CHRISTCHURCH CITY COUNCIL
PRK_1124_BLDG_001 EQ2
Selwyn Reserve – BLD 1 Toilets
58 Brougham St, Addington

QUALITATIVE ASSESSMENT REPORT

FINAL

- Rev B
- 23 May 2013

CHRISTCHURCH CITY COUNCIL

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58 Brougham St, Addington

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Contents

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Approval

	Signature	Date	Name	Title
Author		23/05/2013	Oliver Kingsnorth	Structural Engineer
Approver		23/05/2013	Nick Calvert	Senior Structural Engineer

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1. Executive Summary

1.1. Background

A Qualitative Assessment was carried out on Toilets - Selwyn St, located at Selwyn Reserve. The building is a masonry structure with a steel framed canopy. An aerial photograph illustrating the location of Toilets - Selwyn St is shown below in Figure 1. A detailed description outlining the building age and construction type is given in Section 5 of this report.

- **Figure 1 Aerial Photograph of Selwyn Reserve showing the location of** Toilets - Selwyn St

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 24 May 2012.

1.2. Key Damage Observed

No structural damage to the property was observed at the time of the inspection.

1.3. Critical Structural Weaknesses

No critical structural weaknesses have been identified.

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

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the building's original capacity has been assessed to be in the order of 100%NBS. No structural damage was observed to the building and therefore the post earthquake capacity remains the same.

The building has been assessed to have a seismic capacity in the order of 100% NBS and is therefore not earthquake prone.

1.5. Recommendations

It is recommended that:

a) There is no damage to 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 was engaged by Christchurch City Council to prepare a qualitative assessment report for the building located at 58 Brougham St, Addington 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 document "Guidance on Detailed Engineering Evaluation of Earthquake affected Non-residential Buildings in Canterbury" (part 2 revision 5 dated 19/07/2011 and part 3 draft revision dated 13/12/2011). The qualitative assessment broadly 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 7.2.

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. Construction drawings were not made available. The building description below is based on a visual inspection only.

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

3. Compliance

This section contains a 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 34%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

Toilets - Selwyn St is a single storey amenities block constructed from stack bond concrete masonry. The structure has a steel canopy that is supported on steel posts and is tied in to the block walls. The building has one internal concrete masonry wall and the canopy is clad in corrugated steel roof sheeting. The masonry walls are founded on a concrete strip footing and there is an internal floor slab.

Structural drawings were not made available.

The building is estimated to be constructed in the 1990s

Photos of the structure can be found in Appendix 1 – Photos.

5.2. Gravity Load Resisting system

The steel canopy is supported on both steel posts and the masonry walls. Load in the block walls is transmitted to the strip footing in bearing.

5.3. Seismic Load Resisting system

For the purposes of this report the longitudinal direction of the building is defined as being the east-west direction and the transverse direction is defined as being in the north-south direction.

Lateral load on the steel canopy is transmitted to the masonry walls via steel posts cast in to the walls. In-plane loading the masonry walls is transmitted to ground in shear. The masonry walls span between perpendicular walls in out-of-plane loading.

5.4. Geotechnical Conditions

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

- The site has been assessed as NZS1170.5 Class D (deep or soft soil) from adjacent borehole logs.
- The ultimate bearing capacity of a shallow square pad footing is estimated to be in the order of 240 kPa. However, these may be revised by a site specific investigation.
- Liquefaction risk is low at this site.

Unless a change of use is intended for the site we do not believe that any further geotechnical investigations are required. Specific ground investigation should be undertaken if significant alterations or new structures are proposed. If any excavations are required on the site further investigation of the potential for contamination should be undertaken. The full geotechnical desktop study can be found in Appendix 4.

6. Damage Summary

SKM undertook an inspection of the building from floor level on 24 May 2012. No structural damage to the building was observed at the time of the inspection.

Some cracking was found in the external concrete slab around the perimeter of the building. The cracking looks to be existing and is likely to have been exacerbated by the recent earthquakes.

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 grade is indicated by the percent of the required New Building Standard (%NBS) strength that the building is considered to have. A building is earthquake prone for the purposes of this Act if, having regard to its condition and to the ground on which it is built, and because of its construction, the building—

a) will have its ultimate capacity exceeded in a moderate earthquake (as defined in the regulations); and
b) would be likely to collapse causing—
    i. injury or death to persons in the building or to persons on any other property; or
    ii. damage to any other property.

A moderate earthquake is defined as 'in relation to a building, an earthquake that would generate shaking at the site of the building that is of the same duration as, but that is one-third as strong as, the earthquake shaking (determined by normal measures of acceleration, velocity and displacement) that would be used to design a new building at the site.'

An earthquake prone building will have an increased risk that its strength will be exceeded due to earthquake actions of approximately 10 times (or more) than that of a building having a capacity in excess of 100% NBS (refer Table 1)[3]. Buildings in Christchurch City that are identified as being 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 June 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*, p 2-13
[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 collapse or other forms of 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.

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
- NZS4230:2004 Design of Reinforced Concrete Masonry Structures
- NZS 3603:1993 Timber Structures Standard
- NZS 3604:2011 Timber Framed Buildings

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

7.2. Design Criteria and Limitations

Following our inspection on the 24 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 and inspection findings of the building. Please note no intrusive investigations were undertaken.
- Structural drawings were not made available

The design criteria used to undertake the assessment include:

- 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, based on our assessment and code requirements at the time of design. The structure primarily replies on masonry walls which are expected to be at least partially reinforced due to the age of construction.
  - Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011.

This IEP was based on our 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.
- The IEP does not involve a detailed analysis or an element by element code compliance check.

7.3. Survey

There was no visible settlement of the structure, nor was there any significant ground movement issues around the building. The building is adjacent to land which is zoned TC2 under the CERA Residential Technical Categories Map. The combination of these factors means that we do not recommend that any survey be undertaken at this point.

7.4. Critical Structural Weaknesses

No critical structural weaknesses for the building were observed during our visual inspection.

7.5. Qualitative Assessment Results

The building has had its capacity assessed using the Initial Evaluation Procedure based on the information available. The building's capacity, expressed as a percentage of new building standard (%NBS), 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
Toilets – Selwyn St	100

Our qualitative assessment found that the building is likely to be classed as a 'Low Risk Building' (capacity greater than 67% of NBS). The full IEP assessment form is detailed in Appendix 2 – IEP Reports.

8. Further Investigation

No further investigation is deemed necessary for this building.

9. Conclusion

A qualitative assessment was carried out for Toilets – Selwyn St located at Selwyn Reserve. No structural damage was observed to the structure. The building has been assessed to have a seismic capacity in the order of 100% NBS and is therefore not earthquake prone and is likely to be classified as a 'Low Risk Building' (capacity greater than 67% of NBS).

No further investigation is deemed necessary for the structure.

It is recommended that:

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

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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: The north elevation of the building	Photo 2: The west and south elevations of the building
	
Photo 3: The steel canopy framing	Photo 4: Detail of the steel posts cast in to the walls of the building

	
Photo 5: The narrow external concrete slab on the west, south and east sides of the building	Photo 6: Existing cracking in the narrow slab that have been exacerbated by the recent seismic activity

12. Appendix 2 – IEP Reports

Table IEP-1 **Initial Evaluation Procedure – Step 1**

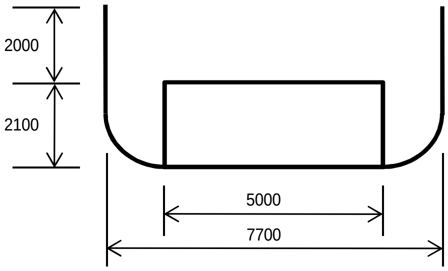
(Refer Table IEP - 2 for Step 2; Table IEP - 3 for Step 3, Table IEP - 4 for Steps 4, 5 and 6)

Building Name:	Selwyn Reserve—Toilets - Selwyn St	Ref.	ZB01276.113
Location:	58 Brougham St, Addington, Christchurch	By	OAK
		Date	23/05/2013

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketch of building plan



1.3 List relevant features

Toilets - Selwyn St is a single storey amenities block constructed from stack bond concrete masonry. The structure has a steel canopy that is supported on steel posts and is tied in to the block walls. The building has one internal concrete masonry wall and the canopy is clad in corrugated steel roof sheeting. The masonry walls are founded on a concrete strip footing and there is an internal floor slab.

1.4 Note information sources

Tick as appropriate

Visual Inspection of Exterior	✓
Visual Inspection of Interior	✓
Drawings (note type)	
Specifications	
Geotechnical Reports	✓
Other (list)	

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:	Selwyn Reserve—Toilets - Selwyn St	Ref.	ZB01276.113
Location:	58 Brougham St, Addington, Christchurch	By	OAK
Direction Considered:	**Longitudinal & Transverse**	Date	23/05/2013

(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 meters

	Longitudinal	Transverse	
Ac =			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	22.2	$(\%NBS)_{nom}$
Transverse	22.2	$(\%NBS)_{nom}$

			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	22.2	$(\%NBS)_{nom}$
Transverse	22.2	$(\%NBS)_{nom}$

Continued over page

Building Name:	Selwyn Reserve—Toilets - Selwyn St	Ref.	ZB01276.113
Location:	58 Brougham St, Addington, Christchurch	By	OAK
Direction Considered:	**Longitudinal & Transverse**	Date	23/05/2013

(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 Type Z 1992 above
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 2.67

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 = 6
Transverse	1.25	μ Maximum = 6

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**	1.00
Transverse	**Factor D**	1.00

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	65.8	$(\%NBS)_b$
Transverse	65.8	$(\%NBS)_b$

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:	Selwyn Reserve—Toilets - Selwyn St	Ref.	ZB01276.113
Location:	58 Brougham St, Addington, Christchurch	By	OAK
Direction Considered:	**a) Longitudinal**	Date	23/05/2013

(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**
	Severe	Significant	Insignificant		
3.1 Plan Irregularity – Effect on Structural Performance	○	○	◉	**Factor A**	1
Comment					
3.2 Vertical Irregularity – Effect on Structural Performance	○	○	◉	**Factor B**	1
Comment					
3.3 Short Columns – 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

Separation	Severe 0<Sep<.005H	Significant .005<Sep<.01H	Insignificant 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

Separation	Severe 0<Sep<.005H	Significant .005<Sep<.01H	Insignificant 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:

The building showed no sign of damage and it is likely that the capacity of the building is not goverened by seismic loading

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

PAR 1.5

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

Building Name:	Selwyn Reserve—Toilets - Selwyn St	Ref.	ZB01276.113
Location:	58 Brougham St, Addington, Christchurch	By	OAK
Direction Considered:	**b) Transverse**	Date	23/05/2013

(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

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

3.2 Vertical Irregularity

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

3.3 Short Columns

Effect on Structural Performance	Severe	Significant	Insignificant	
	○	○	◉	**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)

Effect on Structural Performance	Severe	Significant	Insignificant	
	○ 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:
The building showed no sign of damage and it is likely that the capacity of the building is not goverened by seismic loading

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:	Selwyn Reserve—Toilets - Selwyn St	Ref.	ZB01276.113
Location:	58 Brougham St, Addington, Christchurch	By	OAK
Direction Considered:	**Longitudinal & Transverse**	Date	23/05/2013

(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)	65	65
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	1.50	1.50
4.3 PAR x Baseline $(\%NBS)_b$	98	98
4.4 Percentage New Building Standard (%NBS) (Use lower of two values from Step 4.3)		98

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

%NBS ≤ 33 — NO

Step 6 - Potentially Earthquake Risk?

%NBS < 67 — NO

Step 7 - Provisional Grading for Seismic Risk based on IEP

Seismic Grade — **A**

Evaluation Confirmed by

[signature] Signature

Trevor Robertson — Name

28892 — 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

Location

Building Name:	Toilets - Selwyn St	Reviewer:	Trevor Robertson
Building Address:	Unit: ; No: 58; Street: Brougham St, Addington	CPEng No:	28892
Legal Description:		Company:	SKM
		Company project number:	ZB01276.113
		Company phone number:	03 940 4900
GPS south:	Degrees / Min / Sec:	Date of submission:	24-May
GPS east:		Inspection Date:	24/05/2012
		Revision:	B
Building Unique Identifier (CCC):	PRK_1124_BLDG_001	Is there a full report with this summary?	yes

Site

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

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	
Ground floor split?	no		Ground floor elevation above ground (m):	
Storeys below ground	0			
Foundation type:	strip footings		if Foundation type is other, describe:	
Building height (m):	3.00		height from ground to level of uppermost seismic mass (for IEP only) (m):	1.1
Floor footprint area (approx):				
Age of Building (years):	15		Date of design:	1992-2004
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	other (specify)		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):	Amenities			
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	steel framed	rafter type, purlin type and cladding	Steel tube framing lined with corrugated steel roof sheeting
Floors:	concrete flat slab	slab thickness (mm)	
Beams:			
Columns:			
Walls:	partially filled concrete masonry	thickness (mm)	200

Lateral load resisting structure

Lateral system along:	partially filled CMU	**Note: Define along and across in detailed report!**	note total length of wall at ground (m):	5
Ductility assumed, μ:	1.25		wall thickness (m):	0.2
Period along:		0.40 from parameters in sheet	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	partially filled CMU		note total length of wall at ground (m):	3
Ductility assumed, μ:	1.25		wall thickness (m):	0.2
Period across:		0.40 from parameters in sheet	estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

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

Non-structural elements

Stairs:			
Wall cladding:			
Roof Cladding:	Metal	describe	Corrugated steel sheeting
Glazing:			
Ceilings:			
Services(list):			

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:	1	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 how damage ratio arrived at:	
	Describe (summary):	No structural damage recorded		
Across	Damage ratio:	0%		
	Describe (summary):	No structural damage recorded		
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

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

Recommendations

Level of repair/strengthening required:	minor non-structural	Describe:	Replacement of external concrete slab
Building Consent required:	no	Describe:	
Interim occupancy recommendations:	full occupancy	Describe:	

Along	Assessed %NBS before:	100%	%NBS from IEP below	If IEP not used, please detail assessment methodology:	Qualitative Assessment carried out includes NZSEE IEP (refer to SKM report)
	Assessed %NBS after:	100%			
Across	Assessed %NBS before:	100%	%NBS from IEP below		
	Assessed %NBS after:	100%			

14. Appendix 4 – Geotechnical Desktop Study

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Web: www.globalskm.com

Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	113
Address	Selwyn Reserve, corner of Brougham Street and Selwyn street
Report date	20 June 2012
Author	Ananth Balachandra
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 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

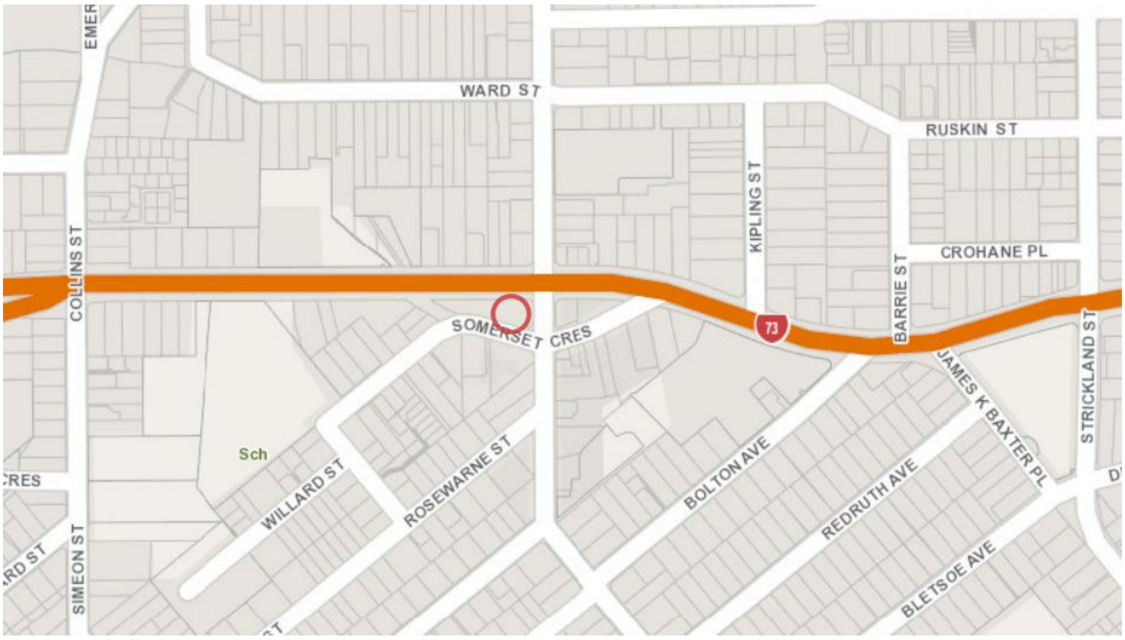
3. Limitations

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

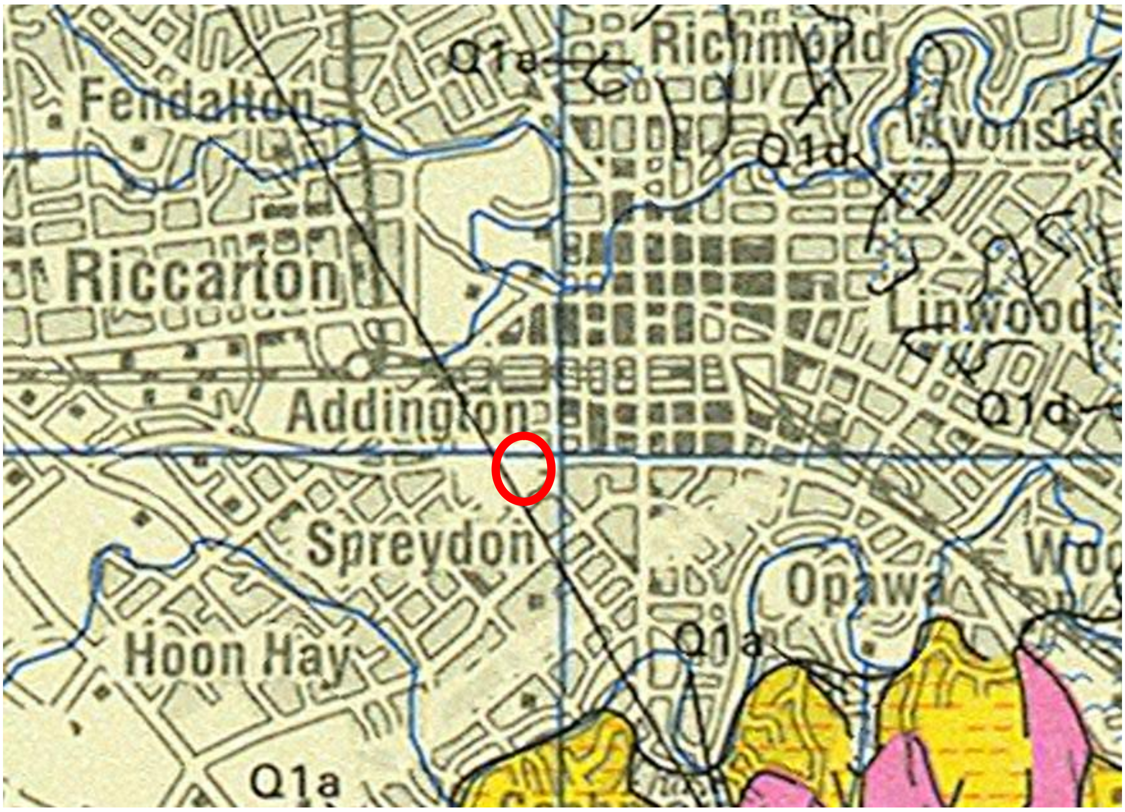


- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

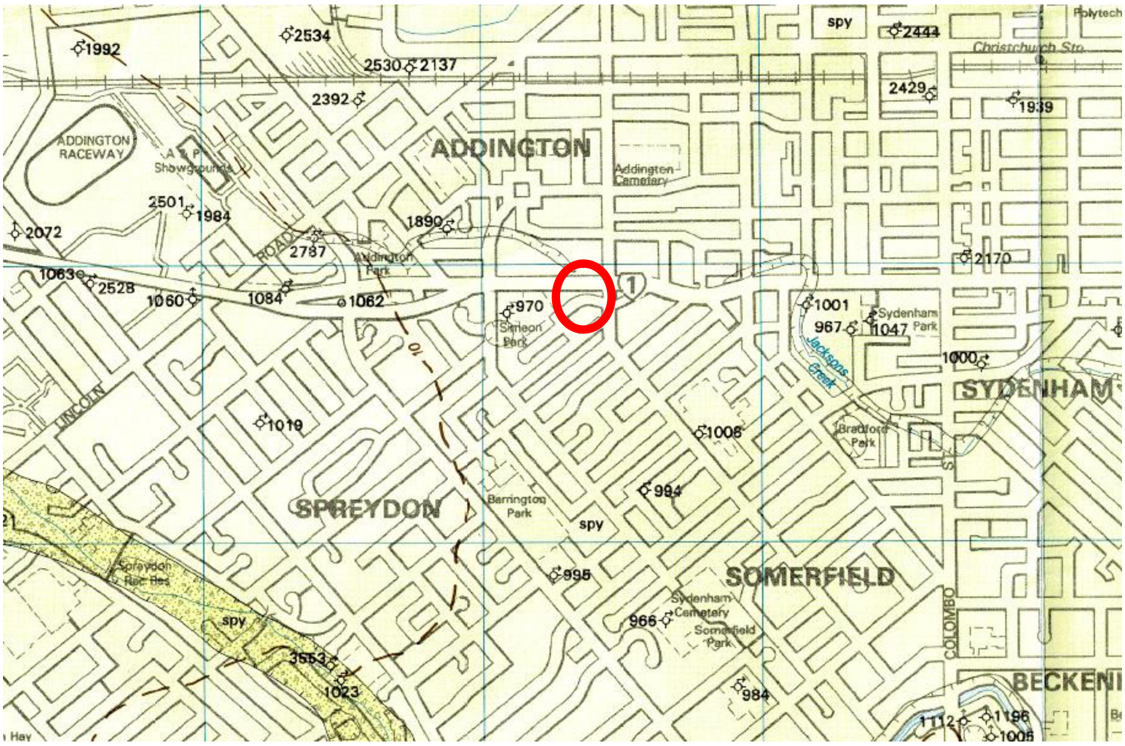
The structure is located on the corner Brougham Street and Selwyn Street at grid reference 1569422 E, 5178294 N (NZTM). The structure can also be entered through Somerset Crescent.

5. Review of available information

5.1 Geological maps



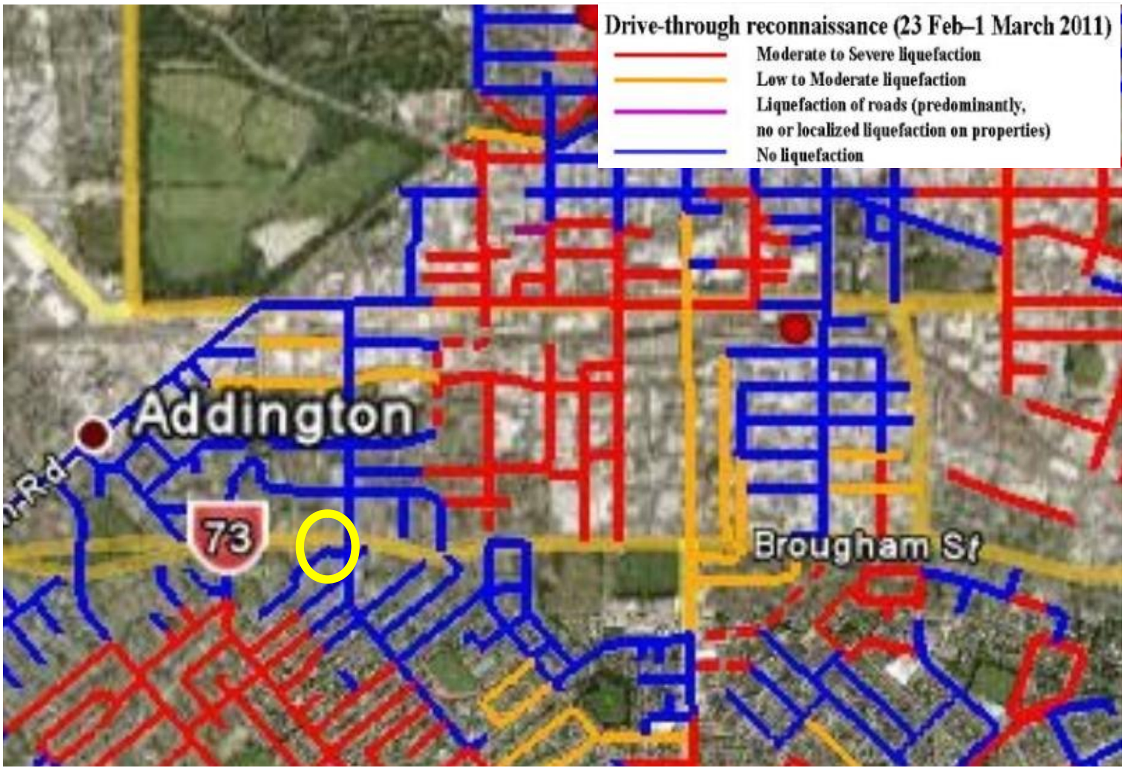
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



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

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 red.**

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 was noted near Selwyn Street and Somerset Crescent side of the site.

5.3 Aerial photography

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

An aerial view of the structure is not possible due to view being obstructed by surrounding trees. However, an aerial photograph of the site is provided in figure 5 to assess any damage to the area surrounding the site.

There appears to be no significant surface evidence that would indicate any liquefaction occurred beneath the site. There are traces of white to grey material on adjacent properties and shoulder of the roadways. However, it is expected that these are unlikely to be liquefied ejecta but potentially dust and other material transported from the CBD through vehicle movement.

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: Classified as TC2

5.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the path of a pre existing stream or creek ran near the site. This may indicate soft river sediments beneath the site that would require additional investigations if a new structure was to be built in the area. A small distance south of the site, the area was recorded as swamp or marshland in 1856.

5.6 Existing ground investigation data

- **Figure 6 – Local boreholes from ECAN GIS (http://arcims.ecan.govt.nz/ecanmapping/)**

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 of the site was undertaken by a SKM engineer on 20 May 2012.

The structure was noted to be a concrete block construction with a concrete slab on grade foundation and metal roofing. The park ground area was undulating; however this is likely to be a landscaping feature. The surrounding road area was observed to be in good condition. Minor cracking of the park paths were noted, potentially due to ground motions experienced from the 22 February 2011 and other recent earthquakes.

No evidence of liquefaction or other land damage was apparent from the external site walkover.

- **Figure 7 - Overview of the toilets and surrounding land area**

- **Figure 8 - Minor cracking of the path asphalt surface**

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 - 0.5	Top soil
0.5 - 4.5	Silty sand to sandy silt with some gravel content.

6.2 Seismic site subsoil class

The site has been assessed as being either NZS1170.5 Class D (deep or soft soil) or NZS1170.5 Class C (shallow soil). However, as limited investigation data was available, with boreholes drilled to very shallow depth a conservative NZS1170.5 Class D is recommended.

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 a combination of the third preferred method and least preferred method has been used to make the assessment. Further site investigation could result in a revision to the recommend site subsoil class.

6.3 Building performance

The performance to date suggests that the existing foundations are adequate for their current purpose.

6.4 Ground performance and properties

Liquefaction risk appears to be low for this site.

No significant evidence of liquefaction was noted in the aerial photographs taken shortly after the earthquake or from the drive through reconnaissance performed. In addition, no evidence of liquefied ejecta remaining on site was noted during the external site walkover undertaken by a SKM engineer. The sandy silt and sand layers inferred to be present between depths of 0.5 to 4.5 m may be susceptible to liquefaction. However, further investigations are required to perform a full liquefaction assessment.

Only very shallow investigations, with no geotechnical measurements, are available for the site. However, no significant land damage or damage to the structure was noted during the external site visit. Additionally, the structure appears to be a lightweight structure supported on shallow foundations. Therefore, following parameters are recommended for the shallow soil layer if a quantitative DEE is to be undertaken for the site.

Parameter	Estimated value
Effective angle of friction	32 degrees
Apparent cohesion	0 kPa
Unit weight	18 kPa
Ultimate bearing capacity of a shallow square pad footing	240 kPa

Note these estimated properties are typical values that could be used for the quantitative DEE of the site. They should not be used for consent or design purposes. Additional investigations are required to confirm the estimated ground properties.

6.5 Further investigations

No further investigations are expected to needed if a quantitative DEE is required to be undertaken for the site.

If consent is required or significant alteration to the existing structure or new structure is proposed on site additional investigations would be required. If consent is required for the site, additional investigations recommended for small scale projects are:

- One borehole on site to a depth of 20 m. SPTs are to be taken at intervals of 1.5m. As some gravel content was noted at shallow depths it is expected that CPTs may reach refusal at shallow depths. The borehole is required to perform a site specific liquefaction assessment.

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.

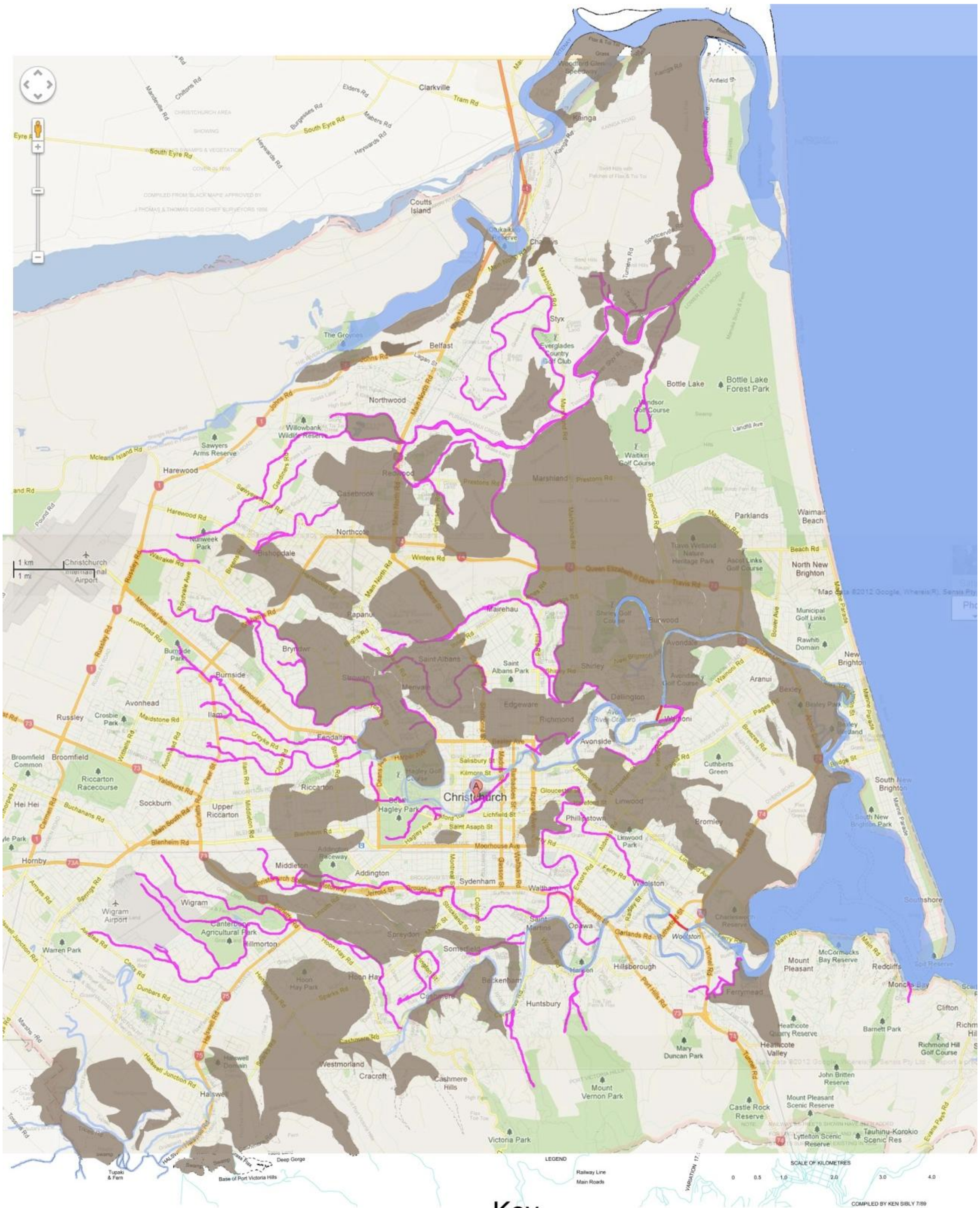
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

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

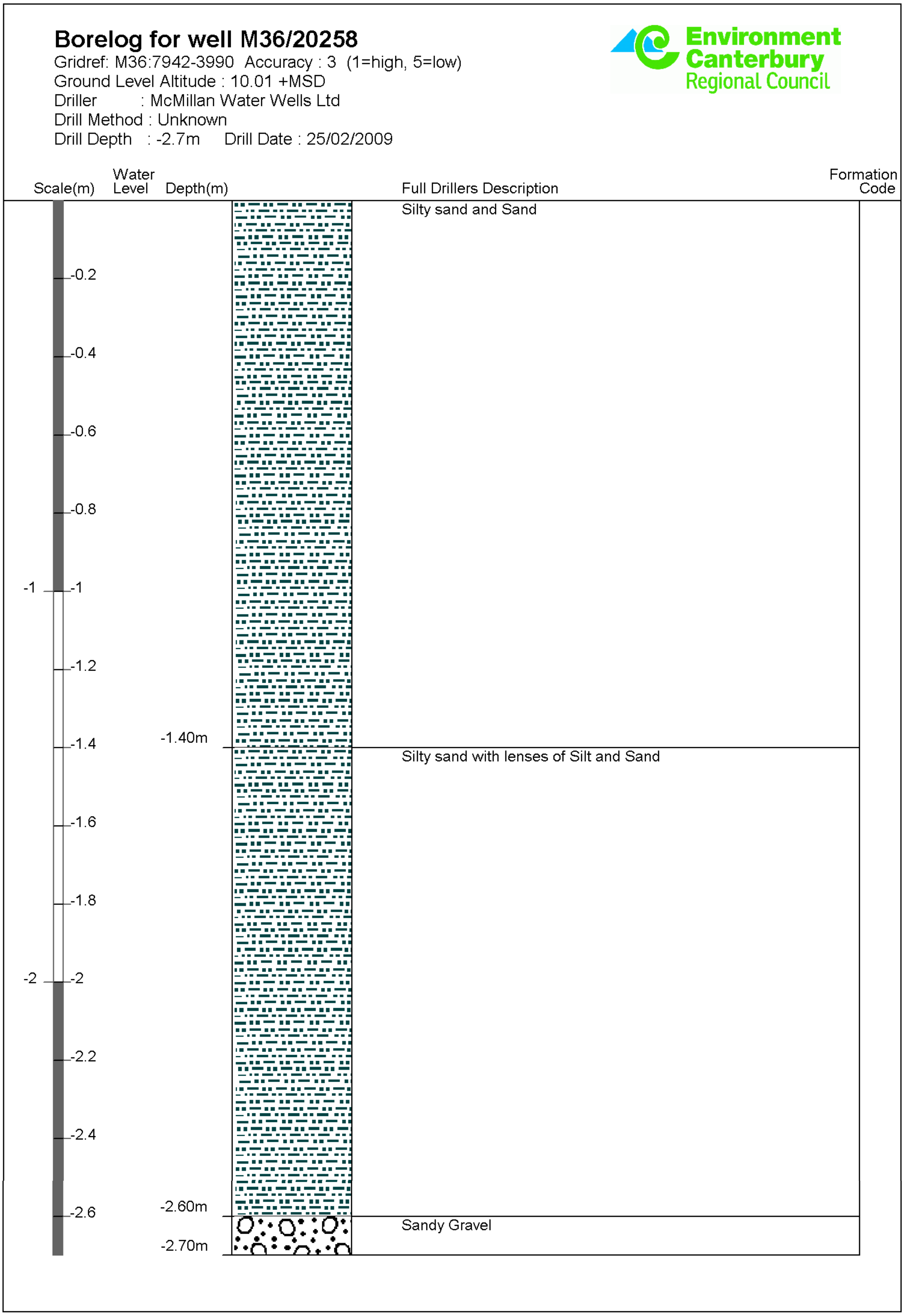


The swamps and previous creeks/rivers from 1856 have been overlayed onto a map of Christchurch in 2012

Key

- Previous creeks/rivers
- Existing creeks/rivers
- New creeks/rivers
- Swamp/Marshland

Appendix B – Existing ground investigation logs


Borelog for well M36/20258
Gridref: M36:7942-3990 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 10.01 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Unknown
Drill Depth : -2.7m Drill Date : 25/02/2009
Environment Canterbury Regional Council
Scale(m)
Water Level
Depth(m)
Full Drillers Description
Formation Code
-0.2
-0.4
-0.6
-0.8
-1
-1
-1.2
-1.4
-1.6
-1.8
-2
-2
-2.2
-2.4
-2.6
Silty sand and Sand
-1.40m
Silty sand with lenses of Silt and Sand
-2.60m
Sandy Gravel
-2.70m

Borelog for well M36/7844

Gridref: M36:7950-3992 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 11 +MSD
Driller : CW Drilling and Investigation
Drill Method : Hand Auger
Drill Depth : -4.5m Drill Date : 9/12/2004

Depth(m)	Full Drillers Description	Formation Code
-0.10m	asphalt	fi
-0.65m	hardfill	fi
-1.40m	sand, coarse, brown	sp
-1.50m	sandy gravel, fine-medium gravel, coarse sand	sp
-2.00m	gravel with sandy silts, fine-medium gravel, grey, slight odour	sp
-3.00m	sandy silt with fine gravel, grey/dark brown	sp
-4.50m	sandy silt, grey, strong odour	sp

Appendix C – Geotechnical Investigation Summary

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

ID		1	2
Type *		BH	BH
Ref		M36-20258	M36-7844
Depth (m)		2.7	4.5
Distance from site (m)		10	90
Ground water level (mBGL)		N/A	N/A
Simplified recorded geological profile (depth below ground level to top of stratum, m)	0		Hard fill
	0.5		
	1		
	1.5		
	2		
	2.5		
	3		
	3.5		
	4		
	4.5		
	5		
	5.5		
	6		
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