LEWIS & BARROW LTD
Consulting Civil and Structural Engineers:

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12 December 2013

File: 21355

Horncastle Homes Limited
PO Box 8255
Riccarton
Christchurch

Attention: Shelley Wood

Your Reference: Flint – J3103

Dear Shelley

Re: Shallow Geotechnical Investigation –194 Burwood Road, Burwood, Christchurch

1. Introduction

Lewis & Barrow Ltd has carried out a Shallow Geotechnical Investigation and prepared this report at the request of Horncastle Homes Limited to determine the type of foundation required for a proposed residential dwelling. The drawing provided for the proposed dwelling shows a single storey, timber framed building with a light weight roof, medium weight wall cladding and concrete floor slab of 160m^2.

The investigation included the following:

- Confirm the Geology of the site.
- Four Scala Penetrometer Tests to a max depth of 1.65m.
- Four 50mm diameter hand auger boreholes down to a maximum depth of 3.0m.
- Preliminary evaluation of shallow liquefaction potential of this site.

2. Site

The property is a predominantly level site and is approximately 809 square metres in area.

The site is currently zoned as Green Zone Technical Category 2 by the Ministry of Business, Innovation & Employment's Guidance indicating that "minor to moderate land damage from liquefaction is possible in future earthquakes. Lightweight construction or enhanced foundations are likely to be required such as enhanced concrete raft foundations (i.e. stiffer floor slabs that tie the structure together)."

3. Geology

The GNS publication "Geology of the Christchurch Urban Area" 1992 shows that the site is underlain by the Christchurch formation which comprises beach, estuarine, lagoonal, dune, and coastal deposits of gravel, sand, silt, clay, shell, and peat.
Underlying this, approximately 30m down, is a thick layer of gravel known as the "Riccarton Gravel" formation.

Environment Canterbury's Database of well bores shows that there are three wells within 300m of this site with useful bore information.

- M35/3425 is located 150m north east of the site and shows sands to 35.8m overlying gravel to the extent of the bore at 40.2m below ground level. The drill date is 24/06/1992 and the accuracy is logged as 4 out of 4 (1 being highest and 4 being the lowest order of accuracy).
- M35/1533 is located 275m north west of the site and shows silts and sands to 32.0m overlying gravel to the extent of the bore at 82.0m. The drill date is not recorded and the accuracy is logged as 4 out of 5 (1 being highest and 5 being the lowest order of accuracy).
- M35/3660 is located 160m south of the site and shows sands to 33.5m overlying gravel with silt lenses to the extent of the bore at 153.0m below ground level. The drill date is 5/02/1973 and the accuracy is logged as 4 out of 4 (1 being highest and 4 being the lowest order of accuracy).

4. Results of Site Tests

Attached is a site plan and separate sheets for each penetrometer test/auger hole. The penetrometer tests have been graphed to show the ultimate bearing strength of each depth alongside the soil types.

The auger bores show topsoil to 0.3m overlying sands to the extent of testing at 3.0m. Shallow fill is indicated to 0.75m below ground level. The penetrometer bearing tests show there is an available bearing capacity of 200kPa at 1.0m below ground level.

5. Groundwater

An average natural groundwater table depth of 2.2m as measured is shown on the plots of the auger holes. This is similar to what we would expect on this site for this time of the year. Groundwater is usually highest about October and lowest about April each year.

The CERA Canterbury Geotechnical Project Orbit database website provided to consultants shows the ground water level was between 2.0m and 3.0m below ground level at the time of the September 2010, February 2011, June 2011 and December 2011 major earthquake events.

6. Liquefaction

The CERA Canterbury Geotechnical Project Orbit database website provided to consultants shows the following relevant recorded information:

- The EQC maps of liquefaction interpreted from the aerial photos shows:
  - No observed liquefaction following the 4th of September 2010 event.
  - No observed liquefaction following the 22nd February 2011 event.
  - Minor observed liquefaction following the 13th June 2011 event.
  - No observed liquefaction following the 23rd December 2011 event.
- The EQC maps of observed liquefaction and lateral spreading shows:
  - No observed ground cracking or ejected liquefied material following the 4th September 2010 event.
  - No observed ground cracking or ejected liquefied material following the 22nd February 2011 event.

- Minor ground cracking but no observed ejected liquefied material following the 13th June 2011 event.

The site auger shows shallow sands with a ground water level at 2.2m and the site penetrometer testing shows the sands have a low bearing capacity indicating a shallow liquefaction potential is likely to exist on this site. The Environment Canterbury well bore logs show that conditions that could cause deep seated liquefaction are also likely to exist on this site.

CERA and the Ministry of Business Innovation & Employment have classified this site as Technical Category 2 indicating minor to moderate ground damage is expected in future earthquake induced liquefaction events and enhanced foundation systems as outlined in the Ministry of Business Innovation & Employment's Guidance "Repairing and rebuilding houses affected by the Canterbury earthquakes" is appropriate as a minimum requirement for this site.

It is considered that the Technical Category 2 classification for this site is appropriate. A foundation system to mitigate for liquefaction settlement to the parameters of the Technical Category 2 classification of the site is required for the dwelling proposed for this site.

7. Lateral Spreading

Lateral spreading is the post liquefaction movement of liquefied soils towards a free edge such as a water course or sloped ground surface.

The nearest free edge to this site is sloping surface down to the lower marsh area approximately 200m west of the site.

The CERA Project Orbit database does not show any recorded lateral spreading ground damage in the vicinity of this site as a result of the 22 February 2011 earthquake.

A foundation system to mitigate for lateral spreading movement to the parameters of the Technical Category 2 classification of the site is required for the dwelling proposed for this site.

8. Seismic Considerations

Conditional mean peak ground accelerations (PGA) have been assessed for each event at this site and are shown on the Canterbury Geotechnical Database Map CGD5110 27 September 2012.

As each of these events vary in magnitude and time, the Conditional Mean PGA's have been adjusted to be equivalent to the design M7.5 event, i.e. the shaking of a M7.1 event is shorter than a M7.5 event and hence the effective equivalent M7.5 PGA will be less. These values are set out as follows:

Earthquake	Date	Conditional Mean P.G.A.	Equivalent P.G.A. for M7.5 Event
M7.1	4 September 2010	0.18g	0.16g
M6.2	22 February 2011	0.33g	0.24g
M6.0	13 June 2011	0.20g	0.14g
M5.9	23 December 2011	0.30g	0.20g

The equivalent design PGA's for a M7.5 event are:

To have no damage and be serviceable (Serviceability Limit State S.L.S.) 0.13g.
To not fail catastrophically (Ultimate Limit State U.L.S.) 0.35g.

As this site has experienced one equivalent M7.5 P.G.A. events of more than 1.7 times the design S.L.S. value, the site can be regarded as having been "sufficiently tested" to SLS design levels by the Canterbury Earthquake sequence once to date.

A site subsoil classification of D in accordance with AS/NZS 1170.5:2002 is appropriate for seismic design for this site.

9. Ground Levels

The nearest LINZ datum to this site, BDVQ, 750m north of the site, shows the following cumulative changes in height from its pre 4th September 2010 height:

- Following 4th September 2010 -0.008m
- Following 22nd February 2011 -0.208m
- Following 6th June 2011 -0.245m

The CERA Canterbury Geotechnical Project Orbit database map of LIDAR and digital elevation model indicates this site has settled -0.3m to -0.4m over the events of the Canterbury Earthquake sequence to date.

A review of Christchurch City Council's district plan shows that this site is not in a flood management area.

10. Foundation Recommendations

This site does not comply with the N.Z.S.3604:2011 definition of good ground due to the low bearing capacity of the shallow soils and the liquefaction potential of the site. The foundations to the dwelling proposed for this site are required to be designed by a Chartered Professional Engineer. A system to mitigate for seismically induced liquefaction settlement is required for this site.

Foundation options 1 to 5 of section 5 Part A of the Ministry of Business, Innovation & Employment's Guidance on "Repairing and rebuilding houses affected by the Canterbury earthquakes" document, are appropriate for this site. Of these options the polystyrene waffle slab system such as a Firth TC2 RibRaft would be the most appropriate for the proposed dwelling.

The MBIE Guide requires that this foundation system bear on ground with an ultimate bearing capacity in excess of 200kPa. The available shallow ultimate bearing capacity on this site is 50kPa and hence it is required that a compacted hardfill building platform be constructed to provide suitable bearing. The compacted hardfill building platform is to be constructed by excavating to a depth of 0.6m below the underside of the proposed foundation level (some localised deepening beyond this depth may be required to reach suitable bearing natural and firm sand), laying Bidim A19 geotextile on the excavated surface, placing and compacted well graded AP65 hardfill in 150mm layers to the underside of foundation level. Refer to the attached drawing.

11. Limitations

1. This report has been prepared for the benefit of Horncastle Homes Limited as our client with respect to the brief. The reliance by any other parties on the information or options contained in this report shall, without prior review and agreement in writing be at such other parties sole risk.
2. The recommendations and opinions contained in this report are based on the information gained. The nature and continuity of subsoil conditions away from the test locations are inferred and it must be appreciated that actual conditions could vary from the assumed model.
3. If any fill, or soils other than those noted in the above report are encountered in the excavations then the author of this report must be consulted for further advice as the foundation design may need to be modified.

Yours faithfully,

Chris Gordon
Structural Engineer
BE MIPENZ CPEng IntPE(NZ)

This report has been prepared solely for the benefit of our Client with respect to the brief. The reliance by other parties on the information or opinions contained in this report, shall without our prior review and agreement in writing, be at such other parties sole risk.

Reviewed/Checked By:

LEWIS & BARROW LTD
Consulting Civil and Structural Engineers:

File: 21355
Date: 11/12/2013

Bore Hole No. 1

SOIL PROFILE AND SCALA PENETROMETER RESULTS

Soil Description

SSANDY SILTY TOPSOIL SOME STONES

BROWN GREY MOTTLED MOIST SOFT SILT
DARK BROWN MOIST SOFT TOPSOILY
SILTY FINE SAND

BROWN GREY MOTTLED MOIST FINE SAND

GREY MOTTLED MOIST FINE SAND

GREY MOTTLED WET FINE SAND

GREY SATURATED MEDIUM SAND

GREY MOTTLED SATURATED MEDIUM SAND
DARK BROWN SOFT SATURATED SLIGHTLY
SILTY PEAT (80 - 90% PEAT)
DARK GREY SOFT SATURATED SLIGHTLY
SILTY MEDIUM SAND. STOPPED, SAND FILLING
BORE HOLE

WT depth approx. 2.15m bgl

Refer to Cover Sheet for Engineer's Recommendations

Site Address: **194 Burwood Road, Burwood**

Client: **Horncastle Homes Ltd**

Technical Category: **2**
Reason for Test: **Council Requirement**

Plotted by: **NB**
Field Worker: **NL**

This report (letter, soil test results sheets and site plan) must be read with the P.I.M. If there is anything adverse regarding ground bearing capacity on the P.I.M. this report shall be referred back to the Engineer for review. If any fill or soils other than those noted in the above report are found at the bottom of the excavations, the Engineer shall be notifed to inspect and issue further details. This report has been prepared solely for the benefit of our client. No liability is accepted by this firm or by any Principal, or Director, or any servant or agent of this firm, in respect of its use by any other person, and any other person who relies upon any matter contained in this report does so entirely at their own risk. This disclaimer shall apply notwithstanding that the report may be made available to any person in connection with any application for permission or approval, or pursuant to any requirement of law

LEWIS & BARROW LTD
Consulting Civil and Structural Engineers:

File: 21355
Date: 11/12/2013

Bore Hole No. 2

SOIL PROFILE AND SCALA PENETROMETER RESULTS

Sheet 2 of 5

Soil Description

SANDY SILTY TOPSOIL SOME STONES AND BRICK

BROWN GREY MOIST TOPSOILY FINE SAND SOME STONES AND BRICK

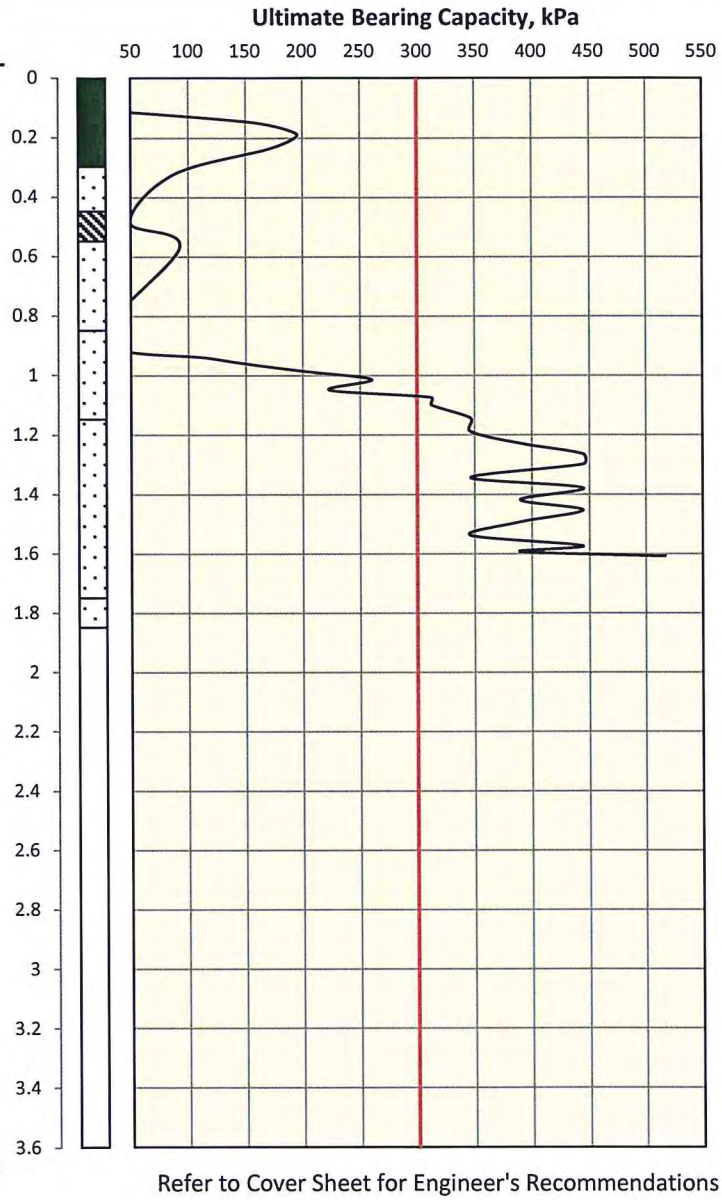
DARK BROWN MOIST SOFT TOPSOILY SILTY FINE SAND

BROWN GREY MOTTLED MOSIT FINE SAND

BROWN GREY MOTTLED MOSIT FINE SAND SOME STONES

GREY MOTTLED MOIST FINE SAND, SOME STONES BETWEEN 1500 - 1600mm

GREY MOTTLED WET FINE SAND



WT not struck

Refer to Cover Sheet for Engineer's Recommendations

Site Address: **194 Burwood Road, Burwood**

Client: **Horncastle Homes Ltd**

Technical Category: **2**
Reason for Test: **Council Requirement**

Plotted by: **NB**
Field Worker: **NL**

This report (letter, soil test results sheets and site plan) must be read with the P.I.M. If there is anything adverse regarding ground bearing capacity on the P.I.M. this report shall be referred back to the Engineer for review. If any fill or soils other than those noted in the above report are found at the bottom of the excavations, the Engineer shall be notifed to inspect and issue further details. This report has been prepared solely for the benefit of our client. No liability is accepted by this firm or by any Principal, or Director, or any servant or agent of this firm, in respect of its use by any other person, and any other person who relies upon any matter contained in this report does so entirely at their own risk. This disclaimer shall apply notwithstanding that the report may be made available to any person in connection with any application for permission or approval, or pursuant to any requirement of law

LEWIS & BARROW LTD
Consulting Civil and Structural Engineers:

File: 21355
Date: 11/12/2013

Bore Hole No. 3

SOIL PROFILE AND SCALA PENETROMETER RESULTS

Soil Description

SANDY SILTY TOPSOIL SOME STONES

BROWN GREY MOTTLED MOIST FINE SAND

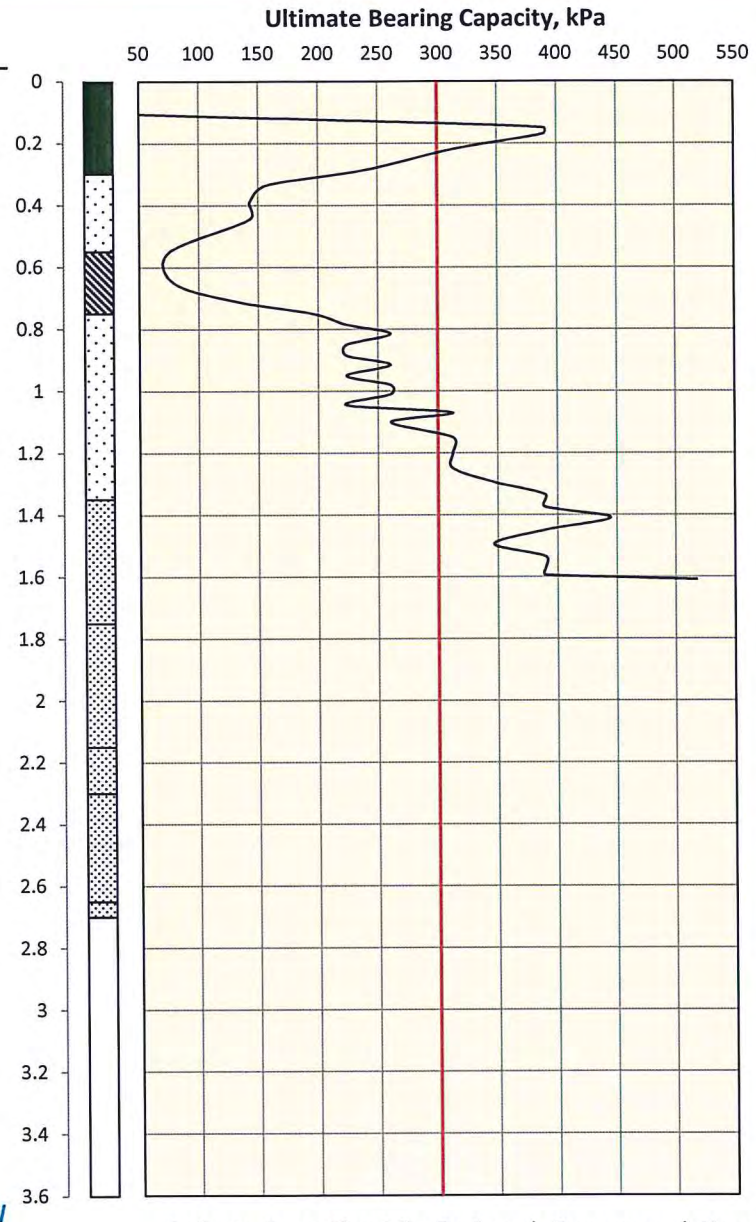
DARK BROWN MOIST SOFT TOPSOIL
SILTY FINE SAND
BROWN GREY MOTTLED MOIST FINE SAND

GREY MOTTLED MOIST MEDIUM SAND

GREY MOTTLED WET MEDIUM SAND

GREY SATURATED MEDIUM SAND
DARK GREY SATURATED MEDIUM SAND

DARK GREY SATURATED MEDIUM SAND
TRACE PEATY ORGANICS



WT depth approx. 2.30m bgl

Refer to Cover Sheet for Engineer's Recommendations

Site Address: **194 Burwood Road, Burwood**

Client: **Horncastle Homes Ltd**

Technical Category: **2**
Reason for Test: **Council Requirement**

Plotted by: **NB**
Field Worker: **NL**

This report (letter, soil test results sheets and site plan) must be read with the P.I.M. If there is anything adverse regarding ground bearing capacity on the P.I.M. this report shall be referred back to the Engineer for review. If any fill or soils other than those noted in the above report are found at the bottom of the excavations, the Engineer shall be notifed to inspect and issue further details. This report has been prepared solely for the benefit of our client. No liability is accepted by this firm or by any Principal, or Director, or any servant or agent of this firm, in respect of its use by any other person, and any other person who relies upon any matter contained in this report does so entirely at their own risk. This disclaimer shall apply notwithstanding that the report may be made available to any person in connection with any application for permission or approval, or pursuant to any requirement of law

LEWIS & BARROW LTD
Consulting Civil and Structural Engineers:

File: 21355
Date: 11/12/2013

Bore Hole No. 4

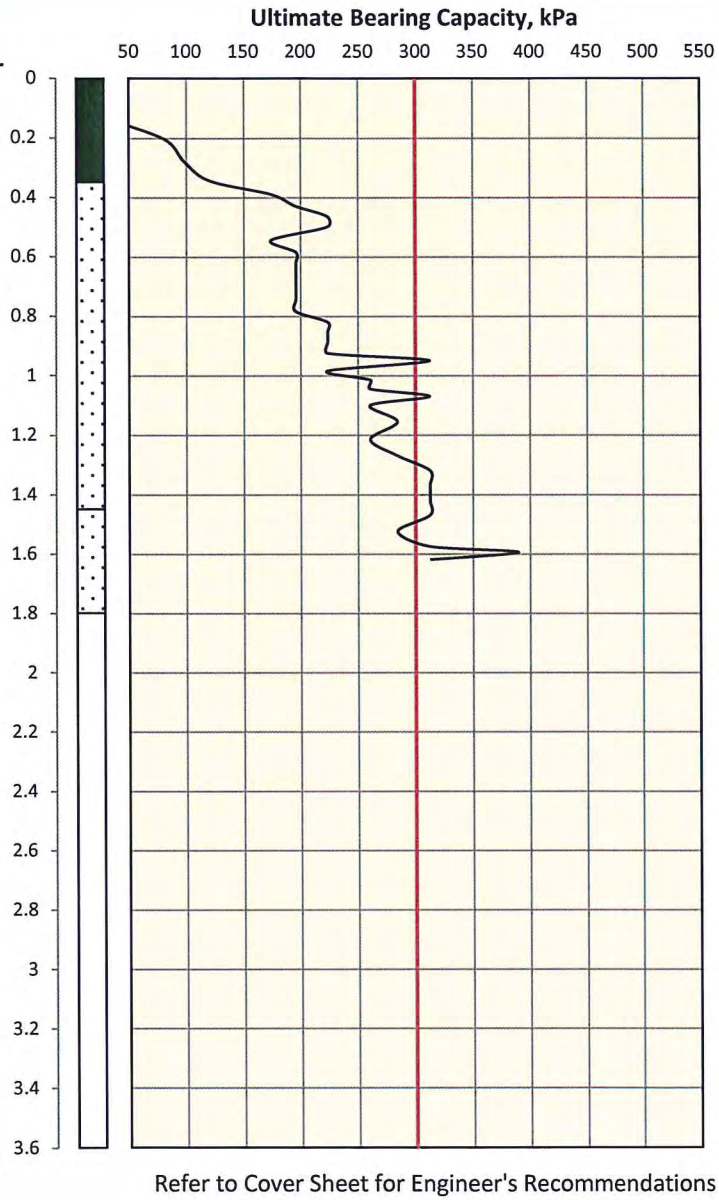
SOIL PROFILE AND SCALA PENETROMETER RESULTS

Soil Description

SANDY SILTY TOPSOIL

BROWN GREY MOTTLED MOIST FINE SAND

GREY MOTTLED MOIST FINE SAND



WT not struck

Refer to Cover Sheet for Engineer's Recommendations

Site Address: **194 Burwood Road, Burwood**

Client: **Horncastle Homes Ltd**

Technical Category: **2**
Reason for Test: **Council Requirement**

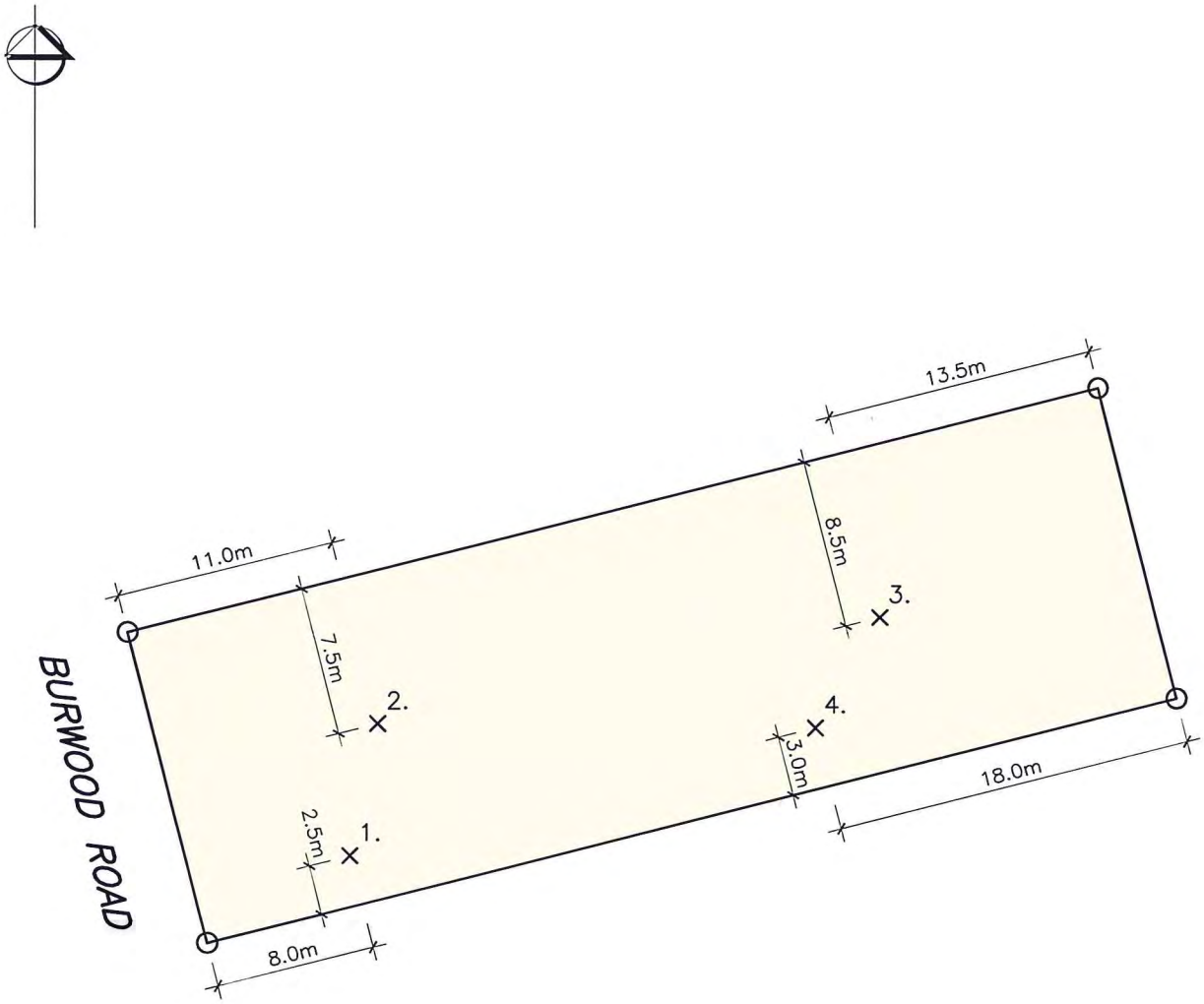
Plotted by: **NB**
Field Worker: **NL**

This report (letter, soil test results sheets and site plan) must be read with the P.I.M. If there is anything adverse regarding ground bearing capacity on the P.I.M. this report shall be referred back to the Engineer for review. If any fill or soils other than those noted in the above report are found at the bottom of the excavations, the Engineer shall be notifed to inspect and issue further details. This report has been prepared solely for the benefit of our client. No liability is accepted by this firm or by any Principal, or Director, or any servant or agent of this firm, in respect of its use by any other person, and any other person who relies upon any matter contained in this report does so entirely at their own risk. This disclaimer shall apply notwithstanding that the report may be made available to any person in connection with any application for permission or approval, or pursuant to any requirement of law

LEWIS & BARROW LTD
Consulting Civil and Structural Engineers:

FILE : 21355
DATE : 11/12/2013

SITE PLAN

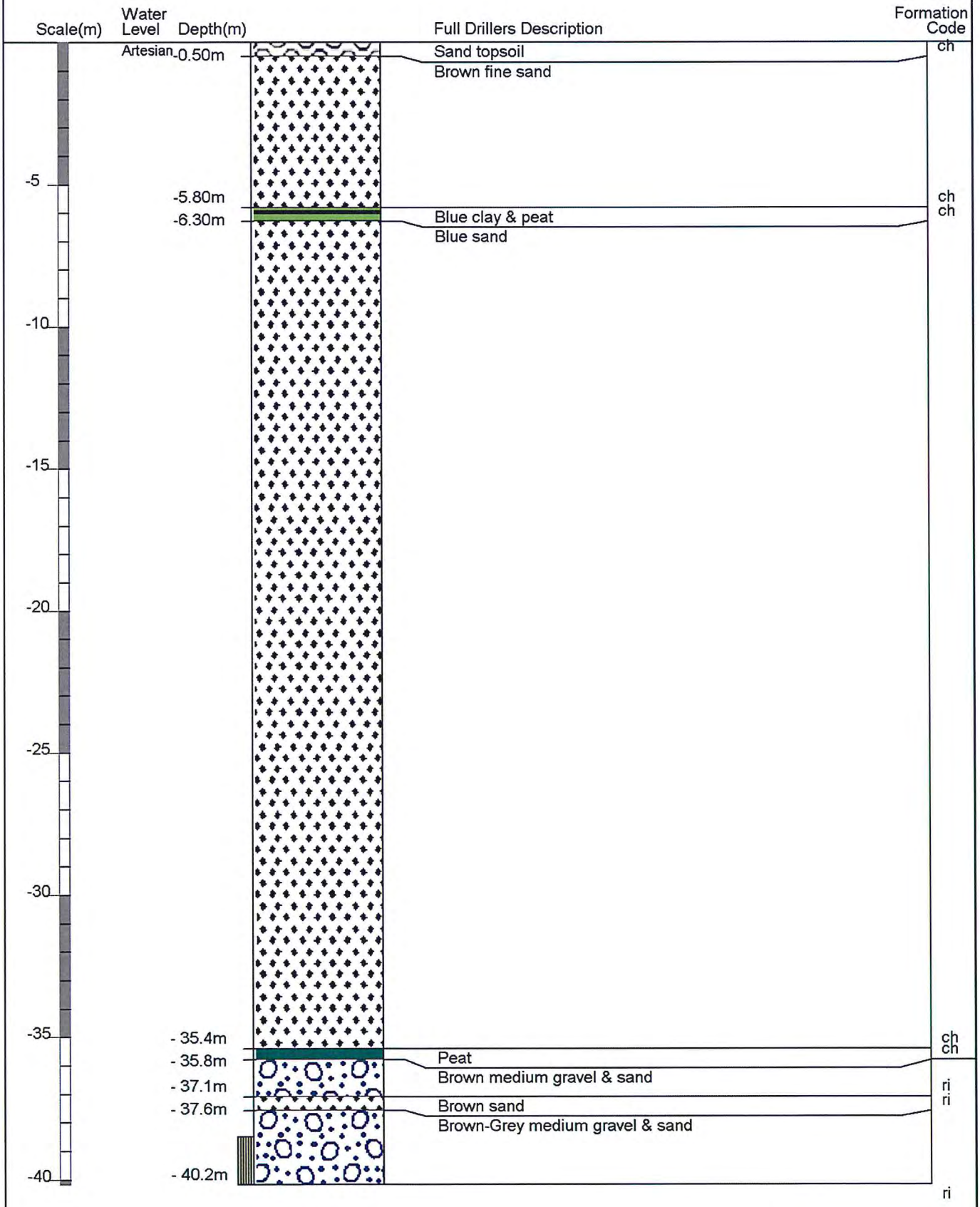


1. × Approximate Position of Penetrometer Test and Auger Hole.

ADDRESS: 194 BURWOOD ROAD ROAD
LOT: 5
DP: 18476

Borelog for well M35/3425

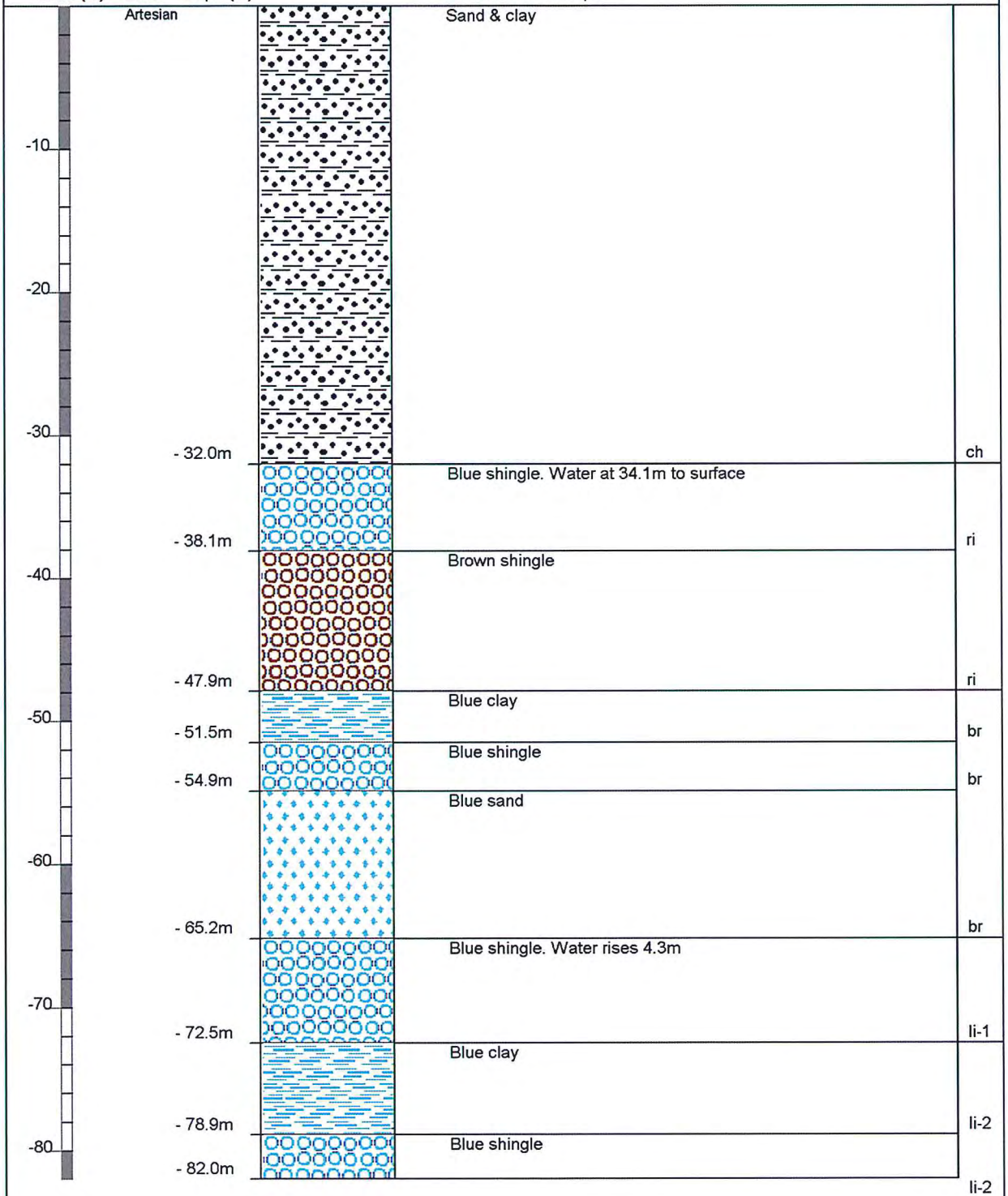
Gridref: M35:8448-4667 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 5.5 +MSD
Driller : Canterbury Groundwater Ltd
Drill Method : Driven Pipe
Drill Depth : -40.18m Drill Date : 24/06/1992



Borelog for well M35/1533

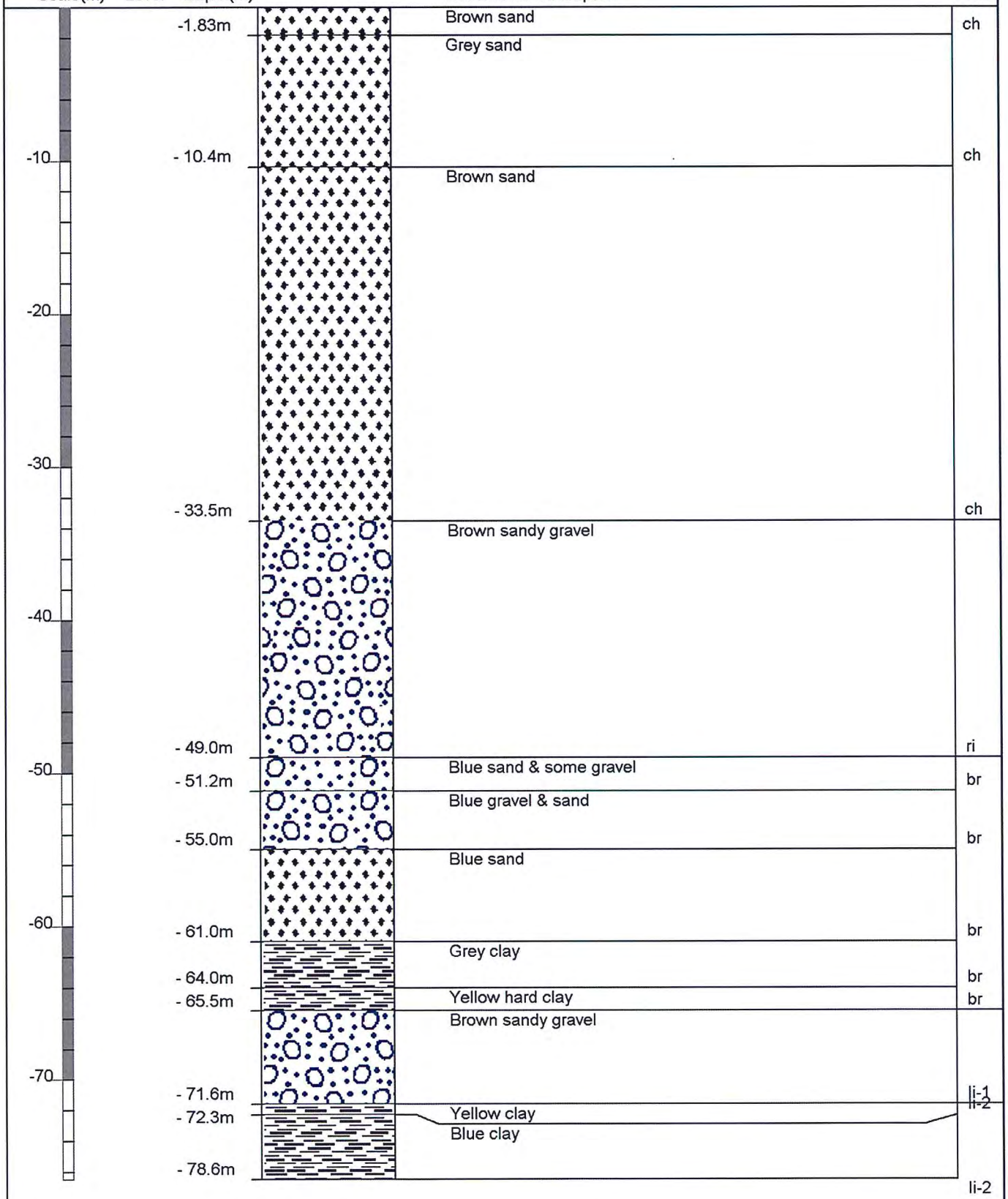
Gridref: M35:842-467 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 3.1 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -82m Drill Date :

Environment Canterbury Regional Council



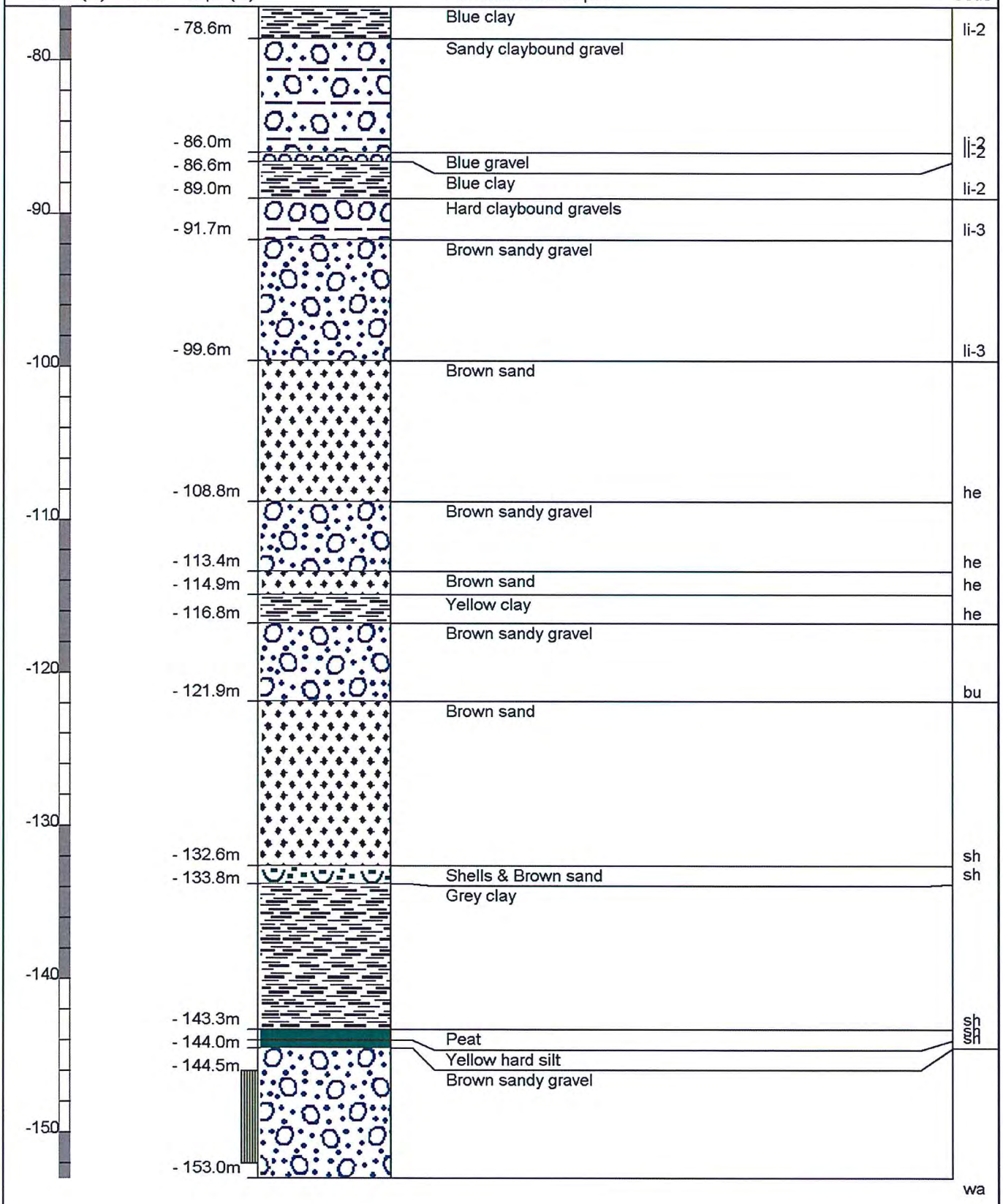
Borelog for well M35/3660 page 1 of 2

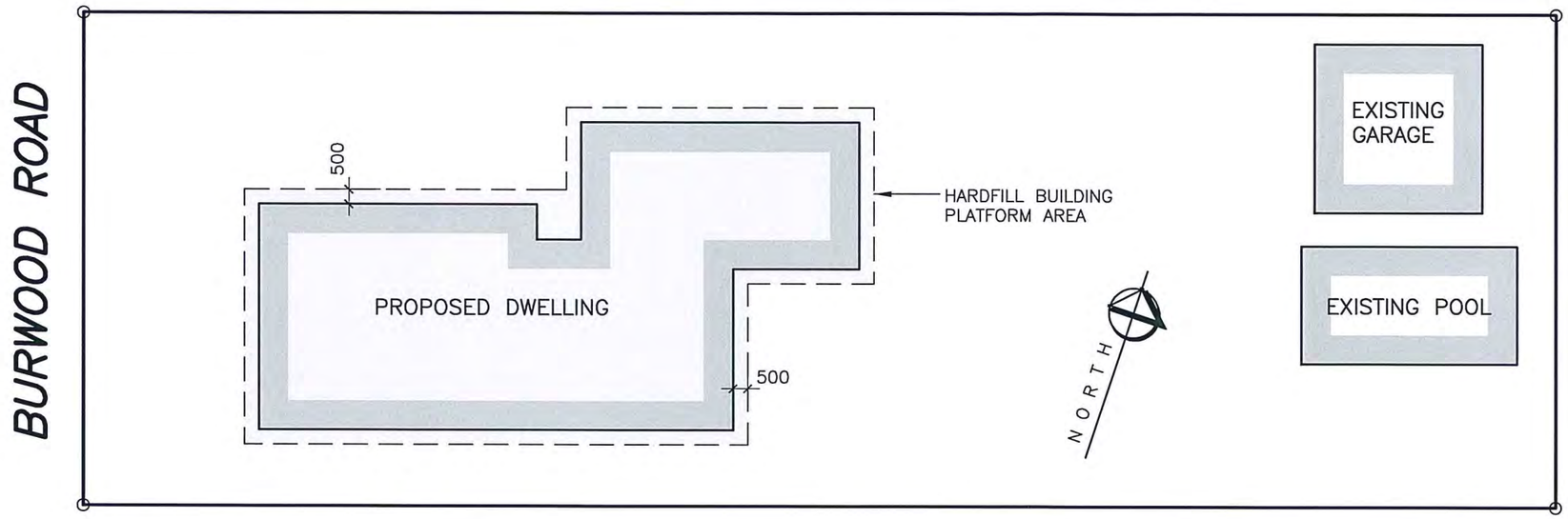
Gridref: M35:844-464 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 4.8 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -153m Drill Date : 5/02/1973



Borelog for well M35/3660 page 2 of 2

Gridref: M35:844-464 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 4.8 +MSD
Driller : A M Bisley & Co
Drill Method : Cable Tool
Drill Depth : -153m Drill Date : 5/02/1973



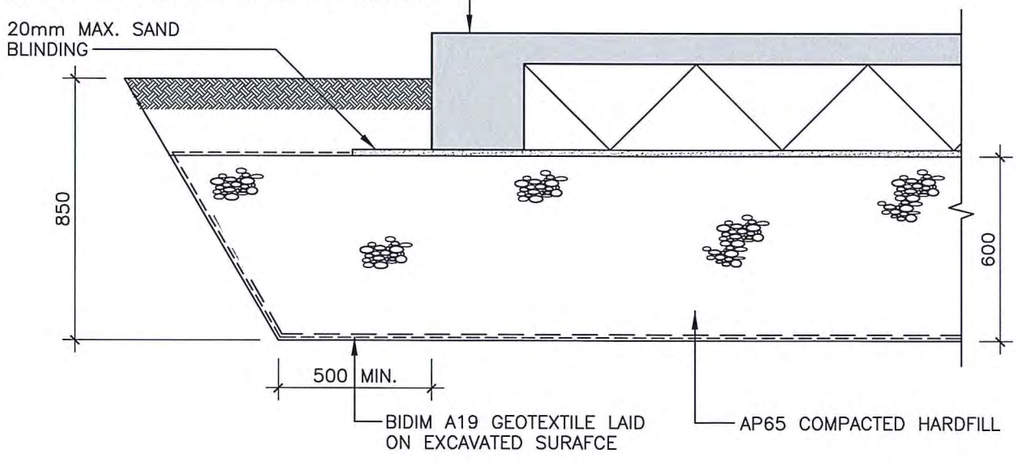


SITE PLAN
SCALE 1:200

ENGINEERING SPECIFICATION NOTES:

1. ALL WORK SHALL COMPLY WITH THE RELEVANT CLAUSES OF N.Z. BUILDING CODE.
2. SHOULD SOFT CLAY, PEAT OR FILLED GROUND BE ENCOUNTERED ON THE SITE, THE ENGINEER SHALL BE CONSULTED FOR ADDITIONAL DETAILS.
3. THE AP65 COMPACTED HARDFILL SHALL BE PLACED AND COMPACTED IN MAXIMUM 150mm LAYERS TO ACHIEVE AN AVERAGE DRY DENSITY OF 2200kg/m³ AND A MINIMUM POINT DENSITY OF 2050kg/m³. THE TOP LAYER IS TO BE TESTED WITH A NUCLEAR DENSOMETER AND THE RESULTS APPROVED BY THE ENGINEER BEFORE ANY FURTHER CONSTRUCTION PROCEEDS.
4. ALL DRAINS FROM THE DWELLING ARE TO BE PLACED IN THE SOIL ABOVE THE HARDFILL RAFT AND WHERE DRAINS ARE REQUIRED TO RUN AT A DEPTH GREATER THAN THE HARDFILL RAFT THEY ARE TO BE PLACED BEYOND THE HARDFILL AREA.
5. THESE PLANS SHALL BE READ IN CONJUNCTION WITH THE GEOTECHNICAL INVESTIGATION REPORT PREPARED BY LEWIS AND BARROW LTD. CONSULTING ENGINEERS DATED 12th DECEMBER 2013.
6. THE ENGINEER (CHRIS GORDON) SHALL BE ENGAGED BY THE OWNER TO INSPECT AND APPROVE THE BULK SITE EXCAVATION PRIOR TO PLACING GEOTEXTILE AND NUCLEAR DENSOMETER TEST RESULTS FOR THE COMPACTED HARDFILL PRIOR TO PLACING SAND BLINDING. TO ENABLE US TO ATTEND PLEASE BOOK A MUTUALLY ACCEPTABLE TIME, AT LEAST 48 HOURS IN ADVANCE. QUOTING FILE NUMBER 21355.

ENHANCED FOUNDATION SYSTEM DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH RECOMMENDATIONS OF SECTION 5.3 OF DBH NOVEMBER 2011 "REVISED GUIDANCE ON REPAIRING AND REBUILDING HOUSE AFFECTED BY THE CANTERBURY EARTHQUAKE SEQUENCE"



TYPICAL PLATFORM DETAIL
SCALE 1:20

Plotted at Lewis & Barrow Ltd. from Joe - File Path \\HPSERVER\HPData\L&B_JobFile\21355\DRAWINGS (dwg or rvt)\SITE PLAN.dwg - Plotted: Friday, December 13, 2013

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LEWIS & BARROW LTD
Consulting Civil And Structural Engineers
Unit 8, 357 Madras Street - Christchurch - New Zealand
PH: (03) 366 4320 - www.lewisandbarrow.co.nz

DIMENSIONS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.

CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK

HARDFILL BUILDING PLATFORM
194 BURWOOD ROAD, BURWOOD, CHRISTCHURCH

ENG DSN. CG	FILE	DRAWING
DRN. JP	21355	01
CKD.		OF 01
SCALE.	####	
DATE 13.12.13		