CHRISTCHURCH CITY COUNCIL
PRK_1190_BLDG_017 EQ2
North Hagley 3 Bay Garage
Hagley Park, Christchurch Central

QUALITATIVE ASSESSMENT REPORT
FINAL

- Rev B
- 24 September 2013

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	Signature	Date	Name	Title
Author		24/09/2013	Willow Patterson-Kane	Structural Engineer
Approver		24/09/2013	Nick Calvert	Senior Structural Engineer

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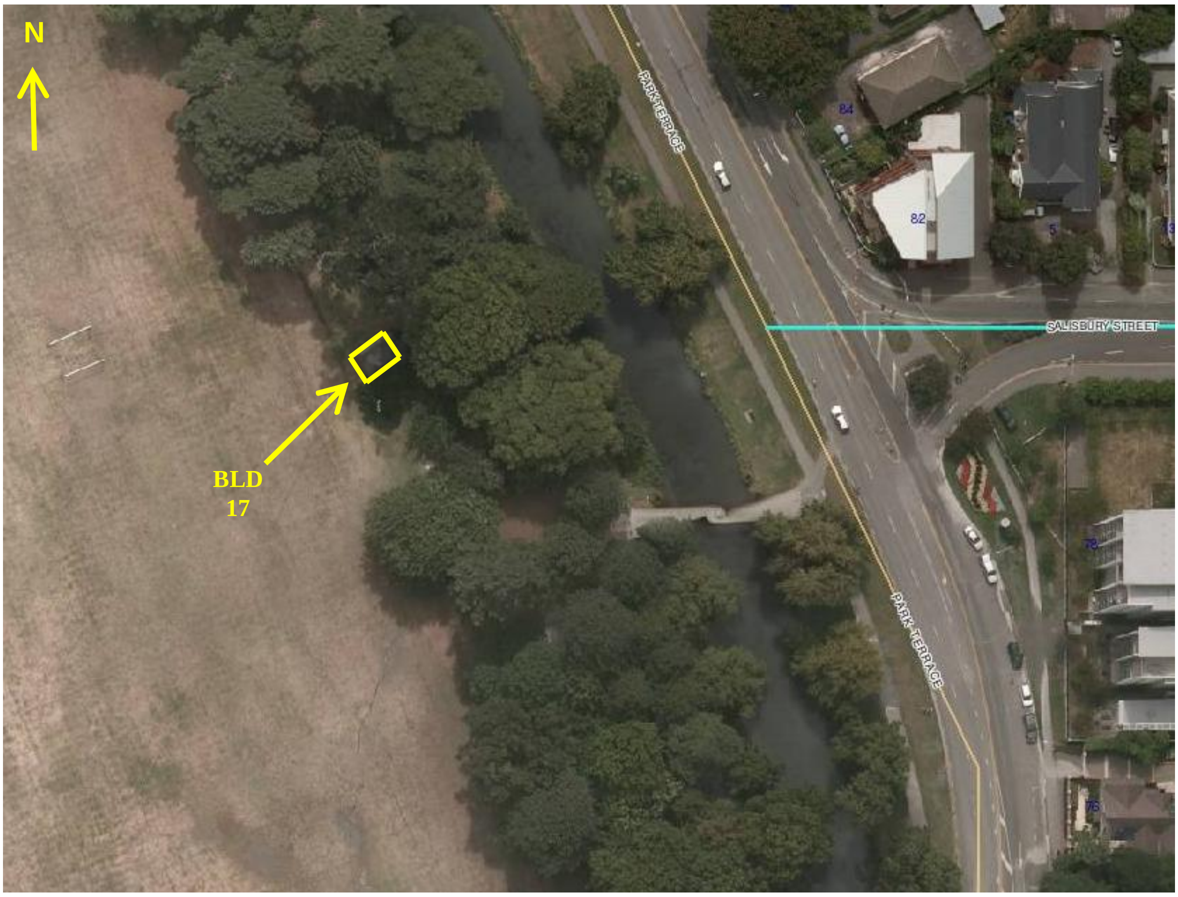
1. Executive Summary

1.1. Background

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



▪ Figure 1 Aerial Photograph of the 3 Bay Garage North Hagley Park

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

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

1.2. Key Damage Observed

Key damage observed includes:-

- Hairline cracking in concrete walls.

Repair recommendations for the damage above are included in section 0.

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 21%NBS. The damage observed during the site investigation was not significant, therefore the post earthquake capacity will not change as a result of earthquake damage.

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

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

1.5. Recommendations

It is recommended that:

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

2. Introduction

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

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

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

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

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

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

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

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

3. Compliance

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

3.1. Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

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

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

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

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

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

3.2. Building Act

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

3.2.1. Section 112 – Alterations

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

3.2.2. Section 115 – Change of Use

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

3.2.3. Section 121 – Dangerous Buildings

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

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

3.2.4. Section 122 – Earthquake Prone Buildings

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

3.2.5. Section 124 – Powers of Territorial Authorities

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

3.2.6. Section 131 – Earthquake Prone Building Policy

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

3.3. Christchurch City Council Policy

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

The 2010 amendment includes the following:

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

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

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

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

- The accessibility requirements of the Building Code.

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

3.4. Building Code

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

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

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

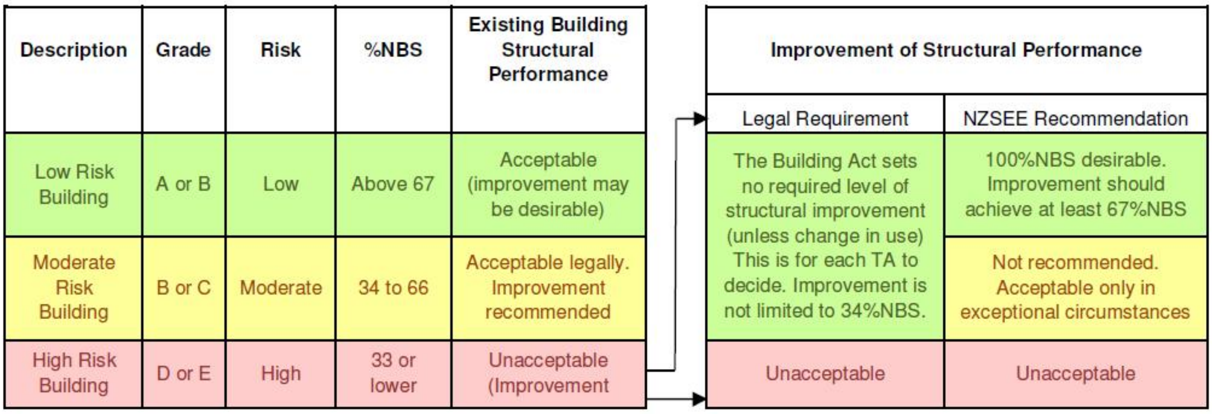
The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

4. Earthquake Resistance Standards

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

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

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

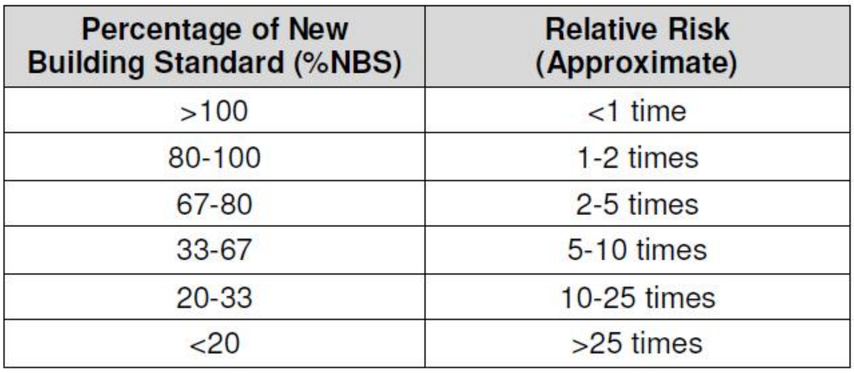


Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless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

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

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

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



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

5. Building Details

5.1. Building description

The building is located near the corner of Salisbury Street and Park Terrace in North Hagley Park. There is only one building on this site. The building has one storey that is believed to be currently utilised for storage. The building is assumed to be constructed from rendered concrete block walls on the east, south and west walls, with an opening on the north side that is 5.1m wide and supported by two 140x140mm timber columns at even spacing. The connection between the timber columns and their concrete footings is unknown. It is assumed that the block walls are unreinforced. The roof is assumed to be timber-framed with corrugated metal roof sheeting. The ground floor appears to be supported on a concrete slab foundation, which extends north of the building in front of the entrance. In the northwest corner, the underside of the foundation seems to be exposed at the surrounding ground level. It is assumed the building was designed and constructed in the 1970’s based on its architecture.

Our evaluation was based on the external visual inspection carried out on 19 June 2012. Internal inspection was not able to be performed as the building was inaccessible at the time of the inspection. Drawings were not available to verify the construction materials, foundation system and the date of construction.

5.2. Gravity Load Resisting system

It appears that the gravity loads are taken by the timber-framing in the roof and then transferred into the concrete walls, with direct transfer into the concrete slab foundation below.

5.3. Seismic Load Resisting system

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

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

5.4. Geotechnical Conditions

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

- In accordance with NZS1170.5 the site is likely to be seismic subsoil Class D (deep or soft soil) ground performance and properties.
- Liquefaction risk in the area has been assessed as low to moderate. No significant liquefaction was noted in the area immediately surrounding the structure.

As there is some variation in the shallow soil indicated by the available investigation data, ground properties cannot be recommended at this stage in order to perform a quantitative assessment. Therefore, the additional investigations recommended are:

- Two cone penetrometer tests on site to refusal. Note there is some chance the CPT's may refuse on shallow gravel layers, therefore we recommend a dual tube rig that can drill through gravels and obtain CPT data from below this level or a larger CPT with high push capability that may be able to penetrate gravel layers.

6. Damage Summary

SKM undertook an inspection on 19 June 2012. The following areas of damage were observed during the time of inspection:

General

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

Building Damage

1) Horizontal hairline cracking of the paintwork on the rendered concrete block walls. This damage is non-structural, therefore a repair recommendation will not be provided.
2) Existing impact damage was noted on wall corners, but this is not earthquake-related damage.
3) Cracking of the concrete ground slab to the north of the building was noted (up to 10mm wide). This is believed to be due to gradual settlement as greater earthquake damage to the structure would be expected if the concrete ground slab had a 10mm wide crack as a result of earthquake damage (refer to Photo 10).

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

7. Initial Seismic Evaluation

7.1. The Initial Evaluation Procedure Process

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

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

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

Table 2: IEP Risk classifications

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

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

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

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

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

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

7.2. Available Information, Assumptions and Limitations

Following our inspection on 19 June 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 following assumptions and design criteria were used in this assessment:

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

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

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

7.3. Critical Structural Weaknesses

No critical structural weaknesses have been identified in this building.

7.4. Qualitative Assessment Results

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

Table 3: Qualitative Assessment Summary

Item	%NBS
Likely Seismic Capacity of Building	21

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

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

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

The Engineering Advisory Group notes:

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

8. Further Investigation

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

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

- Construction materials, especially in the walls.
- Depth of foundation.
- Structural roof member sizes and layouts.
- Connections sizes and layouts.

9. Conclusion

A qualitative assessment was carried out on the building located near the corner of Salisbury Atreet and Park Terrace in North Hagley Park, in Christchurch Central. The building has sustained minor damage with paint tearing along the external concrete walls. The building has been assessed to have a seismic capacity in the order of 21% NBS and is therefore potentially earthquake prone and is likely to be classified as a 'High Risk Building' (capacity less than 34% of NBS).

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

It is recommended that:

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

10. Limitation Statement

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

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

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

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

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

11. Appendix 1 – Photos

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

<table>
<tr><td></td><td></td></tr>
<tr><td>Photo 5: Timber roofing elements on the north side.</td><td>Photo 6: Timber column on north side in front of garage door.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Photo 7: Timber ceiling cladding shown above garage door on north side of building.</td><td>Photo 8: Timber column on north side in front of garage door.</td></tr>
</table>

Photo 9: Concrete footing under 140x140mm timber column on north side.

Photo 10: Cracking of concrete ground slab in front of entrance on north side.

Photo 11: Existing impact damage to timber column embedded into concrete wall on north side.

Photo 12: Timber roofing elements on north side.

Photo 13: Hairline cracking in concrete wall on northwest corner (typical).

Photo 14: Hairline cracking in concrete wall on southwest corner (typical).

Photo 15: Underside of concrete footing exposed on northwest corner.

Photo 16: Corrugated metal roof cladding.

	
Photo 17: Timber cladding on soffit.	Photo 18: Existing impact damage on southeast corner (typical).

12. Appendix 2 – IEP Reports

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

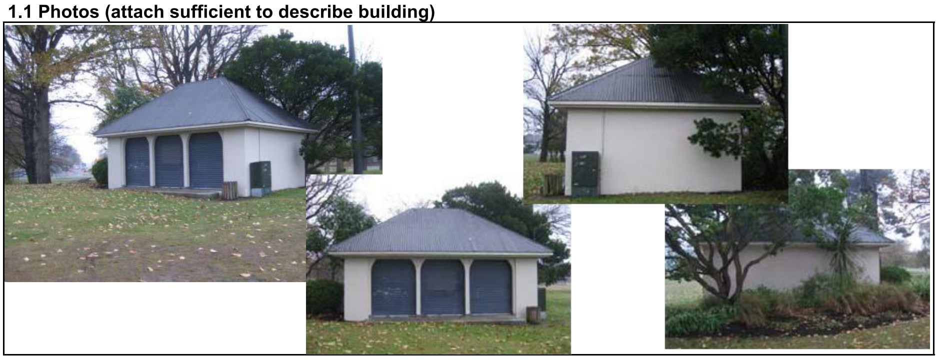
Page 1

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

Building Name:	North Hagley 3 Bay Garage	Ref.	ZB01276.164
Location:	Near cnr of Salisbury St & Park Terrace, Christchurch Central	By	WPK
		Date	20/06/2012

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)



1.2 Sketch of building plan

1.3 List relevant features

The building in North Hagley Park near the corner of Salibury Street and Park Terrace is one storey and is believed to be currently used for storage. The building is assumed to consist of unreinforced rendered concrete block walls and a timber-framed roof. The main lateral load-resisting system appear to be the walls. These act as shear walls in the north-south and east-west direction. The roof structure appears to consist of timber rafters that support a lightweight roof. The walls appear to be founded on a concrete slab footing. The building is assumed to have been constructed in the 1970's.

1.4 Note information sources

Tick as appropriate

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

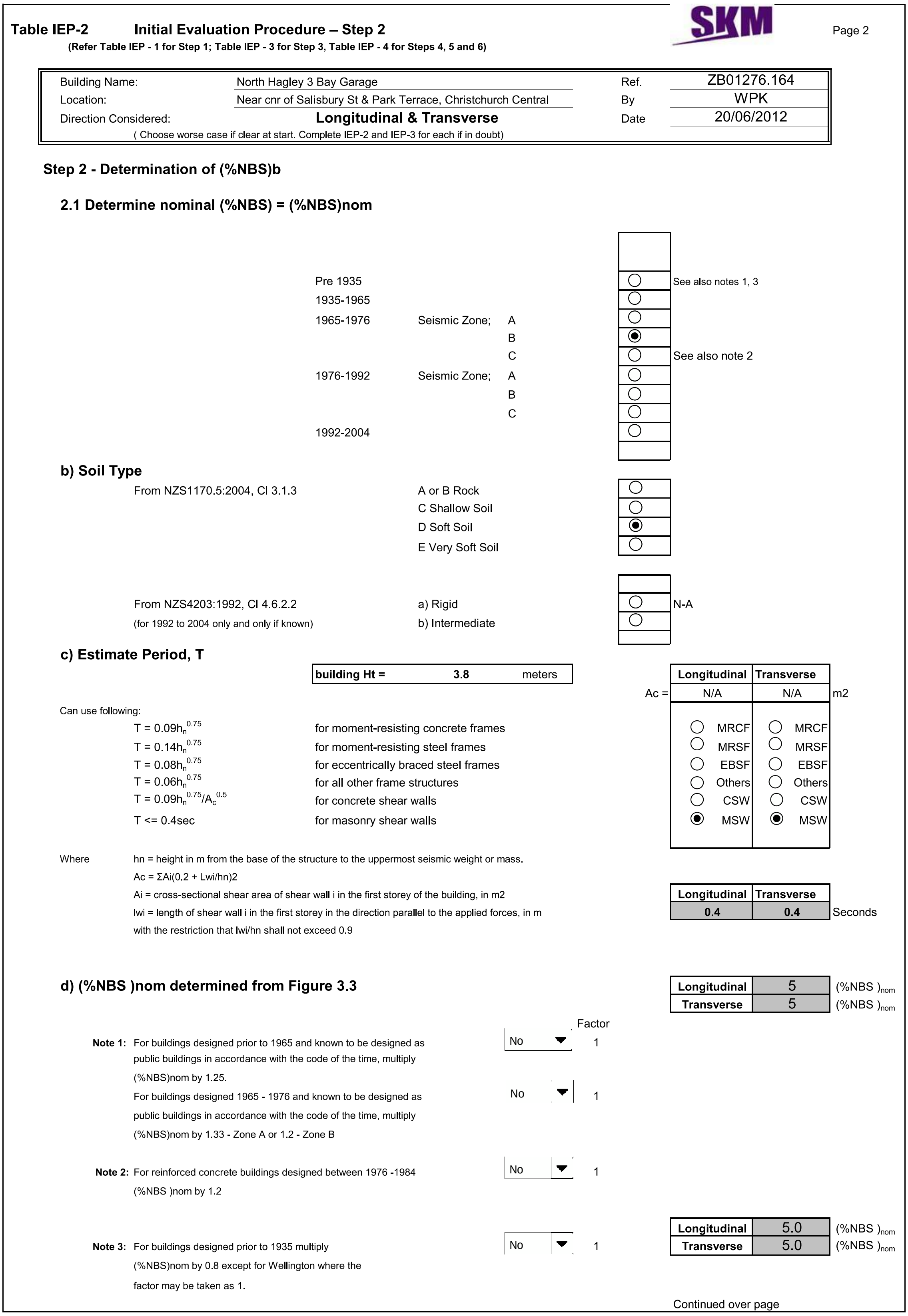


Table IEP-2 **Initial Evaluation Procedure – Step 2**

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

Page 2

Building Name:	North Hagley 3 Bay Garage	Ref.	ZB01276.164
Location:	Near cnr of Salisbury St & Park Terrace, Christchurch Central	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/06/2012

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

Step 2 - Determination of (%NBS)b

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

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

b) Soil Type

From NZS1170.5:2004, Cl 3.1.3	A or B Rock	○
	C Shallow Soil	○
	D Soft Soil	●
	E Very Soft Soil	○

From NZS4203:1992, Cl 4.6.2.2	a) Rigid	○	N-A
(for 1992 to 2004 only and only if known)	b) Intermediate	○	

c) Estimate Period, T

building Ht = **3.8** meters

	Longitudinal	**Transverse**	
Ac =	N/A	N/A	m2

Can use following:

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

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

Longitudinal	**Transverse**	
0.4	**0.4**	Seconds

d) (%NBS)nom determined from Figure 3.3

Longitudinal	5	$(\%NBS)_{nom}$
Transverse	5	$(\%NBS)_{nom}$

			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	5.0	$(\%NBS)_{nom}$
Transverse	5.0	$(\%NBS)_{nom}$

Continued over page

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Table IEP-2 **Initial Evaluation Procedure – Step 2 continued**

Building Name:	North Hagley 3 Bay Garage	Ref.	ZB01276.164
Location:	Near cnr of Salisbury St & Park Terrace, Christchurch Central	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/06/2012

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

2.2 Near Fault Scaling Factor, Factor A

If T < 1.5sec, Factor A = 1

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

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

2.3 Hazard Scaling Factor, Factor B

Select Location: Christchurch ▼

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

Z = 0.3
Z 1992 = 0.8

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

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

Factor B 3.33

2.4 Return Period Scaling Factor, Factor C

a) **Building Importance Level** 2 ▼
(from NZS1170.0:2004, Table 3.1 and 3.2)

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

2.5 Ductility Scaling Factor, D

a) **Assessed Ductility of Existing Structure, μ**
(shall be less than maximum given in accompanying Table 3.2)

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

b) **Ductility Scaling Factor**
For pre 1976 = k_μ
For 1976 onwards = 1
(where k_μ is NZS1170.5:2005 Ductility Factor, from accompanying Table 3.3)

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

2.6 Structural Performance Scaling Factor, Factor E

Select Material of Lateral Load Resisting System

Longitudinal	Masonry Block ▼
Transverse	Masonry Block ▼

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

Longitudinal	Sp	0.90
Transverse	Sp	0.90

b) **Structural Performance Scaling Factor**

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

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

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

Longitudinal	21.2	(%NBS)b
Transverse	21.2	(%NBS)b

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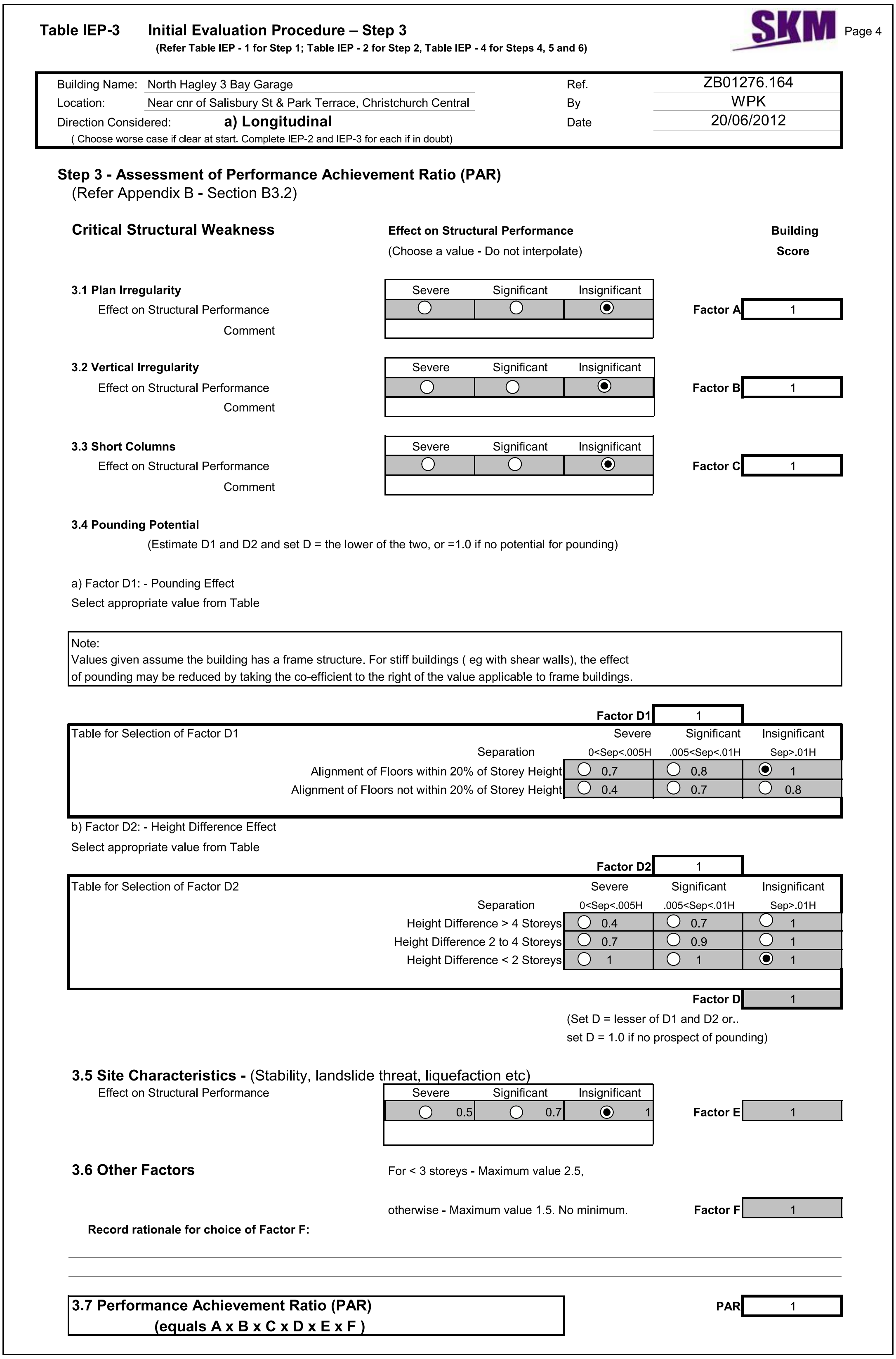

Table IEP-3 **Initial Evaluation Procedure – Step 3** Page 4

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

Building Name: North Hagley 3 Bay Garage
Location: Near cnr of Salisbury St & Park Terrace, Christchurch Central
Direction Considered: **a) Longitudinal**
(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)
Ref. ZB01276.164
By WPK
Date 20/06/2012

Step 3 - Assessment of Performance Achievement Ratio (PAR)
(Refer Appendix B - Section B3.2)

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

3.1 Plan Irregularity

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

3.2 Vertical Irregularity

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

3.3 Short Columns

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

3.4 Pounding Potential

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

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

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

Factor D1 1

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

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

Factor D2 1

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

Factor D 1

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

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

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

3.6 Other Factors For < 3 storeys - Maximum value 2.5,

otherwise - Maximum value 1.5. No minimum. **Factor F** 1

Record rationale for choice of Factor F:

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

PAR 1

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:	North Hagley 3 Bay Garage	Ref.	ZB01276.164
Location:	Near cnr of Salisbury St & Park Terrace, Christchurch Central	By	WPK
Direction Considered:	**b) Transverse**	Date	20/06/2012

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

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

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

3.1 Plan Irregularity

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

3.2 Vertical Irregularity

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

3.3 Short Columns

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

3.4 Pounding Potential

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

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

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

Factor D1 1

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

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

Factor D2 1

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

Factor D 1

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

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

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

3.6 Other Factors

For < 3 storeys - Maximum value 2.5,

otherwise - Maximum value 1.5. No minimum. **Factor F** 1

Record rationale for choice of Factor F:

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

PAR 1

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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)

Page 6

Building Name:	North Hagley 3 Bay Garage	Ref.	ZB01276.164
Location:	Near cnr of Salisbury St & Park Terrace, Christchurch Central	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/06/2012

(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)	21	21
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	1.00	1.00
4.3 PAR x Baseline (%NBS)$_b$	21	21
4.4 Percentage New Building Standard (%NBS) (Use lower of two values from Step 4.3)		21

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

%NBS ≤ 33 YES

Step 6 - Potentially Earthquake Risk?

%NBS < 67 YES

Step 7 - Provisional Grading for Seismic Risk based on IEP

Seismic Grade D

Evaluation Confirmed by

Signature

Name

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

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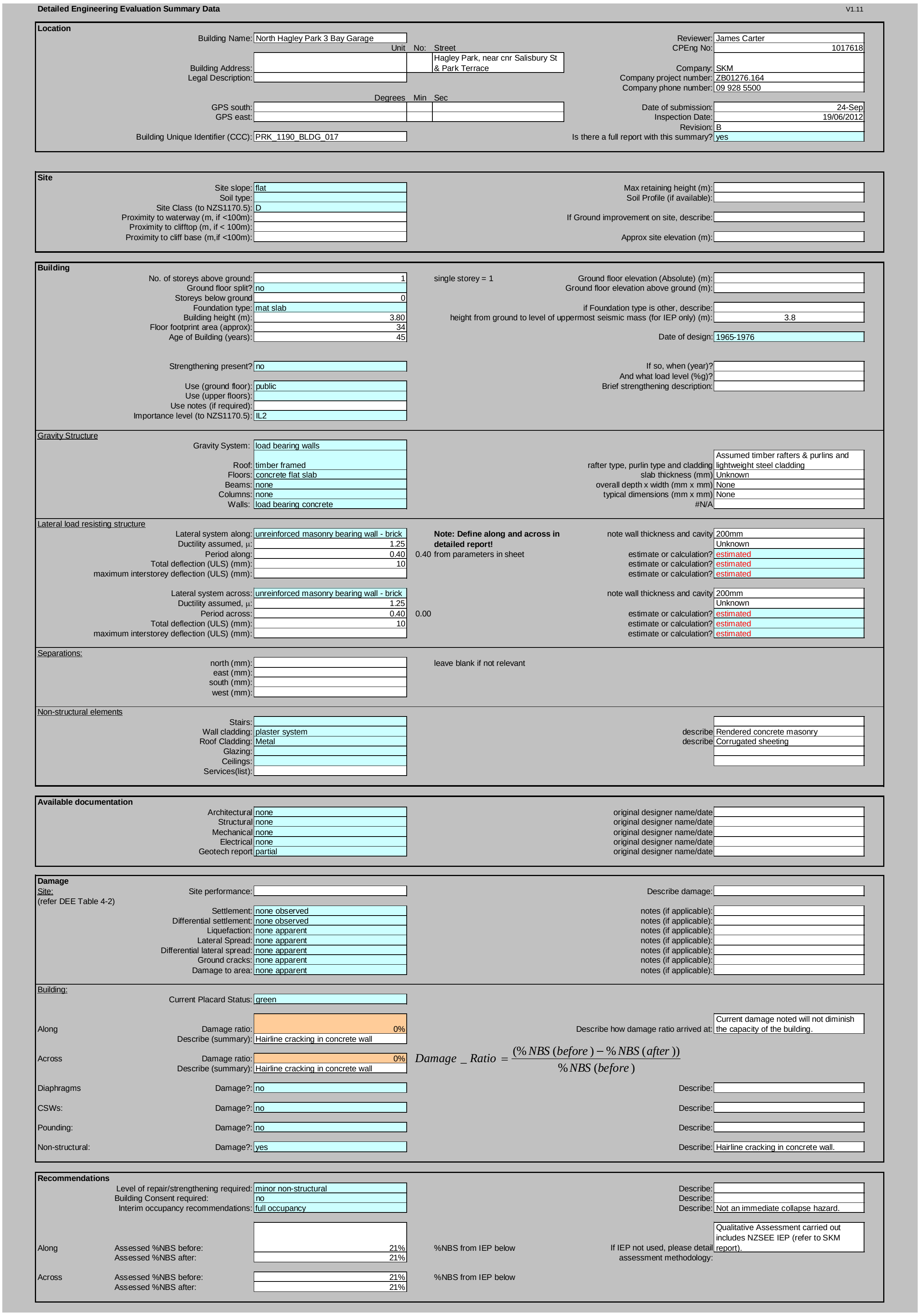
13. Appendix 3 – CERA Standardised Report Form



Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name: North Hagley Park 3 Bay Garage
Unit No: Street
Building Address: Hagley Park, near cnr Salisbury St & Park Terrace
Legal Description:
Degrees Min Sec
GPS south:
GPS east:
Building Unique Identifier (CCC): PRK_1190_BLDG_017

Reviewer: James Carter
CPEng No: 1017618
Company: SKM
Company project number: ZB01276.164
Company phone number: 09 928 5500
Date of submission: 24-Sep
Inspection Date: 19/06/2012
Revision: B
Is there a full report with this summary? yes

Site

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

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

Building

No. of storeys above ground: 1 single storey = 1
Ground floor split? no
Storeys below ground 0
Foundation type: mat slab
Building height (m): 3.80
Floor footprint area (approx): 34
Age of Building (years): 45

Ground floor elevation (Absolute) (m):
Ground floor elevation above ground (m):
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m): 3.8
Date of design: 1965-1976

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

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

Gravity Structure

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

rafter type, purlin type and cladding Assumed timber rafters & purlins and lightweight steel cladding
slab thickness (mm) Unknown
overall depth x width (mm x mm) None
typical dimensions (mm x mm) None
#N/A

Lateral load resisting structure

Lateral system along: unreinforced masonry bearing wall - brick
Ductility assumed, μ: 1.25
Period along: 0.40
Total deflection (ULS) (mm): 10
maximum interstorey deflection (ULS) (mm):

Note: Define along and across in detailed report!
0.40 from parameters in sheet

note wall thickness and cavity 200mm
Unknown
estimate or calculation? estimated
estimate or calculation? estimated
estimate or calculation? estimated

Lateral system across: unreinforced masonry bearing wall - brick
Ductility assumed, μ: 1.25
Period across: 0.40 0.00
Total deflection (ULS) (mm): 10
maximum interstorey deflection (ULS) (mm):

note wall thickness and cavity 200mm
Unknown
estimate or calculation? estimated
estimate or calculation? estimated
estimate or calculation? estimated

Separations:

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

Non-structural elements

Stairs:
Wall cladding: plaster system describe Rendered concrete masonry
Roof Cladding: Metal describe Corrugated 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 partial original designer name/date

Damage

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

Building:

Current Placard Status: green

Along Damage ratio: 0%
Describe (summary): Hairline cracking in concrete wall
Describe how damage ratio arrived at: Current damage noted will not diminish the capacity of the building.

Across Damage ratio: 0%
Describe (summary): Hairline cracking in concrete wall

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

Diaphragms Damage?: no Describe:
CSWs: Damage?: no Describe:
Pounding: Damage?: no Describe:
Non-structural: Damage?: yes Describe: Hairline cracking in concrete wall.

Recommendations

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

Along Assessed %NBS before: 21% %NBS from IEP below
Assessed %NBS after: 21%
If IEP not used, please detail assessment methodology: Qualitative Assessment carried out includes NZSEE IEP (refer to SKM report).

Across Assessed %NBS before: 21% %NBS from IEP below
Assessed %NBS after: 21%

14. Appendix 4 – Geotechnical Desktop Study

Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	164
Address	Hagley Park North – 3 Bay Garage
Report date	August 2012
Author	Ain Kim
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:

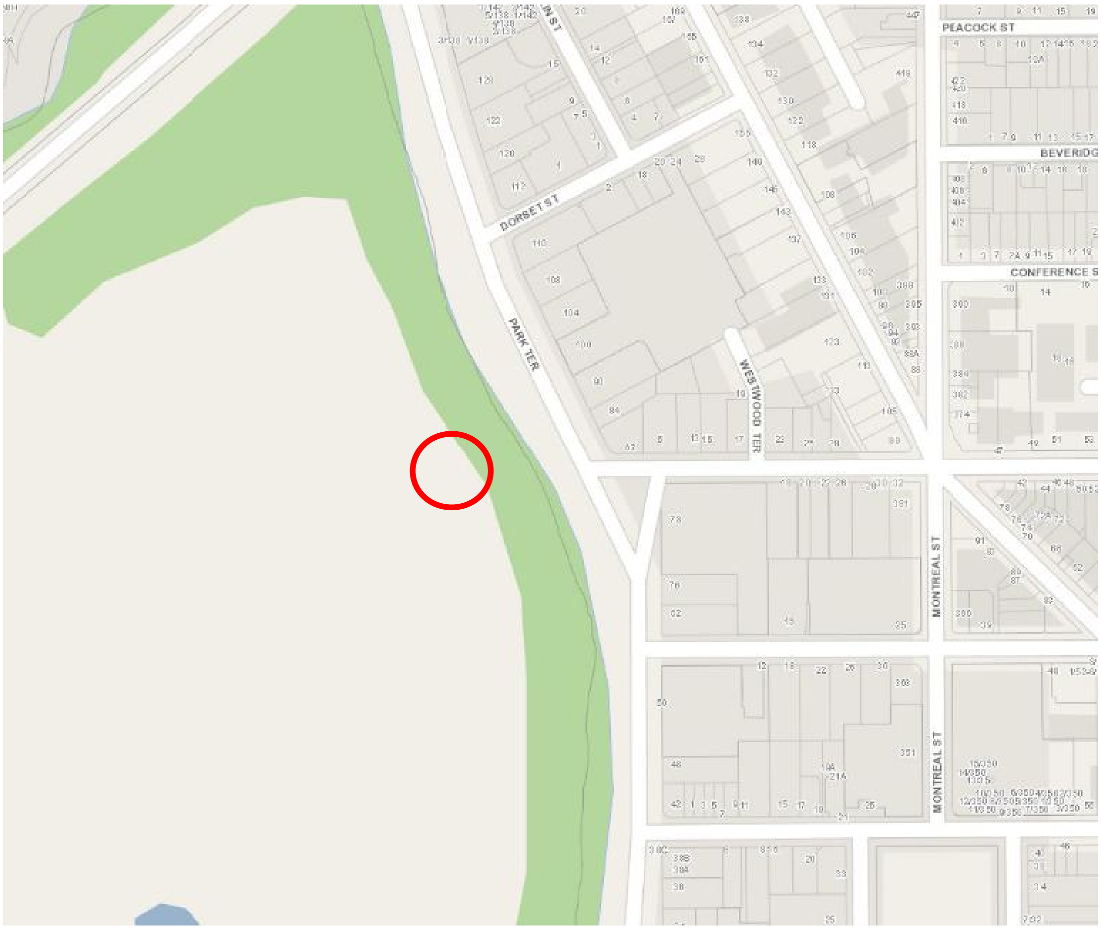
- Published geology
- Publically available borehole records
- Liquefaction records
- Aerial photography
- Council files
- A preliminary site walkover

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.

4. Site location

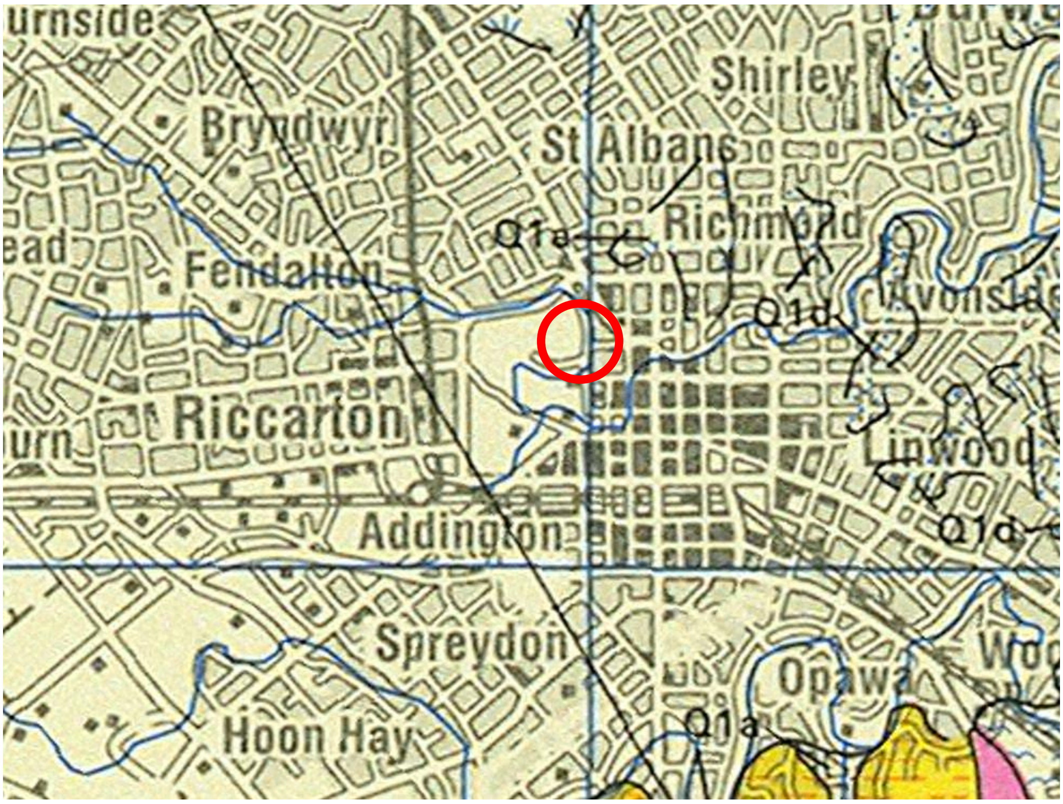


- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

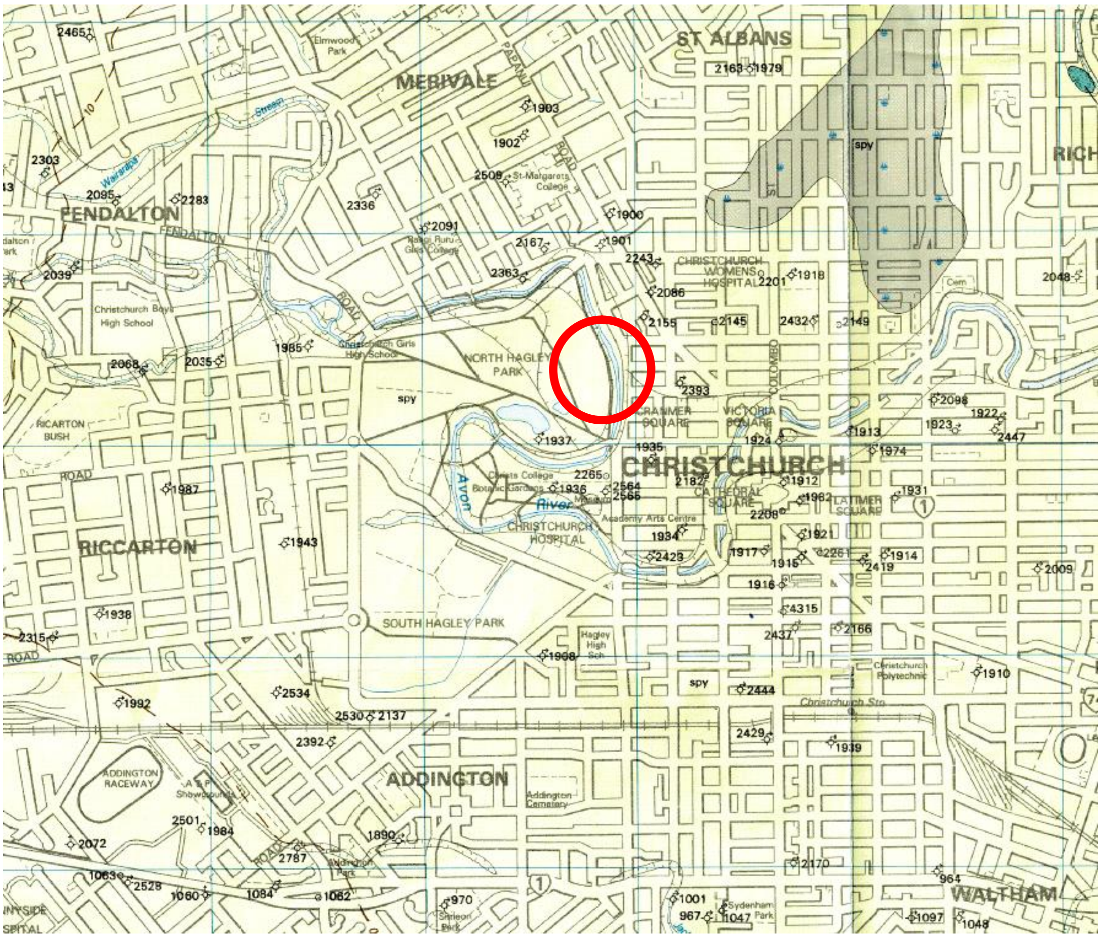
The structure is located at the east end of the North Hagley Park near Park Terrace at grid reference 1569847 E, 5180867 N (NZTM).

5. Review of available information

5.1 Geological maps



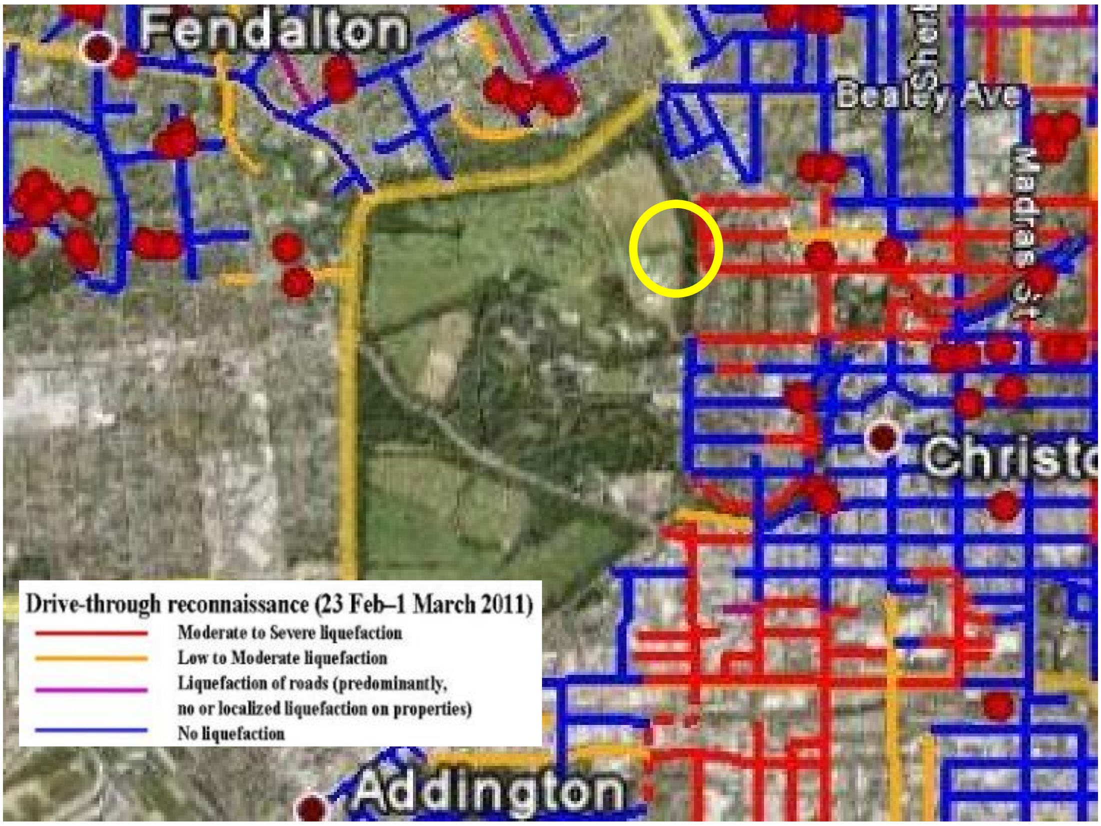
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



- **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.

5.2 Liquefaction map



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

Following the 22 February 2011 event drive through reconnaissance was undertaken from 23 February until 1 March by M Cubrinovsko and M Taylor of Canterbury University. Their findings show that moderate to severe liquefaction occurred in the region immediately east of the area housing the site.

5.3 Aerial photography

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

Figure 5 above, shows no significant ejected material immediately around the site but eject material can be clearly seen approximately 100m away to the southwest and to the east of the structure.

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) properties to the east are classified as TC3

5.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the site was recorded as marshland or swamp in 1856. It is therefore possible that soft or liquefiable ground would be present near the site. Given the relatively low accuracy of these historical documents, it should be considered possible that old swamp deposits are present on 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

No drawings showing a detailed outline of the foundations used for the relevant building or any significant ground investigation information was found in the available council property files.

5.8 Site walkover

An external site walkover was conducted by an SKM engineer on 10 August 2012.

The building was noted to be constructed from reinforced concrete walls with a timber framed roof and slab on grade foundation. The building has an opening roller door on the northern side that is supported by timber columns at even spacing. From the external inspection, cracking in concrete ground slab and impact damage to the timber column on the northern side was noted. No apparent evidence of liquefaction or land damage was observed on the site; however, there is undulating grass land noted farther south of the building, and a new lawn has been laid approximately 150 m to the south of the building where significant liquefaction occurred during the Feb 2011 earthquake.

The Avon River flows close to the east of the building. The nearby Park Terrace and footbridge appeared to be undamaged.

- **Figure 7 Overview of the building (Northern Elevation)**

- **Figure 8 Observed impact damage to timber column on the northern side**

- **Figure 9 New lawn laid approximately 150 m to the south of the building**

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 – 1.5 m	Fill
1.5 – 5.5 m	Silty sand and gravels
5.5 – 6.0 m	Silt with minor clay
6.0 – 8.0 m	Silty fine to medium sand
8.0 – 10.5 m	Fine to coarse gravels
10.5 – 19.5 m	Fine to coarse sand
19.5+ m	Fine to coarse gravels

6.2 Seismic site subsoil class

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

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

In this case the absence of deep boreholes within 50 m from the site has resulted in the use of the least preferred method. It is therefore possible that site specific investigation could revise the site class though we consider this unlikely.

6.3 Building Performance

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

6.4 Ground performance and properties

Liquefaction risk in the area has been assessed as low to moderate. No significant liquefaction was noted in the area immediately surrounding the structure. However, significant amount of liquefaction was noted on the lawn and roadways approximately 100 m away to southwest and east of the structure respectively. Nearby boreholes indicate silt, sand and gravel mixtures underlain by approximately 3 m of gravel layer followed by fine sand layers to be present beneath the site. Any lens of sand that may be present in the gravel layer could be susceptible to liquefaction. There is some variation in the shallow soil indicated by the available investigation data, which means it is not possible to assess the liquefaction susceptibility of this layer.

As all available ground investigation data was greater than 50m away from the site, an estimation of the ground properties has not been provided in this desk study. Additional, investigations closer to the site would be required to perform a full quantitative DEE.

6.5 Further investigations

As there is some variation in the shallow soil indicated by the available investigation data we cannot recommend ground properties at this stage to perform a full quantitative DEE we therefore recommend the following investigation:

- two cone penetrometer tests on site to refusal. Note there is some chance the CPTs may refuse on shallow gravel layers, we therefore recommend a dual tube rig that can drill through gravels and obtain CPT data from below this level or a larger CPT with high push capability that may be able to penetrate gravel layers.

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.

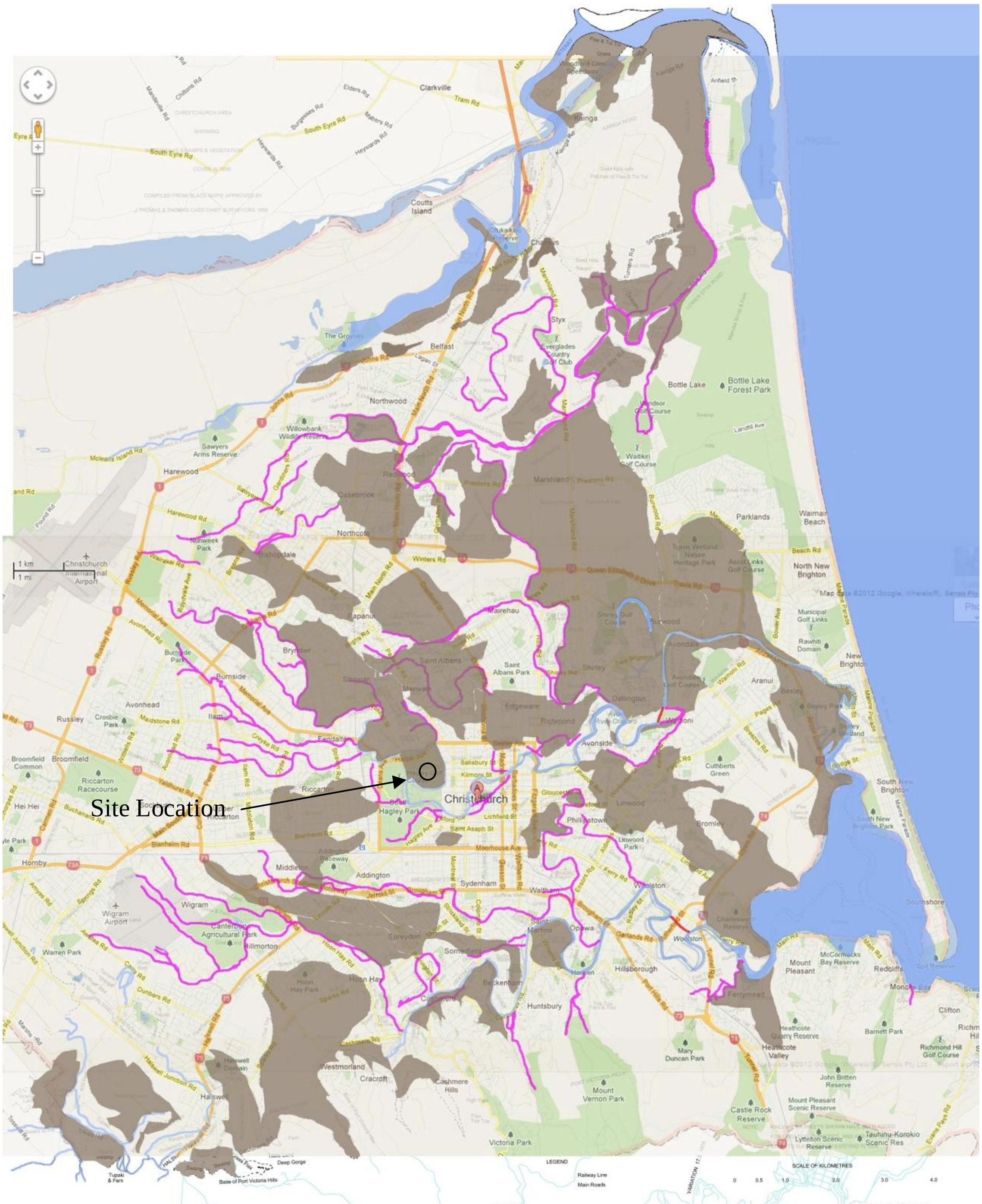
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

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

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 04
Hole Location: Park Terrace

SHEET 1 OF 5

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

CO-ORDINATES 5742484.62 mN
2479914.28 mE
R.L. 6.45 m
DATUM NZGM

DRILL TYPE: Rotary
DRILL METHOD: Triple Tube
DRILL FLUID: Mud

HOLE STARTED: 9/6/11
HOLE FINISHED: 13/6/11
DRILLED BY: McNeill
LOGGED BY: RKH/CP
CHECKED: BMcD

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
HAND DIG FILL. (Potholed for services check and backfilled.)			0	PRE-DUG												FILL: Borehole drilled through pre-dug and backfilled pothole.
								6.0	0.5							
								5.5	1.0							
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)				SPT		1/1/1/1/4/4 N=10 ✱FC	B	5.0	1.5	SP	M	MD				Silty, fine SAND with minor gravel, brownish grey. Medium dense, moist. Gravel is fine to medium, subrounded. Rootlets present. 1.85m to 1.95m no recovery
			71	HQTT				4.5	2.0	GW	M	L				- thin bed of sandy silt Silty, fine to coarse GRAVEL with some sand and cobbles, grey. Loose, moist. Gravel is subrounded to subangular. Sand is fine to coarse.
								4.0	2.5							2.7m to 3.0m no recovery
				SPT		4/5/3/1/1/1 N=6		3.5	3.0							3.2m to 4.5m no recovery
			0	HQTT				3.0	3.5							
								2.5	4.0							
				SPT		2/2/2/1/1/1 N=5		2.0	4.5	SP	M	L				Silty, fine SAND, grey. Loose, moist.
								1.5	5							

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 04
Hole Location: Park Terrace

SHEET 2 OF 5

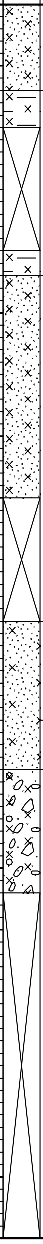
PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5742484.62 mN
2479914.28 mE
R.L. 6.45 m
DATUM NZGM

DRILL TYPE: Rotary
DRILL METHOD: Triple Tube
DRILL FLUID: Mud

HOLE STARTED: 9/6/11
HOLE FINISHED: 13/6/11
DRILLED BY: McNeill
LOGGED BY: RKH/CP
CHECKED: BMcD

GEOLOGICAL
ENGINEERING DESCRIPTION



GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)										SP	M	L				- moderately thin bed of peat, moderately plastic
										ML	M	S				SILT with minor clay, trace sand and rootlets, grey. Soft, moist, low plasticity.
			52	HQTT		✱PSD WS	B	1.0	5.5							5.5m to 6.0m no recovery
				SPT		1/1/1/1/ 3/2 N=7		0.5	6.0							
						✱FC	B			SP	M	L				Silty, fine SAND with closely spaced laminated silt beds, grey. Loose, moist.
								0.0	6.5							
			52	HQTT				-0.5	7.0							7.0m to 7.54m no recovery
						✱FC	B									
				SPT		1/1/2/3/ 4/5 N=14		-1.0	7.5	SW	M	MD				Fine to medium SAND with some silt, grey. Medium dense, moist.
								-1.5	8.0	SP	M	MD				Silty, fine SAND with closely spaced laminated silt beds, grey. Medium dense, moist.
										GW	M	D				Fine to coarse GRAVEL with cobbles and minor silt and sand, grey. Dense, moist. Gravel is subrounded to subangular. Sand is fine to coarse.
			62	HQTT				-2.0	8.5							8.6m to 10.5m no recovery
				SPT		2/3/5/6/ 10/13 N=34		-2.5	9.0							
								-3.0	9.5							
			0	HQTT				-3.5	10							

SINCLAIR KNIGHT MERZ SKM

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 04
Hole Location: Park Terrace

SHEET 3 OF 5

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE		LOCATION: CENTRAL CITY	JOB No: 52000.3400
CO-ORDINATES	5742484.62 mN 2479914.28 mE	DRILL TYPE: Rotary	HOLE STARTED: 9/6/11
		DRILL METHOD: Triple Tube	HOLE FINISHED: 13/6/11
R.L.	6.45 m		DRILLED BY: McNeill
DATUM	NZGM	DRILL FLUID: Mud	LOGGED BY: RKH/CP CHECKED: BMcD

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

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

GEOLOGICAL UNIT	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)																8.6m to 10.5m no recovery
CHRISTCHURCH FORMATION (MARINE & ESTUARINE)				SPT		3/6/7/10/ 9/12 N=38		-4.0	10.5	SW	M	D				Fine to coarse SAND, grey. Dense, moist. - thin bed of silty, fine gravel
								-4.5	11.0							10.9m to 11.1m very closely spaced laminated silt beds - thin bed of silt
			33	HQTT				-5.0	11.5							11.3m to 12.0m no recovery
				SPT		1/2/6/8/ 9/11 N=34		-5.5	12.0							- thin bed of silt
								-6.0	12.5							- becoming fine to medium SAND with minor silt
			33	HQTT				-6.5	13.0							12.8m to 13.5m no recovery
				SPT		1/3/5/10/ 10/13 N=38 * FC	B	-7.0	13.5							
								-7.5	14.0							
			71	HQTT				-8.0	14.5							14.7m to 15.0m no recovery
								-8.5	15							

T+T DATATEMPLATE.GDT eek

BORELOG 650494.000 BOREHOLE LOGS.GPJ 19/8/11

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 04
Hole Location: Park Terrace

SHEET 4 OF 5

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

CO-ORDINATES 5742484.62 mN
2479914.28 mE
R.L. 6.45 m
DATUM NZGM

DRILL TYPE: Rotary
DRILL METHOD: Triple Tube
DRILL FLUID: Mud

HOLE STARTED: 9/6/11
HOLE FINISHED: 13/6/11
DRILLED BY: McNeill
LOGGED BY: RKH/CP
CHECKED: BMcD

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION / ROCK DESCRIPTION
CHRISTCHURCH FORMATION (MARINE & ESTUARINE)		SPT	2/5/8/10/ 12/16 N=46				SW	M	D	15.2m to 15.3 closely spaced laminated silt beds
					-9.0	15.5				
	24	HQTT								15.7m to 16.5m no recovery
					-9.5	16.0				
					-10.0	16.5				
		SPT	2/2/3/4/ 7/11 N=25						MD	- becoming medium dense - 16.6m to 16.7m trace shells
			✱PSD WS	B	-10.5	17.0				
	19	HQTT								17.2m to 18.0m no recovery
					-11.0	17.5				
					-11.5	18.0				
		SPT	2/2/2/4/ 7/12 N=25							- 18.0m to 18.05m very closely spaced laminated silt beds
							SP	M	MD	Fine SAND with some silt and moderately widely spaced silt laminates, grey. Medium dense, moist.
					-12.0	18.5				
	38	HQTT								18.9m to 19.5m no recovery
					-12.5	19.0				
					-13.0	19.5				
		SPT	5/13/15/ 19/16 for 220mm N=50				ML	M	St	SILT with minor sand, grey. Stiff, moist, non-plastic. Sand is fine.
RICCARTON GRAVELS							GW	M	VD	Fine to coarse GRAVEL with minor silt and sand, grey. Very dense, moist. Gravel is subrounded to subangular. Silt/sand is brown. Sand is fine.
					-13.5	20				

T+T DATATEMPLATE.GDT eek

BORELOG 650494.000 BOREHOLE LOGS.GPJ 19/8/11

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 04
Hole Location: Park Terrace

SHEET 5 OF 5

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

CO-ORDINATES 5742484.62 mN
2479914.28 mE
R.L. 6.45 m
DATUM NZGM

DRILL TYPE: Rotary
DRILL METHOD: Triple Tube
DRILL FLUID: Mud

HOLE STARTED: 9/6/11
HOLE FINISHED: 13/6/11
DRILLED BY: McNeill
LOGGED BY: RKH/CP
CHECKED: BMcD

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
RICCARTON GRAVELS			76	HQTT				GW	M	VD				Fine to coarse GRAVEL with minor silt and sand, grey. Very dense, moist. Gravel is subrounded to subangular. Silt/sand is brown. Sand is fine.
														20.8m to 21.0m no recovery
				SPT		14/16/20 for 200mm N=50	■							
			52	HQTT										22.0m to 22.95m no recovery
				SPT		16/34 N=50	■							
														End of borehole at 22.95mbgl. Open standpipe piezometer installed. Please see attached diagram in Appendix C.

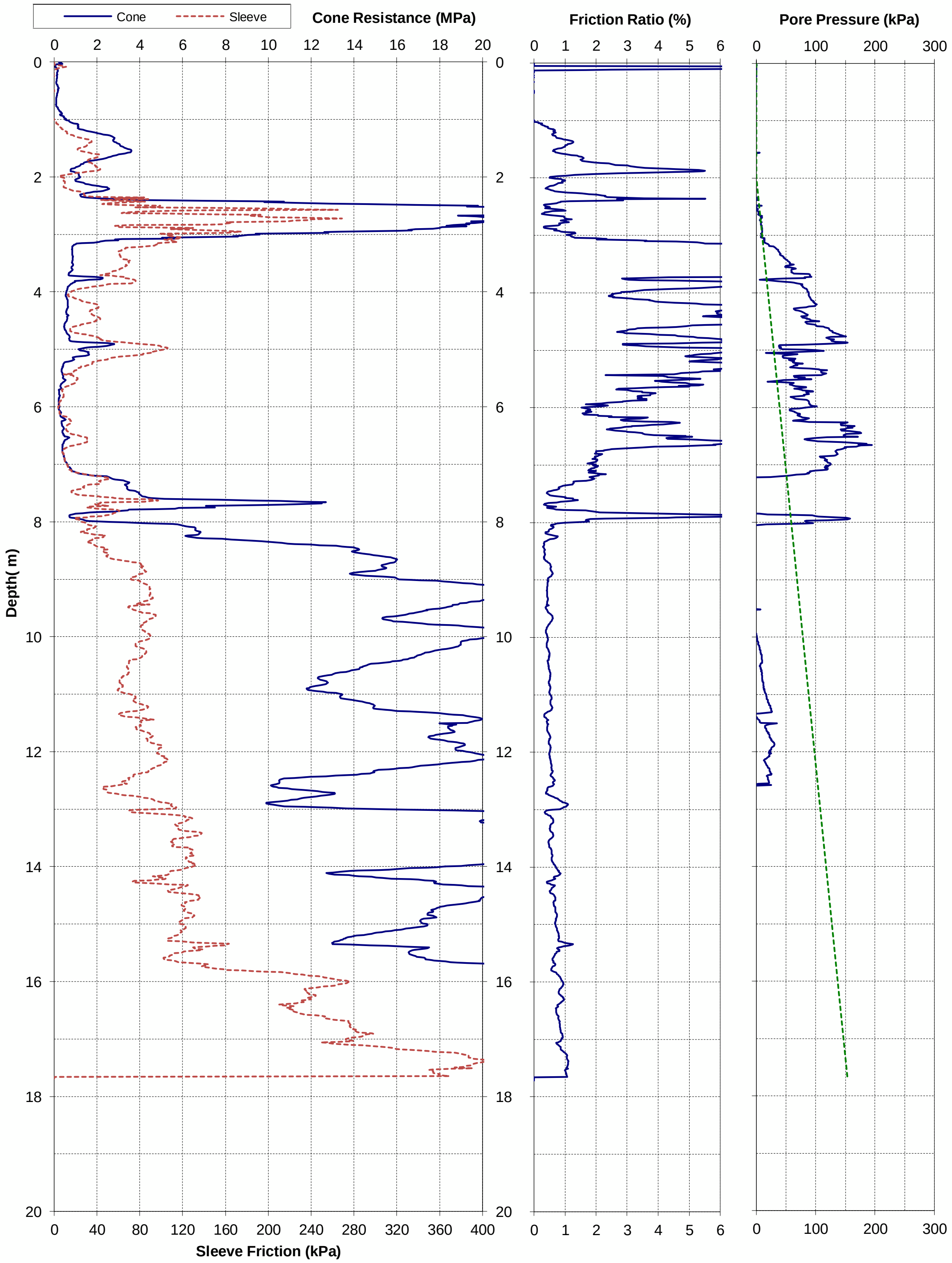
R.L. (m)	DEPTH (m)
-14.0	20.5
-14.5	21.0
-15.0	21.5
-15.5	22.0
-16.0	22.5
-16.5	23.0
-17.0	23.5
-17.5	24.0
-18.0	24.5
-18.5	25

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

T+T DATATEMPLATE.GDT eek

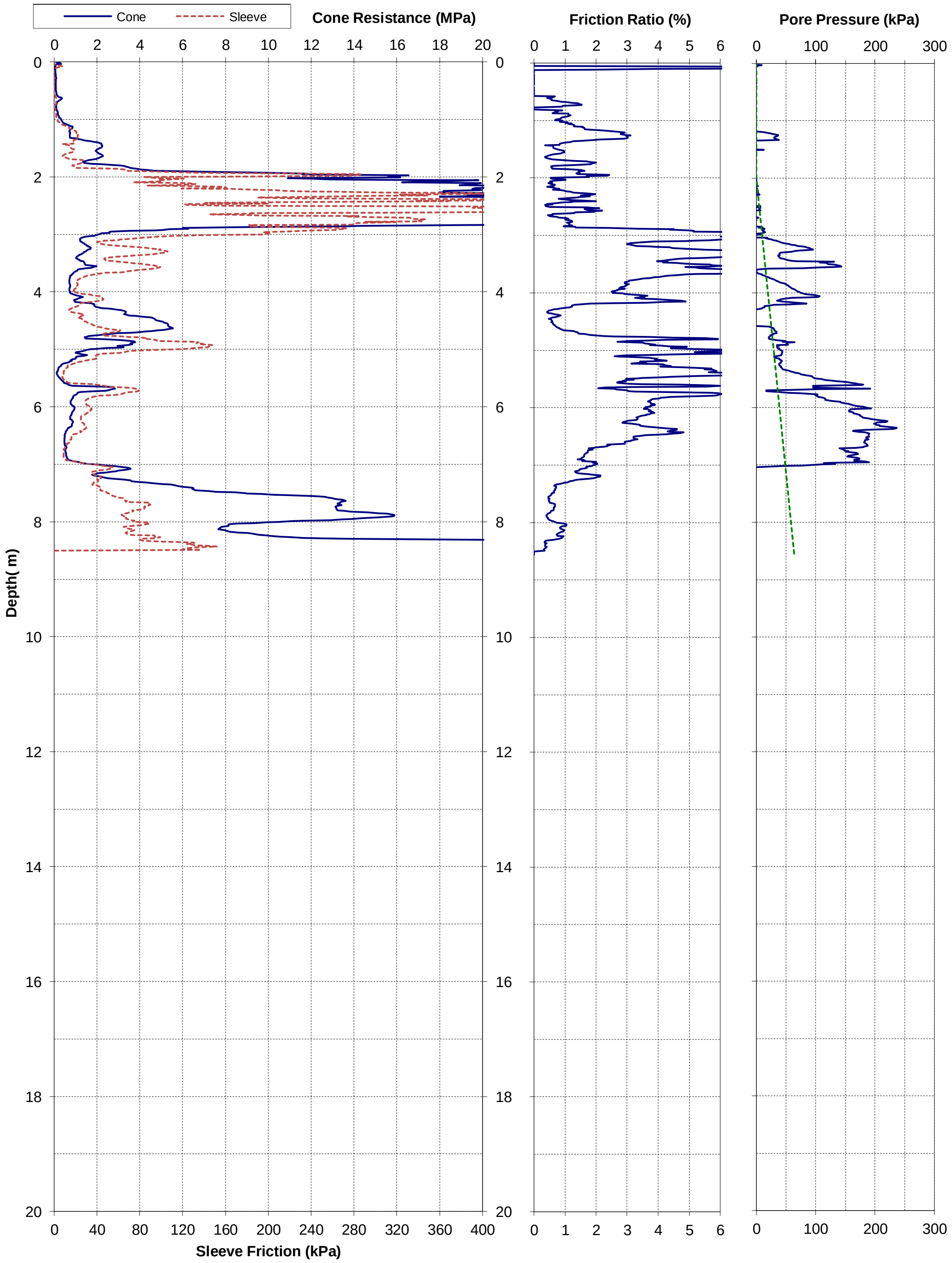
BORELOG 650494.000 BOREHOLE LOGS.GPJ 19/8/11

Project:	Christchurch 2011 Earthquake - CCC Ground Investigations			**Page:** 1 of 1	**CPT-CBD-10**
Test Date:	20-Jun-2011	**Location:**	Central City	**Operator:**	Perry
Pre-Drill:	1.5m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS
Position:	2479845.3mE	5742645.3mN	6.632mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	



T+T Ref: 52000.3400 Printed: 4/11/2011 11:44 a.m. Template: CPT Graph Template v0.41.xls

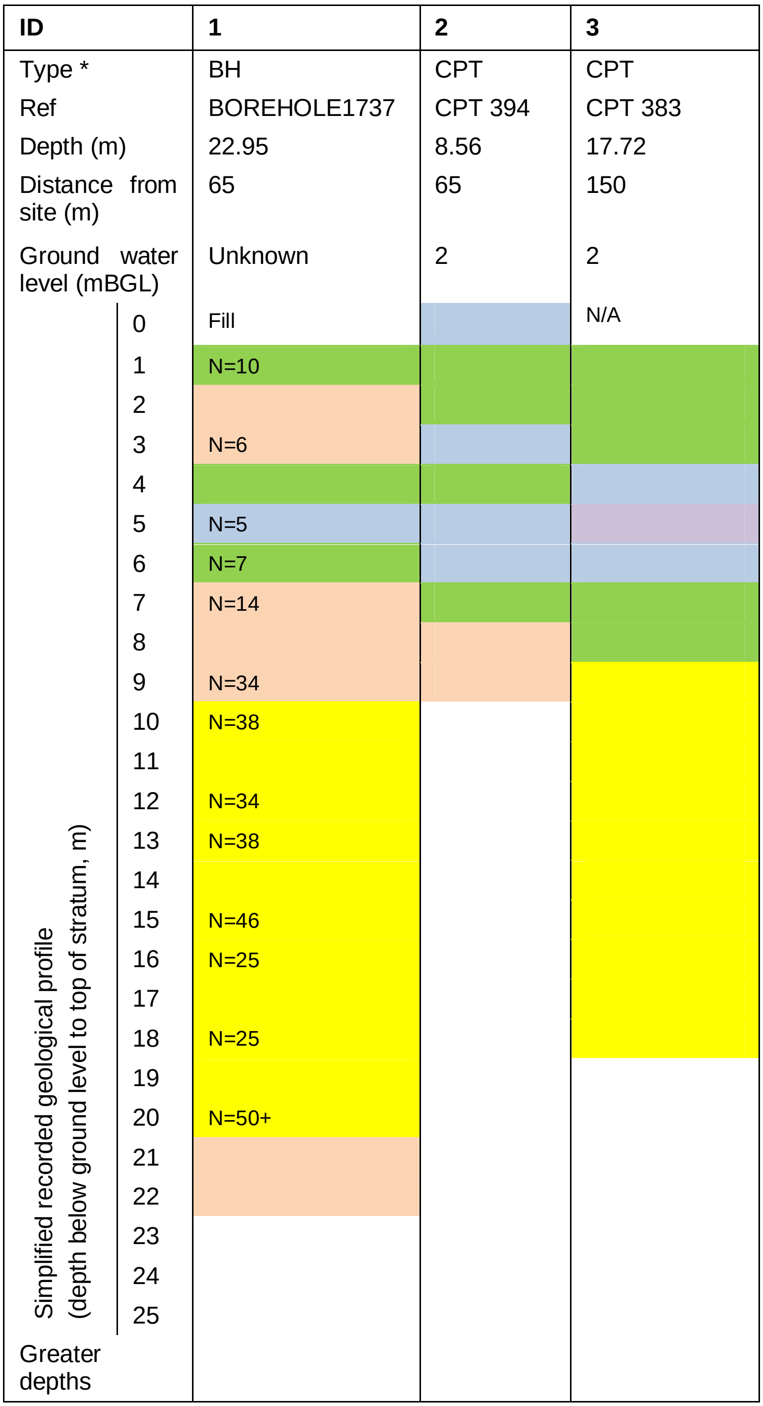
Project:	Christchurch 2011 Earthquake - CCC Ground Investigations			**Page:** 1 of 1	**CPT-CBD-19**
Test Date:	20-Jun-2011	**Location:**	Central City	**Operator:**	Perry
Pre-Drill:	1.5m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS
Position:	2479917.1mE	5742486.8mN	6.495mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	



T+T Ref: 52000.3400 Printed: 4/11/2011 11:49 a.m. Template: CPT Graph Template v0.41.xls

Appendix C – Geotechnical Investigation Summary

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



ID		1	2	3
Type *		BH	CPT	CPT
Ref		BOREHOLE1737	CPT 394	CPT 383
Depth (m)		22.95	8.56	17.72
Distance from site (m)		65	65	150
Ground water level (mBGL)		Unknown	2	2
Simplified recorded geological profile (depth below ground level to top of stratum, m)	0	Fill	▦	N/A
	1	🟩 N=10	🟩	🟩
	2	🟧	🟩	🟩
	3	🟧 N=6	▦	🟩
	4	🟩	🟩	▦
	5	▦ N=5	▦	🟪
	6	🟩 N=7	▦	▦
	7	🟧 N=14	🟩	🟩
	8	🟧	🟧	🟩
	9	🟧 N=34	🟧	🟨
	10	🟨 N=38		🟨
	11	🟨		🟨
	12	🟨 N=34		🟨
	13	🟨 N=38		🟨
	14	🟨		🟨
	15	🟨 N=46		🟨
	16	🟨 N=25		🟨
	17	🟨		🟨
	18	🟨 N=25		🟨
	19	🟨		
	20	🟨 N=50+		
	21	🟧		
	22	🟧		
	23			
	24			
	25			
Greater depths				

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

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

VL = very loose, L = loose, MD = medium dense, D = dense, VD = very dense

VS = very soft, So = soft, F = firm, St = stiff, VS = very stiff, H = hard