Fort Street Public School
Geotechnical Investigation

SSD 10340
Prepared by J+K Geotechnics
For School Infrastructure NSW
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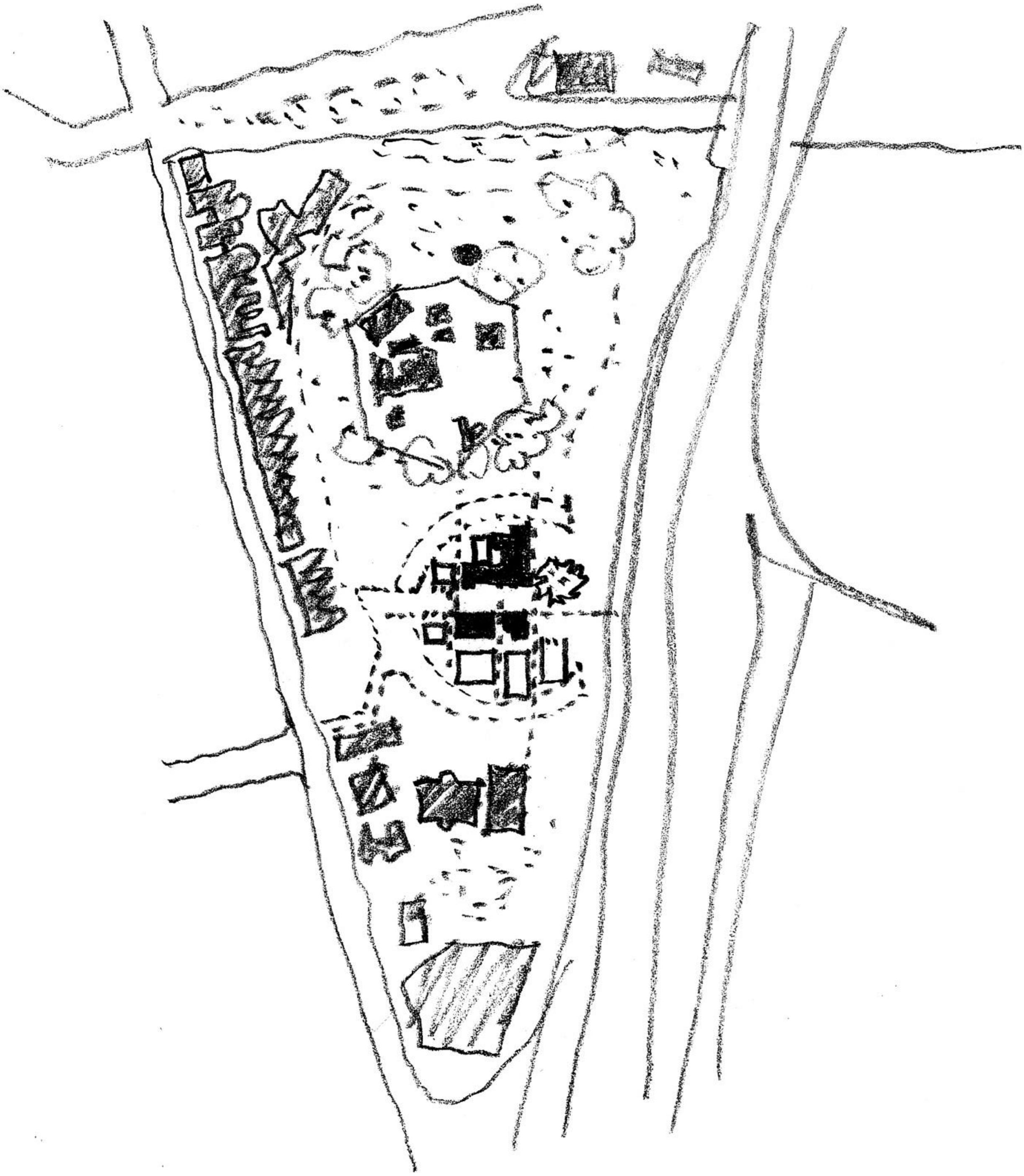

REPORT

TO
CONRAD GARGETT ANCHER MORTLOCK WOOLLEY

ON
GEOTECHNICAL INVESTIGATION

FOR
PROPOSED SCHOOL UPGRADE

AT
FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

29 June 2017
Ref: 30276Lrpt

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

PO Box 976, North Ryde BC NSW 1670
Tel: 02 9888 5000 Fax: 02 9888 5001
www.jkgeotechnics.com.au

Jeffery & Katauskas Pty Ltd, trading as JK Geotechnics ABN 17 003 550 801

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Report prepared by:

Linton Speechley
Principal I Geotechnical Engineer

For and on behalf of
JK GEOTECHNICS
PO Box 976
NORTH RYDE BC NSW 1670

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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed Fort Street Public School upgrade, at Upper Fort Street, Millers Point, NSW. The site location is shown on the attached Figure 1. The investigation was commissioned by Ms Jane McGarry, Senior Project Co-ordinator, of Conrad Gargett Ancher Mortlock Woolley by email dated 3rd April 2017 and was issued on behalf of the Department of Education. The commission was on the basis of our proposal (Ref: P44011L, dated 8th December 2016). In addition to the agreed scope, a test pit to expose the footings of one of the existing heritage buildings was also requested.

We understand that the Department of Education proposes to upgrade the facilities at the school, including classrooms, and other core facilities such as a library, administration area, toilets and a hall; all of which will be designed to bring the school facilities in line with the Department of Education's education facilities standards. The development works are only in concept stages and the location of the proposed facilities and structures, development levels, proposed earthworks and structural loads were unavailable at the time of the investigation and preparation of this report.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for preliminary comments and recommendations on excavation conditions, earthworks, retention, footings and pavements.

2 INVESTIGATION PROCEDURE

Prior to the commencement of the fieldwork, we carried out a dial before you dig (DBYD) search and the borehole locations were electromagnetically scanned by a specialist subcontractor for buried services.

The fieldwork for the investigation was carried out on the 11th and 12th of April and 7th May 2017 and comprised the following;

- Thirteen boreholes (BH1 to BH4 inclusive and BH6 to BH14 inclusive) drilled to total depths ranging from 2.3m to 6.0m below existing surface levels, using our track mounted JK308 and JK305 drill rigs.
- In boreholes BH1, BH4, BH7, BH9, BH10, BH11, BH12 and BH13, the bedrock was drilled using a Tungsten Carbide 'TC' bit to the termination depths.

- In boreholes BH2, BH3, BH6, BH8, and BH14, the bedrock was initially auger drilled using the 'TC' bit and then continued using NMLC diamond coring techniques and water flush.
- Excavation of one test pit (TP5) to a termination depth of 0.85m below existing surface level, and completion of a Dynamic Cone Penetration test (DCP5) next to the test pit.

The borehole locations, as shown on the attached Figure 2, were set out by taped measurements from existing surface features shown on the survey plan prepared by RPS Australia Pty Ltd, Drawing Number PR133183 Fort Street Public School-DET-A.dwg, and survey date Sep 2016.

The fieldwork was completed in the full-time presence of our engineering geologist, Mr Tom Clent, who set out the boreholes, nominated the sampling and testing, carried out the DCP testing, prepared the borehole logs and produced the test pit cross sectional sketch. The borehole logs, DCP test result and the test pit cross sectional sketch are attached to this report, together with a glossary of the terms and symbols used in the logs. The surface reduced levels shown on the borehole logs, DCP test results sheet and test pit cross sectional sketch, were determined by interpolation between spot levels shown on the above referenced survey plan, and so should be considered to be approximate only. The datum of the levels is Australian Height Datum (AHD).

The apparent compaction of the fill and the strength of the residual soils encountered in the boreholes was assessed from the Standard Penetration Test (SPT) 'N' values and DCP blow counts. The strength of the weathered bedrock in the augered portion of the boreholes was assessed by observation of the auger penetration resistance when using the 'TC' bit, together with examination of the recovered rock cuttings and subsequent correlation with laboratory moisture content test results. We note that strengths estimated in this way are approximate only and may vary by at least one strength order of magnitude.

Where the bedrock was core drilled, the recovered rock core was returned to our NATA registered laboratory (Soil Test Services), for photographing and Point Load Strength Index (Is_{50}) testing. Using established correlations the Unconfined Compressive Strength (UCS) of the bedrock was then inferred from the Is_{50} results. The Point Load Strength Index test results are summarized in the attached Table C and are also plotted on the borehole logs. Colour photographs of the rock core are provided with the borehole logs.

Selected soil samples were also returned to Soil Test Services, for Moisture Content and Four-Day soaked CBR tests. The results of the laboratory soil testing are provided in the attached STS Tables A and B.

Selected samples were sent for soil aggression testing to Envirolab Services Pty Ltd, a NATA registered laboratory, the results of this testing are provided in the attached Envirolab Certificate of Analysis No. 166856.

Groundwater observations were made in all boreholes during auger drilling, on completion of auger drilling and a short time after completion of auger drilling. No longer term groundwater monitoring was carried out. We note that water is used during the core drilling process and therefore water levels after core drilling have not been recorded on the borehole logs as they will be artificially high and not representative of any ‘true’ groundwater level.

For further details of the investigation techniques adopted, reference should be made to the attached Report Explanation Notes.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located on top of a hill and is circular in plan view. Local slopes within the site typically grade down towards the south-east at about 1-3°. The boundaries of the site have been formed by the vertical sandstone cuts for the Cahill Expressway which surrounds the site on all sides. The soils along the boundaries appear to be supported by concrete retaining walls founded at the crest of the vertical sandstone cuts. The surface level of the Cahill Expressway is about 16m below the subject site surface levels in the north, rising to 12m in the west, 6m in the south and about 1m to 2m in the east.

The site includes brick buildings which are both older (heritage) and of more recent construction. The buildings range from one to three storeys. The more recent buildings, located in the northern portion of the site, make up the main Fort Street Public School buildings, with the Environmental Education Centre buildings located in the southern portions of the site. The older buildings are located within the central portion of the site and comprise a three storey brick heritage building and a single storey cottage with a metal roof. On the western side of the heritage building is a single storey garage. All the existing buildings across the site appeared to be in good external condition based on a cursory inspection.

Vegetation on the site consisted predominantly of lawns, garden plants and number of mature trees of medium height located around the Environmental Education Centre and the brick cottage in the southern and middle portions of the site. An artificial turf and soft surface play area exists on the eastern and western sides of the main school building in the north of the site.

The main access is from Upper Fort Street which bridges over the Cahill Expressway in the north-east of the site. A foot bridge connecting the site to the National Trust Centre exists on the southern boundary of the site.

3.2 Subsurface Conditions

Reference to the Sydney 1:100,000 Geological Series Sheet indicates that the site is underlain by Hawkesbury Sandstone.

The investigation encountered a generalised profile consisting of a shallow to moderate depth of granular fill directly overlying sandstone bedrock. Some residual clayey sand was encountered between the base of the fill and the top of the sandstone bedrock in BH3 and BH10 only. The weathered sandstone bedrock was encountered in all boreholes at depths ranging from 0.4m to 3.47m below existing surface levels. Some of the more pertinent subsurface observations are discussed below, however for specific details reference should be made to the attached borehole logs, as well as Figures 3 and 4 which show approximate rock depth contours, and top of rock contour levels respectively.

Pavements

Asphaltic concrete (AC) pavements were encountered in BH1 to BH4, BH10 and BH14 and ranged from 30mm to 50mm thick. The AC in BH2 was underlain by a 150mm thick concrete slab. In TP5, a 90mm thick concrete slab was encountered at ground surface.

Fill

Fill was encountered below the pavement layers in BH1 to BH4, TP5, BH10 and BH14 and extended to depths ranging from 0.8m to 2.1m below existing surface levels. The remaining boreholes encountered fill beneath grassed surfaces to depths ranging from 0.4m to 3.47m below existing surface levels. Generally the fill was deepest toward the south-eastern portion of the site, with the deepest fill encountered in BH6. The fill generally comprised gravelly sand, sandy gravel and clayey sand, although there was some silty sand fill in BH11, BH12 and BH13. The fill was assessed as being generally poorly to moderately compacted with the exception of BH1, BH4 and BH6 which encountered some well compacted fill. The fill contained various gravel inclusions and varying fractions of brick, mortar, concrete and timber fragments. We consider that the fill would be classed as ‘uncontrolled’

Residual Clayey Sand

Residual clayey sand was encountered in BH3 and BH10 only. In BH10, the clayey sand was assessed as being of very loose relative density, while no testing of the clayey sand was carried out in BH3 and as such a strength assessment is not provided. Fractions of fine-grained ironstone gravel were present within the clayey sand in BH3.

Weathered Bedrock

The depth to sandstone bedrock generally increased to the south-east, with sandstone bedrock being encountered at depths ranging from about 0.4m in the south-western portion of the site to 3.47m in the south-eastern portion. The attached figures 3 and 4 show approximate depth and reduced level contours of the rock surface across the site. We note that the contours are based on simplified interpolations from the known borehole locations, so should be treated as approximate only. Figures 3 and 4 show a steeper drop off in rock depth toward the south-eastern corner of the site.

The upper 0.5m to 1.0m of bedrock across the site was generally distinctly weathered and of lower strength ranging from very low to low strength on first contact. BH7, BH10 and BH13 appeared to have a more weathered upper rock profile with up to 0.6m of extremely weathered and extremely low strength bedrock. The bedrock in all boreholes then typically increased to medium strength and medium to high strength at depths ranging from about 1.5m to 4.0m or about RL39.5m to RL35.6m.

Within cored portions of the sandstone bedrock there were several joints with inclinations of approximately 35° and 80° and extremely weathered seams to about 140mm thickness. BH6 and BH14 contained zones of core loss up to 0.5m thick indicating extremely weathered seams or clay bands.

Groundwater

All boreholes were dry on completion of auger drilling. We note that during the coring process, water is introduced into the borehole and therefore water levels immediately after completion of coring have not been recorded as they would be artificially high.

3.3 Laboratory Test Results

The moisture content tests on the recovered rock chips obtained during auger proving of the rock are generally consistent with our field assessment of rock strength.

Four Day Soaked CBR tests have been carried out on samples of the fill, residual clayey sand and remoulded very low strength sandstone bedrock. The clayey sand and sandstone bedrock samples gave soaked CBR values ranging from 8% to 11%, while the gravelly sand fill gave a soaked CBR of 30%. These soaked CBR values are quite high and typical for these types of materials.

The point load strength index test results are provided in the attached Table C, and are shown graphically on the cored borehole logs. These results correlate reasonably well with the field logging assessment of the rock strength with UCS values ranging from 1MPa to 24MPa.

The following table provides a summary of the soil aggression tests completed by Envirolab Pty Ltd. For specific details reference should be made to the Envirolab Certificate of Analysis No. 166856.

Summary Table of Envirolab Aggression Testing

Borehole Number	Soil Type	Soil pH (pH Units)	Chloride Content (mg/kg)	Sulphate Content (mg/kg)	Resistivity (ohm.cm)
BH4 (1.5m to 1.95m)	Fill	8.9	<10	20	16000
BH6 (0.5m to 0.95m)	Fill	7.8	88	960	2000
BH10 (0.5m to 0.95m)	Residual Clayey Sand	7.3	<10	<10	56000
BH3 (2.1m to 2.4m)	Residual Clayey Sand	7.6	<10	10	33000
BH7 (0.5m to 0.95m)	Fill	11.6	28	41	1900
BH9 (0.5m to 0.95m)	Fill	7.6	10	10	28000

The soil aggression tests indicate that all the fill and residual clayey sand samples tested will have a 'non aggressive' exposure classification for concrete piles when assessed in accordance with AS2159-2009 Tables 6.4.2(C). For steel piles, the test results indicate that the residual clayey sands would have a 'non-aggressive' exposure classification, however some of the fill will have a 'Mild' exposure classification when assessed in accordance with Table 6.5.2(C) of AS2159-2009.

4 COMMENTS AND RECOMMENDATIONS

The following comments and recommendations are of a general nature only, since we have not been provided with specific details of any of the proposed development works. Therefore once further development details are provided, we recommend that we be requested to review these comments and recommendations to confirm that they are consistent and representative for the proposed works.

4.1 Site Classification

Due to the depth of fill on the site, we consider that the site will classify as Class 'P' in accordance with AS2870-2011 'Residential Slabs and Footings'. Therefore all footings will need to be designed by engineering principles. Where all footings are uniformly founded on the underlying bedrock (as recommended in Section 4.5 below), then footings for structures within the scope and scale identified in AS2870-2011, may be designed on the basis of Class 'A' site conditions.

4.2 Excavation Conditions

The following recommendations should be read in conjunction with the 'Excavation Work – Code of Practise' by Safe Work Australia (July 2015). At this stage we do not know the extent of any excavation works on the site, and therefore these recommendations have been provided for general guidance on excavation works. Specific advice will be required once details of the proposed works are provided.

Excavation of the fill and residual clayey sand soils, as well as any extremely weathered sandstone will be readily achievable using the buckets of conventional hydraulic excavators. Where very low strength sandstone is encountered it will require larger excavators with ripping tynes, or a Dozer (say D7 size) with ripping tyne where space permits for the economical use of such equipment.

As the excavation depth increases, low and then medium strength sandstone bedrock will be encountered, and it is possible that for any deeper excavations, high strength sandstone bedrock may be also be encountered. Low, medium and high strength sandstone bedrock will require the use of rock excavation techniques, such as hydraulic impact hammers, rock saws and/or rock grinders. High strength sandstone will present 'very hard' rock excavation conditions.

During the use of hydraulic impact hammers, precautions must be made to reduce the risk of vibrational damage to adjoining structures. At the commencement of the use of hydraulic impact hammers we recommend that some quantitative vibration monitoring be carried out on any adjoining or nearby structures (including boundary retaining walls). Vibration monitoring should be carried out by an experienced vibration consultant or geotechnical engineer to check that vibrations are within acceptable limits. Dilapidation reports on these adjoining/nearby structures should also be carried out prior to works commencing. Once the details of the works are known we could advise which structures should be the subject of dilapidation reports.

If during excavation with hydraulic impact hammers, vibrations are found to be excessive or there is concern, then alternative lower vibration emitting equipment, such as rock saws, rock grinders or smaller hammers may need to be used. The use of a rotary grinder or rock sawing in conjunction with ripping presents an alternative low vibration excavation technique, however, productivity is likely to be slower. When using a rock saw or rotary grinder, the resulting dust must be suppressed by spraying with water.

We recommend that only excavation contractors with appropriate insurances and experience on similar projects be used. Excavation contractors should be provided with a copy of this geotechnical report, including the borehole logs and point load strength test results, so that they can make their own assessment of suitable excavation equipment.

Groundwater was not encountered during auger drilling of any of the boreholes and therefore during bulk excavation, significant groundwater inflows are not expected. Some localised seepage will occur at the soil rock interface and through defects within the rock during and immediately following rainfall periods. During construction we expect that any groundwater seepage will be able to be controlled by conventional sump and pump techniques.

The excavated material will need to be disposed off site and therefore will need to be suitably classified for waste disposal.

4.2.1 Excavation Batters

The excavation of temporary batter slopes may be feasible provided there is suitable space around the perimeter of the excavation.

Temporary batter slopes may be excavated as per the recommendations below and are contingent on the batter slopes being not greater than 3m high and the batter slopes being inspected by a geotechnical engineer at not greater than 1.5m depth intervals. Higher batter slopes would require more specific geotechnical appraisal and advice.

- Temporary batters through the residual clayey sands and all bedrock up to and including very low strength should be battered at not steeper than 1 Vertical (V) in 1 Horizontal (H). Seepage may occur at the soil/rock interface, from defects within the cut face or at the toe of the batter. Where the geotechnical engineers consider that the seepage is causing a higher risk of instability, it may be necessary to flatten batters or to provide some other local toe support.
- Where low strength bedrock is encountered it may be temporarily battered at not steeper than 1V in 0.5H.
- Vertical excavation would be feasible through sandstone bedrock of at least medium strength.
- Where adverse defects are encountered within temporary batter slopes they would need to be stabilised with rock bolts, shotcrete or other measures approved by the geotechnical engineers.
- Surcharge loads, including adjoining buildings, construction loads etc must be kept well clear of the crest of temporary batters (at least 2H from the crest, where H is the vertical height of the batter slope in metres). Closer spacing of surcharge loads would require specific geotechnical appraisal.
- After temporary batter slopes are fully formed, we recommend ongoing monitoring and inspections by the geotechnical engineers to check for any adverse weathering that may affect stability. Additional stabilisation may be required if adverse weathering occurs.
- Surface drainage should not be allowed to flow over the crest of temporary batters, and should be directed and discharged in a manner which avoids concentrated flows and erosion.

Where temporary batters are formed, consideration needs to be given to the type of backfill to be used against the permanent retaining walls. Uncompacted backfill placed up against retaining walls will result in large settlements which can have adverse effects on structures, paving or landscaping supported above. Backfill placed against permanent retaining walls should preferably comprise a uniform sized durable granular material (such as 40mm size igneous gravel) which is surrounded in a geotextile fabric. A capping layer of at least 0.5m thickness of clayey material should be placed above the geofabric, to reduce water infiltration. A subsoil 'agg' drain surrounded by a geofabric filter sock should also be placed at the base and rear of the retaining wall to collect seepage and discharge it to the stormwater system. This type of backfill has the advantage that only nominal compaction is required (such as by the use of a plate attached to the excavator). The alternative (although less preferred) is to use the site won material as backfill, however it will require careful control of moisture content, placement and compaction of material in thin layers, and density testing of each layer to ensure it is placed in a controlled manner as an engineered fill material. Placement and compaction of site won material at the rear of retaining walls is difficult and time consuming due to the space limitations. Care should also be taken when compacting fill behind retaining walls, to ensure that compaction stresses do not exceed the design earth pressures. Advice during construction is recommended when the type of equipment proposed is known.

There are cost implications of excavating and disposing of the additional soil from the batters, and importing large amounts of drainage material to backfill permanent retaining walls. The space required to form the temporary batters may also be problematic due to limited storage and construction space. Therefore it may be preferable to install a shoring system to avoid the excavation of the material in the batters and replacement with high quality material.

Where permanent batter slopes are being proposed, the formation will be dependent on the height of the cut and the materials exposed. As a guide we suggest the following general recommendations;

- Permanent batters through the fill, clayey sand and all bedrock up to and including very low strength should be battered at not steeper than 1 Vertical (V) in 2 Horizontal (H).
- Permanent batters through low strength bedrock should be battered at not steeper than 1V in 1H.
- Permanent batters through medium or high strength sandstone bedrock may be cut vertically subject to inspection and approval by the geotechnical engineers.

Any exposed permanent batters through the fill, clayey sands and very low strength bedrock will need to be fully protected from erosion in the long term, by suitable and approved erosion protection measures. Suitable measures would include revegetation or shotcrete. Where revegetation is being proposed, consideration should be given to flattening the permanent batters even further than recommended above to assist with initial vegetation and topsoil establishment and provide for ease of maintenance. Permanent batters through low strength and medium strength sandstone bedrock may not require erosion protection, and further advice from the geotechnical engineers should be obtained when the location of the batters and the material exposed is more fully understood.

4.3 Earthworks

At this stage we do not know the extent of any site earthworks and as such the following should be used as a guide only. The nature and extent of earthworks will depend on the design and use of structures and pavements and their performance expectations. The boreholes have shown that the site is underlain by poorly compacted granular fill which ranges from 0.4m to 3.47m deep. Therefore depending on the location of any proposed structures or pavements, removal of fill (either partial removal or complete removal) may be necessary. The following earthworks recommendations are provided, but will need to be reviewed once details of new structures and pavements are provided.

- Strip off the existing pavements, grass, topsoil, root affected material, and any obvious deleterious fill materials. The root balls of any trees or shrubs should also be fully removed. Stripped materials will generally not be suitable for re-use as engineered fill and should be stockpiled separately. Stripped topsoil materials may be suitable for re-use within landscaped areas.
- Some of the existing fill may also need to be removed to satisfy proposed new site levels or to provide a higher confidence in performance of ground floor slabs or pavements supported on fill. The excavated granular fill may be re-useable as an engineered fill provided it does not contain any deleterious substances, organic materials and any particles greater than a nominal 70mm diameter.
- Any exposed soil subgrade should be proof rolled with 8 passes of a minimum 10 tonne smooth drum roller to detect any soft or heaving areas. The proof rolling should be carried out in the presence of a geotechnical engineer or experienced earthworks technician. The boreholes have generally indicated that there is an upper layer of poorly compacted granular fill across the site and therefore where the entire depth of fill is not removed some heaving of the subgrade is expected. Heaving areas will require subgrade stabilisation; such as localised removal and replacement with engineered fill or the use of bridging layers and geogrid reinforcement. The subgrade should be well graded to promote runoff and reduce the risk of water ponding on the surface.
- Any areas of heaving subgrade should be locally removed to a competent base and replaced with engineered fill. As discussed above, where poorly compacted fill is encountered as the subgrade, further more specific subgrade improvement may be required and this is best determined in consultation with the geotechnical engineers at the time of construction when the details are performance expectations of the structures and pavements are more fully known.
- Engineered fill should comprise a good quality granular material, such as crushed sandstone or the existing granular fill material, and should be compacted in horizontal layers with a maximum 200mm loose thickness to at least 98% of Standard Maximum Dry Density (SMDD).
- Density testing should be regularly carried out on any engineered fill. Regular density testing in accordance with at least Level 2 requirements of AS3798-2007 'Guidelines on Earthworks

for Commercial and Residential Developments' are recommended. Level 1 testing would be required where structures are to be supported on the engineered fill.

- Any of the existing sandstone bedrock excavated from the site would also be suitable for use as an engineered fill, provided it does not contain particles greater than a nominal 70mm size.

Soil may need to be removed from site during earthworks operations. A contamination assessment has not been carried out as part of these geotechnical works. A waste classification will be required prior to any soils being removed from the site.

4.4 Retaining Walls

Where temporary batter slopes are not preferred or cannot fit within the boundary constraints, we recommend that properly designed insitu shoring systems be constructed and installed prior to commencement of excavation. Such a shoring system may also be used as a permanent basement wall if required.

Given the granular subsurface conditions encountered, we consider that contiguous piled walls should be adopted for this site. Any gaps between contiguous piles should be grouted as soon as they are exposed to reduce the risk of loss of soil from the rear of the wall.

Given the granular nature of the soils, we consider that grout injected piles will be required to reduce the risk of collapsing pile sides, which may occur if bored piles were adopted. If the use of bored piles is being considered, then a few trial bored piles should be drilled to assess the suitability of the granular soils to remain unsupported during piling. Temporary liners may be necessary to reduce the risk of collapse of bored pile sides. During our investigations we did not encounter any groundwater seepage, however we anticipate that some seepage may occur at the soil/rock interface during or immediately following periods of wet weather. The presence of groundwater seepage will be problematic for bored piles and almost certainly cause the pile hole sides to collapse. For this reason alone we consider that grout injected piles will provide a lower risk option for piling.

Piles for the shoring system should be socketed at least 1.0m below the bulk excavation level, including allowances for nearby lift pits, footing and services excavations. Greater embedment may be required for lateral stability of the shoring system. Deeper shoring systems may need to penetrate medium and even high strength sandstone bedrock which will require the use of large capacity piling rigs. Even with large capacity piling rigs, productivity may be very slow. We recommend that further advice from piling contractors be obtained on the suitability of their equipment to cost effectively penetrate through the required strength of rock.

Care will be required where piles need to penetrate a significant depth into bedrock to ensure that excess soil is not removed from the pile hole during drilling (termed de-compression). De-compression can cause settlement of the ground around the pile, which can cause distress to nearby buildings, services and pavements etc. The ground surface around the piles should be monitored by the site superintendent and if settlement is occurring, then further advice should be obtained from the geotechnical engineers.

Temporary lateral support of the shoring system may need to be provided by anchors or internal propping. We have assumed that the permanent support of the shoring system will be provided by bracing or propping from the floor slabs in the long term if required.

Where temporary batter slopes are adopted, conventional concrete block retaining walls can be constructed.

4.4.1 Insitu Shoring Systems – Design Parameters

The following characteristic parameters may be adopted for shoring wall design.

- Where minor movements of the shoring wall are tolerable, we recommend a rectangular lateral earth pressure distribution of 5H (where H is the depth of excavation in metres).
- Where adjoining structures or movement sensitive services are within a horizontal distance of 2H from the shoring wall we recommend that the magnitude of the rectangular lateral earth pressure be increased to 8H to reduce the risk of adverse deflections.
- If the retaining wall is to support a significant depth of sandstone bedrock, then the above earth pressure envelopes may be able to be amended to reflect the strength of the bedrock. Further advice can be obtained when details of any required shoring are known.
- Measures should be taken to provide permanent and effective drainage of the ground immediately behind the pile walls. We recommend weep holes be placed within the contiguous piled wall at not greater than 1.5m vertical and horizontal centres. However at least one row of weep holes must be placed just above the soil rock interface. Out of balance hydrostatic pressures may occur during construction and these need to be considered as part of the shoring wall design.

- All surcharge loads affecting the walls (e.g. nearby footings, construction loads and traffic etc) are additional to the earth pressure recommendations above and should be included in the design.
- Anchors should be bonded a minimum of 3m into sandstone bedrock of at least low strength for which we consider that a maximum allowable bond stress of 150kPa may be adopted. The anchor bond length should commence beyond a line drawn up at 45° from the bulk excavation level.
- All anchors should be proof loaded to 1.3 times their design working load and then locked off at about 85% of the working load under the direction of an experienced engineer or construction superintendent, independent of the anchor contractor. Lift off tests should be completed on all anchors about 4 days after lock off to confirm that anchors are holding their load.
- Piles embedded below bulk excavation level into sandstone bedrock of at least low strength may be designed for a uniform passive resistance of 250kPa. The upper 0.5m of the rock socket should be ignored in the passive resistance calculations to account for some disturbance and jointing within the upper rock from the excavation processes.

Shoring wall designs should include an assessment of wall movements during all stages of the excavation and anchoring construction stages. The wall designer should review the wall movements and assess whether such movements will adversely affect any nearby adjoining structures and services.

4.4.2 Permanent Basement Walls and Landscaping Walls

Where temporary batter slopes are adopted and permanent basement walls constructed within the excavation, we recommend that the following characteristic parameters may be adopted for shoring wall design. The following parameters are on the basis of either a properly placed and compacted engineered backfill or backfill comprising a uniform sized durable granular material which is surrounded in a geotextile fabric as discussed in Section 4.2.1 above.

- For cantilever walls where some movement can be tolerated we recommend a triangular lateral earth pressure distribution using an ‘active’ earth pressure coefficient (Ka) of 0.35.
- For cantilever walls which will be propped by floor slabs or where movements are to be reduced, we recommend a triangular lateral earth pressure distribution using an ‘at rest’ earth pressure coefficient (Ko) of 0.6.

- A bulk unit weight of 20kN/m^3 may be used for the backfill.
- All surcharge loads affecting the walls (e.g. nearby footings, construction loads and traffic etc) are additional to the earth pressure recommendations above and should be included in the design.
- Measures must be taken to provide permanent and effective drainage of the ground immediately behind the basement walls. We recommend the use of a free draining durable aggregate (such as 20mm size blue metal) with 'agg' pipe surrounded by a geotextile at the base and connected to the stormwater drainage system.

4.4.3 Computer Based Retaining Wall Analysis

Where detailed computer based shoring wall analysis is to be utilised for construction of insitu retaining walls we have provided the following parameters that may be used in the shoring wall analysis. These parameters would be suitable for use in programs such as Wallap or Plaxis. We note that the use of Wallap for rock needs to be carried out with great care as Wallap will not model jointing. The rock parameters in the table below are for **intact** rock and therefore additional consideration and allowance must be made in the shoring wall analysis for defect driven failure planes (such as jointing). We would be pleased to assist with any specific computer based shoring wall designs if commissioned to do so.

Material	Unit Weight (kN/m^3)	Cohesion (c)	Friction Angle (ϕ)	Elastic Modulus (MPa)
Granular Fill	18	0	27	10
Clayey Sand	18	0	27	8
Sandstone (VL & L)	24	100	35	500
Sandstone (M)	24	1000	40	1500

4.5 <u>Footings</u>

For uniformity of support we recommend that all structural loads be supported on footings founded on the underlying sandstone bedrock. Shallow strip/pad or piled footings founded on and with a minimum socket of at least 0.3m into the upper very low or low strength sandstone bedrock may be designed on the basis of a maximum allowable bearing pressure of 1000kPa. Where shallow pad/strip footings are founded on and with a minimum socket of 0.3m into the underlying medium strength sandstone bedrock a maximum allowable bearing pressure of 1500kPa may be adopted.

Where grout injected piles are adopted it will not be possible to inspect the founding stratum. Therefore bearing pressures should be limited to 1000kPa.

Higher allowable bearing pressures may be feasible for footings uniformly founded on the underlying sandstone bedrock, however additional site proving in the form of further cored boreholes would be required. The above maximum allowable bearing pressures are serviceability pressures and would be expected to induce footing settlements at founding level of less than 1% of the minimum footing width or pile diameter.

An allowable skin friction of 100kPa and 150kPa may be adopted through very low/low strength sandstone and medium strength sandstone bedrock respectively, provided the rock sockets are suitably roughened with a side wall grooving tool fitted the auger attachment.

Footing excavations should be inspected by a geotechnical engineer to confirm that a suitable founding stratum is being achieved. Any loose or softened material in the base of footings must be removed immediately prior to pouring concrete.

4.6 Ground Floor Slabs

Where ground floor slabs are to be lightly loaded pedestrian trafficked slabs only, then it may be feasible to support the ground floor slabs on the existing granular fill subgrade, subject to the subgrade preparation requirements outlined in Section 4.3 above. Any ground floor slabs supported on the existing granular fill should be isolated from the structural loads (which will be supported on the rock) to allow some relative movement. Ground floor slabs (even if the subgrade is sandstone bedrock) should be underlain by a subbase layer of DGB20, compacted to at least 100% of Standard Maximum Dry Density (SMDD).

Where ground floor slabs are sensitive to movements, then either the subgrade will require specific treatment (such as removal and re-compaction) or the ground floor slab may need to be designed as a fully suspended slab piled to rock. We can provide further advice once specific details are provided on the performance expectations of the ground floor slabs.

4.7 Pavements

Following satisfactory preparation of the subgrade (as detailed in Section 4.3 above), new pavements will need to be designed on the basis of the specific subgrade material. Where the existing granular fill is to be used as the subgrade material below pavements then we consider that it will be suitable for a design CBR value of 10%. Where the natural clayey sand is adopted we recommend a design CBR of 5% be adopted. These values are lower than the laboratory tests indicated, however they have been factored down to reflect the possible variability in the granular fill and the possible presence of a higher proportion of clay fines in the residual clayey sands.

Flexible pavements should be underlain by a good quality base-course layer comprising crushed rock to RTA QA specification 3051 (2010) unbound base material, or equivalent good quality and durable fine crushed rock compacted to at least 100% of Standard Maximum Dry Density (SMDD).

Concrete pavements should also be underlain by a subbase layer of at least 100mm thickness comprising DGB20 compacted to at least 100% of SMDD. This will reduce the risk of pumping of fines.

4.8 Earthquake Design Parameters

The following parameters can be adopted for earthquake design in accordance with AS1170.4-2007 'Structural Design Actions, Part 4: Earthquake Actions in Australia':

- Hazard factor (Z) = 0.08
- Site Subsoil Class = Class Ce

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

A waste classification will need to be assigned to any soil excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous Waste. Analysis takes seven to 10 working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) should be expected. We strongly recommend that this issue is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, BC 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
MOISTURE CONTENT TEST REPORT

Client:	JK Geotechnics	**Ref No:**	30276L
Project:	Proposed School Upgrade	**Report:**	A
Location:	Fort Street Public School, Upper Fort Street, Millers Point, NSW	**Report Date:**	18/05/2017
		Page 1 of 1	

AS 1289	**TEST METHOD**	**2.1.1**
BOREHOLE NUMBER	**DEPTH m**	**MOISTURE CONTENT %**
1	1.50-2.00	1.8
2	0.90-1.10	5.1
3	2.80-2.87	3.8
4	2.50-3.00	5.1
4	4.20-4.50	4.9
6	2.50-2.60	4.4
7	1.70-2.50	6.0
7	3.50-4.00	6.7
7	5.00-5.50	4.9
9	1.40-1.80	5.0
9	3.20-3.70	5.5
9	4.40-4.60	6.5
10	2.50-3.00	5.1
11	1.50-2.00	5.8
11	3.20-3.80	7.2
12	1.50-2.00	5.9
12	2.50-3.00	5.1
12	5.00-6.00	5.6
13	1.00-1.50	6.2
13	1.80-2.20	5.7
13	2.50-2.80	5.0
14	0.50-0.80	1.9
14	1.00-1.10	3.3

115 Wicks Road
Macquarie Park, NSW 2113
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Facsimile: 02 9888 5001

SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
FOUR DAY SOAKED CALIFORNIA BEARING RATIO TEST REPORT

Client:	JK Geotechnics	**Ref No:**	30276L
Project:	Proposed School Upgrade	**Report:**	B
Location:	Fort Street Public School, Upper Fort Street, Millers Point, NSW	**Report Date:**	18/05/2017
		Page 1 of 1	

BOREHOLE NUMBER	1	10	12
DEPTH (m)	0.50 - 1.00	0.50 - 1.50	0.50 - 1.50
Surcharge (kg)	4.5	4.5	4.5
Maximum Dry Density (t/m^3)	1.97 STD	1.85 STD	1.91 STD
Optimum Moisture Content (%)	9.6	10.3	12.5
Moulded Dry Density (t/m^3)	1.93	1.81	1.87
Sample Density Ratio (%)	98	98	98
Sample Moisture Ratio (%)	101	106	104
Moisture Contents			
Insitu (%)	5.4	15.2	8.3
Moulded (%)	9.7	10.9	12.9
After soaking and After Test, Top 30mm(%)	10.5	15.6	17.6
Remaining Depth (%)	10.5	13.8	13.3
Material Retained on 19mm Sieve (%)	0	0	0
Swell (%)	0.0	0.0	0.0
C.B.R. value: @2.5mm penetration			
@5.0mm penetration	30	8	11

NOTES:

- Refer to appropriate Borehole logs for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1
- Date of receipt of sample:26/4/17 & 12/5/17

NATA
NATA Accredited Laboratory
Number:1327

Accredited for compliance with ISO/IEC 17025 - Testing.

Authorised Signature / Date
(A. Tatikonda) 18/5/17

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, BC 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

TABLE C
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed School Upgrade
Location: Fort Street Public School, Upper Fort Street, Millers Point, NSW

Ref No: 30276L
Report: C
Report Date: 26/04/2017

BOREHOLE NUMBER	DEPTH m	$I_{S\,(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
2	1.46-1.50	0.05	1
	1.89-1.93	0.4	8
	2.30-2.35	0.5	10
	2.86-2.91	0.9	18
	3.33-3.38	0.8	16
	3.85-3.90	0.7	14
	4.02-4.07	0.9	18
3	2.93-2.97	0.2	4
	3.30-3.34	0.1	2
	3.86-3.90	0.6	12
	4.30-4.35	1.2	24
	4.85-4.89	0.8	16
	5.30-5.35	0.6	12
	5.95-6.00	0.9	18
6	3.20-3.25	0.9	18
	3.80-3.85	0.8	16
	4.14-4.19	0.7	14
	4.80-4.85	0.8	16
	5.15-5.20	1.2	24
	5.52-5.57	0.9	18
8	1.92-1.96	0.4	8
	2.36-2.40	0.3	6
	2.85-2.90	0.4	8
	3.50-3.55	0.7	14
	3.86-3.90	0.6	12
	4.35-4.39	0.7	14
	4.76-4.80	0.9	18

NOTES: See Page 2 of 2

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, BC 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

TABLE C
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed School Upgrade
Location: Fort Street Public School, Upper Fort Street,

Ref No: 30276L
Report: C
Report Date: 26/04/2017

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
14	1.72-1.76	0.1	2
	2.16-2.20	0.6	12
	2.64-2.68	0.3	6
	3.20-3.25	0.4	8
	3.63-3.67	0.4	8
	4.07-4.12	0.7	14

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1MPa, or to one significant figure if less than 0.1MPa
5. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :
   U.C.S. = 20 $I_{S(50)}$

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

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

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

CERTIFICATE OF ANALYSIS **166856**

Client:
JK Geotechnics
PO Box 976
North Ryde BC
NSW 1670

Attention: Tom Clent

Sample log in details:

Your Reference:	**30276L, Millers Point**
No. of samples:	6 soils
Date samples received / completed instructions received	11/05/17 / 11/05/17

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

Report Details:

Date results requested by: / Issue Date:	18/05/17 / 15/05/17
Date of Preliminary Report:	Not Issued

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Accredited for compliance with ISO/IEC 17025 - Testing **Tests not covered by NATA are denoted with *.**

Results Approved By:

David Springer
General Manager

Misc Inorg - Soil						
Our Reference:	UNITS	166856-1	166856-2	166856-3	166856-4	166856-5
Your Reference	-------------	BH4	BH6	BH10	BH3	BH7
Depth	------------	1.5-1.95	0.5-0.95	0.5-0.95	2.1-2.4	0.5-0.95
Date Sampled		7/05/2017	11/04/2017	11/04/2017	7/05/2017	12/04/2017
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	13/05/2017	13/05/2017	13/05/2017	13/05/2017	13/05/2017
Date analysed	-	13/05/2017	13/05/2017	13/05/2017	13/05/2017	13/05/2017
pH 1:5 soil:water	pH Units	8.9	7.8	7.3	7.6	11.6
Chloride, Cl 1:5 soil:water	mg/kg	<10	88	<10	<10	28
Sulphate, SO4 1:5 soil:water	mg/kg	20	960	<10	10	41
Resistivity in soil*	ohm m	160	20	560	330	19

Misc Inorg - Soil		
Our Reference:	UNITS	166856-6
Your Reference	-------------	BH9
Depth	------------	0.5-0.95
Date Sampled		7/05/2017
Type of sample		Soil
Date prepared	-	13/05/2017
Date analysed	-	13/05/2017
pH 1:5 soil:water	pH Units	7.6
Chloride, Cl 1:5 soil:water	mg/kg	10
Sulphate, SO4 1:5 soil:water	mg/kg	10
Resistivity in soil*	ohm m	280

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			13/05/2017	[NT]	[NT]	LCS-1	13/05/2017
Date analysed	-			13/05/2017	[NT]	[NT]	LCS-1	13/05/2017
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-1	102%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-1	84%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-1	91%
Resistivity in soil*	ohm m	1	Inorg-002	<1.0	[NT]	[NT]	[NR]	[NR]

Report Comments:

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

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

Quality Control Definitions

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

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

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

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

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

Laboratory Acceptance Criteria

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

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

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 1

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~40.6 m
Date: 12/4/17 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING		0			ASPHALTIC CONCRETE: 30mm.t	M			APPEARS WELL COMPACTED
					FILL: Sandy gravel, fine to medium grained sandstone, grey and brown.				
	N = 22 14,11,11				FILL: Gravelly sand, fine to coarse grained, red brown, grey and brown, fine to medium grained sandstone and ironstone gravel, trace of clayey sand.				
		1		-	SANDSTONE: fine to medium grained, grey and red brown.	DW	VL - L		VERY LOW 'TC' BIT RESISTANCE
					SANDSTONE: fine to medium grained, orange brown and grey.		M		LOW TO MODERATE RESISTANCE
		2.30			END OF BOREHOLE AT 2.30 m				'TC' BIT REFUSAL

RL (m AHD): 40, 39, 38, 37, 36, 35, 34
Depth (m): 1, 2, 3, 4, 5, 6

SAMPLES: ES, U50, DB, DS

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
2

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~41.0 m
Date: 12/4/17 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING							ASPHALTIC CONCRETE: 30mm.t				
						-	CONCRETE: 150mm.t				
	U50						FILL: Gravelly sand, fine to coarse grained, orange brown, grey and dark brown, with medium to coarse grained sandstone gravel.	M			(APPEARS POORLY COMPACTED)
	DS		40	1			SANDSTONE: fine to medium grained, orange brown and red brown.	DW	L		LOW TO MODERATE 'TC' BIT RESISTANCE
							REFER TO CORED BOREHOLE LOG				
			39	2							
			38	3							
			37	4							
			36	5							
			35	6							

JK Geotechnics

GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY

Project: PROPOSED SCHOOL UPGRADE

Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L	**Core Size:** NMLC	**R.L. Surface:** ~41.0 m
Date: 12/4/17	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK308	**Bearing:** N/A	**Logged/Checked By:** T.C./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
					START CORING AT 1.27m						
100% RETURN					SANDSTONE: fine to medium grained, orange brown and grey, with red brown iron indurated bands.	DW	VL - L			(1.37m) XWS, 0°, 100 mm.t	
							M			(1.57m) J, 80°, Un, R, IS	
										(1.68m) Be, 0°, P, R, IS	
					SANDSTONE: fine to medium grained, orange brown and grey, bedded at 10-15°.					(1.83m) Be, 0°, P, R, IS	
		39	2								
										(2.66m) XWS, 0°, 20 mm.t	
										(2.72m) XWS, 0°, 15 mm.t	
		38	3								
										(3.45m) Be, 5°, P, R, IS	
										(3.63m) XWS, 0°, 10 mm.t	
		37	4								
										(4.12m) XWS, 0°, 20 mm.t	
										(4.20m) J, 45°, P, R, IS	
					END OF BOREHOLE AT 4.21 m						
		36	5								
		35	6								
		34	7								


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30276L BH2 START CORING AT 1.27m
1
2
3
4
EOH AT 4.21m

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
3
1 / 2

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~38.9 m
Date: 7/5/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** T.C./L.S.

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING				0	-	ASPHALTIC CONCRETE: 50mm.t				
						FILL: Gravelly sand, fine to medium grained, red brown and grey, fine to coarse grained sandstone gravel, with mortar and brick fragments.	M			APPEARS POORLY TO MODERATELY COMPACTED
	DS	N = 7 3,3,4	38	1						
	DS	N > 6 12,6/ 20mm REFUSAL	37			as above, but trace of asphalt and brick fragments.				
	DS			2	CL	CLAYEY SAND: fine to medium grained, grey and red brown, with fine to medium grained ironstone gravel.	M			RESIDUAL
			36	3	-	SANDSTONE: fine to medium grained, grey and orange brown.	DW	L		HIGH 'TC' BIT RESISTANCE
						REFER TO CORED BOREHOLE LOG				
			35	4						
			34	5						
			33	6						
			32							

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
3

CORED BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L | **Core Size:** NMLC | **R.L. Surface:** ~38.9 m
Date: 7/5/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK305 | **Bearing:** N/A | **Logged/Checked By:** T.C./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT SPACING (mm)	DEFECT DETAILS DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific / General
					START CORING AT 2.87m					
0% RETURN		36	3		SANDSTONE: fine to medium grained, orange brown and grey.	DW	VL - L			
		35	4		SANDSTONE: fine to medium grained, grey.	SW	M - H			
		34	5							
		33	6		END OF BOREHOLE AT 6.00 m					
		32	7							
		31	8							
		30								

Point load scale: EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH
Defect spacing scale: 500, 300, 100, 50, 30, 10


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30276L BH3 START CORING AT 2.87m
2
3
4
5
END OF BOREHOLE AT 6.0m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
4
1 / 1

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY

Project: PROPOSED SCHOOL UPGRADE

Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~38.9 m

Date: 7/5/17 **Datum:** AHD

Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING			0		ASPHALTIC CONCRETE: 50mm.t				
	N > 6 9,6/ 20mm REFUSAL	38	1	-	FILL: Gravelly sand, fine to medium grained, dark brown and dark grey, fine to medium grained sandstone gravel, with concrete and brick fragments.	M			APPEARS WELL COMPACTED
	N = 29 8,9,20	37			as above, but trace of concrete cobbles.				
			2	-	SANDSTONE: fine to medium grained, orange brown.	DW	VL - L		LOW 'TC' BIT RESISTANCE
		36	3				M		MODERATE RESISTANCE
		35	4		SANDSTONE: fine to medium grained, grey.	SW	M - H		HIGH RESISTANCE
		34	5		END OF BOREHOLE AT 5.00 m				
		33	6						
		32							

Samples columns: ES, U50, DB, DS

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
6
1 / 2

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~39.1 m
Date: 11/4/17 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING						39	0			FILL: Gravelly sand, fine to medium grained, brown, dark grey and yellow brown, fine to medium grained sandstone gravel, with timber fragments.	M			GRASS COVER APPEARS POORLY COMPACTED
					N = 1 1,0,1									
						38	1							
					N = 27 6,12,15									APPEARS WELL COMPACTED
						37	2			FILL: Sandstone boulder and bitumen bonded gravel, fine to medium grained, orange brown.				'TC' BIT REFUSAL ON INFERRED SANDSTONE BOULDER
						36	3			REFER TO CORED BOREHOLE LOG				
						35	4							
						34	5							
						33	6							

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CORED BOREHOLE LOG

Borehole No.
6
2 / 2

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L | **Core Size:** NMLC | **R.L. Surface:** ~39.1 m
Date: 11/4/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK308 | **Bearing:** N/A | **Logged/Checked By:** T.C./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		37			START CORING AT 2.60m					
0% RETURN		36	3		CORE LOSS 0.50m					
					FILL: Sandstone boulder and bitumen bonded gravel.	-	M			(3.40m) CS, 70 mm.t
		35	4		SANDSTONE: fine to medium grained, orange brown and grey, bedded at 0-5°.	DW	M			
		34	5		SANDSTONE: fine to medium grained, grey brown, bedded at 15-20°.	SW	M - H			(4.91m) Be, 0°, P, R, IS
		33, 32, 31	6, 7, 8		END OF BOREHOLE AT 5.57 m					

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30276L BH6 START CORING AT 2.60m
2
CORE LOSS: 0.5m
3
4
5
EOH AT 5.57m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 7

1 / 1

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY

Project: PROPOSED SCHOOL UPGRADE

Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~39.3 m

Date: 12/4/17 **Datum:** AHD

Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING	DS	N = 7 3,3,4	39 – 38	0 – 1.4			FILL: Gravelly sand, fine to medium grained, dark brown, medium to coarse grained sandstone gravel, with brick, concrete and morter fragments and root fibres.	M			GRASS COVER APPEARS POORLY TO MODERATELY COMPACTED
	DS	N=SPT 10/ 20mm REFUSAL		1.4		-	SANDSTONE: fine to medium grained, grey and orange brown.	XW	EL		
			37 – 36	1.7 – 3.5				DW	L		LOW 'TC' BIT RESISTANCE
	DS		36 – 35	3.5			SANDSTONE: fine to medium grained, grey.	SW	M		MODERATE RESISTANCE
	DS		34	5.0 – 6.0					M - H		MODERATE TO HIGH RESISTANCE
			33	6			END OF BOREHOLE AT 6.00 m				

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BOREHOLE LOG

Borehole No.
8
1 / 2

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~39.7 m
Date: 11/4/17 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING							0			FILL: Gravelly sand, fine to medium grained, dark grey, fine to medium grained shale gravel.	M			GRASS COVER
														APPEARS MODERATELY COMPACTED
				■	N = 9 10,7,2	39				as above, but with clay.				
							1							
				■					-	SANDSTONE: fine to medium grained, orange brown.	DW	L - M		LOW TO MODERATE 'TC' BIT RESISTANCE
						38								
							2			REFER TO CORED BOREHOLE LOG				
						37	3							
						36	4							
						35	5							
						34	6							
						33								

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Borehole No.
8

CORED BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L | **Core Size:** NMLC | **R.L. Surface:** ~39.7 m
Date: 11/4/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK308 | **Bearing:** N/A | **Logged/Checked By:** T.C./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION (Rock Type, grain characteristics, colour, structure, minor components.)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT SPACING (mm)	DEFECT DETAILS DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) Specific	General
		38			START CORING AT 1.80m						
0% RETURN		37, 36, 35	2, 3, 4		SANDSTONE: fine to medium grained, grey, orange brown and red brown, bedded at 0-5°.	DW	L - M			(2.10m) XWS, 0°, 15 mm.t (2.25m) XWS, 0°, 10 mm.t	
						SW	M			(3.24m) Be, 0°, P, R, IS (3.47m) XWS, 0°, 10 mm.t (3.60m) Be, 5°, P, R, IS (3.65m) Cr, 5°, 10 mm.t (3.70m) Be, 0°, P, R, IS	
					SANDSTONE: fine to medium grained, grey brown, with dark grey laminae at 15-20°.						
		34, 33, 32	5, 6, 7		END OF BOREHOLE AT 4.78 m						

Point load scale: EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH
Defect spacing scale: 500, 300, 100, 50, 30, 10


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30276L BH8 START CORING AT 1.80m
1
2
3
4
EOH 4.78m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 9

1 / 1

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L | **Method:** SPIRAL AUGER | **R.L. Surface:** ~39.3 m
Date: 7/5/17 | **Datum:** AHD
Plant Type: JK305 | **Logged/Checked By:** T.C./L.S.

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING				0.0			FILL: Gravelly sand, fine to medium grained, dark brown and dark grey, fine to medium grained sandstone gravel.	M			GRASS COVER APPEARS MODERATELY COMPACTED
	DB	N = 8 3,4,4					FILL: Clayey sand, fine to medium grained, dark grey, with fine to coarse grained sandstone gravel.				
						-	SANDSTONE: fine to medium grained, orange brown and grey.	DW	L - M		LOW 'TC' BIT RESISTANCE
							SANDSTONE: fine to medium grained, grey and orange brown.		M		MODERATE TO HIGH RESISTANCE
				4.60			END OF BOREHOLE AT 4.60 m				'TC' BIT REFUSAL

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
10
1 / 1

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~39.1 m
Date: 11/4/17 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING			39	0			ASPHALTIC CONCRETE: 30mm.t				
							FILL: Clayey sand, fine to medium grained, brown, with fine to medium grained sandstone gravel.	D			APPEARS POORLY COMPACTED
	DB	N = 4 1,1,3				SC	CLAYEY SAND: fine to medium grained, orange brown and yellow brown.	D	VL		RESIDUAL
	DB		38	1							
	DS	N=SPT 12/ 70mm REFUSAL					SANDSTONE: fine to medium grained, grey and orange brown.	XW	EL		
			37	2				DW	L		LOW 'TC' BIT RESISTANCE
	DS								M		MODERATE TO HIGH RESISTANCE
			36	3					M - H		HIGH RESISTANCE
							END OF BOREHOLE AT 3.60 m				'TC' BIT REFUSAL
			35	4							
			34	5							
			33	6							

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Borehole No.
11

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~40 m
Date: 12/4/17 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING					FILL: Silty sand, fine to medium grained, dark brown, with root fibres.	M			GRASS COVER
		39	1	-	SANDSTONE: fine to medium grained, red brown and grey, with red brown ironstone bands.	DW	L - M		LOW 'TC' BIT RESISTANCE WITH HIGH BANDS
		38	2		SANDSTONE: fine to medium grained, orange brown and grey.		M		MODERATE RESISTANCE
		37	3		SANDSTONE: fine to medium grained, grey.	SW	M - H		HIGH RESISTANCE
		36	4		END OF BOREHOLE AT 3.90 m				'TC' BIT REFUSAL
		35	5						
		34	6						

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
12
1 / 1

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~39.9 m
Date: 12/4/17 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING		0		FILL: Silty sand, fine to medium grained, dark brown, with fine grained sandstone gravel and root fibres.	M			GRASS COVER
	N=SPT 6/ 10mm REFUSAL	~0.4	-	SANDSTONE: fine to medium grained, grey and orange brown.	DW	VL - L		VERY LOW 'TC' BIT RESISTANCE
		~1.5		SANDSTONE: fine to medium grained, orange brown and grey.		L - M		LOW TO MODERATE RESISTANCE WITH VERY LOW BANDS.
		~4.0				M		MODERATE RESISTANCE
		~5.0		SANDSTONE: fine to coarse grained, grey.	SW	M - H		HIGH RESISTANCE
		6.00		END OF BOREHOLE AT 6.00 m				'TC' BIT REFUSAL

RL (m AHD): 39, 38, 37, 36, 35, 34, 33
Depth (m): 1, 2, 3, 4, 5, 6

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
13
1 / 1

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~40.4 m
Date: 7/5/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** T.C./L.S.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING				0			FILL: Silty sand, fine to coarse grained, dark brown and dark grey, with clay.	M			MULCH COVER
		N=SPT 10/ 10mm REFUSAL	40			-	SANDSTONE: fine to medium grained, orange brown and grey.	XW - DW	EL - VL		VERY LOW 'TC' BIT RESISTANCE
											LOW RESISTANCE
				1				DW	L - M		LOW TO MODERATE RESISTANCE
			39								MODERATE RESISTANCE
				2							MODERATE RESISTANCE WITH HIGH BANDS
			38						M - H		HIGH RESISTANCE
							END OF BOREHOLE AT 2.80 m				'TC' BIT REFUSAL
				3							
			37								
				4							
			36								
				5							
			35								
				6							
			34								

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BOREHOLE LOG

Borehole No.
14
1 / 2

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** SPIRAL AUGER **R.L. Surface:** ~40.4 m
Date: 12/4/17 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** T.C./L.S.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING							0			ASPHALTIC CONCRETE: 30mm.t	D			APPEARS MODERATELY COMPACTED
					N > 10 13,10/ 30mm REFUSAL	40				FILL: Gravelly sand, fine to medium grained, dark grey and grey, with fine to medium grained sandstone gravel. trace of brick and porcelain fragments.				
							1		-	SANDSTONE: fine to medium grained, red brown and grey.	DW	L		LOW TO MODERATE 'TC' BIT RESISTANCE
						39				REFER TO CORED BOREHOLE LOG				
							2							
						38								
							3							
						37								
							4							
						36								
							5							
						35								
							6							
						34								

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Borehole No.
14

CORED BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L | **Core Size:** NMLC | **R.L. Surface:** ~40.4 m
Date: 12/4/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK308 | **Bearing:** N/A | **Logged/Checked By:** T.C./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS – DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific	General
		40	1		START CORING AT 1.18m						
		39			CORE LOSS 0.30m						
100% RETURN		38, 37	2, 3, 4		SANDSTONE: fine to medium grained, orange brown and grey, bedded at 5-10°.	DW	VL - L; M			(1.52m) XWS, 0°, 20 mm.t (1.57m) Be, 0°, P, R, IS (1.62m) XWS, 0°, 30 mm.t (1.87m) Be, 0°, P, R, IS (2.08m) XWS, 0°, 5 mm.t (2.32m) XWS, 0°, 140 mm.t (3.14m) XWS, 5°, 10 mm.t (3.55m) XWS, 0°, 10 mm.t (3.74m) XWS, 0°, 90 mm.t	
		36, 35, 34	5, 6		END OF BOREHOLE AT 4.12 m						


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30276L BH14 START CORING AT 1.18m
1
CORE LOSS: 0.30m
2
3
4
END OF BOREHOLE AT 4.12m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Test Pit No.
5

TEST PIT LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL UPGRADE
Location: FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW

Job No.: 30276L **Method:** HAND EXCAVATION **R.L. Surface:** ~40.1 m
Date: 7/5/17 **Datum:** AHD
Plant Type: N/A **Logged/Checked By:** T.C./L.S.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING					REFER TO DCP TEST RESULTS	40				CONCRETE: 90mm.t				NO OBSERVED REINFORCEMENT
									-	BRICK MORTAR MIX: 20mm.t	M			
										FILL: Gravelly sand, fine to medium grained, dark brown and dark grey, with medium to coarse grained sandstone gravel, ceramic, brick, glass, timber and fabric fragments.				APPEARS POORLY TO MODERATELY COMPACTED
						39	1			END OF TEST PIT AT 0.85 m				REFUSAL ON SANDSTONE BEDROCK
						38	2							
						37	3							
						36	4							
						35	5							
						34	6							

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

DYNAMIC CONE PENETRATION TEST RESULTS

Client:	CONRAD GARGETT ANCHER MORTLOCK WOOLLEY		
Project:	PROPOSED SCHOOL UPGRADE		
Location:	FORT STREET PUBLIC SCHOOL, UPPER FORT STREET, MILLERS POINT, NSW		
Job No.	30276L	Hammer Weight & Drop: 9kg/510mm	
Date:	7-5-17	Rod Diameter: 16mm	
Tested By:	T.C.	Point Diameter: 20mm	

Number of Blows per 100mm Penetration							
Test Location	RL ~40.1m						
Depth (mm)	**5**						
0 - 100	1						
100 - 200	3						
200 - 300	3						
300 - 400	2						
400 - 500	REFUSAL						
500 - 600							
600 - 700							
700 - 800							
800 - 900							
900 - 1000							
1000 - 1100							
1100 - 1200							
1200 - 1300							
1300 - 1400							
1400 - 1500							
1500 - 1600							
1600 - 1700							
1700 - 1800							
1800 - 1900							
1900 - 2000							
2000 - 2100							
2100 - 2200							
2200 - 2300							
2300 - 2400							
2400 - 2500							
2500 - 2600							
2600 - 2700							
2700 - 2800							
2800 - 2900							
2900 - 3000							

Remarks:
1. The procedure used for this test is similar to that described in AS1289.6.3.2-1997, Method 6.3.2.
2. Usually 8 blows per 20mm is taken as refusal
3. Survey datum is AHD.

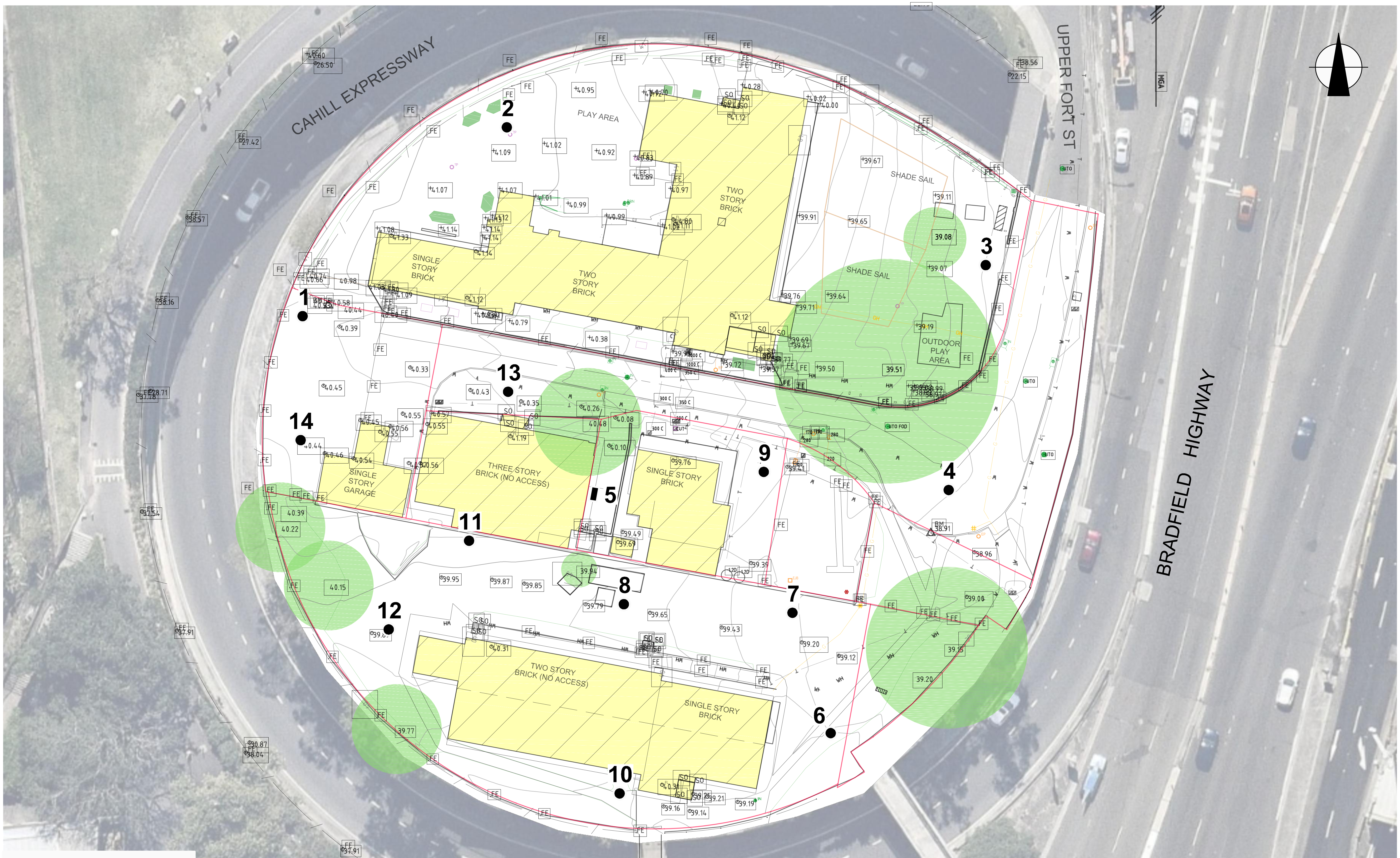
DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30276L MILLERS POINT\CAD\30276L.DWG
PLOT DATE: 16/05/2017 3:34:21 PM

AERIAL IMAGE SOURCE: GOOGLE EARTH PRO 7.1.5.1557
AERIAL IMAGE ©: 2015 GOOGLE INC.

This plan should be read in conjunction with the JK Geotechnics report.

Title:	**SITE LOCATION PLAN**
Location:	FORT STREET PUBLIC SCHOOL MILLER STREET, SYDNEY, NSW
Report No: 30276L	Figure No: 1

JK Geotechnics



LEGEND

- ● BOREHOLE
- ▬ TEST PIT

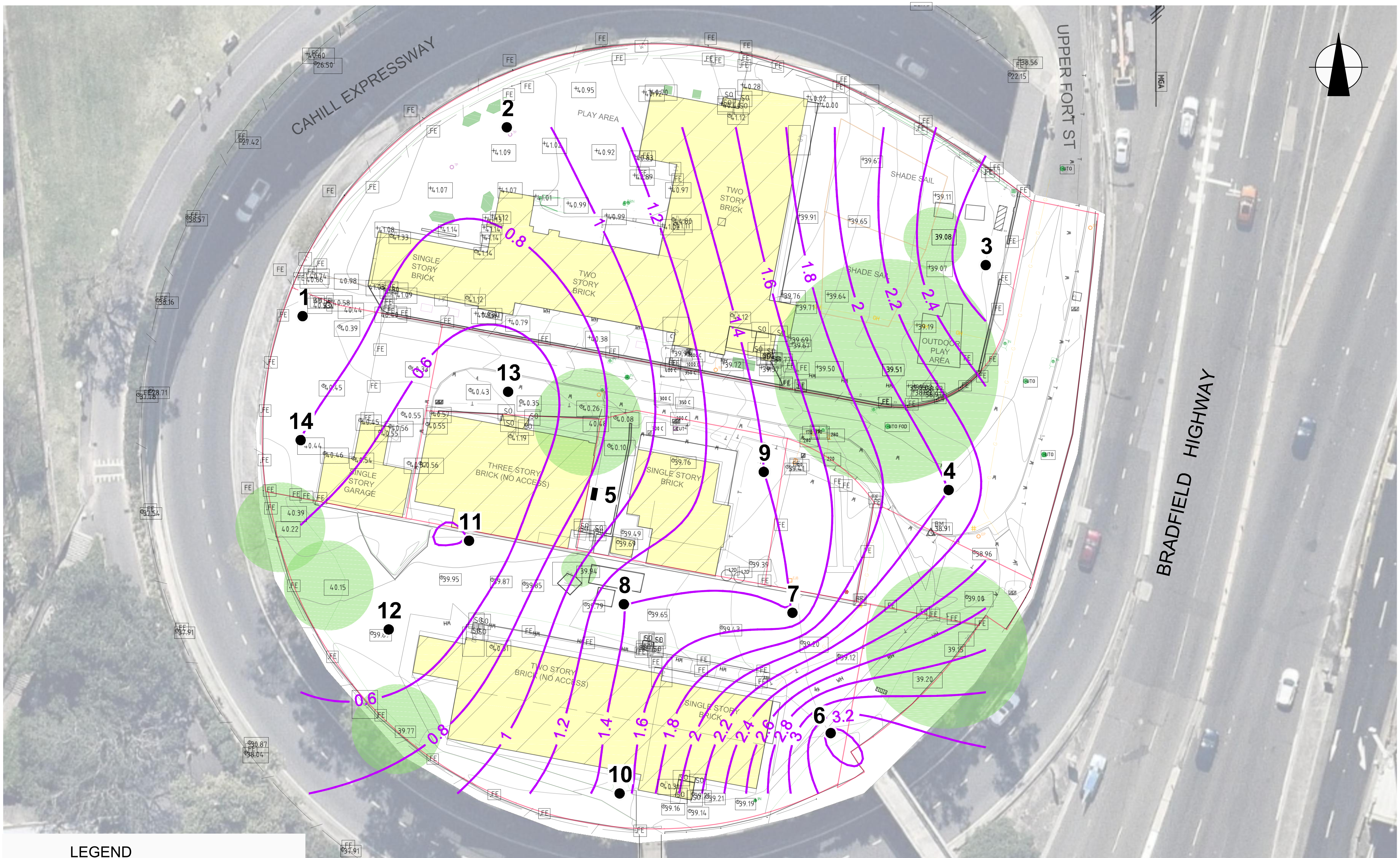
SCALE 1:400 @A3 (0 4 8 12 16 20 METRES)

This plan should be read in conjunction with the JK Geotechnics report.

Title:	**TEST LOCATION PLAN**
Location:	FORT STREET PUBLIC SCHOOL MILLER STREET, SYDNEY, NSW
Report No: 30276L	Figure No: 2

JK Geotechnics

PLOT DATE: 21/06/2017 10:29:52 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30276L MILLERS POINT\CAD\30276L2.DWG



LEGEND

- ● BOREHOLE
- ▬ TEST PIT
- 0.8 TOP OF ROCK CONTOURS (METRES)

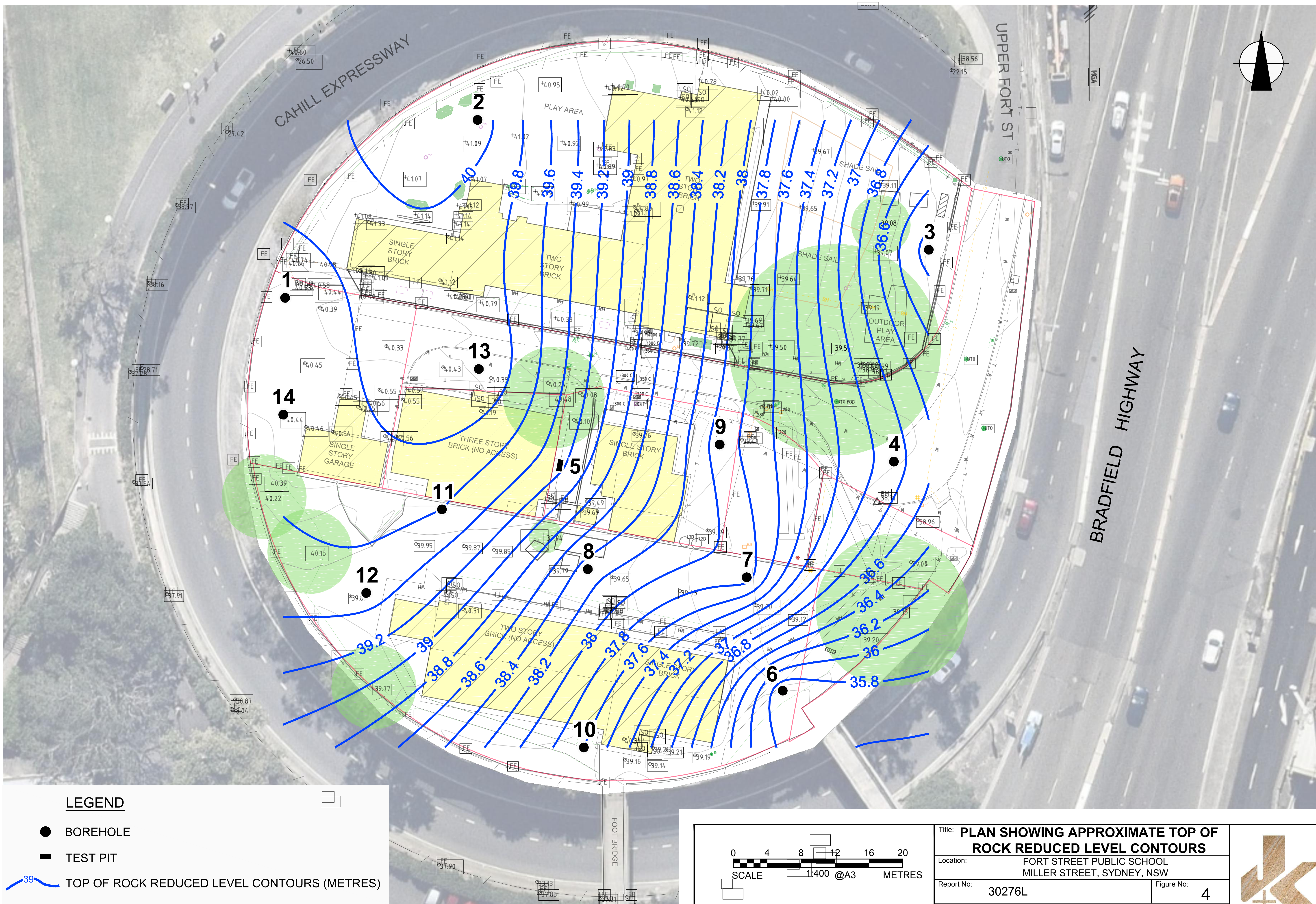
SCALE 1:400 @A3 — 0 4 8 12 16 20 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:	PLAN SHOWING APPROXIMATE DEPTH TO TOP OF ROCK CONTOURS
Location:	FORT STREET PUBLIC SCHOOL MILLER STREET, SYDNEY, NSW
Report No:	30276L
Figure No:	3

JK Geotechnics

PLOT DATE: 21/06/2017 10:50:39 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30276L MILLERS POINT\CAD\30276L2.DWG

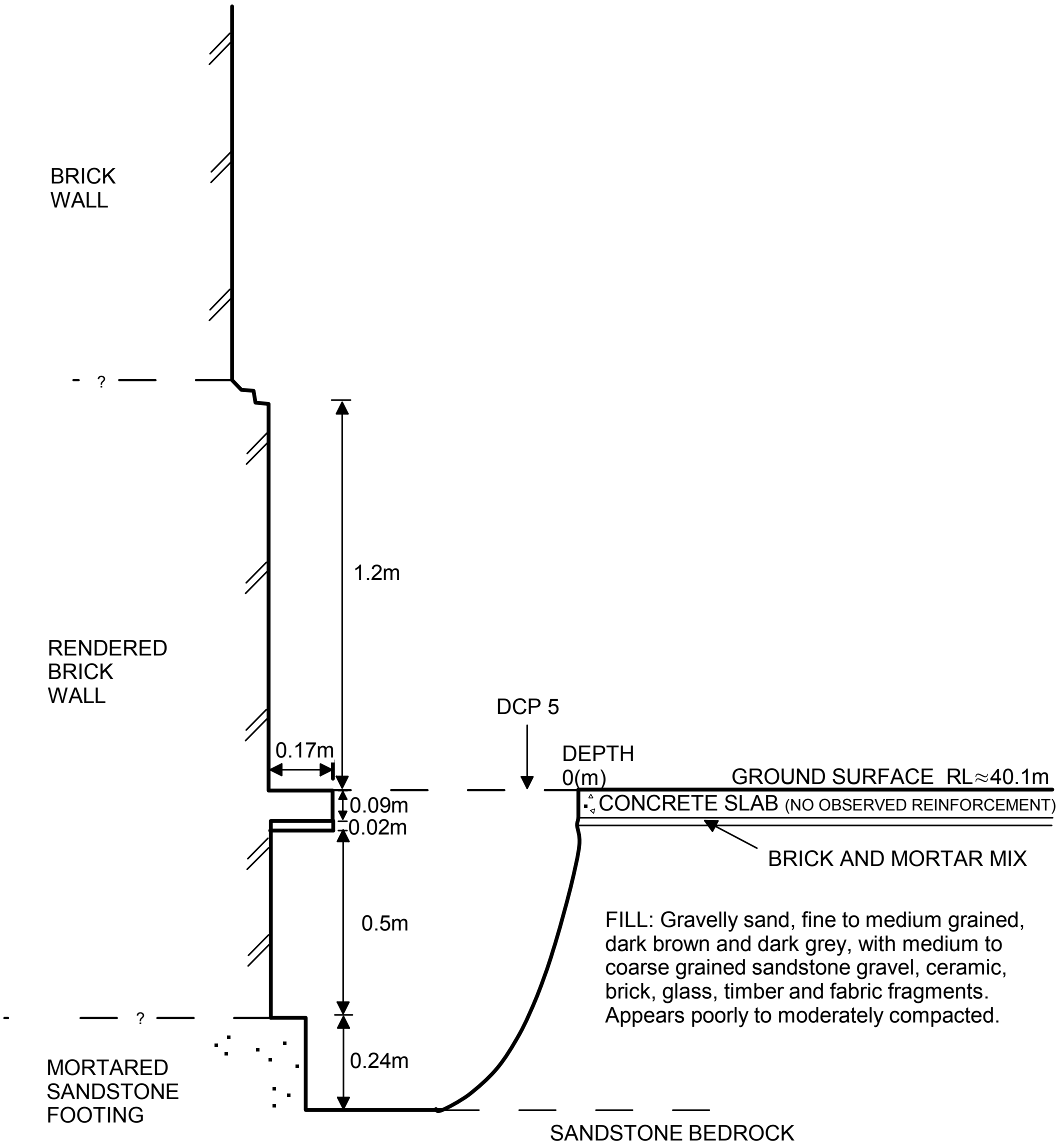


This plan should be read in conjunction with the JK Geotechnics report.

Title:	PLAN SHOWING APPROXIMATE TOP OF ROCK REDUCED LEVEL CONTOURS
Location:	FORT STREET PUBLIC SCHOOL MILLER STREET, SYDNEY, NSW
Report No: 30276L	Figure No: 4

JK Geotechnics

PLOT DATE: 21/06/2017 10:48:56 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30276L MILLERS POINT\CAD\30276L2.DWG



END OF TEST PIT AT 0.85m

TEST PIT 5
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 1.0
Scale 1:20 @A4 Metres

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

Report No. 30276L   Figure No. 5

VIBRATION EMISSION DESIGN GOALS

German Standard DIN 4150 – Part 3: 1999 provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 1 below.

It should be noted that peak vibration velocities higher than the minimum figures in Table 1 for low frequencies may be quite 'safe', depending on the frequency content of the vibration and the actual condition of the structure.

It should also be noted that these levels are 'safe limits', up to which no damage due to vibration effects has been observed for the particular class of building. 'Damage' is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. Should damage be observed at vibration levels lower than the 'safe limits', then it may be attributed to other causes. DIN 4150 also states that when vibration levels higher than the 'safe limits' are present, it does not necessarily follow that damage will occur. Values given are only a broad guide.

Table 1: DIN 4150 – Structural Damage – Safe Limits for Building Vibration

Group	Type of Structure	Peak Vibration Velocity in mm/s			
		At Foundation Level at a Frequency of:			Plane of Floor of Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use.	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 and 2 and have intrinsic value (eg. buildings that are under a preservation order).	3	3 to 8	8 to 10	8

Note: For frequencies above 100Hz, the higher values in the 50Hz to 100Hz column should be used.

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

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

DESCRIPTION AND CLASSIFICATION METHODS

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

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'Shale' is used to describe thinly bedded to laminated siltstone.

SAMPLING

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

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

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

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

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

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

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

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

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

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

The test results are reported in the following form:

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

  N = 13
  4, 6, 7

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

  N>30
  15, 30/40mm

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

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

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as 'N_c' on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using a Cone Penetrometer Test (CPT). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm or 44mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm or 165mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

  The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between CPT and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of CPT values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

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

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

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

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

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

GROUNDWATER

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

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

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

FILL

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

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

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soil for Engineering Purposes'*. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

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

SITE ANOMALIES

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

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed <u>or</u> where only a limited investigation has been completed <u>or</u> where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

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

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or

iii) full time engineering presence on site.

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

- FILL
- TOPSOIL
- CLAY (CL, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CH)
- SILTY CLAY (CL, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML)
- PEAT AND ORGANIC SOILS

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE
- SILTSTONE, MUDSTONE, CLAYSTONE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

DEFECTS AND INCLUSIONS

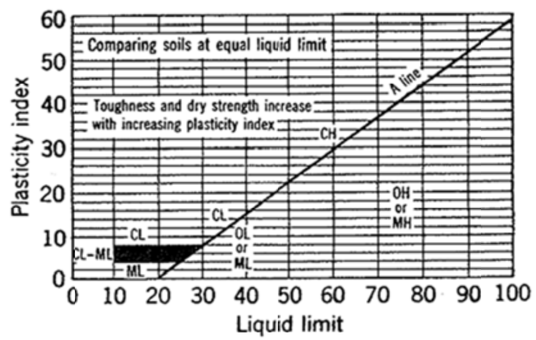
- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

Major divisions			Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria	
Coarse-grained soils. More than half of material is *larger* than 75 μm sieve size[b] (The 75 μm sieve size is about the smallest particle visible to naked eye)	Gravels. More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics		Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures			Atterberg limits above "A" line, with *PI* greater than 7
	Sands. More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures			Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures			Atterberg limits below "A" line with *PI* greater than 7

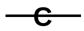
Major divisions		Identification Procedures on Fraction Smaller than 380 μm Sieve Size: Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils. More than half of material is *smaller* than 75 μm sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines).
2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES U50 DB DS ASB ASS SAL	Soil sample taken over depth indicated, for environmental analysis. Undisturbed 50mm diameter tube sample taken over depth indicated. Bulk disturbed sample taken over depth indicated. Small disturbed bag sample taken over depth indicated. Soil sample taken over depth indicated, for asbestos screening. Soil sample taken over depth indicated, for acid sulfate soil analysis. Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25 PID = 100	Vane shear reading in kPa of Undrained Shear Strength. Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils) (Cohesionless Soils)	MC>PL MC≈PL MC<PL D M W	Moisture content estimated to be greater than plastic limit. Moisture content estimated to be approximately equal to plastic limit. Moisture content estimated to be less than plastic limit. DRY – Runs freely through fingers. MOIST – Does not run freely but no free water visible on soil surface. WET – Free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS S F St VSt H ( )	VERY SOFT – Unconfined compressive strength less than 25kPa SOFT – Unconfined compressive strength 25-50kPa FIRM – Unconfined compressive strength 50-100kPa STIFF – Unconfined compressive strength 100-200kPa VERY STIFF – Unconfined compressive strength 200-400kPa HARD – Unconfined compressive strength greater than 400kPa Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)	 VL L MD D VD ( )	**Density Index (I_D) Range (%)** **SPT 'N' Value Range (Blows/300mm)** Very Loose <15 0-4 Loose 15-35 4-10 Medium Dense 35-65 10-30 Dense 65-85 30-50 Very Dense >85 >50 Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit 'TC' bit T 60	Hardened steel 'V' shaped bit. Tungsten carbide wing bit. Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

LOG SYMBOLS continued

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
----------------------	-------------	0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is "sugary" and friable.
----------------------	-------------	0.1	
Low:	L		A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
----------------------	-------------	0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
----------------------	-------------	1	
High:	H		A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
----------------------	---------------	3	
Very High:	VH		A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
----------------------	---------------	10	
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	