CHRISTCHURCH CITY COUNCIL

PRK_1044_BLDG_006 EQ2
Waltham Park -Toilets
30-40 Waltham Rd, Waltham

QUALITATIVE ASSESSMENT REPORT

FINAL

- Rev C
- 24 April 2014

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Waltham Park – Toilets
30-40 Waltham Rd, Waltham

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- Rev B
- 24 April 2014

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Contents

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1. Executive Summary

1.1. Background

A Qualitative Assessment was carried out on PRK_1044_BLDG_006 EQ2 Waltham Park Toilets, located at Waltham Park. The building is a masonry structure with a steel framed canopy. An aerial photograph illustrating the location of Building 6 is shown below in Figure 1. A detailed description outlining the building age and construction type is given in Section 5 of this report.

▪ **Figure 1 : Aerial Photograph of PRK_1044_BLDG_006 EQ2 Waltham Park - Toilet**

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 22 May 2012.

1.2. Key Damage Observed

No structural damage to the property was observed at the time of the inspection.

1.3. Critical Structural Weaknesses

No critical structural weaknesses have been identified.

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

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the building's original capacity has been assessed to be in the order of 100%NBS. No structural damage was observed to the building and therefore the post earthquake capacity remains the same.

The building has been assessed to have a seismic capacity in the order of 100% NBS and is therefore not earthquake prone.

1.5. Recommendations

No further investigation work is deemed necessary.

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

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 at 30-40 Waltham Rd, Waltham 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 broadly includes a summary of the building damage as well as an initial assessment of the likely current Seismic Capacity compared with current seismic code requirements.

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

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

This report describes the structural damage observed during our inspection and indicates suggested remediation measures. The inspection was undertaken from floor levels and was a visual inspection only. Our report reflects the situation at the time of the inspection and does not take account of changes caused by any events following our inspection. A full description of the basis on which we have undertaken our visual inspection is set out in Section 7.2.

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. Construction drawings were not made available. The building description below is based on a visual inspection only.

[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

Building 6 is a single storey amenities block constructed from stack bond concrete masonry. The structure has a steel canopy supported on steel posts and is tied in to the block walls. The building has one internal concrete masonry wall and the canopy is clad in corrugated steel roof sheeting. The masonry walls are founded on a concrete strip footing and there is an internal floor slab.

Structural drawings were not made available for this structure.

The building is estimated to have been built in the 1990s.

Photos of the structure can be found in Appendix 1 – Photos.

5.2. Gravity Load Resisting system

The steel canopy is supported on both steel posts and the masonry walls. Load in the block walls is transmitted to the strip footing in bearing.

5.3. Seismic Load Resisting system

For the purposes of this report the longitudinal direction of the building is defined as being the north-south direction and the transverse direction is defined as being in the east-west direction.

Lateral load on the steel canopy is transmitted to the masonry walls via steel posts cast in to the walls. In-plane loading the masonry walls is transmitted to ground in shear. The masonry walls span between perpendicular walls in out-of-plane loading.

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.
- The ultimate bearing capacity of a shallow pad footing on this site has been estimated to be in the order of 300kPa. However this may be revised by a site specific investigation.
- Liquefaction risk is low at this site.

Unless a change of use is intended for the site we do not believe that any further geotechnical investigations are required. Specific ground investigation should be undertaken if significant alterations or new structures are proposed. If any excavations are required on the site further investigation of the potential for contamination should be undertaken. The full geotechnical desktop study can be found in Appendix 4.

6. Damage Summary

6.1. Damage Summary

SKM undertook an inspection of the building from floor level on 22 May 2012. No structural damage to the building was observed at the time of the inspection. Some cracking was found in the concrete fillet at the base of the masonry walls; however this cracking is not thought to be earthquake related.

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 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

[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 22 May 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. Please note no intrusive investigations were undertaken.

The design criteria used to undertake the assessment include:

- Standard design assumptions for typical office and factory buildings as described in AS/NZS1170.0:2002
  - 50 year design life, which is the default NZ Building Code design life.
  - Structure importance level 2. This level of importance is described as 'normal' with medium or considerable consequence of failure.
  - Ductility level of 1.25, based on our assessment and code requirements at the time of design. The structure primarily replies on masonry walls which are expected to be at least partially reinforced due to the age of construction.
  - 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 adjacent to land which is zoned TC2 under the CERA Residential Technical Categories Map. The combination of these factors means that we do not recommend that any survey be undertaken at this point.

7.4. Critical Structural Weaknesses

No critical structural weaknesses for the building were observed during our visual inspection.

7.5. Qualitative Assessment Results

The building has had its capacity assessed using the Initial Evaluation Procedure based on the information available. The building's capacity, expressed as a percentage of new building standard (%NBS), 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
Toilets	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 Reports.

8. Further Investigation

No further investigation is deemed necessary for this building.

9. Conclusion

A qualitative assessment was carried out for PRK_1044_BLDG_006 EQ2 located at Waltham Park. No structural damage was observed to the structure. The building has been assessed to have a seismic capacity in the order of 100% NBS and is therefore not earthquake prone and is likely to be classified as a 'Low Risk Building' (capacity greater than 67% of NBS).

No further investigation is deemed necessary for the structure.

a) The current placard status of the building remain as 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: The east elevation of Building 6

Photo 2: The north and west elevations of Building 6

Photo 3: Non-earthquake related cracking in the concrete fillet at the base of the masonry walls

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)

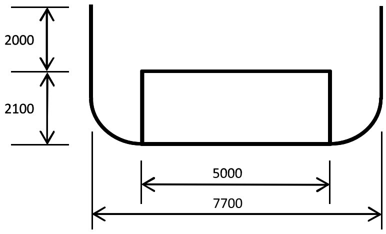
Page 1

Building Name:	**PRK_1044_BLDG_006 EQ2 Waltham Park Toilet**	Ref.	**ZB01276.110**
Location:	30-40 Waltham Rd, Waltham, Christchurch	By	OAK
		Date	9/08/2012

Step 1 - General Information

1.1 Photos (attach sufficient to describe building)

1.2 Sketch of building plan



1.3 List relevant features

Building 6 is a single storey amenities block constructed from stack bond concrete masonry. The structure has a steel canopy supported on steel posts and is ties in to the block walls. The building has one internal concrete masonry wall and the canopy is clad in corrugated steel roof sheeting. The masonry walls are founded on a concrete strip footing and there is an internal floor slab.

1.4 Note information sources

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

Table IEP-2 Initial Evaluation Procedure – Step 2

Page 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_1044_BLDG_006 EQ2 Waltham Park Toilet	Ref.	ZB01276.110
Location:	30-40 Waltham Rd, Waltham, Christchurch	By	OAK
Direction Considered:	Longitudinal & Transverse	Date	9/08/2012

(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 = 3 meters

Ac = 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	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**

Page 3

Building Name:	**PRK_1044_BLDG_006 EQ2 Waltham Park Toilet**	Ref.	**ZB01276.110**
Location:	30-40 Waltham Rd, Waltham, Christchurch	By	OAK
Direction Considered:	**Longitudinal & Transverse**	Date	9/08/2012

(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

b) **Hazard Scaling Factor** Type Z 1992 above

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

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** 2
(from NZS1170.0:2004, Table 3.1 and 3.2)

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

2.5 Ductility Scaling Factor, D

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

Longitudinal	1.25	μ Maximum = 6
Transverse	1.25	μ Maximum = 6

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

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

2.6 Structural Performance Scaling Factor, Factor E

Select Material of Lateral Load Resisting System
Longitudinal 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	65.8	(%NBS)b
Transverse	65.8	(%NBS)b

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

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

Building Name:	**PRK_1044_BLDG_006 EQ2 Waltham Park Toilet**	Ref.	**ZB01276.110**
Location:	30-40 Waltham Rd, Waltham, Christchurch	By	OAK
Direction Considered:	**a) Longitudinal**	Date	9/08/2012

(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)

	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** 1.5

Record rationale for choice of Factor F:

The building showed no sign of damage and it is likely that the capacity of the building is not govered by seismic loading

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

PAR 1.5

Table IEP-3 **Initial Evaluation Procedure – Step 3** Page 5

(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_1044_BLDG_006 EQ2 Waltham Park Toilet**	Ref.	**ZB01276.110**
Location:	30-40 Waltham Rd, Waltham, Christchurch	By	OAK
Direction Considered:	**b) Transverse**	Date	9/08/2012

(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)

	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** 1.5

Record rationale for choice of Factor F:
The building showed no sign of damage and it is likely that the capacity of the building is not govered by seismic loading

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

PAR 1.5

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

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

Page 6

Building Name:	PRK_1044_BLDG_006 EQ2 Waltham Park Toilet	Ref.	ZB01276.110
Location:	30-40 Waltham Rd, Waltham, Christchurch	By	OAK
Direction Considered:	Longitudinal & Transverse	Date	9/08/2012

(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)	65	65
4.2 Performance Achievement Ratio (PAR) (from Table IEP - 2)	1.50	1.50
4.3 PAR x Baseline (%NBS)$_b$	98	98
4.4 Percentage New Building Standard (%NBS) (Use lower of two values from Step 4.3)		98

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_1044_BLDG_006 EQ2	Reviewer:	Kimberley Wylie
	Unit / No: / Street	CPEng No:	1007058
Building Address:	Waltham Park - Toilet / 30-40 / Waltham Rd, Waltham	Company:	SKM
Legal Description:		Company project number:	ZB01276.110
		Company phone number:	03 940 4900
	Degrees / Min / Sec		
GPS south:		Date of submission:	24-Apr
GPS east:		Inspection Date:	22/05/2012
		Revision:	C
Building Unique Identifier (CCC):		Is there a full report with this summary?	yes

Site

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

Building

No. of storeys above ground:	1	single storey = 1 / Ground floor elevation (Absolute) (m):	
Ground floor split?	no	Ground floor elevation above ground (m):	
Storeys below ground	0		
Foundation type:	strip footings	if Foundation type is other, describe:	
Building height (m):	3.00	height from ground to level of uppermost seismic mass (for IEP only) (m):	1.1
Floor footprint area (approx):			
Age of Building (years):	15	Date of design:	1992-2004
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	other (specify)	Brief strengthening description:	
Use (upper floors):			
Use notes (if required):	Amenities		
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	load bearing walls		
Roof:	steel framed	rafter type, purlin type and cladding	Steel tube framing lined with corrugated steel roof sheeting
Floors:	concrete flat slab	slab thickness (mm)	
Beams:			
Columns:			
Walls:	partially filled concrete masonry	thickness (mm)	200

Lateral load resisting structure

Lateral system along:	partially filled CMU	Note: Define along and across in detailed report! / note total length of wall at ground (m):	5
Ductility assumed, μ:	1.25	wall thickness (m):	0.2
Period along:		0.40 from parameters in sheet / estimate or calculation?	
Total deflection (ULS) (mm):		estimate or calculation?	
maximum interstorey deflection (ULS) (mm):		estimate or calculation?	
Lateral system across:	partially filled CMU	note total length of wall at ground (m):	3
Ductility assumed, μ:	1.25	wall thickness (m):	0.2
Period across:		0.40 from parameters in sheet / estimate or calculation?	
Total deflection (ULS) (mm):		estimate or calculation?	
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:			
Wall cladding:			
Roof Cladding:	Metal	describe	Corrugated steel 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	none	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:	1	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:	
	Describe (summary):	No structural damage recorded		
Across	Damage ratio:	0%		
	Describe (summary):	No structural damage recorded		
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

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

Recommendations

Level of repair/strengthening required:	minor non-structural	Describe:	Repair of cracks in concrete fillet at base of masonry walls required
Building Consent required:	no	Describe:	
Interim occupancy recommendations:	full occupancy	Describe:	

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

14. Appendix 4 – Geotechnical Desktop Study

Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	110
Address	Toilets – Waltham Park, Waltham
Report date	July 2012
Author	Dominic Hollands / Ain Kim
Reviewer	Leah Bateman / Ross Roberts
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:

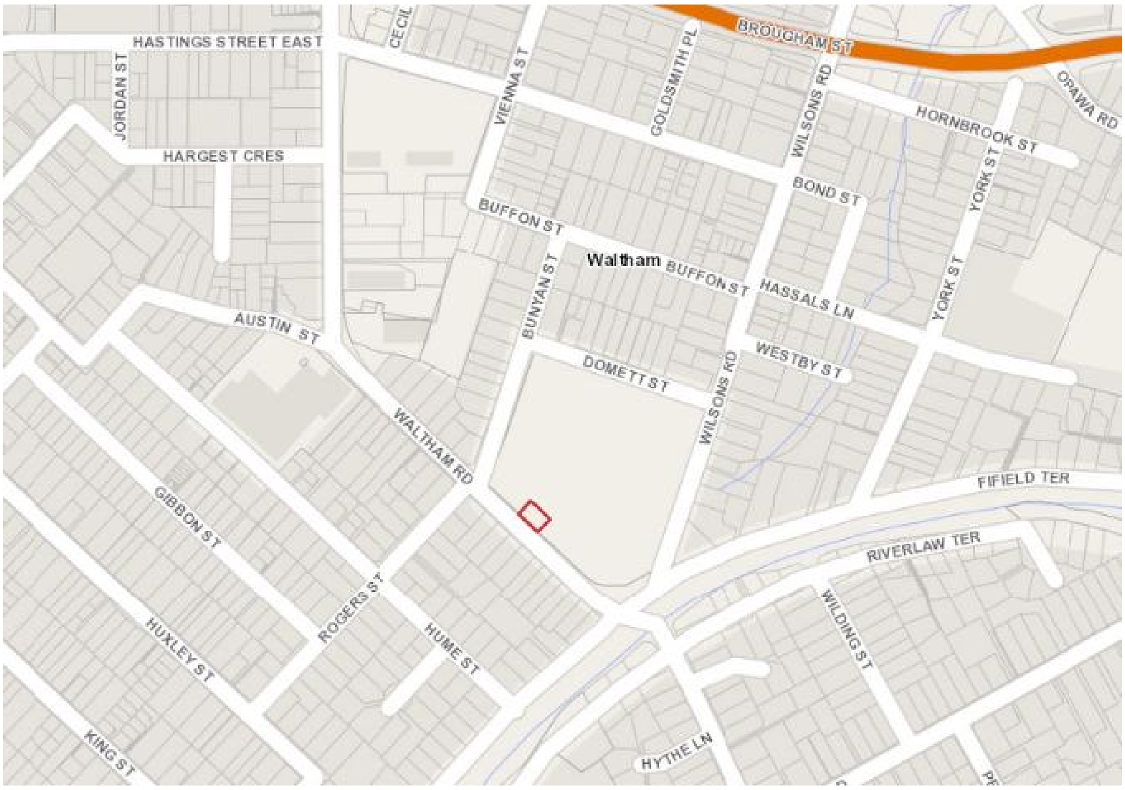
- Published geology
- Publically available borehole records
- Liquefaction records
- Aerial photography
- A preliminary site walkover

3. Limitations

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

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

4. Site location

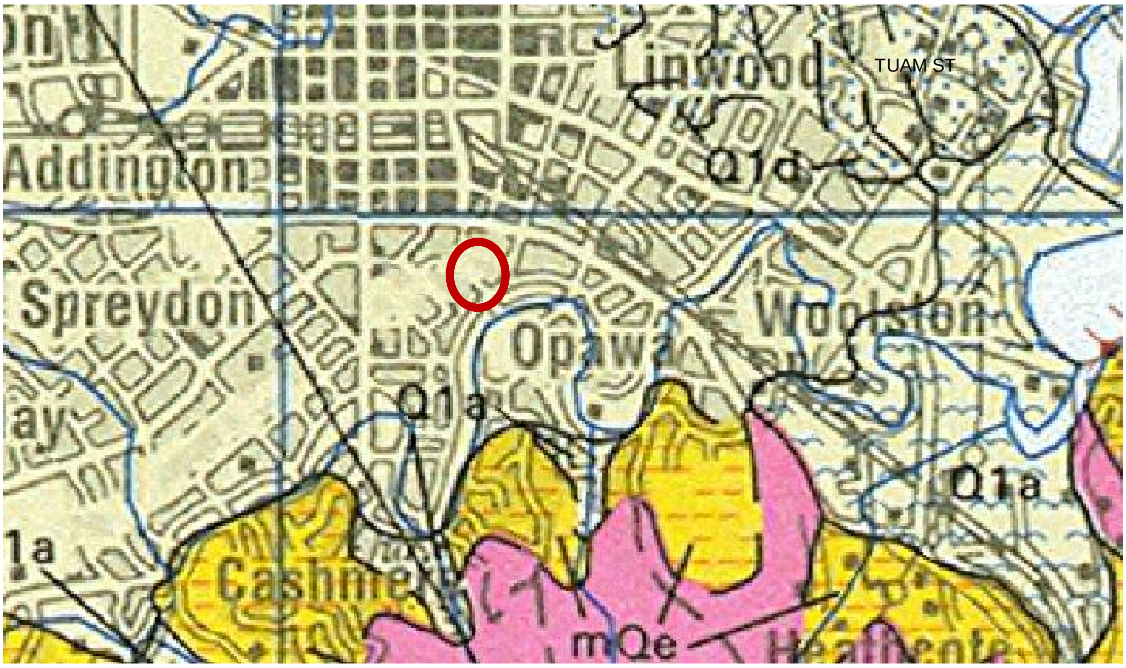


- **Figure 1 – Site location (courtesy of LINZ http://viewers.geospatial.govt.nz)**

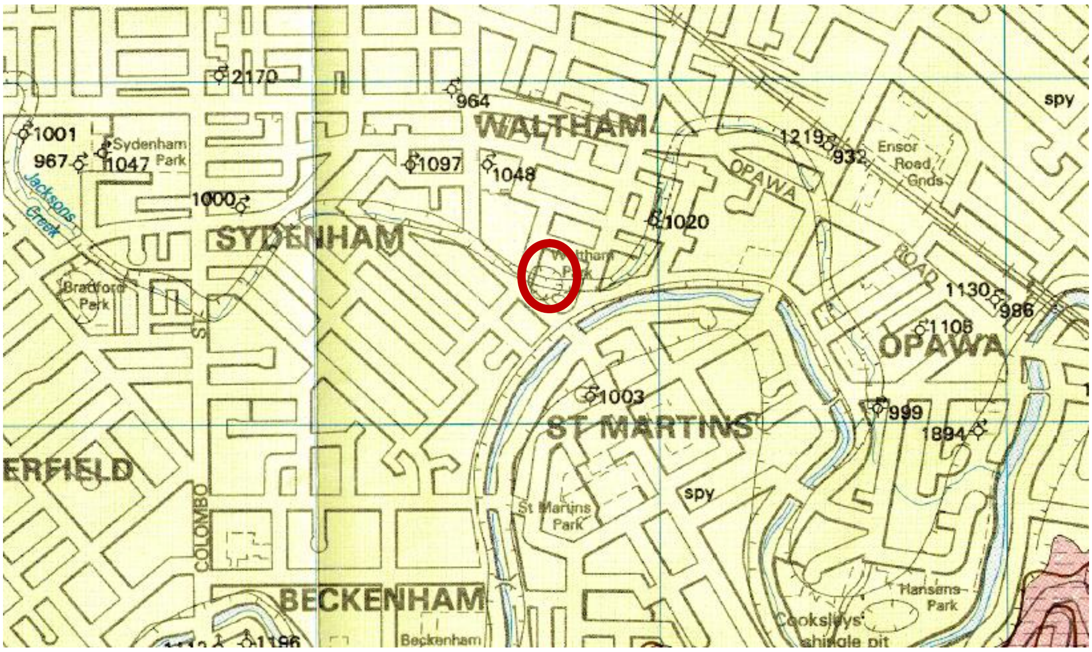
The structure is located at Waltham Park along Waltham Road immediately west of Waltham Swimming Pools at grid reference 1571660 E, 5177758 N (NZTM).

5. Review of available information

5.1 Geological maps



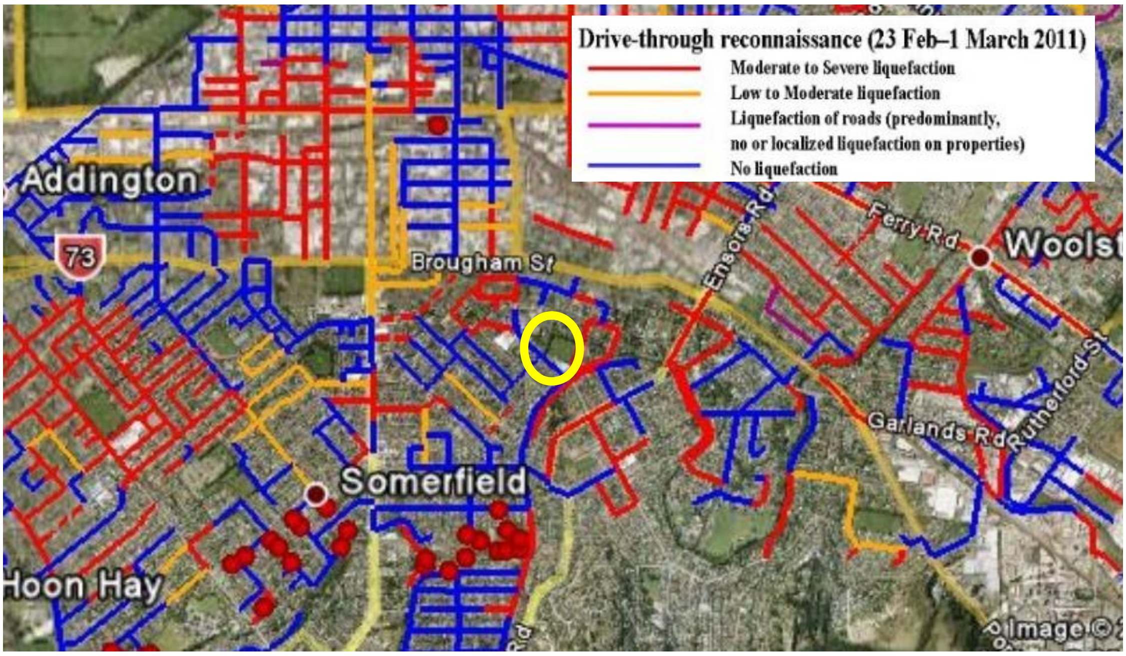
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



- **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. According to the local geological map there was terraced topography as well as a stream (Jacksons Creek) traversing the site in the past.

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 no liquefaction along Waltham Road which is immediately to the south of Waltham Park. However moderate to severe liquefaction is highlighted along Wilsons Road and Fifield Terrace located approximated 130 m east of the site.

5.3 Aerial photography

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

Aerial photography does not show any obvious signs of liquefaction in the local area after the 22 Feb 2011 event, including at a road intersection to the south west of the site. No evidence of lateral spreading associated with the nearby Heathcote River to the south east is observed.

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: Urban Non-residential (adjacent residential properties are TC2)

5.5 Historical land use

Reference to historical documents (e.g. Appendix A) indicates a waterway (Jacksons Creek) traversed the site in 1856 and this waterway does not now exist at the site. It is therefore possible that soft ground would be present near the site.

5.6 Existing ground investigation data

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

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

5.7 Council property files

Council files were not available at the time of writing this report.

5.8 Site walkover

An engineer from SKM undertook a site walkover on 20 May 2012.

Waltham Park is a flat site located approximately 150 m northwest of the Heathcote River.

The toilet block is a masonry block building with corrugated iron roof and has a concrete slab on grade foundation. Very little indication of damage could be observed of the toilet buildings on site, with minor hairline cracks on the concrete masonry block wall. The adjacent pavilion building did not exhibit any damage.

The asphalt, cobble and concrete paths close the toilet block did show some minor settlement. It is possible that this is settlement of fill, however their condition was generally poor and root damage was common. The nearby basketball court was undamaged. Waltham Road appeared to be undamaged.

- **Figure 7** Toilet block at Waltham Park

- **Figure 8** A view from the toilet block of Waltham Rd and the basketball court with no damage observed.

6. Conclusions and recommendations

6.1 Site geology

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

Approximate Depth range (m BLG)	Soil type
0 – 10	Gravel, sand, clay and minor silt (Springston Formation)
10 – 25	Sands, clays and minor gravels (Christchurch Formation)
25 – 35	Gravel (Riccarton Gravel)
35 – 55	Clay, sand and gravel (Bromley Formation)
55 +	Gravel (Linwood Gravel)

Borehole data indicate variable ground conditions including sands, gravels, silts and clays in the general area which is typical of the Springston Formation. The presence of a historical waterway and terracing close to or at the site adds to the uncertainty and variability of the ground conditions. A shallow 1 m deep borehole at the site indicates sand with gravel confirmed at 1 m below ground level. Nearby borehole indicate variable ground of gravel, sand, clay and silt with clay content increases towards the south east (Heathcote River). The Springston Formation terminates at approximately 10 m below ground level.

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 there is one deep boreholes nearby which indicate sediments up to 70 m below ground level which provides confidence to the sites seismic subsoil classification

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 is low at this site. Although groundwater would likely to be less than 2 m bgl based on the river level the presence of predominantly gravels, sands and clays and the lack of silty material indicate that the ground is not likely to be susceptible to liquefaction.

The aerial photographs after the February 2011 earthquake do not show any evidence of liquefaction at the site or within close vicinity of the site. The nearest sand and silt ejecta was observed approximately 250 m north and west of the site. No sign of liquefaction was observed during the site walkover. However, any sand and silt could have been removed during the time between the earthquake event and the site walkover.

Using data from the closest borehole located approximately 50 m away which indicates shallow sand and gravel the following parameters are recommended in order to perform a quantitiative DEE. It should be noted that these parameters should not be used for design or consent purposes without confirming the properties through site specific investigation.

Parameter	Estimated value
Effective angle of friction	35 degrees
Apparent cohesion	0 kPa
Unit weight	19 kPa
Ultimate bearing capacity of a shallow square pad footing	*300 kPa

*likely minimum ultimate bearing capacity which may increase following a site specific geotechnical investigation.

6.5 Further investigations

If consent is required for the structure or significant alterations to the structure are proposed, additional tests on site is likely to be required to confirm recommended properties:

- One Boreholes to a depth of 25 m below ground level including SPTs to obtain geotechnical parameters and ground conditions.

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.

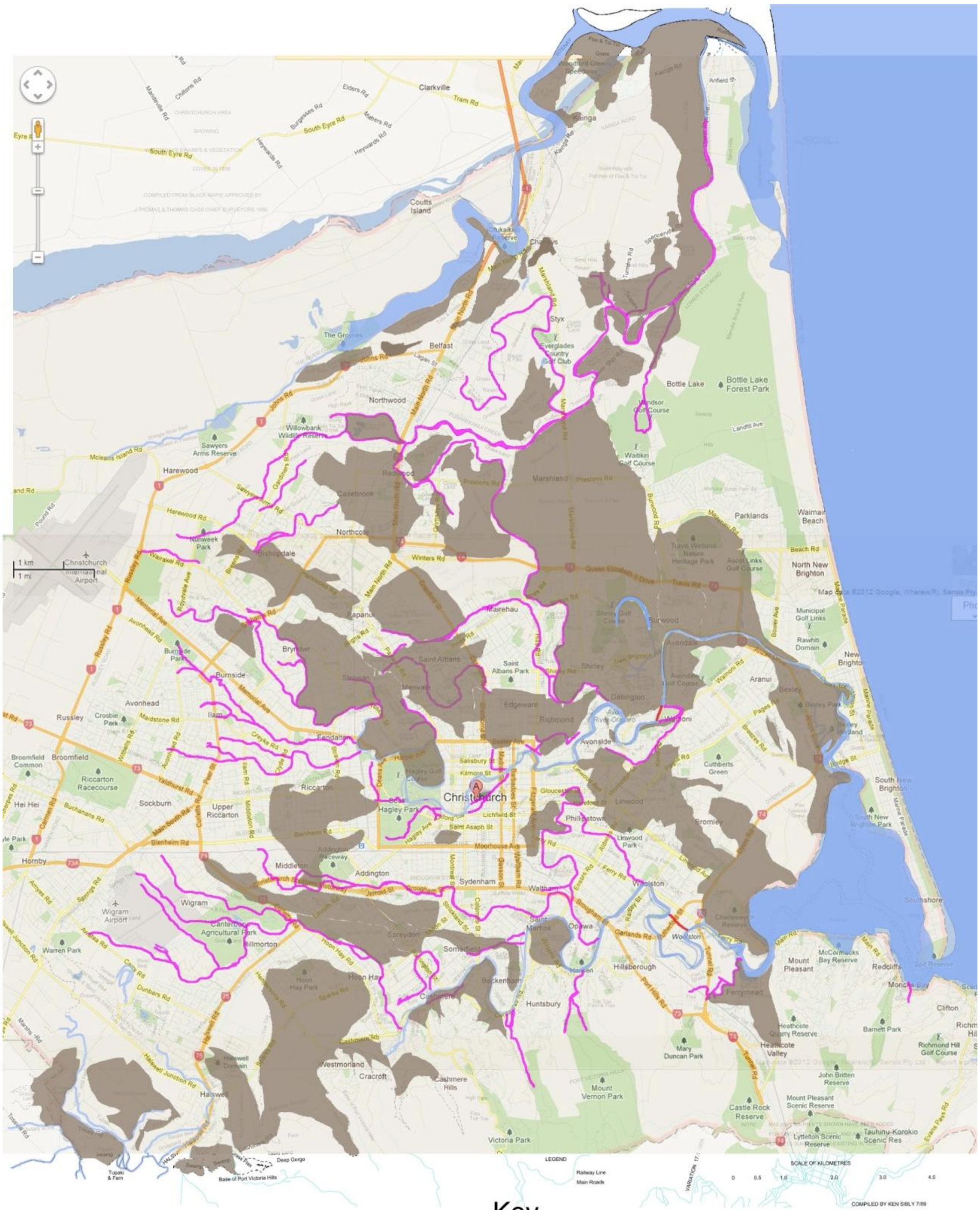
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

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



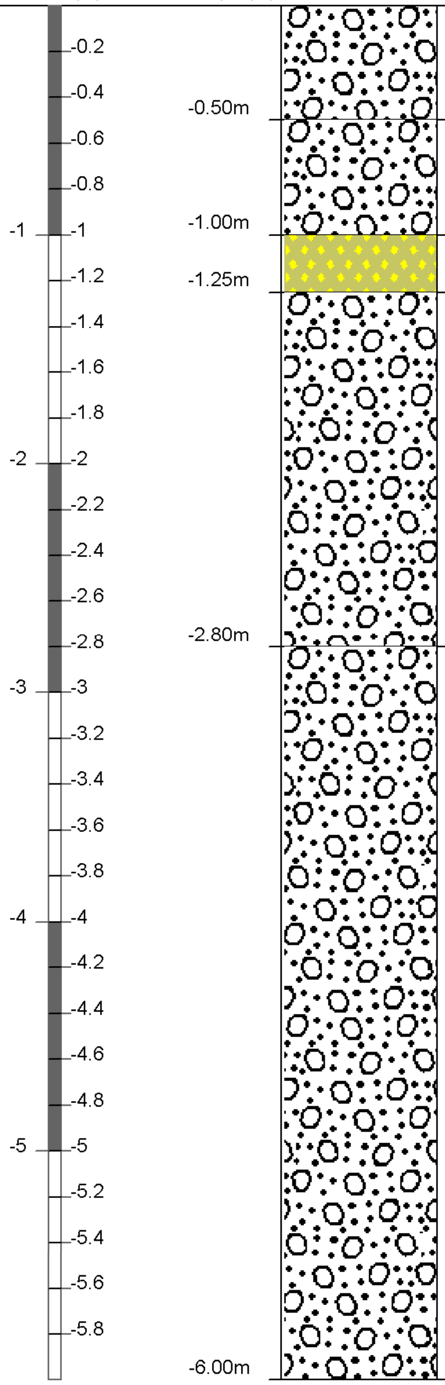
The swamps and previous creeks/rivers from 1856 have been overlayed onto a map of Christchurch in 2012

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

Appendix B – Existing ground investigation logs

Borelog for well M36/9704

Gridref: M36:81608-39400 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.1 +MSD
Well name : CCC BorelogID 4364
Drill Method : Not Recorded
Drill Depth : -6m Drill Date :



Water Level	Depth(m)	Full Drillers Description	Formation Code
	-0.50m	yellow brown non-cohesive dry sand and gravel	
	-1.00m	yellow brown non-cohesive moist gravel and fine sand	
	-1.25m	yellow non-cohesive moist dune sand	
	-2.80m	yellow grey non-cohesive moist wet gravel and dune sand	
	-6.00m	yellow grey non-cohesive saturated gravel and dune sand	

SINCLAIR KNIGHT MERZ SKM

Borelog for well M36/1194

Gridref: M36:8174-3931 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 5.8 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -34.09m Drill Date : 2/07/1966

Environment Canterbury
Your regional council

Water Level: -1.3CalcMin

Depth(m)	Full Drillers Description	Formation Code
-0.89m	Surface soil	sp
-3.00m	Silt & sand	sp
-3.30m	Yellow clay	sp
-3.90m	Blue gravel	sp
- 10.3m	Soft Blue clay	sp
- 14.9m	Fine Blue sand	ch
- 17.0m	Coarse Blue sand & some grit	ch
- 23.4m	Soft Blue clay	ch
- 33.8m	Fine to medium Grey/Brown gravel & fine sand	ri
- 34.1m	Yellow clay	ri

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

SINCLAIR KNIGHT MERZ SKM

Borelog for well M36/1006 page 1 of 2

Environment Canterbury Your regional council

Gridref: M36:815-395 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 7.1 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -120.3m Drill Date : 23/09/1936

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
-1.80m	Sand & clay	sp
- 10.6m	Brown shingle	sp
- 16.1m	Blue sand	ch
- 17.1m	Blue shingle	ch
- 22.2m	Blue sand	ch
- 28.0m	Blue clay & peat	ch
- 28.3m	Blue shingle	
- 38.1m	Brown shingle (Water 1.8m below)	ri
- 41.7m	Yellow & Blue clay	br
- 44.1m	Brown shingle	br
- 50.2m	Brown sand	br
- 53.3m	Blue sand & clay	br
- 55.4m	Yellow sand & clay	br
- 70.1m	Brown shingle	li

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

Borelog for well M36/1006 page 2 of 2

Gridref: M36:815-395 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 7.1 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -120.3m Drill Date : 23/09/1936

Water Level: Artesian

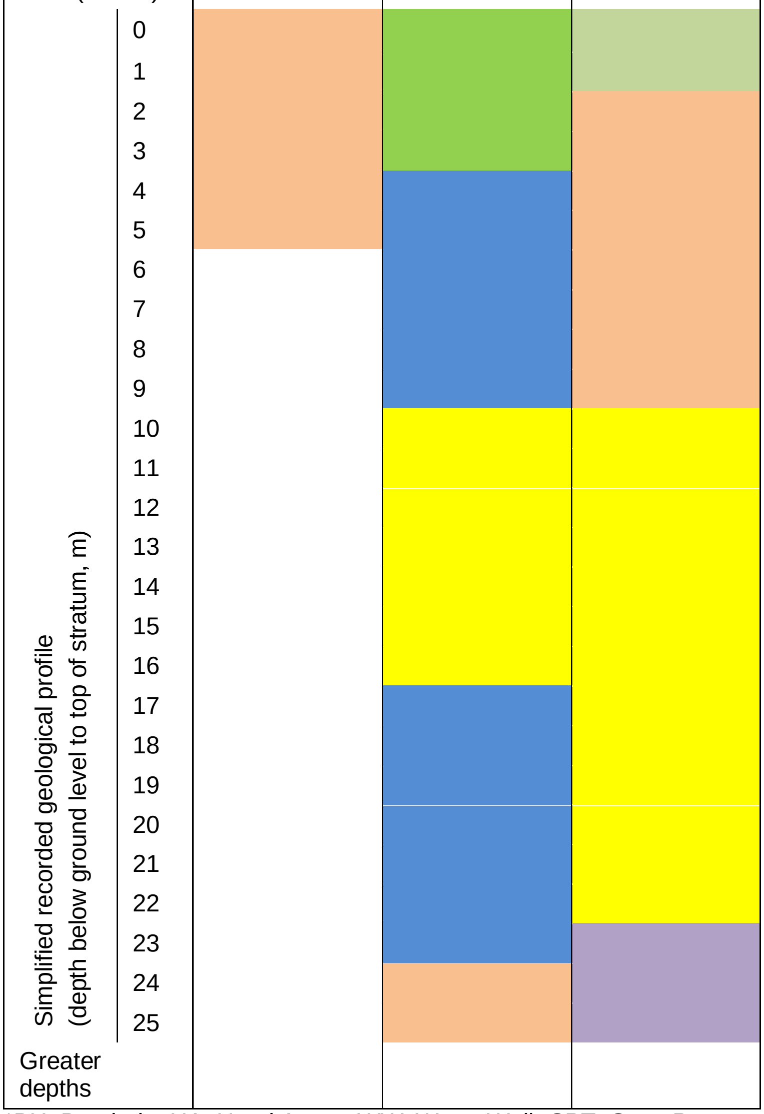
Depth(m)	Full Drillers Description	Formation Code
- 70.1m	Brown shingle	li
- 75.0m	Blue clay & peat	li-2
- 78.9m	Brown shingle (Water level 0.3m below ground level)	li-3
- 82.3m	Brown sand	he
- 84.1m	Brown shingle	he
- 91.1m	Brown sand & gravel	he
- 94.8m	Yellow clay	he
- 98.5m	Brown shingle (Water level +3.35m)	bu
- 100.6m	Yellow clay	sh
- 103.6m	Brown shingle	sh
- 105.8m	Yellow clay	sh
- 114.3m	Brown shingle (Water level +3.65m)	sh
- 115.5m	Blue clay & peat	sh
- 117.3m	Yellow sand & clay	sh
- 120.3m	Brown shingle	wa

Scale(m): -70, -80, -90, -100, -110, -120

Appendix C – Geotechnical Investigation Summary

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

ID	1	2	3
Type *	BH	BH	BH
Ref	M36-9704	M36-1194	M36-1006
Depth (m)	6	34	70
Distance from site (m)	52	118	203
Ground water level (mBGL)			



*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