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Report on
Stability Assessment

Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

Prepared for
Boyuan Bringelly Pty Ltd

Project 92225.06
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Douglas Partners
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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
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Report on Stability Assessment
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1. Introduction

This report presents the results of a stability assessment undertaken by Douglas Partners Pty Ltd (DP) for a proposed residential subdivision at South Creek West, Precinct 5, Cobbitty (also referred to as the ‘Cobbitty Bringelly Precinct’). The investigation was commissioned in an email dated 18 October 2022 by Mr. Trent Argaet of BHL Group Pty Ltd on behalf of Boyuan Bringelly Pty Ltd, and was undertaken in accordance with our proposal 92225.05.P.001.Rev0 dated 10 October 2022.

The ‘site’ incorporates four existing property lots (and another part-lot) which cover an area of approximately 170 hectares within the Oran Park Precinct of the ‘south-west growth centre’. The proposed development master plan for the sub-division includes residential land lots, residential access road pavements, areas for drainage, open space and playing fields, together with an area for a service station, a school and a ‘local centre’. The area within the southern part of the development master plan footprint proposed to be a ‘water tower’ (i.e. Lot 1 in DP1273487) is excluded from the current assessment.

A preliminary geotechnical investigation and salinity assessment was previously carried out for the eastern part of the site (DP Report 92225.02.R.001.Rev2 dated 17 June 2022). Portions of the site were assessed in the preliminary assessment as having intermediate or major slope constraints to development (delineated as either ‘Zone 2’ or ‘Zone 3’).

Subsequent to the submission of that report, Camden Council issued a request for information (RFI) in August 2022. Item 24 (a) of that RFI requested that further investigation be carried out for both the ‘Zone 2’ and ‘Zone 3’ portions of the proposed development footprint, to delineate portions of the site which may be subject to existing or potential slope constraints, to assess the risk of slope instability, and to provide recommendations and guidelines for residential development at the site. Item 25 (a) of that RFI requested that the geotechnical and salinity assessments be expanded to cover the land parcel to the west (Lot 500 in DP1231858). This report has been prepared to address Item 24 (a) of Council’s August 2022 RFI (relating to slope instability), and also to address Item 25 (a) of the RFI relating to the geotechnical assessment component (the salinity assessment component will be addressed under separate cover).

The investigation aims included obtaining information on the subsurface profile, groundwater, depth to the underlying bedrock, and to determine the extent and thickness of movement-affected soils within areas of potential slope instability, in order to:

- prepare geotechnical model(s) for the site;
- provide an assessment of the extent of movement-affected soils in the steep hillsides;
- delineate areas of the site with slope stability constraints and assess the risk of slope instability;
- assess the geotechnical suitability for residential development within the hillsides; and

- provide potential options for hazard reduction works and precautionary measures, for the areas of hillside where development is proposed.

The investigation included a review of available geotechnical information for the site and surrounding areas, inspection and geotechnical mapping of hillside slopes which were previously identified as having potential slope instability or other geotechnical constraints, and excavation of additional test pits across three of the four property lots. Details of the field work are presented in this report, together with comments and recommendations on the items listed above.

The field work for the investigation was carried out together with a salinity investigation for re-zoning purposes, the findings of which are reported separately.

This report must be read in conjunction with the notes "*About this Report*" which are included in Appendix A.

2. Proposed Development

The land parcels included in the revised 'Indicative Layout Plan' (ILP) for the development (prepared by Design and Planning Pty Ltd, project reference 'BHLCO-2-001a-2', Rev F, dated 2 December 2022: included in Appendix B) are Lots 2 and 4 in DP1216380, Lots 1 and 4 in DP1273487, Lot 500 in DP1231858, and Part Lot 45 in DP1104369 (access road connection to The Northern Road). The revised ILP shows that most of the site is proposed to become either 'low density' or 'medium density' residential land, together with some education, civic and open spaces, playing fields and park areas, drainage basins, roads and a powerline easement.

Our previous report for the site (DP, 2022a) identified major or intermediate slope constraints within four of the lots within the ILP area ('Zone 3' or 'Zone 2' respectively, for Lot 4 in DP1216380, Lots 1 and 4 in DP1273487, and Lot 500 in DP1231858). The ILP drawing indicates that Lot 1 in DP1273487 is to be a water storage tower, and it is understood that Sydney Water Corporation has ownership and control of this Lot. Site investigation and stability assessments have been carried out separately for this Lot, and therefore this portion of the ILP footprint is not further considered in this report.

Further details on potential proposed modifications to the land surface to facilitate residential development (e.g. benching of the hillside slope, engineered retaining walls) were not provided, however, it is likely that some portions of the site will require completion of cut-to-fill earthworks. The currently proposed layout for the sub-division is presented in Figure 1 (also in Appendix B, and on Drawing 6 in Appendix D for the south-western portion of the ILP footprint).

Figure 1: Proposed Sub-Division Master Plan, 'South Creek West, Precinct 5', Cobbitty (also included within Appendix B).

As indicated in Figure 1, the proposed residential roads will extend into the site from an adjoining Lot to the south and west (i.e. Lot 1006 in DP1251974), and adjoining Lots to the north of the site (i.e. Lot 45 in DP1104369 and Lot 10 in DP1218155), and from The Northern Road to the west.

3. Background Information

The following reports (prepared by DP), which contain site investigation data, site stability observations or stability assessments for the site and surrounding areas, have been used as background information:

- *Report on Land Capability and Contamination Assessment, Oran Park Precinct, Oran Park and Cobbitty, Report 40740* dated February 2007 (DP, 2007);
- *Report on Preliminary Geotechnical and Salinity Assessment, Proposed Rezoning, Sub Precinct 5, South Creek West, NSW, Report 92225.02.R.001.Rev2* dated 17 June 2022 (DP, 2022a);
- *Preliminary Groundwater Investigation, Proposed Rezoning, 621-705 The Northern Road, Cobbitty, NSW, Report 92225.04.R.002.Rev4 dated 22 December 2022* (DP, 2022b); and
- *Report on Geotechnical Investigation, Proposed Residential Subdivision, Arkendale Estate, Lot 1006 DP 1251974, Cobbitty, Report 92430.21.R.001.DftA*, dated 27 January 2023 (DP, 2023).

Test pit or groundwater well data was presented in the reports listed above. The test locations considered in the current assessment (within or adjacent to the current site boundary) are shown on Drawing 1 in Appendix D. Selected available previous investigation logs for the test locations shown on Drawing 1 are included in Appendix F.

Geotechnical mapping observations by a senior engineering geologist were also presented in DP (2007), for identified areas of potential instability. An excerpt of the features identified within the current study area (dashed black line) is shown in Figure 2. In summary, slope instability was previously identified within portions of the upper slopes within the site area. These movement-affected features were considered in preparation of Drawing 4.

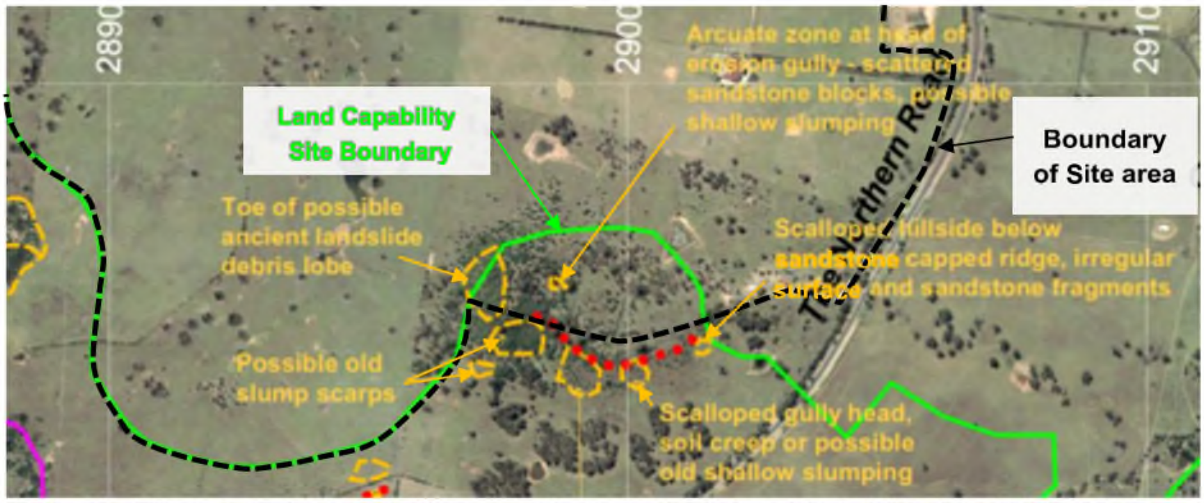

Figure 2: Excerpt of slope instability mapping from DP's Land Capability Study (DP, 2007).

The DP (2007) report for the broader Oran Park Precinct noted that:

- deep-seated hillslope instability affects the upper slopes of the ridgeline (near the southern site boundary), which is considered to be a major constraint to development;
- observed or inferred surficial soil creep, and possible ancient slumping of residual soils, was present in over-steepened gullies and steeper ridgelines below mapped (or interpreted) un-named sandstone members of the Bringelly Shale geological formation (outcropping to the south of the site area: denoted using red dotted lines in Figure 2);
- potential soil creep, shallow slump instability of soil, and erosion features are likely to impose constraints to development (minor to intermediate), including for residential and infrastructure development in both current landslide (movement-affected) areas, and bordering areas with equivalent topography and stratigraphy.

The DP (2022a) report for the South Creek West ('Sub Precinct 5') site noted that:

- portions of the site are affected by slope instability, which have been designated as 'Zone 2' (intermediate constraint) and 'Zone 3' (major constraint), whilst 'Zone 1' areas are those with minor or no constraints to development with respect to slope instability;
- the soil profiles of the lower and mid-slopes below the elevated ridgelines comprise thick residual soil profiles of the Blacktown and Luddenham Soil Landscapes, which are prone to slope instability (e.g. slumping and soil creep) triggered by erosion or seepage, particularly on steep slopes underlain by shale (likely to impose only minor to moderate development constraints);
- slopes below ridgelines could be affected by 'run-out' of landslides from steeper terrain above (could be a major constraint to development);

- numerous historical landslides have previously been mapped within hillside slopes adjacent to ridgelines. Although many of these are external to the site boundary, portions of the site could be affected by run-out of a significant landslide event; and
- development of the site is geotechnically feasible, however, geotechnical constraints are present for specific portions of the site (i.e. areas delineated as 'Zone 2' and 'Zone 3').

The DP (2022b) report noted that:

- the depth to groundwater within the installed groundwater wells varied between 0.98 m and 5.78 m (measured 10 March 2020);
- four of the five installed groundwater wells were 'dry' when constructed, with water subsequently measured in all five wells;
- the hydraulic conductivity of the surrounding soils and rock was inferred to be 'low'; and
- measurement of water electrical conductivity indicated that the water within the wells was saline.

The DP (2023) report for the adjoining site to the south-west (Lot 1006 in DP 1251974) noted that:

- colluvial soils were encountered in two of the test pits which were excavated near to the adjoining site boundary (e.g. test pits 2 and 16), which were both positioned on moderately sloping ground;
- alluvial soils were present within an incised gully near current test pit 312 (near the western limit of the current study area);
- indications of slope instability were present within a north-facing slope, south of test pits 310 and 311 (near the south-western limit of the current study area), including steepened side slopes with gravelly soil at the surface, together with hummocky and stepped slopes; and
- indications of historical landslide activity and slope instability were present on the flanks of north-east-trending ridgelines, downslope mapped (or interpreted) un-named sandstone members of the Bringelly Shale geological formation.

A review of available historical aerial photographic images of the site, for time periods 1955-2006 (NSW Government Spatial Services Portal, 2023) and 2005-2022 (MetroMap Web Portal, 2023), indicate that obvious landslide activity was not observed in the site during these time periods, and that vegetation has re-grown over the higher-elevation areas of the site following an earlier phase of apparent land clearance.

Previous subsurface investigation and mapping data which has been used as part of this assessment (also shown on Drawing 1) includes:

- Eight test pits excavated adjacent to the southern property boundary of Lot 500 in DP1231858 (namely test pits 1-6 and 16-17 from DP (2023));
- Two test pits excavated within Lot 4 in DP1273487 (namely test pits 56 and 215 from DP (2007));
- Test pits and groundwater wells completed for a previous phase of this project (i.e. DP (2022a) and DP (2022b); and
- Geological mapping by a senior engineering geologist (DP (2007), and DP (2023)).

4. Site Description

The site, incorporating Lots 2 and 4 in DP1216380, Lot 4 in DP1273487, Lot 500 in DP1231858, and Part Lot 45 in DP1104369, is an irregular, roughly ‘L’-shaped site, with maximum plan dimensions 1.27 km long (approximately parallel to The Northern Road) by 1.77 km wide (approximately east-west), and a combined area of about 170 hectares. The street address for the northern limit of the site is currently 670 The Northern Road, Cobbitty. The site is bounded to the north, south and west by rural residential and agricultural land, and to the east by The Northern Road. The layout of the site and the lot numbers identified above are included on Drawing 1, together with the positions of current and previous test pits.

Overall, the site generally slopes down towards the north, with elevations ranging between RL120 m-RL145 m along the southern site boundary (falling towards the west), RL96 m-RL120 m along the eastern site boundary (falling from south to north), and to about RL84 m near the northern limit of the site (i.e. the lowest point along the northern boundary of Lot 2 in DP1216380). A meandering, northward-flowing ephemeral creek is present within the western part of the site (Lot 500 in DP1231858), which has an elevation at the northern property boundary of about RL94 m.

Hillside slopes are present within three of the lots (Lot 500 in DP1231858, Lot 4 in DP1273487, and Lot 4 in DP1216380), including:

- Lot 500 in DP1231858: the ‘lower’ portions of slopes which slope down to the north, and extend upslope and southward into the adjoining property (i.e. Lot 1006 in DP1251974);
- Lot 4 in DP1273487: a ridgeline is present which includes an east-north-east trending spur along the southern property boundary, and a north-east trending spur which extends beneath the proposed water tower and along an access road which connects to The Northern Road; and
- Lot 4 in DP1216380: the north-east-trending spur (from Lot 4 in DP1273487) grades downward towards the north, extending into this Lot. An electricity transmission tower has been constructed on the extension of this ridgeline within this Lot.

The western and south-western part of the site (Lot 500, which includes an incised meandering ephemeral creek), and the northern part of the site (Lots 2 and 4 in DP1216380) is generally characterised by:

- creek bank slopes ranging between ‘moderately steep’ (slope angles 10-18 degrees) and ‘very steep’ (up to about 45 degrees), with gully lines trending either north-west or north-east;
- slightly undulating slopes above the banks of the creeks (typical slopes up to about 10 degrees); and
- ‘moderately steep’ slopes below slope crests (slope angles 10-18 degrees), where present.

The eastern part of the site (Lot 4 in DP1273487) is generally characterised by:

- slightly undulating lower slopes (typical slopes up to about 10 degrees), with ‘moderately steep’ slopes in north-east trending gully lines (typically 10-18 degrees);
- ‘moderately steep’ middle slopes;
- ‘steep’ upper slopes (typical slope angles 18-25 degrees, up to about 30 degrees); and
- relatively flat ridgeline crests.

At the time of the field work for the present study, the site was mostly covered with grass and a scattering of tall trees, although steeper slopes on the ridgeline flanks of the eastern part of the site (Lot 4 in DP1273487) were covered with tall and/or dense vegetation (including wild olives). Several dams are scattered across the site, being generally clustered in the north-eastern quadrant of Lot 500, and the eastern and western portions of Lot 4 in DP1216380 and Lot 4 in DP1273487.

Photographs of the site are presented in Appendix C, and the approximate positions of the photographs are included on Drawings 2A and 2B. Topographic contours for the site, based on LiDAR satellite data, are included on these drawings.

As areas of current or inferred slope instability are not present within Lot 2 in DP1216380 (the northern-most Lot of the ILP footprint), this portion of the site will not be further considered in this report.

5. Published Data

5.1 Topography

The topography across most of the site is gently undulating, with a ridge line present within the southern portion of the site. A series of incised gullies have formed on the flanks of the ridge, creating an ephemeral dendritic drainage system that flows into the farm dams.

As previously noted, site elevation falls from a topographical high-point of about RL145 m (relative to the Australian Height Datum (AHD)) at the ridgeline and southern property boundary of Lot 4 in DP1273487, to a topographical low-point of approximately RL84 m adjacent to the northern property boundary of Lot 2 in DP1216380. The ridgeline comprises 'steep' upper slopes up to about 30 degrees, with lower slopes of up to about 15 degrees. Most of the site's undulating terrain comprises slopes ranging between 0-10 degrees.

Construction of retaining walls and earth platforms was in progress at the time of the site works within Lot 1 in DP1273487.

5.2 Soil Landscape

Reference to the Penrith 1:100 000 Soils Landscape Sheet (Bannerman & Hazelton, 2011) indicates that the following soil landscapes are present at the site (also refer to Figure 3 on the following page):

- Luddenham erosional landscape (mapping unit 'lu'): associated with the steeper areas of the site, including the Lots inferred to be subject to slope instability;
- Blacktown residual landscape (mapping unit 'bt'): generally associated with the flatter areas of the site; and
- South Creek alluvial landscape (mapping unit 'sc'): associated with a small sub-area of the site near the northern site boundary.

The Luddenham erosional soil landscape is characterised by undulating to rolling low hills on Wianamatta Group shales, with slopes usually 5 - 20% and local relief of 50 - 80 m. Soils within this landscape are typically described as moderately reactive with a high erosion hazard. On crests and upper slopes (which is consistent with the observed topographic features around the southern property boundaries of Lot 500 in DP1231858 and Lot 4 in DP1273487), these soils are typically described as dark brown or red podzolic soils, shallow to moderately deep (<1.0 m thick). On lower slopes and within drainage lines these soils are typically described as yellow podzolic soils, moderately deep (<1.5 m thick). The encountered soil thicknesses within test pits on the lower slopes indicate that the extent of the Luddenham erosional soil landscape is likely to be mis-classified within parts of Lot 500 in DP1231858, Lot 4 in DP1273487 and Lot 4 in DP1216380, with these areas instead probably underlain by the Blacktown soil landscape.

The Blacktown residual soil landscape is characterised by gently undulating rises on Wianamatta Group shales, with slopes usually <5% and local relief to 30 m. Soils within this landscape are typically described as moderately reactive with low fertility, poor soil drainage and highly plastic subsoil. On crests, upper slopes and well drained areas, these soils are typically described as red and brown, shallow to moderately deep podzolic soils (<1.0 m thick). Elsewhere, on lower slopes and in areas of poor drainage, these soils are typically described as yellow, deep podzolic soils and soloths (1.5 - 3.0 m thick).

The South Creek alluvial soil landscape is characterised by floodplains, valley flats and drainage depressions within channels across the Cumberland Plain, and are usually relatively flat with incised channels. Soils are often very deep and layered, overlying bedrock or relict residual soils (red and yellow podzolic soils). Soils within this landscape are typically described as being subject to erosion (hazard) and frequent flooding.

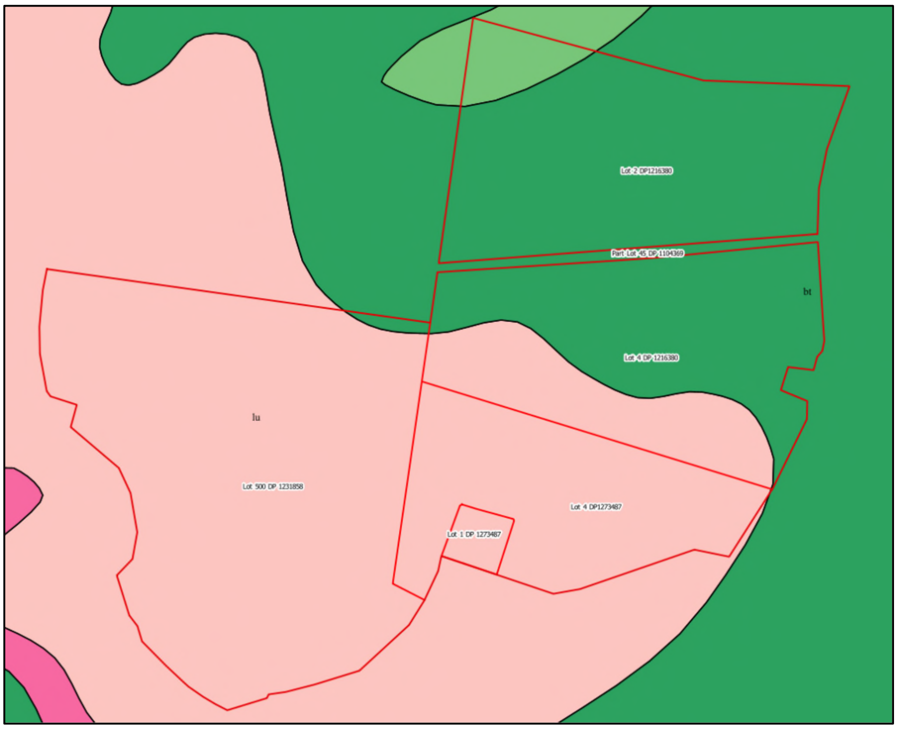

Figure 3: Penrith 1:100 000 Soils Landscape Sheet, for the revised ILP footprint. Coloured zones are pale pink for 'Luddenham erosional landscape', dark green for 'Blacktown residual landscape', and pale green for 'South Creek alluvial landscape'.

5.3 Geology

Reference to the Penrith 1:100 000 Geological Sheet (Herbert & Smith, 1991) indicates that the site is underlain by both Bringelly Shale (mapping unit 'Rwb') of the Wianamatta Group of Triassic age, and Fluvial Sediments (mapping unit 'Qal') of Quaternary age. The Bringelly Shale formation typically comprises shale, carbonaceous claystone, claystone, laminite, fine to medium-grained lithic sandstone, rare coal and tuff, whereas fluvial sediments typically comprise fine-grained sand, silt and clay. Un-named sandstone members within the Bringelly Shale are inferred to be present within the southern part of the site (i.e. Lot 4 in DP1273487), interpreted to be one of the factors contributing to the formation of the ridgeline.

The NSW Seamless geology dataset (Colquhoun, et al., 2019) indicates that a broad, north-west striking synclinal fold structure is present within the western part of the site, with another synclinal fold structure present about 5 km to the north-east (refer to Figure 4 on the following page). This data indicates that Lot 4 in DP1273487 is on the eastern limb of the syncline, that most of Lot 500 in DP1231858 is on the western limb of the syncline, and that an anticline (or a series of more than one smaller anticlines) is likely to be present within the eastern part of the site. Therefore, bedding within the rock on the western side of the syncline is likely to be dipping towards the north-east, and bedding within the rock on the eastern side of the syncline (within the ridgeline in Lot 4 in DP1273487) is likely to be dipping towards the south-west.

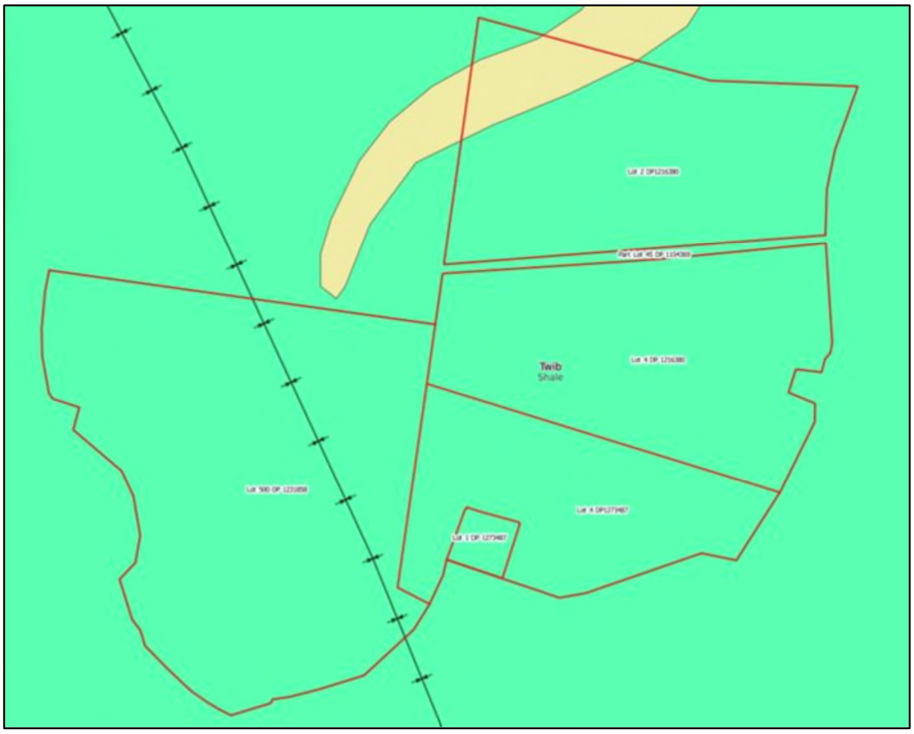

Figure 4: Penrith 1:100 000 Geological Sheet, for the revised ILP footprint. Coloured zones are pale green for 'Bringelly Shale' of the Wianamatta Group, and pale yellow for the fluvial sediments. The black line with convergent arrows indicates the mapped strike of the synclinal fold trough structure.

5.4 Hydrogeology

Ephemeral water courses traverse through the site, generally trending in a northerly direction, with farm dams present within these watercourses. Surface water is anticipated to flow towards the north along these watercourses, towards Lowes Creek (about 2 km to the north).

A search of the publicly available registered groundwater bore database indicated that registered groundwater bores are not present within 1 km of the site.

Based on the regional surface topography and the inferred flow direction of the watercourses, the anticipated flow direction of groundwater beneath the site is northward towards Lowes Creek.

Given the presence of Bringelly Shale, and as indicated in previous testing of water obtained from groundwater wells (DP, 2022b), groundwater within the rock beneath the site is expected to be highly saline, with the rock mass permeability likely to be dominated by flow through fractures / defects within the rock, and resultant low yields in groundwater wells (typically < 1 L/s). Accordingly, it is considered there would be no significant potential beneficial uses for groundwater which could be extracted from the underlying rock.

6. Field Work Methods

Field work for the current investigation was carried out between 31 October 2022 and 27 January 2023 (four days of test pit works) and included:

- Geological mapping by a senior engineering geologist on three occasions (31 October 2022, 04 November 2022, and 17 November 2022), to identify surface features indicative of previous or potential slope instability, potential trigger and failure mechanisms, and for comparison of site conditions with those observed during the previous periods of field work by DP;
- Excavation of 23 test pits across the site (test locations 301 – 323: completed between 16 November 2022 and 27 January 2023, in conjunction with a salinity investigation), using an 8-tonne JCB 4CX backhoe fitted with a 450 mm toothed bucket, to depths ranging between 1.8 - 3.4 m. With the exception of three test pits (locations 316, 317 and 323: terminated on very stiff or hard gravelly clay / extremely weathered shale), each test pit was terminated within either weathered shale or sandstone bedrock of at least very low to low strength;
- Each of the test pits was logged and photographed by a geotechnical engineer, who also collected soil samples for identification purposes;
- Groundwater or seepage observations within test pits were recorded whilst the pits were open. Completed test pits were subsequently backfilled; and
- Dynamic cone penetrometer (DCP) testing was carried out adjacent to each test pit, taken to depths ranging between 1.12 - 1.2 m below the ground surface. Some of the tests were able to penetrate a short distance into the underlying weathered shale bedrock, though were mostly terminated in residual soil (with or without relict rock texture), which ranged in consistency between stiff and hard.

The co-ordinates and ground surface levels at the test locations were measured using a differential global positioning system receiver, relative to (respectively) Map Grid of Australia 1994 (MGA94), Zone 56 datum, and with reduced levels (RL) relative to the Australian Height Datum (AHD).

The co-ordinates and levels determined for each test location are considered to have an accuracy of 0.5 m in plan and 0.1 m in elevation, and are provided on the test pit logs in Appendix E. The test locations are shown on Drawing 1, and Drawings 2A and 2B. The positions of the tests relative to the current sub-division masterplan are presented on Drawings 3A to 3C.

7. Field Work Results

7.1 General

Surface observations from our recent mapping are shown together with a projection of the proposed sub-division master plan on Drawings 3A to 3D. The drawing sequence is in a clockwise-direction, with Drawing 3A covering the eastern part of the site and Drawing 3D covering the northern part of the site. Previous surface mapping observations from DP (2023) are included on Drawing 3B and Drawing 3C.

7.2 Geological Mapping

Site observations made during the geological mapping of October to November 2022 are presented on Drawings 3A to 3D. These observations include:

- Areas of hummocky and/or bulging or stepped ground, present on steep slopes facing either north-east or north-west within Lot 4 in DP1273487. These features are indicative of previous landsliding. Test pits near these areas confirmed the presence of colluvium;
- Sandstone boulders and cobbles (inferred colluvial origin) at a change in slope angle within the eastern part of the site (refer Photo 6 in Appendix C, with the photo position shown on Drawing 2A);
- A small terrace of colluvial soil is present near the eastern limit of a north-east trending ‘spur’ within Lot 4 in DP1273487, forming an arcuate lobe about 0.3-0.5 m high and 5-10 m wide (test pit 302 excavated upslope of this area), indicative of previous landsliding;
- Upslope of the southern property boundary of Lot 500 in DP1231858, sandstone gravel, cobbles, and boulders are present at the ground surface on both the moderately steep and steep slopes flanking the nearby ridge, which is indicative of previous landsliding;
- A small zone of seepage (inferred to be a spring) was present on a west-facing slope near test pit 305 (within Lot 4 in DP1216380), upslope of a farm dam;
- Fill materials were inferred to be present on the western side of the ridgeline and house on Lot 4 in DP1216380, forming a batter slope about 70 m long, 20 m wide (toe to crest), up to about 3 m high, and with a batter slope of about 10-20 degrees;
- Areas of wet soil were present within gully lines / depressions within the western part of the site (i.e. Lot 500 in DP1231858);
- Inferred alluvial soils were present within an incised gully, adjacent to the western property boundary (between test pits 312 and 313); and
- Outcrops or exposures of bedrock were not observed within the property boundaries, or within upslope or downslope areas adjacent to property boundaries. Isolated minor sandstone bedrock outcrops were previously observed during DP’s 2007 site inspection, beyond and south of the current development footprint (e.g. within Lot 23 DP1288963). These outcrops are associated with

one or more un-named sandstone members within the Bringelly Shale, present near the crest of ridges and exposed in the head-scarps of a few nearby interpreted landslides. The sandstone is interpreted to underlie the ridgeline in Lot 4 in DP1273487. Shale and siltstone were also previously observed at shallow depths (0.5 m to 1.0 m) on adjoining sites in exposures or cuttings.

The interpreted boundaries of discrete identified historical landslides or landslide zones are shown on Drawing 4. These zones (which are either within or upslope of the site boundaries) vary in extent, typically covering larger areas on the west-facing and south-facing slopes of the ridgeline in Lot 4 in DP1273487, and smaller areas on the north-east-facing slope of the ridgeline and further to the north. The identified historical landslide areas have been incorporated into the numbered regions shown.

7.3 Subsurface Investigation

The subsurface conditions encountered or interpreted from the field investigation are shown on the test pit logs in Appendix E, together with selected photographs of the test pit sides and the recovered spoil. Test pit logs previously excavated by DP (outlined in Section 3) are included in Appendix F. Notes defining classification methods and descriptive terms used for each phase of work are included in the relevant appendix.

A summary of the typical sequence of subsurface conditions encountered at the site is presented below:

Topsoil:	Generally comprising silty clay or clayey silt to depths of between 0.15 m and 0.4 m (present at all locations), low or medium plasticity, with organic content (rootlets), and with or without trace gravel.
Colluvium:	Silty clay or clayey silt to depths of between 0.2 m and 0.9 m (identified at test locations 303-305, and 308-309: refer also Drawing 8A and Drawing 8B), typically dark brown or grey, low plasticity up to medium to high plasticity, typically firm or stiff consistency and with sub-angular to sub-rounded gravel.
Residual soil and extremely weathered shale:	Stiff to hard silty clay, grading with depth to gravelly clay (relict rock texture: extremely weathered shale). Red-brown, orange, brown or pale grey (generally grading to darker grey with increasing depth), grading into pale grey, grey-brown or red-brown extremely weathered rock (i.e. very stiff to hard or hard gravelly clay, with bands of very low strength shale or sandstone), to depths ranging between 0.4 m to greater than 3.3 m. Soil is medium or high plasticity, grading with increasing depth to low to medium plasticity.
Shale Bedrock:	Bedrock encountered within the current test pits was either shale with bands of clayey silt or silty clay, or sandstone, being typical of rocks within the Bringelly Shale formation. Where encountered, the weathered rock was present below depths of 0.4 m (typically 1 - 3 m: refer Drawings 5A to 5C) and was generally initially of very low to low strength at the soil-rock interface (highly weathered, or highly to moderately weathered). Rock strength increased with increasing depth in most test pits, to medium strength, and some test pits refused on medium strength bedrock. For test

locations where refusal to the backhoe was reached, the toothed backhoe bucket was able to penetrate the weathered rock a further 0 - 2.6 m (typically 0.5 - 1.5 m).

7.4 Groundwater

Free groundwater was observed within two of the test pits on the day of site works (prior to backfilling), at test locations 317 and 319, which were positioned in the lower-lying areas of the valley, adjacent to the meandering creek. In both test pits the groundwater was observed as slow seepage inflow from the gravelly clay (extremely weathered shale), at depths in the range 2.5-2.6 m. The soil moisture content was assessed (in the field) as being greater than the plastic limit at these two test locations, whilst intervals of clay soil at or just below the soil's plastic limit were observed within the upper 0.5 - 1 m of most test pits.

It is noted that groundwater levels are potentially transient and may fluctuate over time in response to climatic variations or anthropogenic influences.

8. Comments

8.1 Geotechnical Model

The geotechnical model for the site has been divided into four terrain units (Terrain Units 1 – 4) the inferred boundaries of which are given on Drawings 7A to 7C. Descriptions of each terrain unit are set out below. Potential constraints to development are presented in Section 8.3.

Terrain Unit 1
The land included within this unit comprises flat to gently sloping ridgeline crests. These are present at the crest of the southern ridgeline (including external to the site), extending north-east into Lot 4 in DP1216380 from the proposed water tower, and extending eastward from the western property boundary of Lot 500 in DP1231858. Based on both site mapping and subsurface investigations, the areas of Terrain Unit 1 which are inside the property boundary are characterised by relatively shallow soil cover, with or without a layer of gravelly clay (extremely weathered shale), overlying either sandstone or shale at a depth of about 1-2 m.

Terrain Unit 2
The land included within this unit comprises two localised, moderately steep up to steep areas adjacent to the southern, eastern and western property boundaries of Lot 500 in DP1231858 (refer Drawing 7A and Drawing 7B), and the moderately steep up to very steep side-slopes on the northern and western sides of the ridgeline in Lot 4 in DP1273487 (refer Drawings 7B and 7C). The terrain unit includes areas with previous slope instability and colluvial soils, extending upslope into adjoining Lots. Soil profiles, including in the areas of accumulated landslide debris, were generally in the range of 1 - 3 m deep. Based on previous site mapping, it is inferred that an un-named sandstone member (or members) is present within the elevated terrain of Lot 4 in DP1273487. Due to the steep topography, it is considered that downslope creep in the soil profile (generally less than 2 m deep) is also likely.

It is likely that episodes of previous slope instability at the site was due to an increase in pore water pressures during and following rainfall events. Other possible triggering events for slope instability include the initial clearing of hillside vegetation for agricultural activities, or potentially following bushfires (prior to clearing).

A risk assessment to property due to slope instability for Terrain Unit 2 (which incorporates slope constraint Zone 2 and Zone 3) is presented in Table 1 further on.

Terrain Unit 3
The land in this unit comprises the slightly undulating lower slopes (typical slope angles up to 10 degrees), and the moderately steep slopes in gullies, adjacent to and generally north of Terrain Unit 2. The soil in these areas is considered to be 'residual', and generally increases in thickness away from the ridgelines. Evidence of large-scale instability was not present within this unit.

A risk assessment to property due to slope instability for Terrain Unit 3 is presented in Table 2 further on.

Terrain Unit 4
The land in this unit comprises meandering creeks and creek bank slopes, which range between relatively flat to sub-vertical. Based on site mapping and subsurface investigations in nearby properties, the areas of Terrain Unit 4 (within or adjacent to creeks) are indicated to have about 1-2 m of either alluvial or residual soil overlying shale bedrock, with the slope changes implying that the creek banks may have been subject to soil slumping or erosion / scouring.

Near-surface 'perched' water may be present within the soil in gullies and towards the base of the valley in Terrain Unit 4, and the designs for roads crossing these areas (which are denoted in the ILP drawings as either 'drainage' or 'riparian corridors') will need to consider the potential drainage challenges for road embankments and pavements.

8.2 Slope Stability Risk Assessment

8.2.1 Risk Assessment Definitions

Included in the Australian Geomechanics Society Guidelines (AGS, 2007) are definitions of 'acceptable risk', 'tolerable risk' and 'unacceptable risk', when applied to slope stability assessments. These definitions are summarised below.

Acceptable Risk – a risk for which, for the purposes of life or work, owners/clients are prepared to accept as it is, with no regard to its management. Society does not generally consider expenditure in further reducing such risks as justifiable. An acceptable risk to property is typically qualitatively described as being of 'low or very low' risk.

Tolerable Risk – a risk that society is willing to live with to secure certain net benefits in the confidence that the risk is being properly controlled, kept under review (e.g. by installation of monitoring instruments, such as piezometers or inclinometers), and the risk further reduced as and when possible. AGS (2007) suggests that for most developments in existing urban areas, criteria based on Tolerable Risks levels (typically 'moderate' risk) are applicable due to the trade-off between the risks, the benefits of development, and the cost of risk mitigation. It is noted that the regulator (i.e. Council) is the appropriate authority to set standards for tolerable risk.

Unacceptable Risk – a risk that society is unwilling to 'live with' without treatment. Detailed investigation, planning and implementation of treatment options is required to reduce the risk to an acceptable level. An unacceptable risk to property is typically qualitatively described as being 'high or very high' risk.

Acceptance criteria have not yet been established for landslides in Australia (or internationally) for loss of life due to a hazardous event such as a landslide. Notwithstanding this, for new slopes or those zones which are affected by known or previous instability (including new developments), the AGS (2007) suggests that an appropriate 'acceptable risk' annual probability of loss of life for the person most-at-risk is taken as 1×10^{-6}, and an appropriate 'tolerable risk' annual probability of loss of life is taken as 1×10^{-5}.

8.2.2 Risk Assessment Methodology

The stability assessment methodology adopted here follows the methods of AGS (2007), relevant extracts of which are included in Appendix G. The methodology for description and assessment of risk levels associated with hazards (e.g. landslides, rock falls and soil slumps) is based upon inputs including:

- Identification of landslide susceptibility, landslide hazards including potential triggers (e.g. erosion, undercutting, saturation, earthquake), and frequency (or likely range of frequencies) of occurrence;
- Probability of the effects of a hazard on the element at risk (i.e. property, services or site including occupants) requiring assessment of the translational mode of landsliding (rate of movement and run out distance);
- Probability of occupation of the element at risk at the time of the event; and
- Vulnerability: the probability and cost of damage to the property or loss of life, given the impact of the particular hazard.

8.2.3 Identified Slope Instability Hazards

Based on the results of the current assessment and DP's experience in the area, the slope instability hazards assessed as affecting or potentially affecting the site and the adjacent areas in its current profile are considered to be:

- Extremely slow soil creep affecting the colluvial or residual soils developed on the moderately steep and steep slopes of the Bringelly Shale;
- Rapid, surficial soil slump and shallow rotational failures affecting the colluvial soils and potentially the upper section of the residual soils, particularly in the moderately steep up to very steep flanks of the ridgeline in Lot 4 in DP1273487 and Lot 500 in DP1231858 (i.e. slope constraint zones denoted as Zone 2 and Zone 3 within Terrain Unit 2);
- Slow, intermediate-depth failure due to periods of elevated pore pressures or saturation, affecting the colluvial and residual soils and potentially the upper section of the weathered rock (very low to low strength), extending as 'run-out' from the steep and moderately steep slopes into the slightly undulating lower slopes (e.g. Terrain Unit 3) downslope of Terrain Unit 2; and
- Very rapid failure (rock fall or rock roll) of sandstone or ironstone cobbles and boulders (present in places on the slope surface), dislodged during site works and running downslope into the works zone.

8.2.4 Assessed Risk of Slope Instability

In accordance with the AGS (2007) Guidelines, the risk of slope instability has been assessed for the hazards identified in Section 8.2.3 for current site conditions and following the implementation of hazard reductions works. A qualitative assessment of likelihood, consequence and risk to property has been made based on experience with similar sites in south-western Sydney and nearby areas. The slope instability risk assessments for both property and life are summarised in Table 1 and Table 2.

The presence of surface features indicative of previous slope instability, including colluvial soils in areas denoted as ‘Terrain Unit 2’ (inclusive of slope constraint zones denoted as ‘Zone 2’ and ‘Zone 3’), indicate that, where these are present, the current factor of safety for slope stability is likely to be less than 1.5 (i.e. not ‘acceptable’ for hillside development), and therefore the implementation of geotechnical remediation and hazard reduction measures will be required to reduce the risk of slope instability.

While an area may be assessed as being currently unaffected by slope instability, unsuitable development or the lack of maintenance may trigger slope instability. Alternatively, sites which are assessed as having some risk of slope instability may be improved by such features as subsurface drainage.

The implication of the assessed *‘High to Very High’* risk of slope instability in certain areas of the site is that the risk is *'Unacceptable'* for the current site conditions. Remedial and hazard reduction works will be required to facilitate residential development in these sub-areas of the site, to reduce and maintain the risk of slope instability to no greater than an ‘Acceptable*’* level. The implication of the assessed *‘Low’* risk following the implementation of remedial and hazard reduction works is that the risk will be *'Acceptable'*, which will be acceptable to property owners and authorities. Recommendations for geotechnical remediation and hazard reduction works to reduce and maintain the nominated risk level are provided in Section 8.4 and a site maintenance programme is included in Section 8.4.4.

Table 1: Risk Assessment for Property for the Proposed Hillside Development (Terrain Unit 2) Due to Slope Instability

Hazard	Consequence	Instability - Current Site Conditions		Instability - Following Hazard Reduction Works	
		Likelihood	Assessed Risk to Property [(1)]	Likelihood	Assessed Risk to Property [(1)]
Extremely slow soil creep	Insignificant for engineered structures designed for creep loadings	Almost Certain	Moderate	Likely but minimised following hazard reduction works including surface and subsurface drainage	Low
Rapid, surficial soil slumps or shallow rotational failures in the moderately steep to steep hillside	Minor, due to the potential for part of the site requiring reinstatement / stabilisation works	Likely	Moderate	Unlikely following hazard reduction works including surface drainage	Low
Slow, intermediate-depth slide through the soil and extremely weathered rock profile	Major to Catastrophic	Possible	High to Very High	Barely credible following hazard reduction works including removal and replacement of movement-affected material, surface and subsurface drainage	Low
Very rapid, dislodgement and runout of blocks from the hillside slope during site works	Minor: low-speed car impact with block, clean-up of small volume of material	Possible during site works	Moderate	Unlikely following hazard reduction works	Low

Note: (1) The assessed risk levels reflect the likelihood (i.e. the probability) and consequence (i.e. the cost of reinstatement, stabilisation works, delays, etc.) affecting the element at risk (e.g. new dwellings). The assessed risk levels do not reflect the risk levels for loss of life (refer text).

Table 2: Risk Assessment for Property for Slightly Undulating Lower Slopes (Terrain Unit 3) Due to Slope Instability in the Adjacent Steep Hillside

Hazard	Consequence	Current Site Conditions		Following Hazard Reduction Works	
		Likelihood	Assessed Risk to Property (1)	Likelihood	Assessed Risk to Property (1)
Extremely slow soil creep	Minor	Barely Credible in the slightly undulating lower slopes	Very Low	Barely Credible in the slightly undulating lower slopes	Very Low
Rapid, surficial soil slumps or shallow rotational failures in the steep hillside or where batters are constructed on moderately steep slopes	Minor, due to clean up costs and the potential for part of the slope/cut batter requiring reinstatement/stabilisation works	Possible	Moderate	Unlikely following hazard reduction works including surface and subsurface drainage	Low
Slow, intermediate-depth slide through the soil and extremely weathered rock profile extending downslope from steep or very steep slopes	Medium, due to clean-up costs and the potential for part of the slope/cut batter requiring reinstatement/large stabilisation works	Unlikely	Low	Barely Credible following hazard reduction works including removal and replacement of movement-affected material, surface and subsurface drainage	Very Low
Very rapid, dislodgement and run-out of blocks embedded in the hillside extending into downslope developments during site works	Minor, repairs to damage and clean-up of small volume of material	Possible during site works	Moderate	Unlikely following hazard reduction works	Low

Note: (1) The assessed risk levels reflect the likelihood (i.e. the probability) and consequence (i.e. the cost of reinstatement, stabilisation works, delays, etc.) affecting the element at risk (e.g. new residential dwellings). The assessed risk levels do not reflect the risk levels for loss of life (refer text).

For loss of life, the individual risk can be calculated from:

$$R_{(LoL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$$

where:

$R_{(LoL)}$ is the risk (annual probability of loss of life of an individual).

$P_{(H)}$ is the annual probability of the hazardous event (e.g. intermediate-depth failure) occurring.

$P_{(S:H)}$ is the probability of the hazardous event affecting the residence taking into consideration the travel distance and travel direction of the event.

$P_{(T:S)}$ is the temporal probability (e.g. the affected section of the dwelling being occupied by the individual) given the spatial impact allowing for likelihood of evacuation.

$V_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact).

A preliminary assessment of risk-to-life has also been carried out for the assessed slope instability hazards for the proposed Lots. Based on velocity and consequences of previous failures within nearby areas, it is expected that there would be a high probability of safe evacuation from dwellings should a slow, intermediate-depth failure occur (assessed as a ‘barely credible event’ following remedial works). The annual probability of loss-of-life of a person most at risk, as a result of the effects of an intermediate-depth failure (considered to be the most dangerous of the assessed hazards to structures) is summarised in Table 3 assuming that:

- an intermediate-depth failure extends through the entire footprint of the dwelling;
- the probability of non-evacuation is taken as 0.05;
- the person most-at-risk occupies the dwelling for an average of 12 hours/day for a typical year;
- the structure does not collapse; and
- vulnerability of the individual (i.e. the probability of death) is 0.1.

Table 3: Summary of Estimated Annualised Risk of Slope Instability – Person Most at Risk

Scenario	Hazard	$P_{(H)}$	$P_{(S:H)}$	$P_{(T:S)}$	$V_{(D:T)}$	$R_{(LoL)}$
Site conditions following remedial works	Intermediate-depth failure	1×10^{-6}	1.0	2.5×10^{-2}	0.1 (1.0×10^{-1})	6×10^{-9}

The risk of loss of life with respect to the identified geotechnical hazards (i.e. $<1\text{x}10^{-6}$ annual probability) for the proposed development in Table 3 is considered to be acceptable.

8.3 Assessment of Slope Stability Constraints

8.3.1 General

The areas of this site considered to have potential constraints to development are those areas identified as ‘Terrain Unit 2’ (inclusive of slope constraint zones denoted as ‘Zone 2’ and ‘Zone 3’: refer Section 8.1), for which the risk assessment for property due to slope instability (for ‘current’ site conditions) was calculated to be either ‘Moderate’ risk or ‘High to Very High’ risk (refer Table 1 in Section 8.2.4).

The slope stability risk ‘zones’ (as potential constraints to development), which were outlined in DP (2022a), are based on an assessment of historical slope instability, geological mapping, subsurface investigations, and a qualitative risk assessment. These assessed zones of potential constraints (shown on Drawing 8A and Drawing 8B) are:

- Zone 1: No constraints to development, or only minor constraints (typically corresponds with Terrain Units 1, 3 and 4, and ‘Very Low’ or ‘Very Low to Low risk’ (i.e. AGS (2007));
- Zone 2: Intermediate constraints to development (corresponds with Terrain Unit 2, and ‘Moderate’ risk); and
- Zone 3: Major constraints to development (corresponds with Terrain Unit 2, and ‘High to Very High’ risk).

8.3.2 Zone 1 (No Constraints or Minor Constraints to Development)

The land in this zone comprises gently-graded slopes which are incised by a few minor drainage gullies. Other than soil slumping from low-height gully sides, with the volume of movement-affected materials probably no more than a few cubic metres and probably triggered by soil erosion, there does not appear to be a significant risk of soil slope or gully instability.

It is considered that potential instability of these low-height slopes (along drainage lines) would impose only a minor constraint to development, which could be addressed by good engineering practices during the construction phase of the project (e.g. benched and battered temporary and permanent soil slopes, installation of surface and sub-soil drainage, prevention of ponding of stormwater).

8.3.3 Zone 2 (Intermediate Constraints to Development)

The lower and mid-slopes below the ridgelines on the southern part of the site comprise thick soil profiles of the Blacktown (residual) and Luddenham (erosional) soil landscapes, which have been documented as being prone to slope instability (slumping and soil creep) when triggered by erosion or groundwater seepage, particularly on steep slopes underlain by shale. The low permeability, poorly draining clayey soils can lose strength due to saturation induced by periods of high rainfall or where natural drainage has been disturbed by development. The slopes below the ridgelines could be affected by ‘run-out’ of landslides from steeper terrain above.

It is considered that potential soil creep or shallow slump instability is likely to impose minor to moderate development constraints which can be addressed by good engineering practices for hillside development (including site-specific investigation and engineering of structures), while areas of run-out from landslides further upslope may be a major constraint to development. On this basis, it is considered that residential development will be possible for areas of the site delineated as 'Zone 2' provided that precautionary and remedial measures are carried out (refer to Section 8.4). Further investigation is likely to be required for areas where residential development is proposed, which could be carried out at a later stage of the project (e.g. Development Application stage).

8.3.4 Zone 3 (Major Constraints to Development)

The upper areas of the hillside slopes within Lot 4 in DP1273487, and isolated areas of Lot 500 in DP1231858 and Lot 4 in DP1216380, are considered to be affected by shallow to moderately deep hillslope instability. Slopes below these areas of the site could be affected by the 'run-out' of significant landslide event(s), potentially by at least 20 m below the current limit of these zones, including the area west of Slope Numbers 111, 115, 116 and 119 (refer Drawing 4).

The potential for instability (or re-activation of previous instability) is a major constraint to development within these areas, and it may be difficult to provide cost-effective engineering solutions for proposed development in these areas. Construction of buildings should be avoided without completion of specific geotechnical investigations, probably in conjunction with the installation of slope stabilisation measures and the implementation of other engineering recommendations. On this basis, it is considered that landscaping and use as 'open space' is appropriate within this zone, provided slope integrity is maintained and erosion control measures are implemented, as detailed in Section 8.4.2.

8.4 Geotechnical Remediation and Hazard Reduction Measures

8.4.1 General

Based on the results of the current assessment and previous work on similar sites, geotechnical remediation and hazard reduction works will be required to reduce and/or maintain the current risk of slope instability, to facilitate residential development in the steep hillside of the site to within acceptable risk levels. The geotechnical remediation and hazard reduction measures for this site include:

- Removal of all movement-affected materials on the hillside slopes (slope constraint Zone 2 within Terrain Unit 2: refer Drawing 6) and replacement with 'Level 1' engineered fill. This includes the removal of residual soils overlying weathered bedrock within these slopes, which may include relict joint planes with reduced strength. Further details on the potential requirement for earthworks is presented in Section 8.4.2;
- Installation of sub-surface drainage in the steep hillside (slope constraint Zone 2 within Terrain Unit 2), to control pore water pressures within the soil profile. Sub-surface drainage will be required within slope constraint area 'Zone 2', as depicted on Drawing 8A and Drawing 8B. Further details on subsurface drain requirements are provided in Section 8.4.3;
- Improvements to surface drainage to collect and direct overland stormwater flows in a controlled manner to the Council stormwater system;
- Consideration for the construction of one or more 1 m-high earth bunds upslope of site work areas which are downslope of areas of steep to very steep slopes, where there is potential for the run-out of dislodged material during the construction period;
- While the assessment of individual lot geometries is beyond the scope of the current assessment, indicative development guidelines are provided in Section 8.4.4;

- Maintain slope integrity and implement erosion control measures, including the maintenance and/or improvement of soil stabilisation in reserves, parks and other green spaces. This is likely to be attained by keeping existing shrubs and trees, and/or by planting additional local, native, deep-rooted shrubs or trees;
- Site-specific investigation and the review of development plans by an experienced geotechnical consultant with experience in slope instability will be required, for hillside lots such as those currently positioned within slope constraint Zone 2 in Terrain Unit 2;
- Transfer of structural loads (e.g. for dwellings) to a uniform bearing stratum of weathered bedrock following completion of rectification works, for dwellings which are within slope stability risk Zone 2 in Terrain Unit 2 (refer also Appendix G: ‘Examples of good hillside practice’, page 114 of AGS, 2007); and
- Ongoing site maintenance and inspections for the developed lots and infrastructure within the steep hillside (e.g. by property owners with individual lots, and by Council within public reserves: refer also CSIRO Publication BTF-18 in Appendix H: ‘Foundation Maintenance and Footing Performance: a Homeowner’s Guide’).

8.4.2 Site Preparation and Earthworks

Preliminary earthworks plans must be reviewed by DP to ensure the geotechnical recommendations provided below have been met.

Based on the results of the investigations completed to date, topsoil stripping depths within slope constraint Zone 2 in Terrain Unit 2 are expected to be in the range 0.2 - 0.4 m. Stripping depths for colluvial and residual soils for the same area are generally expected to be in the range of 1.0 – 3.0 m.

The following methodology is suggested for earthworks associated with the removal and replacement of movement-affected and movement-prone soils in the steep hillside:

- Removal and stockpiling of organic-rich topsoil ahead of bulk earthworks operations, for re-use on site for landscaping purposes. Organic topsoil and vegetation will not be suitable for incorporation into and construction of engineered fill platforms. Alternatively, provision will need to be made for off-site disposal of these soils;
- Removal and stockpiling of colluvial and residual soils (i.e. to the level of the weathered bedrock) for re-use as engineered fill within the steep hillside (possibly following moisture conditioning);
- Inspection of stripped surfaces by an experienced geotechnical consultant, to confirm the removal of the movement-affected and movement-prone soil profile and the continuity of the exposed bedrock;
- Due to the topography of the hillside, it will be necessary to bench the surface prior to the placement of fill. Where the ground slopes are steeper than 8H:1V, each layer should be placed and compacted horizontally in a cut and benched formation, in accordance with Australian Standard AS 3798 (AS 3798, 2007);
- All lot fill materials should be approved and placed under full-time supervision (to ‘Level 1’ criteria in accordance with AS 3798:2007). Supervision to ‘Level 2’ standard is considered appropriate for backfilling of service trenches and subsurface drains, unless otherwise specified by the designer. It is also recommended that the Geotechnical Inspection and Testing Authority (GITA) should be engaged directly on behalf of the principal and not by the earthworks contractor. Testing of all fill

materials should be undertaken progressively during the earthworks, to ensure quality control with respect to material type, compaction and moisture. The test frequency should be in accordance with Table 8.1 of AS 3798:2007;

- Fill depths on the hillside lots should be generally restricted to a maximum height of 3 m above the stripped surface, with batters formed not steeper than 3H:1V (i.e. to have a minimum FoS of 1.5) to provide for establishment of grass cover (as soon as possible after placement of the fill) and subsequent maintenance, unless supported by engineer-designed retaining walls. These walls should be founded on intact bedrock of at least low strength. The global stability of batters that exceed a height of 3 m and/or a batter slope of 3H:1V must be confirmed by an experienced geotechnical consultant;
- Cut batters either into the natural slope or within fill materials which exceed a height of 5 m must include an intermediate berm/s (i.e. at every 5 m height interval maximum), which should be at least 2.5 m wide;
- All cut and fill batters must include drains along their crest and toe;
- New fill materials brought to site should be approved by either the civil or geotechnical engineer as being geotechnically appropriate, before they are used. Imported fill should also be approved by the environmental consultant as being in accordance with environmental protocols (if any);
- Retaining walls should include free-draining backfill over the full height for a width of at least 0.3 m behind the face, to reduce the risk of water pressure build-up. Drainage should be facilitated by an ‘ag’ drain at the base of the granular fill, and by a lined surface drain at the crest. The collected water should be discharged to the site’s stormwater system. The drainage lines should include flexible couplings and inspection points for maintenance purposes;
- ‘Borrow’ material or approved imported fill material for geotechnical remediation should be placed in horizontal layers of nominally 250 mm thickness, with the actual thickness dependent upon the equipment proposed for use on site. Over-sized material (i.e. particle with a minimum dimension greater than 100 mm) will require removal prior to compaction (e.g. when material is spread). All fill placed as part of the construction process should be compacted to at least 98% of the maximum dry density (MDD) obtained in the laboratory Standard compaction test. Where fill comprises clays of high plasticity, compaction should not exceed 102% of the MDD to prevent potential for heave. Moisture contents of the fill material should be maintained within ± 2% of the optimum moisture content for standard compaction;
- Prompt protection of placed earth fill by vegetation cover to minimise erosion, facilitated by spray mulching or by use of jute mattresses or rip-rap protection; and
- To minimise the effects of erosion and to prevent drying of the site soils, all allotments will need to be revegetated promptly after completing filling/regrading. This should include a minimum of 100 mm of topsoil. The allotments must also be graded to a minimum of 1% fall.

The soil materials on site are typically clayey or silty in composition and of either medium or high plasticity, and hence are likely to be moisture-sensitive. It is therefore important to ensure that cut and fill surfaces are kept dry and that surface ponding of water is avoided. Wherever practical, the ground surface exposed after stripping should be shaped to assist drainage and be compacted to the same requirements as for the overlying layers of fill. If rain is forecast/expected, or the site is to be left unattended, the upper surfaces of fill should be crowned and if possible ‘blinded’ by smooth-wheeled plant. Any stockpiles should be ‘blinded’ to allow water to run off. It is also important to avoid allowing the subgrade to become overly dry in hot weather. The reason for the above precautions is to limit the amount of shrink-swell movement resulting from a future change in moisture content of the clay.

8.4.3 Subsurface Drainage

Construction of subsurface drainage lines should be carried out following the removal and replacement of movement-affected or movement-prone material with engineered fill (refer Section 8.4.2).

The drains should fall at a slope of at least 2 degrees towards the discharge points. Subsurface drains should be installed at least 0.5 m into the weathered bedrock (i.e. below the base of the replacement engineered fill), with the depth maintained to a point where tapering of the trench is required to tie into a collection pit. The drains should be finished with permanent structures, including flushing points and a discharge point protected from damage and constructed to provide flushing access. Based on the concept layout, it is anticipated that subsurface drains will be required along upslope/downslope lot boundaries (as a minimum) and that intermediate drain/s will also be required within large lots.

The subsurface drains are to have a minimum width of 500 mm and include dual 100 mm diameter ag-lines set into geo-textile wrapped, free-draining aggregate, extending to approximately 1 m below the surface. The upper 1 m of the trench is to be backfilled with selected clayey material compacted in layers to provide a surface seal. It is anticipated that the trenching would commence from the downslope end and be progressively laid to minimise the length of trench open at one time. The ag-lines should be transitioned into solid pipes in the road reserve(s) and discharged into collection pits, which then discharge into Council’s stormwater system. If significant groundwater inflows are encountered at the trench head, it may be necessary to allow drainage of the upslope material prior to continuing the trenching, to minimise the risk of trench collapse. If unsatisfactory excavation or drainage conditions are encountered, if may be also necessary to construct pressure relief bores by drilling below the base of the drainage trenches. Excavation support, such as shoring, may also be required. Reinstatement with controlled (i.e. compacted) fill will be required to minimise the potential for erosion scouring.

Discharge into a collection pit will allow for monitoring of drain flows following construction. Surface drains must not be directed into subsurface drainage.

Drawings for stormwater and subsurface drainage must be reviewed by DP to confirm that the recommendations in this report have been followed.

8.4.4 Design Guidelines

Development of individual lots within the site must consider the topographic nature of the site. The following design guidelines are recommended for the development of concept design plans for future lots:

- Cut and fill on individual lots (i.e. following the completion of bulk earthworks) must be balanced to ensure that the overall load on the slope is unchanged. Unsupported fill and cuttings must not exceed a vertical height of 1 m above or below the design surface profile. All batters should be constructed no steeper than 3H:1V and vegetated to reduce the effects of erosion. All other excavations or fill must be supported by engineer-designed retaining walls;
- Due to site topography and the likelihood of bedrock exposure during site preparation for individual structures, a footings-to-rock system is recommended for dwellings. Design compliance to be confirmed following inspection by a suitably qualified geotechnical consultant during construction.

Provision will also need to be made for articulation (i.e. control joints) between sections of the dwellings;

- Overall conceptual design for proposed developments must be reviewed by a geotechnical consultant experienced with slope instability, to ensure that the geotechnical requirements of the site are accommodated in the design;
- All stormwater must be collected and discharged from the site in a controlled manner. Lots must be maintained in accordance with the CSIRO publication BTF-18 *"Foundation Maintenance and Footing Performance: A Homeowner's Guide"*, a copy of which is included in Appendix H. Whilst it must be accepted that minor cracking in most structures is inevitable, the guide describes suggested site maintenance practices aimed at minimising foundation movements and keeping cracking within acceptable limits; and
- Site inspections and maintenance must be carried out to ensure that hazard reduction measures remain in effect and operational at the site. As a minimum, it is suggested that drainage lines and pits, retaining walls and site slopes are inspected yearly and following each major rainfall event, and a relevant professional (e.g. structural engineer or geotechnical engineer) should be consulted where changes to site conditions are identified.

9. Geotechnical Requirements Moving Forward

Geotechnical aspects that are discussed in this report and which will require input during design and construction are summarised below:

- Further assessment of landslide run-out distances, for area of the site where residential developments are proposed;
- Additional subsurface investigation (i.e. at the commencement of bulk earthworks) to delineate the downslope extent of movement-affected areas;
- Review of concept drainage and earthworks plans prior to finalisation for the proposed development;
- Inspections during stripping of soils and ‘Level 1’ supervision and testing during placement of engineered fill within the steep hillside;
- Inspections during subsurface drain construction in the hillside;
- Site-specific geotechnical assessment for individual hillside lots; and
- Notwithstanding the abovementioned items, the client and the earthworks contractor(s) should also be aware of any conditions in the development consent that require professional input during design and construction. In particular, care must be exercised to ensure that DA Consent conditions are satisfied.

10. Conclusion

The current assessment indicates that the steeper areas of hillside slopes within Lot 4 in DP 1216380, Lot 4 in DP1273487 and Lot 500 in DP1231858 have previously been affected by slope instability, with landslide debris and movement-affected soils observed in some areas of the steeper slopes.

Zones of the site assessed (in its current state) to have a '*High to Very High'* risk of slope instability have been delineated as 'Zone 3', and zones assessed to have a *'Moderate'* risk of slope instability have been delineated as 'Zone 2'. Notwithstanding this, the steep hillsides within Zones 1 to 3 at the site are considered suitable for the proposed development (from a geotechnical perspective), provided design and construction is undertaken in accordance with good practice for hillside construction and the recommendations presented in this report.

11. References

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12. Limitations

Douglas Partners (DP) has prepared this report for this project at South Creek West, Precinct 5, Cobbitty in accordance with DP's proposal 92225.05.P.001.Rev0 dated 10 October 2022 and acceptance received from Mr. Trent Argaet of BHL Group Pty Ltd on behalf of Boyuan Bringelly Pty Ltd dated 18 October 2022. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Boyuan Bringelly 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 another site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

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

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

November 2020

Introduction

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

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

Copyright

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

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

continued next page

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.

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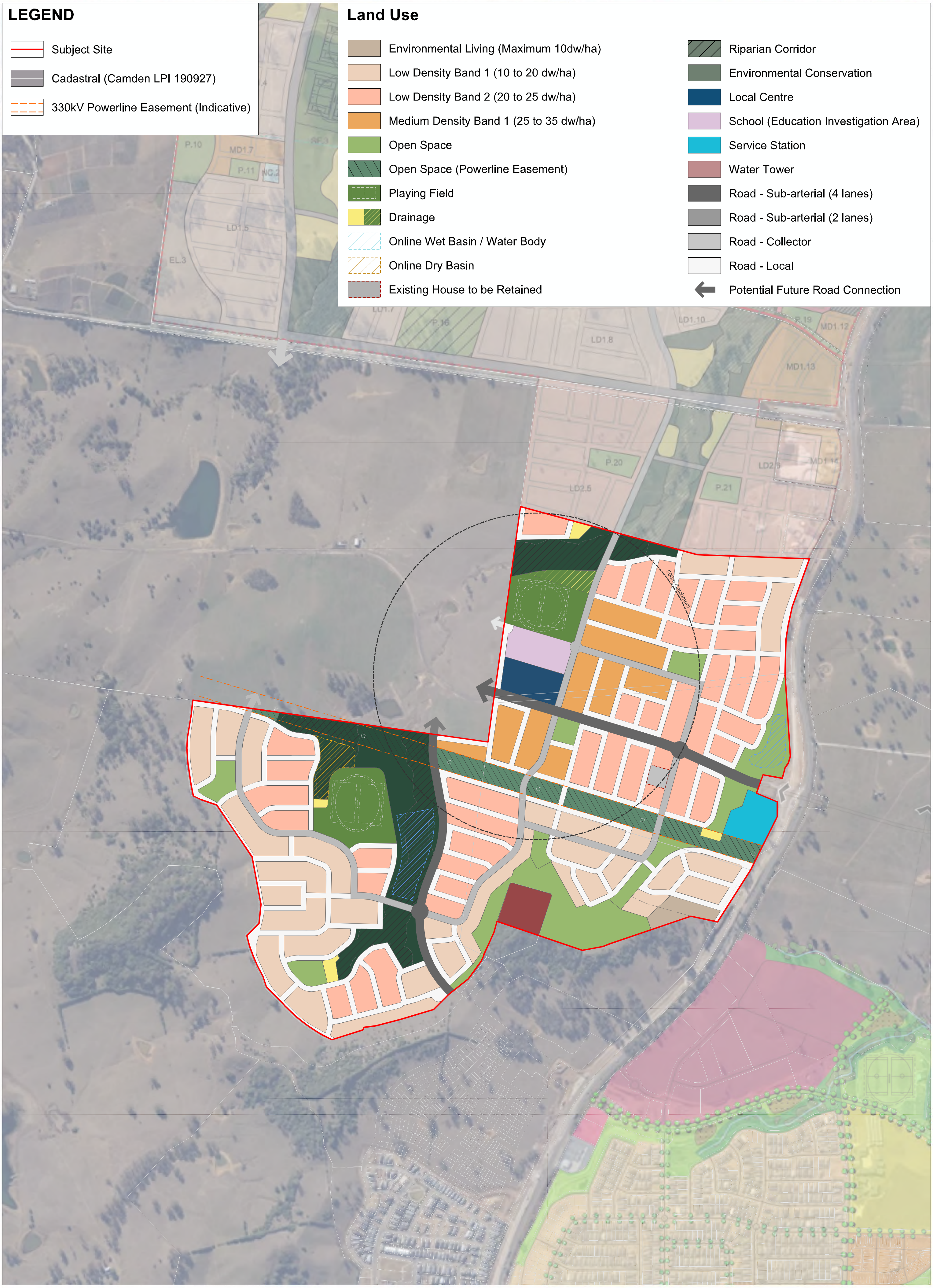
Appendix B

Indicative Layout Plan



LEGEND

- Subject Site
- Cadastral (Camden LPI 190927)
- 330kV Powerline Easement (Indicative)

Land Use

- Environmental Living (Maximum 10dw/ha)
- Low Density Band 1 (10 to 20 dw/ha)
- Low Density Band 2 (20 to 25 dw/ha)
- Medium Density Band 1 (25 to 35 dw/ha)
- Open Space
- Open Space (Powerline Easement)
- Playing Field
- Drainage
- Online Wet Basin / Water Body
- Online Dry Basin
- Existing House to be Retained
- Riparian Corridor
- Environmental Conservation
- Local Centre
- School (Education Investigation Area)
- Service Station
- Water Tower
- Road - Sub-arterial (4 lanes)
- Road - Sub-arterial (2 lanes)
- Road - Collector
- Road - Local
- Potential Future Road Connection

Draft Indicative Layout Plan - BHL Land Holding

COBBITTY

NORTH

50 0 100 200 300 400 500 metres

Ref:BHLCO-2-001a-2 **Date:** 02/12/2022 **Revision:** F **Scale:** 1:5,000@A1

Note: All areas and dimensions subject to detailed survey

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Appendix C

Site Photographs

Photo 1 - View towards the west near Test Pit 301, near the crest of the ridgeline.

Photo 2 - View towards the south-east near Test Pit 301. The approximate test location is indicated.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	1
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 3 - View towards the west at Test Pit 301.

Photo 4 - View towards the south-west and Test Pit 302. The approximate test location is indicated.

Douglas Partners
Geotechnics / Environment / Groundwater

Site Photographs	PROJECT:	92225.06
Proposed Residential Subdivision	PLATE No:	2
SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 5 - View towards the north-east and downslope, from the location of Test Pit 302.

Photo 6 - Sandstone boulders partially buried within the slope (inferred colluvial soil).

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	3
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 7 - View towards the south, upslope along a fenceline obscured by wild olives, west of Test Pit 302.

Photo 8 - View towards the south-west. The approximate position of Test Pit 303 is indicated.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	4
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 9 - View towards the north and upslope, east of Test Pit 304.

Photo 10 - View north-west towards the location of Test Pit 304. The approximate test location is indicated.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	5
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 11 - View north towards the location of Test Pit 305. The approximate position of the test location is indicated.

Photo 12 - View north-west, upslope and south of the location of Test Pit 305.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	6
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 13 - View west towards the location of Test Pit 305. The approximate test location is indicated.

Photo 14 - View west from the location of Test Pit 306.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	7
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 15 - View south from the location of Test Pit 307.

Photo 16 - View south-east towards the location of Test Pit 308. The approximate test location is indicated.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	8
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 17 - View south along a fenceline, west of Test Pit 308.

Photo 18 - View south from the location of Test Pit 308.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	9
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 19 - View east towards the ridgeline and the location of Test Pit 309. The approximate test location is indicated.

Photo 20 - View north towards the location of Test Pit 309 on the slope below. The approximate test location is indicated.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	10
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 21 - View south-east at the location of Test Pit 309.

Photo 22 - View north from the location of Test Pit 310 towards Test Pit 309 (obscured on far side of side-slope).

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	11
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 23 - View west near the location of Test Pit 311.

Photo 24 - View south-west towards a nearby ridgeline on an adjoining property, west of Test Pit 311.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	12
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Photo 25 - View east from the neighbouring Lot towards the location of Test Pit 311.

Photo 26 - View north and upslope towards the location of Test Pit 312. The test pit is positioned near the crest of the slope.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	13
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

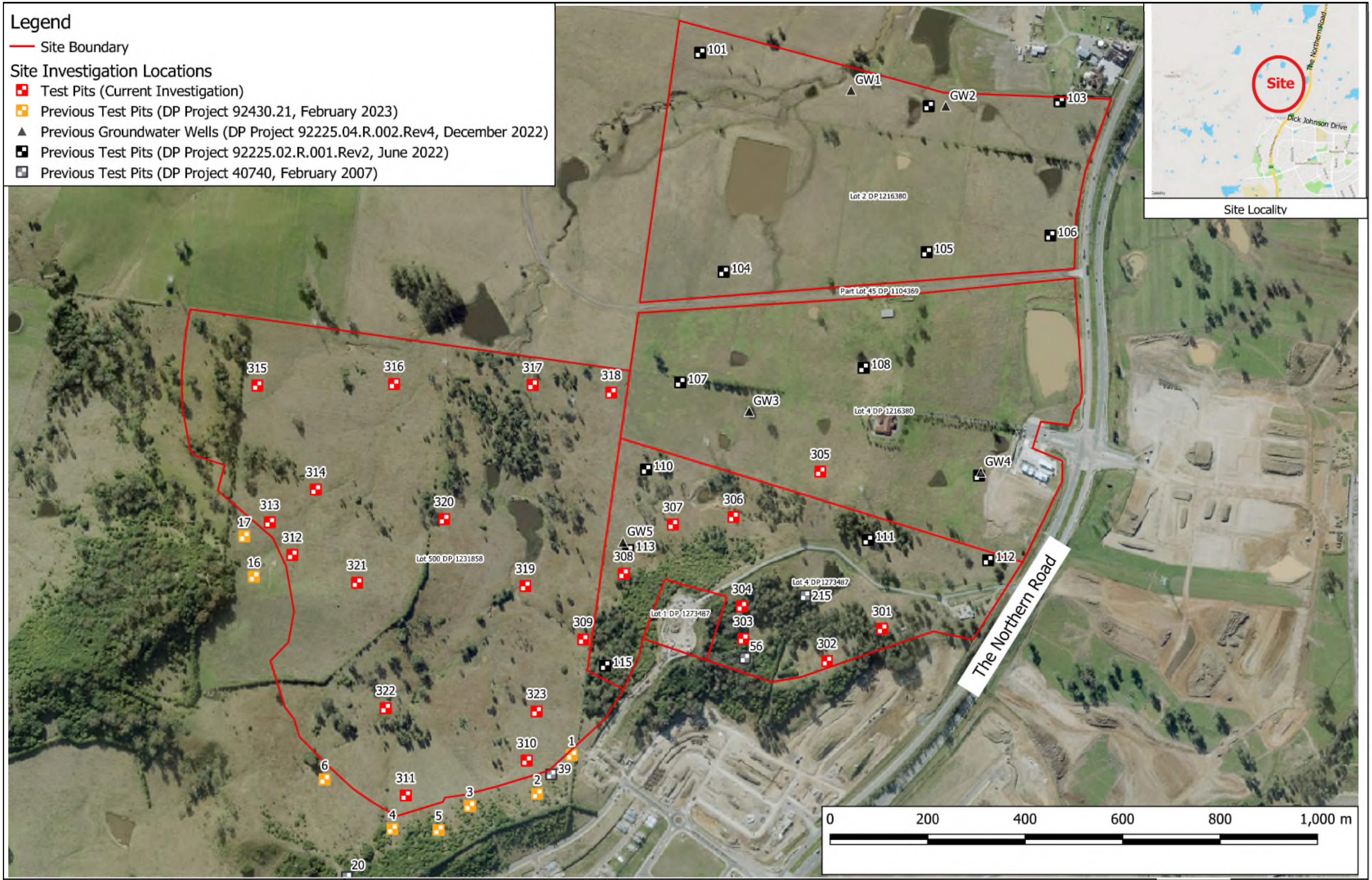
Photo 27 - View east at the location of Test Pit 312, towards a shallow gully.

Photo 28 - View west and upslope to a neighbouring property from the location of Test Pit 313.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	14
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Appendix D

Drawings



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd		TITLE: Site and Test Location Plan Further Stability Assessment Proposed Residential Subdivision South Creek West, Precinct 5, Cobbitty
OFFICE: Macarthur	DRAWN BY: HDS	
SCALE: 1:7000 (A3)	DATE: 22/02/2023	

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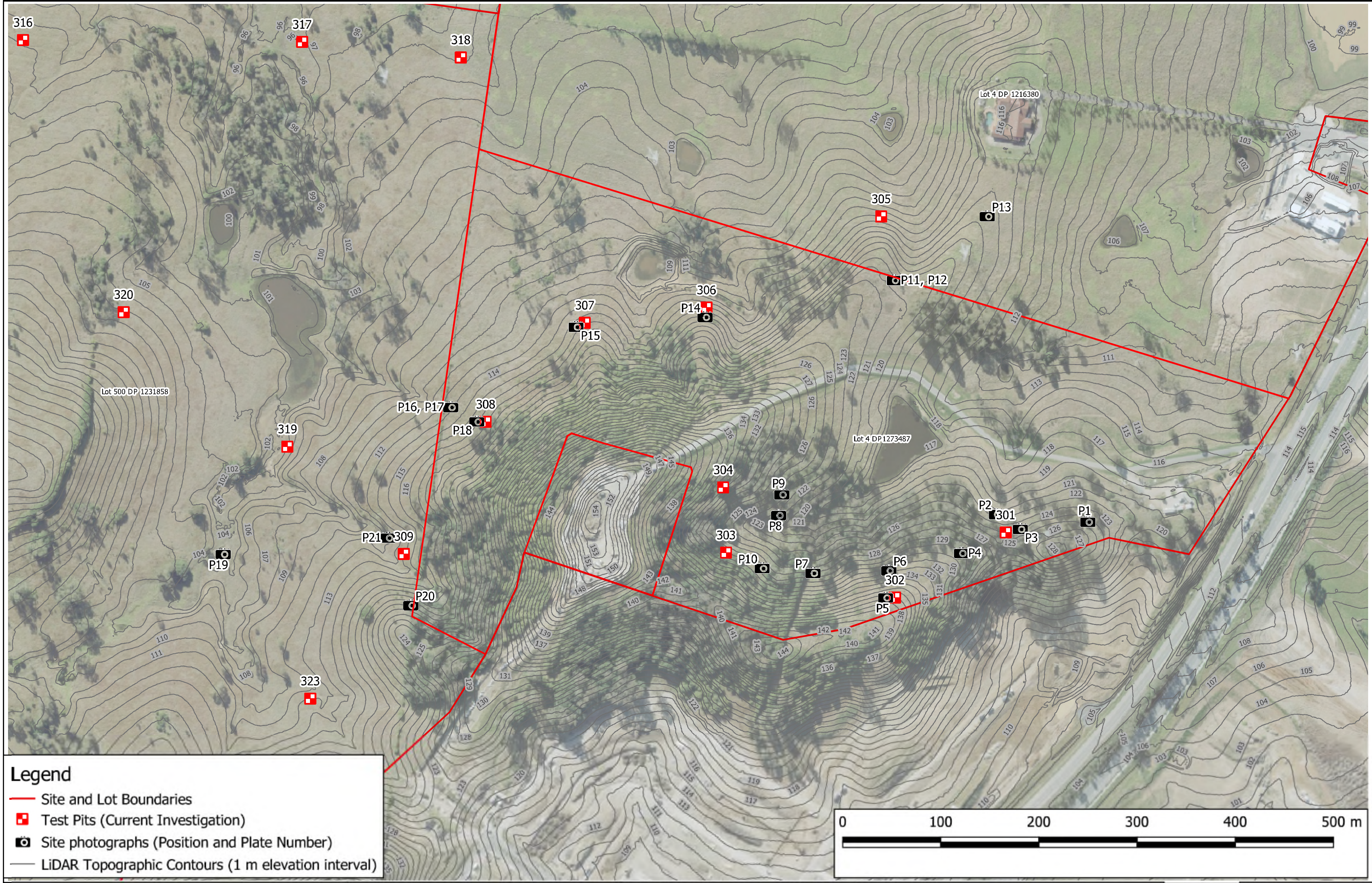
REVISION:	0



Legend

- Site and Lot Boundaries
- 🟥 Test Pits (Current Investigation)
- ● Site photographs (Position and Plate Number)
- LiDAR Topographic Contours (1 m elevation interval)

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd	
OFFICE: Macarthur	DRAWN BY: HDS
SCALE: 1:3500 (A3)	DATE: 22/02/2023

TITLE: Test Plan with Surface Contours and Site Photo Overlay (Eastern Portion)
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

PROJ. #:	92225.06
DRAWING No:	2 A
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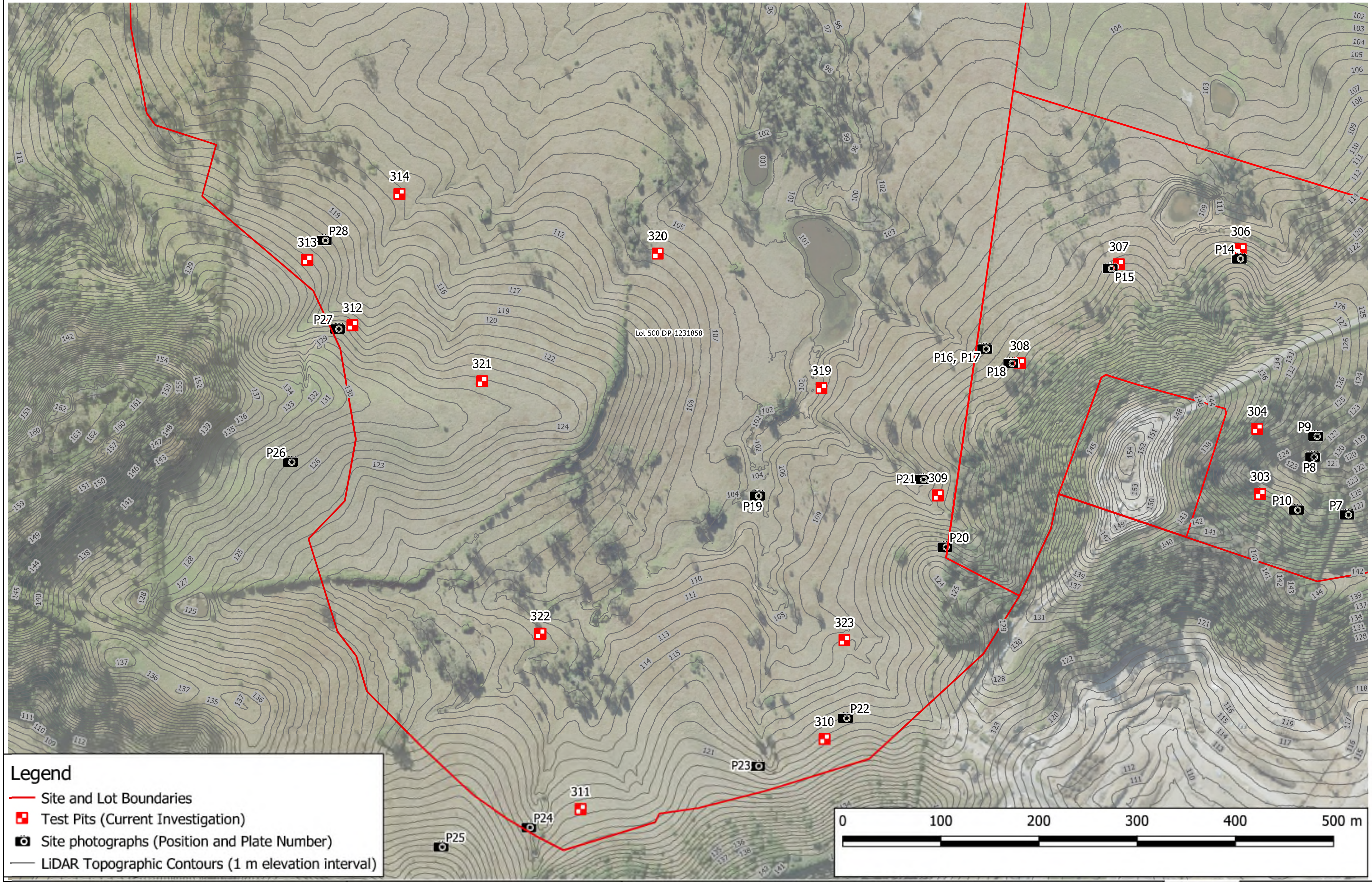


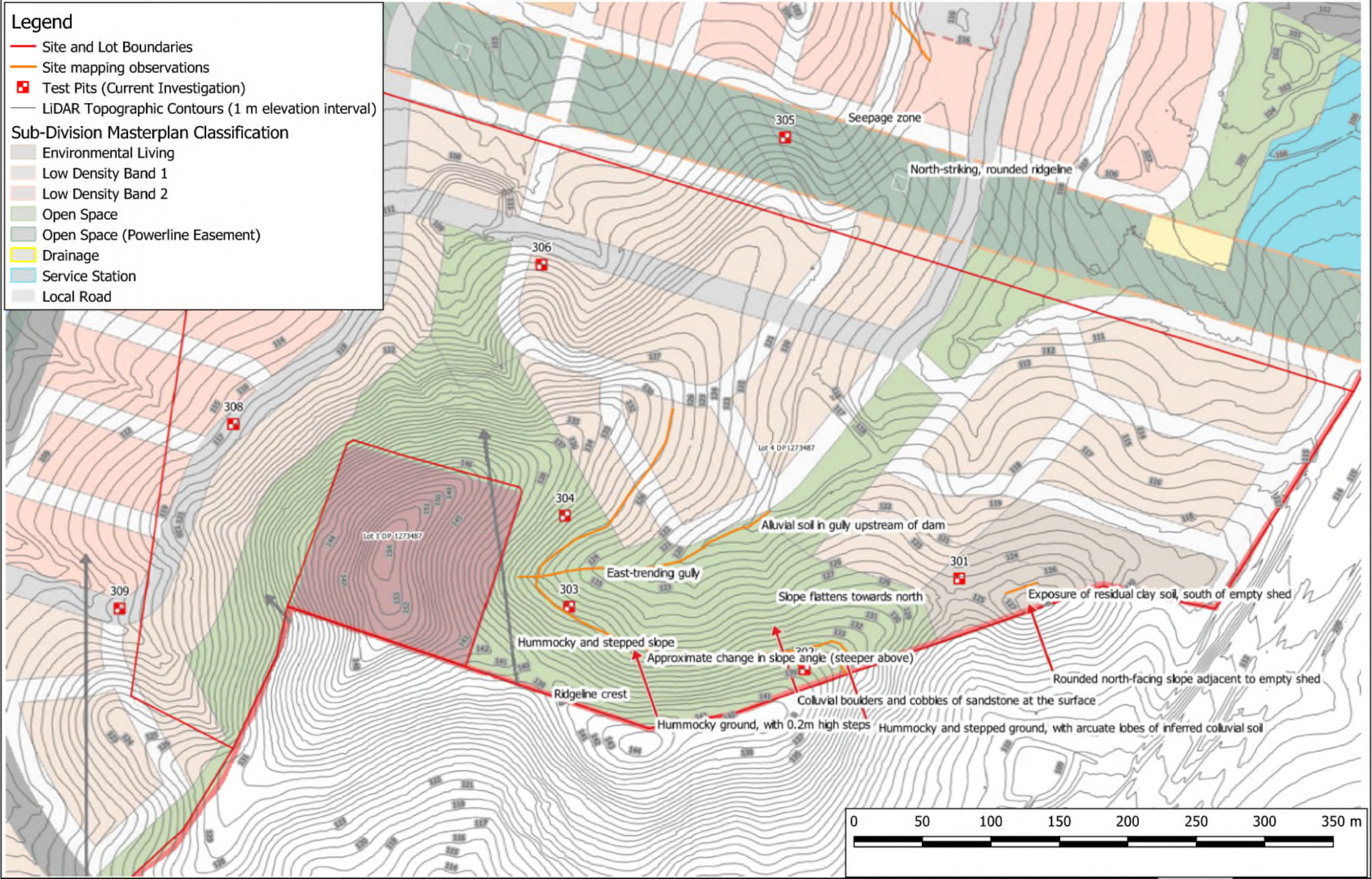
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd
OFFICE: Macarthur
DRAWN BY: HDS
SCALE: 1:3500 (A3)
DATE: 22/02/2023

TITLE: Test Plan with Surface Contours and Site Photo Overlay (Western Portion)
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

N
MGA

PROJ. #: 92225.06
DRAWING No: 2 B
REVISION: 0



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd		
OFFICE: Macarthur	DRAWN BY: HDS	
SCALE: 1:2500 (A3)	DATE: 27/02/2023	

TITLE: Site Mapping Observations (Eastern Portion), with Proposed Sub-Division Plan Overlay
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

PROJ. #: 92225.06	
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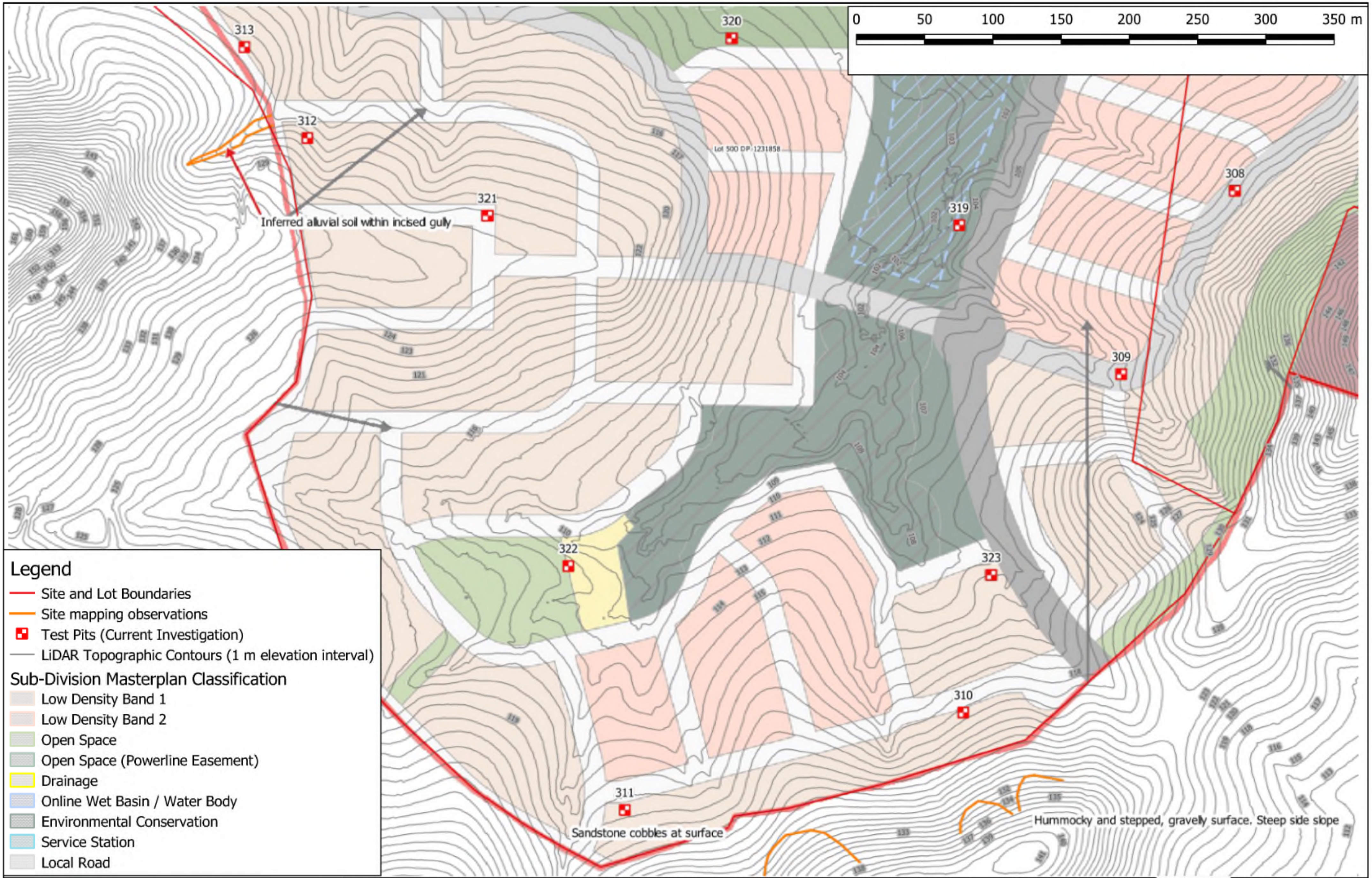
REVISION:	0



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd
OFFICE: Macarthur
DRAWN BY: HDS
SCALE: 1:2500 (A3)
DATE: 22/02/2023

TITLE: Site Mapping Observations (South-Western Portion), with Proposed Sub-Division Plan Overlay
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

PROJ. #: 92225.06
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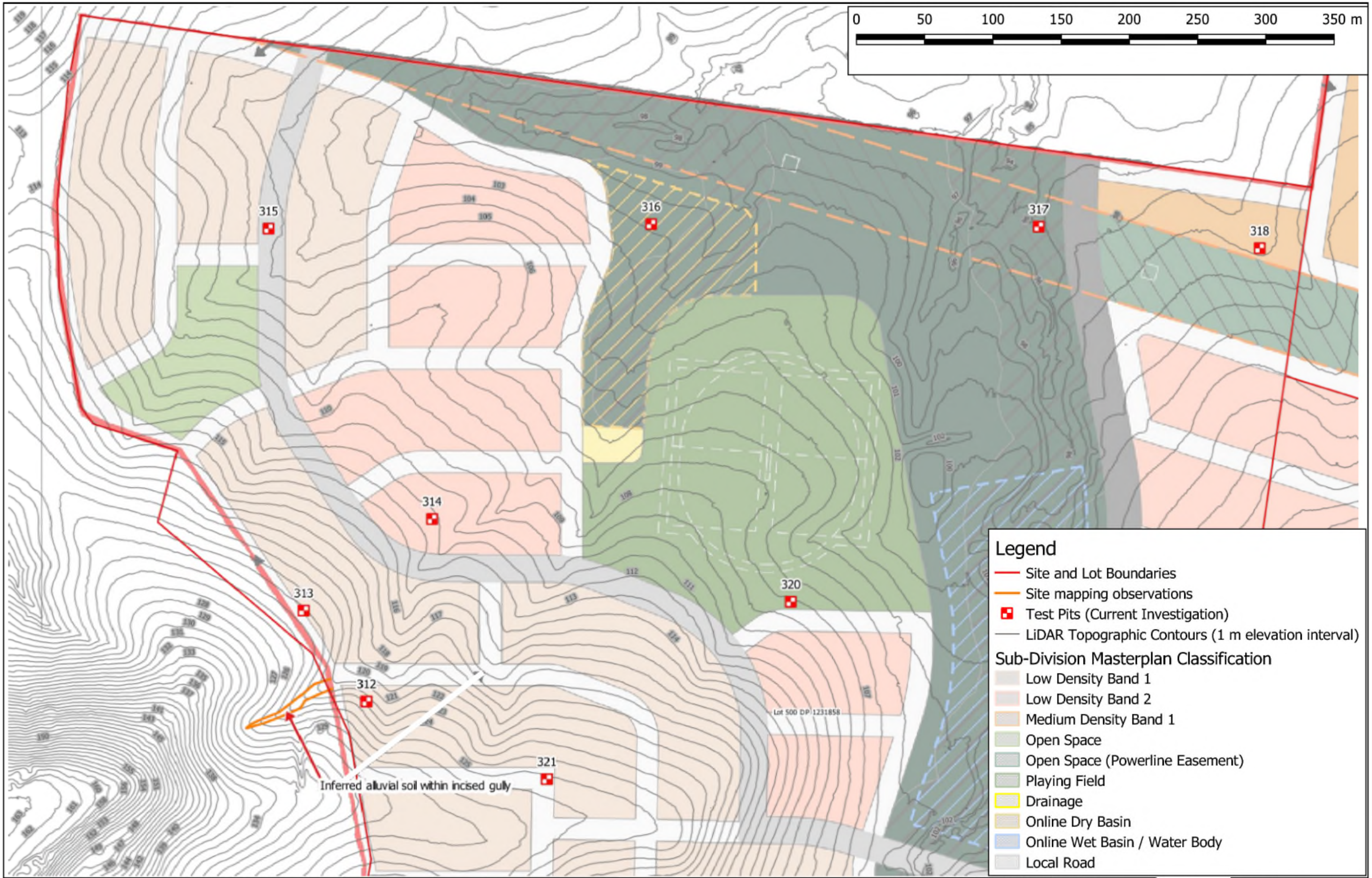

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd
OFFICE: Macarthur
DRAWN BY: HDS
SCALE: 1:2500 (A3)
DATE: 22/02/2023

TITLE: Site Mapping Observations (Western Portion), with Proposed Sub-Division Plan Overlay
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

PROJ. #: 92225.06
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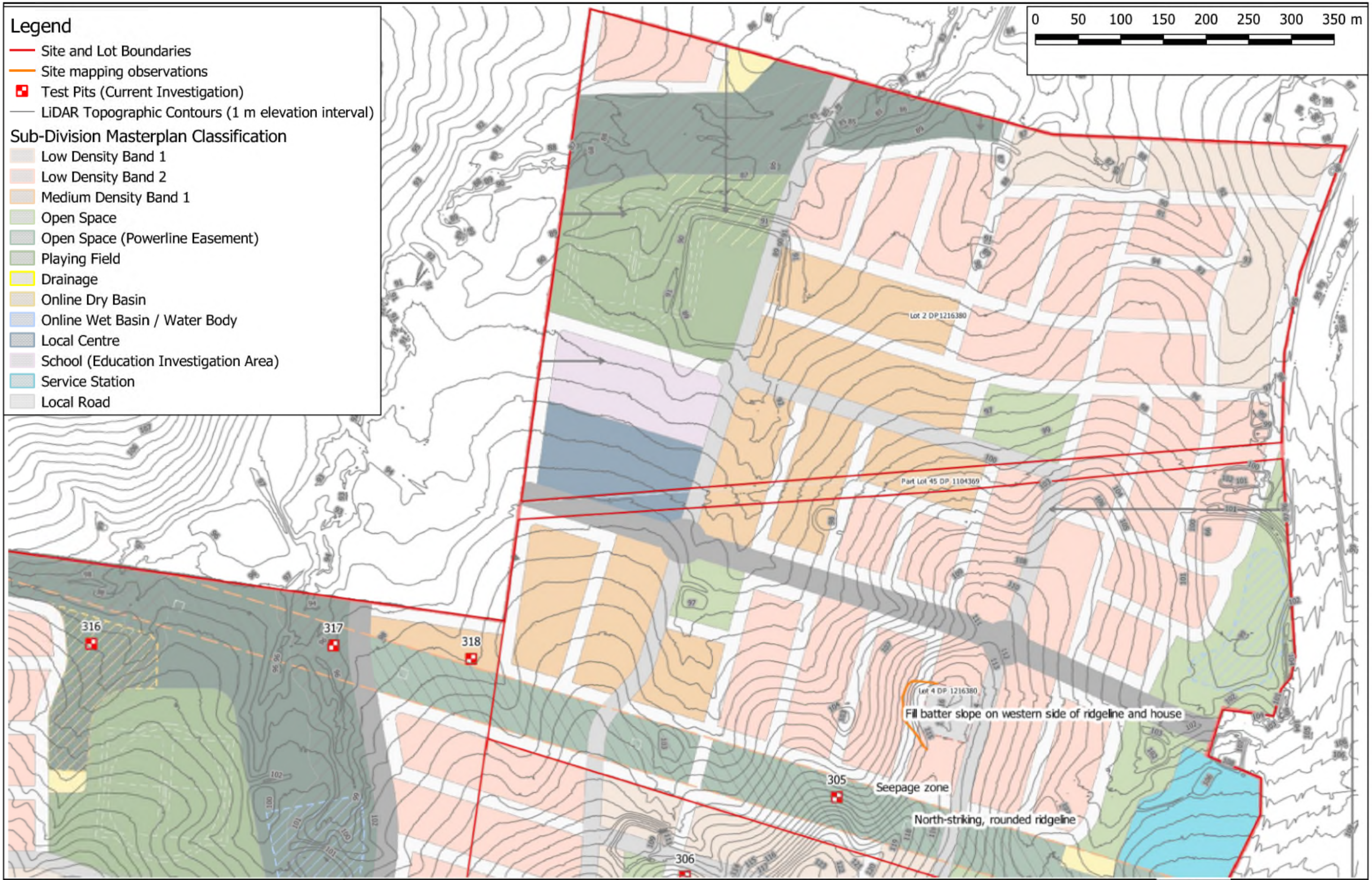
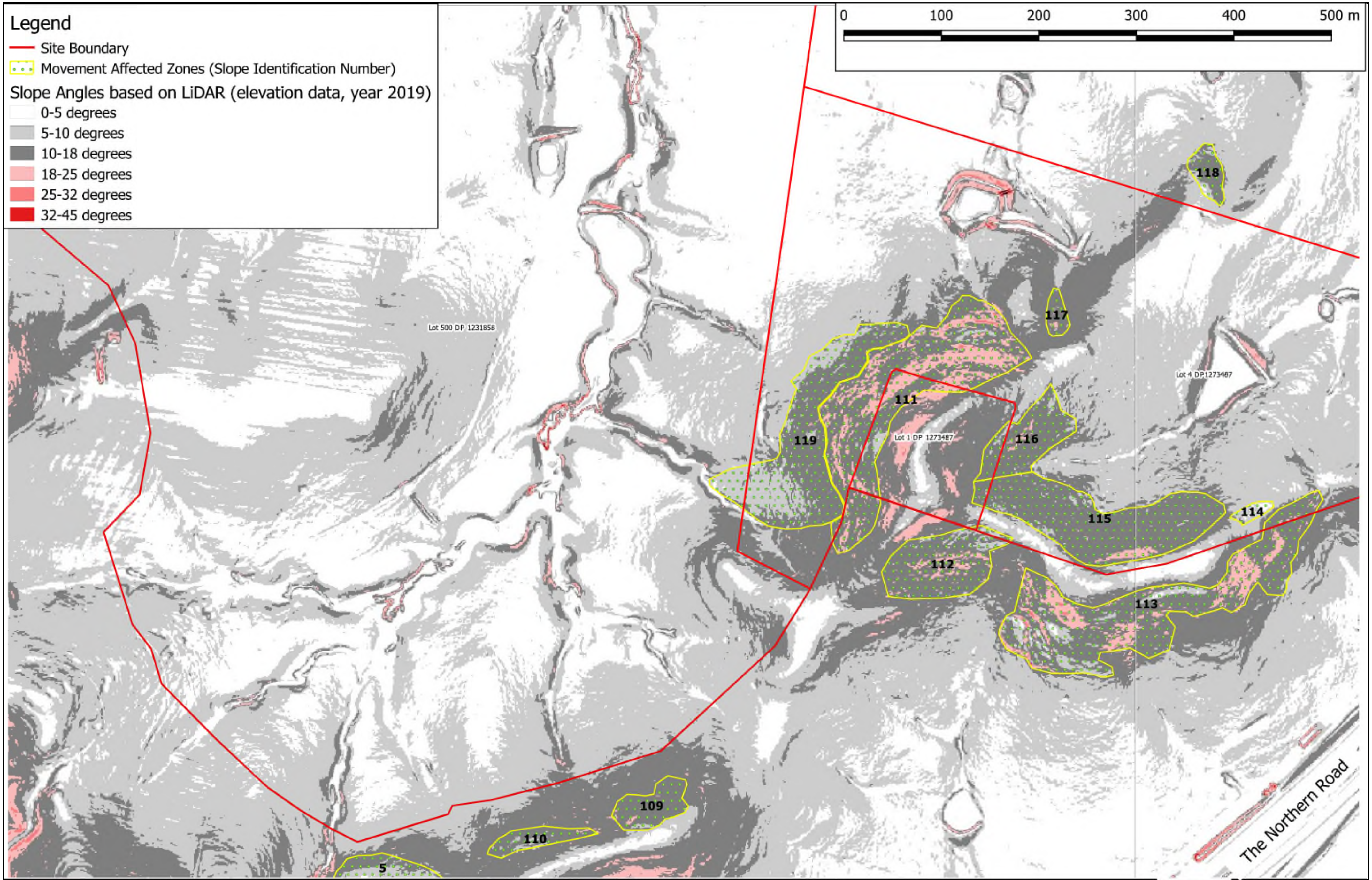


Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd		
OFFICE: Macarthur	DRAWN BY: HDS	
SCALE: 1:4000 (A3)	DATE: 27/02/2023	

TITLE: Site Mapping Observations (Northern Portion), with Proposed Sub-Division Plan Overlay
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

PROJ. #: 92225.06
DRAWING No: 3 D
REVISION: 0



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd		TITLE: Slope Inventory Further Stability Assessment Proposed Residential Subdivision South Creek West, Precinct 5, Cobbitty	PROJ. #: 92225.06
OFFICE: Macarthur	DRAWN BY: HDS		DRAWING No: 4
SCALE: 1:3500 (A3)	DATE: 22/02/2023		REVISION: 0

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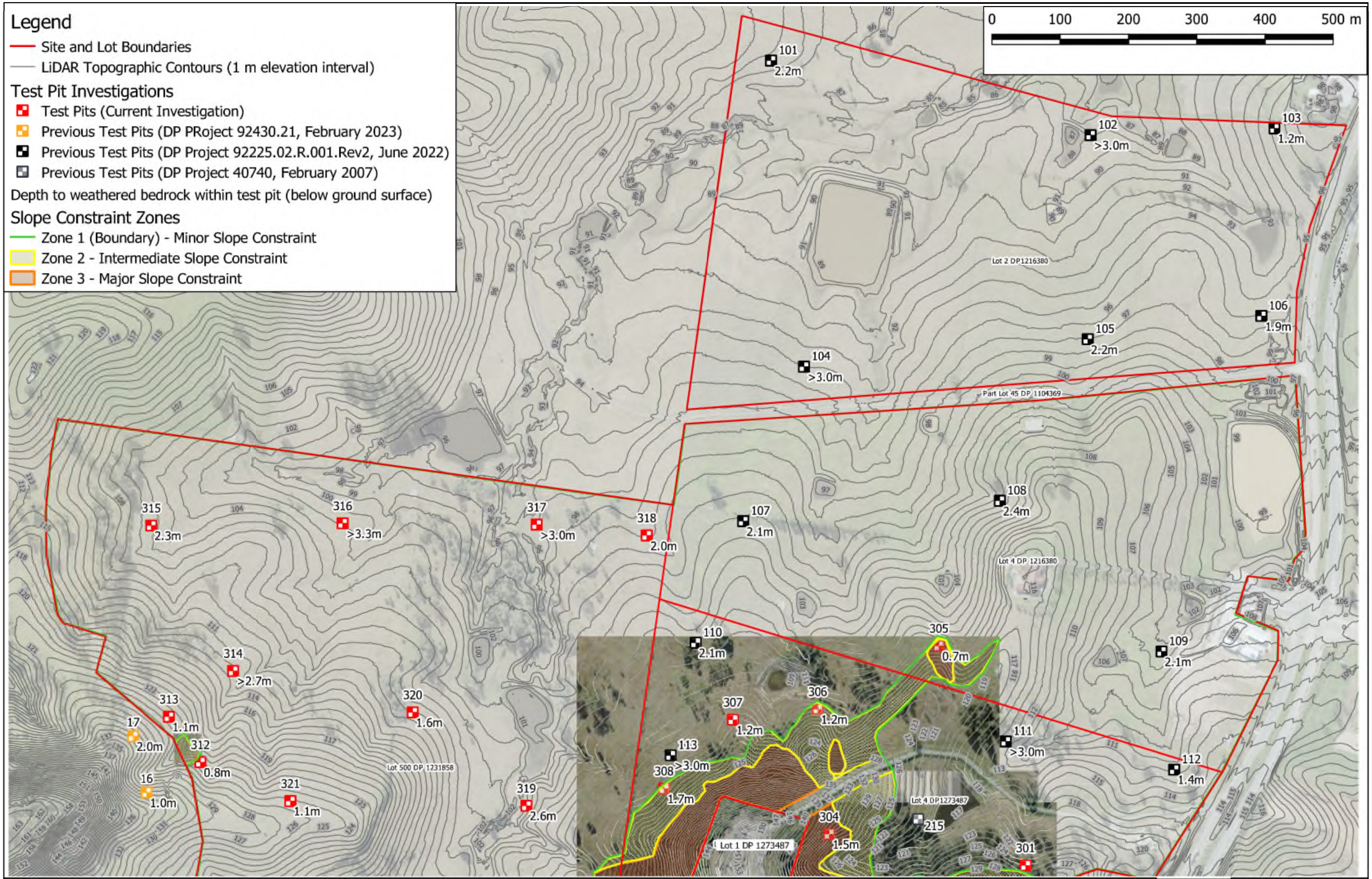
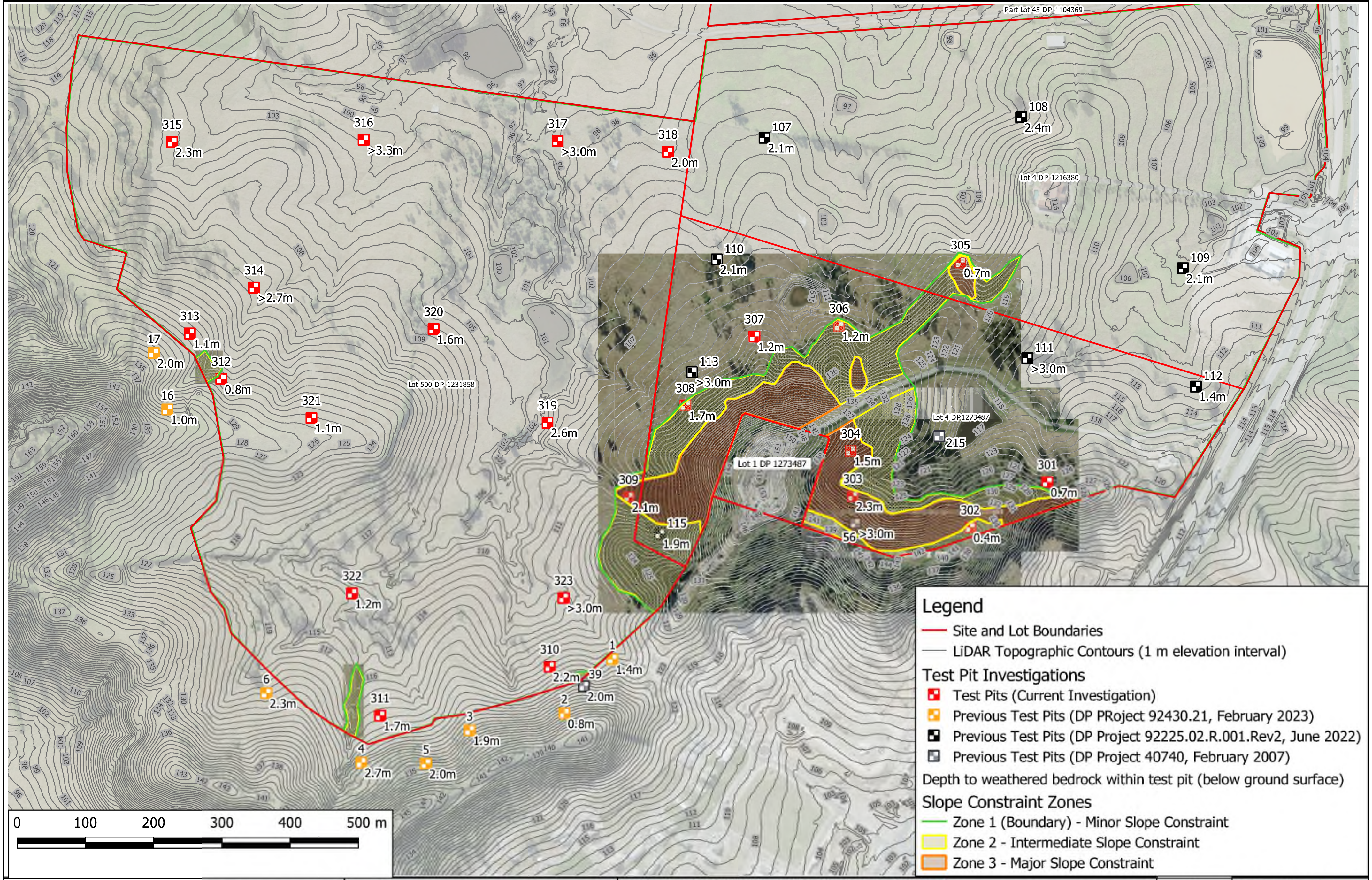


Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Boyuan Bringelly Pty Ltd
OFFICE: Macarthur
DRAWN BY: HDS
SCALE: 1:5000 (A3)
DATE: 22/02/2023

TITLE: Slope Constraint Plan and Depth to Bedrock (Northern)
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

PROJ. #: 92225.06
DRAWING No: 5 A
REVISION: 0



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd		TITLE: Slope Constraint Plan and Depth to Bedrock (Southern) Further Stability Assessment Proposed Residential Subdivision South Creek West, Precinct 5, Cobbitty
OFFICE: Macarthur	DRAWN BY: HDS	
SCALE: 1:5000 (A3)	DATE: 22/02/2023	

PROJ. #: 92225.06
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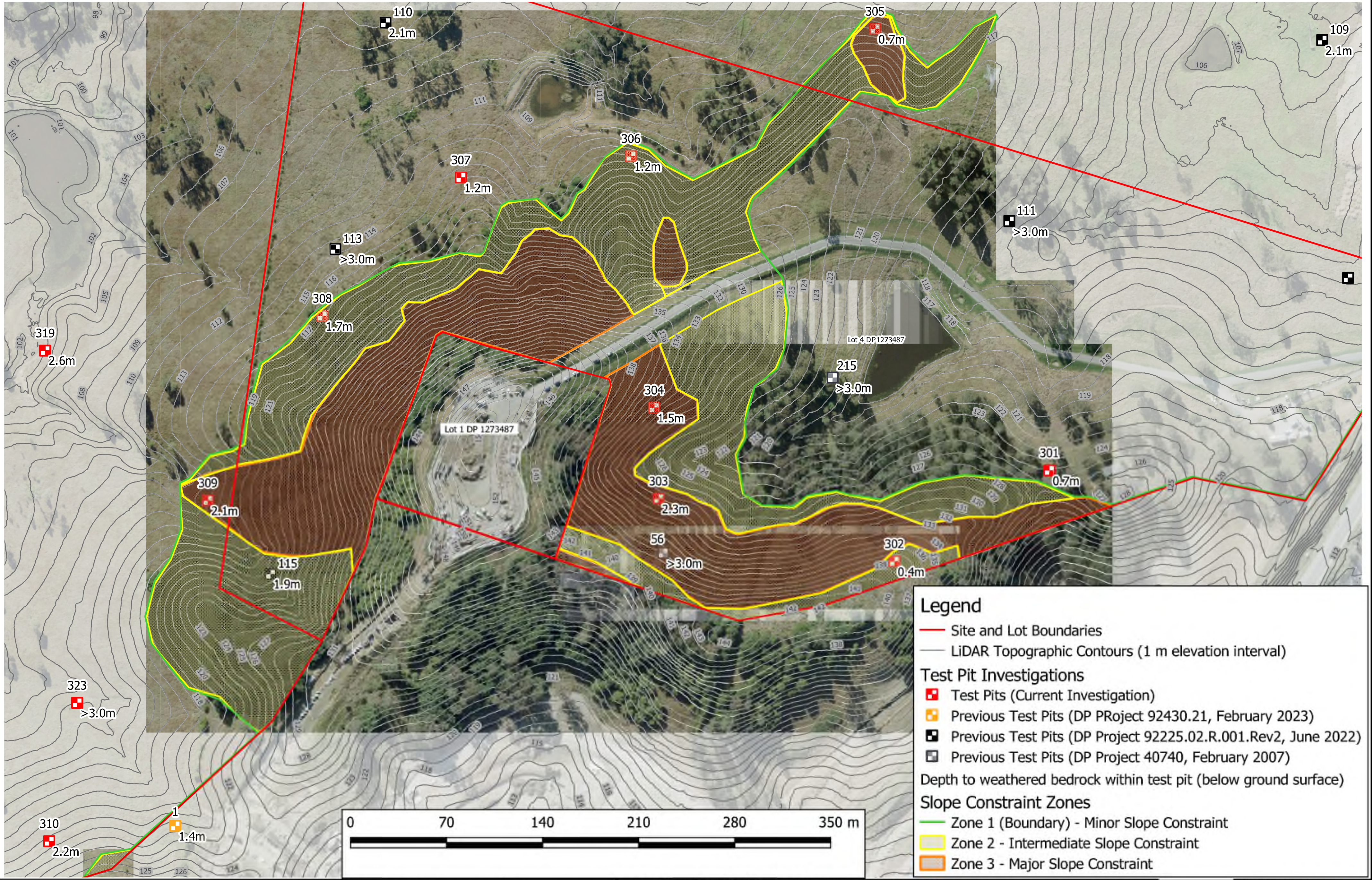
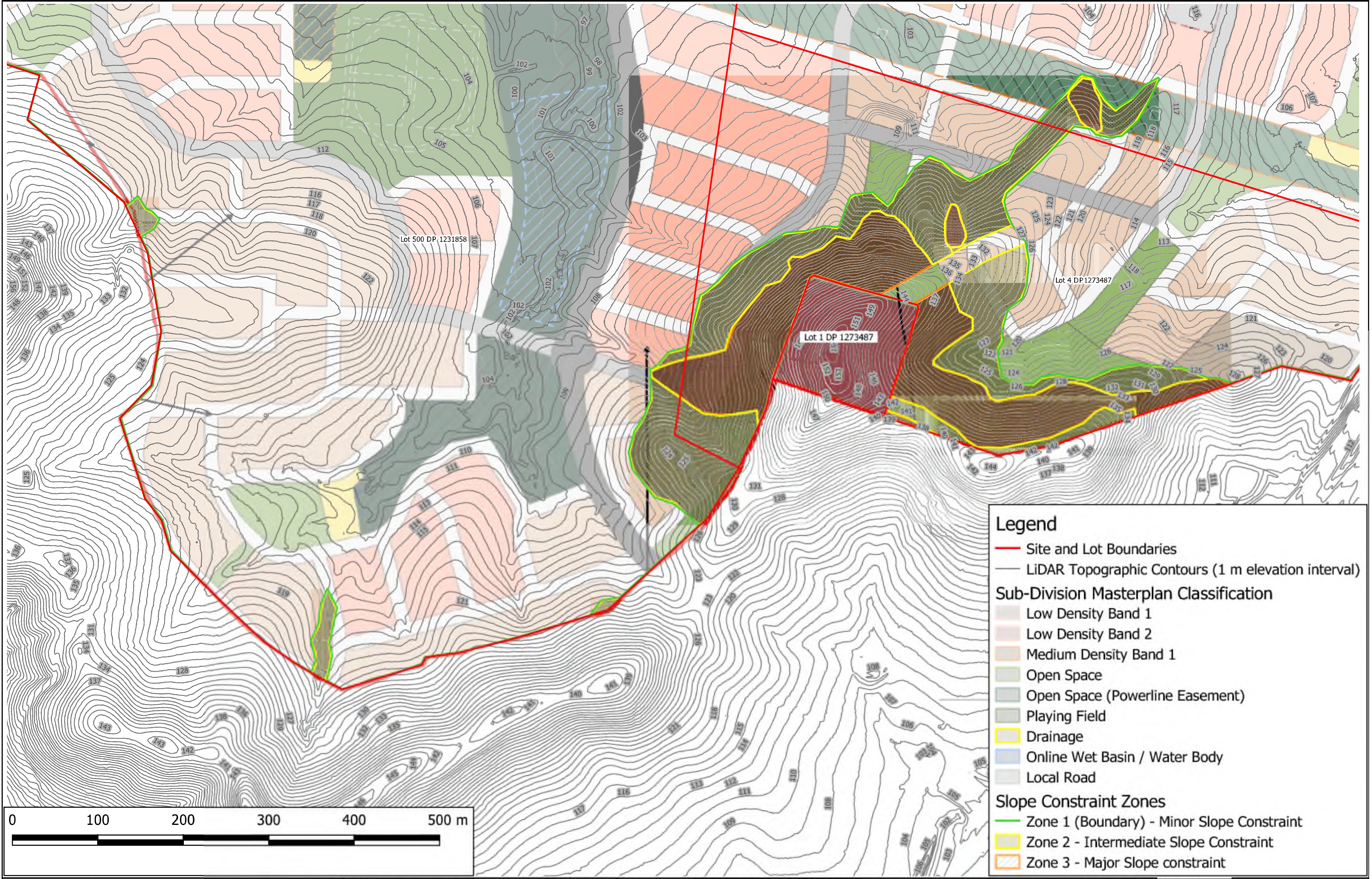


Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd
OFFICE: Macarthur
DRAWN BY: HDS
SCALE: 1:2500 (A3)
DATE: 22/02/2023

TITLE: Slope Constraint Plan and Depth to Bedrock (Central)
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbity

PROJ. #: 92225.06
DRAWING No: 5 C
REVISION: 0



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd
OFFICE: Macarthur
DRAWN BY: HDS
SCALE: 1:5000 (A3)
DATE: 22/02/2023

TITLE: Slope Constraint Plan with Proposed Sub-Division Plan Overlay
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

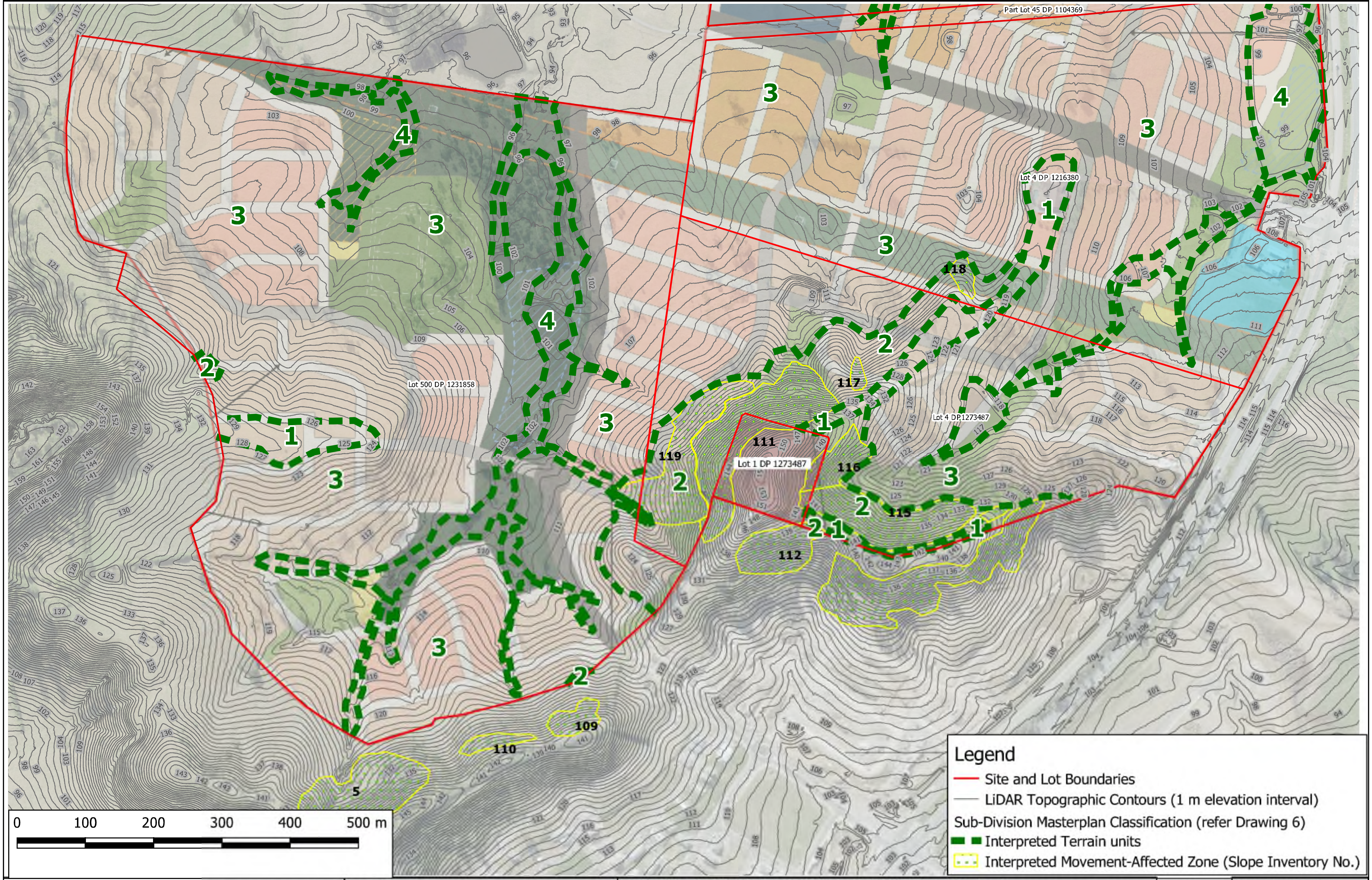
N
MGA

PROJ. #: 92225.06
DRAWING No: 6
REVISION: 0

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd		TITLE: Interpreted Terrain Units and Movement-Affected Zones (Northern) Further Stability Assessment Proposed Residential Subdivision South Creek West, Precinct 5, Cobbitty	PROJ. #: 92225.06
OFFICE: Macarthur	DRAWN BY: HDS		DRAWING No: 7 A
SCALE: 1:5000 (A3)	DATE: 23/02/2023		REVISION: 0

N
MGA



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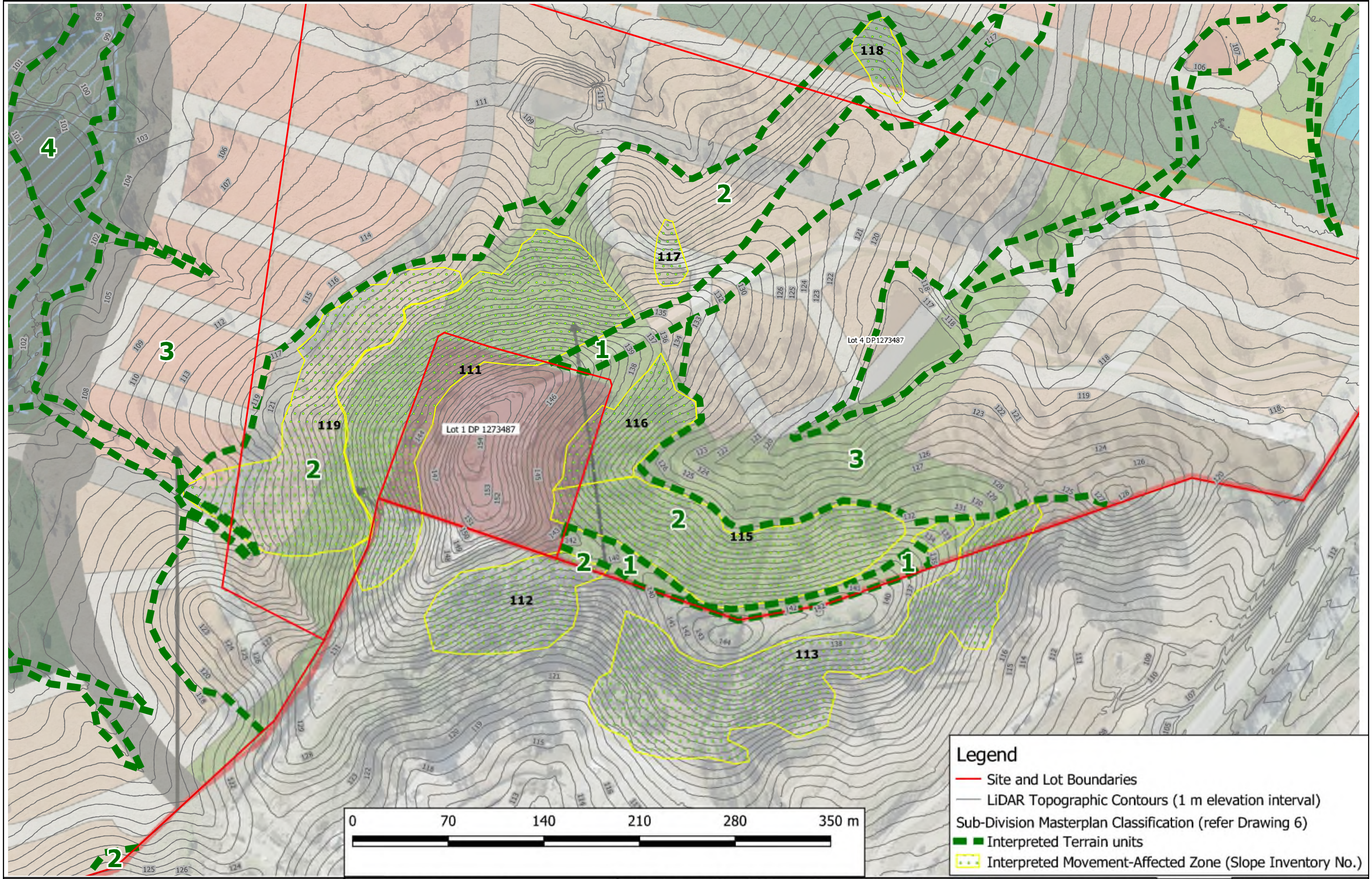
CLIENT: Boyuan Bringelly Pty Ltd	
OFFICE: Macarthur	DRAWN BY: HDS
SCALE: 1:5000 (A3)	DATE: 23/02/2023

TITLE: Interpreted Terrain Units and Movement-Affected Zones (Southern)
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

PROJ. #: 92225.06
DRAWING No: 7 B
REVISION: 0



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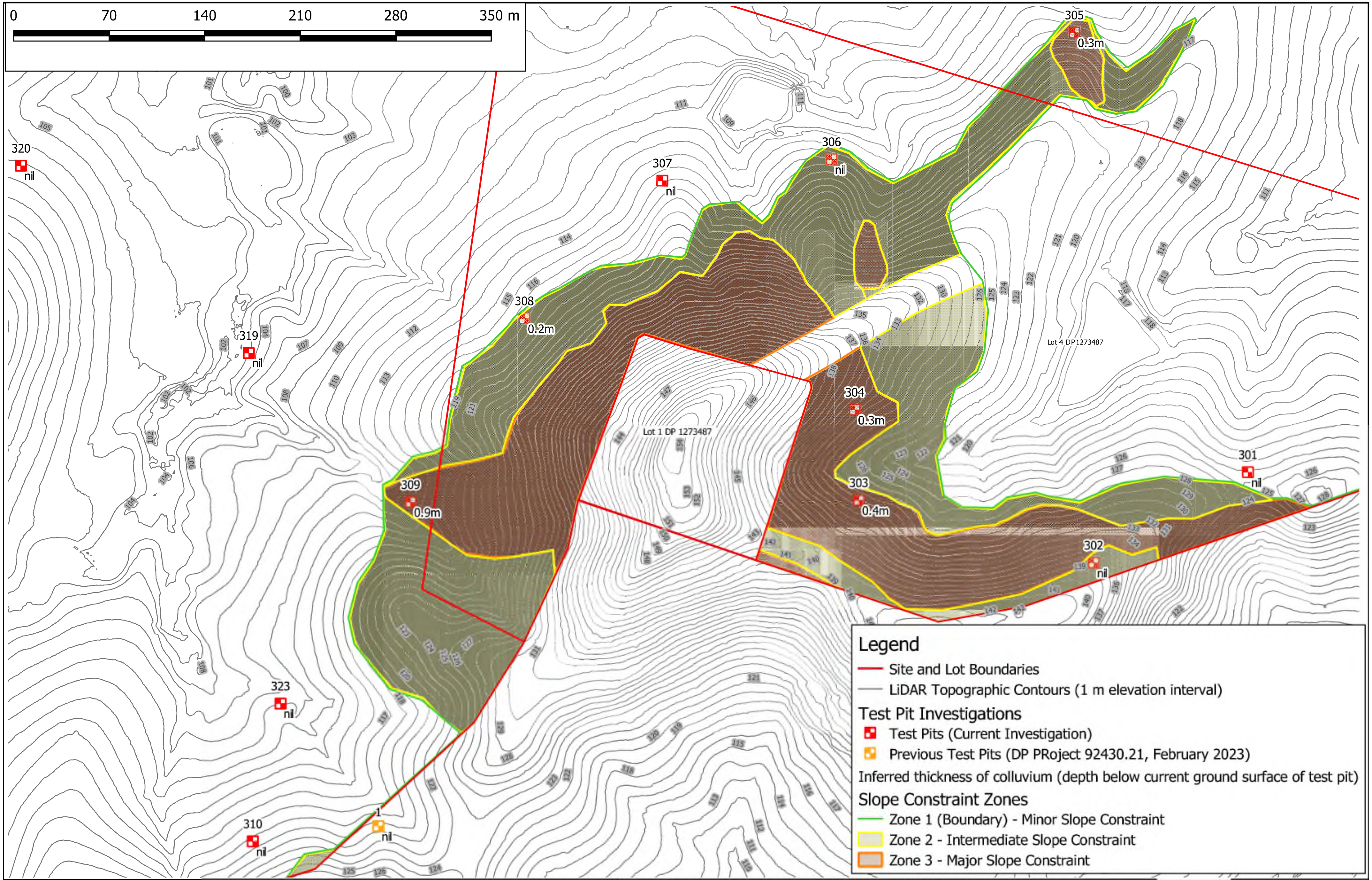
CLIENT: Boyuan Bringelly Pty Ltd
OFFICE: Macarthur
DRAWN BY: HDS
SCALE: 1:2500 (A3)
DATE: 23/02/2023

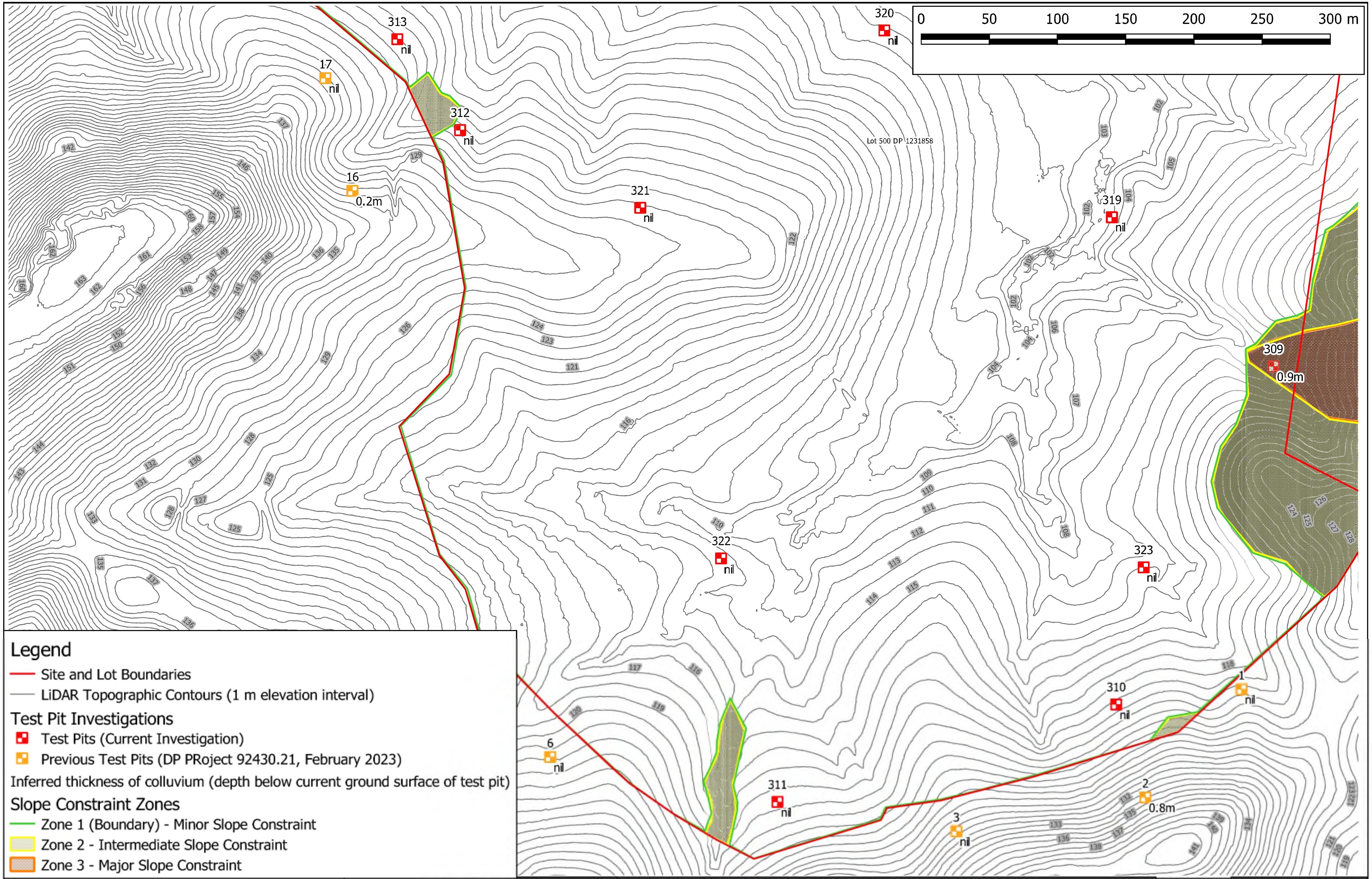
TITLE: Interpreted Terrain Units and Movement-Affected Zones (Central)
Further Stability Assessment
Proposed Residential Subdivision
South Creek West, Precinct 5, Cobbitty

PROJ. #: 92225.06
DRAWING No: 7 C
REVISION: 0



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd		TITLE: Slope Constraint Plan and Inferred Thickness of Colluvium (Eastern) Further Stability Assessment Proposed Residential Subdivision South Creek West, Precinct 5, Cobbitty	PROJ. #: 92225.06
OFFICE: Macarthur	DRAWN BY: HDS		DRAWING No: 8 A
SCALE: 1:2500 (A3)	DATE: 22/02/2023		REVISION: 0



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Boyuan Bringelly Pty Ltd		TITLE: Slope Constraint Plan and Inferred Thickness of Colluvium (Western) Further Stability Assessment Proposed Residential Subdivision South Creek West, Precinct 5, Cobbity	PROJ. #: 92225.06
OFFICE: Macarthur	DRAWN BY: HDS		DRAWING No: 8 B
SCALE: 1:2500 (A3)	DATE: 22/02/2023		REVISION: 0

Appendix E

Field Work Results

Terminology, Symbols and Abbreviations

November 2020

Introduction to Terminology, Symbols and Abbreviations

Douglas Partners' reports, investigation logs, and other correspondence may use terminology which has quantitative or qualitative connotations. To remove ambiguity or uncertainty surrounding the use of such terms, the following sets of notes pages may be attached Douglas Partners' reports, depending on the work performed and conditions encountered:

- Soil Descriptions;
- Rock Descriptions; and
- Sampling, insitu testing, and drilling methodologies

In addition to these pages, the following notes generally apply to most documents.

Abbreviation Codes

Site conditions may also be presented in a number of different formats, such as investigation logs, field mapping, or as a written summary. In some of these formats textual or symbolic terminology may be presented using textual abbreviation codes or graphic symbols, and, where commonly used, these are listed alongside the terminology definition. For ease of identification in these note pages, textual codes are presented in these notes in the following style `XW`. Code usage conforms with the following guidelines:

- Textual codes are case insensitive, although herein they are generally presented in upper case; and
- Textual codes are contextual (i.e. the same or similar combinations of characters may be used in different contexts with different meanings (for example `PL` is used for plastic limit in the context of soil moisture condition, as well as in `PL(A)` for point load test result in the testing results column)).

Data Integrity Codes

Subsurface investigation data recorded by Douglas Partners is generally managed in a highly structured database environment, where records "span" between a top and bottom depth interval. Depth interval "gaps" between records are considered to introduce ambiguity, and, where appropriate, our practice guidelines may require contiguous data sets. Recording meaningful data is not always appropriate (for example assigning a "strength" to a concrete pavement) and the following codes may be used to maintain contiguity in such circumstances.

Term	Description	Abbreviation Code
Core loss	No core recovery	`KL`
Unknown	Information was not available to allow classification of the property. For example, when auguring in loose, saturated sand auger cuttings may not be returned.	`UK`
No data	Information required to allow classification of the property was not available. For example if drilling is commenced from the base of a hole predrilled by others	`ND`
Not Applicable	Derivation of the properties not appropriate or beyond the scope of the investigation. For example providing a description of the strength of a concrete pavement	`NA`

Graphic Symbols

Douglas Partners' logs contain a "graphic" column which provides a pictorial representation of the basic composition of the material. The symbols used are directly representing the material name stated in the adjacent "Description of Strata" column, and as such no specific graphic symbology legend has been provided in these notes.

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Soil Descriptions

Terminology
Symbols
Abbreviations

November 2020

Introduction

All materials which are not considered to be "in-situ rock" are described in general accordance with the soil description model of AS 1726-2017 Part 6.1.3, and can be broken down into the following description structure:

The "classification" comprises a two character "group symbol" providing a general summary of dominant soil characteristics. The "name" summarises the particle sizes within the soil which most influence it's behaviour. The detailed description presents more information about the soil's composition, condition, structure, and origin.

Classification, naming and description of soils requires the relative proportion of particles of different sizes within the whole soil mixture to be considered.

Particle size designation and Behaviour Model

Solid particles within a soil are differentiated on the basis of size.

The engineering behaviour properties of a soil can subsequently be modelled to be either "fine grained" (also known as "cohesive" behaviour) or "coarse grained" ("non cohesive" behaviour), depending on the relative proportion of fine or coarse fractions in the soil mixture.

Particle Size Fraction	Particle Size (mm)	Behaviour Model	
		Behaviour	Approximate Dry Mass
Boulder	>200	Excluded from particle behaviour model as "oversize"	
Cobble	63 - 200		
Gravel[1]	2.36 - 63	Coarse	>65%
Sand[1]	0.075 - 2.36		
Silt	0.002 - 0.075	Fine	>35%
Clay	<0.002		

[1] – refer grain size subdivision descriptions below

The behaviour model boundaries defined above are not precise, and the material behaviour should be assumed from the name given to the material (which considers the particle fraction which dominates the behaviour, refer "component proportions" below), rather than strict observance of the proportions of particle sizes. For example, if a material is named a "Sandy CLAY", this is indicative that the material exhibits fine grained behaviour, even if the dry mass of coarse grained material may exceed 65%.

Component proportions

The relative proportion of the dry mass of each particle size fraction is assessed to be a "primary", "secondary", or "minor" component of the soil mixture, depending on its influence over the soils behaviour.

Component Proportion Designation	Definition[1]	Relative Proportion	
		In Fine Grained Soil	In Coarse Grained Soil
Primary	The component (particle size designation, refer above) which dominates the engineering behaviour of the soil	The clay/silt component with the greater proportion	The sand/gravel component with the greater proportion
Secondary	Any component which is not the primary, but is significant to the engineering properties of the soil	Any component with greater than 30% proportion	Any granular component with greater than 30%; or Any fine component with greater than 12%
Minor[2]	Present in the soil, but not significant to it's engineering properties	All other components	All other components

[1] As defined in AS1726-2017 6.1.4.4

[2] In the detailed material description, minor components are split into two further sub categories. Refer "identification of minor components" below

Composite Materials

In certain situations a lithology description may describe more than one material, for example, collectively describing a layer of interbedded sand and clay. In such a scenario, the two materials would be described independently, with the names preceded or followed by a statement describing the arrangement by which the materials co-exist. For example "INTERBEDDED Silty CLAY AND SAND".

Classification

The soil classification comprises a two character group symbol. The first symbol identifies the primary component. The second symbol identifies either the grading or presence of fines in a coarse grained soil, or the plasticity in a fine grained soil. Refer AS1726-2017 6.1.6 for further clarification.

Soil Name

For most soils the name is derived with the primary component included as the noun (in upper case), preceded by any secondary components stated in an adjective form. In this way the soil name also describes the general composition and indicates the dominant behaviour of the material.

Component[1]	**Prominence in Soil Name**
Primary	Noun (eg "CLAY")
Secondary	Adjective modifier (eg "Sandy")
Minor	No influence

[1] – for determination of component proportions, refer component proportions on previous page

For materials which cannot be disaggregated, or which are not comprised of rock or mineral fragments, the names "ORGANIC MATTER" or "ARTIFICIAL MATERIAL" may be used, in accordance with AS1726-2017 Table 14.

Commercial or colloquial names are not used for the soil name where a component derived name is possible (for example "Gravelly SAND" rather than "CRACKER DUST").

Materials of "fill" or "topsoil" origin are generally assigned a name derived from the primary/secondary component (where appropriate). In log descriptions this is preceded by uppercase "FILL" or "TOPSOIL". Origin uncertainty is indicated in the description by the characters `(?)`, with the degree of uncertainty described (using the terms "probably" or "possibly" in the origin column, or at the end of the description.

Identification of minor components

Minor components are identified in the soil description immediately following the soil name. The minor component fraction is usually preceded with a term indicating the relative proportion of the component.

Minor Component Proportion Term	**Relative Proportion**	
	In Fine Grained Soil	**In Coarse Grained Soil**
With	All fractions: 15-30%	Clay/silt: 5-12% sand/gravel: 15-30%
Trace	All fractions: 0-15%	Clay/silt: 0-5% sand/gravel: 0-15%

The terms "with" and "trace" generally apply only to gravel or fine particle fractions. Where cobbles/boulders are encountered in minor proportions (generally less than about 12%) the term "occasional" may be used. This term describes the sporadic distribution of the material within the confines of the investigation excavation only, and there may be considerable variation in proportion over a wider area which is difficult to factually characterize due to the relative size of the particles and the investigation methods.

Soil Composition

Plasticity

Descriptive Term	**Laboratory liquid limit range**	
	Silt	**Clay**
Non-plastic materials	Not applicable	Not applicable
Low plasticity	≤50	≤35
Medium plasticity	Not applicable	>35 and ≤50
High plasticity	>50	>50

Note, Plasticity descriptions generally describe the plasticity behaviour of the whole of the fine grained soil, not individual fine grained fractions.

Grain Size

Type		**Particle size (mm)**
Gravel	Coarse	19 - 63
	Medium	6.7 - 19
	Fine	2.36 – 6.7
Sand	Coarse	0.6 - 2.36
	Medium	0.21 - 0.6
	Fine	0.075 - 0.21

Grading

Grading Term	**Particle size (mm)**
Well	A good representation of all particle sizes
Poorly	An excess or deficiency of particular sizes within the specified range
Uniformly	Essentially of one size
Gap	A deficiency of a particular particle size with the range

Note, AS1726-2017 provides terminology for additional attributes not listed here.

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Soil Condition

Moisture

The moisture condition of soils is assessed relative to the plastic limit for fine grained soils, while for coarse grained soils it is assessed based on the appearance and feel of the material. The moisture condition of a material is considered to be independent of stratigraphy (although commonly these are related), and this data is presented in its own column on logs.

Applicability	Term	Tactile Assessment	Abbreviation code
Fine	Dry of plastic limit	Hard and friable or powdery	`<PL`
	Near plastic limit	Can be moulded	`≈PL`
	Wet of plastic limit	Water residue remains on hands when handling	`>PL`
	Near liquid limit	"oozes" when agitated	`≈LL`
	Wet of liquid limit	"oozes"	`>LL`
Coarse	Dry	Non-cohesive and free running	`D`
	Moist	Feels cool, darkened in colour, particles may stick together	`M`
	Wet	Feels cool, darkened in colour, particles may stick together, free water forms when handling	`W`

The abbreviation code `NDF`, meaning "not-assessable due to drilling fluid use" may also be used.

Note, observations relating to free ground water or drilling fluids are provided independent of soil moisture condition.

Consistency/Density/Compaction/Cementation/Extremely Weathered Rock

These concepts give an indication of how the material may respond to applied forces (when considered in conjunction with other attributes of the soil). This behaviour can vary independent of the composition of the material, and on logs these are described in an independent column and are generally mutually exclusive (i.e it is inappropriate to describe both consistency and compaction at the same time). The method by which the behaviour is described depends on the behaviour model and other characteristics of the soil as follows:

- In fine grained soils, the "consistency" describes the ease with which the soil can be remoulded, and is generally correlated against the materials undrained shear strength;
- In granular materials, the relative density describes how tightly packed the particles are, and is generally correlated against the density index;
- In anthropogenically modified materials the compaction of the material is described qualitatively;
- In cemented soils (both natural and anthropogenic), the cemented "strength" is described qualitatively, relative to the difficulty with which the material is disaggregated; and
- In soils of extremely weathered rock origin, the engineering behaviour may be governed by relic rock features, and expected behaviour needs to be assessed based the overall material description

Quantitative engineering performance of these materials may be determined by laboratory testing, or estimated by correlated field tests (for example penetration or shear vane testing). In some cases performance may be assessed by tactile or other subjective methods, in which case investigation logs will show the estimated value enclosed in round brackets, for example `(VS)`.

Consistency (fine grained soils)

Consistency Term	Tactile Assessment	Undrained Shear Strength (kPa)	Abbreviation Code
Very soft	Extrudes between fingers when squeezed	<12	`VS`
Soft	Mouldable with light finger pressure	>12 - ≤25	`S`
Firm	Mouldable with strong finger pressure	>25 - ≤50	`F`
Stiff	Cannot be moulded by fingers	>50 - ≤100	`ST`
Very stiff	Indented by thumbnail	>100 - ≤200	`VST`
Hard	Indented by thumbnail with difficulty	>200	`H`
Friable	Easily crumbled or broken into small pieces by hand	-	`FR`

Relative Density (coarse grained soils)

Relative Density Term	Density Index	Abbreviation Code
Very loose	<15	`VL`
Loose	>15-≤35	`L`
Medium dense	>35-≤65	`MD`
Dense	>65-≤85	`D`
Very dense	>85	`VD`

Note, tactile assessment of relative density is difficult, and generally requires penetration testing, hence a tactile assessment guide is not provided.

Compaction (anthropogenically modified soil)

Compaction Term	Abbreviation Code
Well compacted	`WC`
Poorly compacted	`PC`
Moderately compacted	`MC`
Variably compacted	`VC`

Cementation (natural and anthropogenic)

Cementation Term	Abbreviation Code
Moderately cemented	`MCE`
Weakly cemented	`WKCE`
Cemented	`CE`
Strongly bound	`SB`
Weakly bound	`WB`
Unbound	`UB`

Extremely Weathered Rock

AS1726-2017 considers weathered rock material to be soil if the unconfined compressive strength is less than 0.6 MPa (i.e. very low strength rock). These materials may be identified as "extremely weathered rock" in reports and by the abbreviation code `XWR` on log sheets. This identification is not correlated to any specific qualitative or quantitative behaviour, and the engineering properties of this material must therefore be assessed according to engineering principles with reference to any relic rock structure, fabric, or texture described in the description.

Soil Origin

Term	Description	Abbreviation Code
Residual	Derived from in-situ weathering of the underlying rock	`RES`
Extremely weathered material	Formed from in-situ weathering of geological formations. Has strength of less than 'very low' as per as1726 but retains the structure or fabric of the parent rock.	`XWM`
Alluvial	Deposited by streams and rivers	`ALV`
Estuarine	Deposited in coastal estuaries	`EST`
Marine	Deposited in a marine environment	`MAR`
Lacustrine	Deposited in freshwater lakes	`LCS`
Aeolian	Carried and deposited by wind	`AEO`
Colluvial	Soil and rock debris transported down slopes by gravity	`COL`
Topsoil	Mantle of surface soil, often with high levels of organic material	`TOP`
Fill	Any material which has been moved by man	`FILL`
Littoral	Deposited on the lake or sea shore	`LIT`
Unidentifiable	Not able to be identified	`UID`

Cobbles and Boulders

The presence of particles considered to be "oversize" may be described using one of the following strategies:

- Oversize encountered in a minor proportion (when considered relative to the wider area) are noted in the soil description; or
- Where a significant proportion of oversize is encountered, the cobbles/boulders are described independent of the soil description, in a similar manner to composite soils (described above) but qualified with "MIXTURE OF".

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

[1] Assumes a ratio of 20:1 for UCS to $I_{s(50)}$. It should be noted that the UCS to $I_{s(50)}$ ratio varies significantly for different rock types and specific ratios may be required for each site.

On investigation logs only, the following data contiguity codes may be in rock strength tables for layers or seams of material "within rock", but for which the equivalent UCS strength is less than 0.6 MPa.

Scenario	Abbreviation Code
The material encountered has an equivalent UCS strength of less than 0.6 MPa, and therefore is considered to be soil (as per Note 1 of Table 20 of AS 1726-2017). The properties of the material encountered over this interval are described in the "Description of Strata" and soil properties columns.	`SOIL`
The material encountered has an equivalent UCS strength of less than 0.6 MPa, and therefore is considered to be soil (as per Note 1 of Table 20 of AS 1726-2017). The prominence of the material is such that it can be considered to be a seam (as defined in Table 22 of AS1726-2017) and the properties of the material are described in the defect column.	`SEAM`

Degree of Weathering

The degree of weathering of rock is classified as follows:

Weathering Term	Description	Abbreviation Code
Residual Soil[1,2]	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.	`RS`
Extremely weathered[1,2]	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	`XW`
Highly weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not 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.	`HW`
Moderately weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.	`MW`
Slightly weathered	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.	`SW`
Fresh	No signs of decomposition or staining.	`FR`
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	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.	`DW`

[1] AS1726-2017 6.1.9 provides similar definitions for "residual soil" and "extremely weathered material" as soil origins. Generally, the soil origin terms would be used above the depth at which very low strength or stronger rock material is first encountered, while both soil origin and weathering should may be stated for soil encountered below the first contact with rock material, where appropriate.

[2] The parent rock type, of which the residual/extremely weathered material is a derivative, will be stated in the description (where discernible).

Degree of Alteration

The degree of alteration of the rock material (physical or chemical changes caused by hot gasses or liquids at depth) is classified as follows:

Term	Description	Abbreviation Code
Extremely altered	Material is altered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.	XA
Highly altered	The whole of the rock material is discoloured, usually by staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is changed by alteration. Some primary minerals are altered to clay minerals. Porosity may be increased by leaching, or may be decreased due to precipitation of secondary materials in pores.	HA
Moderately altered	The whole of the rock material is discoloured, usually by 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.	MA
Slightly altered	Rock is slightly discoloured but shows little or no change of strength from fresh rock	SA
Note: If HA and MA cannot be differentiated use DA (see below)		
Distinctly altered	Rock strength usually changed by alteration. The rock may be highly discoloured, usually by staining or bleaching. Porosity may be increased by leaching, or may be decreased due to precipitation of secondary minerals in pores.	DA

Degree of Fracturing

The following descriptive classification apply to the spacing of natural occurring fractures in the rock mass. It includes bedding plane partings, joints and other defects, but excludes drilling breaks. These terms are generally not required on investigation logs where fracture spacing is presented as a histogram, and where used are presented in an unabbreviated format.

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:

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

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

These terms may be used to describe the spacing of bedding partings in sedimentary rocks. Where used, these terms are generally presented in an unabbreviated format

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

Defect Descriptions

Defect Type

Term	Abbreviation Code
Bedding plane	`B`
Clay seam	`CS`
Cleavage	`CV`
Crushed zone	`CZ`
Decomposed seam	`DS`
Fault	`F`
Joint	`J`
Lamination	`LAM`
Parting	`PT`
Sheared zone	`SZ`
Vein	`VN`
Drilling/handling break	`DB` , `HB`
Fracture	`FCT`

Rock Defect Orientation

Term	Abbreviation Code
Horizontal	`H`
Vertical	`V`
Sub-horizontal	`SH`
Sub-vertical	`SV`

Rock Defect Coating

Term	Abbreviation Code
Clean	`CLN`
Coating	`CO`
Healed	`HE`
Infilled	`INF`
Stained	`STN`
Tight	`TI`
Veneer	`VEN`

Rock Defect Infill

Term	Abbreviation Code
Calcite	`CA`
Carbonaceous	`CBS`
Clay	`CLY`
Iron oxide	`FE`
Manganese	`MN`
Silty	`SLT`

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Rock Defect Shape/Planarity

Term	Abbreviation Code
Curved	`CU`
Irregular	`IR`
Planar	`PL`
Stepped	`ST`
Undulating	`UN`

Rock Defect Roughness

Term	Abbreviation Code
Polished	`PO`
Rough	`RO`
Slickensided	`SL`
Smooth	`SM`
Very rough	`VR`

Other Rock Defect Attributes

Term	Abbreviation Code
Fragmented	`FG`
Band	`BND`
Quartz	`QTZ`

Defect Orientation

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

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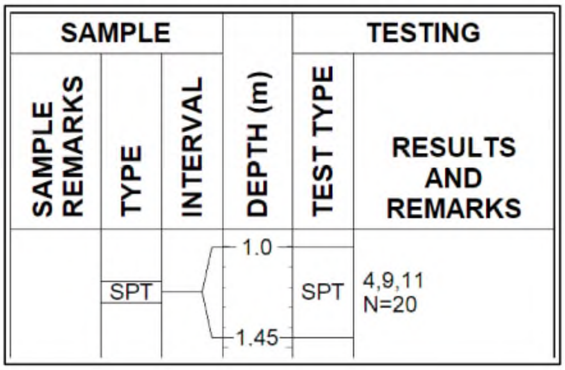
Sampling, Testing and Excavation Methodology

Terminology
Symbols
Abbreviations

November 2020

Sampling and Testing

A record of samples retained and field testing performed is usually shown on a Douglas Partners' log with samples appearing to the left of a depth scale, and selected field and laboratory testing (including results, where relevant) appearing to the right of the scale, as illustrated below:



Sampling

The type or intended purpose for which a sample was taken is indicated by the following abbreviation codes.

Sample Type	Code
Auger sample	`A`
Acid sulfate sample	`ASS`
Bulk sample	`B`
Core sample	`C`
Disturbed sample	`D`
Sample from SPT test	`SPT`
Environmental sample	`E`
Gas sample	`G`
Jar sample	`J`
Undisturbed tube sample	`U`[1]
Water sample	`W`
Piston sample	`P`
Core sample for unconfined compressive strength testing	`UCS`

[1] – numeric suffixes indicate tube diameter/width in mm

The above codes only indicate that a sample was retained, and not that testing was scheduled or performed.

Field and Laboratory Testing

A record that field and laboratory testing was performed is indicated by the following abbreviation codes.

Test Type	Code
Pocket penetrometer (kPa)	`PP`
Photo ionisation detector (ppm)	`PID`
Standard Penetration Test `x/y` =*x* blows for *y* mm penetration `HB` = hammer bouncing	`SPT`
Shear vane (kPa)	`V`
Unconfined compressive strength, (MPa)	`UCS`

Field and laboratory testing (continued)

Test Type	Code
Point load test, (MPa), axial `(A)`, diametric `(D)`, irregular `(I)`	`PLT(_)`
Dynamic cone penetrometer, followed by blow count penetration increment in mm (cone tip, generally in accordance with AS1289.6.3.2)	`DCP/150`
Perth sand penetrometer, followed by blow count penetration increment in mm (flat tip, generally in accordance with AS1289.6.3.3)	`PSP/150`

Groundwater Observations

▷	seepage/inflow
▽	standing or observed water level
`NFGWO`	no free groundwater observed
`OBS`	Observations obscured by drilling fluids

Drilling or Excavation Methods/Tools

The drilling/excavation methods used to perform the investigation may be shown either in a dedicated column down the left hand edge of the log, or stated in the log footer. In some circumstances abbreviation codes may be used.

Method	Abbreviation Code
Excavator/backhoe bucket	`B`[1]
Toothed bucket	`TB`[1]
Mud/blade bucket	`MB`[1]
Ripping tyne/ripper	`RT`
Rock breaker/hydraulic hammer	`RB`
Hand auger	`HA`[1]
NMLC series coring	`NMLC`
HMLC series coring	`HMLC`
NQ coring	`NQ`
HQ coring	`HQ`
PQ coring	`PQ`
Push tube	`PT` [1]
Rock roller	`RR`[1]
Solid flight auger. Suffixes: `(TC)` = tungsten carbide tip, `(V)` = v-shaped tip	`SFA`[1]
Sonic drilling	`SON`[1]
Vibrocore	`VC`[1]
Wash bore (unspecified bit type)	`WB`[1]
Existing exposure	`X`
Hand tools (unspecified)	`HT`
Predrilled	`PD`
Specialised bit (refer report)	`SPEC`[1]
Diatube	`DT`[1]
Hollow flight auger	`HFA`[1]
Vacuum excavation	`VE`

[1] – numeric suffixes indicate tool diameter/width in mm

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 4 DP1273487

SURFACE LEVEL: 124.3 mAHD
COORDINATE E:290196 **N:** 6236611
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 301
PROJECT No: 92225.06
DATE: 18/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 18/11/22, No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE
	0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine to medium grained, angular to sub-rounded; with rootlets and tree roots	TOP	ST VST	
124	0.3	(CI-CH) Silty CLAY; red-brown and orange brown; medium to high plasticity; trace roots and rootlets	RES	VST	<PL
	0.7	SHALE; red-brown, grey brown and brown; with silty clay bands; Bringelly Shale 1.4-1.8m: bands of low to medium strength, moderately weathered shale 2.6-2.8m: red-brown, grey brown and grey			
	2.8	Test pit discontinued at 2.80m depth Limit of investigation. Refusal on moderately weathered, medium strength shale			

RL (m): 124, 123, 122, 121

ROCK

DEPTH (m)	WEATH.	STRENGTH
0.7	XW-HW	VL-L
1.12	HW	
1.4	HW-MW	
1.8	HW	
2.6	MW	L-M
2.8		

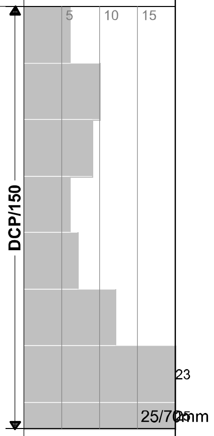
STRENGTH: VL L M H VH EH

SAMPLE

TYPE	DEPTH (m)
D	0.1
D	0.5
D	1.0
D	1.5
D	2.0
D	2.5

TESTING

TEST TYPE	RESULTS AND REMARKS
DCP/150	0.0–1.12 m



NOTES: (#)Soil origin is "probable" unless stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

Photo 1 - View of side of Test Pit 301

Photo 2 - View of side of Test Pit 301

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D1
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 4 DP1273487

SURFACE LEVEL: 138.1 mAHD
COORDINATE E:290083 **N:** 6236545
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 302
PROJECT No: 92225.06
DATE: 18/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 18/11/22, No free groundwater observed

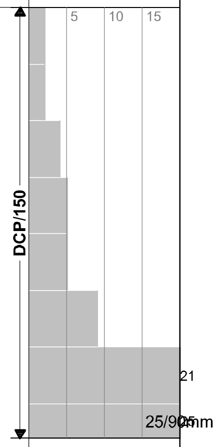
RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS. (*) DENSITY. (*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)
138	0.0	TOPSOIL/ (ML) Clayey SILT, with gravel, trace sand; brown; silt fraction low plasticity; gravel fraction fine to medium, sub-angular; sand fraction fine; with rootlets	//////	TOP	F	<PL			
	0.4	SANDSTONE; red-brown and grey brown; fine; with sandy clay bands; Bringelly Shale	⁘				XW-HW	0.4	L-M
137	1.1	SHALE; grey brown, grey and orange brown; with silty clay bands; Bringelly Shale	═				HW	1.1	VL-L
136	1.8	SHALE; grey brown and brown; with low to medium strength sandstone bands and silty clay bands; Bringelly Shale	═				HW-MW	1.8	L-M
135	3.0	Test pit discontinued at 3.00m depth Limit of investigation. Terminated in low to medium strength shale						3.0	

SAMPLE

SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)
	D		0.1
	D		0.5
	D		1.0
	D		1.5
	D		2.0
	D		2.5
	D		3.0

TESTING

TEST TYPE / RESULTS AND REMARKS



NOTES: (#)Soil origin is "probable" unless stated otherwise. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

Photo 3 - View of side of Test Pit 302

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D2
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 4 DP1273487

SURFACE LEVEL: 129.1 mAHD
COORDINATE E:289911 **N:** 6236591
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 303
PROJECT No: 92225.06
DATE: 18/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 18/11/22, No free groundwater observed

RL (m): 129, 128, 127, 126

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH
0.0 – 0.4	(CL-CI) Silty CLAY; dark brown; clay fraction low to medium plasticity; fraction fine, sub-angular to sub-rounded; with rootlets	COL	ST	=PL			
0.4 – 1.7	(CI) Silty CLAY, trace gravel; brown and grey brown; clay fraction medium plasticity; gravel fraction sub-angular to sub-rounded; trace rootlets and decomposed organic matter 1.1m: trace fine to medium grained, sub-rounded to sub-angular gravel 1.4m: trace fine to coarse grained, sub-rounded to sub-angular gravel	RES	ST - VST (0.4–1.1) VST - H (1.1–1.7)	=PL (to 1.1) <PL			
1.7 – 2.3	(CL-CI) Gravelly Silty CLAY; grey and grey brown; clay fraction low to medium plasticity; gravel fraction fine to medium, angular and sub-rounded; appears to be shaly clay	XWM	H	<PL			
2.3 – 3.2	SHALE; brown, grey brown and dark grey; with medium strength sandstone bands; Bringelly Shale				HW-MW	2.3 2.9 3.2	VL-L (2.3–2.9) L-M (2.9–3.2)

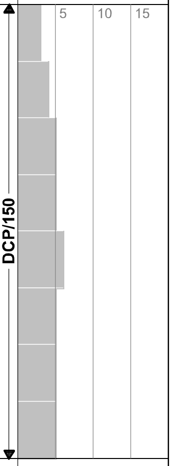
Test pit discontinued at 3.20m depth
Limit of investigation. Terminated in low to medium strength shale

SAMPLE

TYPE	DEPTH (m)
D	0.1
D	0.5
D	1.0
D	1.5
D	2.0
D	2.5
D	3.0

TESTING

DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
0.0 – 1.2	DCP/150	
2.0	PP	>600



NOTES: (#)Soil origin is "probable" unless stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

Photo 4 - View of side of Test Pit 303

Photo 5 - View of inferred colluvial spoil from Test Pit 303

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	D3
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 4 DP1273487

SURFACE LEVEL: 132.5 mAHD
COORDINATE E:289908 **N:** 6236657
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 304
PROJECT No: 92225.06
DATE: 18/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 18/11/22, No free groundwater observed

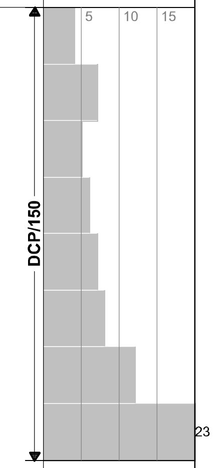
RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	SOIL ORIGIN[(#)]	SOIL CONSIS.[(*)] DENSITY.[(*)]	SOIL MOISTURE	ROCK WEATH.	ROCK DEPTH (m)	ROCK STRENGTH
	0.0	(ML) Clayey SILT, trace gravel; dark brown; clay fraction medium; gravel fraction fine to coarse, angular and sub-rounded; trace angular sandstone cobbles, with rootlets and tree roots	COL	ST	<PL			
132	0.3	(CI-CH) Silty CLAY, with gravel; red brown and grey brown; clay fraction medium to high plasticity; gravel fraction fine to coarse, angular to sub-angular; trace rootlets, tree roots and decomposed organic matter	RES	ST - VST	<PL - =PL			
	0.7	(CL-CI) Silty Gravelly CLAY; orange-brown, grey and grey brown; clay fraction low to medium plasticity; gravel fraction fine to coarse, sub-angular to angular; with bands of low to medium strength sandstone appears to be shaly clay	XWM	VST H	<PL			
131	1.5	SHALE; red brown, brown and grey; Bringelly Shale				XW-HW	1.5	VL-L
						HW-MW	1.9	L-M
						MW	2.3	
130	2.5	Test pit discontinued at 2.50m depth Limit of investigation. Refusal on moderately weathered, medium strength shale					2.5	
129								

SAMPLE

SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)
	D		0.1
	D		0.5
	D		1.0
	D		1.5
	D		2.0
	D		2.5

TESTING

TEST TYPE	RESULTS AND REMARKS
DCP/150	



NOTES: [(#)]Soil origin is "probable" unless stated otherwise. [(*)]Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface. Top layer thickens downslope to 0.6m thick. Residual layer reduces in thickness downslope

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

Photo 6 - View of side of Test Pit 304

Photo 7 - View of side of Test Pit 304

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D4
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT:	Boyuan Bringelly Pty Ltd	**SURFACE LEVEL:**	112.9 mAHD	**LOCATION ID:**	305
PROJECT:	Proposed Residential Subdivision	**COORDINATE**	**E:**290069 **N:** 6236933	**PROJECT No:**	92225.06
LOCATION:	South Creek West, Precinct 5, Cobbitty Lot 4 DP1216380	**DATUM/GRID:**	MGA94 Zone 56	**DATE:**	27/01/23
				SHEET:	1 of 1

CONDITIONS ENCOUNTERED

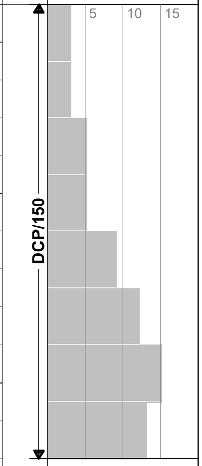
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	SOIL: ORIGIN(#)	SOIL: CONSIS.(*) DENSITY.(*)	SOIL: MOISTURE	ROCK: WEATH.	ROCK: DEPTH (m)	ROCK: STRENGTH
		0.0	(CL-CI) Silty CLAY, with gravel; dark grey brown and brown; clay fraction low to medium plasticity; gravel fraction fine to medium, sub-rounded to sub-angular; trace tree roots and rootlets	COL	F - ST	<PL			
		0.3	(CL-CI) Gravelly Silty CLAY; grey, brown and red brown; clay fraction low to medium plasticity; fraction fine to medium, sub-angular to angular gravel; trace rootlets and decomposed organic matter, appears to be shaly clay	XWM	ST - VST	<PL			
		0.7	SHALE; grey, grey brown and orange brown; Bringelly Shale				HW-MW	0.7	VL-L
	112	1							
	111	2							
			2.1m: red brown and grey brown					2.1	L
			2.7m: brown, grey brown and dark grey					2.7	L-M
	110	2.9	Test pit discontinued at 2.90m depth Limit of investigation. Refusal on moderately weathered, medium strength shale					2.9	
		3							
	109								

SAMPLE

SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)
	D		0.1
	D		0.5
	D		1.0
	D		1.5
	D		2.0
	D		2.5
	D		2.9

TESTING

TEST TYPE	RESULTS AND REMARKS
DCP/150 (0.0 – 1.2 m)	



NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe **OPERATOR:** WC **LOGGED:** DN

METHOD: 450 mm toothed bucket

REMARKS: Grass cover at the surface. Located upslope of a nearby dam

Refer to explanatory notes for symbol and abbreviation definitions

Photographs 8 and 9 - View of side and end of Test Pit 305

Photo 10 - View of inferred colluvial spoil from Test Pit 305

Douglas Partners
Geotechnics / Environment / Groundwater

Test Pit Photographs

Proposed Residential Subdivision

SCW, Cobbitty Bringelly Precinct, Cobbitty

CLIENT: Boyuan Bringelly Pty Ltd

PROJECT:	92225.06
PLATE No:	D5
REV:	A
DATE:	Feb-23

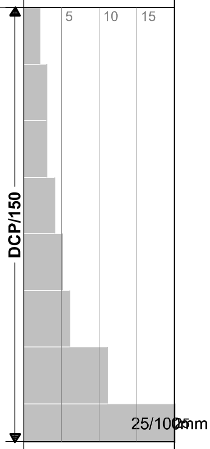
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 4 DP1273487

SURFACE LEVEL: 115 mAHD
COORDINATE E:289891 **N:** 6236840
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 306
PROJECT No: 92225.06
DATE: 17/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED										SAMPLE				TESTING	
				SOIL			ROCK								
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN[#]	CONSIS.[*] DENSITY.[*]	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
17/11/22, No free groundwater observed	115	0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine, sub-angular; with rootlets	TOP	F	<PL					D		0.1	DCP/150	
		0.2	(CI-CH) Silty CLAY, trace gravel; red brown and brown; clay fraction medium to high plasticity; gravel fraction fine, sub-angular; trace rootlets	RES	ST	=PL					D		0.5		
	114	0.7	(CI) Silty CLAY, with gravel; red brown, brown and brown grey; clay fraction medium plasticity; gravel fraction fine to medium, angular to sub-angular	RES	VST - H	<PL					D		1.0		25/100mm
		1.2	SHALE; grey brown and red-brown; Bringelly Shale				HW	1.2	VL-L						
							HW-MW	1.5	L-M		D		1.5		
	113	1.8	Test pit discontinued at 1.80m depth Limit of investigation. Refusal on moderately weathered, medium strength shale					1.8							



NOTES: [#]Soil origin is "probable" unless stated. [*]Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Photo 11 - View of side of Test Pit 306

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D6
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 4 DP1273487

SURFACE LEVEL: 115.8 mAHD
COORDINATE E:289767 **N:** 6236825
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 307
PROJECT No: 92225.06
DATE: 17/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 17/11/22, No free groundwater observed

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS. (*) DENSITY. (*)	MOISTURE
0.0	TOPSOIL/ (CL-CI) Silty CLAY, trace gravel; dark brown; clay fraction low to medium plasticity; gravel fraction fine, sub-angular; with rootlets	TOP	F	<PL
0.2	(CI-CH) Silty CLAY, trace gravel; red brown and brown grey; clay fraction medium to high plasticity; silt fraction medium; gravel fraction fine, sub-angular; trace rootlets and decomposed organic matter	RES	F	=PL
0.8	(CI) Silty CLAY, with gravel; red brown mottled pale grey; clay fraction medium plasticity; gravel fraction fine to medium, angular to sub-angular	RES	ST	<PL
1.2	SHALE; pale grey and red-brown; Bringelly Shale 1.5m: brown, grey and red-brown 2.2m: grey brown, red brown and dark grey 2.6m: grey brown and dark grey			
2.7	Test pit discontinued at 2.70m depth Limit of investigation. Refusal on moderately weathered, medium strength shale			

RL (m): 115, 114, 113, 112

ROCK

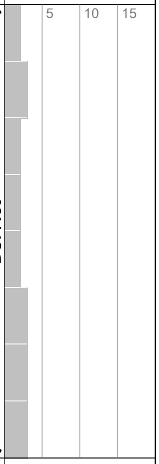
DEPTH (m)	WEATH.	STRENGTH
1.2	HW	VL-L
1.5	HW-MW	
2.2		L-M
2.6	MW	
2.7		

SAMPLE

TYPE	DEPTH (m)
D	0.1
D	0.5
D	1.0
D	1.5
D	2.0
D	2.5
D	2.7

TESTING

TEST TYPE: DCP/150 (0.0 – 1.2 m)



NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
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EXPORTED 31/01/23 17:13. TEMPLATE ID: DP_104.02.00_TESTPIT_ROCK

Photo 12 - View of side of Test Pit 307

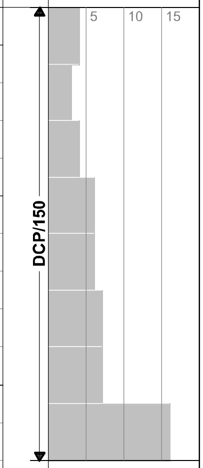
Photo 13 - View of side of Test Pit 307

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	D7
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT:	Boyuan Bringelly Pty Ltd	**SURFACE LEVEL:**	116.8 mAHD	**LOCATION ID:**	308
PROJECT:	Proposed Residential Subdivision	**COORDINATE**	**E:**289666 **N:** 6236724	**PROJECT No:**	92225.06
LOCATION:	South Creek West, Precinct 5, Cobbitty Lot 4 DP1273487	**DATUM/GRID:**	MGA94 Zone 56	**DATE:**	18/11/22
				SHEET:	1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN[#]	CONSIS.[*] DENSITY.[*]	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	SAMPLE REMARKS	TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
18/11/22, No free groundwater observed		0.0	(ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine, sub-angular to sub-rounded; with rootlets	COL	ST						D	0.1	DCP/150	
		0.2	(CI) Silty CLAY, trace gravel; yellow brown and grey brown; clay fraction medium plasticity; gravel fraction sub-angular to sub-rounded; trace rootlets	RES	ST						D	0.5		
	116	0.6	(CL-CI) Gravelly Silty CLAY; red brown and pale grey; clay fraction low to medium plasticity; gravel fraction fine to coarse, angular to sub-angular; appears to be shaly clay	XWM	VST H	<PL					D D	1.0 1.5		
	115	1.7	SHALE; red brown, brown and pale grey; with silty clay bands; Bringelly Shale				HW	1.7	VL-L		D	2.0		
			2.1m: red brown, grey brown and dark grey				HW-MW	2.1	L-M		D	2.5		
			2.6m: grey brown and dark grey				MW	2.6						
	114	2.8	Test pit discontinued at 2.80m depth Limit of investigation. Refusal on moderately weathered, medium strength shale					2.8			D	2.8		
	113	3										3		



NOTES: [#]Soil origin is "probable" unless stated otherwise. [*]Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe **OPERATOR:** WC **LOGGED:** DN

METHOD: 450 mm toothed bucket

REMARKS: Grass cover at the surface

Refer to explanatory notes for symbol and abbreviation definitions

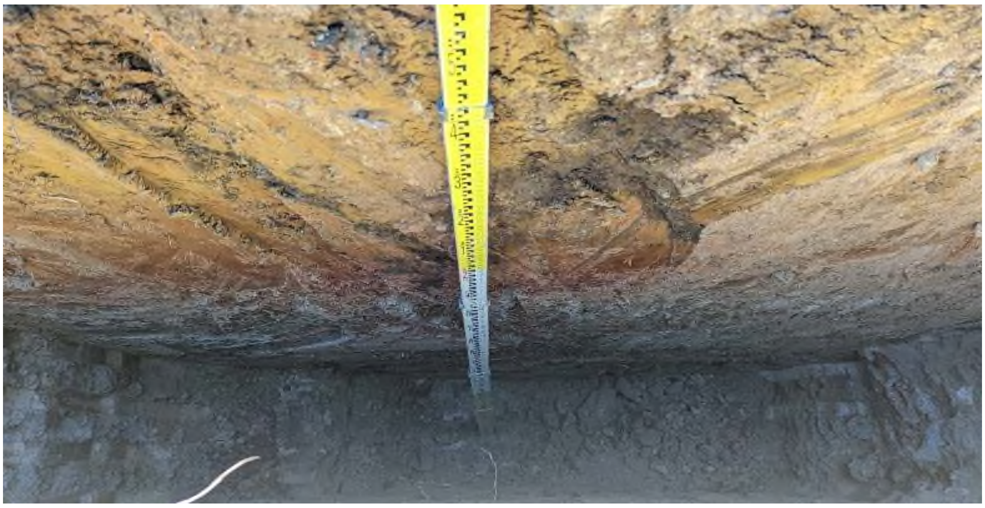


Photo 14 - View of side of Test Pit 308

Photo 15 - View of side of Test Pit 308

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D8
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 112.9 mAHD
COORDINATE E:289583 **N:** 6236589
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 309
PROJECT No: 92225.06
DATE: 17/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 17/11/22, No free groundwater observed

DEPTH (m)	DESCRIPTION OF STRATA	SOIL ORIGIN(#)	SOIL CONSIS. (*) DENSITY. (*)	SOIL MOISTURE	ROCK WEATH.	ROCK DEPTH (m)	ROCK STRENGTH
0.0	(ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine, sub-angular to sub-rounded; with rootlets and tree roots	COL	F	<PL			
0.2	(CI-CH) Silty CLAY, trace gravel; red brown; clay fraction medium to high plasticity; gravel fraction fine, sub-angular to sub-rounded; trace rootlets	COL	F	<PL - =PL			
0.4	(CL-CI) Silty CLAY, with gravel, trace sand; brown and grey brown; clay fraction low to medium plasticity; gravel fraction fine to coarse, angular and sub-rounded; sand fraction fine	COL possibly RES	ST	<PL			
0.9	(CL-CI) Silty CLAY, trace sand; brown and grey brown; clay fraction low to medium plasticity; sand fraction fine	RES	VST H				
2.1	SHALE; grey, red brown and brown; Bringelly Shale				HW	2.1	VL-L
	2.9m: dark grey, brown grey and red brown				HW-MW	2.9	L-M
3.1	Test pit discontinued at 3.10m depth Limit of investigation. Refusal on moderately weathered, medium strength shale					3.1	

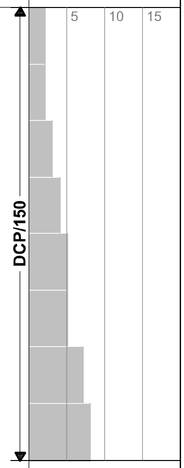
RL (m): 112, 111, 110, 109

SAMPLE

SAMPLE REMARKS	TYPE	DEPTH (m)
	E	0.0 – 0.1
	E	0.5
	E	1.0
	E	2.0
	E	2.5
	E	3.0

TESTING

TEST TYPE	RESULTS AND REMARKS
DCP/150	
PP	>600



NOTES: (#)Soil origin is "probable" unless stated otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

EXPORTED 14/02/23 11:23. TEMPLATE ID: DP_104.02.00_TESTPIT_ROCK

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

Photographs 16 and 17 - View of side and end of Test Pit 309

Photo 18 - inferred colluvial spoil from Test Pit 309

Douglas Partners
Geotechnics | Environment | Groundwater

Test Pit Photographs	PROJECT:	92225.06
Proposed Residential Subdivision	PLATE No:	D9
SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 121.7 mAHD
COORDINATE E:289467 **N:** 6236341
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 310
PROJECT No: 92225.06
DATE: 17/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 17/11/22, No free groundwater observed

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN$^{(\#)}$	CONSIS. / DENSITY.$^{(*)}$	MOISTURE	WEATH.	ROCK DEPTH (m)	STRENGTH
0.0 – 0.2	TOPSOIL/ (CL-CI) Silty CLAY, trace gravel; dark brown; clay fraction low to medium plasticity; gravel fraction fine, sub-angular	TOP	S - F	=PL			
0.2 – 1.3	(CI-CH) Silty CLAY, trace gravel; red brown and grey brown; clay fraction medium to high plasticity; gravel fraction fine, sub-angular; trace rootlets	RES	F ST	=PL			
1.3 – 2.2	(CI) Silty CLAY, trace gravel, trace sand; red-brown, grey and brown; clay fraction medium plasticity; gravel fraction angular to sub-angular; sand fraction fine; trace rootlets	RES	VST - H	<PL			
2.2 – 3.3	SHALE; pale grey and red brown; with silty clay bands; Bringelly Shale				XW HW	2.2 – 2.8 2.8 – 3.3	VL VL-L

RL (m): 121, 120, 119, 118

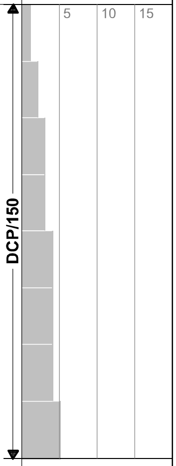
Test pit discontinued at 3.30m depth
Limit of investigation. Refusal on highly to moderately weathered, low to medium strength shale

SAMPLE

TYPE	DEPTH (m)
E	0.0 – 0.1
E	0.5
E	1.0
E	1.5
E	2.0
E	2.5
E	3.0

TESTING

TEST TYPE: DCP/150 (0.0 – 1.2 m)



NOTES: $^{(\#)}$Soil origin is "probable" unless otherwise stated. $^{(*)}$Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

EXPORTED 14/02/23 11:24. TEMPLATE ID: DP_104.02.00_TESTPIT_ROCK

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

Photo 19 - View of side of Test Pit 310

Photo 20 - View of side and end of Test Pit 310

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D10
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

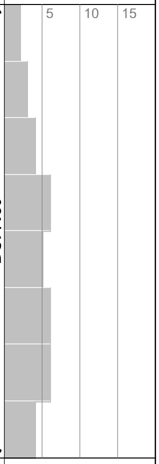
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 119.5 mAHD
COORDINATE E:289219 **N:** 6236269
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 311
PROJECT No: 92225.06
DATE: 16/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED										SAMPLE			TESTING	
				SOIL			ROCK							
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN[#]	CONSIS.[*] DENSITY.[*]	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)	SAMPLE REMARKS	TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
16/11/22, No free groundwater observed		0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine, sub-angular; with rootlets	TOP	F	=PL					E	0.0–0.1	DCP/150 (0.0–1.2)	5 10 15
	119	0.2	(CI-CH) Silty CLAY, trace gravel; red brown and brown; clay fraction medium to high plasticity; gravel fraction fine to medium, sub-angular to sub-rounded; trace rootlets	RES	ST						E	0.5		
	118	0.6	(CI-CH) Silty CLAY, with gravel; red brown and grey; clay fraction medium to high plasticity; gravel fraction fine to medium; trace rootlets	RES	ST VST	<PL					E E	1.0 1.5		
		1.7	SHALE; red brown and brown grey; with low to medium strength sandstone bands; Bringelly Shale				HW-MW	1.7 2.0 2.2	VL-L L-M		E	2.0		
	117 116	2.2	Test pit discontinued at 2.20m depth Limit of investigation. Refusal on moderately to slightly weathered, medium to high strength sandstone									3		



NOTES: [#]Soil origin is "probable" unless otherwise stated. [*]Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Photo 21 - View of side and end of Test Pit 311

Photo 22 - View of side of Test Pit 311

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	D11
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 122.7 mAHD
COORDINATE E:288986 **N:** 6236763
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 312
PROJECT No: 92225.06
DATE: 16/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	SOIL ORIGIN(#)	SOIL CONSIS.(*) / DENSITY.(*)	SOIL MOISTURE
16/11/22, No free groundwater observed	0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine, sub-angular; with rootlets	TOP	F	<PL
	0.2	(CI) Silty CLAY, with gravel; red brown and grey brown; clay fraction medium plasticity; gravel fraction fine, sub-angular; trace rootlets	RES	ST	
	0.8	SHALE; grey brown and brown; with silty clay bands; Bringelly Shale 1.5m: grey brown, dark grey and brown 2.7m: grey brown and dark grey			
	3.4	Test pit discontinued at 3.40m depth Limit of investigation. Refusal on moderately weathered, medium strength shale			

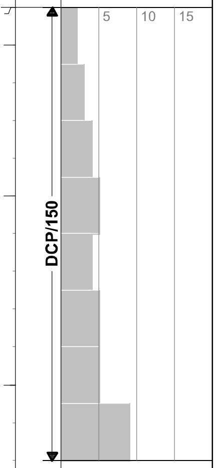
ROCK WEATH.	ROCK DEPTH (m)	ROCK STRENGTH
XW	0.8	VL
HW-MW	1.05	VL
	1.3	VL-L
	1.5	L-M
MW	2.7	L-M
	3.4	

SAMPLE

SAMPLE REMARKS	TYPE	DEPTH (m)
	E	0.0–0.1
	E	0.5
	E	1.0
	E	1.5
	E	2.0
	E	2.5
	E	3.0

TESTING

TEST TYPE	RESULTS AND REMARKS
DCP/150	0.0–1.2 m



NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

EXPORTED 14/02/23 11:24. TEMPLATE ID: DP_104.02.00_TESTPIT_ROCK

Photo 23 - View of side and end of Test Pit 312

Photo 24 - View of side of Test Pit 312

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	D12
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT:	Boyuan Bringelly Pty Ltd	**SURFACE LEVEL:**	123.2 mAHD	**LOCATION ID:**	313
PROJECT:	Proposed Residential Subdivision	**COORDINATE**	**E:**288940 **N:** 6236829	**PROJECT No:**	92225.06
LOCATION:	South Creek West, Precinct 5, Cobbitty Lot 500 DP1231858	**DATUM/GRID:**	MGA94 Zone 56	**DATE:**	16/11/22
				SHEET:	1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 16/11/22, No free groundwater observed

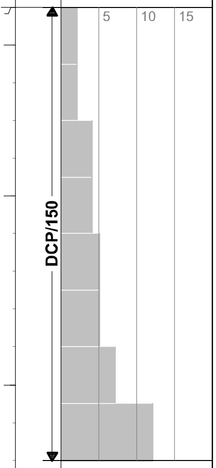
RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL: ORIGIN(#)	SOIL: CONSIS.(*) DENSITY.(*)	SOIL: MOISTURE	ROCK: WEATH.	ROCK: DEPTH (m)	ROCK: STRENGTH
	0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine, sub-angular; with rootlets		TOP	F	=PL			
123	0.2	(CI-CH) Silty CLAY, trace gravel; red brown mottled grey brown; clay fraction medium to high plasticity; gravel fraction fine, sub-angular; trace rootlets		RES	ST				
	0.6	(CL-CI) Gravelly CLAY, with silt, trace sand; orange-brown, brown and grey; clay fraction low to medium plasticity; gravel fraction fine to medium, angular to sub-angular; sand fraction fine; appears to be shaly clay		XWM	ST VST - H	<PL - =PL			
122	1.1	SHALE; red brown, brown and grey; with silty clay bands; Bringelly Shale					XW-HW	1.1 1.3	VL VL-L
121	2.0	2.0m: grey brown, dark grey and grey					MW	2.0	L-M
	2.3	Test pit discontinued at 2.30m depth Limit of investigation. Refusal on moderately weathered, medium strength shale						2.3	
120	3								

SAMPLE

SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)
	E		0.0 - 0.1
	E		0.5
	E		1.0
	E		1.5
	E		2.0

TESTING

TEST TYPE: DCP/150 (0.0 – 1.2 m)



NOTES: (#)Soil origin is "probable" unless stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe **OPERATOR:** WC **LOGGED:** DN

METHOD: 450 mm toothed bucket

REMARKS: Grass cover at the surface

Refer to explanatory notes for symbol and abbreviation definitions

Photo 25 - View of side of Test Pit 313

Photo 26 - View of side and end of Test Pit 313

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D13
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

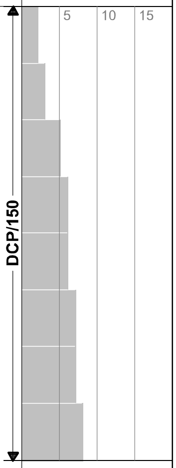
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 112.3 mAHD
COORDINATE E:289034 **N:** 6236897
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 314
PROJECT No: 92225.06
DATE: 16/11/22
SHEET: 1 of 1

Groundwater: 16/11/22, No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine, sub-angular; with rootlets	TOP	F - ST	=PL	E	0.0–0.1	DCP/150	
112	0.3	(CI-CH) Silty CLAY, trace gravel; red brown and brown; clay fraction medium to high plasticity; gravel fraction fine, sub-angular to sub-rounded; trace rootlets trace decomposed organic matter	RES	ST VST		E	0.5		
111	1.0	(CI) Silty CLAY, with gravel; red brown; clay fraction medium plasticity; gravel fraction fine to medium, angular to sub-angular; trace rootlets 1.8m: red brown and grey	RES	VST - H H	<PL	E E E	1.0 1.5 2.0	PP	460-560
110	2.4	(CL) Gravelly CLAY, with silt, trace sand; red-brown, brown and grey; clay fraction low plasticity; gravel fraction fine to coarse, angular to sub-angular; sand fraction fine; with bands of low to medium strength sandstone, appears to be shaly clay	XWM	H		E	2.5		
109	2.7	Test pit discontinued at 2.70m depth Limit of investigation. Refusal on moderately to slightly weathered, medium to high strength sandstone							



NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface
OPERATOR: WC
LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

Photo 27 - View of side of Test Pit 314

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	D14
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

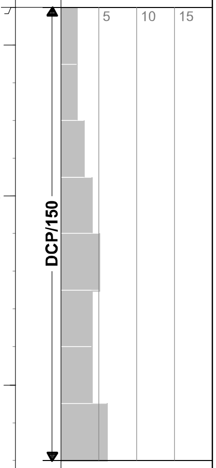
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 105.3 mAHD
COORDINATE E:288914 **N:** 6237110
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 315
PROJECT No: 92225.06
DATE: 16/11/22
SHEET: 1 of 1

GROUNDWATER: 16/11/22, No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN[#]	CONSIS.[*] DENSITY.[*]	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE
	0.0	TOPSOIL/ (CL) Silty CLAY; dark brown; low plasticity; with rootlets	TOP	F					E	0.0 – 0.1	DCP/150 (0.0 – 1.2)
105	0.2	(CI-CH) Silty CLAY, trace gravel; red brown and pale brown; clay fraction medium to high plasticity; gravel fraction fine to medium, sub-angular; trace rootlets	RES	ST					E	0.5	
	0.7	(CI-CH) Silty CLAY, trace gravel; red brown mottled pale grey; clay fraction medium to high plasticity; gravel fraction fine, sub-angular; trace rootlets	RES	ST - VST	=PL				E	1.0	
104	1.5	(CL) Gravelly CLAY, with silt; red-brown, brown and pale grey; clay fraction low plasticity; gravel fraction fine to medium, angular to sub-angular; appears to be shaly clay	XWM	VST	<PL				E E	1.5 2.0	
103	2.3	SHALE; red brown, brown and grey; with silty clay bands; Bringelly Shale				XW-HW	2.3 – 3.1	VL-L	E E	2.5 3.0	
102	3.1	Test pit discontinued at 3.10m depth Limit of investigation. Terminated in very low to low strength shale									



NOTES: [#]Soil origin is "probable" unless stated otherwise. [*]Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

Photo 28 - View of side of Test Pit 315

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs Proposed Residential Subdivision SCW, Cobbitty Bringelly Precinct, Cobbitty	PROJECT:	92225.06
		PLATE No:	D15
		REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 100.8 mAHD
COORDINATE **E:**289195 **N:** 6237113
DATUM/GRID: MGA94 Zone 56

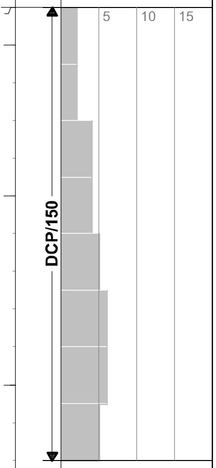
LOCATION ID: 316
PROJECT No: 92225.06
DATE: 16/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	SOIL ORIGIN(#)	SOIL CONSIS.(*) DENSITY.(*)	SOIL MOISTURE	ROCK WEATH.	ROCK DEPTH (m)	ROCK STRENGTH VL L M H VH EH
16/11/22, No free groundwater observed		0.0	TOPSOIL/ (ML) Clayey SILT, with gravel, trace sand; dark brown; silt fraction low plasticity; gravel fraction fine to medium, sub-angular to sub-rounded; sand fraction fine; with rootlets	TOP	F	<PL			
	100	0.3	(CI-CH) Silty CLAY, trace gravel; red brown and pale brown; clay fraction medium to high plasticity; gravel fraction fine, sub-angular to sub-rounded; trace rootlets and decomposed organic matter	RES	ST - VST	=PL			
	99	1.5	(CI-CH) Silty CLAY, trace gravel; red brown mottled pale grey; clay fraction medium to high plasticity; gravel fraction fine, sub-angular to sub-rounded; trace rootlets and decomposed organic matter 2.2m: with fine to medium, sub-angular to angular ironstone and shale gravel and clayey silt bands	RES	VST	<PL to =PL			
	98	2.7	(CI-CH) Gravelly CLAY; pale grey mottled red-brown; fine to medium, angular to sub-angular, medium to high plasticity; shale gravel and clayey silt bands	XWM					
	97	3.3	Test pit discontinued at 3.30m depth Limit of investigation. Terminated in very stiff, extremely weathered shale						

SAMPLE / TESTING

SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	E		0.0 0.1	DCP/150	
	E		0.5		
	E		1.0		
	E		1.5	PP	220-260
	E		2.0		
	E		2.5	PP	210-290
	E		3.0		



NOTES: (#)Soil origin is "probable" unless stated otherwise. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
OPERATOR: WC
LOGGED: DN
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface. Topsoil layer appears disturbed by past farming activity

Refer to explanatory notes for symbol and abbreviation definitions

Photo 29 - View of side of Test Pit 316

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D16
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 96.4 mAHD
COORDINATE E:289479 **N:** 6237111
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 317
PROJECT No: 92225.06
DATE: 17/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

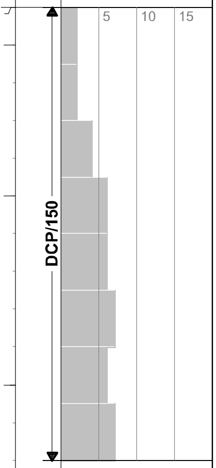
GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE
moderate seepage	0.0	TOPSOIL/ (ML) Clayey SILT; dark brown; low plasticity; trace rootlets	TOP	F	<PL
	0.3	(CI) Silty CLAY, trace gravel; red brown and brown; clay fraction medium plasticity; gravel fraction fine, sub-angular; trace rootlets	RES	ST	
	0.6	(CI) Silty CLAY, with gravel; brown and brown grey; clay fraction medium plasticity; gravel fraction fine to medium, angular to sub-angular	RES	VST	
	1.6	(CL-CI) Gravelly Silty CLAY, trace sand; brown, orange brown and dark grey; clay fraction low to medium plasticity; gravel fraction fine to coarse, angular to sub-angular; sand fraction fine	XWM	VST - H	=PL
2.6 m depth, 17/11/22, Groundwater seepage					=PL - >PL
	3.0	Test pit discontinued at 3.00m depth Limit of investigation. Terminated in very stiff to hard, extremely weathered shale			

RL (m): 96, 95, 94, 93

SAMPLE

TYPE	DEPTH (m)
E	0.0 – 0.1
E	0.5
E	1.0
E	1.5
E	2.0
E	2.5
E	3.0

TESTING



NOTES: (#)Soil origin is "probable" unless stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

Photo 30 - View of side of Test Pit 317

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D17
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 98.8 mAHD
COORDINATE **E:**289641 **N:** 6237095
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 318
PROJECT No: 92225.06
DATE: 17/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 17/11/22, No free groundwater observed

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN[(#)]	CONSIS.[(*)] DENSITY.[(*)]	MOISTURE	WEATH.	DEPTH (m)	STRENGTH
0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction fine, sub-angular; with roots	TOP	S - F				
0.3	(CI-CH) Silty CLAY, trace gravel; red brown and brown; clay fraction medium to high plasticity; gravel fraction fine, sub-angular; trace rootlets	RES	ST	=PL			
0.6	(CI-CH) Silty CLAY, trace gravel; red brown mottled pale grey; clay fraction medium to high plasticity; gravel fraction fine to medium, angular to sub-angular	RES	VST				
1.1	(CL-CI) Gravelly Silty CLAY; red brown mottled pale grey; clay fraction low to medium plasticity; gravel fraction fine to coarse, angular to sub-angular; iron-cemented in parts, appears to be shaly day	XWM	VST - H	<PL			
2.0	SHALE; red brown and pale grey; with silty clay bands; Bringelly Shale				XW-HW	2.0	VL-L
					HW-MW	2.4	L-M
	3.0m: grey brown, grey and red brown				MW	3.0	
3.2	Test pit discontinued at 3.20m depth Limit of investigation. Refusal on moderately weathered, medium strength shale					3.2	

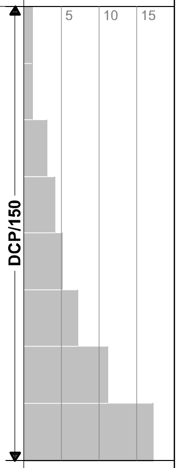
RL (m): 98, 97, 96, 95

SAMPLE

TYPE	DEPTH (m)
E	0.0 – 0.1
E	0.5
E	1.0
E	1.5
E	2.0
E	2.5
E	3.0

TESTING

TEST TYPE: DCP/150 (0.0 – 1.2)



NOTES: [(#)]Soil origin is "probable" unless otherwise stated. [(*)]Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

EXPORTED 14/02/23 11:24. TEMPLATE ID: DP_104.02.00_TESTPIT_ROCK

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC
LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

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Photo 31 - View of side and end of Test Pit 318 (oblique view)

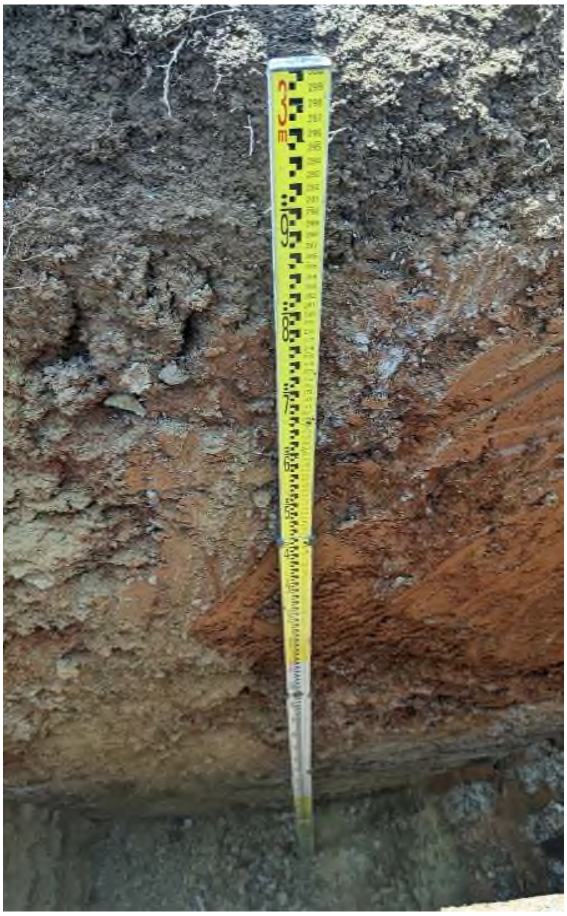


Photo 32 - View of side of Test Pit 318

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D18
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 102.9 mAHD
COORDINATE E:289464 **N:** 6236699
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 319
PROJECT No: 92225.06
DATE: 17/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	ROCK DEPTH (m)	STRENGTH
moderate seepage	0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; dark brown; silt fraction low plasticity; gravel fraction sub-angular; with rootlets	TOP	F				
	0.3	(CI-CH) Silty CLAY, trace gravel; red brown and brown; clay fraction medium to high plasticity; gravel fraction fine, sub-angular; with rootlets	RES	F - ST				
	0.6	(CI) Silty CLAY, with gravel; brown and grey brown; clay fraction medium plasticity; gravel fraction fine to medium, angular	RES	ST	=PL			
	1.8	(CL-CI) Gravelly Silty CLAY; orange brown, brown and grey; clay fraction low to medium plasticity; gravel fraction fine to medium, angular to sub-angular	XWM	ST - VST	=PL - >PL			
2.5 m depth, 17/11/22, Groundwater seepage	2.6	SHALE; grey brown and grey; Bringelly Shale				HW	2.6–2.9	L-M
	2.9	Test pit discontinued at 2.90m depth Limit of investigation. Refusal on moderately weathered, medium strength shale						

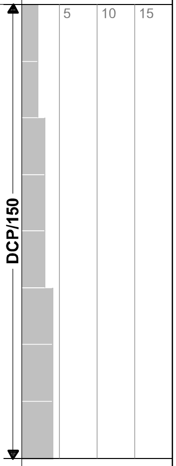
RL (m): 102 at approx. 0.9 m; 101 at approx. 1.9 m; 100 at 2.9 m; 99 at approx. 3.9 m.

SAMPLE

TYPE	DEPTH (m)
E	0.0–0.1
E	0.5
E	1.0
E	1.5
E	2.0
E	2.5
E	2.9

TESTING

DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
0.0–1.2	DCP/150	
1.5	PP	130-180



NOTES: (#)Soil origin is "probable" unless stated otherwise. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

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Photo 33 - View of side and end of Test Pit 319 (oblique view)

Photo 34 - View of side of Test Pit 319

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D19
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 107.2 mAHD
COORDINATE E:289297 **N:** 6236836
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 320
PROJECT No: 92225.06
DATE: 16/11/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

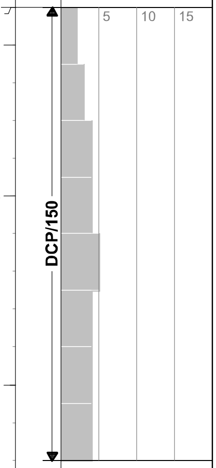
GROUNDWATER: 16/11/22, No free groundwater observed

DEPTH (m)	RL (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS. (*) / DENSITY (*)	MOISTURE	WEATH.	ROCK DEPTH (m)	STRENGTH
0.0		TOPSOIL/ (ML) Clayey SILT, with gravel; dark brown; silt fraction low plasticity; gravel fraction fine to medium, sub-angular; with rootlets	TOP	F - ST	=PL			
0.2	107	(CI-CH) Silty CLAY, trace gravel; red brown and brown; clay fraction medium to high plasticity; gravel fraction fine to medium, sub-angular to sub-rounded; trace rootlets and decomposed organic material	RES	ST				
0.7		(CI-CH) Silty CLAY, with gravel; red brown mottled grey and brown; clay fraction medium to high plasticity; gravel fraction fine to medium, angular and sub-rounded; trace rootlets	RES					
1.1	106	(CL-CI) Gravelly CLAY, with silt; red brown and pale grey; clay fraction low to medium plasticity; gravel fraction fine to coarse, angular to sub-angular; appears to be shaly clay	XWM	ST - VST	<PL			
1.6		SHALE; pale grey and red brown; Bringelly Shale				XW	1.6	VL
2.2	105	2.2m: brown, red brown and pale grey				HW	2.2	VL-L
3.0	104	Test pit discontinued at 3.00m depth Limit of investigation. Terminated in very low to low strength shale					3.0	

SAMPLE

TYPE	DEPTH (m)
E	0.0–0.1
E	0.5
E	1.0
E	1.5
E	2.0
E	2.5
E	3.0

TESTING



NOTES: (#)Soil origin is "probable" unless stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

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Photo 35 - View of side of Test Pit 320

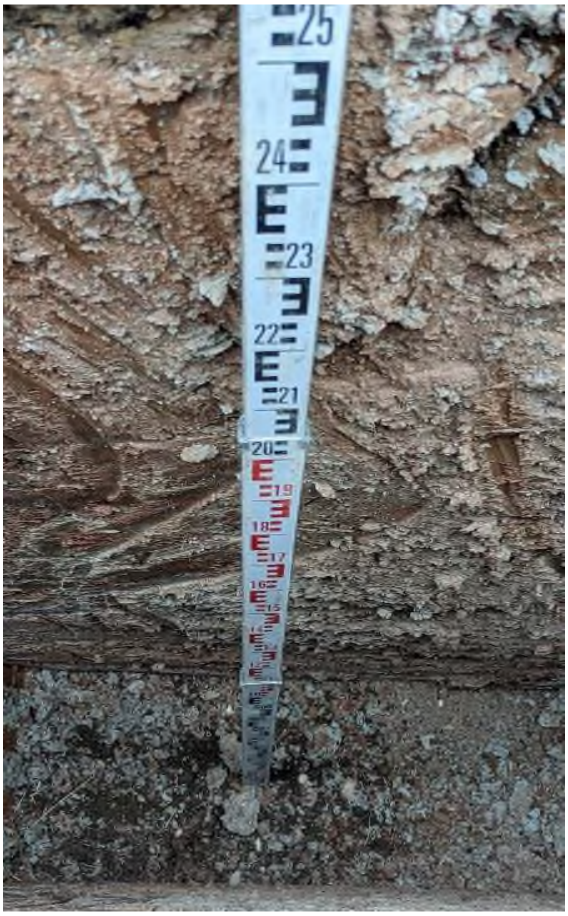


Photo 36 - View of side of Test Pit 320

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D20
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 125.1 mAHD
COORDINATE E:289118 **N:** 6236706
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 321
PROJECT No: 92225.06
DATE: 16/11/22
SHEET: 1 of 1

GROUNDWATER: 16/11/22, No free groundwater observed

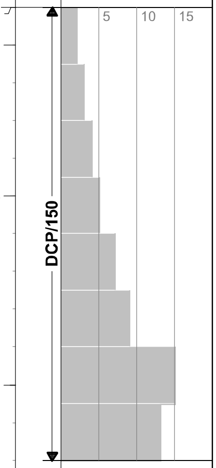
RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH
125	0.0	TOPSOIL/ (ML) Clayey SILT; dark brown; low plasticity; with rootlets	TOP	F				
	0.15	(CI-CH) Silty CLAY, trace gravel; red brown and pale grey; clay fraction medium to high plasticity; gravel fraction fine, sub-angular; trace rootlets	RES	ST	<PL			
	0.6	(CL-CI) Gravelly CLAY, with silt; orange brown and grey brown; clay fraction low to medium plasticity; gravel fraction fine to coarse, angular to sub-angular; appears to be shaly clay	XWM	VST TO H				
124	1.1	SHALE; pale grey, brown and brown grey; with bands of low to medium strength sandstone; Bringelly Shale				HW	1.1	VL-L
		1.7m: pale grey and brown				MW	1.7	L-M
	2.0	Test pit discontinued at 2.00m depth Limit of investigation. Refusal on moderately to slightly weathered, medium to high strength sandstone					2.0	

SAMPLE

DEPTH (m)	TYPE	SAMPLE REMARKS
0.0–0.1	E	
0.5	E	
1.0	E	
1.5	E	
2.0	E	

TESTING

TEST TYPE	RESULTS AND REMARKS
DCP/150	0.0 – 1.2 m



NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

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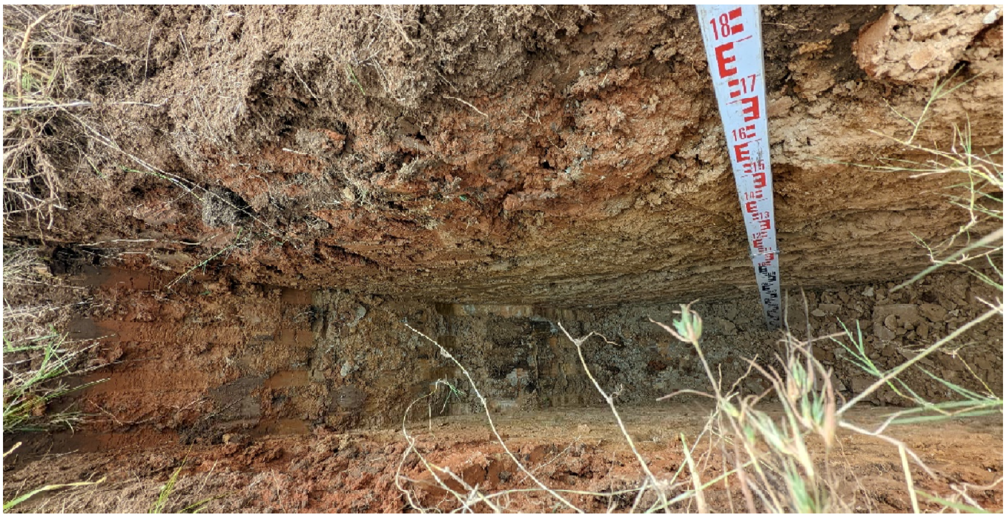


Photo 37 - View of side and end of Test Pit 321 (oblique view)

Photo 38 - View of side of Test Pit 321

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D21
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

SURFACE LEVEL: 112.4 mAHD
COORDINATE E:289177 **N:** 6236448
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 322
PROJECT No: 92225.06
DATE: 16/11/22
SHEET: 1 of 1

GROUNDWATER: 16/11/22, No free groundwater observed

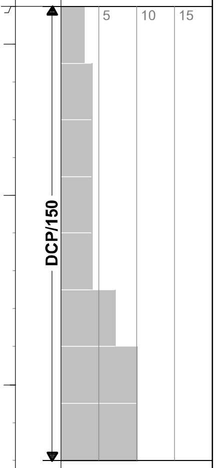
DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m) (ROCK)	STRENGTH
0.0	TOPSOIL/ (CL-CI) Silty CLAY; dark brown; low to medium plasticity; with rootlets	TOP		<PL			
0.2	(CI-CH) Silty CLAY, trace gravel; red brown mottled brown grey; clay fraction medium to high plasticity; gravel fraction fine, angular to sub-angular; trace rootlets	RES	ST	=PL			
0.8	(CI-CH) Silty CLAY, with gravel; pale grey mottled red brown; clay fraction medium to high plasticity; gravel fraction fine to medium, angular to sub-angular	RES	VST				
1.2	SHALE; pale grey and grey brown; with silty clay bands; Bringelly Shale				HW	1.2	VL-L
	2.1-2.6m: pale grey, extremely weathered, very low strength zone				XW	2.1	VL
					HW-MW	2.6	L-M
3.1						3.1	

RL (m): 112, 111, 110, 109

SAMPLE

TYPE	DEPTH (m)
E	0.0–0.1
E	0.5
E	1.0
E	2.0
E	2.5
E	3.0

TESTING



Test pit discontinued at 3.10m depth
Limit of investigation. Refusal on moderately weathered, medium strength shale

NOTES: (#)Soil origin is "probable" unless stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface

OPERATOR: WC

LOGGED: DN

EXPORTED 14/02/23 11:24. TEMPLATE ID: DP_104.02.00_TESTPIT_ROCK

Refer to explanatory notes for symbol and abbreviation definitions

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Photo 39 - View of end of Test Pit 322

Douglas Partners
Geotechnics / Environment / Groundwater

Test Pit Photographs
Proposed Residential Subdivision
SCW, Cobbitty Bringelly Precinct, Cobbitty
CLIENT: Boyuan Bringelly Pty Ltd

PROJECT:	92225.06
PLATE No:	D22
REV:	A
DATE:	Feb-23

Photo 40 - View of side of Test Pit 322

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D23
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: South Creek West, Precinct 5, Cobbitty
Lot 500 DP1231858

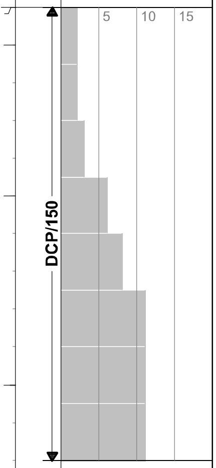
SURFACE LEVEL: 112 mAHD
COORDINATE E:289487 **N:** 6236442
DATUM/GRID: MGA94 Zone 56

LOCATION ID: 323
PROJECT No: 92225.06
DATE: 17/11/22
SHEET: 1 of 1

GROUNDWATER: 17/11/22, No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE
	0.0	TOPSOIL/ (ML) Clayey SILT, trace gravel; brown; silt fraction low plasticity; gravel fraction sub-angular to sub-rounded; with rootlets	TOP	F	<PL
	0.3	(CI-CH) Silty CLAY, trace gravel; red brown and grey brown; clay fraction medium to high plasticity; gravel fraction sub-angular; trace rootlets and decomposed organic matter	RES	ST - VST	=PL
111 (1 m)	0.8	(CL-CI) Silty CLAY, with gravel; grey brown and brown; clay fraction low to medium plasticity; gravel fraction fine, sub-angular to sub-rounded; trace rootlets 2.0m: with fine to medium grained sub-rounded to sub-angular gravel, trace fine grained sand	RES	VST - H (0.8–2.0 m) H (2.0–3.0 m)	<PL
110 (2 m)	2.7	(CL-CI) Gravelly CLAY, with silt; pale grey; clay fraction low to medium plasticity; gravel fraction fine to coarse, angular to sub-angular; with fine grained sandstone bands, appears shaly clay	XWM	H	
109	3.0	Test pit discontinued at 3.00m depth Limit of investigation. Terminated in hard, extremely weathered shale			

SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
E	0.0–0.1	DCP/150 (0.0–1.2)	
E	0.5		
E	1.0		
E	1.5		
E	2.0	PP	>600
E	2.5		
E	3.0		



NOTES: (#)Soil origin is "probable" unless stated otherwise. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: JCB 4CX 8t Backhoe
METHOD: 450 mm toothed bucket
REMARKS: Grass cover at the surface. Topsoil layer appears disturbed by past farming activity

OPERATOR: WC

LOGGED: DN

Refer to explanatory notes for symbol and abbreviation definitions

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Photo 41 - View of end of Test Pit 323

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D24
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23


Photo 42 - View of side of Test Pit 323

Douglas Partners Geotechnics / Environment / Groundwater	Test Pit Photographs	PROJECT:	92225.06
	Proposed Residential Subdivision	PLATE No:	D25
	SCW, Cobbitty Bringelly Precinct, Cobbitty	REV:	A
	CLIENT: Boyuan Bringelly Pty Ltd	DATE:	Feb-23

Appendix F

Previous Field Work Results

NOTES RELATING TO THIS REPORT

Introduction

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

Geotechnical reports are based on information gained from limited subsurface test boring 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.

Description and Classification Methods

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

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT “N” Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling 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 with 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.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of 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 sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole 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 in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 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.

ñ 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

ñ In the case where the test is discontinued short of full penetration, 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 tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

ñ Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.

ñ Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.

ñ Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) \text{ N (blows per 300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

$$q_c = (12 \text{ to } 18)\, c_u$$

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

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. 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 relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

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

Bore Logs

The bore logs presented herein 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. 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 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, the frequency of sampling and the possibility of other than ‘straight line’ variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

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

Engineering Reports

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

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

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation 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, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

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

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical 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.

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DESCRIPTION AND CLASSIFICATION OF ROCKS FOR ENGINEERING PURPOSES

DEGREE OF WEATHERING

Term	Symbol	Definition
Extremely Weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly Weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.
Moderately Weathered	MW	Rock substance affected by weathering to the extent that staining or discolouration of the rock substance usually by limonite has taken place. The colour of the fresh rock is no longer recognisable.
Slightly Weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh Stained	Fs	Rock substance unaffected by weathering, but showing limonite staining along joints.
Fresh	Fr	Rock substance unaffected by weathering.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index ($I_{S(50)}$) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by Australian Standard 4133.4.1 - 1993.

Term	Symbol	Field Guide*	Point Load Index $I_{S(50)}$ MPa	Approx Unconfined Compressive Strength q_u ** MPa
Extremely low	EL	Easily remoulded by hand to a material with soil properties	<0.03	< 0.6
Very low	VL	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; too hard to cut a triaxial sample by hand. SPT will refuse. Pieces up to 3 cm thick can be broken by finger pressure.	0.03-0.1	0.6-2
Low	L	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long 40 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.	0.1-0.3	2-6
Medium	M	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.	0.3-1.0	6-20
High	H	Can be slightly scratched with a knife. A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow, rock rings under hammer.	1 - 3	20-60
Very high	VH	Cannot be scratched with a knife. Hand specimen breaks with pick after more than one blow, rock rings under hammer.	3 - 10	60-200
Extremely high	EH	Specimen requires many blows with geological pick to break through intact material, rock rings under hammer.	>10	> 200

Note that these terms refer to strength of rock material and not to the strength of the rock mass, which may be considerably weaker due to rock defects.

* The field guide assessment of rock strength may be used for preliminary assessment or when point load testing is not able to be done.

** The approximate unconfined compressive strength (q_u) shown in the table is based on an assumed ratio to the point load index of 20:1. This ratio may vary widely.

STRATIFICATION SPACING

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

DEGREE OF FRACTURING

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks. The orientation of rock defects is measured as an angle relative to a plane perpendicular to the core axis. Note that where possible, recordings of the actual defect spacing or range of spacings is preferred to the general terms given below.

Term	Description
Fragmented	The core consists mainly of fragments with dimensions less than 20 mm.
Highly Fractured	Core lengths are generally less than 20 mm - 40 mm with occasional fragments.
Fractured	Core lengths are mainly 40 mm - 200 mm with occasional shorter and longer sections.
Slightly Fractured	Core lengths are generally 200 mm - 1000 mm with occasional shorter and longer sections.
Unbroken	The core does not contain any fracture.

ROCK QUALITY DESIGNATION (RQD)

This is defined as the ratio of sound (i.e. low strength or better) core in lengths of greater than 100 mm to the total length of the core, expressed in percent. If the core is broken by handling or by the drilling process (i.e. the fracture surfaces are fresh, irregular breaks rather than joint surfaces) the fresh broken pieces are fitted together and counted as one piece.

SEDIMENTARY ROCK TYPES

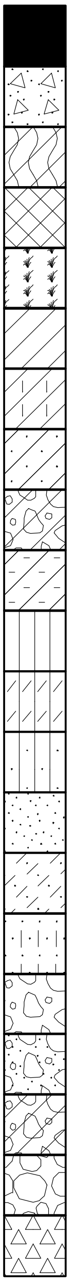
This classification system provides a standardised terminology for the engineering description of sandstone and shales, particularly in the Sydney area, but the terms and definitions may be used elsewhere when applicable.

Rock Type	Definition
Conglomerate	More than 50% of the rock consists of gravel-sized (greater than 2 mm) fragments
Sandstone:	More than 50% of the rock consists of sand-sized (0.06 to 2 mm) grains
Siltstone:	More than 50% of the rock consists of silt-sized (less than 0.06 mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of clay or sericitic material and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay-sized particles and the rock is laminated.

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, eg. clayey sandstone, sandy shale.

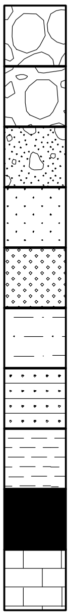
GRAPHIC SYMBOLS FOR SOIL & ROCK

SOIL



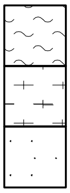
- BITUMINOUS CONCRETE
- CONCRETE
- TOPSOIL
- FILLING
- PEAT
- CLAY
- SILTY CLAY
- SANDY CLAY
- GRAVELLY CLAY
- SHALY CLAY
- SILT
- CLAYEY SILT
- SANDY SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- GRAVEL
- SANDY GRAVEL
- CLAYEY GRAVEL
- COBBLES/BOULDERS
- TALUS

SEDIMENTARY ROCK



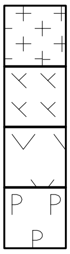
- BOULDER CONGLOMERATE
- CONGLOMERATE
- CONGLOMERATIC SANDSTONE
- SANDSTONE FINE GRAINED
- SANDSTONE COARSE GRAINED
- SILTSTONE
- LAMINITE
- MUDSTONE, CLAYSTONE, SHALE
- COAL
- LIMESTONE

METAMORPHIC ROCK



- SLATE, PHYLITTE, SCHIST
- GNEISS
- QUARTZITE

IGNEOUS ROCK



- GRANITE
- DOLERITE, BASALT
- TUFF
- PORPHYRY

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TEST PIT LOG

CLIENT: Growth Centres Commission
PROJECT: Land Capability Assessment
LOCATION: Oran Park

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

PIT No: 39
PROJECT No: 40740
DATE: 17 Jan 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
				Type	Depth	Sample	Results & Comments		
		TOPSOIL - brown silty clay		D	0.1				
	0.4	SILTY CLAY - hard, light orange brown silty clay		D	0.5		pp > 400kPa		
	1			D	1.0		pp > 400kPa		1
				D	1.5		pp > 400kPa		
	2 2.0	SHALE - extremly to highly weathered, extremly low to medium strength, orange brown and grey shale		D	2.0		pp > 400kPa		2
	2.1	Pit discontinued at 2.1m (refusal in low to medium strength shale)							
	3								3
	4								4

RIG: Backhoe - 450mm bucket

LOGGED: N Boers

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⊻ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: Growth Centres Commission
PROJECT: Land Capability Assessment
LOCATION: Oran Park

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

PIT No: 56
PROJECT No: 40740
DATE: 17 Jan 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
				Type	Depth	Sample	Results & Comments		
		TOPSOIL - brown silty clay		D	0.1				
	0.2	SILTY CLAY - hard, brown silty clay with some gravel, dry		D	0.5		pp > 400kPa		
1				D	1.0		pp > 400kPa		1
	1.4	GRAVELLY SILTY CLAY - hard, brown gravelly silty clay, dry		D	1.5		pp > 400kPa		
2				D	2.0		pp > 400kPa		2
	2.3	GRAVELLY SILTY CLAY - hard, grey gravelly silty clay, dry. High gravel content		D	2.5		pp > 400kPa		
3	3.0	Pit discontinued at 3.0m (limit of investigation in low strength shale)							3
4									4

RIG: Backhoe - 450mm bucket

LOGGED: N Boers

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: Growth Centres Commission
PROJECT: Land Capability Assessment
LOCATION: Oran Park

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

PIT No: 215
PROJECT No: 40740
DATE: 17 Jan 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
				Type	Depth	Sample	Results & Comments		
		TOPSOIL - brown silty clay		D	0.1				
	0.2	SILTY CLAY - hard, brown silty clay, humid		D	0.5		pp > 400kPa		
				D	1.0		pp > 400kPa		
				D	1.5		pp > 400kPa		
	1.7	GRAVELLY SILTY CLAY - hard to very hard, grey and orange brown gravelly silty clay, humid		D	2.0		pp > 400kPa		
				D	2.5		pp > 400kPa		
	2.9	Pit discontinued at 2.9m (limit of investigation in gravelly clay)							

RIG: Backhoe - 450mm bucket

LOGGED: N Boers

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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Sampling Methods

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

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

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Degree of Fracturing

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

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

Rock Descriptions

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Symbols & Abbreviations

Douglas Partners

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
▽	Water level

Sampling and Testing

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

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

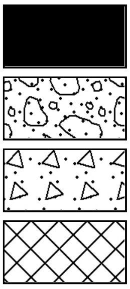
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

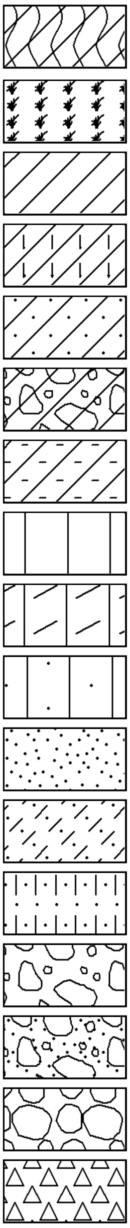
Graphic Symbols for Soil and Rock

General



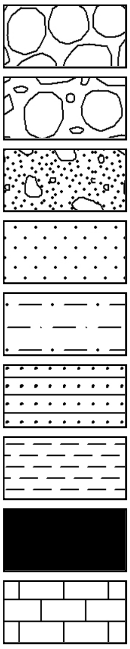
- Asphalt
- Road base
- Concrete
- Filling

Soils



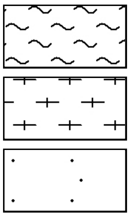
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks



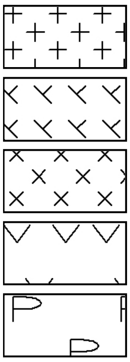
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks



- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks



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

May 2017

TEST PIT LOG

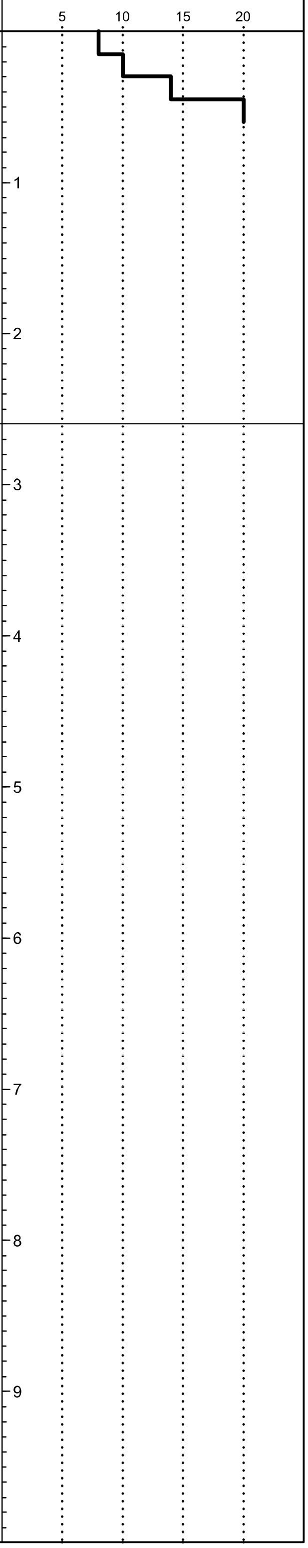
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 90 mAHD
EASTING: 289823
NORTHING: 6237792

PIT No: 101
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
90		TOPSOIL/Silty CLAY CI: brow, trace gravel and sand, rootlets in top 0.1m, w<PL						
	0.4	Silty CLAY CI: grey, brown, yellow and red mottled, trace gravel and sand, w<PL, hard		Dx2	0.5			
				U$_{50}$				
89	1				0.9		pp >400	
				D	1.0			
	1.4	Silty CLAY CI: grey and red brown, trace sandstone gravel, w<PL, hard - becoming grey below 1.7m		Dx2	1.5		pp >400	
88	2			D	2.0		pp = 300	
	2.2	SANDSTONE: brown, with iron staining, low to medium strength, highly to moderately weathered						
				D	2.5			
	2.6	Pit discontinued at 2.6m - refusal on low to medium strength sandstone						
87	3							
86	4							
85	5							
84	6							
83	7							
82	8							
81	9							

Dynamic Penetrometer Test (blows per 150mm)



RIG: John Deere 315SE backhoe - 450mm toothed bucket **LOGGED:** ERL **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

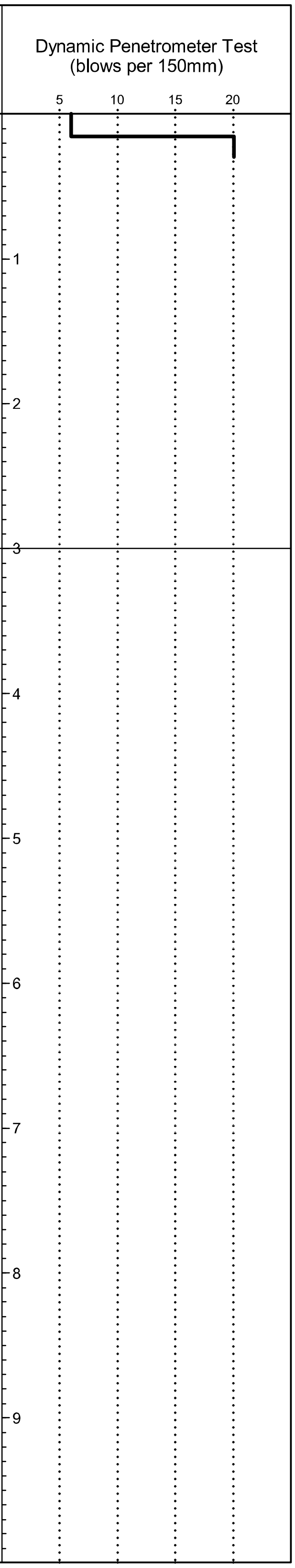
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 88 mAHD
EASTING: 290291
NORTHING: 6237683

PIT No: 102
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
88		TOPSOIL/Silty CLAY CI: brown, trace gravel, rootlets in top 0.05m, w<PL					
	0.4	Silty CLAY CI: red brown, trace ironstone gravel, w<PL, hard	D	0.5		pp >400	
87	1		D/B	1.0		pp >400	
			D	1.5		pp >400	
	1.8	Silty CLAY CI: grey and red brown mottled, trace sandstone gravel, w<PL, very stiff					
86	2		D	2.0		pp = 300	
			D	2.5		pp = 300	
85	3 3.0	Pit discontinued at 3.0m - limit of investigation	D	3.0			
84	4						
83	5						
82	6						
81	7						
80	8						
79	9						



RIG: John Deere 315SE backhoe - 450mm toothed bucket
LOGGED: ERL
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

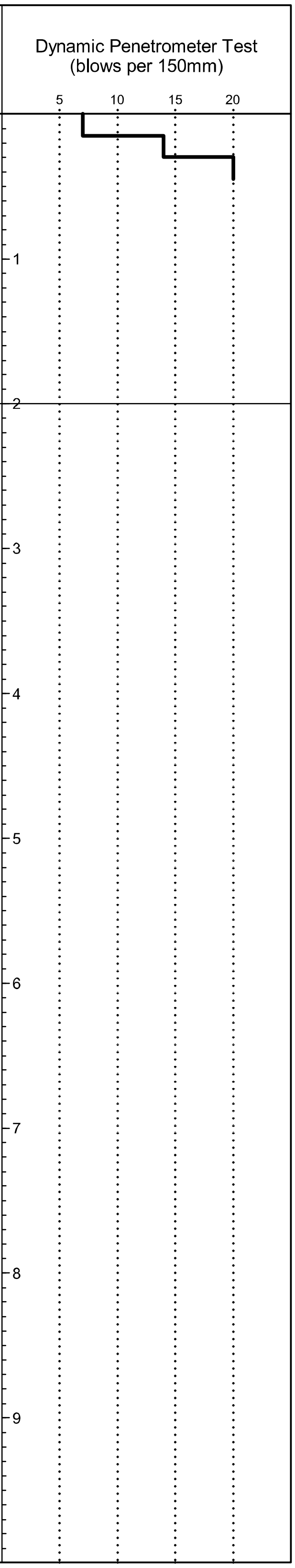
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 95 mAHD
EASTING: 290561
NORTHING: 6237693

PIT No: 103
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
95		TOPSOIL/Silty CLAY CI: brown, trace rootlets in top 0.1m, w<PL						
	0.3	Silty CLAY CI: red brown and grey mottled, trace gravel and sand, w<PL, hard		Dx2	0.5			
94	1			D	1.0			
	1.2	SANDSTONE: fine grained, grey, low strength, moderately weathered - becoming brown, low to medium strength, moderately weathered		Dx2	1.5			
93	2 2.0	Pit discontinued at 2.0m - refusal on low to medium strength sandstone		D	2.0			
92	3							
91	4							
90	5							
89	6							
88	7							
87	8							
86	9							



RIG: John Deere 315SE backhoe - 450mm toothed bucket

LOGGED: ERL

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

TEST PIT LOG

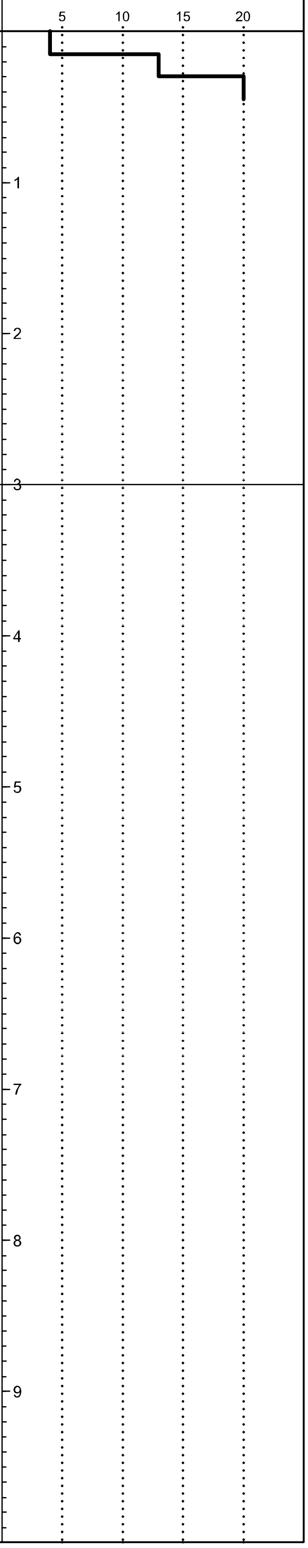
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 94 mAHD
EASTING: 289871
NORTHING: 6237343

PIT No: 104
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
94		TOPSOIL/Silty CLAY CI: with rootlets in top 0.1m, w<PL						
	0.2	Silty CLAY CI: brown, trace gravel and sand, w<PL, hard		Dx2	0.5		pp >400	
	0.6	Silty CLAY CI: red brown and grey mottled, trace gravel and sand, m<PL, hard						
93	1			D	1.0			
				Dx2	1.5			
		- becoming more grey with depth below 1.7m						
92	2			D	2.0			
				Dx2	2.5		pp >400	
		- becoming extremely weathered below 2.8m						
91	3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0			
90	4							
89	5							
88	6							
87	7							
86	8							
85	9							

Dynamic Penetrometer Test (blows per 150mm)



RIG: John Deere 315SE backhoe - 450mm toothed bucket

LOGGED: ERL

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

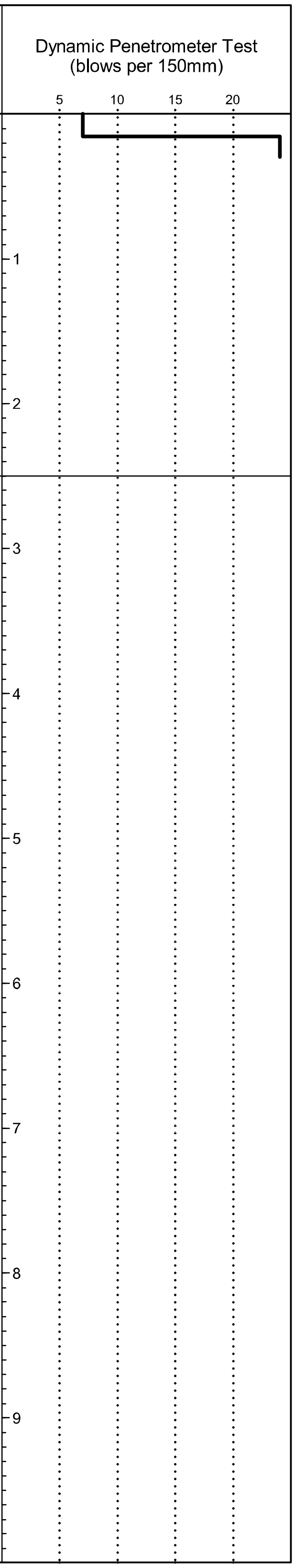
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 97 mAHD
EASTING: 290287
NORTHING: 6237383

PIT No: 105
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
97	0.2	TOPSOIL/Silty CLAY CI: brown, with rootlets in top 0.1m, w<PL					
	0.5	Silty CLAY CI: brown, trace gravel and sand, w<PL, hard		0.35		pp >400	
			Dx2/B	0.5			
96	1	Silty CLAY CI: red brown, trace gravel and sand, w<PL, hard	D	1.0			
			Dx2	1.5		pp >400	
95	2		D	2.0			
	2.2	SANDSTONE: fine grained, pale grey and brown, with iron staining, low strength, highly to moderately weathered					
	2.5		Dx2	2.5			
		Pit discontinued at 2.5m - refusal on low to medium strength sandstone					
94	3						
93	4						
92	5						
91	6						
90	7						
89	8						
88	9						



RIG: John Deere 315SE backhoe - 450mm toothed bucket **LOGGED:** ERL **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

TEST PIT LOG

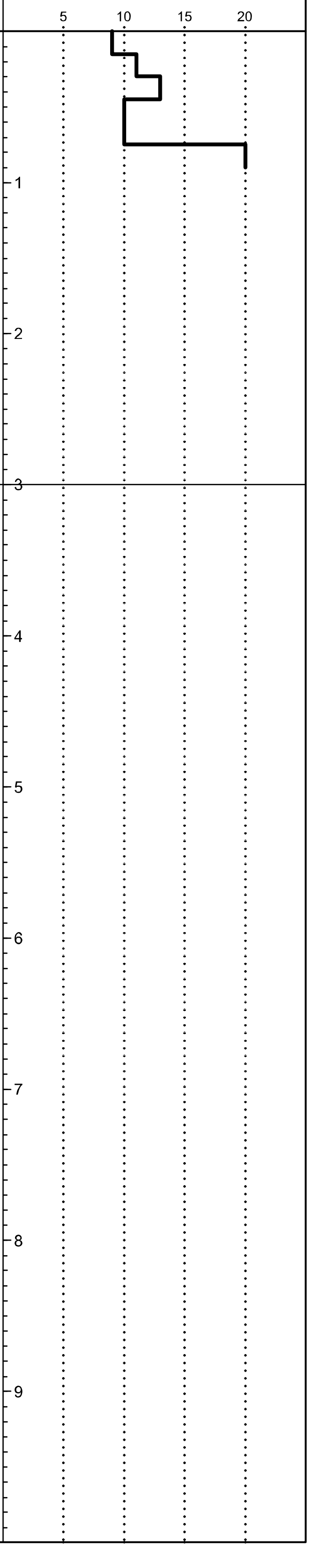
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 95 mAHD
EASTING: 290542
NORTHING: 6237417

PIT No: 106
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
95	0.15	TOPSOIL/Silty CLAY CI: brown, trace gravel and sand, with rootlets in top 0.05m, w<PL, hard						
		Silty CLAY CI: brown and red brown, trace gravel and sand, w<PL, hard		Dx2	0.5		pp >400	
94	1			D	1.0			
		- becoming red grey mottled below 1.2m						
				Dx2	1.5			
		- becoming grey, red, yellow mottled below 1.6m						
	1.9	SHALE : mid grey, with iron staining, low strength, highly to moderately weathered, Bringelly Shale						
93	2			D	2.0			
				Dx2	2.5			
		- becoming extremely weathered below 2.8m						
92	3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0			
91	4							
90	5							
89	6							
88	7							
87	8							
86	9							

Dynamic Penetrometer Test (blows per 150mm)



RIG: John Deere 315SE backhoe - 450mm toothed bucket
LOGGED: ERL
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

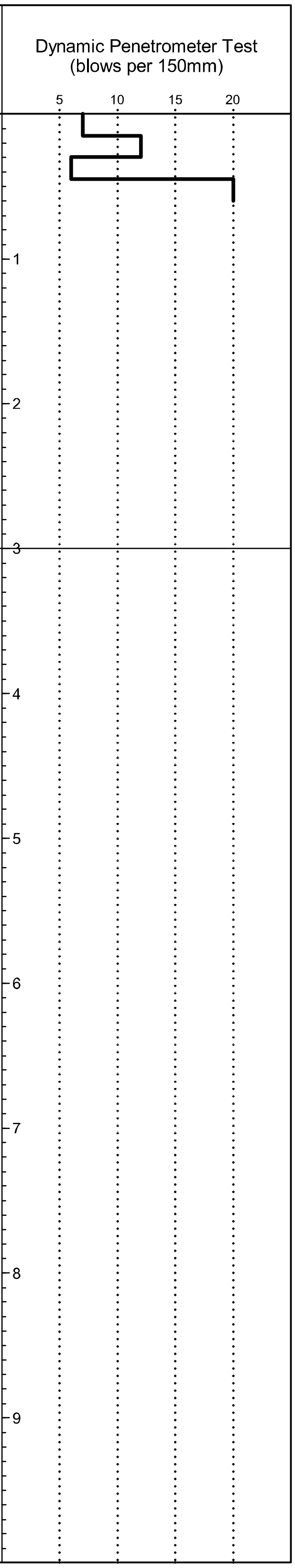
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 102 mAHD
EASTING: 289782
NORTHING: 6237116

PIT No: 107
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water
				Type	Depth	Sample	Results & Comments	
102	0.2	TOPSOIL/Silty CLAY CI: trace rootlets in top 0.05m, w<PL						
	2.1	Silty CLAY CI: red brown and grey mottled, becoming more grey with depth, trace ironstone and sandstone bands, w<PL		Dx2	0.5			
101	1			D	1.0			
				Dx2	1.5			
100	2			D	2.0			
	3.0	SANDSTONE: fine grained, grey, becoming more brown with depth, with iron staining, low strength, highly to moderately weathered		Dx2	2.5			
99	3			D	3.0			
		Pit discontinued at 3.0m - limit of investigation						



RIG: John Deere 315SE backhoe - 450mm toothed bucket

LOGGED: ERL

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

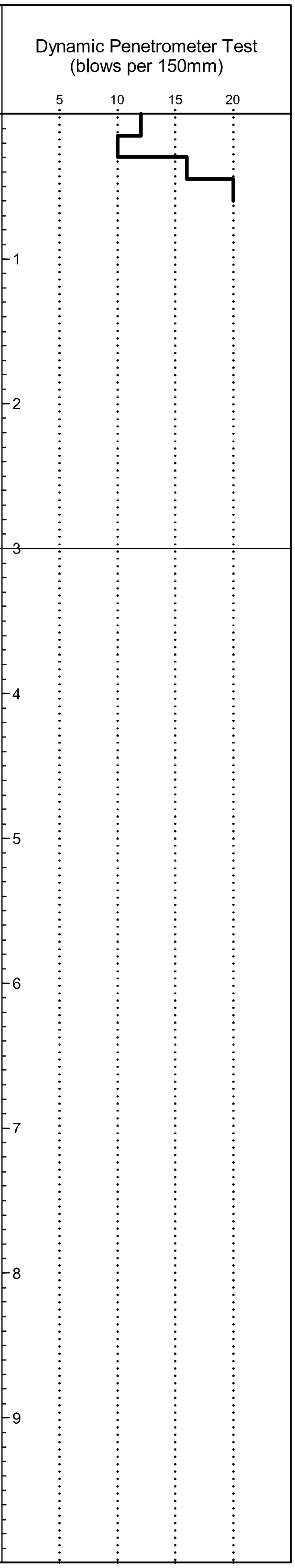
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 105 mAHD
EASTING: 290158
NORTHING: 6237146

PIT No: 108
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
105		FILL/Silty CLAY CI: with rootlets in top 0.1m, trace gravel and anthropogenics comprising brick fragments, roof tiles, pipe, metal, concrete, w<PL		Dx2	0.5		pp >400	
	0.8	Silty CLAY CI: medium plasticity, red brown, trace gravel, with sandstone bands, w<PL, hard		UU_{50}	0.9			
104	1			D	1.0			
				Dx2	1.5		pp >400	
103	2			D	2.0			
	2.4	SANDSTONE: fine grained, brown and grey, with iron staining, very low to low strength, highly to moderately weathered		Dx2	2.5			
102	3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0			
101	4							
100	5							
99	6							
98	7							
97	8							
96	9							



RIG: John Deere 315SE backhoe - 450mm toothed bucket
LOGGED: ERL
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

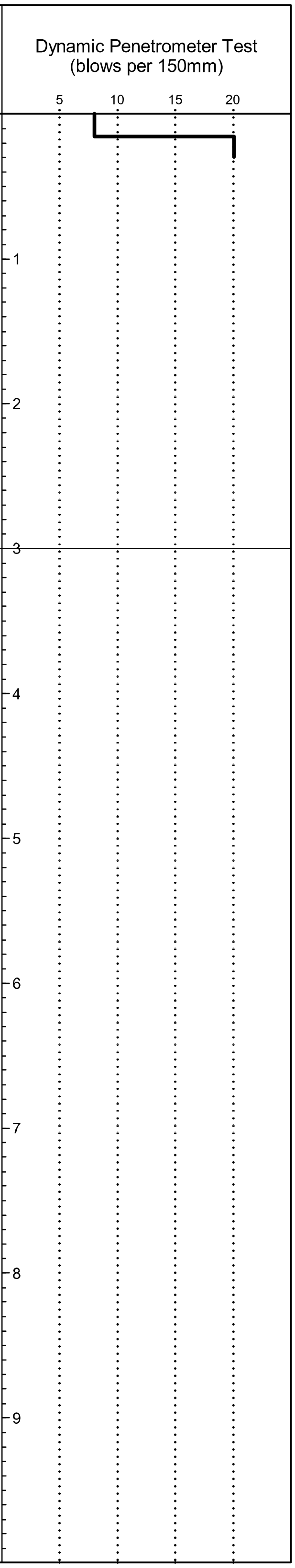
SURFACE LEVEL: 104 mAHD
EASTING: 290395
NORTHING: 6236925

PIT No: 109
PROJECT No: 92225.02
DATE: 3/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata
104		TOPSOIL/Silty CLAY CI: trace rootlets in top 0.15m, w<PL
	0.3	Silty CLAY CI: brown, trace gravel, w<PL, hard - becoming red brown, very stiff below 0.6m - becoming red brown grey mottled below 1.8m
	2.1	SANDSTONE: fine grained, grey and brown, with iron staining, low strength, highly to moderately weathered - becoming extremely weathered with depth
	3.0	Pit discontinued at 3.0m - limit of investigation

Sampling & In Situ Testing

Type	Depth	Sample	Results & Comments
Dx2	0.5		pp >400
D	1.0		
Dx2	1.5		
	1.8		pp = 350
D	2.0		
Dx2	2.5		
D	3.0		



RIG: John Deere 315SE backhoe - 450mm toothed bucket

LOGGED: ERL

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

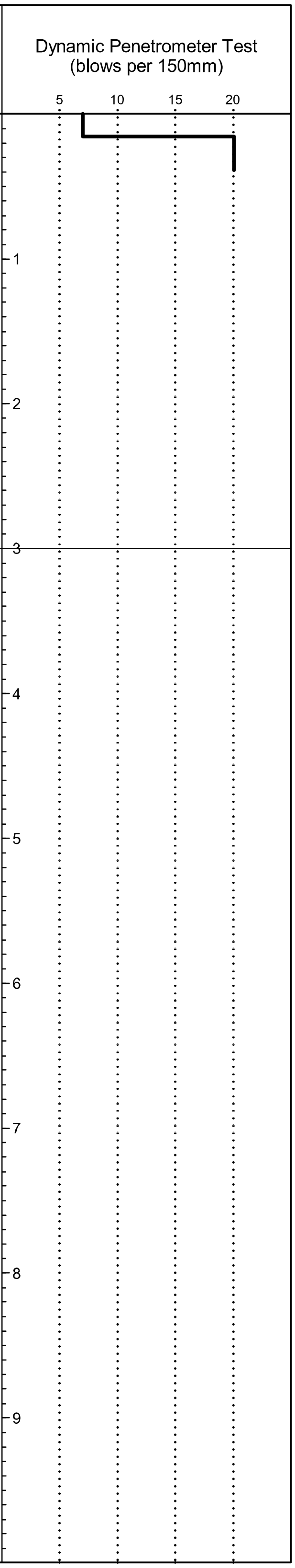
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 105 mAHD
EASTING: 289712
NORTHING: 6236938

PIT No: 110
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
105	0.05	TOPSOIL/Silty CLAY CI: brown, trace rootlets, w<PL						
	0.3	Silty CLAY CI: brown, w<PL, hard						
104	1.4	Silty CLAY CI: medium to high plasticity, red brown and grey, yellow mottled, with ironstone gravel, w<PL, hard, residual			1.0		pp >400	
103	2.1	Silty CLAY CH: high plasticity, pale grey, with iron staining (red and yellow), with very low to low strength siltstone bands, (extremely weathered siltstone, residual)						
102	3.0	SILTSTONE: pale brown and grey, with iron staining, with clay seams, very low to low strength, moderately to slightly weathered - no clay seams below 2.7m						
		Pit discontinued at 3.0m - limit of investigation						



RIG: John Deere 315SE backhoe - 450mm toothed bucket

LOGGED: ERL

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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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TEST PIT LOG

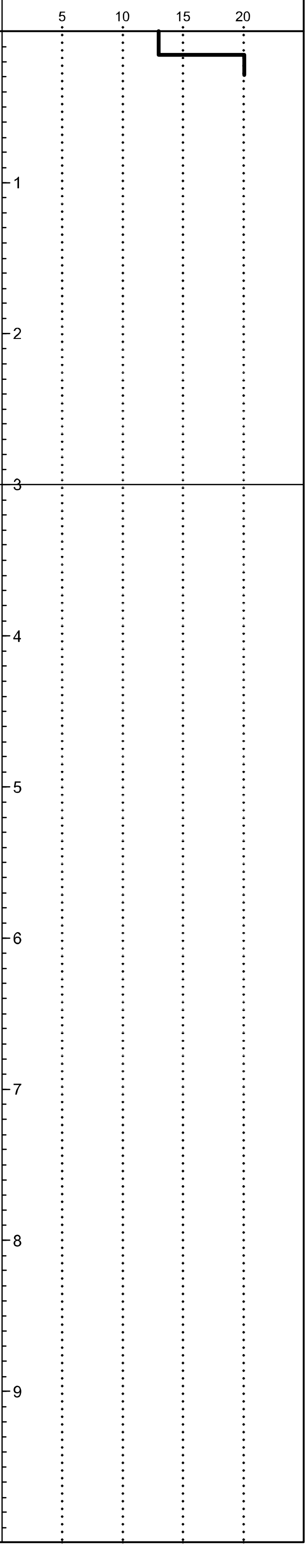
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 113 mAHD
EASTING: 290167
NORTHING: 6236793

PIT No: 111
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
113	0.1	TOPSOIL/Silty CLAY CI: trace rootlets, w<PL					
	0.4	Silty CLAY CI: brown, trace gravel, w<PL, hard					
		Silty CLAY CI: medium to high plasticity, orange brown, trace ironstone and siltstone gravel, hard	Dx2	0.5			
112	1		D/B	1.0			
			Dx2	1.5			
111	2		D	2.0			
		- becoming grey and orange/red mottled, with siltstone (possible sandstone) bands (possible extremely weathered siltstone)	Dx2	2.5			
110	3.0		D	3.0			
		Pit discontinued at 3.0m - limit of investigation					

Dynamic Penetrometer Test (blows per 150mm)



RIG: John Deere 315SE backhoe - 450mm toothed bucket
LOGGED: ERL
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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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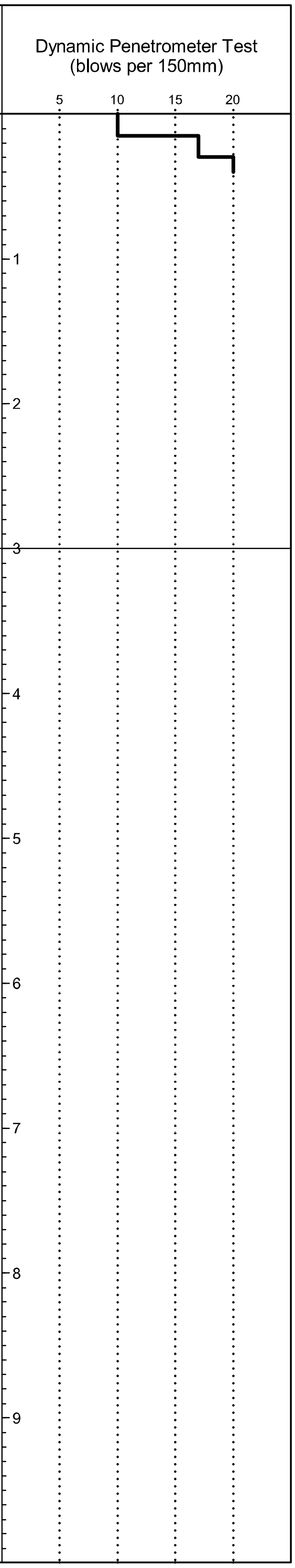
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 111 mAHD
EASTING: 290414
NORTHING: 6236752

PIT No: 112
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
111	0.05	TOPSOIL/Silty CLAY CI: trace rootlets, w<PL						
	0.3	Silty CLAY CI: w<PL, hard						
	0.6	Silty CLAY CI; medium to high plasticity, brown, w<PL, hard, residual		Dx2	0.5			
				U$_{50}$				
110	1	Silty CLAY CH: high plasticity, red brown and grey mottled, becoming grey with depth, w<PL, hard		D	0.9 1.0			
	1.4	SILTSTONE: pale grey and brown, with iron staining, with clay seams, low strength, highly weathered		Dx2	1.5			
109	2	- becoming extremely weathered below 2.1m		D	2.0			
				Dx2	2.5			
108	3 3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0			
107	4							
106	5							
105	6							
104	7							
103	8							
102	9							



RIG: John Deere 315SE backhoe - 450mm toothed bucket **LOGGED:** ERL **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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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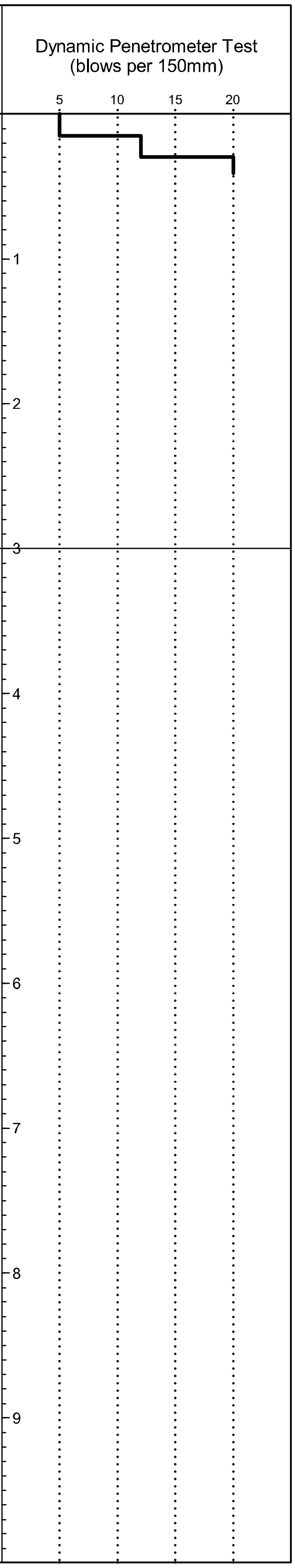
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 114 mAHD
EASTING: 289676
NORTHING: 6236773

PIT No: 113
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
114	0.05	TOPSOIL/Silty CLAY CI: brown, trace rootlets, w<PL					
	0.2	Silty CLAY CI: brown, w<PL, hard					
		Silty CLAY CI: medium to high plasticity, orange brown, w<PL, hard - becoming orange brown and grey mottled, trace ironstone gravel below 0.7m	Dx2 D Dx2	0.5 1.0 1.5			
113	1.6	Silty CLAY CI: medium to high plasticity, pale brown and grey, with iron staining, with siltstone (possible sandstone) bands, w<PL, very low strength, highly to slightly weathered - becoming more grey, banding decreasing, hard below 2.4m - banding increasing below 2.8m	D Dx2 D	2.0 2.5 3.0			
111	3.0	Pit discontinued at 3.0m - limit of investigation					



RIG: John Deere 315SE backhoe - 450mm toothed bucket

LOGGED: ERL

SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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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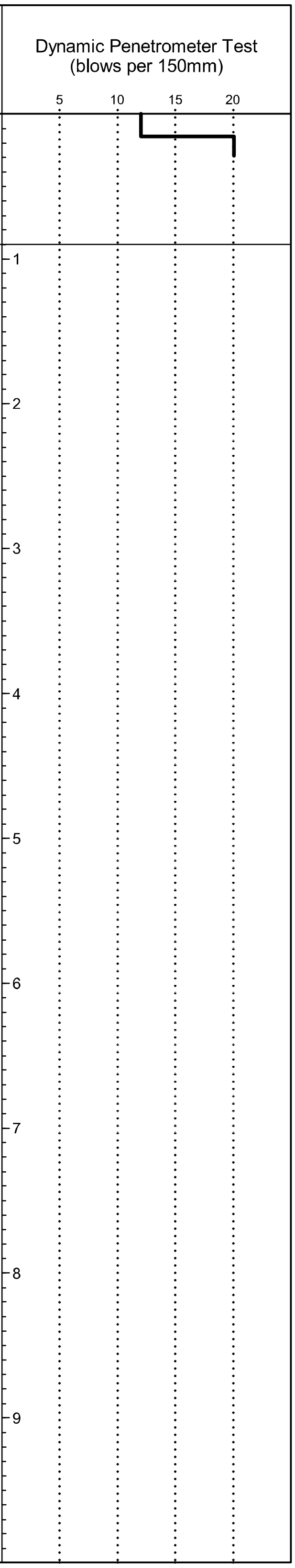
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 148 mAHD
EASTING: 289750
NORTHING: 6236549

PIT No: 114
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
148		Silty CLAY CI: red brown, w<PL, hard, residual		D	0.5			
	0.6	SANDSTONE: fine to medium grained, low to medium strength, highly to slightly weathered, horizontally bedded, Bringelly Shale		D	0.9			
	0.9	Pit discontinued at 0.9m - refusal on medium strength sandstone						


Dynamic Penetrometer Test (blows per 150mm)

RIG: John Deere 315SE backhoe - 450mm toothed bucket
LOGGED: ERL
SURVEY DATUM: MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

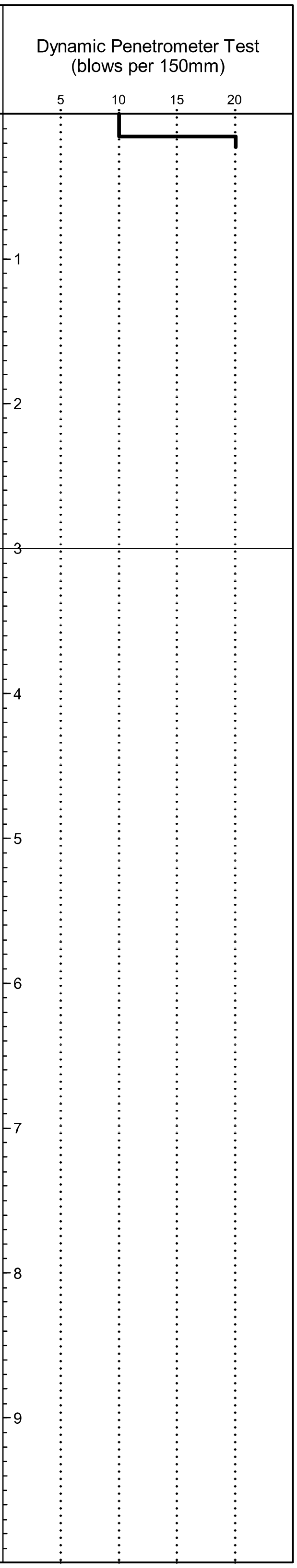
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 119 mAHD
EASTING: 289628
NORTHING: 6236536

PIT No: 115
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
119	0.05	TOPSOIL/Silty CLAY CI: trace ironstone gravel and rootlets, w<PL						
	0.4	Silty CLAY CI: trace ironstone gravel, w<PL, hard		Dx2	0.5			
		Silty CLAY CI: brown, trace ironstone gravel, w<PL, hard, residual						
118	1.0	- becoming orange brown and dark grey mottled		D	1.0			
		Silty CLAY CH: high plasticity, brown and grey mottled, trace ironstone and sandstone bands, w<PL, hard, residual		Dx2	1.5			
117	1.9	SANDSTONE: fine grained, pale brown, iron staining, with ironstone gravel, low strength, highly to slightly weathered, Bringelly Shale		D	2.0			
				Dx2	2.5			
116	3.0	Pit discontinued at 3.0m - limit of investigation		D	3.0			
115	4							
114	5							
113	6							
112	7							
111	8							
110	9							



RIG: John Deere 315SE backhoe - 450mm toothed bucket **LOGGED:** ERL **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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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TEST PIT LOG

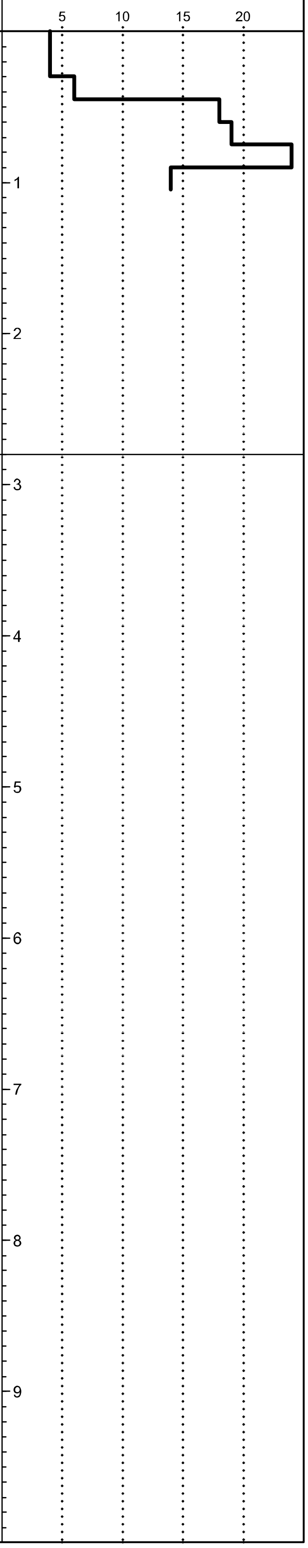
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 131 mAHD
EASTING: 289922
NORTHING: 6236441

PIT No: 116
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
131	0.15	TOPSOIL/Silty CLAY CI: brown, trace gravel, with rootlets, w<PL, stiff						
	0.6	Silty CLAY CI: medium to high plasticity, orange brown, slightly mottled, with angular siltstone gravel (colluvium), w<PL, stiff		Dx2/B	0.5			
130	1	SILTSTONE: pale brown and grey, with clay seams, very low to low strength, highly to slightly weathered - with clay seams, becoming low strength below 1.0m		D	1.0			
				Dx2	1.5			
129	2			D	2.0			
				Dx2	2.5			
	2.8	- becoming low to medium strength at 2.6m						
128	3	Pit discontinued at 2.8m - limit of investigation		D	3.0			
127	4							
126	5							
125	6							
124	7							
123	8							
122	9							

Dynamic Penetrometer Test (blows per 150mm)



RIG: John Deere 315SE backhoe - 450mm toothed bucket **LOGGED:** ERL **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 125 mAHD
EASTING: 290014
NORTHING: 6236427

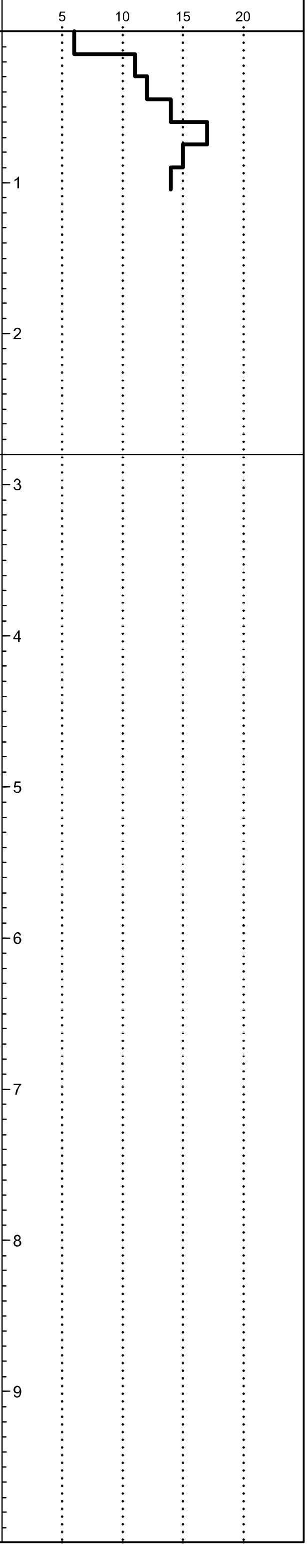
PIT No: 117
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata
125	0.1	TOPSOIL/Silty CLAY CI: brown, fissured, with rootlets, trace gravel (colluvium), w<PL
	0.6	Silty CLAY CI: brown, fissured, trace SR ironstone and SA siltstone gravel (colluvium), w<PL
124	1.0	Silty CLAY CI: orange brown, fissured, trace ironstone gravel, w<PL, residual
	1.7	Silty CLAY CI: medium to high plasticity,orange brown and grey mottled, trace SR siltstone gravel, w<PL, residual - very low to medium strength band below 1.5m
123	2.0	Clayey SILT ML: pale grey and orange mottled, friable, with very low to low strength siltstone seams, w<PL (extremely weathered siltstone)
	2.8	SILTSTONE: pale orange and brown, with iron staining, low to medium strength, moderately to slightly weathered, Bringelly Shale - becoming medium strength below 2.7m
122		Pit discontinued at 2.8m - limit of investigation

Sampling & In Situ Testing

Type	Depth	Sample	Results & Comments
U50	0.5 0.7		
D	0.7 0.9		
D	1.1		
Dx2	1.5		
D	2.0		
Dx2	2.5		

Water: —



RIG: John Deere 315SE backhoe - 450mm toothed bucket **LOGGED:** ERL **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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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TEST PIT LOG

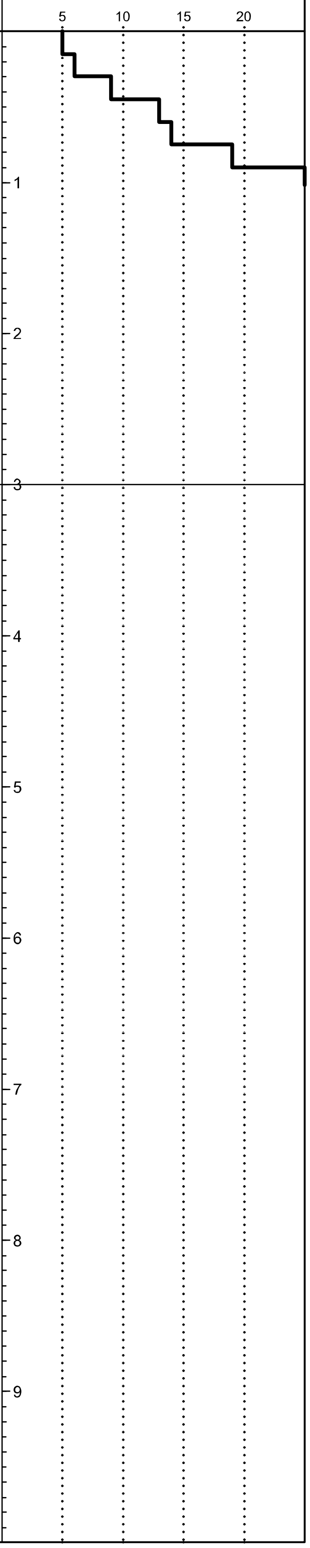
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 117 mAHD
EASTING: 290123
NORTHING: 6236402

PIT No: 118
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
117	0.2	TOPSOIL/Silty CLAY CI: brown, with rootlets to 0.1m, trace gravel, w<PL, residual					
	0.9	Silty CLAY CI: red brown and grey mottled, trace gravel, w<PL, very stiff to hard, residual	Dx2	0.5			
116	3.0	SILTSTONE: pale grey and red brown, with clay seams, very low to low strength, moderately to slightly weathered, Bringelly Shale	D	1.0			
			Dx2	1.5			
115		- becoming low to medium strength, no clay seams below 2.0n	D	2.0			
			Dx2	2.5			
114		Pit discontinued at 3.0m - limit of investigation	D	3.0			

Dynamic Penetrometer Test (blows per 150mm)



RIG: John Deere 315SE backhoe - 450mm toothed bucket **LOGGED:** ERL **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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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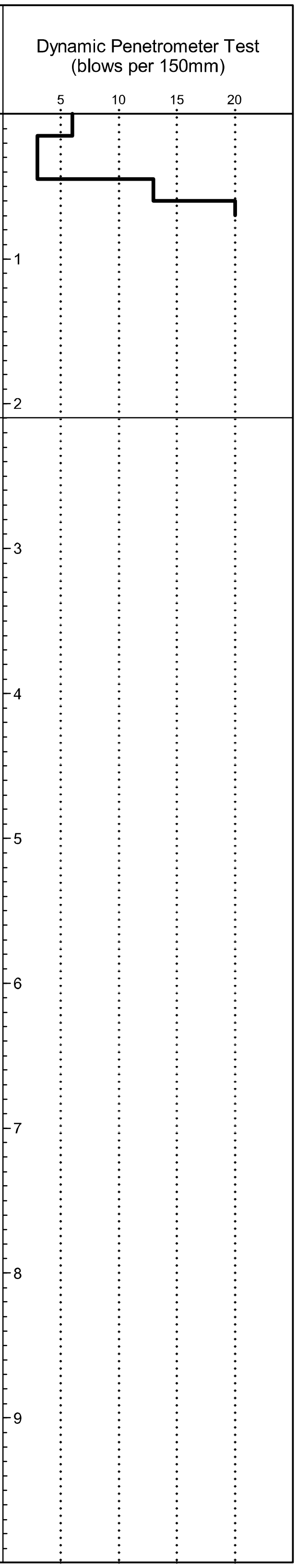
TEST PIT LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: 113 mAHD
EASTING: 290301
NORTHING: 6236517

PIT No: 119
PROJECT No: 92225.02
DATE: 4/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
113	0.15	TOPSOIL/Silty CLAY CI: brown, fissured, with rootlets, w<PL, stiff						
112	1	Silty CLAY CI: medium to high plasticity, orange brown and grey mottled, fissured, trace ironstone and siltstone gravel, w<PL, stiff, residual - becoming hard below 0.6m - becoming grey and orange brown mottled, extremely weathered siltstone below 1.2m		Dx2 D Dx2	0.5 1.0 1.5			
111	1.6 2	SILTSTONE: pale grey and brown, with yellow and red iron staining, low to medium strength, moderately to slightly weathered, Bringelly Shale		D	2.0			
	2.1	Pit discontinued at 2.1m - refusal on low to medium strength siltstone						
110	3							
109	4							
108	5							
107	6							
106	7							
105	8							
104	9							



RIG: John Deere 315SE backhoe - 450mm toothed bucket **LOGGED:** ERL **SURVEY DATUM:** MGA94 Zone 56

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

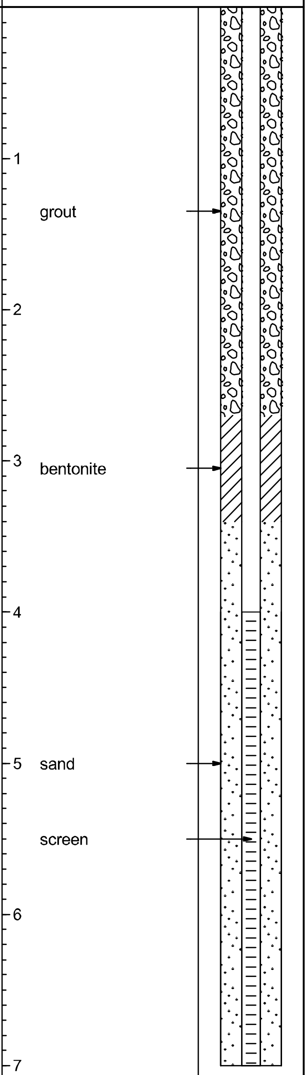
CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: --
EASTING: 290132
NORTHING: 6237715
DIP/AZIMUTH: 90°/--

BORE No: GW1
PROJECT No: 92225.02
DATE: 21/2/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.05	TOPSOIL/Silty CLAY: brown, with rootlets						
		Silty CLAY: pale grey and brown						
	3.0	SHALE: pale grey and brown						▼ 10-03-21
	7.1	Bore discontinued at 7.1m - limit of investigation						

Well Construction Details



RIG: Comacchio GEO 405 **DRILLER:** Terratest **LOGGED:** ERL **CASING:**
TYPE OF BORING: SFA and rotary air blast
WATER OBSERVATIONS: No free groundwater observed whilst augering
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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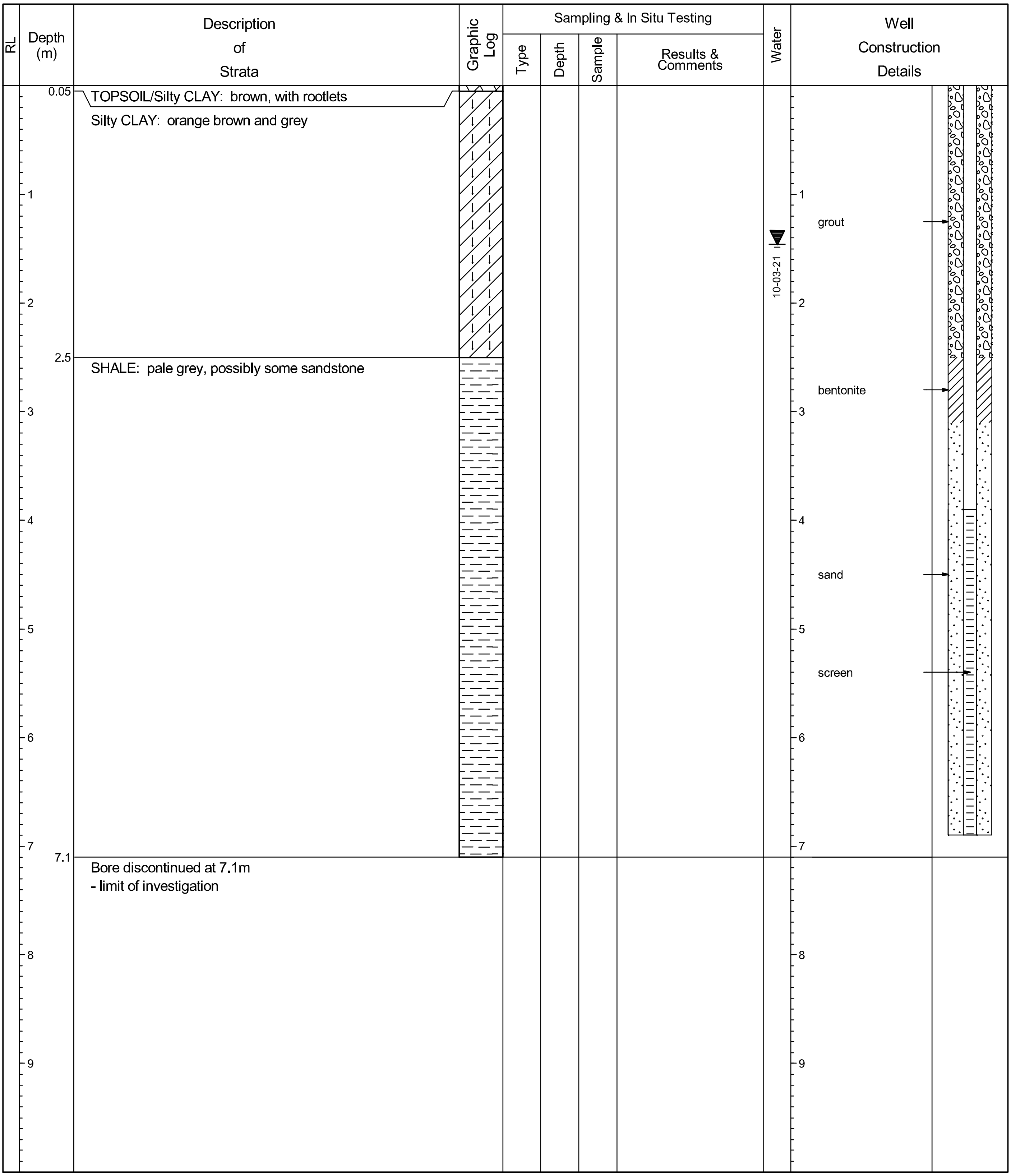
BOREHOLE LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: --
EASTING: 290327
NORTHING: 6237683
DIP/AZIMUTH: 90°/--

BORE No: GW2
PROJECT No: 92225.02
DATE: 21/2/2020
SHEET 1 OF 1



RL	Depth (m)	Description of Strata
	0.05	TOPSOIL/Silty CLAY: brown, with rootlets
		Silty CLAY: orange brown and grey
	2.5	SHALE: pale grey, possibly some sandstone
	7.1	Bore discontinued at 7.1m - limit of investigation

RIG: Comacchio GEO 405 **DRILLER:** Terratest **LOGGED:** ERL **CASING:**
TYPE OF BORING: SFA and rotary air blast
WATER OBSERVATIONS: No free groundwater observed whilst augering
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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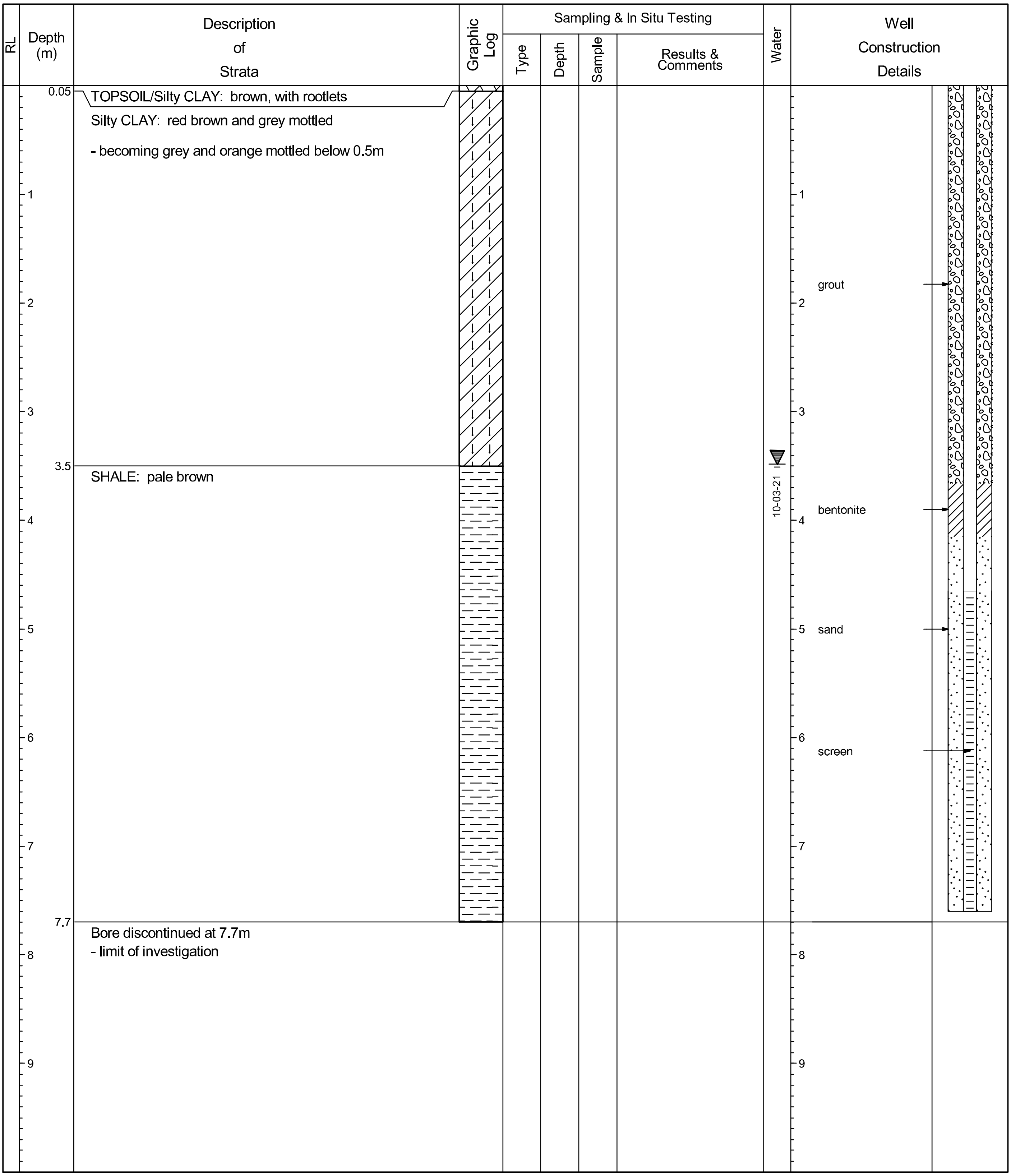
BOREHOLE LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: --
EASTING: 289923
NORTHING: 6237057
DIP/AZIMUTH: 90°/--

BORE No: GW3
PROJECT No: 92225.02
DATE: 24/2/2020
SHEET 1 OF 1



Depth (m)	Description of Strata
0.05	TOPSOIL/Silty CLAY: brown, with rootlets
	Silty CLAY: red brown and grey mottled - becoming grey and orange mottled below 0.5m
3.5	SHALE: pale brown
7.7	Bore discontinued at 7.7m - limit of investigation

RIG: Comacchio GEO 405 **DRILLER:** Terratest **LOGGED:** ERL **CASING:**
TYPE OF BORING: SFA and rotary air blast
WATER OBSERVATIONS: No free groundwater observed whilst augering
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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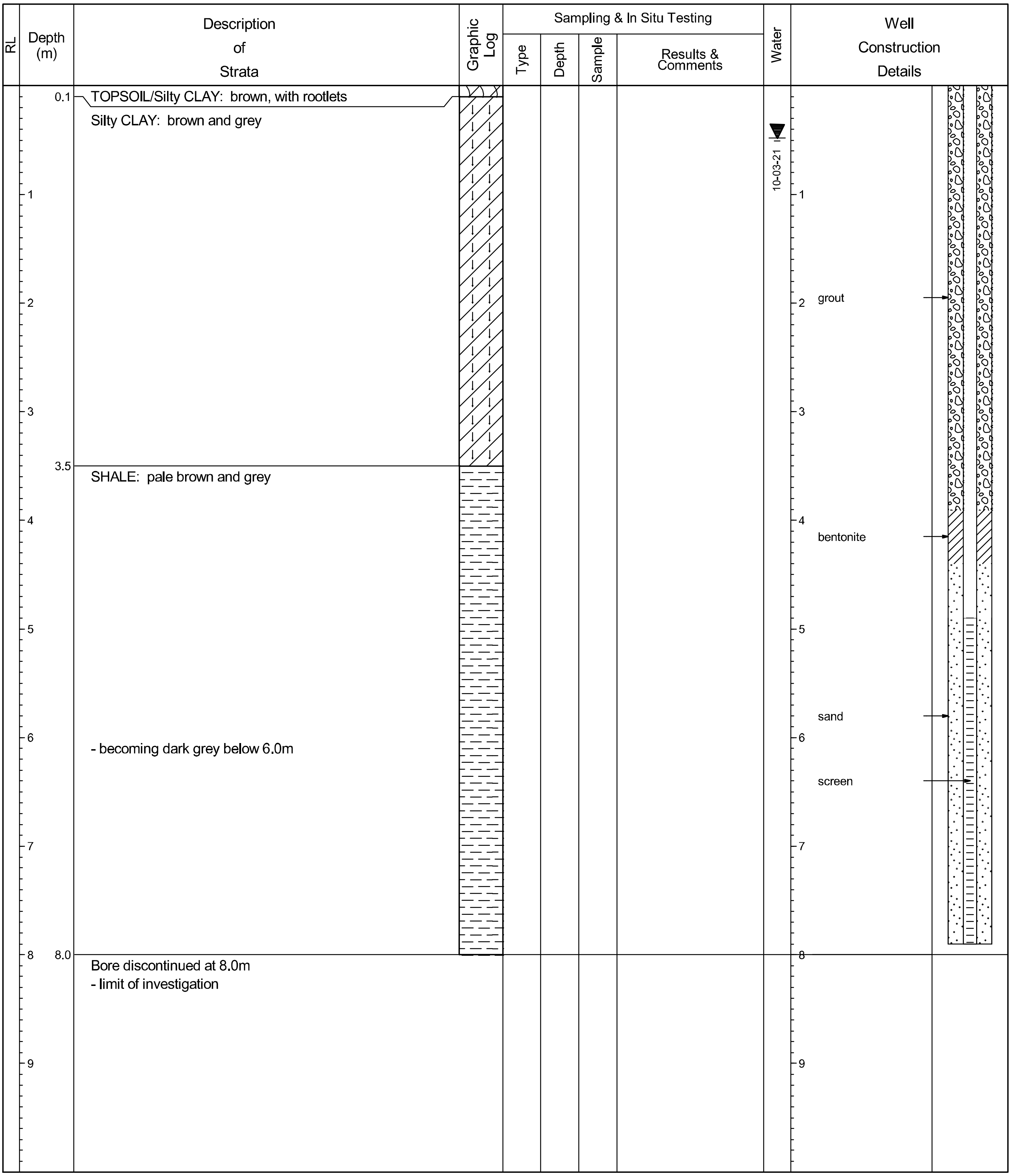
BOREHOLE LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: --
EASTING: 289665
NORTHING: 6236789
DIP/AZIMUTH: 90°/--

BORE No: GW4
PROJECT No: 92225.02
DATE: 24/2/2020
SHEET 1 OF 1



Depth (m)	Description of Strata
0.1	TOPSOIL/Silty CLAY: brown, with rootlets
	Silty CLAY: brown and grey
3.5	SHALE: pale brown and grey - becoming dark grey below 6.0m
8.0	Bore discontinued at 8.0m - limit of investigation

RIG: Comacchio GEO 405 **DRILLER:** Terratest **LOGGED:** ERL **CASING:**
TYPE OF BORING: SFA and rotary air blast
WATER OBSERVATIONS: Groundwater observed whilst augering at 7.3m
REMARKS: Location coordinates are in MGA94 Zone 56.

SAMPLING & IN SITU TESTING LEGEND

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

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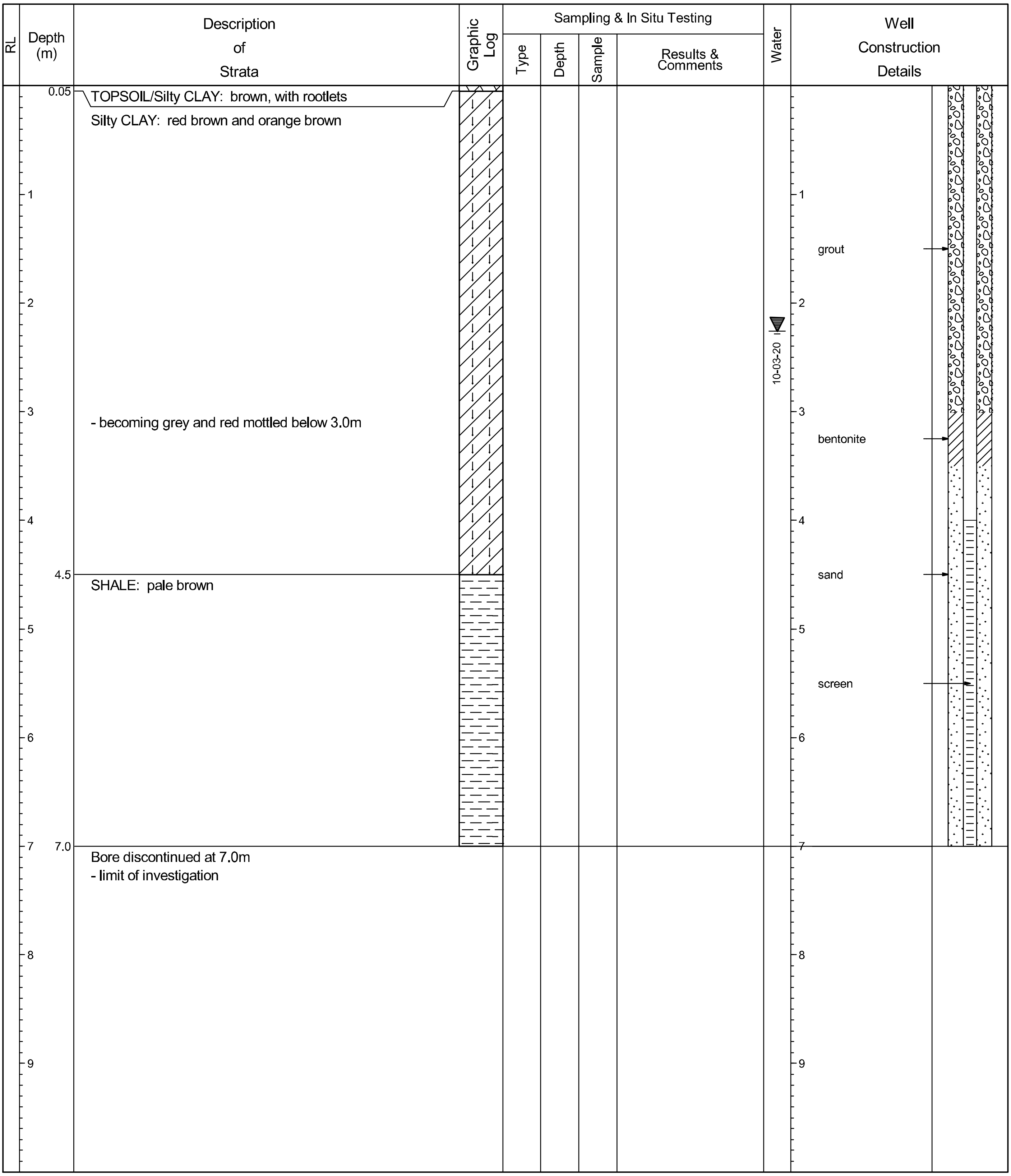
BOREHOLE LOG

CLIENT: Boyuan Bringelly Pty Ltd
PROJECT: Proposed Rezoning
LOCATION: 621 - 705 The Northern Road, Cobbitty, NSW

SURFACE LEVEL: --
EASTING: 289665
NORTHING: 6236789
DIP/AZIMUTH: 90°/--

BORE No: GW5
PROJECT No: 92225.02
DATE: 21/2/2020
SHEET 1 OF 1



Depth (m)	Description of Strata
0.05	TOPSOIL/Silty CLAY: brown, with rootlets
	Silty CLAY: red brown and orange brown - becoming grey and red mottled below 3.0m
4.5	SHALE: pale brown
7.0	Bore discontinued at 7.0m - limit of investigation

RIG: Comacchio GEO 405 **DRILLER:** Terratest **LOGGED:** ERL **CASING:**

TYPE OF BORING: SFA and rotary air blast

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Location coordinates are in MGA94 Zone 56. Not bailed

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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Appendix G

AGS Guideline Extracts

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	**1: CATASTROPHIC 200%**	**2: MAJOR 60%**	**3: MEDIUM 20%**	**4: MINOR 5%**	**5: INSIGNIFICANT 0.5%**
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2}	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3}	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4}	H	M	**L**	**L**	**VL**
E - RARE	10^{-5}	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6}	**L**	**VL**	**VL**	**VL**	**VL**

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.

(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		**Example Implications** (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	**Notional Boundary**					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	**Notional Boundary**			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

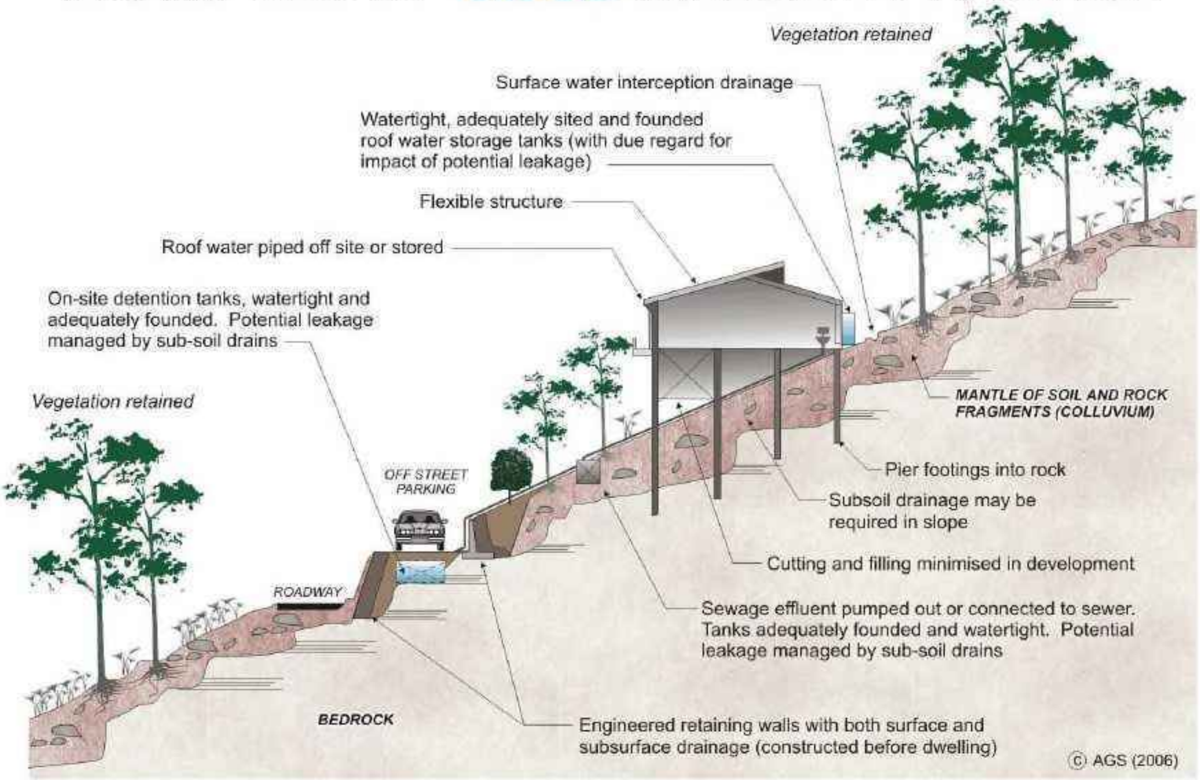
(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

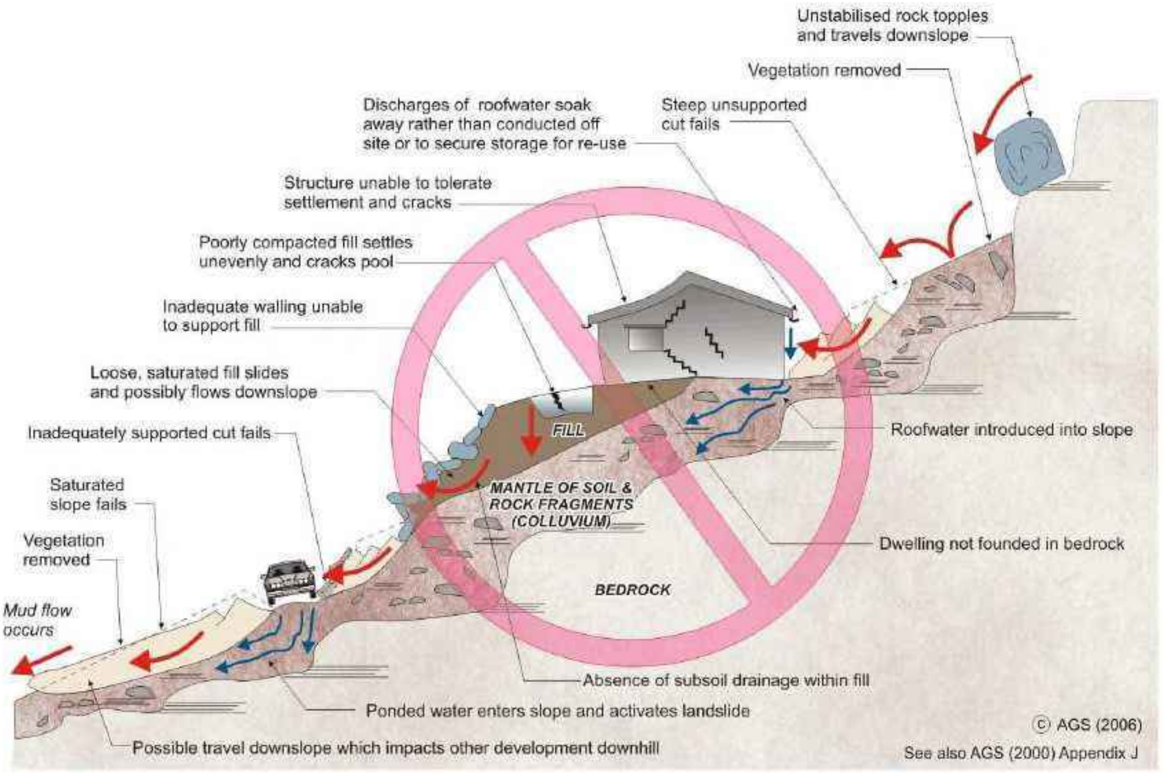
APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE



AUSTRALIAN GEOGUIDE LR3 (LANDSLIDES IN SOIL)

LANDSLIDES IN SOIL

Landslides occur on soil slopes and the consequences can include damage to property and loss of life. Soil slopes exist in all parts of Australia and can even occur in places where rock outcrops can be seen on the surface. If you live on, or below, a soil slope it is important to understand why a landslide might occur and what you can do to reduce the risk it presents.

It is always worth asking the question *"why is this slope here?"*, because the answer often leads to an understanding of what might happen in the future. Slopes are usually formed by weathering (breakdown) and erosion (physical movement) of the natural ground - the "parent material". Many factors are involved including rain, wind, chemical change, temperature variation, plant growth, animal activity and our own human enthusiasm for development. The general process is outlined in Figure 1.

The upper levels of the parent material progressively weather over thousands, or millions, of years, losing strength. This can result in a surface layer which looks similar to the parent material (although its colour has probably changed) but has the strength of a soil - this is called "residual soil". At some stage the weathered surface layer is exposed to the elements and fragments are transported down the slope. In this context a fragment could be a single sand grain, a boulder, or a landslide. The time scale could be anything from a few seconds to many thousands of years. The transported fragments often collect on the lower slopes and form a new soil layer that blankets the original slope - "colluvium". If material reaches a river or the sea it is deposited as "alluvium" or as a "marine deposit". With appropriate changes in river and sea level this material can again find itself on the surface to commence another cycle of weathering and erosion. In places often, but not only, near the coast, this can include sand sized fragments which form beaches and are sometimes blown back onto the land to form dunes.

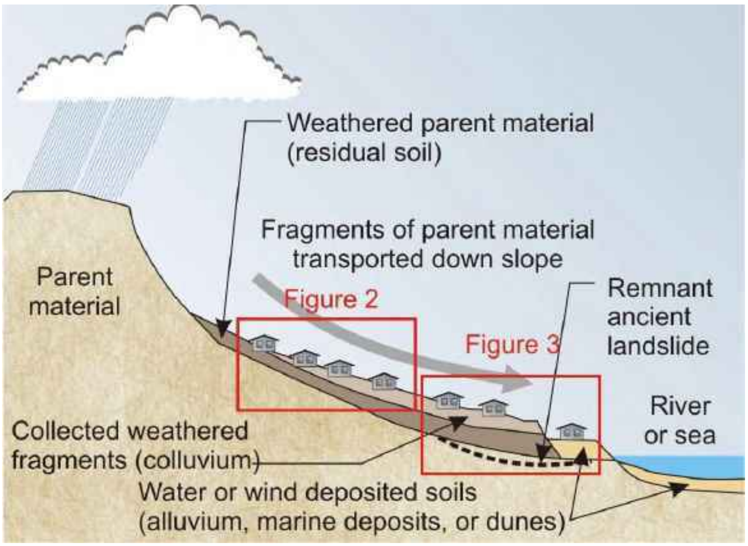


Figure 1

Landslides can occur almost anywhere on a soil slope. Slides can be rotational, translational, or debris flows (see GeoGuide LR2) and may have a number of causes.

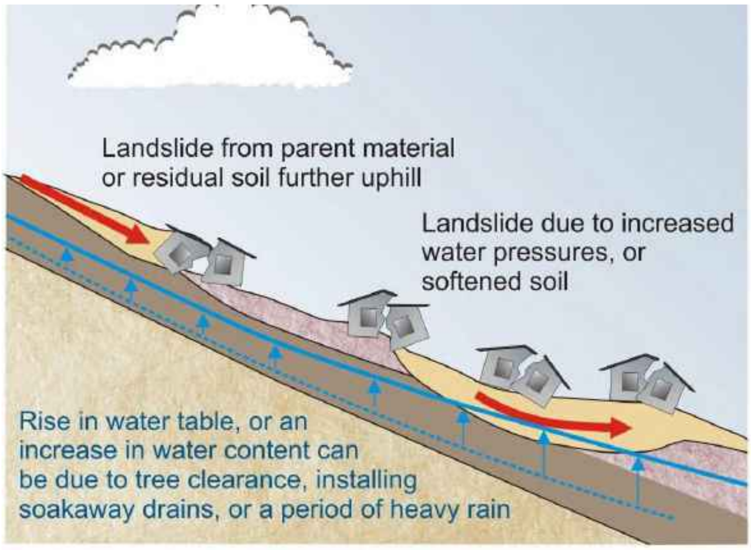


Figure 2

AUSTRALIAN GEOGUIDE LR3 (LANDSLIDES IN SOIL)

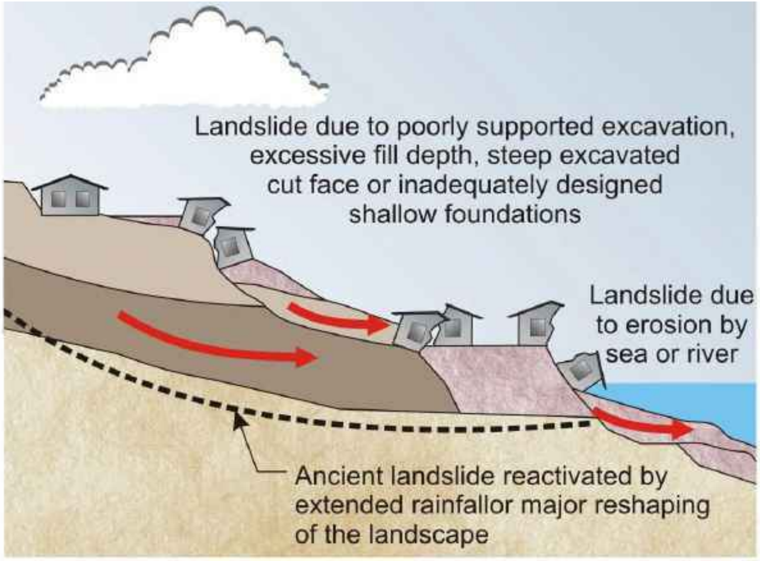


Figure 3

Some of the more common causes of landslides in soil are:

1) Falls of the parent material or residual soil from above, due to natural weathering processes (Figure 2).
2) Increased moisture content and consequent softening of the soil, or a rise in the water table. These can be due to excessive tree clearance, ill-considered soak-away drainage or septic systems, or heavy rainfall (Figure 2).
3) Excavation without adequate support, increased surface load from fill placement, or inadequately designed shallow foundations (Figure 3).
4) Natural erosion at the toe of the slope due to scour by a river or the sea (Figure 3).
5) Re-activation of an ancient landslide (Figure 3).

Most soil slopes appear stable, but they all achieved their present shape through a process of weathering and erosion and are often sensitive to minor changes in the factors that affect their stability. As a general rule, human activities only improve the situation if they have been designed to do so. Once this idea is understood, it is probably easy to see why the following basic rules are so important and should not be ignored without seeking site specific advice from a geotechnical practitioner:

ñ Do not clear trees unnecessarily.
ñ Do not cut into a slope without supporting the excavated face with an engineer designed structure.
ñ Do not add weight to a slope by placing earth fill or constructing buildings with inadequately designed shallow foundations (Note: in certain circumstances weight is added to the toe of a slope to inhibit landslide movement, but this must be carried out in accordance with a proper engineering design).
ñ Do not allow water from storm water drains, or from septic waste or effluent disposal systems to soak into the ground where it could trigger a landslide.

More information in relation to good and poor hillside construction practice is given in GeoGuide LR8. With appropriate engineering input it is often possible to reduce the likelihood, or consequences, of a landslide and so reduce the risk to property and to life. Such measures can include the construction of properly designed storm water and sub-soil drains, surface protection (GeoGuide LR5) and retaining walls (GeoGuide LR6). **Design should be undertaken by a geotechnical practitioner and will normally require local council approval.**

More information relevant to your particular situation may be found in other Australian GeoGuides:

ñ GeoGuide LR1 - Introduction
ñ GeoGuide LR2 - Landslides
ñ GeoGuide LR4 - Landslides in Rock
ñ GeoGuide LR5 - Water & Drainage
ñ GeoGuide LR6 - Retaining Walls
ñ GeoGuide LR7 - Landslide Risk
ñ GeoGuide LR8 - Hillside Construction
ñ GeoGuide LR9 - Effluent & Surface Water Disposal
ñ GeoGuide LR10 - Coastal Landslides
ñ GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

AUSTRALIAN GEOGUIDE LR5 (WATER & DRAINAGE)

WATER, DRAINAGE & SURFACE PROTECTION

One way or another, water usually plays a critical part in initiating a landslide (GeoGuide LR2). For this reason, it is a key factor to be controlled on sites with more than a low landslide risk (GeoGuide LR7).

Groundwater and Groundwater Flow

The ground is permeable and water flows through it as illustrated in Figure 1. When rain falls on the ground, some of it runs along the surface ("surface water run-off") and some soaks in, becoming groundwater. Groundwater seeps downwards along any path it can find until it meets the water table: the local level below which the ground is saturated. If it reaches the water table, groundwater either comes to a halt in what is effectively underground storage, or it continues to flow downwards, often towards a spring where it can seep out and become surface water again. Above the water table the ground is said to be "partially saturated", because it contains both water and air. Suctions can develop in the partially saturated zone which have the effect of holding the ground together and reducing the risk of a landslide. Vegetation and trees in particular draw large quantities of water out of the ground on a daily basis from the partially saturated zone. This lowers the water table and increases suctions, both of which reduce the likelihood of a landslide occurring.

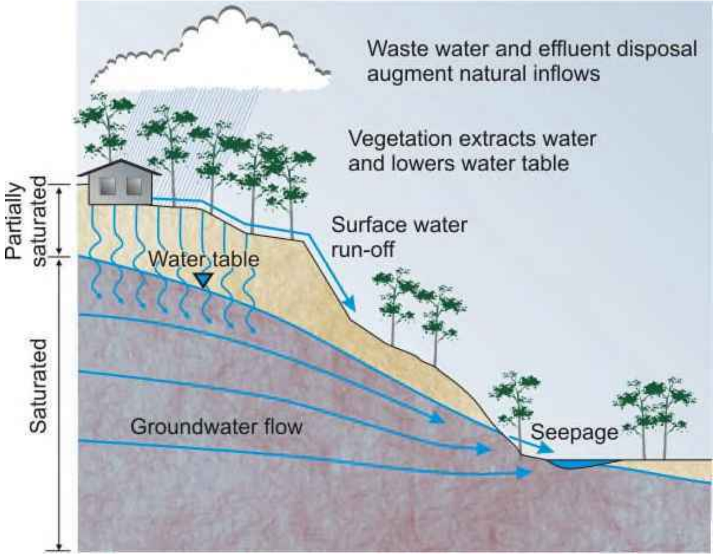


Figure 1 - Groundwater flow

Groundwater Flow and Landslides

The landslide risk in a hillside can be affected by increase in soak-away drainage or the construction of retaining walls which inhibit groundwater flow. The groundwater is likely to rise after heavy rain, but it can also rise when human interference upsets the delicate natural balance. Activities such as felling trees and earthworks can lead to:

- a reduction in the beneficial suctions in the partially saturated zone above the water table.
- increased static water pressures below the water table,
- increased hydraulic pressures due to groundwater flow,
- loss of strength, or softening, of clay rich strata,
- loss of natural cementing in some strata,
- transportation of soil particles.

Any of these effects, or a combination of them, can lead to landslides like those illustrated in GeoGuides LR2, LR3 and LR4.

Limiting the Effect of Water

Site clearance and construction must be carefully considered if changes in groundwater conditions are to be limited. GeoGuide LR8 considers good and poor development practices. Not surprisingly much of the advice relates to sensible treatment of water and is not repeated here. Adoption of appropriate techniques should make it possible to either maintain the current ground water table, or even cause it to drop, by limiting inflow to the ground.

If drainage measures and surface protection are relied on to keep the risk of a landslide to a tolerable level, it is important that they are inspected routinely and maintained (GeoGuide LR11).

The following techniques may be considered to limit the destabilising effects of rising groundwater due to development and are illustrated in Figure 2.

AUSTRALIAN GEOGUIDE LR5 (WATER & DRAINAGE)

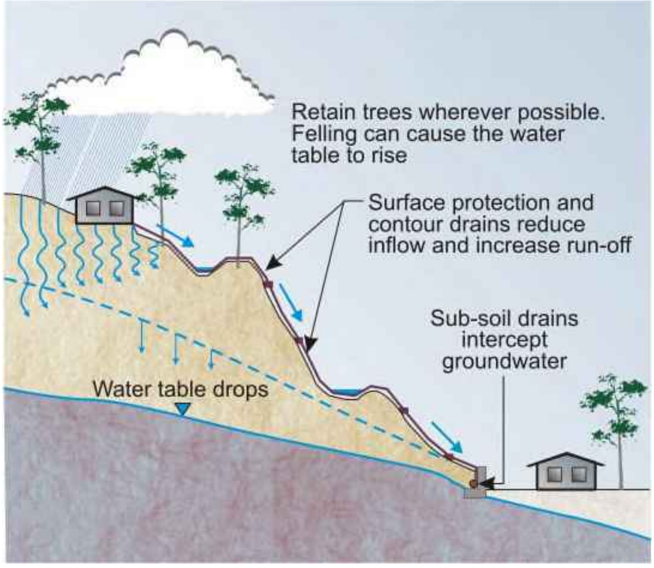


Figure 2 - Techniques used to control groundwater flow

Surface water drains (dish drains, or table drains) - are often used to prevent scour and limit inflow to a slope. Other than in rock, they are relatively ineffective unless they have an impermeable lining. You should clear them regularly, and as required, and not less than once a year. If you live in an area with seasonal rainfall, it is best to do this near the end of the dry season. If you notice that soil or rock debris is falling from the slope above, determine the source and take appropriate action. This may mean you have to seek advice from a geotechnical practitioner.

Surface protection - is sometimes used in addition to surface water drainage to prevent scour and minimise water inflow to a slope. You should inspect concrete, shotcrete or stone pitching for cracking and other signs of deterioration at least once a year. Make sure that weepholes are free of obstructions and able to drain. If the protection is deteriorating, you should seek advice from a geotechnical practitioner.

Sub-soil drains - are often constructed behind retaining walls and on hillsides to intercept groundwater. Their function is to remove water from the ground through an appropriate outlet. It is important that subsoil drains are designed to complement other measures being used. They should be laid in a sand, or gravel, bed and protected with a graded stone or geotextile filter to reduce the chance of clogging. Sub-soil drains should always be laid to a fall of at least 1 vertical on 100 horizontal. Ideally the high end should be brought to the surface, so it can be flushed with water from time to time as part of routine maintenance procedures.

Deep, underground drains - are usually only used in extreme circumstances, where the landslide risk is assessed as not being tolerable and other stabilisation measures are considered to be impractical. They work by permanently lowering the water table in a slope. They are not often used in domestic scale developments, but if you have any on your site be aware that professional maintenance is essential. If they are not maintained and stop working, the water table will rise and a landslide may even occur during normal weather conditions. Both an increase or a reduction in the normal flow from deep drains could indicate a problem if it appears to be unrelated to recent rainfall. If changes of this sort are observed, you should have the drains and your site checked by a geotechnical practitioner.

Documentation - design drawings and specifications for geotechnical measures intended to minimise landslide risk can be of great assistance to a geotechnical specialist, or structural engineer, called in to inspect and report on them. Copies of available documentation should be retained and passed to the new owner when the property is sold (GeoGuide LR11). You should also request details of an appropriate maintenance program for drainage works from the designer and keep that information with other relevant documentation and maintenance records.

More information relevant to your particular situation may be found in other Australian GeoGuides:

ñ GeoGuide LR1 - Introduction
ñ GeoGuide LR2 - Landslides
ñ GeoGuide LR3 - Landslides in Soil
ñ GeoGuide LR4 - Landslides in Rock
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Appendix H

CSIRO Publication BTF-18

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

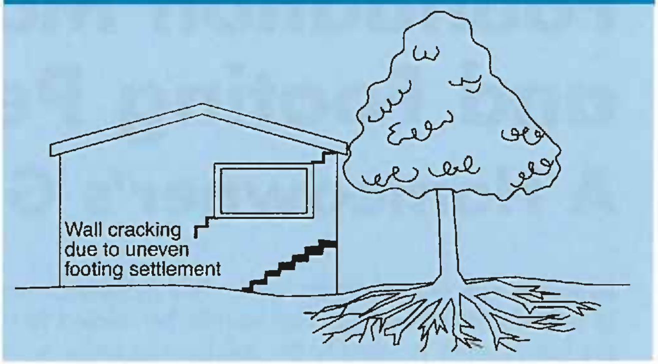
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter

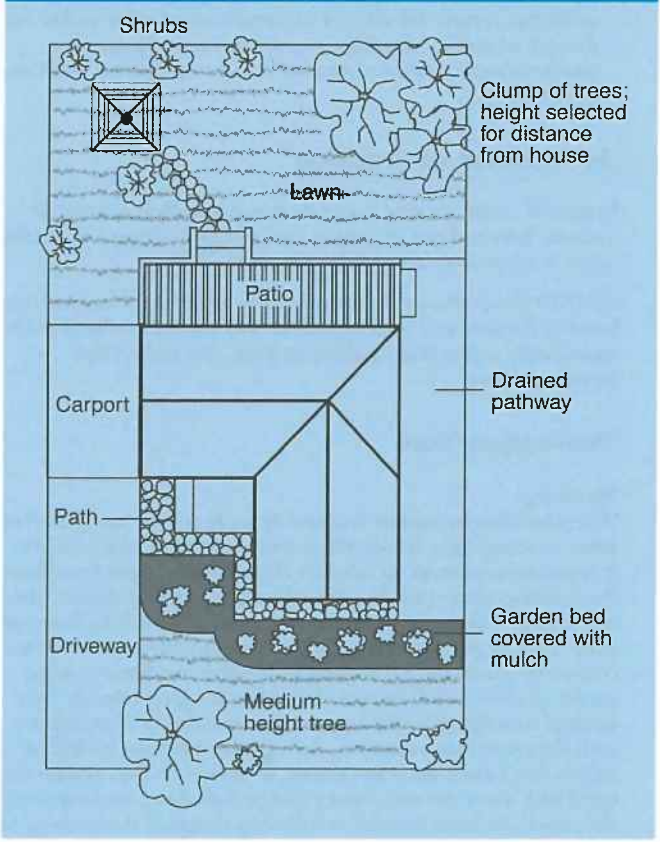
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

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