HUNTER
GEOTECHNICAL SERVICES

Geotechnical Assessment

Proposed Retention System

286-310 Gregory Street, South West Rocks

Report Ref: G0730-GI-001-Rev1

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Client: South West Rocks Living Pty Ltd

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Prepared for

South West Rocks Living Pty Ltd

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Project Details

Site Address:	286-310 Gregory Street, South West Rocks
Project Type:	Proposed Residential Development

Project no	Report type	Report no
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Report Register

Revision Number	Reported By	Reviewed By	Date
Rev0	DP	DS	7/11/24
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We confirm that the following report has been produced for South West Rocks Living Pty Ltd, based on the described methods and conditions within.

For and on behalf of Hunter Geotechnical Services,

Daniel Soffer
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Annex List:

1 Introduction

At the request of South West Rocks Living Pty Ltd, Hunter Geotechnical Services (HGS) have undertaken a geotechnical assessment for the proposed residential development to be constructed at 286-310 Gregory Street, South West Rocks.

Based on the supplied drawing, the proposed development is to include:

- Site regrading works comprising up to 8 cut and placement of site won fill
- Site preparation works for a 101 Dwelling Site Multi Dwelling Housing estate
- Construction of retaining walls up to approximately 1.0m in height in association with proposed lot terracing works
- Construction of internal road pavements
- Construction works for associated infrastructure including water, sewer and stormwater services.

The investigation works were undertaken in accordance with HCL services agreement Q2957, dated 20 September 2024.

The purpose of the investigation was to provide geotechnical comment and recommendations on the following:

- Desktop review of published geological and soil landscape mapping and review supplied plans and assessment of geotechnical conditions present informed by geomorphology mapping
- A geotechnical model of the subdivision that includes the following (if encountered);
    - Identification of poor or potentially problematic ground conditions including presence of boulders
    - Ground water levels
    - Depth and characterisation of soil profiles
    - Depth to weathered rock
    - Prescence of fill
    - Ground water levels including evidence of spring activity
- An interpreted Geotechnical Long Section of the site
- Slope risk assessment in accordance with the principles and protocols of the Australian Geomechanics Society publication 'Practice Note Guidelines for Landslide Risk Management' (2007). This methodology represents the currently accepted state of practice for landslide risk assessment
- Recommended foundation types to support the proposed structures within the subdivision, including:
    - Suitable shallow footing types and foundation design parameters (Allowable Bearing Capacity)

    - Bored pile design parameters (ultimate and allowable capacities for compression, tension and lateral loads) and founding depths
- Earthworks advice including site preparation to support concentrated building loads, safe batter slopes and temporary support for excavations, excavation conditions and geotechnical suitability of excavated material for re-use as filling;
- Retaining wall parameters (γ – unit weight, Φ' – angle of friction, C' – drained cohesion, Cu – undrained cohesion, Ka – Coefficient of active earth pressure, Kp – Coefficient of passive earth pressure and Ko – Coefficient of at rest earth pressure)
- Recommended safe temporary and permanent batter slopes
- Further geotechnical constraints to the development

This report provides details of the investigation, laboratory testing and provides recommendations for the proposed development.

2 Site Description

The site was located at 286-310 Gregory Street, South West Rocks The site was bordered by Gregory street to the west, Tallowwood Place residential housing to the south, and dense mature tree line covering the north and eastern boundaries.

The site is situated on the south-westerly facing mid to lower slopes of a rounded ridge that is up to 45mAHD. Surface elevations range from RL30m in the northeast corner to RL6m in the southwest corner. The upper slopes of the site were convex in plan and profile and fell to the southwest by approximately 8 – 10°. The slope breaks at approximately RL14m, where slopes are straight in plan and concave in profile, falling to the southwest by 3 – 4°. The break in slope is critical to managing the key geotechnical risks present at the site.

The upper slopes comprised colluvial deposits and residual clays comprising very high strength, crystalline granite boulders, ranging from 300mm to 3000mm. Boulders were not observed along the northern boundary, and increase in size and density from the slope crest in the upper northern corner of the site west of section C as outcrops of very high strength granite tors and boulders. Surface soils in the lower slopes comprised exposed saprolite (decomposed residual granite clays as clayey sand to sand).

Vegetation comprised a covering of slashed Kikuya grasses and was densely populated with mature native trees along the perimeters that will encroach the excavation limits.

The upper slopes had evidence of spring activity with moisture favouring grass and mosses evident in two locations to the eastern and southeast boundaries. Drainage of the site would be via a combination of overland flow and surface infiltration into topsoil.

Figure 1: Aerial image obtained from 'NearMap' depicting the site location and setting

Figure 2: Looking west across the site from Gregrory Street. Proposed excavations in areas of rounded upper slopes that coincide with boulder floaters that increase in incidence as the slope trends south

Figure 3: Looking southeast across the gently undulating lower slopes comprising residual clays and sandy saprolite

Figure 4: Looking east from the northeast boundary of the site. Excavation extents are populated with mature native trees.

Figure 5: High strength granite boulders increasing in frequency in a southeast direction

Figure 6: Looking south across the site, showing an increase in slope to 6° to colluvial hills

Figure 7: Showing Adamellite (granitic) boulders outcropping at the surface near TP4

Figure 8: looking east across the site at the southern boundary, showing seepage from spring activity with moisture favouring grasses and poor ground conditions located at TP6

Figure 9: Boulders frequent in bushland upslope, it is likely that the paddock has been cleared of surface boulders during previous land uses.

3 Desktop Review

3.1 Geological & Soil Landscape Setting

Reference to the 1:250,000 Dorrigo-Coffs Geology Map indicates the site is underlain by the intrusive Triassic aged Smokey Cape Adamellite comprising hornblende-biotite leucocratic monzogranite and granophyre. The Smokey Cape Adamellite comprises foliated, low strength quartz-rich granitic saprolite found in joint spaces of varying thickness depending on the depth to bedrock and degree of fracturing. The formation is known to comprise vertical and horizontal discontinuities, which allow for large corestones to be present within the residual profile overlying bedrock. The presence of large, high-strength granite boulders up to 3m in size can present challenges for excavation, foundation design, and wall stability.

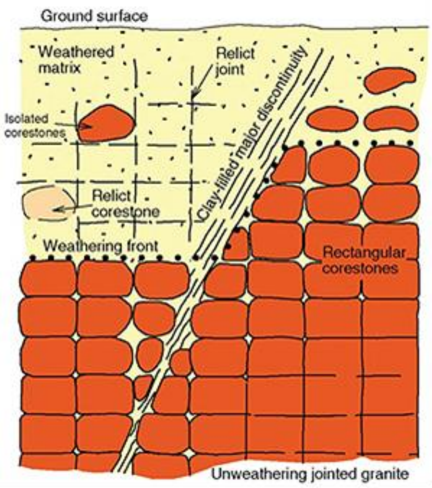
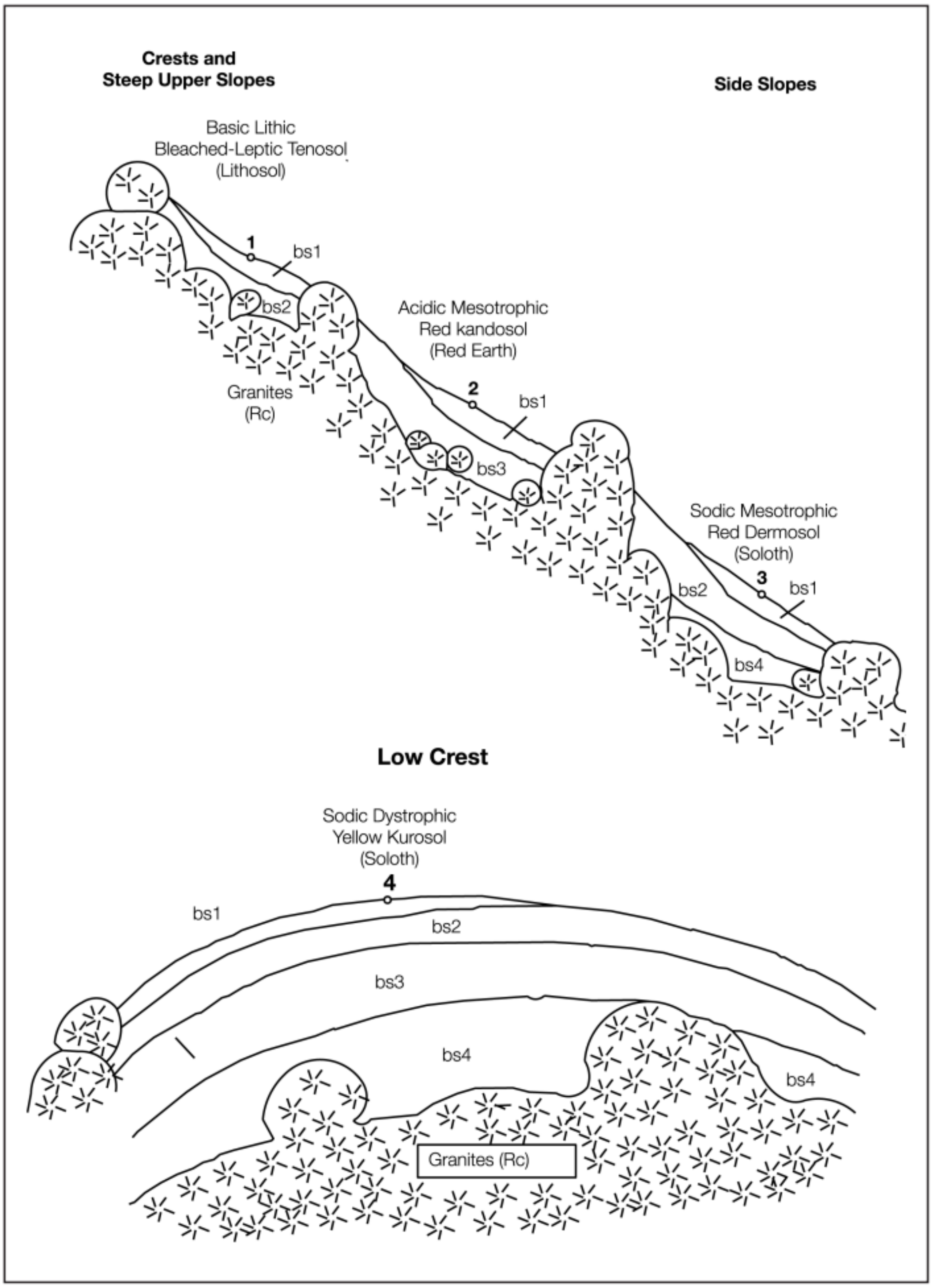


Figure 10: Granite weathering process leading to tors and boulders

Further, weathering process of the monzogranite, at depth, results in kaolin rich clays, known to influence sub artesian groundwater conditions and a preferential slide path for deep-seated ground movement.

Reference to published soil landscape mapping (eSPADE) indicates that the site is underlain by the Transition of the Big Smokey and Big Smokey Variant A Soil Landscapes that can be delineated in accordance with terrain. The upper slopes are underlain by the Big Smokey Soil Landscape characterised by rolling to steep hills on granitics, and soils comprised of well-drained Leptic Tenosols on crests and steep slopes, moderately well-drained Red Kandosols and Red Kurosols on side slopes. The limitations of the landscape include Stony soils with low wet bearing strength, acidity, high erodibility, sodicity/dispersibility, hardsetting surfaces and low fertility. Steep slopes; mass movement hazard; high sheet and gully erosion hazards; moderate wind erosion hazard; localised shallow soils; localised noncohesive soils; rock outcrop; engineering hazard; rapid drainage; low moisture availability.



■ *Distribution diagram of Big Smoky soil landscape illustrating occurrence and relationship of dominant soil materials.*

Figure 11: Big Smoky soil landscape (eSPADE)

3.2 Acid Sulfate Soils Risk Maps

Reference to the NSW Office of Environment and Heritage's online database 'ESPADE' indicates that the site lies in an area of no known occurences of acid sulfate soils.

4 Fieldwork Methodology

Fieldwork was undertaken on 2 October 2024 and comprised a general site walkover and observations of the site and surrounding features. Six test pits were excavated using a 14-ton excavator equipped with a 1.0-meter tiger tooth bucket, to depths of up to 4.3m or prior refusal. The test pits were logged and sampled by an Engineering Geologist from HGS in accordance with AS1726-2017, within the proposed development footprint. Further investigations were undertaken on 8 October 2024, which compromised a further five boreholes to depths of 8m using a track mounted drilling rig, and an installation of a groundwater well to gauge fluctuations in groundwater activity to depths of 5m.

5 Subsurface Conditions

The subsurface soil conditions encountered at test locations are presented in detail in the borehole logs.

A summary of the soil unit depths encountered in each test pit and borehole are presented below.

Table 5.1: Summary of subsurface units

Unit	Unit Description
Unit 1 **Topsoil**	Sandy SILT, low plasticity, brown
Unit 2 **Colluvial**	Sandy CLAY to Silty SAND, medium plasticity, brown to orange, stiff, with very high strength rounded boulders up to 700 to 1500mm
Unit 3A **Residual – Saprolite**	Clayey SAND, low plastic clay, pale brown to orange, medium dense, with weathered granite cobbles up to 100mm
Unit 3B **Residual Clay**	Sandy CLAY, medium plasticity, pale brown to orange, mottled grey, stiff to very stiff
Unit 4A **EW Granite**	Sandy CLAY, medium plasticity, pale brown to orange, very stiff to hard, distinct granitoid rock fabric
Unit 4B **EW Granite – Kaolin**	Sandy CLAY, medium to high plasticity, pale grey, firm, indistinct rock fabric, distinct strength and weathering reversal, preferential slide plane, zone of weakness and groundwater bearing zone
Unit 5 **HW Granite**	Highly Weathered GRANITE, coarse grained, pale grey and red, porphyritic, distinct rock fabric, inferred low strength, typically resulting in Tungsten Carbide Bit refusal

A summary of the soil unit depths encountered in each borehole are presented below in **Table 5.2**.

Table 5.2 - Summary of the soil unit depths encountered

ID	Unit Depth (m)							
	UNIT 1 Topsoil	UNIT 2 Colluvial	UNIT 3A Saprolite	UNIT 3B Residual Clay	UNIT 4A EW Granite	UNIT 4B EW Kaolin	Unit 5 HW Granite	Ground water Inflow
TP1	0.0 – 0.2	--	0.2 – 1.0	1.0 – 1.8	≥ 3.2	--	--	*3.0*
TP2	0.0 – 0.2	0.2 – 1.1	--	--	≥ 3.9			*3.5*
BH1	0.0 – 0.2	0.2 – 1.5	--	--	1.5 – 4.5	**≥ 8.95**	--	--
BH2	0.0 – 0.1	0.1 – 1.5	--	--	1.5 – 4.1	--	**≥ 5.7***	--
TP3	0.0 – 0.2	0.2 – 1.5	--	--	1.5 – 3.8	--	**≥ 4.3**	--
BH3	0.0 – 0.2	0.2 – 1.0	--	--	1.5 – 3.3	--	**≥ 3.45***	--
TP4	0.0 – 0.2	**≥1.3^**	--	--	--	--	--	--
BH4	0.0 – 0.2	0.2 – 0.5	--	--	**≥ 2.2^**	--	--	--
TP5	0.0 – 0.2	**≥1.2^**	--	--	--	--	--	--
TP6	0.0 – 0.2	0.2 – 0.6	--	**≥1.9^**	--	--	--	*0.3*
BH5	0.0 – 0.2	--	--	0.2 – 1.4	1.4 – 6.7	**≥ 8.45**	--	--

Notes:
≥ indicates that the base of the material layer was not encountered
-- indicates that the material was not encountered within the borehole
* indicates refusal on bedrock
^ indicates refusal on granite boulders

Figure 12: TP1 comprising colluvial deposits overlying pale orange residual clays, grading to extremely weathered granite as mottled clay

Figure 13: Boulders excavated from TP2, approximately 600mm diameter.

Figure 14: HW Granite excavated as gravelly sand from TP3. Excavator refusal was not encountered within limits of reach

Figure 15: 1000mm colluvial boulder recovered from TP4

Figure 16: TP4 resulting to bucket and ripper tyne refusal on large colluvial boulders

Figure 17: High plasticity, firm kaolinite clay from 7.5m below ground level in BH5

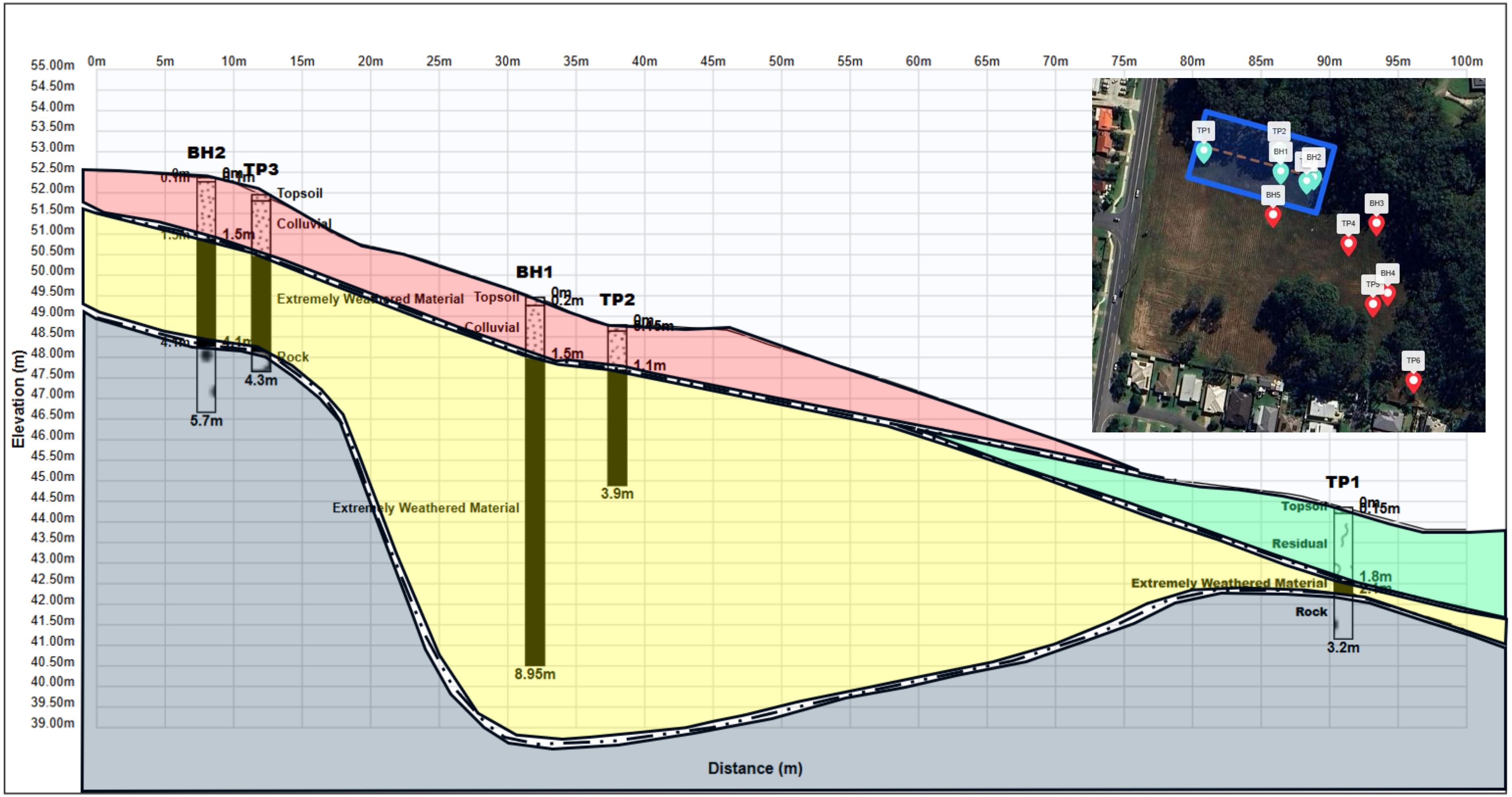


Figure 18: Geotechnical Long Section Ground Model Interpretation

6 Considerations for Design and Construction

6.1 Key Geotechnical Considerations

The key geotechnical constraints for design and construction of the 375m long and 8m high retaining structure include:

- **Kaolinite profiles were encountered at depth:**
  - These profiles comprised firm pale grey clays and are prone to rapid softening upon exposure, dispersion and conduit for groundwater flow.
  - Previous attempts to excavate in similar kaolinite layers in the adjacent Seascape Subdivision have demonstrated instability issues. Anecdotal reports indicate slow-moving, raft-like rotational failures of stiff overlying clays atop pale grey kaolinite. This failure mechanism should be considered in assessing slope stability and excavation plans, particularly to prevent similar rotational movement.
  - The engineering performance of kaolinite is generally poor for end-bearing piles and has a low subgrade modulus, meaning that foundation settlements and lateral movements could be significant. The kaolinite layer may also act as a preferential sliding plane under lateral loads from the retaining structure, necessitating additional reinforcement or alternative retaining solutions.
- **Subsurface Variability and Corestone Presence:**
  - The Smokey Cape Adamellite is characterised by a presence of corestones and varying thickness of saprolite (decomposed granite clays). The presence of large, high-strength granite boulders up to 3m in size can present challenges for excavation, foundation design, and wall stability. There may also be a need for temporary retention measures during construction to ensure stability of the cut slopes and safety during excavation.
  - Corestones will impact the uniformity of subsurface conditions, making excavation unpredictable and potentially necessitating heavy machinery or blasting.
  - Groundwater can impact the stability of the retaining wall. The fractured nature of the underlying bedrock can lead to seepage and water pressure behind the wall. Adequate drainage design will be essential to manage groundwater and prevent hydrostatic pressures from compromising the wall's integrity.
- **Discontinuities and Jointing Patterns:**
  - The site is anticipated to have significant vertical and horizontal discontinuities due to the foliated nature of the formation. These discontinuities can lead to potential sliding planes or zones of weakness within the retaining structure foundation and the retained material. Careful consideration should be given to the orientation and spacing of these joints during design.
- **Potential for Slope Instability:**
  - The proposed 8m high retaining wall will require analysis of the existing slope stability and potential for slope failure during construction and in the long-term. A detailed slope

stability analysis will be necessary to ensure the retaining wall will adequately resist lateral pressures and that slope conditions do not lead to a global failure.

- **Excavation-induced stress changes and potential softening of kaolinite may lead to increased lateral pressures on the retaining wall.** Proper wall design, including considerations for active and passive earth pressures and surcharge loads, will be essential to ensure structural adequacy and prevent failure under varying loading conditions.

6.2 Excavation Conditions

Reference to Section D of the supplied drawing indicates that excavations in to order of 8 to 10m are proposed, with 2.5m of the property boundary that will require retention. Bulk excavations would be required to RL 20m, which coincides with the break in slope midway through the development site.

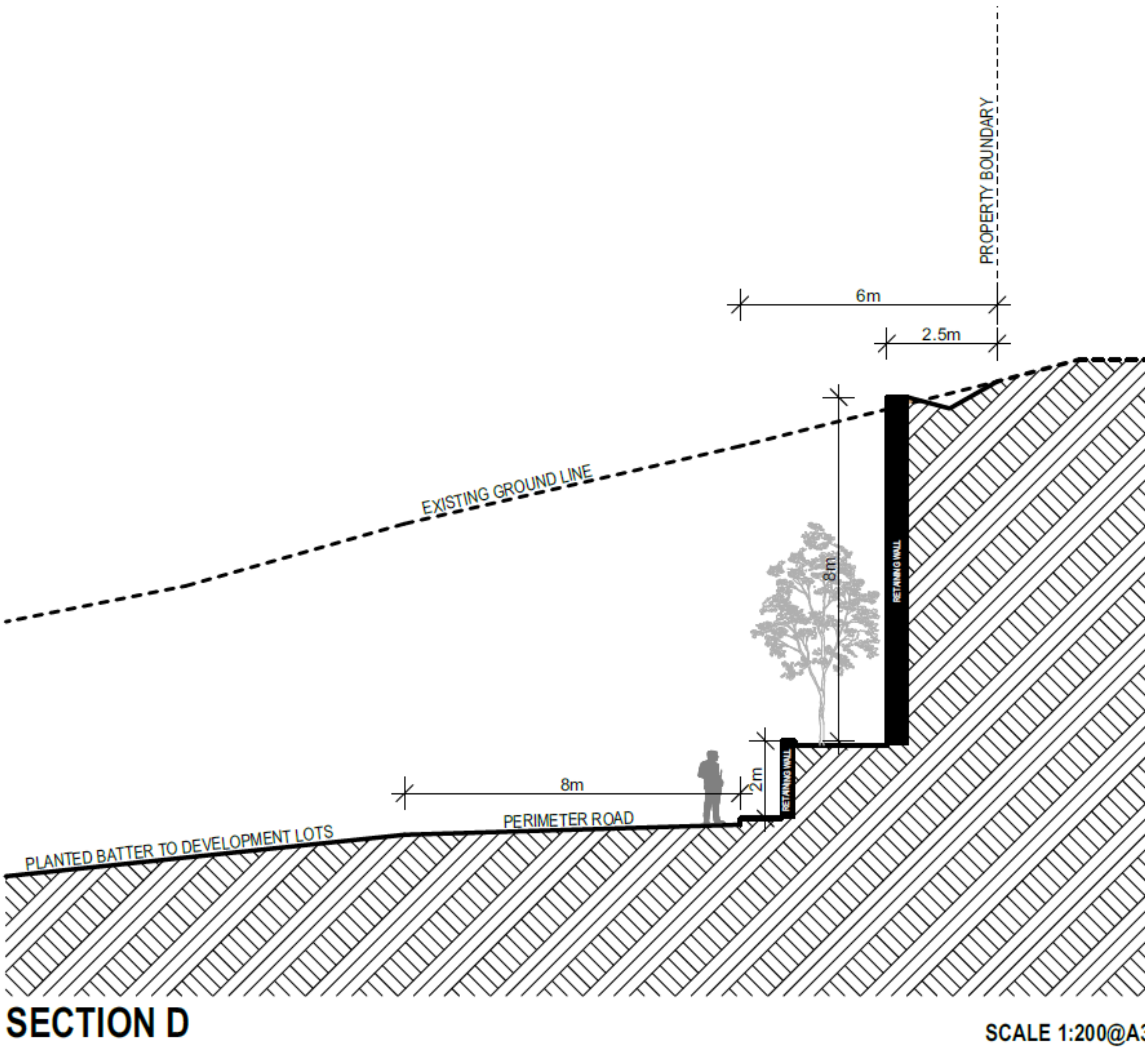


Figure 19: Section D indicating vacations in the order of 10m.

6.3 Excavation Conditions

Colluvial and deeply weathered granite profiles were encountered along the alignment of the proposed excavations. The weathering process in granitic soils leads to a highly variable rock surface profile, often including large, very high strength boulders stacked atop one another surrounded by areas of highly weathered granite.

The residual and extremely weathered granite profiles comprised stiff to very stiff clays soils with an estimated UCS of less than 1MPa. Where in absence of boulders, easy digging conditions with a 12t excavator with tooth bucket where encountered. Excavator bucket refusal was not encountered on weathered rock within the limit of reach of excavator.

Excavator bucket and ripper tyne refusal was encountered on very high strength granite boulders that frequent the site. The ripper attachment was used in TP5, where the tool had no effects on the very high strength granite. The boulders were evident through the middle towards the eastern extent of the site outcropping at surface level. Towards the lower western extent only a limited number of smaller boulders were encountered at surface level.

Tungsten Carbite Bit refusal was encountered in BH2 and BH3 at depths of 5.7m and 3.45m respectfully. A large excavator with a toothed bucket and hydraulic rock breaking capabilities is likely to be required to excavate highly weathered granite profiles within the proposed depth of excavation. However, upon refusal or isolated bands of high strength rock, will pose excavation difficulties. An allowance should be made for a large excavator and dozer with ripping capabilities and use of a hydraulic rock hammer where bands of high strength rock are encountered along ridge crests. Pervasive blocky defects can be expected in the excavation walls of weathered granite with a tendency for wedge and topple failures may be encountered.

On the basis of the investigation and previous experience with similar profiles it is assessed to be of potentially low to high strength and is unlikely to exceed an UCS strength of 30MPa with defect spacing less than 600mm. Where the presence of rock with these characteristics will have cost implications for construction, further investigation comprising advancing of boreholes using rock coring methods to confirm the profile present and rock strength parameters and fracture spacing could be undertaken.

Excavations should be conducted in accordance with The Safe Work Australia "Excavation Work" Code of Practice October 2018.

https://www.safeworkaustralia.gov.au/doc/model-codes-practice/model-code-practice-excavation-work

Excavations can seriously affect the stability of adjacent buildings. Careful consideration must be taken in order to prevent the collapse of partial collapse of adjacent structures.

Construction material and equipment should not be placed within the zone of influence of an excavation unless a suitably qualified geotechnical engineer has designed ground support structures to withstand these loads. The zone of influence is dependent on the material encountered at the site and is the area in which possible failures can occur.

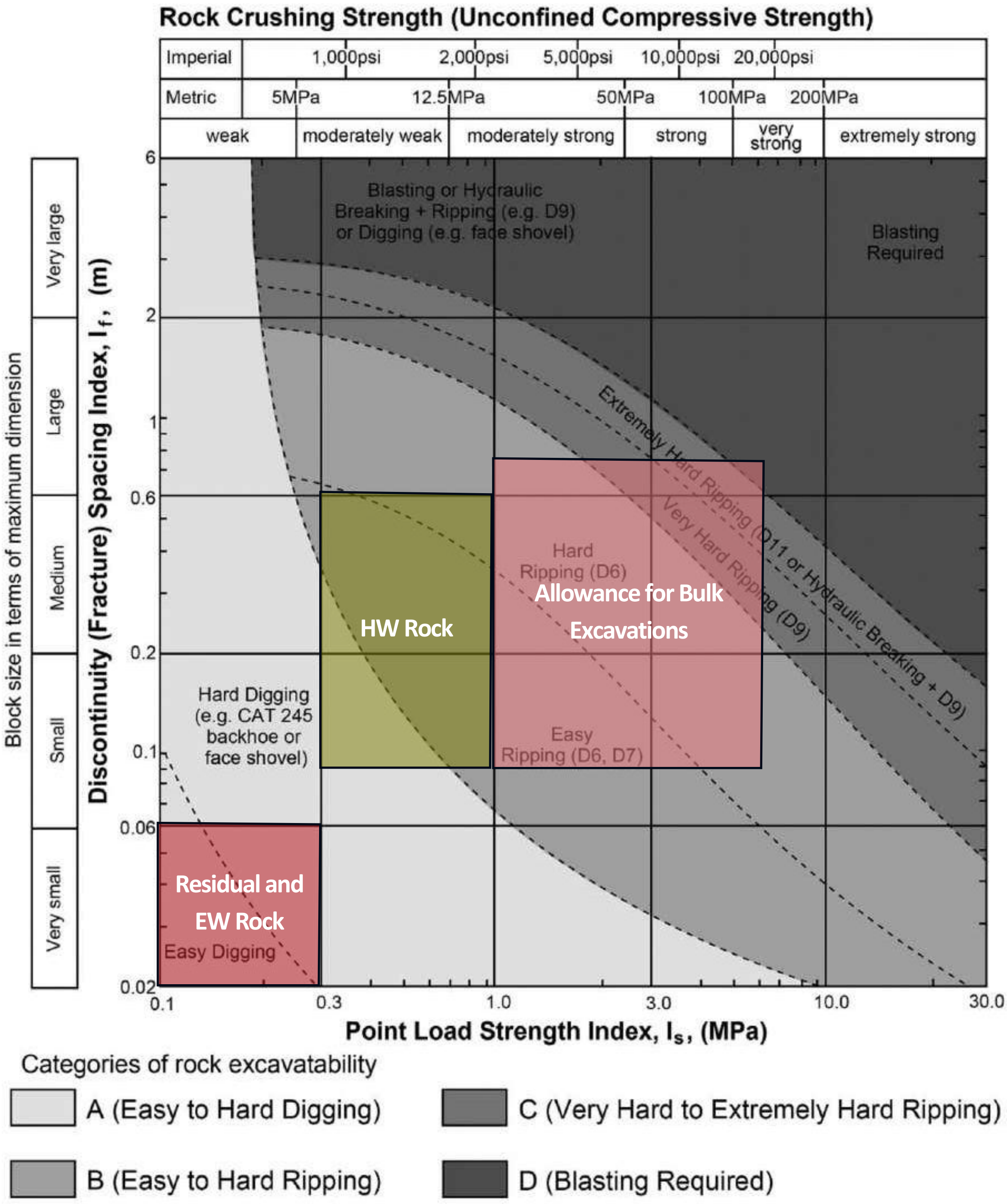


Figure 20 - Excavation productivity

6.3.1 Kaolin Profiles

Proposed excavations of kaolinite-rich clays as encountered in BH1 and BH5 presents specific challenges. Kaolinite, being a fine-grained clay, is susceptible to rapid softening upon exposure that can significantly impact excavation stability.

When kaolinite is exposed to air and water, it readily absorbs moisture, which leads to a reduction in strength and a tendency to soften and deform. This softening can result in unstable excavation faces, sloughing, and slope instability if left unsupported. Additionally, kaolinite's dispersive nature means it can dissolve and migrate with groundwater flow, exacerbating erosion and undermining the excavation's structural integrity. Careful planning and mitigation strategies will be required to address these characteristics and ensure stable excavation conditions.

Due to kaolinite's high swell potential, particularly in the presence of water, excavations will need to be carefully monitored for changes in soil volume. Upon exposure, kaolinite can undergo volumetric swelling, increasing lateral earth pressures on temporary supports and potentially affecting nearby structures. This behaviour can result in heaving at the excavation base, which could complicate excavation operations and impact foundation design if swelling is unaccounted for. Close control of groundwater infiltration is recommended, and minimising exposure time. Employing temporary cover systems and rapid placement of backfill materials can help reduce exposure to air and moisture, mitigating the risks of softening and swelling.

The historical performance of kaolinite-rich soils in similar conditions—such as the slow-moving rotational failures observed in nearby subdivisions—suggests a predisposition for rotational or translational slope failures. In these cases, the weak kaolinite layer may act as a preferential failure plane, especially under conditions of lateral loading from the proposed retaining structure. This risk is further amplified in excavation environments where horizontal stresses are relieved, and moisture infiltration is likely. Given these risks, the use of temporary shoring, **such as soldier piles**, should be considered to maintain stability along excavation faces. Additionally, a global slope stability analysis specific to the kaolinite profiles is advisable to account for potential failure mechanisms, especially in instances where excavation depth exceeds 8m.

Groundwater infiltration is another critical concern when excavating in kaolinite. The kaolinite layer's low permeability could lead to the buildup of pore water pressures during and after excavation, increasing the risk of soil softening and instability. Managing groundwater will be essential, potentially requiring the installation of dewatering systems, such as well points or horizontal drains, to control pore pressures. In addition to drainage considerations, monitoring systems should be implemented to detect changes in moisture content and pore pressure, allowing for real-time adjustments to the excavation plan if destabilising conditions arise.

6.3.2 Excavations of Boulders

Simply put, there are frequent and very large boulders up to 3 meters in diameter, along the upper slopes and within the upper colluvial soil profile presents challenges for excavation. The crystalline structure and very high compressive strength make it difficult to break down and remove using standard excavation equipment. These boulders will require specialised handling and removal techniques to prevent delays, reduce wear on machinery, and manage safety risks associated with unstable excavation faces or unexpected boulder shifts. Boulders of this size and strength cannot be removed as a part of typical soil excavation and require mechanical breakdown before transport.

Effective removal of granite boulders generally requires the use of heavy-duty equipment such as hydraulic rock breakers or wire saws. For particularly large or embedded boulders, drill-and-blast methods may be considered to fracture the rock into manageable pieces. For areas where blasting is restricted, chemical rock breaking agents (e.g., expansive grout) can be used. These agents are inserted into drilled holes, expanding and cracking the rock over time.

In addition, stockpiling crushed material at a staging area within the site may be advantageous if used as engineered fill for other onsite applications, reducing transportation costs.

6.3.3 Vibration Monitoring

The use of rock breaking an pneumatic equipment for side trimming and footing excavation in the granite rock normally has the potential to affect structures adjoining the proposed excavation.

It would be prudent to allow for dilapidation surveys to be carried out on the nearby buildings and existing services to document their condition prior to the commencement of all work.

As a guide, the damage threshold due to vibration is dependent on the quality of the building foundations and construction of the building as well as the wavelength of the vibration and the source distance. The longer the wavelength, the more likely a building is to resonate and suffer damage. For construction equipment (generally in the high frequency or short wavelength range), the damage threshold is 40 mm / sec to 80 mm / sec for buildings founded on rock. Most vibration codes set safe limits for building vibrations at lower levels.

6.1 Slope Stability

6.1.1 Risk Assessment

The risk of slope instability has been assessed in accordance with using the principles and protocols of the Australian Geomechanics Society publication, Practice Note Guidelines for Landslide Risk Management, 2007. This methodology represents the currently accepted state of practice for landslide risk assessment.

The process of the slope risk assessment involves the identification of potential slope failures hazards and events, an evaluation of the likelihood of the identified event occurring, and the potential consequences that may arise should the event occur.

In accordance with the Australian Geomechanics Society publication, Practice Note Guidelines for Landslide Risk Management, 2007, the terminology used in the risk assessment are defined below:

Hazard: A condition with the potential for causing an undesirable consequence

Likelihood: A qualitative description of probability, or frequency, of occurrence that the hazardous event may occur.

Consequence: The outcome, or potential outcome, arising from the occurrence of the hazardous event expressed quantitatively, or qualitatively, in terms of loss, disadvantage, damage, injury, or loss of life.

Risk: A measure of the likelihood and consequence of an adverse effect to life, health, property or the environment

The primary geotechnical risks associated with instability at this site were considered to relate to modification of the site for the proposed residential development, which may include site regrading work, and site surface and subsurface drainage.

The following potential slope instability hazards were assessed in relation to the site and the proposed development:

1. Deep seated rotational or translational failure of proposed foundations and retaining walls caused by sliding of the site soil profile over a plane of weakness such as the identified kaoline clay profile or zone of water concentration within the underlying soil or rock mass. Should such a failure occur it could potentially cause extensive structural damage and require large scale, costly repairs, and possibly temporary evacuation of the building until repairs are complete
2. Small to deep seated rotational or translational failure of proposed foundations and retaining walls caused by poor construction of structures and / or high groundwater presures. Such a failure could cause moderate structural damage and require large scale, costly repairs, and possibly temporary evacuation of the building until repairs are complete
3. Small scale rotational slide due to destabilisation of slope by potential unsupported excavations associated with future works. Such a failure could cause moderate damage to structures and impact the ongoing utility of the site until repairs are undertaken.

6.1.2 Risk Assessment

HGS have undertaken a site risk assessment for the site post construction, including potential risk to neighbouring properties, on the hazards noted above. Both a qualitative risk assessment to determine risk to property and a quantitative risk assessment to determine risk to life have been undertaken on the hazards noted above as per AGS guidelines.

The AGS "Practice Note Guidelines" indicates tolerable risk levels for loss of life. The following table and notes is an extract from the Australian Geomechanics Society (AGS) Landslide Taskforce "Practice Note Guidelines for Landslide Risk Management" March 2007.

Table 6.1 - Australian Geomechanics Society tolerable risks for loss of life

Situation	Suggested tolerable loss of life risk for the person most at risk
Existing slope[1] / existing development[2]	10^{-4} / annum
New constructed slope[3] / new development[4] / existing landslide[5]	10^{-5} / annum

Notes:

(1) "Existing Slopes" in this context are slopes that are not part of a recognizable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years;

(2) "Existing Development" includes existing structures, and slopes that have been modified by cut and fill, that are not located on or part of a recognizable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years;

(3) "New Constructed Slope" includes any change to existing slopes by cut or fill or changes to existing slopes by new stabilisation works (including replacement of existing retaining walls or replacement of existing stabilization measures, such as rock bolts or catch fences);

(4) "New Development" includes any new structure or change to an existing slope or structure. Where changes to an existing structure or slope result in any cut or fill of less than 1.0m vertical height from the toe to the crest and this change does not increase the risk, then the Existing Slope / Existing Structure criterion may be adopted. Where changes to an existing structure do not increase the building footprint or do not result in an overall change in footing loads, then the Existing Development criterion may be adopted;

(5) "Existing Landslides" have been considered likely to require remedial works and hence would become a New Constructed Slope and require the lower risk. Even where remedial works are not required per se, it would be reasonable expectation of the public for a known landslide to be assessed to the lower risk category as a matter of "public safety".

The result of the risk assessments have been summarised in **Table 6.2** below.

Table 6.2 - Summary of Risk Assessment for risk to property

Hazard	H1: Large rotational failure	H2: Small rotational failure	H3: Rotational failure within unsupported excavations	H4: Soil Creep
Cause or trigger	Unusually severe rainfall event (eg. 1 in 1000 yr event)	Poor construction of structures within zone of influence of services, service leaks saturating foundation or followed by extreme weather, large east coast low (1in 100yr event)	Cut steeper than angle of repose, unsupported, high rainfall (1 in 10yr event)	Ongoing process of imperceptibly slow soil movement

Hazard	H1: Large rotational failure	H2: Small rotational failure	H3: Rotational failure within unsupported excavations	H4: Soil Creep
Proportion of slope affected	0.5	0.5	0.5	1
Estimated annual probability	10^{-4}	10^{-2}	10^{-2}	10^{-1}
Likelihood	Unlikely	Likely	Likely	Almost Certain
Consequence	Major	Medium	Medium	Insignificant
Risk to Property	Medium	**High**	**High**	Low

6.1.3 Retention

Excavations have at the site have the potential to trigger rotational failures if not properly staged, constructed or retained particularly if we weather is experienced before or during construction. Construction works should be conducted such that temporary batters are either suitably flat or appropriate support is provided

Adequate drainage of surface and subsurface flows should be maintained during construction and throughout the design life of the proposed structure. Careful attention should be paid to the treatment of water emanating from springs at the site which have the potential to increase risks associated with instability if they are not appropriately handled and designed for.

Methods for treatment of water emanating from springs may take the form of cut off trench drains, and subsoil drains upslope of the development to intersect groundwater flow, with water flows directed to the stormwater system. They should be laid in a sand, or gravel, bed and protected with a graded stone or geotextile filter to reduce the chance of clogging. Sub-soil drains should always be laid to a fall of at least 1 vertical on 100 horizontals. Ideally the high end should be brought to the surface, so it can be flushed with water from time to time as part of routine maintenance procedures.

The need for such systems and the location and design of will need to be assessed during construction after stripping of topsoils, and after excavation to design RL's. We recommend that a suitably qualified geotechnical engineer be engaged at that time to observe site conditions.

The type of excavation support is dependent on several variables including ground condition, dewatering methods, method and staging of construction as well as surrounding structures and services. The design and construction of sheet pile walls should consider associated risks of vibration during installation hich may negatively impact adjacent structures. Anchors or internal props may be needed for temporary restraint of the retaining structure walls.

Gravity walls are unlikely to be suitable due to the presence of firm kaolin clay due to the risk of sliding, overturning and bearing failure of the retaining wall.

Options for excavation and retention include:

- Pre-support of the excavation using soldier piles, secant piles and / or continuous piled walls. These can penetrate the firm kaolinite layer and provide a more reliable foundation. Secant pile walls, in particular, can be designed to control groundwater flow, reducing the risk of kaolinite softening.
- Bulk excavation methods by ramping down from one side with excavation walls battered at temporary batter angles of 1(V):3(H).
- Anchored walls using tiebacks (anchored cables or rods) driven into competent behind the wall to resist lateral forces.

It is recommended that PLAXIS 2D Finite Element Analysis be undertaken to optimise geotechnical design parameters and the shoring design. Recommended site soil parameters for retaining wall design at the site are provided in **Table 6.3** below.

Table 6.3 - Recommended retaining wall design soil parameters

Parameter	Supported material		
	UNIT 3B Residual Clay	UNIT 4A EW Granite	UNIT 4B EW Kaolin
γ (kN/m^3)	19	21	18
Φ' (o)	27	29	23
C' (kPa)	5	8	2
Cu (kPa)	50	100	25
K_a	0.37	0.34	0.44
K_p	2.66	2.88	2.28
K_o	0.54	0.51	0.61
Allowable base bearing pressure	100	200	Not Recommended

Legend:

γ – unit weight

Φ' – angle of friction

C' – drained cohesion

Cu – undrained cohesion

K_a – coefficient of active earth pressure

K_p – coefficient of passive earth pressure

K_o – coefficient of at rest earth pressure

The earth pressure coefficients have been calculated using Rankine's Theory assuming level backfill. The retaining wall designer should ensure that the use of this method is appropriate for the individual retaining wall(s). Any surcharge affecting the walls such as adjacent footings, adjacent retaining walls and their backfill, or sloping surfaces, should be allowed for in the design.

The design of retaining walls should account for the separate hydrostatic water pressures behind the walls unless adequate subsurface and surface drainage is provided behind the wall to prevent build-up of water pressure including the provision for maintenance (i.e. flushing points).

The pressure distribution given above assumes that no surcharging of the walls occurs from nearby footings. If the footings behind retaining walls from existing retaining walls, or proposed structures are not taken below the retaining wall zone of influence (which is approximated by a line drawn at 45° above the horizontal from the base of the wall) or to low strength rock or stronger, than additional allowance should be made for the load from the footings.

Cantilever walls should not be used to support nearby building foundations or underground services.

Where drainage is provided behind retaining walls, retaining wall backfill should include geotextile encapsulated free draining backfill (ie single sized aggregate) behind the wall with a slotted drainage pipe at the base of this backfill. The slotted drain should discharge downslope of the wall to the site stormwater system to provide long term drainage behind excavated walls. If the retaining wall is integral to the proposed building, an impermeable membrane should be installed between the geotextile encapsulated free draining material and the wall of the building.

Flushing points should be incorporated into the design of the perimeter drain to allow periodic maintenance.

6.2 Site Drainage

It is imperative that sufficient drainage is in place to manage surface and subsurface water to ensure the long-term stability of the site. Site drainage must be designed by a suitably qualified engineer in accordance with Section 3 of the BCA and Appendix B of AS2870 – 2011.

Stormwater from roofs should be directed to the stormwater drainage system. Infiltration systems are not recommended.

7 Foundations

7.1 Foundation Conditions

Investigations below the colluvial and boulder profile encountered TC Bit refusal on weathered granite in BH2 and BH3 through the centre of the site and firm kaolin rich profiles in BH1 and BH5 and the flanks of retention. The preferred design would be to anchor structures to weathered rock within cut areas with reinforced bored piers socketed into and tie the structure up and down the slope into weathered rock. Results from the investigation indicate that the centre profile in cut will likely expose weathered rock, however, piles should be installed below the kaolinite layer will provide consistent bearing capacity and reduce risk of instability and wall displacement or tilting over time. The piles should be adequately embedded into the competent layer below the kaolinite to support the wall's load. The depth of the EW Kaolin profile was not able to be assessed within the prescribed investigation depth limits in BH1 and BH5.

Controlling water around the foundation is critical in areas underlain by kaolin rich clays. A drainage system should be implemented to manage surface and groundwater infiltration, preventing the kaolinite from softening and losing bearing capacity. Measures could include drainage blankets, backfill drainage systems, and sub-horizontal drains within the retaining wall structure to relieve hydrostatic pressure

7.1.1 Deep Footings

The ultimate end bearing pressure (fb) for residual and extremely weathered material has been assessed based on engineering judgement, SPT N vales and the relationship proposed by Decourt (1995) as follows.

$f_b = a_b q_u{}^{Bb}$ in units of kN/m²

Where:

f_b = ultimate end bearing pressure

a_b = correlation factor of 4.8

q_u = unconfined compressive strength of rock (UCS) (MPa)

Similarly, the empirical correlation for the ultimate shaft friction (fs) is given by:

$f_s = \alpha(2.8\ N_{60} + 10)$ in units of kN/m²

Where:

f_s = ultimate skin friction

α = 1 for displacement piles in all soils, and non-displacement piles in clays

N_{60} = SPT value in the vicinity of the pile tip – corrected to 60% energy

Undrained shear strength (su) values were assessed based on pocket penetrometers undertaken in SPT samples, as well as correlations with SPT N values.

The design of piles should be based on the geotechnical parameters presented . The parameters assume the sides and base of the piles are clean and rough. It will be necessary to clean the sides of open bored piles to remove the layer of softened, smeared, or remoulded material which forms on the walls of the piles, and a pile cleaning bucket will be required for the base.

In accordance with AS2159-2009 *Piling Design and Installation*, a geotechnical reduction factor (Φ_g) should be applied to the ultimate values shown in Table 4A and 4B to derive ultimate geotechnical strengths ($R_{d,g}$) for limit state design.

In accordance with AS2159-2009, a risk rating of 2.59 is estimated. Therefore, assuming the pile configuration will have low redundancy a Geotechnical Strength Reduction Factor of Φ_g=0.52 would be appropriate for the site.

Table 7.1 - Pile design parameters

Unit	Ultimate End bearing, fb (MPa)	Ultimate Skin Friction, fs (kPa)	Lateral Yield Pressure* (MPa)		Elastic Modulus (E_{field}) (MPa)
			Depth to Top of Rock <1.5m	Depth to Top of Rock >1.5m	
Unit 3B Residual Clay	--	20	--	--	--
Unit 4A EW Granite	--	30	--	--	--
Unit 4B EW Granite – Kaolin	--	10	--	--	--
Unit 5 HW Granite	1	300	0.25	0.5	100

Care should be taken during construction to ensure that the base of the bored pile holes are clean and free from loose debris or water prior to placement of concrete. Pile hole inspections should be undertaken during construction by a suitably qualified geotechnical engineer to confirm that the appropriate foundation stratum is achieved.

All pile types should be suitably protected against decay or corrosion, taking account of the subsurface conditions, water table fluctuations and site-specific conditions (existing chemical concentrations at the site).

The following points are noted in relation to the parameters provided.

- Loading a pile to the ultimate capacities provided will incur large settlements, typically of the order of 5% of pile diameter;
- Limit state design requires the piles to be designed for an acceptable level of serviceability, which typically assumes a maximum settlement of not more than 1% of pile diameter. If the structure

is more sensitive or less sensitive to settlement than this value assumes, serviceability criteria should be re-assessed;

- Piles should either be dewatered prior to pouring concrete or a tremmie mix and tremmie pouring method used;
- It is recommended that a geotechnical engineer be on site at least during the initial stages of pile drilling and installations to assess the founding materials encountered and confirm required founding depths.

7.1.2 Pile Drilling

Soilmec provides a guideline for bored pile tool selection based on typical RQD and UCS, as shown below. The indicative UCS and RQD values indicate that excavation will be achievable with an auger, however, where less fractured and/or higher strength materials are encountered then a core barrel will likely be required.

Construction material and equipment should not be placed within the zone of influence of an excavation unless a suitably qualified geotechnical engineer has designed ground support structures to withstand these loads. The zone of influence is dependent on the material encountered at the site and is the area in which possible failures can occur.

Refer to Council development guidelines before conducting any excavation works.

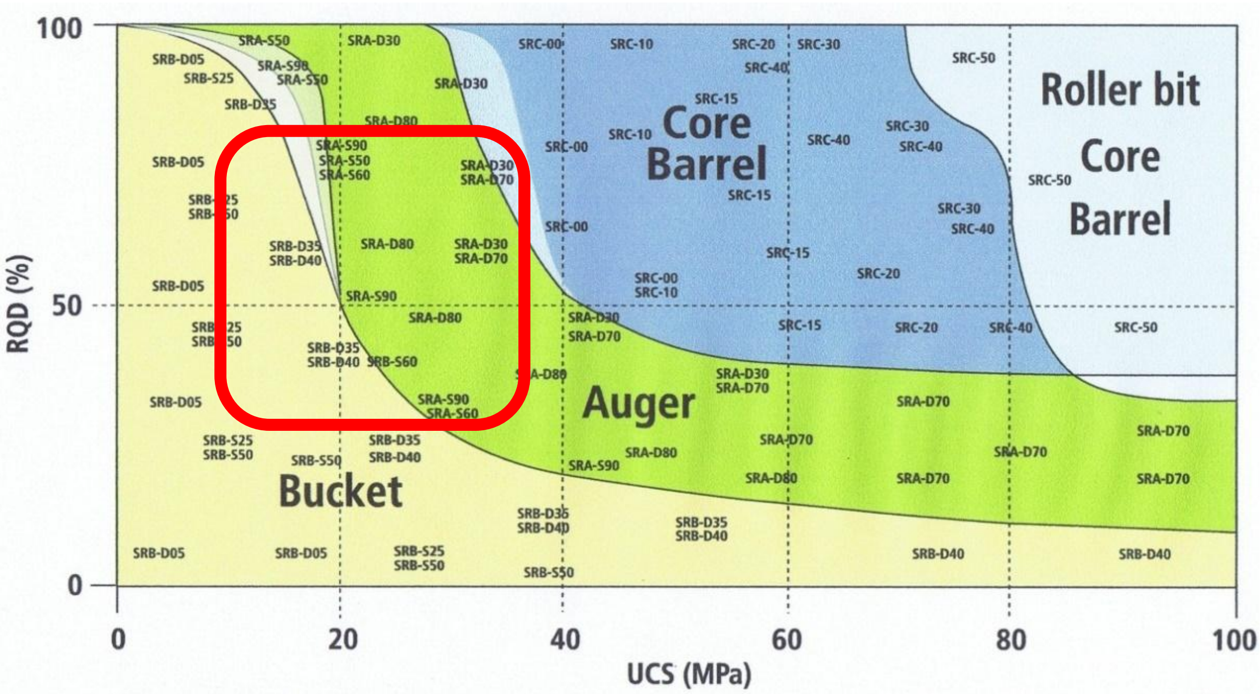


Figure 21: Guide to bored pile tool selection (Reproduced from Soilmec document 'Rock Drilling Tools' www.soilmec.com)

8 Report Limitations

This report has been prepared by HGS for the specific site and purposes described within this report. HGS will accept no responsibility or liability for the use of this report by any third party, without the express consent of HGS or the Client, or for use at any other site or purpose than that described in this report.

This report and the services provided have been completed in accordance with relevant professional and industry standards of interpretation and analysis. This report must be read in its entirety without separation of pages or sections and without any alterations, other than those provided by HGS.

The scope of the investigation described in this report is based on information and plans provided to HGS by the Client as well as any additional limitations imposed by either the Client and / or site restraints. Such limitations may include but are not limited to budget restraints, the presence of underground services or accessibility issues to a site. Where the report has been prepared for a specific design proposal the information and interpretation may not be relevant if the design proposal is changed. HGS should be consulted if site plans or design proposal is changed as the recommendations and / or opinions presented may not be suitable for the new revisions or variations made.

The conclusions, recommendations and opinions expressed within this report are subject to the specific conditions encountered and the limited geotechnical data gathered at the site during the time of the current investigation. The sub-surface conditions and results presented in this report are indicative of the conditions encountered at the discrete sampling and testing locations within the site at the time of the investigation and within the depths investigated. Variations in ground conditions may exist between the locations that were investigated, and the subsurface profile cannot be inferred or extrapolated from the limited investigation conducted by HGS. For this reason, the report must be regarded as interpretative, rather than a factual document.

Sub-surface conditions are subject to constant change and can vary abruptly as a result of human influences and /or natural geological and / or climatic processes and events. As such, conditions may exist at the site that could not be identified during or may develop after the current investigation has been conducted and as such, may impact the accuracy of this report. HGS should be contacted for further consultation and site re-assessment should sub-surface conditions differ from those conditions identified in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by HGS.

HGS recommends geotechnical reports older than 5 years from the date shown on the report, reports submitted for a previous (unrelated) development application on the site, or sites that have been altered by earthworks be reviewed by a qualified geotechnical consultant to confirm that the scope of the investigation undertaken for the report and the contents of the report are appropriate for the current development being proposed.

We are pleased to present this report and trust that the recommendations provided are sufficient for your present requirements. If you have any further questions about this report, please contact the undersigned.

For and on behalf of

Hunter Geotechnical Services

Reported by:	Reviewed by:
Drouin Pike *Graduate Engineering Geologist* Bachelor of Geology	**Daniel Soffer** *Senior Geotechnical Engineer* Bachelor of Engineering (Hon) (Civil) Bachelor of Engineering (Hon) (Enviro)

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HUNTER
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Annex A

HUNTER GEOTECHNICAL SERVICES

CLIENT:	Corio Projects	JOB NO:	G0730
PROJECT:	Proposed Retension System	DRAWN BY:	DS
LOCATION:	286-310 Gregory Street, South West Rocks	DATE:	8 Nov 2024
		SCALE:	1:2,000
TITLE:	Investigation Location Plan	FIGURE NO:	Figure 1

0 25 50 75 100 m

SIZE: A3

REVISION: 1

1 Introduction

The following notes are provided to be used in conjunction with Hunter Civilab's report to explain the terms and abbreviations used throughout the report.

2 Material Descriptions

Descriptions of soil and rock are generally in accordance with the Unified Soil Classification System and Australian Standard AS1726-2017 – Geotechnical Site Investigations. The descriptions of soil and rock are based on field tests and observations and are independent of any laboratory test results. The data presented throughout this report is as factual as possible. However, some interpretations is unavoidable.

2.1 Unified Soil Classification Group Symbols

Soils are generally assigned one of the following unified soil classification group symbols:

Table 2.1 - Unified Soil Classification Group Symbols

Symbol	Description	Symbol	Description
CH	Organic clays of high plasticity	Pt	Peat and other highly organic soils
OL	Organic silts of low plasticity	CH	Inorganic clays of high plasticity
MH	Inorganic silts of high plasticity	CI	Inorganic clays of low plasticity
ML	Inorganic silts of low plasticity	CL	Inorganic clays of low plasticity
GC	Clayey gravels	SC	Clayey sands
GM	Silty gravels	SM	Silty sands
GP	Poorly graded gravels	SP	Poorly graded sands
GW	Well graded gravels	SW	Well graded sands

2.2 Soil Description

Soils are described in general accordance with AS1726-2017, Section 6.1:

Table 2.2 - Particle Size Definitions (AS1726-2017, Table 1)

Component	Subdivision	Size (mm)
BOULDERS		>200
COBBLES		63 - 200
GRAVEL	Coarse	19 - 63
	Medium	6.7 - 19
	Fine	2.36 - 6.7
SAND	Coarse	0.6 - 2.36
	Medium	0.21 - 0.6
	Fine	0.075 - 0.21
SILT		0.002 - 0.075
CLAY		<0.002

Table 2.3 - Descriptive Terms for Accessory Soil Components (AS1726-2017, Table 2)

Designation of Components	In Coarse Grained Soils				In Fine Grained Soils	
	% Fines	Terminology	% Accessory Coarse Fraction	Terminology	% Sand / Gravel	Terminology
Minor	≤ 5	Add 'trace clay / silt' to description where applicable	≤ 15	Add 'trace sand / gravel' to description where applicable	≤ 15	Add 'trace sand / gravel' to description where applicable
Minor	> 5, ≤ 12	Add 'with clay / silt' to description where applicable	> 15, ≤ 30	Add 'with sand / gravel' to description where applicable	> 15, ≤ 30	Add 'with sand / gravel' to description where applicable
Secondary	> 12	Prefix soil name as 'Silty' or 'Clayey', as applicable	> 30	Prefix soil name as 'Sandy' or 'Gravelly', as applicable	> 30	Prefix soil name as 'Sandy' or 'Gravelly', as applicable

Table 2.4 - Descriptive Terms for Plasticity (AS1726-2017, Table 6)

Descriptive Term	Range of Liquid Limit for SILT	Range of Liquid Limit for CLAY
Non-Plastic	Not applicable	Not applicable
Low Plasticity	≤ 50	≤ 35
Medium Plasticity	Not applicable	> 35 and ≤ 50
High Plasticity	> 50	> 50

Table 2.5 - Moisture Condition (AS1726-2017, Clause 6.1.7 (a))

Material	Term	Abbreviation	Field Description Terms
Coarse Grained Soil	Dry	D	Non-cohesive and free-running
	Moist	M	Soil feels cool, darkened in colour; Soil tends to stick together
	Wet	W	Soil feels cool, darkened in colour; Soil tends to stick together, free water forms when handling
Fine Grained Soil	Moist, dry of plastic limit	w < PL	Hard and friable or powdery
	Moist, near plastic limit	w ≈ PL	Soil can be moulded at a moisture content approximately equal to the plastic limit
	Moist, wet of plastic limit	w > PL	Soil usually weakened and free water forms on hands when handling
	Wet, near liquid limit	w ≈ LL	Near liquid limit
	Wet, wet of liquid limit	w > LL	Wet of liquid limit

Table 2.6 - Consistency Terms for Cohesive Soils (AS1726-2017, Table 11)

Consistency	Abbreviation	Field Guide to Consistency
Very Soft	VS	Exudes between the fingers when squeezed in hand
Soft	S	Can be moulded by light finger pressure
Firm	F	Can be moulded by strong finger pressure
Stiff	St	Cannot be moulded by fingers
Very Stiff	VSt	Can be indented by thumb nail
Hard	H	Can be indented with difficulty by thumb nail
Friable	Fr	Can be easily crumbled or broken into small pieces by hand

Table 2.7 - Relative Density of Non-Cohesive Soils (AS1726-2017, Table 12)

Relative Density	Abbreviation	Density Index (%)
Very Loose	VL	≤ 15
Loose	L	> 15 and ≤ 35
Medium Dense	MD	> 35 and ≤ 65
Dense	D	> 65 and ≤ 85
Very Dense	VD	> 85

Table 2.8 - Soil Origin (AS1726-2017, Clause 6.1.9)

Origin	Description
Residual Soil	Formed directly from in situ weathering of geological formations. These soils no longer retain any visible structure of fabric of the parent soil or rock material.
Extremely weathered material	Formed directly from in situ weathering of geological formations. Although this material is of soil strength, it retains the structure and / or fabric of the parent rock material.
Alluvial soil	Deposited by streams and rivers.
Estuarine soil	Deposited in coastal estuaries, and including sediments carried by inflowing rivers and streams, and tidal currents.
Marine soil	Deposited in a marine environment.
Lacustrine soil	Deposited in freshwater lakes.
Aeolian soil	Carried and deposited by wind.
Colluvial soil	Soil and rock debris transported down slopes by gravity, with or without the assistance of flowing water and generally deposited in gullies or at the base of slopes. Colluvium is often used to refer to thicker deposits such as those formed from landslides, whereas the term 'slopewash' may be use for thinner and more widespread deposits that accumulate gradually over longer geological timeframes.
Topsoil	Surface and / or near surface soils often, but not always, defined by high levels of organic material.
Fill	Material placed by anthropogenic processes.

2.3 Rock Description

Rocks are described in general accordance with AS1726-2017, Clause 6.2.

Table 2.9 - Rock Material Strength Classification (AS1726-2017, Table 19)

Strength	Abbreviation	Field Assessment
Very Low Strength	VLS	Material crumbles under firm blows with sharp end of pick; Can be peeled with sharp knife; Too hard to cut a triaxial sample by hand; Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	LS	Easily scored with a knife; Indentations 1mm to 3mm show in the specimen with firm blows of the pick point; Has dull sound under the hammer; A piece of core 150mm long by 50mm diameter may be broken by hand; Sharp edges of core may be friable and break during handling.
Medium Strength	MS	Readily scored with a knife; A piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	HS	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; Rock rings under hammer.
Very High Strength	VH	Hand specimen breaks with pick after more than one blow; Rock rings under hammer.
Extremely High Strength	EH	Specimen required many blows with geological pick to break through intact material; Rock rings under hammer.

Note: Material with strength less than 'Very Low' shall be described using soil characteristics. The presence of an original rock structure, fabric or texture should be noted, if relevant.

Table 2.10 - Classification of Material Weathering (AS1726-2017, Table 20)

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>Material is weathered to such an extent that is has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported. The material is described using soil descriptive terms.</td></tr>
<tr><td colspan="2">Extremely Weathered</td><td colspan="2">XW</td><td>Material is weathered to such an extent that is has soil properties. Mass structure and material structure and fabric of original rock are still visible. The material is described using soil descriptive terms.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered</td><td>HW</td><td rowspan="2">DW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Rock strength is significantly changed by weathering.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable, but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition of individual minerals or colour changes.</td></tr>
</table>

3 Drilling, In Situ Testing & Sampling Methodology

Table 3.1 - Drilling Methods

Abbreviation	Method
HA	Hand Auger
EX	Excavator bucket
AV	Auger drilling with steel 'V' bit
AT	Auger drilling with tungsten carbide bit
AB	Auger for bulk sampling
WB	Wash bore rotary drilling
NMLC	Rock coring using a NMLC core barrel
HQ	Rock coring using a HQ core barrel

Table 3.2 - Field Sampling and In Situ Testing Key

Abbreviation	In Situ Test
DCP	Dynamic Cone Penetrometer (blows/100mm)
PSP	Perth Sand Penetrometer (blow/100mm)
SPT	Standard Penetrometer Test
PP	Pocket Penetrometer Measurement (kPa)
3,4,5 (example)	SPT blows per 150mm
N=9 (example)	STP 'blow count number' over 300mm after initial 150mm seating
VS	Handheld Shear Vane Measurement (kPa)
CPT	Cone Penetrometer Test
IS50 (D) (A)	Point Load Index Value (reported in MPA) (D) = Diametric (A) = Axial

Abbreviation	Sample Type
U	Undisturbed Sample (50mm)
D	Disturbed Sample
B	Bulk Disturbed Sample
ES	Environmental Sample
W	Water Sample

4 Groundwater Observations

Table 4.1 - Water Comments Key

Water Comment	Symbol
Water Inflow	▶—
Water / drilling fluid loss	—◀
Measurement of standing water level	▼
Water Noted	▽

Hunter Geotechnical Services
2/40 Glenwood Drive, Thornton NSW 2322
Phone: (02) 4966 1844

Geotechnical Log - Borehole

TP1

UTM	**: 56J**	**Drill Rig**	**: 15T Excavator**	**Job Number**	**: G0730**
Easting (m)	**: 504,232.90**	**Driller Supplier**	**: Hunter Civilab**	**Client**	**: Cash**
Northing (m)	**: 6,580,418.94**	**Logged By**	**: DP**	**Project**	**: 286-310 Gregory Street**
Ground Elevation	**: 18.35 (m)**	**Reviewed By**	**: DS**	**Location**	**: South West Rocks NSW, Australia**
Total Depth	**: 3.2 m BGL**	**Date**	**: 02/10/2024**	**Loc Comment**	**:**

General comments: 1500mm bucket 12 Ton excavator test pit size 1500 x 3000mm

Drilling Method	Water	DCP	Testing: Pocket Penetrometer	Samples: Disturbed	Samples: Undisturbed	Samples: Bulk	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks
							0.15		ML	Sandy SILT, low plasticity, brown, fine to coarse grained sand.	w ≈ PL		Topsoil	
							0.65		SC	Clayey SAND, fine to coarse grained, trace fine to medium sized gravel, low plasticity clay, pale brown mottled pale grey	M		Residual	
							0.95		SC	As above, but pale brown mottled pale grey with weathered granite cobbles up to 100mm	M		Residual	
			400 160 190 290				1.8		CI	Sandy CLAY, medium plasticity, pale brown to orange mottled grey, fine to coarse grained sand, with fine to medium sized gravel, quartz gravels .	w ≈ PL	St	Residual	
			200 340				2.1		CI	Sandy CLAY, medium plasticity, pale brown to grey mottled pale brown with pale red relict veining, fine to coarse grained sand, with fine sized gravel, with indistinct granite rock fabric .	w ≈ PL	VSt-H	Extremely Weathered Material	
	Water Inflow - ndefine		500				3.2		CI	Sandy CLAY, medium plasticity, pale grey and red mottled pale brown, heavily iron stained, fine to coarse grained sand.	w ≈ PL	VSt	Extremely Weathered Material	

TP1 Terminated at 3.2m

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2/40 Glenwood Drive, Thornton NSW 2322

Phone: (02) 4966 1844

Geotechnical Log - Borehole

TP2

UTM	**: 56J**	**Drill Rig**	**: 15T Excavator**	**Job Number**	**: G0730**
Easting (m)	**: 504,288.22**	**Driller Supplier**	**: Hunter Civilab**	**Client**	**: Cash**
Northing (m)	**: 6,580,418.63**	**Logged By**	**: DP**	**Project**	**: 286-310 Gregory Street**
Ground Elevation	**: 12.73 (m)**	**Reviewed By**	**: dS**	**Location**	**: South West Rocks NSW, Australia**
Total Depth	**: 3.9 m BGL**	**Date**	**: 02/10/2024**	**Loc Comment**	**:**

General comments: 1m tiger tooth bucket 1000mm x 3000 pit size

Drilling Method	Water	DCP	Testing: Pocket Penetrometer	Samples: Disturbed	Samples: Undisturbed	Samples: Bulk	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks
							0.15		SM	Silty SAND, fine to coarse grained, with fine to medium sized gravel, brown, with rootlets	M		Topsoil	
			260				1.1		SM	Silty SAND, fine to coarse grained, pale brown to grey mottled dark grey, with very high strength rounded boulders up to 700mm			Colluvial	
			300				2		CI	Sandy CLAY, medium plasticity, pale brown to orange mottled grey, fine to coarse grained sand, with fine to medium sized gravel.	w ≈ PL		Extremely Weathered Material	
			500				2.7		CI	As above, but pale grey and orange.				
							3.2		CI	Sandy CLAY, medium plasticity, pale grey and red mottled grey, fine to coarse grained sand, distinct rock fabric .				
	Water Inflow - ndefin								CI	As above, but pale grey and red mottled grey.				
										TP2 Terminated at 3.9m				

Hunter Geotechnical Services

2/40 Glenwood Drive, Thornton NSW 2322
Phone: (02) 4966 1844

Geotechnical Log - Borehole

TP3

UTM	: 56J	Drill Rig	: 15T Excavator	Job Number	: G0730
Easting (m)	: 504,308.39	Driller Supplier	: Hunter Civilab	Client	: Cash
Northing (m)	: 6,580,396.34	Logged By	: DP	Project	: 286-310 Gregory Street
Ground Elevation	: 11.83 (m)	Reviewed By	: dS	Location	: South West Rocks NSW, Australia
Total Depth	: 4.3 m BGL	Date	: 02/10/2024	Loc Comment	:

General comments: 1m tiger tooth bucket 1000mm x 3000mm pit size

Drilling Method	Water	DCP	Testing: Pocket Penetrometer	Samples: Disturbed	Samples: Undisturbed	Samples: Bulk	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks
							0.15		ML	Sandy SILT, low plasticity, brown, fine to coarse grained sand.	w < PL		Topsoil	
			290; 250				1.5		CI-CH	Sandy CLAY, medium to high plasticity, pale browm mottled dark grey, fine to coarse grained sand, with very high strength rounded boulders up to 700mm .	w ≈ PL		Colluvial	
			250; 290				2.7		CI	Sandy CLAY, medium plasticity, pale brown and pale grey, fine to coarse grained sand, with fine to medium sized gravel, cobbles up to 500mm.	w ≈ PL		Extremely Weathered Material	
							3.8		CL-CI	Sandy CLAY, low to medium plasticity, pale grey and pale brown mottled orange, fine to coarse grained sand, sand content increase with depth, indistinct rock fabric .	w < PL-w ≈ PL		Extremely Weathered Material	
									GRA	Highly weathered GRANITE, coarse grained, pale grey mottled grey, porphyritic texture, distinct, low strength. friable, high quartz sand content to be considered for abrasiveness	D	LS	Rock	

TP3 Terminated at 4.3m (on HW granite)

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Geotechnical Log - Borehole

TP4

UTM	: 56J	Drill Rig	: 15T Excavator	Job Number	: G0730
Easting (m)	: 504,339.10	Driller Supplier	: Hunter Civilab	Client	: Cash
Northing (m)	: 6,580,350.98	Logged By	: DP	Project	: 286-310 Gregory Street
Ground Elevation	: 12.02 (m)	Reviewed By	: dS	Location	: South West Rocks NSW, Australia
Total Depth	: 1.3 m BGL	Date	: 02/10/2024	Loc Comment	:

General comments: 1000mm Tiger tooth bucket 1000mm x 3000mm pit size

Drilling Method	Water	DCP	Testing: Pocket Penetrometer	Samples: Disturbed	Samples: Undisturbed	Samples: Bulk	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks
							0.2		CL	Sandy CLAY, low plasticity, browm, fine to coarse grained sand, with fine to medium sized gravel.	w < PL-w ≈ PL		Topsoil	
			230 260				1.1		CI-CH	Sandy CLAY, medium to high plasticity, pale brown mottled pale grey, fine to coarse grained sand, with fine to coarse sized gravel, cobbles up to 500mm consistent past 1.0m.	w ≈ PL		Colluvial	
									CI-CH	As above, but boulders up to 1000mm.				

TP4 refusal at 1.3m (refusal on granite boulders)

Depth scale: 1, 2, 3

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Geotechnical Log - Borehole

TP5

UTM	: 56J	Drill Rig	: 15T Excavator	Job Number	: G0730
Easting (m)	: 504,356.85	Driller Supplier	: Hunter Civilab	Client	: Cash
Northing (m)	: 6,580,306.68	Logged By	: DP	Project	: 286-310 Gregory Street
Ground Elevation	: 15.72 (m)	Reviewed By	: DS	Location	: South West Rocks NSW, Australia
Total Depth	: 1.2 m BGL	Date	: 02/10/2024	Loc Comment	:

General comments: 1000mm Tiger Tooth bucket 1000mm x 3000 pit size

Drilling Method	Water	DCP	Testing: Pocket Penetrometer	Samples: Disturbed	Samples: Undisturbed	Samples: Bulk	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks
							0.15		ML	Sandy SILT, low plasticity, brown woth rootlets, fine to coarse grained sand.	w < PL		Topsoil	
			270 350 390				1		CI-CH	Sandy CLAY, medium to high plasticity, brown to orange mottled grey, fine to coarse grained sand, with boulders up to 1500mm.	w ≈ PL	VSt	Colluvial	
							2			**TP5 refusal at 1.2m (refusal on granite boulder used ripper attachment)**				

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Geotechnical Log - Borehole

TP6

UTM	: 56J	Drill Rig	: 15T Excavator
Easting (m)	: 504,386.69	Driller Supplier	: Hunter Civilab
Northing (m)	: 6,580,251.06	Logged By	: DP
Ground Elevation	: 30.42 (m)	Reviewed By	: DS
Total Depth	: 1.9 m BGL	Date	: 02/10/2024

Job Number	: G0730
Client	: Cash
Project	: 286-310 Gregory Street
Location	: South West Rocks NSW, Australia
Loc Comment	:

General comments: 1000mm tiger tooth bucket 1000mm x 3000mm pit size

Drilling Method	Water	DCP	Testing: Pocket Penetrometer	Samples: Disturbed	Samples: Undisturbed	Samples: Bulk	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks
							0.0–0.2		SC	Clayey SAND, fine to coarse grained, with fine to medium sized gravel, grey mott brown, low to medium plasticity clay, decomposing strong odour	W		Topsoil	
	Water Inflow		120				0.2–0.6		CI	Sandy CLAY, medium plasticity, grey and red/browm mottled dark grey, with fine to coarse sized gravel, cobbles up to 500mm boulders up to 900mm.	w ≈ PL		Colluvial	
			270 250 350				0.6–1.9		CI	Sandy CLAY, medium plasticity, pale grey and red brown mottled dark grey, fine to coarse grained sand, with fine to coarse sized gravel, cobbles up to 700mm .			Residual	

TP6 refusal at 1.9m (refusal on granite boulders)

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Geotechnical Log - Borehole

BH1

UTM	: 56J	**Drill Rig**	: 15T Excavator	**Job Number**	: G0730
Easting (m)	: 504,289.30	**Driller Supplier**	:	**Client**	: Cash
Northing (m)	: 6,580,403.55	**Logged By**	: DP	**Project**	: 286-310 Gregory Street
Ground Elevation	: Not Surveyed	**Reviewed By**	: DS	**Location**	: South West Rocks NSW, Australia
Total Depth	: 8.95 m BGL	**Date**	: 08/10/2024	**Loc Comment**	:

Drilling Method	Water	Testing: Pocket Penetrometer	Testing: SPT	Samples	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks: General
					0.0–0.2		ML	Sandy to silty SILT, low plasticity, brown, fine to coarse grained sand.	w < PL		Topsoil	
		450 480	3,4,5 (N=9)		0.2–1.5		CI	Sandy CLAY, medium plasticity, brown and orange mottled grey, fine to coarse grained sand, with fine to medium sized gravel.	w ≈ PL	VSt	Colluvial	
		500 540	4,7,10 (N=17)		1.5–3		CL	Sandy CLAY, low plasticity, pale grey, brown, red mottled dark grey, fine to coarse grained sand, indistinct rock fabric, heavy feo staining, nearly friable .	w ≈ PL-w < PL	VSt	Extremely Weathered Material	1.5-8.95 m: Extremely weathered Granite
		250 270	3,3,5 (N=8)		3–4.5		CI	As above, but medium plasticity, becoming red mottled pale grey and dark grey .	w ≈ PL	VSt	Extremely Weathered Material	
		190 150	2,2,3 (N=5)		4.5–7		CI	Sandy CLAY, medium plasticity, pale brown mottled brown, fine to coarse grained sand, indistinct rock fabric, distinct preferential weakness plane, flow path, reduced drilling resistance with depth, inferred strength and weathering reversal	w > PL	St	Extremely Weathered Material	
		140 110 90	2,3,4 (N=7) 3,2,4 (N=6)		7–8.95		CI	As above, but becoming pale grey and pale brown mottled brown and dark grey, distinct rock fabric .	w ≈ PL	St	Extremely Weathered Material	

BH1 Terminated at 8.95m

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Geotechnical Log - Borehole

BH2

UTM	: 56J	**Drill Rig**	: 15T Excavator	**Job Number**	: G0730
Easting (m)	: 504,313.26	**Driller Supplier**	:	**Client**	: Cash
Northing (m)	: 6,580,399.46	**Logged By**	: DP	**Project**	: 286-310 Gregory Street
Ground Elevation	: Not Surveyed	**Reviewed By**	: DS	**Location**	: South West Rocks NSW, Australia
Total Depth	: 5.7 m BGL	**Date**	: 08/10/2024	**Loc Comment**	:

Drilling Method	Water	Pocket Penetrometer	SPT	Samples	Depth (m)	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks – General
					0.0–0.1	ML	Sandy to silty SILT, low plasticity, brown to dark brown, fine to coarse grained sand.	w < PL		Topsoil	
		290	3,5,5 (N=10)		0.1–1.5	CI	Sandy CLAY, medium plasticity, brown / orange mottled pale grey and dark grey, fine to coarse grained sand, with fine to coarse sized gravel, with cobbles up to 300mm.	w ≈ PL	St	Colluvial	
		350, 250	3,5,5 (N=10)		1.5–4.1	CL-CI	Sandy CLAY, low to medium plasticity, pale brown to orange mottled pale grey and dark grey, with fine to medium sized gravel, distinct rock fabric, friable, crystalline structure.	w < PL	St	Extremely Weathered Material	1.5-4.1 m: Extremely Weathered Granite
		400, 410	4,5,8 (N=13); 20/70mm (N=85) Refusal double bounce		4.1–5.5	GRA	Highly weathered GRANITE, coarse grained, pale grey and pale orange mottled grey and brown, porphyritic texture, distinct, very low strength. friable.	D	VLS	Rock	
					5.5–5.7	GRA	Highly weathered GRANITE, coarse grained, pale grey and orange mottled grey and dark grey, porphyritic texture, distinct, medium strength. inferred low to medium strength.	D	MS	Rock	

BH2 Terminated at 5.7m (Refusal on HW granite bedrock)

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Geotechnical Log - Borehole

BH3

UTM	: 56J	Drill Rig	: Track Mounted Drill Rig	Job Number	: G0730
Easting (m)	: 504,359.70	Driller Supplier	:	Client	: Cash
Northing (m)	: 6,580,365.71	Logged By	: DP	Project	: 286-310 Gregory Street
Ground Elevation	: Not Surveyed	Reviewed By	: DS	Location	: South West Rocks NSW, Australia
Total Depth	: 3.45 m BGL	Date	: 08/10/2024	Loc Comment	:

Drilling Method	Water	Testing: Pocket Penetrometer	Testing: SPT	Samples	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks: General
					0–0.2		ML	Sandy to silty SILT, low plasticity, brown, fine to coarse grained sand.	w < PL		Topsoil	
					0.2–1		CH	Sandy CLAY, high plasticity, brown to pale brown mottled grey and pale grey, fine to coarse grained sand, with fine sized gravel, cobbles up to 300mm.	w ≈ PL	St-VSt	Colluvial	
		400 320	2,3,4 (N=7)		1–1.5		CH	As above, but brown to pale brown mottled grey and pale grey, becoming pale grey to grey mottled brown and orange .	w ≈ PL	St-VSt	Colluvial	
			4,10,9 (N=19)		1.5–3.3		CI	Sandy CLAY, medium plasticity, pale grey mottled grey, red, brown, fine to coarse grained sand, indistinct rock fabric, approaching highly weathered .	w < PL	VSt	Extremely Weathered Material	1.5-3 m: Extremely weathered Granite
					3.3–3.45		GRA	Highly weathered GRANITE, coarse grained, pale grey mottled red and brown, distinct, low strength.	D	LS	Rock	3.3 m: Increase Resistance

BH3 refusal at 3.45m (Refusal on weathered granite bedrock)

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Geotechnical Log - Borehole

BH4

UTM	: 56J	Drill Rig	: Track Mounted Drill Rig	Job Number	: G0730
Easting (m)	: 504,367.69	Driller Supplier	:	Client	: Cash
Northing (m)	: 6,580,314.76	Logged By	: DP	Project	: 286-310 Gregory Street
Ground Elevation	: Not Surveyed	Reviewed By	: DS	Location	: South West Rocks NSW, Australia
Total Depth	: 2.2 m BGL	Date	: 08/10/2024	Loc Comment	:

Drilling Method	Water	Testing: Pocket Penetrometer	Testing: SPT	Samples	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks: General
					0.15		ML	Sandy to silty SILT, low plasticity, brown, fine to coarse grained sand.	w < PL		Topsoil	
					0.5		CI	Sandy CLAY, medium plasticity, brown and orange mottled dark grey and pale grey, fine to coarse grained sand, with fine to medium sized gravel, cobbles up to 200mm .	w ≈ PL	St	Colluvial	
		360 410	3,3,4 (N=7)		1 2		CI	Sandy CLAY, medium plasticity, red and pale grey mottled orange, dark grey, and brown, fine to coarse grained sand, indistinct rock fabric .	w ≈ PL	VSt	Extremely Weathered Material	0.5-2.2 m: Extremely weathered Granite
					3 4 5 6 7 8 9			**BH4 refusal at 2.2m (Refusal on Granite boulder)**				

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Geotechnical Log - Borehole

BH5

UTM	: 56J	**Drill Rig**	: Track Mounted Drill Rig	**Job Number**	: G0730
Easting (m)	: 504,283.90	**Driller Supplier**	:	**Client**	: Cash
Northing (m)	: 6,580,371.92	**Logged By**	: DP	**Project**	: 286-310 Gregory Street
Ground Elevation	: Not Surveyed	**Reviewed By**	: DS	**Location**	: South West Rocks NSW, Australia
Total Depth	: 8.45 m BGL	**Date**	: 08/10/2024	**Loc Comment**	:

Depth (m)	Water	Pocket Penetrometer	SPT	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks: General
0 – 0.15				ML	Sandy to silty SILT, low plasticity, brown to dark brown, fine to coarse grained sand.	w < PL		Topsoil	
0.15 – 1.8		450, 500	3,3,4 (N=7)	CI	Sandy CLAY, medium plasticity, red and brown mottled dark grey and pale grey, fine to coarse grained sand.	w ≈ PL	VSt	Residual	
1.8 – 4		600+, 600+	4,8,13 (N=21)	CL-CI	Sandy CLAY, low to medium plasticity, red to dark red mottled dark grey, orange, and pale grey, heavy iron oxide stained, distinct rock fabric.	w < PL	H	Extremely Weathered Material	1.8 m: Extremely weathered Granite
4 – 5		600+	5,8,13 (N=21)	CL-CI	As above, but red to dark red mottled dark grey, orange, and pale grey, becoming more pale grey mottled orange, red and dark red.	w < PL	H	Extremely Weathered Material	
5 – 5.5				CI-CH	Sandy CLAY, medium to high plasticity, red to dark red mottled pale grey and orange, fine to coarse grained sand.	w > PL	VSt	Extremely Weathered Material	
5.5 – 6.7		280, 240	3,7,10 (N=17)	CI	As above, but medium plasticity, red to dark red mottled pale grey and orange, becoming pale grey and dark red mottled orange and grey, distinct rock fabric .	w ≈ PL	VSt	Extremely Weathered Material	
6.7 – 7.7	Water Inflow	180, 110	2,3,3 (N=6)	CH	Sandy CLAY, high plasticity, pale grey to white, mottled grey and pale orange, fine to coarse grained sand, distinct rock fabric, kaolinite minerals, strength and weathering reversals	w > PL	F	Extremely Weathered Material	
7.7 – 8.45		40	1,1,4 (N=5)	CH	As above, but pale grey to white, mottled grey and pale orange, becoming red, pale grey and pink mottled grey.	w > PL	F	Extremely Weathered Material	

BH5 Terminated at 8.45m

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Annex B