16 September 2022 Document Ref: AKL2021-0235AC Rev 2

Maven Associates Limited

5 Owens Road
Epsom
Auckland

Attention: Glen Bellingham

RE: GEOTECHNICAL APPRAISAL REPORT

1738 STATE HIGHWAY 1, WARKWORTH

1 INTRODUCTION

CMW Geosciences (CMW) was engaged by Maven Associates Limited to carry out a geotechnical appraisal investigation of a site located at 1738 State Highway 1, Warkworth, which is being considered for a Plan Change application.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced AKL2021-0235AB Rev 0 dated 23 August 2021. An additional subsequent scope was added for the completion of 3 soakage tests.

This report is to support a Plan Change application to Auckland Council.

2 SCOPE OF WORK

As detailed in our proposal letter, the agreed scope of work to be conducted by CMW was defined as follows:

- Desktop study of the entire site including review of available reporting and geotechnical data, aerial photos and geological map references.
- Preparation of a Geotechnical Appraisal Report including relevant geotechnical plans, outlining a preliminary site-specific geotechnical hazards assessment and recommendations relating to future development.
- Soakage testing at 3 locations has also been completed and included in this report.

3 SITE LOCATION

The site, legally described as PT Allot 72 Psh of Mahurangi SO 891, PT Allot 73 Psh of Mahurangi SO 891E and PT Allot 64 Psh of Mahurangi SO 891E, comprises approximately 46.5 Hectares and is located at 1738 State Highway 1, Warkworth.

The site location and current general landform, together with associated features located within and adjacent to the site is presented on Figures 1 and 2 below.

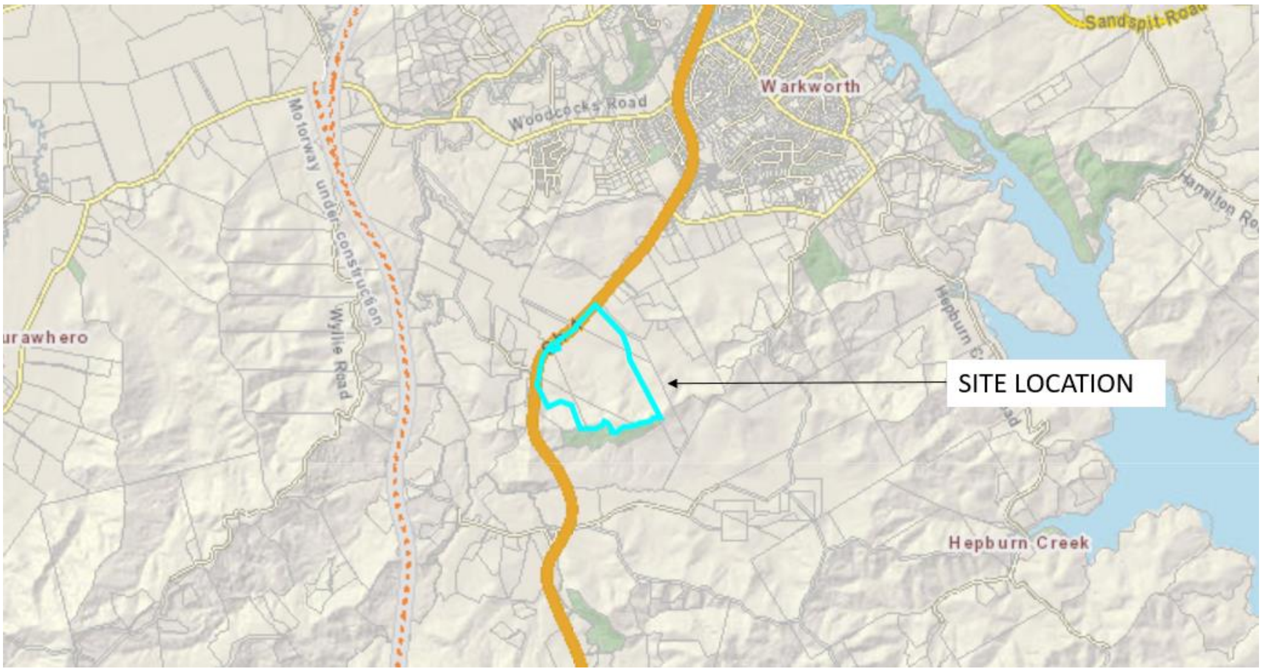


Figure 1: Site Location (Auckland Council GeoMaps)

Figure 2: Site Location and Landform (Auckland Council GeoMaps)

Topography of the site is dominated by a relatively steep, prominent ridgeline along the southern boundary with a maximum elevation of approximately RL 129m. Two smaller ridgelines spur off this prominent ridge, grading steeply to moderately to the north of the site. Maximum elevations along these spur ridges range between RL 50m and RL 100m. Topography in the northern portion of the site is generally characterised by gentler, rolling hills. Multiple head scarps are visible across the site, mainly along the heads and flanks of gullies, with a large instability feature present toward the southeast corner of the site extending outside of the site boundary.

Three small gullies run down to the northern boundary through the west, east and centre of the site. These align with the ridges mentioned above. Multiple overland flow paths, flood plains and flood prone areas also surround these streams. An existing stormwater pipe runs in close proximity to the western boundary.

An existing dwelling and swimming pool are present in the western portion of the site, and multiple farm structures surround the house. A gravel driveway runs from State Highway 1 from the north to give access to the house. We understand the property is currently being used for farming purposes.

The site is bound to the west and the north by State Highway 1, to the south by Avice Miller Scenic Reserve and to the east by rural properties and farmland. The site is located approximately 1km south of the Warkworth town centre. Unitary zoning has currently noted the majority of the site as a future urban zone, and a small strip in the southern section as a rural production zone.

Historical aerial photographs show that the dwelling was constructed before 1970. Surrounding land appears undeveloped and/or used for agricultural purposes. The majority of the site has remained unchanged apart from the construction of a few more minor structures and minor vegetation. Ground levels and contouring appear to remain similar to present. The large instability/landslide feature present in the south eastern corner of the site is also clearly visible from the earliest historic aerial documentation (1963), with only a small number of active instability features evident since aerial documentation began, around the flanks and heads of gullies.

4 PROPOSED DEVELOPMENT

It is understood from the Proposed Contours Plan provided by Maven Associates, (referenced Warkworth South Plan Change Fore Ka Waimanawa Lp & Stepping Towards Far Ltd – Project number 211001, Rev A, dated August 2022), that the proposed development could comprise numerous high density residential lots and several roads in the northern two thirds of the development, with multiple larger rural residential lots on the southern third of the development. It is evident from the Proposed Cut/Fill Plan supplied by Maven Associates that cuts of up to 7m and fills of up to 9m are anticipated.

It is expected that this geotechnical appraisal may alter preliminary development plans and feasibility options for this site.

5 DESKTOP STUDY

CMW carried out a review of relevant geotechnical information for the site and neighbouring sites, historical aerial photographs, the New Zealand Geotechnical Database (NZGD) and previous reports. The most relevant geotechnical reports and aerial photographs are referenced below.

- *Aerial Photographs:*
    - S/N3288, Run G Photos 3, 2, 1, Scale 8,000, 25.08.1970; S/N3288, Run F, Photos 7, 6, 5, Scale 8,000, 25.08.1970; S/N1404, Run E, Photos 8, 7, 6, Scale 8,100, 27.04.1963.
- *NZGD:*
    - Three Auckland Council Boreholes drilled in close proximity to the sites boundaries referenced Auckland Council Waterbore Database SH1 Warkworth and dated 17/02/1986, 28/02/1994 and

06/04/2010. These boreholes found clays of depths up to 12.0m below ground level, and alternating hard mudstones and sandstones to depths up to 186m.

- One CPT by Tonkin + Taylor referenced SH1 Four Laning – job number 16663 and dated 25/03/1999 located just north of the site interpreted to be clays from 0.1m to 10.1m then into transitional until rock is met at 10.2m.

- *Preliminary Geological Appraisal Report by Lander Geotechnical Ref No: J01249 and dated 21 August 2019:*
  - Six hand auger boreholes denoted HA01-HA06 were drilled to depths between 1.2 and 3.0m below ground level in the northern half of the site. Topsoil and unsuitable fills were encountered to depths of 0.6m overlying Pakiri Formation which consisted of very stiff to hard silts, sands and clays.
  - HA01, HA04, and HA05 encountered alluvium deposits within the gully inverts with some organic deposits. Alluvium strengths ranged between soft and hard. HA05 terminated at 1.2m due to hard ground.
  - Groundwater was encountered in HA01, HA04 and HA05 at respective levels of 2.9m, 1.0m and 2.7m below ground level.
- *Auckland Council "Geotechnical and coastal hazards assessment – Draft Warkworth Structure Plan", dated November 2018:*
  - This report outlines the existing environment in the wider Warkworth study area with regards to geotechnical and coastal hazards in relation to the Draft Warkworth Structure Plan. It highlights that the Future Urban Zone (FUZ) is located upstream of the Mahurangi River, extending further landwards in northerly, southerly, and westerly directions (the subject site encompasses part of this FUZ). It also identifies that most of the FUZ is underlain by Waitemata Group rocks with smaller areas of Northland Allochthon, and soft estuarine and alluvial sediments. Although landslides have been observed on some slopes, no areas within the study area have been determined as unsuitable for development because of slope instability, and hazards identified should be practical to address with engineering controls.

6 GROUND MODEL

6.1 Published Geology

Published geological maps[1] depict the area as comprising Pakiri Formation of the Waitemata Group, described as alternating thick-bedded, volcanic rich, graded sandstone and siltstone with volcanic grit beds which age back to the Neogene. North of the site the Pakiri Formation is overlain with middle to late Pleistocene river and hillslope deposits from the Tauranga Group. Surrounding geologies also include Holocene river deposits and Mahurangi Limestone of the Northland Allochthon, as illustrated in Figure 3 below.

[1] Edbrooke, S. W. (compiler) 2001: Geology of the Auckland area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 3. 1 sheet +74 p. Lower Hutt, New Zealand. Institute of Geological & Nuclear Sciences.

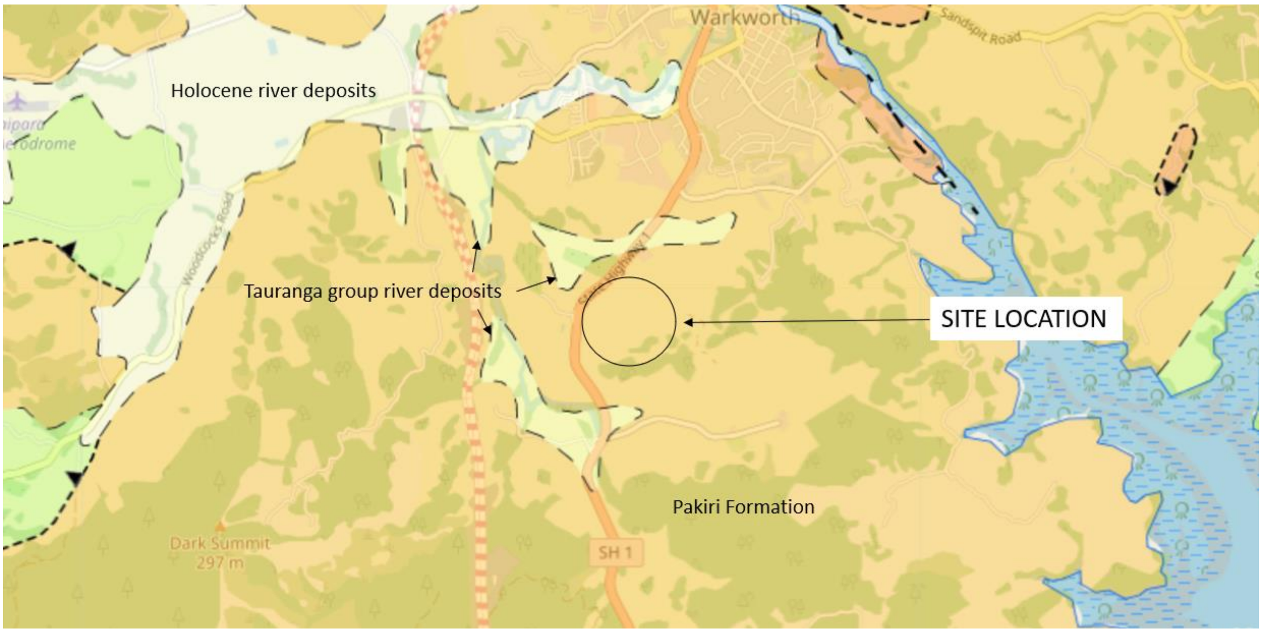


Figure 3: Regional Geology (GNS Science Web Geology Map)

Based on the known history of the site and surrounding land levels, some superficial depths of fill could be anticipated as a result of soft landscaping.

6.2 Geomorphology

The geomorphology of the site reflects the underlying geology and associated slope processes. The dominant regional structure is evident in the subject and neighbouring sites in the form of features (i.e. persistent alignments of gullies, ridgelines, rivers etc.) oriented approximately E/W and SE/NW as well as strong north-south oriented lineations.

This geology is typically faulted into gently tilted blocks along sub-vertical defects, and this appears to be the case with this site also. The contour of the prominent southern ridgeline and adjacent blocks to the east and south suggests significant slope movement has occurred, in the form of large head scarps, hummocky ground, mid-slope benches and shallow failures around the gullies. This is consistent with examination of the historic aerial photos and findings from the preliminary Lander Geotechnical report.

7 GEOHAZARDS ASSESSMENT

The following sections of this report provide an assessment of the geohazards relevant to this site. Our assessment of hazards is based on the existing landform, unaltered by potential future works.

7.1 Liquefaction

7.1.1 General

Soil liquefaction is a process where typically saturated, granular soils develop excess pore water pressures during cyclic (earthquake) loading that exceed the effective stress of the soil. In loose soils, some dilation can occur during this process, which can lead to individual soil grains moving into suspension. Following the onset of liquefaction, the shear strength and stiffness of the liquefied soil is effectively lost causing excessive differential settlement of the ground surface, bearing capacity failure and collapse of structures and low-angle lateral spreading of slopes in liquefiable soils.

In accordance with NZGS guidance[2] the liquefaction susceptibility of the soils at this site has been considered with respect to geological age, soil fabric and soil consistency / density.

7.1.2 Geological Age

The vast majority of case history data compiled in empirical charts for liquefaction evaluation come from Holocene deposits or man-made fills[3,4]. Pleistocene aged alluvium (>12,000 years) is considered to have a very low to low risk of liquefaction[4.]

Although not mapped on the geological map, Lander found recent alluvium and organics within the low-lying areas and gully inverts in the northern portion of the site. It is possible that recent alluvium could be susceptible to liquefaction.

Notwithstanding this, age alone is often debated as being of insufficient evidence to discount liquefaction potential due to its qualitative nature.

7.1.3 Soil Fabric

Soils are also classified with respect to their grain size and plasticity to assess liquefaction susceptibility. Based on more recent case histories, there is general agreement that sands, non-plastic silts, gravels and their mixtures form soils that are susceptible to liquefaction. Clays, although they may significantly soften under cyclic loading, do not exhibit liquefaction features, and therefore are not considered liquefiable. NZGS guidance[5] sets out the plasticity index (PI) criteria for liquefaction susceptibility as follows:

PI < 7: Susceptible to Liquefaction

7 ≤ PI ≥ 12: Potentially Susceptible to Liquefaction

PI ≥ 12: Not Susceptible to Liquefaction

The fines content of the sands beneath the site also has a significant impact on their liquefaction susceptibility.

Although future investigation works will need to further define this hazard, based on our experience in the area, we would anticipate most of the site soils to be clayey and silty I nature, and thus at low risk of liquefaction. Based on our preliminary assessment criteria, liquefaction is anticipated to be low risk to this development.

7.2 Lateral Spread

Following the onset of liquefaction, the liquefied soils behave as a very weak undrained material, which can give rise to lateral spreading where a free face is present within the vicinity of the site or where proposed cut and fill batters are proposed over or within liquefied soils. As noted above, liquefaction is considered to be a low risk, however further assessment will be required following intrusive site investigations.

7.3 Slope instability

A qualitative assessment of slope instability potential has been undertaken based on the visually observed features across the site, in conjunction with findings from the Lander Geotechnical Preliminary Geological Appraisal report and historic investigations on adjacent sites.

[2] Earthquake Geotechnical Engineering Practice, Module 3: Identification, assessment and mitigation of liquefaction hazards", (May 2016)

[3] Seed, H.B. and Idriss, I.M. (1971) *A simplified procedure for evaluating soil liquefaction potential*, Earthquake Engineering Research Centre, Report No. EERC 70-9, University of California

[4] Youd, T.L. and Perkins, D.M. (1978) Mapping liquefaction-induced ground failure potential, *Journal of the Geotechnical Engineering Division,* ASCE, Vol. 104, No. GT4, Proc Paper 13659, p. 433-446

We consider the instability features present within the southern portion of the site to be relatively large-scale features and that significant engineering solutions such as shear keys, in-ground (palisade) walls and or/ counterfort drainage will be required to remediate the landform here to allow for the proposed development.

Other small-scale instability features present around the heads and flanks of gullies are expected to be remediated through palisade walls and subsoil drainage.

Specific slope stability analysis will need to be undertaken as part of detailed investigation and design to assess construction requirements for the overall design of any future development to ensure appropriate slope stability factors of safety are achieved.

Approximate locations of potential engineering solutions required for the proposed development are indicated on the attached Potential Remediation Markup Plan. It should be noted that this plan is indicative only and will be adjusted as required once detailed investigations and analyses are completed.

7.4 Load Induced Settlement

Soft and/ or organic soils that are susceptible to load induced settlement are likely to be present within the low-lying areas of the gullies.

Remedial works may be required. Typically, this would incorporate either undercutting and removal, or preloading the soils to drive settlement prior to the development of infrastructure or buildings.

It is understood however, that little to no fill will be placed directly on top of the locations where Lander recorded alluvium.

Further assessment and/or analysis will be required as part of detailed investigations and scheme development.

7.5 Expansive Soils

Seasonal shrinking and swelling results in vertical surface ground movement which can cause significant cracking of floor slabs and walls. There have been instances of concrete floors and/ or foundations that have been poured on dry, desiccated subgrades in summer months on expansive soils and have undergone heaving and cracking requiring extensive repairs or re-building once the soil moisture contents have returned to higher levels. This hazard is addressed by a combination of careful foundation design and site preparation.

Based on our testing and experience in the Warkworth area, we anticipate that site soils will fall within the high to extreme expansive soil classification range.

Mitigation of the expansive hazard is undertaken by a combination of appropriate foundation design selection at Building Consent stage and appropriate moisture control within subgrade soils during construction. Foundation contractors must be aware of this issue and the need to maintain appropriate moisture contents in the footings and building platform subgrade between the time of excavation and pouring concrete.

This hazard will be further addressed at the completion of earthworks for the development, with specific testing on a lot-by-lot basis in a Geotechnical Completion Report (GCR).

7.6 Uncontrolled/Uncertified Fills

It is evident that some amounts of uncertified fill will be present across the site, in areas of past building works or landscaping.

Existing, non-engineered fills will need to be undercut and replaced or reworked with engineered fill. We anticipate that most of the deposits, other than any organic material, should be able to be reused as engineered fill once dried and blended.

8 SOAKAGE TESTING

We have carried out three falling head tests with locations shown on the appended Soakage Testing Plan. The soil units within the boreholes can be characterised as both Alluvium and Residual Pakiri Formation Soils, generally comprised of clay/silt mixtures.

The falling head percolation testing methodology is in accordance with the Auckland Council Technical Publication Stormwater Soakage and Groundwater Recharge in the Auckland Region GD2021/007.

This comprised drilling 0.1m diameter boreholes to up to 2m depth and pre-soaking the boreholes for a period of no less than 17 hours. Soakage testing was then conducted the following day. Full test results are attached to this report.

Based on test data, we have estimated the percolation rates with the followings methods:

- Ciria 113 Appendix 4, Control of Groundwater for Temporary Works.
- Hvorslev (1951) Time Lag and Soil Permeability in Ground-Water Observations, Fig 18, p49.

The percolation rate estimates are summarised in Table 1 below.

Table 1: Percolation Rate Estimates

Location	Calculation Method	Percolation Rate	
		m/s	m/day
HA01-22	Ciria 113	0	0
	Hvorslev (1951)	0	0
HA02-22	Ciria 113	$1.59x10^{-5}$	1.37
	Hvorslev (1951)	$1.66x10^{-6}$	0.14
HA03-22	Ciria 113	0	0
	AHvorslev (1951)	0	0

The permeability results of the falling head test are considered low and on-site disposal of stormwater via infiltration may not be appropriate for this site.

9 CONCLUSION

The majority of the <u>northern</u> portion of the site is anticipated to require minimal engineering input to be suitable for residential development. Geotechnical hazards associated with recent alluvium such as liquefaction and load induced settlement may require small scale remediation.

The <u>southern</u> portion of the site and gullies, however, is anticipated to require more extensive engineering solutions such as shear keys, in-ground walls, and subsoil drainage to remediate the geotechnical risk here.

Indicative remediation is detailed on the Potential Remediation Plan, attached to this report.

Further subsurface investigation is required to confirm assumptions in this report and provide further recommendations around the development of the site.

Permeability of the natural soils is low and in two of the three test locations, no significant soakage was measured.

10 LIMITATION

This report has been prepared for use by our client, Maven Associates Limited and their consultants. Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

Information for this report has been obtained from a review of existing documents. As such, there may be special conditions pertaining to this site which have not been disclosed to date and which have not been considered in the report. Specific investigation will be required to confirm the assumptions contained.

11 CLOSURE

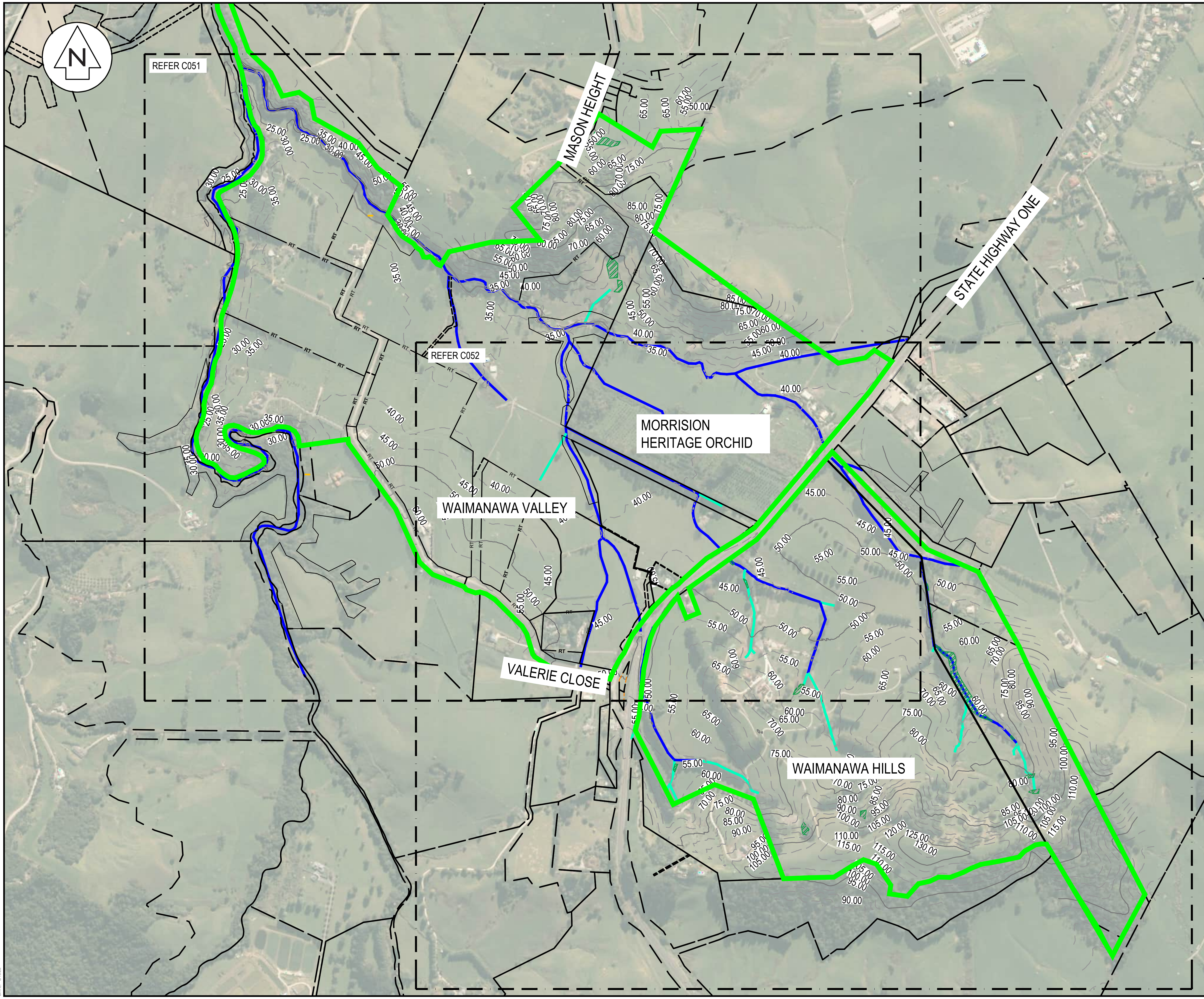
We trust this report meets your requirements. Should you require any further information or clarification regarding the information provided in this report, please do not hesitate to contact the undersigned.

For and on behalf of CMW Geosciences

Prepared by:	Reviewed and authorised by:
Tessa Egan	Andrew Linton
Project Engineering Geologist	Principal Geotechnical Engineer, CPEng

Distribution: 1 electronic copy to Maven Associates Limited via email
Original held at CMW Geosciences

Attachments: Supplied Maven Plans
Soakage Testing Plan, Results and Hand Auger Logs
Potential Remediation Markup Plan



Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Origin of Levels = CA 97 (ABLQ)
   Published RL=43.36, sourced from The LINZ Digital Geodetic Database.
5. Boundaries are subject to final survey.

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Rev	Description	By	Date
A	PPC	KH	08/22

	By	Date
Survey	PARALAX & MAVEN	03/21
Design		
Drawn	KH	08/22
Checked	GB	08/22

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Project
WARKWORTH SOUTH PLAN CHANGE FORE KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD

Title
TOPOGRAPHICAL SURVEY OVERVIEW PLAN

Project no.	211001
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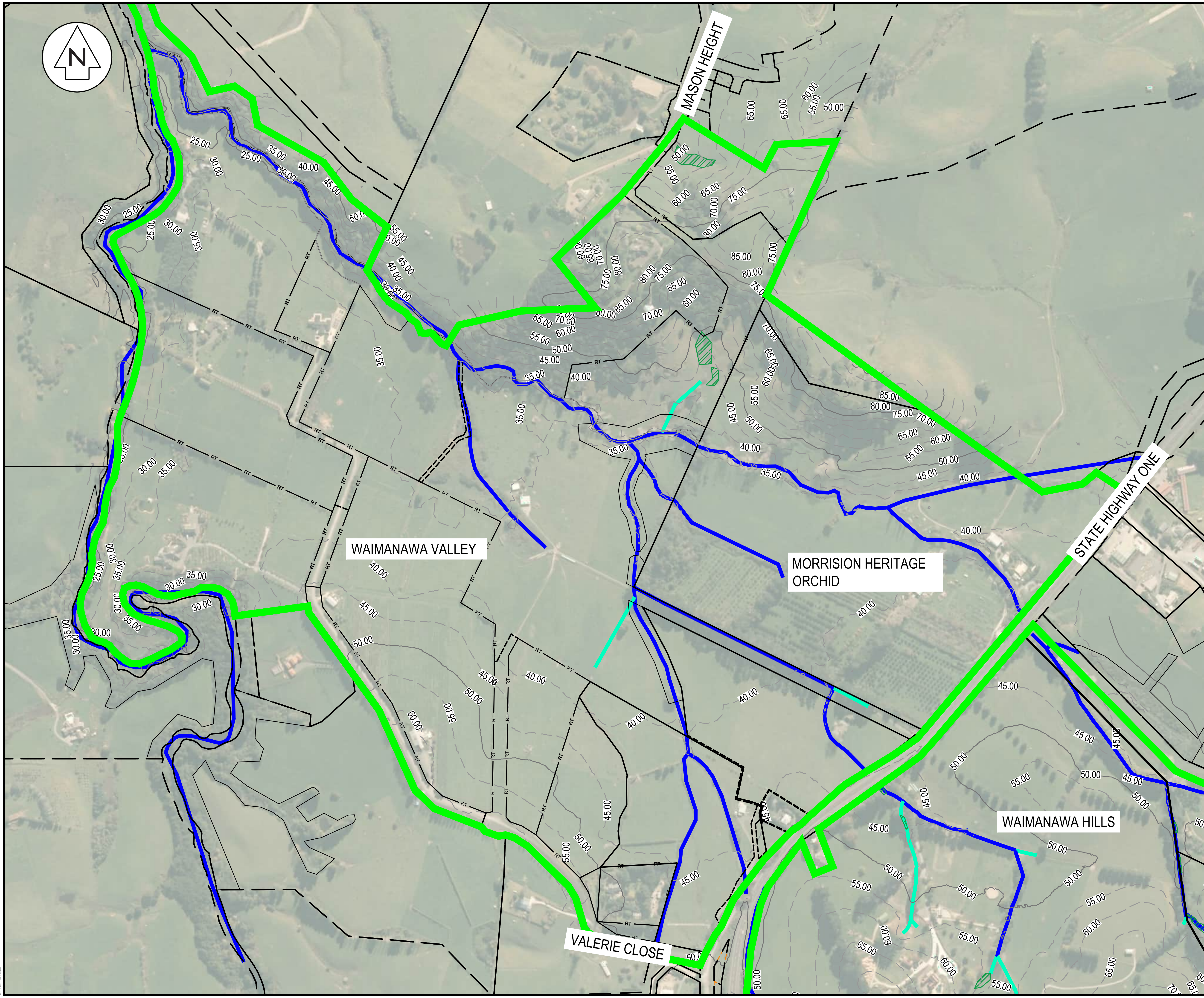
Drawing no.	C050 — Rev A

DATE: 8/19/22



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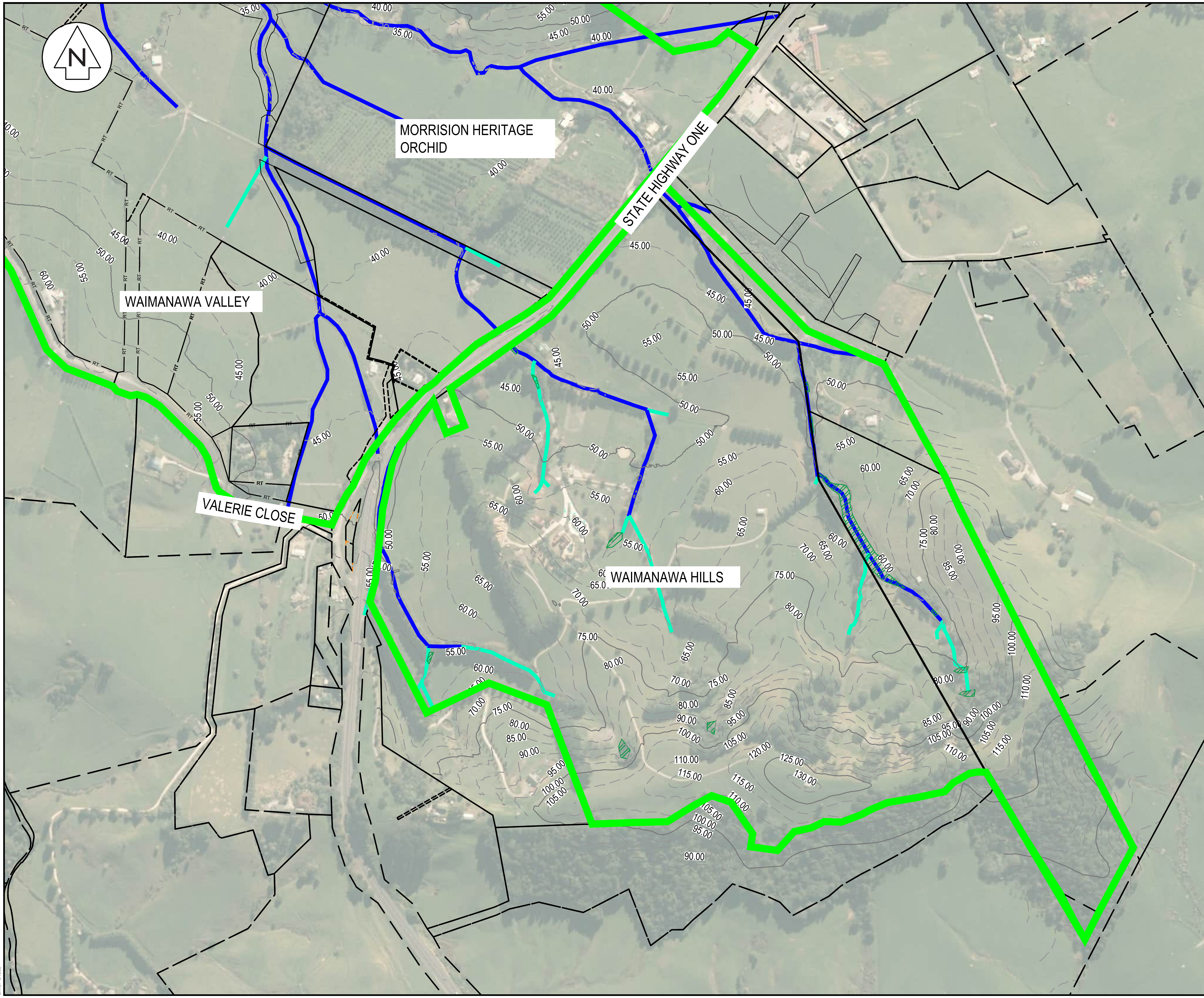

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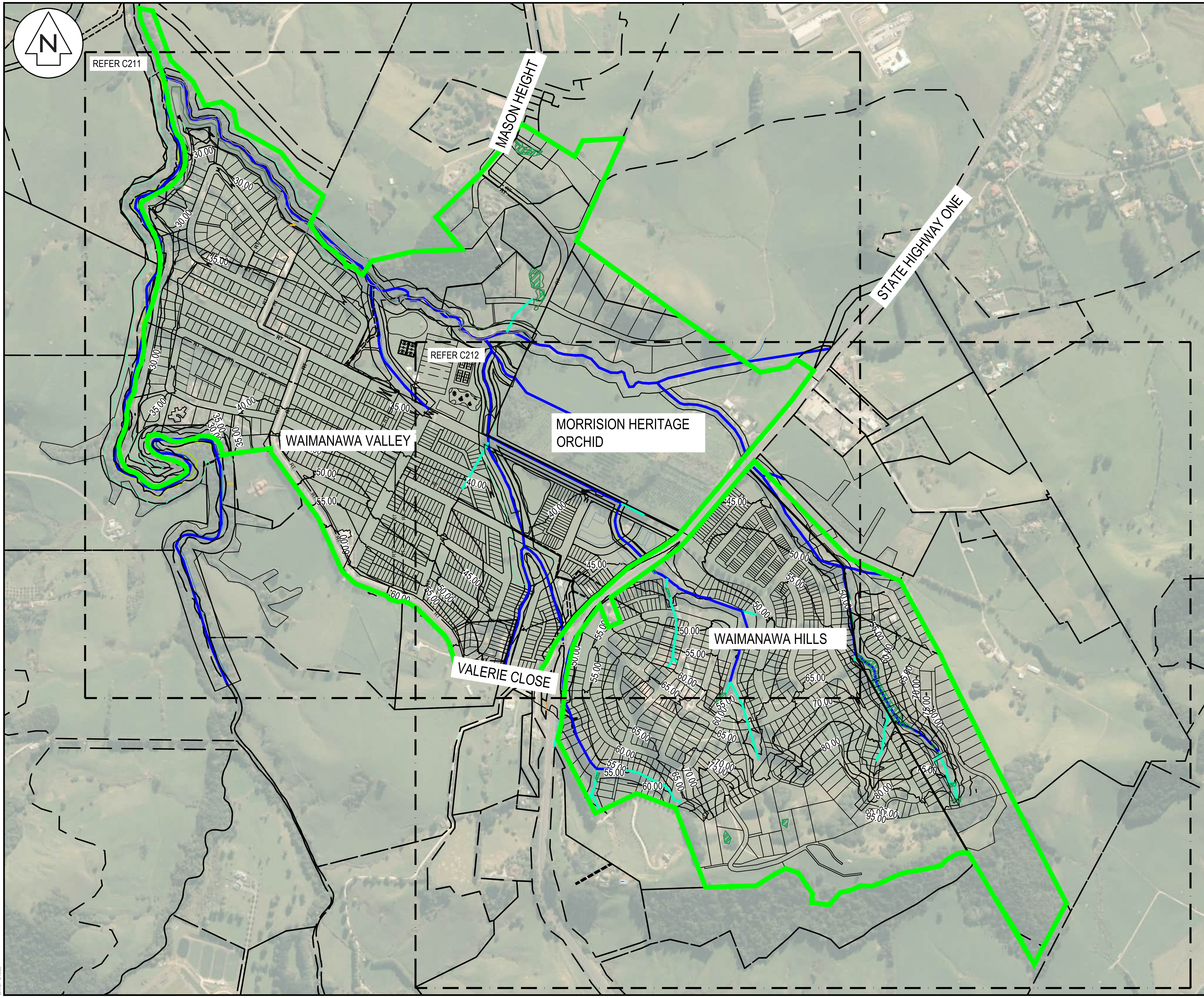

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Drawing no.	C210
Rev	A

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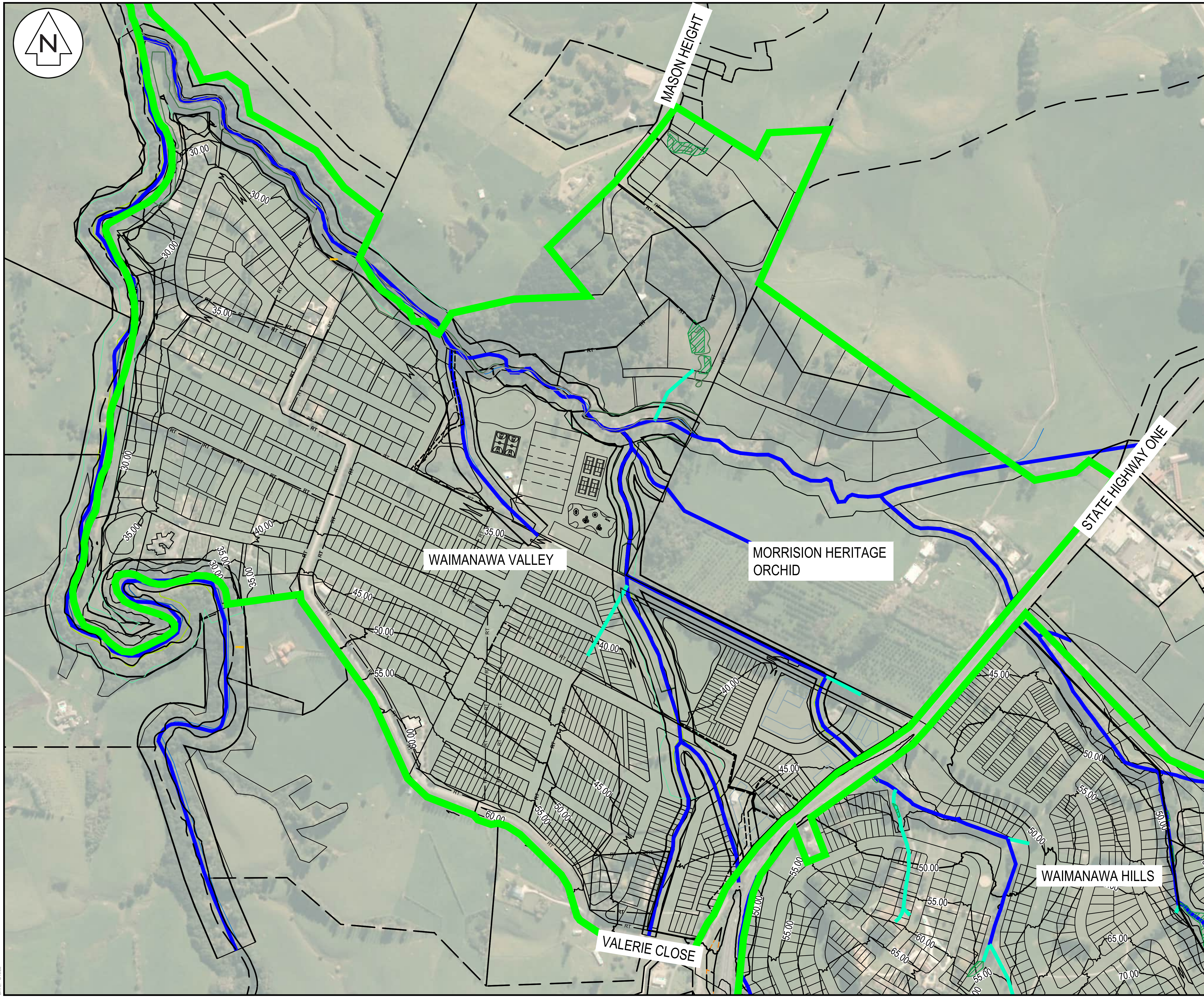

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PROPOSED CONTOURS PLAN

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Rev	A

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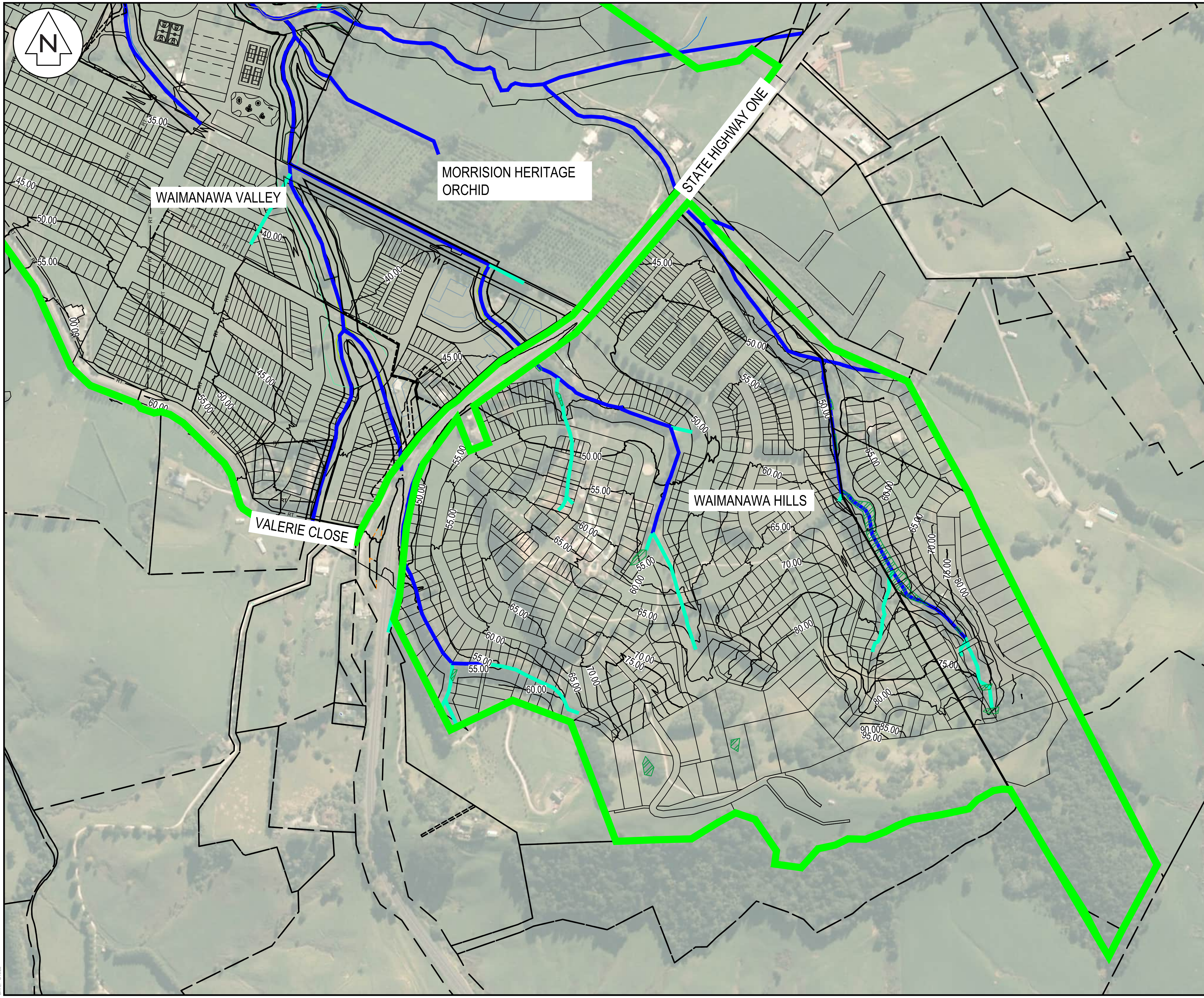

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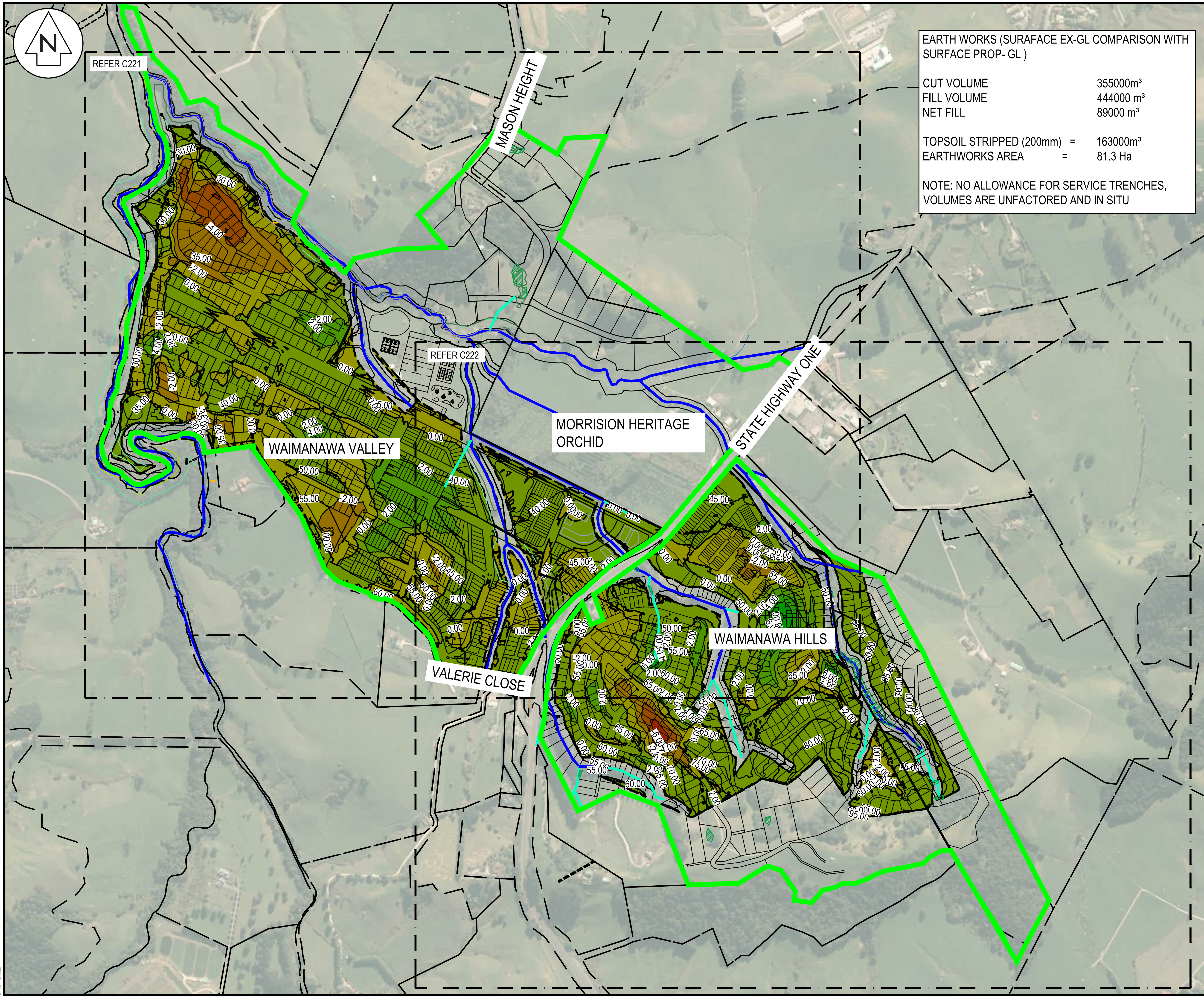

EARTH WORKS (SURAFACE EX-GL COMPARISON WITH SURFACE PROP- GL)

CUT VOLUME	355000m³
FILL VOLUME	444000 m³
NET FILL	89000 m³
TOPSOIL STRIPPED (200mm) =	163000m³
EARTHWORKS AREA =	81.3 Ha

NOTE: NO ALLOWANCE FOR SERVICE TRENCHES, VOLUMES ARE UNFACTORED AND IN SITU

Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Origin of Levels = CA 97 (ABLQ) Published RL=43.36, sourced from The LINZ Digital Geodetic Database.
5. Boundaries are subject to final survey.

Legend
- EX BDY
- PROP BDY
- PLAN CHANGE BDY
- EX PERM. STREAM
- EX INT. STREAM
- EX WETLAND

Cut/Fill Table

Number #	Minimum Elevation	Maximum Elevation	Color
1	-7.019	-6.000	
2	-6.000	-4.000	
3	-4.000	-2.000	
4	-2.000	0.000	
5	0.000	2.000	
6	2.000	4.000	
7	4.000	6.000	
8	6.000	8.684	

Rev	Description	By	Date
A	PPC	KH	08/2022

	By	Date
Survey	PARALAX & MAVEN	03/21
Design	KH	07/22
Drawn	KH	08/22
Checked	GB	08/22

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5 Owens Road, Epsom
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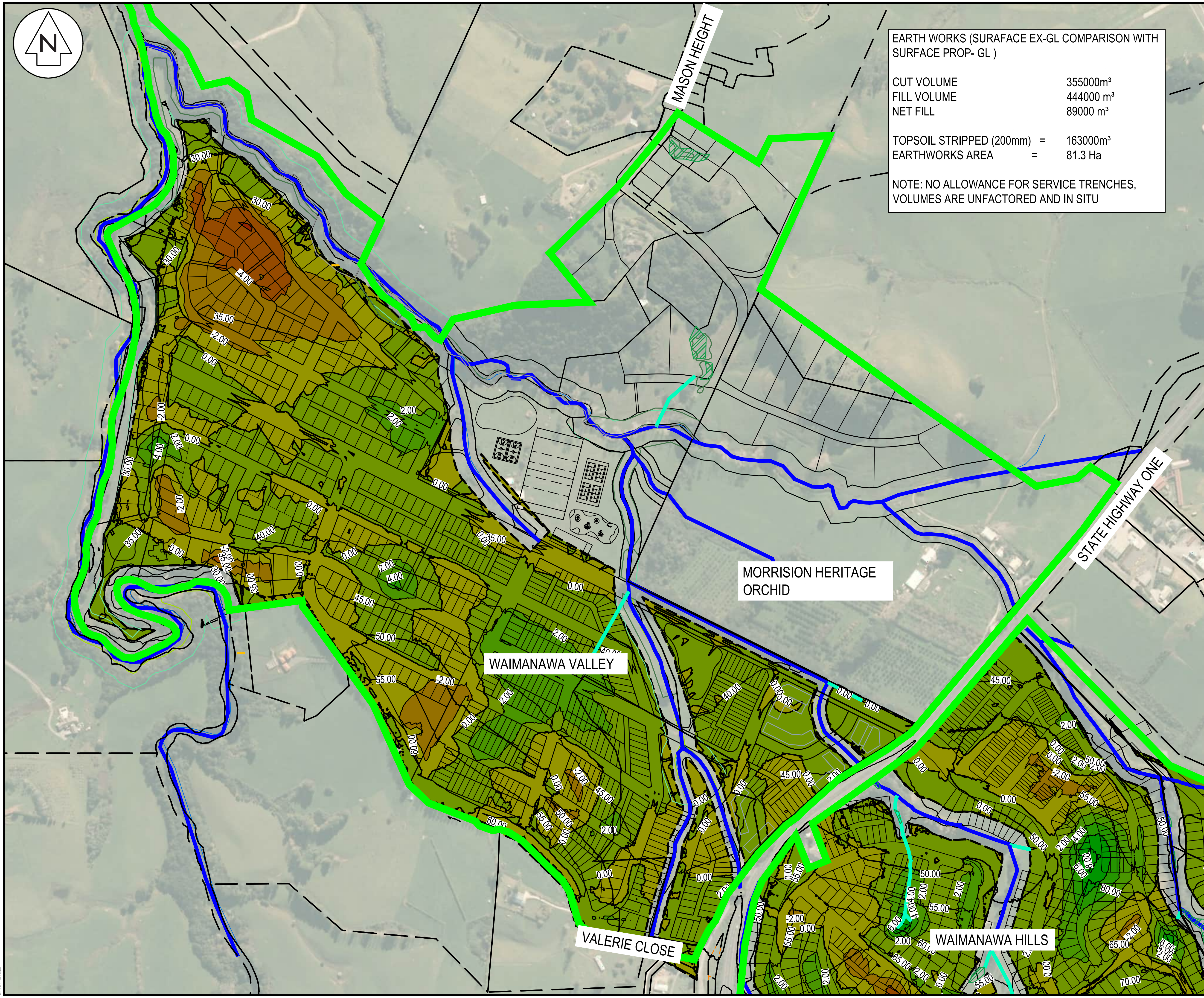
Project
WARKWORTH SOUTH PLAN CHANGE FORE KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD

Title
PROPOSED CUT/FILL OVERVIEW PLAN

Project no.	211001
Scale	1:7500 @ A3
Cad file	211001- COMBINED PC EW.DWG
Drawing no.	C220
Rev	A

DATE: 8/19/22



EARTH WORKS (SURAFACE EX-GL COMPARISON WITH SURFACE PROP- GL)

CUT VOLUME	355000m³
FILL VOLUME	444000 m³
NET FILL	89000 m³
TOPSOIL STRIPPED (200mm) =	163000m³
EARTHWORKS AREA =	81.3 Ha

NOTE: NO ALLOWANCE FOR SERVICE TRENCHES, VOLUMES ARE UNFACTORED AND IN SITU

Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Origin of Levels = CA 97 (ABLQ) Published RL=43.36, sourced from The LINZ Digital Geodetic Database.
5. Boundaries are subject to final survey.

Legend

- EX BDY
- PROP BDY
- PLAN CHANGE BDY
- EX PERM. STREAM
- EX INT. STREAM
- EX WETLAND

Cut/Fill Table

Number #	Minimum Elevation	Maximum Elevation	Color
1	-7.019	-6.000	
2	-6.000	-4.000	
3	-4.000	-2.000	
4	-2.000	0.000	
5	0.000	2.000	
6	2.000	4.000	
7	4.000	6.000	
8	6.000	8.684	

Rev	Description	By	Date
A	PPC	KH	08/2022

	By	Date
Survey	PARALAX & MAVEN	03/21
Design	KH	07/22
Drawn	KH	08/22
Checked	GB	08/22

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Project

WARKWORTH SOUTH PLAN CHANGE FORE KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD

Title

PROPOSED CUT/FILL PLAN

Project no.	211001
Scale	1:5000 @ A3
Cad file	211001- COMBINED PC EW.DWG
Drawing no.	C221 Rev A

DATE: 8/19/22

EARTH WORKS (SURAFACE EX-GL COMPARISON WITH SURFACE PROP- GL)

CUT VOLUME	355000m³
FILL VOLUME	444000 m³
NET FILL	89000 m³
TOPSOIL STRIPPED (200mm) =	163000m³
EARTHWORKS AREA =	81.3 Ha

NOTE: NO ALLOWANCE FOR SERVICE TRENCHES, VOLUMES ARE UNFACTORED AND IN SITU

Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Origin of Levels = CA 97 (ABLQ) Published RL=43.36, sourced from The LINZ Digital Geodetic Database.
5. Boundaries are subject to final survey.

Legend
- EX BDY
- PROP BDY
- PLAN CHANGE BDY
- EX PERM. STREAM
- EX INT. STREAM
- EX WETLAND

Cut/Fill Table

Number #	Minimum Elevation	Maximum Elevation	Color
1	-7.019	-6.000	
2	-6.000	-4.000	
3	-4.000	-2.000	
4	-2.000	0.000	
5	0.000	2.000	
6	2.000	4.000	
7	4.000	6.000	
8	6.000	8.684	

Rev	Description	By	Date
A	PPC	KH	08/2022

	By	Date
Survey	PARALAX & MAVEN	03/21
Design	KH	07/22
Drawn	KH	08/22
Checked	GB	08/22

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Project
WARKWORTH SOUTH PLAN CHANGE FORE KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD

Title
PROPOSED CUT/FILL PLAN

Project no.	211001
Scale	1:5000 @ A3
Cad file	211001- COMBINED PC EW.DWG
Drawing no.	C222
Rev	A

LEGEND:

Site Boundary

HAND AUGER (HA) LOCATION

NOTES: 1. BASE PLAN ADAPTED FROM AUCKLAND COUNCIL OPEN DATA VIA QGIS

0 25 50 75 m

CMW Geosciences

CLIENT: MAVEN ASSOCIATES LTD	DRAWN: TE	PROJECT: AKL2021-0235
PROJECT: 1738 STATE HIGHWAY 1 WARKWORTH	CHECKED: TE	DRAWING: 01
	REVISION: 0	SCALE: 1:1750
TITLE: SOAKAGE TESTING PLAN	DATE: 29/07/2022	SHEET: A3 L

CMW Geosciences	CLIENT: **Maven Associates Ltd**	DESIGNER:	TE
	PROJECT: **1738 State Highway 1, Warkworth**	CHECKED:	RK
		REVISION:	4
	TITLE: **Falling Head Permeability Test**	DATE:	5/08/2022
		PROJECT:	AKL2021-0235

Specifications - Open-Ended Tube

Length L_1: 2 m

Diameter: 90 mm

Non-Perm L_2: 0 m

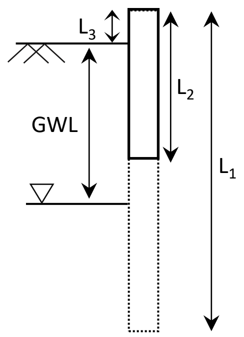
Above Gnd L_3: 0 m

Ground Conditions

GWL: 0.5 m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$



Bottom of Test Hole: 2.00 m BGL

Hydraulic Conductivity (k)

Note: CMW considers the CIRIA 113 value the most appropriate method for most purposes, but also provides the analysis method as outlined by Hvorslev if desired.

CIRIA 113: Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

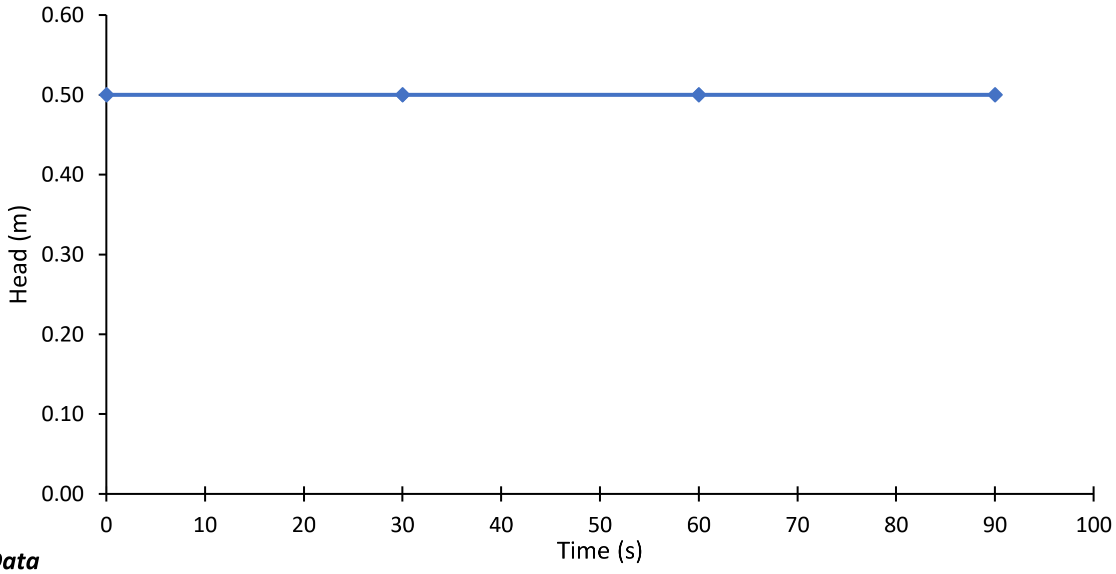
$$k = \left(\log\frac{h_1}{h_2} - \log\frac{2h_1+d}{2h_2+d}\right)\cdot\frac{(h_1+h_2)}{2(t_2-t_1)} =$$

0.00E+00 ms^{-1} = 0.00 m/day

Hvorslev: Hvorslev (1951) *Time Lag and Soil Permeability in Ground-Water Observations* , Fig 18, p49

$$k = \frac{d^2 \ln\left(\frac{mL}{d} + \sqrt{\left(\frac{mL}{d}\right)^2 + 1}\right)}{8L(t_2-t_1)} \ln\frac{H_1}{H_2} =$$

0.00E+00 ms^{-1} = 0.00 m/day



STRATIGRAPHIC LOG
Topsoil
Silty Clay
EOH @ 1.6m

Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	0.500				
30	0.000	0.500	2.000		0.00E+00	0.00E+00
60	0.000	0.500	2.000		0.00E+00	0.00E+00
90	0.000	0.500	2.000		0.00E+00	0.00E+00

CLIENT:	Maven Associates Ltd	DESIGNER:	TE
PROJECT:	1738 State Highway 1, Warkworth	CHECKED:	RK
		REVISION:	4
TITLE:	Falling Head Permeability Test	DATE:	5/08/2022
		PROJECT:	AKL2021-0235

Specifications - Open-Ended Tube

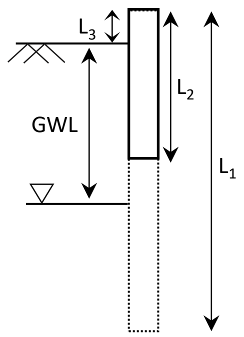
Length L_1:	2	m
Diameter:	90	mm
Non-Perm L_2:	0	m
Above Gnd L_3:	0	m

Ground Conditions

GWL: 1.7 m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h / k_v}$



Bottom of Test Hole: 2.00 m BGL

Hydraulic Conductivity (k)

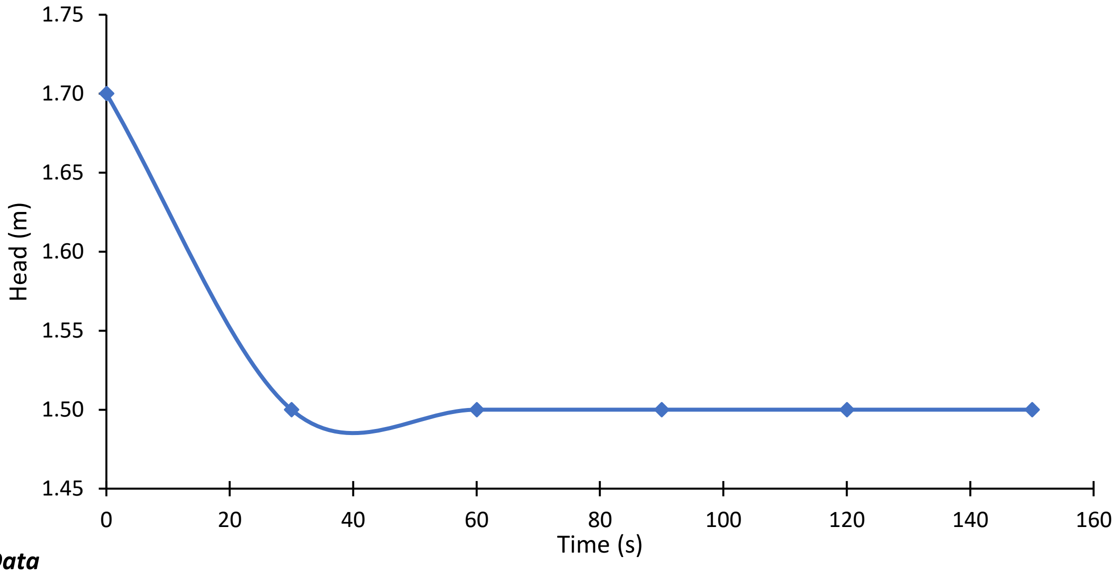
Note: CMW considers the CIRIA 113 value the most appropriate method for most purposes, but also provides the analysis method as outlined by Hvorslev if desired.

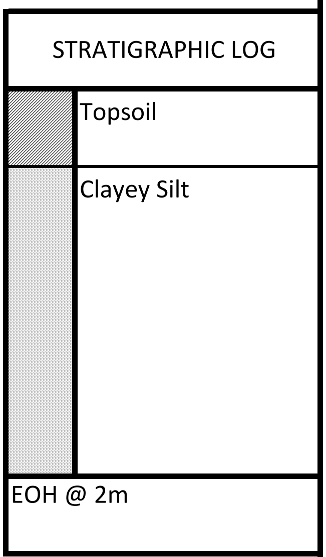
CIRIA 113: Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

$$k = \left(log\frac{h_1}{h_2} - log\frac{2h_1 + d}{2h_2 + d}\right)\cdot\frac{(h_1 + h_2)}{2(t_2 - t_1)} =$$ 1.59E-05 ms^{-1} = 1.37 m/day

Hvorslev: Hvorslev (1951) *Time Lag and Soil Permeability in Ground-Water Observations*, Fig 18, p49

$$k = \frac{d^2\, ln\left(\frac{mL}{d} + \sqrt{\left(\frac{mL}{d}\right)^2 + 1}\right)}{8L(t_2 - t_1)}\, ln\frac{H_1}{H_2} =$$ 1.66E-06 ms^{-1} = 0.14 m/day





Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	1.700				
30	0.200	1.500	1.900		8.32E-06	7.95E-05
60	0.200	1.500	1.800		0.00E+00	0.00E+00
90	0.200	1.500	1.800		0.00E+00	0.00E+00
120	0.200	1.500	1.800		0.00E+00	0.00E+00
150	0.200	1.500	1.800		0.00E+00	0.00E+00

CLIENT: Maven Associates Ltd	DESIGNER: TE
PROJECT: 1738 State Highway 1, Warkworth	CHECKED: RK
	REVISION: 4
TITLE: Falling Head Permeability Test	DATE: 5/08/2022
	PROJECT: AKL2021-0235

Specifications - Open-Ended Tube

Length L_1: 2 m

Diameter: 90 mm

Non-Perm L_2: 0 m

Above Gnd L_3: 0 m

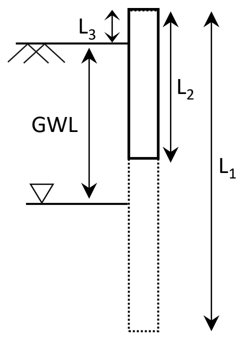
Ground Conditions

GWL: 1.2 m BGL (Blank = Bottom of hole)

Permeability Anisotropy

m: 1 $m = \sqrt{k_h/k_v}$

Bottom of Test Hole: 2.00 m BGL



Hydraulic Conductivity (k)

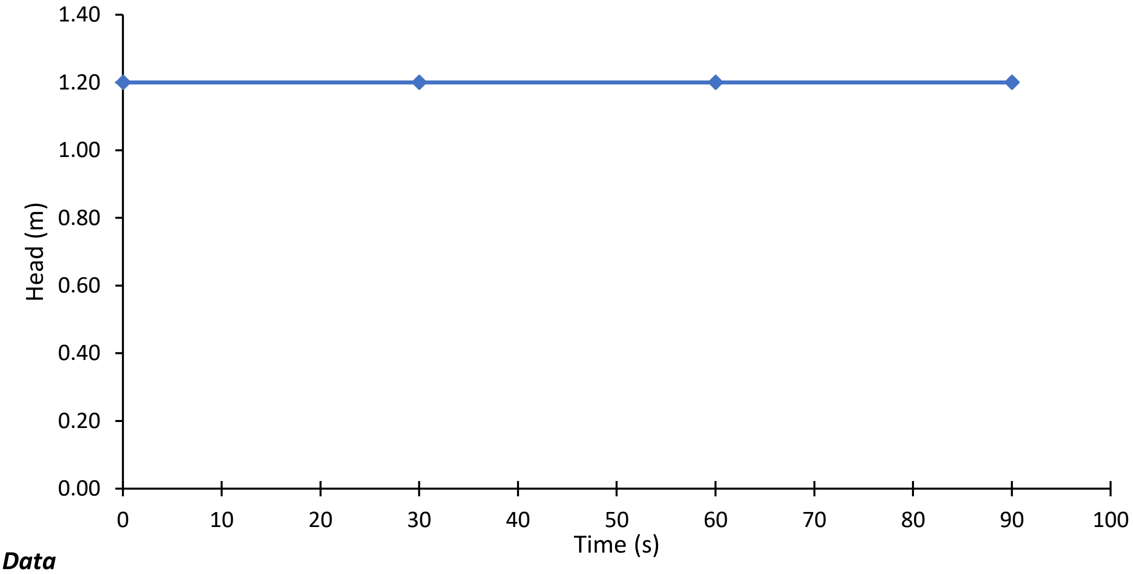
Note: CMW considers the CIRIA 113 value the most appropriate method for most purposes, but also provides the analysis method as outlined by Hvorslev if desired.

CIRIA 113: Somerville (1986), *Control of groundwater for temporary works,* CIRIA Report 113, Appendix 4

$$k = \left(log\frac{h_1}{h_2} - log\frac{2h_1+d}{2h_2+d}\right)\cdot\frac{(h_1+h_2)}{2(t_2-t_1)} =$$ 0.00E+00 ms^{-1} = 0.00 m/day

Hvorslev: Hvorslev (1951) *Time Lag and Soil Permeability in Ground-Water Observations*, Fig 18, p49

$$k = \frac{d^2\,ln\left(\frac{mL}{d} + \sqrt{\left(\frac{mL}{d}\right)^2+1}\right)}{8L(t_2-t_1)}\,ln\frac{H_1}{H_2} =$$ 0.00E+00 ms^{-1} = 0.00 m/day



STRATIGRAPHIC LOG

Topsoil

Clayey Silt

EOH @ 2m

Data

Time (s)	Tape Avg (m)	Head (m)	Perm. Length (m)		Hvorslev 'k' Case G (ms^{-1})	CIRIA 113 'k' (ms^{-1})
0	0.000	1.200				
30	0.000	1.200	2.000		0.00E+00	0.00E+00
60	0.000	1.200	2.000		0.00E+00	0.00E+00
90	0.000	1.200	2.000		0.00E+00	0.00E+00

HAND AUGER BOREHOLE LOG - HA01-22

Client: Maven Associates Ltd
Project: 1738 State Highway 1, Warkworth
Site Location: Warkworth
Project No.: AKL2021-0235
Date: 20/07/2022
Borehole Location: Refer to site plan   Logged by: DW   Checked by: TE   Scale: 1:25   Sheet 1 of 1

Position: 1747959.8mE; 5967998.3mN   Projection: NZTM
Elevation: 46.10m   Datum: AUCKHT1946   Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15
			46.1			TOPSOIL: Dark brown. Low plasticity. Silty.			
			45.8			CH: Silty CLAY: Grey mottled light brown. High plasticity. (Alluvium)	M to W	St	
▼	0.5	Peak = 54kPa Residual = 22kPa							
	1.0	Peak = 52kPa Residual = 18kPa		1					
	1.5	Peak = 50kPa Residual = 28kPa							
						Borehole terminated at 1.6 m			
				2					
				3					
				4					
				5					

Termination Reason: Target Depth Reached
Shear Vane No: 2992   DCP No:
Remarks: Ground water encountered at 0.5m

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA02-22

Client: Maven Associates Ltd
Project: 1738 State Highway 1, Warkworth
Site Location: Warkworth
Project No.: AKL2021-0235
Date: 20/07/2022
Borehole Location: Refer to site plan | Logged by: DW | Checked by: TE | Scale: 1:25 | Sheet 1 of 1

Position: 1747818.4mE; 5967752.1mN Projection: NZTM
Elevation: 71.00m | Datum: AUCKHT1946 | Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)
			71.0	0.0	TOPSOIL: Dark brown. Low plasticity. Silty.			
			70.7	0.3	MH: Clayey SILT: Light brown mottled orange. Low plasticity. (Pakiri Formation)	M	VSt	
	0.5	Peak = 103kPa Residual = 50kPa						
	1.0	Peak = 133kPa Residual = 62kPa						
			69.9	1.1	MH: Clayey SILT: Dark brown mottled purple. Low plasticity. With some fine to medium sand. (Pakiri Formation)	M to W		
	1.5	Peak = 159kPa Residual = 68kPa						
▼ (1.7 m)								
	2.0	Peak = 115kPa Residual = 41kPa		2.0	Borehole terminated at 2.0 m			

Termination Reason: Target Depth Reached
Shear Vane No: 2992 | DCP No:
Remarks: Ground water encountered at 1.7m

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

HAND AUGER BOREHOLE LOG - HA03-22

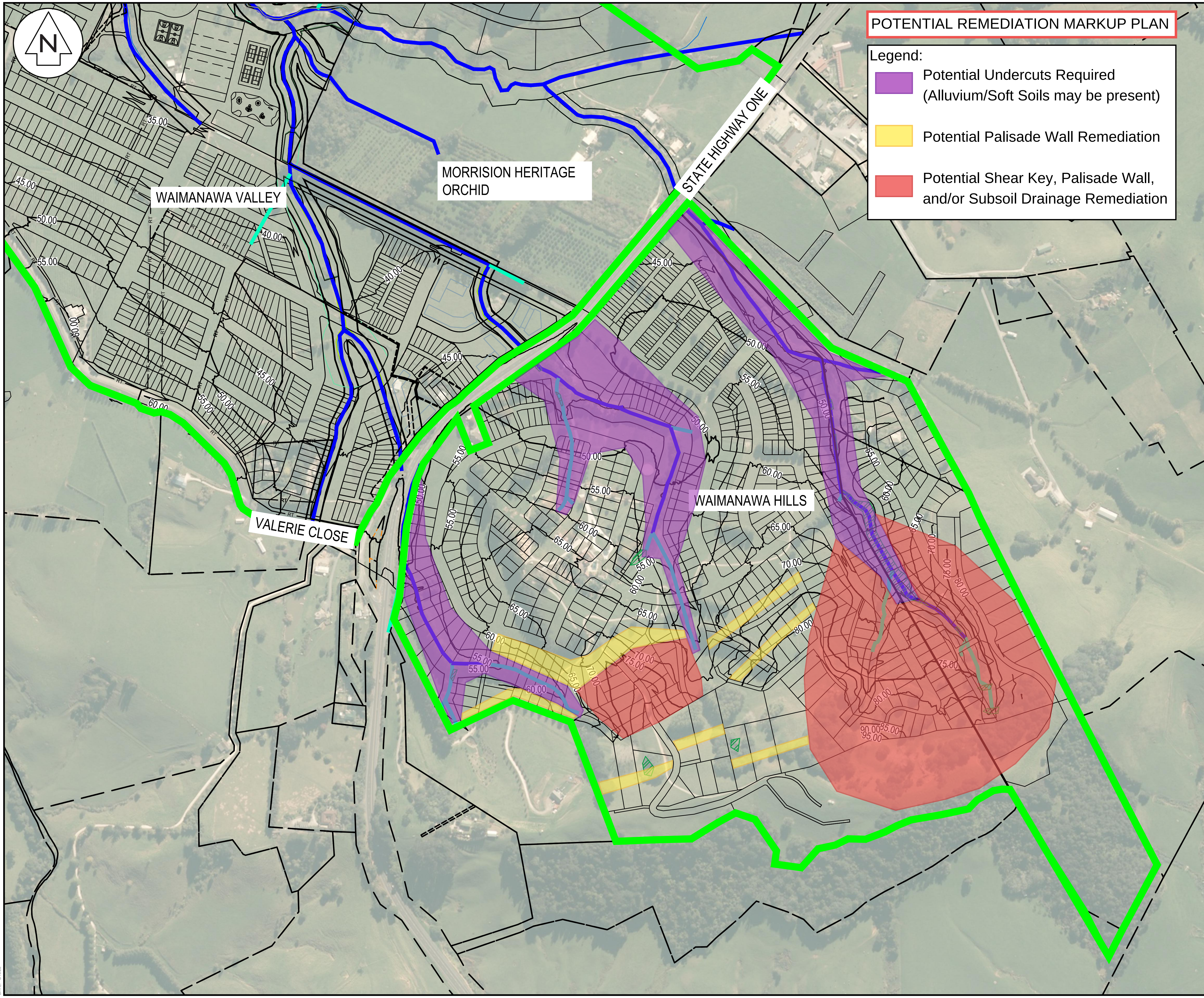
Client: Maven Associates Ltd
Project: 1738 State Highway 1, Warkworth
Site Location: Warkworth
Project No.: AKL2021-0235
Date: 20/07/2022
Borehole Location: Refer to site plan   Logged by: DW   Checked by: TE   Scale: 1:25

Position: 1748187.0mE; 5967759.0mN Projection: NZTM
Elevation: 68.60m   Datum: AUCKHT1946   Survey Source: Hand Held GPS

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15
			68.6		TOPSOIL: Dark brown. Low plasticity. Silty.			
			68.4		MH: Clayey SILT: Light brown mottled orange. Low plasticity. (Pakiri Formation)			
	0.5	Peak = 109kPa Residual = 18kPa				M		
▼	1.0	Peak = 106kPa Residual = 47kPa		1			VSt	
			67.3		MH: Clayey SILT: Light grey mottled orange and light brown. Low plasticity. With some fine to medium sand. (Pakiri Formation)			
	1.5	Peak = 145kPa Residual = 50kPa				W		
	2.0	Peak = 133kPa Residual = 47kPa		2	Borehole terminated at 2.0 m			
				3				
				4				
				5				

Termination Reason: Target Depth Reached
Shear Vane No: 2992   DCP No:
Remarks: Ground water encountered at 1.2m

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.



Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Origin of Levels = CA 97 (ABLQ)
   Published RL=43.36, sourced from The LINZ Digital Geodetic Database.
5. Boundaries are subject to final survey.

Legend

EX BDY	
PROP BDY	
RT — RT	EX TITLE BDY
PLAN CHANGE BDY	
20	PR MAJOR CONTOUR
PR MINOR CONTOUR	
EX PERM. STREAM	
EX INT. STREAM	
EX WETLAND	

Rev	Description	By	Date
A	PPC	KH	08/22

	By	Date
Survey	PARALAX & MAVEN	03/21
Design	KH	03/22
Drawn	KH	08/22
Checked	GB	08/22

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Project
WARKWORTH SOUTH PLAN CHANGE FORE KA WAIMANAWA LP & STEPPING TOWARDS FAR LTD

Title
PROPOSED CONTOURS PLAN

Project no.	211001
Scale	1:5000 @ A3
Cad file	211001- COMBINED PC EW.DWG
Drawing no.	C212

Rev A

DATE: 8/19/22