report without a clear understanding of the terms of engagement under which it has been prepared, including the scope of the instructions and directions given to, and the assumptions made by, SKM. The report may not address issues which would need to be considered for another party if that party's particular circumstances, requirements and experience were known and, further, may make assumptions about matters of which a third party is not aware. No responsibility or liability to any third party is accepted for any loss or damage whatsoever arising out of the use of or reliance on this report by any third party.

Without limiting any of the above, in the event of any liability, SKM's liability, whether under the law of contract, tort, statute, equity or otherwise, is limited in as set out in the terms of the engagement with the Client.

It is not within SKM's scope or responsibility to identify the presence of asbestos, nor the responsibility of SKM to identify possible sources of asbestos. Therefore for any property pre-dating 1989, the presence of asbestos materials should be considered when costing remedial measures or possible demolition.

There is a risk of further movement and increased cracking due to subsequent aftershocks or settlement.

Should there be any further significant earthquake event, of a magnitude 5 or greater, it will be necessary to conduct a follow-up investigation, as the observations, conclusions and recommendations of this report may no longer apply Earthquake of a lower magnitude may also cause damage, and SKM should be advised immediately if further damage is visible or suspected.

11. Appendix 1 – Photos

	
Photo 1: West elevation	Photo 2: South elevation
	
Photo 3: East elevation	Photo 4: North elevation

Photo 5: Existing impact damage to concrete footing on northwest corner, with rusted footing reinforcing exposed.

Photo 6: Hairline crack in concrete footing under west wall (typical).

Photo 7: Soffit on west side.

Photo 8: Door connection on west wall. Bolts through masonry wall visible.

	
Photo 9: Crack in external concrete ground slab on west side.	Photo 10: Hairline crack in concrete footing under masonry wall.
	
Photo 11: Large aggregate sizes visible in concrete footing.	Photo 12: Cracking and spalling of concrete footing on west wall, exposing footing reinforcing.

	
Photo 13: Existing low quality pointing of west masonry wall.	Photo 14: External roof cladding.
	
Photo 15: Existing warping of timber roof member on north side.	Photo 16: Existing spalling of concrete footing (typical).

12. Appendix 2 – IEP Reports

Table IEP-1 Initial Evaluation Procedure – Step 1

(Refer Table IEP - 2 for Step 2; Table IEP - 3 for Step 3, Table IEP - 4 for Steps 4, 5 and 6)

Building Name: South Hagley - Pavilion/Shelter (Polo)
Location: South Hagley Park, Christchurch Central (near the Hagley Oval)

Ref. ZB01276.229
By WPK
Date 10/05/2012

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketch of building plan

1.3 List relevant features

The building in South Hagley Park by the Hagley Oval is a one storey building that appears to be used for storage. The building consists of concrete masonry block walls. The main lateral load-resisting system appear to be the walls. These act as shear walls in the north-south and east-west direction. The roof structure appears to consist of timber rafters that support a lightweight roof. Internal inspection was not able to be performed as the doors were locked. The block walls appear to be founded on a concrete slab footing. The building is assumed to have been constructed in the 1960's.

1.4 Note information sources

Tick as appropriate

Visual Inspection of Exterior	☑
Visual Inspection of Interior	☐
Drawings (note type)	☐
Specifications	☐
Geotechical Reports	☐
Other (list)	☑

Cover meter survey

Table IEP-2 Initial Evaluation Procedure – Step 2

(Refer Table IEP - 1 for Step 1; Table IEP - 3 for Step 3, Table IEP - 4 for Steps 4, 5 and 6)

Building Name:	South Hagley - Pavilion/Shelter (Polo)	Ref.	ZB01276.229
Location:	South Hagley Park, Christchurch Central (near the Hagley Oval)	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	10/05/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Step 2 - Determination of (%NBS)b

2.1 Determine nominal (%NBS) = (%NBS)nom

Pre 1935			○	See also notes 1, 3
1935-1965			●	
1965-1976	Seismic Zone;	A	○	
		B	○	
		C	○	See also note 2
1976-1992	Seismic Zone;	A	○	
		B	○	
		C	○	
1992-2004			○	

b) Soil Type

From NZS1170.5:2004, Cl 3.1.3

A or B Rock	○
C Shallow Soil	○
D Soft Soil	●
E Very Soft Soil	○

From NZS4203:1992, Cl 4.6.2.2

(for 1992 to 2004 only and only if known)

a) Rigid	○	N-A
b) Intermediate	○	

c) Estimate Period, T

building Ht = **3.3** meters

	Longitudinal	Transverse	
Ac =	N/A	N/A	m2

Can use following:

		Longitudinal	Transverse
$T = 0.09h_n^{0.75}$	for moment-resisting concrete frames	○ MRCF	○ MRCF
$T = 0.14h_n^{0.75}$	for moment-resisting steel frames	○ MRSF	○ MRSF
$T = 0.08h_n^{0.75}$	for eccentrically braced steel frames	○ EBSF	○ EBSF
$T = 0.06h_n^{0.75}$	for all other frame structures	○ Others	○ Others
$T = 0.09h_n^{0.75}/A_c^{0.5}$	for concrete shear walls	○ CSW	○ CSW
T <= 0.4sec	for masonry shear walls	● MSW	● MSW

Where
hn = height in m from the base of the structure to the uppermost seismic weight or mass.
Ac = ΣAi(0.2 + Lwi/hn)2
Ai = cross-sectional shear area of shear wall i in the first storey of the building, in m2
lwi = length of shear wall i in the first storey in the direction parallel to the applied forces, in m
with the restriction that lwi/hn shall not exceed 0.9

Longitudinal	Transverse	
0.4	**0.4**	Seconds

d) (%NBS)nom determined from Figure 3.3

Longitudinal	2.8	$(\%NBS)_{nom}$
Transverse	2.8	$(\%NBS)_{nom}$

			Factor
Note 1:	For buildings designed prior to 1965 and known to be designed as public buildings in accordance with the code of the time, multiply (%NBS)nom by 1.25.	No ▼	1
	For buildings designed 1965 - 1976 and known to be designed as public buildings in accordance with the code of the time, multiply (%NBS)nom by 1.33 - Zone A or 1.2 - Zone B	No ▼	1
Note 2:	For reinforced concrete buildings designed between 1976 -1984 (%NBS)nom by 1.2	No ▼	1
Note 3:	For buildings designed prior to 1935 multiply (%NBS)nom by 0.8 except for Wellington where the factor may be taken as 1.	No ▼	1

Longitudinal	2.8	$(\%NBS)_{nom}$
Transverse	2.8	$(\%NBS)_{nom}$

Continued over page

Building Name:	South Hagley - Pavilion/Shelter (Polo)	Ref.	ZB01276.229
Location:	South Hagley Park, Christchurch Central (near the Hagley Oval)	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	10/05/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

2.2 Near Fault Scaling Factor, Factor A

If T < 1.5sec, Factor A = 1

a) Near Fault Factor, N(T,D) 1

(from NZS1170.5:2004, Cl 3.1.6)

b) Near Fault Scaling Factor = 1/N(T,D) **Factor A** 1.00

2.3 Hazard Scaling Factor, Factor B

Select Location Christchurch ▼

a) Hazard Factor, Z, for site

(from NZS1170.5:2004, Table 3.3)

Z = 0.3

Z 1992 = 0.8

Auckland	0.6	Palm Nth	1.2
Wellington	1.2	Dunedin	0.6
Christchurch	0.8	Hamilton	0.67

b) Hazard Scaling Factor

For pre 1992 = 1/Z

\# For 1992 onwards = Z 1992/Z

(Where Z 1992 is the NZS4203:1992 Zone Factor from accompanying Figure 3.5(b))

Factor B 3.33

2.4 Return Period Scaling Factor, Factor C

a) Building Importance Level 2 ▼

(from NZS1170.0:2004, Table 3.1 and 3.2)

b) Return Period Scaling Factor from accompanying Table 3.1 **Factor C** 1.00

2.5 Ductility Scaling Factor, D

a) Assessed Ductility of Existing Structure, μ

(shall be less than maximum given in accompanying Table 3.2)

Longitudinal	1.25	μ Maximum = 2
Transverse	1.25	μ Maximum = 2

b) Ductility Scaling Factor

For pre 1976 = k_μ

For 1976 onwards = 1

(where k_μ is NZS1170.5:2005 Ductility Factor, from accompanying Table 3.3)

Longitudinal	**Factor D**	1.14
Transverse	**Factor D**	1.14

2.6 Structural Performance Scaling Factor, Factor E

Select Material of Lateral Load Resisting System

Longitudinal	Masonry Block ▼
Transverse	Masonry Block ▼

a) Structural Performance Factor, S_p

from accompanying Figure 3.4

Longitudinal	Sp	0.90
Transverse	Sp	0.90

b) Structural Performance Scaling Factor

Longitudinal	$1/S_p$	**Factor E**	1.11
Transverse	$1/S_p$	**Factor E**	1.11

2.7 Baseline %NBS for Building, $(\%NBS)_b$

(equals $(\%NSB)_{nom}$ x A x B x C x D x E)

Longitudinal	11.9	(%NBS)b
Transverse	11.9	(%NBS)b

Table IEP-3 Initial Evaluation Procedure – Step 3

(Refer Table IEP - 1 for Step 1; Table IEP - 2 for Step 2, Table IEP - 4 for Steps 4, 5 and 6)

Building Name:	South Hagley - Pavilion/Shelter (Polo)	Ref.	ZB01276.229
Location:	South Hagley Park, Christchurch Central (near the Hagley Oval)	By	WPK
Direction Considered:	**a) Longitudinal**	Date	10/05/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

Critical Structural Weakness	**Effect on Structural Performance** (Choose a value - Do not interpolate)	**Building Score**

3.1 Plan Irregularity

	Severe	Significant	Insignificant		
Effect on Structural Performance	○	○	●	**Factor A**	1
Comment					

3.2 Vertical Irregularity

	Severe	Significant	Insignificant		
Effect on Structural Performance	○	○	●	**Factor B**	1
Comment					

3.3 Short Columns

	Severe	Significant	Insignificant		
Effect on Structural Performance	○	○	●	**Factor C**	1
Comment					

3.4 Pounding Potential

(Estimate D1 and D2 and set D = the lower of the two, or =1.0 if no potential for pounding)

a) Factor D1: - Pounding Effect
Select appropriate value from Table

Note:
Values given assume the building has a frame structure. For stiff buildings (eg with shear walls), the effect of pounding may be reduced by taking the co-efficient to the right of the value applicable to frame buildings.

Factor D1 1

Table for Selection of Factor D1	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Alignment of Floors within 20% of Storey Height	○ 0.7	○ 0.8	● 1
Alignment of Floors not within 20% of Storey Height	○ 0.4	○ 0.7	○ 0.8

b) Factor D2: - Height Difference Effect
Select appropriate value from Table

Factor D2 1

Table for Selection of Factor D2	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Height Difference > 4 Storeys	○ 0.4	○ 0.7	○ 1
Height Difference 2 to 4 Storeys	○ 0.7	○ 0.9	○ 1
Height Difference < 2 Storeys	○ 1	○ 1	● 1

Factor D 1

(Set D = lesser of D1 and D2 or..
set D = 1.0 if no prospect of pounding)

3.5 Site Characteristics - (Stability, landslide threat, liquefaction etc)

	Severe	Significant	Insignificant		
Effect on Structural Performance	○ 0.5	○ 0.7	● 1	**Factor E**	1

3.6 Other Factors

For < 3 storeys - Maximum value 2.5,

otherwise - Maximum value 1.5. No minimum. **Factor F** 1.5

Record rationale for choice of Factor F:

Based on the inherent strength, shape and condition of the building and no earthquake damage was noted.

3.7 Performance Achievement Ratio (PAR)
(equals A x B x C x D x E x F)

PAR 1.5

Table IEP-3 **Initial Evaluation Procedure – Step 3**

(Refer Table IEP - 1 for Step 1; Table IEP - 2 for Step 2, Table IEP - 4 for Steps 4, 5 and 6)

Building Name:	South Hagley - Pavilion/Shelter (Polo)	Ref.	ZB01276.229
Location:	South Hagley Park, Christchurch Central (near the Hagley Oval)	By	WPK
Direction Considered:	**b) Transverse**	Date	10/05/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

Critical Structural Weakness

Effect on Structural Performance

(Choose a value - Do not interpolate)

Building Score

3.1 Plan Irregularity

	Severe	Significant	Insignificant		Building Score
Effect on Structural Performance	○	○	●	**Factor A**	1
Comment					

3.2 Vertical Irregularity

	Severe	Significant	Insignificant		Building Score
Effect on Structural Performance	○	○	●	**Factor B**	1
Comment					

3.3 Short Columns

	Severe	Significant	Insignificant		Building Score
Effect on Structural Performance	○	○	●	**Factor C**	1
Comment					

3.4 Pounding Potential

(Estimate D1 and D2 and set D = the lower of the two, or =1.0 if no potential for pounding)

a) Factor D1: - Pounding Effect

Select appropriate value from Table

Note:
Values given assume the building has a frame structure. For stiff buildings (eg with shear walls), the effect of pounding may be reduced by taking the co-efficient to the right of the value applicable to frame buildings.

Factor D1 1

Table for Selection of Factor D1

	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Alignment of Floors within 20% of Storey Height	○ 0.7	○ 0.8	● 1
Alignment of Floors not within 20% of Storey Height	○ 0.4	○ 0.7	○ 0.8

b) Factor D2: - Height Difference Effect

Select appropriate value from Table

Factor D2 1

Table for Selection of Factor D2

	Severe	Significant	Insignificant
Separation	0<Sep<.005H	.005<Sep<.01H	Sep>.01H
Height Difference > 4 Storeys	○ 0.4	○ 0.7	○ 1
Height Difference 2 to 4 Storeys	○ 0.7	○ 0.9	○ 1
Height Difference < 2 Storeys	○ 1	○ 1	● 1

Factor D 1

(Set D = lesser of D1 and D2 or..
set D = 1.0 if no prospect of pounding)

3.5 Site Characteristics - (Stability, landslide threat, liquefaction etc)

	Severe	Significant	Insignificant		Building Score
Effect on Structural Performance	○ 0.5	○ 0.7	● 1	**Factor E**	1

3.6 Other Factors

For < 3 storeys - Maximum value 2.5,

otherwise - Maximum value 1.5. No minimum.

Factor F 1.5

Record rationale for choice of Factor F:

Based on the inherent strength, shape and condition of the building and no earthquake damage was noted.

3.7 Performance Achievement Ratio (PAR)

(equals A x B x C x D x E x F)

PAR 1.5

Table IEP-4

Initial Evaluation Procedure – Steps 4, 5 and 6

(Refer Table IEP - 1 for Step 1; Table IEP - 2 for Step 2, Table IEP - 3 for Step 3)

Building Name:	South Hagley - Pavilion/Shelter (Polo)	Ref.	ZB01276.229
Location:	South Hagley Park, Christchurch Central (near the Hagley Oval)	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	10/05/2012

(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Step 4 - Percentage of New Building Standard (%NBS)

	Longitudinal	Transverse
4.1 Assessed Baseline ($\%NBS)_b$ (from Table IEP - 1)	11	11
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	1.50	1.50
4.3 PAR x Baseline ($\%NBS)_b$	17	17
4.4 Percentage New Building Standard (%NBS) (Use lower of two values from Step 4.3)		17

Step 5 - Potentially Earthquake Prone?
(Mark as appropriate)

%NBS ≤ 33 YES

Step 6 - Potentially Earthquake Risk?

%NBS < 67 YES

Step 7 - Provisional Grading for Seismic Risk based on IEP

Seismic Grade E

Evaluation Confirmed by

Signature

Nick Calvert Name

242062 CPEng. No

Relationship between Seismic Grade and % NBS :

Grade:	A+	A	B	C	D	E
%NBS:	> 100	100 to 80	80 to 67	67 to 33	33 to 20	< 20

13. Appendix 3 – CERA Standardised Report Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name: South Hagley - Pavilion Storage Shec
Unit No: Street
Building Address: South Hagley Park, Christchurch Central (near the Hagley Oval)
Legal Description:
Degrees Min Sec
GPS south:
GPS east:
Building Unique Identifier (CCC):

Reviewer: Nick Calvert
CPEng No: 242062
Company: SKM
Company project number: ZB01276.125
Company phone number: 09 928 5500
Date of submission: 27-Feb
Inspection Date: 8/05/2012
Revision: C
Is there a full report with this summary? yes

Site

Site slope: flat
Soil type:
Site Class (to NZS1170.5): D
Proximity to waterway (m, if <100m):
Proximity to clifftop (m, if < 100m):
Proximity to cliff base (m,if <100m):

Max retaining height (m):
Soil Profile (if available):
If Ground improvement on site, describe:
Approx site elevation (m):

Building

No. of storeys above ground: 1 single storey = 1
Ground floor split? no
Storeys below ground 0
Foundation type: mat slab
Building height (m): 3.30
Floor footprint area (approx): 104
Age of Building (years): 50

Ground floor elevation (Absolute) (m): 3.30
Ground floor elevation above ground (m): 3.30
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m):
Date of design: 1935-1965

Strengthening present? no
Use (ground floor): recreational
Use (upper floors):
Use notes (if required):
Importance level (to NZS1170.5): IL2

If so, when (year)?
And what load level (%g)?
Brief strengthening description:

Gravity Structure

Gravity System: load bearing walls
Roof: timber framed
Floors: concrete flat slab
Beams: none
Columns: none
Walls: partially filled concrete masonry

rafter type, purlin type and claddinc Assumed timber rafters & purlins and lightweight steel claddinc
slab thickness (mm) Unknown
overall depth x width (mm x mm) None
typical dimensions (mm x mm) None
thickness (mm) 200

Lateral load resisting structure

Lateral system along: partially filled CMU
Ductility assumed, μ: 1.25
Period along: 0.40 ##### enter height above at H31
Total deflection (ULS) (mm): 10
maximum interstorey deflection (ULS) (mm):

Note: Define along and across in detailed report!

note total length of wall at ground (m): 22
wall thickness (m):
estimate or calculation? estimated
estimate or calculation? estimated
estimate or calculation? estimated

Lateral system across: partially filled CMU
Ductility assumed, μ: 1.25
Period across: 0.40 ##### enter height above at H31
Total deflection (ULS) (mm): 10
maximum interstorey deflection (ULS) (mm):

note total length of wall at ground (m): 4.8
wall thickness (m):
estimate or calculation? estimated
estimate or calculation? estimated
estimate or calculation? estimated

Separations:

north (mm): leave blank if not relevant
east (mm):
south (mm):
west (mm):

Non-structural elements

Stairs:
Wall cladding: exposed structure describe Masonry walls
Roof Cladding: Metal describe Assumed corrugated sheeting
Glazing:
Ceilings:
Services(list): Unknown

Available documentation

Architectural none original designer name/date
Structural none original designer name/date
Mechanical none original designer name/date
Electrical none original designer name/date
Geotech report partial original designer name/date

Damage

Site: (refer DEE Table 4-2)
Site performance: Describe damage:
Settlement: none observed notes (if applicable):
Differential settlement: none observed notes (if applicable):
Liquefaction: none apparent notes (if applicable):
Lateral Spread: none apparent notes (if applicable):
Differential lateral spread: none apparent notes (if applicable):
Ground cracks: none apparent notes (if applicable):
Damage to area: none apparent notes (if applicable):

Building:
Current Placard Status: green

Along Damage ratio: 0%
Describe (summary):
Describe how damage ratio arrived at: No structural damage noted therefore the capacity of the building will not be reduced.

Across Damage ratio: 0%
Describe (summary):

$$Damage\_Ratio = \frac{(\%NBS(before) - \%NBS(after))}{\%NBS(before)}$$

Diaphragms Damage?: no Describe:
CSWs: Damage?: no Describe:
Pounding: Damage?: no Describe:
Non-structural: Damage?: no Describe:

Recommendations

Level of repair/strengthening required: minor non-structural Describe:
Building Consent required: no Describe:
Interim occupancy recommendations: full occupancy Describe: Not an immediate collapse hazard.

Along Assessed %NBS before: 17% %NBS from IEP below
Assessed %NBS after: 17%

If IEP not used, please detail assessment methodology: Qualitative Assessment carried out includes NZSEE IEP (refer to SKM report).

Across Assessed %NBS before: 17% %NBS from IEP below
Assessed %NBS after: 17%

14. Appendix 4 – Geotechnical Desktop Study

Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	125, 126, 127, 128
Address	Pavillion and three Toilet Blocks, Hagley Park South
Report date	12 July 2012
Author	Chris Ritchie
Reviewer	Ross Roberts
Approved for issue	Yes

1. Introduction

This report outlines the geotechnical information that Sinclair Knight Merz (SKM) has been able to source from our database and other sources in relation to the property listed above. We understand that this information will be used as part of an initial qualitative Detailed Engineering Evaluation (DEE), and will be supplemented by more detailed information and investigations to allow detailed scoping of the repair or rebuild of the building.

2. Scope

This geotechnical desk top study incorporates information sourced from:

- Published geology
- Publically available borehole records
- Liquefaction records
- Aerial photography
- A preliminary site walkover

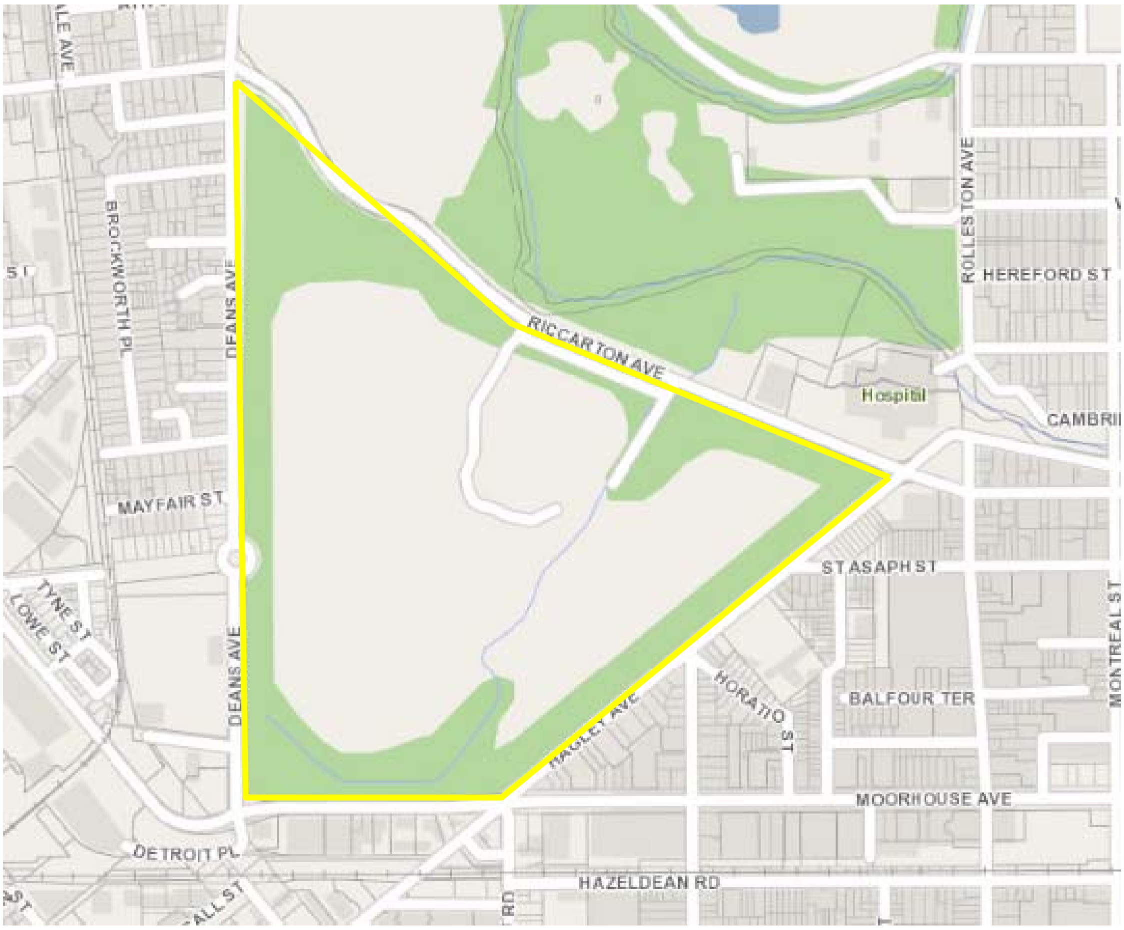
3. Limitations

This report was prepared to address geotechnical issues relating to the specific site in accordance with the scope of works as defined in the contract between SKM and our Client. This report has been prepared on behalf of, and for the exclusive use of, our Client, and is subject to, and issued in accordance with, the provisions of the contract between SKM and our Client. The findings presented in this report should not be applied to another site or another development within the same site without consulting SKM.

The assessment undertaken by SKM was limited to a desktop review of the data described in this report. SKM has not undertaken any subsurface investigations, measurement or testing of materials from the site. In preparing this report, SKM has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by our Client, and from other sources as described in the report. Except as otherwise stated in this report, SKM has not attempted to verify the accuracy or completeness of any such information.

This report should be read in full and no excerpts are to be taken as representative of the findings. It must not be copied in parts, have parts removed, redrawn or otherwise altered without the written consent of SKM.

4. Site location

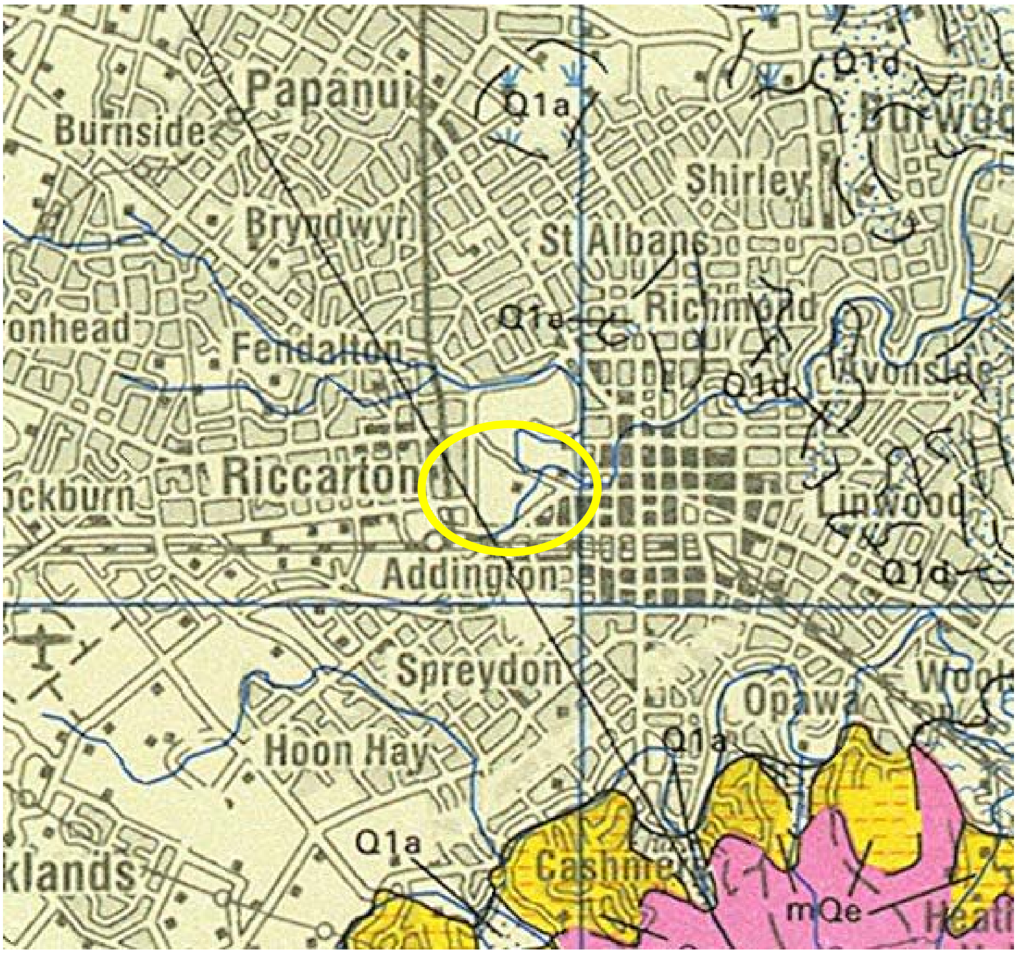


- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

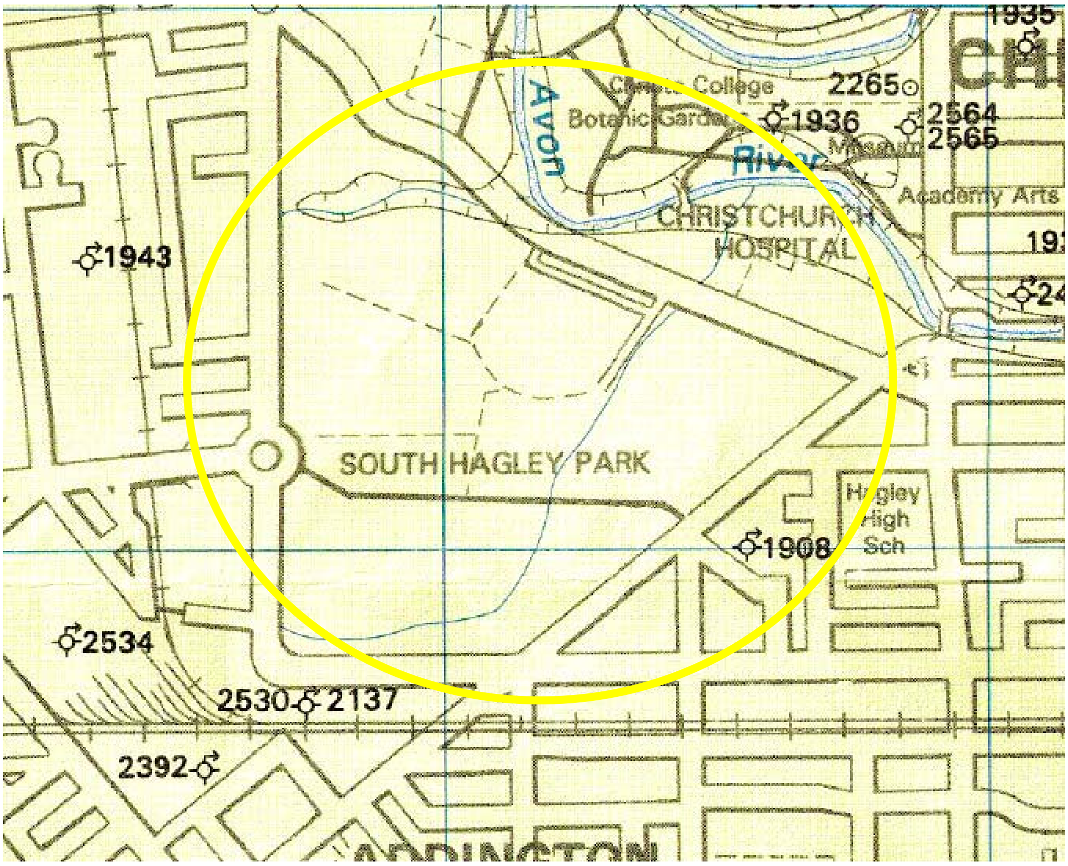
The structures are located within South Hagley with entrance to site located on Deans Avenue, Riccarton Avenue and Hagley Avenue.

5. Review of available information

5.1 Geological maps



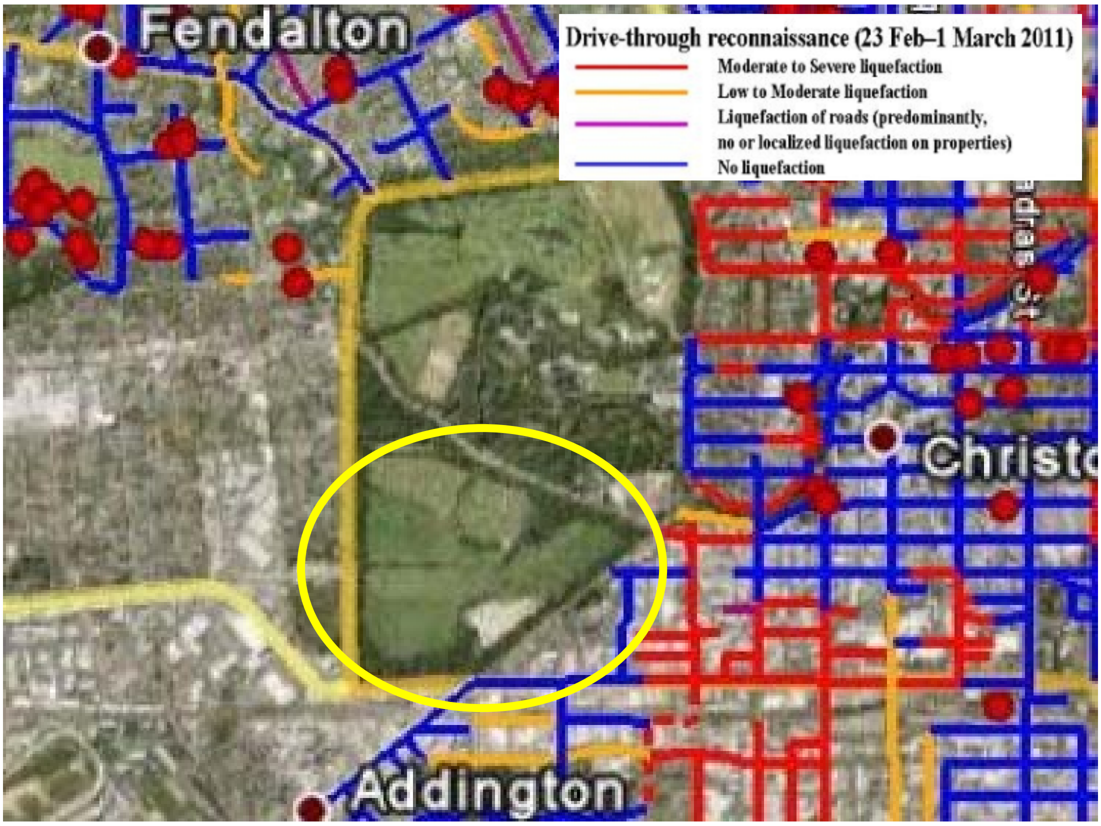
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in yellow.**



- **Figure 3 – Local geological map (Brown et al, 1992). Site marked in yellow.**

The site is shown to be underlain by Holocene deposits comprising predominantly alluvial sand and silt overbank deposits of the Springston Formation.

5.2 Liquefaction map



- **Figure 4 – Liquefaction map (Cubrinovski & Taylor, 2011). Site marked in yellow.**

Following the 22 February 2011 event drive through reconnaissance was undertaken from 23 February until 1 March by M Cubrinovsko and M Taylor of Canterbury University. Their findings show low to moderate liquefaction on Deans Avenue and Moorhouse Avenue and no liquefaction on western Moorhouse and to the east.

5.3 Aerial photography

- **Figure 5 – Aerial photography from 24 Feb 2011 (http://viewers.geospatial.govt.nz/)**

Aerial photography shows little evidence for surface liquefaction after the 22 February 2011 event.

5.4 CERA classification

A review of the LINZ website (http://viewers.geospatial.govt.nz/) shows that the site is:

- Zone: Green
- DBH Technical Category TC2 to the west, TC to the north and east

5.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the site next to land that was recorded as marshland or swamp in 1856. It is therefore possible that soft or liquefiable ground would be present near the site. A previous watercourse is marked running southwest northeast through the park.

5.6 Existing ground investigation data

- **Figure 6 – Local boreholes from Project Orbit and SKM files (https://canterburyrecovery.projectorbit.com/)**

Where available logs from these investigation locations are attached to this report (Appendix B), and the results are summarised in Appendix C.

5.7 Council property files

Council property files were not available for the site at the time of writing this report.

5.8 Site walkover

An external site walkover was conducted by an SKM engineer on 3 May 2012. Four buildings were assessed during the walk over.

5.8.1 PRK_1507_BLDG_001_EQ2 - Pavilion/Shelter

The Pavilion was noted to be a masonry block building with sheet metal roof, slab on grade foundations. From the external inspection, cracking and spalling in concrete footing under masonry walls was observed on the west side of the building. Minor cracking in external concrete ground slab was also noted.

Some patches in grass were observed to the west of the building which may be evidence of liquefied material being ejected to the surface. No apparent land damage was observed on the site.

- **Figure 7 Overview of structures – Pavilion**

5.8.2 PRK_1507_BLDG_010_EQ2 – Hospital Toilets

The building was a masonry block construction with sheet metal roof and timber frames. The ground floor appeared to be supported on slab on grade foundation. Cracking and spalling of concrete footing was noted on the south east corner and some cracks were observed in external concrete ground slab.

No evidence of land damage was visible during the external inspection; however, the patchy grass present to the south of the building suggests that some liquefied material was ejected at surface due to the 22 February earthquake.

- **Figure 8 Overview of structures – Hospital toilet**

5.8.3 PRK_1507_BLDG_013 EQ2 – Netball Toilets

The toilet block was observed to comprise concrete walls with brick cladding and a timber-framed ceiling. The foundation was noted to be a slab on grade foundation and the roof appeared to be lightweight construction with a glazed skylight in the centre. The toilet block appeared to be attached to the Christchurch Netball Centre building. There were some gaps in the mortar between bricks at the footing and at the top of the wall.

Resealed patches were observed on the nearby netball courts, likely as a result of services being broken underneath. Surface cracks were also noted which had been sealed with resin. No evidence of liquefaction or land damage was visible during the external site inspection.

- **Figure 9 Overview of structures – Netball toilets**

5.8.4 PRK_1507_BLDG_014_EQ2 – Rugby toilets

The building was observed to be a masonry block building with sheet metal roof, slab on grade foundations. Some minor cracks in the masonry wall and external concrete slab were observed during the external inspection of the site. There was no evidence of surface expression of liquefaction or any land damage around the site.

- **Figure 10 Overview of structures – Rugby toilets**

6. Conclusions and recommendations

6.1 Site geology

An interpretation of the most relevant local investigation suggests that the site is underlain by:

Depth range (mBGL)	Soil type
0 – 5	Sands/silts/clays
5-12	Sands/Gravels
12-25	Sands/Silts
25+	Gravels

6.2 Seismic site subsoil class

The site has been assessed as NZS1170.5 Class D (deep or soft soil).

As described in NZS1170, the preferred site classification method is from site periods based on four times the shear wave travel time through material from the surface to the underlying rock. The next preferred methods are from borelogs including measurement of geotechnical properties or by evaluation of site periods from Nakamura ratios or from recorded earthquake motions. Lacking this information, classification may be based on boreholes with descriptors but no geotechnical measurements. The least preferred method is from surface geology and estimates of the depth to underlying rock.

In this case the absence of deep boreholes near the site has resulted in the use of the least preferred method. It is therefore possible that site specific investigation could revise the site class.

6.3 Building Performance

Although detailed records of the existing foundations are not available, the performance to date suggests that they are adequate for their current purpose.

6.4 Ground performance and properties

Liquefaction risk is expected to be low to moderate on this site. Little surface evidence of liquefaction was noted from the aerial photograph taken shortly after the 22 February earthquake and during the external site walkover undertaken by a SKM engineer. Some liquefaction was however noted during the reconnaissance performed by Canterbury University.

Due to the variability of ground conditions found across the site, an estimation of the ground properties has not been provided in this desk study. Additional, investigations closer to each building would be required to perform a full quantitative DEE.

6.5 Further investigations

If a quantitative DEE is to be performed for the structures on site, intrusive geotechnical investigations are required to provide a reliable estimate of shallow ground properties. Additional investigations recommended are:

- Two hand augers to a minimum depth of 3 m are required near buildings 1, 10 and 13 as shown in figure 6 if a quantitative DEE is to be performed for the structures
- One borehole to a depth of 20m with SPT at intervals of 1.5 m is required near building 14
- CPTs are expected to be unsuitable as they are likely reach refusal at shallow depths as gravel layers are inferred to be present between 5 to 12 m

7. References

Brown LJ, Weeber JH, 1992. Geology of the Christchurch urban area. Scale 1:25,000. Institute of Geological & Nuclear Sciences geological map 1.

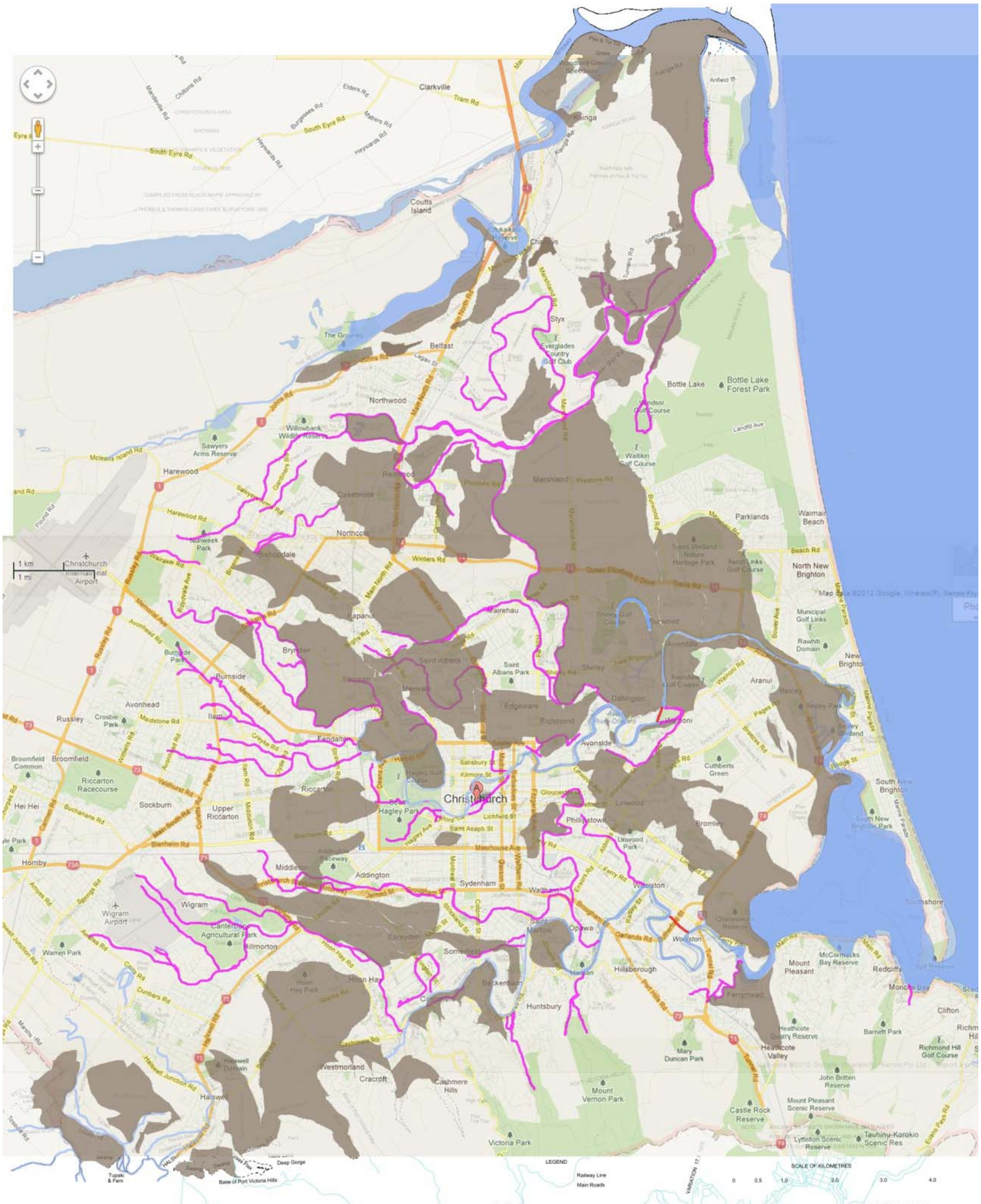
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

Forsyth PJ, Barrell DJA, Jongens R, 2008. Geology of the Christchurch area. Institute of Geological & Nuclear Sciences geological map 16.

Land Information New Zealand (LINZ) geospatial viewer (http://viewers.geospatial.govt.nz/)

EQC Project Orbit geotechnical viewer (https://canterburyrecovery.projectorbit.com/)

Appendix A – Christchurch 1856 land use



The swamps and previous creeks/rivers from 1856 have been overlayed onto a map of Christchurch in 2012

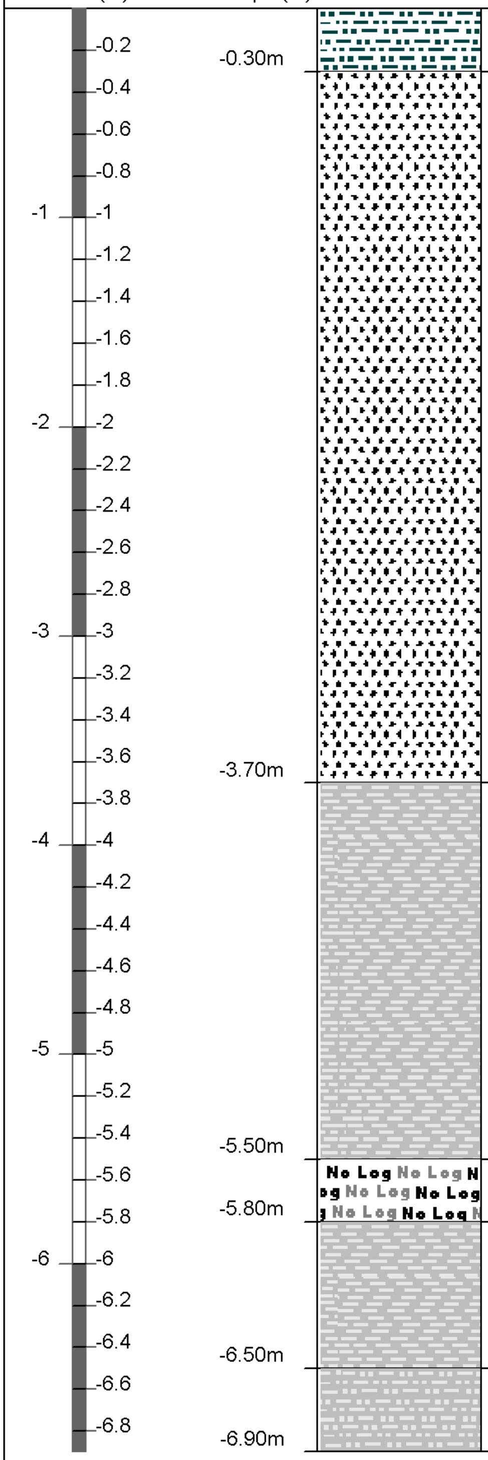
Key

- 🟪 Previous creeks/rivers
- 🟦 Existing creeks/rivers
- 🟥 New creeks/rivers
- 🟫 Swamp/Marshland

Appendix B – Existing ground investigation logs

Borelog for well M35/11100

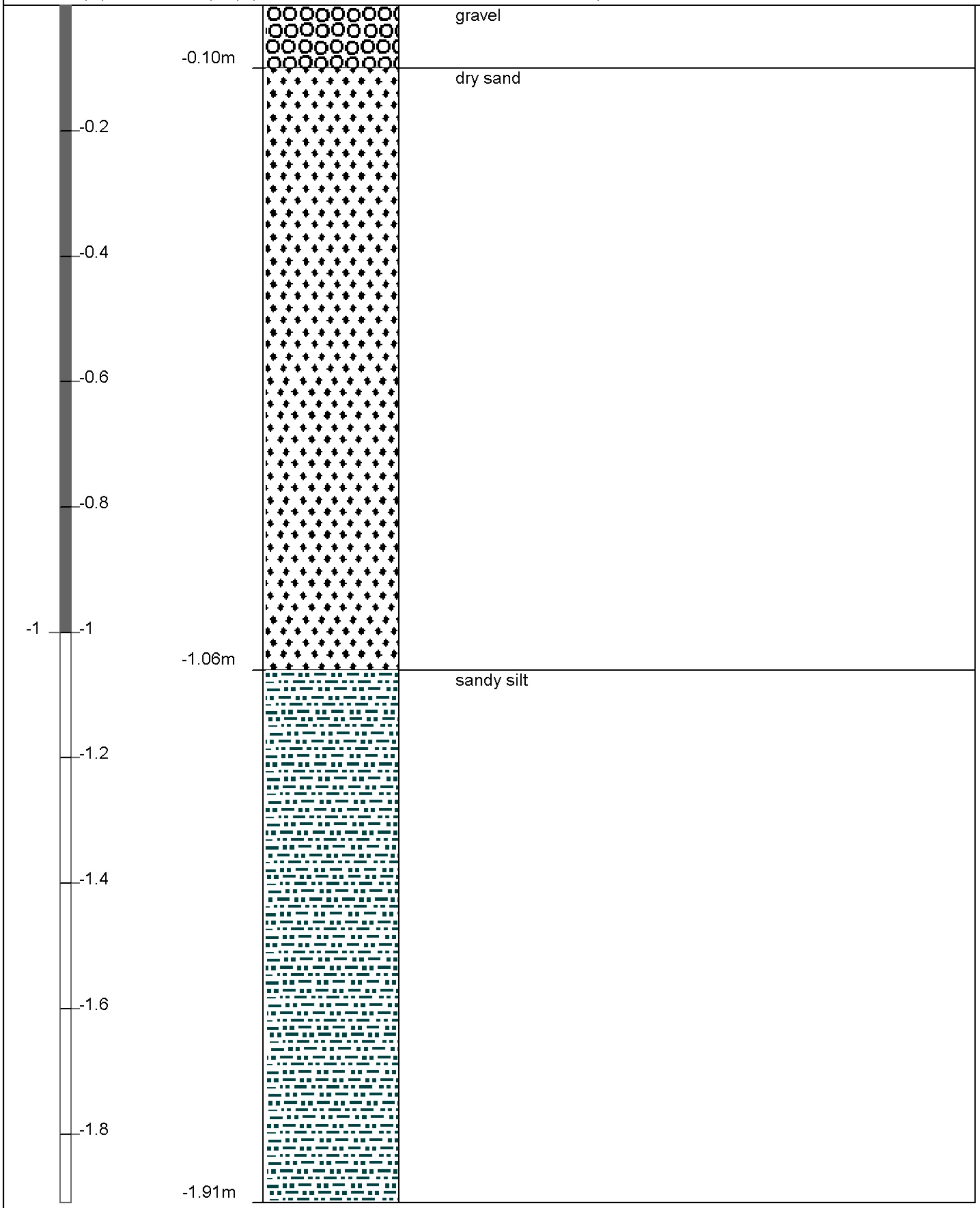
Gridref: M35:79577-41151 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 7.83 +MSD
Driller   : McMillan Water Wells Ltd
Drill Method : Rotary Rig
Drill Depth : -6.9m   Drill Date : 8/03/2006



Water Level	Depth(m)	Full Drillers Description	Formation Code
	-0.30m	Grey mottled red brown and orange silt with some very fine sand: firm, moist. -1.8m less mottled with depth, -2.2-3.7m grading sandier (very fine sandy), -2.7m blue grey, homogeneous with depth	
	-3.70m	Grey, fine sand with minor to some silt: saturated	
	-5.50m	Grey, silt with minor very fine sand and trace of peat: saturated	
	-5.80m	Core loss 5.8-6.5m	
	-6.50m	Grey, silt with minor very fine sand and trace of peat: saturated. -6.5m, 150mm thick lens of peaty silt	
	-6.90m	Grey, fine sand with minor silt: saturated	

Borelog for well M35/13525

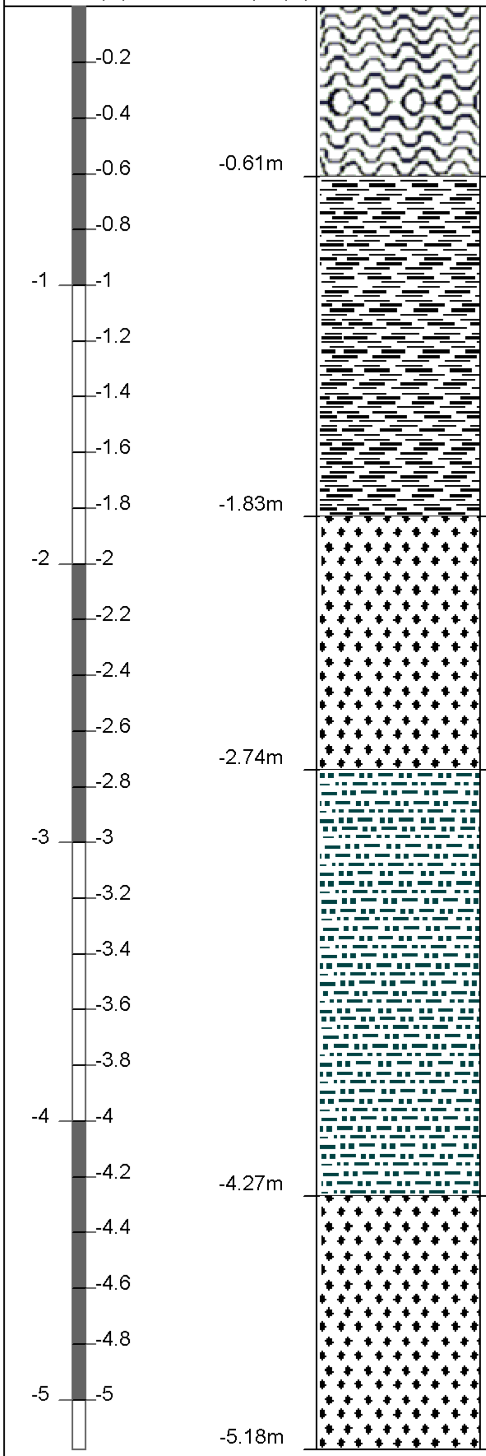
Gridref: M35:78336-42909 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 8.51 +MSD
Well name : CCC BorelogID 1854
Drill Method : Not Recorded
Drill Depth : -1.91m Drill Date :



Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.10m	gravel	
		-1.06m	dry sand	
		-1.91m	sandy silt	

Borelog for well M35/13915

Gridref: M35:78915-41189 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.07 +MSD
Well name : CCC BorelogID 2270
Drill Method : Not Recorded
Drill Depth : -5.18m Drill Date :

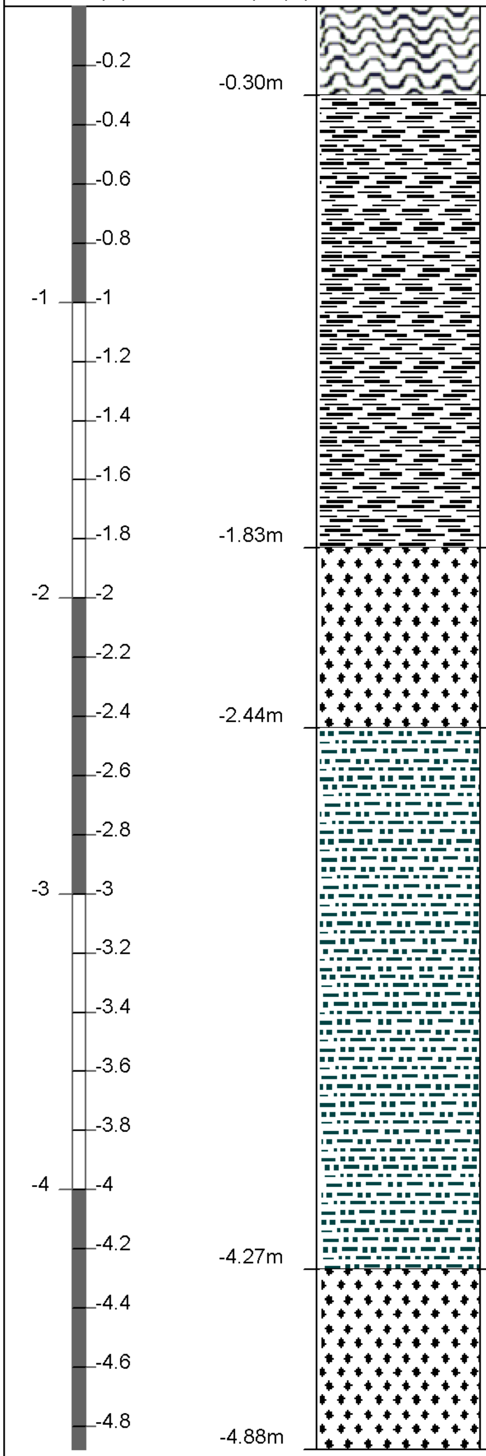


Depth(m)	Full Drillers Description	Formation Code
-0.61m	topsoil	
-1.83m	clay	
-2.74m	sand	
-4.27m	sandy silt	
-5.18m	sand	

Borelog for well M35/13916

Gridref: M35:78750-41178 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 6.63 +MSD
Well name : CCC BorelogID 2271
Drill Method : Not Recorded
Drill Depth : -4.88m Drill Date :

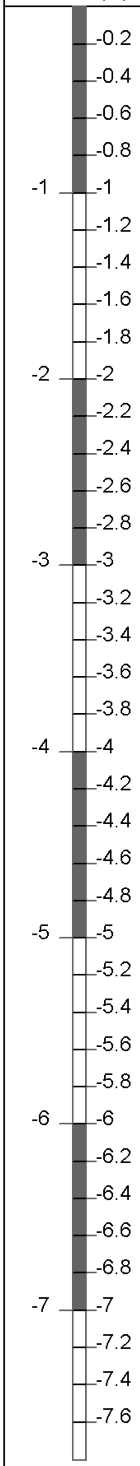
Environment Canterbury Regional Council

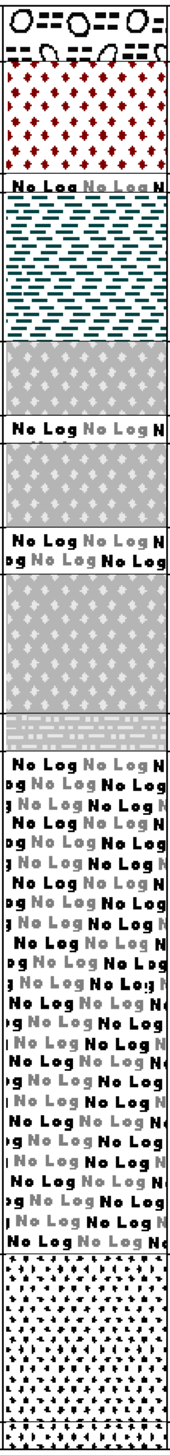


Depth(m)	Full Drillers Description	Formation Code
-0.30m	topsoil	
-1.83m	clay	
-2.44m	sand	
-4.27m	sandy silt	
-4.88m	loose saturated sand	

Borelog for well M35/11101

Gridref: M35:78704-41193 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.51 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Rotary Rig
Drill Depth : -7.75m Drill Date : 8/03/2006





Water Level	Depth(m)	Full Drillers Description	Formation Code
	-0.30m	Brown gravel fill: firm, dry, less gravel, more silt with depth	
	-0.90m	Red brown sand; dry	
	-1.00m	Core loss 1.02-1.8m	
	-1.80m	Grey, mottled yellow brown silt; firm, moist. -1.9m thin silt and peaty silt lens. -2.1m sandier with depth	
	-2.20m	Grey, fine sand; saturated	
	-2.35m	Core loss 2.35-2.8m	
	-2.80m	Grey, fine sand; saturated	
	-3.05m	Core loss 3.05-3.8m	
	-3.80m	Grey, fine sand: saturated	
	-4.00m	Grey, silty fine sand: saturated, grades to fine sandy silt in lenses. -5.8m, grading generally less silty (some)	
	-6.70m	Core loss 6.7-7.6m	
	-7.60m	Grey, fine sand some silt: saturated	
	-7.81m	Grey, very fine sandy silt with minor silt: saturated. -8.2m, 100mm think peaty silt lens	

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 47
Hole Location: Riccarton Ave

SHEET 1 OF 5

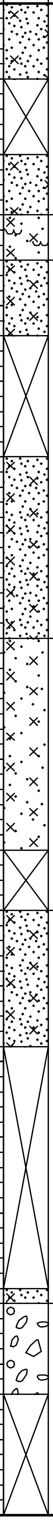
PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES	5741361.98 mN 2479634.32 mE	DRILL TYPE: Rotary	HOLE STARTED: 16/9/11
		DRILL METHOD: HQTT/OB	HOLE FINISHED: 17/9/11
R.L.	7.21 m		DRILLED BY: Pro-Drill
DATUM	NZMG	DRILL FLUID: Mud	LOGGED BY: CP CHECKED: BMcD

GEOLOGICAL — GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION — SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

CORE RECOVERY (%)	METHOD	TESTS	DEPTH (m)
57	OB		0 to 1.5
	SPT	2/3/4/3/4/5 N=16	1.5 to 1.95
81	HQTT	✱FC (2.5)	1.95 to 3.0
	SPT	2/4/4/5/5/5 N=19	3.0 to 3.45
24	HQTT		3.45 to 4.5
	SPT	6/11/10/ 10/12/13 N=45	4.5 to 4.95



GEOLOGICAL UNIT	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
TOPSOIL (Not pre-dug).	0	SW	M	L	Fine to medium SAND with some silt and roots, dark brown. Loose, moist. 0.25 to 0.5m no recovery
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)	0.7	MOL	M	F	Organic SILT with trace sand, dark brown. Firm, moist, low plasticity. Sand is fine.
	0.85	SP	M	MD	Silty, fine SAND, grey mottled orange brown. Medium dense, moist. 1.1 to 1.5m no recovery
	2.1	ML	D	VSt	SILT with trace sand, grey mottled orange brown. Very stiff, dry, low plasticity. Sand is fine. 2.8 to 3.0m no recovery
	3.0	SW	M	MD	Silty, fine to medium SAND, grey mottled orange-brown. Medium dense, moist. 3.45 to 4.25m no recovery
	4.3	GW	M	D	Fine to coarse GRAVEL, grey. Dense, moist. Gravel is subrounded to subangular. Fines washed away during drilling process. - contains trace coarse sand 4.6 to 6.3m no recovery

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 47
Hole Location: Riccarton Ave

SHEET 2 OF 5

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5741361.98 mN
2479634.32 mE
R.L. 7.21 m
DATUM NZMG

DRILL TYPE: Rotary
DRILL METHOD: HQTT/OB
DRILL FLUID: Mud

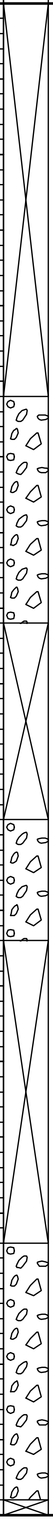
HOLE STARTED: 16/9/11
HOLE FINISHED: 17/9/11
DRILLED BY: Pro-Drill
LOGGED BY: CP
CHECKED: BMcD

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (mm) 50 250 1000 2000

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.



GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	TESTS	R.L. (m)	DEPTH (m)	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)							4.6 to 6.3m no recovery
				2.0			
					5.5		
	13	HQTT		1.5			
					6.0		
				1.0			
					6.5	MD	- becoming medium dense
		SPT	3/5/5/5/5/5 N=20	0.5			
					7.0		7.05 to 7.7m no recovery
				0.0			
	29	HQTT			7.5		
				-0.5			
					8.0		8.1 to 9.1m no recovery
		SPT	6/8/5/5/4/4 N=18	-1.0			
					8.5		
				-1.5			
	38	HQTT			9.0		
				-2.0			
					9.5		
		SPT	3/6/4/7/5/3 N=19	-2.5			
					10		9.95 to 10.0m no recovery

BOREHOLE LOG

BOREHOLE No: CBD 47
Hole Location: Riccarton Ave

SHEET 3 OF 5

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5741361.98 mN
2479634.32 mE
R.L. 7.21 m
DATUM NZMG

DRILL TYPE: Rotary
DRILL METHOD: HQTT/OB
DRILL FLUID: Mud

HOLE STARTED: 16/9/11
HOLE FINISHED: 17/9/11
DRILLED BY: Pro-Drill
LOGGED BY: CP
CHECKED: BMcD

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)			24	HQTT				-3.0		GW	M	MD				Fine to coarse GRAVEL with trace coarse gravel, grey. Medium dense, moist. Gravel is subrounded to subangular. Fines washed away during drilling process. 10.25 to 11.0m no recovery
								-3.5	10.5							
CHRISTCHURCH FORMATION (MARINE & ESTUARINE)				SPT		11/16/13/ 15/12/10 for 70mm N>50		-4.0	11.0	SW	M	VD				Fine to coarse SAND with minor silt, grey. Very dense, moist.
			100	HQTT		✱FC		-4.5	11.5							
								-5.0	12.0							
				SPT		3/5/8/ 12/10/10 N=40		-5.5	12.5			D				- becoming dense
			76	HQTT		✱FC		-6.0	13.0	ML	M	F				SILT, bluish grey. Firm, moist, low plasticity.
								-6.5	13.5							- contains minor fine sand 13.75 to 14.0m no recovery
				SPT		✱FC 0/0/0/ 1/1/2 N=5		-7.0	14.0	SW	M	L				Fine to medium SAND with some silt, grey. Loose, moist.
			81	HQTT				-7.5	14.5							
									15							

BOREHOLE LOG

BOREHOLE No: CBD 47
Hole Location: Riccarton Ave

SHEET 4 OF 5

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES: 5741361.98 mN
2479634.32 mE
R.L.: 7.21 m
DATUM: NZMG

DRILL TYPE: Rotary
DRILL METHOD: HQTT/OB
DRILL FLUID: Mud

HOLE STARTED: 16/9/11
HOLE FINISHED: 17/9/11
DRILLED BY: Pro-Drill
LOGGED BY: CP
CHECKED: BMcD

GEOLOGICAL: GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION: SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

GEOLOGICAL UNIT: CHRISTCHURCH FORMATION (MARINE & ESTUARINE)

DEPTH (m)	R.L. (m)	CORE RECOVERY (%)	METHOD	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
15.2	-8.0			✱FC	ML	M	F	Sandy SILT, bluish grey. Firm, moist, low plasticity. Sand is fine to medium. 15.3 to 15.5m no recovery
15.5	-8.5		SPT	2/0/2/1/2/3 N=8	SW	M	L	Fine to medium SAND with some silt, grey. Loose, moist.
16.0	-9.0	57	HQTT	✱FC				
16.5	-9.5							16.6 to 17.0m no recovery
17.0	-10.0		SPT	0/0/0/0/1/1 N=2			VL	- contains minor silt. Becoming very loose.
17.5	-10.5	38	HQTT					17.85 to 18.5m no recovery
18.0	-11.0							
18.5	-11.5		SPT	1/1/2/4/4/4 N=14			MD	- contains trace silt. Becoming medium dense.
19.0	-12.0	100	HQTT	✱FC				
19.5	-12.5			✱FC	ML	M	F	SILT with trace sand, bluish grey. Firm, moist, low plasticity. Sand is fine to medium.
20					SW	M	L	Fine to medium SAND with some silt, grey. Loose, moist.

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 47
Hole Location: Riccarton Ave

SHEET 5 OF 5

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE	LOCATION: CENTRAL CITY	JOB No: 52000.3400
CO-ORDINATES 5741361.98 mN 2479634.32 mE	DRILL TYPE: Rotary	HOLE STARTED: 16/9/11
	DRILL METHOD: HQTT/OB	HOLE FINISHED: 17/9/11
R.L. 7.21 m		DRILLED BY: Pro-Drill
DATUM NZMG	DRILL FLUID: Mud	LOGGED BY: CP CHECKED: BMcD

GEOLOGICAL — ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
CHRISTCHURCH FORMATION (MARINE & ESTUARINE)				SPT		0/0/1/1/0/1 N=3		-13.0			ML	M	S				SILT with some sand, grey. Soft, moist, low plasticity. Sand is fine to medium.
			100	HQTT		✱FC		-13.5	20.5 21.0								
								-14.0			MOL	M	S				Organic SILT with trace roots, dark brown. Soft, moist, low plasticity.
				SPT		2/4/13/ 22/15 for 65mm N>50		-14.5	21.5		SW	M	VD				Fine to medium SAND with minor silt, grey. Very dense, moist.
RICCARTON GRAVELS			31	HQTT				-15.0	22.0		GW	M	VD				Fine to medium GRAVEL, grey. Very dense, moist. Gravel is subrounded to subangular. Fines washed away during drilling process.
								-15.5	22.5								22.5 to 23.0m no recovery
				SPT		10/9/10/ 17/18/5 for 70mm N>50		-16.0	23.0		GW	M	VD				Sandy, fine to coarse GRAVEL, brown. Very dense, moist. Gravel is subrounded to subangular. Sand is fine to coarse. 23.3 to 24.5m no recovery
			28	HQTT				-16.5 -17.0	23.5 24.0								
				SPT		12/16/ 21/29 for 65mm N>50		-17.5	24.5								
									25								**End of borehole at 24.79mbgl.** Open Standpipe piezometer installed. Please see attached diagram in Appendix F.

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 28
Hole Location: 60 Grove Rd

SHEET 1 OF 6

PROJECT: CHRISTCHURCH CITY 2011 REMEDIATION	LOCATION: CENTRAL CITY	JOB No: 52000.3400
CO-ORDINATES 5740707.35 mN 2479140.92 mE	DRILL TYPE: Rotary	HOLE STARTED: 26/7/11
	DRILL METHOD: OB/HQTT	HOLE FINISHED: 28/7/11
R.L. 8.51 m		DRILLED BY: Pro-Drill
DATUM NZMG	DRILL FLUID: Mud	LOGGED BY: CP CHECKED: BMcD

GEOLOGICAL — ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
HAND DIG FILL. (Potholed for services check and backfilled.)			0	PRE-DUG				8.0 7.5	0.5 1.0							Fill: Borehole drilled through pre-dug and backfilled pothole.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)				SPT		0/0/0/0/1/1 N=2		7.0	1.5							1.5m to 1.95m no recovery
			71	OB		✱FC	B	6.5	2.0	SP	M	VL				Silty, fine SAND, grey. Very loose, moist.
								6.0	2.5	ML	M	S				Sandy SILT, grey. Soft, moist, low plasticity. Sand is fine. - organic fibrous material
																2.7m to 3.0m no recovery
				SPT		1/1/1/1/1/1 N=4		5.5	3.0	ML	W	S				SILT, grey. Soft, wet, low plasticity.
			71	OB		✱FC	B	5.0	3.5	SP	W	L				Silty, fine SAND, grey. Loose, wet.
								4.5	4.0							4.05m to 4.5m no recovery
				SPT		3/3/5/5/5/7 N=22		4.0	4.5			MD				- becoming medium dense
									5							4.8m to 4.95m no recovery

T+T DATATEMPLATE.GDT eek

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 28
Hole Location: 60 Grove Rd

SHEET 2 OF 6

PROJECT: CHRISTCHURCH CITY 2011 REMEDIATION
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5740707.35 mN
2479140.92 mE
R.L. 8.51 m
DATUM NZMG

DRILL TYPE: Rotary
DRILL METHOD: OB/HQTT
DRILL FLUID: Mud

HOLE STARTED: 26/7/11
HOLE FINISHED: 28/7/11
DRILLED BY: Pro-Drill
LOGGED BY: CP
CHECKED: BMcD

GEOLOGICAL: YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)

DEPTH (m)	R.L. (m)	CORE RECOVERY (%)	METHOD	TESTS	SAMPLES	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
5.0	3.5	29	OB			SP	W	MD	
						ML	W	VS	SILT, grey. Very soft, wet, low plasticity. 5.25m to 6.0m no recovery
5.5	3.0								
6.0	2.5		SPT	0/0/0/0/0/0 N=0					
6.5	2.0	95	OB						- fibrous organic material
7.0	1.5								
7.5	1.0		SPT	0/1/1/1/1/2 N=5				F	7.45m to 7.5m no recovery - becoming firm
8.0	0.5	100	OB	✱PSD WS	B				
8.5	0.0								- fibrous organic material - contains trace roots. Becoming bluish-grey.
9.0	-0.5		SPT	2/1/2/2/2/2 N=8					
9.5	-1.0	100	OB						
10									

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 28
Hole Location: 60 Grove Rd

SHEET 3 OF 6

PROJECT: CHRISTCHURCH CITY 2011 REMEDIATION
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5740707.35 mN
2479140.92 mE
R.L. 8.51 m
DATUM NZMG

DRILL TYPE: Rotary
DRILL METHOD: OB/HQTT
DRILL FLUID: Mud

HOLE STARTED: 26/7/11
HOLE FINISHED: 28/7/11
DRILLED BY: Pro-Drill
LOGGED BY: CP
CHECKED: BMcD

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)										ML	W	VS				SILT, grey. Very soft, wet, low plasticity. - contains trace wood - contains minor fine sand
				SPT		0/0/1/0/0/0 N=1		-2.0	10.5							
			100	OB				-2.5	11.0							
										SW	W	MD				Fine to coarse SAND with some silt, grey. Medium dense, wet.
				SPT		2/4/6/ 8/8/12 N=34		-3.0	11.5			D				- contains trace silt. Becoming dense.
			95	HQTT				-3.5	12.0							
				SPT		7/13/13/ 9/9/9 N=40		-4.0	12.5							12.45m to 12.5m no recovery - contains some fine to coarse gravel, grey. Gravel is subangular to subrounded. 12.7m to 13.4m no recovery
			71	HQTT				-4.5	13.0							
								-5.0	13.5	GW	W	D				Sandy, fine to coarse GRAVEL, grey. Dense, wet. Gravel is subangular to subrounded. Sand is fine to coarse. 13.7m to 14.0m no recovery
CHRISTCHURCH FORMATION (MARINE ESTUARINE)				SPT		2/3/3/5/7/7 N=22		-5.5	14.0	SW	W	MD				Fine to coarse SAND, grey. Medium dense, wet. 14.2m to 14.45m no recovery
			90	HQTT		✱FC	B	-6.0	14.5							
									15							

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 28
Hole Location: 60 Grove Rd

SHEET 4 OF 6

PROJECT: CHRISTCHURCH CITY 2011 REMEDIATION
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5740707.35 mN
2479140.92 mE
R.L. 8.51 m
DATUM NZMG

DRILL TYPE: Rotary
DRILL METHOD: OB/HQTT
DRILL FLUID: Mud

HOLE STARTED: 26/7/11
HOLE FINISHED: 28/7/11
DRILLED BY: Pro-Drill
LOGGED BY: CP
CHECKED: BMcD

GEOLOGICAL / ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	TESTS	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
CHRISTCHURCH FORMATION (MARINE ESTUARINE)						SW	W	MD	Fine to coarse SAND, grey. Medium dense, wet.
									15.4m to 15.5m no recovery
		SPT	3/4/6/6/9/9 N=30	-7.0	15.5			D	- becoming fine to medium SAND, dense
									- contains minor silt
	81	HQTT		-7.5	16.0				
				-8.0	16.5				
									16.8m to 17.0m no recovery
		SPT	2/3/5/ 7/10/10 N=32	-8.5	17.0				
	76	HQTT		-9.0	17.5				
				-9.5	18.0				
									- contains trace shells 18.25m to 18.95m no recovery
		SPT	1/0/0/1/1/0 N=2	-10.0	18.5				
	86	HQTT		-10.5	19.0	SW	M	MD	Interbedded SILT and fine to coarse SAND, bluish grey and grey, moist. Silt has low plasticity. Sand is medium dense.
				-11.0	19.5				
									19.85m to 20.0m no recovery
					20				

T+T DATATEMPLATE.GDT eek

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 28
Hole Location: 60 Grove Rd

SHEET 5 OF 6

PROJECT: CHRISTCHURCH CITY 2011 REMEDIATION
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES: 5740707.35 mN
2479140.92 mE
R.L.: 8.51 m
DATUM: NZMG

DRILL TYPE: Rotary
DRILL METHOD: OB/HQTT
DRILL FLUID: Mud

HOLE STARTED: 26/7/11
HOLE FINISHED: 28/7/11
DRILLED BY: Pro-Drill
LOGGED BY: CP
CHECKED: BMcD

GEOLOGICAL

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	TESTS
CHRISTCHURCH FORMATION (MARINE ESTUARINE)		SPT	1/1/2/2/3/4 N=11
	76	HQTT	
RICCARTON GRAVELS		SPT	5/19/20/30 for 75mm N>50
	38	HQTT	
		SPT	25/25 for 55mm N>50
	29	HQTT	
		SPT	2/2/2/ 4/10/10 N=26

R.L. (m)	DEPTH (m)
-12.0	20.5
-12.5	21.0
-13.0	21.5
-13.5	22.0
-14.0	22.5
-14.5	23.0
-15.0	23.5
-15.5	24.0
-16.0	24.5
	25

ENGINEERING DESCRIPTION

CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
SW	M	MD	Interbedded SILT and fine to coarse SAND, bluish grey and grey, moist. Silt has low plasticity. Sand is medium dense.
SW	M	MD	Fine to medium SAND with extremely closely spaced thin silt lense, brown. Medium dense, moist. 21.25m to 21.5m no recovery
SW	W	VD	Gravelly, fine to coarse SAND, mottled brown and grey. Very dense, wet. Gravel is fine to coarse, subangular to subrounded. 21.95m to 22.6m no recovery
GW	W	VD	Medium to coarse GRAVEL, grey. Very dense, wet. Gravel is subrounded to subangular. Fines washed away from drilling. 23.0m to 24.2m no recovery
GW	W	MD	Sandy, fine to coarse GRAVEL, mottled brown and grey. Medium dense, wet. Gravel is subangular to subrounded. Sand is medium to coarse.

SHEAR STRENGTH (kPa): 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250
DEFECT SPACING (mm): 50 250 1000 2000

T+T DATATEMPLATE.GDT eek

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 28
Hole Location: 60 Grove Rd

SHEET 6 OF 6

PROJECT: CHRISTCHURCH CITY 2011 REMEDIATION
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5740707.35 mN
2479140.92 mE
R.L. 8.51 m
DATUM NZMG

DRILL TYPE: Rotary
DRILL METHOD: OB/HQTT
DRILL FLUID: Mud

HOLE STARTED: 26/7/11
HOLE FINISHED: 28/7/11
DRILLED BY: Pro-Drill
LOGGED BY: CP
CHECKED: BMcD

GEOLOGICAL: GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION: SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

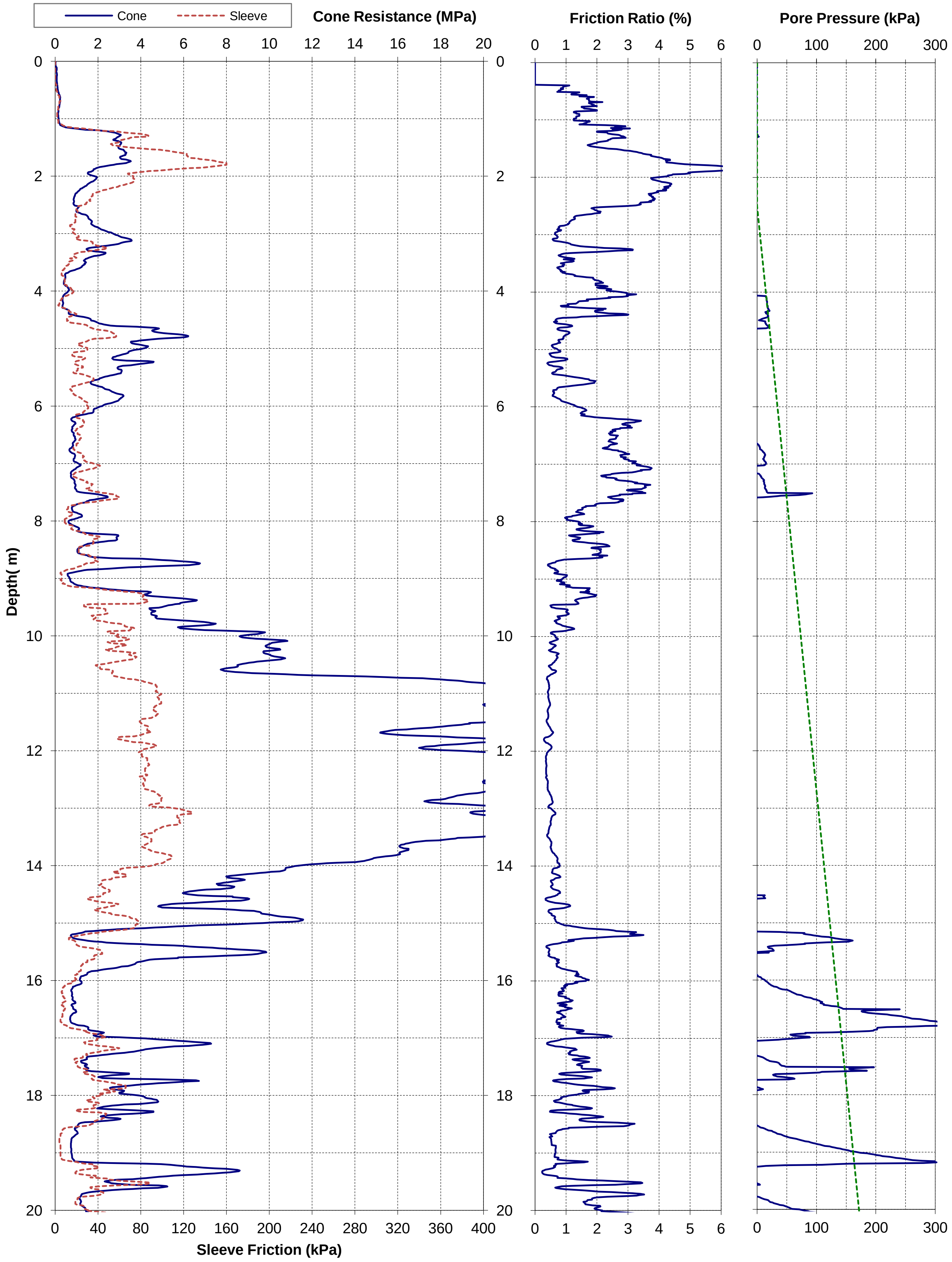
SHEAR STRENGTH (kPa): 10, 25, 50, 100, 200
COMPRESSIVE STRENGTH (MPa): 1, 5, 20, 50, 100, 250
DEFECT SPACING (mm): 50, 250, 1000, 2000

GEOLOGICAL UNIT	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL / ROCK DESCRIPTION
RICCARTON GRAVELS			33	HQTT							25.0m to 25.7m no recovery
								GW	W	D	Medium to coarse GRAVEL, grey. Dense, wet. Gravel is subrounded to subangular. Fines washed away from drilling.
				SPT		6/10/14 17/9 for 40mm N>50		GW	W	VD	Sandy, fine to coarse GRAVEL, mottled brown and grey. Very dense, wet. Gravel is subangular to subrounded. Sand is medium to coarse. 26.4m to 27.2m no recovery
			33	HQTT				GW	W	VD	Medium to coarse GRAVEL, grey. Very dense, wet. Gravel is subrounded to subangular. Fines washed away from drilling. 27.5m to 28.7m no recovery
				SPT		13/1415/ 18/18 for 55mm N>501					
			33	HQTT							
				SPT		4/4/10/ 17/27 for 25mm N>50		GW	W	VS	Sandy, fine to coarse GRAVEL, mottled brown and grey. Very dense, wet. Gravel is subangular to subrounded. Sand is medium to coarse.
											End of borehole at 29.35mbgl. Open Standpipe piezometer installed. Please see attached diagram in Appendix F.

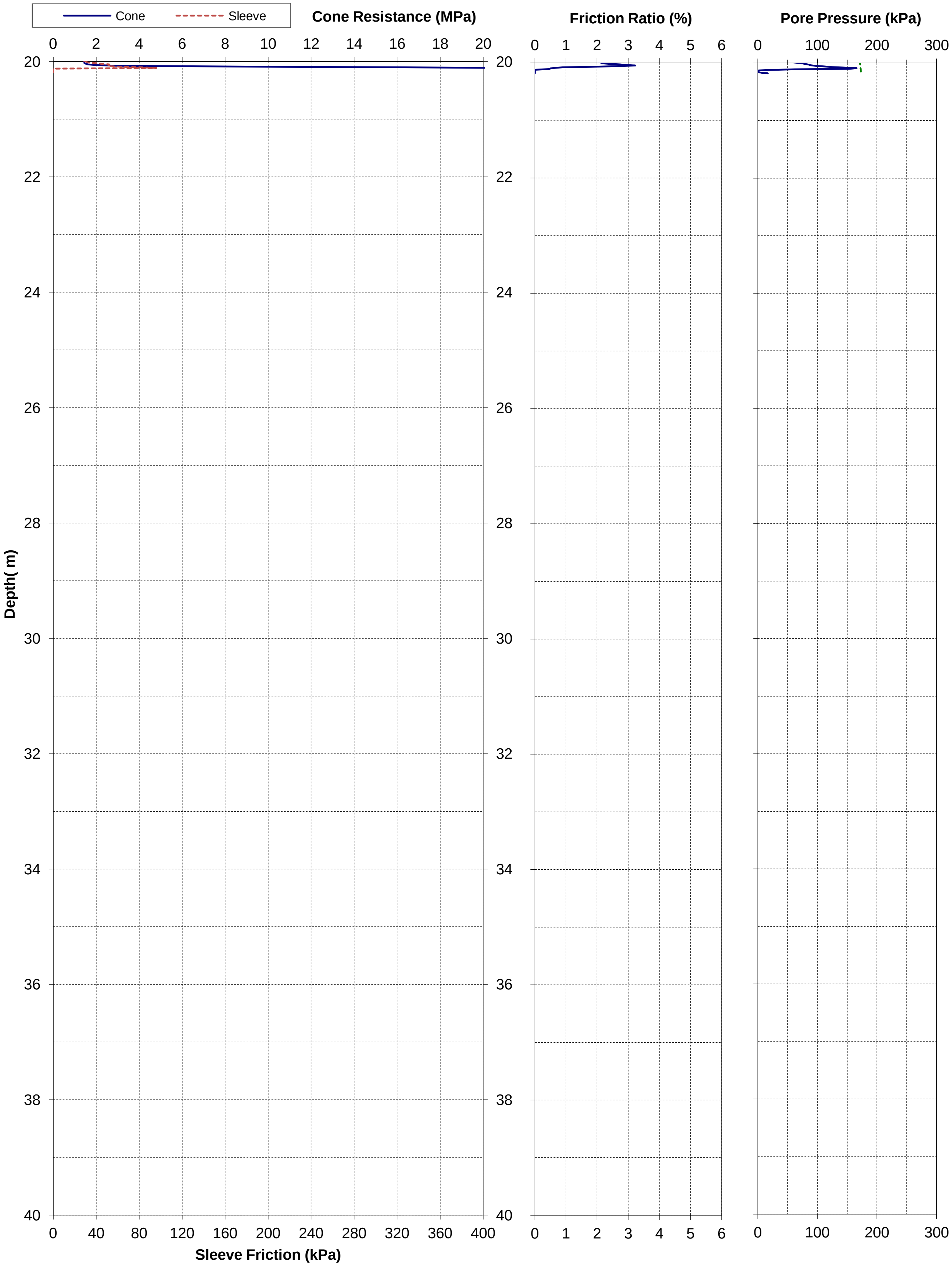
R.L. (m)	DEPTH (m)
-17.0	25.5
-17.5	26.0
-18.0	26.5
-18.5	27.0
-19.0	27.5
-19.5	28.0
-20.0	28.5
-20.5	29.0
-21.0	29.5
	30

T+T DATATEMPLATE.GDT eek

Project:	Christchurch 2011 Earthquake - CCC Ground Investigations			**Page:**	1 of 2	**CPT-CBD-83**	
Test Date:	20-Jul-2011	**Location:**	Central City	**Operator:**	Opus		
Pre-Drill:	1.5m	**Assumed GWL:**	2.5mBGL	**Located By:**	Survey GPS		
Position:	2479428mE	5741029.5mN	7.08mRL	**Coord. System:**	NZMG & MSL		
Other Tests:				**Comments:**			



Project:	Christchurch 2011 Earthquake - CCC Ground Investigations			**Page:** 2 of 2		**CPT-CBD-83**
Test Date:	20-Jul-2011	**Location:**	Central City	**Operator:**	Opus	
Pre-Drill:	1.5m	**Assumed GWL:**	2.5mBGL	**Located By:**	Survey GPS	
Position:	2479428mE	5741029.5mN	7.08mRL	**Coord. System:**	NZMG & MSL	
Other Tests:				**Comments:**		



Appendix C – Geotechnical Investigation Summary

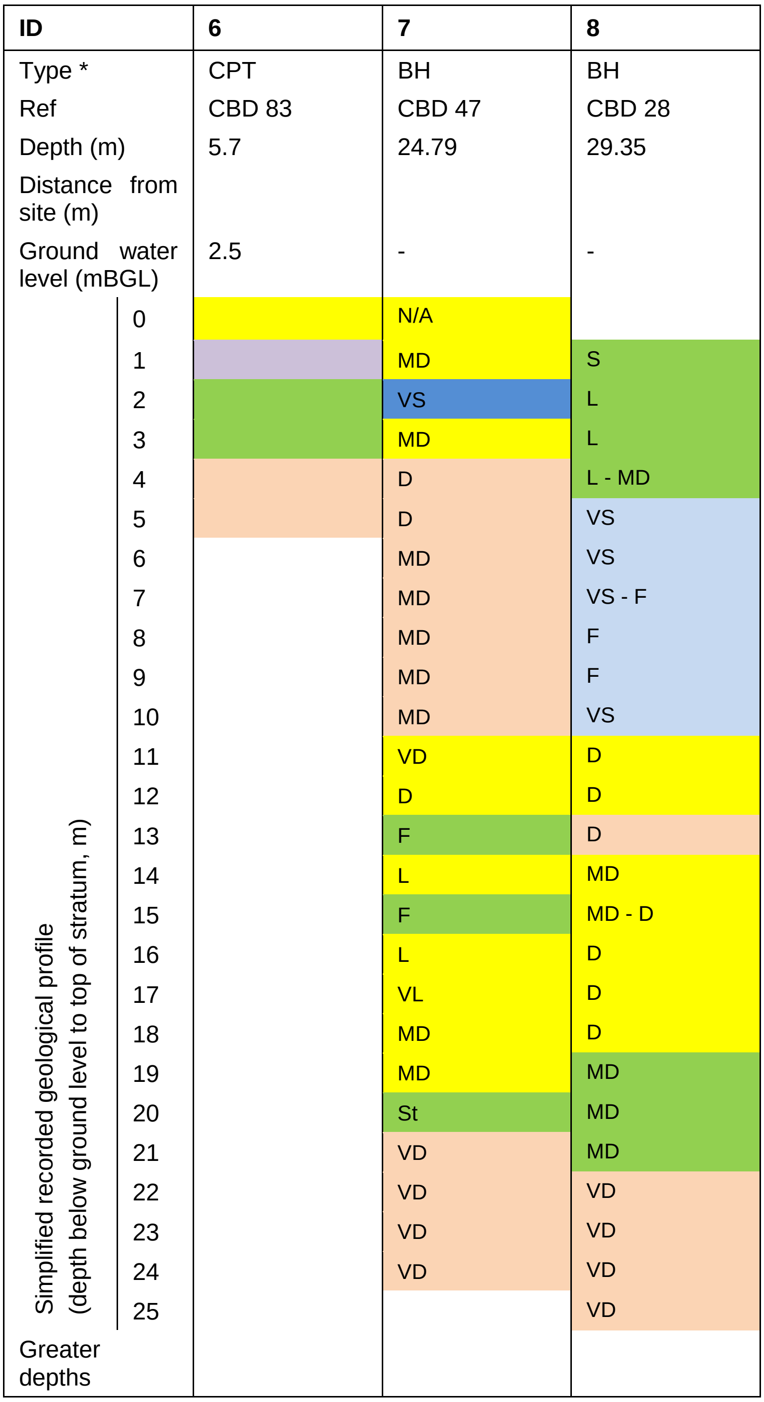
Table 1 Summary of most relevant investigation data

ID	1	2	3	4	5
Type *	WW	WW	WW	WW	WW
Ref	M35-11100	M35-13525	M35_13915	M35_13916	M35_11101
Depth (m)	6.9	2	5	4.8	7.8
Distance from site (m)					
Ground water level (mBGL)					
Simplified recorded geological profile (depth below ground level to top of stratum, m)					
0	🟨	🟨	🟦	🟦	🟨
1	🟨	🟩	🟦	🟦	🟦
2	🟨		🟩	🟩	🟨
3	🟨		🟩	🟩	🟨
4	🟩		🟩	🟩	🟦
5	🟩				🟨
6	🟨				🟨
7					🟨
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Greater depths					

*BH: Borehole, HA: Hand Auger, WW: Water Well, CPT: Cone Penetration Test

🟪 Sensitive or organic clay/silt
🟦 Clay to silty clay
▨ Clayey silt to silt
🟩 Silty sand to silt
▩ Clayey sand
🟨 Sand
🟧 Gravelly sand or gravel

VL = very loose, L = loose, MD = medium dense, D = dense, VD = very dense
VS = very soft, So = soft, F = firm, St = stiff, VS = very stiff, H = hard



ID		6	7	8
Type * Ref Depth (m) Distance from site (m) Ground water level (mBGL)		CPT CBD 83 5.7 2.5	BH CBD 47 24.79 -	BH CBD 28 29.35 -
Simplified recorded geological profile (depth below ground level to top of stratum, m)	0	🟨	🟨 N/A	
	1	🟪	🟨 MD	🟩 S
	2	🟩	🟦 VS	🟩 L
	3	🟩	🟨 MD	🟩 L
	4	🟧	🟧 D	🟩 L - MD
	5	🟧	🟧 D	▨ VS
	6		🟧 MD	▨ VS
	7		🟧 MD	▨ VS - F
	8		🟧 MD	▨ F
	9		🟧 MD	▨ F
	10		🟧 MD	▨ VS
	11		🟨 VD	🟨 D
	12		🟨 D	🟨 D
	13		🟩 F	🟧 D
	14		🟨 L	🟨 MD
	15		🟩 F	🟨 MD - D
	16		🟨 L	🟨 D
	17		🟨 VL	🟨 D
	18		🟨 MD	🟨 D
	19		🟨 MD	🟩 MD
	20		🟩 St	🟩 MD
	21		🟧 VD	🟩 MD
	22		🟧 VD	🟧 VD
	23		🟧 VD	🟧 VD
	24		🟧 VD	🟧 VD
	25			🟧 VD
Greater depths				

*BH: Borehole, HA: Hand Auger, WW: Water Well, CPT: Cone Penetration Test

🟪 Sensitive or organic clay/silt	🟦 Clay to silty clay	▨ Clayey silt to silt	🟩 Silty sand to silt
▧ Clayey sand	🟨 Sand	🟧 Gravelly sand or gravel	

VL = very loose, L = loose, MD = medium dense, D = dense, VD = very dense
VS = very soft, So = soft, F = firm, St = stiff, VS = very stiff, H = hard