Christchurch City Council

BU 0659-001 EQ2
Westminster Street Depot - Office/Amenities
280 Westminster Street

QUANTITATIVE REPORT
FINAL

- Rev C
- 25 September 2013

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BU 0659-001 EQ2
Westminster Street Depot - Office/Amenities
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QUANTITATIVE ASSESSMENT REPORT

FINAL

- Rev C
- 25 September 2013

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1. Executive Summary

1.1. Background

A Quantitative Assessment was carried out on the Westminster Street Depot - Office/Amenities building located at 280 Westminster Street. The building is a single storey structure, formed by resisting frame elements with masonry infill panels. An aerial photograph illustrating the area of the building is shown below in Figure 1. Detailed descriptions outlining the buildings age and construction type are given in Section 5.5 of this report.

Figure 1 Aerial Photograph of Westminster Street Depot - Office/Amenities

This Quantitative report for the building structure is based on the Engineering Advisory Group's "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings" (draft) July 2011, visual inspections on 16th August 2012 and 26th March 2013 and calculations.

1.2. Key Damage Observed

Key damage observed includes:-

- 0.3mm step cracking in some of the masonry walls
- 50 x 50 SHS columns supporting the canopy roof on the east side of the building have buckled

1.3. Critical Structural Weaknesses

No critical structural weaknesses have been identified.

1.4. Indicative Building Strength

As described in the Engineering Advisory Group's "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings" (draft) July 2011, we have assessed the capacity of the building as a percentage new building standard seismic resistance using the quantitative method. Our assessment included consideration of geotechnical conditions, existing earthquake damage to the building and structural engineering calculations to assess both strength and ductility/resilience.

The assessments were based on the following:

- On-site investigation to assess the extent of existing earthquake damage including limited intrusive investigation.
- Qualitative assessment of critical structural weaknesses (CSWs) based on review of available structural drawings and inspection where drawings were not available.
- A geotechnical desktop study of the site
- Assessment of the strength of the existing structures taking account of the current condition.

Any building that is found to have a seismic capacity less than 33% of the new building standard (NBS) is required to be strengthened up to a capacity of at least 67%NBS in order to comply with Christchurch City Council (CCC) policy - Earthquake-prone dangerous & insanitary buildings policy 2010.

Based on the information available, and using the Quantitative Assessment Procedure, the buildings original capacity has been assessed to be in the order of 43%NBS and post earthquake capacity in the order of 43%NBS, and is therefore no earthquake prone. The buildings post earthquake capacity excluding critical structural weaknesses is in the order of 43%NBS.

1.5. Recommendations

Based on the findings of this assessment indicating the building is in the order of 43 %NBS, strengthening is required in order to comply with Christchurch City Council (CCC) policy – Earthquake-prone dangerous & insanitary buildings policy 2010. If the building is strengthened it is recommended that the size and spacing of column reinforcing is confirmed, and a geotechnical investigation is carried out.

It is recommended that:

a) There is no damage within the building that would cause it to be unsafe to occupy.
b) We consider that barriers around the building are not necessary.

2. Introduction

Sinclair Knight Merz were engaged by Christchurch City Council to carry out a Quantitative Assessment of the seismic performance of 280 Westminster Street.

The scope of this quantitative analysis includes the following:

- Analysis of the seismic load carrying capacity of the building compared with current seismic loading requirements or New Buildings Standard (NBS). It should be noted that this analysis considers the building in its damaged state where appropriate.
- Identify any critical structural weaknesses which may exist in the building and include these in the assessed %NBS of the structure.

The recommendations from the Engineering Advisory Group[1] were followed to assess the likely performance of the structures 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[2].

This assessment identified that the seismic capacity of the building was likely to be less than 33% of the new building standard (NBS). A quantitative assessment was recommended to confirm the initial assessment findings and to determine a more accurate seismic rating of the building.

At the time of this report, only limited intrusive investigation had been carried out. Construction drawings were not available. The building description below is based on our visual inspections as well as our site measure and cover meter survey.

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[1] EAG 2011, *Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury - Draft*, p 10

[2] 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 1 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 compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year). It is noted that the current seismic risk in Christchurch results in a 6% risk of exceedance in the next year.

- **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 a single storey structure, formed by moment resisting frames (concrete columns and steel beams) with masonry infill panels, located at 280 Westminster Street. The roof is clad with corrugated iron. The building has a party wall creating two units so there are two separate entrances, an entrance on east of the building and an entrance on the west of the building. A canopy roof shelters the pavement along the eastern side of the building. The building has a concrete slab on grade with edge thickenings.

Drawings of the structure were not made available. Our evaluation was based on the exterior and interior inspections on 16th August 2012 and 26 March 2013. Based on the architecture and the condition of the building we believe it was built in the 1980's.

5.2. Gravity Load Resisting system

The majority of the roof structure is being supported by steel beams that transfer the loads to concrete columns, which are being supported by the concrete foundations. Other parts of the roof structure are being supported by the internal masonry walls which in turn are being supported by a concrete slab on grade.

5.3. Seismic Load Resisting system

For the purposes of this report the along direction of the building is defined as being the northeast-southwest direction and the across direction is defined as being in the northwest-southeast direction.

Lateral loads on the building in the across direction, are carried by the portal frames, or portal frames with masonry infill panels. In the along direction, the loads are carried by frame columns with masonry infill panels. There are no beams to form portal frames in the along direction, the loads that are transferred to the columns come from the beams or walls in the across direction.

5.4. Geotechnical Conditions

A geotechnical desktop study was carried out for adjacent buildings, but the information contained within are thought to be relevant. The main conclusions from this report are:

- No apparent evidence of liquefaction was observed on the site; however, there was some settlement (approximately 150 mm) in the external concrete slab on the eastern side of the building.
- As per the geotechnical report, the site subsoil classification is class D
- Liquefaction risk is expected to be low to moderate for the site. However, additional investigations closer to the site are required to confirm this assessment.

A copy of this study is included here as Appendix 3 – Geotechnical Desk Study

5.5. Building Damage

SKM undertook inspections on the 16th August 2012. The following areas of damage were observed during the time of inspection:

1) 0.3mm step cracking in some of the masonry walls
2) 50 x 50 SHS columns supporting the canopy roof on the east side of the building are bent outwards at the centre.

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

6. Available Information and Assumptions

6.1. Available Information

Following our inspections on the 16th August 2012 and 26th March 2013, SKM carried out a seismic review on the structure. This review was undertaken using the available information which was as follows:

- SKM site measurements and inspection findings of the building. Please note no intrusive investigations were undertaken.
- Structural drawings were not available

6.2. Survey

A survey was carried out on this building by CityCare on 29th August 2012.

The survey showed that most of the structure was generally level, with slopes within the maximum slope indicated in the "DBH Revised guidance on repairing and rebuilding houses affected by the Canterbury earthquake sequence" of 0.5%. Three rooms had levels taken which showed the floor was sloping towards the middle of the rooms with a slope greater than 0.5%, it is likely that this fall was provided for drainage purposes, however this needs to be verified.

The pavement on the southeast of the building beneath the veranda was shown to be out of level with a slope of 3.3%, this is outside the maximum slope indicated in the "DBH Revised guidance on repairing and rebuilding houses affected by the Canterbury earthquake sequence" of 0.5%, it is recommended that this slope is corrected.

6.3. Assumptions

The assumptions made in undertaking the assessment include:

- The building was built according to good practice at the time.
- The soil was assumed to be Class D as described in AS/NZS1170.5:2004, Clause 3.1.3, Soft Soil. This is a conservative assumption based on our experience of soils around Christchurch.
- Standard design assumptions 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 for loss of human life, or considerable economic, social or environmental consequence of failure.
- The building has a short period less than 0.4 seconds.
- Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011

- The following ductility criteria used in the building:
- **Table 2: Assumed Building Ductility**

Building	Ductility of Building in Current State
280 Westminster Street	1.25

  - Ductility level of 1.25 represents a nominally ductile structure which is considered appropriate given the steel-concrete portal frames and masonry infill panels.
- The following material properties were used in the analyses:
- **Table 3: Material Properties**

Material	Nominal Strength	Structural Performance
Structural Steel	f_y = 300MPa	S_p = 0.9
Masonry (unreinforced)	f_m = 12MPa	S_p = 0.9
Concrete	f_c' = 20MPa	S_p = 0.9

- The building is mainly formed by moment resisting frames with masonry infill panels. The procedure recommended in the "*Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*, NZSEE 2006" for this kind of structure was followed, although some considerations were made due to the fact that the building has not beams in the along direction.
- It was assumed a longitudinal reinforcement in the columns of 6 bars of 12mm and a transverse reinforcement of 8mm bars at 250mm. It is recommended an intrusive inspection to confirm these assumptions.

The detailed engineering analysis is a post construction evaluation. Since SKM did not complete a full design and construction monitoring, it has the following limitations:

- It is not likely to pick up on any concealed construction errors (if they exist)
- Other possible issues that could affect the performance of the building such as corrosion and modifications to the structure will not be identified unless they are visible and have been specifically mentioned in this report.
- The detailed engineering evaluation deals only with the structural aspects of the structure. Other aspects such as building services are not covered.

6.4. The Detailed Engineering Evaluation (DEE) process

The DEE is a procedure written by the Department of Building and Housing's Engineering Advisory Group and 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[3].

The procedure of the DEE is as follows:

1) Qualitative assessment procedure
    a. Determine the building's status following any rapid assessment that have been done
    b. Review any existing documentation that is available. This will give the engineer an understanding of how the building is expected to behave. If no documentation is available, site measurements may be required
    c. Review the foundations and any geotechnical information available. This will include determining the zoning of the land and the likely soil behaviour, a site investigation may be required
    d. Investigate possible Critical Structural Weaknesses (CSW) or collapse hazards
    e. Assess the original and post earthquake strength of the building (this assessment is subsequently superseded by the quantitative assessment)
2) Quantitative procedure
    a. Carry out a geotechnical investigation if required by the qualitative assessment
    b. Analyse the building according to current building codes and standards. Analysis accounts for damage to the building.

The DEE assessment 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 4. 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[4]. Buildings that are identified to be earthquake prone are required by law to be strengthened within 30 years of the owner being notified that the building is potentially earthquake prone[5].

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3 http://resources.ccc.govt.nz/files/EarthquakeProneDangerousAndInsanitaryBuildingsPolicy2010.pdf
4 NZSEE 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes,* p 2-2
5 http://resources.ccc.govt.nz/files/EarthquakeProneDangerousAndInsanitaryBuildingsPolicy2010.pdf

- **Table 4: DEE 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 DEE method rates buildings based on the plans (if available) and other information known about the building 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 DEE does also consider Serviceability Limit State (SLS) performance of the building and or the level of earthquake that would start to cause damage to the building but this result is secondary to the ULS performance.

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

- AS/NZS 1170 parts 0, 1 and 5 Structural Design Actions
- NZS 3101:2006 Concrete Structures Standard
- NZS 3404:1997 Steel Structures Standard
- NZS 2606:1993 Timber Structures Standard
- NZS 4230:1990 Design of Reinforced Concrete Masonry Structures

7. Results and Discussions

7.1. Critical Structural Weaknesses

No critical structural weaknesses have been identified.

7.2. Analysis Results

The equivalent static force method was used to analyse the seismic capacity of the building. The results of the analysis are reported in the following table as %NBS. The results below are calculated for the building in its damaged state. The building results have been broken down into their seismic resisting elements.

(%NBS = the reliable strength / new building standards)

Table 5: DEE Results

Building	Seismic Resisting Element	Action	Seismic Rating %NBS
Westminster Street Depot - Office/Amenities	Masonry infill panels (Across direction)	Out of plane bending	43%
	Frame columns (Along direction)	Shear	56%
	Masonry infill panels (Along direction)	Out of plane bending	57%
	Frame columns (Across direction)	Shear	69%
	Infill panels (Along direction)	Shear	80%
	Infill panels (Across direction)	Shear	>100%

7.3. Recommendations

It is recommended that prior to strengthening the building the concrete column shear reinforcing size and spacing is confirmed.

If it is determined that the building should be repaired there are a number of issues which will need to be investigated and associated documents prepared in order to submit a building consent application. These issues will need to be considered during the initial phase of strengthening works.

8. Conclusion

SKM carried out a quantitative assessment on BU 0659-001 EQ2 located at 280 Westminster Street. This assessment concluded that the building is classified as Moderate risk building.

Table 6: Quantitative assessment summary

Description	Grade	Risk	%NBS	Structural performance
Westminster Street Depot - Office/Amenities	C	Moderate	43%	Acceptable legally. Improvement recommended.

If the building is strengthened it is recommended that the size and spacing of column reinforcing is confirmed, and a geotechnical investigation is carried out.

It is recommended that:

a) There is no damage within the building that would cause it to be unsafe to occupy.
b) We consider that barriers around the building are not necessary.

9. 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.

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.

10. Appendix 1 – Photos

	
Photo 1: View along the east side of the building (1)	Photo 2: West Entrance
	
Photo 3: View inside the west end of the building, entrance from photo 2 is shown on the right	Photo 4: View inside the west end of the building

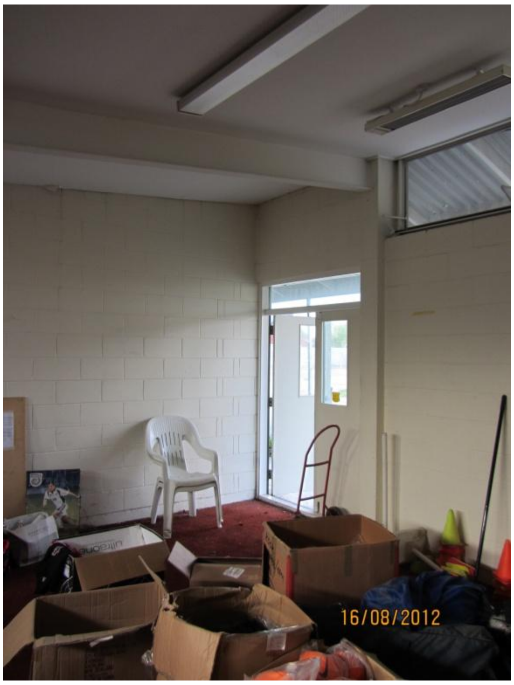

Photo 5: View of the partition wall with the portal frame and the concrete encased column

Photo 6: View of the east side of the building

Photo 7: View along the east side of the building (2)

Photo 8: 0.3mm crack found in one of the interior masonry walls in the west partition

Photo 9: East entrance

Photo 10: Opening in the east end of the building (1)

Photo 11: Opening in the east end of the building (2)

Photo 12: View of the beam and wall connection

Photo 13: Inteior view of the east partition (1)

Photo 14: Inteior view of the east partition (2)

	
Photo 15: View of one of the interior masonry walls in the east partition, showing location of crack (1)	Photo 16: Close up view of one of the interior masonry walls in the east partition, showing location of crack (2)
	
Photo 17: Close up view from photo 16	

11. Appendix 2 – CERA Standardised Report Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Westmintser Street Depot - Office/Amenities	Reviewer:	N Calvert
	Unit / No: / Street	CPEng No:	242062
Building Address:	280 Westminster Street	Company:	Sinclair Knight Merz
Legal Description:		Company project number:	ZB01276.182
		Company phone number:	940 4900
	Degrees / Min / Sec		
GPS south:		Date of submission:	25-Sep
GPS east:		Inspection Date:	16/08/2012
		Revision:	C
Building Unique Identifier (CCC):	PRO 0659-001	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	0
Soil type:		Soil Profile (if available):	
Site Class (to NZS1170.5):	C		
Proximity to waterway (m, if <100m):		If Ground improvement on site, describe:	NA
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	0.00

Building

No. of storeys above ground:	1	single storey = 1 / Ground floor elevation (Absolute) (m):	0.00
Ground floor split?	yes	Ground floor elevation above ground (m):	0.00
Storeys below ground	0		
Foundation type:	strip footings	if Foundation type is other, describe:	
Building height (m):	4.50	height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	545		
Age of Building (years):	30	Date of design:	1976-1992
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	institutional	Brief strengthening description:	
Use (upper floors):			
Use notes (if required):			
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	frame system		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:	concrete flat slab	slab thickness (mm)	
Beams:	steel non-composite	beam and connector type	310deep x 110 I beam
Columns:	cast-insitu concrete	typical dimensions (mm x mm)	300x200
Walls:	partially filled concrete masonry	thickness (mm)	190

Lateral load resisting structure

Lateral system along:	concrete frame with infill	**Note: Define along and across in detailed report!**	note total length of wall at ground (m):	
Ductility assumed, μ:	1.25		wall thickness (m):	190
Period along:	0.40	##### enter height above at H31	estimate or calculation?	estimated
Total deflection (ULS) (mm):	20		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):	20		estimate or calculation?	estimated
Lateral system across:	concrete frame with infill		note total length of wall at ground (m):	
Ductility assumed, μ:	1.25		wall thickness (m):	190
Period across:	0.40	##### enter height above at H31	estimate or calculation?	estimated
Total deflection (ULS) (mm):	20		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):	20		estimate or calculation?	estimated

Separations:

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

Non-structural elements

Stairs:			
Wall cladding:	brick or tile	describe (note cavity if exists)	
Roof Cladding:	Metal	describe	corrugated iron
Glazing:	aluminium frames		
Ceilings:	fibrous plaster, fixed		
Services(list):	electrical		

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	none	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:		Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	1:250-1:150	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 how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			
Diaphragms	Damage?:		Describe:	
CSWs:	Damage?:	yes	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	0.3mm step cracks in masonry, deformation of canopy columns	Describe:	

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

Recommendations

Level of repair/strengthening required:	minor structural	Describe:	
Building Consent required:	no	Describe:	
Interim occupancy recommendations:	full occupancy	Describe:	

Along	Assessed %NBS before:	56%	%NBS from IEP below	If IEP not used, please detail assessment methodology:	Quantitative Assessment
	Assessed %NBS after:	56%			
Across	Assessed %NBS before:	43%	%NBS from IEP below		
	Assessed %NBS after:	43%			

12. Appendix 3 – Geotechnical Desk Study

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Saint Albans
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Christchurch, New Zealand

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1. Christchurch City Council - Structural Engineering Service

2. Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	041 to 042 inclusive
Address	264 Westminster St
Report date	03 April 2012
Author	Ananth Balachandra / Ross Roberts
Reviewer	Leah Bateman
Approved for issue	Yes

3. 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.

4. Scope

This geotechnical desk top study incorporates information sourced from:

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

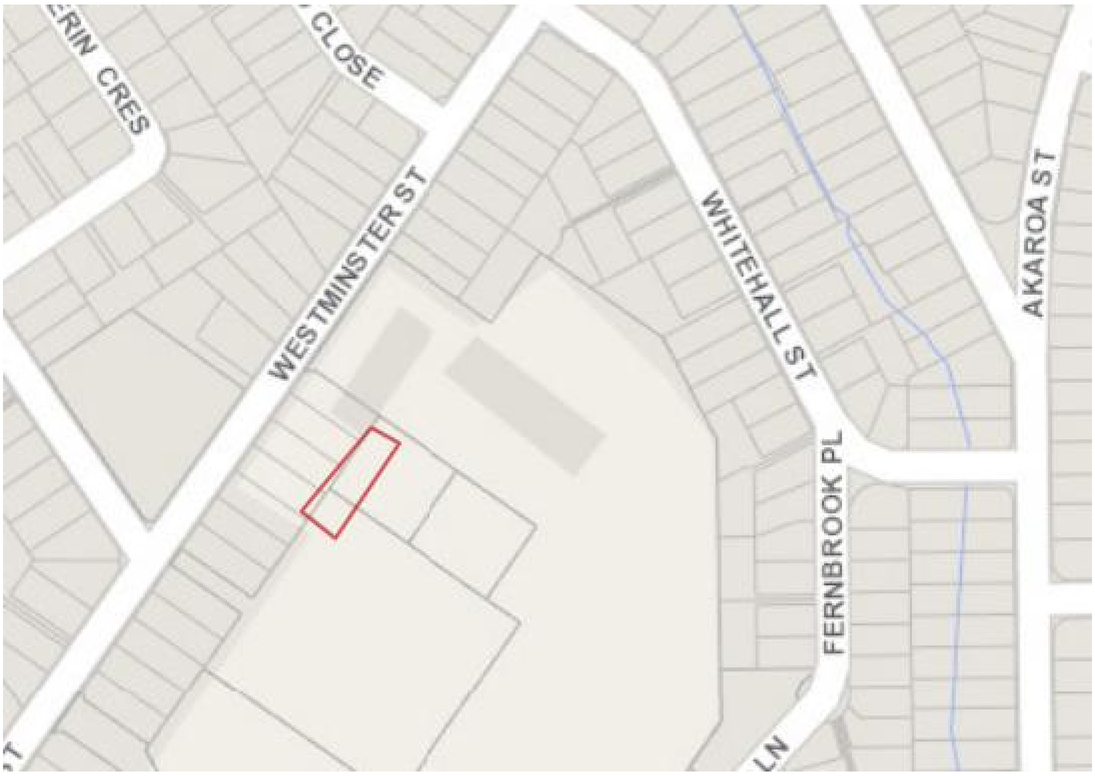
5. Limitations

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.

6. Site location



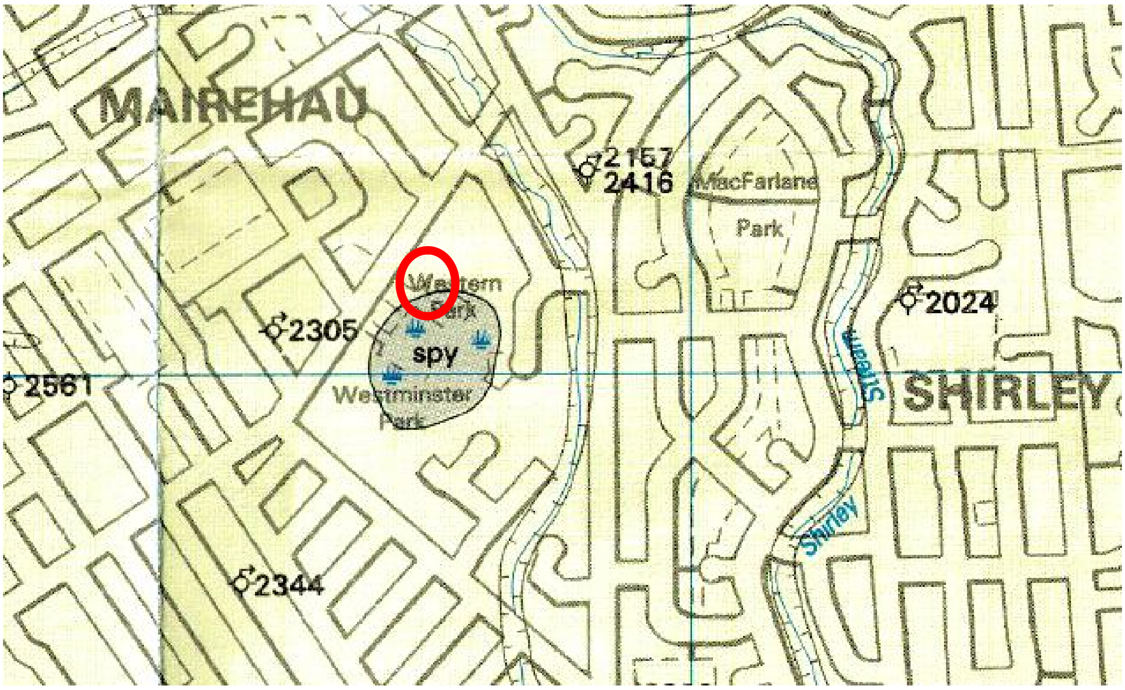
- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

The structures are located on 264 Westminster St at grid reference 1571472 E, 5183547 N (NZTM).

7. Review of available information

7.1 Geological maps

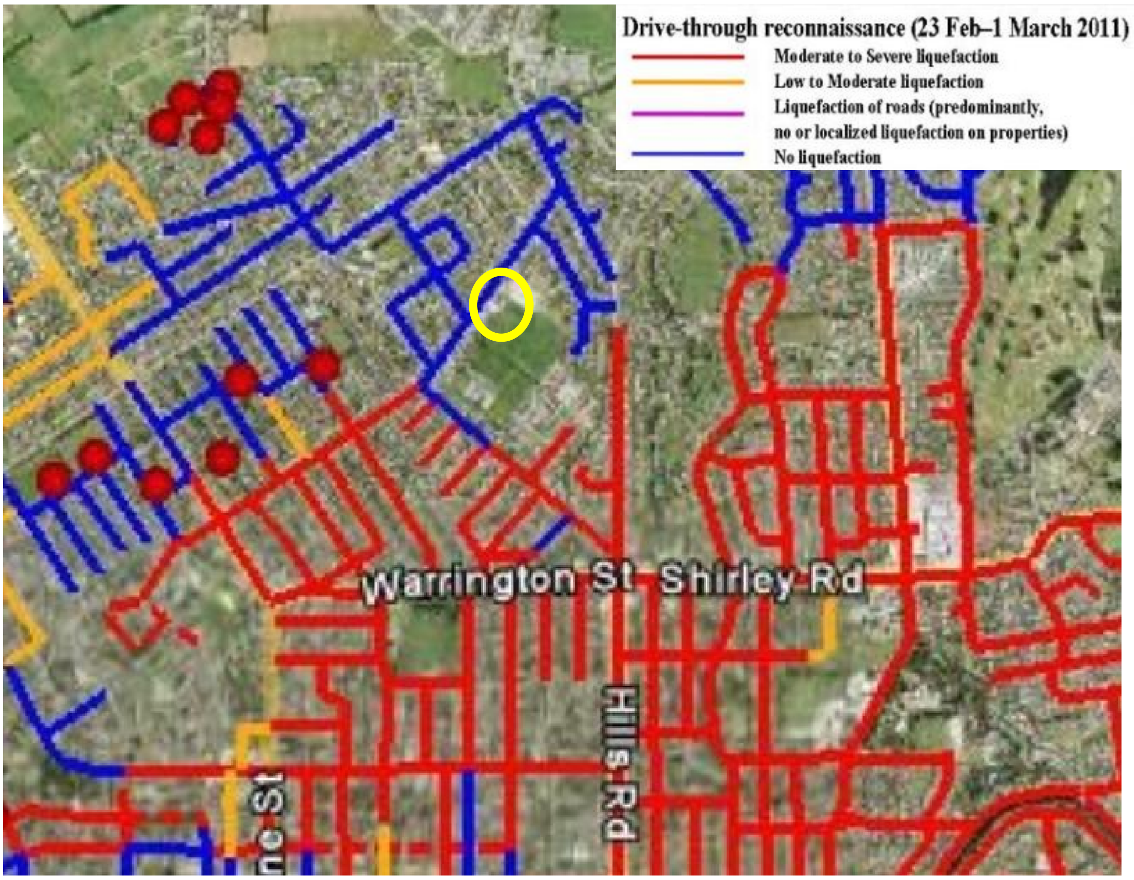
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



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

Most of the site is shown to be underlain by Holocene deposits comprising predominantly alluvial sand and silt over bank deposits of the Springston Formation. The ground immediately south east of the site is shown to be underlain by peat swamp deposits, now drained, of the Springston Formation.

7.2 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 no liquefaction at this site.

7.3 Aerial photography

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

The dark patches at the front of the property may be evidence of liquefied material and pore water being ejected to the surface. Similar dark patches were observed from aerial photographs taken after the September 2010, June 2011 and December 2011 earthquake events. As no liquefaction was observed in the mapping exercise the dark colouration may also be water from a broken water main or leaking hydrant.

7.4 CERA classification

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

- Zone: Green
- DBH Technical Category: N/A (Urban Non-residential) – with properties surrounding the site classed as TC2

7.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the site was recorded as grassland in1856. However, as geological maps show some areas near the site to be underlain by swamp deposits, it is possible some of the site used to be swamp or marshland. These areas are likely to be underlain by soft deposits including potentially compressible peat deposits.

7.6 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.

7.7 Council property files

The available council property files pertain to the reworking of the Westminster drain. The work includes naturalising the drain by using an open channel with sloping side embankments replacing the existing pipe and timber supported open channel drain.

Council records show significant earthworks were proposed in constructing the new drain. However, no record on the material excavated was found in the available council records. Additionally, no information regarding the community building or underlying ground conditions was found during the review of council files.

The drawings for the proposed drain show the sides of the channel to slope at a grade of 1V:3H to 1V:2.5H. Additionally the drawings show up to 300mm of top soil on the slopes of the channel and AP40 compacted layer used at the base of the channel. An Amoco 4550 Geotextile is shown to be installed under the AP40 compacted layer.

7.8 Site walkover

An engineer from SKM undertook a site walkover in the week commencing 12 March 2012.

Both of the buildings on site were concrete and metal roof constructions. Some cracks in the walls of buildings were observed during the external inspection of the site. The windows on both of the building were boarded up but it is unknown if this is a result of earthquake damage. There were no signs that liquefaction occurred at the site. The site was asphalted to the NW, with large playing field to the SE of the building. There was no obvious land damage on site.

- **Figure 7 Observed cracks in the Westminster Street community building**

- **Figure 8 Overview of the Westminster community building**

8. Conclusions and recommendations

8.1 Site geology

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

Depth range (mBLG)	Soil type
0 – 3	Sensitive fine grained soils (clay or silt) and peat deposits.
3 – 5	Firm clays, silty clays and clayey silts.
5 -9	Medium dense sand and silty sand.
9 - 25+	Dense sand.

However, it should be noted that most of the available investigation data were located a significant distance away from the site. Additionally, a different underlying geology immediately south east of the site was inferred from the local geological maps. Therefore, additional investigations near the site would be needed to confirm the boundary of the swamp peat deposits present south east of the site.

8.2 Seismic site subsoil class

In accordance with NZS1170.5 the site is likely to be seismic subsoil Class D (deep or soft soil) from adjacent borehole logs. It should be noted the nearest borehole log is 90m from the site and therefore it is possible to site could be subsoil Class E.

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 second preferred method has been used to make the assessment however the distance to the nearest ground investigation information is 90m. It is therefore possible that site specific investigation could revise the site class.

8.3 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.

8.4 Ground performance and properties

Liquefaction risk is expected to be low to moderate for the site. However, additional investigations closer to the site are required to confirm this assessment. An estimation of the ground properties for the site has not been made in this desk study. Most of the available investigation data are located at a significant distance away from the site. Additionally, there are uncertainties regarding the underlying geology due to the presence of swamp deposits immediately south east of the site. Therefore, additional investigations are required in order to provide an estimate of the ground properties.

8.5 Further investigations

Additional investigations recommends are:

- Two boreholes to a minimum depth of 20m. One borehole to be located south east of the existing buildings
- Three dynamic cone penetration tests to estimate likely properties of the soil near the surface

9. 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/)

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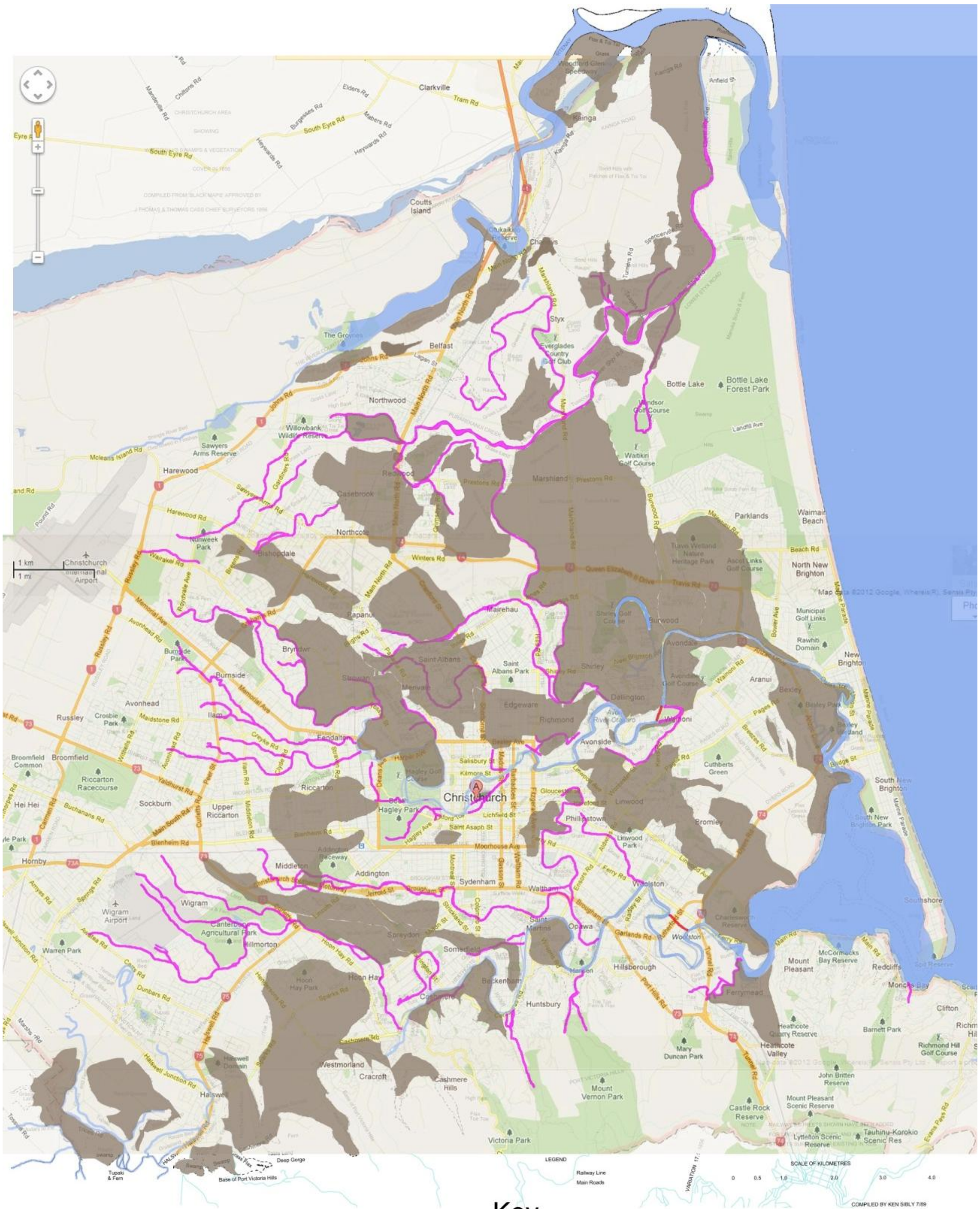
10. Appendix A – Christchurch 1856 land use



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

11. Appendix B – Existing ground investigation logs

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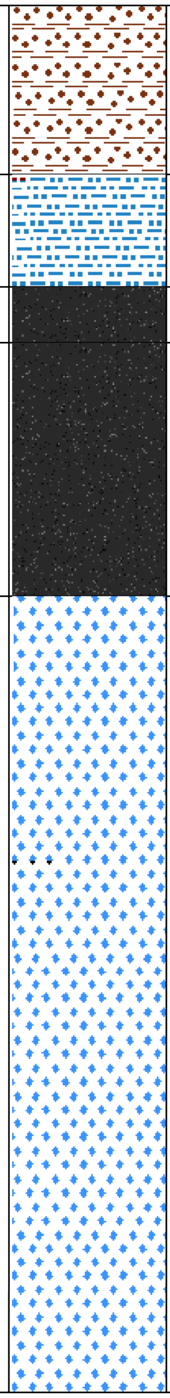
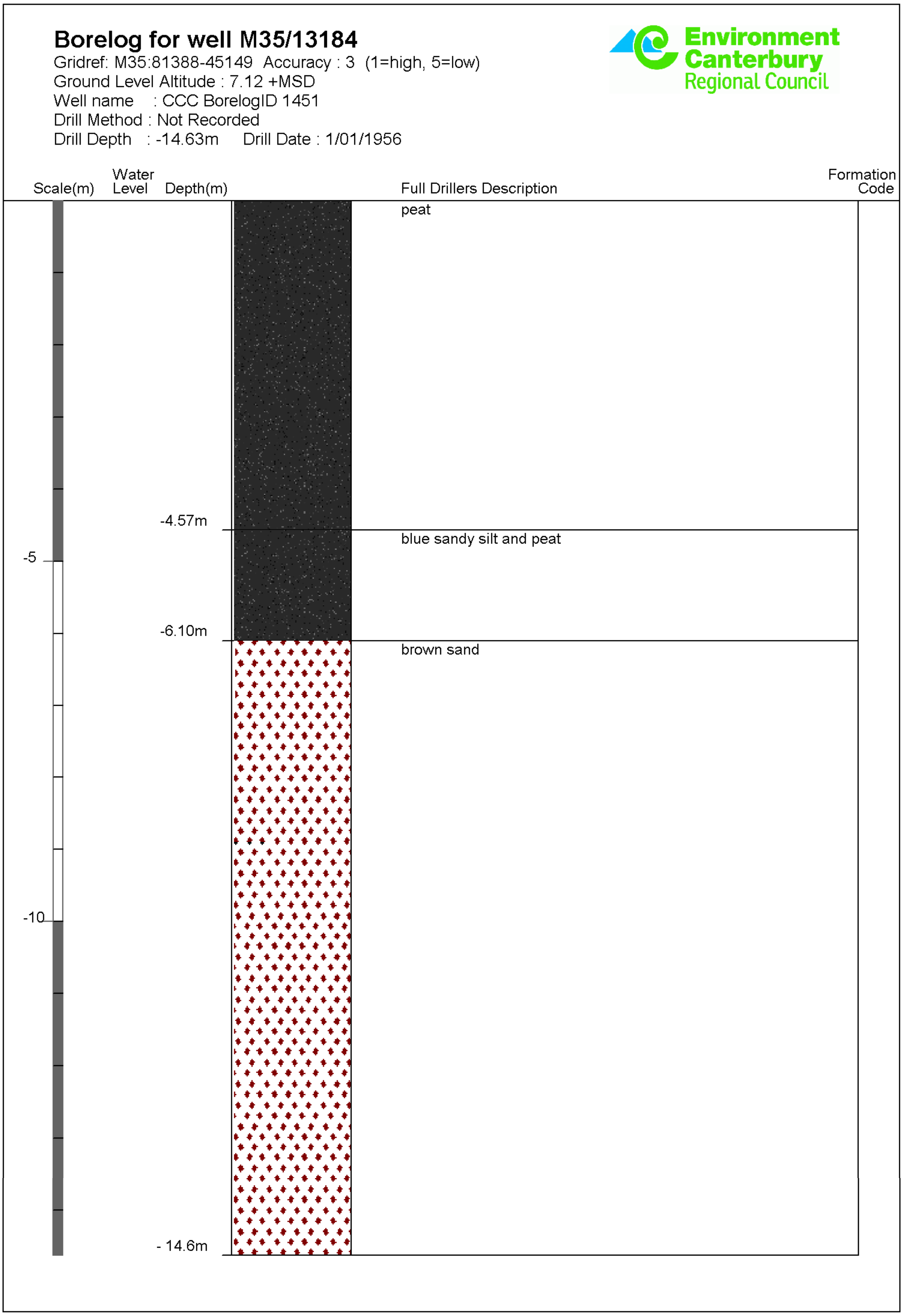
Borelog for well M35/13177

Gridref: M35:81232-45318 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.27 +MSD
Well name : CCC BorelogID 1444
Drill Method : Not Recorded
Drill Depth : -15.04m Drill Date : 1/01/1956

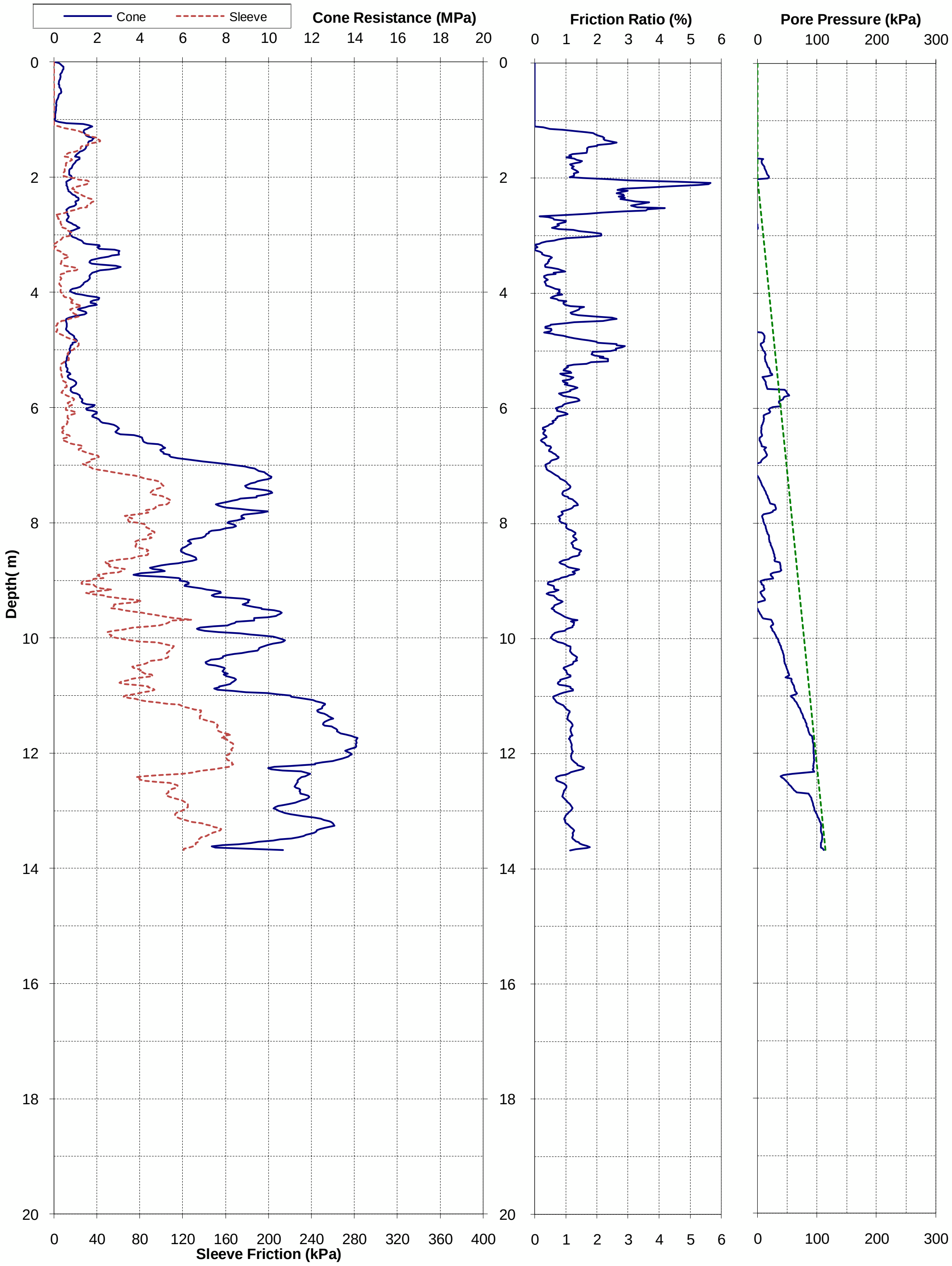
Environment Canterbury Regional Council



Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
			brown clay and sand	
		-1.83m	blue sandy silt	
		-3.05m	peat	
		-3.66m	blue peat and sandy silt	
-5				
		-6.40m	blue sand	
-10				
-15		- 15.0m		

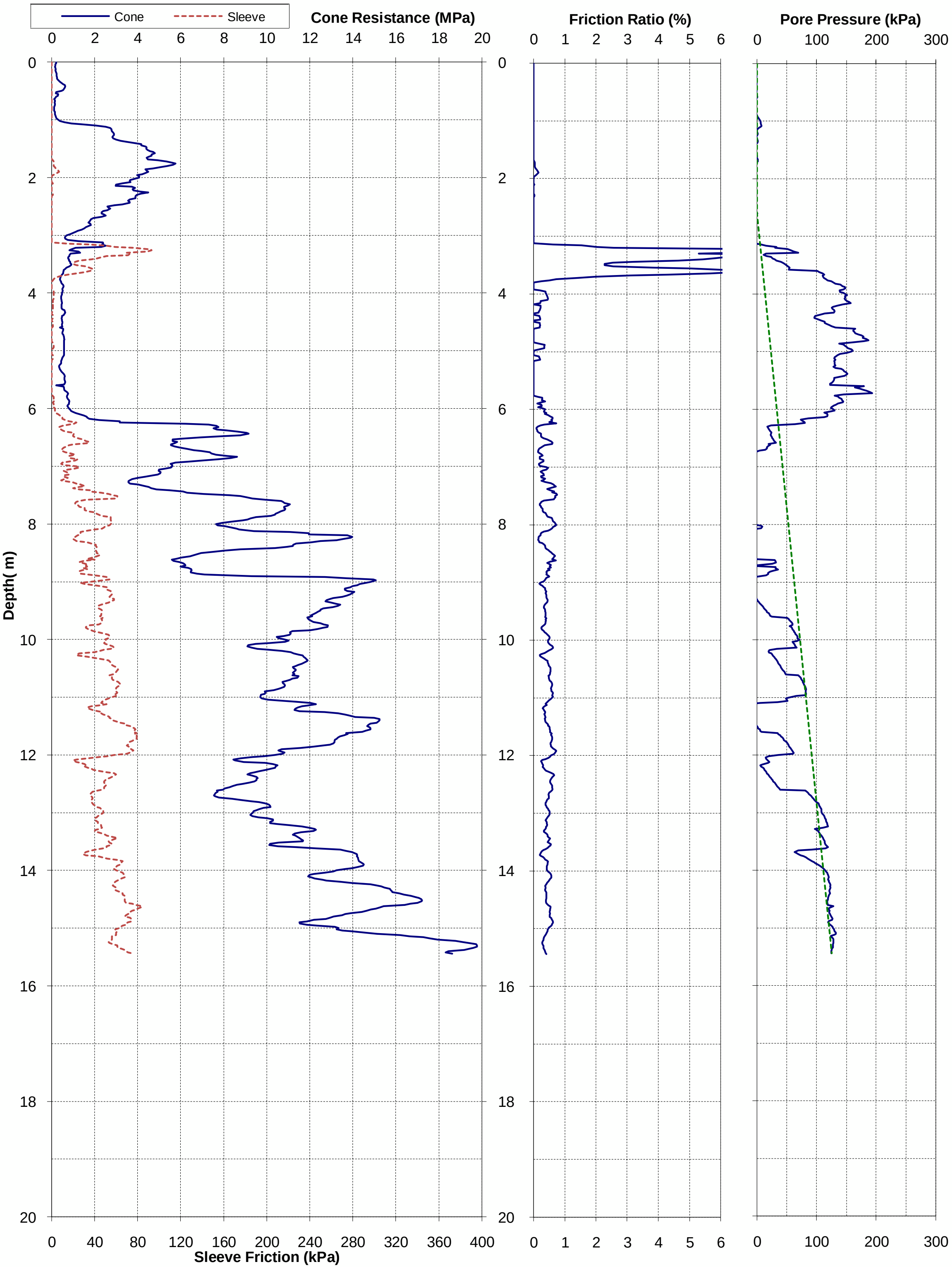

Borelog for well M35/13184
Gridref: M35:81388-45149 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.12 +MSD
Well name : CCC BorelogID 1451
Drill Method : Not Recorded
Drill Depth : -14.63m Drill Date : 1/01/1956
Environment Canterbury Regional Council
Scale(m)
Water Level
Depth(m)
Full Drillers Description
Formation Code
peat
-4.57m
blue sandy silt and peat
-5
-6.10m
brown sand
-10
- 14.6m

Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			**Page:**	1 of 1	**CPT-STA-57**	
Test Date:	25-May-2011	**Location:**	St Albans	**Operator:**	Geotech		
Pre-Drill:	1.2m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS		
Position:	2481801.4mE	5744879.2mN	5.35mRL	**Coord. System:**	NZMG & MSL		
Other Tests:				**Comments:**			



T+T Ref: 52000.3000 Printed: 12/08/2011 11:07 a.m. Template: CPT Graph Template v0.41.xls

Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	1 of 1	CPT-SHY-21
Test Date:	20-Jun-2011	Location:	Shirley	Operator:	Geotech	
Pre-Drill:	1.2m	Assumed GWL:	2.6mBGL	Located By:	Survey GPS	
Position:	2481842.9mE	5745056.1mN	5.43mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



T+T Ref: 52000.3000 Printed: 8/09/2011 3:34 p.m. Template: CPT Graph Template v0.41.xls

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Borelog for well M35/10325 page 1 of 4

Gridref: M35:81819-45310 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.95 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -116.1m Drill Date : 10/06/2005

Environment Canterbury Regional Council

Scale(m): -5, -10, -15, -20, -25

Depth(m)	Full Drillers Description	Formation Code
-0.30m	Topsoil	sp
-2.40m	Silt, brown	sp
- 17.3m	Sandy silt, trace wood fragments thoughout. Grey & brown silt @3m	sp-ch
- 17.5m	Wood, relic tree stump	ch
- 20.3m	Silt with shells and wood throughout, blue / grey. Dark grey medium sand & shells (mainly cockle, some oyster) @ 18m	ch
- 22.7m	Gravel (fine, well rounded, dark grey/black) in silt & fine sand matrix with shells (mainly pipi, cockle) throughout, blue / grey	ch
- 24.2m	As above, brown, no shellls. @23m light brown silt & fine sand, some iron staining, minor very fine gravel/granule	ch
- 25.5m	Grey fine sand/silt with shells (mainly pipi, oyster) and some gravel (fine, brown-dark grey)	ch
- 26.1m	Gravel (Brown, fine-coarse (^50mm)) in silt matrix. Lump of organic silt @26m	ri
- 29.0m	Sandy gravel, water-bearing. Sand medium-coarse. Gravel grey, some rust (Fe) staining, rounded to well rounded, fine-cobble (^100mm)	ri

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Borelog for well M35/10325 page 2 of 4

Environment Canterbury Regional Council

Gridref: M35:81819-45310 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.95 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -116.1m Drill Date : 10/06/2005

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
-30		- 33.1m	Sandy gravel, water-bearing. Sand medium-coarse. Gravel grey, some rust (Fe) staining, rounded to well rounded, fine-cobble (^100mm)	ri
		- 33.2m	Some gravel in yellow/brown silt matrix. Gravel brown, fine-cobble (^110mm), rounded	
-35		- 35.5m	Sandy gravel , water-bearing. Sand medium-very coarse. Gravel brownish-grey, fine-coarse (^50mm), rounded-well rounded	ri
		- 35.9m	Gravel in silt matrix, yellow	ri
		- 38.9m	Sandy gravel, water-bearing, grey, iron staining. @37.7m light brown-orange clay/silt layer. @38m Gravel brown, fine-cobble (^120mm), brown-black stained, rounded-well rounded.	ri
-40		- 39.2m	Gravel in light brown- orange silt/clay matrix. Gravel grey/brown, fine-coarse, rounded-well rounded	ri
		- 43.5m	Medium-coarse sandy fine-coarse grey gravel with much brown/black staining. Water-bearing.	ri
-45		- 43.7m	Gravel in yellow/brown silt & medium sand matrix. Gravel brown/grey, fine-coarse (^70mm).	
		- 47.9m	Sandy gravel, water-bearing, grey / brown. Gravel fine-cobble(>80mm), rounded-well rounded.	ri
-50		- 50.2m	Gravel in bright yellow silt matrix. Gravel fine-coarse, brown with some orange rust stain.	ri
		- 51.8m	Sandy gravel, water-bearing, grey / brown. Clay/silt trace. Sand fine-coarse. Gravel fine-coarse (^40mm), rounded-well rounded	ri?
		- 52.4m	Fine gravel in yellow/brown-orange silt matrix	br
		- 52.7m	Some fine grey/brown Gravel in grey very soft silt with some fine sand matrix.	br
		- 53.6m	Yellow & grey fine sand and some clay/silt	br
-55		- 56.9m	Fine Sand, brown	br
		- 57.7m	Silt/clay with organic material (peat), hard, blue/grey. @57.1m, peat + grey silt (some laminated). @57.5 light yellow/brown fine sandy silt/clay with trace organic material.	br
		- 58.5m		br

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Borelog for well M35/10325 page 3 of 4

Environment Canterbury Regional Council

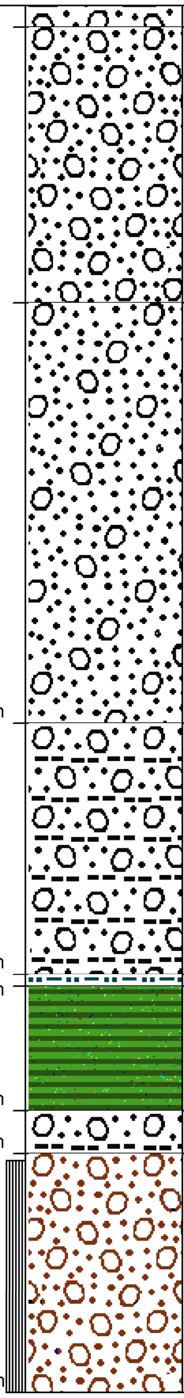
Gridref: M35:81819-45310 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.95 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -116.1m Drill Date : 10/06/2005

Depth(m)	Full Drillers Description	Formation Code
- 58.3m	Silt / clay, hard, white	br
- 61.1m	Sandy gravel, water-bearing, grey/brown with rust staining common. Sand medium-coarse. Gravel fine-coarse (^75mm), rounded-well rounded.	li-1
- 62.9m	Dark grey Silt / clay with grey/black organic material (peat), hard	li-2
- 64.2m	Silty sand, blue / grey	li-2
- 67.7m	Silt / clay, blue / grey, soft	li-2
- 67.9m	Grey-grey/brown Silt / clay with organic material (peat) (check for beetle remains???)	li-2
- 69.3m	Sandy gravel, blue, some iron staining, fine-cobble (^100mm) rounded-well rounded.	li-2
- 70.2m	Silt / clay, blue / grey, soft	li-2
- 71.1m	Silt / clay, yellow, soft-stiff	li-2
- 72.8m	Silt / clay with organic material (peat), grey/brown, soft-firm	li-2
- 74.1m	Fine-medium Sandy grey/brown fine-coarse gravel, rounded-well rounded	li-2
- 75.3m	Sandy gravel, water-bearing, brown	li-2
- 75.6m	Yellow/brown Silt / clay, firm-stiff	li-2
- 75.8m	Silt / clay with organic material (peat), grey, soft	li-2/li-3
- 76.0m	Yellow/brown fine-medium sand and silt.	li-2/li-3
- 76.2m	Silt / clay with organic material (peat), grey, stiff	li-2
- 83.6m	Gravel with sand, water-bearing, brown / grey. @77m gravel fine-cobble (^150mm), rounded-well rounded, Sand fine-coarse.	li-3/li-2
- 83.7m	@83.6m light yellow/brown + dark brown soft Silt/clay. @83.7m Dark brown (organic?) soft silt/clay	li-3/li-2
- 85.1m	Gravel and peat, blue	li-3/li-2
- 85.2m	Yellow + grey orange mottled fine sandy silt	
- 87.1m	Fine-coarse iron stained brown Gravel with sand and traces of silt/clay. Gravel rounded-well rounded.	li-3

Scale(m): -60, -65, -70, -75, -80, -85

Borelog for well M35/10325 page 4 of 4

Gridref: M35:81819-45310 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 6.95 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Cable Tool
Drill Depth : -116.1m Drill Date : 10/06/2005



Depth(m)	Full Drillers Description	Formation Code
- 87.5m	Fine-coarse iron stained brown Gravel with sand and traces of silt/clay. Gravel rounded-well rounded.	li-3
	Gravel with sand , water-bearing, brown/grey . @ 87.75m Gravel brown/grey, fine-cobble (^110mm), rounded-well rounded. Sand fine-coarse. @89.9m gravel brown/grey, fine (some coarse up to 45mm), rounded-well rounded. Sand fine-coarse. Clay trace.	
- 93.3m	Sand with some gravel, brown. Sand fine @98m	li-3
- 102.1m	Gravel in silt and sand matrix, brown. @104m gravel brown, fine-cobble (^140mm), rounded-well rounded. Sand brown, fine-medium.	he
- 107.4m	Grey & yellow Silt/fine sand, some lamination, stiff. Trace organic material????	he
- 107.6m	As above , blue with peat fragments throughout. @107.7 grey silt, not laminated. @110m silt/clay grey + yellow/brown + dark orange/brown (+ organic matter?)	he
- 110.2m	Gravel in yellow to orange silty sand matrix. Gravel brown with brown staining, fine-coarse (<80mm), rounded-well rounded. Sand fine-medium	he
- 111.1m	Gravel with sand, water-bearing, brown	bu
- 116.1m		bu

Scale(m): -90, -95, -100, -105, -110, -115

12. Appendix C – Geotechnical Investigation Summary

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- **Table 1 Summary of most relevant investigation data**

ID		1	2	3	4	5
Type *		BH	BH	CPT	CPT	BH
Ref		M35 - 13177	M35 - 13184	STA - 57	SHY - 21	M35 - 10325
Depth (m)		15	14.6	13.7	15.4	116.1
Distance from site (m)		270	90	430	380	370
Ground water level (mBGL)		N/A	N/A	2	2.6	N/A
Simplified recorded geological profile (depth below ground level to top of stratum, m)	0			N/A	N/A	
	1			VL	L	
	2			F	L	
	3			F	F	
	4			MD	F	
	5			MD F	F	
	6			F	MD	
	7			MD	MD	
	8			MD	MD	
	9			MD	D	
	10			D	D	
	11			D	D	
	12			D	D	
	13			D	D	
	14				D	
	15				D	
	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