CHRISTCHURCH CITY COUNCIL
PRK_0339_BLDG_004 EQ2
Harewood Nursery – Pumphouse (x2)
239 Gardiners Road, Harewood

QUALITATIVE ASSESSMENT REPORT

FINAL

- Rev B
- 23 November 2012

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	Signature	Date	Name	Title
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Approver		23 Nov. 2012	Nick Calvert	Senior Structural Engineer

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1. Executive Summary

1.1. Background

A Qualitative Assessment was carried out on the Pumphouse structures, PRK_0339_BLDG_004 EQ2, located at Harewood Nursery on 239 Gardiners Road, Harewood. These structures are single storey sheds constructed from light weight steel frames with metal cladding that are used as for storage and housing water pumps. An aerial photograph illustrating the locations of these sheds is shown below in Figure 1. Detailed descriptions outlining their age and construction type is given in Section 5 of this report. However it is worth noting that both these structures are propriety garden shed structures that can be purchased from local hardware stores.

- Figure 1 Aerial Photograph of Building PRK_0339_BLDG_004 EQ2 Located at 239 Gardiners Road

The qualitative assessment broadly includes a summary of the buildings 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 our visual inspection carried out on the 3 March 2012.

1.2. Key Damage Observed

No damage was observed during our site inspection of both sheds.

1.3. Critical Structural Weaknesses

This structure contains no critical structural weaknesses.

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

Based on the information available, and using the NZSEE Initial Evaluation Procedure, both structures original seismic capacity has been assessed to be greater than 100%NBS. No damage was observed during our site investigation. Due to this the post earthquake capacity of both structures is also greater than 100%NBS. Due to the lack of structural drawings available the quality of the hold-downs for both sheds is unknown. However due to the geometry and the light-weight nature of these structures if they were subjected to major shaking the end result could be that they would potentially slide away from their original location or end up out of plumb. This is unlikely to be life threatening and hence the building is still not considered earthquake prone as defined by regulations.

As noted above our analysis indicates that the current seismic capacity of the building is over 100% NBS and therefore is not a potentially earthquake prone building.

1.5. Recommendations

It is recommended that:

a) No placard was displayed on the building however we recommend that the current placard status of the building be Green 1.
b) We consider that barriers around the building are not necessary.

2. Introduction

Sinclair Knight Merz was engaged by the Christchurch City Council to prepare a qualitative assessment report for the Pumphouse structures PRK_0339_BLDG_004 EQ2 located at Harewood Nursery on 239 Gardiners Road, Harewood following the magnitude 6.3 earthquake which occurred in the afternoon of the 22nd of February 2011 and the subsequent aftershocks.

The Qualitative Assessment uses the methodology recommended in the Engineering Advisory Group document "Guidance on Detailed Engineering Evaluation of Earthquake affected Non-residential Buildings in Canterbury" (part 2 revision 5 dated 19/07/2011 and part 3 draft revision dated 13/12/2011). The qualitative assessment 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 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, detailed analysis, or modelling of the structures have been carried out. No structural drawings were available for these structures therefore the description outlined in Section 5 are based only on our visual inspection carried out on the 3 March 2012.

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

3. Compliance

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

3.1. Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

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

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

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

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

3.2. Building Act

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

3.2.1. Section 112 – Alterations

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

3.2.2. Section 115 – Change of Use

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

3.2.3. Section 121 – Dangerous Buildings

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

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

3.2.4. Section 122 – Earthquake Prone Buildings

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

3.2.5. Section 124 – Powers of Territorial Authorities

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

3.2.6. Section 131 – Earthquake Prone Building Policy

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

3.3. Christchurch City Council Policy

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

The 2010 amendment includes the following:

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

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

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

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

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

3.4. Building Code

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

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

a) Hazard Factor increased from 0.22 to 0.3 (36% increase in the basic seismic design load)

b) Serviceability Return Period Factor increased from 0.25 to 0.33 (80% increase in the serviceability design loads when combined with the Hazard Factor increase)

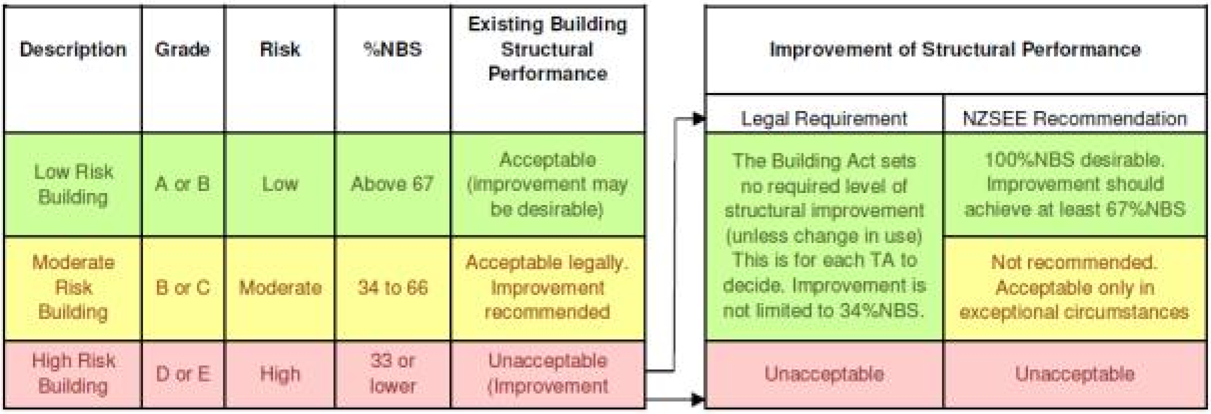
The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

4. Earthquake Resistance Standards

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

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

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

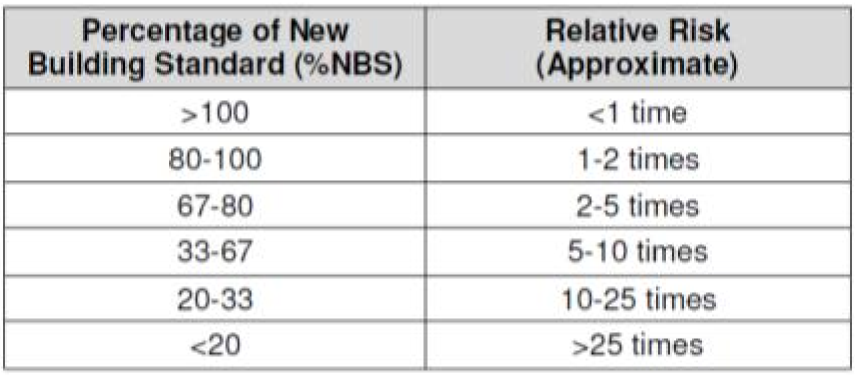


Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless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

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

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

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



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

5. Building Details

5.1. Building Description

The Pumphouse structures, PRK_0339_BLDG_004 EQ2, are both single storey structures that are used as storage sheds at Harewood Nursery. Both structures are proprietary garden sheds that can be purchased from local hardware stores. They are constructed from light weight steel cladding and apart from some minimal light weight framing present at the roof apex and the top of the walls the structure is predominately formed from the cladding. Both sheds are supported on a concrete floor slab. The footprint of these structures is approximately 2.0m x 2.0m and 2.0m high. No structural drawings were available for these structures. Due to this we are unable to confirm their age. However based on the condition of this structure we believe that they were erected sometime in the 1990's and as a result have taken a construction period of 1992-2004 for our assessment.

5.2. Gravity Load Resisting System

Our evaluation was based on our site investigation conducted on the 3 March 2012.

As detailed above the structure of both sheds is formed by the light-weight cladding present on the roof and walls.

5.3. Seismic Load Resisting System

Lateral loads acting across and along the building will be resisted by the roof and wall cladding. Due to the lack of structural drawings available the quality of the hold-downs for both sheds is unknown. However due to the geometry and the light-weight nature of these structures if they were subjected to major shaking the end result could be that they would potentially slide away from their original location or end up out of plume. This is unlikely to be life threatening.

5.4. Geotechnical Conditions

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

- The site has been assessed as NZS1170.5 Class D (deep or soft soil) from adjacent borehole logs.
- Liquefaction risk appears to be low at this site.

The full geotechnical desktop study can be found in Appendix 4 of this report.

6. Damage Summary

SKM undertook inspections on the 3 March 2012. The following was observed during the time of inspection:

6.1. Damage Summary

1) No external or internal damage was noted.
2) No visual evidence of settlement was noted at this site. Therefore a level survey is not required at this stage of assessment.

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 **Error! Not a valid bookmark self-reference.**. The building grade is indicated by the percent of the required New Building Standard (%NBS) strength that the building is considered to have. A building is earthquake prone for the purposes of this Act if, having regard to its condition and to the ground on which it is built, and because of its construction, the building—

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

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

An earthquake prone building will have an increased risk that its strength will be exceeded due to earthquake actions of approximately 10 times (or more) than that of a building having a capacity in excess of 100% NBS (refer Table 1)[3]. Buildings in Christchurch City that are identified as being earthquake prone are required by law to be followed up with a detailed assessment and strengthening work within 30 years of the owner being notified that the building is potentially earthquake prone[4].

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

[3] NZSEE June 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*, p 2-13

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

Table 2: IEP Risk classifications

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

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

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

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

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

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

7.2. Design Criteria and Limitations

Following our inspection on the 3 March 2012, SKM carried out a preliminary structural review. The structural review was undertaken using the available information which was as follows:

- SKM site measurements and inspection findings of the building.
- No structural drawings were available for this building.

The design criteria used to undertake the assessment include:

- The building was built according to good practices at the time.
- Standard design criteria as described in AS/NZS1170.0:2002:
  - 50 year design life, which is the default NZ Building Code design life.
  - Structure Importance Level 1 since the total floor area is <30m^2 and represents structures presenting a low degree of hazard to life and other property.
- Ductility level of 1, 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 visual inspection of the building. Since it is not a full design and construction review, it has the following limitations:

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

7.3. Survey

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

7.4. Critical Structural Weaknesses

This structure contains no critical structural weaknesses.

7.5. Qualitative Assessment Results

Both structures have had their seismic capacity assessed using the Initial Evaluation Procedure based on the information available. Their capacities are expressed as a percentage of new building standard (%NBS) and are in the order of that shown below in Table 3.

Table 3: Qualitative Assessment Summary

Item	%NBS
Likely Seismic Capacities for both Structures	>100

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

8. Further Investigation

Due to the likely seismic rating of this building being greater than 67% and the lack of any structural damage no further investigation is required.

9. Conclusion

A qualitative assessment was carried out on the Pumphouse structures, PRK_0339_BLDG_004 EQ2, located at Harewood Nursery on 239 Gardiners Road, Harewood. This structures have been assessed to have a likely seismic capacity greater than 100% NBS and is therefore are both 'Low Risk Buildings' (capacity greater than 67% of NBS).

Due to the likely seismic rating of this building and the lack of any structural damage no further investigation is required.

It is recommended that:

a) No placard was displayed on the building however we recommend that the current placard status of the building be Green 1.
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: External View of First Pumphouse	Photo 2: Internal View of Pumphouse
	
Photo 3: Roof Structure (Typical)	Photo 4: Concrete Floor Slab
	
Photo 5: External View of Second Pumphouse	

12. Appendix 2 – IEP Report

Table IEP-1 Initial Evaluation Procedure – Step 1

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

Building Name:	PRK_0339_BLDG_004 EQ2 Pumphouse	Ref.	ZB01276.035
Location:	Harewood Nursery, 239 Gardiners Road	By	KW
		Date	4/05/2012

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketch of building plan

1.3 List relevant features

The Pumphouse structures, CCC-PRK-0339-001, are both single storey structures that are used as storage sheds at Harewood Nursery. Both structures are proprietary garden sheds that can be purchased from local hardware stores. They are constructed from light weight steel cladding and apart from some minimal light weight framing present at the roof apex and the top of the walls the structure is predominately formed from the cladding. Both sheds are supported on a concrete floor slab. The footprint of these structures is approximately 2.0m x 2.0m and 2.0m high. No structural drawings were available for these structures. Due to this we are unable to confirm their age. However based on the condition of this structure we believe that they were erected sometime in the 1990's and as a result have taken a construction period of 1992-2004 for our assessment.Lateral loads acting across and along the building will be resisted by the roof and wall cladding. Due to the lack of structural drawings available the quality of the hold-downs for both sheds is unknown. However due to the geometry and the light-weight nature of these structures if they were subjected to major shaking the end result could be that they would potentially slide away from their original location or end up out of plumb. This is unlikely to be life threatening.

1.4 Note information sources

Tick as appropriate

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

Inspection Date - 03/03/2012

Table IEP-2 Initial Evaluation Procedure – Step 2

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

Building Name:	PRK_0339_BLDG_004 EQ2 Pumphouse	Ref.	ZB01276.035
Location:	Harewood Nursery, 239 Gardiners Road	By	KW
Direction Considered:	**Longitudinal & Transverse**	Date	4/05/2012

(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 = 2 meters

	Longitudinal	Transverse	
Ac =	2	2	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	
0.1	**0.1**	Seconds

d) (%NBS)nom determined from Figure 3.3

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

		Factor
Note 1: For buildings designed prior to 1965 and known to be designed as public buildings in accordance with the code of the time, multiply (%NBS)nom by 1.25.	No	1
For buildings designed 1965 - 1976 and known to be designed as public buildings in accordance with the code of the time, multiply (%NBS)nom by 1.33 - Zone A or 1.2 - Zone B	No	1
Note 2: For reinforced concrete buildings designed between 1976 -1984 (%NBS)nom by 1.2	No	1
Note 3: For buildings designed prior to 1935 multiply (%NBS)nom by 0.8 except for Wellington where the factor may be taken as 1.	No	1

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

Continued over page

Table IEP-2 Initial Evaluation Procedure – Step 2 continued

Building Name: PRK_0339_BLDG_004 EQ2 Pumphouse
Location: Harewood Nursery, 239 Gardiners Road
Direction Considered: **Longitudinal & Transverse**
(Choose worse case if clear at start. Complete IEP-2 and IEP-3 for each if in doubt)

Ref. ZB01276.035
By KW
Date 4/05/2012

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

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

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

Factor A	1.00

2.3 Hazard Scaling Factor, Factor B

Select Location: Christchurch

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

Z = 0.3
Z 1992 = 0.8

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

b) Hazard Scaling Factor Type Z 1992 above

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

Factor B	2.67

2.4 Return Period Scaling Factor, Factor C

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

b) Return Period Scaling Factor from accompanying Table 3.1

Factor C	2.00

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	μ Maximum = 6
Transverse	1	μ Maximum = 6

b) Ductility Scaling Factor

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

Longitudinal	**Factor D**	1.00
Transverse	**Factor D**	1.00

2.6 Structural Performance Scaling Factor, Factor E

Select Material of Lateral Load Resisting System

Longitudinal	Steel
Transverse	Steel

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	131.6	(%NBS)b
Transverse	131.6	(%NBS)b

Table IEP-3 Initial Evaluation Procedure – Step 3

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

Building Name:	PRK_0339_BLDG_004 EQ2 Pumphouse	Ref.	ZB01276.035
Location:	Harewood Nursery, 239 Gardiners Road	By	KW
Direction Considered:	**a) Longitudinal**	Date	4/05/2012

(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:

An F factor >1 could be justified for this type of structure, however since the %NBS is already greater than 100 we have left it as 1

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:	PRK_0339_BLDG_004 EQ2 Pumphouse	Ref.	ZB01276.035
Location:	Harewood Nursery, 239 Gardiners Road	By	KW
Direction Considered:	**b) Transverse**	Date	4/05/2012

(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:

An F factor >1 could be justified for this type of structure, however since the %NBS is already greater than 100 we have left it as 1

3.7 Performance Achievement Ratio (PAR)

(equals A x B x C x D x E x F)

PAR 1

Initial Evaluation Procedure – Steps 4, 5 and 6

(Refer Table IEP - 1 for Step 1; Table IEP - 2 for Step 2, Table IEP - 3 for Step 3)

Building Name:	PRK_0339_BLDG_004 EQ2 Pumphouse	Ref.	ZB01276.035
Location:	Harewood Nursery, 239 Gardiners Road	By	KW
Direction Considered:	**Longitudinal & Transverse**	Date	4/05/2012

(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)	131	131
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	1.00	1.00
4.3 PAR x Baseline (%NBS)$_b$	131	131
4.4 Percentage New Building Standard (%NBS) (Use lower of two values from Step 4.3)		131

Step 5 - Potentially Earthquake Prone?

(Mark as appropriate)

%NBS ≤ 33 NO

Step 6 - Potentially Earthquake Risk?

%NBS < 67 NO

Step 7 - Provisional Grading for Seismic Risk based on IEP

Seismic Grade A+

Evaluation Confirmed by

Signature

NICK CALVERT Name

242062 CPEng. No

Relationship between Seismic Grade and % NBS :

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

13. Appendix 3 – CERA Standardised Report Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name: PRK_0339_BLDG_004 EQ2

	Unit	No:	Street
Building Address:	Harewood Nursery -Pumphouse	239	Gardiners Road, Harewood
Legal Description:			

	Degrees	Min	Sec
GPS south:			
GPS east:			

Building Unique Identifier (CCC):

Reviewer: **NICK CALVERT**
CPEng No: **242062**
Company: SKM
Company project number: ZB01276.33
Company phone number: 03 940 4900

Date of submission:
Inspection Date: 3/03/2012
Revision: A
Is there a full report with this summary? yes

Site

Site slope: flat
Soil type: mixed
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): 0
Soil Profile (if available): refer to geotech desktop study attached in SKM report
If Ground improvement on site, describe:
Approx site elevation (m): 20.00

Building

No. of storeys above ground: 1 single storey = 1
Ground floor split? yes
Storeys below ground 0
Foundation type: mat slab
Building height (m): 2.00
Floor footprint area (approx): 4
Age of Building (years): 20 (max)

Ground floor elevation (Absolute) (m): 20.00
Ground floor elevation above ground (m): 0.10
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m): 2
Date of design: 1992-2004

Strengthening present? no
Use (ground floor): other (specify)
Use (upper floors):
Use notes (if required): Storage
Importance level (to NZS1170.5): IL1

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

Gravity Structure

Gravity System: load bearing walls
Roof: other (note) describe system light weight cladding forms the roof structure
Floors:
Beams:
Columns:
Walls: light weight cladding forms the wall structure

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along: other (note) describe system light weight steel cladding provide diaphragm action
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): estimate or calculation?

Lateral system across: other (note) describe system light weight steel cladding provide diaphragm action
Ductility assumed, μ: 1.00
Period across: 0.10 0.00 estimate or calculation? estimated
Total deflection (ULS) (mm): 5 estimate or calculation? estimated
maximum interstorey deflection (ULS) (mm): estimate or calculation?

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: n/a
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 damage was observed
Describe (summary):

Across Damage ratio: 0%
Describe (summary):

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

Diaphragms Damage?: no Describe:
CSWs: Damage?: no Describe:
Pounding: Damage?: no Describe:
Non-structural: Damage?: no Describe:

Recommendations

Level of repair/strengthening required: none Describe:
Building Consent required: no Describe:
Interim occupancy recommendations: full occupancy Describe:

Along Assessed %NBS before: 100% %NBS from IEP
Assessed %NBS after: 100%

If IEP not used, please detail assessment methodology: NZSEE IEP used, refer to SKM Qualitative Report

Across Assessed %NBS before: 100% %NBS from IEP
Assessed %NBS after: 100%

14. Appendix 4 – Geotechnical Desk 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.

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

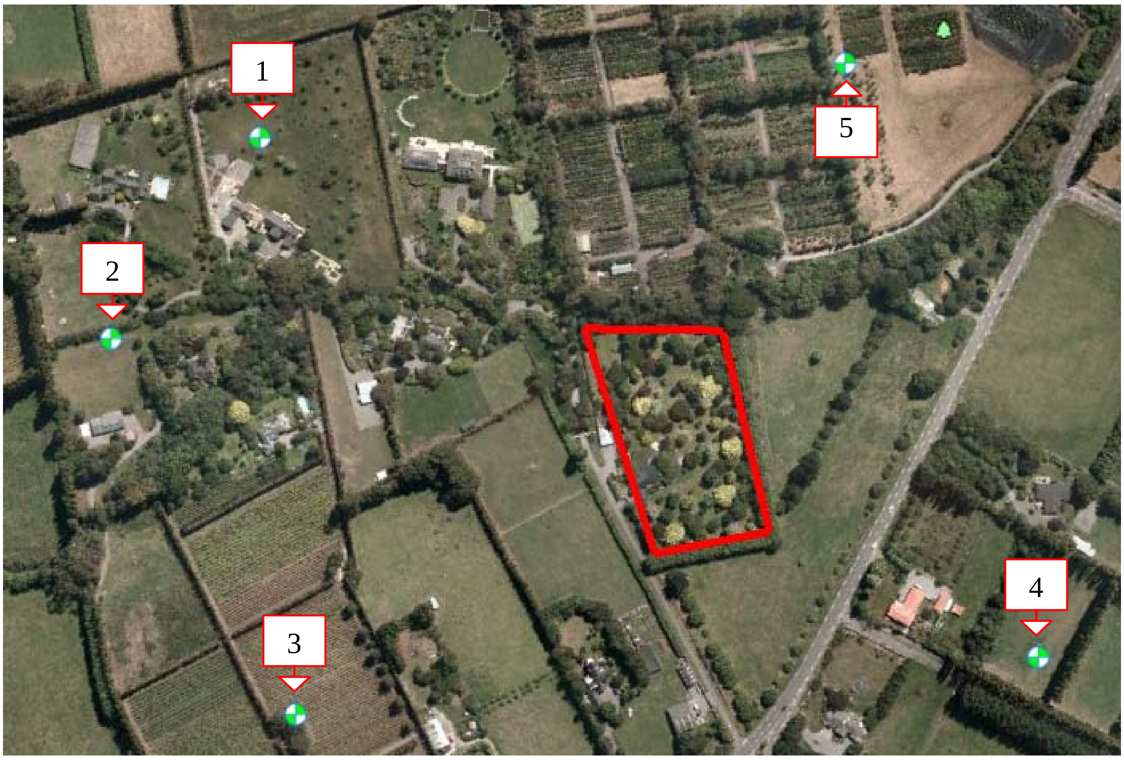
A review of the LINZ website (http://viewers.geospatial.govt.nz/) shows that the site is:

- 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

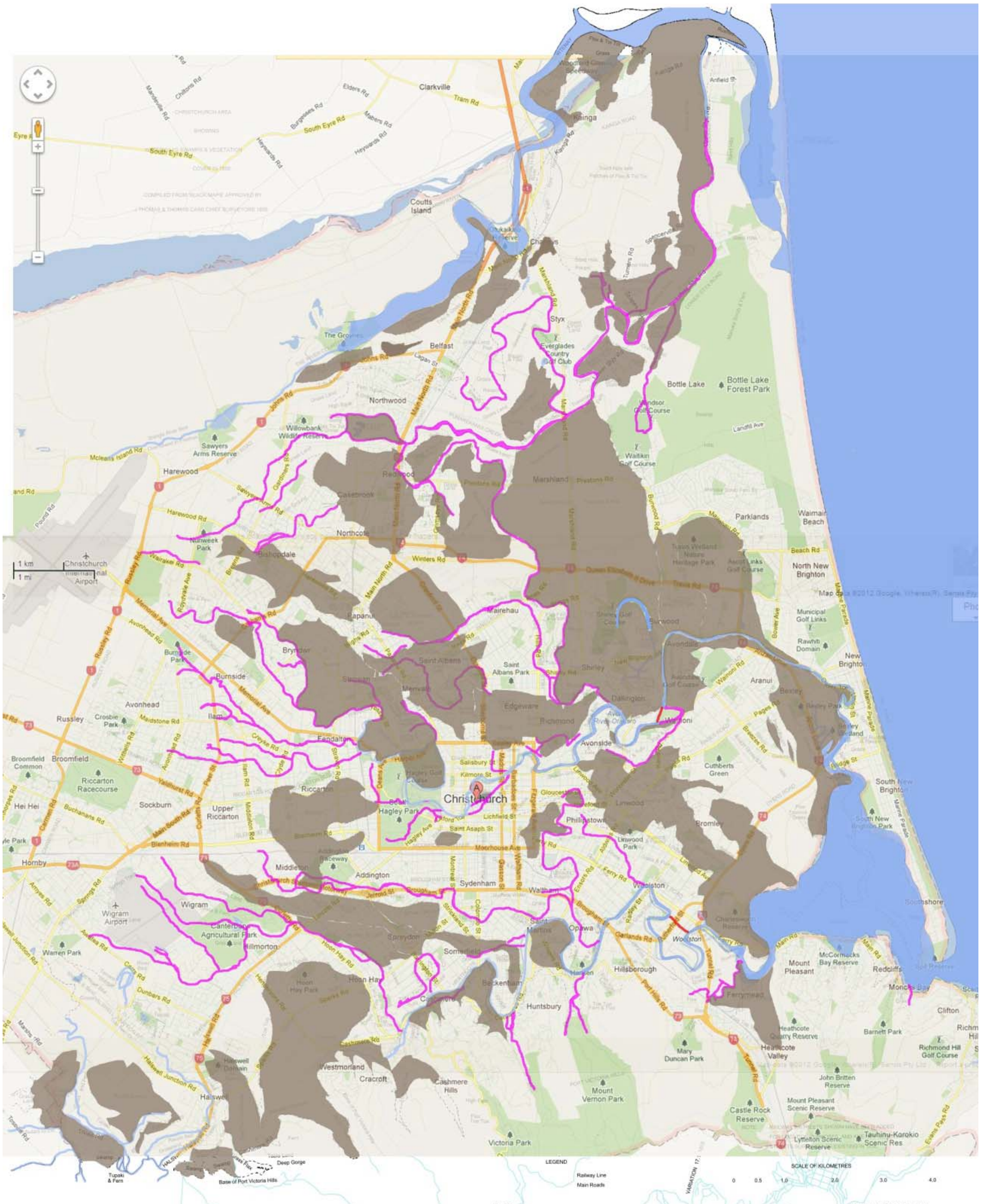
Brown LJ, Weeber JH, 1992. Geology of the Christchurch urban area. Scale 1:25,000. Institute of Geological & Nuclear Sciences geological map 1.

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



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

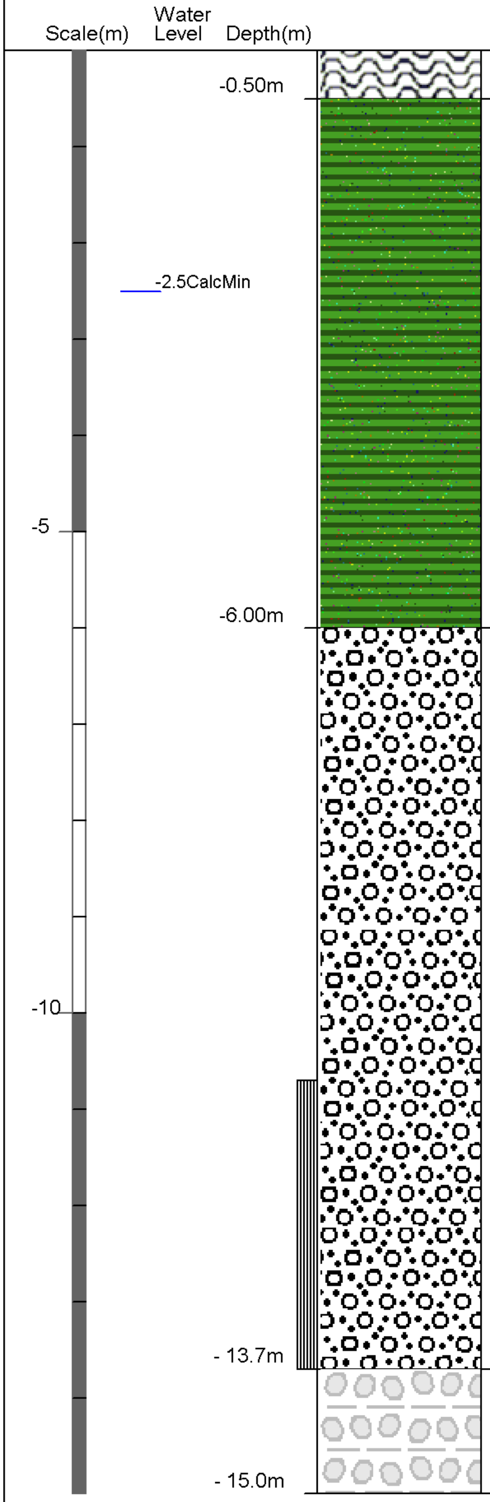
Key

- 🟪 Previous creeks/rivers
- 🟦 Existing creeks/rivers
- 🟥 New creeks/rivers
- ▨ Swamp/Marshland

Appendix B – Existing ground investigation logs

Borelog for well M35/1670

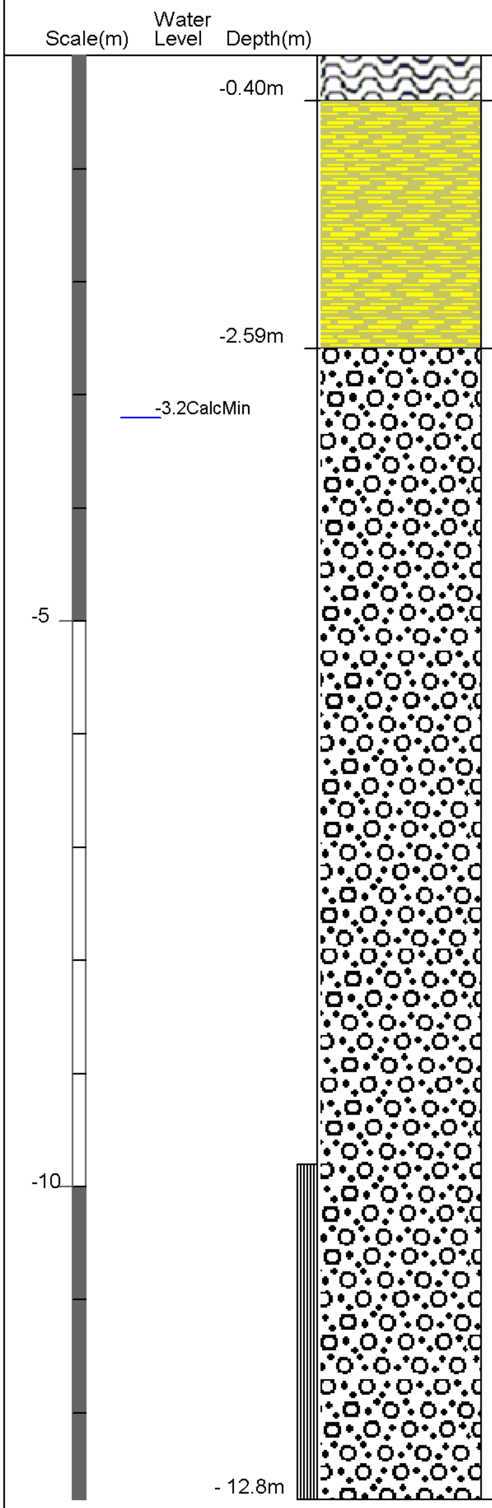
Gridref: M35:76546-48195 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 17.2 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -15m Drill Date : 23/08/1978



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 M35/1671

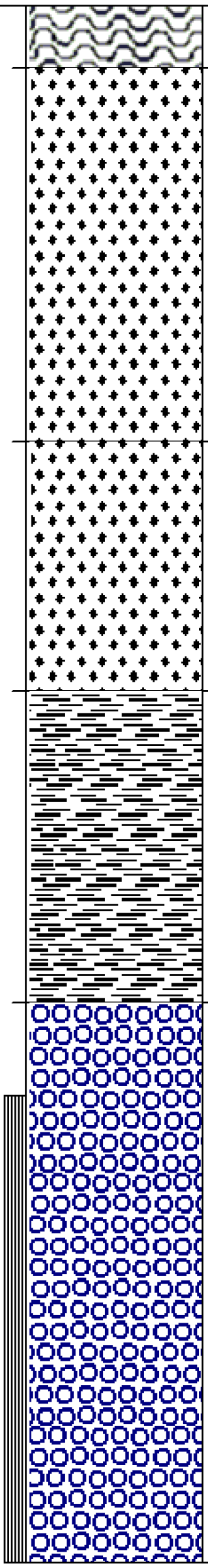
Gridref: M35:7630-4834 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 17.8 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -12.77m Drill Date : 24/08/1978



Full Drillers Description	Formation Code
Topsoil	sp?
Hard Yellow clay	sp?
Small Blue/Grey gravel & sand	sp?

Borelog for well M35/2590

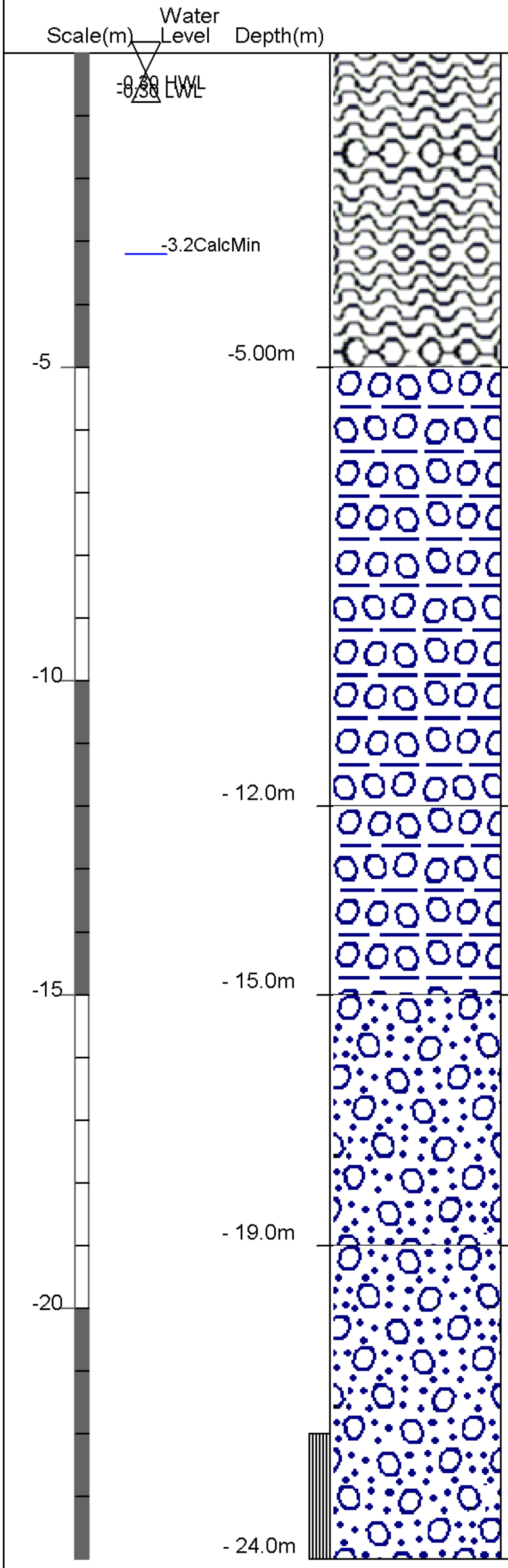
Gridref: M35:7695-4850 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 15.6 +MSD
Driller : not known
Drill Method : Auger Rig
Drill Depth : -5m Drill Date : 21/07/1982



Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.20m	Black soil	sp?
		-1.40m	Brown sand	sp?
	-2.1CalcMin	-2.20m	Blue sand	sp?
		-3.20m	Blue/Grey clay	sp?
		-5.00m	Gravel	sp?

Borelog for well M35/8883

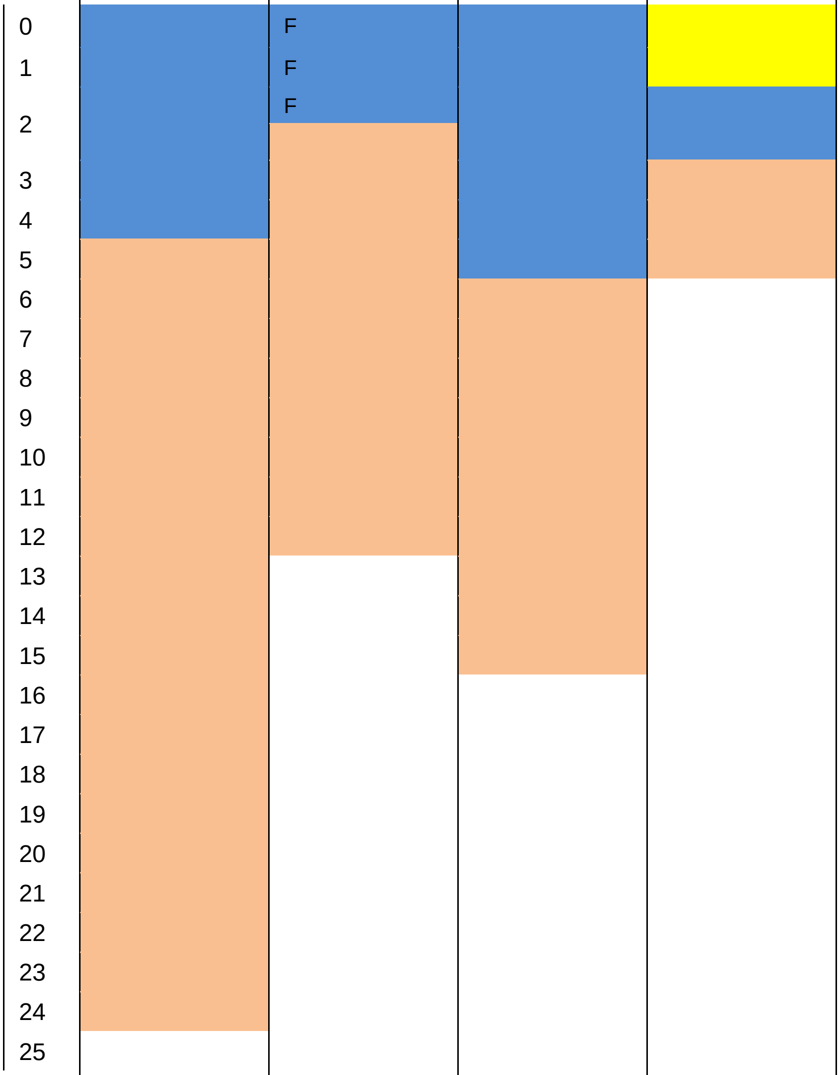
Gridref: M35:7631-4851 Accuracy : 3 (1=best, 4=worst)
Ground Level Altitude : 17.9 +MSD
Driller : East Coast Drilling
Drill Method : Rotary Rig
Drill Depth : -24m Drill Date : 2/04/2000



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

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
Simplified recorded geological profile (depth below ground level to top of stratum, m)				
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