Appendix V

Geotech Assessment

Geotechnical Report

237 Wanaka-Luggate Highway,

Wanaka

Report prepared for:

Mt Iron Junction Limited

Report prepared by:

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Distribution:

Mt Iron Junction Limited

Paterson Pitts Group

GeoSolve Limited (File)

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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, stormwater soakage capability and earthworks recommendations at 237 Wanaka-Luggate Highway, Wanaka. Geotechnical design parameters and foundation bearing parameters are provided. Rockfall and seismic hazard has been assessed. The proposed development plan area has been provided by McCoy Wixon Architects via Paterson Pitts Group.

Photo 1. View of the site looking northeast from TP1.

The investigation was carried out for Mount Iron Junction Limited in accordance with GeoSolve Ltd.'s proposal dated 27 October 2017, which outlines the scope of work and conditions of engagement. This report will supplement a resource and earthworks consent application.

1.2 Proposed Development

We understand it is proposed to develop the above property into a commercial area and this requires geotechnical assessment of the site to assess suitability for development and to identify any geotechnical issues.

Figure 1, Appendix A shows a concept plan for the proposed development.

2 Site Description

2.1 General

The subject property, legally described as Lot 5 DP 15016, is located approximately 2.5 km east of central Wanaka, as shown in Figure 1 below.

Figure 1: Site location (blue symbol) in relation to Wanaka township (Source: http://maps.qldc.govt.nz/qldcviewer/)

The property is accessed off Wanaka-Luggate Highway and is situated to the southeast of Mt Iron.

Two dwellings, a large garage and a sleepout currently occupy the site. The remaining area of the site has been divided into small paddocks which are separated by fencing. Unsealed roads have been created to access the dwellings with some asphalt poured within the driveway of the northeast dwelling. Ground cover comprises grass, shrubs and pine trees.

The site is bounded by the Wanaka-Luggate Highway to the south, Albert Town-Lake Hawea Road to the east and Crown Land and 37 Albert Town-Lake Hawea Road to the northwest.

2.2 Topography and Surface Drainage

The site topography is generally sub-horizontal across the property. The site was observed to be naturally free-draining. No earthworks plans have been provided to GeoSolve at this stage although these are anticipated to be relatively minor.

No spring flows or seepages were observed during site investigations.

3 Geotechnical Investigations

GeoSolve Ltd visited the subject property on the 18th and 19th of December 2017 and the 17th of January 2018 undertaking an engineering geological site inspection with confirmatory subsurface investigations.

The investigations carried out for the purposes of this report are as follows:

- A site inspection and field mapping by an engineering geologist to assess rockfall risk for the proposed development;
- 17 Test pits (TP), extending to a maximum depth of 4.5 m below ground level (bgl) to produce geological logs of the subsoils;
- 10 Scala penetrometer tests extending to a maximum depth of 1.4 m bgl to assess relative density of the subsoils;
- 2 Heavy Dynamic Probe (DPH) tests, extending to a maximum depth of 15 m bgl to assess relative density of subsoils at depth and confirm the ground water model below the site;
- Piezometer installation;
- 4 Soakage pits and 2 HT21 standpipe permeability tests to assess permeability in the two proposed soakage areas at the development.

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

DPH locations and logs are presented in Appendices A and C.

Permeability test locations and logs are presented in Appendices A and D.

4 Subsurface Conditions

4.1 Geological Setting

The site is located in the Wanaka Basin, a feature formed predominantly by glacial advances. The schist bedrock within the basin has been extensively scoured by ice and lies at considerable depth below this site. Overburden material above the schist in this region includes glacial till, alluvial outwash sediments, lake sediment and beach deposits.

During the Mt Iron and Hawea Glacial Advances 18-23,000 years before present, the glaciers terminated upstream from Albert Town forming moraine loops and outwash terraces. Well-consolidated glacial till gravels were laid down on the flanks and beds of the glaciers. With the final retreat of the ice, about 16,000 years ago, Lake Wanaka formed and the Clutha River became entrenched in the glacial deposits.

Mt Iron lies directly to the north of the property where bedrock is exposed along the face of the southeastern bluff.

The Cardrona fault is mapped near the southeast corner of the property, this fault is considered capable of earthquakes of Magnitude 7.3 but has an average return period of

5,000-10,000 years. The Alpine Fault, located approximately 70 km away, runs along the western foothills of the Southern Alps, and is likely to present a more significant seismic risk to the site in the short term. There is a high probability that an earthquake of Magnitude 8 or more will occur along the Alpine Fault within the next 50 years and such a rupture is likely to result in strong ground shaking in the vicinity of Wanaka.

4.2 Stratigraphy

Results from the test pitting indicate the sub-surface stratigraphy comprises:

- 0.1 to 0.2 m of topsoil, overlying;
- Isolated uncontrolled fill (1.2-1.7 m in TP6, SP1 and 2 only), overlying;
- Isolated buried topsoil (0.1-0.4 m in TP6, SP1 and 2 only), overlying;
- 0.1 to 0.3 m of loess, overlying;
- 0.3 to 4.2 m+ of outwash gravel, interbedded with;
- Lenses of outwash sand, 0.3-0.9 m thick were observed within the outwash gravel.
- Lake sediment is inferred to underlie the outwash gravel at approximately 11-12 m bgl in the area of DPH 1.

Topsoil was observed at the surface of all test pits except SP1 and 2 and predominately comprises brown, organic SILT with roots and rootlets.

Uncontrolled fill was observed to underlie the topsoil in TP6, SP 1 and 2 and extends to 1.2 to 1.7 m bgl. The fill comprises light grey/grey, loose to medium dense, gravelly SAND with minor organic silt and trace sticks, rootlets and wire, SAND with some gravel and silt, and sandy GRAVEL with trace cobbles, boulders and organic silt.

Buried topsoil was observed to underlie the uncontrolled fill in TP6, SP1 and 2 and extends to 1.6 to 1.8 m bgl. Buried topsoil comprises, brown sandy organic SILT with minor rubbish and gravel.

Loess was observed to underlie the topsoil in 15 of the 17 test pits and extends to a depth of 0.2 to 0.5 m bgl. The loess predominately comprises light brown, firm silty SAND with minor rootlets.

Outwash gravel was observed to underlie the loess, topsoil or buried topsoil in all test pits. Outwash gravel typically comprises brown, grey and dark grey medium dense, sandy GRAVEL with some to trace cobbles and trace boulders. Boulders up to 0.7 m diameter were observed. Outwash gravel was observed to the termination depth of all test pits.

0.3 to 0.9 m thick outwash sand lenses were observed in TPs 3, 6 and 11 and typically comprise grey/brown, medium dense SAND with minor to some gravel and gravelly SAND.

Lake sediment is inferred to underlie the outwash gravel at 11-12 m bgl in the DPH 1 area from the relative density observed in the DPH test and knowledge of relative levels and relative density of lake sediment in the Albert Town area.

Full details of the observed subsurface stratigraphy can be found within the test pit and soakage pit logs contained in Appendix B and D respectively.

4.3 Groundwater

Groundwater was not observed during test pit investigations which extend to 4.5 m bgl.

A piezometer was installed to 6.7 m depth in close proximity to DPH2 and was dipped dry to full depth. Piezometers could not be installed any deeper to reach the water table due to coarse cobbles and boulders within the outwash gravel unit.

4.4 Slope Stability

No instability features were observed on the site during investigations.

The bluffs of Mt Iron outcrop to the north of the site and a rockroll hazard is shown on the QLDC hazard database within 70 m of the north-western boundary. Rockfall from the bluffs to the north has been assessed as part of site investigations, this is detailed in section 6.7 of this report.

5 Liquefaction Analysis

5.1 Introduction

A preliminary liquefaction assessment has been undertaken using test pit and heavy dynamic probe (DPH) data. Two Heavy Dynamic Probe (DPH) tests were undertaken within the site to assess liquefaction risk.

5.2 Earthquake Scenarios

In accordance with NZS1170 – Structural Design Actions[1], the following two earthquake scenarios were considered based on a building with Importance Level 2 with a 50 year design life.

These scenarios represent the following design performance requirements:

- Serviceability Limit State (SLS) – to avoid damage that would prevent the structure from being used as originally intended, without repair, and;
- Ultimate Limit State (ULS) – to avoid collapse of the structural system.

In terms of NZS 1170, Class D subsoil conditions (deep soils) were assumed to underlie the site.

The methods presented within the NZTA Bridge Manual (2014)[2] have been adopted for deriving the site peak ground accelerations (PGA) as they use unweighted seismic hazard factors and corresponding (effective) earthquake magnitudes that are better suited to be used in the assessment of liquefaction.

[1]NZS1170-5 (2004) Structural Design Actions, Part 5: Earthquake Actions – New Zealand.
[2] NZTA Bridge Manual, Third Addition, Amendment 2, Effective from May 2016 (Manual Number SP/M/022).

Table 1 below provides a summary of the annual exceedance probability, effective magnitude and PGA adopted for each seismic case analysed in the liquefaction assessment.

Table 1: Annual exceedance probability, effective earthquake magnitude and peak horizontal ground accelerations for each seismic case

Seismic Case	Annual Exceedance Probability (AEP)	Effective Magnitude	Peak Horizontal Ground Acceleration (g)
Serviceability Limit State (SLS) design earthquake	1/25	6.1	0.08
Ultimate Limit State (ULS) design earthquake	1/500	6.2	0.32

5.3 Liquefaction Assessment

5.3.1 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 (i.e. surface disruptions), and;
- Post-liquefaction volumetric densification as the soils reconsolidate.

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

The occurrence of liquefaction is dependent on several factors, including the intensity and duration of ground shaking, soil density, particle size distribution, and depth to the groundwater table.

5.3.2 DPH Analysis

Analyses were performed to evaluate the liquefaction potential of the lake sediment unit underlying the outwash gravel and the discrete sand lenses within the outwash gravel unit utilising the methods recommended by Idriss & Boulanger (2014)[3]. These methods use information obtained from soil logging and in situ testing, such as soil type, fines content, layer thicknesses, and blow count.

[3] Boulanger R.W. and Idriss, I.M. (2014). 'CPT and SPT Based Liquefaction Triggering Procedures,' Report No. UCD/CMG–14/01, Dept. of Civil & Environmental Engineering, University of California at Davis.

A piezometer was installed to 6.7 m bgl in close proximity to DPH 1 which was dipped dry to full depth. This has been assumed as the water table depth for analysis purposes even though this is likely a conservative assumption.

The liquefaction analysis results are summarised below in Table 2.

Table 2: Summary of liquefaction results from DPH testing

Factor	Assessment		Implications
Crust thickness	The crust thickness is determined to be at least 8.7 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 is significantly thicker than 3.5 m and therefore should be sufficiently thick to limit surface damage in a ULS seismic event. Particularly given the minor (0-10 mm) predicted liquefaction induced settlement within the upper 10 m of the soil profile.
LSN	1/500 AEP (ULS)	LSN range = 0-7	Surface expression of liquefaction unlikely.
Free field settlement	1/500 AEP (ULS)	0-10 (80) mm	0-10 mm estimated in the upper 10 m in the areas tested. 80 mm of total settlement is predicted within testing completed to 15 m depth. Lake sediment is inferred at 11.5-14.5 m bgl in DPH 1 which is predicted to liquefy under ULS seismic loading.
Lateral spread	Lateral spreading under seismic loading is not expected to occur as the site is relatively flat without any nearby free face.		None.

[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.

6 Engineering Considerations

6.1 General

The recommendations and opinions contained in this report are based upon ground investigation data obtained at discrete locations on site 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 soils expected to be encountered during construction of any future buildings and retaining walls.

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/Buried Topsoil (organic SILT with roots and rootlets and sandy organic SILT with minor rubbish and gravel)	0.1-0.4	16	To be removed from building and engineered fill footprints			
Uncontrolled Fill (loose to medium dense, gravelly SAND with minor organic silt, SAND with some gravel an silt and sandy GRAVEL with trace organic silt, cobbles and boulders)	1.2-1.7	18	To be removed from building and engineered fill footprints			
Loess (firm, silty SAND)	0.1-0.3	18	0	31	5,000	0.3
Outwash Gravel with Outwash Sand lenses (medium dense, sandy GRAVEL with trace to some cobbles and trace boulders. Lenses of gravelly SAND to SAND with minor gravel)	0.3-4.2	18	0	36 (32 in Sand)	10,000-20,000	0.3

6.3 Site Preparation/Earthworks

During the earthworks operations all topsoil, uncontrolled fill, organic matter and other unsuitable materials should be removed from the construction areas in accordance with

the recommendations of NZS 4431:1989. These soil types (and loess SILT) will also need to be removed from areas where engineered fill is proposed.

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

Water should not 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.

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 outwash gravel soils can be used as engineered fill on site (during good weather and in accordance with an earthfill specification). The topsoil, loess and uncontrolled fill is not suitable as a fill source. Maximum density and optimum moisture content will vary in the outwash gravel. Boulders and cobbles over 100 mm in size will need to be screened from engineered fill sources.

6.4 Excavations

At this stage no earthworks plans have been provided, although it is expected cuts will be made within topsoil, uncontrolled fill, loess, and outwash soils. It is expected that only minor earthworks will take place across the site due to the generally sub-horizontal topography and the shallow depth to suitable bearing soils across the majority of the site. Earthworks plans have yet to be developed for the development.

Recommendations for temporary and permanent batter slope angles are described below in Table 4. 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.

No seepage was encountered during test pitting and hence groundwater is unlikely to be encountered during excavations. However, a geotechnical practitioner should inspect any seepage, spring flow or under-runners that may be encountered during construction.

The soils are anticipated to be excavated by conventional methods, however boulders are likely to be encountered within the outwash gravel.

6.4.1 Cut Slopes in Soil Materials

Table 4 summarises the recommended batter angles for temporary and permanent slopes up to 3 m high, which are formed in the soil materials identified at the site.

Table 4: Recommended maximum batter angles for cut slopes up to 3 m high in site soils

Material Type	Recommended Maximum Batter Angles for Temporary Cut Slopes Formed in Soil (horizontal to vertical)		Recommended Maximum Batter Angles for Permanent Cut Slopes Formed in Soil – dry ground only (horizontal to vertical)
	Dry Ground	Wet Ground	
Topsoil/Loess/Uncontrolled Fill	2H: 1V	3H: 1V	3H: 1V
Outwash gravel	1H: 1V	2H: 1V	2H: 1V

6.5 Engineered Fill Slopes

All fill should be placed and compacted in accordance with the recommendations of NZS4431: 1989 and Queenstown Lakes District Council Standards. All cut and fill earthworks should be inspected and tested as appropriate during construction and certified by a Chartered Professional Engineer.

All un-retained fill slopes which are less than 3.0 m high should be constructed with a batter slope angle of 2.0H:1.0V (horizontal to vertical) or flatter and be benched into sloping ground.

Reinforced earth slopes can be considered if batters need to be steeper than 2H:1V.

6.6 Ground Retention

All retaining walls should be designed by a Chartered Professional Engineer using the geotechnical parameters recommended in Table 3 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 the retaining walls, groundwater, seismic and traffic loads.

All temporary slopes for retaining wall construction should be battered in accordance with the recommendations outlined in Table 4 of this report. Where these batter slopes cannot be achieved temporary retaining will be required.

Groundwater was not observed within a piezometer installed to 6.7 m beneath the site or within any of the test pit excavations. To ensure any 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 dwelling to minimise groundwater seepage into the finished buildings.

It is recommended that the retaining wall excavation batters are inspected by a suitably qualified and experienced Geotechnical Engineer or Engineering Geologist.

6.7 Rockfall Hazard

6.7.1 General

An engineering geologist has undertaken site mapping to assess the risk of rockfall hazard to the proposed development. The assessment reviews the risk of boulders originating as rockfall from the steep bluffs below Mount Iron rolling out into the proposed development and damaging proposed structures. Rockfall events require a trigger such as strong seismic shaking or long-term weathering and failure of the rock mass.

Numerous boulders of varying diameters and shapes have been observed on the sub-horizontal alluvial outwash surface at the base of Mount Iron. To assess the risk to the proposed development boulders observed on the ground surface were mapped and differentiated between those originating as rockfall and those originating as alluvial outwash boulders (Appendix A, Figure 2). Roll out distance between the base of Mount Iron and the north-western property boundary was also considered including any natural barriers against rockroll.

There is no evidence of historic rockroll boulders on the ground surface within the boundaries of the proposed development nor was there any evidence of historic rockroll boulders observed in test pits. All boulders observed in test pits are interpreted to be alluvial outwash boulders. The mapped maximum roll out distance of historic rockroll boulders from the base of Mount Iron onto the outwash surface ranges between 40-70 m. The minimum distance between the base of Mount Iron and the northwest property boundary is approximately 115 m at the southwest corner of the proposed development. The roll out distance between the base of Mount Iron and the proposed development gradually increases towards the northeast to a maximum distance of approximately 180 m. It is also noted on the proposed development plans provided by McCoy Wixon Architects that there is a designated “no build zone” on the southwest corner of the proposed development.

There are several existing natural barriers against rockroll present between the base of Mount Iron and the proposed development. Existing rockfall debris at the base of Mount Iron and the dense patches of native kanuka scrub on the outwash surface provide a natural barrier against rockroll. The wing of a lateral moraine ridge extends towards the northeast and acts as a natural rockroll bund for the southwest corner of the proposed development (see Appendix A, Figure 2). Numerous boulders resulting from rockroll have already been observed to be piled up behind this moraine ridge north of the Wanaka-

Luggate Highway. The sub-horizontal (0-5°) alluvial outwash surface from the base of Mount Iron to the proposed development provides a suitable setback for rockroll fallout.

Rockfall hazard mapping is shown on Appendix A, Figure 2.

6.7.2 Rockfall Hazard Considerations and Recommendations

Based on the mapping of historic rockroll boulders and the roll out distance from the base of Mount Iron the resulting hazard envelope does not reach the proposed development. Therefore, the rockfall hazard poses no risk to the proposed development and further detailed analysis of the rockfall hazard is not considered necessary.

As a precaution the existing row of pine trees along the northwest property boundary could be left in place to provide a further natural barrier against rockroll. Alternatively, the pine trees could be replaced with another tree species if this is desired.

6.8 Seismic Hazard

The Cardrona Fault is mapped near the southeast corner and eastern boundary of the property and its location is recorded as concealed on published geological mapping beneath the Albert Town area. The Cardrona Fault is indicated as 'active'. The risk of ground rupture on the site from known faulting is considered unlikely. Movement on the Cardona Fault would however result in ground shaking of the site, and the wider Wanaka area.

Geosolve have completed an assessment of the risk posed by the Cardona Fault using guidelines provided by the Ministry of Environment for developing land close to active faults. For the assessment, the Cardrona Fault has been categorised with a return period of 5,000 to 10,000 years (GNS Science website, Active Faults Database), and the location is assessed as uncertain, as indicated on published geological mapping.

Following the Ministry of the Environment guidelines provided in Section 11 "Taking a Risk-Based Approach to Resource Consents", building importance category structures 1, 2a and 2b, are a permitted activity and category 3 structures are a discretionary activity. NZS 3604 dwelling structures fall under category 2a, and are therefore considered to be a permitted activity in close proximity to the Cardrona Fault system.

In conclusion, given the relatively long return period for the Cardrona Fault (5,000 - 10,000 Years), the Alpine Fault, with a return period for major earthquakes of 300-350 years, and predicted ground accelerations an order of magnitude higher than the Nevis Cardona, is considered to provide the governing seismic risk to the area.

6.9 Groundwater Issues

The regional water table is expected to lie at depth below any future foundation levels and is not expected to be encountered during construction on this site. Dewatering or other groundwater-related construction issues are therefore unlikely to be required.

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

6.10 Foundation Considerations

Topsoil, uncontrolled fill and loess should be stripped from the building platform areas. Foundation loads will be transferred to the outwash gravel or engineered fill overlying outwash gravel in all cases.

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.

To minimise the effects of freeze-thaw cycles in footings founded on soil, all shallow foundations should be founded a minimum of 0.4 m below the adjacent finished ground surface.

Figure 2 summarises the recommended working stresses for shallow footings, which bear upon outwash gravel and engineered fill overlying the same. It should be noted the foundation working stresses presented on Figure 2 are governed by bearing capacity in the case of narrow footings and settlement in the case of wide footings.

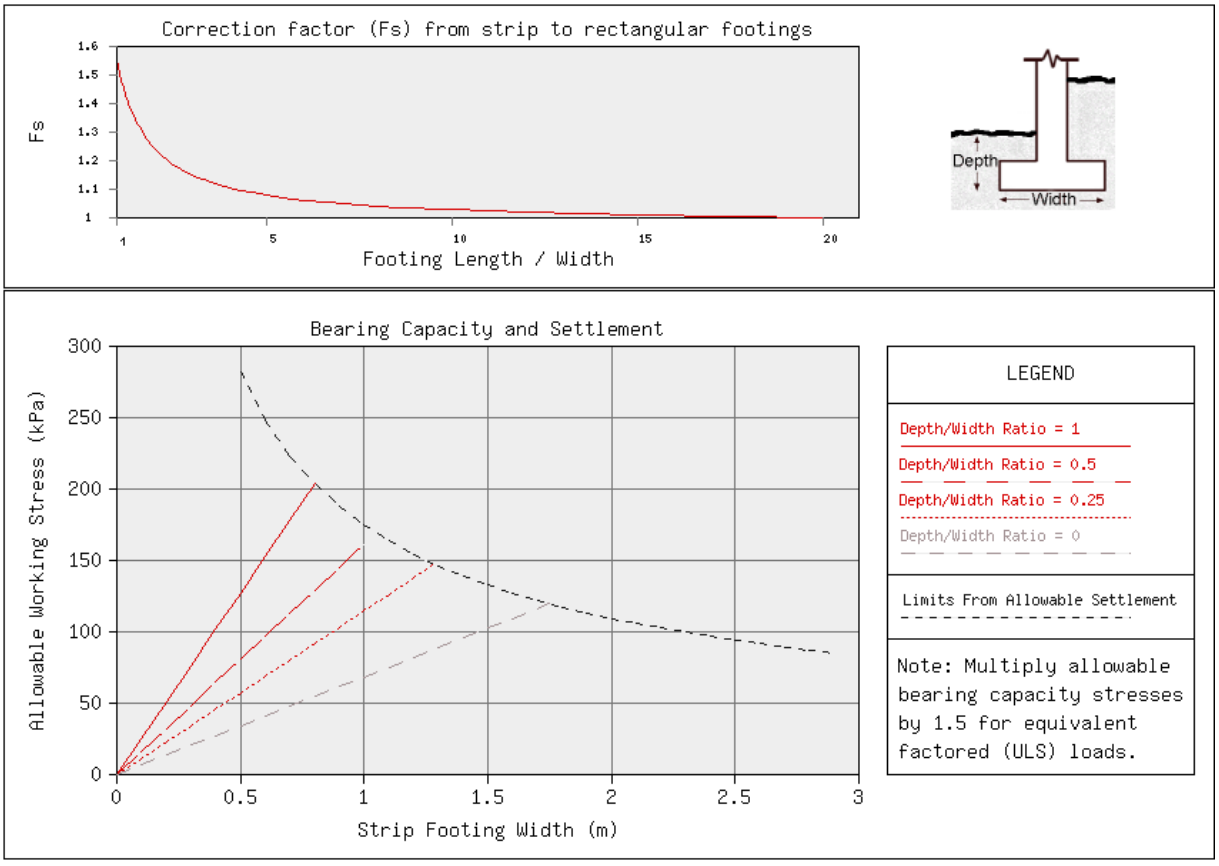

Figure 2. Recommended Bearing for Shallow Footings on Outwash Gravel and Engineered Fill overlying Outwash Gravel.

From Figure 2 it can be seen an allowable working stress of approximately 100 kPa is recommended for a 400 mm wide by 400 mm deep strip footing founded within outwash gravel and engineered fill overlying outwash gravel. This corresponds to a factored (ULS) bearing capacity of approximately 150 kPa and an ultimate geotechnical bearing capacity of 300 kPa.

Inspection and testing (dynamic probe/Scala penetrometers) should be completed along footing alignments during construction to confirm the above values are applicable and that the soil has not been softened by weather or excavation. Plate compaction or rolling is recommended following building platform and footing excavation.

6.10.1 Outwash Sand Bearing

Thin lenses of outwash sand have been observed in test pits. If substantial outwash sand is observed under a building platform bearing capacity should be assessed on a case by case basis.

6.11 Settlement

Settlement and differential settlement of shallow foundations are expected to be within structurally acceptable limits provided the recommendations of Section 6.10 are followed and all unsuitable materials, particularly those softened by water, are undercut and replaced with engineered fill during construction.

6.12 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 D” (Deep soil site) in accordance with NZS 1170.5:2004 seismic provisions.

6.13 QLDC Land Development and Subdivision Code of Practice

Section 2.2.4 of the QLDC Land Development and Subdivision Code of Practice (QLDC CoP) requires the developer of any subdivision to appoint a geo-professional to carry out the following functions from the planning to construction phases of the subdivision:

a) Check regional and district plans, records, and requirements prior to commencement of geotechnical assessment;
b) Prior to the detailed planning of any development, to undertake a site inspection and such investigations of subsurface conditions as may be required, and to identify geotechnical hazards affecting the land, including any special conditions that may affect the design of any pipelines, underground structures, or other utility services;
c) Before construction commences, to review the drawings and specifications defining any earthworks or other construction and to submit a written report to the Territorial Authority (TA) on the foundation and stability aspects of the project (if required);

d) Before and during construction, to determine the extent of further geo-professional services required (including geological investigation);
e) Any work necessary to manage the risk of geotechnical instability during the construction process;
f) Before and during construction, to determine the methods, location, and frequency of construction control tests to be carried out, determine the reliability of the testing, and to evaluate the significance of test results and field inspection reports in assessing the quality of the finished work;
g) During construction, to undertake regular inspection consistent with the extent and geotechnical issues associated with the project;
h) On completion, to submit a written report (i.e. Geotechnical Completion Report) to the Territorial Authority (TA) attesting to the compliance of the earthworks with the specifications and to the suitability of the development for its proposed use including natural ground within the development area. Where NZS 4431 is applicable, the reporting requirements of that Standard shall be used as a minimum requirement.

This resource consent level report can be considered to have completed items a) and b) from the above list. Once resource consent for the subdivision has been granted a geo-professional will need to be appointed by the developer to review the earthworks drawings and specifications prior to finalising the documentation for tendering and/or construction, and to oversee the construction phase of the project including certification of fill and provide a Geotechnical Completion Report (GCR) and Schedule 2A in accordance with the QLDC CoP.

The GCR and Schedule 2A should detail the results of site observations, testing and monitoring during earthworks construction, confirm the stability of the finished earthworks, and identify any specific geotechnical design requirements that must be addressed in order to construct a building on site. Any identified specific design requirements will then be registered on the subject lots' 'certificate of title' and will need to be addressed during the building consent process.

The geo-professional completing the GCR and Schedule 2A which includes the certification of fill should in all cases be engaged by the developer not the contractor. It is also advisable that the geo-professional review the earthworks contract to assist in managing the developers risk and ensuring that the contract is clear with respect to geotechnical risks and responsibilities during construction.

The use of this report and any of its findings or recommendations as part of the GCR and Schedule 2A may only be used with our prior review and written agreement.

7 Stormwater Disposal

7.1 Suitability of soil types

We understand that an on-site soakage system, in keeping with other developments nearby, will be adopted to manage stormwater at the site.

The geotechnical investigations identified that stormwater infiltration areas are located on a glacial outwash terrace that runs adjacent to Albert Town-Lake Hawea Road with the exception of soakage area one (SP1) where moderate depths of fill were observed, presumably associated with the historic construction of the adjacent highway.

Table 5. Suitability of soakage disposal based on soil type

Location	Stratigraphy	Suitability for Stormwater Disposal
SP1	1.8 m of fill and buried topsoil (SAND with some gravel and silt and organic SILT with minor rubbish) overlying outwash gravel and sand to base of pit.	Confirmed favourable from 1.8-2.6 m and 2.9-4.2 m (TP6 shows a 0.3 m thick sand lens at 2.6 m underlying outwash gravel). Soakage rate = 0.07 L/s/m^2
SP2	1.6 m of fill and buried topsoil (sandy GRAVEL and sandy organic SILT) overlying outwash gravel and sand to base of pit.	Confirmed favourable from 1.6-2.4 m and 2.9-4.2 m (TP6 shows 0.3 m thick sand lens at 2.6 m underlying outwash gravel). Soakage rate = 0.18 L/s/m^2
TP6	1.6 m of fill and buried topsoil (gravelly SAND and organic SILT) overlying outwash gravel with a 0.3 m thick gravelly SAND and SAND lens observed at 2.6 m.	Favourable from 1.6-2.6 m and 2.9-4.2 m depth. Will need to consider thin sand lens. No test completed in this test pit.
HT21 (1)	2.0 m of fill and buried topsoil (sandy GRAVEL and sandy organic SILT) overlying outwash gravel.	Favourable from 2 m (TP6 shows 0.3 m thick sand lens at 2.6-2.9 m depth in the outwash gravel). K (m/s) = 5 x10^{-5}
SP3	0.3 m of topsoil and loess overlying outwash gravel.	Favourable from 0.3 m. Soakage rate undetermined, water draining away faster than could put into test pit. Free draining.
SP4	0.3 m of topsoil and loess overlying outwash gravel.	Favourable from 0.3 m. Soakage rate undetermined, water draining away faster than could put into test pit. Free draining.
HT 21 (2)	0.3 m of topsoil and loess overlying outwash gravel.	Favourable from 0.3 m. K (m/s) = 2 x10^{-4}

7.2 Site testing

Standpipe field permeability testing and soakage testing of the outwash gravel was carried out at six field locations (see Site Plan, Appendix A and D for test locations and results respectively).

Four soakage pit tests and two standpipe field permeability tests were completed, all within the predominant sandy GRAVEL soils. It is important to note that the subordinate sand lenses will have significantly lower permeability than the gravels, possibly of the order of 1 x 10^{-5} m/sec which has likely influenced the testing in soakage area 1 and will affect long-term soakage rates.

Soakage testing was undertaken at the base of the soak pits in SP1-4. This was performed by introducing water from an 8,000L watercart until the water level of the pit reached the designated testing level. The inflow was then ceased and the time it took for the water level to drop recorded. The results were then analysed to determine indicative soakage rates, which are presented in Appendix D.

The standpipe field permeability test was undertaken using the HT21 methodology. Hydraulic conductivity was then obtained using published correlations (Van Hoorn, Glover, Phillip, HT21).

Table 6: Hydraulic Conductivity and Soakage Rate Values

Location	Test method	Output	Results
SP1	Open pit soakage test	Soakage Rate	0.07 L/s/m^2
SP2	Open pit soakage test	Soakage Rate	0.18 L/s/m^2
HT21 (1)	Standpipe field permeability test	Hydraulic Conductivity (K)	5x10^{-5} m/s
SP3	Open pit soakage test	Soakage Rate	Free draining*
SP4	Open pit soakage test	Soakage Rate	Free draining*
HT21 (2)	Standpipe field permeability test	Hydraulic Conductivity (K)	2 x10^{-4} m/s
*Insufficient water was able to be introduced to establish a pool of water at the base of the pit due to high soakage			

7.3 Infiltration design

Extensive permeability testing of outwash gravels was carried out for hydroelectric investigations in Upper Clutha Valley in the 1980s. This found typical bulk hydraulic conductivities (K) in outwash gravels, similar to those in soakage area 2 (SP3 and 4) of the proposed development at Mt Iron Junction, to be of the order of 4 x 10^{-4} m/s.

Standpipe field permeability HT21 (2) in outwash gravels within soakage area 2 found K=2 x 10^{-4} m/s which agrees well with the historic Upper Clutha Valley testing. HT21 (1),

however, indicates lower than anticipated hydraulic conductivity (5 x 10^{-5} m/s) which is interpreted to be influenced by the underlying sand lens observed in TP6.

Estimation of a representative average hydraulic conductivity of the outwash soils is difficult, due to the limited number of tests and importance that geological variations (i.e. discrete minor sand lenses) can have on these values. The presence of lenses and layers of sand in the sequence will tend to lower the overall [bulk] hydraulic conductivity compared with that of the gravel component. The test pit logs indicate the sand lenses constitute only a small minority of the soil materials across the site.

However, a provisional estimate of the order of K=2x 10^{-4} m/s is considered reasonable for this unit, based on the site data and comparison with the known hydraulic conductivities of similar local outwash gravels. It is considered a value of 1 x 10^{-5} to 5 x 10^{-5} is suitable within the outwash gravel with sand lenses in soakage area 1. It is recommended that the infiltration zone is excavated to at least 3 m bgl in soakage area 1 to pass through the observed sand lens (TP6) and uncontrolled fill. This is anticipated to increase soakage potential, however confirmation that no extensive sand lenses are present is required during construction excavation inspections.

SP1 and SP2 also appear to have been influenced by the underlying outwash sand lens observed in TP6. SP1 and 2 returned an estimated soakage rate of 0.07 and 0.18 L/s/m^2 respectively.

Soakage pit testing in SP3 and SP4 was unable to establish a full test due to high soakage rates, in both cases, draining away all introduced after the hole was pre-soaked.

Table 7 presents the recommended soakage rate and hydraulic conductivity values[5] to be used for design. We recommend a reduction factor of at least 0.5 be applied to these values to allow for any loss of soakage performance over time.

Table 7: Summary of results in soakage areas 1 and 2

Location	Soakage Rate	Hydraulic Conductivity (K)
Soakage Area 1*	0.07 – 0.18 L/s/m^2	5x10^{-5} m/s
Soakage Area 2	Free Draining**	2 x10^{-4} m/s
*Soakage Area 1 results likely influenced by sand lens observed from 2.6-2.9 m in TP6 **Water did not fill up bottom of soakage pit, draining away too fast		

Due to the uncertainties associated with soakage/permeability estimation and the importance that the value can have on design of soakage systems, we recommend that additional field tests (such as permeameter tests in 44 gallon drums) be conducted during construction to allow any necessary adjustments to be made to the design.

[5] It should be appreciated that estimation of soakage rates and hydraulic conductivity values utilize separate methods and hence cannot be balanced by unit conversion. We are happy to review our test results and provide alternative units (i.e. infiltration rates in mm/hr) if needed.

8 Neighbouring Structures/Hazards

Natural Hazards: Known seismic hazards affecting the development are detailed in Section 4.1 and appropriate allowance should be made for seismic loading during detailed design of the proposed building, foundations, and retaining walls. The development is not located within any mapped slope instability features, liquefaction susceptibility areas or any other hazard features on the QLDC or GeoSolve databases.

Liquefaction has been assessed using DPH testing, detailed in Section 5. Liquefaction risk is considered to be low due to the depth to groundwater and observed relative density of the site subsoils within the upper 11.5 m.

A rockfall hazard has been mapped within 70 m of the northwest boundary of the property on the QLDC hazard register. An assessment of the rockfall risk to this property has been completed and is detailed in section 6.7 of this report.

Seismic risk associated with the Cardrona Fault is detailed in Section 6.8.

Flooding has not been assessed as part of this assessment, the site is naturally free draining and the development is significantly higher than the closest body of flowing water that runs to the south of the site.

Distances to adjoining structures: It is assumed the existing buildings on site will be removed prior to construction and therefore no adverse geotechnical implications are expected to apply for neighbouring properties during construction provided appropriate vibration and dust mitigation measures are taken during construction. If existing buildings should remain onsite then the vibration effects should be considered if fill is to be compacted within 10 m of an existing structure.

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

Erosion and Sediment Control: The site presents low potential to generate silt runoff during heavy rainfall events due to the predominately sub-horizontal topography and site geology. However if required effective systems for erosion control are runoff diversion drains and contour drains, while for sediment control, options are earth bunds, silt fences, hay bales, vegetation buffer strips and sediment ponds. Only the least amount of subsoil should be exposed at any stage and surfacing established as soon as practical. Details for implementation are given in Appendix B within the following link: http://esccanterbury.co.nz/.

Noise: It is expected that conventional earthmoving equipment, such as excavators, trucks and rollers will be required during construction. The earthworks contractor should take appropriate measures to control the construction noise, and ensure QLDC requirements are met in regard to this issue.

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

Vibration: No vibration induced settlement is expected in these soil types. The effects of vibrations from rollers and plate compactors on adjacent structures will need to be considered if fill is compacted within 10 m of an existing structure.

9 Conclusions and Recommendations

- The site is underlain by surficial topsoil and loess, which overlies outwash gravel with rare thin outwash sand lenses, which extends to at least 4.5 m beneath the surface of the proposed development. Isolated areas of uncontrolled fill were observed.
- Groundwater seepage was not observed during test pit investigations on the site completed to a maximum depth of 4.5 m. A piezometer was installed in close proximity DPH 1 to 6.7 m bgl and was dipped dry to full depth.
- No to minor liquefaction induced settlement (0-10 mm) is predicted across the site within the upper 10 m of the soil profile.
- No evidence of existing slope instability has been identified on site. Rockfall hazard is assessed as low risk and is detailed in section 6.7 of this report.
- Bearing on the site will be governed by the outwash gravel or engineered fill overlying outwash gravel. The outwash gravel and engineered fill will provide good bearing (100 kPa allowable), for 400 mm wide by 400 mm deep shallow footings.
- Recommendations for temporary and permanent batter slope angles are described in Table 4. Slopes that are required to be steeper than those described should be structurally retained or subject to specific geotechnical design.
- All retaining walls should be designed by a Chartered Professional Engineer using the geotechnical parameters recommended in Table 3 of this report.
- The outwash gravel soils are considered suitable for use as engineered fill (in accordance with an earthfill specification).
- All unsuitable soils 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.
- For detailed design purposes it is recommended that the site is classified “Class D – Deep subsoil” in accordance with NZS 1170.5:2004 seismic provisions.
- Based on the geological conditions observed, testing data and experience with similar outwash gravel, the bulk permeability of the deposit is estimated to be in the order of 2 $x10^{-4}$ m/s in Soakage area 2. A lesser value of 1-5$x10^{-5}$ is recommended where sand lenses are present such as observed in Soakage area 1. Soakage rates are also provided in Table 7. To allow for any loss of soakage performance over time we recommend a reduction factor of at least 0.5 be applied to the value adopted in each of the two soakage areas for design purposes.
- A geotechnical practitioner should inspect all foundation excavations, batter slopes, soak pit excavations and additionally any seepage, spring flow or under-runners that may be encountered during construction.

10 Applicability

This report has been prepared for the benefit of Mt Iron Junction Limited 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.

Please don't hesitate to contact the undersigned if we can provide any further assistance with this project.

Report prepared by:

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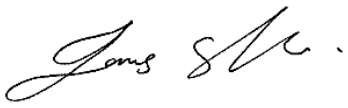
Mike Plunket

Geotechnical Engineer



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James Stewart

Engineering Geologist

Reviewed for GeoSolve Ltd by:

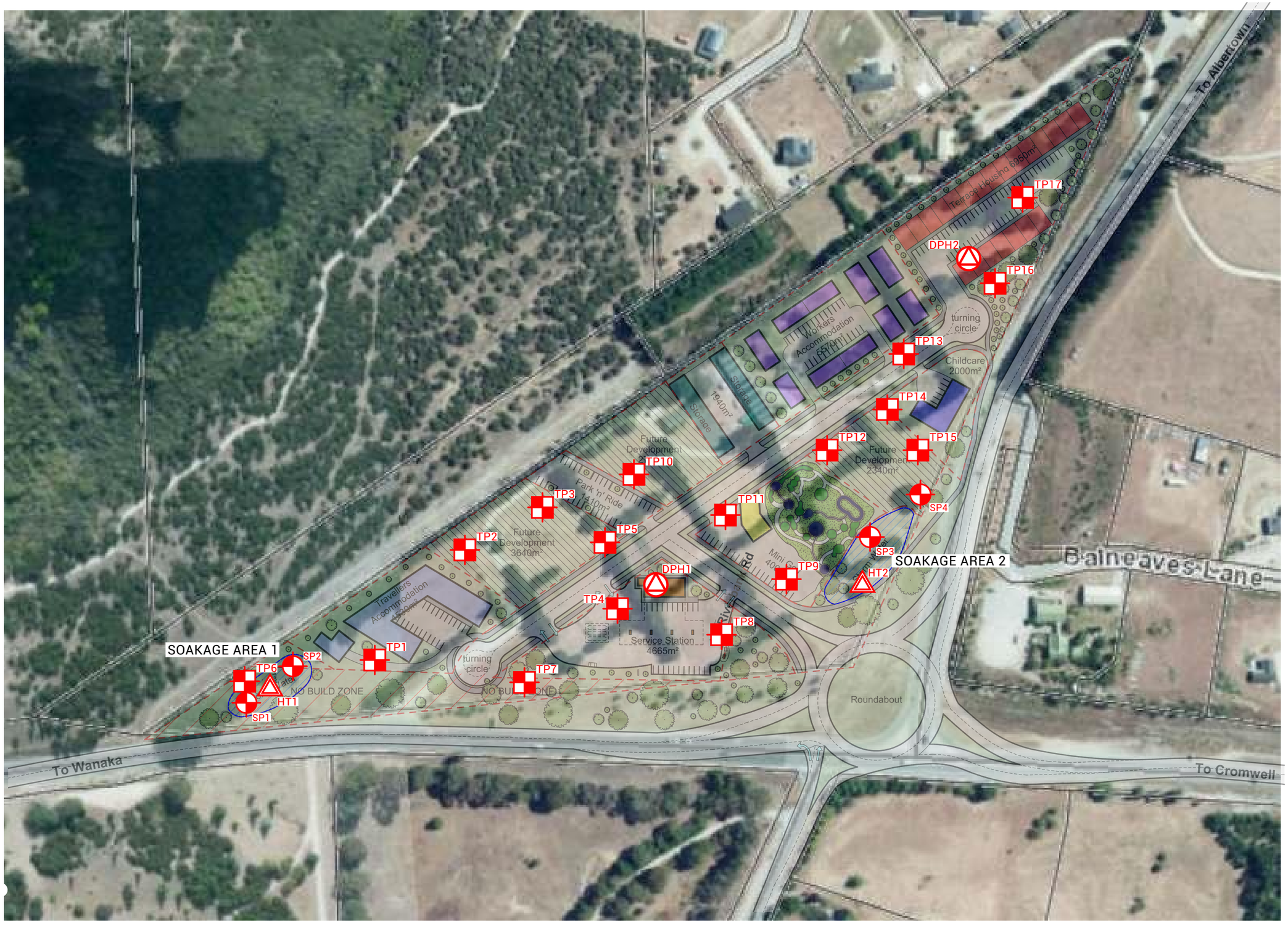
.....

Fraser Wilson

Senior Engineering Geologist

GeoSolve Ltd

Appendix A: Site Investigation Plan



Key

TP1 = Test Pit

DPH1 = Heavy Dynamic Probe (DPH) test location

SP1 = Soakage Pit Test

HT1 = HT21 Permeability Test

Scale 1:2000

0 20 40 60 80 (m)

GEOSOLVE

70 Macandrew Road, PO Box 2427,
South Dunedin 9044. ph 03 466 4024

DRAWN	MDP	2/18
DRAFTING CHECKED	FAW	2/18
APPROVED	FAW	2/18
FILE : PDF		
SCALE: (AT A3 SIZE) As Shown		
PROJECT No. 170839		

MT IRON JUNCTION LIMITED
Geotechnical Investigation
237 Wanaka-Luggate Highway
Site Plan

FIG No. Appendix A - Figure 1

REV. 0

Note: Boulders are not to scale

N

Sub-horizontal outwash surface (0-5°)

26
28
31
33
35
30
21
237

Albert Town-Lake Hawea Rd

Wanaka-Luggate Hwy

Key

= Observed rockroll boulder

= Observed outwash boulder

= Base of Mount Iron slopes

= Crest of lateral moraine ridge

= Property boundary

Scale 1:2000

0 20 40 60 80 (m)

GEOSOLVE

70 Macandrew Road, PO Box 2427,
South Dunedin 9044. ph 03 466 4024

DRAWN	MDP	2/18
DRAFTING CHECKED	JAS	2/18
APPROVED	FAW	2/18
FILE : PDF		
SCALE: (AT A3 SIZE) As Shown		
PROJECT No. 170839		

MOUNT IRON JUNCTION LTD
Geotechnical Investigation
237 Wanaka-Luggate Highway
Rockroll Hazard Map

FIG No. Appendix A - Figure 2

REV. 0

Appendix B: Investigation Data

GEOSOLVE

EXCAVATION LOG

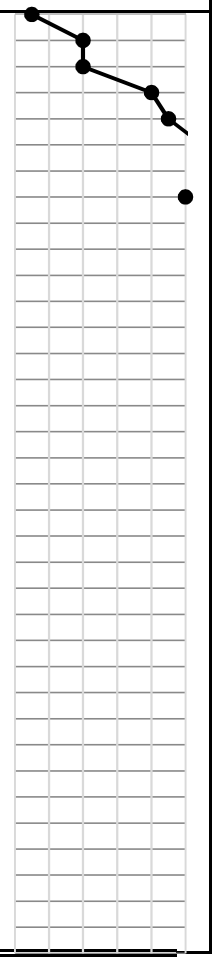
EXCAVATION NUMBER: **TP 1**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm (0 2 4 6 8 10)
0.15	TOPSOIL		Light brown/brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
1.2	OUTWASH GRAVEL		Brown/grey, sandy GRAVEL with trace cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 80 mm. Medium dense. Bedded. Dry.			
3.6	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 3.6 m



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	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 2**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

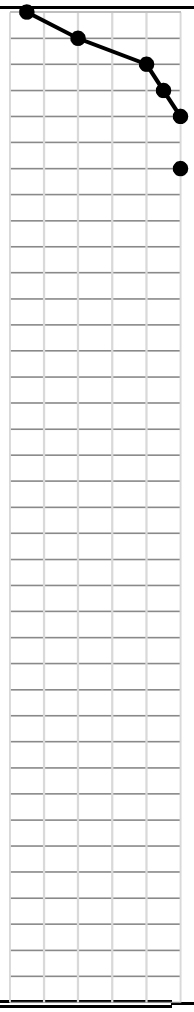
DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE
0.15	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.		
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.		
1.3	OUTWASH GRAVEL		Grey, sandy GRAVEL with minor rootlets. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		
3.8	OUTWASH GRAVEL		Grey, sandy GRAVEL with trace cobbles and boulders. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Boulders to 300 mm. Medium dense. Bedded. Dry.		NO SEEPAGE

Total Depth = 3.8 m

SCALA PENETROMETER

Blows per 100mm

0 2 4 6 8 10



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	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 3**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm (0 2 4 6 8 10)
0.15	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.35	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
0.6	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense.			
1.5	OUTWASH SAND		Grey/brown, SAND with some to minor gravel. Sand is fine to coarse. Medium dense. Bedded. Dry.			
4.0	OUTWASH GRAVEL		Grey, sandy GRAVEL with minor cobbles and boulders. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Boulders to 300 mm. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 4 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 4**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

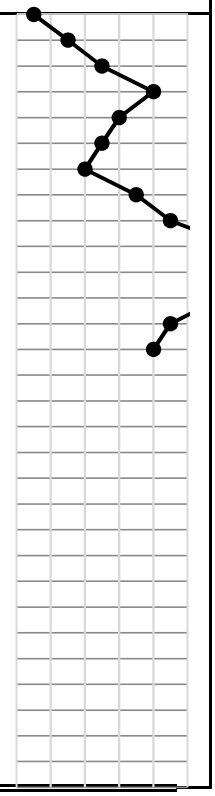
EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE
0.2	TOPSOIL		Brown, organic SILT with roots and rootlets. Silt is non-plastic. Dry.		
0.5	LOESS		Light brown, silty SAND with minor gravel. Sand is fine to medium. Silt is non-plastic. Firm. Dry.		
3.0	OUTWASH GRAVEL		Grey, sandy GRAVEL with minor rootlets. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		NO SEEPAGE

SCALA PENETROMETER

Blows per 100mm

0 2 4 6 8 10



Total Depth = 3 m

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GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 5**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.2	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
1.8	OUTWASH GRAVEL		Grey, sandy GRAVEL with minor rootlets. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.			
3.5	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 3.5 m

COMMENT:	Logged By: MDP
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	Sheet: 1 of 1

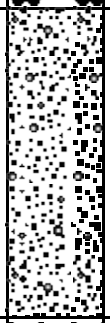
GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 6**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
1.3	UNCONTROLLED FILL		Grey, gravelly SAND with minor topsoil and trace sticks, rootlets and wire. Sand is fine to coarse. Gravel is fine to medium. Gravel is sub-angular to sub-rounded. Loose. Dry.			
1.6	BURIED TOPSOIL		Brown, organic SILT with rootlets and roots. Silt is non-plastic. Dry.			
2.6	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.			
2.9	OUTWASH SAND		Grey/brown, gravelly SAND to SAND with some gravel. Sand is fine to coarse. Medium dense. Bedded. Dry.			
4.2	OUTWASH GRAVEL		Grey, sandy GRAVEL with some cobbles and minor boulders. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Boulders to 300 mm. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 4.2 m

COMMENT:	Logged By: MDP
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	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 7**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.15	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
2.3	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.			
4.0	OUTWASH GRAVEL		Dark grey, sandy GRAVEL with minor cobbles and boulders. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Boulders to 250 mm. Medium dense. Bedded. Dry to moist.		NO SEEPAGE	

Total Depth = 4 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 8**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
2.6	OUTWASH GRAVEL		Grey, sandy GRAVEL with minor rootlets, cobbles and boulders. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Boulders to 200 mm. Medium dense. Bedded. Dry.			
3.8	OUTWASH GRAVEL		Dark grey, sandy GRAVEL with minor cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 90 mm. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 3.8 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 9**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm (0 2 4 6 8 10)
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
1.3	OUTWASH GRAVEL		Grey, sandy GRAVEL with some cobbles and minor boulders. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Boulders to 200 mm. Medium dense. Bedded. Dry.			
4.5	OUTWASH GRAVEL		Dark grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 4.5 m

COMMENT:

Logged By: MDP

Checked Date:

Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 10**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.		
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.		
2.4	OUTWASH GRAVEL		Brown/grey, sandy GRAVEL with minor rootlets and trace cobbles and roots. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 80 mm. Medium dense. Bedded. Dry.		
3.5	OUTWASH GRAVEL		Brown/grey, sandy GRAVEL with some to minor cobbles and minor boulders. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Boulders to 300 mm. Medium dense. Bedded. Dry.		NO SEEPAGE

SCALA PENETROMETER
Blows per 100mm
0 5 10 15

Total Depth = 3.5 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 11**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
1.1	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.			
2.5	OUTWASH GRAVEL		Grey, sandy GRAVEL with some to minor cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 100 mm. Medium dense. Bedded. Dry.			
2.9	OUTWASH SAND		Grey/brown, gravelly SAND. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-rounded to sub-angular. Medium dense. Bedded. Dry.			
3.4	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 3.4 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 12**

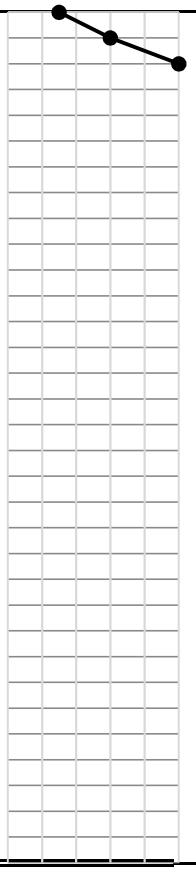
PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE
0.1	TOPSOIL		Brown, organic SILT with rootlets and roots. Silt is non-plastic. Dry.		
0.3	LOESS		Light brown, silty SAND with minor rootlets and trace roots. Sand is fine to medium. Silt is non-plastic. Firm. Dry.		
1.9	OUTWASH GRAVEL		Grey, sandy GRAVEL with some cobbles, minor rootlets and trace boulders. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Boulders to 300 mm. Medium dense. Bedded. Dry.		
3.3	OUTWASH GRAVEL		Dark grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		NO SEEPAGE

Total Depth = 3.3 m

SCALA PENETROMETER
Blows per 100mm
0 2 4 6 8 10



COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 13**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm (0 2 4 6 8 10)
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
2.5	OUTWASH GRAVEL		Grey/brown, sandy GRAVEL with some cobbles and trace rootlets. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 100 mm. Medium dense. Bedded. Dry.			
4.2	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 4.2 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 14**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
1.2	OUTWASH GRAVEL		Grey, sandy GRAVEL with some cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 100 mm. Medium dense. Bedded. Dry.			
3.1	OUTWASH GRAVEL		Grey, sandy GRAVEL with minor to trace cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 100 mm. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 3.1 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 15**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

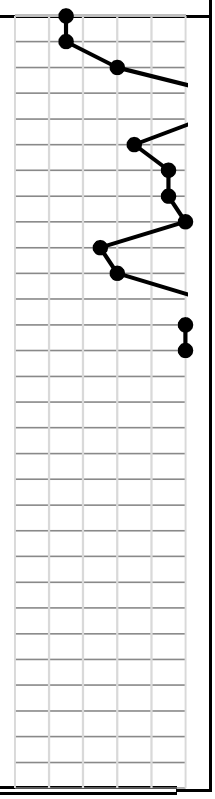
DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.		
0.3	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.		
1.6	OUTWASH GRAVEL		Grey/brown, sandy GRAVEL with minor cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 100 mm. Medium dense. Bedded. Dry.		
3.0	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Medium dense. Bedded. Dry.		NO SEEPAGE

Total Depth = 3 m

SCALA PENETROMETER

Blows per 100mm

0 2 4 6 8 10



COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 16**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm (0 2 4 6 8 10)
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.2	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
3.7	OUTWASH GRAVEL		Grey, sandy GRAVEL with trace rootlets and cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 200 mm. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 3.7 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **TP 17**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	19-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	19-Dec-17

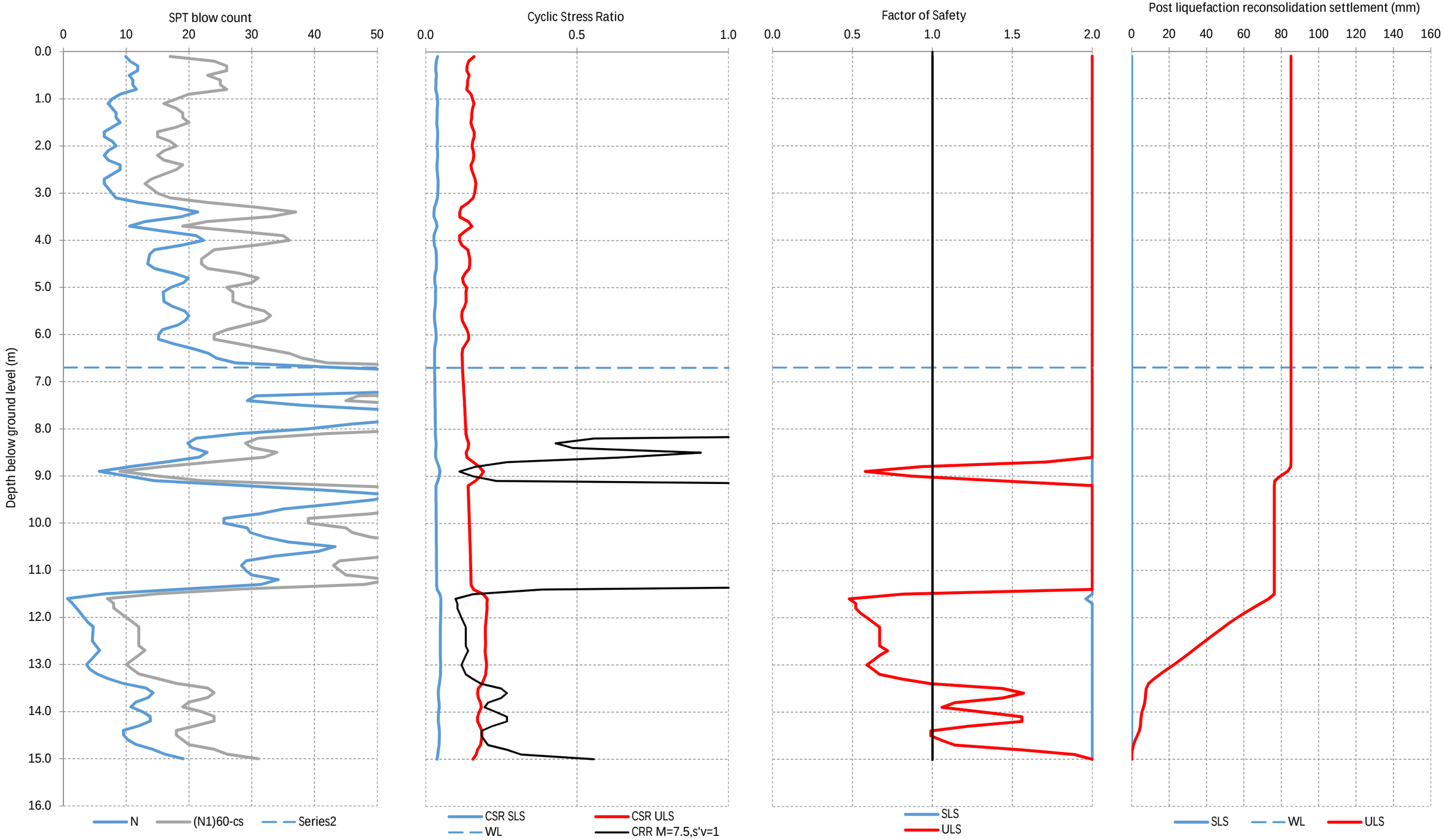
DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.1	TOPSOIL		Brown, organic SILT with rootlets. Silt is non-plastic. Dry.			
0.2	LOESS		Light brown, silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Dry.			
1.9	OUTWASH GRAVEL		Grey, sandy GRAVEL with trace rootlets and cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 200 mm. Medium dense. Bedded. Dry.			
3.5	OUTWASH GRAVEL		Grey/brown, sandy GRAVEL with minor cobbles. Sand is fine to coarse. Gravel is fine to coarse. Gravel is sub-angular to sub-rounded. Cobbles to 200 mm. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 3.5 m

COMMENT:	Logged By: MDP
	Checked Date:
	Sheet: 1 of 1

Appendix C: Liquefaction Analysis

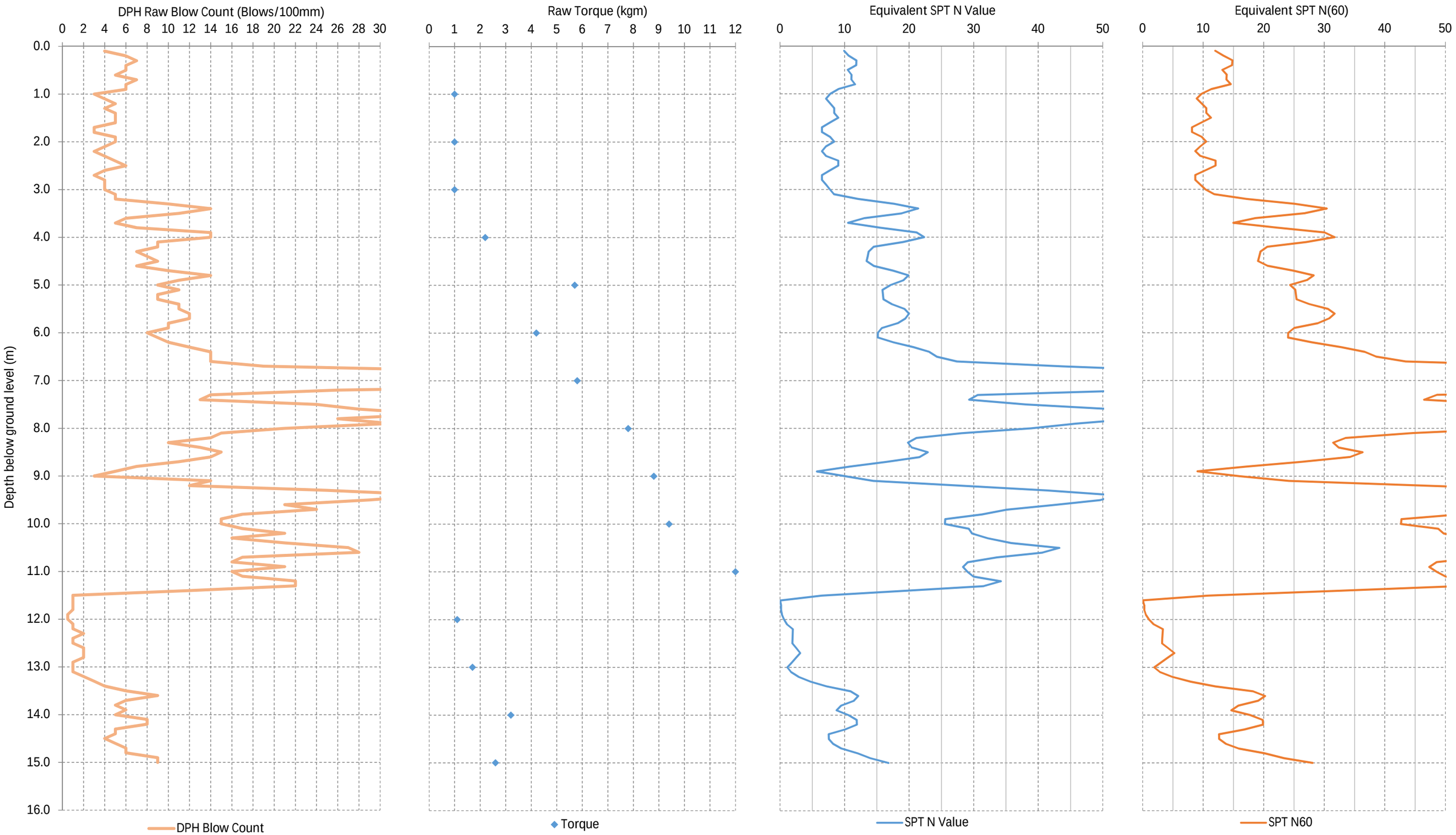
LSN (SLS)	LSN (ULS)	Crust Thickness (SLS)	Crust Thickness (ULS)
0.0	7.1	0.0	8.7



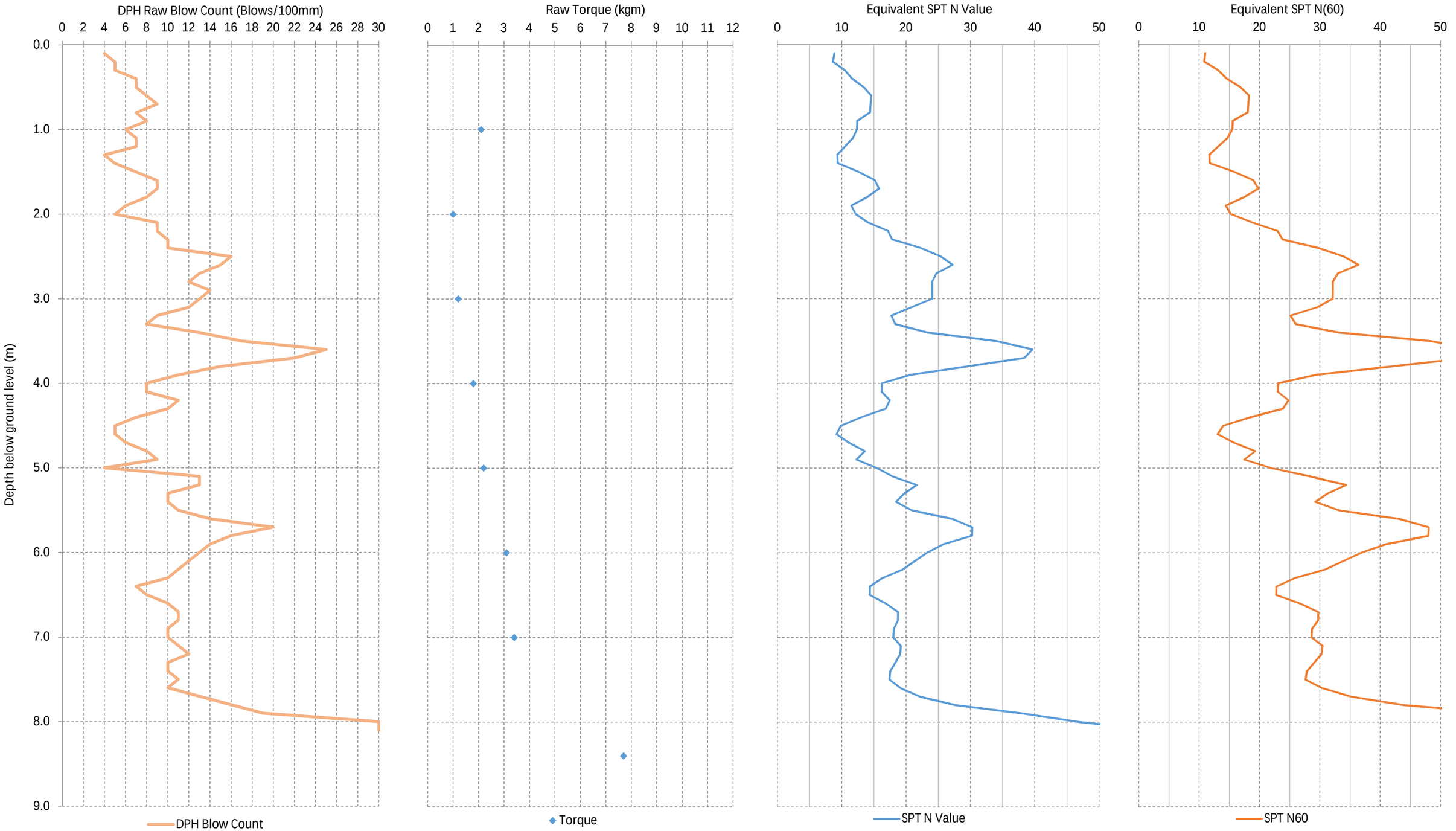
Note: Settlements as per Idriss and Boulanger (2014)

GEOSOLVE

PROJECT	170839 - Mt Iron Junction
DESCRIPTION	Liquefaction Analysis
LOCATION	Wanaka
CLIENT	Mt Iron Junction Limited
TEST NUMBER	DPH1
DATE	17/01/2018
LOGGED BY	RC
ANALYSED BY	MDP
CHECKED BY	FAW



GEOSOLVE	PROJECT	170839 - Mt Iron Junction	CLIENT: Mt Iron Junction Limited
	DESCRIPTION	Liquefaction Analysis	TEST NUMBER: DPH1
	LOCATION	Wanaka	DATE: 17/01/2018
			LOGGED BY: RC
			ANALYSED BY: MDP
			CHECKED BY: FAW



GEOSOLVE	PROJECT	170839 - Mt Iron Junction	CLIENT: Mt Iron Junction Limited
	DESCRIPTION	Liquefaction Analysis	TEST NUMBER: DPH2
	LOCATION	Wanaka	DATE: 17/01/2018
			LOGGED BY: RC
			ANALYSED BY: MDP
			CHECKED BY: FAW

Appendix D: Permeability Testing Results

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **SP 1**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
1.7	UNCONTROLLED FILL		Light grey, SAND with some gravel and silt, trace cobbles and boulders. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded. Boulders up to 700 mm diameter. Loose to medium dense. Massive. Dry.			
1.8	BURIED TOPSOIL		Brown, organic SILT with minor rubbish. Rubbish includes wire fence. Firm. Massive. Dry.			
2.6	OUTWASH GRAVEL		Grey, sandy GRAVEL with lenses of gravelly SAND and silty SAND. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded. Medium dense. Bedded. Moist.		NO SEEPAGE	

Total Depth = 2.6 m

COMMENT:	Logged By: JAS/MDP
	Checked Date:
	Sheet: 1 of 1

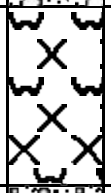
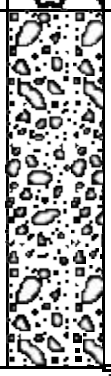
GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **SP 2**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
1.2	UNCONTROLLED FILL		Light grey, sandy GRAVEL with trace cobbles and organic SILT. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded. Loose to medium dense. Massive. Dry.			
1.6	BURIED TOPSOIL		Dark brown, sandy organic SILT with minor gravel. Sand is fine. Gravel is fine to coarse. Firm. Massive. Moist.			
2.4	OUTWASH GRAVEL		Grey, sandy GRAVEL with trace cobbles. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded. Medium dense. Bedded. Moist.		NO SEEPAGE	

Total Depth = 2.4 m

COMMENT:	Logged By: JAS/MDP
	Checked Date:
	Sheet: 1 of 1

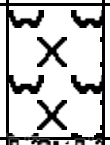
GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: SP 3

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.3	TOPSOIL/LOESS		Brown, organic SILT and silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Massive. Dry.			
1.3	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded to sub-angular. Medium dense. Bedded. Dry.		NO SEEPAGE	

Total Depth = 1.3 m

COMMENT:	Logged By: JAS/MDP
	Checked Date:
	Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

EXCAVATION NUMBER: **SP 4**

PROJECT:	Mt Iron Junction	JOB NUMBER:	170839

EASTING:		mE	EQUIPMENT:	8 T Excavator	OPERATOR:	Ben
NORTHING:		mN	INFOMAP NO.		COMPANY:	Diverse Works
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	18-Dec-17
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	18-Dec-17

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER
0.3	TOPSOIL/LOESS		Brown, organic SILT and silty SAND with minor rootlets. Sand is fine to medium. Silt is non-plastic. Firm. Massive. Dry.		NO SEEPAGE	
1.2	OUTWASH GRAVEL		Grey, sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse and sub-rounded to sub-angular. Medium dense. Bedded. Dry.			

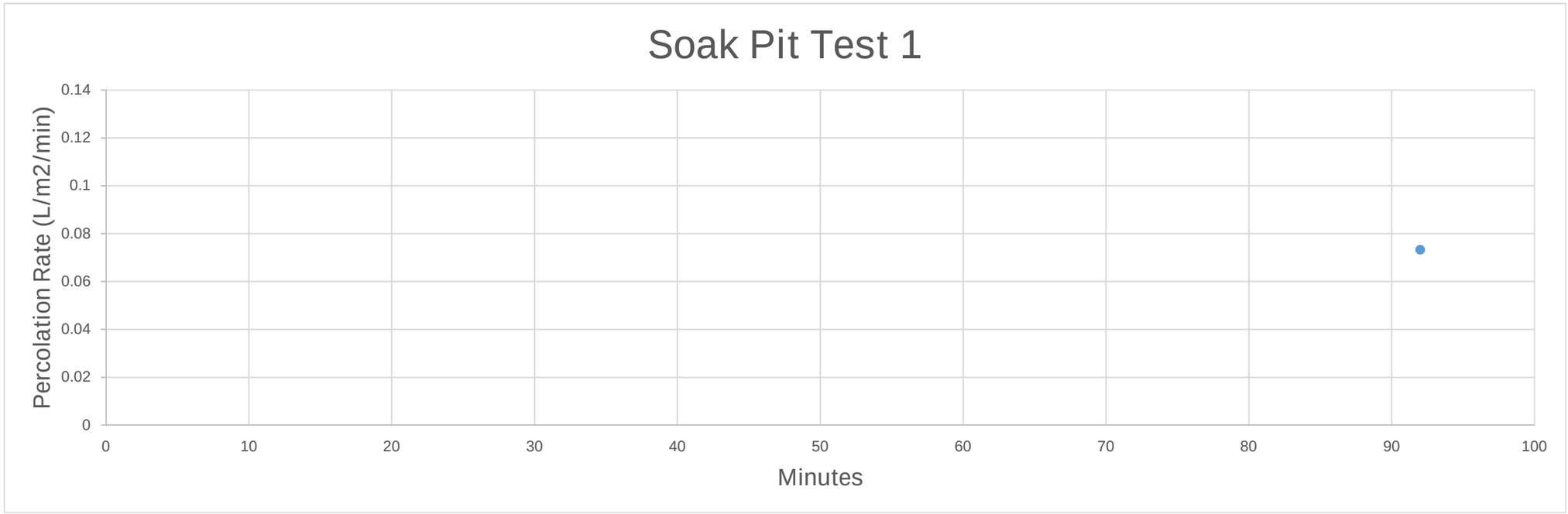
Total Depth = 1.2 m

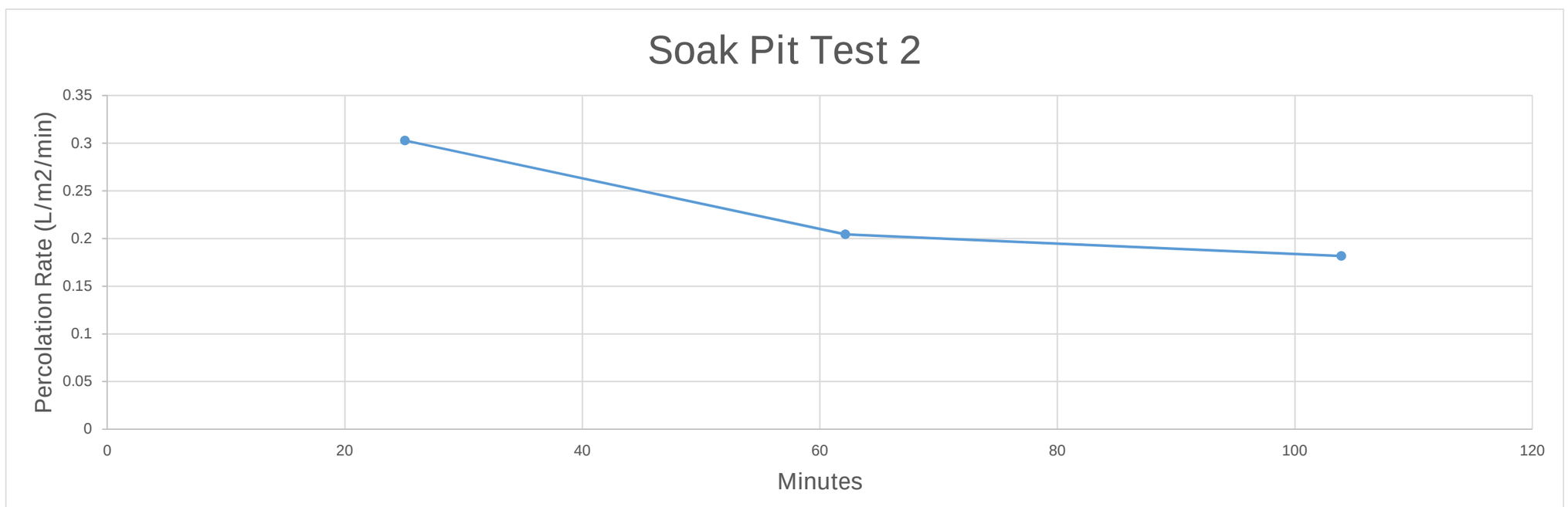
COMMENT:

Logged By: JAS/MDP

Checked Date:

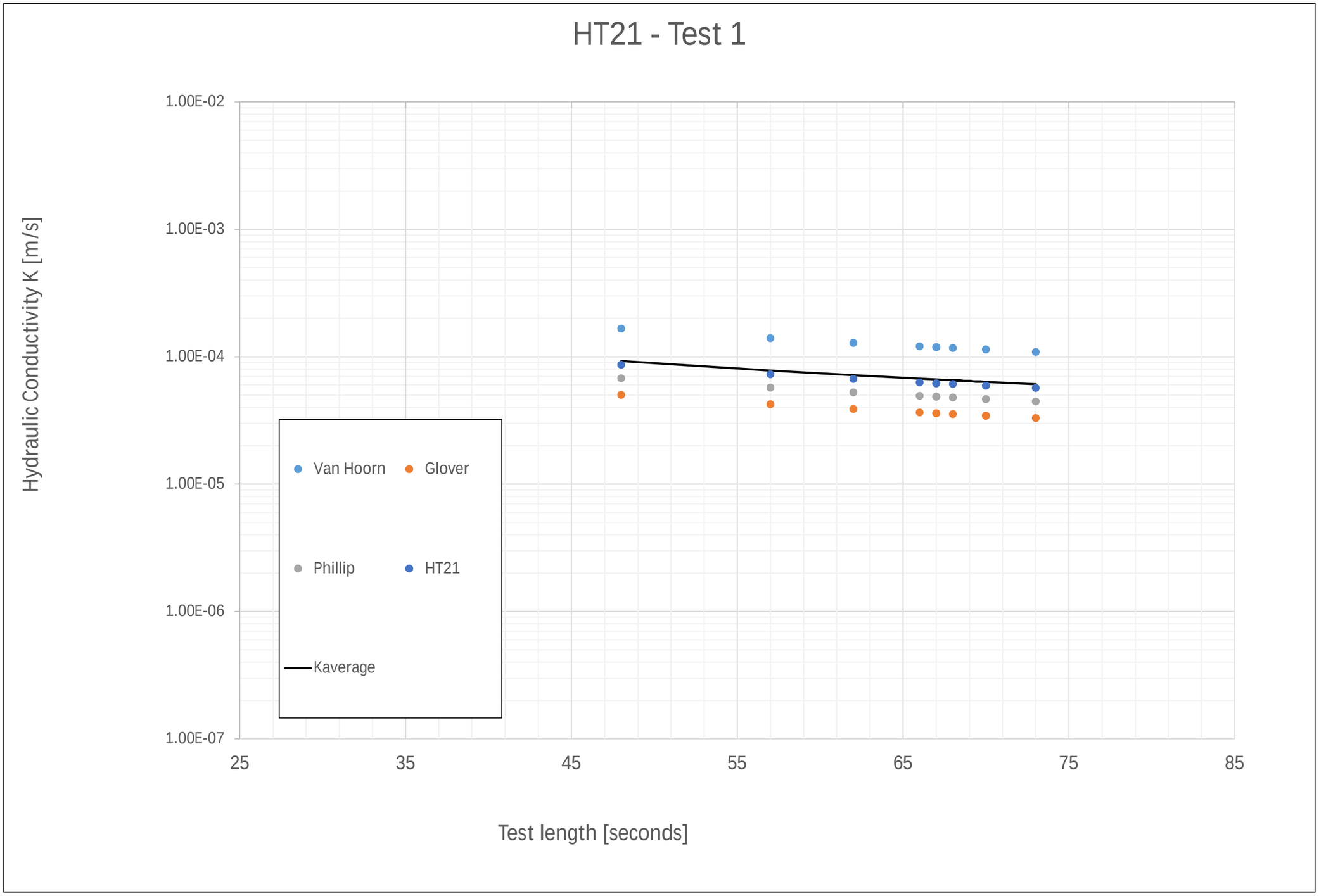
Sheet: 1 of 1



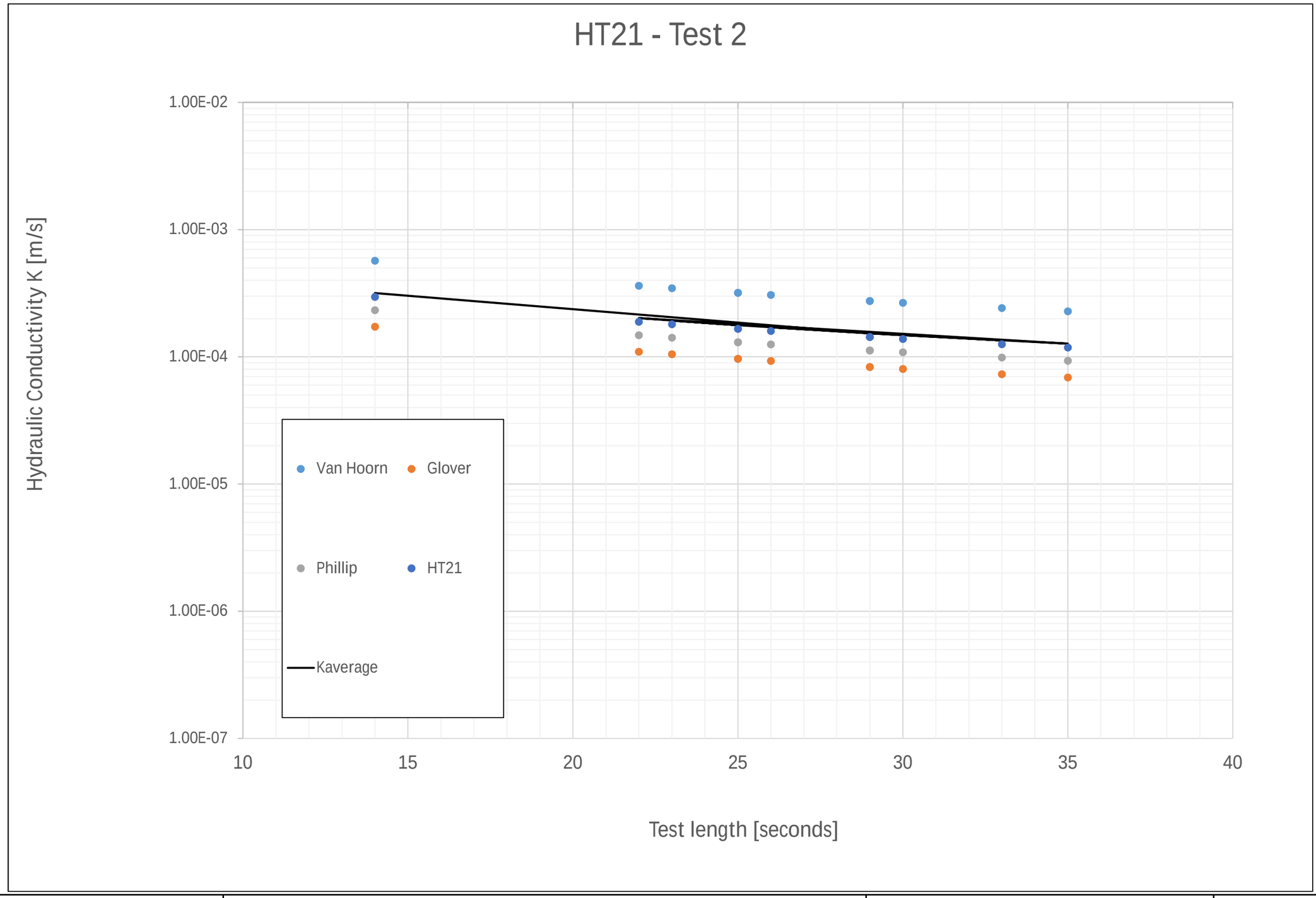


GEOSOLVE

PROJECT	170839 - Mt Iron Junction	CLIENT	Mt Iron Junction Limited
DESCRIPTION	Peremability Testing	TEST NUMBER	SP 1 and 2
LOCATION	Wanaka	DATE	18/12/2017
		LOGGED BY	JAS/MDP
		ANALYSED BY	MDP
		CHECKED BY	FAW



GEOSOLVE	PROJECT	170839 - Mt Iron Junction	CLIENT: Mt Iron Junction Limited
	DESCRIPTION	Peremability Testing	TEST NUMBER: HT21 1
	LOCATION	Wanaka	DATE: 18/12/2017
			LOGGED BY: JAS/MDP
			ANALYSED BY: MDP
			CHECKED BY: FAW



GEOSOLVE	PROJECT	170839 - Mt Iron Junction	CLIENT: Mt Iron Junction Limited
	DESCRIPTION	Peremability Testing	TEST NUMBER: HT21 2
	LOCATION	Wanaka	DATE: 18/12/2017
			LOGGED BY: JAS/MDP
			ANALYSED BY: MDP
			CHECKED BY: FAW