REPORT

Tonkin+Taylor

Te Rangihaeata / Manor Park Development

Geotechnical Assessment Report

Prepared for
Rosco Ice Cream Ltd
Prepared by
Tonkin & Taylor Ltd
Date
May 2022
Job Number
1015081.1000.v1.0

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13/05/22	1.0	Final report for client review	Tim Haxell	Richard Mulvad Cole	Chris Hillman

Distribution:

Rosco Ice Cream Ltd	1 PDF copy
Tonkin & Taylor Ltd (FILE)	1 electronic copy

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1 Introduction

Tonkin & Taylor Ltd (T+T) have undertaken a preliminary geotechnical assessment to support the lodgement of a Bulk Earthworks Consent for the proposed Te Rangihaeata / Manor Park Development.

This report presents a preliminary ground model for the site based on existing geological and geotechnical information, sets out the relevant geotechnical hazards and considerations for earthworks development of the site. A scope for further geotechnical investigation and assessment in support of a Plan Change Consent submission is also included.

This assessment has been carried out for Rosco Ice Cream Ltd in accordance with our letter of engagement of 17 September 2021, and has specifically consisted of:

- Desktop review of the available geological and geotechnical information;
- Site inspection to identify geological, hydrological, and geomorphic features;
- Development of a preliminary geotechnical model;
- Identification of the relevant geotechnical hazards and consideration of how these can be mitigated;
- Consideration of the site suitability for earthworks development; and
- Consideration of further geotechnical work in support of a Plan Change Consent submission.

T+T has previously provided geotechnical advice regarding the proposed development of the site which has included the following:

- Desktop literature review of the Wellington Fault to estimate the likelihood and scale of horizontal and vertical fault displacements in the vicinity of the site[1]; and
- Geophysical and borehole investigation to constrain the likely location of the Wellington Fault through the site[2].

1.1 Site description

Te Rangihaeata / Manor Park is located within the northeast-trending Hutt Valley flood plain and immediately between hills of Belmont Regional Park to the west, and KiwiRail's Wairarapa Line and the Hutt River to the east (refer Figure 1.1). At the base of the hills a steep linear escarpment (inferred to be the result of ongoing movement along the Wellington Fault) and State Highway 2 (SH2).

The site is predominantly flat and consists of open areas of scrub. There is evidence of the land's past industrial and agricultural use e.g., fencing, derelict buildings, concrete foundation slabs and general waste. Uncontrolled fill is exposed and widespread across the site associated with historic road and rail construction, and more recent clean-fill operations. Most of the site lies at approximately 32 mRL (10 m above the level of the adjacent Hutt River). The southwest corner of the site, however, drops in elevation to about 26 mRL.

Two unnamed southeast-trending tributaries of the Hutt River intersect the western hills and issue immediately adjacent to the north and south of the site. The northern stream (named Dry Creek in this report), which is located in a valley north of Buchanan Road, is culverted beneath SH2 and discharges into the site where it is constrained to a narrow and possibly manmade channel

[1] T+T (14 December 2020). Manor Park Development – Wellington Fault Desktop Study and Investigation Options.
[2] T+T (7 July 2021). Te Rangihaeata / Manor Park Development – Wellington Fault Investigation Report.

(manipulation of the original stream location is likely associated with historic earthworks at the site). The narrow channel turns at right angles towards the southwest corner of the site where it discharges into the Hutt River (the confluence is located beyond the site). The southern stream also culverted beneath SH2, discharges into the Hutt River approximately 100 m southwest of the site.

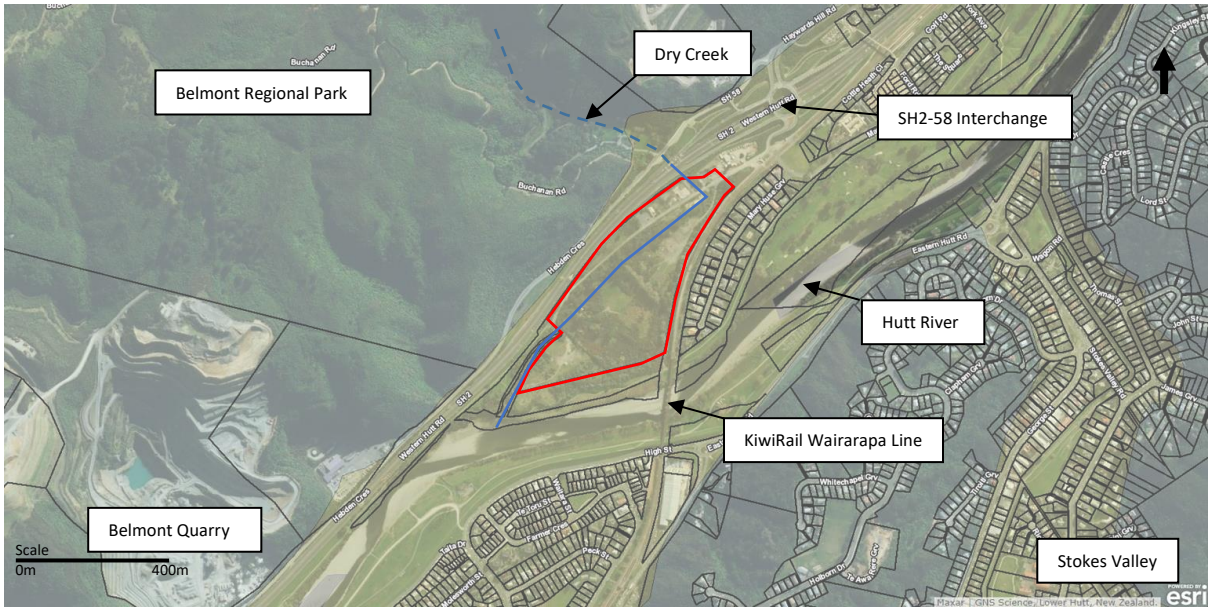

Figure 1.1: Plan of the proposed development site of Te Rangihaeata / Manor Park (highlighted red) located within the Hutt Valley flood plain between greywacke hills to the west and the Hutt River to the east.

1.2 Proposed development

The site is proposed to be rezoned as industrial and subdivided in to 16 lots (based on current understanding from architectural plans provided by the client dated January 2022).

The proposed conceptual platform involves approximately 82,000 m^3 of cutting and re-using that material elsewhere on the site to fill lower areas, predominantly the southern sections of the site, refer Figure 1 in Appendix A for the conceptual fill platform design.

1.2.1 Previous geotechnical investigations

Previous geotechnical investigations have been carried out at the site for the purposes of identifying the location of the Wellington Fault, and for environmental sampling of the fill soils only. Relevant subsurface information has also been obtained from the State Highway 2-58 Haywards interchange project, located immediately north of the site.

The geotechnical information used to develop a ground model for the site includes the following:

- Numerous test pits, cone penetrometer tests and boreholes carried out by Opus, AECOM, and T+T during 2009 and 2015, immediately north of the site;
- Fault trenches carried out by GNS in 2008[3] as part of an investigation to identify the location of the Wellington Fault, at the southwest corner of the site;

[3] Beetham, R.D., Sagpoole, V., Palmer, N., Begg, J. G., Berkenbosch,, H. 2008. "Investigation and location of the Wellington Fault at Manor Park". GNS Science Consultancy Report 2008/36.

- Three seismic refraction survey profiles though the site undertaken by A J Sutherland Consulting as part of an investigation to identify the location of the Wellington Fault in 2020[4]; and
- Four vertical and two inclined boreholes logged by T+T as part of an investigation to identify the location of the Wellington Fault in 2020.

The geotechnical information obtained from the previous investigations provides sufficient information to support this consent submission, however further specific investigations will be required to support the proposed plan change consent.

2 Assessment and interpretation of site conditions

2.1 Published Geology

The published geology[5] of the area indicates that the site is directly underlain by Holocene alluvial deposits consisting of well sorted floodplain gravels. Triassic sandstone and mudstone of the Rakaia Terrane (Greywacke) form the adjacent valley sides and underly the alluvial deposits that fill the valley. The Wellington-Hutt Valley segment of the Wellington Fault is mapped within the western margin of the Hutt Valley and through the site.

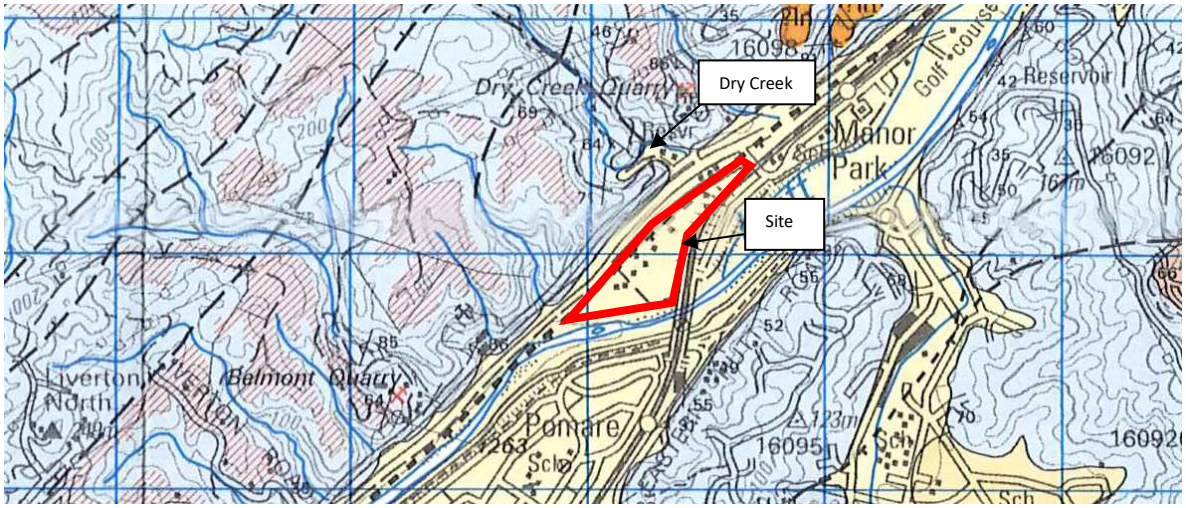

Figure 2.1: Published geological map (Begg & Mazengarb, 1996). Blue indicates Greywacke rock and cream indicates alluvium within the Hutt Valley. The approximate site extent is outlined in red and the black dashed line indicates the approximate location of the Wellington Fault.

2.2 Preliminary geotechnical and geological model

The geotechnical and geological model is based on a desktop review of the available geotechnical and geological information, an inspection of the site and recent fault investigations completed in February and March 2021. It should appreciated that the actual subsurface conditions may vary from has been presented here and addition geotechnical investigations will be required to verify this inferred model. Table 2.1 presents a summary of the geotechnical and geological model.

[4] A J Sutherland Consulting. Manor Park seismic refraction survey, January 2021
[5] Begg, J.G., Mazengarb, C., 1996. Geology of the Wellington area, scale 1:50 000. Institute of Geological & Nuclear Sciences geological map 22. 1 sheet + 128 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences Limited.

Table 2.1Geotechnical and geological model

Geological description	Typical geotechnical description	Material strength	Typical thickness	Depth to top of layer
Fill	Silty, Sandy GRAVEL; and Sandy SILT with some gravel. Contains roots, red brick, rebar, metal, concrete, glass, and other refuse debris	Medium dense / Firm to Stiff	2 to 4 m	0 m
Holocene Alluvium	Sandy SILT, low plasticity	Firm (qc= 2-10kPa)	0.5 to 2 m	2 to 4 m
	Sandy, cobbly GRAVEL; may contain thin lenses of silt, sand, and organics.	Dense	5 to 15 m	2 to 4 m
Rakaia Terrane (Greywacke)	Moderately weathered to slightly weathered, MUDSTONE and SANDSTONE (highly fractured and crushed near the Wellington Fault)	Very weak to moderately strong	Not proven	5 (northwest margin) to 15 m (southeast margin)

2.3 Preliminary groundwater conditions

The site is located within the unconfined zone of the Lower Hutt Groundwater Zone[6]. The groundwater is expected to be sourced from surface infiltration and the two southeast-trending streams that intersect the western hills, and likely to be influenced by the Hutt River to the east, seasonal and barometric variation.

Limited groundwater information is available within the site. Static water level measurements were recorded during the drilling of four fault investigation boreholes. The water levels measured in each borehole (except those that are elevated by drilling fluid) are likely to represent the actual groundwater level. On this basis, the groundwater beneath the site is expected to be within the overlying alluvial deposits between approximately 21 to 24 mRL. The groundwater level is expected to be shallowest along the southeast margin of the site nearest the Hutt River (approximately 3 m below ground level), and deepest at the northern end (approximately 8 m below ground level).

3 Geotechnical hazards

3.1 Ground shaking

Due to the proximity of the site to the Wellington Fault (and other nearby active faults) the site should be expected to experience high ground motions during an earthquake that may be amplified due to the presence of alluvial soils that directly underly the site.

This hazard can be mitigated through geotechnical foundation design by an experienced geotechnical engineer.

[6] Greater Wellington Regional Council, Lower Hutt Aquifer Model Revision (HAM3): Sustainable Management of the Waiwhetu Aquifer, June 2014.

3.2 Fault surface rupture

A significant geotechnical issue concerning future development of the site is the proximity to the Wellington Fault and the consequences of fault rupture. The Wellington-Hutt Valley segment of the Wellington Fault lies within the site and therefore presents a risk of future development. Estimates suggest that there is a 10-15% likelihood of fault rupture in the next 100 years that could result in the order of 5 m horizontal and up to 1 m vertical displacements.

The site lies within the Hutt City Council (HCC) Wellington Fault Special Study Zone. Previous fault investigation and reporting[7] presents a zone that constrains the likely location of the Wellington through the site. Therefore, to mitigate the risk of fault surface rupture, and pursuant to Rule 14H2 and Clause 14H 1.1.1 of the HCC District Plan, any proposed buildings should not be within 20 m of the defined zone.

3.3 Liquefaction

The alluvial soils that underly the site may be susceptible to liquefaction particularly where they are non-cohesive and lie below the groundwater table (are saturated). Liquefaction could result in ground deformation (sand boils, settlement, undulation, and cracking), damage to infrastructure, buildings, and foundations. Lateral spreading (movement of the ground nearest the Hutt River due to shearing along weak liquified soils under seismic and/or gravity forces) is unlikely to be possible failure mechanism due to the significant distance to the Hutt River, some c. 100 m away.

Areas of significant liquefaction risk could be mitigated through engineering design of structures in accordance with NZ building standards, or by avoidance where practical e.g., locating infrastructure and structures away from these areas of risk. The vulnerability of these soils to liquefaction will need to be explored further during a next stage of investigation (discussed in Section 6).

The uncontrolled fill soils at the ground surface are expected to lie above the groundwater table and therefore unlikely to present a liquefaction risk.

3.4 Ground settlement

The alluvial deposits that underly the site may contain isolated zones of compressible cohesive and organic material that may result in settlement of the ground surface when loaded by the proposed fill platform, buildings or structures. Similarly, the uncontrolled fill soils present at the ground surface may also present a settlement risk due to the nature of the material and uncontrolled method of placement.

Settlement of the alluvial deposits or uncontrolled fill soils at depth below the proposed fill platform may result in subsidence of the fill surface levels and may result in damage to building or structures.

Ground settlement can be mitigated through specific engineering foundation design of any proposed buildings or structures, however the presence, or absence of compressive soils and their impacts to the development should be explored further during the next stage of investigation (discussed in Section 6).

3.5 Slope stability

No significant existing slope have been identified that may pose a risk to a development of the site.

[7] T+T (7 July 2021). Te Rangihaeata / Manor Park Development – Wellington Fault Investigation Report.

3.6 Erosion

Most of the site is covered by vegetation or pavement and no evidence of erosion was observed during our inspection.

Due to the relatively low gradient across the site, erosion does not present a significant risk for development. However, the materials present at the ground surface are likely to be vulnerable to erosion if they are exposed. Erosion of surface soils could be expected to occur when exposed on slopes including those adjacent to stream channels. This may result in the formation of rills and channels in the surface soil and an increased sediment load into stream.

Mitigation and prevention of any erosion during earthworks construction could be specifically addressed through implementation of erosion and sediment control measures e.g., erosion matting, planting, hydro-seed etc.

4 Earthworks construction considerations

4.1 Earthworks methodology

Earthworks will be undertaken following an Earthworks Management Plan that sets out how the works are to be compliant with, where appropriate, NZS4431:1989 (Code of practice for earth fill for residential development) and NZS4404:2010 (Land development and subdivision infrastructure). This should specifically include, but not limited to the following:

- Enabling works / site preparation;
- Confirm suitability of materials for use as fill;
- Erosion and sediment control measures;
- Stockpiling of imported fills;
- Staging of earthworks;
- Compaction methodology;
- Compaction testing requirements; and
- Encapsulation.

4.2 Fill platform

4.2.1 Fill source

Structural Fill (fill used to form the fill platform and to provide founding for the structures, access roads and services) will need to be imported from a nearby source (note that this material does not necessarily need to be a high-quality rock fill however could be overburden material sourced from a nearby quarry) to address any cut-fill deficit. Structural Fill shall contain no unsuitable material e.g., organics, rubbish, or any material by which its inherent nature cannot be satisfactorily reconditioned by wetting and drying, to mitigate the risk of settlement of the fill or instability of the fill slopes. Laboratory compaction testing of the proposed fill source(s) will be required to confirm its suitability for use as a structural fill and compliance with NZS4431:1989. Topsoil or other organic material, while not suitable for use as Structural Fill, may be suitable for reuse as a surface soil layer for establishing vegetation growth at the completion of the works.

Material that is considered unsuitable for structural fill may be used as landscape (non-structural) fill with the agreement of the geotechnical engineer.

Any other unsuitable material shall be removed off-site.

4.2.2 Fill slopes

The fill slopes that achieve the desired fill platform levels are proposed to be 1.0 vertical: 2.0 horizontal (approximately 26° from horizontal). The adopted fill slope angle presents a low risk of instability, provided there is adequate compaction of the fill and suitable surface treatment on the slope e.g., grass, vegetation or erosion matting, to prevent erosion of the fill

Should the batter slope require steepening i.e., to extend the fill platform area to the south, the batter slope could be reinforced using regular geogrid layers. Slope stability analysis and design of a reinforced slope should be carried out by an experienced geotechnical engineer.

No cut slopes are expected as part of earthworks design.

5 Conclusion

There are three significant geotechnical hazards associated with the proposed site for development including the potential for fault surface rupture, liquefaction, and ground settlement. However, these hazards are unlikely to present a practical constraint to the proposed earthworks development of the site provided proper mitigation measures are taken as discussed in Sections 3.2 to 3.4 in this report.

6 Further investigations

In accordance with the Ministry of Business, Innovation and Employment (MBIE)/ Ministry for the Environment (MfE) guidelines for assessing potentially liquifiable land, an investigation scope has been developed to allow ground characterisation and assessment of liquefaction potential to inform a resource consent submission for plan change. Indicative investigation locations are presented in Figure 2, Appendix A. Further investigations at the site should include, but not limited to the following:

- 6 No. sonic drilled machine boreholes to a depth of up to 15 m depth or effective refusal on rock;
- Standard Penetration Testing at 1.5 m intervals in all boreholes;
- Installation of two standpipe piezometers including allowance for four monitoring visits;
- Laboratory testing of natural ground for material classification:
  - 12 Particle Size Distribution;
  - 12 Atterberg limits; and
  - 20 Natural water content.
- Laboratory testing of the proposed Structural Fill source if required:
  - 2 Particle Size Distribution;
  - 2 Heavy compaction; and
  - 1 Solid density.

7 Applicability

This report has been prepared for the exclusive use of our client Rosco Ice Cream 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, or by any person other than our client, without our prior written agreement.

Recommendations and opinions in this report are based on desktop review and from subsurface investigations as described above. The nature and continuity of subsoil conditions away from these investigation locations are inferred but it must be appreciated that actual conditions could vary from the assumed model.

Tonkin & Taylor Ltd

Report prepared by:

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Tim Haxell
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Authorised for Tonkin & Taylor Ltd by:

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Chris Hillman
Project Director

Technical review by Richard Mulvad Cole (Technical Director – Geotechnical Engineering).

13-May-22
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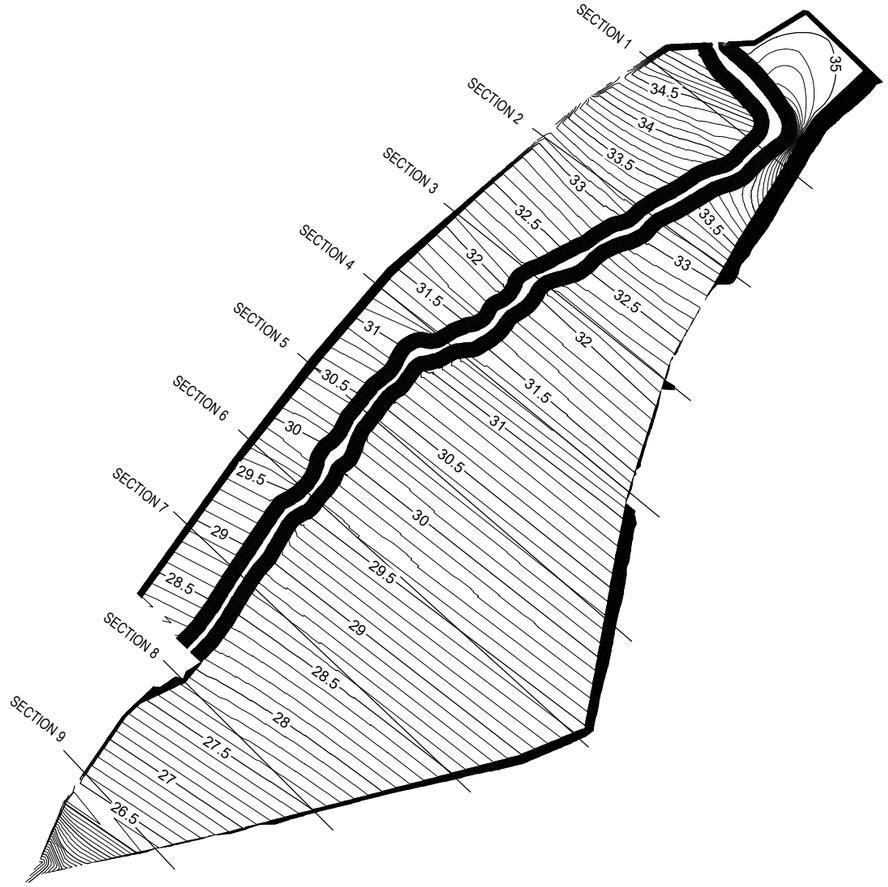
Appendix A: Figures

- **Figure 1 – Conceptual cut/fill platform**
- **Figure 2 - Site Plan of site investigations for Plan Change**



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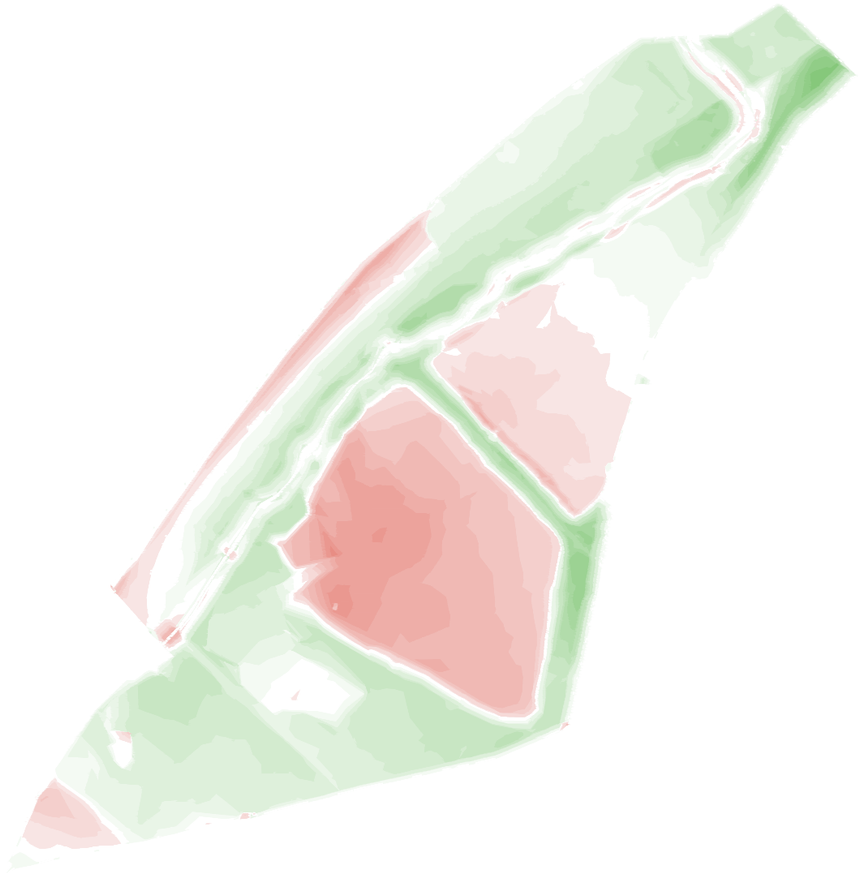

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Proposed fill platform

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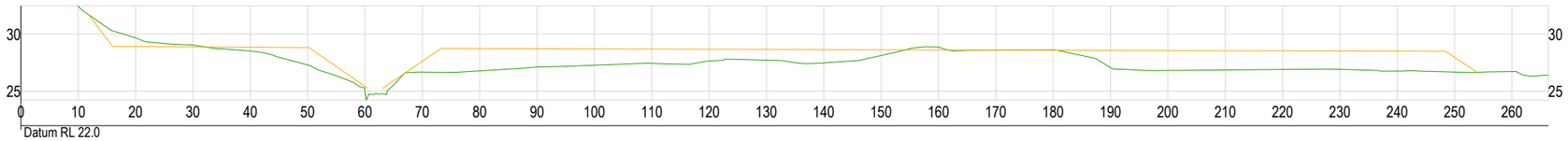

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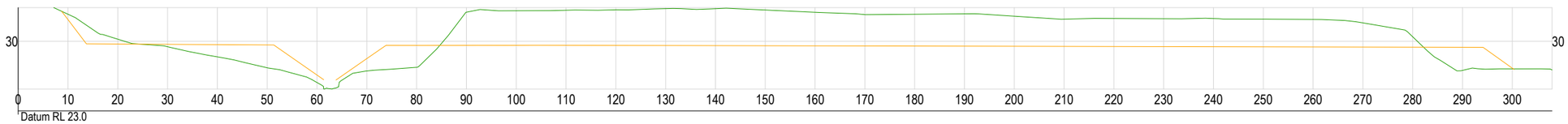

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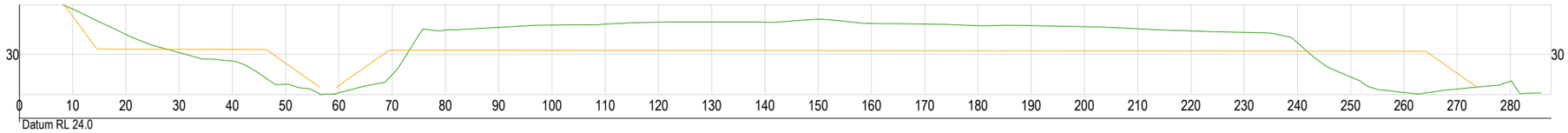

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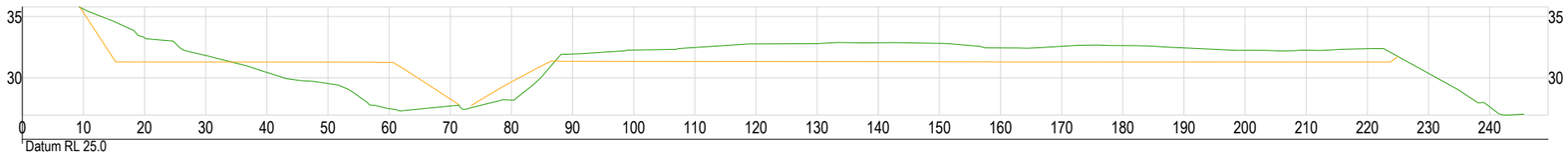

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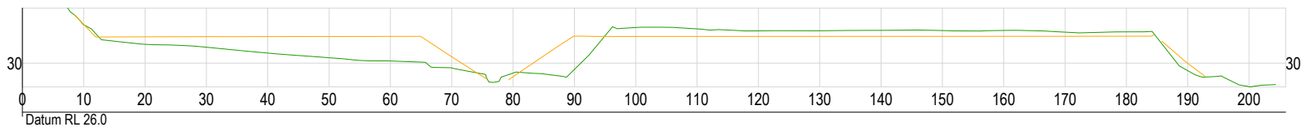

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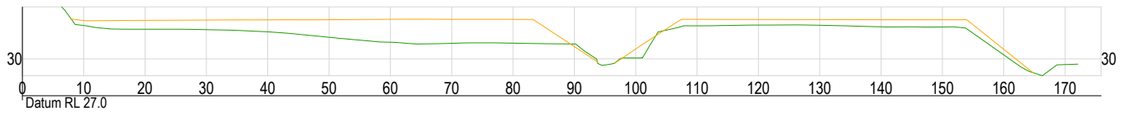

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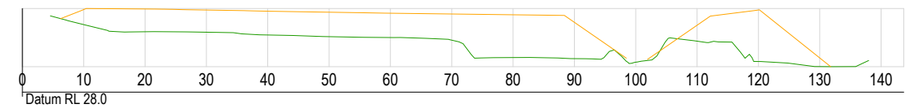

SECTION 1

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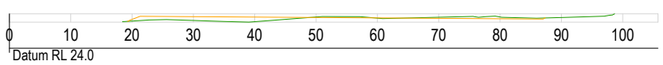
Proposed fill platform

Existing landorm



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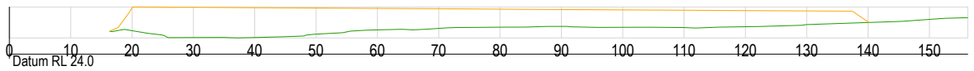

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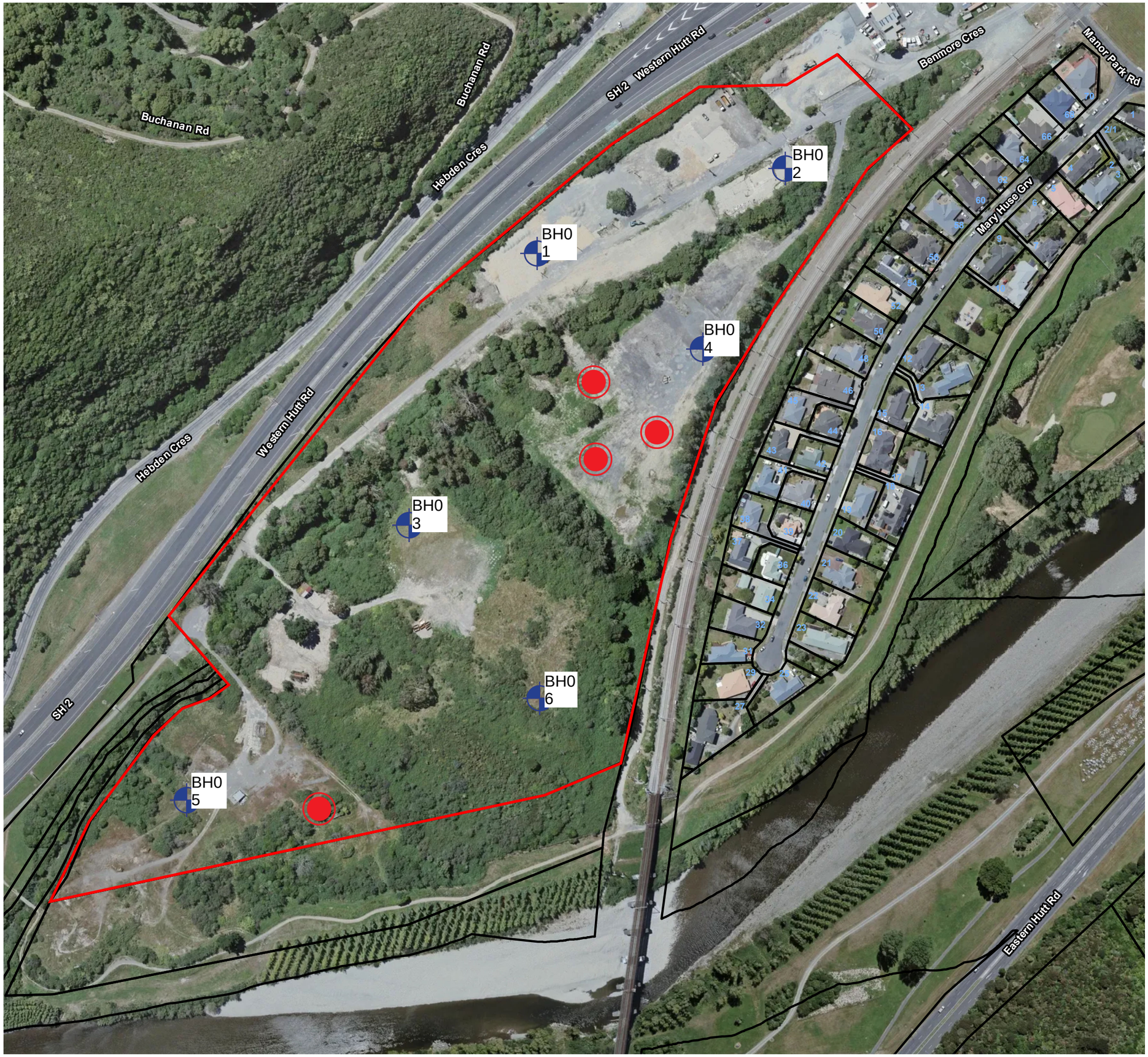

LEGEND

Property Boundary

2020 ENGEO sample - asbestos contamination below human health risk levels

Indicative borehole location

Site boundary

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0 25 50 75 100 125 (m)

1. Property Boundary,Street Name,Street Number sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.
2. LINZ Aerial Basemap Copyright LINZ CC BY 4.0. www.linz.govt.nz/linz-copyright Imagery Basemap Contributors. https://www.linz.govt.nz/data/linz-data/linz-basemaps/data-attribution

Created On:	25/02/2022
Created By:	DHerlihy
Approved By:	
TT Proj Ref:	1015081.1000
TT Map Ref:	TTMAPREF1433463001.902

Tonkin+Taylor
105 Carlton Gore Road, Newmarket, Auckland
www.tonkintaylor.co.nz

ROSCO ICE CREAM LTD
MANOR PARK INVESTIGATIONS
Indicative Borehole Locations
Manor Park

FIGURE No. 1

Appendix B: T+T Fault Study

Tonkin+Taylor

Job No: 1015081
7 July 2021

Rosco Investments
111 Brougham Street
Mt Victoria,
Wellington 6011

Attention: Richard Burrell

Dear Richard

Te Rangihaeata / Manor Park Development
Wellington Fault Investigation Report

1 Introduction

Tonkin & Taylor Ltd (T+T) have undertaken an investigation at the proposed Manor Park development site to constrain the likely location of the Wellington Fault. This work has been completed in accordance with our letter of engagement of 7 August 2020 and variation of 3 September 2020.

The Manor Park development site is located within the Hutt City Council (HCC) 'Wellington Fault Special Study Area' as presented in hazard maps of the HCC District Plan. A primary geotechnical issue concerning future development of the site is the proximity to the Wellington Fault, and the consequences of fault rupture. Specifically:

a Fault rupture presents a risk of severe damage to future building development; and

b Rule 14H2 of the HCC District Plan states: *'All structures and buildings on any site where the whole site or a portion of the site falls within the Wellington Fault Special Study Area'*, is a restricted discretionary activity i.e., requires resource consent.

Clause 14H 1.1.1 states: *'Subdivision and development will be managed to ensure that no building is constructed within 20 metres of the fault line, and that no subdivision results in an allotment being created which is unusable for development purposes. An engineering report will be required prior to any development, to ensure that any buildings proposed are not within 20 metres of the fault line. The level of investigation required will depend on the particular circumstances and this could include a range of methods necessary to determine the position of the fault. The buildings will need to be constructed to New Zealand Building Code specifications. This will ensure that buildings are constructed in a safe manner and at a safe distance from the area susceptible to permanent ground deformation.'*

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This report presents the results of the investigation and defines a zone depicting the likely location of the Wellington Fault through the site for the purposes of meeting local council regulatory requirements. Other District Plan rules may also be relevant to the proposal however we have only considered the requirements in relation to the Wellington Fault Special Study Area. Also, other geotechnical considerations e.g., liquefaction, lateral spreading, settlement, bearing capacity etc., have not been considered as part of this report, but are expected to be considered during next stages.

2 Previous fault investigations and mapping

The following section presents a review of previous investigations of the Wellington Fault in the vicinity of the site.

2.1 Begg & Mazengarb (1996)

In Begg & Mazengrab (1996)[1], the Wellington Fault through the Manor Park site was mapped as 'concealed' due to an overburden of alluvial deposits, and therefore the precise location was not well understood. This lineament through the site is based on interpretation of the geomorphology and aligns with surface exposure of the fault to the northeast and southwest of the site. This approximate location is shown in Figure A1, Appendix A.

2.2 Beetham et. al. (2008)

Beethem et. al. (2008)[2] carried out fault investigations in the vicinity of the Manor Park site to guide the planning and design of the major interchange between SH58 and SH2. The investigations completed included a fault trench immediately to the south of the site, and three micro-gravity survey profiles (one of which is located through the site, and two to the northeast). The investigation constrained the likely location of the Wellington fault to a narrow (35 to 60 m wide) zone through the site as shown in Figure A1, Appendix A. Two of the three survey profiles are also shown in Figure A1.

2.2.1 Fault trench

A 15 m long fault trench on the western (true right) side of the Hutt River was excavated through alluvial gravels to Greywacke rock. The location of this trench was surveyed and is shown in Figure A1, Appendix A. We note that the river has subsequently eroded away the land where the trench was excavated.

A sub-horizontal rock bench was exposed at the base of the trench consisting of fault breccia i.e., disintegrated fault rock (also known as Cataclasite). The excavation also exposed a sub-vertical step (of at least 1 m) in the rock generally parallel with the Wellington Fault trace (strike 044°/dip 78° SE). Close to this step, the rock quality deteriorated from 'hard, grey fault breccia to moderately soft, dark brecciated argillite'. A thin (c. 1 cm) layer of soft gouge material consisting of angular rock fragments in a dark, clay-rich matrix was plastered against the face of the step. No deformation of the overlaying alluvial gravels was observed.

The report concludes that this step is either the primary fault plane of the Wellington Fault, or at least its westernmost possible location.

[1] Begg, J.G., Mazengarb, C., 1996. Geology of the Wellington area, scale 1:50 000. Institute of Geological & Nuclear Sciences geological map 22. 1 sheet + 128 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences Limited.
[2] Beetham et. al. (2008). Investigation and location of the Wellington Fault at Manor Park, Report 2008/36. GNS Science.

2.2.2 Micro-gravity survey

A micro-gravity survey was carried out through the site located perpendicular to the inferred fault alignment.

A small variation in the gravity profile through the site was modelled as a vertical, 30 m high step in the greywacke basement rock, inferred to represent the location of the Wellington Fault.

2.3 Van Dissen (2020)

Observations of the Wellington Fault within the Hutt River bed and on the western (true right) riverbank were made in 2010 and 2014[3], are have recently been presented to T+T by Van Dissen (2020). These observations were made immediately to the south of the Manor Park site as shown in Figure A1, Appendix A.

In 2010, a subvertical rock outcrop on the western (true right) riverbank exposed 30 to 50 cm thick fault gauge comprising dark brown clay and gravel and was inferred to be the Wellington Fault. Either side of the fault gauge was dark grey crushed and sheared greywacke which aligned with brecciated rock exposed in the riverbed about 50 m downstream. In 2014, the outcrop was examined again after further erosion had exposed more of the subvertical rock scarp.

3 Recent investigations

3.1 Methodology

Prior to commencing investigations, a series of fault investigation options were reviewed, and these are presented in our fault study and investigation options report[4]. These options were also discussed with GNS[5].

It was considered unlikely that the location of the Wellington Fault could be obtained by traditional fault trenching due to the significant depth of overlying fill and alluvial deposits (c. 10 m) that have not seen displacement of the fault i.e., the last displacement of the fault pre-dates deposition of the alluvium. It was also noted that evidence (if any) of fault displacement in river gravels is not always well preserved.

Therefore, as agreed with you, we have progressed fault investigations in stages, after interrogation of past information and latest results. The following investigations have been completed:

- Three seismic refraction lines perpendicular to approximate fault trace to determine the rock head profile and the presence of low velocity zones within the rock;
- Four vertically drilled boreholes to verify the depth to rock obtained by seismic refraction surveys; and
- Two inclined machine drilled boreholes to verify low velocity signature obtained by the seismic refraction surveys i.e., drill through the inferred location of the Wellington Fault.

3.2 Seismic refraction survey

Three seismic refraction survey profiles (SL1, SL2 and SL3) were undertaken and assessed using the Plus-Minus method by A J Sutherland Consulting between 10 November and 16 December 2020. The start and end locations of SL1, SL2 and SL3 were surveyed by Spencer Holmes on 22 December 2020.

[3] Russ Van Dissen (2020). Wellington Fault at Manor Park, presentation notes. GNS.
[4] Tonkin + Taylor (14 December 2020). Manor Park Development – Wellington Fault Desktop Study and Investigation Options.
[5] Meeting of 23/09/2020, Russ Van Dissen (GNS), Tim Haxell (T+T) and Nick Peters (T+T)

A plan showing the location of the profiles are presented in Figure A1, Appendix A, and the final A J Sutherland Consulting report is included in Appendix C.

Table 3.1: Seismic refraction survey summary

Seismic Line	Start Location (NZTM)[1]		End Location (NZTM)[1]		Total length (m)	Geophone spacing (m)
	Easting (m)	Northing (m)	Easting (m)	Northing (m)		
SL1	1765067	5441260	1765183	5441143	165	2.5
SL2	1765208	5441372	1765279	5441289	110	5[2]
SL3	1765316	5441460	1765387	5441375	110	5[2]

[1] Start and end locations were surveyed by Spencer Holmes (Total Station GPS).

[2] The geophone spacing was reduced to 1m over the low velocity zone to improve the data resolution.

3.3 Machine boreholes

Four vertical and two inclined boreholes was drilled over the period between 25 February 2021 and 23 March 2021. The works were carried out using a rotary coring drilling rig, supplied, and operated by Webster Drilling and Exploration.

All drilling works were completed under the supervision of an engineering geologist from T+T. The recovered drill core was photographed and logged to NZGS 'Field Description of Soil and Rock' guidelines. The borehole locations are presented in Figure A1, Appendix A. Borehole logs and core photographs are presented in Appendix B and summary details are presented in Table 3.2 below.

Table 3.2: Machine borehole summary

BH ID	Inclination from horizontal	Location (NZTM)[1]		Ground surface elevation RL (m)[2]	Total depth drilled (m)
		Easting (m)	Northing (m)		
SL1-A	90°	1765108	5441219	26.1	12.5
SL1-B	90°	1765118	5441208	25.5	11.8
SL1-C	45° - NW	1765127	5441199	25.5	48.0
SL3-A	90°	1765339	5441433	32.8	14.6
SL3-B	90°	1765348	5441423	32.2	14.8
SL3-C	45°- NW	1765355	5441415	32.3	48.5

[1] Borehole locations were surveyed by Spencer Holmes (Total Station GPS).

[2] Ground level obtained by Wellington LiDAR 1m DEM (2013), from Land Information NZ.

3.4 Interpretation of results

3.4.1 Seismic refraction survey

A 5 m wide low velocity zone with a signal time loss of 4 and 6 milliseconds was observed in SL1 and SL2, respectively. We infer that the signal time loss is attributed to highly disintegrated material i.e., fault gauge of the Wellington Fault, which has a significantly reduced seismic velocity than the surrounding greywacke rock (which was measured between 2750 and 2900 m/s). Additionally, an attenuation of the maximum geophone signal amplitude at SL2 was observed within the low velocity zone.

A less-well defined, 3 m wide low velocity zone with a signal time loss of less than 1 milliseconds was observed in SL3. A small attenuation of the maximum geophone amplitude was also measured within the low velocity zone in this location. We infer that at this location, the fault width narrows and therefore the low velocity zone is less distinct than observed in SL1 or SL2. It is understood that the Wellington Fault zone varies in width along its length.

When extrapolating the low velocity zones between the seismic refraction surveys and the exposures observed by Van Dissen to the south of the site, the inferred alignment of the fault is relatively consistent through the site (azimuth ~048°).

No significant step in bedrock was identified that corroborates the 30 m step modelled by GNS (as described in Section 2.2.2 above). We infer that downcutting of the Hutt River has planed off any evidence of a step in bedrock at this location. It should be appreciated that due to the sensitivity of micro-gravity processing and modelling, other models of the bedrock profile i.e., without a 30 m high step, may still reconcile a small variation measured in the gravity survey.

3.4.2 Machine boreholes

Two cross sections presenting our interpretation of the ground model at SL1 and SL3 are shown in Figure A2 and A3, Appendix A. The depth to rock beneath the ground surface, obtained by seismic refraction survey, was verified by vertically drilled machine boreholes and is generally between 8 and 10 m below ground level. All boreholes encountered markedly crushed and broken greywacke rock i.e., cataclasite, formed by near-fault stresses.

No significant clay gouge thickness was encountered in the inclined (SL1-C and SL3-C) boreholes that were drilled through the inferred location of the Wellington Fault. It is expected that any softened material was washed away by the drilling process. At SL1-C and as shown in Figure A2, there is compounding evidence that confirms the existence of a low velocity zone and the likely location of the Wellington Fault. Specifically, within the low velocity zone we noted the following drilling observations which are recorded on Figures A2 and A3:

- Up to 1.4 m of core was loss (negligible core loss outside of the low velocity zone);
- Rock samples were more crushed and disintegrated;
- Drill core lengths were reduced by the driller due to an increase in pump pressure; and
- Driller noted ‘soft’ between 29.7 to 30 m (although no material was recovered).

The inclined (SL3-C) borehole provided less evidence to confirm the low velocity zone, however there was up to 0.7 m of core was loss within low velocity zone. There was negligible core loss outside of the low velocity zone.

4 Development considerations

Based on the previous and recent investigations discussed in Sections 2 and 3, we infer that the zone that constrains the likely location of the Wellington Fault through the site is highlighted yellow in Figure A1, Appendix A.

There are several uncertainties that have been allowed for when defining this zone, specifically:

- Deformation at the surface may not be a simple single plane rupture. During fault rupture, horizontal and vertical displacement through bedrock may distribute through overlying alluvial gravels and result in a wider zone of disturbance. It is unlikely that any additional investigation will reduce this uncertainty;
- Uncertainties in the measurement associated with seismic refraction survey and machine boreholes; and
- Limited investigation data the north of SL3. An additional seismic refraction survey could be completed to reduce this uncertainty however this would need to be completed outside the property boundary, adjacent to Manor Park Road.

The HCC District Plan requires that proposed buildings should not be located within 20 m of fault line. Therefore, any proposed buildings should not be within 20 m of the zone highlighted yellow in Figure A1, Appendix A.

The nature and continuity of the subsurface conditions away from the borehole locations and seismic refraction lines are inferred. It must be appreciated that strain along the Wellington Fault may exploit multiple other planes of weakness within the basement rock and overlying soils (that have not been investigated), and surface rupture may occur outside of the inferred zone presented in this report.

5 Applicability

This report has been prepared for the exclusive use of our client, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Hutt City Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:

.....

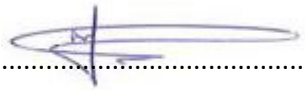
Tim Haxell
Engineering Geologist

Authorised for Tonkin & Taylor Ltd by:

.....

Richard Cole
Project Director

Report Reviewed by:



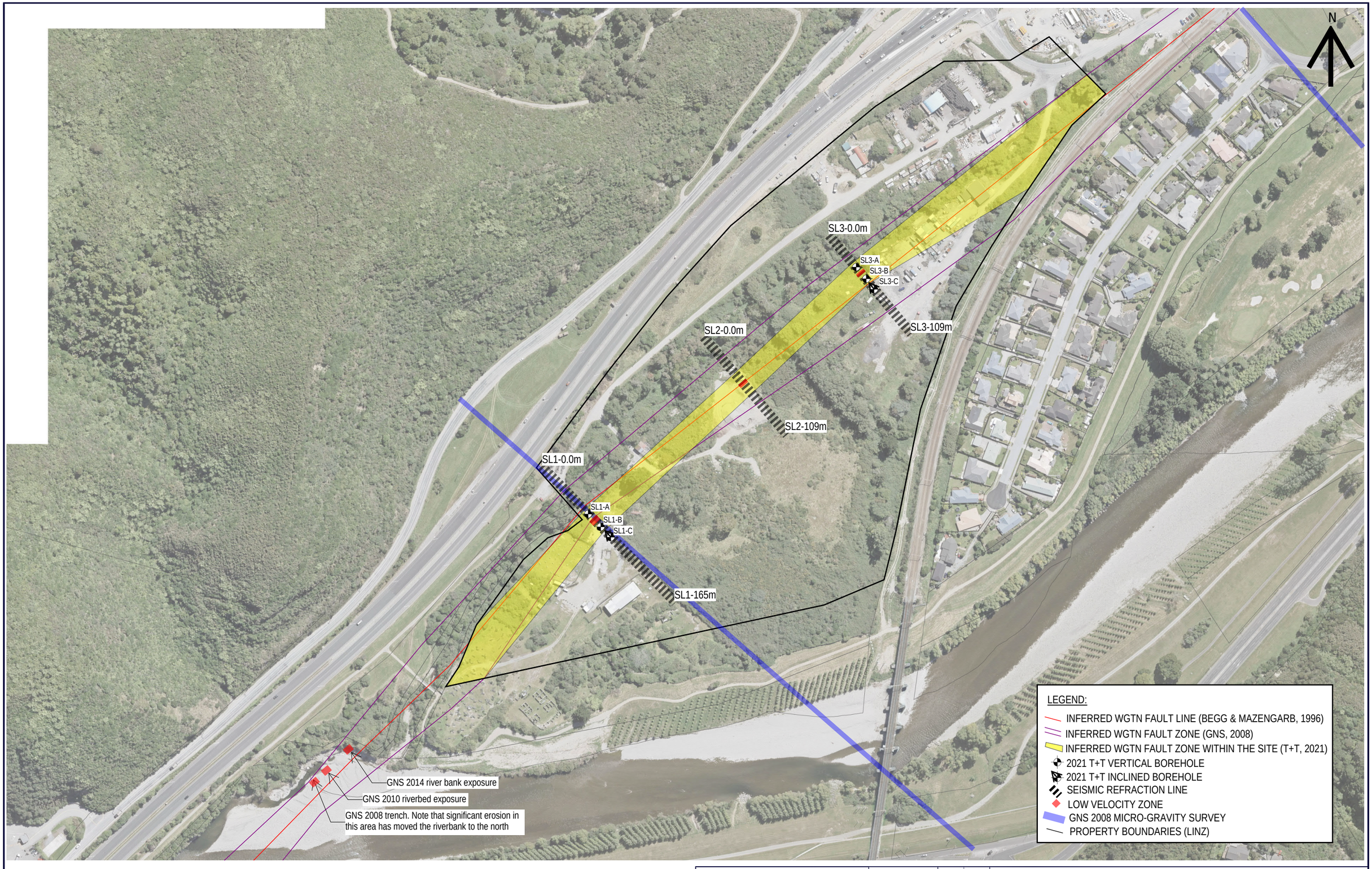
.....

Nick Peters
Senior Engineering Geologist

TH
\\ttgroup.local\corporate\wellington\tt projects\1015081\issueddocuments\1015081 t+t manor park wellington fault study - restructure.docx

Appendix A: Figures

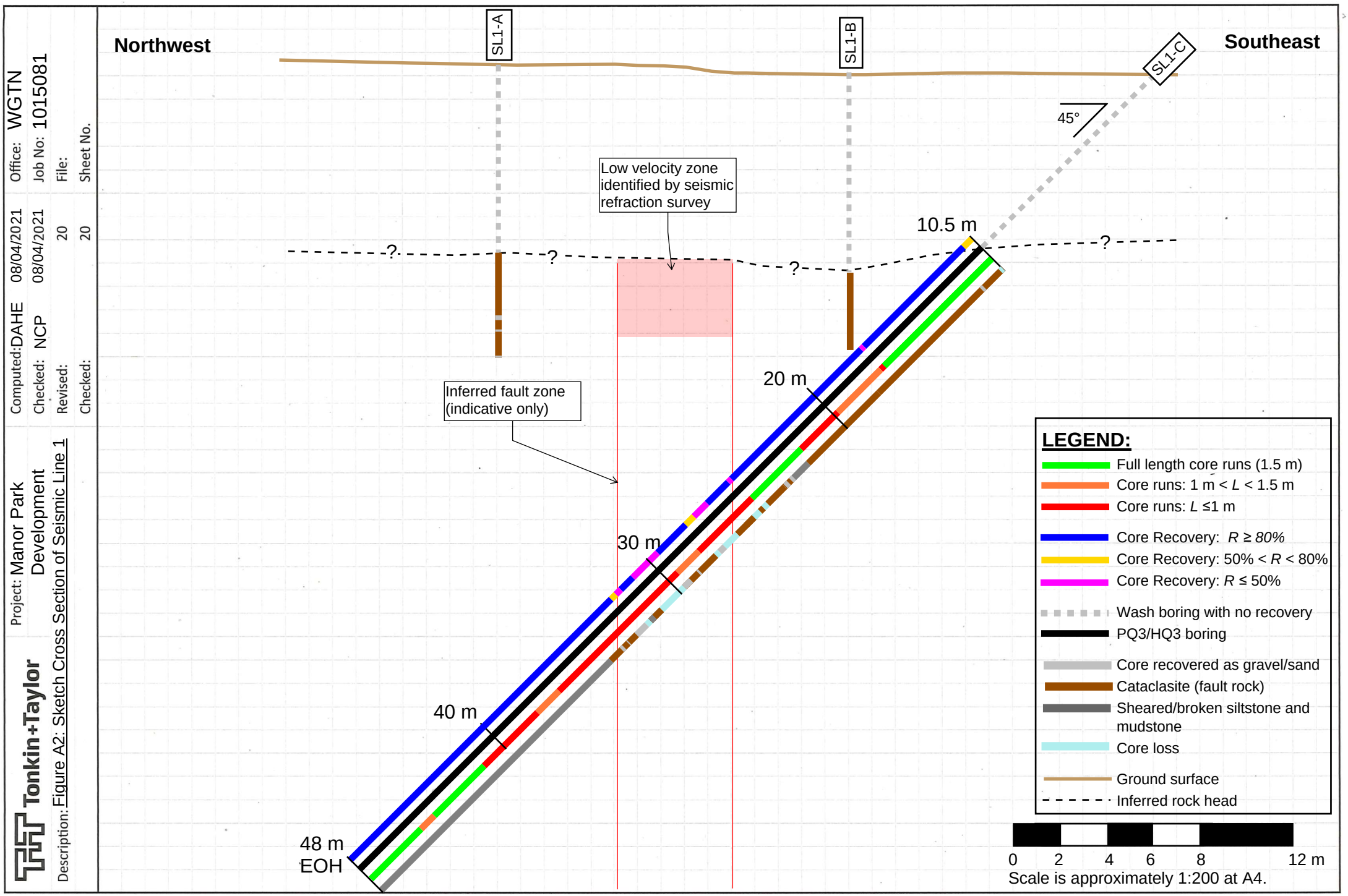
- **Figure A1 Wellington Fault investigation location plan**
- **Figure A2 Cross Section SL-1**
- **Figure A3 Cross Section SL-3**

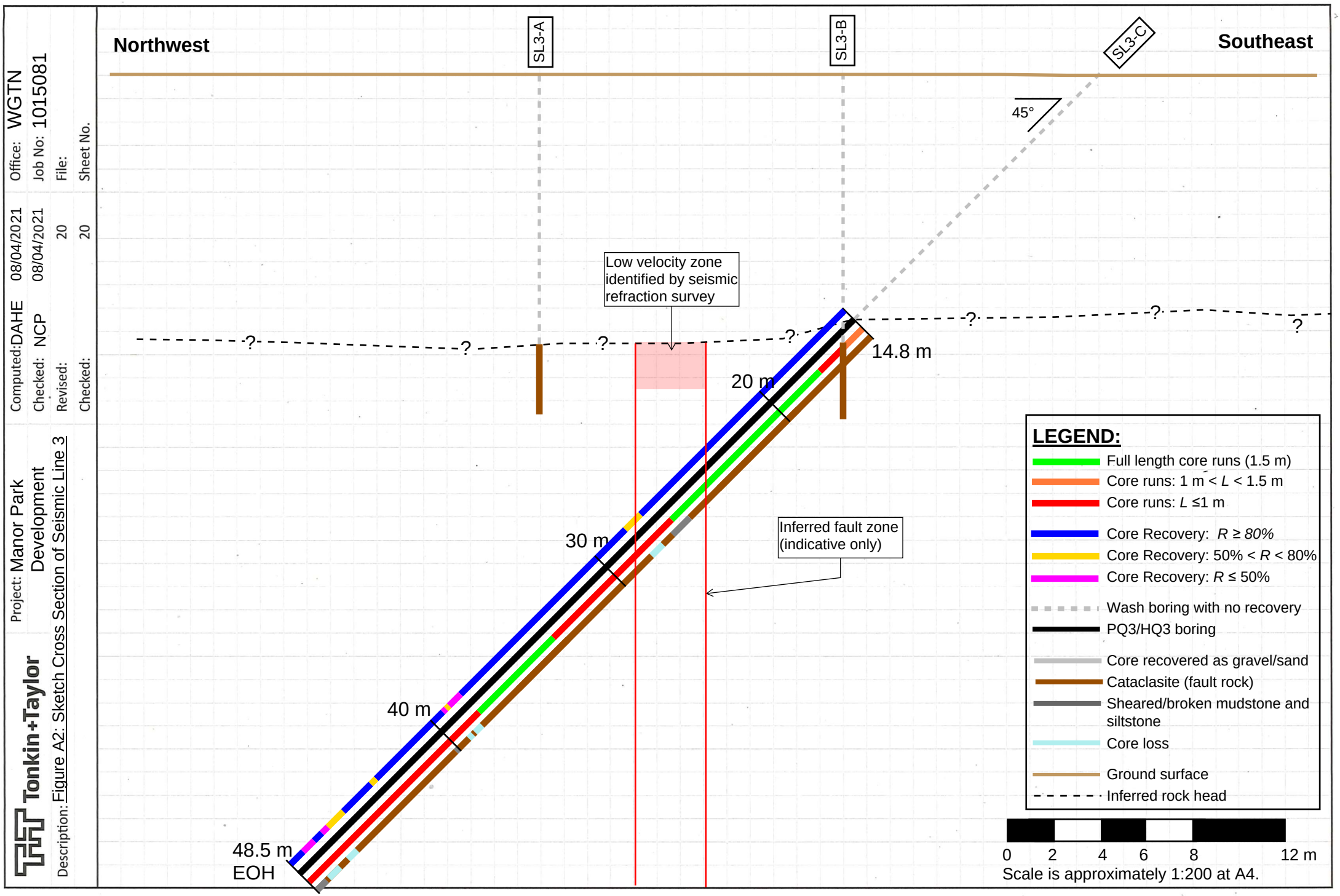


Tonkin+Taylor

DRAWN	TH	1/05/21
CHECKED	NCP	1/06/21
APPROVED	RGC	1/06/21
FILE : \\ttgroup.local\corporate\Wellington\TT Projects\1015081\		
APPROX. SCALE (AT A3 SIZE) 1:3000		
PROJECT No. 1015081	FIG. No. A1	REV. 0

TE RANGIHAEATA / MANOR PARK DEVELOPMENT
WELLINGTON FAULT INVESTIGATION PLAN


Northwest
Southeast
SL1-A
SL1-B
SL1-C
45°
Low velocity zone identified by seismic refraction survey
Inferred fault zone (indicative only)
10.5 m
20 m
30 m
40 m
48 m EOH
?
?
?
?
LEGEND:
Full length core runs (1.5 m)
Core runs: 1 m < L < 1.5 m
Core runs: L ≤1 m
Core Recovery: R ≥ 80%
Core Recovery: 50% < R < 80%
Core Recovery: R ≤ 50%
Wash boring with no recovery
PQ3/HQ3 boring
Core recovered as gravel/sand
Cataclasite (fault rock)
Sheared/broken siltstone and mudstone
Core loss
Ground surface
Inferred rock head
0 2 4 6 8 12 m
Scale is approximately 1:200 at A4.
Office: WGTN
Job No: 1015081
File:
Sheet No.
Computed: DAHE 08/04/2021
Checked: NCP 08/04/2021
Revised: 20
Checked: 20
Project: Manor Park Development
Tonkin+Taylor
Description: Figure A2: Sketch Cross Section of Seismic Line 1


Northwest
SL3-A
SL3-B
SL3-C
Southeast
45°
Low velocity zone identified by seismic refraction survey
?
?
?
?
?
?
14.8 m
20 m
30 m
40 m
48.5 m
EOH
Inferred fault zone (indicative only)
LEGEND:
Full length core runs (1.5 m)
Core runs: 1 m < L < 1.5 m
Core runs: L ≤1 m
Core Recovery: R ≥ 80%
Core Recovery: 50% < R < 80%
Core Recovery: R ≤ 50%
Wash boring with no recovery
PQ3/HQ3 boring
Core recovered as gravel/sand
Cataclasite (fault rock)
Sheared/broken mudstone and siltstone
Core loss
Ground surface
Inferred rock head
0 2 4 6 8 12 m
Scale is approximately 1:200 at A4.
Office: WGTN
Job No: 1015081
File:
Sheet No.
Computed: DAHE 08/04/2021
Checked: NCP 08/04/2021
Revised: 20
Checked: 20
Project: Manor Park Development
Tonkin+Taylor
Description: Figure A2: Sketch Cross Section of Seismic Line 3

Appendix B: Borehole logs

- **BH SL1-A**
- **BH SL1-B**
- **BH SL1-C**
- **BH SL3-A**
- **BH SL3-B**
- **BH SL3-B**

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: SL1-A

SHEET: 1 OF 2

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: East side of culvert, adjacent to abandoned paintball stall and pedestrian access.

CO-ORDINATES: 5441219.11 mN, 1765107.63 mE (NZTM2000)

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 26.10m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: TH

CHECKED: NCP

START DATE: 25/02/2021

FINISH DATE: 26/02/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW SW MW HW CW DW)	Rock Strength (ES VS S MS W VW EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log	Fracture Spacing (mm) (2000 600 200 60 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25 50 75)	Water Level	Casing	Installation	Core Box No
	0.00m: Wash boring with no sample recovered.						26											
							25	1										
							24	2										
							23	3										
							22	4										
							21	5										
							20	6										
							19	7										
							18	8										
Rakaia Terrane	*8.00m:* Unweathered to slightly weathered, grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay. *8.30 - 8.36m:* Shear zone. 60° from horizantal. 60 mm across. Hard, dark grey.			PQ3	100							0						
	8.25m: Unweathered to slightly weathered, dark grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of dark grey clay. *9.10m:* Core loss to 9.7 m.			PQ3	50		17	9				0						
	9.70m: Dark grey CATACLASITE as described at 8.25 m.											0						

COMMENTS: 1) Groundwater level not recorded. 2)Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 12.5m

Scale 1:50

Rev.: B

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: SL1-A

SHEET: 2 OF 2

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: East side of culvert, adjacent to abandoned paintball stall and pedestrian access.

CO-ORDINATES: 5441219.11 mN, 1765107.63 mE (NZTM2000)

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 26.10m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: TH

CHECKED: NCP

START DATE: 25/02/2021

FINISH DATE: 26/02/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations	Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*10.70m:* Unweathered to slightly weathered, dark grey MUDSTONE and SILTSTONE. Weak to moderately strong, extremely closely spaced joints. Sheared rock. Discontinuities are filled with pale grey quartz. Recovered as gravel from 10.7 to 10.8. *11.30 - 11.40m:* Recovered as fine to coarse, angular gravel. *12.00 - 12.10m:* Recovered as fine to coarse, angular gravel. *12.40 - 12.50m:* Recovered as fine to coarse, angular gravel.			PQ3 PQ3 PQ3 PQ3 PQ3 PQ3 PQ3	100 100 86 69 100 100 100		16 15 14	10 11 12				0 0 0 0 0 0 0						Box 1: 8.00-10.55m Box 2: 10.55-12.50m
	12.5m: END OF BOREHOLE						13 12 11 10 9 8 7	13 14 15 16 17 18 19										

COMMENTS: 1) Groundwater level not recorded. 2)Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 12.5m

Scale 1:50

Rev.: B

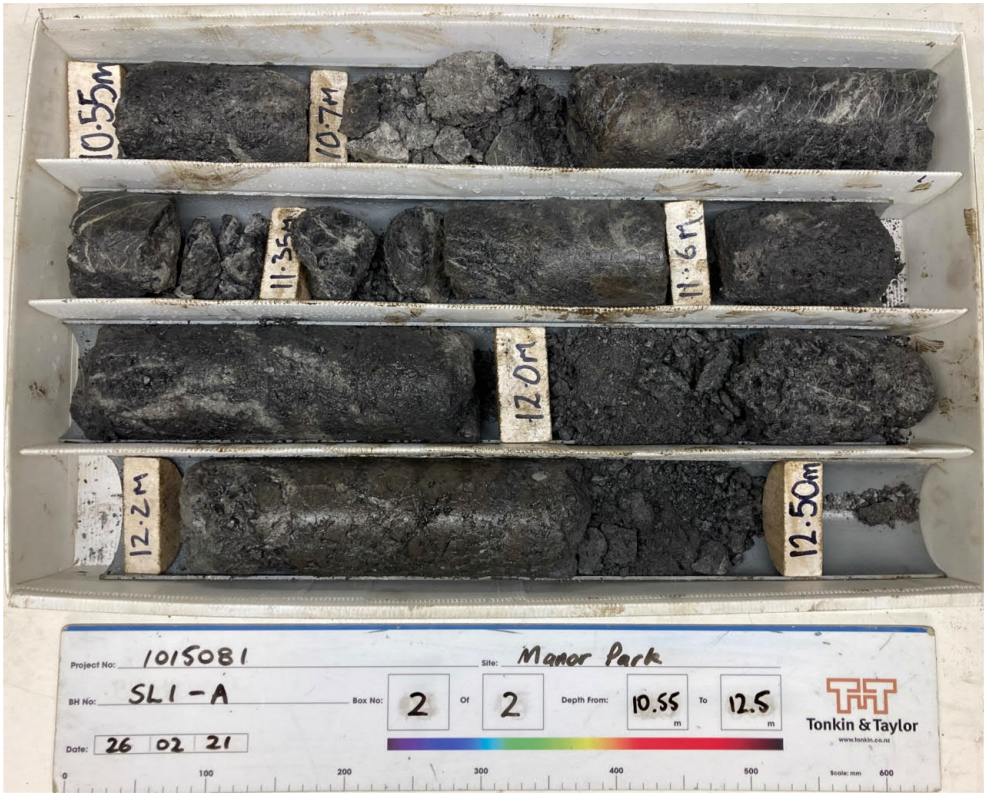
CORE PHOTOS

BOREHOLE No.: **SL1-A**

Hole Location: East side of culvert, adjacent to abandoned paintball stall and pedestrian access.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441219.11 mN (NZTM2000) 1765107.63 mE R.L.: 26.10m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 25/02/2021 HOLE FINISHED: 26/02/2021 DRILLED BY: Webster Drilling LOGGED BY: TH CHECKED: NCP

8.00-10.55m



10.55-12.50m

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL1-B

SHEET: 1 OF 2

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: On driveway to abandoned paintball stall on a the vacant lot.

CO-ORDINATES: 5441208.38 mN, 1765118.18 mE (NZTM2000)

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Jacob Fuller

LOGGED BY: TH

CHECKED: NCP

START DATE: 24/02/2021

FINISH DATE: 26/02/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, EW, HW, MW, HW, CW)	Rock Strength (ES, VS, S, MS, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log	Fracture Spacing (mm) (2000, 600, 200, 60, 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
	0.00m: Wash boring with no sample recovered.						25	0							26/02/2021; Morning reading.			
							24	1										
							23	2										
							22	3										
							21	4										
							20	5							25/02/2021; Time of reading not recorded.			
							19	6										
							18	7										
							17	8										
	8.50m: 8.5 to 8.6 m: Core loss.			HQ3	66							0						
Rakaia Terrane	*8.60m:* Unweathered to slightly weathered, dark grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of dark grey clay.			HQ3	100		16	9				0						
												0						

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 11.8m

Scale 1:50

Rev.: B

BOREHOLE LOG

BOREHOLE No.: SL1-B

SHEET: 2 OF 2

Tonkin+Taylor

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: On driveway to abandoned paintball stall on a the vacant lot.

CO-ORDINATES: 5441208.38 mN, 1765118.18 mE (NZTM2000)

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Jacob Fuller

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START DATE: 24/02/2021

FINISH DATE: 26/02/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, SW, MW, HW, CW)	Rock Strength (ES, VS, S, MS, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log	ROCK DEFECTS: Fracture Spacing (mm) (2000, 600, 200, 60, 20)	ROCK DEFECTS: RQD (%)	ROCK DEFECTS: Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane				HQ3	100		15	10										
				HQ3	100		14	11				0						Box 1, 8.50-11.40m
	11.8m: END OF BOREHOLE						13	12										
							12	13										
							11	14										
							10	15										
							9	16										
							8	17										
							7	18										
							6	19										

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 11.8m

Scale 1:50

Rev.: B

CORE PHOTOS

BOREHOLE No.: **SL1-B**

Hole Location: On driveway to abandoned paintball stall on a the vacant lot.

PROJECT: Manor Park Development		LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: (NZTM2000)	5441208.38 mN 1765118.18 mE	DRILL TYPE: Tractor-Mounted Rig DRILL METHOD: RC	HOLE STARTED: 24/02/2021 HOLE FINISHED: 26/02/2021 DRILLED BY: Webster Drilling
R.L.:	25.50m		
DATUM:	NZVD2016		LOGGED BY: TH CHECKED: NCP

8.50-11.40m

11.40-11.80m

BOREHOLE LOG

BOREHOLE No.: SL1-C

SHEET: 1 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

CO-ORDINATES: (NZTM2000) 5441199.09 mN, 1765127.21 mE

DIRECTION: 315°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 10/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	ROCK DEFECTS: Fracture Spacing (mm)	ROCK DEFECTS: RQD (%)	ROCK DEFECTS: Description & Additional Observations	Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
	0.00m: Wash boring with no sample recovered.	UW SW MW HW CW DW	EX VS S MS M W EW				25 24 23 22 21 20 19	1 2 3 4 5 6 7 8 9			2000 600 200 60 20			25 50 75	05/03/2021 08/03/2021 09/03/2021; Morning reading. 10/03/2021; Morning reading.			

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 48m

Scale 1:50

Rev.: B

General Log - 6/05/2021 1:17:12 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL1-C

SHEET: 2 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

CO-ORDINATES: (NZTM2000) 5441199.09 mN, 1765127.21 mE

DIRECTION: 315°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 10/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, SW, MW, HW, CW)	Rock Strength (ES, VS, S, MS, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	Fracture Spacing (mm) (2000, 600, 200, 60, 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*10.50m:* Core loss.			PQ3	70		18	11				0						
	10.65m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in a pale grey clay matrix.			PQ3	100		17	12				0						Box 1, 10.50-12.80m
	11.60 - 11.75m: Recovered as fine to coarse, angular gravel.																	
	12.00 - 12.80m: Bands of dark grey argillite within the siltstone dip at approximately 45°. The bands are estimated to be subvertical when in situ.																	
	12.80 - 13.10m: Crushed siltstone is dark grey with argillite inclusions.			PQ3	100		16	13				0						Box 2, 12.80-14.85m
	14.55 - 14.65m: Argillite bands dip at approximately 45° in the core. Bands are estimated to be subvertical when in-situ. *14.75 - 14.80m:* Large argillite band within siltstone.			PQ3	100		15	14				0						
	15.75 - 15.95m: Thick, subvertical argillite band. Argillite is moderately weathered, dark grey, weak.			PQ3	100		14	15				0						Box 3, 14.85-17.00m
	16.80 - 17.00m: Argillite bands dip at approximately 45° in the core. Bands are estimated to be subvertical when in-situ.			PQ3	50		13	16				0						
	17.60m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in a pale grey to dark grey clay matrix. Colour varies along the length of the core.			PQ3	100		12	17				0						Box 4, 17.00-19.10m
				PQ3	100			18				0						
								19										

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 48m

Scale 1:50

Rev.: B

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL1-C

SHEET: 3 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

CO-ORDINATES: (NZTM2000) 5441199.09 mN, 1765127.21 mE

DIRECTION: 315°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 10/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, SW, MW, HW, CW)	Rock Strength (ES, VS, S, MS, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	Fracture Spacing (mm) (2000, 600, 200, 60, 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*22.20m:* Unweathered to slightly weathered, dark grey MUDSTONE and SILTSTONE. Weak to moderately strong, extremely closely spaced joints. Sheared rock. Discontinuities are filled with pale grey quartz. *23.10 - 23.25m:* Recovered as fine to coarse, angular gravel.			PQ3	100		11	21				0						Box 5, 19.10-21.45m
	23.25m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in a pale grey to dark grey clay matrix. Colour varies along the length of the core. *23.40 - 23.60m:* Recovered as fine to coarse, angular gravel.			PQ3	118		10	22				0						
	24.75m: Core loss.			PQ3	100		9	23				0						Box 6, 21.45-23.50m
	25.00m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in a grey clay matrix.			PQ3	83		8	24				0						
	25.20m: Core loss.			PQ3	0			25				0						
	25.50m: Unweathered to slightly weathered, dark grey CATACLASITE. Weak, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in a dark grey clay matrix. *25.60 - 25.70m:* Sheared mudstone and siltstone. Moderately strong, extremely closely spaced joints. Abrupt transition at 45°. Transition is estimated to be subvertical when in-situ. *25.70 - 26.30m:* Cataclasite becomes dark grey and moderately strong *26.30 - 26.50m:* Cataclasite is black, slightly weathered and weak. Transition to black material is abrupt and at a 45°. Transition is estimated to be subvertical when in-situ.			PQ3	100							0						
	26.50m: Core loss.			PQ3	0		7	26				0						Box 7, 23.50-26.00m
	27.30m: Unweathered to slightly weathered, dark grey CATACLASITE. Weak, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in dark grey clay matrix. Recovered as angular, fine to coarse gravel.			PQ3	0							0						
	27.58m: Core loss.			PQ3	56		6	27				0						
	27.80m: Unweathered to slightly weathered, dark grey CATACLASITE. Weak to moderately strong, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in a dark grey clay matrix. *28.76 - 28.85m:* Recovered as fine to coarse, angular gravel. *28.85 - 29.30m:* Becomes more broken. Fine, white infill in joints. *29.30 - 29.70m:* Recovered as fine to coarse, angular gravel and sand.			PQ3	100		5	28				0						Box 8, 26.00-28.76m
	29.70m: Core loss.			PQ3	0			29				0						

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 48m

Scale 1:50

Rev.: B

General Log - 6/05/2021 1:17:13 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

BOREHOLE No.: SL1-C

SHEET: 4 OF 5

Tonkin+Taylor

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

CO-ORDINATES: (NZTM2000) 5441199.09 mN 1765127.21 mE

DIRECTION: 315°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 10/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	ROCK DEFECTS: Fracture Spacing (mm)	RQD (%)	Description & Additional Observations	Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*31.10m:* Slightly weathered, dark grey CATACLASITE. Weak to moderately strong, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in a dark grey clay matrix. *31.50m:* Unweathered to slightly weathered, grey MUDSTONE and SILTSTONE. Weak, extremely closely spaced joints. Sheared rock. *31.75m:* Core loss. *32.00m:* Slightly weathered, dark grey CATACLASITE. Weak to moderately strong, crushed. Fine to coarse, angular sandstone, siltstone and mudstone gravel in a dark grey clay matrix. *32.00 - 32.60m:* Recovered as fine to coarse, angular gravel with some fine to coarse, angular sand. *33.05 - 33.10m:* Recovered as fine to coarse, angular gravel. *33.35 - 33.50m:* Recovered as fine to coarse, angular gravel with some fine to coarse, angular sand. *34.15m:* Unweathered to slightly weathered, dark grey to black SILTSTONE and MUDSTONE. Moderately strong, crushed and sheared, extremely closely spaced joints. Discontinuities are filled with pale grey quartz.	UW SW MW HW CW DW	EW VS S MS HS VW EW	PQ3	0		4 3 2 1 0 -1 -2	31 32 33 34 35 36 37 38 39			0		25 50 75				Box 9, 28.76-32.40m Box 10, 32.40-34.15m Box 11, 34.15-36.20m Box 12, 36.20-38.54m

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 48m

Scale 1:50

Rev.: B

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL1-C

SHEET: 5 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

CO-ORDINATES: (NZTM2000) 5441199.09 mN, 1765127.21 mE

DIRECTION: 315°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 10/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, SW, MW, HW, CW)	Rock Strength (ES, VS, S, MS, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	ROCK DEFECTS: Fracture Spacing (mm) (2000, 600, 200, 60, 20)	ROCK DEFECTS: RQD (%)	ROCK DEFECTS: Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*45.00m:* SILTSTONE and MUDSTONE become slightly weathered and weak.			PQ3	100		-3	41				0						Box 13, 38.54-40.71m
				PQ3	100		-4	42				0						Box 14, 40.71-42.82m
				PQ3	100		-5	43				0						
				PQ3	100		-6	44				0						Box 15, 42.82-45.00m
				PQ3	100		-7	45				0						
				PQ3	100		-8	46				0						Box 16, 45.00-47.29m
								47										Box 17, 47.29-48.00m
	48m: END OF BOREHOLE						-9	48										
								49										

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 48m

Scale 1:50

Rev.: B

General Log - 6/05/2021 1:17:13 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

10.50-12.80m

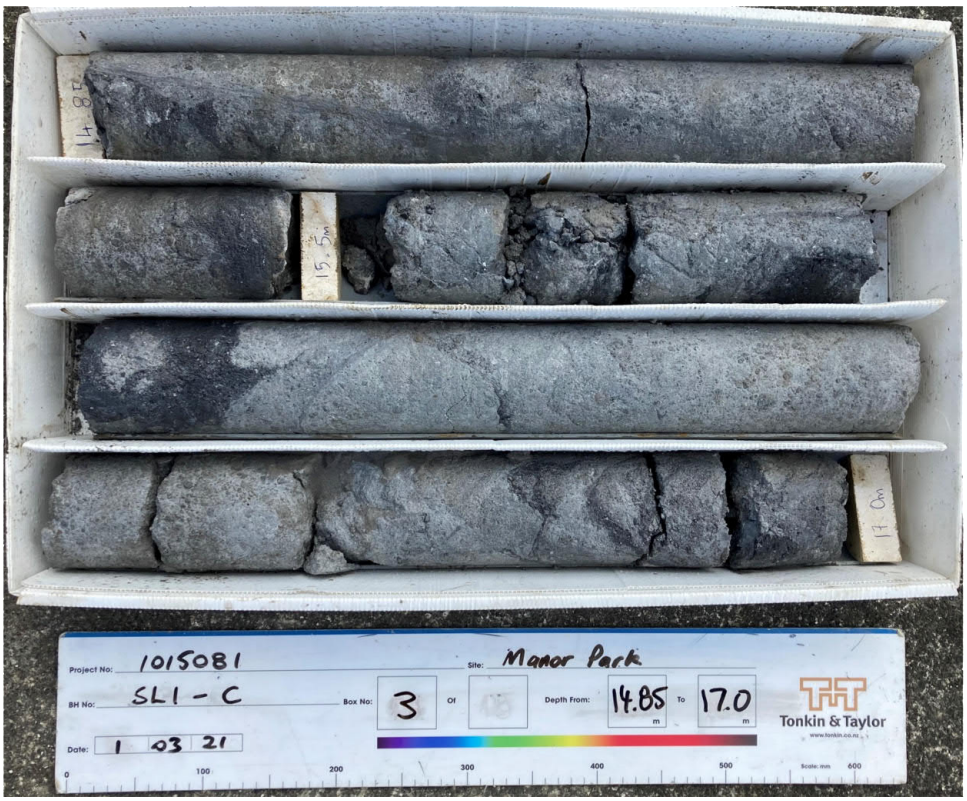
12.80-14.85m

CORE PHOTOS

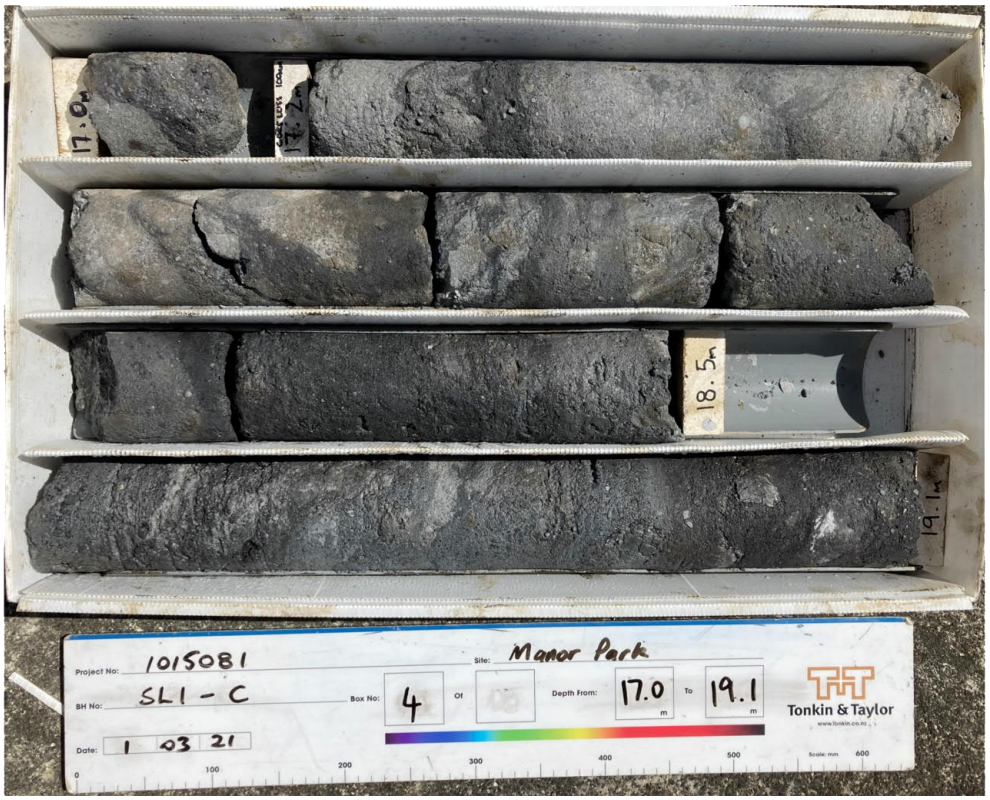
BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP



14.85-17.00m



17.00-19.10m

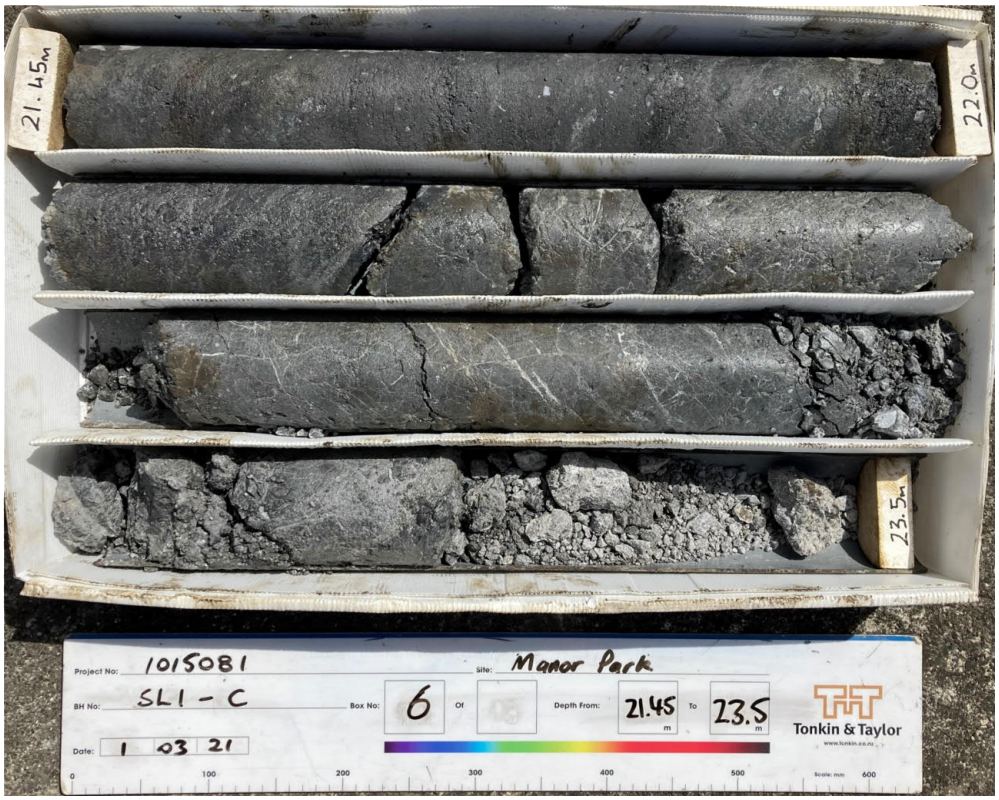
CORE PHOTOS

BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

19.10-21.45m



21.45-23.50m

CORE PHOTOS

BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

23.50-26.00m

26.00-28.76m

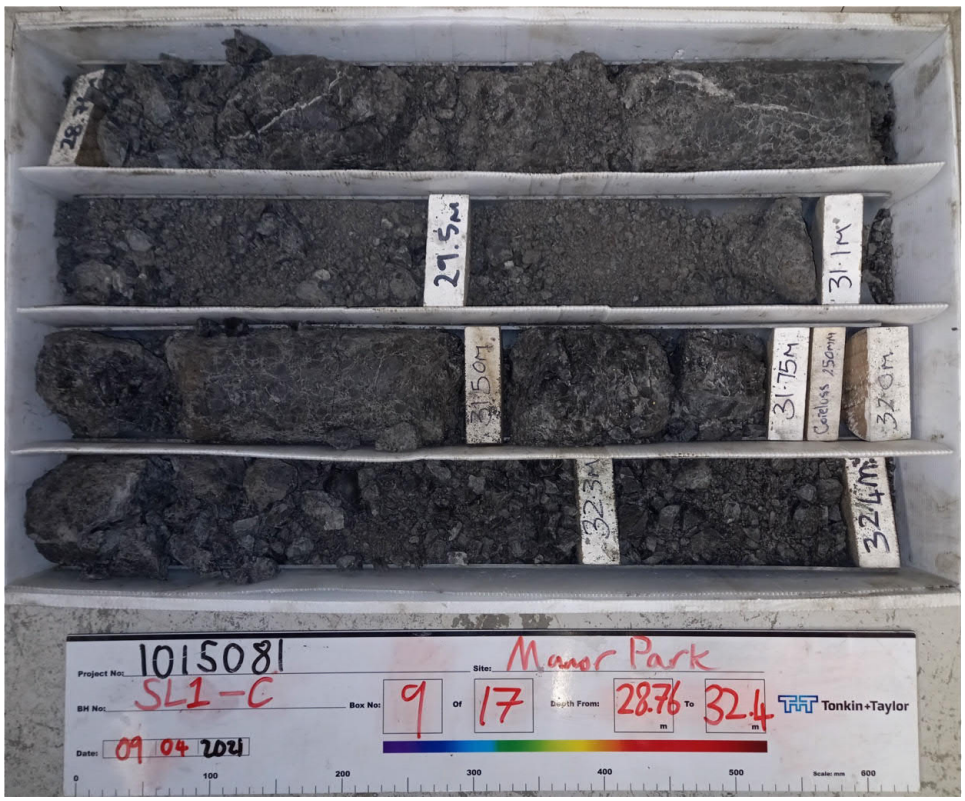
Tonkin+Taylor

CORE PHOTOS

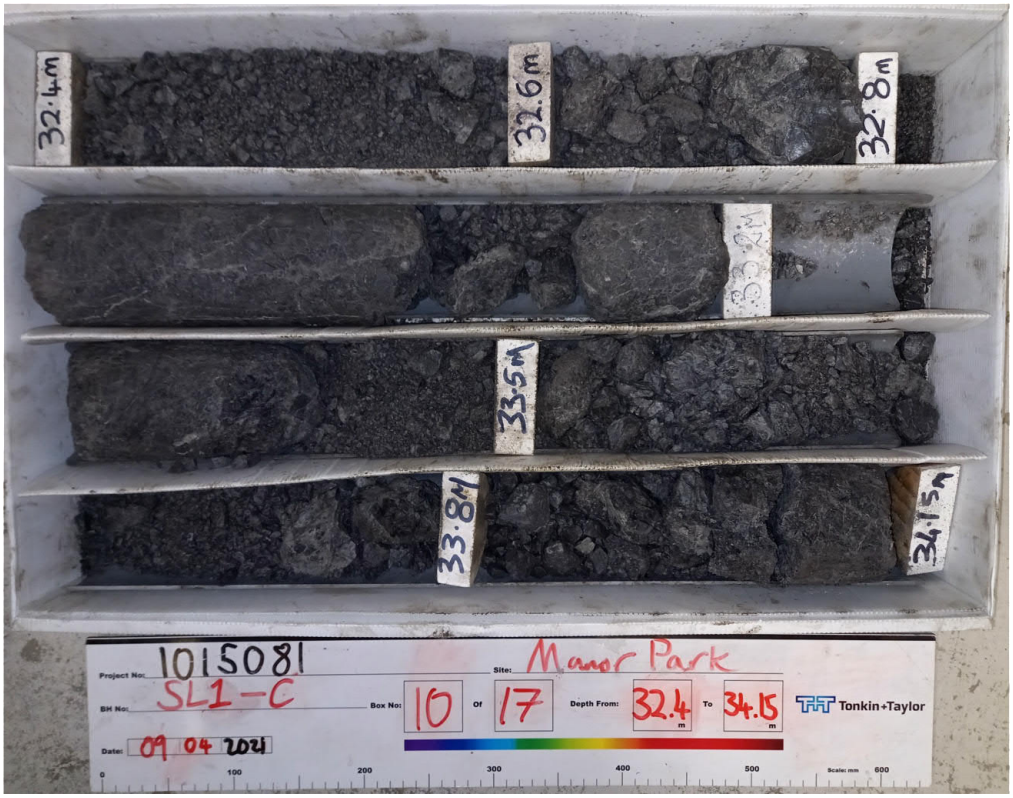
BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP



28.76-32.40m



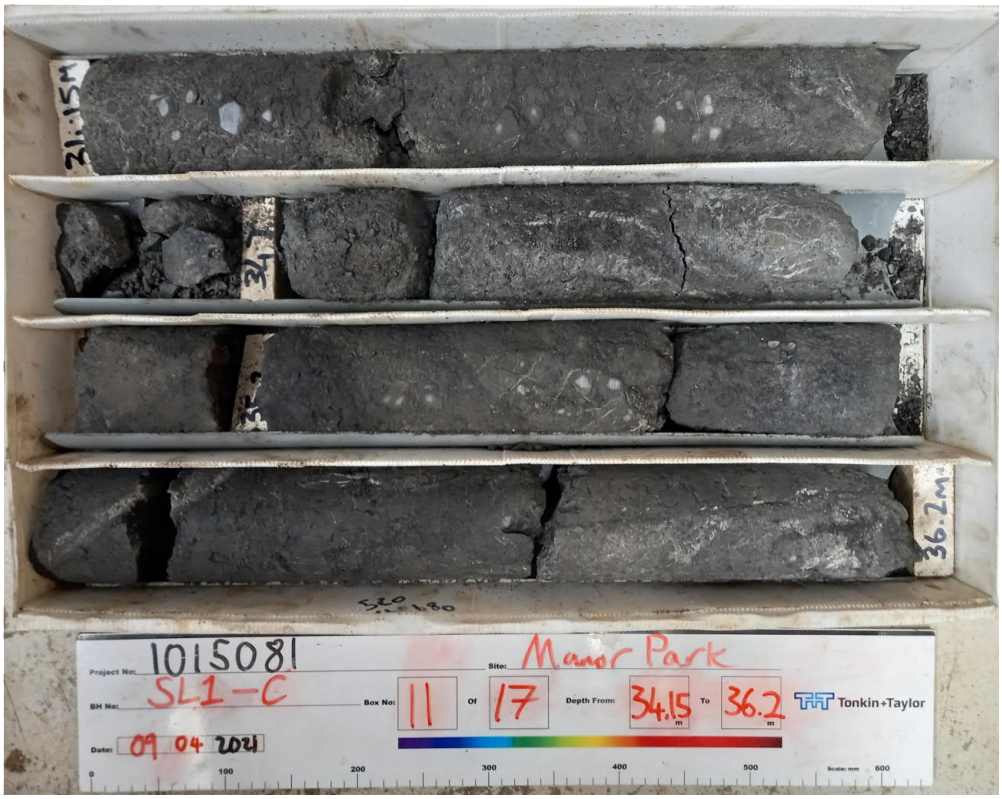
32.40-34.15m

CORE PHOTOS

BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP



34.15-36.20m

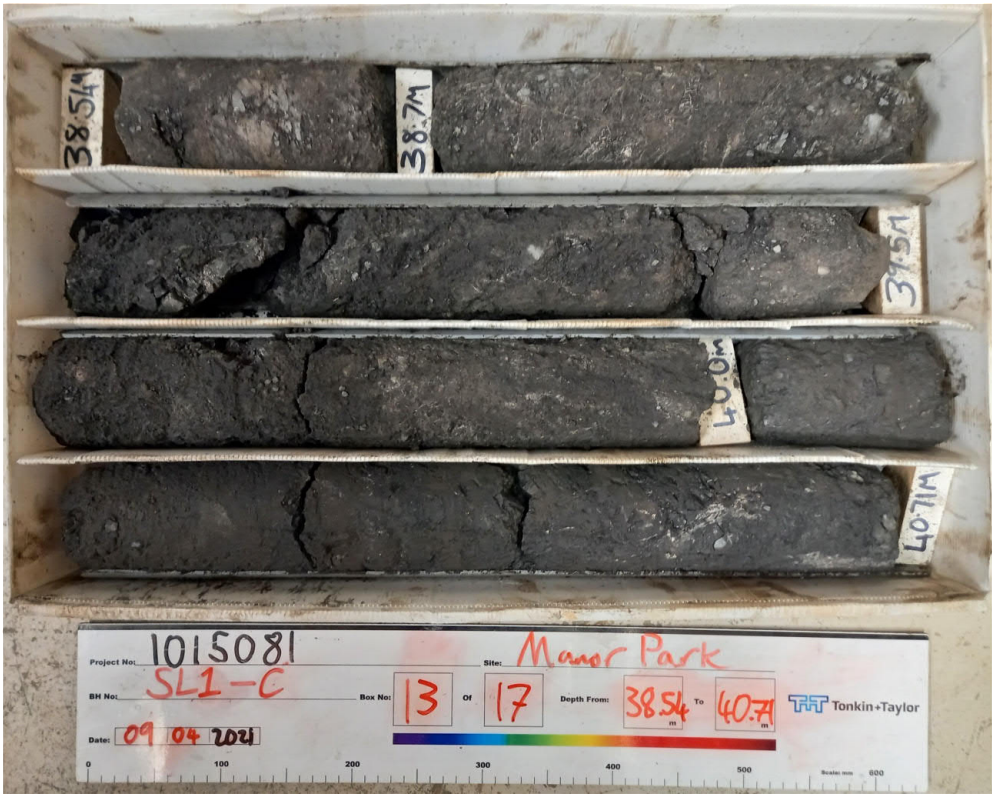
36.20-38.54m

CORE PHOTOS

BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP



38.54-40.71m

40.71-42.82m

CORE PHOTOS

BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

42.82-45.00m

45.00-47.29m

CORE PHOTOS

BOREHOLE No.: **SL1-C**

Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441199.09 mN (NZTM2000) 1765127.21 mE R.L.: 25.50m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 10/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

47.29-48.00m

BOREHOLE LOG

BOREHOLE No.: SL3-A

SHEET: 1 OF 2

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot.

CO-ORDINATES: 5441432.76 mN, 1765339.49 mE (NZTM2000)

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 32.80m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Jacob Fuller

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 02/03/2021

FINISH DATE: 04/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, EW, HW, MW, HW, CW)	Rock Strength (ES, VS, S, MS, M, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log	Fracture Spacing (mm) (2000, 600, 200, 60, 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
	0.00m: Wash boring with no sample recovered.						32 31 30 29 28 27 26 25 24 23	1 2 3 4 5 6 7 8 9							03/05/2021: Afternoon reading.			

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 14.6m

Scale 1:50

Rev.: B

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL3-A

SHEET: 2 OF 2

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot.

CO-ORDINATES: 5441432.76 mN, 1765339.49 mE (NZTM2000)

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 32.80m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Jacob Fuller

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 02/03/2021

FINISH DATE: 04/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW SW MW HW CW DW)	Rock Strength (ES VS S MS W VW EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log	Fracture Spacing (mm) (2000 600 200 60 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25 50 75)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*11.60m:* Unweathered to slightly weathered, dark grey CATACLASITE. Weak. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of dark grey clay. *12.00 - 12.15m:* Pale grey vein. Weak. Subvertical. 5 to 10 mm across.			HQ3	100		22 21 20 19 18 17 16 15 14 13	11 12 13 14 15 16 17 18 19				0						
	12.40m: Unweathered to slightly weathered, black CATACLASITE. Very weak to weak. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of dark grey clay. Breaks down to silt and fine to coarse sand and gravel			HQ3	100							0						
	12.70m: Unweathered to slightly weathered, grey CATACLASITE. Weak. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale to dark grey clay. Colour of material varies along the core sample. *13.25 - 13.45m:* Unweathered to slightly weathered, pale grey CATACLASITE cobble. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay.			HQ3	100							0						Box 1, 11.60-14.30m
	14.6m: END OF BOREHOLE																	

COMMENTS: Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.

Hole Depth 14.6m

Scale 1:50

Rev.: B

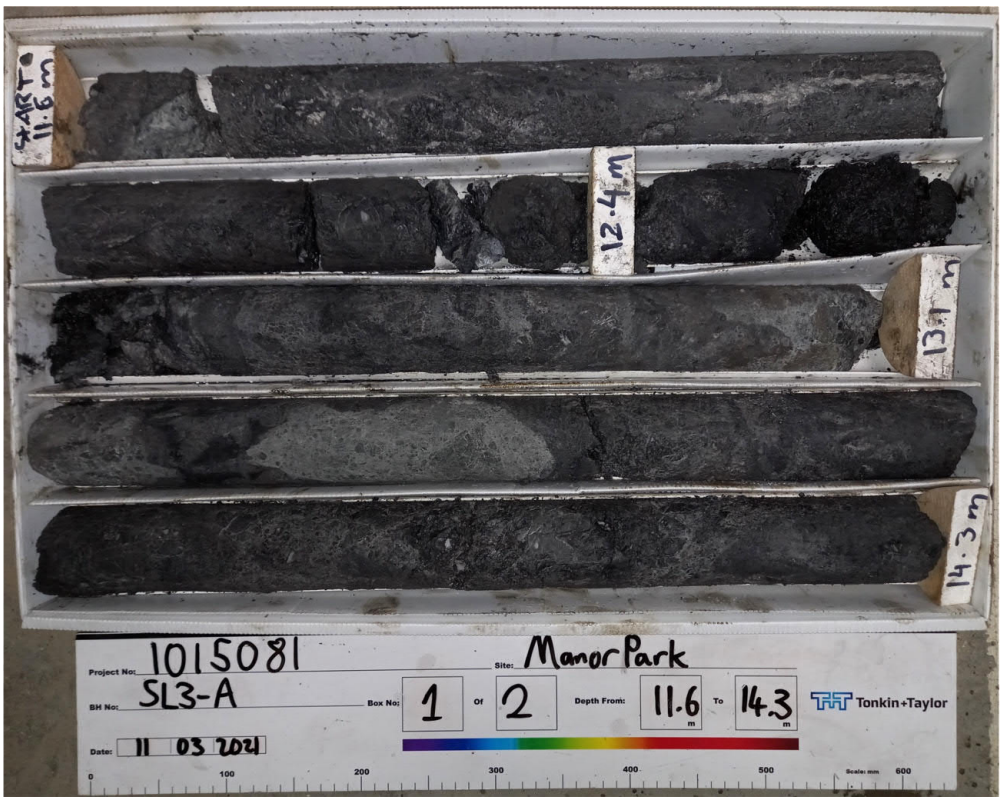
General Log - 6/05/2021 1:18:47 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **SL3-A**

Hole Location: At far western corner of the northernmost vacant industrial lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441432.76 mN (NZTM2000) 1765339.49 mE R.L.: 32.80m DATUM: NZVD2016	DRILL TYPE: Tractor-Mounted Rig DRILL METHOD: RC	HOLE STARTED: 02/03/2021 HOLE FINISHED: 04/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP



11.60-14.30m

14.30-14.60m

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL3-B

SHEET: 1 OF 2

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot.

CO-ORDINATES: (NZTM2000) 5441422.77 mN 1765347.82 mE

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 32.20m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Jacob Fuller

LOGGED BY: TH

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 02/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, EW, HW, MW, HW, CW)	Rock Strength (ES, VS, S, MS, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log	Fracture Spacing (mm) (2000, 600, 200, 60, 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
	0.00m: Wash boring with no sample recovered.						32 31 30 29 28 27 26 25 24 23	0 1 2 3 4 5 6 7 8 9										

COMMENTS: 1) Groundwater level not recorded.2) Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.3) Borehole is vertical so angles of shear zones represent the angle from horizontal.

Hole Depth 14.8m

Scale 1:50

Rev.: B

BOREHOLE LOG

BOREHOLE No.: SL3-B

SHEET: 2 OF 2

Tonkin+Taylor

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot.

CO-ORDINATES: 5441422.77 mN, 1765347.82 mE (NZTM2000)

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 32.20m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Jacob Fuller

LOGGED BY: TH

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 02/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW SW MW HW CW DW)	Rock Strength (ES VS S MS W VW EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log	Fracture Spacing (mm) (2000 600 200 60 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25 50 75)	Water Level	Casing	Installation	Core Box No
	11.50m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay. *12.70 - 12.73m:* Shear zone at 80°. 3 mm across. Hard, dark grey.			HQ3	66		22 21 20 19 18 13	11 12 13 14				0						
	13.00m: Core loss.			HQ3	80							0						
	13.30m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay. *14.20 - 14.23m:* Shear zone at 80°. 3 mm across. Hard, dark grey.			HQ3	112							0						Box 1, 11.50-14.60m
				HQ3	100							0						
	14.8m: END OF BOREHOLE						17 16 15 14 13	15 16 17 18 19										

COMMENTS: 1) Groundwater level not recorded.2) Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.3) Borehole is vertical so angles of shear zones represent the angle from horizontal.

Hole Depth 14.8m

Scale 1:50

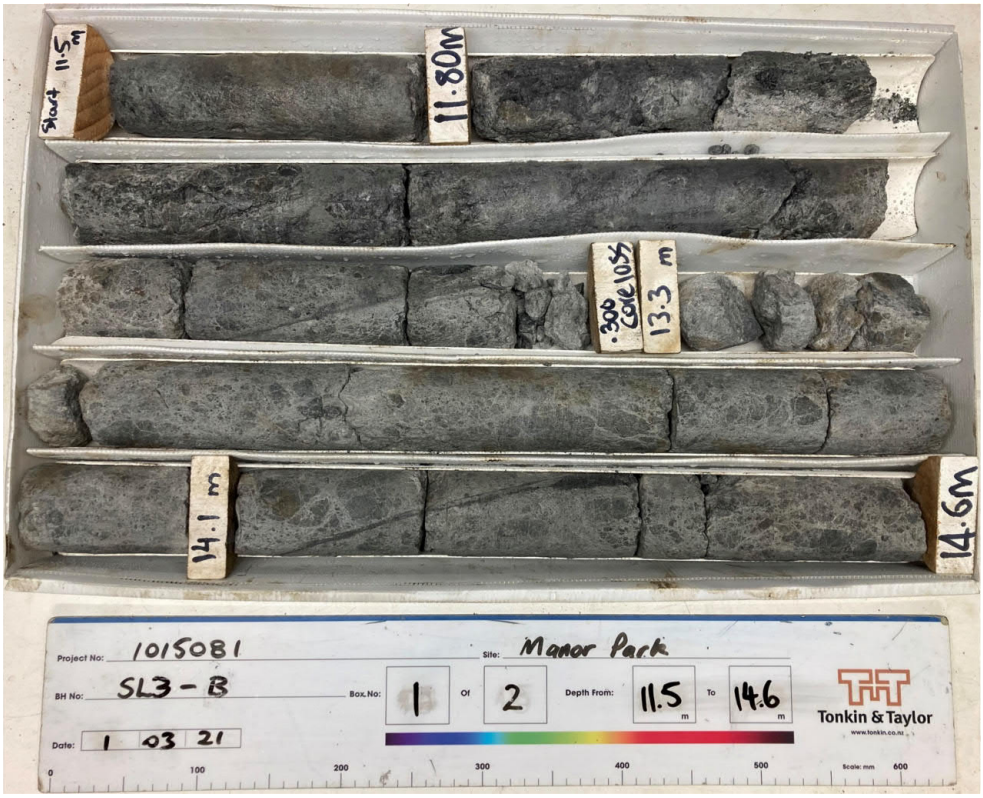
Rev.: B

CORE PHOTOS

BOREHOLE No.: **SL3-B**

Hole Location: At far western corner of the northernmost vacant industrial lot.

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441422.77 mN (NZTM2000) 1765347.82 mE R.L.: 32.20m DATUM: NZVD2016	DRILL TYPE: Tractor-Mounted Rig DRILL METHOD: RC	HOLE STARTED: 01/03/2021 HOLE FINISHED: 02/03/2021 DRILLED BY: Webster Drilling LOGGED BY: TH CHECKED: NCP



11.50-14.60m

14.60-14.80m

Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.: SL3-C

SHEET: 1 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

CO-ORDINATES: (NZTM2000) 5441414.59 mN 1765355.11 mE

DIRECTION: 310°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 12/03/2021

FINISH DATE: 23/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, EW, HW, MW, SW, DW)	Rock Strength (ES, VS, S, MS, M, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	ROCK DEFECTS: Fracture Spacing (mm) (2000, 600, 200, 60, 20)	ROCK DEFECTS: RQD (%)	ROCK DEFECTS: Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
	0.00m: Dark. Wash boring with no sample recovered.						32 31 30 29 28 27 26	1 2 3 4 5 6 7 8 9							16/03/2021: Water level same over following two days.			

COMMENTS: 1) Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.2) Measurements of groundwater level on 5th and 8th March were both taken on the mornings of those days.

Hole Depth 48.5m

Scale 1:50

Rev.: C

General Log - 6/05/2021 6:07:49 pm - Produced with Core-GS by GeRoc

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL3-C

SHEET: 2 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

CO-ORDINATES: (NZTM2000) 5441414.59 mN 1765355.11 mE

DIRECTION: 310°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 12/03/2021

FINISH DATE: 23/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW SW MW HW CW DW)	Rock Strength (ES VS S MS M W VW EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	Fracture Spacing (mm) (2000 600 200 60 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25 50 75)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*14.80m:* Unweathered to slightly weathered, grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay.			PQ3	83			15				0						
	16.40 - 16.42m: Colour changes to dark grey. Band of dark grey mudstone across sample.			PQ3	100			16				0						
				PQ3	90			17				0						Box 1, 14.80-17.00m
	17.80 - 17.85m: Colour changes to dark grey. Band of dark grey mudstone across sample.							18										
	18.45 - 18.75m: Colour changes to dark grey. Matrix composed of dark grey clay. Weak.			PQ3	93			19				0						Box 2, 17.00-19.29m
	19.55 - 19.65m: Dark grey, weak.																	

COMMENTS: 1) Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.2) Measurements of groundwater level on 5th and 8th March were both taken on the mornings of those days.

Hole Depth 48.5m

Scale 1:50

Rev.: C

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL3-C

SHEET: 3 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

CO-ORDINATES: 5441414.59 mN, 1765355.11 mE (NZTM2000)

DIRECTION: 310°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 12/03/2021

FINISH DATE: 23/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, SW, MW, HW, CW)	Rock Strength (ES, VS, S, MS, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	Fracture Spacing (mm) (2000, 600, 200, 60, 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*20.20 - 20.50m:* Colour changes to dark grey. Matrix composed of dark grey clay. *20.50 - 21.10m:* Material becomes weak. Partially recovered as fine to coarse sand and fine to coarse gravel; dark grey.			PQ3	100			18				0						
				PQ3	100			21				0						Box 3, 19.29-21.70m
	22.05 - 22.25m: Dark grey. Cataclasite with dark grey matrix. Weak. Abrupt transition.			PQ3	100			22				0						
				PQ3	100			23				0						Box 4, 21.70-23.67m
				PQ3	100			24				0						
	25.00 - 25.20m: Partially recovered as fine to coarse, angular gravel and sand. *25.30 - 25.45m:* Rock is recovered as fine to coarse, angular gravel and sand. *25.45 - 25.90m:* Colour darkens to dark grey. *25.60 - 25.62m:* Pale grey band of cataclasite at 45°. Band is estimated to be subvertical when in-situ. *25.90 - 25.95m:* Recovered as fine to coarse, angular gravel.			PQ3	80			25				0						
	25.95m: Unweathered to slightly weathered, pale grey MUDSTONE and SILTSTONE. Moderately strong, extremely closely spaced joints. Sheared rock. Discontinuities are filled with pale grey quartz. *26.55 - 26.65m:* Recovered as fine to coarse, angular gravel. *26.80 - 26.85m:* Recovered as fine to coarse, angular gravel.			PQ3	100			26				0						Box 5, 23.67-25.88m
	27.00m: Unweathered to slightly weathered, grey CATACLASITE. Weak. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay. Partially recovered as fine to coarse, angular gravel from 27.0 to 27.15 m. *27.15 - 27.25m:* Recovered as fine to coarse, angular gravel. *27.45 - 27.50m:* Recovered as fine to coarse, angular gravel. *27.50m:* Core loss.			PQ3	77			27				0						
	28.20m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay. *28.90 - 29.10m:* Dark grey band of cataclasite at approximately 60°. Dip angle in the core implies an in-situ dip angle of approximately 15° from vertical. *29.15 - 29.25m:* Sheared rock. Very closely spaced joints.			PQ3	100			28				0						Box 6, 25.88-28.60m
				PQ3	100			29				0						
				PQ3	100							0						

COMMENTS: 1) Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.2) Measurements of groundwater level on 5th and 8th March were both taken on the mornings of those days.

Hole Depth 48.5m

Scale 1:50

Rev.: C

BOREHOLE LOG

BOREHOLE No.: SL3-C

SHEET: 4 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

CO-ORDINATES: (NZTM2000) 5441414.59 mN, 1765355.11 mE

DIRECTION: 310°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 12/03/2021

FINISH DATE: 23/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE (SOIL: Classification, colour, consistency / density, moisture, plasticity; ROCK: Weathering, colour, fabric, name, strength, cementation)	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations	Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*33.25 - 33.45m:* Large, dark grey, argillitic band. Weak. 60° relative to core. Dip angle in core suggests an in-situ angle of approximately 15° from vertical.			PQ3	100		11	31			2000 600 200 60 20	0		25 50 75				Box 7, 28.60-30.58m
				PQ3	100		10	32				0						
				PQ3	100							0						Box 8, 30.58-32.50m
				PQ3	100		9	33				0						
	34.95m: Unweathered to slightly weathered, dark grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of dark grey clay.			PQ3	100			34				0						Box 9, 32.50-34.55m
	35.45m: Unweathered to slightly weathered, pale grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay.			PQ3	93		8	35				0						
	36.00 - 36.60m: Colour becomes dark grey. Clay infill is dark grey.			PQ3	100		7	36				0						
				PQ3	100							0						Box 10, 34.55-36.81m
	38.51m: Core loss.			PQ3	44		6	37				0						
				PQ3	75			38				0						
	38.90m: Unweathered to slightly weathered, pale grey CATACLASITE. Weak to moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay.			PQ3	0		5					0						
	39.05m: 39.05 to 39.3 m: Core loss.			PQ3	100			39				0						Box 11, 36.81-39.45m
	39.30m: Unweathered to slightly weathered, pale grey CATACLASITE. Description same as described at 38.9 m.			PQ3	100							0						

COMMENTS: 1) Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.2) Measurements of groundwater level on 5th and 8th March were both taken on the mornings of those days.

Hole Depth 48.5m

Scale 1:50

Rev.: C

BOREHOLE LOG

Tonkin+Taylor

BOREHOLE No.: SL3-C

SHEET: 5 OF 5

PROJECT: Manor Park Development

JOB No.: 1015081.0000

LOCATION: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

CO-ORDINATES: (NZTM2000) 5441414.59 mN, 1765355.11 mE

DIRECTION: 310°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 12/03/2021

FINISH DATE: 23/03/2021

CONTRACTOR: Webster Drilling

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering (UW, EW, HW, MW, SW, DW)	Rock Strength (ES, VS, S, MS, W, VW, EW)	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS: Defect Log (relative to inclination)	Fracture Spacing (mm) (2000, 600, 200, 60, 20)	RQD (%)	Description & Additional Observations	Fluid Loss (%) (25, 50, 75)	Water Level	Casing	Installation	Core Box No
Rakaia Terrane	*39.95 - 41.10m:* Recovered as fine to coarse, angular gravel and sand. *40.10 - 40.20m:* Recovered as fine to coarse, angular gravel and sand.			PQ3	100		4	41				0						
	41.10 - 41.38m: Cataclasite is smeared with CLAY; pale grey. Very soft, saturated.			PQ3	100		3	42				0						Box 12, 39.45-41.38m
				PQ3	100							0						
				PQ3	100		2	43				0						Box 13, 41.38-43.35m
				PQ3	100							0						
				PQ3	57							0						
	44.30 - 44.40m: Recovered as fine to coarse, angular gravel.			PQ3	100		1	44				0						
				PQ3	100			45				0						Box 14, 43.35-45.72m
	46.10m: Core loss.			PQ3	78		0	46				0						
	46.65m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay. *47.00 - 47.15m:* Recovered as fine to coarse, angular gravel and sand.			PQ3	0							0						
				PQ3	100		-1	47				0						
	47.15m: Core loss.			PQ3	0							0						
	47.80m: Unweathered to slightly weathered, grey CATACLASITE. Moderately strong. Comprises fine to coarse, angular sandstone, siltstone and mudstone gravel within a matrix of pale grey clay.			PQ3	100			48				0						Box 15, 45.72-48.50m
	48.05m: Unweathered to slightly weathered, pale grey MUDSTONE and SILTSTONE. Moderately strong, extremely closely spaced joints. Sheared rock. Discontinuities are filled with pale grey quartz. *48.45 - 48.50m:* Recovered as fine to coarse, angular gravel.						-2											
	48.5m: END OF BOREHOLE							49										
							-3											

COMMENTS: 1) Due to the significant crushing and shearing throughout the length of the core, no specific defect data has been recorded.2) Measurements of groundwater level on 5th and 8th March were both taken on the mornings of those days.

Hole Depth 48.5m

Scale 1:50

Rev.: C

General Log - 6/05/2021 6:07:49 pm - Produced with Core-GS by GeRoc

CORE PHOTOS

BOREHOLE No.: **SL3-C**

Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441414.59 mN (NZTM2000) 1765355.11 mE R.L.: 32.30m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 12/03/2021 HOLE FINISHED: 23/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

14.80-17.00m

17.00-19.29m

Tonkin+Taylor

CORE PHOTOS

BOREHOLE No.: **SL3-C**

Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441414.59 mN (NZTM2000) 1765355.11 mE R.L.: 32.30m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 12/03/2021 HOLE FINISHED: 23/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

19.29-21.70m

21.70-23.67m

Tonkin+Taylor

CORE PHOTOS

BOREHOLE No.: **SL3-C**

Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441414.59 mN (NZTM2000) 1765355.11 mE R.L.: 32.30m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 12/03/2021 HOLE FINISHED: 23/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

23.67-25.88m

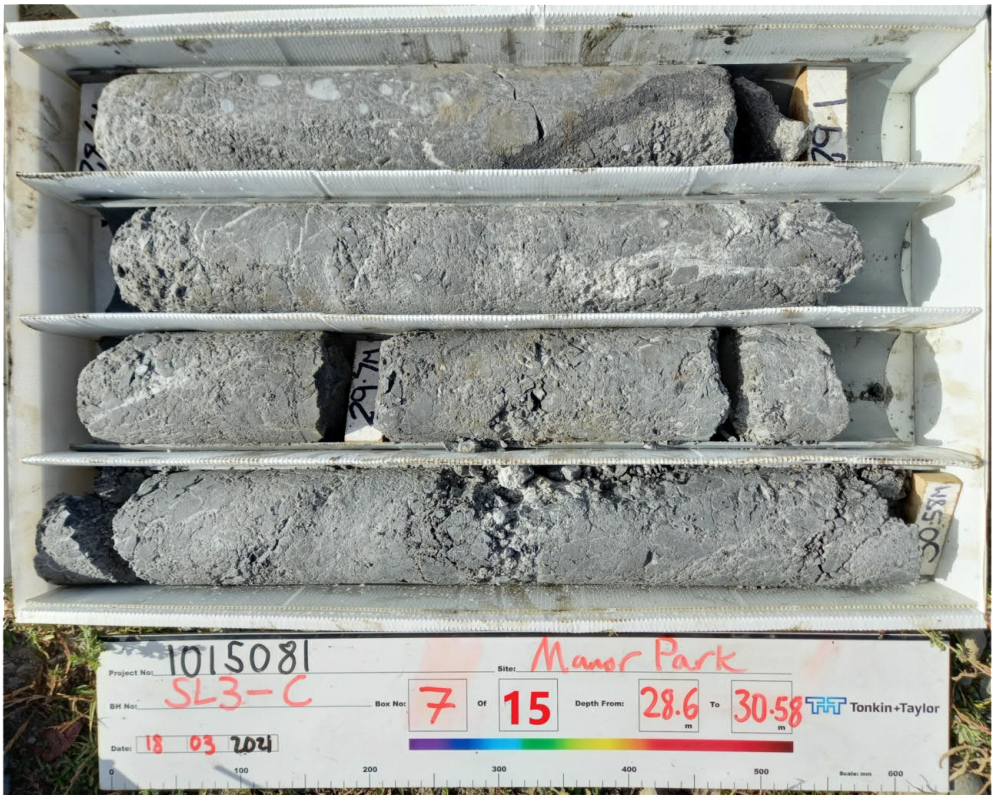
25.88-28.60m

CORE PHOTOS

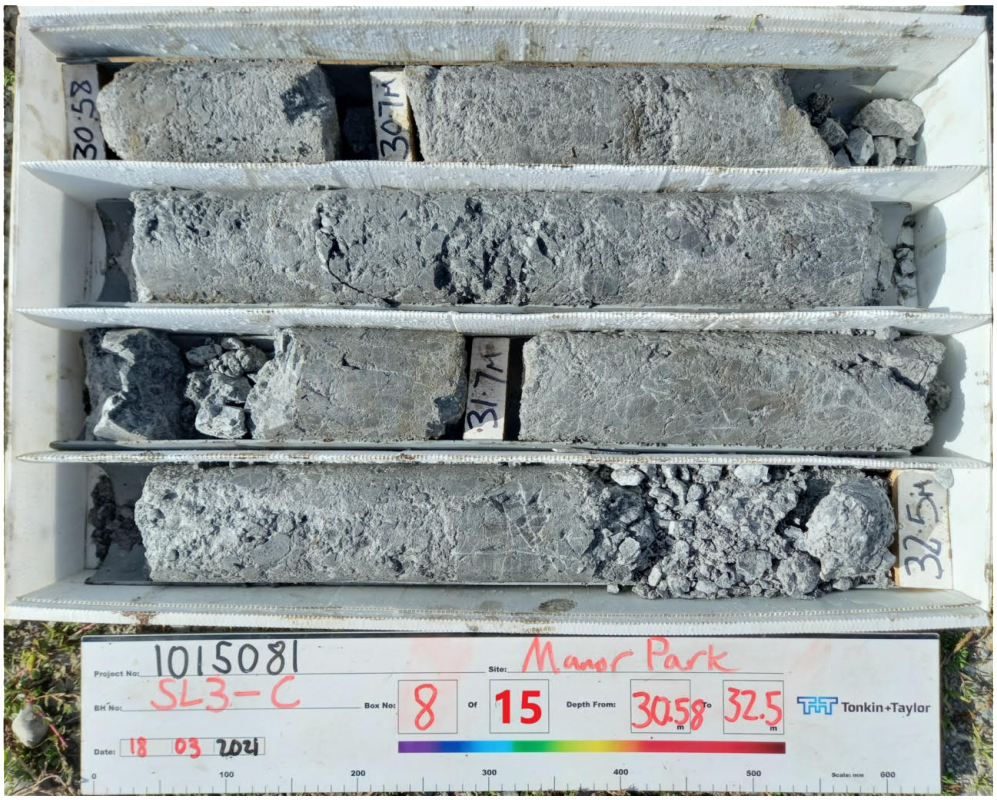
BOREHOLE No.: **SL3-C**

Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441414.59 mN (NZTM2000) 1765355.11 mE R.L.: 32.30m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 12/03/2021 HOLE FINISHED: 23/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP



28.60-30.58m



30.58-32.50m

Tonkin+Taylor

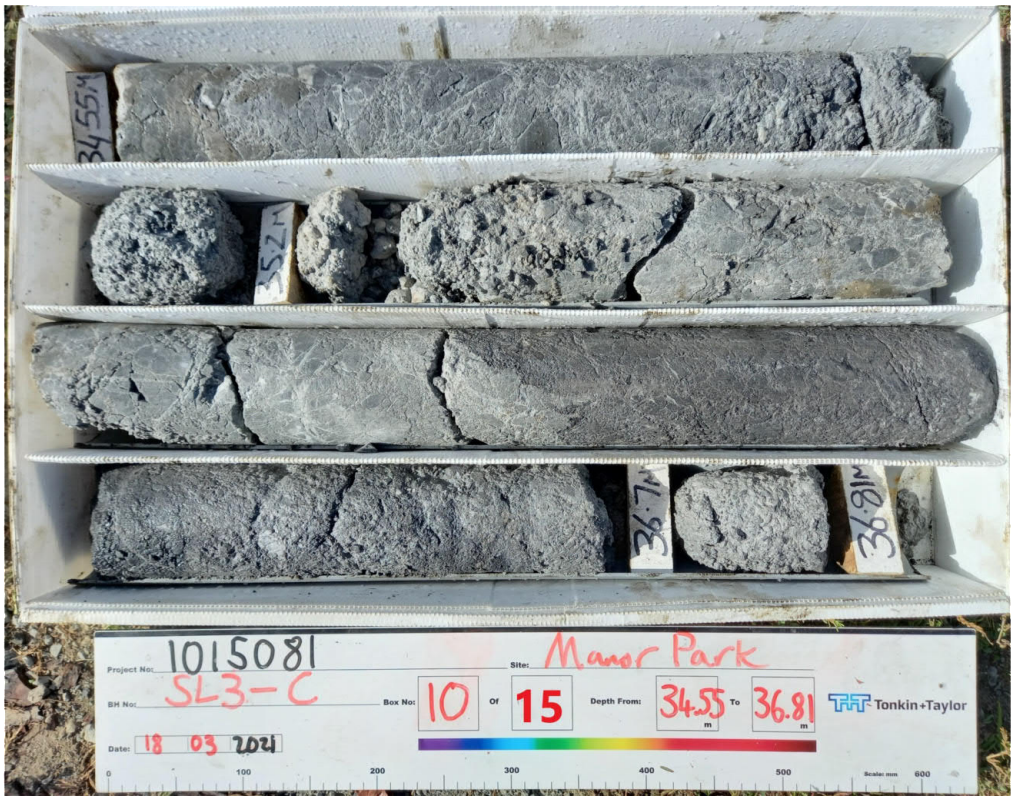
CORE PHOTOS

BOREHOLE No.: **SL3-C**

Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441414.59 mN (NZTM2000) 1765355.11 mE R.L.: 32.30m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 12/03/2021 HOLE FINISHED: 23/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

32.50-34.55m



34.55-36.81m

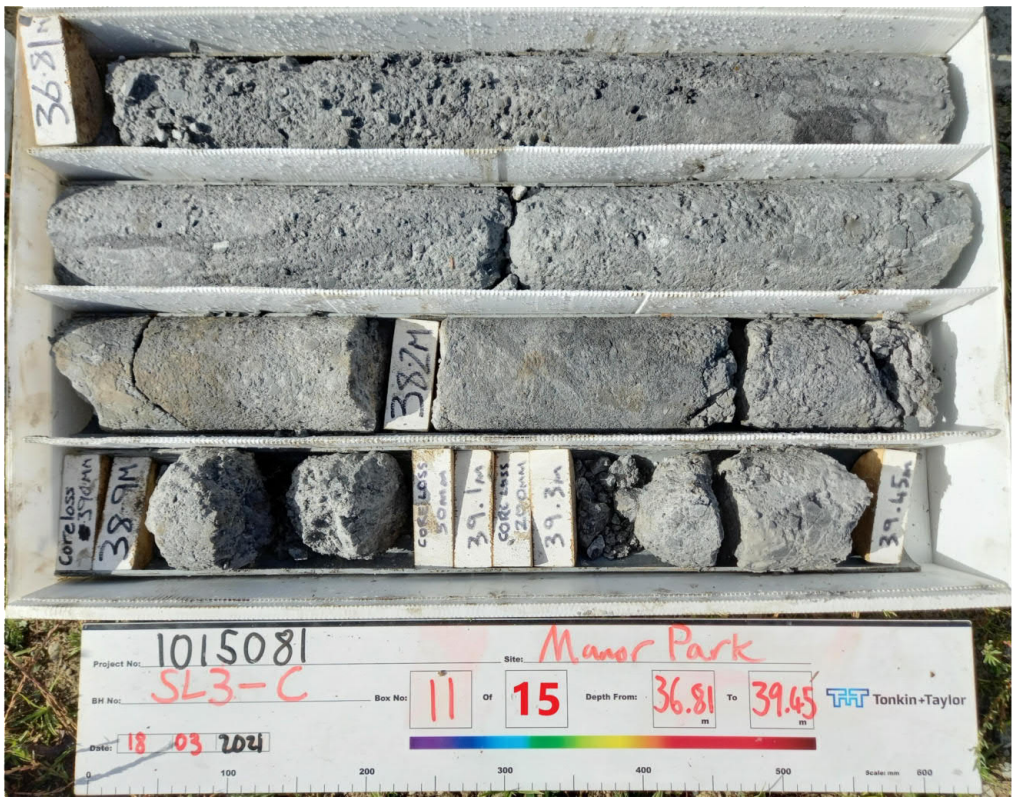
Tonkin+Taylor

CORE PHOTOS

BOREHOLE No.: **SL3-C**

Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441414.59 mN (NZTM2000) 1765355.11 mE R.L.: 32.30m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 12/03/2021 HOLE FINISHED: 23/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP



36.81-39.45m

39.45-41.38m

Tonkin+Taylor

CORE PHOTOS

BOREHOLE No.: **SL3-C**

Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441414.59 mN (NZTM2000) 1765355.11 mE R.L.: 32.30m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 12/03/2021 HOLE FINISHED: 23/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

41.38-43.35m

43.35-45.72m

Tonkin+Taylor

CORE PHOTOS

BOREHOLE No.: **SL3-C**

Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

PROJECT: Manor Park Development	LOCATION:	JOB No.: 1015081.0000
CO-ORDINATES: 5441414.59 mN (NZTM2000) 1765355.11 mE R.L.: 32.30m DATUM: NZVD2016	DRILL TYPE: Atlas Drill Rig DRILL METHOD: RC	HOLE STARTED: 12/03/2021 HOLE FINISHED: 23/03/2021 DRILLED BY: Webster Drilling LOGGED BY: DAHE CHECKED: NCP

45.72-48.50m

Appendix C: Supporting documentation

- **A J Sutherland Consulting. Manor Park seismic refraction survey, January 2021**

Manor Park
Seismic Refraction Survey

January 2021

A J Sutherland Consulting Ltd

Prepared for Tonkin and Taylor

Prepared by Alan Sutherland

Contents

1 Introduction

This report describes the test procedures and results of a seismic refraction survey, comprising three lines, at Manor Park. The site is accessed from Benmore Crescent.

The site work for these lines was completed between 10 November and 16 December 2020.

2 Seismic Refraction Surveying Procedures

The seismic refraction survey was carried out using small explosive charges (shots) placed in augered holes. The compression wave arrival times, for each shot, were measured on a spread of up to 24 geophones at a time, connected to cables laid along the ground. The lines were marked out by tape measure and pegged or marked on the ground. The end points of the lines were surveyed later. The survey data is shown in Appendix C.

Shots were placed at regular intervals along the line and offset from the end of each spread. A total of up to 6 shots were fired for each spread of 24 geophones.

Data were recorded on a 24 channel Geometrics Geode digital seismograph which was attached to the shot firing equipment. Shot firing was controlled by the geophysicist operating the seismograph after receiving an “all clear” from the geophysicist placing the charges. The explosive used in this survey was Senatel Magnum™ emulsion explosive, initiated with instantaneous electric detonators.

3 Data Processing and Interpretation

The first stage of the data processing, involving measurement of the p-wave arrival times for each shot was carried out using LabView™ routines. Subsequent processing was carried out interactively using spreadsheet calculations, rather than by relying on semi-automatic processing software.

Seismic velocities and depths to shallow layers were determined using the Plus-Minus method, which is essentially the same as the GRM method for shallow refractors. The program GRAPHER™ was used plot the depth and velocity data and to measure the seismic velocities from the gradients of linear fits applied to appropriate segments of the data.

The calculations used to produce the profiles are based on some assumptions. For example, both velocity and depth calculations assume that seismic waves travel along the survey line in two dimensions (longitudinal and vertical). If there are major lateral variations in the refractor depth, then this assumption may be inaccurate and the calculated “depth” may in fact be a slope distance to a point on the refractor surface to the side of the seismic line.

The interpretation also assumes that layers will increase in velocity with depth. Any layer with a velocity lower than the layer above will not be detected and will lead to an error in the depth calculation.

Velocities calculated are the velocity at the top of a particular layer and these velocities may increase slightly within the layer.

Intercepts and delay times from either direction were also used to determine depths to rock to supplement the depths calculated by the Plus-Minus method. This was generally used where there was insufficient overlap to use the Plus-Minus method for all geophone positions.

Low velocity zones were identified on the minus times plot, where shots from opposite ends of the line are subtracted from each other. This is normally used to determine the velocity of the rock, but will also indicate low velocity zones within the rock.

In addition, the signal amplitude of the signal was looked at to determine whether there was an increase in the attenuation, coinciding with the low velocity zone. This was useful for lines SL2 and SL3, but on SL1 the location of the low velocity zone coincided with the edge of a concrete slab at the surface which influenced the signal amplitude.

4 Survey Results

Cross sections of each seismic line are attached in Appendix A and time distance plots are shown in Appendix B. The cross sections show:

- the estimated ground surface profile along each line,
- seismic compression wave (p-wave) velocity and thickness of the various surface layers and
- the compression wave velocity of the rock layer.

All velocities referred to are compression wave velocities measured in metres per second (m/s).

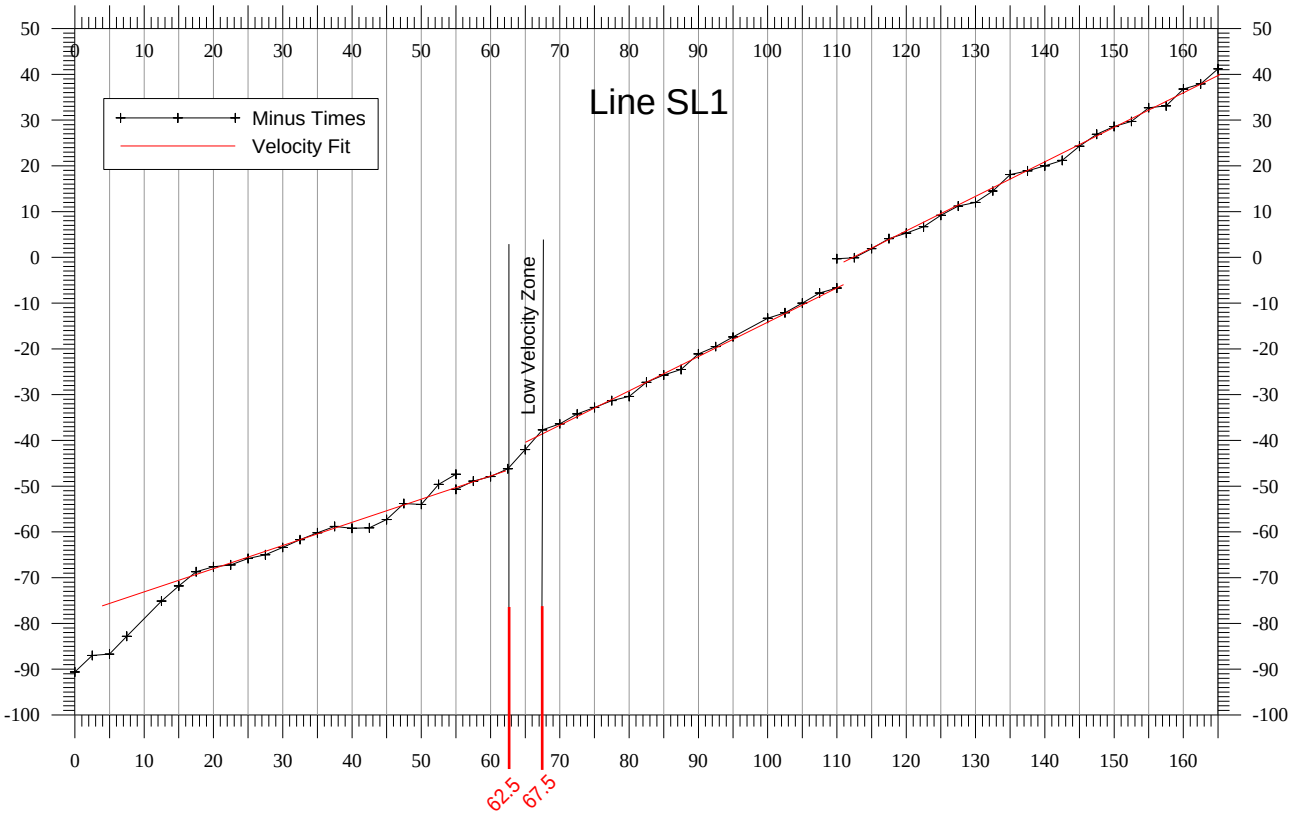
The following is a brief description of any features found on each of the seismic lines. The purpose of the survey was to locate low velocity zones and/or steps associated with the Wellington Fault.

4.1 Seismic Line 1

This line ran along an access track, starting on the grass slope up to SH2, at the end of Benmore Crescent. The total length of the line is 165 metres. The geophone spacing was 2.5m.

A surface layer of 300m/s is present along all of the line and an intermediate layer of 900m/s is also present. The rock layer has a velocity of 2750m/s along the eastern end of the line and 3900m/s at the western end of the line.

The plot below shows the times for the end shots at peg zero subtracted from the times for the offset shot at the far end of the line. The slope of the line is related to the velocity of the rock where the refraction is from the rock. A low velocity zone with a loss of 4 milliseconds was found between pegs 62.5 and 67.5m.



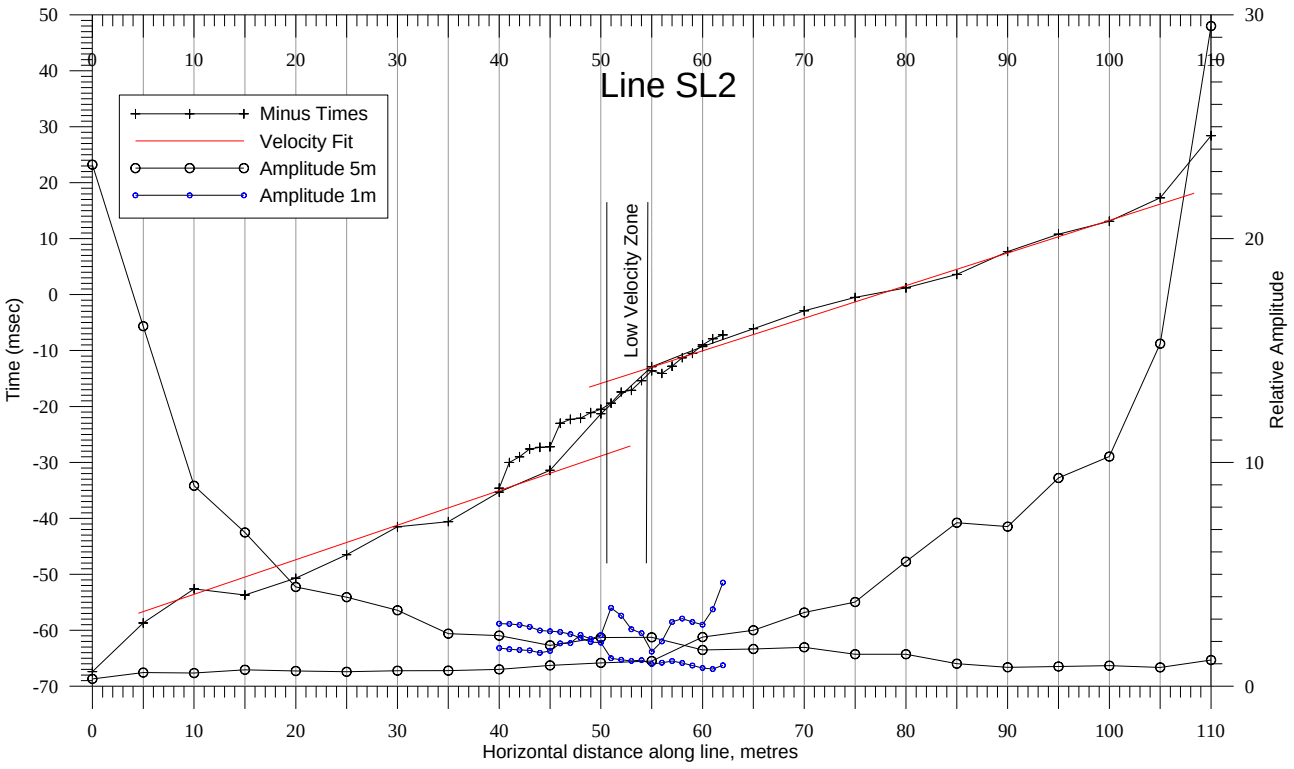
4.2 Seismic Line 2

This line to the east of Benmore Crescent, beside the stream, North of SL1, then crossed the stream and ran up the slope to a flat area of fill. The total length of the line is 110 metres. The geophone spacing was 5m.

After firing 6 shots, the arrival times for the two offset shots were picked and a velocity plot of the line was made to locate the likely position of the low velocity zone. The geophones were then placed at 1m spacing over the likely zone and two more shots, at the offset positions were fired.

A surface layer of 250 to 300m/s is present along all of the line and an intermediate layer of 700 to 800m/s is also present. The rock layer has a velocity of 2900m/s along the length of the line.

The plot below shows the times for the offset shots from peg zero subtracted from the times for the offset shot at the far end of the line. The slope of the line is related to the velocity of the rock where the refraction is from the rock. A low velocity zone with a loss of 6 milliseconds was found between pegs 45 and 55m. Additionally, the maximum amplitude of the signal at each geophone, for each offset shot is shown. The signal should be attenuated as it passes through the low velocity zone. The values of amplitude will be affected by background noise superimposed on the signal so may have some scatter in the values. The 1m spaced shot from the zero end of the shows a sudden step between 50 and 51m, with a relatively even attenuation either side.
Taking into account the velocity step and the amplitude changes the most likely position of the low velocity zone is between pegs 50 to 55m.



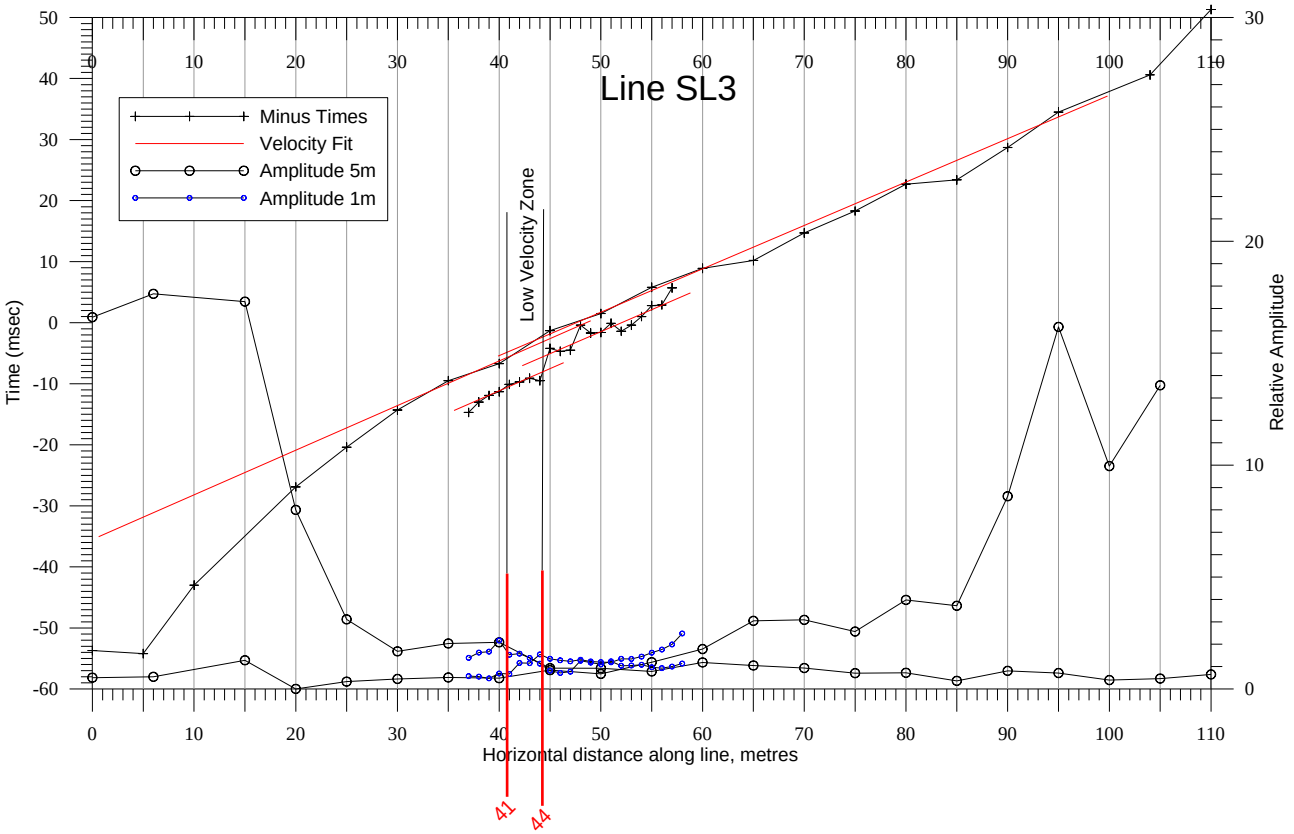
4.3 Seismic Line 3

This line to the east of Benmore Crescent, beside the stream, further North of SL2, then crossed the stream and ran up the slope to a flat area of fill. The total length of the line is 110 metres. The initial geophone spacing was 5m.

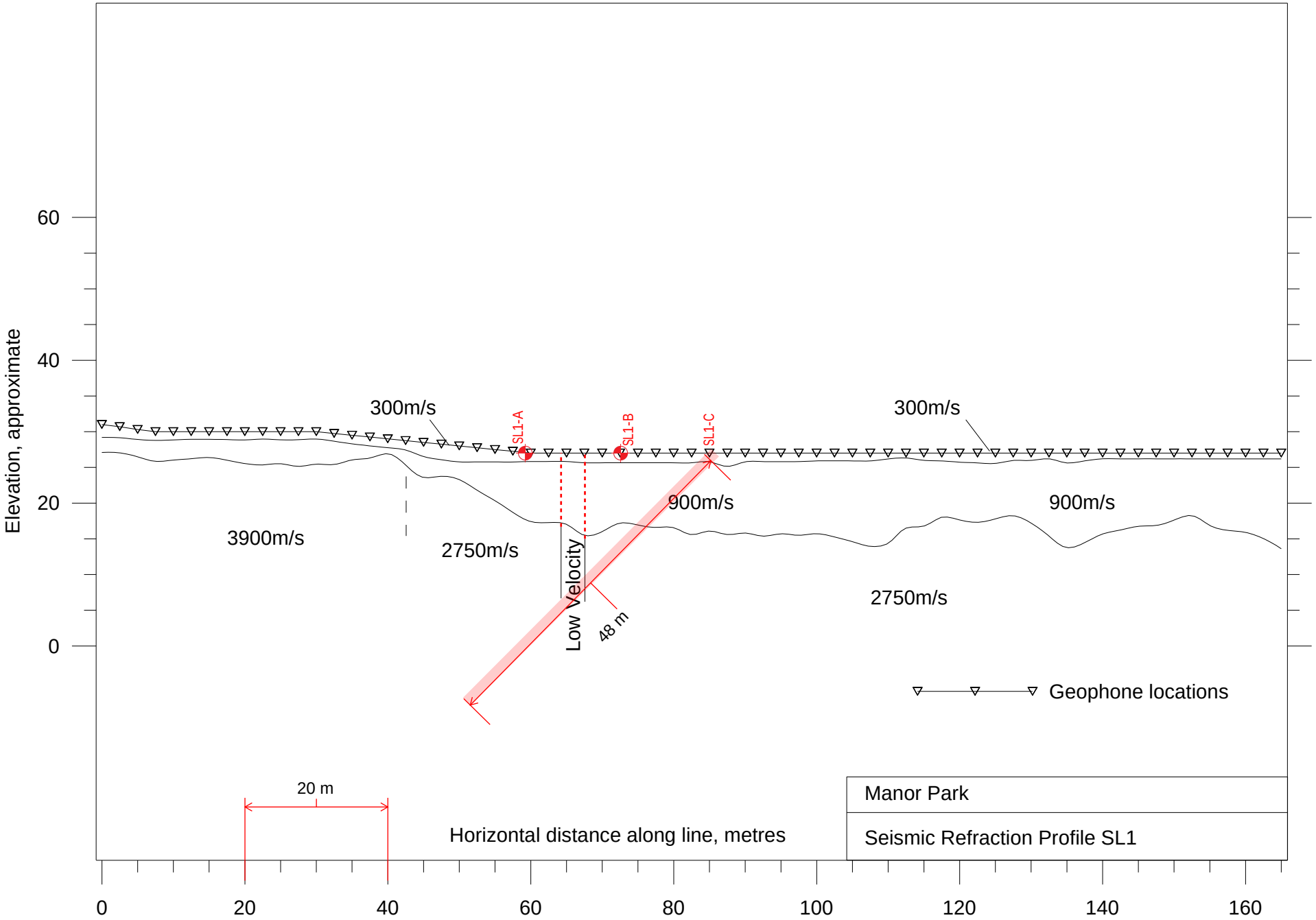
After firing 6 shots, the arrival times for the two offset shots were picked and a velocity plot of the line was made to locate the likely position of the low velocity zone. The geophones were then placed at 1m spacing over the likely zone and two more shots, at the offset positions were fired.

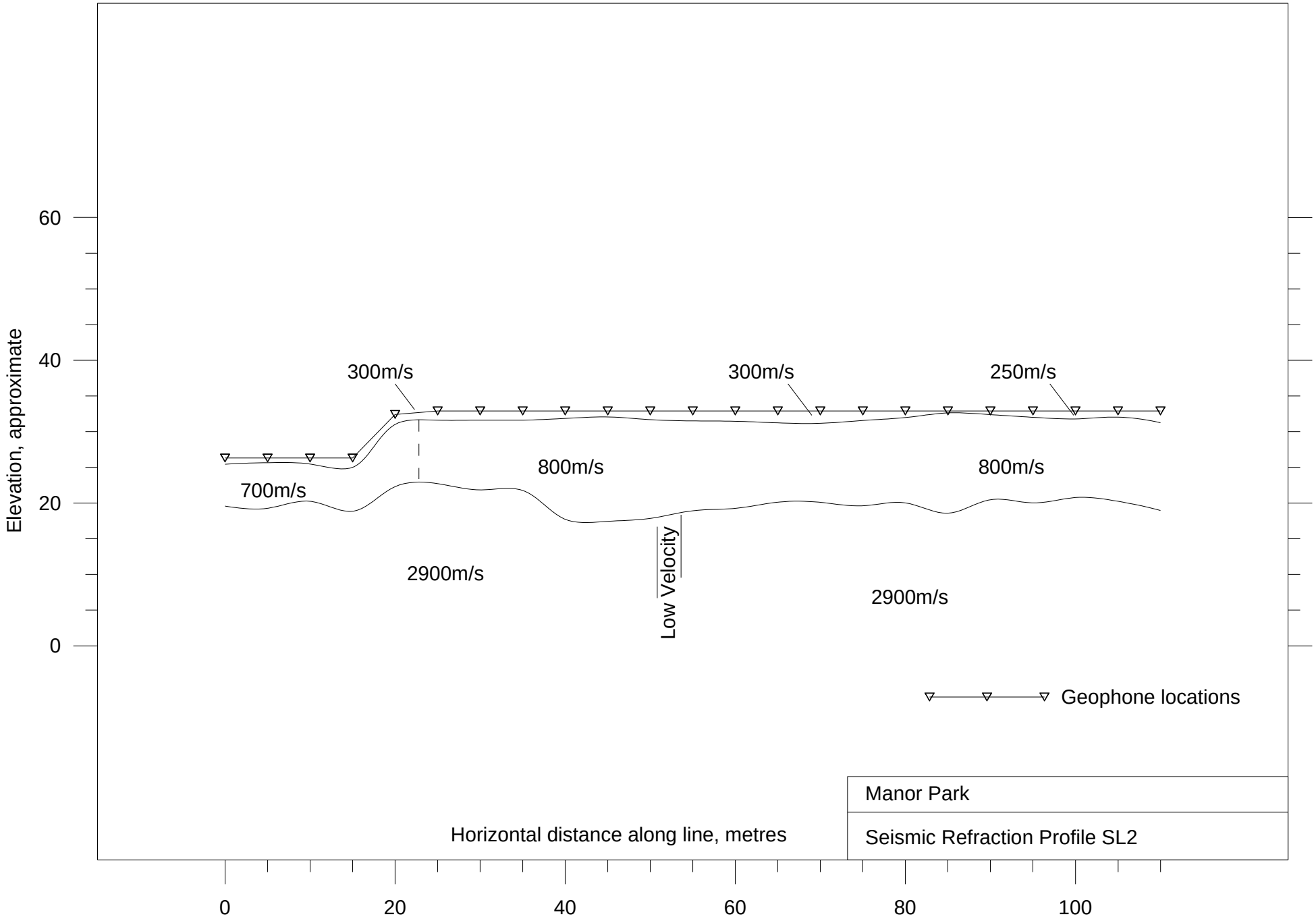
A surface layer of 300m/s is present along all of the line and an intermediate layer of 600 to 800m/s is also present. The rock layer has a velocity of 2900m/s along the length of the line.

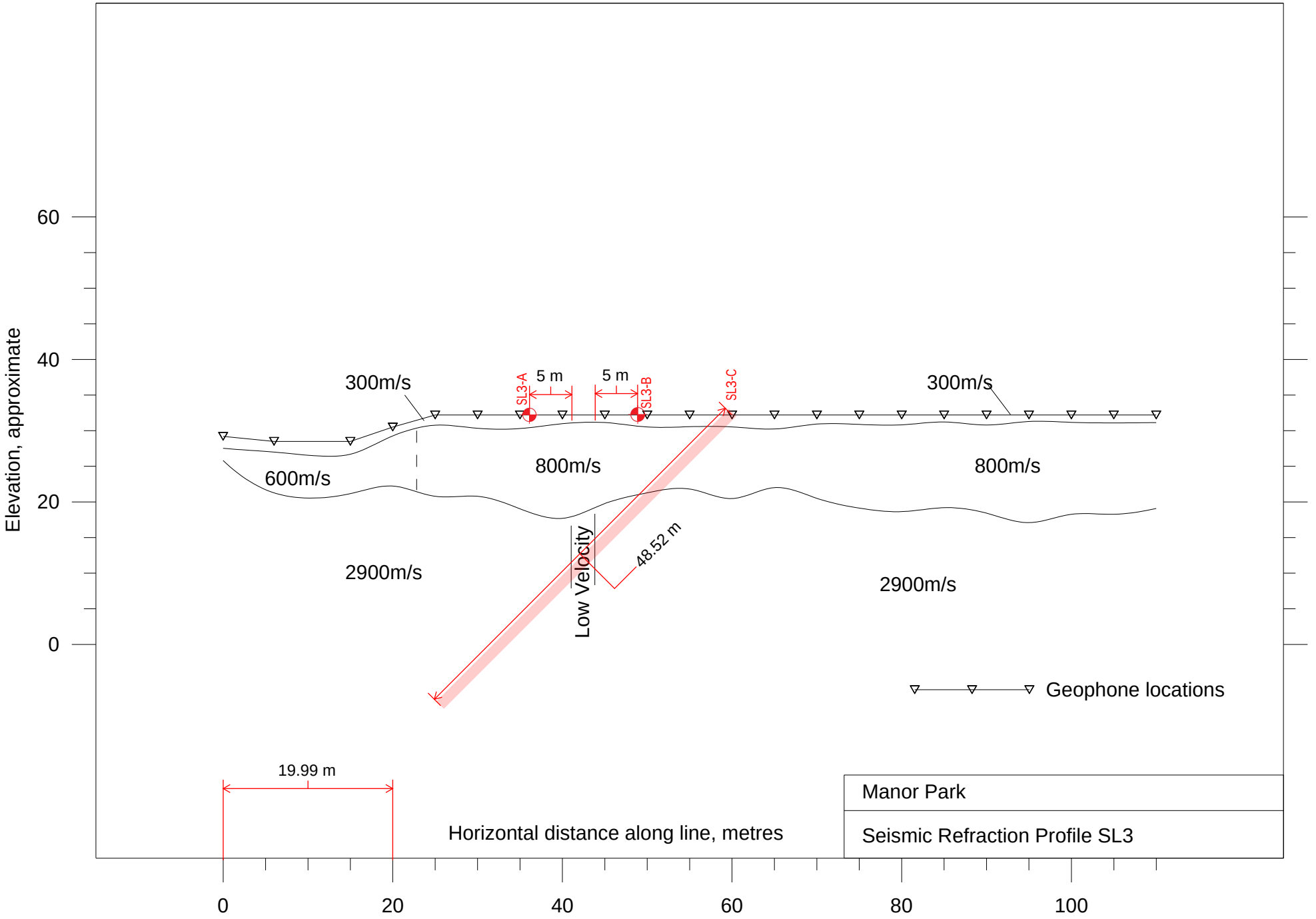
The plot below shows the times for the offset shots from peg zero subtracted from the times for the offset shot at the far end of the line. The slope of the line is related to the velocity of the rock where the refraction is from the rock. A low velocity zone with a loss less than 1 milliseconds was found between pegs 40 and 45m. Additionally the maximum amplitude of the signal at each geophone, for each offset shot is shown, as with line 2. Both of the 1m spaced shots and the 5m spaced offset from the zero end of the shows a step between 40 and 45m, which reinforces the small step seen on the velocity plot.



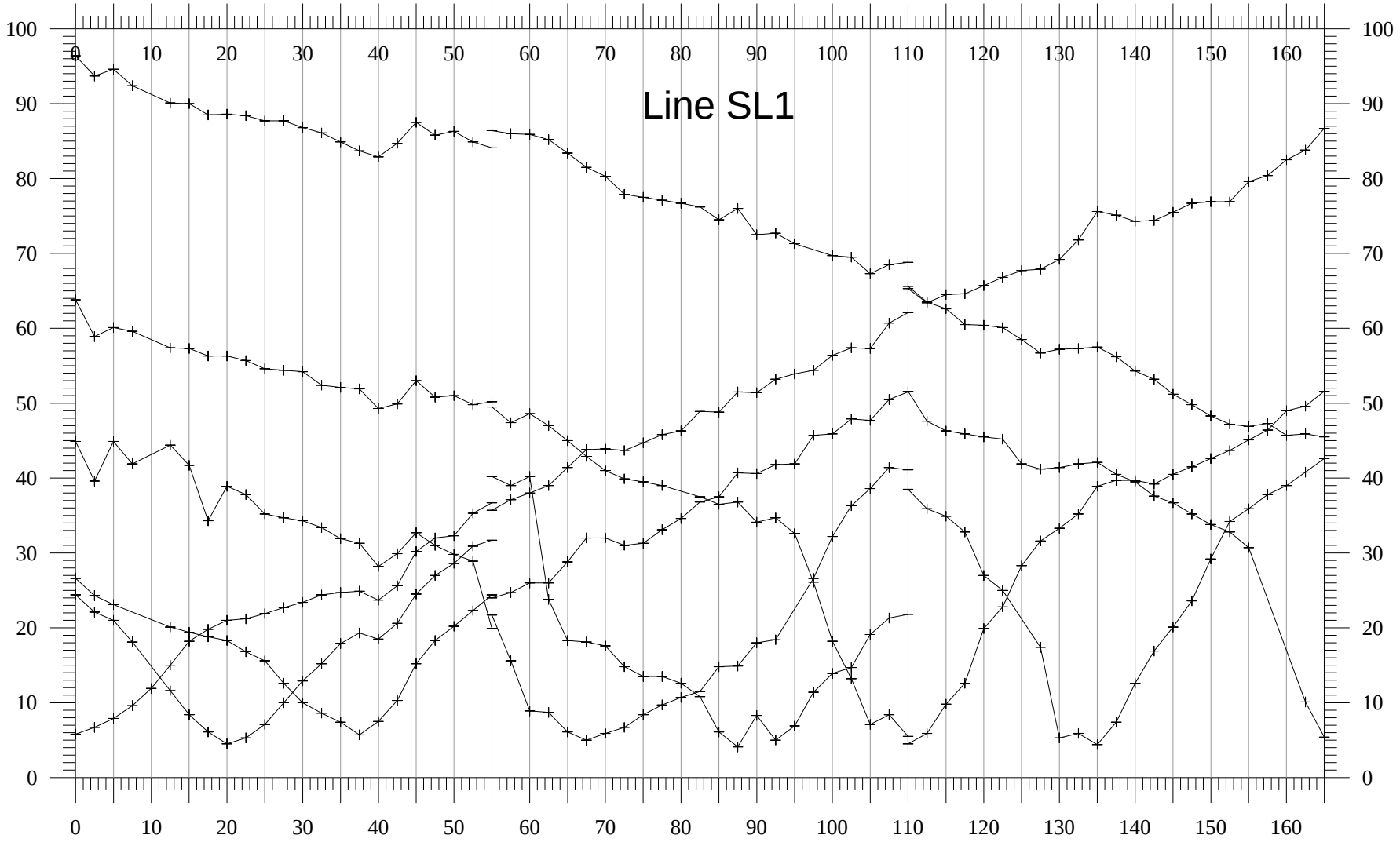
Appendix A: Seismic Refraction Cross Section

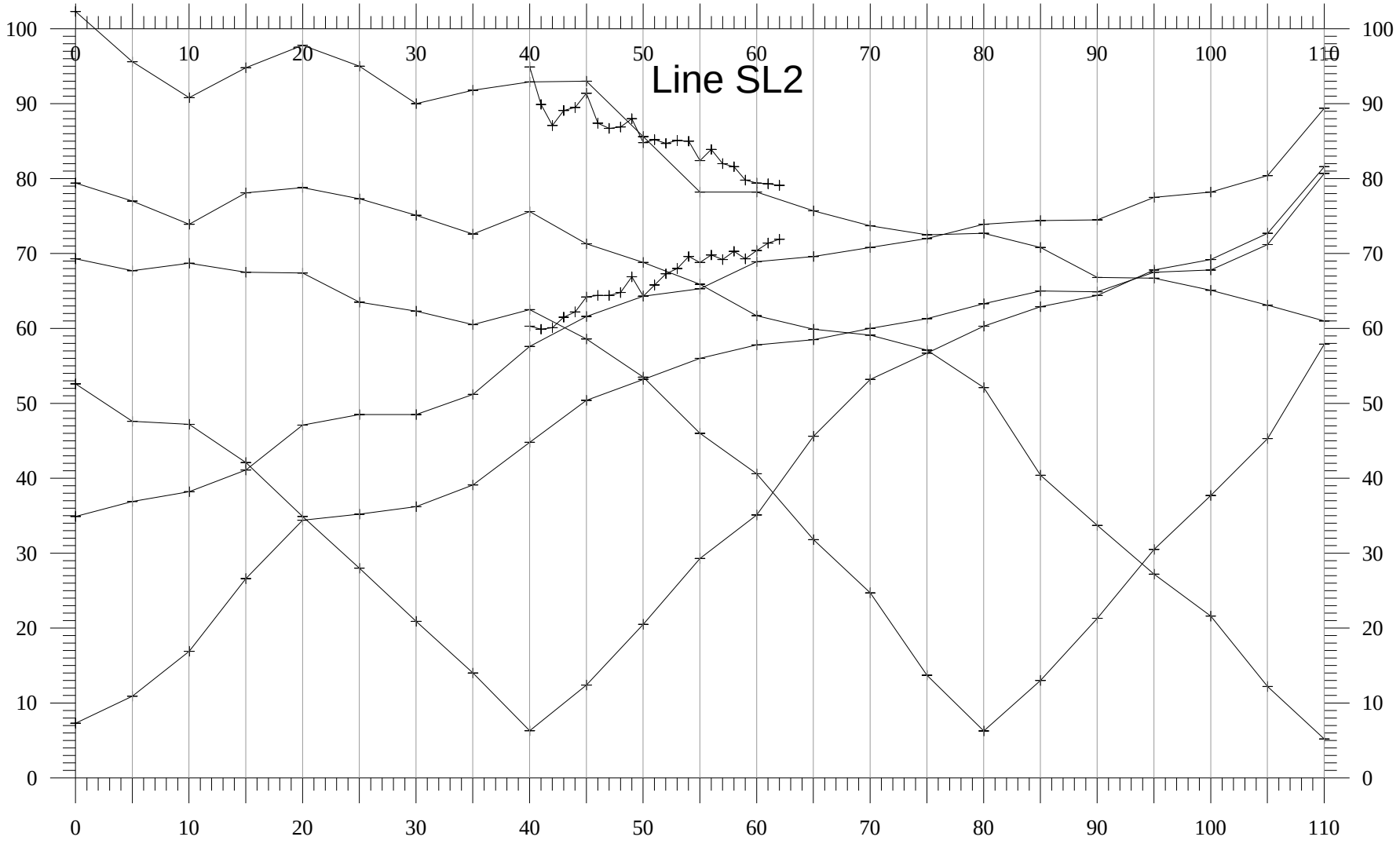

Elevation, approximate
60
40
20
0
300m/s
300m/s
SL1-A
SL1-B
SL1-C
900m/s
900m/s
3900m/s
2750m/s
2750m/s
Low Velocity
48 m
Geophone locations
20 m
Horizontal distance along line, metres
0
20
40
60
80
100
120
140
160
Manor Park
Seismic Refraction Profile SL1

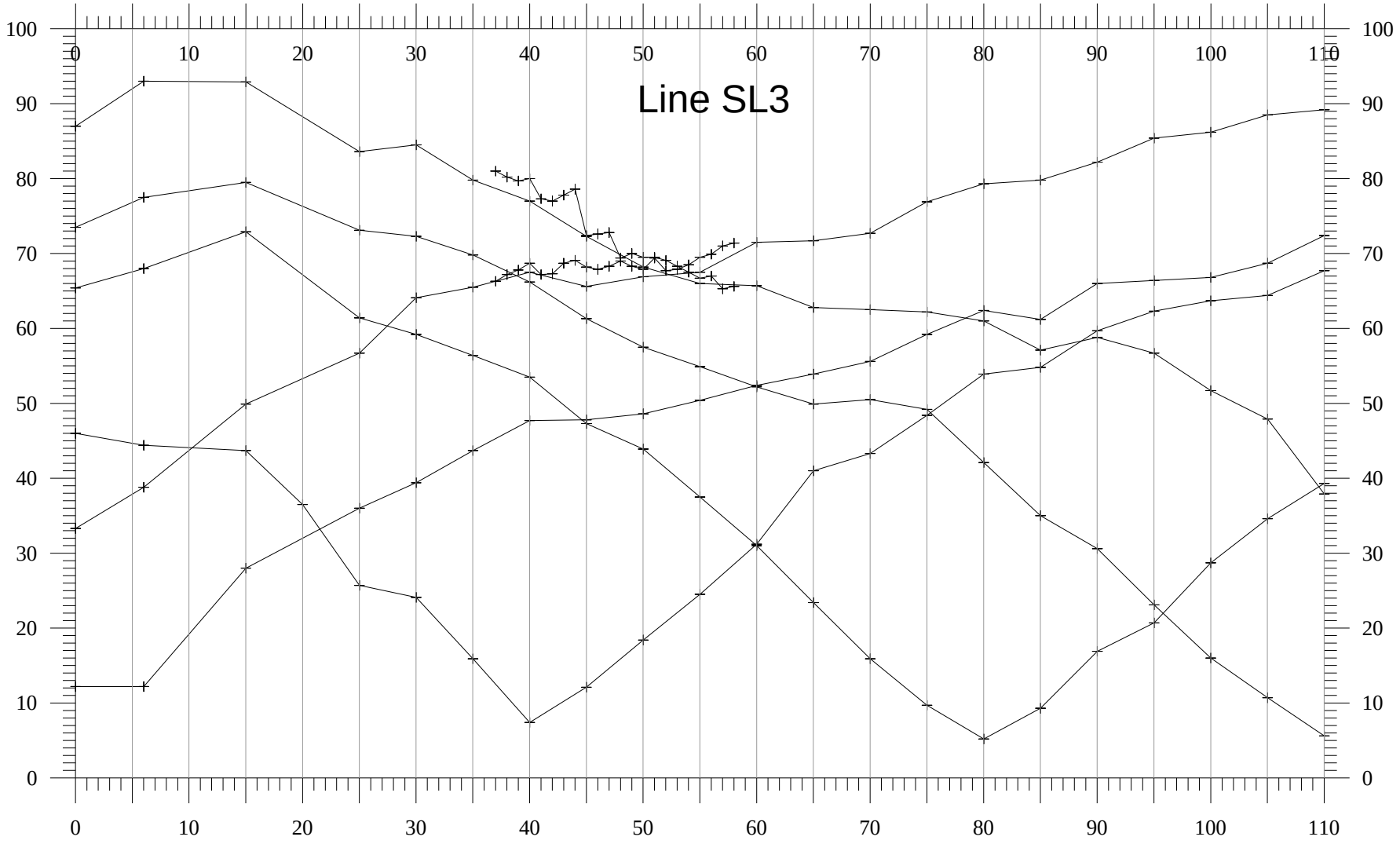

Elevation, approximate
60
40
20
0
300m/s
300m/s
250m/s
800m/s
800m/s
700m/s
2900m/s
2900m/s
Low Velocity
Geophone locations
Manor Park
Seismic Refraction Profile SL2
Horizontal distance along line, metres
0
20
40
60
80
100


Elevation, approximate
60
40
20
0
300m/s
5 m
5 m
SL3-A
SL3-B
SL3-C
300m/s
800m/s
800m/s
600m/s
2900m/s
Low Velocity
48.52 m
2900m/s
Geophone locations
19.99 m
Horizontal distance along line, metres
0
20
40
60
80
100
Manor Park
Seismic Refraction Profile SL3

Appendix B: Time Distance Plots


Line SL1
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160


Line SL2
0
10
20
30
40
50
60
70
80
90
100
110


Line SL3
0
10
20
30
40
50
60
70
80
90
100
110

Appendix C: Survey Data

Survey data,

Peg number	Eastings	Northings	Elevation
SL1 - 0	1765067	5441260	30.602
SL1 - 165	1765183	5441143	25.743
SL2 - 0	1765208	5441372	26.296
SL2 - 110	1765279	5441289	32.909
SL3 - 0	1765316	5441460	29.189
SL3 - 110	1765387	5441375	32.187