Christchurch City Council

Roimata Place Housing Complex PRO 0917

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Roimata Place Housing Complex

Quantitative Assessment Report

Roimata Place, Woolston, Christchurch

Prepared By

Andrew Sawers
Building Technologist

Reviewed By

Lachlan Howat
Graduate Structural Engineer

Approved for Release By

Mary Ann Halliday
Senior Structural Engineer

Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Avenue
PO Box 1482, Christchurch Mail Centre, Christchurch 8140
New Zealand

Telephone: +64 3 363 5400
Facsimile: +64 3 365 7858

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Summary

Roimata Place Housing Complex
PRO 0917

Detailed Engineering Evaluation
Quantitative Report - Summary
Final

Background

This is a summary of the quantitative report for the Roimata Place Housing Complex, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This assessment covers the 24 residential units on site.

Key Damage Observed

The residential units suffered minor damage to non-structural elements.

Structural damage to the residential units was generally minor and was limited to the wall and ceiling lining and cracking of the concrete foundation perimeter footing in some residential unit blocks. The floor slopes in five units exceeded the MBIE limitation of 5mm/m. These floor slopes do not influence the structural system and its capacity.

Critical Structural Weaknesses

No critical structural weaknesses were found in any of the buildings.

Indicative Building Strength

No buildings on the site are considered to be earthquake prone.

Table A: Summary of Building Performance

Block	NBS%	Floor Levels	Nail Spacings
PRO 0917 B001 (Block A)	58%	8mm/m	Pass
PRO 0917 B002 (Block B)	58%	8mm/m	Pass
PRO 0917 B003 (Block C)	58%	Pass	Pass
PRO 0917 B004 (Block D)	58%	Pass	Pass
PRO 0917 B005 (Block E)	58%	Pass	Pass
PRO 0917 B006 (Block F)	58%	Pass	Pass

The residential units have a capacity of 58%NBS and are limited by the in-plane shear capacity lined timber-framed shear walls in the longitudinal direction.

Recommendations

It is recommended that;

- A strengthening works scheme be developed to increase the seismic capacities of the buildings to at least 67% NBS. This will need to consider compliance with accessibility and fire requirements.

- Cosmetic repairs be undertaken.

- Veneer at height (gable ends) have their veneer ties checked.

- A geotechnical site investigation be carried out to determine the liquefaction potential of the site and the shallow bearing capacities of the soils if this information is required for future construction on the site.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council to undertake a detailed seismic assessment of the Roimata Place Housing Complex, located at Roimata Place, Woolston, Christchurch, following the Canterbury Earthquake Sequence since September 2010. The site was visited by Opus International Consultants on 19 June 2013.

The purpose of the assessment is to determine if the buildings in the complex are classed as being earthquake prone in accordance with the Building Act 2004.

The seismic assessment and reporting have been undertaken based on the qualitative and quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) [2] [3] [4] [5].

2 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.

2.1 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 to carry out a full structural survey before the building is re-occupied.

We understand that CERA 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). CERA have adopted the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011. This document sets out a methodology for both initial qualitative and detailed quantitative assessments.

It is anticipated that a number of factors, including the following, will determine the extent of evaluation and strengthening level required:

1. The importance level and occupancy of the building.

2. The placard status and amount of damage.
3. The age and structural type of the building.
4. Consideration of any critical structural weaknesses.

Christchurch City Council requires any building with a capacity of less than 34% of New Building Standard (including consideration of critical structural weaknesses) to be strengthened to a target of 67% as required under the CCC Earthquake Prone Building Policy.

2.2 Building Act

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

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 the alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

The Earthquake Prone Building policy for the territorial authority shall apply as outlined in Section 2.3 of this report.

Section 115 – Change of Use

This section requires that the territorial authority is satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'.

This is typically interpreted by territorial authorities as being 67% of the strength of an equivalent new building or as near as practicable. This is also the minimum level recommended by the New Zealand Society for Earthquake Engineering (NZSEE).

Section 121 – Dangerous Buildings

This section was extended by the Canterbury Earthquake (Building Act) Order 2010, and defines a building as dangerous if:

1. 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
2. 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
3. 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
4. There is a risk that other property could collapse or otherwise cause injury or death; or
5. A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone (EPB) 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 loads 33% of those used to design an equivalent new building.

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.

Section 131 – Earthquake Prone Building Policy

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

2.3 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in October 2011 following the Darfield Earthquake on 4 September 2010.

The policy includes the following:

1. A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
2. A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
3. A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
4. 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.

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.

Where an application for a change of use of a building is made to Council, the building will be required to be strengthened to 67% of New Building Standard or as near as is reasonably practicable.

2.4 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.

On 19 May 2011, Compliance Document B1: Structure, was amended to include increased seismic design requirements for Canterbury as follows:

- Increase in the basic seismic design load for the Canterbury earthquake region (Z factor increased to 0.3 equating to an increase of 36 – 47% depending on location within the region);
- Increased serviceability requirements.

2.5 Institution of Professional Engineers New Zealand (IPENZ) Code of Ethics

One of the core ethical values of professional engineers in New Zealand is the protection of life and safeguarding of people. The IPENZ Code of Ethics requires that:

Members shall recognise the need to protect life and to safeguard people, and in their engineering activities shall act to address this need.

1.1 Giving Priority to the safety and well-being of the community and having regard to this principle in assessing obligations to clients, employers and colleagues.

1.2 Ensuring that responsible steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.

All recommendations on building occupancy and access must be made with these fundamental obligations in mind.

3 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 loadings are in accordance with the current earthquake loading standard NZS1170.5 [1].

A generally accepted classification of earthquake risk for existing buildings in terms of %NBS that has been proposed by the NZSEE 2006 [2] is presented in Figure 1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)

Improvement of Structural Performance	
Legal Requirement	NZSEE Recommendation
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
	Not recommended. Acceptable only in exceptional circumstances
Unacceptable	Unacceptable

Figure 1: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines [2]

Table 1 below compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year).

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

3.1 Minimum and Recommended Standards

Based on governing policy and recent observations, Opus makes the following general recommendations:

3.1.1 Occupancy

The Canterbury Earthquake Order[1] in Council 16 September 2010, modified the meaning of "dangerous building" to include buildings that were identified as being EPB's. As a result of this, we would expect such a building would be issued with a Section 124 notice, by the Territorial Authority, or CERA acting on their behalf, once they are made aware of our assessment. Based on information received from CERA to date and from the MBIE guidance document dated December 2012 [6], this notice is likely to prohibit occupancy of the building (or parts thereof), until its seismic capacity is improved to the point that it is no longer considered an EPB.

3.1.2 Cordoning

Where there is an overhead falling hazard, or potential collapse hazard of the building, the areas of concern should be cordoned off in accordance with current CERA/territorial authority guidelines.

3.1.3 Strengthening

Industry guidelines (NZSEE 2006 [2]) strongly recommend that every effort be made to achieve improvement to at least 67%NBS. A strengthening solution to anything less than 67%NBS would not provide an adequate reduction to the level of risk.

It should be noted that full compliance with the current building code requires building strength of 100%NBS.

3.1.4 Our Ethical Obligation

In accordance with the IPENZ code of ethics, we have a duty of care to the public. This obligation requires us to identify and inform CERA of potentially dangerous buildings; this would include earthquake prone buildings.

[1] This Order only applies to buildings within the Christchurch City, Selwyn District and Waimakariri District Councils authority.

4 Background Information

4.1 Building Descriptions

The site contains 24 residential units which were constructed in 1973. The units are numbered 1 to 24 and are grouped to form 6 blocks of 4 units. A site plan showing the locations of the units is shown in Figure 2. Figure 3 shows the location of the site in Christchurch City.

Figure 2: Site plan of Roimata Place Housing Complex.

Figure 3: Location of site relative to Christchurch City CBD *(Source: Google Maps).*

The residential units are timber-framed buildings with timber roof trusses supporting light-weight metal roofs on timber sarking. Walls and ceilings are lined with plasterboard. Cladding outside the bathroom and kitchen spaces is timber panel cladding with the remaining wall areas clad with concrete brick veneer. The foundations of the residential units are concrete pads with foundations beams under the perimeter of the units and under the fire walls.

The units are separated by 190mm block masonry fire walls which is potentially filled with reinforcement to its perimeter. A reinforced bond beam is located mid-level within the block fire wall.

Figure 4 shows a typical floor plan of a residential unit produced from site measurements by Opus. Figure 5 shows a typical cross section from the original construction drawings.

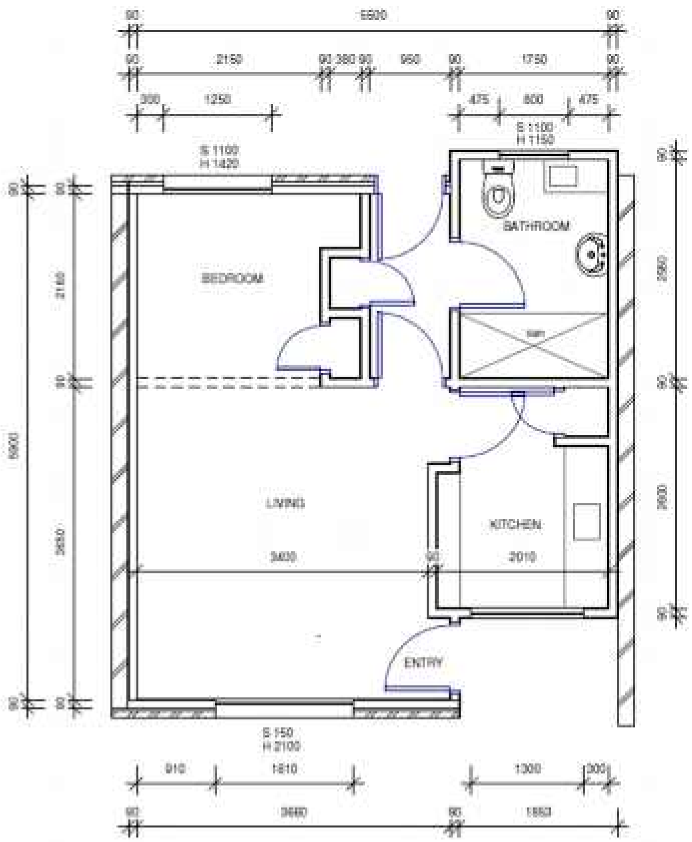

Figure 4: Typical floor plan of a residential unit within each block.

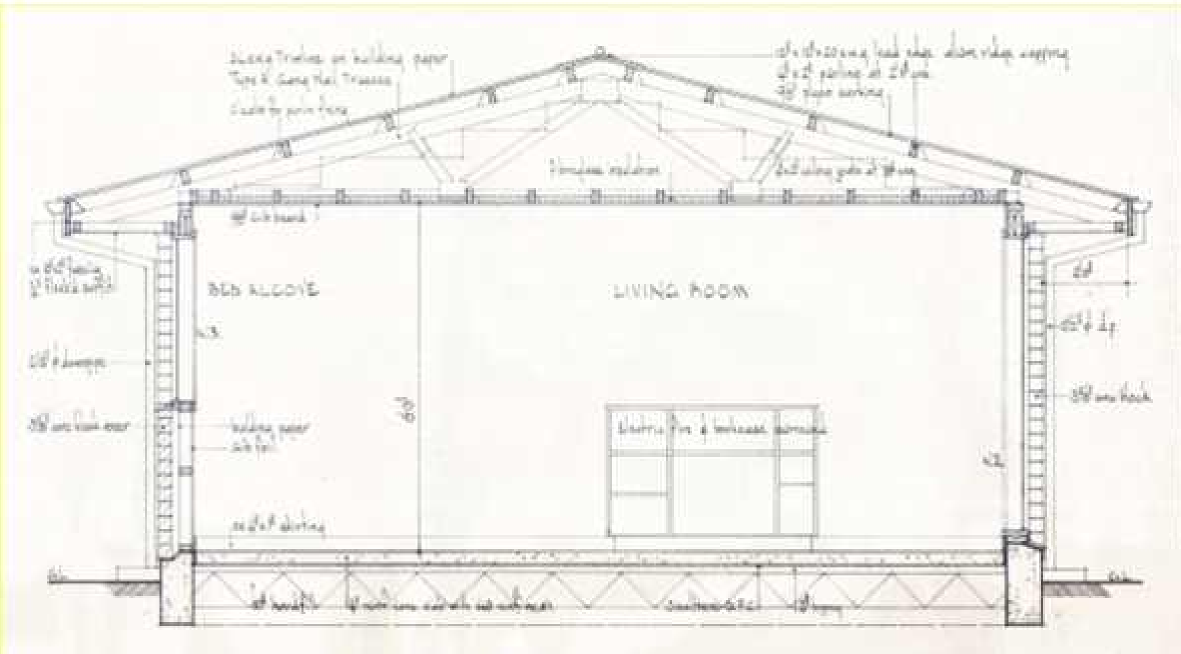

Figure 5: Typical section of a residential unit.

4.2 Survey

4.2.1 Level Survey

A full level survey was deemed to be necessary at the Roimata Place Housing Complex as it is located in a TC3 zone (Figure 8). Properties in TC3 zones suffered moderate to significant amounts of damage due to liquefaction and/or settlement. A full level survey was completed in all units which were accessed. The values from this level survey could then be used to determine the floor slope of the entire unit. Results for this level survey are summarised in Table 2. For this site, the floor slopes in five units were greater than the 5mm/m limitation recommended by MBIE.

Table 2: Summary of level survey data

Block	Flat	Comment	Maximum Fall
A	1	Pass	-
	2	Fail	8mm/m
	3	Pass	-
	4	Pass	-
B	5	Fail	8mm/m
	6	Fail	7mm/m
	7	Fail	7mm/m
	8	Fail	7mm/m
C	9	Pass	-
	10	Pass	-
	11	Pass	-
	12	Pass	-
D	13	Pass	-
	14	Pass	-
	15	Pass	-
	16	Pass	-
E	17	Pass	-
	18	Pass	-
	19	Pass	-
	20	Pass	-
F	21	No access	-
	22	Pass	-
	23	No access	-
	24	Pass	-

4.2.2 Plasterboard Nail Spacing

Nail spacings were not checked at this complex.

4.3 Original Documentation

Copies of the following construction drawings were provided by CCC:

- Plans, elevations, sections and details for the construction of the residential units (File No. BU/18/1/26 Drawn July 1972).

The drawings have been used to confirm the structural systems, investigate potential critical structural weaknesses (CSW) and identify details which required particular attention.

Copies of the design calculations were not provided.

5 Structural Damage

This section outlines the damage to the buildings that was observed during site visits. It is not intended to be a complete summary of the damage sustained by the buildings due to the earthquakes. Some forms of damage may not be able to be identified with a visual inspection only.

5.1 Residual Displacements

The results of the level survey indicate that moderate ground settlement has occurred due to the earthquakes.

5.2 Foundations

A small area of spawling is evident in the perimeter footing of Unit 5 (Photo 6 and 7). Foundation damage was not observed in the other buildings.

5.3 Primary Gravity Structure

No damage was evident in the timber framing or roof structure.

5.4 Primary Lateral-Resistance Structure

No damage to the primary lateral resistance structure.

5.5 Non Structural Elements

Very minimal cracking of plasterboard ceiling diaphragms and wall linings was observed in the units. This form of damage is not widespread throughout the units.

5.6 General Observations

The buildings appeared to have performed reasonably well, as would be expected for buildings of this type, during the earthquakes. They have suffered distributed amounts of minor damage which is typical of the construction type and age of construction.

6 Detailed Seismic Assessment

The detailed seismic assessment has been based on the NZSEE 2006 [2] guidelines for the "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" together with the "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure" [3] draft document prepared by the Engineering Advisory Group on 19 July 2011, and the SESOC guidelines "Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes" [5] issued on 21 December 2011.

As the residential units have the same floor plan, the analysis was simplified by conducting the analysis of one multi-unit block with concrete block cladding and using this for all multi-unit blocks.

6.1 Critical Structural Weaknesses

The term Critical Structural Weakness (CSW) refers to a component of a building that could contribute to increased levels of damage or cause premature collapse of a building.

No CSW's were identified in the buildings.

6.2 Quantitative Assessment Methodology

The assessment assumptions and methodology have been included in Appendix D. A brief summary follows:

Hand calculations were performed to determine seismic forces from the current building codes. These forces were applied globally to the structure and the capacities of the walls were calculated and used to estimate the %NBS. The walls, highlighted in Figure 6 and Figure 7, were used for bracing in their respective directions.

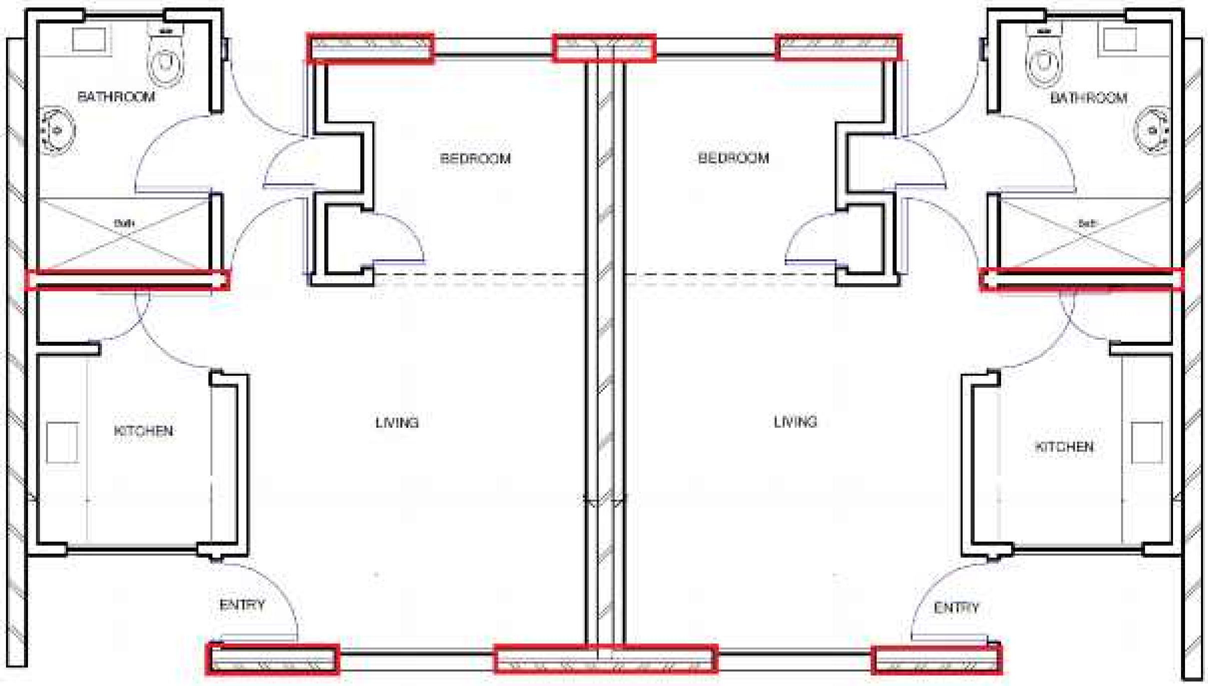

Figure 6: Walls used for bracing in the longitudinal direction.

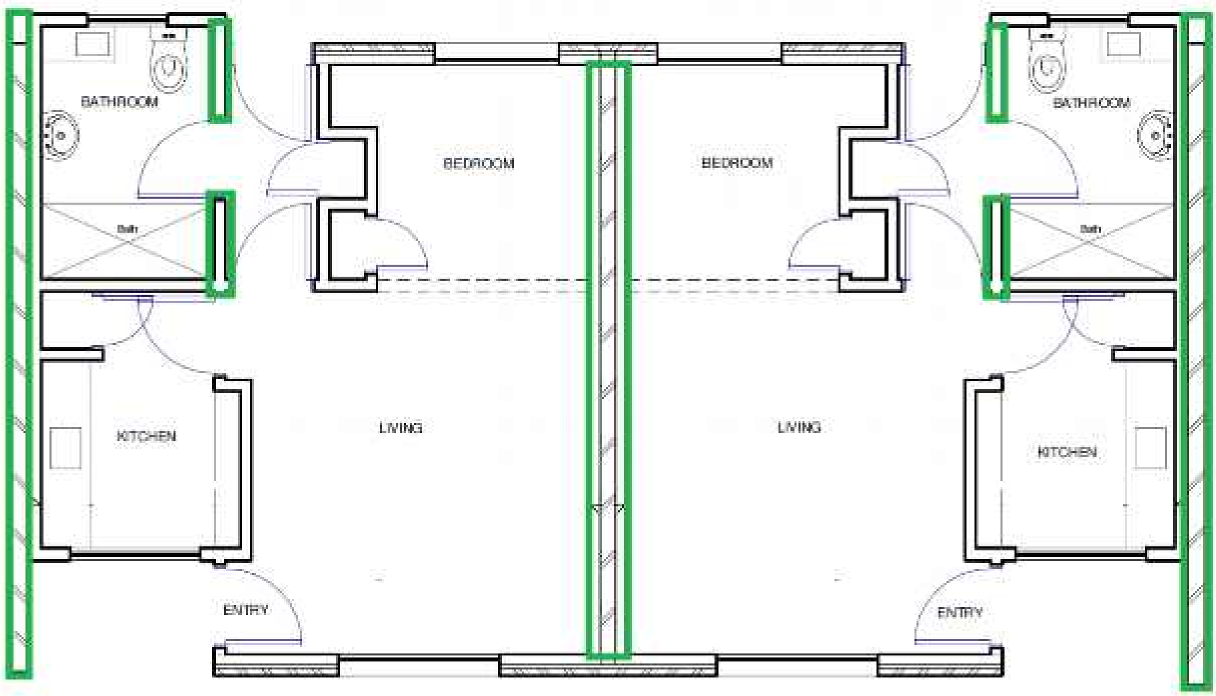

Figure 7: Walls used for bracing in the longitudinal direction.

6.3 Limitations and Assumptions in Results

The observed level of damage suffered by the buildings was deemed low enough to not affect their capacity. Therefore the analysis and assessment of the buildings was based on them being in an undamaged state. There may have been damage to the buildings that was unable to be observed that could cause the capacity of the buildings to be reduced; therefore the current capacity of the buildings may be lower than that stated.

The results have been reported as a %NBS and the stated value is that obtained from our analysis and assessment. Despite the use of best national and international practice in this analysis and assessment, this value contains uncertainty due to the many assumptions and simplifications which are made during the assessment. These include:

- Simplifications made in the analysis, including boundary conditions such as foundation fixity.
- Assessments of material strengths based on limited drawings, specifications and site inspections.
- The normal variation in material properties which change from batch to batch.
- Approximations made in the assessment of the capacity of each element, especially when considering the post-yield behaviour.
- Construction is consistent with normal practise of the era in which constructed.

6.4 Assessment

A summary of the structural performance of the buildings is shown in Table 3: Summary of Seismic Performance. Note that the values given represent the worst performing elements in the building, where these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing elements.

Table 3: Summary of Seismic Performance

Building Description	Critical element	% NBS based on calculated capacity in longitudinal direction	% NBS based on calculated capacity in transverse direction.
All Multi-Unit Blocks	Bracing capacity of structural walls	58%	100%

7 Summary of Geotechnical Appraisal

7.1 General

CERA indicates that Roimata Place Housing Complex is located on the boundary of a TC2/TC3 zone (as shown in Figure 8). This classification suggests future significant earthquakes will cause moderate to considerable land damage due to liquefaction and/or settlement. Due to this risk, a separate geotechnical desktop study was undertaken by Opus.

Figure 8: TC1 zoning for Roimata Place Housing Complex.

7.2 Liquefaction Potential

Total liquefaction induced free field subsidence of up to 240mm has been predicted in a future ULS earthquake event, for a ground water depth of 1.1m. The total subsidence predicted to occur in the top 10m is greater than 100mm for CPT 937 and CPT 8546, which would indicate that the land to the west of the site is comparable to MBIE Technical Category Three (TC3). Differential settlement is expected to occur due to variable thicknesses of liquefiable layers with expected differential settlements of up to 100mm, for a ULS earthquake event.

The Liquefaction Potential Index (LPI) is another tool used to identify the soil's susceptibility to liquefaction. This index weights the potential impact of the predicted liquefaction with the depth. Results obtained from the liquefaction analysis of CPT937 and CPT 940 indicates an LPI of greater than 15 in a ULS seismic event. This categorises the site as having a very high liquefaction risk. Liquefaction analysis of CPT 8546 and CPT 4908 indicates an LPI of less than 15. This categorises as having a high liquefaction risk.

Due to the absence of open watercourses or free surfaces close to the site, the site is considered to have a low risk of lateral spreading.

7.3 Summary

Although nearby ground investigations and EQC maps indicate that the Roimata Place site has a high risk of liquefaction for a ULS seismic event, the site has performed relatively well in the 2010 – 2011 seismic events. Minor ground damage was observed and the level survey indicates that the units have suffered minor differential settlement. This suggests that the site is likely to have settled uniformly.

7.4 Further Work

It is recommended that in order to determine foundation repair options at Roimata Place, a site specific investigation is undertaken including CPTs, Hand Augers and Scalas. The site investigation will enable a site specific liquefaction assessment to be undertaken to identify conceptual repair and re-levelling options.

The scope of the proposed site specific geotechnical investigations will be:

- • Two CPTs to a target depth of 20m in the centre of the site.
- • Hand Auger and Scala tests carried out to 3m depth or refusal near units 2, 5-8.
- • Assessment and reporting.

8 Conclusions

- None of the buildings on site are considered to be Earthquake Prone.
- The residential units have a capacity of 58% NBS, as limited by the in-plane capacity of the bracing walls. They are deemed to be a 'moderate risk' in a design seismic event according to NZSEE guidelines. Their level of risk is 5-10 times that of a 100% NBS building (Figure 1).
- Based on the geotechnical appraisal, differential settlement as a result of liquefaction could result in further damage, similar in nature to that which has occurred in the recent earthquake sequence. However, based on the nature of construction, this is unlikely to result in the collapse of the structure.

9 Recommendations

It is recommended that;

- A strengthening works scheme be developed to increase the seismic capacities of the buildings to at least 67% NBS. This will need to consider compliance with accessibility and fire requirements.
- Cosmetic repairs be undertaken.
- Veneer at height (gable ends) have their veneer ties checked.

- A geotechnical site investigation be carried out to determine the liquefaction potential of the site and the shallow bearing capacities of the soils if this information is required for future construction on the site.

10 Limitations

- This report is based on an inspection of the buildings and focuses on the structural damage resulting from the Canterbury Earthquake sequence since September 2010. Some non-structural damage may be described but this is not intended to be a complete list of damage to non-structural items.
- Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time.
- This report is prepared for the Christchurch City Council to assist in the assessment of any remedial works required for the Roimata Place Housing Complex. It is not intended for any other party or purpose.

11 References

[1] NZS 1170.5: 2004, Structural design actions, Part 5 Earthquake actions, Standards New Zealand.

[2] NZSEE (2006), Assessment and improvement of the structural performance of buildings in earthquakes, New Zealand Society for Earthquake Engineering.

[3] Engineering Advisory Group, Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure, Draft Prepared by the Engineering Advisory Group, Revision 5, 19 July 2011.

[4] Engineering Advisory Group, *Guidance on Detailed Engineering Evaluation of Non-residential buildings, Part 3 Technical Guidance*, Draft Prepared by the Engineering Advisory Group, 13 December 2011.

[5] SESOC (2011), Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes, Structural Engineering Society of New Zealand, 21 December 2011.

[6] MBIE (2012), Repairing and rebuilding houses affected by the Canterbury earthquakes, Ministry of Building, Innovation and Employment, December 2012.

Appendix A - Photographs

Roimata Place Housing Complex		
Residential Units		
1	Typical 'front' elevation	
2	Typical 'rear' elevation	

3	Typical end elevation	
4	Entry porch to units	
5	Typical roof cavity	

6	Spawling of concrete foundation (unit 5)	
7	Cracking of concrete foundation	
8	Cracking to GIB wall lining above window	

Appendix B - Level Survey

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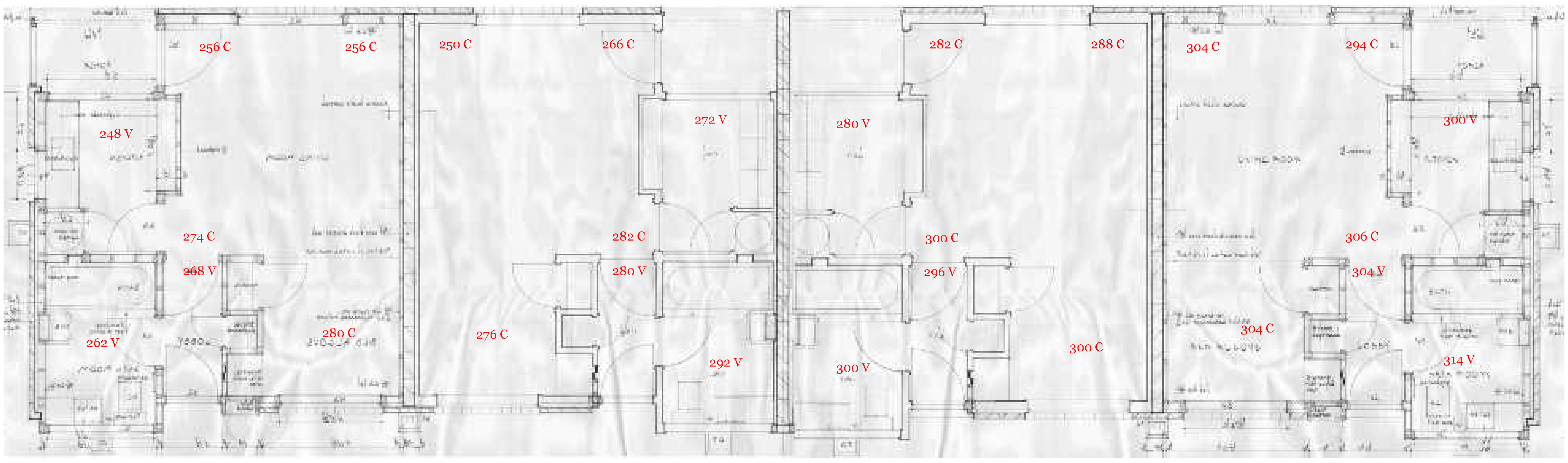

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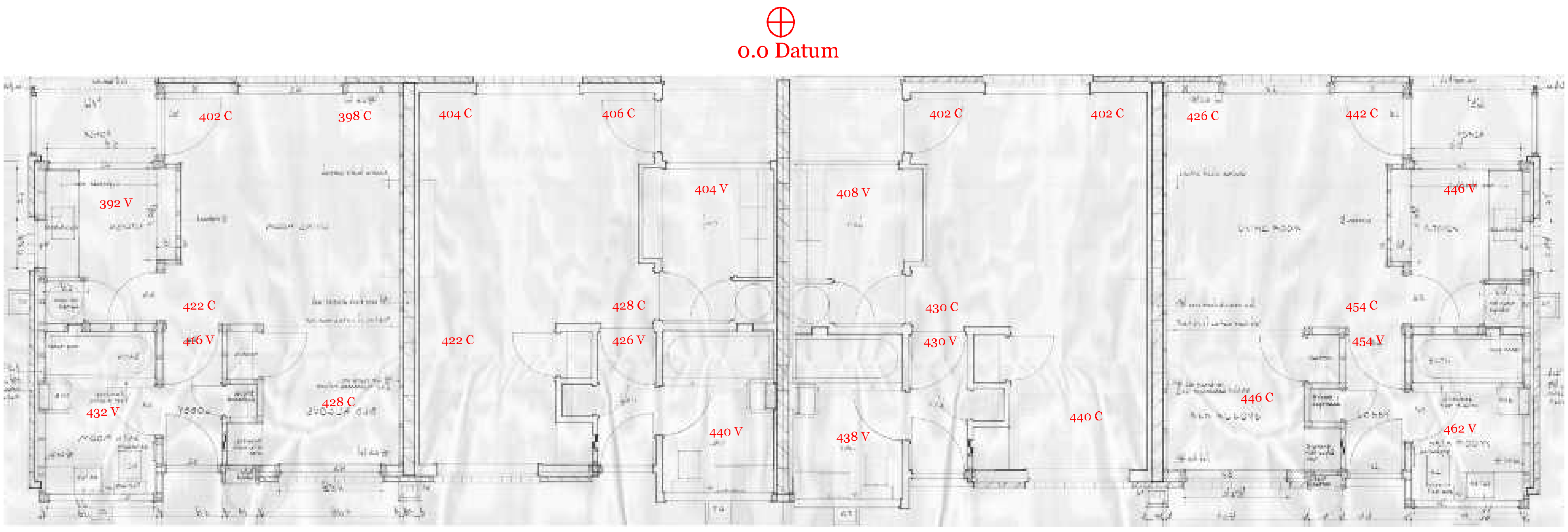
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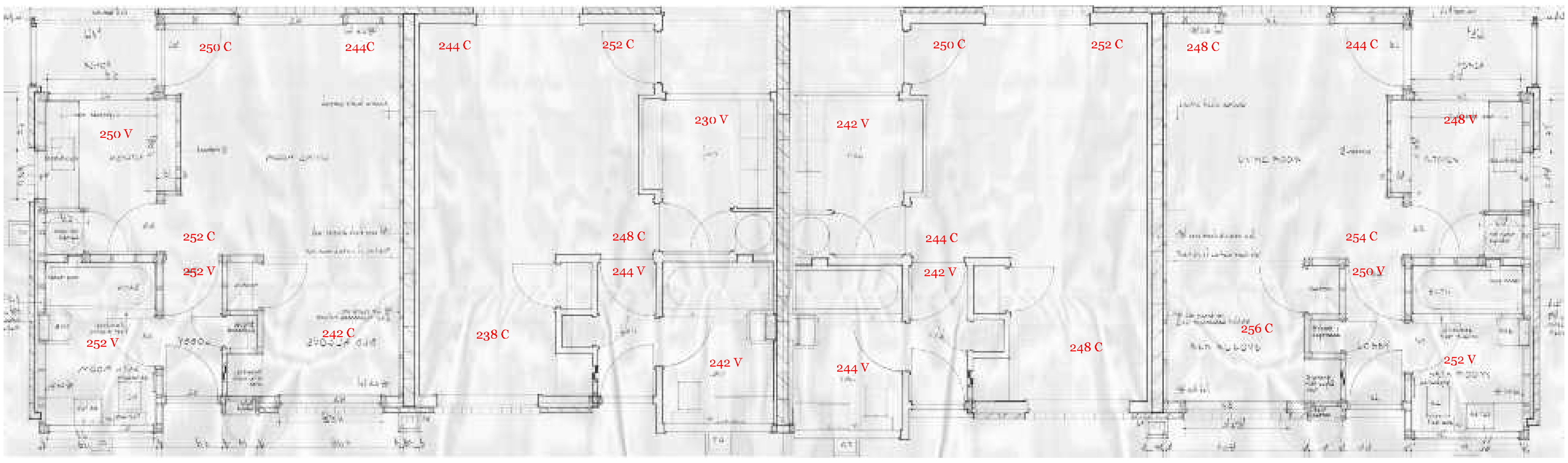

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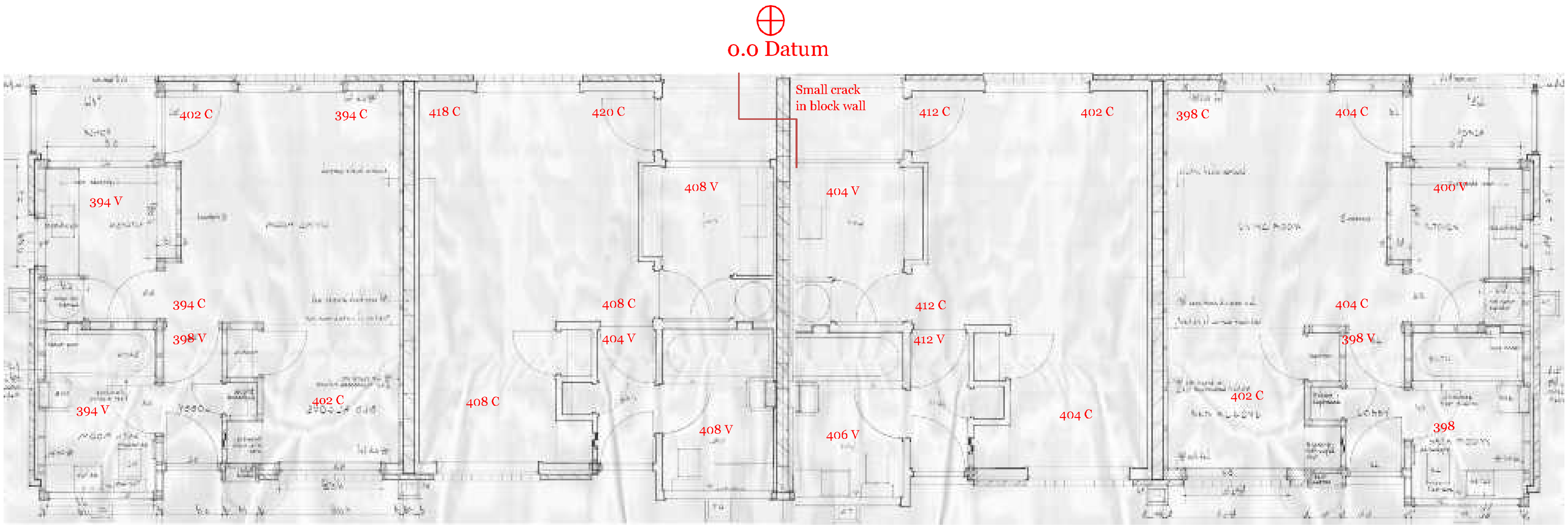
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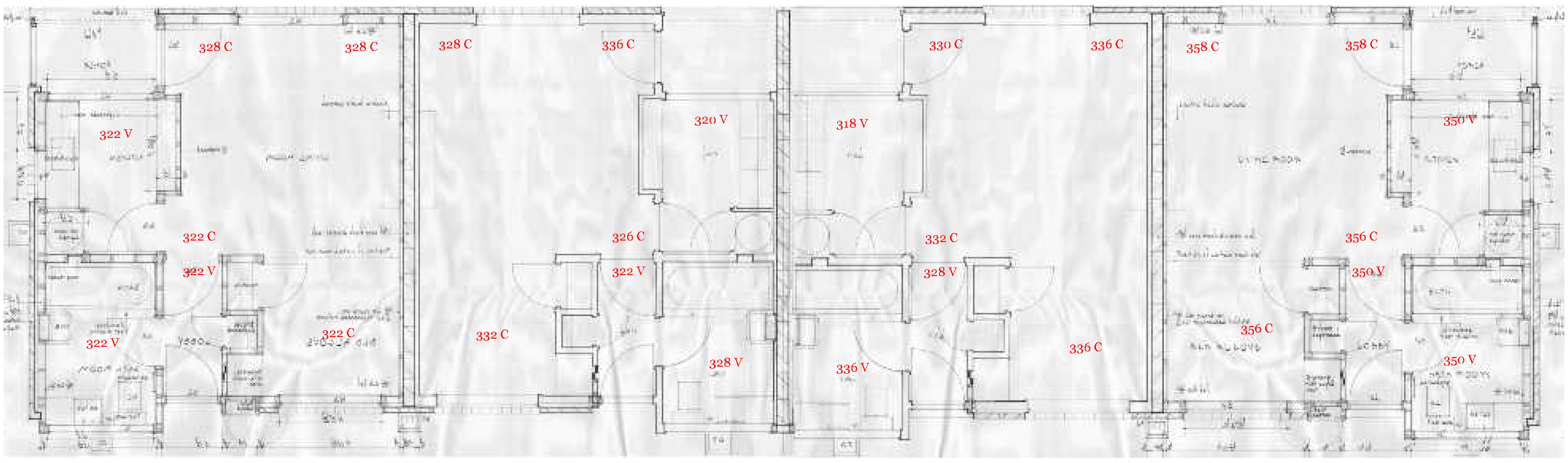

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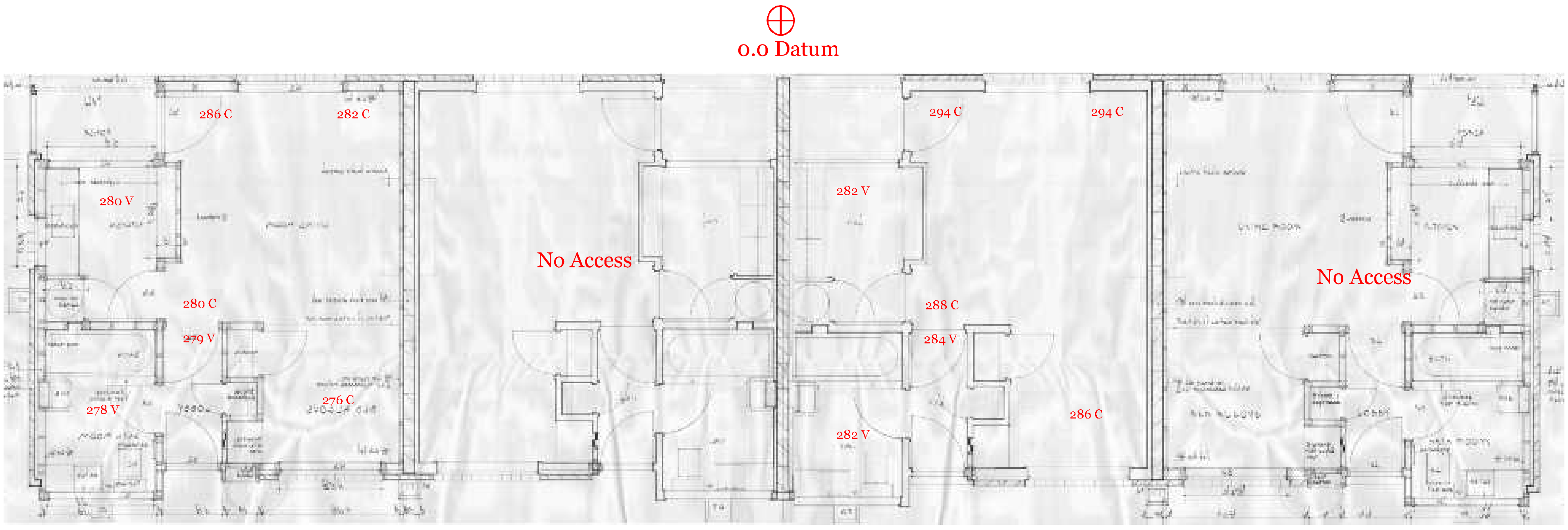
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Appendix C - Geotechnical Appraisal

Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Avenue
PO Box 1482, Christchurch Mail Centre, Christchurch 8140
New Zealand

t: +64 3 363 5400
f: +64 3 365 7858
w: www.opus.co.nz

4 November 2013

Christchurch City Council
C/- Opus International Consultants Ltd
PO Box 1482
Christchurch 8140
Attention: Geoff Bawden

QC398.00

Geotechnical Desk Study – Roimata Place

1 Introduction

Christchurch City Council (CCC) has commissioned Opus International Consultants (Opus) to undertake a Geotechnical Desk Study and site walkover of the Roimata Place Pensioner Cottages in Woolston. The purpose of this study is to: collate existing subsoil information, undertake an appraisal of the potential geotechnical hazards at this site, and determine whether further subsurface investigations are required. The site walkover was completed by Opus International Consultants on 18 June 2013.

This Geotechnical Desk Study has been prepared in accordance with the Engineering Advisory Group's Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Revision 5, 19 July 2011.

This geotechnical desk study has been undertaken without the benefit of any site specific investigations and is therefore preliminary in nature.

2 Desktop Study

2.1 Site Description

The Roimata Place Pensioner Cottages are located approximately 3.0km southeast of Christchurch city centre, 300m southeast of the Ferry Road/Ensors Road/ Aldwins Road junction in the suburb of Woolston. The site is bounded by residential areas to the east, south, and west, and Ferry Road to the North. See Site Location Plan in Appendix B.

The Roimata Place Pensioner Cottages were designed in 1972 and comprise 6 blocks with 24 single storey residential units. The units are constructed of concrete masonry block veneer with Gib board wall partitions on timber framing and reinforced masonry firewall between units.

2.2 Available Building Drawings

Design drawings prepared by City Architects Division of the Christchurch City Council for Roimata Place Pensioner Cottages were sourced from the CCC property file. See Appendix D for the Structural Drawings.

The drawings indicate that the building foundations are concrete perimeter strip footings, typically 300mm wide for the perimeter footings and 250mm wide for the firewall. The footings were founded typically 600mm below finish floor slab level, with a 100mm thick reinforced concrete floor slab laid on 250mm compacted hardfill. The floor slab reinforcement does not appear to be tied to the strip footings. This is considered to be equivalent to a Type C2 foundation as defined in MBIE Guidance 2012.

2.2 Regional Geology

The published geological map of the area (Geology of the Christchurch Urban Area 1:25,000, Brown and Weeber, 1992), indicates the site is of the Springston Formation with dominantly sand alluvial sand and silt overbank deposits.

A groundwater depth of approximately 1m has been shown on Figure 33.

2.3 Expected Ground Conditions

Ground investigation data is available from investigations by Environment Canterbury (ECan) and the Earthquake Commission (EQC). Four Cone Penetrometer Tests (CPT) have been completed within 100m of the site and one Borehole (BH) within 60m of the site. The Borehole and CPTs were used to determine the expected subsurface ground conditions of the site. Refer to Site Location Plan in Appendix B and Surrounding Site Investigations in Appendix E.

The information obtained from ECan and EQC databases has been used to infer the ground conditions of the site, as shown in Table 1 below.

Table 1: Inferred Ground Conditions

Stratigraphy	Thickness (m)	Depth Encountered (m)
Sandy GRAVEL, trace Silt	1.1	Surface
SILT and sandy SILT, firm – stiff	1.9-2.9	1.1
SAND, trace-minor Silt, loose-medium dense	13	4.0-5.0
Sandy SILT, stiff	1.0-1.5	17.0-18.0
Sandy GRAVEL, loose-dense	-	18.5-19.0

Groundwater level was recorded as 1.1m bgl in the borehole records.

2.4 Liquefaction Hazard

A liquefaction hazard study was conducted by the Canterbury Regional Council (ECan) in 2004 to identify areas of Christchurch susceptible to liquefaction during an earthquake. The Roimata Place site is located in the area of having ‘high liquefaction potential’, for a low groundwater scenario.

Tonkin and Taylor Ltd (T&T Ltd), the Earthquake Commission’s (EQC) Geotechnical Consultants, have prepared maps showing areas of liquefaction interpreted from high resolution aerial photos for the September 2010 earthquake and the aftershocks of February 2011, June 2011 and December 2011. The maps indicate evidence of moderate to severe observed liquefaction on the site, or in the vicinity, after the February 2011 and June 2011 seismic events. The maps indicate minor observed liquefaction on the site or in the vicinity after the December 2011 seismic event and no observed liquefaction after the September 2010 seismic event.

EQC maps showing observed crack locations (refer to EQC Map Output in Appendix F) after the February 2011 seismic event, indicate that no ground cracking occurred at the site or in the near vicinity. Some <10mm cracks were observed more than 150m north of the site.
Following the recent strong earthquakes in Canterbury, the Canterbury Earthquake Recovery Authority (CERA, 2012) has zoned land in the Greater Christchurch area according to its expected ground performance in future large earthquakes.

The Ministry of Business, Innovation and Employment (MBIE) has sub-divided the CERA "Green" residential recovery zone land on the flat in Christchurch into technical categories. The three technical categories are summarised in Table 2 which has been adapted from the MBIE guidance document (MBIE, 2012).

Roimata Place has been zoned as N/A-Urban Non-residential. However, the neighbouring residential properties have been zoned as either Green-TC2 or Green-TC3, which indicates minor-moderate land deformations are expected in future small to medium sized earthquakes and possibly moderate-significant land deformations in a future moderate to large earthquake.

Table 2: Technical Categories based on Expected Land Performance

Foundation Technical Category	Future land performance expected from liquefaction	Expected SLS land settlement	Expected ULS land settlement
TC 1	Negligible land deformations expected in a future small to medium sized earthquake and up to minor land deformations in a future moderate to large earthquake.	0-15 mm	0-25 mm
TC 2	Minor land deformations possible in a future small to medium sized earthquake and up to moderate land deformations in a future moderate to large earthquake.	0-50 mm	0-100 mm
TC 3	Moderate land deformations possible in a future small to medium sized earthquake and significant land deformations in a future moderate to large earthquake.	>50 mm	>100 mm

A preliminary liquefaction assessment has been completed using CLiq Software (Version 1.7, 2012) adopting the NCEER Method. Cone Penetrometer Tests (CPTs) form the basis for the prediction of liquefaction potential, with a Magnitude 7.5 earthquake considered, and earthquake groundwater depth of 1.1 m below ground level. The CLiq analysis was undertaken using four CPTs located within approximately 100m of the site boundary, as specified in Table 3 (refer to Site Location Plan in Appendix B).

Both the Serviceability and Ultimate Limit States have been assessed for an Importance Level 2 Structure (with Peak Ground Accelerations (PGAs) as specified in Table 3). The free field liquefaction induced subsidence estimates have been calculated over the complete test depth and are presented in Table 3 (refer Appendix G for CLiq output). For comparison with MBIE (2012) guidelines the estimated settlement in the top 10m of the soil profile has also been presented.

Table 3: Estimated Liquefaction Induced Settlements

CPT	Test Depth (m)	Event	Mag / PGA	Depth to Groundwater (m)	Estimated Settlement (mm)	Estimated Settlement in top 10m of soil profile (mm)
CPT 937 (CPT-WSW-04)	20.41	ULS	M7.5 / 0.35g	1.1	240	110
		SLS	M7.5 / 0.13g		55	50
CPT 8546 (WST-POD09-CPT003)	18.45	ULS	M7.5 / 0.35g	1.1	160	140
		SLS	M7.5 / 0.13g		40	40
CPT 4908 (WST-PoD09-CPT008)	18.46	ULS	M7.5 / 0.35g	1.1	180	70
		SLS	M7.5 / 0.13g		40	25
CPT 940 (CPT-WSW-07)	12.42	ULS	M7.5 / 0.35g	1.1	160	60
		SLS	M7.5 / 0.13g		25	10

Total liquefaction induced free field subsidence of up to 240mm has been predicted in a future ULS earthquake event, for a ground water depth of 1.1m. The total subsidence predicted to occur in the top 10m is greater than 100mm for CPT 937 and CPT 8546, which would indicate that the land to the west of the site is comparable to MBIE Technical Category Three (TC3). Differential settlement is expected to occur due to variable thicknesses of liquefiable layers with expected differential settlements of up to 100mm, for a ULS earthquake event.

The Liquefaction Potential Index (LPI) is another tool used to identify the soil's susceptibility to liquefaction. This index weights the potential impact of the predicted liquefaction with the depth. Results obtained from the liquefaction analysis of CPT937 and CPT 940 indicates an LPI of greater than 15 in a ULS seismic event. This categorises the site as having a very high liquefaction risk. Liquefaction analysis of CPT 8546 and CPT 4908 indicates an LPI of less than 15. This categorises as having a high liquefaction risk.

Due to the absence of open watercourses or free surfaces close to the site, the site is considered to have a low risk of lateral spreading.

3 Observations

A walkover site inspection Roimata Place was carried out by an Opus Geotechnical Engineer on 18 June 2013. The following observations were made (refer to Walkover Inspection Plan in Appendix C):

- Pavement damage (depressions and heave) and evidence of sand boils observed at the southern corner of Roimata Place access road, refer to photos 1 and 2.
- Uplift of pavement observed at curb edge, refer to photo 3.
- Cracking of concrete porches, typically 4mm crack width throughout site, refer to photos 4, 6, 7, 10, 14, 17, and 18.
- Foundation sprawling damage, refer to photo 5,
- Exposed concrete around drain, indicates possible settlement of the garden areas, refer to photos 8 and 23.
- Differential settlement and heave causing change in surface levels of asphalt areas affecting drainage, refer to photos 13 and 15.
- Differential settlement of concrete footpath and curb/drain, up to 40mm, refer to photos 12 and 21.
- Differential settlement of concrete path causing unlevelled sections of up to 40mm, refer to photos 19, 24, 26, and 33.
- Fence tilting, indicating differential settlement of fence footings, refer to photos 25, 30, and 32.
- Uplift, separation and cracking of concrete path, refer to photo 31.
- Differential settlement causing drain to change grade, refer to photo 29
- Separation of concrete porch, up to 10mm, refer to photo 11 and 34.

4 Level Survey

A summary of the level survey undertaken by Opus Structural Engineers on 18 June 2013 at Roimata Place is given in Table 4.

Unit no.	Maximum variation in floor level (mm)	Maximum Slope (%)	Direction of fall
1	22	0.5	West
2	32	0.8	West
3	20	0.5	West
4	10	0.3	Northwest
5	30	0.8	West
6	24	0.7	Northwest
7	28	0.7	Northwest
8	28	0.7	West
9	10	0.2	East
10	14	0.3	North
11	8	0.2	North
12	10	0.3	Northwest
13	4	0.1	West
14	12	0.4	Northwest
15	10	0.2	North
16	6	0.1	West
17	6	0.2	Southeast
18	10	0.3	East
19	8	0.2	South
20	2	0.1	Northwest
21	-	-	-
22	6	0.2	North
23	-	-	-
24	6	0.2	North

No level survey of units 21 and 23 could be undertaken as access was restricted.

The highlighted rows indicate foundations that have a (maximum) slope greater than 5mm/m (0.5%). In accordance with Table 2.3 of the MBIE Guidance, for units with floor slopes greater than 0.5% a foundation relevel is recommended.

5 Discussion

All Units are constructed on concrete slab on grade type foundations. This is equivalent to Type C2 foundations in accordance with the MBIE (2012) guidance.

At the time of the 18 June 2013 inspection, little evidence of ejected material and differential ground settlement was observed. The damage to pavements appears to be a result of minor differential settlement and heaves due to liquefaction. Minor cracking within the building footings was observed. The EQC maps showing areas of liquefaction interpreted from high resolution aerial photos indicate evidence of moderate to severe observed liquefaction on the site, or in the vicinity, after the February 2011 and June 2011 seismic event with minor observed liquefaction after the December 2011 seismic events.

The level survey results have been assessed and indicated moderate variations (up to 32mm with slopes greater than 0.5%) in floor level in Units 2, and 5-8 in the Roimata Place complex. In accordance with the MBIE guidance (December 2012), a foundation re-level is recommended.

Boreholes and CPTs undertaken for EQC indicate the residential complex is likely to be founded on loose sandy Gravels overlying firm to stiff Silt, sandy Silt and loose to medium dense Sand, with groundwater depths of approximately 1.1 m below ground level. Liquefaction typically occurs in recent (i.e. less than 10,000 years old), normally consolidated silts and sands beneath groundwater and is dependent on material density, grain size and soil composition. The liquefaction assessment identified liquefiable layers from 2.5m to 20m below ground level from CPT 937 and CPT 940 for a ULS event. The subsurface ground profile indicates that the site has a high risk of liquefaction.

GNS Science indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the September 2010 earthquake. Recent advice (Geonet) indicates there is currently an 11% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. Such an event may cause liquefaction induced land damage similar to that experienced, dependent on the location of the earthquake's epicentre. This confirms that there is currently a risk of liquefaction and further differential settlement at Roimata Place.

Based on analysis of adjacent CPT data the site is considered to be on the boundary between TC2 and TC3 land with low risk of lateral spreading.

Although nearby ground investigations and EQC maps indicate that the Roimata Place site has a high risk of liquefaction for a ULS seismic event, the site has performed relatively well in the 2010 – 2011 seismic events. Minor ground damage was observed and the level survey indicates that the units have suffered minor differential settlement. This suggests that the site is likely to have settled uniformly.

6 Recommendations

It is recommended that in order to determine foundation repair options at Roimata Place, a site specific investigation is undertaken including CPTs, Hand Augers and Scalas. The site investigation will enable a site specific liquefaction assessment to be undertaken to identify conceptual repair and re-levelling options.

The scope of the proposed site specific geotechnical investigations will be:

- Two CPTs to a target depth of 20m in the centre of the site.
- Hand Auger and Scala tests should then be carried out to 3m depth or refusal near units 2, 5-8.
- Assessment and reporting.

7 Limitation

This report has been prepared solely for the benefit of the Christchurch City Council as our client with respect to the particular brief given to us. Data or opinions in this desk study may not be used in other contexts, by any other party or for any other purpose.

It is recognised that the passage of time affects the information and assessment provided in this Document. Opus's opinions are based upon information that existed at the time of the production of this Desk Study. It is understood that the Services provided allowed Opus to form no more than an opinion on the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings or any laws or regulations.

8 References

Brown, LJ; Webber, JH 1992: Geology of the Christchurch Urban Area. Scale 1:25,000. Institute of Geological and Nuclear Sciences geological map, 1 sheet + 104p.

Environment Canterbury, Canterbury Regional Council (ECan) website:

ECan 2004: The Soild Facts on Christchurch Liquefaction. Canterbury Regional Council, Christchurch, 1 sheet.

Project Orbit, 2011: Interagency/organisation collaboration portal for Christchurch recovery effort. https://canterburygeotechnicaldatabase.projectorbit.com/

GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury-quakes/aftershocks/ updated on 28 February 2013.

'Repairing and rebuilding houses affected by the Canterbury earthquakes': Ministry of Business, Innovation and Employment (December 2012).

Appendices:
Appendix A: Site Inspection Photographs
Appendix B: Site Location Plan
Appendix C: Walkover Inspection Plan
Appendix D: Construction Details
Appendix E: Surrounding Site Investigations
Appendix F: EQC Map Output
Appendix G: CLiq Liquefaction Analysis

Prepared By: | Reviewed By:

Thomas de Malmanche
Graduate Geotechnical Engineer

Graham Brown
Senior Geotechnical Engineer

Appendix A:

Site Inspection Photographs

Photo 1: Pavement depression damage and sand boil evidence

Photo 2: Pavement depression damage and view of block 2 (unit 5 – 6)

Photo 3: Pavement up lift, up to 30mm

Photo 4: Concrete porch cracking at unit 5, up to 3mm wide


Photo 5: Foundation damage of unit 5


Photo 6: Crack of concrete porch at unit 6 and 7, up to 4mm wide

Photo 7: Cracking of concrete porch and building foundation at unit 8, up to 3mm wide

Photo 8: Exposed concrete at unit 8, possible settlement of 60mm

Photo 9: North east elevation of block 3 (unit 9 - 12) and side elevation of unit 13

Photo 10: Crack of concrete porch at unit 6 and 7, up to 5mm wide and 2mm vertical

Photo 11: Separation of concrete porch at unit 11, up to 10mm wide

Photo 12: Concrete path unlevelled, up to 20mm


Photo 13: North east elevation of block 4 (unit 13 - 16) and water pooling, evidence of pavement and drainage level change


Photo 14: Cracking of concrete porch at unit 14 and 15, up to 5mm wide

Photo 15: Pavement heave

Photo 16: North east elevation of block 5 (unit 17 - 20) and block 6 (unit 21 - 24)


Photo 17: Cracking of concrete porch at unit 17, up to 2mm wide


Photo 18: Cracking of concrete porch at unit 18 and 19, up to 4mm wide

Photo 19: Differential settlement of concrete path, up to 15mm

Photo 20: East elevation of block 6

Photo 21: Unlevelled concrete path, up to 3mm

Photo 22: Separation of concrete path near unit 24, up to 10mm

Photo 23: Exposed concrete at unit 21, evidence of settlement, up to 70mm

Photo 24: Elevation of cloths drying area between unit 20 and 21. Unlevelled concrete path and path settlement of up to 40mm

Photo 25: Tilting of fence, evidence of differential settlement up to 100mm

Photo 26: South west elevation behind unit 5, evidence of concrete path settlement of up to 30mm

Photo 27: Elevation of cloths drying area between block 3, 4 and 5

Photo 28: Elevation of cloths drying area between block 1, 2 and 3

Photo 29: Differential settlement causing pipe change of grade towards Block 2

Photo 30: Tilting of fence, possible differential settlement of fence foundations of up to 50mm

Photo 31: Concrete path uplift, separation and cracking, up to 25mm separation and 5mm wide cracks

Photo 32: Tilting of fence, possible differential settlement of fence foundations of up to 100mm

Photo 33: Settlement of concrete path, up to 40mm

Photo 34: Separation of concrete porch at unit 1, up to 10mm

Appendix B:
Site Location Plan

CPTs assessed for liquefaction potential.

Approximate Scale:1 to 1250at A3

SOURCE:canterburyrecovery.projectorbit.com (Accessed on 21/06/2013)

OPUS
Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Ave
PO Box 1482
Christchurch, New Zealand
Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Roimata Place, Woolston
Project No.: 6-QC398.00
Client: Christchurch City Council

Site Location Plan

Drawn: Opus Geotechnical Engineer

Date: 1-Jul-13

Appendix C:
Walkover Inspection Plan

Pavement heave caused by uplift

x Cracks up to 5mm wide in concrete porch unit entrances

Unlevelled concrete path (up to 40mm) caused by differential settlement

Differential settlement of footpath and curb, up tp 40mm

Exposed concrete around drain, possible settlement of up to 70mm

1-24: Residential Unit Numbers

OPUS

Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Ave
PO Box 1482
Christchurch, New Zealand
Tel: +64 3 363 5400 Fax: +64 3 365 7857

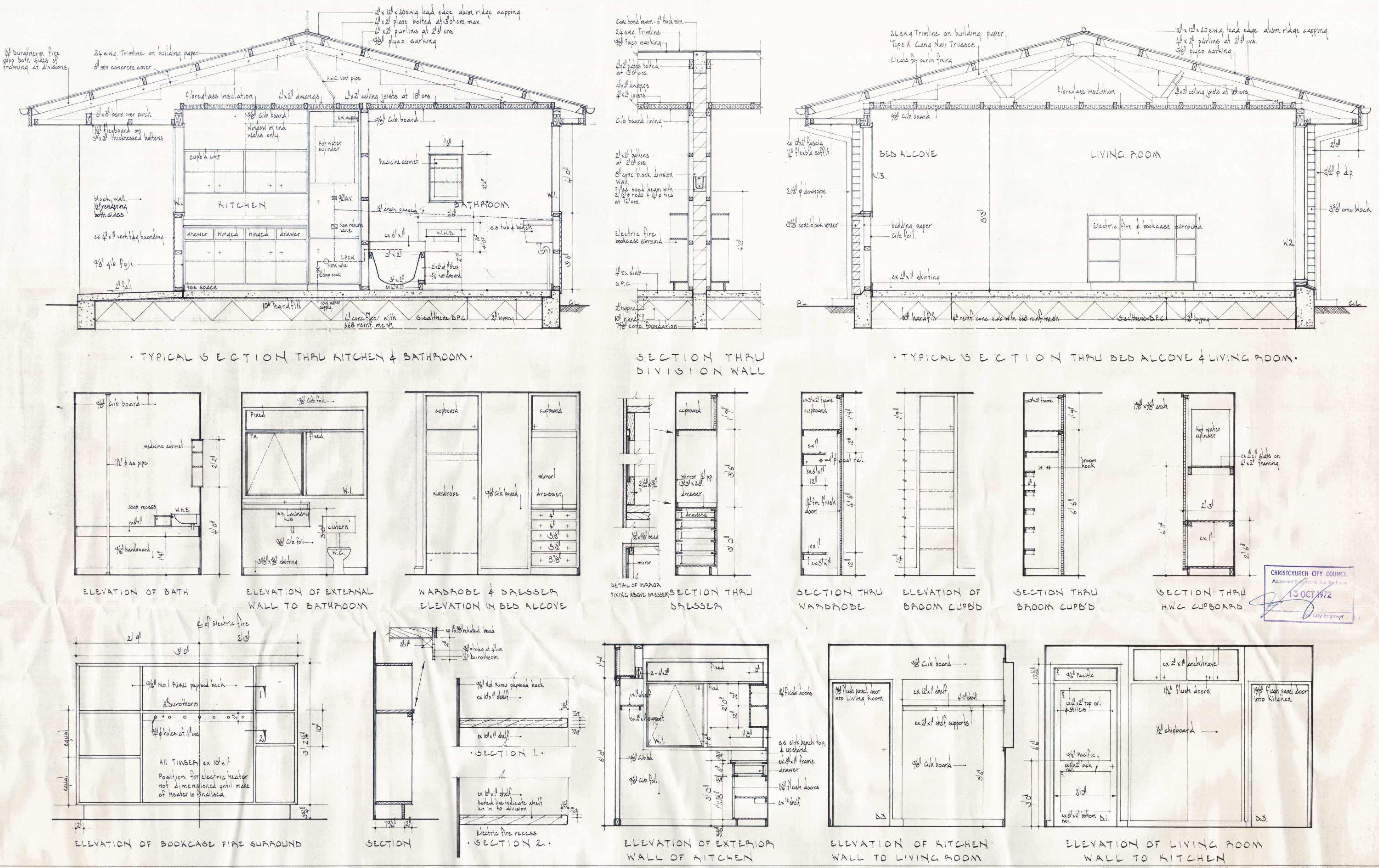
Project: Roimata Place, Woolston
Project No.: 6-QC398.00/005HC
Client: Christchurch City Council

Walkover Inspection Plan

Drawn: Opus Geotechnical Engineer

Date: 18-Jun-13

Appendix D:
Construction details



CITY ARCHITECT'S DIVISION	CONSULTANT		SCALES	DESIGN	AMENDMENTS	SHEET TITLE	REFERENCE	SHEET
CHRISTCHURCH CITY COUNCIL		FERRY ROAD PENSIONERS COTTAGES	½" to 1'0" 1" to 1'0"	DSN G.S.A.F DRN G.M.L TCD G.M.L CKD		CROSS SECTIONS INTERIOR ELEVATIONS & SECTIONS FIRE SURROUND DETAILS	JOB A 228 FILE 34/18/1/25 CONT 12-72/73	4
CITY ENGINEER'S DEPARTMENT			DATE	CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK				OF

Appendix E:

Surrounding Site Investigations

TONKIN & TAYLOR LTD

BOREHOLE LOG

BH No: WST-POD09-BH003
Hole Location: 13 Manning Place

PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS | LOCATION: WOOLSTON | JOB No: 52003.000

CO-ORDINATES: 5740293.98 mN, 2483086.47 mE
R.L.: 2.41 m
DATUM: NZMG, MSL (CCC 20/01/12 Datum -9.043m)

DRILL TYPE: Roto-Soni
DRILL METHOD: PQDT/Auto SPT
DRILL FLUID: LP2000

HOLE STARTED: 15/10/12
HOLE FINISHED: 15/10/12
DRILLED BY: Pro-Drill
LOGGED BY: GLDS-HT CHECKED: BMcD

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION	CORE RECOVERY (%)	METHOD	TESTS	SAMPLES	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)	53	PQDT			0.0–1.5	GW	M		Sandy fine to coarse GRAVEL with trace silt, greyish brown, moist, well graded. Sand is fine to coarse. 0.8 to 1.5m- no recovery.
	100	SPT	✱ATP@1.5m ✱FC@1.5m 1/1//1/1/2/2 N=6	B	1.5–2.8	ML	W	F	SILT with trace sand, grey, firm, wet, low plasticity. Sand is fine to medium.
	100	PQDT							
	100	SPT	✱FC@3.0m 2/2//2/2/3/5 N=12	B	2.8–4.5			St	Sandy SILT, grey, firm, wet, low plasticity. Sand is fine to medium. 3.0m- stiff.
	100	PQDT							
CHRISTCHURCH FORMATION (MARINE/ ESTUARINE)	100	SPT	1/3//5/5/6/6 N=22		4.5–6.5	SM		MD	Silty fine to medium SAND, grey, medium dense, wet, poorly graded.
	100	PQDT							
	100	SPT	✱FC@6.0m 2/2//3/2/3/4 N=12	B					6.0m- 0.05m heave observed prior to SPT.
	100	PQDT			6.5–10.0	SP			Fine to medium SAND with trace silt, grey, medium dense, wet, poorly graded.
	100	SPT	0/0//0/1/2/3 N=6					L	7.5m- trace broken shells, loose.
	100	PQDT							8.45m- minor fibrous organics (wood).
	100	SPT	✱FC@9.0m 0/1//2/3/4/4 N=13	B				MD	9.0m- 0.05m heave observed prior to SPT. 9.0m- medium dense.
	100	PQDT							

Groundwater level marked at approx. 1.5 m depth. R.L. scale: 2, 1, 0, -1, -2, -3, -4, -5, -6, -7.

TONKIN & TAYLOR LTD

BOREHOLE LOG

SHEET 2 OF 2

BH No: WST-POD09-BH003
Hole Location: 13 Manning Place

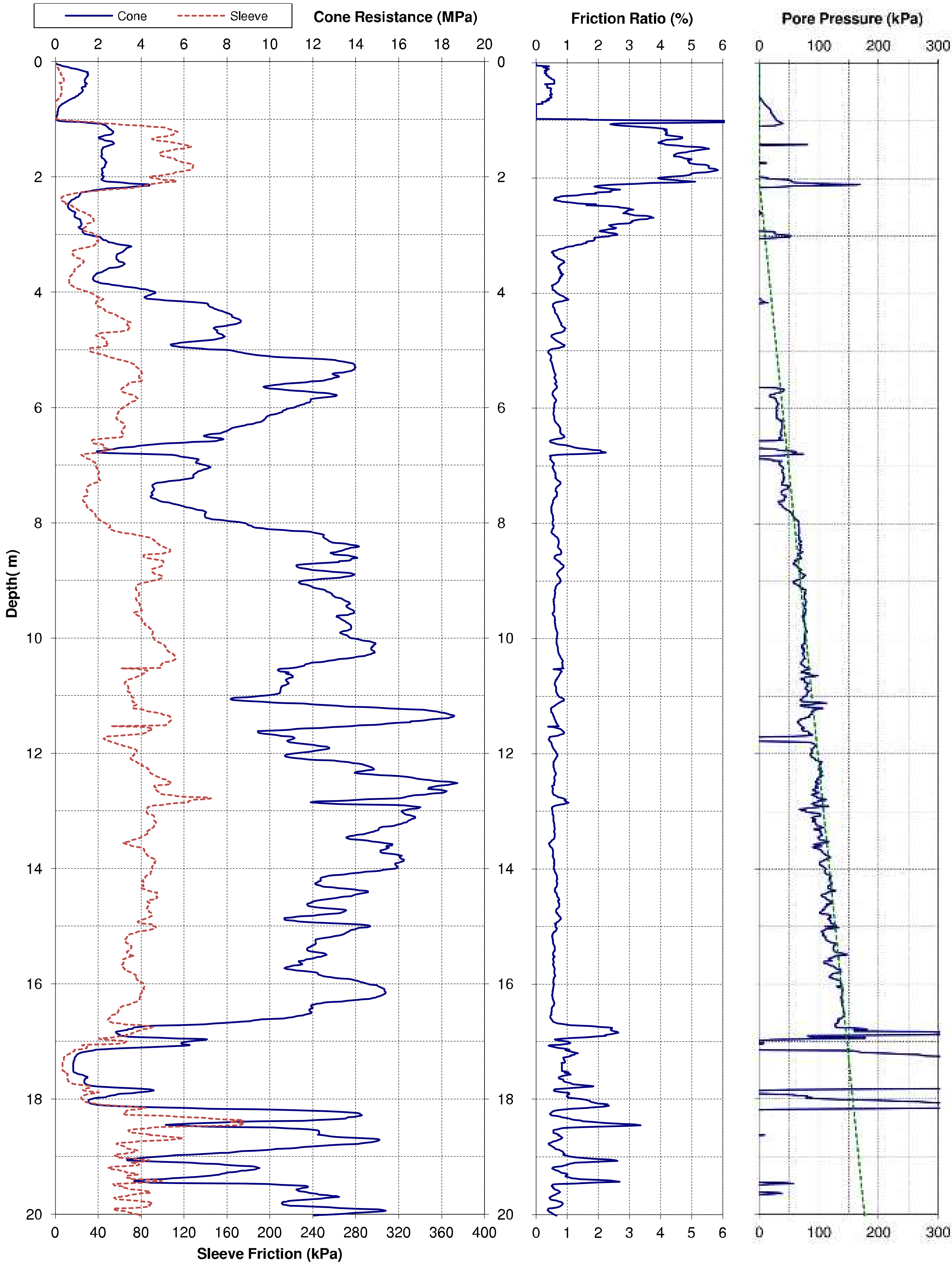
PROJECT: CHCH TC3 GEOTECHNICAL INVESTIGATIONS　LOCATION: WOOLSTON　JOB No: 52003.000

CO-ORDINATES: 5740293.98 mN, 2483086.47 mE
R.L.: 2.41 m
DATUM: NZMG, MSL (CCC 20/01/12 Datum -9.043m)
DRILL TYPE: Roto-Soni
DRILL METHOD: PQDT/Auto SPT
DRILL FLUID: LP2000
HOLE STARTED: 15/10/12
HOLE FINISHED: 15/10/12
DRILLED BY: Pro-Drill
LOGGED BY: GLDS-HT　CHECKED: BMcD

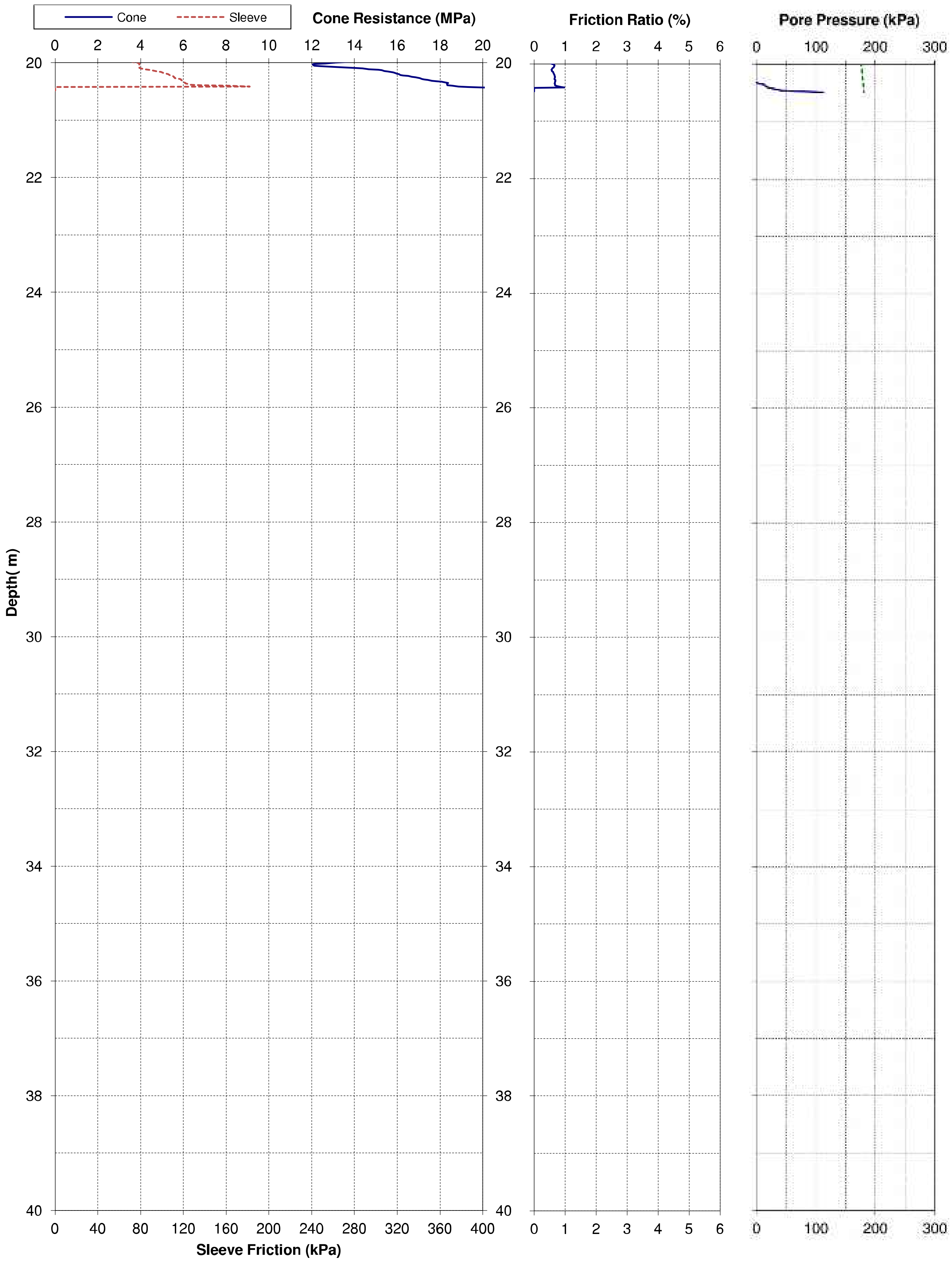
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION	CORE RECOVERY (%)	METHOD	TESTS	SAMPLES	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION / ROCK DESCRIPTION
CHRISTCHURCH FORMATION (MARINE/ ESTUARINE)	100	PQDT				SP	W	MD	Fine to medium SAND with minor silt, grey, medium dense, wet, poorly graded.
	100	SPT	0/0//2/2/2/4 N=10		10.5			L	10.5m- loose.
	100	PQDT			11				
	100	SPT	*FC@12.0m 0/0//2/3/3/4 N=12	B	12			MD	12.0m- medium dense.
	100	PQDT			13				
	100	SPT	0/0//0/1/1/2 N=4		13.5			L	13.5m- loose.
	100	PQDT			14				
	100	SPT	*FC@15.0m 0/0//0/1/1/1 N=3	B	15			VL	15.0m- trace silt, very loose.
	72	PQDT			16	ML		S	Sandy SILT, grey, soft, wet, low plasticity. Sand is fine to medium. 16.5 to 16.9m- no recovery.
	100	SPT	3/3//1/2/2/3 N=8		17			St	16.9m- stiff.
	100	PQDT							
	100	SPT	0/0//0/2/2/3 N=7		18			F	18.0m- 0.05m heave observed prior to SPT. 18.0m- firm.
RICCARTON GRAVEL	100	PQDT			19	GW		L	Sandy fine to coarse GRAVEL with trace silt, grey, subrounded, loose, wet, well graded. Sand is fine to coarse.
	100	SPT	9/13//11/10/10/9 N=40		19.5			D	19.5m- dense.
					20				End of borehole at 19.95mbgl (target depth)

R.L. (m): -8, -9, -10, -11, -12, -13, -14, -15, -16, -17

Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	1 of 2	CPT-WSW-04
Test Date:	3-Jun-2011	Location:	Woolston	Operator:	Opus	
Pre-Drill:	1.2m	Assumed GWL:	2mBGL	Located By:	Survey GPS	
Position:	2483101.6mE	5740306.8mN	2.56mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	2 of 2	CPT-WSW-04
Test Date:	3-Jun-2011	Location:	Woolston	Operator:	Opus	
Pre-Drill:	1.2m	Assumed GWL:	2mBGL	Located By:	Survey GPS	
Position:	2483101.6mE	5740306.8mN	2.56mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



Project:	Christchurch 2011 Earthquake - EQC Ground Investigations			Page:	1 of 1	CPT-WSW-07
Test Date:	31-May-2011	Location:	Woolston	Operator:	Geotech	
Pre-Drill:	1.2m	Assumed GWL:	2mBGL	Located By:	Survey GPS	
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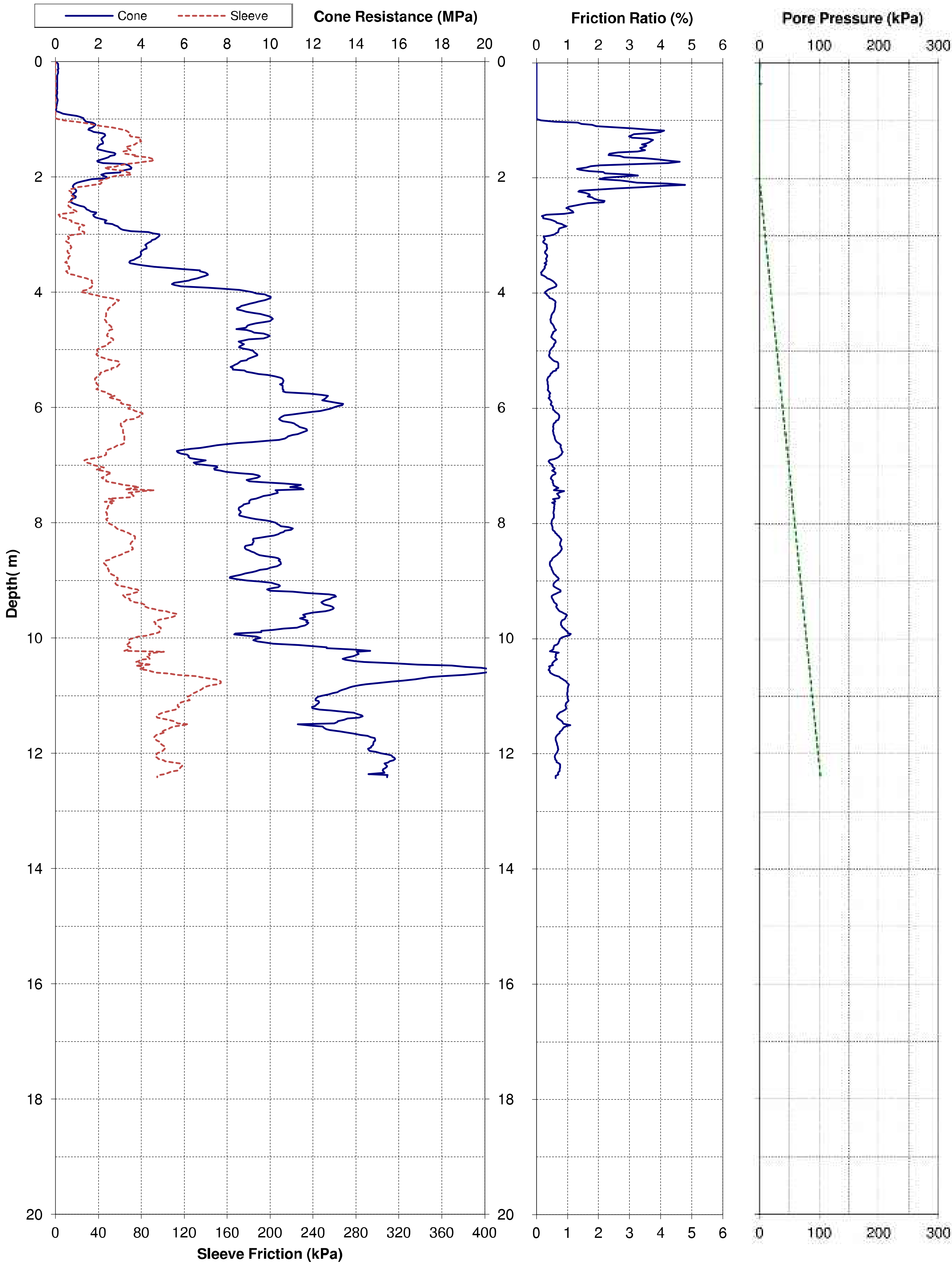
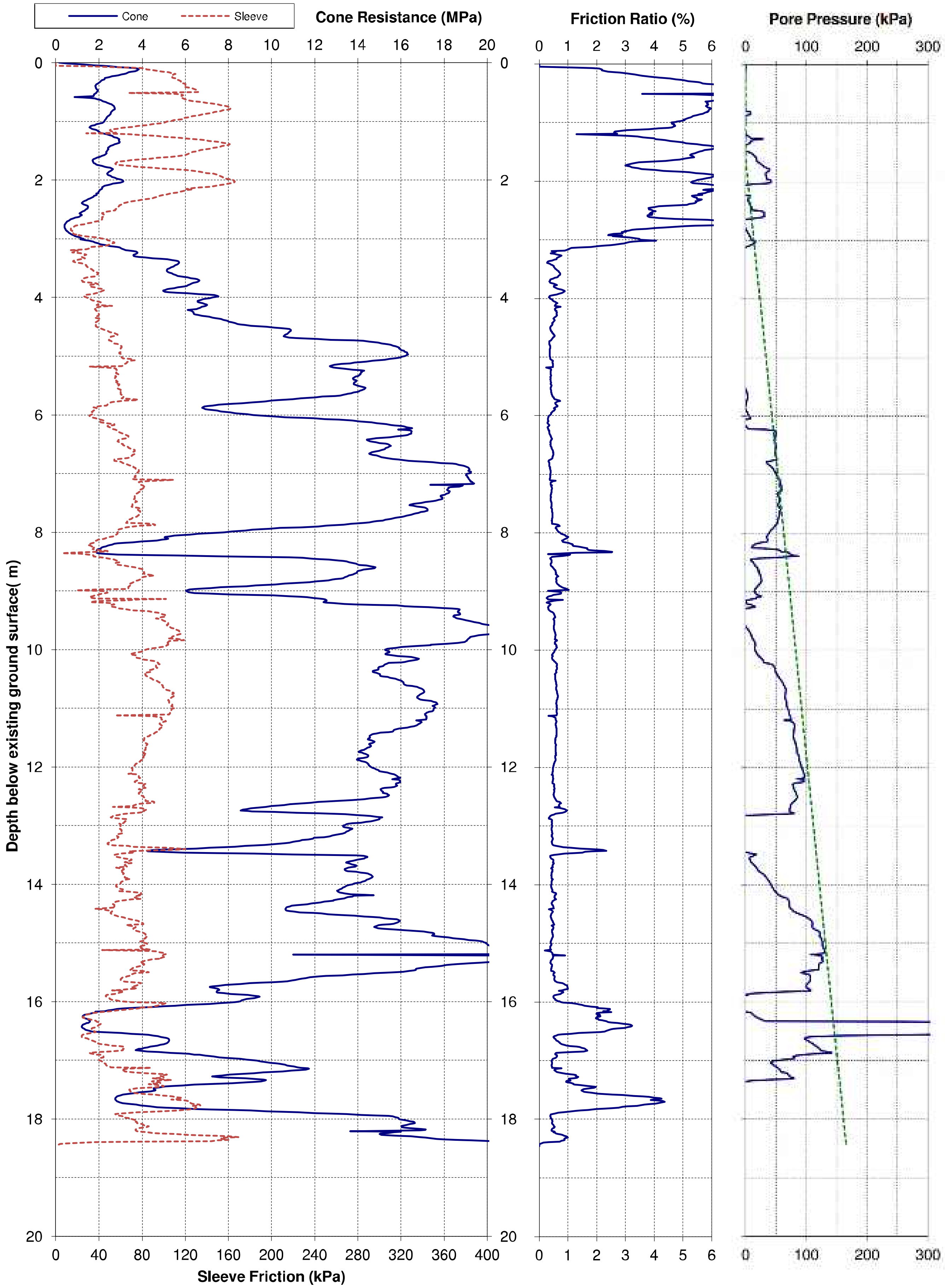
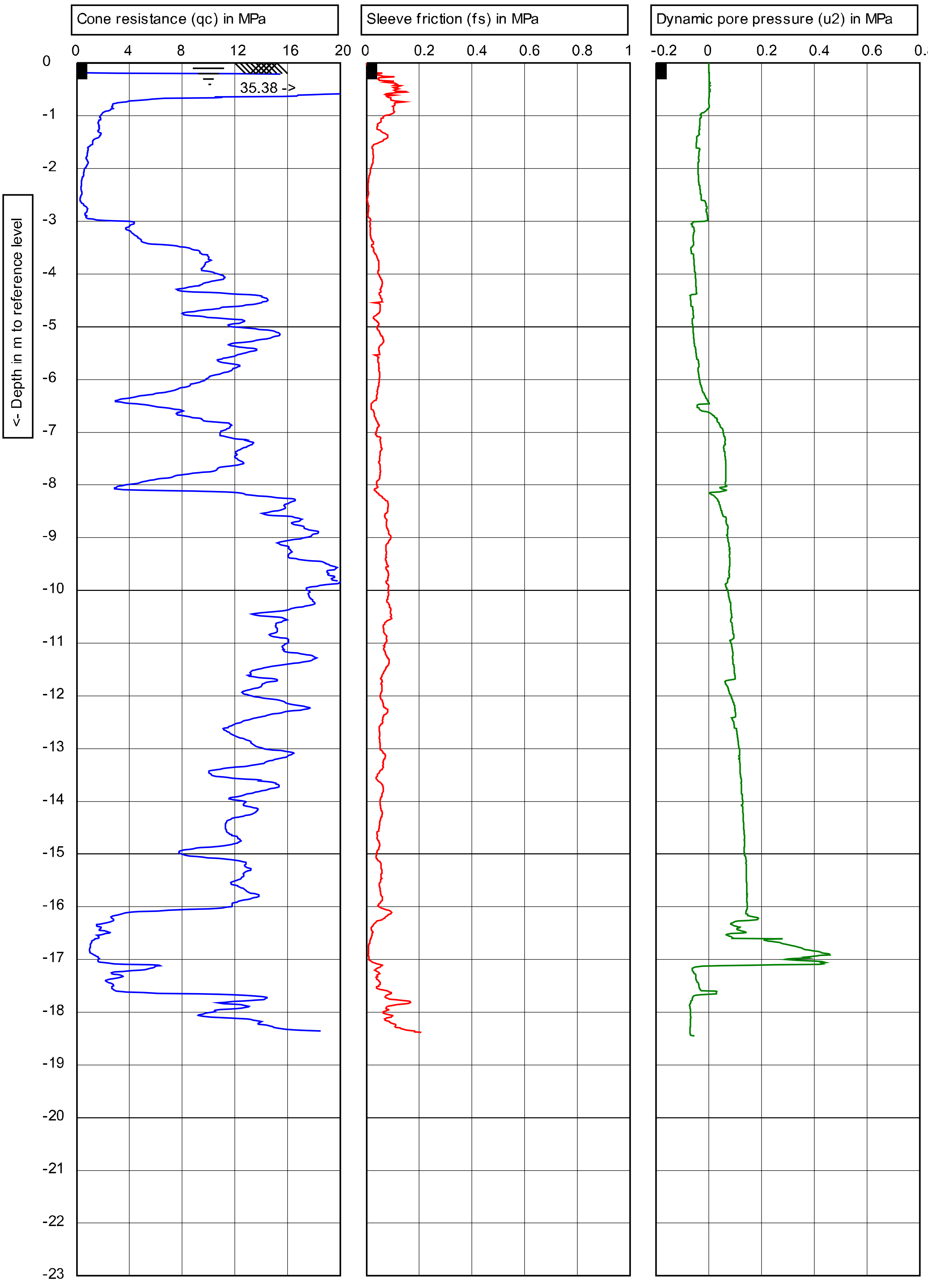
Other Tests:				Comments:		



Project:	Christchurch TC3 Geotechnical Investigations				Page: 1 of 1	WST-P0D09-CPT008
Test Date:	4-Sep-2012	Suburb:	Woolston	Operator:	Pro-Drill	
Pre-Drill:	0m	Assumed GWL:	1.6mBGL	Located By:	Survey GPS	
Position:	2483070.85mE	5740147.32mN	2.62mRL	Coord. System:	NZMG	
Address:	18 Wildberry St			Datum Reference:	MSL (CCC 20/01/12 Datum -9.043)	

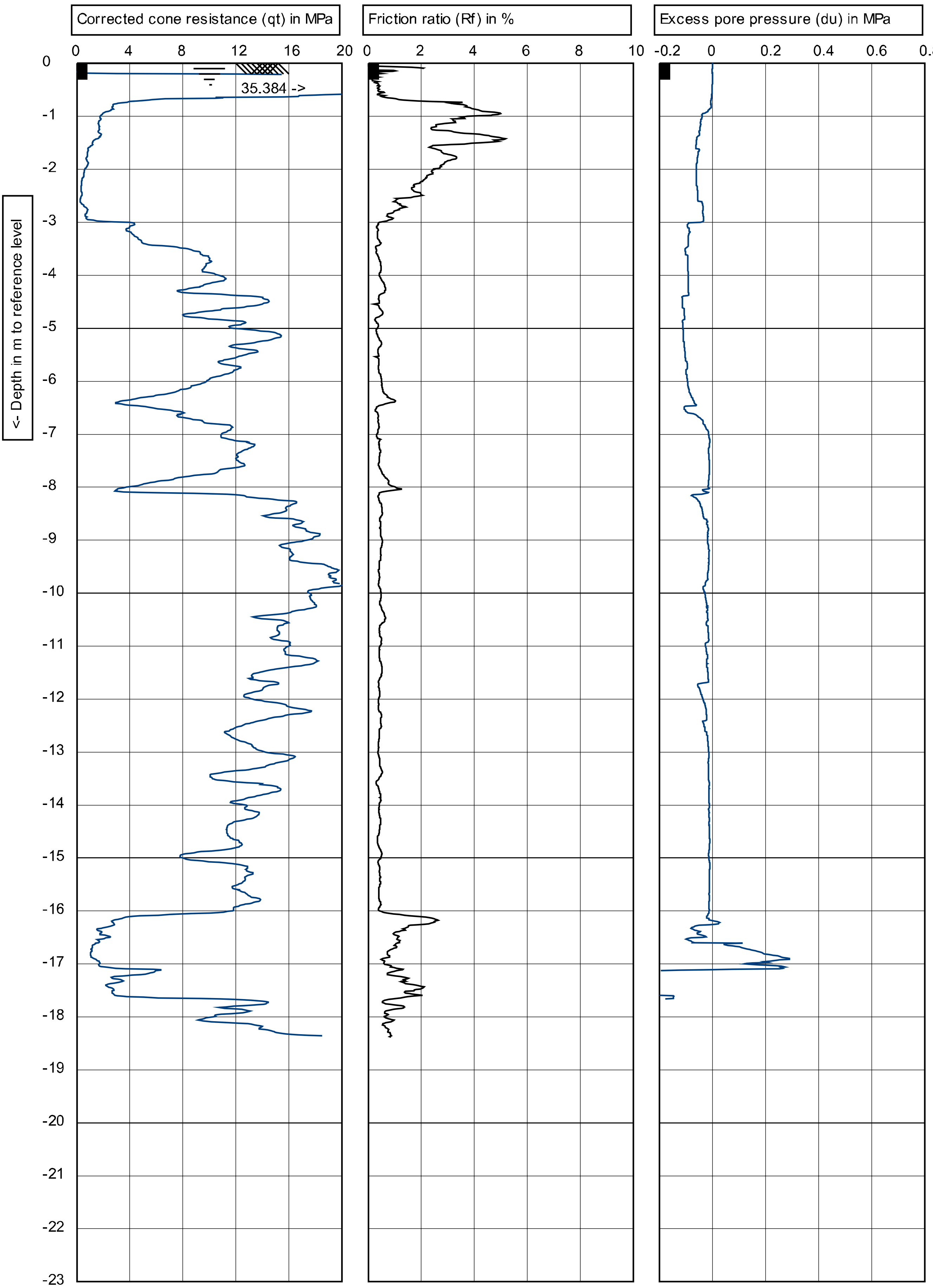




OPUS
HAMILTON LABORATORY

CPTask V1.20

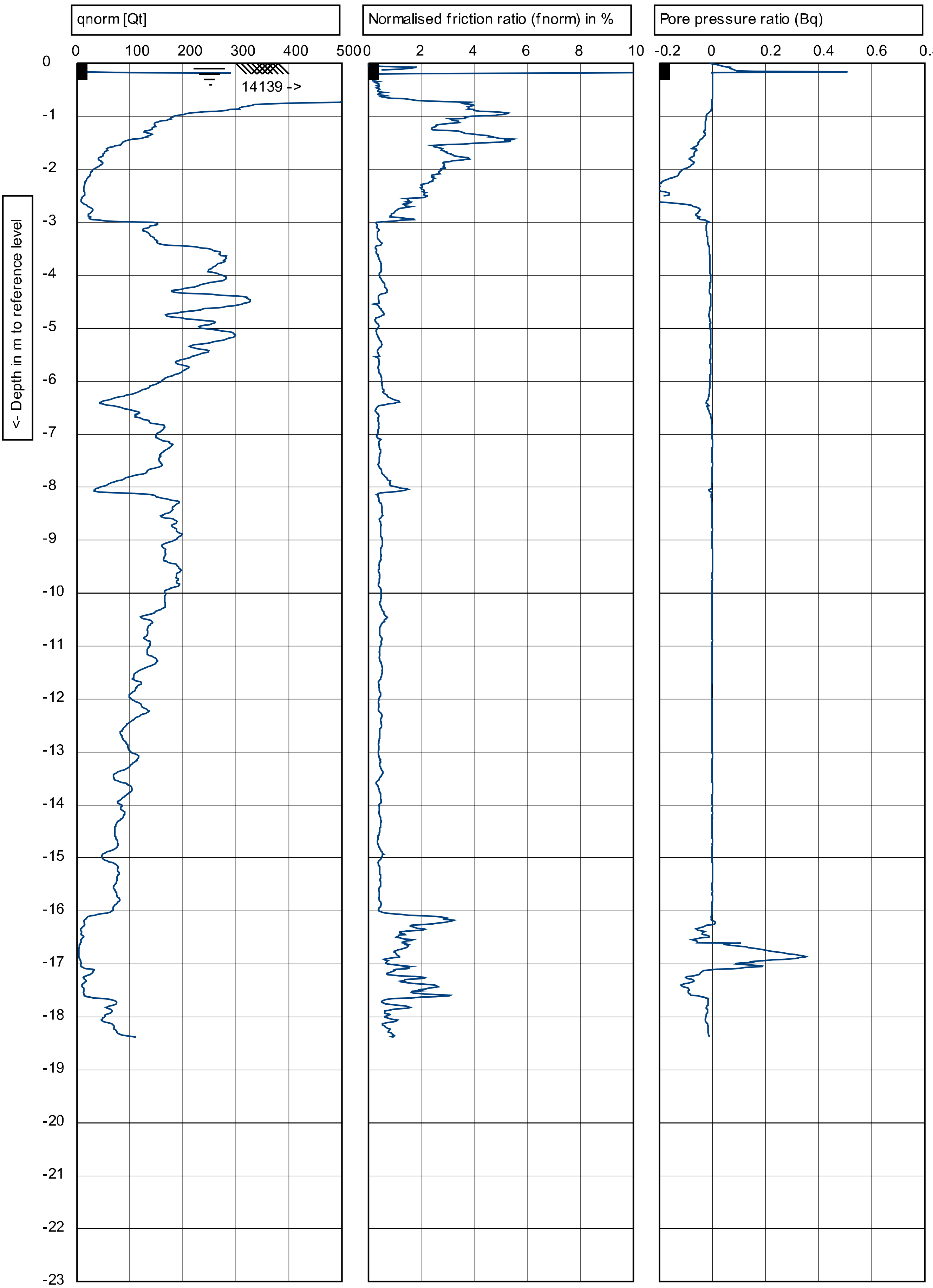
u2 150 cm² 10 cm²	Test according to A.S.T.M standard D-5778-07		Predrill :	0.3
	G.L. **0**	W.L.: **0**	Date:	**15/10/2012**
Project: **Geotechnical Investigation**			Cone no.:	**C10CFIIP.C10021**
Location: **GPS: E1573081 N5178678**			Project no.:	**268292.12_029**
Position:			CPT no.: WST-POD09-CPTBOO3	**1/6**



CPTask V1.20

OPUS
HAMILTON LABORATORY

u2 150 cm² 10 cm²	Test according to A.S.T.M standard D-5778-07		Predrill :	0.3
	G.L. **0**	W.L.: **0**	Date:	**15/10/2012**
Project: **Geotechnical Investigation**			Cone no.:	**C10CFIIP.C10021**
Location: **GPS: E1573081 N5178678**			Project no.:	**268292.12_029**
Position:			CPT no.:	WST-POD09-CPTBOO3 **2/6**



CPTask V1.20

HAMILTON LABORATORY

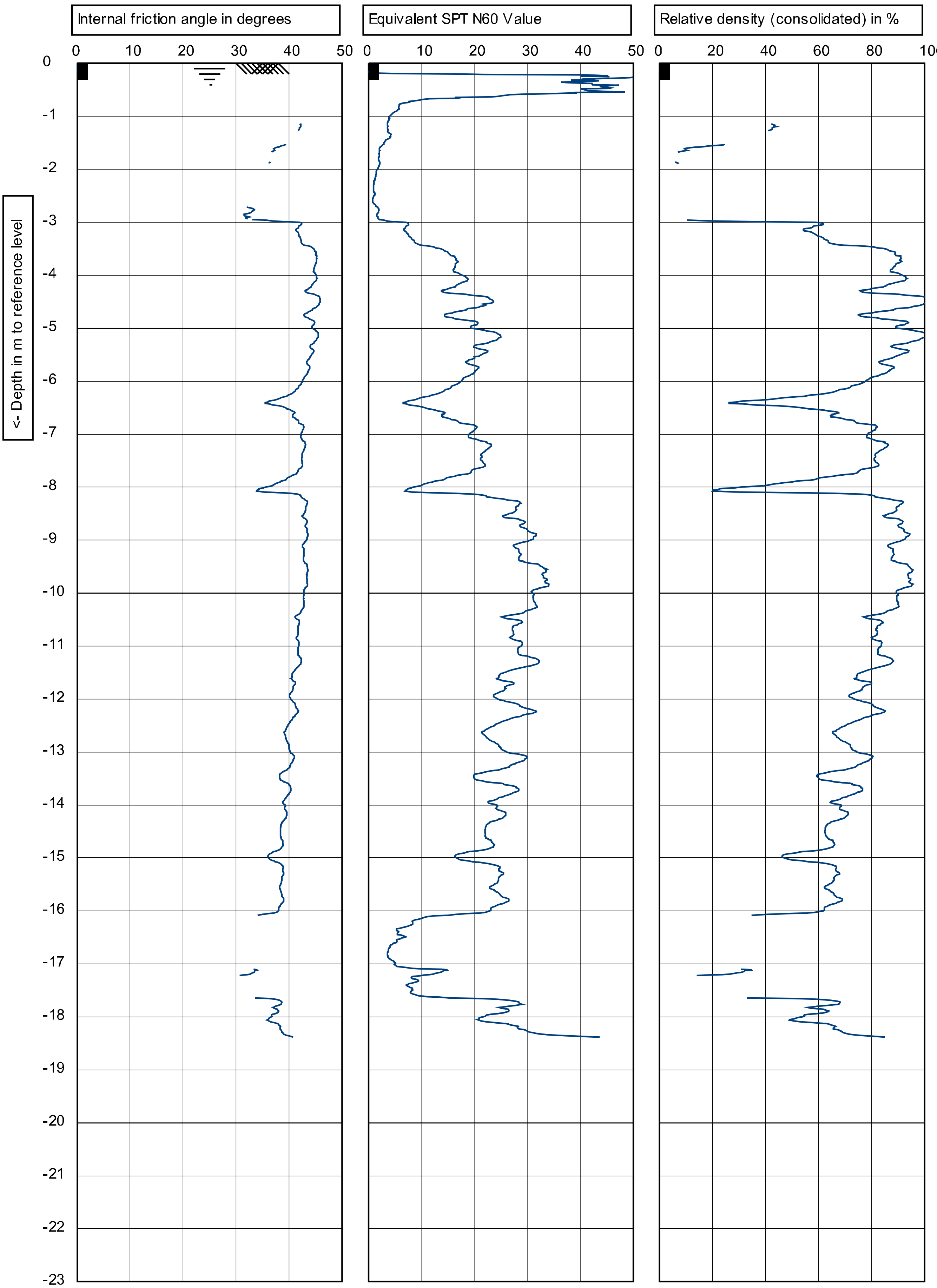
u2
150 cm²
10 cm²

Test according to A.S.T.M standard D-5778-07

G.L.: **0** W.L.: **0**

Project: **Geotechnical Investigation**
Location: **GPS: E1573081 N5178678**
Position:

Predrill :	**0.3**
Date:	**15/10/2012**
Cone no.:	**C10CFIIP.C10021**
Project no.:	**268292.12_029**
CPT no.:	WST-POD09-CPTBOO3 **3/6**

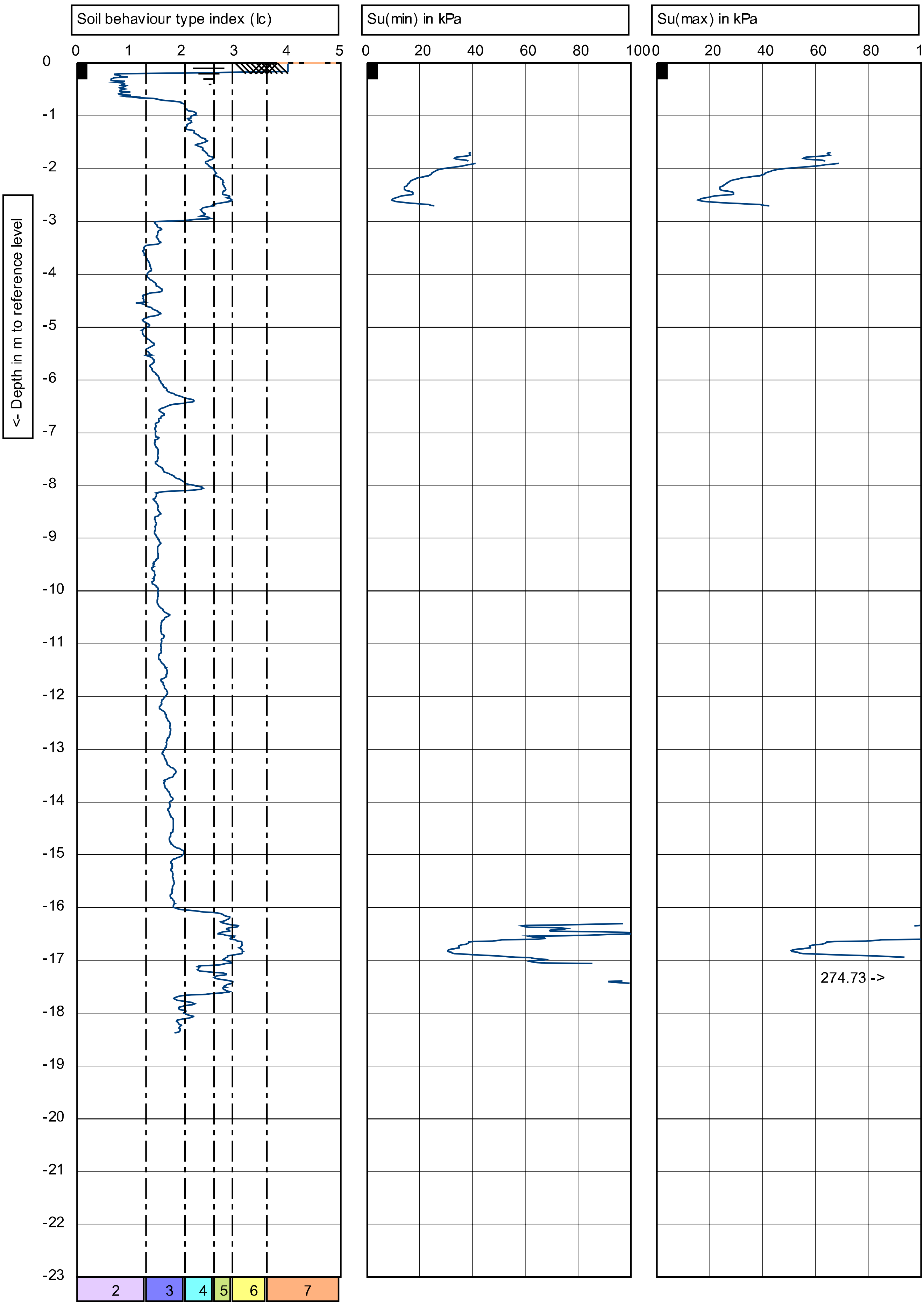


OPUS HAMILTON LABORATORY

u2 150 cm² 10 cm²

Test according to A.S.T.M standard D-5778-07		Predrill :	**0.3**
G.L. **0**	W.L.: **0**	Date:	**15/10/2012**
Project: **Geotechnical Investigation**		Cone no.:	**C10CFIIP.C10021**
Location: **GPS: E1573081 N5178678**		Project no.:	**268292.12_029**
Position:		CPT no.: WST-POD09-CPTBOO3	**4/6**

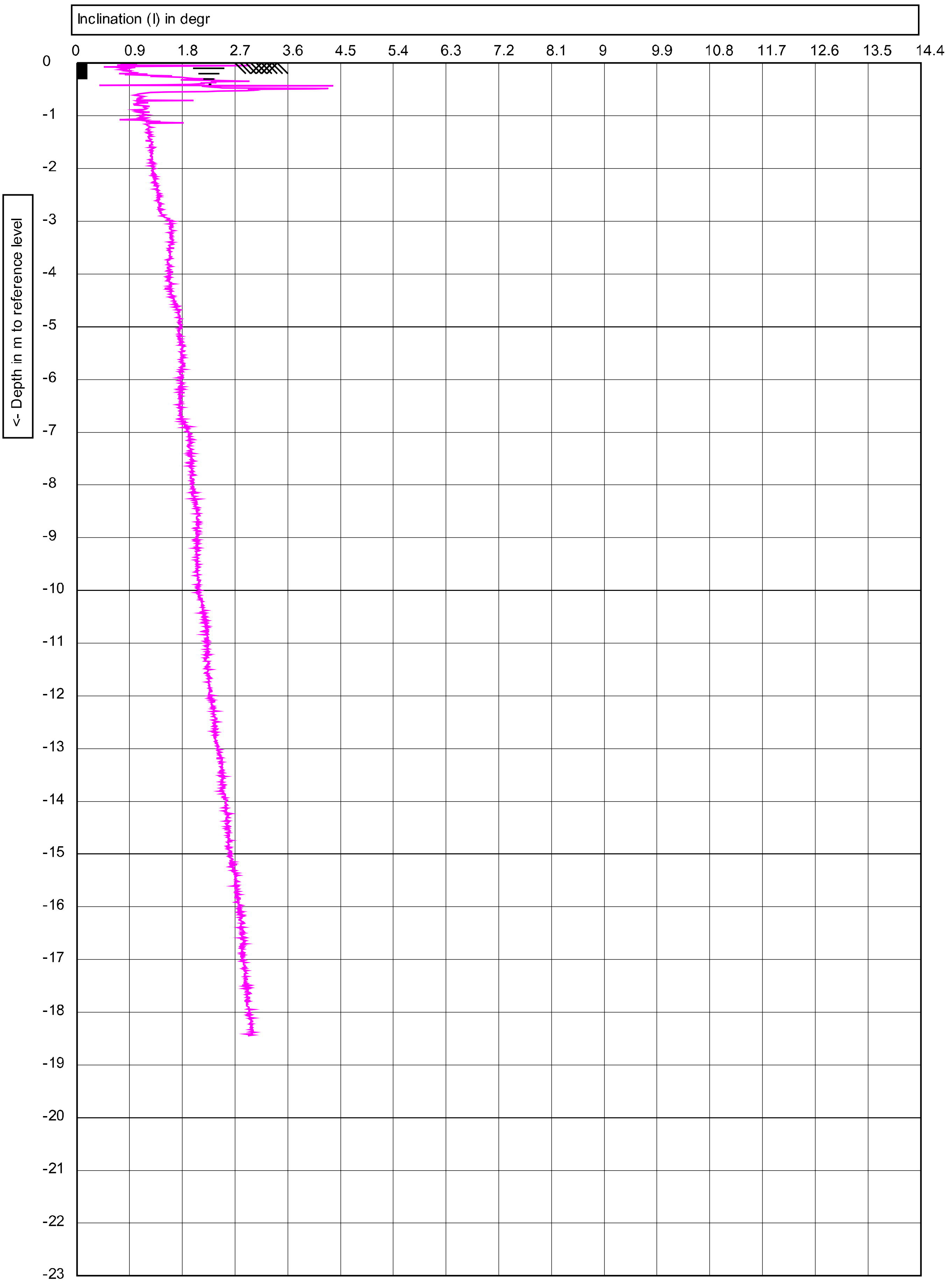
CPTask V1.20



CPTask V1.20

OPUS
HAMILTON LABORATORY

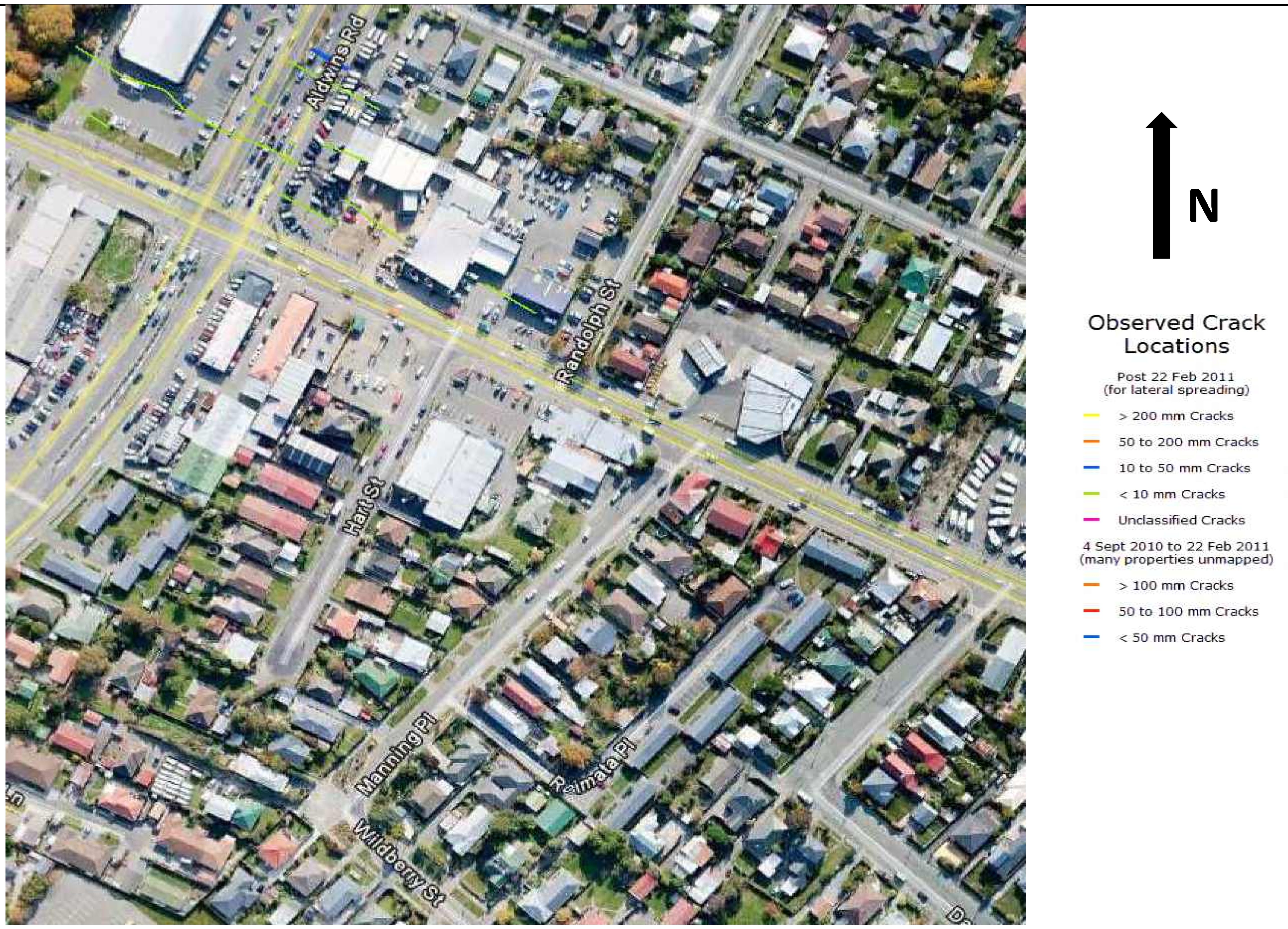
u2 150 cm² 10 cm²	Test according to A.S.T.M standard D-5778-07		Predrill : 0.3
	G.L. 0	W.L.: 0	Date: 15/10/2012
Project: **Geotechnical Investigation**			Cone no.: **C10CFIIP.C10021**
Location: **GPS: E1573081 N5178678**			Project no.: **268292.12_029**
Position:			CPT no.: WST-POD09-CPTBOO3 **5/6**



OPUS HAMILTON LABORATORY	u2 150 cm² 10 cm²	Test according to A.S.T.M standard D-5778-07	Predrill : 0.3
		G.L. 0 W.L.: 0	Date: 15/10/2012
	Project:	Geotechnical Investigation	Cone no.: C10CFIIP.C10021
	Location:	GPS: E1573081 N5178678	Project no.: 268292.12_029
	Position:		CPT no.: WST-POD09-CPTBOO3 6/6

CPTask V1.20

Appendix F:
EQC Map Output



Approximate Scale: 1 to 1000 at A3.

SOURCE:canterburyrecovery.projectorbit.com (Accessed on 21/06/2013)

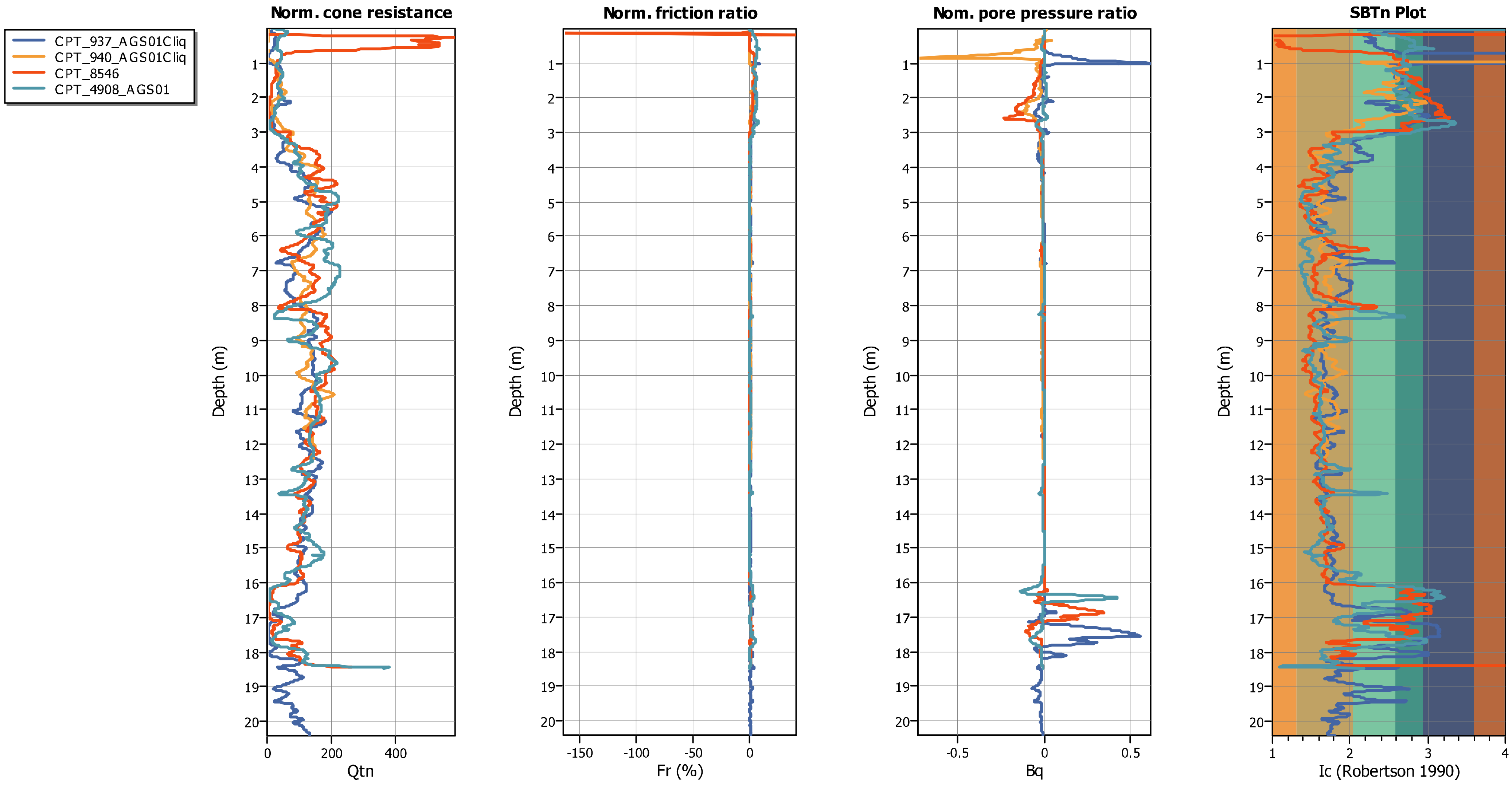
OPUS Opus International Consultants Ltd Christchurch Office 20 Moorhouse Ave PO Box 1482 Christchurch, New Zealand Tel: +64 3 363 5400 Fax: +64 3 365 7857	**Project:** Roimata Place, Woolston **Project No.:** 6-QC398.00 **Client:** Christchurch City Council	**EQC Observed Ground Cracking** **Drawn:** Opus Geotechnical Engineer **Date:** 1-Jul-13

Appendix G:
CLiq Liquefaction Analysis

Opus International Consultants
20 Moorhouse Ave
Christchurch

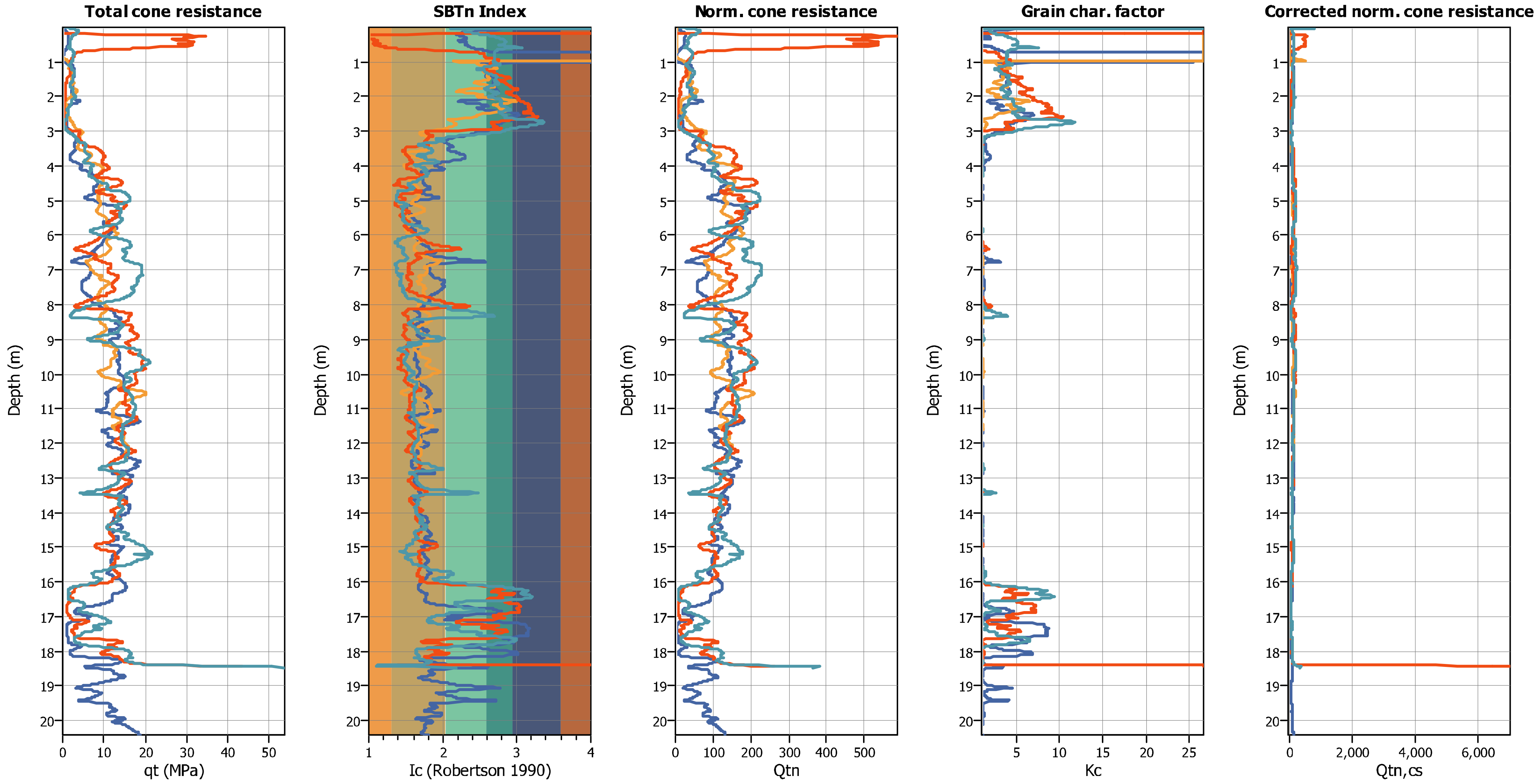
Project: Romiata Place - Geotechnical Desk Study ULS

Overlay Normalized Plots



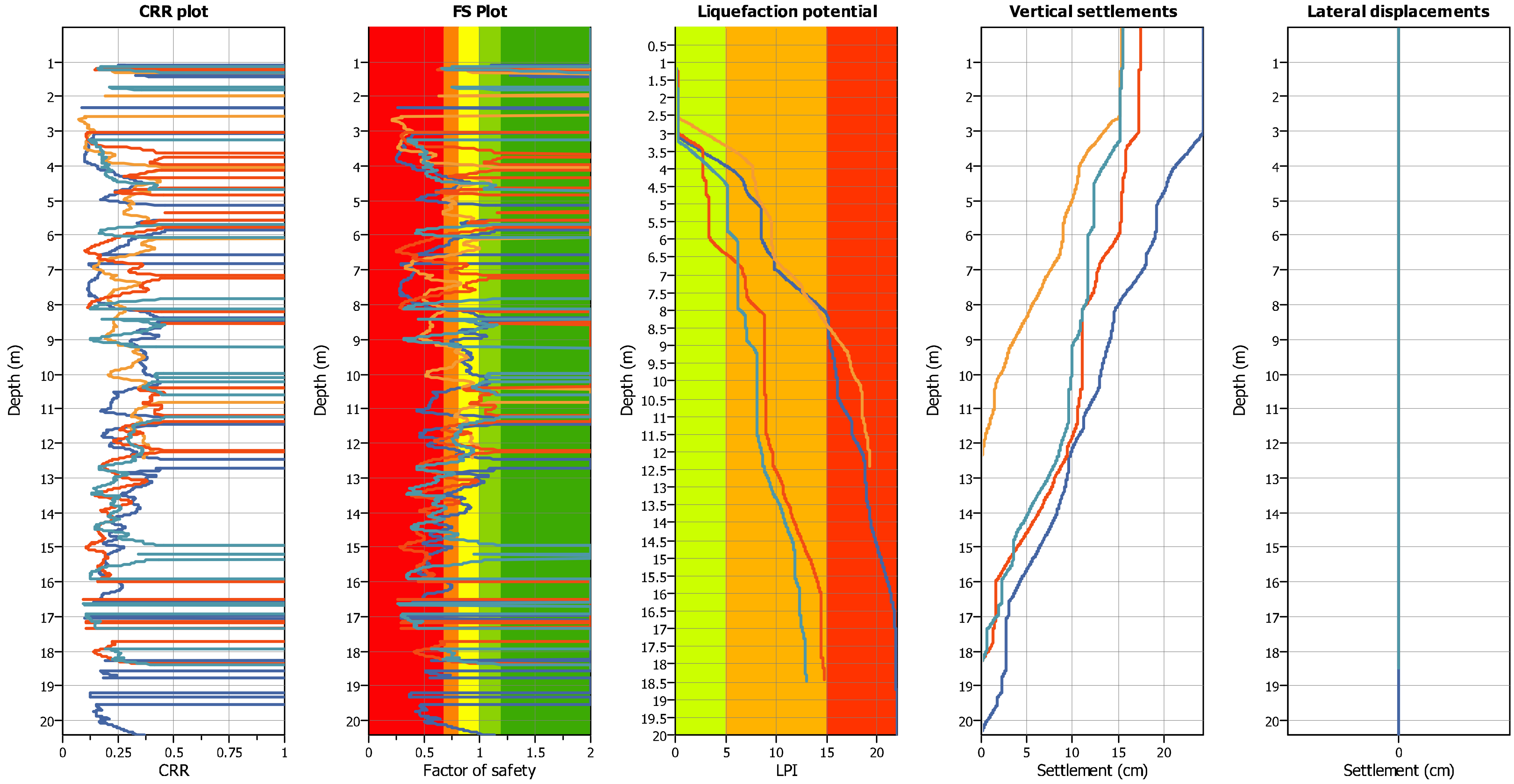
Project: Romiata Place - Geotechnical Desk Study ULS

Overlay Intermediate Results



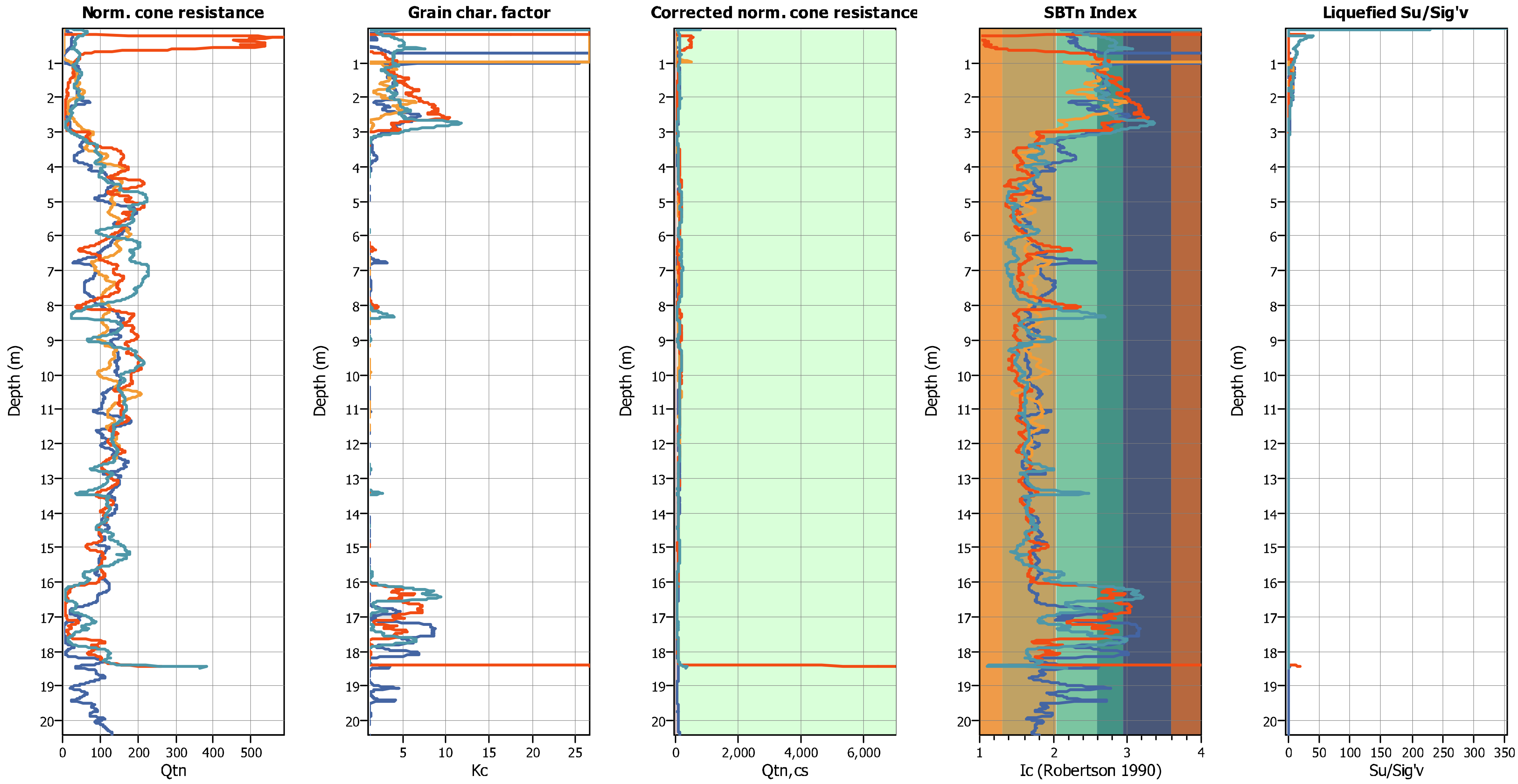
Project: Romiata Place - Geotechnical Desk Study ULS

Overlay Cyclic Liquefaction Plots



Project: Romiata Place - Geotechnical Desk Study ULS

Overlay Strength Loss Plots



Appendix D - Methodology and Assumptions

Seismic Parameters

As per NZS 1170.5:

- T < 0.4s (assumed)
- Soil: Category D
- Z = 0.3
- R = 1.0 (IL2, 50 year)
- N(T,D) = 1.0

For the analyses, a μ of 2 was assumed for the residential units.

Analysis Procedure

As the units are small and have a number of closely spaced walls in both directions, the fibrous plaster board ceilings are assumed to be capable of transferring loads to all walls. It was therefore assumed that a global method could be used to carry the forces down to ground level in each direction. Bracing capacities were found by assuming a certain kN/m rating for the walls along each line. Due to the relatively unknown nature of the walls, the kN/m rating was taken as 3 kN/m for all timber walls with an aspect ratio (height: length) of less than 2:1. This was scaled down to zero kN/m at an aspect ratio of 3.5:1 as per NZSEE guidelines. %NBS values were then found through the ratio of bracing demand to bracing capacity for all walls in each direction.

Additional Assumptions

Further assumptions about the seismic performance of the buildings were:

- Foundations and foundation connections had adequate capacity to resist and transfer earthquake loads.
- Connections between all elements of the lateral load resisting systems are detailed to adequately transfer their loads sufficiently and are strong enough so as to not fail before the lateral load resisting elements.

Appendix E - CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Roimata Place Housing Complex	Reviewer:	Mary Ann Halliday
	Unit / No: / Street	CPEng No:	67073
Building Address:	Units 1-24 / Roimata Place	Company:	OPUS International Consultants Ltd
Legal Description:	Residential Units	Company project number:	6-QC398.00
		Company phone number:	6433635400
	Degrees / Min / Sec		
GPS south:	-43.54449326	Date of submission:	Nov-13
GPS east:	172.6675695	Inspection Date:	19-Jun-13
		Revision:	Final
Building Unique Identifier (CCC):	PRO 0917	Is there a full report with this summary?	yes

Site

Site slope:	slope < 1in 10	Max retaining height (m):	
Soil type:		Soil Profile (if available):	
Site Class (to NZS1170.5):			
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):	4.46

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:	mat slab		if Foundation type is other, describe:
Building height (m):			height from ground to level of uppermost seismic mass (for IEP only) (m):
Floor footprint area (approx):			
Age of Building (years):	40	Date of design:	1965-1976
Strengthening present?		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:	frame system		
Roof:	timber truss	truss depth, purlin type and cladding	
Floors:	concrete flat slab	slab thickness (mm)	
Beams:	timber	type	
Columns:			
Walls:			

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	lightweight timber framed walls			
Ductility assumed, μ:	2.00		note typical wall length (m)	
Period along:	0.10	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	lightweight timber framed walls			
Ductility assumed, μ:	2.00		note typical wall length (m)	
Period across:	0.10	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

leave blank if not relevant

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

Non-structural elements

Stairs:			
Wall cladding:	brick or tile	describe (note cavity if exists)	
Roof Cladding:	Metal	describe	lightweight
Glazing:	aluminium frames		
Ceilings:	strapped or direct fixed		
Services(list):			

Available documentation

Architectural	full	original designer name/date	1972
Structural	full	original designer name/date	1972
Mechanical	none	original designer name/date	
Electrical	none	original designer name/date	
Geotech report	full	original designer name/date	2013

Damage

Site:
(refer DEE Table 4-2)

Site performance:		Describe damage:	
Settlement:		notes (if applicable):	
Differential settlement:		notes (if applicable):	
Liquefaction:		notes (if applicable):	
Lateral Spread:		notes (if applicable):	
Differential lateral spread:		notes (if applicable):	
Ground cracks:		notes (if applicable):	
Damage to area:		notes (if applicable):	

Building:

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

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

Recommendations

	Level of repair/strengthening required:		Describe:	
	Building Consent required:		Describe:	
	Interim occupancy recommendations:		Describe:	
Along	Assessed %NBS before e'quakes:	58%	##### %NBS from IEP below	If IEP not used, please detail assessment methodology: Equivalent Static
	Assessed %NBS after e'quakes:	58%		
Across	Assessed %NBS before e'quakes:	100%	##### %NBS from IEP below	
	Assessed %NBS after e'quakes:	100%		

Opus International Consultants Ltd
20 Moorhouse Avenue
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140
New Zealand

t: +64 3 363 5400
f: +64 3 365 7858
w: www.opus.co.nz