



Geotechnical Report

19 Woodside Terrace
Andersons Bay, Dunedin

Report prepared for:

[Redacted]

Report prepared by:

GeoSolve Limited

Distribution:

[Redacted]

GeoSolve Limited (File)

September 2018

GeoSolve Ref: 180505

Revision	Issue Date	Purpose	Author	Reviewed
1		Client issue	MB	CEM



GEOTECHNICAL



WATER RESOURCES



PAVEMENTS



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1 Introduction

1.1 General

This report presents the results of geotechnical investigations carried out by GeoSolve Ltd in order to determine subsoil conditions, provide geotechnical inputs and to determine if the extent of works proposed are appropriate for 19 Woodside Terrace. Geotechnical design parameters for foundation and retaining wall design are also provided.



Figure 1.1 – Proposed building platform, 19 Woodside Terrace

The investigations were carried out for Alastair Mortensen in accordance with GeoSolve Ltd's proposal dated 7 August 2018, which outlines the scope of work and conditions of engagement.

1.2 Development

We understand the proposed development is for the development of a vacant residential section into eight adjoining, multilevel apartments.

We understand that the current proposal is to establish a series of level building platforms along the elevated extent of the site to support the garage, with two levels of each apartment above. The intent is to cut into the slope to allow foundations to be constructed



on cut material below the garage. Cuts to establish the building platforms are estimated to be approximately 2-4 m.

Excavated soil from the building platforms, is to be placed adjacent to Woodside Terrace at the bottom of the slope, infilling a small gully to provide a flat area for additional carparking.

Latest plans show an access way to be constructed by retention of both cut and fill material. Retained heights along the accessway are up to 4-5 m. It is understood gabion basket style retaining walls are currently being considered, with geogrid reinforcement in the compacted engineered fill. The accessway will turn adjacent to the apartments and flatten to provide access into garages and provide guest carparking. Development plans are shown in Appendix A Figure 1.

Gradients of the accessway are expected to be approximately 1 in 5 with transition zones between changes in slopes.



2 Site Description

2.1 General

The subject property is located in the Dunedin suburb of Andersons Bay which is situated approximately 4 km southeast of central Dunedin.

The property is accessed from the southern boundary adjoining Woodside Terrace and lies on the slopes above Anderson Bay.

The site is currently undeveloped and bounded by residential properties. The section has recently been cleared of native trees and shrubs.

2.2 Topography and Surface Drainage

The building site has been surveyed and the site topography is shown in Figure 1, Appendix A.

The building site occupies the flanks of an incised valley sloping to the south towards Woodside Terrace. The slope is approximately 25 ° at its steepest and flattens out to 10° at the top where the proposed building platforms are located.

The difference in elevation between the highest and lowest surveyed parts of the site is approximately 26 m.

A watercourse is present at the base of the slope. A culvert is proposed to channel the water across this section, allowing the infilling of the gully to accommodate carparking. Seepages are evident at the base of the slope.

3 Geotechnical Investigations

An engineering geological site assessment has been undertaken with confirmatory subsurface investigations. GeoSolve Ltd visited the subject property on 21 August 2018, undertaking geotechnical investigations comprising:

- Six test pits advancing to a maximum depth of 1.8 m.
- Track cuttings were logged at AH6 and AH7 with the hole further advanced using a hand auger to 1.2 m and 1.0 m respectively.
- Dynamic cone (Scala) penetrometer tests were undertaken at each test pit location advancing to refusal.

Test pit and Scala penetrometer locations and logs are contained in Appendices A and B respectively.



4 Subsurface Conditions

4.1 Geological Setting

4.1.1 Regional Geology

The geology of the Dunedin area is dominated by volcanic rock types of basaltic to andesitic composition that were intruded through pre-existing marine sediments during Miocene times. Extensive volcanism at that time produced lava flows and bedded volcanoclastic materials were widely distributed by eruptions. The generalized stratigraphic profile comprises schist at depth, overlain by a Cretaceous to Tertiary-age sequence; initially by thin non-marine sediments and then a thick accumulation of marine sediments including sandstones and mudstones. The volcanic rock types cross cut these sediments where vents were present and extensively mantle them where lava flows or volcanic ejecta were deposited.

More recently (Pleistocene times), the hills of Dunedin have been extensively mantled by windblown loess to depths of up to several metres. Watercourses and tidal embayments such as Otago Harbour have locally deposited alluvial, estuarine and marine deposits and generally modified the volcanic landscape by deep incision and sedimentation. Fill and refuse has been placed locally during post-settlement times. Landslips have occurred on steeper hillsides particularly where springs emerge or where fills have been placed.

4.1.2 Seismicity

Dunedin has traditionally been considered to have lower than average seismic activity when compared to other areas in New Zealand, however nearby active faults are known and strong shaking is certain to occur periodically.

McCahon et al¹ states that the earthquake hazard in Dunedin is dominated by relatively infrequent moderate to large earthquakes (magnitude up to M_w 7.5) in eastern Otago, and large to very large earthquakes in the much more seismically active Fiordland and Westland regions.

The nearest active faults with demonstrated Late Quaternary movement history are the Green Island Fault and the Akatore Fault. The Green Island Fault is currently considered to be the cause of the 1974 earthquake that caused damage in Dunedin. The fault's projection is believed to continue through South Dunedin and may run northeast up the harbour in which case it would pass within about 2 km of the site. The Akatore Fault has also been projected beneath South Dunedin; the fault likely continues beneath South Dunedin and may run northeast up the harbour as well. Sheared fault rocks have been identified in recent drilling near Portsmouth Drive indicating continuation of fault traces up the harbour is very probable. It should be noted the fault terminations shown on fault trace maps are often approximations (owing to lack of data) and the presence of other active faults may be unknown because they may be obscured by overburden soils. Both of these faults are likely to be capable of generating magnitude 7.5 earthquakes in Dunedin. Other known faults that

¹ McCahon, I.F., Yetton, M.D., Cook, D.R.L. (1993). The Earthquake Hazard in Dunedin. EQC report 91/56.



have some potential to cause strong shaking in Dunedin are the Titri Fault and the North Taieri Fault, located roughly 10 km and 17 km west of the site, respectively.

The above faults are not included in Table 3.6 of NZS 1170.5:2004 as major faults requiring near fault factors when assessing structural design actions. Recent events in Canterbury have highlighted the issue that previously unidentified faults may be very significant factors in the actual future risk applying to any particular site.

Strong ground shaking throughout the South Island is likely to be associated with a rupture of the Alpine Fault, located along the West Coast of South Island. There is a high probability an earthquake with an expected magnitude of over 7.5 will occur along the Alpine Fault within the next 50 years.

Average return periods for shaking intensity are: MM 7 = 100 years, MM 8 = 450 years and MM 9 = >2,500 years. The most recent major earthquake to affect Dunedin occurred in 1974 and produced damage consistent with MM 7 intensity.

4.2 Stratigraphy

An engineering geological model for the site is shown in Figure 2 and 3, Appendix A. Apart from the thin layer of surficial topsoil, the site is underlain by colluvium deposits which overlie volcanic rock.

Topsoil comprises soft organic SILT with rootlets. Topsoil thickness is between 0.15 m and 0.5 m.

Underlying topsoil at all test pit locations is **colluvium**. Colluvium comprises SILT with some to minor clay and trace amounts of sand and gravel. Colluvium was soft to hard in condition. Colluvium thickness was between 0.3 m and 1.5 m in thickness.

Underlying colluvium was variably weathered **basalt** of the Dunedin Volcanic Group. Basalt was completely to slightly weathered with varying amounts of residual clayey silt. Basalt was in very weak to moderately strong condition. Basalt was found at a depth as shallow as 0.45 m in TP2 and was not encountered at a depth of 1.8 m at TP1.

More detailed geotechnical description of soils is provided in the test pit logs contained in Appendix B.

4.3 Groundwater

Groundwater seepage was observed at 0.3 m below ground level at AH 7. Other than AH 7, soils were observed to be in moist condition. Seepage is evident at the base of the slope immediately above the stream.



4.4 Slope Stability

The area is not mapped as being proximal to known landslide activity², although there is evidence and records of active landslides on the slopes to the northeast of the site, especially on the Otago Peninsula as shown within the Dunedin City Lifelines Project³.

No evidence of any recent landslide movement or any resulting debris was identified while on site. With basaltic rock at shallow depths on this site and an absence of historical records of land slippage, the risk of deep-seated land slippage is considered to be low. Significant seepage was observed at the base of the slope but as minimal seepage was identified in the test pits it is therefore likely that groundwater is flowing within a permeable layer within the Dunedin Volcanic Group rock. The basalt observed within test pits was competent and therefore the risk of groundwater seepage inducing instability in the Dunedin Volcanic Group is low. However, the slope may be prone to near surface instability within the colluvium if stormwater is not managed appropriately.

² Barrell, D.J.A., Smith Lyttle, B., Glassey, P.J. (2017). Revised landslide database for the coastal sector of the Dunedin City district. GNS Science Consultancy Report 2017/41, 29p.

³ *Dunedin City Lifelines Project – Map 2 Landslide Distribution – Mosgiel, Dunedin City, Peninsula Area*



5 Engineering Considerations

5.1 General

The recommendations and opinions contained in this report are based upon ground investigation data obtained at discrete locations and historical information held on the GeoSolve database. The nature and continuity of subsoil conditions away from the investigation locations is inferred and cannot be guaranteed.

5.2 Geotechnical Parameters

Table 5.1 provides a summary of the recommended geotechnical design parameters for the soil materials expected to be encountered during construction of the proposed dwelling.

Table 5.1 – Recommended geotechnical design parameters

Unit	Thickness (m)	Bulk Density γ (kN/m ³)	Effective Cohesion c' (kPa)	Effective Friction ϕ' (deg)	Elastic Modulus E (kPa)	Poissons Ratio ν
Topsoil (soft organic SILT)	0.15-0.5	16	Not suitable for bearing			
Colluvium (firm becoming very stiff, SILT with some clay, trace sand and gravel)	0.3-1.5	18	0-2	30	5,000	0.3
Completely to highly weathered basalt (weak to moderately strong with some residual very stiff soils)	0.45-0.5	20	5+	30	50,000	0.3
Moderately weathered basalt (moderately strong)	Not proven	23	10+	30	100,000	0.25

5.3 Site Preparation

During the earthworks operations all topsoil, organic matter, fill and other unsuitable materials should be removed from the construction areas in accordance with the recommendations of NZS 4431:1989.

Robust, shallow graded sediment control measures should be instigated during construction where rainwater and drainage run-off over exposed soils is anticipated. If slope gradients in excess of 4% are present in soils then the construction and lining of drainage channels is recommended, e.g. with geotextile and suitably graded rock, or similarly effective armouring.



Under no circumstances should water be allowed to pond or collect near or under a foundation slab. Positive grading of the subgrade should be undertaken to prevent water ingress or ponding. Exposure to the elements should be limited for all soils.

All fill that is utilised as bearing for foundations should be placed and compacted in accordance with the recommendations of NZS 4431:1989 and certification provided to that effect. The excavated colluvium soils may be suitable to be used as engineered fill. However, we recommend that cohesive fill not be placed and compacted during winter months, and only when fair weather is expected as significant softening can occur when the soils become wet. An earthfill specification can be provided on request.

We recommend topsoil stripping and subsequent earthworks be undertaken only when a suitable interval of fair weather is expected, or during the earthworks construction season.

5.4 Excavations

Architectural and survey drawings provided to us indicate maximum cut excavations are estimated to be in the order of 4 m. In this case it is expected that these cuts will be made in colluvium and basalt.

A resource consent for the earthworks will likely be required and this should be in place prior to construction; we recommend that this should be discussed with the DCC planning department at an early stage.

The upper 0.5-1 m of the excavations are likely to be easily excavated by conventional methods; however, the rippability of the rock has not been proven to the full depth of the proposed cut and hence some rock-breaking may be required. For this reason, we recommend early confirmatory pilot cuts as the presence of strong rock could result in significant additional excavation costs.

At this stage, we expect that the majority of the cut will be in colluvium or variably weathered volcanic rock which is likely to stand readily at moderate to steep angles, providing the soil materials are dry in condition. Wet/saturated soils will require flatter temporary batters. If unexpected conditions are encountered then some contingency for temporary support may be required. Depending on final retaining wall design and locations some temporary support may be required for safe construction of the walls.

It is also important to consider the need for safe worker access to the rear of any concrete block walls integral to the dwelling (e.g. for waterproofing) and hence some measures to address safe access may be required as there is likely to be a sub-vertical cut locally up to 4 m behind the wall. A working space of at least 1 m is recommended between any basement walls and the toe of the cuts.

Recommendations for temporary and permanent batter slope angles are described below in Table 5.2 for dry to moist soils. Slopes that are required to be steeper than those described below should be structurally retained or subject to specific geotechnical design.

All slopes should be periodically monitored during construction for signs of instability and excessive erosion, and where necessary, corrective measures should be implemented to the satisfaction of a geotechnical engineer or engineering geologist.



Minor seepage was encountered during test pitting and maybe encountered during excavations. A geotechnical practitioner should inspect any seepage, spring flow or under-runners that may be encountered during construction.

Table 5.2 – Recommended batters for permanent cuts up to 3 m in height

Material Type	Recommended maximum batter angles for <u>temporary</u> cut slopes formed in <u>dry</u> soil up to 3m in height (horizontal to vertical)	Recommended maximum batter angles for <u>permanent</u> <u>dry</u> slopes up to 3 m in height (horizontal to vertical)
Fill, Topsoil	2 : 1	2 : 1.
Colluvium	1 : 1 (subject to confirmation)	1.5 : 1
Weathered Highly Weathered Basalt	0.25 : 1 to 0.5 : 1 (subject to confirmation)	1 : 1

5.5 Engineered Fill

Engineered fill is currently being proposed to provide geogrid incorporated reinforcement behind accessway retaining walls and for car park construction.

If any re-use of the excavated soils on the site as engineered fill is required, then an earthfill specification can be supplied on request. Laboratory testing and verification will be required and boulders and cobbles over 75 mm in size will need to be screened from engineered fill sources. For landscaping purposes (where loads are not applied), certification is generally not required but we recommend that a compaction methodology should be specified to minimise future settlement and landslip risk in yard areas.

For engineered fills, the contractor will need to submit a sample of the proposed fill materials (possibly more than one) to obtain laboratory compaction curves, and in-situ Nuclear Density Meter (NDM) testing of the fill will need to be arranged. An engineer will need to specify the fill methodology and review the lab results to ensure that a producer statement can be issued; this will be required for code compliance.

All fill slopes less than 3 m in height should be constructed with a maximum batter of 2:1 (horizontal to vertical) or flatter, if well drained. To minimise erosion, effective vegetation cover should be established on fill batters and no water flows should be directed to these slopes. Thicker or steeper fills will require specific engineering assessment and design.

The subgrade of any proposed fills will need to be sub-horizontal (with benching of slopes as required) to ensure stability.

Maintaining the moisture content of any cohesive fill soils to achieve the required compaction will need to be addressed by the contractor. It is recommended that cut to fill soils be placed and compacted immediately as they are excavated, as stockpiling and reworking is highly likely to degrade the compaction properties of the soils.



Engineered fill specification and certification to NZS 4431:1989 can be provided on request.

5.6 Ground Retention

The proposed building development incorporates retaining walls up to approximately 5 m in height. Retention will occur of both cut faces and placed fill and gabion baskets are currently being proposed for retention of accessways.

We note that the current plans have the rear walls of the buildings performing a retaining function. The earth pressures on the lower parts of these walls will be dependent on the nature of the rock encountered during bulk excavations. Although strong rock will exert minimal pressure on a retaining wall, some forces may be exerted by unstable rock wedges, or where the rock is more weathered.

The accessway retaining walls are to be built on sloping ground. Typically gravity walls such as gabions are not used on sloping ground due to bearing capacity issues. In this case, provided the gabions are well founded on rock, this should not be an issue, but should be considered by the designer.

All retaining walls should be designed by a Chartered Professional Engineer using the geotechnical parameters recommended in Table 5.1 of this report. Due allowance should be made during the detailed design of all retaining walls for forces such as surcharge due to the sloping ground surface behind and at the base of the retaining walls, groundwater, seismic and structural loads from the upslope dwelling and accessway.

All temporary slopes for retaining wall construction should be battered in accordance with the recommendations outlined in Table 5.2 of this report. Where these batter slopes cannot be achieved temporary retaining will be required.

Groundwater was not identified in the test pits but has the potential to develop following completion of the earthworks, in particular as a result of heavy or prolonged rainfall. To ensure potential groundwater seeps and flows are properly controlled behind the retaining walls, the following recommendations are provided:

- A minimum 0.3 m width of durable free draining granular material should be placed behind all retaining structures;
- A heavy duty non-woven geotextile cloth, such as Bidim A14, should be installed between the natural ground surface and the free draining granular material to prevent siltation and blockage of the drainage media;
- A heavy-duty (TNZ F/2 Class 500) perforated pipe should be installed within the drainage material at the base of all retaining structures to minimise the risk of excessive groundwater pressures developing. This drainage pipe should be connected to the permanent piped storm water system, and;
- Comprehensive waterproofing measures should be provided to the back face of all retaining walls forming changes in floor level within the dwellings to minimise groundwater seepage into the finished buildings.



5.7 Groundwater Issues

The watertable is expected to lie well below the indicated finished floor levels. It is important that GeoSolve be contacted should there be any seepage, spring flow or under-runners encountered during construction.

5.8 Slope Stability

No instability was identified during the time of inspection. The finished subgrade should be inspected by a geotechnical practitioner to ensure that no shear surfaces or other unstable features are exposed.

Owing to the evidence of landslide activity on adjacent hillsides, care will be required to ensure that the development does not promote slope instability on the steeper flanks of the spur. Placement of uncontrolled side-cast fill should be avoided on the slopes and adequate setbacks should be defined for structures and areas of surcharge adjacent to moderate or steep slopes. All sources of slope saturation should be eliminated by cutoff drains upslope of the cuts and no stormwater or wastewater should be discharged to these slopes.

All cuts should be subject to inspection during construction and if higher than outlined in Table 5.2 should be subject to specific design.

5.9 Foundations

It is expected the building foundations will comprise a concrete slab on strip footings. Foundations designed to NZS 3604 should be extended to bear on stiff colluvium soils or bedrock from depths of at least 0.7 m and up to 1.1 m below existing ground level, which meets the “good ground” requirements of the above standard. Table 5.3 outlines the depth to “good ground” at TP 1 to TP 5.

Table 5.3: Depth to “Good Ground” as defined by NZ3604:2011.

Test locations	TP 1	TP 2	TP 3	TP 4	TP 5
Depth to “good ground”	0.7 m	0.7 m	1.0 m	0.8 m	1.1 m

Current plans show excavations of between 1 m and 4 m are required to construct level building platforms. It is therefore expected that all foundation loads will bear directly on completely to unweathered basalt which meet the requirements of good ground (see Appendix A Cross Section A-A’).

All unsuitable materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during construction. Any fill that is utilised as bearing for foundations should be placed and compacted in accordance with NZS 4431:1989 and certification provided to that effect.



It is recommended the foundation excavations be inspected by a suitably qualified and experienced geotechnical specialist to confirm the conditions are in accordance with the assumptions and recommendations provided in this report.

5.10 Accessway

Access to the apartments will be from Woodside Terrace ascending a vertical height of approximately 16 m. Proposed alignment drawings are available and retention and fill placement will be required to form the accessway. Benching of the slope will be required to allow fill placement and to form a temporary working platform. Retaining walls should be designed as per Section 5.6 and excavations and fill placement carried out following the recommendations of Section 5.4 and Section 5.5 of this report, respectively.

Conceptual cross sections have been provided in Appendix A Figure 3 to illustrate benching and battering of slopes required for construction of the walls.

The accessway should be contoured appropriately to allow surface runoff to fall to a contour drain or equivalent in order to intercept any surface runoff.

Construction of the accessway should be carried out under the supervision of a geotechnical practitioner. Any seepage encountered will require appropriate drainage measures during the earthworks.

5.11 Pavements

The subgrade under the proposed surfaced areas is expected to comprise colluvium, weathered basalt and engineered fill. Preliminary CBR value of 3% for colluvium and 15% for weathered basalt is considered appropriate. Increased values may be applicable after inspection once stripping is carried out.

All unsuitable organic fill should be removed from beneath the access road footprints prior to commencement of pavement construction.

All soft and/or unsuitable materials which are exposed during preparation of pavement subgrade should be excavated and replaced with engineered fill.

Inspections of the pavement subgrade should be completed during construction by a suitably qualified geotechnical practitioner.

5.12 Site Subsoil Category

For detailed design purposes it is recommended the magnitude of seismic acceleration be estimated in accordance with the recommendations provided in NZS 1170.5:2004.

The site is Class B (Rock) in accordance with NZS 1170.5:2004 seismic provisions.



6 Neighbouring Structures/Hazards

6.1 Natural Hazards

6.1.1 Landslide

The subject site is not identified in a 2017 GNS Science Consultancy Report⁴ as being within any mapped landslides. No landslide features or debris were identified while on site. Seepage was identified at the base of the slope within the Dunedin Volcanic Group basalt.

Based on this information and the presence of shallow competent basalt, we consider the future landslide hazard at the site to be low, providing the recommendations in Section 5 are adopted.

6.1.2 Liquefaction

The site has been mapped in a 2014 liquefaction hazard assessment⁵ as belonging to Domain A, which is predominantly underlain by rock or firm sediments; in this domain there is little or no likelihood of damaging liquefaction occurring. The existence of shallow basalt indicates the likelihood on site to be very low.

A risk of seismic activity has been identified for the region as a whole and appropriate allowance should be made for seismic loading during detailed design of the proposed development, but there are no site specific constraints.

6.1.3 Expansive Soils

The area in which the subject property is located has not been mapped as an area containing expansive soils.

6.2 Other Hazards

Distances to adjoining structures: No adverse geotechnical implications apply for neighbouring properties during construction of the dwelling provided the above excavation considerations are noted (Section 5.4).

Aquifers: No aquifer resource will be adversely affected by the development.

Erosion and Sediment Control: The site presents a risk of generating silt runoff and this would naturally drain downslope. Only the least amount of subsoil should be exposed at any stage and surfacing established as soon as practical. Silt runoff should not be permitted to enter the watercourse at the base of the site.

We recommend advice be sought from a qualified specialist where compliance with local and regional erosion and sediment control regulations is uncertain.

⁴ Barrell, D.J.A., Smith Lyttle, B., Glassey, P.J. (2017). Revised landslide database for the coastal sector of the Dunedin City district. GNS Science Consultancy Report 2017/41, 29p.

⁵ Barrell, D.J.A., Glassey, P.J., Cox, S.C., Smith Lyttle, B. (2014). Assessment of liquefaction hazards in the Dunedin City district. GNS Science Consultancy Report 2014/068. 68p.



Noise: Rock-breaking and/or blasting is likely to be required. As the surrounding area is residential, the construction contractor should take appropriate measure to control the construction noise and ensure DCC requirements are met in regard to this issue.

Dust: Regular dampening of soil materials with sprinklers should be effective if required.

Vibration: No vibration induced settlement is expected in these soil types; however, any works that create vibrations should be subject to geotechnical advice. The neighbouring dwelling should be considered by the contractor with respect to vibration effects and further advice sought if there is any uncertainty.



7 Conclusions and Recommendations

- Apart from a surficial layer of topsoil, the site is underlain by firm to stiff colluvium, with weathered basalt present at shallow depth over the site.
- We understand that the current proposal is to establish a level building platform to support the garage, and above two levels of each apartment. The intent is to cut into the slope to allow foundations to be constructed on cut material below the garage. Cuts to establish the building platforms are estimated to be approximately 1-4 m in height. It is therefore expected that all foundation loads will bear directly on completely to unweathered basalt which meet the requirements of 'good ground'.
- Latest plans show an access way to be constructed by retention of both cut and fill material. Retained heights along the accessway are up to 4-5 m. It is understood a gabion basket style retaining wall is currently being considered, with geogrid reinforcement in the compacted engineered fill.
- All retaining walls should be designed by a Chartered Professional Engineer using the geotechnical parameters recommended in Table 5.1 of this report. Due allowance should be made during the detailed design of all retaining walls for forces such as surcharge due to the sloping ground surface behind and at the base of the retaining walls, groundwater, seismic and structural loads from the upslope dwelling and accessway.
- For engineered fills, the contractor will need to submit a sample of the proposed fill materials (possibly more than one) to obtain laboratory compaction curves, and in-situ Nuclear Density Meter (NDM) testing of the fill will need to be arranged. An engineer will need to specify the fill methodology and review the lab results to ensure that a producer statement can be issued; this will be required for code compliance.
- No landslides have been mapped in the area of the site. No landslides or debris were mapped while on site. Groundwater seepage was observed at the base of the slope with the basalt rock. However, based on the nature of the soils and rock observed, we consider the future landslide hazard at the site to be low, provided the recommendations in Section 5 are adopted.
- Permanent and temporary cuts in dry to moist soils should be battered at angles outlined in Table 5.2 providing cuts are less than 3.5 m in height.
- All unsuitable materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during construction. Any fill that is utilised as bearing for foundations should be placed and compacted in accordance with NZS 4431:1989 and certification provided to that effect.
- A geotechnical practitioner should inspect all excavations and additionally any seepage, spring flow or under-runners that may be encountered during construction.



8 Applicability

This report has been prepared for the benefit of Alastair Mortensen with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

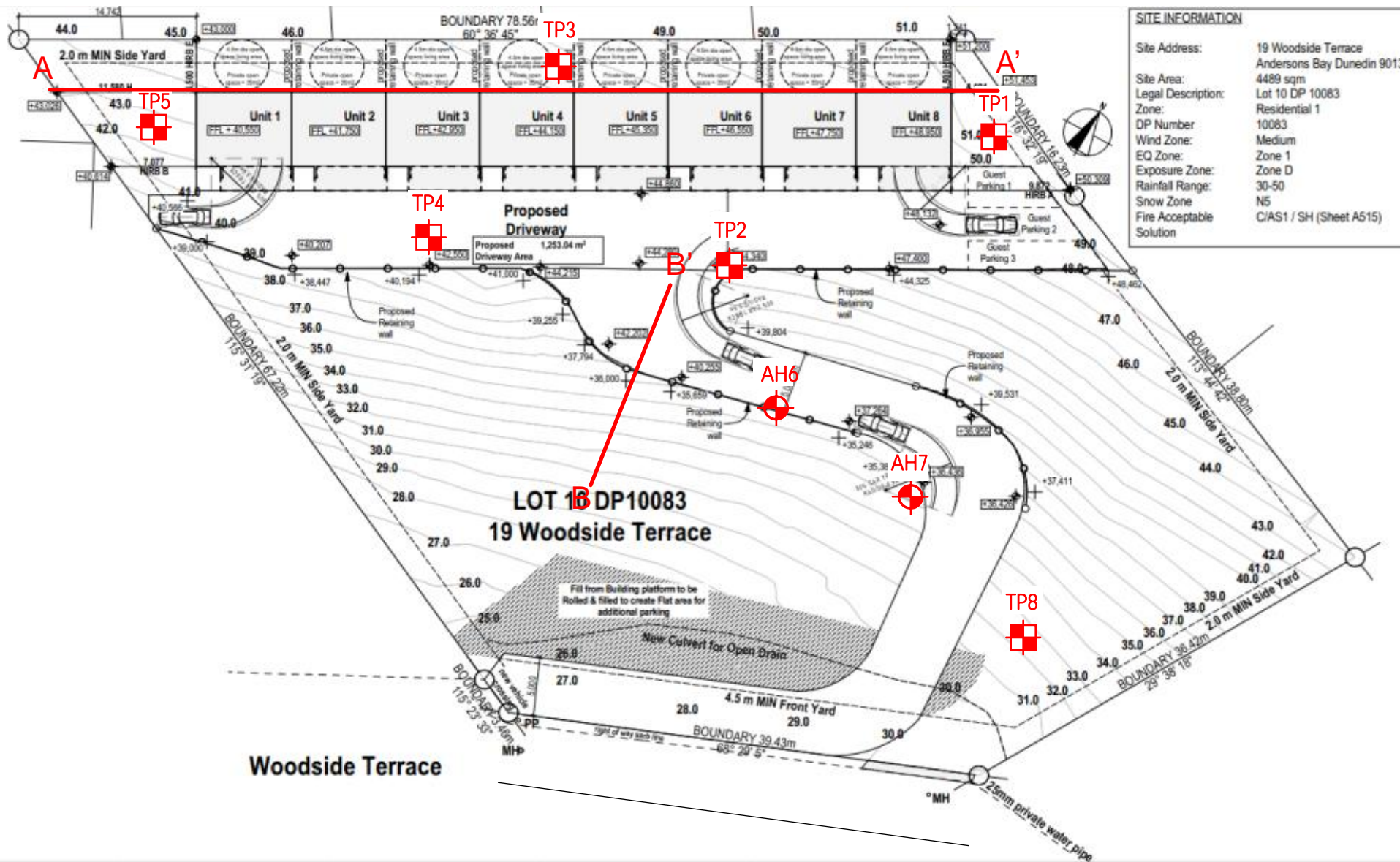
Report prepared by:

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Matthew Bruce
Engineering Geologist

Reviewed and authorised for GeoSolve Ltd by:

.....
Colin Macdiarmid
Geotechnical Group Director

Appendix A: Site Plan & Cross-section



SITE INFORMATION	
Site Address:	19 Woodside Terrace Andersons Bay Dunedin 9013
Site Area:	4489 sqm
Legal Description:	Lot 10 DP 10083
Zone:	Residential 1
DP Number	10083
Wind Zone:	Medium
EQ Zone:	Zone 1
Exposure Zone:	Zone D
Rainfall Range:	30-50
Snow Zone	N5
Fire Acceptable Solution	C/AS1 / SH (Sheet A515)

Key

- Test pit and Scala test location
- Hand auger and Scala test location

0 m 20 m

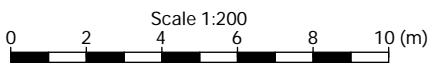
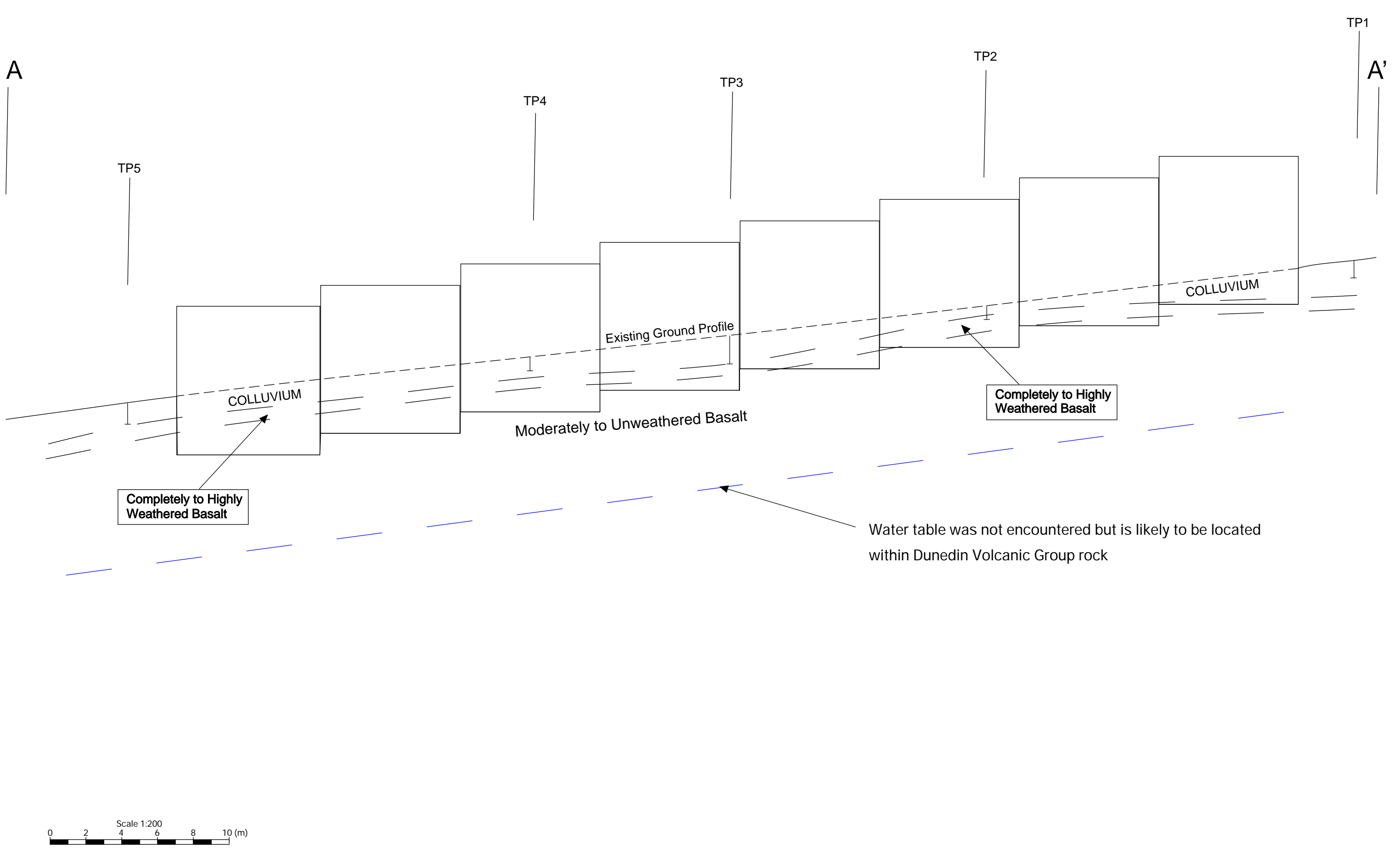


DRAWN	RC	08/18
DRAFTING CHECKED	MB	08/18
APPROVED	CEM	08/18
FILE :	PDF	
SCALE:	As shown (approx)	
PROJECT No.	180505	

Alastair Mortensen
Geotechnical Investigation
19 Woodside Terrace, Dunedin
Site Plan

FIG No. Site Plan

REV. 1



Key

- = Scala penetrometer refusal
- = Inferred geological boundary

CADFILE:	Cross Section A-A'.xar	DRAWN	MB	08/2018
SCALE: (AT A3 SIZE)	AS SHOWN	DRAFTING CHECKED	MB	08/2018
PROJECT No.:	180505	APPROVED	CEM	08/2018

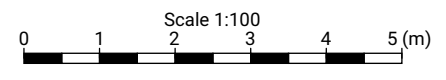
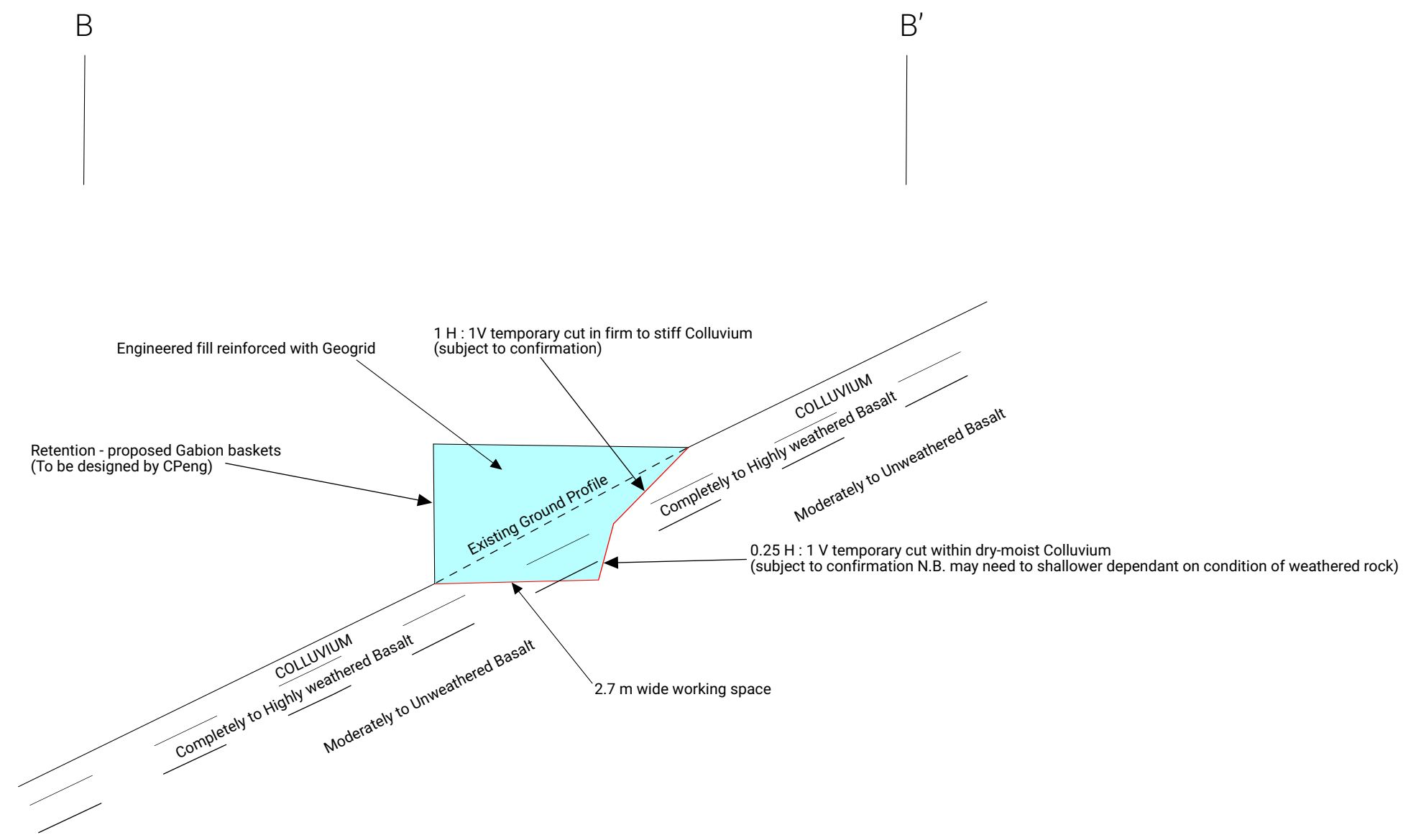
GEO SOLVE
ENGINEERING CONSULTANTS

GEO TECHNICAL

WATER RESOURCES

PAVEMENTS

Alastair Mortensen
19 Woodside Terrace
Andersons Bay, Dunedin
Cross Section A-A'



CADFILE:	Site Plan.xar	DRAWN	MB	09/2018
SCALE: (AT A3 SIZE)	AS SHOWN	DRAFTING CHECKED	MB	09/2018
PROJECT No.:	180505	APPROVED	CEM	09/2018

GEOSOLVE
ENGINEERING CONSULTANTS

GEOTECHNICAL
 WATER RESOURCES
 PAVEMENTS


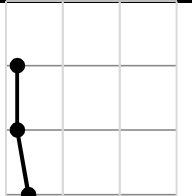
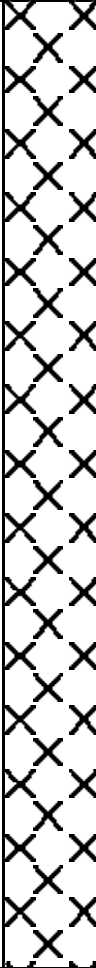
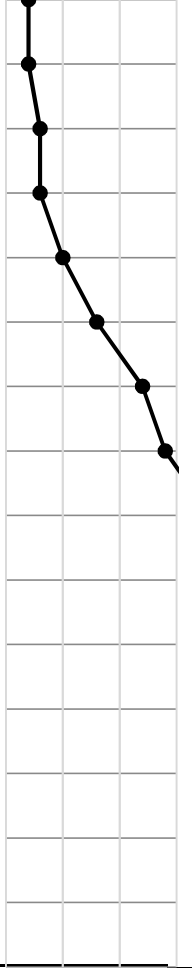
Alastair Mortensen
19 Woodside Terrace
Dunedin
Cross Section B-B'

Appendix B: Investigation Data

EXCAVATION LOG

EXCAVATION NUMBER:
TP 1

PROJECT: 19 Woodside Terrace, Dunedin				JOB NUMBER: 180505	
EASTING:		mE	EQUIPMENT: 8.5T excavator	OPERATOR:	Peter
NORTHING:		mN	INFOMAP NO.	COMPANY:	Nash & Ross
ELEVATION:		m	DIMENSIONS:	HOLE STARTED:	21-Aug-18
METHOD:			EXCAV. DATUM: GL	HOLE FINISHED:	21-Aug-18

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.3	TOPSOIL		Brown, organic SILT. Soft. Moist.			
1.8	COLLUVIUM		Grey mottled orange, SILT with minor clay, sand and gravel. Sand is fine to coarse. Gravel is fine to medium, subrounded to subangular. Non-plastic to low plasticity. Firm to stiff. Becomes very stiff from 1.0 m and hard from 1.5 m. Moist to dry.		NO SEEPAGE	


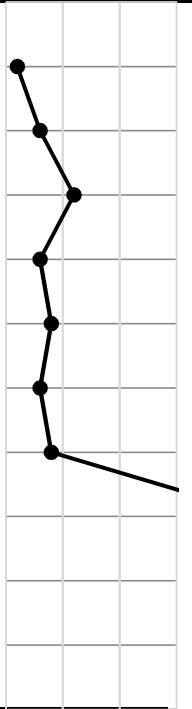


Total Depth = 1.8 m

COMMENT: Excavation terminated at 1.8 m as unable to penetrate hard silts.	Logged By: MB
	Checked Date: 5-Sep-18
	Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:
TP 2

PROJECT: 19 Woodside Terrace, Dunedin				JOB NUMBER: 180505	
EASTING:		mE	EQUIPMENT: 8.5T excavator	OPERATOR:	Peter
NORTHING:		mN	INFOMAP NO.	COMPANY:	Nash & Ross
ELEVATION:		m	DIMENSIONS:	HOLE STARTED:	21-Aug-18
METHOD:			EXCAV. DATUM: GL	HOLE FINISHED:	21-Aug-18

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.15	TOPSOIL		Brown, organic SILT. Soft. Moist.		NO SEEPAGE	
0.45	COLLUVIUM		Orange brown, SILT with minor clay and sand. Sand is fine. Non-plastic to low plasticity. Firm. Moist.			
1.1	WEATHERED DUNEDIN VOLCANIC GROUP		Light orange grey, volcanic ROCK. Highly weathered, becomes moderately to slightly weathered at 1.0 m. Weak to moderately strong. Becomes moderately strong to strong from 1.0 m.			

Total Depth = 1.1 m


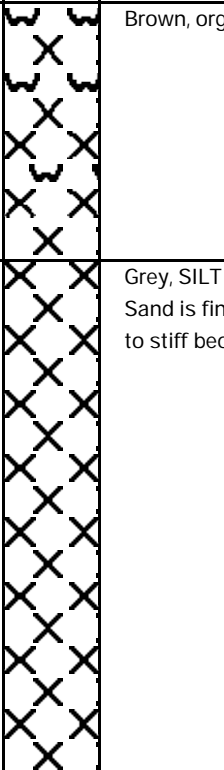
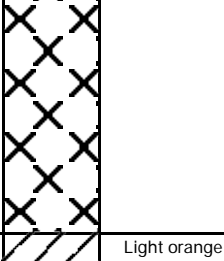
COMMENT: Unable to penetrate rock beyond 1.1 m.	Logged By: MB
	Checked Date: 5-Sep-18
	Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:

TP 3

PROJECT: 19 Woodside Terrace, Dunedin				JOB NUMBER: 180505	
EASTING:		mE	EQUIPMENT: 8.5T excavator	OPERATOR:	Peter
NORTHING:		mN	INFOMAP NO.	COMPANY:	Nash & Ross
ELEVATION:		m	DIMENSIONS:	HOLE STARTED:	21-Aug-18
METHOD:			EXCAV. DATUM: GL	HOLE FINISHED:	21-Aug-18

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER			
						Blows per 100mm			
						0	5	10	15
0.4	TOPSOIL		Brown, organic SILT. Soft. Moist.						
1.55	COLLUVIUM		Grey, SILT with a trace of sand and gravel. Mottled orange brown. Sand is fine to coarse. Gravel is fine to medium, subangular. Firm to stiff becoming very stiff. Moist.						
1.6	WEATHERED DUNEDIN VOLCANIC GROUP		Light orange grey, volcanic ROCK. Highly weathered. Weak to moderately strong.		NO SEEPAGE				

Total Depth = 1.6 m

COMMENT: Unable to penetrate rock beyond 1.6 m.

Logged By: MB

Checked Date: 5-Sep-18

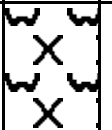

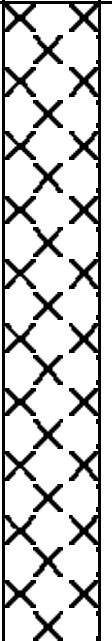

Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:

TP 4

PROJECT: 19 Woodside Terrace, Dunedin				JOB NUMBER: 180505	
EASTING:		mE	EQUIPMENT: 8.5T excavator	OPERATOR:	Peter
NORTHING:		mN	INFOMAP NO.	COMPANY:	Nash & Ross
ELEVATION:		m	DIMENSIONS:	HOLE STARTED:	21-Aug-18
METHOD:			EXCAV. DATUM: GL	HOLE FINISHED:	21-Aug-18

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.2	TOPSOIL		Brown, organic SILT. Soft. Moist.		NO SEEPAGE	
1.2	COLLUVIUM		Grey, SILT with minor clay and a trace of sand. Mottled orange brown. Sand is fine to coarse. Non-plastic to low plasticity. Firm. Moist.			
1.5	WEATHERED DUNEDIN VOLCANIC GROUP		Light orange grey, clayey SILT. Residual soil. Completely to highly weathered volcanics. Stiff/very weak becoming moderately strong at base. Moist.			

Total Depth = 1.5 m

COMMENT: Unable to penetrate beyond 1.5 m.

Logged By: MB

Checked Date: 5-Sep-18


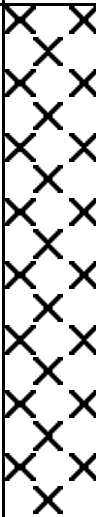

Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:

TP 5

PROJECT: 19 Woodside Terrace, Dunedin				JOB NUMBER: 180505	
EASTING:		mE	EQUIPMENT: 8.5T excavator	OPERATOR:	Peter
NORTHING:		mN	INFOMAP NO.	COMPANY:	Nash & Ross
ELEVATION:		m	DIMENSIONS:	HOLE STARTED:	21-Aug-18
METHOD:			EXCAV. DATUM: GL	HOLE FINISHED:	21-Aug-18

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER			
						Blows per 100mm			
						0	5	10	15
0.5	TOPSOIL/FILL		Brown, organic SILT with a trace of rubbish. Non-plastic. Soft. Moist.						
1.3	COLLUVIUM		Orange brown, SILT with minor clay and a trace of sand and gravel. Sand is medium to coarse. Gravel is fine to coarse, subangular to angular. Low plasticity to non-plastic. Firm. Moist.						
1.7	WEATHERED DUNEDIN VOLCANIC GROUP		Light to dark grey, clayey SILT. Residual soil. Completely weathered volcanics. Becomes moderately to highly weathered at base. Stiff/weak to very weak. Moist.		NO SEEPAGE				

Total Depth = 1.7 m

COMMENT: Unable to penetrate beyond 1.7 m.

Logged By: MB



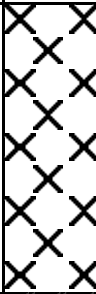

Checked Date: 5-Sep-18

Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:
AH6

PROJECT: 19 Woodside Terrace, Dunedin				JOB NUMBER: 180505	
EASTING:		mE	EQUIPMENT: Hand auger	OPERATOR:	Peter
NORTHING:		mN	INFOMAP NO.	COMPANY:	Nash & Ross
ELEVATION:		m	DIMENSIONS:	HOLE STARTED:	21-Aug-18
METHOD:			EXCAV. DATUM: GL	HOLE FINISHED:	21-Aug-18

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.35	TOPSOIL		Brown, organic SILT with a trace of rootlets. Soft. Moist.		NO SEEPAGE	
0.8	COLLUVIUM		Orange brown, SILT with some clay. Firm. Moist.			
1.2	WEATHERED DUNEDIN VOLCANIC GROUP		Grey becomes red at base, volcanic ROCK. Completely to highly weathered. Becomes highly weathered from 1.1 m. Very weak to weak. Becomes weak to moderately strong from 1.1 m.			

Total Depth = 1.2 m

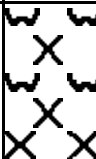
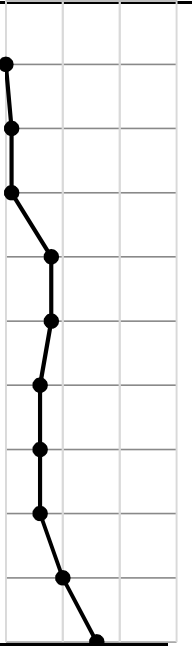
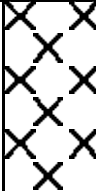
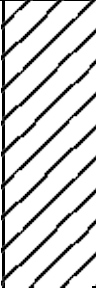
COMMENT: Log of cut face to 1.2 m. Hand auger attempted from 1.2 m but unable to penetrate volcanics.	Logged By: MB
	Checked Date: 5-Sep-18
	Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:

AH7

PROJECT: 19 Woodside Terrace, Dunedin				JOB NUMBER: 180505	
EASTING:		mE	EQUIPMENT: Hand auger	OPERATOR:	Peter
NORTHING:		mN	INFOMAP NO.	COMPANY:	Nash & Ross
ELEVATION:		m	DIMENSIONS:	HOLE STARTED:	21-Aug-18
METHOD:			EXCAV. DATUM: GL	HOLE FINISHED:	21-Aug-18

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.25	TOPSOIL		Brown, organic SILT with a trace of roots. Non-plastic. Soft. Moist to wet.		Seepage @ 0.3 m 	
0.55	LOESS/ COLLUVIUM		Orange brown, SILT with some clay and a trace of gravel. Non-plastic to low plasticity. Soft to firm. Moist. Saturated at 0.3 m.			
1.0	WEATHERED DUNEDIN VOLCANIC GROUP		Orange, volcanic ROCK. Red and grey. Completely to highly weathered. Very weak to weak.			

Total Depth = 1 m

COMMENT: Log of cut face to 0.95 m. Hand auger attempted from 0.95 m - unable to penetrate beyond 1.0 m.

Logged By: MB

Checked Date: 5-Sep-18


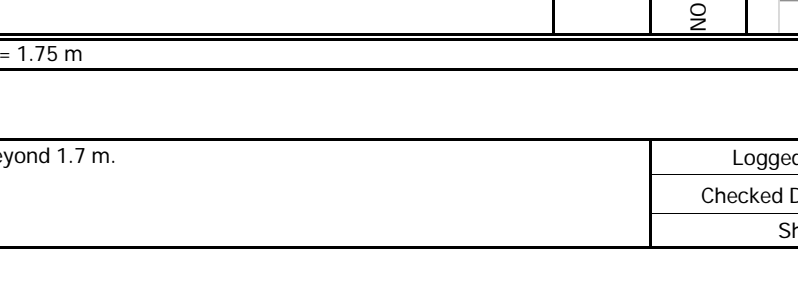
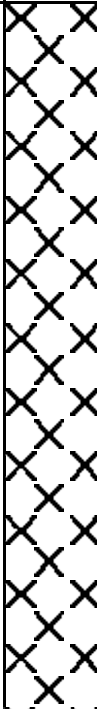
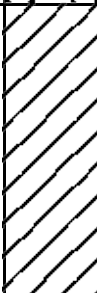
Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:

TP 8

PROJECT: 19 Woodside Terrace, Dunedin				JOB NUMBER: 180505	
EASTING:		mE	EQUIPMENT: 8.5T excavator	OPERATOR:	Peter
NORTHING:		mN	INFOMAP NO.	COMPANY:	Nash & Ross
ELEVATION:		m	DIMENSIONS:	HOLE STARTED:	21-Aug-18
METHOD:			EXCAV. DATUM: GL	HOLE FINISHED:	21-Aug-18

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.2	TOPSOIL		Brown, organic SILT. Soft. Moist.		NO SEEPAGE	
1.3	COLLUVIUM		Orange brown, SILT with some clay and a trace of gravel. Gravel is fine to coarse, subrounded to subangular. Non-plastic to low plasticity. Firm. Moist.			
1.75	WEATHERED DUNEDIN VOLCANIC GROUP		Red and grey, volcanic ROCK with some clayey SILT (residual soil). Highly weathered. Weak to moderately strong. Moist.			

Total Depth = 1.75 m

COMMENT: Unable to penetrate beyond 1.7 m.

Logged By: MB

Checked Date: 5-Sep-18

Sheet: 1 of 1

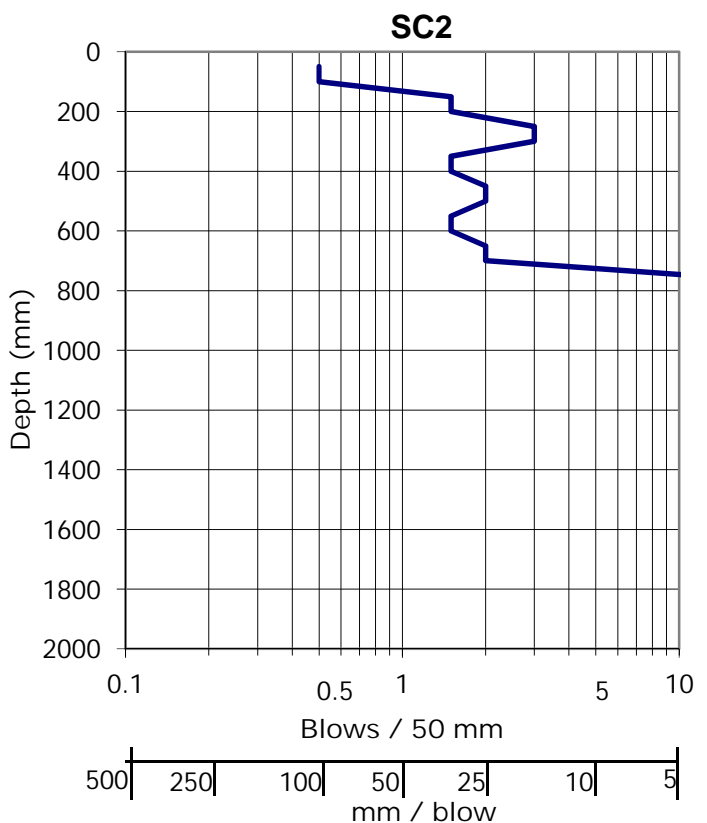
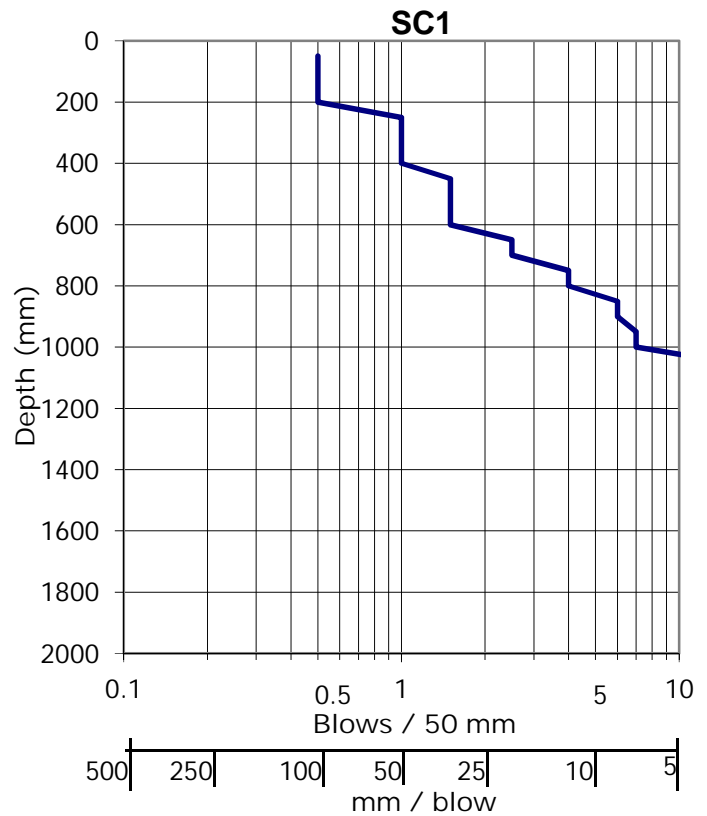
SCALA PENETROMETER LOG

 Job No: **180505**
 Project: **19 Woodside Terrace,
 Dunedin**

 Date: **21/08/2018**
 Operated by: **MB**
 Logged by: **MB**

Test Number	SC1 & SC2
Sheet of	1 of 5

SC1		SC2	
Location: TP1 RL: 0 m		Location: TP2 RL: 0 m	
mm Driven	No. of Blows	mm Driven	No. of Blows
50	0.5	50	0.5
100	0.5	100	0.5
150	0.5	150	1.5
200	0.5	200	1.5
250	1	250	3
300	1	300	3
350	1	350	1.5
400	1	400	1.5
450	1.5	450	2
500	1.5	500	2
550	1.5	550	1.5
600	1.5	600	1.5
650	2.5	650	2
700	2.5	700	2
750	4	750	11.5
800	4	800	11.5
850	6	850	
900	6	900	
950	7	950	
1000	7	1000	
1050	15	1050	
1100		1100	
1150		1150	
1200		1200	
1250		1250	
1300		1300	
1350		1350	
1400		1400	
1450		1450	
1500		1500	
1550		1550	
1600		1600	
1650		1650	
1700		1700	
1750		1750	
1800		1800	
1850		1850	
1900		1900	
1950		1950	
2000		2000	
Inferred Soil Type		Inferred Soil Type	
Watertable Depth		Watertable Depth	



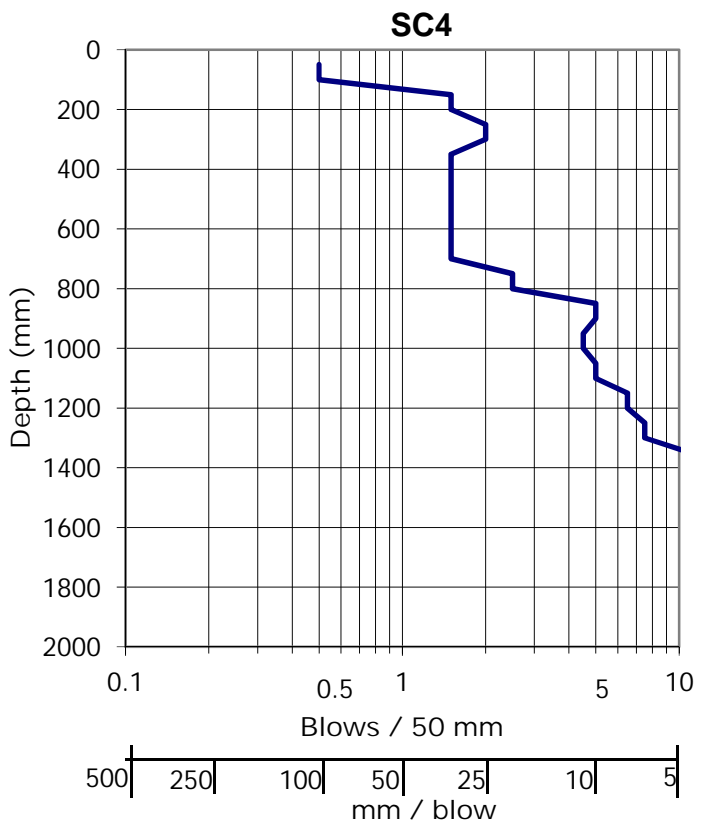
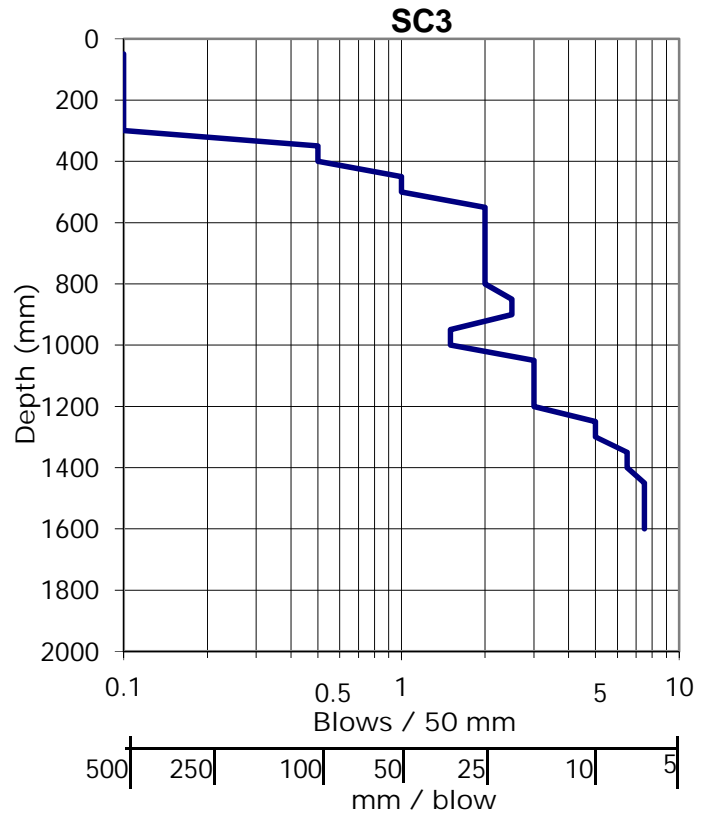
SCALA PENETROMETER LOG

 Job No: **180505**
 Project: **19 Woodside Terrace,
 Dunedin**

 Date: **21/08/2018**
 Operated by: **MB**
 Logged by: **MB**

Test Number	SC3 & SC4
Sheet of	2 of 5

SC3		SC4	
Location: TP3 RL: 0 m		Location: TP4 RL: 0 m	
mm Driven	No. of Blows	mm Driven	No. of Blows
50	0.1	50	0.5
100	0.1	100	0.5
150	0.1	150	1.5
200	0.1	200	1.5
250	0.1	250	2
300	0.1	300	2
350	0.5	350	1.5
400	0.5	400	1.5
450	1	450	1.5
500	1	500	1.5
550	2	550	1.5
600	2	600	1.5
650	2	650	1.5
700	2	700	1.5
750	2	750	2.5
800	2	800	2.5
850	2.5	850	5
900	2.5	900	5
950	1.5	950	4.5
1000	1.5	1000	4.5
1050	3	1050	5
1100	3	1100	5
1150	3	1150	6.5
1200	3	1200	6.5
1250	5	1250	7.5
1300	5	1300	7.5
1350	6.5	1350	11
1400	6.5	1400	
1450	7.5	1450	
1500	7.5	1500	
1550	7.5	1550	
1600	7.5	1600	
1650		1650	
1700		1700	
1750		1750	
1800		1800	
1850		1850	
1900		1900	
1950		1950	
2000		2000	
Inferred Soil Type		Inferred Soil Type	
Watertable Depth		Watertable Depth	



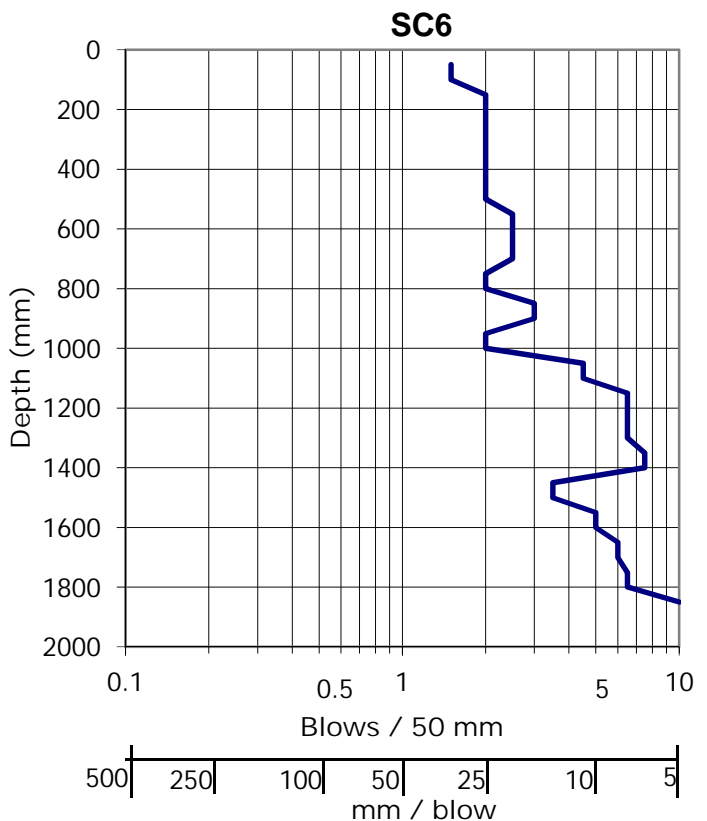
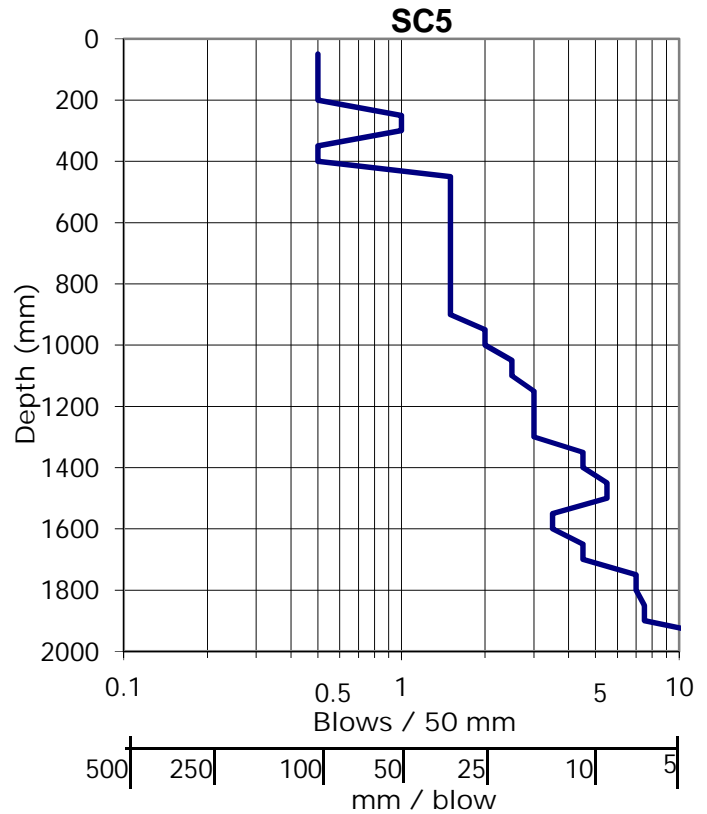
SCALA PENETROMETER LOG

 Job No: **180505**
 Project: **19 Woodside Terrace,
 Dunedin**

 Date: **21/08/2018**
 Operated by: **MB**
 Logged by: **MB**

Test Number	SC5 & SC6
Sheet of	3 of 5

SC5		SC6	
Location: TP5 RL: 0 m		Location: AH6 RL: 0 m	
mm Driven	No. of Blows	mm Driven	No. of Blows
50	0.5	50	1.5
100	0.5	100	1.5
150	0.5	150	2
200	0.5	200	2
250	1	250	2
300	1	300	2
350	0.5	350	2
400	0.5	400	2
450	1.5	450	2
500	1.5	500	2
550	1.5	550	2.5
600	1.5	600	2.5
650	1.5	650	2.5
700	1.5	700	2.5
750	1.5	750	2
800	1.5	800	2
850	1.5	850	3
900	1.5	900	3
950	2	950	2
1000	2	1000	2
1050	2.5	1050	4.5
1100	2.5	1100	4.5
1150	3	1150	6.5
1200	3	1200	6.5
1250	3	1250	6.5
1300	3	1300	6.5
1350	4.5	1350	7.5
1400	4.5	1400	7.5
1450	5.5	1450	3.5
1500	5.5	1500	3.5
1550	3.5	1550	5
1600	3.5	1600	5
1650	4.5	1650	6
1700	4.5	1700	6
1750	7	1750	6.5
1800	7	1800	6.5
1850	7.5	1850	10
1900	7.5	1900	
1950	14	1950	
2000		2000	
Inferred Soil Type		Inferred Soil Type	
Watertable Depth		Watertable Depth	



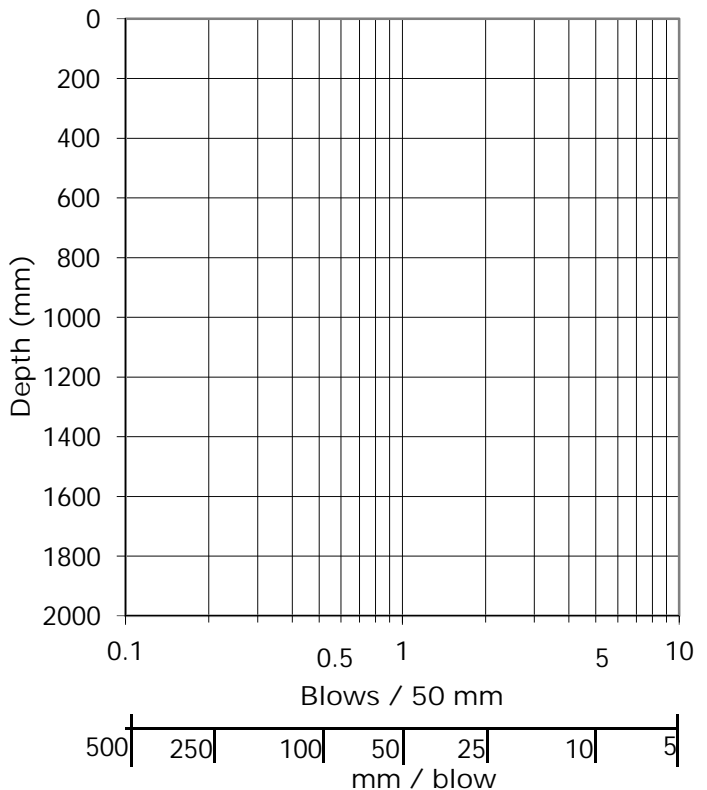
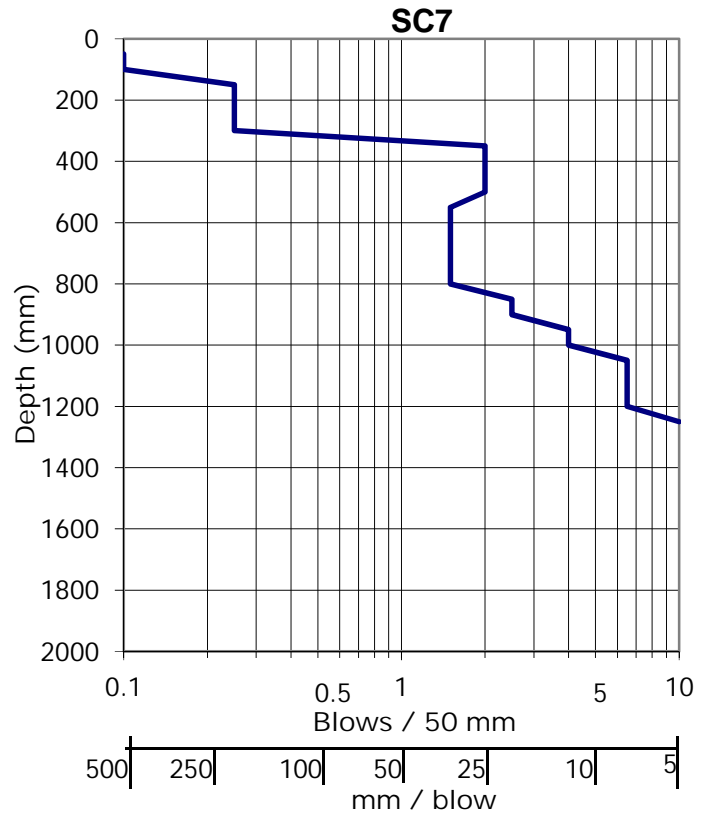
SCALA PENETROMETER LOG

 Job No: **180505**
 Project: **19 Woodside Terrace,
 Dunedin**

 Date: **21/08/2018**
 Operated by: **MB**
 Logged by: **MB**

Test Number	SC7
Sheet of	4 of 5

SC7		Location:	
Location: AH7		RL:	
RL: 0 m		RL:	
mm Driven	No. of Blows	mm Driven	No. of Blows
50	0.1	50	
100	0.1	100	
150	0.25	150	
200	0.25	200	
250	0.25	250	
300	0.25	300	
350	2	350	
400	2	400	
450	2	450	
500	2	500	
550	1.5	550	
600	1.5	600	
650	1.5	650	
700	1.5	700	
750	1.5	750	
800	1.5	800	
850	2.5	850	
900	2.5	900	
950	4	950	
1000	4	1000	
1050	6.5	1050	
1100	6.5	1100	
1150	6.5	1150	
1200	6.5	1200	
1250	10	1250	
1300		1300	
1350		1350	
1400		1400	
1450		1450	
1500		1500	
1550		1550	
1600		1600	
1650		1650	
1700		1700	
1750		1750	
1800		1800	
1850		1850	
1900		1900	
1950		1950	
2000		2000	
Inferred Soil Type		Inferred Soil Type	
Watertable Depth		Watertable Depth	



SCALA PENETROMETER LOG

 Job No: **180505**

 Date: **21/08/2018**

 Project: **19 Woodside Terrace, Dunedin**

 Operated by: **MB**

 Location: **TP8**

 Logged by: **MB**

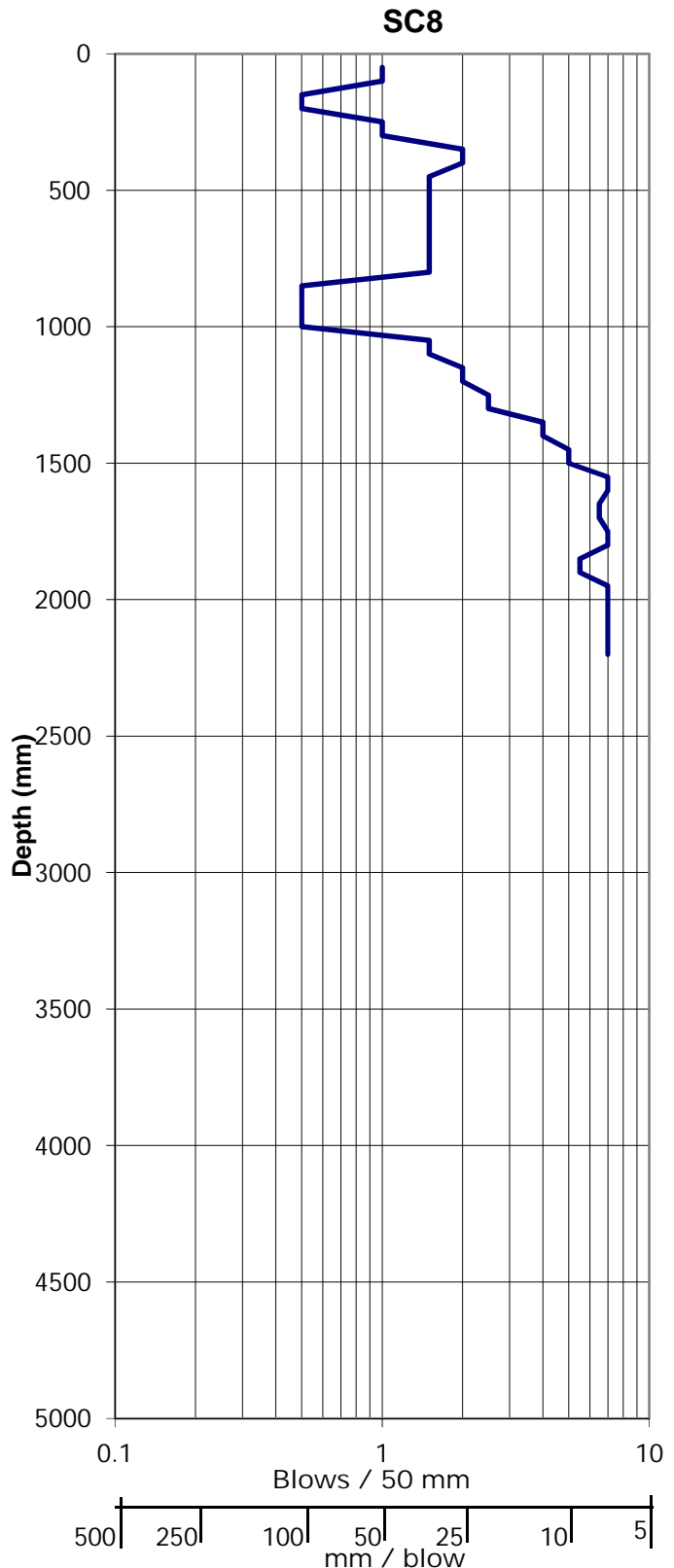
 RL: **0 m**

Inferred Soil Type:

Test No. SC8
Sheet of 5 5

SC8	
mm Driven	No. of Blows
50	1
100	1
150	0.5
200	0.5
250	1
300	1
350	2
400	2
450	1.5
500	1.5
550	1.5
600	1.5
650	1.5
700	1.5
750	1.5
800	1.5
850	0.5
900	0.5
950	0.5
1000	0.5
1050	1.5
1100	1.5
1150	2
1200	2
1250	2.5
1300	2.5
1350	4
1400	4
1450	5
1500	5
1550	7
1600	7
1650	6.5
1700	6.5
1750	7
1800	7
1850	5.5
1900	5.5
1950	7
2000	7
2050	7
2100	7
2150	7
2200	7
2250	
2300	
2350	
2400	
2450	
2500	

SC8 cont...	
mm Driven	No. of Blows
2550	
2600	
2650	
2700	
2750	
2800	
2850	
2900	
2950	
3000	
3050	
3100	
3150	
3200	
3250	
3300	
3350	
3400	
3450	
3500	
3550	
3600	
3650	
3700	
3750	
3800	
3850	
3900	
3950	
4000	
4050	
4100	
4150	
4200	
4250	
4300	
4350	
4400	
4450	
4500	
4550	
4600	
4650	
4700	
4750	
4800	
4850	
4900	
4950	
5000	



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