Waterworks MPS Workshop
Detailed Engineering Evaluation
Quantitative Report

Christchurch City Council

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Waterworks MPS Workshop

Detailed Engineering Evaluation Quantitative Report

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Waterworks MPS Workshop
BU 1759-002 EQ2

Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Final

54 Colombo St, Christchurch

Background

This is a summary of the quantitative report for the building structure, and is based on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, visual inspections on 02 March 2012, available drawings and calculations.

Damage Observed

Damage observed includes:-

- Cracking of the concrete slab on grade adjacent to several column locations
- Movement of the precast concrete wall panel at the western end
- Minor separation of precast concrete wall panels at joint locations around openings

Structural Weaknesses

The following potential structural weaknesses have been identified:

- No structural member and wall bracings connecting the portal frames in the longitudinal direction - without the longitudinal members, the connection of the precast concrete wall panels to the portals and floor slab is inadequate.

Indicative Building Strength

Based on the information available, and from undertaking a quantitative assessment, the building's original capacity has been assessed to be less than 67% NBS in the longitudinal (east-west) direction. The building's post-earthquake capacity is in the order of 38% NBS in the longitudinal direction (along the building) and 72%NBS in the transverse direction (across the building).

The building has been assessed to have a seismic capacity greater than 33% NBS and is therefore not earthquake prone. No further strengthening action is required by law. The building is founded on sandy clay (soil class D), and the peak ground accelerations from the February earthquake were high near the site, especially in the vertical direction. However the building has sustained little structural damage, this could be due to the relatively lightweight nature of the structure, as the precast concrete wall panels do not extend to the full height along the building.

Recommendations

There following recommendations are made:

1) Carry out minor repair work remedying the above observed damage.
2) Strengthen the building to 67% NBS.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Waterworks MPS Workshop building, located at 54 Colombo Street, Christchurch. This report has been commissioned 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 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 3.1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	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 3.1: NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines

Table 3.1 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 3.1: %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.

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.

4 Building Description

4.1 General

The Waterworks MPS Workshop building is a single storey warehouse type structure with steel portal frames and precast concrete wall panels. The roof is a light corrugated iron roof cladding. The construction drawings are dated July 1986 and it is assumed that construction was soon after this.

The building is approximately 36.9m long in the east-west direction and 17.9m wide in the north-south direction. The height to the portal knee (eaves) is 5.8m and the height to the apex from ground level is approximately 8.16m. The structure is a single storey structure with a mezzanine floor at the western end. The mezzanine floor is approximately 17.6m x 10.4m and comprises 75mm deep precast cast unispan slab units with a 70mm thick

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

concrete topping. The height to the mezzanine floor from ground level is approximately 3.15m.

The structure has a 150mm thick concrete slab on grade with concrete pads under the portal columns. The outside cladding of the structure comprises 150mm thick precast concrete walls or cladding panels between glazings. The wall panels are spot fillet welded to the slab and the outside flange of the portal columns.

Refer to Appendix B for the floor plan of the building.

4.2 Gravity Load Resisting System

The roof of the structure is lightweight corrugated roofing supported on 'Brownbuilt' purlins, which in turn are supported on the portal rafters. There are 8 portal frames in total with a spacing of 5.2m.

The two short ends of the building (west and east) have precast concrete wall panels going to the full height of the building. The north and south ends of the building have panels with various heights with window glazing above.

4.3 Seismic Load Resisting System

Lateral support for the roof in the transverse direction is provided through the portal frames and the west and east end walls.

In the longitudinal direction, there are no structural members connecting the frames together. There are no wall cross bracing elements and most of the precast wall panels do not go to the full height of the structure. Therefore the panels that extend to full height are expected to resist all of the loads in the longitudinal direction.

5 Survey

Copies of the following drawings were referred to as part of the assessment:

- 14 pages consisting of structural drawings for the original building structure. The drawings were prepared by Christchurch City Council – City Works and Planning Department, signed by the design engineer in July 1986

- Aerial photographs from Google Earth that show the current plan view of the building

No copies of the original design calculations have been obtained for this building.

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

We have carried out a site visit on 02 March 2012 to confirm the accuracy of the drawing information, identify the structural systems of the building, note any critical structural weaknesses and any damage resulting from the February 2011 earthquake.

6 Damage Assessment

The building appears to have suffered only minor damage as a result of the recent earthquake events. The following damage has been noted:

6.1 Slab Cracks

We observed cracks on the concrete slab on grade. These cracks were around and adjacent to several column locations.

6.2 Cracking in Panels and Separation

There is some minor cracking in the panels and separation of joints around window openings and panel joints.

7 General Observations

Overall the building has performed well under the recent seismic conditions. The building has sustained little damage and continues to be fully operational.

Due to the non-intrusive nature of the original survey, many connection details could not be inspected.

8 Detailed Seismic Assessment

8.1 Critical Structural Weaknesses

As outlined in the Critical Structural Weakness and Collapse Hazards draft briefing document, issued by the Structural Engineering Society (SESOC) on 7 May 2011, 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 the building.

We have identified the following potential critical structural weakness in the building:

a) There are no structural strut members and bracings connecting the portal frames in the longitudinal direction

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.
- Ductility factor μ_{max} = 1.25 for the portal-framed building.

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
Portal frame in the north-south direction i.e. transverse direction	No fly-bracing provided to the lower flange (compression flange) of the portal rafter adjacent to the knee	No	72%
Connection of the walls to the building and foundations in the east-west direction i.e. longitudinal direction	Capacity of the wall panel connections in the longitudinal direction of the building	Yes	38%
Precast concrete wall panels	Capacity of the wall panels in the out-of-plane direction	No	90%
Precast concrete wall panels	Capacity of the wall panels in in-plane shear	No	100%

8.4 Discussion of Results

The building has a calculated seismic capacity of 38% NBS in the longitudinal (north-south) direction.

This is above the 33% NBS limit as required by the CCC Earthquake Prone Building Policy and Industry guidelines (NZSEE 2006 [2]). No further action is required by law, however the building may still be considered as representing an unacceptable risk and it is recommended that the building be strengthened to at least 67% NBS in order to reduce the seismic risk.

We do not believe that occupancy needs to be restricted in this building.

8.5 Limitations and Assumptions in Results

Our analysis and assessment is based on an assessment of the building in its undamaged state. However we haven't observed any significant structural damage to the building.

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 the drawings, 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

Refer to Appendix C: Geotechnical Desktop Study for the Waterworks MPS Workshop Building, dated 15 May2012.

The ground profile is relatively flat and level with the adjacent buildings and paved areas.

9.1 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 underlain by the Springston Formation with dominantly alluvial sand and silt overbank deposits. This map also indicates a non-working pit or quarry approximately 50m south of the site.

9.2 Expected Ground Conditions

A review of the Environmental Canterbury (ECan) wells database showed seven wells located within approximately 140m of the site. Five CPT's were completed by the Earthquake Commission (EQC) within 250m of the site have also been reviewed. Material logs available from the wells and CPT's have been used to infer the ground conditions at the site at the site as shown in the Geotechnical Desktop Study.

9.3 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 Waterworks MPS - Workshop is located in an area identified as 'high liquefaction ground damage potential' for a low groundwater scenario. According to this study, the ground damage potential is high, indicating the ground may be affected by greater than 300mm of subsidence.

The Waterworks MPS – Workshop is bounded by residential properties located in the CERA "green" zone. The "green" zone has been further categorised into technical categories by the Department of Building and Housing (DBH). This site is bounded by both "Technical Category 2" (TC2) and "Technical Category 3" (TC3) sites. The DBH technical categories are guidelines for residential foundations, however are likely to be used as a guideline by the Christchurch City Council for building consent. TC2 identifies the area may be subject to minor to moderate land damage from liquefaction in future large earthquakes, whilst TC3 identifies the area may be subject to moderate to significant land damage from liquefaction in future large earthquakes.

9.4 Discussion and Recommendation of Geotechnical Assessment

Minor land damage has occurred at the Waterworks MPS - Workshop due to the Canterbury Earthquake Sequence following the 4 September 2010 earthquake. Externally, land settlement has been observed at the south-eastern corner of the building; the land has settled relative to the building, maximum 30mm. Shallow foundations would also be affected by liquefaction at depth.

Buildings are typically designed to allow for up to 50mm of land settlement in a serviceability limit state (SLS) event, or up to 100mm in an ultimate limit state event (ULS). Based on observations and the likely presence of a shallow gravel layer, the existing foundations appear to have performed adequately.

Based on the past performance in recent earthquakes, the existing foundations should be acceptable in terms of future SLS and ULS loadings, although CCC may have to accept the risk for potential differential settlement in the order of 0 to 50mm in a future seismic event.

If CCC wish to further evaluate and quantify the liquefaction potential at this site, additional site specific testing with CPT's and associated analysis would be necessary. Further investigations are currently not considered necessary.

10 Remedial Options

Any remedial options for increasing the seismic capacity above 67% NBS would need to address strut members and wall bracing in the longitudinal direction, to ensure that the loads are transferred between the portal columns and down to the ground.

11 Conclusions

(a) The building has a seismic capacity of 38% NBS and therefore has a medium earthquake risk.

(b) Due to the calculated capacity the building is classed as grade C, medium risk and has a relative risk of failure of approximately 9 times that of building complying with current codes.

(c) The seismic capacity is governed by the capacity of the connections between the precast concrete walls and the structure/foundations in the longitudinal direction.

(d) Repairs are required to the damaged walls and ground slab.

(e) It is recommended that the building be strengthened to at least 67% NBS in order to reduce the seismic risk.

(f) We believe that the building can continue to be occupied.

12 Recommendations

(a) Carry out repair of the concrete slab

(b) Carry out repair to the precast wall panel at the western end which has misaligned.

(c) Carry out repair on the separation of panels around openings.

(d) Strengthen the building to at least 67% NBS.

13 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.

(b) 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.

(c) 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.

14 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

Photo 1: North facing wall

Photo 2: South facing wall

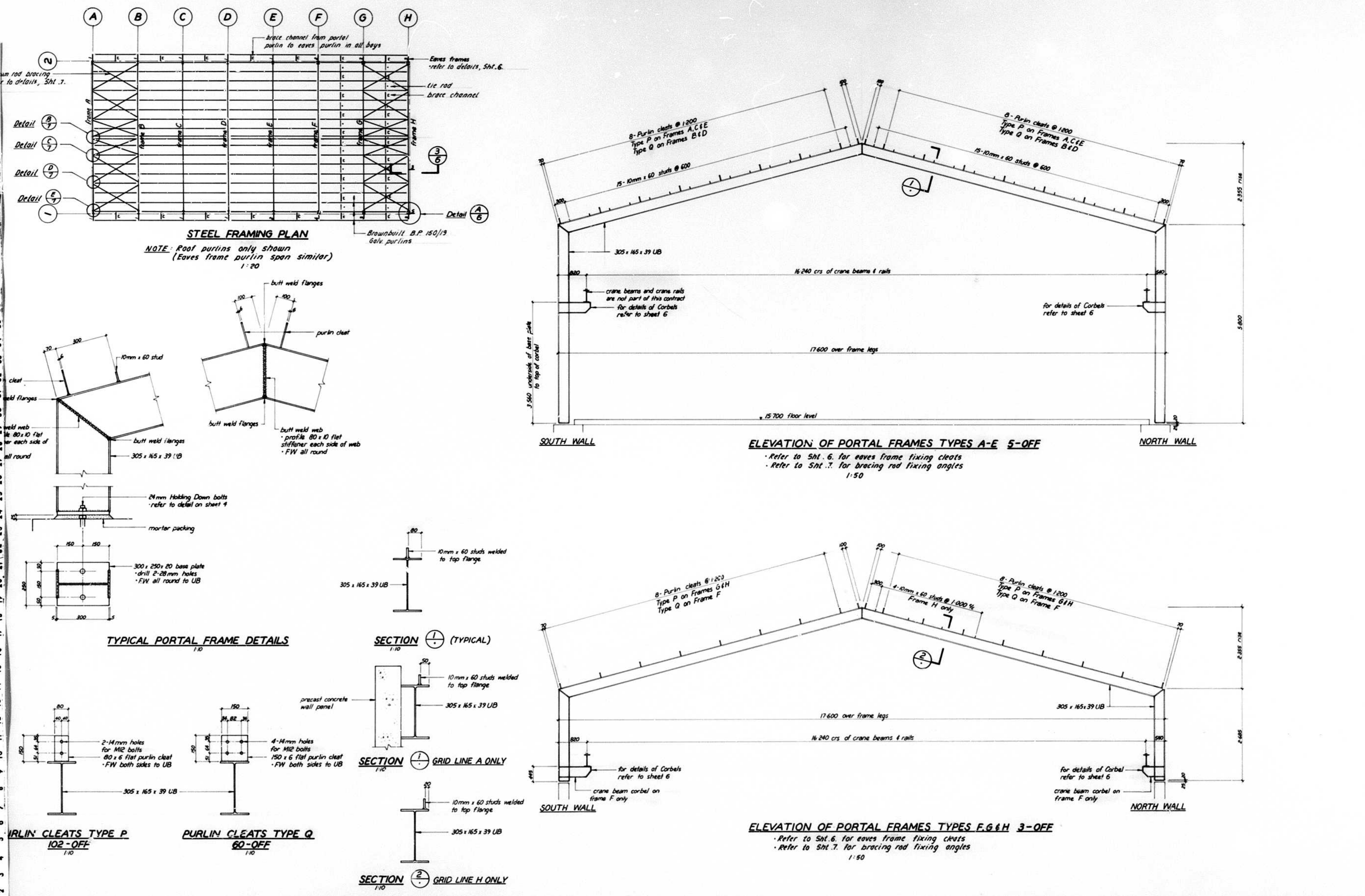
Photo 3: Misalignment of wall panel at western end

Photo 4: Cracking of floor slab

Photo 5: Cracks between panel joints

Photo 6: Crack at panel seating

IF IN DOUBT ASK — ALL DIMENSIONS TO BE SITE CHECKED BEFORE WORK COMMENCES



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Dwg. Chk.		7/86
Des. Chk.		7/86
Indexed		

Approved: DESIGN ENGINEER 25/7/86 — City Engineer

CHRISTCHURCH CITY COUNCIL — CITY WORKS AND PLANNING DEPARTMENT

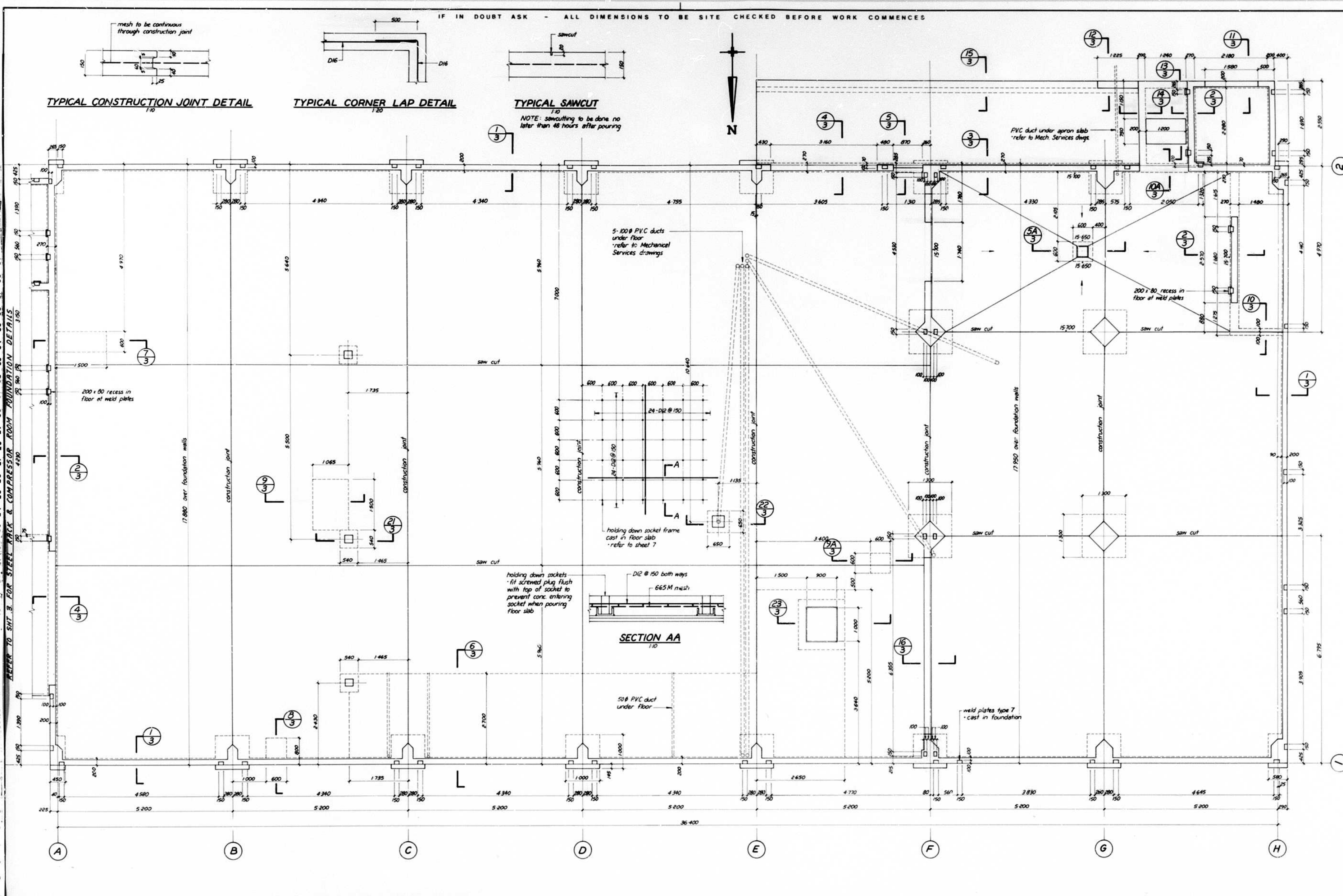
MAIN PUMPING STATION WORKSHOP
STEELWORK FRAMING PLAN & PORTAL DETAILS

Scales: 1:10, 1:50, 1:200

D.3307

Sheet 5 of 14

Appendix B – Floor Plans



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Sewer		Planning				
S.W. Drainage						
Gas						
Cables (M.E.D.)						
(P.O.)						

	Book	Page	Initials	Date
Surveyed				
Levelled				
B.M.				
Compiled from				

		Date
Designed	W.R. Sissons	5/86
Drawn	W.D. Inwood	7/86
Traced	W.D. Inwood	7/86
Dwg. Chk.		7/86
Des. Chk.		7/86
Indexed		

Approved
DESIGN ENGINEER — Date 25/7/86
City Engineer

CHRISTCHURCH CITY COUNCIL — CITY WORKS AND PLANNING DEPARTMENT

MAIN PUMPING STATION WORKSHOP
FOUNDATION PLAN

Scales 1:50

File No. D.3307
Issue
Sheet 2 of 14

Appendix C – Geotechnical Appraisal

15 May 2012

Christchurch City Council
C/O:- Michael Sheffield
Property Asset Manager

6-QUCCC.69/005SC

Dear Michael

Geotechnical Desktop Study – Waterworks MPS - Workshop

1. Introduction

Christchurch City Council (CCC) has commissioned Opus International Consultants (Opus) to undertake a geotechnical desktop study and site walkover of the Waterworks MPS - Workshop, 54 Colombo St, Christchurch. The purpose of this study is to collate existing subsoil information, undertake an appraisal of the potential geotechnical hazards at this site and to determine whether further investigations are required. The site walkover was completed by Opus on 3 May 2012. Refer to Appendix A for site photos.

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.

The Geotechnical Desk Study forms part of a Detailed Engineering Evaluation prepared by Opus. The Geotechnical Desk Study has been undertaken without the benefit of any site specific investigations and is therefore preliminary in its nature.

2. Desktop Study

2.1 Site Description

The Waterworks MPS - Workshop is located at 54 Colombo Street, Christchurch, and comprises an asphalt driveway and carpark and the Workshop. The Waterworks MPS – Workshop is a steel portal framed, single storey structure and is comprised of pre-cast concrete wall panels and a steel framed roof.

The Waterworks MPS - Workshop was built in 1986 and is bounded by residential properties to the west and non-residential properties to the north, east and south. The South Christchurch Library is located on the northern side of the access-way. A Geotechnical Desk Study for the South Christchurch Library has been submitted by Opus. The Heathcote River is within approximately 100m to 150m of the building to the west, north and east. Refer to Appendix B for the Site Location Plan.

No Geotechnical Reports were available from the CCC Property File.

The ground profile is relatively flat and level with the adjacent buildings and paved areas.

2.2 Structural Drawings

Extracts from the Structural Drawings have been available for review. The drawings typically indicate a 150mm thick 665 mesh reinforced concrete slab on hardfill, with a perimeter footing to 500mm below ground level (bgl) that is 200mm to 270mm thick. The portal frames are supported on pad foundations that are 1.0m to 1.5m wide to a depth of 500mm bgl.

Refer to Appendix C for extracts from the Structural Drawings.

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 underlain by the Springston Formation with dominantly alluvial sand and silt overbank deposits. This map also indicates a non-working pit or quarry approximately 50m south of the site.

2.4 Expected Ground Conditions

A review of the Environmental Canterbury (ECan) wells database showed seven wells located within approximately 140m of the Waterworks MPS - Workshop. Refer to the Site Location Plan in Appendix B. Five CPT's were completed by the Earthquake Commission (EQC) within 250m of site have also been reviewed. Material logs available from the wells and CPT's have been used to infer the ground conditions at the site, as shown in Table 1 below. Refer to Appendix B for Well and CPT Logs.

Table 1: Inferred Ground Conditions

Stratigraphy	Thickness (m)	Depth Encountered From (m)
Blue Gravel and Sand	3.59 – 4.9m	Surface
Brown, blue sandy clay with peat and marine deposits	9.4 – 15.2m	Surface – 4.9m
Brown Gravel and Sand	1.6 – 6.1m	10.9 – 15.2m
Sandy GRAVEL (RICCARTON FORMATION)	-	15.2 – 17.7m

The upper soils (to a maximum depth of 15.2m) are interpreted as being a part of the Christchurch Formation that overlies the Springston Formation. The Riccarton Gravel Formation underlies the upper formations and is located at approximately 16m bgl.

Brown and Weeber also indicated that the central area of Christchurch experienced marine incursions in the past which is consistent with the presence of the Christchurch Formation on site.

The ECan well logs indicate the groundwater is either artesian within the Riccarton Gravels or within 1.9m bgl. The Brown and Weeber "Geology of the Christchurch Urban Area" map suggests a water table less than 1m bgl.

2.5 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 Waterworks MPS - Workshop is located in an area identified as 'high liquefaction ground damage potential' for a low groundwater scenario. According to this study, the ground damage potential is high, indicating the ground may be affected by greater than 300mm of subsidence.

Tonkin and Taylor Ltd (T&T Ltd) have been engaged as the Earthquake Commission's (EQC) geotechnical consultants and have prepared maps showing areas of liquefaction interpreted from high resolution aerial photos for the 4 September 2010 earthquake, and the aftershocks of February 2011 and June 2011. An interpretation of these maps indicates there was liquefaction at site during the February 2011 earthquake and no liquefaction at the site as a result of the September 2010 and June 2011 earthquakes.

The Waterworks MPS – Workshop is bounded by residential properties located in the CERA "green" zone. The "green" zone has been further categorised into technical categories by the Department of Building and Housing (DBH). This site is bounded by both "Technical Category 2" (TC2) and "Technical Category 3" (TC3) sites. The DBH technical categories are guidelines for residential foundations, however are likely to be used as a guideline by the Christchurch City Council for building consent. TC2 identifies the area may be subject to minor to moderate land damage from liquefaction in future large earthquakes, whilst TC3 identifies the area may be subject to moderate to significant land damage from liquefaction in future large earthquakes.

3. Site Walkover Inspection

A walkover inspection of the exterior and interior was carried out by an Opus Engineering Geologist on 3 May 2012. The following observations were made (refer to Appendix A for Site Photos and Appendix D for the Site Walkover Plans:

- Minor gaps have opened up between some floor slabs, maximum width of 10mm. Refer to Photos 2 and 3.
- Minor cracks have been observed within some floor slabs, the majority of these cracks are closed; however some have maximum widths of between 1mm to 2mm. Refer to Photo 4.
- Minor cracking has been noted around the base of some of the columns on the northern side of the building, maximum width of 5mm. Refer to Photo 5.
- A gap has opened up between the roller door on the eastern wall of the building and the floor slab with a maximum width of 10mm. Refer to Photo 6.
- Minor gaps have been observed between the base of some walls and the floor slabs. Refer to Photo 7.
- Minor differential settlement of approximately 5mm has been observed over some cracks in the floor. Refer to Photo 8 and 9.
- The concrete drainage channel that runs parallel to the southern side of the building appears to be approximately 1mm to 2mm above the asphalt carpark, indicating possible minor differential settlement of the land around the drainage channel. Refer to Photo 10.
- Land settlement around a manhole and adjacent to the south-eastern corner of the building, maximum 30mm. Refer to Photo 11 and 12.

- Minor spalling of the concrete adjacent to the roller door on the eastern side of the building. Refer to Photo 13.

- Minor gaps have been observed between the base of the building and the asphalt carpark, maximum width of 5mm. Refer to Photo 14.

- No liquefaction was observed on site by staff during the Canterbury Earthquake Sequence.

4. Discussion

Minor land damage has occurred at the Waterworks MPS - Workshop due to the Canterbury Earthquake Sequence following the 4 September 2010 earthquake.

No significant foundation damage was observed during the site walkover. Minor gaps have opened up between some floor slabs of the building (maximum gap width 10mm). Minor cracking has been observed within the floor slab with some cracks displaying minor differential settlement of up to 5mm. The age of the cracking is unknown, based on comments of staff, cracking and movement likely to have resulted from the Earthquake sequence.

Externally, land settlement has been observed at the south-eastern corner of the building; the land has settled relative to the building, maximum 30mm. Shallow foundations would also be affected by liquefaction at depth.

Minor spalling of concrete at one location was observed, and gaps between the building and the asphalt carpark were noted on the eastern side of the building. This damage is likely to be caused by ground shaking during an earthquake event.

No liquefaction was noted on site by staff during the Canterbury Earthquake Sequence that started on 4 September 2010 and no evidence of liquefaction was observed on site during the walkover inspection.

ECan well logs indicate the building is likely to be founded on a 4.5m thick layer of sandy gravel underlain by layers of sand, peat and timber; with the Riccarton Gravels at approximately 16m bgl. The existing perimeter strip footings, shallow pads and concrete floor slab do not appear to have suffered significant damage. No significant evidence of differential settlement across the building footprint was observed during the walkover; however no level survey has been completed.

Buildings are typically designed to allow for up to 50mm of land settlement in a serviceability limit state (SLS) event, or up to 100mm in an ultimate limit state event (ULS).

GNS Science[1] 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 a 15% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. We would expect that similar ground damage could occur in a future earthquake, 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.

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[1] GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury- quakes/aftershocks/ updated on 30 April 2012.

Based on observations and the likely presence of a shallow gravel layer, the existing foundations appear to have performed adequately. No further investigations are recommended at this stage.

5. Recommendations

- Based on the past performance in recent earthquakes, the existing foundations should be acceptable in terms of future SLS and ULS loadings, although CCC may have to accept the risk for potential differential settlement in the order of 0 to 50mm in a future seismic event;

- If CCC wish to further evaluate and quantify the liquefaction potential at this site, additional site specific testing with CPT's and associated analysis would be necessary. Further investigations are currently not considered necessary.

6. Limitation

This report has been prepared solely for the benefit of CCC 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 the 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 nay 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.

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 Solid 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

Prepared By:

Danielle Belcher
Engineering Geologist

Reviewed By:

Graham Brown
Senior Geotechnical Engineer

Appendices:
Appendix A: Site Photos
Appendix B: Site Location Plan, ECan Well Logs and CPT Logs
Appendix C: Structural Drawings
Appendix D: Site Walkover Plans

APPENDIX A:

Site Photos

Photo 1: Northern elevation, Waterworks MPS - Workshop, 54 Colombo Street.


Photo 2: Gaps opened up between floor slabs, maximum 10mm wide.

Photo 3: Gaps opened up between floor slabs, maximum 10mm wide.

Photo 4: Cracks observed within floor slab, 1mm to 2mm wide.

Photo 5: Cracks observed at the base of column, 1mm to 2mm wide.

Photo 6: Gap opened up between the base of the roller door on the eastern side of the building and the floor slab.

Photo 7: Crack at the base of the wall, 1mm to 2mm wide.

Photo 8: Differential Settlement of 5mm across a crack within the floor slab.

Photo 9: Differential Settlement of 5mm across a crack within the floor slab.


Photo 10: Raised drainage channel by approximately 1mm to 2mm.

Photo 11: Land settlement around manhole and south-eastern corner of building, maximum settlement 30mm.

Photo 12: Land settlement around manhole and south-eastern corner of building, maximum settlement 30mm.

Photo 13: Minor spalling of concrete at the eastern roller door.

Photo 14: Minor gap opened up between eastern side of the building and the asphalt carpark.

APPENDIX B:

Site Location Plan
ECan Well Logs
CPT Logs

Key: ECan Well Logs
CPT's

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: Waterworks MPS - Workshop
Geotechnical Desktop Study

Project No.: 6-QUCCC.69

Client: Christchurch City Council

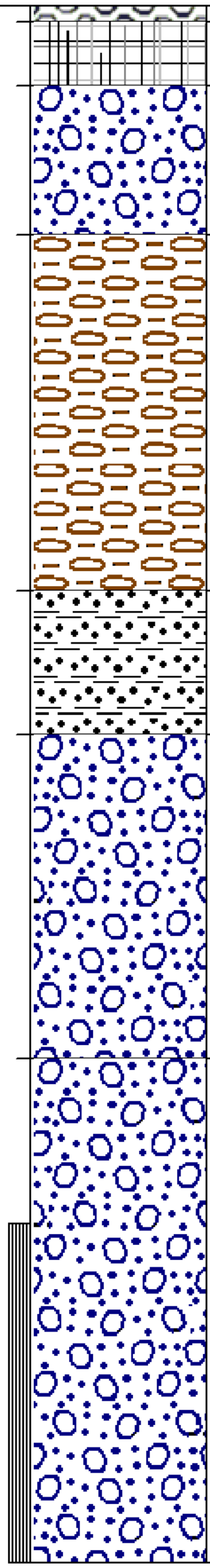
Site Plan

Drawn: Danielle Belcher
Engineering Geologist

Date: 8-May-12

Borelog for well M36/0985

Gridref: M36:80802-38272 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 6.6 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -29.29m Drill Date : 12/09/1975



Water level: -1.9CalcMin

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

Depth(m)	Full Drillers Description	Formation Code
-0.30m	Soil	fi
-1.50m	Fill	fi
-4.30m	Grey gravel & sand	sp
- 11.0m	Grey clay & timber	ch
- 13.7m	Sandy Grey clay	ch
- 19.8m	Sandy Brown gravel	sp
- 29.3m	Brown gravel & sand	ri

Borelog for well M36/1040

Gridref: M36:8075-3825 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.6 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Unknown
Drill Depth : -21.29m Drill Date : 8/08/1907

Water Level: -1.9CalcMin

Depth(m)	Full Drillers Description	Formation Code
-4.30m	Blue shingle	sp
- 11.6m	Blue sand & clay	ch
- 16.5m	Brown shingle	sp
- 17.7m	Yellow sand	sp
- 18.2m	Blue shingle	ri
- 21.3m	Unknown	ri

Borelog for well M36/1042

Gridref: M36:8077-3824 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.4 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Unknown
Drill Depth : -25.2m Drill Date : 5/12/1907

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
	-1.9CalcMin	-4.30m	Blue shingle	sp
-5, -10		- 11.6m	Blue sand & clay	ch
		- 13.1m	Blue shingle	sp
-15, -20, -25		- 25.2m	Brown shingle	sp-ri

Borelog for well M36/1112

Gridref: M36:808-382 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 5.7 +MSD
Driller : not known
Drill Method : Cable Tool
Drill Depth : -72.5m Drill Date : 1/07/1926

Environment Canterbury
Your regional council

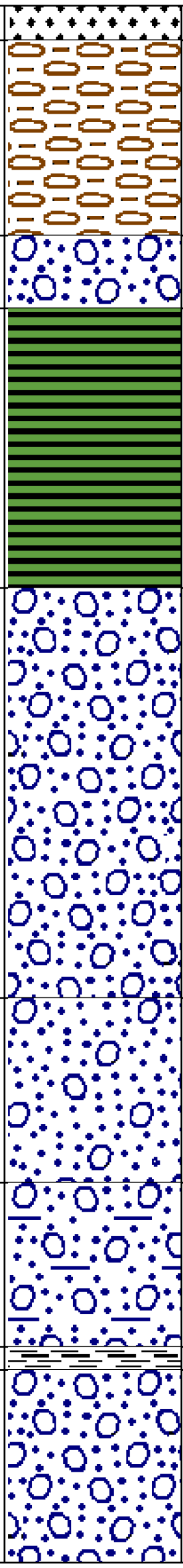
Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
- 13.7m	Earth, Blue sandy clay & traces of sea shells	sp-ch
- 24.9m	Grey sand then sand & gravel	sp-ri
- 35.9m	Grey Water-bearing gravel	ri
- 37.1m	Clay	br
- 43.2m	Grey Water-bearing gravel	br
- 49.0m	Tight fine gravel & sand	br
- 53.0m	Water-bearing gravel	br
- 54.2m	Clay	br
- 60.0m	Brown Water-bearing gravel	li-1
- 66.1m	Clay	li-2
- 72.5m	Rough Brown Water-bearing gravel & sand	li-3

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

Borelog for well M36/1196 page 1 of 3

Gridref: M36:8075-3840 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.5 +MSD
Driller : A M Bisley & Co
Drill Method : Driven Pipe
Drill Depth : -121.9m Drill Date : 6/11/1965



Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	-0.89m	Sand	sp
	-6.00m	Brown clay & timber	sp
	-7.90m	Blue gravel & sand	sp
	- 15.2m	Sandy Blue clay, some peat & timber	ch
	- 25.9m	Grey gravel & sand	sp-ri
	- 30.7m	Sand & some gravel	ri
	- 35.0m	Tight dirty gravel, sand & some Yellow clay	ri
	- 35.6m	Yellow clay	ri
	- 41.1m	Grey/Brown gravel & fine sand	ri

Scale(m): -5, -10, -15, -20, -25, -30, -35, -40

Borelog for well M36/1196 page 2 of 3

Gridref: M36:8075-3840 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.5 +MSD
Driller : A M Bisley & Co
Drill Method : Driven Pipe
Drill Depth : -121.9m Drill Date : 6/11/1965

Environment Canterbury
Your regional council

Water Level: Artesian

Depth(m)	Full Drillers Description	Formation Code
41.1m	Grey/Brown gravel & fine sand	ri
- 42.0m	Grey/Brown gravel & clay	ri
- 42.6m	Yellow sand	br
- 46.6m	Grit & sand	br
- 48.1m	Sandy Grey/Brown gravel	br
- 51.2m	Tight Grey/Brown gravel	br
- 53.0m	Sandy Grey/Brown gravel	br
- 54.2m	Hard Brown clay	br
- 61.2m	Brown gravel & sand	li-1
- 62.4m	Brown sand	li-2
- 71.6m	Firm Yellow clay	li-2
- 73.7m	Grey gravel & sand	li-2
- 77.4m	Grey sand	li-2
- 78.9m	Grey sand & some gravel	li-3
- 83.5m	Dirty sand gravel	li-3

Scale(m): -45, -50, -55, -60, -65, -70, -75, -80

Borelog for well M36/1196 page 3 of 3

Gridref: M36:8075-3840 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.5 +MSD
Driller : A M Bisley & Co
Drill Method : Driven Pipe
Drill Depth : -121.9m Drill Date : 6/11/1965

Water Level: Artesian

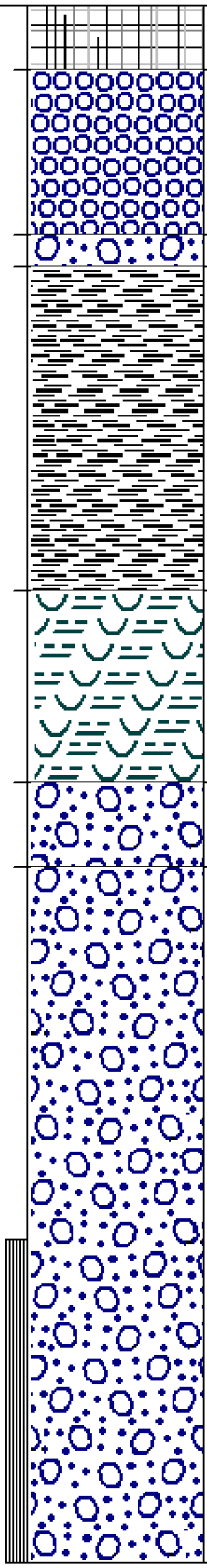
Scale(m): -85, -90, -95, -100, -105, -110, -115, -120

Depth(m)	Full Drillers Description	Formation Code
- 83.5m	Dirty sand gravel	li-3
- 84.7m	Grey gravel, Yellow clay & sand	he
- 87.1m	Grey gravel & fine sand	he
- 89.0m	Sandy Grey/Brown gravel	he
- 91.7m	Grey/Brown gravel & sand. Flow 218.3m3/d	he
- 92.3m	Hard Yellow clay	he
- 96.0m	Firm Blue clay	he
- 97.8m	Hard sandy Yellow clay	he
- 99.3m	Dirty Brown gravel & Yellow clay	bu
- 101.4m	Sandy Brown gravel 98.4m - 101.4m 218.3m3/d	bu
- 105.7m	Firm Grey clay	sh
- 106.0m	Dark Brown clay	sh
- 107.2m	Firm Grey clay	sh
- 109.1m	Hard Yellow clay	sh
- 111.2m	Volcanic scoria & some clay	sh
- 121.9m	Firm Yellow clay, almost White towards 121.9m	sh

Borelog for well M36/1363

Gridref: M36:808-382 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 5.7 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -29.29m Drill Date : 25/09/1973

Environment Canterbury
Your regional council



Water Level: -1.9CalcMin

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

Depth(m)	Full Drillers Description	Formation Code
-1.20m	Fill	fi
-4.30m	Blue gravel	sp
-4.90m	Blue sand, gravel & timber	sp
- 11.0m	Grey clay	ch
- 14.6m	Grey clay & shells	ch
- 16.2m	Sandy Grey gravel	sp
- 29.3m	Grey/Brown gravel & fine sand	sp-ri

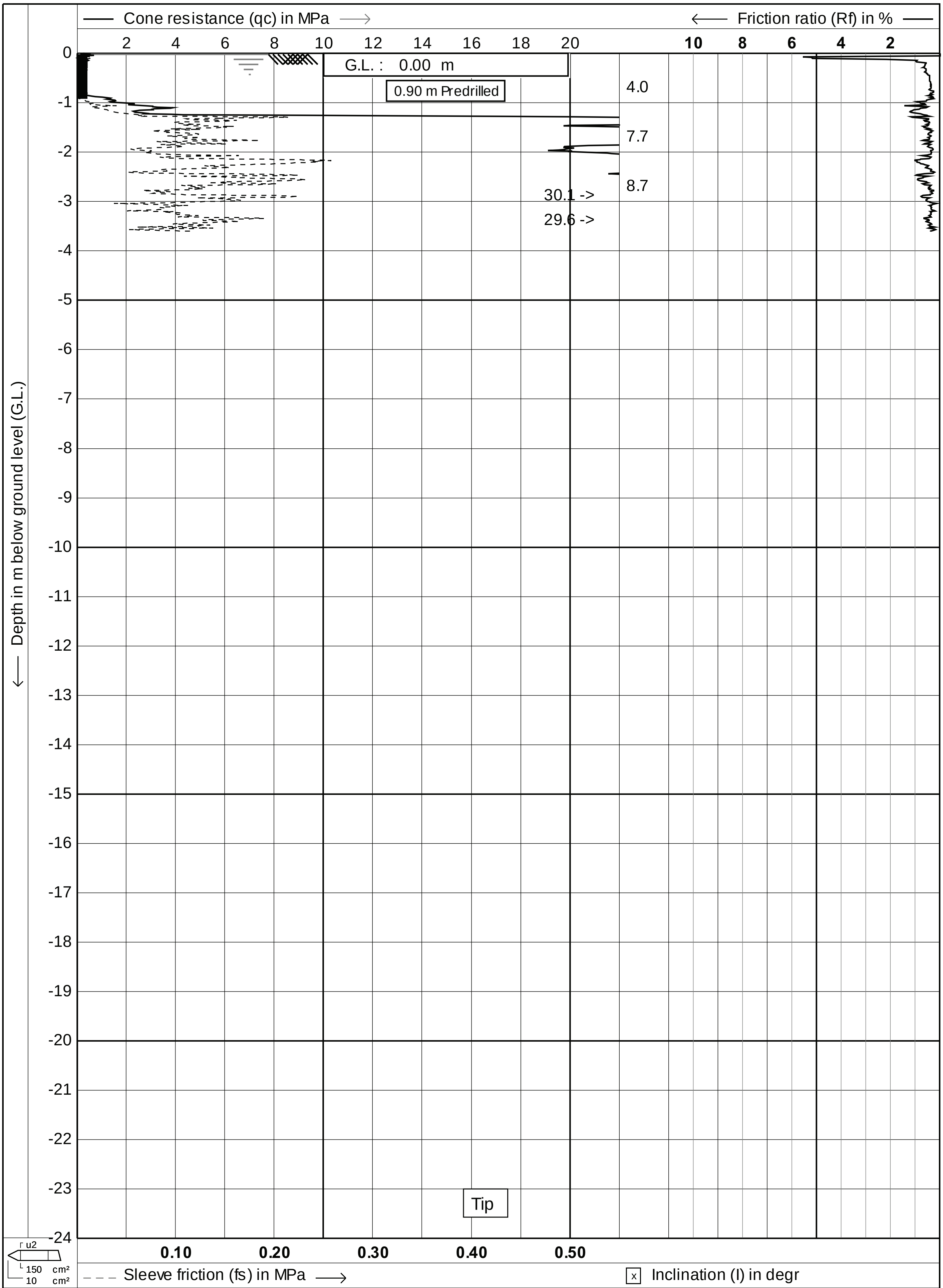
Borelog for well M36/1355

Gridref: M36:8081-3822 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -24m Drill Date : 1/09/1914

Water Level: -1.9CalcMin

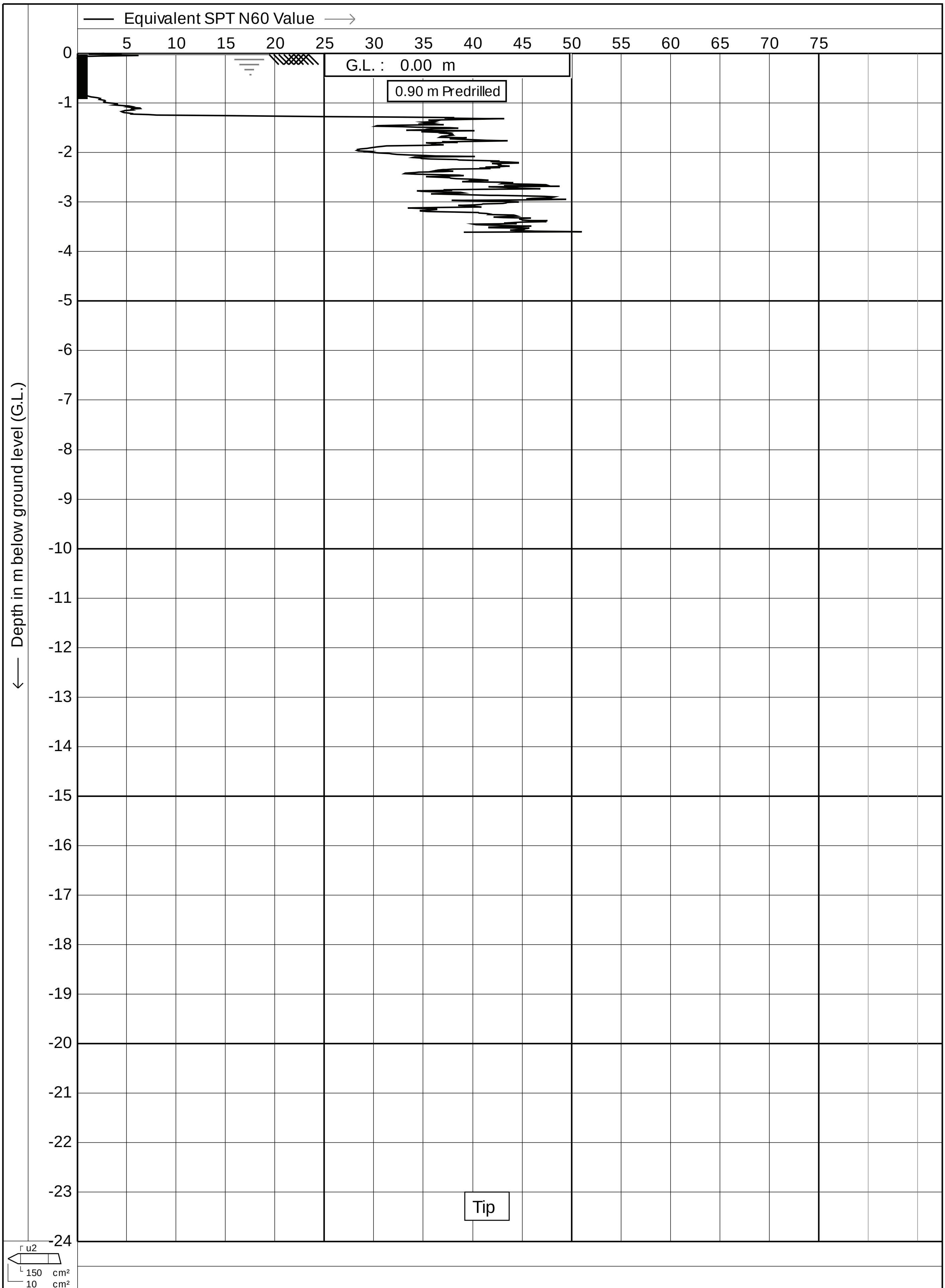
Depth(m)	Full Drillers Description	Formation Code
-3.59m	Shingle	sp
- 10.9m	Sand, clay & timber	ch
- 14.6m	Blue shingle	sp
- 15.2m	Hard timber log	sp
- 21.3m	Shingle	sp
- 24.0m	Open shingle	ri

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



CPTask V1.25

Test according A.S.T.M. Standard D 5778-07	Date : **30-5-2011**	
	Cone no. : **C10CFIIP.E59**	
Project : **Site Investigations**	Project no. : **01TT12**	
Location: **Beckenham - Christchurch City**	CPT no. : **BKM-05**	**1/14**



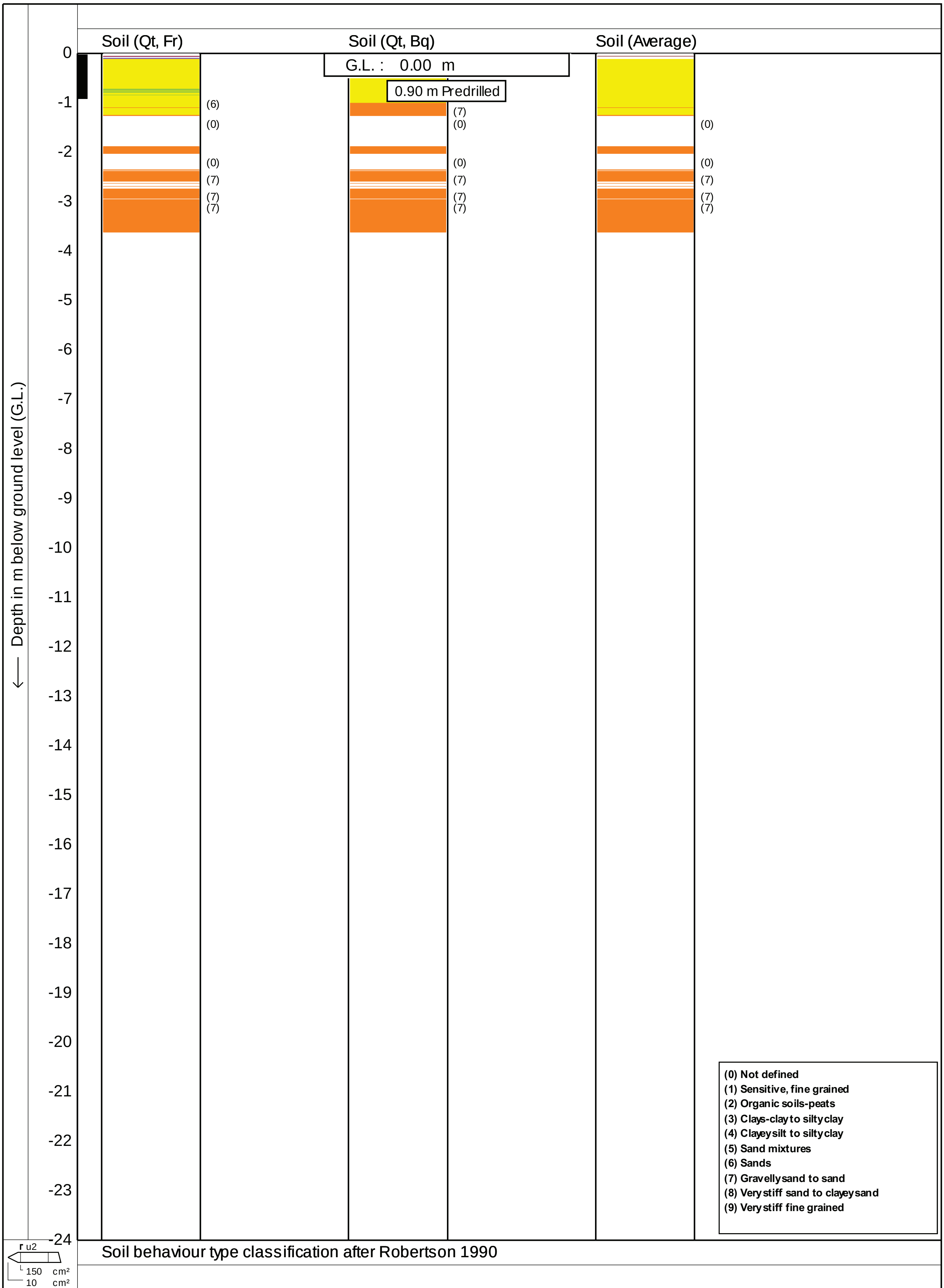
CPTask V1.25

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Beckenham - Christchurch City**

Date	: **30-5-2011**
Cone no.	: **C10CFIIP.E59**
Project no.	: **01TT12**
CPT no.	: **BKM-05**



Soil behaviour type classification after Robertson 1990

Perry DRILLING GEO PROBE
Ground Drilling and Environmental Specialists

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Beckenham - Christchurch City**

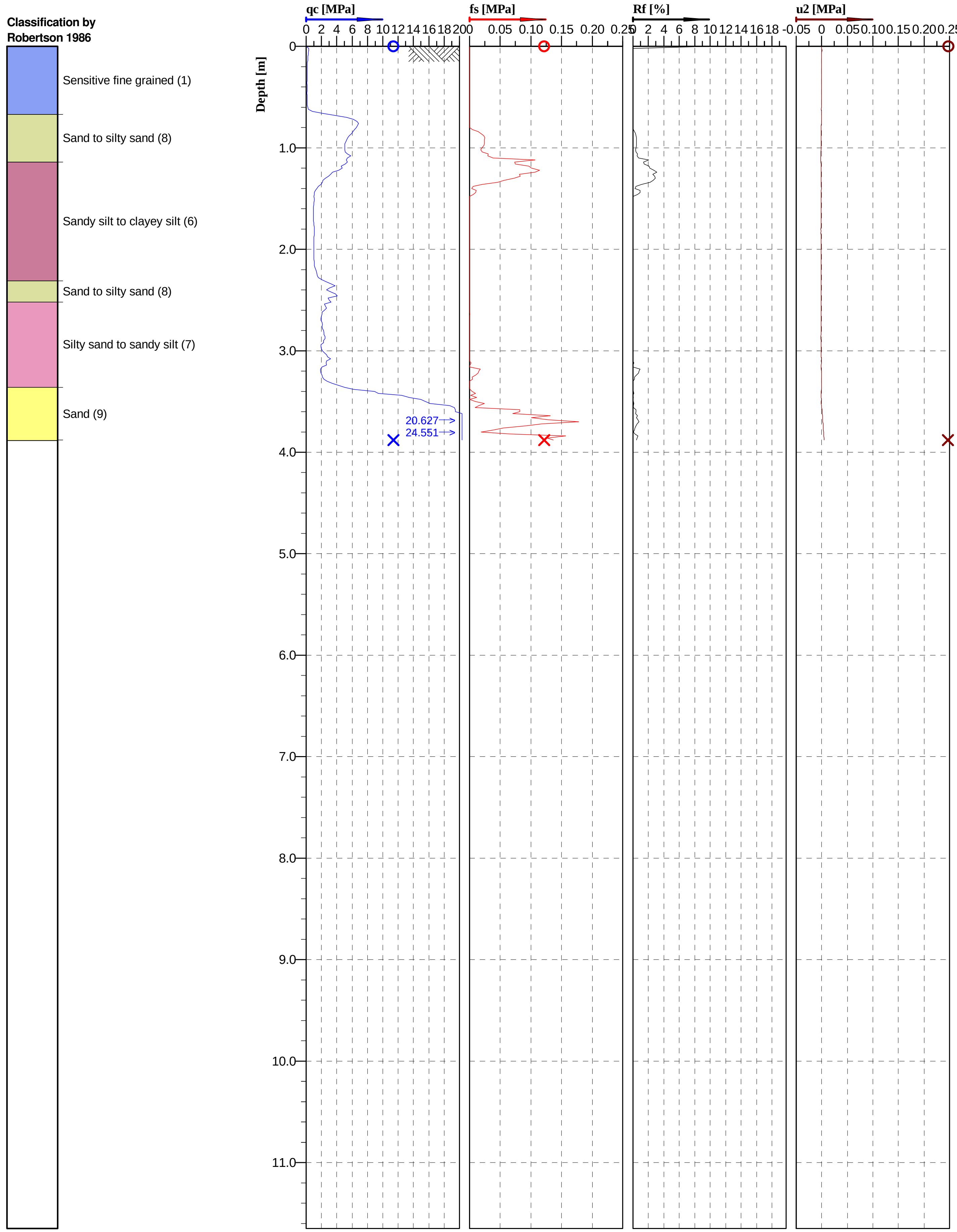
Date : **30-5-2011**

Cone no. : **C10CFIIP.E59**

Project no. : **01TT12**

CPT no. : **BKM-05** **13/14**

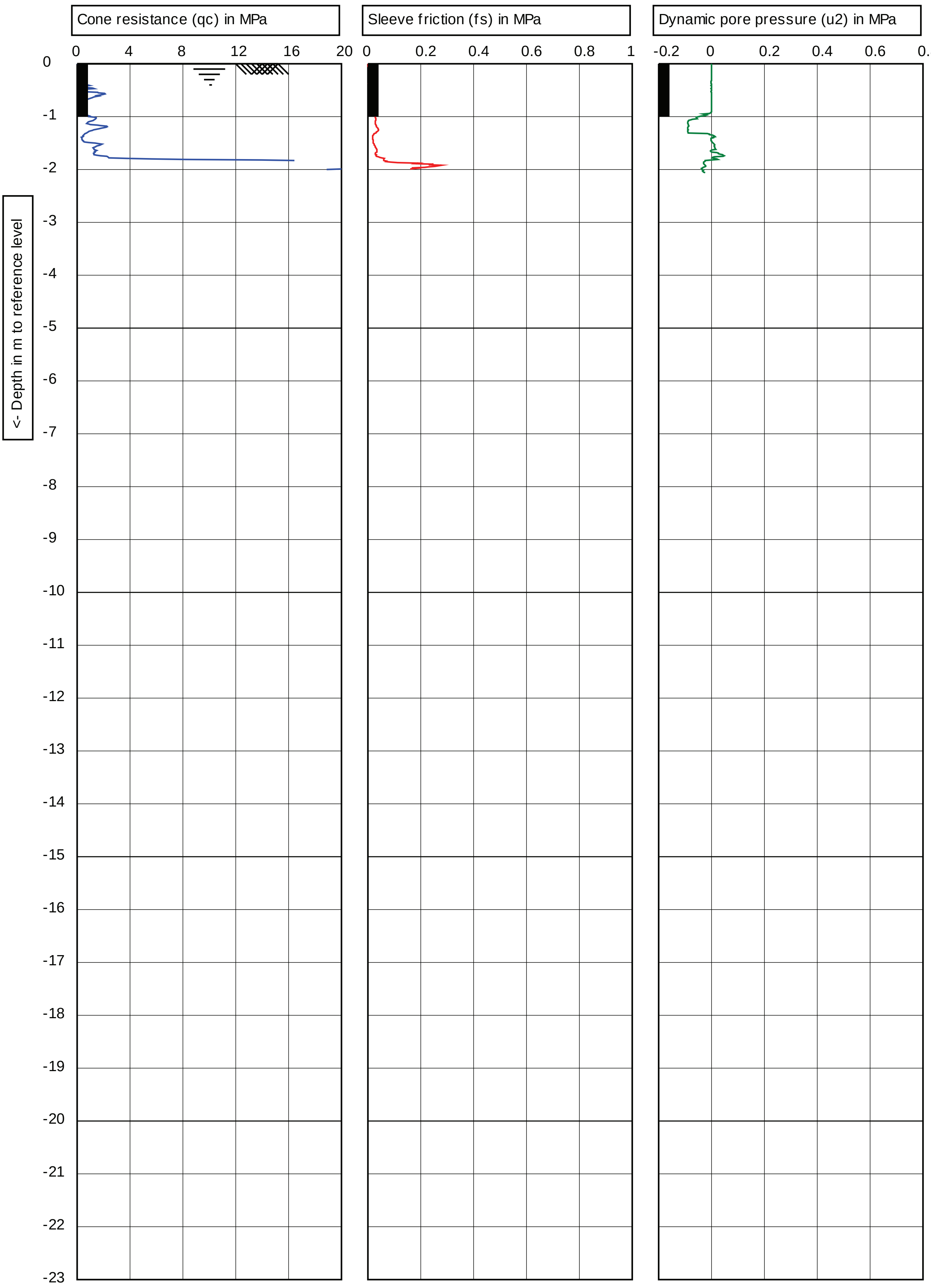
CPTask V1.25



U2

Cone No: 100KN 4341
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: BECKINGHAM	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: CPT-BKM-06
Project ID:	Client: TONKIN & TAYLOR LTD	Date: 22/06/2011	Scale: 1 : 50
Project: EQCSITES		Page: 1/1	Fig:
		File: CPT-BKM-06.CPT	



CPTask V1.20

OPUS
HAMILTON LABORATORIES

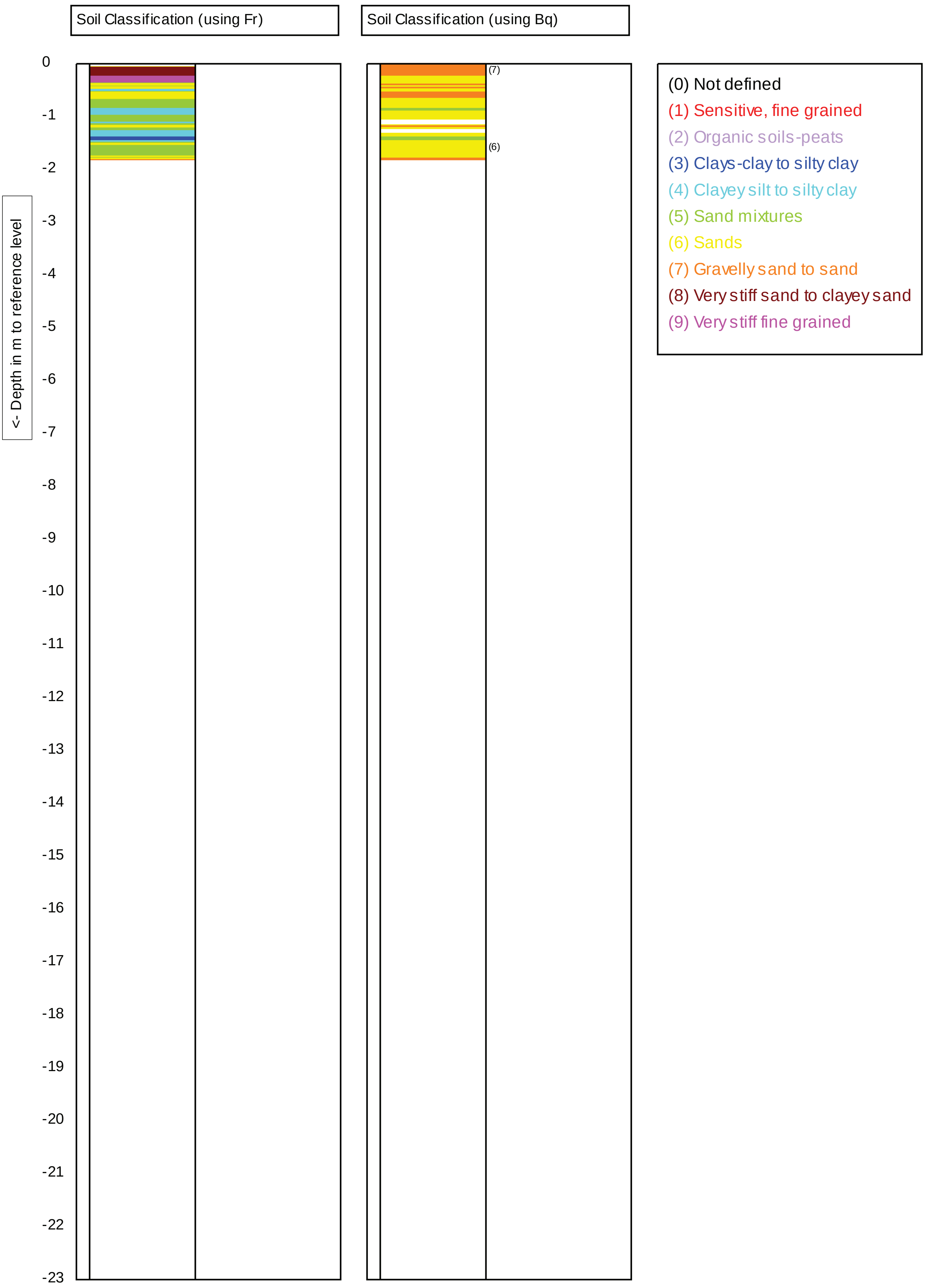
u2
150 cm²
10 cm²

Test according to A.S.T.M standard D-5778-95

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

Project: **BKM**
Location: **GPS:E2480786 N5738214**
Position:

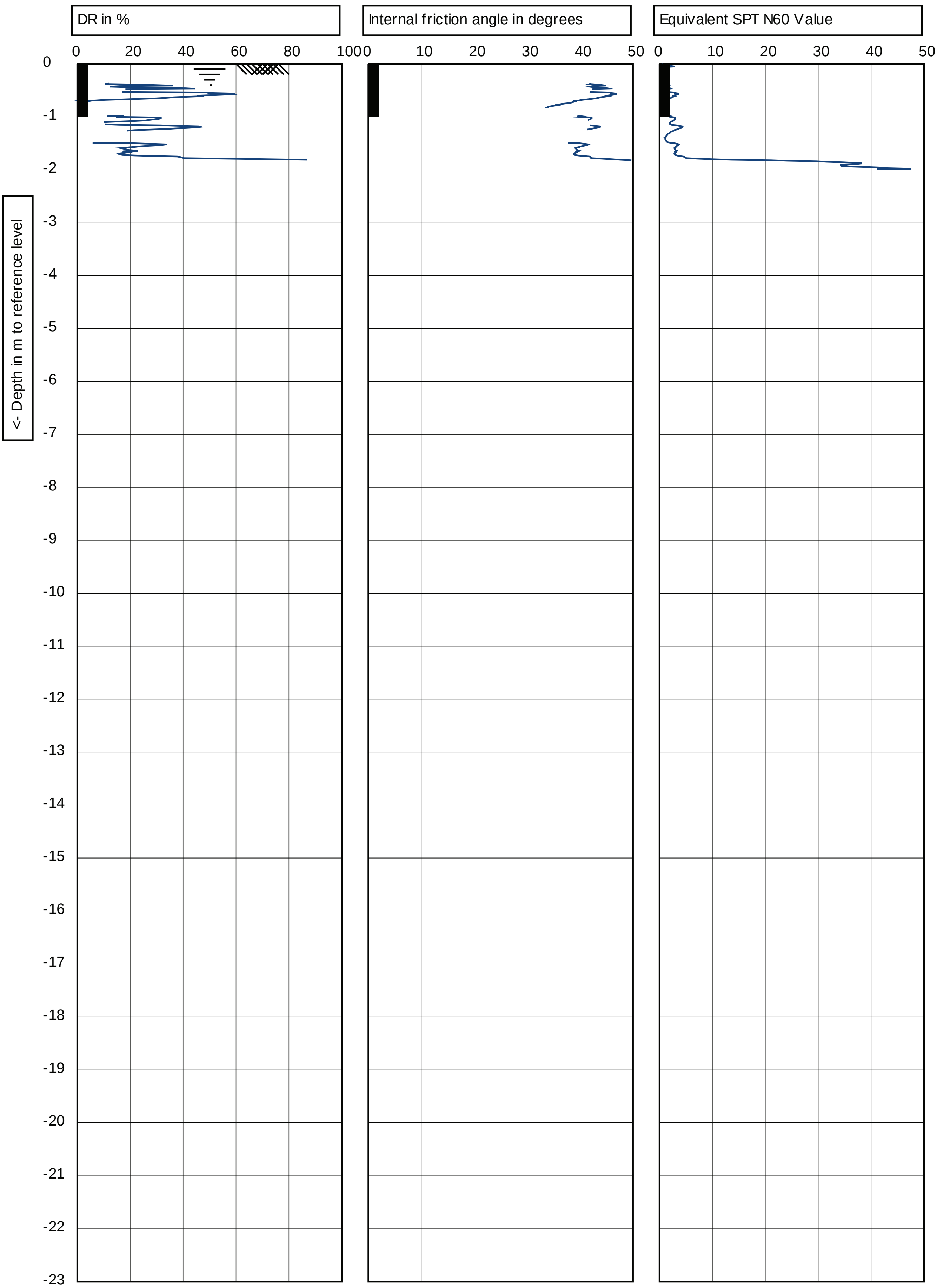
Predrill :	**1**
Date:	**9/05/2011**
Cone no.:	**C10CFIIP.E09**
Project no.:	**2-68292.11**
CPT no.:	**CPTBKM08** 1/6



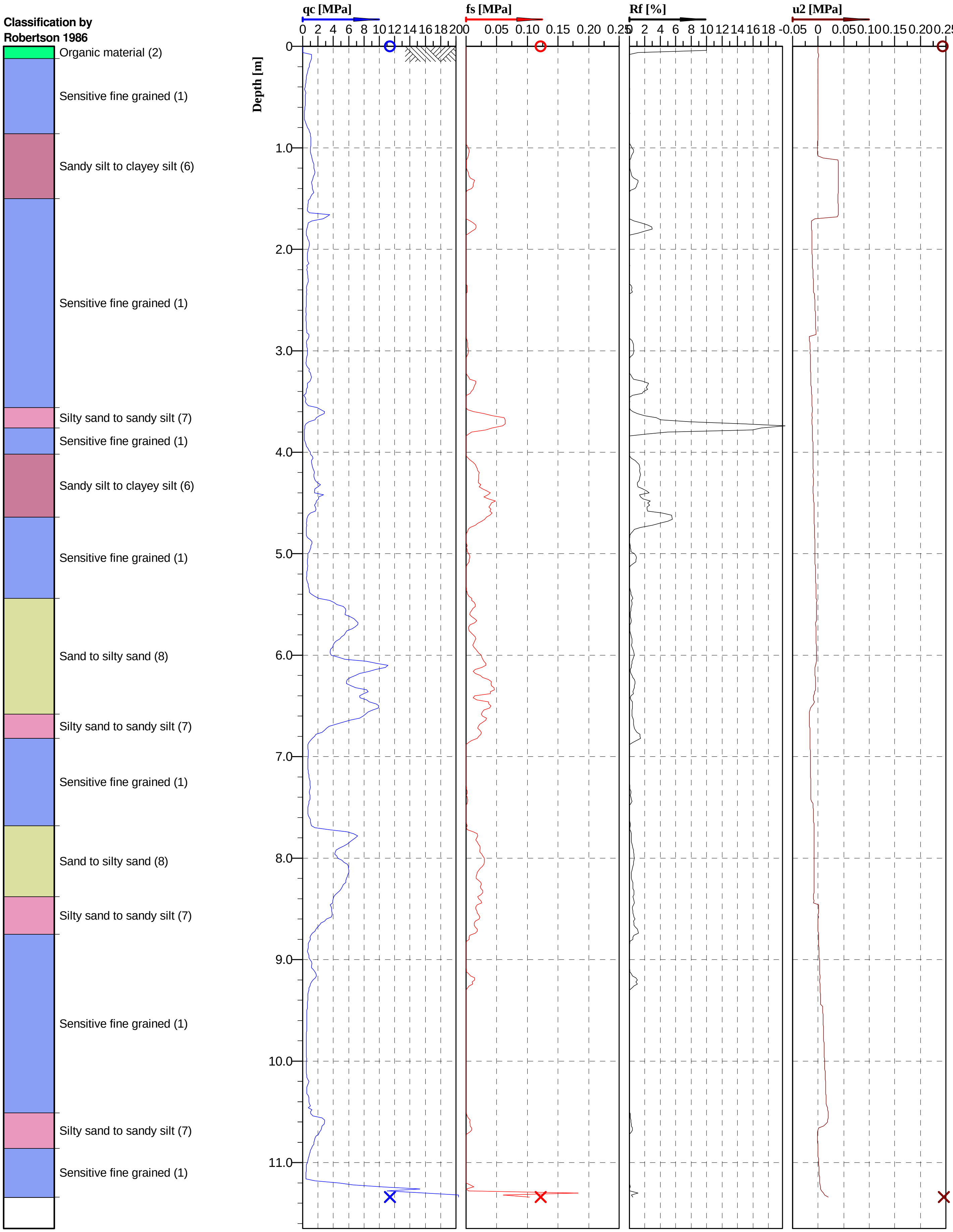
CPTask V1.20

OPUS HAMILTON LABORATORIES

u2 150 cm² 10 cm²	Test according to A.S.T.M standard D-5778-95		Predrill : **1**
	G.L. **0**	W.L.: **0**	Date: **9/05/2011**
Project: **BKM**			Cone no.: **C10CFIIP.E09**
Location: **GPS:E2480786 N5738214**			Project no.: **2-68292.11**
Position:			CPT no.: **CPTBKM08** **4/6**



OPUS HAMILTON LABORATORIES	u2, 150 cm², 10 cm²	Test according to A.S.T.M standard D-5778-95	Predrill : **1**
		G.L. **0** / W.L.: **0**	Date: **9/05/2011**
		Project: **BKM**	Cone no.: **C10CFIIP.E09**
		Location: **GPS:E2480786 N5738214**	Project no.: **2-68292.11**
		Position:	CPT no.: **CPTBKM08** **5/6**



Cone No: 100KN 4341
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Sleeve area [cm2]: 150

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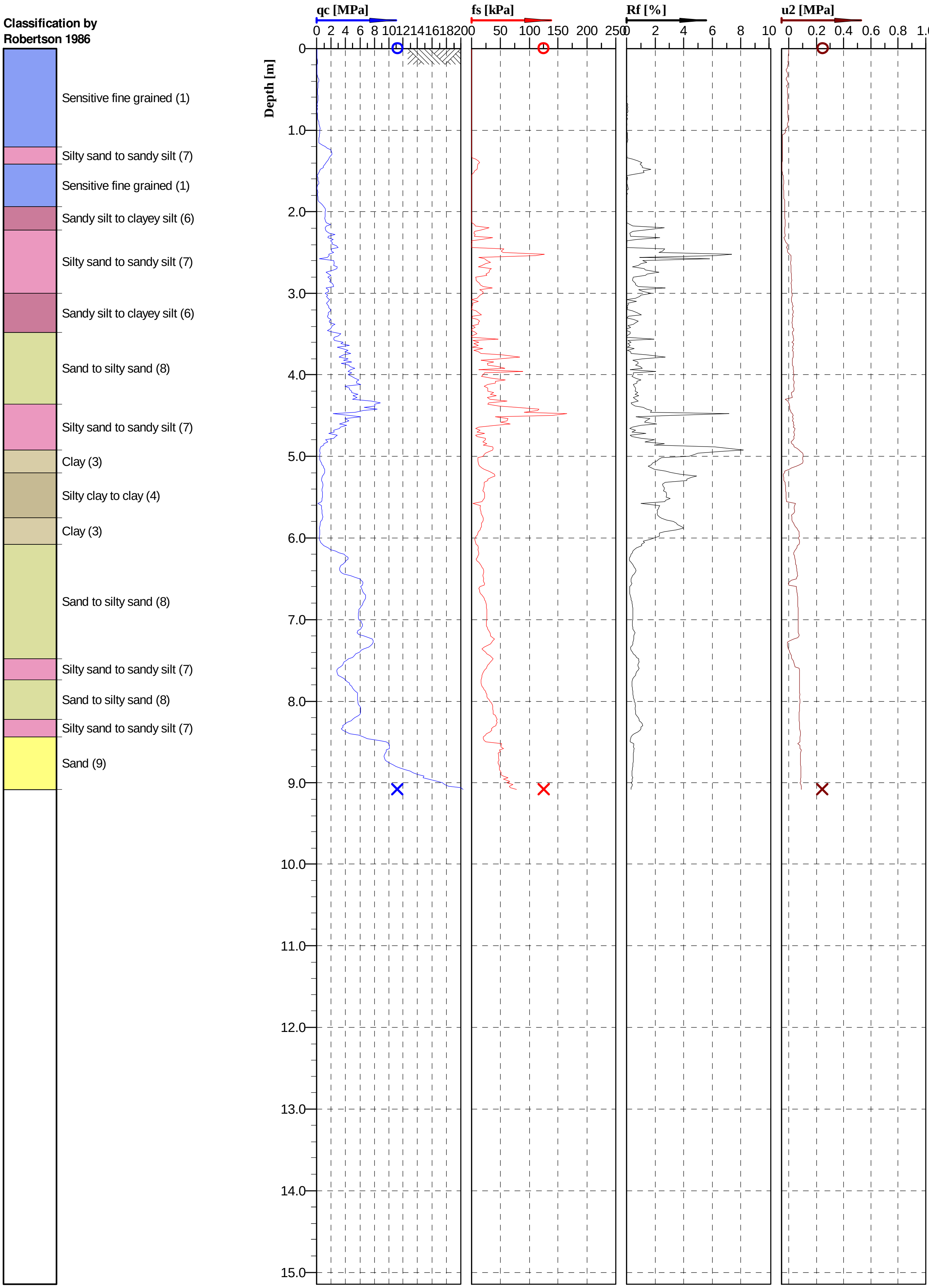
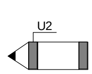
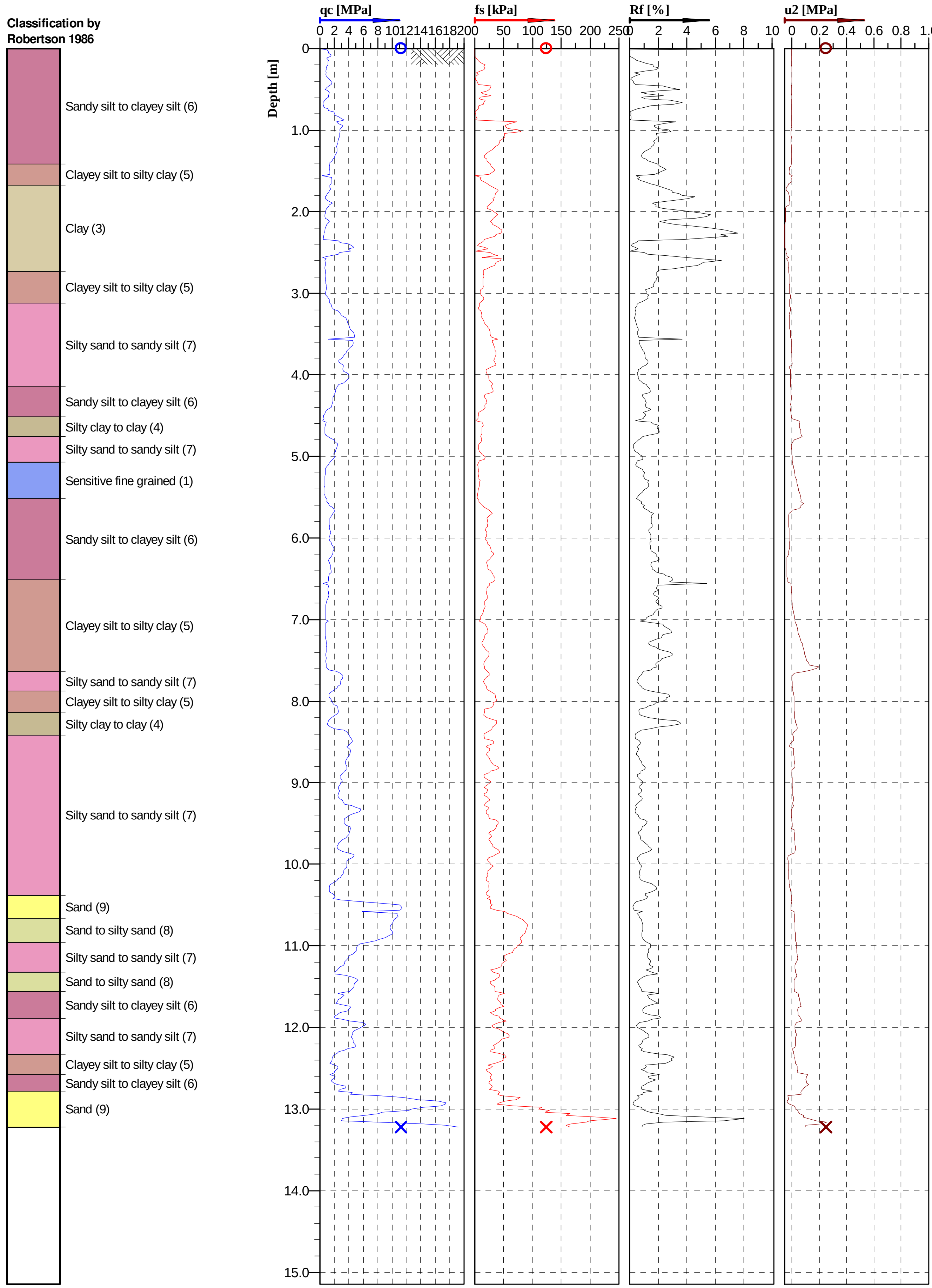
Project ID:	Client: TONKIN & TAYLOR LTD	Date: 22/06/2011	Scale: 1 : 50
Project: EQCSITES		Page: 1/1	Fig:
		File: CPT-BKM-09.CPT	





Cone No: 100KN 4341
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: CHRISTCHURCH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: SMF-CPT-21
Project ID:	Client: TONKIN & TAYLOR LTD	Date: 4/05/2011	Scale: 1 : 65
Project: EQC SITES		Page: 1/1	Fig:
		File: SMF-CPT-21.CPT	



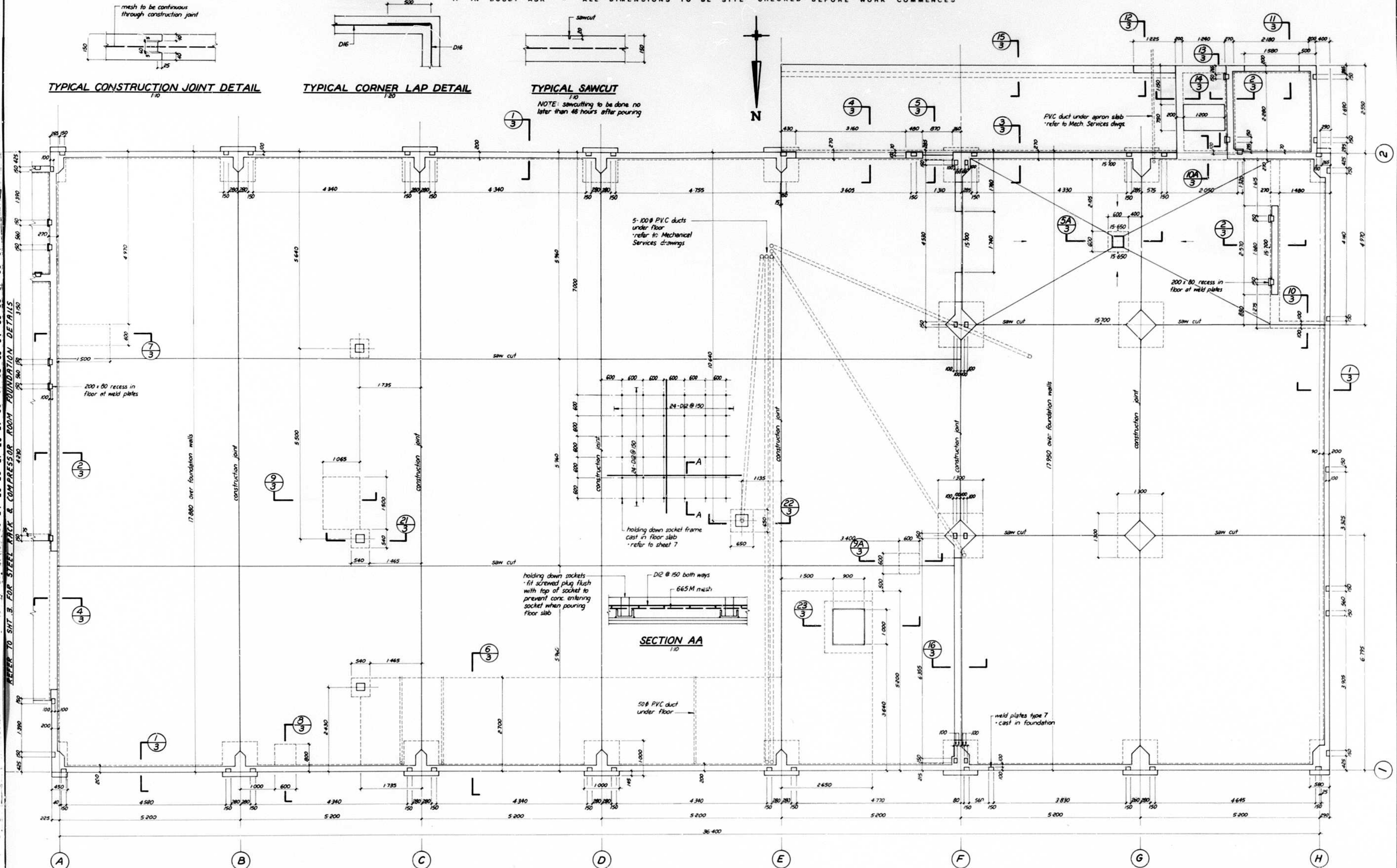
Cone No: 100KN 4341
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: CHRISTCHURCH	Position: X: 0.00 m, Y: 0.00 m	Ground level: 0.00	Test no: SMF-CPT-22
Project ID:	Client: TONKIN & TAYLOR LTD	Date: 5/05/2011	Scale: 1 : 65
Project: EQC SITES		Page: 1/1	Fig:
		File: SMF-CPT-22.CPT	

APPENDIX C:

Structural Drawings

IF IN DOUBT ASK - ALL DIMENSIONS TO BE SITE CHECKED BEFORE WORK COMMENCES



Service	Initials	Service	Initials	Amendments	Initials	Date		Book	Page	Initials	Date			Date	Approved
H.P. Water		Lands & Survey					Surveyed					Designed	W.R. Sissons	5/86	DESIGN ENGINEER 25/7/86 Date
Sewer		Planning					Levelled					Drawn	W.D. Inwood	7/86	
S.W. Drainage							B.M.					Traced	W.D. Inwood	7/86	
Gas												Dwg. Chk.		7/86	City Engineer
Cables (M.E.D.)							Compiled from					Des. Chk.		7/86	
" (P.O.)												Indexed			

CHRISTCHURCH CITY COUNCIL — CITY WORKS AND PLANNING DEPARTMENT

MAIN PUMPING STATION WORKSHOP
FOUNDATION PLAN

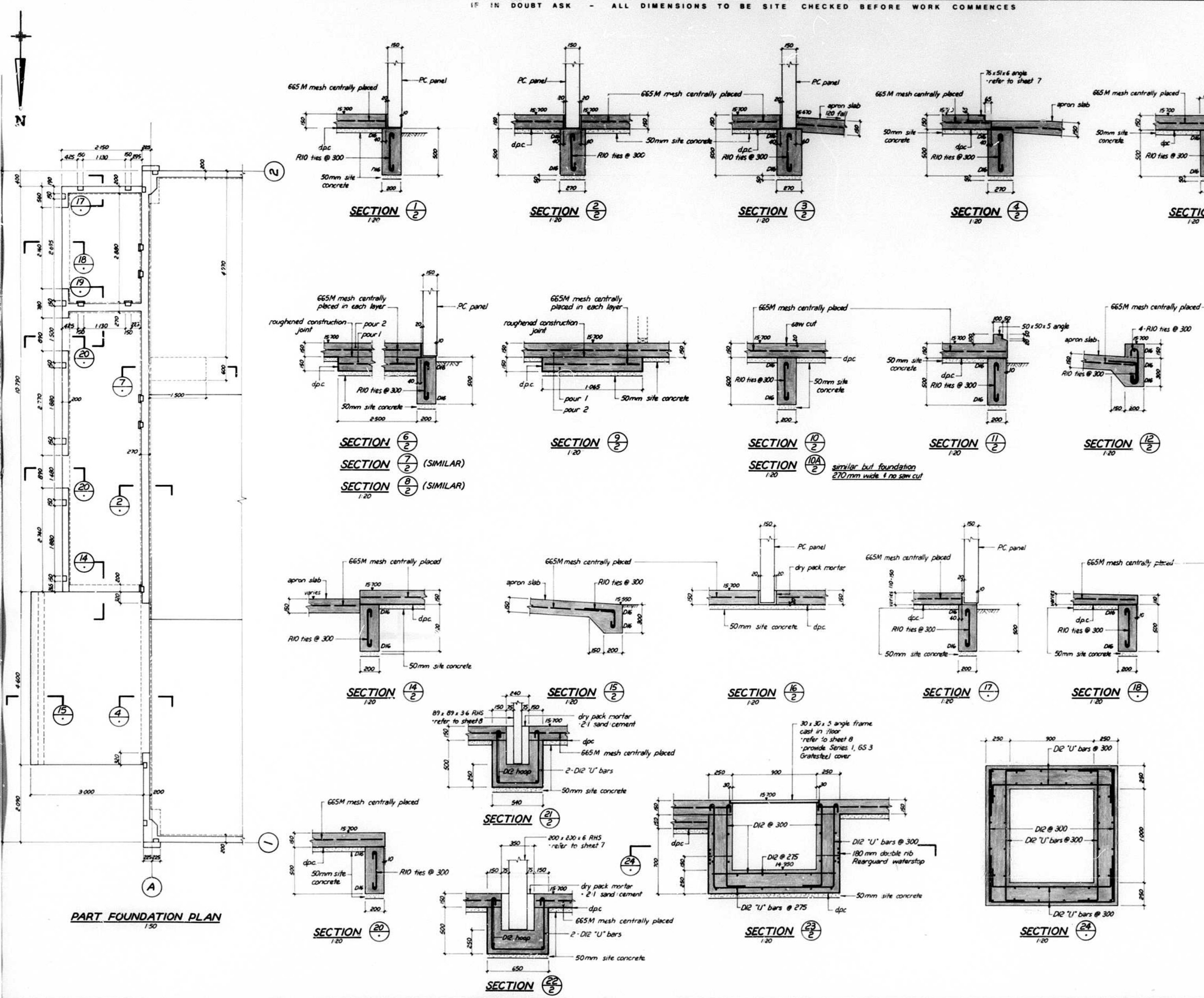
Scales 1:50

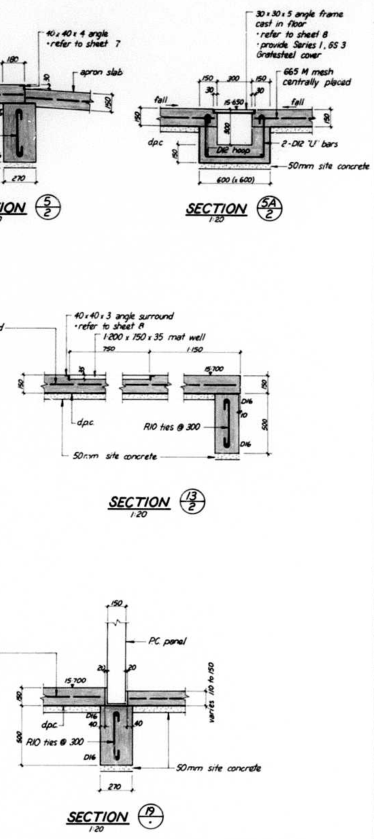
File No. D.3307

Issue

Sheet 2 of 14

IF IN DOUBT ASK - ALL DIMENSIONS TO BE SITE CHECKED BEFORE WORK COMMENCES





NOTES FOR FOUNDATIONS AND FLOOR SLAB

1) Concrete

(a) All concrete work shall comply with the provisions of NZS 3109:1980 Specification for Concrete Construction

(b) Concrete strength shall be as follows:

site concrete	f_c (28 days) = 10 MPa
foundations, floor slabs, apron slabs, sumps	f'_c (28 days) = 25MPa

(c) Surface finish to all exposed concrete shall be fairface equivalent to the following standards as specified in NZS 3114:1980:-

exposed sides of foundations, sump walls and edges of floor slab	F5x
floor slab	U2
apron slabs	U2 (power float with light broom)

x implies abrupt changes shall not exceed 1mm and gradual variations shall not exceed 4mm.

2) Reinforcing

(a) The following notation applies:
R = plain round bar Grade 275
D = deformed bar Grade 275

(b) Cover to reinforcing shall be 40mm to sides and bottom

(c) Reinforcing shall be continuous throughout and continuous through construction joints. Laps shall be kept to a minimum with the following minimum lap lengths being used:

D12	400 mm
D16	500 mm
Mesh	300 mm

3) Refer to Mechanical Services & Architectural drawings for all pipes, ducts and chases required to be cast or formed in concrete.

	Date
Designed W.R. Sissons	5/86
Drawn W.D. Inwood	6/86
Traced W.D. Inwood	6/86
Dwg. Chk.	7/86
Des. Chk.	7/86
Indexed	

Approved: DESIGN ENGINEER 25/7/86 — City Engineer

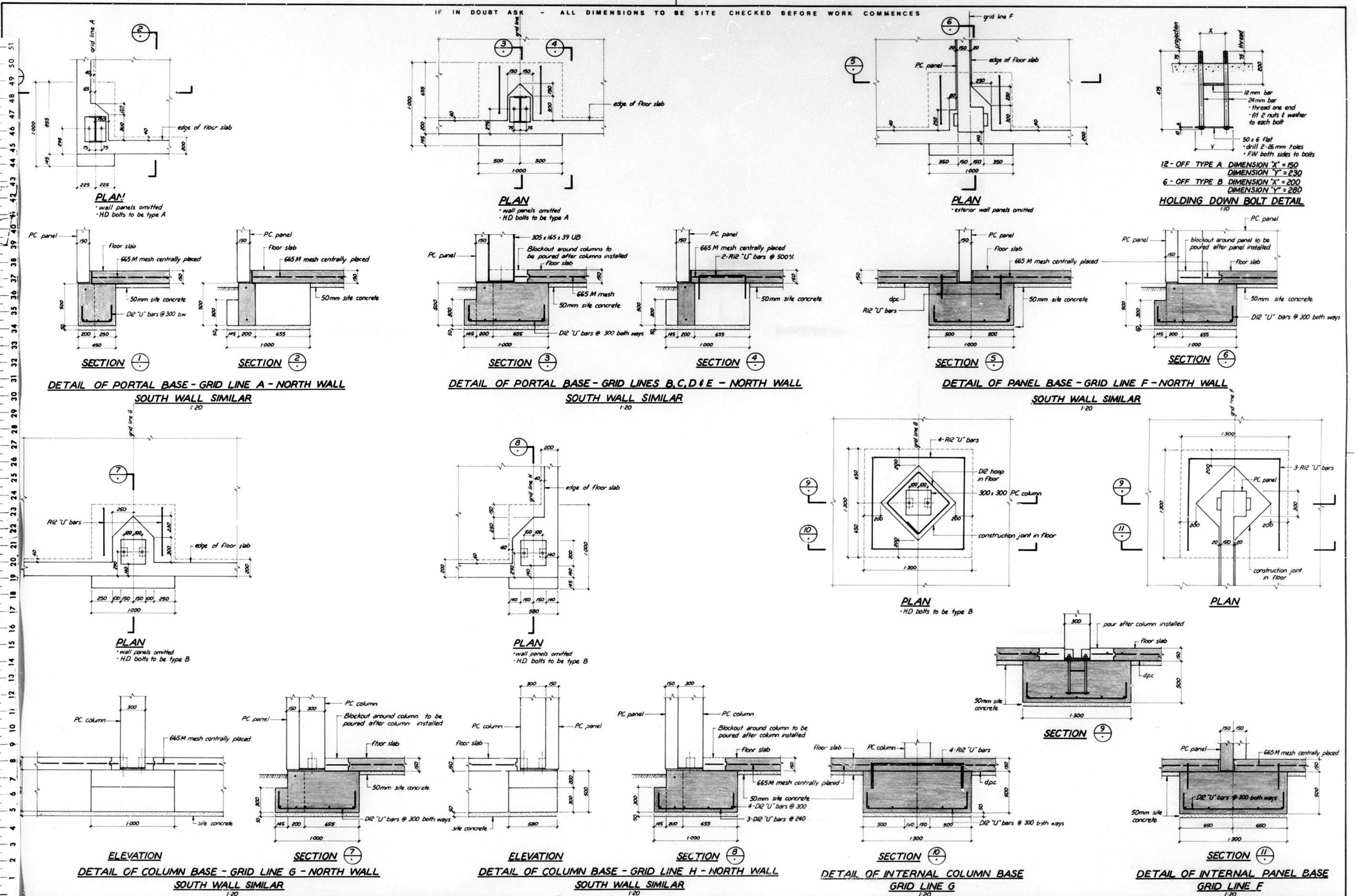
CHRISTCHURCH CITY COUNCIL — CITY WORKS AND PLANNING DEPARTMENT

MAIN PUMPING STATION WORKSHOP
PART FOUNDATION PLAN AND SECTIONS

Scales: 1:20, 1:50

D. 3307

Sheet 3 of 14



CHRISTCHURCH CITY COUNCIL — CITY WORKS AND PLANNING DEPARTMENT

MAIN PUMPING STATION WORKSHOP
DETAILS OF PORTAL BASES

	Initials	Date
Designer	W.R Sissons	5/86
Drawn	W.D Inwood	5/86
Traced	W.D Inwood	5/86
Dwg. Chk.		7/86
Des. Chk.		7/86
Indexed		

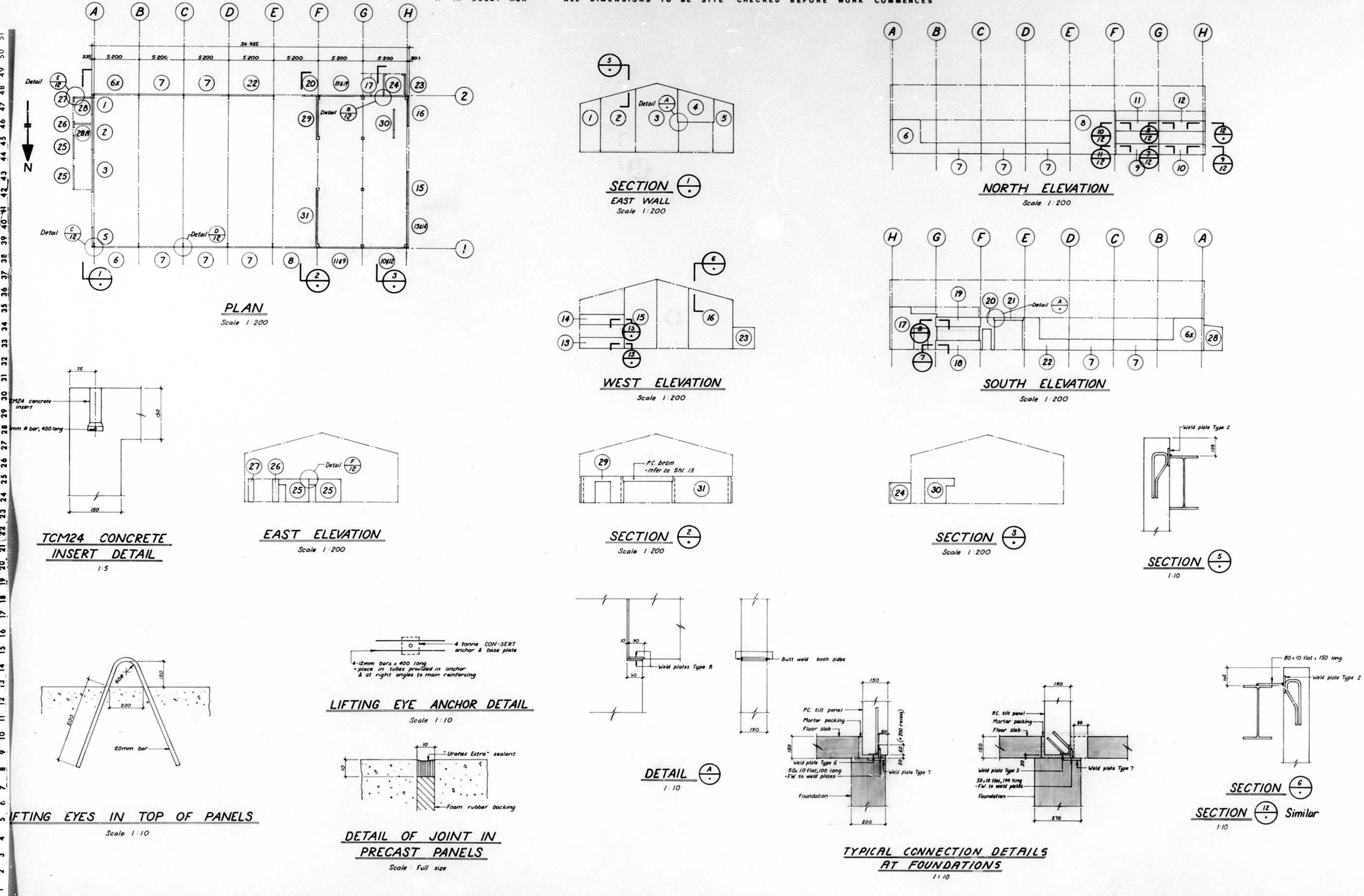
Approved: 25/7/86 — Design Engineer — City Engineer

Scales: 1:10, 1:20

D.3307

Sheet 4 of 14

IF IN DOUBT ASK — ALL DIMENSIONS TO BE SITE CHECKED BEFORE WORK COMMENCES



Service	Initials	Service	Initials	Amendments	Initials	Date		Book	Page	Initials	Date			Date	Approved	
		Lands & Survey					Surveyed					Designed	W.R. SISSONS	6/86	[signature] Design Engineer	25/7/[illegible] Date
		Planning					Levelled					Drawn	S.J. HORE	7/86		
							B.M.					Traced	S.J. HORE	"		
												Dwg. Chk.	[signature]	7/86	[signature] City Engineer	
(M.E.D.)							Compiled from					Des. Chk.	[signature]	7/86		
(P.O.)												Indexed				

CHRISTCHURCH CITY COUNCIL — CITY WORKS AND PLANNING DEPARTMENT

MAIN PUMPING STATION WORKSHOP
P.C. WALL PANELS - PLAN, ELEVATIONS & JOINT DETAILS

Scales: 1:1, 1:5, 1:10, 1:200

File No. — Issue

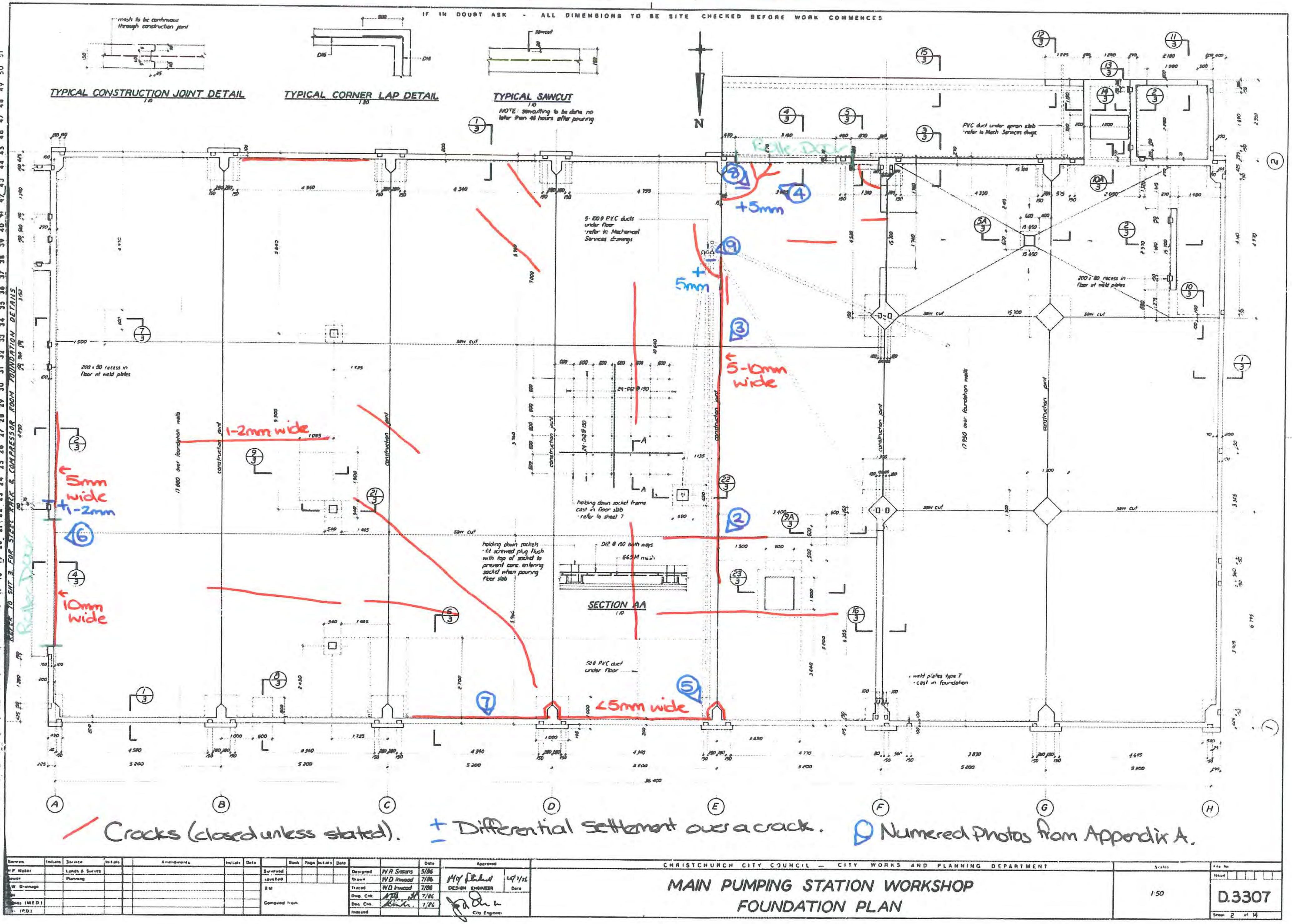
D. 3307

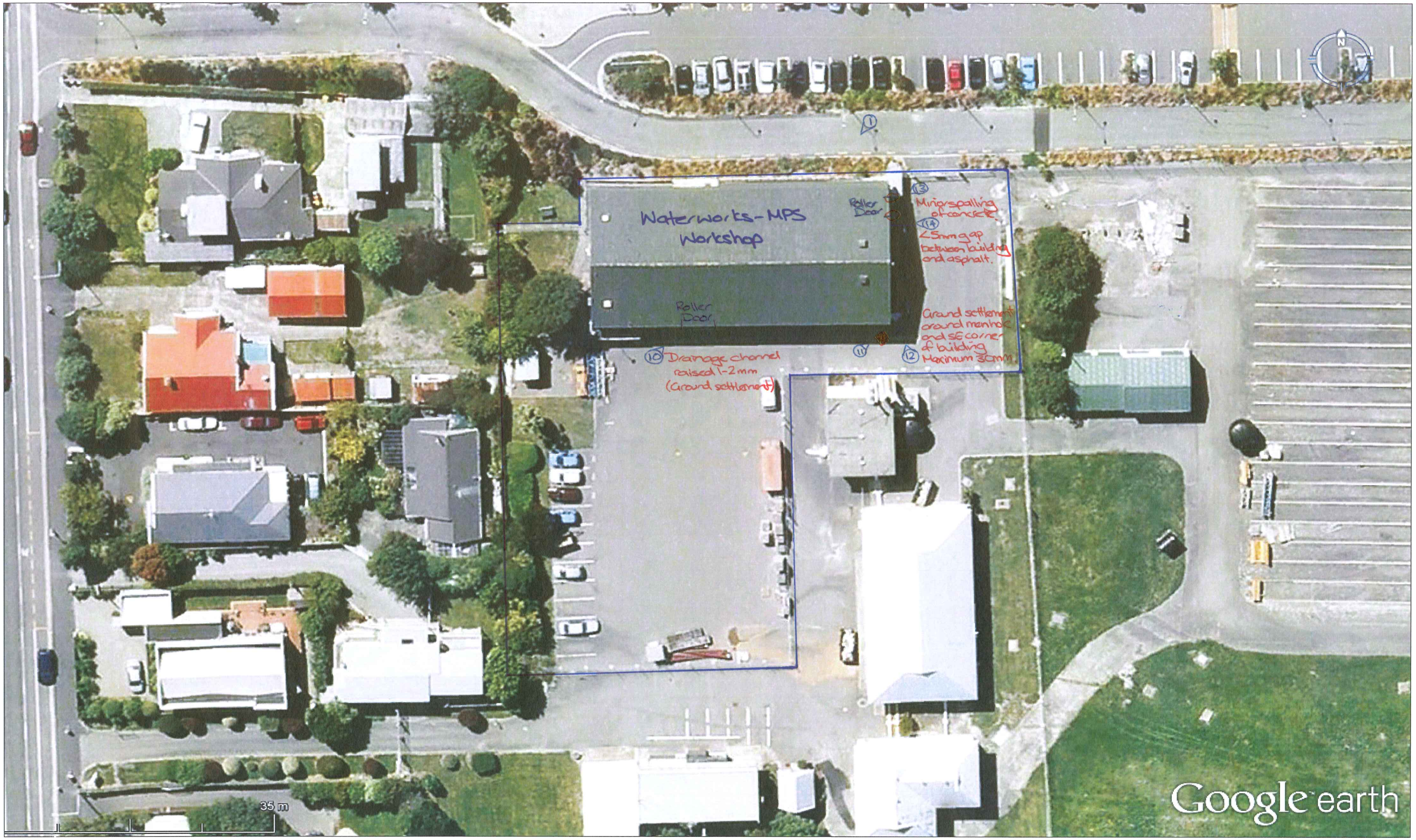
Sheet 9 of 14

APPENDIX D:

Site Walkover Plan
Site Walkover Aerial Plan

Site Walkover Plan - Interior 03/05/2012





Key: Numbered Photos from Appendix A.

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:** Waterworks MPS - Workshop Geotechnical Desktop Study **Project No.:** 6-QUCCC.69 **Client:** Christchurch City Council	**Site Walkover Plan** **Drawn:** Engineering Geologist **Date:** 3-May-12

Appendix D – CERA DEE Datasheet

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Waterworks MPS Workshop	Reviewer:	Dave Dekker
	Unit / No: / Street	CPEng No:	
Building Address:	54 Colombo Street	Company:	Opus International Consultants Ltd
Legal Description:		Company project number:	6-QUCCC.69
		Company phone number:	07 834 1897
	Degrees / Min / Sec		
GPS south:		Date of submission:	8-Feb-13
GPS east:		Inspection Date:	2-Mar-12
		Revision:	Final
Building Unique Identifier (CCC):	BU 1759-002 EQ2	Is there a full report with this summary?	yes

Site

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

Building

No. of storeys above ground:	1 (single storey = 1)	Ground floor elevation (Absolute) (m):	36.90
Ground floor split?	yes	Ground floor elevation above ground (m):	36.90
Storeys below ground	0		
Foundation type:	other (describe)	if Foundation type is other, describe:	Column pad ftg with perimeter strip ftg
Building height (m):	8.16	height from ground to level of uppermost seismic mass (for IEP only) (m):	5.8
Floor footprint area (approx):	650		
Age of Building (years):	25	Date of design:	1976-1992
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	commercial	Brief strengthening description:	
Use (upper floors):	other (specify)		
Use notes (if required):	office		
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	frame system		
Roof:	steel framed	rafter type, purlin type and cladding	Portal frames with C purlins
Floors:	precast concrete with topping	unit type and depth (mm), topping	75mm unispan, 75
Beams:	precast concrete	overall depth (mm)	400
Columns:	structural steel	typical dimensions (mm x mm)	305 x 165
Walls:	non-load bearing	0	

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	other (note)		describe system	precast panels
Ductility assumed, μ:	1.25			150
Period along:	0.40	0.00	estimate or calculation?	estimated
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):			estimate or calculation?	
Lateral system across:	steel frame with infill		note typical frame sizes and bay length (m)	
Ductility assumed, μ:	1.25			
Period across:	0.83	##### enter height above at H31	estimate or calculation?	calculated
Total deflection (ULS) (mm):	73		estimate or calculation?	calculated
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:	precast, full flight	describe supports	bolted. Free to move
Wall cladding:	precast panels	thickness and fixing type	150mm. Spot welded to portal column
Roof Cladding:	Metal	describe	
Glazing:	aluminium frames		
Ceilings:	none		
Services(list):			

Available documentation

Architectural	full	original designer name/date	
Structural	full	original designer name/date	CCC- City Works & Planning Department
Mechanical	none	original designer name/date	
Electrical	none	original designer name/date	
Geotech report	none	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:	Good	Describe damage:	minor floor crackings
Settlement:	none observed	notes (if applicable):	
Differential settlement:	0-1:350	notes (if applicable):	5mm observed
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	0-20mm/20m	notes (if applicable):	
Damage to area:	slight	notes (if applicable):	

Building:

	Current Placard Status:	green		
Along	Damage ratio:		Describe how damage ratio arrived at:	
	Describe (summary):			
Across	Damage ratio:	#DIV/0!		
	Describe (summary):			
Diaphragms	Damage?:	no	Describe:	
CSWs:	Damage?:	no	Describe:	
Pounding:	Damage?:	no	Describe:	
Non-structural:	Damage?:	yes	Describe:	

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

Recommendations

	Level of repair/strengthening required:	minor structural	Describe:	install strut members and wall bracings in the longitudinal
	Building Consent required:	yes	Describe:	
	Interim occupancy recommendations:	full occupancy	Describe:	
Along	Assessed %NBS before:	##### %NBS from IEP below	If IEP not used, please detail assessment methodology:	
	Assessed %NBS after:	38%		
Across	Assessed %NBS before:	##### %NBS from IEP below		
	Assessed %NBS after:	72%		

OPUS