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**Plywood Clad Barn**  
**PRK 2635 BLDG 006 EQ2**  
Detailed Engineering Evaluation  
Qualitative Report  
Version FINAL

51 Lower Styx Road, Styx River Reserve

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Qualitative Report  
Version FINAL

51 Lower Styx Road, Styx River Reserve

Christchurch City Council

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**Date**  
12th December 2013

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# Qualitative Report Summary

**Plywood Clad Barn**

**PRK 2635 BLDG 006 EQ2**

**Detailed Engineering Evaluation**

**Qualitative Report - SUMMARY**

**Version FINAL**

**51 Lower Styx Road, Styx River Reserve, Christchurch**

## **Background**

This document is a summary of the Qualitative report for the above 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 16<sup>th</sup> April 2012.

## **Building Description**

The 'Plywood Clad Barn' is located at 51 Lower Styx Road, Styx River Reserve, Christchurch. It was constructed in 1990's. The building is currently used for storage purposes.

The building is of lightweight timber frame construction. The roof structure consists of lightweight steel roofing fixed to timber rafters. The walls are ply cladding and the foundations are concrete slab on grade.

## **Key Damage Observed**

- ▶ Uneven floor surface with significant cracking of the slab

## **Critical Structural Weaknesses**

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

- ▶ Liquefaction Probable (60% reduction)
  - ▶ Earthquake damage (40% reduction)
  - ▶ Plan Irregularity (30% reduction)
- } →17% NBS

## **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 29% NBS and post-earthquake capacity is in the order of 17% NBS.

The building's post-earthquake capacity excluding critical structural weaknesses is in the order of 102% NBS.

The building has been assessed to have a seismic capacity in the order of 17% NBS and is therefore considered to be potentially Earthquake Prone.

### **Recommendations**

The building has achieved less than 33% 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 plywood clad barn at 51 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

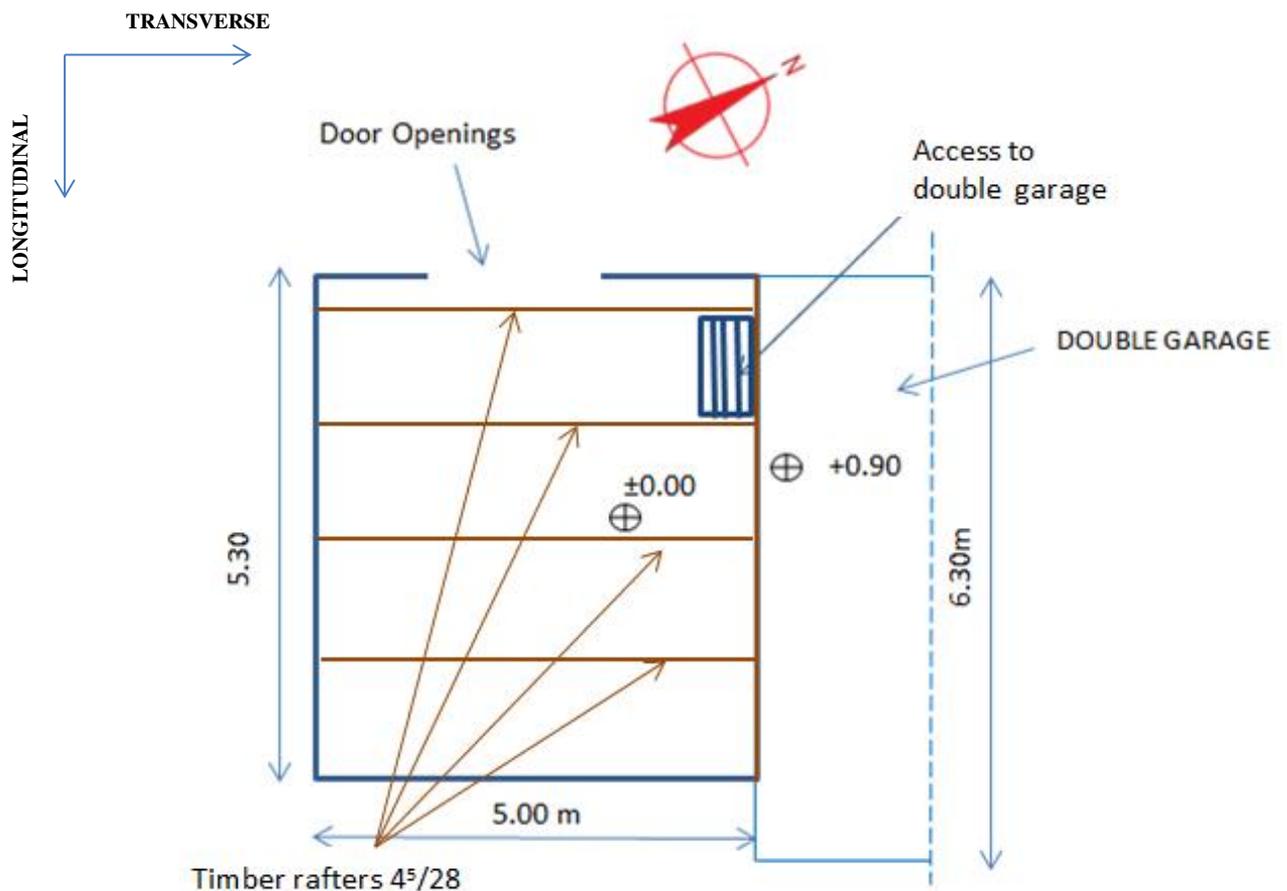
**Table 1 %NBS compared to relative risk of failure**

## 4. Building Description

### 4.1 General

The building is located at 51 Lower Styx Road, Styx River Reserve, Christchurch. It is estimated that the building was constructed in in the 1990's (between 1992 and 2004). The building is owned by the Christchurch City Council and is not currently in use. There are seven other buildings located on the site with various uses and other reports address these other buildings.

- ▶ The building has a mono pitch corrugated steel roof supported on timber rafters without purlins which span in the transverse direction (no cross bracing is evident in the roof structure). The rafters are supported directly by the ply cladding and not timber framing.
- ▶ Walls are ply cladding with timber studs
- ▶ Floor is unreinforced concrete slab on grade with no apparent perimeter thickening



**Figure 2 Plan Sketch Showing Key Structural Elements**

The building dimensions are 5.3m in length, 5m in width and 2.50m in height. The plan area of the building is approximately 26m<sup>2</sup>.

The nearest building to the Plywood Clad Barn is the Double Garage, which is immediately adjacent to the plywood clad barn. There is no apparent structural connection between the two buildings. The closest waterway is the Styx River approximately 15m to the west.

The site slopes approximately 1.5m between Lower Styx Road and the Styx River.

#### **4.2 Gravity Load Resisting System**

Gravity loads are transferred from the roof cladding to the timber rafters which span in the transverse direction between the external timber walls. The connection between the rafters and the wall is via a direct connection between the rafter and the ply cladding. This connection does not comply with NZS 3604 and this detail is not considered appropriate. Vertical loads are then transferred down through the ply cladding and timber studs to the concrete floor slab.

#### **4.3 Lateral Load Resisting System**

In transverse directions lateral loads at the roof level are transferred from the steel roof cladding through timber rafters to the top of the longitudinal walls as there is no cross bracing in the roof plane. The longitudinal walls are required to resist the rafter point loads in bending, which they are not detailed for. It is likely that diaphragm action in the roof cladding is occurring to share carry the bulk of the roof load to the end walls. The lack of cross bracing in the roof plane makes the building susceptible to side sway at the door opening. The only reliable load path for transverse loads is eventually to the foundations by the rear wall.

In the longitudinal direction lateral load resistance at roof level is provided by the roofing system. Nominal roof bracing is provided by the metal cladding and the timber rafters, transferring loads back to the lateral load resisting side walls. Loads are transferred down through the timber framed external walls by sheet action of the plywood cladding.

## 5. Assessment

An inspection of the building was undertaken on the 16<sup>th</sup> of April 2012. Both the interior and exterior of the building were inspected.

The inspection involved an visual inspection of the structure and the site and site measure of the building.

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.

## 6. Damage Assessment

### 6.1 Surrounding Buildings

The plywood clad barn at 51 Lower Styx Road is located in a rural area with 7 other buildings.

These buildings are:

- Double Garage- some cracking of the perimeter strip foundations.
- Single garage - significant cracking of the slab on grade foundation and lateral displacement of the wall.
- Dwelling - severely affected by the differential settlement and lateral displacement of the building.
- Aviary- no seismic damage identified.
- Fowl House- no seismic damage identified.
- Barn (Iron Clad) - no seismic damage identified.
- Swimming pool- no seismic damage identified.

### 6.2 Residual Displacements and General Observations

During the site inspection significant cracking of the slab was noted (see the photograph 5 and 6).

### 6.3 Ground Damage

The site was severely affected by the lateral spreading and differential settlement as the site has slumped towards the Styx River.

## 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

No cross bracing was visible in the roof of the building. The roof elements are expected to combine to give nominal roof diaphragm action but this is not expected to provide adequate roof bracing.

### 7.4 Staircases

There is a timber staircase between Double Garage and Plywood Clad Barn. This staircase is not structurally significant.

### 7.5 Site Characteristics

The site is severely affected by lateral spreading and differential settlement. Following the geotechnical appraisal it was found that the site has a severe potential for liquefaction. As the building has a concrete slab on grade foundation, the effects of liquefaction are likely to adversely affect the structure of the building. 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 a 'severe' site characteristic in accordance with the NZSEE guidelines.

### 7.6 Plan Irregularity

The presence of a large opening in the front wall and a lack of adequate roof bracing to transfer the lateral loads back to the lateral load resisting rear wall constitutes a 'significant' critical structural weakness.

## 8. Geotechnical Consideration

### 8.1 Site Description

The subject site is situated immediately to the east of the Styx River, within the suburb of Bottle Lake to the north of Christchurch. It is relatively flat at approximately 6m 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 area<sup>1</sup> indicates that the site is on or near the boundary of the following units:

- Grey river alluvium beneath plains or low-level terraces (Q1a), Holocene in age; and,
- Stabilised beach sand or river sand dunes (Q1d), Holocene in age.

#### 8.2.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that one borehole is located within 230m of the site (see Table 1). The bore log indicates the ground to be underlain by sand layers to ~6m below ground level (bgl), clay sand, sand and gravelly sand to 19m bgl, with “pug” underlying the sand. An additional borehole over 300m to the south of the site indicates sand to ~24m bgl.

**Table 2 ECan Borehole Summary**

Bore Name	Log Depth	Groundwater	Distance & Direction from Site
M35/11929	~32.5m	~0.72m bgl	230m NE

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.

#### 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.

<sup>1</sup> 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.

The site is classified as Technical Category Not Applicable (TC N/A), being non-residential properties in urban areas, properties in rural areas or those beyond the extent of land damage mapping.

### 8.2.5 Post February Aerial Photography

Aerial photography taken following the 22 February 2011 earthquake shows no signs of liquefaction visible within the property boundary as shown in Figure 3. However, liquefaction in the form of sand boils and lateral spreading is evident on the western side of the Styx River (subject property is to the east).

**Figure 3 Post February 2011 Earthquake Aerial Photography** <sup>2</sup>



### 8.2.6 Summary of Ground Conditions

From the information presented above, the ground conditions underlying the site are anticipated to comprise predominantly of sand with varying amounts of clay and gravel.

## 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.

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

**Table 3 Summary of Known Active Faults<sup>3,4</sup>**

Known Active Fault	Distance from Site	Direction from Site	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	120 km	NW	8.3	~300 years
Greendale (2010) Fault	25 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 new active fault system / zone underneath Christchurch City and the Port Hills. Research and published information on this system is in development and not generally available and average recurrence intervals are yet to be estimated.

### 8.3.2 Ground Shaking Hazard

This recent 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 recent alluvial deposits, a 475-year PGA (peak ground acceleration) of ~0.4 (Stirling et al, 2002<sup>4</sup>), and bedrock anticipated to be in excess of 500m deep, ground shaking is expected to be moderate to high.

### 8.4 Slope Failure and/or Rockfall Potential

The topography surrounding the site is typically flat, rockfalls are not considered to be a hazard at this site. However, given the site's proximity to the Styx River, it is considered possible and likely that lateral spreading and/or river bank failure may occur.

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

<sup>3</sup> 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.

<sup>4</sup> GNS Active Faults Database

## **8.5 Liquefaction Potential**

Due to the presence of alluvial and/or estuarine deposits, it is possible and likely that liquefaction will occur in layers where sands and silts are present. Evidence is visible of liquefaction to the west of the site (both sand boils and lateral spreading).

It is considered likely that lateral spreading will occur again in this area as a result of similar-size seismic events.

Further investigation is recommended to better determine subsoil conditions, and quantify the liquefaction potential of the soils directly under the site. From this, a more comprehensive liquefaction assessment could be undertaken.

## **8.6 Recommendations**

Given the anticipated ground conditions and proximity to local waterways, we recommend that further investigation is undertaken. Specifically, two CPT investigations should be conducted to a target depth of 20m bgl. From this a numerical liquefaction assessment can be undertaken.

A soil class of **D** (in accordance with NZS 1170.5:2004) should be adopted for the site. This soil class can be confirmed following assessment of intrusive ground investigation data.

## **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 appears to be situated on recent alluvial deposits, comprising predominantly of sand with varying amounts of clay and gravel. Associated with this the site also has a moderate to high liquefaction potential.

Further investigation is recommended to enable a more comprehensive liquefaction and/or ground condition assessment to be undertaken. It is recommended that intrusive investigation comprising two piezocone CPT tests be conducted.

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

The site is also considered susceptible to lateral spreading along the Styx River.

## 9. Survey

No level surveys have been undertaken for this building at this stage.

## 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	102
Liquefaction Potential (60% Reduction)	
Plan Irregularity (30% Reduction)	
Earthquake Damage (40% Reduction)	
Net result	17

**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 17% 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 bearing capacity and as a result the %NBS of the building has had a further 40% 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  $R_u = 0.5$ , NZS 1170.5:2004, Table 3.5, Importance level 1 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 2.0 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 lower than those expected for a building of this age and construction type. The building was constructed between 1992 and 2004 and was likely to have

been designed in accordance with the loading standards of the time, NZS 4203:1992. The design loads used in this standard are less than those required by the current loading standard. 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 Critical Structural Weaknesses in the form of possible soil liquefaction and Plan Irregularity, it is reasonable to expect the building to be classified as 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 17% NBS and is therefore considered to be potentially Earthquake Prone. In accordance with CCC policy to regarding occupancy of potentially Earthquake Prone buildings, it is recommended that the building is not occupied subject to further investigation and/or strengthening.

## 12. Recommendations

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.

## 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 51 Lower Styx Road.**



**Photograph 2 View of the plywood clad from the northeast.**



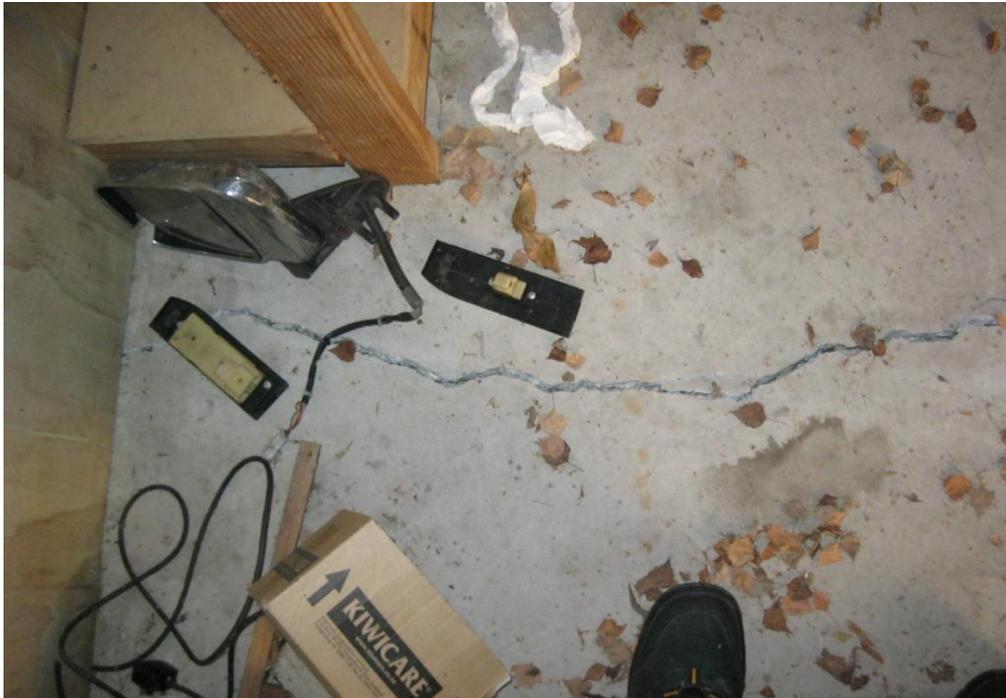
**Photograph 3 Internal view of the access to the double garage.**



**Photograph 4 Internal view of the building showing roof construction and connection of the rafters to the cladding.**

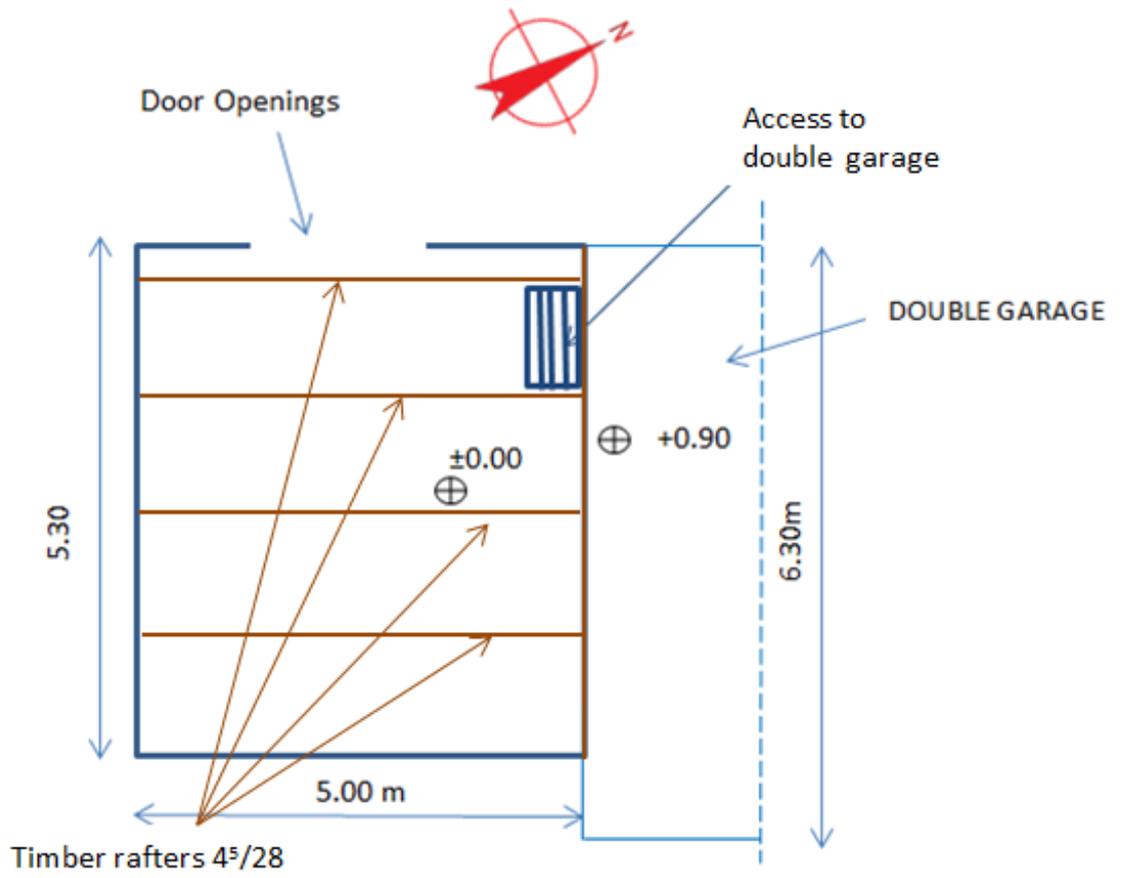


**Photograph 5 Internal view of the building showing cracking of the concrete floor.**



**Photograph 6 Significant cracking of the concrete floor, cracks ~ 3cm**

Appendix B  
Existing Drawings



Appendix C  
CERA Building Evaluation Form

**GHD**

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**Document Status**

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		Name	Signature	Name	Signature	Date
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