ANNEXURE G:

GEOTECHNICAL REPORT

REPORT ON:
GEOPHYSICAL GROUND CONDITION SCREENING

PROJECT:
HAREWOOD CAR STORAGE YARD

CLIENT:

CAR HAULWAYS LTD

PO BOX 22740

OTAHUHU, AUCKLAND 1640

R-160305066

EXECUTIVE SUMMARY

Car Haulways Ltd engaged Resource Development Contractors Ltd (RDCL) to undertake a Surface Wave Geophysical and targeted trial pit investigation at a proposed car storage facility in Harewood, Christchurch. The work was to help "future proof" the site so that, prior to sealing, ground remediation could be undertaken to preserve options for building.

The geophysical investigation was conducted along eight (8) profiles to provide a grid of shear wave velocity (Vs) profiles across the site.

Geophysical scanning indicates the site is fairly consistent with isolated pockets of "soft" ground.

Trial pitting suggests that the site comprises un-engineered fill, with "soft" spots being silty sand with likely some organics and petroleum based products from odour.

We consider that:

- The site is generally suitable for a car park preferably with rolling to identify soft spots and remedial work to protect pavements under heavy loads.
- For buildings, either shallow foundations with targeted ground shallow improvement and building able to tolerate potential deformation are likely, or piles. This is because the site is underlain by un-engineered fill with a low certainty of condition. For higher value, heavy or sensitive buildings, piles would be required to penetrate fill to natural ground and would remove any uncertainty around foundations.
- We consider that a gas drainage system is required in all case to manage methane and petroleum.

In terms of improving the site, we recommend for a:

- Carpark proof rolling and stripping to remove unsuitables near surface; and
- Light building, shallow compaction using a roller or falling weight with deflection testing for confirmation.

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FIGURES

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1 INTRODUCTION

Car Haulways Ltd (the client) engaged Resource Development Contractors Limited (RDCL) to undertake a Surface Wave geophysical investigation at a proposed car storage facility in Harewood, Christchurch, New Zealand (Figure 1).

The survey was conducted to assess the suitability of the site for future development by providing shear wave velocity (Vs) profiles across the site. The profiles were to be used to efficiently target intrusive testing (trial pits).

The Surface Wave survey (MASW) was conducted along eight (8) geophysical beneath the proposed footprint of the car storage facility.

1.1 UNDERSTANDING OF THE PROJECT

This survey was undertaken to assess the suitability of the site for future development.

The site is to be used as car storage facility near to Christchurch airport.

The site is anecdotally thought to be an infilled gravel pit up to 8 m deep.

2 SCOPE OF WORK

2.1 DATA ACQUISITION

The agreed scope of work includes:

- Mobilisation of all equipment and RDCL personnel to complete the job.
- Active source MASW geophysical profiles providing coverage of the site.
- Targeting of identified geophysical features using trial pits.

2.2 PROJECT DELIVERABLES

RDCL's project deliverables were to include:

- Technical report with:
  - Commentary on data processing method, data quality and shear wave velocity modelling.
  - Geotechnical assessment of the suitability of the site for further development.

- Report including:
  - Raw sg2 data (.dat) format.
  - Processed digital data submission.
  - Processed 2D Vs model sections.
  - Survey line location map.
  - Identification of geophysical features using trial pits.

2.3 TERMS OF REFERENCE

This investigation employed geophysical methods and therefore the majority of the findings presented here are the result of the measurement and interpretation of seismic (acoustic) signals. As such any results derived from the geophysical investigation should be taken in the context of and in reference to the complete ground investigation. Reasonable skill and care was taken to ensure that the results are accurate and reliable, including reference where appropriate to published date from this and/or other sites. However, as with other indirect methods there is a possibility of localised inconsistencies and inaccuracies within the results.

3 SITE DESCRIPTION AND GEOLOGY

3.1 SITE DESCRIPTION

The site is located to the north-west of Christchurch, in the Harewood suburb. The Surface Wave testing profiles intersected an area of approximately 7.34 hectares (Figure 1).

The site is reported as a former gravel pit up to 8m deep, backfilled with uncontrolled fill of unknown makeup and condition. The site is generally flat with localised spoil heaps and shrubby vegetation, with gravel tracks that traverse the survey area.

To the north the site was bounded by State Highway One (SH1). To the east and south the site was bounded by Waimakariri Road. To the west the site was bounded by brown field land designated for possible future development.

3.2 SITE GEOLOGY

1:250000 scale geological maps (GNS Science, 2013) indicate that the site is underlain by Holocene river deposits. These deposits are thought to consist of modern river floodplain and/or low-level degradation terraces. The deposits are un-weathered, variably sorted gravel/sand/silt and clays.

4 SURVEY RATIONALE

4.1 GEOPHYSICS AND TEST PITTING

4.1.1 MULTI-CHANNEL ANALYSIS OF SURFACE WAVES (MASW)

A screening survey has been undertaken using the MASW geophysical method for Surface Wave testing across the site. MASW provides *in-situ* measurements of shear wave velocity (Vs) which varies the elastic properties of geological material. A description of the MASW method and site survey is in Appendix A.

Outputs from the technique are essentially 2D cross-sections along the survey line, contoured to shear wave velocity. The 2D velocity sections are indicative of relatively "soft" and "hard" ground conditions.

4.1.2 TEST PITTING

Test pits have been targeted on the velocity sections to assess insitu ground conditions. Test pits were excavated using a 12T digger and logged by an RDCL Geotechnical Engineer with test pit logs in Appendix B.

5 RESULTS

5.1 GENERAL

Eight (8) MASW profiles were acquired across the site (Figure 1), for total line chainage acquired 1640 m.

2D shear wave velocity (Vs) profiles were generated from the acquired data for each line to a depth of ~22.5 m bgl. Of the order of 174 individual MASW "soundings" were made across the site.

MASW profiles are numbered 1 – 9. MASW line 7 was aborted onsite due to technical issues and is not presented in this report.

5.2 SHEAR WAVE VELOCITIES

A shear wave velocity range of 177 – 657 m/s was recorded across the site (Figures 3 – 10).

To aid interpretation, shear wave velocity classification using the National Earthquake Hazards Reduction Program (NEHRP) was applied to it to aid interpretation.

The observed shear wave velocity model of the site was generally laterally homogeneous and materials beneath the site fell into the following shear wave classifications:

- Between 0 – 10 m bgl materials typically have shear wave velocities less than 360 m/s and are classified as soft and stiff soils.
    - Soft soils (<180 m/s) typically presented as localised near surface lensoidal features.
- Below 10 m bgl materials typically have shear wave velocities greater than 360 m/s and are classified using the NEHRP system as very dense soils (or soft rock).

5.3 TARGET IDENTIFICATION

Seven (7) trial pits were targeted from the MASW profiles (Figure 2, Table 1).

TABLE 1- TEST PIT TARGETS FROM MASW

Target ID	MASW Line #	Chainage (m)	Eastings (NZTM)	Northings (NZTM)	Notes
TP01	1	90	1564934	5186560	Near surface low velocity target
TP02	3	60	1564980	5186496	Near surface low velocity target
TP03	5	120	1564919	5186393	Near surface low velocity target
TP04	6	50	1564814	5186395	Velocity inversion - fast over slow
TP05	9	80	1565035	5186511	Localised anomaly
TP06	2	90	1564830	5186411	Homogenous Vs in top 5 m
TP07	4	100	1564859	5186416	Homogenous Vs in top 5 m

5.4 TRIAL PITS

Test pits show generally silty Gravel and gravelly Silt with minor residual building and roading materials (brick, iron fragments and asphalt) and occasional plastic. Organic materials are generally logged in trace amounts, although all pits had an "organic" or "petrochemical" odour. Of note:

- TP01 was logged as general rubbish and was observed to smell strongly of rotting organics;
- TP04 was logged also with a strong odour of decaying rubbish.

6 ENGINEERING RECOMMEDATIONS

The underlying fill is uncontrolled and so construction of any future building will require specific design. The value of the property for on-sell as a building proposition will also be so affected.

6.1 GROUND CONDITIONS

Geophysics survey indicates that the site is underlain by fill in the order of 10m to 12m below ground. The bottom of the fill (gravel pit) is inferred by a consistent increase in shear wave velocity in the order of 360m/s (red brown colour in interpretative sections).

Fill from geophysics appears to be relatively uniform in shear wave velocity, but with lenticular, isolated zones of lower velocity. The fill materials are inferred as being "stiff" from published correlation, with "soft" spots.

Test pits show that the materials comprise mostly silty gravel with residual building and roading materials and trace organics. Two test pits (TP01 and TP04) indicate softer silt and more organics from direct observation and odour.

6.2 FOUNDATION CONSIDERATIONS

For a:

- Carpark, isolated soft spots comprising silt and organics should be stripped and/or subgrade improved possibly with a geo-grid to prevent damage to pavements particularly under heavy loads (viz. trucks, high traffic areas).
- Investigations found material near the entrance to the site comprised soft material with a significant amount of organic content.
  - This should be stripped and replaced, or
  - The entrance should be relocated to reduce traffic at that location.
- Light weight building, shallow foundations with some resistance to possible differential settlement are possible. Site specific engineering and potential ground improvement would be targeted specifically at the building footprint.
- Heavy, sensitive or higher value building, deep foundations comprising piles into natural would be required to remove ground uncertainty. Natural ground appears to be defined with some certainty at the ~360m/s contour.

Gas ventilation is in our opinion required at this site because of the presence of methane odour in all test pits, and particularly in TP01 and TP04. As above, site specific design and investigation should target the specific footprint.

6.3 POSSIBLE GROUND IMPROVEMENT PRIOR TO CARPARK FORMATION

The site is generally suitable for us as a light vehicle car park in the current state allowing for improvement of soft spots. Higher loads (viz. trucks etc.) could in particular deform and damage the pavement in the softer areas. Treatment (of soft areas) might comprise stripping to a nominal depth with subgrade repair including hard fill or geogrid.

For future buildings with shallow footings, foundation improvement should target the specific building footprint. For deep foundations, bored piles are likely with no need to undertake any special work at this stage.

In terms of improving the site, we recommend for a:

- Carpark proof rolling and stripping to remove unsuitables near surface; and
- Light building, shallow compaction using a roller or falling weight with deflection testing for confirmation.

7 LIMITATIONS

- This report has been prepared for the particular purpose outlined in the project brief and no responsibility is accepted for the use of any part in other contexts or for any other purpose.
- This investigation employed geophysical methods and therefore the majority of the findings presented here are the result of the measurement and interpretation of seismic (acoustic) signals. As such any results derived from the geophysical investigation should be taken in the context of and in reference to the complete ground investigation. Reasonable skill and care was taken to ensure that the results are accurate and reliable, including reference where appropriate to published data from this and/or other sites. However, as with other indirect methods there is a possibility of localised inconsistencies and inaccuracies within the results.
- Ground conditions assessed in this report are inferred from data provided by the client, published sources, site inspection and the investigations described. Variations from the interpreted conditions may occur, and special conditions relating to the site may not have been revealed by this investigation, and which are therefore not taken into account. No warranty is included either expressed or implied that the actual conditions will conform to the interpretation contained in this report.
- No responsibility is accepted by RDCL for inaccuracies in data supplied by others. Where data has been supplied by others, it has been assumed that this information is correct.
- This report is provided for sole use by the client and is confidential to the client and their professional advisors. No responsibility whatsoever for the contents of this report shall be accepted for any person other than the client.

8 REFERENCES

GNS Science (2013). New Zealand Geology Web Map. http://data.gns.cri.nz/geology/

National Earthquake Hazards Reduction Program (NEHRP). (2016). http://www.nehrp.gov/

Park, C. B. (2000). Surfseis User's Manual. Kansas Geological Survey.

Park, C. B., Miller, R. D., & Miura, H. (2002). Optimum field parameters of an MASW survey. Ext. Abstract, Society of Exploration Geophysicists of Japan, Tokyo, 22-23.

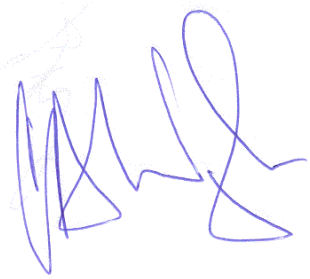
Subramanian, N. (2008). Design of steel structures. Oxford University Press

Stephenson, W. J., Louie, J. N., Pullammanappallil, S., Williams, R. A., & Odum, J. K. (2005). Blind shear-wave velocity comparison of ReMi and MASW results with boreholes to 200 m in Santa Clara Valley: implications for earthquake ground-motion assessment. Bulletin of the Seismological Society of America, 95(6), 2506-2516.

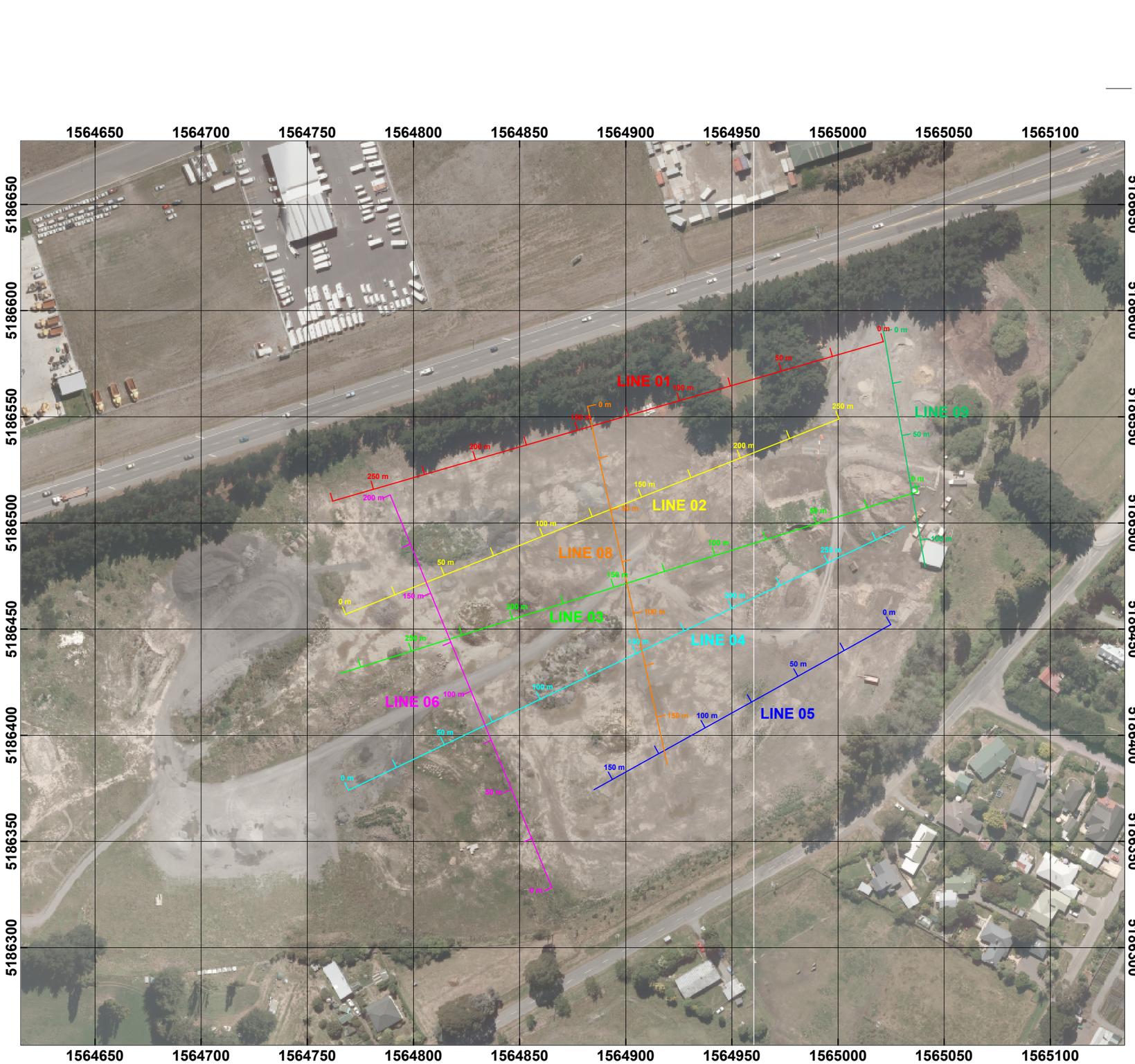
9 CLOSURE

We trust this meets your current needs. Should you wish to discuss any aspect of the contents of this document please contact me the undersigned on 06 877 1652.

Sincerely,



Oliver Gibson	Cam Wylie
BSc, MRes, FGS	MSc, MIPENZ, CPEng
Senior Geophysicist	Principle Geotechnical Engineer



GENERAL LOCATION PLAN:

GENERAL LOCATION PLAN SCALE: Scale 1:400000

10000 0 10000 20000

metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE: Scale 1:2000

50 0 50 100

metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

LEGEND:

MASW LINE LOCATIONS 0 m 25 m 50 m 75 m 100 m

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT: CAR HAULWAYS LIMITED

PROJECT: HAREWOOD CAR STORAGE FACILITY

TITLE: SURVEY LOCATION MAP

INTERP. BY: OG	DATE: 25/05/2016	DRAWN BY: OG	DATE: 25/05/2016
CHECKED BY: TW	DATE: 27/05/2016	APPROVED BY: TG	DATE: 27/05/2016

CONTRACT No.: 160705066 FIGURE 01

FILE NAME: 160705066 - masw carhaulaways.gpf

PLOTTED DRAWING SIZE: A3 (420 x 297)

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PO Box 28057, 15 Havelock Road
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Tel: +64 6 877 1652 Fax: +64 6 877 5015
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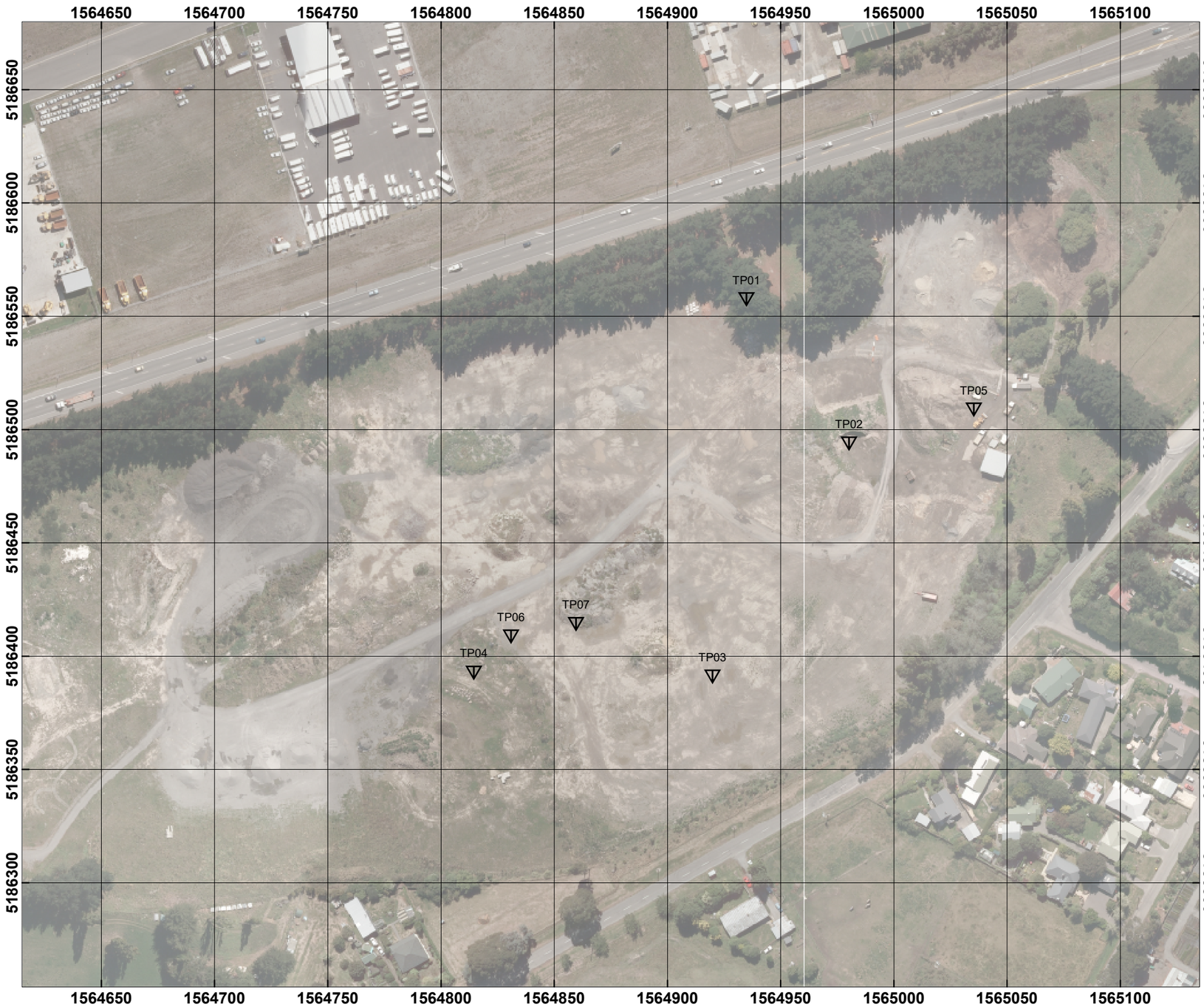

GENERAL LOCATION PLAN:

GENERAL LOCATION PLAN SCALE: Scale 1:400000

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metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE: Scale 1:2000

50 0 50 100

metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

LEGEND:

MASW LINE LOCATIONS 0 m 25 m 50 m 75 m 100 m

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT: CAR HAULWAYS LIMITED

PROJECT: HAREWOOD ROAD CAR STORAGE FACILITY

TITLE: MASW TARGETS

INTERP. BY: OG	DATE: 25/05/2016	DRAWN BY: OG	DATE: 25/05/2016
CHECKED BY: TW	DATE: 27/05/2016	APPROVED BY: TG	DATE: 27/05/2016

CONTRACT No.: 160705066 FIGURE 02

FILE NAME: 160705066 - masw carhaulaways.gpf

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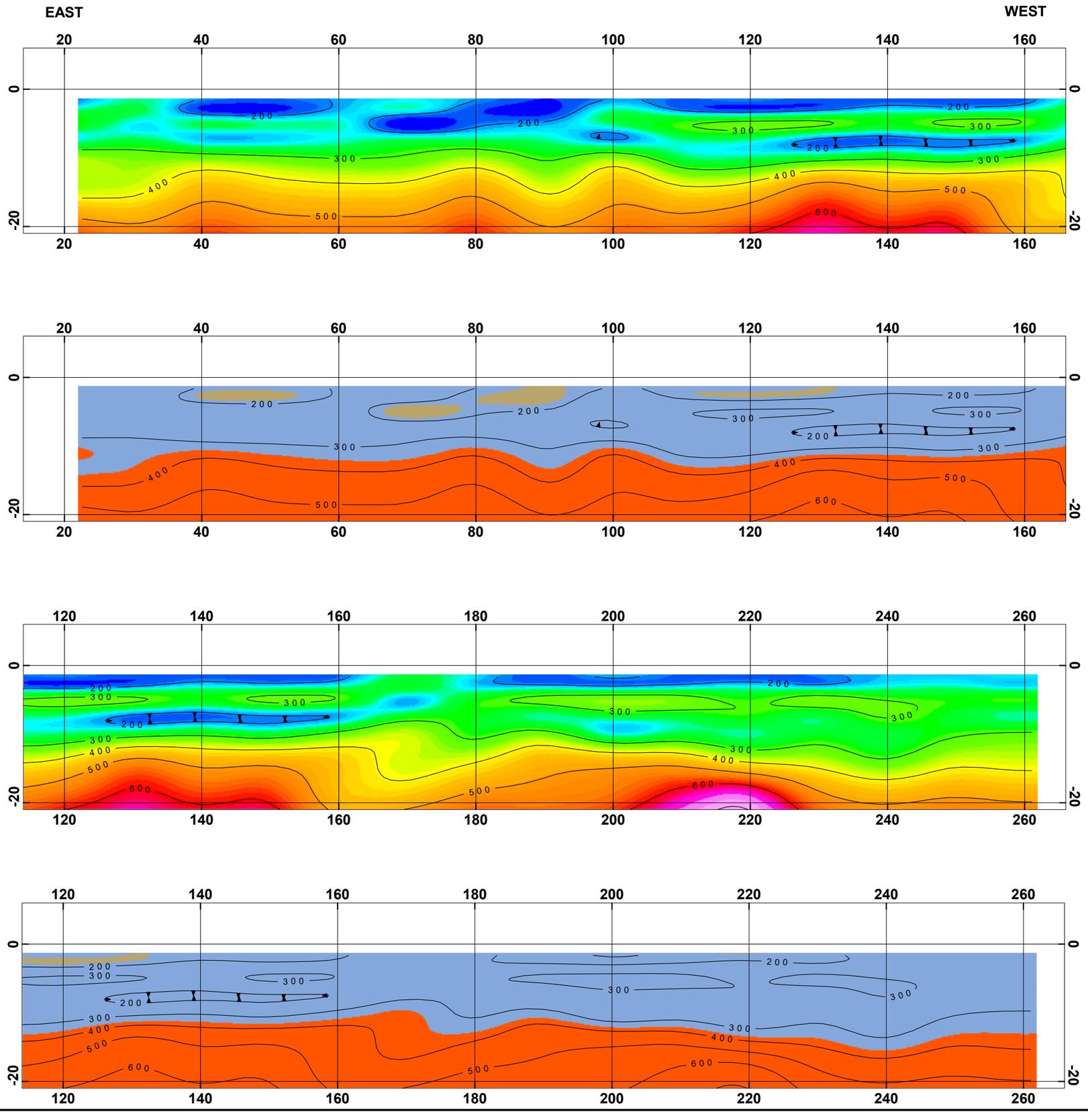

GENERAL LOCATION PLAN:

GENERAL LOCATION PLAN SCALE:

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metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE:

Scale 1:600

10 0 10 20 30

metres

LEGEND:

1500	Hard Rock
760	Rock
360	Very dense soil/soft rock
180	Stiff soil
	Soft soil

NEHRP Vs Classification

657 626 606 584 559 530 497 461 423 385 352 322 287 261 241 227 215 200 177

Shear Wave Velocity (m/s)

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT:

CAR HAULWAYS LIMITED

PROJECT:

HAREWOOD CAR STORAGE FACILITY

TITLE:

MASW LINE 01

INTERP. BY: OG	DATE: 01/06/2016	DRAWN BY: OG	DATE: 01/06/2016
CHECKED BY: CAW	DATE: 01/06/2016	APPROVED BY: CAW	DATE: 01/06/2016

CONTRACT No.: 160705066 | FIGURE 03

FILE NAME: 160705066 - masw carhaulaways.gpf

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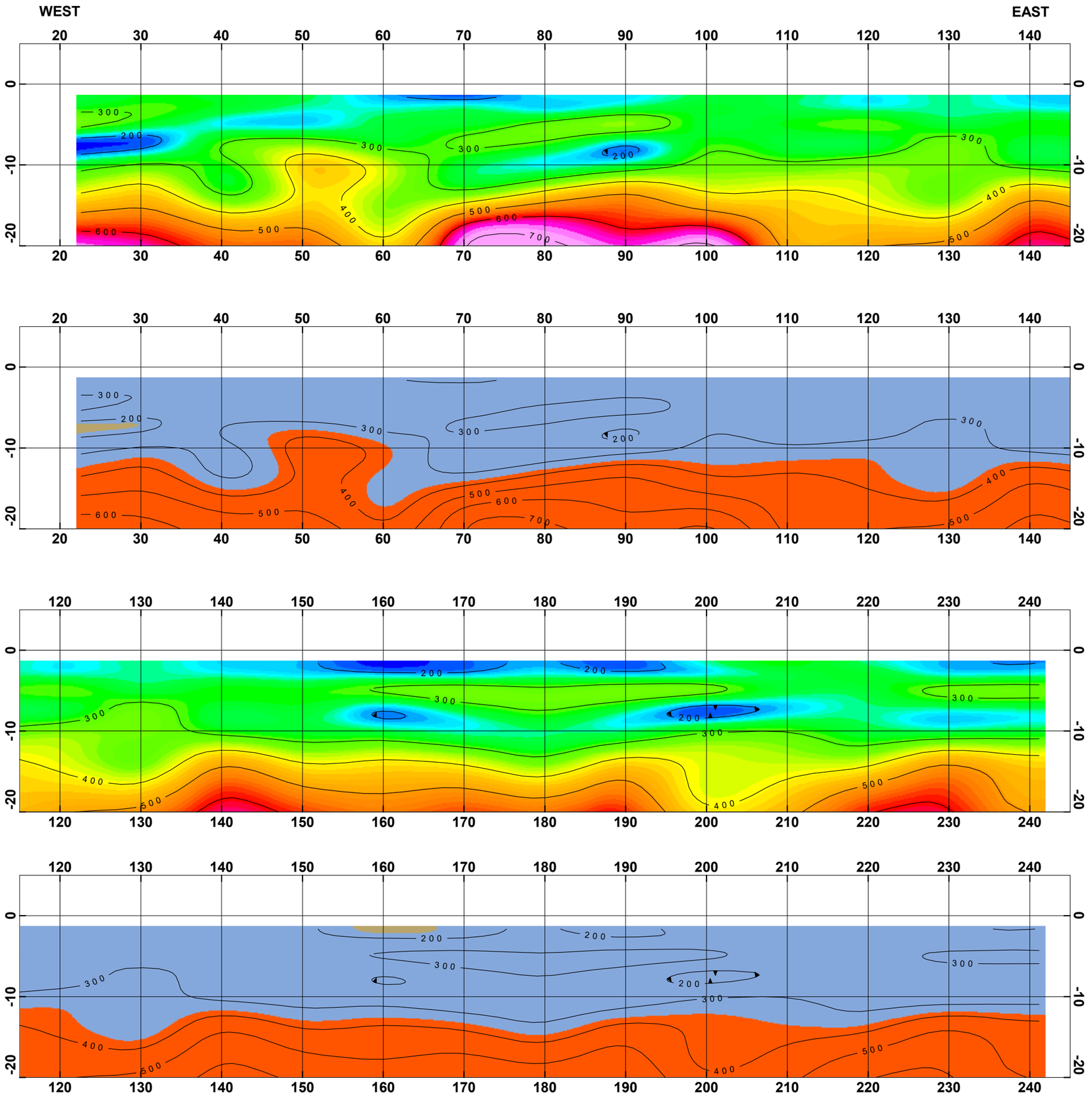

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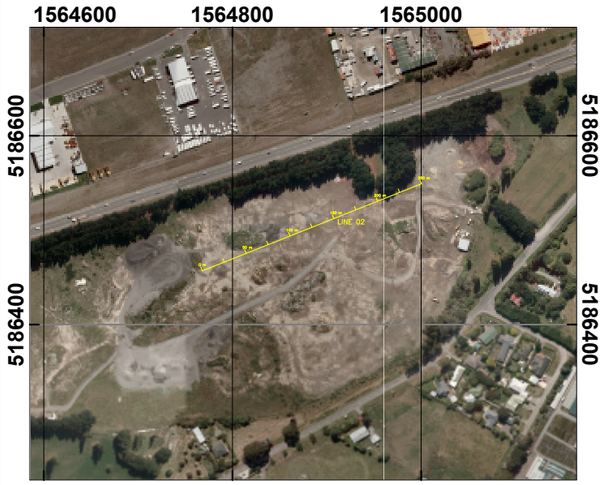

GENERAL LOCATION PLAN SCALE:

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metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE:

Scale 1:500

10 0 10 20

metres

LEGEND:

1500	Hard Rock
760	Rock
360	Very dense soil/soft rock
180	Stiff soil
	Soft soil

NEHRP Vs Classification

657 626 606 584 559 530 497 461 423 385 352 322 287 261 241 227 215 200 177

Shear Wave Velocity (m/s)

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT: CAR HAULWAYS LIMITED

PROJECT: HAREWOOD CAR STORAGE FACILITY

TITLE: MASW LINE 02

INTERP. BY: OG	DATE: 01/06/2016	DRAWN BY: OG	DATE: 01/06/2016
CHECKED BY: CAW	DATE: 01/06/2016	APPROVED BY: CAW	DATE: 01/06/2016

CONTRACT No.: 160705066 FIGURE 04

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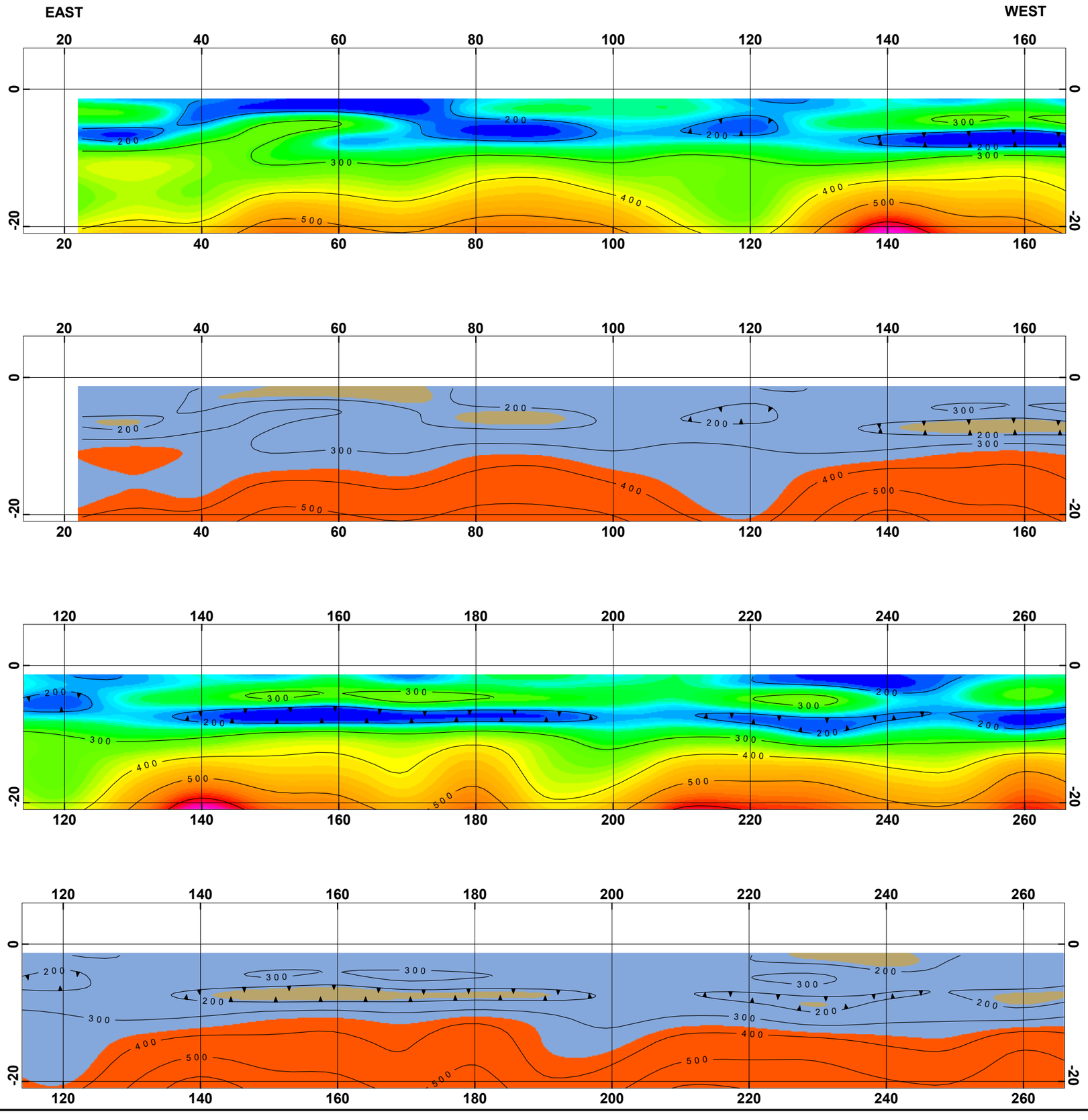

GENERAL LOCATION PLAN:

GENERAL LOCATION PLAN SCALE:

Scale 1:6500

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metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE:

Scale 1:600

10 0 10 20 30

metres

LEGEND:

1500	Hard Rock
760	Rock
360	Very dense soil/soft rock
180	Stiff soil
	Soft soil

NEHRP Vs Classification

657 626 606 584 559 530 497 461 423 385 352 322 287 261 241 227 215 200 177

Shear Wave Velocity (m/s)

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT:

CAR HAULWAYS LIMITED

PROJECT:

HAREWOOD CAR STORAGE FACILITY

TITLE:

MASW LINE 03

INTERP. BY: OG	DATE: 01/06/2016	DRAWN BY: OG	DATE: 01/06/2016
CHECKED BY: CAW	DATE: 01/06/2016	APPROVED BY: CAW	DATE: 01/06/2016

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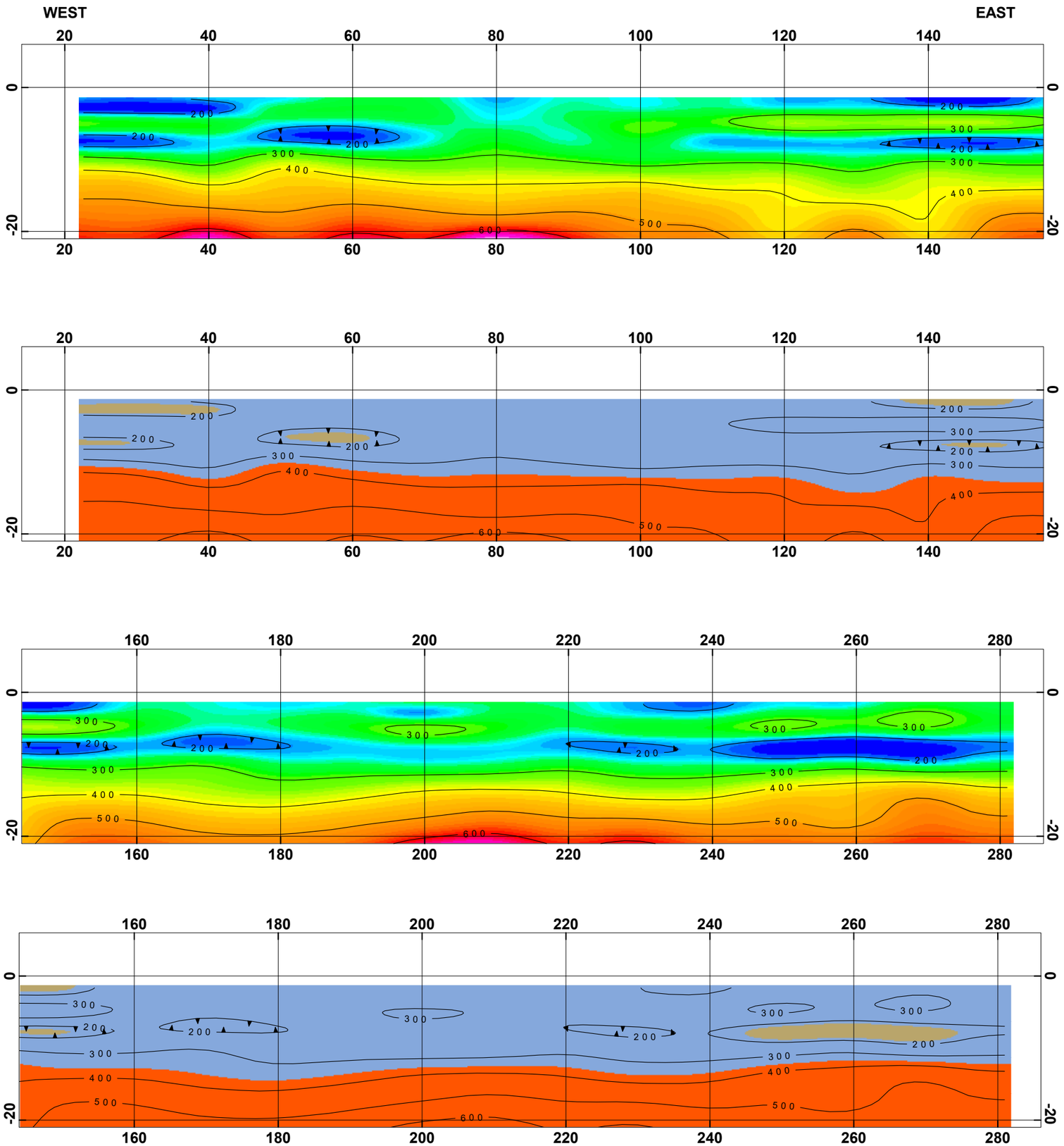

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GENERAL LOCATION PLAN SCALE:

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*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE:

Scale 1:600

10 0 10 20 30

metres

LEGEND:

NEHRP Vs Classification		Shear Wave Velocity (m/s)
1500	Hard Rock	657 626 606 584 559 530 497 461 423 385 352 322 287 261 241 227 215 200 177
760	Rock	
360	Very dense soil/soft rock	
180	Stiff soil	
	Soft soil	

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT: CAR HAULWAYS LIMITED

PROJECT: HAREWOOD CAR STORAGE FACILITY

TITLE: MASW LINE 04

INTERP. BY: OG	DATE: 01/06/2016	DRAWN BY: OG	DATE: 01/06/2016
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CONTRACT No.: 160705066 FIGURE 06

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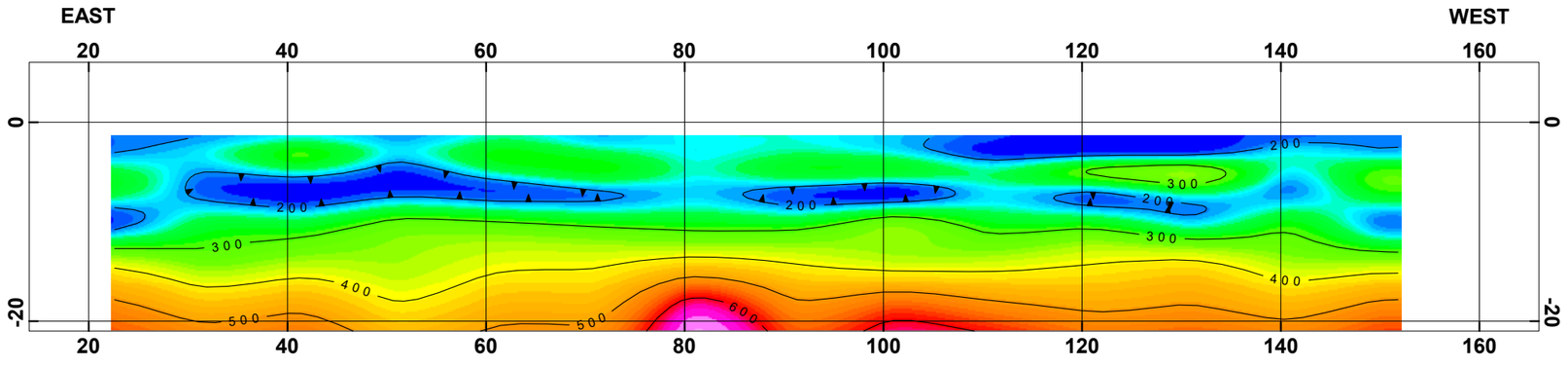

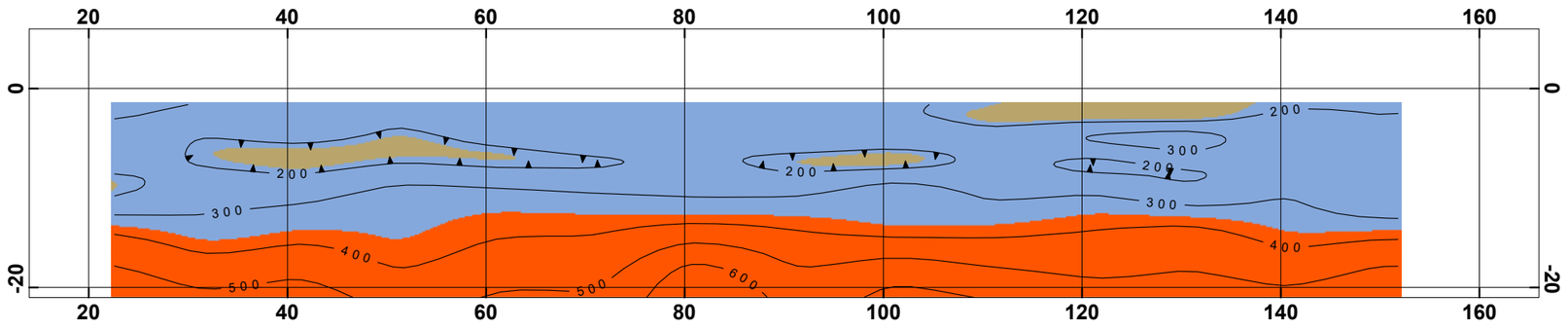

GENERAL LOCATION PLAN:

GENERAL LOCATION PLAN SCALE:

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metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE:

Scale 1:600

10 0 10 20 30

metres

LEGEND:

NEHRP Vs Classification		Shear Wave Velocity (m/s)
1500	Hard Rock	657 626 606 584 559 530 497 461 423 385 352 322 287 261 241 227 215 200 177
760	Rock	
360	Very dense soil/soft rock	
180	Stiff soil	
	Soft soil	

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT:

CAR HAULWAYS LIMITED

PROJECT:

HAREWOOD CAR STORAGE FACILITY

TITLE:

MASW LINE 05

INTERP. BY: OG	DATE: 01/06/2016	DRAWN BY: OG	DATE: 01/06/2016
CHECKED BY: CAW	DATE: 01/06/2016	APPROVED BY: CAW	DATE: 01/06/2016

CONTRACT No.: 160705066

FIGURE 07

FILE NAME: 160705066 - masw carhaulaways.gpf

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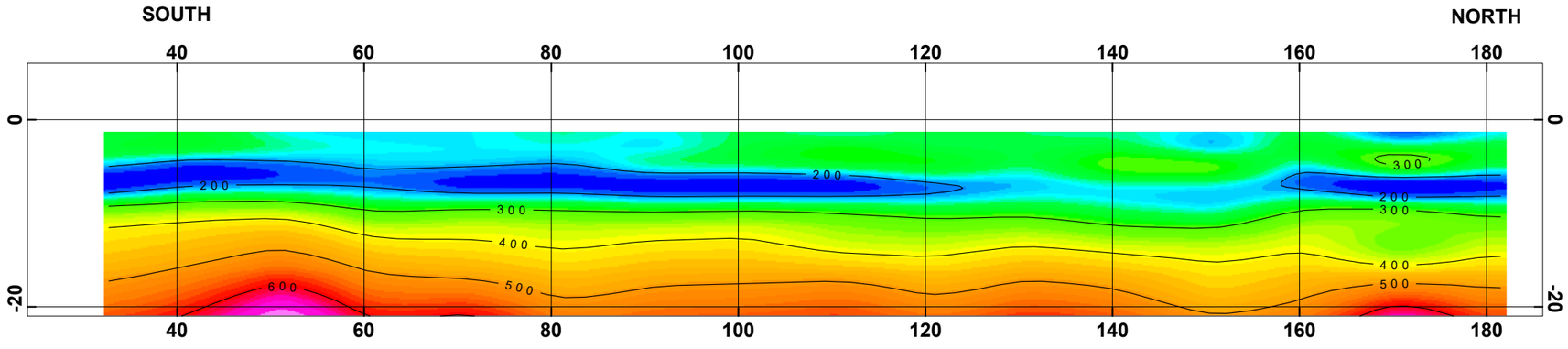

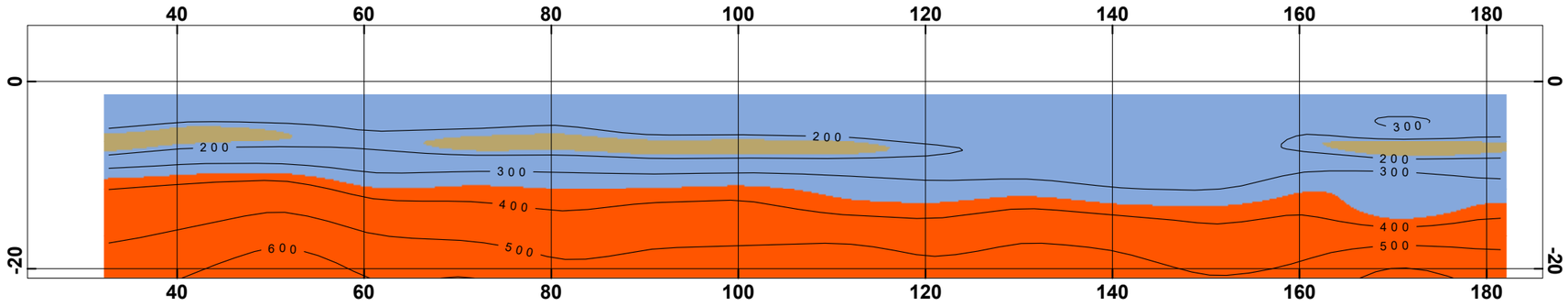

GENERAL LOCATION PLAN:

GENERAL LOCATION PLAN SCALE:

Scale 1:6500

100 0 100 200 300 400

metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE:

Scale 1:600

10 0 10 20 30

metres

LEGEND:

NEHRP Vs Classification		Shear Wave Velocity (m/s)
1500	Hard Rock	657 626 606 584 559 530 497 461 423 385 352 322 287 261 241 227 215 200 177
760	Rock	
360	Very dense soil/soft rock	
180	Stiff soil	
	Soft soil	

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT: CAR HAULWAYS LIMITED

PROJECT: HAREWOOD CAR STORAGE FACILITY

TITLE: MASW LINE 06

INTERP. BY: OG	DATE: 01/06/2016	DRAWN BY: OG	DATE: 01/06/2016
CHECKED BY: OG	DATE: 01/06/2016	APPROVED BY: CAW	DATE: 01/06/2016

CONTRACT No.: 160505066 | FIGURE 08

FILE NAME: 160505066 - masw carhaulaways.gpf

PLOTTED DRAWING SIZE: A3 (420 x 297)

RDCL
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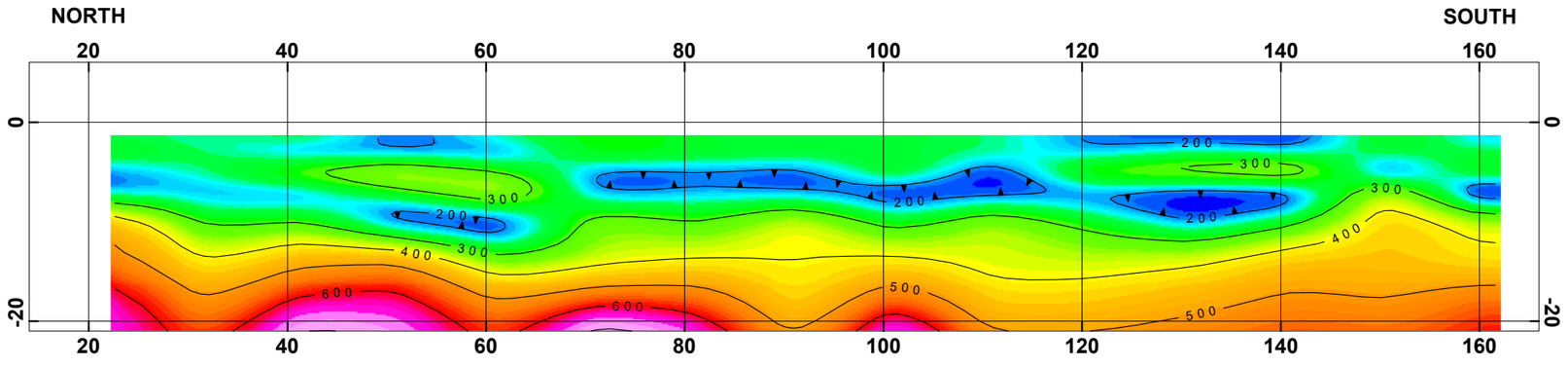
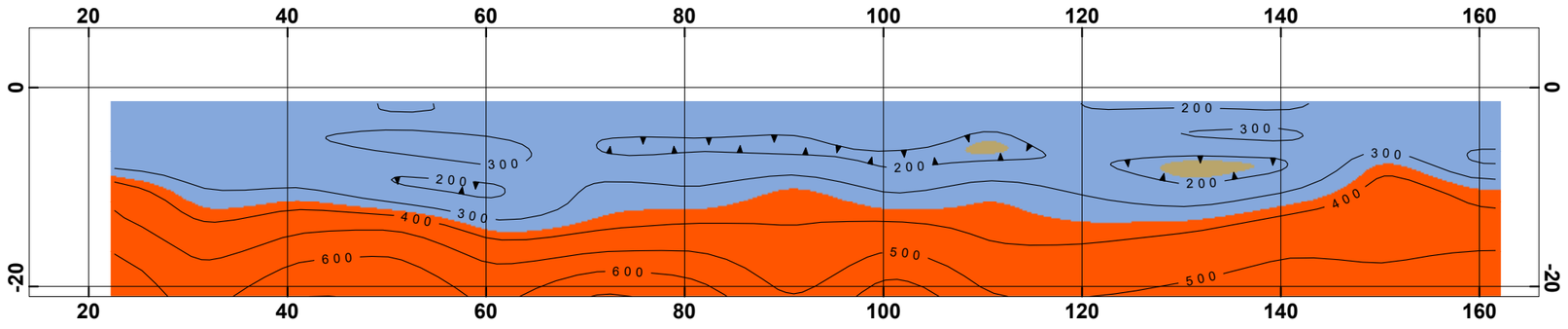
Havelock North, Hawke's Bay, New Zealand
Tel: +64 6 877 1652 Fax: +64 6 877 5015
Email: info@rdcl.co.nz www.rdcl.co.nz





GENERAL LOCATION PLAN:

GENERAL LOCATION PLAN SCALE:

Scale 1:6500

100 0 100 200 300 400

metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE:

Scale 1:600

10 0 10 20 30

metres

LEGEND:

1500	Hard Rock
760	Rock
360	Very dense soil/soft rock
180	Stiff soil
	Soft soil

NEHRP Vs Classification

657 626 606 584 559 530 497 461 423 385 352 322 287 261 241 227 215 200 177

Shear Wave Velocity (m/s)

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT:

CAR HAULWAYS LIMITED

PROJECT:

HAREWOOD CAR STORAGE FACILITY

TITLE:

MASW LINE 08

INTERP. BY: OG	DATE: 01/06/2016	DRAWN BY: OG	DATE: 01/06/2016
CHECKED BY: CAW	DATE: 01/06/2016	APPROVED BY: CAW	DATE: 01/06/2016

CONTRACT No.: 160705066

FIGURE 09

FILE NAME: 160705066 - masw carhaulaways.gpf

PLOTTED DRAWING SIZE: A3 (420 x 297)

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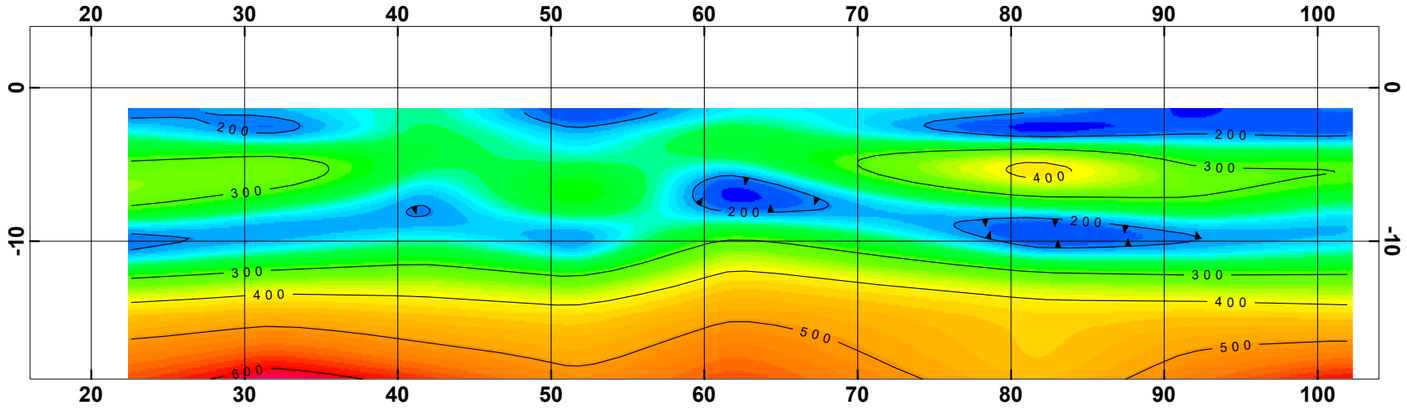

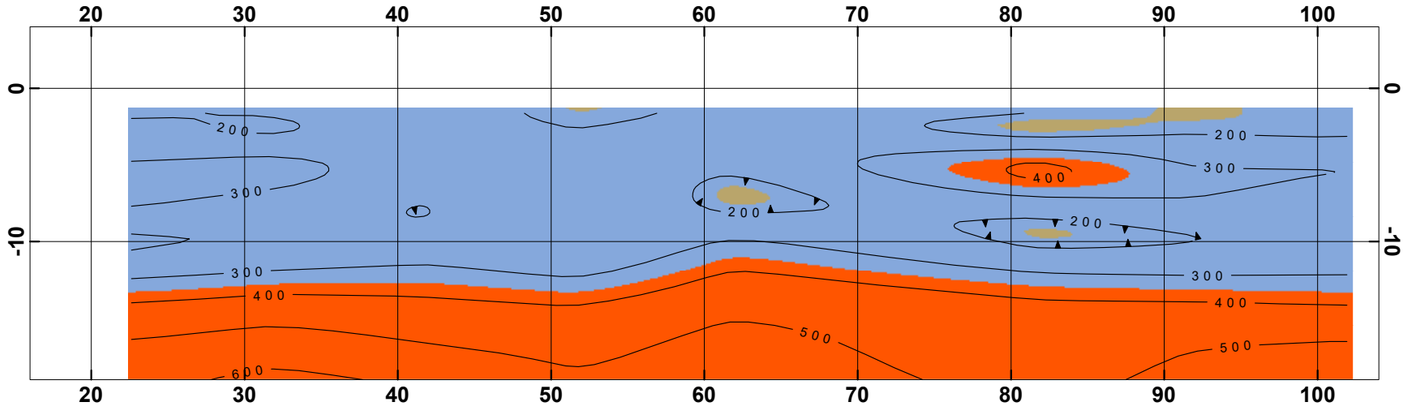

GENERAL LOCATION PLAN:

GENERAL LOCATION PLAN SCALE:

Scale 1:6500

100 0 100 200 300 400

metres

*NZGD2000 / *NZGD 2000 New Zealand Transverse Mercator*

SCALE:

Scale 1:400

10 0 10 20

metres

LEGEND:

1500	Hard Rock
760	Rock
360	Very dense soil/soft rock
180	Stiff soil
	Soft soil

NEHRP Vs Classification

657 626 606 584 559 530 497 461 423 385 352 322 287 261 241 227 215 200 177

Shear Wave Velocity (m/s)

NOTES:

1. Imagery and topographic data sourced from https://data.linz.govt.nz/. May 2016.

CLIENT:

CAR HAULWAYS LIMITED

PROJECT:

HAREWOOD CAR STORAGE FACILITY

TITLE:

MASW LINE 09

INTERP. BY: OG	DATE: 01/06/2016	DRAWN BY: OG	DATE: 01/06/2016
CHECKED BY: CAW	DATE: 01/06/2016	APPROVED BY: CAW	DATE: 01/06/2016

CONTRACT No.: 160705066

FIGURE 10

FILE NAME: 160705066 - masw carhaulaways.gpf

PLOTTED DRAWING SIZE: A3 (420 x 297)

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RDCL

APPENDIX A
MASW METHOD AND SITE SURVEY

1 DATA ACQUISITION METHOD - MASW

1.1 ACQUISITION SYSTEM

Acquisition of active source MASW data was conducted using a Geometrics Geode seismograph addressing 24 channels of 4.5 Hz geophones mounted on a vehicle towed landstreamer. Geophones were spaced at a constant 1 m.

1.2 SEISMIC SOURCE

Shots were:

- Produced by sledgehammer for seismic signal generation ("shots").
- Offset at 10 m from the seismic spread.
- Typically stacked (at least 4 shots) to improve signal to noise ratio.

The landstreamer was typically dragged 10 m and the acquisition process repeated after each shot.

1.3 ACQUISITION PARAMETERS

Acquisition parameters were:

- Record Length 900 ms
- Delay 0 ms
- Sample interval 62.50 μs
- Acquisition filters OUT

1.4 POSITIONAL CONTROL

Positional control was undertaken using a hand held GPS device. The extent of the investigation profiles is defined by the positions of the first and last geophones in the survey line. Based on the error margins of the handheld GPS device relative positional accuracy is likely to be of the order of ±4 m.

The site was assumed to be flat for the purposes of this investigation.

1.5 QUALITY ASSURANCE

Prior to data acquisition, channels were checked for interference related to poor ground coupling or external noise.

Electronically induced noise shots were undertaken at the start of each seismic line to record representative background noise and allow subsequent assessment of signal to noise ratio.

All data acquired was quality controlled by the lead field geophysicist for signal to noise ratio and trigger errors before being stored digitally in SEG-2 format for subsequent processing.

1.6 RESOLUTION LIMITATIONS

Depth resolution is likely to be no better than ±2 m due to geophone spacing. Lateral resolution is likely to be no better than ±10 m due to shot separation distance and spread length.

1.7 DATA PROCESSING - MASW

Data processing consisted of:

- Phase 1 comprising of file conversion and geometry assignment; and
- Phase 2 comprising Rayleigh wave identification, overtone image generation and dispersion curve picking; and
- Phase 3 comprising an iterative approach to inversion modelling.

1.8 PROCESSING PHASE 1

Raw data files were first imported into Geogiga Seismic Pro 7.1. Data files were then visually examined and the noise component assessed by comparing the shots in the frequency domain with the noise records recorded at the start of end line.

Subsequently raw data files were imported into Surfseis 3 KGS software and the following processing undertaken:

- Converted into the KGS format.
- Geometry information was applied to the shot and geophone stations.

1.9 PROCESSING PHASE 2

For each MASW recording along a seismic profile:

- The Rayleigh wave window was automatically identified by the Surfseis 3 software. Where appropriate traces were nulled below and above the Rayleigh wave window.
- An overtone image in the frequency/phase velocity domain was developed.
- A dispersion curve of the fundamental mode was automatically picked by the software and manually edited by the processing geophysicist with reference to:
  - Signal to noise ratios.
  - Previous dispersion curves.
  - Influence of higher modes.

1.10 PROCESSING PHASE 3

Processing Phase 3 involved an iterative approach to inversion modelling within the Surfseis 3 software. The following generalised approach was undertaken:

- An initial automatic starting model was generated from all the dispersion curves picked from a geophysical profile.
- The dispersion curves were inverted to generate an initial 2D Vs profile.
- Root Mean Square (RMS) Errors were assessed and where appropriate dispersion curves were re-picked. This was typically necessary where the fundamental mode had not been identified correctly or where there were anomalous picks.

1.11 STARTING MODELS

A nine layer site specific starting ground model for was developed (Table 1). The starting ground model is required to guide the inversion processes and produced the final Vs models with the lowest RMS Errors.

The starting shear wave velocity (Vs) model is approximated from the measured dispersion curve. The starting compressional wave velocity (Vp) model is approximated using the initial Vs model and a constant Poisson's ratio of 0.4.

The influence of Vp and Poisson's ratio on final inverted Vs values can be neglected as long as they have been reasonably estimated (Park, C.B. (2000)).

A Poisson's ratio of 0.4 for the full site was considered a reasonable estimate for the purposes of the starting model because:

- Rayleigh dispersion curves are much more sensitive to S-wave than to P-wave shallow velocity structure (Stephenson, W.J. (2005)).
- A Poisson's ratio of 0.4 is typical for gravels, dense sands and saturated clays (Subramanian, N. (2008)).

No groundwater was accounted for in the MASW modelling. As such model values of Vp below ground water depth may be unrepresentative (<1500 m/s). The modelling is relatively insensitive to Vp, and inverted Vs measurements are not adversely effected.

TABLE 1 - STARTING MODEL

Layer #	Layer Base Depth (m)	Thickness (m)	Vs (m/s)	Vp (m/s)
1	1.145	1.145	208	509
2	2.575	1.431	210	514
3	4.363	1.788	234	573
4	6.599	2.235	255	624
5	9.393	2.794	317	777
6	12.886	3.493	397	972
7	17.252	4.366	481	1178
8	22.709	5.457	570	1395
9	Half Space	N/A	580	1420

1.12 DATA PRESENTATION

Final Vs 2D model grids were imported into Geosoft Target software and presented using a site standard colour ramp (Figures 3 – 10). Data contours are presented at 100 m/s intervals.

1.13 DATA QUALITY

Raw seismic data presented with high signal to noise ratios.

The fundamental mode is typically readily identified in the overtone images with low interference from higher modes.

Dispersion curves typically have high signal to noise ratios and the fundamental mode could typically be picked between a frequency range of 5 – 50 Hz.

APPENDIX B
TEST PIT LOGS

TP01

Client	Project No.	Location
Car Haulways Ltd	160305066	Harewood Car Storage Yard Geotechnical Investigation

Started: 2/06/2016 Finished:2/06/2016	Logged By: JJN - 2/06/2016 Checked By: SLK - Status: DRAFT	Contractor: Operator: Plant:	Easting: Northing: R. L.: 12.50 m

Depth (m)	Geology	Graphic Log	ROCK / SOIL DESCRIPTION	WATER	MOISTURE	CONSISTENCY/ DENSITY	Tests & Samples	ADDITIONAL REMARKS	R.L. (m)
0.0			Silty **GRAVEL** with some concrete; dark brown, moist, with minor sand, organics and brick. sub rounded - angular.		M				12.0
1.0			**FILL** general rubbish, rope, plastic and glass, eoh 3.5m target depth.						11.5
1.5									11.0
2.0									10.5
2.5									10.0
3.0									9.5
3.5			EOH: 3.5m						9.0

Remarks:

Elevation Datum:
Coordinate System:
NZTM2000

Log Scale at A4 - 1:25

Resource Development Consultants Ltd.
Cnr Porter Dr & Havelock Rd | PO Box 28057 | Havelock North 4130 | New Zealand
Ph: +64 6 8771652 | Fax: +64 6 8775015 | Email: info@rdcl.co.nz

TP02

Client	Project No.	Location
Car Haulways Ltd	160305066	Harewood Car Storage Yard Geotechnical Investigation

Started: 2/06/2016 Finished:2/06/2016	Logged By: JJN - 2/06/2016 Checked By: SLK - Status: DRAFT	Contractor: Operator: Plant:	Easting: Northing: R. L.: 12.50 m

Depth (m)	Geology	Graphic Log	ROCK / SOIL DESCRIPTION	WATER	MOISTURE	CONSISTENCY/ DENSITY	Tests & Samples	ADDITIONAL REMARKS	R.L. (m)
0.0			Silty **GRAVEL** with minor organics; dark brown, firm, moist, low plasticity, subrounded, trace brick and concrete. gravel is fine to coarse.		M	F			12.5
0.5									12.0
1.0									11.5
1.5									11.0
2.0			**SILT** with some organics and minor gravel.; black, moist, subrounded, gravels are fine to coarse. minor traces of metal bar.		M				10.5
2.5									10.0
3.0			**GRAVEL** with minor silt and sand; grey, very dense, moist, fine to coarse gravel. orange mottle (natural ground).		M	VD			9.5
			EOH: 3.2m						

Remarks:

Elevation Datum:
Coordinate System:
NZTM2000

Log Scale at A4 - 1:25

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TP03

Client	Project No.	Location
Car Haulways Ltd	160305066	Harewood Car Storage Yard Geotechnical Investigation

Started: 2/06/2016 Finished:2/06/2016	Logged By: JJN - 2/06/2016 Checked By: SLK - Status: DRAFT	Contractor: Operator: Plant:	Easting: Northing: R. L.: 12.50 m

Depth (m)	Geology	Graphic Log	ROCK / SOIL DESCRIPTION	WATER	MOISTURE	CONSISTENCY/ DENSITY	Tests & Samples	ADDITIONAL REMARKS	R.L. (m)
0.0			Silty **GRAVEL** with some and trace asphalt, brick and sand; dark grey, medium dense, moist, well graded gravel is fine to coarse.		M	MD			12.5
0.5									12.0
1.0									11.5
1.5									11.0
2.0									10.5
2.5									10.0
3.0									9.5
3.5			EOH: 3.5m						9.0

Remarks:

Elevation Datum:
Coordinate System:
NZTM2000

Log Scale at A4 - 1:25

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Cnr Porter Dr & Havelock Rd | PO Box 28057 | Havelock North 4130 | New Zealand
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TP04

Client	Project No.	Location
Car Haulways Ltd	160305066	Harewood Car Storage Yard Geotechnical Investigation

Started: 2/06/2016 Finished:2/06/2016	Logged By: JJN - 2/06/2016 Checked By: SLK - Status: DRAFT	Contractor: Operator: Plant:	Easting: Northing: R. L.: 12.50 m

Depth (m)	Geology	Graphic Log	ROCK / SOIL DESCRIPTION	WATER	MOISTURE	CONSISTENCY/ DENSITY	Tests & Samples	ADDITIONAL REMARKS	R.L. (m)
0.0			Gravelly **SILT** with some sand and trace organics; brownish grey, firm, moist, low plasticity, trace rubbish, concrete and asphalt - smells of decaying rubbish.		M	F			12.5
0.5									12.0
1.0									11.5
1.5									11.0
2.0			**FILL** with some silt and minor organics bluish grey, medium dense, well graded gravels are fine to coarse, rounded to angular. 2.0m hard layer comprising chunks of asphalt and concrete.			MD			10.5
2.5									10.0
3.0									9.5
3.5			EOH: 3.5m						9.0

Remarks:

Elevation Datum:
Coordinate System:
NZTM2000

Log Scale at A4 - 1:25

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TP05

Client	Project No.	Location
Car Haulways Ltd	160305066	Harewood Car Storage Yard Geotechnical Investigation

Started: 2/06/2016 Finished:2/06/2016	Logged By: JJN - 2/06/2016 Checked By: SLK - Status: DRAFT	Contractor: Operator: Plant:	Easting: Northing: R. L.: 12.50 m

Depth (m)	Geology	Graphic Log	ROCK / SOIL DESCRIPTION	WATER	MOISTURE	CONSISTENCY/ DENSITY	Tests & Samples	ADDITIONAL REMARKS	R.L. (m)
0.0			**GRAVEL** with some silt and occassioal cobble (fill); black, dry, gravel is fine to coarse.		D				12.5
0.5			Silty **GRAVEL** with some organics (fibrous and amorphus); light brown, dry, well graded subrounded, gravel is fine to medium.		D				12.0
1.0									11.5
1.5			**GRAVEL** with trace of cobble and concrete; dry, poorly graded angular, with minor sand and silt. eoh 3.2m (wall collapse).		D				11.0
2.0									10.5
2.5									10.0
3.0									9.5
			EOH: 3.2m						

Remarks:

Elevation Datum:
Coordinate System:
NZTM2000

Log Scale at A4 - 1:25

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TP06

Client	Project No.	Location
Car Haulways Ltd	160305066	Harewood Car Storage Yard Geotechnical Investigation

Started: 2/06/2016 Finished:2/06/2016	Logged By: JJN - 2/06/2016 Checked By: SLK - Status: DRAFT	Contractor: Operator: Plant:	Easting: Northing: R. L.: 12.50 m

Depth (m)	Geology	Graphic Log	ROCK / SOIL DESCRIPTION	WATER	MOISTURE	CONSISTENCY/ DENSITY	Tests & Samples	ADDITIONAL REMARKS	R.L. (m)
0.0			Silty **GRAVEL** with minor organics; brownish grey, medium dense, moist, well graded gravels are fine to coarse, subrounded to angular.		M	MD			12.5
0.5									12.0
1.0									11.5
1.5			**SILT** with minor sand, gravels and organics; brownish grey, firm, moist, odorous - smells of decaying rubbish.		M	F			11.0
2.0									10.5
2.1			**FILL**.						
2.2			Sandy **GRAVEL** with some silt, asphalt and trace rubbish; bluish grey, medium dense, subrounded, gravel is fine to coarse.			MD			
2.5									10.0
3.0			EOH: 3m						9.5

Remarks:

Elevation Datum:
Coordinate System:
NZTM2000

Log Scale at A4 - 1:25

Resource Development Consultants Ltd.
Cnr Porter Dr & Havelock Rd | PO Box 28057 | Havelock North 4130 | New Zealand
Ph: +64 6 8771652 | Fax: +64 6 8775015 | Email: info@rdcl.co.nz

TP07

Client	Project No.	Location
Car Haulways Ltd	160305066	Harewood Car Storage Yard Geotechnical Investigation

Started: 2/06/2016 Finished:2/06/2016	Logged By: JJN - 2/06/2016 Checked By: SLK - Status: DRAFT	Contractor: Operator: Plant:	Easting: Northing: R. L.: 12.50 m

Depth (m)	Geology	Graphic Log	ROCK / SOIL DESCRIPTION	WATER	MOISTURE	CONSISTENCY/ DENSITY	Tests & Samples	ADDITIONAL REMARKS	R.L. (m)
0.0			**GRAVEL** with minor sand and silt; very dense, trace cobbles and boulders (0.5 - 0.7mm in size - fill and quarry waste).			VD			12.5
0.5									12.0
1.0									11.5
1.5									11.0
1.8			Gravelly **SILT** trace concrete and brick dark grey, firm, moist, low plasticity, trace concrete and brick (smells of decaying rubbish). eoh 3.0m unable to advance due to concrete blocks.		M	F			
2.0									10.5
2.5									10.0
3.0			EOH: 3m						9.5

Remarks:

Elevation Datum:
Coordinate System:
NZTM2000

Log Scale at A4 - 1:25

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Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you —* should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely on Your ASFE-Member Geotechnical Engineer for Additional Assistance

Membership in ASFE/The Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE THE GEOPROFESSIONAL BUSINESS ASSOCIATION

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

IIGER01115.0MRP

ANNEXURE H (I):

ACOUSTIC ASSESSMENT REPORT TO CCC (FURTHER INFORMATION REQUEST)

acoustic
engineering services

Level 3, 518 Colombo Street
Christchurch 8011
PO Box 549
Christchurch 8140

Ph 03 377 8952
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File Ref: AC16076 – 03 – D2

8 June 2017

Kim McCracken
McCracken & Associates Limited
PO Box 2551
CHRISTCHURCH 8140

Email: office@rgmc.co.nz

Dear Kim,

Re: Car Distribution Group Yard – 711 Johns Road
Response to CCC Request for Information, RMA/2017/765

As requested, please find below our response to the Request for Information (RFI) by the Christchurch City Council (CCC) for Resource Consent Application RMA/2017/765 regarding the establishment of a yard for Car Distribution Group at 711 Johns Road.

1.0 Response to RFI Questions

1. *The site is within the 50 and 55 dB Engine Testing Contour and the 55 dB Ldn Air Noise Contour. Please confirm that the proposed buildings will / can be compliant with the standards at Rule 6.1.7.2.2. This information is likely to require specialist input.*

AES have reviewed the plans for the building which contains office spaces. Rule 6.1.7.2.2 states that private offices must achieve an internal noise level of 70 dB L_{AE} / 45 dB $L_{dn.}$ Based on the location of the site, operational noise levels in the order of 59 dB L_{dn} and 56 dB L_{dn} from engine testing are expected.

Based on the size and layout of office spaces shown in the architectural drawings titled *John's Road Car Storage Facilities Building*, as prepared by Cardno and dated the 15th of March 2017, we have calculated an indicative required Aircraft Noise Attenuation (ANA). The calculations have been based on Appendix C of AS 2021:2015 *Acoustics – Aircraft noise intrusion – Building siting and construction*. The required ANA is 19 for wall and roof areas and 16 for glazing. It can be seen from the table below that typical constructions should achieve this reduction by some margin.

Façade Element	Aircraft Noise Attenuation	Source
Roof – 0.4 mm profiled steel, minimum 200 mm cavity, 13 mm plasterboard ceiling	29	Insul software version 8.0.4 with adjustment from Appendix G Section 3.2 in AS2021:2015
Wall – 0.4 mm profiled steel, 140 mm timber framing, 10 mm plasterboard	28	Insul software version 8.0.4 with adjustment from Appendix G Section 3.2 in AS2021:2015
External glazing – 4 mm float glass	24	Insul software version 8.0.4 with adjustment from Appendix G Section 3.2 in AS2021:2015

We recommend that a report from a suitably qualified Acoustics Engineer is submitted at the time of the building consent to confirm that the requirements outlined in Rule 6.1.7.2.2 of the District Plan are achieved.

2. *AES has done assessment on background noise levels along the Waimakariri Road (sic). Please provide location point(s) for measurements and advise if measurements taken at 4am are considered representative of the background noise from 11pm to 6am. The Council suggest additional measurements be taken at around 1am.*

Ambient measurements were undertaken at 4 am as this is when the bulk of trucks will depart the yard and is considered the critical noise effects period.

As there are only two trucks departing at 1 am, noise levels at this time will be 3 dB lower than predicted in section 3.3. of the acoustic assessment. However, as suggested by CCC, AES have undertaken additional measurements at 1 am to determine the ambient environment at this time. AES undertook three 15 minute duration measurements on the 10th of May 2017 in accordance with NZS 6801:2008 as presented in the table below.

Measurement locations are also shown in the figure below, with original measurements shown blue and the May 2017 measurements shown red. We note that an original iteration of the design had access further west along Waimakariri Road, hence the location of some of the original measurements.

Location	Measured noise levels	Notes
A	50 dB L_{Aeq} / 34 dB L_{A90}	Noise generally from traffic on Johns Road, particularly heavy vehicles. 737 departure from Christchurch airport
B	35 dB L_{Aeq} / 28 dB L_{A90}	Insects, birds, limited heavy vehicles on Johns Road during this period
C	47 dB L_{Aeq} / 34 dB L_{A90}	Traffic on Johns Road / Sawyers Arms Road, light aircraft departure from Christchurch airport, unidentifiable industrial noise from across Johns Road

Our measurements illustrate that background noise levels (L_{A90}) at this time are lower than the measurements at 4 am. The measurements at location B also indicate that there are reasonable periods where the L_{Aeq} overall noise levels are low. However, the area is still characterised by transient high noise events as observed during other measurements, in particular the aircraft departures and heavy vehicles approaching the Sawyers Arms roundabout (hence the much higher L_{Aeq} noise levels at locations A and C).

These additional observations support our earlier comments regarding the influence of transient aircraft and traffic noise in the area and our conclusions regarding the acceptability of the predicted noise levels remain unchanged.

3. *Please confirm the reason for the houses to the west of Watsons Road e.g. 91 Watson being shown bounded in red in Figure 3.3.*

The houses are bounded red as during the peak night time period (a 15 minute period from 4 am), noise levels at the notional boundary of the dwellings on these properties will exceed 40 dB L_{Aeq} which is the District Plan night time noise limit.

4. *It has been recognised that noise criteria at the notional boundary of 37 Waimakariri Road will not be met, but 23 Waimakariri Road's façade is closer to the road and has higher measurement. Please confirm and provide explanation as to why noise criteria will be met at 23 Waimakariri Road?*

Higher noise levels are predicted at 23 Waimakariri Road from trucks on the road due to the closer proximity of this dwelling to the road as described in section 3.3 of the report (50 dB L_{Aeq} compared to 43 dB L_{Aeq} for 37 Waimakariri Road). However, noise from vehicles on the road is not of relevance when considering strict compliance or otherwise with the District Plan noise limits.

With regard to noise from vehicles on the site (which is relevant with regard to District Plan compliance) you will observe that 37 Waimakariri Road is closer to the site access, and receives minimal benefit from the screening installed along the site access. Therefore, while trucks are still on the site, this dwelling will receive higher noise levels than 23 Waimakariri Road.

Please do not hesitate to contact us to discuss further as required.

Kind Regards,

William Reeve
B.E. MASNZ
Acoustic Engineer

Acoustic Engineering Services

8 June 2017

ANNEXURE H:

ACOUSTIC ASSESSMENT

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Report Number: AC16076 – 02 – D4

The Car Distribution Group Ltd Proposed yard 711 Johns Road: Assessment of Environmental Noise Effects

Prepared for:

Simon Gunn
The Car Distribution Group Ltd
PO Box 19524
CHRISTCHURCH

6 April 2017

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ACENZ

Revision History

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AC16076 – 02 – D1	DRAFT FOR CLIENT REVIEW	14 October 2016	W. Reeve
AC16076 – 02 – D2	REVISION	17 March 2017	W. Reeve
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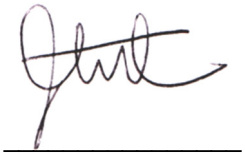
AC16076 – 02 – D4	REVISION	6 April 2017	W. Reeve

Document Acceptance

Author:

William Reeve
B.E.(Hons.) Mech, MASNZ
Acoustic Engineer

Reviewed & Approved:



Dr Jeremy Trevathan
Ph.D. B.E.(Hons.) Assoc. NZPI® MASNZ
Managing Director

On behalf of Acoustic Engineering Services Limited
6 April 2017

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1.0 BACKGROUND

Acoustic Engineering Services (AES) have been engaged by the Applicant (The Car Distribution Group Limited - CDG) to provide acoustic engineering advice in relation to the application for Resource Consent for the establishment of a yard at 711 Johns Road in Christchurch. The Applicant requires an assessment of the environmental noise emitted by this activity, with regard to the Resource Management Act 1991 (RMA), which requires the actual and potential effects of the activity on the environment to be considered.

Our analysis is based on the following documentation:

- Site layout plan as prepared by Cardno Ltd and dated the 1st of March 2017.
- Information regarding operation and vehicle movements from the site received via email from Simon Gunn on the 19th of May 2016.
- Briefing at the existing Bromley yard on the 13th of May 2016 attended by Jeremy Trevathan of AES.

1.1 Site and surrounding area

The applicant site is located at 711 Johns Road (State Highway 1) and is within the Rural Urban Fringe zone as defined in the replacement Christchurch District Plan. The surrounding area to the south of Johns Road is also zoned Rural Urban Fringe and there are several dwellings located on sites adjoining the site, and across Waimakiriri Road.

To the north of Johns Road, the land in the vicinity of the site is used for various industrial and commercial purposes, located within an Industrial Heavy zone.

Christchurch International Airport is located to the west of the site across Johns Road, within a Specific Purpose (Airport) zone. The western edge of the proposed yard is located in the order of 1.2 km from the end of the primary Christchurch International Airport runway (02 / 20), and in the order of 1.3 km from the runup pad, one of the principal locations used for aircraft engine testing. The site and dwellings in the vicinity are located within the bounds of the 50 dB Ldn On-Aircraft Engine Testing Contour, and 55 dB Ldn Air Noise Contour and are therefore exposed to moderate levels of aircraft noise.

A large portion of the site has previously been excavated as a quarry, to a depth of 5 metres. Subsequently, City Care has substantially refilled the quarry with cleanfill. At this time the site was also used for storage of various materials including gravel, soil, bark, asphalt and concrete. Screening of soil and asphalt, mulching of bark and concrete crushing with mobile plant were undertaken on the site although the crushing and mulching mobile plant only operated up to 30 days annually each. The site predominantly operated during daytime hours, with occasional truck access during the night time period for asphalt deliveries during the summer.

Figure 1.1 – Applicant site location (source: Canterbury Maps 13-06-16)

1.2 Proposed activity on site

The site will primarily be used for vehicle storage and loading of vehicle transporters. The area shown orange in figure 1.1 above indicates the developed area of the site which will contain hardstand areas for vehicles, truck wash facilities and a building to provide administration and staff facilities.

Vehicles will access the site from Sawyers Arms Road as shown in figure 1.1 above. The roadway is existing, and is currently used by Orion to access the Waimakariri Substation.

CDG operates a fleet of vehicle transporters which are generally HPMV 23 meter long units (as shown in figure 1.2 below). Typically there would be no more than five or six transporters operating or loading and unloading at any one time. The lifting equipment on the transporters is operated by a power take off system (PTO) which runs the engine at no more than 800 rpm.

Figure 1.2 – CDG vehicle transporters

The northern corner of the site will be used for loading and unloading the vehicle transporters and will also be where the truck wash and buildings are located in order to maximise separation to residential dwellings. The balance of the site will be used for vehicle storage.

We understand that typically CDG will operate with up to 130 vehicle movements per day (65 in and 65 out, primarily during a 0700 to 1700 hours workday. On occasion up to 170 vehicle movements per day may be expected. Approximately half of these movements would be car

movements. This includes staff movements and movements associated with rental car relocations. We understand that the typical CDG operation is Monday – Friday, although there may be two transporter movements over the weekend.

Due to shipping timetables there are also several transporter movements during the night time period, as follows:

0100 hours	2 transporters depart
0200 to 0300 hours	3 transporters depart
0400 hours	6 to 7 transporters depart
0600 hours	2 transporters arrive, unload and reload
2300 to 0100 hours	2 transporters arrive, unload and reload (these trucks depart at 0100 hours)

1.3 Proposed mitigation

The applicant has proposed to include the following mitigation to reduce noise from the activity:

- A 2 – 3 metre bund along the site boundary
- 2 metre high acoustic screening alongside the vehicle access
- 2 metre high internal screening alongside the car unloading / truck wash area (75 metres in length)
- To limit the use of the truck wash area to the daytime period (0700 – 2200 hours)

The screening could be achieved with an earth bund or a barrier which meets the following specifications:

- Surface Mass – 8.0 kg/m^2 (for example 25 mm timber, 18 mm plywood, 6 mm fibre cement, or 1 mm steel)
- The fences must be continuous, and maintained with no gaps or cracks. If constructed with timber palings this will require timber palings to be well overlapped (25 mm minimum) or a “board and batten” system, and a sleeper rail connecting the base of the palings to the ground.

2.0 ACOUSTIC CRITERIA

The Resource Management Act requires consideration of the significance of any adverse effects associated with the proposal. Guidance as to what constitutes a reasonable level may be obtained from several sources.

2.1 District Plan noise limits

As described in section 1.1, the site is located within a Rural Urban Fringe Zone as defined within the operative Christchurch (Replacement) District Plan.

The noise standards which apply for this zone are stated in Table 1 of Rule 6.1.5.2 as follows:

Table 2.1 – District Plan noise limits

Zone of site receiving noise from the activity	Hours	L_{Aeq}	L_{Amax}
All rural zones, except Rural Quarry Zone, assessed at any point within a notional boundary	0700 - 2200	50 dB L_{Aeq}	n/a
	2200 - 0700	40 dB L_{Aeq}	65 dB L_{AFmax}
All rural zones, except Rural Quarry Zone, assessed at the site boundary	0700 - 2200	55 dB L_{Aeq}	n/a
	2200 - 0700	45 dB L_{Aeq}	70 dB L_{AFmax}

The plan goes on to say that any activity that exceeds the Permitted Standards is a Restricted Discretionary Activity and it is a Non-Complying activity where it exceeds the Permitted Standard by more than 10 dB.

We note that the operative Christchurch (Replacement) District Plan does not provide an assessment period but states that noise shall be measured in accordance with NZS 6801:2008 *Acoustics – Measurement of environmental sound*, and assessed in accordance with NZS 6802:2008 *Acoustics - Environmental noise* which recommends a 15 minute measurement interval for fluctuating continuous sound. The Plan also notes that the provisions in NZS 6802 referring to Special Audible Characteristics shall not be applied.

We note that noise from vehicles on roads is specifically excluded within the District Plan.

2.3 Existing ambient environment

2.3.1 Night time noise measurements

William Reeve of AES visited the site between 0400 and 0500 hours on Wednesday the 25th of May 2016 to observe ambient noise levels in the area. During this time it was overcast, with light westerly breezes at times, and the air temperature was mild (approximately 7° C).

Background noise levels recorded in the vicinity of dwellings on Waimakariri Road, were in the order of 40 - 45 dB L_{A90} and 42 - 48 dB L_{Aeq} mainly due to traffic on Johns and Harewood Roads. For a brief period, elevated noise levels were also observed from aircraft engine testing reaching around 60 dB L_{Aeq} during the loudest period.

AES has recently been involved in a process relating to changes in the District Plan with regard to engine testing noise, and on review it appears that noise levels in excess of 80 dB L_{Aeq} may be received at times at this site.

2.3.2 Daytime

AES revisited the site between 1100 and 1130 hours on Friday the 2nd of September 2016 to undertake site specific measurement of trucks travelling on the site access and onto Waimakariri Road. During this time we also undertook brief ambient noise measurements.

Background noise levels recorded in the vicinity of dwellings on Waimakariri Road, were in the order of 48 dB L_{A90} / 62 dB L_{Aeq} mainly due to traffic on Johns and Harewood Roads. Other specific noise sources observed during our time on site included aircraft movements, heavy vehicles engine braking on Johns Road, general noise from the industrial area across Johns Road (including grinding), occasional traffic on Waimakariri Road, bird call and other noise associated with the natural environment.

During our measurement period, we observed the departure of a Singapore Airlines 777 jet from Christchurch airport which generated noise levels in excess of 60 dB L_{Aeq} for a brief period (30 seconds).

2.4 New Zealand Standard 6802

NZS 6802:2008 *Acoustics – Environmental noise* outlines a guideline daytime limit of 55 dB $L_{Aeq\ (15\ minute)}$ and a night-time noise limit of 45 dB $L_{Aeq\ (15\ minute)}$ and 75 dB L_{AFmax} for "the reasonable protection of health and amenity associated with the use of land for residential purposes".

The standard recommends the boundary or notional boundary of noise sensitive sites as the appropriate assessment location.

The Standard explicitly states that an L_{max} noise limit should be set where sleep protection is required, and should only be set for night time hours. It goes on in clause C7.2 to state that *"the intention of $L_{AF,max}$ noise limits is to provide protection against the effects of 'typical maxima' of the specific sound and not the 'absolute maxima'. A noise nuisance does not generally arise from a single isolated incident. A single isolated noise event which exceeds an applicable limit might not be representative of the sound under investigation and should not be used as the sole basis for compliance action."*

2.5 World Health Organisation

Guidelines for Community Noise[1], a document produced by the World Health Organisation based on extensive international research recommends a guideline limit of 55 dB $L_{Aeq\ (16\ hours)}$ to ensure few people are seriously annoyed in residential situations. A guideline limit of 50 dB $L_{Aeq\ (16\ hours)}$ is recommended to prevent moderate annoyance.

A guideline night time limit of 45 dB L_{Aeq} and 60 dB L_{Amax} is recommended to allow occupants to sleep with windows open. This is based on achieving an internal noise level of 30 dB L_{Aeq} with a 15 dB allowance for the outside to inside reduction provided by an open window. This document recommends the assessment of noise at the façade of dwellings and other noise sensitive locations.

2.6 Proposed limits of acceptability

Based on the above, we observe that the District Plan noise standards are more restrictive than the limits recommended by the WHO and NZS 6802:2008 for the protection of residential amenity.

It therefore appears conservative to conclude that if general operational noise from the site complies with the 50 dB $L_{Aeq\ (15\ minute)}$ daytime and 40 dB $L_{Aeq\ (15\ minute)}$ night time District Plan noise limits at the notional boundary of any nearby residential dwellings then noise effects will be acceptable.

Given that the existing area is influenced by traffic noise from Johns Road and transient aircraft noise during the night time period (being located within the 50 dB L_{dn} on-aircraft engine testing contours), we consider that night-time noise levels of 45 dB $L_{Aeq\ (15\ minute)}$ and 75 dB L_{AFmax} between 2200 and 0700 hours from heavy vehicles on the site access would result in acceptable noise effects at any nearby dwellings.

[1] Edited by Berglund, B *et al. Guidelines for community noise*. World Health Organization 1999.

3.0 NOISE GENERATED BY THE ACTIVITY

The noise sources associated with the operation of the distribution yard are expected to be:

- Noise generated by light and heavy vehicles moving about on the site and using the site access
- The operation of the lifting equipment on the transporters (which runs from the engine)
- Noise from vehicles once they have left the site travelling on Waimakariri Road
- Noise associated with the truck wash

Based on the traffic movements described in section 1.3, along with the site layout and physical acoustic mitigation measures adopted we have conducted detailed analysis of the expected noise emissions from the site, and our results are as follows:

3.1 Noise emissions from the site during the daytime period

On a peak day, there may be an additional 170 vehicle movements, with generally less than 130 movements on a typical day. Half of the movements will be made up of heavy vehicles and the remaining movements from light vehicles. We also understand that generally there will be no more than 5 – 6 transporters unloading at any one time.

Given that typical working hours are 0700 to 1700 hours, and assuming an even split over the day would result in a 4 to 5 movements for a fifteen minute period on a peak day. We have therefore based our calculations on the following activities occurring in a fifteen minute period:

- 3 light vehicle movements on the access, moving to the far point of the yard
- 4 heavy vehicle movements on the access
- 2 trucks idling in the yard with the operation of lifting equipment
- A water blaster being used in the truck wash area

SoundPlan computational noise modelling based on ISO 9613 *Acoustics – Attenuation of sound outdoors – Part 2: General method of calculation* has been used to calculate the propagation of noise from the site, taking into account acoustic screening and sound power levels for each of the noise sources.

To determine the sound power generated by the transporters, measurements were undertaken at the Bromley yard of both truck movements and the use of the lifting equipment with the PTO. A site specific study (at 711 Johns Road) of the noise levels generated by trucks using the access was also undertaken. Based on this study we have determined that the use of the lifting equipment on the trucks will generate a sound power of 100 dB L_{wA} each. A single truck movement will generate 78 dB L_{AE} at 15 metres when travelling on the access road. We have modelled a single light vehicle movement as generating 88 dB L_{AE} at 5 metres.

We have assumed a sound power of 90 dB L_{wA} for the use of water blasting equipment in the truck wash based on experience with units used in similar commercial operations.

Based on the above, the expected noise levels have been calculated within the worst affected neighbouring property boundaries during the daytime period. The resulting noise contour is shown in figure 3.1 below.

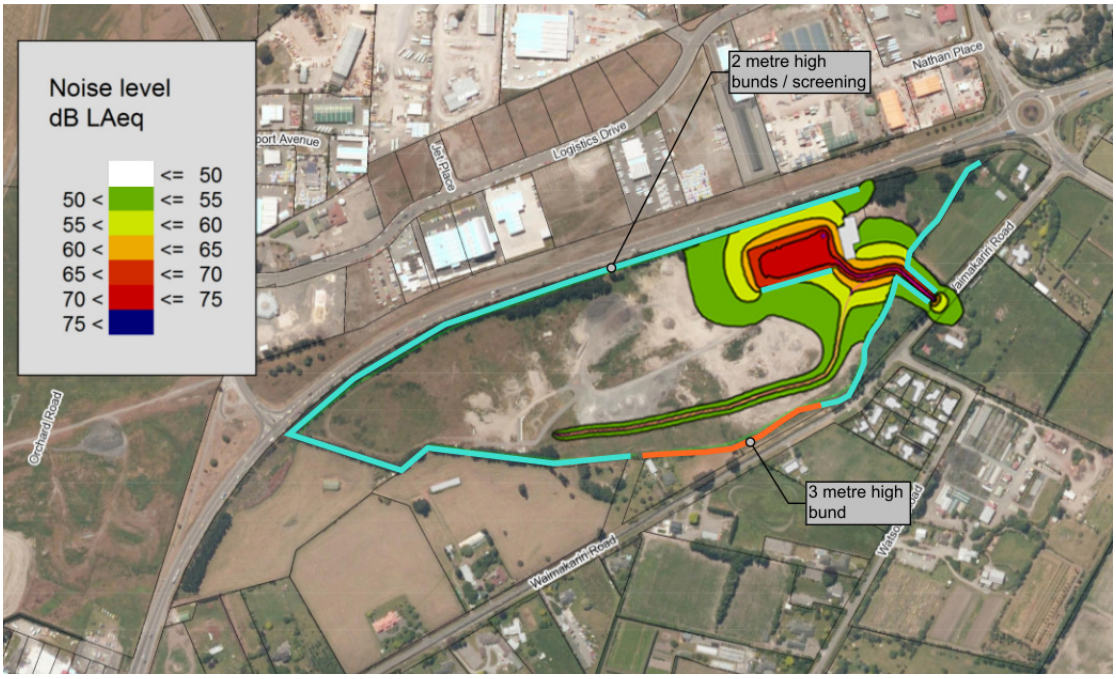

Figure 3.1 – Noise emissions during a peak daytime period

This analysis indicates that the noise levels from the daytime operation of the site are expected to comply with the District Plan 50 dB L_{Aeq} criterion at the notional boundary of any dwellings in the vicinity of the site.

3.2 Typical noise emissions from the site during the night time period

We have assessed a typical operational scenario during the night time period for activities occurring within the yard. The scenario modelled includes light vehicles moving from the far point of the yard to the loading area (6 light vehicles) and 2 trucks idling in the yard with the operation of lifting equipment. The resulting noise emissions from the site are shown in figure 3.2 below.

Figure 3.2 – Noise emissions from operational noise on site

Based on the above, noise levels are less than 40 dB L_{Aeq} at the notional boundary of nearby dwellings during a typical 15 minute period.

3.3 Heavy vehicles accessing the site during the night time period

As outlined in section 1.3, due to shipping timetables transporters need to depart the site during the night time period.

Figure 3.3 depicts the predicted night time noise levels based on four transporters departing the site in a fifteen minute period (i.e. from 0400 hours), with seven transporters idling in the yard for five minutes each.

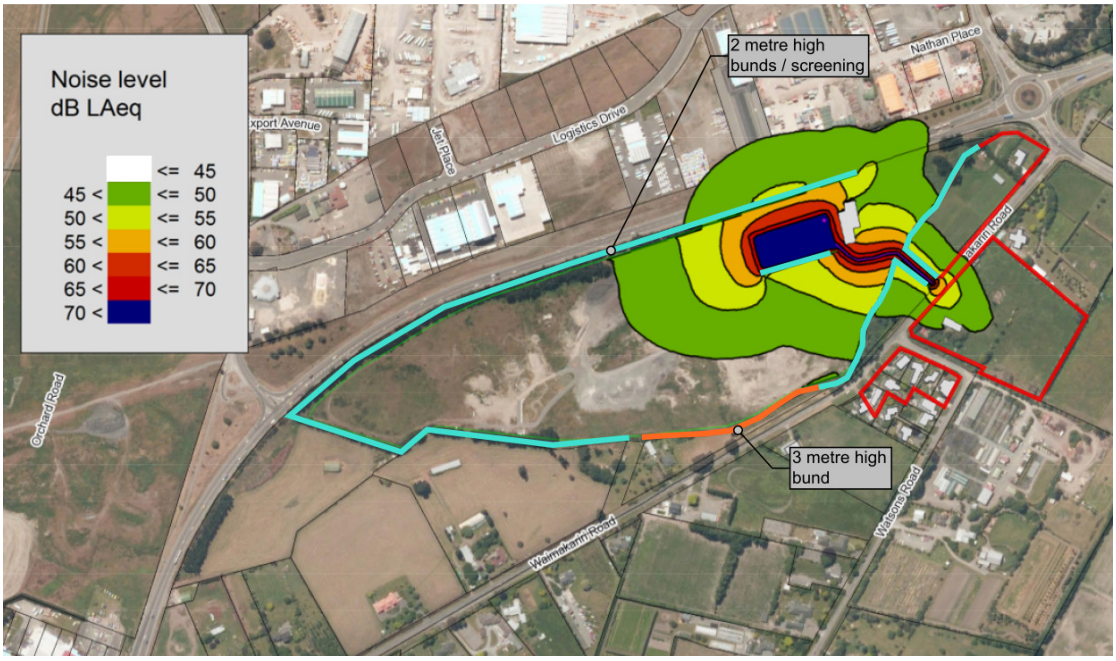

Figure 3.3 – Noise emissions during a peak night time period when trucks leave the site

Based on the above, noise levels are less than 45 dB L_{Aeq} at the notional boundary of nearby dwellings during the worst case 15 minute period. This is in line with WHO and NZS 6802:2008 guidelines for the protection of residential amenity. The character of the noise is also consistent with existing noise sources in the area (from engine testing and traffic).

The exception is the dwelling at 37 Waimakariri Road, where noise levels of up to 47 dB L_{Aeq} are expected on the façade during this peak period even with the screening adopted as shown in figure 3.3.

To avoid negative effects on sleep, internal noise levels of 30 dB L_{Aeq} are recommended by the World Health Organisation. Allowing for a 15 dB reduction for a typical dwelling with windows ajar, we expect sleep disturbance could be likely in situations where there is a bedroom on the side of the dwelling exposed to noise levels in excess of 45 dB L_{Aeq} and the resident is sleeping with windows ajar for ventilation.

Therefore the noise effects realised in practice will depend on a number of factors for this dwelling, including the location of bedrooms and opening windows as well as the type of construction. Where residents sleep with windows closed, or at dwellings where bedrooms used for sleeping are oriented away from the access, then acceptable internal noise levels will be achieved.

Sites where the 45 dB L_{Aeq} boundary or 40 dB L_{Aeq} notional boundary District Plan limits will be exceeded when heavy vehicles access the site are highlighted red in figure 3.3.

3.3 Noise on the road

We note that from a legal perspective the need to assess noise from off-site sources may be contestable, and that from an acoustic point of view the criteria against which assessments should be made is less clear. Nevertheless, we note that it is considered best practice to consider the effects of placing additional vehicle traffic on the existing roading network.

We understand that Waimakariri Road is a relatively low volume road, with only 700 vehicles per day. On peak days, the proposal will add up to 250 vehicle movements with half of these being heavy vehicle movements, including sixteen during the night time period.

We note the following with regard to assessment criteria:

- The Christchurch District Plan specifically excludes traffic noise generated within a Transport Zone from assessment as noted in Rule 6.1.4.2 Exempt Activities.

- NZS6802:2008 seems generally to exclude traffic on public roads, noting in section 1.2.2: *'Sound from vehicles on public roads as a specific source is outside the scope of this Standard'*. However, in clause 1.2.3, the Standard also notes that *'Where sound from transportation or construction is part of the ongoing sound emission from activities, it shall be assessed using this Standard. This includes the use of vehicles on private roads'*.

- The other main guidance typically used to assess road traffic noise is the New Zealand Standard 6806:2010 *Acoustics – Road-traffic noise – New and altered roads*. The Standard does not apply to existing roads, only new or altered roads which carry more than 2000 ADT at the design year. In the scope of the Standard an altered road is a road subject to a horizontal or vertical alignment.

The proposed activity would introduce an increase in the level of traffic to this road. The level of noise from night time movements expected at 4, 23 and 37 Waimakariri Road, is a relevant consideration. Based on specific movements of a car transporter travelling on Waimakariri Road, we predict the following levels at the façade of these dwellings during a worst case hour (seven transporters travelling towards Sawyers Arms Road during the night time period).

4 Waimakariri Road – 55 dB $L_{Aeq\ (1\ hour)}$

23 Waimakariri Road – 50 dB $L_{Aeq\ (1\ hour)}$

37 Waimakariri Road – 43 dB $L_{Aeq\ (1\ hour)}$

We note that 4 Waimakariri Road is already exposed to elevated traffic noise due to its proximity to the Johns Road, Sawyers Road intersection. All dwellings in the vicinity are also exposed to night time engine testing noise from the airport and aircraft movements from international flights into the evening period.

4.0 CONSTRUCTION NOISE

Noise generated by demolition and construction activities associated with the development of the distribution yard has the potential to adversely affect adjoining properties, especially if carried out during the early morning or evening hours.

The operative Christchurch District Plan refers to New Zealand Standard NZS 6803:1999 *Acoustics – Construction Noise.*

We therefore recommend that the applicant adopts best practice procedures to reduce the likelihood of annoyance, nuisance and adverse health effects to people in the vicinity of construction work, and that these activities are planned and managed in accordance with NZ 6803:1999 *Acoustics – Construction Noise*, and that construction is undertaken to ensure noise does not exceed the sound levels specified in Table 2 and 3 of the Standard.

We recommend that where practicable, the bunds to the south of the yard are installed before hardstand areas and buildings to assist with reducing noise emissions during the construction period.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Noise from sources likely to be associated with the proposed establishment of a yard at 711 Johns Road in Christchurch has been assessed.

Based on our review of the Christchurch District Plan, and relevant local and international guidance such as WHO and NZS 6802, we observe that the District Plan noise standards are more restrictive than the limits recommended by the WHO and NZS 6802:2008 for the protection of residential amenity.

It therefore appears conservative to conclude that if general operational noise from the site complies with the 50 dB $L_{Aeq\ (15\ minute)}$ daytime and 40 dB $L_{Aeq\ (15\ minute)}$ night time District Plan noise limits at the notional boundary of any nearby residential dwellings then noise effects will be acceptable.

Given that the existing area is influenced by traffic noise from Johns Road and transient aircraft noise during the night time period (being located within the 50 dB L_{dn} on-aircraft engine testing contours), we consider that night-time noise levels up to 45 dB $L_{Aeq\ (15\ minute)}$ and 75 dB L_{AFmax} between 2200 and 0700 hours from heavy vehicles using the access to the site would still result in acceptable noise effects at any nearby dwellings.

Based on the traffic data provided, these criteria will be met at the notional boundary of all nearby dwellings, with the exception of 37 Waimakariri Road during the night time period where levels of up to 47 dB L_{Aeq} are expected at the façade. For this dwelling, sleep disturbance may occur if there is a bedroom on the side of the dwelling exposed to noise levels in excess of 45 dB L_{Aeq} and the resident is sleeping with windows ajar for ventilation.

The noise effects realised in practice will depend on a number of factors for this dwelling, including the location of bedrooms and opening windows as well as the type of construction. Where residents sleep with windows closed, or at dwellings where bedrooms used for sleeping are oriented away from the access, then acceptable internal noise levels will be achieved.

To give confidence that noise emissions associated with the establishment and operation of the proposed development are maintained at appropriate levels, we recommend that the following condition of consent or advice notes are adopted:

- *Physical acoustic mitigation being acoustic site fencing / bunding shall be adopted and constructed as outlined in this report.*
- *Reversing beepers should be disabled, or replaced with an alternative warning system where it is practical and safe to do so.*
- *Construction and demolition noise be planned and managed in accordance with NZ 6803:1999 Acoustics – Construction Noise to minimise adverse effects on adjoining properties.*
- *Limit the use of the truck wash area to between 0700 and 2200 hours*