Report for Geotechnical Investigation
Proposed Apartment Development

21-23 Watland Street, Springwood

Watland Pty Ltd

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1.0 Introduction

1.1 General

This report presents the results of the geotechnical investigation carried out by Soil Surveys Engineering Pty. Limited for the Proposed Apartment Development at 21-23 Watland Street, Springwood.

The investigation was carried out in accordance with Soil Surveys Engineering Pty Limited proposal 1-29680 PR 1.1 and following authorisation to proceed received from Watland Pty Ltd on the 5th November, 2025.

1.2 Proposed Development

Based on information provided to us on the 27th October, 2025, it is understood that the proposed development will comprise construction of a three storey building with a single level basement.

The excavations for the basement are expected to range between approximately 1.0m (at the rear of the site) to 3.0m (towards the street), increasing to 4.0m at the site entrance below the existing ground surface level.

At this stage, the design loads are unknown but are expected to be typical for this type of structure.

1.3 Scope of Geotechnical Services

The objective of this study was to identify materials and material properties and groundwater conditions to enable geotechnical assessment of the following: -

- Earthworks recommendations
- Excavation retention system options (temporary and permanent)
- Foundation recommendations
  - recommended foundation type (high & deep support)
  - bearing capacity
  - skin friction
  - site classification (AS 2870)
  - predicted ground surface movement
- Retaining wall design parameters for the basement walls
- Construction recommendations (where applicable)
- Site management recommendations

The site is subject to the Landslide Hazard and Steep Slope Area Overlay. In addition to the above, the following is also addressed and presented in our report:

- Suitability of the proposed development based on the existing geotechnical conditions
- Identify all risk mitigations measures to ensure that the development remains geologically stable in the long term

2.0 Site Description

The site is located at 21-23 Watland Street, Springwood. Refer to Figure 1 below for location.

Figure 1 - Site Location

At the time of the field investigation, the site was occupied by existing buildings, driveways, carparking, gardens and other features.

Field observations and review of the survey plan provided indicate that the site slopes slightly from the northern to the southern boundaries, ranging from approximately RL 31.2m to RL 27.8m and a surface relief of about 3.5m.

Vegetation comprised gardens areas with medium and large size trees at the front and rear of the site.

Refer to the photos in Figure 2 and Figure 3 to view typical conditions of the site observed at the time of the fieldwork and where boreholes BH01 and BH04 were carried out.

Figure 2 - Site Photo Looking towards Borehole BH01 Location

Figure 3 - Site Photo Borehole BH04 Location

3.0 Geotechnical Investigation

3.1 Field Investigation

Subsurface conditions at the site were investigated by the following: -

- Drilling of four (4) boreholes to depths of between 1.40m and 2.95m within the proposed building area using a 4WD mounted Christies Engineering (CDR-2) drilling rig as access permitted on the site.
- All boreholes terminated at 'TC' bit refusal depth within weathered rock.
- In addition, dynamic cone penetrometer (DCP) tests were carried out adjacent to each borehole.
- Collection of undisturbed and disturbed samples for laboratory testing.

The field work was carried out on the 14th November, 2025.

The soil classification descriptions, field and laboratory testing were carried out in general accordance with the following Australian Standards: -

- AS 1726-2017 - Geotechnical Site Investigations
- AS 1289 - Methods of Testing Soils for Engineering Purposes

A description of the investigation method, borehole records and a site plan showing the location of the boreholes are included in the Appendices.

Borehole coordinates were recorded using a handheld GPS device, with accuracy consistent with such devices. The RL's were interpolated from the survey plan provided and are only indicative.

4.0 Geotechnical Model

4.1 Local Geology

Based on the review of the Queensland Geotechnical Database website, the regional geology of the area is expected to be made up of the following:

- RJbw - Woogaroo Subgroup - Sublabile to quartzose sandstone, siltstone, quartz-rich granule to cobble conglomerate and coal (Late Triassic - Early Jurassic).

4.2 Subsurface Profile

The subsurface profiles intersected during the drilling program at the proposed development site generally consisted of fill materials overlying natural clay soils and weathered rock which extended to the borehole termination depths. These strata are discussed in the following sections of this report.

4.2.1 Fill Materials

Fill materials were encountered in all boreholes extending to depths ranging between approximately 0.25m and 0.50m. The fill generally comprised concrete cover that is between 100mm and 140mm in thickness over sand, gravel and clay based materials with a varying content of silt.

In the absence of certification and compaction documents regarding the existing fill and in accordance with AS3798-2007, the existing fill materials must be considered as being uncontrolled in their current state.

Based on the field investigation and review of the site, it is believed that the fill materials have been placed in control manner during the construction of the subdivision estate development and the existing complex that is present.

4.2.2 Natural Soils

Below the fill materials, natural soils were encountered in all boreholes, generally consisting of very stiff and hard, clay, sandy clay and silty clay of low, medium and high plasticity. A layer of stiff sandy clay was noted only in borehole BH03 at depth of 0.25m to 0.50m.

4.2.3 Weathered Rock

Underlying the fill and natural soils, weathered rock was intersected at depths ranging between 0.90m and 2.00m in all boreholes and extending to the borehole termination depths. The weathered rock generally comprised extremely weathered (XW) or distinctly weathered (DW) low strength (LS), sandstone and siltstone. Drilling rig refusal, at maximum 'TC' bit penetration, was reached in all boreholes at depths ranging between 1.40m and 2.95m indicating that less weathered and stronger rock may be present at these depths.

A summary of the subsurface profile is presented in **Table 1** with detailed borehole records included in Appendix B.

Table 1 Geotechnical Summary of the Subsurface Profile

Location	Surface Level RL (m) 3	Fill (m)	Natural Clay (m)	Weathered Sandstone/Siltstone (m)		Termination Depth (m) 4
				XW 5	DW	
BH01	30.25	0.00-0.50	0.50-1.20	NE	1.20-TD	1.40
BH02	29.85	0.00-0.25	0.25-1.00	1.00-1.60	1.60-TD	1.70
BH03	28.70	0.00-0.25	0.25-0.90	0.90-2.80	2.80-TD	2.95
BH04	27.85	0.00-0.45	0.45-2.00	NE	2.00-TD	2.20

Notes:-
1. NE = Not Encountered; TD = Termination Depth.
2. All depths below existing ground level at date of drilling (14th November, 2025).
3. RL approximated from provided survey plan.
4. 'TC' bit refusal.
5. AS 1726-2017 'Geotechnical Site Investigations' requires that XW rock be described using soil terms. XW rock on this site was primarily recovered as dense clayey sand.

4.3 Groundwater

Groundwater was not encountered at borehole locations at the time of the investigation. Whilst groundwater was not encountered in the boreholes, it should be noted that groundwater may be present; please note that the period of time available (during the drilling of boreholes) is relatively short, and hence, the opportunity to observe the presence (or otherwise) of groundwater is limited.

However, seepage may be encountered, particularly within the fill materials and at the fill/natural and soil/rock interfaces, especially following rainfall events.

It should also be noted that groundwater levels can vary both seasonally and with prevailing weather conditions. The presence and depth to groundwater is dependent on rainfall, subsurface material and permeability, integrity of in-ground services, proximity to existing waterways and water bodies and the proximity to, type and density of vegetation.

4.4 Laboratory Testing

Laboratory testing was carried out on selected samples retrieved from the field investigation programs and was directed towards assessing the following:-

- Atterberg Limits
- Particle Size Distribution
- Shrink Swell Index

The results of the laboratory testing are summarised in **Table 2** and **Table 3** below with certificates contained in Appendix C.

Table 2 Classification Testing

Location	Sample Depth (m)	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Percent Passing 0.075mm Sieve (%)
BH03	0.5-0.9	50	36	13.5	36
BH04	0.5-1.0	44	28	13.5	50

Table 3 Shrink Swell Index

Location	Sample Depth (m)	Unit Weight (t/m^3)	Shrink Swell Index (%)
BH04	1.3-1.55	2.06	1.0

5.0 Engineering Assessment

5.1 Trafficability

Trafficability conditions were considered to be very good during the investigation due to the existing concrete pavement covering the majority of the site.

The soils on site are sensitive to repetitive vehicle loading and water (i.e. they will lose strength through repetitive vehicle loading or if they become overly moist or wet). Further, seepage may also result in a subsequent loss of strength. This may limit trafficability and create difficulties for earthworks operations. This situation would be more pronounced if rainfall followed initial clearing, stripping and grubbing.

Problems may also arise from disturbance of the upper level soil fabric with removal of vegetation. Depressions could be formed resulting in water traps and potential softening of adjacent and underlying soils. It is recommended that after stripping, clearing and grubbing, the exposed surface in the construction area be proof rolled (where appropriate) to assist in identifying weak areas and to improve trafficability. In areas of cut, proof rolling may be deferred until after the cut operation. Areas which demonstrate excessive movement and/or do not improve sufficiently under proof rolling should be removed and replaced as required.

Maintaining adequate drainage conditions is essential. It should be ensured that runoff is diverted away from the construction area to prevent ponding of water. In addition, the construction area should be "sealed" at the completion of each day and in the event of rain.

Potential trafficability problems with this site should not be underestimated. The site will very quickly become untrafficable if appropriate seepage and drainage control measures, along with construction practices appropriate for site conditions, are not maintained.

If weather conditions and time constraints do not allow for site drains to effect sufficient site improvement to allow earthworks to proceed, then site traffickability may be improved by constructing haulage roads into and within the site. Imported materials could be used as a blanket course for the haulage roads.

Preferably, earthworks should be scheduled in dry weather following a period of not less than one week of little or no rainfall.

Nevertheless, the contractor should fully inform themselves of the ground conditions on site prior to commencement of earthworks. This requirement should be explicit in any earthworks specifications or contract.

Working Platforms For Tracked Plant and Heavy Construction Vehicles

The scope of Soil Surveys Engineering's study DOES NOT include the design of a working platform for heavy construction vehicles or heavy tracked plant.

Detailed design of a working platform should be carried out considering the operation of actual machinery proposed to be used.

This is particularly important when considering the use of heavy piling rigs and heavy cranes - the piling/crane contractor should be consulted regarding their requirements.

Demolition and Clearing Activities

Care should be exercised during the demolition/clearing phase to ensure that excessive subgrade disturbance is not caused during removal of existing structures, trees, services, etc.

5.2 Earthworks

Based on the supplied information, earthworks will likely comprise of cuts varying from approximately 1.0m (at rear) to 4.0m (at the entrance) of the site.

The following provides general recommendations with respect to earthworks and should be reviewed once the earthworks extent has been established.

Earthwork procedures should be carried out in a responsible manner in accordance with AS 3798-2007 "Guidelines on Earthworks for Commercial and Residential Developments" and include the following:-

5.2.1 Subgrade Preparation

Subgrade preparation procedures should include the following:-

- Clearing, stripping and grubbing should be carried out in areas subject to earthworks (as trafficability conditions allow). Also, all soils containing organic matter should be stripped from the construction area; this material is not considered suitable for use as structural fill.
- Depressions formed by the removal of vegetation, underground elements, etc. should have all disturbed weakened soil cleaned out and be backfilled with compacted select material.
- It is envisaged that upper level soils beneath existing concrete may be wet and may require removal.

- The subgrade should be proof rolled (where appropriate) under the supervision of Soil Surveys Engineering in accordance with methods and equipment as per Clause 5.5 of AS 3798-2007. In areas of cut, proof rolling may be deferred until after the cut operation. Areas demonstrating excessive movement should be treated (dried and recompacted) or removed and replaced with compacted fill. Treatment should be to a standard sufficient so that the subgrade passes proof rolling and that compaction can be achieved in the first layer of fill.
- All fill material encountered should be considered uncontrolled and requiring treatment (i.e. excavate/condition/replace/compact as required). However, this requirement could be reconsidered subject to verification of fill quality, compaction, etc. and considering foundation options.

5.2.2 Material Usage

- The insitu soils, where free of organic and deleterious material, may be used for structural fill provided the moisture content of the soils on placement approximates the optimum moisture content required for compaction. This will require conditioning to bring the soils to optimum. However, it should be noted that the on site soils could be expected to present difficulties in handling, placement and compaction if the appropriate moisture content could not be achieved, particularly if the soils were overly moist. Use of imported fill may be a more economical alternative. The designer should consider the effect of earthworks on site classification.
- With use of reactive clay soils, close control of moisture content during placement and compaction is required so as to minimise the potential for swelling and shrinkage movement. A moisture content within the range of OMC (Standard Optimum Moisture Content) -1% to OMC +2% is recommended. Foundation design must reflect the use of the potentially reactive clays if they are used as structural fill.
- The weathered sandstone and siltstone should constitute the bulk of the borrow material won from the site excavations. It is considered that the extremely and distinctly weathered material will break down sufficiently during the earthworks operations using large compactors.
- The weathered rock, where broken down on extraction, may be used in areas of structural fill provided no rock over 75mm greatest dimension is included above a plane 300mm below the final subgrade/platform. Below this plane, rocks up to 150mm greatest dimension may be used. These rocks should however not represent more than 20% of the fill make-up. Rocks over 150mm greatest dimension, which cannot be broken down, should be removed.
- Consideration should be given to the exclusion of rock pieces with a greatest dimension of 35mm or greater from areas where trenching and piling may occur, as larger rock pieces could impede the trenching and piling operations.
- Imported general fill material (if required) should be cohesive in nature and be a good quality low plasticity (Liquid Limit of less than 45%, Plasticity Index of less than 15%, Shrink/Swell Index of less than 1.0%) select fill material with a Soaked CBR >10% and a maximum particle size of 75mm.

- Quality testing to confirm imported fill quality should be carried out prior to delivery to site; frequency of testing is subject to assessment by Soil Surveys Engineering, however, a sufficient number of tests should be carried out so that all parties are confident of material characteristics. Quality test results should be reviewed by Soil Surveys Engineering.
- Contractors should submit details of their proposed fill source (with quality certificates) with their tender submission. The proposed fill source should be reviewed by Soil Surveys Engineering prior to awarding the earthworks contract.
- Pavement gravels should comply with Department of Transport and Main Roads quality specification for base, sub-base and blanket materials.

5.2.3 Compaction Procedures & Specifications

- Provided the placement moisture content of the imported fill or select insitu material approximates the optimum moisture content for compaction, suitable compaction should be achievable using typical compaction machinery. The fill material should be compacted in layers not exceeding 250mm, loose thickness. However, layer thicknesses will be dependent on the compaction plant type and size, use of vibration, material type and condition. Final maximum placement layer thicknesses will need to be determined when compaction plant as well as material type and conditions are known. Fill batters should be overfilled and cut-back to design batter angles.
- Guidelines for minimum relative compaction values for insitu soils and imported general fill for the building and pavements are presented in **Table 4**.

Table 4 Minimum Relative Compaction

Location	Minimum Dry Density Ratio
General Fill/Subgrade	98 (1)
Pavement Area	
Base Course	98 (2)
Subbase	98 (2)

Notes:
1. The recommended compactions are percentages of the maximum dry density determined by Australian Standard 1289 (Standard Compaction).
2. For processed pavement gravels, minimum density requirements should be a percentage of maximum dry density in accordance with AS 1289 5.2.1, Modified Compaction.

- Field density testing should be carried out to check the standard of compaction achieved and the placement moisture content. The frequency and extent of testing should be as per guidelines in AS 3798-2007, Section 8.0.
- Backfilling for service trenches, etc. should use good quality material. The backfill should be placed in uniform layers over the full width of the excavations with the layers not exceeding 200mm thickness, loosely placed using wheeled plant and 100mm loose thickness using hand held vibrating plates. The backfill material should be compacted to the specifications outlined above for insitu or imported cohesive material.

5.2.4 Trenching

Shoring of deep trench excavations is recommended. Suitable precautions to satisfy Health & Safety requirements must be adopted. Construction procedures (i.e. operation of plant, storage of materials, etc.) should also consider the nature of the site soils.

5.2.5 Earthworks Supervision

Engineering supervision of the earthworks operations by Soil Surveys Engineering Pty Limited is recommended.

Following production of AS 3798-2007, the terms "Level 1 and 2 Supervision" have been adopted in earthworks specifications to describe what could also be termed Engineering Supervision. Whilst there is no particular problem with using these terms, there does not seem to be wide agreement as to what Level 1 or 2 Supervision actually means or entails.

Regardless of terminology, it should be made clear in any earthworks specification as to what is actually required in terms of certification.

It is recommended that the following objectives (as a minimum) be incorporated into the earthworks specification:-

- Engineering certification that all general earthworks operations (i.e. stripping, proof rolling of subgrade, subgrade treatment, etc.) have been carried out in accordance with the earthworks specification.
- Engineering certification that fill has been placed and compacted to the required minimum density in accordance with the earthworks specification.
- If required, engineering certification that the controlled fill material is suitable to support a conventional slab on ground floor.
- Engineering certification that the quality of any imported fill complies with the earthworks specification requirements.
- Engineering certification that the stability of cut/fill batters and trenches is adequate.

Engineering certification should be provided by a Registered Professional Engineer of Queensland.

Compaction testing (alone) by a testing authority which does not include inhouse RPEQ certification (supported with adequate Professional Indemnity insurance coverage) that geotechnical engineering requirements associated with earthworks operations have been met, is considered inadequate and unacceptable.

Please note that Soil Surveys Engineering in our role as Earthworks Supervisor (under normal circumstances) cannot authorise variations to the contract or the use of provisional items. If the Contractor considers that any recommendation/instruction issued by Soil Surveys Engineering is a variation to the contract, the Contractor should advise the Superintendent and obtain written approval before proceeding with Soil Surveys Engineering’s recommendation/instruction.

5.3 Excavation Characteristics

It is anticipated that excavations will consist of the following:-

- Bulk Cuts - for site stripping and excavation to create building platform.
- Trenching - for high level footings and underground services.
- Drilling - for bored pier foundations.

The assessment of excavation characteristics of soil and weathered rock is normally based on the depth of penetration of the drilling rig using the 'TC' bit attachment. These depths are recorded on the Borehole Record Sheets and summarised in **Table 5**.

Table 5 Summary of Drill Bit Limits

Borehole No	Limit of 'TC' Bit (m)	Borehole Termination Depth (m)
BH01	1.40	1.40
BH02	1.70	1.70
BH03	2.95	2.95
BH04	2.20	2.20

When augering, the bits are attached to the flight auger.

The limit of the 'TC' bit is indicative of the limit of excavations using a small dozer in bulk excavations (Cat D 6) or a medium sized backhoe in trenches (Case 580 or M.F. 50).

Generally, below the 'TC' bit limit, large excavators (say 30 tonne) possibly with hydraulic rock breakers are required for excavation.

Ripping depths can be significantly increased when the rock is bedded, laminated and highly jointed. The nature of the rock and inherent planes of weakness therefore play an important part in rock excavation assessment.

It is considered that excavations could be carried out to the depths of the 'TC' bit limit using the appropriate plant as indicated above. Below the depth of the 'TC' bit limit, larger plant with specialised attachments, e.g. rock breakers, may be required for the proposed construction. Budgeting should be allocated for the possibility of encountering zones of stronger rock.

Vibrations

The effect of vibrations on adjacent structures from excavation works, particularly use of rock breakers, must be carefully considered. Regardless, adequate vibration monitoring and control is recommended.

5.4 Excavation/Boundary Retention

5.4.1 General

It is expected that the proposed basement excavation will be in close proximity to the site boundaries, requiring excavation support. Where limited space does not allow the construction of excavation batters, temporary retention system will be required for the basement. The temporary retention system that may be considered is a pier and panel system.

The temporary retention system above can also be incorporated into the permanent retaining walls, with long term support provided by the internal building floors.

The retention system must be installed prior to excavation works.

5.4.2 Detailed Design

DETAILED RETENTION SYSTEM DESIGN IS REQUIRED; a detailed soil-structure analysis must be carried out to determine an effective retention support system. This design would follow the detailed geotechnical investigation.

The requirement to limit deflections to acceptable levels should be explicit in the brief to retention system designers.

The effect of potential vertical and horizontal movements (resulting from deflection of the retention system) on existing adjacent structures, services, road, etc. must be carefully considered. Services locations and adjacent building foundation systems must be considered in the retention system design.

The design of a support system should take into account overexcavation possibly associated with foundation construction, earthworks, services installation, etc.

UNSUPPORTED EXCAVATIONS ARE NOT RECOMMENDED.

Further, it is recommended that several monitoring stations be set up to check for movement during excavation. A regular monitoring program of these stations should be implemented e.g. twice daily during excavation and daily at any other time.

5.4.3 Pier and Panel System

In this system, piers are drilled (either at close spacing or more widely spaced, up to three diameters), with infill panels; piers are joined at the surface using a capping beam.

The following general construction procedure would be applicable:-

- Install bored piers **with a suitable embedment** into the natural hard clay or weathered rock stratum. This pier and panel option is dependent on suitable pier embedment below final platform level being achieved.
- Construct panels - excavate, install reinforcement between piers and spray with shotcrete.

- Install temporary ground anchors through each pier or install internal propping (as required)
- Continue panel construction (i.e. excavation, installation, reinforcement and shotcrete).

To reduce size (or need) of anchors, the pier spacing could be reduced. Please note that permission to install anchors into adjacent properties would be required.

A maximum panel height of 2.0m is recommended; inspection by Soil Surveys Engineering is recommended at the commencement of construction to confirm panel height.

It is recommended that a capping beam be incorporated into the design. A capping beam has the advantage of joining the tops of the piers together thereby reducing the possibility of excessive movement of the top of a single pier which could increase the potential for toe “kick out”.

A capping beam also provides a convenient location for the first row of anchors (if required), allowing an increase in anchor spacing and not restricting the anchor points to the post positions only. In addition, a capping beam provides a larger bearing surface for the top row of anchors and allows the adoption of larger anchors in the top row.

Anchor Design (if required)

Anchor design should consider the following:-

- Anchor free length should extend from the anchor head to 0.15H (H is total excavation height) behind the design failure plane drawn up at 60° from the base of the cut with a minimum length of 3.0m (temporary only).
- Anchor bond length will depend upon desired anchor capacity, drill hole size and material parameters of intersected material. An allowable bond stress of 50kPa for natural hard clay and 100kPa for DW rock or better could be adopted. It is recommended that pull out tests be carried out during excavation to better assess these values. It is possible that greater values could be used, subject to test results.
- Anchors are designed as temporary.

A minimum pier diameter of 0.60m should be adopted for anchored piers, however, pier diameter is dependent on the moment capacity of the pier section, lateral deflection requirement, boundary conditions, etc.

Design Comments

As noted previously, **detailed retention system design is required**; Soil Surveys Engineering would be pleased to assist with the geotechnical engineering aspects of the design process following the detailed geotechnical investigation.

However, please note that Soil Surveys Engineering do not produce engineering drawings; our geotechnical engineering retention design will be provided in a report which sets out sufficient detail to allow the drafting (by others) of engineering drawings for construction. These drawings should (at least) consist of an elevation showing anchor installation locations (if required) as well as typical sections and other design/construction parameters. Soil Surveys Engineering can provide geotechnical design review of the drawings.

It should be noted that as well as geotechnical design review of drawings, construction inspections (i.e. inspection of piers associated with pier and panel system, inspections during bulk earthworks, etc. - please contact Soil Surveys Engineering for advice) will also be required. **Soil Surveys Engineering is however not able to provide construction inspection services unless we have reviewed and approved any drawings prepared from our report PRIOR TO CONSTRUCTION COMMENCING**.

Further, vertical and lateral movement of soils will occur for any non-anchored system; movements occur as a result of stress release caused by the excavation.

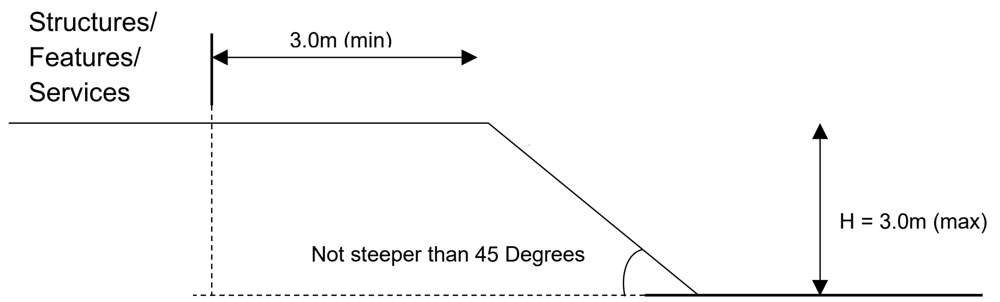
The effect of potential vertical and horizontal movement on the adjacent buildings, road, services, etc. must be carefully considered. Service location must be considered in the retention system design. The construction methods described may need to be modified following detailed design.

5.4.5 Temporary Cut Batters

Where space permits, the following general recommendations are made for short term stability of unsurcharged batters on this site.

- Overall batter angle not steeper than 45°.
- Top of batter minimum of 3.0m from any structure, feature, services, etc.
- Height of temporary cut batter not to exceed 3.0m. Horizontal benches at least 1.0m wide will be required to be constructed where height of cut batter exceeds 3.0m.

Refer to Figure 4 below.



Notes:
1. Buttress width and batter angles highly dependent on soil thickness, rock defects etc., and are subject to inspection by Soil Surveys Engineering at commencement of construction.
2. A batter angle not steeper than of 26° (2H:1V) is recommended for uncontrolled fill material.
3. Planning should consider that natural soils will need to be battered at angles between 26° (2H:1V) and 45°.
4. Planning should consider that weathered sandstone/siltstone will need to be battered at angles between 45° and 60°.

Figure 4

The suitability of this temporary cut batter system is subject to on site assessment by Soil Surveys Engineering prior to commencement of earthworks and following review of

survey/sections, review of advice regarding adjacent structures footing systems, determination of service locations/depth, etc.

Further, inspection of cut batters would need to be carried out by Soil Surveys Engineering, at the commencement of, and during, bulk excavation works, to further assess the stability of temporary cut batters.

Please note that vertical and lateral movement will occur with this option (stress release caused by excavation). The temporary batter option will not be suitable in movement sensitive areas.

It is recommended that several monitoring stations be set up to check for movement during excavation. A regular monitoring program of these stations should be implemented e.g. twice daily during excavation and daily at any other time.

5.4.6 Retaining Walls

It is recommended that any retaining structure be designed in accordance with AS 4678-2002 'Earth Retaining Structures'. Section 3 of this code outlines the design requirements for retaining structures which specifically includes both Ultimate and Serviceability Limit Modes. It is recommended that the retaining structures be assessed for each of these modes.

Please note that the following section provides general recommendations with respect to some of these limit modes, however, it doesn't provide a detailed assessment in full accordance with the above mentioned modes for AS 4678. A detailed assessment can be undertaken of the geotechnical aspects of the Limit Modes for the proposed retaining structures once details of the wall have been provided.

For cantilever walls, or temporarily braced walls, which allow movement at the top, i.e. at least 0.005H in clays, the active case (Ka) applies with a triangular distribution. For walls which cannot tolerate this movement, the at rest (Ko) case applies with a triangular distribution.

Lateral pressure assessment must also consider hydrostatic pressure and surcharge loadings.

The following parameters (unfactored) may be adopted for wall design (refer to **Table 6**).

Table 6 Parameters for use in Retaining Wall Design

Material	Density (kN/m^3)	Earth Pressure Coefficient Vertical Wall			Long Term Drained Ø
		Active ‘Ka’	At Rest ‘Ko’	Passive ‘Kp’	
Fill Materials	18	0.41	0.58	2.46	25°
Natural Clay Soils	19	0.39	0.56	2.56	26°
Natural Clayey Sand (XW Sandstone)	20	0.29	0.46	3.39	33°
DW Siltstone	23	0.33	0.50	3.00	30°
DW Sandstone	23	0.27	0.43	3.69	35°

Notes:
1. These values of earth pressure coefficient ignore the effect of wall friction.
2. These values do not account for backslope.

Any backfill placed behind the wall should be loose granular material. The backfill should not be heavily compacted since research has shown that compaction can raise the earth pressure to above the 'at rest' pressure.

Adequate surface and subsoil drainage should be provided for all retaining walls on the site. Cut-off / interceptor drains should also be provided around the high side of the wall to ensure stormwater runoff from the area above the wall is suitably diverted.

The placement of a filter fabric between the retained soil and the drainage material (e.g. granular backfill) for protection against silting of the drainage material is recommended. The outlets to subsoil pipe drains must be located beyond the ends of the walls and connected to a proper drainage system. It is suggested the pipes be wrapped in filter fabric to minimise silting.

In weather exposed locations, to reduce infiltration by surface runoff, the surface of the backfill should be sealed. This can be achieved by either compacting a material of low permeability, i.e. on site clay, or concrete, with a slope towards an open drain.

Due to possible long term problems with blocking of gravel filters and drains and short term storm conditions that could flood the fill behind retaining walls, it is recommended that all retaining walls be designed for some water pressure distribution.

During installation of any retaining walls, the insitu soils should be battered back to minimise fall-in and subsequent disruption of works. Suitable precautions to satisfy Health & Safety requirements must also be adhered to.

5.4.7 Dilapidation Survey

Adjacent buildings, road and underground services are located adjacent to proposed works.

It is recommended that a dilapidation survey of adjoining structures, road, etc. be carried out in order to establish their present condition prior to commencement of construction.

This survey should include the following:-

- The general condition of the property, i.e. condition of all exposed walls, pavement condition, etc.
- The extent of existing damage (if any)
- Photographs/video

Actual locations of underground services and adjacent building foundation systems should be established prior to construction.

5.4.8 Underpinning

Considering the proposed development and taking into account the location of the structure, the footings of the existing structures/features need to be checked and may possibly need to be underpinned. The underpinning options and amount of support required is determined by several factors. Of most significance:-

- Depth of footings to be underpinned;
- Type of footings to be underpinned;
- The depth of excavation proposed adjacent to or in the vicinity of the existing footings;
- Strength of the founding material.

Further assistance can be provided with any underpinning details, if required, once planning has further advanced and details of the existing and proposed footings are available. Also, refer to Section 5.7.5.

5.5 Site Classification

5.5.1 AS 2870 ‘Residential Slabs and Footings’

While a site classification in accordance with AS 2870 'Residential Slabs and Footings' relates to residential type construction and is not directly applicable for this development, it is, however, a valuable method of classification.

In assessing the site classification in accordance with AS 2870 'Residential Slabs and Footings', the following has been considered:-

- The subsurface profile (as per borehole records).
- Laboratory test results.

- Geotechnical data held by Soil Surveys Engineering.
- That the site is considered to be a reactive site (as per AS 2870-2011).
- That the site is subject to abnormal moisture conditions due to the presence of trees, (on the building site and adjacent sites) and existing buildings and proposed removal of the existing buildings or trees (as per Clause 1.3.3 of AS 2870-2011).
- The presence of uncontrolled fill deeper than 0.4m.

Considering the above, at this site abnormal soil moisture conditions are likely to prevail in the short to medium term. On this basis, future ground movements are likely to be affected by the expected abnormal soil moisture conditions and therefore the site must be classified as a Class ’P’ site in accordance with AS.2870-2011. Class ‘P’ does not signify any particular severity of potential problems but rather that the site is disqualified from the other classes and therefore requires special consideration using engineering principles.

5.5.2 Plumbing, Drainage and Onsite Sewerage Works

The soil classification to AS 2870 for the purpose of design of plumbing, drainage and onsite sewerage works (Form 1 Section 5 - Permit Work Application) is Class ‘M’ where natural clay soils are present and Class ‘S’ where weathered rock is exposed.

5.6 Site Reactivity

If this reactive site is assessed to be subject to ground surface movement predominantly due to soil reactivity **under normal moisture conditions**, a characteristic surface movement (ys) within the Class ‘M’ range (ys = ≤ 40mm) could be calculated (considering the proposed development, existing subsurface profile as per boreholes records, laboratory test results, and considering other relevant geotechnical data held by Soil Surveys Engineering) for the full natural clay profile using a Hs of 1.8m and a 50% crack depth; please note that tree induced movement would be additional to this value (refer below).

The above ground surface movement (ys) estimates would be reduced where clay thicknesses are limited, i.e. if weathered Sandstone/Siltstone exists within 0.5m of platform level, Class ‘S’ conditions exist.

Trees can greatly affect ground surface movement (greater movements than what would be expected may occur), and subsequently negatively impact structures.

The footing system should be designed for the effect of trees, with the Designer (Soil Surveys Engineering are not the Designer) considering the following cases (as appropriate):-

- Existing trees are left in place.
- Existing trees are removed prior to construction/development.
- New trees are subsequently planted.

AS 2870-2011 includes an informative section (refer Appendix H) on the design of footings for trees and in particular the calculations of the maximum potential surface movement due to the tree-induced suction change (that is in addition to the normal design suction profile). The Designer should refer to AS 2870-2011 for detailed discussion on this matter.

5.7 Building Foundations

5.7.1 Foundation Options

Following bulk excavations to the basement level, it is expected that extremely or distinctly weathered sandstone/siltstone will be exposed across most of the basement building footprint. Natural very stiff (or stronger) clay materials will likely be encountered at the rear of the site basement.

Depending on the design loads, high level footings comprising pedestal, strip and pad footings or a stiffened raft slab may be adopted for the proposed building. Where loads preclude high level footings, deep footings may be required. Allowable bearing pressures for high level and deep footings are given in Sections 5.7.2 and 5.7.3 respectively.

5.7.2 High Level Footings

The design of high level footings including pedestals, pads, strips and the ground beams of stiffened rafts founding at a minimum depth of 0.5m into natural hard sandy clay or dense clayey sand based soils (extremely weathered, extremely low strength sandstone rock) or low strength siltstone/sandstone below the basement floor can be based on the allowable bearing pressures presented in **Table 7**. Footings should extend though all fill and natural soils that are not dense or hard in consistency.

Table 7 outlines recommended allowable bearing capacities for high level footings.

Table 7 Allowable Bearing Capacities

Material		Allowable Bearing Capacity (kPa)	
		Strip Footing	Pad Footing
Fill	- Uncertified	NR	NR
Natural Clays	- Stiff and Very Stiff - Hard	NR 350	NR 400
Natural Clayey Sand (XW Rock)	- Dense	450	500
Sandstone/Siltstone (DW)	- Low Strength	600	750
Notes: 1. NR = Not Recommended.			

If footings are designed in accordance with the information presented in **Table 7**, high level footing settlements are not expected to exceed 1% of the footing width.

Footings and floors founding in different strata (ie. natural soils or weathered rock), may result in potential differential settlements across the building footprints. Differential settlements equal to 50% of the predicted settlements are expected. If these settlements are excessive, all footings should be founded within consistent strata, preferably weathered rock.

Where required, such as in areas of uncontrolled fill or weaker materials, footings may be made up of mass concrete poured to the underside of the footing, or alternatively, footings may be constructed over mass concrete filled, backhoe excavated pedestals.

All shallow footing bases must be thoroughly cleaned of all loose soil and rock debris prior to construction and inspected by a representative of this office to confirm the allowable bearing pressures presented in **Table 7**.

If footings cannot be poured on the same day as the excavation, a concrete blinding layer of at least 50mm thickness is recommended.

5.7.3 Deep Foundations

If high level footing founding depths are considered to be excessive, wall or column loads are high or ground surface movements cannot be tolerated, a deep foundation system may be considered.

Given the materials encountered, bored piles are considered a suitable system for deep footings on this site.

It is recommended that all piles be socketed at least 3 diameters into the natural hard clays or dense clayey sand (XW rock) or low strength siltstone/sandstone. Bored piles can be designed using the ultimate compressive geotechnical pressures presented in **Table 8**.

The design of a deep foundation system should consider the following:-

- Capacity
- Construction considerations

It is recommended that the deep foundation system on this project be designed in accordance with AS 2159-2009 'Piling - Design and Installation'. This code uses the limit state design method.

Compressional Capacity

The design of a single pile or a pile group must be such that both the geotechnical design strength $R_{d,g}$ and the structural design strength $R_{d,s}$ are greater than or equal to the design action effect E_d*, i.e.

$$R_{d,g} \geq E_d \text{ and } R_{d,s} \geq E_d$$

The design geotechnical strength ($R_{d,g}$) can be calculated as the ultimate geotechnical design strength ($R_{d,ug}$) multiplied by the geotechnical strength reduction factor $Ø_g$. Ultimate design geotechnical strength ($R_{d,ug}$) parameters for the materials encountered on the site are outlined in **Table 8**.

Table 8 Ultimate Geotechnical Strength (R_{ug}) Parameters

Material		f_b - Base Bearing (kPa		$f_{m,s}$ - Skin Friction (kPa)
		D/B<4	D/B>4	
Fill Material		NR	NC	NC
Natural Clay Soils	- Stiff - Very Stiff - Hard	NR NR 1200	NR NR 1800	30 45 60
Clayey Sand (XW Rock)	- Dense	2500		90
Weathered Sandstone/Siltstone (DW Rock)	- Low Strength	3500		150

Notes:
1. NR = Not Recommended; NC = Not Considered in skin friction calculations.
2. D = Pier Depth; B = Pier Diameter.
3. Ultimate geotechnical strength for compression can be determined from $R_{d,ug} = f_b A_B + A_s f_{m,s}$.
4. Recommended geotechnical strength reduction factor ($Ø_g$) - Refer Table 4.3.2(c) AS 2159. Without considering the structural design of the building, structure footings and piling system adopted, a ($Ø_g$) of 0.5 is recommended when assessing the design geotechnical strength.
5. Considering limit state analysis (AS 2159-2009), the design geotechnical strength R^*_g is calculated by multiplying the ultimate design geotechnical strength $R_{d,ug}$ by the geotechnical strength reduction factor $Ø_g$, i.e. $R^*_{d,g} = R_{d,ug} \times Ø_g$.
6. Should a "working stress" approach be adopted, a minimum factor of safety of 3.0 on base and 2.0 on skin friction is recommended.
7. Skin friction contribution from clays in the upper 1.8m of the profile should be ignored.
8. The above parameters are for single piers. If piers are spaced at closer than three diameters, a reduction factor (Group Efficiency Ratio) may apply.
9. Base bearing and skin friction parameters to be confirmed by inspection by Soil Surveys Engineering.
10. If there is any doubt about strength of underlying rock, a reduced value may need to be used.
11. For uplift loading the shaft friction values shown in **Table 8** above should be factored by 0.7.

The total long term settlements of bored piles designed in accordance with the information given in this section should be limited to 20mm. Differential settlements should not exceed 50% of the total settlements.

Allowance for Settlements

Differential settlements will occur between piled and non-piled areas should high and deep footing systems be adopted.

It is important that appropriate allowances be made for settlement/differential settlement. As a minimum, we suggest the following:-

- Any elements that are assessed to be unable to tolerate potential settlement/differential settlements should be piled.
- Use flexible connections to all services. Sleeve downpipe connections to allow for vertical movements.
- Hang services from the underside of any piled structures.
- Do not connect free standing structures to piled structures without appropriate articulation, i.e. no rigid connection between piled and non piled areas.

- Use soft finishes between piled and non piled areas.
- Driveways - use a relieving slab, hinged at building. Alternatively, consideration could be given to the use of pavers allowing relevelling at future stages.

Construction Considerations

Some difficulty with fall-in may occur with bored piles. It should be ensured that all loose material is removed from the base of piers prior to pouring of concrete. The use of a 'clean-out' bucket should be explicit in instructions to the drilling contractor. The practice of 'using water and spinning the augers' to remove loose material from the pier base is generally unacceptable.

If seepage or groundwater is encountered during bored pile drilling, special treatment will be required. This may vary between removal of the water and water affected material prior to concrete placement (where the inflow rate is low) or lining the holes with steel liners socketed into low permeability material to achieve an impermeable seal against any water charged soils above. If seepage into the pile hole still occurs, it may be controllable by pumping, otherwise the piles will have to be constructed under water using tremie methods. Shaft adhesion must be ignored for the portion of the pile that is permanently lined.

Drilling piles is not only dependent on the subsurface material characteristics but also the type (power and size) of the bored pile drilling rig, drilling teeth, size of pile, etc. It is recommended that a specialist drilling contractor be consulted to be able to manage the above conditions and materials encountered.

During construction, all bored piles must be inspected by an experienced geotechnical engineer or engineering geologist to confirm the geotechnical strength parameters presented in Table 9 and to check the capacity of the piles.

5.7.4 Slab on Ground

Field and laboratory test results indicate that the existing natural soils/weathered rock, along with any controlled fill, are suitable for slab on ground construction provided that earthworks are carried out in accordance with Section 5.2 and that appropriate engineering certification is provided (refer to Section 5.2.5).

Slab on ground floor options that can be considered also include:-

Stiffened Raft

A stiffened raft comprises perimeter and internal beams and is designed to accommodate potential ground surface movements.

This option generally does not suit large slab areas.

Basement Carpark Slab

For design purposes, it is recommended that the basement slab be designed adopting principles as contained in the Cement & Concrete Association of Australia, Industrial Floors & Pavements, Guidelines for Design, Construction & Specification.

Based on borehole record sheets, it is envisaged that natural clay and weathered sandstone/siltstone will likely be exposed at basement level over the site following the excavation works.

For the preliminary design purpose (but subject to inspection), the following subgrade CBR values can be considered:

- 5% - Natural Sandy Clay (CI-CH) and Weathered Siltstone
- 7% - Natural Clayey Sand (SC) (XW Rock)
- 10% - Weathered Sandstone

Following the subgrade preparation, CBR testing must be carried out on the subgrade to confirm the preliminary assigned designed values given above.

5.7.5 Adjacent Feature/Excavation Considerations

Where proposed or existing (e.g. neighbouring property) footings/piers are located adjacent to proposed or existing feature/excavations (e.g. retaining walls, underground service trenches, unsupported batters, etc.), the effect of the feature/excavation on proposed or existing footings/piers must be carefully considered. Deepening of proposed footings/piers is expected to be required in such circumstances; existing footings may need to be underpinned (or similar).

Soil Surveys Engineering and the Structural Engineer should be consulted on this matter prior to construction.

For underground service trenches (as a general guide) proposed footings and piers should extend to base a minimum of 500mm and 1.0m respectively below the feature/excavation base level for a distance of 1.0m out from the feature/excavation. Beyond 1.0m the footings and piers should be taken a minimum of 500mm and 1.0m respectively below an imaginary line (influence line) drawn up at 45° (1H:1V) from the feature/excavation base level. Note that actual depths (Soil Surveys Engineering should be consulted on this matter prior to construction) below the influence line will depend on footing/pier capacity and possible uplift considerations. Figure 5 refers.

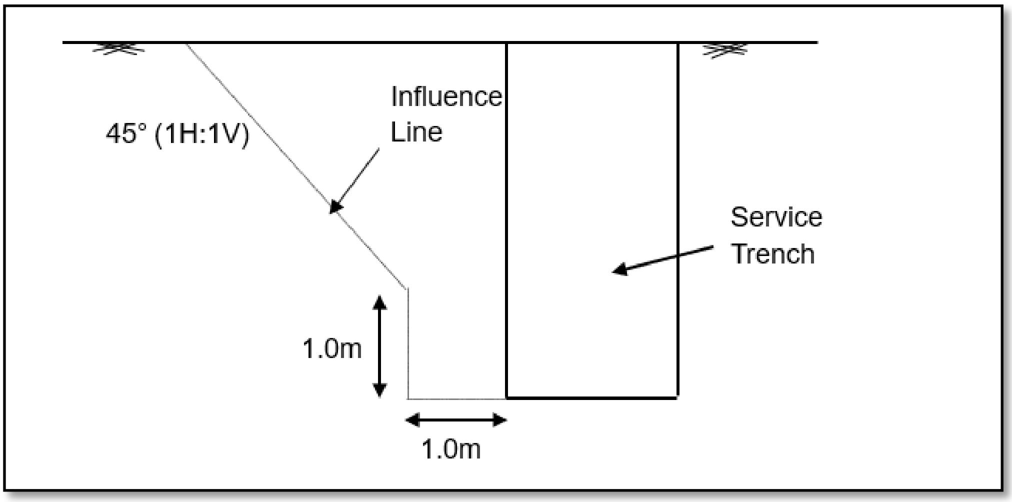


Figure 5

For all other feature types including the existing footings/piers that are located adjacent to a proposed feature/excavation, Soil Surveys Engineering and the Structural Engineer should be consulted prior to construction.

5.8 Articulation and Detailing

Given the potentially reactive nature of the subsurface material, the importance of architectural and structural detailing cannot be over-emphasised. It is essential that the building be suitably articulated/detailed to allow for ground surface movement. In addition, the overall design of the building and surrounds should consider the reactive soils, with the objective being to maintain a stable moisture environment. Your attention is drawn to recommendations contained in Section 5.9.

It is recommended that any masonry walls be articulated. This articulation may be achieved by the use of full height (footings to eaves) openings or vertical construction joints at regular intervals. Guidelines on articulation are contained in the Cement and Concrete Association's Technical Note 61, 'Articulated Walling'.

5.9 Site Management

It is important that proper site management methods be observed for the existing soil conditions by both the builder at the time of the construction and the owner(s) throughout the life of the proposed development.

Particular reference to site management matters is set out in AS 2870-2011. It should be noted that where proper site management, particularly with respect to change in moisture conditions, is not followed, the foundation recommendations contained in this report could be considered void.

The following are some specific comments with respect to site management and the reader is also directed to CSIRO publication, “Foundation Maintenance and Footing Performance: A Homeowners Guide” (Building Technology File 18) for further information:-

- It is important that the site be well drained. The ground around the structures should slope away at 1 in 50 for 3 metres and then fall to the stormwater system to prevent ponding of water adjacent to the structures.
- Roof downpipes and garden taps should not be allowed to saturate founding soils.
- It is recommended that service trenches under the building be minimised, as disruption or breakage of these service lines could lead to saturation of the under slab material resulting in an increase to moisture condition. If this were to occur, all footing recommendations contained within this report would be void.
- Footings should be placed with minimal delay after excavation to avoid desiccation or wetting of the founding soils. If footings cannot be poured on the same day as excavation, a blinding layer of 75mm thickness is recommended. Piers should be poured immediately.
- Do not let the slab subgrade "dry out" prior to casting.

- Future shrubs and trees should be planted at a distance at least equivalent to their mature height away from the building to avoid shrinkage movement in the potentially expansive founding soils. Existing trees that may encroach this restriction should be removed as soon as possible prior to commencement of construction to enable soil moisture to reach. equilibrium conditions.

6.0 Construction Inspections

It is recommended that placement of all structural fill, footing excavations, and cut batter slopes in soil and rock together with pavement subgrades should be inspected by Soil Surveys Engineering Pty Limited or a duly qualified Geotechnical Engineer. Should subsurface conditions other than those described in this report be encountered, Soil Surveys Engineering Pty Limited should be consulted immediately and appropriate modifications developed and implemented if necessary.

7.0 Steep Slope Overlay Assessment

It is understood that parts of the site are subject to the Landslide Hazard and Steep Slope Area Overlay.

Field observations and review of the survey plan indicate that the site slopes slightly from the entrance to the rear and that the areas indicated on the steep slope overlay are based off Lidar readings from the existing onsite retaining structures.

Based on geotechnical conditions encountered during the investigation carried out, the site is considered suitable for the proposed development provided that all recommendations in this report are considered, addressed and implemented.

8.0 Limitations

We have prepared this report for the use of **Watland Pty Ltd**, for design purposes in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made as to the professional advice included in this report. This report has not been prepared for use by parties other than **Watland Pty Ltd**; it may not contain sufficient information for purposes of other parties or for other uses. Please note that any third party relying on the information contained in this report for any purpose whatsoever does so entirely at its own risk, and any duty of care to that third party is excluded.

Any interpretation or recommendation given by Soil Surveys Engineering shall be understood to be based on judgement and experience and not on greater knowledge of the facts than the reported investigations would imply. The interpretation and recommendations are therefore opinions provided for our client's sole use in accordance with the specific brief. As such they do not necessarily address all aspects of ground behaviour on the subject site. Information provided by others has been taken in good faith, but no liability can be accepted for information provided by others.

Your attention is drawn to ‘Appendix A’, ‘Notes Relating to this Report’. Interpretation of factual data given in this report is based on judgement, not a greater knowledge of facts other than those reported.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore consider the spacing and depth of test locations, the method of investigation, the frequency of sampling and testing and the possibility of other than “straight line” variations between the test locations. Subsurface conditions between and below test locations may vary significantly from conditions encountered at the test locations.

Please note that should, following detailed design, footings or piers/piles be required to extend within 3B (B = footing width/pier diameter) above the termination level of the boreholes/DCP or any excavations extend below borehole/DCP termination levels, Soil Surveys Engineering should be contacted immediately. In this case, geotechnical data in this report should be considered preliminary only; additional investigation is likely to be required.

If conditions encountered on site during construction appear to vary from those expected from the information contained in the report, the Company strongly recommends that it immediately be notified. Most problems are more readily resolved when conditions are exposed than at some later stage, after the event. Should Soil Surveys Engineering not be notified or if this notification is delayed, then Soil Surveys cannot be held responsible for the affect that any variation has on any aspect of the development.

Soil Surveys Engineering consider that a documentation review service (during the design phase and prior to construction) to verify that the intent of geotechnical recommendations is properly reflected in the design, along with construction inspections, forms a very important component of the geotechnical engineering design service/process.

The geotechnical review ensures geotechnical risks to our client and their project are minimised at the design and tender stage of the project. Further, with Soil Surveys Engineering being commissioned to carry out geotechnical construction inspections, an opportunity at the time of construction to confirm any assumptions made in the preparation of the report and allow the effect of any normally occurring variation in ground conditions to be assessed with respect to construction becomes available.

The above statements are not intended to reduce the level of responsibility accepted by Soil Surveys Engineering in accordance with our commission, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so and the risks they accept should they decline to have Soil Surveys Engineering carry out a geotechnical documentation review and geotechnical construction inspections.

Davor Dragun (RPEQ 16310)
Senior Geotechnical Engineer

For and on behalf of
Soil Surveys Engineering Pty Limited

Appendices

Appendix A
Notes Relating to this Report

INTRODUCTION

These notes are provided by Soil Surveys Engineering Pty Limited (the Company) to complement the geotechnical report in regard to classification methods and field procedures. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited information about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such information obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and at the time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

Soils - The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726-2017 (Geotechnical Site Investigations), where appropriate. In general, descriptions cover the following properties - soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the dominant particle size and behaviour as set out in AS 1726-2017.

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, shear vane, laboratory testing or engineering examination. The strength terms are defined in AS 1726-2017 Table 11.

Non-cohesive soils are classified on the basis of relative density usually based on insitu testing or engineering examination (see AS 1726-2017 Table 12).

Rocks - Rock types are classified by their geological names (AS 1726-2017 Tables 15 to 18), together with descriptive terms regarding weathering (AS 1726-2017 Table 20), strength (AS 1726-2017 Table 19), defects (AS 1726-2017 Table 22), etc.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon sample disturbance, (information on strength and structure).

Undisturbed samples are taken by pushing a thin walled sample tube, usually 50mm diameter (U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength, volume change potential and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

SAMPLE STORAGE – SOIL, ROCK AND WATER SAMPLES

Soil samples (not subject to testing) are not stored beyond a period of 90 days of taking or receiving said soil sample. Rock core (not subject to testing) is not stored beyond a period of six months of taking or receiving said rock core.

Should any party require that soil samples (not subject to testing) be stored beyond 90 days, or rock core (not subject to testing) be stored beyond six months, please contact Soil Surveys Engineering.

Water samples (not subject to testing) are not stored beyond a period of seven days of taking or receiving water samples.

TEST LOCATIONS

Test locations (e.g. boreholes, CPT's, test pits etc.) were based on available access at the time of testing. Test locations may have been shifted if access was not suitable.

Unless noted otherwise, accuracy of test locations are to the accuracy of hand held GPS equipment.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application.

Test Pits - These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to approximately 3.0m for a backhoe and up to 6.0m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling - A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Refusal of the augers can occur on a variety of materials such as hard clay, gravel or rock fragments and does not necessarily indicate rock level.

Continuous Spiral Flight Augers - The borehole is advanced using 75mm to 300 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the augers. Information from the drilling (as distinct from specific sampling) is of relatively lower reliability due to remoulding, inclusion of cuttings from above or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table has a lower reliability than augering above the water table. Various drill bits are attached to the base of the augers during the drilling. The depth of refusal of the different bit types can provide information as to the strength of the material encountered. Generally the 'TC' bit (a tungsten carbide tipped screw type bit) is used.

Wash Boring - The borehole is usually advanced by a rotary bit with water or fluid pumped down the hollow drill rods and returned up in the space between the rods and the soil or casing, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration. More accurate information on soil strata is gained by regular testing and sampling using the Standard Penetration Test (SPT) and undisturbed thin walled tube samples (U50).

Mud Stabilized Drilling - Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilize the borehole. The term "mud" encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from regular intact sampling (e.g. from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling - A continuous core sample is obtained using a diamond or tungsten carbide tipped core barrel. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable method of investigation. In rocks, NMLC coring (nominal 52 mm diameter) is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses is determined on site by the supervisor. If the location of the loss is uncertain, it is placed at the top end of the run, when the core is placed in a storage tray and recorded on the log.

Standard Penetration Tests - Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils, as a means of indicating density or strength. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" - Test 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm, the upper 150 mm being neglected due to possible disturbance from the drilling method. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued at a reduced penetration.

In the case where full penetration is obtained with successive blow counts for each 150 mm of, say 4, 6 and 7 blows, the record shows,

4, 6, 7 N = 13

In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm, the record shows:

15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, it is noted on the borehole logs.

A modification to the SPT test is where the same driving system is used with a solid 600 tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid SPT are shown as "N_c" on the borehole logs, together with the number of blows per 150 mm penetration.

Cone Penetration Tests - Test Method - Cone Penetration Tests (CPT) are carried out in accordance with AS 1289 Test 6.5.1-1999, using an electrical friction-cone penetrometer.

The test essentially comprises the measurement of resistance to penetration of a cone of 35.7 mm diameter pushed into the soil at a rate of 10-20 mm per second by hydraulic force. The resistance to penetration is recorded in terms of pressure on the end area of the cone (cone resistance, q_c, in MPa) and friction on the side of the 135 mm long sleeve immediately above the top of the cone (friction resistance, f_s, in kPa). These forces are measured by electrical transducers (strain gauges) within the cone device. The ratio between friction resistance and cone resistance is also calculated as a percentage, i.e.-

$$\text{Friction Ratio (FR)} = \frac{\textit{Friction Resistance},\ f_s\ (kPa)\ x\ 100}{\textit{cone resistance},\ q_c\ (kPa)}$$

The friction ratio, FR, is generally low in sands (less than 1% or 2%) and generally higher in clays (say 3% or more). The interpretation of sandy clays, clayey sands and material with a high silt content is more difficult, but intermediate values (between 1% and 3%) would be expected. Highly organic clays and peats generally have a friction ratio in excess of 5%.

Static cone data is recorded in the field on disc for later presentation using computer aided drafting.

The equipment can be operated from any conventional drill rig. A total applied load in the range of 4 to 10 tonnes is required for practical purposes, although lighter loads may be used. The cone penetrometers are available with various capacities of cone resistance ranging up to 100 MPa for general purpose investigations, while a range of 0 to 10 MPa can be used where more sensitive investigations of soft clay are required.

The cone resistance value provides a continuous measure of soil strength or density, and together with the friction ratio, provide very useful indications of the presence of narrow bands of geotechnically significant layers such as thin, soft clay layers or lenses of sand which might otherwise be missed using conventional drilling methods.

The lithology of the encountered soils is interpreted from static cone data and is generally presented on the static cone log sheets.

It is important to note that the lithology is interpreted information and is based on research by Schmertmann (1970), Sanglerat (1972), Robinson and Campinalli (1986), modified to suit local conditions as indicated by borehole information and laboratory testing.

As soils generally change gradually it is sometimes difficult to accurately describe depths of strata changes, although greater accuracy is obtained with the static cone compared with conventional drilling. In addition, friction ratios decrease in accuracy with low cone resistance values, and in desiccated soils. As a result, some overlap and minor discrepancies may exist between static cone and nearby borehole information.

Portable Dynamic Cone Penetrometers - Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 100mm increments of penetration.

The DCP comprises a Cone of 20 mm diameter with 30 degree taper attached to steel rods of smaller section.

The cone end is driven with a 9 kg hammer falling 510 mm (AS 1289 Test 6.3.2). The test was developed initially for pavement subgrade investigations, and empirical correlations of the test results with California Bearing Ratio have been published by various Road Authorities. The Company has developed their own correlations with Standard Penetration tests and Density Index tests in sands.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems.

- Although groundwater may be present in lower permeability soils, it may enter the hole slowly or perhaps not at all during the time the hole is open.
- A localized perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be bailed out of the bore and mud must be washed out of the hole or "reverted" if water observations are to be made.

More reliable measurements can be made by use of standpipes which are read after stabilizing at periods ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (e.g. bricks, steel, etc.) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is important to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms and the attached explanatory notes summarize important aspects of the Laboratory Test Procedures adopted.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. The information provided in Soil Surveys Engineering reports is opinion and interpretation and not factual. The client/contractor increases their risk by not retaining the person who authored the geotechnical report, to carry out site inspection and review (overseeing role) during construction, to confirm opinion and interpretation expressed in the report is accurate. 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. If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. Since the test sites in any exploration represent a very small proportion of the total site and since the exploration only identifies actual ground conditions at the test sites, even under the best circumstances actual conditions may vary from those inferred to exist. No responsibility is taken for:-

- Unexpected variations in ground and/or groundwater conditions.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of other persons.
- Any work where the company is not given the opportunity to supervise the construction using the Companies designs/recommendations.

If differences occur, the Company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are more readily resolved when conditions are exposed than at some later stage, well after the event.

Extreme events including but not limited to the results of climate change, e.g. flood levels above previously identified levels, beach scour or erosion beyond normal expectations (as identified by local authorities) extreme rainfall events, war, espionage, sabotage may result in different conditions between time of investigation and time of construction.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Construction Contracts (1987)", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances, where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

REVIEW OF DESIGN

Where major civil or structural developments are propose <u>or</u> where only a limited investigation has been completed <u>or</u> where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer. We would be happy to assist in this regard as an extension of our investigation commission. Construction drawings should be reviewed by Soil Surveys Engineering, with sufficient time to allow changes if required, prior to inspections. Otherwise Soil Surveys Engineering reserves the right to refuse to carry out inspections.

SITE INSPECTION

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

i. Site visits during construction to confirm reported ground conditions
ii. Site visits to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, the stability of a filled or excavated slope; or
iii. Full-time engineering presence on site.

In the vast majority of cases it is advantageous to the principal for the geotechnical engineer who wrote the investigation report to be involved in the construction stage of the project.

The geotechnical engineer cannot take responsibility for variations in encountered conditions, where he is not given the opportunity to review plans for the proposed development with sufficient time to allow review and make changes to the proposed development if required, and where he is not given the opportunity to inspect the site and oversee construction methods with regard to site conditions with sufficient time to observe all relevant site conditions and operations.

RESPONSIBLE USE OF GEOTECHNICAL INFORMATION

Recommendations in our report are for design purposes only and provided on the basis that inspections are carried out to allow finalisation of opinions and recommendations contained in our report.

The geotechnical investigation consisting of field and laboratory testing has been carried out to indicate typical conditions by indicating conditions and parameters at the specific locations of boreholes/test pits. Subsurface conditions are indicated at these locations only and the inference of conditions between or away from these locations (interpolation and extrapolation) involves a certain degree of risk. Persons inferring such conditions or carrying out such inferences should do so with a degree of caution and conservatism which is commensurate with the consequences of the risk of error.

Estimates of volumes based on our findings require interpolation and extrapolation between test locations and as such may be significantly different from actual volumes.

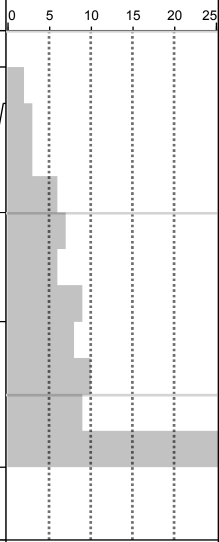
Appendix B
Borehole Record Sheets

BOREHOLE: BH01

SOIL SURVEYS

Job No	: 1-29680	Easting	: 512983.00	Sheet	: 1 OF 1
Client	: Watland Pty Ltd	Northing	: 6944330.00	Logged	: Rick Hayward
Project	: Proposed Apartment Development	RL	: 30.25 m	Logged Date	: 14/11/2025
Location	: 21-23 Watland Street, Springwood	Drill Rig	: CDR-2	Checked	: DD

Drilling Method	Water	Depth (m)	Graphic Log	Material Description	DCP	Samples and Remarks
		0.1		PAVEMENT Concrete 1x layer of reinforcing.		
		0.2		FILL Silty SAND (SM): very loose, fine to coarse grained, dark brown, trace of fine to medium size gravel, moist.		
		0.5		FILL Sandy CLAY (CL): very stiff, low plasticity, dark brown mottled dark grey, fine to coarse grained sand, trace of fine to medium size gravel, moist, tending to clayey sand.		0.20-0.50, D
		0.8		NATURAL CLAY (CI): hard, medium plasticity, light brown mottled orange brown, trace of fine to coarse grained sand, trace of fine size gravel, moist.		0.50-0.80, D
		1.2		NATURAL Silty CLAY (CL-CI): hard, low to medium plasticity, light grey mottled light brown, trace of fine to medium grained sand, trace of fine size gravel, moist.		0.60-0.85, U50 PP>600
				SILTSTONE (DW): distinctly weathered, low strength, light grey white mottled light brown, fine to medium grained, moist.		



BH01 Refusal at 1.4 m

Comments

1. Ground water not encountered.
2. Terminated at 1.40m.
3. RL's approximated from provided survey plan.

Key

U - Undisturbed Tube	XW - Extremely Weathered
D - Disturbed (small)	DW - Distinctly Weathered
B - Bulk Disturbed (large)	Groundwater Observed
ASS - Acid Sulfate Soil	Standing Water
PP - Pocket Penetrometer	
VS - Vane Shear	

Approved By: DD

Approval Date: 09/12/2025

SOIL SURVEYS

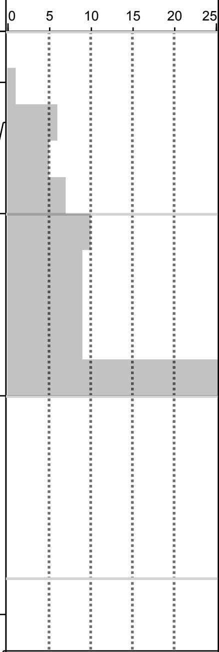
BOREHOLE: BH02

Job No	: 1-29680	Easting	: 513012.00	Sheet	: 1 OF 1
Client	: Watland Pty Ltd	Northing	: 6944321.00	Logged	: Rick Hayward
Project	: Proposed Apartment Development	RL	: 29.85 m	Logged Date	: 14/11/2025
Location	: 21-23 Watland Street, Springwood	Drill Rig	: CDR-2	Checked	: DD

Depth (m)	Material Description	Samples and Remarks
0.14	PAVEMENT Concrete 1x layer of reinforcing.	
0.25	FILL Sandy CLAY (CL-CI): stiff, low to medium plasticity, dark brown, fine to coarse grained sand, trace of fine to medium size gravel, moist.	
0.5	NATURAL Sandy CLAY (CI): hard, medium plasticity, light brown mottled orange brown, fine to coarse grained sand, trace of fine to medium size gravel, moist.	0.25-0.50, D
1	NATURAL Sandy CLAY (CL): hard, low plasticity, mottled orange brown light brown light grey, fine to coarse grained sand, trace of fine to medium size gravel, moist.	0.50-0.80, D 0.60-0.70, U50 nil recovery crushed tube
1.6	Extremely weathered SANDSTONE (XW): recovered as Clayey Sand - very dense, fine to coarse grained, mottled red brown light grey, low plasticity fines, moist.	1.00-1.50, D
	SANDSTONE (DW): distinctly weathered, low strength, light grey white mottled red brown, fine to coarse grained, moist.	

BH02 Refusal at 1.7 m

DCP



Comments

1. Ground water not encountered.
2. Terminated at 1.70m.
3. RL's approximated from provided survey plan.

Key

U - Undisturbed Tube
D - Disturbed (small)
B - Bulk Disturbed (large)
ASS - Acid Sulfate Soil
PP - Pocket Penetrometer
VS - Vane Shear
XW - Extremely Weathered
DW - Distinctly Weathered
Groundwater Observed
Standing Water

Approved By: DD

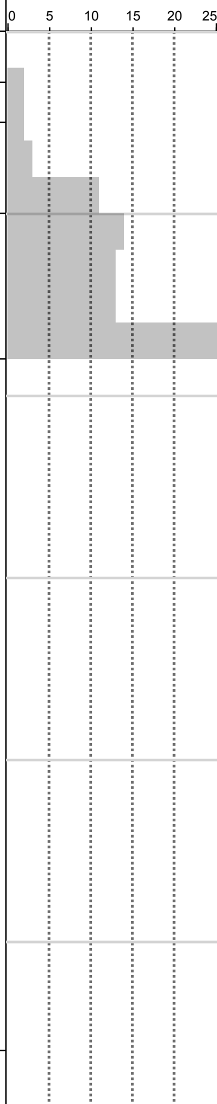
Approval Date: 09/12/2025

SOIL SURVEYS

BOREHOLE: BH03

Job No	: 1-29680	Easting	: 513003.00	Sheet	: 1 OF 1
Client	: Watland Pty Ltd	Northing	: 6944304.00	Logged	: Rick Hayward
Project	: Proposed Apartment Development	RL	: 28.7 m	Logged Date	: 14/11/2025
Location	: 21-23 Watland Street, Springwood	Drill Rig	: CDR-2	Checked	: DD

Drilling Method	Water	Depth (m)	Graphic Log	Material Description	DCP	Samples and Remarks
		0.14		PAVEMENT Concrete 1x layer of reinforcing.		
		0.25		FILL SAND (SW): very loose, fine to medium grained, dark brown, trace of silt, moist.		
		0.5		NATURAL Sandy CLAY (CI-CH): stiff, medium to high plasticity, dark brown mottled orange brown, fine to coarse grained sand, trace of fine to medium size gravel, moist.		0.25-0.50, D
		0.9		NATURAL Silty Sandy CLAY (CH): hard, high plasticity, light brown mottled orange brown, trace fine to medium gravel, moist.		0.50-0.90, D
		2.8		Extremely weathered SANDSTONE (XW): recovered as Clayey Sand - very dense, fine to coarse grained, low plasticity fines, light grey mottled red brown, trace of fine to medium size gravel, moist.		1.00-1.50, D
				SANDSTONE (DW): distinctly weathered, low strength, light grey mottled light brown, fine to coarse grained, moist.		
				BH03 Refusal at 2.95 m		



Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5

Comments

1. Ground water not encountered.
2. Terminated at 2.95m.
3. RL's approximated from provided survey plan.

Key

U - Undisturbed Tube	XW - Extremely Weathered
D - Disturbed (small)	DW - Distinctly Weathered
B - Bulk Disturbed (large)	Groundwater Observed
ASS - Acid Sulfate Soil	Standing Water
PP - Pocket Penetrometer	
VS - Vane Shear	

Approved By: DD

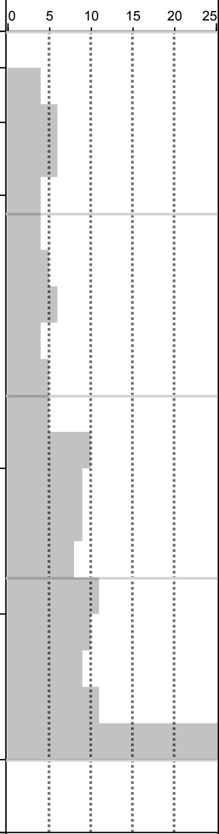
Approval Date: 09/12/2025

SOIL SURVEYS

BOREHOLE: BH04

Job No	: 1-29680	Easting	: 512979.00	Sheet	: 1 OF 1
Client	: Watland Pty Ltd	Northing	: 6944293.00	Logged	: Rick Hayward
Project	: Proposed Apartment Development	RL	: 27.85 m	Logged Date	: 14/11/2025
Location	: 21-23 Watland Street, Springwood	Drill Rig	: CDR-2	Checked	: DD

Drilling Method	Water	Depth (m)	Graphic Log	Material Description	DCP	Samples and Remarks
		0.1		PAVEMENT Concrete 1x layer of reinforcing.		
		0.25		FILL Clayey Sandy GRAVEL (GC): medium dense, fine to coarse sized, dark brown, fine to coarse grained sand, low plasticity clay, moist.		
		0.45		FILL Sandy CLAY (CI-CH): very stiff, medium to high plasticity, dark brown mottled dark grey, fine to coarse grained sand, trace of fine to medium size gravel, moist.		0.25-0.40, D
		1.2		NATURAL Sandy CLAY (CI): very stiff, medium plasticity, dark brown mottled orange brown, fine to coarse grained sand, trace of fine to medium size gravel, moist.		0.50-1.00, D
		1.6		NATURAL Sandy CLAY (CI): hard, medium plasticity, mottled light brown orange brown, fine to coarse grained sand, trace of fine to medium size gravel, moist.		1.20-1.50, D; 1.30-1.55, U50 PP>600
		2		NATURAL Sandy CLAY (CL): hard, low plasticity, mottled red brown light grey, fine to medium grained sand, trace of fine size gravel, moist.		1.60-2.00, D
				SILTSTONE (DW): distinctly weathered, low strength, light brown mottled light grey, fine to medium grained, moist.		



BH04 Refusal at 2.2 m

Comments

1. Ground water not encountered.
2. Terminated at 2.20m.
3. RL's approximated from provided survey plan.

Key

U - Undisturbed Tube
D - Disturbed (small)
B - Bulk Disturbed (large)
ASS - Acid Sulfate Soil
PP - Pocket Penetrometer
VS - Vane Shear
XW - Extremely Weathered
DW - Distinctly Weathered
Groundwater Observed
Standing Water

Approved By: DD

Approval Date: 09/12/2025

Appendix C
Laboratory Test Certificates

SOIL SURVEYS

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QLD, 4212
Tel: 07 3369 6000
info@soilsurveys.com.au

ATTERBERG LIMITS REPORT

Client :	**Watland Pty Ltd**	Report No:	1-29680 26.11.2025 PI
Client Address :	**C/O 1/87 Schneider Road, Eagle Farm, QLD, 4009**	Report Date:	26/11/2025
Project Number :	**1-29680**	Issue Number:	1
Project :	**Proposed Apartment Development**	Page 1 of 1	
Location :	**21-23 Watland Street, Springwood**		

SAMPLE DETAILS:					
Sample ID:	1-29680-BH03-D00050	1-29680-BH04-D00050			
Date Sampled:	14/11/2025	14/11/2025			
Date Tested:	25/11/2025	25/11/2025			
Soil Description:	Silty Sandy Clay (CH) Trace of Gravel, Brown with Orange Mottle	Silty Sandy Clay (CI) With Gravel, Brown with Orange Mottle			
Sampling Method:	AS1726:2017 Geotechnical Site Investigations	AS1726:2017 Geotechnical Site Investigations			
Sampled by:	SSE - Driller RH	SSE - Driller RH			
Sample Location:	**BH03**	**BH04**			
Depth (m):	**0.50-0.90**	**0.50-1.00**			
Source:	Borehole	Borehole			
Material:	Unknown	Unknown			
TEST RESULTS:					
Sample Information					
Sample History (AS1289.1.1)	Air Dried	Air Dried			
Preparation (AS1289.1.1)	Dry Sieved	Dry Sieved			
Linear Shrinkage (AS1289.3.4.1)					
Linear Shrinkage (%):	**13.5**	**13.5**			
Mould Length (mm):	125	125			
Crumbing:	None	None			
Curling:	None	None			
Cracking:	None	None			
Liquid Limit (AS1289.3.1.2)					
Liquid Limit (%):	**50**	**44**			
Plastic Limit (AS1289.3.2.1)					
Plastic Limit (%):	**14**	**16**			
Plasticity Index (AS1289.3.3.1)					
Plasticity Index (%):	**36**	**28**			

Remarks :

NATA
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APPROVED SIGNATORY
Mark Rutten

NATA Accred No:15301

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Helensvale
QLD, 4212
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info@soilsurveys.com.au

PARTICLE SIZE DISTRIBUTION

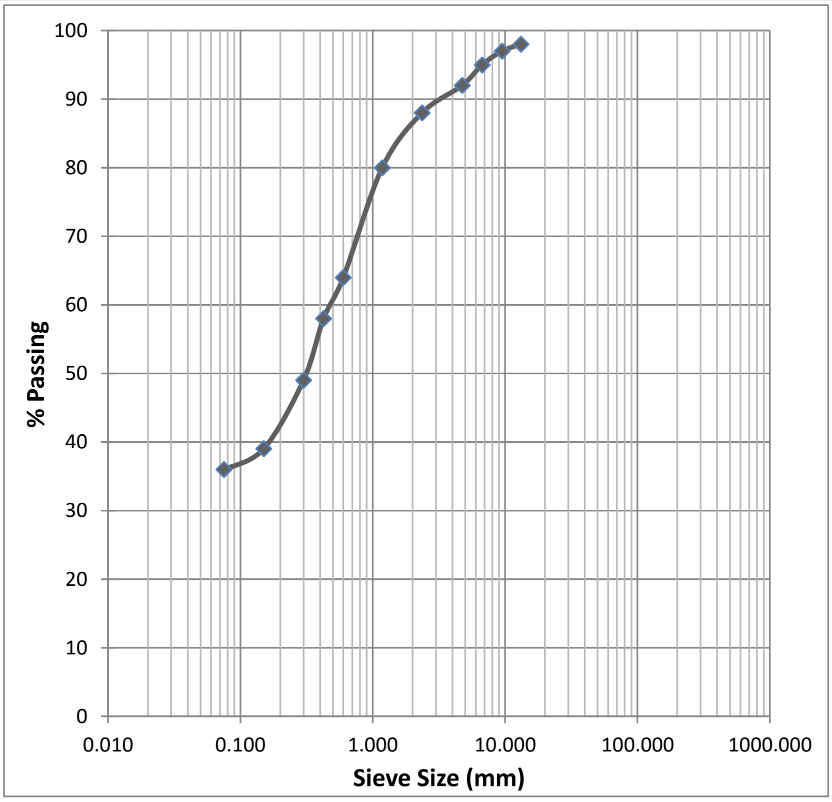
Client :	**Watland Pty Ltd**	Report No:	1-29680-BH03-D00050
Client Address :	**C/O 1/87 Schneider Road, Eagle Farm, QLD, 4009**	Report Date:	26/11/2025
Project Number :	**1-29680**	Issue Number:	1
Project :	**Proposed Development**	Page 1 of 1	
Location :	**21-23 Watland Street, Springwood**		

SAMPLE DETAILS:

Sample ID:	1-29680-BH03-D00050
Date Sampled:	14/11/2025
Date Tested:	25/11/2025
Soil Description:	Silty Sandy Clay (CH) Trace of Gravel, Brown with Orange Mottle
Sampling Method:	AS1726:2017 Geotechnical Site Investigations
Sampled by:	SSE - Driller RH
Sample Location:	**BH03**
Depth (m):	**0.50-0.90**
Source:	Borehole
Material:	Unknown
Test Methods	AS1289.3.6.1

TEST RESULTS:

Sieve Size(mm)	Passing (%)
150.0	
75.0	
37.5	
26.5	
19.0	
13.2	98
9.5	97
6.7	95
4.75	92
2.36	88
1.18	80
0.600	64
0.425	58
0.300	49
0.150	39
0.075	36



Remarks :

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PARTICLE SIZE DISTRIBUTION

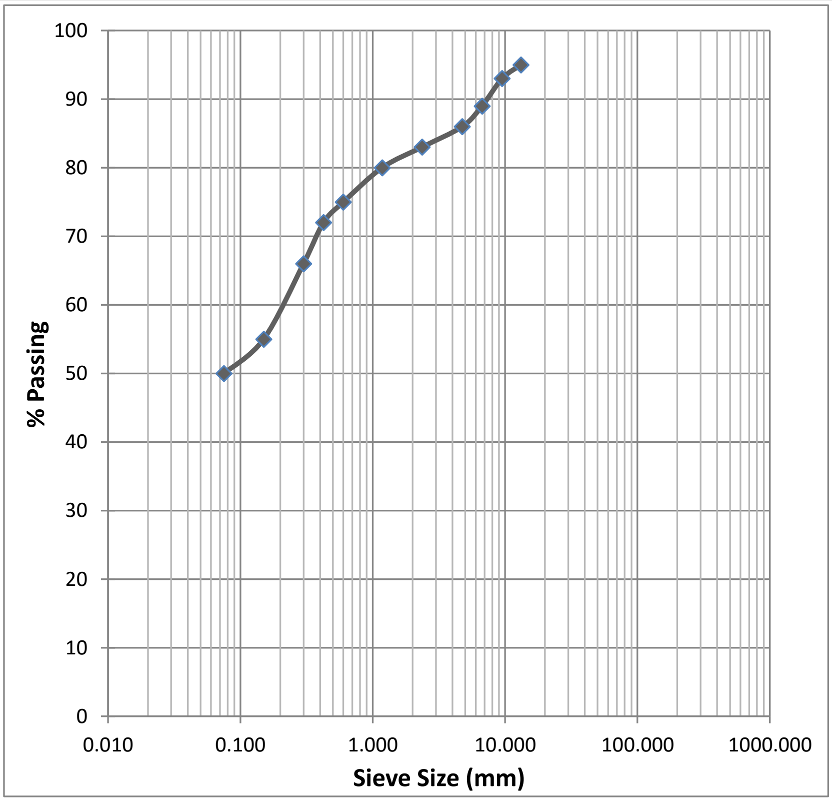
Client :	**Watland Pty Ltd**	Report No:	1-29680-BH04-D00050
Client Address :	**C/O 1/87 Schneider Road, Eagle Farm, QLD, 4009**	Report Date:	26/11/2025
Project Number :	**1-29680**	Issue Number:	1
Project :	**Proposed Development**	Page 1 of 1	
Location :	**21-23 Watland Street, Springwood**		

SAMPLE DETAILS:

Sample ID:	1-29680-BH04-D00050
Date Sampled:	14/11/2025
Date Tested:	25/11/2025
Soil Description:	Silty Sandy Clay (CI) With Gravel, Brown with Orange Mottle
Sampling Method:	AS1726:2017 Geotechnical Site Investigations
Sampled by:	SSE - Driller RH
Sample Location:	**BH04**
Depth (m):	**0.50-1.00**
Source:	Borehole
Material:	Unknown
Test Methods	AS1289.3.6.1

TEST RESULTS:

Sieve Size(mm)	Passing (%)
150.0	
75.0	
37.5	
26.5	
19.0	
13.2	95
9.5	93
6.7	89
4.75	86
2.36	83
1.18	80
0.600	75
0.425	72
0.300	66
0.150	55
0.075	50



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info@soilsurveys.com.au

SHRINK SWELL INDEX REPORT

Client :	**Watland Pty Ltd**
Client Address :	**C/O 1/87 Schneider Road, Eagle Farm, QLD, 4009**
Project Number :	**1-29680**
Project :	**Proposed Apartment Development**
Location :	**21-23 Watland Street, Springwood**

Report No:	1-29680 26.11.2026 PI
Report Date:	26/11/2025
Issue Number:	1
Page 1 of 1	

SAMPLE DETAILS:					
Sample ID:	1-29680-BH04-U00130				
Date Sampled:	14/11/2025				
Date Tested:	24/11/2025				
Soil Description:	Silty Sandy Clay (CI) Trace of Gravel, Orange Brown with Brown Mottle				
Sampling Method:	AS1726:2017 Geotechnical Site Investigations				
Sampled by:	SSE - Driller RH				
Sample Location:	**BH04**				
Depth (m):	**1.30-1.55**				
Source:	Borehole				
Material:	Unknown				
TEST RESULTS:					
Swell Test (AS1289.7.1.1)					
Swell on Saturation(%)	**0.7**				
Moisture Content Before(%)	19.6				
Moisture Content After(%)	22.8				
Shrink Test (AS1289.7.1.1)					
Shrink on Drying(%)	**1.5**				
Shrinkage Moisture Content(%)	20.4				
Est. Inert Material(%)	2				
Crumbling	None				
Cracking	Moderate				
Results:					
Shrink Swell Index - Iss (%):	**1.0**				
Unit Weight (t/m^3):	2.06				

Remarks :

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APPROVED SIGNATORY
Mark Rutten

Nata Accreditation Number: 15301

Appendix D
Site Plan

LEGEND

Borehole Locations

Image from Nearmap.com (23/08/2025)

SCALE 1:350 at A4				DRAWING TITLE **BOREHOLE LOCATION PLAN** Proposed Apartment Development
A4	DRAWING NO. 1-29680-01	DATE 14/11/2025	CHECKED BY DD	

CLIENT
Watland Pty Ltd

LOCATION
21-23 Watland Street, Springwood

SOIL SURVEYS
Geotechnical Specialists