# GEOTECHNICAL INVESTIGATION REPORT

*Ref. 25224G.SL.R1 rev2*
*30 May 2025*

*Issued to*
**ARCM Design**
*for the*
**Proposed Residence**
*at*
**12 Lincoln Avenue Collaroy**

*Australian Ground Sciences Pty Ltd*
*www.groundsciences.com.au*
*admin@groundsciences.com.au*
*2 / 65 Marigold Street Revesby NSW*

Report prepared by:

Sami Azzi (BEng Civil, MIEAust)
Geotechnical Engineer

# REPORT CONTENTS



**Document Revision History**

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|---|---|---|
| 25224G.SL.R1 | Final Issue | 30 May 2025 |

# 1 BACKGROUND AND INTRODUCTION

This report presents the findings of a geotechnical investigation undertaken by Australian Ground Sciences (AGS) for the proposed residence at 12 Lincoln Avenue Collaroy. The investigation was commissioned by Marc Mourad of ARCM Design and was completed in general accordance with our issued proposal. The site location is shown on figure A. Based on our review of the provided architectural drawings, it is understood that a new residence with an undercroft basement is proposed for the site, requiring excavations of up to 4m.

Our geotechnical investigation was commissioned to obtain subsurface geotechnical information to be used to provide comments and recommendations on site classification, footing design, retention and excavation conditions. The report has been written in accordance with AS1726:2017, Geotechnical Site Investigations. A geotechnical engineer was present during the fieldwork to set out testing locations, complete the boreholes and DCP tests and prepare the attached borehole logs.

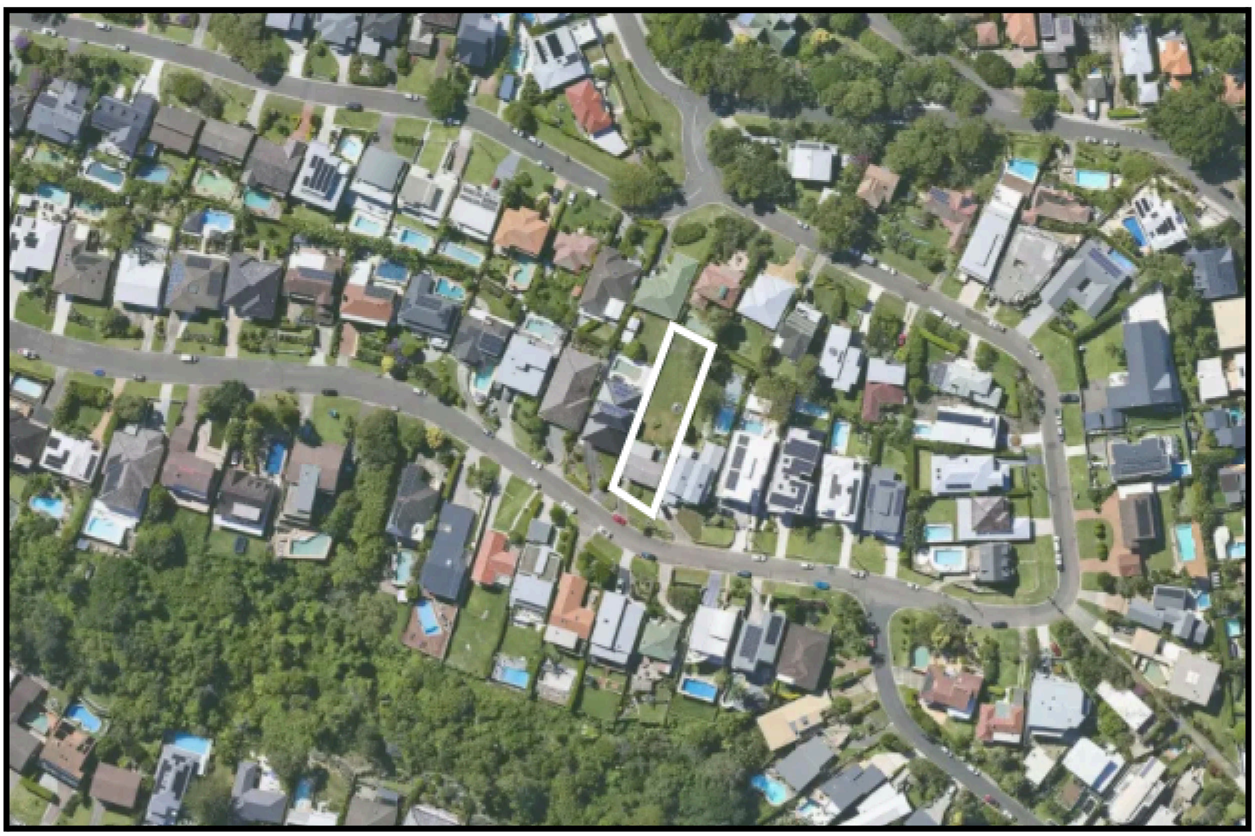

***Figure A: Site Location***

# 2 GATHERED INFORMATION

## *2.1 The Site*

The site is located on a south facing hillside within steep topography. The site is generally surrounded by residential dwellings and is bound by Lincoln Avenue to the south. The ground levels are sloping down towards the south in the vicinity of the site at angles ranging between 5-10 degrees. At the time of the fieldwork, the site comprised a one and two storey residence, whose bottom storey was cut into the hillside. The structure appeared to be in good external condition based on a cursory external inspection. The front lawn of the site was elevated above the road and the driveway was cut into the hillside.

The neighbouring property to the east comprised a two storey residence that appeared to be in good condition. This residence was offset approximately 1m from the common boundary with the site. Ground levels for this property were similar to those of the subject site in the vicinity of the common boundary. The neighbouring property to the west comprised a two storey brick residence that also appeared to be in good condition. This residence was offset approximately 1m from the common boundary with the site. Ground levels for this property were similar to those of the subject site in the vicinity of the common boundary.

## *2.2 Method*

The fieldwork was completed on 21 May 2025 and involved the drilling of three hand augered boreholes (BH1 to BH3) with handheld equipment. Access for a drilling rig was not possible in the rear yard and unpaved areas of the front yard. Dynamic Cone Penetration (DCP) tests were completed adjacent to each borehole. The DCP was used to determine the inferred depth to bedrock, the relative density of the soils and relative compaction of the fill. The location of the boreholes and DCP tests are shown on figure B.

Groundwater observations were made in the boreholes during and on completion of spiral auger drilling. Long term groundwater monitoring, geotechnical and environmental laboratory testing were not completed as part of the investigation.

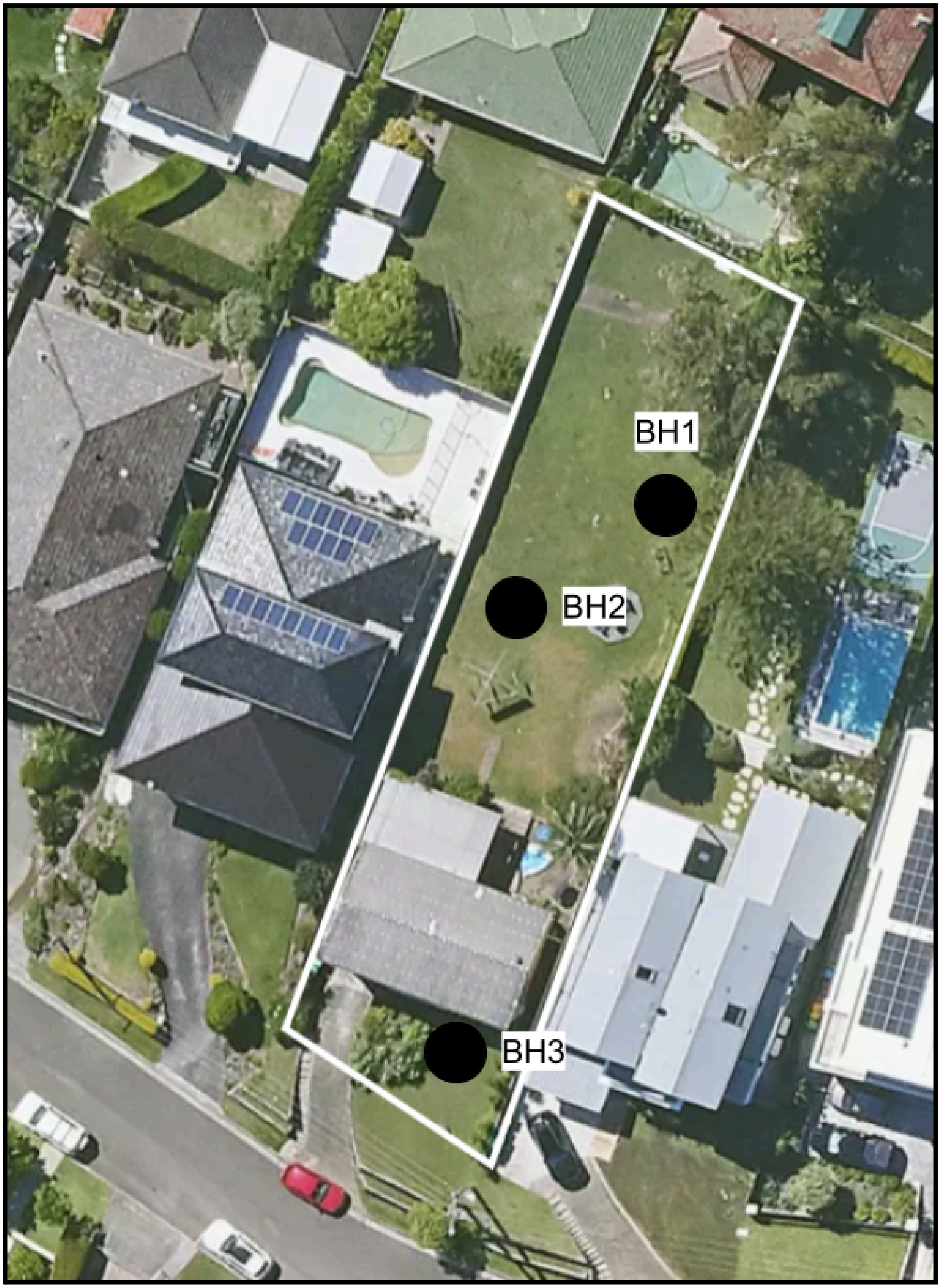


***Figure B: Test Location Plan***

### *2.3 Subsurface Conditions*

The 1:100,000 Geological Map of Sydney indicates that the site is underlain by medium to fine-grained “marine” sand with podsols.

The boreholes encountered a general subsurface profile comprising shallow sand fill overlying natural sand. Table A summarises the encountered subsurface conditions. Reference should be made to the attached borehole logs in the appendices for more detailed descriptions.

<table>
<tr><th>Test Location</th><th>Fill Type</th><th>Depth to Residual Sandy Clays (m)</th><th>Depth to inferred bedrock (m)</th><th>Groundwater Seepage Depth (m)</th></tr>
<tr><td>BH1/DCP1</td><td rowspan="3">Sandy clay, poorly compacted</td><td>0.6</td><td>0.9</td><td rowspan="3">Boreholes ‘dry’ on completion.</td></tr>
<tr><td>BH2/DCP2</td><td>0.6</td><td>1.1</td></tr>
<tr><td>BH3/DCP3</td><td>0.5</td><td>0.7</td></tr>
</table>

*Table A: Summary of Encountered Soil Conditions. Refer to Appendices for Borehole Logs*

# 3 GEOTECHNICAL ASSESSMENT

## 3.1 Dilapidation Reports

Prior to demolition and excavation, it is recommended that detailed dilapidation reports are carried out on adjoining properties. As a minimum, these reports are recommended for the properties to the east, west and north of the site.

Dilapidation reports can be used against future claims for damage arising from site works. Dilapidation reports should include detailed inspections of the adjoining properties to be used as a baseline of the condition of structures. The reports should rigorously describe both internal and external defects (e.g. crack type, width, length, orientation, etc). The owners should be provided with a copy of their dilapidation report and provide signed confirmation that it presents a fair representation of the condition of their property.

## 3.2 Excavation and Earthworks

All works relating to excavation should be completed with reference to Safe Work Australia's 'Excavation Work - Code of Practice' October 2018.

From our review of the provided architectural drawings, up to 4m of excavation will be required for the proposed undercroft basement. Excavations to such depths are expected to encounter sandy and clayey fill, residual clays and sandstone bedrock. Based on our limited data, we have inferred that medium and high strength rock may possibly be encountered during basement excavation. As such, rock excavation techniques will be required for the majority of the basement excavation and partially for the swimming pool excavation.

Fill, natural soils and some extremely weathered sandstone can be excavated with the bucket of an excavator. Often the upper rock may be 'ripped' by a medium sized excavator with a ripping tyne or toothed bucket. However, deeper weathered sandstone may require rock excavating equipment. Due to the relatively shallow depth to bedrock at the southern end of the site, it is highly likely that the primary excavation techniques will involve hydraulic rock hammers, rotary grinders or rock saws.

If possible, It is advised that non-percussive equipment (e.g. ripping hooks, rotary grinders and rock saws) are used for excavating through rock. If rock hammers must be utilised, then excavation should be strictly controlled as there may be a direct transmission of ground vibrations to neighbouring houses and other structures. Excessive vibrations may cause damage and/or settlement of structures. Therefore, it is necessary to commence rock excavation using the smallest possible rock hammer and gauge the extent of vibrations. If percussive rock excavation techniques are to be undertaken, then quantitative vibration monitoring should be carried out on adjoining neighbouring structures. We recommend a peak particle velocity limit of 5mm/s be applied for the neighbouring structures to the east and west of the site. If vibrations are found to be excessive, then smaller rock hammers are to be utilised. Other strategies to reduce in ground vibrations include but are not limited to the following:

- Rock saw faces of excavation before hammering
- Use only small jack hammer bursts to reduce vibration amplification
- Ensure the hammer is oriented towards the rock face and enlarge the excavation by breaking small wedges of rock. This should be combined with rock sawing in a grid
- Ensure the hammer's moil is kept sharp

Assuming that the inferred bedrock is confirmed to be at a similar depth, then a temporary batter may be feasible for parts of the proposed basement and swimming pools. This is provided that they are able to be **battered at no steeper than 1 Vertical (V) to 1. Horizontal (H) through fill and 1V to 1H through natural clay soils and extremely weathered sandstone. Where very low strength bedrock is encountered, the rock may be cut at a steeper slope (1 H to 0.5V), provided that the cut faces are inspected regularly by a geotechnical engineer (i.e. no more than 1.5m vertical cut exposed at any time). Higher strength bedrock may be cut at subvertical angles,** subject to regular geotechnical inspections. Surcharge loads such as heavy machinery and nearby structures should be kept well clear of the crest of temporary batters (at least 2L from the crest, where L is the vertical height of the batter slope). If these conditions cannot be met, then temporary batters should not be implemented and an insitu retention system should be adopted instead and installed prior to bulk excavation commencement.

Where temporary batters are possible, the type and compaction of backfill against permanent basement walls should be considered. Poorly compacted backfill may lead to large settlements, which can affect structures, pavements or landscaping. This backfill should comprise suitable uniformly sized granular material surrounded by geotextile fabric covered with compacted 0.5m thick clayey site won material to reduce water infiltration.

Seepage from the soil rock interface and/or defects in the rock may cause unstable batter slopes, and so it may be necessary to flatten them, subject to a geotechnical engineer's inspection and recommendations. Surface water should be allowed to flow over the crest of temporary batters and should be discharged so that water flows are not concentrated. This is particularly important if there are periods of sustained heavy rainfall.

### 3.3 Retaining Walls

Where temporary batter slopes can be accommodated, then permanent fully engineered and waterproofed masonry retaining walls may be constructed. However it is crucial that excavation is monitored frequently by a geotechnical engineer (every 1.5m of excavation) to ensure there are no adverse defects that could compromise the integrity of the exposed sandstone and become a safety risk.

Surcharge loads are additional to these earth pressure recommendations and must be taken into account for the design if present. Compaction of backfill material will impose additional stresses on retaining walls and so these must be considered for retaining wall design. Where temporary batters cannot be accommodated, an insitu shoring system comprising soldier pile walls with shortcrete infills should be adopted. The retention system along the site boundaries must be stiff enough to reduce settlements and lateral movements of the neighbouring structures.

Retaining walls structures should be designed to withstand the lateral earth pressure imposed by surcharge loads in their zone of influence, including but not limited to the eastern and western neighbouring structures, traffic and construction related activities.

### 3.4 Retention Parameters

It is recommended that the following soil parameters are adopted for retention design:

| Geological Unit | Unit Weight, ϒ (kN/m³) | Cohesion, c' (kPa) | Friction Angle, Φ' (deg) | Poisson's Ratio v | Elastic Modulus E' (MPa) | Earth Pressure Coefficient At Rest ($K_o$) | Earth Pressure Coefficient Active ($K_a$) | Earth Pressure Coefficient Passive ($K_p$) |
|---|---|---|---|---|---|---|---|---|
| **Fill** | 16 | 0 | 24 | 0.4 | 3 | 0.59 | 0.42 | 2.37 |
| **Natural Sandy Clay Soils** | 18 | 2 | 26 | 0.35 | 15 | 0.56 | 0.39 | 2.56 |
| **Sandstone Bedrock** | 23 | 50 | 34 | 0.3 | 200 | 0.44 | 0.28 | 3.5 |

### 3.5 Slabs on Grade

For lightly trafficked slabs such as the proposed pavements, the subgrade should be stripped of any topsoil, root affected soil or deleterious material and the underlying soil should be compacted. Unsuitable fill should be replaced by granular material that has been compacted to at least 98% Standard Maximum Dry Density or a density index of 70% for sandy soils.

### 3.6 Site Classification and Footings

In accordance with AS2870-2011 'Residential Slabs and Footings,' the site is classified as 'Class P' due to abnormal moisture conditions from the presence of existing buildings, pavements and nearby trees. For design considerations, footings would be subject to shrink swell movements by the site soils equivalent to that of a class M site.

All recommendations provided in regards to footings should be completed with reference to AS 2870-2011 "Residential slabs and footings".

We expect that sandstone will be encountered near the bulk excavation level over the majority of the development footprint. As such, shallow strip/pad footings are feasible for the basement of the swimming pool and main residence structures.

We recommend that shallow footings for the main residence structure are founded on sandstone of at least low strength sandstone. They may be designed for a maximum allowable bearing pressure of 1,000kPa provided that all footing excavations are inspected by a geotechnical engineer. Footing inspections are critical for this project as we were unable to confirm the strength, quality and properties of the underlying sandstone. We note that there may be some sections of the house that extend over the footprint of the proposed basement and piled footings for those sections must be socketed into sandstone below a to a depth below a 45 degree line drawn up from the bottom of the basement bulk excavation level into medium strength rock. These sections may also be socketed at least 0.3m into sandstone bedrock of at least low strength, with a maximum allowable bearing pressure of 1000kPa. Sockets greater than 0.3m may adopt a skin friction of 100kPa in compression and 50kPa in tension.

All footings should be poured as soon as possible after excavation, ensuring to clean and inspect them prior. Water ponding in these footing excavations should be avoided and should be dewarted prior to pouring concrete.

### 3.7 Groundwater, Drainage and Seepage

Groundwater was not encountered during our investigation and is not expected to be encountered during the proposed excavations.

However it is possible that there may be some minor seepage into excavations, especially after rainfall events. Due to the elevated hillside position of the site, seepage from rainwater and/or perched water should be minimal during excavation and is expected to be manageable by sumps and pumps during temporary dewatering.

All cut faces and retaining walls should incorporate spoon drains to collect seepage and discharge to the stormwater system, provided that all Sydney Water and/or WaterNSW approvals and conditions are met. As excavation progresses, the groundwater should be monitored by the builder and AGS to confirm the drainage requirements.

# 4 GENERAL COMMENTS AND LIMITATIONS

Australian Ground Sciences (AGS) has based its geotechnical assessment on information gathered from our fieldwork. The recommendations and observations provided in this report are limited to the information gathered from test and inspection areas and are presented to address specific issues during construction. In the event that our recommendations are not implemented in full, AGS does not accept responsibility for the performance of any structures.

The accuracy of our recommendations and factual information may be limited by undetected variations (or misinterpretations) in subsurface conditions between test and inspection locations. Subsurface conditions may change after field testing and/or inspections. It is recommended that if for any reason, there are changes to the site surface, subsurface or geotechnical and groundwater conditions during or before construction, AGS should be contacted immediately. Further recommendations may be required at an additional cost. AGS does not accept responsibility for any variations in subsurface conditions that were not observed or accessible during our fieldwork.

This report and any associated information has been prepared solely for the addressed client and for the proposed works mentioned in the provided documentation. Any misinterpretation or reliance by third parties shall be at their own risk. Designers and consultants should satisfy themselves that this report has been understood thoroughly. This report should be read in full. Please contact AGS to clarify any concerns or misunderstandings related to this report or if ground conditions have been found to differ to those presented.

A waste classification is required for any soil excavated from the site prior to offsite disposal.
This report may only be reproduced in full. This report is only valid once the client has paid the full agreed cost.

# 5 REPORT EXPLANATION NOTES

Soil and rock description and classification are based on Australian Standard 1726:2017. Identification of soil and rock requires judgement and groundsciences infers accuracy only to the extent that is common in geotechnical practice.

Sampling of soil is carried out during drilling to allow examination. Samples are used to provide information about plasticity, colour, moisture content, grain size, minor constituents, and sometimes strength and structure.

A borehole with a diameter of approximately 100mm is advanced by manually operated equipment. Refusal of the hand auger and/or dynamic cone penetrometer (DCP) does not necessarily indicate rock level and can occur on many materials such as fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders.

Dynamic Cone Penetrometer (DCP) tests involve the dropping of a 9kg hammer down 510mm onto an anvil that drives a 16mm diameter rod with a 20mm diameter cone end into the soil. The DCP test results are used to assess the compaction of fill, strength of cohesive soils and the relative density of granular soil.

The attached borehole log presents our geological interpretation of subsurface conditions. Boreholes represent a very small sample of the total subsurface conditions and therefore cannot capture all subsurface features of a site. The reliability of the results rely on the method of drilling and how often there is sampling. One of the most reliable assessments of soil is the use of continuous undisturbed sampling or core drilling, however this is not always practical or affordable.

Groundwater is measured during, on completion of and sometimes a short time after drilling. It is possible that although groundwater may be present, it may not be shown in the short time the borehole is observed, especially in low permeability soils. On the other hand, a local perched water table may misleadingly represent a true water table. Water tables often vary over time with seasons or with recent rain and may change by the time construction begins. The installation and use of standpipes may be more reliable to read groundwater levels as the groundwater may stabalise after several days or weeks.

The distinction of fill from natural material can often be determined only by foreign inclusions such as brick, concrete, plastic, etc). Therefore it is often difficult to distinguish fill from natural material if the fill material is similar to the natural material present on site. The presence of fill should be noted because there is much more potential for fill to vary over a site than it is for natural material. Therefore there is an increased risk of loading on fill due to its unpredictable nature.

This report has been prepared by a qualified engineer and is based on the interpretation of factual information obtained from the site. If a report has been prepared for a specific project, the information and interpretation may not be relevant if the structure is changed. Therefore it is imperative that Australian Ground Sciences is informed of any changes so that we may adjust the advice or engage in further investigation. Additional fees may apply.

If subsurface or site conditions differ to those that have been expected from the information gathered from our investigation, it is crucial that groundsciences is notified immediately. It is much easier to resolve issues once subsurface conditions have been exposed and before structures have been constructed.

It is recommended that a joint design review is undertaken with an experienced geotechnical engineer or engineering geologist, especially where investigation was limited.

It is recommended that groundsciences is contacted to perform inspections. Site visits may be required to confirm expected conditions as well as assist contractors in identifying soil/rock and appropriate footing/pile depths and conditions.

**COHESIVE SOILS - CONSISTENCY**

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding.

A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. The undrained shear strength of cohesive soils is approximately half the UCS. The values are recorded in kPa as follows:

| Strength | Symbol | Undrained Shear Strength, $C_u$ (kPa) |
|---|---|---|
| Very Soft | VS | < 12 |
| Soft | S | 12 to 25 |
| Firm | F | 25 to 50 |
| Stiff | St | 50 to 100 |
| Very Stiff | VSt | 100 to 200 |
| Hard | H | > 200 |

**COHESIONLESS SOILS - RELATIVE DENSITY**

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

| Term | Symbol | Density Index | N Value (blows/0.3 m) |
|---|---|---|---|
| Very Loose | VL | 0 to 15 | 0 to 4 |
| Loose | L | 15 to 35 | 4 to 10 |
| Medium Dense | MD | 35 to 65 | 10 to 30 |
| Dense | D | 65 to 85 | 30 to 50 |
| Very Dense | VD | >85 | >50 |

**COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS**

| Name | Subdivision | Size |
|---|---|---|
| Boulders | | >200 mm |
| Cobbles | | 63 mm to 200 mm |
| Gravel | coarse | 20 mm to 63 mm |
| | medium | 6 mm to 20 mm |
| | fine | 2.36 mm to 6 mm |
| Sand | coarse | 600 µm to 2.36 mm |
| | medium | 200 µm to 600 µm |
| | fine | 75 µm to 200 µm |

Water level at date shown

Partial water loss

Water inflow

Complete water loss

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

**PLASTICITY**

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

| Description of Plasticity | LL (%) |
|---|---|
| Low | <35 |
| Medium | 35 to 50 |
| High | >50 |

**MOISTURE CONDITION**

Dry - Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist - Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet - Cohesive soils usually weakened

**UNIFIED SOIL CLASSIFICATION**

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

| USC Symbol | Description |
|---|---|
| GW | Well graded gravel |
| GP | Poorly graded gravel |
| GM | Silty gravel |
| GC | Clayey gravel |
| SW | Well graded sand |
| SP | Poorly graded sand |
| SM | Silty sand |
| SC | Clayey sand |
| ML | Silt of low plasticity |
| CL | Clay of low plasticity |
| OL | Organic soil of low plasticity |
| MH | Silt of high plasticity |
| CH | Clay of high plasticity |
| OH | Organic soil of high plasticity |
| Pt | Peaty Soil |

## 6 APPENDICES

Enclosed in appendices

- Borehole and DCP logs

| **Borehole Log** | BH01 |
|---|---|
| **Job No.** | 25224 |
| **Address** | 12 Lincoln Avenue Collaroy |

**Drilling Date:** 21 May 2025
**Drilling Method**: Hand Auger and DCP
**Drilling Rig: -**
**Groundwater Seepage:** -

**Approximate RL:** N/A
**Well details:** N/A
**Logged by:** Sami Azzi
**Reviewed by:** Sami Azzi

| Elevation (mAHD) | Depth (m) | Profile Start Depth (m) | Strata Description | USCS | Moisture Content / Weathering | Strength / Relative Density | Samples | Tests (SPT, DCP, etc) | Comments (ORIGIN IN BRACKETS) |
|---|---|---|---|---|---|---|---|---|---|
| - | 0.0<br>0.1<br>0.2<br>0.3<br>0.4<br>0.5 | 0.0 | FILL: Silty sandy clay, low plasticity, grey brown | - | w> PL | | | 1<br>2<br>1<br>1<br>2<br>2<br>2<br>2<br>2 | Fill appears to be poorly compacted |
| | 0.6<br>0.7<br>0.8 | 0.6 | Silty Sandy CLAY: medium plasticity, orange brown. | | w> PL | F | | | (Residual) |
| Hand Auger Refusal at 0.9m on Inferred Sandstone Bedrock | | | | | | | | | |

| | |
|---|---|
| **Borehole Log** | BH02 |
| **Job No.** | 25224 |
| **Address** | 12 Lincoln Avenue Collaroy |

**Drilling Date:** 21 May 2025
**Drilling Method**: Hand Auger and DCP
**Drilling Rig: -**
**Groundwater Seepage:** -

**Approximate RL:** N/A
**Well details:** N/A
**Logged by:** Sami Azzi
**Reviewed by:** Sami Azzi

| Elevation (mAHD) | Depth (m) | Profile Start Depth (m) | Strata Description | USCS | Moisture Content / Weathering | Strength / Relative Density | Samples | Tests (SPT, DCP, etc) | Comments (ORIGIN IN BRACKETS) |
|---|---|---|---|---|---|---|---|---|---|
| - | 0.0 0.1 0.2 0.3 0.4 0.5 | 0.0 | FILL: Silty sandy clay, low plasticity, grey brown | - | w> PL | | | 1 2 2 1 2 2 3 2 2 6 | Fill appears to be poorly compacted |
| | 0.6 0.7 0.8 0.9 1.0 | 0.6 | Silty Sandy CLAY: medium plasticity, orange brown. | | w> PL | F | | | (Residual) |
| Hand Auger Refusal at 1.1m on Inferred Sandstone Bedrock | | | | | | | | | |

| | |
|---|---|
| **Borehole Log** | BH03 |
| **Job No.** | 25224 |
| **Address** | 12 Lincoln Avenue Collaroy |

**Drilling Date:** 21 May 2025
**Drilling Method**: Hand Auger and DCP
**Drilling Rig: -**
**Groundwater Seepage:** -

**Approximate RL:** N/A
**Well details:** N/A
**Logged by:** Sami Azzi
**Reviewed by:** Sami Azzi

| Elevation (mAHD) | Depth (m) | Profile Start Depth (m) | Strata Description | USCS | Moisture Content / Weathering | Strength / Relative Density | Samples | Tests (SPT, DCP, etc) | Comments (ORIGIN IN BRACKETS) |
|---|---|---|---|---|---|---|---|---|---|
| - | 0.0<br>0.1<br>0.2<br>0.3<br>0.4 | 0.0 | FILL: Silty sandy clay, low plasticity, grey brown | - | w> PL | | | 1<br>1<br>2<br>2 | Fill appears to be poorly compacted |
| | 0.5<br>0.6 | 0.5 | Silty Sandy CLAY: medium plasticity, orange brown. | | w> PL | F | | 2<br>2<br>5 | (Residual) |
| Hand Auger Refusal at 0.7m on Inferred Sandstone Bedrock | | | | | | | | | |