

REPORT ON:
STAGE 9, LYNDHURST ROAD SUBDIVISION, FRIMLEY, HASTINGS
(LOTS 142 TO 162)

PROJECT:
GEOTECHNICAL ASSESSMENT

CLIENT: GREENSTONE LAND DEVELOPMENTS LTD.

GREENSTONE LAND DEVELOPMENTS LTD.
P O Box 1200
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EXECUTIVE SUMMARY

Greenstone Land Developments Ltd. (Greenstone) engaged Resource Development Consultants Ltd (RDCL) to undertake a geotechnical assessment for Stage 9 Lyndhurst Road, Frimley in Hastings..

The information contained in this report:

- May be relied on for Building Consent only for light weight timber framed, single level, residential buildings and foundations as prescribed.
- Any change to building or foundation type will require re-assessment which may include additional site testing and geotechnical analyses.

Stage 9 of the development covers ~12,000 m², with twenty-one (21) residential lots (Lots 142 – 162) accessed from Arbuckle Road (Figure 1).

Investigations comprise both shallow (hand auger and Dynamic Cone Penetrometer) and deep (Cone Penetrometer Testing) in accordance with Hastings District Council (HDC) guidelines for assessment of liquefaction prone land.

Based on the liquefaction assessment, the site is considered susceptible to:

- High to very high risk of liquefaction during a ULS event; with
 - Minor to moderate surface expression; and
 - 15mm to 125mm vertical (free field) settlement indicated.
- Low risk of liquefaction during a SLS earthquake event; with
 - Little to no surface expression; and
 - Up to 2mm to 15mm vertical (free field) settlement

In accordance with MBIE (2015) guidelines for lightweight timber framed buildings:

- The site is classified Technical Category TC2/TC3 Hybrid in accordance with MBIE (April 2015) Technical Guidance, Part C, V3a.
- Vertical settlement due to liquefaction governs design.

For TC2/TC3 hybrid foundation recommendations are, indicative foundation recommendations are for:

- A 0.6m deep gravel raft foundation; with
 - Geofabric placed in the base; and
 - Two (2) layers of geogrid reinforcement; with
- Option 2 enhanced raft; or Option 4 waffle slab foundation; in accordance with
 - MBIE Part A, December 2012

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1 OVERVIEW

Greenstone Land Developments Ltd. (GLDL) engaged Resource Development Consultants Ltd (RDCL) to undertake a geotechnical investigation and assessment report for Stage 9 of the Greenstone Subdivision on Lyndhurst Road in Hastings.

1.1 PURPOSE OF THIS REPORT

The purpose of this report is to provide geotechnical information to support subdivision and building consent at individual Lot level for Stage 9, Lyndhurst Subdivision.

The information contained in this report may be relied on for Building Consent only for foundations as prescribed in this document. Any change for foundation type will require re-assessment which may include additional site testing and geotechnical analyses.

1.2 UNDERSTANDING THE PROJECT

The proposed development for Stage 9 includes twenty-one (21) residential lots comprising Lots 142-162 as indicated on the GLDL Stage 9 Proposed Subdivision Plan, prepared by Zorn Surveying (Job No: 16-EQH; Plan No: V22a, dated 10 August 2018).

The site is located in a zone of “high liquefaction vulnerability”, as mapped by Hawke’s Bay Emergency Management Group (HBEMGP); requiring assessment of liquefaction potential and likely ground settlements under seismic conditions.

RDCL has previously completed geotechnical investigations for Stages 2-6 of the Greenstone development, comprising 67 residential lots in neighbouring sections on Arbuckle & Lyndhurst Roads ([RDCL](#) reports R170602050_02, R170602050_03 and R181090602_01).

1.3 SCOPE OF WORK

Work was undertaken in general accordance with RDCL proposal 183970602, dated 4 October 2018.

2 SITE DESCRIPTION

Stage 9 of the development is accessed off Arbuckle Road (Figure 1), and comprises generally flat land with original levels altered by minor cut and fill for shaping.

2.1 REGIONAL GEOLOGY

Regional geology maps indicate the site is underlain by Holocene river deposits; comprising poorly consolidated alluvial gravel, sand and mud (GNS Science, 2011).

The HBEMGP hazard maps indicate the site geology to comprise finely to moderately interlayered silt and fine sand deposits; (overbank flood deposit), consistent with the regional geology maps.

2.1.1 ACTIVE FAULTS

The site is located approximately 2.5 km southeast of the active trace of the Awanui Fault, as identified in the GNS Science Active Faults Database (2016).

3 RELEVANT GUIDELINES

Geotechnical investigations and assessment has been undertaken in accordance with relevant guidelines:

- Hastings District Council (June 2019). Geotechnical Site Investigations Guidelines. Residential Building Consents.
- MBIE Guidance Version 3 (Dec 2012) Revised issue of Repairing and Rebuilding Houses Affected by the Canterbury Earthquakes. Part A: Technical Guidance (TC1 and TC2).
- MBIE Guidance Version 3a (April 2015) Part C: Assessing, Repairing and Rebuilding foundations in TC3.

5 SUBSOIL INVESTIGATION

Geotechnical testing completed comprised for:

- Shallow hand testing at each Lot (Figure 1):
 - Four (4) dynamic cone penetrometer (DCP) tests.
 - Engineering geological logging of materials recovered by hand auger; and
- Deep Testing for the Subdivision (Figure 2):
 - Seventeen (17) Cone Penetration Tests (CPT) to between 2.3m (refusal) and 20 m bgl.

Results of subsurface investigations for individual lots are in Appendix A, with CPT Logs in Appendix B.

5.1 SUBSOIL CONDITIONS

The results of shallow investigations suggest the site is generally underlain in the near surface by:

- Silty TOPSOIL to between 0.25 - 0.5 m bgl; overlying
- Sandy SILT, stiff, non-plastic, and
- SAND with some silt, medium dense, to between 1.4 – 2.3 m bgl;

The results of CPT investigations suggest the site is generally underlain by:

- Loose to medium dense silt, sand and clay mixture (Alluvial deposits) with lenses of clay.

The following CPT tests were terminated at shallow depth, indicated to be dense sandy gravels (CPT 101, 102, 103, 105, 201, & 205) where Coner Resistance (qt) was recorded in excess of 30MPa.

5.2 GROUNDWATER

Groundwater was not encountered during investigations.

5.3 TOPSOIL DEPTH

Topsoil depth has been inferred from a single hand auger within each lot. The depth of topsoil is indicative at the location tested only (Table 1).

TABLE 1 TOPSOIL INDICATIVE DEPTH

Lot Number	Indicative depth of Topsoil (m)	Lot Number	Indicative depth of Topsoil (m)
Lot 142	0.4	Lot 153	0.3
Lot 143	0.6	Lot 154	0.5
Lot 144	0.5	Lot 155	0.5
Lot 145	0.2	Lot 156	0.5
Lot 146	0.4	Lot 157	0.7
Lot 147	0.4	Lot 158	0.5
Lot 148	0.3	Lot 159	0.3
Lot 149	0.4	Lot 160	0.3
Lot 150	0.4	Lot 161	0.4
Lot 151	0.5	Lot 162	0.3
Lot 152	0.3		

5.4 INFERRED BEARING CAPACITY

DCP test results have been correlated with Ultimate Bearing Capacity (UBC) in accordance with M.J. Stockwell 1977. Inferred UBC for each site is presented in Table 2:

TABLE 2: INFERRED ULTIMATE BEARING CAPACITY FOR LOTS 142 - 162

Lot Number	Available Ultimate Bearing Capacity	Depth achieved (m)	Lot Number	Available Ultimate Bearing Capacity	Depth achieved (m)
Lot 142	200 kPa	0.4	Lot 153	200 kPa	1.1
Lot 143	200 kPa	1.1	Lot 154	200 kPa	1.4
Lot 144	200 kPa	1.1	Lot 155	200 kPa	0.5
Lot 145	200 kPa	0.8	Lot 156	300 kPa	0.5
Lot 146	200 kPa	0.4	Lot 157	300 kPa	0.7
Lot 147	200 kPa	0.4	Lot 158	300 kPa	0.5
Lot 148	200 kPa	0.3	Lot 159	200 kPa	0.3
Lot 149	200 kPa	1.1	Lot 160	200 kPa	0.3
Lot 150	200 kPa	2.1	Lot 161	200 kPa	0.4
Lot 151	200 kPa	1.1	Lot 162	200 kPa	0.3
Lot 152	200 kPa	1.0			

5.5 SEISMIC SOIL CLASSIFICATION

The site is classified as site subsoil “Class D – Deep or Soft Soil Site” in accordance with NZS1170.5:2004, part 5: Earthquake Actions – New Zealand.

The site subsoil class was determined based on conservative review of the Hawkes Bay well database.

The Hawkes Bay well database indicates ground conditions are variable in the area, such that the site can be expected to be underlain by deep soils; specifically:

- Well 2008;
- Well 5554;
- Well 671;
- Well 10847; and
- Well 8474.

5.6 LIQUEFACTION ASSESSMENT

A liquefaction assessment was carried out using CPT 101 to 113 (13 CPT tests) and CPT 201 to 208 (8 CPT tests) and CLiq v.2.1.6.7 Liquefaction Assessment Software.

In accordance with the CPT testing across the site, the Lyndhurst Subdivision is assessed to be:

- For SLS earthquake event:
 - Low risk of liquefaction, with
 - Little to no surface expression;
 - Up to 15mm vertical settlement predicted (Free-field).
- For ULS earthquake event:
 - High to very high risk of liquefaction; with
 - Minor to moderate surface expression; and
 - ~15mm to ~125mm of estimated vertical settlement (Free-field).

Liquefaction potential and induced settlement results are summarised in Table 3; lateral displacements are not expected due to the generally flat relief across the site and surrounding area.

The output results of our liquefaction assessment are presented in Appendix C and summarised in Table 3 below.

TABLE 3: CPT ASSESSED LPI, LSN AND VERTICAL SETTLEMENT FOR SLS AND ULS

Development Stage	Test ID	Liquefaction Potential Index	Liquefaction Severity Number	Estimated Vertical Settlement (mm)	Termination Depth (m)
7 - 12	CPT101 to 113 & CPT201 to 208	Low Risk	Little to no expression	2 - 15	See below
Development Stage	Test ID	Liquefaction Potential Index	Liquefaction Severity Number	Estimated Vertical Settlement (mm)	Termination Depth (m)
7	CPT106	Very High	Moderate	125	13.5
7	CPT107	Low Risk	Little to none	11	3.4
7	CPT108	Very High	Moderate	127	16
7	CPT206	Very High	Moderate	119	20
7	CPT208	High Risk	Minor	71	6.9
8	CPT113	Very High	Moderate	121	17
8	CPT203	Very High	Moderate	117	14.2
8	CPT204	Very High	Minor	102	14.4
8	CPT205	Very High	Minor	99	10.6
9	CPT109	Very High	Moderate	120	20
9	CPT110	Very High	Moderate	115	20
9	CPT201	Low	Little to None	7	3.3
9	CPT202	Very High	Minor	103	20.1
10	CPT111	Very High	Minor	96	9
10	CPT112	Very High	Moderate	123	20
11	CPT101	Low	Little to none	15	4.9
12	CPT102	Low	Little to none	3	2.4
12	CPT103	High Risk	Minor	49	4.9
12	CPT104	Very High	Moderate	117	13.8
12	CPT105	High Risk	Minor	86	8.2
12	CPT207	Low	Little to None	5	2.6

5.6.1 BASIS OF ASSESSMENT

The liquefaction analyses for the site were assessed using CLiq, accepted industry software package (Geoligismiki, 2014), CPT data of current ground conditions, soil logs from Test Pit investigations and the following input parameters (GNS Consultancy Report (2015/185), October 2015):

- PGA = 0.12g (SLS) & 0.42g (ULS), with:
 - Magnitude (M) = 6.2 (SLS) & 6.5 (ULS)
 - C=1.12 (Class D Soil), and
 - R=0.25 (SLS) & 1.0 (ULS).
- Ground water table 2.0 m bgl based on our knowledge of the area.

The design earthquake was chosen on the basis of probability of recurrence. The probability is based on historical earthquakes. A 6.5 magnitude earthquake for an importance level category 2 correlates with a 25 year return period (SLS) and 500 year return period (ULS). A 50 year design life was assigned.

6 GEOTECHNICAL CONSIDERATIONS

6.1 FOUNDATION RECOMMENDATIONS

Based on the results of these investigations, we consider Stage 9 to be suitable for the proposed residential development provided:

- Foundations meet TC2/TC3 type foundation requirements in accordance with MBIE (April 2015) TC3 Technical Guidance, V3a; where
- A gravel raft foundation and enhanced slab or waffle slab in general accordance with MBIE Technical Guidance, Part A, December 2012 is employed.

GRAVEL RAFT FOUNDATION

The gravel raft specification requires:

- Undercut to 0.6m bgl and 1m horizontal distance outside the building footprint;
- Placement of geotextile filter cloth (Strength Class C) in the base and wrapped up the sides;
- Placement of two (2) layers of Cirtex geogrid SS30 or equivalent, where the first layer is placed in the base with a second layer separated by ~150mm gravel fill.
- Placement of compacted, well graded gravels with maximum particle size of 70mm and free of topsoil or deleterious materials; and
- Compacted to 95% MDD at optimum water content;
- Tested by NDM testing by an independent laboratory.

FLOOR SLAB

The Floor slab should incorporate from MBIE Part A, December 2012, either:

- Option 2 (300mm – 400mm thick) enhanced raft; or
- Option 4 Waffle Slab

6.1.1 SUITABILITY FOR USE

Foundation solutions given in this report are considered suitable for use to support a Building Consent provided:

- Proposed structure generally meets the description of a Light weight, single level timber framed buildings of “simple shape”; and the
- Proposed foundations meet the requirements of TC2/TC3 hybrid category solutions.

Alternative solutions require specific geotechnical testing and design to confirm.

The depth to bearing is indicative based on site testing on the day. Experience shows that depth may vary with excavation, particularly in wet conditions.

6.1.2 ALTERNATIVE FOUNDATION SOLUTIONS; SPECIFIC DESIGN

Alternative, acceptable foundation solutions may be possible based on additional geotechnical testing, or structural design.

6.2 GEOTECHNICAL VERIFICATION

The following inspections are required for verification:

- Excavation Inspection (Geotechnical Engineer)
- Inspection of geotextile and geogrid components;
- Granular backfill confirmation
- Independent compaction testing (NDM)
- Verification of Compaction tests; and
- Issue of Producer Statement (PS4)

7 STATEMENT OF PROFESSIONAL OPINION - FORM 6 (224C)

A statement of professional opinion as to the suitability of land for building development is presented in Appendix D.

8 REFERENCES

GNS Science. (2004). Active Faults Database. *Institute of Geological and Nuclear Sciences*. GNS Science.

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NZS1170.5. (2004, December 22). NZS1170.5:2004 - Structural Design Actions; Part 5: Earthquake actions - New Zealand. Standards New Zealand.

NZS3604. (2011). *NZS3604:2011 - Timber-framed buildings*. Standards New Zealand.

M.J. Stockwell, Determination of allowable bearing pressure under small structures, 15 June 1977, *New Zealand Engineering*, 32,6 p 132-135

9 LIMITATIONS

- This report has been prepared for the particular purpose outlined in the project scope and no responsibility is accepted for the use of any part in other contexts or for any other purpose.
- Ground conditions assessed in this report are inferred from published sources, site inspection and the investigation described. Variations from the interpreted conditions may occur, and special conditions relating to the site may not have been revealed by this investigation, and which are therefore not taken into account. No warranty is included either expressed or implied that the actual conditions will conform to the interpretation contained in this report.
- No responsibility is accepted by Resource Development Consultants Ltd for inaccuracies in data supplied by others. Where data has been supplied by others, it has been assumed that this information is correct.
- Groundwater conditions can vary with season or due to other events. Any comments on groundwater conditions are based on observation at the time.
- This report is provided for use by the client, section owners, and Hastings District Council and is confidential to the client and their professional advisors. No responsibility whatsoever for the contents of this report shall be accepted for any person other than the client.

10 CLOSURE

We trust this meets your current needs. Should you wish to discuss any aspect of the contents of this document please contact the undersigned on 06 877-1652.

Prepared by:

Reviewed by:



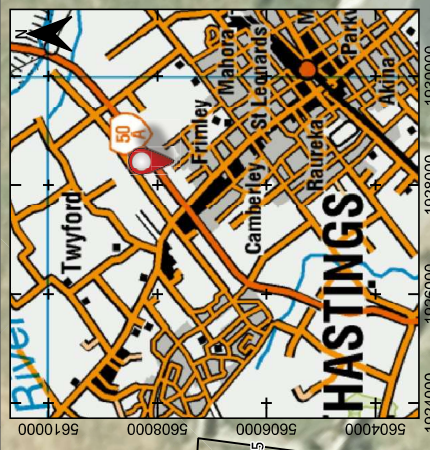
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Principal

FIGURES

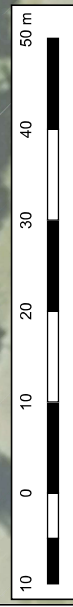
FIGURE 1



Legend

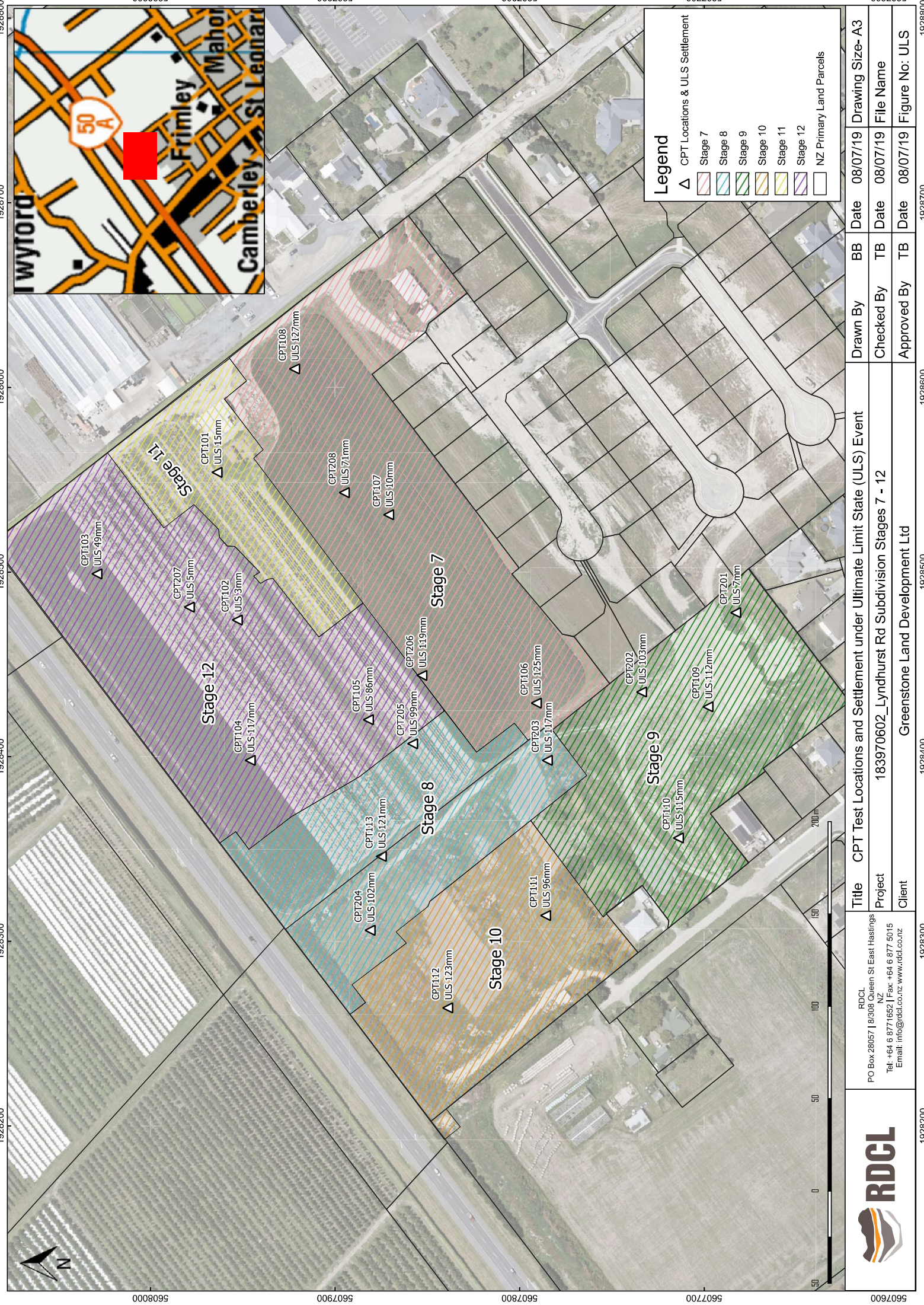
- ⊕ Hand Auger (HA)
- ⊗ Dynamic Cone Penetrometer (DCP)
- △ Cone Penetrometer Test (CPT)
- Proposed lot boundaries

Notes:
 New Zealand Topo250 Map and Hawke's Bay 0.3 m Rural Aerial Imagery (2014-2015) obtained from <https://data.linz.govt.nz/>



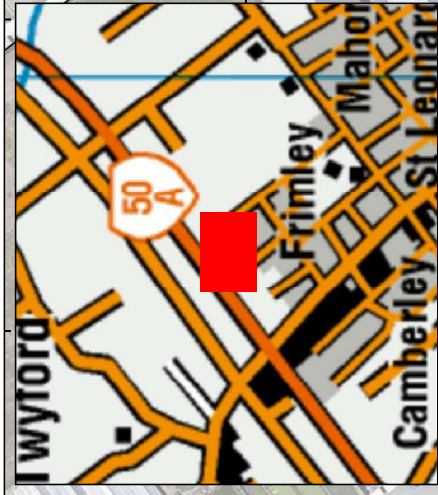
	RDCL P O Box 28057 B/308 Queen St East Hastings NZ Tel: +64 6 8771652 Fax: +64 6 877 5015 Email: info@rdcl.co.nz www.rdcl.co.nz	Title Site Investigation Layout		Drawn By SD	Date 09/05/19	Drawing Size- A3
		Project Stage 9 - Lyndhurst Rd Subdivision		Checked By BB	Date 09/05/19	Project No.: 183970602
		Client Greenstone Land Development Ltd		Approved By TB	Date 20/05/19	Figure Number: 1

FIGURE 2



Legend

- △ CPT Locations & ULS Settlement
- Stage 7
- Stage 8
- Stage 9
- Stage 10
- Stage 11
- Stage 12
- NZ Primary Land Parcels



Drawn By	BB	Date	08/07/19	Drawing Size-	A3
Checked By	TB	Date	08/07/19	File Name	
Approved By	TB	Date	08/07/19	Figure No:	ULS

Title		CPT Test Locations and Settlement under Ultimate Limit State (ULS) Event			
Project		183970602_Lyndhurst Rd Subdivision Stages 7 - 12			
Client		Greenstone Land Development Ltd			

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