Christchurch City Council

Redcliffs Park Toilets PRK 1400 BLDG 003

Detailed Engineering Evaluation

Quantitative Assessment Report

Christchurch City Council

Redcliffs Park Toilets

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Detailed Engineering Evaluation

Quantitative Assessment Report

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Redcliffs Park Toilets, Redcliffs
PRK 1400 BLDG 003

Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Final

Background

This is a summary of the Quantitative report for the Redcliffs Park Toilets and is based on the Detailed Engineering Evaluation Procedure document issued by the Structural Advisory Group on 19 July 2011, visual inspections on 19 January 2012, available drawings and calculations.

Key Damage Observed

The building structure suffered no visible damage as a result of recent earthquakes. Some damage to the pathway in the close proximity of the building was observed, suggesting some ground movement. There is some evidence of differential movement between the building and the ground immediately adjacent to it.

Critical Structural Weaknesses

No potential critical structural weaknesses have been identified.

Indicative Building Strength

Based on the information available and from undertaking a quantitative assessment, the building's capacity has been assessed to be more than 100% NBS and is therefore not classified as earthquake risk.

Recommendations

No signs of cracking or other damage requiring repair were evident, but a level survey is recommended to confirm the level of differential settlement that has been observed.

It is recommended that the current foundations are accepted and CCC accepts that future differential settlement and damage to services may occur at this site.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Redcliffs Park toilet building, located in Redcliffs, Christchurch, following the M6.3 Christchurch earthquake on 22 February 2011.

The purpose of the assessment is to determine if the building is classed as being earthquake prone or earthquake risk 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) on 19 July 2011.

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.

Any building with a capacity of less than 33% of new building standard (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% as required by 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).

Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) 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 CCC as being 67% of the strength of an equivalent new building. 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 2006. This policy was amended immediately following the Darfield Earthquake on 4 September 2010.

The 2010 amendment 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.

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:

- 36% increase in the basic seismic design load for Christchurch (Z factor increased from 0.22 to 0.3);
- 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	Improvement of Structural Performance: Legal Requirement	Improvement of Structural Performance: 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 required under Act)	Unacceptable	Unacceptable

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

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). It is noted that the current seismic risk in Christchurch results in a 6% risk of exceedance 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, 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/Christchurch City Council guidelines. Opus has not undertaken any assessment of the potential falling hazard due to the rock face located approximately 20m to the rear of the subject building – such an assessment is outside the scope of this project. However, if such an assessment has not been completed by others Opus can provide this service upon your request.

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.

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

4 Building Description

4.1 General

The subject building is located at Redcliffs Park, Redcliffs, Christchurch, and is a single storey small rectangular reinforced concrete masonry unit (CMU) building (approximately 4m x 2.5m with 3.5m ridge height) with a lightweight pitched roof comprising steel hollow section trusses and timber purlins. All of the walls stop at eaves level and the building is divided in half across its width by a CMU partition wall. The building is situated on a gently sloping site and is assumed to be founded on a concrete ground slab.

The building is according to the DBH Residential Technical Category in an area adjacent that categorised as Technical Category 3 i.e. at risk of moderate to significant damage due to liquefaction.

4.2 Gravity Load Resisting System

The gravity load resisting system consists of timber purlins bolted to steel hollow section roof trusses supporting the roof cladding bearing on, and bolted to, concrete masonry unit (CMU) perimeter and partition walls on what appears to be a concrete slab on grade.

4.3 Seismic Load Resisting System

Seismic loads in both principal directions are resisted by the perimeter CMU shear walls, with the internal partition wall acting in the transverse direction as an additional shear wall to distribute the lateral loads to and from the external wall elements.

There is no ceiling and no effective diaphragm within the plane of the roof, however it is assumed that horizontal reinforcement of 16 diameter bars of 300Mpa yield strength are present at the head of all walls, providing a bond beam as would have been typical for the time at which the building was designed. Similarly, the CMU walls are assumed to be reinforced vertically with 10 diameter reinforcement bars of 300 MPa yield strength at 400mm centres and cells are assumed to be fully filled.

No opening up works have been undertaken to investigate the foundations.

5 Survey

Although the survey was non-intrusive, the exposed nature of the construction and the accessibility of connection details enabled a detailed assessment to be made.

No structural design calculations or drawings have been obtained for this building.

At the time of the structural survey, no excavation was undertaken to ascertain the thickness of the floor slab. It has been assumed that the slab has an edge thickening projecting 200mm into the ground, with a general slab thickness of 100mm.

6 Damage Assessment

The building superstructure suffered no visible damage as a result of recent earthquakes. Some damage to the pathway in the close proximity of the building was observed, suggesting some ground movement, and visual observations suggest that the foundations have differentially settled towards the south.

7 General Observations

Overall the building has performed well under seismic conditions.

8 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 16 May 2012, and the SESOC guidelines "Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes" [5] issued on 21 December 2011.

8.1 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 critical structural weaknesses have been identified with this building. The toilet block is located on an area identified as having 'moderate liquefaction ground damage potential', for a low groundwater scenario. Moderate ground damage potential indicates the ground may be affected by 100mm to 300mm of subsidence in a future seismic event.

8.2 Seismic Coefficient Parameters

The seismic design parameters based on current design requirements from NZS1170.5:2004 and the NZBC clause B1 for this building are:

- Site soil class D, clause 3.1.3 NZS 1170.5:2004;
- Site hazard factor, Z=0.3, B1/VM1 clause 2.2.14B;
- Return period factor R_u = 1.0 from Table 3.5, NZS 1170.5:2004, for an Importance Level 2 structure with a 50 year design life;
- μ_{max} = 1.25 for a reinforced CMU shear wall building without special steel detailing.
- It is assumed that the building was designed for a seismic hazard factor of Z = 0.22 versus the current code requirement of Z = 0.3 (0.73 times current code.)

8.3 Detailed Seismic Assessment Results

A summary of the structural performance of the building is shown in the following table. Note that the values given represent the worst performing elements in the building, as these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing element.

Table 2 - Summary of Seismic Performance

Structural Element/System	Failure mode and description of limiting criteria	Critical Structural Weakness and Collapse Hazard	% NBS based on calculated capacity
CMU walls in-plane	Capacity of reinforced masonry	No	>100%
Walls out-of-plane	flexure	No	>100%
Bond beam at head of CMU walls	flexure	No	>100%
Foundation slab	Resistance to sliding	No	>100%

8.4 Discussion of Results

The building has a calculated capacity of greater than 100%.

The building superstructure has performed well in earthquakes to date, showing no obvious signs of damage to the superstructure. By calculation, the building achieves a value in excess of 100% NBS and therefore no seismic strengthening is required.

8.5 Limitations and Assumptions in Results

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

9 Geotechnical Assessment

This is a summary of the Geotechnical Desk Study completed by Opus International Consultants dated 7 November 2012. A copy of the report can be found in Appendix B.

9.1 Regional Geology

As a result of the September 2010 to December 2011 Canterbury Earthquakes; ground cracking, rock fall and lateral spreading have occurred in the vicinity of the Redcliffs Park Toilet Block.

The toilet block appears to be founded on a shallow concrete pad of unknown depth. The existing foundations appear to have performed relatively well, but visual observations suggest that the building has differentially settled towards the south.

Significant ground shaking which has occurred in the vicinity of the site has resulted in foundation damage to the building directly north, the house directly south and significant rockfall 20m west.

Seismic shaking is the most likely cause of the 25mm to 30mm wide cracking in the footpath directly north of the toilet block. No settlement of the footpath was observed. Settlement of the footpath along Main Road directly west of the building and the leaning street lights, is inferred to have been a result from consolidation of the underlying fill material.

The estuary is located 150m north of the toilet block and lateral spread damage has been observed within the closest 30m of reclaimed land adjacent to the water’s edge. There has been no indication of lateral spreading damage in the immediate vicinity of the toilet block.

No site specific investigation results have been available for review at the time of reporting. No level survey, verticality survey or site investigations have been undertaken as part of this Geotechnical Desk Study.

GNS Science indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice (Geonet) indicates there is currently a 13% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. Ground damage is similar to what has been observed is anticipated in such an event, dependent on the location of the epicentre. It is expected that the probability of occurrence is likely to decrease with time, following periods of reduced seismic activity.

The services appear to be in good working order.

A level survey may be undertaken to quantify the observed differential settlement. The foundations may be accepted based on the relatively good performance in the recent seismic events. CCC will need to accept that further differential settlement and damage to services is likely to occur in future seismic events.

If CCC wishes to confirm the underlying soil profile and liquefaction potential of the site, site specific investigations are recommended. Due to the cost of these tests and the relatively good performance of the toilet block, site specific investigations seem unwarranted.

10 Conclusions

The building has a seismic capacity of at least 100%, and is therefore not classified as earthquake risk.

11 Recommendations

It is recommended that;

(a) A level survey is undertaken to confirm the differential settlement that has been observed.

(b) The current foundations are accepted and CCC accepts that future differential settlement and damage to services may occur at this site.

12 Limitations

(a) This report is based on an inspection of the structure with a focus on the damage sustained from the 22 February 2011 Canterbury Earthquake and aftershocks only. Some non-structural damage is mentioned but this is not intended to be a comprehensive list of non-structural items.

(c) 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 the time.

(d) This report is prepared for the CCC to assist with assessing remedial works required for council buildings and facilities. It is not intended for any other party or purpose.

13 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, Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes, Structural Engineering Society of New Zealand, 21 December 2011.

Appendix A – Photographs

			
1	Elevation (W)	2	Front elevation (NW)
			
3	Gable (NE)	4	Ground level rise to rear
			
5	Rear elevation (SE)	6	Gable, internal

			
7	Partition wall	8	Front elevation internal showing front pier
			
9	Roof/wall connection detail	10	Purlin/truss connection detail
			
11	Roof detail	12	Ridge detail

			
13	Partition wall/roof detail	14	Jack-rafter detail
			
15	Cracking to path in vicinity of building	16	Location
			
17	Location/General topography		

Appendix B – Geotechnical Desk Study

Geotechnical Desk Study – Redcliffs Park Toilet Block

1. Introduction

Christchurch City Council (CCC) has commissioned Opus International Consultants (Opus) to undertake a Geotechnical Desk Study and site walkover of the Redcliffs Park Toilet, Christchurch. 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 investigations are required. The site walkover was completed by Opus International Consultants on 19 June 2012.

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 Redcliffs Park Toilet Block is located on the south western boundary of Redcliffs Park at 7 Main Road. The toilet block is bounded by Main Road to the west, residential properties to the south and Redcliff Park to the north and east.

The toilet block occupies an approximate footprint of $8m^2$ and is constructed of concrete masonry with a light timber framed roof. The internal walls and floor have been lined with tiles.

The ground profile surrounding the toilet block is relatively flat, low lying and is typically level with the surrounding road. The land gently slopes downwards towards the east, where the playing field is located. The grounds surrounding the site are generally paved surfaces and planted gardens.

2.2 Structural Drawings

No structural drawings detailing the existing foundation type were made available during the writing of this report.

No geotechnical investigations or geotechnical reports associated with the building design were available on the CCC property file.

2.3 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 located on dominantly sand of fixed and semi-fixed dunes and beaches.

2.4 Expected Ground Conditions

A review of the Environmental Canterbury (ECan) wells database showed three wells located within approximately 350m of the property (refer to Site Location Plan in Appendix B). The locations of Boreholes and Cone Penetrometer Test's (CPT) undertaken by the Earthquake Commission (EQC) have been reviewed. Two CPT's have been identified approximately 400m south east of the toilet block (refer to the Site Location Plan in Appendix B).

Material logs available from the above sources have been used to infer the ground conditions at the site, as shown in Table 1 below.

Table 1: Inferred Ground Conditions.

Stratigraphy	Thickness (m)	Depth Encountered (m)
Silty SAND (1)	23.2-23.7m	Surface
Sand and Gravel (1)	1.5-9.8m	23.2-23.7m
Clay	-	25.2-33.0m
Note: *(1) Potentially Liquefiable*		

The CPT's RCL-01 and RCL-02 refused at approximate depths of 0.75m and 25.5m, respectively.

A groundwater depth of approximately 0.5m to 1.5m below ground level has been interpreted from groundwater depth contour maps (Brown and Weeber (1992)).

2.5 Liquefaction Hazard

A liquefaction hazard study was conducted by Environment Canterbury (ECan) in 2004 to identify areas of Christchurch susceptible to liquefaction during an earthquake. The toilet block is located on an area identified as having 'moderate liquefaction ground damage potential', for a low groundwater scenario. Moderate ground damage potential indicates the ground may be affected by 100mm to 300mm of subsidence in a future seismic event.

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. There has been very minor evidence from these aerial photos of liquefaction in the vicinity of the site after the recent seismic events.

Redcliffs Park Toilet block has been zoned as N/A-Urban Non-residential. However, the neighbouring residential properties 5m south of the toilet block has been zoned as Green-TC2 "yellow zone", which is determined to have a minor to moderate risk of land damage due to liquefaction in future significant earthquakes. Residential properties 170m north east of the building which has been zoned as Green-TC3 "blue zone", indicating moderate to significant risk of land damage due to liquefaction in future significant earthquakes.

2.6 Lateral Spreading Hazard

Significant lateral spreading has been observed along the 30m of reclaimed land closest to the estuary.

At its closest point the estuary is located 150m to the north. The vicinity of the building, along with the inferred ground conditions, indicates there is a moderate lateral spreading hazard at this site.

2.7 Rockfall Hazard

The Port Hills Geotechnical Group (PHGG) Geotechnical Engineer in charge of this area of interest released the following statement (dated 25 June 2012) in regards to the rockfall hazard of this toilet block:

"In the Redcliffs Park site there is a highly unstable cliff across the road (Moa Bone point). The toilet block is beyond the modelled rockfall limit for individual blocks. A large scale collapse may however result in debris reaching the block. This isn't thought to be likely at this time but not impossible."

The Negligible Risk Line runs along the south west elevation of the toilet block. However, the occupancy level of the toilet block is less than that used in the Cliff Collapse model which reduces the risk furthermore.

3. Site Walkover Inspection

A walkover inspection of the exterior, interior, and adjacent paved area was carried out by an Opus Geotechnical Engineer on 19 June 2012. The following observations were made (refer to the Walkover Inspection Plan and Site Photos attached to this report):

- No cracking of the internal tiles were observed.
- Cracking, 20mm to 30mm wide, has been observed in the paved footpath along the north of the building (Figure 2).
- Street Lights along Main Road approximately 4m west are leaning towards the east (Figure 4).
- Visual observations suggest that the toilet block has differentially settled towards the south.
- The residential house 5m to the south east has suffered significant damage to the exterior masonry facade.
- The neighbouring building located 4m north of the toilet block appears to have been laterally offset off its piles by approximately 100mm. The piles located on the north of the building have rested in a horizontal position (Figure 6).
- Shipping containers have been placed along the western side of Main Road approximately 20m west of the toilet block as part of a rock fall protection scheme (Figure 5).
- The footpath 4m west has settled by up to 30mm relative to the concrete kerb (Figure 3).

4. Discussion

As a result of the September 2010 to December 2011 Canterbury Earthquakes; ground cracking, rock fall and lateral spreading have occurred in the vicinity of the Redcliffs Park Toilet Block.

Flooding and tidal risks to this site have not been assessed as part of this geotechnical desk study.

The toilet block appears to be founded on a shallow concrete pad of unknown depth. The existing foundations appear to have performed relatively well, but visual observations suggest that the building has differentially settled towards the south.

Significant ground shaking has occurred in the vicinity of this site which has resulted in foundation damage to the building directly north, the house directly south and significant rockfall 20m west.

Seismic shaking is the most likely cause of the 25mm to 30mm wide cracking in the footpath directly north of the toilet block. No settlement of the footpath was observed.

Settlement of the footpath along Main Road directly west of the building and the leaning street lights, is inferred to have been a result from consolidation of the underlying fill material.

The estuary is located 150m north of the toilet block and lateral spread damage has been observed within the closest 30m of reclaimed land adjacent to the water's edge. There has been no indication of lateral spreading damage in the immediate vicinity of the toilet block.

No site specific investigation results have been available for review at the time of reporting.

No level survey, verticality survey or site investigations have been undertaken as part of this Geotechnical Desk Study.

GNS Science indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice (Geonet) indicates there is currently a 13% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. Ground damage similar to what has been observed is anticipated in such an event, dependent on the location of the epicentre. It is expected that the probability of occurrence is likely to decrease with time, following periods of reduced seismic activity.

The services appear to be in good working order.

A level survey may be undertaken to quantify the observed differential settlement. The foundations may be accepted based on the relatively good performance in the recent seismic events. CCC will need to accept that further differential settlement and damage to services is likely to occur in future seismic events.

If CCC wish to confirm the underlying soil profile and liquefaction potential of the site, site specific investigations are recommend. Due to the cost of these tests and the relatively good performance of the toilet block, site specific investigations seem unwarranted.

5. Recommendations

It is recommended that;

- A level survey is undertaken to confirm the differential settlement that has been observed.
- The current foundation are accepted, based on the provision that the Structural Engineers can confirm that the toilet block has the capacity for further differential settlement, and CCC accepts that future differential settlement and damage to services may occur at this site.

6. Limitations

This report has been prepared solely for the benefit of 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.

7. 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. Institute of Geological and Nuclear Sciences Limited, Lower Hutt, New Zealand

Environment Canterbury, Canterbury Regional Council (ECan) website:

ECan Well Card

http://ecan.govt.nz/services/online-services/tools-calculators/Pages/well-card.aspx

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://canterburyrecovery.projectorbit.com/SitePages/Home.aspx

GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury-quakes/aftershocks/ updated on 7 September 2012.

Appendices:

Appendix A: Site Photographs

Appendix B: Land Zone Recovery, Site Location and Site Walkover Plans

Appendix C: Surrounding Site Investigation Data

Appendix A:
Site Photographs

Figure 1: North eastern view of the Redcliffs Park Toilet Block.

Figure 2: 20mm to 30mm wide cracking of the paved footpath north of the building

Figure 3: Main Road footpath has settled 30mm relative to the kerb.

Figure 4: Street Lights along Main Road lean towards the east.

Figure 5: Shipping containers are being used as a rockfall protection scheme along the western side of the Main Road.

Figure 6: Foundation damage to the neighbouring building towards the north.

Appendix B:
Land Recovery Zone Plan
Site Location Plan
Site Walkover Plan

0m 100m

Approximate Scale: 1:1400 (A3)

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Christchurch, New Zealand
Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Redcliffs Park Toilet Block Geotechnical Desk Study

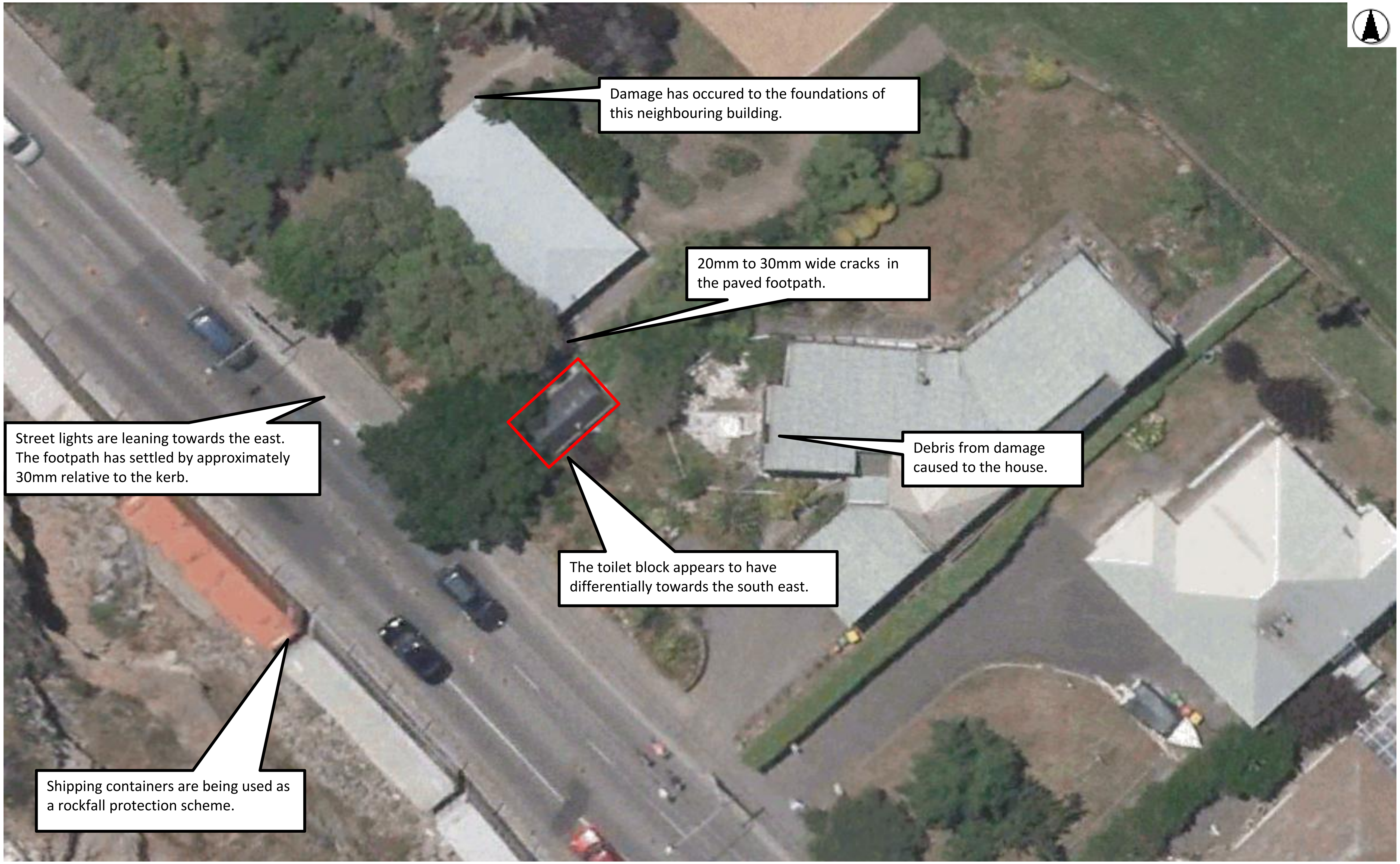
Project No.: 6-QUCC1.14

Client: Christchurch City Council

Land Recovery Zones

Drawn: Opus Geotechnical Engineer

Date: 25/07/2012



OPUS

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Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Redcliffs Park Toilet Block Geotechnical Desk Study

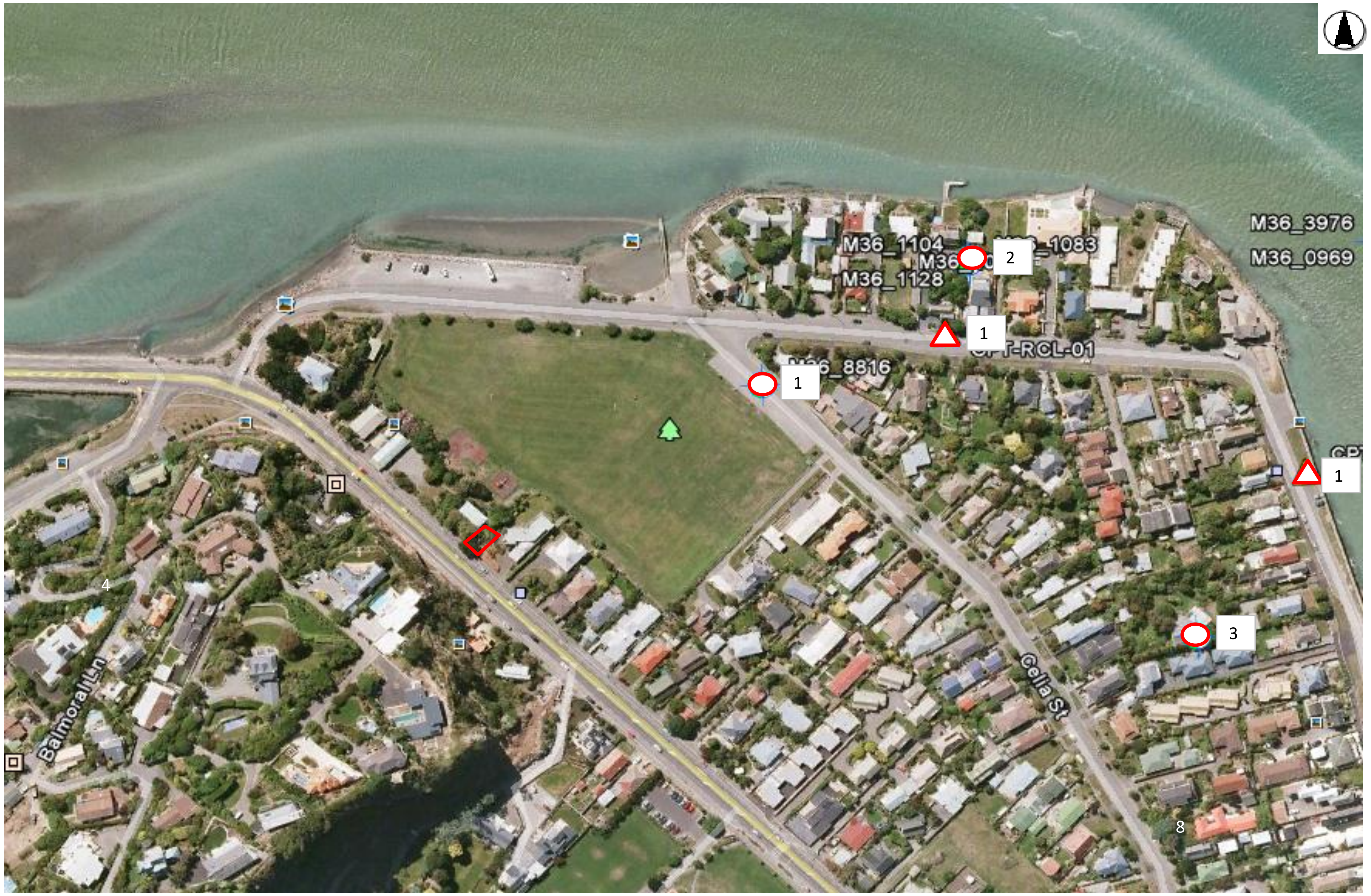
Project No.: 6-QUCC1.14

Client: Christchurch City Council

Site Walkover Plan

Drawn: Opus Geotechnical Engineer

Date: 25-Jul-12



0 — 100m
Approximate Scale: 1:2500 (A3)

△ EQC CPT
○ ECan Borehole

BH	ECan Ref
1	M36/8816
2	M36/1104
3	M36/1128

CPT	EQC Ref
4	CPT-RCL-01
5	CPT-RCL-02

OPUS
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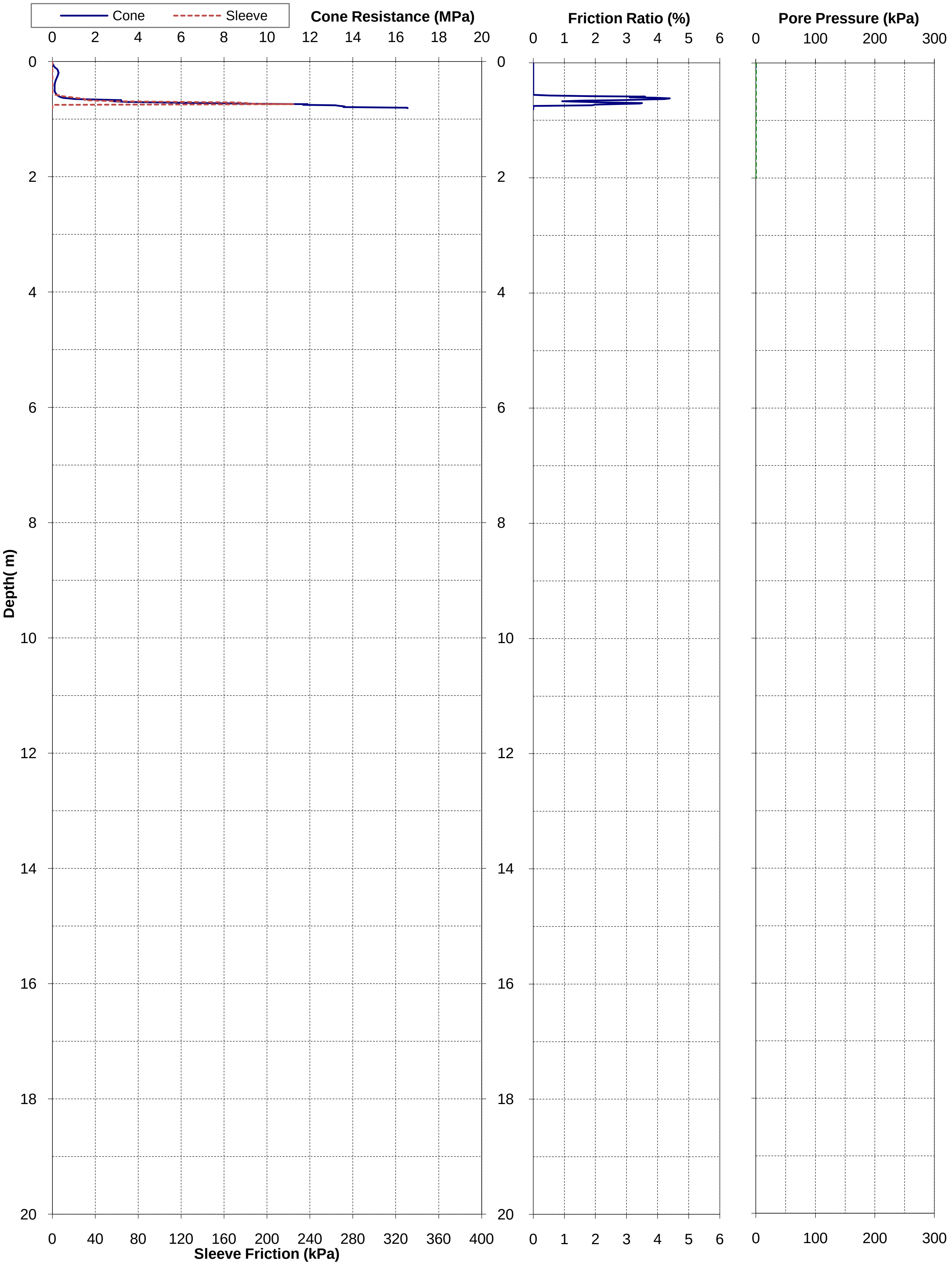
Project: Redcliffs Park Toilet Geotechnical Desk Study
Project No: 6-QUCC1.13
Client: Christchurch City Council

Site Location Plan

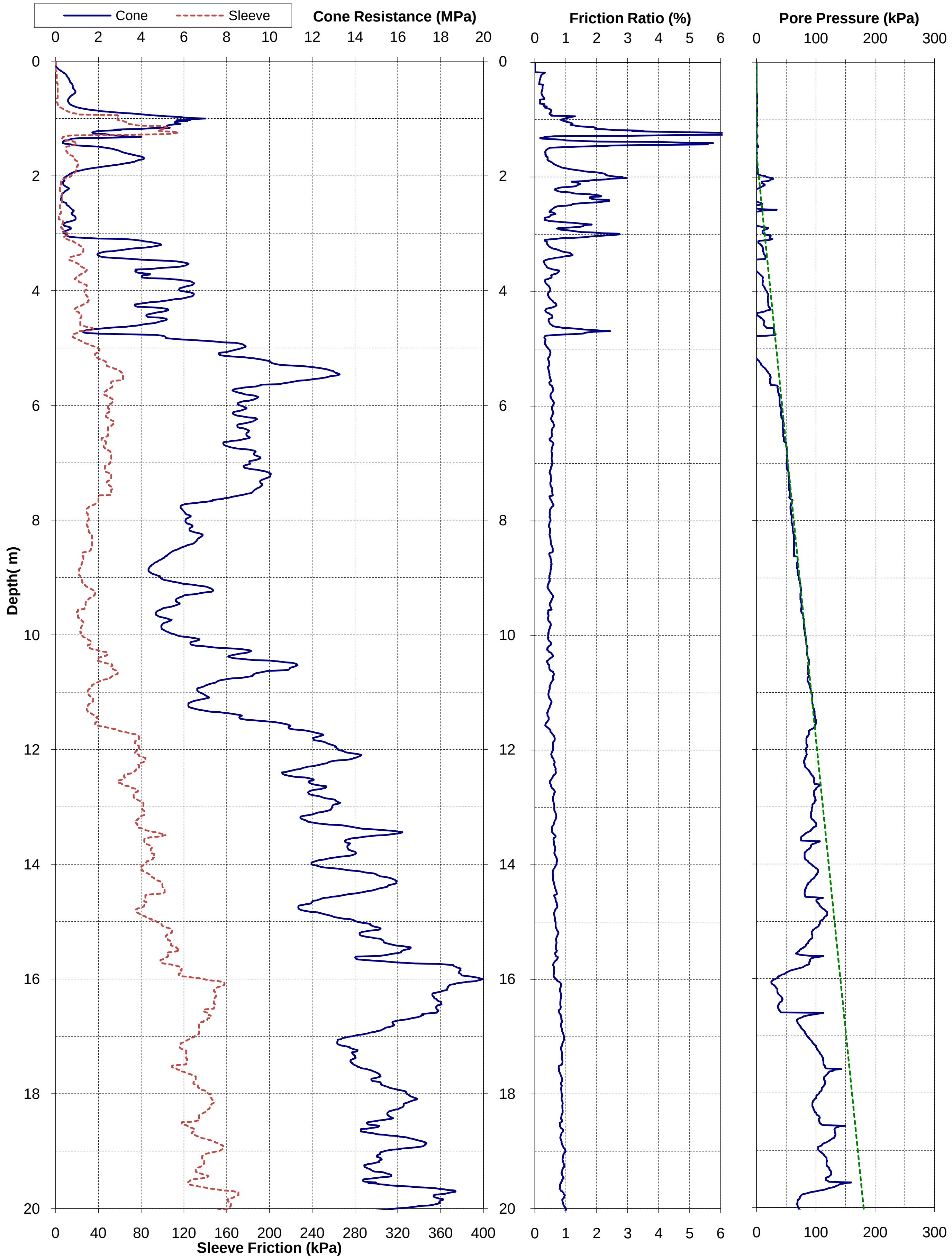
Drawn: Opus Geotechnical Engineer
Date: 18/07/2012

Appendix C:
Surrounding Site Investigation Data

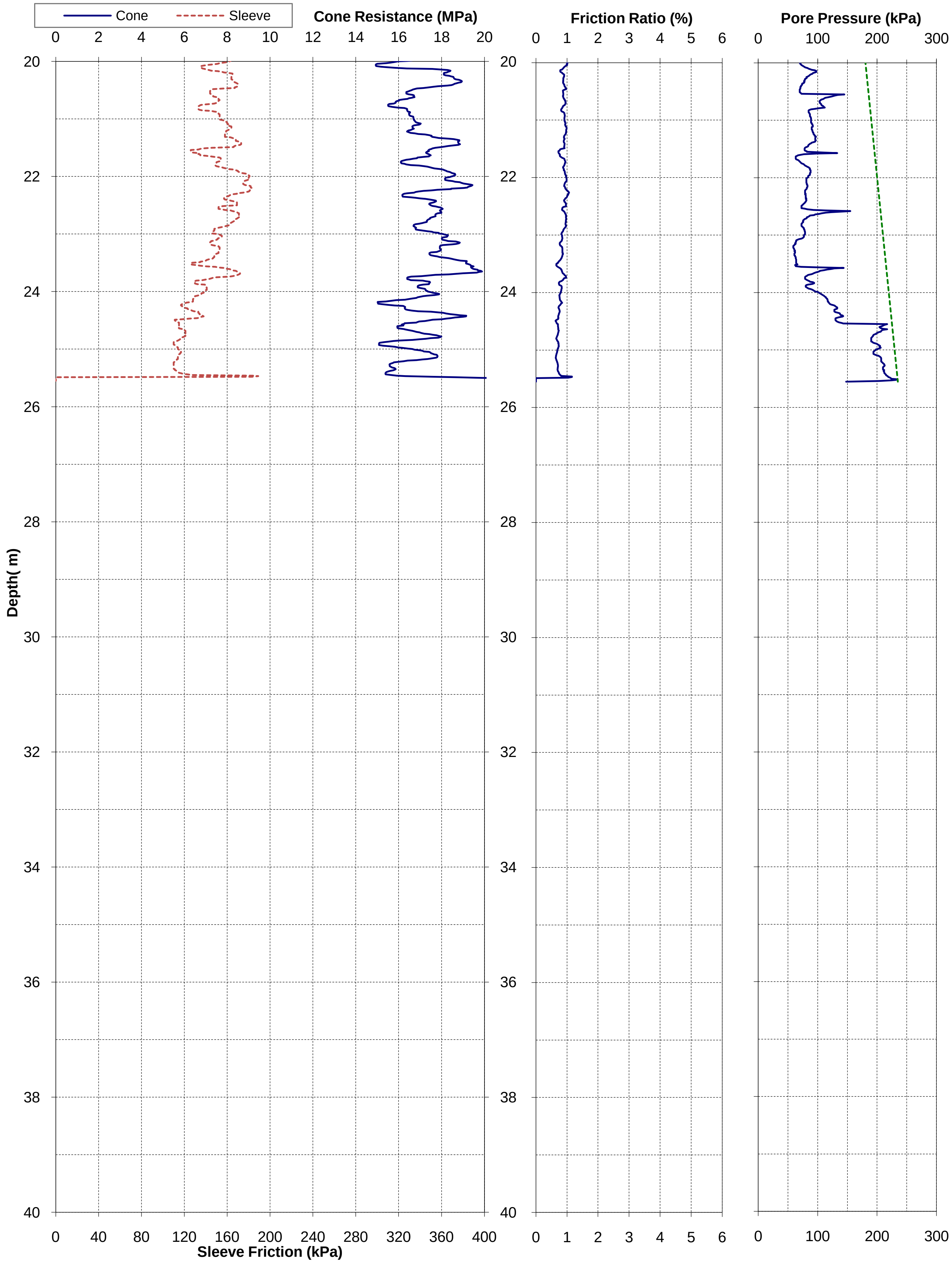
Project:	Darfield 2010 Earthquake - EQC Ground Investigations			**Page:** 1 of 1	**CPT-RCL-01**
Test Date:	6-Dec-2010	**Location:**	Redcliffs	**Operator:**	Opus
Pre-Drill:	1.2m	**Assumed GWL:**	2mBGL	**Located By:**	Survey GPS
Position:	2488686.5mE	5738964.2mN	1.56mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	



Project:	Darfield 2010 Earthquake - EQC Ground Investigations			**Page:** 1 of 2	**CPT-RCL-02**
Test Date:	6-Dec-2010	**Location:**	Redcliffs	**Operator:**	Opus
Pre-Drill:	1.2m	**Assumed GWL:**	1.6mBGL	**Located By:**	Survey GPS
Position:	2488857.6mE	5738882mN	1.72mRL	**Coord. System:**	NZMG & MSL
Other Tests:				**Comments:**	



Project:	Darfield 2010 Earthquake - EQC Ground Investigations				Page: 2 of 2	CPT-RCL-02
Test Date:	6-Dec-2010	Location:	Redcliffs	Operator:	Opus	
Pre-Drill:	1.2m	Assumed GWL:	1.6mBGL	Located By:	Survey GPS	
Position:	2488857.6mE	5738882mN	1.72mRL	Coord. System:	NZMG & MSL	
Other Tests:				Comments:		



Borelog for well M36/1128 page 1 of 2

Gridref: M36:887-390 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 1.8 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -139.2m Drill Date : 30/09/1910

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
- 23.1m	Blue sand	ch
- 47.5m	Blue sand & clay	ri-br
- 51.8m	Yellow sand & clay	br
- 57.6m	Blue sand & clay & small rocks	li
- 58.2m	Yellow sand & clay	li
- 58.8m	Brown gravel small flow	li
- 61.5m	Yellow sand & clay, small show of water	li
- 78.0m	Yellow sand, gravel & shells	li

Borelog for well M36/1128 page 2 of 2

Gridref: M36:887-390 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 1.8 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -139.2m Drill Date : 30/09/1910

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
- 78.0m	Yellow sand, gravel & shells	li
- 81.0m	Fine Brown gravel	li-3
- 82.6m	Yellow sand & clay	he
- 90.2m	Grey sand & clay	he
- 91.4m	Rotten rock	he
- 111.5m	Blue clay	he-sh
- 111.8m	Clay & peat	sh
- 117.6m	Blue clay	sh
- 118.5m	Yellow clay	sh
- 122.2m	Yellow clay & rock	sh
- 126.0m	Yellow clay & sand	sh
- 126.7m	Yellow sand & gravel, rise 3.3m 104.8m3/d	wa
- 131.9m	Scoria	vo
- 132.8m	Black rock	vo
- 134.4m	Scoria	vo
- 136.2m	Hard rock	vo
- 136.8m	Scoria	vo
- 139.2m	Very hard rock	vo

Borelog for well M36/1011 page 1 of 2

Gridref: M36:880-390 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 1 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -104.6m Drill Date : 22/11/1944

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
- 23.2m	Blue sand	ch
- 33.0m	Blue sand and gravel	ch
- 38.7m	Blue clay and peat	ri
- 47.0m	Blue clay	br
- 48.5m	Blue sand	br
- 56.7m	Blue clay	br

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

Borelog for well M36/1011 page 2 of 2

Gridref: M36:880-390 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 1 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -104.6m Drill Date : 22/11/1944

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
- 56.7m	Blue clay	br
- 57.0m	Blue sand	li?
- 58.2m	Scoria	li?
- 62.8m	Brown sand	li?
- 64.0m	Yellow clay	li?
- 68.3m	Blue clay	li?
- 70.4m	Yellow clay & scoria	li?
- 74.1m	Brown sand	li?
- 81.6m	Blue sand & clay	he?
- 86.0m	Brown sand & pieces of rock	he?
- 88.7m	Blue clay	he?
- 90.2m	Scoria	bu?
- 93.3m	Blue sand	bu?
- 104.5m	Blue clay	sh?
- 104.6m	Rock	vo

Scale(m): -60, -70, -80, -90, -100

Borelog for well M36/1104

Gridref: M36:887-390 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 1.8 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Driven Pipe
Drill Depth : -56m Drill Date : 1/10/1942

Depth(m)	Full Drillers Description	Formation Code
- 23.7m	Blue sand	ch
- 25.2m	Blue sand & gravel	ri
- 27.1m	Yellow clay	ri
- 34.4m	Blue clay	ri
- 45.7m	Blue sand	br
- 50.2m	Scoria	br
- 51.8m	Blue sand	br
- 52.7m	Brown sand	br
- 53.3m	Yellow clay	br
- 54.2m	Brown sand	br
- 56.0m	Brown gravel	li-1

Water Level: Artesian

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

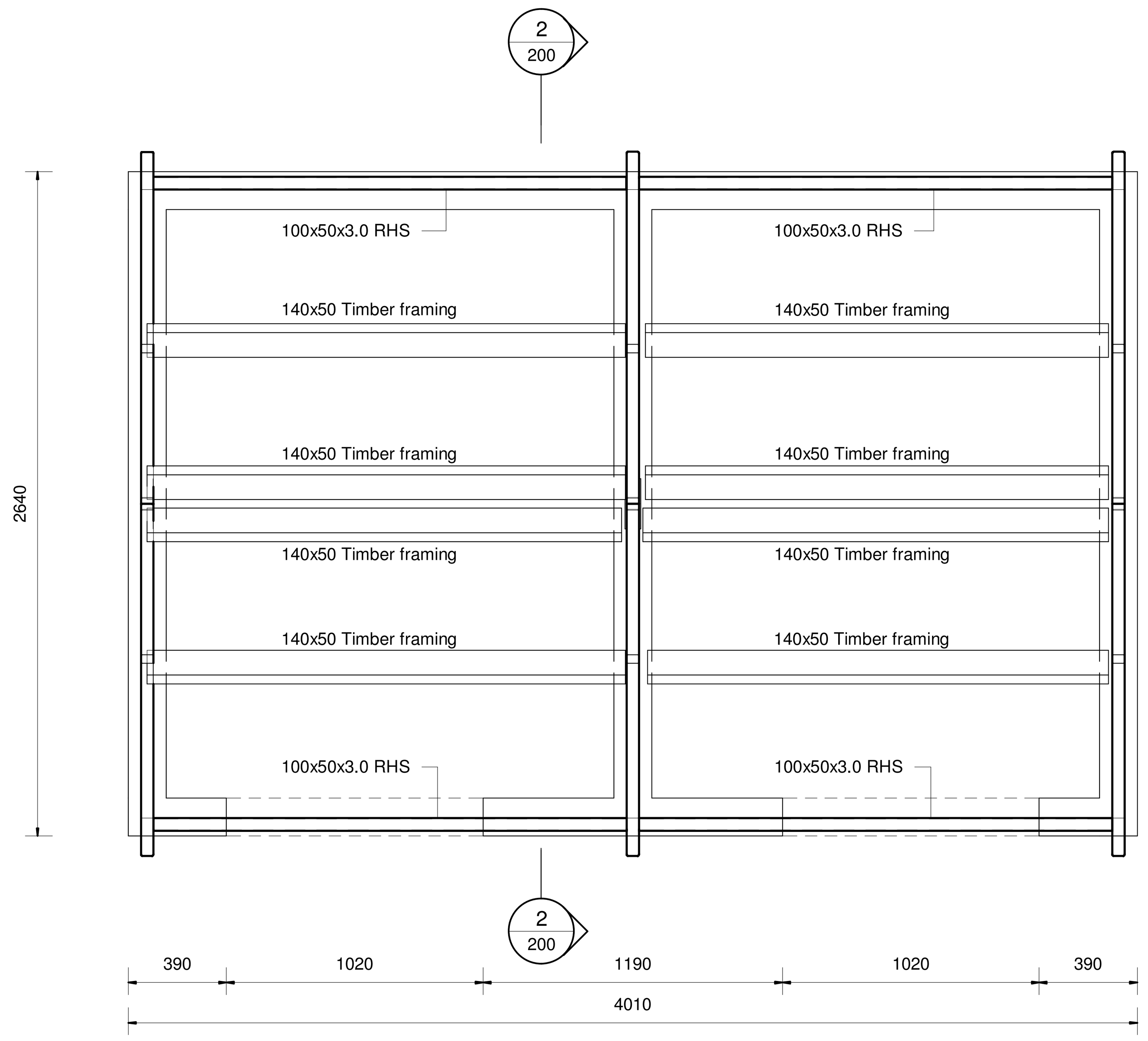
Borelog for well M36/8816

Gridref: M36:88596-38942 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 1.8 +MSD
Well name : CCC BorelogID 722
Drill Method : Not Recorded
Drill Depth : -4.65m Drill Date : 2/10/1981

Water Level	Depth(m)	Full Drillers Description	Formation Code
	-0.25m	brown loose dry topsoil	
	-0.96m	dark blue moist silt with a little cobbles	
	-4.65m	blue grey wet silty sand	

Appendix C – Sketch Drawing

3D View



Layout
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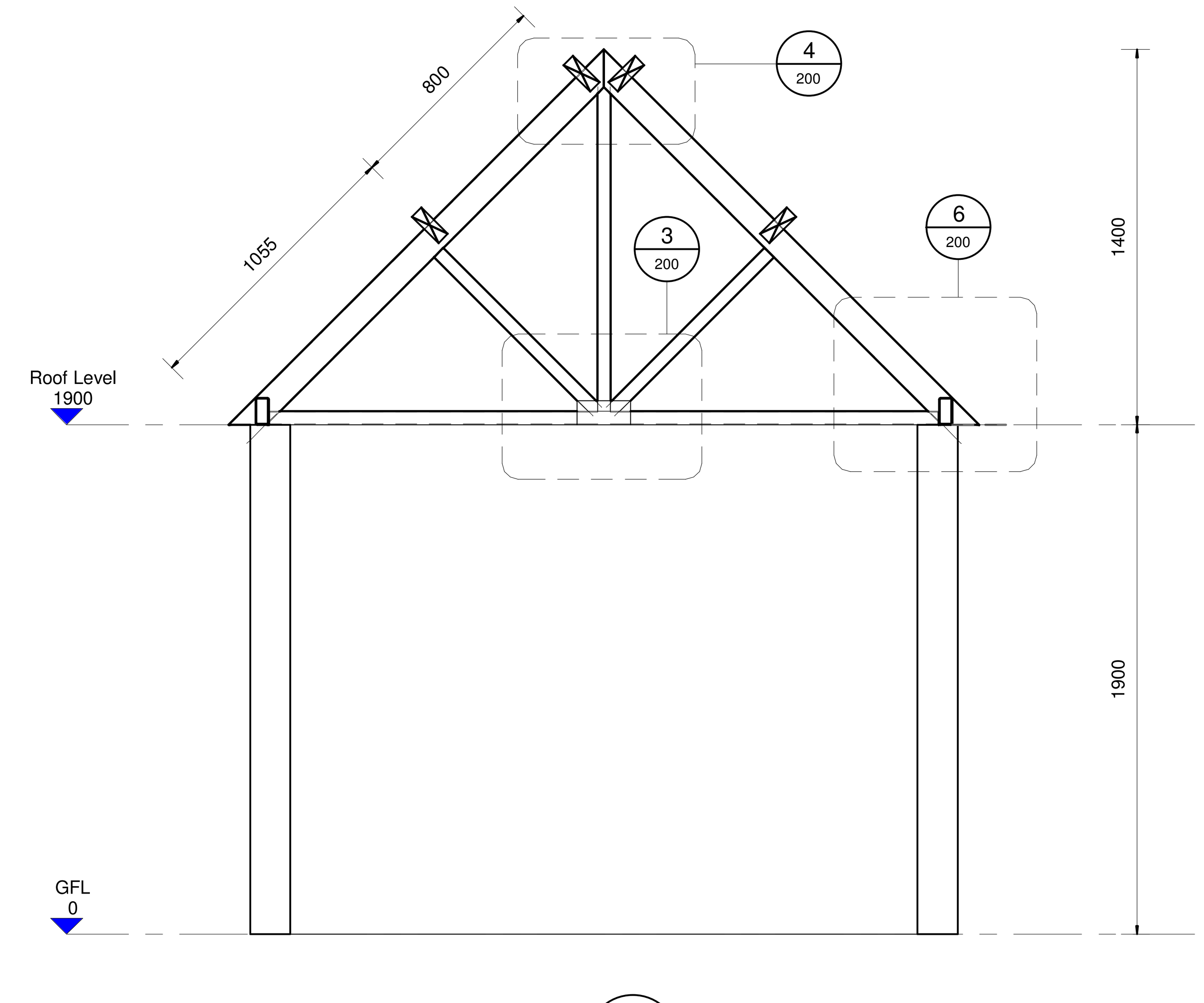
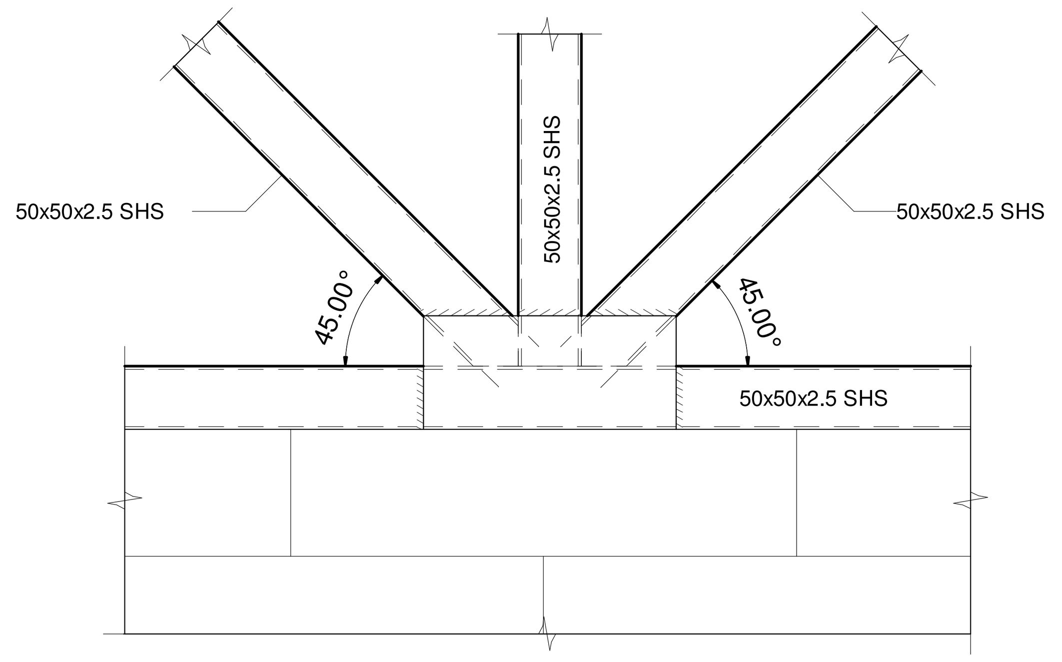
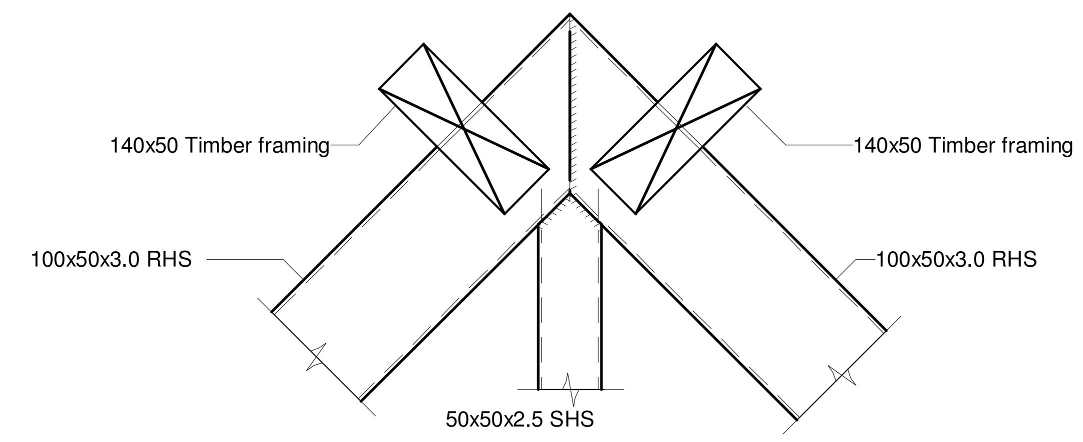


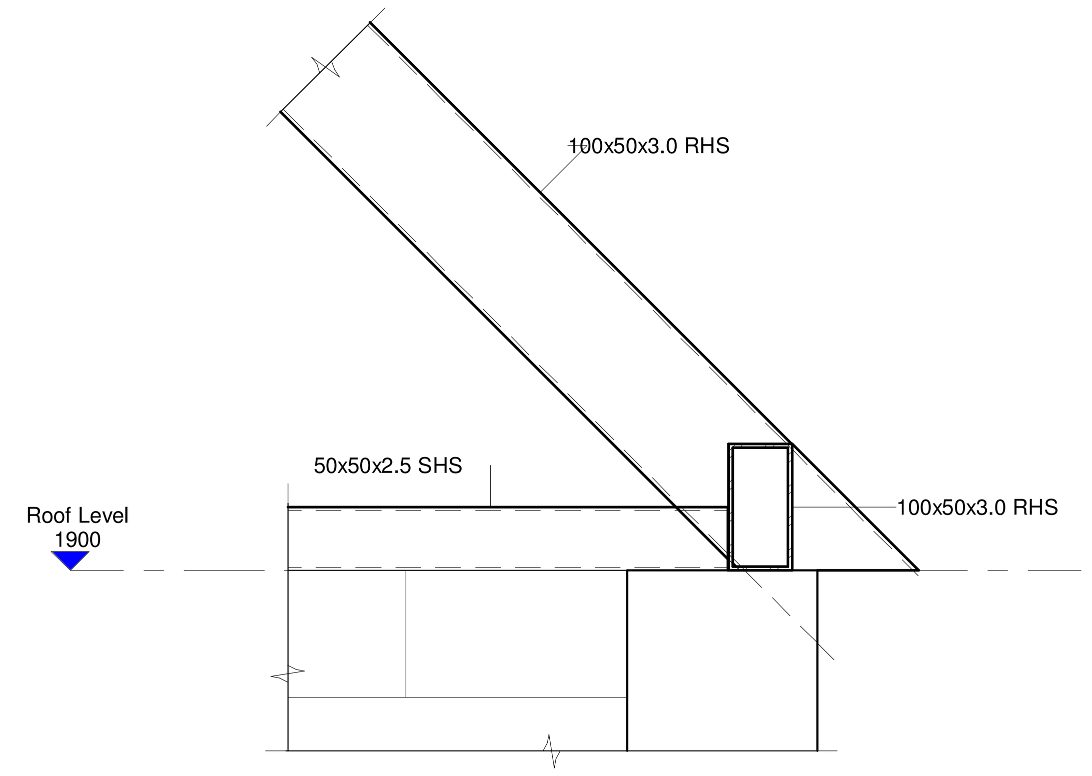
SECTION 2/200
SCALE 1 : 20



DETAIL 3/200
SCALE 1 : 5



DETAIL 4/200
SCALE 1 : 5



DETAIL 6/200
SCALE 1 : 5

CONSTRUCTION DETAILS

Revision	Amendment	Approved	Revision Date

OPUS
Auckland Office
PO Box 5848,
Auckland 1010, New Zealand
+64 9 355 9500

Drawn	Designed	Approved	Revision Date
J.R.W	Designer	Approver	Date

Project
Christchurch City Council
Celia Sreet / Main Road, Redcliffs, Christchurch
Toilet Block

Title
Existing plan, details, elevations

Project No.	Scale	Drawing No.	Sheet No.	Revision
6-QUCC1.14	As indicated	6/1366/321/8602	200	RA

Original sheet size A1 (841x594) Plot date: 23/01/2013 1:04:32 p.m. \\chsv01\branchlib\Projects\6-QUAKE.01\CCC_Parks Buildings\Redcliffs Park\Redcliffs Park Toilet\Drawings\Redcliffs toilet\Redcliffs toilet.rvt

Appendix D – CERA DEE Spreadsheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Redcliffs Park Toilets		Reviewer:	Paul Campbell
	Unit / No: / Street		CPEng No:	197688
Building Address:	Redcliffs Park Toilets	7 Main Road	Company:	Opus International Consultants
Legal Description:			Company project number:	6-QUCC1.14
			Company phone number:	+64 3 3635400
	Degrees / Min / Sec			
GPS south:			Date of submission:	8-Mar-13
GPS east:			Inspection Date:	June 2012 (latest Structural)
			Revision:	Final
Building Unique Identifier (CCC):	PRK_1400_BLDG_003		Is there a full report with this summary?	yes

Site

Site slope:	slope < 1in 10	Max retaining height (m):	0
Soil type:	silty sand	Soil Profile (if available):	Clay and SAND to min 25.9m
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):	20	Approx site elevation (m):	

Building

No. of storeys above ground:	1	single storey = 1	Ground floor elevation (Absolute) (m):	
Ground floor split?	no		Ground floor elevation above ground (m):	0.00
Storeys below ground	0			
Foundation type:	other (describe)		if Foundation type is other, describe:	slab on grade (not investigated)
Building height (m):	3.50		height from ground to level of uppermost seismic mass (for IEP only) (m):	
Floor footprint area (approx):	10			
Age of Building (years):			Date of design:	2004-
Strengthening present?	no		If so, when (year)?	
			And what load level (%g)?	
Use (ground floor):	public		Brief strengthening description:	
Use (upper floors):				
Use notes (if required):				
Importance level (to NZS1170.5):	IL2			

Gravity Structure

Gravity System:	load bearing walls		
Roof:	steel truss	truss depth, purlin type and cladding	1.3m, timber, profiled metal sheeting
Floors:	concrete flat slab	slab thickness (mm)	unknown
Beams:			
Columns:			
Walls:	fully filled concrete masonry	#N/A	

Lateral load resisting structure

Lateral system along:	fully filled CMU	**Note: Define along and across in detailed report!**	note total length of wall at ground (m):	6
Ductility assumed, μ:	2.00		wall thickness (m):	0.2
Period along:	0.16	##### enter height above at H31	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	fully filled CMU		note total length of wall at ground (m):	7.5
Ductility assumed, μ:	2.00		wall thickness (m):	0.2
Period across:	0.16	##### enter height above at H31	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	

Separations:

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

Non-structural elements

Stairs:			
Wall cladding:	brick or tile	describe (note cavity if exists)	external weather boarding (upvc)
Roof Cladding:	Metal	describe	
Glazing:	other (specify)		none
Ceilings:	none		
Services(list):	electrical, water		

Available documentation

Architectural	none	original designer name/date	
Structural	none	original designer name/date	
Mechanical	none	original designer name/date	
Electrical	none	original designer name/date	
Geotech report	partial	original designer name/date	Desktop - Opus Intern. Consultants

Damage

Site: (refer DEE Table 4-2)

Site performance:	generally good	Describe damage:	cracking to adjacent foorpath
Settlement:	none observed	notes (if applicable):	
Differential settlement:	0-1:350	notes (if applicable):	minor, not measured
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	20-100mm/20m	notes (if applicable):	localised
Damage to area:	slight	notes (if applicable):	

Building:

	Current Placard Status:	yellow		
Along	Damage ratio:	0%	Describe how damage ratio arrived at:	
	Describe (summary):	none		
Across	Damage ratio:	0%		
	Describe (summary):	none		
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	no	Describe:	

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

Recommendations

	Level of repair/strengthening required:	none	Describe:	
	Building Consent required:	no	Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before:	100%	##### %NBS from IEP below	
	Assessed %NBS after:	100%		
Across	Assessed %NBS before:	100%	##### %NBS from IEP below	
	Assessed %NBS after:	100%		

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