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Project: Brookside Road Subdivision

Geotechnical Report

Prepared for: CDL Land New Zealand Limited

Project: 224926

1 November 2011

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Document Control Record

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Document control						aurecon
Report Title		Geotechnical Report				
Document ID			**Project Number**		224926	
File Path		P:\224926\001 Concept Design\Geotech\Reporting\224926 Brookside Road Subdivision Geotech Report Rev 1.docx				
Client		CDL Land New Zealand Limited	**Client Contact**			
Rev	**Date**	**Revision Details/Status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	17 October 2011	Internal Review	RJH	RJH	JM	
1	1 November 2011	Issue to Client	RJH	RJH	JM	JK
Current Revision		1				

Approval			
Author Signature		Approver Signature	
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Title	Geotechnical Engineer	Title	Technical Director Ground Engineering

Contents

1. Introduction

CDL Land New Zealand Limited (CDL) are planning on subdividing land on the north side of Brookside Road, Rolleston (see Figure 1) for the purpose of constructing residential housing. The block of land proposed for development is approximately 42 hectares in area.

Aurecon New Zealand Limited has been engaged to undertake geotechnical investigations for the purposes of determining the sub surface soil conditions and assessing the liquefaction potential of the site, as part of the subdivision consent.

The scope of works undertaken was as follows:

- A detailed desk study considering geological and geotechnical information available for this site, including a review of Environment Canterbury (ECan) borehole and groundwater information;
- A geotechnical investigation comprising 64 test pits and two boreholes across the site.
- A report detailing the investigation and analysis results, as well as providing recommendations on the geotechnical suitability of the site for development.

This work excludes the detailed design of foundation options which would be dealt with at the detailed design stage of the subdivision development.

The terms and conditions of our engagement are as set out in our letter – Reference 211377, dated 9 August 2011. Approval to proceed was given by Jason Adams of CDL.

2. Site Conditions

2.1 Site description

The site investigated is located adjacent Main South Road - State Highway 1 (SH1) – less than 1km south of Rolleston town centre (see Figure 1). The site consists of three blocks of land totalling approximately 42ha. The block of land is legally described as Pt Sec 1 SO 19540, Pt Secs 2 & 3 SO 18584, Pt Sec 1 SO 19340 and Pt Lot 1 DP 75811. The site is bounded by Main South Road to the north, Burnham School Road to the south, residential housing (private property) to the east and southeast and open land (private property) to the west. The proposed subdivision will have approximalety 460 lots.

It should be noted that the proposal is for the subdivision to extend across the open land to the west up to Dunns Crossing Road. This would increase the total proposed subdivision to 60ha in area. This land is not yet accessible and will need to be investigated once access is obtained. The proposed subdivision will have approximately 630 lots. The area so far investigated encompasses approximately 440 lots.

The site is essentially flat and is currently used for pastoral farming activities and is crossed by a series of internal post and wire farm fences.

2.2 Site Access

The site is accessed via farm gates directly off Burnham School. Internal access is across grassed paddocks and via a network of gates within the internal farm fencing network.

2.3 Vegetation

The site is primarily vegetated with pastoral grass. There are occasional stands of trees and hedges along parts of the external site boundaries and along internal farm fence lines.

2.4 Drainage

Site drainage consists of natural drainage channels and man-made swales. Drainage is inferred to be via the internal drainage network of swales or via direct soakage to the ground.

2.5 Regional Geology

The geology of the site is shown on the Institute of Geological and Nuclear Sciences Map 16, Christchurch. The map shows the site to be underlain by *"Brownish grey river alluvium (Q2a)" and is directly adjacent to "Grey river alluvium, comprising gravel, sand and silt, in active floodplains (Q1a)".*

2.6 Regional Earthquake Hazard

The GNS Active Fault System database (GNS, 2011a) indicates that the site is within close proximity to the Greendale Fault. Movement on the Greendale Fault was responsible for the Magnitude 7.1 Darfield (Canterbury) Earthquake on 4 September 2010. The location of the Greendale Fault is presented on Figure 1. The site is located 6km east of the main fault rupture and 2.5km south of the eastern extension of the fault.

The site is also located approximately 28km west of the epicentre of the Magnitude 6.3 Christchurch Earthquake on 22 February 2011 and 34km west of the Magnitude 6.3 aftershock on 13 June 2011 (GNS, 2011b). In addition, the site is located approximately 130km southeast of the Alpine Fault which is listed in NZS1170.5 Table 3.6 as a Major Fault.

2.7 Liquefaction

No evidence of liquefaction such as sand boils or other surface manifestations were encountered following the recent earthquake events. This is based on observations on site during investigations, discussions with local residents and inspection of the Selwyn District Council Liquefaction Map (Selwyn District Council, 2011).

3. Geotechnical Site Investigation

3.1 General

The objective of the ground investigation was to investigate the overall subsoil and groundwater conditions across the site.

The geotechnical investigation comprised the following:

- A review of the available Environment Canterbury GIS database borehole logs;
- Site walk over by a Geotechnical Engineer from Aurecon;
- Two Boreholes extending to a maximum depth of 15m;
- 64 Test pits excavated to a maximum depth of 4.8m.

3.2 Geotechnical Investigations

The boreholes (BH1 and BH2) were drilled by McMillan Drilling Services on 5 to 7 October 2011. They extended to depth of 15m below ground level and included SPTs (Standard Penetration Tests) at 1.5m centres. Each boreholes had standpipe piezometers installed to allow monitoring of the groundwater level. The samples recovered from the boreholes were logged by a geotechnical engineer from Aurecon.

The test pits were excavated with a 22 ton excavator to a maximum depth of 4.8m on 27 to 30 September 2011. They were located to give a reasonable coverage across the site. A geotechnical engineer from Aurecon supervised test pit excavation and logged and photographed the pits.

The logging of the soil from the boreholes and test pits was undertaken using NZ Geotechnical Society's "Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes: 2005".

The test locations are shown on Figure 2 and the logs from the boreholes and test pits are presented in Appendix A. An explanatory sheet outlining the terms and symbols used on logs is also included in Appendix A.

The results of the geotechnical investigations consistently show between 150mm and 350mm of topsoil overlying alluvial sand and gravel mixtures with occasional lenses of silt extending beyond the depth investigated. Tests conducted in alluvium gave SPT 'N' values ranging from 35 to 50+.

3.3 Environment Canterbury Boreholes

A review of the Environment Canterbury GIS System (ECan, 2011) has been undertaken to identify borehole logs within the direct vicinity of the site. The review indicates that eleven suitable boreholes have been identified. See Figure 2 for the borehole locations and Appendix B for the borehole logs.

Borehole logs describe a layer of soil variously described as gravel, sandy gravel and clay-bound gravel extending to at least 60m below ground level (the maximum depth investigated). In addition, occasional layers of sand, silt and clay are identified at various depths. The logs record water levels typically12m to 14m below ground level with 7.7m and 16.1m below ground level being the highest and lowest ground water levels recorded.

3.4 Geotechnical Ground Model

The results of the site investigations show that the surficial ground layers are very consistent with 0.15m to 0.35m of topsoil overlying sandy gravel and gravel with occasional clay, silt and sand lenses (alluvium). Table 1 presents a generalised subsurface profile, with a summary of the materials encountered and their properties:

Table 1: Generalised Subsurface Profile

Layer	Depth below ground to top of layer	Layer thickness	Description	Consistency
1	0m	0.15m to 0.35m	Topsoil: Dark brown SILT	Soft
2	0.15m to 0.35m	At least 60m	Alluvium: Brownish grey GRAVEL and Sandy GRAVEL with occasional silt, clay and sand lenses	Sands/Gravels: Moderately dense to very dense

3.5 Groundwater

The standpipe piezometers installed in the boreholes recorded groundwater 10.3m and 13.1m below ground level. No groundwater was encountered during the test pit investigations. This is consistent with the results of the ECan borehole logs which encountered the water table at 7.7m to 16.1m below ground level.

3.6 DBH Requirements

The investigations have been conducted in accordance with the Department of Building and Housing Interim Minimum Requirements for Geotechnical Assessment of Liquefaction for Land Development – Canterbury Region (DBH, 2011). These requirements call for total investigation locations of "*0.25 per lot*" which equates to 110 investigation locations across the area currently investigated. However, there is allowance for fewer investigations to be conducted "*If initial investigations demonstrate a lack of liquefaction potential*". As liquefaction is considered a very low risk (see Section 4.2) we have conducted investigations at 66 locations which we believe is adequate for a development of this size.

4. Engineering Considerations

4.1 General

CDL Land New Zealand Limited (CDL) are planning on subdividing land on the north side of Brookside Road, Rolleston for the purpose of constructing residential housing. The proposed subdivision will cover approximately 42ha and will accommodate 460 residential lots.

As part of the subdivision consent, a geotechnical engineering assessment has been conducted to determine the suitability of the land for development from a geotechnical viewpoint. This is of particular importance in light of the recent Darfield Earthquake in September 2010 and Christchurch Earthquake in February 2011, which resulted in extensive damage due to liquefaction in some parts of the Canterbury Region.

The details of our assessment, as well as recommendations regarding the suitability of the land for development are discussed in the following sections.

4.2 Liquefaction Assessment

The three primary factors that contribute to liquefaction potential are:

- Loose uniformly graded soils;
- High ground water table
- Sufficiently high, earthquake induced ground acceleration and sustained shaking.

Each of these is considered below together with our conclusion on the site liquefaction.

a) *Soil Grading*

Liquefiable soils generally have a Coefficient of Uniformity of less than 5 and a low proportion of soil finer than 75 microns in size (typically less than 5% to 10% but up to 30%). Test logs indicate the ground conditions consist of sandy gravels with occasional lenses of clay, silt and sand.

Based on the test logs and in-situ test results the silts and fine sands at shallow depths may have a liquefaction potential, however we infer the gravel material will have a Coefficient of Uniformity greater than 5 and therefore may have a low risk of liquefaction.

b) *Ground Water*

Groundwater is inferred to be at least 8m below ground level so liquefaction will not occur in any soils above this level. This will result in a sufficiently thick crust to prevent any surface expressions or deformation of the ground.

c) *Earthquake Intensity and Soil Resistance to Liquefaction*

Based on the recent Darfield and Christchurch earthquakes and the site's proximity to the Alpine Fault, we infer that the site is susceptible to sufficiently high shaking for liquefaction to occur in suitably susceptible soils. Peak horizontal ground accelerations of 0.35g were recorded at Rolleston School (located approximately 1km to the northeast) in the September earthquake and 0.19g in the February earthquake.

Considering the above factors, we infer that the risk of liquefaction is very low. The only soils of liquefiable particle size below the water table are located at least 8m deep where they are likely to be dense enough to be resistant to liquefaction. In addition, the layers of these soils are thin and generally surrounded by highly permeable gravels which will help dissipate any excess pore water pressure generated during earthquake shaking. Furthermore, no liquefaction surface expression (sand boils) or liquefaction induced damage to the site was observed from the recent earthquakes in September 2010 and February 2011.

4.3 Greendale Fault

The Greendale fault is in close proximity to the site, with the northern extension of the fault approximately 2.5km to the north. Based on our investigations results we note the following:

- There were no distinct surface features, such as surface ruptures, bulging, terraces or distinctive lineal features, which would indicate the presence of a fault through the site.
- Test pitting across the site and within the topographic features identified no displacement of the bedding or disorientation of the gravel clasts, within the sides of the test pits, which would indicate the presence of fault trace.
- Based on site walkover there was no evidence that would suggest structures around the site are undergoing deformation, as a result of faulting.

Therefore based on this information we consider that it is unlikely that the site has been directly affected by movement of the Greendale Fault, and the risk of future surface ruptures extending from the Greendale Fault to affect the site is low.

There is the possibility that an unidentifiable fault trace is hidden beneath the site, with no surficial evidence of the fault presence. However the risk associated with any unidentifiable faults to the site, would be similar to all the buildings and sites within the area.

The other fault rupture hazard that could be present on site is intense seismic shaking associated with further movement on the Greendale Fault. The design of any new structure will need to take this into account and refer to the appropriate design standards.

4.4 Earthworks Recommendations

It is anticipated that minor earthworks will be required during the construction of the proposed residential subdivision. It is not anticipated that any significant earthworks issues will be encountered and we make the following recommendations:

4.4.1 General

- All earthworks should be conducted in accordance with Selwyn District Council Engineering Code of Practice and NZS4404:2010 – *Land Development and Subdivision Engineering*;
- Topsoil and vegetation should be stripped in all earthworks areas (i.e. where roads or structures are to be constructed and cut or fill areas). This material should be stockpiled for later use.

4.4.2 Cuts

- All cuts steeper than 2H:1V should be inspected by a geotechnical engineer or engineering geologist as work proceeds to confirm the acceptability of the actual slopes;
- The alluvial gravel is anticipated to be suitable for use as fill material elsewhere on site.

4.4.3 Fills

- Filling shall generally be carried out in accordance with NZS4431:1989 – *Code of Practice for Earth Fill for Residential Development*, with appropriate on site quality control;
- All fill material should be compacted to at least to 95% of standard compaction in accordance with NZS4402:1986 – *Methods of Testing Soils for Civil Engineering Purposes*, Test 4.1.1.

4.5 Foundation Assessment Against NZS3604:2011

The site comprises 150mm to 350mm of topsoil overlying dense to very dense alluvial gravels. We anticipate that these gravels will provide suitable bearing capacity for foundations of residential structures designed in accordance with NZS3604:2011. However, as part of any final subdivision certification testing may be required to satisfy the requirements of NZS3604:2011 – *Timber Framed Buildings.*

4.6 Assessment Against RMA

Section 106 of the Resource Management Act (RMA) states *inter alia*

1. … "a consent authority may refuse to grant a subdivision consent, or may grant a subdivision consent subject to conditions, if it considers that:

    a) *the land in respect of which a consent is sought, or any structure on the land, is or is likely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source; or*

    b) *any subsequent use that is likely to be made of the land is likely to accelerate, worsen, or result in material damage to the land, other land, or structure by erosion, falling debris, subsidence, slippage, or inundation from any source; or*

    c) *sufficient provision has not been made for legal and physical access to each allotment to be created by the subdivision."*

Our assessment of the site against the requirements of Section 106 is presented below. A summary is provided in Table 2 with more detail following.

Table 2: Assessment of the Site against the RMA

Hazard	Potential Susceptibility	
	Current (Section 106 1a)	**Post Development (Section 106 1b)**
Erosion	No erosion observed on site.	Loose sandy soils could be vulnerable to erosion if topsoil layer is removed and underlying soils left unprotected.
Falling Debris	Site is essentially flat so there is no risk of falling debris.	
Slippage	Site is essentially flat so there is no risk of slippage.	
Subsidence	Due to the nature of the soil and the very low risk of liquefaction the risk of subsidence is very low.	Very low risk provided building foundations are properly designed to ensure soils are not over loaded.

Hazard	Potential Susceptibility	
Inundation	The risk of inundation from liquefaction is very low. However, a full flood risk assessment is outside the scope of this report.	Provided stormwater discharge is appropriately managed the risk of inundation will not be exacerbated by developing the land.

4.6.1 Erosion

No erosion was observed on the site. Due to the site being underlain by sandy gravel there exists the potential for erosion of the sand component and rilling of the sandy soils if vegetation cover is removed for prolonged periods of time, due to both stormwater runoff (if it is not discharged in a controlled manner), and from the wind. This susceptibility to erosion of the sandy soils can be minimised with appropriate industry standard design measures undertaken during construction.

4.6.2 Falling Debris and Slippage

The site is essentially flat so there is no risk of falling debris or slippage.

4.6.3 Subsidence

Due to the nature of the soil on the site the risk of subsidence is very low from both static loads and during seismic loads (i.e. liquefaction – see Section 4.2). Provided that buildings constructed on the site are appropriately founded the risk of subsidence will remain very low.

4.6.4 Inundation

The risk of liquefaction, and therefore inundation from liquefaction is very low. The overall risk of inundation is inferred to be very low as the soils are relatively free draining and there are no major watercourses nearby. However, a full flood risk assessment has not been carried out. Development of the site may alter the existing drainage patterns of the site. However, provided that stormwater discharge is appropriately dealt with in detailed Civil Engineering design the risk of inundation will not be exacerbated by the proposed development.

4.6.5 Conclusions

The site is not at risk of erosion, falling debris, subsidence, slippage, or inundation from liquefaction. From a geotechnical perspective the site complies with the requirements of Clause 106 1(a).

Provided appropriate engineering design measures are implemented, the man-made and natural hazards resulting from the earthworks or general development of the site are unlikely to accelerate, worsen, or result in further material damage to the land. Therefore, in our opinion, the proposed building sites will comply with the requirements of Clause 106 1(b).

Section 106 1(c) is not relevant to a geotechnical appraisal and therefore has not been considered in this report.

In our opinion, under Section 106 1 of the RMA, there are no geotechnical reasons evident at the site to make it unsuitable for development provided any development is undertaken with appropriate engineering design measures.

5. References

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Selwyn District Council (2010) *Engineering Code of Practice.*

Selwyn District Council (2011) *Areas of Liquefaction – Map 1.*

Tonkin and Taylor, (2010), *Darfield Earthquake 4 September 2010 Geotechnical Land Damage Assessment Report – Stage 1 Report*, Earthquake Commission (EQC)

6. Limitations

We have prepared this report in accordance with the brief as provided. The contents of the report are for the sole use of the Client and no responsibility or liability will be accepted to any third party. Data or opinions contained within the report may not be used in other contexts or for any other purposes without our prior review and agreement.

The recommendations in this report are based on data collected at specific locations and by using suitable investigation techniques. Only a finite amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay.

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