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Storage Shed
PRK 2561 BLDG 003 EQ2
Detailed Engineering Evaluation
Qualitative Report
Version FINAL

75 Lower Styx Road, Bottle Lake

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Qualitative Report
Version FINAL

75 Lower Styx Road, Bottle Lake

Christchurch City Council

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Date
12th December 2013

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Qualitative Report Summary

Storage Sheds

PRK 2561 BLDG 003 EQ2

Detailed Engineering Evaluation

Qualitative Report - SUMMARY

Version FINAL

75 Lower Styx Road, Bottle Lake, Christchurch

Background

This is a summary of the Qualitative report for the building structure, and is based in part on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 and visual inspections on 16th April 2012.

Building Description

The storage shed is located at 75 Lower Styx Road, Bottle Lake, Christchurch. The exact date of construction of the original portion of the building is unknown but it is known to be pre-1974. A significant portion of the building was rebuilt in 1974. The building is currently used for storage of hay and as a workshop/tool shed. There are 6 buildings located on the site with various uses.

The roof of the building is corrugated iron on timber sarking. The sarking is fixed to timber roof joists spanning longitudinally between the timber purlins. The timber purlins rest on the timber framed walls to the rear and a timber beam and post frame system along the front of the building. Intermediate support is provided by a timber beam and post frame system. External walls are timber framed with metal cladding to the exterior and no internal linings. The front of the building is open with timber posts providing support for the timber beams. Floors are concrete slab on grade. Foundations are concrete strip footings to the perimeter walls.

Key Damage Observed

- ▶ No earthquake related damage was noted
- ▶ Cracking was noted to one of the timber posts along the north-west side of the building. It is suspected that this damage is as a result of an impact with a vehicle.

Critical Structural Weaknesses

The following potential critical structural weaknesses have been identified in the structure.

- | | | |
|-------------------------------------|---|---------|
| ▶ Plan Irregularity (30% Reduction) | } | 24% NBS |
| ▶ Existing Damage (10% Reduction) | | |

Indicative Building Strength (from IEP and CSW assessment)

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the original capacity of the building has been assessed to be in the order of 24% NBS and post-earthquake capacity also in the order of 24% NBS. The building's post-earthquake capacity excluding critical structural weaknesses is in the order of 37% NBS.

The building has been assessed to have a seismic capacity in the order of 24% NBS and is therefore considered to be potentially Earthquake Prone.

Recommendations

The recent seismic activity in Christchurch has caused no visible damage to the building. However, as the building has achieved less than 34% NBS following a qualitative Detailed Engineering Evaluation of the building, further assessment is required. It is recommended that a quantitative assessment be carried out and if necessary strengthening options explored.

The building should not be occupied as per CCC policy regarding the occupancy of potentially Earthquake Prone buildings.

1. Background

GHD has been engaged by the Christchurch City Council (CCC) to undertake a detailed engineering evaluation of the storage shed at 75 Lower Styx Road.

This report is a Qualitative Assessment of the building structure, and is based in part on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011.

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

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

At the time of this report, no intrusive site investigation, detailed analysis, or modelling of the building structure had been carried out. Construction drawings were made available, and these have been considered in our evaluation of the building. The building description is based on a review of the drawings and our visual inspections.

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

We understand that CERA will require a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). It is anticipated that CERA will adopt the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

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

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

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

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

2.2.1 Section 121 – Dangerous Buildings

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

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

Section 122 – Earthquake Prone Buildings

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

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 of the 4th September 2010.

The 2010 amendment includes the following:

- ▶ A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- ▶ A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
- ▶ A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- ▶ Repair works for buildings damaged by earthquakes will be required to comply with the above.

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

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

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

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

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.

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

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

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

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 new building standard load requirements have been determined in accordance with the current earthquake loading standard (NZS 1170.5:2004 Structural design actions - Earthquake actions - New Zealand).

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

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 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	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement	Unacceptable	Unacceptable

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

Table 1 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.

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

Table 1 %NBS compared to relative risk of failure

4. Building Description

4.1 General

The building is located at 75 Lower Styx Road, Bottle Lake, Christchurch. The exact date of construction of the original portion of the building is unknown but it is believed to be pre-1974 as a portion of the building was rebuilt in 1974. The building is currently used for storage of hay and as a workshop. There are 6 buildings located on the site with various uses.

The roof of the building is corrugated iron on timber sarking. The sarking is fixed to timber purlins spanning longitudinally between the timber rafters. The spacing of the rafters is 0.9m centres for the 1974 portion of the building and 0.6m centres for the pre-1974 portion of the building as indicated in Figure 2. The timber rafters rest on the timber framed walls to the rear of the building and timber beams along the front of the building. Intermediate support is provided by the central timber beams as shown in Figure 2. External walls along the rear and sides of the building are timber framed with metal cladding to the exterior and no internal linings. The front face of the 1974 portion of the building is open with timber posts providing support for the timber beams. The pre-1974 portion also uses a timber beam and post frame system but has non-load bearing timber framed walls between posts. Floors are concrete slab on grade. Foundations are concrete strip footings to the rear and sides of the building. The timber posts are supported by the concrete piles.

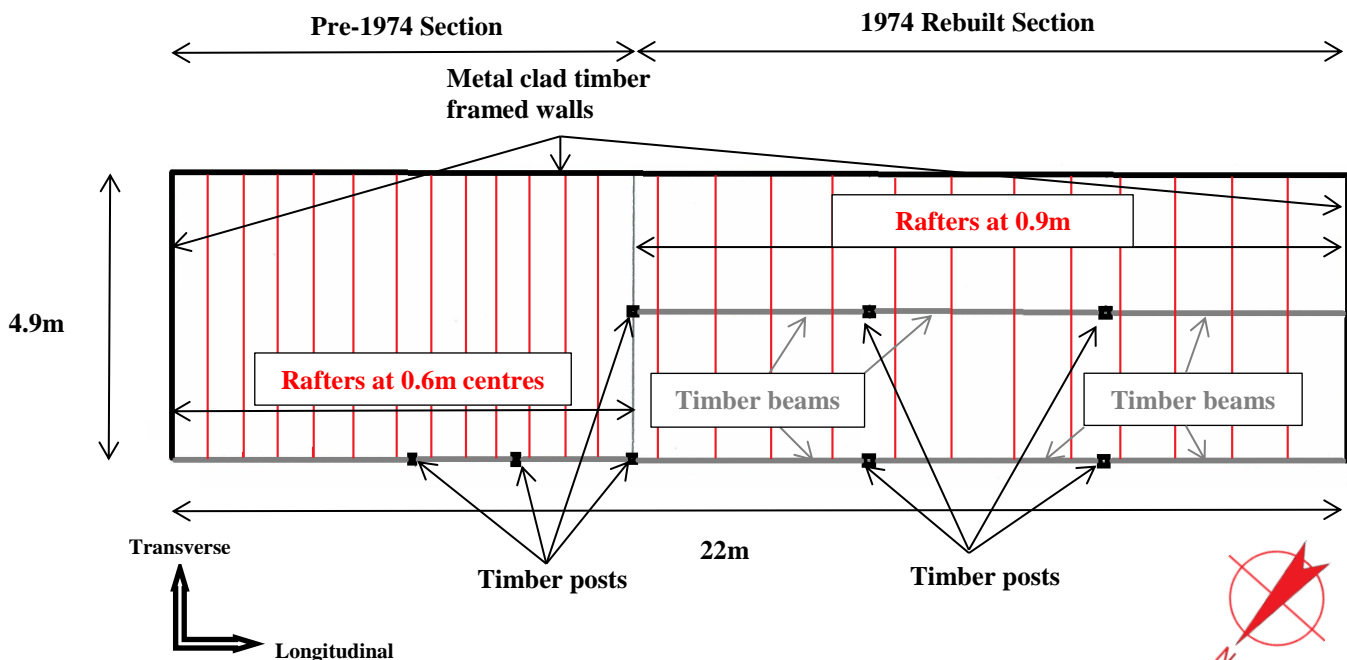


Figure 2 Plan Sketch Showing Key Structural Elements

The dimensions of the building are approximately 22m in length, 5m in width and 2.8m in height. The plan area of the building is approximately 110m².

The nearest building to the storage shed is the shed approximately 4m to the south-west. The closest waterway is the Styx River approximately 45m to the south-west. The site is predominantly flat with insignificant variations in the ground levels throughout.

4.2 Gravity Load Resisting System

Gravity loads are transferred from the metal roof cladding to the timber roof sarking, then through to the timber purlins. In the 1974 portion of the building, the roof purlins are supported by the external load bearing timber framed walls to the rear of the building and timber beams spanning longitudinally along the centre of the building and along the front edge. In the older section of the building it is believed that the timber rafters span the width of the building to the load bearing timber frame walls to the rear and timber beams along the front wall. Loads transferred down through the external timber frame walls are then transmitted through to the concrete perimeter strip foundations and into the ground below. Loads transferred to the timber beams to the front of the building are transferred to the timber posts and down to the concrete piles.

Internal gravity loads are transferred directly through to the concrete floor slab which transfers the loads to the ground below.

4.3 Lateral Load Resisting System

4.3.1 Longitudinal

The primary lateral load path in the longitudinal direction of the building is from the roof cladding, to the sarking, to the rafters, back to the timber framed rear wall of the building, on to the strip footings and finally to the ground below.

The roof cladding, sarking, rafters and joists combine to form a roof diaphragm which will transfer the majority of the lateral loading to the back wall of the building. No cross bracing was seen in the roof or walls of the building. Loads are then transferred to the ground through diaphragm action of the metal wall cladding. As with the roof, it is expected that the metal cladding fixed to the timber framed walls will provide some diaphragm action. Some lateral load resistance is provided by the timber beam and post frame system along the centre line and the front of the building. Knee bracing helps to create a moment frame system in these instances. Torsional effects are partially resisted by the metal clad side walls.

4.3.2 Transverse

The primary lateral load path through the structure in the transverse direction is from the roof cladding, to the sarking, to the rafters, back to the timber framed side walls.

It is not believed that the wall between the pre-1974 portion and the rebuilt section will provide any support in the transverse direction as cladding appears to be haphazard and inadequately fixed. Nominal diaphragm action of the roof cladding and timber sarking transfer lateral roof loads to the side walls. The side walls through diaphragm/sheet bracing action of the metal wall cladding will transfer the load to the ground.

5. Assessment

An inspection of the building was undertaken on the 16th of April 2012. Both the interior and exterior of the rebuilt portion and the exterior of the pre-1974 portion of the building were inspected. A portion of the interior of the pre-1974 portion was visible through a window.

The inspection consisted of scrutinising the building to determine the structural systems and likely behaviour of the building during an earthquake. The site was assessed for damage, including examination of the ground conditions, checking for damage in areas where damage would be expected for the type of structure and noting general damage observed throughout the building in both structural and non-structural elements.

The %NBS score determined for this building has been based on the IEP procedure described by the NZSEE and based on the information obtained from visual observation of the building and available drawings.

6. Damage Assessment

6.1 Surrounding Buildings

The storage shed at 75 Lower Styx Road is located in a rural area with 5 other buildings. These buildings are a house, a garage, a hay barn, a dairy unit and a barn. There did not appear to be any earthquake related damage to any of these structures.

6.2 Residual Displacements and General Observations

No residual displacements of the structure were noticed during our inspection of the building.

The only damage noted to the building was cracking to the timber posts along the north-west of the building but this is not believed to be as a result of the earthquakes. It is believed that this damage is as a result of an impact from a farm vehicle. See photograph 6. This damage has been taken into account when assessing the building by applying a 10% reduction to the % NBS of the building.

6.3 Ground Damage

There was no evidence of ground damage on the property. Neighbouring land to the southwest, at 51 Lower Styx Road, was severely affected by lateral spreading.

7. Critical Structural Weakness

7.1 Short Columns

No significant short columns are present in the structure.

7.2 Lift Shaft

The building does not contain a lift shaft.

7.3 Roof

Roof bracing was achieved through the metal cladding and timber sarking. This is probably not sufficient in the transverse direction as the building is relatively long and narrow.

7.4 Staircases

The building does not contain a staircase.

7.5 Site Characteristics

Based on the findings of the desktop geotechnical study, the site has a moderate to high potential for liquefaction. As the building is timber framed and can accommodate moderate movement, for the purposes of the IEP assessment of the building and the determination of the %NBS score, the effects of soil liquefaction on the performance of the building has been assessed as an 'insignificant' site characteristic in accordance with the NZSEE guidelines.

7.6 Plan Irregularity

The building has a large opening in the front face and a relatively stiff rear wall. Some central and front face bracing exists in the form of knee braced timber beams and posts. However, in the longitudinal direction, this building is considered to have a 'significant' critical structural weakness.

8. Geotechnical Consideration

8.1 Site Description

The site at 75 Lower Styx Road is situated in Bottle Lake, just north of Christchurch City. It is situated between the Styx River and Lower Styx Road, and is relatively flat at approximately 3m above mean sea level. It is approximately 4km south of the Waimakariri River, and 4km west of the coast (Pegasus Bay).

8.2 Published Information on Ground Conditions

8.2.1 Published Geology

The geological map of the area¹ indicates that the site to be on or near the boundary of the following units:

- grey river alluvium, comprising gravel, sand and silt, in active floodplains, Holocene in age; and,
- beach sand or river sand dunes, Holocene in age.

8.2.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that three boreholes are located within a 200m radius of the site. Of these boreholes, two of them had lithographic logs (see Table 2), which indicate the area is typically underlain by 30m of sand and gravel. The logs also indicate the potential presence of strata containing peat at approximately 27m below ground level (bgl).

Table 2 ECan Borehole Summary

Bore Name	Log Depth	Groundwater	Distance & Direction from Site
M35/9747	30.0m	0.30m bgl	150m NE of the site
M35/11929	32.5m	0.72m bgl	150m SW of the site

It should be noted that the purpose of the boreholes the well logs are associated with, were sunk for groundwater extraction and not for geotechnical purposes. Therefore, the amount of material recovered and available for interpretation and recording will have been variable at best and may not be representative. The logs have been written by the well driller and not a geotechnical professional or to a standard. In addition strength data is not recorded.

8.2.3 EQC Geotechnical Investigations

The Earthquake Commission has not undertaken geotechnical testing in the area of the subject site.

¹ Forsyth P.J., Barrell D.J.A., & Jongens R. 2008: *Geology of the Christchurch Area*. Institute of Geological and Nuclear Sciences 1:250,000 Geological Map 16. Lower Hutt. Institute of Geological and Nuclear Sciences Limited.

8.2.4 Land Zoning

Canterbury Earthquake Recovery Authority (CERA) has published areas showing the Green Zone Technical Category in relation to the risk of future liquefaction and how these areas are expected to perform in future earthquakes.

The site is classified as Green Zone, indicating the land is generally suitable for repair and rebuilding to take place. It is also categorised Technical Category Not Applicable (rural & unmapped), as the property is considered non-residential.

8.2.5 Post February Aerial Photography

Aerial photography taken following the 22 February 2011 earthquake doesn't show clear signs of liquefaction (see Figure 3), however, liquefaction was observed close to the property.

Figure 3 Post February 2011 Earthquake Aerial Photography ²



8.2.6 Summary of Ground Conditions

From the information presented above, the ground conditions underlying the site are anticipated to comprise beach sands and gravels. However, due to the limited information available, this is subject to confirmation.

² Aerial Photography Supplied by Koordinates sourced from <http://koordinates.com/layer/3185-christchurch-post-earthquake-aerial-photos-24-feb-2011/>

8.3 Seismicity

8.3.1 Nearby Faults

There are many faults in the Canterbury region, however only those considered most likely to have an adverse effect on the site are detailed below.

Table 3 Summary of Known Active Faults³⁴

Known Active Fault	Distance from Site	Direction from Site	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	130 km	NW	~8.3	~300 years
Greendale (2010) Fault	30 km	SW	7.1	~15,000 years
Hope Fault	100 km	N	7.2~7.5	120~200 years
Kelly Fault	110 km	NW	7.2	150 years
Porters Pass Fault	60 km	NW	7.0	1100 years

Recent earthquakes since 22 February 2011 have identified the presence of a previously unmapped active fault system underneath Christchurch City and the Port Hills. Research and published information on this system is in development and not generally available. Average recurrence intervals are yet to be estimated.

8.3.2 Ground Shaking Hazard

This seismic activity has produced earthquakes of Magnitude-6.3 with peak ground accelerations (PGA) up to twice the acceleration due to gravity (2g) in some parts of the city. This has resulted in widespread liquefaction throughout Christchurch.

New Zealand Standard NZS 1170.5:2004 quantifies the Seismic Hazard factor for Christchurch as 0.30, being in a moderate to high earthquake zone. This value has been provisionally upgraded recently (from 0.22) to reflect the seismicity hazard observed in the earthquakes since 4 September 2010.

In addition, anticipation of marine and/or estuarine sands of varying density, a 475-year PGA (peak ground acceleration) of ~0.4 (Stirling et al, 2002⁴), and bedrock anticipated to be in excess of 500m deep, and hence ground shaking is likely to be relatively high.

8.4 Slope Failure and/or Rockfall Potential

Given the site's location in a flat area northeast of Christchurch, global slope instability is considered negligible. However, the Styx River may be susceptible to lateral spreading, as evident to the north in Spencerville following the 4th September 2010 and 22nd February 2011 earthquakes.

³ Stirling, M.W, McVerry, G.H, and Berryman K.R. (2002) A New Seismic Hazard Model for New Zealand, Bulletin of the Seismological Society of America, Vol. 92 No. 5, pp 1878-1903, June 2002.

⁴ GNS Active Faults Database

In addition, any localised retaining structures or embankments should be further investigated to determine the site-specific slope instability potential.

8.5 Liquefaction Potential

Due to the anticipated presence of sand at the shallow depth, and the sites proximity to a local water course, it is considered possible that liquefaction will occur at the site. It is not clear from the post-earthquake aerial photography (Figure 3) whether liquefaction has occurred at the site, however, it was observed close to the property. The site is considered to have a moderate-high liquefaction potential at this stage of investigation.

This liquefaction may occur in the form of sand boils, lateral spreading or both.

Ground Investigation should be undertaken to establish the liquefaction potential of the site and allow a comprehensive liquefaction assessment to be undertaken.

8.6 Recommendations

A soil class of **D** (in accordance with NZS 1170.5:2004) should be adopted for the site.

It is recommended that three piezocone CPTs be conducted to target depths of 20m. This will allow a liquefaction assessment to be carried out.

8.7 Conclusions & Summary

This assessment is based on a review of the geology and existing ground investigation information, and observations from the Christchurch earthquakes since 4 September 2010.

The site is anticipated to be situated predominantly on sand and gravel. Associated with this the site also has a moderate-high liquefaction potential. This may also arise in the form of lateral spreading on the Styx River.

A soil class of **D** (in accordance with NZS 1170.5:2004) should be adopted for the site.

It is recommended that intrusive investigation comprising three piezocone CPTs be conducted to target depths of 20m.

9. Survey

No level or verticality surveys have been undertaken for this building at this stage in accordance with Christchurch City Council guidelines.

10. Initial Capacity Assessment

10.1 % NBS Assessment

The building's capacity was assessed using the Initial Evaluation Procedure based on the information available. The building's capacity excluding critical structural weaknesses and the capacity of any identified weaknesses are expressed as a percentage of new building standard (%NBS) and are in the order of that shown below in Table 4. These capacities are subject to confirmation by a more detailed quantitative analysis.

<u>Item</u>	<u>%NBS</u>
Building excluding CSW's	37
Plan Irregularity (30% Reduction)	} 24
Existing Damage (10% Reduction)	

Table 4 Indicative Building and Critical Structural Weaknesses Capacities based on the NZSEE Initial Evaluation Procedure

Following an IEP assessment, the building has been assessed as achieving 24% New Building Standard (NBS). Under the New Zealand Society for Earthquake Engineering (NZSEE) guidelines the building is considered potentially Earthquake Prone as it achieves less than 34% NBS. The existing damage to the building is believed to adversely affect the load carrying capacity and as a result the % NBS of the building has had a further 10% Reduction applied to it.

10.2 Seismic Parameters

The seismic design parameters based on current design requirements from NZS 1170:2002 and the NZBC clause B1 for this building are:

- Site soil class: D, NZS 1170.5:2004, Clause 3.1.3, Soft Soil
- Site hazard factor, $Z = 0.3$, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011
- Return period factor $R_u = 1$, NZS 1170.5:2004, Table 3.5, Importance level 2 structure with a 50 year design life.

An increased Z factor of 0.3 for Christchurch has been used in line with requirements from the Department of Building and Housing resulting in a reduced % NBS score.

10.3 Expected Structural Ductility Factor

A structural ductility factor of 2 has been assumed based on the structural system observed and the date of construction.

10.4 Discussion of Results

The results obtained from the initial IEP assessment are consistent with those expected for a building of this age and construction type. The building was constructed prior to 1975 and would have been designed to the standards at the time, most likely NZS 1900: 1964. This standard would have used

design loads significantly less than those required by current loading standards and lower detailing requirements for ductile seismic behaviour than those that are present in current standards. When combined with the increase in the hazard factor for Christchurch to 0.3, it would be expected that the building would not achieve 100% NBS. Due to the presence of a critical structural weakness in the form of plan irregularity, it is reasonable to expect the building to be classified as potentially Earthquake Prone.

10.5 Occupancy

As the building has been found to have a % NBS less than 34%, it is deemed as potentially Earthquake Prone. It is recommended, as per Christchurch City Council's (CCC) policy regarding occupancy of potentially Earthquake Prone buildings, that the structure is unoccupied pending further detailed assessment and strengthening.

11. Initial Conclusions

The building has been assessed to have a seismic capacity in the order of 24% NBS and is therefore potentially Earthquake Prone in accordance with the NZSEE guidelines. In accordance with CCC policy to not occupy potentially Earthquake Prone buildings, it is recommended that the building is not occupied subject to further investigation and/or strengthening.

12. Recommendations

The recent seismic activity in Christchurch has caused no visible damage to the building. However, as the building has achieved less than 34% NBS following a qualitative Detailed Engineering Evaluation of the building, further assessment is required. It is recommended that a quantitative assessment and geotechnical investigation be carried out and if necessary strengthening options explored.

The building should not be occupied as per CCC policy regarding the occupancy of potentially Earthquake Prone buildings.

13. Limitations

13.1 General

This report has been prepared subject to the following limitations:

- ▶ No intrusive structural investigations have been undertaken.
- ▶ No intrusive geotechnical investigations have been undertaken.
- ▶ No level or verticality surveys have been undertaken.
- ▶ No material testing has been undertaken.
- ▶ No calculations, other than those included as part of the IEP in the CERA Building Evaluation Report, have been undertaken. No modelling of the building for structural analysis purposes has been performed.

It is noted that this report has been prepared at the request of Christchurch City Council and is intended to be used for their purposes only. GHD accepts no responsibility for any other party or person who relies on the information contained in this report to a specific limitations section.

13.2 Geotechnical Limitations

This report presents the results of a geotechnical appraisal prepared for the purpose of this commission, and for prepared solely for the use of Christchurch City Council and their advisors. The data and advice provided herein relate only to the project and structures described herein and must be reviewed by a competent geotechnical engineer before being used for any other purpose. GHD Limited (GHD) accepts no responsibility for other use of the data.

The advice tendered in this report is based on a visual geotechnical appraisal. No subsurface investigations have been conducted. An assessment of the topographical land features have been made based on this information. It is emphasised that Geotechnical conditions may vary substantially across the site from where observations have been made. Subsurface conditions, including groundwater levels can change in a limited distance or time. In evaluation of this report cognisance should be taken of the limitations of this type of investigation.

An understanding of the geotechnical site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experienced based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances, which arise from the issue of the report, which have been modified in any way as outlined above.

Appendix A

Photographs



Photograph 1 Aerial photograph of site at 75 Lower Styx Road.



Photograph 2 View of the storage shed from the north-west. The 1974 rebuilt portion is to the right and original portion is to the left in this photo. A large opening is clearly visible.



Photograph 3 View of the storage sheds from the west.



Photograph 4 View of the storage sheds from the south-west.



Photograph 5 Intersection of the original portion of the building on the left and the 1974 rebuild section on the right.



Photograph 6 Cracking to the timber post at the north-west wall. It is not believed to be earthquake related.



Photograph 7 Timber roof sarking on timber roof purlins on timber joists supported by the timber beam and post frame system.

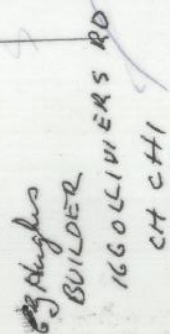


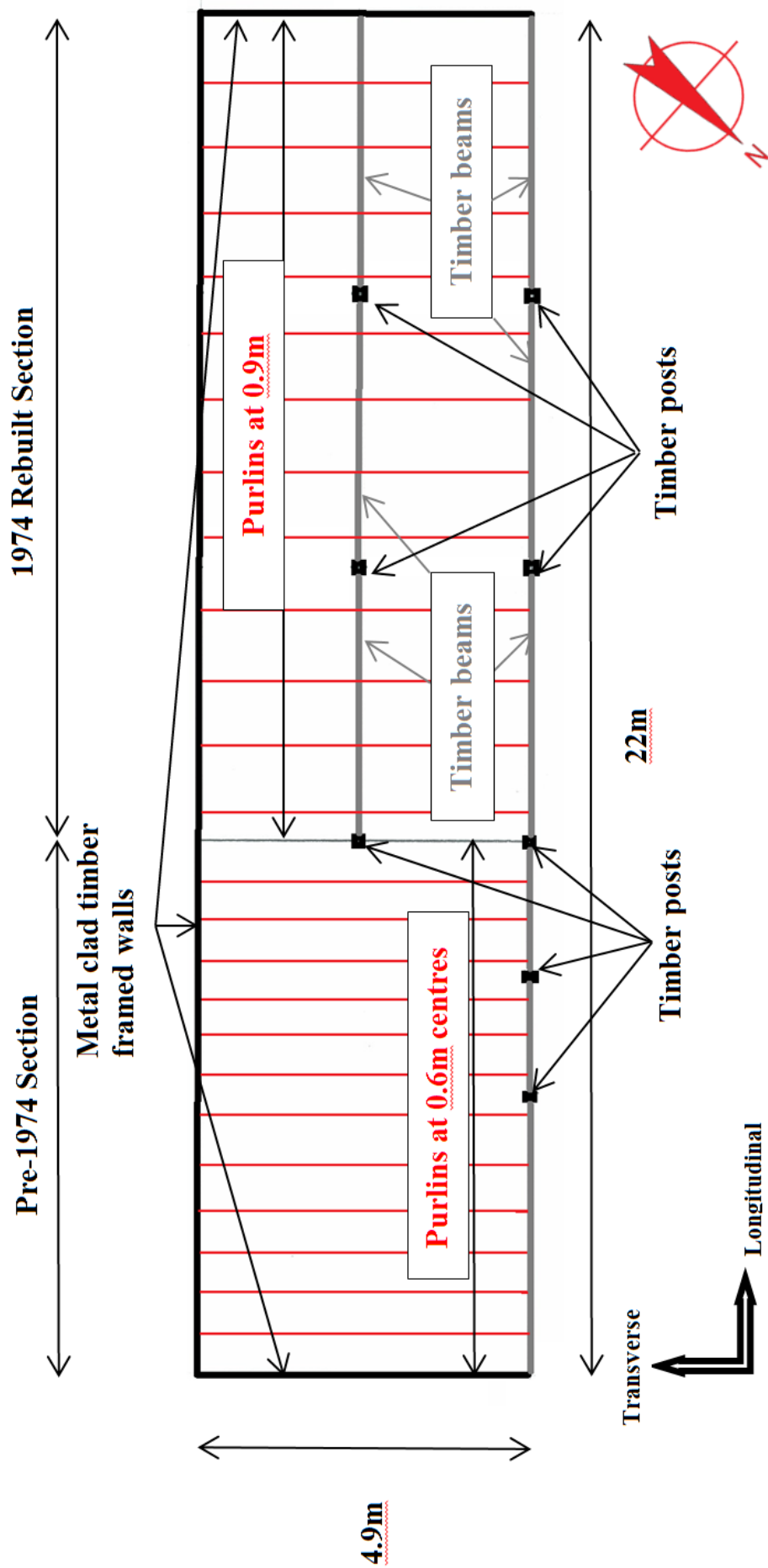
Photograph 8 Interior of the original portion of the building showing unbraced timber frame walls and roof.

Appendix B

Existing Drawings

MR G. F. HUTCHESON
75 LWR STYX RD
MARSHLANDS
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Appendix C

CERA Building Evaluation Form

V1.11

Site	Site slope:	flat	Max retaining height (m):	0
	Soil type:	mixed	Soil Profile (if available):	Gravel Sand and Silt
	Site Class (to NZS1170.5):	D		
	Proximity to waterway (m, if <100m):	45	If Ground improvement on site, describe:	n/a
	Proximity to clifftop (m, if < 100m):			
	Proximity to cliff base (m,if <100m):		Approx site elevation (m):	3.00

<u>Lateral load resisting structure</u>		Note: Define along and across in detailed report! 0.00	note typical wall length (m)	
Lateral system along:	lightweight timber framed walls		estimate or calculation?	estimated
Ductility assumed, μ :	2.00		estimate or calculation?	
Period along:	0.40		estimate or calculation?	
Total deflection (ULS) (mm):				
maximum interstorey deflection (ULS) (mm):				
<u>Lateral system across:</u>		0.00	note typical wall length (m)	16
Lateral system across:	lightweight timber framed walls		estimate or calculation?	0.1
Ductility assumed, μ :	2.00		estimate or calculation?	estimated
Period across:	0.40		estimate or calculation?	
Total deflection (ULS) (mm):			estimate or calculation?	
maximum interstorey deflection (ULS) (mm):				

Non-structural elements		
Stairs:		
Wall cladding:	profiled metal	describe Corrugated Iron
Roof Cladding:	Metal	describe Corrugated Iron
Glazing:		
Ceilings:	none	
Services(list):		

Damage		Describe damage:
Site: (refer DEE Table 4-2)	Site performance: <input type="text" value="Good"/>	<input type="text"/>
Settlement:	<input type="text" value="none observed"/>	notes (if applicable): <input type="text"/>
Differential settlement:	<input type="text" value="none observed"/>	notes (if applicable): <input type="text"/>
Liquefaction:	<input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>
Lateral Spread:	<input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>
Differential lateral spread:	<input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>
Ground cracks:	<input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>
Damage to area:	<input type="text" value="none apparent"/>	notes (if applicable): <input type="text"/>

Building:	Current Placard Status: green	
Along	Damage ratio:	0%
	Describe (summary): No damage	
Across	Damage ratio:	0%
	Describe (summary): No damage	
Diaphragms	Damage?:	no
CSWs:	Damage?:	no
Pounding:	Damage?:	no
Non-structural:	Damage?:	no

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

Recommendations	Level of repair/strengthening required:	significant structural and strengthening	Describe:	
	Building Consent required:	yes	Describe:	
	Interim occupancy recommendations:	do not occupy	Describe:	
Along	Assessed %NBS before:	24%	24% %NBS from IEP below	If IEP not used, please detail assessment methodology:
	Assessed %NBS after:	24%		
Across	Assessed %NBS before:	24%	24% %NBS from IEP below	
	Assessed %NBS after:	24%		

IEP					Use of this method is not mandatory - more detailed analysis may give a different answer, which would take precedence. Do not fill in fields if not using IEP.				
Period of design of building (from above): 1965-1976					h _n from above: 2.8m				
Seismic Zone, if designed between 1965 and 1992: B					not required for this age of building				
					not required for this age of building				
					along		across		
Period (from above):					0.4		0.4		
(%NBS) _{nom} from Fig 3.3:					5.0%		5.0%		
Note:1 for specifically design public buildings, to the code of the day: pre-1965 = 1.25; 1965-1976, Zone A =1.33; 1965-1976, Zone B = 1.2; all else 1.0					1.00				
Note 2: for RC buildings designed between 1976-1984, use 1.2					1.0				
Note 3: for buildings designed prior to 1935 use 0.8, except in Wellington (1.0)					1.0				
					along		across		
Final (%NBS) _{nom} :					5%		5%		
2.2 Near Fault Scaling Factor					Near Fault scaling factor, from NZS1170.5, cl 3.1.6:				
					along		across		
Near Fault scaling factor (1/N(T,D), Factor A:					1		1		
2.3 Hazard Scaling Factor					Hazard factor Z for site from AS1170.5, Table 3.3:				
					Z ₁₉₉₂ , from NZS4203:1992				
Hazard scaling factor, Factor B:					3.33333333				
2.4 Return Period Scaling Factor					Building Importance level (from above):				
					Return Period Scaling factor from Table 3.1, Factor C:		1.00		
2.5 Ductility Scaling Factor					Assessed ductility (less than max in Table 3.2)		along		across
Ductility scaling factor: =1 from 1976 onwards; or =k _u , if pre-1976, from Table 3.3:					2.00		2.00		
					1.57		1.57		
Ductility Scaling Factor, Factor D:					1.57		1.57		
2.6 Structural Performance Scaling Factor:					Sp:				
					0.700		0.700		
Structural Performance Scaling Factor Factor E:					1.428571429		1.428571429		
2.7 Baseline %NBS, (NBS%) _b = (%NBS) _{nom} x A x B x C x D x E					%NBS _b :				
					37%		37%		
Global Critical Structural Weaknesses: (refer to NZSEE IEP Table 3.4)									
3.1. Plan Irregularity, factor A:					significant		0.7		
3.2. Vertical irregularity, Factor B:					insignificant		1		
3.3. Short columns, Factor C:					insignificant		1		
3.4. Pounding potential					Pounding effect D1, from Table to right		1.0		
Height Difference effect D2, from Table to right					1.0				
Therefore, Factor D:					1				
3.5. Site Characteristics					insignificant		1		
3.6. Other factors, Factor F					For ≤ 3 storeys, max value =2.5, otherwise max value =1.5, no minimum		Along		Across
							0.9		0.9
Rationale for choice of F factor, if not 1					Reduction due to non-earthquake related damage		Reduction due to non-earthquake related damage		
Detail Critical Structural Weaknesses: (refer to DEE Procedure section 6)									
List any:					Refer also section 6.3.1 of DEE for discussion of F factor modification for other critical structural weaknesses				
3.7. Overall Performance Achievement ratio (PAR)					0.63		0.63		
4.3 PAR x (%NBS) _b :					PAR x Baseline %NBS:		24%		24%
4.4 Percentage New Building Standard (%NBS), (before)									24%



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