CHRISTCHURCH CITY COUNCIL

PRK_1190_BLDG_001 EQ2
North Hagley Pumphouse
10 Riccarton Ave, Christchurch Central

QUALITATIVE ASSESSMENT REPORT
FINAL

- Rev B
- 25 March 2013

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Contents

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
A	4/10/2012	J. Carter	N Calvert	4/10/12	Draft for Client Approval
B	25/03/2013	N Calvert	N Calvert	25/03/2013	Final Issue

Approval

	Signature	Date	Name	Title
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Distribution of copies

Revision	Copy no	Quantity	Issued to
A	1	1	CCC
B	1	1	CCC

Printed:	25 March 2013
Last saved:	25 March 2013 10:01 AM
File name:	ZB01276.163_CCC_PRK_1190_BLDG_001_EQ2_Qualitative Assmt_B.docx
Author:	Willow Patterson-Kane
Project manager:	Alex Martin
Name of organisation:	Christchurch City Council
Name of project:	Christchurch City Council Structures Panel
Name of document:	North Hagley Pumphouse Qualitative Assessment
Document version:	B
Project number:	ZB01276.163

1. Executive Summary

1.1. Background

A qualitative assessment was carried out on the pumphouse east of the croquet courts in North Hagley Park at 10 Riccarton Ave, Christchurch Central. The building is single storey and is currently utilised as a pumphouse. It is believed to be constructed from unreinforced masonry walls and a timber-framed ceiling with a lightweight roof. An aerial photograph illustrating this area is shown below in Figure 1. Detailed descriptions outlining the buildings age and construction type is given in Section 5 of this report.

■ **Figure 1 Aerial Photograph of the pumphouse at 10 Riccarton Ave**

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

This qualitative report for the building structure is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 and a visual inspection on 20 June 2012.

1.2. Key Damage Observed

Key damage observed includes:-

- Gaps opening up between timber elements.

1.3. Critical Structural Weaknesses

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

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

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the buildings original capacity has been assessed to be in the order of 84% NBS. The damage observed during the site investigation was not significant, therefore the post earthquake capacity will not change as a result of earthquake damage.

The building has been assessed to have a seismic capacity greater than 67% NBS and is therefore not a potential earthquake risk.

1.5. Recommendations

It is recommended that:

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

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

2. Introduction

Sinclair Knight Merz was engaged by Christchurch City Council to prepare a qualitative assessment report for the building located in North Hagley Park at 10 Riccarton Ave following the magnitude 6.3 earthquake which occurred in the afternoon of the 22nd of February 2011 and the subsequent aftershocks.

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

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

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

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

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

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

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

3. Compliance

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

3.1. Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

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

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

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

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

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

3.2. Building Act

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

3.2.1. Section 112 – Alterations

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

3.2.2. Section 115 – Change of Use

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

3.2.3. Section 121 – Dangerous Buildings

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

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

3.2.4. Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to

3.2.5. Section 124 – Powers of Territorial Authorities

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

3.2.6. Section 131 – Earthquake Prone Building Policy

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

3.3. Christchurch City Council Policy

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

The 2010 amendment includes the following:

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

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

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

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

- The accessibility requirements of the Building Code.

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

3.4. Building Code

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

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

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

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

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

4. Earthquake Resistance Standards

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

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

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

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

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

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

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

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

5. Building Details

5.1. Building description

The building is located in North Hagley Park, east of the croquet courts at 10 Riccarton Ave. There is one building on this site. The building has one storey that is currently utilised as a pumphouse. The building is believed to be constructed from unreinforced masonry walls. The roof appears to be timber-framed, with corrugated metal roof sheeting. The ground floor appears to be supported on a concrete slab foundation. It is assumed the building was designed and constructed in the 1970's. It is roughly 5m away from a waterway and is located very close to a tree, which may have structural implications to the block walls in the future.

Our evaluation was based on the external visual inspection carried out on 20 June 2012. An internal inspection was not able to be performed as the building was inaccessible at the time of the inspection. Drawings were not available to verify the foundation system and the date of construction.

5.2. Gravity Load Resisting system

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

5.3. Seismic Load Resisting system

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

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

5.4. Geotechnical Conditions

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

- In accordance with NZS1170.5 the site is likely to be seismic subsoil Class D (deep or soft soil) ground performance and properties.
- Liquefaction risk at the site has been assessed as low. There was no visible evidence of liquefaction near the structure.

If a quantitative assessment is to be undertaken for the structure on site, additional investigations would be required to provide an estimation of shallow ground properties. As the structure is relatively small and as there appears to be about 8m of gravel below a depth of 2m, it is expected that shallow investigations would be adequate for the quantitative assessment stage. Therefore, additional investigations recommended are:

- Two hand augers to a depth of 3m or to refusal or two trial pits to a minimum depth of 3m.

6. Damage Summary

SKM undertook an inspection on 20 June 2012. The following areas of damage were observed during the time of inspection:

General

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

Building Damage

1) Gaps opening up between timber elements.
2) Longitudinal cracking in timber roof edge beam was noted, but this is believed to be due to age of the structure and is not earthquake-related damage.
3) Impact damage was noted on the timber doorframe above the door on the north side, but this is not earthquake-related damage.

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

7. Initial Seismic Evaluation

7.1. The Initial Evaluation Procedure Process

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

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

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

Table 2: IEP Risk classifications

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

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

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

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

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

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

7.2. Available Information, Assumptions and Limitations

Following our inspection on 20 June 2012, SKM carried out a preliminary structural review. The structural review was undertaken using the available information which was as follows:

- SKM site measurements and external inspection findings of the building. Please note no intrusive investigations were undertaken.
- There were no drawings available to carry out our review.

The following assumptions and design criteria were used in this assessment:

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

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

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

7.3. Critical Structural Weaknesses

No critical structural weaknesses have been identified in this building.

7.4. Qualitative Assessment Results

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

Table 3: Qualitative Assessment Summary

Item	%NBS
Likely Seismic Capacity of Building	84

Our qualitative assessment found that the building is not likely to be classed as a potential earthquake risk and probably a 'Low Risk Building' (capacity greater than 67% of NBS). The full IEP assessment form is detailed in Appendix 2 – IEP Reports.

8. Further Investigation

Since the building has a seismic capacity greater than 67% and has sustained no structural damage, no further investigation is required at this stage.

9. Conclusion

A qualitative assessment was carried out on the building located in North Hagley Park, east of the croquet courts, at 10 Riccarton Ave, Christchurch Central. The building has sustained minor damage with gaps opening up between the timber elements. The building has been assessed to have a seismic capacity in the order of 84% NBS and is therefore not a potential earthquake risk and is likely to be classified as a ‘Low Risk Building’ (capacity greater than 67% of NBS).

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

It is recommended that:

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

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

10. Limitation Statement

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

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

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

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

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

11. Appendix 1 – Photos

Photo 1: North elevation

Photo 2: West elevation

Photo 3: South elevation

Photo 4: East elevation

	
Photo 5: Gaps opening up between timber elements in the doorframe on the north side.	Photo 6: Gap opening up between masonry wall and timber roof edge beam on north side.
	
Photo 7: Gaps opening up between timber elements in the doorframe on the north side.	Photo 8: Gaps opening up between timber elements in the doorframe on the north side.

Photo 9: Existing impact damage to timber doorframe on the north side.

Photo 10: Level of the path is one block higher than the ground level at the entrance to the pumphouse on the north side.

Photo 11: Gaps opening up between masonry wall and timber roof edge beam on northwest side.

Photo 12: Longitudinal cracking on timber roof edge beam on west side.

	
Photo 13: Gap opening up between masonry wall and timber roof edge beam on west side.	Photo 14: Overhang of 250 x 30 timber roof edge beam.
	
Photo 15: Concrete slab footing exposed on southwest corner.	Photo 16: Gap opening up between masonry wall and timber roof edge beam on south side.

	
Photo 17: Close proximity of pumphouse to nearby tree.	Photo 18: Concrete slab footing exposed on southeast corner.
	
Photo 19: Gap opening up between masonry wall and timber roof edge beam on east side.	Photo 20: Sloped ground profile on northeast side influenced by nearby tree.

	
Photo 21: Disrupted connection on east side of pumphouse.	Photo 22: Gap opening up between masonry wall and timber roof edge beam on east side.

12. Appendix 2 – IEP Reports

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

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

Building Name:	North Hagley Pumphouse (east of the croquet courts)	Ref.	ZB01276.163
Location:	10 Riccarton Ave, Christchurch Central	By	WPK
		Date	20/06/2012

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketch of building plan

1.3 List relevant features

The building in North Hagley Park at 10 Riccarton Avenue, east of the croquet courts is one storey and is currently in use as a pumproom. The building consists of concrete masonry block walls and an assumed timber-framed roof. The main lateral load-resisting system appear to be the walls. These act as shear walls in the north-south and east-west direction. The roof structure is believed to consist of timber rafters that support a lightweight, corrugated roof. The block walls appear to be founded on a concrete slab footing. The building is assumed to have been constructed in the 1970's.

1.4 Note information sources

	Tick as appropriate
Visual Inspection of Exterior	✓
Visual Inspection of Interior	
Drawings (note type)	
Specifications	
Geotechical Reports	✓
Other (list)	

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

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

Building Name:	North Hagley Pumphouse (east of the croquet courts)	Ref.	ZB01276.163
Location:	10 Riccarton Ave, Christchurch Central	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/06/2012

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

Step 2 - Determination of (%NBS)b

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

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

b) Soil Type

From NZS1170.5:2004, Cl 3.1.3

A or B Rock	○
C Shallow Soil	○
D Soft Soil	◉
E Very Soft Soil	○

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

a) Rigid	○	N-A
b) Intermediate	○	

c) Estimate Period, T

building Ht =	2.6	meters

	Longitudinal	Transverse	
Ac =	N/A	N/A	m2

Can use following:

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

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

Longitudinal	Transverse	
0.4	**0.4**	Seconds

d) (%NBS)nom determined from Figure 3.3

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

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

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

Continued over page

Building Name:	North Hagley Pumphouse (east of the croquet courts)	Ref.	ZB01276.163
Location:	10 Riccarton Ave, Christchurch Central	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/06/2012

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

2.2 Near Fault Scaling Factor, Factor A

If T < 1.5sec, Factor A = 1

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

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

2.3 Hazard Scaling Factor, Factor B

Select Location Christchurch

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

Z = 0.3
Z 1992 = 0.8

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

b) **Hazard Scaling Factor**

For pre 1992 = 1/Z

\# For 1992 onwards = Z 1992/Z

(Where Z 1992 is the NZS4203:1992 Zone Factor from accompanying Figure 3.5(b))

Factor B 3.33

2.4 Return Period Scaling Factor, Factor C

a) **Building Importance Level** 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	**1.25**	μ Maximum = 2
Transverse	**1.25**	μ Maximum = 2

b) **Ductility Scaling Factor**

For pre 1976 = k_μ

For 1976 onwards = 1

(where k_μ is NZS1170.5:2005 Ductility Factor, from accompanying Table 3.3)

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

2.6 Structural Performance Scaling Factor, Factor E

Select Material of Lateral Load Resisting System

Longitudinal Masonry Block

Transverse Masonry Block

a) **Structural Performance Factor, S_p**

from accompanying Figure 3.4

Longitudinal	Sp	0.90
Transverse	Sp	0.90

b) **Structural Performance Scaling Factor**

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

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

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

Longitudinal	42.3	(%NBS)b
Transverse	42.3	(%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:	North Hagley Pumphouse (east of the croquet courts)	Ref.	ZB01276.163
Location:	10 Riccarton Ave, Christchurch Central	By	WPK
Direction Considered:	**a) Longitudinal**	Date	20/06/2012

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

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

Critical Structural Weakness	Effect on Structural Performance (Choose a value - Do not interpolate)				Building Score
	Severe	Significant	Insignificant		
3.1 Plan Irregularity Effect on Structural Performance	○	○	●	**Factor A**	1
Comment					
3.2 Vertical Irregularity Effect on Structural Performance	○	○	●	**Factor B**	1
Comment					
3.3 Short Columns Effect on Structural Performance	○	○	●	**Factor C**	1
Comment					

3.4 Pounding Potential

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

a) Factor D1: - Pounding Effect

Select appropriate value from Table

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

Factor D1 1

Table for Selection of Factor D1

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

b) Factor D2: - Height Difference Effect

Select appropriate value from Table

Factor D2 1

Table for Selection of Factor D2

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

Factor D 1

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

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

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

3.6 Other Factors

For < 3 storeys - Maximum value 2.5,

otherwise - Maximum value 1.5. No minimum. **Factor F** 2

Record rationale for choice of Factor F:

Small scale building unlikely to be governed by seismic loading.

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

PAR 2

Initial Evaluation Procedure – Step 3

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

Building Name:	North Hagley Pumphouse (east of the croquet courts)	Ref.	ZB01276.163
Location:	10 Riccarton Ave, Christchurch Central	By	WPK
Direction Considered:	**b) Transverse**	Date	20/06/2012

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

Step 3 - Assessment of Performance Achievement Ratio (PAR)

(Refer Appendix B - Section B3.2)

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

3.1 Plan Irregularity

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

3.2 Vertical Irregularity

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

3.3 Short Columns

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

3.4 Pounding Potential

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

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

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

Factor D1 1

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

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

Factor D2 1

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

Factor D 1

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

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

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

3.6 Other Factors

For < 3 storeys - Maximum value 2.5,

otherwise - Maximum value 1.5. No minimum. **Factor F** 2

Record rationale for choice of Factor F:

Small scale building unlikely to be governed by seismic loading.

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

PAR 2

Table IEP-4 **Initial Evaluation Procedure – Steps 4, 5 and 6**

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

Building Name:	North Hagley Pumphouse (east of the croquet courts)	Ref.	ZB01276.163
Location:	10 Riccarton Ave, Christchurch Central	By	WPK
Direction Considered:	**Longitudinal & Transverse**	Date	20/06/2012

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

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

	Longitudinal	Transverse
4.1 Assessed Baseline (%NBS)$_b$ (from Table IEP - 1)	42	42
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	2.00	2.00
4.3 PAR x Baseline (%NBS)$_b$	84	84

4.4 Percentage New Building Standard (%NBS) **84**

(Use lower of two values from Step 4.3)

Step 5 - Potentially Earthquake Prone?

(Mark as appropriate)

%NBS ≤ 33 NO

Step 6 - Potentially Earthquake Risk?

%NBS < 67 NO

Step 7 - Provisional Grading for Seismic Risk based on IEP

Seismic Grade **A**

Evaluation Confirmed by

Signature

James Carter — Name

1017618 — 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: North Hagley Pumphouse

	Unit	No:	Street
Building Address:		10	Riccarton Ave (east of the croquet courts)
Legal Description:			

	Degrees	Min	Sec
GPS south:			
GPS east:			

Building Unique Identifier (CCC): PRK_1190_BLDG_001 EQ2

Reviewer: James Carter
CPEng No: 1017618
Company: SKM
Company project number: ZB01276.163
Company phone number: 09 928 5500

Date of submission: 25-Mar
Inspection Date: 20/06/2012
Revision: B
Is there a full report with this summary? yes

Site

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

Max retaining height (m): 0.4
Soil Profile (if available):
If Ground improvement on site, describe:
Approx site elevation (m):

Building

No. of storeys above ground: 1 — single storey = 1
Ground floor split? no
Storeys below ground: 0
Foundation type: mat slab
Building height (m): 2.60
Floor footprint area (approx): 6
Age of Building (years): 80

Ground floor elevation (Absolute) (m):
Ground floor elevation above ground (m):
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m): 2.6
Date of design: 1965-1976

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

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

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	Unknown
Floors:	concrete flat slab	slab thickness (mm)	Unknown
Beams:	none	overall depth x width (mm x mm)	None
Columns:	none	typical dimensions (mm x mm)	None
Walls:	unreinforced concrete masonry	thickness (mm)	200

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	unreinforced masonry bearing wall - stone		note wall thickness and cavity	200mm
Ductility assumed, μ:	1.25			
Period along:	0.40	0.40 from parameters in sheet	estimate or calculation?	estimated
Total deflection (ULS) (mm):	10		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	estimated
Lateral system across:	unreinforced masonry bearing wall - stone		note wall thickness and cavity	200mm
Ductility assumed, μ:	1.25			
Period across:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):	10		estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	estimated

Separations:

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

Non-structural elements

Stairs:			
Wall cladding:	exposed structure	describe	Masonry walls
Roof Cladding:	Metal	describe	Corrugated sheeting
Glazing:			
Ceilings:			
Services(list):			

Available documentation

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

Damage

Site:
(refer DEE Table 4-2)

Site performance: — Describe damage:

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

Building:

Current Placard Status: green

Along — Damage ratio: 0%
Describe how damage ratio arrived at: Current damage noted will not diminish the capacity of the building
Describe (summary): Gaps opening up between timber elements

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

Across — Damage ratio: 0%
Describe (summary): Gaps opening up between timber elements

Diaphragms — Damage?: no — Describe:
CSWs: — Damage?: no — Describe:
Pounding: — Damage?: no — Describe:
Non-structural: — Damage?: yes — Describe: Gaps opening up between timber elements

Recommendations

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

Along — Assessed %NBS before: 84% — %NBS from IEP below
Assessed %NBS after: 84%

If IEP not used, please detail assessment methodology: Qualitative Assessment carried out includes NZSEE IEP (refer to SKM report).

Across — Assessed %NBS before: 84% — %NBS from IEP below
Assessed %NBS after: 84%

14. Appendix 4 – Geotechnical Desktop Study

Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	163
Address	Hagley Park North – Pump House
Report date	27 August 2012
Author	Ananth Balachandra
Reviewer	Leah Bateman
Approved for issue	Yes

1. Introduction

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

2. Scope

This geotechnical desk top study incorporates information sourced from:

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

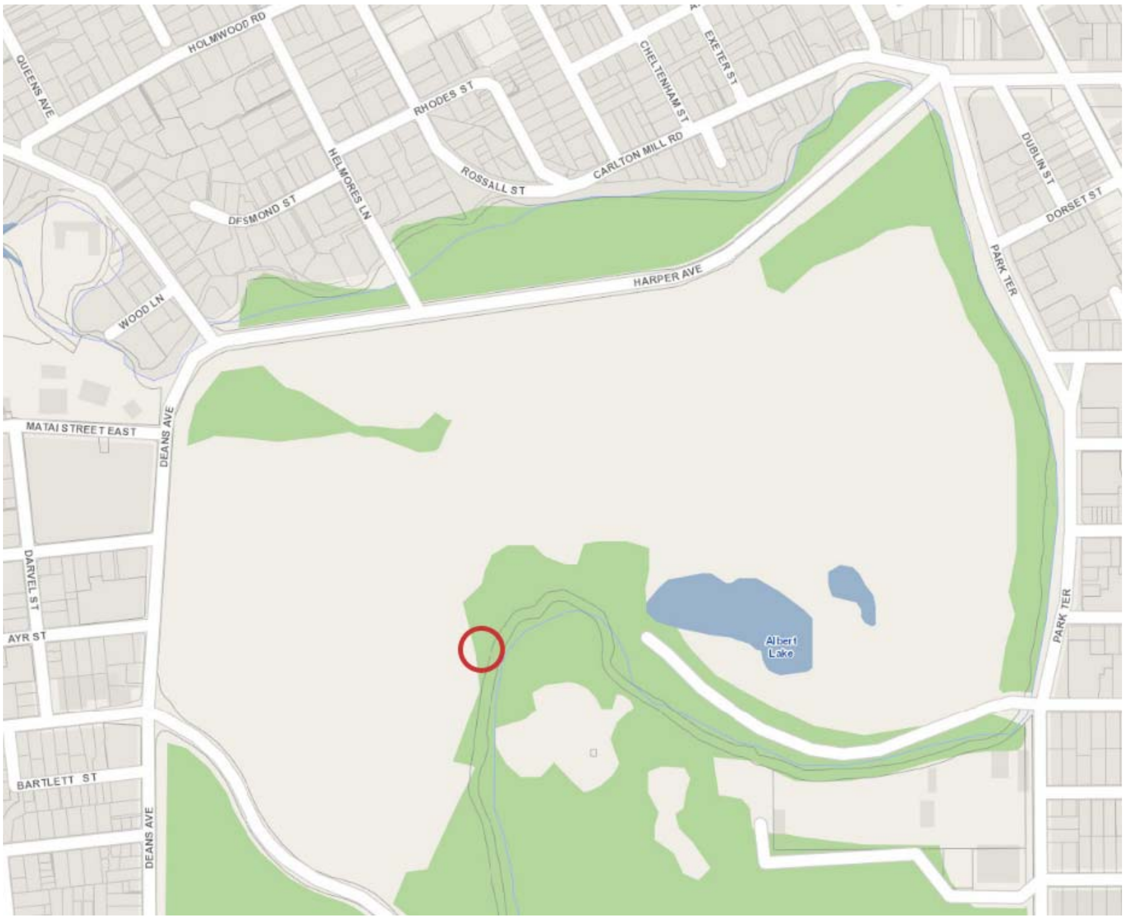
3. Limitations

This report was prepared to address geotechnical issues relating to the specific site in accordance with the scope of works as defined in the contract between SKM and our Client. This report has been prepared on behalf of, and for the exclusive use of, our Client, and is subject to, and issued in accordance with, the provisions of the contract between SKM and our Client. The findings presented in this report should not be applied to another site or another development within the same site without consulting SKM.

The assessment undertaken by SKM was limited to a desktop review of the data described in this report. SKM has not undertaken any subsurface investigations, measurement or testing of materials from the site. In preparing this report, SKM has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by our Client, and from other sources as described in the report. Except as otherwise stated in this report, SKM has not attempted to verify the accuracy or completeness of any such information.

This report should be read in full and no excerpts are to be taken as representative of the findings. It must not be copied in parts, have parts removed, redrawn or otherwise altered without the written consent of SKM.

4. Site location

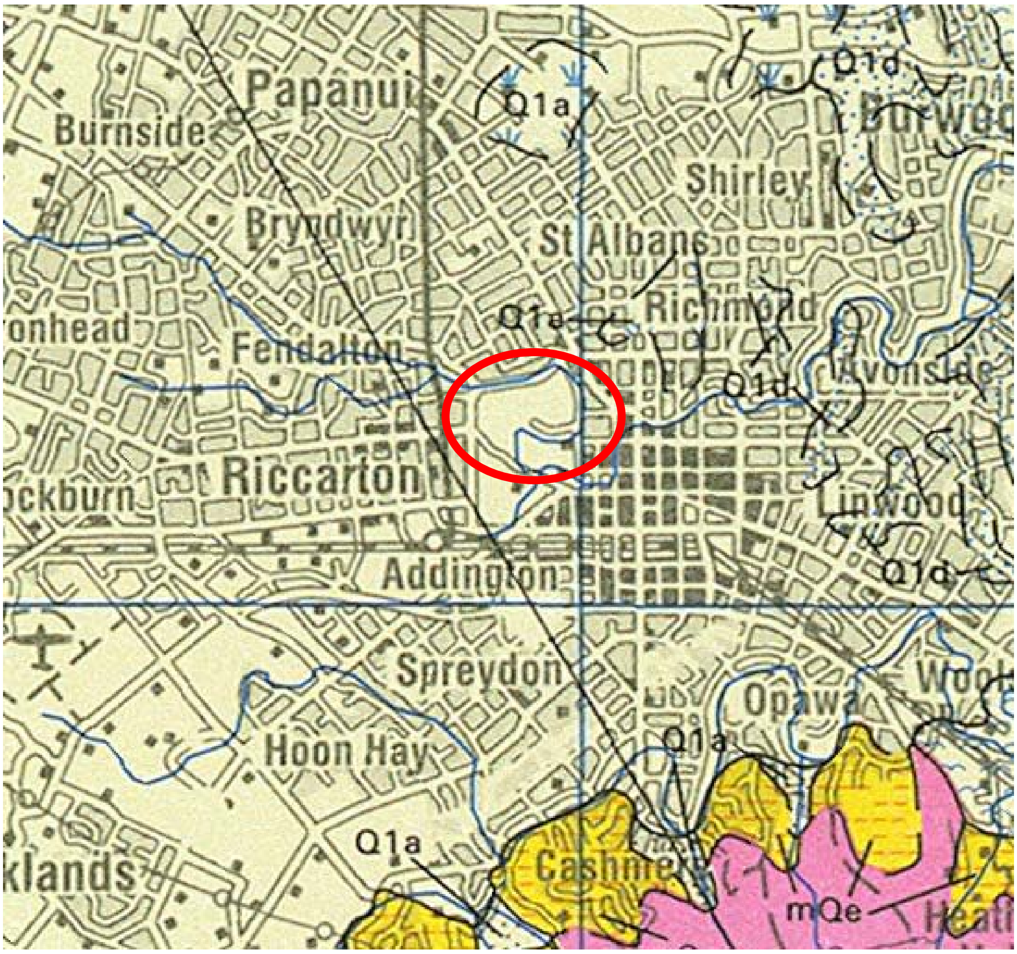


- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

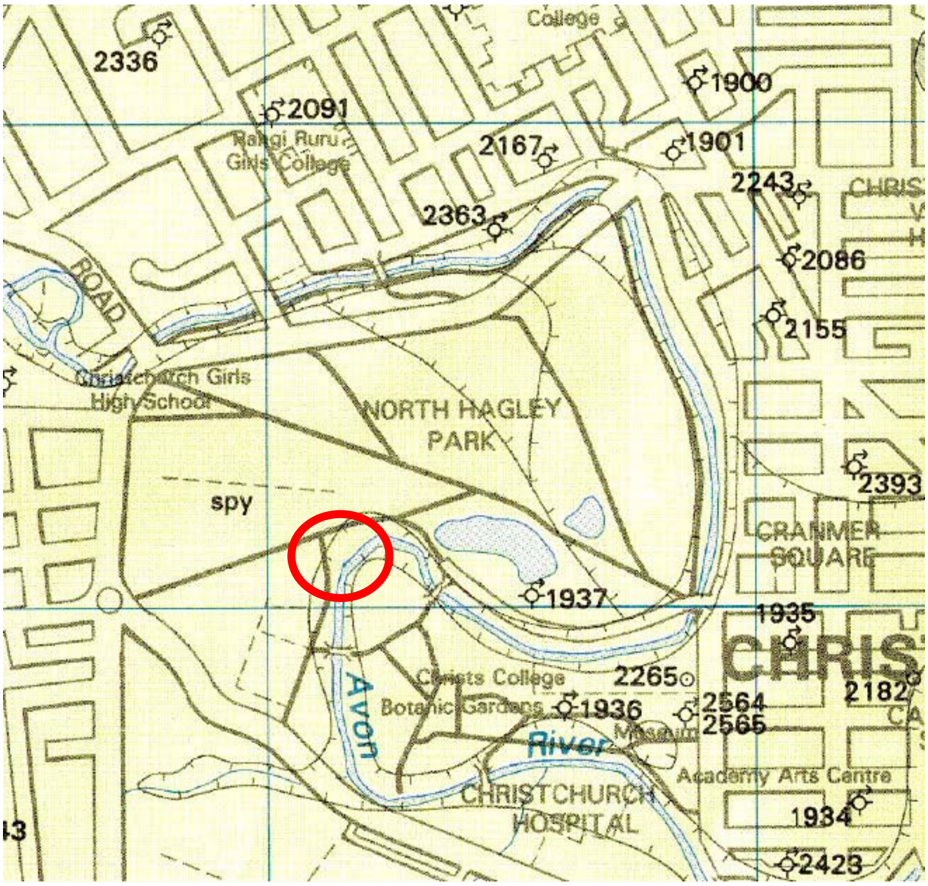
The structure is located within North Hagley Park at grid reference 1569128 E, 5180476 N (NZTM).

5. Review of available information

5.1 Geological maps



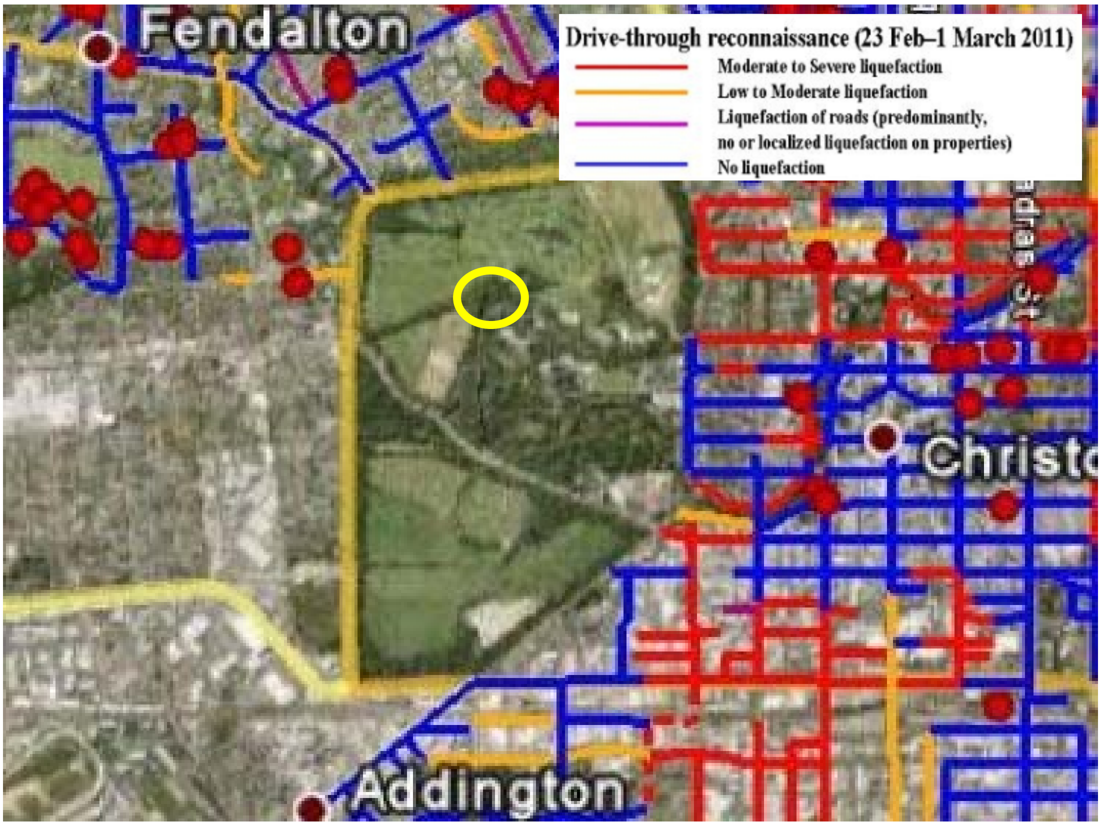
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



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

The site is shown to be underlain by Holocene deposits comprising predominantly alluvial sand and silt overbank deposits of the Springston Formation.

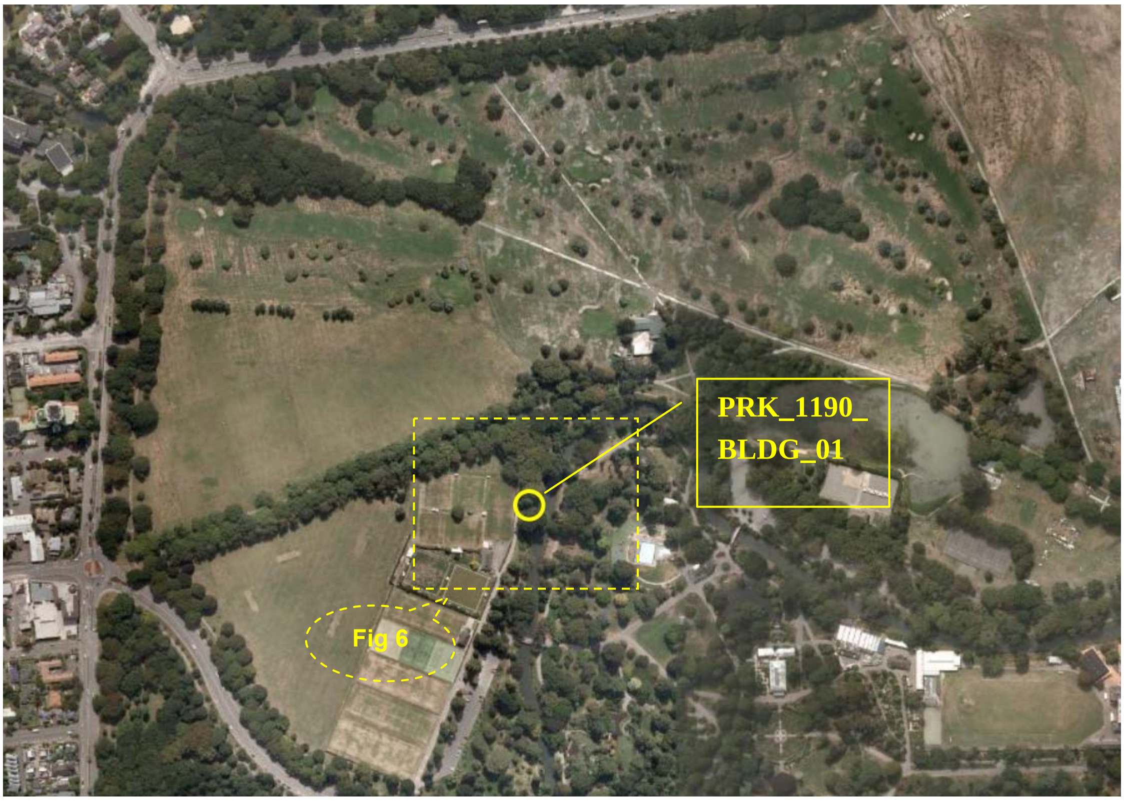
5.2 Liquefaction map



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

Following the 22 February 2011 event drive through reconnaissance was undertaken from 23 February until 1 March by M Cubrinovsko and M Taylor of Canterbury University. Their findings show low to moderate liquefaction in areas west of the site (with the area driven through located approximately 500 m from the relevant structure) and moderate to severe liquefaction east of the site (with the area driven through approximately 800 m from the relevant structure).

5.3 Aerial photography



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

- **Figure 6- Aerial photography from 24 Feb 2011 (http://viewers.geospatial.govt.nz/)**

An aerial view of the structure itself was not possible as the pump house is obstructed by the branches of surrounding trees. However, there appears to be no evidence of any liquefied ejecta in the immediate surrounding area. Additionally, there appears to be no lateral land movement towards the river running immediately east of the site. However, the dark murky colour of the river may indicate liquefaction of the loose river bed sediments with suspended silt material still present in the water at the time the aerial photograph was taken.

Wider view of the area shows a significant amount of liquefied ejecta to be present in areas north and north east of the site while little to no sign of any liquefied ejecta could be seen in areas west and south of the site.

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) (due to the significant distance to the residential properties, classification of adjacent residential area is not provided)

5.5 Historical land use

Reference to historical documents (eg Appendix A) show that areas immediately north and north east of the site were classified as swamp or marshland in 1856. This may mean that soft or loose liquefiable material is present in these areas. The area classified as being part of the swamp or marshland area relates well with the area noted, from aerial photographs, to have experienced a significant amount of liquefaction.

5.6 Existing ground investigation data

- **Figure 7– Local boreholes from Project Orbit and SKM files (https://canterburyrecovery.projectorbit.com/).**

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

5.7 Council property files

No information relevant to this report was found in the available council property files.

5.8 Site walkover

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

The building was a masonry block construction with a corrugated sheet metal roof over a timber frame and slab on grade foundation. No significant structural damage was noted from the external site inspection. The Avon River flows approximately 6 m to the east of the building, and there is a tree located next to the building on the north east corner. The ground slopes upward to the west approximately 2 m towards the above driveway.

No apparent evidence of liquefaction or land damage was observed on site. However, resealed patches and undulations in the road surface were observed on the above driveway. These are likely to have occurred as a result of the earthquake however it is not clear what state of repair the driveway was in prior to the earthquake events.

- **Figure 8 - Overview of the building (northern elevation)**

- **Figure 9 – Observed damage to the above driveway**

- **Figure 10– Observed ground bulges**

6. Conclusions and recommendations

6.1 Site geology

An interpretation of the most relevant local investigation suggests that the site is underlain by:

Depth range (mBGL)	Soil Type
0 - 2.0 m	Silt mixture containing sandy silt and clayey silt
2.0 - 10.0 m	Sandy gravel (Springston formation)
10.0 - 23.0 m	Bedded layers of clay and sand
23.0 m +	Riccarton gravels

6.2 Seismic site subsoil class

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

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

The third preferred method has been used in assessing the seismic site subsoil class. However, the bedrock layer in this region is expected to be present at depths greater than 100 m below ground level, with bedded gravel, sand and clay layers extending to the respective depth. Additionally, from available investigation data it is expected that the site is not underlain by Class E soil. Therefore, we are reasonably confident with the assessed seismic site subsoil class and we expect that this is unlikely to change if a site specific investigation is undertaken.

6.3 Building Performance

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

6.4 Ground performance and properties

Liquefaction risk at the site has been assessed as low. There was no visible evidence of liquefaction near the structure. The upper silt layers are likely to be present above the level of the water table. Additionally, a sandy gravel layer is inferred to be present at relatively shallow depths with the layer approximately 8 m thick. Ground information inferring this is approximately 380 m east of the site. However due to the lack of liquefaction at the site, it is considered the sandy gravel layer continues through this area. The sandy gravel layer is not susceptible to liquefaction. Additionally, due to the thickness of the respective layer, it is unlikely that there would be any surface manifestation of liquefaction that occurs beneath this layer. Furthermore, any liquefaction that occurs beneath the inferred sandy gravel layer is unlikely to have any adverse effect on the present structure.

Risk of lateral spreading has been assessed as low. Even though, a free face due to the Avon River is present less than 10 m, as the shallow layers are not expected to be susceptible to liquefaction, it is unlikely that any significant lateral spreading towards the free face will occur.

As the available investigation did not contain any geotechnical measurement in addition to being located a significant distance away from the structure, an estimation of ground properties is not provided in this report.

6.5 Further investigations

If a quantitative DEE is to be undertaken for the structure on site, additional investigations would be required to provide an estimation of shallow ground properties. As the structure is relatively small and as there appears to be about 8 m of gravel below a depth of 2 m, it is expected that shallow investigations would be adequate for the quantitative DEE stage. Therefore, additional investigations recommended are:

- Two hand augers to a depth of 3 m or to refusal or two trial pits to a minimum depth of 3 m

7. References

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

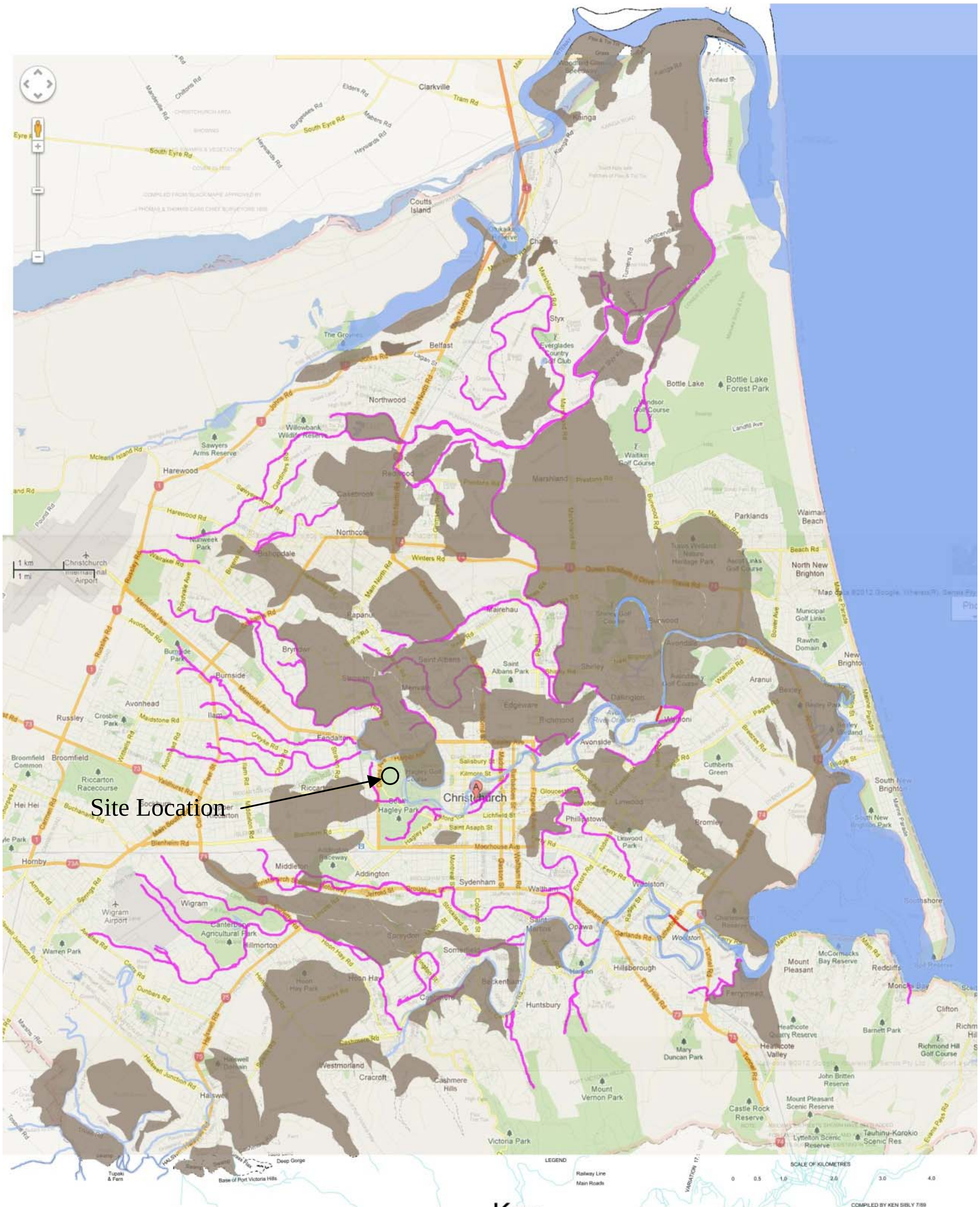
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

Forsyth PJ, Barrell DJA, Jongens R, 2008. Geology of the Christchurch area. Institute of Geological & Nuclear Sciences geological map 16.

Land Information New Zealand (LINZ) geospatial viewer (http://viewers.geospatial.govt.nz/)

EQC Project Orbit geotechnical viewer (https://canterburyrecovery.projectorbit.com/)

Appendix A – Christchurch 1856 land use



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

Key

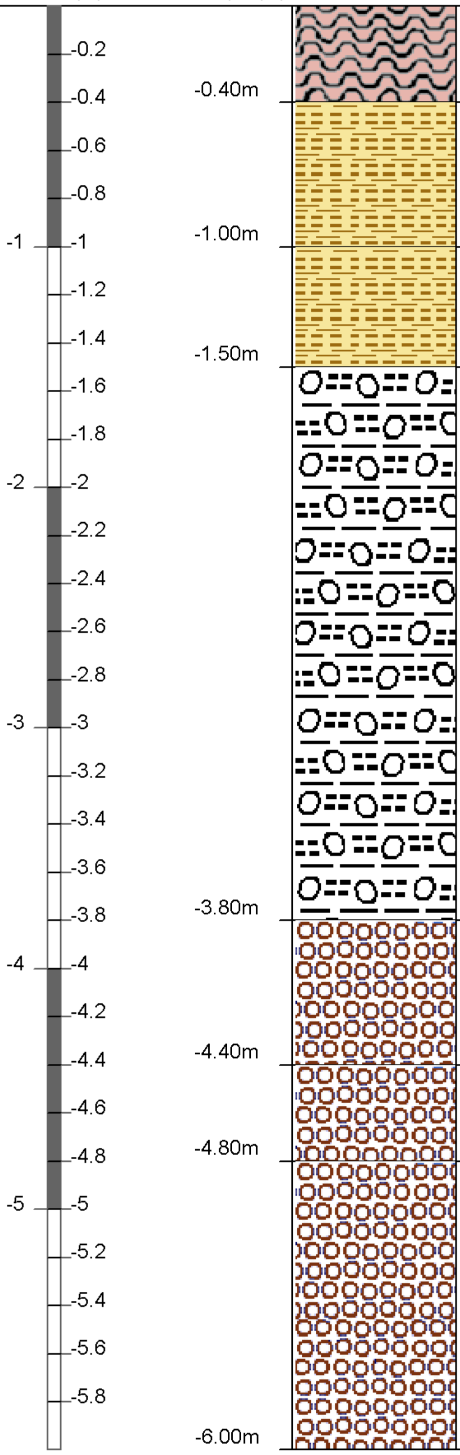
- Previous creeks/rivers
- Existing creeks/rivers
- New creeks/rivers
- Swamp/Marshland

Appendix B – Existing ground investigation logs

Borelog for well M35/14837

Gridref: M35:78774-41914 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.62 +MSD
Well name : CCC BorelogID 3800
Drill Method : Not Recorded
Drill Depth : -6m Drill Date :

Depth(m)	Full Drillers Description	Formation Code
-0.40m	light brown non-cohesive moist silt and topsoil	
-1.00m	light brown semi-cohesive moist silt with a trace of clay	
-1.50m	light brown mottled semi-cohesive moist silt with a trace of clay	
-3.80m	light brown non-cohesive wet clayey silt and gravel with a little cobbles	
-4.40m	light brown non-cohesive wet gravel with a little cobbles and clayey silt	
-4.80m	light brown non-cohesive wet gravel with a little clayey silt	
-6.00m	light brown non-cohesive wet gravel with a trace of clayey silt	



Borelog for well M35/13525

Gridref: M35:78336-42909 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 8.51 +MSD
Well name : CCC BorelogID 1854
Drill Method : Not Recorded
Drill Depth : -1.91m Drill Date :

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.10m	gravel	
-0.2, -0.4, -0.6, -0.8, -1		-1.06m	dry sand	
-1.2, -1.4, -1.6, -1.8		-1.91m	sandy silt	

Borelog for well M35/2285

Gridref: M35:792-417 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 5.9 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -79.19m Drill Date : 19/08/1911

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
-4.50m	Clay	sp?
- 10.6m	Blue shingle	sp?
- 22.8m	Blue clay & sand	ch
- 36.5m	Brown shingle, water 0.6m above surface	ri
- 39.6m	Blue clay	br
- 42.6m	Brown shingle	br
- 51.8m	Brown sand	br
- 53.6m	Yellow clay	br
- 63.0m	Brown shingle	li-1
- 65.2m	Yellow clay	li-2
- 68.2m	Blue clay & sand	li-2
- 71.9m	Blue shingle	li-2
- 75.5m	Blue clay	li-2
- 79.2m	Brown shingle water flows 229.2m3/d 0.3m above surface & rises 3.0m	li-3

Scale(m): -10, -20, -30, -40, -50, -60, -70

Borelog for well M35/14836

Gridref: M35:78666-42111 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.78 +MSD
Well name : CCC BorelogID 3799
Drill Method : Not Recorded
Drill Depth : -6m Drill Date :

Depth(m)	Full Drillers Description	Formation Code
-0.25m	brown non-cohesive dry topsoil	
-0.90m	grey non-cohesive moist silt	
-1.20m	yellow brown non-cohesive moist clayey silt	
-1.80m	grey non-cohesive wet silt	
-2.20m	grey medium dense loose wet silty sand	
-6.00m	grey brown medium dense loose wet saturated sandy silt and gravel and cobbles	

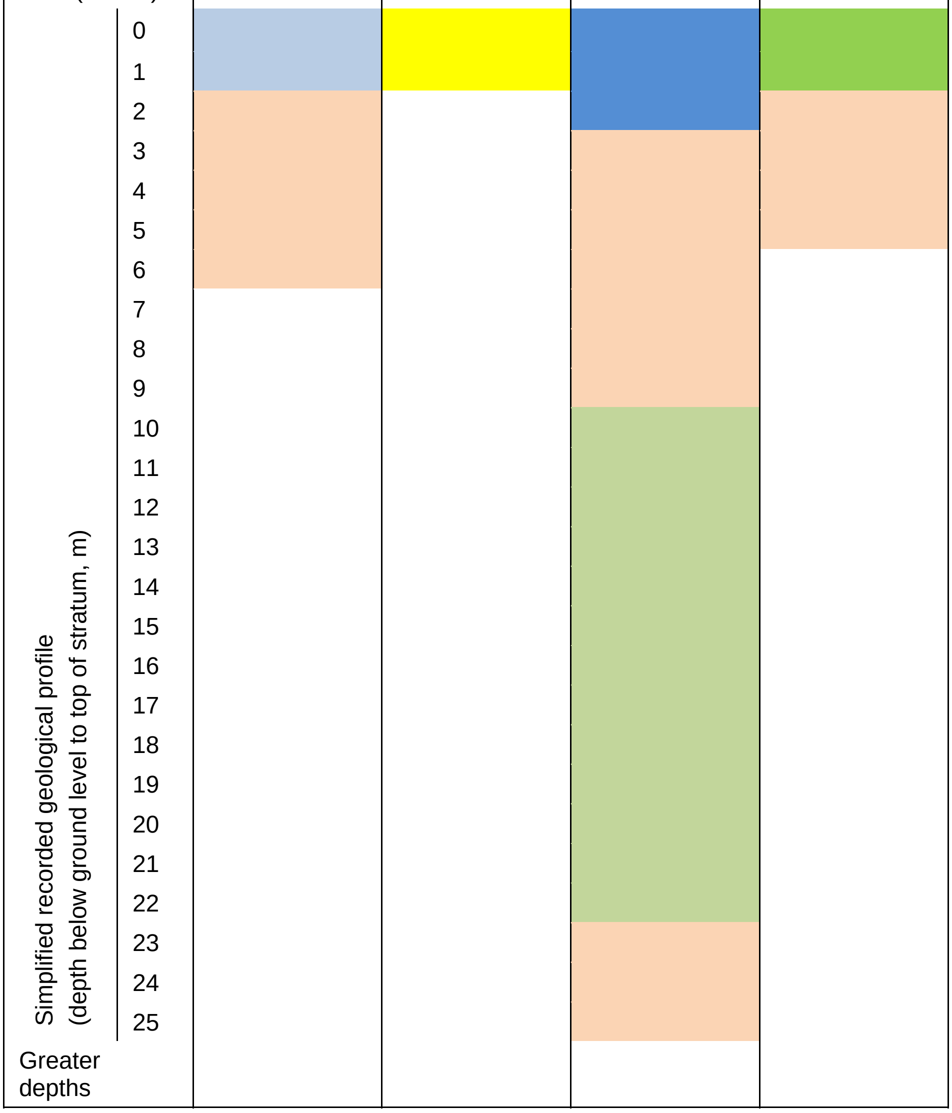
Scale(m): -0.2, -0.4, -0.6, -0.8, -1, -1.2, -1.4, -1.6, -1.8, -2, -2.2, -2.4, -2.6, -2.8, -3, -3.2, -3.4, -3.6, -3.8, -4, -4.2, -4.4, -4.6, -4.8, -5, -5.2, -5.4, -5.6, -5.8

Water Level

Appendix C – Geotechnical Investigation Summary

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

ID	1	2	3	4
Type *	WW	WW	WW	WW
Ref	M35/14837	M35/14838	M35/2285	M35/14836
Depth (m)	6	2	79	6
Distance from site (m)	380	370	370	460
Ground water level (mBGL)	N/A	N/A	N/A	N/A



*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