Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Thornton Central Village High-Rise Development
184, 192 and 41 Lord Sheffield Circuit, Penrith

Prepared for
Thornton Operations Limited

Project 85715.00
November 2021

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	85715.00	Document No.	R.001.Rev3
Document title	Report on Geotechnical Investigation Proposed Thornton Central Village High-Rise Development		
Site address	184, 192 and 41 Lord Sheffield Circuit, Penrith		
Report prepared for	Thornton Operations Limited		
File name	85715.00.R.001.Rev3.docx		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Revision 0	Konrad Schultz	Michael J Thom	28 February 2017
Revision 1	Konrad Schultz	Arthur Castrissios	6 October 2021
Revision 2	Konrad Schultz	Arthur Castrissios	27 October 2021
Revision 3	Konrad Schultz	Arthur Castrissios	16 November 2021

Distribution of copies

Status	Electronic	Paper	Issued to
Revision 0	1	0	Frank Katsanevas, St Hilliers Group
Revision 1	1	0	Yvan Nimbona, St Hillers Grpoup
Revision 2	1	0	Yvan Nimbona of St Hillers Grpoup on behalf of Thornton Operations Limited
Revision 3	1	0	Yvan Nimbona of St Hillers Grpoup on behalf of Thornton Operations Limited

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		16 November 2021
Reviewer		16 November 2021

bsi. ISO 9001 Quality Management
FS 604853

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
18 Waler Crescent
Smeaton Grange NSW 2567
Phone (02) 4647 0075

Douglas Partners
Geotechnics / Environment / Groundwater

Table of Contents

Page

1. Introduction 1
2. Proposed Development 1
3. Site Description and Geology 2
4. Field Work 2
   - 4.1 Methods 2
   - 4.2 Results 3
5. Laboratory Testing 4
6. Comments 5
   - 6.1 Site Classification 5
   - 6.2 Excavation Conditions 5
   - 6.3 Excavation Support 5
     - 6.3.1 General 5
     - 6.3.2 Earth Pressures 6
     - 6.3.3 Temporary Ground Anchors 7
   - 6.4 Disposal or Re-use of Excavated Material 8
   - 6.5 Vibrations 8
   - 6.6 Site Preparation 8
   - 6.7 Footings 9
     - 6.7.1 Shallow Pad and Strip Footings 9
     - 6.7.2 Raft Slab 9
     - 6.7.3 Piles 9
   - 6.8 Pavement Design 11
7. References 11
8. Limitations 11

Appendix A: About This Report
Results of Field Work
Drawing 1

Appendix B: Results of Laboratory Testing

Report on Geotechnical Investigation
Proposed Thornton Central Village High-Rise Development
184, 192 and 41 Lord Sheffield Circuit, Penrith

1. Introduction

This revised report presents the results of a geotechnical investigation undertaken for the proposed Thornton Central Village high-rise development at 184, 192 and 41 Lord Sheffield Circuit, Penrith. The revised report was commissioned in an email dated 28 September 2021 by Mr Yvan Nimbona of St Hilliers Group on behalf Thornton Operations Limited and was undertaken in accordance with Douglas Partners Pty Ltd proposal P85715.01 dated 27 September 2021. Previous investigation of the site was commissioned in an email dated 20 October 2016 by Mr Frank Katsanevas of St Hilliers Group and was undertaken in accordance with DP proposal SYD161147 dated 29 September 2016. The results were given in a report (Project 85715.00.R.001.Rev0) dated 28 February 2017.

The aim of the investigation was to provide information on the subsurface soil and groundwater conditions to allow an assessment of:

- the geotechnical suitability of the site for the proposed development;
- an appropriate site classification in accordance with the requirements of AS2870;
- recommendations on site preparation and earthworks;
- recommendations on excavations and retaining structures;
- an appropriate foundation system for the proposed development, including an assessment of allowable bearing pressures and likely settlements; and
- suitable parameters for the design of new pavements.

The previous investigation included borehole drilling followed by laboratory testing of selected samples. The details of the field and laboratory work are presented in this report, together with comments and recommendations on the issues listed above.

The field work was carried out in conjunction with investigation on Lots 3008 (Project 85755.00 dated February 2017) which comprised one borehole for a similar residential development.

This report supersedes all previous correspondence and reports by DP relating to this site.

2. Proposed Development

It is understood that the proposed mixed-use high-rise development of the site includes up to five podium levels of commercial, retail and parking space, up to 30 levels of units in residential towers all over a single level basement. This is expected to require bulk excavations to approximately 4 m depth (RL 23 m AHD).

Typical column loads for this type of development are expected to be in the order of 5000 – 10 000 kN.

The original DP2017 report (Project 85715.00.R.001.Rev0) was for a proposed development of nine levels of residential units over one or two levels of basement car parking. This was expected to require bulk excavations to approximately 7 m depth (RL 20 m AHD).

3. Site Description and Geology

The site, known as Lots 3003, 3004 and 3005 in DP 1184498, is a near rectangle shape with maximum plan dimensions approximately 185 m by 76 m and an area of 11 024 m^2. The location and boundary shown on Drawing 1 in Appendix A. It is bounded to the north and east by the Lord Sheffield Circuit reserve, to the west by Dunshea Street reserve and the south by a carpark and railway line.

The site surface is near flat at RL 27 m relative to the Australian Height Datum (AHD), sloping very gently to water features north east of the site. At the time of the investigation, the site was vacant, grassed, fenced and bisected by a fenced walking path to the Penrith Railway Station and carpark.

The Penrith 1:100 000 Geology Series Sheet indicates that the site is underlain by Quaternary aged alluvial soils of the Cranebrook Formation which include gravel, sand, silt and clay. The alluvium is in turn underlain by Triassic-aged Bringelly Shale of the Wianamatta Group which typically comprises shale, carbonaceous claystone, fine to medium grained lithic sandstone and rare coal seams and tuff.

Acid sulfate soil (ASS) risk mapping indicates that the site is not located within an area of known ASS occurrence.

The results of the boreholes confirmed the mapping with alluvium, sandstone and laminite encountered during the investigation.

4. Field Work

4.1 Methods

In accordance with the brief, a truck-mounted drilling rig was used to drill six boreholes at accessible locations on the site. The boreholes were initially drilled using solid flight augers and rotary mud flush through soil, with regular standard penetration tests (SPT) for strata identification and sampling for laboratory testing. Once refusal occurred on the underlying "Penrith" gravel, the boreholes were cased and a down hole percussion casing advancing system (Tubex) was used to penetrate the gravel layer until bedrock was encountered, then NMLC sized diamond drilling techniques were used to recover continuous rock core samples.

Observations for groundwater were made during the augering and casing advancing within the boreholes. Wells were installed in two borehole locations, BH 1 and BH 3 on completion for longer term monitoring of groundwater levels.

The co-ordinates (easting and northing to Map Grid of Australia [MGA] Zone 56) and surface level (AHD) at the borehole locations were recorded using a differential GPS which is accurate to about 20 mm.

The locations of the boreholes are shown on Drawing 1 in Appendix A.

4.2 Results

The field work results are presented on the borehole logs in Appendix B, together with notes explaining descriptive terms and classification methods used.

The subsurface profiles encountered within Boreholes 1 - 6 can be summarised as follows:

TOPSOIL:	50 - 250mm thick clayey or silty sand topsoil filing with some vegetation; overlying
FILLING:	Typically light grey silty clay filling with crushed shale fragments to depths 0.4 - 1.1 m; overlying
ALLUVIUM:	Generally stiff to hard red/brown clay with traces of ironstone gravels, medium dense sand or mixtures of sand and clay to depths 4.6 - 6.4 m; overlying
ALLUVIUM ('PENRITH' GRAVEL):	Generally dense, light grey-brown gravels and cobbles with some coarse sands and traces of peat to depths 12.6 - 14.05m; overlying
BEDROCK:	Extremely low to very low strength, grey laminite to depths 12.8 - 14.4m, becoming generally high strength, fresh, slightly fractured laminite to the termination depths of 15.6 to 17.1 m

Groundwater was observed during casing advancing within the boreholes and in the wells installed in Boreholes BH 1 and BH 2 on completion. The levels are generally consistent with other recent groundwater observations on nearby sites. It should be noted that groundwater levels will vary with changes in rainfall and other activities. The results of groundwater monitoring are set out in Table 1.

Table 1 – Summary of Groundwater Level Monitoring

Bore	Surface (RL)	Depth During Drilling (m)	Level during Drilling (m AHD)	Depth 11/11/2016 (m)	Level 11/11/2016 (m AHD)	Depth 16/11/2016 (m)	Level 16/11/2016 (m AHD)
1	26.89	8.95	17.94	6.90	19.99	6.13	20.76
2	26.91	10.00	19.66	-	-	-	-
3	27.01	7.25	19.76	6.30	20.71	6.67	20.34
4	26.74	8.90	17.84	-	-	-	-
5	26.78	8.00	18.78	-	-	-	-
6	27.18	8.90	18.28	-	-	-	-

5. Laboratory Testing

Selected soil samples from the boreholes were tested in the laboratory to determine the pH, sulfate and chloride ion concentrations as well as the electrical conductivity to assess the aggressivity potential of the soil towards buried concrete and steel structures. The results of the chemical properties are included in Appendix B and are summarised in Table 2.

Table 2: Results of pH, Sulfate, Chloride and Electrical Conductivity Testing

Bore	Material	Sample Depth (m)	pH	Chloride Ion (mg/kg)	Sulfate Ion (mg/kg)
BH1	Silty Clay	1	6.2	410	110
BH1	Sandy Clay	2.5	6.2	750	<10
BH2	Filling	0.1	7.5	37	36
BH2	Sand	5.5	7.8	120	<10
BH3	Filling	0.5	7.8	84	150
BH3	Filling	1	7.8	88	110
BH4	Sandy Clay	2.5	6.6	440	<10
BH4	Sand	4	7.6	310	<10
BH5	Silty Clay	0.5	6.6	45	25
BH5	Sandy Gravel	5	7.2	310	61
BH6	Sandy Clay	1	8	25	50
BH6	Sandy Clay	4	7.5	10	26

Comparison of the results of the aggressivity testing with Tables 6.4.2(C) and 6.5.2(C) in Australian Standard AS 2159 Piling Design and Installation - 2009, indicates that the subsurface conditions are *mildly* to *non-aggressive* towards buried concrete elements and *non-aggressive* to buried steel elements.

Point load strength index tests were also carried out on rock core samples at each metre to provide an indication of the strength of the rock encountered within the boreholes. The I_{s50} results were in the range of 0.35 - 3.8 MPa consistent with rock ranging in strength from medium to very high strength.

6. Comments

6.1 Site Classification

Site classification in accordance with the Residential Slabs and Footings standard (AS 2870, 2011) can be used to assess reactive movements of foundation soils and hence provide an indication of the potential for cracking to occur in brittle materials such as concrete, block work and tiles. The boreholes indicate in excess of 0.4 m depth of uncontrolled filling is present and therefore the site in its current condition is classified 'Class P'. However, reclassification of the site may be possible if suitable documentation can be provided to confirm appropriate compaction levels in existing or new filling that will provide support for buildings, floor slabs and pavements. If it is not possible to confirm compaction levels in existing filling it should be removed and replaced. It is noted however that AS2870 serves to classify sites from the reactivity potential only and classification is independent of proposed site works and development. Furthermore, the standard footing details given in the code are not applicable to the type of development proposed for this site.

6.2 Excavation Conditions

Based on the results of the boreholes, the upper level of the basement car parking will be in filling and then natural alluvial soil. Shoring will be required if space is restricted where there are vertical cuts proposed near the boundaries. Deeper sections of the basement will probably extend into water charged sand and possibly Penrith gravel requiring low permeability shoring systems to facilitate excavation and floor slab construction. Suitable shoring types could include secant piles or a diaphragm walls.

The groundwater levels, measured at around RL 20 – 21 m could rise to about RL 23 m during wet periods. Analysis will be required to determine appropriate dewatering, shoring and anchor or propping systems.

Whilst filling, natural sand and clay materials could be expected to be excavated relatively easily, high torque piling plant or heavy excavating equipment will be required to penetrate dense 'Penrith' gravels which can include very densely packed, high strength particle up to boulder size and the underlying high strength (or stronger) bedrock.

Retaining walls will be required to support any permanent excavations.

6.3 Excavation Support

6.3.1 General

The excavation will need to be supported by basement walls that are keyed into the Penrith Gravel or if the basement is to be isolated from the groundwater, the underlying bedrock. Embedment in the order of 1 m into dense gravel or rock of at least medium strength is recommended. Suitable wall types include:

- Secant pile wall (suitable for single level), which is constructed using 'hard' and 'soft' flight auger piles where each successive hard pile cut into the soft grout previously drilled. These are normally drilled through a top template to guide the piles and therefore reduce the incidence of misalignment.

Alternatively, segmentally cased auger piles could be used to increase uniformity and ensure verticality. At depths of 8 m or greater (unlikely for a single basement) there can still be gaps in the piles near the bottom, which will need to be repaired with grout to provide a fully water-tight structure, which is difficult to achieve.

- Diaphragm walls: if the design changes and the basement becomes greater than 2 levels in depth diaphragm walls are preferred. They are constructed using a clam shell bucket to excavate the material and bentonite slurry to temporarily support the side walls until a steel reinforcement cage and concrete is placed.

As parts of the single basement may extend below the water table, non-watertight methods of shoring (e.g. contiguous piles) are unlikely to form a sufficient cut-off and are therefore not likely to be suitable for construction of the proposed development.

Lateral support will need to be provided by means of temporary ground anchors. If temporary anchors are used they will only be necessary until the basement slabs and ground floor slabs provide internal support for the walls. The toe of the piles will need to be anchored if they are above the base of the excavation.

Drawings indicate parts of the basement penetrate below about RL 23 m AHD (the maximum wet period groundwater levels based on previous experience). These areas, such as lift overruns, fire pump and tank room will need to be tanked. The floor slabs must include provision for buoyancy and the walls for a triangular distribution of water pressure. Due to the likely relatively high permeability of the gravel a sump and pump ('drained') basement for areas below the likely water table is not recommended. A drained basement for the areas above the likely water table may be possible. If the whole basement is tanked, pressure relief valves should be included if water levels do exceed the design levels of RL23 m AHD.

6.3.2 Earth Pressures

The basement walls will be subject to earth pressures from the ground surface down to the top of medium strength rock. Table 3 summarises material and strength parameters that could be used for design of the excavation support structure.

The lateral earth pressure distribution for a wall with multiple rows of lateral support is complex. For preliminary design purposes, the magnitude of lateral earth pressure acting on perimeter shoring walls may be approximated as a uniform rectangular pressure of 4H (kPa) (or 8H (kPa) for sensitive structures), where H is the height of the retained material down to the top of rock, in metres. Detailed design should ideally be undertaken using a computer program such as WALLAP, FLAC or PLAXIS to model soil-structure interactions and refine the preliminary design.

Surcharge pressures from adjacent structures, construction machinery and traffic should also be incorporated into the detailed design of the wall, as necessary.

Table 3: Material and Strength Parameters for Preliminary Design Purposes

Material	Dry Unit Weight (kN/m^3)	Saturated Unit Weight (kN/m^3)	Coefficient of Active Earth Pressure (K_a)	Coefficient of Earth Pressure at Rest (K_o)	Passive Earth Pressure*
Filling	20	10	0.40	0.60	N/A
Sand, L to md	20	10	0.35	0.53	K_p = 3
Clay, St-vst	20	10	0.30	0.45	100 kPa
Penrith gravel, d	22	12	0.1	0.15	250 kPa

Notes: L = loose; vl = very loose; md = medium dense; st = stiff, vst = very stiff; d = dense

* Ultimate values and only below bulk excavation level

6.3.3 Temporary Ground Anchors

The basement walls will need to be temporarily restrained to minimise ground movements within the zone of influence of the excavation. Inclined tie-back (ground) anchors could be used for the temporary lateral restraint of the basement walls. The ground anchors should be inclined below the horizontal to allow anchorage into the denser materials. The preliminary design of temporary ground anchors may be carried out using the ultimate average bond stresses at the grout-soil interface given in Table 4.

Table 4: Ultimate Bond Stresses for Preliminary Anchor Design

Material Description	Ultimate Bond Stress (kPa)
Sand, loose to medium dense	11D
Clay, stiff to very stiff	40
Gravel, dense	17D
Sandstone/Laminite, low strength and medium strength	300

Notes: Where D is depth below ground surface to centre of bond length in m

Ground anchors should be designed to have an appropriate free length (minimum of 3 m) and have a minimum 3 m bond length. After installation they should be proof loaded to 125% of the design working load and locked-off at no higher than 80% of the working load. Periodic checks should be carried out during the construction phase to ensure that the lock-off load is maintained and not lost due to creep effects or other causes.

The parameters given in Table 4 assume that the anchor holes are clean, with grouting and other installation procedures carried out carefully and in accordance with good anchoring practice. Careful installation and close supervision by a geotechnical specialist may allow increased bond stresses to be adopted during construction, subject to satisfactory load testing.

It will be necessary to obtain permission from neighbouring landowners prior to installing anchors that will extend beyond the perimeter of the site. In addition, care should be taken to avoid damaging buried services and pipes, or drilling through foundation piles during anchor installation.

6.4 Disposal or Re-use of Excavated Material

It is understood that no fill is to be placed on the site.

The scope of this investigation did not include sampling and testing for Waste Classification or Contamination Assessment purposes. All excess excavated materials will need to be classified and disposed of in accordance with current NSW Environment Protection Authority (EPA) regulations. Classification should be undertaken with reference to NSW EPA (2014) *Waste Classification Guidelines* prior to disposal. This includes filling and virgin excavated natural materials (VENM), such as may be removed from this site. Accordingly, environmental testing will need to be carried out to classify spoil prior to disposal. The type and extent of testing undertaken will depend on the final use or destination of the spoil, and requirements of the receiving site. It should be noted that some fill sites, such as those operated by Councils or other bodies might have their own special environmental criteria to be met before admitting any materials.

6.5 Vibrations

A maximum peak particle velocity of 8 mm/sec (in any component direction) at the foundation level of adjacent structures is suggested for both structural and human comfort considerations, although this vibration limit may need to be reduced if there are sensitive buildings or equipment nearby.

6.6 Site Preparation

The following general procedure is suggested for site preparation and filling required at the site:

- Strip to design subgrade level. If reclassification of the site is required and suitable documentation cannot be sourced, then all 'uncontrolled' filling should also be removed, unless footings are constructed and found on natural soils.
- Scarify and moisture condition the exposed surface;
- Roll the exposed surface with at least six passes of a minimum 12 tonne deadweight roller with a final test roll pass accompanied by careful visual inspection to ensure that any deleterious materials such as soft, wet or highly compressible soil and any organics are identified and removed;
- Replacement and additional filling should be placed in loose layer thicknesses not greater than 300 mm and compacted to a dry density ratio of 98 - 102% (for lightly loaded building floor slabs) and 100% (for pavements) relative to Standard compaction and with moisture contents maintained within 2% of Standard optimum moisture content. Replacement and new filling should be free of oversize particles (>100 mm) and deleterious material.
- Maintain moisture contents for clay filling in the range 2% dry to 2% wet of optimum moisture content for Standard compaction, as the long term equilibrium moisture content is typically marginally dry of the optimum moisture content in this area; and
- Seal or cover any natural or compacted clay foundation soil, at or close to formation level, as soon as practicable, to reduce the opportunity for desiccation and cracking or swelling and softening.

Compaction testing to a Level 1 standard, as defined in Section 8 of Earthworks Guidelines (AS 3798, 2007) is required where structural loads are supported by filling. A Level 1 report must also be prepared

at the completion of the works stating that the filling has been completed as recommended above and as required by AS 2870:2011.

6.7 Footings

6.7.1 Shallow Pad and Strip Footings

For relatively lightly loaded structure such as garden retaining walls or similar, it should be feasible to found in controlled filling or natural stiff clay soils using an allowable bearing pressure of 100 kPa.

6.7.2 Raft Slab

The proposed single level basement excavation will not result in Penrith gravel uniformly exposed in the basement excavation. Therefore the design a raft slab is not considered appropriate for the site.

6.7.3 Piles

For more highly loaded or settlement sensitive structures. piles founding in the underlying 'Penrith' gravel or bedrock should be suitable.

It should be feasible to use continuous flight auger (CFA) piles to found on or within the dense "Penrith" gravel encountered at depths of 4.6 - 6.4 m within the boreholes. If higher capacities are required, conventional, cased bored piers could be used to penetrate the gravel (with some difficulty) and found within the medium or high strength bedrock beneath the site at depths 16 – 17 m. It is noted that if design parameters above an allowable base bearing pressure of 3500 kPa are used additional investigation and testing of piles will be required at at least 50% of pile locations. High torque rigs will be required to penetrate the gravel and rock underlying the site.

Preliminary design of piles could be based on the parameters provided in Table 5.

Table 5: Design Parameters for CFA and Bored Piles

Material Description	Allowable End-Bearing Pressure (kPa)	Allowable Shaft Adhesion (kPa) [1]	Ultimate End-Bearing Pressure (kPa)	Ultimate Shaft Adhesion (kPa)[1]	Elastic Modulus (MPa)
Silty/Sandy Clay, stiff to very stiff at least 5 pile diameters below ground level	250	30	1200	100	40
Very Dense Gravel	2000	50[(2)]	6000	100 [(2)]	80
Medium Strength Sandstone/Laminite	3500	300	30 000	600	1000
High Strength Sandstone/Laminite[3]	6000[3]	500	100 000	1000	2000

Notes: [1] Reduce by 50% for uplift loads and ensure cone-pull out criteria are met

[2] For piles bearing in the gravel layer

[3] Bearing pressures above 3500 kPa have to be verified by additional boreholes and testing of at least 50% of pile bases

It should be noted that the serviceability limit-state is likely to govern the design of the piles. An appropriate geotechnical strength reduction factor (ϕ_g) should be selected by the pile designer using the procedure outlined in Australian Standard AS 2159 – 2009 Piling – Design and Installation. Typically a ϕ_g of 0.4 should be used if no testing is to be carried out. This value can be refined once the design progresses and the factors used for assessing ϕ_g become known.

Settlement of a pile is dependent on the loads applied to the pile and the foundation conditions in the socket zone and below the pile toe. The total settlement of a pile designed using the 'allowable' parameters provided in Table 2 would be expected to be less than 1% of the pile diameter.

If heavily-loaded piles for the proposed multi-storey building are designed to be founded on the gravel layer (i.e. in the instance that drilling through the gravel is unsuccessful using CFA pilling methods), the installation of test piles and/or pile load testing should be undertaken to confirm the pile capacity, pile settlement, foundation design parameters, and an appropriate geotechnical strength reduction factor.

Soil decompression can occur during CFA piling when a strong stratum is encountered. In this case, the augers continue to rotate but the rate of auger progression decreases and soil from around the auger is displaced upwards towards the surface. Decompression can cause weakening and settlement of the soils adjacent to the pile and should be avoided by monitoring auger speed and progression closely.

CFA piles are a proprietary product which involves a 'blind' drilling technique and relies predominantly on monitoring from on-board equipment and the operator. For these reasons, CFA piles should be certified by the piling contractor.

If bored piles are used, the drilling of rock sockets can be witnessed by a geotechnical consultant to confirm that the foundation conditions satisfy the design parameters adopted.

6.8 Pavement Design

Preliminary pavement design could be based on a California bearing ratio of 3% for filling reworked in accordance with Section 6.4 or natural soils. This value should be confirmed by testing during construction.

7. References

AS 2870. (2011). *Residential Slabs and Footings.* Standards Australia.

AS 3798. (2007). *Guidelines on Earthworks for Commercial and Residential Developments.* Standards Australia.

8. Limitations

Douglas Partners Pty Ltd (DP) has prepared this revised report for this project at Lots 3003, 3004 and 3005 Lord Sheffield Circuit, Penrith in accordance with DP's proposal P85715.01 dated 27 September 2021 and email acceptance received from Yvan Nimbona of St Hilliers Group dated 28 September 2021. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of St Hilliers Group for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attachments and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or

Appendix A

About This Report
Results of Field Work
Drawing 1

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

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

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

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

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, 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. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or 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 a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. 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, DP 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 and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

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

Information for Contractual Purposes

Where information obtained from this report 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. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling

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

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. 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 50 mm diameter split sample tube 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. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq \text{100 mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

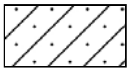
Soils


Topsoil

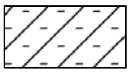

Peat


Clay

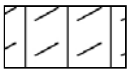

Silty clay

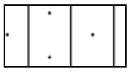

Sandy clay

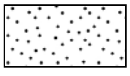

Gravelly clay

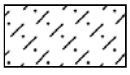

Shaly clay

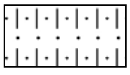

Silt


Clayey silt


Sandy silt

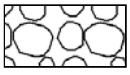

Sand

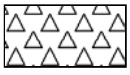

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

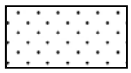

Talus

Sedimentary Rocks

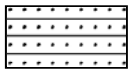

Boulder conglomerate

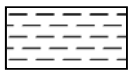

Conglomerate


Conglomeratic sandstone

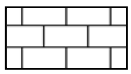

Sandstone


Siltstone


Laminite

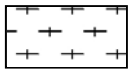

Mudstone, claystone, shale

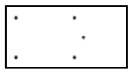

Coal


Limestone

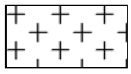
Metamorphic Rocks

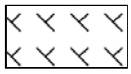

Slate, phyllite, schist

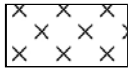

Gneiss

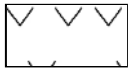

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 26.8894 AHD **BORE No:** 1
EASTING: 286653.98 **PROJECT No:** 85715.00
NORTHING: 6263380.87 **DATE:** 1/11/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
26	0	FILLING - light grey silty clay and shale fragments filling, humid							A			
	0.6								A			
	1	SILTY CLAY - very stiff, light brown silty clay with a trace of fine sand, moist							A			
									S			4,8,18 N = 26
25	1.8											
	2	SANDY CLAY - hard, slightly cemented, brown fine sandy clay, damp										
									S			9,14,17 N = 31
24	3											
23	4											
	4.0	CLAYEY SAND - medium dense, light brown, fine grained clayey sand							S			9,12,11 N = 23
22	5											
		5.5m: becoming hard with sandstone gravel, moist							S			8,11,39 N = 50
21	5.8	SANDY GRAVEL - apparently dense, light grey-brown, rounded and subrounded gravel/cobble with some coarse sand, moist										
	6											
20	7											
19	8											
18	9	8.9m: becoming wet				▼						
17												

RIG: Explorer **DRILLER:** LC **LOGGED:** SI **CASING:** HQ/ODEX to 14.3m

TYPE OF BORING: Solid flight auger to 5.5m; ODEX drilling to 14.3m; NMLC-Coring to 16.98m

WATER OBSERVATIONS: Free groundwater observed at 8.95 whilst ODEX drilling

REMARKS: Location coordinates are in MGA94 Zone 56. Standpipe installed to 13.8m (screen 3.0-13.8m; gravel 2.5-13.8m; bentonite 2.0-2.5m; backfill to GL with 1.0m stick-up)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BORE: 1 **PROJECT: 85715.00** **November 2016**

14.3 – 16.98m

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 26.8894 AHD **BORE No:** 1
EASTING: 286653.98 **PROJECT No:** 85715.00
NORTHING: 6263380.87 **DATE:** 1/11/2016
DIP/AZIMUTH: 90°/-- **SHEET** 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
16	11	SANDY GRAVEL - apparently dense, light grey-brown, rounded and subrounded gravel/cobble with some coarse sand, moist *(continued)*						Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°				
15	12											
14	13											
13	13.8 14	LAMINITE - very low strength, light grey laminite										
12	14.3 15	LAMINITE - high strength, fresh, slightly fractured then unbroken, light grey fine grained sandstone (60%) interlaminated and bedded with siltstone (40%)						14.3-14.6m: B (x3) 0°, cly vn 14.95m: B5°, cly, 5mm 15.9m: B5°, cly, 5mm	C	100	99	PL(A) = 1.36 PL(A) = 2.93 PL(A) = 2.54
11	16											
10	16.95 17	Bore discontinued at 16.95m										
9	18											
8	19											
7												

RIG: Explorer **DRILLER:** LC **LOGGED:** SI **CASING:** HQ/ODEX to 14.3m

TYPE OF BORING: Solid flight auger to 5.5m; ODEX drilling to 14.3m; NMLC-Coring to 16.98m

WATER OBSERVATIONS: Free groundwater observed at 8.95 whilst ODEX drilling

REMARKS: Location coordinates are in MGA94 Zone 56. Standpipe installed to 13.8m (screen 3.0-13.8m; gravel 2.5-13.8m; bentonite 2.0-2.5m; backfill to GL with 1.0m stick-up)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 26.9046 AHD **BORE No:** 2
EASTING: 286633.07 **PROJECT No:** 85715.00
NORTHING: 6263388.31 **DATE:** 31/10/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
26	0.4	FILLING - light grey silty clay and crushed shale fragments, filling damp							A			
		SILTY CLAY - very stiff, light grey-brown, silty clay, moist							A			
26	1								A			
	1.2	SANDY CLAY - very stiff, mottled orange-brown, fine grained sandy clay, moist							S			4,7,12 N = 19
25	2											
									S			4,8,12 N = 20
24	3											
	3.4	SAND - medium dense, brown, fine to medium grained sand with some silt/clay, moist										
23	4								S			5,9,9 N = 18
22	5											
									S			6,9,7 N = 16
21	6											
	6.4	SANDY GRAVEL - apparently dense, light grey-brown, rounded to subrounded river transported gravel/cobble with sand, moist										
20	7											
19	8											
18	9											
17		10.0m: becoming wet				▼						

RIG: Explorer **DRILLER:** LC **LOGGED:** SI **CASING:** HQ to 13.4m

TYPE OF BORING: Solid flight auger to 7.0m; ODEX to13.4m; NMLC-Coring to 16.85m

WATER OBSERVATIONS: Free groundwater observed at 10.0m

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BORE: 2 **PROJECT: 85715.00** **November 2016**

13.4 – 16.8m

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 26.9046 AHD **BORE No:** 2
EASTING: 286633.07 **PROJECT No:** 85715.00
NORTHING: 6263388.31 **DATE:** 31/10/2016
DIP/AZIMUTH: 90°/-- **SHEET** 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering	Graphic Log	Rock Strength	Water	Fracture Spacing (m)	Discontinuities	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		B - Bedding J - Joint S - Shear F - Fault	EW HW MW SW FS FR		Ex Low Very Low Low Medium High Very High Ex High		0.01 0.05 0.10 0.50 1.00					
16	11	SANDY GRAVEL - apparently dense, light grey-brown, rounded to subrounded river transported gravel/cobble with sand, moist *(continued)*						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0° - 10°				
15	12											
	12.6	LAMINITE - extremely low to very low strength, grey laminite										
14	13											
	13.55	INTERLAMINATE/BEDDED SANDSTONE & SILTSTONE - medium and high strength, slightly weathered, fragmented and slightly fractured, light grey to grey, fine grained sandstone (60%) interlaminated and bedded with siltstone (40%)						13.55-14.05m: fg 14.15-14.45m: fg	C	100	15	PL(A) = 0.5 PL(A) = 2.07
13	14											
12	15							14.8m: J70°, pl, ro, cln 15.12-15.22m: fg, cly co 15.22m: J80° & 60°, st, ro, cln 15.43m: B0°, cly, co	C	100	88	PL(A) = 1.82 PL(A) = 0.35
	15.0	LAMINITE - low to medium strength, slightly weathered, slightly fractured, light grey, laminite with approx 25% fine sandstone lamination 15.22-15.4m: high strength sandstone bed										
11	16							15.82m: J80°, ti 15.9-15.95m: fg 16.1-16.21m: B's, 0°, cly co, 1mm				
	16.1	LAMINITE - high strength, fresh, slightly fractured, light grey fine grained sandstone (60%) interlaminated with siltstone (40%)										PL(A) = 2.33
10	16.85	Bore discontinued at 16.85m										
	17											
9	18											
8	19											
7												

RIG: Explorer **DRILLER:** LC **LOGGED:** SI **CASING:** HQ to 13.4m

TYPE OF BORING: Solid flight auger to 7.0m; ODEX to13.4m; NMLC-Coring to 16.85m

WATER OBSERVATIONS: Free groundwater observed at 10.0m

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 27.0914 AHD **BORE No:** 3
EASTING: 286609.06 **PROJECT No:** 85715.00
NORTHING: 6263320.98 **DATE:** 26 - 27/10/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
27	0	FILLING - grey to grey-brown silty clay and crushed shale fragments filling with grass cover at top							A			
									A			
26	1								A			
	1.1	CLAY - stiff, light brown clay, slightly silty, moist (possible filling)							S			4,5,10 N = 15
25	1.75	SILTY CLAY - very stiff, mottled orange-brown silty clay with some fine grained sand and a trace of ironstone gravel, moist										
	2								S			7,10,13 N = 23
24	3											
	3.5	SAND - medium dense, brown fine to medium grained sand, slightly cemented and some clay, moist										
23	4								S			7,12,15 N = 27
22	5											
	5.3	SANDY GRAVEL - apparently dense, light grey-brown, rounded and subrounded gravel/cobble with coarse sand, moist										
21	6											
20	7	7.25m: becoming wet				▼						
19	8											
18	9											

RIG: Explorer **DRILLER:** JS **LOGGED:** SI **CASING:** HQ to 13.7m

TYPE OF BORING: Solid flight auger to 5.5m; ODEX to 13.1m; NMLC-Coring to 15.65m

WATER OBSERVATIONS: Free groundwater observed at 7.25m

REMARKS: Location coordinates are in MGA94 Zone 56. Standpipe installed to 12.8m (screen 3.8-12.8m; gravel 2.5-12.8m; bentonite 2.0-2.5m; backfill to GL with gatic cover)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BORE: 3 **PROJECT: 85715.00** **November 2016**

13.75 – 15.65m

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 27.0914 AHD **BORE No:** 3
EASTING: 286609.06 **PROJECT No:** 85715.00
NORTHING: 6263320.98 **DATE:** 26 - 27/10/2016
DIP/AZIMUTH: 90°/-- **SHEET** 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
17		SANDY GRAVEL - apparently dense, light grey-brown, rounded and subrounded gravel/cobble with coarse sand, moist *(continued)*						Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°				
16	11											
15	12											
14	13								C	0	0	
13	14								C	100	0	
	14.05	LAMINITE - very high then high strength, fresh, unbroken, light grey fine grained sandstone (40%) interlaminated with siltstone (60%)							C	100	100	PL(A) = 3.8
12	15											PL(A) = 2.21
	15.65	Bore discontinued at 15.65m						15.6m: J25°, pl, ro, cln				
11	16											
10	17											
9	18											
8	19											

RIG: Explorer **DRILLER:** JS **LOGGED:** SI **CASING:** HQ to 13.7m

TYPE OF BORING: Solid flight auger to 5.5m; ODEX to 13.1m; NMLC-Coring to 15.65m

WATER OBSERVATIONS: Free groundwater observed at 7.25m

REMARKS: Location coordinates are in MGA94 Zone 56. Standpipe installed to 12.8m (screen 3.8-12.8m; gravel 2.5-12.8m; bentonite 2.0-2.5m; backfill to GL with gatic cover)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 26.7363 AHD **BORE No:** 4
EASTING: 286634.29 **PROJECT No:** 85715.00
NORTHING: 6263312.85 **DATE:** 27 - 31/10/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
26	0	FILLING - light grey to grey silty clay and shale fragments filling, damp							A			
									A			
									A			
25	1								S			5,7,13 N = 20
	1.1	SANDY CLAY - very stiff to hard, mottled brown-light grey slightly cemented, fine grained sandy clay, moist										
24	2								D			8,13,17 N = 30
		3.0m; becoming hard										
23	3											
	3.75	SAND - medium dense, red-brown slightly cemented, fine to medium grained sand with some clay/silt, moist							S			12,12,14 N = 26
22	4											
	5											
	5.15	SANDY GRAVEL - apparently dense, light grey-brown, rounded and subrounded gravel/cobble with coarse sand, moist										
21	6											
20	7											
19	8											
18	9	8.9m: becoming wet				▼						
17												

RIG: Explorer **DRILLER:** JS **LOGGED:** SI **CASING:** HQ to 14.2m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary (ODEX) to 14.2m; NMLC-Coring to 17.1m

WATER OBSERVATIONS: Free groundwater observed at 8.9m

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BORE: 4 **PROJECT: 85715.00** **November 2016**

14.2 – 17.1m

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 26.7363 AHD **BORE No:** 4
EASTING: 286634.29 **PROJECT No:** 85715.00
NORTHING: 6263312.85 **DATE:** 27 - 31/10/2016
DIP/AZIMUTH: 90°/-- **SHEET** 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SANDY GRAVEL - apparently dense, light grey-brown, rounded and subrounded gravel/cobble with coarse sand, moist *(continued)*						Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°				
	13.8	LAMINITE - extremely low to very low strength, grey laminite										
	14.4	LAMINITE - medium and high strength, slightly weathered, highly to slightly fractured, light grey to grey laminite with approximately 40% fine sandstone and 60% siltstone laminations and beds 15.5-15.88m: carbonaceous shale						14.2m: CORE LOSS: 200mm 14.7-14.96m: B's 0°, cly vn 15.2-15.45m: B's 0°, cly vn 15.5-15.65m: carbonaceous shale 15.75-15.88m: carbonaceous shale 16.4 & 16.45m: B0°, cly co 16.85-16.92m: fg, cly	C	93	60	PL(A) = 1.23 PL(A) = 1.75 PL(A) = 0.79 PL(A) = 1.43 PL(A) = 2.48
	15.88	LAMINITE - high strength, slightly weathered and fresh, slightly fractured, light grey, fine grained sandstone(50%) interlaminated with (50%) siltstone laminations										
	17.1	Bore discontinued at 17.1m										

RIG: Explorer **DRILLER:** JS **LOGGED:** SI **CASING:** HQ to 14.2m
TYPE OF BORING: Solid flight auger to 5.5m; Rotary (ODEX) to 14.2m; NMLC-Coring to 17.1m
WATER OBSERVATIONS: Free groundwater observed at 8.9m
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 26.7844 AHD **BORE No:** 5
EASTING: 286634.29 **PROJECT No:** 85715.00
NORTHING: 6263259.41 **DATE:** 10/11/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
26	0	FILLING - light grey silty clay and shale fragments filling, humid							A			
	0.5	SILTY CLAY - grey silty clay with a trace of grass rootlets, moist (possible filling)							A			
25	1.0	SILTY CLAY - very stiff, mottled red-brown silty clay with some fine sand and a trace of ironstone gravel, moist							A			
									S			5,11,14 N = 25
	1.9	CLAYEY SAND - medium dense, brown, fine grained clayey sand, moist										
24									S			6,10,9 N = 19
23		4.3m: becoming sandy							S			10,14,13 N = 27
22	4.8	SANDY GRAVEL - apparently dense, light grey-brown, rounded to subrounded medium to coarse gravel/cobble with coarse sand							A			
21												
20												
19		8.0m: becoming wet				▼						
18												
17												

RIG: Explorer **DRILLER:** LC **LOGGED:** SI **CASING:** ODEX to 13.17m

TYPE OF BORING: Solid flight auger to 5.0m; ODEX drilling to 13.17m; NMLC-Coring to 16.05m

WATER OBSERVATIONS: Free groundwater observed at 8.0m whilst ODEX drilling

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BORE: 5 **PROJECT: 85715.00** **November 2016**

13.17 – 16.05m

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 26.7844 AHD **BORE No:** 5
EASTING: 286634.29 **PROJECT No:** 85715.00
NORTHING: 6263259.41 **DATE:** 10/11/2016
DIP/AZIMUTH: 90°/-- **SHEET** 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
16	11	SANDY GRAVEL - apparently dense, light grey-brown, rounded to subrounded medium to coarse gravel/cobble with coarse sand *(continued)*										
	11.6											
15	12	PEATY CLAYEY SAND - apparently loose, grey to dark grey, fine sand with peaty clay lenses										
	12.0	GRAVELLY SAND - brown gravelly sand, wet						Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°				
14	12.8											
	13	LAMINITE - very low strength, light grey to grey laminite										
	13.17											
13	14	INTERBEDDED SANDSTONE & SILTSTONE - medium and high strength, fresh, slightly fractured and unbroken, light grey to grey, fine grained sandstone (40%) interbedded/laminated with siltstone (60%)						13.17-13.27m: B (x2) 0°-5°, cly co, 5mm 13.38m: B5°, cly co, 2mm	C	100	92	PL(A) = 3.03 PL(A) = 0.65
12	15							15.26m: B5°, cly, 2mm 15.5-15.52m: fg 15.98m: B/J20°, pl, sm, cbs co	C	100	96	PL(A) = 1.15 PL(A) = 0.41
11	16											
	16.05	Bore discontinued at 16.05m										
10	17											
9	18											
8	19											
7												

RIG: Explorer **DRILLER:** LC **LOGGED:** SI **CASING:** ODEX to 13.17m

TYPE OF BORING: Solid flight auger to 5.0m; ODEX drilling to 13.17m; NMLC-Coring to 16.05m

WATER OBSERVATIONS: Free groundwater observed at 8.0m whilst ODEX drilling

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 27.1883 AHD **BORE No:** 6
EASTING: 286615.45 **PROJECT No:** 85715.00
NORTHING: 6263249.07 **DATE:** 1/11/2016
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
27	0.0	FILLING - light grey, silty clay filling with shale fragments, humid							A			
	0.5	FILLING - light grey-brown sandy clay filling with some fine roadbase gravel, wet							A			
26	1.0	SANDY CLAY - stiff, brown, fine grained sandy clay, moist							A			
									S			4,4,8 N = 12
25	2											
									S			4,6,9 N = 15
24	3											
23	4	4.0m: becoming very stiff							S			7,10,15 N = 25
	4.6	GRAVELLY SAND - very stiff, brown, gravelly (sandstone) sand with some clay, moist										
22	5.0	SANDY GRAVEL - apparently dense, light grey-brown, rounded and subrounded gravel/cobbles with coarse sand, moist							A			
21	6											
20	7											
19	8											
18	9	8.9m: becoming wet				▼						

RIG: Explorer **DRILLER:** LC **LOGGED:** SI **CASING:** HQ/ODEX to 12.83m

TYPE OF BORING: Solid flight auger to 5.2m; ODEX drilling to 12.83m; NMLC-Coring to 16.15m

WATER OBSERVATIONS: Free groundwater observed at 8.9m whilst ODEX drilling

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BORE: 6 **PROJECT: 85715.00** **November 2016**

12.83 – 16.15m

BOREHOLE LOG

CLIENT: St Hilliers Group
PROJECT: Proposed High Rise Unit Development
LOCATION: Lot 3003-3005, Sheffield Close, Penrith

SURFACE LEVEL: 27.1883 AHD **BORE No:** 6
EASTING: 286615.45 **PROJECT No:** 85715.00
NORTHING: 6263249.07 **DATE:** 1/11/2016
DIP/AZIMUTH: 90°/-- **SHEET** 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering	Graphic Log	Rock Strength	Water	Fracture Spacing (m)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
17		SANDY GRAVEL - apparently dense, light grey-brown, rounded and subrounded gravel/cobbles with coarse sand, moist *(continued)*										
16	11											
15	12							Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°				
	12.4	SANDSTONE - very low strength, light grey fine grained sandstone										
	12.83	SANDSTONE - high to very high strength, fresh, slightly fractured then unbroken, light grey fine grained sandstone										PL(A) = 3.3
14	13								C	100	82	
13	14	13.73-14.2m: medium strength interlaminated sandstone and siltstone band						13.73m: J30° & 85°, st, sm, cln 13.75-13.9m: B's 0°, cly vn 13.9m: J, sv, pl, ro, cln				PL(A) = 0.5
	14.6	SILTSTONE - medium and high strength, fresh, slightly fractured, light grey to grey siltstone interlaminated with some fine sandstone lamination										PL(A) = 1.23
12	15							15m: B0°, cly co, 4mm 15.21m: J30°, he/ti 15.55m: J60°, pl, ro, cln 15.75m: J30°, pl, ro, cbs co	C	100	91	PL(A) = 0.49
	16											
11	16.15	Bore discontinued at 16.15m										PL(A) = 1.8
10	17											
9	18											
8	19											

RIG: Explorer **DRILLER:** LC **LOGGED:** SI **CASING:** HQ/ODEX to 12.83m

TYPE OF BORING: Solid flight auger to 5.2m; ODEX drilling to 12.83m; NMLC-Coring to 16.15m

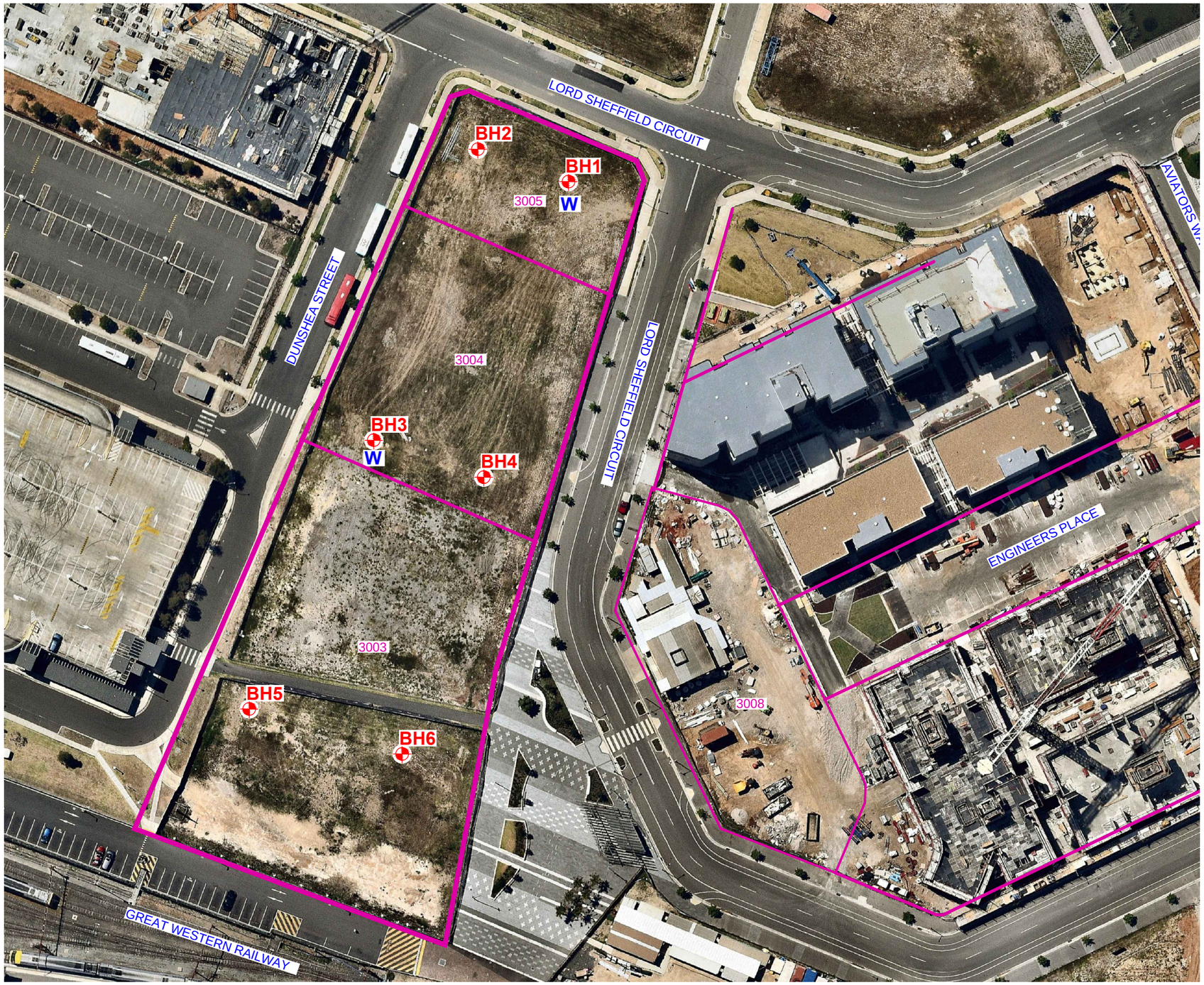
WATER OBSERVATIONS: Free groundwater observed at 8.9m whilst ODEX drilling

REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater



Locality Plan

NOTE:
1: Base image from Nearmap.com (Dated Novenber 2016)
2: Test locations are approximate only and are shown with reference to existing features.

0 10 20 30 40 50 75 100m

1:1000 @ A3

LEGEND

- Borehole 1m into bedrock
- W Standing water gauge

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: St Hilliers Group		TITLE: **Location of Boreholes**	PROJECT No: 85715.00
OFFICE: Sydney	DRAWN BY: PSCH	**Lots 3005, 3004 & 3005**	DRAWING No: 1
SCALE: 1:1000 @ A3	DATE: 1.12.2016	**Lord Sheffield Circuit, PENRITH**	REVISION: 0

Appendix B

Results of Laboratory Testing

12 Ashley Street, Chatswood, NSW 2067
tel: +61 2 9910 6200

email: sydney@envirolab.com.au
envirolab.com.au

Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 158523

Client:
Douglas Partners Pty Ltd
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Konrad Schultz

Sample log in details:

Your Reference:	**85715.00, Penrith Lot 3003, 3004, 3005**
No. of samples:	12 Soils
Date samples received / completed instructions received	05/12/16 / 05/12/16

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	12/12/16 / 9/12/16
Date of Preliminary Report:	Not Issued

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025 - Testing **Tests not covered by NATA are denoted with *.**

Results Approved By:

David Springer
General Manager

Misc Inorg - Soil						
Our Reference:	UNITS	158523-1	158523-2	158523-3	158523-4	158523-5
Your Reference	---------- -	BH1	BH1	BH2	BH2	BH3
Depth	----------	1.0	2.5	0.1	5.5	0.5
Date Sampled		1/11/2016	1/11/2016	27/10/2016	27/10/2016	27/10/2016
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	06/12/2016	06/12/2016	06/12/2016	06/12/2016	06/12/2016
Date analysed	-	06/12/2016	06/12/2016	06/12/2016	06/12/2016	06/12/2016
pH 1:5 soil:water	pH Units	6.2	6.2	7.5	7.8	7.8
Chloride, Cl 1:5 soil:water	mg/kg	410	750	37	120	84
Sulphate, SO4 1:5 soil:water	mg/kg	120	<10	36	<10	150

Misc Inorg - Soil						
Our Reference:	UNITS	158523-6	158523-7	158523-8	158523-9	158523-10
Your Reference	---------- -	BH3	BH4	BH4	BH5	BH5
Depth	----------	1.0	2.5	4.0	0.5	5.0
Date Sampled		27/10/2016	27/10/2016	27/10/2016	1/11/2016	1/11/2016
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	06/12/2016	06/12/2016	06/12/2016	06/12/2016	06/12/2016
Date analysed	-	06/12/2016	06/12/2016	06/12/2016	06/12/2016	06/12/2016
pH 1:5 soil:water	pH Units	7.8	6.6	7.6	6.6	7.2
Chloride, Cl 1:5 soil:water	mg/kg	88	440	310	45	310
Sulphate, SO4 1:5 soil:water	mg/kg	110	<10	<10	25	61

Misc Inorg - Soil			
Our Reference:	UNITS	158523-11	158523-12
Your Reference	---------- -	BH6	BH6
Depth	----------	1.0	4.0
Date Sampled		1/11/2016	1/11/2016
Type of sample		Soil	Soil
Date prepared	-	06/12/2016	06/12/2016
Date analysed	-	06/12/2016	06/12/2016
pH 1:5 soil:water	pH Units	8.0	7.5
Chloride, Cl 1:5 soil:water	mg/kg	25	10
Sulphate, SO4 1:5 soil:water	mg/kg	50	26

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			06/12/2016	158523-1	06/12/2016 || 06/12/2016	LCS-1	06/12/2016
Date analysed	-			06/12/2016	158523-1	06/12/2016 || 06/12/2016	LCS-1	06/12/2016
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	158523-1	6.2 || 6.1 || RPD: 2	LCS-1	102%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	158523-1	410 || 410 || RPD: 0	LCS-1	91%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	158523-1	120 || 110 || RPD: 9	LCS-1	105%

QUALITY CONTROL Misc Inorg - Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	158523-11	06/12/2016 || 06/12/2016	158523-2	06/12/2016
Date analysed	-	158523-11	06/12/2016 || 06/12/2016	158523-2	06/12/2016
pH 1:5 soil:water	pH Units	158523-11	8.0 || 7.8 || RPD: 3	[NR]	[NR]
Chloride, Cl 1:5 soil:water	mg/kg	158523-11	25 || 26 || RPD: 4	158523-2	#
Sulphate, SO4 1:5 soil:water	mg/kg	158523-11	50 || 46 || RPD: 8	158523-2	96%

Report Comments:

Chloride
Percent recovery is not possible to report due to the high concentration of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NR: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.