Christchurch City Council
PRK_0339_BLDG_006 EQ2
Harewood Nursery Vehicle Shed
239 Gardiners Road, Harewood

QUANTITATIVE ASSESSMENT REPORT

FINAL

- Rev B
- 12 March 2013

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Contents

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Approval

	Signature	Date	Name	Title
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1. Executive Summary

1.1. Background

A Quantitative Assessment was carried out on the building located at 239 Gardiners Road. The building located on this site comprises of two separate structural areas: an original relocated building and an addition consented in 1977; the two halves making up the vehicle shed. The relocated structure utilises diagonal timber bracing and the addition uses metal angle bracing. Specifications state that this angle bracing is suitable for wind bracing only. The older structure is situated to the north with the addition at the rear (south). The areas have been connected together to share bracing and transfer load between areas. An aerial photograph illustrating these areas is shown below in Figure 1. Detailed descriptions outlining the building's age and lateral systems is given in Section 5 of this report.

- Figure 1 Aerial Photograph of 239 Gardiners Road Harewood Nursery building 6.

This Quantitative report for the building structure is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19th of July 2011, our visual inspection carried out on the 3rd of March 2012, structural drawings and calculations.

1.2. Key Damage Observed

There is hairline cracking of the concrete foundation slab at the main entrance with no visual signs of local settlement.

1.3. Critical Structural Weaknesses

The following potential critical structural weaknesses have been identified:

- Lack of a reliable lateral load path to the central four spans of the roof, although the building will have some nominal capacity from the steel roof cladding acting as diaphragm bracing. However, this is a non desirable system.
- Light weight galvanised strapping used for the roof bracing and lateral restraint of the garage. This is not rated for seismic loading.
- Plan irregularity of the bracing layout causing torsional effects in the east-west loading.

1.4. Indicative Building Strength

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

The assessments were based on the following:

- On-site investigation to assess the extent of existing earthquake damage including limited intrusive investigation.
- Qualitative assessment of critical structural weaknesses (CSWs) based on review of available structural drawings and inspection.
- No geotechnical investigation has been undertaken. We have based this report on our knowledge of the site and the absence of liquefaction ejecta on the site.
- Assessment of the strength of the existing structures taking account of the current condition.

Any building that is found to have a seismic capacity less than 33% of the new building standard is required to be strengthened up to a capacity of at least 67%NBS.

Based on the information available including the lack of a complete roof bracing system, and using the Quantitative Assessment Procedure, the buildings original capacity has been assessed to be in the order of 16%NBS and post earthquake capacity in the order of 16%NBS. The building's post earthquake capacity excluding critical structural weaknesses is in the order of 16%NBS.

The building has been assessed to have a seismic capacity in the order of 16% NBS and is therefore a Grade E "High Risk Building".

Please note that structural strengthening is required by law for buildings that are confirmed to have a seismic capacity of less than 33% NBS.

1.5. Recommendations

Based on the findings of the assessment, we have provided two conceptual options for improvement of the structure since it is an earthquake prone building.

It is recommended that:

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

2. Introduction

Sinclair Knight Merz was engaged by Christchurch City Council to carry out a Quantitative Assessment of the seismic performance of the Harewood Vehicle shed located at 239 Gardiners Road Harewood. The scope of this quantitative analysis includes the following:

- Analysis of the seismic load carrying capacity of the building compared with current seismic loading requirements or New Buildings Standard (NBS). It should be noted that this analysis considers the building in its damaged state where appropriate.
- Identify any critical structural weaknesses which may exist in the building and include these in the assessed %NBS of the structure.
- Preparation of a summary report outlining the areas of concern in the building as well as identifying strengthening concepts to 67%NBS for any areas which have insufficient capacity if the building is found to be an earthquake prone building.

The recommendations from the Engineering Advisory Group[1] were followed to assess the likely performance of the structures in a seismic event relative to the New Building Standard (NBS). 100% NBS is equivalent to the strength of a building that fully complies with current codes. This includes a recent increase of the Christchurch seismic hazard factor from 0.22 to 0.3[2].

Our visual inspection identified that the seismic capacity of the building was likely to be less than 34% of the New Building Standard (NBS). A quantitative assessment was recommended to confirm these initial findings and to determine a more accurate seismic rating of the building.

At the time of this report, no intrusive site investigation had been carried out. Construction drawings were made available, and these have been considered in our evaluation of the building. The building description below is based on a review of the drawings and our visual inspections.

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[1] EAG 2011, *Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury - Draft*, p 10
[2] http://www.dbh.govt.nz/seismicity-info

3. Compliance

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

3.1. Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

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

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

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

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

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

3.2. Building Act

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

3.2.1. Section 112 – Alterations

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

3.2.2. Section 115 – Change of Use

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

3.2.3. Section 121 – Dangerous Buildings

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

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

3.2.4. Section 122 – Earthquake Prone Buildings

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

3.2.5. Section 124 – Powers of Territorial Authorities

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

3.2.6. Section 131 – Earthquake Prone Building Policy

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

3.3. Christchurch City Council Policy

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

The 2010 amendment includes the following:

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

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

We anticipate that any building with a capacity of less than 34%NBS (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67%NBS of new building standard as recommended by the Policy.

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

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

3.4. Building Code

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

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

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

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

4. Earthquake Resistance Standards

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

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

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

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

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

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

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- **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

Building PRK_0339_BLDG_006 EQ2 is a single storey timber framed building that is used as a vehicle shed at Harewood Nursery. The building's roof is constructed from timber trusses that support timber purlins and a light weight profiled steel cladding. The walls are constructed from 100 x 50mm timber studs. The cladding to the wall is also light weight profiled steel. The building is supported on concrete foundations and has a concrete floor slab. The footprint of this building is approximately 14.0m x 7.5m and 4.3m high. Limited structural drawings were available for this building which indicated the extension of the shed was consented in December 1995. The same drawings also suggest that the original half of the shed may have been designed in 1977.

5.2. Gravity Load Resisting system

As detailed above, the roof structure consists of timber trusses that support the roof structure. These trusses span across the building and are supported on the timber stud walls. The building is supported on concrete foundations and a concrete floor slab.

5.3. Seismic Load Resisting system

For the lateral analysis of this building, the transverse or 'across direction' has been taken as east-west whereas the longitudinal or 'along direction' has been taken as north-south.

Lateral loads acting along the building will be resisted by the light weight galvanised strap braces. It is worth noting that these braces are not rated for seismic loads. The lateral loads will then be transferred into the wall bracing which is a combination of diagonal timber struts and light weight galvanised strap braces. Lateral loads acting across the building will be resisted by the light weight galvanised strap braces in the southern three roof bays. However, the central four roof bays were shown to have insufficient reliable load paths with nominal capacity coming from timber connections and roof cladding. Subsequently, the northern three braced bays have an insufficiently robust load path to the south wall. Torsional response due to the large opening along the north wall is resisted by the east and west braced walls as a moment couple. Note that the bracing present along the south wall is also galvanised light weight strap bracing and therefore is unsatisfactory in resisting seismic loads acting across the building.

5.4. Building Damage

1) No visual evidence of settlement was noted at this site. Therefore a level survey is not required at this stage of assessment.
2) Hairline cracking was present to the concrete slab near the main entrance of the building (PHOTO 7 & 8).

Photos detailing the damage observed can be found in Appendix 1 – Photographs.

6. Available Information and Assumptions

6.1. Available Information

Following our inspections on the 3rd of March 2012, SKM carried out a seismic review on the structure. This review was undertaken using the available information which was as follows:

- Structural drawings of the buildings relocation and extension of the building consent approved 7th December 1995.
- SKM site measurements and inspection findings for Harewood vehicle shed.

6.2. Survey

There was no visible settlement of the structure, nor were there any significant ground movement issues around the building. The building is zoned as ‘urban non-residential’ under the CERA Residential Technical Categories Map. Due to these factors we do not recommend that any survey be undertaken at this stage of the assessment.

6.3. Design Criteria and Assumptions

The following design criteria and assumptions made in undertaking the assessment include:

- The building was built according to the drawings and according to good practice at the time. We have reviewed the building and from our visual inspection the structure appears to be built in accordance with the drawings.
- The soil on site is class D as described in AS/NZS1170.5:2004, Clause 3.1.3, Soft Soil. This is a conservative assumption based on our experience of soils around Christchurch. The ultimate bearing capacity on site is 300kPa; we believe that this assumption is reasonable. Liquefaction does not need to be accounted for in the foundation design. The latter two assumptions assume that the ground conditions classify as “good ground”.
- Standard design criteria 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 for loss of human life, or considerable economic, social or environmental consequence of failure.
- The building has a short period less than 0.4 seconds.
- Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011

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

Building	Ductility of Building in Current State	Ductility of Building in Strengthened State
Vehicle shed	1.0	1.25

Ductility factor in the current state is based on non ductile galvanised bracing and timber bracing

The following material properties were used in the analyses:

- **Table 3: Material Properties**

Material	Nominal Strength	Structural Performance
Timber – Assumed No.1 Timber framing	f_b = 10MPa f_c = 11MPa	S_p = 1.0

The detailed engineering analysis is a post construction evaluation therefore it has the following limitations:

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

6.4. The Detailed Engineering Evaluation (DEE) process

The DEE is a procedure written by the Department of Building and Housing's Engineering Advisory Group and grades buildings according to their likely performance in a seismic event. The procedure is not yet recognised by the NZ Building Code but is widely used and recognised by the Christchurch City Council as the preferred method for preliminary seismic investigations of buildings[3].

The procedure of the DEE is as follows:

1) Qualitative assessment procedure

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

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

2) Quantitative procedure
   a. Carry out a geotechnical investigation if required by the qualitative assessment
   b. Analyse the building according to current building codes and standards. Analysis accounts for damage to the building.

The DEE assessment ranks buildings according to how well they are likely to perform relative to a new building designed to current earthquake standards, as shown in Table 4. The building rank is indicated by the percent of the required New Building Standard (%NBS) strength that the building is considered to have. Earthquake prone buildings are defined as having less than 34 %NBS strength which correlates to an increased risk of approximately 20 times that of 100% NBS[4]. Buildings that are identified to be earthquake prone are required by law to be strengthened within 30 years of the owner being notified that the building is potentially earthquake prone[5].

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

- **Table 4: DEE Risk classifications**

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

The DEE method rates buildings based on the plans (if available) and other information known about the building and some more subjective parameters associated with how the building is detailed and so it is possible that %NBS derived from different engineers may differ.

This assessment describes only the likely seismic Ultimate Limit State (ULS) performance of the building. The ULS is the level of earthquake that can be resisted by the building without catastrophic failure. The DEE does also consider Serviceability Limit State (SLS) performance of the building and or the level of earthquake that would start to cause damage to the building but this result is secondary to the ULS performance.

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

- AS/NZS 1170 Structural Design Actions
- NZS 3101:2006 Concrete Structures Standard
- NZS 3404:1997 Steel Structures Standard
- NZS4230:2004 Design of Reinforced Concrete Masonry Structures
- NZS 3603:1993 Timber Structures Standard
- NZS 3604:2011 Timber Framed Buildings

7. Results and Discussions

7.1. Critical Structural Weaknesses

The building has the following critical structural weaknesses:

- Plan irregularity causing torsional loading to the longitudinal walls. The roof is not detailed as a diaphragm to allow for longitudinal walls to resist torsion about the rear wall.
- Insufficient bracing to create a reliable load path for east west lateral loads applied over the north half of the building.
- Metal strap bracing is not rated for seismic loading.

These critical structural weaknesses have been incorporated into the quantitative results below. The effect of these will be a lower quantitative assessment result when compared to a building containing no critical structural weaknesses.

7.2. Analysis Results

Applied loading by hand calculation was used to analyse the seismic capacity of the building. The results of the analysis are reported in the following table as %NBS. The results below are calculated for the building in its damaged state. The building results have been broken down into their seismic resisting elements. As the building has elements that are less than 34%NBS, any item with a capacity less than 67%NBS will need to be strengthened so that the overall building capacity is greater than 67%NBS.

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

- **Table 5: DEE Results**

Building	Seismic Resisting Element	Action	Seismic Rating %NBS
Harewood Nursery Vehicle Shed	Insufficient transverse roof bracing creating reliance on roof cladding	Load path	<33%
	Plan irregularity induced torsion	Bending	16%
	Transverse wall bracing	Tension	21%
	Longitudinal wall bracing	Tension and compression	29%
	Longitudinal roof bracing	Tension	45%
	Timber purlins North South Loading	Compression	>100%

7.3. Recommendations

The quantitative assessment carried out on Harewood Nursery Vehicle Shed indicates that the building has a seismic capacity less than 34% of NBS and is therefore classed as being in the category of 'High Risk Buildings'. Strengthening of the building is required to bring it up to a minimum of 67% of NBS.

We recommend that the following actions are taken:

Strengthening of the building should include the replacement of non seismic metal strap bracing or the addition of plywood sheathing to create 'stiff corners' of the building in combination with upgrading the roof bracing and/or lining.

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

- A geotechnical investigation will be required and associated factual and interpretive geotechnical reports prepared – the geotechnical reports will be required to enable completion of the strengthening design.
- A fire report will be required and all necessary upgrades to egress routes, emergency lighting and specified systems will need to be undertaken.
- An emergency lighting design will be required to meet the provisions noted in the fire report.

- A disabled access summary will be required including provision for disabled facilities.
- The site amenities (toilets and the like) will need to be reviewed to ensure that there are sufficient facilities for the expected number of people on site.

8. Conclusion

SKM carried out a quantitative assessment on Harewood Nursery vehicle shed located at 239 Gardiners Road. This assessment concluded that the building is classified as Earthquake Prone.

- **Table 6: Quantitative assessment summary**

Description	Grade	Risk	%NBS	Structural Performance
Building 10	E	High	16	Unacceptable. Improvement required.

Strengthening is required on the building to bring the seismic capacity up to at a minimum of 67% of NBS. We have provided concept strengthening options in appendix 1.

We make the following additional recommendations if the building is to be repaired:

- A full geotechnical investigation will be required prior to lodging a consent for the repairs and any design changes recommended in the geotechnical investigation will need to be incorporated in the detailed strengthening design
- A full strengthening and repair specification should be prepared accounting for the damage contained in the damage assessment report and strengthening as confirmed by the detailed design.

It is recommended that:

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

Limitation Statement

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

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

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

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

Appendix 1 – Photographs

Photo 1: East Elevation

Photo 2: Internal Structure of Building

Photo 3: South Wall Bracing

Photo 4: North Wall Bracing

Photo 5: North Wall Bracing Continued

Photo 6: West Wall & Roof Bracing

	
Photo 7: Hairline Cracking to Floor Slab – Near Main Entrance	Photo 8: Close up of Photo 8

Appendix 2 – CERA Standardised Report Form

Location

Building Name:	PRK_0339_BLDG_006 EQ2		Reviewer:	James Carter
	Unit No:	Street	CPEng No:	1017618
Building Address:	Harewood Nursery - Vehicle Shed	239 Gardiners Road, Harewood	Company:	SKM
Legal Description:			Company project number:	ZB01276.036
			Company phone number:	03 940 4900
	Degrees	Min Sec		
GPS south:			Date of submission:	12-Mar
GPS east:			Inspection Date:	3/03/2012
			Revision:	B
Building Unique Identifier (CCC):			Is there a full report with this summary?	yes

Site

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

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	
Ground floor split?	no		Ground floor elevation above ground (m):	
Storeys below ground	0			
Foundation type:	strip footings		if Foundation type is other, describe:	
Building height (m):	4.30		height from ground to level of uppermost seismic mass (for IEP only) (m):	4.3
Floor footprint area (approx):	105			
Age of Building (years):	20	(max)	Date of design:	1976-1992
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	other (specify)		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):	Vehicle Shed			
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls			
Roof:	timber framed		rafter type, purlin type and cladding	timber trusses supporting light weight roof. Trusses sit directly on to timber framed walls
Floors:	concrete flat slab		slab thickness (mm)	125mm (assumed)
Beams:	timber		type	refer to roof details above
Columns:	load bearing walls		typical dimensions (mm x mm)	100x50 timber stud
Walls:		Tmber framed walls		

Lateral load resisting structure

Lateral system along:	other (note)	**Note: Define along and across in detailed report!**	describe system	timber and light weight steel braces
Ductility assumed, μ:	1.00			
Period along:	0.10	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):	5		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):	5		estimate or calculation?	estimated
Lateral system across:	other (note)		describe system	timber and light weight steel braces
Ductility assumed, μ:	1.00			
Period across:	0.10	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):	10		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):	10		estimate or calculation?	estimated

Separations:

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

Non-structural elements

Stairs:			n/a
Wall cladding:	profiled metal	describe	light weight profiled steel
Roof Cladding:	Metal	describe	light weight profiled steel
Glazing:	aluminium frames		
Ceilings:			n/a
Services(list):	none		

Available documentation

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

Damage

Site:
(refer DEE Table 4-2)

Site performance:	1	Describe damage:	none observed
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	no structural damage observed
	Describe (summary):			
Across	Damage ratio:	0%		
	Describe (summary):			
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	yes	Describe:	minor hairline cracking to the slab

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

Recommendations

Level of repair/strengthening required:	minor structural	Describe:	Strengthening of bracing; replacement of bracing or addition of plywood shear panels
Building Consent required:	no	Describe:	
Interim occupancy recommendations:	full occupancy	Describe:	

Along	Assessed %NBS before:	16%	%NBS from IEP	If IEP not used, please detail assessment methodology:	NZSEE IEP used, refer to SKM Qualitative Report
	Assessed %NBS after:	16%			
Across	Assessed %NBS before:	29%	%NBS from IEP		
	Assessed %NBS after:	29%			

Appendix 3 – Geotechnical Desktop Study

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Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	033 to 036 inclusive
Address	145a Claridges Rd
Report date	16 March 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, 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)**

These structures are located on 145a Claridges Rd at grid reference 1566643 E, 5186853 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

No liquefaction map was available for the site.

5.3 Aerial photography

- **Figure 4 – Aerial photography from 24 Feb 2011 (http://viewers.geospatial.govt.nz/)**

Aerial photography shows relatively little damage to no damage after the 22 Feb 2011 event. There appears to be some ground disturbance shown in the bottom left hand corner of the aerial photograph, however this may not be related to the earthquakes, No liquefied material could be seen.

5.4 CERA classification

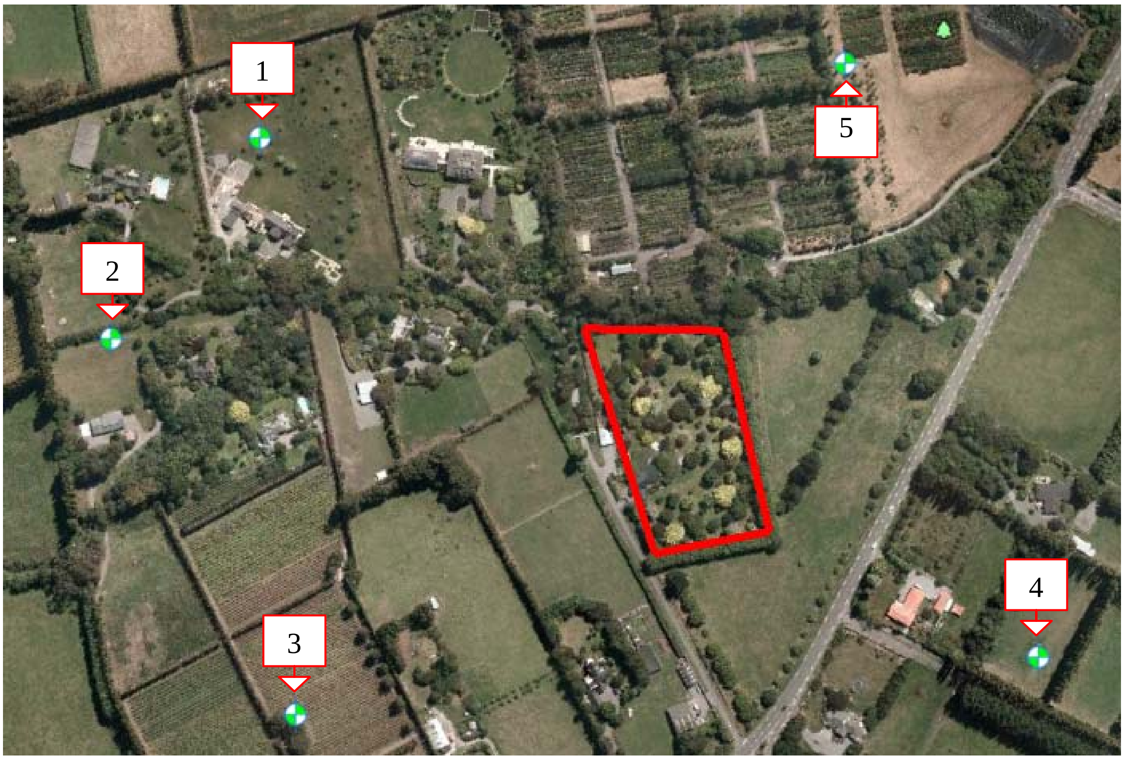
A review of the LINZ website (http://viewers.geospatial.govt.nz/) shows that the site is:

- Zone: Green
- DBH Technical Category: N/A (Urban Non-residential)

5.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the site was recorded as grassland in 1856. Historical records also show a previous creek or river running through the site indicating the possibility of soft river alluvium being present underneath the site.

5.6 Existing ground investigation data



- **Figure 5 – 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.

Borehole 5 identified in figure 5 was not accessible and therefore has not be included in this desk study.

5.7 Council property files

Available council property files relates to documents regarding the relocation and alteration of an existing shed on site. In addition, documents relating to the installation of septic and associated drainage works were available for review.

The drawing labelled "Proposed Nursery Building" shows the building's floor to consist of a 100mm concrete slab with HRC 665 mesh overlying a thin moistop 737 DPC layer. A 40mm site concrete supported on granular hardfill is shown below the moistop layer. A thickened reinforced concrete foundation is shown below the walls of the building. The concrete foundation is approximately 400mm deep and 230mm wide, reinforced with 2-D12 rods. A similar foundation detail is shown for the storage shed in the drawings labelled "Proposed extension to existing store shed".

No detailing of the ground condition underlying the site was found in the available council records.

5.8 Site walkover

The amenity building was a brick and a metal roof construction. The vehicle shed was a portal frame building with metal sheet walls and a metal roof. The pump houses were metal sheds and the garage was a timber structure with a metal sheet roof. There was no obvious structural damage on any of the buildings. There were no signs of liquefaction on site, and no land damage was observed.

- **Figure 6 No visible liquefied material on the driveway**

- **Figure 7 No visible damage to the structure**

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 (mBLG)	Soil type
0 - 3	Top soil/ soft to firm Clay (Springston Formation)
3-15	Sandy Gravel and clay bound gravel, with occasional sand layers. (Springston Formation)
15-24	Gravel, very dense. (Riccarton Formation)

Ground water level was inferred to be between 2m to 3m below ground level from the available investigation data.

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 third preferred method has been used to make the assessment utilising boreholes records, which are on average 300m away from site. Boreholes indicate soft to firm clay with some peat to be present to a depth of 3 to 4m below surface. Further geotechnical investigation or site specific study could result in a revision to the subsoil class.

6.3 Building performance

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

6.4 Ground performance and properties

Liquefaction risk appears to be low at this site.

The shallow clay layer near the surface is not susceptible to liquefaction. The occasional sand layers within the sandy and clayey gravel matrix are potentially susceptible to liquefaction. However, the presence of the shallow clay layer could have prevented any ejection of liquefied material at surface. Additional site specific investigation would need to be conducted to further assess the liquefaction risk for this site.

Design parameter recommendations have not been made for this site as the historical ground investigation data does not provide sufficient data to make an informed and reasonable interpretation. The current available geotechnical investigations are on average greater than 300m away from the site.

6.5 Further investigations

There is some uncertainty regarding ground conditions at this site due to the distance between existing investigations and the site location. To enable completion of a quantitative DEE a ground investigation will need to be carried out. We recommend the following:

- Two borehole on site to a minimum depth of 20m with one borehole near the river Styx River identified in the local geological map

7. References

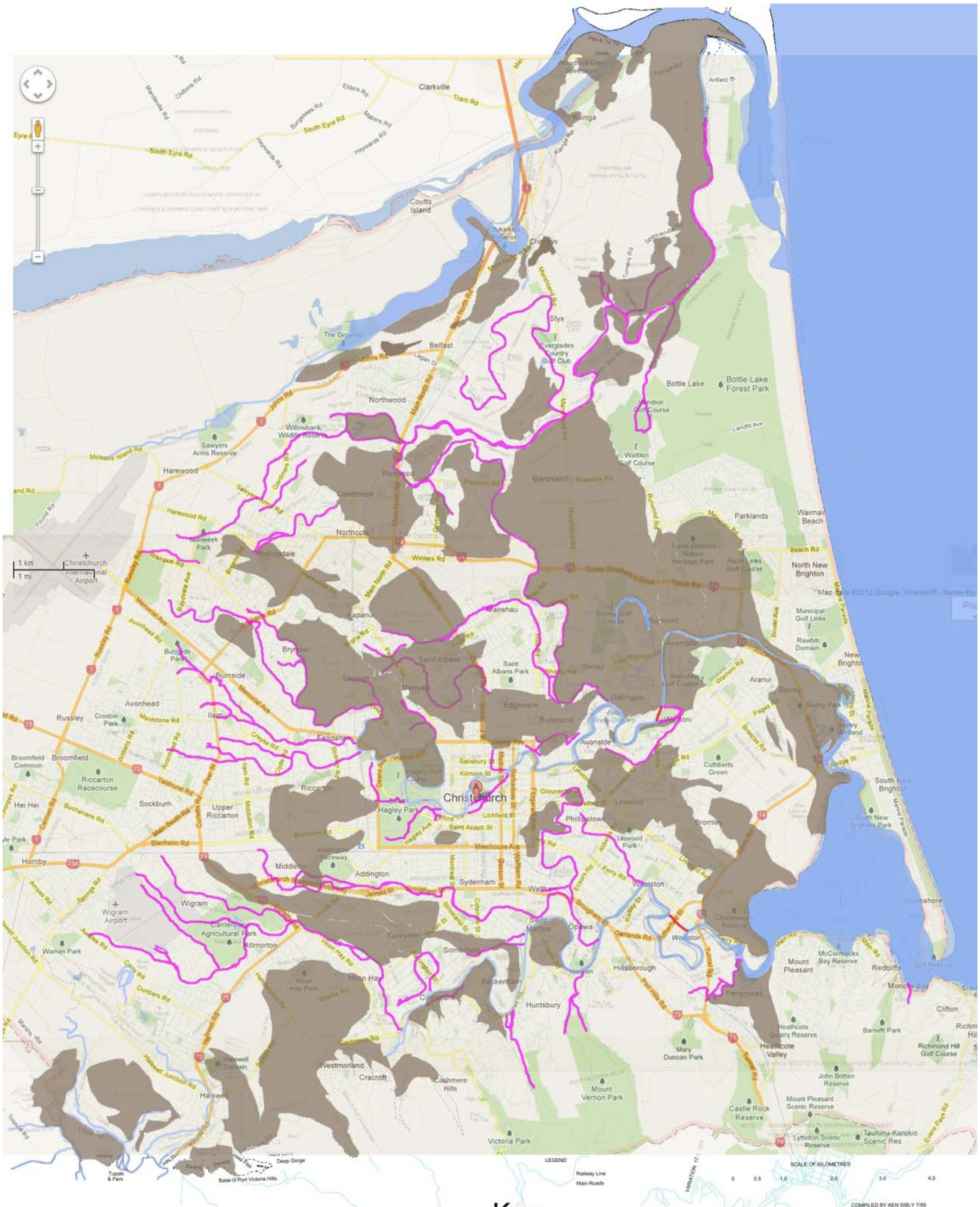
Brown LJ, Weeber JH, 1992. Geology of the Christchurch urban area. Scale 1:25,000. Institute of Geological & Nuclear Sciences geological map 1.

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

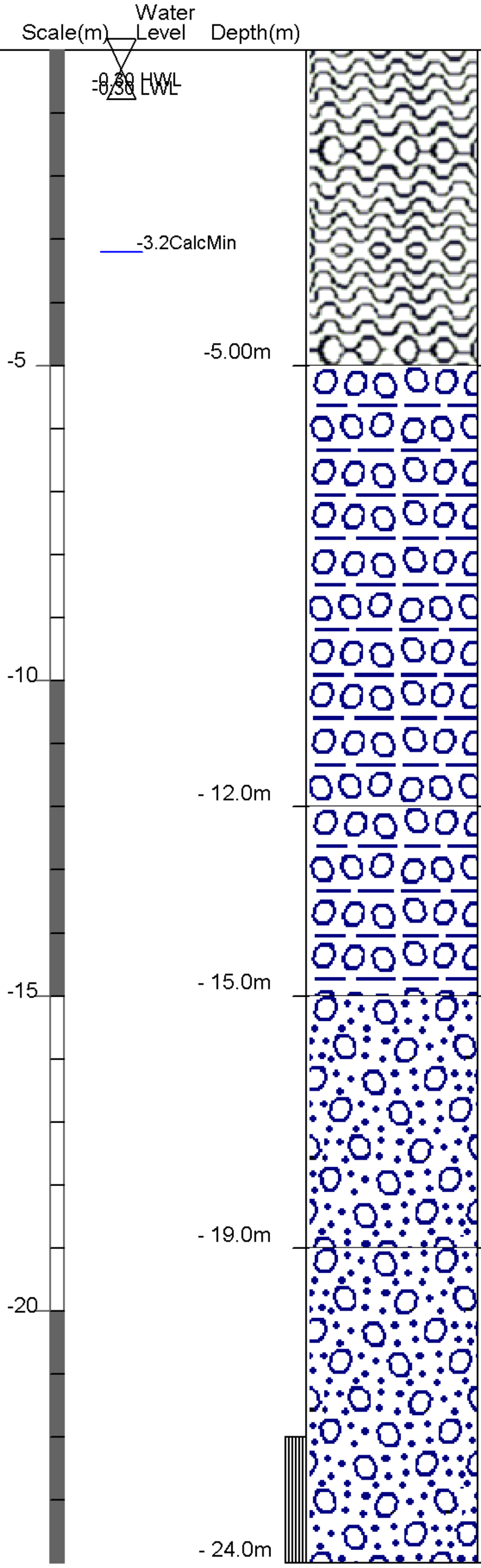
- Previous creeks/rivers
- Existing creeks/rivers
- New creeks/rivers
- Swamp/Marshland

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 M35/8883

Gridref: M35:7631-4851 Accuracy : 3 (1=best, 4=worst)
Ground Level Altitude : 17.9 +MSD
Driller : East Coast Drilling
Drill Method : Rotary Rig
Drill Depth : -24m Drill Date : 2/04/2000



Depth(m)	Full Drillers Description	Formation Code
-5.00m	Soil, clay	sp
- 12.0m	Gravel, grey clay	sp
- 15.0m	Clay , claybound gravel	sp
- 19.0m	Sandy gravels	sp?
- 24.0m	Gravel, some sand.	ri

Borelog for well M35/1671

Gridref: M35:7630-4834 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 17.8 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -12.77m Drill Date : 24/08/1978

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.40m	Topsoil	sp?
		-2.59m	Hard Yellow clay	sp?
-5, -10	-3.2CalcMin	- 12.8m	Small Blue/Grey gravel & sand	sp?

Borelog for well M35/1670

Gridref: M35:76546-48195 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 17.2 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -15m Drill Date : 23/08/1978

Water level: -2.5CalcMin

Depth(m)	Full Drillers Description	Formation Code
-0.50m	Topsoil	sp?
-6.00m	Yellow clay, peat in patches	sp?
- 13.7m	Small Blue/Grey gravel & sand.Water-bearing	sp?
- 15.0m	Grey clay & gravel (Hard)	ri

Borelog for well M35/2590

Gridref: M35:7695-4850 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 15.6 +MSD
Driller   : not known
Drill Method : Auger Rig
Drill Depth   : -5m   Drill Date : 21/07/1982

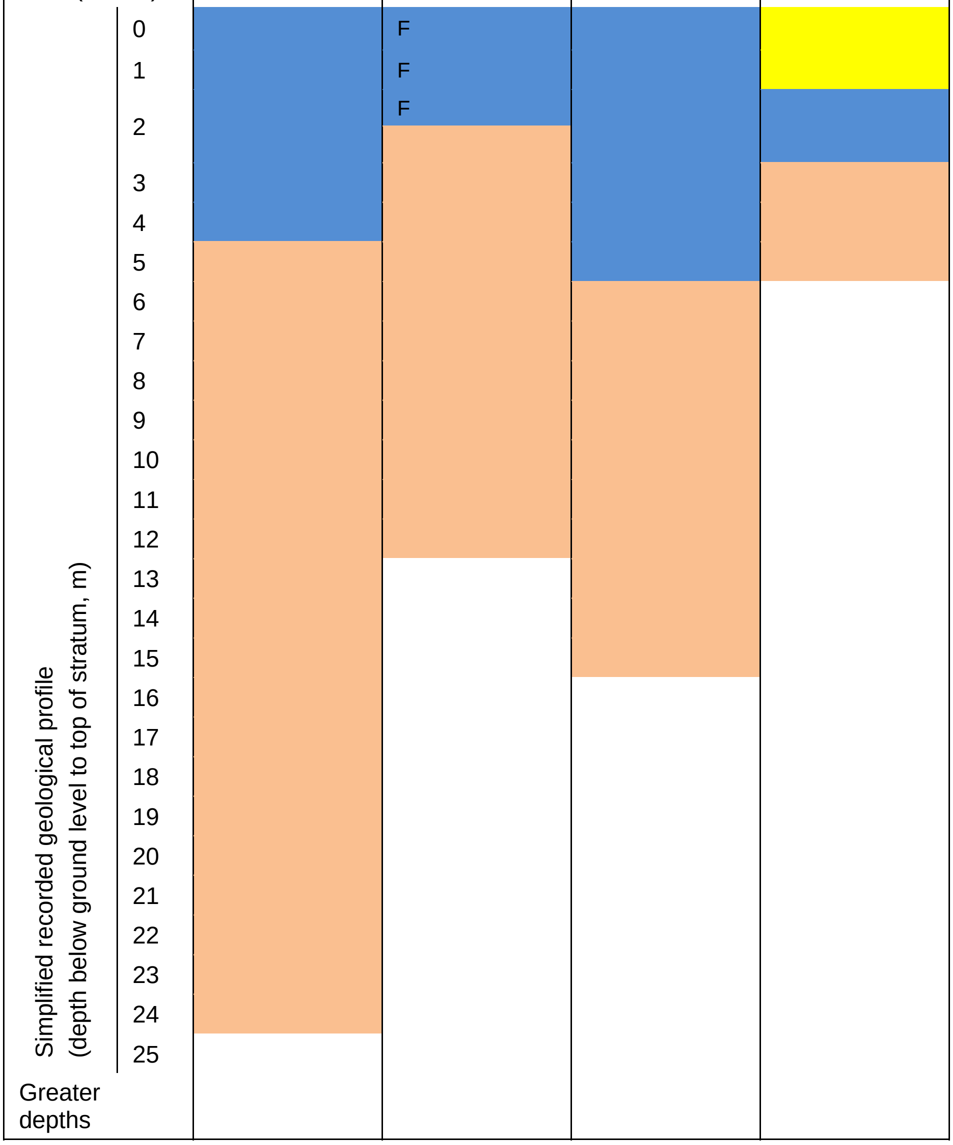
Water Level: -2.1CalcMin

Depth(m)	Full Drillers Description	Formation Code
-0.20m	Black soil	sp?
-1.40m	Brown sand	sp?
-2.20m	Blue sand	sp?
-3.20m	Blue/Grey clay	sp?
-5.00m	Gravel	sp?

Appendix C – Geotechnical Investigation Summary

▪ Table 1 Summary of most relevant investigation data

ID	1	2	3	4
Type *	BH	BH	BH	BH
Ref	M35 - 8883	M35 - 1671	M35 - 1670	M35 - 2590
Depth (m)	24	12.8	15	5
Distance from site (m)	330	380	320	280
Ground water level (mBGL)	3.2	3.2	2.5	2.1



*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