Before a Panel Appointed by the

Dunedin City Council

Under	the Resource Management Act 1991 (**RMA**)
In the Matter of	Hearing 4 of the Proposed Variation 2 (Additional Housing Capacity) of the Second Generation Dunedin District Plan – Appeals Version (**2GP**)
By	**Ron & Suzanne Balchin**

Brief of Evidence of **Mark Tapio Walrond** on behalf of:

Ron & Suzanne Balchin
(Submission 229 – GF05 & GF05a)

Dated 15th August 2022

Brief of Evidence of Mark Walrond

1. My full name is Mark Tapio Walrond. I am a senior engineering geologist at GeoSolve based in Dunedin, though operating throughout Otago/Southland.

2. I hold a MSc (Geology) from the University of Otago.

3. I have over 19 years' experience in engineering geology within New Zealand.

4. Although not necessary in respect of council hearings, I can confirm I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note dated 1 December 2014 and agree to comply with it. I have complied with the Code of Conduct in preparing this evidence, and I agree to comply with it while giving oral evidence before the hearing panel. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

5. I have prepared a geotechnical assessment report in relation to this matter which I append as Appendix 1.

Date: 15th August 2022

Mark Tapio Walrond

Appendix 1: Geotechincal Assessment Report.

GeoSolve Ref: 220581
12 August 2022

Ron Balchin
353 Main South Road
Sunnyvale
Dunedin

c.c: Emma Peters (Sweep Consultancy Ltd)

Geotechnical Assessment
353 Main South Road, Sunnyvale, Dunedin

Dear Ron,

In accordance with our Agreement dated 28 July 2022 we have undertaken a geotechnical investigation at the above property. Our investigation has comprised a site inspection by an engineering geologist, desktop review of existing information and subsurface test pitting investigations.

This report provides a summary of recent test pitting carried out at the site and comment on geotechnical concerns raised by Dunedin City Council's geotechnical advisor (Stantec NZ Ltd).

Photo 1 – Typical view of the northern extents of the site adjacent to recent residential development

Background and Potential Development

We understand that you are seeking to rezone the above site to enable increased residential development (from Rural Residential 2 to General Residential 1) which could involve minimum lot sizes of 400 m^2. This area is known as the GF05 site.

In addition, a further building platform is desired within the extents of the Miller St Landslide to the east of the existing dwelling (known as the GF05a site).

The following plan (Figures 1 and 2) shows the detail of the GF05 and GF05a areas.

Figure 1 – Location of the GF05 site

Figure 2 – Location of the GF05a site (yellow/blue dashed line to east of the GF05 site)

Site Description

The site topography (Figure 3) can be summarised as an upper area of gently to moderately sloping land (sown in pasture) adjacent to the existing residential developments on the south side of Severn St. To the south of this are relatively steep slopes of approximately 20 degrees that define the incised valley margins of Abbotts Creek. These slopes have been sown in gum trees. The south-eastern extents of the site also comprises mostly gently to moderately sloping land.

A large gully drains south-westwards from Severn St to Abbotts Creek and its axis lies just to the west of the existing dwelling on site. Several other minor drainage swales exist. A pond has been established within the gully.

The site has been used for farming and forestry in recent times. We understand that the site was previously owned by a brick manufacturer and there has been localised excavation over parts of the site. Some residual fill is locally present on site as a result of these activities.

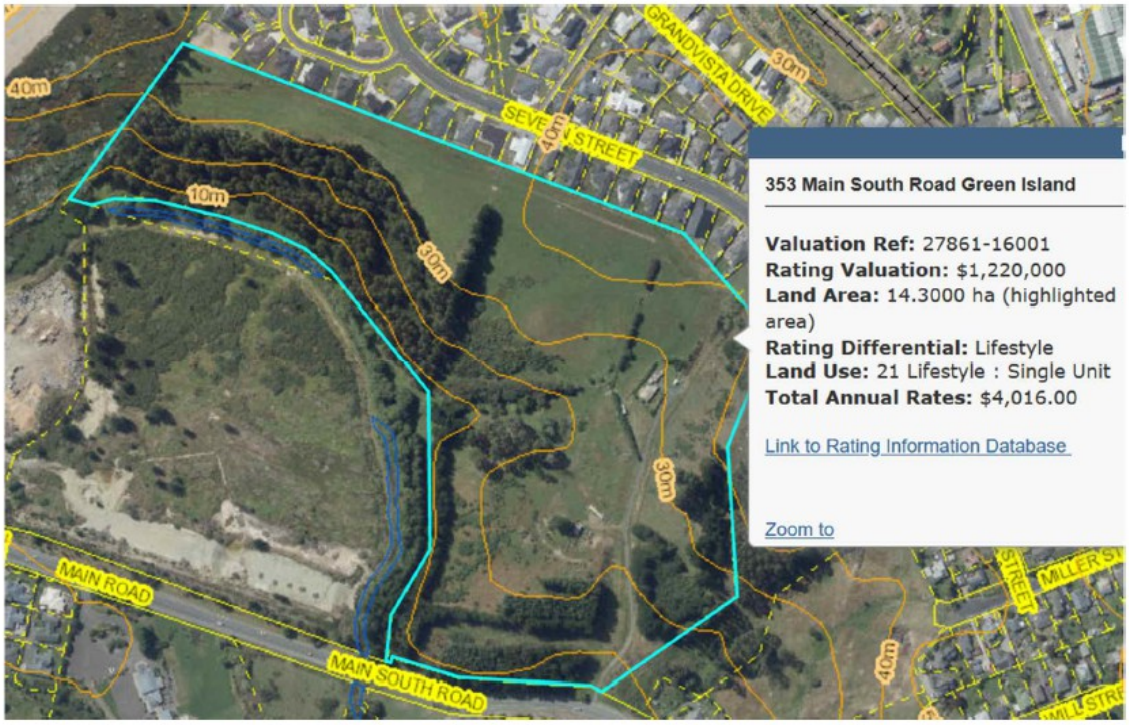

Figure 3 – Site extents and topography

Natural Hazards

In terms of natural hazards, the most relevant consideration in this location relates to landslide hazard. The site is underlain by Abbotsford Formation sedimentary rock types and underlying units that can be prone to slope instability. The site is almost entirely outside the area of adjacent landslide (the Miller St Landslide) as mapped in a 2017 GNS

Science report[1]. This is mapped as being a landslide with variable certainty ('definite' or 'likely'), 'prehistoric activity/initiation', 'probably prehistoric' last activity and 'low' sensitivity to destabilising influences.

GNS Science Ltd further describe the landslide as follows:

> **A1.6.1 Miller Street Landslide**
>
> The 'Miller Street Landslide' was first depicted on a map by Barrell & Glassey (1993), based on the interpretation of landform features in aerial photos, and examined on the ground. This interpreted feature was examined in more detail by Glassey (2005) and Golder Associates (2009). An impediment to understanding is that a prominent topographic step (scarp) marking the uphill extent of the interpreted landslide west of Reeves Street was removed during mining for clay in the 1970s. This scarp is well expressed in vertical aerial photo runs collected in 1942, 1962 and 1970, all of which can be viewed stereoscopically which allows the ground to be seen in 3D.
>
> The original scarp extended to the southeast, where it is still present today, as a ~5 m high and ~40 m broad topographic step evident on the ground and viewable in Google Earth Street View. However, the form of the scarp has been greatly subdued by residential development in Reeves Street, Miller Street and Will Street, and that development had occurred prior to 1942, when the earliest aerial photos were taken. As a result, there is no visual record of the original form of the scarp in the Miller Street area. Golder Associates (2009) undertook a geotechnical investigation in the area where the scarp had been removed, and concluded that there was no offset of the near-surface deposits and thus the topographic step was not of landslide origin. As part of the present assessment, detailed rectification of the historical aerial photos was undertaken, and showed that the base of the now-removed scarp was incorrectly positioned on previous maps, both of Glassey (2005) and Golder Associates (2009). The actual position was between 8 and 15 m northeast of the position shown on maps in those reports. As a result, we consider it highly probable that the test pits G3 and G4 that were crucial to the Golder Associates (2009) interpretation were sited on the landslide block, and not to the northeast of it, as they assumed. In that case, a landslide origin is not disproved. In the present dataset, the interpreted landslide feature is retained, and its location adjusted to accord with the detailed rectified aerial photo evidence. The evidence from aerial photos, and what can be still seen today in the Miller Street area, is judged sufficient to classify the *Certainty* of the feature as likely. The particularly evident landslide terrain farther west, also judged by Golder Associates (2009) to be of landslide origin and to which they confined the name 'Miller Street Landslide', is classified here as definite. There is no evidence for recent activity of the wider slide area, such as might be indicated by cracking or disruption of the Miller Street carriageway where it crosses the scarp. Both components of the Miller Street Landslide are assigned a *Sensitivity* value of low.

[1] Barrell D.J.A., Smith Lyttle B., Glassey P.J. (2017). Revised landslide database for the coastal sector of the Dunedin City district. Lower Hutt (NZ): GNS Science. 29 p. (GNS Science consultancy report; 2017/41).

Miller Street Landslide

Landslide

OBJECTID = 525
landslide_id = 100463
name = Miller Street Landslide
initiation = prehistoric
lastMovement = probably prehistoric
activity = prehistoric activity
certainty = definite
moveType = complex
geolContext = bedrock
sensitivity = low
recogn = stereoscopic aerial photography
recogn2 = lidar data
recogn3 = technical report
recognDetail = aerial photos SN3504/56-57 & SN4347/15-16; also guided by map of Glassey (2005)
source1 = Barrell 2017
source2 = Golder Associates 2009
source3 = Glassey 2005
resScale = 5000
capScale = 2500
comments = Refer to report (Barrell et al. 2017) for discussion of interpretation.
Shape_Length = 1085.3313
Shape_Area = 62013.956

Figure 4 – Location of the Miller St landslide over the extreme east of the subject site.

The Miller St landslide is considered an ancient area of instability. There is no available evidence that the landslide is moving at present although areas within such landslides can become reactivated, especially during storms or severe earthquake shaking and on steeper areas. In addition, elevated groundwater can be problematic, but drainage solutions can generally be applied in these cases.

Only the GF05a site (and a very small part of the GF05 site) lies within the extents of the Miller St Landslide. We note that recent residential development has taken place within the extents of the landslide but this may have been consented via Section 72-73 of the Building Act.

No active landslip activity was identified on the site at the time of inspection.

Stratigraphy

Our recent test pitting comprised 11 test pits taken to a depth of 3.2 m to assess the near surface soils and groundwater conditions. In summary the soils are mostly colluvium or ancient landslide debris overlying Abbotsford Formation bedrock which was visually observed in 2 test pits at depths of between 0.5 m (TP2) and 2.7 m (TP6).

No groundwater was observed for most of the site, apart from the test pit in the GF05a area (TP11).

The soils are predominantly firm within the upper 0.5 m and becoming stiff to hard beyond this depth.

Only localised uncontrolled fill was observed (up to 1 m in TP3 and 9 – likely associated with forestry and brick works). Some obvious stockpiles of fill are also located near the north-east corner of the site.

The test pit locations are shown in Figure 1 (appended) and Figure 5 below (with respect to the mapped landslide extents). We have retained a photographic record of the test pitting on file.

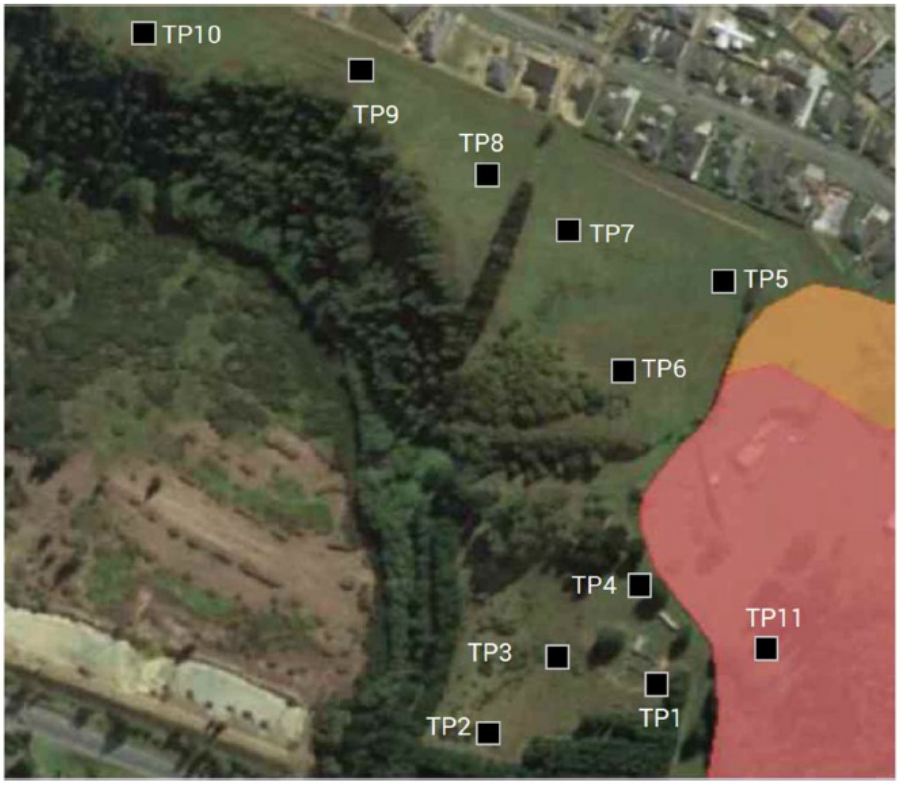

Figure 5 – Location of the test pits with respect to the Miller St landslide.

The ancient landslide debris comprises firm to stiff silty clay with rare slickensides and cobbles of volcanic rock. There were no seepages of groundwater observed from within the debris or any soft moist clay layers that could indicate recent shearing, however some clay bands and other evidence of previous prehistoric internal shearing were commonly observed.

The weathered mudstone below the debris was considerably more difficult to excavate and comprises weathered weak sedimentary rock (glauconitic mudstone). Further investigations are recommended at the subdivision consenting stage to confirm local depth and persistence of bedrock.

Slope Stability Interpretation

Based on the absence of visual evidence for recent landslide activity, we consider that the Miller Street Landslide is not likely to be highly active. We note that there appears to have been no damage (e.g. deep headscarp tension cracking) as a result of the major July 2017 and July 2022 storm events.

The existing dwelling located on the 'definite' extents of the Miller St Landslide has been in place for many decades and is clearly serviceable and appropriate for residential use despite numerous storms since construction.

We also note that GNS Science has assigned low sensitivity for the site. This means that: *"no geomorphic modifiers are currently active".*

Full confirmation of inactivity would however need survey monitoring over a number of years. Based on the test pitting and our visual engineering geological observations there is no evidence that the remainder of the site outside the Miller St Landslide is prone to global landslide movements (i.e. most of the GF05 area that lies well outside the landslide extents).

However, there are some steeper areas (mostly tree-covered) and areas of softer soils within the main gully on site where some under-runners exist which could cause localised instability if insufficient engineering measures are applied. The presence of localised ancient landslide debris can indicate that reactivation of any softened debris is possible in major storm events or if the soils are able to become saturated. However, in this case the landslide debris was confirmed to be stiff, clearly ancient in origin and contained no groundwater (apart from TP11 which is within the Miller St landslide extents).

Consequently, risk of slope stability for most of the property (GF05 area) can be managed by ensuring that sufficiently detailed geotechnical investigation is in place to support subdivision intentions and design is applied at the design stage for individual dwellings, depending on their eventual locations and construction styles. In addition, any proposed earthworks should be subject to specific geotechnical assessments to ensure that these do not promote global slope instability and this work should include determination of bedrock persistence, bedrock dip angles and any potential zones of shearing. These items can be addressed during preparation of future geotechnical report to accompany the subdivision consent application and individual building consent applications.

Particular emphasis on geotechnical advice should be applied to any proposal for residential development on land steeper than 15 degrees or within the gully area/Miller St landslide shown approximately on Figure 6. These areas may be better suited to reserves, however with sufficient engineering and acceptance of risk, some areas such as these could be considered for development.

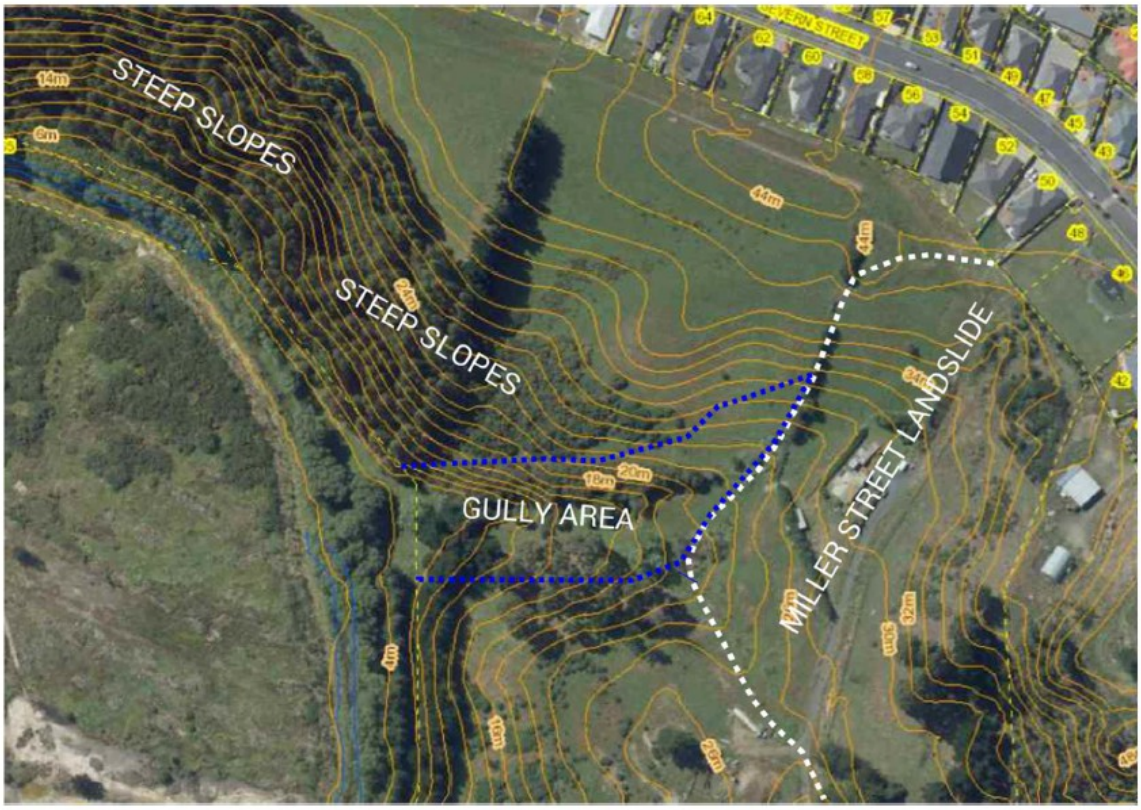

Figure 6 – General areas where residential development may be constrained.

Development of the GF05a Area (and any other areas within the Miller St Landslide extents)

We consider that residential development of the GF05a area and generally within the Miller St Landslide is also feasible, however some specific measures should be adopted for design and construction, as outlined below.

The test pit that was excavated in this area (TP 11), shows less favourable geotechnical conditions than elsewhere on the property (e.g. softer soils, slickensides and groundwater at 1.6 m depth). This is consistent with landslide terrain.

There is however precedent for development on the Miller St landslide. The existing dwelling has been in place for many decades, and we understand that there is no damage that affects its serviceability. In addition, there has been a new neighbouring building recently constructed within the area defined as "definite" landslide by GNS Science Ltd. Additionally, there are over 20 dwellings within the area defined as "likely" landslide by GNS Science Ltd.

Our main recommendation in landslide terrain is to ensure that structures are piled with easy access underneath to enable re-levelling in the event of any movement. The general intent should be to minimise earthworks as far as possible, as retaining cuts appropriately in landslide debris can be very costly.

Based on site observations and the GNS Science reports of 'prehistoric activity' and 'low' sensitivity to destabilising influences as well as the firm to stiff nature of the soils, we consider that the site is likely to present a low risk of global slope instability, provided that the recommendations of this report are followed.

However, if minor creep movement does occur then this may cause some damage. The type of damage that may be expected in that case comprises slight changes in foundation levels, accumulation of minor racking damage in the longer term and minor cracking of rigid materials. This can generally be addressed by a commitment to a moderate degree of future maintenance.

If developed, this single proposed site (and any others within the Miller St Landslide) will need to be managed in accordance with typical advice in landslide settings, i.e.:

1. Detailed geotechnical investigations will be required for any dwelling within the Miller St Landslide. This may require specific deeper tests and groundwater monitoring, as well as slope stability analysis.
2. The timber pile foundations are preferable for ease of maintenance in landslide terrain. Serviceability considerations should be addressed by the architect. Sufficient working space under the structure should be permanently available to allow for long-term re-levelling of the dwelling if ever required.
3. We recommend that more ductile materials such as timber should be used wherever possible to reduce potential maintenance requirements. Rigid claddings may crack if movement does occur.
4. All pile holes and excavated subgrades should be carefully checked by a geotechnical specialist to identify any potential shear surfaces that may cross the building footprint. It is noted that there are shear surfaces apparent in TP 11, however the site topography is gentle (~6 degrees) and there is no evidence of creep movement within adjacent batters etc.
5. All stormwater should be piped well away from the building platform to a Council-approved discharge point. Runoff should be similarly controlled using contour drains. A contingency should be in place for deep drainage if required because groundwater was observed. It would be beneficial to install some deep drains upslope or across the eventual building platform to draw down groundwater levels locally and the best form of drainage can be advised during the design phase.
6. There is some evidence of surficial movement on the steep slope above the proposed dwelling (mostly on neighbouring land). There could be some risk of future smaller landslips on this slope but this potential can be reduced by drainage measures and planting. The most beneficial practical risk reduction measures for this slope are likely to be simple cut-off drain to effectively ensure that the slope cannot become saturated by runoff from upslope sources.
7. Cuts should be generally minimised and all cuts should be inspected by a geotechnical practitioner to check for shear surfaces.

8. Surface point monitoring by a surveyor is not considered essential but is recommended for quantification of any movement and to enable movement data to be collected in the longer term.
9. If there is any indication of movement, engineering geological assessment should be carried out.

Numerous dwellings have recently been established on ancient landslide debris in the Dunedin area, however we understand that DCC has applied Section 72-73 of the Building Act in at least some of these cases. This encumbrance is typically applied only in areas where the district plan mapping identifies likely hazard, rather than situations of prehistoric activity and low sensitivity to destabilising influences, such as the Miller St landslide and this site. Planning consideration is required to confirm requirements.

If applied, a Section 72-73 notice means that the owner carries the risk of future landslide damage. Implications include a lack of insurance cover for landslip and possibly some issues with obtaining finance and or difficulties in selling the property at a later date. If applied it may be that that the Section 72-73 encumbrance can be lifted in future, provided that sufficient survey monitoring is arranged. If so, we recommend precise site-specific survey monitoring so that movement rates can be quantified and used to demonstrate long-term lack of movement if applicable.

The planning considerations relating to Section 72-73 notices in the case of proposed boundary readjustment will need to be considered by others, however there may be consent conditions that can be applied to adequately convey residual risk.

Alternatively, it may also be possible to carry out slope analysis to confirm numerically that the site meets accepted safety factors for residential development. This will require drilling and piezometer installation followed by slope stability modelling and possibly some mitigation works.

Geotechnical Review Comments

We note that Stantec NZ Ltd has responded to the application with some concerns regarding slope instability. As discussed, most of the site is not recognised as a landslide, however test pitting investigations have now been undertaken and discussed above to confirm if residential development is appropriate or if any constraints exist.

We have also reviewed the specific supplied evidence presented by Stantec NZ on site stability hazard. Their main concerns are as follows and GeoSolve's responses are provided below each comment for consideration:

Comments relating to the GF05 Area:

> The steepest part of the site is located within the vegetated embankment with consistent slopes of 20-26 degrees. Earthworks within this area may cause significant large scale instability within the uphill lots off Severn St and Tate Cres.

- We agree, however the steeper land would be subject to specific controls to mitigate risk as discussed above (e.g. any proposed earthworks should be subject to specific geotechnical assessments to ensure that these do not promote global slope instability). In addition, the

soils are stiff and bedrock has been observed at relatively shallow depth which indicates favourable conditions. We understand that the steeper parts of the site may however become reserve land, but development could be contemplated with adequate geotechnical overview.

Abbotsford Mudstone is known for its susceptibility to groundwater and earthworks and historic large-scale instabilities. The material typically become unstable at slopes of over 15 degrees, however there have been several cases of instabilities within slopes of less than 12 degrees. An example of this is the historic Abbotsford motorway landslide within the same geology. Excavation of the toe of the slope caused a global landslip within land sloping by less than 12 degrees.

- Many residential areas exist on Abbotsford Formation, however landslides are clearly hosted by this rock type locally. However, instability appears to be most pronounced on dip slopes (i.e. where bedding dips out of slope). In this case the steeper slopes appear to be perpendicular to the dip slope of the sedimentary rocks. There are areas where failure has occurred more obliquely to the dip direction (e.g. Miller St Landslide, West Abbotsford Landslide etc), however in these cases the failures appear to be mostly in relatively thick debris where weathered rock is not present near the surface. For example, the historic reactivation of the lower extents of the West Abbotsford Landslide (known as the Motorway Slip) was within older debris or solifluction deposits of 10-20 m thickness where reactivation is usually much more probable than in bedrock. In addition, this landslide was promoted by earthworks cuts at the toe of the slope (for motorway construction). Test pitting has now confirmed that the geology at the Motorway Slip differs considerably from the subject site and is not within the same geology. Despite slopes of about 20 degrees, there is no evidence of major landslide activity on most of the GF05 area.

There is also a large quarry still active directly adjacent to the west of the proposed site, and was previously active within the lower slopes and terraces to the southwest.

- The quarry excavations lie approximately 90 m north-west of the site and are clearly in the up-dip direction of the regional bedrock dip. There are no landslides mapped near this area. Consequently, risk from the quarry cuts is likely to be low.

There are several **high level hazards** associated with slope instability and precedent for land instability within similar geology and slope angles nearby.

The site is located within the same geology and slope angles as other large historic landslides nearby.

- Parts of the site slope steeply but much of the site is occupied by relatively gentle slopes of less than 10 degrees and the test pitting has found no evidence of extensive soft landslide debris or adverse groundwater conditions.

Global stability of the site could be affected by development, especially from earthworks and/or groundwater changes. Any global instabilities would be large to massive in scale and affect multiple potential lots.

- To mitigate the potential for global instability, the extent and depths of earthworks can be controlled as appropriate during detailed subdivision assessment and reporting. There is no evidence of groundwater within the shallow soil profile.

Geological investigations are required to determine the suitability of the site. Investigations may require deep drilling.

- Test pitting investigations have now been carried out as reported above with no indication of adverse or unmanageable subsurface conditions. Full investigations, analysis and reporting can be carried out to support a subdivision consent application in due course when a scheme plan becomes available. Depending on earthworks plans, this could include confirmatory deep drilling.

Comments relating to the GF05a Area:

We consider that the hazard level for this adjacent site is **high**. The site is located entirely within the Miller Street landslide with distinct head scarps from historic landslide features as recent as 1970s. It is uncertain that there will be any location within the site that a geotechnical engineer would consider stable enough for a dwelling. As such it is a possibility that any new structures within this area will be uninsurable, though this cannot be known until geotechnical investigations have been sought.

- As described above, there is precedent for successful residential development within the Miller Street landslide, but this will require the above geotechnical recommendations to be adopted, as well as planning inputs relating to issues such as Section 72-73 notices in the case of proposed boundary readjustments. If required, it may be possible to carry out slope analysis to confirm numerically that the site meets accepted safety factors for residential development. This will require drilling and piezometer installation followed by slope stability modelling.
- We are unaware of the references to 1970s landslide features as the available GNS reporting suggests the last movements were "probably prehistoric" but we can review and consider any available reporting.

Applicability

This report has been prepared for the sole use of our client, Ron Balchin, with respect to the particular brief and on the terms and conditions agreed with our client. It may not be used or relied on (in whole or part) by anyone else, or for any other purpose or in any other contexts, without our prior review and written agreement.

It must be appreciated that the nature and continuity of subsoil conditions away from the investigation locations cannot be guaranteed. The recommendations and opinions contained in this report are based upon ground investigation data obtained at discrete locations and historical information held on the GeoSolve database. The nature and continuity of subsoil conditions away from the investigation locations is inferred and cannot be guaranteed.

Further investigations are required at the subdivision consent application stage when a scheme plan becomes available. During construction, foundation excavations should be examined by an inspector or engineer competent to confirm that subsurface conditions encountered throughout are compatible with the findings of this report. It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

Yours faithfully,

Mark Walrond
Senior Engineering Geologist
GeoSolve Limited

Attached:

- Site plan (1 p)
- Test pit logs (11 p)

Key

Test pit locations

CADFILE:	Site Plan.xar	DRAWN	RC	08/2022
SCALE: (AT A3 SIZE)	As shown (approx)	DRAFTING CHECKED	MTW	08/2022
PROJECT No.:	220581	APPROVED	MTW	08/2022

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ENGINEERING CONSULTANTS

GEOTECHNICAL
WATER RESOURCES
PAVEMENTS

Ron Balchin
353 Main South Rd, Dunedin
Geotechnical Investigation
Site Plan

FIG No: Figure 1 - Site Plan

REV. 1

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ENGINEERING CONSULTANTS

TEST PIT LOG

EXCAVATION NUMBER: **TP 1**

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL	0m Organic SILT; brown. Soft; moist.		0.0		
UNCONTROLLED FILL	0.1m Clayey SILT; light orange brown. Soft to firm; moist.		0.1		
	0.4m		0.4		
ANCIENT LANDSLIDE DEBRIS	Clayey SILT with a trace of sand, gravel and cobbles; light orange brown. Stiff to hard; moist; sand, fine to coarse; gravel, fine to medium, weathered volcanic clasts. Cobbles to 100 mm diamater. Some slickensides.		0.5 – 2.9	NO SEEPAGE	
	3m		3.0		

Total Excavation Depth = 3.0 m

COMMENT:	Exacavtion terminated in hard silts and close to max reach.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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ENGINEERING CONSULTANTS

TEST PIT LOG

EXCAVATION NUMBER: **TP 2**

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL	0m Organic SILT; brown. Soft; moist. 0.2m		0.0 0.1 0.2	NO SEEPAGE	
COLLUVIUM	Clayey SILT with a trace of sand; light brown. Firm; moist; sand, fine to coarse. 0.5m		0.3 0.4 0.5		
ABBOTSFORD FORMATION BEDROCK	Fine to medium SAND; light green orange mottled, weak laminations. No evidence of shearing. Weak; slightly moist; iron pan at upper contact. 0.9m		0.6 0.7 0.8 0.9		

Total Excavation Depth = 0.9 m

COMMENT:	Excavation terminated due to hard digging.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER: **TP 3**

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
UNCONTROLLED FILL	0m Clayey SILT with a trace of sand and gravel; light brown to brown. Soft; moist; sand, fine to coarse; gravel, fine.		0.0 – 0.8		
BURIED TOPSOIL	0.9m Organic SILT; dark brown. Soft; moist; a trace of rootlets. 1.2m		0.9 – 1.2		
ALLUVIUM	Silty CLAY; orange brown to light grey. Firm to stiff; moist. A trace of free water; a trace of plant fragments. Blue grey organic tint. 2.8m		1.2 – 2.8	NO SEEPAGE	

Total Excavation Depth = 2.8 m

COMMENT:	Some forestry uncontrolled fill nearby.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER: **TP 4**

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL	0m Organic SILT; brown. Soft; moist. 0.2m		0.0 – 0.2		
COLLUVIUM	Clayey SILT; light brown. Firm; moist.		0.2 – 0.6		
ANCIENT LANDSLIDE DEBRIS	0.6m Clayey SILT with a trace of sand, gravel and boulders; light brown. Stiff; moist; sand, fine to coarse; gravel, fine; boulders to 300 mm diameter, volcanic clasts.		0.6 – 2.4	Seepage @ 2.4 m	
ANCIENT LANDSLIDE DEBRIS	2.4m Silty CLAY with a trace of gravel; orange brown to light grey. Firm to stiff. Driver reports softer digging below 2.5 m; moist. Wet at 2.4 m; gravel, fine to medium, angular mudstone clasts. 3.2m		2.4 – 3.2		

Total Excavation Depth = 3.2 m

COMMENT:	Excavation terminated at max reach.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER:
TP 5

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL	0m Organic SILT; brown. Soft; moist. 0.3m		0.0 – 0.3		
ALLUVIUM	Clayey SILT; light orange brown. Firm; moist; a trace of brown organic stains. 0.6m		0.3 – 0.6		
ANCIENT LANDSLIDE DEBRIS	Clayey SILT with a trace of sand and gravel; light orange brown grey mottled. Stiff to hard; moist; sand, completely weathered volcanic and glauconite derived; gravel, completely weathered volcanic clasts. Lenses of clay silt. Minor silty horizons. 2.7m		0.6 – 2.7	NO SEEPAGE	

Total Excavation Depth = 2.7 m

COMMENT:	Excavation terminated due to hard digging.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER: **TP 6**

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL	Organic SILT with a trace of sand and gravel; brown. Soft; moist; non-plastic; sand, coarse; gravel, fine, subrounded. A trace of rootlets.	0m – 0.2m		
COLLUVIUM	SILT with minor clay and a trace of cobbles and boulders; orange brown mottled. Stiff; moist; non-plastic; cobbles and boulders, subangular to subrounded, up to 400 mm diameter, slightly weathered clasts.	0.2m – 0.8m		
ANCIENT LANDSLIDE DEBRIS	Clayey SILT with a trace of sand and gravel; orange light brown mottled. Stiff, locally firm; moist with a trace of free water around boulders from 1.9 m; non-plastic to low plasticity; sand, fine to coarse, volcanic and glauconite derived; gravel, fine to coarse, weathered clasts. Some boulders from 1.5 m, subangular to subrounded, up to 450 mm diameter. Isolated boulder to 900 mm diameter. Some onion weathering on boulders. Minor dark brown and grey zones.	0.8m – 2.4m		
ANCIENT LANDSLIDE DEBRIS	Clayey SILT; dark orange. Very stiff to hard; moist; a trace of grey weathered glauconitic sand seams.	2.4m – 2.7m		
ABBOTSFORD MUDSTONE	MUDSTONE; brown with orange yellow and grey mottles. Weak to moderately strong; moist. A trace of free water at mudstone contact; minor/trace of orange and yellow seams. A trace of wet clay rich seams - possible slickensides?.	2.7m – 2.9m	NO SEEPAGE	

Total Excavation Depth = 2.9 m

COMMENT:	Excavation terminated due to hard digging on mudstone and close to max reach.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER: **TP 7**

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL	Organic SILT; brown. Soft; moist; a trace of rootlets. 0m – 0.25m		0.0 – 0.2		
COLLUVIUM	Clayey SILT; light grey orange mottled. Firm. Very stiff from 0.7 m; moist. Isolated saturated pockets; low plasticity; a trace of rootlets. 0.8m		0.3 – 0.8		
ANCIENT LANDSLIDE DEBRIS	Clayey SILT with a trace of sand; grey dark orange mottled. Very stiff to hard. Hard digging from 1.3 m; moist; low plasticity; sand, fine to medium. Glauconitic smears and lenses. A trace of organic fragements. Pocket of dark orange silt in west end of pit at 1.7 m. 2.2m		0.8 – 2.2	NO SEEPAGE	

Total Excavation Depth = 2.2 m

COMMENT:	Excavation terminated due to very hard digging.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER:
TP 8

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL	Organic SILT; brown. Soft; moist to wet; non-plastic; a trace of rootlets. 0m – 0.3m		0.0 – 0.3		
ALLUVIUM	SILT with minor clay and a trace of gravel; light grey orange mottled. Firm; moist; non-plastic to low plasticity; gravel, fine, subangular to subrounded quartz clasts. Gravel absent from 0.5 m. A trace, locally minor, of organic fragments. 0.7m		0.3 – 0.7		
ANCIENT LANDSLIDE DEBRIS	Clayey SILT with a trace/minor sand and a trace of gravel; dark orange and grey mottled. Very stiff; moist. A trace of free water in voids; non-plastic; sand, fine to medium, glauconitic lenses; gravel, fine, rounded to subangular. Bouldery and cobbly from 1.7 m. Cobbles and boulders, subrounded to subangular, up to 350 mm diameter. 2.1m		0.7 – 2.1		
ANCIENT LANDSLIDE DEBRIS	Clayey SILT; dark orange. Very stiff to hard; moist; minor grey weathered glauconitic sandy seams. 2.7m		2.1 – 2.7	NO SEEPAGE	

Total Excavation Depth = 2.7 m

COMMENT:	Exacavtion terminated in hard silts and close to max reach.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER: **TP 9**

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL/ UNCONTROLLED FILL	Organic SILT; brown. Soft; moist. 0m – 1m		0.0 – 1.0		
COLLUVIUM	Clayey SILT; orange brown. Stiff; moist. 1m – 2.6m		1.0 – 2.6		
COLLUVIUM	Clayey SILT with a trace of sand; orange brown. Stiff to hard; slightly moist. 2.6m – 3m		2.6 – 3.0	NO SEEPAGE	

Total Excavation Depth = 3.0 m

COMMENT:	Exacavtion terminated in hard silts and close to max reach.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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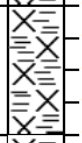
TEST PIT LOG

EXCAVATION NUMBER: **TP 10**

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description	Graphic Log	Depth (m)	Groundwater / Seepage	Scala Penetrometer (Blows per 100mm) 0 5 10 15
TOPSOIL	Organic SILT; brown. Soft; moist. 0m – 0.3m		0.0 – 0.3		
COLLUVIUM	Clayey SILT; orange brown. Stiff; moist. 0.3m – 1m		0.3 – 1.0		
COLLUVIUM	Clayey SILT with a trace of sand; brown. Stiff; moist; sand, fine to medium. 1m – 1.4m		1.0 – 1.4		
COLLUVIUM	Clayey SILT with some boulders; brown. Stiff; moist; boulders, subrounded, up to 350 mm diameter. 1.4m – 2m		1.4 – 2.0	NO SEEPAGE	

Total Excavation Depth = 2.0 m

COMMENT:	Difficult to penetrate beyond 2.0 m.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1

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TEST PIT LOG

EXCAVATION NUMBER:
TP 11

PROJECT:	353 Main South Rd, Dunedin			JOB NUMBER:	220581
LOCATION:	See Site Plan	INCLINATION:	Vertical		

EASTING:		EQUIPMENT:	8T excavator	OPERATOR:	Brad
NORTHING:		COORD. SYSTEM:		COMPANY:	Hollands Excavation
ELEVATION:		EXCAV. DATUM:	Existing ground level	HOLE STARTED:	03/08/2022
METHOD:	Aerial Photography	ACCURACY:	± 5 m	HOLE FINISHED:	03/08/2022

Soil / Rock Type	Description
TOPSOIL	0m Organic SILT with some boulders; dark brown. Soft; moist; boulders, subrounded basalt, up to 400 mm diameter. 0.4m
ANCIENT LANDSLIDE DEBRIS	Clayey SILT; light orange brown. Firm becoming stiff; moist. Wet to saturated from 1.6 m; a trace of organic mottles. 30° inclined planes with slickensides at 1.6 m - pit walls collapsing on these planes. 3.1m

Graphic Log

Depth (m): 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0, 3.1

Groundwater / Seepage

Groundwater @ 1.6 m

Scala Penetrometer (Blows per 100mm)
0 5 10 15

Total Excavation Depth = 3.1 m

COMMENT:	Excavation terminated at max reach.	LOGGED BY:	MTW/RC
		CHECKED DATE:	10/08/2022
		SHEET:	1 of 1