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Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on

Preliminary Geotechnical Assessment

Proposed Rezoning
Hydro Aluminium Kurri Kurri
Loxford Portion

Prepared for
ESS Australia
On behalf of
Hydro Aluminium Kurri Kurri

Project 81520
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	Signature	Date
Author		23 March 2015
Reviewer		23 March 2015

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

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Hydro Aluminium Kurri Kurri Rezoning Area
Loxford Portion

1. Introduction

This report presents the findings of a preliminary geotechnical assessment for a portion of the proposed redevelopment of the Hydro Aluminium Kurri Kurri Rezoning area, located at Loxford. This assessment was commissioned by Hydro Aluminium Kurri Kurri Pty Ltd (Hyrdo), in consultation with ESS Australia Pty Ltd (ESS).

It is understood that this study has been commissioned to support an application to rezone land owned by Hydro for residential, commercial and industrial purposes. This report covers only the portion of the site located within the Cessnock City Council area, and only the proposed residential, commercial and industrial component. Areas designated as being for conservation / non-development purposes are not included within this report.

In conjunction with this report, a preliminary geotechnical assessment was also undertaken for a broader selection of land owned by Hydro, however the remaining portion of the site is located within the Maitland City Council area, and the results are presented in a separate report (Ref 1).

The work included a desktop study, preliminary walkover assessment, limited scope of field investigation (test pits) and laboratory testing, preliminary engineering analysis, and preparation of this report.

2. Proposed Development

Land currently owned by Hydro is proposed to be rezoned for a variety of purposes. The portion of the site covered by this report is proposed to be rezoned for a range of residential, commercial and industrial purposes.

At the time of the assessment, a concept plan was provided indicating a potential road and lot layout. Details regarding earthworks were not known at this time.

For the purpose of the work, the project surveyors provided regional topographic and cadastral data in AutoCAD and MapInfo format.

3. Site Description

The portion of the site covered by this report is shown on Drawing 1 in Appendix C. The portion of the overall site which is identified for residential or industrial / commercial development in Drawing 1, attached, is an irregular shaped area and covers approximately 375 ha. It is located in several distinct areas as follows:

- Residential Central Precinct (northern / eastern part of the site): Land located east of the South Maitland Railway, and west of an existing residential development at Cliftleigh, from the boundary with Maitland City Council / Gillieston Heights in the north, to an approximately east-west oriented line located roughly projected west from between Glen Ayr Crescent and Forbes Avenue Cliftleigh;
- Residential Southern Precinct (southern / eastern part of the site): Pockets of rural-residential land which currently are located on either side of the South Maitland Railway, approximately between the Hunter Expressway to the south, and to just north of Dickson Road to the north;
- Business Park Precinct (southern part of the site): An area of land located south of the Hunter Expressway, and approximately bordered by Bishops Bridge Road to the west, the South Maitland Railway to the east and the boundary between Loxford and Kurri Kurri to the south.
- General Industrial and Heavy Industrial Precinct (western part of the site): The area of the former Hydro Aluminium Smelter, located at the northern end of Hart Rd, Loxford;

The above precinct descriptors, which were defined by the client, are used throughout this report to reference the areas described above.

The site is located generally within the suburb of Loxford in the Cessnock City Council local government area.

Residential Central Precinct part of the site generally includes a broadly rolling landscape, predominantly cleared and grassed, and used for grazing. A number of unsealed tracks traverse the site. Localised areas of uncleared mature trees can also be found in this area of the site, in addition to scattered stands of mature trees, mainly along drainage features. Reference to historical aerial photos indicates that there may have previously been isolated structures in this part of the site, assumed to have been rural-residential type structures. The site is currently undeveloped, however includes a fill embankment (refer Drawing 3), which is understood to have been associated with a former railway line to Stanford Merthyr.

The Residential Southern Precinct part of the site generally comprises rural-residential land, which includes a number of rural structures such as chicken and machinery sheds, and also included evidence of previously demolished rural structures (i.e. chicken sheds). This part of the site also included areas where filling is expected to occur, generally through the creation of level building pads for house and/or farm shed construction. In addition, a low lying area was observed between the Residential Southern and Residential Central areas where some fill mounds were observed. This was generally in the vicinity of Dams 5 and 6 (refer Drawing 4).

The Business Park Precinct part of the site includes two distinct areas. The portion east of Hart road includes rural-residential development similar to the Residential Southern part of the site, with cleared grazing land, and rural-type structures. Filling is likely to be present in the areas around existing structures where cut and fill processes may have been used to create level platforms. The portion west of Hart Road includes thickly vegetated mature trees and scrub with several unsealed tracks. It is understood that this area of the site included areas of previously demolished houses, and a possible former landfill / filling area (refer Drawing 7).

The General and Heavy Industrial Precinct part of the site comprises the former Hydro Aluminium Smelter, which was permanently closed in May 2014. This area of the site has been heavily developed with infrastructure associated with the smelter, including industrial buildings, hardstand areas, equipment compounds, effluent ponds and by-product stockpiles. Based on previous experience at the Hydro site, there is significant filling expected to be present around the smelter structures. The client indicated that areas of buried waste / filling also exist on the site. It is understood that the area of the proposed Heavy Industrial development includes a storage pad area, which has possibly been used to store crushed concrete and refactory bricks.

A senior engineer from Douglas Partners Pty Ltd (DP) undertook a walkover assessment of the site, with the client on 17 June 2014. The aim of the assessment was to develop a broad understanding of major site features that may be relevant to the geotechnical investigation. In addition, an engineer from DP observed general site features in conjunction with the excavation of test pits which were excavated across the site in July 2014.

Several farm dams were located in the eastern part of the site. For descriptive purposes, four of these dams were numbered Dams 3 to 6. Dams 3 to 6 are generally located in the Residential Central and Residential Southern parts of the site. (Dams 1 and 2 are located in the Maitland Council portion of the Hydro site and therefore not included in this report). Drawings 3 and 4 in Appendix C shows the approximate location of Dams 3 to 6.

Drawings 3 to 7 in Appendix C present some annotations regarding the locations of general site features, particularly areas where filling was either observed, or was possibly present. The following photos show general site features at specific locations at the time of the field work.

Photo 1: Looking south-west near north-western part of the Residential Central Precinct (general area of Pit 11)

Photo 2: Probable fill platform, looking towards farm sheds / chicken sheds off Bowditch Avenue in Residential Southern part of site

Photo 3: Dam 3, looking north-west from Pit 12 (Residential Central Precinct)

Photo 4: Area around Pit 12, looking north-east (Residential Central Precinct)

Photo 5: From Pit 13 looking west / north-west (Residential Central Precinct)

Photo 6: Pit 14, looking generally east / north-east (Residential Central Precinct)

Photo 7: Dam 4 (Residential Central Precinct)

Photo 8: Pit 16 looking south (Residential Central Precinct)

Photo 9: Looking towards Kurri Smelter (General Industrial Precinct) from near Pit 15 (Residential Central Precinct)

Photo 10: Looking west from near Pit 19 (Residential Central Precinct)

Photo 11: Mounds of filling in vicinity of area between Southern and Central Residential Precincts

Photo 12: Looking south / south-west from near Pit 21 (Residential Southern Precinct)

Photo 13: Looking south-east near Pit 25 (Residential Southern Precinct)

Photo 14: Looking north / north-west near Pit 26 (Residential Southern Precinct)

Photo 15: Looking south-west towards Hart Road at Pit 30 (Business Park Precinct)

4. Desktop Review

4.1 Topography

Reference to the provided regional topographical data indicates that surface levels within the site area range from about RL 0 AHD in the area between the Residential Central and Residential Southern part of the site (in the vicinity of Dams 5 and 6) to about RL 35 AHD adjacent to the Business Park Precinct, north of Hart Road, and west of the Hunter Expressway.

4.2 Drainage

To the west of the railway line, and to the north of the former Kurri Smelter is a series of lagoons referred to as Wentworth Swamp. A series of west draining gullies in the Residential Central part of the site seem to drain towards Wentworth Swamp. In addition, a gully on the western side of the former Kurri smelter drains to the north to The Black Waterholes Creek, which then drains to Wentworth Swamp to the north.

In addition, an east-draining gully is present in the Residential Central part of the site, which drains towards a series of dams located east of the site, which then drain to Wallis Creek to the east.

In addition, a number of farm dams were observed within the site, particularly in the Residential Central and Southern Precincts. The dams were generally located along, or in proximity to the drainage lines noted above.

4.3 Geology/Hydrogeology

Reference to the 1:100,000 Newcastle Coalfield Regional Geology map indicates the site is underlain by several Permian aged formations as follows:

- Residential Central Precinct: Farley Formation of Dalwood group of rocks, which typically includes silty sandstone;
- Western limits of Residential Central Precinct: Quaternary alluvium, which typically comprises gravel, sand, silt and clay;
- Residential Southern Precinct: Rutherford Formation of the Dalwood group of rocks, which typically comprise siltstone, marl and sandstone;
- Heavy and General Industrial Precinct (former Kurri Smelter area): Rutherford Formation, as per residential southern part of site, above;
- Business Park Precinct part of site (south of Hunter Expressway): Farley Formation, as per Residential Central part of site, above.

Drawing 2 in Appendix C shows the local geology mapping relative to the site.

In addition to the above, DP has undertaken numerous previous geotechnical investigations on the site of the former Kurri Hyrdo smelter (i.e. General and Heavy Industrial Precinct). A review of previous data in this area of the site can be generalised as follows:

- Filling was encountered at many locations, including up to 6.5 m depth;
- Natural soils encountered were generally consistent with that encountered in other areas of the site during the current investigation, and included clayey, sandy clay and silty soils;
- Where encountered, rock depths ranged from 1 m to 18.3 m below the ground surface;
- Where encountered, groundwater depths ranged from 0.6 m to 9.4 m below the ground surface, however some of the shallower groundwater was considered likely to be perched within filling;
- Where available, CBR data ranged from 2% to 13%.

The conditions encountered in the current investigation were generally consistent with those found during previous investigations on the Kurri smelter site (i.e. Heavy and General Industrial Precinct). It is likely, however, that the depth and extent of filling on the former smelter site will be greater than what was encountered in Pits 11 to 30.

4.4 Soil Landscape

Reference to the 1:250,000 Soil Landscape Series Sheet for Singleton indicates that the majority of the site is underlain by the Neath Landscape, with some of the eastern part of the site underlain by the Bolwarra Heights Landscape, as shown on the 1:100,000 Newcastle Soil Landscape series sheet.

Little information was available regarding the Neath soil landscape, however overlaps in adjoining sections of the 1:250,000 mapping and the 1:100,000 mapping suggest that the Neath landscape may be similar to the Bolwarra Heights Landscape.

The Bolwarra Heights landscape is generally defined as having the following properties:

- Rolling low hills on Permian sediments in the centre-west of the East Maitland Hills region;
- Slopes are 5% to 20%, with elevation to 100 m, and local relief up to 80 m;
- Cleared tall open forest;
- Soils typically comprise moderately deep (< 150 cm), well-dressed yellow podzolic soils, red podzolic soils and brown podzolic soils, with moderately deep (< 100 cm), well drained lithosols on crests, moderately deep (< 140 cm), imperfectly drained yellow soloths on lower slopes;
- Hazards include a moderate foundation hazard, water erosion hazard, high run-on (localised), seasonal water logging (localised), localised steep slopes with mass movement hazard.

4.5 Acid Sulphate

Reference to the acid sulphate soils risk maps published by DLWC indicates that select low lying areas of the site, which typically correspond to the two main drainage gullies identified in, and adjacent to, the Residential Central Precinct, are located in areas where there is a low to high risk of acid sulphate soils being present. The mapping suggests that acid sulphate soils may be present in these areas either within 1 m of the ground surface, or between 1 m and 3 m below the ground surface.

4.6 Salinity

A search on the Department of Lands web site (www.nratlas.nsw.gov.au) indicated that no areas of the site have been identified as having dryland salinity occurrences or indicators.

5. Field Work

5.1 Methods

A preliminary scope of geotechnical testing was undertaken in the project area in the period 17 June 2014 to 16 July 2014 and comprised the following:

- Walkover by senior engineer of select areas of the site;
- Excavation of 20 test pits (Pits 11 to 30) within the Cessnock City Council portion of the site. An additional ten test pits (Pits 1 to 10) were excavated within the adjoining Maitland City Council portion of the site, and are reported separately, but were referred to during the preparation of this report;
- Collection of soil samples from test pits for geotechnical testing and identification;
- pH and Electrical Conductivity (EC) testing of selected surface waters within the project area.

The test pit locations were set out by an engineer from DP using a hand-held GPS, which is typically accurate to ±10 m, depending on satellite coverage. The engineer logged the subsurface profile in each test pit and collected samples for identification and testing purposes.

Surface levels for each test pit were interpolated from the provided contour data for the site. The contour interval on the plan is 0.5 m. This, together with the approximate spatial location of the test pits, means that the surface levels shown on the attached test pit logs are approximate only.

Test pits were not able to be excavated in the general vicinity of water courses / drainage features on the site due to cultural / heritage restrictions.

The test pit logs for Pits 11 to 30 are included in Appendix A. The approximate test locations are shown on Drawings 1 to 7, Appendix C.

5.2 Results

Detailed test pit logs are attached and should be read in conjunction with the attached general notes which explain the descriptive terms and classification methods used on the logs.

In general, the pits encountered silt and clayey silt topsoil, overlying silty clay, clayey silt and silt. The soil was underlain by siltstone bedrock in Pit 17, 26, 29 and 30.

The following is a summary of the subsurface conditions encountered in Pits 11 to 30.

From (m)	To (m)	Description
0.0	0.0 / 0.3	TOPSOIL: encountered in all pits (except Pits 17, 18 and 19), generally loose to medium dense, silt and clayey silt with abundant rootlets.
0.0 / 1.8	0.4 / Termination Depth (>2)	SILT / CLAYEY SILT: generally loose to medium dense and dense; Not encountered in Pits 11, 13, 15, 17 and 27.
0.1 / 1.5	0.5 / Termination Depth (>1.9/>2.3)	CLAY / SILTY CLAY: generally stiff to very stiff and hard; some firm zones in Pits 14, 15 and 18; Not encountered in Pits 17, 26, 27, 28 and 30.
0.2 / 0.4	1.1 / Termination Depth (1.95)	SILTY SAND: encountered in Pits 22 and 27, generally loose to medium dense.
1.3 / 1.7	> 1.6 / > 1.9	SILTSTONE: encountered in Pits 17, 26, 29 and 30; generally very low to low strength, moderately weathered.

Table 1, below summarises the depth to rock in each of the Pits 17, 26, 29 and 30, including the depth to refusal, where encountered.

Table 1: Summary of Depth to Rock

Test Pit	Depth to Rock (m)	Depth to Backhoe Refusal (m)
17	1.7	NE to 1.9
26	1.3	1.75
29	1.5	1.95
30	0.5	1.6

Notes to Table 1:
NE – Not Encountered

Testing of surface waters within several dams was undertaken for pH and EC during the fieldwork investigation. The testing locations (Dam 3 to Dam 5) are shown on Drawing 2, Appendix C. The results of surface water testing are presented in Table 2 below:

Table 2: Surface Water Testing Results

Dam Identification	Location	pH	EC (µS/cm)	Observations
Dam 3	North-west of Pit 12	6.7	461	Brown, high turbidity, no flow, green algae on surface
Dam 4	North of Pit 19	6.8	235	Brown, low turbidity, no flow
Dam 5	East of Pit 20	7.1	225	Brown, moderate turbidity, no flow , film on surface

The results of surface water testing indicate the pH was neutral to slightly acidic with fresh water conditions within the dams tested.

Groundwater was not encountered in any of the test pits during the time they were open. It should be noted that groundwater levels are affected by factors such as soil permeability and the prevailing weather conditions, and will therefore vary with time.

6. Laboratory Testing

The following laboratory testing was undertaken on samples collected during field work:

- Four Atterberg limits tests to assess soil plasticity;
- Four shrink-swell tests on undisturbed soil samples to provide a preliminary indication of soil reactivity within proposed residential redevelopment areas of the site area;
- Three standard compaction / California bearing ratio (CBR) tests to provide a preliminary indication of subgrade strength within proposed residential redevelopment areas of the site area;

The geotechnical testing was undertaken by the NATA accredited DP Newcastle laboratory.

The results of laboratory testing are presented in the attached laboratory report sheets, and are summarised in Tables 3 and 4 below.

Table 3: Results of Shrink-Swell & Plasticity

Pit	Depth (m)	Description	FMC (%)	W_L (%)	W_P (%)	PI	Iss (% per ΔpF)
14	0.35-0.75	Clay- brown with trace orange mottling	25.0	-	-	-	3.5
23	0.45-0.85	Clay- red / brown clay, slightly silty	24.3	88	22	66	2.4
25	0.5-0.9	Silty Clay / Clayey Silt - grey and orange or grey	19.2	45	15	30	1.7
30	0.15-0.55	Clayey Silt - orange mottled grey and red	18.1	-	-	-	2.6

Notes to Table 3:

FMC - Field moisture content

W_L – liquid limit

W_L – plastic limit

PI – Plasticity Index

Iss - Shrink/Swell Index

Table 4: Results of CBR & Plasticity Index

Pit	Depth (m)	Description	FMC (%)	W_L (%)	W_P (%)	PI	SOMC (%)	SMDD (t/m^3)	CBR (%)	Swell under 4.5 kg surcharge (%)
11	0.4-0.7	Clay- brown	24.0	67	18	49	22.5	1.59	2.5	2.2
16	0.05 – 0.4	Silt	9.7	19	18	1	13.5	1.78	30	-0.2
27	0.5-0.8	Silty Sand - brown	11.2	-	-	-	12.5	1.76	60	-0.1

Notes to Table 4:

FMC - Field moisture content

SOMC - Standard optimum moisture content

SMDD - Standard maximum dry density

CBR - California bearing ratio (4 day soaked)

7. Site Geotechnical Characteristics

7.1 General

The assessment of geotechnical characteristics of the project area comprised the following:

- Walkover survey to assess site conditions;
- Excavation and logging of 20 test pits;
- Desktop study;

- Preliminary indicative site classification to AS 2870-2011 (Ref 2);
- Preliminary indicative pavement thickness designs;
- Discussions with Mine Subsidence Board (MSB) regarding mining activities and likelihood of mine subsidence;
- Assessment of the need for further investigations.

Test pits were not able to be excavated in the general vicinity of water courses / drainage features on the site due to heritage / cultural restrictions. Additional investigation will be required in these areas during the design stage of the works.

7.2 Slope Stability

The majority of the project area is typically characterised by gently undulating topography with some localised steeper slopes along gully lines.

Some subsidence features were observed in the adjoining Maitland City Council portion of the site, to the north, predominantly related to mine-subsidence. Information available from the MSB indicates that while some of the properties to the east of the Residential Central part of the site have been undermined, the Cessnock City Council portion of the site does not include known / documented mine workings beneath it. Therefore, the risk of existing or future steep slopes due to subsidence has not been further considered.

With reference to the available information, and the site walkover, there were no signs of deep-seated slope instability within the observed portions of the site at the time of the assessment. Based on the site observations and topographical / geological information for the project area, the majority of the site (ie the developable portions of the Cessnock City Council (Loxford) portion of the site) is considered to have a low risk of slope instability.

There are however known areas of slope instability within filling on the Hydro aluminium smelter portion of the site, and the possibility of instability associated with filling could exist elsewhere on the site.

No assessment of the integrity of existing dam embankments has been undertaken.

It is possible that areas of the site in the vicinity of steeper slopes, fill embankments and dam embankments could have a low to moderate risk of slope stability. Further assessment of the long term stability of dam embankments, fill embankments and locally steeper topography is recommended if they are to be incorporated into the proposed development.

The project area is considered suitable for the proposed residential, commercial and industrial development with respect to slope stability providing design and construction are undertaken in accordance with good engineering practice that includes the following:

- Earthworks:
  - Excavations and filling should be limited to about 2 m depth unless subject to further geotechnical investigation;
  - Fill should be placed and compacted and tested in accordance with the procedures presented in AS 3798-2007 (Ref 4).
- Batter Slopes:
  - Fill batters should not exceed 1V:2H in soil and compacted fill;
  - Permanent batter slopes for excavations should be determined following specific geotechnical investigations, but would generally be 1V:2H or flatter in soil;
  - Batter slopes should be protected against erosion.
- Footings:
  - Footings should be designed in accordance with AS 2870 (Ref 2). Footings should be founded in natural material or engineering filling.
- Retaining Walls:
  - Retaining walls exceeding 1 m high or which support a footing should be engineer designed for appropriate earth pressures;
  - Retaining walls should include geotextile encapsulated free draining backfill (i.e. single sized aggregate) behind the wall and a slotted drainage pipe at the base of this backfill.
- Drainage:
  - Stormwater should be discharged to the street drainage system or to an on-site system designed to minimise erosion. The heavy clay soils of the project area are not suitable for on-site stormwater infiltration.

In addition to the above, it is recommended that specific slope stability assessment is undertaken in steeper areas of the project area, such as in the vicinity of drainage gullies and fill embankments (if they are to be retained). The additional assessment should be undertaken when details of the proposed development are known.

7.3 Shallow Bedrock

Bedrock was encountered at depths ranging from 0.5 m to 1.7 m in each of Pits 17, 26, 29 and 30.

A visual assessment during field work indicated that rock, where it was encountered in the recent test pits may range from very low to low and possibly medium strength, however no qualitative testing was undertaken, hence a detailed assessment of rock strength has not been undertaken as part of this preliminary geotechnical assessment.

Specific investigation is recommended if proposed development could be affected by rock at the surface or shallow bedrock, eg utilities installation, footing excavations, bulk earthworks etc. The additional investigation should include coring of bedrock, if excavations will be required in areas of shallow bedrock, in order to assess excavatability / rippability.

7.4 Soft / Wet Soils

While soft and / or overly wet soils were generally not encountered in the test pits, it is noted that the site includes several farm dams and intermittent water courses / drainage features which may require at least partial filling where site levels are to be raised and / or roads are to be constructed. Significantly wet of optimum soils should be expected in these areas.

Depending on the time elapsed from these areas being ‘drained’ of inundation waters, and the height of filling to be placed, some over-excavation and replacement could be required to facilitate the placement of engineered filling and/or reduce the risk of post-construction settlement.

These areas were not accessible during the current assessment due to cultural / heritage restrictions. Additional investigation will be required in these areas to identify the extent of soft / wet soils, if present.

Firm clay and clayey silt was encountered to depths of between 0.5 m and 0.7 m in Pits 14, 15 and 18.

One of the three CBR samples was up to about 1.5% wet of optimum at the time of testing. The moisture condition of the on-site soils will be a function of the prevailing weather conditions prior to, and during, construction.

In addition, silty soils can also be difficult to work, particularly when wet. Silty soils were encountered in a number of pits across the site. These soils may require over-excavation and replacement, if present at subgrade level in roads, and if present in areas to receive engineered filling.

7.5 Preliminary Site Classification

Site classification of foundation soil reactivity provides an indication of the propensity of the ground surface to move with seasonal variation in moisture. Site classification is based on procedures presented in AS 2870-2011 (Ref 2), the typical soil profiles revealed in the test pits, and on the results of laboratory testing.

A significant proportion of the western part of the site will be classified Class P in its current condition due to the presence of filling / disturbed ground. Drawings 3 to 7 in Appendix C, indicate areas of the site where filling may be present based on field observations. These areas can be re-classified if the uncontrolled filling is removed and replaced with engineered filling to the requirements of AS3798 (Ref 4).

In areas of the site not impacted by filling, the results of the preliminary field and laboratory testing indicate that the site classifications at the test pit locations range from Class M (moderately reactive) to Class H1 (Highly reactive). This however does not account for the removal and/or presence of trees, which will impact on seasonal movements. The presence of Class H2 sites (or higher reactivity) cannot be precluded.

In areas where more than 0.4 m of uncontrolled filling is present, a Class P site classification will apply, and design of footings will need to be by engineering principles, unless the filling is removed and replaced with controlled filling.

Filling is generally expected in areas which are already developed and which may be re-developed such as around railway corridors (current and previous), farm dams, and areas where rural structures may have been constructed on cut / fill platforms (eg sheds). Filling is also expected within the former aluminium smelter site, as discussed above.

Areas with abnormal moisture conditions are also considered to be Class P sites by AS2870-2011. Abnormal moisture conditions can occur in areas where existing structures are to be demolished, where dams / ponds may be decommissioned, and areas where trees are to be removed. Class P sites will also be present in areas where soft to firm foundation conditions may be present. Class P soils can become soft to firm when wet. Hence areas which may periodically become inundated could also be considered Class P.

The above is intended to provide preliminary planning information only. Once the proposed layout of the development is known, then it is recommended that site classification be undertaken on a lot by lot basis, including more field and laboratory testing.

The process of cutting and filling will affect the site classification. The use of reactive clay filling in the earthworks may lead to a more severe classification than the classification of a site in its ‘natural’ condition. Therefore, earthworks will need to consider potential changes to site classification. Based on previous experience in the local area, developers will sometimes chose to import non-reactive filling to a site to reduce the chance of creating more a severe classification due to earthworks operations. Alternatively, if on-site filling is used to raise site levels, the developer needs to accept the risk and cost implication of potential Class H2, and possibly even Class E sites.

Where site levels are to be raised, filling intended to support footings should be placed and compacted to the requirements of AS3798 (Ref 4).

Site classifications are dependent on proper site maintenance, which should be carried out in accordance with the attached CSIRO Sheet BTF18 and Appendix B of AS2870-2011.

7.6 Salinity Potential

The geotechnical investigation did not include testing for soil salinity, however reference to the Department of Lands website indicated that there were no mapped salinity indicators within the project area (ie no surface observations of saline indicator species or salt outbreaks).

Future design and construction should be undertaken with respect to good practices to minimise the potential for saline impact to occur. Typical construction practices include:

- Correctly installing a damp-proof course or equivalent within each building;
- Providing adequate floor ventilation beneath buildings if they are constructed on bearers and joists;
- Minimise the disruption to natural water courses (surface and subsurface) to reduce the potential for waters to come in contact with structures, i.e. minimising cut and fill;
- Maintaining the natural water balance and maintaining good drainage to prevent rises in ground water levels;
- Maintaining good drainage and minimising excessive infiltration;
- Ensuring that paths which are provided around buildings slope away from the building;
- Careful design of landscaping and landscape watering methods;
- Adequate drainage provided behind retaining walls;
- Regular monitoring of pipes, etc for leaks.

Most of the above features are consistent with the guidelines AS 2870 (Ref 2) for standard non-saline sites.

7.7 Mine Subsidence

The Loxford / Cessnock City Council portion of the proposed Kurri Kurri Hydro Redevelopment Area is not located within a proclaimed Mine Subsidence District. Enquiries with the Mine Subsidence Board (MSB) indicated that there are no known areas of undermining beneath the current investigation area.

Relatively shallow mine workings are located in the Gillieston Heights portion of the site, to the north, which is not covered in this current investigation (refer Ref 1). The provided information indicates that there are no mapped workings beneath the project area covered by this report.

7.8 Acid Sulphate Soils

The acid sulphate soil risk maps indicate that potential acid sulphate soils may be present in low lying areas of the site. These generally correspond to the areas between the Residential Central and Residential Southern Precincts, however may overlap into the areas of proposed residential development.

Assessment of acid sulphate soils should be included in future geotechnical assessment of the site, particularly where the proposed development will disturb areas below RL 10 AHD.

7.9 Typical Pavement Profiles

7.9.1 Subgrade

The results of laboratory testing indicated a range of materials which could be present within the project area at subgrade level. These include high plasticity clay, silty sand, silt and clayey silt.

High plasticity clays provide an increased risk of poor subgrade conditions, depending on the prevailing weather conditions at the time of construction.

Silty soils were encountered in a significant number of pits. These soils deteriorate quickly with small changes in moisture, and are generally not recommended as subgrade materials. Despite providing a relatively good CBR value under laboratory conditions, the plasticity index results illustrate how this material can change from its plastic limit condition to its liquid limit condition with a relatively small change in moisture content. Control of moisture in silty soils can be difficult in practice, therefore, where these are encountered at the pavement subgrade they are likely to require excavation and replacement, depending on how tightly the contractor can control moisture during earthworks.

In areas where clay soils are wet of optimum at the time of construction, they either require over-excavation and replacement to a limited depth with a select subgrade, or they require tyning and drying back to an appropriate moisture.

Laboratory testing indicated the following:

- One clay sample tested had a soaked CBR of 2.5%. Another clay sample tested in the Gillieston Heights portion of the site had a soaked CBR of 7%;
- Samples of silt and silty sand had soaked CBRs of 30% and 60%, respectively;
- A sample of siltstone from the Gillieston Heights portion of the site had a soaked CBR of 25%;

The clay samples were up to 2% wet of optimum at the time of testing.

In addition, previous work by DP in the local area, including on the former aluminium smelter site, indicate laboratory soaked CBR values in the range 2% to 3.5% for clayey soils, and up to 13% for clayey sand / sandy clay soils.

Based on the results of the limited laboratory testing, together with previous experience in the local area and with similar soils, the following values have been adopted for the purpose of preliminary / concept design:

- Clay subgrade: CBR $\geq$ 3%;
- Silty Sand / Clayey Sand subgrade: CBR $\geq$ 8%.

Silty soils are not suitable as a pavement subgrade material, and should be over-excavated to a limited depth, where present at subgrade level and replaced with select subgrade.

Similarly, high plasticity clay with poor CBR values may be encountered (e.g. Pit 11 and other previous tests by DP in the vicinity of the former smelter). These soils may also require over-excavation and replacement with a select subgrade, depending on moisture conditions at the time of construction.

Preliminarily, over-excavation of poor subgrade soils could be required to a depth of 300 mm to 500 mm, however this will depend on conditions at the time of construction, and the thickness of filling to be placed over them.

Select subgrade, where required, should comprise a granular material with a CBR of at least 15%.

7.9.2 Design Traffic Loading

This report relates to a proposed residential, commercial and industrial development within the Cessnock City Council local government area. Pavements in these areas will therefore need to be designed with reference to the Cessnock City Council Engineering Guidelines for Development (Ref 3).

The following table summarises the range of design traffic loadings outlined in Ref 3, for a range of road classifications. Confirmation should be sought from Council regarding which classification may apply to each road within the development. Significant roads, particularly those in industrial areas, may require more detailed analysis to assess the likely range of design traffic loadings.

Table 5: Summary of Indicative Design Traffic Loadings

Road Classification		Design Traffic Loading (ESA)
Urban Residential	Cul-de-sac / Accessway	1×10^4
	Minor / Local Access	6×10^4
	Local Access	3×10^5
	Collector	1×10^6
	Sub-Arterial / Distributor	2×10^6
Rural-Residential	Cul-de-sac	1×10^4
	Other	3×10^5
Commercial / Industrial		5×10^6

The above traffic loadings should be reviewed as more detailed information on traffic loading becomes available. In particular, the likely number and types of trucks should be confirmed to assess the suitability of the suggested pavement thickness.

7.9.3 Indicative Pavement Thickness Designs

For the purpose of preliminary planning, indicative pavement thickness designs have been prepared for a range of expected subgrade conditions, and the design traffic loadings outlined in Table 5 above. The preliminary pavement thicknesses have been based on the procedures presented in Austroads 2012 (Ref 5). Table 6 presents preliminary pavement thicknesses for a subgrade CBR $\geq$ 3%, and also for subgrade CBR $\geq$ 8%.

Table 6: Indicative Pavement Thicknesses

Road Type	Design Traffic Loading (ESA)	Subgrade CBR (%)	Minimum Thickness (mm)			
			AC	Basecourse	Subbase	Total
Cul-de-sac / Accessway (Urban / Rural-Residential)	1×10^4	3	30[1]	100	190	320
		8	30[1]	160	-	190
Minor / Local Access	6×10^4	3	30[1]	100	240	370
		8	30[1]	190	-	220
Local Access (urban) or Other Rural-Residential	3×10^5	3	30[1]	120	300	450
		8	30[1]	230	-	260
Collector	1×10^6	3	40[2]	140	340	520
		8	40[2]	140	120	300
Sub-Arterial / Distributor	2×10^6	3	40[2]	150	370	560
		8	40[2]	150	130	320
Commercial / Industrial	5×10^6	3	40[2]	160	410	610
		8	40[2]	160	150	350

Notes to Table 6:

* Where asphalt is to be used as a wearing course, a 7 mm prime seal should first be laid

1 – AC 14 or equivalent

2 – AC 10 or equivalent

Refer following text for additional comments

Ref 3 indicates that Council's minimum thickness for a granular pavement layer is 100 mm. Ref 3 does not indicate an overall minimum pavement thickness.

It may be appropriate for the higher traffic loading above to also consider an alternative of bound pavement in areas of clay subgrade.

If Council will permit the use of a spray seal in lieu of the nominated asphalt thickness shown above, the subbase thickness must be increased by the thickness of the asphalt layer, to maintain the total minimum thickness.

It should be noted that there may be 'constructability minimum values' which apply in relation to minimum thickness of subbase under kerb, and minimum thickness of basecourse to match kerb height. It is understood that these minimums can vary depending on the type of kerb being used and an individual Council's requirements. The pavement thicknesses above are minimum values. The minimum basecourse thickness may be increased, if it assists with the practical aspects of construction. It is possible to then decrease the subbase thickness, but the overall total pavement thickness must be observed. It is also to increase the minimum subbase thickness if practical considerations govern.

It is noted that Council specifies Benkelman beam deflection testing of the finished base as part of construction QA requirements. The characteristic deflections for each of the street types listed above, can be difficult to achieve for pavements constructed over clay subgrades, even for pavements that have been designed and constructed in accordance with Ref 5. Consideration should therefore be given to lightly stabilising the pavement basecourse layer with 1% cement, or similar, to achieve the deflection criteria.

It is noted that areas used by tightly turning heavy vehicles / trucks will be subject to high shear and torsional forces. Concrete pavements should be considered in these areas (e.g. roundabouts on high traffic and / or industrial pavements).

Any changes in overall pavement thickness between adjoining sections of road should be transitioned and not abruptly stepped.

The pavement thicknesses presented above are dependent on the provision and maintenance of adequate surface and subsurface drainage.

7.9.4 Material Quality and Compaction Requirements

Recommended pavement material quality and compaction requirements are presented in Table 7 below.

Table 7: Material Quality and Compaction Requirements

Pavement Layer	Material Quality	Compaction
Basecourse	CBR > 80%, PI ≤ 6%, Grading in accordance with Ref 3	Compact to at least 98% dry density ratio Modified (AS 1289.5.2.1)
Subbase	CBR > 30%, PI ≤ 12%, Grading in accordance with Ref 3	Compact to at least 95% dry density ratio Modified (AS 1289.5.2.1)
Select Subgrade	CBR ≥ 15%	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)
Subgrade (CLAY)	CBR ≥ 3 %	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)
Subgrade (Silty Sand / Clayey Sand)	CBR ≥ 8 %	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)

As previously discussed, silty soils are present on the site, and these soils may be difficult to compact, depending on conditions at the time of construction.

7.9.5 Subgrade Preparation

The following procedure is recommended for preparation of the pavement subgrade:

- Excavate to design subgrade level;
- Remove any additional topsoil or deleterious materials;
- Test roll the surface in order to determine any soft zones and assess moisture condition. Moisture contents should be in the range OMC -3% (dry) to OMC where OMC is the optimum content at standard compaction;
- It should be noted that the limited samples tested ranged from 4% dry of OMC to 1.5% wet of optimum at the time of field testing. Moisture conditioning may therefore be required if similar moisture conditions are encountered during construction;
- Compact the tyned natural subgrade to a minimum dry density ratio of 100% Standard. The compacted clay subgrade should be left exposed for a minimum of time prior to placement of pavement layers, to minimise the occurrence of desiccation cracking and/or softening due to weather exposure;
- If raising of the subgrade level is required, all deleterious material should be removed, and approved filling placed in layers not exceeding 300 mm loose thickness and compacted to a dry density ratio in the range 98% to 102% Standard.

It is understood that some of the road alignments within the adopted master plan layout will pass through areas where structures are to be demolished and also areas where dams may be decommissioned. There is a risk of uncontrolled filling, wet of optimum subgrade and other deleterious materials in these areas.

Geotechnical inspections and testing should be performed during construction in accordance with Ref 3.

8. Conclusions

The project area is considered to be generally geotechnically suitable for the proposed residential and industrial development, subject to more detailed investigation being undertaken at the appropriate stage of the project planning and design.

The development may encounter soft / wet soils in areas of high moisture, poor subgrade soils and reactive clays. These however can be readily managed by good engineering and construction practices, and are similar to the geotechnical conditions of the local area where other developments have occurred.

Design and construction should be undertaken with respect to good practices to minimise the potential for saline impact to occur.

The presence of filling in areas to be re-developed from current / former landuse will require specific engineering controls.

Low lying areas of the site should be assessed for potential acid sulphate soils, if ground disturbance will occur as part of development.

9. References

1. Douglas Partners Pty Ltd, "Report on Preliminary Geotechnical Assessment, Proposed Rezoning, Hydro Aluminium Site, Gillieston Heights Portion", Project 81520 dated 23 March 2015.
2. Australian Standard AS 2870-2011 "Residential Slabs and Footings", Standards Association of Australia, 17 January 2011 Standards Australia.
3. Cessnock City Council "Engineering Requirements for Development"
4. Australian Standard AS 3798–2007, 'Guidelines on earthworks for commercial & residential developments', Standards Australia, March 2007.
5. Austroads "Guide to Pavement Technology, Part 2: Pavement Structural Design", AUSTROADS AGPT02-12 February 2012.

10. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at they Hydro Aluminium Kurri Kurri rezoning area, in accordance with DP's proposal dated 27 March 2014 and acceptance received from Shannon Sullivan dated 13 May 2014. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of ESS Australia on behalf of Hydro Aluminium Kurri Kurri for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

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

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

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Appendix A

About this Report
Sampling Methods
Soil Description
Symbols & Abbreviations
CSIRO BTF18
Test Pit Logs – Pits 11 to 30

About this Report

Douglas Partners

Introduction

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

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

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

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

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.

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

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Description and Classification Methods

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

Soil Types

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

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

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

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

The proportions of secondary constituents of soils are described as:

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

Definitions of grading terms used are:

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

Cohesive Soils

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

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

Cohesionless Soils

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

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

Soil Descriptions

Soil Origin

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

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

Transported soils may be further subdivided into:

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

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

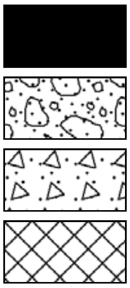
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

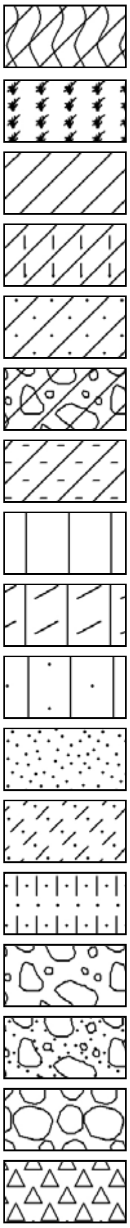
Graphic Symbols for Soil and Rock

General



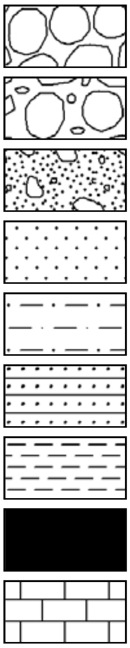
- Asphalt
- Road base
- Concrete
- Filling

Soils



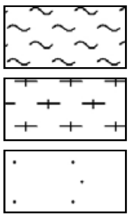
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks



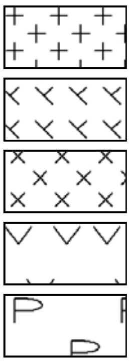
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks



- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks



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

Foundation Maintenance and Footing Performance: A Homeowner's Guide

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).

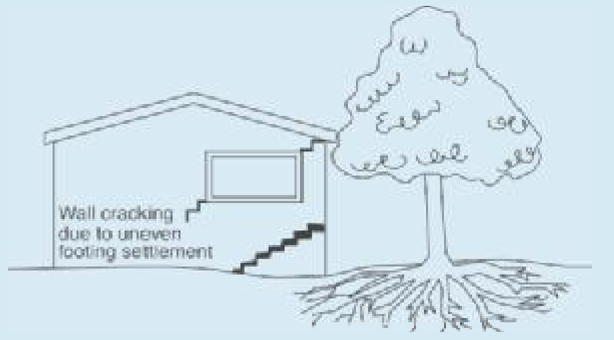
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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.

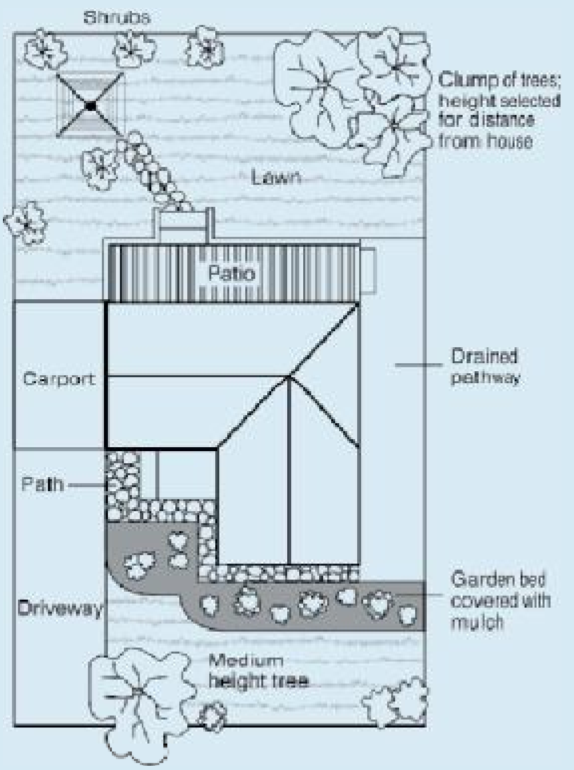
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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Email: publishing.sales@csiro.au

TEST PIT LOG

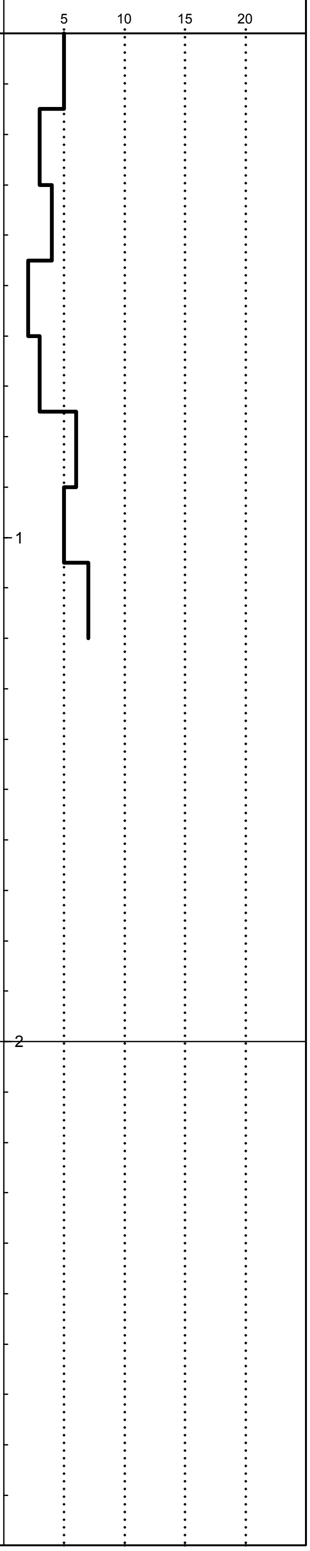
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 14.0 AHD*
EASTING: 360615
NORTHING: 6372573

PIT No: 11
PROJECT No: 81520
DATE: 14/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising medium dense, dark brown clayey silt topsoil with abundant rootlets						
	0.3	CLAY - Stiff to very stiff, brown clay, trace silt, M>Wp			0.4			
				D B	0.5		pp = 300-380	
		At 0.6m, tree root			0.7			
1				D	1.0		pp = 280-350	
				D	1.5		pp = 280-350	
		From 1.6m, very stiff to hard, trace to some orange and red mottling						
				D	1.8		pp >400	
2	2.0	Pit discontinued at 2.0m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

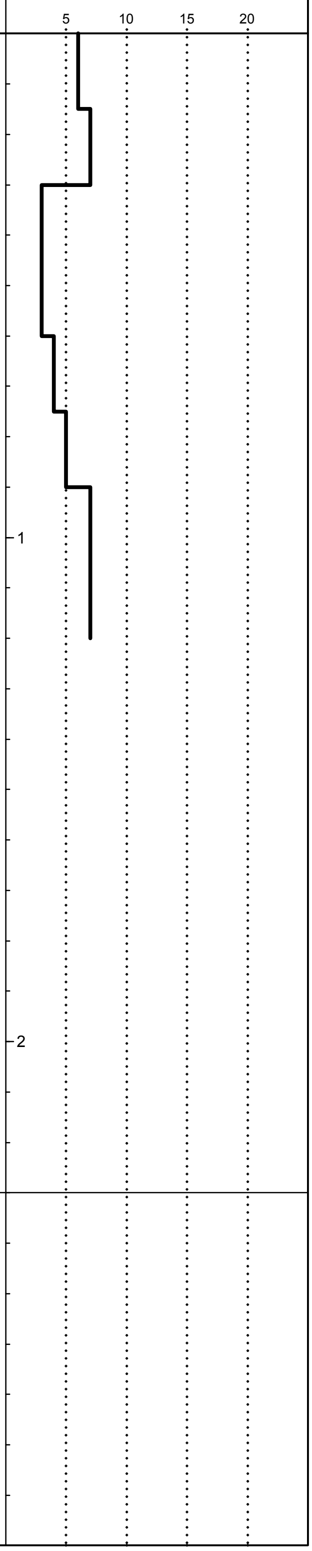
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 10.0 AHD*
EASTING: 360338
NORTHING: 6372417

PIT No: 12
PROJECT No: 81520
DATE: 14/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising medium dense, dark brown silt topsoil with abundant rootlets, humid to moist						
	0.1	SILT - Medium dense, dark brown silt with some clay, humid to moist		D	0.2			
	0.4	SILTY CLAY - Stiff, brown silty clay, with trace rootlets, M>Wp			0.4			
				D	0.5		pp = 150-180	
	0.6	CLAY - Stifft to very stiff, brown, with some orange mottled clay, trace silt, M≥Wp		U_{50}				
					0.85			
				D	0.9		pp = 220-250	
	1							
	1.2	CLAY - Very stiff, grey clay, with some orange and red mottling, M>Wp (increase in plasticity)		D	1.4		pp = 250-300	
		From 1.6m, dark grey with red mottling						
				D	1.8		pp = 280-300	
	2							
	2.3	Pit discontinued at 2.3m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

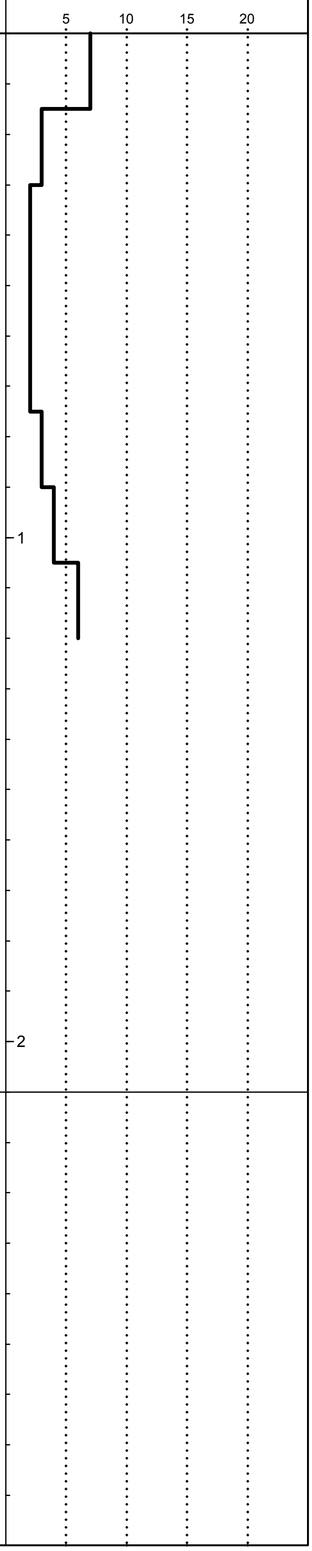
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 14.0 AHD*
EASTING: 360205
NORTHING: 6372165

PIT No: 13
PROJECT No: 81520
DATE: 14/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising very stiff, dark brown silty clay topsoil with abundant rootlets, M>Wp						
	0.1	CLAY - Stiff to very stiff to hard, brown clay with trace rootlets, M>Wp						
				D	0.3		pp = 350-400	
	0.5	CLAY - Stiff to very stiff, brown / grey clay with trace silt, M>Wp		B	0.5			
					0.8			
	1	From 1.0m, grey with trace orange and red mottling		D	1.0		pp = 250-300	
				D	1.5		pp = 250	
	2			D	2.0		pp = 180-200	
	2.1	Pit discontinued at 2.1m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth **LOGGED:** Fulham **SURVEY DATUM:** MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

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

SAMPLING & IN SITU TESTING LEGEND

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BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
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Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

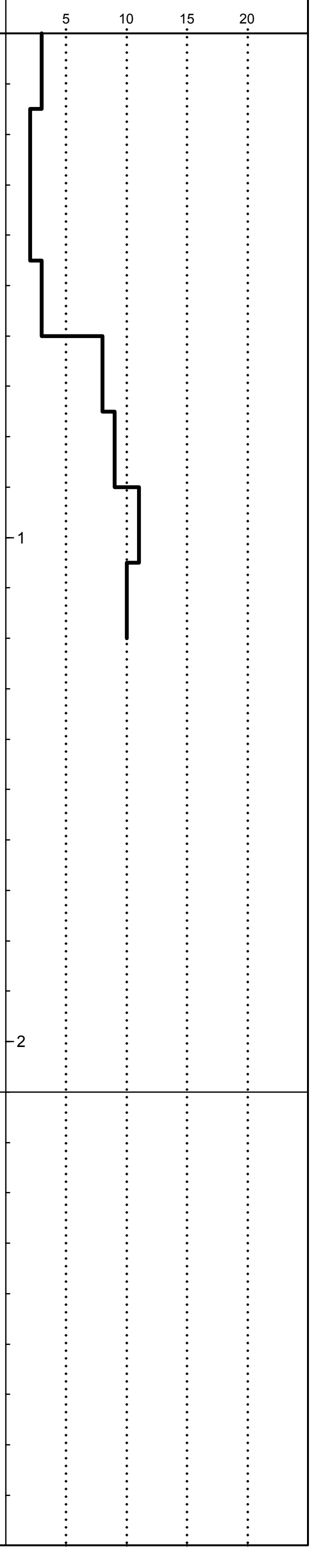
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 15.5 AHD*
EASTING: 360018
NORTHING: 6371918

PIT No: 14
PROJECT No: 81520
DATE: 14/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising loose to medium dense, dark grey silt topsoil, humid to damp						
	0.1	SILT - Loose, dark brown silt with trace clay, trace fine grained sand, and trace rootlets, humid to damp		D	0.2			
	0.35	CLAY - Firm to stiff, brown with trace orange mottling clay, M>Wp		U50	0.35			
				D	0.7		pp = 120	
		From 0.7m, stiff to very stiff, grey mottled red, trace silt			0.75		pp = 200	
	1			D	1.1		pp = 350	
				D	1.7		pp = 350	
		At 1.8m, tree root						
	2							
	2.1	Pit discontinued at 2.1m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

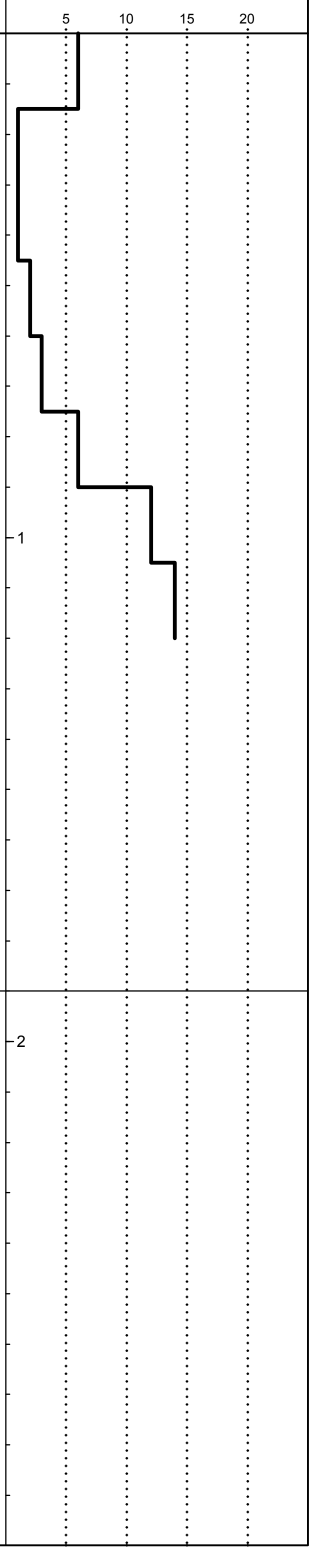
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 17.0 AHD*
EASTING: 360135
NORTHING: 6371635

PIT No: 15
PROJECT No: 81520
DATE: 15/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising medium dense, dark brown silt topsoil with abundant rootlets, humid to damp		D	0.1			
	0.2	CLAY - Firm, brown clay, with trace red mottling, M>Wp						
		From 0.5m, stiff to very stiff		D	0.5		pp = 100-250	
		From 0.65m, grey mottled red						
		From 0.9m, very stiff to hard						
	1			D	1.0		pp = 300	
	1.4	SILTY CLAY - Very stiff, grey mottled red silty clay, with some fine grained sand, M>Wp		D	1.6		pp = 300-400	
	1.9	Pit discontinued at 1.9m, limit of investigation						
	2							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth **LOGGED:** Fulham **SURVEY DATUM:** MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

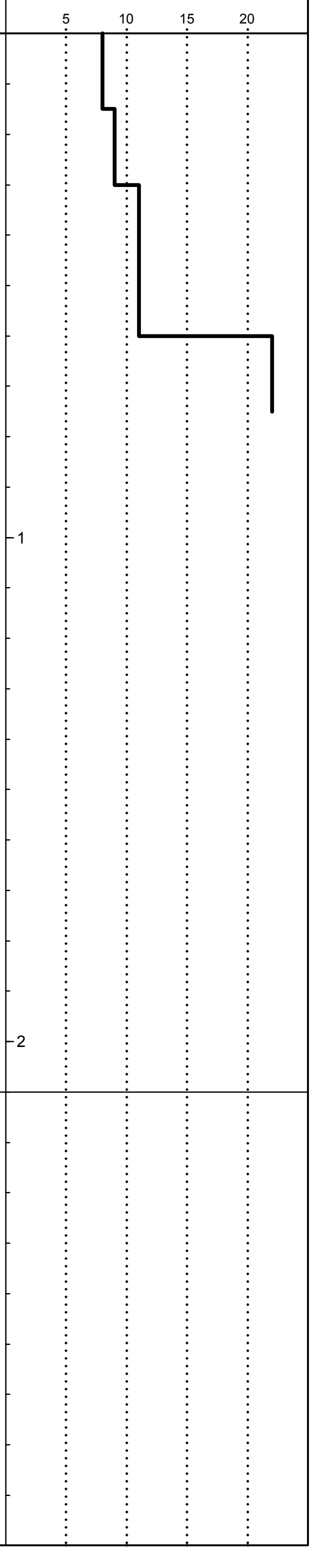
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 14.5 AHD*
EASTING: 359946
NORTHING: 6371363

PIT No: 16
PROJECT No: 81520
DATE: 14/7/2014
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 - Generally comprising medium dense, brown silt with abundant rootlets, moist			0.05			
		SILT - Dense, brown silt with trace rootlets, moist		D B	0.2			
	0.4	SILTY CLAY - Very stiff, brown silty clay, M<Wp			0.4			
				B D	0.5			
	0.6	SILT - Very dense to hard, orange silt with trace clay, moist			0.6			
				D	0.8			
		From 0.9m, grey mottled orange						
	1				1.0		pp >400	
				D	1.5		pp >400	
	2							
	2.1	Pit discontinued at 2.1m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

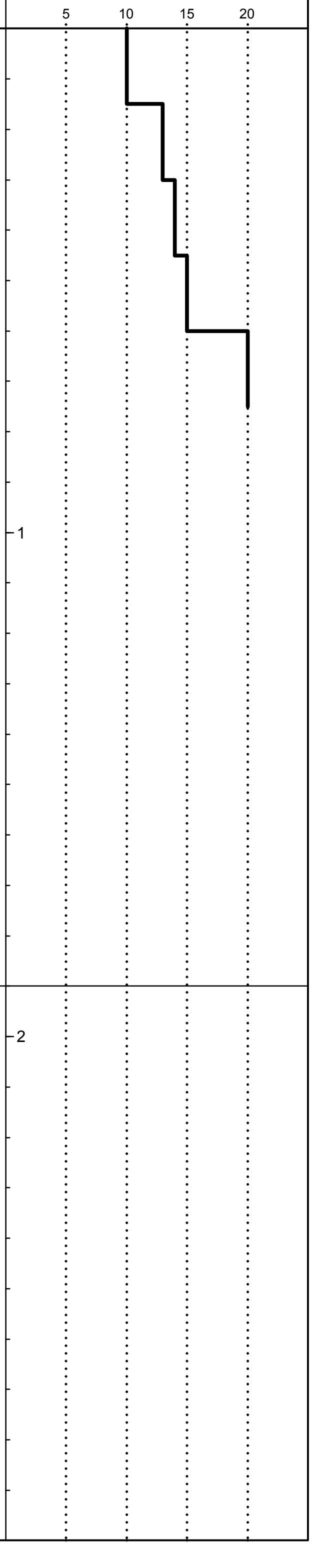
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 17.0 AHD*
EASTING: 359904
NORTHING: 6371233

PIT No: 17
PROJECT No: 81520
DATE: 15/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		SILT - Dense / very stiff to hard, dark brown silt, humid		D	0.2			
	0.45	CLAYEY SILT - Very stiff to hard, brown and orange clayey silt, dry / M<Wp		pp	1.0		pp >400	
	1.7	SILTSTONE - (Very low to low and possibly medium strength), moderately weathered, fractured, grey and orange siltstone From 1.8m, slightly weathered, grey		D	1.75			
				D	1.85			
	1.9	Pit discontinued at 1.9m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

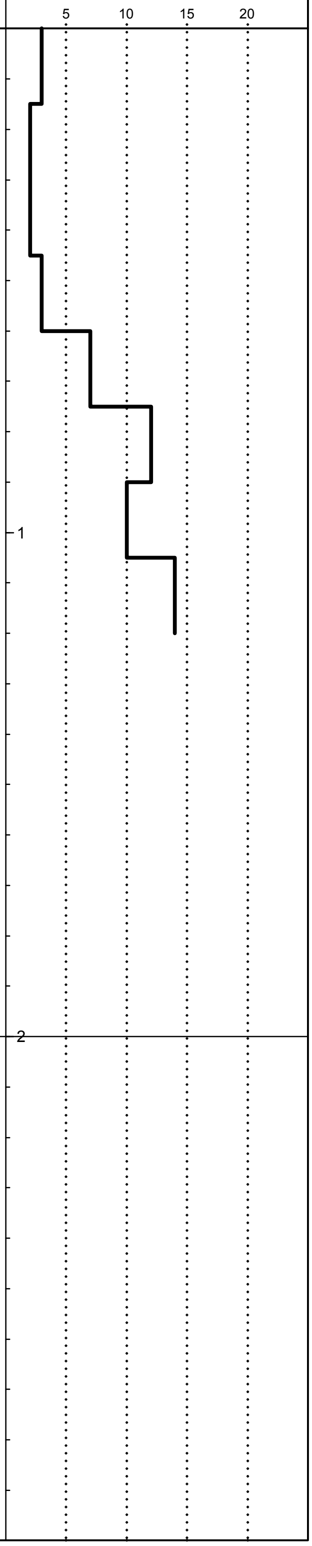
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 15.0 AHD*
EASTING: 359824
NORTHING: 6371123

PIT No: 18
PROJECT No: 81520
DATE: 15/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		SILT - Loose to medium dense, dark brown silt, with trace rootlets, humid From 0.0m to 0.1m, abundant rootlets		D	0.2			
	0.3	CLAYEY SILT - Firm to stiff, brown mottled orange clayey silt, M>Wp			0.4			
				D U_{50}	0.6		pp = 100-150	
	0.8	CLAY - Very stiff to hard, red clay with some silt, and trace fine sized subangular gravel, M<Wp			0.8		pp >400	
	1							
				D	1.2		pp >400	
	1.8	CLAYEY SILT - Stiff, grey clayey silt with trace red mottling, M>Wp		D	1.9		pp = 100-200	
	2 2.0	Pit discontinued at 2.0m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

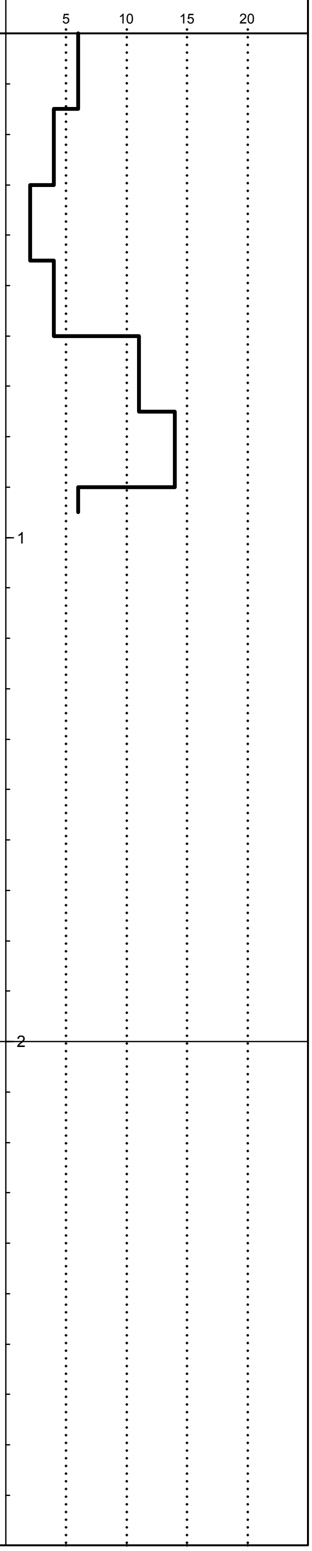
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 12.0 AHD*
EASTING: 359703
NORTHING: 6371416

PIT No: 19
PROJECT No: 81520
DATE: 15/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		SILT - Loose to medium dense / stiff, brown silt with trace medium sized subrounded gravel, damp		D	0.2			
	0.4	SILTY CLAY - Stiff to very stiff, red / brown / orange silty clay with some fine grained sand and fine sized gravel, M>Wp		D	0.6		pp = 150-200	
	0.8	SILT - Dense / very stiff, grey mottled orange silt with some clay, M>Wp						
1				D	1.2		pp = 300-350	
		From 1.8m, red with some fine grained sand		D	1.9		pp = 200	
2	2.0	Pit discontinued at 2.0m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

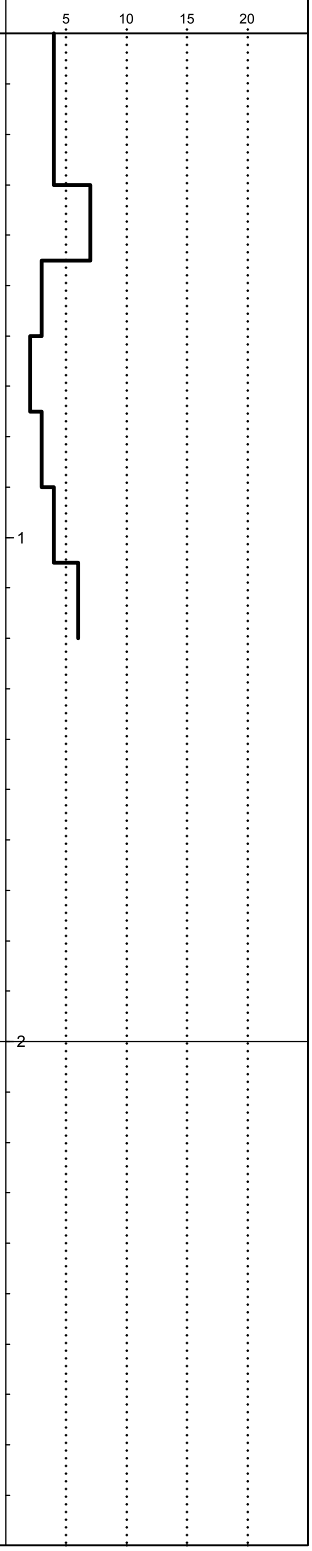
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 5.0 AHD*
EASTING: 359318
NORTHING: 6371187

PIT No: 20
PROJECT No: 81520
DATE: 15/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
	0.15	TOPSOIL - Generally comprising medium dense, dark brown silt topsoil with abundant rootlets, humid		D	0.1			
	0.45	SILT - Medium dense / hard, dark brown silt, with trace rootlets and trace clay, humid		D	0.25		pp >400	
		SILTY CLAY - Stiff, brown / red-brown silty clay with trace fine grained sand, M>Wp		B	0.45			
		From 0.8m, stiff to very stiff		D	0.8		pp = 250-350	
1					1.2			
		From 1.2m, orange mottled grey		B	1.4			
				D	1.4		pp = 250-300	
					1.5			
2	2.0	Pit discontinued at 2.0m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.
Silty clay layer was red/brown in the west end and brown in the east end

☐ 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

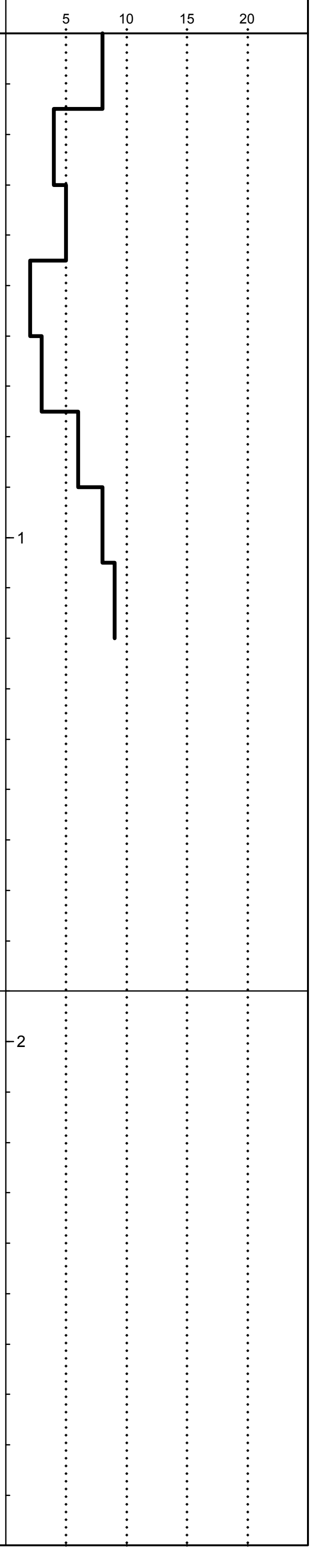
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 8.0 AHD*
EASTING: 359305
NORTHING: 6370895

PIT No: 21
PROJECT No: 81520
DATE: 15/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising medium dense, dark brown silt topsoil with some clay, humid		D	0.1		pp = 250	
	0.2	SILTY CLAY - Stiff to very stiff, brown clay with trace medium sized subrounded gravel, M>Wp		D	0.3		pp = 180-250	
	0.4	CLAY - Stiff to very stiff, red / orange with some grey mottling, trace silt, M>Wp		D	0.6		pp = 150-180	
	0.9	SILTY CLAY / CLAYEY SILT - Very stiff to hard, grey mottled orange and red silty clay / clayey silt with trace fine grained sand, M<Wp		D	1.5		pp >400	
	1.9	Pit discontinued at 1.9m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.
Pit moved to avoid possible services

☐ 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

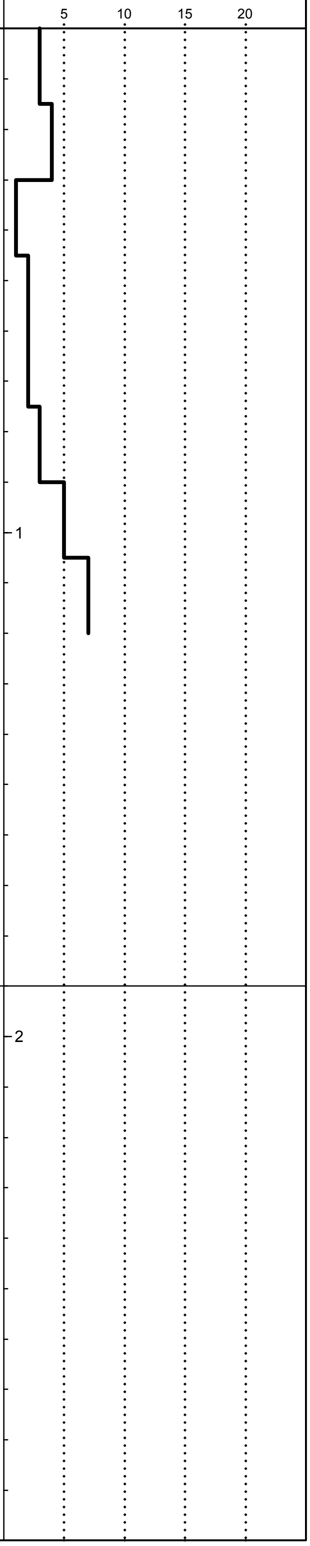
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 17.0 AHD*
EASTING: 359038
NORTHING: 6371245

PIT No: 22
PROJECT No: 81520
DATE: 16/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising loose to medium dense, dark brown silt topsoil, with abundant rootlets, damp						
	0.15	SILT - Loose to medium dense, dark brown silt, damp		D	0.3			
	0.4	SILTY SAND - Loose to medium dense, light brown, fine grained silty sand, moist			0.4			
				D B	0.7			
	1							
	1.1	SILTY CLAY and SILT - Medium dense / very stiff, grey mottled orange silty clay with some fine grained sand, M>Wp, and intermixed grey silt, moist			1.1			
				D	1.5		pp = 200-300	
	1.9	Pit discontinued at 1.9m, limit of investigation						
	2							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.
Silt clay and silt layer was encountered at 1.1m in east end and 1.7m in west end

☐ 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

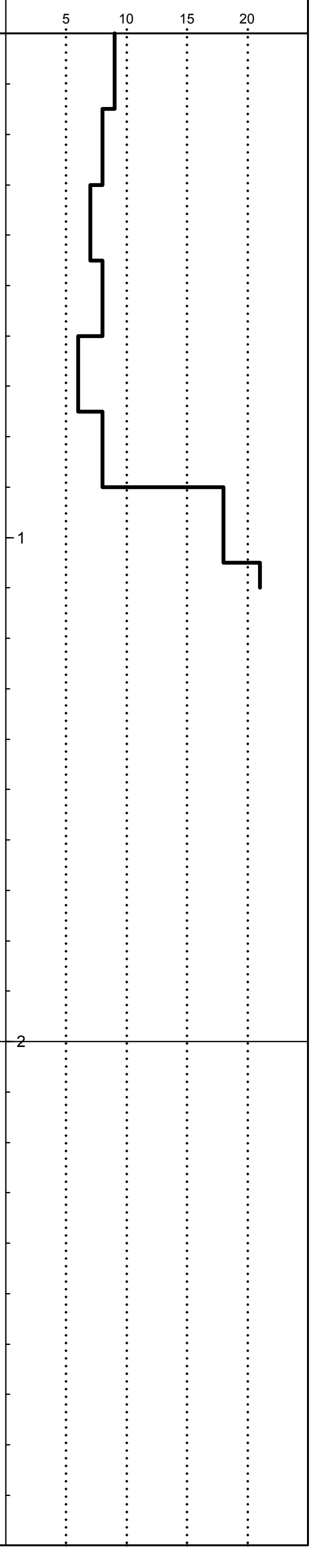
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 16.5 AHD*
EASTING: 359048
NORTHING: 6371082

PIT No: 23
PROJECT No: 81520
DATE: 16/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
	0.00–0.15	TOPSOIL - Generally comprising dense, light brown silt topsoil with abundant rootlets, humid					
	0.15–0.45	SILT - Medium dense / very stiff, light brown silt, humid	D	0.3			
	0.45–1.05	CLAY - Very stiff to hard, red / brown clay, some to slightly silty, M<Wp From 0.5m to 0.85m, tree roots	U_{50}	0.45–0.85			
			D	0.8		pp = 350-400	
				0.85		pp >400	
1	1.05–2.0	SILT - (Dense / hard), grey mottled red-brown and orange silt with some highly weathered red siltstone in parts	D	1.5			
2	2.0	Pit discontinued at 2.0m, limit of investigation					

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

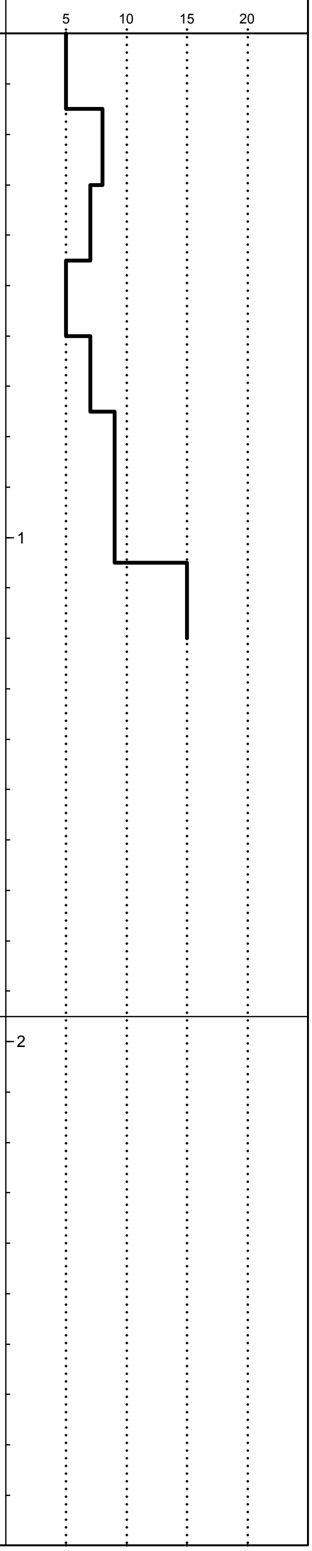
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 16.0 AHD*
EASTING: 358897
NORTHING: 6370895

PIT No: 24
PROJECT No: 81520
DATE: 16/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising medium dense, dark brown silt topsoil with abundant rootlets, humid to damp		D	0.1			
	0.15	SILT - Medium dense very stiff, light brown silt, humid		D	0.3			
		At 0.55m, tree roots						
	0.6	CLAYEY SILT - Very stiff to hard, light brown clayey silt		D	1.0		pp = 250-400	
	1.5	SILTY CLAY - Hard, grey mottled orange silty clay		D	1.8		pp >400	
	1.95	Pit discontinued at 1.95m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

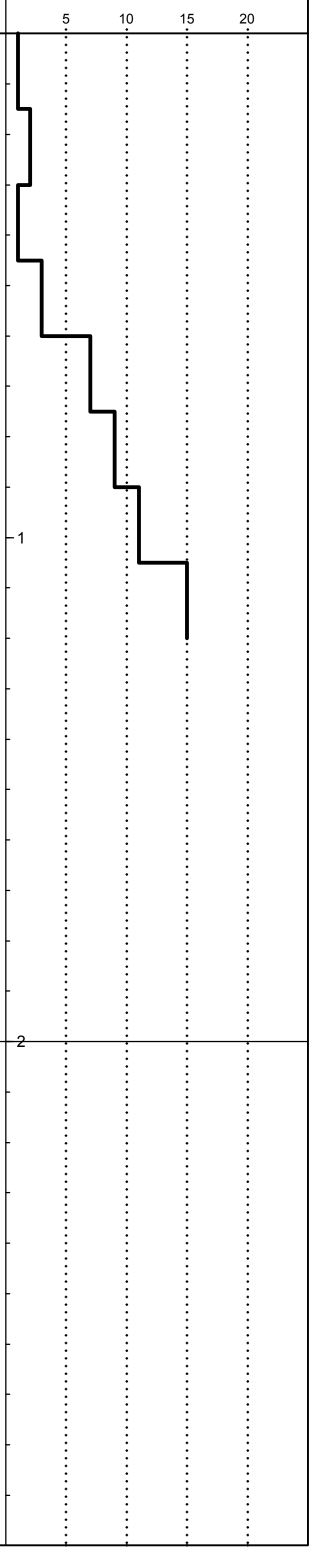
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 19.0 AHD*
EASTING: 359042
NORTHING: 6370626

PIT No: 25
PROJECT No: 81520
DATE: 16/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising loose, dark brown silt topsoil with abundant rootlets						
	0.1	SILT - Loose, dark brown silt, slightly clayey in parts, humid to damp (possibly filling)		D	0.3			
	0.5	SILTY CLAY / CLAYEY SILT - Very stiff to hard, grey and orange or grey silty clay / clayey silt, M>Wp		D	0.5–0.6		pp = 250-400	
				U_{50}				
				D	0.8–0.9		pp >400	
1	1.0	SILTY - Dense / very stiff to hard, grey mottled orange silt, slightly clayey with some medium to high strength siltstone in parts		B	1.0–1.5			
2	2.0	Pit discontinued at 2.0m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

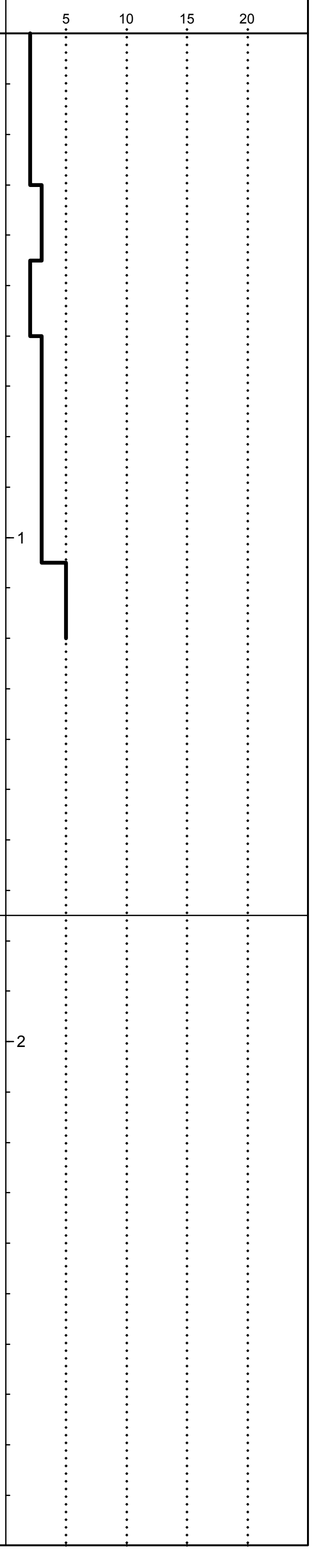
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 26.0 AHD*
EASTING: 358819
NORTHING: 6370309

PIT No: 26
PROJECT No: 81520
DATE: 16/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising loose, dark brown silt topsoil with abundant rootlets, damp						
	0.1	SILT - Loose / stiff, brown silt, damp		D	0.15			
				D	0.3			
	0.35	CLAYEY SILT - Stiff to very stiff, grey mottled orange clayey silt, M>Wp		D	0.8		pp = 150-200	
	1.3	SILTSTONE - (Very low to low and possibly medium strength), slightly weathered, grey with some orange siltstone		D	1.4			
	1.75	Pit discontinued at 1.75m, refusal						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.
Refusal at 1.55m in north-east end and 1.75m in south-west end

☐ 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

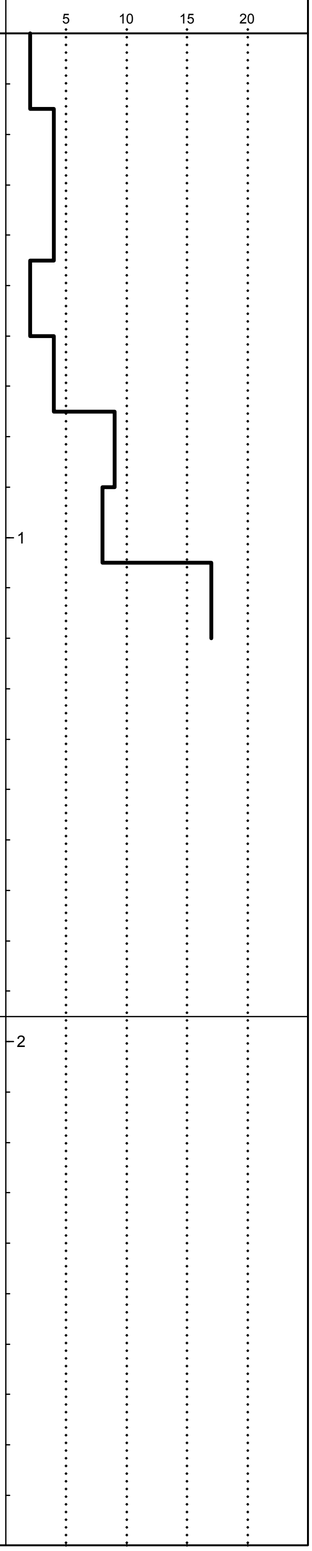
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 19.0 AHD*
EASTING: 358295
NORTHING: 6369875

PIT No: 27
PROJECT No: 81520
DATE: 26/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising loose, dark grey silty, fine grained sand topsoil, with abundant rootlets, damp to moist		D	0.1			
	0.2	SILTY SAND - Loose to medium dense, light grey silty, fine grained sand, moist		D	0.3			
					0.5			
		From 0.5m, brown		D B	0.6			
					0.8			
		From 0.8m, medium dense to dense, light brown		D	0.85			
		From 0.9m, grey with some orange silty sand, slightly clayey						
	1							
				D	1.5			
	1.95	Pit discontinued at 1.95m, limit of investigation						
	2							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth **LOGGED:** Fulham **SURVEY DATUM:** MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

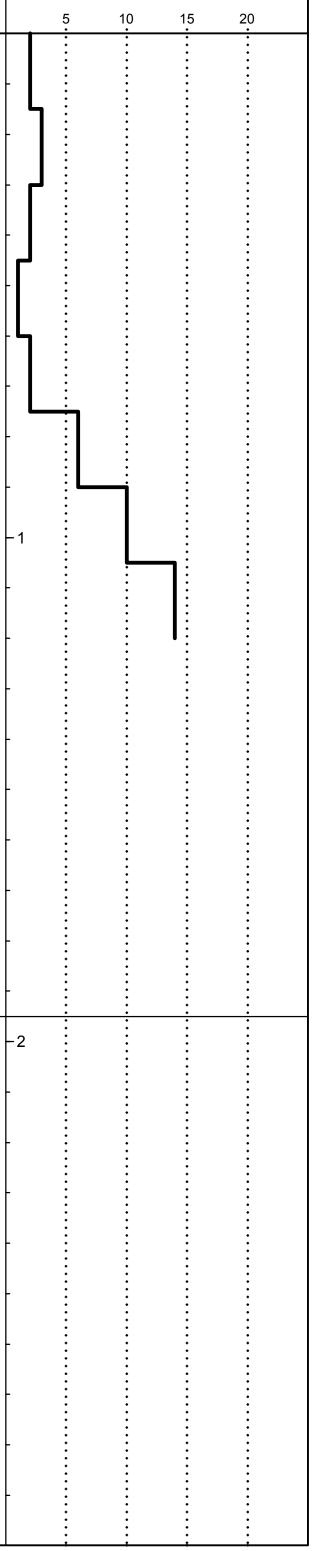
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 28.0 AHD*
EASTING: 357338
NORTHING: 6369723

PIT No: 28
PROJECT No: 81520
DATE: 16/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising loose, dark grey silt with abundant rootlets, damp						
	0.1	SILT - Loose to medium dense / stiff, dark grey silt, damp		D	0.15			
		From 0.25m, light grey		D	0.3			
		From 0.45m, brown						
				D	0.6			
		From 0.7m, stiff to very stiff, grey mottled orange and slightly clayey						
	1			D	1.0		pp = 200	
				D	1.6			
	1.95	Pit discontinued at 1.95m, limit of investigation						
	2							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth **LOGGED:** Fulham **SURVEY DATUM:** MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

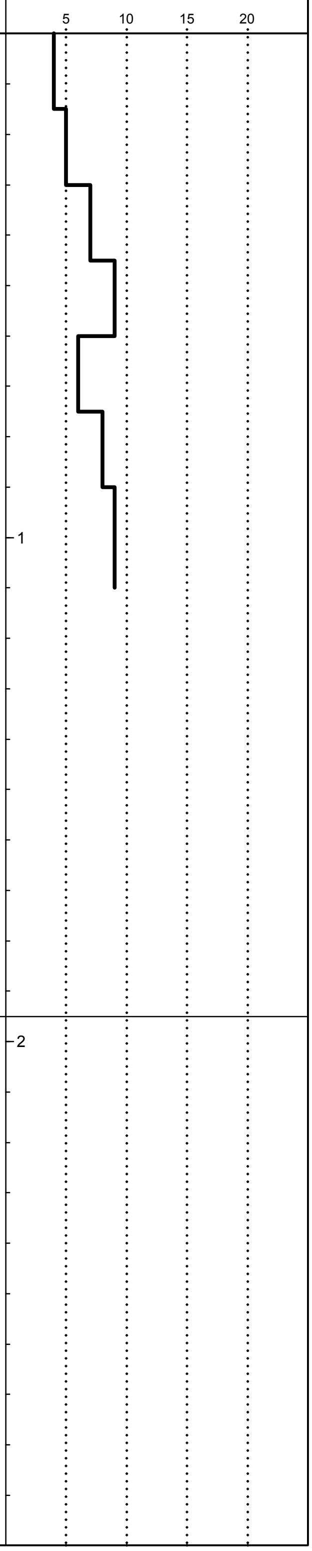
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 20.0 AHD*
EASTING: 356660
NORTHING: 6369763

PIT No: 29
PROJECT No: 81520
DATE: 16/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising medium dense, dark brown silt topsoil with abundant rootlets						
	0.1	SILT - Medium dense, brown silt with trace fine grained sand, and trace rootlets, damp From 0.1m to 0.8m, tree roots		D	0.2			
	0.4	CLAY - Very stiff, orange / brown clay, slightly silty, M<Wp		B D	0.4–0.75 0.6			
	0.75	SILT - Dense / very stiff, light grey mottled orange silt, moist		D	1.1			
	1.5	SILTSTONE - (Very low to low and possibly medium strength) moderately weathered, orange and grey siltstone		D D	1.6 1.9			
	1.95	Pit discontinued at 1.95m, limit of investigation (near refusal)						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth
LOGGED: Fulham
SURVEY DATUM: MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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

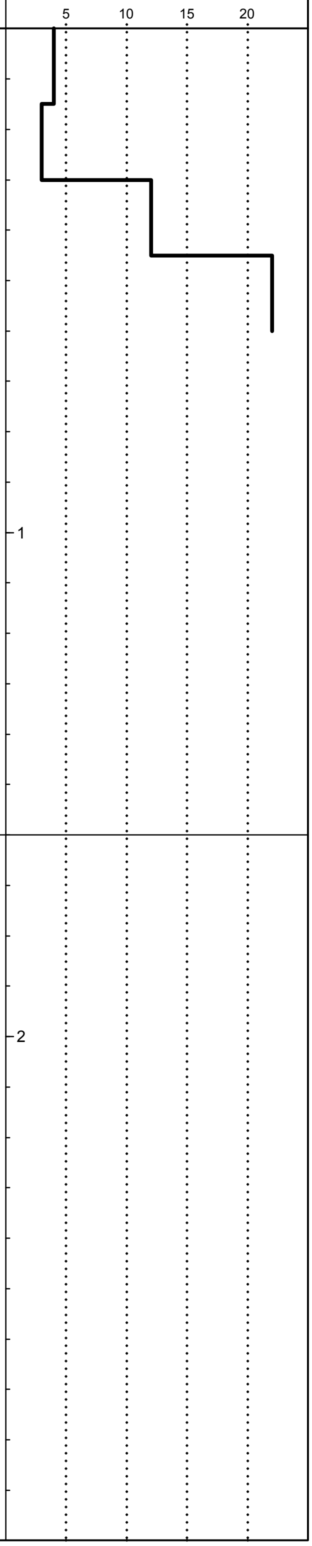
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd
PROJECT: Hydro Aluminium Kurri Kurri Redevelopment
LOCATION: Loxford

SURFACE LEVEL: 23.5 AHD*
EASTING: 356945
NORTHING: 6369953

PIT No: 30
PROJECT No: 81520
DATE: 16/7/2014
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising medium dense, brown clayey silt topsoil, moist		D	0.05			
	0.1	CLAYEY SILT - Stiff to very stiff, orange mottled grey and red clayey silt			0.15			
				D U_{50}	0.3		pp = 300	
		At 0.5m, tree roots						
	0.5	SILTSTONE - (Very low to low strength), moderately weathered, orange and grey siltstone			0.55		pp = 400	
	1			D	1.0			
		From 1.5m, (medium strength)		D	1.55			
	1.6	Pit discontinued at 1.6m, refusal						
	2							

Dynamic Penetrometer Test (blows per 150mm)



RIG: 10 tonne backhoe with 600mm bucket with teeth **LOGGED:** Fulham **SURVEY DATUM:** MGA

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from contour plan is approximate only.

☐ 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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Appendix B

Laboratory Test Results

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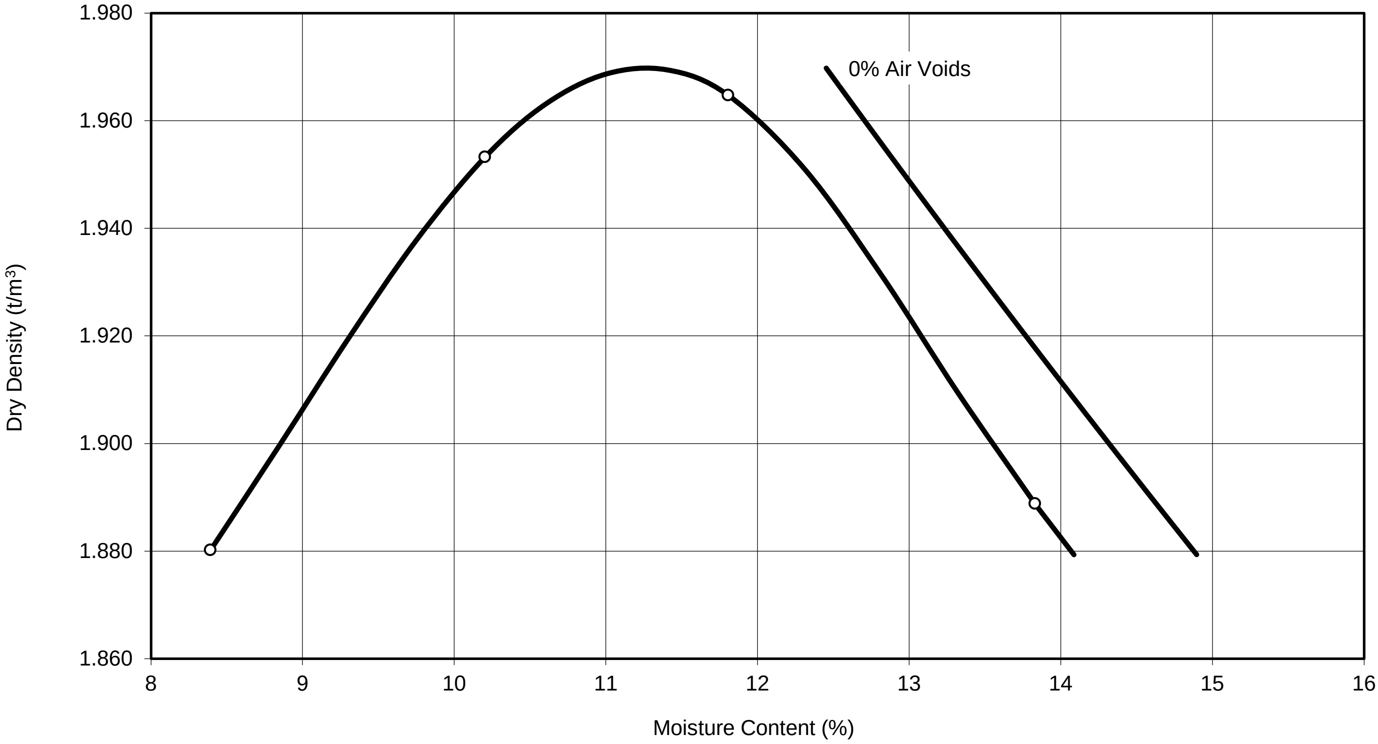
Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Results of Compaction Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_1
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
		Page:	1 of 1



Sample Details: **Location:** 2 **Particles > 19mm:** 46%

Depth: 0.9 - 1.1m

Description: SILTSTONE - Orange grey

Maximum Dry Density:	**1.97 t/m^3**
Optimum Moisture Content:	**11.5 %**

Remarks: Field Moisture Content - 8.4%

Test Methods: AS 1289.5.1.1, AS 1289.2.1.1

Sampling Methods: Sampled by DP Engineering Department

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NATA Accredited Laboratory Number: 828
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested:	JH
Checked:	NH

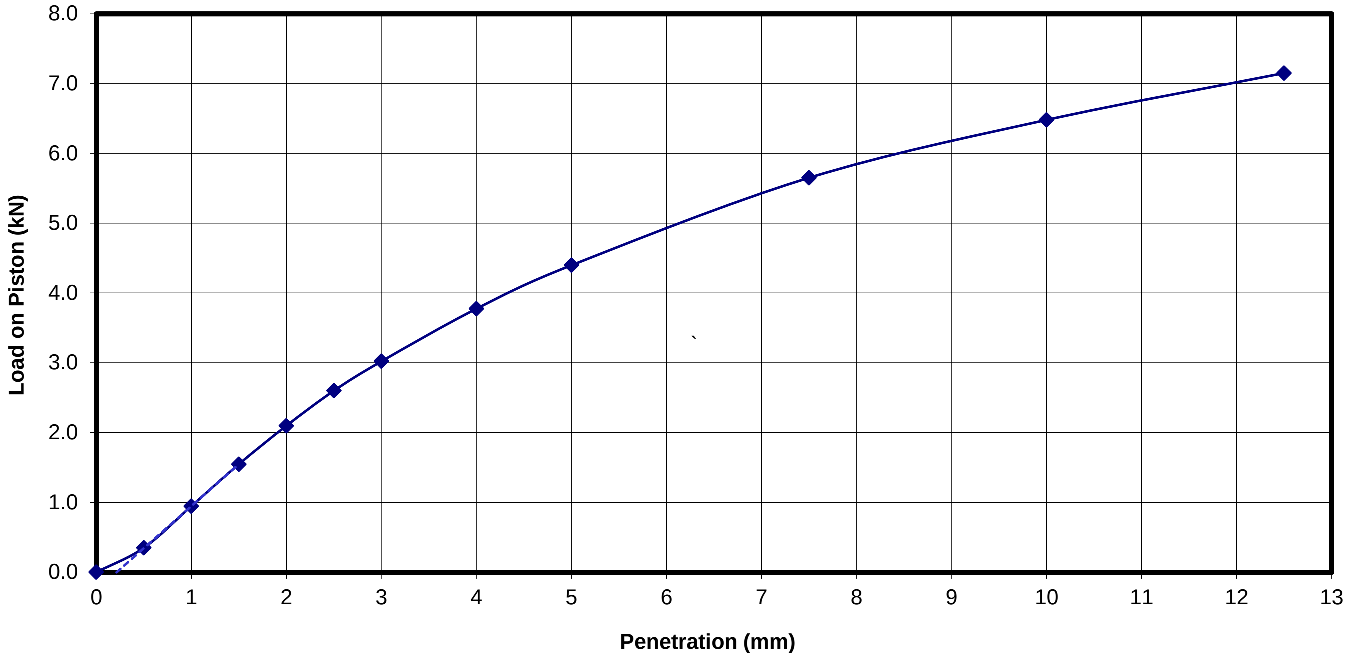
Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Regional MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of California Bearing Ratio Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_2
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	28.07.2014
Test Location :	2		
Depth / Layer :	0.9 - 1.1m	**Page:**	1 of 1



Description: SILTSTONE - Orange grey **Test Method(s):** AS 1289.6.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Remarks:

Percentage > 19mm: 46.0% (Excluded)

LEVEL OF COMPACTION: 98% of STD MDD **SURCHARGE:** 4.5 kg **SWELL:** 0.1%

MOISTURE RATIO: 100% of STD OMC **SOAKING PERIOD:** 4 days

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		11.5	1.94
After soaking		13.9	1.94
After test	Top 30mm of sample	14.1	-
	Remainder of sample	12.9	-
Field values		8.4	-
Standard Compaction		11.5	1.97

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**5.0mm**	**25**

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Tested:	JH
Checked:	NH

Nick Hardacre
Earthworks Manager

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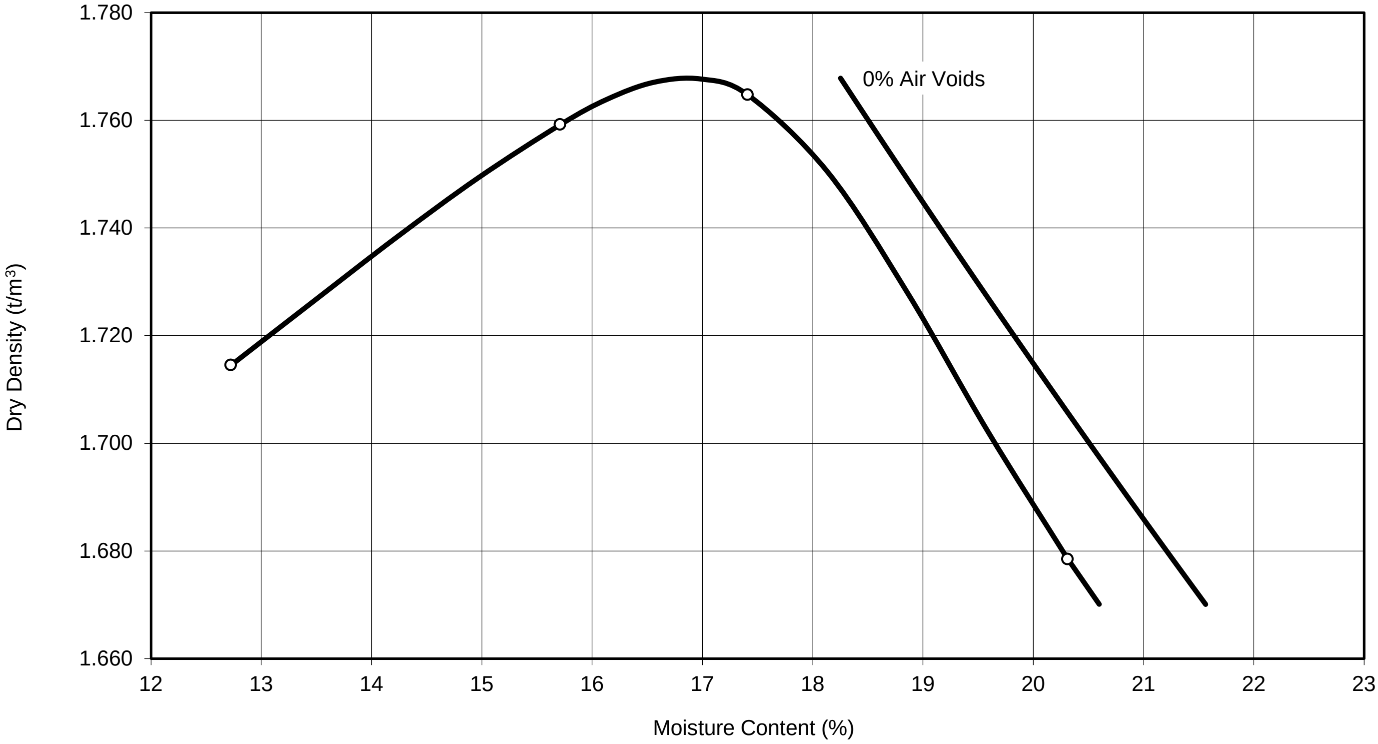
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Results of Compaction Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_3
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
		Page:	1 of 1



Sample Details: **Location:** 5 **Particles > 19mm:** 0%

Depth: 0.2 - 0.42m

Description: Silty CLAY - Grey mottled orange red

Maximum Dry Density:	**1.77 t/m^3**
Optimum Moisture Content:	**17.0 %**

Remarks: Field Moisture Content - 19.0%

Test Methods: AS 1289.5.1.1, AS 1289.2.1.1

Sampling Methods: Sampled by DP Engineering Department

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Tested:	MF
Checked:	NH

Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

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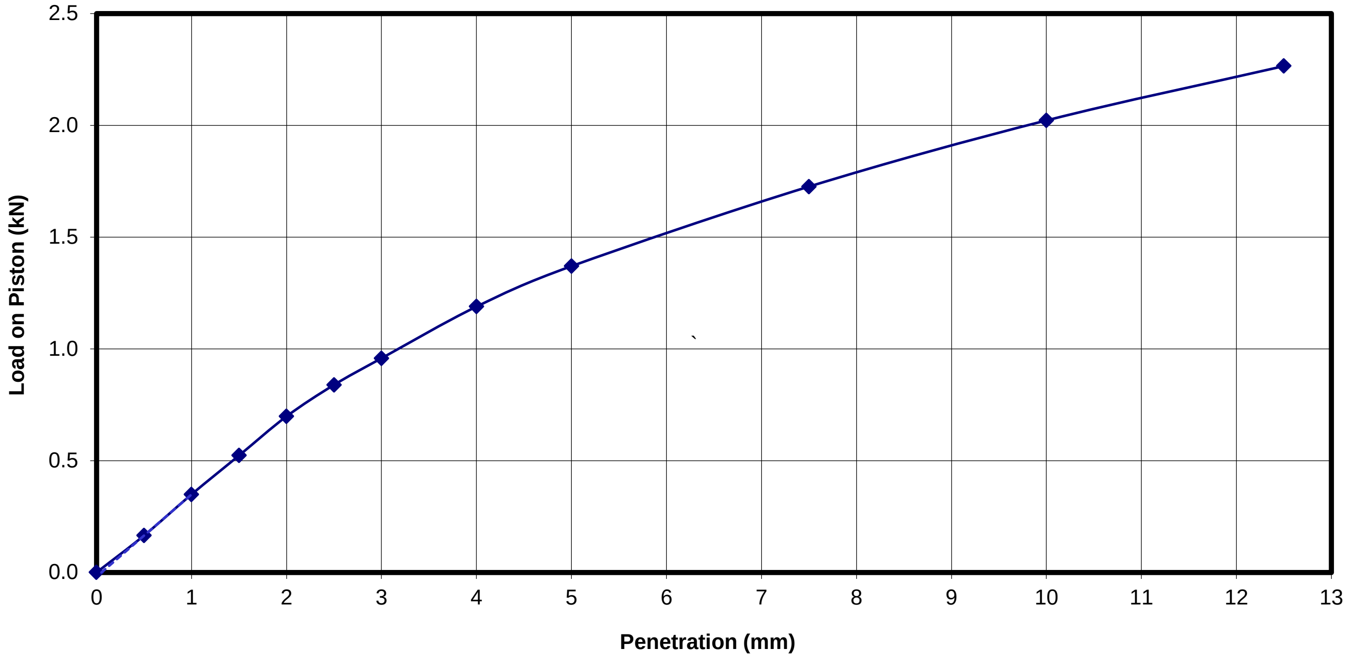
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Regional MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of California Bearing Ratio Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_4
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	28.07.2014
Test Location :	5		
Depth / Layer :	0.2 - 0.42m	**Page:**	1 of 1



Description: Silty CLAY - Grey orange red **Test Method(s):** AS 1289.6.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Remarks:

Percentage > 19mm: 0.0%

LEVEL OF COMPACTION: 101% of STD MDD **SURCHARGE:** 4.5 kg **SWELL:** 1.1%

MOISTURE RATIO: 98% of STD OMC **SOAKING PERIOD:** 4 days

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		16.6	1.78
After soaking		19.4	1.76
After test	Top 30mm of sample	20.4	-
	Remainder of sample	18.2	-
Field values		19.0	-
Standard Compaction		17.0	1.77

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**5.0mm**	**7**

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Tested:	JH
Checked:	NH

Nick Hardacre
Earthworks Manager

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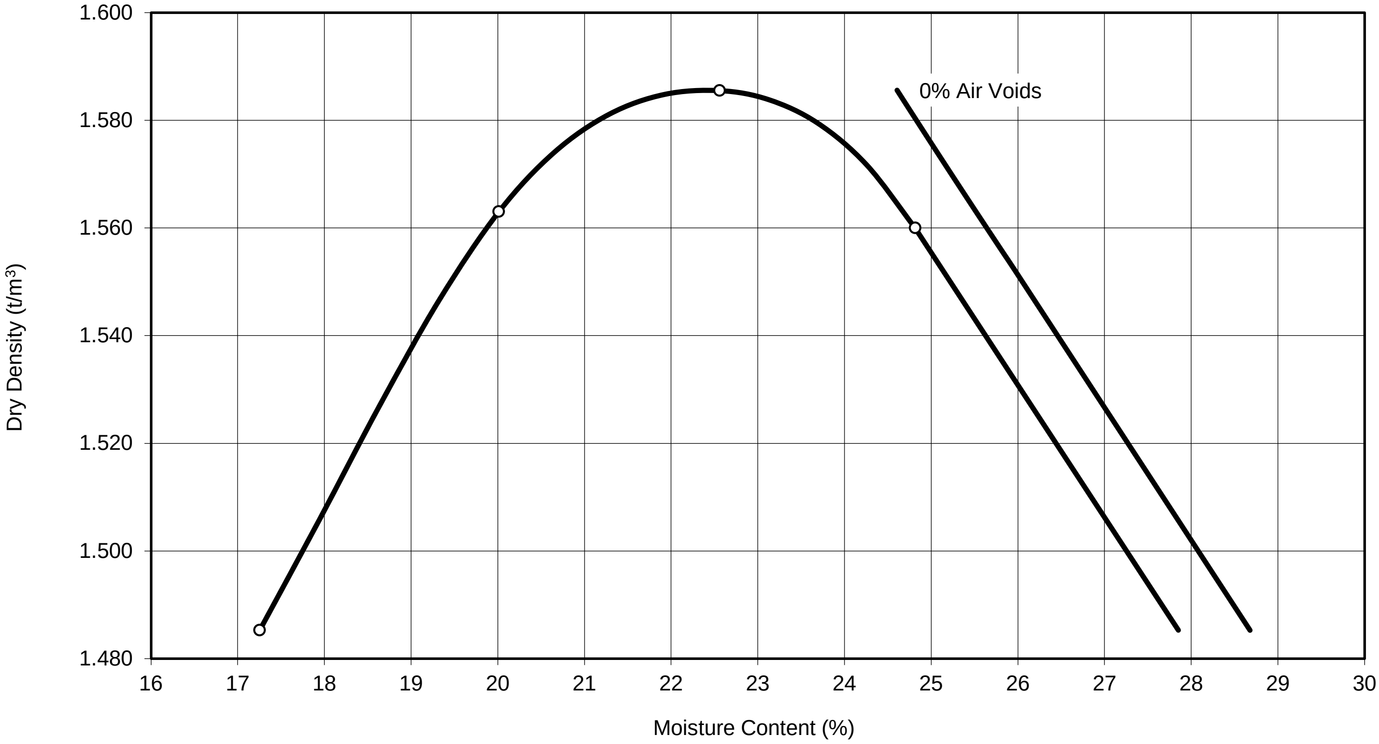
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Results of Compaction Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_5
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
Location :	Kurri Kurri / Loxford	**Date of Test:**	23.07.2014
		Page:	1 of 1



Sample Details: **Location:** 11 **Particles > 19mm:** 0%

Depth: 0.4 - 0.7m

Description: CLAY - Brown

Maximum Dry Density:	**1.59 t/m³**
Optimum Moisture Content:	**22.5 %**

Remarks: Field Moisture Content - 24.0%

Test Methods: AS 1289.5.1.1, AS 1289.2.1.1

Sampling Methods: Sampled by DP Engineering Department

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Tested:	JH
Checked:	NH

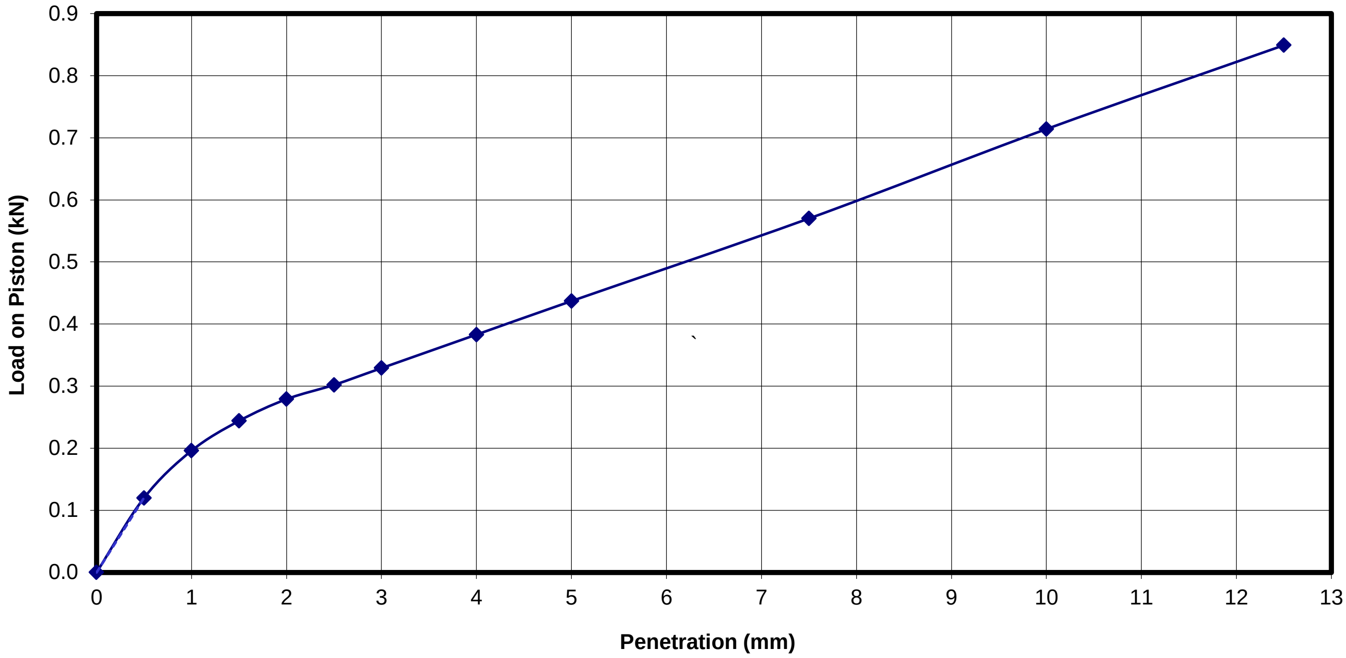
Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Regional MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of California Bearing Ratio Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_6
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	28.07.2014
Test Location :	11		
Depth / Layer :	0.4 -0.7m	**Page:**	1 of 1



Description: CLAY - Brown

Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Remarks:

Percentage > 19mm: 0.0%

LEVEL OF COMPACTION: 100% of STD MDD
MOISTURE RATIO: 101% of STD OMC

SURCHARGE: 4.5 kg
SOAKING PERIOD: 4 days

SWELL: 2.2%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m³
At compaction		22.8	1.58
After soaking		25.8	1.55
After test	Top 30mm of sample	30.8	-
	Remainder of sample	23.5	-
Field values		24.0	-
Standard Compaction		22.5	1.59

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**2.5mm**	**2.5**

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NATA Accredited Laboratory Number: 828

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Tested:	JH
Checked:	NH

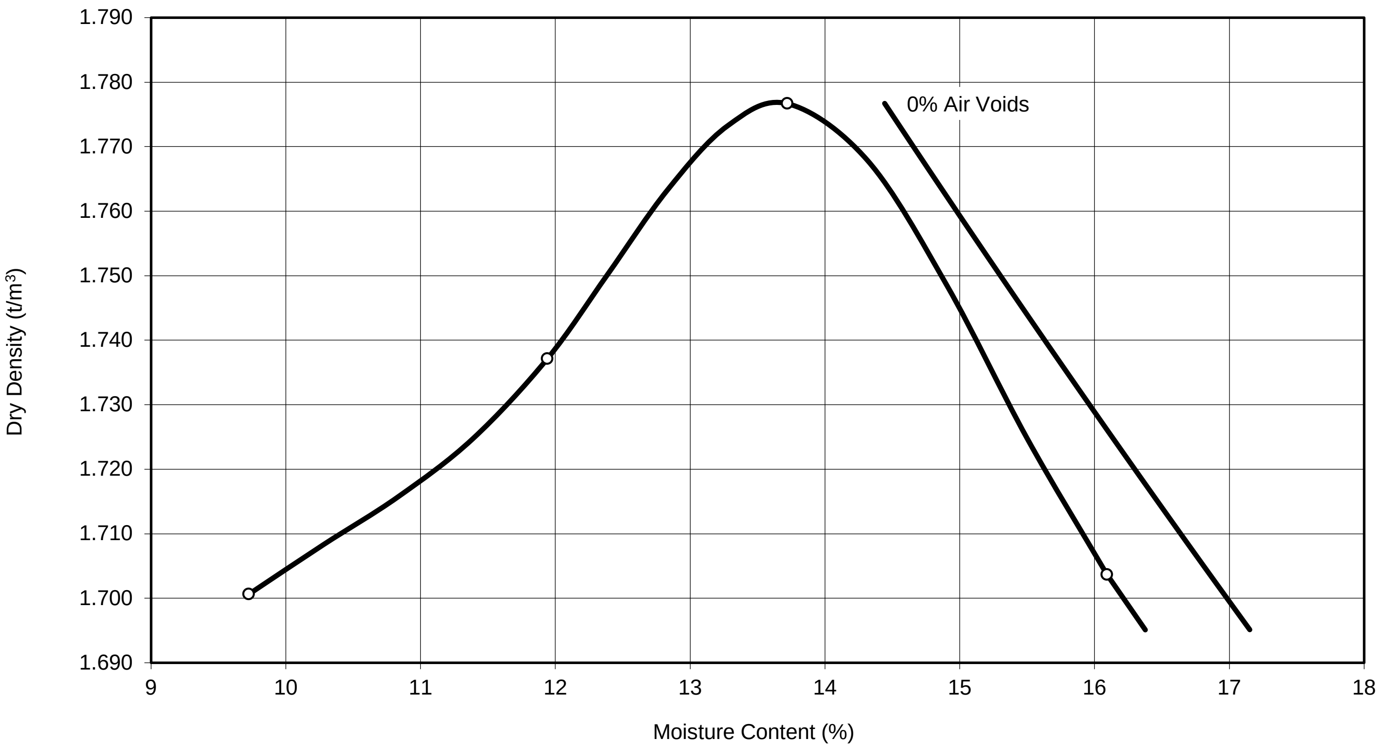
Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics | Environment | Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Results of Compaction Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_7
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
		Page:	1 of 1



Sample Details: **Location:** 16 **Particles > 19mm:** 0%

Depth: 0.05 - 0.4m

Description: SILT - Brown

Maximum Dry Density:	**1.78 t/m^3**
Optimum Moisture Content:	**13.5 %**

Remarks: Field Moisture Content - 9.7%

Test Methods: AS 1289.5.1.1, AS 1289.2.1.1

Sampling Methods: Sampled by DP Engineering Department

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Checked:	NH

Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

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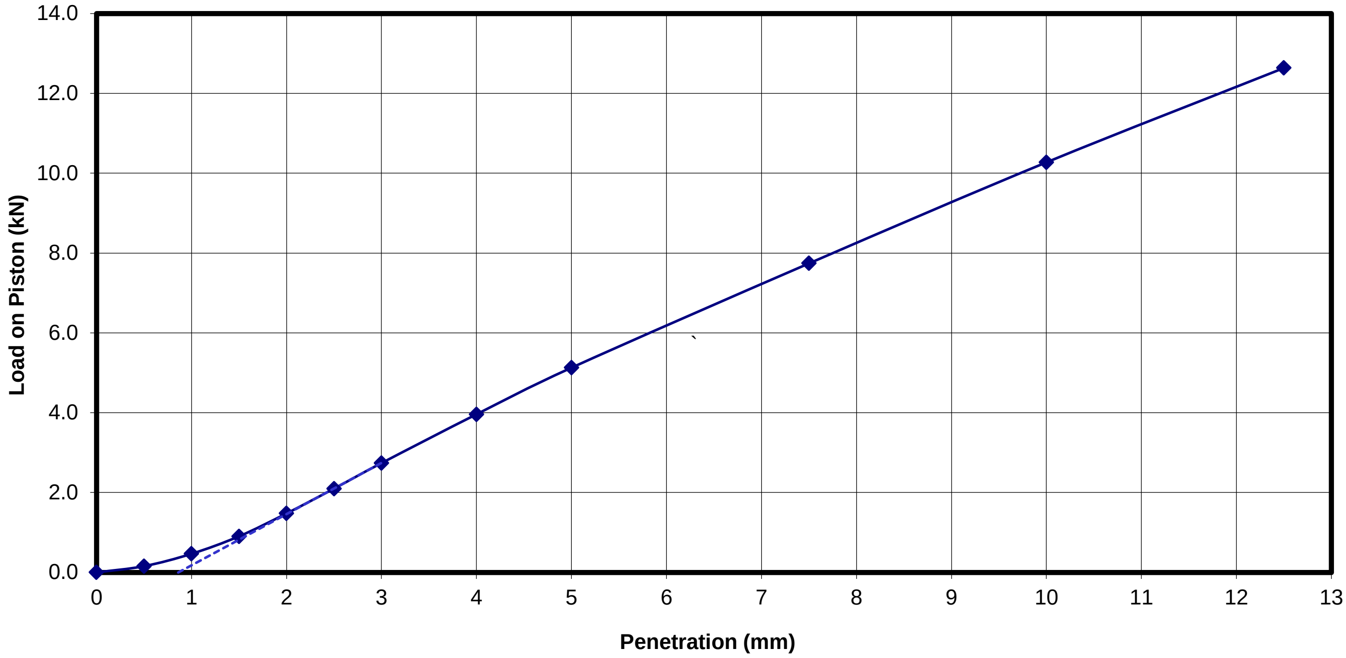
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Regional MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of California Bearing Ratio Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_8
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	28.07.2014
Test Location :	16		
Depth / Layer :	0.05 - 0.4m	**Page:**	1 of 1



Description: SILT - Brown

Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Remarks:

Percentage > 19mm: 0.0%

LEVEL OF COMPACTION: 100% of STD MDD
MOISTURE RATIO: 101% of STD OMC

SURCHARGE: 4.5 kg
SOAKING PERIOD: 4 days

SWELL: -0.2%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		13.6	1.78
After soaking		15.6	1.79
After test	Top 30mm of sample	15.2	-
	Remainder of sample	14.9	-
Field values		9.7	-
Standard Compaction		13.5	1.78

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**5.0mm**	**30**

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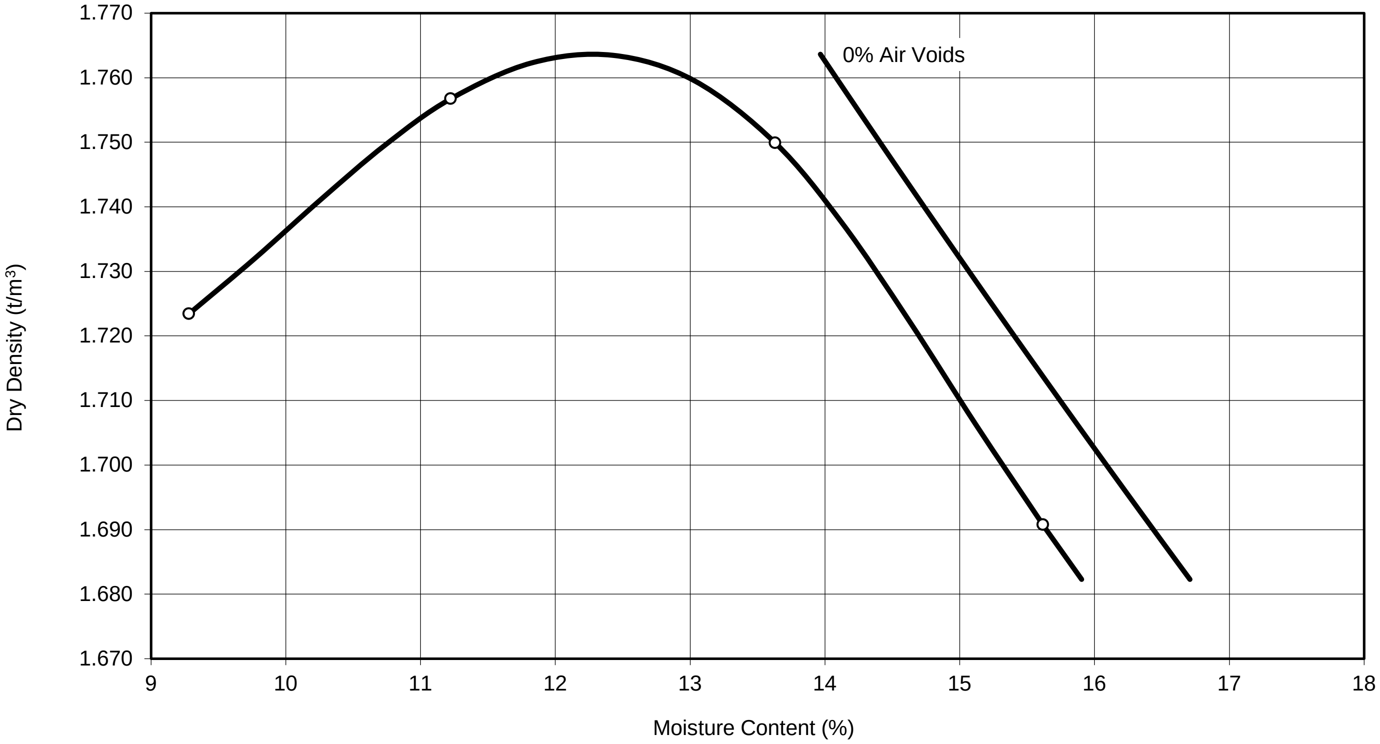
Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics | Environment | Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Results of Compaction Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_9
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
		Page:	1 of 1



Sample Details: **Location:** 27 **Particles > 19mm:** 0%
Depth: 0.5 - 0.8m

Description: Silty SAND - Brown

Maximum Dry Density:	**1.76 t/m^3**
Optimum Moisture Content:	**12.5 %**

Remarks: Field Moisture Content - 11.2%

Test Methods: AS 1289.5.1.1, AS 1289.2.1.1

Sampling Methods: Sampled by DP Engineering Department

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Checked:	NH

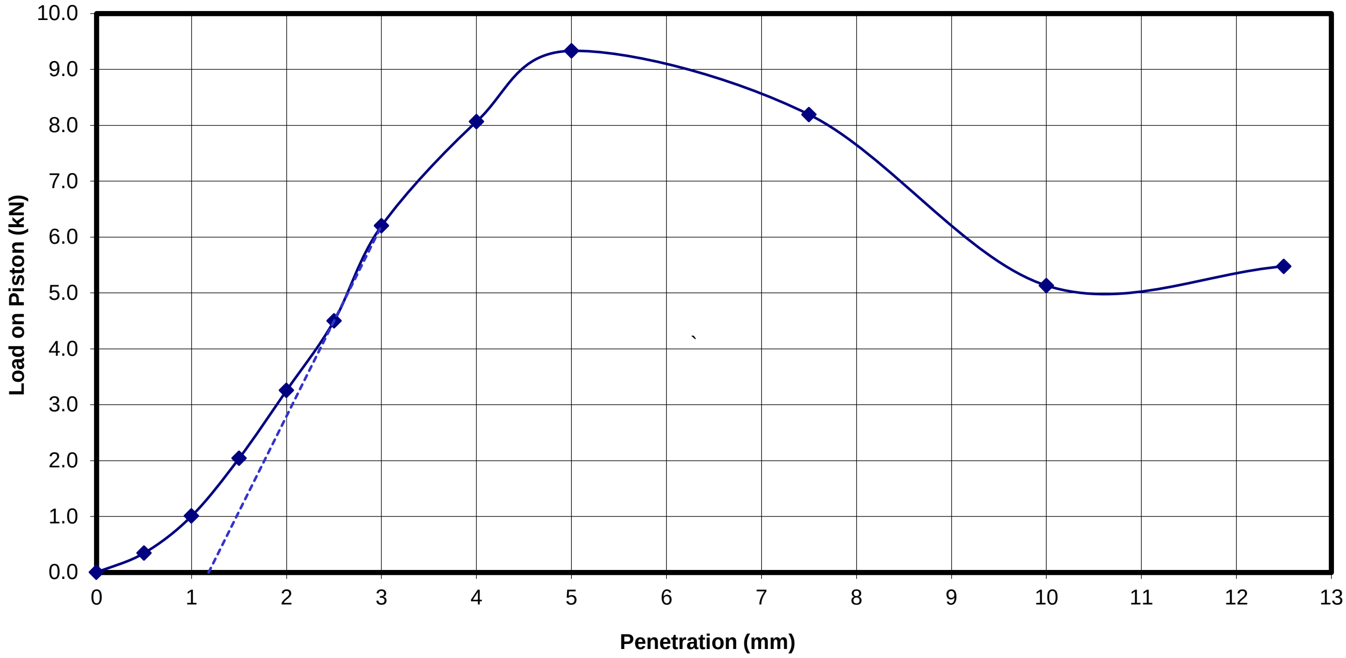
Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Regional MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of California Bearing Ratio Test

Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520
		Report No. :	N14-278_10
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	28.07.2014
Test Location :	27		
Depth / Layer :	0.5 - 0.8m	**Page:**	1 of 1



Description: Silty SAND - Brown

Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Remarks:

Percentage > 19mm: 0.0%

LEVEL OF COMPACTION: 100% of STD MDD

MOISTURE RATIO: 98% of STD OMC

SURCHARGE: 4.5 kg

SOAKING PERIOD: 4 days

SWELL: -0.1%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		12.2	1.76
After soaking		14.7	1.76
After test	Top 30mm of sample	14.7	-
	Remainder of sample	14.2	-
Field values		11.2	-
Standard Compaction		12.5	1.76

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**2.5mm**	**60**

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Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

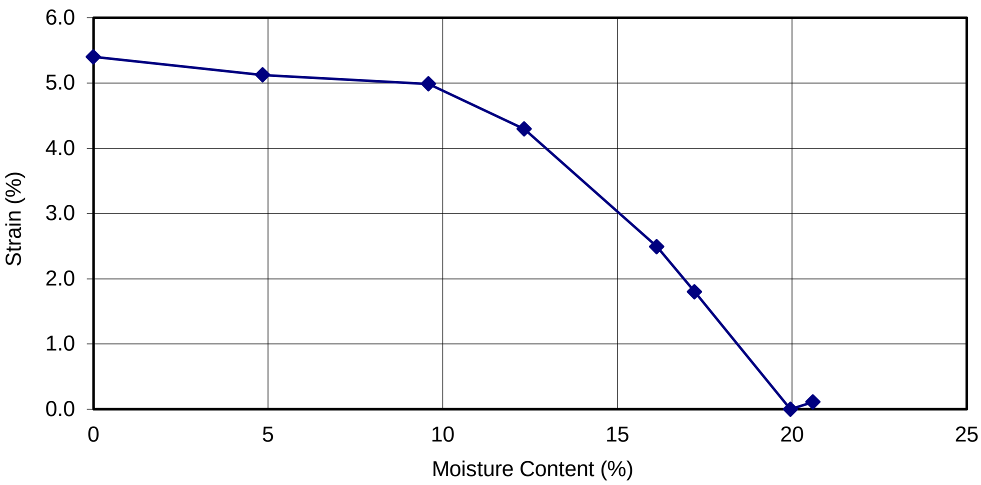
Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520.00
		Report No. :	N14-278_11
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	21.07.2014
Test Location :	5		
Depth / Layer :	0.3 - 0.42m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	5.1 %
Shrinkage - oven dried	5.4 %
Significant inert inclusions	Nil %
Extent of cracking	SC
Extent of soil crumbling	Nil %
Moisture content of core	20.0 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	150 kPa
Pocket penetrometer reading at final moisture content	120 kPa
Initial Moisture Content	18.8 %
Final Moisture Content	20.6 %
Swell under 25kPa	-0.1 %



SHRINK-SWELL INDEX Iss 3.0% per Δ pF

Description:	Silty CLAY - Grey mottled orange	
Test Method(s):	AS 1289.7.1.1, AS 1289.2.1.1	
Sampling Method(s):	Sampled by DP Engineering Department	
Extent of Cracking:	**UC** - Uncracked	**HC** - Highly cracked
	SC - Slightly cracked	**FR** - Fractured
	MC - Moderately cracked	

Remarks:

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the performance of pocket penetrometer readings

NATA Accredited Laboratory Number: 828

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Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

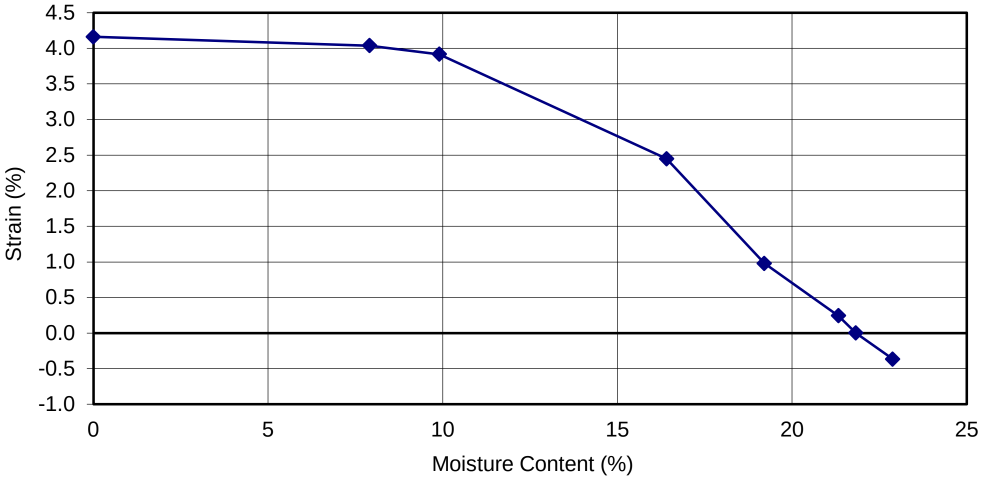
Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520.00
		Report No. :	N14-278_12
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
Test Location :	6A		
Depth / Layer :	0.45 - 0.85m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	4.0 %
Shrinkage - oven dried	4.2 %
Significant inert inclusions	Nil %
Extent of cracking	SC
Extent of soil crumbling	Nil %
Moisture content of core	21.8 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	270 kPa
Pocket penetrometer reading at final moisture content	220 kPa
Initial Moisture Content	18.9 %
Final Moisture Content	22.9 %
Swell under 25kPa	0.4 %



SHRINK-SWELL INDEX Iss 2.4% per Δ pF

Description:	Silty CLAY - Orange mottled light grey
Test Method(s):	AS 1289.7.1.1, AS 1289.2.1.1
Sampling Method(s):	Sampled by DP Engineering Department

Extent of Cracking:

UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover the performance of pocket penetrometer readings

NATA Accredited Laboratory Number: 828

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Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

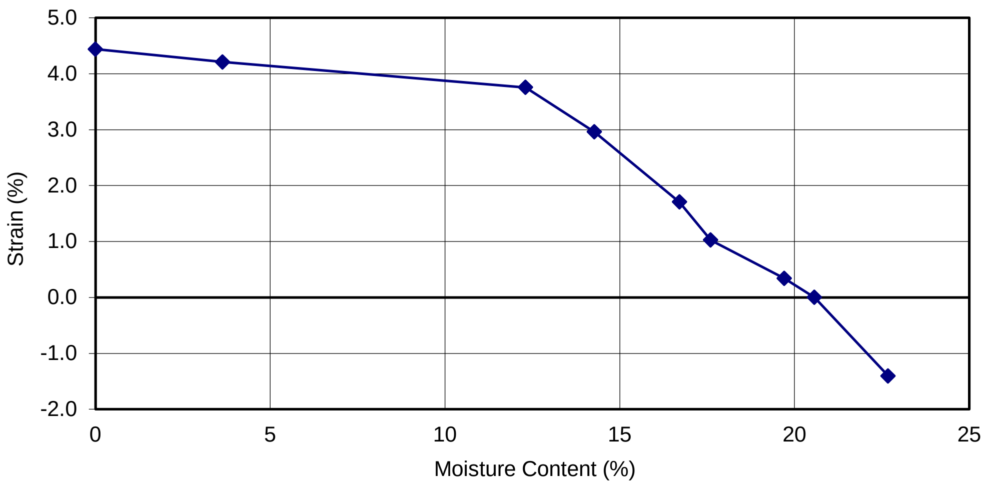
Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520.00
		Report No. :	N14-278_13
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
Test Location :	8		
Depth / Layer :	0.6 - 1.0m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	4.2 %
Shrinkage - oven dried	4.4 %
Significant inert inclusions	Nil %
Extent of cracking	SC
Extent of soil crumbling	Nil %
Moisture content of core	20.6 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	160 kPa
Pocket penetrometer reading at final moisture content	120 kPa
Initial Moisture Content	22.2 %
Final Moisture Content	22.7 %
Swell under 25kPa	1.4 %



SHRINK-SWELL INDEX Iss 2.9% per Δ pF

Description:	Silty CLAY - Light grey mottled orange
Test Method(s):	AS 1289.7.1.1, AS 1289.2.1.1
Sampling Method(s):	Sampled by DP Engineering Department

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

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Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

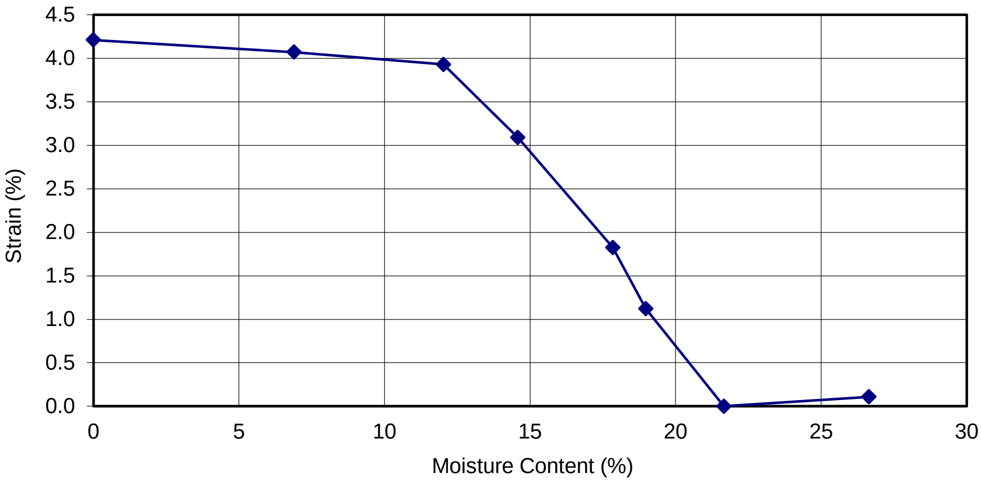
Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520.00
		Report No. :	N14-278_14
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	21.07.2014
Test Location :	10		
Depth / Layer :	0.3 - 0.6m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	4.1 %
Shrinkage - oven dried	4.2 %
Significant inert inclusions	5.0 %
Extent of cracking	SC
Extent of soil crumbling	5.0 %
Moisture content of core	21.7 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	290 kPa
Pocket penetrometer reading at final moisture content	120 kPa
Initial Moisture Content	17.8 %
Final Moisture Content	26.6 %
Swell under 25kPa	-0.1 %



SHRINK-SWELL INDEX Iss 2.3% per Δ pF

Description: CLAY - Brown

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

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Tested: NH
Checked: NH

Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

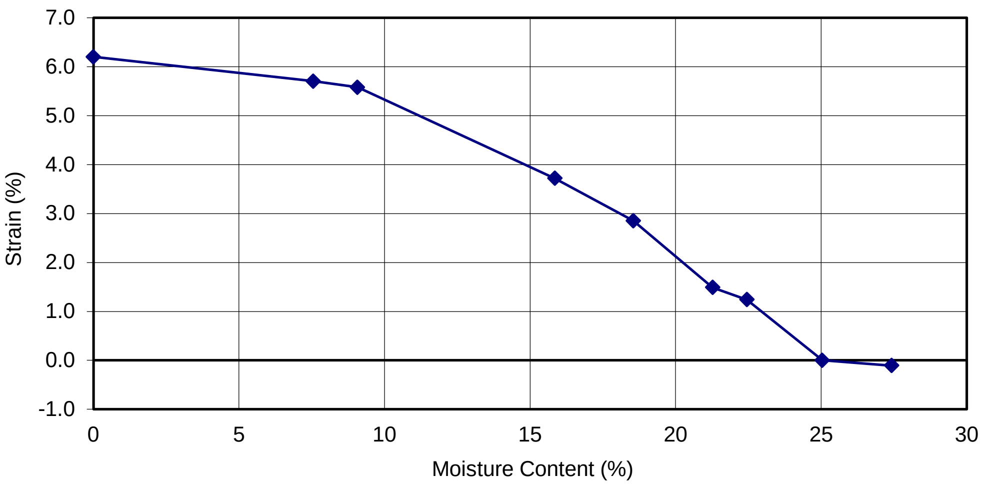
Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520.00
		Report No. :	N14-278_15
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	21.07.2014
Test Location :	14		
Depth / Layer :	0.35 - 0.75m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	5.7 %
Shrinkage - oven dried	6.2 %
Significant inert inclusions	Nil %
Extent of cracking	UC
Extent of soil crumbling	Nil %
Moisture content of core	25.0 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	140 kPa
Pocket penetrometer reading at final moisture content	50 kPa
Initial Moisture Content	24.2 %
Final Moisture Content	27.4 %
Swell under 25kPa	0.1 %



SHRINK-SWELL INDEX Iss 3.5% per Δ pF

Description: CLAY - Brown

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Extent of Cracking:
- **UC** - Uncracked
- **SC** - Slightly cracked
- **MC** - Moderately cracked
- **HC** - Highly cracked
- **FR** - Fractured

Remarks:

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Nick Hardacre
Earthworks Manager

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

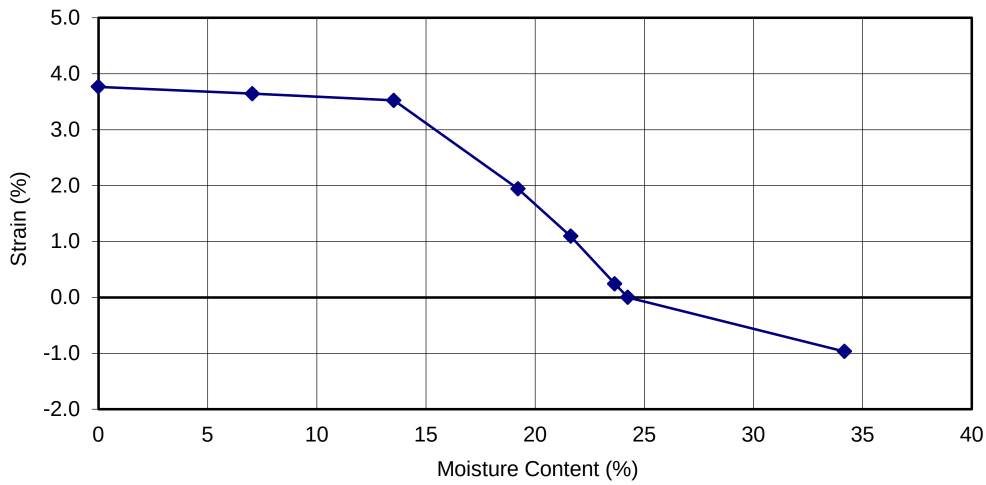
Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520.00
		Report No. :	N14-278_16
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
Test Location :	23		
Depth / Layer :	0.45 - 0.85m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	3.6 %
Shrinkage - oven dried	3.8 %
Significant inert inclusions	Nil %
Extent of cracking	SC
Extent of soil crumbling	Nil %
Moisture content of core	24.3 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	520 kPa
Pocket penetrometer reading at final moisture content	200 kPa
Initial Moisture Content	27.4 %
Final Moisture Content	34.2 %
Swell under 25kPa	1.0 %



SHRINK-SWELL INDEX Iss 2.4% per Δ pF

Description: CLAY, slightly silty - Red brown

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

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Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

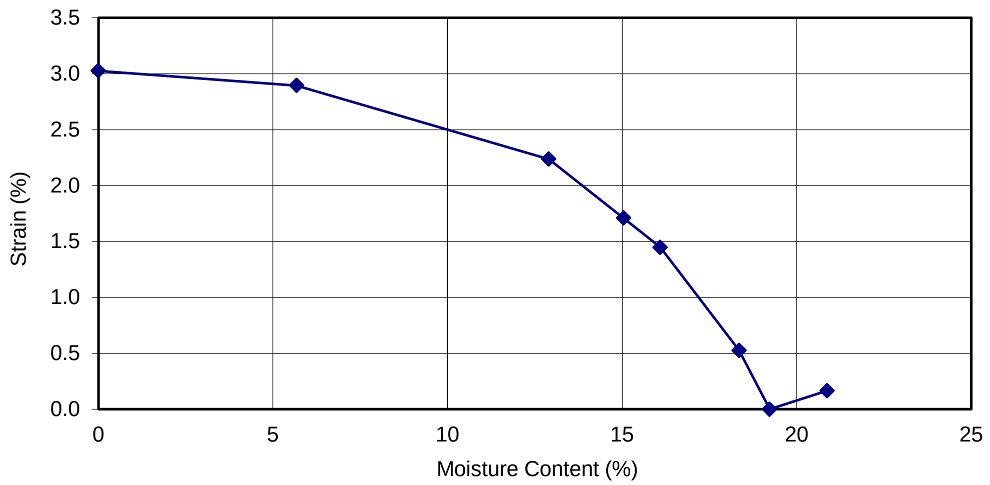
Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520.00
		Report No. :	N14-278_17
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
Test Location :	25		
Depth / Layer :	0.5 - 0.9m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	2.9 %
Shrinkage - oven dried	3.0 %
Significant inert inclusions	Nil %
Extent of cracking	SC
Extent of soil crumbling	Nil %
Moisture content of core	19.2 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	100 kPa
Pocket penetrometer reading at final moisture content	110 kPa
Initial Moisture Content	20.9 %
Final Moisture Content	20.9 %
Swell under 25kPa	-0.2 %



SHRINK-SWELL INDEX Iss 1.7% per Δ pF

Description:	Clayey SILT / Silty CLAY - Grey orange
Test Method(s):	AS 1289.7.1.1, AS 1289.2.1.1
Sampling Method(s):	Sampled by DP Engineering Department

Extent of Cracking:

UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

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Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

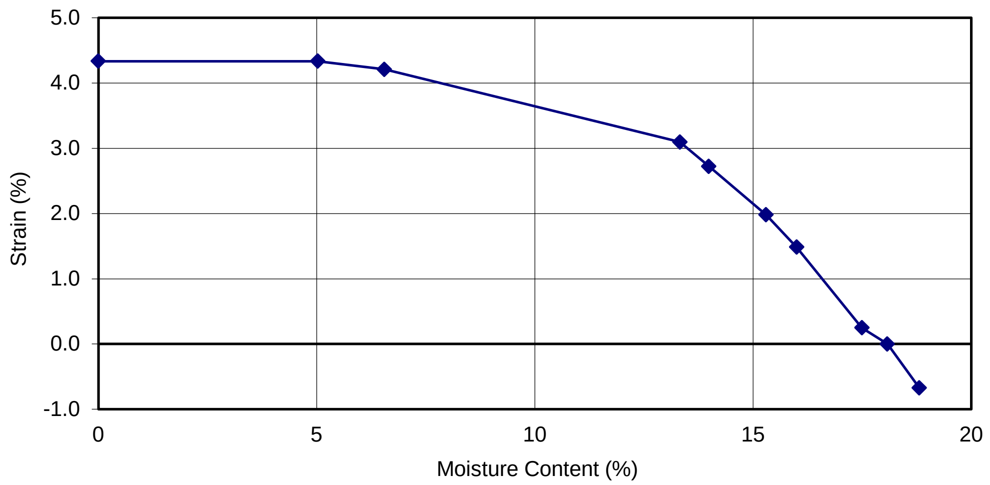
Client :	Hydro Aluminium Kurri Kurri Pty Ltd	**Project No. :**	81520.00
		Report No. :	N14-278_18
Project :	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date :**	30.07.2014
		Date Sampled :	14-16.07.14
Location :	Kurri Kurri / Loxford	**Date of Test:**	22.07.2014
Test Location :	30		
Depth / Layer :	0.15 - 0.55m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	4.3 %
Shrinkage - oven dried	4.3 %
Significant inert inclusions	Nil %
Extent of cracking	UC
Extent of soil crumbling	Nil %
Moisture content of core	18.1 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	580 kPa
Pocket penetrometer reading at final moisture content	420 kPa
Initial Moisture Content	15.6 %
Final Moisture Content	18.8 %
Swell under 25kPa	0.7 %



SHRINK-SWELL INDEX Iss 2.6% per Δ pF

Description: Clayey SILT - Orange mottled grey and red

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by DP Engineering Department

Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover
the performance of pocket penetrometer readings

NATA ACCREDITED FOR TECHNICAL COMPETENCE

NATA Accredited Laboratory Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested:	NH
Checked:	NH

Nick Hardacre
Earthworks Manager

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Regional MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Results of Moisture Content, Plasticity and Linear Shrinkage Tests

Client:	**Hydro Aluminium Kurri Kurri Pty Ltd**	**Project No:**	81520
		Report No:	N14-278_19
Project:	Hydro Aluminium Kurri Kurri Redevelopment	**Report Date:**	30.07.2014
		Date Sampled:	14-16.07.14
		Date of Test:	25.07.2014
Location:	Kurri Kurri / Loxford	**Page:**	1 of 1

Test Location	Depth (m)	Description	Code	W_F %	W_L %	W_P %	PI %	*LS %
5	0.2 – 0.42	Silty CLAY – Grey mottled orange red	2,5	19.0	50	19	31	-
6A	0.45 – 0.85	Silty CLAY – Orange mottled light grey	2,5	19.8	67	18	49	-
8	0.6 – 1.0	Silty CLAY – Light grey mottled orange	2,5	22.6	74	17	57	-
11	0.4 – 0.7	CLAY – Brown	2,5	24.0	67	18	49	-
16	0.05 – 0.4	SILT – Brown	2,5	9.7	19	18	1	-
23	0.45 – 0.85	CLAY, slightly silty – Red brown	2,5	22.7	88	22	66	-
25	0.5 – 0.9	Clayey SILT / Silty CLAY – Grey orange	2,5	22.5	45	15	30	-

Legend:
W_F Field Moisture Content
W_L Liquid limit
W_P Plastic limit
PI Plasticity index
LS Linear shrinkage from liquid limit condition (Mould length125mm)

Test Methods:
Moisture Content: AS 1289 2.1.1
Liquid Limit: AS 1289 3.1.2
Plastic Limit: AS 1289 3.2.1
Plasticity Index: AS 1289 3.3.1

Code:
Sample history for plasticity tests
1. Air dried
2. Low temperature (<50ºC) oven dried
3. Oven (105ºC) dried
4. Unknown

Method of preparation for plasticity tests
5. Dry sieved
6. Wet sieved
7. Natural

Sampling Methods: Sampled by DP Engineering Department

Remarks:

NATA Accredited Laboratory Number: 828
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Tested: MF
Checked: NH

Nick Hardacre
Earthworks Manager

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15 Callistemon Close
Warabrook NSW 2304
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Hunter Regional MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Results of Moisture Content, Plasticity and Linear Shrinkage Tests

Client: **Hydro Aluminium Kurri Kurri Pty Ltd**

Project: Hydro Aluminium Kurri Kurri Redevelopment

Location: Kurri Kurri / Loxford

Project No: 81520
Report No: N14-278_20
Report Date: 30.07.2014

Date Sampled: 14-16.07.14
Date of Test: 25.07.2014
Page: 1 of 1

Test Location	Depth (m)	Description	Code	W_F %	W_L %	W_P %	PI %	*LS %
27	0.5 – 0.8	Silty SAND – Brown	2,5	11.2	-	-	NP	-
30	0.15 – 0.55	Clayey SILT – Orange mottled grey and red	2,5	15.9	65	18	47	-

Legend:
W_F Field Moisture Content
W_L Liquid limit
W_P Plastic limit
PI Plasticity index
LS Linear shrinkage from liquid limit condition (Mould length125mm)

Test Methods:
Moisture Content: AS 1289 2.1.1
Liquid Limit: AS 1289 3.1.2
Plastic Limit: AS 1289 3.2.1
Plasticity Index: AS 1289 3.3.1

Code:
Sample history for plasticity tests
1. Air dried
2. Low temperature (<50ºC) oven dried
3. Oven (105ºC) dried
4. Unknown

Method of preparation for plasticity tests
5. Dry sieved
6. Wet sieved
7. Natural

Sampling Methods: Sampled by DP Engineering Department

Remarks: NP denotes non-plastic

NATA Accredited Laboratory Number: 828

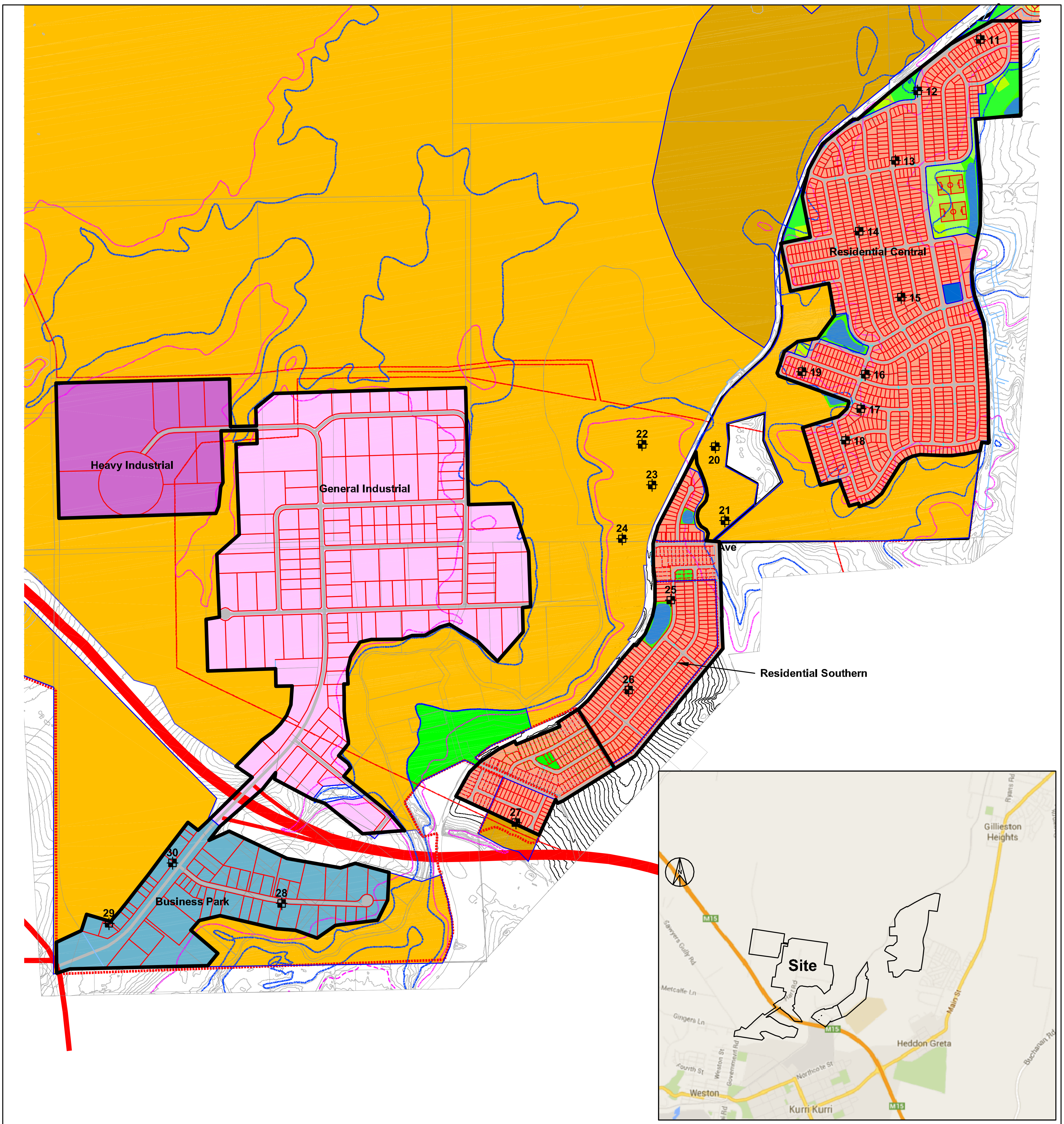
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

Tested: MF
Checked: NH

Nick Hardacre
Earthworks Manager

Appendix C

Drawing 1 – Site Overview and Test Location Plan
Drawing 2 – Site Geology
Drawing 3 to 7 – Site Observations



Locality Plan

LEGEND

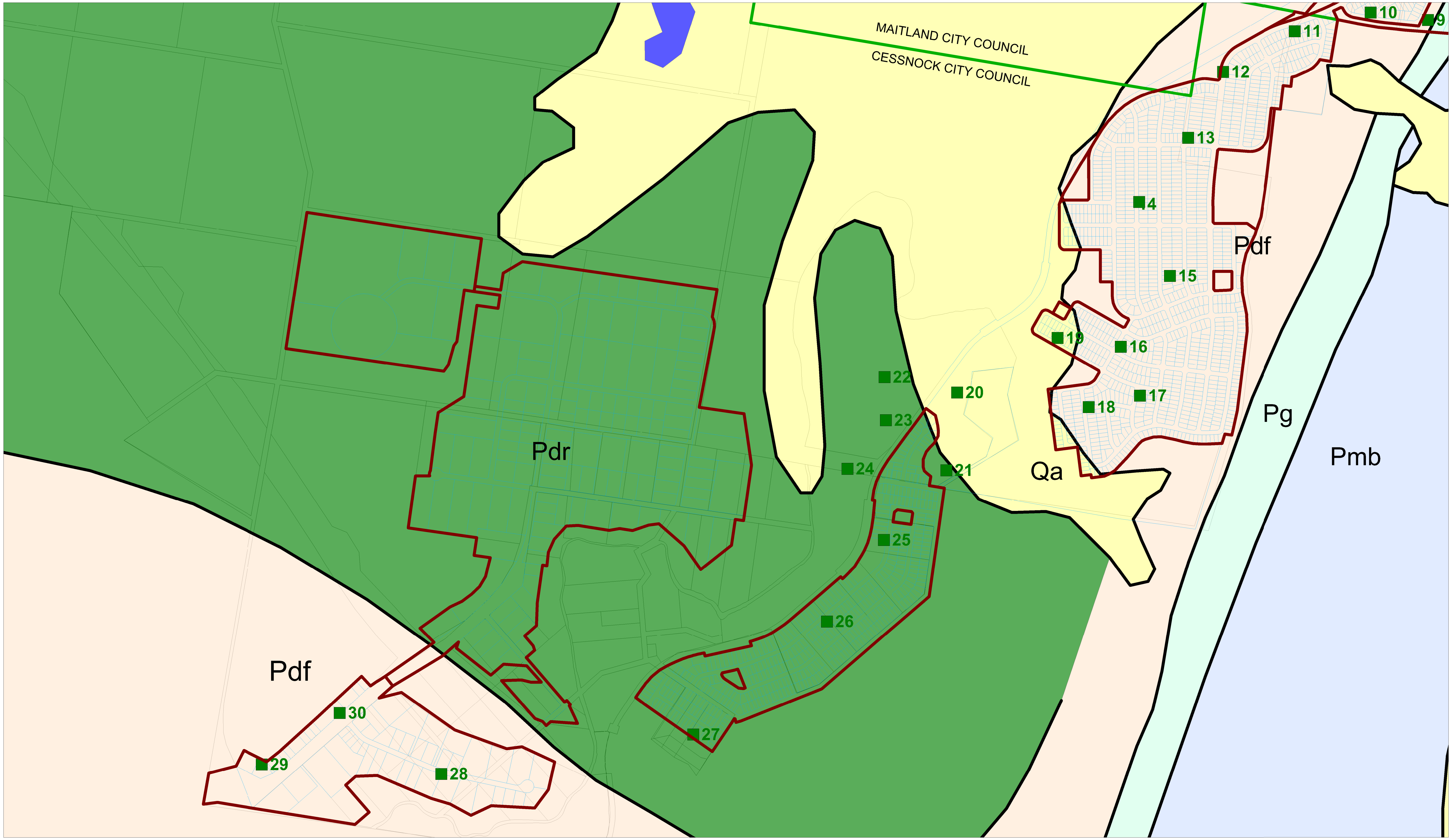
- Approximate Test Pit Location
- Approximate Site Extents
- Proposed Open Spaces
- Residential
- Neighbourhood Centre
- Business Park
- General Industrial
- Heavy Industrial

NOTE: Base drawing from plans by Monteath & Powys Pty Ltd, Ref 13119 Base Plan 03-Dec-2014.dwg

0 100 200 300 400 500 750 100m

1:10,000 @ A3

Douglas Partners Geotechnics / Environment / Groundwater	TITLE: **Site Overview & Test Location Plan** **Proposed Residential Rezoning Area** **Hydro Aluminium, Loxford**		OFFICE: Newcastle
			DRAWN BY: PLH
			DATE: 06.03.2015
CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd	PROJECT No: 81520.R.002	DRAWING No: 1	REVISION: 0	SCALE: As shown



LEGEND:

Site Extents

Local Government Area Boundary

Approximate Test Pit Location

GEOLOGY LEGEND

Branxton Formation (Pmb)

Greta Coal Measures (Pg)

Farley Formation (Pdf)

Rutherford Formation (Pdr)

Quaternary Alluvium (Qa)

81520.R.002.Drawing.2

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd		TITLE: Geologic Map Proposed Rezoning Loxford	PROJECT No: 81520
OFFICE: Newcastle	DRAWN BY: JAW		DRAWING No: 2
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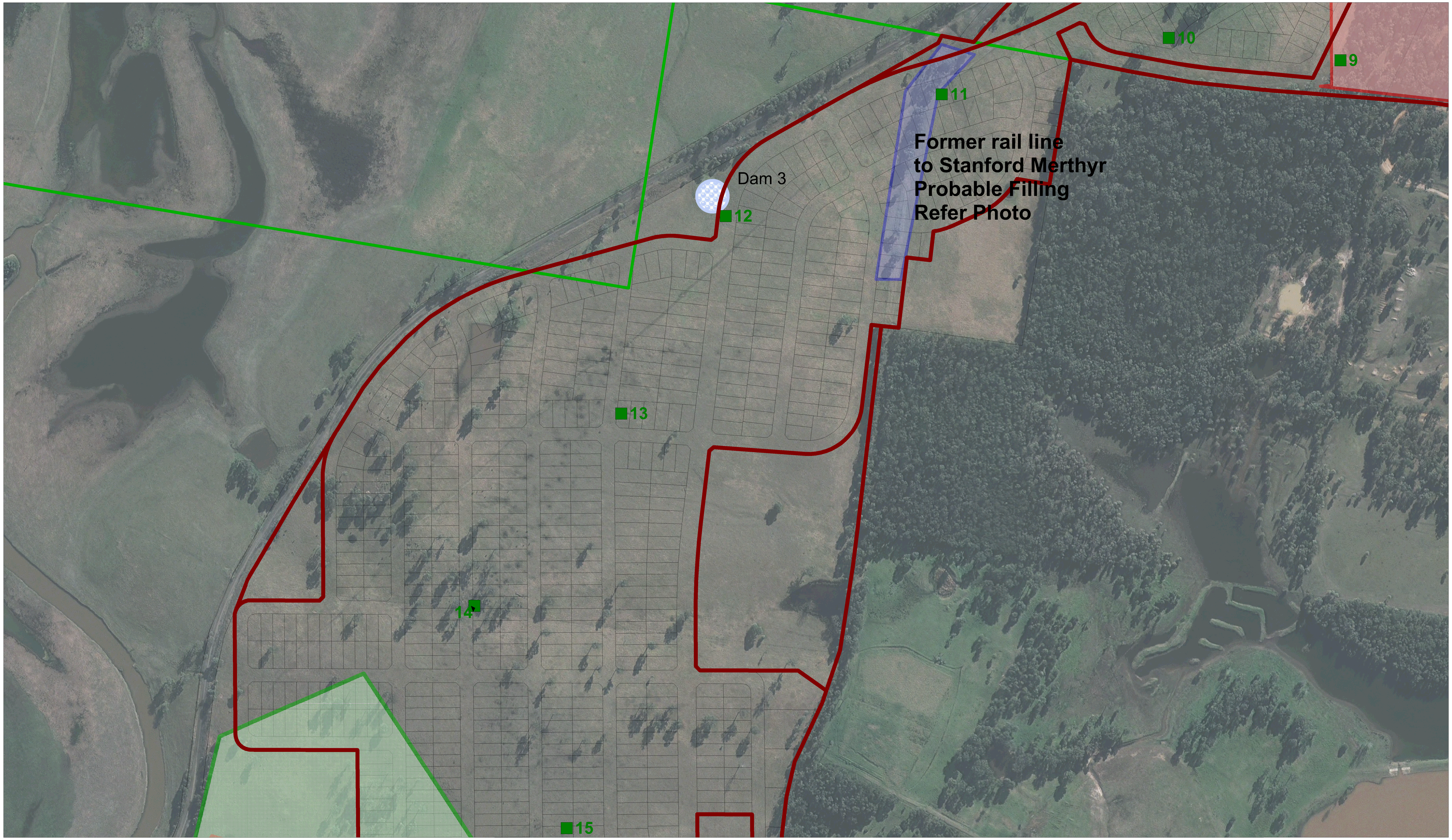

LEGEND:

Site Extents

Local Government Area Boundary

Approximate Test Pit Location

General Areas of Observed Filling or Possible Filling

Area of Observed Steeper Land

Approximate location of dam and assigned number (refer text of report)

81520.R.002.Drawing.3

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd		TITLE: Site Observations Proposed Rezoning Loxford	PROJECT No: 81520
OFFICE: Newcastle	DRAWN BY: JAW		DRAWING No: 3
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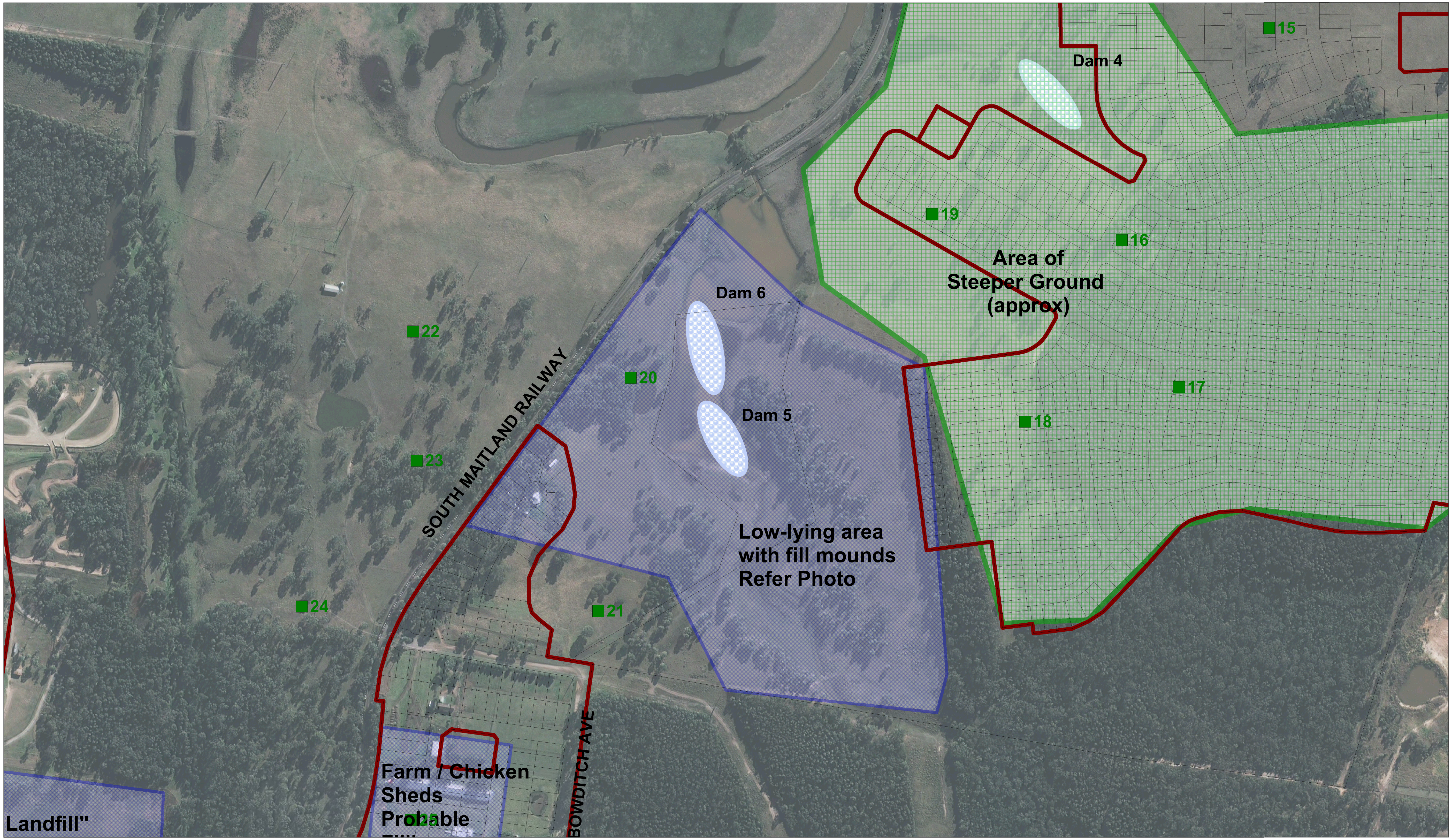

LEGEND:

- Site Extents
- Local Government Area Boundary
- Approximate Test Pit Location
- General Areas of Observed Filling or Possible Filling
- Area of observed steeper land
- Approximate Location of dam and assigned number (refer text of report)

81520.R.002.Drawing.4

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd		TITLE: Site Observations Proposed Rezoning Loxford	PROJECT No: 81520
OFFICE: Newcastle	DRAWN BY: JAW		DRAWING No: 4
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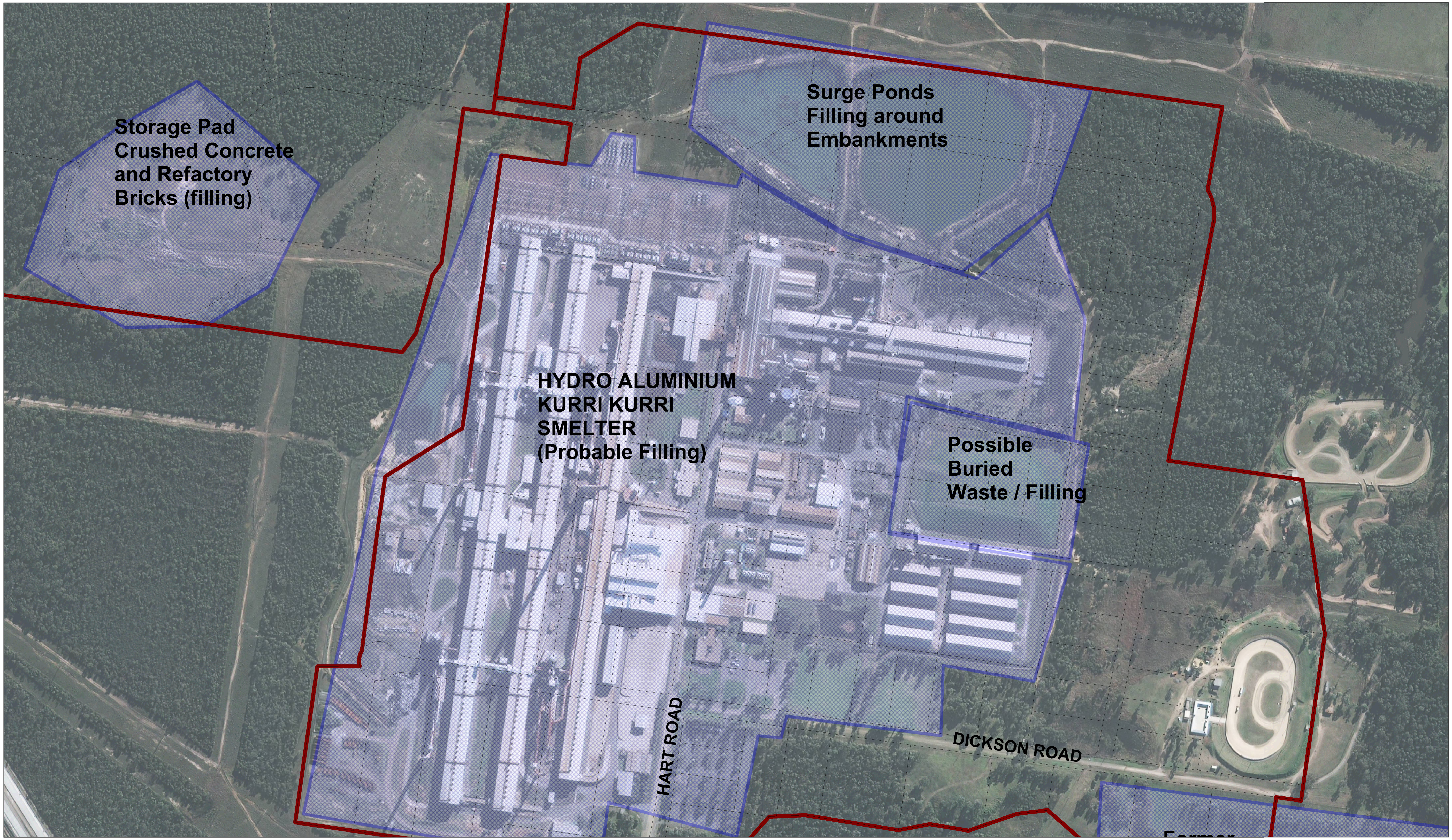
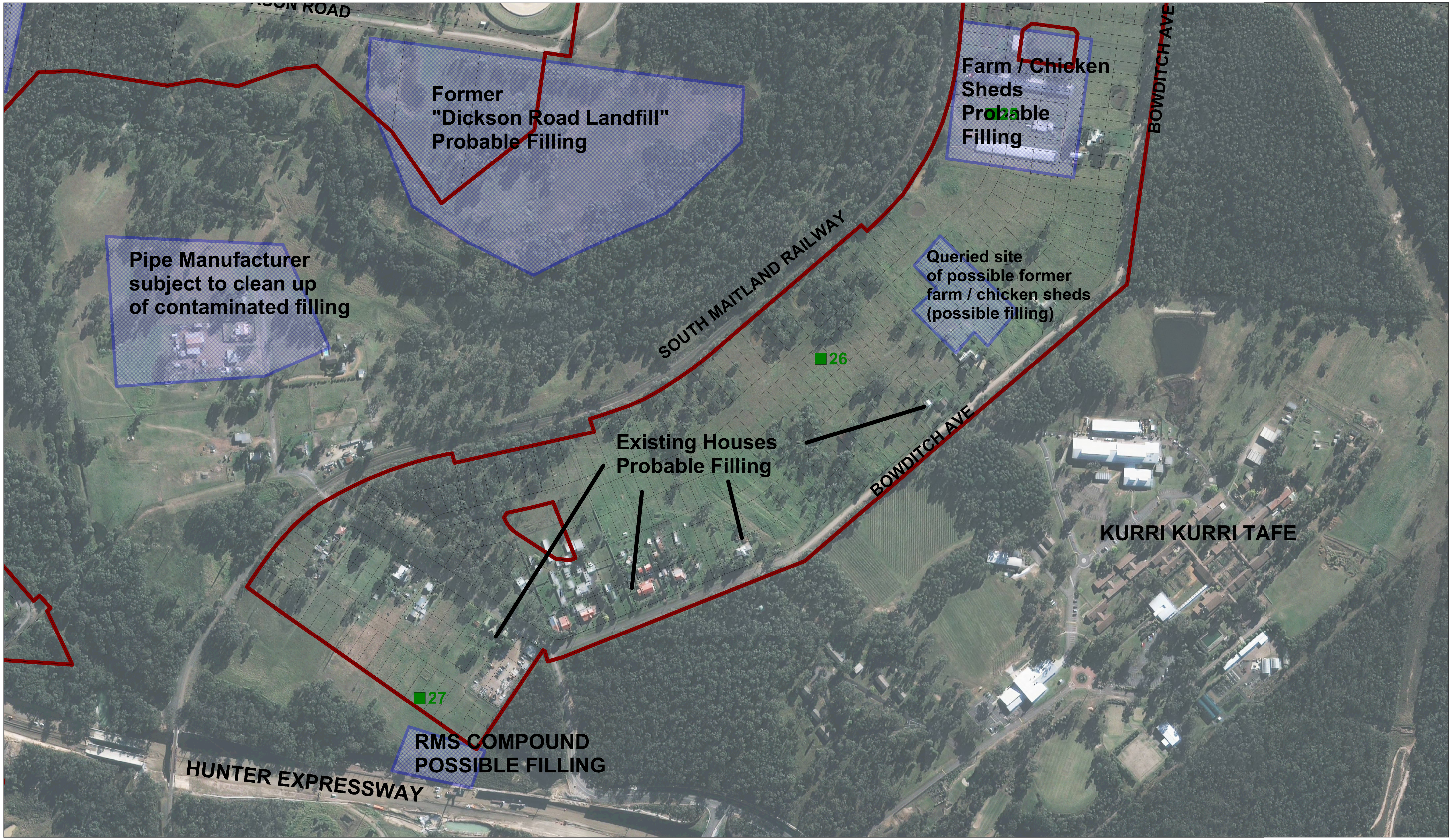


LEGEND:

- Site Extents
- Local Government Area Boundary
- Approximate Test Pit Location
- General Areas of Observed Filling or Possible Filling

81520.R.002.Drawing.5

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd	TITLE: Site Observations Proposed Rezoning Loxford
	OFFICE: Newcastle / DRAWN BY: JAW	PROJECT No: 81520
	SCALE: 1:5000 (A3 Sheet) / DATE: 09.01.2015	DRAWING No: 5
MGA		REVISION: 0



LEGEND:

Site Extents

Local Government Area Boundary

Approximate Test Pit Location

General Areas of Observed Filling or Possible Filling

81520.R.002.Drawing.6

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd		TITLE: Site Observations Proposed Rezoning Loxford	PROJECT No: 81520
OFFICE: Newcastle	DRAWN BY: JAW		DRAWING No: 6
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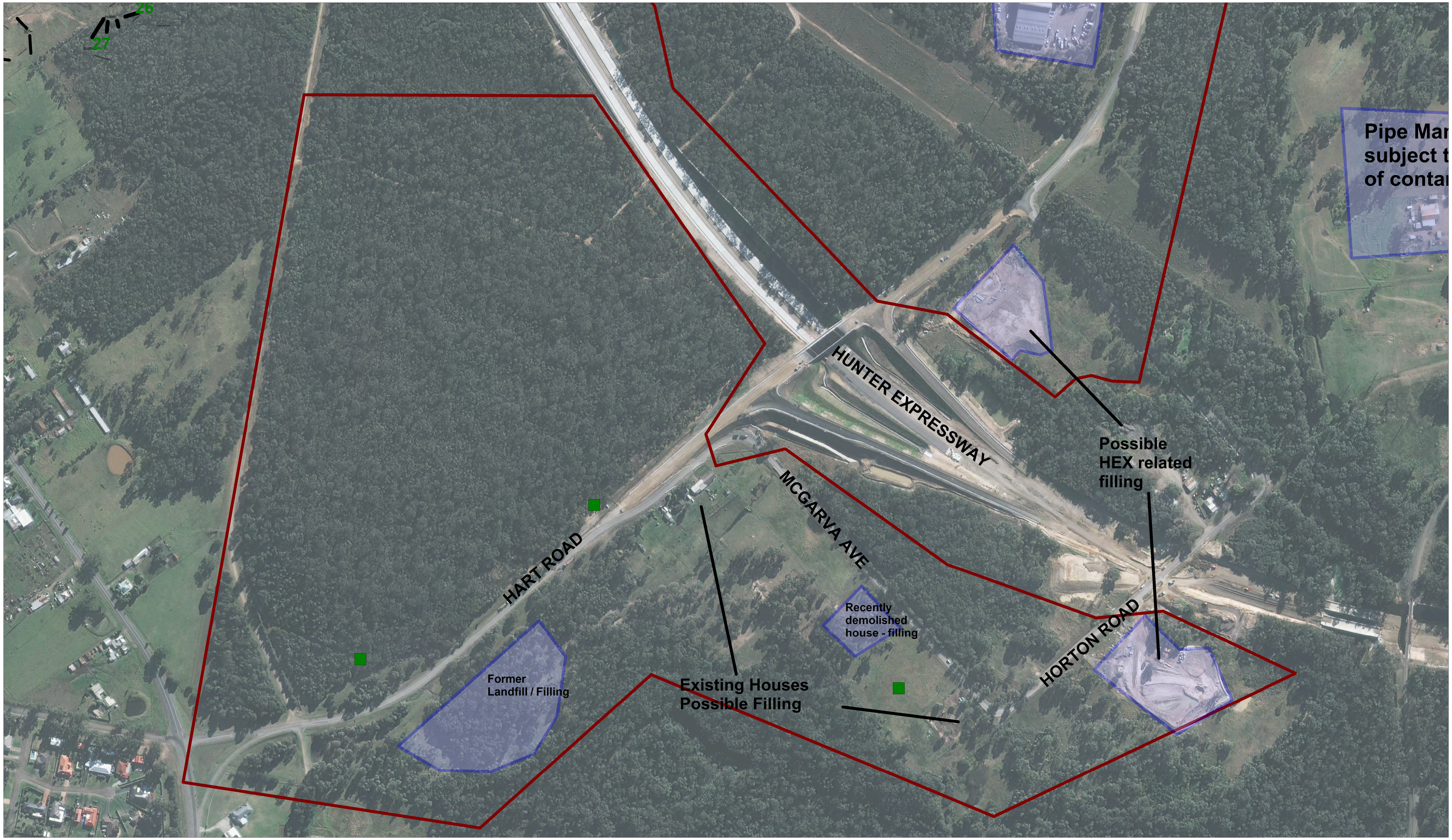
MGA



LEGEND:

Site Extents

Local Government Area Boundary

Approximate Test Pit Location

General Areas of Observed Filling or Possible Filling

81520.R.002.Drawing.7

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Hydro Aluminium Kurri Kurri Pty Ltd	TITLE: Site Observations Proposed Rezoning Loxford	PROJECT No: 81520
	OFFICE: Newcastle / DRAWN BY: JAW		DRAWING No: 7
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