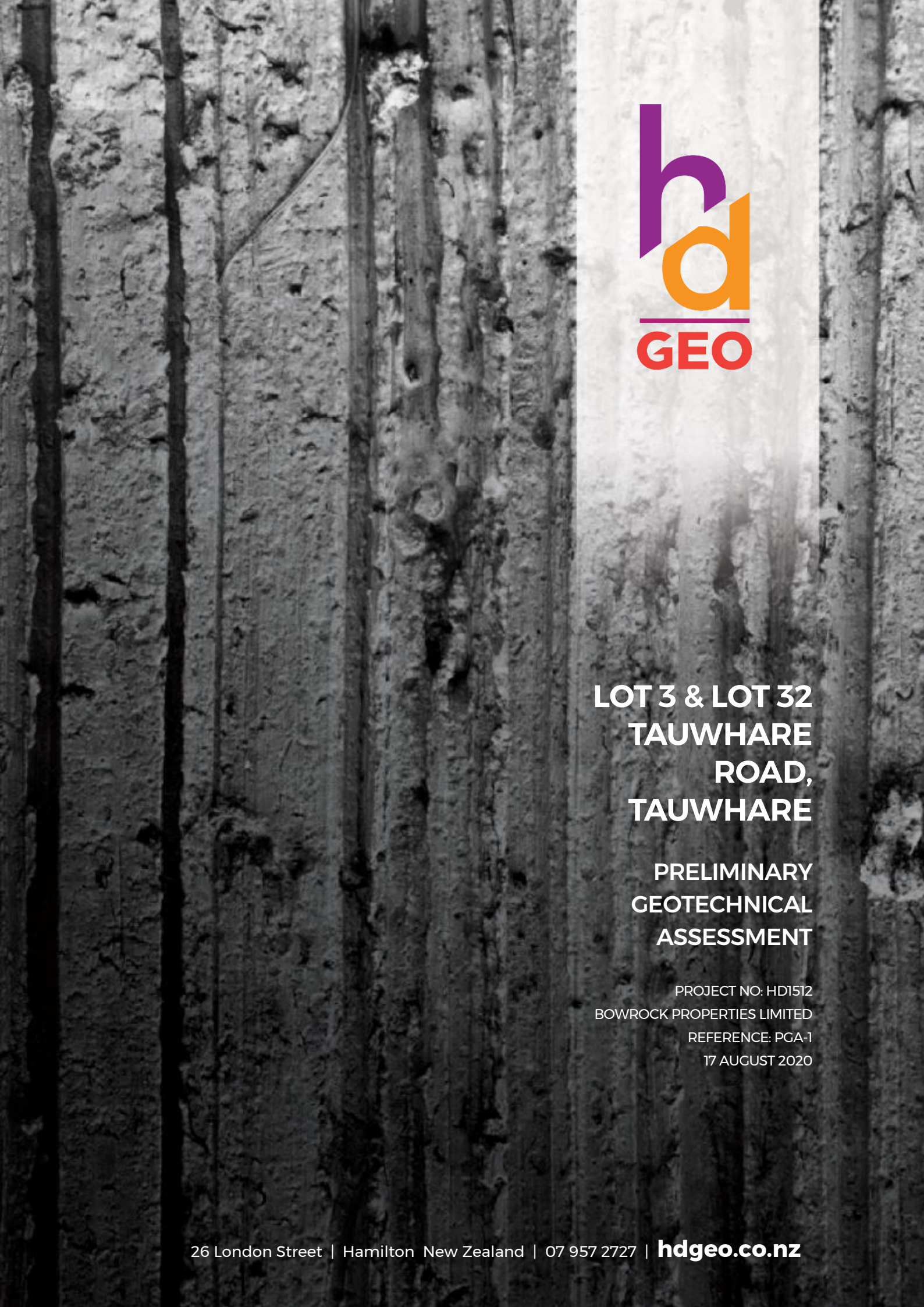

LOT 3 & LOT 32 TAUWHARE ROAD, TAUWHARE

PRELIMINARY GEOTECHNICAL ASSESSMENT

PROJECT NO: HD1512
BOWROCK PROPERTIES LIMITED
REFERENCE: PGA-1
17 AUGUST 2020

26 London Street | Hamilton New Zealand | 07 957 2727 | **hdgeo.co.nz**

Executive summary

Introduction

Bowrock Properties Limited have engaged us to undertake a preliminary geotechnical assessment for their site located at 1110 Tauwhare Road, Tauwhare. This report is in support of a request to Waikato District Council to rezone the land (Lot 3 and Lot 32) from Rural to Country Living Zone as part of the Waikato District Plan review process (and any subsequent subdivision consent application that may follow successful rezoning).

Our scope included

- a desktop study of the site to review existing information, including historical aerial images, geology maps, contour maps, and the NZ Geotechnical Database (NZGD)
- an intrusive investigation consisting of:
    - 5 hand augers to 3.0 m depth with strength testing
    - 2 soakage tests to 2.0 m depth
- a natural hazards assessment, including a qualitative liquefaction assessment
- a qualitative slope stability assessment based on desk study and site walkover
- recommendations for developing the site

Our key findings and outcomes were

- the site spans two different geologies, Hills Terrain (Walton Subgroup) and Plains Terrain (Hinuera Formation)
- the geotechnical conditions within each of these terrains is different
- Hills Terrain:
    - the Hills Terrain is all ground that is elevated above the Plains Terrain. It can range from gently sloping to steeply sloping
    - stiff to hard silty clay or clay consistent with the mapped geology was encountered up to 3.0 m bgl.
    - groundwater was not encountered during the investigation
    - the Hills Terrain is not suitable for soakage
    - based on the assessment of the soil plasticity on site and the Waikato soil's clay mineralogy, the site is likely to be Class S to Class M, slightly to moderately expansive soils. Some mitigation may be needed for buildings (stiffened foundations etc).
    - the degree of liquefaction induced ground damage is 'none to minor'
    - moderate to steep slopes would generally mean significant modification and engineering is likely to be needed (retaining etc)
    - for development outside of 'steep' slope areas, shallow foundations designed to tolerate slightly to moderately expansive soils are expected to be suitable
    - ash soils are typically good earthworks materials. Laboratory testing of the materials and an earthworks specification will be required
- Plains Terrain:
    - the Plains Terrain is all of the flat terrain in the area. The Plains Terrain is bisected with man-made drains and naturally incised gullies. The drains and gullies tend to be steep sided.

- loose to dense silt and sand consistent with the mapped geology was encountered up to 1.4 m bgl.
- groundwater was encountered at between 0.6 m and 1.2 m below ground level (HA01 and HA04) during the investigation (July 2020)
- two soakage tests were located in the Plains Terrain and the soakage data was forwarded to a stormwater consultant for their assessment
- the degree of liquefaction induced ground damage is likely to be 'moderate' in a ULS earthquake. Further consideration of liquefaction is needed during assessment and design for buildings on the site
- the open-drain along the eastern boundary, poses a risk of lateral spreading or instability related to seismic loading for areas within 20 m of this drain
- the test results show that the strength requirements for 'good ground' in accordance with NZS3604:2011 are not achieved in the Plains Terrain
- standard foundations are not appropriate, given the potential for liquefaction and low strength soils.
- the design of the foundations will need to consider the low bearing and potential effects from liquefaction. Raft type foundation systems are likely to be appropriate for the site

The site is suitable for any proposed subdivision, subject to the recommendations within this report. No major geotechnical constraints or natural hazards are anticipated for any proposed subdivision.

Further testing will be needed to inform design of the subdivision and future buildings.

Contents

PREPARED BY:	**Retha Richards**	REVIEWED BY:	**Andrew Holland, CPEng**
			
	Geotechnical Engineer		Technical Director Principal Engineer
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Introduction

Bowrock Properties Limited have engaged us to undertake a preliminary geotechnical assessment for their site located at 1110 Tauwhare Road, Tauwhare. This report is in support of a request to Waikato District Council to rezone the land (Lot 3 and Lot 32) from Rural to Country Living Zone as part of the Waikato District Plan review process (and any subsequent subdivision consent application that may follow successful rezoning).

Scope

The scope of our assessment included:

- a desktop study of the site to review existing information, including historical aerial images, geology maps, contour maps, and the NZ Geotechnical Database (NZGD)
- an intrusive investigation consisting of:
    - 5 hand augers to 3.0 m depth with strength testing
    - 2 soakage tests to 2.0 m depth
- a natural hazards assessment, including a qualitative liquefaction assessment
- a qualitative slope stability assessment based on desk study and site walkover
- recommendations for developing the site

Site description

The site is located in Tauwhare, east of Hamilton City . Lot 3 and Lot 32 (The site), legally described as DP 325499 and DPS 81580 respectively, currently consist of rural farmland and are accessed off Tauwhare Road. The site covers an area of approximately 20.2 ha and is generally covered with pasture. An existing drain is located along the eastern boundary. A wetland area is located off-centre towards the north-west and covers a total area of approximately 1.9 ha. A track is running through the site from the north to the east, separates the wetland into two sections.

The site has two distinct geomorphologies, Hills Terrain and Plains Terrain. Hills Terrain is all of the elevated land, typically mapped as Walton Subgroup geology. The Hills Terrain is generally gently to moderately sloping and typically ends abruptly as it meets the Plains Terrain. The Plains Terrain is all of the flat terrain in the area typically mapped as Hinuera Formation. The Plains Terrain is bisected with man-made drains and naturally incised gullies. The drains and gullies tend to be steep sided. The geomorphology of the site is shown in Figure 1 and 2 in Appendix B.

Proposed development

Bowrock Properties presented two concept plans to create 22 lots for future rural residential development. The final number of lots for the proposed concepts will ultimately be determined by the site constraints identified beforehand and opportunities to retain character and amenity of the site.

The proposed subdivision concept plans are included in Appendix A.

Desk study

Geological setting

A geologic map[1] of the area indicates that both the alluvial soils of the Hinuera Formation and the Walton Subgroup are found locally.

The Walton Subgroup formation is made up of alluvium dominated by primary and reworked, non-welded ignimbrite. This area is typically mantled by several metres of highly weathered airfall tephra (Hamilton Ash).

The Hinuera Formation is described as cross-bedded pumice sand, silt and gravel with interbedded peat.

Aerial photography

Historic[2] and recent[3] photos were reviewed to identify past land uses and evidence of historic instability at the site and surrounding areas. The earliest available aerial imagery dates back to 1950 and shows the site as an unoccupied rural area. From the review, there appears to be no significant changes to the geomorphology at the site or surrounding area over the period reviewed.

Manmade changes include development in the wider area to the east. A wetland restoration project on the site started in April 2014 and was completed in September 2019. The aerial images are included in Appendix D.

NZGD

The New Zealand Geotechnical Database (NZGD) was accessed to determine whether ground investigations have been conducted at or near the site. No testing was available within a 2 km range of the site.

Site investigation

Our site investigation included a site walkover, five hand augers and two soakage tests completed on 23 July 2020 and 27 July 2020 to broadly characterise the ground conditions across the site. In-situ strength testing was undertaken using a dynamic cone penetrometer and shear vane. The hand augers had a target of 3.0 m, which was not achieved for some of the hand augers due to poor recovery and hole collapse. Two soakage tests were undertaken in general accordance with Building Code 'Clause E1 Surface Water'[4].

Ground conditions

The materials we encountered on site were consistent with the mapped Walton Subgroup and Hinuera Formation. The site investigation plan and the hand auger logs of the recovered soil are provided in Appendix C.

[1] 1:250,000 Geological Map of New Zealand (QMAP). New Zealand Web Map. GNS, 2013. https://data.gni.cri.nz/geology

[2] Sourced from http://retrolens.nz and licensed by LINZ CC-BY

[3] Google Earth Pro

[4] New Zealand Building Code E1/VM4 Surface Water Section 9.0.2, prepared by Ministry of Business, Innovation and Employment, dated 2000

Hills Terrain

The Hills Terrain is all ground that is elevated above the Plains Terrain. It ranges from gently sloping to steeply sloping. The hand augers HA02 and HA05 were in the Hills Terrain and had a target depth of 3.0 m, which was achieved.

The ground conditions encountered were:

- topsoil up to 0.3 m depth below ground level (bgl);
- silty clay or clay consistent with Hamilton Ash deposits up to 3.0 m bgl.;
- peak shear strength in the silty clay or clay ranged from 99 kPa to 216+ kPa showing the material to be stiff to hard;
- groundwater was not encountered during the investigation.

Plains Terrain

The Plains terrain is all of the low-lying ground at the site. The hand augers HA01, HA03 and HA04 were located in the Plains Terrain and had a target depth of 3.0 m, which was not achieved due to poor recovery and hole collapse. The average depth of the hand augers completed was 1.2 m bgl.

The ground conditions encountered were:

- topsoil up to 0.3 m depth below ground level (bgl);
- silt and sand consistent with Hinuera Formation deposits was encountered up to 1.4 m bgl.
- peak shear strength in the silt with minor sand ranged from 74 kPa to 161 kPa showing the material to be stiff to very stiff;
- dynamic cone penetrometer (DCP) test results in the sand ranged from 2 blows/100 mm to 20 blows/100 mm showing the material to be loose to dense;
- groundwater was encountered at between 0.6 m and 1.2 m below ground level (HA01 and HA04) during the investigation (July 2020).

Soakage testing

Two falling head permeability tests were undertaken within the proposed site to determine the capacity of the soils to receive concentrated stormwater flows. The falling head tests were undertaken generally in accordance with the Regional Infrastructure Technical Specifications (RITS) and the NZBC E1 Method. The hand augers had a target depth of 2.0 m, which could not be achieved for ST02 due to the auger hole collapsing and poor recovery. The Hills Terrain is underlain by stiff clay soils and is not suitable for soakage.

The soakage tests were located in the Plains Terrain and the materials we encountered were consistent with the mapped Hinuera Formation. The hand auger logs of the recovered soil are provided in Appendix C. The soakage data was forwarded to a stormwater consultant for their assessment.

Geotechnical assessment

This assessment is a collection of general information and advice for the site. The site is suitable for the proposed subdivision, subject to the geotechnical recommendations in this report.

Natural hazards

As per Section 106 of the Resource Management Act, we carried out an assessment of the natural hazards considering the geomorphology of the site. The assessment is divided into sections discussing the Hills Terrain and the Plains Terrain separately below. The site as a whole does not have a risk of Tsunami, volcanic, geothermal, sedimentation activity, erosion or landslips

Hills terrain		
Natural hazards	**Risk**	**Discussion**
Slope stability	Moderate	The slopes were divided in to restriction categories. Slopes with angles of 1V: 3H to 1V: 4H are considered moderate and angles greater than 1V: 3H are considered high. See 'Slope stability' section below.
Expansive soils	Slight to moderate	Typically plastic materials. Expansive behaviour can be slight to moderate in these materials. Actual behaviour should be confirmed for design of structures.
Liquefaction	Low	The soils underlying the Hills Terrain are plastic and have no susceptibility to liquefaction.
Subsidence	Low	The stiff to hard clay soils have a low risk of significant settlement.

Plains terrain		
Natural hazards	**Risk**	**Discussion**
Slope stability	Low	The plains are generally flat and stable.
Expansive soils	Low	Generally low risk of expansive behaviour (sand and silt soils).
Liquefaction	Moderate	The site subsoil class is D (Deep or soft soils). Earthquake induced liquefaction is a moderate risk (see 'Liquefaction' section below).
Lateral spreading	Moderate	Lateral spreading or seismic related instability are possible hazards on the Plains Terrain where adjacent to open-drains or gully slopes.
Subsidence	Low	The soils encountered at the site consisted of silt and sand. These have a generally low risk of consolidation/subsidence.

Slope stability

As part of our assessment, we undertook a review of recent and historic aerial photography to identify features which might indicate previous instability at the site and surrounding area. Aerial images dating back to 1950 did not show changes indicating instability of the slopes on site or in the immediately surrounding area. There was no evidence of significant instability at the site or surrounding area during the site walkover. Slopes are generally gentle to moderate.

Gentle slopes

No signs of slope instability were observed on the gentle slopes, defined as < 14° (1V: 4H). We consider these slopes generally stable in their present condition and no special consideration is needed to develop on these slopes.

Moderate slopes:

No signs of slope instability were observed on the moderate slopes, defined as ≥ 14° (1V: 4H) to ≤ 18.4° (1V: 3H). We consider these slopes generally stable in their present condition, however developing sites this steep would generally mean significant modification and engineering is likely to be needed (retaining etc).

Steep slopes:

Steep slopes were defined as > 18.4° (1V: 3H). We consider these slopes generally stable in their present condition but they may not be up to the required factor of safety for residential construction. Engineering is likely to be needed (retaining etc).

Minor erosion was noted along the areas of the slopes above the modified steep cuts along the track (> 25°). The steep cut faces are steeper than most natural slopes in the area and are expected to be marginally stable.

An approximate interpretation of the slope zones is presented in Figure 4 Appendix B.

Water control

Slope stability is often driven by or significantly influenced by surface water or groundwater. Control of water from the proposed development will be necessary to ensure that there is no adverse effect on the nearby slopes across the site. Water should be collected and directed away from slopes. Any collected water will need to be discharged in controlled manner to a protected outlet. Any hardstand areas will need to be shaped to collect water and direct it to the reticulation rather than sheet-flow to the top of slopes. The nature of the ground conditions indicates that soakage will not be viable as a means of stormwater control. Detention and slow release to a controlled outlet at the base of the slopes will be needed. Stormwater disposal will need specific design. Wastewater disposal will need to be designed to avoid steep slopes and to minimise water on sloping land.

Expansive soils

Natural soils consisting of the Hinuera Formation were encountered during the site investigation at HA01, HA03 and HA04. These soils have no potential to change in volume (“shrink and swell”) in response to moisture content changes.

Natural soils consisting of the Walton Subgroup with low to moderate plasticity were encountered during the site investigation at HA02 and HA05. These soils have a potential to change in volume (“shrink and swell”) in response to moisture content changes, typically with seasonal periodicity. This means they are likely to be outside the definition of ‘good ground’ in accordance with NZS 3604:2011. Based on the assessment of the soil plasticity on site and the Waikato soil’s clay mineralogy, the site is likely to be Class S to Class M, slightly to moderately expansive soils. Some mitigation may be needed for buildings (stiffened foundations etc).

Liquefaction assessment

We have undertaken a qualitative liquefaction assessment for the site using the latest guidelines[5]. This assessment qualifies as a Level B (calibrated desk study) in accordance with the 2017 planning guideline[6]. Class D soils have been assumed for this assessment. A site plan showing the liquefaction risk on site is provided in Figure 3 Appendix B.

We have assessed the likely potential liquefaction hazard at the site using the information presented in the Hamilton City Liquefaction Hazard Desktop Study[7]. The site is consistent with the geomorphic zones 'alluvial plains' and 'low hills' used in the desk study and so is relevant. Our site investigation confirmed this geology and geomorphology.

Low hills:

No groundwater was encountered in the upper 3.0 m below ground level within the hill terrain of the site. Using the analysis in the desk study for an expected groundwater level between 3.0 m and 4.0 m, the degree of liquefaction induced ground damage is 'none to minor' based on the HCC desk study. No further definition of the liquefaction risk is needed for any structures planned on the hill terrain within the site.

Alluvial plains:

The groundwater at the site is within 1.2 m of the current ground surface within the low-lying area of the site. Using the analysis in the desk study, for an expected groundwater in the upper 2.0m, the degree of liquefaction induced ground damage is likely to be 'moderate'.

Lateral spreading

On the basis that the soils on the plains terrain are potentially liquefiable and that there is an open-drain along the eastern boundary, the risk of lateral spreading or instability related to seismic loading is assessed as moderate for areas within 20 m of this drain.

Foundations

Hills Terrain

The ground conditions as tested within the Hills Terrain typically consist of stiff to hard, low to moderate plasticity ash deposits. For this development outside of 'steep' slope areas, shallow foundations designed to tolerate slightly to moderately expansive soils are expected to be suitable.

Options include:

- NZS3604 foundations modified to tolerate the expected movements (typically deepened and/or strengthened)
- Raft type foundations designed to tolerate the expected movements
- Specific design within 'steep' slope areas

[5]Ministry of Business Innovation and Employment (MBIE)/New Zealand Geotechnical Society (NZGS). *Module 3: Identification, assessment and mitigation of liquefaction hazards.* Dated May 2016.

[6]Earthquake Commission (EQC)/Ministry of Business Innovation and Employment (MBIE). *Planning and engineering guidance for potentially liquefaction prone land.* Dated September 2017.

[7]'Liquefaction Desktop Study' prepared for Hamilton City Council by Tonkin & Taylor. Job no. 1007144.v1.1. Dated February 2019.

Plains Terrain

The test results show that the strength requirements for 'good ground' in accordance with NZS3604:2011 are not achieved in the top 1.0 m across the Plains Terrain.

Standard foundations are not appropriate, given the potential for liquefaction and low strength soils. The design of the foundations will need to consider the low bearing and potential effects from liquefaction. Raft type foundation systems are likely to be appropriate for the site.

Earthworks

There is currently no design for cut and fill at the site, however we anticipate that cut and fill may be needed to create level or near level building platforms.

The soils encountered across the site included ash soils which are typically good earthworks materials. It is likely that the materials will be wet of optimum moisture content and conditioning will be required. Laboratory testing of the materials and an earthworks specification will be required.

We recommend any proposed cut/fill plans are reviewed by HD Geo before finalising.

Pavements

Currently the road grading design has not been completed and so subgrade levels are not known. Subgrades in the ash hill material encountered in the Hills Terrain will typically have a CBR 3 to 5 and standard pavements with some undercutting are likely to be appropriate.

The material strength below the topsoil in the Plains Terrain was very loose to dense (1 to 9 blows per 100 mm) to a tested depth of 1.0 m bgl. Our testing shows variable conditions and we recommend a CBR of 2 is adapted for design. During construction, testing will be needed to confirm the subgrade and low strength areas may need undercutting.

Once the design of the subdivision is complete, testing should be undertaken and the pavement requirements confirmed.

Summary

Based on our assessment, the site is geotechnically suitable for the proposed subdivision, subject to mitigating the following hazards:

Hills Terrain:

- Steep slopes and potential instability
- Slightly to moderately expansive soils

Plains Terrain:

- Liquefaction
- High groundwater
- Low bearing
- Lateral spreading near the open-drain

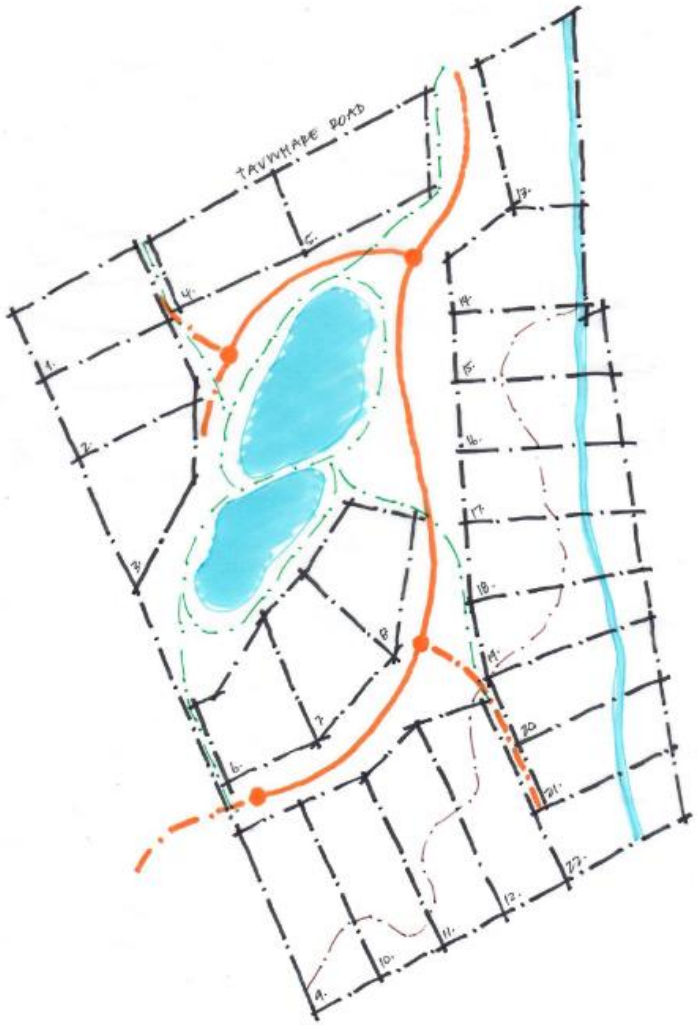
During the construction of the subdivision, observation and testing will be required to enable certification of pavements and any subdivision structures along with completion report.

Limitation

This report has been prepared for our client, Bowrock Properties Limited, their professional advisers and the relevant local authority for the purposes detailed above and may not be relied on by any other party for any other purposes. This report contains a preliminary assessment to establish suitability for subdivision based on a site walkover and testing in discrete locations. Further testing and assessment is required during the development of the site. Inferences about the conditions at the site have been made based on the testing undertaken and our understanding of the geological environment in which the site lies.

We recommend that a suitably qualified engineer is engaged to undertake further testing and assessment for building consent, and to observe works during the site preparation.

APPENDIX A – CONCEPT PLANS



TYPICAL SUBDIVISION *(5000SQM LOTS)*

ALTERNATIVE SUBDIVISION *(1250SQM LOTS)*

07-079

PROPOSED TAUWHARE SUBDIVISION
FOR BOWROCK PROPERTIES LIMITED

1110 TAUWHARE ROAD, TAUWHARE

16 APRIL 2020

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pauaarchitects.co.nz
3 Anzac Parade, Hamilton
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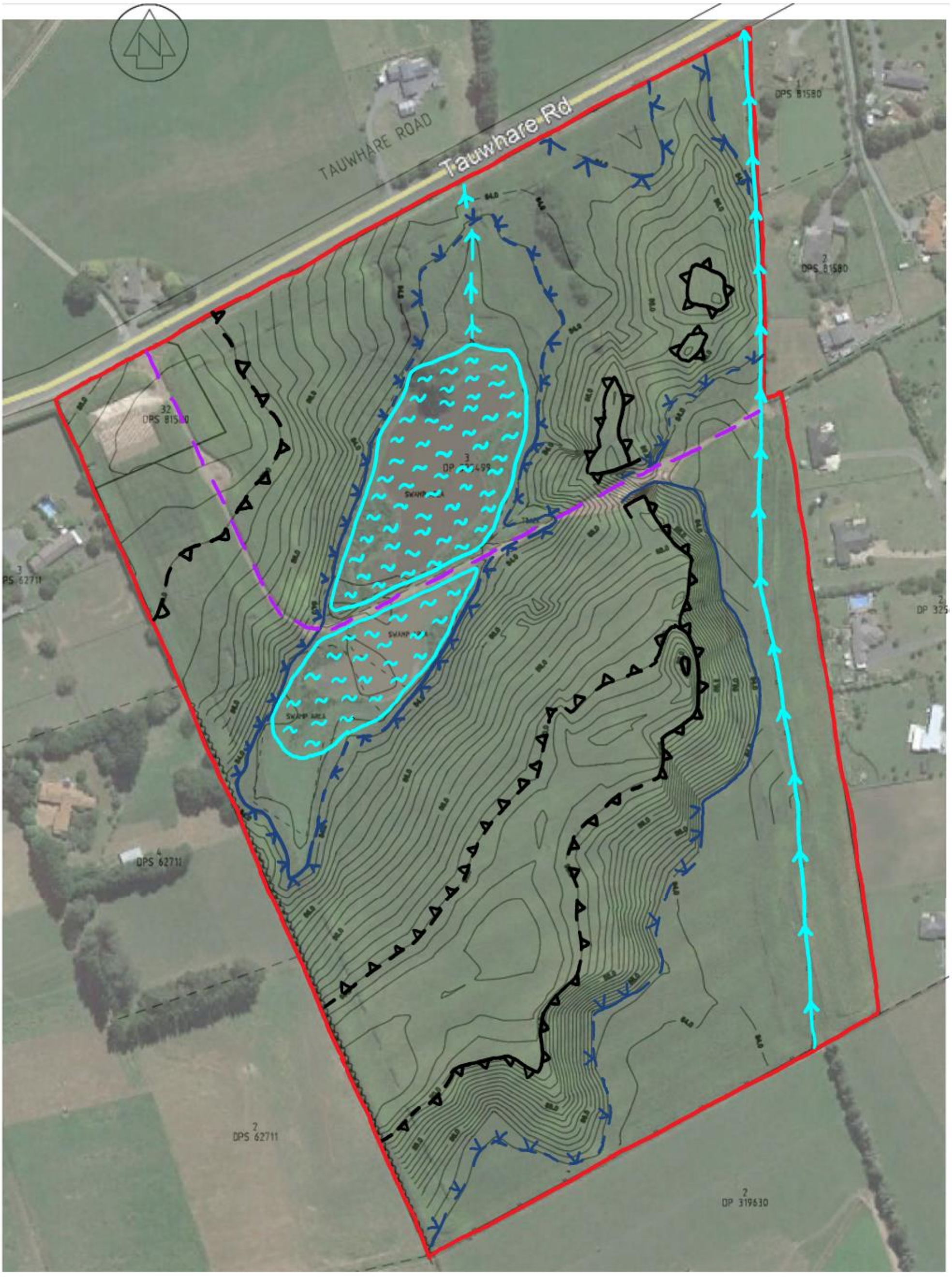
T 07 839 6521

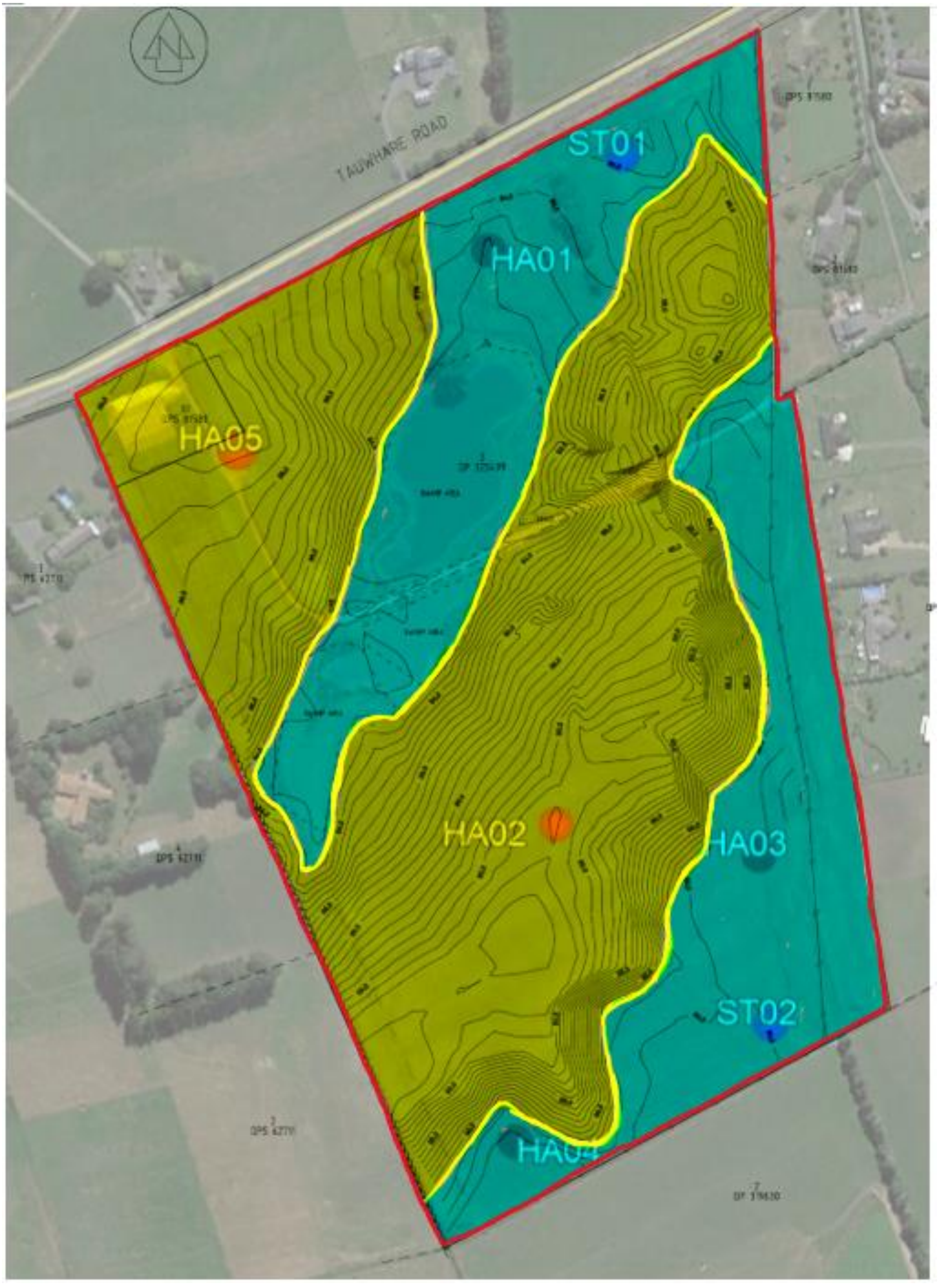
APPENDIX B – FIGURES



LEGEND:

- Site boundary
- Open-drain
- Drainage line
- Wetland
- Top of slope (sharp)
- Top of slope (indistinct)
- Base of slope (sharp)
- Base of slope (indistinct)
- Track

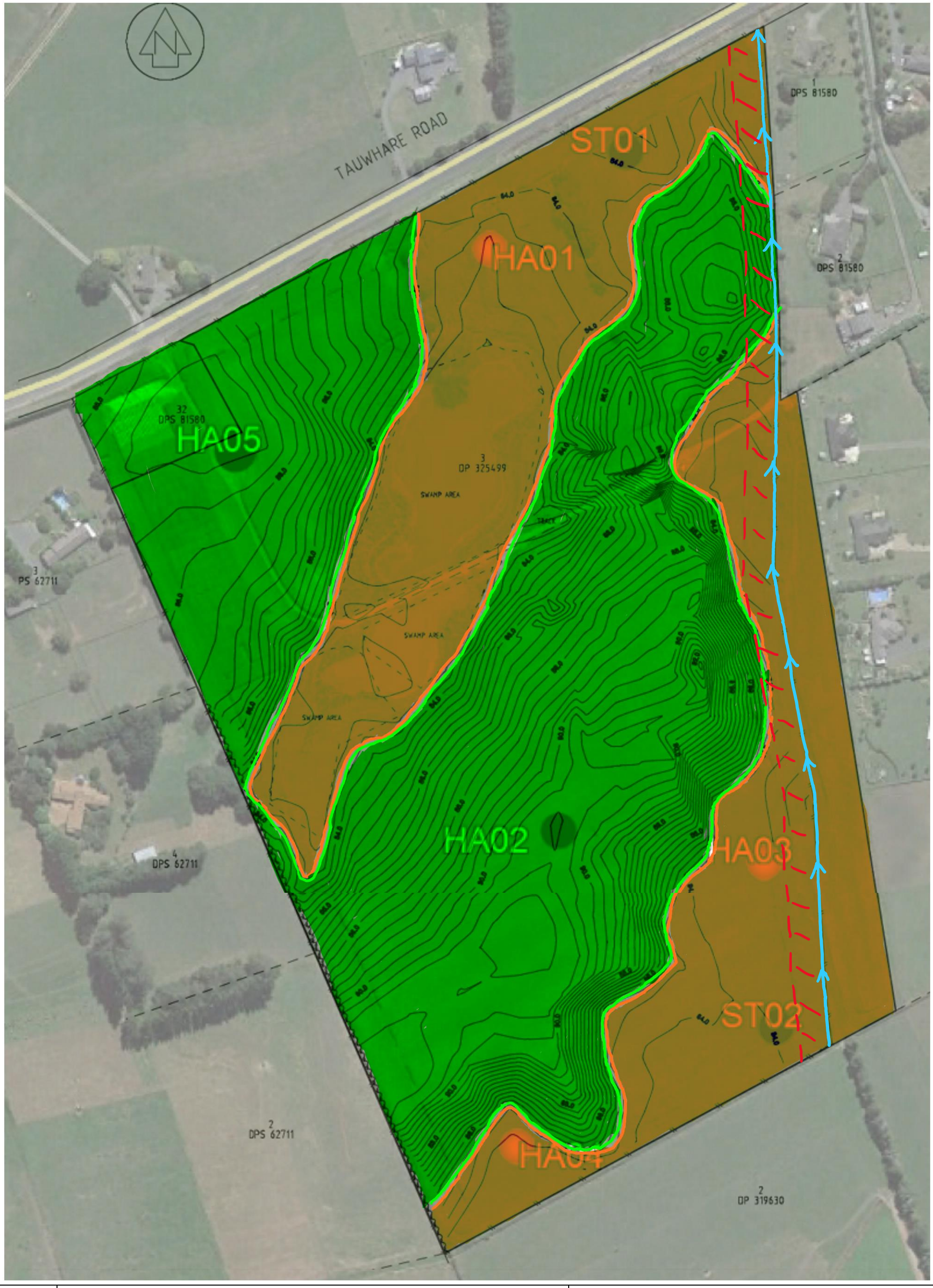
PROJECT: Lot 3 & Lot 32 Tauwhare Road, Tauwhare	
PROJECT NO: HD1512	
CLIENT: Bowrock Properties Limited	
TITLE: Hazard plan – Geomorphology	
SCALE: N/A	
Figure: 1	**Rev No:** 0
Drawn by: RR	



LEGEND:

- Site boundary
- Hills Terrain
- Plains Terrain

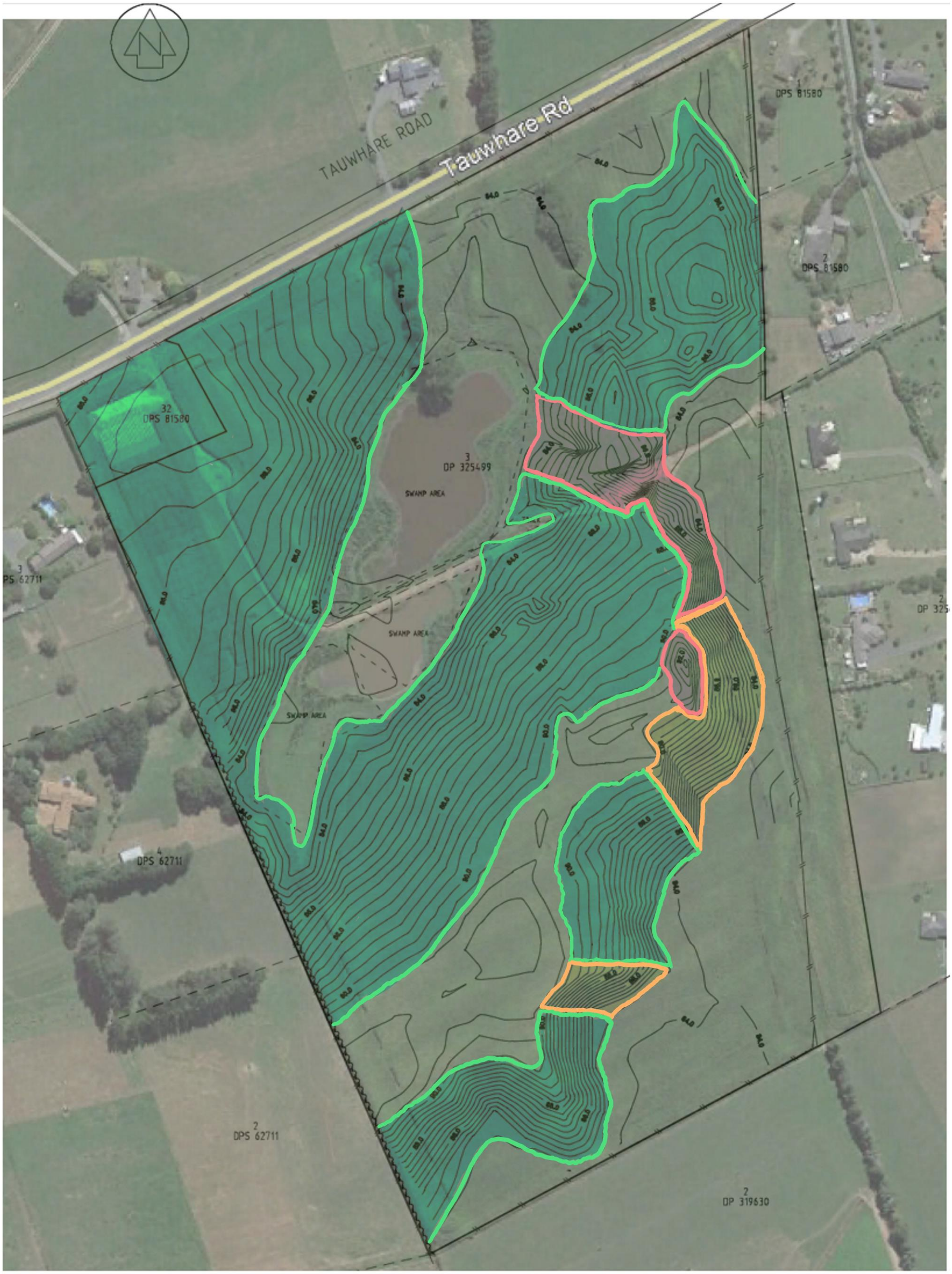
PROJECT: Lot 3 & Lot 32 Tauwhare Road, Tauwhare	
PROJECT NO: HD1512	
CLIENT: Bowrock Properties Limited	
TITLE: Hazard plan – Geomorphology	
SCALE: N/A	
Figure: 2	**Rev No:** 0
Drawn by: RR	



LEGEND:

- Liquefaction vulnerability 'none to minor'
- Liquefaction vulnerability 'moderate'
- Open-drain
- 20 m lateral spreading zone

PROJECT: Lot 3 & Lot 32 Tauwhare Road, Tauwhare	
PROJECT NO: HD1512	
CLIENT: Bowrock Properties Limited	
TITLE: Hazard plan – Liquefaction category	
SCALE: N/A	
Figure: 3	**Rev No:** 0
Drawn by: RR	

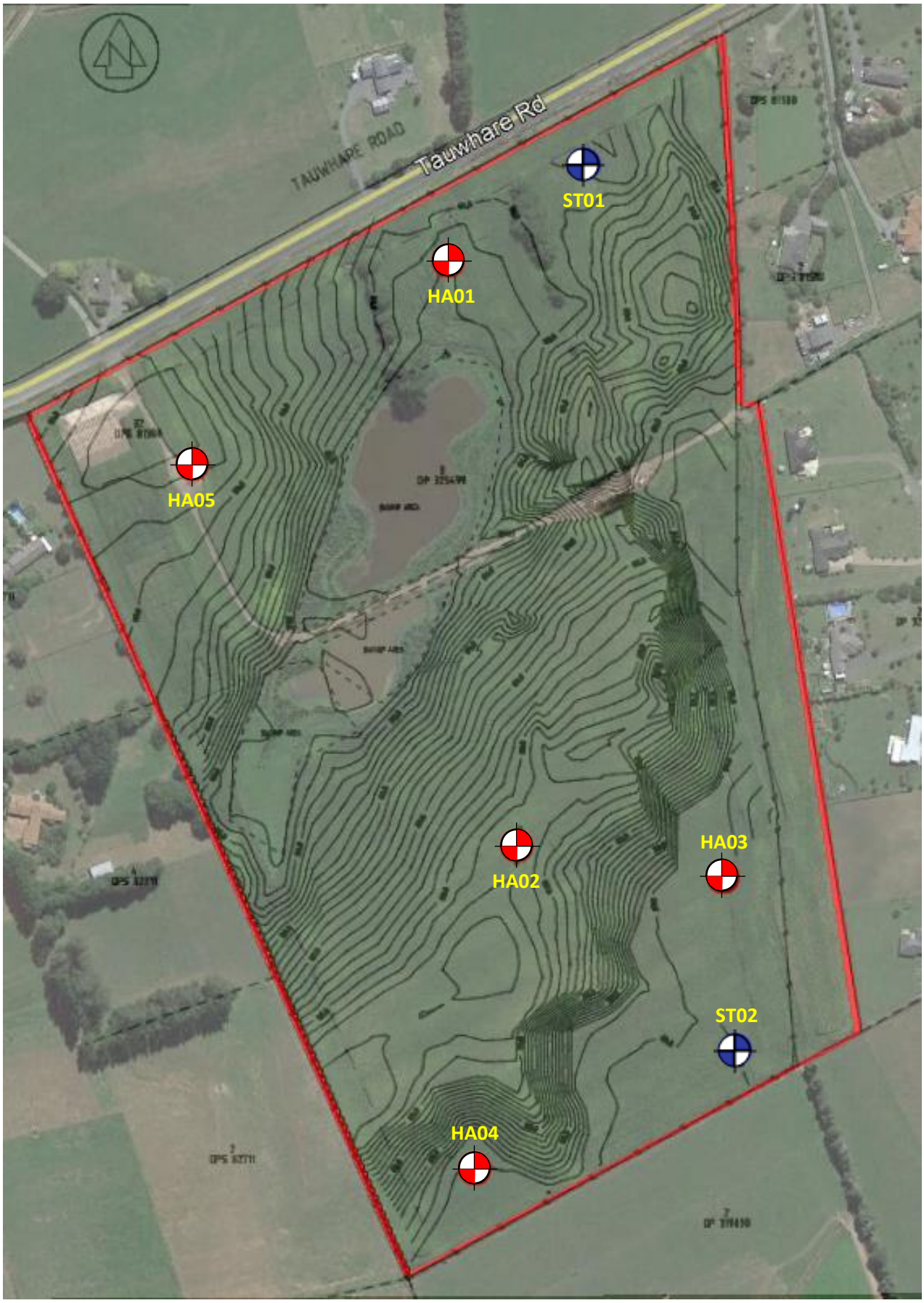


LEGEND:

- Slope angle < 1V: 4H – Gentle slopes
- Slope angle 1V: 3H to 1V: 4H – Moderate slopes
- Slope angle > 1V: 3H – Steep slopes

PROJECT: Lot 3 & Lot 32 Tauwhare Road, Tauwhare	
PROJECT NO: HD1512	
CLIENT: Bowrock Properties Limited	
TITLE: Hazard plan – Slope category	
SCALE: N/A	
Figure: 4	**Rev No:** 0
Drawn by: RR	

APPENDIX C – INVESTIGATION DATA



LEGEND:

- Site boundary
- Hand Auger (HA)
- Soakage Test (ST)

PROJECT: Lot 3 & Lot 32 Tauwhare Road, Tauwhare	
PROJECT NO: HD1512	
CLIENT: Bowrock Properties Limited	
TITLE: Site investigation plan	
SCALE: N/A	
Figure: 5	**Rev No:** 0
Drawn by: RR	

INVESTIGATION LOG

Job No.:	HD1512
No.:	ST01
Client:	Bowrock Properties Limited
Project:	Lot 3 & 32 Tauwhare Road, Tauwhare
Location:	North-east of pond.
Co-ordinates:	1815746mE, 5816540mN
Elevation:	Ground
Date:	23.07.20
Logged By:	RR
Checked By:	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); brownish black. Moist; Rootlets.	
Hinuera Formation	SILT (ML), with minor sand; light brownish grey, mottled orange. Very stiff to stiff; moist; low dilatency, insensitive; sand, fine; moderate iron staining.	0.2
		0.4
		0.6
		0.8
	SILT (ML), with trace sand; light grey, mottled orange. Stiff; wet; low dilatency, moderately sensitive; sand, fine; moderate iron staining.	1.0
		1.2
	No recovery. 1.5 m: pushed down with body weight to 2.0 m.	1.4
		1.6
		1.8
	EOH: 2.00 m	
	2.0 m: becomes very stiff.	2.0
		2.2
		2.4

Legend

Scala Penetrometer (Blows / 100 mm)

Depth (m)	Blows / 100 mm
0.0	1, 2
0.2	5, 6
0.4	4, 4
0.6	2, 1
0.8	1, 2
1.0	2, 2
1.2	2, 2
1.4	3, 3
1.6	2, 3
1.8	3, 4
2.0	5

Vane Shear Strength (kPa) — Vane: 534

Depth (m)	Peak	Remoulded
0.2	151	31
0.6	93	19
1.2	74	22
1.8	133	37

Water: 0.8 m

Photo

Remarks

End of log at 2.0 m.
Target depth achieved.
Groundwater encountered at 0.8 m.

Shear Vanes
- Peak
- Remoulded

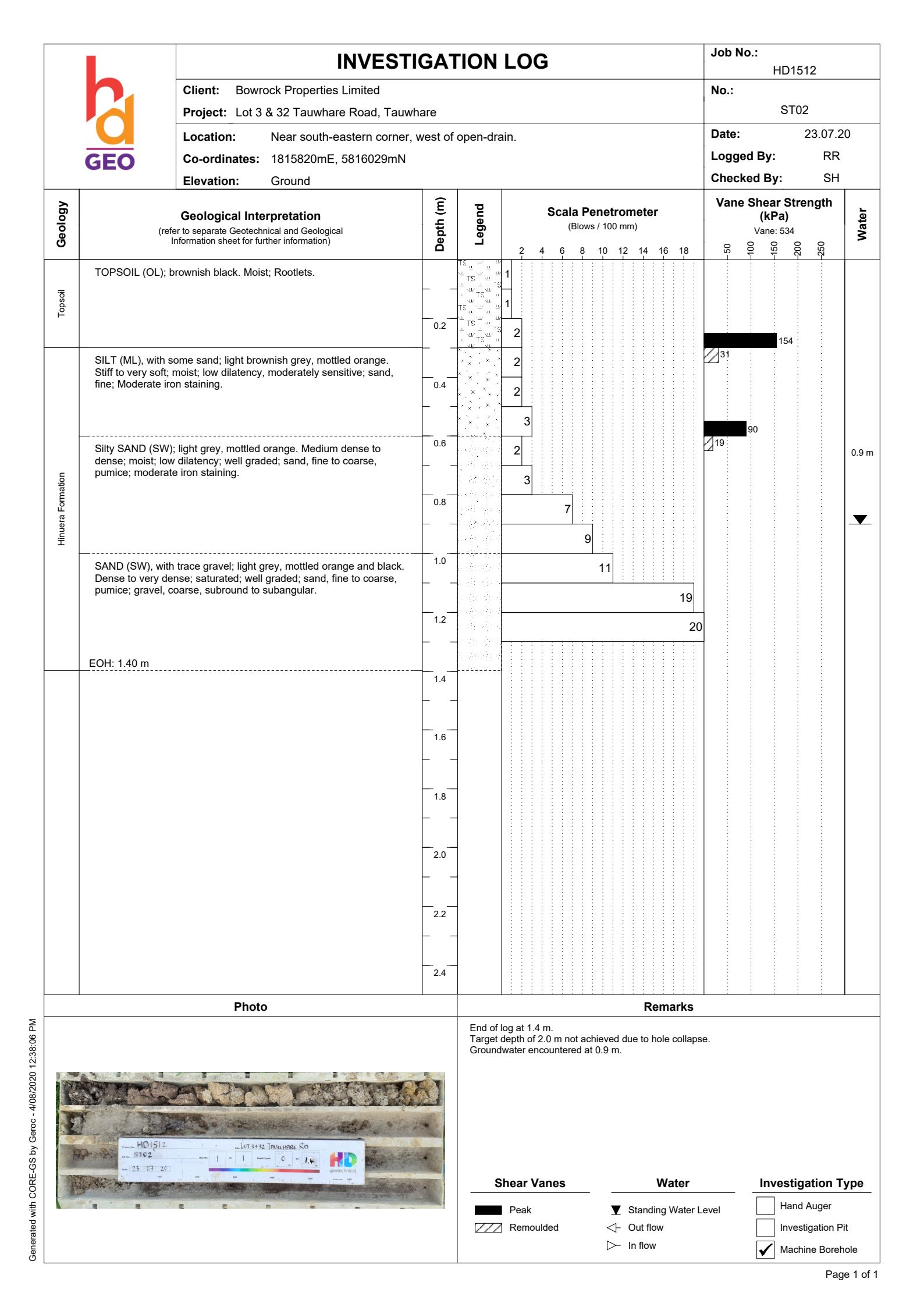
Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- ☐ Hand Auger
- ☐ Investigation Pit
- ☑ Machine Borehole

INVESTIGATION LOG

Job No.:	HD1512
No.:	ST02
Client:	Bowrock Properties Limited
Project:	Lot 3 & 32 Tauwhare Road, Tauwhare
Location:	Near south-eastern corner, west of open-drain.
Co-ordinates:	1815820mE, 5816029mN
Elevation:	Ground
Date:	23.07.20
Logged By:	RR
Checked By:	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); brownish black. Moist; Rootlets.	0.2
Hinuera Formation	SILT (ML), with some sand; light brownish grey, mottled orange. Stiff to very soft; moist; low dilatency, moderately sensitive; sand, fine; Moderate iron staining.	0.4
	Silty SAND (SW); light grey, mottled orange. Medium dense to dense; moist; low dilatency; well graded; sand, fine to coarse, pumice; moderate iron staining.	0.6 0.8
	SAND (SW), with trace gravel; light grey, mottled orange and black. Dense to very dense; saturated; well graded; sand, fine to coarse, pumice; gravel, coarse, subround to subangular.	1.0 1.2
	EOH: 1.40 m	1.4 1.6 1.8 2.0 2.2 2.4



Photo

Remarks

End of log at 1.4 m.
Target depth of 2.0 m not achieved due to hole collapse.
Groundwater encountered at 0.9 m.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

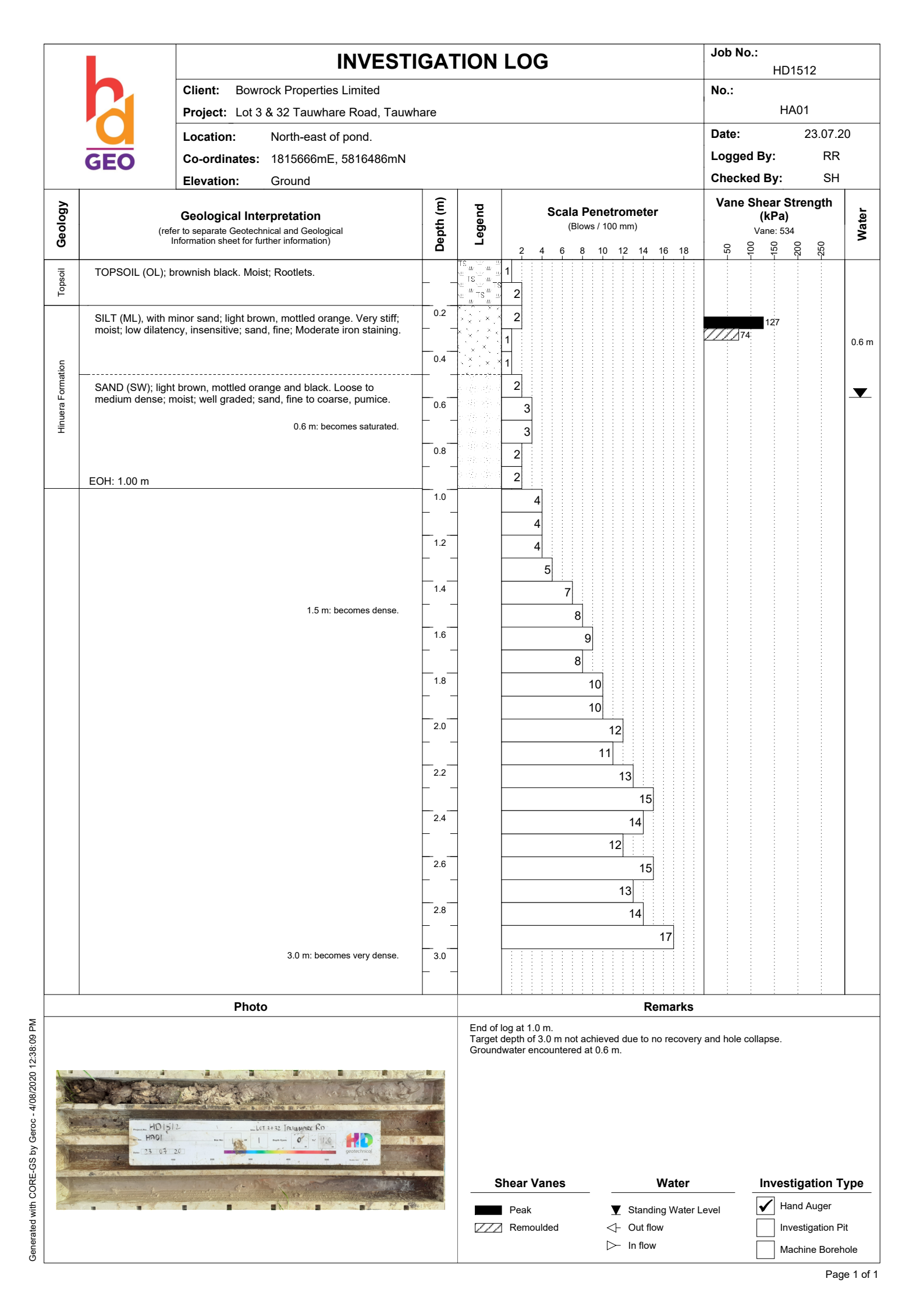
Investigation Type
- ☐ Hand Auger
- ☐ Investigation Pit
- ☑ Machine Borehole

INVESTIGATION LOG

Client:	Bowrock Properties Limited
Project:	Lot 3 & 32 Tauwhare Road, Tauwhare
Location:	North-east of pond.
Co-ordinates:	1815666mE, 5816486mN
Elevation:	Ground

Job No.:	HD1512
No.:	HA01
Date:	23.07.20
Logged By:	RR
Checked By:	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); brownish black. Moist; Rootlets.	
Hinuera Formation	SILT (ML), with minor sand; light brown, mottled orange. Very stiff; moist; low dilatency, insensitive; sand, fine; Moderate iron staining.	0.2
		0.4
	SAND (SW); light brown, mottled orange and black. Loose to medium dense; moist; well graded; sand, fine to coarse, pumice.	0.6
	0.6 m: becomes saturated.	0.8
	EOH: 1.00 m	1.0
		1.2
		1.4
	1.5 m: becomes dense.	1.6
		1.8
		2.0
		2.2
		2.4
		2.6
		2.8
	3.0 m: becomes very dense.	3.0



Photo

Remarks

End of log at 1.0 m.
Target depth of 3.0 m not achieved due to no recovery and hole collapse.
Groundwater encountered at 0.6 m.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Job No.:	HD1512
No.:	HA02
Client:	Bowrock Properties Limited
Project:	Lot 3 & 32 Tauwhare Road, Tauwhare
Location:	South of pond.
Co-ordinates:	1815697mE, 5816149mN
Elevation:	Ground
Date:	27.07.20
Logged By:	BK
Checked By:	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark brownish black. Moist; rootlets.	0.2
Hamilton Ash Formation	Silty CLAY (CL); dark brown. Stiff to hard; moist; moderate plasticity, moderately sensitive.	0.4, 0.6, 0.8, 1.0
	CLAY (CL); dark brown. Hard; moist; low plasticity.	1.2, 1.4, 1.6, 1.8
	Silty CLAY (CL); dark yellowish brown. Very stiff; moist; low plasticity, moderately sensitive.	2.0, 2.2, 2.4, 2.6, 2.8
	EOH: 3.00 m	3.0

Legend

Scala Penetrometer (Blows / 100 mm): 2, 4, 6, 8, 10, 12, 14, 16, 18

Vane Shear Strength (kPa) — Vane: 534: 50, 100, 150, 200, 250

Depth (m)	Peak	Remoulded
0.2	139	62
0.4	99	43
0.6	204	74
0.8	UTP	-
1.0	216+	-
1.2	216+	-
1.4	154	49
1.6	185	62
1.8	182	49
2.0	191	56

Water: Groundwater Not Encountered

Photo

Remarks

End of log at 3.0 m.
Target depth achieved.
Groundwater not encountered.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Job No.:	HD1512
No.:	HA03
Client:	Bowrock Properties Limited
Project:	Lot 3 & 32 Tauwhare Road, Tauwhare
Location:	West of open-drain.
Co-ordinates:	1815815mE, 5816128mN
Elevation:	Ground
Date:	23.07.20
Logged By:	RR
Checked By:	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); brownish black. Moist; Rootlets.	0.0
Hinuera Formation	SILT (ML); light brown, mottled orange. Very stiff; moist; low dilatency, sensitive; moderate iron staining.	0.2
		0.4
		0.6
		0.8
	SAND (SW); light brown, mottled orange and black. Medium dense; wet; well graded; sand, fine to coarse, pumice.	1.0
	No recovery, becomes saturated. 1.1 m: becomes dense.	1.2
	EOH: 1.20 m	1.4
		1.6
		1.8
		2.0
	2.7 m: becomes medium dense.	2.2
		2.4
		2.6
		2.8
		3.0

Legend

Scala Penetrometer (Blows / 100 mm): 1, 2, 1, 1, 1, 1, 2, 2, 1, 4, 7, 8, 14, 11, 14, 9, 9, 11, 12, 11, 10, 11, 13, 11, 13, 8, 4, 4, 5, 6

Vane Shear Strength (kPa) — Vane: 534: 154, 34, 161, 34

Water: 1.1 m

Photo

Remarks

End of log at 1.2 m.
Target depth of 3.0 m not achieved due to no recovery and hole collapse.
Groundwater encountered at 1.1 m.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

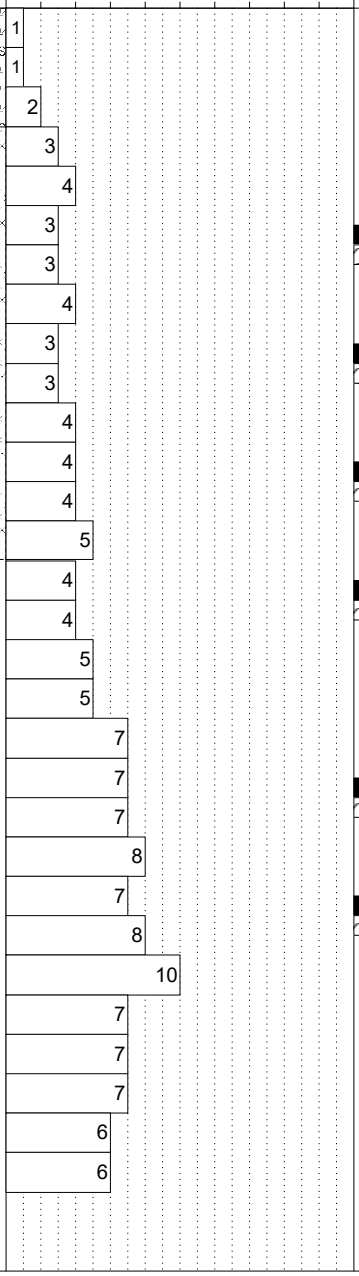
INVESTIGATION LOG

Job No.:	HD1512
No.:	HA04
Client:	Bowrock Properties Limited
Project:	Lot 3 & 32 Tauwhare Road, Tauwhare
Location:	Near southern corner.
Co-ordinates:	1815668mE, 5815964mN
Elevation:	Ground
Date:	23.07.20
Logged By:	RR
Checked By:	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); brownish black. Moist; Rootlets.	0.2
Hinuera Formation	SILT (ML), with trace sand; light brownish grey. Very stiff; moist; low plasticity, moderately sensitive; sand, fine; moderate iron staining.	0.4
		0.6
		0.8
		1.0
	1.2 m: becomes saturated, medium dense.	1.2
	EOH: 1.40 m	1.4
		1.6
		1.8
	1.9 m: becomes dense.	2.0
		2.2
		2.4
		2.6
	2.9 m: becomes medium dense.	2.8
		3.0

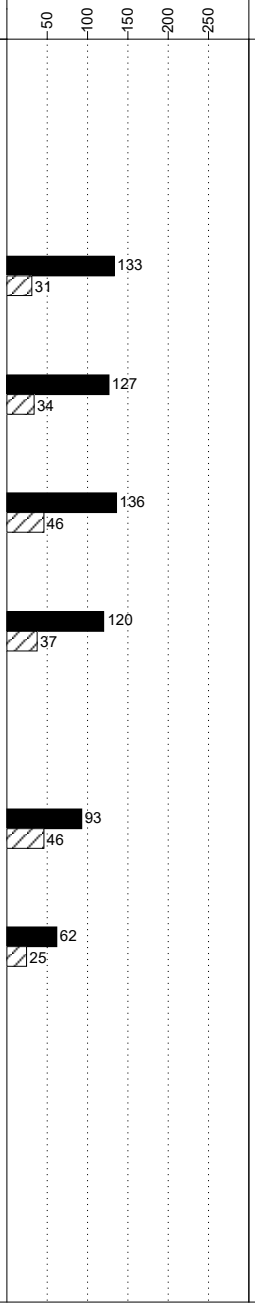
Legend

Scala Penetrometer (Blows / 100 mm)



Vane Shear Strength (kPa)

Vane: 534



Water

Photo

Remarks

End of log at 1.4 m.
Target depth of 3.0 m not achieved due to no recovery and hole collapse.
Groundwater encountered at 1.2 m.

Shear Vanes

- Peak
- Remoulded

Water

- Standing Water Level
- Out flow
- In flow

Investigation Type

- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	Bowrock Properties Limited
Project:	Lot 3 & 32 Tauwhare Road, Tauwhare
Location:	North-west of pond.
Co-ordinates:	1815515mE, 5816373mN
Elevation:	Ground

Job No.:	HD1512
No.:	HA05
Date:	27.07.20
Logged By:	BK
Checked By:	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	TOPSOIL (OL); dark brown. Moist; rootlets.	0.2
Hamilton Ash Formation	Silty CLAY (CL); brown. Very stiff to hard; moist to wet; low plasticity, moderately sensitive.	0.4, 0.6, 0.8, 1.0
	CLAY (CL), with some silt; dark brown. Hard; moist; low plasticity.	1.2, 1.4
	Silty CLAY (CL); brown. Hard; moist; low plasticity, moderately sensitive.	1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8
	EOH: 3.00 m	3.0

Legend

Scala Penetrometer (Blows / 100 mm)

2 4 6 8 10 12 14 16 18

Vane Shear Strength (kPa)

Vane: 534

50 100 150 200 250

Depth (m)	Peak	Remoulded
0.2	154	53
0.4	145	43
0.6	161	46
0.8	216+	-
1.0	UTP	-
1.2	UTP	-
1.4	216+	-
1.6	216+	-
1.8	210	71
2.0	UTP	-

Water: Groundwater Not Encountered

Photo

Remarks

End of log at 3.0 m.
Target depth achieved.
Groundwater not encountered.

Shear Vanes

- Peak
- Remoulded

Water

- Standing Water Level
- Out flow
- In flow

Investigation Type

- [x] Hand Auger
- [ ] Investigation Pit
- [ ] Machine Borehole

APPENDIX D – AERIAL IMAGERY

Figure 1. Aerial imagery from 1950. Site location in red.

Figure 2. Aerial imagery from 1971. Site location in red.

Figure 3. Aerial imagery from 1986. Site location in red.

Figure 4. Aerial imagery from 1995. Site location in red.

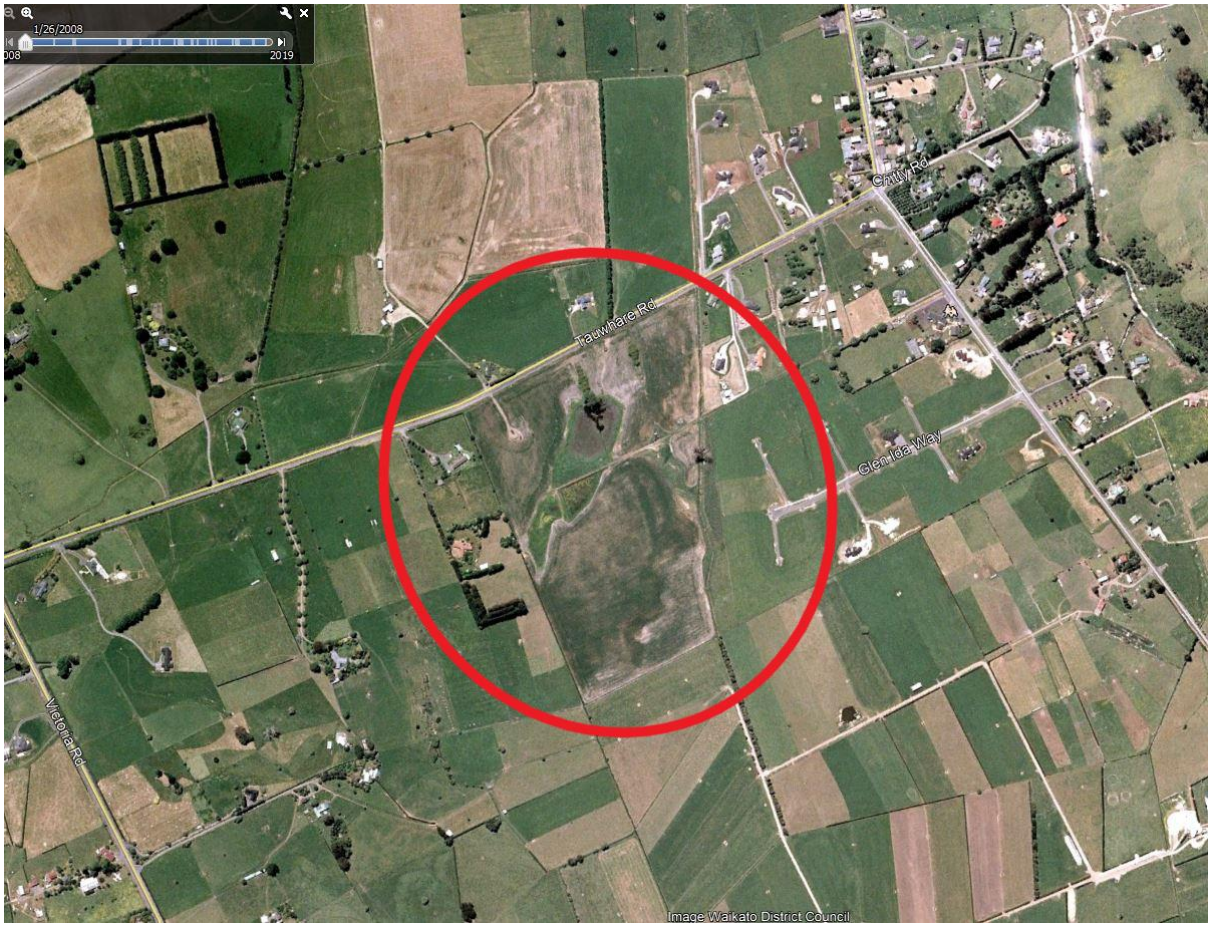


Figure 5. Aerial imagery from 2008. Site location in red.

Figure 6. Aerial imagery from 2017. Site location in red.