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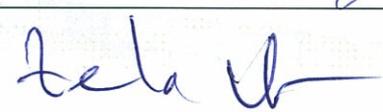
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Geotechnical Engineering Ltd
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**GEOTECHNICAL INVESTIGATION
 FOR PROPOSED SCHEME CHANGE
 151 AND 177 RAUTAWHIRI ROAD, HELENSVILLE**

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1.0 Introduction

1.1 Project Brief and Scope

Soil & Rock Consultants were engaged by Paramount Homes to undertake a geotechnical investigation for the proposed scheme change of 151 & 177 Rautawhiri Road, Helensville. This report summarises our findings and recommendations and may be used to support an application to Auckland Council.

The scope of this report encompasses the geotechnical suitability and land stability in the context of the proposed scheme change as defined in our fee proposal dated 15 August 2013. The principal objectives of the investigation are to develop an appropriate geotechnical model of the site so that any geotechnical constraints can be identified.

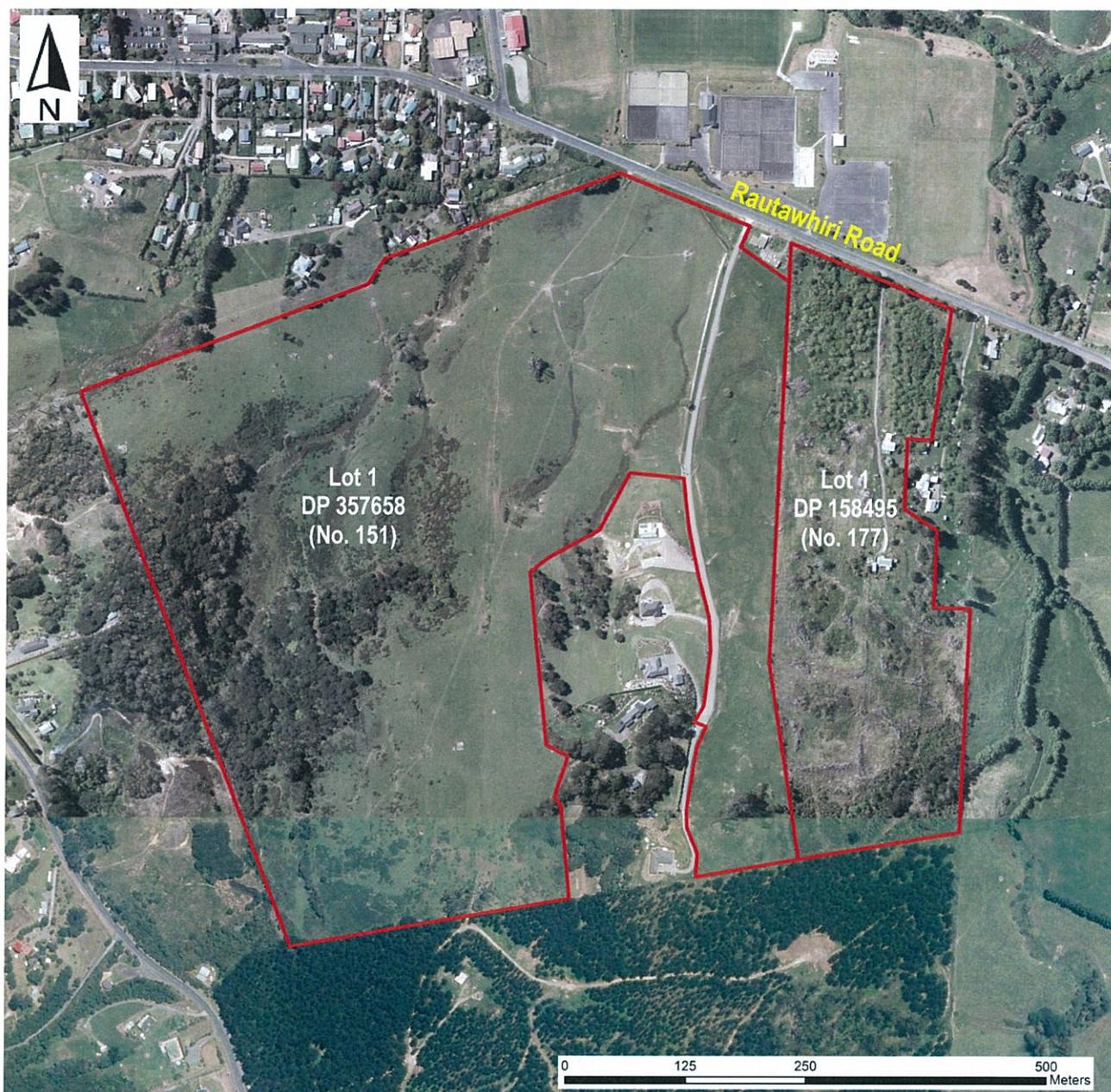
1.2 Limitations

This report has been prepared for the sole benefit of our Client, Paramount Homes, with respect to the particular brief given to us. This report is to be used by our Client's appointed Consultants and may be relied upon by Auckland Council when considering any proposed application in association with the proposed scheme change of the investigated site. The data and/or opinions contained in this report may not be used in other contexts or for any other purpose without our prior review and agreement.

The recommendations given in this report are based on site data from discrete locations. Inferences about the subsoil conditions away from the test locations have been made, but cannot be guaranteed. We have inferred an appropriate geotechnical model that can be applied for our analyses. However, variations in ground conditions from those described in this report could exist across the site. Should conditions encountered differ to those outlined in this report we ask that we be given the opportunity to review the continued applicability of our recommendations. While our recommendations are applicable on a large scale specific to this site; individual geotechnical investigations may be required at certain locations for the sites potential future development.

2.0 Site Description

The investigation site comprises two neighbouring properties 151 & 177 Rautawhiri Road, Helensville. The properties are legally described as Lot 1 DP 357658 (151 Rautawhiri Road, approximate area 36.99Ha) and Lot 1 DP 158495 (177 Rautawhiri Road, approximate area 10.24Ha). The sites are irregular in plan view and encompass a total area of approximately 47.23Ha. The site is shown in Figure 1 and is generally made up of a combination of pastoral farm land, native and exotic bush and scrub. Access to the site is off Rautawhiri Road which runs along the north eastern boundary. The north western boundary is bounded by rural lifestyle blocks merging into residential. Toward the east and west is mostly rural land-use comprising a mixture of bush and pasture and an exotic pine plantation is situated to the south.

Figure 1: Aerial photograph of investigation site

(Source: www.data.linz.govt.nz, 2013)

2.1 Lot 1 DP 357658 (151 Rautawhiri Road)

The site slopes down toward the north between a maximum elevation of approximately 94m above mean sea level (amsl) along the southern boundary and 7m amsl where the site meets Rautawhiri Road. It comprises number of steepened valleys that run in the north south direction average slope inclinations generally vary between 25° and level, however in some parts reach angles greater than 45°.

Various waterways dissect the landscape where perennial first order streams flow all year round, with smaller intermitted second and third order streams running during wetter times.

Slopes within the lower areas of the site below 30m amsl range between moderately inclined to near level. The land-use is generally pastoral however wetlands and swampy areas are present, as indicated on the 'Geomorphic Map', Drawing No. 13567/3 (attached in Appendix B). These areas were extremely wet during our site visit; however are inferred to dry up to certain extents during the summer.

Steeper sections of the site are generally above an elevation of 30m amsl and a number of instabilities are identified and indicated on the 'Geomorphic Map'. These features include relic and recent landslips, slumping, shallow soil creep, hummocky surfaces and erosion.

Cross sections through the major features are represented in Drawing No. 13567/2A (*Cross Section A-A*), Drawing No. 13567/2B (*Cross Section B-B*) and Drawing No. 13567/2C (*Cross Section C-C*). The position of these is shown on our 'Site Plan' Drawing No. 13567/1 (drawings attached in Appendix B). Detailed descriptions of instabilities are discussed in Section 7.0 - Land Stability and associated sub-sections.

2.2 Lot 1 DP 158495 (177 Rautawhiri Road)

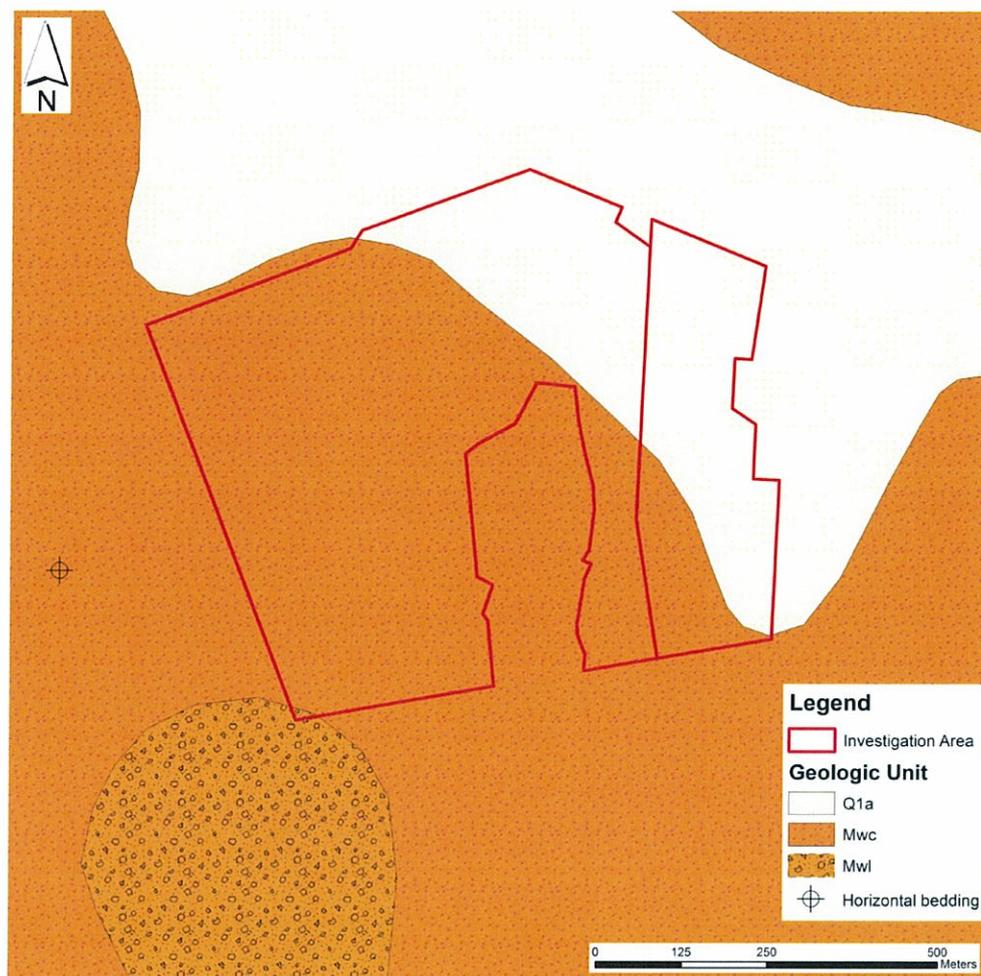
171 Rautawhiri Road comprises a section that generally slopes down in the north and eastern directions at moderate to low inclinations. A waterway cuts through the southern portion of the site almost paralleling (approximately 40m to the north) the southern boundary. Slopes surrounding the stream are vegetated in scrub and generally steep due to bank erosion.

The northern portion of the site comprises an orchard of plum trees extending from the northern boundary approximately 150m toward the south. While the central portion comprises deforested pines (piles of wooden debris) and scrubland. Two buildings are also positioned on the Lot, an existing residential dwelling and a barn/shed, as shown on the aerial photograph of the site (Figure 1).

3.0 Area Geology

According to the GNS Auckland Geological Map, Map 3, Scale 1:250,000, dated 2001 the site is underlain by three separate geologic units shown in Figure 2 and identified as Q1a (Alluvial Deposits), Mwc (Cornwallis Formation) and Mwl (Helensville Conglomerate). The map shows that the Alluvial Deposits are positioned within the lower margins of the site toward the north and east. The Cornwallis Formation and the Helensville Conglomerate underlie the more elevated extents and are both members of the Warkworth Sub-Group (of the larger Waitemata Group). GNS indicate that the contact boundaries between the rock units (Mwc and Mwl) are approximate and due to the coeval nature of the rocks Helensville Conglomerate can often be found within the Cornwallis Formation. A detailed description of each geologic unit is given in the subsequent sections.

Figure 2: Investigation site geology



(Source: GNS, 2001)

3.1 Alluvial Deposits

Alluvial Deposits indicated in Figure 2, underlye the north to eastern portion of the investigation area. These deposits are of Holocene (Recent) age and a member of the Tauranga Group. Alluvial Deposits are typically encountered within flood plains, valley margins and stream channels and are variable in terms of consistency and strength. They are very thinly to thickly bedded, variously coloured, angular to well rounded, mixed sized (usually graded, coarse becoming fine upwards) beds of light grey to orange brown muds, sand and gravel, comprising some rock fragments in places and may include some beds of black, humus rich clay and fibrous peat. Alluvial materials are unconsolidated to very soft and are unweathered. In addition to softer soil considerations, potential for flooding is also a form of hazard where such materials are present. Alluvium can be prone to soil creep and shallow flows on gentle slopes particularly when saturated. Under load Alluvial Deposits can also be susceptible to settlement due to the range of materials and properties likely to be present.

3.2 Cornwallis Formation

Cornwallis Formation rocks are defined as Volcanogenic Flysch comprising alternating muddy sandstone and mudstone with occasional interbedded lenses of grit. They comprise thin to very thick, typically gently to moderately dipping beds of grey-brown, angular to well-rounded, graded (coarse becoming fine upwards) sandstone, with fragments of basalt and Andesite and pebbles of mudstone or muddy limestone, clay minerals and with some minor cobble-conglomerate. The rocks are of extremely weak to strong strength with moderate to extremely widely spaced fractures.

The Cornwallis Formation rocks weather naturally to depths of up to 20m producing firm to very stiff, light yellow-grey to reddish-grey soils and clays of variable plasticity. The weathered soils exhibit variations in thickness and lateral extent. They may also exhibit large variations in strength and compressibility characteristics. At intermediate depths between these completely weathered soils and the less weathered rock materials, the grey moderately to highly weathered materials typically comprise strata of silty fine sand or fine sandy silt. Gravel or cobble sized lithorelics of less weathered material may also be present within the residual soil horizons.

The residually weathered subsoil is prone to instability where the slope inclination, groundwater or soil strength conditions are unfavourable. Joint/defect controlled failures around gully heads may be prevalent. More clayey or clayey silt horizons may be prone to shrink and swell when subject to seasonal soil moisture changes.

3.3 Helensville Conglomerate

The Helensville Conglomerate is described as being locally present within the Cornwallis Formation north of Waimauku. It predominantly comprises well rounded, andesitic, cobble and pebble conglomerate with boulders up to 2.0m in diameter. The clasts are mainly of andesite eroded from the ancient Kaipara Volcano, with less common microdiorite, basalt, limestone and chert derived from the Northland Allochthon. Lenses of Helensville Conglomerate toward the north, up to 100m thick are interpreted as submarine channel or canyon fill deposits. While thinner (1 – 30m thick) sheet-like bodies with channelized lenses further south are inferred to be submarine fan deposits.

These rocks weather naturally to depths of up to 10m producing firm to very stiff cohesive soils and loose to very dense non-cohesive soil types of variable grain size. The sediments are generally layered and exhibit variations in thickness and lateral extent. They may also exhibit large variations in strength and compressibility characteristics. At intermediate depths between the residually weathered soils and the less weathered rock materials, the moderately to highly weathered materials typically comprise strata of slightly cemented grey, dark orange and red fine to coarse grain silty sand and fine to coarse grain sandy silt with the original bedded remaining visible (however clay fractions can be present).

The weathered subsoil can be prone to instability in areas where the slope inclination, groundwater or soil strength conditions are unfavourable. On steeper slopes the residual soils are prone to a translational failure mode when they

become saturated. Generally movement of the residual soils often occurs at the contact between the weaker soil mantle and the underlying harder material. Instability can also be associated with the perching of the groundwater table above the contact with the stronger, less weathered materials. The occurrence of deep-seated failures within the underlying conglomerate is relatively uncommon, however, this is dependent on the joint dip and direction and ground slopes and groundwater elevations. More clayey or clayey silt horizons may also be prone to shrink and swell when subject to seasonal soil moisture changes.

4.0 Previous Geotechnical Reports

Soil & Rock Consultants have not previously investigated the subject sites, however three geotechnical investigations related to the investigation sites have been sourced from the Auckland Council Property Files. These reports are listed and summarised below:

- *'Lots 2, 3 Helensville Subdivision, Rautawhiri Road'*, Riley Consultants Ltd., Job Reference No. 96205-A, dated 25 March 1997.

The report covered the identification of acceptable building platforms within Lots 2 and 3, with respect to slope stability and included the engineering issues connected to the associated access roads. The report also provided relevant information for potential purchasers of the proposed subdivided Lots. Although present instability was not identified at the time of the investigation Riley Consultants Ltd. did acknowledge that the site had seen a level of slope movement and creep in the past, furthermore deep seated failure was not discounted within the site however based on modelling was inferred to be unlikely.

The report concluded recommending that dwellings were to be constructed on driven timber pile foundations (in accordance with NZS 3604:1990) to minimise the effect of any present instabilities and that specific design was required.

- *'Proposed Subdivision – Hounslow Holdings Ltd., 151 Rautawhiri Road, Helensville, Geotechnical Investigation – Lots 1 to 5'*, Engineering Geology Ltd., Job Reference No. 5350, dated 10 May 2004.

This investigation comprised a five Lot subdivision and included the assessment of suitable building sites. The investigation involved a site inspection and the drilling of four hand augerholes. Ancient mass instability was identified comprising a deep gully which passes through the western half of Lots 2 to 5. There was also a large amphitheatre positioned to the south of the Lot 5 building site, represented in this current investigation (Job Reference No. 13567) as Cross Section A-A', Drawing No. 13567/2A (attached in Appendix B).

Generally Engineering Geology Ltd. considered the areas of the proposed building platforms within their investigation to be suitable for conventional shallow foundations (in accordance with NZS 3604:1999). However

building on steeper slopes would require further investigation and specific design with regard to retaining walls and pile foundations.

- *'Proposed Subdivision – Hounslow Holdings Ltd., 151 Rautawhiri Road, Helensville, Geotechnical Investigation – Lots 2 to 6'*, Engineering Geology Ltd., Job Reference No. 5350, dated 9 February 2005.

The 2005 report by Engineering Geology Ltd. involved an investigation for a proposed six Lot subdivision to assess the suitability of the planned building sites. Augerhole information was sourced from the previously referenced report (dated 2004) along with the drilling of two new hand augerholes. Again the historic instabilities are highlighted, however the augerhole information indicated that the subsurface beneath the proposed building sites was of high strength and generally undrained vane shear strengths were above 100kPa (peak). The soils near the surface were considered to be moderately expansive (Class M) in terms of AS 2870:1998.

Once more similar to the Engineering Geology Ltd. 2004 report the recommendations remain the same with the use of conventional shallow foundations in accordance with NZS 3604:1999. A minimum embedment depth of 600mm is specified as a precaution against settlement. However the report indicates that specific design waffle rafts (eg. 'Ribrafts') could be designed for 'Class M' soils.

5.0 Field Investigation

Our field investigation comprised the following components:

- A detailed walkover inspection of the site;
- Engineering geological mapping
- Drilling of 15 hand augerholes (AH01 – AH15);
- Scala Penetrometer testing from the base of the augerholes; and
- The measurement of three cross sections through the site.

The locations of all field tests were measured in by hand held Garmin GPS without survey control and are therefore approximate only. Test locations are shown on the attached '*Site Plan*' Drawing No. 13567/1, attached in Appendix B.

Measurements of the undrained shear strengths were undertaken in the auger holes at intervals of depth by means of a hand held shear vane. The test method was in accordance with the New Zealand Geotechnical Society Guidelines for Hand Held Shear Vane Tests, dated August 2001. The peak vane shear strengths and the remoulded vane shear strength values shown on the attached augerhole logs represent dial readings off the vane, adjusted using the BS 1377 calibration. Correction factors based on calibration tests are shown on the attached logs.

A visual-tactile field classification of the subsoils encountered during drilling was carried out in accordance with the "Guidelines for the Field Classification and Description of Soil and Rock for Engineering Purposes", issued by the New Zealand Geotechnical Society Inc., dated 2005.

Scala Penetrometer (Dynamic Cone) testing was carried out from the base of all augerholes to assess soil penetration resistance at depth. The testing was carried out in accordance with NZS 4402:1988, Test 6.5.2, "Dynamic Cone Penetrometer".

Three tape and clinometer cross sections were measured through the locations of our hand augerholes to obtain representative ground surface profiles within areas of interest for the stability assessment. The cross sections are shown on the attached drawings in Appendix B and titled, Cross Section A-A' (Drawing No. 13567/2A), Cross Section B-B' (Drawing No. 13567/B) and Cross Section C-C' (Drawing No. 13567/2C).

The groundwater table, where encountered was measured following drilling and are shown on the augerhole logs.

6.0 Subsoil Conditions

Subsurface conditions encountered at each test location is summarised below and a detailed description of the soils encountered during the drilling is given on the attached augerhole logs (Appendix A).

Conclusions and recommendations contained in this report are based on the results of our field investigation and in-situ testing within auger holes at point locations and information from geological maps. The nature and continuity of the subsoil conditions away from test locations are inferred and it should be noted that actual subsoil conditions could vary from the assumed model. This is particularly so where previous manmade disturbances and placement of non-engineered fill may have occurred in the past, typically associated with landscaping and/or previous construction activities.

The sites geology generally comprised a surficial layer of topsoil underlain by residually weathered soils of both the Cornwallis Formation and the Helensville Conglomerate (on the elevated slopes) and Alluvial Deposits within lower regions. During our field investigation it was noted that the boundaries of the two rock formations (Mwc and Mwl) were coeval as suggested by GNS (2001). The most common unit below 30m amsl was Alluvium and above this weathered Cornwallis Formation, however weathered Helensville Conglomerate was found at an isolated location within AH14.

The subsoil conditions underlying the site are summarised below in Table 1, and a general description is provided subsequently.

Table 1: Subsoil Summary

Test ID	Drill Depth	Depth of Topsoil	Depth of Alluvium	Depth of Mwc	Depth of Mwl	Scala Penetrometer Refusal	Groundwater Depth
AH01	5.0	0.25	EOB	NE	NE	6.7	3.5
AH02	5.0	0.2	EOB	NE	NE	7.9	0.5
AH03	5.0	0.2	EOB	NE	NE	6.55	2.0
AH04	5.0	0.2	3.1	EOB	NE	5.6	2.3
AH05	5.0	0.2	EOB	NE	NE	6.75	0.2
AH06	5.0	0.2	EOB	NE	NE	6.75	2.9
AH07	5.0	0.2	NE	EOB	NE	5.5	1.9
AH08	2.2	0.2	NE	EOB	NE	4.45	NE
AH09	4.9	0.3	NE	EOB	NE	6.3	NE
AH10	5.0	0.25	EOB	NE	NE	6.55	2.5
AH11	5.0	0.2	EOB	NE	NE	5.85	1.6
AH12	5.0	0.2	NE	EOB	NE	6.65	NE
AH13	5.0	0.2	EOB	NE	NE	5.4	4.9
AH14	3.0	3.0	NE	NE	EOB	4.95	NE
AH15	5.0	0.2	EOB	NE	NE	6.7	1.7

Table Notes: Measurements in metres (m) below present ground level (bpgl)
Mwc = Residual Cornwallis Formation Soils
Mwl = Residual Helensville Conglomerate Soils
NE = Not Encountered
EOB = Encountered to 'End of Bore'

6.1 Topsoil

Topsoil was encountered from the surface of all hand augerholes to depths between 0.2m and 0.3m below present ground level (bpgl). These materials were generally dark brown and comprised major fractions of silt, with minor fractions of clay and fine to coarse grain sand. Topsoil is not considered suitable for the support of buildings and access ways.

6.2 Alluvial Deposits

Alluvium was encountered within nine augerholes to depths between 1.1m (AH01) and 3.1m (AH04) bpgl and to the termination depths (5.0m bpgl) of AH01, AH02, AH03, AH05, AH06, AH10, AH11, AH13 and AH15. These bores were generally positioned within the lower lying areas of the Lots toward the north and east. Alluvial Deposits were generally grey with orange streaking and mottling with some layers containing wood fragments (1.8m bpgl - AH05, 4.0m bpgl - AH11) and fibrous peat inclusions (3.6m bpgl - AH13). Subordinate and major fractions included silt, clayey silt, silty clay, fine to coarse grain sand, and fine to coarse grain silty sand. Minor fractions of the Alluvial Deposits included fine to coarse grain sand, clay, silt and occasionally fine grain siltstone clasts. Strengths of the Alluvial Deposits varied between firm and very stiff with vane shear strengths ranging between 34/15kPa (peak/remoulded, AH03 - 2.0m bpgl) and 169/96kPa (peak/remoulded, AH13 - 3.0m bpgl).

6.3 Weathered Cornwallis Formation

Residually weathered soils of the Cornwallis Formation were found within augerholes AH02, AH04, AH07, AH08, AH09 and AH12 underlying the topsoil and Alluvial Deposits (AH04) to the termination depth of each bore. These soils comprised subordinate and major fractions of silts, clayey silts and fine to coarse grain sandy silt. Minor fractions included clay, fine to coarse grain sand and inclusions of fine siltstone clasts. Strength of the weathered Cornwallis Formation soils was generally stiff to hard with vane shear values ranging between 65/21kPa (peak/remoulded, AH09 – 3.0m bpgl) and soils that were unable to be penetrated with test equipment (AH08 – 1.5m bpgl and indicated as UTP on the auger logs attached in Appendix A).

6.4 Weathered Helensville Conglomerate

Weathered Helensville Conglomerate was encountered at one test location (AH14) underlying the surficial topsoil layer. These materials were distinguished by the Brown, orange, red pink and grey colours of the soil as well as composition. The residual Helensville Conglomerate comprised subordinate and major fractions of silt, fine to coarse grain sandy silt and fine to coarse grain sand. These soils were generally hard and vane shear strengths of cohesive materials were generally above 200kPa where soils were unable to be penetrated with test equipment (indicated on the auger log as UTP, attached in Appendix A). The sand layers are described as 'tightly packed' where materials would require a pick for removal, either as lumps or disaggregated material.

6.5 Scala Penetrometer Testing

Scala Penetrometer testing carried out from the base of the augerholes encountered refusal at depths between 4.45m (AH08) and 6.65m (AH12) bpgl within residually weathered soils. These refusal depths are inferred to be contact with less weathered rock at depth (where refusal is determined by five consecutive blow counts of ten or more per 50mm increment).

Scala Penetrometer refusal depths within the Alluvial Deposits ranged between 5.4m (AH13) and 7.9m (AH02) bpgl. There is a gradual increase in scala blows down the soil profile within these test locations. This is inferred to be attributed to friction on the scala rods as depth increases. Therefore no confirmative harder layer has been defined within the Alluvial Deposits.

6.6 Groundwater Table

Groundwater was encountered within all augerholes on the day of drilling (6 September 2013) with the exception of four test locations, AH08, AH09, AH12 and AH14. Where groundwater was encountered, depths varied between 0.2m (AH05) and 4.9m (AH13) bpgl. It is considered likely that the groundwater table fluctuates, rising higher following periods of prolonged and/or heavy rainfall or lower during drier stages.

7.0 Land Stability

For the purposes of our investigation we have split the stability assessment into two sections, Lot 1 DP 357658 (151 Rautawhiri Road) and Lot 1 DP 158495 (177 Rautawhiri Road). Both areas have differing characteristics from land cover, geology and geomorphology. No. 151 reaches higher elevations and comprises a contrast between steeply inclined bush clad landscapes down to low lying wetland areas. No. 177 is moderately to slightly sloping and generally comprises an underlying alluvial geology.

Our land stability assessment included the amalgamation of engineering geologic site mapping, an intrusive field investigation, aerial photograph interpretation and analysis involving hillslope computer modelling in ArcGIS.

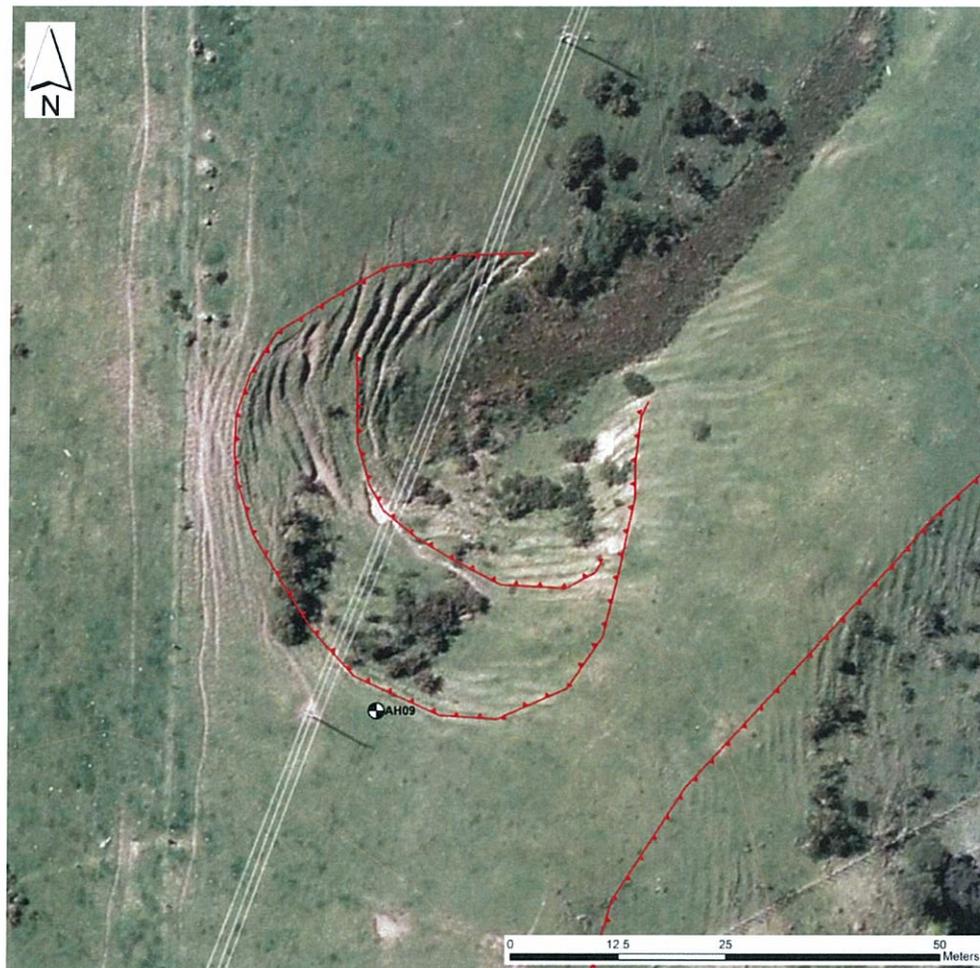
7.1 Lot 1 DP 357658 (151 Rautawhiri Road)

As described the topography of the site generally slopes down toward the north between a maximum elevation of approximately 94m amsl down to approximately 7m amsl where it meets Rautawhiri Road. A number of steepened valleys/gullies dissect the site running in the south to north direction down to a lower gradient landscape that comprises wetland/swampy areas. Inclinations within the gully areas are generally steep to moderately steep with some slopes greater than 25°. At the base of these gullied locations is a combination of perennial and intermitted waterways.

During our engineering geologic mapping of the site a number of instabilities were identified generally in the form of shallow soil creep, slumping and erosion. Historic headscarps were identified in a number of areas, particularly within the higher elevations of the site at the crest of hillslopes. These are indicated on our 'Geomorphic Plan', Drawing No. 13567/3. As discussed three tape and clinometer cross sections were measured through sites of interest and these are detailed in sections 7.1.1, 7.1.2 and 7.1.3.

7.1.1 Cross Section A-A'

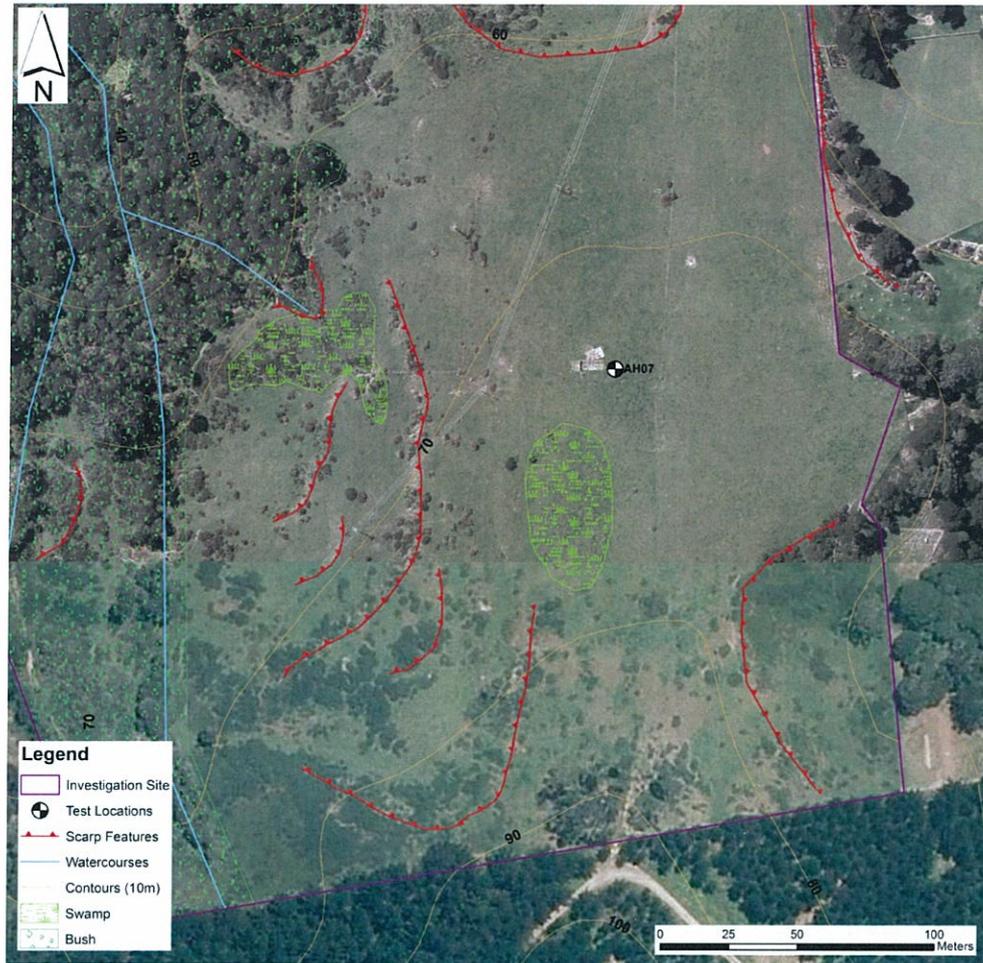
Cross Section A-A' (Drawing No. 13567/2A, attached in Appendix B) is measured through augerhole AH09 and is a profile representation of the relic landslip indicated on the 'Geomorphic Plan'. The slip is discussed in the previous reports referenced in Section 4.0 and comprises an amphitheatre (shown in Figure 3) measuring approximately 50m wide and 20m high. Slumping and soil creep was observed around the crown of the headscarp and tension cracking was identified above the secondary scarp within a slump approximately 15m downslope of the main headscarp feature. We acknowledge that some movement could be attributed to trampling of the surface from farm stock; however this possibly concealed tension cracks that would have otherwise been visible. Debris from the initial failure spreads to the base of the hillslope where a wetland has formed. Mass movement of this region is not foreseen however the continuous erosion and movement of the surface soils will be a constant process with the current headscarp regressing into the hillslope over time.

Figure 3: Aerial image of historic landslide (Cross Section A-A')

7.1.2 Cross Section B-B'

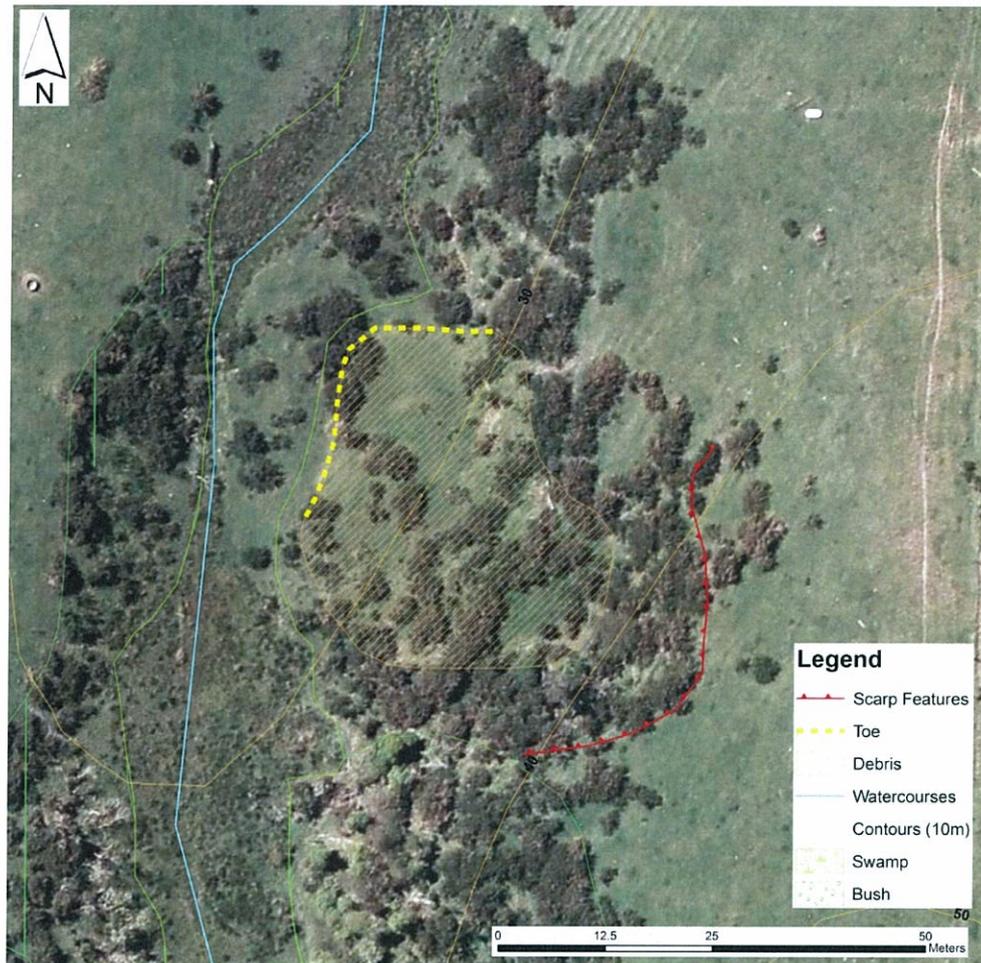
At the southern extent of the site between the top boundary and approximately 60m amsl is an ancient slump sequence represented by Cross Section B-B', Drawing No. 13567/2B (attached in Appendix B) and shown in Figure 4. The area encompasses the south western corner of the Lot and extends from the southern boundary in the north western direction downslope toward the bush. A number of historic scarp features are indicated in Figure 4 and on the 'Geomorphic Plan' however are now highly eroded. It is inferred that these features are a sequence of rotational slumps most probably related to a reduction of toe support as erosion of the slope has transpired below. Swampy areas were identified in various locations within the slumps. The upper soils in this area were observed to be relatively unstable where water has been eroding at the base of the relic scarps and infiltrating the ground surface. Based on information obtained from within AH07 and other test locations it is inferred that the soils in this location are of high clay content. This can become problematic from a stability aspect where groundwater has a large influence on soil strength/bonding. Due to the low permeability of the soils, movements can be triggered when sufficient rainfall intensities and/or duration raise the groundwater table to or near the soil surface. The capacity of the soil to drain is exceeded long enough for hydrostatic pressures to rise substantially. The soil then swells, losing sufficient strength and this can lead to failure.

Figure 4: Aerial image of south western slump sequence (Cross Section B-B')



7.1.3 Cross Section C-C'

Cross Section C-C' portrays the north eastern side of the ridge measured for Cross Section A-A'. It comprises a landslip feature considered characteristic of this portion of the investigation area. Cross Section C-C' is represented in Drawing No. 13567/2C (attached in Appendix B) and displayed in Figure 5. The headscarp almost parallels the curvature of the ridge and is approximately 40m wide and 4.5m tall, however has seen a level of erosion through the past. Inclinations of the slip range between 45° (within the headscarp) and 7° (within the debris flow/colluvium). Colluvial deposits (or slip debris) extend from the base of the headscarp to the toe approximately 30 to 40m toward the stream. Tension cracks were not directly observed above the headscarp however stock trampling may have concealed any evidence of this instability. It is inferred that the on-going downward movement of the slip debris will continue into the future. Similarly with regard to the headscarp, regression will develop/continue as a result of surface erosion and land slipping.

Figure 5: Aerial of historic slip feature (Cross Section C-C')

7.1.4 Overall Assessment Lot 1 DP 357658

The area exhibits extents of instability generally along the steeper/elevated portions of the site. For example, where the slope is inclined greater than 15° and where elevations are greater than 30m amsl. This instability can be accredited to the underlying geology, site topography and hydrology. In most regions the instability is a result of stream erosion reducing the toe support of each hillslope and the continuous creep of surface soils. Soil creep was identified as hummocky surface features and the bowing nature of the tree trunks within the vegetated areas.

Most watercourses were buffered with a wetland/swamp margin where sediments are accumulated generally at elevations less than 30m amsl. Some of these regions are inferred to completely dry during periods of low precipitation (i.e. summer). However these areas were extremely boggy during the time of our investigation (September 2013).

Stable areas within the site included the central parts of ridgelines and within the lower areas where slopes were inclined at a lesser degree (for example below approximately 15°).

7.2 Lot 1 DP 158495 (177 Rautawhiri Road)

This section of the investigation area is relatively stable from a geotechnical perspective. It generally slopes down toward the north and north east at inclinations between level and 10°, however slopes within the south eastern corner reach inclinations of up to approximately 15°. The soils comprise Alluvial Deposits that have eroded from the upper slopes and are of firm to very stiff in strength.

The only instabilities identified in this Lot were related to the watercourse that cuts through the southern extent of the site in the west east direction. Bank erosion had resulted in localised bank collapse however dense scrub had deterred any close inspection. The area surrounding the stream is unstable and surface soil creep is present. No other form of instability or areas of mass failure was observed within this Lot.

8.0 Geotechnical Considerations

8.1 Geotechnical Zonation

Geotechnical Zonation has been developed based on site observations, detailed geotechnical inspection of the site, field investigation and mapping of geotechnical hazards. These zones have been delineated and are detailed on our '*Geotechnical Zonation Plan*', Drawing No. 13567/4, attached in Appendix B. A description of each zone is given below:

8.1.1 Zone A: Residential Building Zone

This is land defined as "Land with little geotechnical constraints, including the land that is potentially suitable for residential development". For the purposes of this report residential development comprises buildings such as residential dwellings, garages and associated auxiliary buildings, for example storage or garden sheds. This zone also includes swimming pools, tennis courts and other similar developments.

The majority of "*Zone A: Residential Building Zone*" has been defined based on the findings during our field investigation, slope angles and the general absence of geotechnical hazards (eg. soil creep and landslides). Lower downslope areas may contain areas of softer/wetter ground and should be assessed by individual geotechnical investigations (for example area underlain by Alluvial Deposits).

8.1.2 Zone B: Specific Design Zone

"*Zone B: Specific Design Zone*" is defined as areas that are "generally suitable for residential development, however will require specific geotechnical investigation, specific design for building foundations and potential design for remedial slope stability works (eg. cut/fill earthworks and installation of buttress drainage)".

Sites within "*Zone B*" also include areas that may require earthworks where cuts/fills may exceed 1.0m depth and in some circumstances these types of works can affect global stability. Buildings and developments designed for "*Zone B*"

need considerations for slope stability, soil creep, expansive soils, foundation design and overall global stability. Other attentions that need to be addressed also include the construction of access ways, stormwater and effluent disposal.

Specific geotechnical investigations and foundation designs should be undertaken by a Registered Engineer, experienced in geotechnical engineering.

8.1.3 Zone C: Limited Building Zone

These areas are defined as land where "due to the present conditions of the hill slope or other geotechnical hazards development is not recommended". With this being said we have included swamp/wetland areas, these areas may be built over following earthworks or piping. Flood zones will also have to be considered within these areas.

"Zone C" includes areas of wetland, land sliding, soil creep, erosion and slope movement. It is inferred based on our observations that these features will continue to move as a result of the nature of the landscape and climatic conditions. Building within these areas in their present state is not recommended based on the currently identified geotechnical hazards. However we have termed "Zone C" as "Limited Building Zone" as this depends on the level of future site remediation. Any site remedial works should be subject to further geotechnical investigation.

8.2 Site Formation Works

8.2.1 Stream Area

If site formation works will include removal of soil materials from the stream banks and replacement with engineered fill, it is likely that a form of bank stabilisation or piping will be constructed. This is why the majority of these areas have been defined as "Zone C". Should excavation within the stream bed be required, further investigation including the drilling of hand augerholes will be necessary to determine the depth of unsuitable alluvial/colluvial material.

8.2.2 General

The site formation may comprise a cut to fill using material won from the site, clear of any unsuitable material such as non-engineered fill, topsoil, soft or organic soils or vegetation. The unsuitable materials should be stripped from any areas of earthworks and stockpiled well clear of earthwork operations or carted from the site.

All earthworks should be carried out to the requirements of NZS 4431:1989, '*Code of Practice for Earthfilling for Residential Development*'. All sloping ground to receive fill should be suitably benched to allow access for compaction plant and to ensure the fill is effectively keyed into the surrounding ground.

Compaction of cohesive fill should be carried out using pad foot compaction plant of a minimum 10 tonne static weight, in loose layers no greater than 200mm thickness. All fill materials should be clear of unsuitable materials as outlined

above. The cohesive soils should be suitably moisture conditioned prior to compaction, so that once compacted they achieve a minimum vane shear strength of 150kPa and maximum air voids of 10%. A Geotechnical Engineer familiar with the findings of this report should carry out compaction testing during construction to ensure the correct level of compaction is being achieved.

It may not be practical to carry out a cut/fill operation and achieve the required level of soil compaction if the work is carried out at a time other than when the weather is suitable for drying the on-site soils. In particular this work should not be attempted during the late autumn, winter and spring periods.

Following compaction to the design level the fill materials should be covered as soon as practical, with a layer of topsoil. Any fill materials left open to the elements can become excessively cracked due to dry weather or excessively softened during wet weather, and will therefore be unsuitable for its intended purpose.

All cuts or fills may be battered no steeper than 1V:3H, or where this cannot be achieved they should be retained by suitable retaining walls.

Particular care should be taken during the construction phase with respect to excavation of any benches to form the building platforms. The cut faces are at risk of instability during the construction phase and measures should be undertaken to protect the faces. We recommend that all cut faces be covered with heavy PVC sheeting which is suitably battened and anchored to protect the exposed soils from the elements. In addition, runoff from the higher ground should be intercepted by means of shallow surface drains or small bunds to protect the building platforms from saturation and erosion. Water collected in the interceptor drains should be diverted away from the building platform to a safe disposal point.

Prior to commencing earthworks a sediment control system needs to be constructed to ensure the Territorial and Regional Authority requirements are met. Typical details can be found in the ARC publication TP 90, which should be followed.

8.3 Building Foundations

It is a requirement of NZS 3604:2011 that buildings shall be founded on 'good ground'. Soils shown to have a liquid limit of more than 50% and a linear shrinkage of more than 15% are excluded from being considered 'good ground'. Based on our experience with these soil types in the Auckland region it is anticipated that the soils encountered will display characteristics in excess of the values given above.

Following completion of the earthworks under engineering supervision, we expect that majority of the houses will be founded on shallow footings in accordance with "good ground" criteria defined by NZS3604:2011. Final and detailed recommendations regarding foundation design will be given in the sites future Geotechnical Completion Report.

A Dependable Bearing Capacity of 150kPa is likely to be available for Ultimate Limit State Design of shallow foundations carried out in accordance with AS/NZS 1170:2002. A Strength Reduction Factor of $\phi = 0.5$ has been applied to the Ultimate Bearing Capacity value to determine the Dependable Bearing Capacity. Bearing capacities for individual lots will require confirmation subsequent to monitoring and testing of subdivision earthworks.

8.4 Seismic Aspects

Based on the findings of our site investigation it is recommended that for the purposes of compliance with NZS4203:1992 the site be considered as having site subsoil category (b) (Intermediate soil sites) or for NZS 1170.5:2004 as being a Class C - Shallow Soil Site.

Any permanent basement walls should also be designed for seismic loads as 'basement walls' in accordance with Transit New Zealand Publication RRU Bulletin 84, '*Bridge Design and Research Seminar 1990. Volume 2: Seismic Design of Bridge Abutments and Retaining Walls*', by J.H. Woods and D.G. Elms with the design parameter $C_{(0)}$ calculated in accordance with the latest amendment (Dec 2005) to the Transit New Zealand *Bridge Manual*.

8.5 Earth Retaining Structures

It must be recognised that the final geometry of any retaining at this site was not known at the time of preparation of this report. It is therefore strongly recommended to the designer of any retaining walls at the site that global stability of the final geometry be checked. In particular, the design of tiered walls must consider global stability implications.

Factors of safety and surcharge loadings appropriate to the conditions should be in accordance with '*Retaining Wall Design Notes - MWD, NZ, Issue C: July 1973*'. Particular attention should be paid to the influence of sloping ground below the proposed wall and the surcharging effect of traffic above the proposed wall.

Free-draining granular backfill, accompanied by a perforated pipe drain located at the base of the wall, should be installed behind all retaining walls to avoid build-up of hydrostatic pressures.

8.5.1 Global Stability

The designer of the retaining walls should ensure that a satisfactory Factor of Safety against global instability is available at all stages of the development; i.e. temporary excavations, tiered retaining walls, final topography. Global stability is a separate consideration to the design of the actual retaining wall, and is a function of soil characteristics, groundwater regime and geometry of the finished ground surface profile.

8.6 Pavement Areas

Provided that the earthworks to form the roadways are carried out in accordance with the appropriate engineering codes and standards, and the recommendations within this report, we anticipate that the road subgrade will be able to achieve a CBR value of 5%. For preliminary design purposes, we recommend a CBR of 2% be assumed for natural cut soils and allowance should be made for lime or cement treatment in some areas. All road subgrades, whether in cut or fill should be subject to CBR truck or laboratory testing subsequent to earthworks to confirm necessary design parameters.

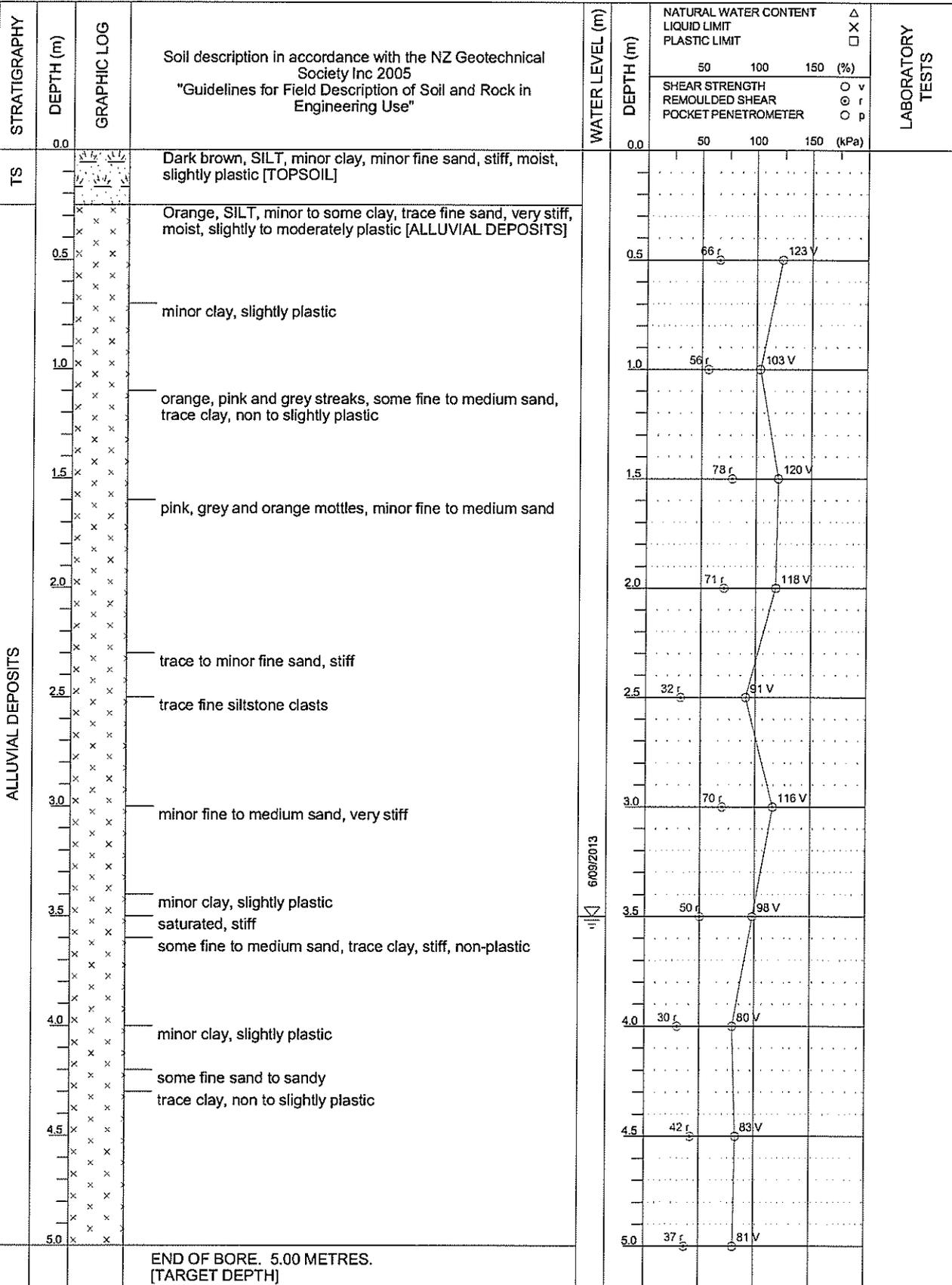
8.7 Stormwater Control

Concentrated stormwater flows from all impermeable areas must be collected and carried in sealed pipes to the Council system or an alternative disposal point subject to approval from Council. Stormwater flows must not be allowed to run onto or over the slopes or saturate the ground so as to adversely affect slope stability or foundation conditions. Under no circumstances should disposal of stormwater be carried out via soakage pits or other subsoil drains (including counterfort drains, perforated drains behind retaining walls, etc.).

End of Report

Appendix A
Field Investigation Logs

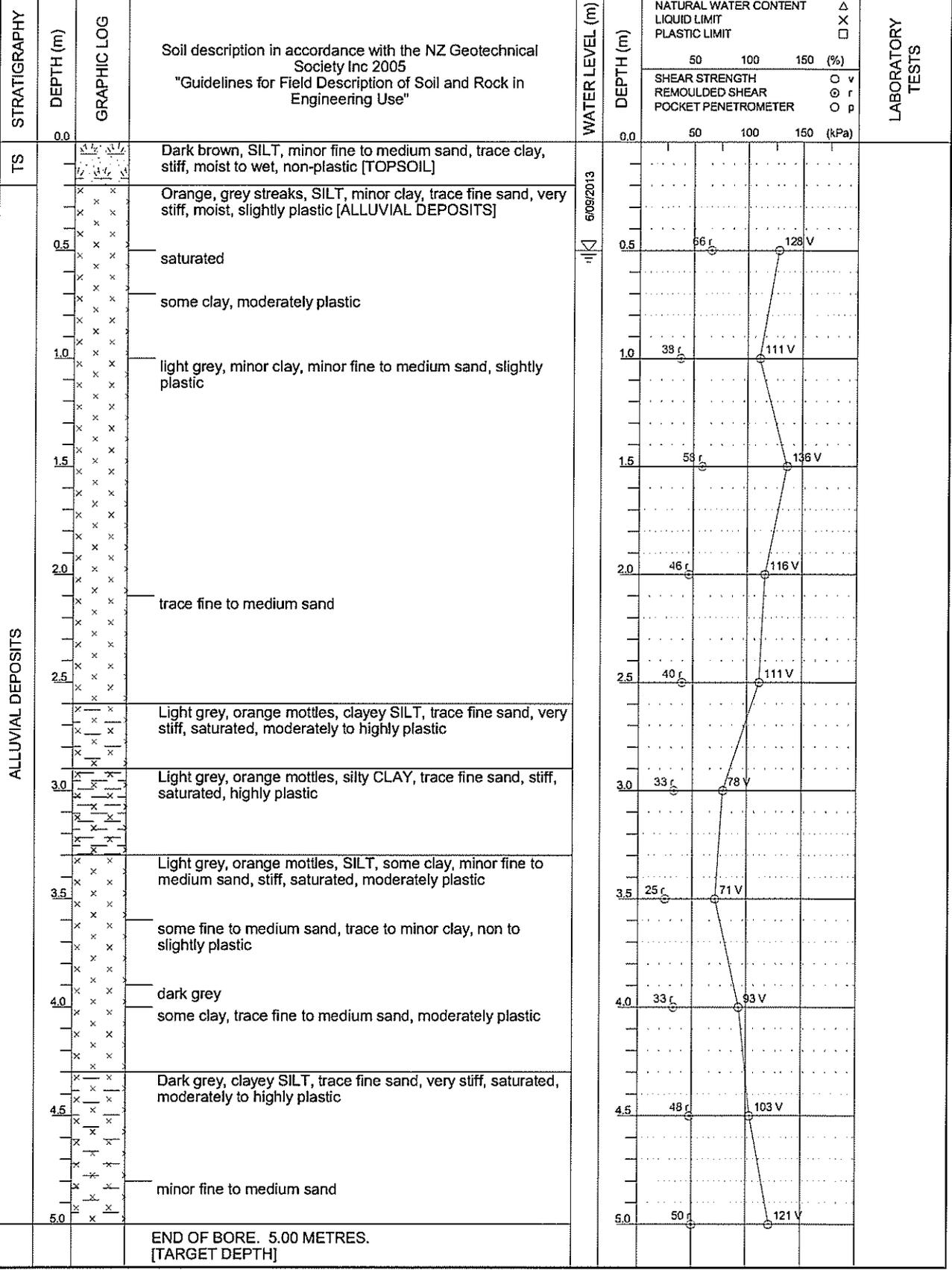
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 Date Started: 6/9/13 Ground Elevation: Surface Conditions: Sloping, grass
 Date Finished: 6/9/13 Water Level: 3.5m 6/09/2013



HAND AUGER LOG 13567 AH 01-15 06.09.13.GPJ S+R_2013.GDT 12/9/13

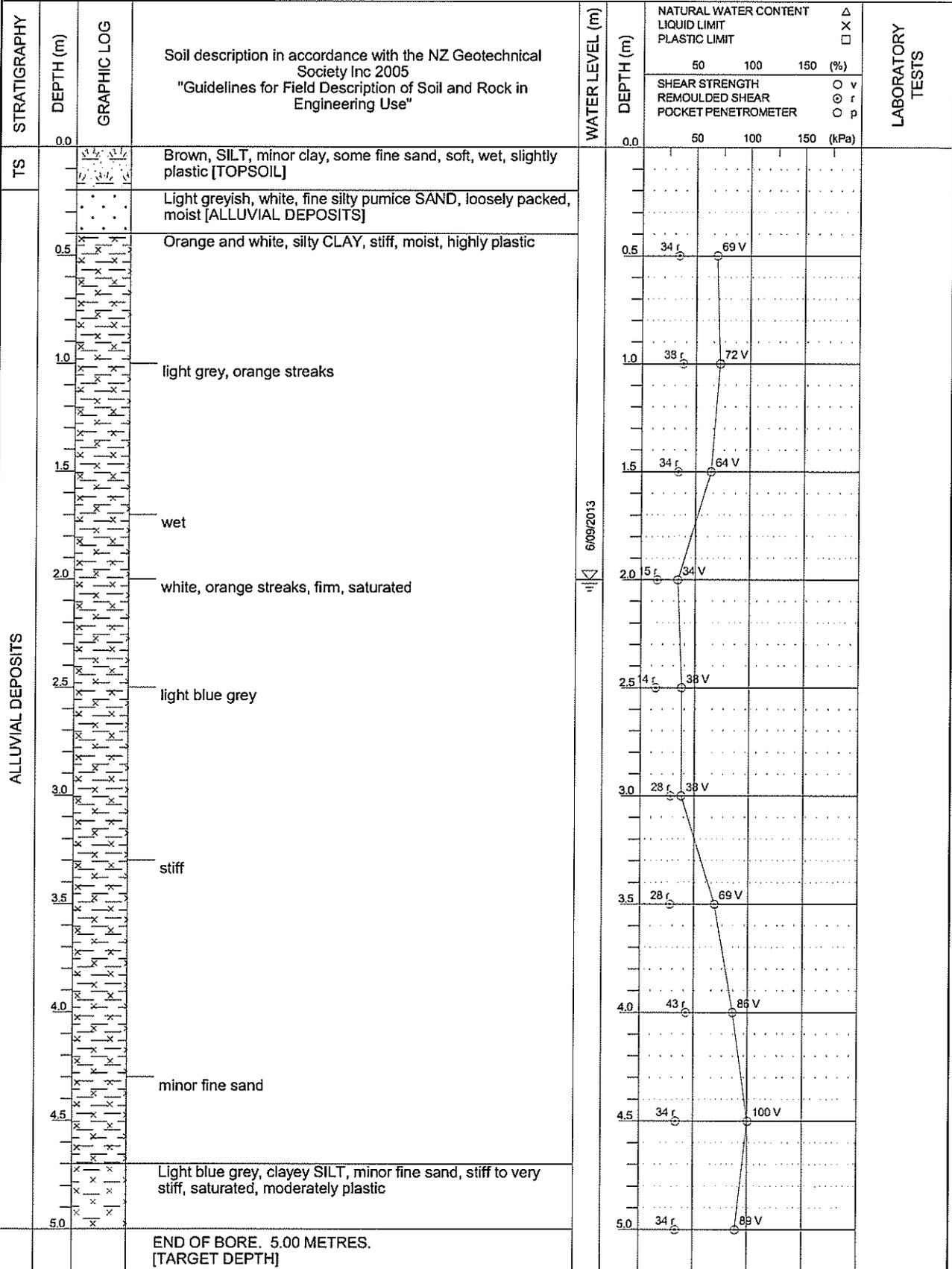
6/09/2013

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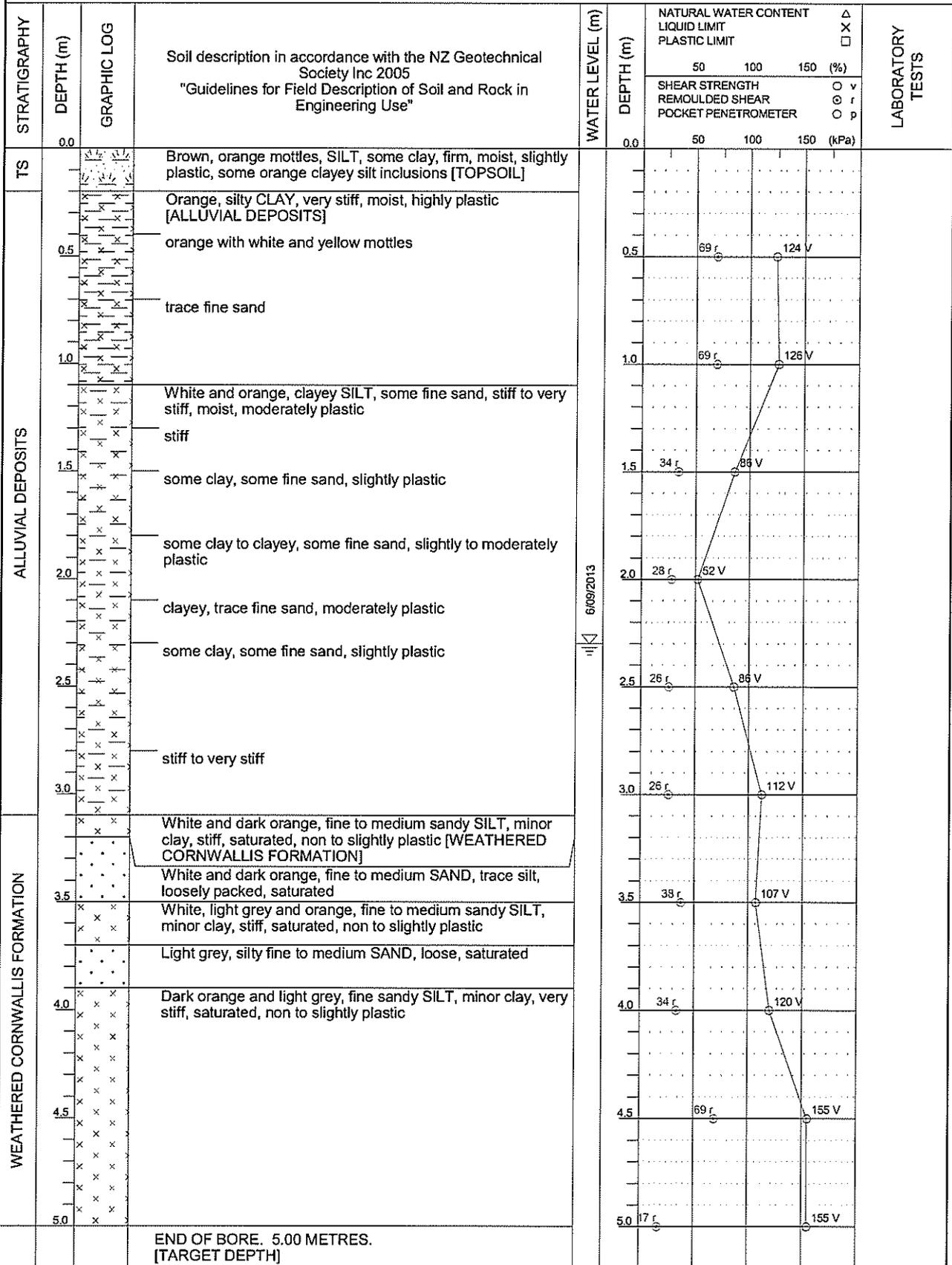
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 Date Started: 6/9/13 Ground Elevation: Surface Conditions: Slightly sloping, grass
 Date Finished: 6/9/13 Water Level: 2.0m 6/09/2013



HAND AUGER LOG 13567 AH 01-15 06.09.13.GPJ S+R_2013.GDT 12/9/13

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 Drilled By: D Grace Coordinates: Shear Vane No - Calibration Date: GEO403 - 8/10/2012
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 Date Finished: 6/9/13 Water Level: 2.3m 6/09/2013

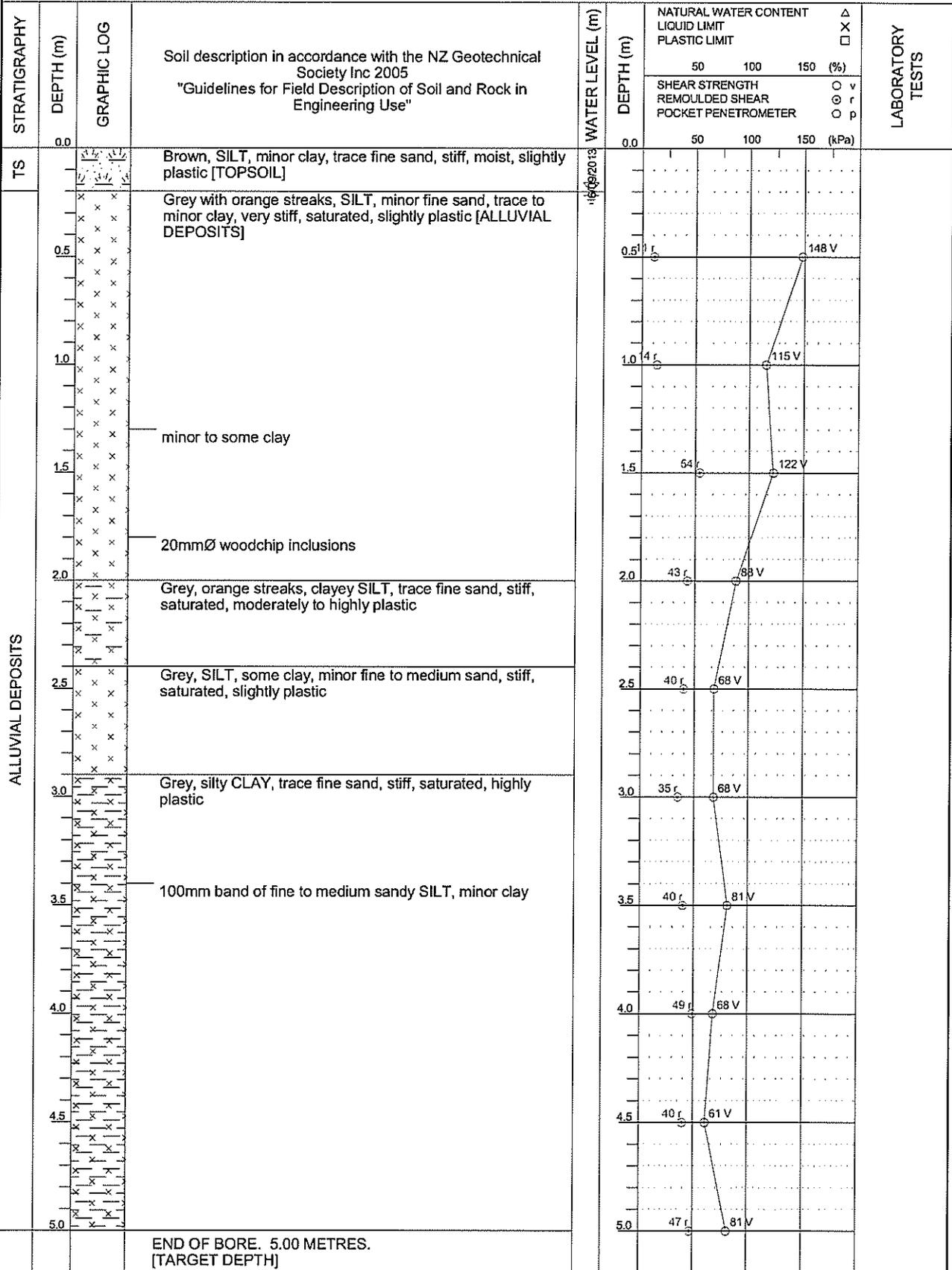


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 Date Finished: 6/9/13

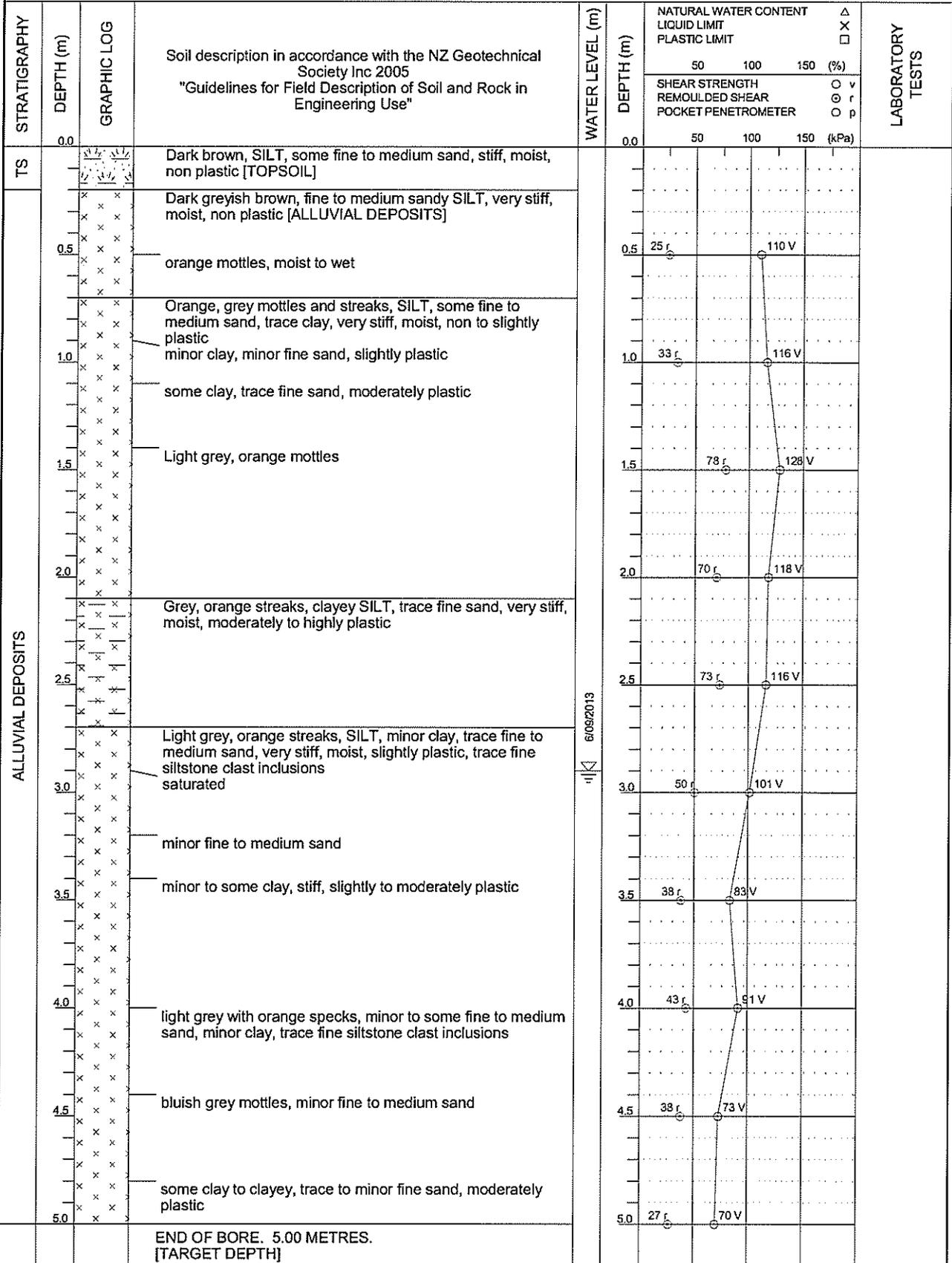
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 Ground Elevation:
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 Shear Vane No - Calibration Date: SN26 - 13/08/2012
 Surface Conditions: Near level, grass



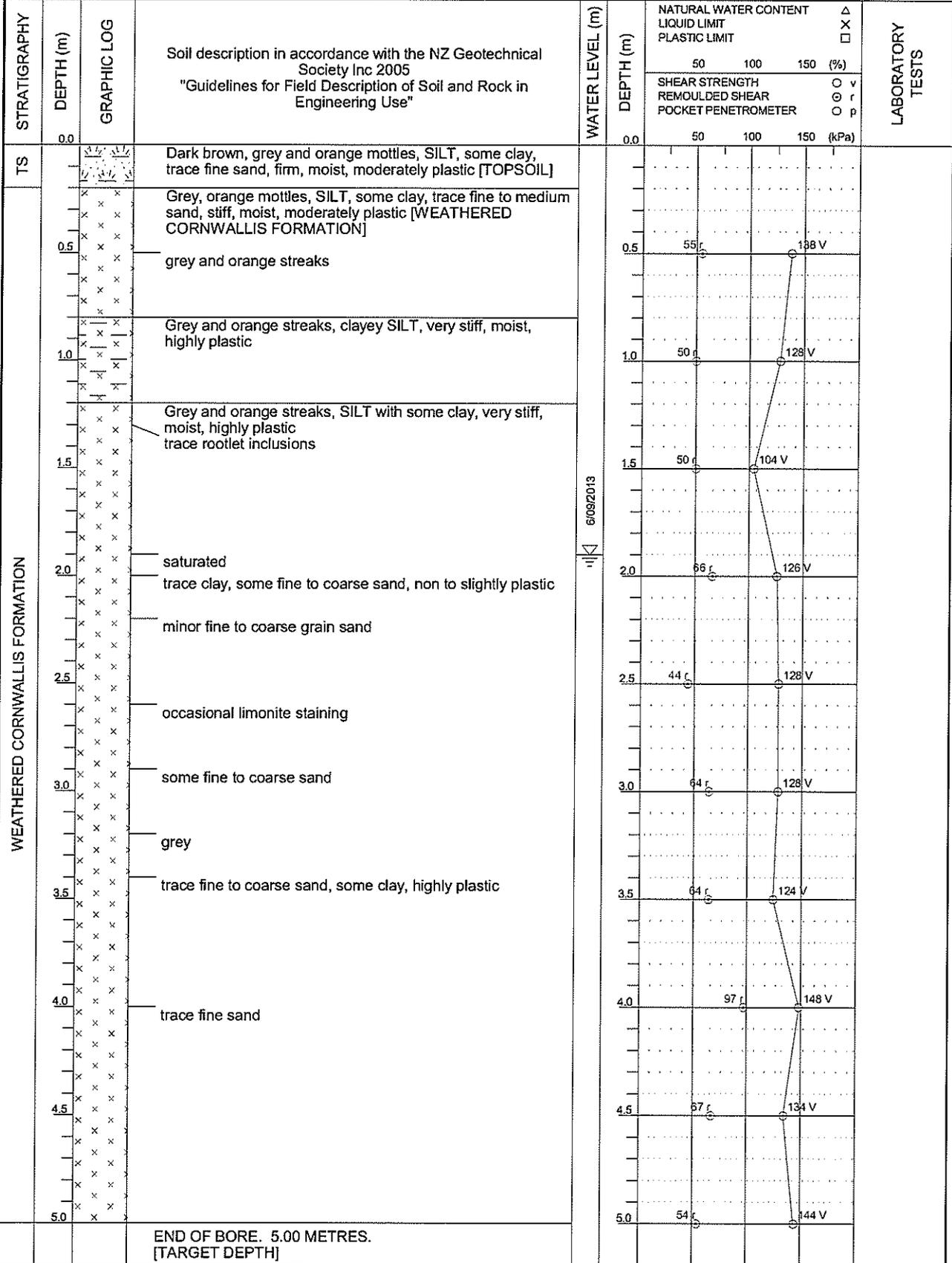
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 Date Finished: 6/9/13 Water Level: 2.9m 5/09/2013



HAND AUGER LOG 13567 AH101-15 06.09.13.GPJ S+R_2013.GDT 12/9/13

Drill Type: 50mm hand auger Project No: 13567 Logged By: LS
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 Date Finished: 6/9/13 Water Level: 1.9m 6/09/2013



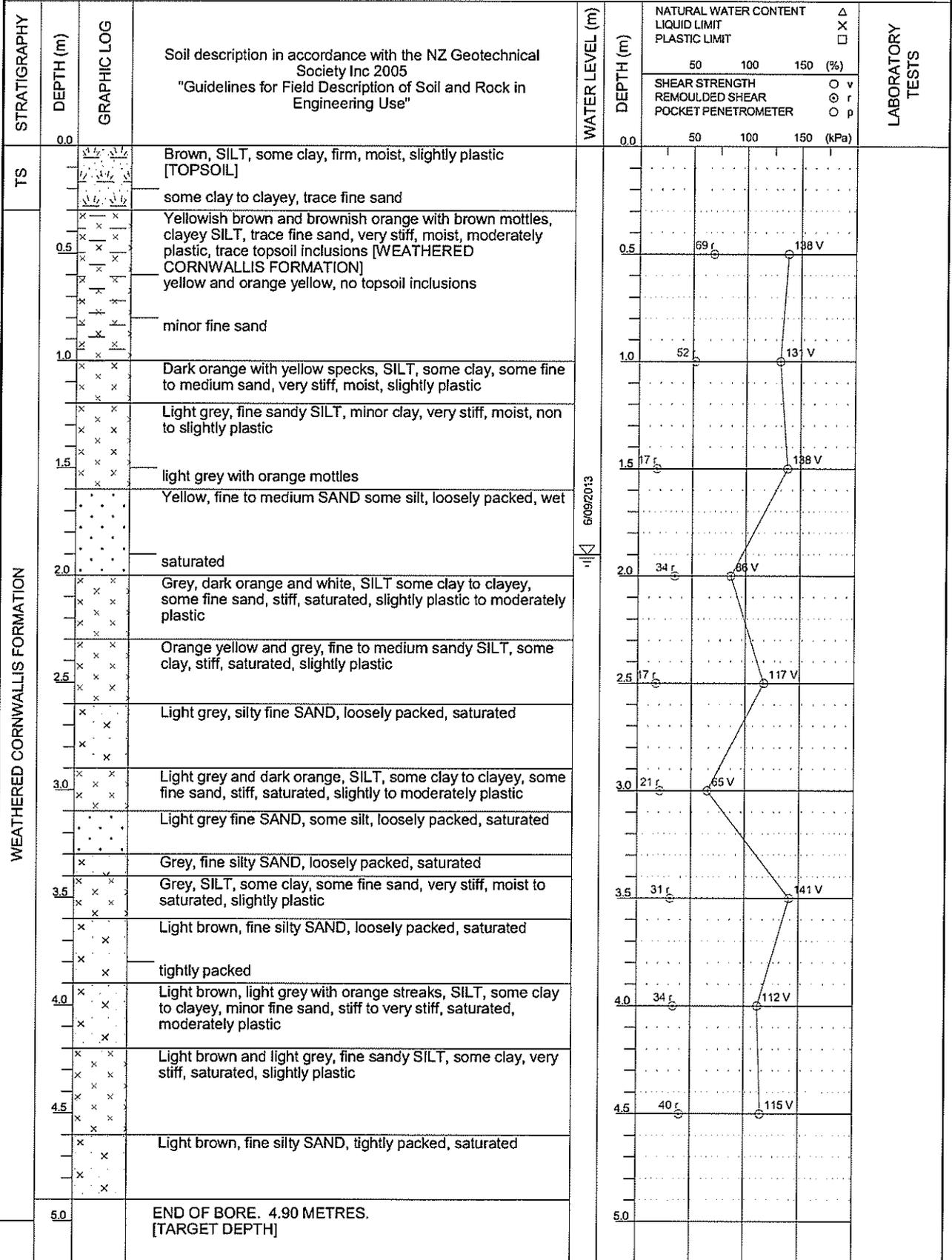
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 Drilled By: D Grace Coordinates: Shear Vane No - Calibration Date: GEO403 - 8/10/2012
 Date Started: 6/9/13 Ground Elevation: Surface Conditions: Slightly sloping, grass
 Date Finished: 6/9/13 Water Level: Groundwater not encountered

STRATIGRAPHY	DEPTH (m)	GRAPHIC LOG	Soil description in accordance with the NZ Geotechnical Society Inc 2005 "Guidelines for Field Description of Soil and Rock in Engineering Use"	WATER LEVEL (m)	DEPTH (m)	NATURAL WATER CONTENT				LABORATORY TESTS		
						LIQUID LIMIT	PLASTIC LIMIT	50	100		150	(%)
TS	0.0		Brown, SILT, some clay, firm, moist, slightly plastic [TOPSOIL]		0.0							
WEATHERED CORNWALLIS FORMATION	0.5		Orange brown, clayey SILT, very stiff, moist, moderately plastic [WEATHERED CORNWALLIS FORMATION] orange, trace fine sand some fine sand stiff to very stiff, occasional pink streak		0.5			72		41	V	
	1.0		Orange, black, red and yellow specks, fine to medium sandy SILT, minor clay, hard, moist, non to slightly plastic Yellow, fine silty SAND, trace clay, tightly packed, moist some inclusions of clayey SILT		1.0			55		107	V	
	1.5		Yellow, orange and yellow grey fine sandy SILT, some inclusions of clayey SILT to 8mm diameter, hard moist non to slightly plastic Yellow white, orange streaks, fine silty SAND, tightly packed, moist		1.5							
	2.0		yellow, orange, dark orange and light grey, trace coarse sand		2.0							
	2.5		END OF BORE. 2.20 METRES. [TARGET DEPTH]		2.5							
		3.0				3.0						
	3.5				3.5							
	4.0				4.0							
	4.5				4.5							
	5.0				5.0							
											200+ UTP V	

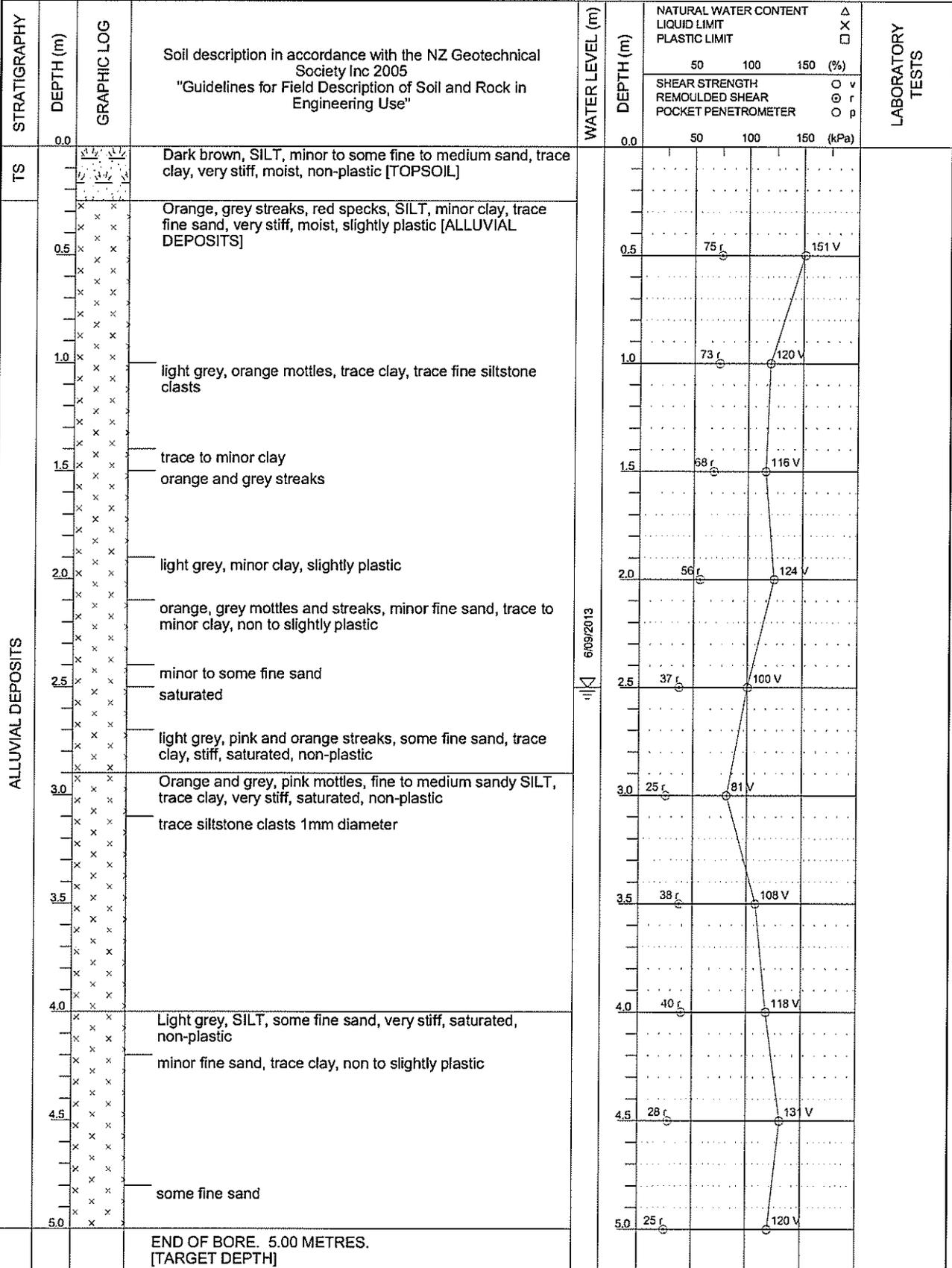
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 Date Finished: 6/9/13 Water Level: 1.9m 6/09/2013



HAND AUGER LOG 13567 AH 01-15 06.09.13.GPJ_S+R_2013.GDT 12/9/13

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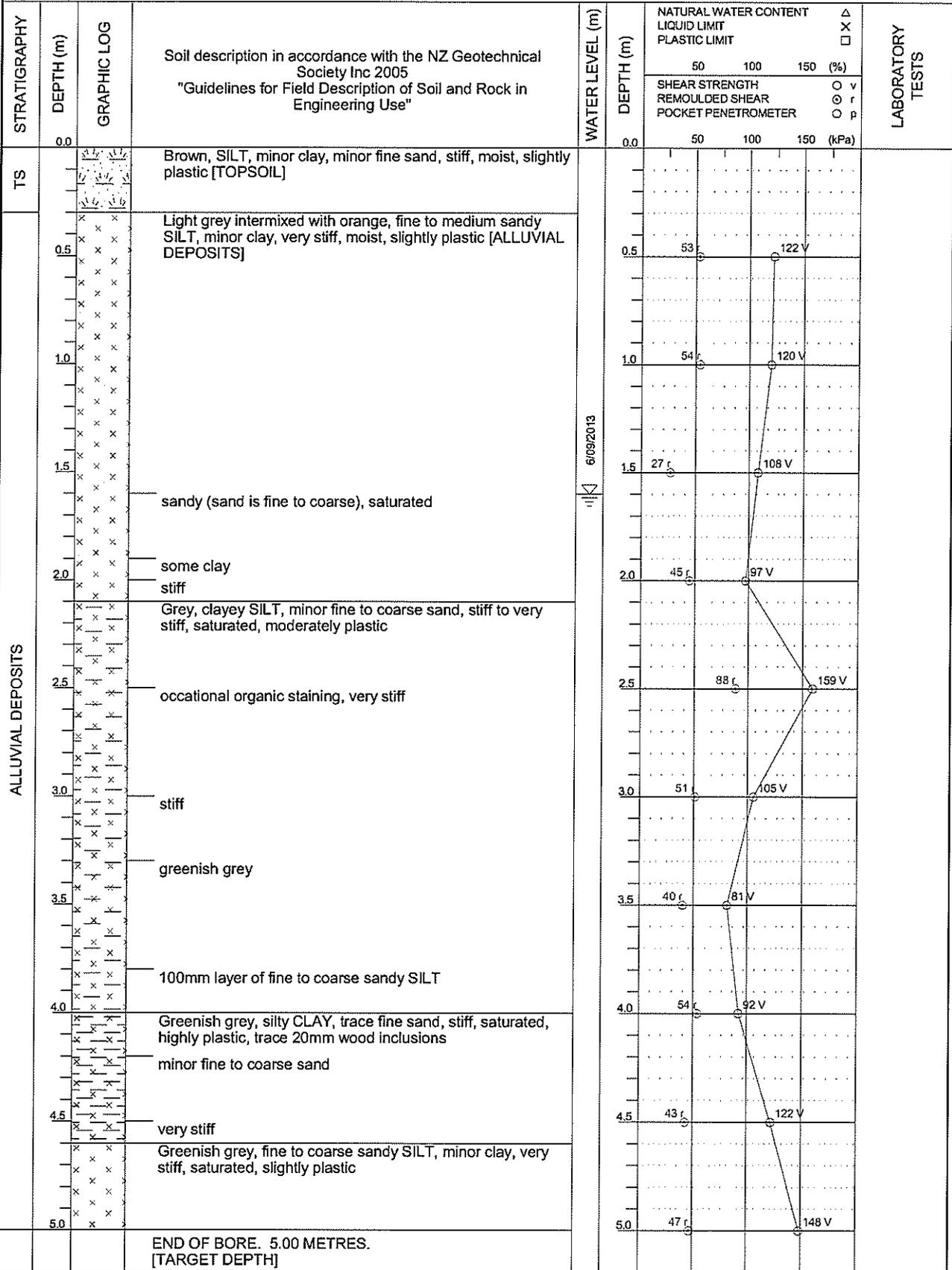


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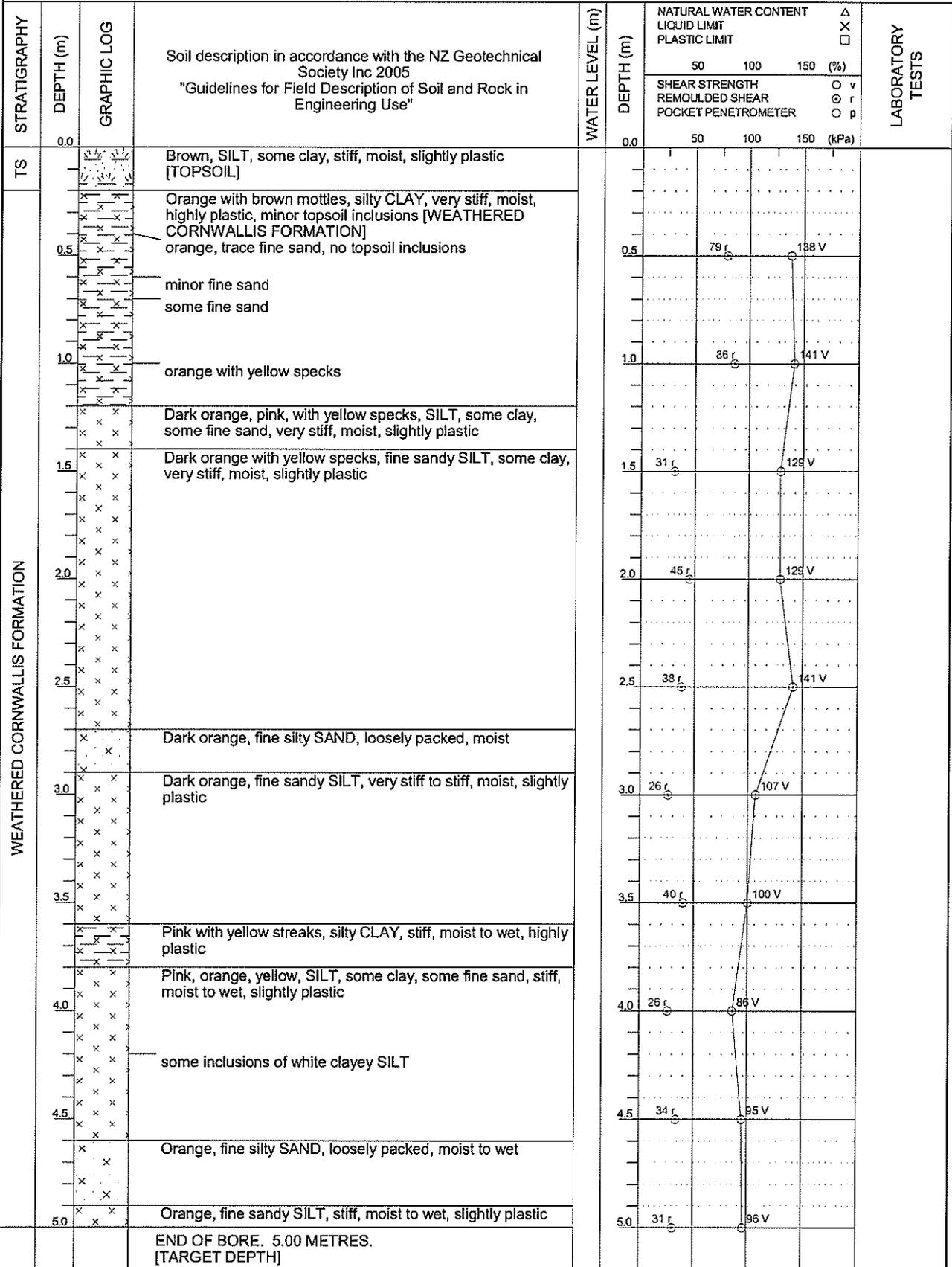
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 Water Level: 1.6m 6/09/2013

Logged By: ZP
 Shear Vane No - Calibration Date: SN26 - 13/08/2012
 Surface Conditions: Slightly sloping, grass



HAND AUGER LOG 13567 AH 01-15 06.09.13.GPJ S+R_2013.GDT 12/9/13

Drill Type: 50mm hand auger Project No: 13567 Logged By: DG
 Drilled By: D Grace Coordinates: Shear Vane No - Calibration Date: GEO403 - 8/10/2012
 Date Started: 6/9/13 Ground Elevation: Surface Conditions: Slightly sloping, grass
 Date Finished: 6/9/13 Water Level: Groundwater not encountered



HAND AUGER LOG 13567 AH 01-15 06.09.13.GPJ S+R_2013.GDT 12/9/13

SCALA PENETROMETER SHEET - TABLE OF BLOWS PER INCREMENT

JOB NAME: 151 & 177 Rautawhiri Road, Helensville JOB NO: 13567 TESTED BY: LS TH DATE: 6.09.2013

Depth of Penetration [mm]	AH01	AH02	AH02	AH03	AH04	AH05	AH06	AH07	AH08	AH08	AH09	AH10
DEPTH START [m] →	5.00	5.00	Contd.	5.00	5.00	5.00	5.00	5.00	2.20	Contd.	4.90	5.00
50 mm	1	1	7	2	5	1	3	3	2	10	5	1
100	2	1	7	2	2	0.5	3	4	2	10	3	1
150	2	1	8	2	2	0.5	3	4	3	12	4	2
200	3	1	9	3	4	0.5	3	4	3	13	5	2
250	2	1	7	3	8	0.5	3	7	4	14	1	2
300	3	1	9	4	8	1	3	8	3		1	4
350	3	2	9	4	7	1	4	10	3		2	3
400	4	1	9	3	10	1	4	10	3		2	4
450	4	2	6	4	10	2	4	15	3		3	3
500	4	3	6	4	12	2	4	20+	2		3	5
550	4	2	7	4	11	3	3		2		4	4
600	4	2	6	5	12	2	3		1		2	5
650	4	3	7	4		3	3		1		3	5
700	5	3	7	4		3	4		3		3	5
750	5	3	7	4		4	4		2		3	6
800	5	4	7	4		3	5		3		2	5
850	6	4	7	4		4	5		2		2	5
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1100	6	6		7		4	7		4		6	8
1150	7	6		6		5	6		5		6	8
1200	9	6		7		5	7		6		10	7
1250	7	7		10		5	7		6		10	8
1300	8	7		7		7	7		6		10	7
1350	8	7		10		7	7		5		11	10
1400	9	8		10		7	8		3		12	10
1450	10	7		11		7	8		4			11
1500	10	7		10		7	9		3			12
1550	10	8		11		10	10		5			12
1600	10	7				10	10		5			
1650	11	8				11	11		4			
1700	11	9				12	12		4			
1750		8				12	12		5			
1800		7							6			
1850		8							6			
1900		8							6			
1950		8							8			
2000		8							7			
DEPTH END [m] →	6.70	Contd.	7.90	6.55	5.60	6.75	6.75	5.50	Contd.	4.45	6.30	6.55

Testing Method: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

SCALA PENETROMETER SHEET - TABLE OF BLOWS PER INCREMENT

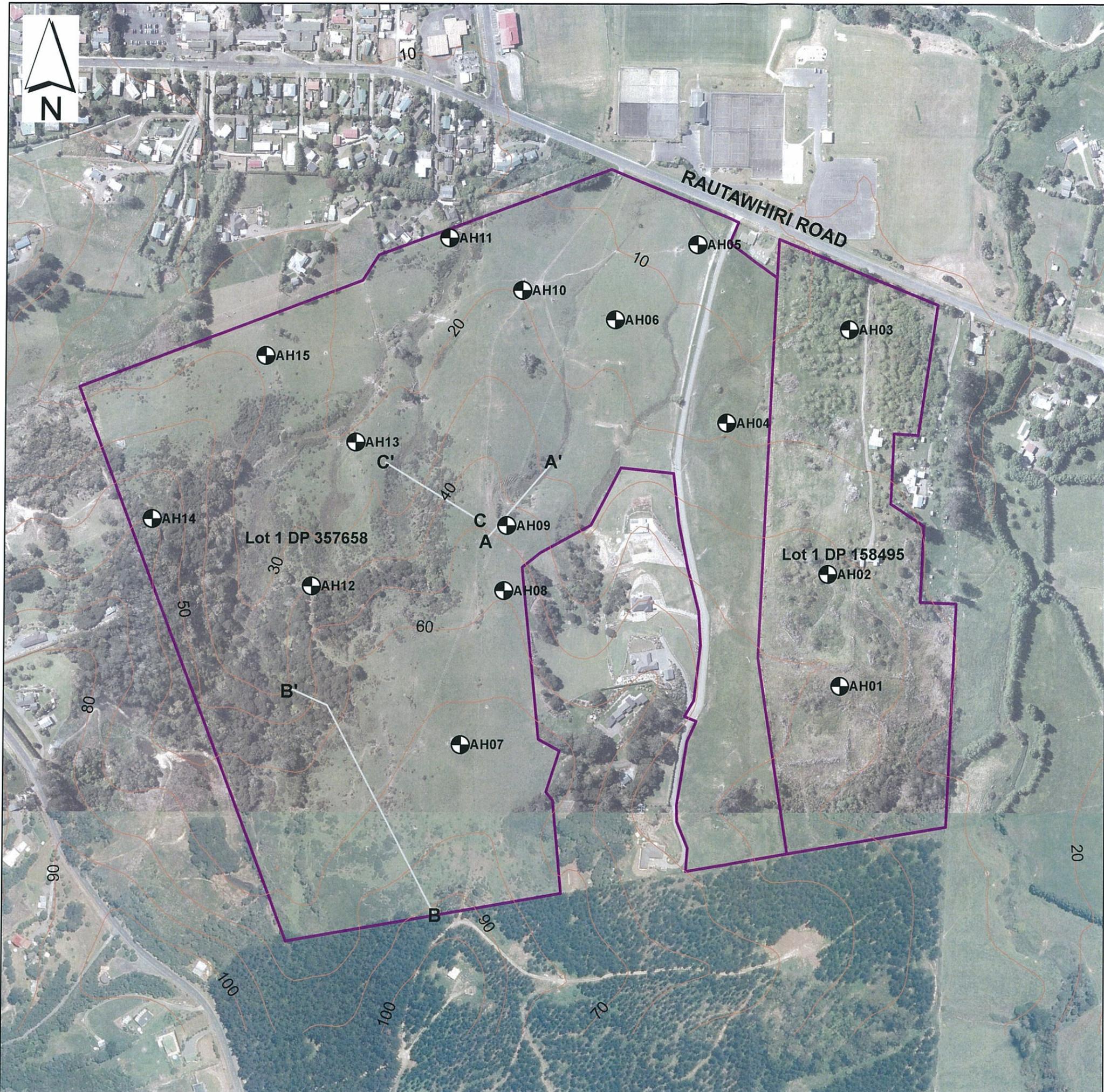
JOB NAME: 151 & 177 Rautawhiri Road, Helensville JOB NO: 13567 TESTED BY: LS TH DATE: 6.09.2013

Depth of Penetration [mm]	AH11	AH12	AH13	AH14	AH15							
DEPTH START [m] →	5.00	5.00	4.90	3.00	5.00							
50 mm	1	1	5	2	1							
100	1	1	7	4	2							
150	0.5	1	6	4	2							
200	0.5	1	7	5	2							
250	1	1	7	3	2							
300	6	1	10	4	2							
350	4	1	7	4	3							
400	5	1	11	6	3							
450	6	2	12	1	3							
500	5	4	12	2	3							
550	7	1		2	4							
600	7	1		2	4							
650	10	1		3	4							
700	10	1		4	5							
750	10	2		4	5							
800	11	2		5	3							
850	12	2		6	5							
900		2		6	6							
950		2		6	6							
1000		3		10	6							
1050		3		8	7							
1100		4		8	7							
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1350		7		6	8							
1400		7		6	8							
1450		10		5	8							
1500		10		7	10							
1550		10		7	11							
1600		11		6	12							
1650		12		7	11							
1700				7	12							
1750				10								
1800				10								
1850				11								
1900				12								
1950				12								
2000												
DEPTH END [m] →	5.85	6.65	5.40	4.95	6.70							

Testing Method: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer

Appendix B

Drawings



SITE PLAN

**151 & 177 Rautawhiri Road
Helensville**
Job No. 13567

Legend

- Investigation Site
- + Test Locations
- Cross Sections
- Contours (10m)

Drawing No. 13567/1
Scale 1: 4,000 (A3)
Drawn By: L Stewart
Date: 9 September 2013



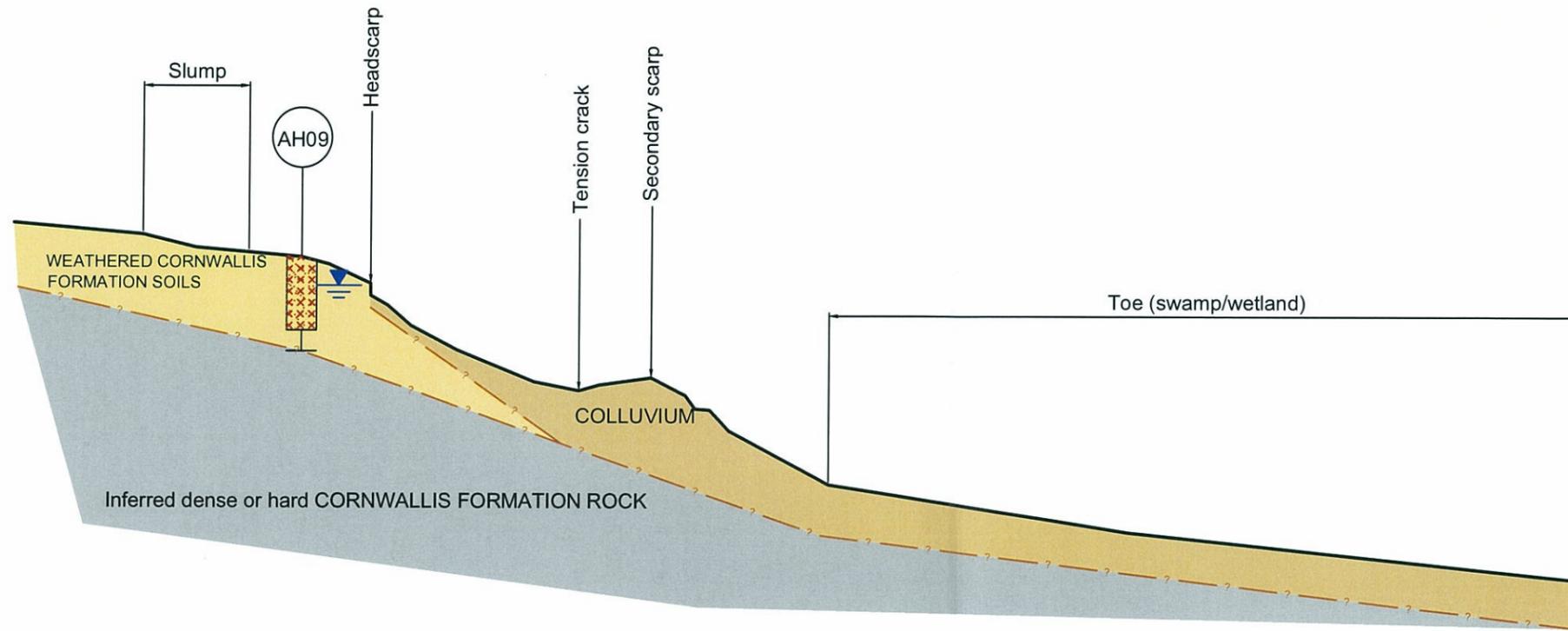
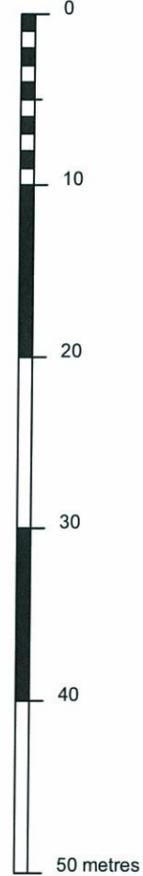
West

East

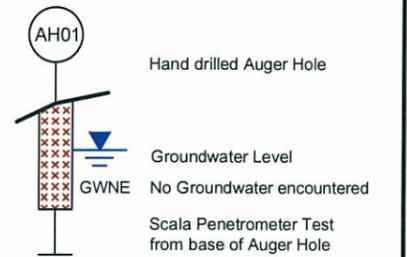
A

A'

SCALE (1:400)



KEY:



NOTES:

1. Soil and Rock Consultants Cross Sections surveyed by tape and clinometer
2. Soil descriptions shown approximate only, refer to borelogs for details.
3. Extrapolation of soil conditions away from boreholes has been made but cannot be guaranteed due to the variability of Soil deposits.
4. Groundwater measurements were made September xx, 2013
5. Locations of features approximate only.
6. Reduced level information based on Contours on Site plan provided by xx

AMENDMENTS		
DATE	REV	DESCRIPTION

Check all dimensions and levels on site before commencing construction.
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Soil & Rock Consultants
 GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

Level 1, 131 Lincoln Road, Waitakere
 PO Box 21-424 Henderson, Waitakere 0650
 Ph 09 835 1740 Fax 09 835 1847
 www.soilandrock.co.nz

151 & 171 Rautawhiri Road

HELENSVILLE

CROSS SECTION A-A'

13567 /2A DRAWN: L Stewart DATE: 10 August 2013

SCALES: 1: 400 AT A3 CHECKED: REV.

VERTICAL EXAGGERATION: 1.0

Filename: cross sectionsaa.dwg

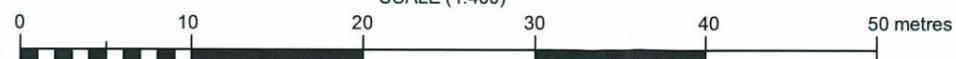
KEY TO LITHOLOGY SHADES

Colluvium
 Weathered Waitamata Group
 Inferred / Actual less weathered Strata

KEY TO LITHOLOGY HATCHES

Fill
 Clay
 Silt
 Sand
 Gravel
 Sandstone
 Siltstone
 Basalt
 Boulders
 Limestone

SCALE (1:400)

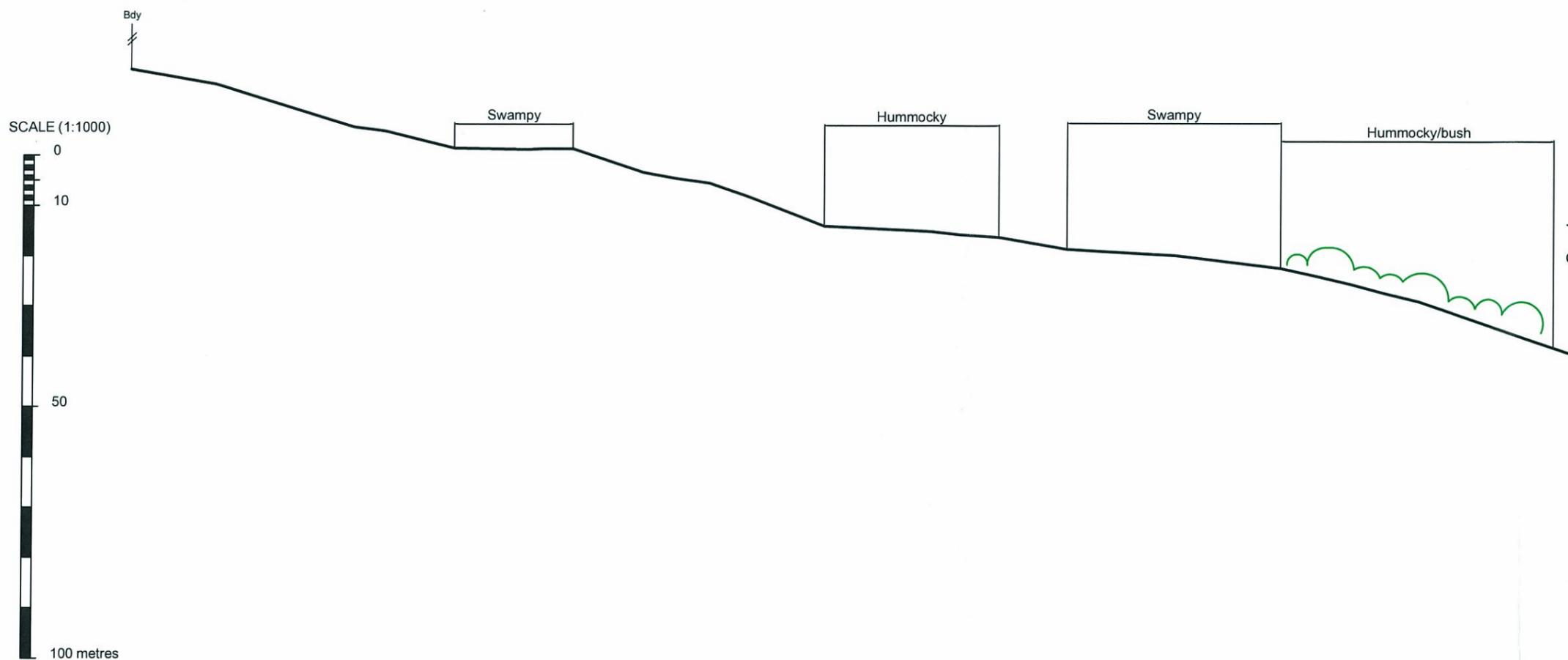


Southeast

Northwest

B

B'



NOTES:

- 1. Soil and Rock Consultants Cross Sections surveyed by tape and clinometer
- 2. Locations of features approximate only.

AMENDMENTS		
DATE	REV	DESCRIPTION

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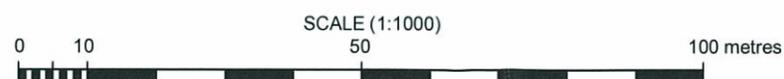


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CROSS SECTION B-B'

13567 /2B	DRAWN: L Stewart	DATE: 10 August 2013
SCALES: 1: 1000 AT A3	CHECKED:	REV.
VERTICAL EXAGGERATION: 1.0		
Filename: cross sectionsbb.dwg		



West

East

C

C'

Fence

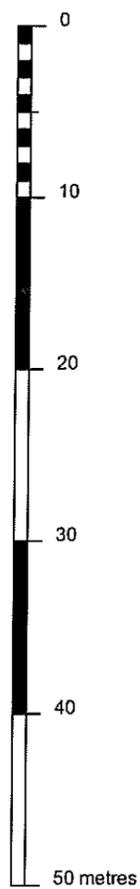
Headscarp

Toe

Swamp/wetland

Stream

SCALE (1:400)



NOTES:

1. Soil and Rock Consultants Cross Sections surveyed by tape and clinometer
2. Locations of features approximate only.

AMENDMENTS		
DATE	REV	DESCRIPTION

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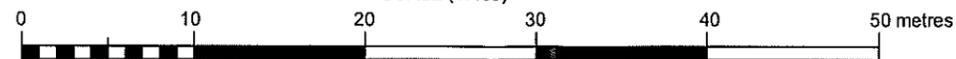
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CROSS SECTION C-C'

13567 /2C	DRAWN: L Stewart	DATE: 10 August 2013
SCALES: 1: 400 AT A3	CHECKED:	REV.
VERTICAL EXAGGERATION: 1.0		
Filename: cross sectionscc.dwg		

SCALE (1:400)



GEOMORPHIC PLAN

151 & 177 Rautawhiri Road
Helensville

Job No. 13567

Legend

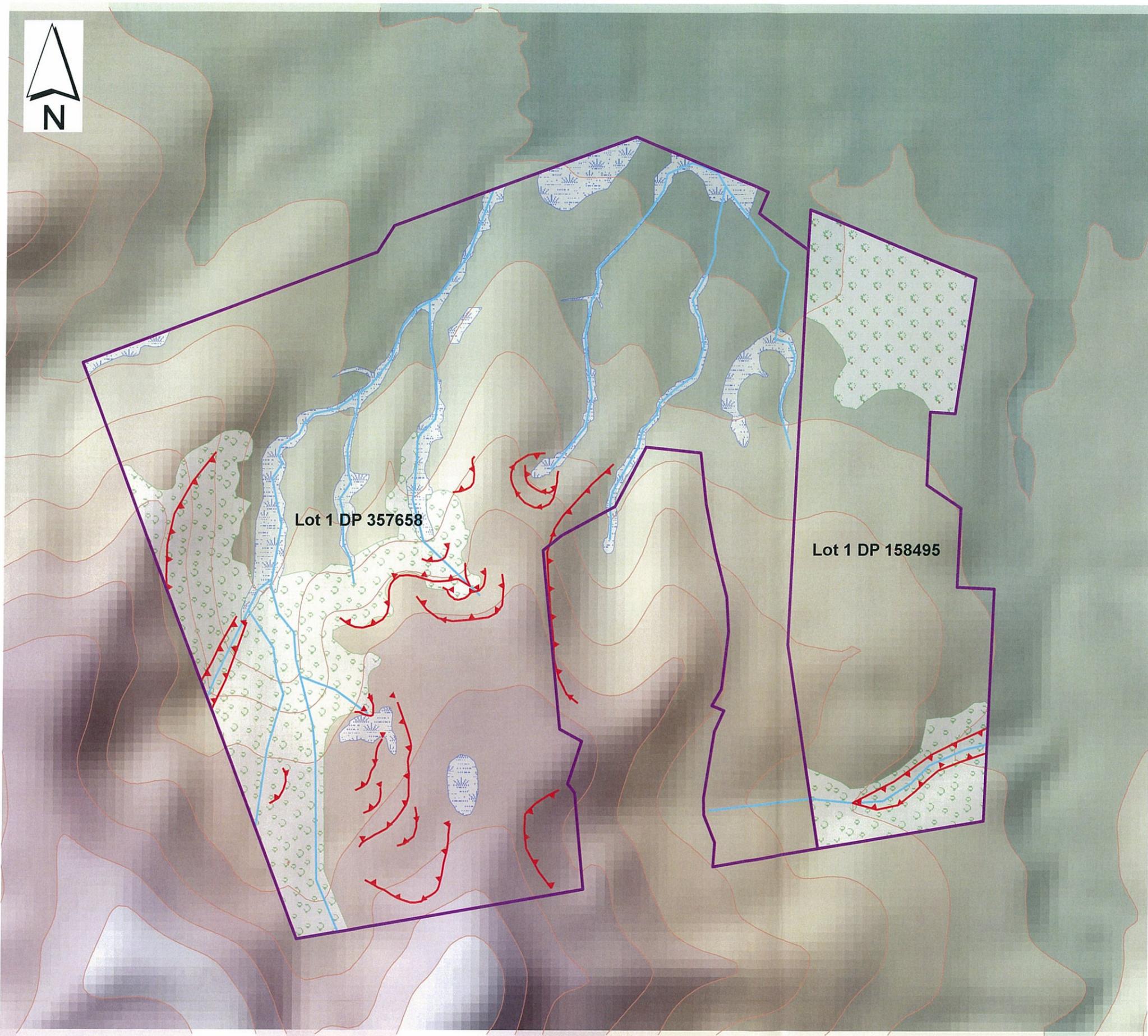
-  Investigation Site
-  Scarp Features
-  Watercourses
-  Contours (10m)
-  Orchard
-  Bush
-  Swamp

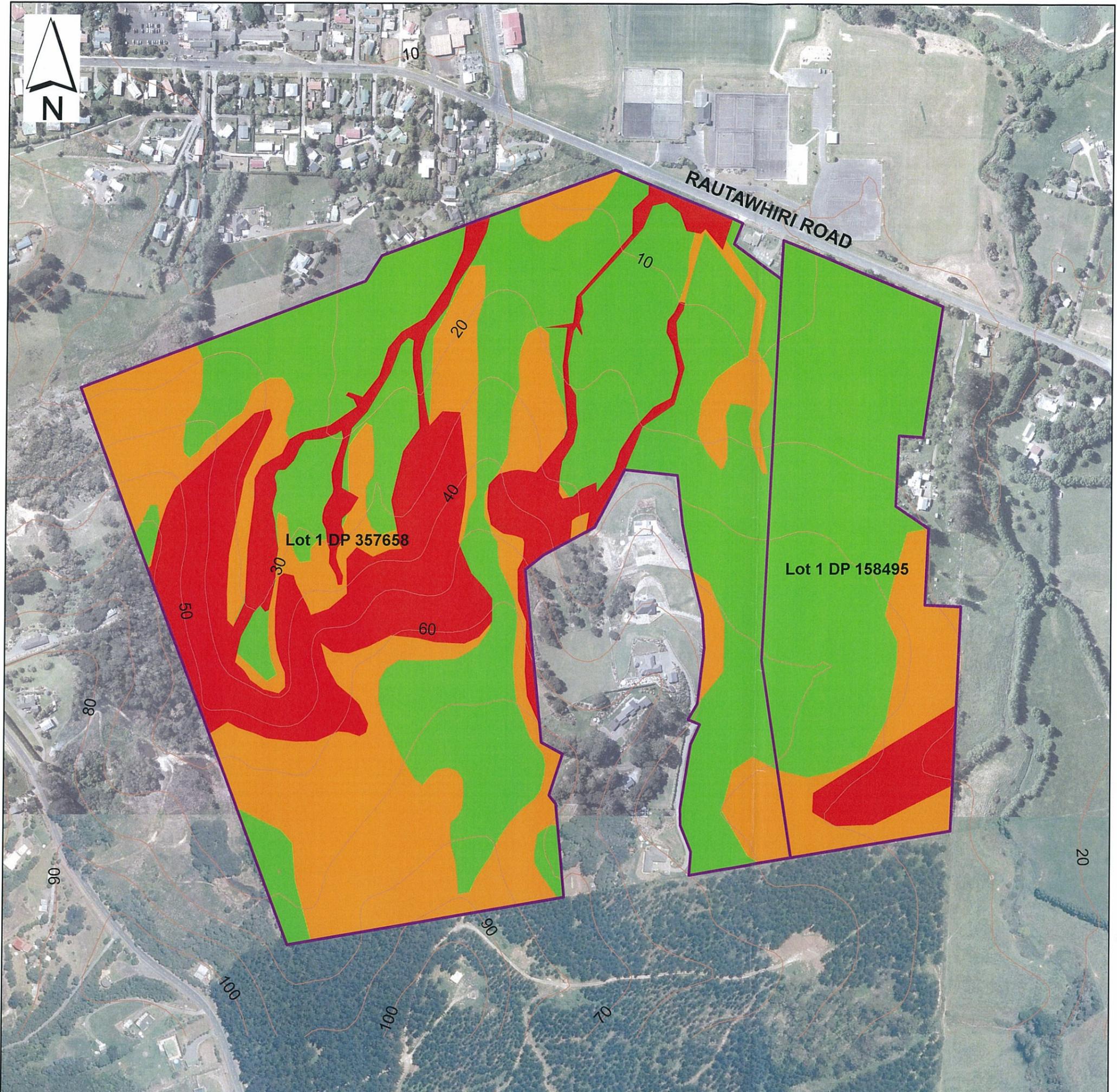
Elevation

m-amsl

-  1 - 10
-  11 - 20
-  21 - 30
-  31 - 40
-  41 - 50
-  51 - 60
-  61 - 70
-  71 - 80
-  81 - 90
-  91 - 100
-  101 - 110

Drawing No. 13567/3
Scale 1: 4,000 (A3)
Drawn By: L Stewart
Date: 9 September 2013





ZONEATION PLAN

**151 & 177 Rautawhiri Road
Helensville**
Job No. 13567

Legend

-  Investigation Site
-  Contours (10m)
-  Zone A
-  Zone B
-  Zone C

Drawing No. 13567/4
Scale 1: 4,000 (A3)
Drawn By: L Stewart
Date: 18 September 2013

