Appendix 4: Geosolve Geotechnical Assessment

Geotechnical Report

805, 815, 819 North Road

Invercargill

Report prepared for:

Tulloch Group Ltd

Report prepared by:

GeoSolve Limited

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GEOTECHNICAL WATER RESOURCES PAVEMENTS

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1 Introduction

1.1 General

This report presents the results of a geotechnical investigation carried out by GeoSolve Ltd in order to determine subsoil conditions and provide geotechnical inputs for a proposed commercial subdivision located at 805, 815 and 819 North Road, Invercargill.



Figure 1 – Site overview photo looking North.

The investigations were carried out for Tulloch Group Ltd. in accordance with GeoSolve Ltd's proposal dated 20 July 2023, which outlines the scope of work and conditions of engagement.

1.2 Development

We understand the proposed development will comprise approximately 10 lease areas for development including associated roading and infrastructure. An engineering feasibility report has been provided by Bonisch Consultants Ltd. (Project number 7895, Rev A, dated May 2023) and outlines the extent and layout of the proposed development.

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2 Site Description

2.1 General

The subject site is located approximately 6.5 km north of Central Invercargill, as shown in Figure 2 below.



Figure 2 – Site location plan (red marking)

The site is bounded by North Road to the west, commercial and residential properties to the north and rural properties to the east and south.

An existing dwelling is located at the southwest corner of the property and a large shed covers the centre-south of the site. The property is currently fenced and covered in grass with some trees along field boundaries.

2.2 Topography and Surface Drainage

The majority of the site occupies a sub-horizontal upper terrace, and slopes down in the east to a lower terrace and drainage ditch. The drainage ditch is approximately 1 m deep and runs generally north-south along the eastern boundary. A second drainage ditch runs generally north to south between the western boundary and North Road.

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A paleochannel cuts across the property from the north-western boundary toward the centre of the site. Water was observed to be ponding in the paleochannel during investigations. A further channel has been excavated along the western and southern boundaries of the south-eastern field. This channel runs to a low point in the southeast corner of the site where evidence of ponded water is noted on the property and a swampy area and pond were observed in the field directly to the south of the property boundary.

3 Geotechnical Investigations

An engineering geological site assessment has been undertaken with confirmatory subsurface investigations. GeoSolve visited the subject property on 7, 8 and 9 August 2023, undertaking geotechnical investigations comprising:

- 13 deep test pits with associated Scala penetrometer tests (TP01- TP13) which were advanced to a maximum depth of 3.9 m.
- 9 shallow test pits with associated Scala penetrometer tests (TP14 – TP22) which were advanced to a maximum depth of 0.4 m.
- 6 heavy dynamic probe tests (DPH 1- 6) advanced to refusal at a maximum depth of 11.6 m, to assess liquefaction potential and the relative density of the subsoils.
- 2 soakage pits (SP1-2) which were advanced to a maximum depth of 2.8 m below ground level (bgl) to undertake soakage testing, assess the relative permeability and soakage potential of the subsoils.

Test pit and Scala Penetrometer locations and logs are contained in Appendix A and B respectively.

DPH locations and logs are contained in Appendix A and C respectively.

4 Subsurface Conditions

4.1 Geological Setting

4.1.1 Regional Geology

The site is underlain by topsoil, which in turn overlies alluvial deposits with Tertiary-age marine sediments at depth.

The alluvial deposits comprise Quaternary outwash gravels developed during former glaciation, which occurred inland. More recent silty and sandy floodplain or mudflat deposits overlie these gravels. The alluvial deposits merge with marine deposits in the vicinity of Invercargill.

No active faults were identified in the field, nor have any been reported in the vicinity of Invercargill. Strong earthquakes are common in Fiordland near the current tectonic plate boundary and consequently some ground shaking can be expected to occur in Invercargill during such events. The nearest trace of any mapped active fault is the Hillfoot Fault, approximately 60 km to the north of the site.

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Seismic risk exists in this region from potentially strong ground shaking, likely to be associated with a rupture of the Alpine Fault, located along the West Coast of the South Island. There is a high probability that an earthquake with an expected magnitude of over 8 will occur along the Alpine Fault within the next 50 years.

4.2 Stratigraphy

Subsurface soils encountered beneath the site generally comprise the following:

- 0.2-0.5 m of **topsoil**, overlying;
- 0.5-0.6 m of **uncontrolled fill** (only in TP01, TP02 and TP04), overlying
- 0.1 m of **buried topsoil** (only in TP02), overlying
- 0.6-2.6 m of **alluvial silt** (all test pits except TP01 & TP02), or 1.2 m of **swamp deposit** (only in TP04), overlying
- 0.5-2.6+ m of **alluvial sand** (TP02, TP03, TP05, TP06, TP07, TP08, TP09, TP10, TP11, TP12, TP13) or
- 1.1-2.9+ m of **alluvial gravel** (TP01, TP02, TP04).

Topsoil was observed at the surface of all test pits to depths of between 0.2 and 0.5 m. The topsoil typically comprises soft to stiff, organic SILT with trace to some sand and/or gravel.

Uncontrolled fill was observed underlying the topsoil in TP01, TP02 and TP04, to depths of between 0.8 and 1.1 m. The uncontrolled fill typically comprises firm to stiff, organic SILT with trace to some sand, gravel and rubbish, or SILT with some gravel and/or trace sand.

Buried topsoil was observed underlying the uncontrolled fill in TP02 at 0.8-0.9 m. The buried topsoil typically comprises stiff, organic SILT with minor sand.

Swamp deposit was observed underlying the uncontrolled fill in TP04 in the southeast corner of the site, to a depth of 2.3 m. The swamp deposit typically comprises very soft to soft, organic SILT with trace to some sand.

Alluvial silt was observed underlying the topsoil, uncontrolled fill or swamp deposit in all test pits, except TP01 and TP02. The alluvial silt typically comprises soft to very stiff, sandy SILT or SILT with trace to some sand**.** Alluvial silt was also interbedded with the alluvial sand in TP02, TP03, TP12 and TP13 in layers up to 1.8 m+ thick.

Alluvial sand was observed underlying or interbedded with the alluvial silt in all test pits except TP01 and TP04. The alluvial sand typically comprises loose to dense, SAND, silty SAND or SAND with trace silt.

Alluvial gravel was observed in TP01 and TP02 below the uncontrolled fill and buried topsoil and TP04 below the alluvial silt. The alluvial gravel typically comprises medium dense to dense, sandy GRAVEL with trace organics and/or silt. DPH testing infers this medium dense to dense material continues to at least the maximum testing depth of 11.6 m bgl.

Although uncontrolled fill was not observed in all test pits during investigations, the use of the site as farmland plus the presence of the existing dwelling, sheds and surrounding landscaping suggest potential for the presence of isolated uncontrolled fill at the site.

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4.3 Groundwater

The static groundwater table was measured in the test pits at 0.8 – 3.0 m below existing ground level (bgl) in the lower terrace, and at 1.8 – 2.8 m bgl in the upper terrace. Groundwater seepages were also observed between 0.9 m and 3.5 m depth.

Groundwater is likely to be subject to seasonal variations and vary in response to rainfall.

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5 Liquefaction Analysis

5.1 Design Earthquakes

The site is mapped in the Invercargill City Council Liquefaction Vulnerability map as "Undetermined" however, due to the variable water-table and alluvial soils a liquefaction assessment has been undertaken.

Two earthquake scenarios have been assessed in accordance with NZS 1170 – Structural Design Actions[1] for an Importance Level 2 structure with a 50-year design life. We have also considered a 1 in 100-year intermediate earthquake event to provide further insight to the liquefaction risk at the site.

Peak horizontal ground accelerations and effective magnitudes were calculated using the procedure from the MBIE NZGS Module 1[2]. Table 1 summarises the scenarios considered.

The MBIE NZGS Module 1 design earthquakes are an interim hazard recommendation until results of the national seismic hazard update are made available for use. Therefore, we have undertaken a sensitivity assessment for a range of earthquake events to provide further insight to the liquefaction risk.

Table 1 – Earthquake accelerations and effective magnitudes for liquefaction assessment

Scenario	Performance Requirements	Annual Probability of Exceedance (APE)	Peak Horizontal Ground Acceleration (PGA)	Effective Magnitude
Serviceability Limit State (SLS)	*Avoid damage that would prevent the structure being used as originally intended without repair.*	1/25	0.05 g	6.1
Intermediate earthquake event	*No specific requirements, unless further resilience is desired.*	1/100	0.11 g	6.1
Ultimate Limit State (ULS)	*Avoid collapse of the structural system.*	1/500	0.21 g	6.1

5.2 Liquefaction Analysis

The following analysis has been undertaken:

- A liquefaction assessment was undertaken using the heavy dynamic probe data based on the method of Boulanger and Idriss (2014).

[1] NZS 1170-5 (2004) Structural Design Actions, Part 5: Earthquake Actions – New Zealand.
[2] https://www.building.govt.nz/assets/Uploads/building-code-compliance/b-stability/b1-structure/geotechnical-guidelines/module-1-overview-of-earthquake-geotechnical-engineering-practice-guidelines-version-1.pdf.

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- The DPH data has been correlated to equivalent SPT N60 values for this assessment.
- All layers have been assumed to be able to liquefy from a plasticity perspective below the ground water level. Fines content has been estimated based on test pit logs and knowledge of the deeper ground conditions. We have assumed that there are no further liquefiable layers below the refusal of the DPH tests at 11.6 m depth.
- Ishihara and Yoshimine (1992) method has been used to calculate settlement.
- Groundwater levels have been adopted at between 1 and 4 m depth based on investigation observations and ground level variations.
- Lateral spreading has been assessed quantitatively based on topography, calculated liquefiable layers and comments in the MBIE (2017) and MBIE/NZGS Module 3[3].

5.3 Liquefaction Results

The liquefaction analysis indicates the following with reference to Table 2 and Figure 3 below:

- No liquefaction is calculated for the SLS and intermediate design earthquakes due to the relatively low levels of shaking.
- The alluvial sand and silt layers are calculated to liquefy at depths between 7-8 m in DPH 1, 5.5-6 m in DPH2, 4-5 m in DPH3, 3.5-4 m in DPH4, 4.5-5 m in DPH 5 and between 4-5.5 m in DPH6. Based on this we have calculated up to 40 mm of liquefaction induced settlement and limited expression of liquefaction or ground damage.
- Liquefaction at the site is triggered at a PGA of around 0.10g which has an annual probability of exceedance (AEP) of around 100 years. More layers liquefy in earthquake events above a ULS design event with up to 90 mm of liquefaction-induced reconsolidation settlements occurring and increased LSN in the 1 in 2,500 year return period (IL4 ULS event). This is shown in Figure 3.
- Although not applicable for this site given the proposed development, the west of the project area is equivalent to a MBIE TC2 site in Canterbury, albeit with a crust thickness typically more than 3.5 m and the remainder of the site is MBIE TC1 equivalent (see Figure 2, Appendix A).
- Further cone penetrometer (CPT) testing may rule out some of the liquefiable zones and reduce the liquefaction hazard.

[3] New Zealand Geotechnical Society (NZGS) and Ministry of Business, Innovation & Employment (MBIE) Earthquake Geotechnical Engineering Practice in New Zealand, Rev 1, Issue date November 2021, ISBN: 947497-51-4 (Online).

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Table 2 – Summary of factors considered to assess the consequences of the predicted liquefaction

Factor	Assessment		Implications
Crust thickness	The crust thickness is typically more than 3.5 m for the ULS design earthquake. Data from the Canterbury earthquake sequence plus other historic earthquakes[4] has been collated and observed surface damage compared with crust thickness. This data indicates that surface damage is likely for crusts of less than about 3.5 m thickness.		The crust across the site is sufficiently thick to limit surface damage in a ULS seismic event.
LSN	1/500 AEP (ULS)	LSN range = 0-11	Insignificant to mild, negligible deformation of the ground and small settlements.
	1/100 AEP (INT)	LSN range = 0-1	
	1/25 AEP (SLS)	LSN range = 0	
Free field settlement	1/500 AEP (ULS)	Settlement = 0-40 mm	Minor differential settlement likely, up to 40 mm estimated in the area tested.
	1/100 AEP (INT)	Settlement = 0-5 mm	
	1/25 AEP (SLS)	Settlement = 0 mm	
Lateral spread	Free faces of less than 2 m depth are present along the channel which runs approximately north to south along the eastern boundary.		The lateral spreading is limited as the free face is less than 2 m and liquefiable layers are not continuous.

A detailed discussion of the process of liquefaction and the various considerations summarised in Table 2 above can be found in Appendix C, which also contains the full liquefaction analysis results from the DPH's.

[4] *Bowen, H.J. and Jacka, M.E. (2013).* Liquefaction induced ground damage in the Canterbury Earthquake: Predictions versus reality. Proceedings of the 19th NZGS Geotechnical Symposium. Editor CY Chin. Queenstown, New Zealand.

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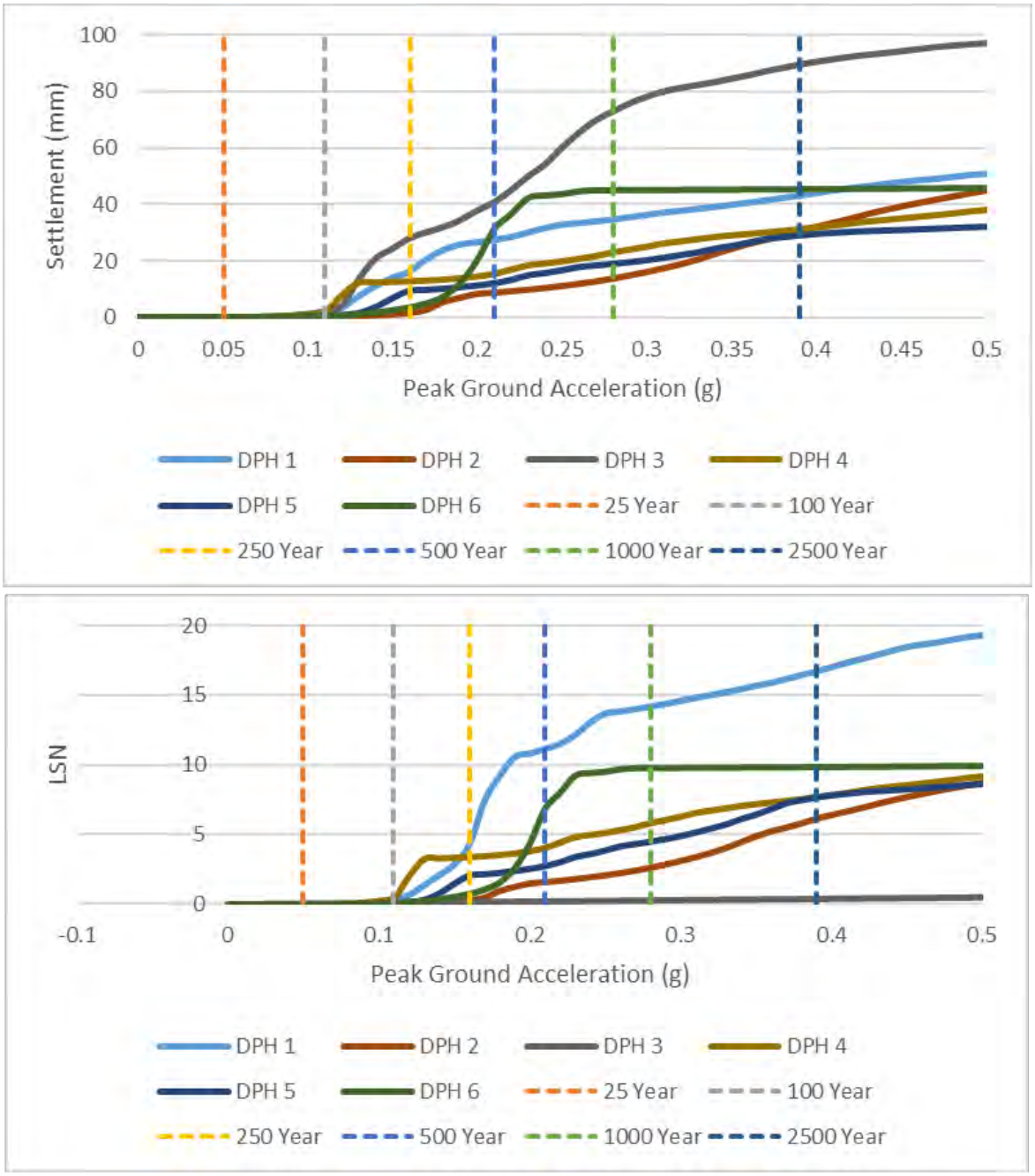


Figure 3: Calculated settlements and LSN for various Peak Ground Accelerations (PGA).

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6 Engineering Considerations

6.1 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.

6.2 Geotechnical Parameters

Table 3 provides a summary of the recommended geotechnical design parameters for the soil materials expected to be encountered during construction of the proposed development.

Table 3 – 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 to stiff, organic SILT with trace to some sand and/or gravel).	0.2-0.5	17	To be removed from beneath building footprint, or piles to extend through these layers.			
Uncontrolled fill (firm to stiff, organic SILT with trace to some sand, gravel and rubbish, or SILT with some gravel and/or trace sand).	0.5-0.6	17				
Buried topsoil (stiff, organic SILT with minor sand).	0.1	17				
Swamp deposit (very soft to soft, organic SILT with trace to some sand)	1.2	17				
Alluvial SILT (soft to very stiff, sandy SILT or SILT with trace to some sand).	0.6-2.6	18	0	29-30	3,000-7,000	0.3
Alluvial Sand (loose to dense, SAND, silty SAND or SAND with trace silt).	0.5-2.6+	18	0	30-32	7,000-10,000	0.3
Alluvial GRAVEL (medium dense to dense, sandy GRAVEL with trace organics and/or silt).	1.1-2.9+	19	0	34-36	20,000-50,000	0.3

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6.3 Site Preparation/Earthworks

During the earthworks operations all topsoil, organic matter, uncontrolled fill and other unsuitable materials (observed to 0.2-1.7 m depth in test pits but possibly deeper in isolated areas) should be removed from the construction areas in accordance with the recommendations of NZS 4431:2022. Alternatively, piles should extend through these layers.

Robust, shallow graded sediment control measures should be instigated during earthworks construction where rainwater and drainage run-off over exposed soils is anticipated.

The fine-grained alluvial silt soils are particularly susceptible to moisture and will weaken if subject to rainfall, frost or vehicle trafficking. Exposure to the elements should be limited for fine-grained soils and covering the soils with polythene sheeting, site concrete or granular engineered fill will reduce degradation due to wind, rain and surface run-off.

Water should not be allowed to pond or collect near or under a foundation slab, footings or earthworks subgrade under any circumstances. Positive grading of the subgrade should be undertaken to prevent water ingress or ponding.

Engineered fill that is utilised as bearing for foundations should be placed and compacted in accordance with the recommendations of NZS 4431:2022 and certification provided to that effect.

Granular fill is recommended to be imported from a local source or quarry for consistency and fine-grained site won soils can be reused as landscaping fill if needed.

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.

Exposure to the elements should be limited for all soils. Excavations in soils should be left proud of the finished subgrade level by 300 mm if a delay prior to construction is expected. The final cut to grade should be performed immediately prior to foundation construction or engineered fill compaction.

6.4 Groundwater Issues

The static groundwater table was measured in the test pits at 0.8 – 3 m depth in the lower terrace, and at 1.8 – 2.8 m in the upper terrace. Groundwater seepages were also observed between 0.9 m and 3.5 m depth. The static groundwater table is expected to lie below typical excavation levels for building platforms. However, this should be reviewed when an earthworks plan and foundation levels are available. Groundwater seepage will need considered during service trench excavations.

It is important that GeoSolve be contacted should there be any seepage, spring flow or under-runners encountered during construction.

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6.5 Excavations

No earthworks plans have been provided to date for this development, however excavations may be required to remove topsoil and uncontrolled fill at the site, create service trenches and to create level building platforms.

Table 4 summarises the recommended batter slopes for temporary and permanent slopes up to 3.0 m high formed in dry ground.

Table 4 - Recommended maximum batters for cut slopes in site soils less than 3.0 m high in dry ground.

Material Type	Recommended Maximum Batter Angles for Temporary Cut Slopes Formed in Dry Soil (horizontal to vertical)	Recommended Maximum Batter Angles for Permanent Cut Slopes Formed in Soil – dry ground only (horizontal to vertical)
Topsoil & Uncontrolled Fill	2H: 1V	3H: 1V
Silt & Sand	1.5H: 1V	3H: 1V
Alluvial Gravel	1H: 1V	2.5H: 1V
Engineered Fill	NA	2.5H: 1V

If wet slopes are encountered, they should be inspected on a case-by-case basis by a geotechnical engineer/engineering geologist to confirm any specific recommendations e.g. drainage installation, cut off diversion drains or retaining.

All cuts 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.

6.6 Preliminary Foundation Options

6.6.1 General

We have undertaken a geotechnical investigation to assist with feasibility and consenting for the development. Further geotechnical investigation will be required to be undertaken following completion of the development plans to support building consent assessments. However, for completeness we have provided advice on potential foundation options, with the geotechnical information to date.

Based on the above either shallow or piled foundations can be used. We have provided further recommendations below.

During earthworks all uncontrolled fill, organic matter and other soft/unsuitable materials should be removed from the building platforms in accordance with the recommendations of NZS 4431:2022. Any engineered fill underlying a foundation should be placed and compacted in accordance with NZS 4431:2022 and certification provided to that effect.

The alluvial silt soils are susceptible to softening from rainfall, frost and vehicle trafficking. If softening occurs further undercutting will be required.

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Once the final development plan has been completed, it should be reviewed by a suitability experienced geotechnical engineer to confirm the design assumptions are met and whether further geotechnical investigation is warranted. It is also standard practice that the stripped building and earthworks platforms will need to be inspected and tested by a geotechnical practitioner.

6.6.2 Shallow Foundations

Near surface foundation bearing will be governed by the alluvial silt which will provide a reduced bearing capacity and will require specific engineering design, as shown on Figure4 below.

Figure 4 provides an assessment of allowable bearing capacity for shallow footings. It should be noted the foundation working stresses presented in Figure 4 are governed by bearing capacity in the case of narrow footings and settlement in the case of wide footings.

As an example, from Figure 4, it can be seen an allowable working stress of approximately 50 kPa is recommended for a 400 mm wide by 400 mm deep strip footing founded within alluvial silt. This corresponds to a factored (ULS) bearing capacity of approximately 75 kPa and an ultimate geotechnical bearing capacity of 150 kPa.

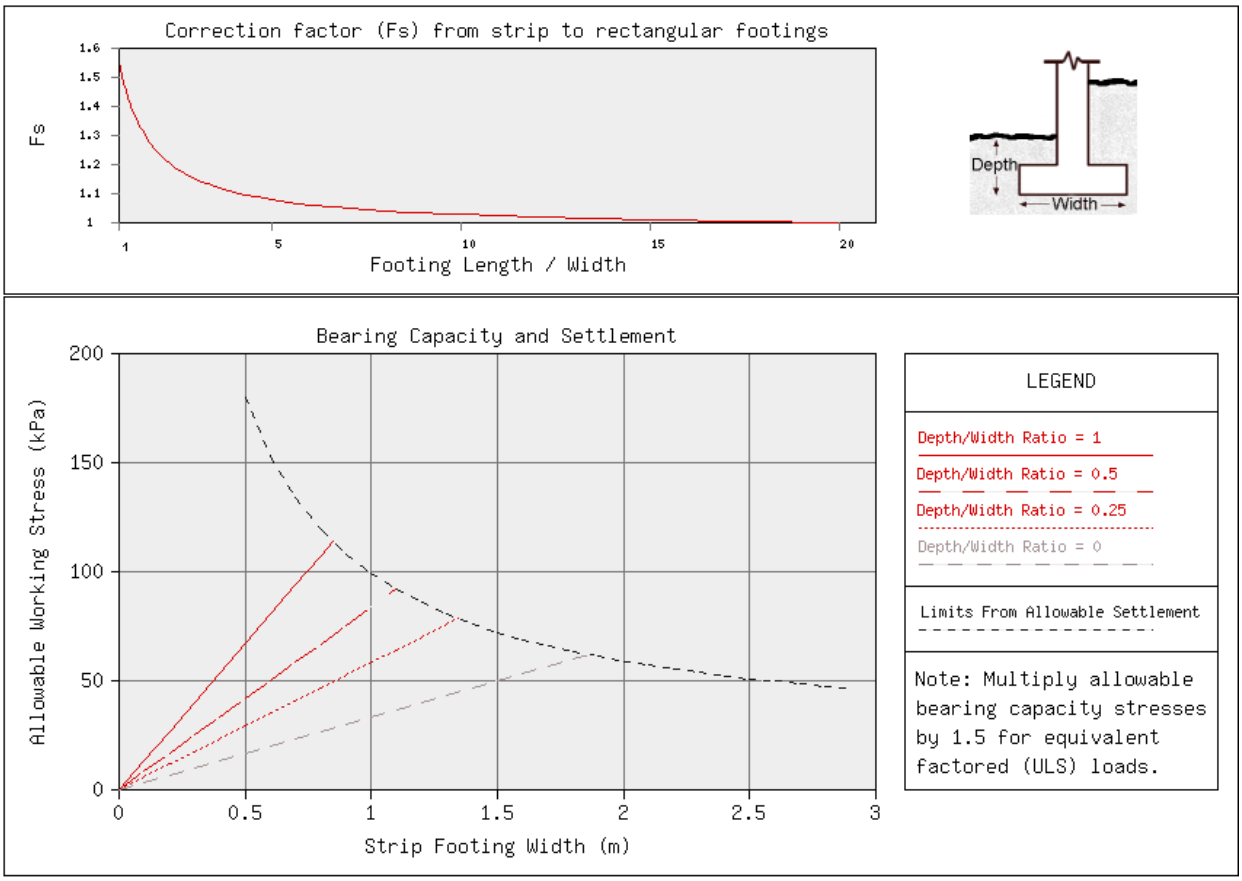


Figure 4– Recommended Bearing for Alluvial Silt

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It should be noted that the bearing capacities presented above assume that the loads are vertical with no horizontal loads or moments applied to the foundations. Reduction factors to account for eccentric and/or horizontal loads can be provided during detailed design once loads are finalised.

If the bearing capacity is not sufficient for design, or structural engineering input is not preferred, ground improvement can be conducted to improve the bearing capacity of the underlying soil materials. Undercut and replacement with engineered fill can be used to increase the bearing capacity. The depth of undercut required can be confirmed during detailed design once the footing dimensions and loads are known. It is recommended that the engineered fill extends sufficiently past the edges of the footings. This is to allow enough width to ensure that there is sufficient allowable load spread below the footing and for a minimum 400 kg plate compactor to work in the footing to compact the engineered fill.

Any softened soils will need to be undercut and replaced with engineered fill placed and compacted in accordance with NZS4431:2022.

Liquefaction is not calculated in a SLS or intermediate level event and is calculated at variable depth in the ULS event. Therefore, as long as foundations are kept narrow and shallow, it is possible to design based on the above to meet minimum building code design levels, subject to final foundation design review. Regardless, thought should be given to design so all foundations are tied together to gain further resilience, where practicable. If further resilience is desired than the above, the foundation could be designed to span fully unsupported 2 m around the edge of the building and 4 m internally. GeoSolve can provide further advice if required.

6.6.3 Piled Foundations

Driven timber or bored piled foundations could be founded within the medium dense to dense alluvial gravel. As the gravel and liquefiable layers vary in depth across the site, GeoSolve can provide further advice on proposed depths and capacities once further development information is known.

6.7 Pavement CBR Values

Preliminary testing for pavements has been undertaken at this stage. Subsurface shallow test pits and Scala penetrometers have been undertaken across the subdivision area providing sufficient information on the near surface soil profile for preliminary pavement CBR recommendations.

Following removal of the unsuitable soils, topsoil and uncontrolled fill, the pavement subgrade layer will predominantly comprise alluvial silt. A preliminary design CBR of 2% can be assumed for the silt subgrade. Note that with rain saturation, ponding and machinery trafficking the CBR could reduce to less than 2%. Further testing including falling weight deflectometer (FWD) testing could be completed if the proposed pavement design requires a value greater than 2%.

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All soft, wet or unsuitable materials, which are exposed during preparation of the pavement subgrade should be excavated and replaced with engineered fill. Note that subgrade soils with any organic content will not be suitable as a pavement subgrade and will require undercutting. Road construction undertaken during the winter months will also need to take into account the presence of fine-grained soils and be planned accordingly. Saturated soils damaged by weathering, frost or construction traffic will need to be undercut and replaced with granular fill.

Silt softened by the excavation process will require rolling to recompact the softened layer prior to placement of any granular pavement layers.

All engineered fill beneath pavements should be placed and compacted in accordance with Invercargill City Council requirements. Inspection of the pavement subgrade should be completed during construction by a suitably qualified geotechnical practitioner/civil engineer to confirm subsurface conditions are in accordance with this report.

A geotextile separation layer is recommended between the undercut surface of fine-grained soils and granular hard fill.

It is recommended that pavement design CBR's are reviewed following earthworks contour design. Specific road alignment testing can be undertaken at detailed design stage to prove higher CBR values at the design pavement levels.

6.8 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.

Based on readily available information at the time of writing this report, GeoSolve recommends that Subsoil Category Class D is used for structural design.

6.9 Further Geotechnical Involvement

Development plans were not confirmed at the time of reporting; therefore, this report is focussed on allowing concept development. Further investigations and assessment may be required for detailed design of structures, these could include additional shallow investigations such as test pitting as well as deep testing such as cone penetrometer testing (CPTs) to confirm piling layers and liquefaction risk.

In addition, further geotechnical assessment of foundations, once loadings and systems are known, may be required.

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7 Wastewater Disposal Infiltration Rates

7.1 General

Soakage infiltration testing was undertaken at two locations, at depths of 2.2 and 2.8 m in the alluvial sand unit, adjacent to TP03 and TP05 respectively (refer to Appendix A and B for soakage/test pit locations and logs) to assess preliminary infiltration rates for wastewater disposal to ground scoping. Five test pits (TP1-5) were undertaken in the east of the site where wastewater disposal is proposed to review the ground model and groundwater levels and should be reviewed alongside the preliminary infiltration rates.

Prior to undertaking soakage testing, adjacent test pits were excavated to 3.5-3.8 m depth to log the subsoil conditions and determine a suitably consistent layer for soakage testing. Two smaller test pits/soak pits (1.4-1.8 m long and 0.4 m wide) were then excavated for the soakage test. The dimensions of the soakage pit were recorded to calculate the volume and area of soakage during testing.

Soakage testing was performed by introducing water until the designated testing level was reached. The inflow was then shut off and the time it took for the water level to drop was recorded. Where possible, testing was completed multiple times until 3 consistent readings had been achieved.

7.2 Permeability Analysis – Infiltration Rates and Soil Category

7.2.1 General

Surficial layers of topsoil, uncontrolled fill, alluvial silt and swamp deposits will provide very low infiltration rates. Infiltration testing has targeted the more permeable sand layers.

GeoSolve are to be consulted to review the final depth and location of the proposed wastewater disposal system to ensure the infiltration rates and recommendations of this report are applicable. Further testing will be required once the proposed wastewater disposal system and location are confirmed.

It is recommended the wastewater disposal areas are located downslope and are well offset from the proposed building platforms.

Provision should be included for long-term inspection and routine maintenance of any disposal system installed. Performance of the disposal systems may decline below an acceptable level over time if sufficient maintenance is not completed.

7.2.2 Wastewater Disposal Infiltration Rates

The results from field soakage infiltration testing are presented below in Table 5 and Appendix C.

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Table 5 - Calculated Infiltration Rates.

Test	Depth of test	Observed thickness of alluvial sand beneath base of test	Soil type at base of pit	Unfactored infiltration rate*	Factored infiltration rate**
SP01	2.2m	1.3 m +	Fine to medium SAND	**45 mm/hr**	**22.5 mm/hr**
SP02	2.8 m	0.7 m (then alluvial SILT)	Fine to medium SAND	**0.15 mm/hr**	**0.07 mm/hr**
*Does not include a reduction factor to account for loss of soakage performance over time. ** Includes a reduction factor of 0.5 to account for loss of soakage performance over time.					

Unfactored and factored infiltration rates are provided above within Table 5. To allow for any loss of soakage performance over, a reduction factor of at least 0.5 should be applied to the unfactored values for detailed design purposes.

As discussed above, the infiltration rate is expected to vary significantly based on the proposed depth and location of the disposal system, and it is recommended that this is considered at an early stage in the layout planning.

A geotechnical practitioner who is familiar with the findings of this report should inspect the base/infiltration depth of any proposed disposal system location to ensure the infiltration rates presented in Table 5 above are applicable.

7.2.3 Preliminary Wastewater Disposal Soil Category

Table 6 – Preliminary wastewater disposal soil category

Test	Depth of test	Soil type at testing level and test subsoil	AS/NZS 1547:2012 Soil Category (Table 5.1)
SP01	2.2m	Fine to medium SAND	3-4
SP02	2.8 m	Fine to medium SAND	5

A preliminary soil category for each test, in accordance with Table 5.1 of AS/NZS 1547:2012, is presented above in Table 6. The category is based on observed grain size, soil structure and permeability test results.

It is recommended that soil category in the proposed system location be reviewed by the wastewater system designer.

7.3 Conclusions and Recommendations

Due to the varying ground model and groundwater level further testing or review will be required once the location and method of the proposed wastewater disposal field is confirmed.

8 Neighbouring Structures/Hazards

Natural Hazards: 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 dwellings, but there are no site-specific constraints.

Liquefaction risk is outlined in Section 5.

No flooding or contamination assessment has been undertaken for this report.

Distances to adjoining structures: The site is located within a rural/commercial area with an existing residential dwelling adjacent to the south-western edge of the site and existing commercial building located on the property and to the north.

Noise and vibration: Pile driving foundation options and construction of engineered fill close to the nearby structures will need to consider vibration effects on these buildings.

The construction contractor should take standard measures to control construction noise, in accordance with Invercargill City Council requirements.

Aquifers: The regional groundwater table is expected to lie below the proposed building platform levels and no aquifer resource is expected to be adversely affected by the proposed development.

Dust: The soils have a relatively low potential to generate dust. However, the Contractor should take appropriate measures to control dust in accordance with Invercargill City Council requirements. Regular dampening with sprinklers during summer months is expected to be an effective measure to control airborne dust during construction.

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9 Conclusions and Recommendations

- The stratigraphy at the site comprises topsoil and uncontrolled fill overlying alluvial silt, sand and gravel.
- The static groundwater table was measured in the test pits at 0.8 – 3.0 m depth in the lower terrace, and at 1.8 – 2.8 m in the upper terrace. Groundwater seepages were also observed between 0.9 m and 3.5 m depth.
- Based on the liquefaction analysis in Section 5 of this report, the site is equivalent to both a MBIE TC1 and MBIE TC2 site in Canterbury.
- No liquefaction is calculated for the SLS and intermediate earthquake due to the relatively low levels of shaking.
- Geotechnical design parameters are presented in Table 3 of the report.
- All unsuitable materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during construction.
- Potential foundation options are discussed in Section 6.6.
- Pavement CBR values are included in Section 6.7.
- Fill that is utilised as bearing for foundations should be placed and compacted in accordance with NZS 4431:2022 and certification provided to that effect.
- Class D subsoil category is recommended to be used for structural design.
- Wastewater disposal infiltration rates and soil categories are presented in Section 7 of this report.
- It is recommended that the foundation excavations and earthworks subgrade be inspected and tested by a suitably qualified and experienced geotechnical specialist to confirm the conditions are in accordance with the assumptions and recommendations provided in this report.

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10 Applicability

This report has been prepared for the benefit of Tulloch Group Ltd. 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:



.....

Sharyn Buunk

Engineering Geologist

Reviewed for GeoSolve Ltd by:



.....

Tim Plunket

Senior Geotechnical Engineer (CPEng)



.....

Fraser Wilson

Senior Engineering Geologist

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Appendix A: Site Investigation Plan



Notes:
1. These drawings have been prepared for the benefit of Tulloch Group Ltd 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.

SCALE 1: 1200

0 12 24 36 48 60 (m)

Key

- TP01 Deep Test pit and Scala Penetrometer
- TP22 Shallow Test pit and Scala Penetrometer
- SP01 Soak pit
- DPH01 Dynamic Probe Heavy Test (DPH)
- Property Boundary

GEOSOLVE
192 Spey Street, Invercargill
www.geosolve.co.nz

DRAWN	AJJ	Sep 23
DRAFTING CHECKED	SLB	Sep 23
APPROVED	FAW	Sep 23
CADFILE: Site Plan-new.dwg		
SCALES (AT A3 SIZE): 1 : 1200		
PROJECT No: 230505		

Tulloch Group Ltd

805, 815 & 819 North Road

Invercargill

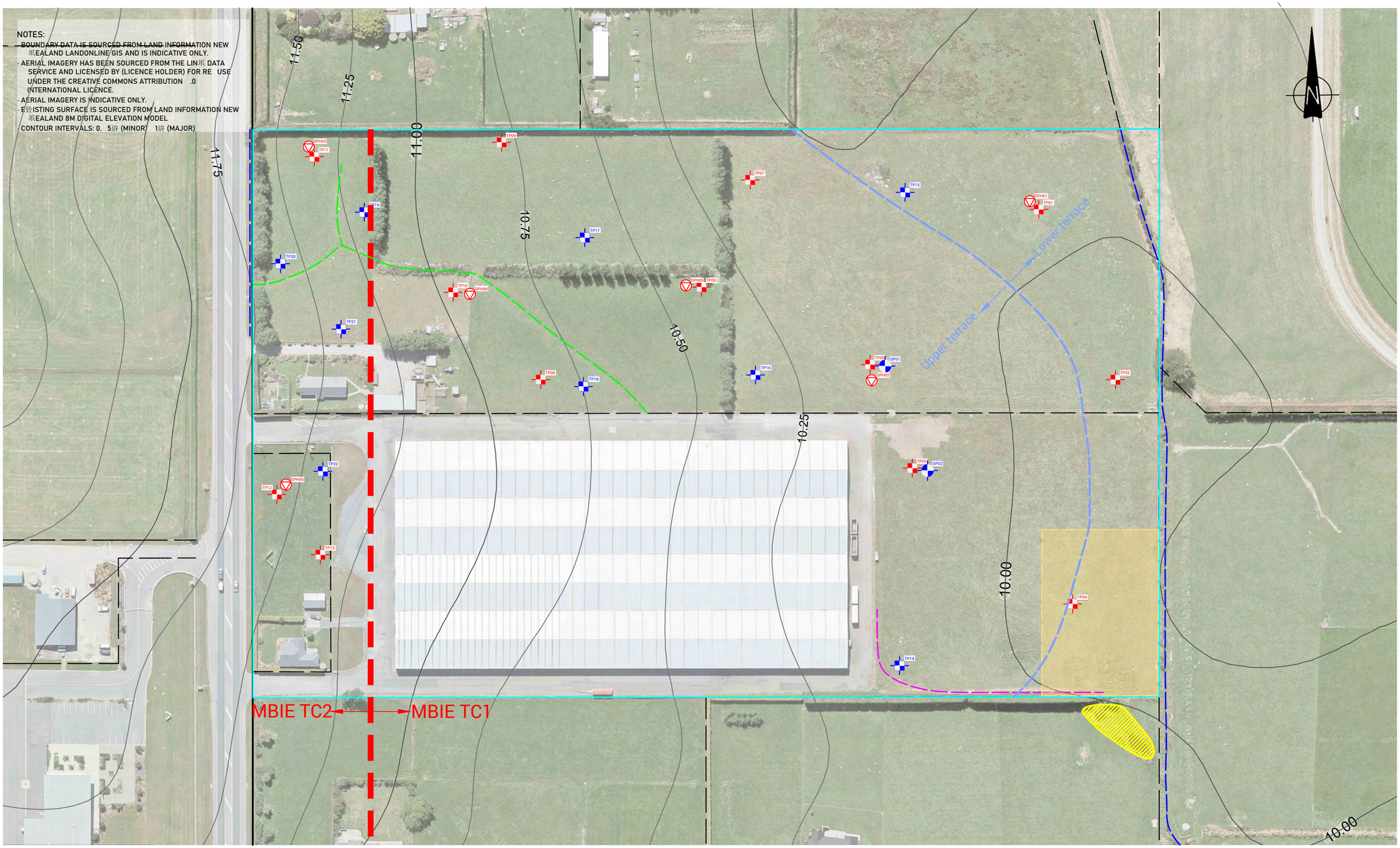
Site Investigation Plan

FIG No: Appendix A - Figure 1

REV. 0

NOTES:

- BOUNDARY DATA IS SOURCED FROM LAND INFORMATION NEW 坂EALAND LANDONLINE GIS AND IS INDICATIVE ONLY.
- AERIAL IMAGERY HAS BEEN SOURCED FROM THE LIN坂 DATA SERVICE AND LICENSED BY (LICENCE HOLDER) FOR RE USE UNDER THE CREATIVE COMMONS ATTRIBUTION .0 INTERNATIONAL LICENCE.
- AERIAL IMAGERY IS INDICATIVE ONLY.
- E坍ISTING SURFACE IS SOURCED FROM LAND INFORMATION NEW 坂EALAND 8M DIGITAL ELEVATION MODEL
- CONTOUR INTERVALS: 0. 5坍 (MINOR) 1坍 (MAJOR)



Notes:
1. These drawings have been prepared for the benefit of Tulloch Group Ltd 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.

SCALE 1: 1500

0 15 30 45 60 75 (m)

Key

- TP01 — Deep Test pit and Scala Penetrometer
- TP22 — Shallow Test pit and Scala Penetrometer
- SP01 — Soak pit
- DPH01 — Dynamic Probe Heavy Test (DPH)
- Property Boundary
- Swampy area and pond
- Potential swamp deposit area
- Approximate TC1/TC2 Boundary
- Drainage Ditch
- Paleochannel
- Excavated channel
- Approximate upper and lower terrace boundary

GEOSOLVE
192 Spey Street, Invercargill
www.geosolve.co.nz

DRAWN	AJJ	Sep 23
DRAFTING CHECKED	SLB	Sep 23
APPROVED	FAW	Sep 23
CADFILE: Site Plan-new.dwg		
SCALES (AT A3 SIZE): 1 : 1500		
PROJECT No: 230505		

Tulloch Group Ltd

805, 815 & 819 North Road

Invercargill

Site Investigation Plan

FIG No: Appendix A - Figure 2

REV. 0

Appendix B: Investigation Data

TEST PIT LOG

HOLE NO.: TP01

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

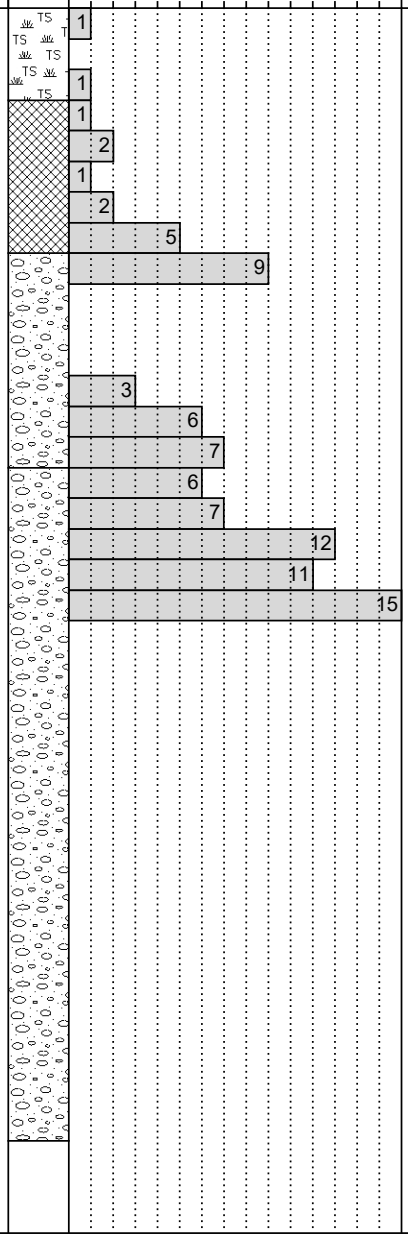
SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 07/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 07/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with some gravel and a trace of sand, dark brown. Soft, moist, sand, fine to medium; gravel, fine to medium, subangular to subrounded; a trace of rootlets. 0.3 m		
UNCONTROLLED FILL	Organic SILT with some sand, gravel and rubbish, dark brown. Firm to stiff, moist to wet, sand, fine to medium; gravel, fine to medium, subangular to subrounded; rubbish, wood, steel, wires, brick, plastic. 0.8 m		0.5
ALLUVIAL GRAVEL	Sandy fine to medium GRAVEL with a trace of organics, grey. Medium dense to dense, saturated, gravel, subangular to subrounded; sand, fine to medium. 1.5 m		1.0
	Sandy fine to medium GRAVEL, orange brown. Medium dense to dense, saturated, gravel, subangular to subrounded; sand, fine to medium. 3.7 m		1.5, 2.0, 2.5, 3.0, 3.5
	End Of Hole: 3.70 m		



SHEAR STRENGTH (kPa)
Vane: 50 100 150 200 Values

WATER
07/08/2023

PHOTO(S)

REMARKS

Excavation terminated at maximum reach.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:30 pm

TEST PIT LOG

HOLE NO.: TP02

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

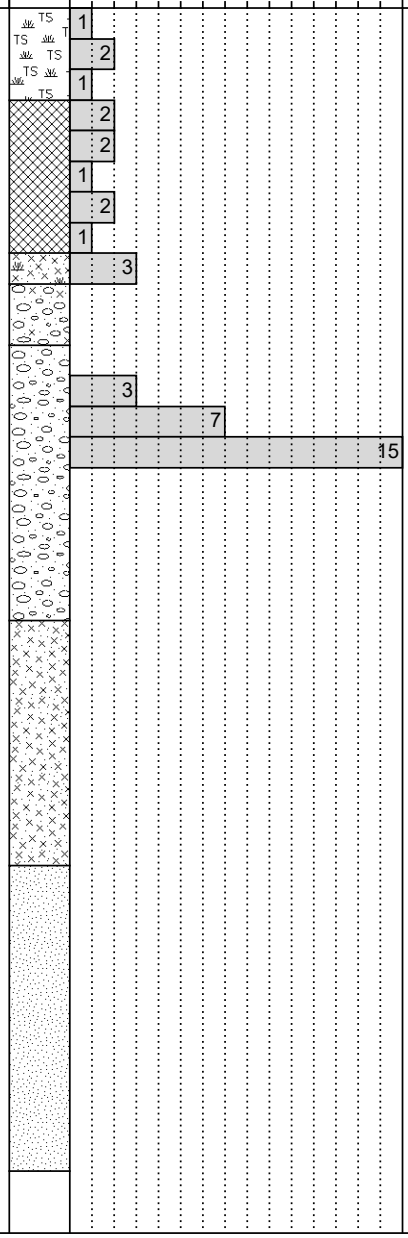
SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 07/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 07/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with some gravel and a trace of sand, dark brown. Firm, moist, gravel, fine to medium, subangular to subrounded; a trace of rootlets. 0.3 m		
UNCONTROLLED FILL	SILT with a trace of sand, gravel and minor organics, orange brown mottled grey. Firm, moist, gravel, fine to medium, subangular to subrounded; sand, fine to medium; a trace of rootlets. 0.8 m		0.5
BURIED TOPSOIL	Organic SILT with minor sand, brown. Stiff, moist, sand, fine to medium; a trace of rootlets. 0.9 m		
ALLUVIAL GRAVEL	Sandy fine to medium GRAVEL with some silt, grey. Medium dense, moist, sand, fine to medium; gravel, subangular to subrounded. 1.1 m		1.0
	Sandy fine to medium GRAVEL, orange brown. Medium dense to dense, moist to wet, sand, fine to medium; gravel, subangular to subrounded. 2.0 m		1.5
ALLUVIAL SILT	Sandy SILT, orange brown. Very stiff, wet, sand, fine to medium. 2.8 m		2.0 2.5
ALLUVIAL SAND	Fine to medium SAND, orange brown. Medium dense, wet. 3.8 m		3.0 3.5
	End Of Hole: 3.80 m		



PHOTO(S)

REMARKS

Excavation terminated at maximum reach.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:33 pm

TEST PIT LOG

HOLE NO.: TP03

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

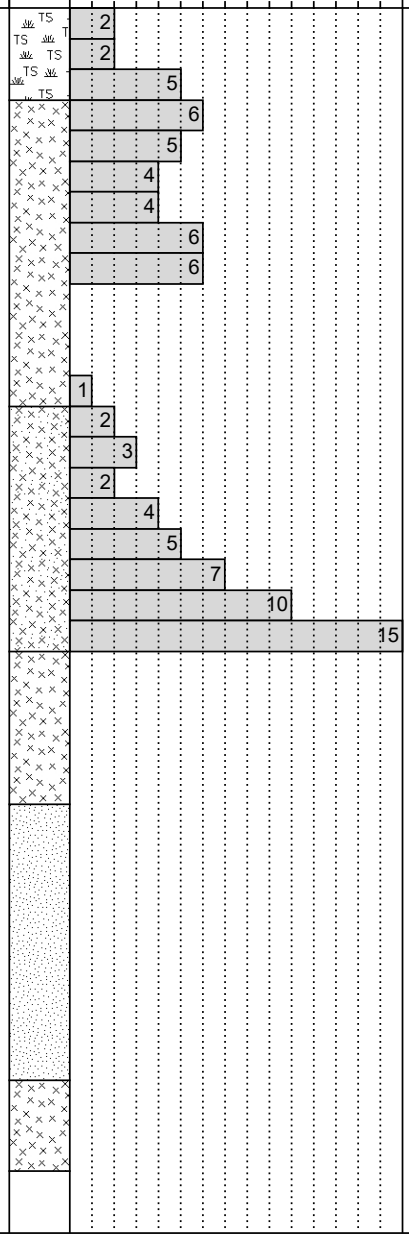
SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 07/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 07/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with minor gravel and a trace of sand, brown. Firm to stiff, moist, sand, fine to medium; gravel, fine to medium, subangular to subrounded; a trace of rootlets. 0.3 m		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium. 1.3 m		
	SILT with some sand, orange brown. Firm to very stiff, moist, sand, fine to medium. 2.1 m		
	SILT with a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium. 2.6 m		
ALLUVIAL SAND	Fine to medium SAND, grey mottled orange brown. Medium dense, moist. 3.5 m		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Very stiff, moist, sand, fine to medium. 3.8 m		
	End Of Hole: 3.80 m		



SHEAR STRENGTH (kPa)
Vane: 50 100 150 200 Values

WATER
07/08/2023

PHOTO(S)

REMARKS

Excavation terminated at maximum reach.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:35 pm

TEST PIT LOG

HOLE NO.: TP04

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill | **CONTRACTOR:** SM Civil | **START DATE:** 07/08/2023

COORDINATES: | **EQUIPMENT:** 5T | **END DATE:** 07/08/2023

LOCATION METHOD: Map or aerial photograph | **ACCURACY:** ± 3 m | **LOGGED BY:** AJJ

ELEVATION: Existing ground level | **OPERATOR:** Johnny | **CHECKED DATE:** 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with some sand, gravel and a trace of rubbish, brown. Soft to firm, moist, sand, fine to medium; gravel, fine to medium, subangular to subrounded; rubbish, brick; a trace of rootlets. 0.5 m		0.5	TS	1, 1, 1, 2, 1		
UNCONTROLLED FILL	SILT with some gravel and a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium; gravel, fine to medium, subangular to subrounded; a trace of rootlets. 0.7 m SILT with a trace of sand, orange brown mottled brown. Stiff, moist, sand, fine to medium. 1.1 m		1.0		4, 5, 4, 3		
SWAMP DEPOSIT	Organic SILT with a trace of sand, dark brown. Very soft to soft, moist, sand, fine to medium; some roots and a trace of rootlets. 1.7 m		1.5		1		07/08/2023
SWAMP DEPOSIT	Organic SILT with some sand, dark grey. Soft to stiff, moist, sand, fine to medium; some roots and a trace of rootlets. 2.3 m		2.0		1, 1, 1, 2, 3, 3		
ALLUVIAL GRAVEL	Sandy fine to medium GRAVEL with minor silt, bluish grey mottled orange brown. Medium dense to dense, wet to saturated, sand, fine to medium; gravel, subangular to subrounded. 3.0 m Sandy fine to coarse GRAVEL with minor silt, orange brown. Medium dense to dense, saturated, sand, fine to medium; gravel, subangular to subrounded. 3.8 m		2.5 3.0 3.5				07/08/2023
	End Of Hole: 3.80 m						

PHOTO(S)

REMARKS

Excavation terminated at maximum reach.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:38 pm

TEST PIT LOG

HOLE NO.: TP05

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 07/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 07/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with a trace of sand, dark brown. Soft to firm, moist, sand, fine to medium; a trace of rootlets.		
			0.3 m
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium; a trace of rootlets.		0.5
			1.0
			1.5
			1.6 m
	Sandy SILT, orange brown. Very stiff, moist, sand, fine to medium.		1.9 m
ALLUVIAL SAND	Fine to medium SAND, grey. Medium dense to dense, moist.		2.0
			2.5
			3.0
			3.1 m
	Fine to coarse SAND, orange brown. Medium dense to dense, moist.		3.5
			3.5 m
	End Of Hole: 3.50 m		

LEGEND

SCALA PENETROMETER (Blows / 100 mm)

Depth	Blows
0.0 – 0.1	1
0.1 – 0.2	2
0.2 – 0.3	2
0.3 – 0.4	3
0.4 – 0.5	3
0.5 – 0.6	6
0.6 – 0.7	6
0.7 – 0.8	6
0.8 – 0.9	6
0.9 – 1.0	2
1.0 – 1.1	4
1.1 – 1.2	4
1.2 – 1.3	4
1.3 – 1.4	7
1.4 – 1.5	6
1.5 – 1.6	7
1.6 – 1.7	9
1.7 – 1.8	12

SHEAR STRENGTH (kPa) Vane: Values

WATER

07/08/2023

PHOTO(S)

REMARKS

Excavation terminated at maximum reach.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:40 pm

GEOSOLVE
ENGINEERING CONSULTANTS

TEST PIT LOG

HOLE NO.: TP06

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 07/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 07/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with a trace of sand and gravel, dark brown. Soft to firm, moist, sand, fine to medium; gravel, fine to medium, subangular to subrounded; a trace of rootlets. 0.3 m		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to very stiff, moist, sand, fine to medium; a trace of rootlets. 2.0 m		0.5, 1.0, 1.5, 2.0
	Sandy SILT, grey. Stiff to very stiff, moist, sand, fine to medium. 2.3 m		
ALLUVIAL SAND	Fine to medium SAND, grey. Medium dense, moist to wet. 3.6 m		2.5, 3.0, 3.5
	Fine to medium SAND, orange brown mottled grey. Medium dense to dense, wet. 3.7 m		
	End Of Hole: 3.70 m		

LEGEND

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.0 – 0.1	1
0.1 – 0.2	1
0.2 – 0.3	2
0.3 – 0.4	4
0.4 – 0.5	3
0.5 – 0.6	3
0.6 – 0.7	3
0.7 – 0.8	3
0.8 – 0.9	3
0.9 – 1.0	3
1.0 – 1.1	2
1.1 – 1.2	2
1.2 – 1.3	3
1.3 – 1.4	5
1.4 – 1.5	4
1.5 – 1.6	5
1.6 – 1.7	4
1.7 – 1.8	6

SHEAR STRENGTH (kPa) Vane: 50, 100, 150, 200 — Values

WATER

07/08/2023

PHOTO(S)

REMARKS

Excavation terminated at maximum reach.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:42 pm

TEST PIT LOG

HOLE NO.: TP07

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 07/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 07/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with a trace of sand, dark brown. Firm, moist, sand, fine to medium; a trace of rootlets.		
			0.3 m
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets.		0.5
			1.0
			1.5
			1.9 m
	Sandy SILT, orange brown mottled grey. Very stiff, moist, sand, fine to medium.		2.0
			2.2 m
ALLUVIAL SAND	Fine to medium SAND, grey. Medium dense, moist to wet.		2.5
			3.0
			3.2 m
	Fine to medium SAND, orange brown mottled grey. Medium dense, wet.		3.5
			3.6 m
	End Of Hole: 3.60 m		

LEGEND

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.0 – 0.3	1, 2, 2
0.3 – 1.9	3, 3, 3, 3, 3, 4, 2, 4, 4, 4, 4, 4, 4
1.9 – 2.2	10, 15

SHEAR STRENGTH (kPa)
Vane: Values

WATER
07/08/2023

PHOTO(S)

REMARKS

Excavation terminated due to pit wall collapse.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:45 pm

TEST PIT LOG

HOLE NO.: TP08

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

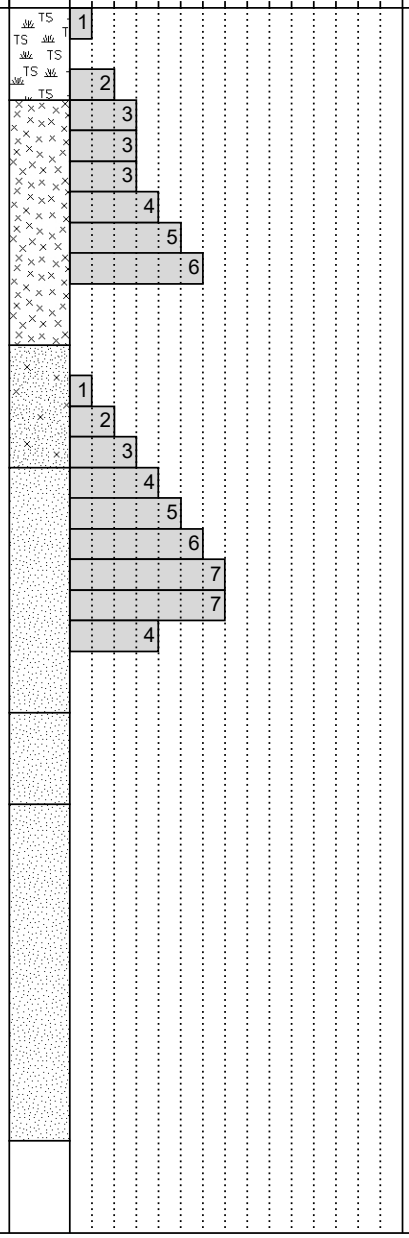
SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 08/08/2023

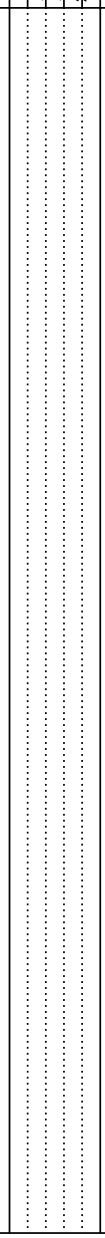
COORDINATES:
EQUIPMENT: 5T
END DATE: 08/08/2023

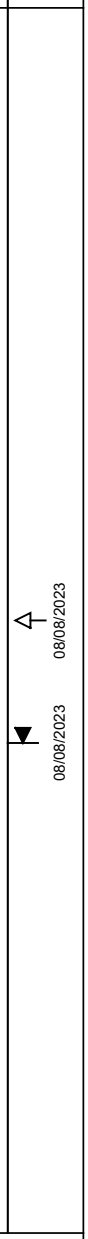
LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with a trace of sand, dark brown. Very soft to firm, moist, sand, fine to medium; a trace of rootlets. 0.3 m		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium; a trace of rootlets. 1.1 m		0.5
ALLUVIAL SAND	Silty fine SAND, grey. Loose to medium dense, moist. 1.5 m		1.0
	Fine to medium SAND, grey. Medium dense to dense, moist to wet. 2.3 m		1.5
	Fine to medium SAND, orange brown. Medium dense, wet. 2.6 m		2.0
	Fine to medium SAND, grey mottled orange brown. Medium dense to dense, wet. 3.7 m		2.5
	End Of Hole: 3.70 m		3.0
			3.5







PHOTO(S)

REMARKS

Excavation terminated due to pit wall collapse.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:47 pm

TEST PIT LOG

HOLE NO.: TP09

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 08/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 08/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with a trace of sand, dark brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets. 0.3 m		
ALLUVIAL SILT	Sandy SILT, orange brown mottled grey. Firm to very stiff, moist, sand, fine to medium. 2.6 m		
	SILT with a trace of sand, grey. Stiff to very stiff, moist to wet, sand, fine to medium. 2.9 m		
ALLUVIAL SAND	Silty fine to medium SAND, grey mottled orange brown. Medium dense, wet. 3.7 m		
	End Of Hole: 3.70 m		

LEGEND

SCALA PENETROMETER (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.0 – 0.5	1, 2, 3, 3, 3, 4, 3, 5, 5
0.5 – 1.0	2, 1, 2, 4, 3, 5, 5, 5, 7

SHEAR STRENGTH (kPa) Vane: Values

WATER — 08/08/2023

PHOTO(S)

REMARKS

Excavation terminated due to groundwater ingress.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:50 pm

TEST PIT LOG

HOLE NO.: TP10

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill | **CONTRACTOR:** SM Civil | **START DATE:** 08/08/2023

COORDINATES: | **EQUIPMENT:** 5T | **END DATE:** 08/08/2023

LOCATION METHOD: Map or aerial photograph | **ACCURACY:** ± 3 m | **LOGGED BY:** AJJ

ELEVATION: Existing ground level | **OPERATOR:** Johnny | **CHECKED DATE:** 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with a trace of sand, dark brown. Firm, moist, sand, fine to medium; a trace of rootlets. 0.3 m			TS	1, 1		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to very stiff, moist, sand, fine to medium; a trace of rootlets. 0.9 m		0.5		2, 3, 3, 2, 2, 2, 5		08/08/2023
	SILT with a trace of sand, grey mottled orange brown. Firm to very stiff, mosit to wet, sand, fine to medium. 2.0 m		1.0		2, 3, 5, 9, 9, 10, 12		
ALLUVIAL SAND	Fine to medium SAND, orange brown mottled grey. Medium dense to dense, wet. 2.8 m		1.5		14, 15		08/08/2023
	Fine to medium SAND, grey. Medium dense to dense, wet. 3.4 m		2.0				
	Fine to medium SAND, orange brown mottled grey. Medium dense, wet. 3.7 m		2.5				
	End Of Hole: 3.70 m		3.0				
			3.5				

PHOTO(S)

REMARKS

Excavation terminated due to pit wall collapse.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:52 pm

TEST PIT LOG

HOLE NO.: TP11

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill

CONTRACTOR: SM Civil

START DATE: 08/08/2023

COORDINATES:

EQUIPMENT: 5T

END DATE: 08/08/2023

LOCATION METHOD: Map or aerial photograph

ACCURACY: ± 3 m

LOGGED BY: AJJ

ELEVATION: Existing ground level

OPERATOR: Johnny

CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with a trace of sand, dark brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets. 0.3 m			TS	1, 1		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets. 1.5 m		0.5		3, 3, 3, 3, 4, 5, 6		
	Sandy SILT, grey mottled orange brown. Firm to stiff, wet, sand, fine to medium. 2.9 m		1.0, 1.5, 2.0, 2.5		2, 2, 2, 4, 2, 2, 3, 4		08/08/2023
ALLUVIAL SAND	Fine to medium SAND, grey. Medium dense, wet. 3.4 m		3.0				
	End Of Hole: 3.40 m		3.5				

PHOTO(S)

REMARKS

Excavation terminated due to groundwater ingress.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:55 pm

TEST PIT LOG

HOLE NO.: TP12

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 08/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 08/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with a trace of sand, dark brown. Soft to stiff, moist, sand, fine to medium; a trace of rootlets. 0.3 m			TS	1, 1, 3		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to very stiff, moist, sand, fine to medium; a trace of rootlets. 1.6 m		0.5, 1.0, 1.5		2, 3, 4, 5, 5, 4, 2, 3, 3, 4		
ALLUVIAL SAND	Silty fine to medium SAND, orange brown mottled grey. Medium dense to dense, moist. 2.1 m		2.0		8, 8, 9, 8, 9		08/08/2023
ALLUVIAL SILT	SILT with trace to minor sand, grey mottled orange brown. Firm, moist to wet, sand, fine to medium. 3.4 m		2.5, 3.0				
ALLUVIAL SAND	Fine to medium SAND with a trace of silt, grey mottled orange brown. Medium dense, wet. 3.9 m		3.5				
	End Of Hole: 3.90 m						

PHOTO(S)

REMARKS

Excavation terminated at maximum reach.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:57 pm

TEST PIT LOG

HOLE NO.: TP13

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 08/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 08/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with a trace of sand, dark brown. Soft, moist, sand, fine to medium; a trace of rootlets. 0.2 m		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium; a trace of rootlets. 0.7 m		0.5
ALLUVIAL SILT	SILT with a trace of sand, orange brown mottled grey. Very stiff, moist, sand, fine to medium; a trace of rootlets. 1.3 m		1.0
ALLUVIAL SAND	Silty fine to medium SAND, orange brown mottled grey. Medium dense, moist. 1.4 m Fine to medium SAND, grey mottled orange brown. Medium dense, wet. 2.1 m		1.5 2.0
ALLUVIAL SILT	Sandy SILT, orange brown. Firm to stiff, wet, sand, fine to medium. 3.1 m		2.5 3.0
	SILT with a trace of sand, orange brown mottled grey. Firm to stiff, wet, sand, fine to medium. 3.9 m		3.5
	End Of Hole: 3.90 m		

SCALA PENETROMETER (Blows / 100 mm)

Depth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0.0	1													
0.1	1													
0.2			3											
0.3			3											
0.4				4										
0.5						6								
0.6								8						
0.7										10				
0.8										10				
0.9														
1.0				4										
1.1				4										
1.2					5									
1.3							7							
1.4			3											
1.5			3											
1.6			3											
1.7						6								
1.8							7							

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER
08/08/2023 (Seepage)
08/08/2023 (Seepage)

PHOTO(S)

REMARKS

Excavation terminated at maximum reach.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:00 pm

TEST PIT LOG

HOLE NO.: TP14

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 07/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 07/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND
TOPSOIL	Organic SILT with some gravel and a trace of sand, brown. Firm, moist, sand, fine to medium; gravel, fine to medium, subangular to subrounded; a trace of rootlets.			TS
			0.3 m	
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Stiff, moist, sand, fine to medium; a trace of rootlets.		0.4 m	
	End Of Hole: 0.30 m		0.5	
			1.0	

SCALA PENETROMETER (Blows / 100 mm)

1 2 3 4 5 6 7 8 9 10 11 12 13 14

5 5 5 5 3 2 2 3 4

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:03 pm

TEST PIT LOG

HOLE NO.: TP15

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill | **CONTRACTOR:** SM Civil | **START DATE:** 07/08/2023

COORDINATES: | **EQUIPMENT:** 5T | **END DATE:** 07/08/2023

LOCATION METHOD: Map or aerial photograph | **ACCURACY:** ± 3 m | **LOGGED BY:** AJJ

ELEVATION: Existing ground level | **OPERATOR:** Johnny | **CHECKED DATE:** 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with a trace of sand, brown. Soft to firm, moist, sand, fine to medium; a trace of rootlets.			TS	2		Groundwater Not Encountered
	0.3 m						
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Soft, moist, sand, fine to medium; a trace of rootlets.		0.5		1		
	0.4 m End Of Hole: 0.30 m				1		
					1		
					1		
			1.0		1		
					1		
					2		
					2		

Scala penetrometer: 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Shear strength (kPa) Vane: 50 100 150 200

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:06 pm

TEST PIT LOG

HOLE NO.: TP16

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 08/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 08/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND
TOPSOIL	Organic SILT with a trace of sand, brown. Firm, moist, sand, fine to medium; a trace of rootlets.			TS
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets. 0.3 m End Of Hole: 0.30 m 0.4 m		0.5 1.0	

SCALA PENETROMETER (Blows / 100 mm)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	2	3	3	5	5	6	5	6	6				

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER

Groundwater Not Encountered

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:08 pm

TEST PIT LOG

HOLE NO.: TP17

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

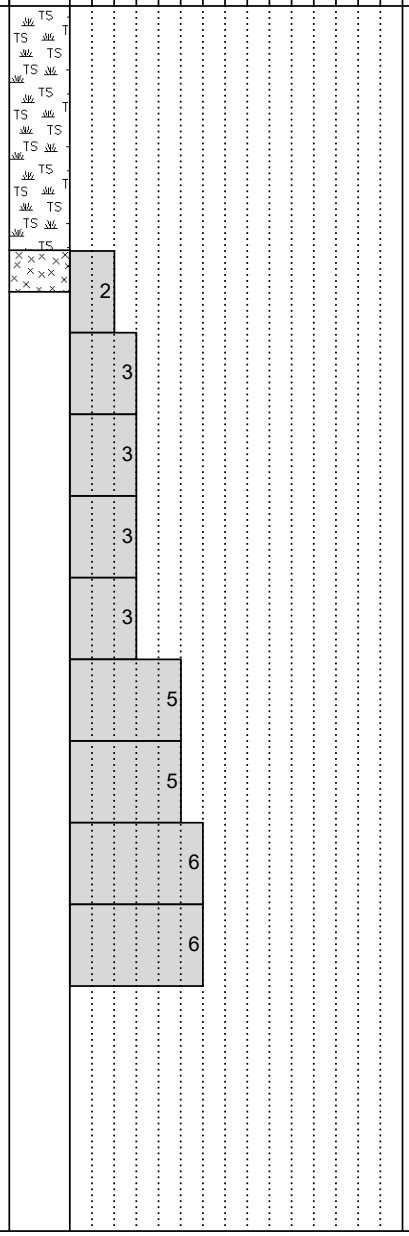
SITE LOCATION: 805, 815, 819 North Road, Invercargill | **CONTRACTOR:** SM Civil | **START DATE:** 08/08/2023

COORDINATES: | **EQUIPMENT:** 5T | **END DATE:** 08/08/2023

LOCATION METHOD: Map or aerial photograph | **ACCURACY:** ± 3 m | **LOGGED BY:** AJJ

ELEVATION: Existing ground level | **OPERATOR:** Johnny | **CHECKED DATE:** 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with a trace of sand, dark brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets.		
			0.3 m
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets.		0.4 m
	End Of Hole: 0.30 m		



SHEAR STRENGTH (kPa)
Vane: 50 100 150 200 | Values

WATER
Groundwater Not Encountered

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:10 pm

TEST PIT LOG

HOLE NO.: TP18

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill | **CONTRACTOR:** SM Civil | **START DATE:** 08/08/2023

COORDINATES: | **EQUIPMENT:** 5T | **END DATE:** 08/08/2023

LOCATION METHOD: Map or aerial photograph | **ACCURACY:** ± 3 m | **LOGGED BY:** AJJ

ELEVATION: Existing ground level | **OPERATOR:** Johnny | **CHECKED DATE:** 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with a trace of sand, dark brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets.						
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets. 0.3 m / 0.4 m		0.5		2, 2, 3, 4, 5, 5, 6, 6, 6		Groundwater Not Encountered
	End Of Hole: 0.30 m		1.0				

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:13 pm

TEST PIT LOG

HOLE NO.: TP19

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill | **CONTRACTOR:** SM Civil | **START DATE:** 08/08/2023

COORDINATES: | **EQUIPMENT:** 5T | **END DATE:** 08/08/2023

LOCATION METHOD: Map or aerial photograph | **ACCURACY:** ± 3 m | **LOGGED BY:** AJJ

ELEVATION: Existing ground level | **OPERATOR:** Johnny | **CHECKED DATE:** 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL
TOPSOIL	Organic SILT with a trace of sand, dark brown. Soft to firm, moist, sand, fine to medium; a trace of rootlets.		
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets. 0.4 m / 0.5 m End Of Hole: 0.40 m		0.5 1.0

LEGEND

SCALA PENETROMETER (Blows / 100 mm)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	2	1	1	2	6	7	6	5	3				

SHEAR STRENGTH (kPa) Vane: 50 100 150 200 Values

WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:15 pm

TEST PIT LOG

HOLE NO.: TP20

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill | **CONTRACTOR:** SM Civil | **START DATE:** 08/08/2023

COORDINATES: | **EQUIPMENT:** 5T | **END DATE:** 08/08/2023

LOCATION METHOD: Map or aerial photograph | **ACCURACY:** ± 3 m | **LOGGED BY:** AJJ

ELEVATION: Existing ground level | **OPERATOR:** Johnny | **CHECKED DATE:** 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with a trace of sand, dark brown. Firm, moist, sand, fine to medium; a trace of rootlets.			TS			
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets. 0.3 m 0.4 m		0.5		2 2 2 2 2 2 4 4 5		Groundwater Not Encountered
	End Of Hole: 0.30 m		1.0				

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:18 pm

TEST PIT LOG

HOLE NO.: TP21

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

JOB NO.: 230505

PROJECT: 805, 815, 819 North Road, Invercargill

SITE LOCATION: 805, 815, 819 North Road, Invercargill | **CONTRACTOR:** SM Civil | **START DATE:** 08/08/2023

COORDINATES: | **EQUIPMENT:** 5T | **END DATE:** 08/08/2023

LOCATION METHOD: Map or aerial photograph | **ACCURACY:** ± 3 m | **LOGGED BY:** AJJ

ELEVATION: Existing ground level | **OPERATOR:** Johnny | **CHECKED DATE:** 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 100 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with a trace of sand, dark brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets.						
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets.		0.5		2, 2, 3, 4, 4, 6, 7, 8, 10		Groundwater Not Encountered
	End Of Hole: 0.40 m		1.0				

0.4 m
0.5 m

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:20 pm

TEST PIT LOG

HOLE NO.: TP22

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 08/08/2023

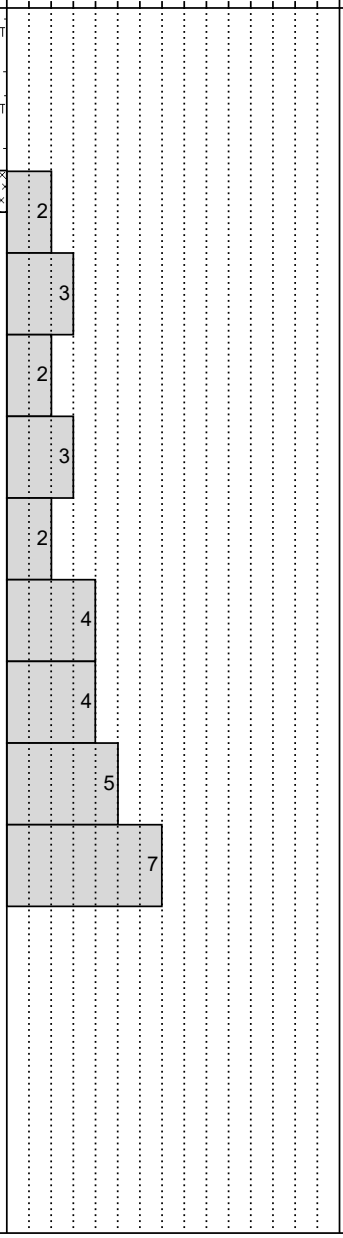
COORDINATES:
EQUIPMENT: 5T
END DATE: 08/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND
TOPSOIL	Organic SILT with a trace of sand and gravel, dark brown. Stiff, moist, sand, fine to medium; gravel, fine to medium, subangular to subrounded; a trace of rootlets.			TS
			0.2 m	
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Firm to stiff, moist, sand, fine to medium; a trace of rootlets.		0.3 m	
	End Of Hole: 0.20 m			

SCALA PENETROMETER (Blows / 100 mm)



SHEAR STRENGTH (kPa)
Vane: 50 100 150 200 Values

WATER
Groundwater Not Encountered

PHOTO(S)

REMARKS

Shallow pit for CBR.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:50:23 pm

TEST PIT LOG

HOLE NO.: SP01

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 08/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 08/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 0 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with a trace of sand, dark brown. Soft to firm, moist, sand, fine to medium; a trace of rootlets. 0.3 m						
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium; trace of rootlets. 1.6 m		0.5, 1.0, 1.5				Groundwater Not Encountered
	Sandy SILT, orange brown. Very stiff, moist, sand, fine to medium. 1.9 m						
ALLUVIAL SAND	Fine to medium SAND, grey. Medium dense, moist. 2.2 m		2.0				
	End Of Hole: 2.20 m		2.5				

Scala penetrometer scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Shear strength (kPa) Vane: 50 100 150 200

PHOTO(S)

REMARKS

Target depth achieved.

WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:25 pm

TEST PIT LOG

HOLE NO.: SP02

CLIENT: Tulloch Group Ltd. C/- Bonish Consultants

PROJECT: 805, 815, 819 North Road, Invercargill

JOB NO.: 230505

SITE LOCATION: 805, 815, 819 North Road, Invercargill
CONTRACTOR: SM Civil
START DATE: 07/08/2023

COORDINATES:
EQUIPMENT: 5T
END DATE: 08/08/2023

LOCATION METHOD: Map or aerial photograph
ACCURACY: ± 3 m
LOGGED BY: AJJ

ELEVATION: Existing ground level
OPERATOR: Johnny
CHECKED DATE: 18/08/2023

SOIL / ROCK TYPE	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH / RL	LEGEND	SCALA PENETROMETER (Blows / 0 mm)	SHEAR STRENGTH (kPa) Vane: Values	WATER
TOPSOIL	Organic SILT with minor gravel and a trace of sand, brown. Firm to stiff, moist, sand, fine to medium; gravel, fine to medium, subangular to subrounded; a trace of rootlets. 0.3 m		0.5 1.0 1.5 2.0 2.5	TS	1 2 3 4 5 6 7 8 9 10 11 12 13 14	50 100 150 200	Groundwater Not Encountered
ALLUVIAL SILT	SILT with a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium. 1.3 m						
	SILT with some sand, orange brown. Firm to very stiff, moist, sand, fine to medium. 2.1 m						
	SILT with a trace of sand, orange brown. Stiff to very stiff, moist, sand, fine to medium. 2.6 m						
ALLUVIAL SAND	Fine to medium SAND, grey mottled orange brown. Medium dense, moist. 2.8 m						
	End Of Hole: 2.80 m						

PHOTO(S)

REMARKS

Target depth achieved.

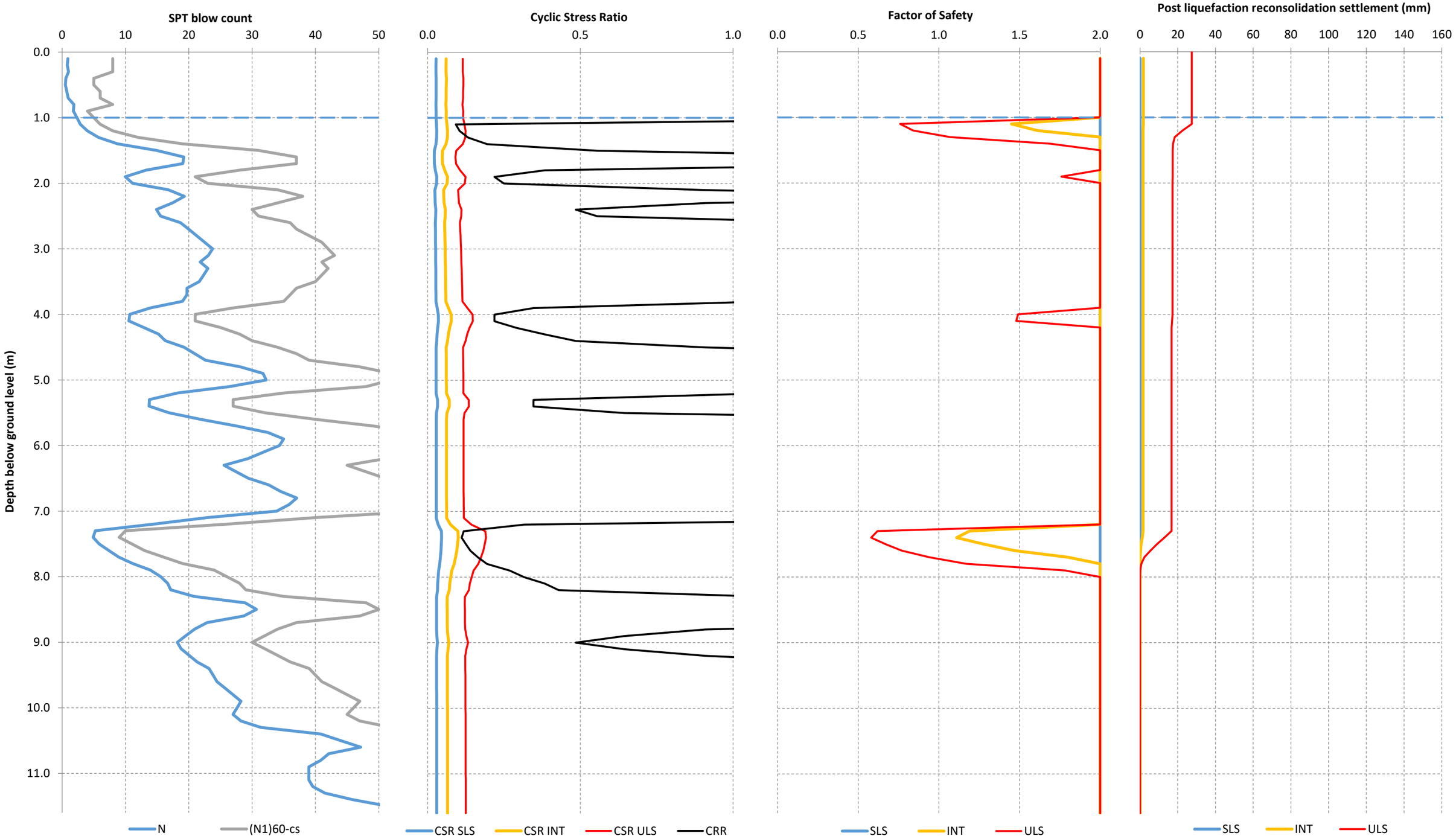
WATER

- Standing Water Level
- Out flow
- Seepage

Generated with CORE-GS by Geroc - Test Pit x Hand Auger - scala & vane bars - 11/09/2023 2:49:28 pm

Appendix C: Liquefaction Analysis

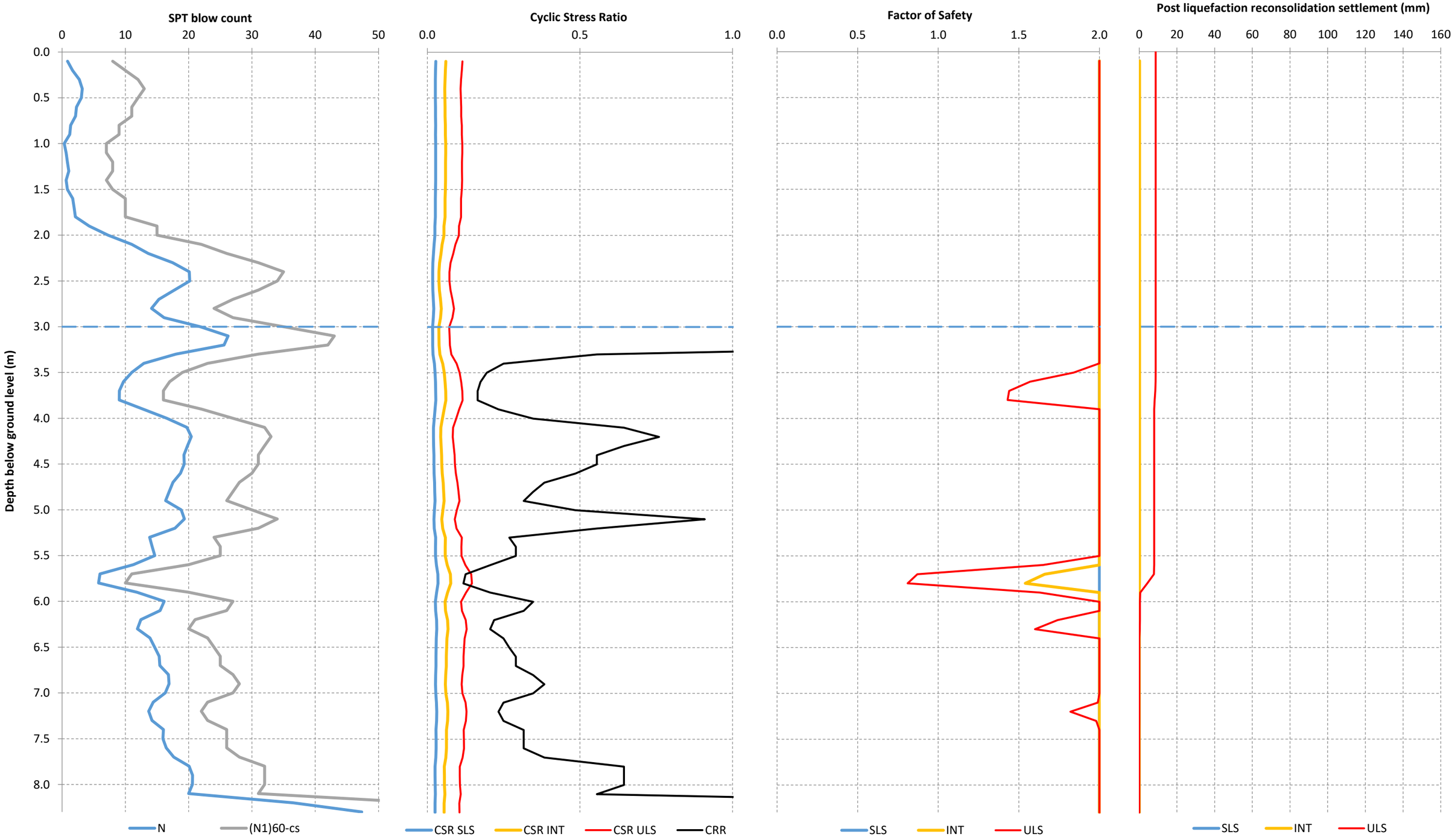
LSN (SLS)	LSN (INT)	LSN (ULS)	Settlement (SLS)	Settlement (INT)	Settlement (ULS)
0	0	11	0 mm	0 mm	25 mm



Note: Settlements as per Idriss and Boulanger (2014)

PROJECT	230505 - 805-815-819NorthRoad_Invercargill	CLIENT	Bonisch Consultants
DESCRIPTION	Liquefaction Assessment	TEST NUMBER	DPH 1
LOCATION	805,815 & 819 North Road, Invercargill	DATE	7/08/2023
		LOGGED BY	RC
		ANALYSED BY	RC
		CHECKED BY	FAW

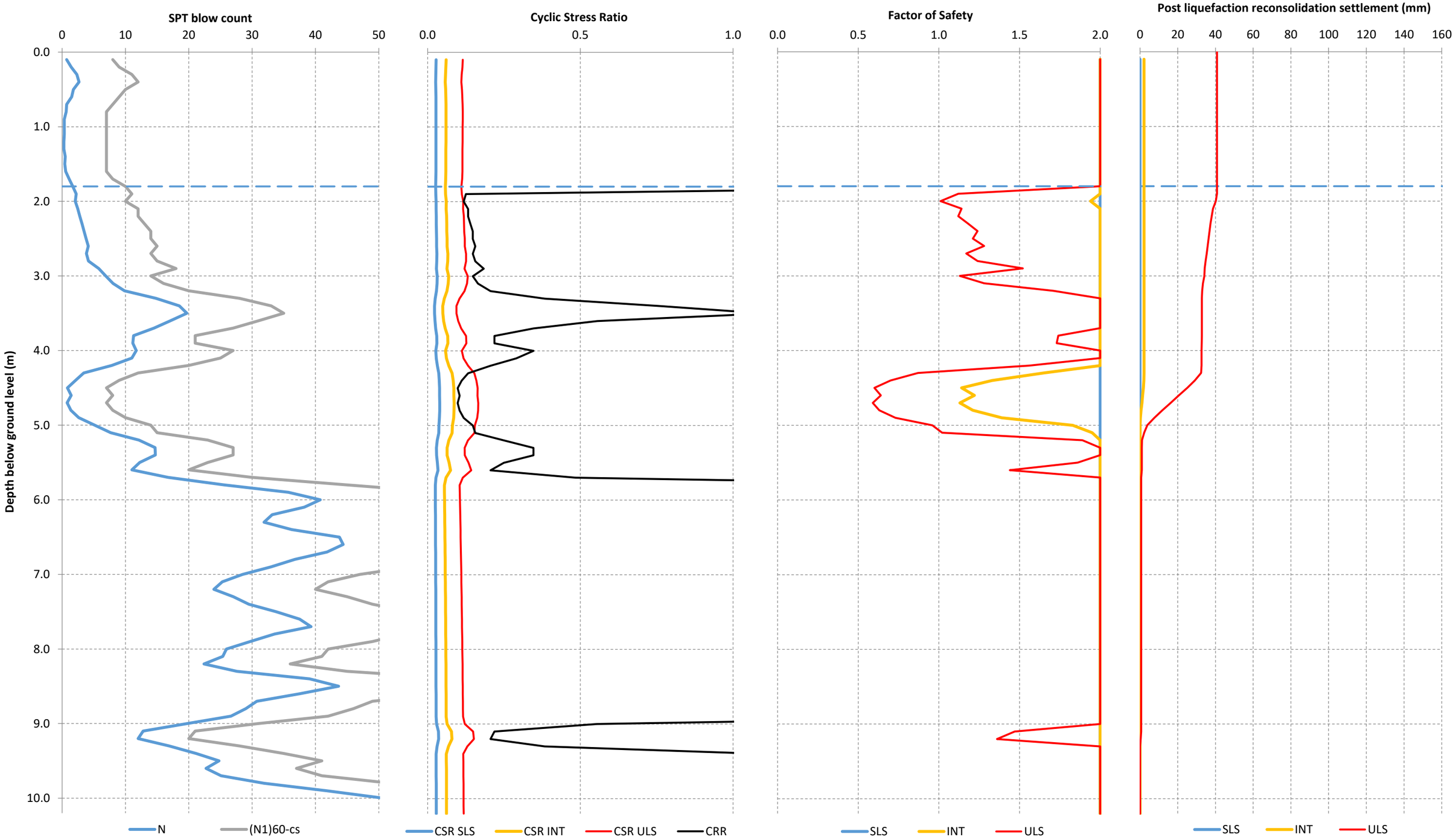
LSN (SLS)	LSN (INT)	LSN (ULS)	Settlement (SLS)	Settlement (INT)	Settlement (ULS)
0	0	2	0 mm	0 mm	10 mm



Note: Settlements as per Idriss and Boulanger (2014)

PROJECT	230505 - 805-815-819NorthRoad_Invercargill	CLIENT	Bonisch Consultants
DESCRIPTION	Liquefaction Assessment	TEST NUMBER	DPH 2
LOCATION	805,815 & 819 North Road, Invercargill	DATE	7/08/2023
		LOGGED BY	RC
		ANALYSED BY	RC
		CHECKED BY	FAW

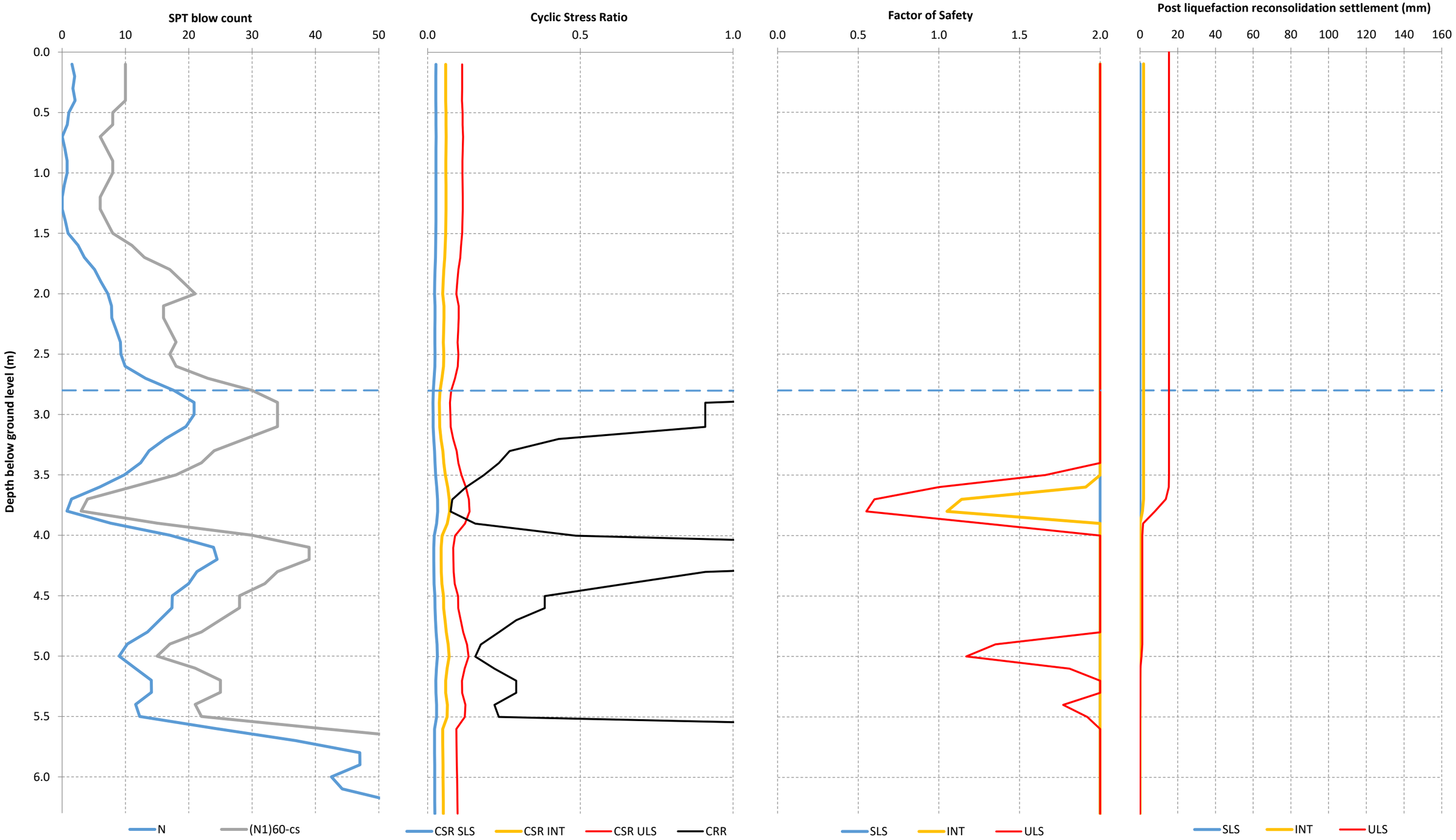
LSN (SLS)	LSN (INT)	LSN (ULS)	Settlement (SLS)	Settlement (INT)	Settlement (ULS)
0	0	10	0 mm	0 mm	40 mm



Note: Settlements as per Idriss and Boulanger (2014)

PROJECT	230505 - 805-815-819NorthRoad_Invercargill	CLIENT	Bonisch Consultants
DESCRIPTION	Liquefaction Assessment	TEST NUMBER	DPH 3
LOCATION	805,815 & 819 North Road, Invercargill	DATE	8/08/2023
		LOGGED BY	RC
		ANALYSED BY	RC
		CHECKED BY	FAW

LSN (SLS)	LSN (INT)	LSN (ULS)	Settlement (SLS)	Settlement (INT)	Settlement (ULS)
0	1	4	0 mm	0 mm	15 mm

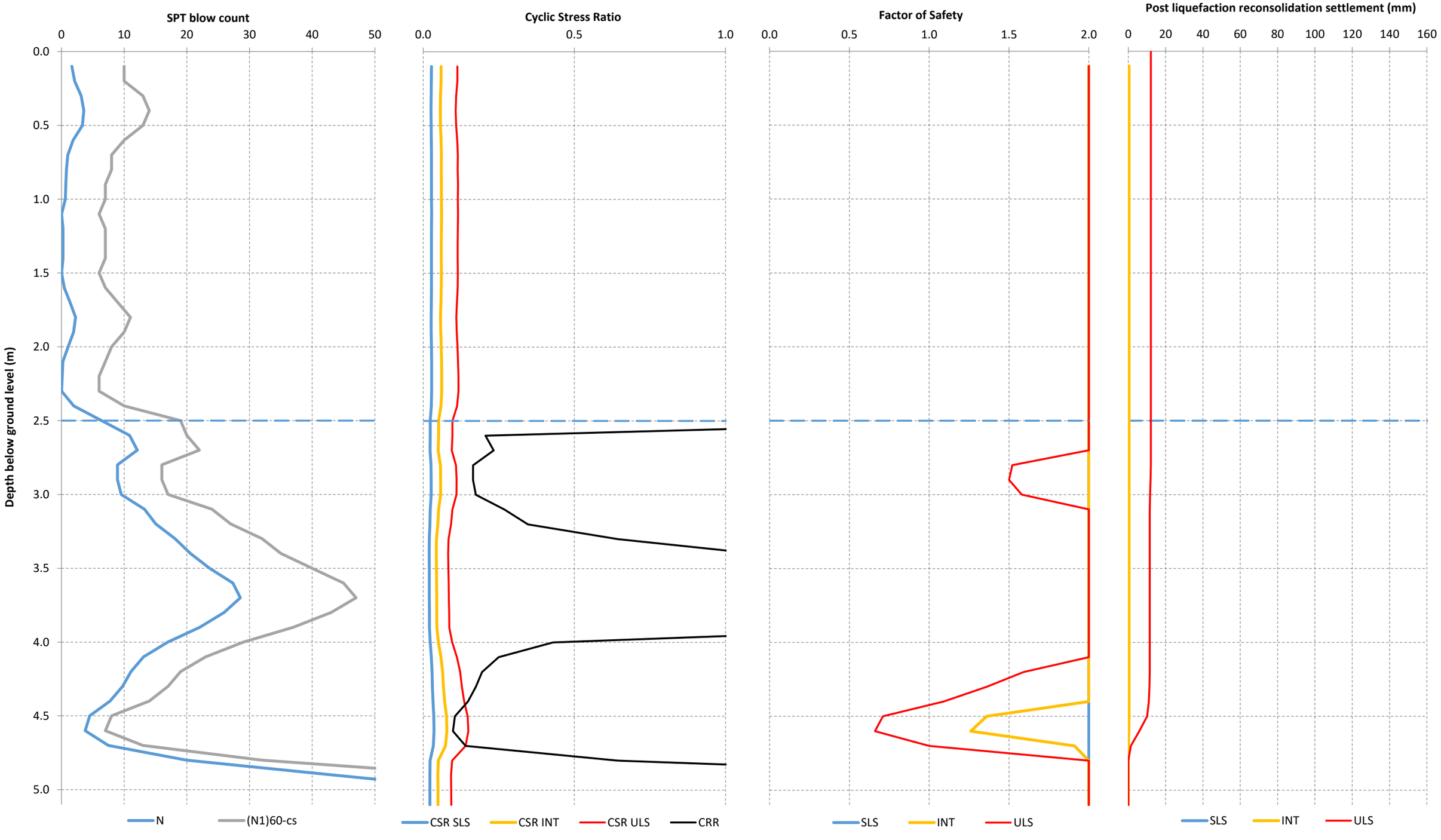


Note: Settlements as per Idriss and Boulanger (2014)

GEOSOLVE

PROJECT	230505 - 805-815-819NorthRoad_Invercargill
DESCRIPTION	Liquefaction Assessment
LOCATION	805,815 & 819 North Road, Invercargill
CLIENT	Bonisch Consultants
TEST NUMBER	DPH 4
DATE	8/08/2023
LOGGED BY	RC
ANALYSED BY	RC
CHECKED BY	FAW

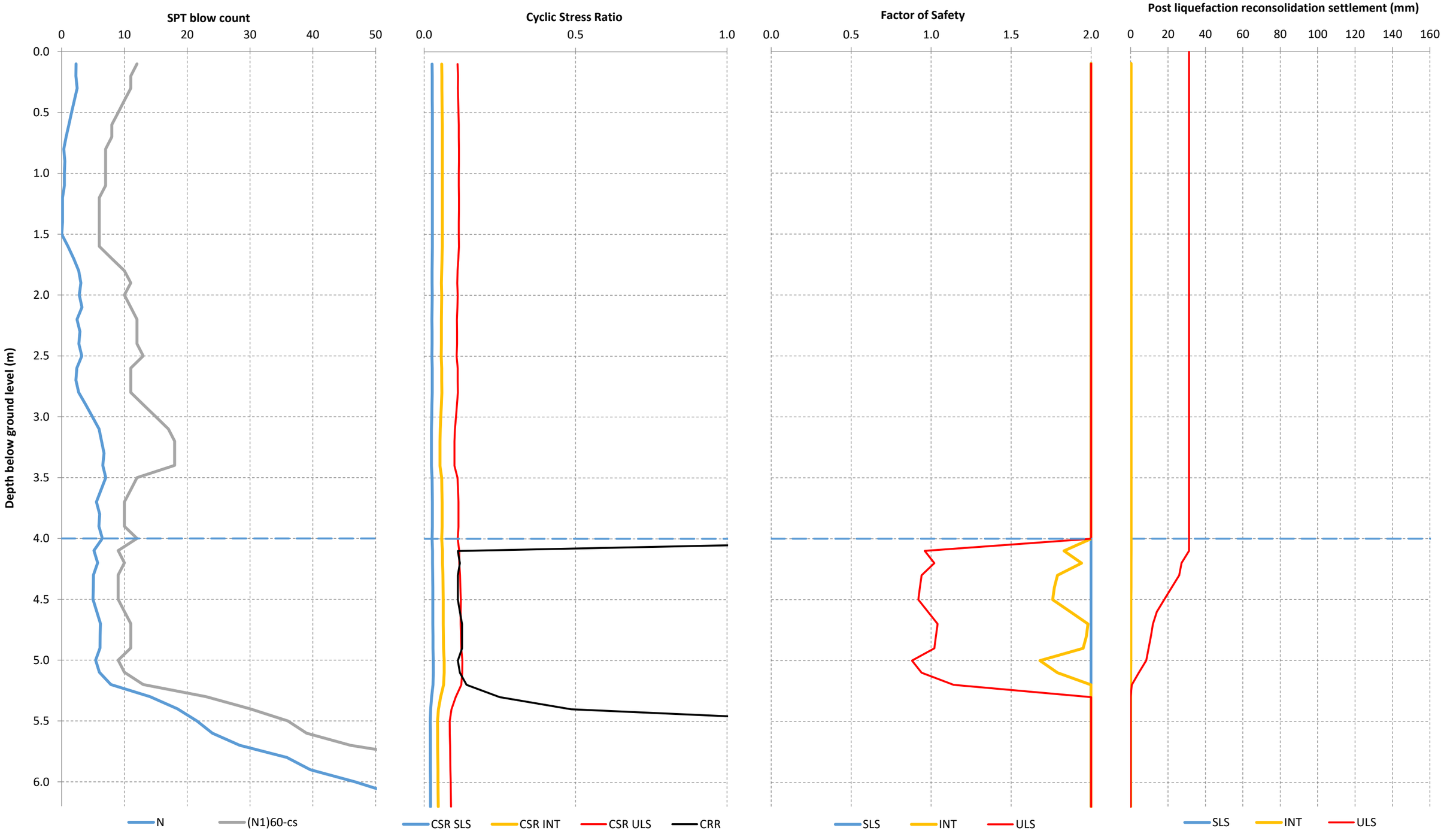
LSN (SLS)	LSN (INT)	LSN (ULS)	Settlement (SLS)	Settlement (INT)	Settlement (ULS)
0	0	3	0 mm	0 mm	10 mm



Note: Settlements as per Idriss and Boulanger (2014)

PROJECT	230505 - 805-815-819NorthRoad_Invercargill	CLIENT	Bonisch Consultants
DESCRIPTION	Liquefaction Assessment	TEST NUMBER	DPH 5
LOCATION	805,815 & 819 North Road, Invercargill	DATE	8/08/2023
		LOGGED BY	RC
		ANALYSED BY	RC
		CHECKED BY	FAW

LSN (SLS)	LSN (INT)	LSN (ULS)	Settlement (SLS)	Settlement (INT)	Settlement (ULS)
0	0	7	0 mm	0 mm	30 mm



Note: Settlements as per Idriss and Boulanger (2014)

PROJECT	230505 - 805-815-819NorthRoad_Invercargill	CLIENT	Bonisch Consultants
DESCRIPTION	Liquefaction Assessment	TEST NUMBER	DPH 6
LOCATION	805,815 & 819 North Road, Invercargill	DATE	8/08/2023
		LOGGED BY	RC
		ANALYSED BY	RC
		CHECKED BY	FAW

Appendix C - Liquefaction Analysis

General

Liquefaction occurs when susceptible, saturated soils attempt to move to a denser state under cyclic shearing. In this report, liquefaction is defined as when pore pressures rise to reach the overburden stress. When this occurs, the following effects can happen at flat sites:

- loss of strength;
- ejection of material under pressure to the ground surface; and
- post-liquefaction volumetric densification as the materials reconsolidate.

In addition, sloping sites or sites with a 'free face' may experience lateral spreading or movement.

Liquefaction Susceptibility

Soils susceptible to liquefaction have the following characteristics:

- Saturated. Below the ground water level;
- Have "sand like" behaviour[5]; and
- Are in loose or medium dense condition.

Soils which are susceptible to liquefaction require a certain level of earthquake shaking (trigger) to cause them to liquefy. Denser soils require more intense and/or longer duration of shaking (higher trigger) than less dense soil.

Analysis Method

Liquefaction analyses were undertaken on the test data using the Boulanger & Idriss (2014)[7] deterministic method.

Assessment of Consequences of Liquefaction

The following can be assessed to estimate the consequences of liquefaction at this site:

- Crust thickness
- Liquefaction severity index
- Free field settlements
- Lateral spread

Crust Thickness

The non-liquefiable upper layer of soils (crust) provides some protection against ground surface damage as a result of liquefaction. The thicker the crust, the less ground surface damage is expected with significant protection provided by thicknesses of more than 5 m.

Empirical correlations have been developed by Ishihara[6] to quantify the thickness of non-liquefiable crust required to prevent the formation of sand boils resulting from the

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[5] "Geotechnical earthquake engineering practice: Module 1 Guideline for the identification, assessment and mitigation of liquefaction hazards", Rev 0, July 2010. New Zealand Geotechnical Society. This document states that soil with: Fc <30%, or; Fc >30% and PI < 7% (where Fc= percent passing a 0.075mm sieve and PI=plasticity index) is considered as "sand-like" and is susceptible to liquefaction.

[6] Ishihara, K. (1985). "Stability of natural deposits during earthquakes," Theme lecture, Proc. 11th Int. Conf. On Soil Mechanics and Foundation Engineering, San Francisco, 2, 321-376pp.

liquefaction of underlying soil layers. These correlations indicate that for a given thickness of liquefiable soil, as the peak ground acceleration increases a greater thickness of non-liquefiable soil is required to prevent liquefaction damage from manifesting on the surface.

Liquefaction Severity Number

Liquefaction severity number (LSN) is a single value which can be calculated from a liquefaction assessment considering the thickness density and depth of liquefiable layers and the intensity of earthquake shaking. Based on observations of ground surface damage in Christchurch an indicative correlation has been developed between ground surface damage from liquefaction and LSN as described below.

As the LSN increases, so does the risk of severe effects on the land and structure. In general, the following surface effects are considered likely at sites with various LSN values.

Table 1C - Liquefaction Severity Number[7]

	Effects from excess porewater pressure and liquefaction	**Characteristic LSN**	**Characteristics of liquefaction and its consequences**
L0	Insignificant	< 10	No significant excess pore water pressures (no liquefaction)
L1	Mild	5 – 15	Limited excess pore water pressures; negligible deformation of the ground and small settlements.
L2	Moderate	10 – 25	Liquefaction occurs in layers of limited thickness (small proportion of the deposit, say 10 percent or less) and lateral extent; ground deformation results in relatively small differential settlements.
L3	High	15 – 35	Liquefaction occurs in significant portion of the deposit (say 30 percent to 50 percent) resulting in transient lateral displacements, moderate-to-large differential movements, and settlement of the ground in the order of 100 mm to 200 mm.
L4	Severe	> 30	Complete liquefaction develops in most of the deposit resulting in large lateral displacements of the ground, excessive differential settlements and total settlement of over 200 mm.
L5	Very severe		Liquefaction resulting in lateral spreading (flow), large permanent lateral ground displacements and/or significant ground distortion (lateral strains/stretch, vertical offsets and angular distortion).

Free Field Settlements

This describes the settlement of ground not occupied by a building, occurring due to dissipation of excess pore water pressure generated during earthquake shaking. Where appropriate, we have estimated reconsolidation settlement of any potentially liquefiable layers using the methodology recommended by Idriss & Boulanger (2014)[7].

A component of building settlement may also occur due to yield of any liquefied founding soils. This component of settlement is very difficult to predict and depends on the interaction of the building and the soil it is founded on.

[7] New Zealand Geotechnical Society [NZGS] and Ministry of Business, Innovation and Employment [MBIE] (2021). Earthquake geotechnical engineering practice in New Zealand. Module 3: Identification, assessment and mitigation of liquefaction hazards. Rev 1.