CHRISTCHURCH CITY COUNCIL

PRK_0722_BLDG_001_EQ2
Horseshoe Lake Reserve - Toilet
Cnr Horseshoe Lake & Lake Terrance Road, Shirley

QUALITATIVE ASSESSMENT REPORT

FINAL

- Rev B
- 17 January 2013

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1. Executive Summary

1.1. Background

A Qualitative Assessment was carried out on the building located on the corner of Horseshoe Lake Road and Lake Terrace Road, Shirley. The building is single story and is used as a toilet block. It appears to be constructed from timber framing in the walls. The roofing and external wall cladding is corrugated metal, and the internal wall cladding appears to be plasterboard. The roofing is supported by a steel frame grid that is supported on two timber portal frames spanning longitudinally. An aerial photograph illustrating these areas is shown below in Figure 1. Detailed descriptions outlining the buildings age and construction type is given in Section 2 of this report.

■ **Figure 1 Aerial Photograph on the corner of Horseshoe Lake & Lake Terrace Road**

The qualitative assessment broadly 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 18 April 2012.

1.2. Key Damage Observed

Key damage observed includes:-

- Cracking in timber beams and columns along the grain

1.3. Critical Structural Weaknesses

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

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

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the buildings original capacity has been assessed to be in the order of 100% NBS. Minor non-structural damage was observed during the site investigation, therefore the post earthquake capacity will also be greater than 100% NBS.

The building has been assessed to have a seismic capacity in the order of 100% NBS and is therefore not potentially earthquake prone. Since the capacity is greater than 34% NBS a quantitative assessment is not required.

1.5. Recommendations

It is recommended that:

a) The current placard status of the building of Green 1 remains as is.

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 on the corner of Horseshoe Lake Road and Lake Terrace Road 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". 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.

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

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

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

3. Compliance

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

3.1. Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

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

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

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

- The importance level and occupancy of the building
- The placard status and amount of damage
- The age and structural type of the building
- Consideration of any critical structural weaknesses
- The extent of any earthquake damage

3.2. Building Act

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

3.2.1. Section 112 – Alterations

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

3.2.2. Section 115 – Change of Use

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

3.2.3. Section 121 – Dangerous Buildings

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

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

3.2.4. Section 122 – Earthquake Prone Buildings

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

3.2.5. Section 124 – Powers of Territorial Authorities

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

3.2.6. Section 131 – Earthquake Prone Building Policy

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

3.3. Christchurch City Council Policy

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

The 2010 amendment includes the following:

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

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

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

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

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

3.4. Building Code

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

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

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

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

4. Earthquake Resistance Standards

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

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

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

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

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

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

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

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

5. Building Details

5.1. Building description

The building is located on the corner of Horseshoe Lake Road and Lake Terrace Road. There is only one building on this site. The building has one story that is used as a public toilet block. The building is assumed to be constructed from free-standing timber framed walls. The roofing is corrugated metal, supported on a horizontal steel grid frame, which is supported by timber portal frames spanning along the building on either side. External wall cladding is corrugated metal, while the interior cladding appears to be plasterboard. The foundation is a concrete slab. It is assumed that the building was built in the 1990s-2000s due to the style of construction.

Our evaluation was based on the external visual inspection carried out on 18 April 2012. Internal inspection was not able to be carried out as the building was locked at the time of the visual inspection; however there were small openings in the doorway that revealed the interior layout. Drawings were not available to verify the presence of reinforcing, the foundation system and the date of construction.

5.2. Gravity Load Resisting system

It appears that gravity loads from the roof are taken by the horizontal steel grid frame, which is transferred into the timber portal frames running along either side of the building. This is then directly transferred into the concrete slab foundation below. The walls are freestanding and support their own gravity load, with direct transfer into the foundation.

5.3. Seismic Load Resisting system

Lateral loads acting along the building appear to be taken by the timber portal frames through cantilever action of the columns. Lateral loads acting across the building will be transferred through the steel grid that supports the roof and into the columns in the timber portal frames. It appears that the walls are not supported by the roof, and they are assumed to take lateral load by timber bracing within the walls.

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

5.4. Geotechnical Conditions

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

- From the available data, seismic site subsoil class cannot be confirmed. In accordance with NZS1170.5 the site is either Class D (deep or soft soil) or Class E (very soft soil) ground performance and properties. Class E has been used in this qualitative analysis.
- Liquefaction risk is expected to be moderate to severe for the site due to the extensive lateral spreading that occurred. However, additional investigations closer to the site are required to confirm this assessment.

Due to insufficient ground investigation data near this site, further investigations are needed in order to perform a quantitative assessment. Additional investigations recommended are:

- Two cone penetration tests to estimate the depth of liquefiable layer and determine the subsoil class in accordance with NZS1170.5.

6. Damage Summary

SKM undertook an inspection on 18 April 2012. The following areas of damage were observed during the time of inspection:

General

1) While visual evidence of settlement was noted at this site, it only appeared to occur around the building and not affect it. Also, this site is classified as TC2 land[2]. Therefore a level survey is not required at this stage of assessment.

External Damage

1) Cracking in timber beams and columns along the grain

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

[2] http://cera.govt.nz/maps/technical-categories

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[3].

The IEP is a coarse screening process designed to identify buildings that are likely to be earthquake prone. The IEP process ranks buildings according to how well they are likely to perform relative to a new building designed to current earthquake standards, as shown in Table 2. The building rank is indicated by the percent of the required New Building Standard (%NBS) strength that the building is considered to have. Earthquake prone buildings are defined as having less than 33 %NBS strength which correlates to an increased risk of approximately 20 times that of 100% NBS[4]. Buildings that are identified to be earthquake prone are required by law to be followed up with a detailed assessment and strengthening work within 30 years of the owner being notified that the building is potentially earthquake prone[5].

[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 2: IEP Risk classifications

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

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

This assessment describes only the likely seismic Ultimate Limit State (ULS) performance of the building. The ULS is the level of earthquake that can be resisted by the building without catastrophic failure. The IEP does not attempt to estimate Serviceability Limit State (SLS) performance of the building, or the level of earthquake that would start to cause damage to the building[6]. This assessment concentrates on matters relating to life safety as damage to the building is a secondary consideration. SLS performance of the building can be estimated by scaling the current code levels if required.

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

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

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

7.2. Available Information, Assumptions and Limitations

Following our inspection on 18 April 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 external inspection findings of the building. Please note no intrusive investigations were undertaken.
- There were no drawings available to carry out our review.

The design criteria and assumptions made in undertaking 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 1. This level of importance is described as 'low' with low or small or moderate consequence of failure since the total floor area is <30m^2.
  - Ductility level of 1.25 in both directions, based on our assessment and code requirements at the time of design.
  - Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011

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

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

7.3. Critical Structural Weaknesses

No critical structural weaknesses have been identified in this building.

7.4. Qualitative Assessment Results

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

Table 3: Qualitative Assessment Summary

Item	%NBS
Likely Seismic Capacity of Building	> 100

Our qualitative assessment found that the building is likely to be classed as a 'Low Risk Building' (capacity greater than 100% of NBS). The full IEP assessment form is detailed in Appendix 2 – IEP Reports.

8. Further Investigation

Since the building has a seismic capacity greater than 100% NBS and has sustained no structural damage no further investigation is required at this stage.

9. Conclusion

A qualitative assessment was carried out on the building located on the corner of Horseshoe Lake Road and Lake Terrace Road, Shirley. The building has sustained minor non-structural damage to the timber beams and columns with cracking along the grain. The building has been assessed to have a seismic capacity greater than 100% NBS and is therefore not potentially earthquake prone.

No further investigation is required at this stage of the assessment.

It is recommended that:

a) The current placard status of the building of Green 1 remains as is.

b) We consider that barriers around the building are not necessary.

10. Limitation Statement

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

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

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

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

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

11. Appendix 1 – Photos

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

Photo 5: Cracking along the grain of one of the South timber columns (typical).

Photo 6: Connection detail of steel grid frame supporting the roofing.

Photo 7: Beam-column connection detail of timber portal frame on West side of building (typical).

Photo 8: No damage to foundation slab (North side of building shown, typical).

	
Photo 9: Top of wall on North side (typical).	Photo 10: Cracking along the grain of central North column (typical).
	
Photo 11: Beam-column connection detail of timber portal frame on East side of building (typical).	Photo 12: Steel grid frame extending down East wall.

	
Photo 13: Ground movement in front of the East side of the building.	Photo 14: Ground movement in front of the East side of the building.
	
Photo 15: Ground movement around the building.	Photo 16: Ramp angled and cracked showing evidence of ground movement Northeast of the building.

	
Photo 17: Ground connection detail of steel grid frame extended down East wall.	Photo 18: Toilet and basin layout inside the building looking from the North side.
	
Photo 19: Interior floor of the building looking from the North side.	Photo 20: Top of interior South wall and ceiling.
	
Photo 21: Bolt at beam-column connection of timber portal frame.	Photo 22: Rivet in corrugated metal exterior wall cladding (typical).

12. Appendix 2 – IEP Reports

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

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

Building Name:	Horseshoe Lake Reserve - Toilet	Ref.	ZB01276.37
Location:	Cnr Horseshoe Lake & Lake Terrace Road, Shirley	By	WPK
		Date	20/04/2012

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketch of building plan

1.3 List relevant features

The building is a one storey toilet block. It consists of a steel grid frame on the roof level, connected to timber portals spanning along the building. The roofing material is lightweight corrugated metal, which is also used as external wall cladding. The main lateral load resisting system are the timber portals. These act as frames in the north-south direction, with the steel grid transferring load into the timber columns of the portals in the east-west direction. The foundation is a concrete slab, which seems to have prevented movement of the building, lateral spreading around the structure was observed. Internal inspection was not able to be performed as the door was locked, however there were small openings above and below the door that allowed viewing of the suspected plaster-cladded interior with one toilet and one basin. The building appears to have been designed and constructed within the last 20 years.

1.4 Note information sources

	Tick as appropriate
Visual Inspection of Exterior	✓
Visual Inspection of Interior	
Drawings (note type)	
Specifications	
Geotechical 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:	Horseshoe Lake Reserve - Toilet	Ref.	ZB01276.37
Location:	Cnr Horseshoe Lake & Lake Terrace Road, Shirley	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/04/2012

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

Step 2 - Determination of (%NBS)b

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

- Pre 1935 — See also notes 1, 3
- 1935-1965
- 1965-1976 Seismic Zone; A
- B
- C — See also note 2
- 1976-1992 Seismic Zone; A
- B
- C
- 1992-2004 (selected)

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 (selected)

From NZS4203:1992, Cl 4.6.2.2
(for 1992 to 2004 only and only if known)

- a) Rigid (selected) — N-A
- b) Intermediate

c) Estimate Period, T

building Ht = 2.5 meters

	Longitudinal	Transverse	
Ac =	100	40	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 (selected)	Others (selected)
$T = 0.09h_n^{0.75}/A_c^{0.5}$	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	
0.1	**0.1**	Seconds

d) (%NBS)nom determined from Figure 3.3

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

Note			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:	Horseshoe Lake Reserve - Toilet	Ref.	ZB01276.37
Location:	Cnr Horseshoe Lake & Lake Terrace Road, Shirley	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/04/2012

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

2.2 Near Fault Scaling Factor, Factor A
If T < 1.5sec, Factor A = 1

a) **Near Fault Factor, N(T,D)** 1
(from NZS1170.5:2004, Cl 3.1.6)

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

2.3 Hazard Scaling Factor, Factor B

Select Location Christchurch

a) **Hazard Factor, Z, for site**
(from NZS1170.5:2004, Table 3.3)
Z = 0.3
Z 1992 = 0.8

Type Z 1992 above

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

b) **Hazard Scaling Factor**
For pre 1992 = 1/Z
\# For 1992 onwards = Z 1992/Z
(Where Z 1992 is the NZS4203:1992 Zone Factor from accompanying Figure 3.5(b))

Factor B 2.67

2.4 Return Period Scaling Factor, Factor C

a) **Building Importance Level** 1
(from NZS1170.0:2004, Table 3.1 and 3.2)

b) **Return Period Scaling Factor from accompanying Table 3.1** **Factor C** 1.20

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 Timber
Transverse Steel

a) **Structural Performance Factor, S_p**
from accompanying Figure 3.4

Longitudinal	Sp	0.93
Transverse	Sp	0.90

b) **Structural Performance Scaling Factor**

Longitudinal	$1/S_p$	**Factor E**	1.08
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	76.8	(%NBS)b
Transverse	78.9	(%NBS)b

Table IEP-3 Initial Evaluation Procedure – Step 3

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

Building Name:	Horseshoe Lake Reserve - Toilet	Ref.	ZB01276.37
Location:	Cnr Horseshoe Lake & Lake Terrace Road, Shirley	By	WPK
Direction Considered:	**a) Longitudinal**	Date	20/04/2012

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

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

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

Lightweight structure with greater capacity than lateral loading demand by inspection. Main loading component is self-weight. F factor decreased only to take into account local weaknesses in timber portal members (cracking along the grain) and uncertainty around connection detailing.

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

PAR 1.5

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

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

Building Name:	Horseshoe Lake Reserve - Toilet	Ref.	ZB01276.37
Location:	Cnr Horseshoe Lake & Lake Terrace Road, Shirley	By	WPK
Direction Considered:	**b) Transverse**	Date	20/04/2012

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

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

Critical Structural Weakness

Effect on Structural Performance (Choose a value - Do not interpolate)

Building Score

	Severe	Significant	Insignificant		Building Score
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

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

b) Factor D2: - Height Difference Effect

Select appropriate value from Table

Factor D2 1

Table for Selection of Factor D2

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

Factor D 1

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

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

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

3.6 Other Factors

For < 3 storeys - Maximum value 2.5,

otherwise - Maximum value 1.5. No minimum. **Factor F** 2.5

Record rationale for choice of Factor F:

Lightweight structure with greater capacity than lateral loading demand. Constrained by maximum allowable factor. Can use either steel frame on East wall or timber columns to transfer load through to the foundation.

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

PAR 2.5

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:	Horseshoe Lake Reserve - Toilet	Ref.	ZB01276.37
Location:	Cnr Horseshoe Lake & Lake Terrace Road, Shirley	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/04/2012

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

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

	Longitudinal	Transverse
4.1 Assessed Baseline (%NBS)$_b$ (from Table IEP - 1)	76	78
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	1.50	2.50
4.3 PAR x Baseline (%NBS)$_b$	114	195

4.4 Percentage New Building Standard (%NBS) 114

(Use lower of two values from Step 4.3)

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

NICK CALVERT Name

242062 CPEng. No

Relationship between Seismic Grade and % NBS :

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

13. Appendix 3 – CERA Standardised Report Form

Location

Building Name: Horseshoe Lake Reserve - Toilet
Unit No: Street
Building Address: Cnr Horseshoe Lake & Lake Terrace Rd
Legal Description:
Degrees Min Sec
GPS south:
GPS east:
Building Unique Identifier (CCC):

Reviewer: N Calvert
CPEng No: 242062
Company: SKM
Company project number: ZB01276.37
Company phone number: 09 928 5500
Date of submission:
Inspection Date: 18/04/2012
Revision: A
Is there a full report with this summary? yes

Site

Site slope: slope < 1in 10
Soil type:
Site Class (to NZS1170.5): E
Proximity to waterway (m, if <100m):
Proximity to clifftop (m, if < 100m):
Proximity to cliff base (m,if <100m):

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

Building

No. of storeys above ground: 1 (single storey = 1)
Ground floor split? no
Storeys below ground: 0
Foundation type: mat slab
Building height (m): 2.50
Floor footprint area (approx): 15
Age of Building (years): 15

Ground floor elevation (Absolute) (m): 2.50
Ground floor elevation above ground (m): 2.50
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m):
Date of design: 1992-2004

Strengthening present? no
If so, when (year)?
And what load level (%g)?
Brief strengthening description:

Use (ground floor): public
Use (upper floors):
Use notes (if required):
Importance level (to NZS1170.5): IL1

Gravity Structure

Gravity System: frame system
Roof: steel framed — rafter type, purlin type and cladding: Timber rafters & purlins, assume lightweight steel cladding
Floors: concrete flat slab — slab thickness (mm): Unknown
Beams: timber — type: 300x320
Columns: timber — typical dimensions (mm x mm): 320x320
Walls: non-load bearing — 0

Lateral load resisting structure

Lateral system along: timber moment frame
Note: Define along and across in detailed report!
note typical bay length (m): 2.2
Ductility assumed, μ: 1.25
Period along: 0.10 — 0.00 — estimate or calculation? estimated
Total deflection (ULS) (mm): 5 — estimate or calculation? estimated
maximum interstorey deflection (ULS) (mm): — estimate or calculation? estimated

Lateral system across: other (note) — describe system: steel grid frame
Ductility assumed, μ: 1.25
Period across: 0.10 — 0.00 — estimate or calculation? estimated
Total deflection (ULS) (mm): 5 — estimate or calculation? estimated
maximum interstorey deflection (ULS) (mm): — estimate or calculation? estimated

Separations:

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

Non-structural elements

Stairs:
Wall cladding: profiled metal — describe: corrugated metal
Roof Cladding: Metal — describe: corrugated metal
Glazing:
Ceilings: none
Services(list): Water, sewerage

Available documentation

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

Damage

Site: (refer DEE Table 4-2)
Site performance: — Describe damage:
Settlement: none observed — notes (if applicable):
Differential settlement: none observed — notes (if applicable):
Liquefaction: none apparent — notes (if applicable):
Lateral Spread: 0-50mm — 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: Current damage noted will not diminish the capacity of the building
Describe (summary): Cracking on timber beams/columns

Across — Damage ratio: 0%
Describe (summary): Cracking on timber beams/columns

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

Diaphragms — Damage?: no — Describe:
CSWs: — Damage?: no — Describe:
Pounding: — Damage?: no — Describe:
Non-structural: — Damage?: yes — Describe: Cracking on timber beams/columns along the grain

Recommendations

Level of repair/strengthening required: minor non-structural — Describe:
Building Consent required: yes — Describe:
Interim occupancy recommendations: full occupancy — Describe:

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

Across — Assessed %NBS before: 100% — ##### %NBS from IEP below
Assessed %NBS after: 100%

14. Appendix 4 – Geotechnical Desktop Study

Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	037
Address	Horseshoe Lake Reserve Toilet, near 148 Lake Terrace Road
Report date	03 April 2012
Author	Ross Roberts / Ananth Balachandra
Reviewer	Leah Bateman
Approved for issue	Yes

1. Introduction

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

2. Scope

This geotechnical desk top study incorporates information sourced from:

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

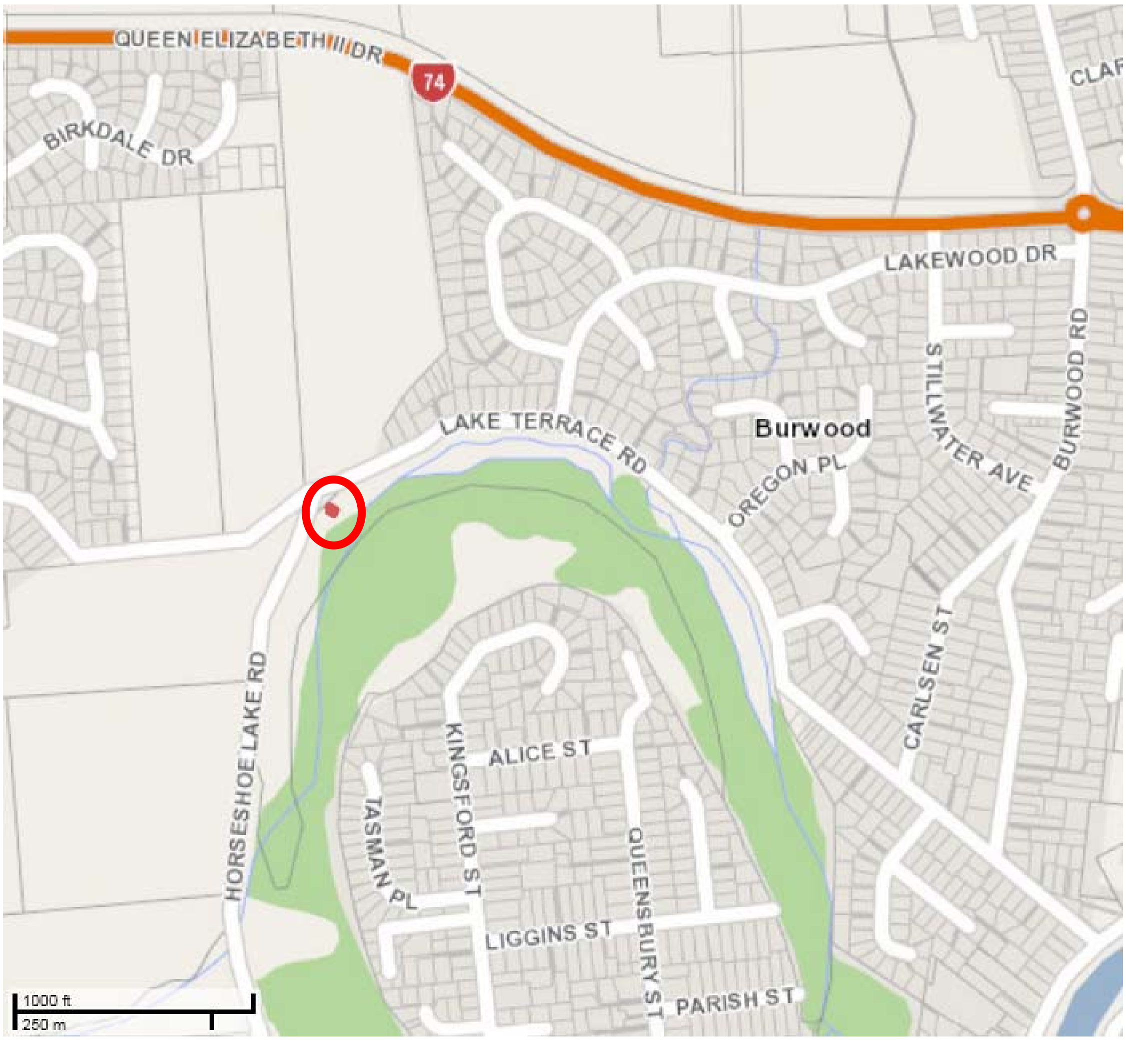
3. Limitations

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

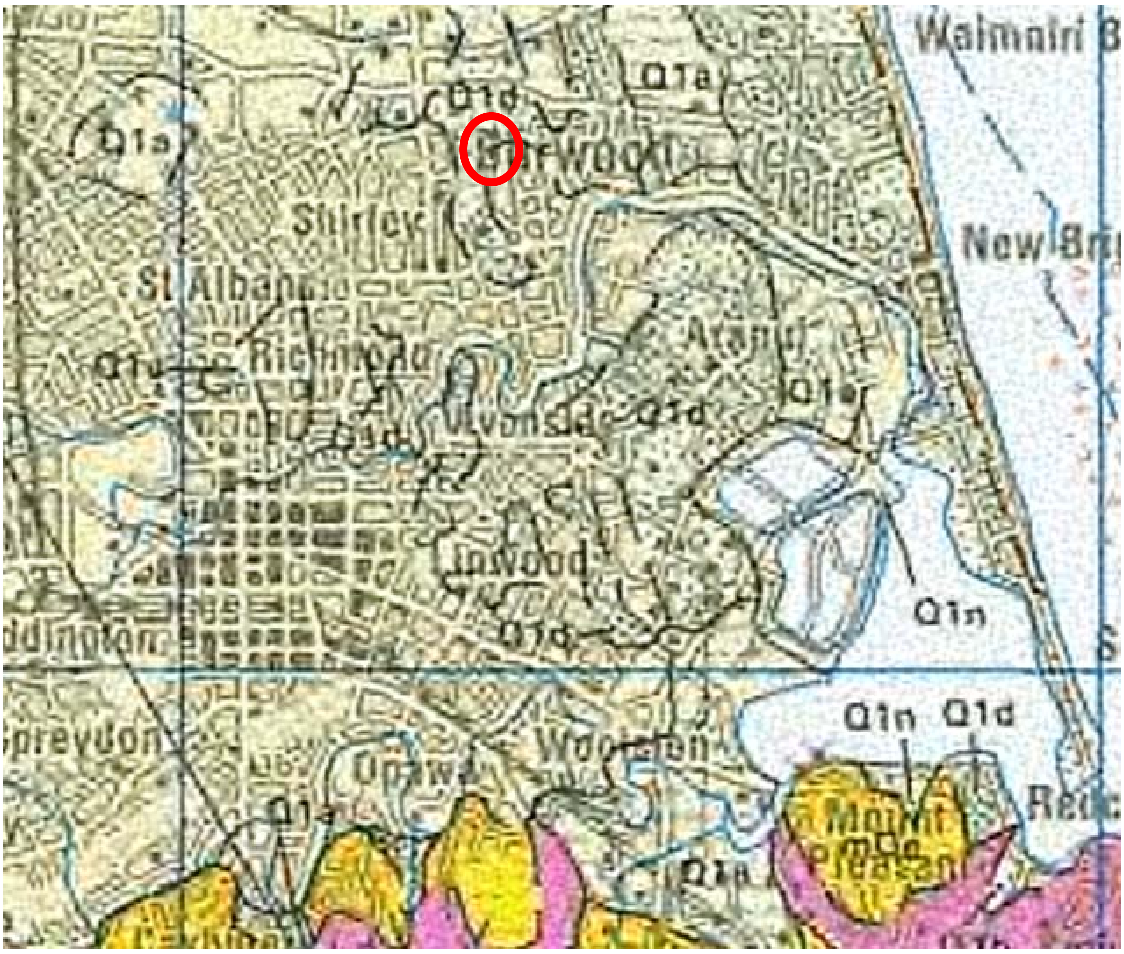


- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

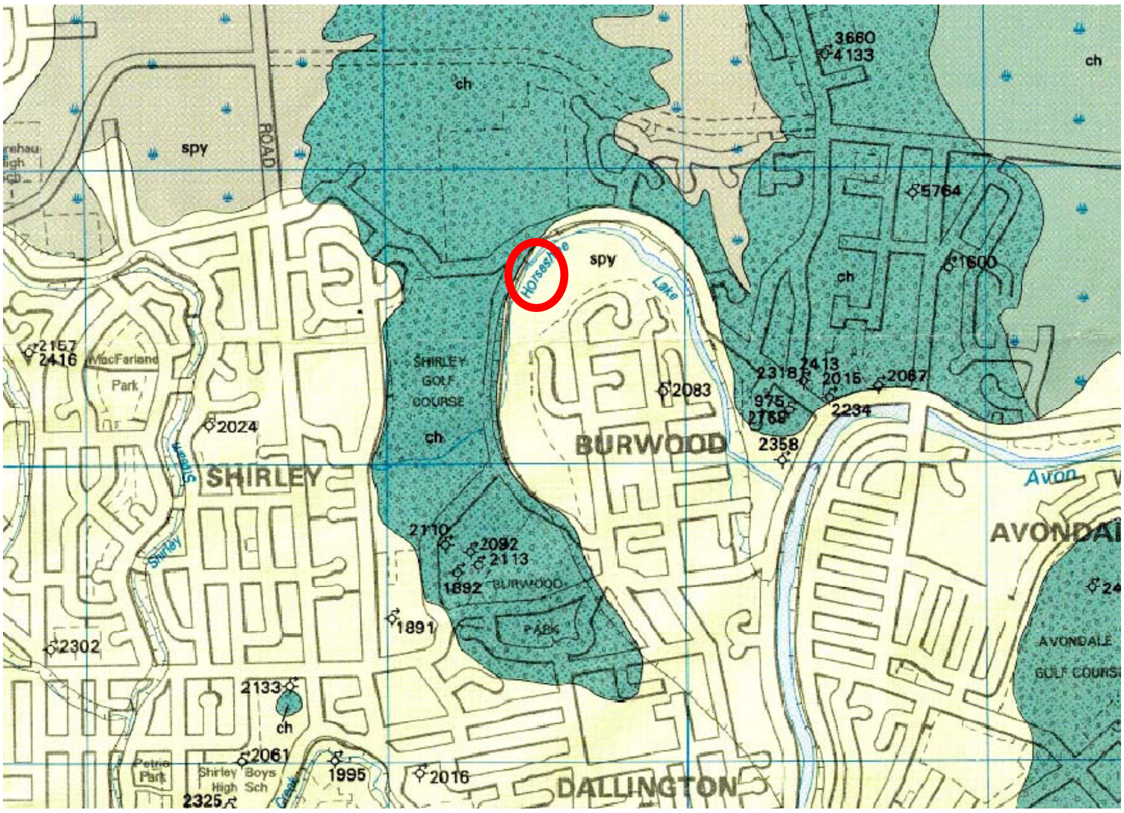
The structure is located on the corner of Horseshoe Lake Road and Lake Terrace Road at grid reference 1573475 E, 5184115 N (NZTM).

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. Immediately to the north and west lies an area of Christchurch Formation sand of fixed dunes.

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 at this site.

5.3 Aerial photography

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

Aerial photography shows significant land damage after the 22 Feb 2011 event. There appears to be minor liquefaction along Horseshoe Lake Road. The majority of damage appears to be lateral spreading in towards the lake.

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: N/A (Urban Non-residential)
- Surrounding residential properties are Technical Category 2 on the northern side of the lake (outside bend) and Residential Red Zone on the Southern side or inside bank of the lake.

5.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the site lies in land that was recorded as marshland or swamp in 1856. It is therefore likely that soft or liquefiable ground would be present near the site.

5.6 Existing ground investigation data

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

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

5.7 Council property files

The council property files include documents pertaining to the construction of a new foot bridge and public toilet block. As the desk study is limited to the public toilet block located in Horseshoe Lake reserve, the foundation details for the foot bridge are not described in this report.

The hazards and information register created for the construction work identifies fill underlying the site to a depth of 800mm to 1200mm. The document refers to a site plan identifying the fill areas. However, this document was not found within the available records. The fill material is described to comprise a combination of onsite brown sand and silt and offsite loess. Additionally, the document identifies that scala penetrometer tests were performed, with the fill identified to have an allowable bearing capacity in excess of 100kPa. However, it is noted in the document that the determined value does not eliminate the need for investigation during future projects.

Additionally, council records show that site specific ground conditions are not known. However, the local area is said to be underlain by "*suspect ground due to the presence of soft soil*". Additionally, the project memorandum from Christchurch City Council identifies the site to be potentially liquefiable during a strong earthquake. Furthermore, the site is identified as “contaminated or possibly contaminated” due to site’s former use as a landfill. There is no further information on the landfill.

5.8 Site walkover

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

The toilets were constructed of metal sheets for walls and the roof, with external wooden columns. There was no obvious structural damage to the building itself, and no remaining evidence of liquefaction around the site.

The paving next to the toilet had been removed. Large amounts of lateral spread was observed to the north east of the building on the asphalted car park area (next to the river) and directly around the toilet (to the north east and south west). Large tension cracks were seen in the ground around the site running parallel to the lake edge.

The bridge to the east of the toilets was severely damaged and was tilted to one side.

- **Figure 7 Overview of toilet block with damaged bridge in foreground**

■ **Figure 8 Overview map showing alignment and distribution of tension cracks**

- **Figure 9 Lateral spreading in access way to north east of toilet block**

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 – 3	Silty sand
3 – 27	Sand
23 – 40+	Gravel

6.2 Seismic site subsoil class

From the available data we can not confirm the seismic site subsoil class. In accordance with NZS1170.5 the site will be either Class D (deep or soft soil) or Class E (Very Soft Soil).

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

In this case the second preferred method has been used to make the assessment utilising records from sites at least 60 m from the site. A site specific investigation could determine the site class.

6.3 Building Performance

Although detailed records of the existing foundations are not available, the foundations of the structure appear to have performed well even after the significant lateral spreading of the site due to the 22nd February earthquake. However, whether the current foundation solution is appropriate to withstand future earthquake events is questionable and would depend on the inspection of the structure performed by a structural engineer.

6.4 Ground performance and properties

Even though no liquefaction was found on site during the reconnaissance undertaken by M Cubrinovsko and M Taylor, the extensive lateral spreading towards the lake would suggest there is moderate to severe risk of liquefaction occurring in the ground underlying the site.

As existing investigation data are generally located at significant distances away from the site or not sufficient detailed, an estimate of ground properties that could be used in design has not been made in this desk study. Additional investigations are recommended in order to estimate likely properties of the shallow soil layer.

6.5 Further investigations

Additional investigations recommended are:

- Two cone penetration tests to estimate the depth of liquefiable layer and determine the sub-soil class in accordance with NZS1170.5

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.

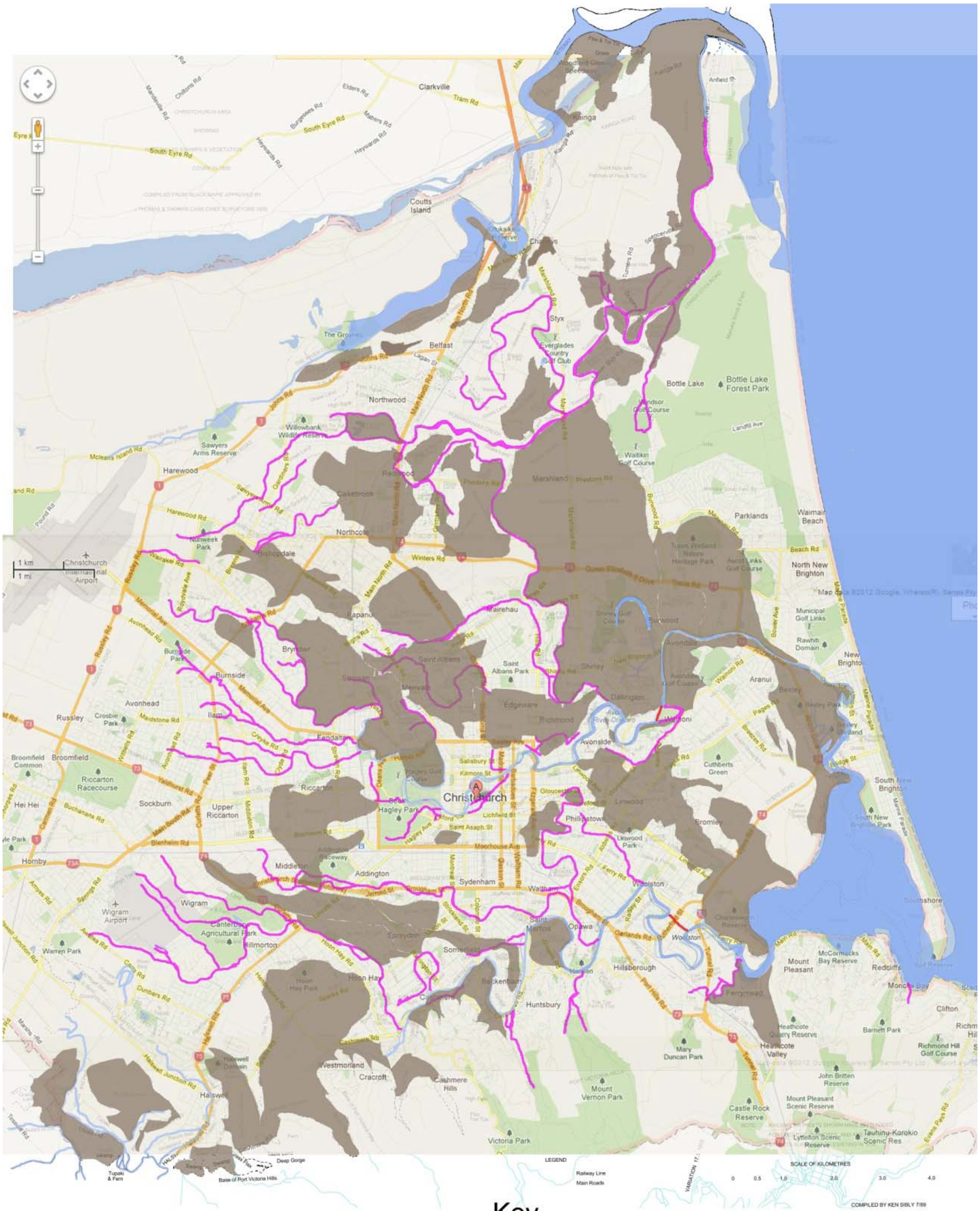
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

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



Key

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

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

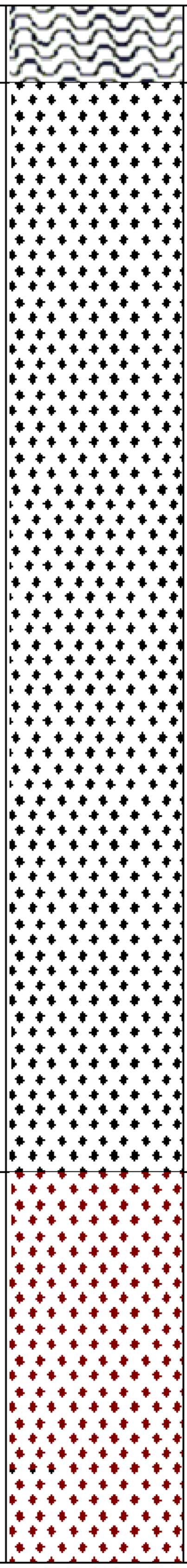
Appendix B – Existing ground investigation logs

Borelog for well M35/12189

Gridref: M35:83412-45729 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 5.33 +MSD
Well name : CCC BorelogID 202
Drill Method : Not Recorded
Drill Depth : -6.1m Drill Date : 1/01/2001

Environment Canterbury Regional Council

Scale(m)	Water Level	Depth(m)	Full Drillers Description	For
-0.2, -0.4		-0.30m	moist topsoil	
-0.6 ... -4.4		-4.57m	blue grey saturated running sand	
-4.6 ... -6		-6.10m	brown saturated sand	

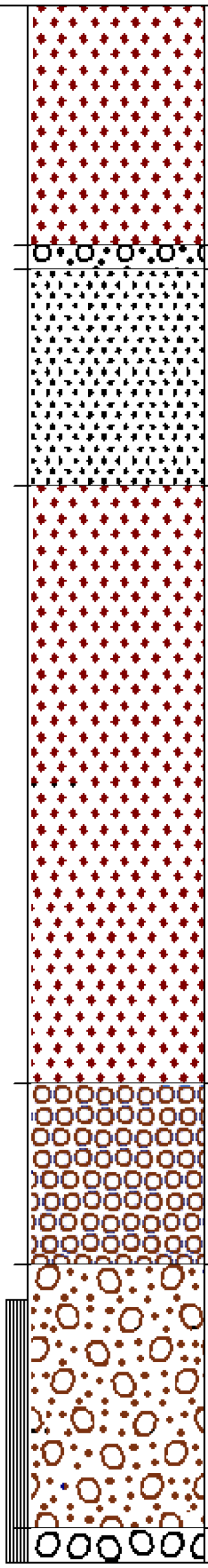


Borelog for well M35/1588

Gridref: M35:833-457 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 4.4 +MSD
Driller : not known
Drill Method : Driven Pipe
Drill Depth : -39.59m Drill Date :

Water level: -2.2CalcMin

Scale(m): -5, -10, -15, -20, -25, -30, -35



Depth(m)	Full Drillers Description	For
	Brown sand	
-6.09m	Seams of very fine gravel in Brown sand	
-6.69m	Fine Brown sand	
- 12.2m	Brown sand	
- 27.4m	Brown shingle	
- 32.0m	Brown sandy shingle	
- 38.7m	Brown shingle with seams of Yellow clay	
- 39.8m		

Ground Investigation

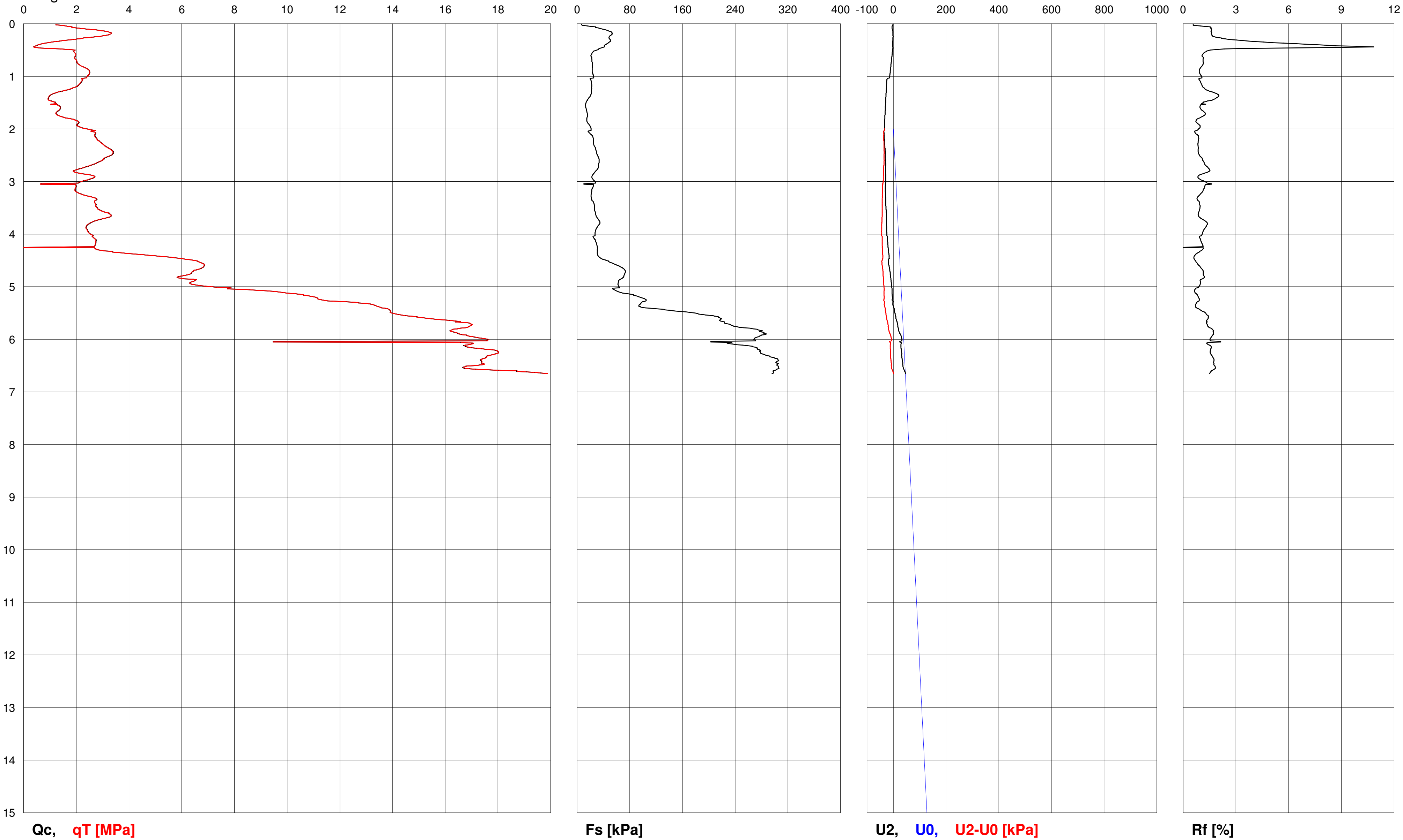
Commissioner: T and T

Site: Christchurch - Horseshoe lakes
Locality: Christchurch

Test Location: CPT 1131
Date: 26/11/2010

Abs. quota [cm]: 0
Prehole [cm]: 0
Hydrostatic Line [cm]: 200

Page 1/1



TGSW03 for Pagani Geotechnical Equipment acquisition systems

Ground Investigation

Commissioner: T and T

Site: Christchurch - Horseshoe lakes
Locality: Christchurch

Test Location: CPT 1153
Date: 26/11/2010

Abs. quota [cm]: 0
Prehole [cm]: 0
Hydrostatic Line [cm]: 200

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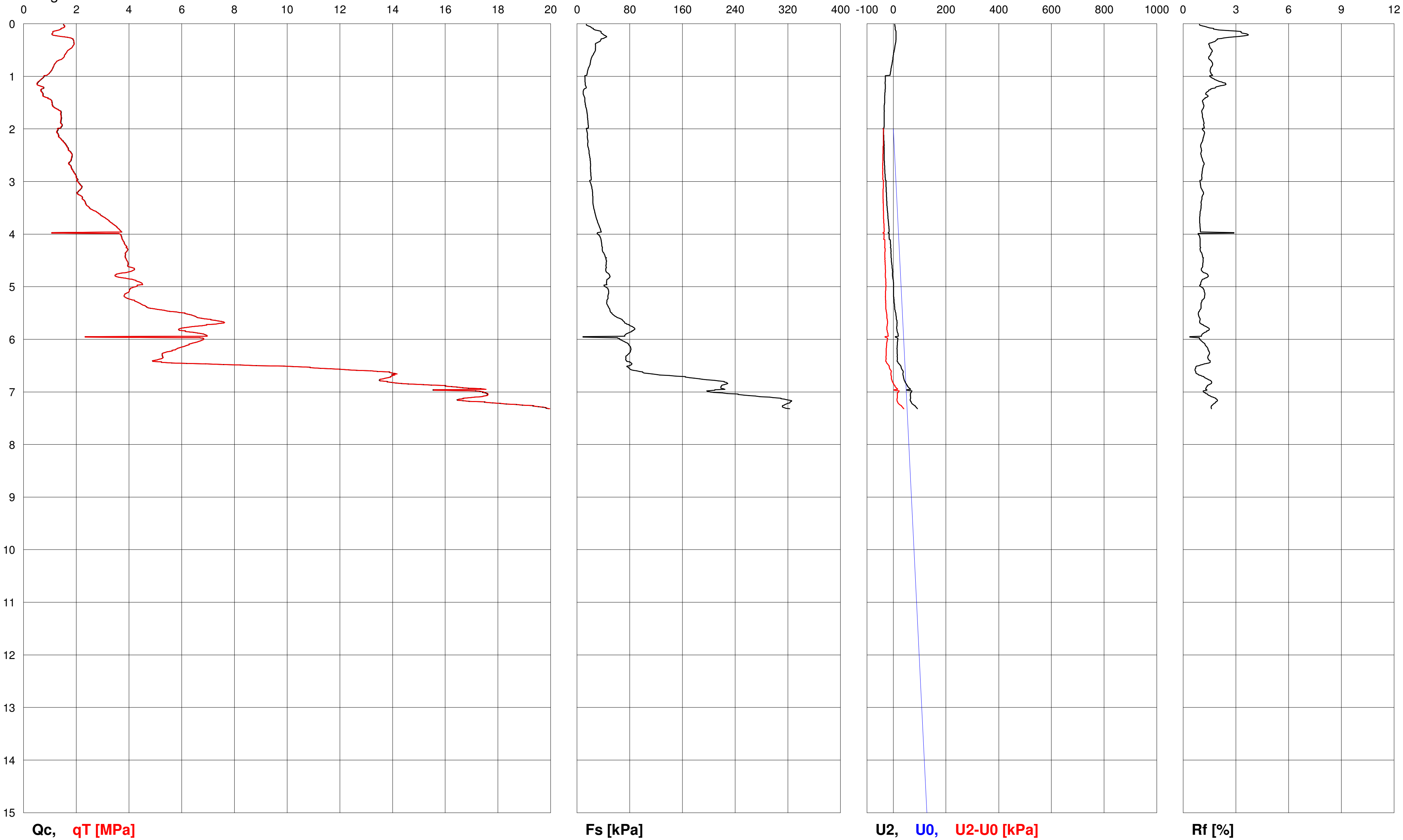
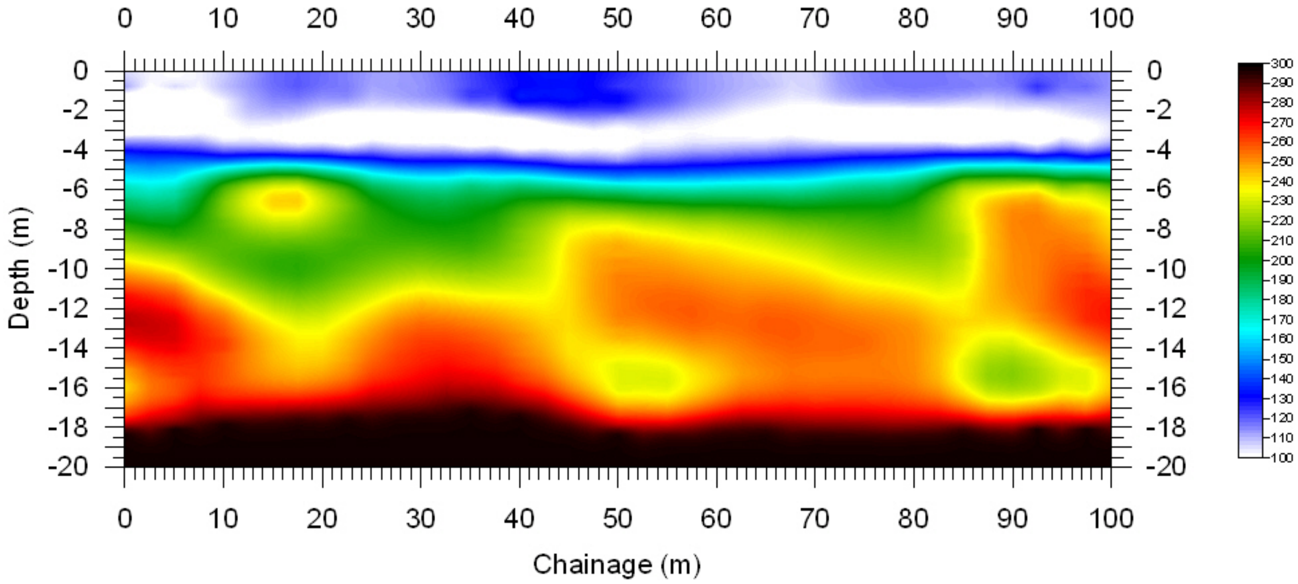


TGSW03 for Pagani Geotechnical Equipment acquisition systems

Horse Shoe Lake Northern 0-100m MASW



Appendix C – Geotechnical Investigation Summary

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

ID	1	2	3	4	5
Type *	BH	BH	CPT	MASW	CPT
Ref	M35-12189	M35-1588	BUR-31	N/A	BUR-53
Depth (m)	6	40	6.7		7
Distance from site (m)	60	180	220	220	230
Ground water level (mBGL)		2.2			
Simplified recorded geological profile (depth below ground level to top of stratum, m) 0	? L			N/A	
1	? L				
2	? L				
3	? L				
4	? L				
5	? L				
6					
7					
8					
9					
10					
11					
12					
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14					
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16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Greater depths		Gravel from 27 m to 40 m			

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

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