GOLDER

REPORT

Proposed Gran Central Development

Geotechnical Preliminary Investigation Report

Submitted to:

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1.0 INTRODUCTION

This report presents the results of preliminary geotechnical investigations conducted by Golder Associates Pty Ltd (Golder) for the proposed Gran Central building development. The project is located at 134-142 Parramatta Road, 26-38 Good Street and 59-61 Cowper Street, Granville.

The work was authorised by Property Development Solutions Pty Ltd (PDS Group), on behalf of Starryland NSW Pty Ltd (Starryland) (the Client) in email authorisation to proceed, dated 28 June 2019. The works were conducted in accordance with our proposal P19122955-001-P-Rev0, dated 8 May 2019.

This investigation is preliminary only and its purpose is to identify / confirm the primary ground related risks and to assist in development of conceptual mitigation measures. Additionally, the investigation is intended to provide suitable information to allow the design to develop, however, further investigations will be required to progress through to detailed design.

This report is based on the results of the Preliminary Geotechnical Investigation (PGI) conducted by Golder between 29th July 2019 and 2nd August 2019. Coincident with the PGI, soil samples were extracted and tests performed to develop a preliminary understanding of the risks associated with the potential presence of contaminated soil and groundwater across the site. A preliminary report (19122955-002-R) presenting these findings has been prepared separately to this PGI report.

1.1 Project Understanding

The following documents, supplied by the Client, were used to assist with the preparation of this PGI report:

- Project Brief prepared by PDS Group – File No: 190418_T6052_A070_Project Brief, Revision 2, dated 18 April 2019; and
- Architectural drawings prepared by PDB Architects – Project No 1838, drawing Nos DA101 (Issue P2, dated 24 May 2019), DA301 (Issue P1, dated 5 July 2019), DA302 (Issue P1, dated 5 July 2019), were attached as the appendix in the Project Brief; and
- Detailed Survey Plan by StrataSurv Surveyors – Drawing No 3646DT-01, Sheet 01 of 01, Revision A4, dated 07 October 2014. The datum is in Australian Height Datum (AHD). All levels referred to in this report are in reference to AHD; and
- Scope for Geotechnical and Environmental Investigation prepared by PDS Group – File No: 190418_T6052_C023_ Scope_of_Service_of Environmental and Geotechnical, Revision 2, dated 24 April 2019;
- Additional documents were reviewed after project award, and include – Project No 1838, drawing Nos DA102 (Issue P1, dated May 2019 – Ground Floor Plan), drawing Nos DA303 (Issue P1, dated May 2019 – Driveway Section),

Based on these documents, Golder understands that the proposed development involves the demolition of existing site structures and construction of three multi-storey mixed-use towers over a common single-level basement car park. The proposed basement extent has a setback of:

- 6.0 m to the northern site boundary (bounded by Parramatta Road).
- 6.5 m to the eastern site boundary (bounded by Good Street).
- 7.5 m to the eastern portion of the southern site boundary (bounded Cowper Street).
- 0 - 1 m to the western portion of the southern site boundary (bounded by Cowper Street).

- 7.5 m to the southern portion of the western site boundary (bounded by a multi-storey mixed-use development).
- 0 m, abutted northern portion of the western site boundary (bounded by a service station).

The proposed basement has a Finished Floor Level (FFL) of Reduced Level (RL) 8.0 m and a ground car park level of 12.3 m RL. To achieve the former, a Bulk Excavation Level (BEL) of RL 7.8 m is assumed, which will allow for the construction of the basement floor slabs. This will require excavations to depths ranging from 3.0 m to 5.0 m Below Existing Ground Level (BEGL). Locally deeper excavations may be required for footings, lift shafts, crane pads and service trenches.

1.2 Aim and Scope of Work

The aim of this preliminary report is to provide a preliminary assessment of geotechnical conditions across the site to inform concept design on the mixed-use development.

The report includes the following:

- A summary of expected ground conditions, including thickness and composition of fill, soils and rock.;
- Preliminary assessment of foundation and retention wall options for both drained and tanked basement.
- Preliminary advice on geotechnical design parameters, including piles and shallow footings, retention design parameters, pavement subgrade design parameters and footing settlement characteristics.
- Comment on possible constructability issues such as excavation stability, groundwater inflow management and site trafficability based on the preliminary scope of works.
- Preliminary assessment of groundwater levels and a qualitative assessment of potential groundwater inflows.
- Assessment and recommendations for additional site investigations, testing and/or monitoring requirements.

2.0 DESKTOP STUDY

The following documents and information were used for the desktop study:

- Department of Mineral Resources Geological Map Sydney 1:100,000 Geological Series Sheet 9130 (DMR 1983); and
- Groundwater monitoring state overview[1] (Water NSW)
- Soil Landscape Maps from eSPADE[2] (NSW Office of Environment and Heritage)
- Six maps[3] (NSW)
- Detailed Survey Plan by StrataSurv Surveyors – Drawing No 3646DT-01, Sheet 01 of 01, Revision A4, dated 07 October 2014. The datum is in Australian Height Datum (AHD). All levels referred to in this report are in reference to AHD; and

2.1 Site Terrain

The site is approximately 5,150 m^2 based on the provided survey map. The site is located on the southern side of Parramatta Road across gently (about 0 – 5 degrees) dipping topography to the north based on the six map and provided survey plan. The site levels range from about RL 13m towards the south-western corner to RL 10.3 m towards the north-eastern corner of the site.

2.2 Regional Geology

Information on regional sub-surface conditions, referenced from the Department of Mineral Resources Geological Map Sydney 1:100,000 Geological Series Sheet 9130 (DMR 1983) indicates the site is underlain by Ashfield Shale (Rwa). The Ashfield Shale is Triassic aged and from the Wianamatta Group of rocks and forms the ridge capping over Hawkesbury Sandstone bedrock within this part of Sydney. The Ashfield Shale geological unit generally comprises an interbedded sequence of shale and laminite which are prone to deep weathering at the surface to clays of medium to high plasticity.

2.3 Rainfall

The climate of Sydney is humid subtropical. Rainfall is fairly evenly spread through the year, with moderate to low variability. Precipitation is slightly higher during the first half of the year and lower in the second half. Due to the unpredictability of rain, the wettest and driest months would change in a yearly basis. Based on the Bureau of Meteorology, the selected rainfall station is Parramatta North (Masons Drive) (about 4.4 km away from the site). The rainfall data is available from 1965 until present. The summary of the rainfall data is summarized in **Figure 1**.

[1] https://realtimedata.waternsw.com.au/water.stm

[2] https://www.environment.nsw.gov.au/eSpade2WebApp

[3] https://maps.six.nsw.gov.au/

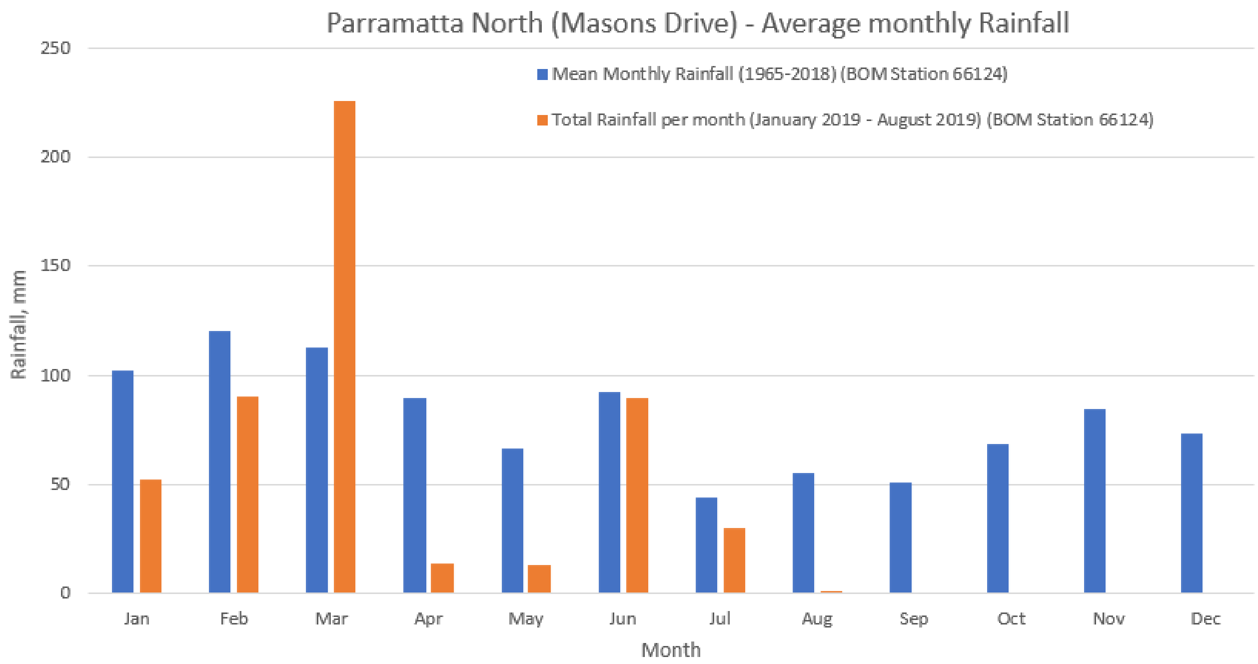

Figure 1: Rainfall Data from BOM at Parramatta North (Masons Drive) (1965-2019)

2.4 Groundwater

There is no published groundwater monitoring data in the vicinity of the site. The nearest creeks, A'becketts Creek and Duck Creek are located more than 380 m away to the north and east from the site respectively.

3.0 SCOPE OF WORKS

The scope of works for the Preliminary Geotechnical Investigation includes:

- Preparation of a Health and Safety Environment Plan (HaSEP).
- Review of relevant geological maps for the project area.
- Electro-magnetic scanning of proposed borehole locations for buried conductive services using a licensed service locator with reference to Dial Before You Dig (DBYD) plans.
- Non-destructive drilling using hang auger at all borehole locations, BH01M, BH02, BH03 and BH04, to a common depth of about 1.5 m below existing ground level (BEGL). The existing ground surface levels shown on the borehole logs were approximated from the spot levels shown on the supplied survey plans. Approximate borehole locations are shown on the attached Map (**APPENDIX A)**.
- Auger drilling of four boreholes, BH01M, BH02, BH03, and BH04, by a track-mounted drill rig using solid flight augers equipped with a 'Tungsten-Carbide' (T-C) bit to depths of about 4.83 m (RL 5.27 m), 1.85 m (RL 10.65 m), 2.25 m (RL 10.05 m) and 3.10 m BEGL (RL 7.90m), respectively.
  - Standard Penetration Testing (SPT) was carried out (as per AS1289.6.3.1 – 2004) during auger drilling of the boreholes to assess soil strength. Soil samples were sent to Resource Laboratories Pty Ltd (Resource) and SGS Sydney Pty Ltd (SGS), which are the National Australian Testing Authority (NATA) accredited laboratories, for testing and storage;
- The strength of the siltstone bedrock in the augered sections of the boreholes was assessed by observation of the penetration resistance, examination of the recovered rock cuttings and the SPT readings.
- Continuation of BH01M, BH02, BH03 and BH04 using NMLC diamond coring techniques to the target termination depths of 10.1 m (RL 0.7 m), 8.75 m (RL 3.75 m), 8.34 m (RL 3.96 m) and 7.8 m (RL 3.2 m) BEGL, respectively.
  - Rock cores recovered from the boreholes were boxed, logged, photographed. Borehole logs and core photographs are provided in **APPENDIX B**.
  - Point Load Strength Index testing (PLT) was carried out (as per AS4133.4.1 - 2007) by a Golder engineer, to assess the intact strength of the recovered rock. The test results are presented in **APPENDIX C**.
- Following the completion of the boreholes:
  - BH01M was converted to a groundwater monitoring well to a depth of about 5.02 m BEGL (RL 5.08 m). This well was screened from 2 to 5 m BEGL. Construction details for the well are provided in **APPENDIX B**. The monitoring well was developed dry using a bailer after installation of the well.
  - BH2, BH03 and BH04 were backfilled with grout to existing ground surface level;
- The boreholes were monitored for possible groundwater seepage during and shortly after completion of auger drilling. Groundwater monitoring and sampling from BH01M was completed one week after the installation of the well. No further long-term groundwater monitoring is scheduled for the PGI.
- Laboratory geotechnical testing was conducted on selected soil samples. This consisted of the following tests:
  - Two (2) Moisture Content tests;

- Two (2) Atterberg Limit Tests;
- Three (3) Aggressivity Suites of tests (i.e. pH, sulfate, chlorides and Electrical Conductivity)
- One (1) Shrink Swell Index Tests on an undisturbed soil sample;

4.0 RESULTS OF THE SITE INVESTIGATIONS

4.1 Site Description

The area of the site is 5148 m^2 based on the survey plan which was provided by PDS.

At the time of the investigation, the site comprised of fifteen lots:

- 26-30 Good Street: A single-storey commercial brick building with no basement occupied the eastern portion of the DP.
- 32 Good Street: The lot consists a single storey commercial rendered building (Holy Shop) located at the south eastern corner of the lot and a two-storey brick building (old fire station) without basement, located at the north-eastern corner of the lot. The buildings abutted each other.
- 59 Cowper Street: A single-storey weatherboard residential dwelling without basement occupied at the southern portion of the lot.
- 61 Cowper Street: Vacant yard with grass.
- 134 Parramatta Road and 38-44 Good street): Gravel paved car storage yard with a metal awning was located at the south-western corner of the site.
- 138 Parramatta Road: A one to two storey brick building without a basement (office furniture shop) occupied the northern portion of the lot. The façade of the building was classified as the heritage based on the provided information and there was a concrete paved car park located at the rear of the address. There were a few medium to large size trees located at the north-eastern corner of the lot.
- 142 Parramatta Road: The lot was paved with concrete and a metal demountable shed was located at the south-western corner of the lot.

4.2 Local Land Use

The site is situated within an area of mixed-use. Current uses on surrounding land at the time of our presence on-site are described in **Table 1** below.

Table 1: Summary of Local Land Use

Direction Relative to Site	Land Use Description
North	Parramatta Road (RMS Asset): A four-lane asphaltic-concrete road followed by few commercial brick/rendered developments. The minimum setback between the road kerb and site boundary is about 3 m, which is the approx. width of the footpath.
East	Good Street: A four-lane asphaltic-concrete road followed by few commercial brick/rendered developments. The minimum setback between the road kerb and site boundary is about 3 m, which is the approx. width of the footpath.
South	Cowper Street: A four-lane asphaltic-concrete road with kerb-side car parking, followed by a few commercial brick/rendered developments. The minimum setback between the road kerb and site boundary is about 3m, which is the approx. width of the footpath.
West	A multi-storey mixed-use development and a service station abutted the western site boundary: We understand that the multi-storey mixed-use building has a single level basement. A service station: the main building has a minimum setback of about 15m from the western site boundary. Underground storage tanks (OSD) was constructed adjacent to the northern portion of the western site boundary. The approx. depth of the OSD is assumed to be 3m below the existing ground level. A single-lane asphaltic-concrete road (runs in west-east direction) located to the west of the site, to provide access to the basement of the multi-storey building at the rear of the lot 12, DP 575064 (142 Parramatta Road)

4.3 Subsurface Investigation Results

A summary of the boreholes completed for the preliminary investigation is provided in **Table 2**.

Table 2: Summary of Boreholes

Investigation Location	Coordinates[1] (MGA)		Surface Elevation[2] (RL m)	Termination Depth (m BGL)	Termination Reason
	Easting	Northing			
BH01M	315964	6254865	10.80	10.10	Target Depth
BH02	315950	6254816	12.50	8.75	Target Depth
BH03	315992	6254806	12.30	8.34	Target Depth
BH04	316032	6254826	11.00	7.80	Target Depth

[1] – Handheld GPS to Map Grid of Australia (MGA94 55), accuracy ±5 m.

[2] – From spot levels shown on the supplied survey plans (Drawing No 3646DT-01, Sheet 01 of 01, Revision A4, dated 07 October 2014), accuracy ±0.5 m.

Groundwater monitoring was carried out in BH01M. The recorded groundwater measurements from this well and during drilling are summarised in the **Table 3**.

Table 3: Groundwater Observation

Investigation Location	Observations Date	Groundwater Level / Seepage Observations
BH01M	30-July-2019	Groundwater not encountered during and shortly after completion of auger drilling
	31-July-2019	First attempt to install monitoring well. Failed due to unknown thickness of backfill material, PVC pipe installed in the borehole (screen 4.1-10.1m) and it was bailed dry.
	1 August 2019	4.0 m [1] below existing ground level or RL 6.8 m
	2 August 2019	Second attempt to install monitoring well. Monitoring well completed (screen 2-5 m), bailed dry after installation. 4.0 m below existing ground level or RL 6.8 m prior to second installation.
	9 August 2019	1.9 m below existing ground level or RL 8.8 m
BH02	31 July 2019	Groundwater not encountered during and shortly after completion of auger drilling
BH03	1 August 2019	Groundwater not encountered during and shortly after completion of auger drilling
BH04	29 July 2019	Groundwater not encountered during and shortly after completion of auger drilling

[1] – We note that the groundwater level may not have stabilised within the limited observation period.

A Golder geotechnical engineer was present on-site to set out the borehole locations, direct the testing and sampling, log the subsurface conditions and record the groundwater levels.

4.4 Results of Laboratory Testing

Laboratory testing of selected samples recovered from the boreholes was carried out to assess soil characterisation and likely behaviours. The tests on the soil samples were carried out in accordance with relevant Australian Standard AS1289 "Methods of testing soils for engineering purposes".

Table 4 and **Table 5** summarises the laboratory test results, and the associated laboratory test certificates are attached in **APPENDIX C**.

Table 4: Summary of Laboratory Characterisation Test Results (Soil Behaviour)

Investigation Location	Sample Depth (m)	Ground Unit [1]	Moisture Content (%)	Atterberg Limits			Shrink Swell Index
				Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	
BH01M	0.53-0.60	2	37.5	90	20	70	-
BH03	0.50-0.60	2	30.8	108	32	76	-
BH04	2.00-2.35	2	-	-	-	-	1.7

[1]For a description of the ground units refer to **Section 5.0.** For more detailed descriptions of the subsurface conditions at each borehole location refer to the borehole logs presented in **APPENDIX B**.

Table 5: Summary of Laboratory Characterisation Test Results (Chemical)

Investigation Location	Sample Depth (m)	Ground Unit [1]	Moisture Content (%)	Aggressivity				
				pH	Electrical Conductivity (µS/cm)	Electrical Resistivity (ohm.cm)	Sulfate SO^4 (ppm)	Chloride Cl (ppm)
BH02	1.8-1.85	2	8.9	5.4	94	11000	60	1.9
BH4	0.55-0.65	2	24.8	5.0	150	6600	87	42
BH1M	Water Sample			6.4	4400	-	660	1100

[1]For a description of the ground units refer to **Section 5.0.** For more detailed descriptions of the subsurface conditions at each borehole location refer to the borehole logs presented in **APPENDIX B**.

Rock core samples were tested by a Golder Engineer (as per AS1289.6.3.1 – 2004) to estimate the Point Load Strength Index (Is50) values to assist with rock strength assessment. A total of twenty-seven (27) tests were carried out and the results of the testing are summarised on the borehole logs provided in **APPENDIX B**. The point load strength index tests correlated reasonably well with our field assessments of rock strength. The approximate Unconfined Compressive Strength (UCS) of the rock core, estimated from correlations with the point load strength index test results, varied from 1.1 MPa to 15.3 MPa.

5.0 GROUND MODEL

5.1 Stratigraphy

Based on the results of the geotechnical investigation and associated testing, we have developed ground units to summarise the typical subsurface profile encountered across the site. **Table 6** presents the ground model.

Table 6: Stratigraphic units

Ground Unit	Inferred Subsurface Conditions
Unit 1 Fill / Topsoil	120mm and 140mm thick concrete pavement was encountered in BH01M and BH02, respectively. No pavement was present in BH03; 20mm thick gravel pavement was encountered in BH04; Fill material was encountered at BH01M, BH02 and BH04, the fill comprised of sandy CLAY (BH01M), silty CLAY (BH02), or Gravelly SAND (BH04), with sand, gravel, trace glass and rootlets. The fill is about 40 – 300 mm thick. Topsoil of medium to high plasticity silty CLAY was encountered at BH03, about 230 mm thick, trace rootlets and wood fibre.
Unit 2 Residual Clay / Class V Siltstone	Silty Clay, medium to high plasticity, brown to red-brown, becoming pale grey with depth, generally very stiff to hard Within the residual clays are zones of very low to medium strength siltstone, that vary in thickness between about 1.3-2.3 m and are underlain with further zones of clayey residual soil.
Unit 3 Class IV and III Siltstone	Generally low or low to medium strength, moderately to slightly weathered, dark grey, iron stained siltstone encountered at all borehole locations. The defects were assessed to be closely spaced (30-300 mm) sub-horizontal beddings, some extremely weathered seams and sub-vertical joints.
Unit 4 Class II Siltstone	Generally medium strength, fresh, dark grey, siltstone encountered at all borehole locations. The defects were assessed to be moderately spaced to widely spaced (300-1000 mm) sub-horizontal beddings, some extremely weathered seams and sub-vertical joints.

The ground conditions encountered in each of the boreholes are summarised in **Table 7**.

Table 7: Ground conditions in boreholes

Ground Unit	BH01M		BH02		BH03		BH04	
	Depth to top of Unit (mBEGL)	Level at top of Unit (mAHD)[1]	Depth to top of Unit (mBEGL)	Level at top of Unit (mAHD)[1]	Depth to top of Unit (mBEGL)	Level at top of Unit (mAHD)[1]	Depth to top of Unit (mBEGL)	Level at top of Unit (mAHD)[1]
Unit 1 Fill/Topsoil	Surface	10.80	Surface	12.50	Surface	12.30	Surface	11.00
Unit 2 Residual CLAY / Class V Siltstone	0.18	10.62	0.30	12.20	0.23	12.07	0.25	10.75
Unit 3 Class IV / III Siltstone	4.90	5.90	4.92	7.58	5.60	6.70	5.70	5.30
Unit 4 Class II Siltstone	5.80	5.00	7.10	5.40	7.70	4.60	7.70	3.30
End of Borehole	10.10	0.70	8.75	3.75	8.34	3.96	7.80	3.20

BEGL – Below existing ground level

[1]Level is based on approximation from site survey plan and GPS locations, accuracy is ± 0.5 m.

5.2 Groundwater Observations

Groundwater was not encountered in any of the boreholes during auger drilling. Groundwater was encountered in the BH01M. The groundwater level was observed at a depth of approximately 4 m bgl on 1 August 2019 (when borehole was drilled). A monitoring well was installed in the borehole and the groundwater level was observed to have risen to 1.9 m bgl during groundwater sampling on 9 August 2019, which is an increase of about 2.1m over 1 week. This would indicate that the groundwater level measured on 1 August 2019 following the drilling had not stabilised, indicating that the soils over which the well is screened (i.e. Unit 2) has a relatively low permeability and therefore a slow groundwater response. We note that the groundwater level measured on 9 August 2019 may not have been the fully recovered groundwater level either and the current actual groundwater level could therefore be higher than what was measured on 9 August 2019. The summary of the groundwater seepage and groundwater level measurements are summarised in the **Table 3.**

Currently, no further long-term groundwater level monitoring is scheduled as part of this preliminary geotechnical investigation. However, it should be considered to install a groundwater logger in BH01M to allow for ongoing measurement of the groundwater level and assess the actual groundwater level elevation. Such monitoring would also allow for an assessment of the groundwater level behaviour following rainfall events.

6.0 DISCUSSION AND RECOMMENDATIONS

The proposed building is to consist of multi-level towers with a single level basement. Excavations for the basement are expected to be 3 to 5 m deep and will be at an approximate RL of 8 m AHD. The foundation system may consist of shallow or deep footings. Based on our understanding of the project and the inferred ground conditions, the following geotechnical consideration have been addressed in this report:

- Basement excavation and retention to limit lateral deflections and ground loss as a result of excavations. This includes consideration of excavations adjacent to RMS Assets and other assets such as the existing multi-story building and service station to the west.
- Groundwater inflows and management of groundwater.
- Foundation design for building loads and ancillary structures.
- Pavement considerations for driveways.
- Trafficability at the bulk excavation level and other construction issues.

6.1 Geotechnical Design Parameters

Geotechnical design parameters for the design of permanent and temporary components of the proposed development are provided in **Table 8**. Recommendations for geotechnical parameters have been developed based on the site conditions encountered during the preliminary geotechnical investigation.

We note that the inferred consistency of the residual soils indicated in the borehole logs are those that are relevant for the moisture conditions at the time of testing. The consistencies are based on the results of SPTs and tactile observations, which have some uncertainty. In addition, the consistency of top 1.5 m clay was unable to be assessed from in-situ testing due to non-destructive drilling using hand augers. Consistency assessment of this upper material was made based on judgement of hand auger resistance.

The parameters provided in **Table 8** are intended to reflect those that the soils and rocks will potentially see across the life of the proposed development. The design parameters are derived from results of in-situ testing, laboratory testing and engineering judgement.

Table 8: Recommended preliminary geotechnical design parameters

Design Parameter	Unit 1 Fill	Unit 2 Residual CLAY / Class V Siltstone	Unit 3 Class IV / III Siltstone	Unit 4 Class II Siltstone
Bulk Unit Weight, γ (kN/m^3)	18	20	23	24
Undrained Shear Strength[1], S_u (kPa)	50	120	-	-
Poisson's Ratio (v)	0.35	0.3	0.2	0.15
Drained Cohesion, c' (kPa)	1	5	50	200
Drained Friction Angle, φ' (deg)	25	28	38	40
Elastic Modulus, E' (Loading) (MPa)	10	30	250	1000
Vertical Modulus of Subgrade (MPa/m) [2]	5/B	16/B	220/B	800/B
Susceptibility to Liquefaction During an Earthquake[3]	Low			

[1]Undrained cohesion & friction angle applies to short-term.

[2]Modulus derived based on Mayne & Poulos (1999); B = Width of structural element

[3]Susceptibility to liquefaction during an earthquake is based on the following definition:

Low – Medium to very dense sands, stiff to hard clays, and rock

Medium –Loose to medium dense sands, soft to firm clays, or uncontrolled fill below the water table

High –Very loose sands or very soft clays below the water table.

Due to the inherent complexity of soil behaviour, subgrade in soil foundation interaction problems is often simplified as Winkler springs, which require input of subgrade reaction coefficient/modulus of subgrade reaction. The foundation designer should note that the provided modulus of subgrade reaction is not a fundamental soil property, but it is a specific to the geometry of the foundation and loading condition (Terzaghi, 1955).

6.2 Groundwater Consideration

Groundwater was observed in the installed monitoring well BH01M (7 days after well installation) at a depth of about 1.9 m BEGL, or RL of about 8.9 m, which is above the assumed Bulk Excavation Level of RL 7.8m.

As discussed in Section 2.3, it was relatively dry leading into the investigation and no significant rainfall was recorded between the completion of the intrusive investigation and the groundwater monitoring one week later. We note that the measured groundwater level may not have fully stabilised following the drilling and the groundwater level could therefore be higher. The groundwater level behaviour (i.e. seasonal changes) following rainfall events is also currently unknown for the site. Given that the groundwater level was found to be above the proposed excavation level, it should be considered to undertake further groundwater level monitoring to get a better understanding of the groundwater level at the site.

The response time for equalization of the groundwater level suggests a relatively low permeability strata. This is consistent with the silty clay residual soils where the groundwater was encountered which typically have permeability in the range of 10^{-7} m/s to 10^{-10} m/s. Locally higher inflows may be present in gravel seams or Class V Shale seams encountered in the Unit 2 residual clay / Siltstone V material.

As the preliminary assessments indicates that the permeability is expected to be low, groundwater inflow into the site during construction and long-term (if a drained basement is planned) would currently be expected to be low. During construction, it should be able to manage the groundwater inflow through the use of sump and pumps. More intensive pumping to manage inflows will be required after periods of rainfall.

If a basement will not be tanked, a drainage system would need to be installed that would collect and remove water seepage into the basement. Drainage should be provided behind all basement retaining walls, around the perimeter of the basement and below the basement slab. This drainage should be connected to the basement drainage system. The groundwater inflow is currently considered to be low, but further investigation on soil permeability and seepage rates would be required, if a drained basement is considered.

The groundwater quality result from BH01M indicates that toluene was above detection level may be present in the groundwater and there are also elevated zinc concentrations, which may be related to the adjacent service station. Other hydrocarbon concentrations were below laboratory detection level in BH01M. If a drained basement is adopted, the groundwater level will be drawn down at the site, which will result in groundwater from neighbouring sites to flow towards our site and into the drain system. Therefore, there is a risk that if hydrocarbons are present in the area (e.g. beneath the service station) then the hydrocarbons could be drawn into the basement excavation.

Furthermore, permission will need to be obtained from relevant authorities for any permanent or temporary discharge of groundwater inflows into the drainage system. Alternatively, it could be disposed to sewer under a Trade Waste Agreement with Sydney Water. Further testing of the groundwater quality for groundwater discharge assessment will be required. This will involve the testing of nutrients and additional metals such as aluminium, manganese and iron.

Additionally, the resultant drawdown of the surrounding groundwater table and implications on surrounding properties and infrastructure will need to be assessed further, if a drained basement solution will be pursued.

Further investigation and monitoring is recommended to gain a better understanding of the groundwater inflow, levels and quality on the site.

6.3 Excavation Retention

6.3.1 Retention Systems

The retention systems will be required to provide support of the walls of the basement both during construction and permanently. Excavations and retention systems will also need to take into consideration their allowable movement so as not to have any adverse effects on the buildings and structures adjoining the excavation. The retention system will also need to consider the requirements for a tanked or drained basement.

Based on the provided documents, Golder understands that the proposed development involves the demolition of the existing site structures, including the existing heritage building on site, and the construction of two multi-storey mixed-use towers over a common single-level basement car park.

Considering the excavation depth and setback to the site boundary (which were outlined in Section 1.1), where site allows, we consider that temporary batters of 1H: 1V may be feasible for this site if setback is greater than the excavation depth. However, temporary excavation batters made during construction may need to be filled to achieve final levels. This is likely to involve the use of engineered fill and suitable earthwork compaction methods.

Where the recommended temporary batters are not feasible or not desirable, a suitable retention system will be required. The adopted retaining wall system will likely be dependent on the tolerable movement adjacent to the retaining wall to limit impacts on neighbouring infrastructure and the requirements for a tanked or drained basement. Consideration should also be made for the potential undermining of adjacent building footings in the adoption of the retention system. Additional investigation of the adjacent building may be required to better understand limitations. Further design considerations and parameters for retaining wall systems are provided in Section 6.3.2.

Some potential retention systems include:

- Drained:
  - Anchored soldier pile walls with concrete infill panels.
  - Contiguous retaining wall or semi-contiguous retaining wall with shotcrete infill
  - Soil nail wall
- Tanked:
  - Diaphragm wall
  - Secant pile wall

Piles must be installed below bulk excavation level (including footings, service trenches and lift overrun pits) with a suitable socket length for lateral resistance. The presence of neighbouring basements (including anchor systems from these basements if any), footings or services and their levels should be considered as part of anchor or soil nail design. Where anchors or soil nails are not suitable, internal propping may be required or an alternative retention system adopted. For tanked basements, there may still be leakage of water through the wall, the amount will vary depending on quality control during construction and details adopted for joints and membranes.

Bored piles may be used for this site. However, larger capacity piling rigs may be required for drilling through the medium strength siltstone encountered in Unit 4 (Class II Siltstone) and in zones of Unit 3 (Class IV / III Siltstone) to achieve required socket lengths. We recommend further advice be sought from piling contractors to assess rig type and excavatability.

Working platforms for the pile rigs are also likely to be required.

Due to the presence of siltstone bedrock at the depths of excavations for the basement, it is assumed that driven piles will not be able to achieve suitable embedment depths and have not been considered further.

6.3.2 Retaining Walls Design Parameters

The following recommendations are provided for the design of temporary and permanent retaining walls at the site:

- For progressively anchored or propped walls where minor movements can be tolerated (provided there are no buried movement sensitive services), we recommend the use of a trapezoidal earth pressure distribution of 6H kPa, where H is the retained height in meters. These pressures should be assumed to be uniform over the central 50% of the support system, tapering to nil at top and bottom.
- For progressively anchored or propped walls which support areas which are sensitive to movement (such as areas where movement sensitive structures or infrastructures or buried services are located in close proximity), we recommend the use of a trapezoidal earth pressure distribution of 8H kPa, where ‘H’ is the retained height in meters. These pressures should be assumed to be uniform over the central 50% of the

support system, tapering to nil at top and bottom. Special consideration may be required where proposed excavations are immediately adjacent existing building footings to ensure serviceability requirements are met.

- All surcharge loading affecting the walls (including from construction equipment, construction loads, adjacent high-level footings, etc.) should be adopted in the retaining wall design as an additional surcharge;
- For a drained basement, measures are to be taken to provide complete and permanent drainage behind the walls. Strip drains protected with a non-woven geotextile fabric should be used behind the shotcrete infill panels for soldier pile walls or inserted between gaps in contiguous piles. Alternatively, for the contiguous pile walls, weepholes comprising 20mm diameter PVC pipes grouted into holes or gaps between adjacent piles may be used. The embedded end of the pipes must, however, be wrapped with a non-woven geotextile fabric (such as Bidim A34) to act as a filter against subsoil erosion;
- For tanked basements and retaining wall design, hydrostatic pressures should be included. We recommend that the active triangular distribution of the hydrostatic pressure be taken as zero from the finished ground surface level to take into account possible groundwater fluctuations that may occur at the site.
- For piles embedded into Unit 3 or better, the ultimate lateral toe resistance value outlined in **Table 9** below may be adopted. This value assumes excavation is not carried out within the zone of influence of the wall toe and the rock does not contain adverse defects, etc. At least the upper 0.5m depth below bulk excavation level should not be taken into account to allow for tolerance and disturbance effects during excavation;
- If anchors or soil nails extend beyond the site boundaries, then permission from the neighbouring properties would need to be obtained prior to installation. Also, the presence of neighbouring basements or services and their levels must be confirmed prior to finalising anchor design. If permission from the neighbouring properties cannot be obtained, then internal props or alternative retention systems may be required.
- Anchors should have their bond length within siltstone bedrock. For the design of anchors bonded into siltstone bedrock, the ultimate bond stress value outlined in **Table 9** below may be used, subject to the following conditions:
  - Anchor bond lengths of at least 3m behind the ‘active’ zone of the excavation (taken as a 45° zone above the base of the excavation) is provided.
  - Overall stability, including anchor group interaction, is satisfied;
  - All anchors should be proof loaded to at least 1.10 times (for temporary anchor with service life less than 6 month) the design working load before locked off at working load. Such proof loading is to be witnessed by an engineer independent of the anchoring contractor. We recommend that only experienced contractors be considered for anchor installation.
  - Permanent anchors must have appropriate corrosion provisions for longevity.

Furthermore, any existing buried services which run below the site will require diversion prior to the commencement of excavation or alternatively be temporarily supported during excavation, subject to permission or other instructions from the relevant service authorities. Enquiries should also be made for further information and details, such as invert levels, on the buried services.

Table 9 provides recommended preliminary geotechnical design parameters to be used for the design of retention systems.

Table 9: Recommended preliminary retaining wall design parameters

Design Parameter		Unit 1 Fill	Unit 2 Residual CLAY / Class V Siltstone	Unit 3 Class IV / III Siltstone	Unit 4 Class II Siltstone
Earth Pressure Coefficients	At rest K_o [1]	0.56	1.0	1.2	-
	Active K_a [1]	0.4	0.3	0.2	-
	Passive K_p [1]	N/A	2.8	4.0	-
Ultimate Lateral Resistance for Piles (kPa)		-	300 [2]	1,500	17,500
Ultimate Bond Stress (kPa)		-	-	180	360

[1] – Earth pressures are provided on the assumption that the ground behind the retaining walls is horizontal.

2 – The lateral pressure subject to pile length and dimensions, the provided ultimate pressure is based on the assumption of pile length is zero.

The parameters in **Table 9** are provided on the basis of the following assumptions:

- Piles have a nominal socket of at least 0.5m, into the relevant founding material;
- For piles, there is intimate contact between the pile and foundation material (a clean socket roughness category of R2 or better);
- Potential soil and groundwater aggressivity will be considered in the design of piles;
- The pile should be drilled in the presence of a Geotechnical Engineer prior to pile construction to verify that ground conditions meet design assumptions. Where groundwater ingress is encountered during pile excavation, concrete is to be placed as soon as possible upon completion of pile excavation. Pile excavations should be pumped dry of water prior to pouring concrete, or alternatively a tremie system could be used;
- The bases of all pile excavations are cleaned of loose and softened material and water is pumped out prior to placement of concrete;
- The concrete is poured on the same day as drilling, inspection and cleaning
- Geotechnical strength reduction factor ϕ_g is discussed in Section 6.4.2.3

6.4 Foundation

6.4.1 Shallow Footings

Following bulk excavations for the basement footprint to an RL about 7.8 m, we expect Unit 2 (Residual Soil / Siltstone V) material to be exposed across the site. Given the heights of the proposed towers, it's unlikely that this material will be suitable as a foundation material for the main structures of the proposed development. Depending on cost assessments, it may be warranted to excavate down to a better-quality material such as Unit 3 (Siltstone Class IV / III) or better and found shallow footings for the main structures. However, this may require an additional 2m of localised excavations in places and additional groundwater inflows to manage.

Cast-in-place concrete pad or strip footings and surface precast footings for lightly loaded ancillary structures may be founded in the Unit 2 Residual Soil / Class V siltstone material.

6.4.1.1 General

Lightly loaded spread footings should be founded below topsoil/fill layers a minimum 0.3 m into the adopted soil unit. If weaker materials than assumed for the design are encountered at the base of the footing excavations, they should be excavated and replaced with compacted structural fill.

Footing excavations should be inspected by a suitably qualified and experienced engineer. An inspection regime should be developed if shallow footings are adopted, in particular for the main structure.

Excavations may require management of health and safety hazards and potential control measures such as benching and battering, shoring, water removal, ground support for adjacent structures, fall prevention barriers and access/egress considerations.

For further construction considerations refer to **Section 6.8**.

6.4.1.2 Bearing Pressures

Table 10 summarises the serviceability bearing pressures for shallow footings. Discrete footings designed using these values should result in settlements of less than 1 % of the least footing dimension.

The proposed parameters assume the construction of the foundation is clean and debris free. They should be excavated in dry condition to prevent softening of the materials in the base of the excavation. This may require active drainage around the footing locations to locally reduce or transfer groundwater from the footing excavations.

Table 10: Summary of serviceability bearing pressure for shallow footing

Ground Unit	Ultimate End Bearing (kPa)	Serviceability Bearing Pressure (kPa) [1]
Unit 1 Fill/Topsoil	-	-
Unit 2 Residual Clay/ Class V Siltstone	-	150
Unit 3 Class IV / III Siltstone	3,000	1,000
Unit 4 Class II Siltstone	35,000	4,000

[1] – The serviceability bearing pressures given above are based on serviceability criteria of settlements at the footing base of less than or equal to 1% of the minimum footing dimension.

6.4.1.3 Soil Reactivity to Shallow Footings

Selection of footing types and founding depth will need to consider the risk of adverse movements due to shrink-swell of reactive clay soils, both within and between proposed lightly loaded structures.

The results of shrink-swell testing and Atterberg Limits results across the site are presented in **Table 4**.

Once the locations of lightly loaded structures have been confirmed, additional site investigations could be completed to assess the shrink-swell index (Iss) for the moisture change depth range. We recommend that the design of such structures be based on a site classification of H1 (AS2870).

The level of site reactivity experienced by structures will depend on the prevailing weather conditions at the time of construction. For example, if construction occurs during drought, the structures may experience the full range of swell following prolonged periods of rainfall. Careful consideration should also be given to site drainage, and the proximity of trees and shrubs in the vicinity of the shallow footings.

Methods to mitigate the impact of expansive soils include the use of a raft slab (larger footings), founding the entire footing deeper into the soil profile, founding structures on pier foundations that resist the soil movements due to moisture change, or by facilitating differential movements through flexible connections to services and other infrastructure.

6.4.2 Pile Footings

If structures are to be supported on pile foundations, we expect they will be and socketed into Unit 4 (Class II siltstone) bedrock. Depending on the retention system adopted, pile footings may be installed from near existing surface level or following bulk excavations for the basement footprint. At this depth we expect Unit 2 (Residual Soil / Siltstone V) material to be exposed across the site.

This section relates to cast-in-place concrete pile foundation for main structures.

6.4.2.1 General

Lateral assessment of piles should include consideration of a “disturbed zone” of 500 mm thickness below the top of pile that may be caused by the installation of the pile, ground surface softening due to lack of confinement, scour, construction vehicular disturbance etc.

6.4.2.2 Pile Design Parameters

Table 11 provided above presents a summary of preliminary geotechnical design parameters recommended for cast-in-place pile foundations. The geotechnical reduction factor ϕ_g to be applied to the ultimate capacities will depend on the foundation type, structural redundancy and level of testing, in accordance with Australian Standard AS2159 (2009). Trial piles and/or pile testing may be necessary to justify the adoption of high ϕ_g factors and/or higher design parameters than suggested in **Table 11.**

Table 11: Summary of ultimate and serviceability bearing pressure for pile foundation

Ground Unit	Ultimate End Bearing (kPa)	Ultimate Shaft Adhesion [1] (kPa)		Serviceability End Bearing [2] (kPa)
		Tension	Compression	
Unit 1 Fill/Topsoil	-	-	-	-
Unit 2 Residual CLAY/ Class V Siltstone	-	-	50	N/A
Unit 3 Class IV/III Siltstone	5,000	100	200	1,000
Unit 4 Class II Siltstone	35,000	300	800	4,000

[1] – Shaft adhesion values given assume there is intimate contact between the pile and foundation material and should achieve a clean socket roughness category R2 or better. For uplift, design engineer to check both 'piston pull-out' and 'cone lift out' mechanics in accordance with AS4678-2002 Earth Retaining Structures.

[2] – The serviceability bearing pressures given above are based on serviceability criteria of settlements at the pile toe of less than or equal to 1% of the minimum pile diameter.

6.4.2.3 Advice on Site Risk Factor

We suggest the use of the following site individual risk rating (IRR) factors to allow an assessment of the geotechnical strength reduction factor ϕ_g as per Table 4.3.2 (A) in AS 2159:

- Geological complexity of site: IRR =2 (Low risk) as it is relatively horizontal, well-defined soil characteristics, some variability over the site but without observed abrupt changes in stratigraphy.
- The extent of ground investigation: IRR = 3 (Moderate risk) as investigations have been carried out to adequate depth. However, we consider additional boreholes may be required following the preliminary design.
- Amount and quality of geotechnical data: IRR = 3 (Moderate risk) as only few laboratory tests were carried out for a site of this size. This may be able to be modified following the detailed geotechnical investigation.
- Method of assessment of geotechnical parameters: IRR = 3 (Moderate risk) as based on limited laboratory and in-situ tests. Non-destructive drilling of top 1.5m which indicate no in-situ test was carried out. The rock strength is estimated based on the correlation between the point load test and uniaxial compressive strength.

6.4.3 Soil Aggressivity

Two soil and one groundwater aggressivity tests had been carried out by SGS (NATA Lab). These results of these are provided in Table 5.

The intrusive investigation indicated a low permeability soil is present above and below the groundwater table. In accordance with Tables 6.4.2(C) and 6.5.2(C) of AS 2159:2009 'Piling – Design and Installation', the results of the pH, chloride and sulfate content and electrical conductivity/resistivity of the soil and groundwater provided the following exposure classifications:

- 'Mild' for buried concrete structural elements; and
- 'Non-Aggressive' for buried steel structural elements.
- In accordance with Table 4.8.1 of AS3600-2018 'Concrete Structures' these soils would be classified as exposure classification 'A2' for concrete in sulfate soils.

6.5 Earthquake Risk Classification

The methods of assessing the earthquake risk classification are outlined in the Australian Standard AS1170.4 (2007) *Structural Design Actions, Part 4: Earthquake Actions in Australia*. The standard uses a number of factors in assessing an earthquake design category for a particular structure at a given site.

The hazard factor (Z) depends on the geographic location of the proposed structure. For the proposed site, AS1170.4 indicates a hazard factor of 0.07.

The governing condition for the site subsoil class is the thickness and consistency of the subsurface materials beneath the building footings. Based on observed ground conditions we recommend that a site Subsoil Class of 'C_e – Shallow soil' is appropriate for the site, in accordance with Section 4.2 of AS1170.4 (2007).

6.6 Earthworks Considerations

Given the clayey nature of the subsurface soils across the site, the following general earthworks advice should be considered inside the building footprint:

- Remove vegetation and strip any organic rich "topsoils" and fill, roots and root bowls from the area.
- Prior to filling for driveway pavements, basement slab construction, shallow footing construction etc, the exposed subgrade should be test rolled. Any "soft spots" with unacceptable movement or materials with a bearing capacity less than footing design identified during test rolling should be excavated and replaced with engineered fill.
- The properties of engineered fill must be assessed once sources are known to confirm suitability. The material shall be placed and compacted in accordance with AS 3798-2007.
- Due to potential variable climatic conditions in the region, moisture conditioning may be required for placement of site-won fill depending on when construction takes place.

Where material from site excavations is intended for reuse onsite, it must be inspected and confirmed by a suitably qualified geotechnical engineer or engineering geologist prior to reuse. Additional laboratory testing may be required to confirm material properties depending on where the fill is intended to be used. Compaction characteristics (density, moisture) should be checked during construction using in situ density testing.

Reference should be made to AS 3798 for details in relation to earthworks procedures as well as geotechnical supervision and testing requirements.

6.7 Pavement Subgrades

No laboratory CBR tests were carried out as part of the preliminary geotechnical investigation. We understand that the driveway to the basement carpark will be off Cowper Street from the existing surface level to the basement. At these depths it is likely that Unit 2 (Residual Soil / Siltstone V) will be encountered. Typically, residual Ashfield Shale clays have low CBR values and are prone to swelling. Pavement designers may need to consider subgrade improvements, such as lime stabilisation, sub-pavement drainage or confinement of the subgrade prior to construction of the pavement.

We recommend that additional sampling and laboratory CBR tests should be carried out close to surface level, to provide better understanding and optimize the pavement design parameter.

6.8 Construction Considerations

The following sections provide some guidance on potential ground related construction issues that should be taken into consideration for the design and construction of the proposed development.

6.8.1 Dilapidation Surveys

Prior to excavation and construction, we recommend that detailed dilapidation surveys be carried out on all structures and infrastructures surrounding the site that falls within the zone of influence of the excavation. The zone of influence of the excavation is defined by a distance back from the excavation perimeter of twice the total depth of the excavation. The zone of influence should also consider the potential groundwater drawdown profile which may extend beyond the excavation zone of influence, should a drained basement be adopted.

6.8.2 Excavation Assessment

Prior to any excavation commencing, we recommend that reference be made to the WorkCover Excavation Work Code of Practice – October 2018.

We understand that the proposed basement has a Finished Floor Level (FFL) of Reduced Level (RL) of 8.0 m AHD. To achieve this latter, a Bulk Excavation Level (BEL) of RL 7.8 m is assumed, which will allow for the construction of the basement floor slabs. Locally deeper excavations may be required for footings, lift shafts, crane pads and service trenches.

Based on the borehole logs, the proposed basement excavation is expected to extend through Unit 1 (Fill / Topsoil and Unit 2 (Residual Soil / Siltstone V) as outlined in **Table 6** and **Table 7**.

Units 1, and 2 at the site should be able to be excavated with medium or large sized hydraulic excavators, fitted with ‘Tiger Teeth’. We note that the low to medium strength siltstone band were encountered at all borehole locations through the Unit 2 material. These may require some moderate to hard ripping to excavate through, depending on the fracture spacing of this material insitu. Smaller size excavator may result in lower productivity.

Should excavations in Unit 3 (Class IV / III Siltstone) be required, these are also expected to be achievable with large hydraulic excavation plant equipped with a ripping type and possibly a rock breaker. Bulk excavations in Unit 4 (Siltstone II) are not expected to be required.

We recommend the excavation contractors make their own assessment of the excavability based on their experiences with the equipment they have access to.

Bored pile excavations are expected to be suitable through all of the units encountered with the use of standard hydraulic piling plant. Temporary casing for Units 1, and 2 may be required, in particular if groundwater seepage is encountered and if gravel siltstone seams are encountered in Unit 2. Greater excavations resistance is expected for Units 3 and 4, in particular Unit 4 where fracture spacing is relatively high.

Some ironstone staining and gravels where encountered in the drilled boreholes, these have the potential to increase excavations resistance and are more abrasive than siltstone which may result in increased wear of drilling teeth. Piling rig contractors should be consulted to make their own assessment of the expected excavation resistance based on the capacities of their piling rigs.

6.8.3 Site Trafficability

The upper clayey soils may be susceptible to loss of strength upon wetting which may impact the performance of access roads and results in trafficability issues. Imported granular materials may need to be brought to site to improve trafficability for construction vehicles, in particular during or following periods of rainfall.

6.8.4 Monitoring

6.8.4.1 Ground Displacement

Consideration should be made to the impact of the proposed development upon neighbouring structures, roadways and services. Basement excavation retention systems should be designed so as to limit lateral deflections.

Monitoring of deflections of retaining structures and surface settlements should be carried out by a registered surveyor at agreed points along the excavation boundaries and along existing building foundations / services / pavements and other structures located within or near the zone of influence of the excavation. Owners of existing services adjacent to the site should be consulted to assess appropriate deflection limits for their infrastructures.

We understand that the Parramatta road is an RMS Asset. The RMS Technical Direction Excavation adjacent to RMS Infrastructure (Ref. GTD 2012/001 dated 27 April 2012) provides a technical direction for all proposed excavations and or any temporary structures by private and commercial developments which have a zone of influence that extends onto the road reserve and RMS easements.

6.8.4.2 Monitoring Regime

Prior to and during excavation works, a monitoring regime should be in operation. This monitoring should include movement trigger levels, based on predicted movement of retention systems, which allow unexpected behaviour to be identified and addressed.

We anticipate that monitoring during excavation for the site could include the following:

- Three dimensional survey targets / monitoring points.
- Settlement monitoring points on adjacent buildings and roads.
- Groundwater monitoring wells.
- Vibration monitoring.

6.8.4.3 Vibration

The impacts on neighbouring infrastructure of vibration from excavations and other construction activities should be considered during the selection of construction methods and construction plant. Reference should be made to German Standard DIN 4150 – Part 3: 1999 for a guide to acceptable limits of transmitted vibrations. The use of rock saws may help to reduce the risk of vibration.

7.0 FURTHER GEOTECHNICAL INPUTS

Based on the results of the preliminary geotechnical investigation, we recommend that the following items be considered for further investigation:

- Groundwater: The one groundwater well installed had a groundwater level of about 1.9 m below existing ground level (groundwater level may not have fully stabilised and could be shallower). This is within the proposed excavation depths of the basement and further information of the groundwater levels around the site and potential inflows are required to allow for better assessments of groundwater management both during and post construction. Further groundwater quality assessments should also be carried out. We recommend the following be carried out to better understand the groundwater conditions on site:
  - Install a data logger into the existing groundwater monitoring well. This should be done as soon as possible and will enable continuous monitoring of groundwater levels and the response to rainfall events.
  - Additional groundwater wells installed around the northern, eastern and southern perimeters of the site (as a minimum). It should be considered to install pairs of wells (one deep and one shallow) at each location to allow assessment of groundwater through the soil and through the rock to be assessed. Data loggers should be installed in each well.
  - Hydraulic assessments of the wells in the form of falling head and rising head slug tests to better understand the hydraulic conductivity of the strata and allow for estimation of groundwater inflow and extent of off-site groundwater level drawdown and impacts.
  - Groundwater quality sampling and testing from all installed wells to better understand the groundwater quality around the site. This testing should include analytes for dewatering discharge disposal requirements (misc. parameters, major ions, metals and nutrients) as wells a potential contaminants of concern (e.g. full suite of hydrocarbons).
- Deeper excavations: should localised deeper excavations such as lift wells or onsite detention systems be required, we recommended completing additional boreholes targeted at these locations.
- Soil and rock properties: From the additional boreholes to be carried out, we would recommend additional laboratory testing also be carried out to better understand the soil and rock properties to provide more refined soil and rock geotechnical design parameters. This is likely to consist of unconfined compressive strength tests for rock and triaxial tests for soil and rock. Other additional testing, such as CBR sampling and testing, may also be warranted.
- Investigations into adjacent building footings (type, levels, dimension and founding material) as part of the detailed investigation and design.

In order to confirm a suitable scope of works for the detailed geotechnical investigation, it may be beneficial for a design workshop to be held to work through where design efficiencies may be able to be achieved with additional geotechnical information.

In addition to further geotechnical investigation, the following geotechnical items should also be considered as the design and construction specifications are progressed:

- Design of working platforms for construction plant should be in accordance with Building Research Establishment (BRE) guidelines.

- Requirements for witnessing installation and proof-testing of anchors and soil nails. In particular adjacent to Parramatta Road, where RMS may require any soil nail wall to be designed and constructed in accordance with their soil nail specification (RMS R64).;
- Geotechnical inspections of footings should be carried out by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata.

8.0 REFERENCES

AS1170.4:2007, Structural Design Actions, Part 4: Earthquake Actions in Australia, Standards Australia

AS1726:1993, Geotechnical Site Investigations, Standards Australia.

AS2159:2009, Piling – Design and Installation, Standards Australia.

AS3600:2018, Concrete Structures, Standards Australia

Mayne, P.W. and Poulos, H.G. (1999). "Approximate Displacement Influence Factors for Elastic Shallow Foundations". Jnl. Geot. and Geoenvironmental Eng., ASCE, 125(6): 453-460.German Standard DIN 4150 – Part 3: 1999

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9.0 ABBREVIATIONS

AHD Australian Height Datum

AS Australian Standard

BEGL Below Existing Ground Level

BH Borehole

DBYD Dial Before You Dig

DP Deposited Plan

NATA National Association of Testing Authorities, Australia

RL Reduced Level

SPT Standard Penetration Test

T-C Tungsten-Carbide

UCS Unconfined Compressive Strength

Signature Page

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Principal Geotechnical Engineer

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APPENDIX A

Investigation Location Plan

LEGEND

- Investigation location
- Site boundary

0 40 80

1:1,000 METRES

NOTE(S)

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 56

REFERENCE(S)

1. AERIAL PHOTO (C) NEARMAP
2. KEYMAP SOURCED FROM ESRI ONLINE BASEMAPS

CLIENT

PDS AND STARRYLANDS

PROJECT

GRAN CENTRAL DEVELOPMENT

TITLE

SITE LAYOUT

CONSULTANT

GOLDER

DD-MM-YYYY	16-08-2019
DESIGNED	EAA
PREPARED	EAA
REVIEWED	-
APPROVED	-

PROJECT NO.	CONTROL	REV.	FIGURE
19122955	-	-	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25mm

APPENDIX B

Borehole Log and Explanatory Notes

DRAFT REPORT OF BOREHOLE: BH01M

GOLDER

SHEET: 1 OF 3

CLIENT: PDS and Starrylands	COORDS: 315964 m E 6254865 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05	
PROJECT: Proposed Gran Central	SURFACE RL: 10.8 m DATUM: AHD (MAP)	CONTRACTOR: Nealings	
LOCATION: Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 31/7/19
JOB NO: 19122955	HOLE DEPTH: 10.10 m	CHECKED: BJF	DATE: 20/8/19

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
DTC	-		0	0.14 / 10.62		-	CONCRETE average 140mm thick igneous aggregate	-	-	ROAD SURFACE
HA	M			0.70 / 10.10	DS 0.14-0.18 m PID = 0.1 ppm; DS 0.35-0.45 m PID = 0.1 ppm; DS 0.53-0.60 m PID = 0 ppm	CI-CH	FILL: Sandy CLAY low plasticity, dark grey, find to medium grained sand, with fine to coarse, sub angular to sub rounded gravel			FILL
HA	H		1	1.10 / 9.70	DS 0.80-0.90 m PID = 1 ppm		Silty CLAY medium - high plasticity, brown mottled orange brown, trace fine to coarse, sub angular to sub rounded gravel	w > PL	-	RESIDUAL SOIL
					DS 1.10-1.20 m PID = 2.1 ppm; DS 1.30-1.40 m PID = 0.5 ppm		red-brown mottled pale grey, with fine to coarse, sub angular to sub rounded gravel			
ADT	L	09/08/19		1.70 / 9.10	SPT 1.45-1.90 m 5, 15, 25 N=40 PID = 0.3 ppm		pale grey mottled pale brown, trace fine to coarse, sub angular to sub rounded gravel, with iron indurate band		H	@ 1.45 m, Hand Auger refusal
ADT	M		2			-	SILTSTONE pale grey, inferred low strength, with medium strength layer, extremely weathered, with clay seams, trace iron staining	-	-	
ADT	M-H	01/08/19	3	3.00 / 7.80	SPT 3.00-3.45 m 10, 16, 22 N=38 PID = 0.1 ppm; DS 3.40-3.50 m PID = 0.4 ppm; DS 3.90-4.00 m PID = 0.1 ppm; DS 4.40-4.50 m PID = 0.2 ppm	CI-CH	Silty CLAY medium - high plasticity, pale grey mottled red-brown, with iron indurate bands	w > PL	H	
WB	-	90-100% Water RETURN	4	4.65	SPT 4.50-4.75 m 6, 21/100mm HB N>21	-	SILTSTONE grey to dark grey and grey brown, very low to low strength	-	-	BEDROCK
			5				For Continuation Refer to Sheet 2			
			6							
			7							
			8							
			9							
			10							

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

GOLDER

DRAFT REPORT OF BOREHOLE: BH01M

CLIENT: PDS and Starrylands
PROJECT: Proposed Gran Central
LOCATION: Cnr Parramatta Rd and Good Street, Granville
JOB NO: 19122955

COORDS: 315964 m E 6254865 m N MGA94 56 (hhGPS)
SURFACE RL: 10.8 m DATUM: AHD (MAP)
INCLINATION: -90°
HOLE DEPTH: 10.10 m

DRILL RIG: Komatsu 05
CONTRACTOR: Nealings
LOGGED: FY DATE: 31/7/19
CHECKED: BJF DATE: 20/8/19

METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH / RL	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	LABORATORY STRENGTH (MPa)	DEFECT DESCRIPTION & Additional Observations
				0–4.83	4.83 / 5.97	Continuation of Sheet 1			
NMLC	90-100% Water RETURN	100	60 (95)	5		SILTSTONE grey to dark grey and grey brown, with pale grey lamination, bedded at 0-5°, with iron staining	HW, MW	PLI(A)=0.09 PLI(A)=0.11 PLI(D)=0.04	4.88 m: EWS, 0°, 5 mm, clay 4.95 m: P, 0-5°, Pl, Sm, Fe Sn 5.11 m: P, 0-5°, Pl, Sm, Fe Sn 5.23 m: EWS, 0°, Fe Sn, 5 mm, clay 5.30 m: P, 0-5°, Pl, Sm, Fe Sn 5.36 m: EWS, 0°, Fe Sn, 5 mm, weathered siltstone 5.48 m: EWS, 0°, Fe Sn, 5 mm, weathered siltstone
					5.60 / 5.20	no ironstaining	FR	PLI(D)=0.43 PLI(A)=0.49	5.60 m: P, 0°, Pl, Sm, Fe Sn 5.93 m: P, 0-5°, Pl, Sm, Cn 5.93-6.04 m: J, 80°, Pl, Sm, Cn, 110 mm 6.04 m: P, 0-5°, Pl, Sm, Cn
		100	80 (90)	6					6.47 m: P, 0°, Pl, Sm, Cn
				7				PLI(D)=0.46 PLI(A)=0.45	6.95 m: EWS, 0°, 5 mm, clay
		100	90 (95)					PLI(D)=0.23 PLI(A)=0.62	7.38 m: EWS, 0°, 5 mm, clay 7.39-7.51 m: Px 5, 0°, sp = 20-30 mm, Pl, Sm, Ve, clay
				8					8.05 m: EWS, 0°, 6 mm, clay 8.35 m: J, 5-15°, Cv, Sm, Cn
		100	85 (100)	9				PLI(D)=0.37 PLI(A)=0.72	8.65-9.91 m: Px 3, 0°, sp = 590-670 mm, Pl, Sm, Cn
				10				PLI(D)=0.14 PLI(A)=0.89	

INFERRED STRENGTH UCS MPa: VL 0.6, L 2.0, M 6.0, H 20, VH 60, EH 200

AVERAGE DEFECT SPACING (mm): 10, 30, 100, 300, 1000, 3000

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

GAP gINT FN. F02a
RL3

GOLDER

DRAFT REPORT OF BOREHOLE: BH01M

CLIENT: PDS and Starrylands
PROJECT: Proposed Gran Central
LOCATION: Cnr Parramatta Rd and Good Street, Granville
JOB NO: 19122955

COORDS: 315964 m E 6254865 m N MGA94 56 (hhGPS)
SURFACE RL: 10.8 m DATUM: AHD (MAP)
INCLINATION: -90°
HOLE DEPTH: 10.10 m

DRILL RIG: Komatsu 05
CONTRACTOR: Nealings
LOGGED: FY DATE: 31/7/19
CHECKED: BJF DATE: 20/8/19

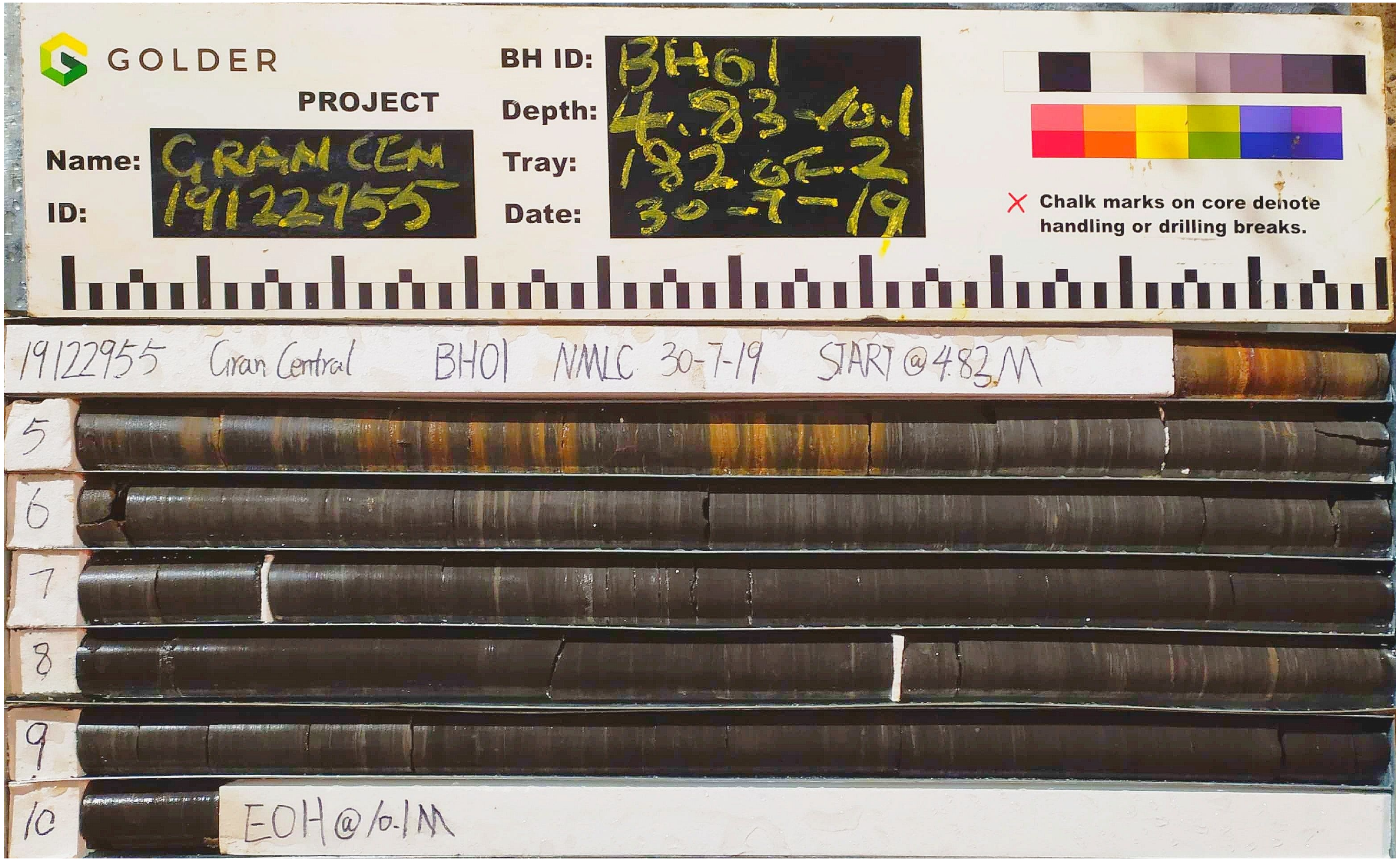
Drilling						Field Material Description					Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH UCS MPa (VL 0.6 L 2.0 M 6.0 H 20 VH 60 EH 200)	LABORATORY STRENGTH (MPa)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10 30 100 300 1000 3000)
				10	10.10 0.70		END OF BOREHOLE @ 10.10 m TARGET DEPTH PIEZOMETER INSTALLED BH01M was redrilled on 2-8-19 using HQ size shoe, to install monitoring well			PLI(D)=0.74 PLI(A)=0.77		
				11								
				12								
				13								
				14								
				15								
				16								
				17								
				18								
				19								
				20								

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

DRAFT REPORT OF CORE PHOTOGRAPHS: BH01M

SHEET: 1 OF 1

CLIENT:	PDS and Starrylands	COORDS: 315964 m E 6254865 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05		
PROJECT:	Proposed Gran Central	SURFACE RL: 10.8 m DATUM: AHD (MAP)	CONTRACTOR: Nealings		
LOCATION:	Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 31/7/19	
JOB NO:	19122955	HOLE DEPTH: 10.10 m	CHECKED: BJF	DATE: 20/8/19	



This report of core photographs must be read in conjunction with accompanying notes and abbreviations.

GOLDER

DRAFT REPORT OF BOREHOLE: BH01M

SHEET: 1 OF 2

CLIENT:	PDS and Starrylands	COORDS:	315964 m E 6254865 m N MGA94 56 (hhGPS)	DRILL RIG:	Komatsu 05
PROJECT:	Proposed Gran Central	SURFACE RL:	10.8 m DATUM: AHD (MAP)	CONTRACTOR:	Nealings
LOCATION:	Cnr Parramatta Rd and Good Street, Granville	INCLINATION:	-90°	LOGGED: FY	DATE: 31/7/19
JOB NO:	19122955	HOLE DEPTH:	10.10 m	CHECKED: BJF	DATE: 20/8/19

Drilling | **Sampling** | **Field Material Description and Instrumentation**

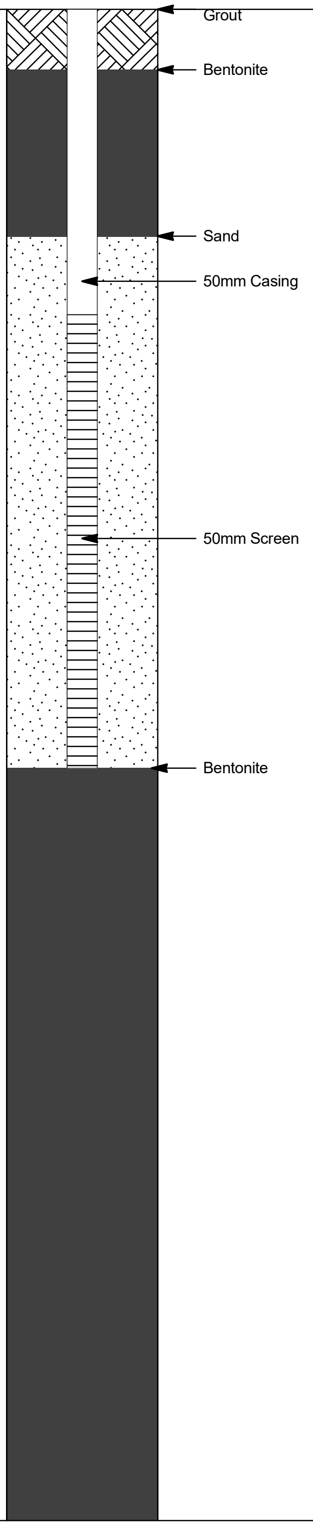
DEPTH	RL	SAMPLE OR FIELD TEST	SOIL/ROCK MATERIAL DESCRIPTION
0.14	10.62	DS 0.14-0.18 m PID = 0.1 ppm DS 0.35-0.45 m PID = 0.1 ppm	CONCRETE average 140mm thick igneous aggregate FILL: Sandy CLAY low plasticity, dark grey, find to medium grained sand, with fine to coarse, sub angular to sub rounded gravel, Moist, wet of plastic limit.
0.70	10.10	DS 0.53-0.60 m PID = 0 ppm DS 0.80-0.90 m PID = 1 ppm	Silty CLAY medium - high plasticity, brown mottled orange brown, trace fine to coarse, sub angular to sub rounded gravel, Moist, wet of plastic limit., hard
1.10	9.70	DS 1.10-1.20 m PID = 2.1 ppm DS 1.30-1.40 m PID = 0.5 ppm	red-brown mottled pale grey, with fine to coarse, sub angular to sub rounded gravel pale grey mottled pale brown, trace fine to coarse, sub angular to sub rounded gravel, with iron indurate band
1.70	9.10	SPT 1.45-1.90 m 5, 15, 25 N=40 PID = 0.3 ppm	SILTSTONE pale grey, inferred low strength, with medium strength layer, extremely weathered, with clay seams, trace iron staining
3.00	7.80	SPT 3.00-3.45 m 10, 16, 22 N=38 PID = 0.1 ppm DS 3.40-3.50 m PID = 0.4 ppm DS 3.90-4.00 m PID = 0.1 ppm DS 4.40-4.50 m PID = 0.2 ppm	Silty CLAY medium - high plasticity, pale grey mottled red-brown, with iron indurate bands, Moist, wet of plastic limit., hard
4.65		SPT 4.50-4.75 m 6, 21/100mm HB N>21	SILTSTONE grey to dark grey and grey brown, very low to low strength
4.83	5.97	C 4.83-5.82 m	SILTSTONE grey to dark grey and grey brown, with pale grey sandstone lamination, bedded at 0-5°, with iron staining, very low to medium strength, highly weathered to fresh
5.60	5.20	C 5.82-7.13 m C 7.13-8.61 m C 8.61-10.10 m	no iron staining

METHOD: DTC (0–0.14 m), HA (to 1.5 m), ADT (to 4.5 m), WB (to 4.83 m), NMLC (to 10.10 m)

WATER: 09/08/19 (at about 2 m); 01/08/19 (at about 4 m); 90-100% Water RETURN

AIRLIFT YIELD (L/s)

CONSTRUCTION
ID Static Water Level BH01M — Reference Point gl 10.73 m AHD



This report of borehole must be read in conjunction with accompanying notes and abbreviations.

GAP gINT FN. F05
RL3

GOLDER

DRAFT REPORT OF BOREHOLE: BH01M

CLIENT: PDS and Starrylands	COORDS: 315964 m E 6254865 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05	
PROJECT: Proposed Gran Central	SURFACE RL: 10.8 m DATUM: AHD (MAP)	CONTRACTOR: Nealings	
LOCATION: Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 31/7/19
JOB NO: 19122955	HOLE DEPTH: 10.10 m	CHECKED: BJF	DATE: 20/8/19

Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION: ID BH01M; Static Water Level; Reference Point gl 10.73 m AHD
		10	10.10 / 0.70				END OF BOREHOLE @ 10.10 m TARGET DEPTH PIEZOMETER INSTALLED BH01M was redrilled on 2-8-19 using HQ size shoe, to install monitoring well		
		11							
		12							
		13							
		14							
		15							
		16							
		17							
		18							
		19							
		20							

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

DRAFT REPORT OF BOREHOLE: BH02

SHEET: 1 OF 2

CLIENT: PDS and Starrylands
PROJECT: Proposed Gran Central
LOCATION: Cnr Parramatta Rd and Good Street, Granville
JOB NO: 19122955

COORDS: 315954 m E 6254814 m N MGA94 56 (hhGPS)
SURFACE RL: 12.5 m DATUM: AHD (MAP)
INCLINATION: -90°
HOLE DEPTH: 8.75 m

DRILL RIG: Komatsu 05
CONTRACTOR: Nealings
LOGGED: FY DATE: 1/8/19
CHECKED: BJF DATE: 20/8/19

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
DTC	-	GWNE	0	0.12	PID = 0 ppm	-	CONCRETE average 120mm thick igneous aggregate	-	-	ROAD SURFACE
HA	H			0.30 / 12.20	DS 0.15-0.20 m; DS 0.20-0.30 m; PID = 0 ppm	-	FILL: Silty CLAY medium - high plasticity, dark grey to dark brown, with fine to coarse, sub rounded to sub angular gravel, trace fine to medium grained sand	w > PL	-	FILL
				0.60 / 11.90	DS 0.30-0.40 m; PID = 0 ppm; DS 0.60-0.70 m; PID = 0 ppm	CI-CH	brown		H	RESIDUAL SOIL
			1	1.00 / 11.50	DS 1.10-1.20 m; PID = 0 ppm		Silty CLAY medium - high plasticity, brown to pale brown, trace gravel; mottled red-brown; pale grey mottled red-brown and pale brown, fine to coarse, sub rounded Ironstone			@ 1.50 m, NDD Target Reached
ADT	H			1.55 / 10.95	DS 1.40-1.50 m; SPT 1.50-1.65 m 23/150mm, 8/0mm HB N>8; PID = 0 ppm; DS 1.80-1.85 m	-	SILTSTONE pale grey, very low to low strength, extremely weathered, trace iron staining	-	-	

For Continuation Refer to Sheet 2

Depth scale (metres): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

DRAFT REPORT OF BOREHOLE: BH02

SHEET: 2 OF 2

CLIENT:	PDS and Starrylands	COORDS:	315954 m E 6254814 m N MGA94 56 (hhGPS)	DRILL RIG:	Komatsu 05
PROJECT:	Proposed Gran Central	SURFACE RL:	12.5 m DATUM: AHD (MAP)	CONTRACTOR:	Nealings
LOCATION:	Cnr Parramatta Rd and Good Street, Granville	INCLINATION:	-90°	LOGGED: FY	DATE: 1/8/19
JOB NO:	19122955	HOLE DEPTH:	8.75 m	CHECKED: BJF	DATE: 20/8/19

Drilling: METHOD: NMLC; WATER: 90-100% Water RETURN

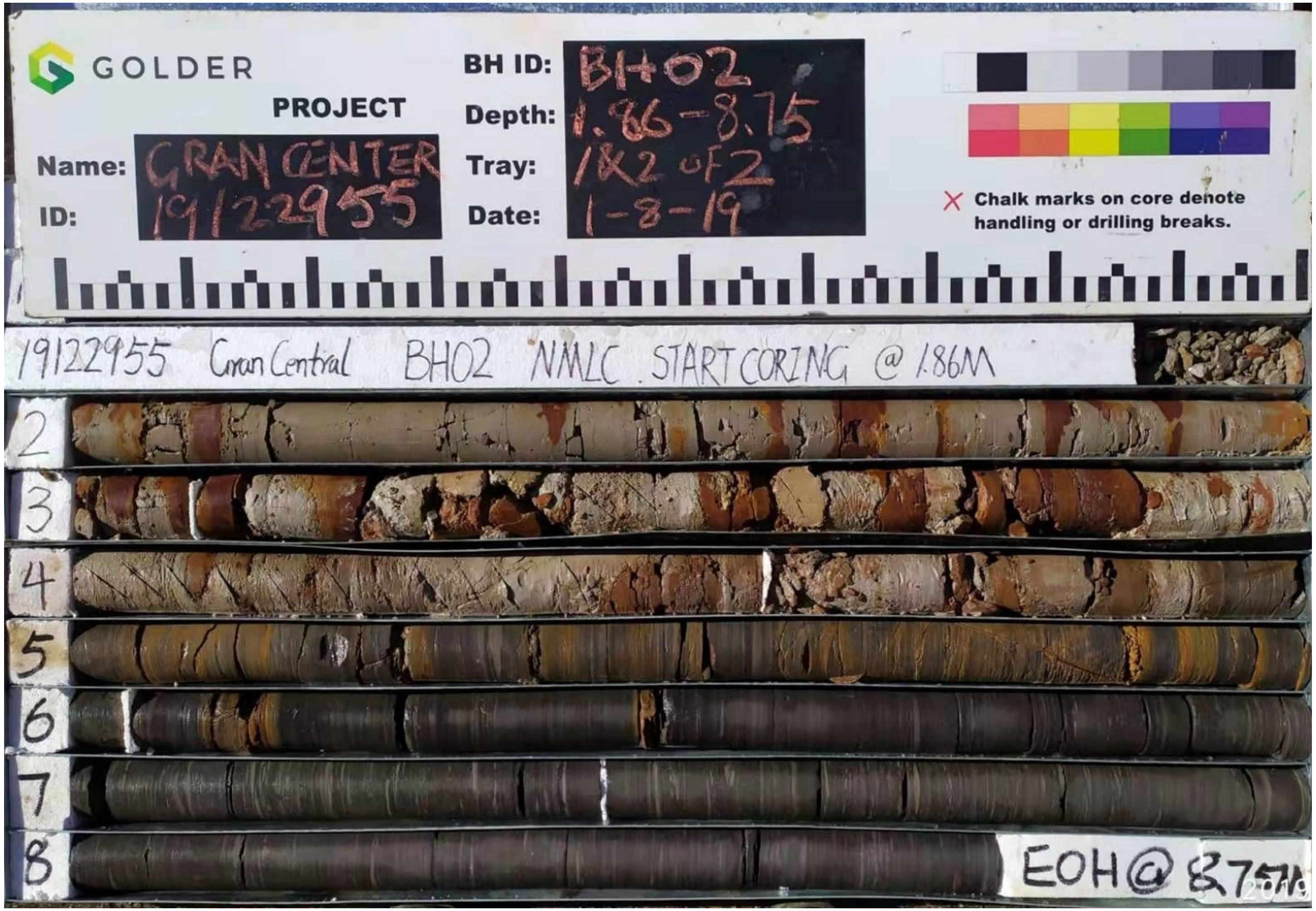
TCR	RQD (SCR)	DEPTH / RL	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	LABORATORY STRENGTH (MPa)	DEFECT DESCRIPTION & Additional Observations
		1.86	Continuation of Sheet 1			
100	0 (20)	10.64	SILTSTONE pale grey, with ironstone band, bedded at 0-20°, trace iron staining	XW		1.86-1.99 m: EWS, 0°, 130 mm, Recovered as fractured core 2.06-2.09 m: EWS, 0°, 30 mm, weathered siltstone 2.16-2.23 m: J, 80-90°, 70 mm, Healed 2.16 m: P, 0°, Pl, Sm, Cn 2.16-2.23 m: J, 80-90°, 70 mm, Healed 2.29-2.36 m: JX2, 70-90°, sp = 5 mm, Pl, Sm, Cn, 70 mm 2.30 m: P, 0°, Pl, Sm, Cn 2.35-2.40 m: PX2, 0-5°, sp = 5-40 mm, St, Sm, Cn 2.46 m: PX3, 0°, sp = 10 mm, Pl, Sm, Cn 2.51 m: PX2, 0°, sp = 3 mm, Pl, Sm, Cn 2.53 m: Px2, 0°, sp = 20 mm, Pl, Sm, Cn 2.62 m: P, 0°, Pl, Sm, Fe Sn 2.77 m: P, 0°, Pl, Sm, Cn 2.85 m: EWS, 0°, 30 mm
100	0 (0)	2.92 / 9.58	Silty CLAY (CI-CH) medium - high plasticity, pale grey, with ironstone gravel/layers, inferred to be at least very stiff	RS		3.00-3.02 m: J, 90°, Pl, Sm, Fe Sn, 20 mm 3.02 m: P, 0°, Pl, Sm, Fe Sn 3.05 m: P, 0°, Pl, Sm, Fe Sn
100	0 (40)	4.92 / 7.58	SILTSTONE dark grey and orange brown, with pale grey lamination, bedded at 0-5°, trace iron staining	MW, SW	PLI(A)=0.16 PLI(A)=0.19	4.94 m: P, 0-45°, Cv, Sm, Fe Sn 5.05-5.51 m: Px6, 0-5°, sp = 60-200 mm, Pl-St, Sm, Fe Sn 5.10 m: J, 0-45°, Ir, Sm, Fe Sn 5.18 m: J, 0-20°, Ir, Sm, Fe Sn 5.23-5.26 m: J, 70°, Pl, Sm, Fe Sn, 30 mm 5.26 m: EWS, 0°, Fe Sn, 15 mm, weathered siltstone 5.37 m: EWS, 0°, clay, 5 mm 5.57-5.84 m: Jx 14, 5-10°, sp = 10-30 mm, Pl, Sm, Fe Sn 5.72-5.86 m: J, 70°, Pl, Sm, Fe Sn, 140 mm 5.85 m: EWS, 0°, clay Sn, 15 mm
100	75 (90)	6.45 / 6.05	no iron staining	FR	PLI(D)=0.03 PLI(A)=0.21 PLI(D)=0.17 PLI(A)=0.28 PLI(A)=0.59 PLI(A)=0.61	5.91-6.00 m: Px4, 0°, sp = 20-30 mm, Pl, Sm, Fe Sn 6.11-6.47 m: EWSx2, 0°, sp = 30-200 mm, Fe Sn, 60 mm 6.71-8.56 m: Px13, 0°, sp = 30-250 mm, Pl, Sm, Cn 7.03 m: EWS, 0°, 15 mm, weathered siltstone
100	85 (100)				PLI(D)=0.73 PLI(A)=0.75 PLI(D)=0.55 PLI(A)=0.59	8.13 m: P, 0°, Pl, Sm, clay Ve
		8.75 / 3.75	END OF BOREHOLE @ 8.75 m TARGET DEPTH GROUTED			

GOLDER

DRAFT REPORT OF CORE PHOTOGRAPHS: BH02

SHEET: 1 OF 1

CLIENT: PDS and Starrylands	COORDS: 315954 m E 6254814 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05	
PROJECT: Proposed Gran Central	SURFACE RL: 12.5 m DATUM: AHD (MAP)	CONTRACTOR: Nealings	
LOCATION: Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 1/8/19
JOB NO: 19122955	HOLE DEPTH: 8.75 m	CHECKED: BJF	DATE: 20/8/19



This report of core photographs must be read in conjunction with accompanying notes and abbreviations.

GOLDER

DRAFT REPORT OF BOREHOLE: BH03

SHEET: 1 OF 2

CLIENT: PDS and Starrylands	COORDS: 315991 m E 6254810 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05	
PROJECT: Proposed Gran Central	SURFACE RL: 12.3 m DATUM: AHD (MAP)	CONTRACTOR: Nealings	
LOCATION: Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 1/8/19
JOB NO: 19122955	HOLE DEPTH: 8.34 m	CHECKED: BJF	DATE: 20/8/19

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	M	GWNE	0	12.30	PID = 0 ppm			-	TOPSOIL: Silty CLAY medium to high plasticity, dark brown, trace rootlets and wood fibre	w > PL	-	TOPSOIL
				0.23 12.07	DS 0.10-0.20 m PID = 0.1 ppm DS 0.40-0.50 m PID = 0 ppm DS 0.50-0.60 m			CI-CH	Silty CLAY medium to high plasticity, pale brown to brown mottled red-brown	w > PL	-	RESIDUAL SOIL
				0.75 11.55					pale grey and red-brown			
	H		1	0.90 11.40	DS 0.80-0.90 m PID = 0 ppm DS 1.30-1.40 m PID = 0 ppm DS 1.40-1.50 m PID = 0 ppm				pale grey mottled red-brown			
ADT	M	RETURN			SPT 1.50-1.95 m 7, 16, 36 N=52 PID = 0 ppm						H	@ 1.50 m, NDD Target Reached
			2	1.80 10.50				-	SILTSTONE pale grey, low to medium strength, extremely weathered	-	-	
WB	-	90-100% Water			SPT 2.00-2.12 m 21/120mm HB N=R PID = 0 ppm							
			3–10						For Continuation Refer to Sheet 2			

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

GOLDER

DRAFT REPORT OF BOREHOLE: BH03

SHEET: 2 OF 2

CLIENT: PDS and Starrylands	COORDS: 315991 m E 6254810 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05	
PROJECT: Proposed Gran Central	SURFACE RL: 12.3 m DATUM: AHD (MAP)	CONTRACTOR: Nealings	
LOCATION: Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 1/8/19
JOB NO: 19122955	HOLE DEPTH: 8.34 m	CHECKED: BJF	DATE: 20/8/19

Drilling: METHOD: NMLC; WATER: 90-100% Water RETURN

TCR	RQD (SCR)	DEPTH / RL	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	LABORATORY STRENGTH (MPa)	DEFECT DESCRIPTION & Additional Observations
		2.25	Continuation of Sheet 1			
100	45 (55)	10.05		XW		2.29-2.59 m: EWS, 0°, sp = 10-20 mm, Ir, Sm, Fe Sn, 100 mm, Recovered as fractured core 2.61 m: P, 0°, Pl, Sm, Fe Sn 2.69-2.77 m: EWS, 0°, Fe Sn, 80 mm 2.91 m: P, 0°, Pl, Sm, Fe Sn 3.12 m: P, 0-15°, Ir, Sm, Fe Sn
100	0 (0)					
		4.05 / 8.25	Silty CLAY (CI-CH) medium - high plasticity, pale grey, with brown, iron indurate shale band.	RS		
100	40 (10)	5.60 / 6.70	SILTSTONE red-brown to brown and dark grey, with iron staining	HW	PLI(D)=0.06 PLI(A)=0.16	5.85-5.94 m: EWS, 0-5°, clay, 90 mm 5.95-6.11 m: J, 90°, Ir, Sm, Fe Sn, 160 mm
		6.06	dark grey	SW		6.11-6.13 m: EWS, 0°, clay, 20 mm
		6.21	Core Loss: 80 mm			
100	65 (40)	6.01	SILTSTONE dark grey, with pale grey lamination, bedded at 0-5°, with iron staining		PLI(A)=0.07 PLI(A)=0.07	6.31 m: Px3, 0°, sp = 10 mm, Pl, Sm, Fe Sn, 3 mm 6.59-6.71 m: EWS, 0°, Fe Sn, 90 mm, weathered siltstone and clay 6.72 m: P, 0-10°, St, Sm, Fe Sn 6.79 m: P, 0-5°, Pl, Sm, Fe Sn 6.84 m: P, 0°, Pl, Sm, Fe Sn 6.86-6.87 m: EWS, 0°, Fe Sn, 10 mm 6.98 m: P, 0°, Pl, Sm, Fe Sn 7.09 m: P, 0-5°, Pl, Sm, Cn
100	95 (90)	7.56 / 4.74	no staining	FR	PLI(D)=0.14 PLI(A)=0.26 PLI(D)=0.28 PLI(A)=0.54 PLI(D)=0.42 PLI(A)=0.79	7.19-7.25 m: Px5, 0-5°, sp = 5-15 mm, Pl, Sm, Fe Sn, 80 mm 7.21-7.23 m: J, 70°, Pl, Sm, Fe Sn, 20 mm 7.42-7.45 m: Px2, 0-5°, sp = 10-20 mm, Pl, Sm, Fe Sn 7.60-7.64 m: Px3, 0-5°, sp = 10-30 mm, Pl, Sm, Cn 8.27 m: Px2, 0°, sp = 5 mm, Pl, Sm, Cn 8.28-8.29 m: J, 90°, Pl, Sm, Cn, 10 mm
		8.34 / 3.96	END OF BOREHOLE @ 8.34 m TARGET DEPTH GROUTED			

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

GAP gINT FN. F02a
RL3

DRAFT REPORT OF CORE PHOTOGRAPHS: BH03

SHEET: 1 OF 1

CLIENT: PDS and Starrylands	COORDS: 315991 m E 6254810 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05	
PROJECT: Proposed Gran Central	SURFACE RL: 12.3 m DATUM: AHD (MAP)	CONTRACTOR: Nealings	
LOCATION: Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 1/8/19
JOB NO: 19122955	HOLE DEPTH: 8.34 m	CHECKED: BJF	DATE: 20/8/19

This report of core photographs must be read in conjunction with accompanying notes and abbreviations.

DRAFT REPORT OF BOREHOLE: BH04

GOLDER

SHEET: 1 OF 2

CLIENT: PDS and Starrylands	COORDS: 316031 m E 6254831 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05	
PROJECT: Proposed Gran Central	SURFACE RL: 11.0 m DATUM: AHD (MAP)	CONTRACTOR: Nealings	
LOCATION: Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 29/7/19
JOB NO: 19122955	HOLE DIA: 90 mm HOLE DEPTH: 7.80 m	CHECKED: BJF	DATE: 20/8/19

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	H	GWNE	0	10.98	DS 0.10-0.20 m PID = 0.8 ppm			-	FILL: GRAVEL medium to coarse grained, poorly graded, sub-angular, blue metal	-	-	FILL
				0.25 10.75	DS 0.25-0.35 m PID = 0.7 ppm DS 0.55-0.65 m PID = 1.8 ppm			-	FILL: Gravelly SAND fine to medium grained, fine to coarse, sub rounded to sub angular gravel, trace glass.			RESIDUAL SOIL
			1		DS 1.05-1.15 m PID = 6.9 ppm DS 1.30-1.35 m PID = 2.4 ppm DS 1.40-1.50 m PID = 3.7 ppm			CI-CH	Silty CLAY medium to high plasticity, brown mottled red-brown	w > PL	-	
ADT	M		2		SPT 1.50-1.95 m 6, 12, 17 N=29 U75 2.00-2.35 m						VSt - H	@ 1.50 m, NDD Target Reached
	H		3	*2.80* 8.20	DS 2.80-3.00 m SPT 3.00-3.15 m 13 HB N>30			-	SILTSTONE pale grey, low to medium strength, extremely weathered, trace iron staining	w < PL	H	
			4						For Continuation Refer to Sheet 2			
			5									
			6									
			7									
			8									
			9									
			10									

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

DRAFT REPORT OF BOREHOLE: BH04

SHEET: 2 OF 2

CLIENT: PDS and Starrylands	COORDS: 316031 m E 6254831 m N MGA94 56 (hhGPS)	DRILL RIG: Komatsu 05	
PROJECT: Proposed Gran Central	SURFACE RL: 11.0 m DATUM: AHD (MAP)	CONTRACTOR: Nealings	
LOCATION: Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°	LOGGED: FY	DATE: 29/7/19
JOB NO: 19122955	HOLE DIA: 90 mm HOLE DEPTH: 7.80 m	CHECKED: BJF	DATE: 20/8/19

Drilling: METHOD: NMLC; WATER: 90-100% Water Return

DEPTH (m)	RL	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	LABORATORY STRENGTH (MPa)	DEFECT DESCRIPTION & Additional Observations
3.10		Continuation of Sheet 1			
3.28	7.72	SILTSTONE pale grey, trace iron staining	XW		3.10-3.95 m: Recovered as fine to medium, sub rounded to sub angular shale gravel
3.77	7.23	Core Loss: 490 mm			
4.15	6.85	SILTSTONE pale grey, trace iron staining			4.05 m: P, 5-10°, St, Sm, clay Ct, 3 mm
5.45	5.55	Silty CLAY (CI-CH) medium to high plasticity, pale grey			
5.84	5.16	SILTSTONE brown and dark grey, with iron staining	HW		5.49-5.50 m: Px 2, 0°, sp = 5 mm, Pl, Sm, Fe Sn 5.49-5.50 m: J, 90°, Ir, Sm, Fe Sn, 10 mm
7.80	3.20	with pale grey lamination, bedded @ 0-5°, no staining	MW SW - FR	PLI(D)=0.12 PLI(A)=0.30 PLI(D)=0.00 PLI(A)=0.17 PLI(D)=0.28 PLI(A)=0.40 PLI(D)=0.23 PLI(A)=0.36 PLI(D)=0.25 PLI(A)=0.43	5.57 m: Px2, 0-5°, sp = 10 mm, Ir, Sm-Ro, Fe Sn, 5 mm, weathered siltstone 5.58-5.60 m: J, 80°, Pl, Sm, Fe Sn, 20 mm 5.60-5.68 m: EWS, 5°, Fe Sn, 80 mm, clay and weathered siltstone 5.90 m: P, 0°, Pl, Sm, clay Ve 6.20-6.27 m: EWSx3, 0°, sp = 60 mm, Fe Sn, 20 mm 6.63 m: P, 0°, Pl, Sm-Ro, Fe Sn 6.66-6.69 m: EWS, 0°, Fe Sn, weathered siltstone 6.83 m: EWS, 0°, 15 mm, clay 7.13 m: Px 2, 0°, sp = 3 mm, Pl, Sm, Cn 7.55 m: P, 0°, Pl, Sm, Cn
		END OF BOREHOLE @ 7.80 m TARGET DEPTH GROUTED			

Core run (approx. depth, m)	TCR	RQD (SCR)
3.10-3.90	40	0 (0)
3.90-4.50	100	35 (80)
4.50-5.75	100	10 (15)
5.75-7.00	100	70 (85)
7.00-7.80	100	80 (95)

This report of borehole must be read in conjunction with accompanying notes and abbreviations.

DRAFT REPORT OF CORE PHOTOGRAPHS: BH04

SHEET: 1 OF 1

CLIENT:	PDS and Starrylands	COORDS: 316031 m E 6254831 m N MGA94 56 (hhGPS)		DRILL RIG: Komatsu 05	
PROJECT:	Proposed Gran Central	SURFACE RL: 11.0 m DATUM: AHD (MAP)		CONTRACTOR: Nealings	
LOCATION:	Cnr Parramatta Rd and Good Street, Granville	INCLINATION: -90°		LOGGED: FY	DATE: 29/7/19
JOB NO:	19122955	HOLE DIA: 90 mm	HOLE DEPTH: 7.80 m	CHECKED: BJF	DATE: 20/8/19

This report of core photographs must be read in conjunction with accompanying notes and abbreviations.

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT REPORTS

GOLDER

DRILLING/EXCAVATION METHOD

ADH	Hollow auger drilling	EX	Excavator	PQ3	Diamond core - 83 mm
ADT	Auger drilling with tc-bit	HA	Hand auger	PT	Push tube sampling
ADV	Auger drilling with v-bit	HAND	Excavated by hand methods	RAB	Rotary air blast
AIRCORE	Aircore	HMLC	Diamond core - 63 mm	RC	Reverse circulation
AT	Air track	HQ3	Diamond core - 61 mm	RT	Rock roller
BH	Backhoe bucket	JET	Jetting	SONIC	Sonic drilling
CT	Cable tool rig	MZ	Mazier tube sampling	SPT	Standard penetration testing
DTC	Diatube coring	NDD	Non-destructive digging	U	Undisturbed tube sampling
EE	Existing excavation	NMLC	Diamond core - 52 mm	WB	Washbore drilling
EPT	Extruded push tube	NQ3	Diamond core - 45 mm		

PENETRATION/EXCAVATION RESISTANCE

L	**Low resistance.** Rapid penetration possible with little effort from the equipment used.
M	**Medium resistance.** Excavation/possible at an acceptable rate with moderate effort from the equipment used.
H	**High resistance** to penetration/excavation. Further penetration is possible at a slow rate and requires significant effort from the equipment.
R	**Refusal or Practical Refusal.** No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition of excavation or drilling tools, and the experience of the operator.

WATER

▽	Water level at date shown	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following 150mm seating
30/80 mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
DS	Disturbed sample
BDS	Bulk disturbed sample
G	Gas Sample
W	Water Sample
FP	Field permeability test over section noted
FV	Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket penetrometer test expressed as instrument reading in kPa
U63	Thin walled tube sample - number indicates nominal sample diameter in millimetres
WPT	Water pressure test
DCP	Dynamic cone penetration test
CPT	Cone penetration test
CPTu	Cone penetration test with pore pressure (u) measurement

RANKING OF VISUALLY OBSERVABLE CONTAMINATION AND ODOUR (for specific soil contamination assessment projects)

R = 0	No visible evidence of contamination	R = A	No non-natural odours identified
R = 1	Slight evidence of visible contamination	R = B	Slight non-natural odours identified
R = 2	Visible contamination	R = C	Moderate non-natural odours identified
R = 3	Significant visible contamination	R = D	Strong non-natural odours identified

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)	RQD = Rock Quality Designation (%)	SCR = Solid Core Recovery (%)	F = Fracture Frequency
$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100$	$= \frac{\sum \text{Axial lengths of core} > 100\text{ mm}}{\text{Length of core run}} \times 100$	$= \frac{\sum \text{Length of cyclindrical core recovered}}{\text{Length of core run}} \times 100$	$= \frac{\text{No. of defects}}{\text{Length of zone (m)}}$

GOLDER

METHOD OF SOIL DESCRIPTION USED ON BOREHOLE AND TEST PIT REPORTS

SYMBOLS

FILL	CLAY (CL, CI or CH)
GRAVEL (GW, GP, GM or GC)	ORGANIC SOILS (OL, OH or Pt)
SAND (SW, SP, SM or SC)	COBBLES or BOULDERS
SILT (ML or MH)	

Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay.

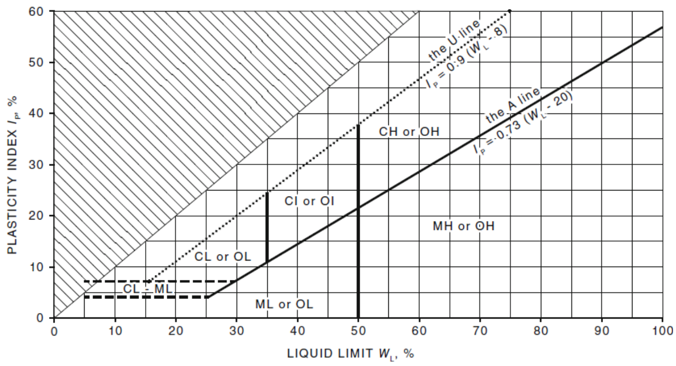
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil and Rock is classified and described in Reports of Boreholes and Test Pits using the preferred method given in AS1726-2017. The material properties are assessed in the field by visual/tactile methods.

Particle Size

Soil Group	Sub Division	Particle Size
BOULDERS		> 200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	19 to 63 mm
	Medium	6.7 to 19 mm
	Fine	2.36 to 6.7 mm
SAND	Coarse	0.6 to 2.36 mm
	Medium	0.21 to 0.6 mm
	Fine	0.075 to 0.21 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties



MOISTURE CONDITION

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sand and gravels tend to cohere.

Moisture condition for fine grained soils is described relative to the plastic limit or liquid limit as specified in AS1726-2017.

CONSISTENCY AND DENSITY

Fine Grained Soils

Symbol	Term	Undrained Shear Strength
VS	Very Soft	0 to 12 kPa
S	Soft	12 to 25 kPa
F	Firm	25 to 50 kPa
St	Stiff	50 to 100 kPa
VSt	Very Stiff	100 to 200 kPa
H	Hard	Above 200 kPa
Fr	Friable	-

Coarse Grained Soils

Symbol	Term	Density Index (%)	SPN "N" *
VL	Very Loose	Less than 15	0 to 4
L	Loose	15 to 35	4 to 10
MD	Medium Dense	35 to 65	10 to 30
D	Dense	65 to 85	30 to 50
VD	Very Dense	Above 85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.

* SPT correlations are not stated in AS1726-2017, and may be subject to corrections for overburden pressure and equipment type.

CEMENTATION

Weakly Cemented	The soil may be easily disaggregated by hand in air or water.
Moderately Cemented	Effort is required to disaggregate the soil by hand in air or water.

TERMS FOR ROCK MATERIAL STRENGTH & WEATHERING AND ABBREVIATIONS FOR DEFECT DESCRIPTIONS

STRENGTH

Symbol	Term	UCS (MPa)	Field Guide
VL	Very Low	0.6 to 2	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm can be broken by finger pressure.
L	Low	2 to 6	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium	6 to 20	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High	20 to 60	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
VH	Very High	60 to 200	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High	>200	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

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

ROCK MATERIAL WEATHERING

Symbol		Term	Field Guide
RS		Residual Soil	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
XW		Extremely Weathered	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.
DW	HW	Highly Weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
DW	MW	Moderately Weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable, but shows little or no change of strength from fresh rock.
SW		Slightly Weathered	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
FR		Fresh	Rock shows no sign of decomposition of individual minerals or colour changes.

ABBREVIATIONS FOR DEFECT TYPES AND DESCRIPTIONS

Defect Type

P	Parting
X	Foliation
L	Cleavage
C	Contact
J	Joint
SSu	Sheared Surface
SS	Sheared Seam
SZ	Sheared Zone
CS	Crushed Seam
IS	Infilled Seam
EWS	Extremely Weathered Seam
V	Vein

Coating or Infilling

Cn	Clean
Sn	Stain
Ve	Veneer
Ct	Coating
In	Infill

Planarity

Pl	Planar
Cv	Curved
Un	Undulating
St	Stepped
Ir	Irregular

Roughness

VRo	Very Rough
Ro	Rough
Sm	Smooth
Po	Polished
Sl	Slickensided

Vertical Boreholes – The dip (inclination from horizontal) of the defect is given.

Inclined Boreholes – The inclination is measured as the acute angle between the core axis and the vertical direction.

APPENDIX C

Laboratory Certificates

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
ABN: 25 131 532 020
Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
Ph: (02) 9674 7711 | **Fax:** (02) 9674 7755 | **Email:** info@resourcelab.com.au

Test Report

Customer: Golder Associates Pty Ltd
Project: 19122955
Location: Granville

Job number: 19-0081
Report number: 1
Page: 1 of 1

Moisture Content

Sampling method: Tested as received

Test method(s): AS 1289.1.1, 2.1.1

	Results				
Laboratory sample no.	19690	19691			
Customer sample no.	BH01_0.53-0.60	BH03_0.50-0.60			
Date sampled	30/07/2019	01/08/2019			
Material description	CLAY, trace of silt and gravel, mottled brown/ red/grey	CLAY, trace of silt and gravel, mottled brown/ red/grey			
Moisture content (%)	37.5	30.8			

Laboratory sample no.					
Customer sample no.					
Date sampled					
Material description					
Moisture content (%)					

Approved Signatory: C. Greely

Date: 26/08/2019

ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025 - Testing.

NATA Accredited Laboratory Number: **17062**

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
ABN: 25 131 532 020
Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
Ph: (02) 9674 7711 | **Fax:** (02) 9674 7755 | **Email:** info@resourcelab.com.au

Test Report

Customer: Golder Associates Pty Ltd
Project: 19122955
Location: Granville

Job number: 19-0081
Report number: 2
Page: 1 of 1

Soil Index Properties

Sampling method: Tested as received

Test method(s): AS 1289.1.1, 2.1.1, 3.1.2, 3.2.1, 3.3.1

	Results				
Laboratory sample no.	19690	19691			
Customer sample no.	BH01_0.53-0.60	BH03_0.50-0.60			
Date sampled	30/07/2019	01/08/2019			
Material description	CLAY, trace of silt and gravel, mottled brown/ red/grey	CLAY, trace of silt and gravel, mottled brown/ red/grey			
Liquid limit (%)	90	108			
Plastic limit (%)	20	32			
Plasticity index (%)	70	76			
Linear shrinkage (%)	-	-			
Cracking / Curling / Crumbling	-	-			
Sample history	Air dried	Air dried			
Preparation	Dry sieved	Dry sieved			

Approved Signatory: C. Greely

Date: 26/08/2019

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025 - Testing.

NATA Accredited Laboratory Number: **17062**

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
ABN: 25 131 532 020
Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
Ph: (02) 9674 7711 | **Fax:** (02) 9674 7755 | **Email:** info@resourcelab.com.au

Test Report

Customer: Golder Associates Pty Ltd
Project: 19122955
Location: Granville

Job number: 19-0081
Report number: 3 rev.1

Shrink Swell Index

Sampling method: Tested as received

Test method(s): AS 1289.1.1, 2.1.1, 7.1.1

	Results				
Laboratory sample no.	19692				
Customer sample no.	BH04_2.00-2.35				
Date sampled	29/07/2019				
Material description	silty CLAY, trace of gravel, grey mottled red/ yellow-brown				
Shrink (%)	2.0				
Moisture content (%)	16.1				
Soil crumbling	n/a				
Extent of cracking	Open cracks				
Inert inclusions (%)	<5				
Swell (%)	2.2				
Moisture content initial (%)	14.3				
Moisture content final (%)	19.6				
Shrink swell index (%)	**1.7**				

Notes: This report has been amended to correct the material description.

Approved Signatory: C. Greely

Date: 26/08/2019

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025 - Testing.

NATA Accredited Laboratory Number: **17062**

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Frank Yu	Manager	Huong Crawford
Client	GOLDER ASSOCIATES PTY LTD	Laboratory	SGS Alexandria Environmental
Address	Level 8, 40 Mount Street North Sydney NSW 2065	Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	0431 063 254	Telephone	+61 2 8594 0400
Facsimile	02 9478 3901	Facsimile	+61 2 8594 0499
Email	FYu@golder.com.au	Email	au.environmental.sydney@sgs.com
Project	**19122955 - Gran Central - Additional**	SGS Reference	**SE196066A R0**
Order Number	**PO21564**	Date Received	7/8/2019
Samples	3	Date Reported	14/8/2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(4354).

SIGNATORIES

Dong Liang
Metals/Inorganics Team Leader

pH in soil (1:2) [AN101] Tested: 12/8/2019

PARAMETER	UOM	LOR	BH02_1.8-1.85 SOIL - 31/7/2019 SE196066A.003
pH (1:2)	pH Units	-	5.4

Conductivity (1:2) in soil [AN106]   Tested: 12/8/2019

PARAMETER	UOM	LOR	BH02_1.8-1.85 SOIL - 31/7/2019 SE196066A.003
Conductivity (1:2) @25 C*	µS/cm	1	94
Resistivity (1:2)*	ohm cm	-	11000

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography [AN245] Tested: 13/8/2019

PARAMETER	UOM	LOR	BH02_1.8-1.85 SOIL - 31/7/2019 SE196066A.003
Chloride	mg/kg	0.25	1.9
Sulfate	mg/kg	0.5	60

Moisture Content [AN002] Tested: 9/8/2019

PARAMETER	UOM	LOR	BH02_1.8-1.85 SOIL - 31/7/2019 SE196066A.003
% Moisture	%w/w	0.5	**8.9**

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:2 and the pH determined and reported on the extract after 1 hour extraction (pH 1:2) or after 1 hour extraction and overnight aging (pH (1:2) aged). Reference APHA 4500-H+.
AN106	Conductivity : Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as μmhos /cm or μS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:2 and the EC determined and reported on the extract basis after the 1 hour extraction (EC(1:2)) or after the 1 hour extraction and overnight aging (EC(1:2) aged). Reference APHA 2510 B.
AN106	Resistivity of the extract is reported on the extract basis and is the reciprocal of conductivity. Salinity and TDS can be calculated from the extract conductivity and is reported back to the soil basis.
AN245	Anions by Ion Chromatography: A water sample or extract is injected into an eluent stream that passes through the ion chromatographic system where the anions of interest ie Br, Cl, NO2, NO3 and SO4 are separated on their relative affinities for the active sites on the column packing material. Changes to the conductivity and the UV-visible absorbance of the eluent enable identification and quantitation of the anions based on their retention time and peak height or area. APHA 4110 B

FOOTNOTES

*	NATA accreditation does not cover the performance of this service.	-	Not analysed.	UOM	Unit of Measure.
**	Indicative data, theoretical holding time exceeded.	NVL	Not validated.	LOR	Limit of Reporting.
		IS	Insufficient sample for analysis.	↑↓	Raised/lowered Limit of Reporting.
		LNR	Sample listed, but not received.		

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Frank Yu	Manager	Huong Crawford
Client	GOLDER ASSOCIATES PTY LTD	Laboratory	SGS Alexandria Environmental
Address	Level 8, 40 Mount Street North Sydney NSW 2065	Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	0431 063 254	Telephone	+61 2 8594 0400
Facsimile	02 9478 3901	Facsimile	+61 2 8594 0499
Email	FYu@golder.com.au	Email	au.environmental.sydney@sgs.com
Project	**19122955 Gran Central - Additional**	SGS Reference	**SE196071A R0**
Order Number	**PO21564**	Date Received	7/8/2019
Samples	6	Date Reported	14/8/2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(4354).

SIGNATORIES

Dong Liang
Metals/Inorganics Team Leader

pH in soil (1:2) [AN101] Tested: 12/8/2019

PARAMETER	UOM	LOR	BH04_0.55-0.65 SOIL - 29/7/2019 SE196071A.006
pH (1:2)	pH Units	-	5.0

Conductivity (1:2) in soil [AN106] Tested: 12/8/2019

PARAMETER	UOM	LOR	BH04_0.55-0.65 SOIL - 29/7/2019 SE196071A.006
Conductivity (1:2) @25 C*	µS/cm	1	150
Resistivity (1:2)*	ohm cm	-	6600

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography [AN245] Tested: 13/8/2019

PARAMETER	UOM	LOR	BH04_0.55-0.65 SOIL - 29/7/2019 SE196071A.006
Chloride	mg/kg	0.25	**42**
Sulfate	mg/kg	0.5	**87**

Moisture Content [AN002] Tested: 9/8/2019

			BH04_0.55-0.65 SOIL - 29/7/2019
PARAMETER	UOM	LOR	SE196071A.006
% Moisture	%w/w	0.5	24.8

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:2 and the pH determined and reported on the extract after 1 hour extraction (pH 1:2) or after 1 hour extraction and overnight aging (pH (1:2) aged). Reference APHA 4500-H+.
AN106	Conductivity : Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos /cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:2 and the EC determined and reported on the extract basis after the 1 hour extraction (EC(1:2)) or after the 1 hour extraction and overnight aging (EC(1:2) aged). Reference APHA 2510 B.
AN106	Resistivity of the extract is reported on the extract basis and is the reciprocal of conductivity. Salinity and TDS can be calculated from the extract conductivity and is reported back to the soil basis.
AN245	Anions by Ion Chromatography: A water sample or extract is injected into an eluent stream that passes through the ion chromatographic system where the anions of interest ie Br, Cl, NO2, NO3 and SO4 are separated on their relative affinities for the active sites on the column packing material. Changes to the conductivity and the UV-visible absorbance of the eluent enable identification and quantitation of the anions based on their retention time and peak height or area. APHA 4110 B

FOOTNOTES

*	NATA accreditation does not cover the performance of this service.	-	Not analysed.	UOM	Unit of Measure.
**	Indicative data, theoretical holding time exceeded.	NVL	Not validated.	LOR	Limit of Reporting.
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Solid samples expressed on a dry weight basis.

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Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

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ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Ben Caruana	Manager	Huong Crawford
Client	GOLDER ASSOCIATES PTY LTD	Laboratory	SGS Alexandria Environmental
Address	Level 8, 40 Mount Street North Sydney NSW 2065	Address	Unit 16, 33 Maddox St Alexandria NSW 2015
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Facsimile	02 9478 3901	Facsimile	+61 2 8594 0499
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Project	**19122955 - Good St, Granville**	SGS Reference	**SE196280 R0**
Order Number	(Not specified)	Date Received	9/8/2019
Samples	1	Date Reported	16/8/2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(4354).

SIGNATORIES

Akheeqar Beniameen	**Dong Liang**	**Ly Kim Ha**
Chemist	Metals/Inorganics Team Leader	Organic Section Head

VOCs in Water [AN433] Tested: 13/8/2019

PARAMETER	UOM	LOR	19122955 WATER - 8/8/2019 SE196280.001
Benzene	µg/L	0.5	<0.5
Toluene	µg/L	0.5	**0.9**
Ethylbenzene	µg/L	0.5	<0.5
m/p-xylene	µg/L	1	<1
o-xylene	µg/L	0.5	<0.5
Total Xylenes	µg/L	1.5	<1.5
Total BTEX	µg/L	3	<3
Naphthalene	µg/L	0.5	<0.5

Volatile Petroleum Hydrocarbons in Water [AN433] Tested: 13/8/2019

PARAMETER	UOM	LOR	19122955 WATER - 8/8/2019 SE196280.001
TRH C6-C9	µg/L	40	<40
Benzene (F0)	µg/L	0.5	<0.5
TRH C6-C10	µg/L	50	<50
TRH C6-C10 minus BTEX (F1)	µg/L	50	<50

TRH (Total Recoverable Hydrocarbons) in Water [AN403] Tested: 12/8/2019

PARAMETER	UOM	LOR	19122955 WATER - 8/8/2019 SE196280.001
TRH C10-C14	µg/L	50	<50
TRH C15-C28	µg/L	200	<200
TRH C29-C36	µg/L	200	<200
TRH C37-C40	µg/L	200	<200
TRH >C10-C16	µg/L	60	<60
TRH >C16-C34 (F3)	µg/L	500	<500
TRH >C34-C40 (F4)	µg/L	500	<500
TRH C10-C36	µg/L	450	<450
TRH C10-C40	µg/L	650	<650
TRH >C10-C16 - Naphthalene (F2)	µg/L	60	<60

PAH (Polynuclear Aromatic Hydrocarbons) in Water [AN420] Tested: 12/8/2019

PARAMETER	UOM	LOR	19122955 WATER - 8/8/2019 SE196280.001
Naphthalene	μg/L	0.1	<0.1
2-methylnaphthalene	μg/L	0.1	<0.1
1-methylnaphthalene	μg/L	0.1	<0.1
Acenaphthylene	μg/L	0.1	<0.1
Acenaphthene	μg/L	0.1	<0.1
Fluorene	μg/L	0.1	<0.1
Phenanthrene	μg/L	0.1	<0.1
Anthracene	μg/L	0.1	<0.1
Fluoranthene	μg/L	0.1	<0.1
Pyrene	μg/L	0.1	<0.1
Benzo(a)anthracene	μg/L	0.1	<0.1
Chrysene	μg/L	0.1	<0.1
Benzo(b&j)fluoranthene	μg/L	0.1	<0.1
Benzo(k)fluoranthene	μg/L	0.1	<0.1
Benzo(a)pyrene	μg/L	0.1	<0.1
Indeno(1,2,3-cd)pyrene	μg/L	0.1	<0.1
Dibenzo(ah)anthracene	μg/L	0.1	<0.1
Benzo(ghi)perylene	μg/L	0.1	<0.1
Total PAH (18)	μg/L	1	<1

Anions by Ion Chromatography in Water [AN245] Tested: 12/8/2019

PARAMETER	UOM	LOR	19122955 WATER - 8/8/2019 SE196280.001
Chloride	mg/L	1	1100
Sulfate, SO4	mg/L	1	660

pH in water [AN101] Tested: 14/8/2019

			19122955 WATER - 8/8/2019
PARAMETER	UOM	LOR	SE196280.001
pH**	No unit	-	6.4

Conductivity and TDS by Calculation - Water [AN106] Tested: 14/8/2019

PARAMETER	UOM	LOR	19122955 WATER - 8/8/2019 SE196280.001
Conductivity @ 25 C	µS/cm	2	4400

Trace Metals (Dissolved) in Water by ICPMS [AN318] Tested: 12/8/2019

PARAMETER	UOM	LOR	19122955 WATER - 8/8/2019 SE196280.001
Arsenic, As	µg/L	1	<1
Cadmium, Cd	µg/L	0.1	0.1
Chromium, Cr	µg/L	1	<1
Copper, Cu	µg/L	1	3
Lead, Pb	µg/L	1	<1
Nickel, Ni	µg/L	1	6
Zinc, Zn	µg/L	5	150

Mercury (dissolved) in Water [AN311(Perth)/AN312] Tested: 13/8/2019

PARAMETER	UOM	LOR	19122955 WATER - 8/8/2019 SE196280.001
Mercury	mg/L	0.0001	<0.0001

METHOD	METHODOLOGY SUMMARY
AN020	Unpreserved water sample is filtered through a 0.45µm membrane filter and acidified with nitric acid similar to APHA3030B.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos /cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present , measured by the conductivity, are present as NaCl.
AN245	Anions by Ion Chromatography: A water sample is injected into an eluent stream that passes through the ion chromatographic system where the anions of interest ie Br, Cl, NO2, NO3 and SO4 are separated on their relative affinities for the active sites on the column packing material. Changes to the conductivity and the UV -visible absorbance of the eluent enable identification and quantitation of the anions based on their retention time and peak height or area. APHA 4110 B
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique, in accordance with USEPA 6020A.
AN403	Total Recoverable Hydrocarbons: Determination of Hydrocarbons by gas chromatography after a solvent extraction. Detection is by flame ionisation detector (FID) that produces an electronic signal in proportion to the combustible matter passing through it. Total Recoverable Hydrocarbons (TRH) are routinely reported as four alkane groupings based on the carbon chain length of the compounds: C6-C9, C10-C14, C15-C28 and C29-C36 and in recognition of the NEPM 1999 (2013), >C10-C16 (F2), >C16-C34 (F3) and >C34-C40 (F4). Where F2 is corrected for Naphthalene, the VOC data for Naphthalene is used.
AN403	Additionally, the volatile C6-C9/C6-C10 fractions may be determined by a purge and trap technique and GC /MS because of the potential for volatiles loss. Total Recoveerable Hydrocarbons - Silica (TRH-Silica) follows the same method of analysis after silica gel cleanup of the solvent extract. Aliphatic/Aromatic Speciation follows the same method of analysis after fractionation of the solvent extract over silica with differential polarity of the eluent solvents.
AN403	The GC/FID method is not well suited to the analysis of refined high boiling point materials (ie lubricating oils or greases) but is particularly suited for measuring diesel, kerosene and petrol if care to control volatility is taken. This method will detect naturally occurring hydrocarbons, lipids, animal fats, phenols and PAHs if they are present at sufficient levels, dependent on the use of specific cleanup /fractionation techniques. Reference USEPA 3510B, 8015B.
AN420	(SVOCs) including OC, OP, PCB, Herbicides, PAH, Phthalates and Speciated Phenols (etc) in soils, sediments and waters are determined by GCMS/ECD technique following appropriate solvent extraction process (Based on USEPA 3500C and 8270D).
AN433	VOCs and C6-C9 Hydrocarbons by GC-MS P&T: VOC`s are volatile organic compounds. The sample is presented to a gas chromatograph via a purge and trap (P&T) concentrator and autosampler and is detected with a Mass Spectrometer (MSD). Solid samples are initially extracted with methanol whilst liquid samples are processed directly. References: USEPA 5030B, 8020A, 8260.

FOOTNOTES

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APPENDIX D

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