Appendix S
Geotechnical Report

Douglas Partners

Geotechnics / Environment / Groundwater

Report on Geotechnical Investigation

Powerhouse Ultimo Renewal
Powerhouse Ultimo, 500 Harris St, Ultimo

Prepared for
Create NSW, Department of Enterprise, Investment and Trade

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Integrated Practical Solutions

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

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Executive Summary

This report presents the results and interpretation of a geotechnical investigation undertaken in October 2019 for the Powerhouse Ultimo Renewal project located at the Powerhouse Ultimo, 500 Harris Street, Ultimo. The report has been prepared on behalf of the Department of Enterprise, Investment and Trade (Create NSW) to support a State Significant Development (SSD) Development Application (DA) for alterations and additions to the current site, for the Stage 1 Concept DA. This Concept DA sets the vision for the renewal of Powerhouse Ultimo and the creation of the Powerhouse Creative Industries Precinct, with the detailed design, construction, and operation of the project to be sought at a separate and future stage (Stage 2).

Concept approval is sought for the following:

- A maximum building envelope for any new buildings and alterations and additions to existing buildings retained on the site.
- Use of the new spaces and built form as an 'information and education facility' including exhibition, education, and back of house spaces, and a range of related and ancillary uses to contribute to the operation of Powerhouse Ultimo.
- Endorsement of Urban Design Guidelines and a Design Excellence Strategy to guide the detailed design of the future building, internal spaces, and public domain areas that will be the subject of a competitive design process and a separate and future DA (Stage 2).
- An updated Draft Conservation Management Plan to ensure that future development occurs in a manner that is compatible with, and facilitates the conservation of the heritage values of the site.
- General functional parameters for the future design, construction, and operation of buildings and uses on the site including the principles and strategies for the management of transport and access, flooding, sustainability, heritage and the like.

The investigation results indicated a general subsurface profile that can be summarised as follows:

- **Northern Half**: Limited information was collected from the northern half of the site due to access limitations. A borehole drilled in this area (BH201 on the north western corner) indicated sandstone encountered at 1.5 m below the ground surface. Sandstone was described as generally high strength to depth of 10 m below the ground surface with a thin layer (0.3 m thick) of very low strength on the upper layer of sandstone. Sandy fill and clayey natural soil overlies the sandstone bedrock.

- **Southern Half:** The boreholes drilled on the southern half of the site encountered sandstone at depths of between 3.5 m and 11.8 m below the ground surface. Fill, alluvial and residual soils overly the sandstone bedrock. Up to 4.5 m thickness of fill was encountered in the boreholes. Soft to firm clay and loose sandy alluvial soil up to 2.3 m thick was encountered at the eastern (side) boreholes, only. The underlying stiff to hard residual clays encountered in the boreholes were up to 5 m thick.

The approximate measured groundwater level was RL0 +/-1.0 m (approximately 6 m below the ground level), inferred to be the regional groundwater level from Cockle Bay. Perched water was also encountered higher than this level.

Information is provided in this document for the Stage 1 Concept DA on a preliminary geotechnical model, potential groundwater impacts, acid sulfate soils (ASS), excavatability, temporary batters, salinity, geotechnical hazards (i.e dykes), vibrations and shoring. Future stages of the development will require further geotechnical investigations on which to base the detailed engineering design during Stage 2.

The report also aims to address requirements outlined in the Planning Secretary's Environmental Assessment Requirements (SEAR), Condition 14 – Ground and Water Conditions as discussed in Section 1.

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Introduction

This report presents the results of a geotechnical investigation undertaken for the proposed Powerhouse Ultimo Renewal project at the Powerhouse Ultimo, 500 Harris St, Ultimo. The investigation was commissioned by Create NSW and was undertaken in October 2019, with subsequent reporting delivered March 2020. The investigation was initially carried out in accordance with Douglas Partners Pty Ltd (DP) proposals SYD190416.P.001.Rev2 dated 27 June 2019 and SYD190416.P.002.Rev1 dated 30 October 2019. The report is updated herein in accordance with DP proposal dated 23 February 2022 (ref: 86874.02.P001.Rev1) in response to Create NSW's RFQ ref: PROC 80077294 – 1624.

This report has been updated from the March 2020 issue (ref: 86874.00.R.001.Rev1) to incorporate:

- A groundwater impact assessment / statement.
- An impact statement on salinity.
- An impact statement acid sulphate soils (ASS), and;
- Context regarding submissions, and new relevant project information

This geotechnical report aims to provide a supporting document to be submitted for the Environmental Impact Statement (EIS) for the project State Significant Development (SSD) Development Application (DA), Stage 1 concept. This report addresses requirements outlined in the Planning Secretary's Environmental Assessment Requirements (SEAR), Condition 14 – Ground and Water Conditions documentation:

- *Where applicable, provide an assessment of the potential operational and construction impacts on soil resources, including related infrastructure and riparian lands on and near the site.*
- *Where applicable, provide an assessment of the potential operational and construction impacts on surface and groundwater resources (quality and quantity), including related infrastructure, hydrology, aquatic and groundwater dependent ecosystems, drainage lines, downstream assets and watercourses*
- *Where applicable, provide an assessment of salinity and acid sulfate soil impacts.*

It is noted that the report scope does not cover surface water impacts, which will be addressed by Taylor Thomson Whitting (TTW), with DP providing relevant (subsurface) groundwater information where required.

In 2016, DP carried out desktop geotechnical and contamination assessments (Project No. 85601) for the Powerhouse Ultimo site. The geotechnical assessment indicated subsurface conditions comprising of fill and residual soils over sandstone bedrock. Minimal information on groundwater was provided in the desktop studies.

The aim of the 2019 field investigation was to provide geotechnical data for the site via boreholes. The investigation included the drilling of 11 boreholes and laboratory testing of selected samples. Details of the field work are presented in this report, together with relevant comments and recommendations on design and construction practice.

The report is being prepared concurrently with a separate contamination report by DP, for the Stage 1 Concept DA.

Proposed Development and Scope

The Powerhouse Ultimo Renewal is a transformative $480-$500 million investment by the NSW Government to establish a world-class museum that will significantly contribute to an important and developing part of Sydney. The renewal will see Powerhouse Ultimo deliver a programming focus on design and fashion, presenting exhibitions that showcase the Powerhouse Collection, international exclusive exhibitions and programs that support the design and fashion industries.

The primary focus of the Powerhouse Ultimo Renewal project is the museum to the north of Macarthur Street and bounded by Harris Street, Pier Street and the light rail corridor. However, some enabling and minor decoupling works will occur within the broader Powerhouse Ultimo precinct.

No substantive works or changes in use are proposed to the Harwood Building located between Macarthur Street and Mary Ann Street.

This report provides preliminary comments on a preliminary geotechnical model, groundwater, salinity, acid sulfate soils, excavation conditions, vibration and design parameters for foundations and retaining walls, which will inform project planning and potentially preliminary design for costing purposes, noting that detailed design of the building and public domain areas will be confirmed and further assessed in the subsequent Stage 2 DA (which will require further investigation to inform the design).

Site Description and Regional Geology

The site is situated adjacent to Sydney's CBD, to the west of Darling Harbour and the Darling Square precinct. Mixed commercial and residential developments are located on the western side of the site, on the other side of Harris Street. The Ian Thorpe Aquatic Centre is located on the block to the north, beyond William Henry Street and the Light Rail line and former monorail line on its eastern side, with university buildings (UTS) on its southern side, beyond Mary Ann Street. The site is currently occupied by the Powerhouse Ultimo on the northern half of the site and Harwood Building is located on the southern half. The overall site is partly divided by Macarthur Street.

The Powerhouse Ultimo Building consists of two adjoining three level buildings, formerly used for the generation of electricity for tram cars. Construction of the Powerhouse Ultimo began in 1899 and was followed by additions in 1916 and reconstruction works completed in 1931 (Thomson and Pilz, 1978). The Boiler House and Turbine Room buildings have approximate plan dimensions of 85 m (length: parallel to Harris Street) by 25 m (width), whilst the Switch House has approximate plan dimensions of 61 m (length: parallel to Harris Street) by 18 m (width).

The provided floor plan drawings (A001 to A007, dated September 2005), indicate that the ground floor surface level is RL6.2 m, with the basement floor level of the Boiler Room at an elevation of RL0.2 m (relative to Australian Height Datum (AHD)), and RL2.4 m beneath the Turbine House to the west and the adjoining Switch House to the south. A disused portion of railway line, from the Darling Harbour Goods Yard, runs into the southern end of the Boiler Room, which is partly built over by a kiosk/café and courtyard. Additional buildings have been added to the western side of the Turbine House ("West Building"). Demolition of the former Boiler Room stacks (extending) to roof level has left two 5 m diameter circular voids within the roof.

The Harwood Building is located on the southern portion of the site. It is a 40 m wide by 130 m long warehouse type structure. An on-grade carpark is located at the southern end of the building adjacent to Mary Ann Street.

The approximate locations of the buildings are annotated on Drawing 1, Appendix B.

The site is generally relatively flat, with gradual slopes down to the south (along the eastern side of the site), and to the east (from Harris Street). Outside of the buildings, the majority of the site is surfaced with either concrete or asphalt. Information utilised for previous projects adjacent to and east of the site indicate that underground infrastructure, such as cable tunnels and sewer mains, occur within the rail corridor to the east of the site.

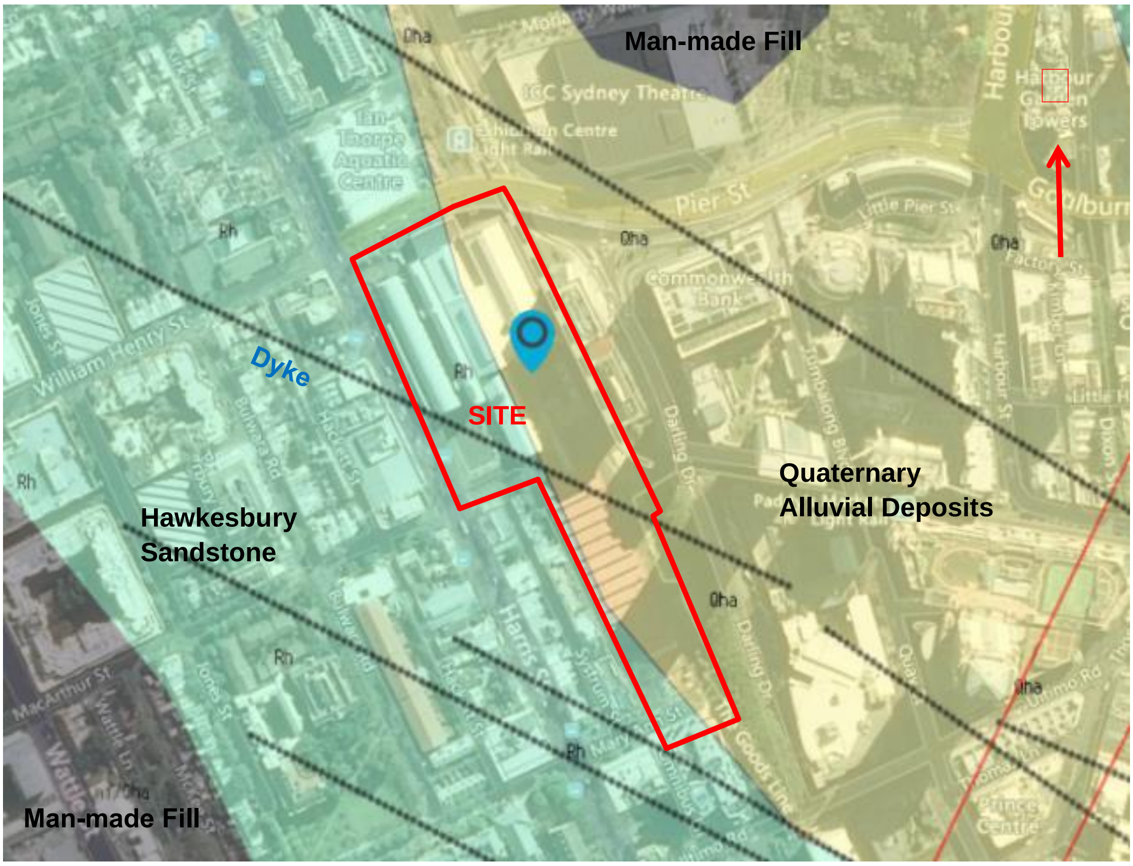


Figure 1: Extract from Sydney 1:100 000 Geological Series Sheet

Reference to the Sydney 1:100 000 Geological Series Sheet 9130 (Geological Survey of NSW) indicates that the upper / western part of the site is underlain by Hawkesbury Sandstone of Triassic age, whereas the lower / eastern part of the site is underlain by Quaternary alluvium (from approximately the interface between the Boiler Room and the Turbine House). An intrusive igneous dyke is inferred to pass obliquely through the south-eastern corner of the building, striking at approximately 110 degrees. This feature is observed elsewhere nearby to have a sub-vertical dip and is likely to be completely weathered to clay. Figure 1 above presents an extract of the geological map showing the site.

Field Work Methods

The field work for the 2019 investigation included:

- Eleven boreholes (BH101 to BH109 and BH201 and BH202) drilled to a maximum depth of 12.3 m below the ground surface.
- Groundwater wells installed in BH104 and BH105 to depths of 11.8 m and 10.0 m below the ground surface, respectively.

The borehole locations are shown on Drawing 1 in Appendix B and were measured using a differential GPS.

BH107, BH108 and BH109 were drilled using hand tools and for contamination assessment purposes only. The rest of the boreholes were drilled using either track or truck mounted drilling rigs (Bobcat and Scout) and were advanced using a diatube where concrete was present at the surface, then solid flight augers and rotary drilling methods through the soils and weathered rock. Standard Penetration Tests (SPTs) were carried out typically at 1.5 m depth intervals to assess soil strength and to obtain samples for logging and testing. Bedrock was cored using a NMLC size core barrel. Boreholes BH101, BH102, BH103 and BH107 were terminated at shallower depths due to obstructions/unexpected conditions encountered.

The soil samples and rock cores recovered from the boreholes were geotechnically logged. The rock cores recovered from the boreholes were photographed with Point Load Strength Index (Is_{50}) tests carried out on selected samples.

Field Work Results

Details of the subsurface conditions encountered are given in the borehole logs in Appendix C, together with notes explaining descriptive terms and classification methods used.

The sequence of subsurface materials encountered at the borehole locations, in increasing depth order, is briefly summarised as follows:

Fill:	Concrete slab or brick pavers over Gravel, Sand, Clay, with some rubble and sandstone boulders to depths of 0.25 m to 4.5 m. Another concrete slab below the ground surface was encountered at 0.55 m depth in BH101, at 1.0 m depth in BH102 and at 1.6 m depth in BH103. A void space to about 3.1 m depth was encountered below the 300 mm thick concrete slab in BH107 which is possibly a disused storage space. BH101 to BH103 and BH107 to BH109 were terminated within this layer at depths of 0.25 m to 1.7 m below the ground surface;
Silty Clay, Sandy Clay, Clay, and Silty Sand:	Varying plasticity from low to high plasticity and generally firm to stiff on the upper layers and becoming very stiff to hard with depth. A loose Silty Sand layer, 1.3 m thick, was encountered in BH104 only. This clayey and sandy layer is about 1.0 m to 7.3 m thick and was encountered to depths of 1.5 m to 11.8 m below the ground surface. This

layer was not encountered in the western boreholes – BH106, BH108, BH109, BH201 and BH202;

Sandstone Encountered at about 0.25 m depth in BH108 and BH109 drilled within Harwood Building, near the western site boudary. Along the eastern side of the site, sandstone was encountered at depths of 4.5 m to 11.8 m below the ground surface (BH104 and BH105). Sandstone is shallower on the western side of the site where it was encountered at depths of 1.5 m to 5.7 m below the ground surface. The sandston e isenerally medium to high strength with a low strength layer less than 1.0 m thick encountered in BH105 and BH106. A very low to low strength layer was encountered at the bottom of BH202 at 9.5 m to 10.0 m depth. BH104 to BH106 and BH201 and 202 were terminated within this layer.

During drilling, a groundwater level was observed at a depth of 4.0 m below the ground surface in BH104, only. Table 1 below, presents measurements of groundwater level within the installed two groundwater wells.

Table 1: Groundwater Level Measurements

Borehole	Ground Surface Level (m AHD)	Date Measured	Groundwater Level	
			Depth (m)	Water Level (m AHD)
BH104	5.8	13 November 2019	6.00	-0.2
		15 November 2019	6.42	-0.6
BH105	6.2	13 November 2019	3.86	2.3
		15 November 2019	3.79	2.4

It should be noted that groundwater levels vary over time due to seasonal, climatic, tidal and other factors.

Laboratory Testing

Selected samples of the rock core were tested in the laboratory to determine the Point Load Strength Index (Is_{50}) values to assist with the rock strength classification. The results of the testing are shown on the borehole logs at the appropriate depth. The Is_{50} values for the rock ranged from 0.2 MPa to 2.8 MPa, indicating that the rock samples tested were of low to high strength.

Based on an approximate Uniaxial Compressive Strength (UCS) to Is_{50} correlation of 20, the estimated UCS values of the rock samples tested are in the range of 4 MPa to 56 MPa.

Geotechnical Model

Based on the borehole logs, Table 2 below presents a general summary of the inferred preliminary geotechnical model for the site.

Table 2: Inferred Preliminary Geotechnical Model

Unit	Material/ Origin	Description	Approximate Thickness[1] (m)	Depth to Top of Unit[1] (m)	RL to Top of Unit[1] (m AHD)
1	Fill	Concrete slab or brick pavers over Gravel, Sand, Clay, with (building) rubble and sandstone boulders	0.25 – 4.5	Ground Surface	3.5-15.6
2	Alluvial Soil	Silty Clay, Silty Sand and Sandy Clay, varying plasticity from low to high plasticity, fine to medium sand, soft to firm and loose sand, encountered in BH104 and BH105, only (i.e. along south eastern corridor)	0.5 – 2.3	3.5 – 4.5	1.3 – 2.7
3	Residual Soil	Silty Clay, Sandy Clay, and Clay, varying plasticity from low to high plasticity, stiff to hard.	0.5 – 5.0	1.5 – 6.8	-1.0 to – 5.5
4a	Class V/IV[2] Sandstone	Sandstone, moderately weathered, very low to low strength.	0.3 – 0.9	1.5 – 11.8	-6.0 to –14.1
4c	Class III[2] (or better) Sandstone	Sandstone, slightly weathered to fresh, medium to high strength, a 0.5 m thick, very low to low strength layer was encountered at the bottom of BH202.	Not Penetrated	1.8 – >11.8	Below -6.0 to – 13.8

Notes:

1. The depth/RL and layer thicknesses provided in the above table are based on subsurface conditions observed at the borehole locations and may not be representative of all areas of the site.
2. Rock classification was assessed as per Pells et al (1998) “Foundations on Sandstone and Shale in the Sydney Region” (Aust. Geomech. Jnl, Dec 1998). This classification is generalised to model average conditions of rock strength and defects interpreted from the boreholes, specifically for foundation/footing design purposes.

Groundwater was encountered in the groundwater wells installed at the site at about RL-0.2 to RL2.4, as shown on Table 1. The lower groundwater level (i.e. RL-0.2) is of a similar level to that of the nearby water body (Cockle Bay). The higher groundwater level (i.e. RL2.4) was measured at similar level to that of the soil and rock interface and is possibly a perched ephemeral water level, associated with stormwater ingress, only. It should be noted that groundwater will fluctuate with climatic conditions and other factors and is likely to rise following periods of extended wet weather.

Comments

Excavation Conditions

A deeper soil profile is expected towards the south-eastern quadrant of the site, where rock was encountered at a depth of 11.8 m below the ground surface. At the north-western corner of the site, rock is shallow and is expected to be at about 1.5 m below the ground surface/floor slab. The other boreholes in between the north and south boundaries indicated that rock is at about 3.5 m to 5.8 m depth below the ground surface.

Excavations in soil (Units 1 to 3, as defined in Table 2) and the very low strength rock (Unit 4a) could possibly be excavated using conventional earthmoving plant such as heavy bulldozers and excavators with toothed buckets. The low strength rock (Unit 4a) and medium to high strength rock (Unit 4b), however, would require high powered excavation plant fitted with ripping tynes and large hydraulic rock breakers, or the use of rock grinders or rock saws.

The use of plant and machinery to remove rock will generate vibrations and care should be taken to reduce the impacts of vibration on existing building, structures and utilities, as described in the following sections of this report.

Potential Groundwater Impacts

The approximate measured groundwater level is RL +1.0 m to RL -1.0m (approximately 6 m below the present ground level), inferred as the regional level from Cockle Bay. Perched water may be encountered higher than this level.

The proposed development is in a planning and concept phase and hence the extent of planned excavation is not known. Any planned excavation below the identified perched and regional water table must consider both potential short-term and long-term dewatering regimes and impacts on the regional hydrogeology.

Dewatering can result in:

- Impacts to ecological systems, in particular Groundwater Dependent Ecosystems (GDE's) or nominated coastal wetlands.
- Settlement of adjacent structures
- Mounding of water upgradient of the structure
- Depletion and rearrangement of hydrological balances
- Oxidisation of Potential Acid Sulfate Soils (PASS).

It is likely that if deep excavations (i.e. below about RL +1 mAHD) are proposed, then due consideration of impacts on the groundwater table will be required and the following studies would generally be required by an experienced geotechnical and/or hydrogeological consultant:

- A hydrogeological investigation would need to be undertaken to determine the aquifer properties (hydraulic conductivities, storage, rock fracturing, dyke properties). This investigation should be completed according to "The minimum requirements for building site groundwater investigations and reporting" (NSW Department of Planning, Industry and Environment, 2021).
- A detailed Groundwater Impact Assessment (GIA) would need to be prepared, including modelling to ascertain potential drawdowns / inflow rates from the excavations, and impacts on regional hydrogeology. The GIA should address requirements of the NSW Aquifer Interference Policy (NSW Department of Primary Industries, 2012). A water access license from Water NSW would generally be required to undertake dewatering.

From a high-level perspective prior to details being known should excavations extend below RL +1.0m, especially in the south-eastern area, then watertight cut-off walls (e.g. secant piles, or diaphragm walls) and active dewatering would be needed during construction. The outcome of a GIA would inform the question of whether the proposed excavation would need to be 'tanked' (ie. fully watertight) or drained, with a subfloor drainage system, for the permanent basement structure (ie. in the long term).

It should also be noted that water seepage may also be encountered at shallower depths, at the interface of soil and rock. Such seepage is usually perched and ephemeral and can usually be controlled by pumping from sumps.

Discharge to the public stormwater drainage system would require a permit and further groundwater quality testing would need to be carried out to assess the suitability of water quality.

For basement excavations above approximately RL +1.0m, it is possible that a drained basement would be feasible. This would allow basement shoring walls to be formed by non-watertight wall systems such as contiguous or soldier piles, which would normally incorporate robust wall drainage feeding to the basement drainage system. Drained basements also usually incorporate subfloor gravel drains that discharge collected seepage into sumps fitted with activated pumping systems (eg. float valves), so that periodically the collected water is pumped to local stormwater utilities, subject to environmental testing and guidelines/charges imposed by the NSW water authority. A drained basement that is above the regional water table is expected to have a negligible impact on groundwater ecosystems or the groundwater depth/level, with no mounding or other effects anticipated.

Due to the high concentration of soluble iron and other metals in groundwater, particularly when derived from Hawkesbury sandstone, the aeration of seepage in drains usually leads to the oxidisation of the iron and the formation of a red-brown precipitate or 'sludge'. This material can lead to the blockage of drains and seizing of pumps, such that a rigorous maintenance regime is required to prevent this impacting the basement drainage system.

Salinity

DP believe there to be a low risk of increased salinity from the development provided due process is followed in the planning and design. The engineering design for the development is expected to be within government statutory requirements (Aquifer Interference Policy 2012, among others) and if followed is unlikely to result in a significant increase in long term groundwater levels.

Surface catchment regimes, water supply pipes, groundwater flow barriers and drains (e.g retaining walls), permanent drainage, and temporary construction drainage should be designed as not to significantly increase the groundwater level such that the urban salinity risk would increase.

Acid Sulfate Soils (ASS)

Acid Sulfate Soils (ASS) are commonly used to label soils and sediments that contain iron sulfides, which, when oxidised by draining or exposure to air, form sulfuric acid. The main form of iron sulfide present is pyrite or iron disulphide (FeS_2). They are typically encountered in low-lying coastal areas e.g. estuaries, floodplains, tidal flats, mangrove swamps, lakes, wetlands, below approximately RL+5 mAHD. It should be noted, however, that they can also be found inland. ASS can be divided into two categories:

- Actual Acid Sulfate Soils (AASS) which are soils that are rich in sulfides already exposed to oxidisation
- Potential Acid Sulfate Soils (PASS) which are soils that are rich in sulfides that have not been exposed to air or oxidisation. Any lowering of the water table, or exposure to air through excavation will result in PASS generating acid and becoming ASS.

ASS can have impacts on biological systems and also effect the durability of buried structures, amongst other things.

A review of the NSW ASS Risk Map (Naylor et al, 1998) indicates the site location lays in a zone with no data, but near to the east of the site a category of “Disturbed Terrain” is nominated by the map. It is observed that Darling Harbour to the north-east is classified as “high risk”.

The site contains natural material deposited in the early Holocene era, currently located at, or under the water table that represents a moderate risk of AASS or PASS. Additionally, historic fill material may have undergone oxidisation in the past, if it was sourced from harbour locations and hence represents a low / moderate risk of AASS.

It is recommended that prior to the detailed design and construction that an ASS screening investigation be undertaken to confirm the risk of PASS or AASS. This investigation should be conducted according to NSW ASS Management Advisory Committee (ASSMAC) guidelines.

If AASS or PASS is identified during the screening investigation, then a detailed ASS Management Plan should be developed to mitigate risk during construction works. A robust ASS Management Plan is an effective way of enabling construction and development works to be undertaken in areas where ASS are present.

Temporary Unsupported Batters

For excavations not affected by groundwater seepage, suggested temporary unsupported excavation to a maximum 3 m vertical height are shown in Table 3.

Table 3: Unsupported Temporary Batters

Unit	Maximum Temporary Batters
Unit 1: Fill	1.5H:1V
Unit 2: Alluvial Soil	1.5H:1V
Unit 3: Residual Soil	1.5H:1V
Unit 4a: Class V/IV Sandstone	1H:1V
Unit 4b: Class III or Better Sandstone	Vertical[1]

Notes: 1. Subject to geotechnical inspection and dependent on rock jointing and defects.

Structures, pavements, or buried services should not be located at a horizontal distance closer to the crest than the depth of excavation. Surcharge loads should also be kept well clear of the excavation crest.

Steeper temporary batter angles may be possible, depending on the depth of unsupported excavation planned and the time period that the excavation will be unsupported. Specific support requirements can only be assessed during excavation. An experienced geotechnical engineer/engineering geologist should assess as excavation progresses. Specific advice should be sought if seepage occurs.

Temporary batters should not be in place for longer than three months and should not be implemented in any stratum where seepage or concentrated runoff could be anticipated. The recommended maximum batters are based on no structures or surcharges located at or near the crest of the cuts. Steeper slopes in the fill, soil and weathered rock materials would generally require engineer designed support or retention (eg. soil nailing). Site specific advice is recommended for unsupported cuts greater than 3 m in height, or where there is potential or active groundwater seepage.

Shoring / Retaining Walls

A temporary shoring system and/or permanent retaining wall would likely be required to support excavations where space constraints do not allow the maximum recommended excavation batters. The use of soldier or contiguous pile shoring walls is expected to be feasible, unless stiffer walls are required to control excavation induced ground movements or support adjacent structures.

Cantilevered shoring walls are likely to be acceptable for excavation depths up to 3 m, where the degree of wall movement (and of the retained ground) is not critical. Where the excavation is deeper, the induced ground movements behind the wall may be unacceptable. Lateral stability of the wall could be provided during construction by anchors installed progressively as the excavation proceeds, or by braced or propped support systems.

Geotechnical design of excavation support is usually controlled by site constraints and tolerable ground movements. Geotechnical issues for excavation support will be influenced by the material strength of the geological unit and the frequency and orientation of defects within the rock mass. Parameters for preliminary retaining wall design are presented in Table 4 .

Table 4: Recommended Preliminary Design Parameters for Shoring Systems

Material	Unit Weight (kN/m^3)	Earth Pressure Coefficient		Effective Cohesion c' (kPa)	Effective Friction Angle (Degrees)
		Active (K_a)	At Rest (K_0)		
Unit 1: Fill	19	0.4	0.5	0	25
Unit 2 & 3: Natural Soil	20	0.3	0.5	5	25
Unit 4a: Class V/IV Sandstone	23	0.3	0.5	30	35
Unit 4b: Class III or Better Sandstone	24	0	0.5	200	38

Notes:

1. The K_0 values are modified rather than in-situ K_0 values which assumes that at least a small amount of wall movement (say about 0.1 to 0.3% of the wall height) could occur. In-situ K_0 values may be significantly higher particularly in residual soils and rock units.
2. If in-situ K_0 values are required for detailed soil-structure analysis, specific testing should be carried out.

Retaining wall analyses will need to consider surcharges, footing loads from adjacent structures, hydrostatic pressures and construction sequences. If drained walls are to be used then adequate drainage will need to be provided behind the walls (eg. strip drains), and a permanent water collection system will be required together with flushing points for drainage system periodic maintenance.

Where it is important to limit adjacent ground movements due to the presence of nearby sensitive structures or services, the use of a relatively stiff shoring with bracing and/or tie-back (ground) anchors designed to resist pressures higher than active earth pressures may be required.

The permission of adjacent landowners and authorities would be required if it is necessary to install temporary anchors outside the site boundaries (e.g. into roadway corridors). The anchor installation should also take into account the external groundwater levels, and a sealed anchor connection will be required for anchors below groundwater.

Table 5 includes recommended ultimate bond stresses for the preliminary design of anchors.

Table 5: Preliminary Design Parameters for Anchors

Unit	Ultimate Bond Stress (kPa)
Unit 2 & 3: Natural Soil	50
Unit 4a: Class V/IV Sandstone	200
Unit 4b: Class III or Better Sandstone	1,000

Anchor designs should be based on bonding to be developed behind an 'active zone' determined by drawing a line upwards from the base of the retained height at 45° from horizontal. Anchor bond lengths should be at least 3 m and not more than 8 m long, to reduce the risk of progressive debonding failures.

In addition to bond stress, anchors should be checked for 'cone pull-out' failure mechanisms in rock.

Anchors should be proof loaded as follows:

1.5 times working load for permanent anchors;

1.3 times working load for temporary anchors.

Vibrations

Excavations in sandstone will induce ground vibrations. During excavation, it will be necessary to use appropriate methods and equipment to keep ground vibrations at adjacent buildings and structures within acceptable limits. The level of acceptable vibration is dependent on various factors including the type of building structure (e.g. reinforced concrete, brick, etc.), its structural condition, the frequency range of vibrations produced by the construction equipment, the natural frequency of the building and the vibration transmitting medium.

Ground vibration can be strongly perceptible to humans at levels above 2.5 mm/s peak particle velocity (PPVi). This is generally much lower than the vibration levels required to cause structural damage to buildings. The Standard AS/ISO 2631.2 – 2014 “Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Vibration in buildings (1 Hz to 80 Hz)” indicates an acceptable day time limit of 8 mm/s PPVi for human comfort.

Based on the experience of DP and with reference to AS/ISO 2631.2, it is suggested that a maximum PPVi of 8 mm/s (applicable at the foundation level of existing buildings) be provisionally adopted at this site for both architectural and human comfort considerations, although this vibration limit may need to be reduced if there are sensitive buildings or equipment in the area.

As the magnitude of vibration transmission is site specific, it is recommended that a vibration trial be undertaken at the commencement of any excavations in rock. The trial may indicate that smaller or different types of excavation equipment should be used for bulk (or detailed) excavation purposes.

Excavation Induced Ground Movements

Basement excavation could induce ground movements adjacent to the excavation due to removal of lateral support. Within the retained soil and weathered rock profile, the magnitude of adjacent ground movements will depend on the ground conditions, design lateral pressure, shoring system adopted, construction sequence and workmanship. Documented data has shown that for well-constructed shoring, the vertical and lateral movements may be in the order of 0.1% to 0.3% of the retained height and may be experienced for lateral distances equal to twice the excavation depth, with the magnitude of displacement reducing away from the excavation.

In rock excavation, lateral movement occurs due to relief of *in situ* locked-in horizontal stresses and must be considered as part of design. DP past experience of deep basements in Sydney, typical lateral movements range from 0.5 mm to 2 mm per metre depth of excavation, depending on rock quality and presence of bedding seams. Lateral ground movements due to stress relief have been measured at distances of up to 1.5 to 2 times the basement depth from the edge of excavations. These typically show that movements can be up to 30% of the displacement around the excavation perimeter at a distance approximately equal to the excavation depth. Stress relief ground movements are unlikely to be significant at distances greater than twice the excavation depth. However, these approximations will be affected by local geological structures and should only be used as an approximate guide.

These ground movements could affect adjacent structures or underground services. If this aspect is critical, numerical analysis should be carried out to assess likely ground movements when designing the shoring system.

The location, foundation type, layout and founding depth for adjacent structures, buried services, and roads surrounding the site should be assessed prior to excavation works. Where adjacent structures are located close to the excavation footprint, the foundation bearing capacity could be reduced or the footings could surcharge the temporary and permanent basement retaining walls.

Dilapidation surveys of the adjacent structures conducted prior to commencement of bulk excavation would provide a baseline for excavation monitoring and management works.

Foundation

Depending on the nature of the structure and the basement configuration and depth, pad or strip footings on rock (i.e. north western corner) may be feasible. An allowable end bearing pressure of at least 1,000 kPa could be assumed for shallow (pad or strip) footings on Unit 4a Class V/IV Sandstone. In other areas, deeper fill is present wherein shallow footings are not recommended. Bored piles will be required in these areas to reach the bedrock. New structures should be uniformly founded on the same stratum to reduce the potential for differential.

Design of footings may be based on the preliminary design values provided in Table 6.

Table 6: Preliminary Foundation Design Parameters

Foundation Stratum	Allowable Pressure		Ultimate Pressure		Elastic Modulus (MPa)
	End Bearing (kPa)	Shaft Adhesion (Compression) (kPa)	End Bearing (kPa)	Shaft Adhesion (Compression) (kPa)	
Unit 3: Residual Soil	-	-	-	-	40
Unit 4a: Class V/IV Sandstone	1,000	150	3,000	250	250
Unit 4b: Class III or Better Sandstone	3,500	350	30,000	800	500

Notes:

1. Piles end bearing on clay are not recommended.
2. Potential shaft adhesion should be ignored where the pile embedment is less than 2 pile diameters. Shaft adhesion values should be ignored for shallow footings.
3. For uplift loads, shaft adhesion values should be factored by 0.6.
4. To adopt these end bearing values, piles should have a minimum embedment of 0.5 m into the founding stratum.
5. Allowable end bearing pressure assumes that the footings are embedded at least 0.5 m into the founding stratum and that settlements will be less than 1% of the least footing width.
6. Ultimate parameters mobilised at large settlements (i.e. >5% of footing width)
7. All shaft adhesion parameters are based on adequately clean and rough sockets of category “R2”, or better.

For limit state design, a geotechnical strength reduction factor (ϕ_g) is applied to the ultimate geotechnical pile capacity assessed using the ultimate parameters above. In accordance with AS2159-2009, ϕ_g is dependent on assignment of an Average Risk Rating (ARR) which takes into account various geotechnical uncertainties, redundancy of the foundation system, construction supervision, and the quantity and type of pile testing. The assessment of ϕ_g therefore depends on the structural design of the foundation system as well as the design and construction method, and testing (if any) to be required by the designer. Where testing is undertaken, it may be possible to adopt a ϕ_g value that results in a more economical design. To assist with preliminary design, a ϕ_g value of 0.4 could be adopted, assuming no pile load testing. Once the pile designer has evaluated the ARR, this value could be revised.

The use of limit state design also requires that serviceability performance of the foundation system be assessed, including pile group interaction effects. Such assessment should be carried out by an experienced geotechnical professional using established methods. The elastic modulus values above may be adopted for such assessment, but it should be recognised that the accuracy of settlement prediction is a function of construction methodology as well as the assessed values of material stiffness, both of which can have inherent uncertainty. Therefore, the accuracy of settlement predictions may be no better than ± 50%. Where foundation settlement is critical to the performance of the structure, serviceability pile load testing should be carried out to confirm the design assumptions and/or assess prediction accuracy.

Dyke

The geological map indicated that a dyke may be present within the site, as shown in **Figure 1** above. The boreholes for this current investigation did not encounter the dyke. The nature and extent of the dyke is not known.

Groundwater inflow may be greater when excavating though dyke materials as groundwater may flow through the dyke which is often a near vertical structure. The rock surrounding the dyke is often highly fractured and altered, forming a higher permeability medium than the surrounding unaffected bedrock.

The dyke may be extremely weathered (essentially clay properties). In this case, it may be necessary to construct footings spanning the dyke or use piles down to competent rock.

If new structures are to be constructed at the anticipated dyke location, further investigation is required to assess the nature and location of the dyke using angled boreholes and possibly geophysical methods, as recommended below.

Earthquake Design

Based on AS1170.4-2007 – Structural design actions Part 4: Earthquake actions in Australia” the following parameters should be adopted for preliminary seismic design:

- Seismic Hazard Factor (Z) 0.08
- Sub-Soil Class C_e – Shallow Soil Site

The Earthquake Design Category could then be assessed based on a Probability Factor, k_p, (which is related to an Annual Probability of being Exceeded) as defined in Table 3.1 of AS 1170.4 – 2007).

Further Investigations

It is recommended that further geotechnical site investigation and possibly land contamination investigations be carried out to support detailed planning and design. This investigation should preferably include the following:

- Boreholes drilled to below the bulk excavation level;
- Angled boreholes to assess the nature and location of the dyke;
- Monitoring of groundwater wells using data loggers;
- Groundwater inflow and rock mass permeability assessments, if required;
- Screening and assessment for the possible presence of acid sulfate soils (AASS/PASS) and saline soils; and
- Assessment of impacts of the development on the existing infrastructure (i.e. train lines, RMS roads) including numerical modelling, if required.

The boreholes should be targeted at the building and basement locations. The two groundwater wells could be monitored further to assist with groundwater inflow assessments, if required.

The aim of such investigation would be to assess the depth and consistency/strength of the soil profile, depths and quality of the bedrock across the site, and to provide data for the design.

Contamination investigations may be coordinated with geotechnical investigations to take advantage of geotechnical boreholes, but may require additional sampling points to meet regulatory guidelines.

Assessment of impacts will be required by authorities (i.e. RMS, TfNSW, Sydney Trains, etc.) as part of approval process for construction near or around existing infrastructure.

References

Naylor S.D. Chapman G.A. Atkinson G. Murphy C.L. Tulau M.J. Flewin T.C. Milford H.B. Morand D.T, "*Guidelines for Use of Acid Sulfate Soils Risk Maps",* NSW Department of Land and Water Conservation, 1998. Retrieved from NSW Department of Environment and Climate Change.

"Acid Sulfate Soil Manual", ASSMAC, 1998.

"Aquifer Interference Policy", NSW Department of Primary Industries, 2012.

"Minimum requirements for building site groundwater investigations and reporting", NSW Department of Planning, Industry and Environment, 2021.

Limitations

DP has prepared this report for the proposed development at Powerhouse Ultimo, 500 Harris St, Ultimo in accordance with DP proposals SYD190416.P.001.Rev2 dated 27 June 2019 and SYD190416.P.002.Rev1 dated 30 October 2019 and, most recently, DP proposal dated 23 February 2022 (ref: 86874.02.P001.Rev1). The work was carried out under standard terms and conditions associated with the NSW Government SCM0005 Performance and Management Services – Prequalification Scheme. Further updates were made to the original report in accordance with DP proposal 86874.02.P.001.Rev0 and RFQ ref: PROC 8007294 - 1624.

This report is provided for the exclusive use of Create NSW, Department of Enterprise, Investment and Trade for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/ or their agents.

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

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

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

A separate contamination investigation report for the site is prepared by DP.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Introduction

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

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

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

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

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

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

Site Anomalies

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

Information for Contractual Purposes

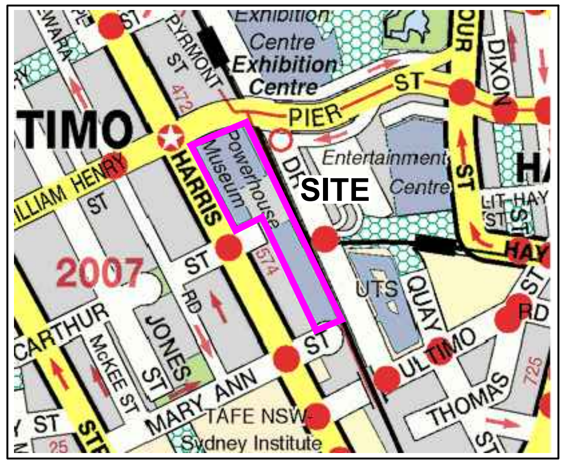
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

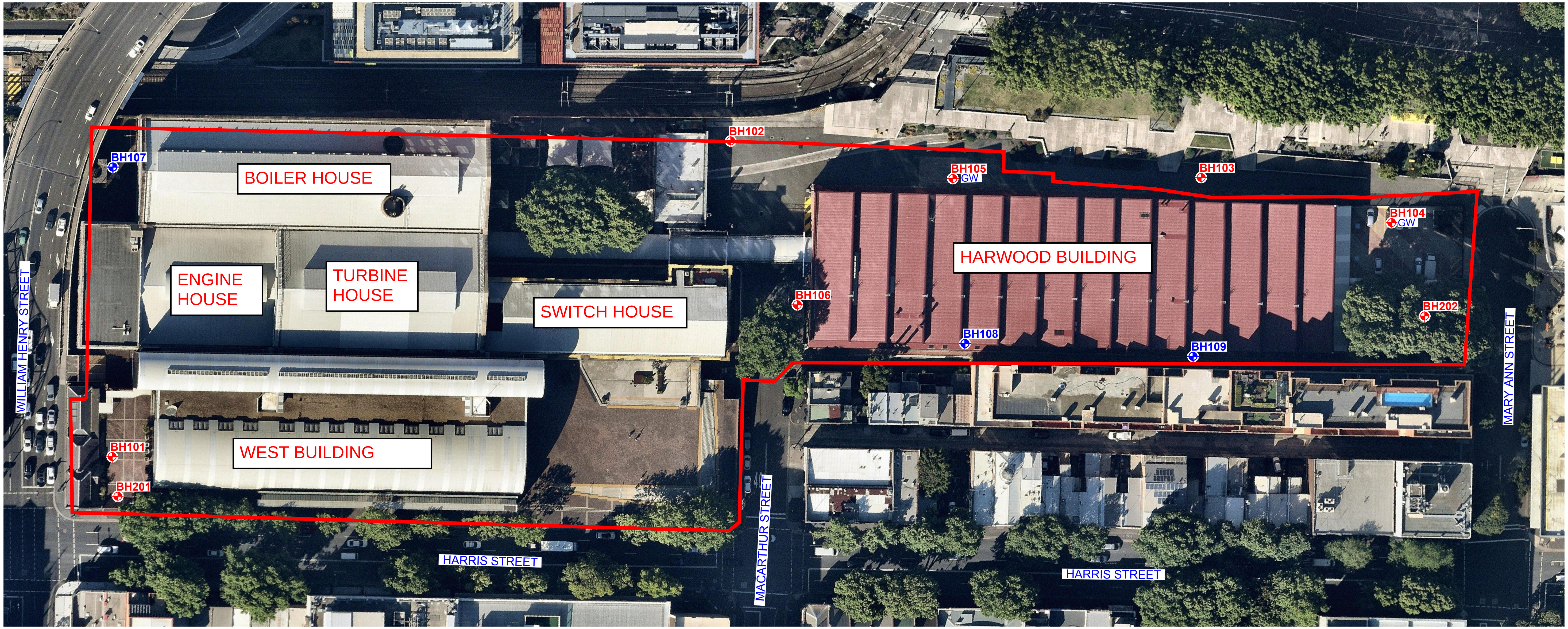
The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawings



Locality Plan



0 10 20 30 40 50 75 100m

1:1000 @ A3

NOTE:
1: Base image from Nearmap.com
(Dated 22.10.2019)
2: Test locations are approximate only and are
shown with reference to existing features.

LEGEND

⊕ Borehole location

⊕ Hand auger bore

GW Groundwater well

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Create NSW, Department of Premier and Cabinet		
OFFICE: Sydney	DRAWN BY: PSCH	
SCALE: 1;1000 @ A3	DATE: 18.11.2019	

TITLE: **Location of Tests**
Powerhouse Museum
500 Harris Street, ULTIMO

PROJECT No:	86874.00
DRAWING No:	1
REVISION:	0

Appendix C

Borehole Logs

Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

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

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Soil Descriptions

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726-1993, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

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

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

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

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

The proportions of secondary constituents of soils are described as:

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

Definitions of grading terms used are:

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

Cohesive Soils

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

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

Cohesionless Soils

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

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

Soil Descriptions

Soil Origin

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

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

Transported soils may be further subdivided into:

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

Rock Descriptions

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 2007. The terms used to describe rock strength are as follows:

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

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Degree of Fracturing

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

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

Rock Descriptions

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Symbols & Abbreviations

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
▽	Water level

Sampling and Testing

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

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

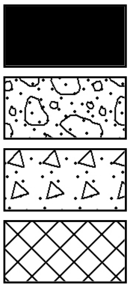
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

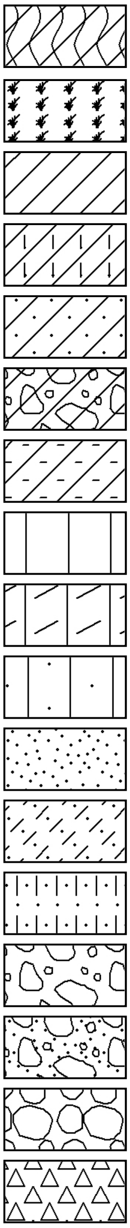
Graphic Symbols for Soil and Rock

General



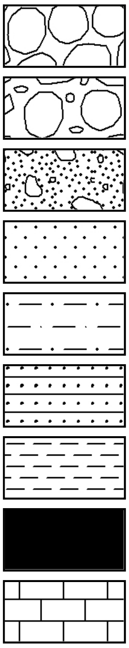
- Asphalt
- Road base
- Concrete
- Filling

Soils



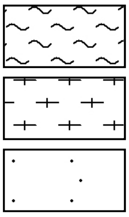
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks



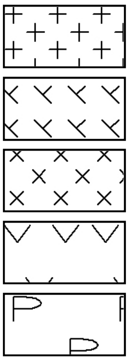
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks



- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks



- Granite
- Dolerite, basalt, andesite
- Dacite, epidote
- Tuff, breccia
- Porphyry

May 2017

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 15.2 AHD
EASTING: 333431
NORTHING: 6249918
DIP/AZIMUTH: 90°/--

BORE No: BH101
PROJECT No: 86874.00
DATE: 22/10/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
15	0.4	FILL/Silty SAND: fine, brown-dark brown, trace fine mixed origin gravel, moist	▨	A/E	0.1		PID<1		
	0.55	FILL/SANDSTONE BOULDER: fine to medium, red-brown, dry	▨	A/E*	0.5		PID<1		
	0.78	CONCRETE: pale grey, aggregate diameter from 10-25mm, 8mm steel reinforcement	△						
		Bore discontinued at 0.78m No further drilling after encountering concrete							
	1								1
14									
	2								2
13									
	3								3
12									
	4								4
11									

RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 0.5m, HQ to 0.5m

TYPE OF BORING: Solid Flight Auger (TC-bit) to 0.55m, NMLC to 0.78m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *replicate BD1_20191022

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics | Environment | Groundwater

BORE: 101 PROJECT: ULTIMO OCTOBER 2019

0.55 – 0.78m

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 6.1 AHD
EASTING: 333572
NORTHING: 6249819
DIP/AZIMUTH: 90°/--

BORE No: BH102
PROJECT No: 86874.00
DATE: 22/10/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
6	0.05	ASPHALTIC CONCRETE: dark grey-black	■						
	0.3	FILL/Silty SAND: fine, dark brown-brown with fine to coarse mixed origin gravel, dry-moist	☒	A/E	0.1		PID<1		
	0.8	FILL/SAND: fine to coarse, dark grey with concrete fragments (20-70mm diameter) and fine to coarse mixed origin gravel, moist	☒	A/E	0.5		PID<1		
	1.0	FILL/Clayey SAND: fine to coarse, low plasticity, dark grey with fine to coarse mixed origin gravel, moist	☒						
5	1	Bore discontinued at 1.0m No further drilling after encountering concrete		A/E S	1.0		PID<1 1/20mm refusal HB		1
4	2								2
3	3								3
2	4								4

RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** none

TYPE OF BORING: Solid Flight Auger (TC-bit) to 1.00m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: HB = SPT hammer bouncing

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 6.3 AHD
EASTING: 333618
NORTHING: 6249712
DIP/AZIMUTH: 90°/--

BORE No: BH103
PROJECT No: 86874.00
DATE: 22/10/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALTIC CONCRETE: black-dark grey	■						
		FILL/SAND: fine to coarse, dark grey-dark brown with fine to coarse mixed origin gravel, dry-moist	▨	A/E	0.1		PID<1		
6			▨						
	0.4	FILL/SANDSTONE BOULDERS: fine to medium, red-brown, with fine to coarse mixed origin gravel, moist	▨	A/E	0.5		PID<1		
			▨	A	0.8				
		0.80m: with building rubble (brick fragments)	▨						
	1		▨	A/E* S	1.0		PID<1 3/20mm refusal HB		1
		1.10-1.20m: steel rebars (x2) in sidewall	▨						
5		1.20-1.30m: dimensioned sandstone block	▨						
			▨	E	1.5		PID<1		
	1.6	CONCRETE: pale grey	△						
	1.7	Bore discontinued at 1.7m No further drilling after encountering concrete							
	2								2
4									
	3								3
3									
	4								4
2									

RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** none

TYPE OF BORING: Solid Flight Auger (TC-bit) to 1.70m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *replicate BD2_20191022, borehole location moved three times, about 0.5m apart, first two attempts refused on steel at a depth of 0.8m, HB = SPT hammer bouncing

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

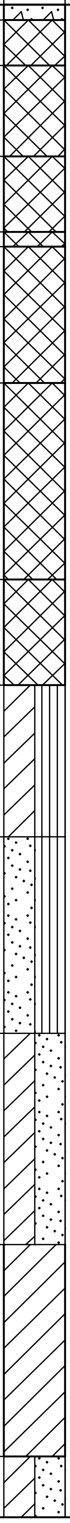
CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 5.8 AHD
EASTING: 333630
NORTHING: 6249665
DIP/AZIMUTH: 90°/--

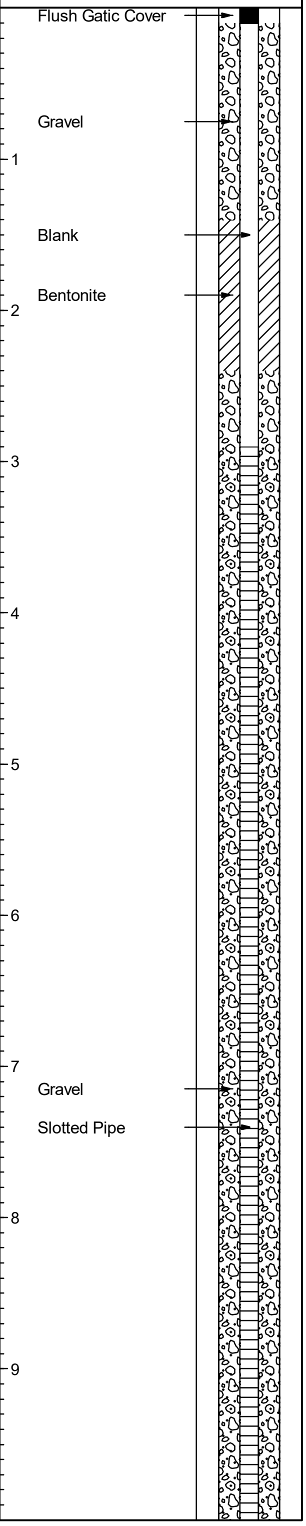
BORE No: BH104
PROJECT No: 86874.00
DATE: 23/10/2019
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing				Water
			Type	Depth	Sample	Results & Comments	
	0.1	CONCRETE: pale grey, aggregate diameter from 15-50mm	A/E	0.1		PID<1	
5	0.4	FILL/SAND: medium to coarse, dark brown-brown, with fine to medium mixed origin gravel, moist-wet (wet from diatube)	A/E*	0.5		PID<1	
	1.0	FILL/Clayey SAND: fine to medium, low plasticity, pale grey, trace building rubble (fragments of terracotta, brick and glass), moist	A/E S	1.0		PID<1 4,5,7 N = 12	
	1.5	FILL/CLAY: low plasticity, brown-dark brown with fine to medium clayey sand and fine to coarse mixed origin gravel, w<PL	A/E	1.5		PID<1	
4	1.6	FILL/COAL WASH: fine to coarse coal wash gravel, black-dark grey with fine to coarse sand, moist	A/E	2.0		PID<1	
		FILL/GRAVEL: fine to coarse mixed origin, dark grey and brown with igneous cobbles and fine to coarse sand, moist					
3	2.5	FILL/SAND: fine to coarse, dark grey-dark brown, trace clay, coal wash, fine to coarse mixed origin gravel and building rubble (fragments of terracotta, brick, ceramics and concrete), moist	E S	2.5		1,2,5 N = 7	
			E	3.0		PID<1	
			E	3.5		PID<1	
2	3.8	FILL/SAND: fine to medium, dark grey-dark brown, trace building rubble (fragments of terracotta and ceramics), moist 4.00m: becoming wet	E S	4.0		PID<1 5,6,8 N = 14	
1	4.5	Silty CLAY CH: high plasticity, dark grey with fine sand, w<PL, firm, alluvial	E	4.5		PID<1	
			A/E	5.0		PID<1	
0	5.5	Silty SAND SP: fine to medium, dark grey with clay, wet, loose, alluvial	S	5.5		2,3,6 N = 9	13-11-19 ▼ 15-11-19 ▼
-1 -2	6.8	Sandy CLAY CL: low plasticity, fine, pale grey mottled yellow-brown, w<PL, very stiff, residual	S	7.0		8,11,12 N = 23	
-3	8.2	CLAY CH: high plasticity, dark grey-grey with fine sand, w<PL, very stiff, residual	S	8.5		5,10,14 N = 24	
-4	9.6	Sandy CLAY CI: low plasticity, fine to medium, pale grey, w<PL, very stiff, residual	S	10.0		7,11,12	

Graphic Log



Well Construction Details



RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 6.0m

TYPE OF BORING: Diatube to 0.10m, Solid Flight Auger (TC-bit) to 6.00m, wash boring to 12.30m

WATER OBSERVATIONS: Free groundwater encountered at 4.00m

REMARKS: *replicate BD3_20191023, HB = SPT hammer bouncing

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

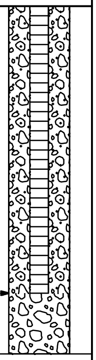
BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 5.8 AHD
EASTING: 333630
NORTHING: 6249665
DIP/AZIMUTH: 90°/--

BORE No: BH104
PROJECT No: 86874.00
DATE: 23/10/2019
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		Sandy CLAY CI: low plasticity, fine to medium, pale grey, w<PL, very stiff, residual *(continued)*					N = 23		
-5	11								11
-6	11.8	SANDSTONE: fine to medium, yellow-brown, inferred low-medium strength		S	12.1		7,5/50mm refusal HB		End Cap
	12								12
	12.3	Bore discontinued at 12.3m Groundwater monitoring well installed							
-7	13								13
-8	14								14
-9	15								15
-10	16								16
-11	17								17
-12	18								18
-13	19								19
-14									



RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 6.0m

TYPE OF BORING: Diatube to 0.10m, Solid Flight Auger (TC-bit) to 6.00m, wash boring to 12.30m

WATER OBSERVATIONS: Free groundwater encountered at 4.00m

REMARKS: *replicate BD3_20191023, HB = SPT hammer bouncing

SAMPLING & IN SITU TESTING LEGEND

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

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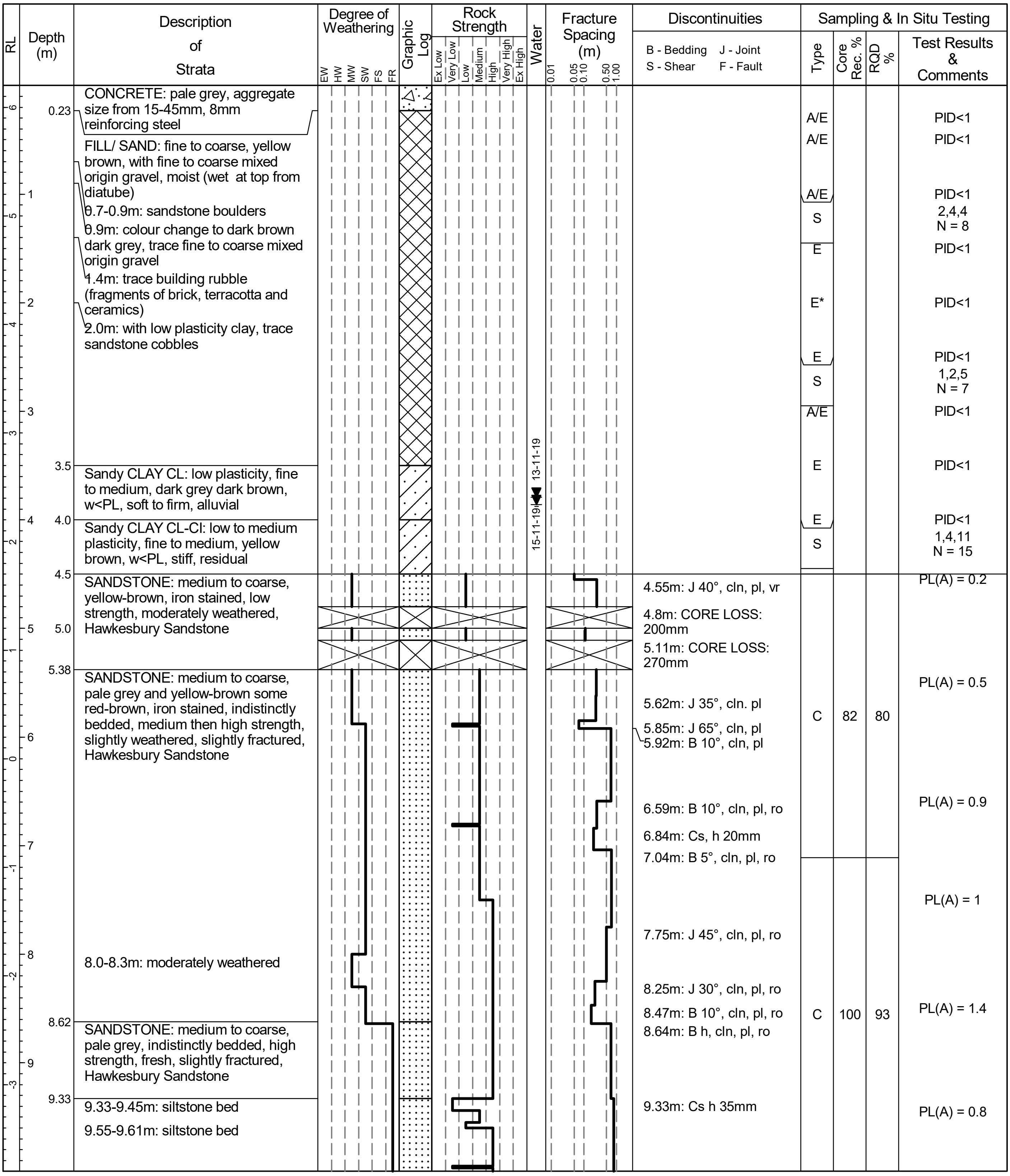
BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 6.2 AHD
EASTING: 333589
NORTHING: 6249766
DIP/AZIMUTH: 90°/--

BORE No: BH105
PROJECT No: 86874.00
DATE: 28/10/2019
SHEET 1 OF 2



Depth (m)	Description of Strata
	CONCRETE: pale grey, aggregate size from 15-45mm, 8mm reinforcing steel
0.23	FILL/ SAND: fine to coarse, yellow brown, with fine to coarse mixed origin gravel, moist (wet at top from diatube) 0.7-0.9m: sandstone boulders 0.9m: colour change to dark brown dark grey, trace fine to coarse mixed origin gravel 1.4m: trace building rubble (fragments of brick, terracotta and ceramics) 2.0m: with low plasticity clay, trace sandstone cobbles
3.5	Sandy CLAY CL: low plasticity, fine to medium, dark grey dark brown, w<PL, soft to firm, alluvial
4.0	Sandy CLAY CL-CI: low to medium plasticity, fine to medium, yellow brown, w<PL, stiff, residual
4.5	SANDSTONE: medium to coarse, yellow-brown, iron stained, low strength, moderately weathered, Hawkesbury Sandstone
5.0	
5.38	SANDSTONE: medium to coarse, pale grey and yellow-brown some red-brown, iron stained, indistinctly bedded, medium then high strength, slightly weathered, slightly fractured, Hawkesbury Sandstone 8.0-8.3m: moderately weathered
8.62	SANDSTONE: medium to coarse, pale grey, indistinctly bedded, high strength, fresh, slightly fractured, Hawkesbury Sandstone
9.33	9.33-9.45m: siltstone bed 9.55-9.61m: siltstone bed

Discontinuities

B - Bedding J - Joint
S - Shear F - Fault

4.55m: J 40°, cln, pl, vr
4.8m: CORE LOSS: 200mm
5.11m: CORE LOSS: 270mm
5.62m: J 35°, cln. pl
5.85m: J 65°, cln, pl
5.92m: B 10°, cln, pl
6.59m: B 10°, cln, pl, ro
6.84m: Cs, h 20mm
7.04m: B 5°, cln, pl, ro
7.75m: J 45°, cln, pl, ro
8.25m: J 30°, cln, pl, ro
8.47m: B 10°, cln, pl, ro
8.64m: B h, cln, pl, ro
9.33m: Cs h 35mm

Sampling & In Situ Testing

Type	Core Rec. %	RQD %	Test Results & Comments
A/E			PID<1
A/E			PID<1
A/E			PID<1
S			2,4,4 N = 8
E			PID<1
E*			PID<1
E			PID<1
S			1,2,5 N = 7
A/E			PID<1
E			PID<1
E			PID<1
S			1,4,11 N = 15
C	82	80	PL(A) = 0.2 PL(A) = 0.5 PL(A) = 0.9
C	100	93	PL(A) = 1 PL(A) = 1.4 PL(A) = 0.8

RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 4.0m, HQ to 4.5m

TYPE OF BORING: Diatube to 0.23m, Solid Flight Auger (TC-bit) to 4.00m, wash boring to 4.50m, NMLC coring to 10.15m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *replicate BD4_20191028

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 6.2 AHD
EASTING: 333589
NORTHING: 6249766
DIP/AZIMUTH: 90°/--

BORE No: BH105
PROJECT No: 86874.00
DATE: 28/10/2019
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01 0.05 0.10 0.50 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	10.15	SANDSTONE: fine to medium, pale grey, indistinctly bedded, high strength with very low to low strength beds, fresh, Hawkesbury Sandstone *(continued)*							C	100	93	PL(A) = 1.3
		Bore discontinued at 10.15m Target depth reached										

RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 4.0m, HQ to 4.5m

TYPE OF BORING: Diatube to 0.23m, Solid Flight Auger (TC-bit) to 4.00m, wash boring to 4.50m, NMLC coring to 10.15m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *replicate BD4_20191028

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BORE: 105 PROJECT: ULTIMO OCTOBER 2019

4.50 – 9.00m

BORE: 105 PROJECT: ULTIMO OCTOBER 2019

9.00 – 10.15m

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 6.2 AHD
EASTING: 333589
NORTHING: 6249766
DIP/AZIMUTH: 90°/--

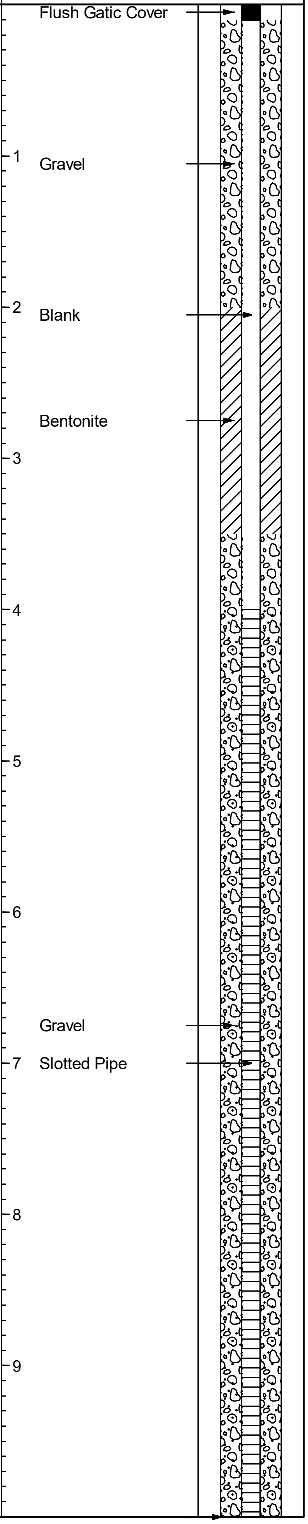
BORE No: BH105
PROJECT No: 86874.00
DATE: 28/10/2019
SHEET 1 OF 2

Depth (m)	Description of Strata
0.23	CONCRETE: pale grey, aggregate size from 15-45mm, 8mm reinforcing steel
	FILL/ SAND: fine to coarse, yellow brown, with fine to coarse mixed origin gravel, moist (wet at top from diatube) 0.7-0.9m: sandstone boulders 0.9m: colour change to dark brown dark grey, trace fine to coarse mixed origin gravel 1.4m: trace building rubble (fragments of brick, terracotta and ceramics) 2.0m: with low plasticity clay, trace sandstone cobbles
3.5	Sandy CLAY CL: low plasticity, fine to medium, dark grey dark brown, w<PL, soft to firm, alluvial
4.0	Sandy CLAY CL-CI: low to medium plasticity, fine to medium, yellow brown, w<PL, stiff, residual
4.5	SANDSTONE: medium to coarse, yellow-brown, iron stained, low strength, moderately weathered, Hawkesbury Sandstone
5.0	
5.38	SANDSTONE: medium to coarse, pale grey and yellow-brown some red-brown, iron stained, indistinctly bedded, medium then high strength, slightly weathered, slightly fractured, Hawkesbury Sandstone 8.0-8.3m: moderately weathered
8.62	SANDSTONE: medium to coarse, pale grey, indistinctly bedded, high strength, fresh, slightly fractured, Hawkesbury Sandstone
9.33	SANDSTONE: fine to medium, pale grey, indistinctly bedded, high strength with very low to low strength beds, fresh, Hawkesbury Sandstone 9.33-9.45m: siltstone bed

Sampling & In Situ Testing

Type	Depth	Results & Comments
A/E	0.3	PID<1
A/E	0.5	PID<1
A/E	1.0	PID<1
S		2,4,4 N = 8
E	1.45 1.5	PID<1
E*	2.0	PID<1
E	2.5	PID<1
S		1,2,5 N = 7
A/E	2.95 3.0	PID<1
E	3.5	PID<1
E	4.0	PID<1
S		1,4,11 N = 15
	4.45 4.5 4.55	PL(A) = 0.2
C	5.5	PL(A) = 0.5
	6.6	PL(A) = 0.9
	7.11	
	7.5	PL(A) = 1
C	8.5	PL(A) = 1.4
	9.45	PL(A) = 0.8
	10.0	PL(A) = 1.3

Water: 13-11-19; 15-11-19



RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 4.0m, HQ to 4.5m
TYPE OF BORING: Diatube to 0.23m, Solid Flight Auger (TC-bit) to 4.00m, wash boring to 4.50m, NMLC coring to 10.15m
WATER OBSERVATIONS: No free groundwater observed during augering
REMARKS: *replicate BD4_20191028

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 6.2 AHD
EASTING: 333589
NORTHING: 6249766
DIP/AZIMUTH: 90°/--

BORE No: BH105
PROJECT No: 86874.00
DATE: 28/10/2019
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water	Well Construction Details
-4	10.15	9.55-9.61m: siltstone bed		C	10.15				End Cap
		Bore discontinued at 10.15m Target depth reached							
-5	11								11
-6	12								12
-7	13								13
-8	14								14
-9	15								15
-10	16								16
-11	17								17
-12	18								18
-13	19								19

RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 4.0m, HQ to 4.5m

TYPE OF BORING: Diatube to 0.23m, Solid Flight Auger (TC-bit) to 4.00m, wash boring to 4.50m, NMLC coring to 10.15m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *replicate BD4_20191028

SAMPLING & IN SITU TESTING LEGEND

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

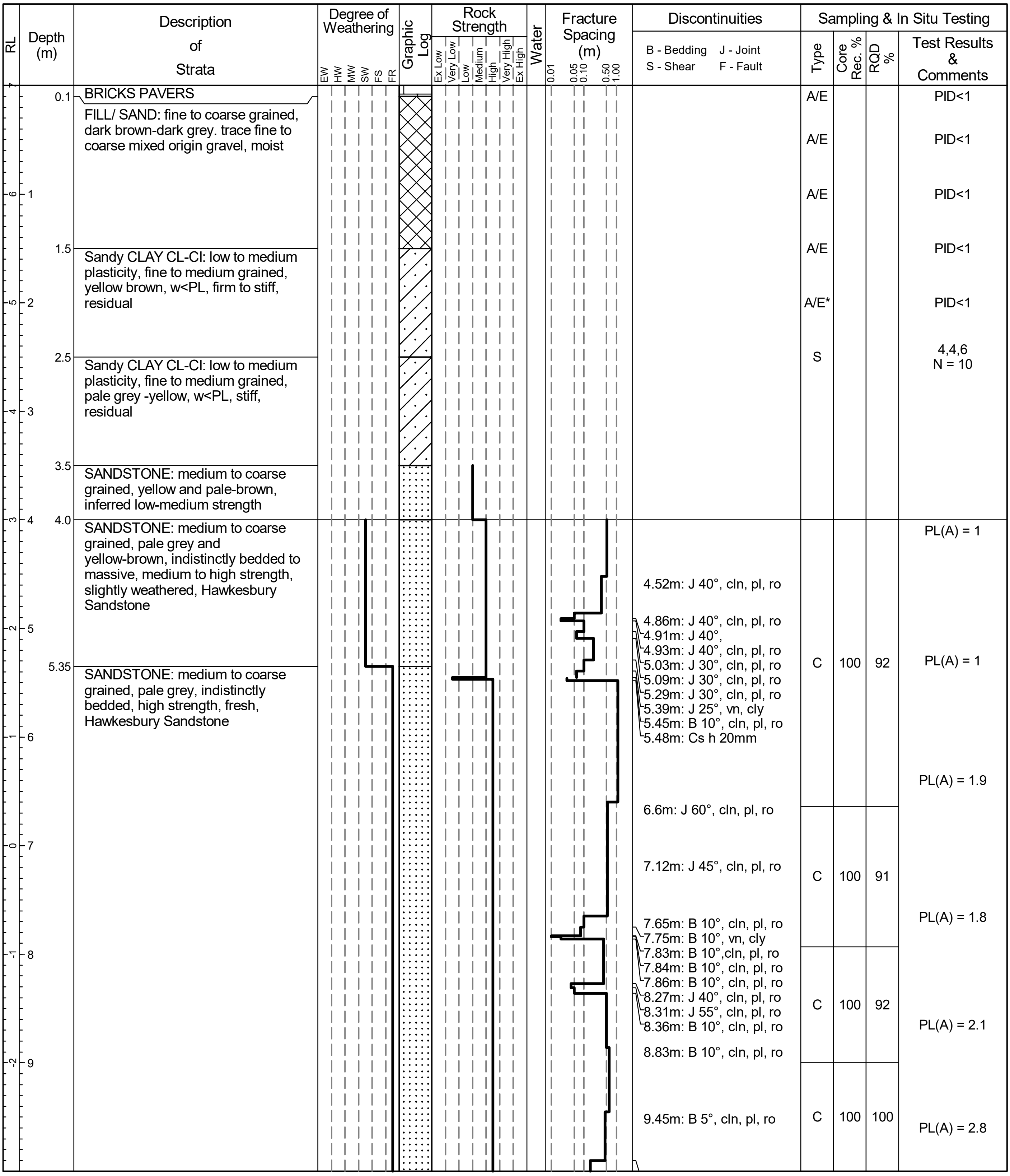
Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 7.0 AHD
EASTING: 333544
NORTHING: 6249786
DIP/AZIMUTH: 90°/--

BORE No: BH106
PROJECT No: 86874.00
DATE: 28/10/2019
SHEET 1 OF 2



Depth (m)	Description of Strata
0.1	BRICKS PAVERS
	FILL/ SAND: fine to coarse grained, dark brown-dark grey. trace fine to coarse mixed origin gravel, moist
1.5	Sandy CLAY CL-CI: low to medium plasticity, fine to medium grained, yellow brown, w<PL, firm to stiff, residual
2.5	Sandy CLAY CL-CI: low to medium plasticity, fine to medium grained, pale grey -yellow, w<PL, stiff, residual
3.5	SANDSTONE: medium to coarse grained, yellow and pale-brown, inferred low-medium strength
4.0	SANDSTONE: medium to coarse grained, pale grey and yellow-brown, indistinctly bedded to massive, medium to high strength, slightly weathered, Hawkesbury Sandstone
5.35	SANDSTONE: medium to coarse grained, pale grey, indistinctly bedded, high strength, fresh, Hawkesbury Sandstone

Discontinuities

B - Bedding J - Joint
S - Shear F - Fault

4.52m: J 40°, cln, pl, ro
4.86m: J 40°, cln, pl, ro
4.91m: J 40°,
4.93m: J 40°, cln, pl, ro
5.03m: J 30°, cln, pl, ro
5.09m: J 30°, cln, pl, ro
5.29m: J 30°, cln, pl, ro
5.39m: J 25°, vn, cly
5.45m: B 10°, cln, pl, ro
5.48m: Cs h 20mm
6.6m: J 60°, cln, pl, ro
7.12m: J 45°, cln, pl, ro
7.65m: B 10°, cln, pl, ro
7.75m: B 10°, vn, cly
7.83m: B 10°,cln, pl, ro
7.84m: B 10°, cln, pl, ro
7.86m: B 10°, cln, pl, ro
8.27m: J 40°, cln, pl, ro
8.31m: J 55°, cln, pl, ro
8.36m: B 10°, cln, pl, ro
8.83m: B 10°, cln, pl, ro
9.45m: B 5°, cln, pl, ro

Sampling & In Situ Testing

Type	Core Rec. %	RQD %	Test Results & Comments
A/E			PID<1
A/E			PID<1
A/E			PID<1
A/E			PID<1
A/E*			PID<1
S			4,4,6 N = 10
			PL(A) = 1
C	100	92	PL(A) = 1
			PL(A) = 1.9
C	100	91	
			PL(A) = 1.8
C	100	92	
			PL(A) = 2.1
C	100	100	PL(A) = 2.8

RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 2.5, HQ to 4.0m

TYPE OF BORING: Hand auger to 1.3m, Solid Flight Auger (TC-bit) to 2.5m, wash boring to 4.0m, NMLC coring to 10.06m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *replicate BD5-20191028

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 7.0 AHD
EASTING: 333544
NORTHING: 6249786
DIP/AZIMUTH: 90°/--

BORE No: BH106
PROJECT No: 86874.00
DATE: 28/10/2019
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low Very Low Low Medium High Very High Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
-3	10.06	Bore discontinued at 10.06m Target depth reached						9.9m: B 5°, cln, pl, ro				PL(A) = 1.5
-4	11											
-5	12											
-6	13											
-7	14											
-8	15											
-9	16											
-10	17											
-11	18											
-12	19											

RIG: Bobcat **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 2.5, HQ to 4.0m

TYPE OF BORING: Hand auger to 1.3m, Solid Flight Auger (TC-bit) to 2.5m, wash boring to 4.0m, NMLC coring to 10.06m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *replicate BD5-20191028

SAMPLING & IN SITU TESTING LEGEND

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

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BORE: 106 PROJECT: ULTIMO OCTOBER 2019

4.00 – 8.00m

BORE: 106 PROJECT: ULTIMO OCTOBER 2019

8.00 – 10.06m

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 5.8 AHD
EASTING: 333494
NORTHING: 6249446
DIP/AZIMUTH: 90°/--

BORE No: BH107
PROJECT No: 86874.00
DATE: 22/10/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
	0.3	CONCRETE: suspended slab	▨						
5 4 3	1 2 3 3.1	VOID: probable disused storage space							1 2 3
2 1	4	Bore discontinued at 3.1m Test Bore discontinued due to substantial void space							4

RIG: Hand tools **DRILLER:** TG **LOGGED:** TG **CASING:** Uncased

TYPE OF BORING: Diatube to 0.3m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: Level interpolated from LTS Lockley drawing 50686 001DT, 30/05/19

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 3.5 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH108
PROJECT No: 86874.00
DATE: 22/10/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		CONCRETE	△ △						
	0.1	FILL/ GRAVEL: dense, grey angular igneous gravel with trace sand	▩	E*	0.1 0.2		PID<1		
	0.25	Bore discontinued at 0.25m refusal on sandstone or sandstone boulder in fill							
3									
	1								1
2									
	2								2
1									
	3								3
0									
	4								4
-1									

RIG: Hand tools **DRILLER:** TG **LOGGED:** TG **CASING:** Uncased

TYPE OF BORING: Diatube to 0.1m; Hand auger to 0.25m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *replicate BDA/2019022, Level from drawing titled PLAN BASEMENT LEVEL, May 2005

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 3.5 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: BH109
PROJECT No: 86874.00
DATE: 22/10/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		CONCRETE	▨						
	0.15	FILL/ GRAVEL: grey angular igneous gravel with trace sand	☒						
3	0.25	Bore discontinued at 0.25m refusal on sandstone or sandstone boulder in fill							
2	1								1
1	2								2
0	3								3
-1	4								4

RIG: Hand tools **DRILLER:** TG **LOGGED:** TG **CASING:** Uncased

TYPE OF BORING: Diatube to 0.15m; Hand auger to 0.25m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: Level from drawing titled PLAN BASEMENT LEVEL, May 2005

SAMPLING & IN SITU TESTING LEGEND

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

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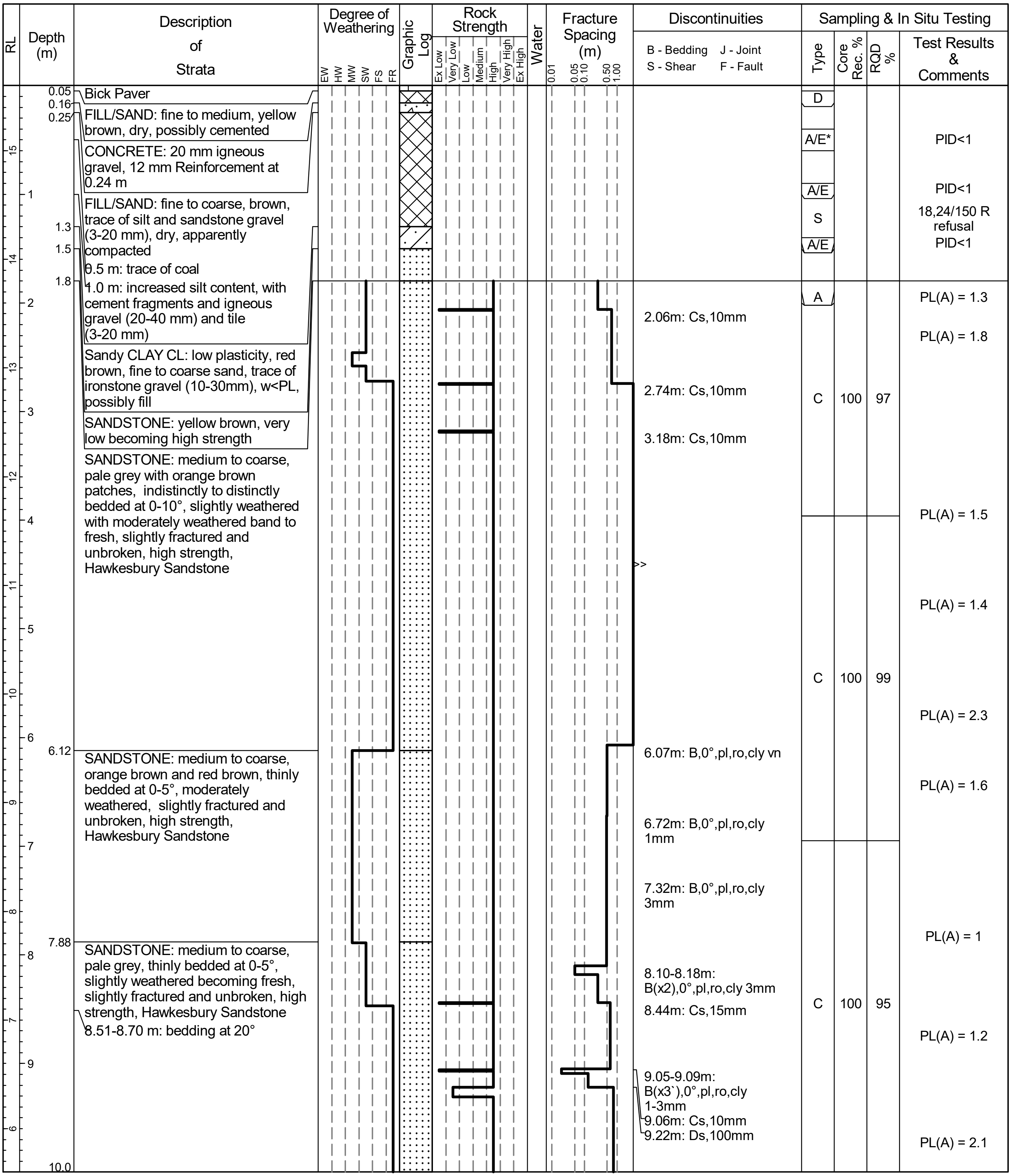
BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 15.6 AHD
EASTING: 333423
NORTHING: 6249912
DIP/AZIMUTH: 90°/--

BORE No: BH201
PROJECT No: 86874.00
DATE: 15/11/2019
SHEET 1 OF 1



Depth (m)	Description of Strata
0.05	Bick Paver
0.16	FILL/SAND: fine to medium, yellow brown, dry, possibly cemented
0.25	CONCRETE: 20 mm igneous gravel, 12 mm Reinforcement at 0.24 m
	FILL/SAND: fine to coarse, brown, trace of silt and sandstone gravel (3-20 mm), dry, apparently compacted 0.5 m: trace of coal 1.0 m: increased silt content, with cement fragments and igneous gravel (20-40 mm) and tile (3-20 mm)
1.3	Sandy CLAY CL: low plasticity, red brown, fine to coarse sand, trace of ironstone gravel (10-30mm), w<PL, possibly fill
1.5	SANDSTONE: yellow brown, very low becoming high strength
1.8	SANDSTONE: medium to coarse, pale grey with orange brown patches, indistinctly to distinctly bedded at 0-10°, slightly weathered with moderately weathered band to fresh, slightly fractured and unbroken, high strength, Hawkesbury Sandstone
6.12	SANDSTONE: medium to coarse, orange brown and red brown, thinly bedded at 0-5°, moderately weathered, slightly fractured and unbroken, high strength, Hawkesbury Sandstone
7.88	SANDSTONE: medium to coarse, pale grey, thinly bedded at 0-5°, slightly weathered becoming fresh, slightly fractured and unbroken, high strength, Hawkesbury Sandstone 8.51-8.70 m: bedding at 20°
10.0	Bore discontinued at 10.0m Target depth reached

Discontinuities:
- 2.06m: Cs,10mm
- 2.74m: Cs,10mm
- 3.18m: Cs,10mm
- >>
- 6.07m: B,0°,pl,ro,cly vn
- 6.72m: B,0°,pl,ro,cly 1mm
- 7.32m: B,0°,pl,ro,cly 3mm
- 8.10-8.18m: B(x2),0°,pl,ro,cly 3mm
- 8.44m: Cs,15mm
- 9.05-9.09m: B(x3`),0°,pl,ro,cly 1-3mm
- 9.06m: Cs,10mm
- 9.22m: Ds,100mm

Type	Core Rec. %	RQD %	Test Results & Comments
D			
A/E*			PID<1
A/E			PID<1
S			18,24/150 R refusal
A/E			PID<1
A			PL(A) = 1.3
C	100	97	PL(A) = 1.8
C	100	99	PL(A) = 1.5 PL(A) = 1.4 PL(A) = 2.3 PL(A) = 1.6
C	100	95	PL(A) = 1 PL(A) = 1.2 PL(A) = 2.1

RIG: Scout 1 **DRILLER:** JE **LOGGED:** LS **CASING:** HW to 1.8m

TYPE OF BORING: Diatube 0.4m, Solid Flight Auger (TC-bit) to 1.8m, NMLC coring to 10.0m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: *BD20191115-1

SAMPLING & IN SITU TESTING LEGEND

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

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BORE: 201 PROJECT: ULTIMO OCTOBER 2019

1.80 – 6.00m

BORE: 201 PROJECT: ULTIMO OCTOBER 2019

6.00 – 10.00m

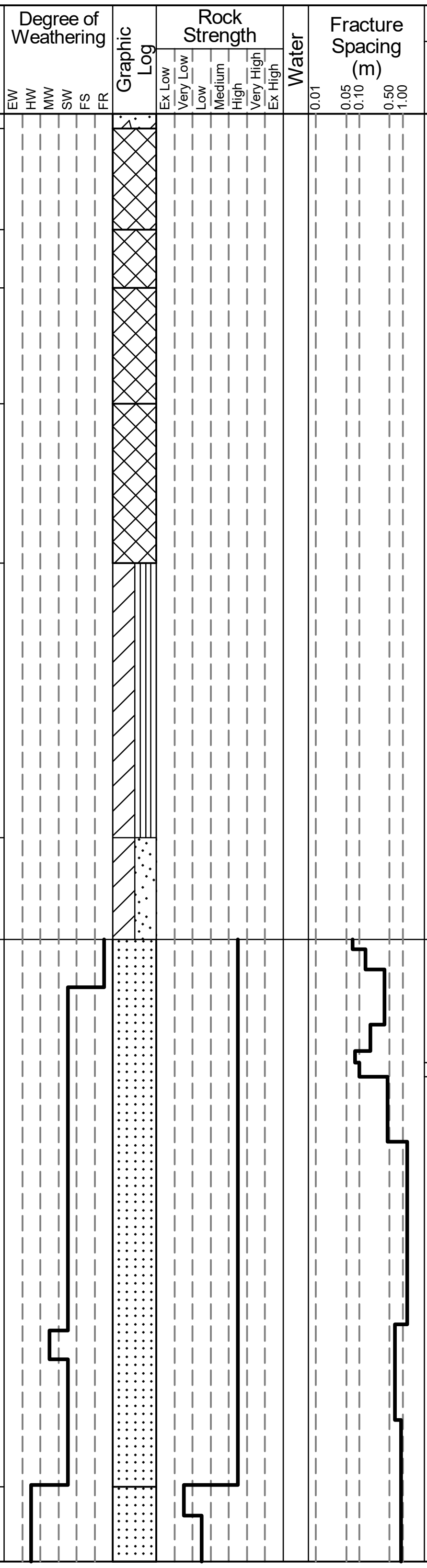
BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 5.4 AHD
EASTING: 333613
NORTHING: 6249647
DIP/AZIMUTH: 90°/--

BORE No: BH202
PROJECT No: 86874.00
DATE: 26/11/2019
SHEET 1 OF 2

Depth (m)	Description of Strata
0.1	CONCRETE: pale grey, aggregate 10-40mm, 8mm diameter steel reinforcement
0.8	FILL/Clayey SAND: fine to medium, pale brown-brown, low plasticity clay, with fine sandstone gravel, trace silt, dry
1.2	FILL/Gravelly SAND: fine to coarse, grey-dark grey, fine to coarse igneous gravel with clay, moist
2.0	FILL/Clayey SAND: fine to coarse, dark grey, low plasticity clay, with fine igneous gravel and silt, moist, slight hydrocarbon odour
3.1	FILL/Silty SAND: fine to medium, dark grey-dark brown, with fine sandstone gravel, moist 2.30m: with terracotta and ceramic fragments and clay
5.0	Silty CLAY CH: high plasticity, grey mottled yellow-brown, trace fine ironstone gravel, w<PL, stiff, appears alluvial (possibly residual)
5.7	Sandy CLAY CL: low plasticity, pale grey, fine to medium sand, w<PL, hard, residual
9.48	SANDSTONE: medium to coarse, pale grey, indistinctly bedded, high strength, fresh, slightly fractured, Hawkesbury Sandstone 6.03m: becoming yellow-brown and pale grey, slightly weathered 9.22m: carbonaceous bed (5mm thick)
10.0	SANDSTONE: fine to medium, pale grey-pale brown, distinct carbonaceous laminations at 0-5°,



Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)

5.77m: B, 10°, cln pl ro
5.91m: B, 10°, cln, pl, ro
6.29m: B, 15°, cln, pl, ro
6.47m: B, 15°, vn, cly, pl
6.55m: B, 15°, cln, pl, ro
6.65m: B, 15°, cln, pl, ro
7.1m: B, 5°, cln, pl, ro
8.36m: B, 15°, cln, pl, ro
9.02m: B, 10°, cln, pl, ro

Sampling & In Situ Testing

Type	Core Rec. %	RQD %	Test Results & Comments
A/E			PID<1
A/E			PID<1
A/E			PID<1
S			24/120 refusal HB
A/E			PID<1
A/E*			PID=1
E			PID<1
S			3,6,14 N = 20
E			PID<1
A/E			PID<1
S			3,4,7 N = 11
S			5,11/50 refusal HB
			PL(A) = 1.1
C	100	88	
			PL(A) = 1.8
			PL(A) = 1.5
C	10	93	
			PL(A) = 1
			PL(A) = 0.2

RIG: Scout 1 **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 4.3m, HQ to 5.5m
TYPE OF BORING: Diatube to 0.1m, Solid Flight Auger (TC-bit) to 4.5m, wash boring to 5.7m, NMLC to 10.0m
WATER OBSERVATIONS: No free groundwater observed during augering
REMARKS: *BD26112019, HB = SPT hammer bouncing

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Create NSW, Department of Premier and Cabinet
PROJECT: Ultimo Creative Industries Precinct
LOCATION: Powerhouse Museum, 500 Harris Street, Ultimo

SURFACE LEVEL: 5.4 AHD
EASTING: 333613
NORTHING: 6249647
DIP/AZIMUTH: 90°/--

BORE No: BH202
PROJECT No: 86874.00
DATE: 26/11/2019
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low, Very Low, Low, Medium, High, Very High, Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
-5		very low strength, highly weathered, Hawkesbury Sandstone 9.70m: becoming indistinctly bedded, low strength Bore discontinued at 10.0m Target depth reached										
	11											
-6												
	12											
-7												
	13											
-8												
	14											
-9												
	15											
-10												
	16											
-11												
	17											
-12												
	18											
-13												
	19											
-14												

RIG: Scout 1 **DRILLER:** JE **LOGGED:** RK **CASING:** HW to 4.3m, HQ to 5.5m
TYPE OF BORING: Diatube to 0.1m, Solid Flight Auger (TC-bit) to 4.5m, wash boring to 5.7m, NMLC to 10.0m
WATER OBSERVATIONS: No free groundwater observed during augering
REMARKS: *BD26112019, HB = SPT hammer bouncing

SAMPLING & IN SITU TESTING LEGEND

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

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BORE: 202 PROJECT: ULTIMO NOVEMBER 2019

5.70 – 10.00m