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For well-grounded solutions

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Geotechnical Engineering Ltd
T/A Soil & Rock Consultants

Date: 23 March 2016
Job Ref: C15449

Attn: Mr MJ Stratford
C/- Graham Fowler
Calibre Consulting

RE: GEOTECHNICAL LETTER
RESPONSE TO PEER REVIEW
PLAN CHANGE REPORT, 631 SHANDS ROAD, CHRISTCHURCH

Introduction

Soil & Rock Consultants have been asked to respond to a peer review by Ian McCahon of Geotech Consulting Limited who have peer reviewed a Soil & Rock Consultants plan change geotechnical report titled "*Geotechnical Investigation, proposed Rural Residential Subdivision, 631 Shands Road, Prebbleton; Rev A, Ref C15449, dated 16 October 2015*". Attached to this letter is the geotechnical peer review letter.

Geotechnical Response to Peer Review

We have reviewed the peer review letter by Ian McCahon of Geotech Consulting Limited and we agree that Ian has raised some valid points as part of his review. In this section we will endeavour to provide insight into our methodology and findings.

With regards to our investigation density, we agree that the site specific testing is somewhat limited, especially considering a number of the proposed deep investigations did not achieve a sufficient investigative depth. We did not recommend further testing as a result of the insufficient testing as we considered that we had sufficient information based on our investigative information, site specific ECan well logs (See attached for plan and well log) and neighbouring deep investigations (See attached Riley Report). For the purpose of a plan change, we considered the information available to be sufficient for the purpose. We also took into account the lack of liquefaction induced surface expression and damage following the recent Christchurch earthquake sequence as well as the inferred (based on CGD information) groundwater level of over 8m depth providing a significantly thick non-liquefiable crust. We will, however, learn from the limitations of certain testing equipment used and ensure that more comprehensive and extensive site specific testing is undertaken during the subdivision consent stage of testing which will include more test pits scattered across the site as per the peer review recommendations as well as ensuring deep investigative information is achieved as per the MBIE guidelines.

Yours faithfully,

SOIL & ROCK CONSULTANTS

Prepared By:

Ferry Haryono
Senior Geotechnical Engineer
CPEng No. 1024076

Approved By:

Robert Smith
Branch Manager Christchurch

4415
16 March 2016

GEOTECH
consulting ltd

Selwyn District Council
PO Box 90
Rolleston

Attention: Craig Friedel

Dear Sir,

RE: Plan Change – Stratford – 631 Shands Rd, Prebbleton, - PC 47

Geotechnical Report Peer Review

Geotech Consulting has been asked to carry out a peer review on the geotechnical report for the proposed plan change of the property at 631 Shands Road (Lot 1 DP 53112) from Inner Plains to Living 3 zone. The report is by Soil & Rock Consultants Ltd dated 16 October 2015, for M.J. Stratford, to provide information for the proposed plan change, which if successful would allow future subdivision of the 15.98 ha property into 26 lots. In particular the peer review is to ensure compliance with the CERA guidelines for the geotechnical assessment of subdivisions.

1 Site Investigation

The report describes a site investigation (in two stages) of twelve test pits to a maximum of 2.2 m depth with associated scala penetrometer tests, and four "Dynamic Probe Super Heavy" DPSH tests to between 1.1m and 7.2m depth. The site test plans show that the test pits were carried out in 3 groups, all in the northern part of the property, and therefore really sample less than about one fifth of the whole property. The DPSH tests were made near each corner of the approximately square site, but of these three stopped at 1.1 – 1.2m depth and only one extended to any significant depth of 7.2m. Deeper information is reported from regional geology maps and two Ecan well–logs are appended to the report, although their locations are not given.

The MBIE Guidance recommends a minimum investigation density for deep investigations of 0.2 to 0.5 per hectare, with a minimum of 5 for a site of 1 ha or greater in area. For this site this indicates between 5 and 8 deep investigations. Deep investigations refer to tests to enable the characterization of the soils to a depth of at least 15m. The guidelines allow for judgement as to the number of tests and their depths if initial investigations demonstrate an absence of liquefaction potential.

We therefore have 12 test pits and one DPSH test across about 20% of the site, to a maximum depth of 2.2m, two DPSH tests near the west and south corners to 1.1m depth and one DPSH test towards the east corner to 7.2m depth, and reference to two well-logs of unknown location. In our opinion, this does not adequately characterize the soil profile under the site, nor meet the intent of the MBIE guidelines.

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However, the site lies to the west of the line in the Ecan liquefaction review (2012) and therefore falls in the area where damaging liquefaction is unlikely and geotechnical investigations can in most cases be designed primarily for other geotechnical hazards, and the MBIE guidance is written around assessing liquefaction.

Although the ground conditions in this area are almost certainly gravel from a shallow depth to many metres depth, as based on our own knowledge and experience of the area, our concern is that this is not well established by the information provided in the report. We recommend that additional test pits are carried out across the 80% of the area away from the existing test pits (we suggest a minimum of five) to verify the soil types and that the refusal as encountered in the DPSH tests is gravel. In addition, the locations of the Ecan well logs referred to must be detailed so that the proximity of otherwise to the site can be assessed. It would be useful to do a wider survey of the well logs to provide more additional supporting evidence that once the gravels are encountered, they are continuous to at least 10 – 15m depth.

2 Subsurface Conditions

The test pits showed 0.2 – 0.3m of topsoil over sandy silt which is between 0.3m and 0.9m thick over sandy gravel. The Ecan borelogs show gravel from close to the ground surface to 20m in one and 30m in the other, before any finer grained soils are encountered. The Ecan data base indicates a ground water level of 8.5 – 10m depth; none of the tests on the site encountered ground water.

3 Liquefaction Assessment

Although the gravel dominated soils and depth to groundwater combine to make the risk of liquefaction at the site very low, it is reported that a liquefaction analysis was carried out on the DPSH data. It is unclear what water table was assumed as both 3m and 8m are reported as being used. Despite the methodology being outlined, the results of the analysis are not given, but rather that as the water table is assessed at 8m depth the site can be considered to have at least an 8m non-liquefiable crust. S&R state that “liquefaction analysis indicates that liquefaction induced ground subsidence” is within the limits for Foundation technical Category TC1, and “does not change the current designation of TC1 “. This last statement is incorrect. The property lies outside the residential areas and has been categorized as “rural and unmapped”.

We find the S&R assessment confused, but we do accept that the liquefaction hazard is low to very low, and that an equivalent TC1 category is appropriate.

4 RMA assessment

The report concludes that there are no significant geotechnical hazards on the site and that it is suitable for subdivision from a geotechnical perspective.

5 Development recommendations

The report indicates ultimate bearing capacity of 200 kPa at 0.3m and 300 kPa below 0.4m depth on the site. We accept these as reasonable, in the area sampled with the test pits. Although there is a reasonable chance that these bearing capacities are applicable across the whole site, this cannot be assumed and additional testing will be needed to verify this.

S&R continue with comments on foundation options. These are confusing as both NZS 3604 options (suitable for TC1 land) and the MBIE enhanced concrete slab options for TC2 land are given without any differentiation or commentary. Site specific testing is recommended at design stage, with which we agree.

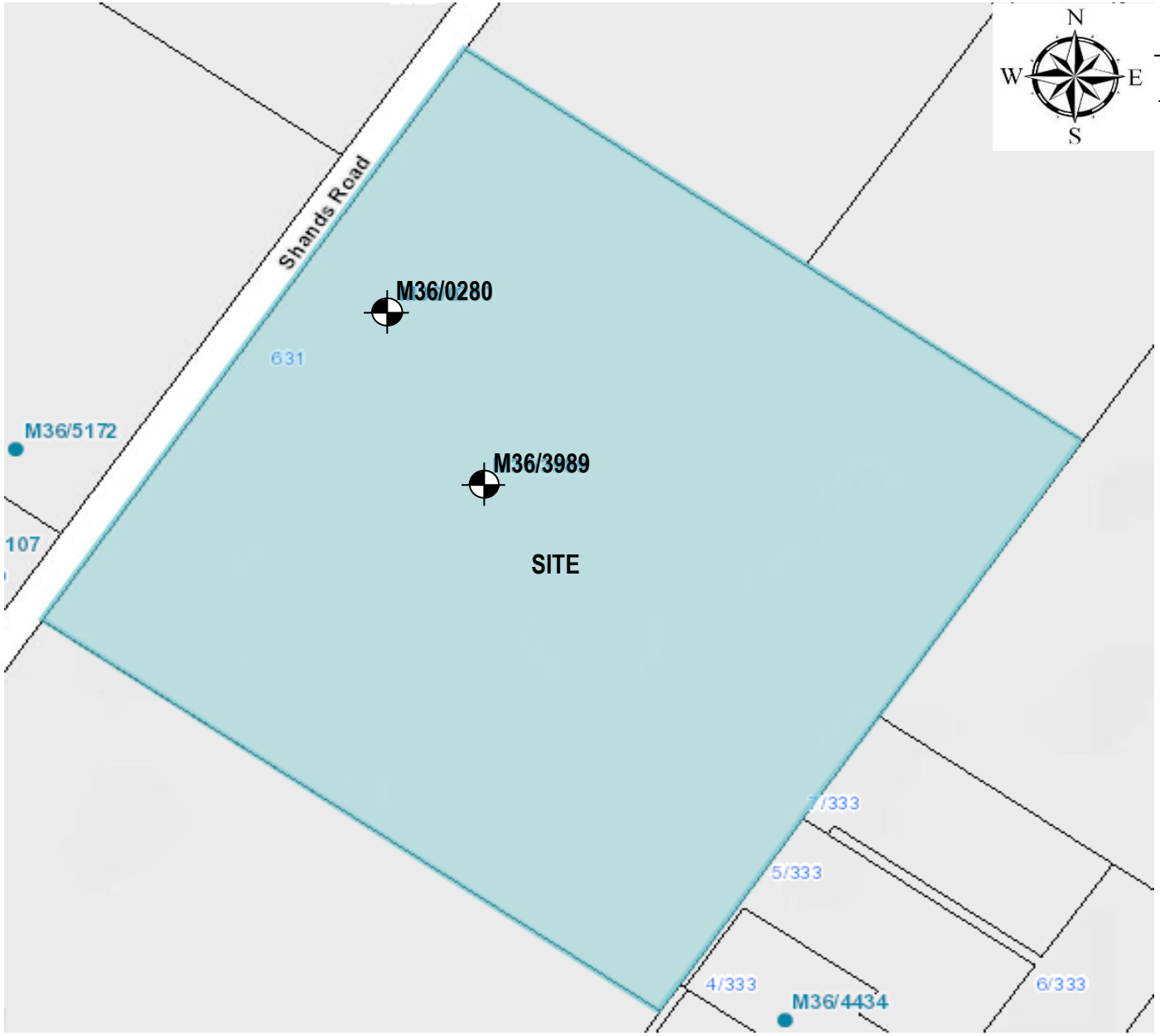
6 Conclusion

We accept that this site is in an area where damaging liquefaction is unlikely, and an equivalent TC1 category is appropriate. From our own knowledge of the area we also accept that the site is likely to be underlain with gravel from a shallow depth. However we perturbed by the poor distribution of site testing over the whole site, with much of the site tested only by penetrometer testing without any sampling to verify soil types, and that the deeper soil profile is not well established by the information provided in the report. Inconsistencies in parts of the report are confusing but of lesser consequence.

While we have recommended further testing on the site, the report is to support a plan change and thus it may be argued that additional testing can be left to a later stage. It is probably a low risk that any geotechnical issues that might adversely affect development are in fact present, but if more testing is not done now, it is important that it is at subdivision stage (if the plan change proceeds). Additional testing will also be subsequently needed at building consent stage for each building.

Yours faithfully
Geotech Consulting Limited

Ian McCahon



N
W E
S

Legend:

M36/0280

ECAN Well Location Plan

Notes:

1. Soil & Rock Consultants Test Location Plan adapted from aerial photography from Google Maps
2. Locations of features are approximate only

Soil&Rock Consultants
For well-grounded solutions

DATE:	March 2016
DRAWN:	RS
SCALE:	NTS
CAD REF:	C15449

ECAN WELL LOCATION PLAN
PROPOSED SUBDIVISION
631 SHANDS ROAD, PREBBLETON

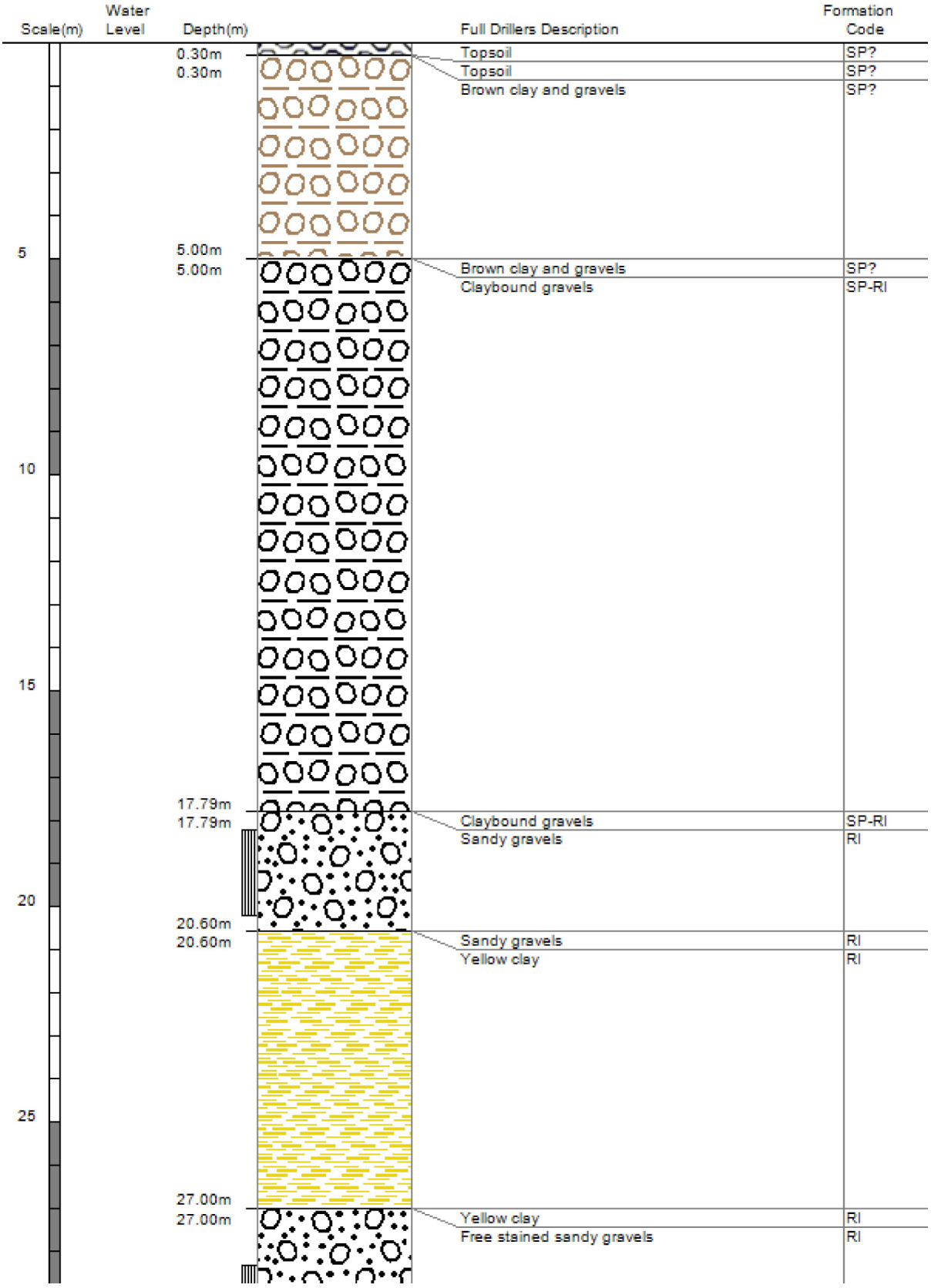
DRAWING NO:
C15449

SHEET 1 OF 1

Borelog for well M36/3989

Grid Reference (NZTM): 1559254 mE, 5175190 mN
Location Accuracy: 50 - 300m
Ground Level Altitude: 30.2 m +MSD Accuracy: < 0.5 m
Driller: McMillan Drilling Ltd
Drill Method: Rotary/Percussion
Borelog Depth: 30.0 m Drill Date: 11-Jan-1989

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha




30.00m

RILEY CONSULTANTS

311 TRENTS ROAD, PREBBLETON, CANTERBURY - GEOTECHNICAL ASSESSMENT FOR SUBDIVISION CONSENT

Engineers and Geologists

E-MAILED 28/2/13

311 TRENTS ROAD, PREBBLETON, CANTERBURY - GEOTECHNICAL ASSESSMENT FOR SUBDIVISION CONSENT

Report prepared for: Mr & Mrs D & S Anderson

Report prepared by: Kate Corcoran, Geologist

.....

Edwyn Ladley, Senior Engineering Geologist

.....

Report reviewed by: pp Don Tate, Director (CPEng)

.....

Report Reference: 12876-A

Date: 28 February 2013

Copies to:

Mr & Mrs D & S Anderson C/- Davie Lovell-Smith Ltd	1 PDF copy
Riley Consultants Ltd	1 copy

Revision:	Details:	Date:
1.0	Geotechnical assessment – for Client review	20 December 2012
2.0	Geotechnical assessment	28 February 2013

Contents

Figures

Tables

Appendices

311 TRENTS ROAD, PREBBLETON, CANTERBURY - GEOTECHNICAL ASSESSMENT FOR SUBDIVISION CONSENT

1.0 Introduction

As requested by David and Sue Anderson, via Davie Lovell-Smith Ltd, Riley Consultants Ltd (RILEY) has undertaken a geotechnical assessment for subdivision at the above property. This report is intended to provide supporting information for a subdivision consent application (by others) to subdivide the current 9.2 ha property into 16 lots, ranging in size from approximately 5,000m² to 6,100m² (refer Davie Lovell-Smith Ltd Dwg: P06845, May 2012).

The main objectives of this assessment are;

- Document geotechnical investigations undertaken by RILEY to confirm the site geology and any geological hazards potentially affecting the site.
- Comment on the likely extent and variation of the principal soil types.
- Comment on the seismic hazard and liquefaction risk, and any other geological hazards associated with the site.
- Comment on foundation options for development of the new lots.

Figure 1. Location plan – north vertical to the page and blue gridlines are 1km spaced (extract from Topo50 1:50,000 scale map, Sheet BX23 v1.02 1998).

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rileychch@riley.co.nz www.riley.co.nz

1.1 Site Description

The property is located approximately 12.7km south-west of Christchurch city, and the property borders Trents Road and Shands Road, just outside of Prebbleton township (Figure 1 and RILEY Dwg: 12876-01). The site (Lot 2 DP 51743) is 9.2ha in size, and generally slopes gently to the southeast (ground slope estimated at 2m over 400m).

A degraded alluvial terrace, less than 1m high, trends north – south across the west of the site (Dwg: 12879-01). The site is predominantly covered with grass and local trees and shrubs. There are no nearby watercourses, although a small pond exists in the north-west of the site at the Shands Road boundary. We understand that the land has been used for horse breeding and farming since the early 1900s. This property has been subdivided from an original 440 acre block that was bound by Shands Road, Blakes Road, Springs Road, and Trents Road.

Currently there are several single storey buildings on the property, including a private residence and stables. These buildings are approximately 25 years old and are supported by a concrete slab on grade foundation system.

No evidence of land damage associated with the recent Canterbury earthquake sequence was observed at the site (i.e. to cracking or liquefaction-induced sand boils etc.).

1.2 Scope of works

The investigation has been completed in general accordance with the 'Guidelines for the Geotechnical Investigation and Assessment of Subdivisions in the Canterbury Region' released by the Department of Building and Housing (DBH) in November 2011. Specific tasks included:

1. Desk study of available published, publicly available, and in-house geological data.
2. Walkover inspection of the site and surrounds, completed by RILEY engineering geologists on 6 and 7 November 2012 (refer RILEY Dwg: 12876-01, Appendix A).
3. Subsurface investigation consisting of:
   - Eight mechanically dug inspection pits to a maximum depth of 5m (completed on 7 November 2012), with associated Scala penetrometer and Clegg hammer testing.

     The pits were logged, and photographed, by a RILEY engineering geologist in general accordance with the New Zealand Geotechnical Society Guidelines for soil description (2005). Logs and photographs are attached as Appendix B.
   - Two dynamic probe profiles (DPH3 and DPH4) that were terminated due to practical refusal at 7.5m and 4.5m depth, respectively.
   - Two infiltration tests in inspection pits TP3 and TP6 after geological logging was completed.
4. Assessment of geotechnical conditions and hazards and report production.

2.0 Council Requirements for Subdivision Assessment

The Department of Building and Housing (DBH) has recently released *Guidelines for the Geotechnical Investigation and Assessment of Subdivisions in the Canterbury Region* (14 September 2012). This document provides guidelines as to what is likely to be required by councils in assessing applications for plan change and subdivision consent. Key points of relevant to the proposed subdivision include:

- Appropriate geotechnical investigations shall be carried out to enable the characterisation of ground forming materials to at least 15m below ground level, unless the ground is known to be of acceptable quality from lesser depths (for example, in areas known to be underlain by competent gravels and deep groundwater profiles, or in hillside areas).
- If initial investigations demonstrate a lack of liquefaction potential then the Engineer may judge fewer test locations or shallower depths of investigation to be appropriate.

We consider that the information gathered from our desk study of regional geology provides an adequate assessment of the site geology and liquefaction risk. As such, we have not proposed any deep investigations as the regional geology indicates that there is a thick sequence of competent gravel beneath near-surface soils. This, combined with a deep groundwater table (approximately 9m below ground level) suggests that liquefaction is not a significant hazard to the site.

Geotechnical peer review for Selwyn Council (Ian McCahon of Geotech Consulting Ltd) agreed that this investigation philosophy was suitable for the anticipated ground conditions.

3.0 Regional Geology and Groundwater

A review of the published geological map of the area (Christchurch QMAP, 1:250,000 scale), publicly available Canterbury Geotechnical Database information and nearby Environment Canterbury (ECan) online well logs has been completed for this geotechnical assessment. The ECan well logs for the area indicate the water level at between 7m and 11m below ground level. Well number M35/3775 was drilled on the property itself when the house and buildings were constructed and records the water level at 9.3m below ground level in July 1987.

The general geological profile of the area is:

- Topsoil (typically less than 250mm thick) consisting of loose, silty fine to medium SAND with some organics and rootlets.
- Fine sandy SILT to silty fine SAND deposited during the last glacial advance (ca. 10,000 years). This material may infill buried channels in the underlying River Alluvium.
- 'Q1a' Alluvium (totalling 100 to 300m thick). The QMAP indicates the site to be underlain by a sequence of glacial outwash alluvium associated with glacial advance and retreat in the Late Quaternary. This typically consists of moderately thick to very thick bedded gravel to sandy GRAVEL. The ECan well logs indicate that the alluvium has a minor clay content (often noted as "claybound gravel", e.g. M3/5606 and M36/4677).

- Bedrock geology to the site is likely to comprise a sequence of weakly indurated Tertiary conglomerates, limestone, and siltstone. These strata are approximately 1.5km thick beneath the site and are underlain by greywacke sandstone and siltstone bedrock correlated to the Torlesse composite terrane.

4.0 Encountered Ground Conditions and Groundwater Conditions

The encountered geology is in general accordance with that anticipated from our desktop study. Investigations identified three soil layers at the site, the characteristics of which are described below:

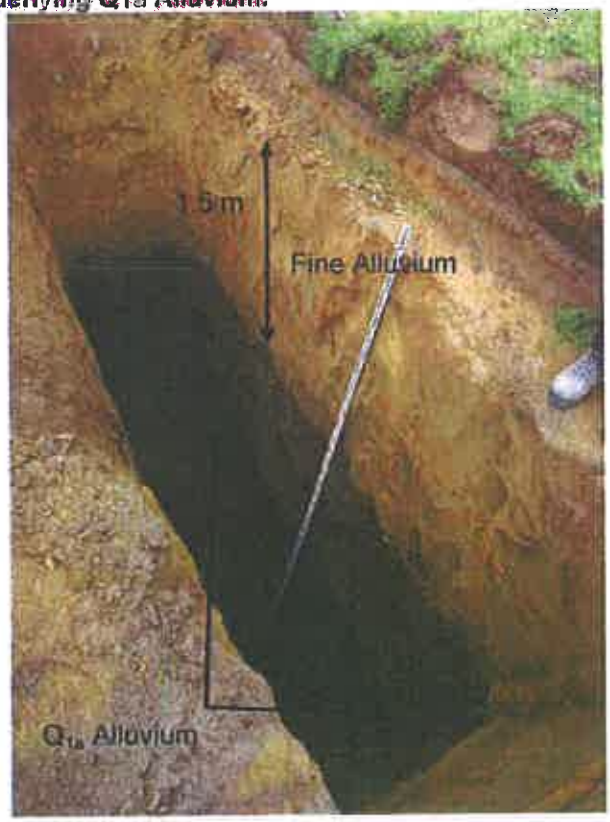
- Layer 1 - Topsoil:

  Topsoil is typically 0.2m to 0.25m thick, consists primarily of dark brown silty fine to medium sand with organics. This material is loose to dense from Scala penetrometer test results.

- Layer 2 - Fine Alluvium:

This unit typically consists of silty SAND and underlies Topsoil. Its thickness ranges between 0.35m (TP8) and 1.6m (TP1) (Figure 2). The variable thickness reflects undulations in the ground surface, and an irregular/channelled surface in the underlying Q1a Alluvium.

Figure 2. Photograph of inspection pit TP2 showing the contact between the Fine Alluvium and underlying Q1a Alluvium.



The Scala penetrometer blow counts indicate variable relative densities within the layer, typically loose to medium dense (Appendix B). Clegg hammer tests were completed at selected depths in inspection pits in the Fine Alluvium. Clegg impact values (IV) from the tests are summarised in Table 1. The impact values ranges between 3 and 15, with a mean of approximately 7.

Table 1: Clegg hammer impact values (IV) in Fine Alluvium

Inspection Pit	Depth (m)	Clegg Impact Value (IV)		
		test 1	test 2	test 3
TP4	0.3	8	10	10
TP4	0.6	11	11	15
TP5	0.3	9	9	10
TP5	0.6	7	7	8
TP6	0.3	9	8	9
TP6	0.6	6	5	5
TP6	0.85	4	4	3
TP6	1	3	4	3
TP7	0.3	6	6	5
TP7	0.6	5	5	5
TP7	0.9	6	7	5

- Layer 3 - Q1a Alluvium:

This unit consists of sandy GRAVEL with some to minor silt with local cobbles up to 0.2m in length. In some of the inspection pits thin sand lenses and orange (iron) and purplish black (manganese) stained lenses occur. This material is typically tightly packed with the inspection pit walls standing vertical. The dynamic probe-heavy tests were terminated early (target depth 15m) due to practical refusal. The calculated SPT N_{60} values from the dynamic probe-heavy profiles suggest the Q1a Alluvium is dense to very dense.

Free groundwater was not encountered in any of the inspection pits; moist soils were logged from ground level. Based on ECan well logs, a minimum groundwater level of 7m below ground level is considered appropriate for the purposes of this assessment. This depth is taken as a conservative estimate from expected seasonal variability of the water level.

5.0 Geotechnical Assessment

5.1 *Recorded Peak Ground Accelerations (2010 to 2011 Canterbury Earthquake Sequence)*

Recorded peak ground accelerations (PGAs) for the Canterbury Earthquake Sequence have been made publicly available by GNS. A review of these PGAs from the nearest recording devices located in Templeton and Lincoln, approximately 3.5km north and 5.4km south of the of the site respectively indicate that the property is likely to have been subject to a PGA in the order of 0.9g in the Mw 7.1 September 2010 earthquake. This equates to a load exceeding the current DBH Guidelines for a design load Serviceability Limit State (SLS) earthquake (Mw 7.5). Lower PGAs were likely to have occurred for the February and June 2011 aftershocks, below the SLS design load.

5.2 Qualitative Liquefaction Risk Assessment

At least 7m of non-liquefiable/non-saturated material underlies the site as a result of the inferred minimum groundwater table. This minimised the potential for liquefaction-induced ground surface damage at the site in a Serviceability Limit State earthquake event.

Liquefaction typically occurs in recent (i.e. less than 10,000 years old), normally consolidated, and saturated (i.e. beneath the groundwater table) silt, sand and gravel. The susceptibility of a soil to liquefaction depends primarily on material density, grain size and soil composition.

Dense granular soils are generally not liquefiable (Youd et al, 1996 & 1998), and the Q1a Alluvium encountered on site is typically dense. Similar soils in Canterbury have generally performed well under recent seismic loading. No land damage was observed, and no ejected sands or lateral spreading were reported by the landowner across the site as a result of the recent Canterbury earthquake sequence.

Although no deep in situ soil tests are available for the Q1 Alluvium (or any older underlying material) it is reasonable to expect that this material is competent to considerable depth. Local looser sand and silt layers and lenses are likely to be interbedded within the gravel alluvium sequence, and these may be susceptible to liquefaction in a future design earthquake event. However, when considering the high-energy deposition environment of the alluvium these layers are likely to be relatively thin and laterally discontinuous – similar to those encountered in the inspection pits. The surrounding and overlying denser gravel is likely to minimise and bridge any local liquefaction induced settlement of these looser layers/lenses at depth (i.e. below the water table).

5.2.1 Foundation Technical Category

The Department of Building and Housing (DBH) has provided a guidance document whereby land is placed into one of three technical categories based on liquefaction deformation limits. In terms of these guidelines, we consider that the subject site is likely to be similar to those sites that fall into technical category TC1. TC1 estimated foundation settlements due to liquefaction are 15mm in an SLS earthquake event and 25mm in a ULS (Ultimate Limit State) earthquake event. The site is not likely to be subject to any lateral spreading.

5.3 Suitability of Ground for Development

It is desirable for new subdivisions on flat or gently sloping ground to provide building platforms that meet the NZS 3604 definition of "good ground", as such building platforms do not require specific engineering design of foundations for residential development. NZS 3604 defines the criteria for "good ground" as that which has an ultimate bearing capacity of 300 kPa, and excludes:

- Potentially compressible ground
- Expansive soils
- Ground which could foreseeably experience movement of 25 mm or greater for any reason

The Department of Building and Housing (DBH) has included liquefiable soils in the ground conditions, for which NZS 3604 is not applicable. On the basis of regional geology, and inspection pit investigations, the site soils, other than the topsoil, are considered unlikely to be expansive or compressible.

The thick sequence of gravelly soils (Q1a Alluvium), which underlies the site from depths of 0.6m to 1.8m, is considered to meet the bearing capacity criteria for "good ground" according to NZS 3604.

The topsoil is not a suitable bearing stratum for dwelling foundations and should be removed from the building platform pre-construction.

The lots do not appear to be at risk from erosion, falling debris, or slippage. From our assessment it is considered that the site is at minor risk of liquefaction-induced settlement. Accordingly, under Section 106 of the RMA, we consider there to be no geotechnical reasons preventing the subdivision of the property provided the appropriate engineering and construction industry standard measures, and recommendations in this report, are carried out.

5.4 Static Bearing Capacity

NZS 3604 provides a Scala penetrometer test criteria whereby if a certain blow count over a measured depth is met, an ultimate bearing capacity of 300kPa may be assumed (5 blows per 100mm). The gravel dominant Q1a Alluvium is considered to have a geotechnical ultimate bearing capacity of greater than 300 kPa. However, a geotechnical ultimate bearing capacity of 200kPa is considered appropriate for the finer alluvium, which overlies the gravel, due to encountered lateral and vertical variability in the strength of this unit.

5.5 Foundation Development Options

In terms of the DBH Guidelines, where the ultimate bearing capacity meets the 200kPa requirement either enhanced slab solutions or other specific engineering design is applicable. At a conceptual level, enhanced house foundation solutions could comprise the following:

- A shallow concrete slab foundation (thickened over the existing site soils, or built over a compacted granular fill raft). It may be possible to excavate and re-compact the fine alluvium to construct a densified surface raft. This would reduce the volume of imported material but would require more engineering design and quality control.
- A deeper piled foundation founded on the Q1a Alluvium soils (e.g. shallow driven timber piles with an integral concrete raft).

Due to the variability of the depth in the fine alluvium further investigations are recommended at the time of individual building development, as outlined in the DBH Guidelines, to assess the most appropriate and cost-effective solution for each building platform.

5.6 Further Development Considerations

5.6.1 Roads

Roads are not subject to the same design criteria as foundations; however, subgrade layers are required to provide appropriate strength and stiffness for pavement design. Following removal of the topsoil/silt (generally 250mm thick), a design California Bearing Ratio (CBR) of 4% is considered appropriate for the underlying fine alluvium sandy soils.

5.6.2 Services

Buried service trenches are not likely to encounter groundwater at shallow depths throughout the site. However, it is likely that trenching works will likely encounter non-cohesive soils at shallow depth, which may unravel into trenches. It is recommended that buried services be designed detailed with flexibility and resilience in mind.

6.0 Soil Infiltration Testing

We understand that on-site disposal of clean stormwater will be via soakage pits. To assist the preliminary design (by others) of the soakage pits two infiltration tests were completed in TP3 and TP6. The tests were undertaken in general accordance with the Auckland City Soakage Design Manual.

Key points to note about the tests include:

- Each pit was pre-soaked twice prior to the commencement of a falling head percolation test. After pre-soaking, each pit was then re-filled with water to the top of the gravel alluvium and the drop in water recorded at regular intervals.
- The two tests were carried out at different depths below the fine alluvium to assess any change in geological conditions resulting in variability in the permeability rates, and as such the percolation rates calculated range in value. (refer Table 2 and Figure 3, with further calculation details in Appendix D).
- The results were calculated using a formula from Digest 365 of the British Research Establishment, and are limited by the fact that the inspection pits excavated were assumed to be perfectly rectangular and the precision of the measuring devices used (stopwatch and survey staff).

Table 2: Soil Infiltration tests summary

Inspection pit number	TP3	TP6
Infiltration test number	1	2
Excavated depth	2.7 m	3.2 m
Depth to Q1a Alluvium	1.6 m	1.75 m
Water depth above base of pit, at beginning of test	0.925 m	0.7 m
Flow rate into the pit	1.826 l/s	1.826 l/s
Adopted permeability (of Q1a Alluvium)	2.95×10^{-5} m/s	2.7×10^{-4} m/s
Adopted Infiltration rate	105mm/hr	980mm/hr

Figure 3. Photograph of infiltration test of gravelly Q1a Alluvium in inspection pit TP3

From the soil infiltration tests undertaken in the (Q1a Alluvium) gravel we the infiltration rates calculated differ by a factor of 10, and that this is most likely due to differences in the geology between the pit locations. Further testing is advised when during detailed design (by others) of the stormwater system for the subdivision.

7.0 Conclusions

RILEY has completed a geotechnical assessment for the subdivision at 311 Trents Road, Prebbleton. Key points are summarised below:

1. The ground has performed well during the recent Canterbury earthquake sequence.
2. Ground conditions typically consist of topsoil underlain by generally loose, fine alluvium (silty sand) to a maximum depth of 1.95m over competent gravel with subordinate sand, silt and cobbles. A design groundwater level of 7m is considered appropriate for the site. The encountered ground conditions correspond well with the regional geology from published information.
3. The fine alluvium has a variable bearing capacity of approximately 200kPa. The gravel has a geotechnical ultimate bearing capacity of at least 300kPa, and is a suitable stratum for any foundation type. Specific investigations for each individual development are recommended in line with the DBH Guidelines.
4. The proposed subdivision is considered acceptable from a geotechnical perspective provided the recommendations outlined in this report are followed.
5. Based on the interpreted geology and design groundwater conditions, the site is considered to have a minor risk of liquefaction from future design earthquake events. The risk of liquefaction-induced ground damage is consistent with a TC1 zoning.
6. Inspections of ground conditions during the construction phase should be undertaken in accordance with accepted practice. RILEY should be informed if there are any changes from the conditions described in this report.

8.0 Limitation

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

Recommendations and opinions in this report are based on data from limited test positions. The nature and continuity of subsoil conditions away from the test positions are inferred, and it must be appreciated that actual conditions could vary considerably from the assumed model.

During excavation and construction the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation and the modification of the design based upon this report.

Riley Consultants Ltd would be pleased to provide this service to David and Sue Anderson and believes the project would benefit from such continuity. In any event, it is essential Riley Consultants Ltd is contacted if there is any variation in subsoil conditions from those described in the report as it may affect the design parameters recommended in the report.

9.0 References

Department of Building and Housing, November 2011. *Revised guidance on repairing and rebuilding houses affected by the Canterbury earthquake sequence.*

Department of Building and Housing, 27 April 2012. *Appendix C to the Guidance Document: Revised guidance on repairing and rebuilding houses affected by the Canterbury earthquake sequence (November 2011).*

Forsyth, P.J., Barrell D.J.A, Jongen R. (compilers), 2008. *Geology of the Christchurch Area.* Institute of Geological & Nuclear Sciences 1:250,000 geological map 16. One sheet + 67 p. Lower Hutt, New Zealand. GNS Science.

New Zealand Geotechnical Society, 2005. *Field description of soil and rock – guidelines for the field classification and description of soil and rock for engineering purposes.*

Youd, T.L. et al, 1996 & 1998, *Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils.* Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

APPENDIX A

Drawings

LEGEND

- TP1 — TEST PIT LOCATION
- DPH1 — DYNAMIC PROBE (HEAVY) TEST LOCATION
- SITE BOUNDARY
- APPROXIMATE DEGRADED ALLUVIAL TERRACE – TYPICALLY LESS THAN 1.0m

SCALE 1: 2000

0 20 40 60 80 120 (m)

NOTES:-

1. PHOTO SOURCED FROM GOOGLE EARTH (28TH MARCH 2011)
2. ORIGINAL SCALE A3

NOT FOR CONSTRUCTION

REV	DESCRIPTION	BY	DATE
2	DRAWING AMENDED	HN	14.11.12
1	DPH's ADDED	HN	23.10.12
0	FIRST ISSUE		

DESIGN: KC | DRAWN: HN | CHECKED: | DATE Drawn: 14 NOV 2012

APPROVED FOR ISSUE: DRAFT DATE: / /

RILEY CONSULTANTS
P.O.BOX 4356 CHRISTCHURCH
TEL. 03-3794302
FAX. 03-3794403

TITLE

DJ ANDERSON

311 TRENTS ROAD, PREBBLETON

GEOTECHNICAL INVESTIGATION SITE LOCATION PLAN

JOB No. 12876-01

SCALES (A3) AS SHOWN

DRAWING No. 12876-01 REV. 2

APPENDIX B

Subsurface Investigation Logs

RILEY CONSULTANTS

Riley Consultants Limited
385 Madras Street
Christchurch 8011
Tel: +64 3 3795 4402
Fax: +64 3 3794403

TEST PIT LOG

Project:	Location:	Hole position:	No.:
311 Trents Road	Prebbleton, Canterbury	Refer to site plan	TP1

Job No.:	Start Date: / Finish Date:	Ground Level (m Lyttelton)	Co-Ordinates (NZTM2000):	Sheet:
12876	06-11-12 / 06-11-12	28.00	E 1,559,112.6 N 5,174,889.9	1 of 1

Client: D & S Anderson

Hole Depth: 4.80 m

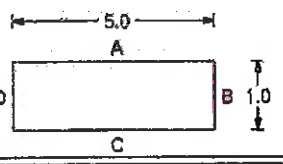
Elevation (m Lyttelton)	Depth (m)	Geological Description	Symbolic Log	Weathering	Field Strength (Soil / Rock)	Scala Penetrometer (blows / 50 mm)	Samples	Tests
+28.00		Soil Description: soil name; particle size, MAJOR, minor; colour; structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; minor qualifications; weathering of clasts; subordinate constituents; minor qualifications; additional structure; (GEOLOGIC UNIT). Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; additional description; (GEOLOGIC UNIT).				0 3 6 9 12 15 18		
+27.80	0.20	Fine to medium silty SAND, with some rootlets, brown. (TOPSOIL)						
	1	Silty fine to medium SAND, mottled yellowish brown. Loose; moist (FINE ALLUVIUM)						No. 1: 1, 2, 2, 1, 1, 2, 1, 2, 1, 1, 1, 1, 1, 2, 1, 2, 1, 2, 2
+26.20	1.80							No. 2: 2, 2, 4, 2, 2, 3, 3, 2, 3, 3, 3, 4, 3, 3, 3, 4, 7, 13, 10
	2	Sandy GRAVEL with minor silt, greyish brown local orange mottling. Tightly packed; moist; gravel, fine to coarse, subangular to rounded, slightly weathered greywacke sandstone; local cobbles and boulders up to 350 mm; local sand lenses (200mm) and orange (iron) and purplish black (manganese) stained lenses. (Q1a ALLUVIUM)						
	3							
	4							
+23.50	4.50							
		EOH @ 4.80 m						

SKETCH:

MAP

1:1,000

Shoring/Support: None
Stability:



- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Permeability Test
- Clegg Hammer; test repetitions (N)
- Insitu Vane Shear Strength (kPa) P=Peak, R=Residual, UTP=Unable to penetrate
- Scala Penetrometer - blows/50mm

GROUNDWATER [X] None
- [ ] Slow Seep (depth)
- [ ] Rapid Inflow (depth)

PIT TERMINATED DUE TO:
- [ ] Target depth
- [ ] Collapse
- [ ] Refusal
- [X] Machine limit

Remarks

1. Inspection pit location and elevation is approximate and subject to survey confirmation.

All dimensions in metres Scale 1:42	Contractor: Fulton Hogan	Rig/Plant Used: Machine Excavator (16 tonne)	Logged by: AvD	Checked by: AvD

RILEY AGS 3_1 NZ LIB 13 GLB Log RILEY TP - SDMA 311 TRENTS ROAD CHRISTCH.GPJ <<DrawingFile>> 20/12/2012 16:14 Produced by pcNT Professional

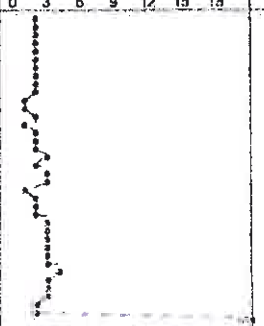
TEST PIT LOG

Riley Consultants Limited
394 Madras Street
Christchurch 8011
Tel. +64 3 3798 4402
Fax: +64 3 3794403

Project: 311 Trents Road	Location: Prebbleton, Canterbury	Hole position: Refer to site plan	No.: TP2
Job No.: 12876	Start Date: 06-11-12 Finish Date: 06-11-12	Ground Level (m Lyttelton): 27.00 Co-Ordinates (NZTM2000): E 1,559,213.3 N 5,174,710.6	
Client: D & S Anderson	Hole Depth: 5.00 m		Sheet: 1 of 1

Elevation (m Lyttelton)	Depth (m)	Geological Description	Scala Penetrometer (blows / 50 mm)	Tests
+27.00		Soil Description: fraction/size, particle size, MAJOR, minor; colour, structure; strength; relative density; grading; bedding; plasticity; sensitivity; major qualifications, weathering of clasts; subordinate qualifications; minor qualifications; additional structure; (GEOLOGIC UNIT). Rock Description: weathering; colour; texture; fabric and orientation; NAME, strength, additional description, (GEOLOGIC UNIT).	0 3 6 9 12 15 18	
+26.80	0.20	Fine to medium silty SAND, with some rootlets, brown (TOPSOIL)		No. 1 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 1, 1, 2, 1, 2, 2, 2, 3, 2, 3
		Silty fine to medium SAND, light greyish brown with orange mottling. Loose, moist. (FINE ALLUVIUM) 0.60 m Grades to nil rootlets		No. 2 3, 1, 2, 2, 2, 3, 3, 3, 3, 3, 3, 4, 3, 3, 3, 2, 2, 30
+25.30	1.70	Sandy GRAVEL with minor silt, greyish brown. Tightly packed; moist; gravel, fine to coarse, subangular to rounded, slightly weathered greywacke sandstone; local cobbles and boulders up to 300 mm; local sand and silt lenses, and orange (iron) and purplish black (manganese) staining. (Q1a ALLUVIUM) 3.20 m Grades to nil silt		
+22.00	5.00			

Columns: Symbolic Log; Weathering; Field Strength (Soil / Rock); Samples



SKETCH: EOH @ 5.00 m

MAP

1:1,000

Shoring/Support: None
Stability:

5.0 (A, B, C, D; 1.0)

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Permeability Test
- Clegg Hammer; test repetitions (IV)
- Insitu Vane Shear Strength (kPa) P=Peak, R=Residual, UTP=Unable to penetrate
- Scala Penetrometer - blows/50mm

GROUNDWATER
[X] None
[ ] Slow Seep (depth)
[ ] Rapid Inflow (depth)

PIT TERMINATED DUE TO:
[ ] Target depth
[ ] Collapse
[ ] Refusal
[X] Machine limit

Remarks
1. Inspection pit location and elevation is approximate and subject to survey confirmation.

All dimensions in metres Scale 1:42	Contractor: Fulton Hogan	Rig/Plant Used: Machine Excavator (16 tonne)	Logged by: KC	Checked by: AvD

RILEY CONSULTANTS

Riley Consultants Limited
325 Madras Street
Christchurch 8011
Tel: +64 3 3798 4402
Fax: +64 3 3784403

TEST PIT LOG

Project:	Location:	Hole position:	No.:
311 Trents Road	Prebbleton, Canterbury	Refer to site plan	TP3

Job No.:	Start Date: / Finish Date:	Ground Level (m Lyttelton)	Co-Ordinates (NZTM2000):	Sheet:
12876	06-11-12 / 06-11-12	28.00	E 1,559,220.0 N 5,174,853.8	1 of 1

Client: D & S Anderson

Hole Depth: 4.50 m

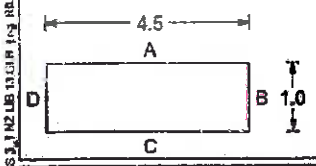
Elevation (m Lyttelton)	Depth (m)	Geological Description	Symbolic Log	Weathering	Field Strength (Soil / Rock)	Scala Penetrometer (blows / 50 mm)	Samples	Tests
+28.00		Soil Description: subordinate, particle size, MAJOR, minor; colour; structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structure; (GEOLOGIC UNIT). Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; additional description, (GEOLOGIC UNIT).				0 3 6 9 12 15 18		
+27.80	0.20	Fine to medium silty SAND, with some rootlets, brown. Earthworms present. (TOPSOIL)						No. 1 1, 3, 2, 2, 2, 2, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1
	1	Silty fine to medium SAND, light greyish brown. Loose, moist, low cohesion.						No. 2 1, 1, 1, 0, 1, 2, 2, 2, 1, 2, 3, 2, 3, 4, 5, 11, 18
+26.40	1.60							
	2	Sandy GRAVEL with minor silt, greyish brown mottled orange. Tightly packed; moist; gravel, fine to coarse, subangular to rounded, slightly weathered greywacke sandstone; local cobbles and boulders up to 300 mm; local sand and silt lenses, sand lenses (100 mm thick) and orange (iron) and purplish black (manganese) stained lenses. (Q1a ALLUVIUM)						
	3							
	4							
+23.50	4.50							
		EOH @ 4.50 m						

SKETCH:

MAP

1:1,000

Shoring/Support: None
Stability:



- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Permeability Test
- Clegg Hammer: test repetitions (fv)
- Insitu Vane Shear Strength (kPa) P=Peak, R=Residual, UTP=Unable to penetrate
- Scala Penetrometer - blows/50mm

GROUNDWATER [X] None
- [ ] Slow Seep (depth)
- [ ] Rapid Inflow (depth)

PIT TERMINATED DUE TO:
- [ ] Target depth
- [ ] Collapse
- [ ] Refusal
- [X] Machine limit

Remarks
1. Inspection pit location and elevation is approximate and subject to survey confirmation.
2. Soil Infiltration test carried out at this location.

All dimensions in metres Scale 1:42	Contractor: Fulton Hogan	Rig/Plant Used: Machine Excavator (16 tonne)	Logged by: KC	Checked by: AvD

RILEY CONSULTANTS

Riley Consultants Limited
335 Moorhouse Street
Christchurch 8011
Tel +64 3 3796 4162
Fax +64 3 3794403

TEST PIT LOG

Project:	Location:	Hole position:	No.:
311 Trents Road	Prebbleton, Canterbury	Refer to site plan	TP4

Job No.:	Start Date: / Finish Date:	Ground Level (m Lyttelton)	Co-Ordinates (NZTM2000):	Sheet:
12876	06-11-12 / 06-11-12	28.00	E 1,559,314.8 N 5,174,868.6	1 of 1

Client: D & S Anderson

Hole Depth: 3.80 m

Elevation (m Lyttelton)	Depth (m)	Geological Description	Symbolic Log	Weathering	Field Strength (Soil / Rock)	Scala Penetrometer (blows / 50 mm)	Samples	Tests
+28.00		Soil Description: consistency, particle size, MAJOR, minor; colour, structure; strength, moisture condition; grading, bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structure; (GEOLOGIC UNIT). Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; additional description, (GEOLOGIC UNIT)				0 3 6 9 12 15 18		
+27.80	0.20	Fine to medium silty SAND, with some rootlets, brown. Earthworms present. (TOPSOIL)						
+27.30	0.70	Silty fine to medium SAND, light greyish brown. Loose, moist. (FINE ALLUVIUM)						
	1	Sandy GRAVEL, with minor silt and trace rootlets, greyish brown. Tightly packed; moist; gravel, fine to coarse, subangular to rounded, slightly weathered greywacke sandstone; local cobbles and boulders up to 300 mm; local lenses of fines-free fine to medium gravel. (Qfa ALLUVIUM)						
	2							
	3	3.20 m Becomes wet						
+24.20	3.80							
	4	EOH @ 3.80 m						

No. 1
4, 2, 2,
2, 2, 3,
2, 2, 2,
1, 2, 2,
2, 1, 6,
10

▼ IV: 0.3m
6, 10, 10

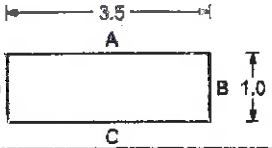
▽ IV: 0.6m
11, 11, 15

SKETCH:

MAP

1:1,000

Shoring/Support: None
Stability:



- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Permeability Test
- Clegg Hammer; test repetitions (IV)
- Insitu Vane Shear Strength (kPa) P=Peak, R=Residual, UTP=Unable to penetrate
- Scala Penetrometer - blows/50mm

GROUNDWATER [X] None
[ ] Slow Seep (depth)
[ ] Rapid Inflow (depth)

PIT TERMINATED DUE TO:
[X] Target depth [ ] Collapse
[ ] Refusal [ ] Machine limit

Remarks
1. Test Pit locations approximate and subject to survey confirmation.

All dimensions in metres Scale 1:42	Contractor: Fulton Hogan	Rig/Plant Used: Machine Excavator (16 tonne)	Logged by: KC	Checked by: AvD

RILEY AGS 3_1 NZ LIB 13.GLB Log: RILEY TP + SCALA 311 TRENTS ROAD CENT.GPJ <<DrawingFile>> 20/12/2012 16:14 Produced by gINT Professional

RILEY CONSULTANTS
Riley Consultants Limited
355 Madras Street
Christchurch 8011
Tel: +64 3 3795 4402
Fax: +64 3 3794403

TEST PIT LOG

Project:	Location:	Hole position:	No.:
311 Trents Road	Prebbleton, Canterbury	Refer to site plan	TP5

Job No.:	Start Date: / Finish Date:	Ground Level (m Lyttelton)	Co-Ordinates (NZTM2000):
12876	07-11-12 / 07-11-12	28.00	E 1,559,166.3 N 5,174,877.6

Client:	Hole Depth:	Sheet:
D & S Anderson	4.00 m	1 of 1

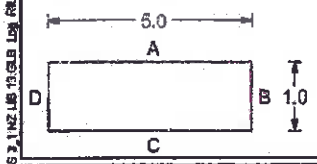
Elevation (m Lyttelton)	Depth (m)	Geological Description	Symbolic Log	Weathering	Field Strength (Soil / Rock)	Scale Penetrometer (blows / 50 mm)	Samples	Tests
+28.00		Soil Description: subordinate, particle size, MAJOR, minor; colour, structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications, weathering of clasts; subordinate qualifications; minor qualifications; additional structure; (GEOLOGIC UNIT) Rock Description: weathering; colour; texture; fabric and orientation; NAME, strength; additional description, (GEOLOGIC UNIT).				0 3 6 9 12 15 18		
+27.75	0.25	Fine to medium silty SAND, with some rootlets, brown. Earthworms present. (TOPSOIL)						
		Silty fine to medium SAND, light greyish brown. Loose, moist. (FINE ALLUVIUM)						
+27.15	0.85							
	1	Sandy GRAVEL with minor silt and trace rootlets, greyish brown. Tightly packed; moist; gravel, fine to coarse, subangular to rounded, slightly weathered greywacke sandstone; local cobbles and boulders up to 300 mm; local sand and silt lenses. (Q1a ALLUVIUM)						
	2							
	3							
+24.00	4.00							
		ECH @ 4.00 m						

Tests:
No. 1: 1, 2, 2; 1, 2, 2; 2, 2, 3; 3, 3, 3; 2, 1, 1; 2, 1, 1; 1, 1
IV: 1 — 9, 9, 10
IV, 2 — 7, 7, 8
No. 2: 2, 1, 2; 2, 2, 2; 2, 3, 3; 3, 3, 6; 10, 11

SKETCH:

MAP
1:1,000

Shoring/Support: None
Stability:



- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Permeability Test
- Clegg Hammer; test repetitions (IV)
- Insitu Vane Shear Strength (kPa) P=Peak, R=Residual, UTP=Unable to penetrate
- Scala Penetrometer - blows/50mm

GROUNDWATER: [X] None
[ ] Slow Seep (depth)
[ ] Rapid Inflow (depth)

PIT TERMINATED DUE TO:
[X] Target depth
[ ] Collapse
[ ] Refusal
[ ] Machine limit

Remarks
1. Inspection pit location and elevation is approximate and subject to survey confirmation.

All dimensions in metres Scale 1:42	Contractor: Fulton Hogan	Rig/Plant Used: Machine Excavator (16 tonne)	Logged by: KC	Checked by: AvD

RILEY AGS 3_1 NZ LIB 13.GLB Log: RILEY TP + SCALA 311 TRENTS ROAD GINT.GPJ <<DrawingFile>> 20/12/2012 18:14 Produced by gINT Professional

RILEY CONSULTANTS

Riley Consultants Limited
385 Madras Street
Christchurch 8011
Tel: +64 3 3795 4402
Fax: +64 3 3794403

TEST PIT LOG

Project:	Location:	Hole position:	No.:
311 Trents Road	Prebbleton, Canterbury	Refer to site plan	TP6

Job No.:	Start Date: / Finish Date:	Ground Level (m Lyttelton)	Co-Ordinates (NZTM2000):	Sheet:
12876	07-11-12 / 07-11-12	29.00	E 1,559,026.7 N 5,175,010.0	1 of 1

Client: D & S Anderson

Hole Depth: 3.35 m

Elevation (m Lyttelton)	Depth (m)	Geological Description	Symbolic Log	Weathering	Field Strength (Soil / Rock)	Scala Penetrometer (blows / 50 mm)	Samples	Tests
+29.00		Soil Description: subordinate, particle size, MAJOR, minor; colour, structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications, weathering of clasts; subordinate qualifications; minor qualifications; additional structure; (GEOLOGIC UNIT). Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; additional description. (GEOLOGIC UNIT)				0 3 6 9 12 15 18		
+28.80	0.20	Fine to medium silty SAND, with some rootlets, brown. (TOPSOIL)						No. 1 1, 2, 2, 1, 1, 3, 2, 2, 2, 3, 4, 4, 5, 7, 23 N: 1 9, 8, 9 N: 2 5, 5, 5 N: 3 4, 4, 4
	1	Silty fine to medium SAND, light greyish brown. Loose, moist. (FINE ALLUVIUM)						
+27.25	1.75							
	2	Sandy GRAVEL with minor silt and trace rootlets, greyish brown. Moist; gravel, fine to coarse, subangular to rounded, slightly weathered greywacke sandstone; local cobbles and boulders up to 300 mm; local sand and silt lenses. (Q1o ALLUVIUM)						
	3							
+25.80	3.20							
	4	EOH @ 3.35 m						

SKETCH:

MAP

1:1,000

Shoring/Support: None
Stability:

5.0
A
D
B 1.0
C

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Permeability Test
- Clegg Hammer; test repetitions (IV)
- Insitu Vane Shear Strength (kPa) P=Peak, R=Residual, UTP=Unable to penetrate
- Scala Penetrometer - blows/50mm

GROUNDWATER [X] None
[ ] Slow Seep (depth)
[ ] Rapid Inflow (depth)

PIT TERMINATED DUE TO:
[X] Target depth [ ] Collapse
[ ] Refusal [ ] Machine limit

Remarks
1. Inspection pit location and elevation is approximate and subject to survey confirmation.
2. Soil infiltration tests also carried out at this location.

All dimensions in metres Scale 1:42	Contractor: Fulton Hogan	Rig/Plant Used: Machine Excavator (16 tonne)	Logged by: KC	Checked by: AvD

Riley Consultants Limited
395 Madras Street
Christchurch 8011
Tel: +64 3 3796 4402
Fax: +64 3 3794403

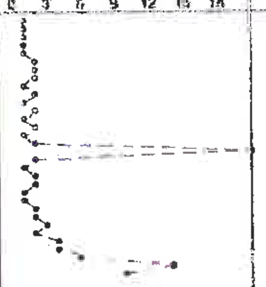
TEST PIT LOG

Project: 311 Trents Road	Location: Prebbleton, Canterbury	Hole position: Refer to site plan	No.: TP7
Job No.: 12876	Start Date: 07-11-12 Finish Date: 07-11-12	Ground Level (m Lyttelton): 27.00	Co-Ordinates (NZTM2000): E 1,559,014.8 N 5,175,090.2
Client: D & S Anderson	Hole Depth: 4.50 m		Sheet: 1 of 1

Geological Description
Soil Description: subordinate, particle size, MAJOR, minor; colour, structure; strength, moisture condition, grading, bedding, plasticity, sensitivity; major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure; (GEOLOGIC UNIT)
Rock Description: weathering, colour, texture, fabric and orientation; NAME; strength, additional description, (GEOLOGIC UNIT)

Elevation (m Lyttelton)	Depth (m)	Geological Description
+27.00		
+26.75	0.25	Fine to medium silty SAND, with some rootlets, brown (TOPSOIL)
+25.40	1.80	Silty fine to medium SAND, light greyish brown. Loose, moist (FINE ALLUVIUM)
+22.50	4.50	Sandy GRAVEL with minor silt and trace rootlets, greyish brown. Tightly packed; moist; gravel, fine to coarse, subangular to rounded, slightly weathered greywacke sandstone; local cobbles and boulders up to 300 mm; local sand and silt lenses (Q1a ALLUVIUM)
		EOH @ 4.50 m

Columns: Symbolic Log | Weathering | Field Strength (Soil, Rock) | Scala Penetrometer (blows / 50 mm) | Samples | Tests



Tests:

Scala No. 1: 1, 1, 1, 1, 1, 2, 2, 2, 1, 2, 1, 2, 1, 2, 1, 2, 21, 2, 1, 2

Scala No. 2: 2, 1, 1, 2, 2, 3, 2, 4, 4, 6, 14, 10

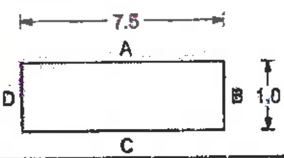
IV: 1 — 6, 6, 5
IV: 2 — 5, 5, 5
IV: 3 — 6, 7, 5

SKETCH:

MAP

1:1,000

Shoring/Support: None
Stability:



Legend:
- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Permeability Test
- Clegg Hammer, test repetitions (IV)
- Insitu Vane Shear Strength (kPa) P=Peak, R=Residual, UTP=Unable to penetrate
- Scala Penetrometer - blows/50mm

GROUNDWATER [X] None
[ ] Slow Seep (depth)
[ ] Rapid Inflow (depth)

PIT TERMINATED DUE TO:
[X] Target depth [ ] Collapse
[ ] Refusal [ ] Machine limit

Remarks
1. Inspection pit location and elevation is approximate and subject to survey confirmation.

All dimensions in metres Scale 1:42	Contractor: Fulton Hogan	Rig/Plant Used: Machine Excavator (16 tonne)	Logged by: KC	Checked by: AvD

RILEY CONSULTANTS

Riley Consultants Limited
395 Madras Street
Christchurch 8011
Tel +64 3 379 4402
Fax +64 3 379 4403

TEST PIT LOG

Project: 311 Trents Road	Location: Prebbleton, Canterbury	Hole position: Refer to site plan	No.: TP8
Job No.: 12876	Start Date: 07-11-12 Finish Date: 07-11-12	Ground Level (m Lyttelton): 28.00	Co-Ordinates (NZTM2000): E 1,558,942.8 N 5,174,899.3
Client: D & S Anderson	Hole Depth: 4.50 m		Sheet: 1 of 1

Elevation (m Lyttelton)	Depth (m)	Geological Description	Symbolic Log	Weathering	Field Strength (Soil / Rock)	Scala Penetrometer (blows / 50 mm) 0 3 6 9 12 15 18	Samples	Tests
+28.00								
+27.75	0.25	Fine to medium silty SAND, with some rootlets, brown. (TOPSOIL)						
+27.40	0.60	Silty fine to medium SAND, light greyish brown. Loose; moist. (FINE ALLUVIUM)						
	1	Sandy GRAVEL with minor silt and trace rootlets, greyish brown. Tightly packed; moist; gravel, fine to coarse, subangular to rounded, slightly weathered greywacke sandstone; local cobbles and boulders up to 300 mm; local sand and silt lenses. (Q1a ALLUVIUM)						
	2							
	3							
	4							
+23.50	4.50							
		EOH @ 4.50 m						

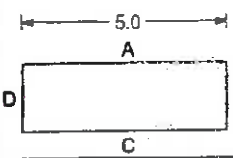
Scala Penetrometer (blows / 50 mm): No. 1; 1, 1, 2, 2, 1, 2, 3, 4, 5, 8, 10, 15

SKETCH:

MAP

1:1,000

Shoring/Support: None
Stability:



- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Permeability Test
- Clegg Hammer, test repetitions (N)
- Insitu Vane Shear Strength (kPa) P=Peak, R=Residual, UTP=Unable to penetrate
- Scala Penetrometer - blows/50mm

GROUNDWATER [X] None
[ ] Slow Seep (depth)
[ ] Rapid Inflow (depth)

PIT TERMINATED DUE TO:
[X] Target depth [ ] Collapse
[ ] Refusal [ ] Machine limit

Remarks
1. Inspection pit location and elevation is approximate and subject to survey confirmation.

All dimensions in metres Scale 1:42	Contractor: Fulton Hogan	Rig/Plant Used: Machine Excavator (16 tonne)	Logged by: KC	Checked by: AvD

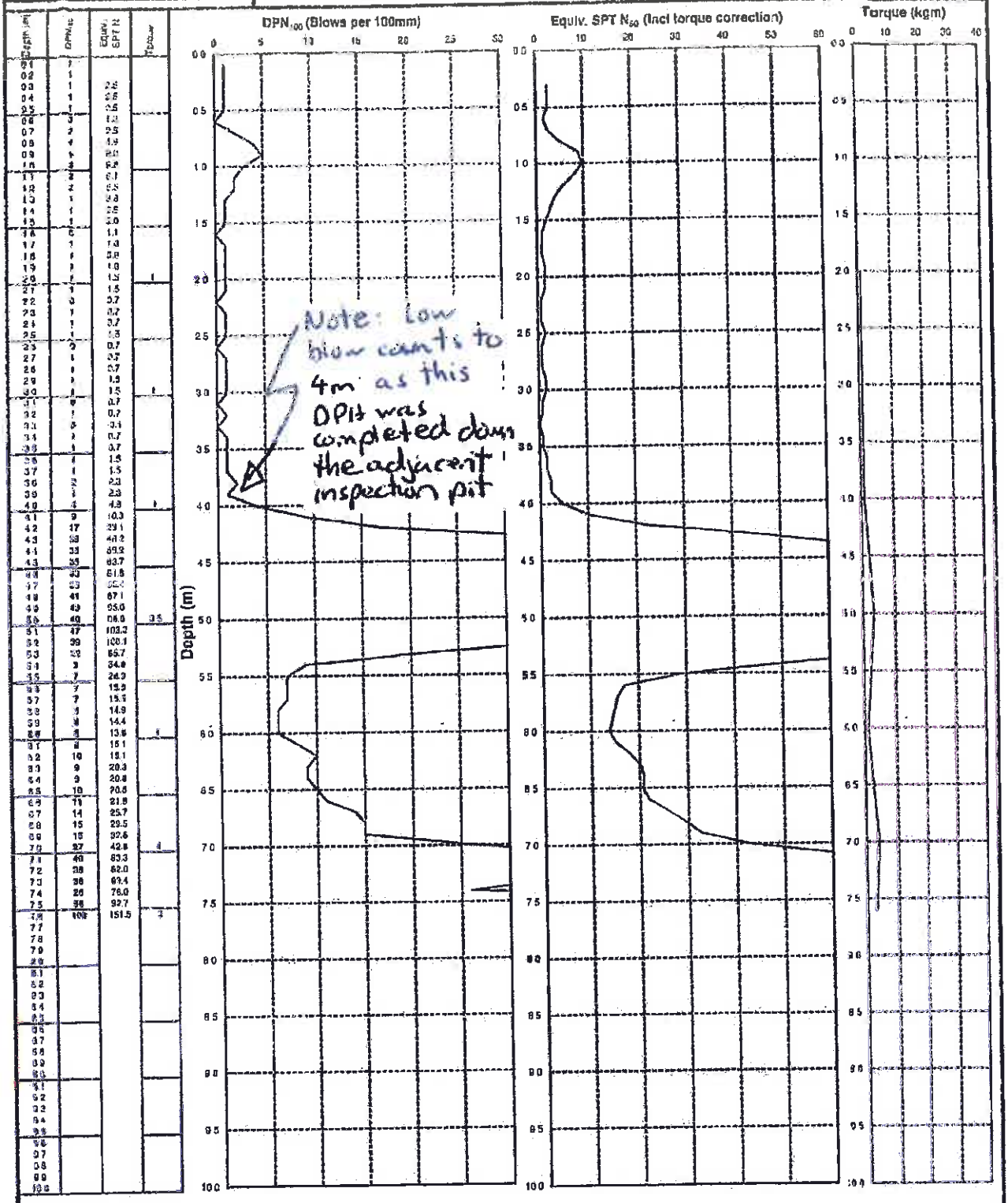
RILEY A4S3_1 NZ LIB 19.GLB Log RILEY TP - SCALA 311 TRENTS ROAD CANT.GPJ <<Drawing File Name>> 20/12/2012 16:14 Produced by <<User Profile>>

DYNAMIC PROBE TEST

DPH 3

Project Number	12876
Project:	311 Travis Road
Location:	Prebbleton

Hammer Weight	50 kg
Hammer Drop	500 mm
Tip Diameter	43.7 mm
Hammer Efficiency	70%



Date Logged	8/11/2012
Logged By	BB/SM
Testing Based on BS 1377	

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CHRISTCHURCH
TEL. 03-379 4402
FAX. 03-379 4403

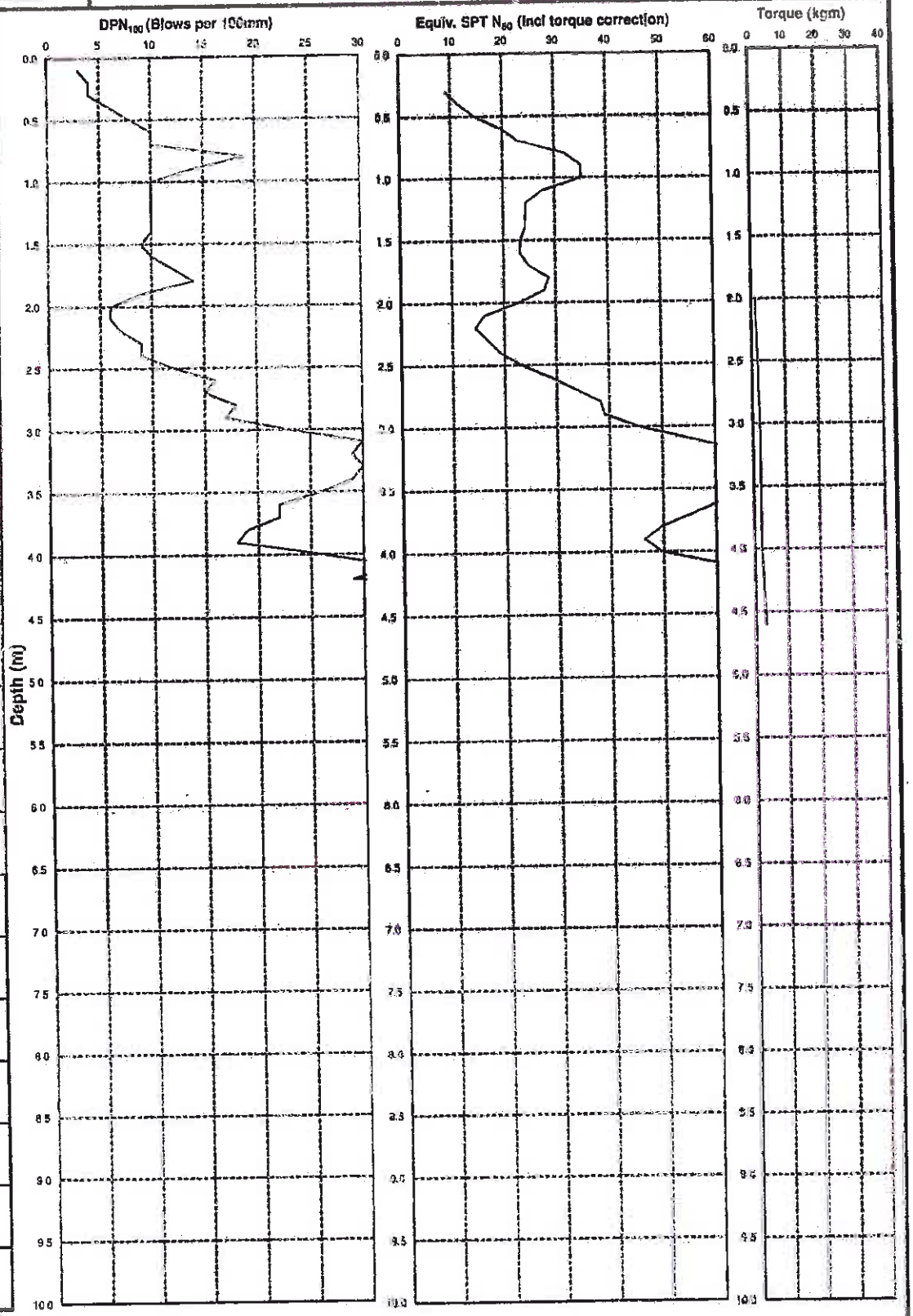
DYNAMIC PROBE TEST

DPH 4

Project Number	12876
Project:	311 Trents Road
Location:	Prebbleton

Hammer Weight	50 kg
Hammer Drop	500 mm
Tip Diameter	43.7 mm
Hammer Efficiency	70%

Depth (m)	DPN	Equiv. SPT N	Torque
0.1	3		
0.2	4		
0.3	4	9.0	
0.4	5	11.4	
0.5	6	14.7	
0.6	10	19.6	
0.7	10	22.9	
0.8	10	31.9	
0.9	14	35.1	
1.0	10	35.1	
1.1	10	27.7	
1.2	10	24.3	
1.3	10	24.2	
1.4	10	24.1	
1.5	9	23.2	
1.6	10	23.1	
1.7	12	24.7	
1.8	14	26.7	
1.9	9	27.7	
2.0	8	22.8	1
2.1	6	16.1	
2.2	7	14.4	
2.3	9	18.6	
2.4	8	19.1	
2.5	12	23.1	
2.6	16	28.7	
2.7	15	33.5	
2.8	18	38.3	
2.9	17	39.1	
3.0	23	45.6	2
3.1	30	55.3	
3.2	25	65.1	
3.3	30	70.8	
3.4	20	70.0	
3.5	26	67.8	
3.6	22	61.0	
3.7	22	55.3	
3.8	13	49.6	
3.9	13	46.3	
4.0	20	45.6	2
4.1	33	61.0	
4.2	25	70.0	
4.3	63	32.1	
4.4	54	130.7	
4.5	76	173.7	
4.6	154	212.9	3
4.7			
4.8			
4.9			
5.0			
5.1			
5.2			
5.3			
5.4			
5.5			
5.6			
5.7			
5.8			
5.9			
6.0			
6.1			
6.2			
6.3			
6.4			
6.5			
6.6			
6.7			
6.8			
6.9			
7.0			
7.1			
7.2			
7.3			
7.4			
7.5			
7.6			
7.7			
7.8			
7.9			
8.0			
8.1			
8.2			
8.3			
8.4			
8.5			
8.6			
8.7			
8.8			
8.9			
9.0			
9.1			
9.2			
9.3			
9.4			
9.5			
9.6			
9.7			
9.8			
9.9			
10.0			



Date Logged	8/11/2012
Logged By	SE/SM
Testing Based on BS 1377	

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APPENDIX C

Ecan Well Logs

Bore or Well No: M36/8391
Well Name:
Owner: MR G J & MRS J L TOD

Environment Canterbury
Your regional council

Street of Well: TRENTS ROAD
Locality: PREBBLETON
NZGM Grid Reference: M36:6935-3628 QAR 3
NZGM X-Y: 2469350 - 5736280
Location Description:
ECan Monitoring:
Well Status: Active (exist, present)

File No: CO6C/4838
Allocation Zone: Selwyn-Waimakariri
Uses: Domestic Supply

Drill Date: 08 Jun 2007
Well Depth: 22.00m -GL
Initial Water Depth: -22.30m -MP
Diameter: 150mm

Water Level Count: 0
Strata Layers: 6
Aquifer Tests: 0
Isotope Data: 0
Yield/Drawdown Tests: 1

Measuring Point Alt: 27.66m MSD QAR 4
GL Around Well: -0.30m -MP
MP Description: ToC

Highest GW Level:
Lowest GW Level:
First Reading:
Last Reading:
Calc. Min. GWL:
Last Updated: 05 Sep 2007
Last Field Check:

Driller: Smiths Welldrilling
Drilling Method: Rotary/Percussion
Casing Material: Steel
Pump Type:
Yield: 3 l/s
Drawdown: 2 m
Specific Capacity: 1.71 l/s/m

Aquifer Type:
Aquifer Name:

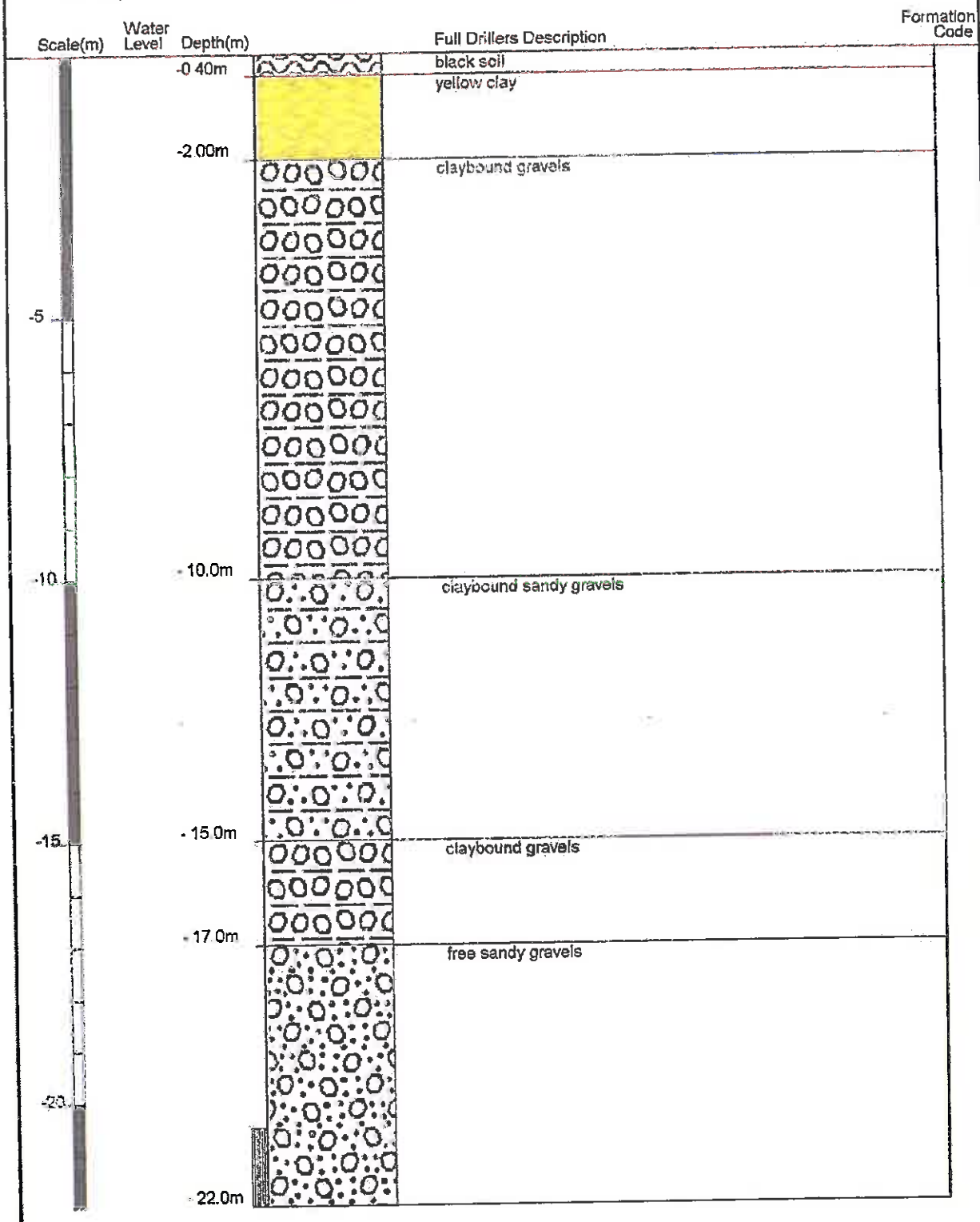
Screens:
Screen Type: Stainless steel
Top GL: 20.50m
Bottom GL: 22.00m

Date	Comments
09 Aug 2007	Gridref changed from: M36:6936-3627, BCR confirms

Borelog for well M36/8391

Gridref: M36:6935-3628 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 27 +MSD
Driller : Smiths Welldrilling
Drill Method : Rotary/Percussion
Drill Depth : -22m Drill Date : 8/06/2007

Environment Canterbury



Bore or Well No: M36/5606
Well Name:
Owner: GARDINER, HJ

Environment Canterbury
Your regional council

Street of Well: CNR SHANDS AND TRENTS ROAD
File No: CO6C/14410
Locality: HORNBY
Allocation Zone: Selwyn-Waimakariri
NZGM Grid Reference: M36:6890-3645 QAR 4
NZGM X-Y: 2468900 - 5736450
Location Description:
Uses: Domestic and Stockwater
ECan Monitoring:
Well Status: Active (exist, present)

Drill Date: 02 Apr 1998
Water Level Count: 0
Well Depth: 31.50m -GL
Strata Layers: 10
Initial Water Depth: -11.53m -MP
Aquifer Tests: 0
Diameter: 150mm
Isotope Data: 0
Yield/Drawdown Tests: 1

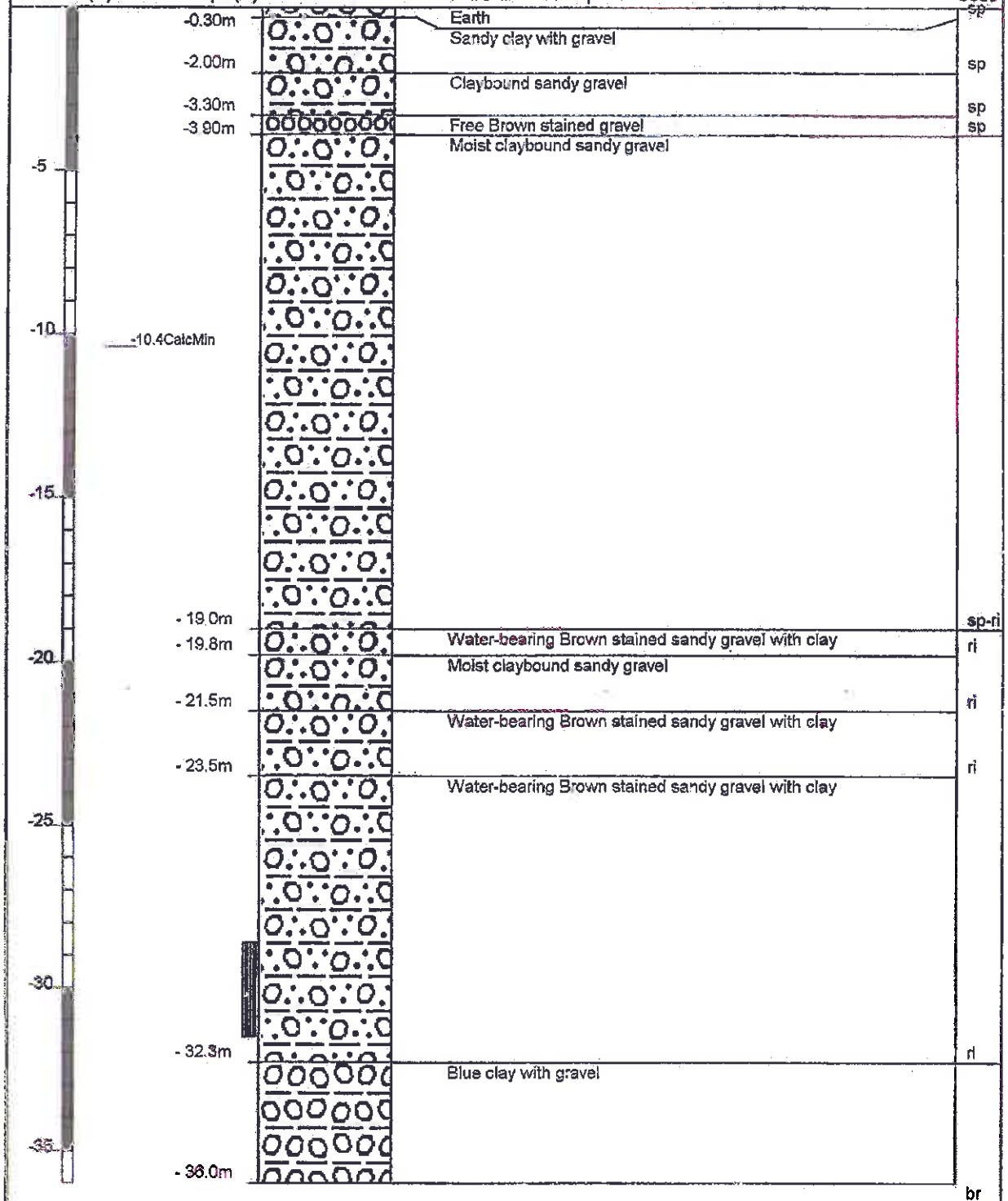
Measuring Point Alt: 28.00m MSD QAR 3
Highest GW Level:
GL Around Well: 0.00m -MP
Lowest GW Level:
MP Description:
First Reading:
Last Reading:
Driller: McMillan Water Wells Ltd
Calc. Min. GWL: -10.40m -MP
Drilling Method: Rotary/Percussion
Last Updated: 29 Jan 2003
Casing Material: STEEL
Last Field Check:
Pump Type:
Yield: 2 l/s
Screens:
Drawdown: 2 m
Screen Type: Stainless steel
Specific Capacity: 1.52 l/s/m
Top GL: 28.60m
Bottom GL: 31.50m
Aquifer Type:
Aquifer Name: Riccarton Gravel

Date	Comments
01 Mar 2000	Dev 2hrs, pumped 2hrs

Borelog for well M36/5606

Gridref: M36:6890-3645 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 28 +MSD
Driller : McMillan Water Wells Ltd
Drill Method : Rotary/Percussion
Drill Depth : -36m Drill Date : 2/04/1998

Environment Canterbury
Your regional council



Bore or Well No: M36/5356
Well Name:
Owner: VERSEY, R & J

Environment Canterbury

Street of Well: TRENTS ROAD
Locality: PREBBLETON
NZGM Grid Reference: M36:6945-3618 QAR 4
NZGM X-Y: 2469450 - 5736180
Location Description: ADJACENT TO HOUSE
ECan Monitoring:
Well Status: Active (exist, present)

File No: CO6C/03685
Allocation Zone: Selwyn-Waimakariri

Uses: Domestic Supply
Irrigation

Drill Date: 05 Nov 1997
Well Depth: 24.00m -GL
Initial Water Depth: -8.50m -MP
Diameter: 150mm

Measuring Point Alt: 27.00m MSD QAR 3
GL Around Well: -0.20m -MP
MP Description: ToC

Driller: Smiths Welldrilling
Drilling Method: Rotary Rig
Casing Material: STEEL
Pump Type:
Yield: 4 l/s
Drawdown: 2 m
Specific Capacity: 1.56 l/s/m

Aquifer Type:
Aquifer Name: Riccarton Gravel

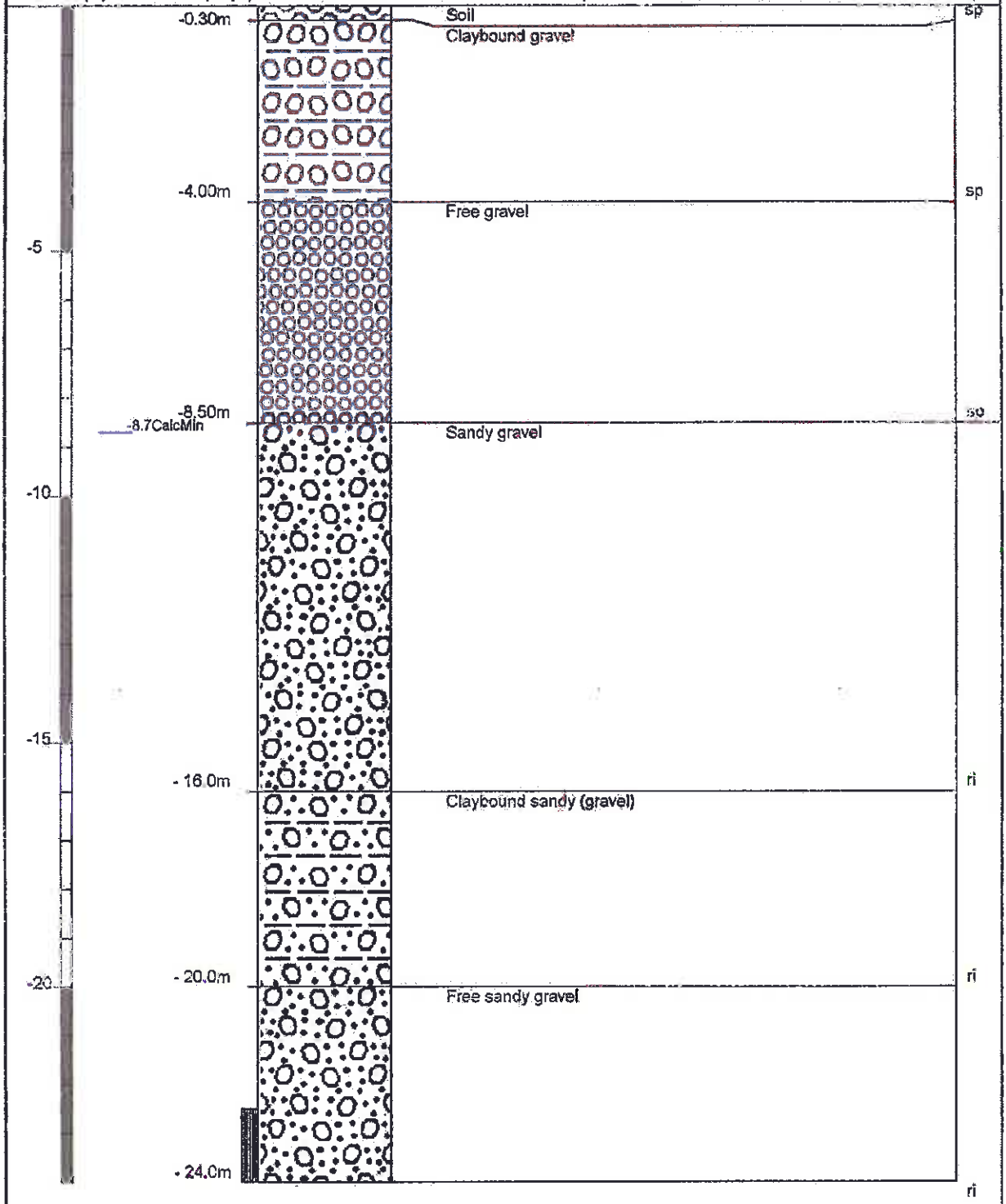
Water Level Count: 0
Strata Layers: 6
Aquifer Tests: 0
Isotope Data: 0
Yield/Drawdown Tests: 1

Highest GW Level:
Lowest GW Level:
First Reading:
Last Reading:
Calc. Min. GWL: -8.70m -MP
Last Updated: 29 Jan 2003
Last Field Check:

Screens:
Screen Type: Stainless steel
Top GL: 22.50m
Bottom GL: 24.00m

Borelog for well M36/5356

Gridref: M36:6945-3618 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 27 +MSD
Driller : Smiths Welldrilling
Drill Method : Rotary Rig
Drill Depth : -24m Drill Date : 5/11/1997



Bore or Well No: M36/4677
Well Name:
Owner: MILLS, K.

Environment Canterbury
Your regional council

Street of Well: TRENTS ROAD
Locality: PREBBLETON
NZGM Grid Reference: M36:69518-36217 QAR 2
NZGM X-Y: 2469518 - 5736217
Location Description:
ECan Monitoring:
Well Status: Active (exist, present)

File No: CO6C/03946
Allocation Zone: Selwyn-Waimakariri
Uses: Domestic Supply
Irrigation

Drill Date: 16 Oct 1996
Well Depth: 46.00m -GL
Initial Water Depth: -5.80m -MP
Diameter: 150mm

Water Level Count: 0
Strata Layers: 9
Aquifer Tests: 0
Isotope Data: 0
Yield/Drawdown Tests: 1

Measuring Point Alt: 27.07m MSD QAR 4
GL Around Well: 0.00m -MP
MP Description:

Highest GW Level:
Lowest GW Level:
First Reading:
Last Reading:

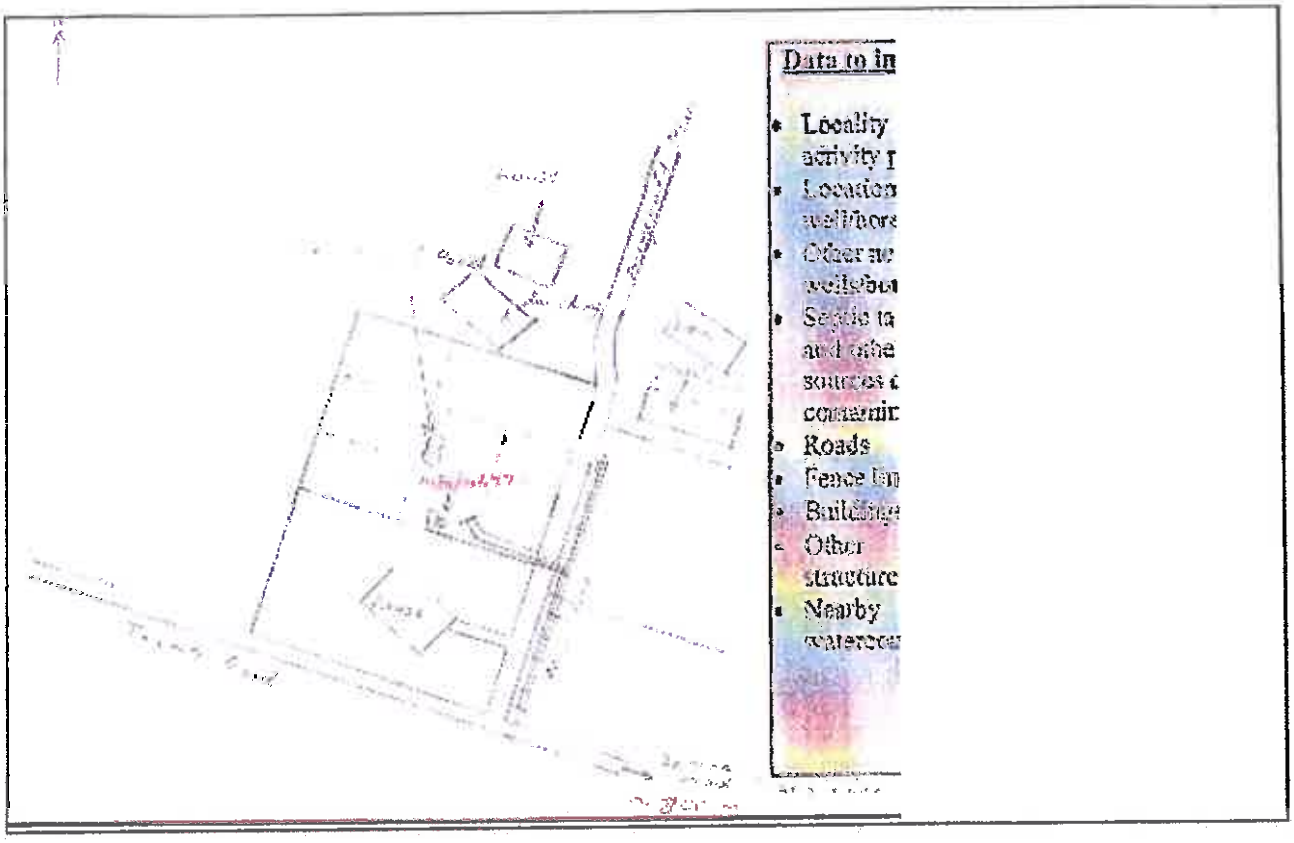
Driller: Dynes Road Drilling
Drilling Method: Cable Tool
Casing Material:
Pump Type: Submersible
Yield: 4 l/s
Drawdown: 25 m
Specific Capacity: 0.15 l/s/m

Calc. Min. GWL: -7.80m -MP
Last Updated: 31 Jan 2007
Last Field Check: 13 May 1997

Screens:
Screen Type: Stainless steel
Top GL: 44.50m
Bottom GL: 46.00m

Aquifer Type: Non-Flowing Artesian
Aquifer Name: Linwood Gravel

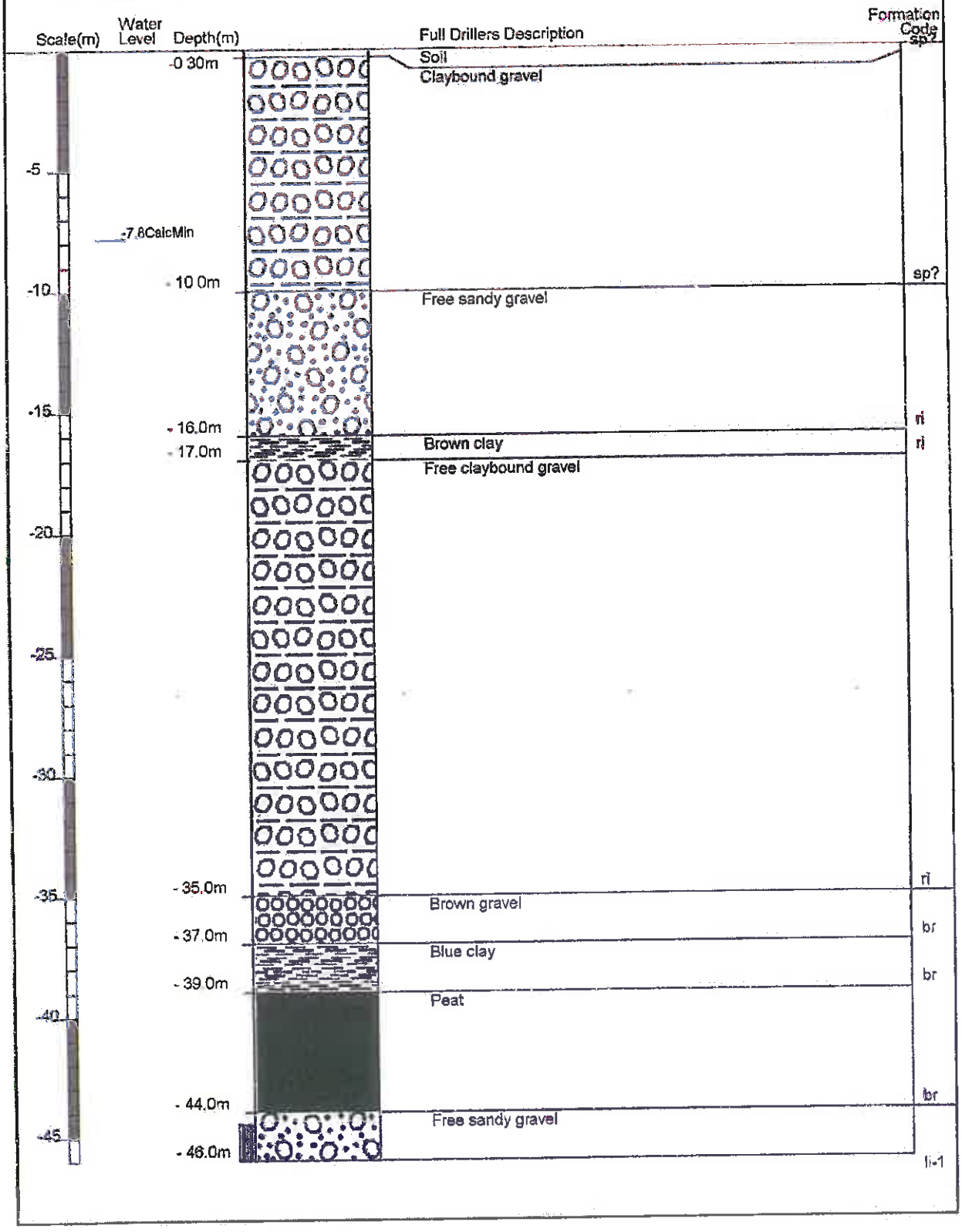
Date	Comments
16 Aug 2002	Same log as M36/4728


Data to in
Locality
activity
Location
wellhead
Other ac
wellhead
Septic ta
and othe
sources
contamin
Roads
Fence lin
Building
Other
structure
Nearby
waterco

Borelog for well M36/4677

Gridref: M36:69518-36217 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 26 +MSD
Driller : Dynes Road Drilling
Drill Method : Cable Tool
Drill Depth : -46m Drill Date : 16/10/1996

Environment Canterbury



Bore or Well No: M36/3775
Well Name:
Owner: Mr & Mrs D J & S J Anderson

Environment Canterbury
Your regional council

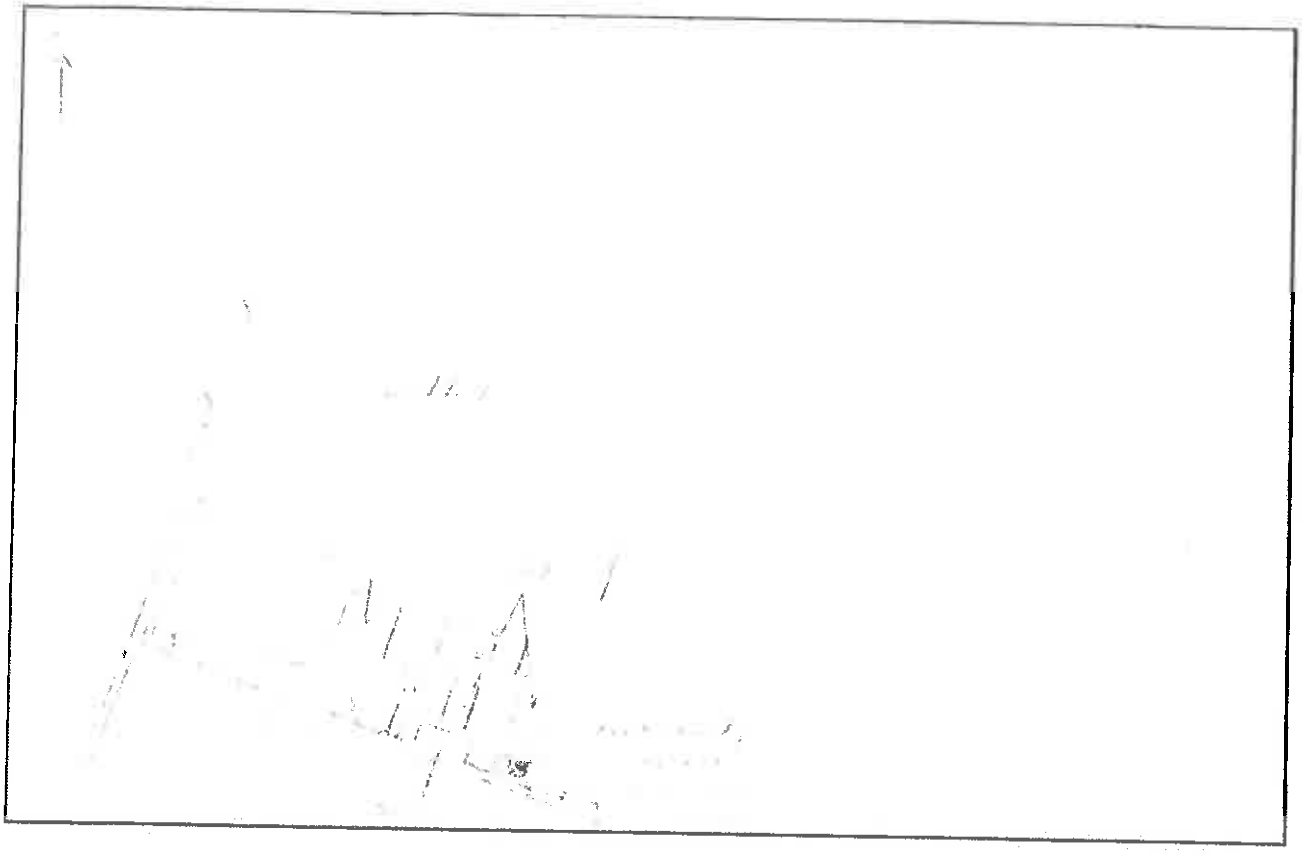
Street of Well: 311 TRENTS RD
File No: CO6C/00048
Locality: PREBBLETON
Allocation Zone: Selwyn-Waimakariri
NZGM Grid Reference: M36:69030-36450 QAR 2
NZGM X-Y: 2469030 - 5736450
Location Description:
Uses: Domestic and Stockwater Irrigation
ECan Monitoring:
Well Status: Active (exist, present)

Drill Date: 12 Jul 1987
Water Level Count: 0
Well Depth: 46.00m -GL
Strata Layers: 13
Initial Water Depth: -7.50m -MP
Aquifer Tests: 0
Diameter: 100mm
Isotope Data: 0
Yield/Drawdown Tests: 2

Measuring Point Alt: 28.18m MSD QAR 4
Highest GW Level:
GL Around Well: 0.00m -MP
Lowest GW Level:
MP Description:
First Reading:
Last Reading:

Driller: Smith, J R & I G
Calc. Min. GWL: -9.30m -MP
Drilling Method: Cable Tool
Last Updated: 30 Mar 2010
Casing Material: STEEL
Last Field Check: 11 Mar 2010
Pump Type: Unknown
Yield: 6 l/s
Screens:
Drawdown: 2 m
Screen Type: Stainless steel
Specific Capacity: 2.85 l/s/m
Top GL: 44.50m
Bottom GL: 46.00m

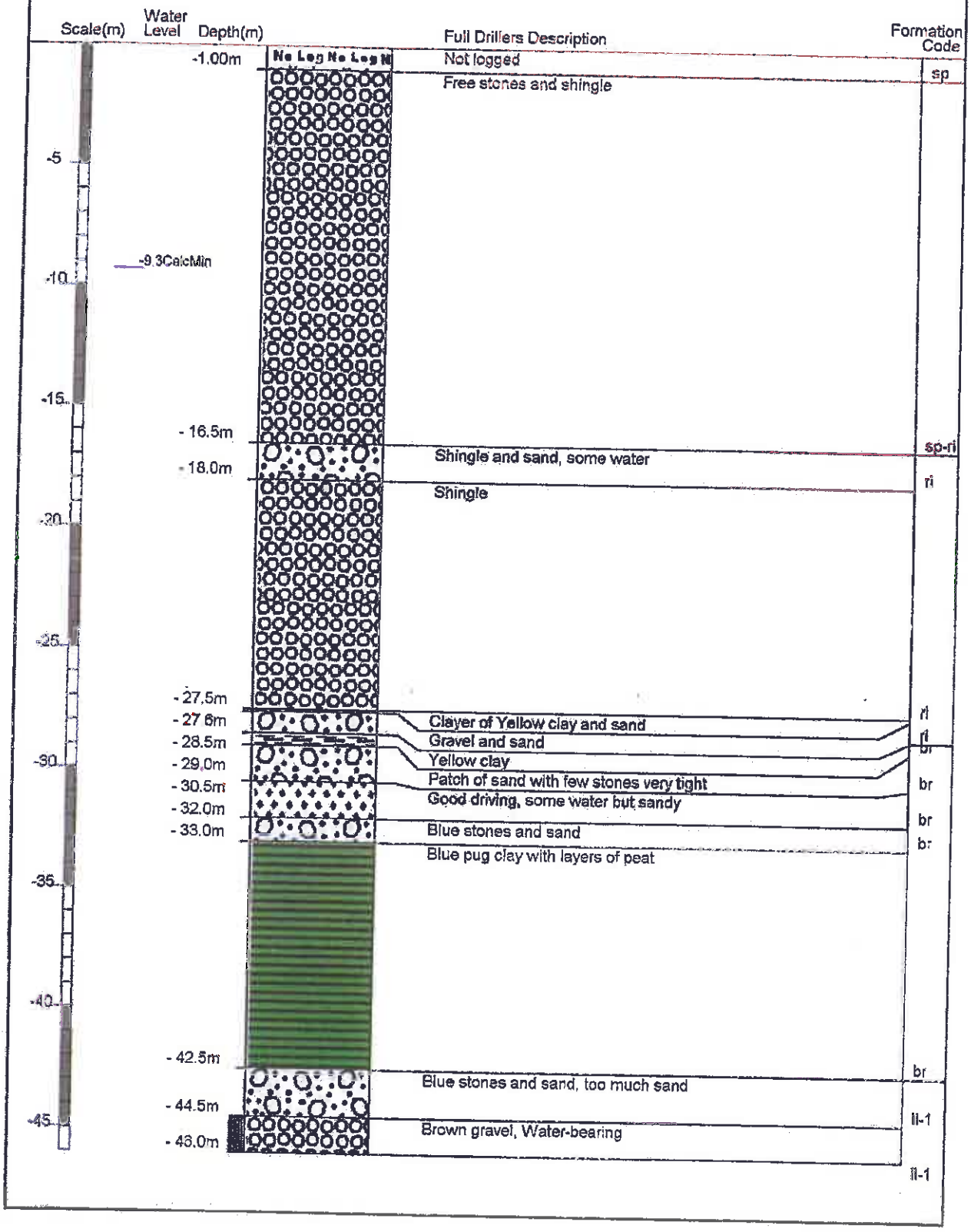
Aquifer Type: Non-Flowing Artesian
Aquifer Name: Linwood Gravel



Borelog for well M36/3775

Gridref: M36:69030-36450 Accuracy : 2 (1=best, 4=worst)
Ground Level Altitude : 28 +MSD
Driller : Smith, J R & I G
Drill Method : Cable Tool
Drill Depth : -46m Drill Date : 12/07/1987

Environment Canterbury
Your regional council



APPENDIX D

Infiltration Test Results and Calculations

RILEY CONSULTANTS

Job No: 12076	Page: 1 of 1	Pages	
Project: 31 TRENTS ROAD PREBBLETON			
Calc:	Date: 7/12/12		
Check:	Date:		

Description: Soil Infiltration Rate Calculations

Soil Infiltration rate : $f = \frac{V_{p75-25}}{apso \times t_{p75-25}}$

where :

V_{p75-25} = the effective storage volume of water in the pit between 75% and 25% effective depth

apso : the internal surface area of the final pit up to 50% effective depth and including the base area.

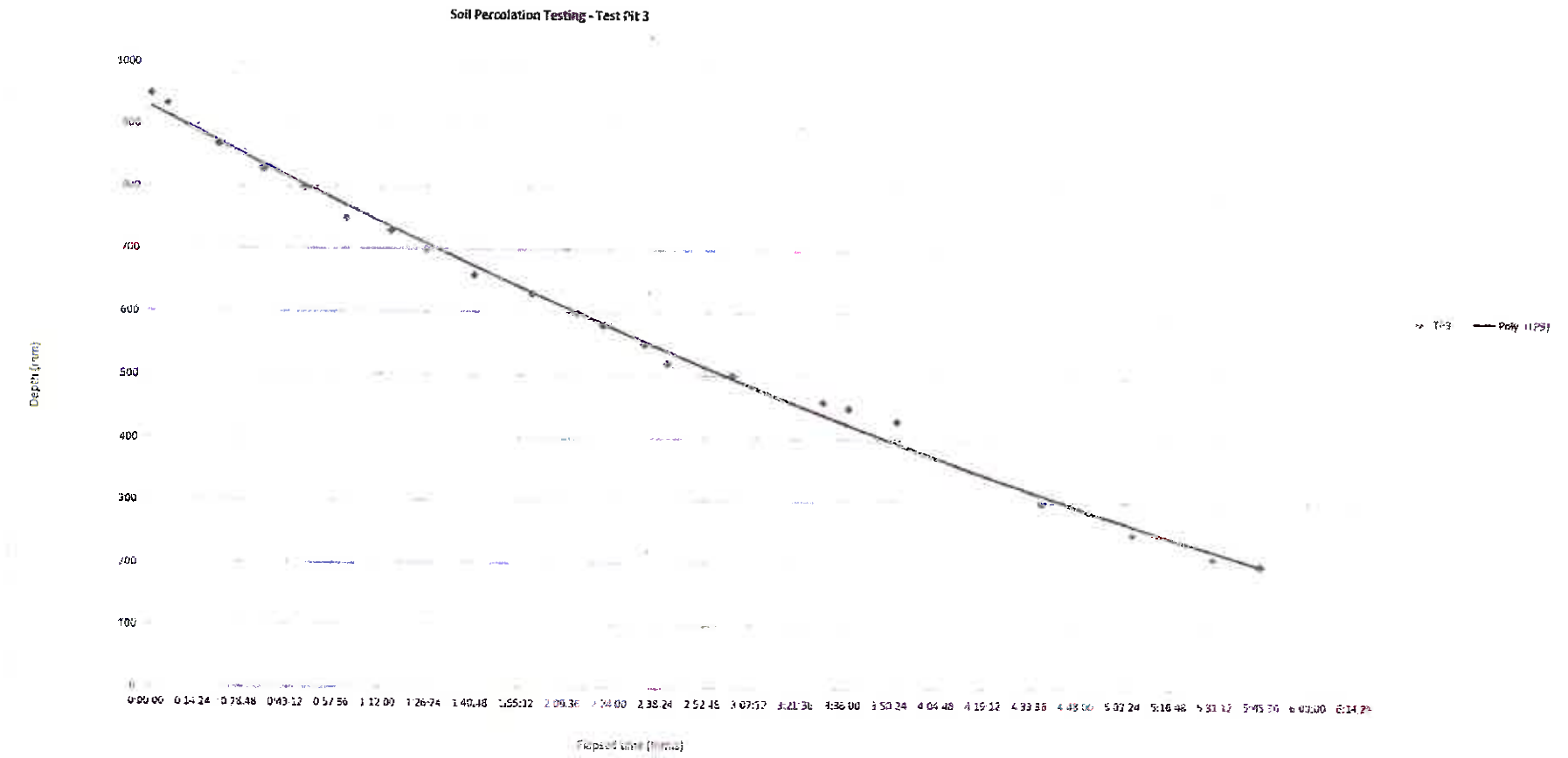
t_{p25-25} = the time for the water level to fall from 75% to 25% effective depth

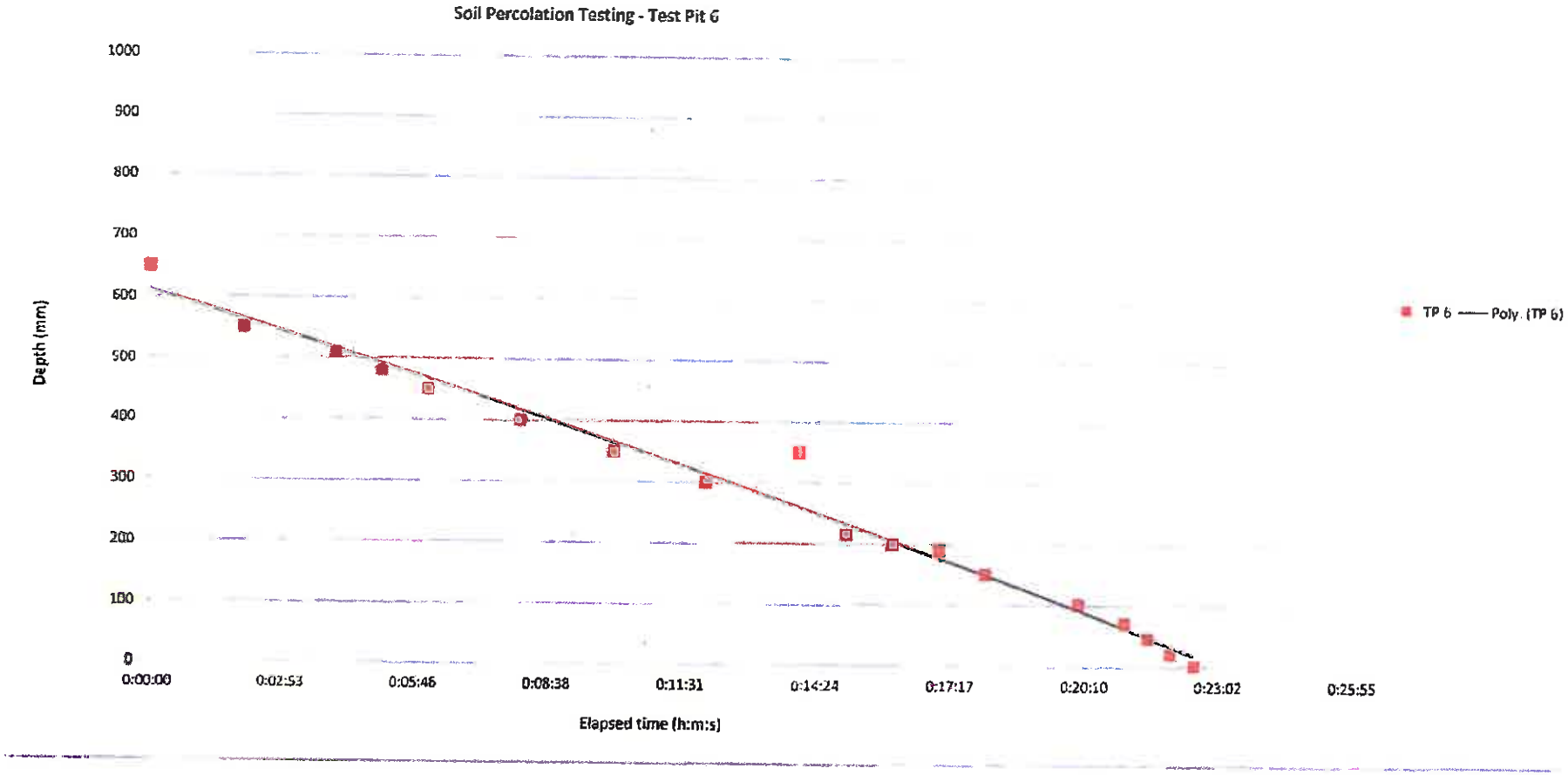
Test Pit No. 3

$$f = \frac{1.89\ m^3}{4.68\ m^2 \times 13643\ s} = 2.96 \times 10^{-5}\ m/s$$

Test Pit No. 6

$$f = \frac{2.09\ m^3}{10.49\ m^2 \times 720\ s} = 2.72 \times 10^{-4}\ m/s$$


Soil Percolation Testing - Test Pit 3
1000
900
800
700
600
500
400
300
200
100
0
Depth (mm)
0:00:00
0:14:24
0:28:48
0:43:12
0:57:36
1:12:00
1:26:24
1:40:48
1:55:12
2:09:36
2:24:00
2:38:24
2:52:48
3:07:12
3:21:36
3:36:00
3:50:24
4:04:48
4:19:12
4:33:36
4:48:00
5:02:24
5:16:48
5:31:12
5:45:36
6:00:00
6:14:24
Elapsed time (hr:min)
T1-3
Poly. (T1-3)


Soil Percolation Testing - Test Pit 6
Depth (mm)
1000
900
800
700
600
500
400
300
200
100
0
0:00:00
0:02:53
0:05:46
0:08:38
0:11:31
0:14:24
0:17:17
0:20:10
0:23:02
0:25:55
Elapsed time (h:m:s)
TP 6
Poly. (TP 6)

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