Douglas Partners
Geotechnics / Environment / Groundwater

Report on
Groundwater Modelling

Proposed Commercial Development
2-8A Lee Street, Haymarket

Prepared for
Toga Development and Construction Pty Ltd

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1. Introduction

This report presents the results of the updated groundwater inflow modelling and dewatering requirements for the proposed commercial development at 2-8A Lee Street, Haymarket. The work was commissioned by David Springford of Toga Development and Construction Pty Ltd and was undertaken in accordance with Douglas Partners' proposal SYD201237.P.003.Rev0 dated 17 August 2021.

This report supersedes a previous report revision (ref: 86884.02.R.006.Rev0, dated December 2021) and reflects the following changes in the updated groundwater inflow modelling:

- The groundwater model now includes the excavation of the adjacent development (ie. Atlassian) as a prior stage to the excavation of the Toga site so that the effect of the adjacent drained basement is accounted for.
- Revision of the basement layout and depth to reflect some changes made after our initial analysis and report.

It is understood that the proposed development of the site is revised to include excavation for a four-level basement (to an average elevation of RL1.7 m) beneath the eastern and southern portions of the Adina Hotel and the adjoining Henry Deane Plaza, with localised deeper excavations for lift shafts and building cores (to an elevation of RL1.0 m), followed by construction of a multi-storey commercial tower.

It is understood that the proposed basement will extend close to property boundaries on each of its four sides, intersecting both the Lee Street and Devonshire Street pedestrian tunnels, and will need to interact with both existing and future basements on neighbouring sites.

The basement excavation is expected to intersect the groundwater table. It is understood that the basement is currently designed as a ‘drained’ basement, for both the construction phase and during the fully operational phase of the building (i.e. over the long-term), to eliminate the need for the provision of full height water-proof basement walls and a hydrostatic slab.

Under the NSW Aquifer Interference Policy, the project is considered to be an ‘aquifer interference activity’ requiring authorisation from an approval body (for State Significant Developments). This groundwater assessment has been prepared to evaluate the feasibility of adopting a ‘drained’ basement for this project, and includes:

- a summary of the geotechnical and hydrogeological investigations undertaken on-site;
- development of a conceptual hydrogeological model (CHM);
- development of a 3D numerical groundwater model, with calibrations to match the groundwater monitoring data;
- estimation of transient groundwater inflow into a drained basement, during and following construction;

- estimation of groundwater drawdown due to the drained basement;
- estimation of settlements at adjacent key structures, due to the predicted drawdown from the proposed drained basement;
- considerations of the NSW Aquifer Interference Policy; and
- comments on disposal options for groundwater contaminants.

2. Previous Work

Two rounds of combined geotechnical, environmental, and hydrogeological investigations have been completed by DP for this project. Previous geotechnical investigations carried out by DP for a neighbouring site, together with an understanding of the geology and hydrogeology for the surrounding project area, were considered in the preparation of this report. The information obtained from previous site investigations (including for neighbouring projects) was sourced from the following DP reports:

- Report 86884.02.R.004.Rev0, Groundwater Monitoring Report (dated 15 July 2021);
- Report 86884.02.R.001.Rev1, Geotechnical Investigation (dated 23 July 2021);
- Report 86884.02.R.005.Rev0, Contamination Information from Boreholes (dated 10 August 2021);
- Report 86884.02.R.001.Rev0, Geotechnical Investigation (dated 15 April 2021);
- Report 86884.02.R.002.Rev0, Factual Summary Report on Contamination Testing (dated 9 April 2021);
- Report 86767.00.R.006.Rev5, Supplementary Geotechnical Investigation (dated 20 November 2020); and
- Report 86767.07.R.001.Rev0, Supplementary Geotechnical Investigation for Devonshire Street Pedestrian Tunnel (dated 20 November 2020).

2.1 Boreholes

The previous work included the drilling of eleven boreholes at the locations shown on Drawings 1 and 2 in Appendix B (Boreholes BH1001-BH1007, BH1003A, BH1004A, BH2001, BH2001A and BH2002), and installation of standpipes in boreholes BH1002, BH1003A and BH1007. In conjunction with groundwater sampling activities for contamination assessment purposes, water levels were measured on three occasions during March 2021 in the new standpipes, and also in a selection of existing standpipes near the eastern site boundary (i.e. boreholes BH8, BH107A, BH107B and BH202 on 19 March, 22 March, and 30 March). Rising head tests were also carried out within boreholes BH1002, BH1003A, BH1007 and BH202 (DP, 2021).

2.2 Standpipes and Permeability Testing

Standpipe piezometers were installed within eight completed boreholes, namely Boreholes BH8, BH107A, BH107B, BH109B, BH202, BH1002, BH1003A and BH1007. The locations of these boreholes are shown on Drawing 1.

The standpipes comprised screened PVC pipe with gravel backfill, a bentonite pellet seal and a 'gatic' cover at ground level. The installed pipes are screened within either alluvial sand (i.e. BH202), or within the underlying sandstone (medium-grained, slightly fractured then unbroken, high strength).

The suffix in the numbering of some boreholes indicates the alternatives for the position of the well screen as:

- Option A: screened within very low or low strength, fine to medium-grained sandstone (interpreted to be Mittagong Formation): Boreholes BH107A, BH1003A and BH112A; and
- Option B: screened within the underlying medium to high strength, medium-grained sandstone (interpreted to be Hawkesbury Sandstone): Boreholes BH104, BH107B, BH1002 and BH109B.

Groundwater permeability testing and long-term monitoring of groundwater levels in standpipes has been carried out at the site since July 2019, with the results presented in DP Report 86884.02.R.004.Rev0, dated 15 July 2021. The installation dates for the data loggers were:

- Borehole BH8: 31 July 2019;
- Boreholes BH107A and BH107B: 17 May 2020;
- Borehole BH109B: 21 May 2020;
- Borehole BH202: 7 November 2020;
- Borehole BH1002: 31 March 2021; and
- Boreholes BH1003A and BH1007: 22 March 2021.

Manual measurements of standing water levels for these standpipes were carried out between 23 July 2019 and 24 June 2021 (up to 11 water level observations made per standpipe). Rising permeability tests were also completed within the installed standpipes.

3. Field Work Results

3.1 Boreholes

The locations of the boreholes and groundwater monitoring wells are presented as Drawings 1 and 2 in Appendix B, interpreted from architectural drawing of general arrangement plan basement Level 04 (extracted from BATESSMART BSMART-AR-DAD-10B04000, dated 06 June 2022) presented as Drawings C. The cross-sections show the interpreted geotechnical divisions of underlying soil and rock, together with the previous proposed basement floor level noting that the basement levels have changed. Borehole logs from the previous work at the site, and selected boreholes from the neighbouring site to the north-east, are included in Appendix C, together with photos of the recovered rock cores. Graphs of groundwater level measurements through time for different standpipe piezometers are also included within Appendix C.

The subsurface conditions encountered in the boreholes within the site can be summarised as:

STONE TILE (Henry Deane Plaza only):	Stone tiles (20-40 mm thick) laid over a layer of sand and cement 0.05-0.08 m thick; over
CONCRETE:	Single concrete slab (steel reinforcement not observed in Boreholes BH1001, BH1002, BH2001, BH2001A and BH2002), thickness ranging between 0.08-0.24 m; over
FILL:	Gravel or gravel and bricks (110 mm thick: Boreholes BH1001 and BH1002 only), or layers of clayey sand, sand, silt, or sandy clay, with either silty clay and gravel, cobble or boulder-sized fragments of sandstone, siltstone, igneous rock (railway ballast), concrete and brick rubble, or other anthropogenic materials (e.g. plastic bottles), trace ash and slag. The boreholes within the Henry Deane Plaza included one or more layers of building rubble in a clayey sand matrix, to depths ranging between 1.2 m and 3.5 m (refusal to Boreholes BH1003, BH1004 and BH1006 within these materials); over
ALLUVIAL SAND:	Medium dense to very dense alluvial sand (absent in Boreholes BH1001, BH1002 and BH2001A), typically wet, 1.0-3.7 m thick, including a thin layer (0.8 m thick) of stiff to very stiff silty clay in BH1007; over
ALLUVIAL SILTY CLAY:	Very soft to very stiff alluvial silty clay (Boreholes BH1004A and BH1005 only), 1.0-1.6 m thick, with traces of either charcoal and fine gravel; over
RESIDUAL CLAY:	Firm to very stiff residual silty clay or sandy clay (absent in Borehole BH1004A), 0.18-1.8 m thick, with traces of fine sand and/or gravel; over
RESIDUAL CLAYEY SAND or SANDY CLAY:	Medium dense to very dense residual clayey sand with occasional thin clay bands or very stiff to hard sandy clay (present in Boreholes BH1003, BH1005, BH1007 and BH2002 only), with relict rock texture (extremely weathered sandstone); over
SANDSTONE (MEDIUM GRAINED):	Very low to medium strength, medium grained sandstone, with both clay seams and iron-cemented bands of up to medium to high strength (absent in Boreholes BH1005 and BH1007); over
SANDSTONE (MEDIUM TO COARSE GRAINED):	Medium or high strength, medium to coarse grained sandstone, typically with widely spaced extremely low or very low strength bands.

The upper fine to medium grained sandstone is interpreted to be part of the Mittagong Formation, and the underlying medium grained sandstone is interpreted to be Hawkesbury Sandstone.

3.2 Groundwater Levels

The groundwater flow direction within both the Mittagong Formation and Hawkesbury Sandstone bedrock, and the perched groundwater within the alluvial soil, is westwards from Central Station towards Lee Street (refer to Drawing M1 in Appendix E).

It is noted that there was a significant relative difference of 12-16 m for water levels measured in standpipes screened within the Hawkesbury Sandstone at Boreholes BH1002 and BH1007 compared to the overlying alluvial aquifer (based on monitoring data available for comparison, to the end of the current monitoring period). The interpreted reason for this water level difference is due to these two standpipes being screened within two separate aquifers, with the lower bore screened in rock aquifer (with only a few sub-horizontal clay-coated bedding defects or weathered seams being present within the screened interval, together with a few inclined rock joints). In addition, the existing tunnels could also contribute to the difference in water level at this location. The monitoring data also indicates a very slow rate of response for Borehole BH109B (i.e. more than 4 weeks required for the water level to stabilise), with no rock joints present within the screened interval. Based on this limited data it is concluded that the rock joints are the main conduits for groundwater movement within the Hawkesbury Sandstone bedrock on this site compared to bedding planes.

A summary of groundwater level observations for the monitoring period July 2019 to March 2021 is reported in Report 86884.02.R.004.Rev0, and presented in Table 1 and Table 2. Groundwater data and observations from these reports indicate minimal variability in groundwater levels following rainfall periods between July 2019 and September 2020. Recent groundwater observations during the current study show a similar trend.

Table 1: Manual Groundwater Observations for piezometers BH8, BH107A, BH107B and BH109B

Measurement Date	Standing Water Level Measurements in Boreholes							
	BH8		BH107A		BH107B		BH109B	
	Depth (m)	RL$^{(1)}$	Depth (m)	RL$^{(1)}$	Depth (m)	RL$^{(1)}$	Depth (m)	RL$^{(1)}$
23 July 2019	2.3	13.2	-	-	-	-	-	-
30 July 2019	2.3	13.2	-	-	-	-	-	-
14 August 2019	2.3	13.2	-	-	-	-	-	-
26 November 2019	2.3	13.2	-	-	-	-	-	-
19 February 2020	1.9	13.6	-	-	-	-	-	-
5 May 2020	2.2	13.3	-	-	-	-	-	-
5 June 2020	-	-	2.0	13.5	2.2	13.3	-	-
7 September 2020	2.3	13.2	2.1	13.4	2.4	13.1	2.5	12.8
8 December 2020	2.3	13.2	2.1	13.4	2.5	13.0	2.5	12.8
9 March 2021	2.2	13.3	2.0	13.5	2.3	13.2	2.5	12.8
19 March 2021	2.0	13.5	1.9	13.6	2.2	13.3	-	-
22 March 2021	1.9	13.6	1.6	13.9	1.9	13.5	-	-

Note: (1) Elevation (RL) are in metres AHD.

Table 2: Manual Groundwater Observations for piezometers BH202, BH1002, BH1003A and BH1007

Measurement Date	Standing Water Level Measurements in Boreholes							
	BH202		BH1002		BH1003A		BH1007	
	Depth (m)	RL(1)	Depth (m)	RL(1)	Depth (m)	RL(1)	Depth (m)	RL(1)
19 March 2021	3.3	13.0	16.4	-3.0	2.8	11.5	-	-
22 March 2021	3.0	13.3	16.3	-2.9	2.8	11.5	-	-
30 March 2021	2.9	13.4	16.3	-2.9	2.5	11.8	14.4	1.4
31 March 2021	2.9	13.4	16.3	-2.9	2.5	11.8	14.4	1.4
24 June 2021	3.7	12.6	16.6	-3.2	3.0	11.4	14.4	1.4

Note: (1) Elevation (RL) are in metres AHD.

3.3 Results of Permeability Testing

Permeability tests have been completed within standpipes (a total of 11 successful tests carried out at various stages between 30 July 2019 and 22 March 2021) and included either ‘rising head’ or ‘falling head’ tests. Rising head tests were completed successfully in each standpipe (with the exception of BH109B and BH1002), and a falling head test was completed successfully in one standpipe (i.e. BH109B). Permeability testing was unsuccessful in Borehole BH1002 (a valid result was not returned from either rising or falling head tests due to the very rapid recharge rate). The rising head test attempted in Borehole BH109B was unsuccessful due to a very slow recharge rate.

Analysis of the change in water levels during the test intervals, to calculate the permeability of the screened interval of the standpipes, was carried out using the Hvorslev analytical method. The calculated permeability results from rising or falling head tests completed within the available standpipes are presented in Table 3. The test reports used in the analysis for this report, including those supplied for the neighbouring site, are included in Appendix D.

Table 3: Calculated permeability results from rising or falling head tests in available standpipe piezometers

Borehole ID	Material Types within Screened Interval	Calculated Permeability (m/sec)
BH8 (1)	Sandstone: medium grained, highly weathered then fresh, with clay seams in upper metre of screened interval, fractured then unbroken, low then high strength	1.0×10^{-6}
BH107A (2)	Sandstone: fine to medium grained, highly weathered, fractured, high strength with very low strength bands	1.4×10^{-7} to 2.0×10^{-7}
BH107B (2)	Sandstone: medium grained, fresh, slightly fractured then unbroken, high strength	5.0×10^{-8} to 7.7×10^{-8}
BH109B	Sandstone: medium grained, fresh, slightly fractured then unbroken, high strength	4.7×10^{-8}

Borehole ID	Material Types within Screened Interval	Calculated Permeability (m/sec)
BH202 (3)	Sand and clay alluvium, and residual clay	7.4×10^{-7} to 2.6×10^{-6}
BH1003A	Alluvial sand: medium grained, medium dense to dense	2.5×10^{-4}
BH1007	Sandstone: medium to coarse grained, slightly fractured then unbroken	3.5×10^{-5}

Notes: (1) Well screen includes an interval of core loss and clay seams, below the top of rock.
(2) Two tests carried out.
(3) Three tests carried out

Typical permeability values for sand, both from our previous experience in the area and from published values, are usually in the range 1×10^{-4} to 1×10^{-5} m/sec: the permeability test result from Borehole BH1003A is within this range. The calculated permeability values for the alluvial sand and clay encountered in Borehole BH202 are not consistent with the published range and are considered not to be representative of the permeability of alluvial sand. Borehole BH202 was positioned close to buildings which may also have deep concrete footings founded on rock, in addition to the layers of alluvial and residual clay. It is considered that these factors have influenced the permeability test results for the sand layers in Boreholes BH202.

A slow groundwater recharge rate was measured within standpipes screened within high-strength rock with few defects (i.e. BH109B). Groundwater levels within standpipes positioned near to each other and screened within different rock units appear to be similar (e.g. BH107A screened within the Mittagong Formation, and BH107B screened within the Hawkesbury Sandstone). The rapid increase in water level within the standpipe screened within the alluvial sand following prolonged rain periods, and the observation of groundwater near the soil-rock interface in some boreholes (e.g. BH107A), indicates that a perched water table is probably present within the soils above rock level.

4. Proposed Development

It is understood that the proposed development of the site will include excavation beneath part of the northern area of the site (i.e. east of the Adina Hotel) for a four-level basement (to an average elevation of RL1.7 m), a localised deeper excavation for lift shafts and building ‘core’ (to an elevation of RL 0.1 m), excavation within the southern part of the site (within the Henry Deane Plaza) for a four-level basement (to an average elevation of RL1.7 m), followed by construction of a multi-storey commercial tower. It is further understood that buried services passing through the site south of the Adina Hotel and above the final basement floor level (i.e. stormwater and sewer pipes, and electrical cables) are to be structurally supported.

Based on the provided drawings, it is understood that the proposed basement will extend close to property boundaries on each of its four sides, intersecting both the Lee Street and Devonshire Street pedestrian tunnels, and will need to interact with both existing and future basements on neighbouring sites.

Excavation for the basement will require excavation to depths ranging between about 18.5 m within the northern part of the site and 17 m within the southern part of the site, being deepened a further 16.5 m for lift shafts and building cores. It is understood that the detailed design of the shoring system for the ‘drained’ basement is yet to be decided, however, it is anticipated that a relatively water-tight perimeter ‘cut-off’ wall socketed a minimum of 2 m into competent, slightly fractured to unbroken sandstone, will be required to prevent any direct inflow from high permeability fill, alluvial soils and upper fractured rock.

5. Geotechnical and Hydrogeological Model

The field work results are summarised on five geotechnical cross-sections in Appendix C, which show the interpreted layers of fill materials, alluvial and residual soil, and sandstone units between the test locations. The interpreted boundaries shown on the sections are accurate only at the test locations and layers shown diagrammatically on the drawings are inferred only. Bands of lower or higher strength rock may be present within the generalised sandstone layers.

Fill materials are inferred to be present across the site, being of greater thickness and with building and demolition rubble inclusions in the southern part of the site (i.e. within the Henry Deane Plaza). Alluvial sand and clay soils are also inferred to be present within the Henry Deane Plaza (sub-parallel with the Devonshire Street pedestrian tunnel), whilst residual silty clay and sandy clay soils are inferred to be present across most of the site, overlying sandstone.

The interpreted geotechnical models for the site are:

- The northern part of the site (i.e. below the Adina Hotel):
    - Loose to medium dense fill materials (gravel and bricks or sand: about 0.1 m thick increasing southwards to about 2 m thick); over
    - Dense to very dense sand alluvium (up to 1 m thick: Borehole BH2002 only);
    - Firm to very stiff sandy or silty clay residual soil (possibly up to 1.5 m thick); overlying
    - Fine to medium grained sandstone (very low strength, with medium to high strength bands: up to about 1.5 m thick); and then overlying
    - Medium grained, medium to high strength sandstone.
- The southern part of the site (i.e. within the Henry Deane Plaza):
    - Stiff or loose to medium dense fill materials (clayey sand, sand, gravelly sand, sandy clay or silty clay, with building rubble, bricks, sandstone gravel, and cobbles: up to 3.3 m thick); over
    - Medium dense to very dense sand and very soft to very stiff silty clay alluvium (up to 5.4 m thick); over
    - Firm to very stiff silty clay, sandy clay, or clayey sand residual soil / extremely weathered sandstone (up to 2.5 m thick); overlying
    - Medium grained sandstone (extremely low or very low strength, with medium strength bands: up to about 1.2 m thick); and then overlying
    - Medium to coarse-grained, medium to high strength sandstone;

Groundwater measurements from standpipe piezometers within and adjacent to the site indicate that the proposed design floor level of ‘Basement 4’ at an average elevation of RL1.7 m will be below the permanent groundwater table: the highest measured groundwater elevation was RL13.9 m within the Mittagong Formation and RL13.5 m within the underlying Hawkesbury Sandstone. Perched groundwater is also indicated to be present within the overlying alluvial soils, for which the highest recorded water level was at an elevation of RL13.5 m, and at or near the soil-rock interface within the residual clay. The interpreted groundwater contours and flow directions are illustrated in Appendix E.

The groundwater level measurements indicate that water inflows within the sandstone bedrock appear to be controlled by rock joints, seams and other fractures in the weathered rock, which are acting as conduits for water flow and temporary water storage. The groundwater tables in the alluvium and sandstone appeared to be relatively independent and separated by a layer of low permeability residual clay, as indicated by the minimal variability in measured groundwater levels within the sandstone after heavy rainfall periods between July 2019 and June 2020. In contrast, more variability in water levels within the alluvium has been observed, both following rainfall periods and during an extended dry period.

Temporary water storage may be present within the seams and other fractures in the weathered rock. Therefore, groundwater inflow is not expected to be uniform around the site and is likely to be concentrated around localised fractured zones. The regional groundwater flow is also expected to be affected by the nearby basements, pedestrian tunnels and the new Sydney Metro underground station. A hydrogeological conceptual site model is presented as Drawing 2 in Appendix B, which assumes the direction of regional groundwater flow is towards the west.

6. Groundwater Modelling

6.1 Methodology

Groundwater modelling was undertaken to assess the potential inflow rates into the proposed basements and the long-term drawdown (or cone of depression), and to indicate the volume of dewatering which is likely to be required during both the construction stage and over the longer term, noting that the proposed excavation for the basement is at lower levels than on adjoining sites.

Groundwater model simulations were conducted using the Visual MODFLOW (VMOD) software engines (McDonald & Harbaugh, 1988). VOMD is a three-dimensional numerical groundwater modelling tool and is accepted as an industry-standard code for groundwater flow and contaminant transport. The model was developed using the pre-processor or 3D visualization technology graphical interface program Visual MODFLOW Flex V7.0 by Waterloo Hydrogeologic. The model was based on site-specific data where possible, as well as estimates of unknown parameters based on experience in similar environments and values from literature (Fetter, 2001).

6.2 Numerical Model Geometry and Hydrogeological Conceptual Model

The subsurface aquifer system surrounding and beneath the proposed development was simulated as a multi-layered numerical model, to represent the site subsurface conditions based on site investigation data, and to allow the vertical flow components to be simulated more accurately.

The recharge boundary condition of 2 mm/year is assigned to the modelled area. As the site land use is currently high-density urban, minimal recharge of the groundwater table due to rainfall infiltration has been assumed across the surface area of the aquifer. Recharge could also possibly be occurring from anthropogenic sources, such as seepage from leaking water mains. Loss of water from the aquifer may be occurring due to extraction activities from nearby properties or drained basements, together with natural discharge into Blackwattle Bay. Water loss from the aquifer to the atmosphere through evapotranspiration (e.g. from vegetation at the surface, above the aquifer) is considered to be negligible.

The length of the model domain from the site boundaries was extended approximately 200 m in an upstream (easterly) direction, 400 m in a downstream (westerly) direction, and 600 m from north to south, to simulate the estimated groundwater catchment domain.

For the numerical model, the geological units were subdivided into four layers corresponding to the main soil and rock units, which are assumed within the area of the model to have a uniform thickness (refer Drawing 2, Appendix B). The top of the model (i.e. Slice of Layer 1: ground surface) was set to approximate the average ground surface across the site at RL 20.0 m. For simplicity, the model did not incorporate topographical variations, or variations in the layer thickness, with the aquifers assumed to be homogeneous and anisotropic. All layers were assigned as MODFLOW (Type 3) layers (confined / unconfined) and therefore the water levels in the layers are interconnected. The assumed average base of the excavation at RL1.7 m will generally be within Hawkesbury Sandstone. The model layers are presented conceptually on Drawing 2 in Appendix B, and the assigned hydraulic parameters for each layer are presented in Table 4, Section 6.3.

6.3 Boundary Conditions and Aquifer Parameters

The northern and southern boundaries of the model were set as ‘no-flow’ boundaries as these were parallel to the inferred groundwater flow direction. Constant head boundary conditions were applied to the eastern and western model boundaries (discharging to Blackwattle Bay, about 500 m to the north-west of the site).

The constant head ‘far-end’ boundary conditions were calibrated to generate a hydraulic gradient in a north-westerly direction, while matching the measured groundwater levels at various monitoring points at the site. For simplicity, the groundwater model was calibrated against the groundwater table of the upper fractured sandstone layer (Mittagong Formation), as it gives a more accurate prediction of both groundwater inflow and drawdown, compared to the results if another, lower groundwater table within the Hawkesbury Sandstone is adopted.

Aquifer parameters required for the model included horizontal (Kh) and vertical (Kv) hydraulic conductivity or permeability, as well as specific yield or storage coefficient. Natural variations in the permeability of the sediments around the site are likely to occur due to the variations in the silt or clay content, and grain size of the sand.

The calculated values from the in-situ permeability testing for the sand encountered in Borehole BH8 (i.e. a value of 5.0×10^{-5} m/sec) adopted in the model for Layer 1 (fill and alluvial soil). To ensure that the modelling is not overly optimistic, the vertical conductivity was set as equal to the horizontal hydraulic conductivity for this layer.

The hydraulic conductivity of the residual clay (Layer 2) was assumed to be 5×10^{-8} m/sec, with an assumed horizontal to vertical hydraulic conductivity ratio of 3.

The permeability or hydraulic conductivity of the rock units (i.e. Layers 3 and 4) will vary according to changes in the secondary structural features, such as joints and fractures which are expected to be conduits for groundwater flow. Whether the fractures are coated by clay, together with the orientation and interconnection of fractures, will also modify the rock mass permeability.

The modelling was carried out adopting mean (geometric) values of all the in-situ permeability test results within both the fine grained, fractured sandstone (Mittagong Formation) and the medium grained, slightly fractured to unbroken sandstone (Hawkesbury Sandstone). The vertical hydraulic conductivity was assumed to be 33% of the horizontal hydraulic conductivity for the weathered and fresh rock units for each of these layers (Cook (2003)).

The adopted hydraulic conductivity or permeability values for all four layers are summarised in Table 4.

Table 4: Model Layer Summary

Model Layer	Top of Layer (RL m AHD)	Represented Material Type	Specific yield (Sy)	Horizontal Hydraulic Conductivity (m/sec)	Vertical Hydraulic Conductivity (m/sec)
1	20.0	Fill and Alluvium	0.2	5×10^{-5}	5×10^{-5}
2	13.4	Residual Clay	0.05	5×10^{-8}	1.7×10^{-8}
3	11.9	Fractured Sandstone (Mittagong Formation)	0.1	5.3×10^{-7}	1.8×10^{-7}
4, 5, 6	10.6	Slightly Fractured to Unbroken Sandstone (Hawkesbury Sandstone)	0.05	1.3×10^{-7}	4.3×10^{-8}

The initial model, inclusive of basement drainage within the Adina Hotel basement, and Dexus Fraser building basement was calibrated to match existing groundwater levels at the site, with the groundwater level (or potentiometric head) ranging between about RL13.8 m to RL13.3 m. These values were uniformly applied to the model as the initial hydraulic head. This calibration confirmed that the bedrock parameters chosen for the model appeared to be realistic, given the disturbed groundwater system with drained basements surrounding the observation wells, with the fractured rock aquifer system considered to be adequate. The calibrated initial (existing) groundwater levels and model calibration output are illustrated on Drawing M2 in Appendix E.

6.4 Basement Dewatering – Drain Cells

The MODFLOW 'drain package' can be used to simulate water loss from the groundwater system, which occurs due to dewatering operations. Drain cells set with a high conductance of 1,400 m/day simulated the dewatering during and post-construction of the basements. The drain cells represent the sub-floor drainage and sumps/pumps located within the basement, to simulate dewatering of the site during construction and provision of permanent drainage over the long term.

Basement inflows for the Toga Building are simulated assuming the drained basements adjacent to the site are active (i.e. drained basements of the Adina Hotel, Dexus Fraser building and the proposed

Atlassian basement). The construction phase for the proposed building is assumed to commence after the Atlassian building basement, and the influence of the proposed basement on the Atlassian site is therefore considered in this report. The proposed positions of the drain cells in the model have been set at the existing basement level of the Adina Hotel, at the proposed bulk excavation levels of the proposed new building at the site, as indicated in Table 5.

Predicted inflows into the drain cells, representing the basement dewatering system, were monitored throughout the model simulation using the zone budget module of VMOD.

Table 5 Drained basements adjacent to the site included in the model

No.	Building	Drain Elevation (RL m, AHD)
1	Existing Basement of Adina Hotel	RL13.3 m
2	Existing Basement, Dexus Fraser Building	RL11.2 m
3	Proposed New Basement, Atlassian commercial development	RL4.7 m
4	Proposed New Basement, Toga Development and Construction	RL1.7 m

6.5 Cut-off Walls

To reduce direct inflow through the sides of the excavation from the high permeability fill, alluvial soils, and upper fractured rock, it is understood that relatively impermeable walls are to be installed around the perimeter of basement excavation.

The design of the cut-off walls is yet to be finalised, but they are envisaged to comprise contiguous piles with the gaps between piles sealed during construction by water-proof linings. The proposed cut-off walls were included in the numerical model by applying a horizontal flow barrier (HFB) to the cells at the excavation faces, which was assigned a nominal 0.5 m thickness, with a hydraulic conductivity of 1×10^{-8} m/s. The wall was simulated considering two scenarios: (a) HFB extended down to RL8.6 m (i.e. at least 2 m of 'cut-off' into the slightly fractured and unbroken sandstone layer); and (b) HFB extended to the basement level at RL1.7 m (i.e. cut-off into the unbroken sandstone layer).

6.6 Groundwater Modelling Simulations

The model was initially run under a steady-state flow condition for the footprints of the Adina Hotel and Dexus Fraser basements, with 'drain cells' activated. The boundary conditions were calibrated to match the existing groundwater measurement data. The model simulation was then developed in stages to account for the existing drained basements and new developments surrounding the site, as follows:

1. **Run 1:** Only the Adina Hotel and Dexus Fraser basement 'drain cell' activated, and the model calibrated for groundwater flow;
2. **Run 2**: Following calibration of the boundary conditions to match the existing groundwater measurement data, the new development of Atlassian basement drain cell at RL4.7 m and the Toga basement 'drain cell' at RL1.7 m was activated with the HFB extended to RL8.6 m; and

3. **Run 3**: The Toga basement ‘drain cell’ was activated and the HFB extended to RL1.7 m.

The model was run under transient flow conditions for a period of 5 years, then after attaining a consistent modelled result the model was then switched to long-term steady-state flow conditions, to assess the groundwater inflow rates into the basement during both construction and over the long term (refer to Section 7.3).

7. Groundwater Modelling Results

7.1 Predicted Groundwater Inflow

Groundwater inflow into the ‘drain cells’, representing the excavation dewatering system, was evaluated throughout the model simulations using the ‘zone budget’ module of VMOD v7.0. The inflow rates represent the estimated total rate of groundwater flowing into the excavation and the volume (per unit time) requiring extraction via the dewatering system (sump-and-pump) so that the basement excavation can remain dry during construction and for the long-term case.

Simulated results for different levels of the cut-off wall are summarised in Table 6 and Table 7. During the early stages of construction, inflow rates will be higher, and will then gradually decrease as the groundwater storage in the aquifer around the excavation decreases, and the cone of depression in the potentiometric surface expands out from the basement.

The cumulative inflows during the first year of basement construction for HFB extending to the basement level of RL1.7 are predicted to be about 12 ML. In the long-term, inflows are predicted to be less than 3.0 ML per year. The predicted inflows accounted for the drained basement of Atlassian working concurrently

The predicted inflow rate to the basement for the two modelled scenarios, as shown in Table 6 and Table 7, show minimal differences after the first year (i.e. 12 ML/year vs. 11.6 ML/year). The minimal difference is attributed to the value of 1 x 10^{-8} m/s being adopted in the model for the horizontal hydraulic conductivity of the HEB and the fractured sandstone aquifer (Hawkesbury Sandstone) of 1.3 x 10^{-7} m/s between elevations of RL8.6 m and RL1.7 m.

Table 6: Predictive Model of Simulated Groundwater Inflow Rates with time, for a cut-off wall extending to RL8.6 m

Elapsed Time	Dewatering Inflow Rate		
	Volume (m^3 / day)	Inflow rate (L / min)	Cumulative Inflow (ML / year)
1 Day	42.7	22.5	12.0 (Cumulative during the first year)
5 Days	38.9	20.4	
14 Days	34.5	18.1	
30 Days	33.6	17.7	
90 Days	30.2	15.9	

Elapsed Time	Dewatering Inflow Rate		
	Volume (m^3 / day)	Inflow rate (L / min)	Cumulative Inflow (ML / year)
180 Days	20.8	10.9	
300 Days	14.6	7.7	
1 Year	13.9	7.3	
2 Years	16.7	11.6	6.1
3 Years	15.1	10.5	5.5
5 Years	13.4	9.3	4.9
Long-term	8.2	5.7	3.0

Table 7: Predictive Model of Simulated Groundwater Inflow Rates with time, for a cut-off wall extending to RL1.7 m

Elapsed Time	Dewatering Inflow Rate		
	m^3 / day	L / min	ML / year
1 Day	41.7	21.9	11.6 (Cumulative during the first year)
5 Days	37.9	19.9	
14 Days	33.7	17.7	
30 Days	32.8	17.2	
90 Days	29.5	15.5	
180 Days	20.1	10.6	
300 Days	14.1	7.4	
1 Year	13.6	7.1	
2 Years	16.5	11.5	6.0
3 Years	15.0	10.4	5.5
5 Years	13.4	9.3	4.9
Long-term	8.3	5.8	3.0

It should be noted that these volumes are 'estimates' of the average inflows. It is entirely possible that there could be localised zones of higher permeability, through which the rate of inflow could be significantly higher, and considering the subsurface heterogeneity and fractured aquifer system, a safety margin for application in the field should be considered. Accordingly, it is recommended that a 'factor of safety' of at least 2 should be applied to these values for design purposes and that inflow rates be monitored during excavation and construction.

It should be noted that the simulated dewatering rates and drawdown are dependent on the dewatering scheme adopted for the site, as included in the numerical models. If the depth of basement drainage and sumps were to change then the currently predicted dewatering rates may change, in which case further modelling would be required.

7.2 Predicted Groundwater Drawdown

The drawdown contours are produced by subtracting the predicted water levels from the initial groundwater levels. The predicted long-term groundwater table following the completion of the proposed ‘drained’ basement is illustrated in Drawing M4 in Appendix E. The drawdown contours are the compounding effect from project site and Atlassian basement dewatering.

The model results indicate that the potential drawdown or impact on the water table may extend up to 125 m from the site boundaries on the upstream side and 270 m on the downstream side, as shown by the 0.5 m drawdown contour in Drawing M4. The model results show minimal differences in groundwater drawdown are predicted for the two scenarios (i.e. HFB to either RL8.6 m or RL1.7 m), as depicted on Drawings M4 and M6 in Appendix E, and summarised in Table 8.

Table 8: The predicted drawdowns below key structures around the site

No.	Adjacent structures	Extent of Predicted Drawdown (m)
1	Central Station - Regional Line Tracks and Platforms	0.5 – 4.5
2	Adina Hotel	6.0 – 8.5
3	Atlassian Basement	8.5 – 5.0
4	Existing Devonshire Street Tunnel	4.5 – 5.0
5	Office Complex at 12-30 Lee Street	3.0 – 5.0
6	Railway Square	1.0 – 2.0

7.3 Drawdown Induced Settlement

The elevation of the upper perched water table within the fill and alluvial soil is expected to be governed by the volume of rainfall infiltration. Assuming that perimeter cut-off walls are constructed down into the sandstone, this perched water table is expected to continue fluctuating both above and below the soil-rock interface, even after the construction of a ‘drained’ basement. Neighbouring structures and pavements founded on either fill or alluvial soils are therefore not expected to experience noticeable dewatering induced settlement.

Following the construction of the ‘drained’ basement, the lower groundwater table in the sandstone is expected to be close to the bulk excavation level, immediately behind the excavated faces of the basement and corresponding to a maximum drawdown of approximately 10 m. This drawdown would gradually reduce to less than 1.0 m at an estimated distance of about 125 - 500 m from the boundaries of the basement.

The maximum drawdown in water levels below the adjacent key structures is predicted to be up to 6.5 m. The relatively high degree of localised drawdown is expected to occur mostly within the sandstone. Due to the high deformation modulus of the sandstone bedrock, there should be minimal impact on nearby structures founded on sandstone (i.e. total additional settlements or differential settlements <5 mm).

8. Sensitivity Analysis

Sensitivity analysis involves quantifying the variation in the value of one or more output variables (e.g. hydraulic heads), due to changes in the value of one or more inputs to a groundwater flow model (e.g. hydraulic properties or boundary conditions).

This section discusses sensitivity in the historic groundwater modelling, through a systematic variation of model input values to:

- Identify model input elements which result in the most significant variations in model output (list of ranked sensitivities); and
- Quantitatively evaluate the calculated output, degree of calibration and predictive capability of the model due to parameter variability (i.e. parameter uncertainty).

The sensitivities are determined from the relative change in the inflow rate due to a 50% change in the hydraulic conductivity parameter value (for both the aquifer and HFB), presented in Table 9. The sensitivity analysis indicates that the groundwater levels are more sensitive to the assumed hydraulic conductivity of the aquifer than to the hydraulic conductivity of the HFB.

Table 9: Sensitivity Parameter Analysis

Elapsed Time	**Inflow Rate (ML / year)**		
		K_d of the aquifer K_d (x 1.5)	**K_d HFB** (1 x 10^{-8} m/s) **(x 1.5)**
1 Year	12	15.3	12
2 Years	6.1	7.9	6.1
3 Years	5.5	7.4	5.5
5 Years	4.9	6.5	4.9
Long-term	3.0	4.2	3.0

9. Potential Impact on Neighbouring Properties

An assessment of the potential effects of dewatering on neighbouring properties and groundwater dependent ecosystems is summarised in Table 10.

Table 10: Assessment of Potential Dewatering Effects

Item	Comment
Proximity of Groundwater Dependent Ecosystems (GDEs)	No known groundwater dependent ecosystems within 1-kilometre radius of the site(1).
Water supply losses by neighbouring groundwater users	A review of registered bores within a 500 m radius of the site was carried out(2), which identified 43 monitoring bores within the search area (no extraction bores), with the nearest bore located approximately 260 m distant of the site. All identified groundwater bores are located beyond the assessed radius-of-influence of any anticipated significant drawdown.
Potential subsidence of neighbouring structures	It is considered that the local lowering of the water levels within the sandstone will have no significant impact on the surrounding properties or structures (refer Section 7.3).
Mounding of water upgradient of structure	Significant mounding of groundwater is not expected. A drained basement would eliminate potential mounding.

Notes: (1) Based on the search results undertaken in Groundwater Dependent Ecosystem (GDE) Atlas on the Bureau of Meteorology's (BoM) website.

(2) Based on the search results undertaken in Australian Groundwater Explorer on the BoM website.

10. Aquifer Interference Policy Considerations

The NSW Aquifer Interference Policy (AIP) indicates that the term "aquifer" is commonly understood to mean a groundwater system that is sufficiently permeable to allow water to move within it, and which can yield productive volumes of groundwater. A groundwater system is defined as any type of saturated geological formation that can yield low or high volumes of water. For the purpose of the AIP, however, the term 'aquifer' has the same meaning as 'groundwater system', and includes both low-yielding and saline systems.

The basement dewatering on site is expected to occur within the sandstone profile, which is indicated to be of relatively low permeability and with a low yield and is therefore considered to be a "less productive groundwater source" as outlined in the AIP.

It is expected that the measured water levels within the rock on the site are probably associated with seepage flowing through bedding planes, fractures, and joints in the rock. Following stabilisation of the groundwater level following completion of the initial excavation, these seepage flows are likely to be relatively minor during periods of dry weather, although they may increase slightly following periods of wet weather.

Table 1 in Section 3.2.1 of the AIP outlines 'minimal impact' considerations. The AIP indicates that *"if predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable"*. The following minimal impact considerations are outlined for less productive groundwater sources:

- less than or equal to 10% cumulative variation in water table at a distance of 40 m from any high priority groundwater dependant ecosystem, high priority culturally significant site, or less than a 2 m decline at any water supply work;
- a cumulative pressure head decline of not more than a 2 m at any water supply work; and
- any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.

The minimal consideration impacts relate to impacts on groundwater dependant ecosystems and groundwater users. The proposed excavation on the site is considered to comply with the AIP minimal consideration requirements for the following reasons:

- the water take for the basement does not involve pumping or extraction of large volumes of groundwater. Water seepage through the rock is to be collected in subfloor drainage and directed to the stormwater or sewer system (subject to approval by Council or by Sydney Water);
- there are no registered groundwater users within 500 m of the site;
- DP is not aware of any groundwater dependant ecosystems within a one-kilometre radius of the site;
- DP is not aware of any water sharing agreements in the area; and
- the water take can be easily measured during the construction period and over the long term, if required.

11. Disposal of Groundwater Contaminants

During previous site investigations, selected groundwater samples were tested for commonly occurring contaminants to assess potential disposal options, with the results presented in DP (2021e).

The report presented a factual summary of the results of the soil and groundwater contamination at the site. Three groundwater monitoring wells installed for the most recent geotechnical site investigation for the project, along with three monitoring wells installed for an adjoining project, were utilised to collect groundwater samples. Monitoring well locations are shown on Drawing 1 in Appendix B. Contamination testing results from previous investigations completed near to the north-eastern boundary of the site have also been considered during the preparation of this report.

The groundwater wells included BH107A, BH107B, BH202, BH1002, BH1003A, and BH1007, which were installed to target different rock strata. No obvious signs of environmental concern (i.e. odours or light nonaqueous phase liquids) were observed during the field investigation. Groundwater analytical results for polycyclic aromatic hydrocarbons, total recoverable hydrocarbons and other metals were below laboratory practical quantitation limits (PQL).

Concentrations of chloroform were detected in groundwater wells at levels which marginally exceed the groundwater site assessment criteria (SAC) of 3 µg/L for drinking water (NEPC, 2013: Boreholes BH202, BH1003A, and BH1007), however, this contaminant was not detected in the other four groundwater wells, whilst other chlorinated hydrocarbons were below PQL. Laboratory analysis also confirmed the presence of some heavy metal contaminants of potential concern in the groundwater from standpipes both within and adjacent to the site (e.g. copper and zinc), at concentrations above the groundwater

SAC. These elevated concentrations of copper and zinc were identified in both up-gradient and down-gradient groundwater wells.

Elevated levels of copper and zinc in groundwater are commonly encountered in heavily urbanised areas. The source of the copper and zinc is uncertain but could be linked to the copper and zinc concentrations in the fill layer on site, or from the buried service pipes within or near to the site. Considering that elevated levels of copper and zinc were not detected in samples of the fill materials, the copper and zinc levels identified in the groundwater wells at the site are likely to represent regional background levels rather than site-specific levels.

DP has also carried out groundwater contamination assessments for the neighbouring site to determine groundwater quality, including installation and sampling from groundwater wells. Given that the bulk of the fill materials will be removed as part of the basement excavation, it is likely that any on-site sources of existing groundwater contamination would be removed (e.g. primarily from historical fill materials). The overall risk of encountering (existing) groundwater contamination from on-site and off-site sources (if any) appear to be low, based on recent groundwater investigations at the site and neighbouring sites. There is, however, a risk of groundwater contamination migrating into the site via joints in the rock from future off-site sources or plumes (e.g. accidental chemical spill near the site). Based on the drawdown modelling, this risk is present if an off-site contamination source occurs within a radius of approximately 150 m of the site.

Further sampling and testing of the groundwater is likely to be required by the City of Sydney Council, to assess the quality and suitability of the groundwater prior to discharge into the stormwater system. Alternatively, groundwater could be discharged into sewers, subject to approval from Sydney Water, or to a licensed liquid waste facility. No disposal of groundwater to stormwater or sewer can be carried out until a permit is issued by Council (for stormwater disposal) or Sydney Water (sewer disposal). It is likely that a groundwater management plan will be required as part of the application for a dewatering license.

On the basis of the current information, any water collected on site should be stored in a holding tank prior to disposal for further assessment of contaminants (including iron), pH, oil and grease, suspended solids, volatile organic compounds and groundwater hardness. Subject to monitoring results, it is anticipated that groundwater will be suitable for disposal following appropriate treatment.

If treatment of contaminants is required by Council (stormwater discharge) or Sydney Water (sewer discharge), a remediation contractor can be engaged to devise a concept and/or detailed design of the treatment system. This would generally involve the following (or similar):

- Settlement tanks, to remove suspended solids from the dewatered excavation;
- Oil-water separator vessels, to recover floating product and separate sinking product (if any);
- Sand filtration, to remove fine sediment from the water stream;
- Aeration, to remove biological oxygen demand (BOD); and
- Granular activated carbon (GAC) filtration and resultant filtration to adsorb contaminants.

12. Conclusions

The groundwater level at the site has been measured in standpipes on the site to range from about RL11.4 m to RL13.7 m within the medium to high strength rock. A perched, intermittent groundwater table is also present within the near-surface fill and alluvial soils. The perched groundwater table is not expected to be adversely impacted by the proposed excavation, provided that the drainage systems of the neighbouring drained basements are functional. The proposed excavation is expected to extend to approximately 9.7 m to 12.0 m below the measured groundwater level, through medium to high strength sandstone.

An estimate of groundwater inflow into the new basement has been undertaken using 3-dimensional finite difference numerical modelling techniques (i.e. using the software package 'Visual MODFLOW Flex v7.0). The key findings and conclusions are summarised below:

- The annual inflow rates have been estimated to be in the order of 12.0 ML for the first year of basement construction, gradually decreasing to 3.0 ML per year for the long term, for basement excavation Scenario 1 (i.e. HFB to RL8.6 m). The predicted annual inflow rate for Scenario 2 (i.e. HFB to RL1.7 m) is 11.6 ML for the first year of basement construction, gradually decreasing to 3.0 ML per year over the long term. Based on our experience in other deep excavations nearby within sandstone bedrock, it is anticipated that the actual seepage into the excavation will be much lower than these predicted values, due to the low volumes of water stored within joints and other defects in the rock;
- If the predicted annual inflow is more than 3 ML per year, the proposed basement (if constructed as a 'drained' basement), will generally require a Water Access License and a Water Supply Work Approval. Consequently, approval for construction and long-term dewatering for the project is likely to be required from the relevant approval bodies (e.g. NRAR (DPIE) or Water NSW);
- On-going groundwater contamination testing and long-term on-site treatment may be required prior to discharge;
- Due to the high deformation modulus (compressibility) of the sandstone, any long-term drawdown of the groundwater level is not expected to cause significant settlement of neighbouring structures; and
- From a hydrogeological viewpoint, it is considered that a 'drained' basement is feasible without a significant impact on surrounding groundwater systems or property, subject to review and approval from Council and relevant authorities.

13. References

Cook, P.G. & CSIRO. Land and Water (2003). *A guide to regional groundwater flow in fractured rock aquifers*. Seaview Press, Henley Beach, South Australia.

DP (2021a), *Groundwater Monitoring Report*, Report 86884.02. R.004.Rev0, dated 15 July 2021.

DP (2021b), *Geotechnical Investigation*, Report 86884.02 R.001.Rev1, dated 23 July 2021.

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DP (2021d*), Geotechnical Investigation,* Report 86884.02 R.001.Rev0, dated 15 April 2021.

DP (2021e), *Factual Summary Report on Contamination Testing*, Report 86884.02. R.002.Rev0, dated 9 April 2021.

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McDonald, M.G., & Harbaugh, A.W. (1988), *MODFLOW, a modular three-dimensional finite difference groundwater flow model.* U.S. Geological Survey, Open-file report 83-875, Chapter A1.

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14. Limitations

Douglas Partners (DP) has prepared this report for this project at 2-8a Lee Street, Haymarket, in accordance with DP's proposal SYD201237.P.003.Rev0 dated 17 August 2021, and approval to proceed received from Mr. David Springford dated 25 October 2021. The work was carried out under an amended Toga Major Consultancy Services agreement (contract number CSC-01, dated 10 March 2021). This report is provided for the exclusive use of Toga Development and Construction Pty Ltd or their agents, for this project only and for the purposes as described in the report. It should not be used by or be 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 previous phases of site 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 budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached pages 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.

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 groundwater 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.

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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

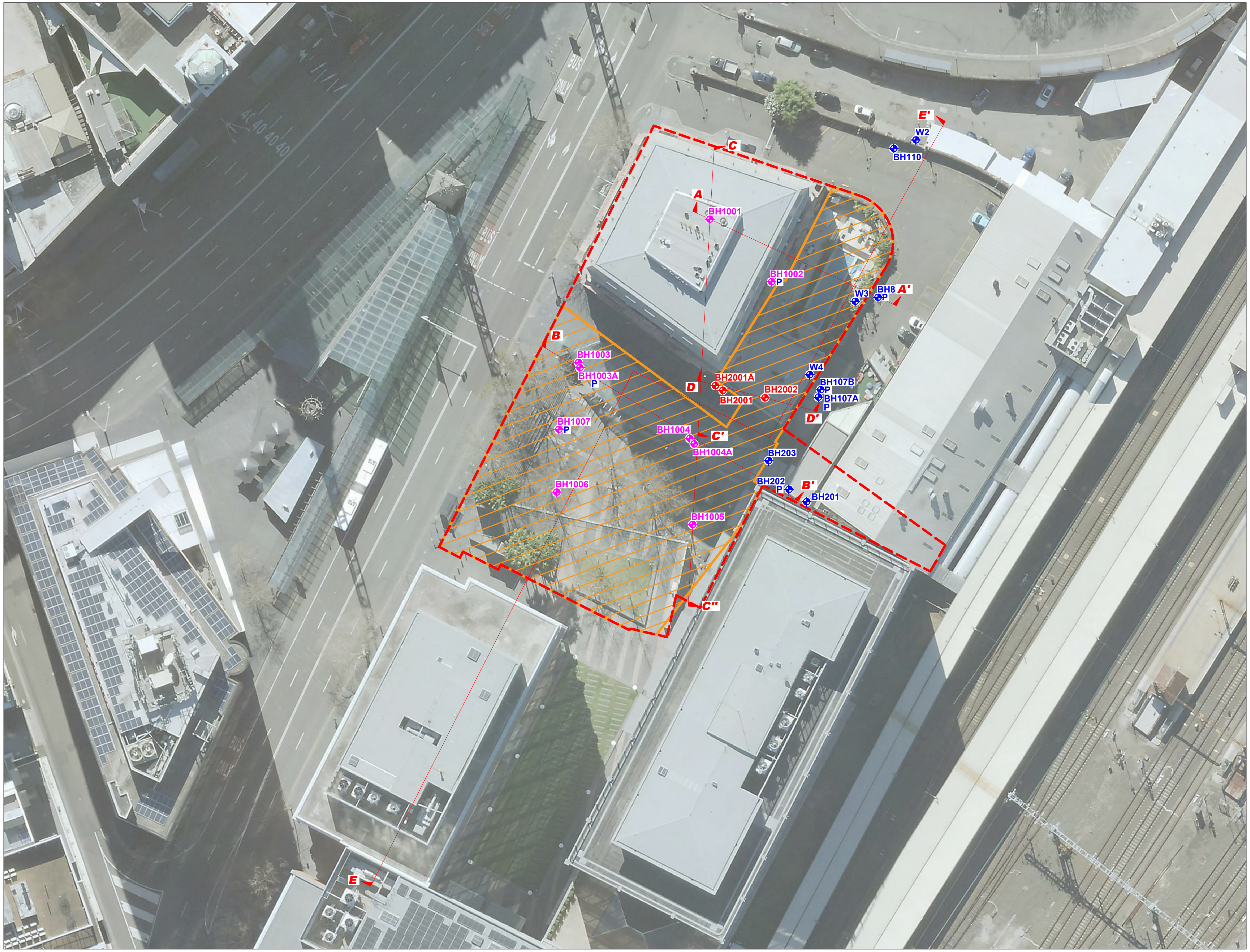
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate 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.

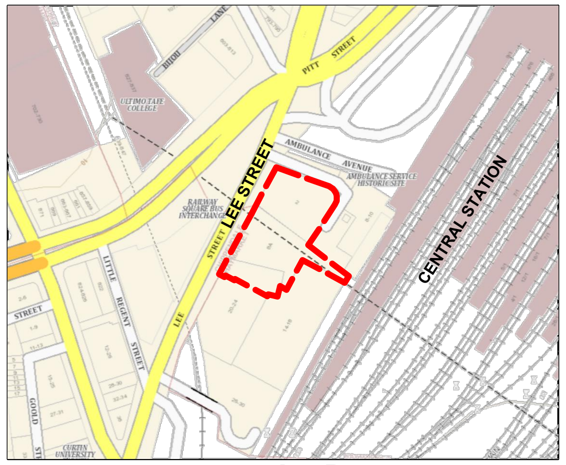
Site Inspection

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

LEGEND

BH ⊕	Previous Borehole Location, DP Reports 86767.00.R.006.Rev5 and 86767.07.R.001.Rev0
BH ⊕	Geotechnical Borehole, DP Report 86884.02.R.001.Rev0, dated April 2021
BH ⊕	Current Geotechnical Borehole
P	Standpipe Piezometer
- - -	Site Boundary
—	Approximate Extent of Excavation for Basement Level 3
⌊⌋	Interpreted Cross-Section

NOTE:
1: Base image from MetroMap, dated 30 July 2021
2: Approximate Extent of Basement Level 3 Outline is from Francis-Jones Morehen Thorp Pty Ltd, Drawing No. F3006, dated August 2020
3: Co-ordinate system relative to Map Grid of Australia 1994 (MGA94).

0 5 10 15 20 30 40 50 75m

1:750 @ A3

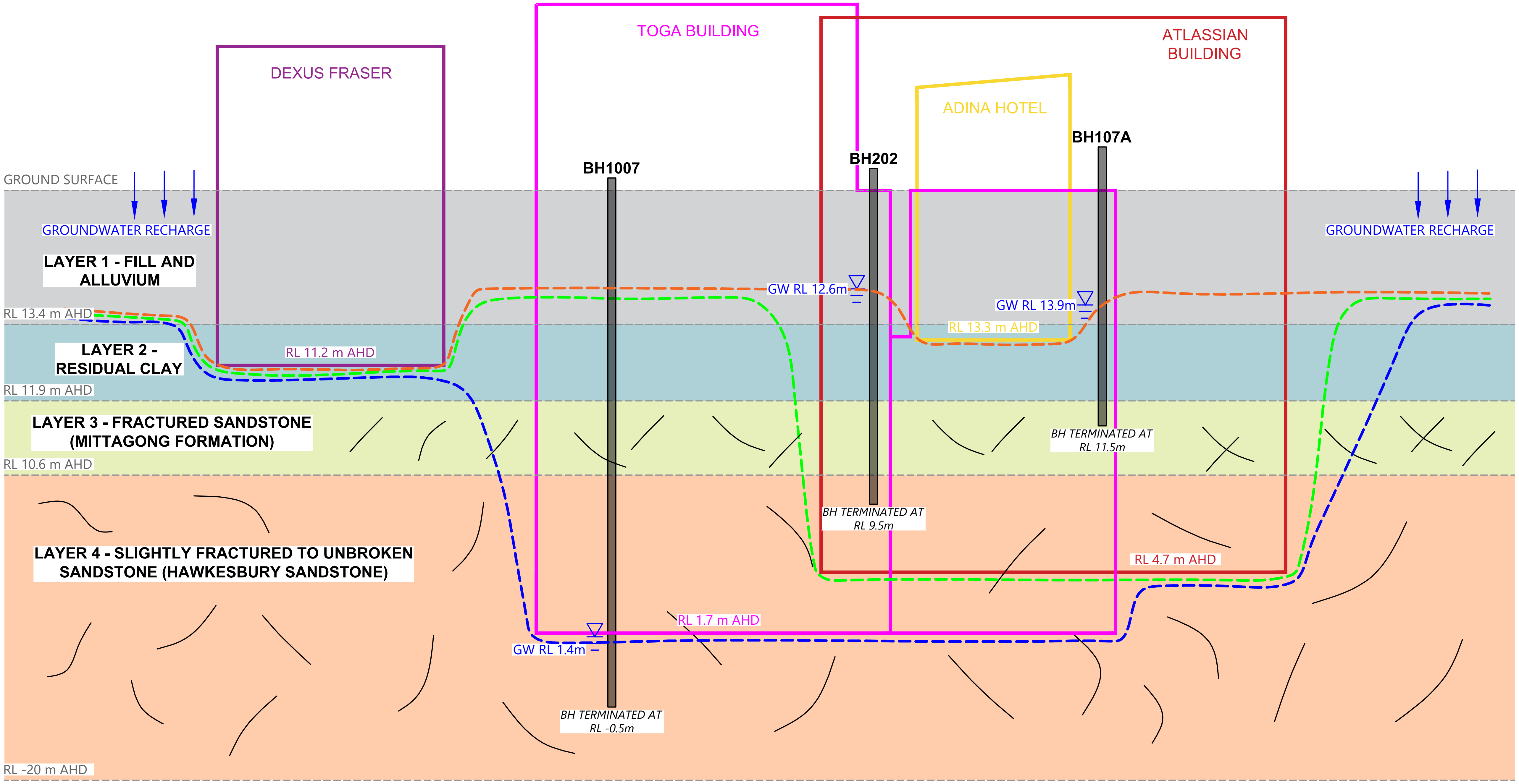
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Toga Development and Construction Pty Ltd
OFFICE: Sydney
DRAWN BY: MG
SCALE: 1:750 @ A3
DATE: 21.06.2022

TITLE: **Site and Test Location Plan**
Proposed Commercial Development
2-8A Lee Street, Haymarket

N

PROJECT No: 86884.02
DRAWING No: 1
REVISION: 3



NOTE:
1: The drawing is a diagrammatic representation of the Hydrogeological Conceptual Model.
2: The hydrogeological model is conceptual only, and does not reflect the encountered geotechnical conditions presented in the Geotechnical Report.

LEGEND

- - - - - Run 1 (Section 6.6) - Existing Groundwater Table without Atlassian Basement
- - - - - Run 2 (Section 6.6) - Groundwater Table with Atlassian Basement
- - - - - Run 3 (Section 6.6) - The Toga Basement Drain Cell Activated

Douglas Partners
Geotechnics / Environment / Groundwater

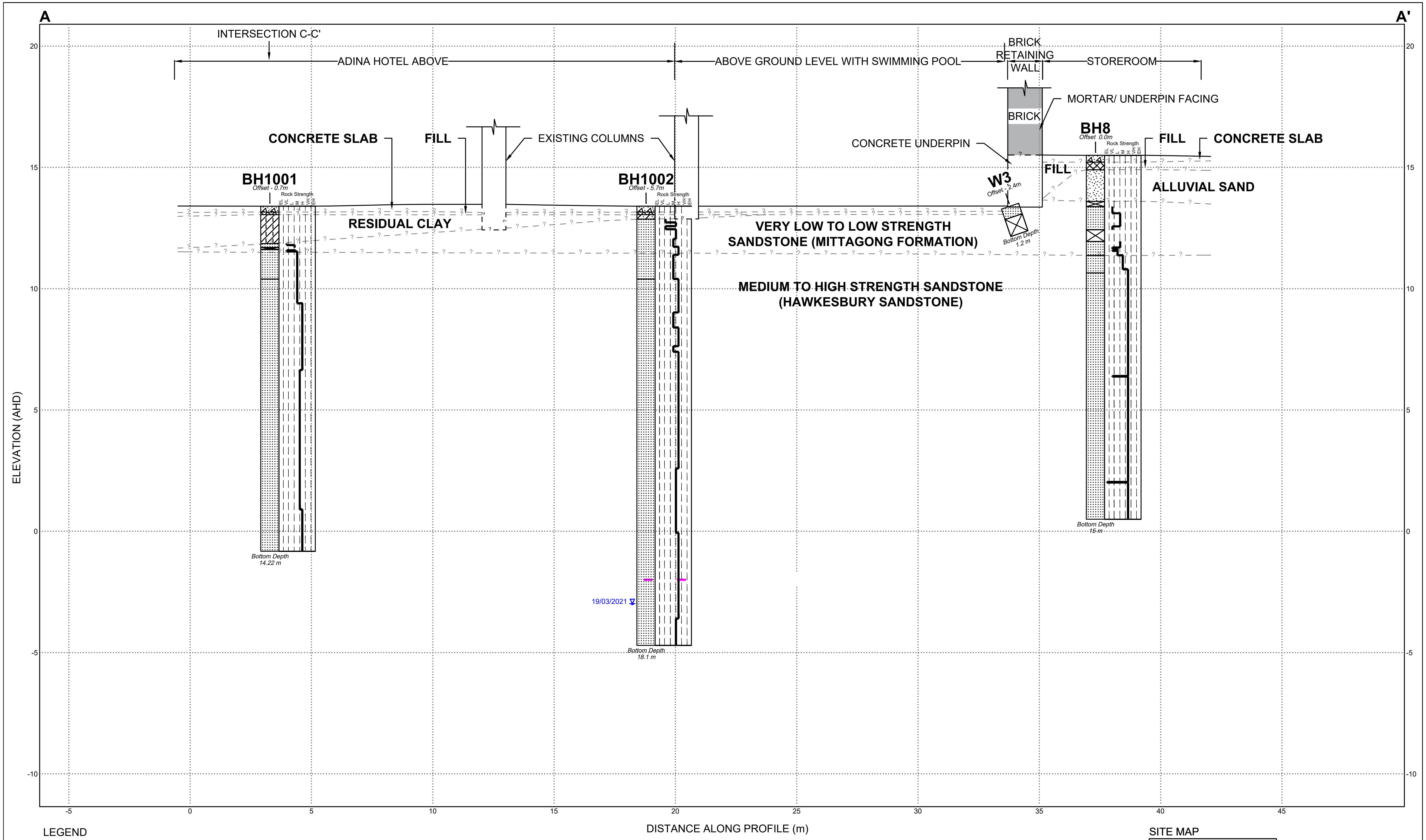
CLIENT: Toga Development and Construction Pty Ltd
OFFICE: Sydney
DRAWN BY: MG
SCALE: N.T.S.
DATE: 21.06.2022

TITLE: **Cross-Section E-E' - Hydrogeological Conceptual Site Model**
Proposed Commercial Development
2-8A Lee Street, Haymarket

PROJECT No: 86884.04
DRAWING No: 2
REVISION: 1

Appendix C

Results of Previous Site Investigation and Groundwater Level Monitoring Data



LEGEND

- ☒ Core Loss
- ▨ Concrete
- ▨ Filling
- ▨ Sand
- ▨ Sandstone
- ▨ Sandy Clay
- ▨ Silty Clay

NOTES:

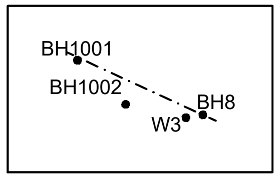
1. Subsurface conditions are accurate at the borehole locations only. Variations in subsurface conditions may occur between borehole locations. Interpreted strata boundaries are approximate and should be used as a guide only.
2. Summary logs only and should be read in conjunction with detailed logs.
3. Horizontal and vertical scales are equal.

TESTS / OTHER

- - Water level

— ? — — - Interpreted geotechnical boundary

SITE MAP



0 3

Horizontal Scale (metres)

Natural Scale

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Toga Development and Construction Pty Ltd

OFFICE: Sydney

DRAWN BY: HDS/MG

SCALE: 1:150 (H) 1:150 (V) @ A3

DATE: 26.03.2021

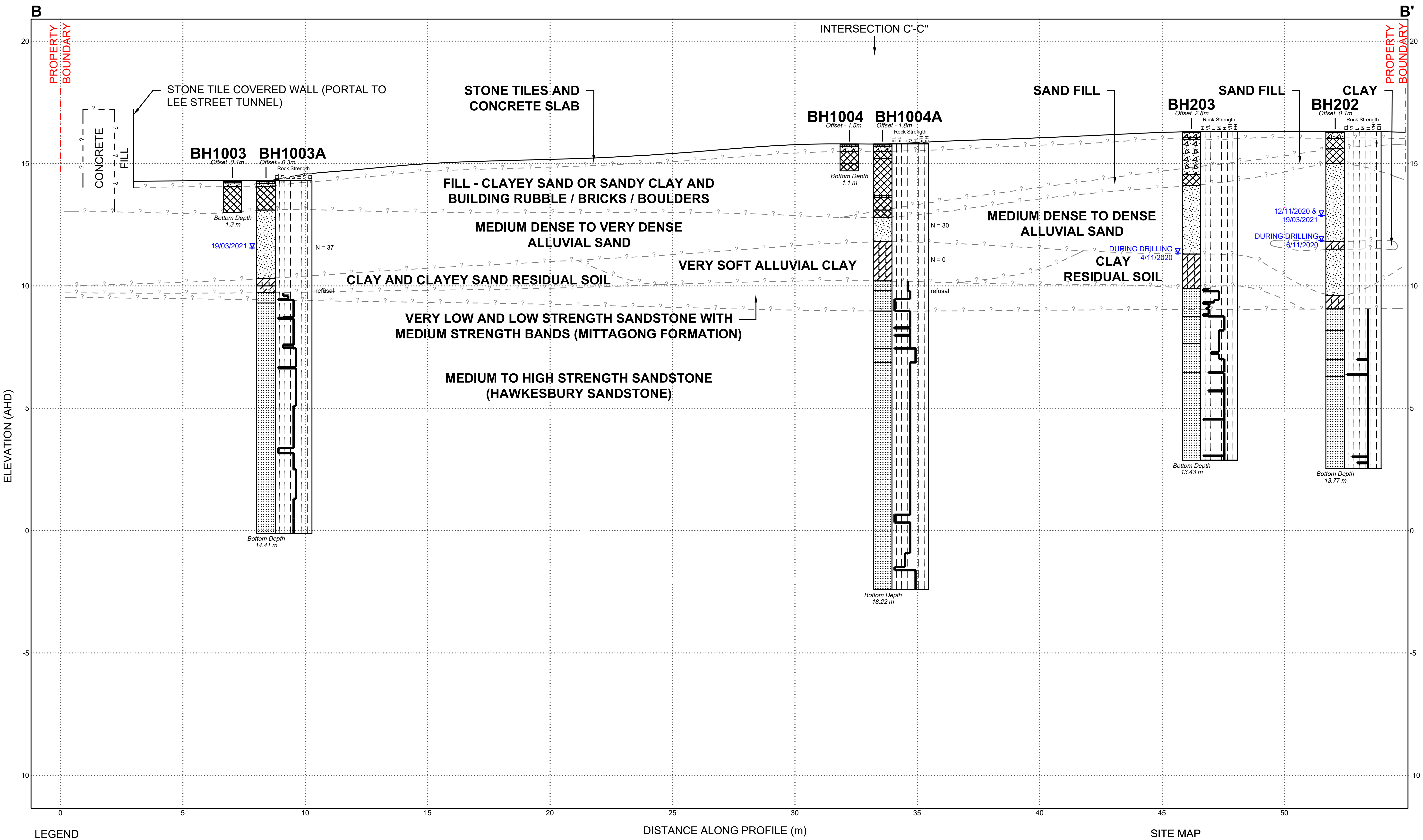
TITLE:

Interpreted Geotechnical Cross-Section A-A'
Proposed Commercial Development
2-8a Lee Street, Haymarket

PROJECT No: 86884.02

DRAWING No: 3

REVISION: 0



LEGEND

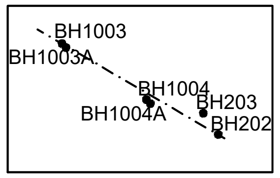
▩ Cemented sand	▤ Pavers
▨ Clayey Sand	░ Sand
▦ Concrete	▦ Sandstone
▩ Filling	▨ Silty Clay

NOTES:
1. Subsurface conditions are accurate at the borehole locations only. Variations in subsurface conditions may occur between borehole locations. Interpreted strata boundaries are approximate and should be used as a guide only.
2. Summary logs only and should be read in conjunction with detailed logs.
3. Horizontal and vertical scales are equal.

TESTS / OTHER

N - Standard penetration test value
▽ - Water level
— ? — - Interpreted geotechnical boundary

SITE MAP



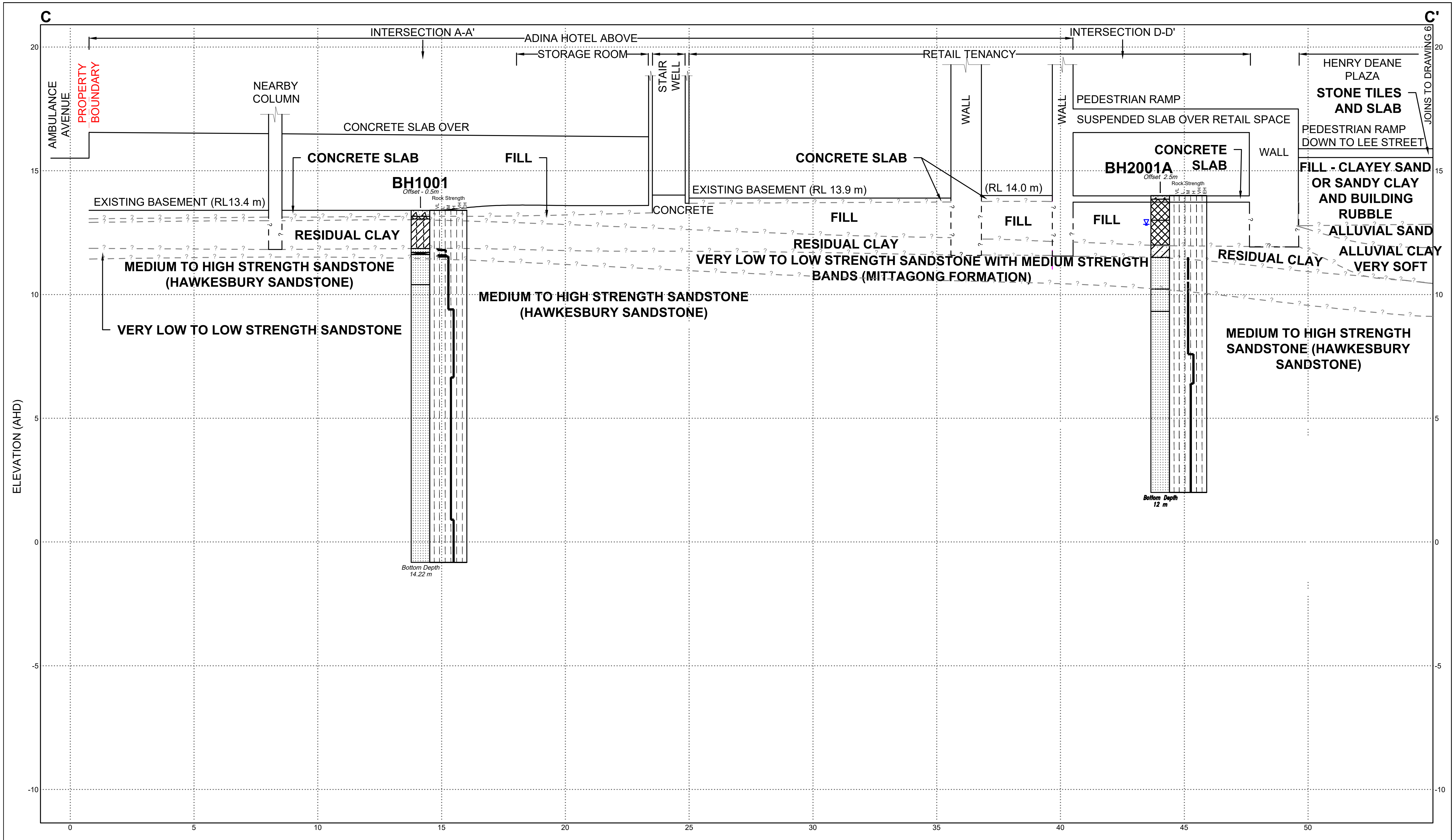
Natural Scale

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Toga Development and Construction Pty Ltd
OFFICE: Sydney
DRAWN BY: HDS/MG
SCALE: 1:150 (H) 1:150 (V) @ A3
DATE: 26.03.2021

TITLE: **Interpreted Geotechnical Cross-Section B-B'**
Proposed Commercial Development
2-8a Lee Street, Haymarket

PROJECT No: 86884.02
DRAWING No: 4
REVISION: 0



LEGEND

☒ Core Loss	▨ Silty Clay
Concrete	
Filling	
Sandstone	

NOTES:

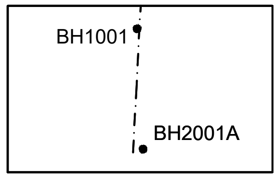
1. Subsurface conditions are accurate at the borehole locations only. Variations in subsurface conditions may occur between borehole locations. Interpreted strata boundaries are approximate and should be used as a guide only.
2. Summary logs only and should be read in conjunction with detailed logs.
3. Horizontal and vertical scales are equal.
4. Surface features based on plan from Synman Justin Bialek Architects Pty Ltd, Job No. 4000, Drawing No. WD 05, Rev. D, Dated 29 July 1999.

TESTS / OTHER

- Water level

— ? — — - Interpreted geotechnical boundary

SITE MAP



Horizontal Scale (metres)

Natural Scale

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Toga Development and Construction Pty Ltd

OFFICE: Sydney

DRAWN BY: HDS/MG

SCALE: 1:150 (H) 1:150 (V) @ A3

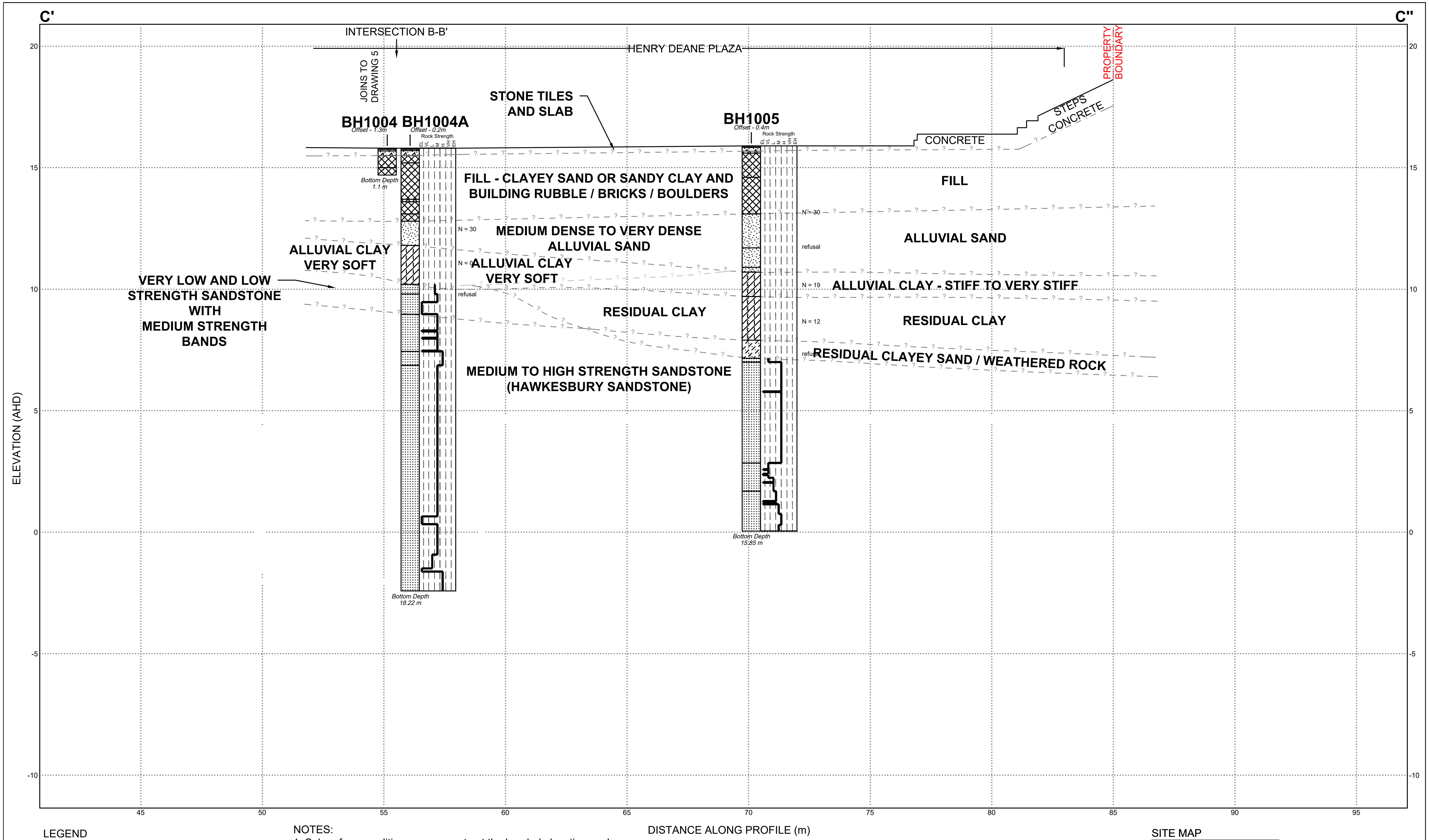
DATE: 30.06.2021

TITLE: **Interpreted Geotechnical Cross-Section C-C'**
Proposed Commercial Development
2-8a Lee Street, Haymarket

PROJECT No: 86884.02

DRAWING No: 5

REVISION: 1



LEGEND

▦ Cemented sand	▤ Pavers
▨ Clayey Sand	░ Sand
▩ Concrete	▦ Sandstone
▩ Filling	▨ Silty Clay

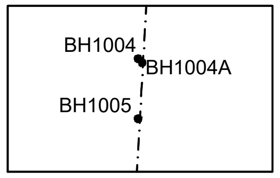
NOTES:

1. Subsurface conditions are accurate at the borehole locations only. Variations in subsurface conditions may occur between borehole locations. Interpreted strata boundaries are approximate and should be used as a guide only.
2. Summary logs only and should be read in conjunction with detailed logs.
3. Horizontal and vertical scales are equal.
4. Surface features based on plan from Synman Justin Bialek Architects Pty Ltd, Job No. 4000, Drawing No. WD 05, Rev. D, Dated 29 July 1999.

TESTS / OTHER

N - Standard penetration test value
▽ - Water level
— ? — - Interpreted geotechnical boundary

SITE MAP



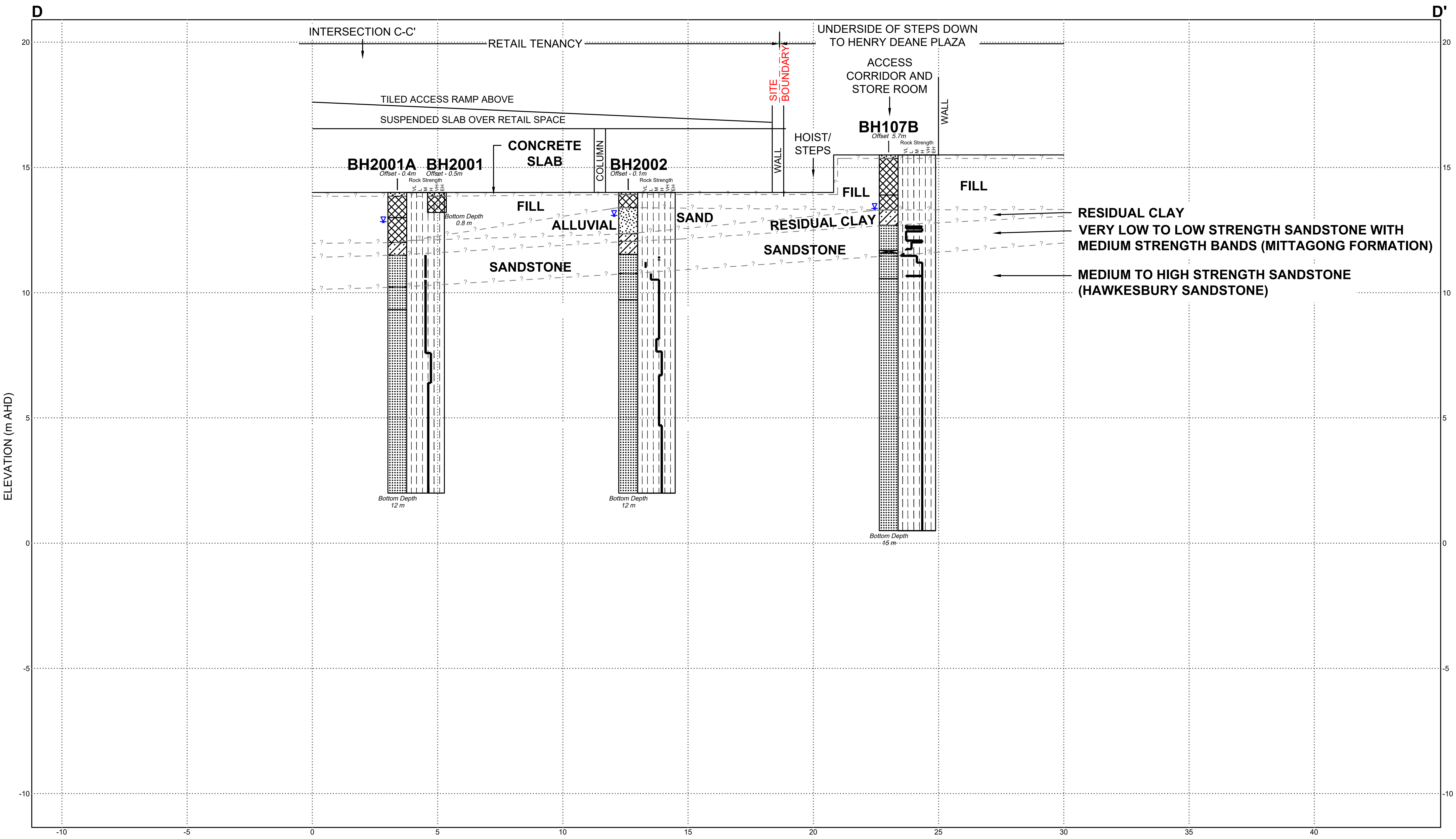
0 3
Horizontal Scale (metres)
Natural Scale

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Toga Development and Construction Pty Ltd
OFFICE: Sydney
DRAWN BY: HDS/MG
SCALE: 1:150 (H) 1:150 (V) @ A3
DATE: 30.06.2021

TITLE: **Interpreted Geotechnical Cross-Section C'-C''**
Proposed Commercial Development
2-8a Lee Street, Haymarket

PROJECT No: 86884.02
DRAWING No: 6
REVISION: 1



LEGEND

- ☒ Core Loss
- ▦ Concrete
- ▩ Filling
- ░ Sand
- ▦ Sandstone
- ▨ Sandy Clay

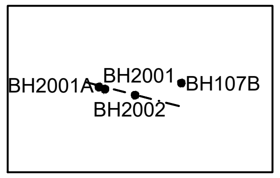
NOTES:

1. Subsurface conditions are accurate at the borehole locations only.
   Variations in subsurface conditions may occur between borehole locations.
   Interpreted strata boundaries are approximate and should be used as a guide only.
2. Summary logs only and should be read in conjunction with detailed logs.
3. Horizontal and vertical scales are equal.
4. Surface features based on plan from Synman Justin Bialek Architects Pty Ltd, Job No. 4000,
   Drawing No. WD 05, Rev. D, Dated 29 July 1999.

TESTS / OTHER

- ▽ - Water level
- — ? — — - Interpreted geotechnical boundary

SITE MAP



Horizontal Scale (metres)

Natural Scale

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Toga Development and Construction Pty Ltd

OFFICE: Sydney

DRAWN BY: HDS

SCALE: 1:150 (H) 1:150 (V) @ A3

DATE: 30.06.2021

TITLE: **Interpreted Geotechnical Cross-Section D-D'**
Proposed Commercial Development
2-8a Lee Street, Haymarket

PROJECT No: 86884.02

DRAWING No: 7

REVISION: 0

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 generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. 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	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

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

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with 'Mix of Soil and Cobbles/Boulders' with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

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
Friable	Fr	-

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	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

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;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

Dry (D)	Non-cohesive and free-running.
Moist (M)	Soil feels cool, darkened in colour. Soil tends to stick together. Sand forms weak ball but breaks easily.
Wet (W)	Soil feels cool, darkened in colour. Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- ‘Moist, dry of plastic limit’ or ‘w <PL’ (i.e. hard and friable or powdery).
- ‘Moist, near plastic limit’ or ‘w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- ‘Moist, wet of plastic limit’ or ‘w >PL’ (i.e. soils usually weakened and free water forms on the hands when handling).
- ‘Wet’ or ‘w ≈LL’ (i.e. near the liquid limit).
- ‘Wet’ or ‘w >LL’ (i.e. wet of the liquid limit).

Rock Strength

Rock strength is defined by the Unconfined Compressive Strength and it 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 Point Load Strength Index $Is_{(50)}$ is commonly used to provide an estimate of the rock strength and site specific correlations should be developed to allow UCS values to be determined. The point load strength test procedure is described by Australian Standard AS4133.4.1-2007. The terms used to describe rock strength are as follows:

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

* 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
Residual Soil	RS	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely weathered	XW	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible
Highly weathered	HW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately weathered	MW	The whole of the rock material is discoloured , usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly weathered	SW	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	FR	No signs of decomposition or staining.
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathered products in pores.

Rock Descriptions

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 occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

Rock Quality Designation

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

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

where 'sound' rock is assessed to be rock of low strength or stronger. 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

BOREHOLE LOG

CLIENT: Toga Development and Construction Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 2-8a Lee Street, Haymarket

SURFACE LEVEL: 13.4 m AHD
EASTING: 333935
NORTHING: 6249290
DIP/AZIMUTH: 90°/--

BORE No: BH1002
PROJECT No: 86884.02
DATE: 11/3/2021
SHEET 1 OF 2

Depth (m)	Description of Strata
	CONCRETE SLAB
0.24 0.35	FILL/MIXTURE OF GRAVEL and BRICKS: coarse sandstone gravel and bricks, brown, apparently in loose to medium dense condition
0.53	Sandy CLAY CI: medium plasticity, pale grey with pale brown, with fine sandstone gravel and silt, w~PL (affected by diatube), apparently very stiff, extremely weathered sandstone (Mittagong Formation)
0.67	SANDSTONE: medium grained, orange-brown and pale grey, bedded at 0°-10°, highly weathered, very low to low strength, fractured, Mittagong Formation
	SANDSTONE: medium to coarse grained, red-brown and orange-brown with some pale grey, with ironstone bands, distinct and indistinct bedding at 0°-10°, highly weathered, high strength with very low strength bands, slightly fractured, Hawkesbury Sandstone Below 1.67m: orange-brown and pale grey, moderately weathered to slightly weathered
3.0	SANDSTONE: medium to coarse grained, pale grey, cross-bedded at 10°-20°, with 20% fine grained, grey to dark grey sandstone laminations, medium or high strength, slightly weathered, slightly fractured to unbroken, Hawkesbury Sandstone Below 4.36m: grading to fresh Below 5.2m: distinct and indistinct bedding at 0°-20°, with 5-10% carbonaceous laminations and flecks

Sampling & In Situ Testing

Type	Depth	Sample	Results & Comments
A/E	0.25		PID<1ppm
A/E	0.35		PID<1ppm
	0.5		PL(A) = 0.1
	0.57		
A/E	0.9		PL(A) = 0.2
	0.91		
C	1.0		PL(A) = 1.1
	1.18		
	1.46		PL(A) = 0.4
C	1.5		
	1.96		PL(A) = 1.9
	2.29		PL(A) = 0.6
C	2.5		
	2.67		PL(A) = 0.5
	3.95		PL(A) = 1.1
C	4.0		
	4.42		PL(A) = 0.6
	4.95		PL(A) = 1.2
C	5.5		
	5.96		PL(A) = 0.7
	6.95		PL(A) = 1.7
C	7.0		
	7.19		PL(A) = 1.3
	7.95		PL(A) = 1.2
	8.3		PL(A) = 1.1
C	8.5		
	8.96		PL(A) = 1
	9.95		PL(A) = 1.6

Well Construction Details

Bentonite 0.0-1.3m

Sand filter
1.3-18.0m
Slotted PVC pipe

RIG: XC Drill **DRILLER:** Terratest **LOGGED:** IT **CASING:** HWT to 0.5m

TYPE OF BORING: Diatube (200mm dia.) to 0.24m, Solid Flight Auger (TC-bit) 0.24-0.53m, NMLC Coring 0.53-18.1m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Field replicate BD1/110311 collected from 0.35-0.5m; Groundwater well installed: blank PVC 0.0-1.5m, screen PVC 1.5-18.0m, bentonite 0.0-1.3m, gravel 1.3-18.0m, backfill 18.0-18.1m, gatic cover at the surface; 100% water loss from 16.0-18.1m

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

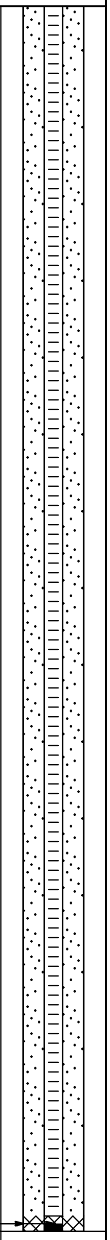
BOREHOLE LOG

CLIENT: Toga Development and Construction Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 2-8a Lee Street, Haymarket

SURFACE LEVEL: 13.4 m AHD
EASTING: 333935
NORTHING: 6249290
DIP/AZIMUTH: 90°/--

BORE No: BH1002
PROJECT No: 86884.02
DATE: 11/3/2021
SHEET 2 OF 2

Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	SANDSTONE: medium to coarse grained, pale grey, cross-bedded at 10°-20°, with 20% fine grained, grey to dark grey sandstone laminations, medium or high strength, slightly weathered, slightly fractured to unbroken, Hawkesbury Sandstone *(continued)*	C	10.03				1.5-18.0m
			10.92		PL(A) = 1.3		
		C	11.55				
			11.95		PL(A) = 0.8		
			12.95		PL(A) = 0.8		
		C	13.0				
			13.95		PL(A) = 1.4		
		C	14.5				
			14.95		PL(A) = 2.6		
			15.95		PL(A) = 1.2		
		C	16.0				
			16.38		PL(A) = 1.3	▼ 19-03-21	
	Between 17.10-17.35m: siltstone clasts, up to 10mm		17.38		PL(A) = 0.8		
		C	17.43				
18.1	Bore discontinued at 18.1m - Target depth reached		18.1				Backfill 18-18.1m End Cap



RIG: XC Drill **DRILLER:** Terratest **LOGGED:** IT **CASING:** HWT to 0.5m

TYPE OF BORING: Diatube (200mm dia.) to 0.24m, Solid Flight Auger (TC-bit) 0.24-0.53m, NMLC Coring 0.53-18.1m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Field replicate BD1/110311 collected from 0.35-0.5m; Groundwater well installed: blank PVC 0.0-1.5m, screen PVC 1.5-18.0m, bentonite 0.0-1.3m, gravel 1.3-18.0m, backfill 18.0-18.1m, gatic cover at the surface; 100% water loss from 16.0-18.1m

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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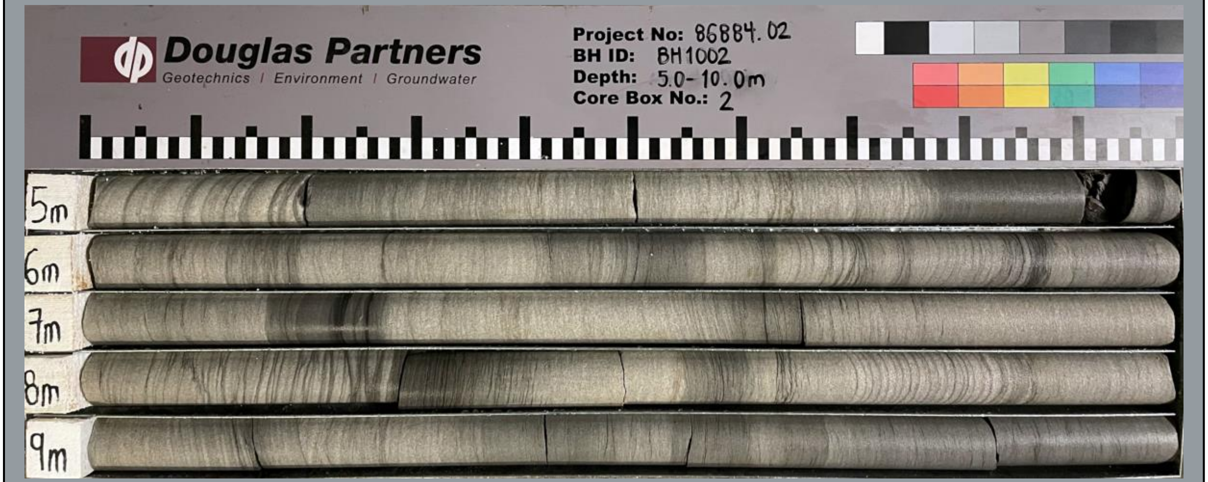
BORE: 1002 PROJECT: HAYMARKET MARCH 2021

0.53 – 5.0m

BORE: 1002 PROJECT: HAYMARKET MARCH 2021



5.0 – 10.0m

BORE: 1002 PROJECT: HAYMARKET MARCH 2021

10.0 – 15.0m

BORE: 1002 PROJECT: HAYMARKET MARCH 2021

15.0 – 18.1m

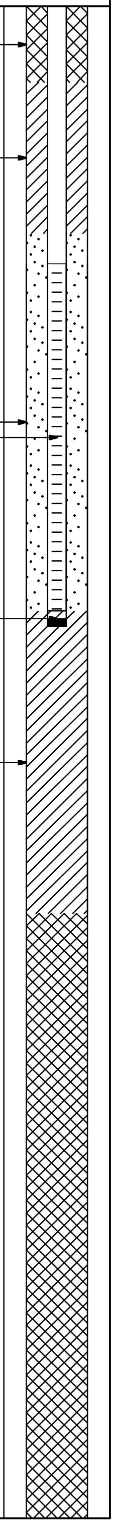
BOREHOLE LOG

CLIENT: Toga Development and Construction Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 2-8a Lee Street, Haymarket

SURFACE LEVEL: 14.3 m AHD
EASTING: 333900
NORTHING: 6249274
DIP/AZIMUTH: 90°/--

BORE No: BH1003A
PROJECT No: 86884.02
DATE: 10 - 19/3/2021
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.04	STONE TILE						
	0.12	SAND and CEMENT						
14	0.23	CONCRETE SLAB At 0.2m: 8mm steel reinforcement	A/E*	0.23 0.3		PID<1		Backfill 0-0.5m
		FILL/Clayey SAND: fine to medium, brown, with sandstone gravel and cobbles, concrete and brick rubble and bricks, trace ash and slag	A/E	0.8 0.9		PID<1		
	1							Bentonite 0.5-1.5m
13	1.2	SAND SP: medium, pale brown and pale grey, moist, medium dense, alluvial	A/E	1.4 1.5		PID<1		
	2		A/E*	1.9 2.0		PID<1		
12			S	2.5 2.95		8,15,22 N = 37	19-03-21	Sand filter 1.5-4.0m Slotted PVC pipe 1.7-4.0m
	3	Below 2.8m: dense						
11								
	4							
	4.0	Silty CLAY CI-CH: medium to high plasticity, pale grey and brown, with ironstone gravel, w<PL, apparently stiff to very stiff, residual soil						End Cap
10	4.3							
	4.58	Clayey SAND SC: medium, brown, moist, apparently medium dense to dense, extremely weathered sandstone	S	4.5 4.58 4.6		5/0 refusal PL(A) = 0.05		
	4.87	SANDSTONE: medium grained, brown, pale grey and red-brown, bedded at 0-10°, very low to low strength, highly weathered, fractured, Mittagong Formation						
9	5 5.0	SANDSTONE: medium to coarse grained, brown, pale grey and red-brown, cross-bedded at 0-20°, medium strength with extremely low and very low strength bands, highly weathered, slightly fractured, Hawkesbury Sandstone	C	5.51		PL(A) = 0.6		Bentonite fill 4.0-6m
	6			6.0				
8			C	6.34		PL(A) = 0.5		
	7	Below 6.85m: pale grey, distinct and indistinct bedding at 0-10° with some cross-bedding, medium and medium to high strength, slightly weathered then fresh		7.48 7.53		PL(A) = 1		
7								
	8		C					
6								
	9			8.95 9.13		PL(A) = 1		
5		Between 9.23-9.35m: grey, fine to medium grained band	C	9.86		PL(A) = 0.9		



RIG: NDD, hand tools, XC Drill **DRILLER:** Excavac, Terratest **LOGGED:** JS **CASING:** HW to 2.0m, HQ to 5.0m

TYPE OF BORING: Diatube (200mm dia.) to 0.23m, Non-Destructive Digging 0.23-2.0m, Solid Flight Auger (TC-bit) 2.0-4.58m, NMLC Coring 4.58-14.41m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Field replicate BD2/100321 from 0.23-0.30m and field replicate BD3/100321 from 1.9-2.0m; Groundwater well installed: Blank PVC 0.0-1.7m, screen PVC 1.7-4.0m, bentonite 0.5-1.5m and 4.0-6.0m, sand 1.5-4m, backfill 0-0.5m and 6.0-14.41m, gatic cover

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
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BOREHOLE LOG

CLIENT: Toga Development and Construction Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 2-8a Lee Street, Haymarket

SURFACE LEVEL: 14.3 m AHD
EASTING: 333900
NORTHING: 6249274
DIP/AZIMUTH: 90°/--

BORE No: BH1003A
PROJECT No: 86884.02
DATE: 10 - 19/3/2021
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
		SANDSTONE: medium to coarse grained, brown, pale grey and red-brown, cross-bedded at 0-20°, medium strength with extremely low and very low strength bands, highly weathered, slightly fractured, Hawkesbury Sandstone *(continued)*		C	10.56		PL(A) = 0.7		Backfill 6-14.41m
					10.66				
		Between 10.93-11.14m: extremely weathered seam		C	11.63		PL(A) = 0.8		
					12.19				
				C	12.93		PL(A) = 1		
					13.61				
		Between 13.58-13.84m: grey, fine to medium grained bed, with 10% dark grey siltstone laminations			13.72		PL(A) = 0.9		
				C					
	14.41	Bore discontinued at 14.41m - Target depth reached			14.41				

RIG: NDD, hand tools, XC Drill **DRILLER:** Excavac, Terratest **LOGGED:** JS **CASING:** HW to 2.0m, HQ to 5.0m

TYPE OF BORING: Diatube (200mm dia.) to 0.23m, Non-Destructive Digging 0.23-2.0m, Solid Flight Auger (TC-bit) 2.0-4.58m, NMLC Coring 4.58-14.41m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Field replicate BD2/100321 from 0.23-0.30m and field replicate BD3/100321 from 1.9-2.0m; Groundwater well installed: Blank PVC 0.0-1.7m, screen PVC 1.7-4.0m, bentonite 0.5-1.5m and 4.0-6.0m, sand 1.5-4m, backfill 0-0.5m and 6.0-14.41m, gatic cover

SAMPLING & IN SITU TESTING LEGEND

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

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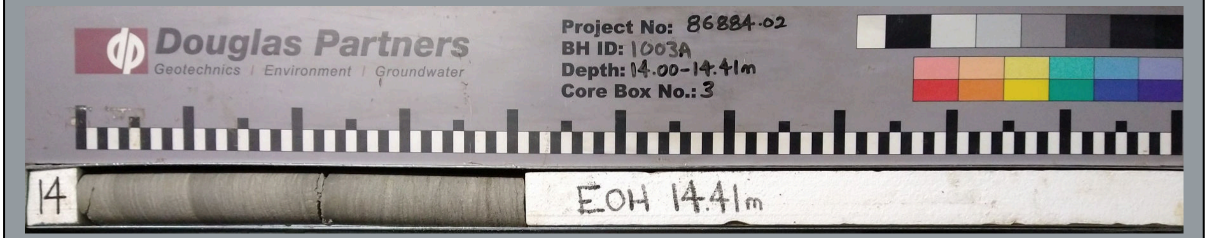
BORE: 1003A PROJECT: HAYMARKET MARCH 2021

4.58 – 9.0m

BORE: 1003A PROJECT: HAYMARKET MARCH 2021

9.0 – 14.0m

BORE: 1003A PROJECT: HAYMARKET MARCH 2021



Project No: 86884.02
BH ID: 1003A
Depth: 14.00-14.41m
Core Box No.: 3

14.0 – 14.41m

BOREHOLE LOG

CLIENT: Toga Development and Construction Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 2-8a Lee Street, Haymarket

SURFACE LEVEL: 15.8 m AHD
EASTING: 333896
NORTHING: 6249263
DIP/AZIMUTH: 90°/--

BORE No: BH1007
PROJECT No: 86884.02
DATE: 11 - 17/3/2021
SHEET 1 OF 2

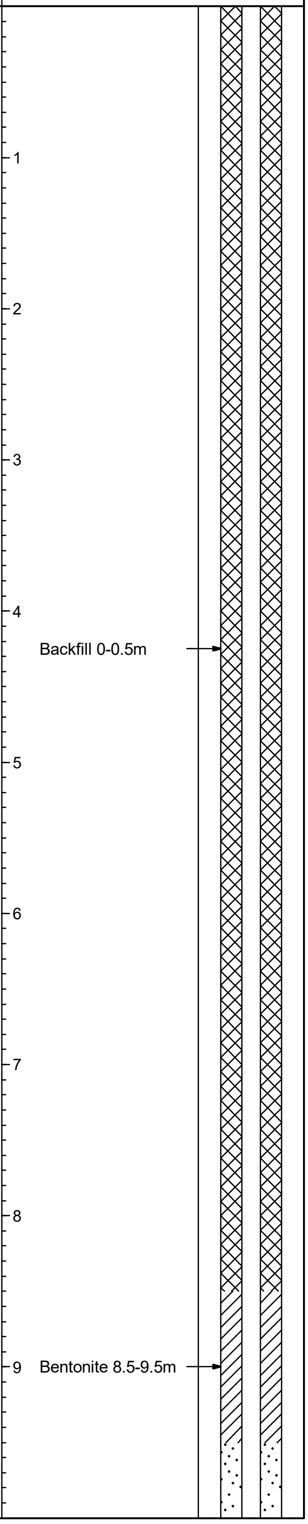
Depth (m)	Description of Strata
0.02	STONE TILE
0.07	SAND and CEMENT
0.2	CONCRETE SLAB Between 0.14-0.15m: 8mm steel reinforcement
	FILL/Clayey SAND: fine to medium, brown and grey, with sandstone gravel and cobbles, igneous rock cobble (railway ballast), concrete rubble and bricks, trace ash and slag
2.3	FILL/SAND: medium to coarse, pale brown and grey, with pale grey and red-brown silty clay and fine to medium gravel, moist
3.5	SAND SP: medium, pale grey, wet, dense, alluvial Below 5.0m: grading to loose
5.7	Silty CLAY CL-CI: low to medium plasticity, grey, trace fine gravel, w>PL, stiff to very stiff, alluvial
6.5	SAND SP: medium, brown, wet, medium dense, alluvial
7.2	Silty CLAY CI-CH: medium to high plasticity, pale grey and brown, with ironstone gravel, w>PL, very stiff, residual soil
8.0	Clayey SAND SC: medium to coarse, pale grey and brown, with silty clay layers, wet, medium dense, extremely weathered sandstone
9.2	SANDSTONE: brown, very low strength, Hawkesbury Sandstone
9.5	SANDSTONE: medium to coarse grained, brown, indistinct bedding at 0-10°, very low strength, highly weathered, fractured, Hawkesbury Sandstone
9.83	
10.0	

Sampling & In Situ Testing

Type	Depth	Sample	Results & Comments
A/E*	0.2 0.3		PID<1ppm
A/E	0.6 0.7		PID<1ppm
A/E	1.5 1.6		PID<1ppm
A/E	2.0 2.1		PID<1ppm
S/E	2.5 2.95		4,6,6 N = 12 PID60 ppm
S/E*	4.0 4.45		8,16,25 N = 41 PID16 ppm
S	5.5 5.95		pp = 100 3,7,9 N = 16
S	7.0 7.45		pp = 500 8,15,15 N = 30
S	8.5 8.95		20,13,8 N = 21
C	9.5 9.52		PL(A) = 0.1

Water: ▼ 16-03-21 (approx. 4.2m); ▼ 19-03-21 (approx. 9.2m)

Well Construction Details



RIG: NDD, hand tools, XC Drill **DRILLER:** Excavac, Terratest **LOGGED:** JS **CASING:** HW to 1.7m, HQ to 9.2m

TYPE OF BORING: Diatube (200mm dia.) to 0.2m, Non-Destructive Digging 0.2-1.6m, Solid Flight Auger (TC-bit) 1.6-8.5m, washbore 8.5-9.5m, NMLC coring 9.5-16.2m

WATER OBSERVATIONS: Free groundwater observed at 4.2m depth whilst augering

REMARKS: *Field replicates BD1/110321 from 0.2-0.3m and BD1/160321 from 4.0-4.45m; 20% water loss below 12.8 and 80% loss below 14.64m; Standpipe installed:- Blank PVC 0.0-10.2m, screen PVC 10.2-16.2m, bentonite 8.5-9.5m, sand 9.5-16.2m, backfill 0-0.5m, gatic

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: Toga Development and Construction Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 2-8a Lee Street, Haymarket

SURFACE LEVEL: 15.8 m AHD
EASTING: 333896
NORTHING: 6249263
DIP/AZIMUTH: 90°/--

BORE No: BH1007
PROJECT No: 86884.02
DATE: 11 - 17/3/2021
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
		SANDSTONE: refer following page			9.96		PL(A) = 1.2		
		SANDSTONE: medium to coarse grained, pale grey, distinct bedding at 0-10°, high strength, fresh, slightly fractured, Hawkesbury Sandstone *(continued)*		C					
					10.7				
5									
	11	Below 10.87m: with 5-10% fine to medium grained beds, and low to medium strength to 10.91m			10.94		PL(A) = 0.3		11
		Below 10.98m: medium strength to high strength, unbroken		C	11.44		PL(A) = 0.4		
4									
	12								12
					12.28				
3									Sand filter 9.5-16.2m
	13			C	12.96		PL(A) = 1.1		13
									Slotted PVC pipe 10.2-16.2m
					13.71				
2					13.94		PL(A) = 0.9		
	14								14
				C					
1									
	15				14.95		PL(A) = 1.5		15
					15.27		PL(A) = 0.8		
					15.3				
0				C					
	16				15.96		PL(A) = 1.3		16
	16.2	Bore discontinued at 16.2m - Target depth reached			16.2				End Cap
-1									
	17								17
-2									
	18								18
-3									
	19								19
-4									

RIG: NDD, hand tools, XC Drill **DRILLER:** Excavac, Terratest **LOGGED:** JS **CASING:** HW to 1.7m, HQ to 9.2m

TYPE OF BORING: Diatube (200mm dia.) to 0.2m, Non-Destructive Digging 0.2-1.6m, Solid Flight Auger (TC-bit) 1.6-8.5m, washbore 8.5-9.5m, NMLC coring 9.5-16.2m

WATER OBSERVATIONS: Free groundwater observed at 4.2m depth whilst augering

REMARKS: *Field replicates BD1/110321 from 0.2-0.3m and BD1/160321 from 4.0-4.45m; 20% water loss below 12.8 and 80% loss below 14.64m; Standpipe installed:- Blank PVC 0.0-10.2m, screen PVC 10.2-16.2m, bentonite 8.5-9.5m, sand 9.5-16.2m, backfill 0-0.5m, gatic

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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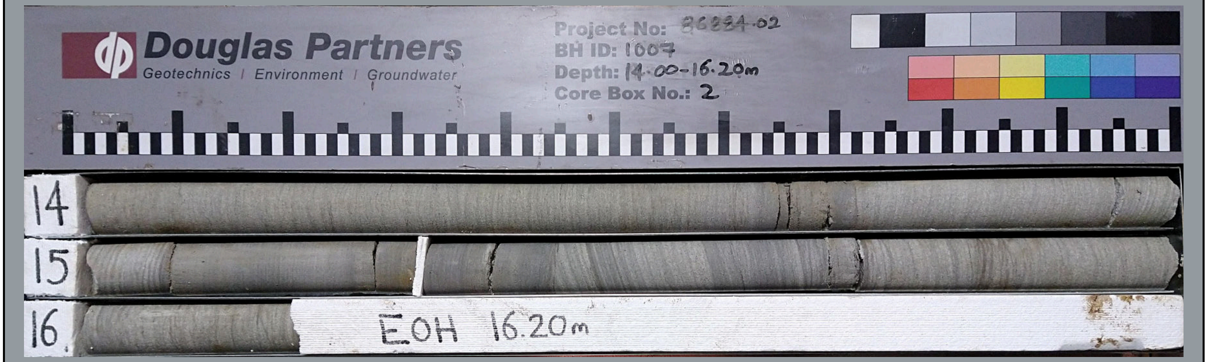
BORE: 1007 PROJECT: HAYMARKET MARCH 2021

9.5 – 14.0m

BORE: 1007 PROJECT: HAYMARKET MARCH 2021



14.0 – 16.2m

BOREHOLE LOG

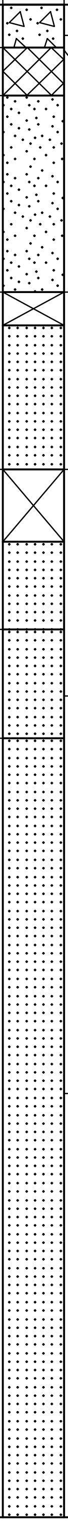
CLIENT: Atlassian Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 8-10 Lee Street, Haymarket

SURFACE LEVEL: 15.5 AHD
EASTING: 333954
NORTHING: 6249289
DIP/AZIMUTH: 90°/--

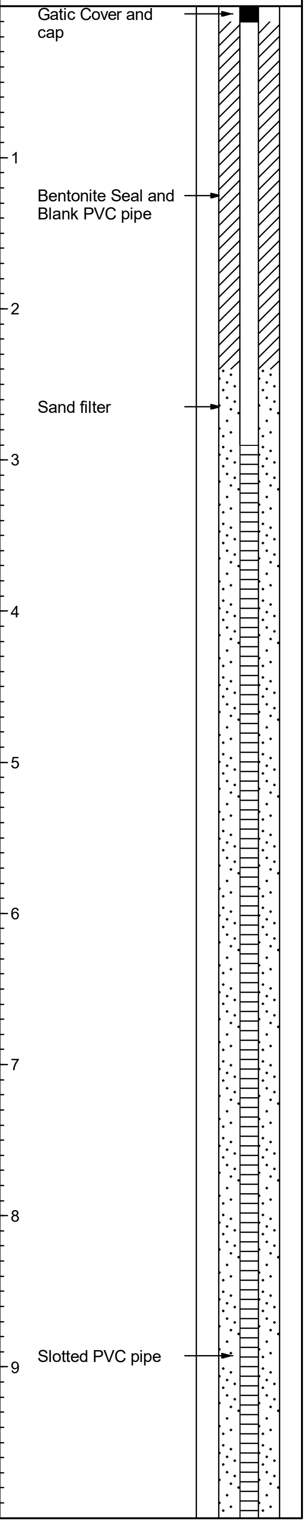
BORE No: BH8
PROJECT No: 86767.00
DATE: 14/7/2019
SHEET 1 OF 2

Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
0.28	CONCRETE SLAB: angular to subangular aggregate to 15mm, negligible voids, 10mm diameter steel reinforcement at 0.09m and 0.10m, plastic at lower interface	A/E	0.2 0.3		PID<1	
0.6	Fill/Clayey SAND: fine to coarse grained sand, brown and yellow, 15% plastic fines, with fine gravel, apparently moderately compacted, moist					
	SAND SW: fine to medium grained sand, yellow, with clay, trace gravel, moist, alluvial soil					
1.9 2.12	SANDSTONE: medium grained, orange-red and grey, low to medium strength, with some very low strength bands, highly weathered, fractured, Mittagong Formation	C	1.9 2.47		PL(A) = 1.5	
3.07 3.55	SANDSTONE: medium grained, orange and red, medium strength with some very low strength bands, highly weathered, fractured, Mittagong Formation	C	3.07 3.66		PL(A) = 0.15	
4.13	SANDSTONE: medium grained, yellow-grey, medium then high strength, moderately weathered, slightly fractured, Hawkesbury Sandstone	C	4.57 4.66		PL(A) = 0.66	
4.85	SANDSTONE: medium grained, grey, high strength, fresh, unbroken, Hawkesbury Sandstone		5.95		PL(A) = 1.2	
			6.95		PL(A) = 1.3	
		C	7.2 7.89		PL(A) = 1.9	
			8.95		PL(A) = 1.2	
			9.95		PL(A) = 1.4	

RL: 15, 14, 13, 12, 11, 10, 9, 8, 7, 6



Well Construction Details



RIG: XC **DRILLER:** Terratest **LOGGED:** NB **CASING:** HQ to 1.9m

TYPE OF BORING: Diacore 0-0.28m; Hand auger 0.28-1.0m; solid flight auger (TC Bit) 1.0-1.9m; NMLC coring 1.9-15.0m

WATER OBSERVATIONS: No groundwater observed during auger drilling

REMARKS: Groundwater well installed: 15.0-2.9m screened PVC with sand backfill, 2.9-2.4m blank PVC with sand backfill, 2.4-0m blank PVC, 2.4-0m bentonite backfill, gatic cover at surface.

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

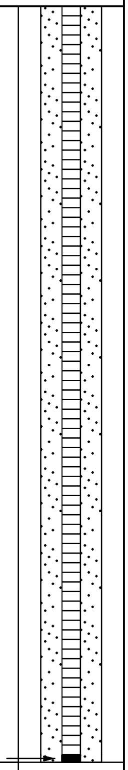
BOREHOLE LOG

CLIENT: Atlassian Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 8-10 Lee Street, Haymarket

SURFACE LEVEL: 15.5 AHD
EASTING: 333954
NORTHING: 6249289
DIP/AZIMUTH: 90°/--

BORE No: BH8
PROJECT No: 86767.00
DATE: 14/7/2019
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
		SANDSTONE: medium grained, grey, high strength, fresh, unbroken, Hawkesbury Sandstone *(continued)* Between 10.2-10.9m: dark grey, fine grained sandstone		C	10.22				
				C	10.95		PL(A) = 2.5		
					11.95		PL(A) = 1.5		
		Between 12.4-12.55m: carbonaceous laminations							
					12.95		PL(A) = 1.1		
					13.25				
				C	13.95		PL(A) = 1.3		
					14.99		PL(A) = 1.3		
	15.0	Bore discontinued at 15.0m			15.0				End Cap



RIG: XC **DRILLER:** Terratest **LOGGED:** NB **CASING:** HQ to 1.9m

TYPE OF BORING: Diacore 0-0.28m; Hand auger 0.28-1.0m; solid flight auger (TC Bit) 1.0-1.9m; NMLC coring 1.9-15.0m

WATER OBSERVATIONS: No groundwater observed during auger drilling

REMARKS: Groundwater well installed: 15.0-2.9m screened PVC with sand backfill, 2.9-2.4m blank PVC with sand backfill, 2.4-0m blank PVC, 2.4-0m bentonite backfill, gatic cover at surface.

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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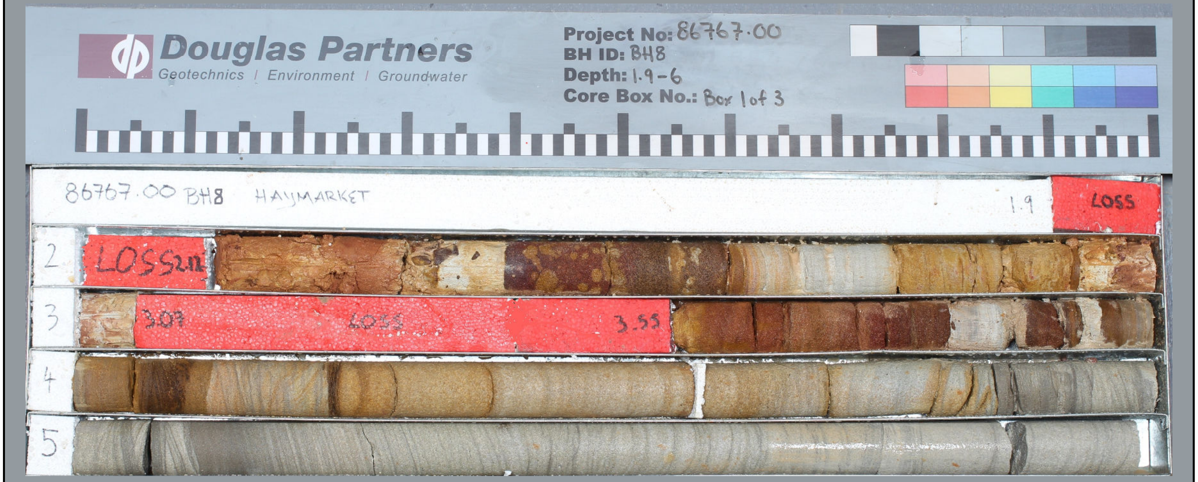
Geotechnics / Environment / Groundwater

BORE: BH8 PROJECT: HAYMARKET AUGUST 2019



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Project No: 86767.00
BH ID: BH8
Depth: 1.9-6
Core Box No.: Box 1 of 3

1.9 – 6m

BORE: BH8 PROJECT: HAYMARKET AUGUST 2019

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Project No: 86767.00
BH ID: BH8
Depth: 6-11
Core Box No.: Box 2 of 3

6m – 11m

BORE: BH8 PROJECT: HAYMARKET AUGUST 2019

11m – 15.19m

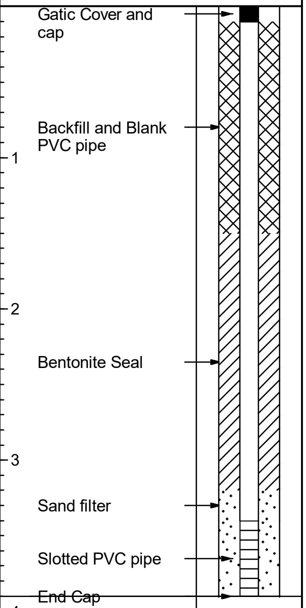
BOREHOLE LOG

CLIENT: Vertical First Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 8-10 Lee Street, Haymarket

SURFACE LEVEL: 15.5 AHD
EASTING: 333945
NORTHING: 6249270
DIP/AZIMUTH: 90°/--

BORE No: BH107A
PROJECT No: 86767.00
DATE: 17/5/2020
SHEET 1 OF 1

Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
0.14	CONCRETE: grey, angular to subangular aggregate to 15mm, negligible voids, 9 mm steel reinforcement at 0.08 m depth					
	FILL/ Sandy CLAY: low to medium plasticity, dark red and brown, fine to medium, with angular igneous and sandstone gravel, trace silt, w<PL, generally in a stiff condition Below 1.0m: grading to medium plasticity, dark grey, trace sandstone gravel, w~PL					
1.6	FILL/ Silty CLAY: medium to high plasticity, pale grey-yellow, with fine to medium sand, w~PL, generally in a stiff condition					▼ 05-06-20
2.2	Sandy CLAY CL: low to medium plasticity, pale yellow, fine to medium, w~PL, apparently stiff to very stiff, residual Below 2.6m: yellow-brown					
2.81	SANDSTONE: fine to medium grained, pale grey and red-brown, high strength with very low then low strength bands, highly weathered, fractured, Mittagong Formation					
3.9	Bore discontinued at 3.9m - Target depth reached					



RIG: Miniprobe **DRILLER:** Terratest **LOGGED:** NB **CASING:** NA
TYPE OF BORING: SFA (TC-bit) to 3.9m
WATER OBSERVATIONS: No free groundwater observed whilst augering
REMARKS: Standpipe installed: 0-3.4m Blank PVC pipe, 3.4-3.9m Slotted PVC pipe, End cap at 3.9m, Sand backfill 0-1.5m, Bentonite 1.5-3.2m, Sand filter 3.2-3.9m, Gatic cover at surface.

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: Vertical First Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 8-10 Lee Street, Haymarket

SURFACE LEVEL: 15.5 AHD
EASTING: 333945
NORTHING: 6249272
DIP/AZIMUTH: 90°/--

BORE No: BH107B
PROJECT No: 86767.00
DATE: 16/5/2020
SHEET 1 OF 2

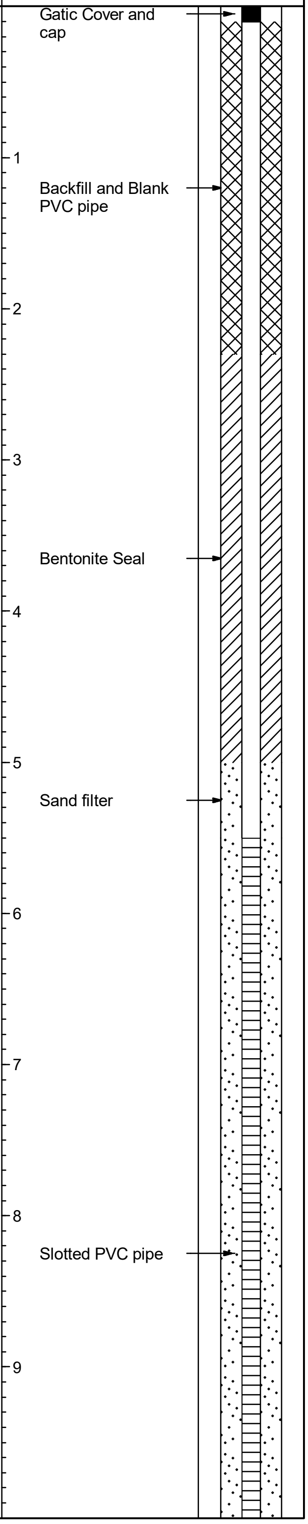
Depth (m)	Description of Strata
	CONCRETE: grey, angular to subangular aggregate to 15mm, negligible voids, 9 mm steel reinforcement at 0.08 m depth
0.14	FILL/ Sandy CLAY: low to medium plasticity, dark red and brown, fine to medium, with angular igneous and sandstone gravel, trace silt, w<PL, generally in a stiff condition Below 1.0m: grading to medium plasticity, dark grey, trace sandstone gravel, w~PL
1.6	FILL/ Silty CLAY: medium to high plasticity, pale grey-yellow, with fine to medium sand, w~PL, generally in a stiff condition
2.2	Sandy CLAY CL-CI: low to medium plasticity, pale yellow, fine to medium, w~PL, apparently stiff to very stiff, residual Below 2.6m: yellow-brown
2.81	SANDSTONE: fine to medium grained, pale grey and red-brown, high strength with very low then low strength bands, highly weathered, fractured, Mittagong Formation
3.92	
4.03	SANDSTONE: fine to medium grained, pale grey and red-brown, medium then high strength, moderately weathered, fractured, Hawkesbury Sandstone
4.94	SANDSTONE: fine to medium grained, pale grey, high strength, fresh, slightly fractured to unbroken, cross-bedding 5°-10°, Hawkesbury Sandstone Between 7.66m-8.10m: band of fine grained sandstone

Sampling & In Situ Testing

Type	Depth	Sample	Results & Comments
A	0.15 0.2		PID=4
A/E*	0.4 0.5		PID=5
A/E	0.9 1.0		PID=2
A/E	1.4 1.5		PID=2
A/E	1.9 2.0		PID=2
A/E	2.4 2.5		PID=1
A/E	2.65 2.8		PID=2
C	2.81 2.94		PL(A) = 1.1
	3.57		PL(A) = 0.1
	3.62		
C	4.25		PL(A) = 0.9
	5.0		PL(A) = 1.5
	5.12		
C	6.0		PL(A) = 1.1
	6.59		
C	7.0		PL(A) = 1.3
	8.0		PL(A) = 1.6
	8.12		
C	9.0		PL(A) = 1.1
	10.0		PL(A) = 1.3

Water: 05-06-20 (at 2.0 m)

Well Construction Details



RIG: XC **DRILLER:** Terratest **LOGGED:** KR **CASING:** HWT to 2.8m

TYPE OF BORING: Diatube (200 mm) to 0.14m, SFA (TC-bit) to 2.81m, NMLC coring to 15.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *BD1/20200516 taken at 0.4-0.5m. Standpipe installed: 0-5.5m Blank PVC pipe, 5.5-11.0m Slotted PVC pipe, End cap at 11.0m, Sand backfill 0-2.3m, Bentonite 2.3-5.0m, Sand filter 5.0-11.0m, Bentonite 11.0-12.0m, Backfill 12.0-15.0m, Gatic cover at surface.

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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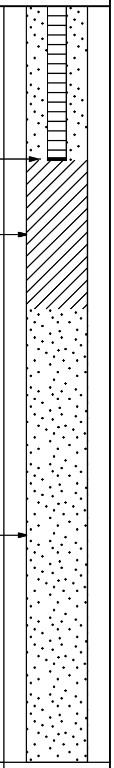
BOREHOLE LOG

CLIENT: Vertical First Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 8-10 Lee Street, Haymarket

SURFACE LEVEL: 15.5 AHD
EASTING: 333945
NORTHING: 6249272
DIP/AZIMUTH: 90°/--

BORE No: BH107B
PROJECT No: 86767.00
DATE: 16/5/2020
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
5		SANDSTONE: fine to medium grained, pale grey, high strength, fresh, slightly fractured to unbroken, cross-bedding 5°-10°, Hawkesbury Sandstone *(continued)*		C					
	11				11.02 11.07		PL(A) = 1.1		11 End Cap
4									Bentonite Seal
	12				12.0		PL(A) = 1.1		12
3		Between 12.60m-13.78m: band of fine grained sandstone		C					
	13				13.03		PL(A) = 1		13
2									Sand Back Fill
	14				14.0 14.08		PL(A) = 1.2		14
1				C					
	15 15.0	Bore discontinued at 15.0m - Target depth reached			15.0				15
0									
	16								16
-1									
	17								17
-2									
	18								18
-3									
	19								19
-4									



RIG: XC **DRILLER:** Terratest **LOGGED:** KR **CASING:** HWT to 2.8m

TYPE OF BORING: Diatube (200 mm) to 0.14m, SFA (TC-bit) to 2.81m, NMLC coring to 15.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *BD1/20200516 taken at 0.4-0.5m. Standpipe installed: 0-5.5m Blank PVC pipe, 5.5-11.0m Slotted PVC pipe, End cap at 11.0m, Sand backfill 0-2.3m, Bentonite 2.3-5.0m, Sand filter 5.0-11.0m, Bentonite 11.0-12.0m, Backfill 12.0-15.0m, Gatic cover at surface.

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: 107B PROJECT: HAYMARKET MAY 2020

2.81 – 7.0 m

BORE: 107B PROJECT: HAYMARKET MAY 2020

7.0 – 12.0 m

BORE: 107B PROJECT: HAYMARKET MAY 2020

12.0 – 15.0 m

BOREHOLE LOG

CLIENT: Vertical First Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 8-10 Lee Street, Haymarket

SURFACE LEVEL: 15.3 AHD
EASTING: 333970
NORTHING: 6249311
DIP/AZIMUTH: 90°/--

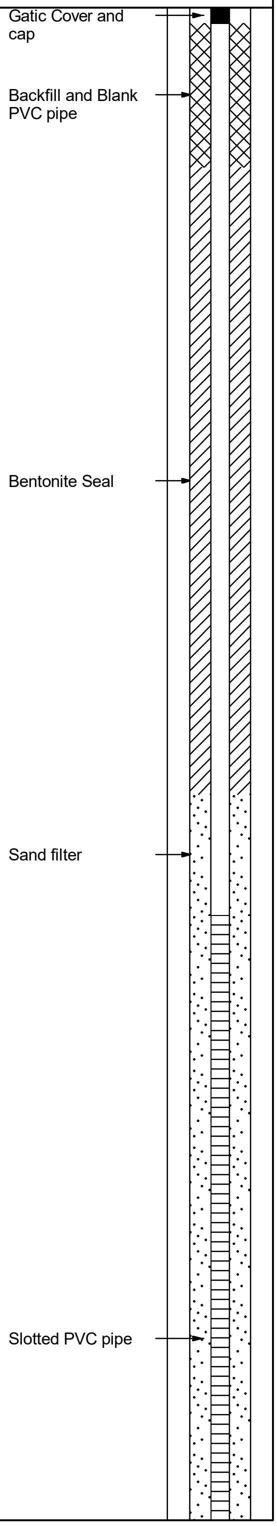
BORE No: BH109B
PROJECT No: 86767.00
DATE: 17/5/2020
SHEET 1 OF 2

Depth (m)	Description of Strata
0.2	CONCRETE: grey, angular to subangular aggregate to 15mm, negligible voids, no reinforcement steel observed
0.3	FILL/ GRAVEL: coarse, black, angular igneous gravel bonded by bitumen, dry, generally in a dense condition
1.05	Silty CLAY CI: medium plasticity, pale orange, w<PL, apparently stiff to very stiff, residual (possibly extremely weathered Mittagong Formation)
	SANDSTONE: fine to medium grained, pale grey and dark orange, highly weathered, medium strength, fractured, Hawkesbury Sandstone
2.93	SANDSTONE: fine to coarse grained, pale grey and pale yellow, moderately weathered then slightly weathered, medium strength, slightly fractured, cross-bedding 5°-10°, Hawkesbury Sandstone
4.9	SANDSTONE: fine to coarse grained, pale grey, fresh, medium then high strength, slightly fractured then unbroken, cross-bedding 5°-10°, Hawkesbury Sandstone

Sampling & In Situ Testing

Type	Depth	Sample	Results & Comments
A/E	0.4 0.5		PID<1
A/E	0.9 1.05		PID<1
	1.16		PL(A) = 1.8
C	1.65		
	2.11		PL(A) = 0.7
C	3.1 3.11		PL(A) = 0.5
C	3.92		PL(A) = 0.7
	4.65		
	4.93 5.04		PL(A) = 0.9 PL(A) = 1
C	6.0		PL(A) = 0.7
C	7.0		PL(A) = 1.2
	7.4		
C	7.75		
	8.0		PL(A) = 1.8
C	9.0		PL(A) = 1.9
	9.25		
C	10.0		PL(A) = 1.4

Water: 09-06-20



RIG: XC **DRILLER:** Terratest **LOGGED:** NB **CASING:** HWT to 1.05m

TYPE OF BORING: Diatube (200mm) to 0.2m, SFA (TC-bit) to 1.05m, NMLC coring to 15m

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: Standpipe installed: 0-6.0m Blank PVC pipe, 6.0-11.6m Slotted PVC pipe, End cap at 11.6m, Sand backfill 0-1.05m, Bentonite 1.05-5.2m, Sand filter 5.2-11.6m, Bentonite 11.6-13.0m, Backfill 13.0-15.0m, Gatic cover at surface. Surface level taken from survey

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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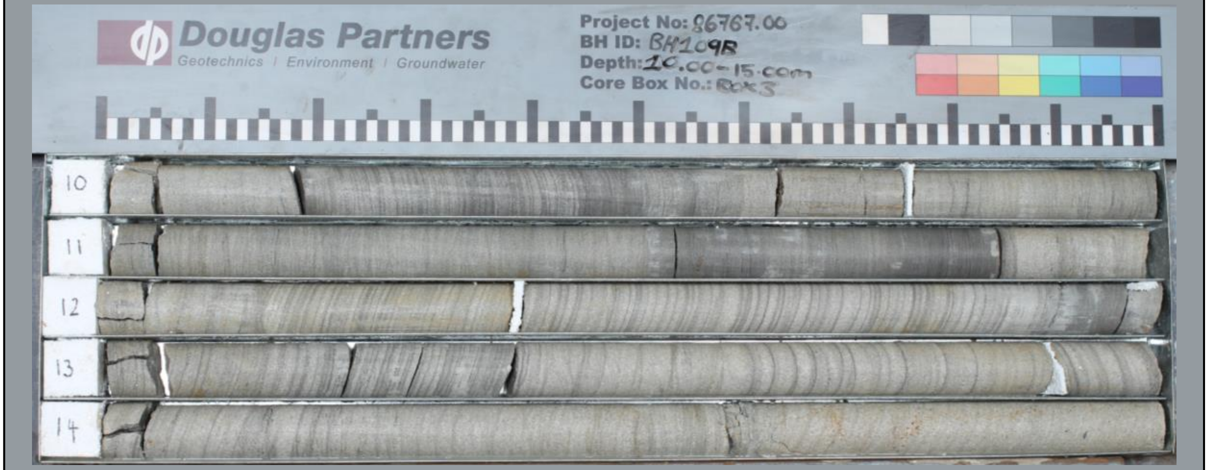
BORE: 109B PROJECT: HAYMARKET MAY 2020

1.05 – 5.0 m

BORE: 109B PROJECT: HAYMARKET MAY 2020

5.0 – 10.0 m

BORE: 109B PROJECT: HAYMARKET MAY 2020



10.0 – 15.0 m

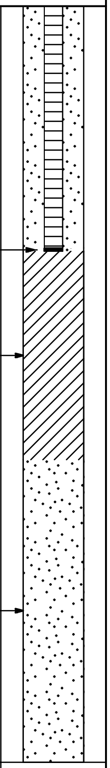
BOREHOLE LOG

CLIENT: Vertical First Pty Ltd
PROJECT: Proposed Commercial Development
LOCATION: 8-10 Lee Street, Haymarket

SURFACE LEVEL: 15.3 AHD
EASTING: 333970
NORTHING: 6249311
DIP/AZIMUTH: 90°/--

BORE No: BH109B
PROJECT No: 86767.00
DATE: 17/5/2020
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
5		SANDSTONE: fine to coarse grained, pale grey, fresh, medium then high strength, slightly fractured then unbroken, cross-bedding 5°-10°, Hawkesbury Sandstone *(continued)*		C					
					10.73				
	11				11.0		PL(A) = 1.8		11
4				C					End Cap
	12				12.0		PL(A) = 1.2		12
3					12.38				Bentonite Seal
	13			C	13.0		PL(A) = 1.4		13
2					13.88				
	14				14.0		PL(A) = 1.3		14 Sand Back Fill
1				C					
	15 15.0	Bore discontinued at 15.0m - Target depth reached			15.0				15
0									
-1	16								16
-2	17								17
-3	18								18
-4	19								19



RIG: XC **DRILLER:** Terratest **LOGGED:** NB **CASING:** HWT to 1.05m

TYPE OF BORING: Diatube (200mm) to 0.2m, SFA (TC-bit) to 1.05m, NMLC coring to 15m

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: Standpipe installed: 0-6.0m Blank PVC pipe, 6.0-11.6m Slotted PVC pipe, End cap at 11.6m, Sand backfill 0-1.05m, Bentonite 1.05-5.2m, Sand filter 5.2-11.6m, Bentonite 11.6-13.0m, Backfill 13.0-15.0m, Gatic cover at surface. Surface level taken from survey

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

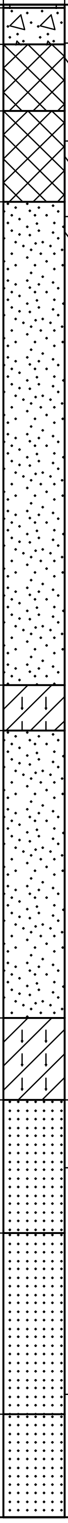
CLIENT: Vertical First Pty Ltd
PROJECT: Link Tunnel
LOCATION: 8-10 Lee Street, Haymarket

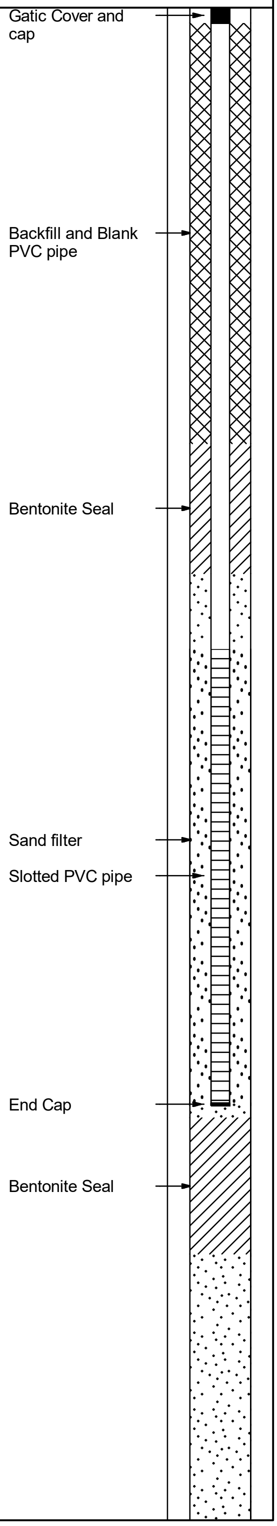
SURFACE LEVEL: 16.3 AHD
EASTING: 333940.8
NORTHING: 6249253.1
DIP/AZIMUTH: 90°/--

BORE No: BH202
PROJECT No: 86767.07
DATE: 29/10 - 6/11/2020
SHEET 1 OF 2

Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments
0.02	TILE: 20mm thick, stone				
0.26	CONCRETE SLAB: sub-angular fine sandstone and igneous aggregate within a coarse sand matrix (0.02-0.11m), sub-angular, fine igneous aggregate, trace voids (0.11-0.26m)	A/E	0.25 0.35		
0.7	FILL/Silty CLAY: medium plasticity, brown, with sub-angular to sub-rounded igneous and sandstone gravel, trace brick fragments, w~PL, generally in a stiff condition	A/E	0.9 1.0		
1.3	FILL/SAND: fine to medium, brown, with clay, moist, generally in a medium dense condition	A/E	1.4 1.5		
	SAND SP: fine to medium, pale grey, moist, apparently loose, alluvial				
	Below 2.7m: grading to medium dense to dense				
	Below 3.3m: grading to dense				
	Below 3.7m: grading to pale yellow-brown, moist to wet				
4.5	Silty CLAY CH: high plasticity, grey, w>PL, apparently stiff to very stiff, alluvial				
4.8	SAND SP: fine to medium, orange, wet, apparently medium dense, alluvial				
6.7	Silty CLAY CH: high plasticity, pale grey, trace fine sand, w>PL, apparently stiff to very stiff, residual				
7.24	SANDSTONE: medium to coarse grained, brown, medium strength, moderately weathered, unbroken, Hawkesbury Sandstone	C	7.24 7.63		PL(A) = 1.7
		C	7.69 8.0		PL(A) = 1.4
8.12	SANDSTONE: medium to coarse grained, pale grey, 10%-30% fine grained laminations, medium to high strength, fresh, slightly fractured to unbroken, Hawkesbury Sandstone		8.34 9.19		PL(A) = 1.2 PL(A) = 1.1
9.32	9.31-9.33m: low strength seam	C	9.21 9.46		PL(A) = 1.1
	SANDSTONE: refer following page				
10.0					

Water: 09-11-20 (approx. 3.3m); 06-11-20 (approx. 4.3m)





RIG: Diatube, Vacuum truck, XC **DRILLER:** TJ Cutting, Excavac, Terr **LOGGED:** KR **CASING:** HWT to 7.2m

TYPE OF BORING: Diatube 0-0.04m (300mm diam.) and 0.04-0.26m (200mm diam.), NDD to 3.0m, SFA (TC-bit) to 7.24m, NMLC to 13.77m

WATER OBSERVATIONS: Groundwater observed at 4.5m

REMARKS: Standpipe details: backfill 13.77-8.24m, bentonite 8.24-7.34m, fine sand 7.34-3.74m, bentonite 3.74-2.88m, backfill 2.88-0.2m, gatic cover 0.2-0.0m, Screen 7.24-4.24m, blank 4.24-0.1m

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: Vertical First Pty Ltd
PROJECT: Link Tunnel
LOCATION: 8-10 Lee Street, Haymarket

SURFACE LEVEL: 16.3 AHD
EASTING: 333940.8
NORTHING: 6249253.1
DIP/AZIMUTH: 90°/--

BORE No: BH202
PROJECT No: 86767.07
DATE: 29/10 - 6/11/2020
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
6		SANDSTONE: medium grained, pale grey, 40%-50% fine grained laminations, medium to high strength, fresh, slightly fractured to unbroken, Hawkesbury Sandstone	⁙	C	10.34		PL(A) = 1.2		
					10.61				
5	11			C	11.2		PL(A) = 1		11 Sand Backfill
4	12				12.22				12
					12.4		PL(A) = 1		
3	13			C	13.33		PL(A) = 1		13
		13.52-13.55m: low strength seam							
	13.77	Bore discontinued at 13.77m - Target depth reached			13.77				
2	14								14
1	15								15
0	16								16
-1	17								17
-2	18								18
-3	19								19

RIG: Diatube, Vacuum truck, XC **DRILLER:** TJ Cutting, Excavac, Terra **LOGGED:** KR **CASING:** HWT to 7.2m

TYPE OF BORING: Diatube 0-0.04m (300mm diam.) and 0.04-0.26m (200mm diam.), NDD to 3.0m, SFA (TC-bit) to 7.24m, NMLC to 13.77m

WATER OBSERVATIONS: Groundwater observed at 4.5m

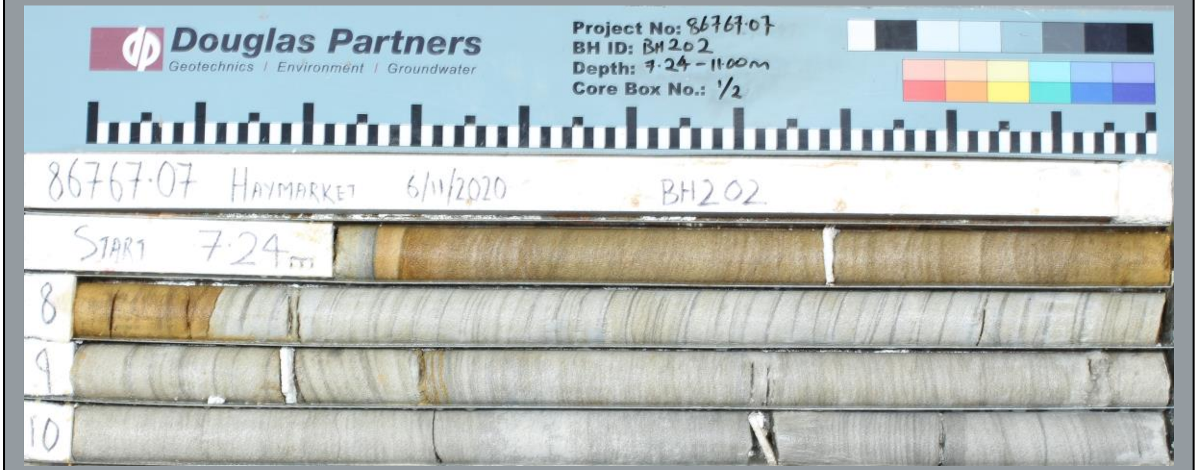
REMARKS: Standpipe details: backfill 13.77-8.24m, bentonite 8.24-7.34m, fine sand 7.34-3.74m, bentonite 3.74-2.88m, backfill 2.88-0.2m, gatic cover 0.2-0.0m, Screen 7.24-4.24m, blank 4.24-0.1m

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

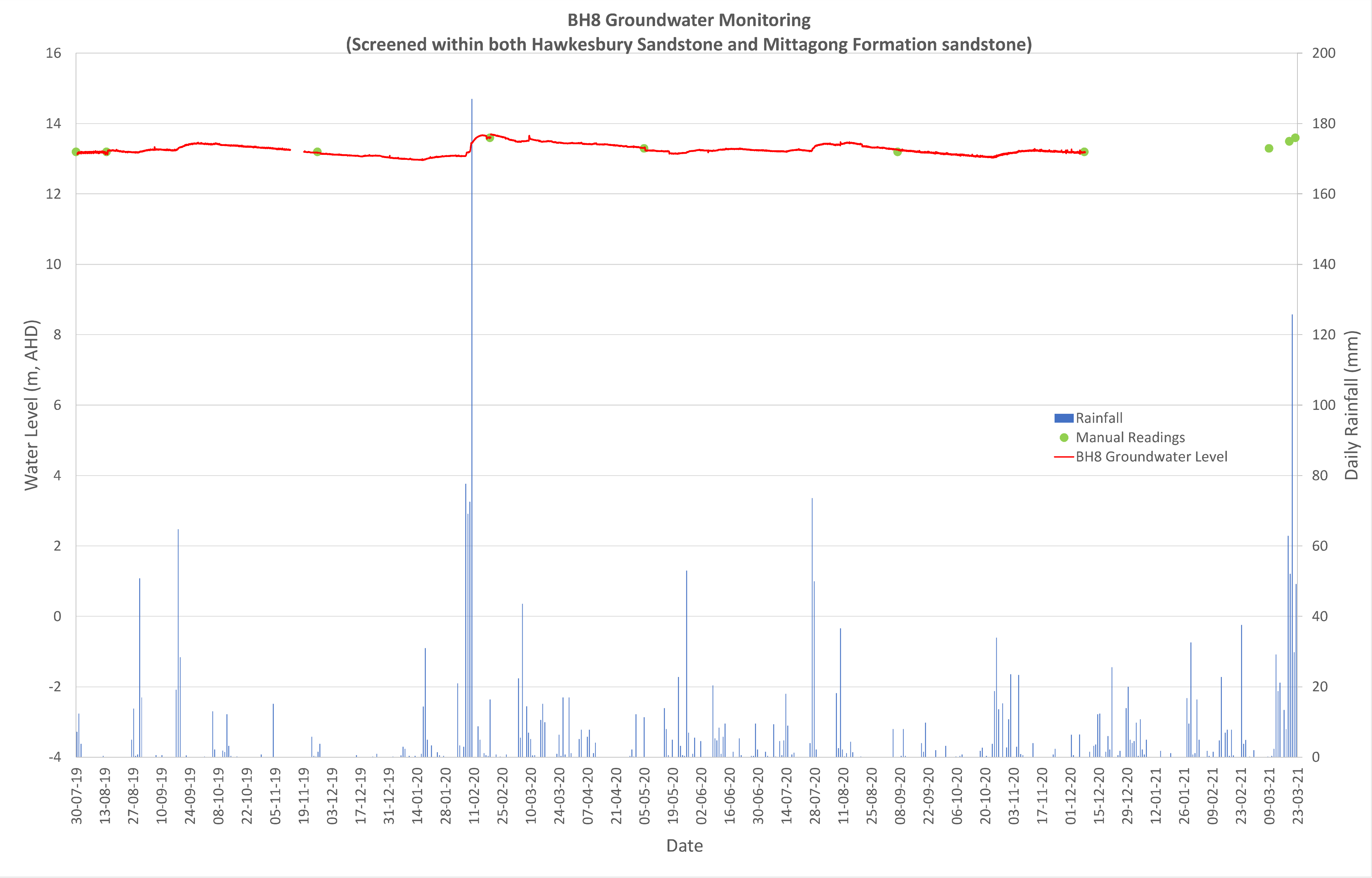
BORE: BH202 PROJECT: HAYMARKET NOVEMBER 2020



7.24 – 11.00m

BORE: BH201 PROJECT: HAYMARKET NOVEMBER 2020

11.00m – 13.77m


BH8 Groundwater Monitoring
(Screened within both Hawkesbury Sandstone and Mittagong Formation sandstone)
Water Level (m, AHD)
16
14
12
10
8
6
4
2
0
-2
-4
Daily Rainfall (mm)
200
180
160
140
120
100
80
60
40
20
0
Rainfall
Manual Readings
BH8 Groundwater Level
30-07-19
13-08-19
27-08-19
10-09-19
24-09-19
08-10-19
22-10-19
05-11-19
19-11-19
03-12-19
17-12-19
31-12-19
14-01-20
28-01-20
11-02-20
25-02-20
10-03-20
24-03-20
07-04-20
21-04-20
05-05-20
19-05-20
02-06-20
16-06-20
30-06-20
14-07-20
28-07-20
11-08-20
25-08-20
08-09-20
22-09-20
06-10-20
20-10-20
03-11-20
17-11-20
01-12-20
15-12-20
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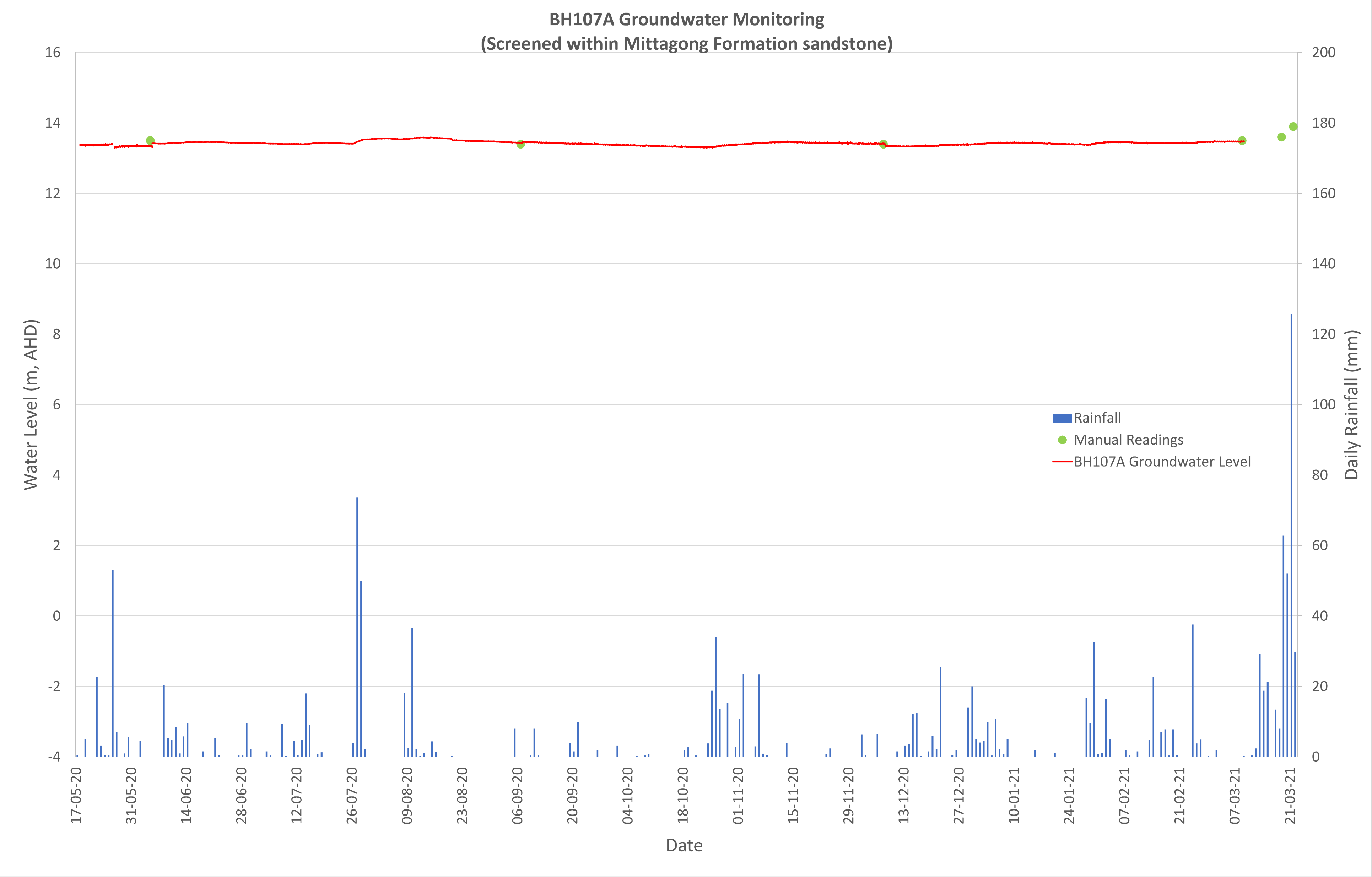
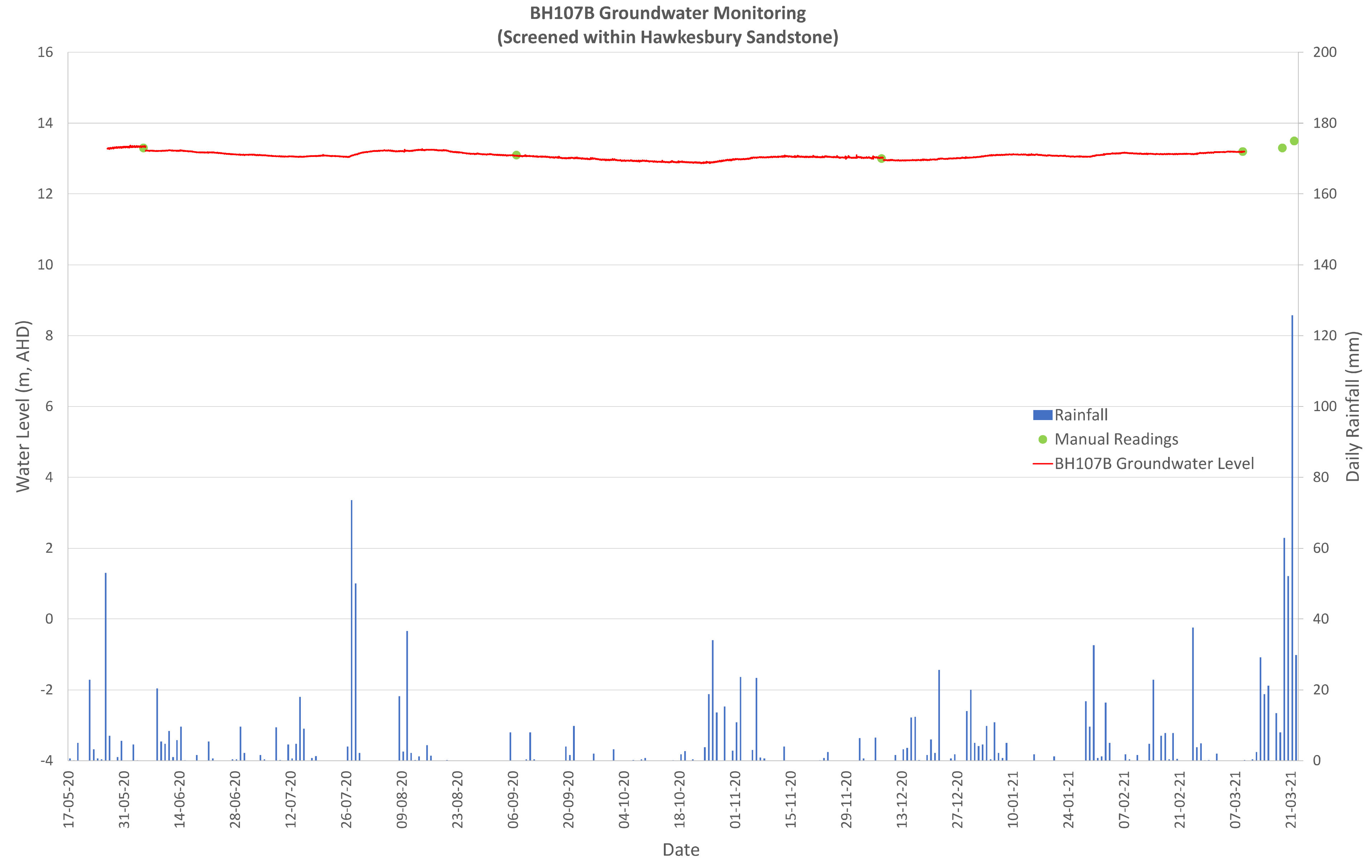
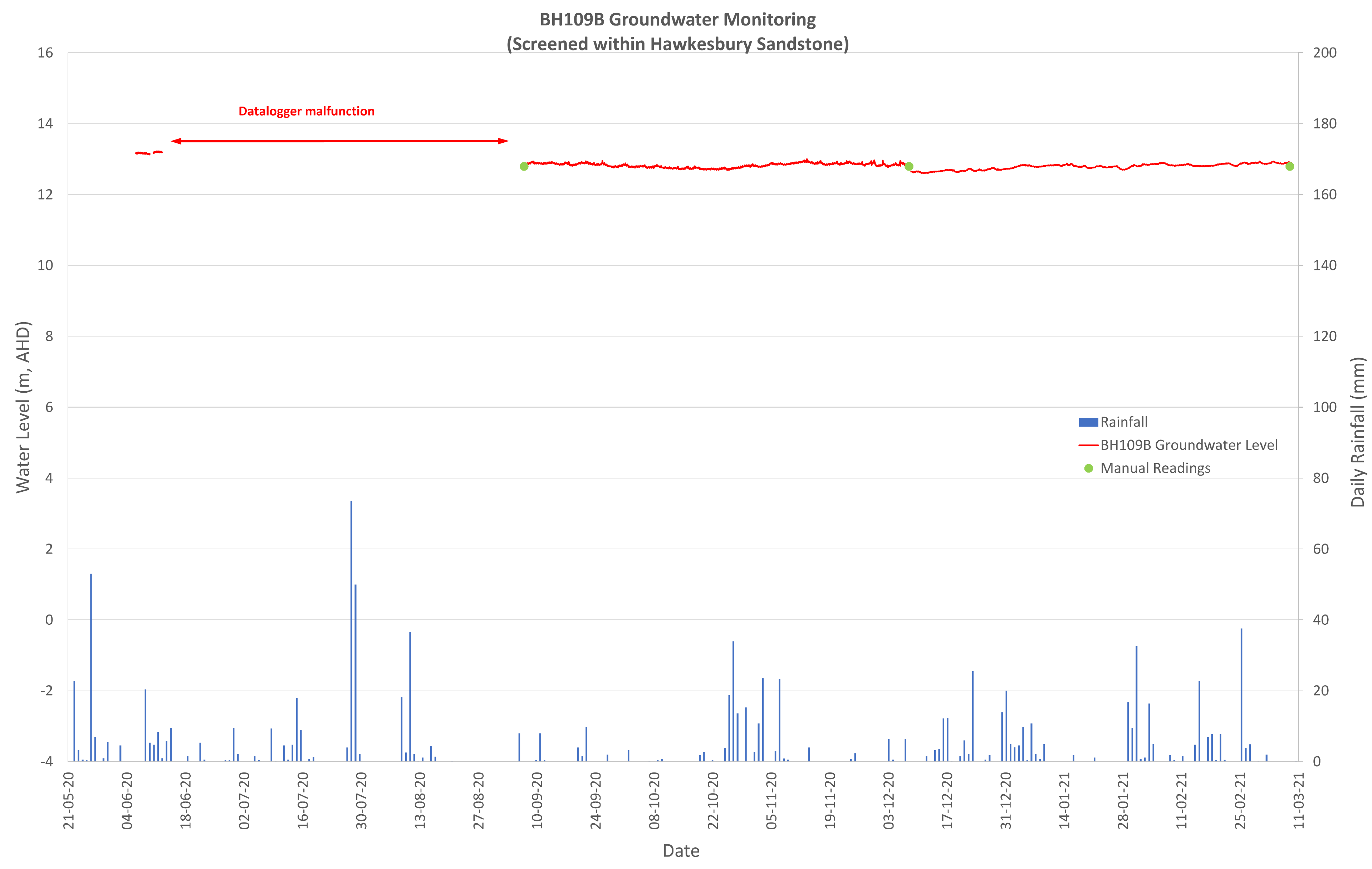
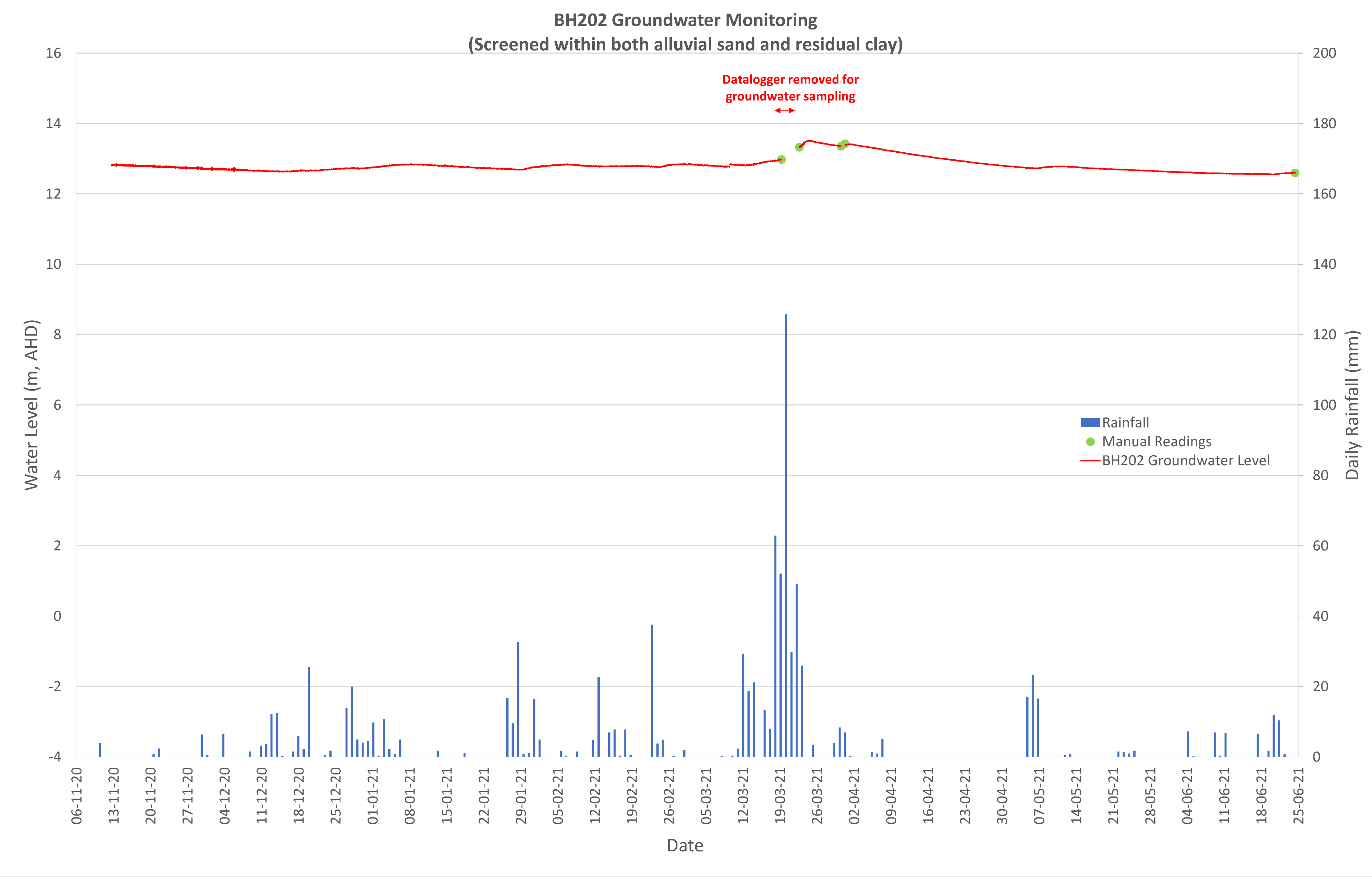
12-01-21
26-01-21
09-02-21
23-02-21
09-03-21
23-03-21
Date

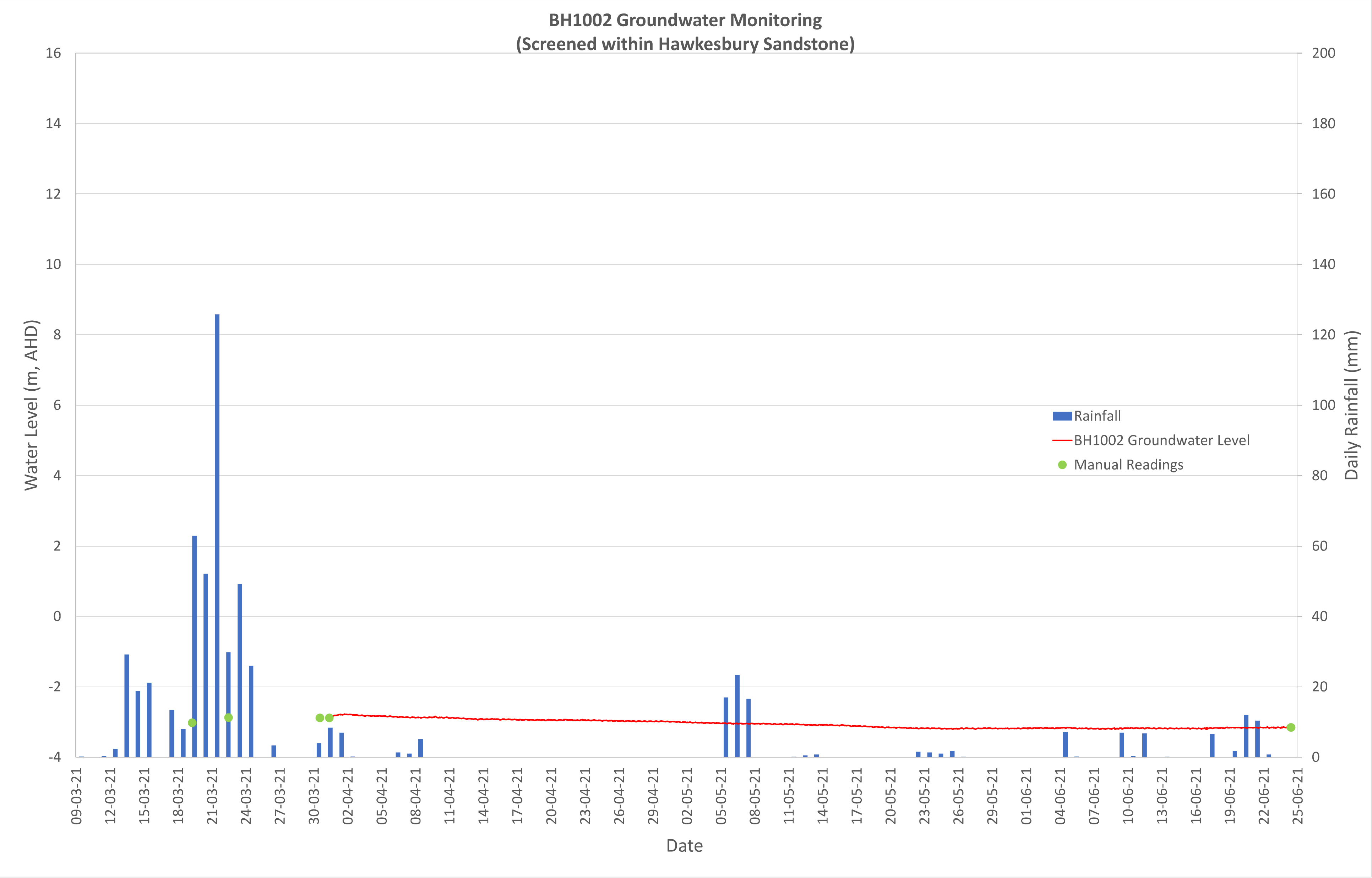


BH107A Groundwater Monitoring
(Screened within Mittagong Formation sandstone)
Water Level (m, AHD)
16
14
12
10
8
6
4
2
0
-2
-4
Daily Rainfall (mm)
200
180
160
140
120
100
80
60
40
20
0
Rainfall
Manual Readings
BH107A Groundwater Level
17-05-20
31-05-20
14-06-20
28-06-20
12-07-20
26-07-20
09-08-20
23-08-20
06-09-20
20-09-20
04-10-20
18-10-20
01-11-20
15-11-20
29-11-20
13-12-20
27-12-20
10-01-21
24-01-21
07-02-21
21-02-21
07-03-21
21-03-21
Date


BH107B Groundwater Monitoring
(Screened within Hawkesbury Sandstone)
Water Level (m, AHD)
16
14
12
10
8
6
4
2
0
-2
-4
Daily Rainfall (mm)
200
180
160
140
120
100
80
60
40
20
0
Rainfall
Manual Readings
BH107B Groundwater Level
17-05-20
31-05-20
14-06-20
28-06-20
12-07-20
26-07-20
09-08-20
23-08-20
06-09-20
20-09-20
04-10-20
18-10-20
01-11-20
15-11-20
29-11-20
13-12-20
27-12-20
10-01-21
24-01-21
07-02-21
21-02-21
07-03-21
21-03-21
Date


BH109B Groundwater Monitoring
(Screened within Hawkesbury Sandstone)
Datalogger malfunction
Water Level (m, AHD)
Daily Rainfall (mm)
16
14
12
10
8
6
4
2
0
-2
-4
200
180
160
140
120
100
80
60
40
20
0
Rainfall
BH109B Groundwater Level
Manual Readings
21-05-20
04-06-20
18-06-20
02-07-20
16-07-20
30-07-20
13-08-20
27-08-20
10-09-20
24-09-20
08-10-20
22-10-20
05-11-20
19-11-20
03-12-20
17-12-20
31-12-20
14-01-21
28-01-21
11-02-21
25-02-21
11-03-21
Date


BH202 Groundwater Monitoring
(Screened within both alluvial sand and residual clay)
Datalogger removed for groundwater sampling
Water Level (m, AHD)
Daily Rainfall (mm)
Date
16
14
12
10
8
6
4
2
0
-2
-4
200
180
160
140
120
100
80
60
40
20
0
06-11-20
13-11-20
20-11-20
27-11-20
04-12-20
11-12-20
18-12-20
25-12-20
01-01-21
08-01-21
15-01-21
22-01-21
29-01-21
05-02-21
12-02-21
19-02-21
26-02-21
05-03-21
12-03-21
19-03-21
26-03-21
02-04-21
09-04-21
16-04-21
23-04-21
30-04-21
07-05-21
14-05-21
21-05-21
28-05-21
04-06-21
11-06-21
18-06-21
25-06-21
Rainfall
Manual Readings
BH202 Groundwater Level


BH1002 Groundwater Monitoring
(Screened within Hawkesbury Sandstone)
Water Level (m, AHD)
16
14
12
10
8
6
4
2
0
-2
-4
Daily Rainfall (mm)
200
180
160
140
120
100
80
60
40
20
0
Rainfall
BH1002 Groundwater Level
Manual Readings
09-03-21
12-03-21
15-03-21
18-03-21
21-03-21
24-03-21
27-03-21
30-03-21
02-04-21
05-04-21
08-04-21
11-04-21
14-04-21
17-04-21
20-04-21
23-04-21
26-04-21
29-04-21
02-05-21
05-05-21
08-05-21
11-05-21
14-05-21
17-05-21
20-05-21
23-05-21
26-05-21
29-05-21
01-06-21
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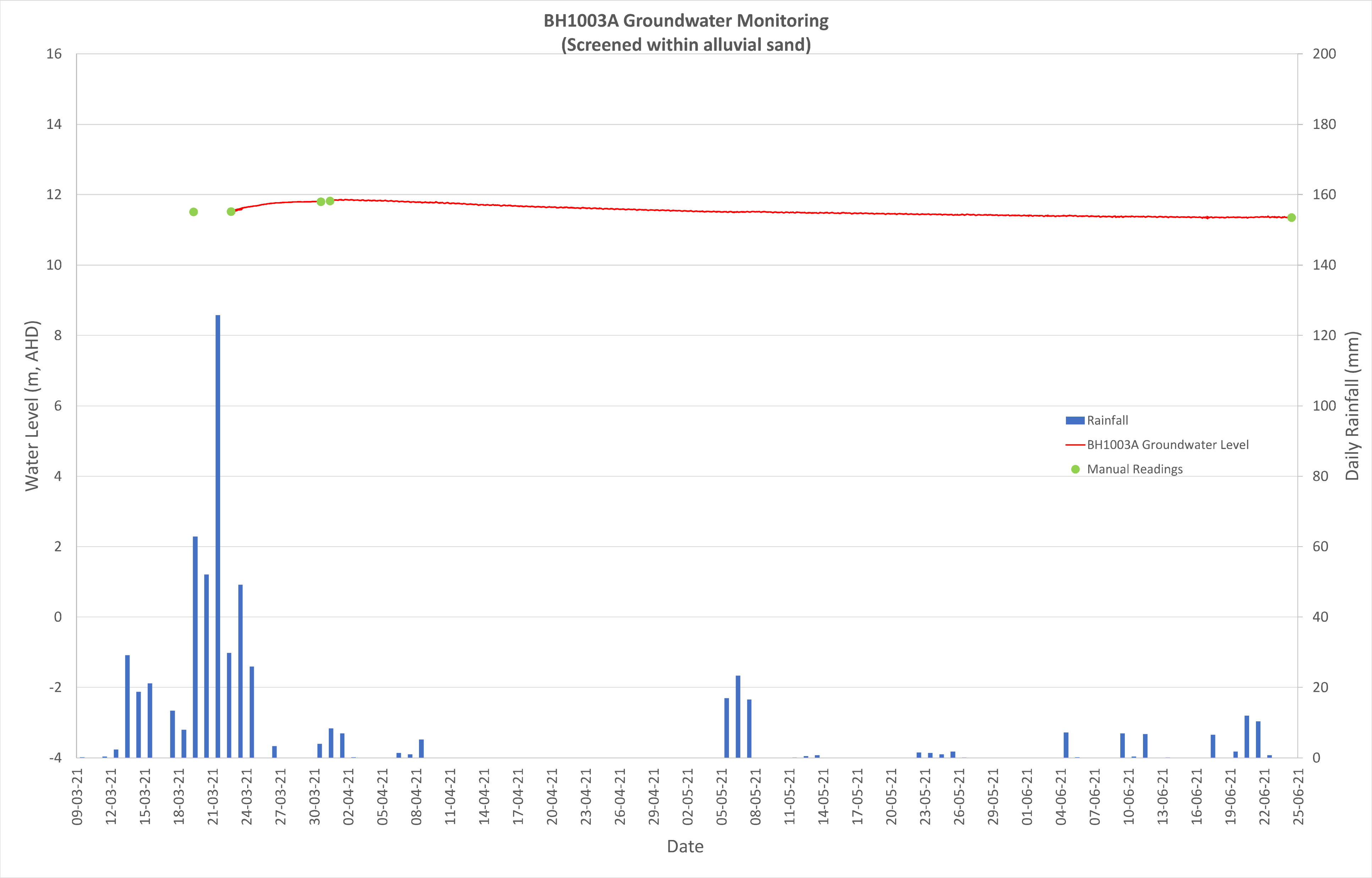
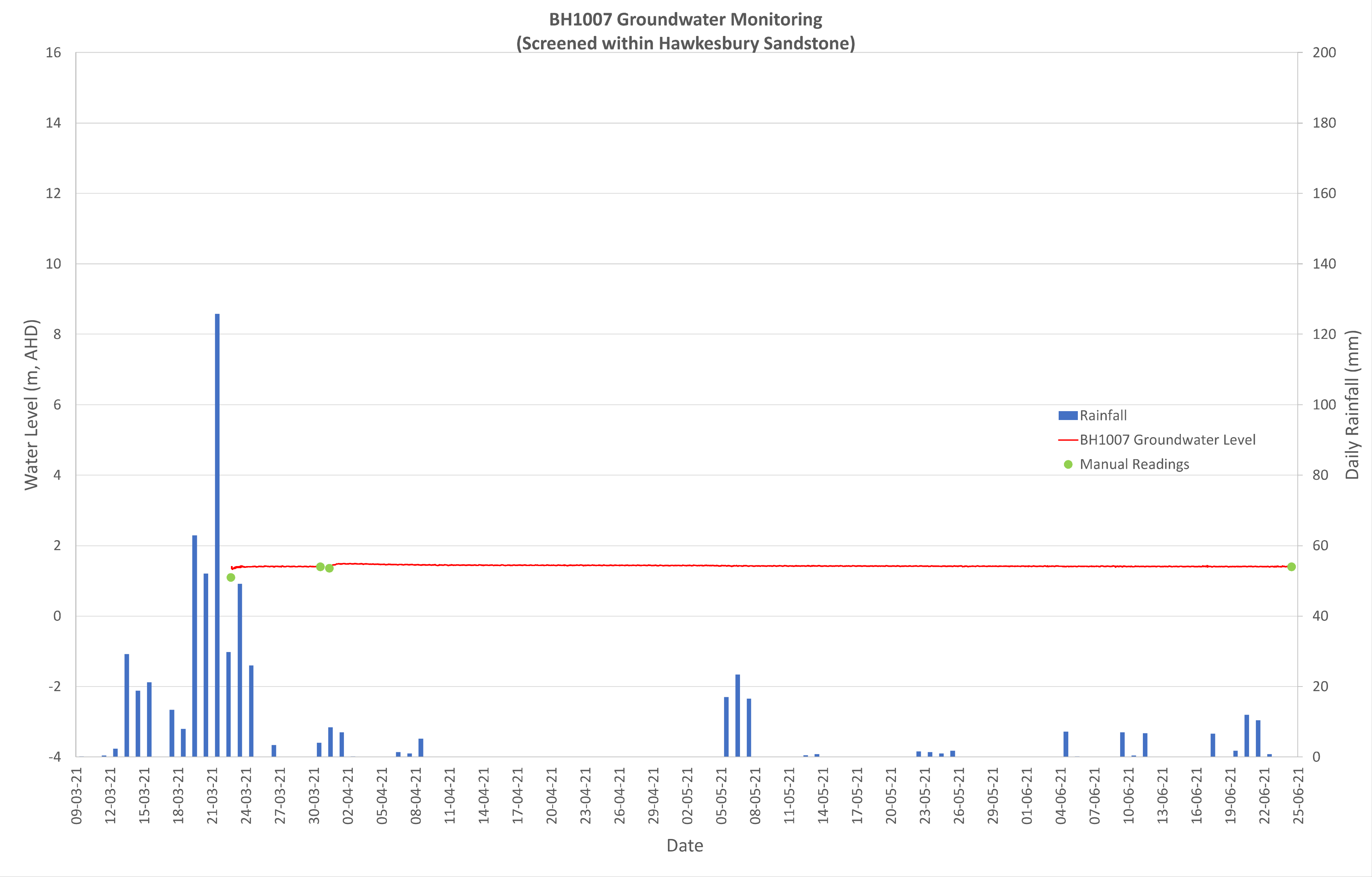
10-06-21
13-06-21
16-06-21
19-06-21
22-06-21
25-06-21
Date


BH1003A Groundwater Monitoring
(Screened within alluvial sand)
Water Level (m, AHD)
16
14
12
10
8
6
4
2
0
-2
-4
Daily Rainfall (mm)
200
180
160
140
120
100
80
60
40
20
0
Rainfall
BH1003A Groundwater Level
Manual Readings
09-03-21
12-03-21
15-03-21
18-03-21
21-03-21
24-03-21
27-03-21
30-03-21
02-04-21
05-04-21
08-04-21
11-04-21
14-04-21
17-04-21
20-04-21
23-04-21
26-04-21
29-04-21
02-05-21
05-05-21
08-05-21
11-05-21
14-05-21
17-05-21
20-05-21
23-05-21
26-05-21
29-05-21
01-06-21
04-06-21
07-06-21
10-06-21
13-06-21
16-06-21
19-06-21
22-06-21
25-06-21
Date


BH1007 Groundwater Monitoring
(Screened within Hawkesbury Sandstone)
Water Level (m, AHD)
Daily Rainfall (mm)
Date
16
14
12
10
8
6
4
2
0
-2
-4
200
180
160
140
120
100
80
60
40
20
0
Rainfall
BH1007 Groundwater Level
Manual Readings
09-03-21
12-03-21
15-03-21
18-03-21
21-03-21
24-03-21
27-03-21
30-03-21
02-04-21
05-04-21
08-04-21
11-04-21
14-04-21
17-04-21
20-04-21
23-04-21
26-04-21
29-04-21
02-05-21
05-05-21
08-05-21
11-05-21
14-05-21
17-05-21
20-05-21
23-05-21
26-05-21
29-05-21
01-06-21
04-06-21
07-06-21
10-06-21
13-06-21
16-06-21
19-06-21
22-06-21
25-06-21

Appendix D

Results of In-situ Permeability Testing

Permeability Testing - Rising Head Test Report

Client:	Atlassian Pty Ltd	Project No:	86767.00
Project:	Proposed Commercial Development	Test date:	30-Jul-19
Location:	8-10 Lee Street, Haymarket	Tested by:	JJH

Test Location

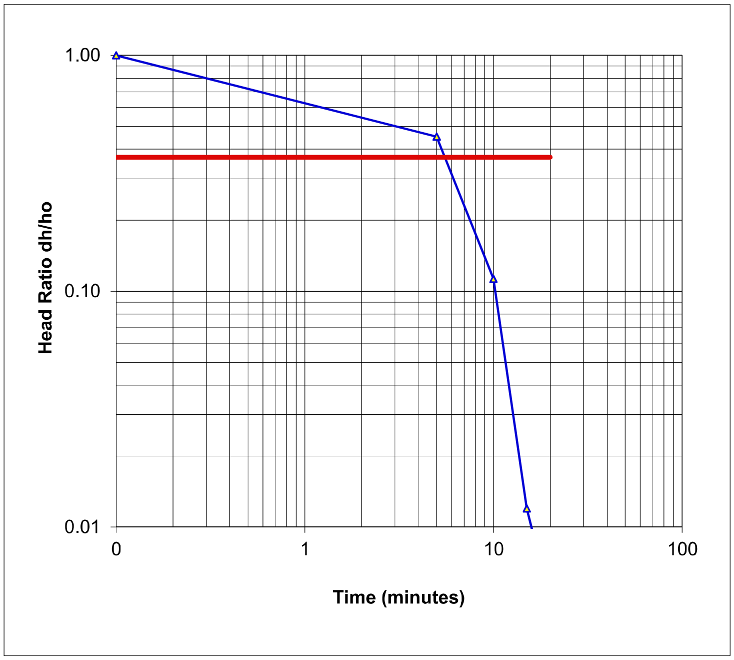
		Test No.	BH8	
Description:	Standpipe in borehole	Easting:	333954	m
Material type:	Sandstone	Northing	6249289	m
		Surface Level:	15.5	m AHD

Details of Well Installation

Well casing diameter (2r)	76	mm	Depth to water before test	2.3	m
Well screen diameter (2R)	76	mm	Depth to water at start of test	14.8	m
Length of well screen (Le)	12.1	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	14.80	12.50	1.000
5	7.95	5.65	0.452
10	3.71	1.41	0.113
15	2.45	0.15	0.012
20	2.36	0.06	0.005



To = 5.5 mins
330 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**1.0E-06**	m/sec
	=	**0.375**	cm/hour

Permeability Testing - Rising or Falling Head Test Report

Client:	Vertical First Pty Ltd	Project No:	86767.00
Project:	Proposed Commercial Development	Test date:	17-May-20
Location:	8-10 Lee Street, Haymarket	Tested by:	NB

Test Location

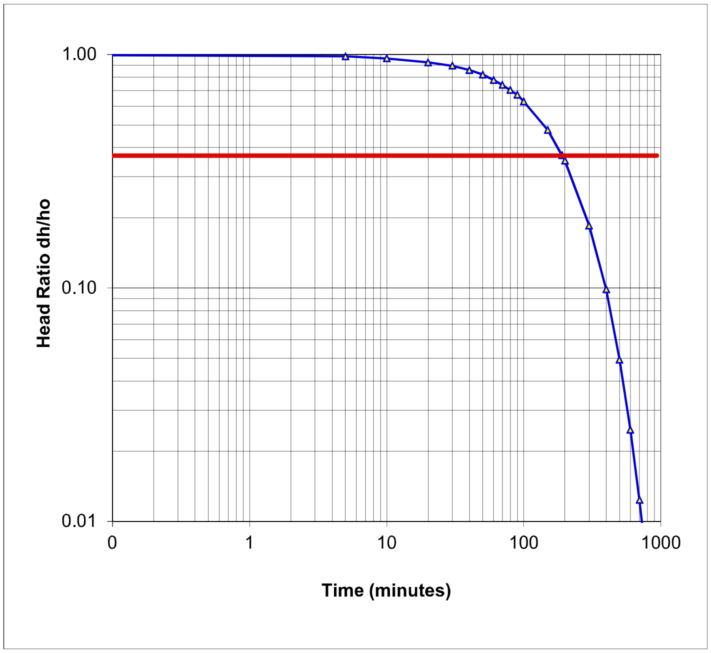
Description:	Standpipe in borehole	**Test No.**	BH107A	
Material type:	Sandstone	Easting:	333945	m
		Northing	6249270	m
		Surface Level:	15.5	m AHD

Details of Well Installation

Well casing diameter (2r)	50	mm	Depth to water before test	2.13	m
Well screen diameter (2R)	76	mm	Depth to water at start of test	3.75	m
Length of well screen (Le)	0.5	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	3.75	1.62	1.000
5	3.72	1.59	0.981
10	3.69	1.56	0.963
20	3.63	1.50	0.926
30	3.58	1.45	0.895
40	3.52	1.39	0.858
50	3.46	1.33	0.821
60	3.39	1.26	0.778
70	3.33	1.20	0.741
80	3.27	1.14	0.704
90	3.22	1.09	0.673
100	3.15	1.02	0.630
150	2.9	0.77	0.475
190.5	2.73	0.6	0.370
200	2.7	0.57	0.352
300	2.43	0.3	0.185
400	2.29	0.16	0.099
500	2.21	0.08	0.049
600	2.17	0.04	0.025
700	2.15	0.02	0.012
800	2.14	0.01	0.006
936	2.13	0	0.000



To = 190.5 mins
11430 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**1.4E-07**	m/sec
	=	**0.051**	cm/hour

Permeability Testing - Rising Head Test Report

Client: Vertical First Pty Ltd
Project: Proposed Commercial Development
Location: 8-10 Lee Street, Haymarket
Project No: 86767.00
Test date: 26-May-20
Tested by: AS

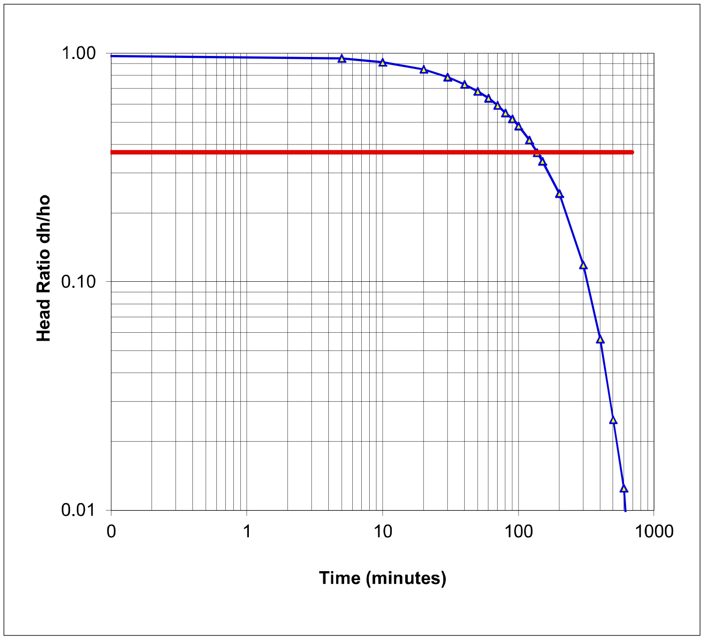
Test Location
Description: Standpipe in borehole
Material type: Sandstone

Test No. BH107A
Easting: 333945 m
Northing 6249270 m
Surface Level: 15.5 m AHD

Details of Well Installation
Well casing diameter (2r) 50 mm
Well screen diameter (2R) 76 mm
Length of well screen (Le) 0.5 m
Depth to water before test 2.2 m
Depth to water at start of test 3.8 m

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	3.8	1.60	1.000
5	3.72	1.52	0.950
10	3.66	1.46	0.913
20	3.56	1.36	0.850
30	3.46	1.26	0.788
40	3.37	1.17	0.731
50	3.29	1.09	0.681
60	3.22	1.02	0.638
70	3.15	0.95	0.594
80	3.08	0.88	0.550
90	3.03	0.83	0.519
100	2.97	0.77	0.481
120	2.87	0.67	0.419
137	2.79	0.59	0.369
150	2.74	0.54	0.338
200	2.59	0.39	0.244
300	2.39	0.19	0.119
400	2.29	0.09	0.056
500	2.24	0.04	0.025
600	2.22	0.02	0.013
650	2.21	0.01	0.006
687	2.2	0	0.000



To = 137 mins
8220 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity **k =** **2.0E-07** m/sec
= **0.071** cm/hour

Permeability Testing - Rising or Falling Head Test Report

Client:	Vertical First Pty Ltd	Project No:	86767.00
Project:	Proposed Commercial Development	Test date:	17-May-20
Location:	8-10 Lee Street, Haymarket	Tested by:	NB

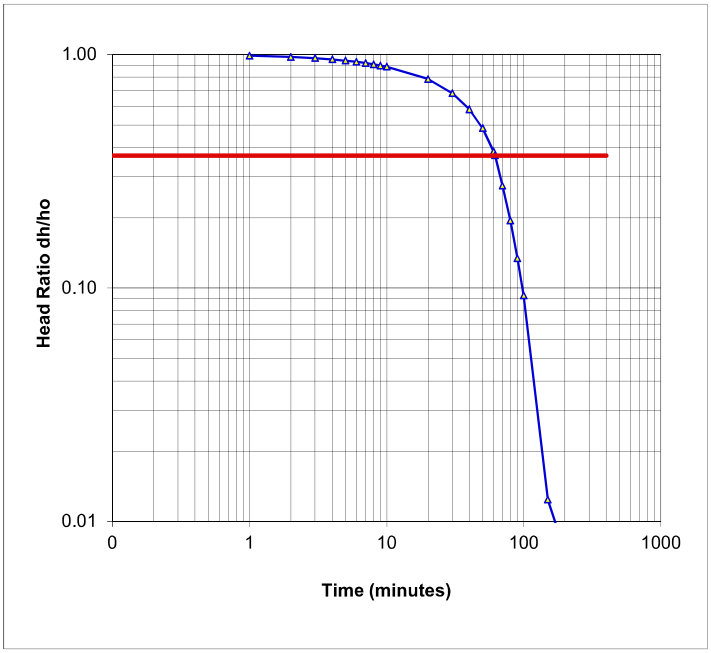
Test Location		**Test No.**	BH107B	
Description:	Standpipe in borehole	Easting:	333945	m
Material type:	Sandstone	Northing	6249272	m
		Surface Level:	15.5	m AHD

Details of Well Installation

Well casing diameter (2r)	50	mm	Depth to water before test	2.65	m
Well screen diameter (2R)	76	mm	Depth to water at start of test	10.72	m
Length of well screen (Le)	5.5	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	10.72	8.07	1.000
1	10.63	7.98	0.989
2	10.53	7.88	0.976
3	10.44	7.79	0.965
4	10.34	7.69	0.953
5	10.25	7.60	0.942
6	10.16	7.51	0.931
7	10.07	7.42	0.919
8	9.98	7.33	0.908
9	9.89	7.24	0.897
10	9.8	7.15	0.886
20	8.98	6.33	0.784
30	8.16	5.51	0.683
40	7.36	4.71	0.584
50	6.56	3.91	0.485
60	5.76	3.11	0.385
61.5	5.64	2.99	0.371
70	4.87	2.22	0.275
80	4.22	1.57	0.195
90	3.73	1.08	0.134
100	3.4	0.75	0.093
150	2.75	0.1	0.012
200	2.71	0.06	0.007
300	2.69	0.04	0.005
400	2.68	0.03	0.004
500	2.66	0.01	0.001
636	2.65	0	0.000



To = 61.5 mins
3690 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**7.7E-08**	m/sec
	=	**0.028**	cm/hour

Permeability Testing - Rising Head Test Report

Client:	Vertical First Pty Ltd	Project No:	86767.00
Project:	Proposed Commercial Development	Test date:	26-May-20
Location:	8-10 Lee Street, Haymarket	Tested by:	AS

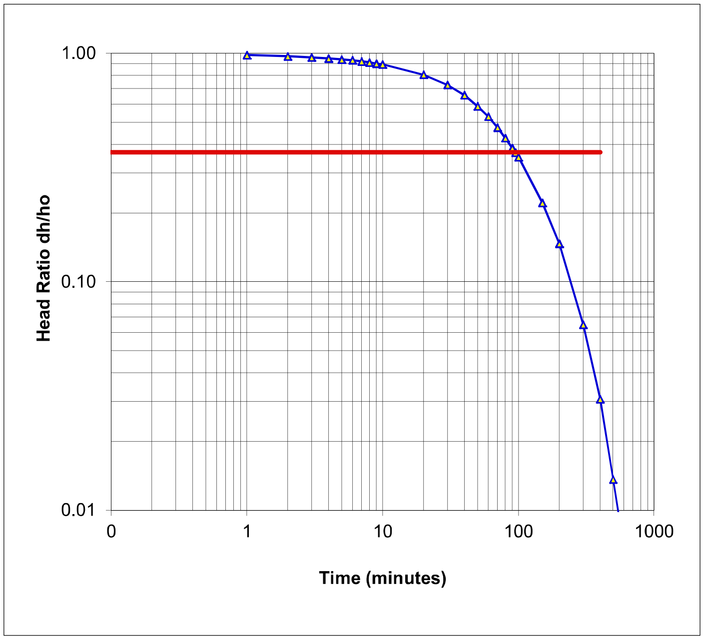
Test Location		**Test No.**	BH107B	
Description:	Standpipe in borehole	Easting:	333945	m
Material type:	Sandstone	Northing	6249272	m
		Surface Level:	15.5	m AHD

Details of Well Installation

Well casing diameter (2r)	50	mm	Depth to water before test	2.22	m
Well screen diameter (2R)	76	mm	Depth to water at start of test	5.15	m
Length of well screen (Le)	5.5	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	5.15	2.93	1.000
1	5.10	2.88	0.983
2	5.06	2.84	0.969
3	5.03	2.81	0.959
4	5.00	2.78	0.949
5	4.97	2.75	0.939
6	4.95	2.73	0.932
7	4.92	2.70	0.922
8	4.89	2.67	0.911
9	4.86	2.64	0.901
10	4.84	2.62	0.894
20	4.58	2.36	0.805
30	4.35	2.13	0.727
40	4.14	1.92	0.655
50	3.94	1.72	0.587
60	3.77	1.55	0.529
70	3.61	1.39	0.474
80	3.47	1.25	0.427
90	3.35	1.13	0.386
95	3.30	1.08	0.369
100	3.25	1.03	0.352
150	2.87	0.65	0.222
200	2.65	0.43	0.147
300	2.41	0.19	0.065
400	2.31	0.09	0.031
500	2.26	0.04	0.014
600	2.24	0.02	0.007



To = 95 mins
5700 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**5.0E-08**	m/sec
	=	**0.018**	cm/hour

Permeability Testing - Falling Head Test Report

Client:	Vertical First Pty Ltd	Project No:	86767.00
Project:	Proposed Commercial Development	Test date:	5-Jun-20
Location:	8-10 Lee Street, Haymarket	Tested by:	NB

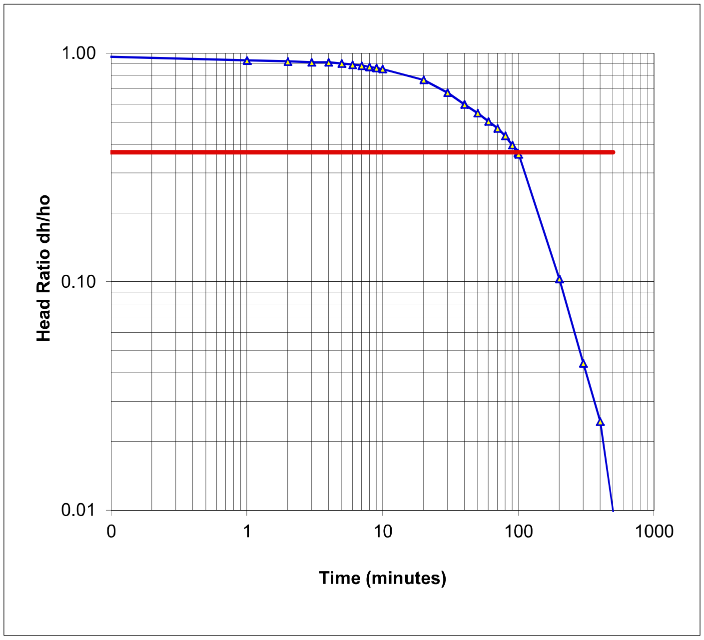
Test Location		**Test No.**	BH109B	
Description:	Standpipe in borehole	Easting:	333970	m
Material type:	Sandstone	Northing	6249311	m
		Surface Level:	15.3	m AHD

Details of Well Installation

Well casing diameter (2r)	50	mm	Depth to water at end of test	2.17	m
Well screen diameter (2R)	76	mm	Depth to water at start of test	0.13	m
Length of well screen (Le)	5.6	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	0.13	2.04	1.000
1	0.27	1.90	0.931
2	0.29	1.88	0.922
3	0.31	1.86	0.912
4	0.31	1.86	0.912
5	0.33	1.84	0.902
6	0.35	1.82	0.892
7	0.37	1.80	0.882
8	0.39	1.78	0.873
9	0.41	1.76	0.863
10	0.43	1.74	0.853
20	0.61	1.56	0.765
30	0.8	1.37	0.672
40	0.95	1.22	0.598
50	1.05	1.12	0.549
60	1.14	1.03	0.505
70	1.21	0.96	0.471
80	1.28	0.89	0.436
90	1.36	0.81	0.397
98.5	1.42	0.75	0.368
100	1.43	0.74	0.363
200	1.96	0.21	0.103
300	2.08	0.09	0.044
400	2.12	0.05	0.025
500	2.15	0.02	0.010
600	2.17	0	0.000



To = 98.5 mins
5910 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**4.7E-08**	m/sec
	=	**0.017**	cm/hour

Permeability Testing - Rising Head Test Report

Client:	Vertical First Pty Ltd	Project No:	86767.07
Project:	Link Tunnel	Test date:	10-Nov-20
Location:	8-10 Lee Street, Haymarket	Tested by:	KR

Test Location

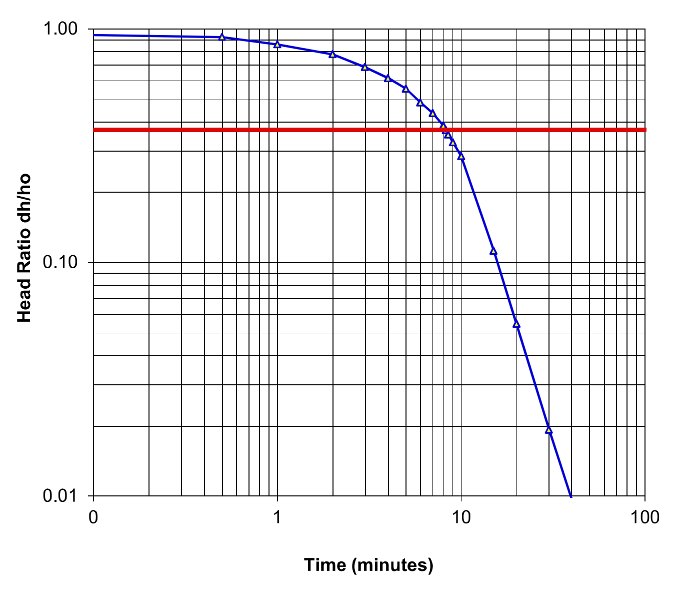
Description:	Standpipe in borehole	**Test No.**	BH202	
Material type:	Alluvial clay and sand underlain by residual clay	Easting:	333941	m
		Northing	6249253	m
		Surface Level:	16.3	m AHD

Details of Well Installation

Well casing diameter (2r)	50	mm	Depth to water before test	3.46	m
Well screen diameter (2R)	114.3	mm	Depth to water at start of test	6.57	m
Length of well screen (Le)	3.5	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	6.57	3.11	1.000
0.5	6.34	2.88	0.926
1	6.14	2.68	0.862
2	5.89	2.43	0.781
3	5.6	2.14	0.688
4	5.38	1.92	0.617
5	5.19	1.73	0.556
6	4.97	1.51	0.486
7	4.82	1.36	0.437
8	4.66	1.20	0.386
8.25	4.61	1.15	0.370
8.5	4.56	1.10	0.354
9	4.48	1.02	0.328
10	4.35	0.89	0.286
15	3.81	0.35	0.113
20	3.63	0.17	0.055
30	3.52	0.06	0.019
40	3.49	0.03	0.010
50	3.47	0.01	0.003



To = 8.25 mins
495 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**7.4E-07**	m/sec
	=	**0.267**	cm/hour

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Permeability Testing - Rising Head Test Report

Client:	Vertical First Pty Ltd	Project No:	86767.07
Project:	Link Tunnel	Test date:	12-Nov-20
Location:	8-10 Lee Street, Haymarket	Tested by:	KR

Test Location

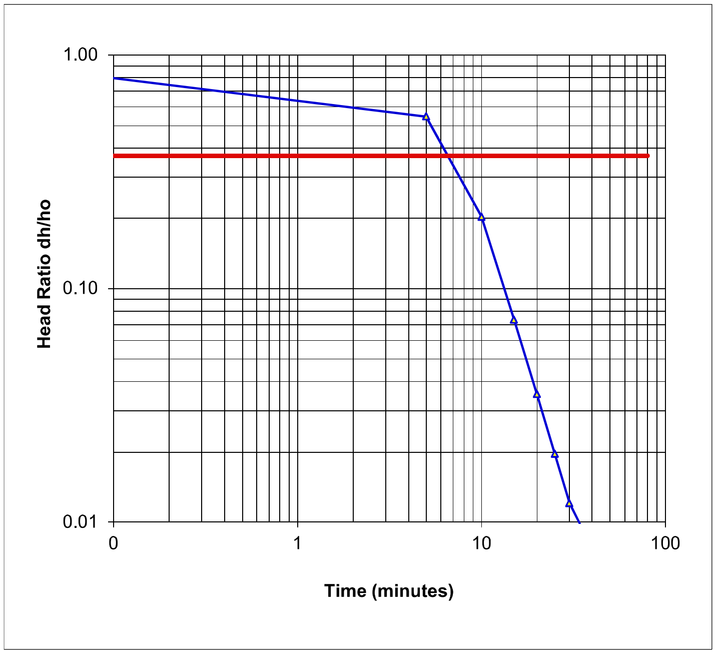
Description:	Standpipe in borehole	**Test No.**	BH202	
Material type:	Alluvial clay and sand underlain by residual clay	Easting:	333941	m
		Northing	6249253	m
		Surface Level:	16.3	m AHD

Details of Well Installation

Well casing diameter (2r)	50	mm	Depth to water before test	3.44	m
Well screen diameter (2R)	114	mm	Depth to water at start of test	6.06	m
Length of well screen (Le)	3.5	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	6.06	2.62	0.998
5	4.87	1.43	0.546
10	3.97	0.53	0.203
15	3.63	0.19	0.074
20	3.53	0.09	0.035
25	3.49	0.05	0.020
30	3.47	0.03	0.012
35	3.47	0.02	0.010
40	3.46	0.02	0.007
45	3.45	0.01	0.005
50	3.45	0.01	0.004
55	3.45	0.01	0.003
60	3.45	0.01	0.003
65	3.45	0.0064	0.002
70	3.45	0.0061	0.002
75	3.45	0.0054	0.002
80	3.44	0.0046	0.002



To = 6 mins
360 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**1.0E-06**	m/sec
	=	**0.368**	cm/hour

Permeability Testing - Rising or Falling Head Test Report

Client:	Toga Development and Construction Pty Ltd	Project No:	86884.02
Project:	Proposed Commercial Development	Test date:	22/3/2021
Location:	2-8A Lee Street, Haymarket	Tested by:	JDB

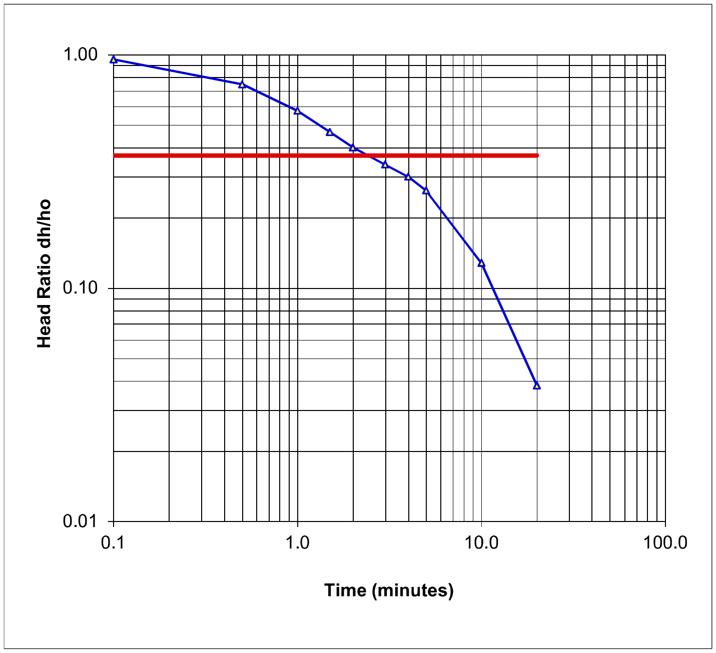
Test Location		**Test No.**	202	
Description:	Standpipe in borehole	Easting:	333941	m
Material type:	Alluvial Sands and Clays	Northing	6249253	m
		Surface Level:	16.3	m AHD

Details of Well Installation

Well casing diameter (2r)	50	mm	Depth to water before test	2.94	m
Well screen diameter (2R)	114	mm	Depth to water at start of test	6.6	m
Length of well screen (Le)	3.5	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	6.60	3.66	1.000
0.1	6.44	3.50	0.956
0.5	5.68	2.74	0.749
1	5.05	2.11	0.577
1.5	4.65	1.71	0.467
2	4.41	1.47	0.402
3	4.18	1.24	0.339
4	4.04	1.10	0.301
5	3.9	0.96	0.262
10	3.41	0.47	0.128
20	3.08	0.14	0.038



To = 2.4 mins
144 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**2.6E-06**	m/sec
	=	**0.919**	cm/hour

Permeability Testing - Rising or Falling Head Test Report

Client:	Toga Development and Construction Pty Ltd	Project No:	86884.02
Project:	Proposed Commercial Development	Test date:	22/3/2021
Location:	2-8A Lee Street, Haymarket	Tested by:	JDB

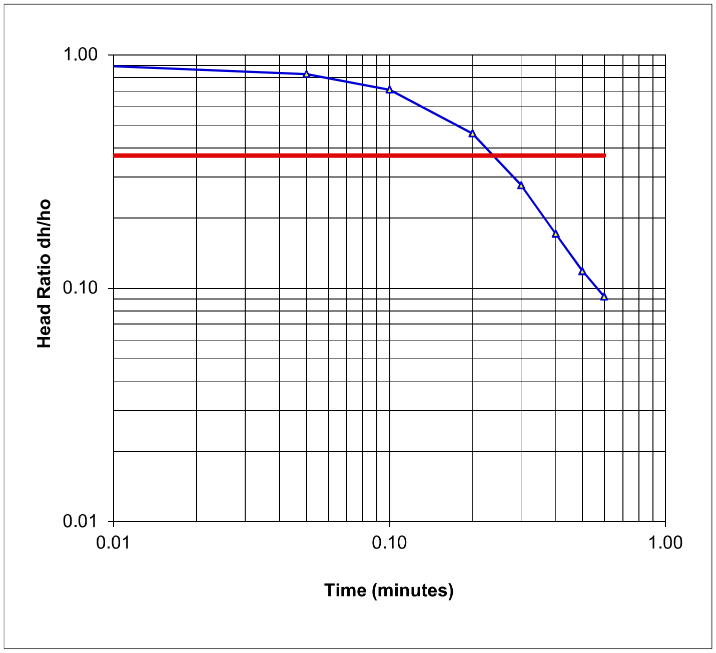
Test Location		**Test No.**	1003A	
Description:	Standpipe in borehole	Easting:	333900	m
Material type:	Alluvial Sand	Northing	6249274	m
		Surface Level:	14.3	m AHD

Details of Well Installation

Well casing diameter (2r)	110	mm	Depth to water before test	2.77	m
Well screen diameter (2R)	110	mm	Depth to water at start of test	3.53	m
Length of well screen (Le)	1.23	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	3.53	0.76	1.000
0.05	3.40	0.63	0.829
0.10	3.31	0.54	0.711
0.20	3.12	0.35	0.461
0.30	2.98	0.21	0.276
0.40	2.9	0.13	0.171
0.50	2.86	0.09	0.118
0.60	2.84	0.07	0.092



To = 0.25 mins
15 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**2.5E-04**	m/sec
	=	**91.707**	cm/hour

Permeability Testing - Rising or Falling Head Test Report

Client:	Toga Development and Construction Pty Ltd	Project No:	86884.02
Project:	Proposed Commercial Development	Test date:	22/3/2021
Location:	2-8A Lee Street, Haymarket	Tested by:	JDB

Test Location

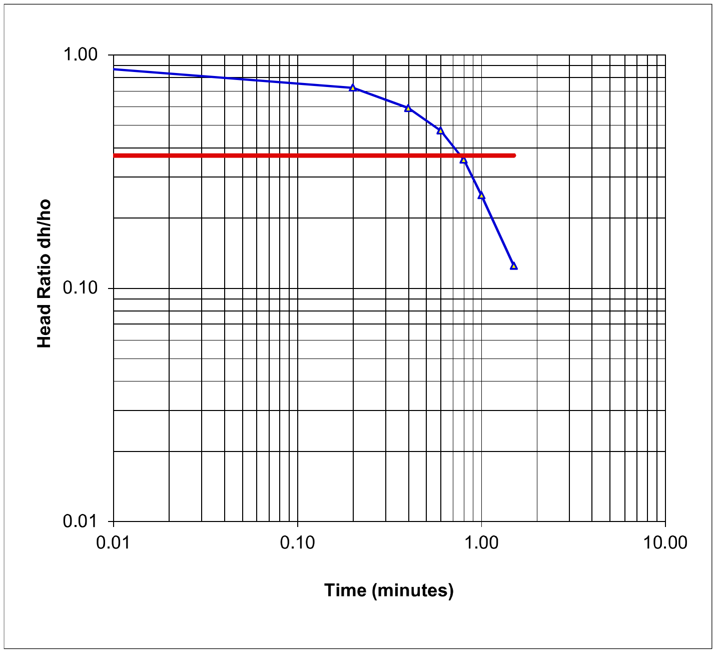
Description:	Standpipe in borehole	**Test No.**	1007	
Material type:	Sandstone	Easting:	333896	m
		Northing	6249263	m
		Surface Level:	15.8	m AHD

Details of Well Installation

Well casing diameter (2r)	76	mm	Depth to water before test	14.56	m
Well screen diameter (2R)	76	mm	Depth to water at start of test	15.32	m
Length of well screen (Le)	1.64	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	15.32	0.76	1.000
0.20	15.11	0.55	0.724
0.40	15.01	0.45	0.592
0.60	14.92	0.36	0.474
0.80	14.83	0.27	0.355
1.00	14.75	0.19	0.250
1.50	14.66	0.09	0.125



To = 0.78 mins
46.8 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

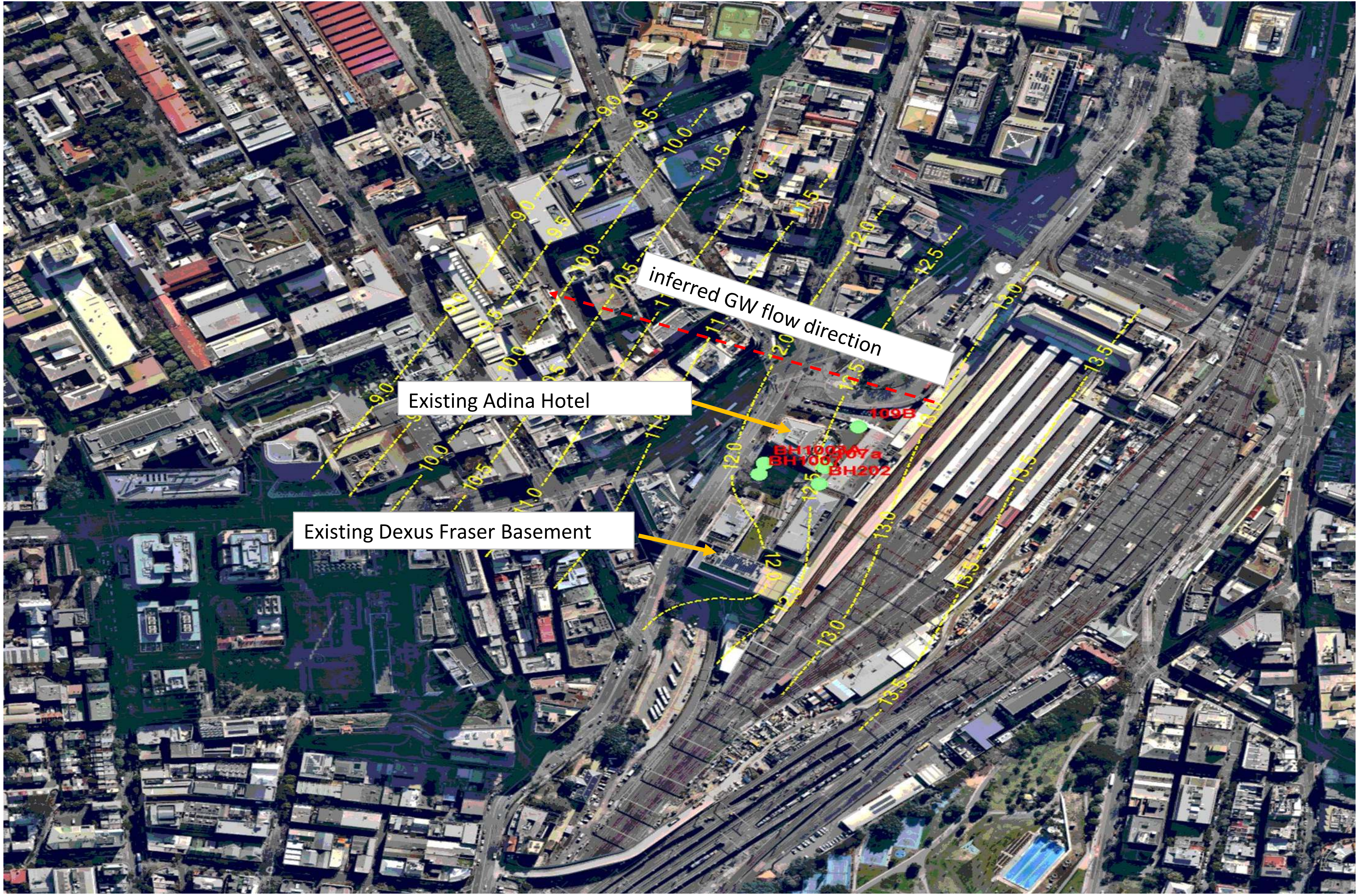
$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**3.5E-05**	m/sec
	=	**12.750**	cm/hour

Appendix E

Modelling Results Model Calibration, Estimated Groundwater Table and Drawdown Contours



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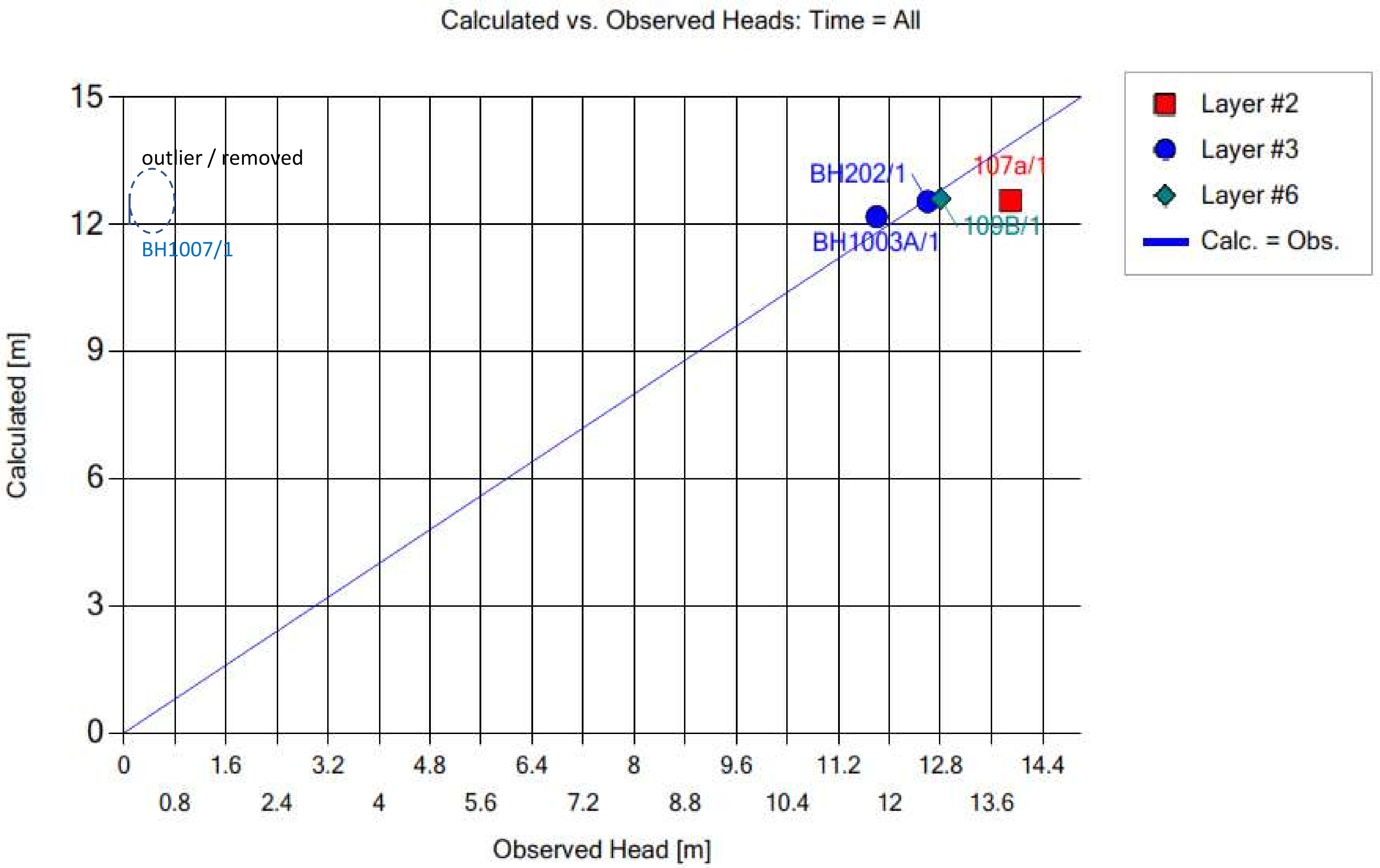
Geotechnics / Environment / Groundwater

CLIENT:	Toga Development and Construction Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	DB
SCALE:	NTS	DATE:	21 Jun 2022

TITLE:
Existing Groundwater Table
Proposed Commercial Development
2-8A Lee Street, Haymarket

PROJECT No:	86884.02
DRAWING No:	M1
REVISION:	Rev01



Number of Data Points: 4
Min.Residual: -0.061 (m) at BH202/1
Max.Residual: -1.3 (m) at 107a/1
Residual Mean: -0.31 (m)
Abs.Residual Mean: 0.5 (m)

Standard Error of the Estimate: 0.37 (m)
Root Mean Squared: 0.71 (m)
Normalized RMS: 33.67 (%)
Correlation Coefficient: 0.73

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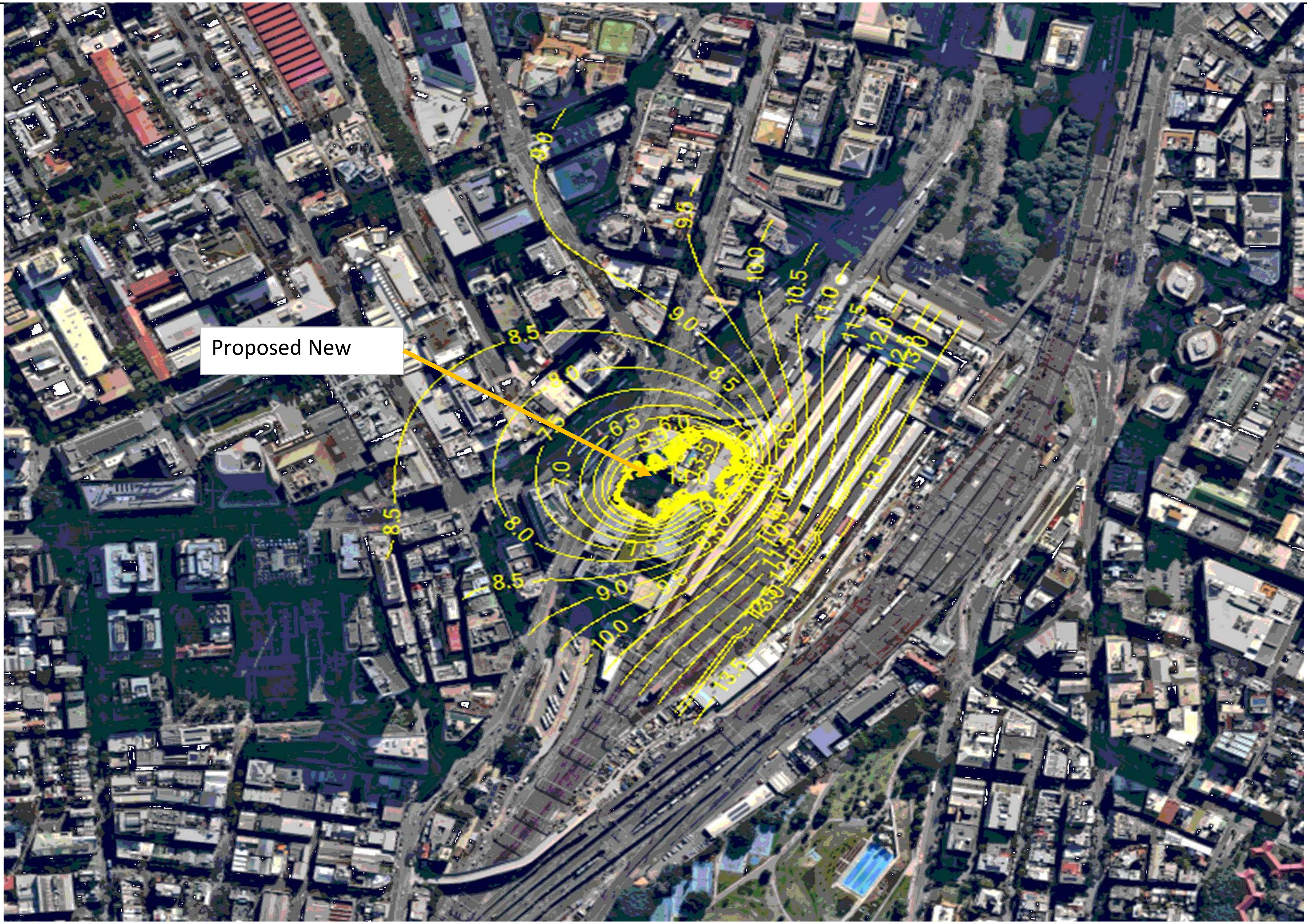
CLIENT:	Toga Development and Construction Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	DB
SCALE:	NTS	DATE:	21 Jun 2022

TITLE: **Calibration curve -Hydraulic head**
Proposed Commercial Development
2-8A Lee Street, Haymarket

PROJECT No:	86884.02
DRAWING No:	M2
REVISION:	Rev01



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CLIENT: Toga Development and Construction Pty Ltd
OFFICE: Sydney
DRAWN BY: DB
SCALE: NTS
DATE: 21 Jun 2022

TITLE: **Long Term Groundwater Table After Dewatering -Scenario 1 (HFB RL 8.6 m)**
Proposed Commercial Development
2-8A Lee Street, Haymarket

PROJECT No: 86884.02
DRAWING No: M3.Rev01
REVISION: Rev01

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Toga Development and Construction Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	DB
SCALE:	NTS	DATE:	21 Jun 2022

TITLE:
Long Term Drawdown Contour -Scenario 1
(HFB RL 8.6 m)
Proposed Commercial Development
2-8A Lee Street, Haymarket

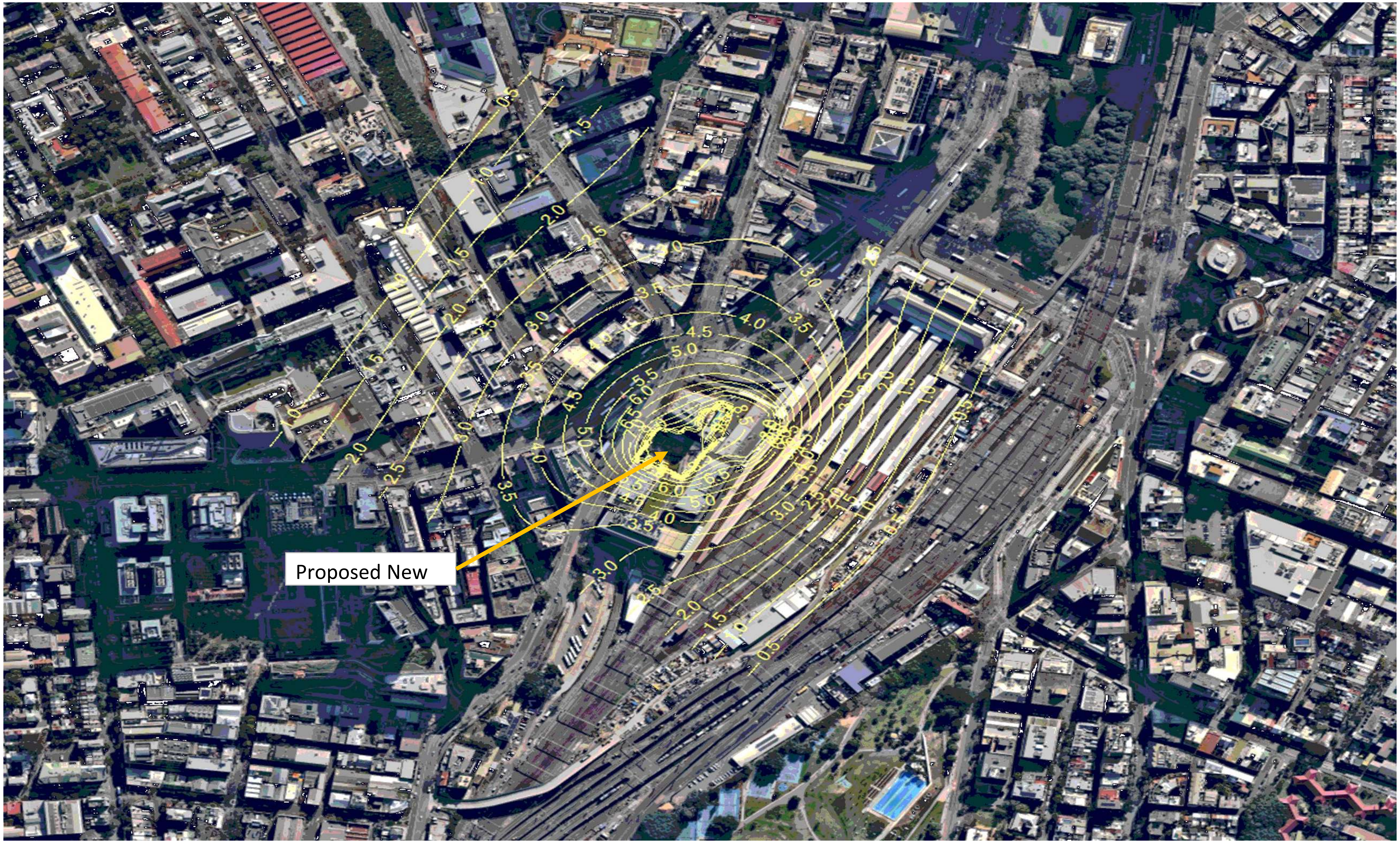
PROJECT No:	86884.02
DRAWING No:	M4
REVISION:	Rev01

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Toga Development and Construction Pty Ltd
OFFICE: Sydney
DRAWN BY: DB
SCALE: NTS
DATE: 21 Jun 2022

TITLE: **Long Term Groundwater Table After Dewatering -Scenario 2, (HFB RL 1.7 m)**
Proposed Commercial Development
2-8A Lee Street, Haymarket

PROJECT No: 86884.02
DRAWING No: M5
REVISION: Rev01



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CLIENT:	Toga Development and Construction Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	DB
SCALE:	NTS	DATE:	21 Jun 2022

TITLE:
Long Term Drawdown Contour - Scenario 2
(HFB RL 1.7 m)
Proposed Commercial Development
2-8A Lee Street, Haymarket

PROJECT No:	86884.02
DRAWING No:	M6
REVISION:	Rev01