

Appendix 5: Faultline Study – Tonkin and Taylor

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.'*

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)

Beetham 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 overlying 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 2014³, and 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 gouge comprising dark brown clay and gravel and was inferred to be the Wellington Fault. Either side of the fault gouge 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 report⁴. These options were also discussed with GNS⁵.

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 gouge 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

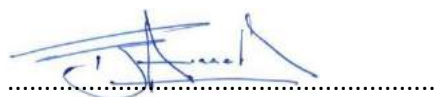
This report has been prepared for the exclusive use of our client, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

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:



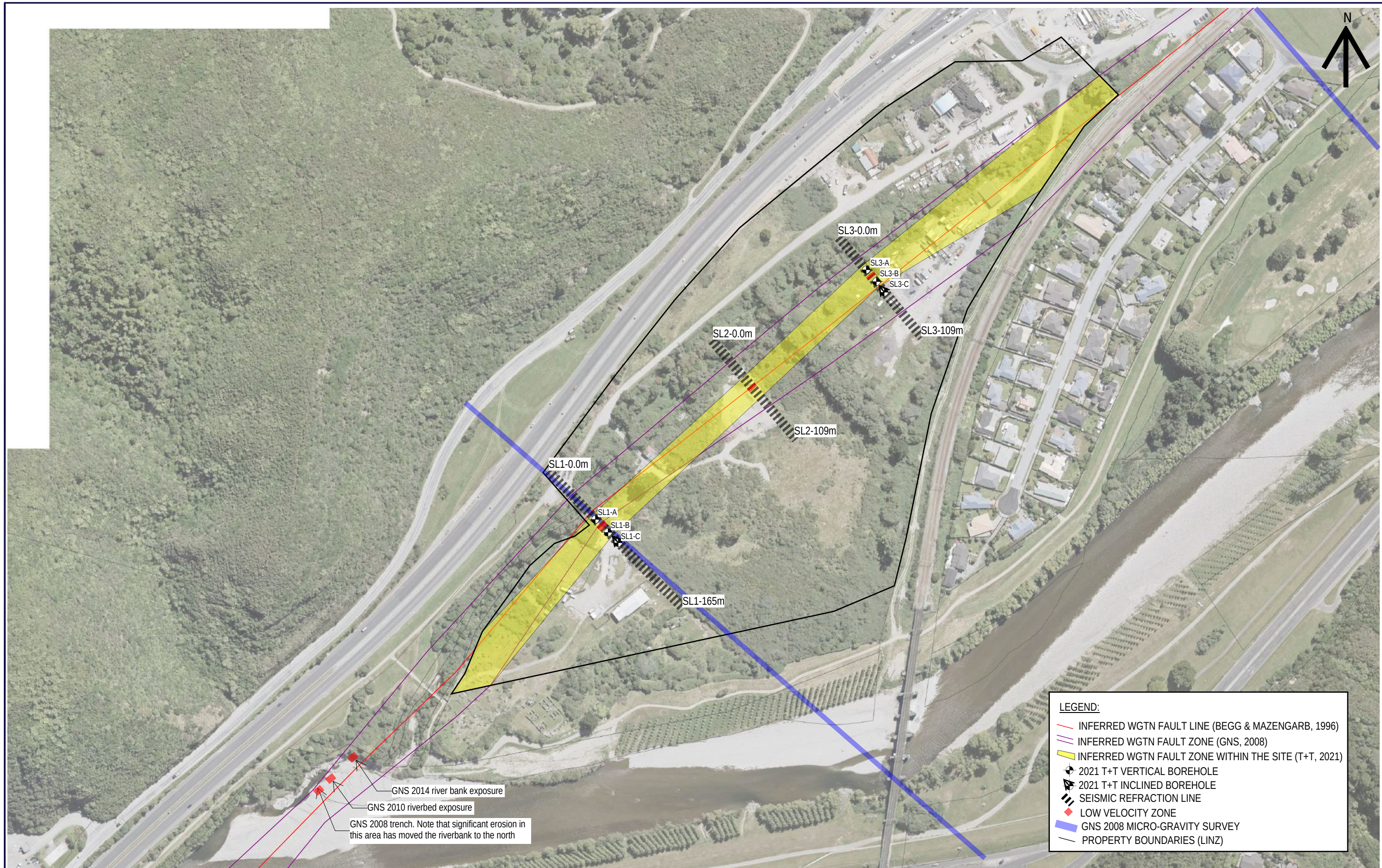
Nick Peters
Senior Engineering Geologist

TH

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Appendix A: Figures

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



- LEGEND:**
- INFERRED WGN FAULT LINE (BEGG & MAZENGARB, 1996)
 - INFERRED WGN FAULT ZONE (GNS, 2008)
 - INFERRED WGN FAULT ZONE WITHIN THE SITE (T+T, 2021)
 - 2021 T+T VERTICAL BOREHOLE
 - 2021 T+T INCLINED BOREHOLE
 - SEISMIC REFRACTION LINE
 - LOW VELOCITY ZONE
 - GNS 2008 MICRO-GRAVITY SURVEY
 - PROPERTY BOUNDARIES (LINZ)



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	

TE RANGIHAEATA / MANOR PARK DEVELOPMENT
WELLINGTON FAULT INVESTIGATION PLAN

FIG. No. A1

REV. 0



Project: Manor Park
Development

Figure A2: Sketch Cross Section of Seismic Line 1

Computed: DAHE 08/04/2021 Office: WGTN

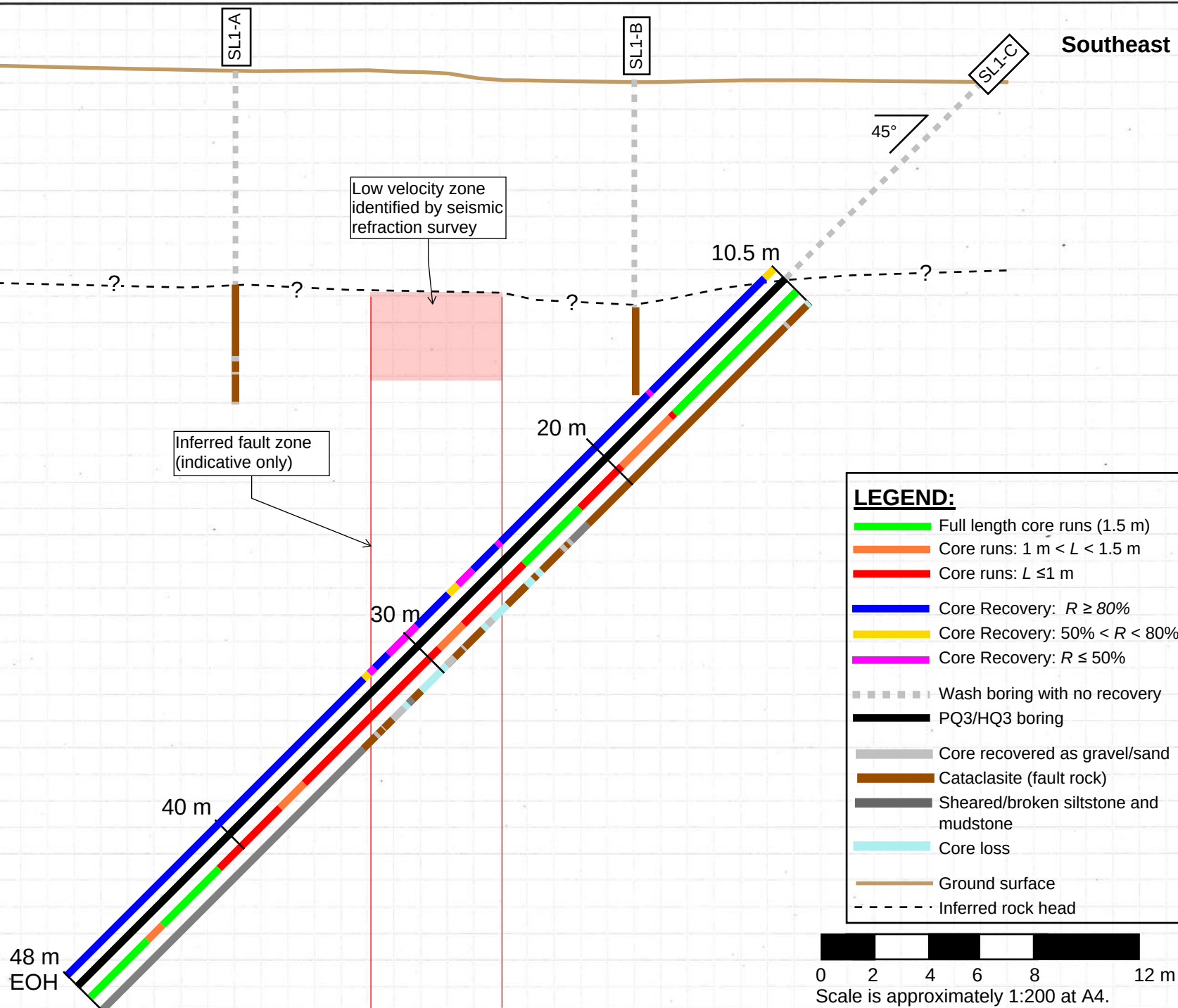
Checked: NCP 08/04/2021 Job No: 1015081

Revised: 20 File:

Checked: 20 Sheet No.

Northwest

Southeast





Project: Manor Park
Development

Figure A2: Sketch Cross Section of Seismic Line 3

Office: WGTN

Computed: DAHE 08/04/2021

Job No: 1015081

Checked: NCP 08/04/2021

Revised: 20

File:

Checked: 20 Sheet No.

Northwest

Southeast

48.5 m
EOH

40 m

30 m

20 m

14.8 m

Low velocity zone
identified by seismic
refraction survey

Inferred fault zone
(indicative only)

LEGEND:

- Full length core runs (1.5 m)
- Core runs: $1\text{ m} < L < 1.5\text{ m}$
- Core runs: $L \leq 1\text{ m}$
- Core Recovery: $R \geq 80\%$
- Core Recovery: $50\% < R < 80\%$
- Core Recovery: $R \leq 50\%$
- 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.

Appendix B: Borehole logs

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

BOREHOLE LOG

BOREHOLE No.:
SL1-A

SHEET: 2 OF 2

DRILLED BY: Cody Longstaff
LOGGED BY: TH

CHECKED: NCP

START DATE: 25/02/2021
FINISH DATE: 26/02/2021

CONTRACTOR: Webster Drilling

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
(NZTM2000) 1765107.63 mE

DIRECTION:
ANGLE FROM HORIZ.: -90°

R.L. GROUND: 26.10m
R.L. COLLAR:
DATUM: NZVD2016
SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation		Rock Weathering UW MS
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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

CORE PHOTOS

BOREHOLE No.: **SL1-A**

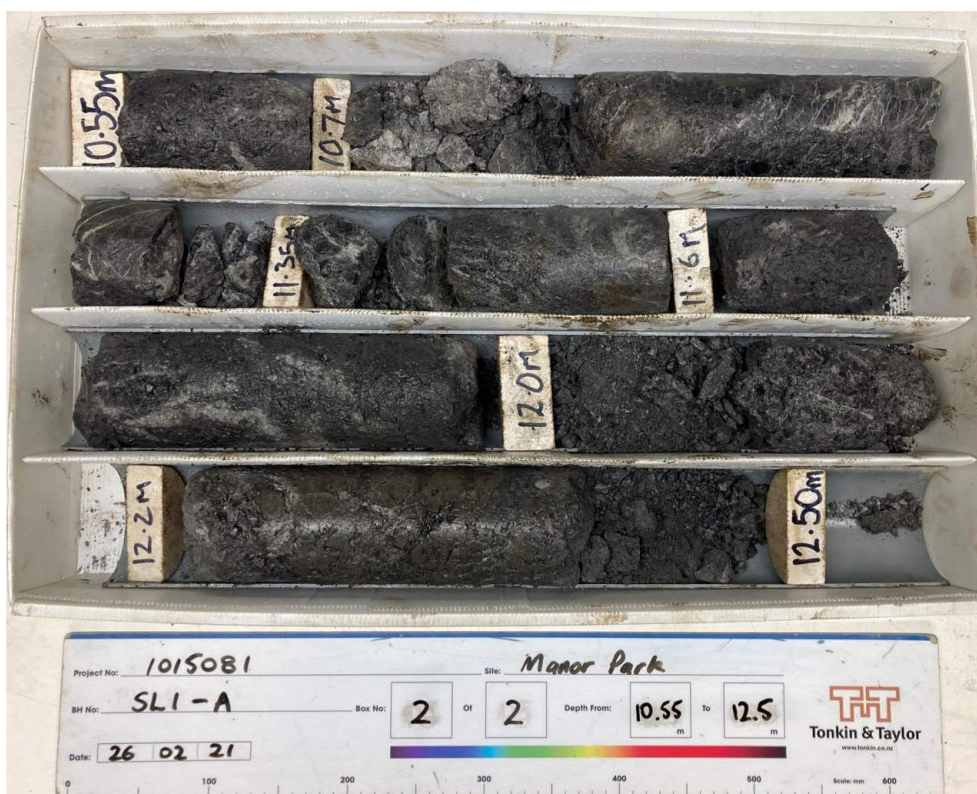
Hole Location: East side of culvert, adjacent to abandoned paintball stall and pedestrian access.

SHEET: 1 OF 1

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



8.00-10.55m



10.55-12.50m

BOREHOLE LOG

BOREHOLE No.:
SL1-B

SHEET: 1 OF 2

DRILLED BY: Jacob Fuller

LOGGED BY: TH

CHECKED: NCP

START DATE: 24/02/2021

FINISH DATE: 26/02/2021

CONTRACTOR: Webster Drilling

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
(NZTM2000) 1765118.18 mE

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE		Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS				Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
	SOIL: Classification, colour, consistency / density, moisture, plasticity	ROCK: Weathering, colour, fabric, name, strength, cementation									Defect Log	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations					
Rakaia Terrane	0.00m: Wash boring with no sample recovered.		UW MS MW SW CN	US MS MW SW CN							2000 1000 500 200 100 50 20			25 50 75	▼				
	8.50m: 8.5 to 8.6 m: Core loss. 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	HQ3								25/02/2021: Time of heading not recorded.	▼				
								25	1						26/02/2021: Morning reading.				
								24	2										
								23	3										
								22	4										
								21	5										
								20	6										
								19	7										
								18	8										
								17	9										
								16											

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

BOREHOLE LOG

BOREHOLE No.:
SL1-B

SHEET: 2 OF 2

DRILLED BY: Jacob Fuller

LOGGED BY: TH

CHECKED: NCP

START DATE: 24/02/2021

FINISH DATE: 26/02/2021

CONTRACTOR: Webster Drilling

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
(NZTM2000) 1765118.18 mE

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE	ROCK DEFECTS										Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
	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	Defect Log	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations			
Rakeia Terrane		UW MS MA CN	US MS MA CN	HQ3	100		15				2000 1000 500 200 100 50 20					
				HQ3	100		11					0				
	11.8m: END OF BOREHOLE						12									
							13									
							13									
							12									
							14									
							11									
							15									
							10									
							16									
							9									
							17									
							8									
							18									
							7									
							19									
							6									

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.

SHEET: 1 OF 1

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



8.50-11.40m



11.40-11.80m

BOREHOLE LOG

BOREHOLE No.:
SL1-C

SHEET: 2 OF 5

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 10/03/2021

CONTRACTOR: Webster Drilling

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: 5441199.09 mN
(NZTM2000) 1765127.21 mE

DIRECTION: 315°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total
Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS				Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
										Defect Log relative to inclination	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations					
	SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	UW MS MW CW US MS MW CW US MS MW CW US MS MW CW	US MS MW CW US MS MW CW US MS MW CW US MS MW CW															
Rakala Terrane	10.50m: Core loss.						18											
	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	70		11					0						
	11.60 - 11.75m: Recovered as fine to coarse, angular gravel.			PQ3	100		17					0						
	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											
	12.80 - 13.10m: Crushed siltstone is dark grey with argillite inclusions.			PQ3	100		13					0						
	14.55 - 14.65m: Argillite bands dip at approximately 45° in the core. Bands are estimated to be subvertical when in-situ.			PQ3	100		15					0						
	14.75 - 14.80m: Large argillite band within siltstone.						15											
	15.75 - 15.95m: Thick, subvertical argillite band. Argillite is moderately weathered, dark grey, weak.			PQ3	100		14					0						
	16.80 - 17.00m: Argillite bands dip at approximately 45° in the core. Bands are estimated to be subvertical when in-situ.			PQ3	50		17					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		13					0						
				PQ3	100		12					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



Tonkin+Taylor

BOREHOLE LOG

BOREHOLE No.:

SL1-C

SHEET: 4 OF 5

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 10/03/2021

CONTRACTOR: Webster Drilling

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: 5441199.09 mN
(NZTM2000) 1765127.21 mE

DIRECTION: 315°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 25.50m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total
Station/Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS				Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
										Defect Log relative to inclination	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations					
Rakaia Terrane	SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	UW M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15 M16 M17 M18 M19 M20 M21 M22 M23 M24 M25 M26 M27 M28 M29 M30 M31 M32 M33 M34 M35 M36 M37 M38 M39 M40 M41 M42 M43 M44 M45 M46 M47 M48 M49 M50 M51 M52 M53 M54 M55 M56 M57 M58 M59 M60 M61 M62 M63 M64 M65 M66 M67 M68 M69 M70 M71 M72 M73 M74 M75 M76 M77 M78 M79 M80 M81 M82 M83 M84 M85 M86 M87 M88 M89 M90 M91 M92 M93 M94 M95 M96 M97 M98 M99 M100	US S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18 S19 S20 S21 S22 S23 S24 S25 S26 S27 S28 S29 S30 S31 S32 S33 S34 S35 S36 S37 S38 S39 S40 S41 S42 S43 S44 S45 S46 S47 S48 S49 S50 S51 S52 S53 S54 S55 S56 S57 S58 S59 S60 S61 S62 S63 S64 S65 S66 S67 S68 S69 S70 S71 S72 S73 S74 S75 S76 S77 S78 S79 S80 S81 S82 S83 S84 S85 S86 S87 S88 S89 S90 S91 S92 S93 S94 S95 S96 S97 S98 S99 S100	PQ3	0		4											
	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.			PQ3	75		31											
	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.			PQ3	100		32											
				PQ3	100		33											
				PQ3	100		34											
				PQ3	100		35											
				PQ3	100		36											
				PQ3	100		37											
				PQ3	88		-1											
				PQ3	100		-2											
				PQ3	100													
				PQ3	90													

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

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.

SHEET: 1 OF 9

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

SHEET: 2 OF 9

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



14.85-17.00m



17.00-19.10m

CORE PHOTOS

BOREHOLE No.: **SL1-C**

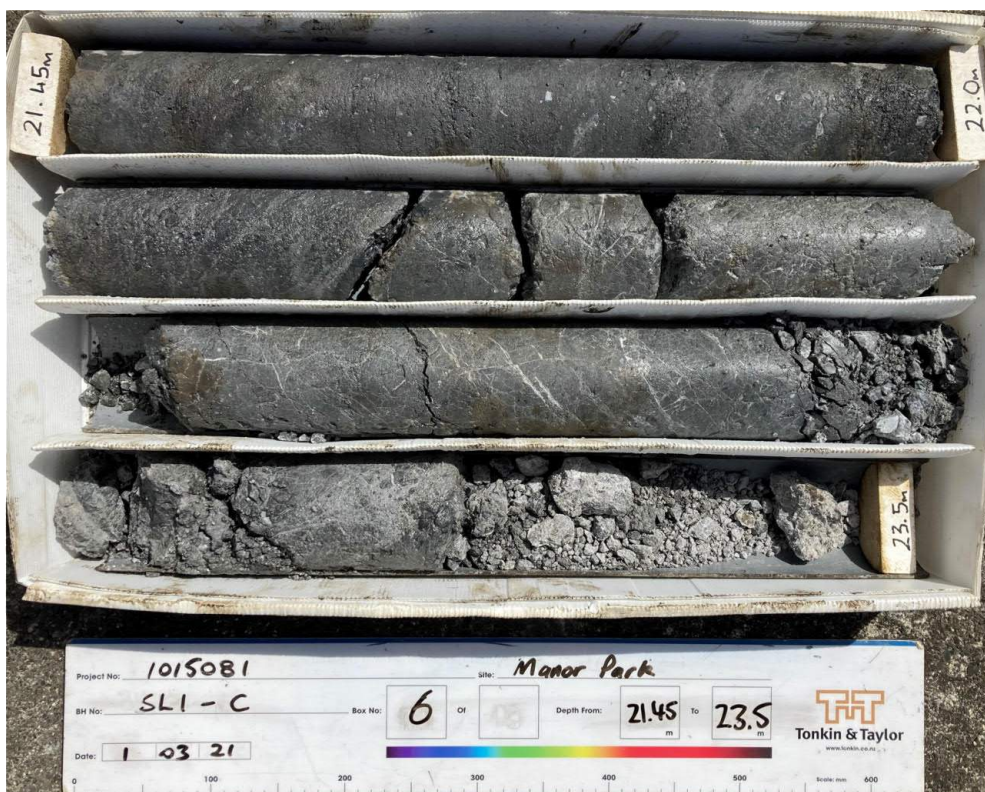
Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

SHEET: 3 OF 9

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

SHEET: 4 OF 9

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



23.50-26.00m



26.00-28.76m

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.

SHEET: 5 OF 9

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

SHEET: 6 OF 9

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

SHEET: 7 OF 9

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



38.54-40.71m



40.71-42.82m

CORE PHOTOS

BOREHOLE No.: **SL1-C**

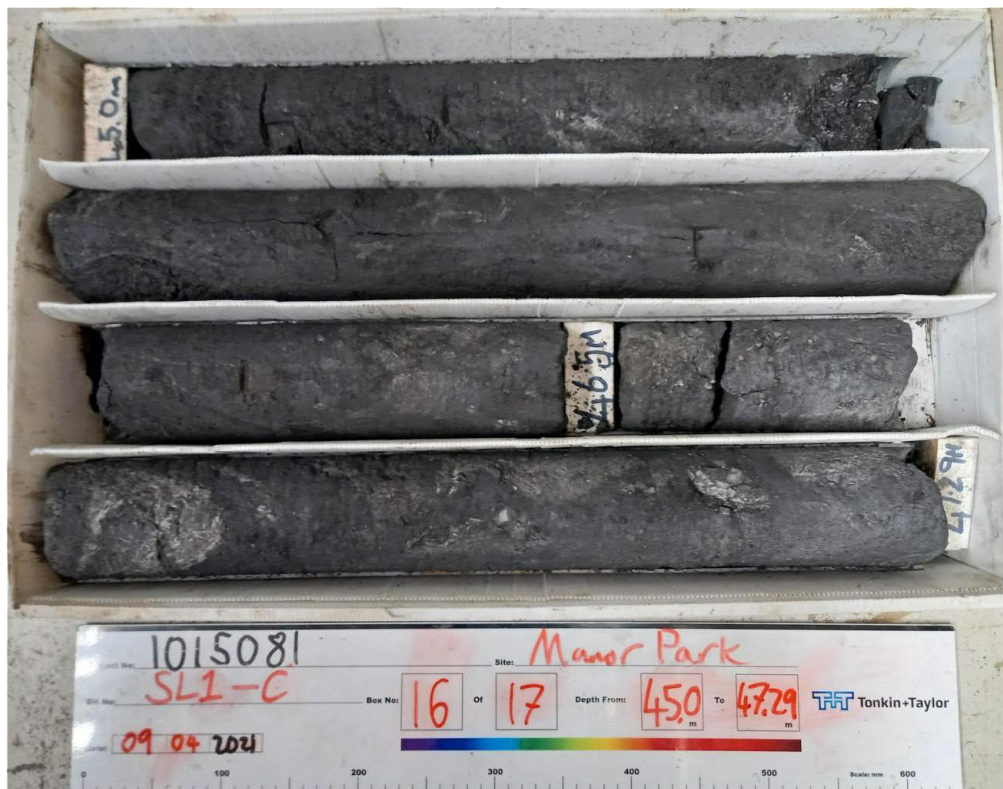
Hole Location: In line with SL1-A and SL1-B, on the driveway to the abandoned paintball stall on the vacant lot.

SHEET: 8 OF 9

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

SHEET: 9 OF 9

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



47.29-48.00m

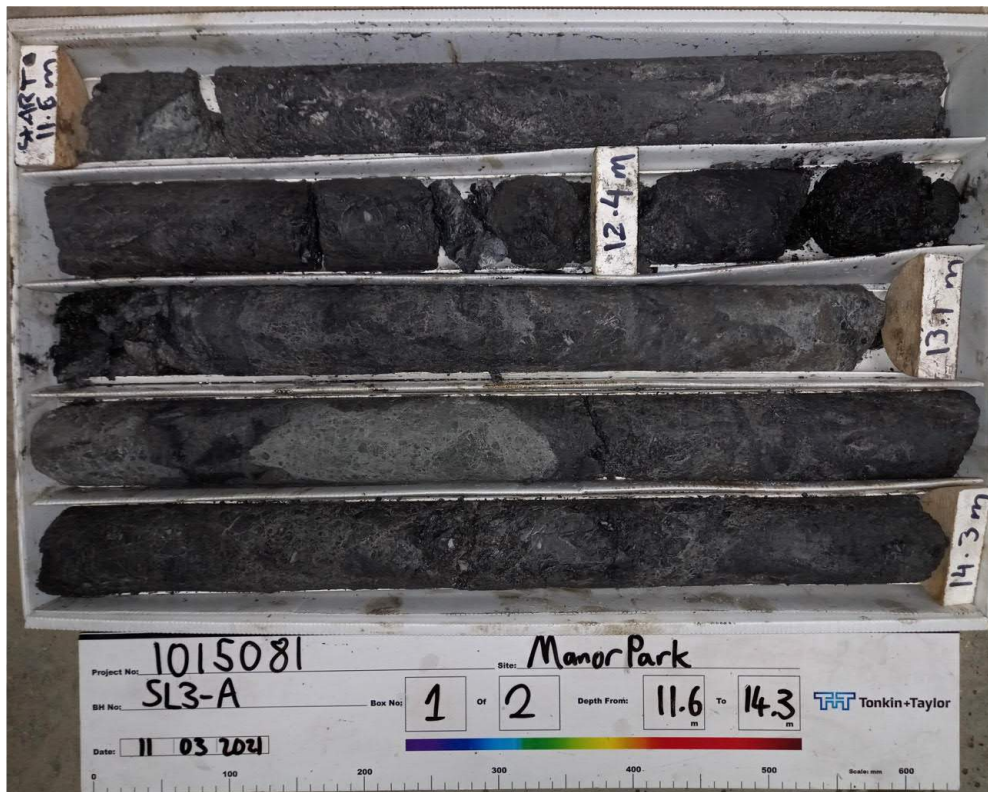
CORE PHOTOS

BOREHOLE No.: **SL3-A**

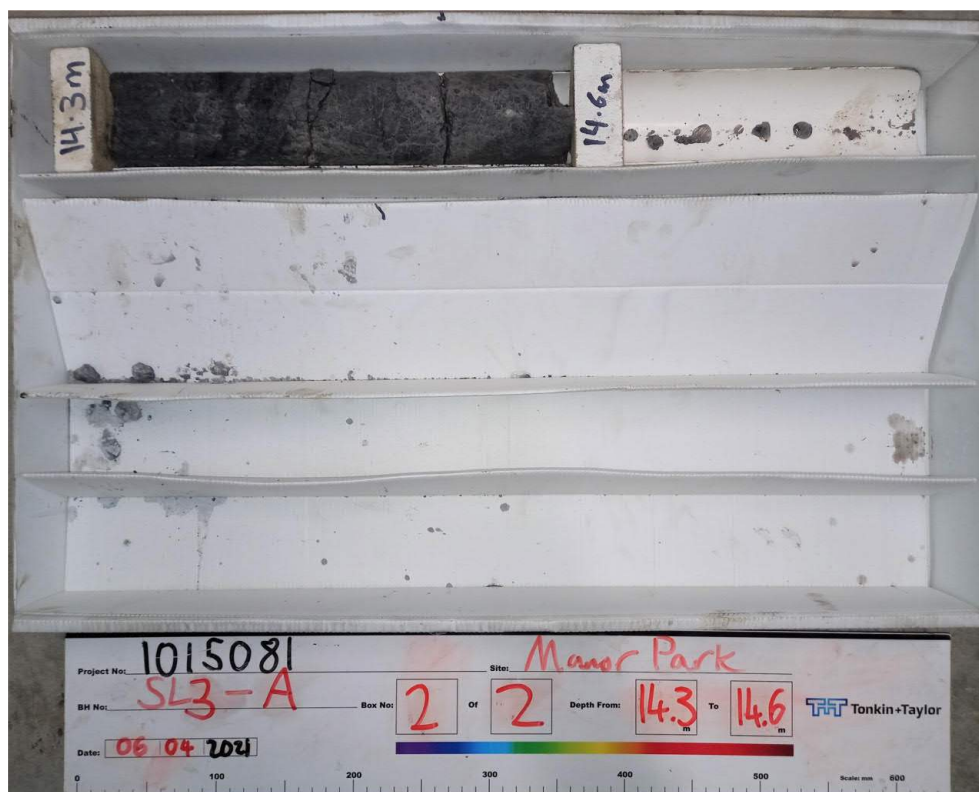
Hole Location: At far western corner of the northernmost vacant industrial lot.

SHEET: 1 OF 1

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



11.60-14.30m



14.30-14.60m

BOREHOLE LOG

BOREHOLE No.:
SL3-B

SHEET: 1 OF 2

DRILLED BY: Jacob Fuller

LOGGED BY: TH

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 02/03/2021

CONTRACTOR: Webster Drilling

PROJECT: Manor Park Development

JOB No.: 1015081.0000

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

CO-ORDINATES: 5441422.77 mN
(NZTM2000) 1765347.82 mE

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 32.20m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE	Rock Weathering USF USM MSF MSM CSF CSM USF USM MSF MSM CSF CSM	Rock Strength USF USM MSF MSM CSF CSM	Sampling Method USF USM MSF MSM CSF CSM	Core Recovery (%) USF USM MSF MSM CSF CSM	Testing USF USM MSF MSM CSF CSM	RL (m) USF USM MSF MSM CSF CSM	Depth (m) USF USM MSF MSM CSF CSM	Graphic Log USF USM MSF MSM CSF CSM	ROCK DEFECTS				Fluid Loss (%) USF USM MSF MSM CSF CSM	Water Level USF USM MSF MSM CSF CSM	Casing USF USM MSF MSM CSF CSM	Installation USF USM MSF MSM CSF CSM	Core Box No USF USM MSF MSM CSF CSM
	SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation									Defect Log	Fracture Spacing (mm) 2000 1000 500 200 100 50 20	RQD (%)	Description & Additional Observations					
	0.00m: Wash boring with no sample recovered.							32										
								31										
								2										
								30										
								29										
								28										
								27										
								26										
								25										
								24										
								23										

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

DRILLED BY: Jacob Fuller

LOGGED BY: TH

CHECKED: NCP

START DATE: 01/03/2021

FINISH DATE: 02/03/2021

CONTRACTOR: Webster Drilling

PROJECT: Manor Park Development

JOB No.: 1015081.0000

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

CO-ORDINATES: 5441422.77 mN
(NZTM2000) 1765347.82 mE

DIRECTION:

ANGLE FROM HORIZ.: -90°

R.L. GROUND: 32.20m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total
Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	Rock Weathering UW MS MW SW CN	Rock Strength US MS MW SW CN	Sampling Method		Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS					Fluid Loss (%) 25 50 75	Water Level	Casing	Installation	Core Box No
				HQ3	Core Recovery (%)						Defect Log	Fracture Spacing (mm) 2000 800 600 400 200 100 50 20	RQD (%)	Description & Additional Observations						
	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. 13.00m: Core loss. 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.	UW MS MW SW CN	US MS MW SW CN	HQ3	66			22												
				HQ3	80			21												
				HQ3	112			20												
				HQ3	100			19												
								18												
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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

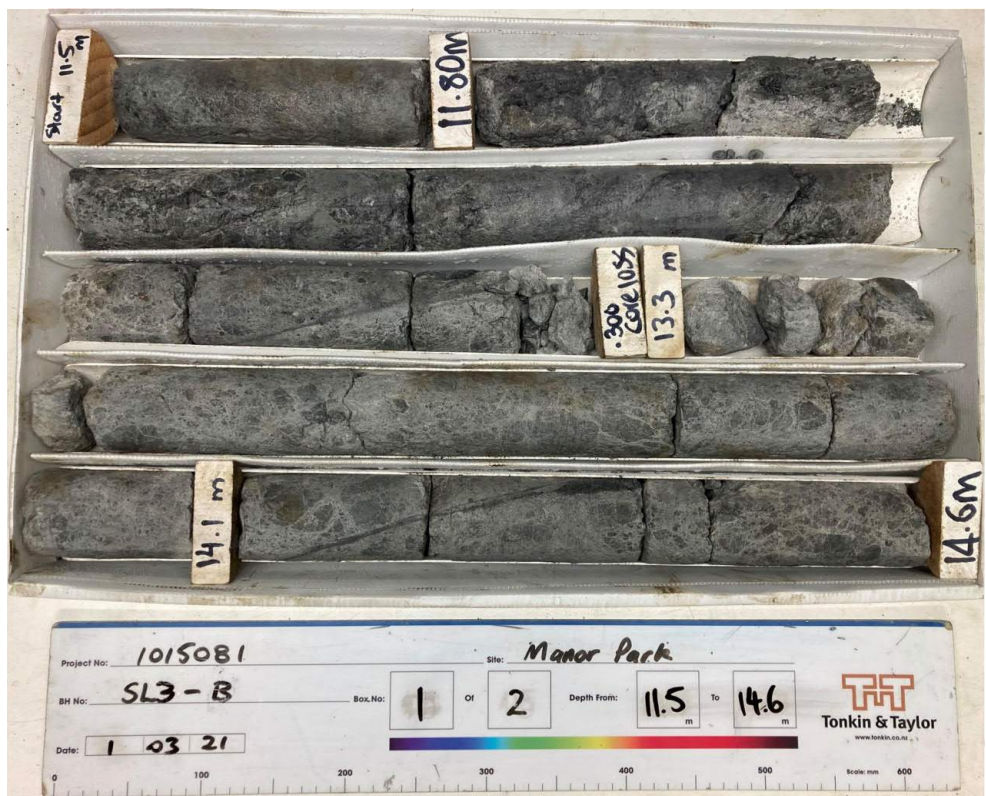
CORE PHOTOS

BOREHOLE No.: **SL3-B**

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

SHEET: 1 OF 1

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



11.50-14.60m



14.60-14.80m

BOREHOLE LOG

BOREHOLE No.:
SL3-C

SHEET: 1 OF 5

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 12/03/2021

FINISH DATE: 23/03/2021

CONTRACTOR: Webster Drilling

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
(NZTM2000) 1765355.11 mE

DIRECTION: 310°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total
Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS				Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
										Defect Log relative to inclination	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations					
	SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	UW MS MC CN	US MS MC CN	US MS MC CN	US MS MC CN					2000 1000 500 200 100 50 20				25 50 75				
	0.00m: Dark. Wash boring with no sample recovered.							32										
								1										
								2										
								3										
								4										
								5										
								6										
								7										
								8										
								9										

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: 2 OF 5

DRILLED BY: Cody Longstaff
LOGGED BY: DAHE
CHECKED: NCP
START DATE: 12/03/2021
FINISH DATE: 23/03/2021
CONTRACTOR: Webster Drilling

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
(NZTM2000) 1765355.11 mE
DIRECTION: 310°
ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m
R.L. COLLAR:
DATUM: NZVD2016
SURVEY: Total Station/Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE	ROCK DEFECTS										Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
		Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	Defect Log relative to inclination	Fracture Spacing (mm)	RQD (%)				
	SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	UW MS MW CW US MS MW CW US MS MW CW	US MS MW CW US MS MW CW							2000 1500 1000 500 200 100 50 20						
Rakaia Terrane								25								
								11								
								24								
								12								
								23								
								13								
								14								
								22								
	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				
	17.80 - 17.85m: Colour changes to dark grey. Band of dark grey mudstone across sample.							20								
	18.45 - 18.75m: Colour changes to dark grey. Matrix composed of dark grey clay. Weak.			PQ3	93			18				0				
								19								
	19.55 - 19.65m: Dark grey, weak.							19				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: 3 OF 5

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 12/03/2021

FINISH DATE: 23/03/2021

CONTRACTOR: Webster Drilling

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
(NZTM2000) 1765355.11 mE

DIRECTION: 310°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total
Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE		Rock Weathering		Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS				Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
	SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation		UW	MS								Defect Log relative to inclination	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations					
Rakala Terrane	20.20 - 20.50m: Colour changes to dark grey. Matrix composed of dark grey clay.					PQ3	100		18					0						
	20.50 - 21.10m: Material becomes weak. Partially recovered as fine to coarse sand and fine to coarse gravel; dark grey.					PQ3	100		21					0						
	22.05 - 22.25m: Dark grey. Cataclasite with dark grey matrix. Weak. Abrupt transition.					PQ3	100		22					0						
						PQ3	100		23					0						
						PQ3	100		24					0						
	25.00 - 25.20m: Partially recovered as fine to coarse, angular gravel and sand.					PQ3	100		25					0						
	25.30 - 25.45m: Rock is recovered as fine to coarse, angular gravel and sand.					PQ3	80		26					0						
	25.45 - 25.90m: Colour darkens to dark grey.					PQ3	100		27					0						
	25.60 - 25.62m: Pale grey band of cataclasite at 45°. Band is estimated to be subvertical when in-situ.					PQ3	77		28					0						
	25.90 - 25.95m: Recovered as fine to coarse, angular gravel.					PQ3	100		29					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.					PQ3	100							0						
	26.55 - 26.65m: Recovered as fine to coarse, angular gravel.					PQ3	100							0						
	26.80 - 26.85m: Recovered as fine to coarse, angular gravel.					PQ3	100							0						
	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.					PQ3	77		13					0						
	27.15 - 27.25m: Recovered as fine to coarse, angular gravel.					PQ3	100		12					0						
	27.45 - 27.50m: Recovered as fine to coarse, angular gravel.					PQ3	100							0						
	27.50m: Core loss.													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.					PQ3	100							0						
	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.					PQ3	100							0						
	29.15 - 29.25m: Sheared rock. Very closely spaced joints.					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

DRILLED BY: Cody Longstaff

LOGGED BY: DAHE

CHECKED: NCP

START DATE: 12/03/2021

FINISH DATE: 23/03/2021

CONTRACTOR: Webster Drilling

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
(NZTM2000) 1765355.11 mE

DIRECTION: 310°

ANGLE FROM HORIZ.: -45°

R.L. GROUND: 32.30m

R.L. COLLAR:

DATUM: NZVD2016

SURVEY: Total
Station\Surveyed

GEOLOGICAL UNIT	DESCRIPTION OF CORE	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS				Fluid Loss (%)	Water Level	Casing	Installation	Core Box No																																																																																																																																																																																																																																																																																																																																																																																																				
										Defect Log relative to inclination	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations																																																																																																																																																																																																																																																																																																																																																																																																									
Rakaia Terrane	SOIL: Classification, colour, consistency / density, moisture, plasticity ROCK: Weathering, colour, fabric, name, strength, cementation	UW M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15 M16 M17 M18 M19 M20 M21 M22 M23 M24 M25 M26 M27 M28 M29 M30 M31 M32 M33 M34 M35 M36 M37 M38 M39 M40 M41 M42 M43 M44 M45 M46 M47 M48 M49 M50 M51 M52 M53 M54 M55 M56 M57 M58 M59 M60 M61 M62 M63 M64 M65 M66 M67 M68 M69 M70 M71 M72 M73 M74 M75 M76 M77 M78 M79 M80 M81 M82 M83 M84 M85 M86 M87 M88 M89 M90 M91 M92 M93 M94 M95 M96 M97 M98 M99 M100	US S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12 S13 S14 S15 S16 S17 S18 S19 S20 S21 S22 S23 S24 S25 S26 S27 S28 S29 S30 S31 S32 S33 S34 S35 S36 S37 S38 S39 S40 S41 S42 S43 S44 S45 S46 S47 S48 S49 S50 S51 S52 S53 S54 S55 S56 S57 S58 S59 S60 S61 S62 S63 S64 S65 S66 S67 S68 S69 S70 S71 S72 S73 S74 S75 S76 S77 S78 S79 S80 S81 S82 S83 S84 S85 S86 S87 S88 S89 S90 S91 S92 S93 S94 S95 S96 S97 S98 S99 S100	PQ3	100		11		2000 1000 500 200 100 50 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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: 5 OF 5

DRILLED BY: Cody Longstaff
LOGGED BY: DAHE
CHECKED: NCP
START DATE: 12/03/2021
FINISH DATE: 23/03/2021
CONTRACTOR: Webster Drilling

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
(NZTM2000) 1765355.11 mE

R.L. GROUND: 32.30m
R.L. COLLAR:
DATUM: NZVD2016
SURVEY: Total Station/Surveyed

DIRECTION: 310°
ANGLE FROM HORIZ.: -45°

GEOLOGICAL UNIT	DESCRIPTION OF CORE	Rock Weathering	Rock Strength	Sampling Method	Core Recovery (%)	Testing	RL (m)	Depth (m)	Graphic Log	ROCK DEFECTS				Fluid Loss (%)	Water Level	Casing	Installation	Core Box No
										Defect Log relative to inclination	Fracture Spacing (mm)	RQD (%)	Description & Additional Observations					
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.	UW UW																

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

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

SHEET: 1 OF 8

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



14.80-17.00m



17.00-19.29m

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

SHEET: 2 OF 8

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



19.29-21.70m



21.70-23.67m

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

SHEET: 3 OF 8

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



23.67-25.88m



25.88-28.60m

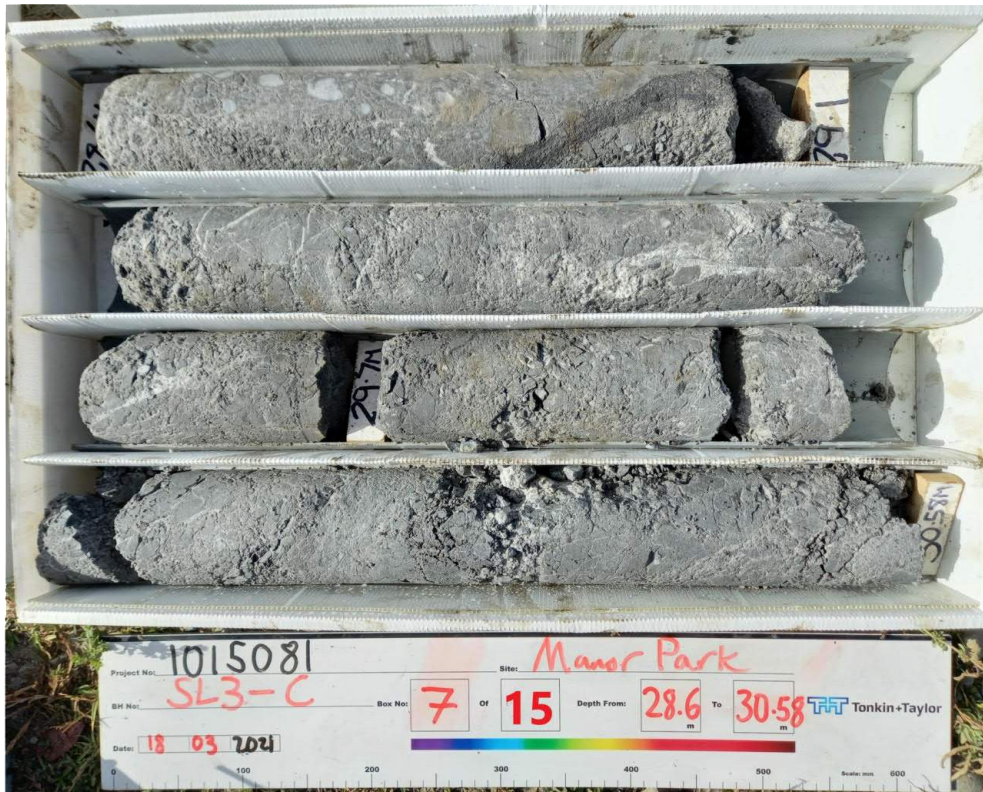
CORE PHOTOS

BOREHOLE No.: **SL3-C**

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

SHEET: 4 OF 8

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



28.60-30.58m



30.58-32.50m

CORE PHOTOS

BOREHOLE No.: **SL3-C**

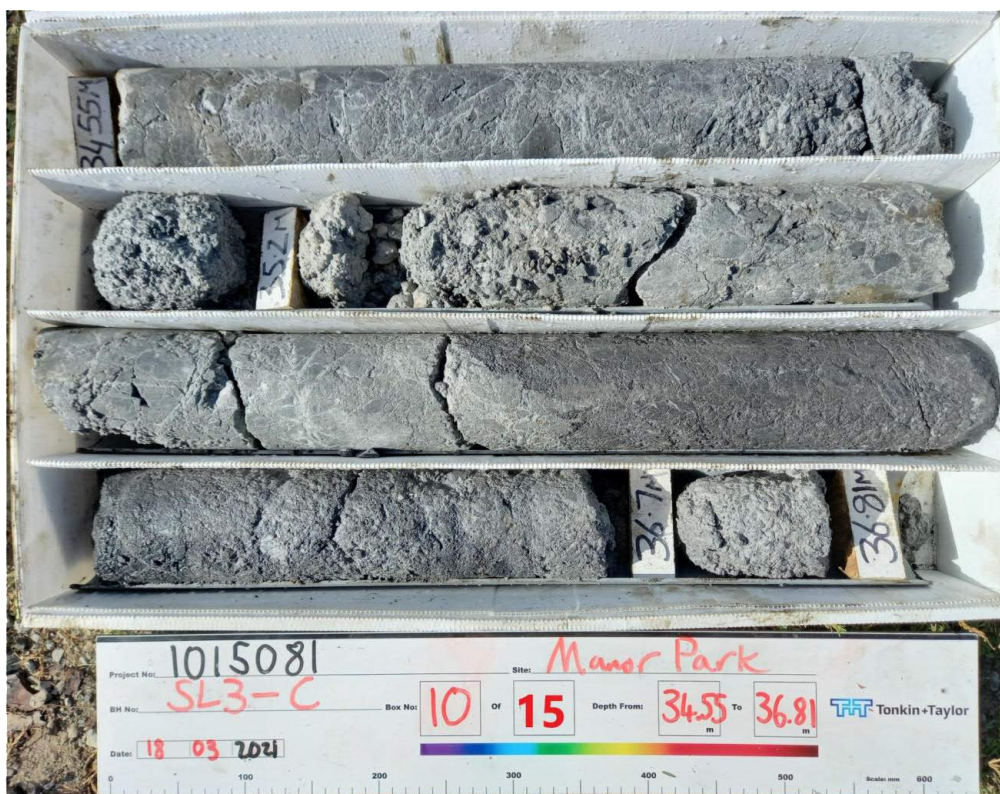
Hole Location: At far western corner of the northernmost vacant industrial lot. In line with SL3-A and SL3-B

SHEET: 5 OF 8

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



32.50-34.55m



34.55-36.81m

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

SHEET: 6 OF 8

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



36.81-39.45m



39.45-41.38m

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

SHEET: 7 OF 8

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



41.38-43.35m



43.35-45.72m

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

SHEET: 8 OF 8

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

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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 MagnumTM 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).

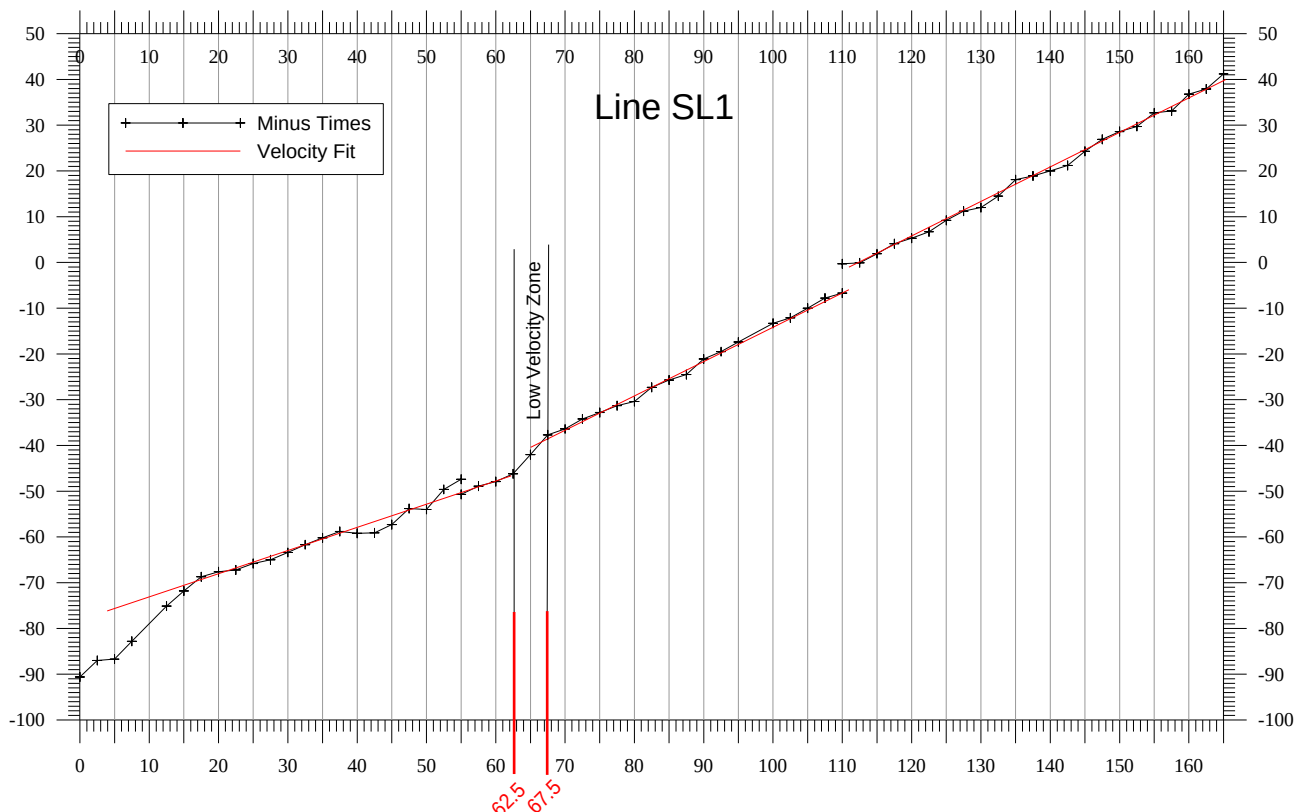
The following is a brief description of any features found on each of the seismic lines. The purpose of the survey was to locate low velocity zones and/or steps associated with the Wellington Fault.

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

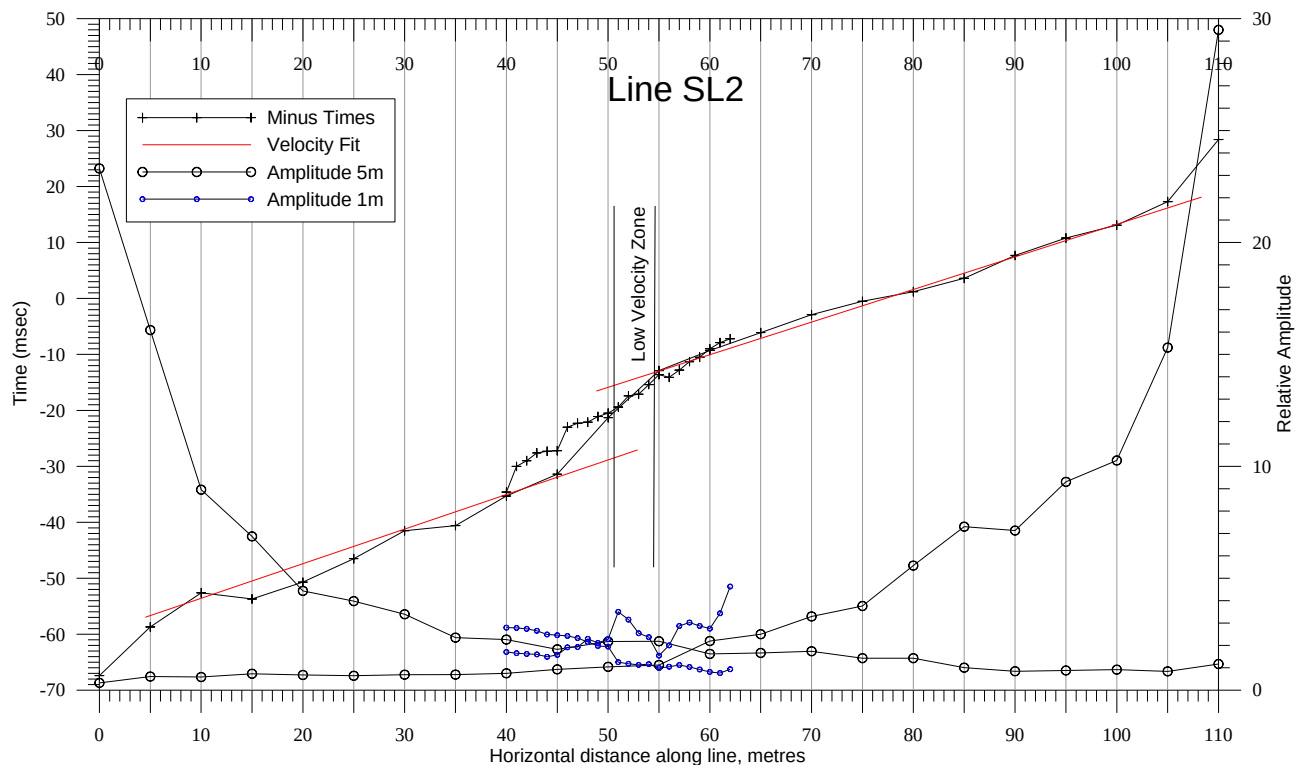
This line to the east of Benmore Crescent, beside the stream, North of SL1, then crossed the stream and ran up the slope to a flat area of fill. The total length of the line is 110 metres. The geophone spacing was 5m.

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.



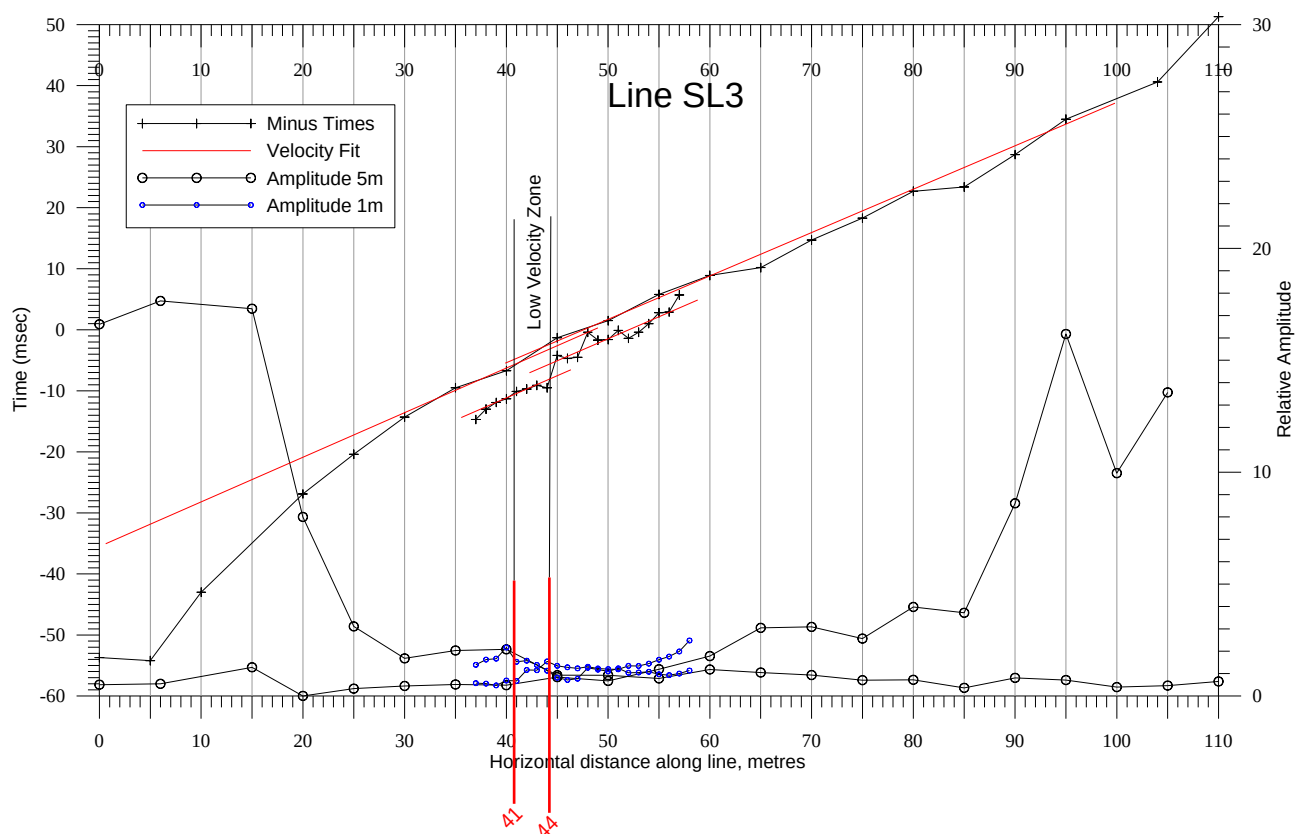
4.3 Seismic Line 3

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.

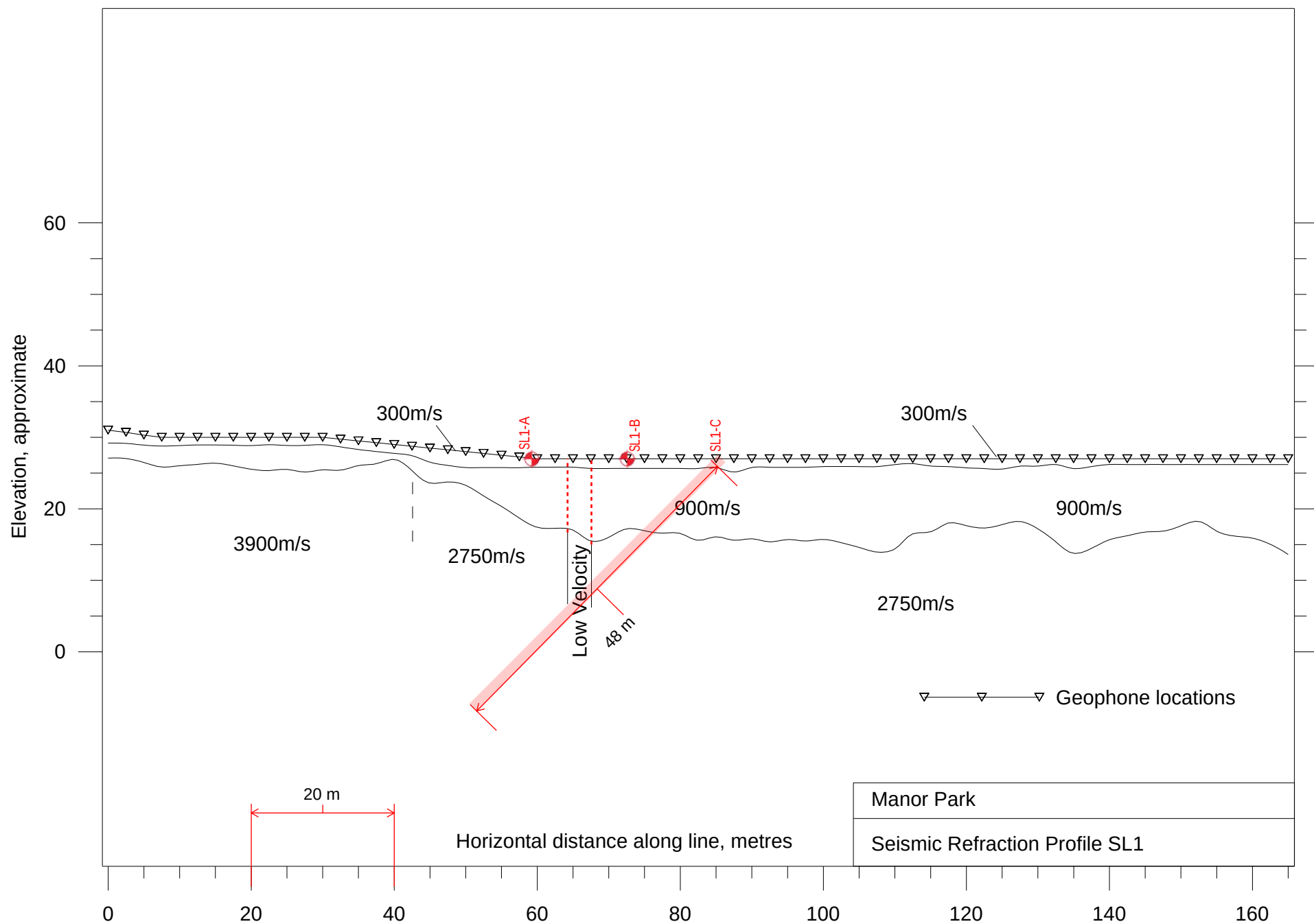
After firing 6 shots, the arrival times for the two offset shots were picked and a velocity plot of the line was made to locate the likely position of the low velocity zone. The geophones were then placed at 1m spacing over the likely zone and two more shots, at the offset positions were fired.

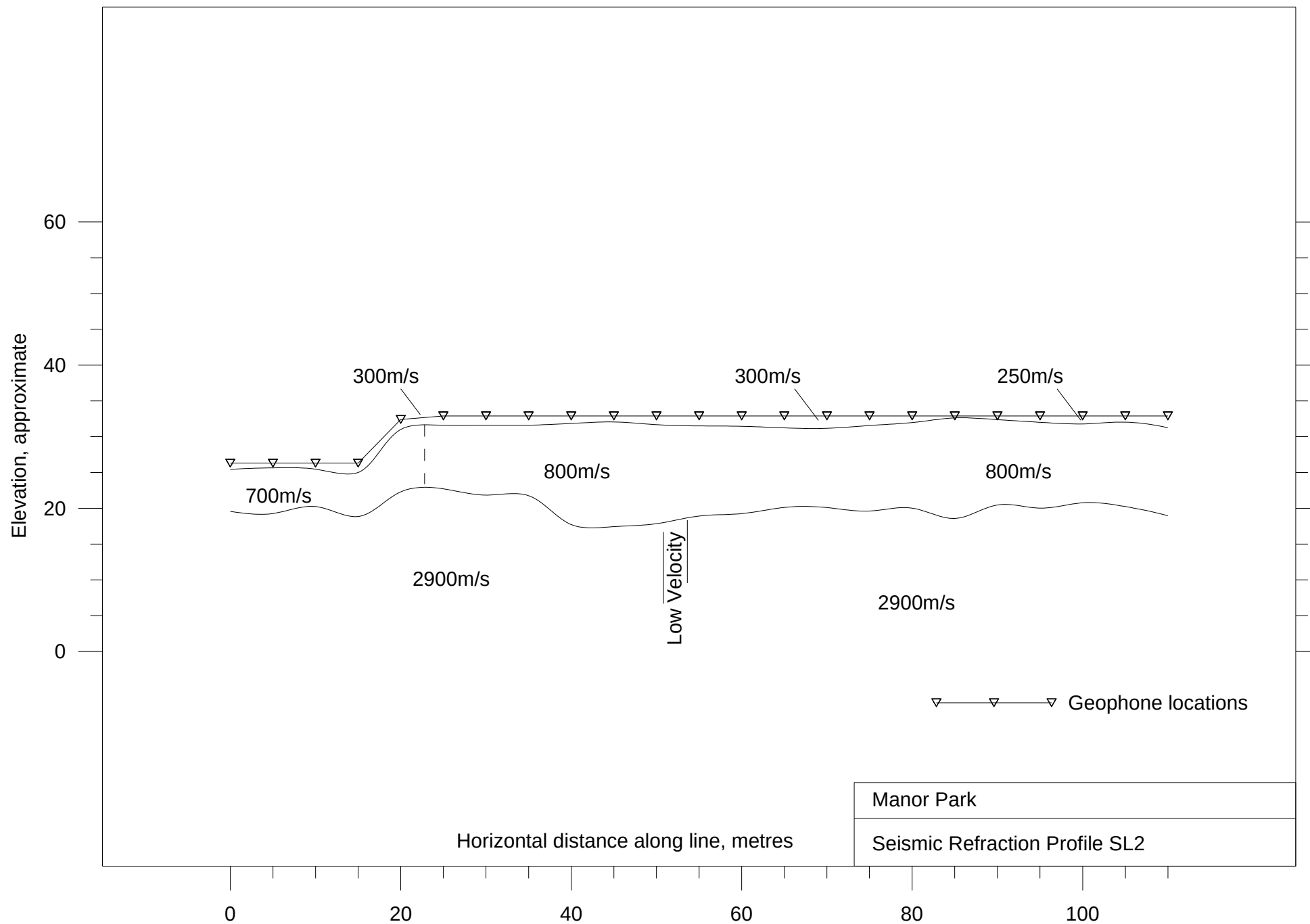
A surface layer of 300m/s is present along all of the line and an intermediate layer of 600 to 800m/s is also present. The rock layer has a velocity of 2900m/s along the length of the line.

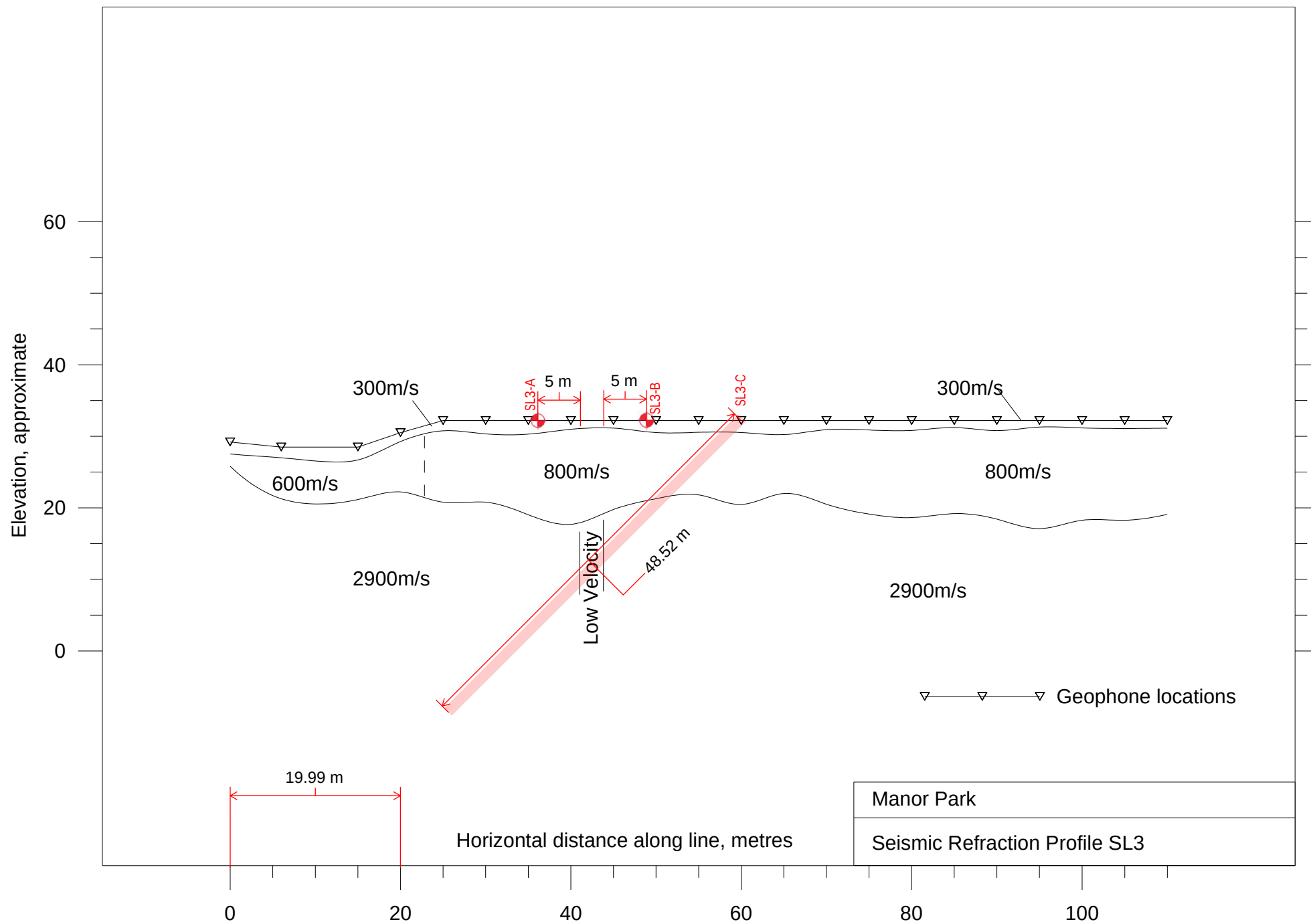
The plot below shows the times for the offset shots from peg zero subtracted from the times for the offset shot at the far end of the line. The slope of the line is related to the velocity of the rock where the refraction is from the rock. A low velocity zone with a loss less than 1 milliseconds was 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.



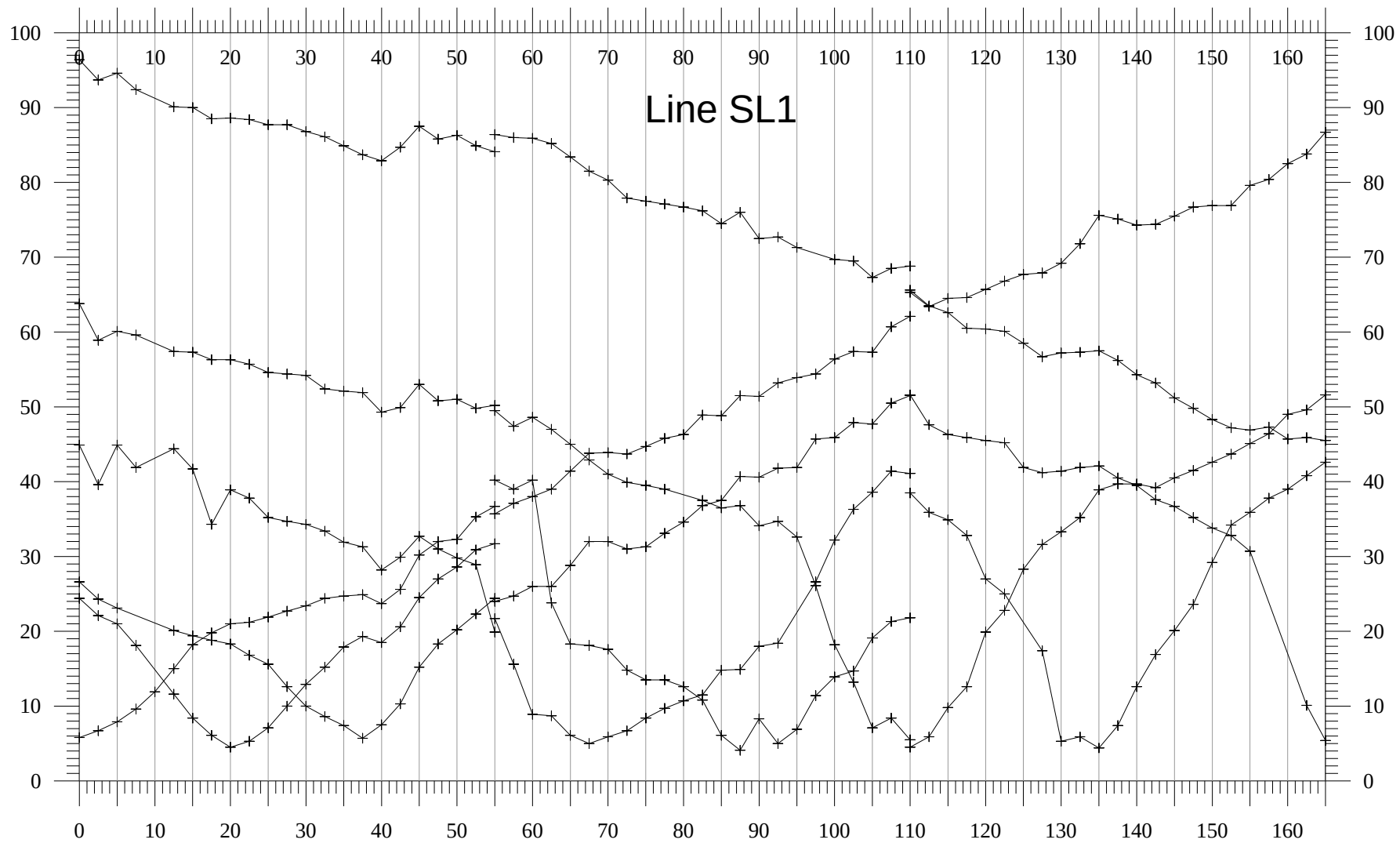
Appendix A: Seismic Refraction Cross Section

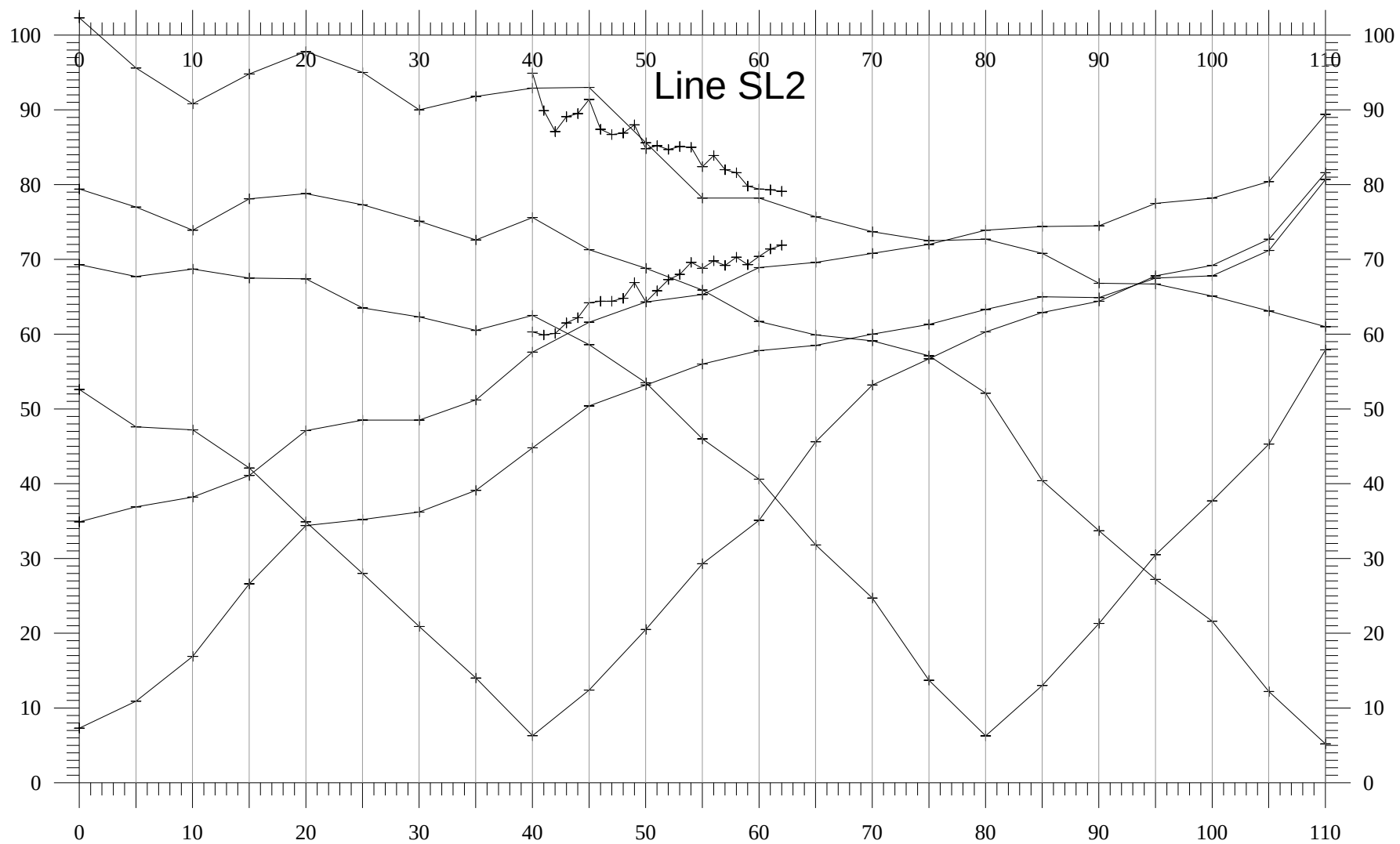


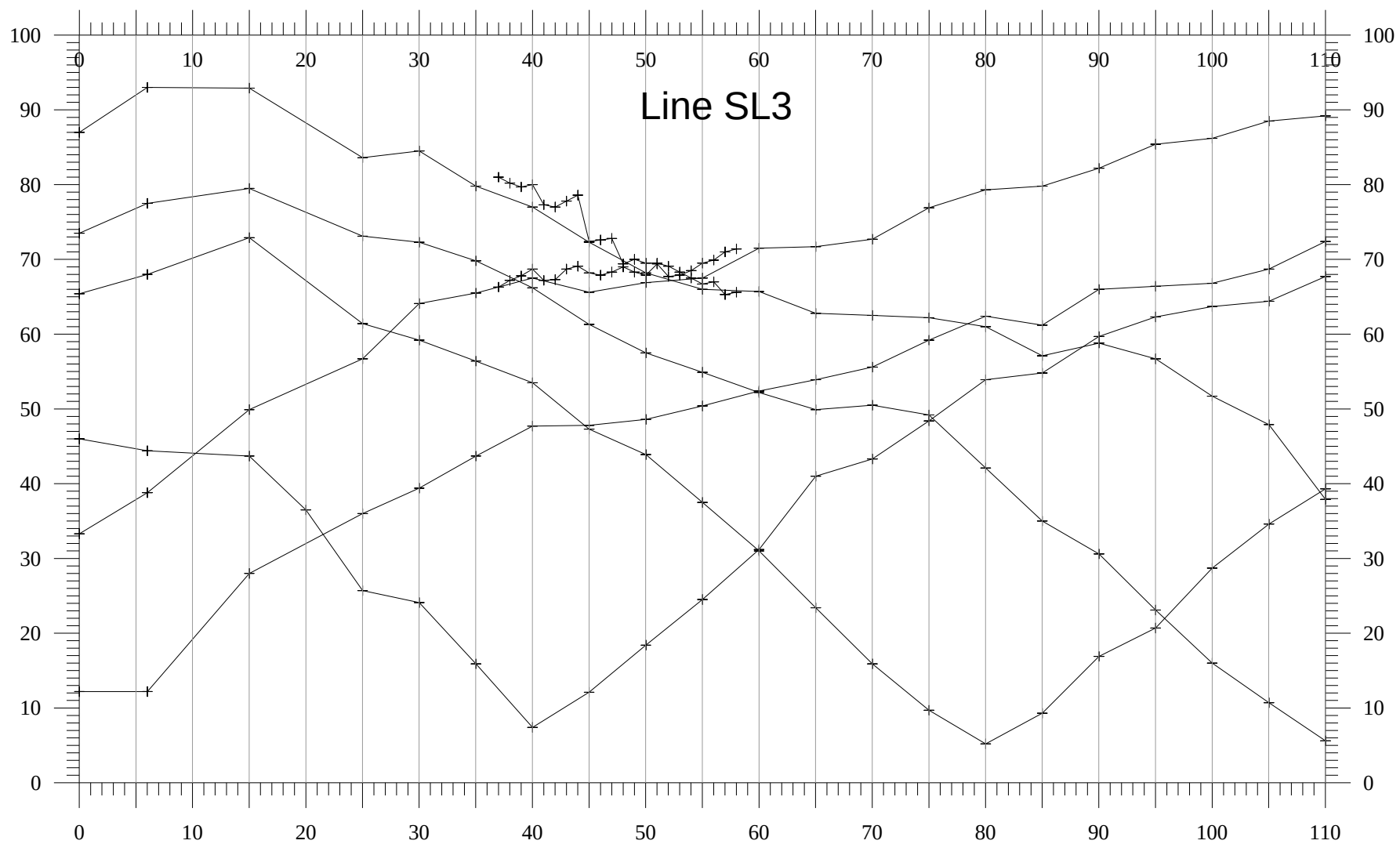




Appendix B: Time Distance Plots







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