CHRISTCHURCH CITY COUNCIL

BU 0812-003 EQ2
Guthrey Courts – Block C
72a Olliviers Road, Phillipstown

QUANTITATIVE ASSESSMENT REPORT

FINAL

- Rev E
- 03 May 2013

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SINCLAIR KNIGHT MERZ

1. Executive Summary

1.1. Background

A qualitative and quantitative assessment was carried out on the building located at 72a Olliviers Road, Phillipstown, for Units 9-15 based on visual inspection of the buildings on the 17th of April 2012 which included cover meter survey and intrusive work to determine steel detailing in the floors and walls. A subsequent intrusive investigation of the timber roof diaphragm to masonry wall connection was carried out on the 7th of March supported by supplementary calculations which showed the building capacities could be increased from approximately 11% NBS to 28% NBS.

Block C is approximately 11m by 35m, each unit is 9m by 5m. The building is single storey and divided into seven residential units. It is constructed from masonry walls running transversely along the building, and timber framing running longitudinally, with a timber framed ceiling and concrete slab floor. An aerial photograph illustrating these areas is shown below in Figure 1 Aerial Photograph of 72a Olliviers Road. Detailed descriptions outlining the buildings age and construction type is given in Section 5 of this report.

▪ **Figure 1 Aerial Photograph of 72a Olliviers Road**

The qualitative assessment is a desktop study using the methodology recommended in the Engineering Advisory Group document 'Guidance on Detailed Engineering Evaluation of Earthquake affected Non-residential Buildings in Canterbury'. The qualitative assessment broadly 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). The quantitative assessment supersedes the IEP and hence an IEP has not been prepared for this report.

This qualitative and quantitative 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, a visual inspection on 17 April 2012, a cover meter survey and intrusive investigations carried out on 12 October 2012, partial architectural drawings and structural calculations.

1.2. Key Damage Observed

Key damage observed includes:-

- Separation along internal plasterboard joints in the walls and ceilings throughout
- Separation along timber joints on external south walls
- Cracking extending from door and window corners through timber linings. Cracking extending through the plasterboards around the timber beams

1.3. Critical Structural Weaknesses

No potential critical structural weaknesses were identified for this building.

1.4. Indicative Building Strength

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

The assessments were based on the following:

- On-site investigation to assess the extent of existing earthquake damage including limited intrusive investigation.
- Qualitative assessment of critical structural weaknesses (CSWs) based on review of the available drawing sheet 106 Christchurch City Council - City architects Division dated 1976 and inspection where drawings were not available.
- A geotechnical desktop study.
- Assessment of the strength of the existing structures taking account of the current condition.

Based on the available drawing, and using the Quantitative Assessment Procedure, the buildings original capacity has been assessed to be in the order of 28% NBS. No structural damage was observed during our site investigation. Due to this, the post earthquake capacity is also in the order of 28% NBS. Since the building's seismic capacity is less than 34% NBS the building is classed as potentially earthquake prone. It is worth noting that this assessment was made with only partial architectural drawings and is accordingly limited.

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

1.5. Recommendations

Based on the findings of this assessment indicating the building is in the order of 28 %NBS, strengthening is required in order to comply with Christchurch City Council (CCC) policy – Earthquake prone dangerous & insanitary buildings policy 2010. From confirmation of the masonry wall to timber ceiling connections the buildings capacity has been revised to be in the order of 28% NBS. Strengthening will be required as the building has been assessed to be potentially earthquake prone.

It is recommended that:

a) We consider that barriers around the building are not necessary.
b) Options to strengthen the building are investigated.

2. Introduction

Sinclair Knight Merz was engaged by Christchurch City Council to prepare a combined Qualitative and Quantitative Assessment report for the building located at 72a Olliviers Road, Units 9-15, following the magnitude 6.3 earthquake which occurred in the afternoon of the 22nd of February 2011 and the subsequent aftershocks.

The quantitative assessment uses the methodology recommended in the Engineering Advisory Group document "Guidance on Detailed Engineering Evaluation of Earthquake affected Non-residential Buildings in Canterbury". The qualitative assessment broadly includes a summary of the building damage as well as an initial assessment of the current Seismic Capacity compared with current seismic code loads.

A quantitative assessment involves inspections of the building and a desktop review of existing structural and geotechnical information, see appendix 3, including existing drawings and calculations, if available.

This report describes the structural damage observed during our inspection. The inspection was undertaken from floor levels and was a visual inspection with additional intrusive investigation where further detail was required. 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 scope of the quantitative analysis includes the following:

- Analysis of the seismic load carrying capacity of the building compared with current seismic loading requirements or New Buildings Standard (NBS). It should be noted that this analysis considers the building in its damaged state where appropriate.
- Identify any critical structural weaknesses which may exist in the building and include these in the assessed %NBS of the structure.
- Preparation of a summary report outlining the areas of concern in the building.

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

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[1] EAG 2011, *Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury - Draft*, p 10

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

At the time of this report an intrusive site investigation including cover meter survey, concrete breakout to determine the wall floor connections and bar sizes and roof to masonry wall connection had been carried out. Only partial structural drawings were available, and as a result our evaluation of the building is accordingly limited. The building's description outlined in Section 5 is based on our visual inspection, cover meter survey, intrusive investigation and partial architectural drawings.

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 Engineering Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

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

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

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

- The extent of any earthquake damage

3.2. Building Act

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

3.2.1. Section 112 – Alterations

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

3.2.2. Section 115 – Change of Use

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

3.2.3. Section 121 – Dangerous Buildings

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

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

3.2.4. Section 122 – Earthquake Prone Buildings

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

3.2.5. Section 124 – Powers of Territorial Authorities

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

3.2.6. Section 131 – Earthquake Prone Building Policy

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

3.3. Christchurch City Council Policy

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

The 2010 amendment includes the following:

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

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

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

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

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

3.4. Building Code

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

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

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

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

4. Earthquake Resistance Standards

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

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

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

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

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

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

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

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

5. Building Details

5.1. Building description

The building is located at 72a Olliviers Road, at Units 9-15. There are eight separate buildings on this site. The building has one storey that is divided into seven residential units. The building has a timber framed roof with metal roof cladding. The building is constructed from masonry walls running transversely and timber framed walls running longitudinally. The masonry walls are fully filled and are reinforced with vertical D12 bars at 600mm centres. The floor consists of a concrete slab on grade. There are strip footings present under the masonry walls, 200mm wide by 600mm deep. From the one structural drawing provided, the building was designed in 1976 and is assumed to have been constructed soon after.

Our evaluation was based on the visual inspection carried out on 17 April 2012 and a cover meter survey and intrusive investigation carried out on 12 October 2012. Only partial architectural drawings were available so we were unable to verify the detailing of reinforcement or connections.

5.2. Gravity Load Resisting system

It appears that the gravity loads are taken by the masonry block walls, with direct transfer into the slab foundation below.

5.3. Seismic Load Resisting system

Lateral loads acting across the building will be resisted by the masonry walls in shear. Roof load are transferred to the masonry walls through ceiling diaphragms and timber walls transfer load by spanning between masonry. Along the building, the masonry walls bend out of plane between the foundations and the roof diaphragm, block wall and roof loads are transferred through the ceiling diaphragms to the in-plane plasterboard wall and transferred to the foundations.

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

6. Damage Summary

SKM undertook an inspection on the 17 April 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 and this site is classified as TC2 land[3]. Therefore a level survey is not required at this stage of assessment.

External Damage

1) Separation along internal plasterboard joints in the walls and ceilings throughout
2) Cracking through the linings extending from doors, windows and the timber roof beams
3) Separation along timber joints on external walls
4) Gaps opening up between window frame and timber wall on the north side. It is unclear whether or not this crack has been caused and/or widened by earthquake activity.
5) Water damage to the ceilings and wall linings due to moisture

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

[3] http://cera.govt.nz/maps/technical-categories

7. Quantitative Assessment

7.1. Available Information

Following our inspection carried out on 17 April 2012, SKM carried out a seismic review on the building located at 72a Olliviers Road for Units 9-15. This review was undertaken using the available information which was as follows:

- SKM site measurements and inspection findings.
- Intrusive investigation findings.
- Partial architectural drawings were available for this building.

Further intrusive investigations were undertaken on the 7th of March 2013 in order to determine the level of connection between roof diaphragms and masonry walls.

7.2. Survey

There was no visible settlement of the structure, nor were there any significant ground movement issues around the building. Due to these factors we do not recommend that any survey be undertaken at this stage of the assessment.

7.3. Assumptions

The assumptions made in undertaking the assessment include:

- The building was built according to the drawings and according to good practice at the time. We have reviewed the building and from our visual inspection the structure appears to be built in accordance with the partial architectural drawings available.
- The soil on site is class D as described in AS/NZS1170.5:2004, Clause 3.1.3, Soft Soil. This is a conservative assumption based on our findings from the Desktop study. Liquefaction needs to be accounted for in the foundation design as our Desktop study established that the liquefaction risk appears moderate to high at this site.
- 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 for loss of human life, or considerable economic, social or environmental consequence of failure.
- The building has a short period less than 0.4 seconds.
- Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011

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

Material	Ductility of Building in Current State
Masonry	1.25
Timber	2.0

The above ductility is based on code requirements at the time of design.

- The following material properties were used in the analyses:
- **Table 3: Material Properties**

Material	Nominal Strength	Structural Performance
Masonry blockwork	f_c = 13.7MPa	S_p = 1.0
Concrete	f_c = 25MPa	S_p = 1.0
Timber	f_c = 15MPa	S_p = 1.0

The quantitative assessment is a post construction evaluation. Since it is not a full design and construction monitoring, it has the following limitations:

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

7.4. The Detailed Engineering Evaluation (DEE) process

The DEE process is a procedure written by the Department of Building and Housing's Engineering Advisory Group and grades buildings according to their likely performance in a seismic event. The procedure is not yet recognised by the NZ Building Code but is widely used and recognised by the Christchurch City Council as the preferred method for preliminary seismic investigations of buildings[4].

The procedure of the DEE is as follows:

1) Qualitative assessment procedure

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

   a. Determine the building's status following any rapid assessment that have been done
   b. Review any existing documentation that is available. This will give the engineer an understanding of how the building is expected to behave. If no documentation is available, site measurements may be required
   c. Review the foundations and any geotechnical information available. This will include determining the zoning of the land and the likely soil behaviour, a site investigation may be required
   d. Investigate possible Critical Structural Weaknesses (CSW) or collapse hazards
   e. Assess the original and post earthquake strength of the building (this assessment is subsequently superseded by the quantitative assessment and hence has not been carried out in this report)

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

The DEE assessment ranks buildings according to how well they are likely to perform relative to a new building designed to current earthquake standards, as shown in Table 4. The building rank is indicated by the percent of the required New Building Standard (%NBS) strength that the building is considered to have. Earthquake prone buildings are defined as having less than 33% NBS strength which correlates to an increased risk of approximately 20 times that of 100% NBS[5]. Buildings that are identified to be earthquake prone are required by law to be strengthened within 30 years of the owner being notified that the building is potentially earthquake prone[6].

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

- **Table 4: DEE Risk classifications**[7]

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[8]	D	High	33 to 20	Unacceptable. Improvement required.
	E		< 20	

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

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

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

- AS/NZS 1170 parts 0, 1 and 5 Structural Design Actions
- NZS 3101:2006 Concrete Structures Standard
- NZS 3404:1997 Steel Structures Standard
- NZS 2606:1993 Timber Structures Standard
- NZS 4230:1990 Design of Reinforced Concrete Masonry Structures

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[7] NZSEE 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes*, §2 pp.13-14

[8] Although the NZSEE guidelines describe a building with a seismic capacity which is assessed as less than 34%NBS as a "High Risk Building", with the structural performance described as "Unacceptable"; note that, in accordance with the local authority *Earthquake-Prone, Dangerous And Insanitary Buildings Policy*, the building can continue to be occupied provided there is no structural damage that would cause all or parts of the building to be unsafe. Note also that it will need to be strengthened to at least 34%NBS in the future.

7.5. Critical Structural Weaknesses

No potential critical structural weaknesses were identified for this building.

7.6. Analysis Results

The equivalent static force method was used to analyse the seismic capacity of the building. The results of the analysis are reported in the following table as %NBS. The results below are calculated for the building in its damaged state. The building results have been broken down into their seismic resisting elements. As the building has elements that are less than 34%NBS the building will need to be strengthened.

The information obtained from the intrusive investigation indicated that the buildings percentage NBS could be updated from 11% NBS to 28%NBS.

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

- **Table 5: DEE Results**

Seismic Resisting Element	Action	Seismic Rating %NBS
Lined timber walls (longitudinal)	Shear	28
Masonry wall in out-of-plane action	Bending	>100
Masonry wall at the base (in plane shear)	Shear	>100

7.7. Recommendations

The quantitative assessment carried out on the building indicates that the building has a seismic capacity less than 34% of NBS and is therefore classed as being in the category of 'High Risk Buildings'. Strengthening of the building is required to bring it up to a target of 67% of NBS (in accordance with the policy of the building consent authority).

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

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

- A disabled access summary will be required including provision for disabled facilities.
- The site amenities (toilets and the like) will need to be reviewed to ensure that there are sufficient facilities for the expected number of people on site.
- Landscaping will need to be considered although we do not anticipate that any modifications will be required since you will not be adjusting the footprint area of buildings on site and will likely only be required for the new build option.

8. Conclusion

A combined qualitative and quantitative assessment was carried out on the building located at 72a Olliviers Road, Phillipstown, for Units 9-15. The building has sustained minor non-structural damage with cracking to the internal wall and ceiling linings and at external timber joints, along with gaps opening up between window frames and the timber walls. The building has been assessed to have a seismic capacity as shown in Table 6 below and is therefore potentially earthquake prone. The assessed capacity of the longitudinal walls requires that the building be strengthened.

Based on follow up intrusive investigations of the roof to wall connections the assessed percentage NBS was able to be increased from 11% NBS to the figure shown below since the detailing of the wall to ceiling connection is sufficient to allow diaphragm action in the roof.

Table 6: Quantitative assessment summary

Grade	Risk	%NBS	Structural performance
D	High	28	Unacceptable. Improvement required.[9]

Strengthening is required on the building to bring the seismic capacity up to at a target of 67% of NBS.

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

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

It is recommended that:

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

b) Options to strengthen the building are investigated.

[9] Although the NZSEE guidelines describe a building with a seismic capacity which is assessed as less than 34%NBS as a "High Risk Building", with the structural performance described as "Unacceptable"; note that, in accordance with the local authority *Earthquake-Prone, Dangerous And Insanitary Buildings Policy*, the building can continue to be occupied provided there is no structural damage that would cause all or parts of the building to be unsafe. Note also that it will need to be strengthened to at least 34%NBS in the future.

9. 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.

10. Appendix 1 – Photos

	
Photo 1: View along the frond of the units in block C	Photo 2: View along the back of block C
	
Photo 3: Vertical separation along the plasterboard	Photo 4: Separation along the roof and wall junctions

	
Photo 5: Photo 6: Separation of the plasterboard linings along the wall to ceiling junction and wall to wall junction	Photo 7: Vertical cracking through the plasterboard linings
	
Photo 8: diagonal cracking from door penetrations	Photo 9: Plasterboard cracking around the timber roof beams

	
Photo 10: Masonry end wall on concrete strip footing	Photo 11: Strip footing 500mm deep with 300 mm above ground

11. Appendix 2 – CERA Standardised Report Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Guthrey Courts - Block C	Reviewer:	N Calvert
	Unit / No: / Street	CPEng No:	242062
Building Address:	9-15 / 72a / Olliviers Road	Company:	SKM
Legal Description:		Company project number:	ZB01276.013
		Company phone number:	03 940 4923
	Degrees / Min / Sec		
GPS south:		Date of submission:	3-May
GPS east:		Inspection Date:	17/04/2012
		Revision:	E
Building Unique Identifier (CCC):	PRO 0812-003	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):	3.00

Building

No. of storeys above ground:	1	single storey = 1	
		Ground floor elevation (Absolute) (m):	3.00
Ground floor split?	no	Ground floor elevation above ground (m):	0.10
Storeys below ground	0		
Foundation type:	mat slab	if Foundation type is other, describe:	
Building height (m):	3.00	height from ground to level of uppermost seismic mass (for IEP only) (m):	3
Floor footprint area (approx):	350		
Age of Building (years):	40	Date of design:	1965-1976
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	multi-unit residential	Brief strengthening description:	
Use (upper floors):			
Use notes (if required):			
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	Unknown
Floors:	concrete flat slab	slab thickness (mm)	150
Beams:	timber	type	Unknown
Columns:	load bearing walls	typical dimensions (mm x mm)	200x10000
Walls:	fully filled concrete masonry	#N/A	200

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	lightweight timber framed walls	note typical wall length (m)	5
Ductility assumed, μ:	1.25		
Period along:	0.40	estimate or calculation?	estimated
Total deflection (ULS) (mm):	10	estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):	10	estimate or calculation?	estimated
Lateral system across:	fully filled CMU	note total length of wall at ground (m):	10
Ductility assumed, μ:	1.25	wall thickness (m):	0.2
Period across:	0.10	estimate or calculation?	estimated
Total deflection (ULS) (mm):	25	estimate or calculation?	estimated
maximum interstorey deflection (ULS) (mm):	25	estimate or calculation?	estimated

Separations:

leave blank if not relevant

north (mm):	
east (mm):	
south (mm):	
west (mm):	

Non-structural elements

Stairs:			
Wall cladding:	exposed structure	describe	Block masonry, some timber.
Roof Cladding:	Lightweight steel	describe	Corrugated
Glazing:	aluminium frames		
Ceilings:	plaster, fixed		
Services(list):	Water, electrical, sewage		

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:		Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	0-2 m³/100m³	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):	Vertical cracking in external weatherboards at corners, gaps between window frame and timber wall. Cracking along internal plasterboard wall lining, paint tearing.		
Across	Damage ratio:	0%		
	Describe (summary):	Cracking along internal plasterboard wall lining, paint tearing.		
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	yes	Describe:	Cracking along internal and external wall cladding, paint tearing.

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

Recommendations

Level of repair/strengthening required:	minor structural	Describe:	masonry walls out of plane
Building Consent required:	no	Describe:	
Interim occupancy recommendations:	full occupancy	Describe:	

Along	Assessed %NBS before:	28%	If IEP not used, please detail assessment methodology:	Quantitative
	Assessed %NBS after:	28%		
Across	Assessed %NBS before:	100%		
	Assessed %NBS after:	100%		

12. Appendix 3 – Geotechnical Desktop Study

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Christchurch City Council - Structural Engineering Service

Geotechnical Desk Study

SKM project number	ZB01276
SKM project site number	011 - 018 inclusive
Address	Housing Guthrey Courts, 72a Olliviers Road
Report date	27 September 2012
Author	Ananth Balachandra / Dominic Hollands
Reviewer	Leah Bateman
Approved for issue	No

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 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.

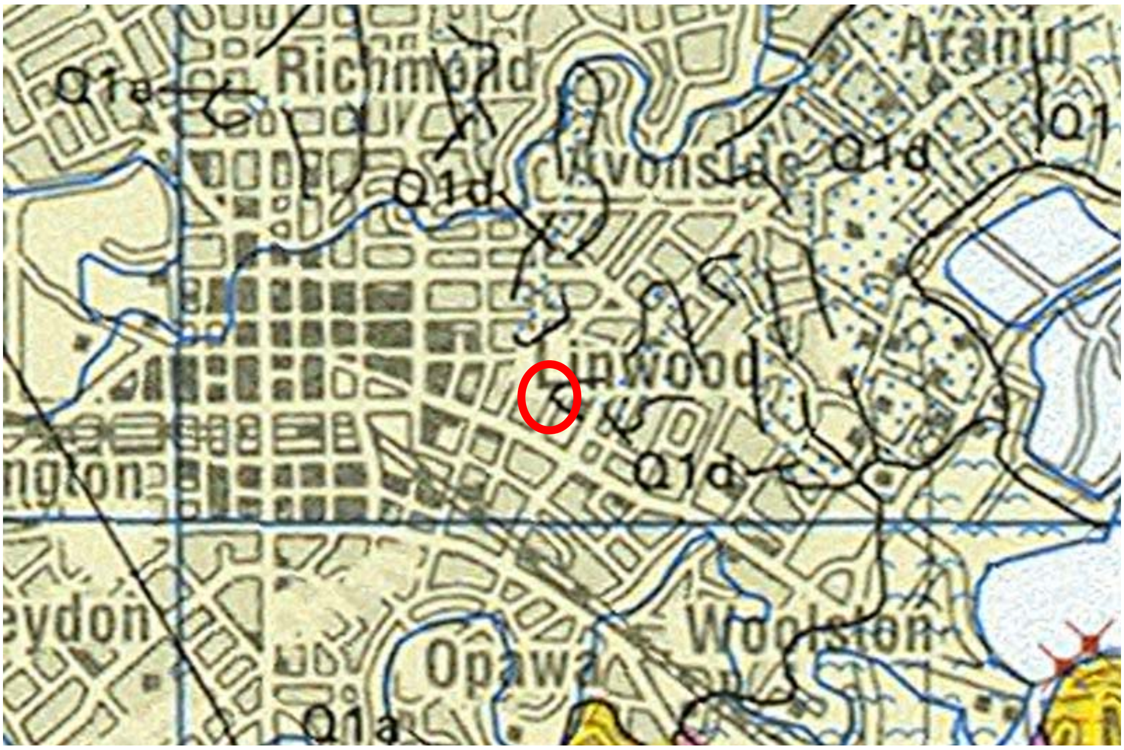
4. Site location

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

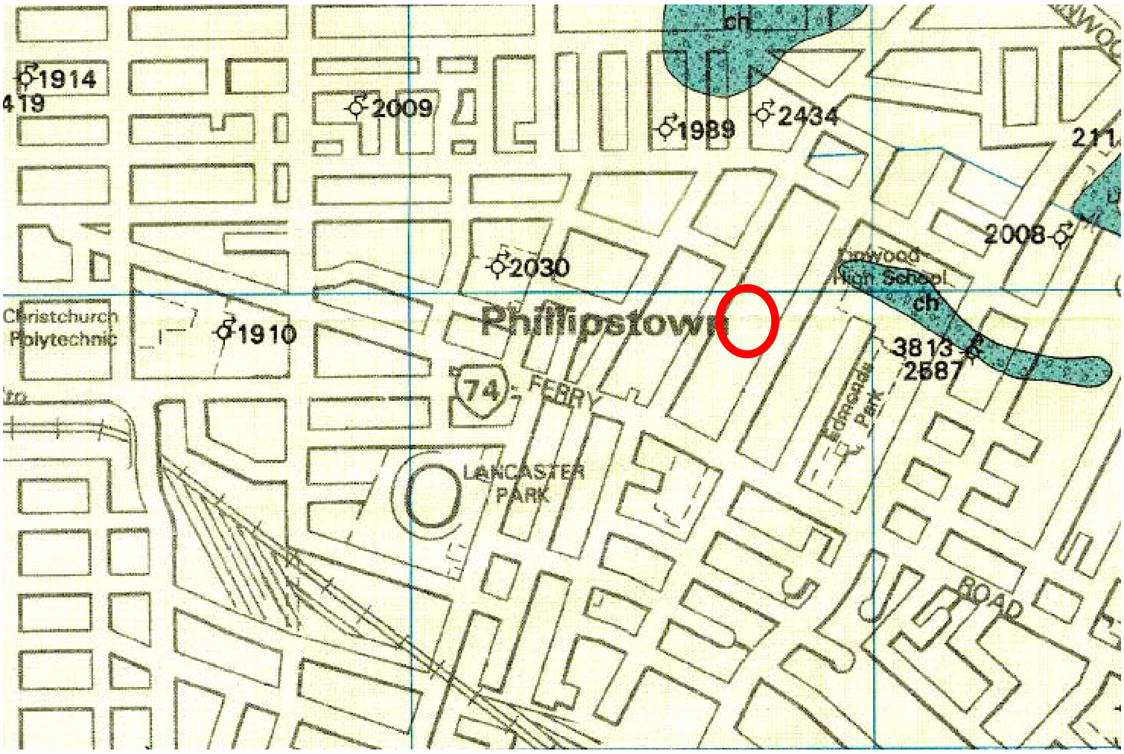
These structures are located on 72a Olliviers Road at grid reference 1572731 E, 5179357 N (NZTM).

5. Review of available information

5.1 Geological maps



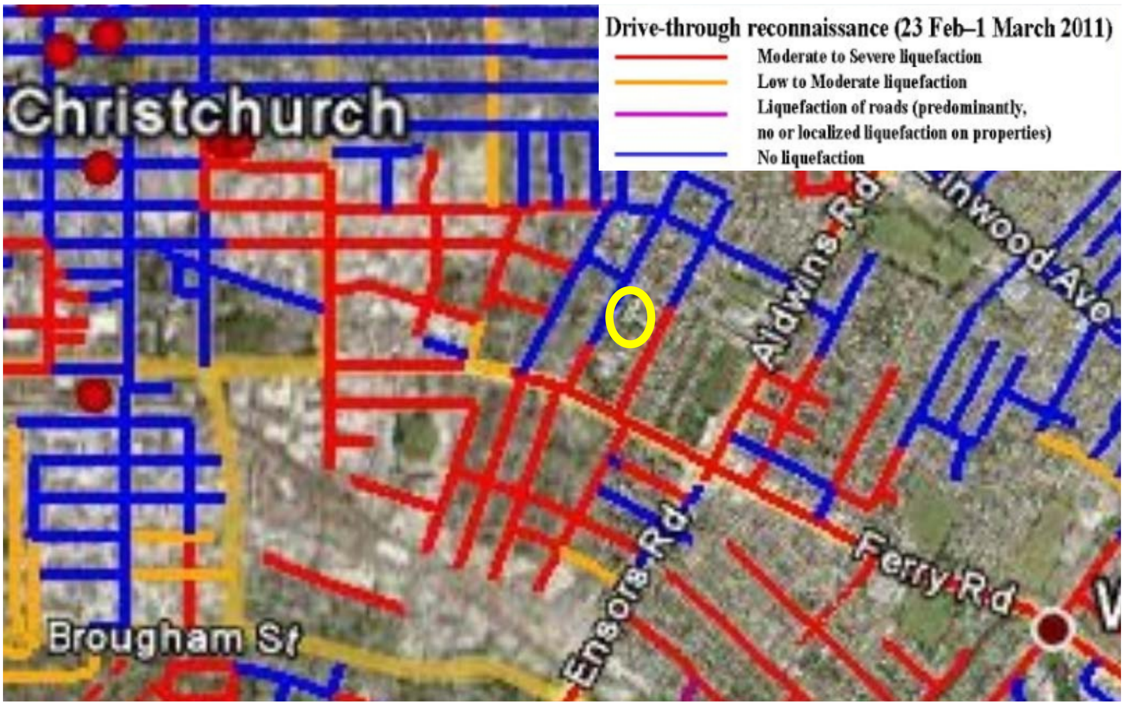
- **Figure 2 – Regional geological map (Forsyth et al, 2008). Site marked in red.**



- **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. Some of the ground approximately 500m north of the site and approximately 300m north east of the site is shown to be underlain by sands of fixed and semi-fixed dunes and beaches of the Christchurch 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.

There finding shows no liquefaction near Olliviers Road side of the site. However, it should be noted that moderate to severe liquefaction was observed on sections of Olliviers Road and Bordesley Street that are located near Ferry Road.

5.3 Aerial photography

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

A significant amount of liquefied on Olliviers Road and Bordesley Street could be seen from the aerial photograph. Additionally, liquefaction around the property and on the driveways of residential properties could also be seen. The findings from the aerial photograph seem to contradict the conclusions from the reconnaissance undertaken between 23 February and 1 March 2011.

No other obvious damage to the roofs of the structures and surrounding properties could be seen from the aerial photographs.

5.4 CERA classification

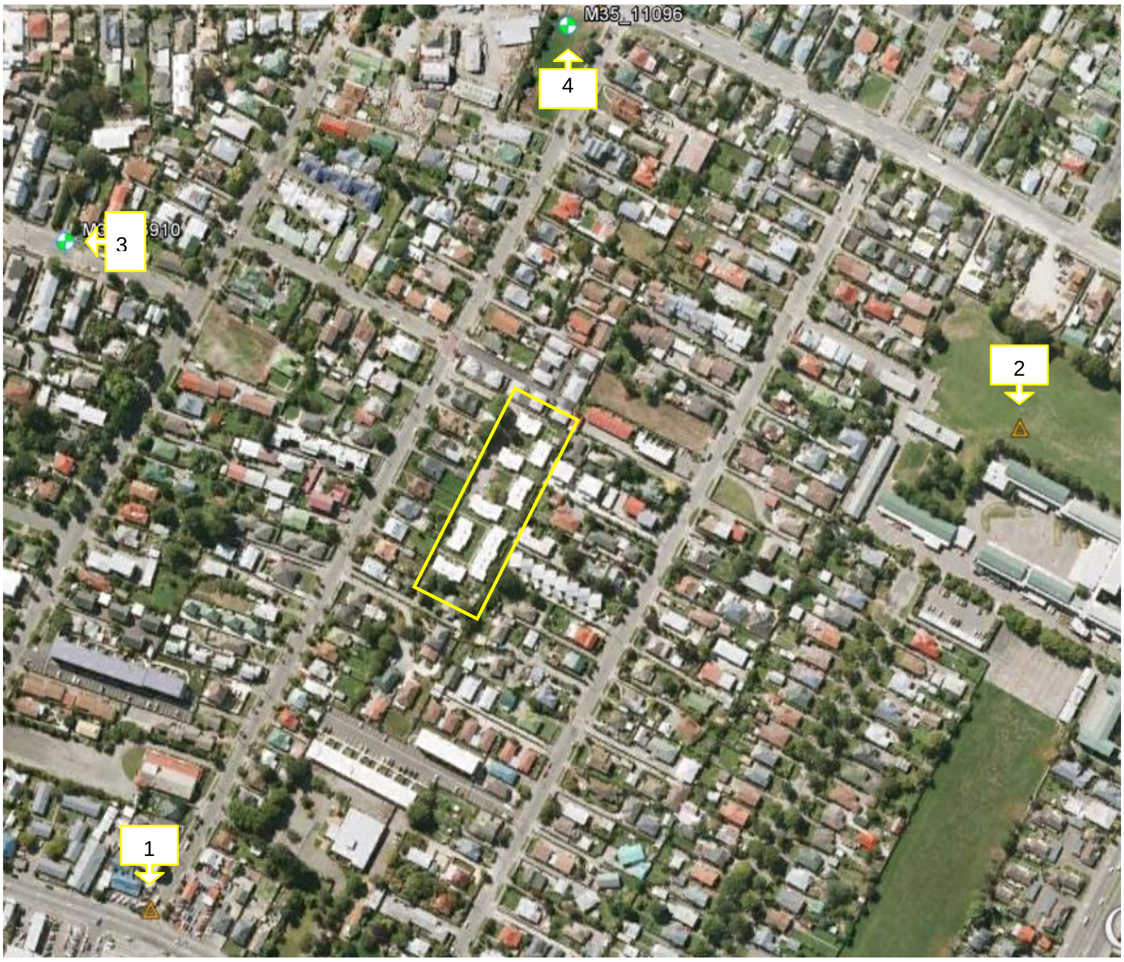
A review of the LINZ website (http://viewers.geospatial.govt.nz/) shows that the site is:

- Zone: Green
- DBH Technical Category: N/A (Urban Non-residential) – surrounding properties in general are classified as TC2. Some properties on Bordesley Street and south of Ferry Road are classified as TC3

5.5 Historical land use

Reference to historical documents (eg Appendix A) shows that the site was recorded to lie near two rivers or creeks in 1856. Additionally, area west of the site is recorded to have been swamp or marshland. This suggest, that soft river or swamp material could be present in the underlying geology of 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. Details of boreholes are summarised in Section 6.1.

5.7 Council property files

The available council records for the site are limited to include site/layout plans, job sheet records and architecture plans the construction of the Guthrey Courts housing complex. The architectural plans indicate a concrete slab foundation construct, however no dimensions are detailed. The plans are dated 1976.

No details regarding ground conditions were found within the council records.

5.8 Site walkover

A site walkover was conducted by a SKM engineer in the week commencing 16 April 2012.

The blocks on site were noted to be constructed using a combination of techniques. The structures comprised masonry block end walls and separation walls but were clad with weatherboards on one side. The structures appeared to be supported on slab on grade and comprised sheet metal roofs.

Significant land damage was observed during the external site walkover. The site had significant liquefaction during the Feb 2011 earthquake, as there was evidence of this over a year later. There were remaining sand ejecta on the site, significant ground undulations including domes in the driveway where sand boils were ejected beneath the asphalt. There was undulating grass land and settlement of footpaths. It is expected that some settlement of the structure would have occurred as a result of significant liquefaction of underlying ground.

There was no evidence that any of the services had been uplifted but there would likely have been some repairs carried out in the year since the earthquake.

- **Figure 7 Overview of the block units on site**

- **Figure 8 Observed undulations on driveways**

- **Figure 9 Remaining evidence of liquefied material ejecta**

- **Figure 10 Remaining evidence of liquefied material ejecta**

A site plan showing the observed damage for the site is provided in Appendix D.

6. Conclusions and recommendations

6.1 Site geology

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

Depth range (mBGL)	Soil type
0 - 1	Fill may have been placed under the building foundations.
1 - 2	Clay and clayey silt with traces of sand
2 - 10	Silt, silty sand and clean sand at greater depths

The ground water table is expected to be 1m to 3m below ground level. This needs to be confirmed through additional investigations.

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 second preferred method has been used to make the assessment.

6.3 Building performance

Evidence of significant liquefaction occurring on site and significant undulation of the land surrounding the site was noted during a site walkover conducted more than a year after the earthquake event. Therefore, it is expected that some settlement of the structure would have occurred due to the liquefaction of the ground onset by the 22 February earthquake event. However, the overall performance of the building suggests that the existing foundations are adequate for their current purpose.

6.4 Ground performance and properties

Liquefaction risk appears to be moderate to severe for this site. Significant amount of liquefied material was observed in the aerial photographs taken after the 22 February earthquake and the land damage noted during the external site walkover support this assessment. Additionally, due to the significant level of liquefaction it is expected that some settlement of the structure has occurred. Whether the level of settlement has had an impact on the structural elements is to be confirmed from the structural inspection being undertaken for the property.

As all available investigation are located at a significant distance away from the site and due to some variations in the geology indicated by existing investigations, an estimation of the surface soil properties is not provided in this desk study. Additional investigations are required in order to assess the likely ground properties.

6.5 Further investigations

To undertake detailed design of any remedial or strengthening work for the structures on site, geotechnical intrusive investigations would be required.

The structures appear to be one story, relatively light constructions. However, due to the moderate to high level of liquefaction risk assessed additional investigations on site are required. Recommended additional investigations are:

- Due to extensive footprint of the structures across the site, four CPTs spread throughout the site are recommended to assess the ground properties and to confirm liquefaction susceptibility of the soil profile underlying the site

Additional site investigation in addition to that noted above may be required for detailed design depending on the scope fo the work to be carried out.

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.

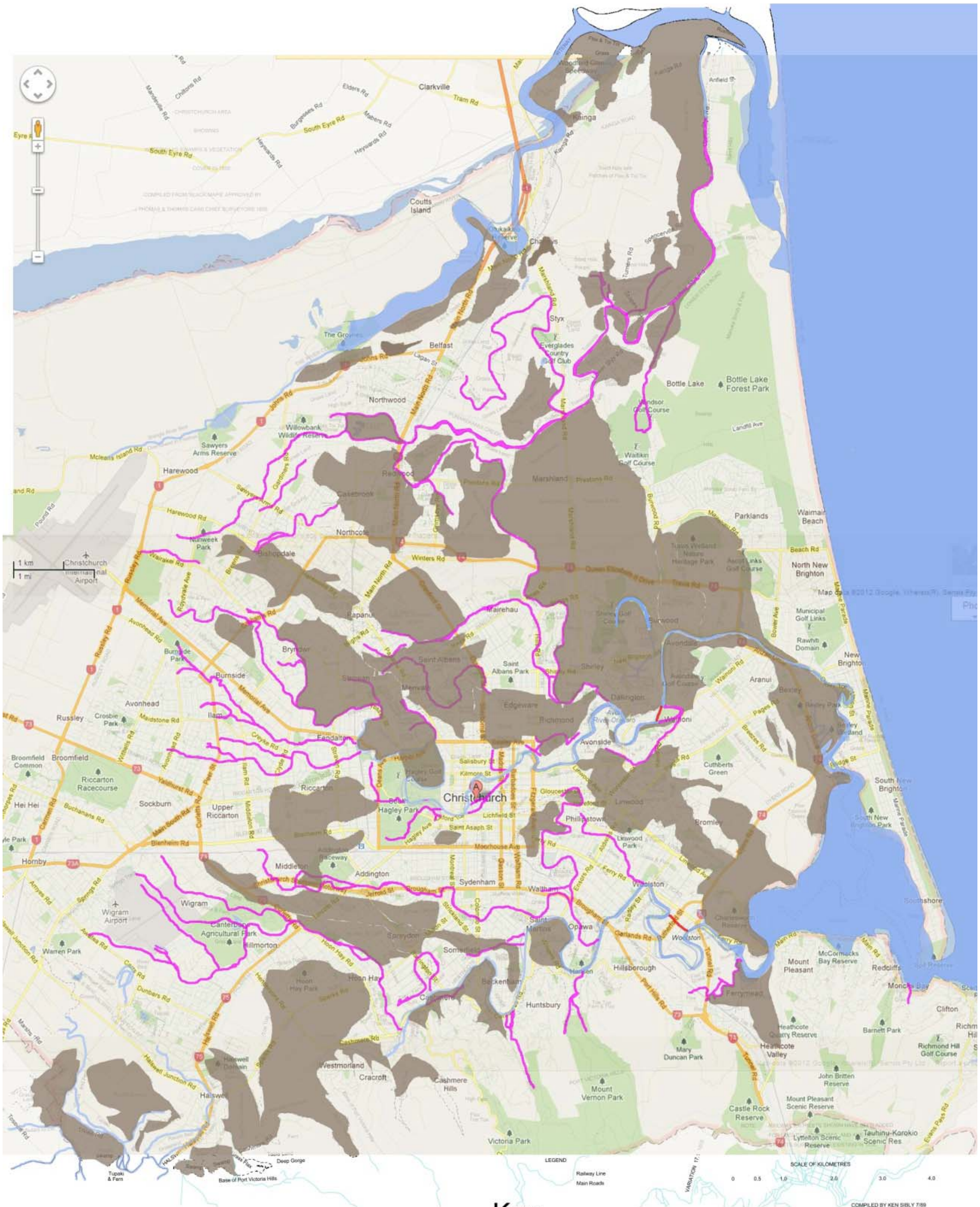
Cubrinovski & Taylor, 2011. Liquefaction map summarising preliminary assessment of liquefaction in urban areas following the 2010 Darfield Earthquake.

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 M35/11096

Gridref: M35:82782-41259 Accuracy : 2 (1=high, 5=low)
Ground Level Altitude : 1.8 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Rotary Rig
Drill Depth : -5.8m Drill Date : 8/03/2006

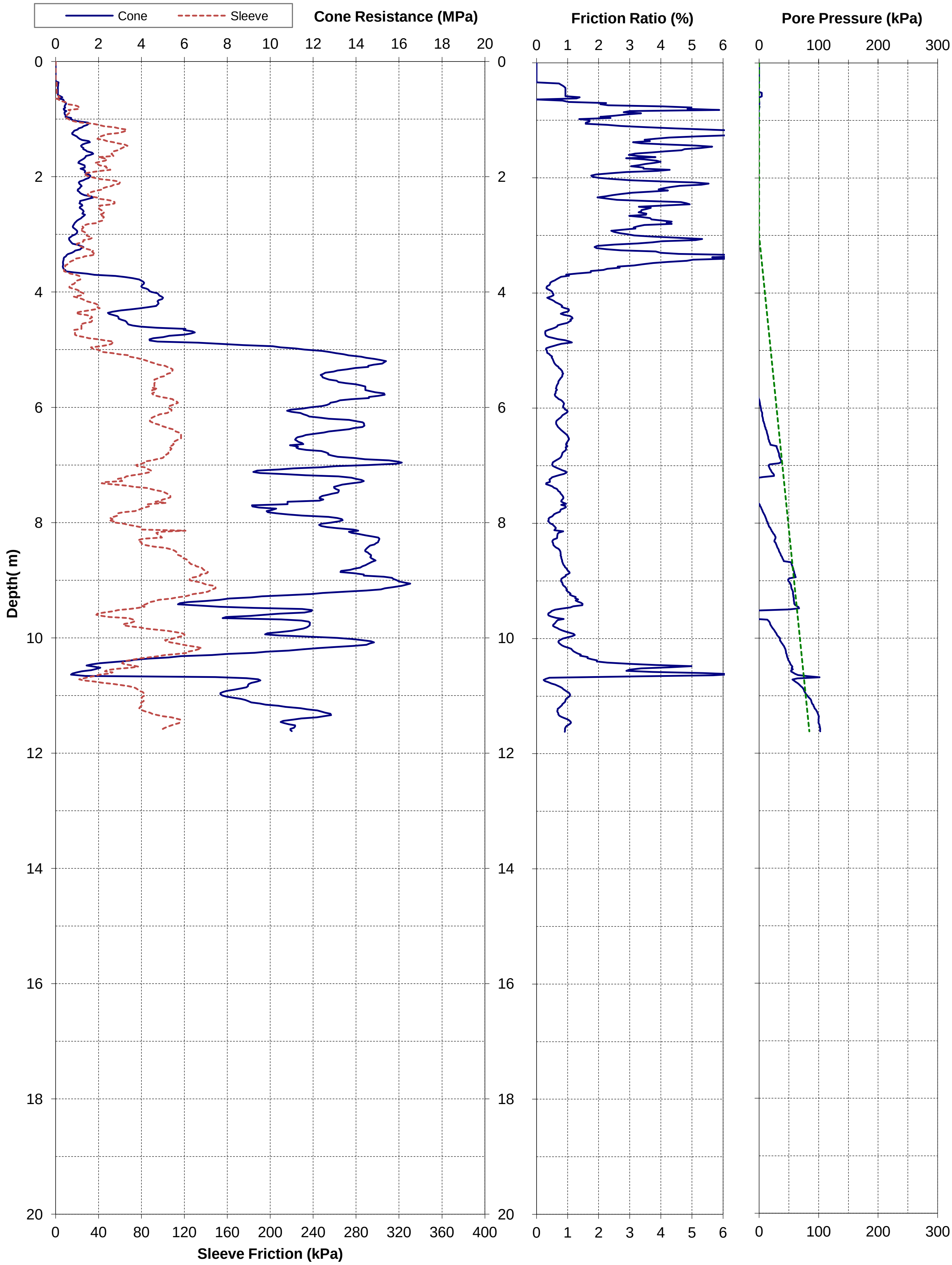
Depth(m)	Full Drillers Description	Formation Code
-0.50m	Black asphalt over gravel fill: dry	
-0.80m	Dark brown organic silt (topsoil), glass, sand and gravelfill: moist	
-1.00m	Light grey; mottled red brown silt: moist, firm.	
-1.20m	Core loss 1.2-1.8m	
-1.80m	Light grey, mottled red brown silt: moist, firm. -2m less mottled with depth. -2.2m sandier (minor to some fine sand)	
-2.25m	Grey, fine to medium sand: wet to saturated. -2m less mottled with depth. -2.2m sandier (minor to some fine sand)	
-2.80m	Core loss 2.8-3.15m	
-3.15m	Grey, fine to medium sand: wet to saturated. -2m less mottled with depth. -2.2m sandier (minor to some fine sand)	
-3.70m	Grey mottled purplish dark brown silt with minor peat and trace of clay: saturated, peaty organics concentrated in lenses. -4m, 50mm thick peaty silt lens. -4.4m, 25mm think peat lens within 150mm think silt with some peat lens. -4.8m, sandier (some fine sand) with depth)	
-4.90m	Grey fine to medium sand: saturated	
-5.60m	Core loss 5.6-5.8m	
-5.80m	Grey fine to medium sand: saturated	

Borelog for well M35/13910

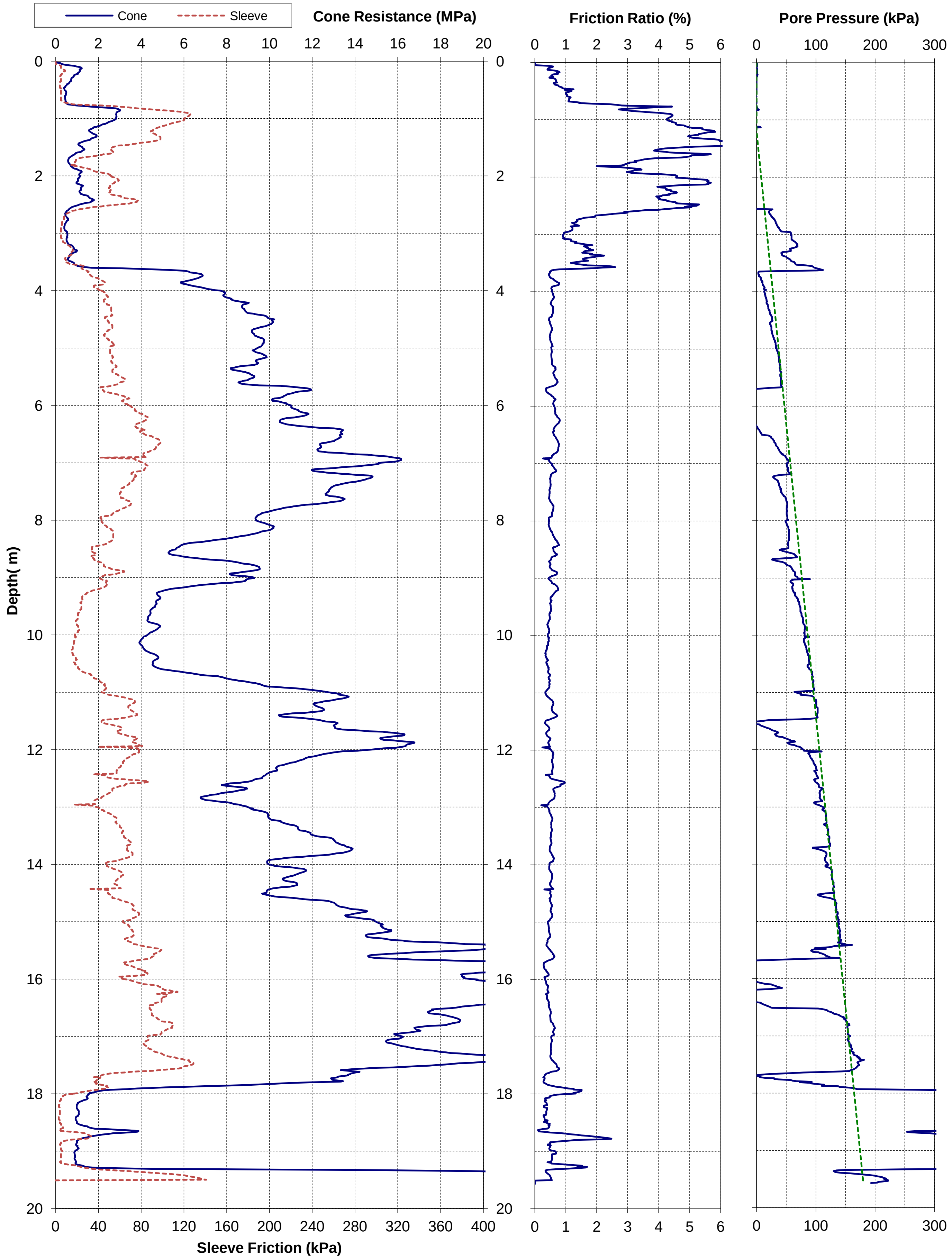
Gridref: M35:82475-41126 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 4.7 +MSD
Well name : CCC BorelogID 2265
Drill Method : Not Recorded
Drill Depth : -5.18m Drill Date :

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.30m	topsoil	
		-1.83m	clay	
		-2.44m	sand	
		-4.57m	sandy silt	
		-5.18m	dry sand	

Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	1 of 1	CPT-LWD-26
Test Date:	19-May-2011	Location:	Linwood	Operator:	Geotech	
Pre-Drill:	1.2m	Assumed GWL:	3mBGL	Located By:	Survey GPS	
Position:	2482529mE	5740719.2mN	2.48mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



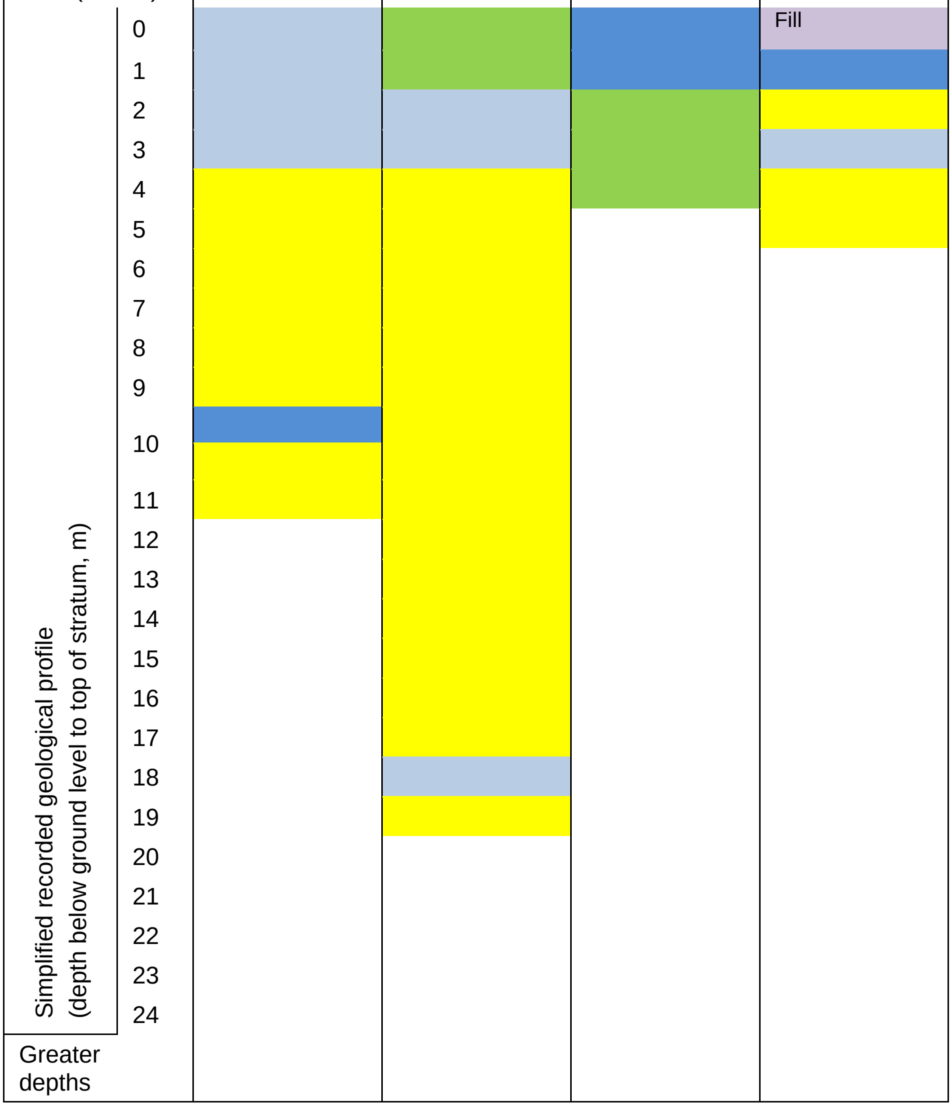
Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	1 of 1	CPT-LWD-29
Test Date:	20-May-2011	Location:	Linwood	Operator:	Opus	
Pre-Drill:	1.2m	Assumed GWL:	1.2mBGL	Located By:	Survey GPS	
Position:	2483138.2mE	5740801.4mN	2.32mRL	Coord. System:	NZMG & MSL	
Other Tests:	Seismic downhole			Comments:		



Appendix C – Geotechnical Investigation Summary

Table 1 Summary of most relevant investigation data

ID	1	2	3	4
Type *	CPT	CPT	BH	BH
Ref	LWD-26TT	LWD-29TT	M35-13910	M35-11096
Depth (m)	11.6	19.6	5.2	5.8
Distance from site (m)	360	430	440	280
Ground water level (mBGL)	3	*1.2 (assumed)*	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

Appendix D – Site Plan showing observed land damage

Undulating Ground Observed

Ejected Silt Observed

Site boundary

Unit Code for photo ref