Douglas Partners
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Report on
Land Capability Assessment

Fernhill Estate
Eastern Precinct
Mulgoa Road, Mulgoa

Prepared for
Cubelic Holdings Pty Ltd

Project 71706.01
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1. Introduction

This report presents the results of a land capability assessment undertaken by Douglas Partners Pty Ltd (DP) in 2010 for an approximate 27 hectare parcel of land known as the "Owston Estate – Eastern Precinct", situated on Mulgoa Road, Mulgoa. The 2010work was commissioned by Urbis Pty Ltd (Urbis – head consultant), on behalf of Owston Nominees No.2 Pty Ltd (Owston – developer). This report comprises an update to the 2010 report, as commissioned by Cubelic Holdings Pty Ltd, on behalf of the new property developer.

It is understood that the proposed development will include the subdivision of the site into approximately 54 residential allotments with a typical allotment size of approximately 1000 m^2. The new lots will be serviced by several new roads that will provide access to the site from two entry points located on Mulgoa Road near to the northern and southern ends of the site. Presently, the development is at a concurrent rezoning and development application stage, with the current proposed development layout shown on Drawing 101, in Appendix A.

To assist the rezoning and development application and to comply with Penrith City Council's (Council) Stage 2 Local Environmental Plan requirements, DP has investigated and assessed the site to determine its suitability for urban development, with specific consideration given to geotechnical surface and subsurface conditions, slope instability and soil erosion risks, soil salinity and the potential for soil contamination. The results of the soil contamination assessment undertaken for this site are reported separately. Please refer to DP's *Report on Phase 1 Contamination Assessment with Limited Sampling – Eastern Precinct* (Project 71706.01, dated June 2013).

The land capability assessment comprised site history searches, site inspections, non-intrusive and intrusive site investigations followed by laboratory testing of selected samples, engineering analysis and reporting.

Details of the work undertaken and the results obtained are presented in this report, together with comments relating to land capability, engineering design and construction practice.

2. Background

The land capability assessment was originally undertaken by DP for a previous developer of the site, Owston Nominees No. 2 Pty Ltd. The results of the assessment were presented in DP's original geotechnical Report on Land Capability Assessment (refer DP Project No. 71706, dated 13 August 2010). DP understands that the appropriate permissions have been granted by the original developer and their appointed Receivers and Managers (Korda Mentha) to access all prior reports to assist the new development proposal.

The current report comprises an update to DP's 2010 report, with amendments made to reflect the newly proposed development layout. Although all references to the previous development proposal have been updated, all data previously presented in the 2010 report appendices remains unchanged. The findings of the report also remain essentially unchanged.

3. Site Description

The portion of land proposed for rural/residential development is approximately 8 hectares in plan area and encompasses the eastern and south-eastern sections of a combined site that comprises three properties, namely:

- Lot 100 in DP717549;
- Lot 1 in DP570484; and
- Lot 6 in DP173159 (refer to Drawing 101).

The proposed development is planned for the eastern parts of Lot 1 and Lot 6 (refer Drawing 101). The proposed development area is bordered by:

- North Side – Lot 100 and the Fernhill Estate (Lot 10 in DP615085);
- South Side – Existing rural and residential lots bordering the northern side of Fairlight Road;
- East Side – Mulgoa Road; and
- West Side – Two existing dams within Lots 1 and 6.

The site is currently a rural property that has an existing residence and accompanying outbuildings in the central eastern part of Lot 1. Surrounding the residence are fenced paddocks that contain a few horses but are otherwise unused. An asphalt sealed driveway provides access to the existing residence from Mulgoa Road. There is evidence of a previous dwelling in the central eastern part of Lot 6, which was reported by Urbis in 2010 to have burnt down during fires in approximately 2001, leaving behind remnant sheet metal and other building refuse within a small compound that is surrounded by a high chain wire fence.

Surrounding the developed areas of the site is vacant rural land that is covered with grass and scattered to dense natural tree growth. Although the site is mostly undeveloped and appears to follow the natural land form, the proposed development areas have been cleared of almost all substantial vegetation leaving a thick grass cover. Previous land uses are not directly evident from site inspection, although it is likely that the site has been used for grazing or other rural activity, which is supported by the presence of two existing rural dams, one which is quite large.

Topographical relief across the majority of the site is slight to moderate, with the overall landform being undulating and varying in elevation from reduced levels of RL 72 m relative to Australian height datum (AHD) in the south east portion of the site to RL 60 m at the waters edge of both dams in the centre of the site. A broad ridge line runs north to south through the central eastern part of the site between the dams and Mulgoa Road. A second broad ridge line runs in a north-east to south-west direction midway between the dams and the western property boundary. The crest of each ridge line is slightly undulating with ground surface slopes to either side of both ridges generally falling to the

east and west, although irregular spurs extend from the main ridge line in varying directions thus ground slopes face many different directions. Ground slopes typically fall at angles of between 3 and 12 degrees within the proposed development area. Local ground slopes fall at up to 30 degrees near the northern boundary of the site and on the downstream side of the large dam embankment (Dam 1 – refer Drawing 101). A selection of general photographs of the site are presented in Appendix B.

4. Site History

A limited site historical information review was conducted, comprising a review of historical aerial photographs, Contaminated Land Register for Notices issued under the *Contaminated Land Management Act 1997*, as well as a groundwater bore search of the NSW Office of Water database. These reviews provide a broad scale indication of potentially contaminating activities that may have been carried out at the subject site. Details of this site history review are presented in DP's *Report on Phase 1 Contamination Assessment with Limited Sampling* (Project 71706, dated August 2010).

Aerial photographs from 1947, 1961, 1970, 1978, 1986, 1998 and 2009 indicate the following:

- 1947 – The site appears to be within an area of rural land use. Due to the poor quality of the 1947 image, it is unclear whether there were any structures present within the subject site, however there may have been a couple of dwellings in the south-eastern corner, near what appears to be agricultural/market gardens. A body of water can be seen within the vicinity of where Dam 2 is currently located. The remainder of the site appears to be covered by sparse bushland. A creek is shown running along to northern boundary of the site. Mulgoa Road does not appear in the photograph.
- 1961 – The site appears to be further developed since the 1947 image, with the presence of the two dams resembling current site conditions. The bushland in the north-western and central areas of the site have been cleared to make way for cultivated agricultural fields. The presence of a few small buildings was noted within the central eastern area amongst the fields, as well as a few small buildings located in the south-eastern corner. The surrounding land use appears similar to the 1947 image, with the addition of Mulgoa Road along the site's eastern boundary.
- 1970 – The 1970 image appears similar to that taken in 1961. As the quality of the 1970 image is slightly better than the 1961 photo, the features of the site and surrounding lands are easier to observe. There does not appear to have been significant change within the subject site, apart from the clearing of some trees. The surrounding area appears to be similar to observations made on the 1961 image, with the bushland appearing more sparse. Dwellings can also be seen at the south-eastern boundary of the site.
- 1978 – Although observations are restricted by the quality of the image, it appears there may have been a building/structure present at the north-eastern corner of the site. There is also an identified circular mark in the south-eastern portion of the site. In general, the site and its surroundings appear generally unchanged to the observations made for the 1970 image.
- 1986 – The majority of the buildings that were located in the south-eastern corner of the site appear to have been removed, as well as one of the buildings in the central area near the eastern boundary. There has been the addition of a rectangular structure near the centre of the site, between the circular marking and the dams. The bushland in the western half of the site appears

more sparse. A few additional dwellings can be seen to the south and east of the site, with what appears to be residential land use at the southern end of the image.

- 1994 – The site appears generally similar to the 1986 image, however it appears that all but one of the buildings in the south-eastern corner, including the added structure that was first observed in the 1986 image, have been removed. The circular mark is also missing, and a few trees have been planted within the south-eastern area. The rectangular building that was present in the 1986 image near the unsealed road within the central east part of the site appears to have been removed. A new grey-roofed building, which is thought to be a residence, is shown on the other side of the unsealed road. The surrounding land appears similar to observations made in the 1986 image, although a few additional buildings are apparent to the south of the site.
- 1998 - Although restricted by image quality, the subject site and surrounding lands do not appear significantly different to observations made in the 1994 image. Due to the cropped imaged that was provided, it is not possible to view the surrounding land to the south.
- 2009 (Current) – The subject site and the surrounding lands do not appear significantly different to observations made in the 1998 image, although there appears to be a few more structures near the residential dwelling. The one remaining structure in the south-eastern corner of the site appears to have been removed. Further development is observed to the south of the site, with the addition of more rural residential buildings as well as a sports court to the south-east. Generally the area has not changed significantly.

In summary, the Eastern Precinct site appears to include undeveloped land that has been partly used as agricultural/market garden land and has seen the construction and demolition of a few structures that have probably comprised residences and various shedding on the three individual lots. Some natural bushland remains at the northern boundary and within the south-western corner of the larger precinct site, although the proposed development area has been subjected to clearing of most vegetation leaving relatively thick grass cover.

5. Desktop Study

5.1 Soil Landscapes

Reference to the 1:100 000 Soil Landscapes of Penrith Sheet (Ref 1) indicates that the site includes only the Luddenham Soil Landscape which is characterised by topography of *"undulating to rolling low hills on Wianamatta Group Shale (although also often associated with Minchinbury Sandstone), with local relief of 50 m to 80 m and slopes usually between 5% and 20%, typically represented by narrow ridges, hillcrests and valleys"*. This is a residual soil landscape, which the mapping indicates comprises soil horizons that include shallow (<1 m) dark podsolic soils or massive earthy clays on crests, moderately deep (0.7 m to 1.5 m) red podsolic soils on upper slopes and moderately deep (<1.5 m) yellow podsolic soils and prairie soils on lower slopes and drainage lines. These soils have a high soil erosion hazard, typically include localised impermeable subsoils, are moderately reactive and highly plastic.

Approximate soil landscape boundaries, as shown on the soil landscape maps, are shown on Drawing 102, in Appendix A.

5.2 Geology

Reference to the Penrith 1:100 000 Geological Series Sheet (Ref 2) indicates that the site is underlain by three geological formations including the Ashfield Shale, Bringelly Shale and Minchinbury Sandstone, all of the Wianamatta Group of Triassic age.

Bringelly Shale, underlying the proposed development area to the east of the two dams, typically comprises shale, carbonaceous claystone, claystone, laminate, fine to medium-grained lithic sandstone. This formation typically weathers forming clays and silty clays of generally medium to high plasticity and low permeability.

Ashfield Shale, underlying the proposed development area to the west of the two dams, typically comprises dark grey to black claystone-siltstone and fine grained sandstone-siltstone laminate. This formation typically weathers forming clays and silty clays of generally medium plasticity and low permeability.
Minchinbury Sandstone, separating the two shale formations (Bringelly overlying Ashfield) and mapped as outcropping along the base of the central north to south gully that includes Dams 1 and 2, typically comprises fine to medium-grained quartz-lithic sandstone. This formation typically weathers forming clays, silty clays and some sandy clays of generally medium plasticity and low permeability.

Approximate geological boundaries, as shown on the geology map, are shown on Drawing 103, in Appendix A.

5.3 Hydrogeology and Salinity

McNally (2005, Ref 3) describes some general features of the hydrogeology of Western Sydney which are relevant to this site. The shale terrain of much of Western Sydney is known for saline groundwater, resulting either from the release of connate salt in shales of marine origin or from the accumulation of windblown sea salt. This salt is concentrated by evapo-transpiration and often reaches highest concentrations in the B-horizon of residual soils. The B-horizon at the site is between 0.4 m and 2.5 m below ground level and typically underlies the topsoil unit. In areas of urban development, this can lead to damage to building foundations, lower course brickwork, road surfaces and underground services, where these affect the saline zone or where the salts are mobilised by changing groundwater levels. Seasonal groundwater level changes of 1 m to 2 m can occur in a shallow regolith aquifer or a deeper shale aquifer due to natural influences, however, urban development should be carried out with a view to maintaining the natural water balance (i.e. between surface infiltration, runoff, lateral through-flow in the regolith, and evapo-transpiration) so that long term rises do not occur in the saline groundwater level.

The former Department of Infrastructure Planning and Natural Resources (DIPNR), now the Office of Environment and Heritage (OEH), infers a "moderate to high salinity potential" for the site on their map entitled "Salinity Potential in Western Sydney 2002" (Ref 4). The DIPNR mapping is based on soil type, surface level and general groundwater considerations but is not generally ground-truthed, hence actual soil salinity needs to be assessed to confirm the DIPNR potential salinity mapping indication.

Approximate salinity potential boundaries, as shown on the salinity potential map, are shown on Drawing 104, in Appendix A.

6. Assessment and Field Work Methodology

Based on the brief provided by Hughes Trueman (HT), on behalf of Urbis for the original assessment, DP identified the following scope of works for the site.

6.1 Geotechnical

The initial stage of the geotechnical study comprised the collection and review of background information, predominantly from aerial photographs, published maps and company data. A scoping study of the site, comprising a site walkover and field mapping by a senior geotechnical engineer was then undertaken to identify site areas that are potentially unstable, affected by salinity and/or erosion, and to finalise the proposed test pit locations for the subsurface investigation.

Surface and subsurface investigations included:

- Dial before you dig services search, survey set out by GPS and on-site scanning for buried services;
- Excavation of 32 test pits within the Eastern Precinct;
- Dynamic cone penetrometer (DCP) tests adjacent to selected test pits to aid the assessment of in-situ soil strength;
- Collection of representative bulk and undisturbed soil samples from the test pits for geotechnical laboratory analysis; and
- Collection of additional near-surface soil samples from shallow hand auger bores or manually excavated test pits, where relevant, between test pit locations.

Test pits were excavated by a backhoe, fitted with a 450 mm wide toothed bucket. Test pits were excavated to a maximum depth of 4 m or until practical refusal on rock was reached at depths of between 0.95 m and 3.5 m. Test pits were reinstated by placing the excavated soils back in the hole in the reverse order to which they were removed. The back of the backhoe bucket was then used to tamp down the soils in layers to minimise the amount of settlement within the test pit footprint following completion of the field work. The upper surface of the test pit was rolled by the backhoe tyres and where possible, was left slightly mounded above the surrounding ground surface to further reduce the effects of settlement.

DCP testing was undertaken adjacent to 16 of the 32 test pits and extended to depths of between 0.45 m and 1.2 m.

Geotechnical sampling from the test pits included large bulk, small disturbed and undisturbed tube samples. A selection of these samples were then scheduled for a variety of laboratory tests including particle size distribution, hydrometer, Atterberg limits, Emerson class number, California bearing ratio, shrink swell index and field moisture content tests to assist the geotechnical assessment.

The scope of the geotechnical investigation was designed to address the various issues under consideration in the land capability assessment. These included slope instability, erosion and sedimentation, geotechnical development constraints, earthworks requirements, AS2870 site classification, typical pavement thicknesses and site drainage.

6.2 Soil Salinity

The salinity assessment comprised the collection and review of background information, including aerial photographs, published maps and company data. A site walkover inspection by a senior geotechnical engineer was then undertaken to identify site areas that are potentially affected by salinity and to map their location.

Surface and subsurface salinity investigations included:

- Concurrent use of several of the same test pits excavated for the geotechnical investigation of the Eastern Precinct; and
- Collection of soil samples from the test pits for salinity laboratory analysis.

Salinity sampling from the test pits included collection of small disturbed samples. A selection of these samples were then scheduled for a variety of laboratory tests including classification for soil texture and analysis for salinity (EC), pH, chlorides, sulphates and sodicity (cation exchange capacity and exchangeable sodium potential) tests to assist the salinity assessment.

The guideline for undertaking salinity assessments on land proposed for urban development (Site Investigations for Urban Salinity – Department of Land and Water Conservation 2002) typically requires the excavation of test pits with full depth profile sampling on a frequency of one test location per two hectares for initial Phase 1 investigations for developments comprising low intensity construction. This requires approximately 14 test pits to be excavated within the Eastern Precinct. However, given the rezoning status of the development, DP has undertaken a Phase 1 investigation, adopting a reduced number of test locations. Salinity sampling and laboratory testing was therefore undertaken at six test locations within the Eastern Precinct, thus providing a test frequency of approximately one per four and a half hectares. Sampling targeted full depth full depth profile sampling at all six test locations.

6.3 Assessment Datum

The coordinates of the field tests and other pertinent features were determined by use of a hand held GPS receiver, with a typically accuracy of about 5 m. Horizontal positioning was referenced to the Map Grid of Australia 1994 (MGA94), Zone 56 datum. Vertical positioning was referenced to reduced levels relative to Australian Height Datum (AHD), with levels at test locations recorded to the nearest 0.5 m, as derived from survey plans provided by Urbis.

7. Field Work Results

7.1 Site Observations

The observations made during the various inspections of the site undertaken during and following the field investigation programme (April and May 2010) are summarised below:

- Rock outcrops were not identified within the site. Outcrops of sandstone and shale are evident to the east and west of the site in road cuttings. Although not observed, it is likely that in-situ rock would be present at the base of the dam excavations at this site.
- The soil profile across the site is residual and comprises silty clay overlying shale and sandstone bedrock. The residual soil is sometimes mottled and contains some ironstone gravel in places.
- The landform is predominantly gently to moderately sloping undulating terrain of shallow relief. Crests and gullies are broad but defined, hence there are no areas of significant soil erosion at site due to concentrated overland water flow.
- Several salt tolerant species are evident at site including paspalum and couch grasses. Although indicative of saline soil conditions, there were no significant signs of salt scalding, efflorescence, iron-staining, or extensive bare areas of soil. Vegetation was relatively healthy across the site with no significant die-back noted, although grasses were dry.
- Areas adjacent to Dam 1 contained potentially intermittently water-logged ground that supported reedy grasses.
- Water levels within the existing dams were below the high water level line, indicating possible recent dry weather conditions, further supported by the dry grasses evident across the site, mostly on crests and mid to upper slopes.

7.2 Subsurface Conditions

The subsurface conditions observed in the test pits excavated at site were logged by DP's geotechnical engineering staff. The results of the test pits and DCP tests are presented on the test pit logs included in Appendix C, together with explanation sheets describing classification methods and descriptive terms.

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

Topsoil:	Consisting of firm to stiff dark brown silty clay with some rootlets. Topsoils were present at all test pit locations and extended to depths of between 0.18 m and 0.41 m, typically 0.25 m to 0.3 m thick with the upper 0.1 m containing organics. Topsoils were generally humid to damp, although are probably wetter now (July 2010), considering the wet weather experienced since the field investigation.
Residual Soil:	Comprising stiff to very stiff and hard, orange brown, mottled red brown and grey silty clay. Residual clays were present in all thirty-two test pits and extended to depths of between 0.4 m and 2.5 m. Residual clays were generally humid to moist and of estimated medium to high plasticity.
Weathered Rock:	Comprising Shale and Sandstone encountered from depths of between 0.4 m and 2.5 m, generally at shallower levels on the eastern side of the site. Initially of extremely low to low strength, bucket penetration in sandstone was typically less than 0.9 m whereas penetration in shale reached 2.4 m in depth.

Soil conditions were relatively uniform across the site, confirming that only one soil landscape is present at the site (Luddenham Soil Landscape), as indicated by the soil landscape map (refer Drawing 102). Sandstone was present at mid slope levels and separated the two shale formations, with Bringelly Shale intersected in test pits on upper slopes and crests and Ashfield Shale intersected on lower slopes surrounding Dam 1. This is consistent with the geology map for the site (refer Drawing 103). Rock depths were typically 0.5 m deeper in the southern part of the site.

In addition to the above soil profiles, filling should be expected within the existing dam walls and is likely to comprise a blend of the residual soils and upper weathered rock profiles.

7.3 Surface Water and Groundwater

Groundwater was not observed in any of the test pits excavated at site. Although test pits were immediately backfilled, preventing long term monitoring of groundwater levels, the moisture contents of the subsurface soils did not indicate free groundwater to be likely within the depth of the investigation. Given the elevation of the site, groundwater levels are expected to lie well below the ground surface.

Surface water was identified only in the existing dams (Dams 1 and 2 – refer Drawing 1) on the site. No other surface water bodies or ponded areas were evident during the field investigation.

8. Laboratory Testing

8.1 Geotechnical

Soil and weathered rock samples were collected from the test pits during the field investigation. Representative samples were selected for the following suite of geotechnical tests:

- California bearing ratio tests – 3 samples;
- Atterberg limits tests – 3 samples;
- Shrink swell index tests – 3 samples;
- Field moisture content tests – 4 samples;
- Particle size distribution tests – 2 samples; and
- Emerson class number tests – 4 samples.

The results of these tests are presented in Appendix D and are summarised in Tables 1 to 3.

Table 1: California Bearing Ratio Test Results

Test Pit No.	Depth (m)	Soil Description	MDD[A] (t/m^3)	OMC[B] (%)	CBR (%) 2.5/5mm[C]	Swell (%)
TP103	0.4 – 0.6	Silty Clay	1.60	24.0	9/8	0.7
TP108	0.4 – 0.6	Silty Clay	1.67	20.5	2.5/2.5	2.4
TP129	0.4 – 0.6	Gravelly Clay	1.73	19.5	6/5	2.3

Notes: [A] MDD = Maximum Dry Density
[B] OMC = Optimum Moisture Content
[C] 2.5 mm/5.0 mm Penetration Reading

The laboratory test results indicate CBR values of 2.5% to 9% for the silty clay and gravelly clay soils at this site. These CBR results are considered typical to slightly high values for the soils tested and suggest there was some finer gravel within the soil samples tested.

Table 2: Shrink Swell Index and Atterberg Limits Test Results

Test Pit No.	Depth (m)	Soil Description	Shrink Swell Index (Iss %)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
TP105	0.6	Silty Clay	2.4	-	-	-
TP118	0.4	Silty Clay	2.6	-	-	-
TP130	0.6	Silty Clay	1.3	-	-	-
TP110	0.5	Silty Clay	-	65	26	39
TP115	0.5	Silty Clay	-	33	18	15
TP131	0.5	Silty Clay	-	68	36	32

The laboratory test results indicate low to high plasticity and moderately reactive soil conditions for soils overlying sandstone and shale.

Table 3: Results of Particle Size Distribution Tests

Test Pit No.	Depth (m)	Soil Description	% of soil mass		
			Sand[D]	Silt[E]	Clay[F]
TP110	0.5	Sandy Silty Clay	17%	33%	45%
TP129	0.5	Sandy Silty Clay	19%	26%	32%

Notes: [D] Sand = 2.36 – 0.075 mm [E] Silt = 0.075 – 0.002 mm [F] Clay = <0.002 mm

The laboratory test results confirm the consistent clayey nature of the residual soils at the site. In conjunction with the Atterberg limit results, the particle size distribution tests indicate soil classifications for the residual soils, in accordance with the Unified Soil Classification System corresponding to inorganic clays of low to medium plasticity (CL), inorganic clays of high plasticity (CH) and inorganic silts or fine sandy or silty soils (MH).

Emerson Class Number tests were undertaken on selected soil samples. The results can be summarised as follows:

- Emerson Class Number 2 – TP114 (1 m);
- Emerson Class Number 3 – TP112 (0.5 m) and TP124 (0.5 m); and
- Emerson Class Number 8 – TP107 (0.5 m).

The Emerson Class number for a soil relates to the potential for the soil to slake and disperse. Higher Emerson class numbers correspond to soils with a lower tendency to disperse. Emerson class numbers of 2 and 3 indicates a tendency for the soil to slake, or break down under contact with water, as well as a moderate tendency for dispersion when moist. An Emerson class number of 8 indicates the soil does not have a tendency to slake or disperse.

8.2 Salinity

Soil salinity is typically assessed with respect to electrical conductivity of a 1:5 soil:water extract ($EC_{1:5}$). This value can be converted to ECe (electrical conductivity of a saturated extract) by multiplication with a factor dependent of soil texture ranging from 6 for heavy clays to 17 for sands. Richards (1954, Ref 5) and Hazelton and Murphy (1992, Ref 6) classify soil salinity on the basis of ECe, and describe the implications of the salinity classes on agriculture as follows:

Table 4: Soil Salinity Classification

Class	ECe (dS/m)	Implication
Non Saline	<2	Salinity effects mostly negligible
Slightly Saline	2 – 4	Yields of sensitive crops affected
Moderately Saline	4 – 8	Yields of many crops affected
Very Saline	8 – 16	Only tolerant crops yield satisfactorily
Highly Saline	>16	Only a few very tolerant crops yield satisfactorily

Following the field investigation, a selection of soil samples were submitted to Envirolab Services Pty Ltd (Envirolab), a NATA accredited facility, for soil tests for salinity and corrosivity. Testing accorded with the guidelines presented in the *Site Investigations for Urban Salinity* booklet, as published in 2002 by the then Department of Land and Water Conservation (DLWC).

Soil tests were performed for their physical and chemical properties. Tests for the effects of water movement included:

- Cation Exchange Capacity – Sodium, Calcium, Magnesium and Potassium;
- Sodicity – Exchangeable Sodium Percentage (ESP); and
- Dispersibility – Emerson Class Number (refer Section 7.1).

These tests were undertaken to determine the potential for salt release and the effects of water on soil chemistry.

The soil tests performed for corrosivity included:

- pH;
- Chlorides;
- Sulphates;
- Resistivity;
- Electrical Conductivity ($EC_{1:2}$); and
- Classification – Soil texture.

These tests were undertaken to gain an understanding of how corrosive the local soil environment might be to buried concrete and steel. The results of these tests indicate whether developments should avoid particular land areas due to high salt content or whether special corrosion resistant materials should be utilised during construction.

Laboratory testing was performed on 30 soil samples collected from the test pits excavated at site. Soil samples were collected from depths of 0.25 m, 0.5 m and then at 0.5 m depth intervals to the rock surface, hence samples were collected from varying soil and rock profiles below the ground surface. Detailed test reports are presented in Appendix E. Summaries of the physical and chemical test results are presented below in Table 5.

Table 5: Results of Laboratory Soil Testing (Chemical)

Test Pit No.	Depth (m)	$EC_{1:5}$ (ds/m)	Texture Class	EC_e (Ds/m)	pHw (1:2)	ESP (%)	Cl (mg/kg)	SO_4 (mg/kg)	Resis. (Ω.m)	Comments		
										Salinity	Acidity	Sodicity
TP106	0.25	0.02	HC	0.12	6.3	-	-	-	500	Non-saline	Neutral	-
TP106	0.5	0.11	LMC	0.88	6.1	14.9	6.1	70	91	Non-saline	Neutral	Sodic
TP106	1.0	0.10	MC	0.80	5.2	-	-	-	100	Non-saline	Acidic	-
TP106	1.5	0.09	LMC	0.70	5.5	-	-	-	110	Non-saline	Acidic	-
TP106	2.0	0.15	MC	1.05	5.4	-	-	-	67	Non-saline	Acidic	-
TP111	0.25	0.08	MC	0.57	6.7	-	<20	<20	120	Non-saline	Neutral	-
TP111	0.5	0.10	MC	0.68	5.0	11.9	46	<20	100	Non-saline	Acidic	Sodic
TP111	1.0	0.09	HC	0.53	5.5	-	50	<20	110	Non-saline	Acidic	-
TP111	1.5	0.10	HC	0.60	6.5	-	20	<20	99	Non-saline	Neutral	-
TP111	1.8	0.14	HC	0.84	6.4	-	77	<20	71	Non-saline	Neutral	-
TP114	0.25	0.02	L	0.21	6.2	-	-	-	480	Non-saline	Neutral	-
TP114	0.5	0.10	MC	0.70	4.6	-	8.5	66	100	Non-saline	Acidic	-
TP114	1.0	0.07	HC	0.42	5.3	-	-	-	140	Non-saline	Acidic	-

Test Pit No.	Depth (m)	$EC_{1:5}$ (ds/m)	Texture Class	EC_e (Ds/m)	pHw (1:2)	ESP (%)	Cl (mg/kg)	SO_4 (mg/kg)	Resis. (Ω.m)	Comments		
										Salinity	Acidity	Sodicity
TP114	1.5	0.11	LMC	0.88	5.3	-	-	-	91	Non-saline	Acidic	-
TP114	2.0	0.10	MC	0.70	5.1	-	-	-	100	Non-saline	Acidic	-
TP114	2.5	0.20	MC	1.60	5.4	-	-	-	50	Non-saline	Acidic	-
TP120	0.25	0.05	L	0.50	5.7	-	980	840	200	Non-saline	Acidic	-
TP120	0.5	0.05	CL	0.48	5.7	6.9	<20	<20	190	Non-saline	Acidic	Sodic
TP120	1.0	0.07	MC	0.47	5.5	-	-	-	150	Non-saline	Acidic	-
TP120	1.5	0.20	HC	1.20	5.2	-	-	-	51	Non-saline	Acidic	-
TP120	2.0	0.23	HC	1.40	5.1	-	-	-	43	Non-saline	Acidic	-
TP127	0.25	0.06	L	0.61	5.4	-	<20	<20	160	Non-saline	Acidic	-
TP127	0.5	0.05	L	0.45	5.2	-	<20	21	220	Non-saline	Acidic	-
TP127	1.0	0.02	LMC	0.18	6.1	5.9	-	-	430	Non-saline	Neutral	Sodic
TP127	1.5	0.03	LMC	0.26	5.8	-	-	-	310	Non-saline	Acidic	-
TP127	2.0	0.02	MC	0.16	5.8	-	-	-	430	Non-saline	Acidic	-
TP131	0.25	0.05	L	0.54	5.5	-	<20	<20	190	Non-saline	Acidic	-
TP131	1.0	0.02	MC	0.15	6.3	-	-	-	480	Non-saline	Neutral	-
TP131	1.5	0.02	MC	0.17	5.8	-	-	-	420	Non-saline	Acidic	-
TP131	2.0	0.01	SL	0.17	6.4	-	-	-	830	Non-saline	Neutral	-

Where
$EC_{1:5}$ = Electrical Conductivity
EC_e = Electrical Conductivity corrected for soil texture
pHw = pH in water
Cl = Chloride
SO_4 = Sulphate
ESP = Exchangeable Sodium Percentage
Resis. = Resistivity

L = Loam
LMC = Light Medium Clay
MC = Medium Clay
HC = Heavy Clay
CL = Clay Loam
SL = Sandy Loam

To the extent that the 30 samples are representative of the study area, results indicate that non-saline conditions can be expected throughout the study area. These results are derived from salinity measurements in soils to depths of up to 2.5 m.

9. Proposed Development

It is understood that the proposed development will include the subdivision of the site into approximately 54 residential allotments with a typical allotment size of approximately 1000 m^2. The new lots will be serviced by several new roads that will provide access to the site from two entry points located on Mulgoa Road near to the northern and southern ends of the site. Presently, the

development is at a concurrent rezoning and development application stage, with the current proposed development layout shown on Drawing 101, in Appendix A.

The following sections provide general comments on development constraints relevant to geotechnical factors and soil chemistry to assist in the conceptual planning of the site. Further investigations will need to be undertaken as the conceptual planning and design process continues (refer Section 11).

10. Comments

10.1 Slope Instability

Generally, there was no evidence of slope instability (landslip, etc) observed within the site, which is consistent with the gentler sloping landforms that typically provide crests, gullies, upper and lower hillside slopes with falls of say 10 degrees or less.

Mid-slopes are typically steeper, up to 20% (sometimes more) and therefore can be prone to instability under adverse subsurface soil/rock and groundwater conditions. Inspection of the Eastern Precinct did not identify any instability within natural mid-slopes, but signs of instability were noted on the downstream side of the Dam 1 embankment, at its western end. These signs included soil creep, minor landslip and deep erosion, for which DP infers, was primarily caused by over-topping dam waters, although subsurface seepage through the dam embankment is also likely and should be further investigated.

Dam 1 embankment appears to be performing satisfactorily and as indicated by the aerial photos, has been in place since at least 1961, or some 52 years. It is likely that the signs of instability have developed progressively over an extended period and appears relatively minor in terms of creep and landslip. However, erosion at the western end of the dam embankment, has progressed to a depth of between 2 m and 3 m, resulting in an erosion gully of about 4 m in width. This gully is likely to worsen exponentially under successive over-topping events and will lead to further instability, including the loss of adjacent vegetation and soils from the downstream face of the dam and probable partial failure of the dam wall.

Although the condition of the Dam 1 embankment is not critical to the land capability assessment, the presence of potential instability serves as an indicator of possible hillside instability at the site, if slopes are left without adequate erosion protection, and erosion is allowed to progress to the point of triggering other forms of slope instability.

In general, the steepest ground surface slopes that are evident at site are at the existing dams, where internal dam batters and external dam wall embankments have been constructed at angles of up to 30 degrees. Although these slopes are steeper than typically recommended for compacted or natural clayey soils, the current performance of the slopes appears adequate for their current use. The condition of the Dam 1 embankment should be investigated further to determine whether improvements are necessary to allow the dam to stay in place and form part of the proposed residential development. Investigations should consider the stability of the embankment and its subsurface condition in terms of ground water movements through and below the embankment. Investigations should include monitoring of groundwater levels.

Apart from Dam 1, it is considered that hillside instability does not impose significant constraints on the proposed site development. As Dam 1 is to be retained within the new residential estate, it will be necessary to assess and upgrade the embankment to a condition that satisfies current dam design standards. A stability hazard map has not been prepared as with the exception of Dam 1, stability hazards are not significant at the site.

10.2 Erosion Potential

Soils of the Luddenham Soil Landscape are typically highly erodible. Test results for samples of soil collected from site confirm the sodic nature of the soil and its tendency to both slake and disperse, particularly under adverse moisture conditions.

Slaking or dispersion was not evident within the waters in either or the two dams, although given the dams' age, it is likely that any suspended soils within the dam waters have settled over time creating a layer of sediment across the base of each dam. This sediment tends to reduce the potential for ongoing slaking and dispersion, as it forms a protective layer between the water and the in-situ soil surface.

Even though the soil within the embankment of Dam 1 is filling, it most likely consists of the natural soils excavated from within the dam footprint. Hence, the embankment materials most likely have the same sodicity as the surrounding natural landform. The deep erosion gully noted at the western end of the embankment is considered to be evidence of the potential for the natural soils at the site to erode if left unprotected from overland water flow, particularly concentrated flow. Accordingly, it is recommended that the sodicity of this site is based on the Emerson class numbers of 2 and 3, rather than the higher value of 8, as obtained for the sample collected from TP107.

As most of the site is unaffected by significant erosion, it is considered that the erosion hazard within the areas proposed for residential development would be within usually accepted limits, which could be managed by good engineering and land management practices. Development should avoid the construction of landforms that create a concentrated overland flow of surface waters. If this is not always possible, then the following measures could be adopted to minimise the risk of soil erosion:

- Placement of filling within overland flow paths using select materials (i.e. non–dispersive or least erodible) placed under controlled conditions;
- Provision of a temporary surface cover within overland flow paths (e.g. biodegradable matting that is pegged in place) during the period of gully floor revegetation;
- Construction of channel lining in sections of rapid change in gully floor grade;
- Collection and discharge of water flows through a piped network, where appropriate; and
- The re-establishment of an appropriate vegetated zone to protect the ground surface over the long term.

10.3 Soil Salinity

Two methods of assessment of soil salinity were adopted to ground-truth the salinity potential map of DIPNR (2002, Ref 4). They included:

- A site walkover inspection to locate and map visible indicators of salinity; and
- EC_e analysis of 30 laboratory tests on soil samples collected from full profile depth sampling in 6 test pits.

In isolation, neither method is sufficient to provide a complete salinity assessment. Although the salinity works undertaken during this study are preliminary, together both methods provide a reasonable early indication of the actual salinity potential for the site. Further salinity studies will be necessary to achieve a greater density of test data, although the preliminary studies did not identify specific areas of concern with regards to urban development.

To date, the implication of screening of soil samples detailed in Section 8.2 is that non-saline soil conditions are present across the site. These results however, are from a small statistical sample size and require additional support before the site is considered free from salinity concern. To date, salinity values appear approximately constant with depth in terms of salinity and sodicity. Although groundwater was not encountered within the 32 test pits excavated, investigations need to further assess the deeper soil and upper shale horizons with greater frequency to ensure potential saline soils are not transferred to the site surface following earthworks, where surface water can freely dissolve and transport salt concentrations. Assessing these soils in terms of salinity values versus soil depth will greatly assist the overall site assessment.

With respect to salinity risks, the site has been assessed by two means, each indicating that non-saline conditions are present. Therefore, provision of salinity risk contours across the site is not warranted, as all areas lie below a contour of 2 dS/m. Salinity risk contours should be prepared only if further testing identifies salinity levels above the non-saline category.

Preliminary salinity testing indicates that the salinity potential of this site would be within usually accepted limits, which could be managed by good engineering and land management practices. Based on the works undertaken to date, specific salinity management plans are not required for this site.

10.4 Soil Aggressivity

10.4.1 Aggressiveness to Concrete

To assess whether the site's soils are potentially aggressive to concrete, the test results (Section 7.2, Table 5) were referenced to Table 6.4.2(C) of AS2159-2009 "Piling – Design and Installation" (Ref 7). Four sets of criteria are tabled, including Sulphates (SO_4) levels in soil and water, pH values and Chloride levels in water. For soils of low permeability that lie above groundwater, Column B within Table 6.4.2(C) provides the exposure classification appropriate for the site's soils.

Each samples test results were compared to the tabulated limits. All samples returned sulphate and chloride content values within the non-aggressive soil condition range. In 18 of the 30 soil pH tests, the soils were shown to lie within the limits stated for non-aggressive soil conditions. However, 12 of the 30 samples tested for pH (from TP106, TP111, TP114, TP120 and TP127, hence scattered across the site) returned values within the mildly aggressive range.

Based on testing to date, this comparison shows that surface and subsurface soils are typically non-aggressive to mildly aggressive to buried concrete. Accordingly, appropriate management strategies will require consideration when constructing concrete structures on mildly aggressive soils at this site. These should include the consideration by designers of the need to use more durable building elements in mildly aggressive (acidic) soil. Further testing may be able to identify specific areas of the site where management strategies are required but at this stage strategies should address the entire Eastern Precinct area.

10.4.2 Aggressiveness to Steel

To assess whether the site's soil and water samples are potentially aggressive to steel, the test results were referenced to Table 6.5.2(C) of AS2159-2009 "Piling – Design and Installation" (Ref 7). Four sets of criteria are tabled, including pH values, chloride levels in soil and water and resistivity. For soils of low permeability that lie above groundwater, Column B within Table 6.5.2(C) provides the exposure classification appropriate for the site's soils.

Each samples test results were compared to the tabulated limits. All samples returned pH, chloride content and resistivity values within the non-aggressive soil condition range. All soils were shown to lie within the limits stated for non-aggressive soil conditions. Based on testing to date, this comparison shows that surface and subsurface soils are typically non-aggressive to buried steel.

10.5 Sodicity

The sodicity of the soil (i.e. the proportion of exchangeable sodium cations as a percentage of total exchangeable cations) can be elevated due to salt content and can affect properties such as dispersion, erodibility and permeability. Sodicity was assessed by measurement of the exchangeable sodium capacity and total cation exchange capacity of 4 soil samples from four of the 32 test pits, for classification of the soil as non-sodic (<5% sodicity), sodic (5-15% sodicity) or highly sodic (>15% sodicity). Samples were taken from depths of 0.5 m to 1.0 m.

Laboratory results indicate sodic conditions for all samples tested, although the sample from TP106 is only marginally below the highly sodic range, hence highly sodic soils are also likely to exist. Based on the presence and extent of the Luddenham soil landscape, these soils are likely to represent the whole of the Eastern Precinct. Accordingly, management strategies will be required to manage the exposure of sodic to highly sodic soils. Strategies should include the design and implementation of an appropriate site drainage system that prevents sodic and highly sodic soils from breaking down and changing the water balance/water movement regime at the site. The application of gypsum can also improve sodic soils by providing a better balance between sodium and calcium in the soil.

10.6 Geotechnical Considerations

10.6.1 Site Classification

Classification of residential lots or residential building areas within the site should comply with the requirements of AS 2870 – 2011 *"Residential Slabs and Footings"* (Ref 8). Based on the limited work for the current investigation, the undisturbed subsurface profiles at most locations are typical of

Class M (moderately reactive) and Class H (highly reactive) sites. Further delineation between Class H1 and Class H2 sites would need to be made for any subsequent construction certificate issue or prior to linen release.

Laboratory shrink swell index tests have returned moderate values, indicating a medium to high shrink swell potential across the site, subject to soil and applicable soil suction depth. The results of Atterberg limits testing also support the moderate to high shrink swell potential, given the medium to high plasticity values obtained during testing. Prior to development construction, lot classification ranges should be clarified and specific classifications should be made for each new residential site.

The exception to the above would be where existing filling, such as that within the existing dam walls, warranted an alternative classification of Class P. However, the construction of residences is unlikely to occur close to these dams. Similarly, placement of filling during subdivisional earthworks may alter the classification of site areas affected by controlled filling, although with appropriate consideration during design, filled lots could be maintained as Class M or Class H sites.

10.6.2 Footings

All footing systems should be designed and constructed in accordance with AS2870-2011 (Ref 8) for the appropriate site classification. High level footing systems founding on stiff to very stiff clay soil would be appropriate for Class M and Class H sites (most new lots). Further delineation between Class H1 and Class H2 sites would need to be made for any subsequent construction certificate issue or prior to linen release. In addition, foundation systems may be required for Class S or Class A sites (a very small proportion of the overall number of lots), subject to post-development rock depths and the depth of excavation undertaken during individual residence construction, particularly where rock depths are currently relatively shallow (central eastern part of proposed development area). It is pointed out though that Class S and Class A sites are difficult to achieve, when dealing with clay soils.

10.6.3 Site Preparation and Earthworks

Site preparation for the construction of residential structures should include the removal of topsoils and other deleterious materials from the proposed building areas.

In areas that require filling, the stripped surfaces should be proof rolled in the presence of a geotechnical engineer. Any areas exhibiting significant deflections under proof rolling should be appropriately treated by over-excavation and replacement with low plasticity filling placed in near horizontal layers no thicker than 250 mm compacted thickness. Each layer should be compacted to a minimum dry density ratio of 98% relative to standard compaction with placement moisture contents maintained within 2% of standard optimum. The upper 0.5 m in areas of pavement construction should achieve a minimum dry density ratio of 100% relative to standard compaction with placement moisture contents similarly maintained.

All batters should be constructed no steeper than 3H:1V and appropriately vegetated to reduce the effects of erosion.

To validate site classifications, sufficient field inspections and in-situ testing of future earthworks should be undertaken in order to satisfy the requirements of a Level 1 inspection and testing service

as defined in AS3798-2007 *"Guidelines on Earthworks for Commercial and Residential Developments"* (Ref 9).

Earthworks required for pavement construction will need to be based on batters formed no steeper than 3H:1V in the residual clays. All batters should be suitably protected against erosion with toe and spoon drains constructed as a means of controlling surface flows on the batters.

10.6.4 Site Maintenance and Drainage

The developed lots should be maintained in accordance with the CSIRO publication *"Guide to Home Owners on Foundation Maintenance and Footing Performance"*, a copy of which is included in Appendix F. Whilst it must be accepted that minor cracking in most structures is inevitable, the guide describes suggested site maintenance practices aimed at minimising foundation movement to keep cracking within acceptable limits.

Adequate surface drainage should be installed and maintained at the site. All collected stormwater, groundwater and roof runoff should be discharged into the stormwater disposal system.

10.6.5 Pavements

Whilst detailed design of pavements will be undertaken at the development application stage, Table 6 summarises a range of pavement thickness designs (excluding asphalt thicknesses). These designs are based on the procedures given in AUSTROADS Guide to Pavement Technology Part 2: Pavement Structural Design, Figure 8.4 (Ref 10) for a range of traffic loadings and subgrade CBR values and are provided to give an indication of the range of pavement thickness that can be expected.

Table 6: Preliminary Pavement Thickness Design

Traffic Loading (ESA)	Total Pavement Thickness (mm)			
	CBR 3%	CBR 4%	CBR 5%	CBR 7%
1×10^5	380	330	290	240
3×10^5	440	380	340	280
1×10^6	520	440	390	320

The pavements should be placed and compacted in layers no thicker than 200 mm with control exercised over placement moisture contents. If layer thicknesses greater than 200 mm are proposed, then it may be necessary to test the top and bottom of the layer to ensure that the minimum level of compaction has been achieved through the layer. Suggested material quality and compaction requirements are given in Table 7.

Table 7: Materials and Compaction

Layer	Material Quality	Minimum Compaction
Wearing Course	To conform to Council requirements Generally AC10/AC14 asphalt	To conform to Council requirements
Base Course	To conform to RTA3051 for DGB20 Soaked CBR ≥ 80%, PI ≤ 6% or Council requirements	Minimum dry density ratio of 98% Modified (AS1289.5.2.1)
Sub-base Course	To conform to RTA3051 for DGS20 Soaked CBR ≥ 30%, PI ≤ 12% or Council requirements	Minimum dry density ratio of 98% Modified (AS1289.5.2.1)
Subgrade		Minimum dry density ratio of 100% Standard (AS1289.5.1.1)

Note: PI = plasticity index

Whilst the use of lesser quality pavement materials than that detailed in Table 7 may be feasible, some compromise in either performance and/or pavement life must be anticipated and accepted. It is also suggested that advice be sought from Council if lesser quality pavement materials are proposed.

Surface and subsoil drainage should be installed and maintained to protect the pavement and subgrade. The subsoil drains should be located at a minimum of 0.6 m depth below the pavement subgrade with drains placed on the high sides of all pavements, as a minimum. Guidelines on the arrangement of subsoil drains are given on Page 20 of ARRB-SR41 (Ref 11).

10.7 Soil and Water Management Plan

Based on the results of the current site assessment, the implementation of a soil and water management plan (SWMP) for this development is not essential, as assessment results indicate non-saline and generally non-aggressive to mildly aggressive soil conditions. However, it may be prudent to develop a SWMP to ensure appropriate site design given that the sodicity and erosion potential is moderate to high. A commonsense approach to the control of ground surfaces, by maintaining constant vegetation or limiting the time of exposure for stripped ground, should be sufficient to maintain the integrity of the site.

Further testing is recommended for soil and surface water salinity prior to development approval. Hence, a SWMP can be developed and implemented then, if the results of these works show a plan is necessary. If adopted, the scope of the plan could also be expanded to cater for controls on minimising soil erosion and maximising the re-use of existing site materials, together with providing guidance for implementation controls, land disturbance, pollution control and construction inspections and maintenance during development.

11. Further Investigation

The results of the land capability assessment to date have not identified any issue that would preclude the rezoning of the Eastern Precinct for residential development. However, further investigation will be required as conceptual design/planning progresses together with additional work during the construction phase. Specific investigation would typically be undertaken at the appropriate development application or construction certificate stage and would include (but not necessarily be limited to):

- Additional salinity investigations for site soils and surface waters to increase the density of the data obtained to date. The investigation programme should be increased to compliment the current study and augment the findings to a frequency of testing satisfying one test location per two hectares, including additional full depth profile sampling and laboratory analysis.
- Additional investigation should be undertaken in development areas which are to be excavated deeper than 2 m or into rock at shallower depth, where direct sampling and testing of salinity has not been carried out. Salinity management strategies should then be reassessed following additional investigation by deep test pitting and/or drilling, sampling and testing for soil and water pH, electrical conductivity, TDS, sodicity, sulphates and chlorides.
- Additional testing of the site's soils and surface water (and groundwater, if encountered) for aggressivity testing and its effects on buried concrete structures.
- Specific geotechnical assessment of the Dam 1 embankment to determine the subsurface conditions, the possible causes of the current instability on the downstream embankment face and to assess whether improvements are required to allow the dam to remain as part of the proposed residential development.
- Detailed geotechnical investigations on a stage-by-stage basis for determination of pavement thickness designs and lot classifications.
- Routine inspections and earthworks monitoring during construction.

12. Summary of Land Capability for Site Development

Based on the results of the assessment thus far, the following summary points are noted:

- No significant evidence of hillside/slope instability was observed within the natural landforms at the site. Although instability was noted at the western end of the Dam 1 embankment, it is considered that this instability can be rectified during subdivisional development, when the dam is augmented to account for current design standards. Excluding Dam1, it is considered that slope instability does not impose significant constraints on the proposed site development.
- The presence of erosive soils on site should not present significant constraints to development provided they are well managed during earthworks and site preparation stages.
- No significant evidence of saline soil was identified within the site. Although further salinity testing is considered necessary, at this stage salinity levels are sufficiently low for this site to be deemed free of significant salinity constraints.
- Although mild aggressivity to concrete is regularly encountered across the site, aggressivity levels are considered to be manageable, subject to appropriate design and construction consideration.

- Highly sodic and sodic soils appear widespread and will require management to reduce dispersion, erosion and to improve drainage.
- The results of the land capability assessment have not identified any issue that would preclude the rezoning of the Eastern Precinct for residential development.

13. Limitations

Douglas Partners (DP) has prepared this updated report for this project at Fernhill Estate, Eastern Precinct, Mulgoa Road, Mulgoa, in accordance with instructions received from Mr Paul Cubelic of Cubelic Holdings Pty Ltd. The work was carried out under DP's Conditions of Engagement. This updated report is provided for the exclusive use of Cubelic Holdings Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by 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 components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

14. References

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4. DIPNR, 2002. Salinity Potential in Western Sydney 1:100 000 Sheet. Department of Infrastructure, Planning and Natural Resources, New South Wales.
5. Richards, L. A. (ed.) 1954. Diagnosis and Improvement of Saline and Alkaline Soils. USDA Handbook No. 60, Washington D.C.
6. Hazelton, P. A. and Murphy B. W. 1992. A Guide to the Interpretation of Soil Test Results. Department of Conservation and Land Management.
7. Standards Australia. 2009. AS2159-2009 Piling – Design and Installation.
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9. Standards Australia. 2007. AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.
10. AUSTROADS Guide to Pavement Technology Part 2: Pavement Structural Design.
11. Australian Roads Research Board – Special Report 41, 1989. A Structural Design Guide for Residential Street Pavements.

Douglas Partners Pty Ltd

Appendix A

About this Report
Drawings 101 to 104

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.

Copyright

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

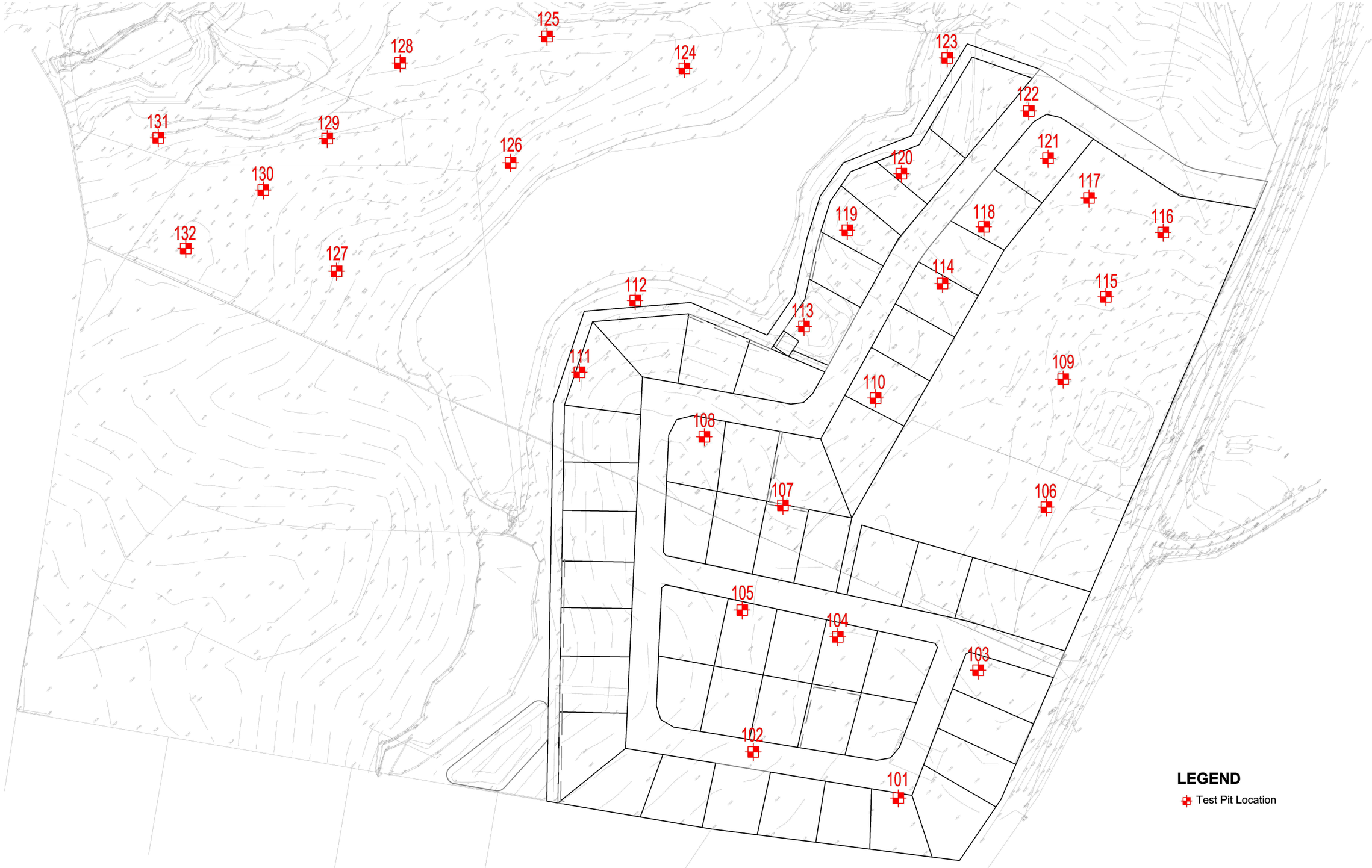
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later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

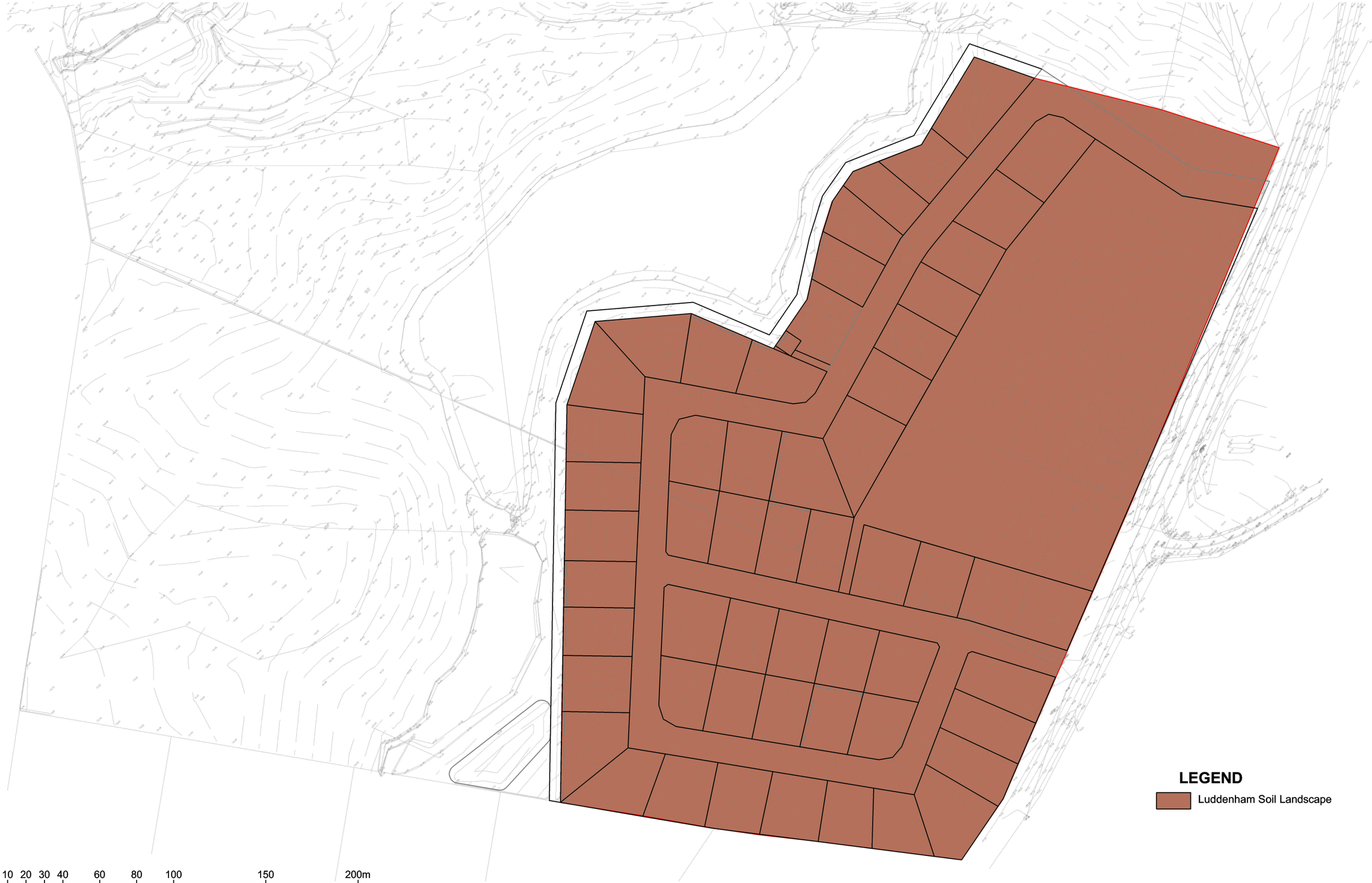


Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Cubelic Holdings Pty Ltd		
OFFICE: Sydney	DRAWN BY: PSCH	
SCALE: As shown	DATE: 25.6.2013	

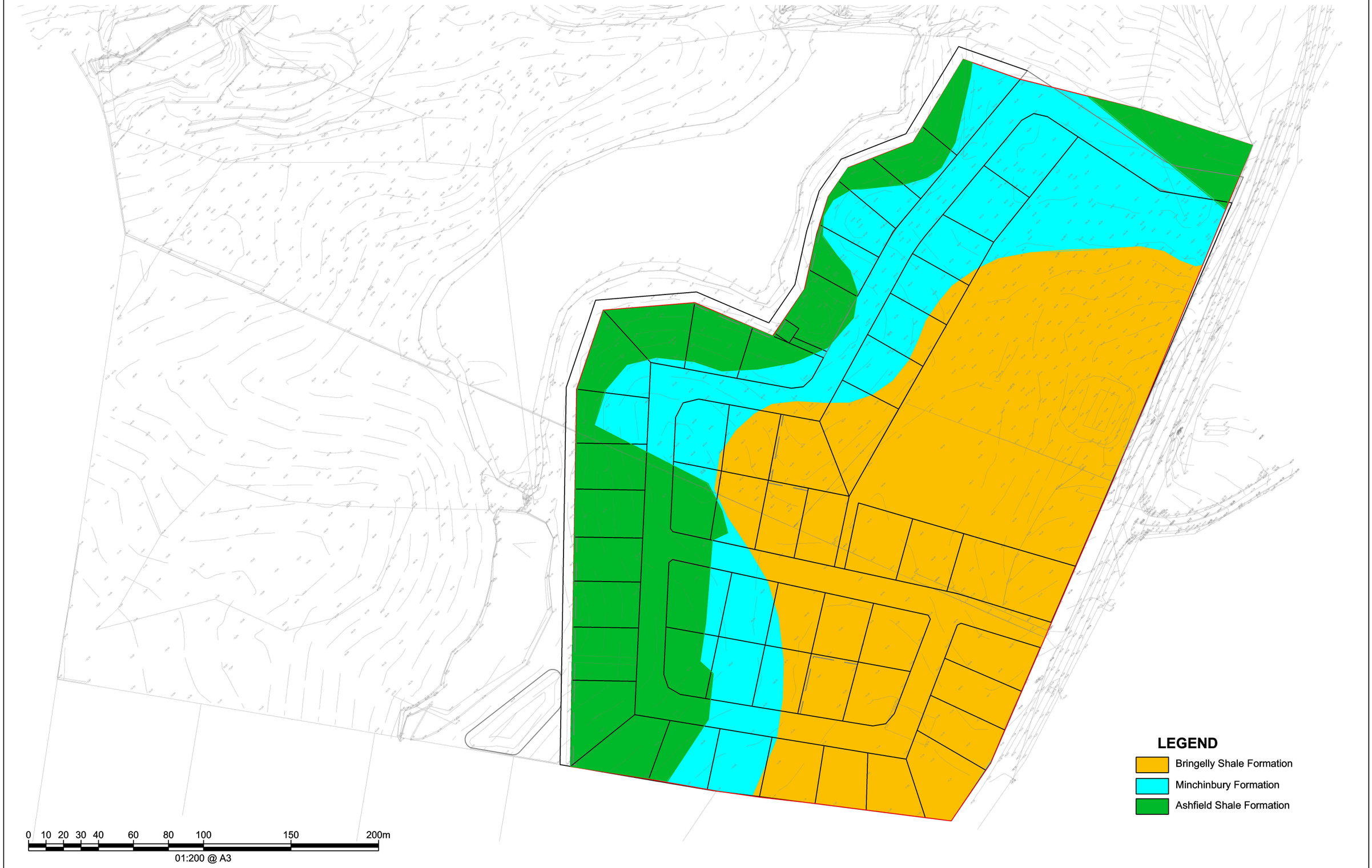
TITLE: **Location of Test Pits**
Land Capability Assessment - Eastern Precint
Mulgoa Road, MULGOA

PROJECT No:	71706.01
DRAWING No:	101
REVISION:	B



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Cubelic Holdings Pty Ltd		TITLE: **Soil Landscape Plan**	PROJECT No: 71706.01
OFFICE: Sydney	DRAWN BY: PSCH	**Land Capability Assessment - Eastern Precint**	DRAWING No: 102
SCALE: As shown	DATE: 25.6.2013	**Mulgoa Road, MULGOA**	REVISION: B



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Cubelic Holdings Pty Ltd		TITLE: **Geological Formation Plan**	PROJECT No: 71706.01
OFFICE: Sydney	DRAWN BY: PSCH	**Land Capability Assessment - Eastern Precint**	DRAWING No: 103
SCALE: As shown	DATE: 25.6.2013	**Mulgoa Road, MULGOA**	REVISION: B

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CLIENT: Cubelic Holdings Pty Ltd		TITLE: **Salinity Potential Plan**	PROJECT No: 71706.01
OFFICE: Sydney	DRAWN BY: PSCH	**Land Capability Assessment - Eastern Precint**	DRAWING No: 104
SCALE: As shown	DATE: 25.6.2013	**Mulgoa Road, MULGOA**	REVISION: B

Appendix B

Site Photographs

Photo 1 – View looking north across eastern part of Lot 1 between existing dwelling and Mulgoa Road

Photo 2 – View looking east across central eastern part of Lot 1 between Dam 1 and existing dwelling

Douglas Partners Geotechnics / Environment / Groundwater	**General Site Photographs** **Proposed Development** **Eastern Precinct, Fernhill Estate, Mulgoa Rd, Mulgoa**	PROJECT:	71706.01
		PLATE No:	1
		REV:	B
	CLIENT: Cubelic Holdings Pty Ltd	DATE:	3-Aug-10

Photo 3 – View looking west across western part of Lot 1 west of Dam 1 towards tree line along western site boundary

Photo 4 – View looking along existing unsealed track traversing partly cleared bushland near northern site boundary

Douglas Partners Geotechnics / Environment / Groundwater	**General Site Photographs** **Proposed Development** **Eastern Precinct, Fernhill Estate, Mulgoa Rd, Mulgoa**	PROJECT: 71706.01 PLATE No: 2 REV: B
	CLIENT: Cubelic Holdings Pty Ltd	DATE: 3-Aug-10

Photo 5 – Panaramic view looking north across Dam 1 through central part of Lot 1

Photo 6 – Panaramic view looking north-east across western part of Lot 1

Photo 7 – Panaramic view looking south across Dam 1 through central part of Lot 1

Douglas Partners Geotechnics / Environment / Groundwater	**General Site Photographs** **Proposed Development** **Eastern Precinct, Fernhill Estate, Mulgoa Rd, Mulgoa**	PROJECT:	71706.01
		PLATE No:	3
		REV:	B
	CLIENT: Cubelic Holdings Pty Ltd	DATE:	3-Aug-10

Appendix C

Field Works Results

Sampling Methods

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Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Soil Descriptions

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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.

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

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

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Degree of Fracturing

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

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

Rock Descriptions

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Symbols & Abbreviations

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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

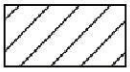

Concrete


Filling

Soils


Topsoil

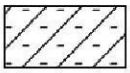

Peat


Clay

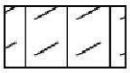

Silty clay

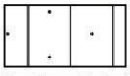

Sandy clay

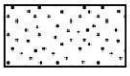

Gravelly clay

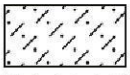

Shaly clay

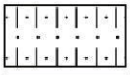

Silt


Clayey silt


Sandy silt

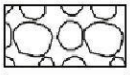

Sand

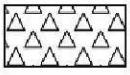

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

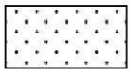

Talus

Sedimentary Rocks

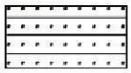

Boulder conglomerate

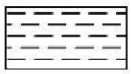

Conglomerate


Conglomeratic sandstone

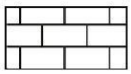

Sandstone


Siltstone

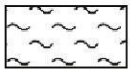

Laminite

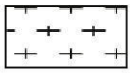

Mudstone, claystone, shale

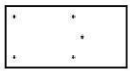

Coal


Limestone

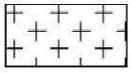
Metamorphic Rocks

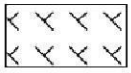

Slate, phyllite, schist

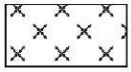

Gneiss

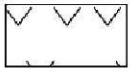

Quartzite

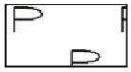
Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 71.5 AHD
EASTING: 282648
NORTHING: 6253569
DIP/AZIMUTH: 90°/--

PIT No: 101
PROJECT No: 71706
DATE: 23/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
71	0.18	TOPSOIL - firm, dark brown, silty clay with some rootlets, damp							
		SILTY CLAY - stiff, brown grey and orange brown, silty clay							
	0.7	SANDSTONE - very low strength, highly weathered, grey, fine grained sandstone with a trace of orange brown silty clay							
	0.95	0.9m: medium strength							
	1	Pit discontinued at 0.95m - refusal on medium strength sandstone							1
70	2								2
69	3								3
68	4								4
67									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	DCB
Date:	3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 69.5 AHD
EASTING: 282569
NORTHING: 6253594
DIP/AZIMUTH: 90°/--

PIT No: 102
PROJECT No: 71706
DATE: 23/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
69	0.31	TOPSOIL - stiff, brown, silty clay with some rootlets		D	0.25				
	0.5	SILTY CLAY - very stiff, brown grey, silty clay with a trace of rootlets, medium to high plasticity		D	0.5				
	0.9	SILTY CLAY - very stiff, orange brown, silty clay, medium to high plasticity		D	0.6				
	1.2	SANDSTONE - low strength, grey, fine grained sandstone with some ironstone banding 1.1m: medium strength		D	1.0				
68		Pit discontinued at 1.2m - refusal on medium strength sandstone							
67									
66									
65									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3, 4

RIG: Case 58 Backhoe
LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 68.5 AHD
EASTING: 282691
NORTHING: 6253639
DIP/AZIMUTH: 90°/--

PIT No: 103
PROJECT No: 71706
DATE: 21/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
68	0.35	TOPSOIL - firm, dark brown, silty clay with some rootlets, damp							
		SILTY CLAY - very stiff, orange brown and red brown, silty clay with a trace of ironstone gravel, medium plasticity		B	0.4 0.6				
67	1.2	SHALE - extremely low to low strength, extremely to highly weathered, grey shale 2.1m: low to medium strength							
66	2.3	Pit discontinued at 2.3m - practical refusal on low to medium strength shale							
65									
64									

RIG: Case 58 Backhoe
LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: QCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 70.0 AHD **PIT No:** 104
EASTING: 282615 **PROJECT No:** 71706
NORTHING: 6253657 **DATE:** 21/4/2010
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
70		TOPSOIL - stiff, brown, silty clay with some rootlets and a trace of gravel, damp			0.2				
				E	0.3				
	0.33	SILTY CLAY - stiff to very stiff, orange brown, silty clay with a trace of ironstone gravel, medium to high plasticity			0.4				
				E	0.5				
69	1								1
	1.1	SHALE - extremely low to low strength, extremely weathered, grey shale with fine grained sandstone bands							
		1.9m: low to medium strength							
68	2								2
	2.0	Pit discontinued at 2.0m - practical refusal on low to medium strength shale							
67	3								3
66	4								4

RIG: Case 58 Backhoe **LOGGED:** AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample. Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	RCB
Date:	3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 69.0 AHD
EASTING: 282563
NORTHING: 6253671
DIP/AZIMUTH: 90°/--

PIT No: 105
PROJECT No: 71706
DATE: 21/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
69		TOPSOIL - firm, dark brown, silty clay with some rootlets, damp							
	0.29	SILTY CLAY - stiff, mottled red brown and grey, silty clay with a trace of ironstone gravel, medium to high plasticity		U	0.6				
					0.8		pp = 420kPa		
68	1								1
	1.1	SANDSTONE - extremely low strength, extremely weathered, grey, fine grained sandstone 1.3m: low to medium strength							
	1.4	Pit discontinued at 1.4m - practical refusal on low to medium strength sandstone							
67	2								2
66	3								3
65	4								4

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 65.5 AHD
EASTING: 282728
NORTHING: 6253727
DIP/AZIMUTH: 90°/--

PIT No: 106
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
65	0.32	TOPSOIL - stiff, dark brown, silty clay with some rootlets, damp		D	0.25				
		SILTY CLAY - very stiff to hard, red brown, silty clay with a trace of ironstone gravel		D	0.5				
	0.6	SHALE - extremely low strength, extremely weathered, grey shale with some orange brown silty clay seams							
	1			D	1.0				1
64	1.3	SANDSTONE - extremely low strength, extremely weathered, grey, fine grained sandstone		D	1.5				
	1.8	SHALE - extremely low to very low strength, extremely to highly weathered, grey shale							
	2			D	2.0				2
	2.3	2.2m: low to medium strength Pit discontinued at 2.3m - practical refusal on low to medium strength shale							
63	3								3
62	4								4
61									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 67.5 AHD
EASTING: 282586
NORTHING: 6253728
DIP/AZIMUTH: 90°/--

PIT No: 107
PROJECT No: 71706
DATE: 21/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
67	0.3	TOPSOIL - firm to stiff, brown, silty clay with some rootlets and a trace of gravel, damp							
		SILTY CLAY - stiff to very stiff, silty clay with a trace of ironstone gravel, medium to high plasticity		D	0.5				
	1			D	1.0				1
66	1.1	SHALE - extremely low to very low strength, extremely to highly weathered, grey shale							
	2								2
	2.2	SANDSTONE - low strength, highly weathered, grey, fine grained sandstone							
65		2.5m: low to medium strength							
	2.6	Pit discontinued at 2.6m - practical refusal on low to medium strength sandstone							
	3								3
64									
	4								4
63									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 68.5 AHD
EASTING: 282543
NORTHING: 6253765
DIP/AZIMUTH: 90°/--

PIT No: 108
PROJECT No: 71706
DATE: 21/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
68	0.32	TOPSOIL - stiff, dark brown, silty clay with some rootlets, damp							
		SILTY CLAY - stiff to very stiff, mottled red brown and orange brown, silty clay with some grey shale gravel, medium to high plasticity		B	0.4				
				D	0.5				
					0.6				
	0.9	SANDSTONE - extremely low to low strength, extremely to highly weathered, grey, fine grained sandstone		D	1.0				
67	1	1.7m: medium strength							
	1.8	Pit discontinued at 1.8m - practical refusal on medium strength sandstone							
66	2								
	3								
65									
	4								
64									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 66.5 AHD
EASTING: 282737
NORTHING: 6253796
DIP/AZIMUTH: 90°/--

PIT No: 109
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
66	0.3	TOPSOIL - firm, dark brown, silty clay with some rootlets and gravel, damp							
		SILTY CLAY - stiff to very stiff, red brown, silty clay with a trace of ironstone gravel		U	0.6 0.8		pp>400kPa		
	0.9	SHALE - extremely low strength, extremely weathered, grey shale with orange brown silty clay seams							
65	1								1
		1.8m: ironstone band							
	2								2
64		2.3m: low strength							
	3								3
		3.0m: medium strength							
	3.2	Pit discontinued at 3.2m - practical refusal on medium strength shale							
63									
	4								4
62									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 65.5 AHD
EASTING: 282635
NORTHING: 6253787
DIP/AZIMUTH: 90°/--

PIT No: 110
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
65	0.3	TOPSOIL - stiff, dark brown, silty clay with some rootlets and gravel, damp		E	0.2				
		SILTY CLAY - stiff to very stiff, mottled red brown and grey, silty clay with a trace of rootlets, medium to high plasticity		E	0.3				
				D	0.4				
	0.9				0.5				
64	1	SHALE - extremely low strength, extremely weathered, grey shale with red brown silty clay seams		D	1.0				
	2	2.3m: low to medium strength, dark grey brown							
63	2.5	Pit discontinued at 2.5m - practical refusal on low to medium strength shale							
62	3								
61	4								

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample. Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 63.5 AHD
EASTING: 282475
NORTHING: 6253800
DIP/AZIMUTH: 90°/--

PIT No: 111
PROJECT No: 71706
DATE: 21/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
		TOPSOIL - firm to stiff, brown, silty clay with some rootlets, humid to damp							
	0.22	SILTY CLAY - very stiff, red brown, silty clay, medium to high plasticity		D	0.25				
63				D	0.5				
	0.9	SANDSTONE - extremely low strength, extremely weathered, grey, fine grained sandstone		D	1.0				1
	1.3	SHALE - low to medium strength, moderately weathered, dark grey brown shale		D	1.5				
62	1.8	Pit discontinued at 1.8m - practical refusal on low to medium strength shale		D	1.8				2
61									3
60									4
59									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 61.5 AHD
EASTING: 282505
NORTHING: 6253839
DIP/AZIMUTH: 90°/--

PIT No: 112
PROJECT No: 71706
DATE: 21/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
61	0.41	TOPSOIL - firm to stiff, dark brown, silty clay with some rootlets, damp							
		SILTY CLAY - stiff to very stiff, red brown then orange brown and grey, silty clay with a trace of ironstone gravel		D	0.5				
	1			D	1.0				
60	1.1	SHALE - extremely low to very low strength, extremely to highly weathered, grey shale							
		1.7m: medium strength, dark grey brown							
	2								
59	2.0	Pit discontinued at 2.0m refusal on medium strength shale							
	3								
58									
	4								
57									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 61.0 AHD
EASTING: 282577
NORTHING: 6253828
DIP/AZIMUTH: 90°/--

PIT No: 113
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
61	0.31	TOPSOIL - firm, brown, silty clay with some rootlets and a trace of gravel							
60	1	SILTY CLAY - stiff, mottled orange brown and grey, silty clay with a trace of ironstone gravel, medium plasticity							
	1.3								
59	2	SHALE - extremely low strength, extremely weathered, grey shale with some orange brown silty clay							
	2.1	SHALE - low strength, highly weathered, grey and dark grey shale 2.6m: medium strength, dark grey brown							
	2.7	Pit discontinued at 2.7m - refusal on medium strength shale							
58	3								
57	4								

Dynamic Penetrometer Test (blows per 0mm): 5, 10, 15, 20

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 67.5 AHD
EASTING: 282672
NORTHING: 6253848
DIP/AZIMUTH: 90°/--

PIT No: 114
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
67	0.32	TOPSOIL - stiff, brown, silty clay with some rootlets, damp		D	0.25				
		SILTY CLAY - stiff to hard, red brown, silty clay with a trace of fine grained sand, medium to high plasticity		D	0.5				
	0.9	SANDSTONE - extremely low strength, extremely weathered, grey, fine grained sandstone		D	1.0				
66	1	1.3m: very low to low strength		D	1.5				
	2			D	2.0				
	2.2	SHALE - extremely low to very low strength, grey shale		D	2.5				
65		2.7m: low strength							
	2.9	Pit discontinued at 2.9m - practical refusal on low to medium strength shale							
64	3								
	4								
63									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 67.5 AHD
EASTING: 282759
NORTHING: 6253842
DIP/AZIMUTH: 90°/--

PIT No: 115
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
67	0.22	TOPSOIL - firm to stiff, dark brown, silty clay with some rootlets, damp							
		SILTY CLAY - very stiff to hard, red brown silty clay, medium plasticity		D	0.5				
	0.9	SHALE - extremely low to very low strength, extremely to highly weathered, grey shale with some orange brown silty clay seams		D	1.0				
66	1								1
		1.8m: very low to low strength							
65	2								2
	3								3
		3.3m: low to medium strength							
64	3.5	Pit discontinued at 3.5m - practical refusal on medium strength shale							4
63	4								

RIG: Case 58 Backhoe
LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 69.5 AHD
EASTING: 282791
NORTHING: 6253876
DIP/AZIMUTH: 90°/--

PIT No: 116
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
69	0.21	TOPSOIL - stiff, dark brown, silty clay with some rootlets, damp							
		SILTY CLAY - very stiff to hard, brown and red brown, silty clay with a trace of ironstone gravel, medium to high plasticity							
	0.8	SANDSTONE - very low to low strength, highly weathered, grey, fine grained sandstone							
68	1.7	1.6m: medium strength Pit discontinued at 1.7m - practical refusal on medium strength sandstone							
67									
66									
65									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3, 4

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

Douglas Partners
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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 70.0 AHD
EASTING: 282751
NORTHING: 6253894
DIP/AZIMUTH: 90°/--

PIT No: 117
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
70	0.25	TOPSOIL - firm to stiff, brown, silty clay with some rootlets, damp							
		SILTY CLAY - very stiff, mottled red brown and grey, silty clay with a trace of ironstone gravel		B	0.4				
		- increasing ironstone from 0.6m			0.6				
69	1								1
	1.6	SANDSTONE - extremely low to very low strength, extremely to highly weathered, grey, fine grained sandstone							
68	2	2.2m: low to medium strength							2
	2.4	Pit discontinued at 2.4m - practical refusal on medium strength sandstone							
67	3								3
66	4								4

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 69.5 AHD
EASTING: 282694
NORTHING: 6253879
DIP/AZIMUTH: 90°/--

PIT No: 118
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
69	0.2	TOPSOIL - firm, brown, silty clay with some rootlets and a trace of gravel, damp							
		SILTY CLAY - very stiff, orange brown mottled red brown and grey, silty clay with some ironstone gravel, medium to high plasticity		U	0.4		pp>400kPa		
					0.73				
68	1.2	SANDSTONE - extremely low strength, extremely weathered, fine grained sandstone with some red brown silty clay seams							
		2.1m: low to medium strength							
67	2.3	Pit discontinued at 2.3m - practical refusal on medium strength sandstone							
66									
65									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 67.0 AHD **PIT No:** 119
EASTING: 282620 **PROJECT No:** 71706
NORTHING: 6253877 **DATE:** 22/4/2010
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
67	0.36	TOPSOIL - firm, brown, silty clay with some rootlets and ironstone cobbles, damp							
66	1.1	SILTY CLAY - very stiff, red brown, silty clay with some ironstone gravel and cobbles, medium to high plasticity							
	1.5	SANDSTONE - extremely low to very low strength, extremely to highly weathered, grey, fine grained sandstone 1.4m: medium strength							
65	2	Pit discontinued at 1.5m - refusal on medium strength sandstone							
64	3								
63	4								

Dynamic Penetrometer Test (blows per 0mm): 5, 10, 15, 20

RIG: Case 58 Backhoe **LOGGED:** AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 65.5 AHD
EASTING: 282649
NORTHING: 6253908
DIP/AZIMUTH: 90°/--

PIT No: 120
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
65	0.46	TOPSOIL - stiff, brown, silty clay with some rootlets, damp		D	0.25				
		SILTY CLAY - very stiff to hard, red brown silty clay, medium to high plasticity		D	0.5				
	0.9	SHALE - extremely low to very low strength, grey shale with some red brown silty clay		D	1.0				
64		1.4m: low strength		D	1.5				
		2.2m: low to medium strength		D	2.0				
63	2.4	Pit discontinued at 2.4m - practical refusal on medium strength shale							
62									
61									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 70.0 AHD
EASTING: 282729
NORTHING: 6253916
DIP/AZIMUTH: 90°/--

PIT No: 121
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
70	0.33	TOPSOIL - stiff, brown, silty clay with some rootlets and a trace of ironstone gravel							
		SILTY CLAY - hard, mottled red brown and grey, silty clay and ironstone gravel, medium to high plasticity		D	0.5				
69	0.95	SANDSTONE - medium strength, slightly weathered, grey, fine grained sandstone		D	1.0				
	1.1	Pit discontinued at 1.1m - practical refusal on medium strength sandstone							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3, 4

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 69.5 AHD
EASTING: 282719
NORTHING: 6253942
DIP/AZIMUTH: 90°/--

PIT No: 122
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
69	0.32	TOPSOIL - firm to stiff, brown, silty clay with some rootlets, humid to damp							
		SILTY CLAY - very stiff, mottled red brown and grey, silty clay with some ironstone gravel, medium to high plasticity							
	0.9	SANDSTONE - very low strength, highly weathered, grey, fine grained sandstone							
68	1.2	1.1m: medium strength Pit discontinued at 1.2m - practical refusal on medium strength sandstone							
67									
66									
65									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: QCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 64.5 AHD
EASTING: 282674
NORTHING: 6253970
DIP/AZIMUTH: 90°/--

PIT No: 123
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
64	0.3	TOPSOIL - stiff, brown, silty clay with some rootlets and gravel, humid		E	0.2				
	0.35	SILTY CLAY - very stiff, red brown silty clay, medium to high plasticity			0.3				
		SHALE - very low strength, highly weathered, grey shale with orange brown silty clay seams		E	0.4				
				D	0.5				
63	1	1.6m: medium strength							
	1.8	Pit discontinued at 1.8m - refusal on medium strength shale							
62	2								
61	3								
60	4								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample. Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 63.0 AHD
EASTING: 282532
NORTHING: 6253965
DIP/AZIMUTH: 90°/--

PIT No: 124
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
63		TOPSOIL - firm to stiff, brown, silty clay with some rootlets and gravel							
	0.21	SILTY CLAY - very stiff, red brown, silty clay with a trace of rootlets, high plasticity		E	0.2				
					0.3				
					0.4				
				E					
				D	0.5				
62	1			D	1.0				1
	1.2	Pit discontinued at 1.2m - practical refusal on low strength shale							
61	2								2
60	3								3
59	4								4

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample. Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 64.0 AHD **PIT No:** 125
EASTING: 282457 **PROJECT No:** 71706
NORTHING: 6253982 **DATE:** 22/4/2010
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
64	0.2	TOPSOIL - firm to stiff, brown, silty clay with some rootlets, damp							
		SILTY CLAY - very stiff to hard, red brown silty clay, medium to high plasticity		B	0.4 0.6				
63	1								1
	1.5	SHALE - medium to high strength, slightly weathered, grey shale							
	1.7	Pit discontinued at 1.7m - practical refusal on high strength shale							
62	2								2
61	3								3
60	4								4

RIG: Case 58 Backhoe **LOGGED:** AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 63.0 AHD
EASTING: 282438
NORTHING: 6253914
DIP/AZIMUTH: 90°/--

PIT No: 126
PROJECT No: 71706
DATE: 22/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
63		TOPSOIL - firm, brown, silty clay with some rootlets and a trace of gravel							
	0.27	SILTY CLAY - stiff, red brown silty clay, medium plasticity							
62	1 1.0	SHALE - extremely low to very low strength, extremely to highly weathered, grey shale 1.4m: medium strength							1
	1.5	Pit discontinued at 1.5m - practical refusal on medium strength shale							
61	2								2
60	3								3
59	4								4

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 63.5 AHD
EASTING: 282367
NORTHING: 6253871
DIP/AZIMUTH: 90°/--

PIT No: 127
PROJECT No: 71706
DATE: 23/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm) 5 10 15 20
63	0.19	TOPSOIL - firm to stiff, dark brown, silty clay with some rootlets and a trace of gravel, damp							
		SILTY CLAY - stiff to very stiff, dark brown grey, silty clay with a trace of rootlets, medium to high plasticity		D	0.25				
	0.6			D	0.5				
		SILTY CLAY - stiff to very stiff, red brown silty clay, medium plasticity							
	1			D	1.0				1
		1.2m: with some shale gravel							
62				D	1.5				
	2			D	2.0				2
	2.2	SHALE - extremely low strength, extremely weathered, grey shale							
61	2.5	- low to medium strength, dark grey brown							
		Pit discontinued at 2.5m - practical refusal on low to medium strength shale							
	3								3
60									
	4								4
59									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 64.0 AHD **PIT No:** 128
EASTING: 282378 **PROJECT No:** 71706
NORTHING: 6253968 **DATE:** 23/4/2010
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
64	0.21	TOPSOIL - stiff, brown, silty clay with some rootlets, humid to damp							
		SILTY CLAY - very stiff to hard, red brown silty clay, medium to high plasticity							
63	1								1
	1.8	SANDY CLAY - very stiff to hard, orange brown, sandy clay with a trace of gravel							
62	2								2
	2.5	SANDSTONE - extremely low strength, extremely weathered, grey, fine grained sandstone							
61	3								3
		- medium strength, dark grey brown							
60	4 4.0	Pit discontinued at 4.0m - target depth reached							4

RIG: Case 58 Backhoe **LOGGED:** AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 67.0 AHD
EASTING: 282338
NORTHING: 6253927
DIP/AZIMUTH: 90°/--

PIT No: 129
PROJECT No: 71706
DATE: 23/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
67	0	TOPSOIL - firm, brown, silty clay with some rootlets, damp							
	0.27	SILTY CLAY - very stiff, red brown silty clay, medium to high plasticity		B	0.4				
				D	0.5				
	0.8	SILTY CLAY - stiff, mottled orange brown and grey, silty clay with some ironstone gravel and cobbles		D	1.0				
66	1								1
	1.8	SHALE - extremely low to very low strength, grey shale with some grey, fine grained sandstone							
65	2								2
	2.8	2.7m: medium strength, dark grey brown							
		Pit discontinued at 2.8m - refusal on medium strength shale							
64	3								3
63	4								4

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RCB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 68.0 AHD **PIT No:** 130
EASTING: 282304 **PROJECT No:** 71706
NORTHING: 6253899 **DATE:** 23/4/2010
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm) 5 10 15 20
68		TOPSOIL - firm, brown, silty clay with some rootlets, damp							
	0.23	SILTY CLAY - very stiff to hard, red brown silty clay, medium plasticity		U	0.6		pp>400kPa		
67	1				0.91				1
	1.9	SHALE - extremely low strength, extremely weathered, grey shale with orange brown silty clay seams							
66	2								2
	2.3	2.3m: low to medium strength, dark grey brown							
	2.4	Pit discontinued at 2.4m - practical refusal on low to medium strength shale							
65	3								3
64	4								4

RIG: Case 58 Backhoe **LOGGED:** AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RAB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 65.0 AHD **PIT No:** 131
EASTING: 282247 **PROJECT No:** 71706
NORTHING: 6253927 **DATE:** 23/4/2010
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 0mm)
65	0.33	TOPSOIL - firm, brown, silty clay with some rootlets, damp		D	0.25				
		SILTY CLAY - very stiff to hard, orange brown silty clay, medium to high plasticity		D	0.5		pp>400kPa		
				U	0.83				
64	1	0.8m: mottled red brown and grey		D	1.0				1
	1.3	SHALE - low to medium strength, extremely weathered, grey shale with some orange brown silty clay seams		D	1.5				
63	1.9	SANDSTONE - low to medium strength, slightly weathered, yellow brown, fine grained sandstone		D	2.0				2
	2								
	2.2	Pit discontinued at 2.2m - practical refusal on low to medium strength sandstone							
62	3								3
61	4								4

RIG: Case 58 Backhoe **LOGGED:** AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: RcB
Date: 3.8.10

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TEST PIT LOG

CLIENT: Owston Nominees No. 2 Pty Ltd
PROJECT: Land Capability Assessment
LOCATION: Mulgoa Road, Mulgoa (Eastern Precinct)

SURFACE LEVEL: 68.5 AHD
EASTING: 282238
NORTHING: 6253882
DIP/AZIMUTH: 90°/--

PIT No: 132
PROJECT No: 71706
DATE: 23/4/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
68	0.2	TOPSOIL - stiff, brown, silty clay with some rootlets and a trace of gravel, humid to damp							
		SILTY CLAY - stiff to very stiff, red brown, silty clay with a trace of ironstone gravel		E	0.2 0.3				
				E	0.4 0.5				
67	1.1	SANDSTONE - extremely low strength, extremely weathered, grey, fine grained sandstone with a trace of grey shale 1.7m: medium strength							
	1.8	Pit discontinued at 1.8m - practical refusal on medium strength sandstone							
66									
65									
64									

RIG: Case 58 Backhoe

LOGGED: AP

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample. Survey levels taken from survey plans provided by Urbis Pty Ltd

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	RCB
Date:	3.8.10

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Appendix D

Laboratory Test Results - Geotechnical

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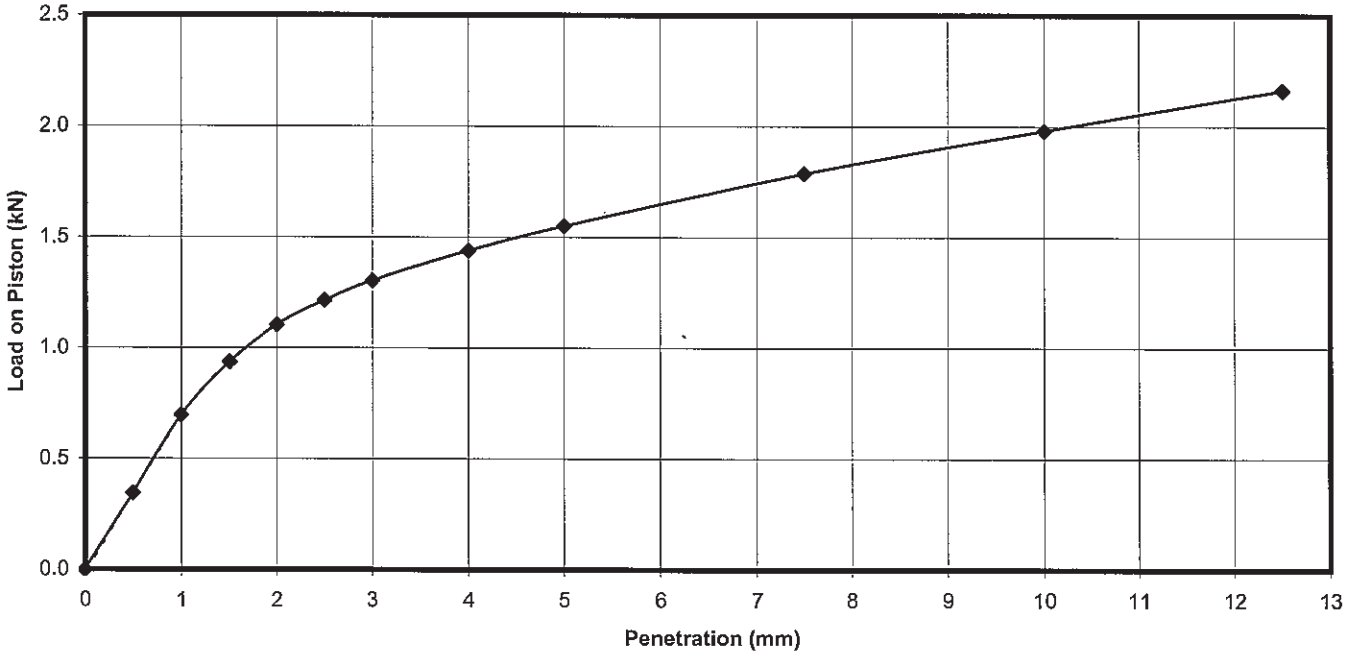
RESULT OF CALIFORNIA BEARING RATIO TEST

Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 A
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	26/05/2010
		Date Sampled :	19-23/04/10
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	14/05/2010
Test Location :	TP 103		
Depth / Layer :	0.4-0.6m	**Page:**	1 of 1



Description: SILTY CLAY - Orange brown and red brown silty clay with a trace of ironstone gravel

Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by Engineering Department

Percentage > 19mm: 8.9% (Excluded)

LEVEL OF COMPACTION: 101% of STD MDD
MOISTURE RATIO: 95% of STD OMC
SURCHARGE: 4.5 kg
SOAKING PERIOD: 4 days
SWELL: 0.7%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		22.6	1.62
After soaking		25.8	1.61
After test	Top 30mm of sample	26.5	-
	Remainder of sample	23.9	-
Field values		21.9	-
Standard Compaction		23.9	1.60

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**2.5 mm**	**9**
	5.0 mm	**8**

Form R019 Rev6 July 2006

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Approved Signatory:

Tested:	DB
Checked:	NW

Norman Weimann
Laboratory Manager

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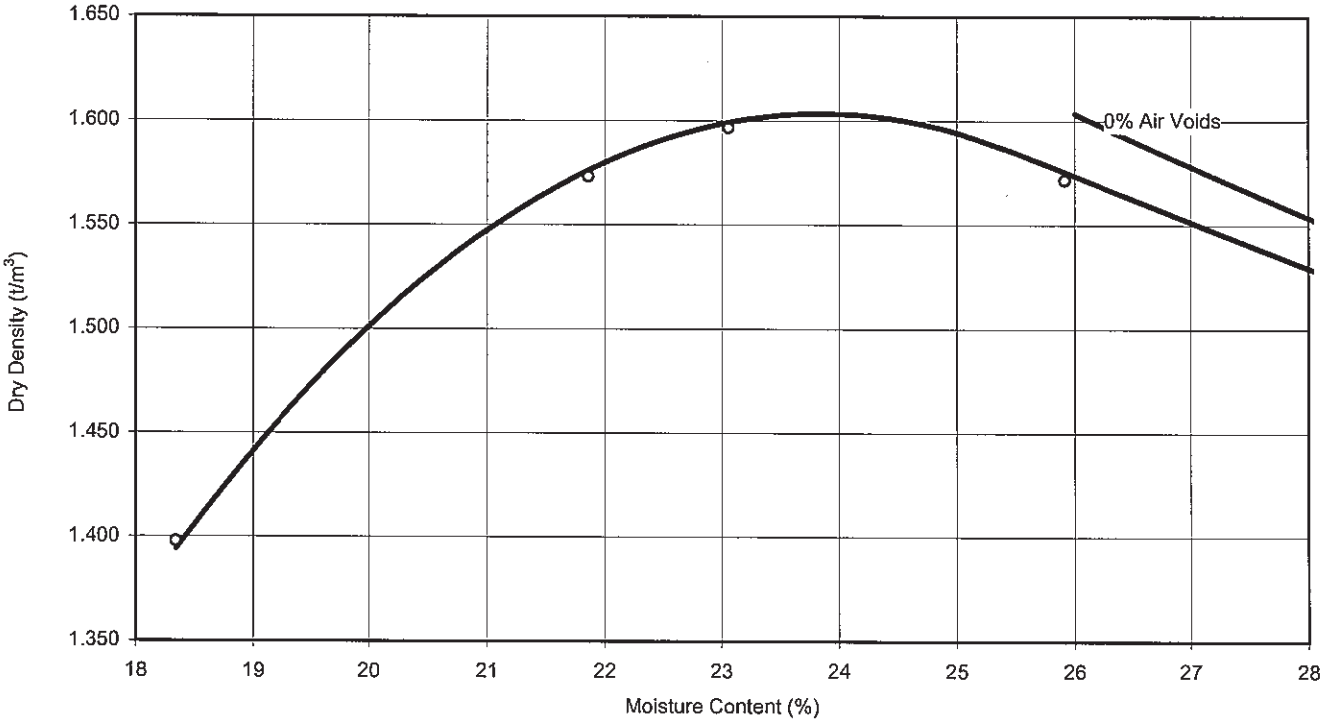
RESULTS OF COMPACTION TEST

Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 A2
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	14/05/2010
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	13/05/2010
		Page:	1 of 1



Sample Details **Location:** TP 103
Depth: 0.4 - 0.6m

Particles > 19mm: 9%

Description: SILTY CLAY - Orange brown and red brown silty clay with a trace of ironstone gravel

Maximum Dry Density:	**1.60 t/m^3**
Optimum Moisture Content:	**24.0 %**

Remarks:

Test Methods: AS 1289.2.1.1, AS 1289.5.1.1

Sampling Methods: Sampled by Engineering Department

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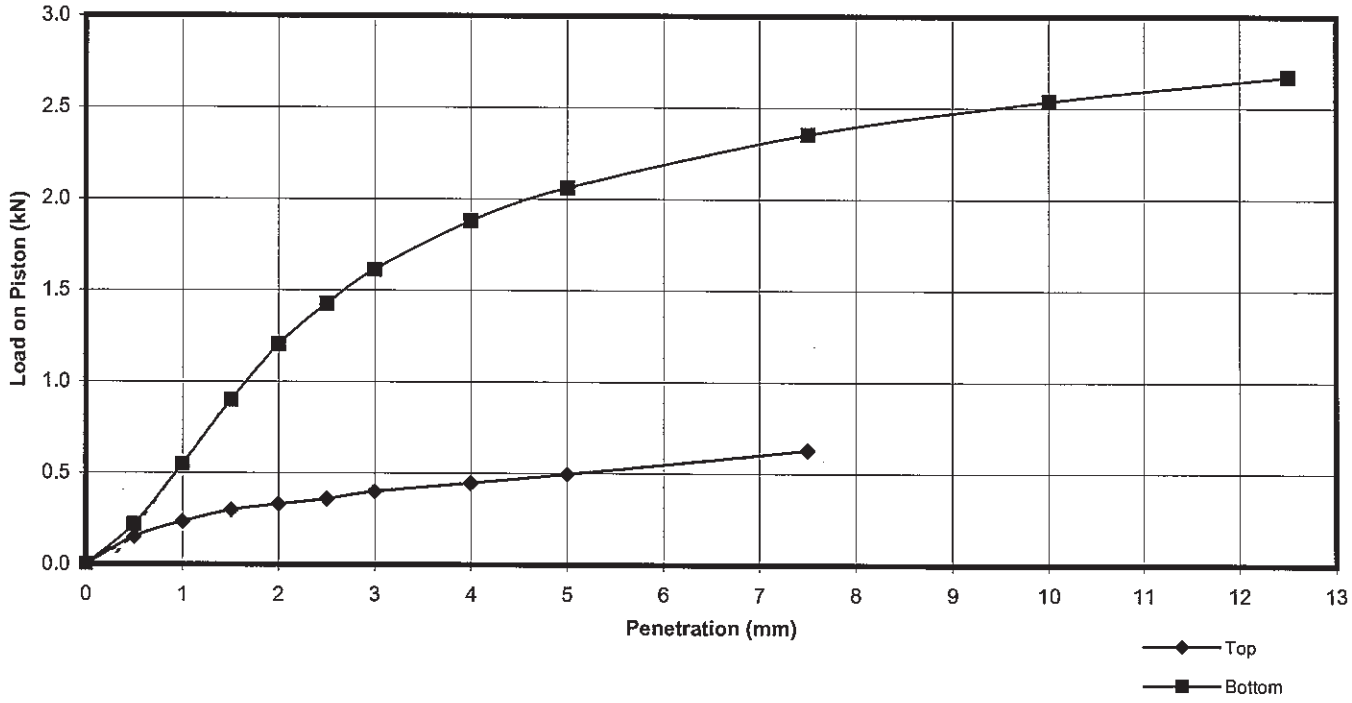
RESULT OF CALIFORNIA BEARING RATIO TEST

Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 B
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	26/05/2010
		Date Sampled :	19-23/04/10
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	14/05/2010
Test Location :	TP 108		
Depth / Layer :	0.4 - 0.6m	**Page:**	1 of 1



Description: SILTY CLAY - Mottled red brown and orange brown silty clay with some grey shale

Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by Engineering Department

Percentage > 19mm: 7.8% (Excluded)

LEVEL OF COMPACTION: 99% of STD MDD
MOISTURE RATIO: 105% of STD OMC
SURCHARGE: 4.5 kg
SOAKING PERIOD: 4 days
SWELL: 2.4%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		21.2	1.66
After soaking		24.8	1.62
After test	Top 30mm of sample	25.7	-
	Remainder of sample	21.8	-
Field values		18.7	-
Standard Compaction		20.3	1.67

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**2.5 mm**	**2.5**
	5.0 mm	**2.5**
BOTTOM	**2.5 mm**	**11**
	5.0 mm	**11**

Form R019 Rev4 July 2006

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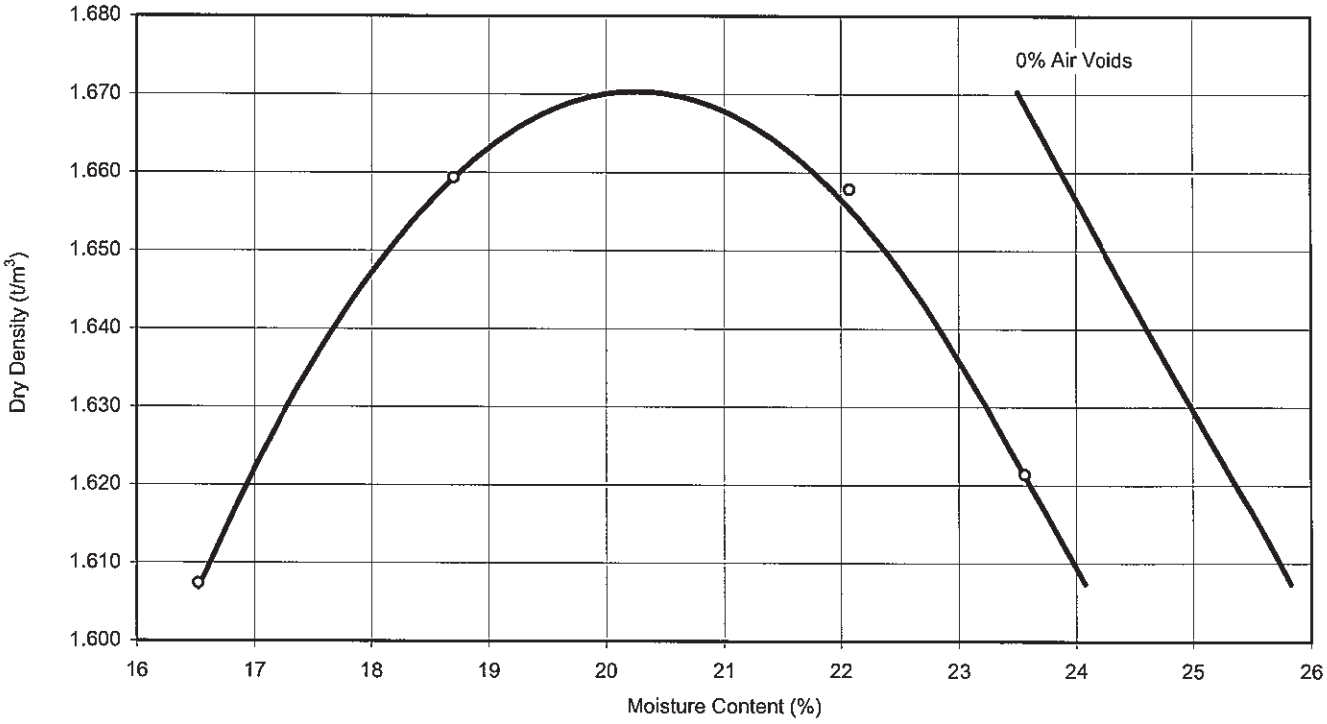
RESULTS OF COMPACTION TEST

Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 B2
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	14/05/2010
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	13/05/2010
		Page:	1 of 1



Sample Details **Location:** TP 108
Depth: 0.4 - 0.6m

Particles > 19mm: 8%

Description: SILTY CLAY - Mottled red brown and orange brown silty clay with some grey shale

Maximum Dry Density:	**1.67 t/m^3**
Optimum Moisture Content:	**20.5 %**

Remarks:

Test Methods: AS 1289.2.1.1, AS 1289.5.1.1

Sampling Methods: AS 1289.1.1.1, AS1289.1.2.1

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Approved Signatory:

Tested:	AH
Checked:	NW

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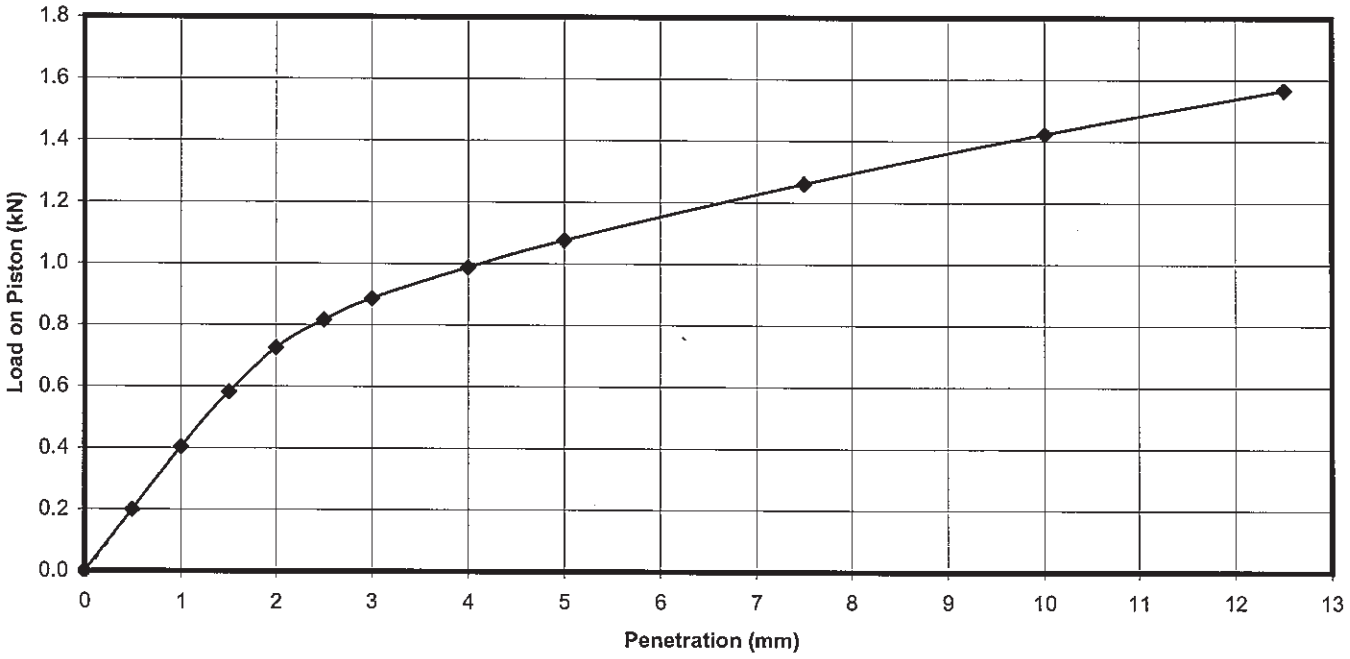
RESULT OF CALIFORNIA BEARING RATIO TEST

Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 C
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	26/05/2010
		Date Sampled :	19-23/04/10
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	14/05/2010
Test Location :	TP 129		
Depth / Layer :	0.4-0.6m	**Page:**	1 of 1



Description: GRAVELLY CLAY - Red brown slightly sandy silty gravelly clay

Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by Engineering Department

Percentage > 19mm: 6.9% (Excluded)

LEVEL OF COMPACTION: 100% of STD MDD
MOISTURE RATIO: 96% of STD OMC
SURCHARGE: 4.5 kg
SOAKING PERIOD: 4 days
SWELL: 2.3%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		18.9	1.74
After soaking		22.9	1.70
After test	Top 30mm of sample	24.2	-
	Remainder of sample	19.7	-
Field values		17.4	-
Standard Compaction		19.6	1.73

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**2.5 mm**	**6**
	5.0 mm	**5**

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Approved Signatory:

Tested:	DB
Checked:	NW

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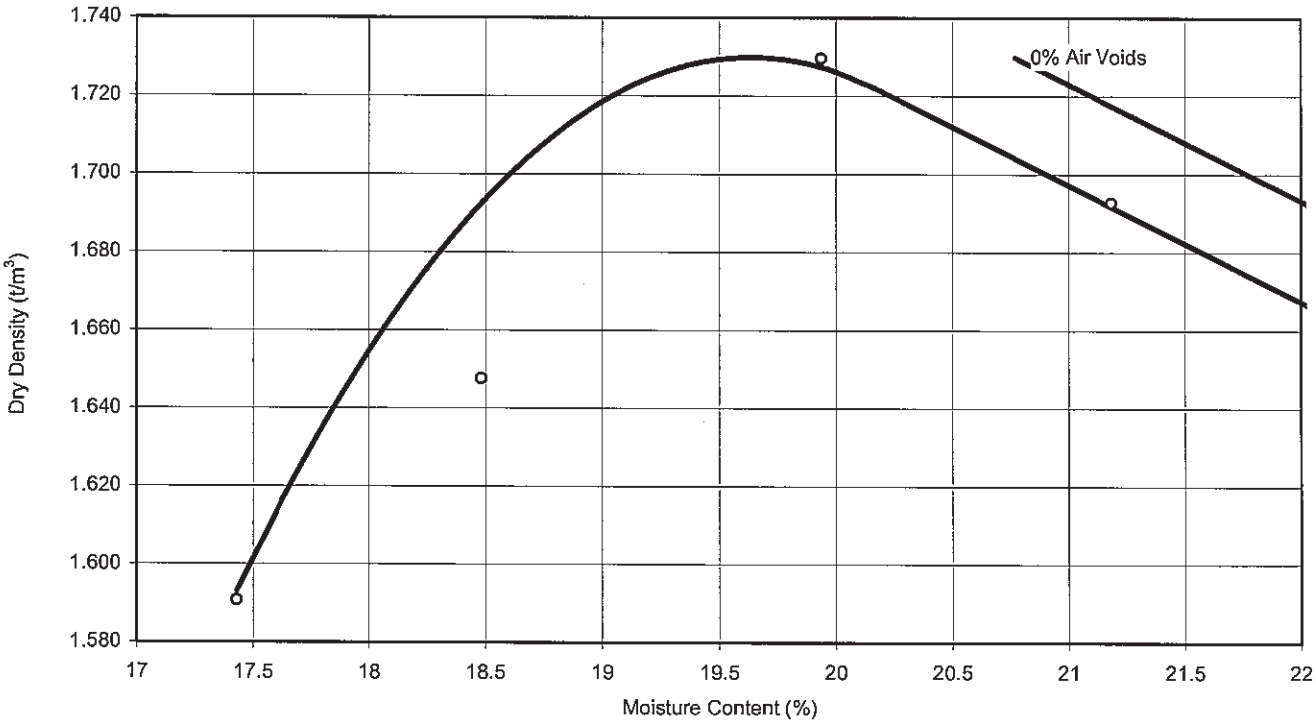
RESULTS OF COMPACTION TEST

Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 C2
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	14/05/2010
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	13/05/2010
		Page:	1 of 1



Sample Details **Location:** TP 129
Depth: 0.4 - 0.6m

Particles > 19mm: 7%

Description: GRAVELLY CLAY - Red brown slightly sandy silty gravelly clay

Maximum Dry Density:	**1.73 t/m^3**
Optimum Moisture Content:	**19.5 %**

Remarks:

Test Methods: AS 1289.2.1.1, AS 1289.5.1.1

Sampling Methods: Sampled by Engineering Department

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Approved Signatory:

Tested:	DB
Checked:	NW

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RESULTS OF MOISTURE CONTENT, PLASTICITY AND LINEAR SHRINKAGE TESTS

Client: OWSTON NOMINEES NO.2 PTY LTD

Project: LAND CAPABILITY ASSESSMENT

Location: MULGOA (EASTERN PRECINCT)

Project No: 71706
Report No: S10-095 M2
Report Date: 27/05/10

Date Sampled: 19-23/04/10
Date of Test: 14-16/05/10
Page: 1 of 1

TEST LOCATION	DEPTH (m)	DESCRIPTION	CODE	W_F %	W_L %	W_P %	PI %	*LS %
TP110	0.5	SILTY CLAY - Mottled red brown and grey slightly sandy silty clay with some ironstone gravel	2,5	-	65	26	39	-
TP115	0.5	SILTY CLAY – Red brown silty clay	2,5	-	33	18	15	-
TP131	0.5	SILTY CLAY – Orange brown silty clay	2,5	-	68	36	32	-

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 length 125mm)

Test Methods:
Moisture Content: AS 1289 2.1.1
Liquid Limit: AS 1289 3.1.2, 3.1.1
Plastic Limit: AS 1289 3.2.1
Plasticity Index: AS 1289 3.3.1
Linear Shrinkage: AS 1289 3.4.1

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

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

*Specify if sample crumbled CR or curled CU

Sampling Method(s): Sampled by Engineering Department

Remarks:

Approved Signatory:

Tested: LW
Checked: NW

Norman Weimann
Laboratory Manager

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RESULT OF SHRINK-SWELL INDEX DETERMINATION

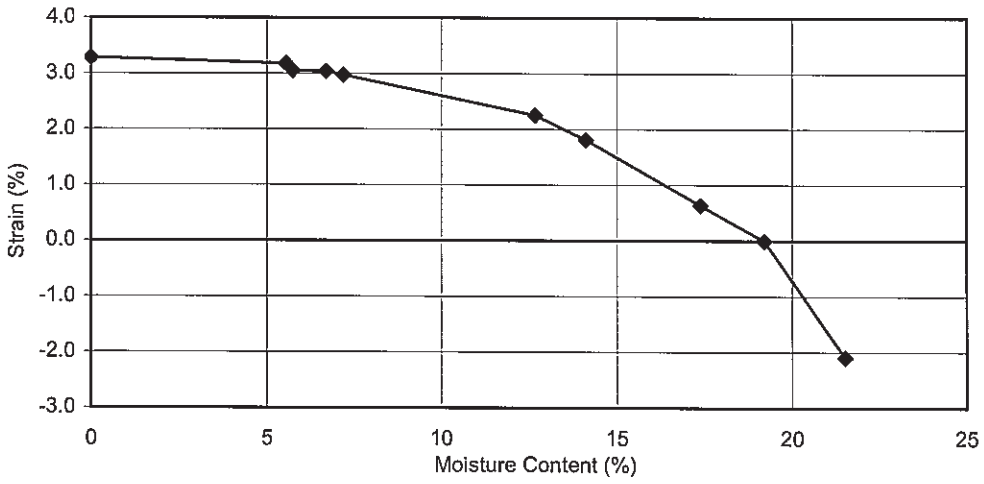
Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 O
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	27/05/2010
		Date Sampled :	19-23/04/10
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	13/05/2010
Test Location :	TP 105		
Depth / Layer :	0.6m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	3.2 %
Shrinkage - oven dried	3.3 %
Significant inert inclusions	0.1 %
Extent of cracking	UC
Extent of soil crumbling	0.0 %
Moisture content of core	19.2 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	>600 kPa
Pocket penetrometer reading at final moisture content	480 kPa
Initial Moisture Content	17.1 %
Final Moisture Content	21.5 %
Swell under 25kPa	2.1 %



SHRINK-SWELL INDEX Iss 2.4% per Δ pF

Description: SILTY CLAY - Mottled red brown and grey silty clay with a trace of ironstone gravel

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by 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
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NATA Accredited Laboratory Number: 828
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Approved Signatory:

Tested:	LW
Checked:	NW

Norman Weimann
Laboratory Manager

Douglas Partners
Geotechnics · Environment · Groundwater

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RESULT OF SHRINK-SWELL INDEX DETERMINATION

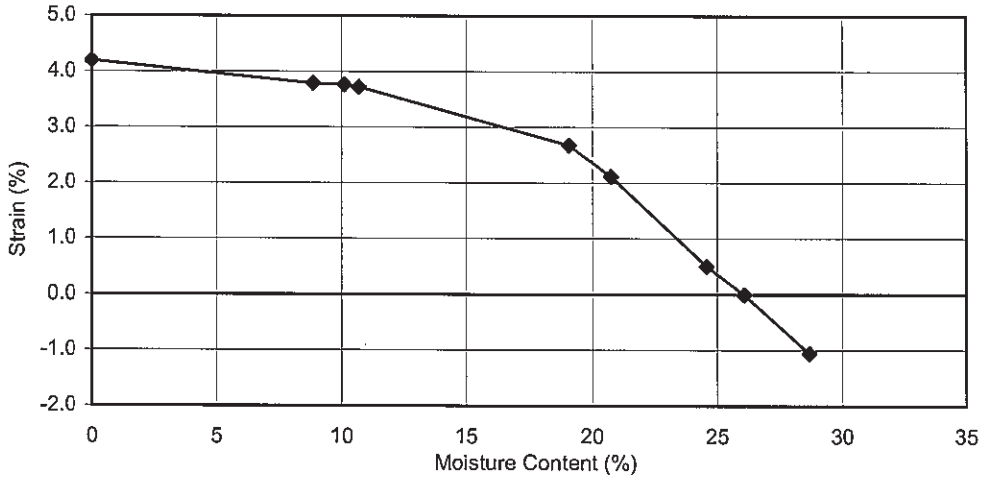
Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 P
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	27/05/2010
		Date Sampled :	19-23/04/10
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	13/05/2010
Test Location :	TP 118		
Depth / Layer :	0.4m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	3.8 %
Shrinkage - oven dried	4.2 %
Significant inert inclusions	3.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	26.1 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	>600 kPa
Pocket penetrometer reading at final moisture content	340 kPa
Initial Moisture Content	21.5 %
Final Moisture Content	28.7 %
Swell under 25kPa	1.1 %



SHRINK-SWELL INDEX Iss 2.6% per Δ pF

Description: SILTY CLAY - Mottled red brown and grey silty clay with a trace of ironstone gravel

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by 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

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Approved Signatory:

Tested:	LW
Checked:	NW

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RESULT OF SHRINK-SWELL INDEX DETERMINATION

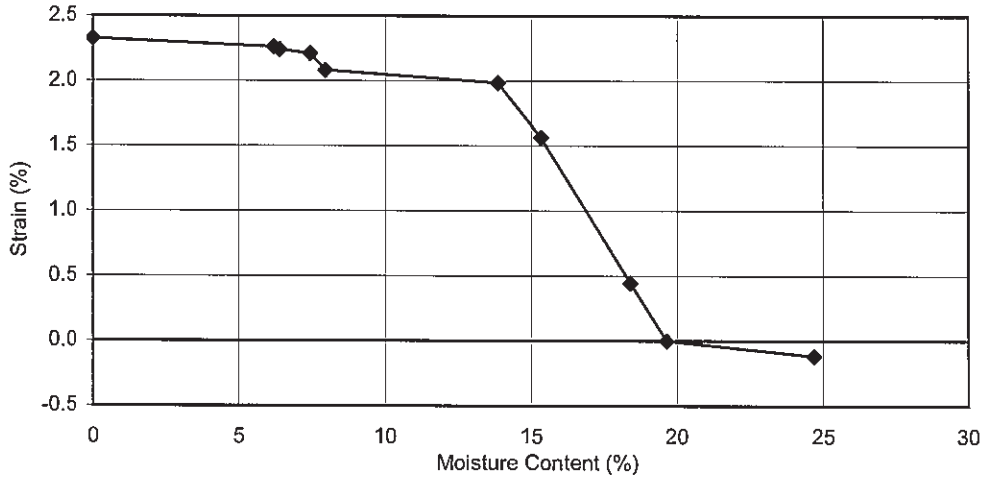
Client :	OWSTON NOMINEES NO.2 PTY LTD	**Project No. :**	71706
		Report No. :	S10-095 Q
Project :	LAND CAPABILITY ASSESSMENT	**Report Date :**	27/05/2010
		Date Sampled :	19-23/04/10
Location :	MULGOA (EASTERN PRECINCT)	**Date of Test:**	13/05/2010
Test Location :	TP 130		
Depth / Layer :	0.6m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	2.3 %
Shrinkage - oven dried	2.3 %
Significant inert inclusions	13.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	19.7 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	>600 kPa
Pocket penetrometer reading at final moisture content	490 kPa
Initial Moisture Content	18.7 %
Final Moisture Content	24.7 %
Swell under 25kPa	0.1 %



SHRINK-SWELL INDEX Iss 1.3% per Δ pF

Description: SILTY CLAY - Red brown silty clay

Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1

Sampling Method(s): Sampled by 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

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RESULTS OF MOISTURE CONTENT TEST

Client:	OWSTON NOMINEES NO.2 PTY LTD	**Project No:**	71706
		Report No:	S10-095 U2
Project:	LAND CAPABILITY ASSESSMENT	**Report Date:**	27/05/10
		Date Sampled:	19-23/04/10
Location:	MULGOA (EASTERN PRECINCT)	**Date of Test:**	12/05/10

TEST LOCATION	DEPTH (m)	DESCRIPTION	MOISTURE CONTENT (%)
TP109	0.6	SILTY CLAY – Red brown silty clay with a trace of ironstone gravel	22.0
TP114	1.0	SANDSTONE – Grey fine grained sandstone with a trace of orange brown silty clay	16.0
TP124	0.5	SILTY CLAY – Red brown silty clay with a trace of rootlets	14.5
TP127	0.5	SILTY CLAY – Dark brown grey silty clay with a trace of rootlets	11.1

Test Method(s): AS 1289. 2.1.4

Sampling Method(s): Sampled by Engineering Department

Remarks:

Approved Signatory:

Tested: LW
Checked: NW

Norman Weimann
Laboratory Manager

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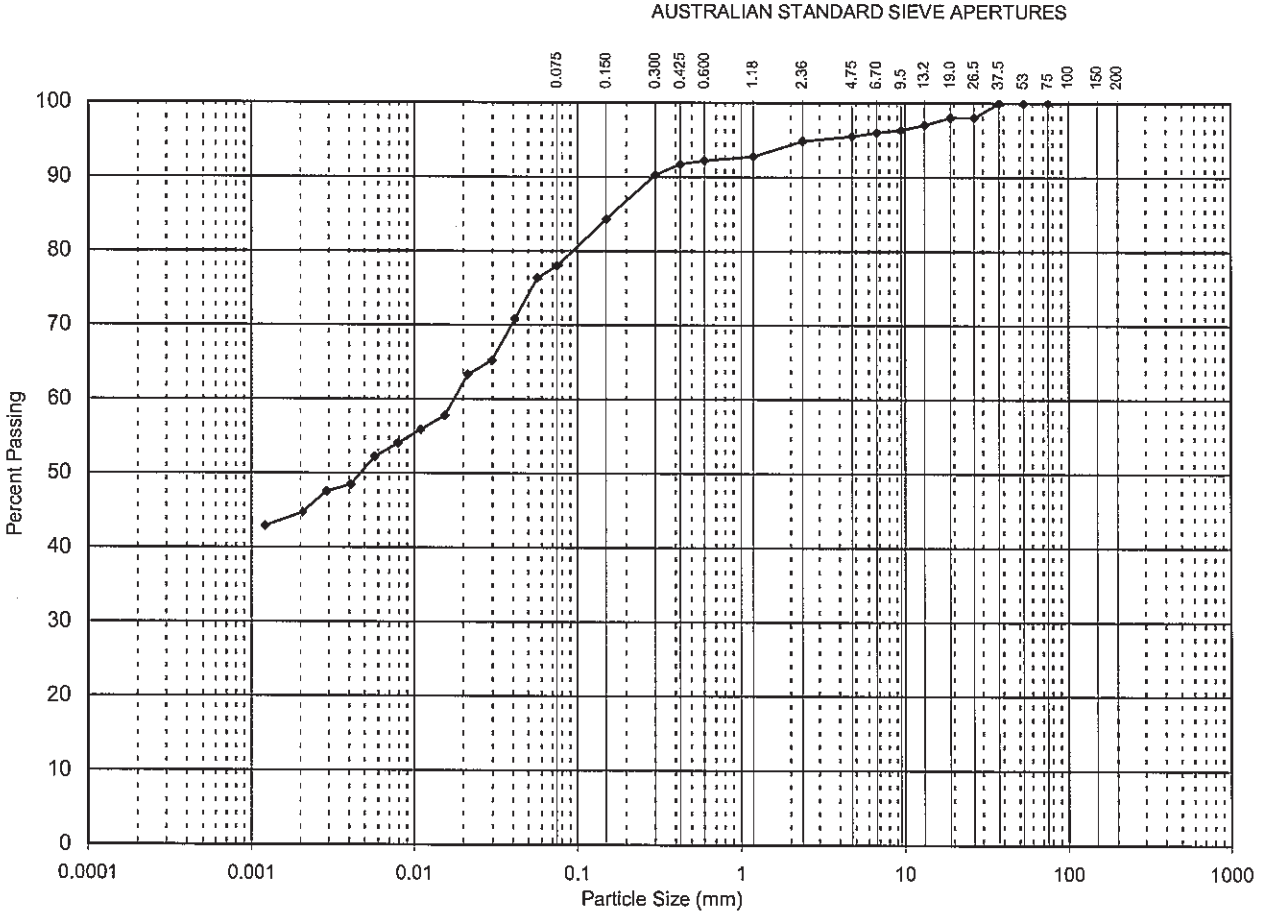
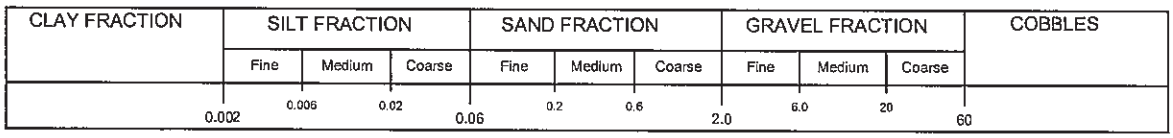
RESULTS OF PARTICLE SIZE DISTRIBUTION (HYDROMETER)

Client :	OWSTON NOMINEES NO.2 PTY LTD			**Project No. :**	71706
				Report No. :	S10-095 H
Project :	LAND CAPABILITY ASSESSMENT			**Report Date :**	27-May-10
				Date Sampled:	19-23/04/10
Location :	MULGOA (EASTERN PRECINCT)			**Date of Test:**	13-May-10
Road No:	-	**Sample / Pit No:**	TP 110	**Depth / Layer:**	0.5m
Chainage:	-	**Section / Lot No:**	-	**Test Request No:**	-
				Page:	1 of 1



Sieve Size (mm)	% Passing
75.0	100%
53.0	100%
37.5	100%
26.5	98%
19.0	98%
13.2	97%
9.5	96%
6.7	96%
4.75	96%
2.36	95%
1.18	93%
0.600	92%
0.425	92%
0.300	90%
0.150	84%
0.075	78%
0.045	71%
0.033	65%
0.023	63%
0.017	58%
0.012	56%
0.009	54%
0.006	52%
0.005	48%
0.003	48%
0.002	45%
0.001	43%



Description: SILTY CLAY - Mottled red brown and grey slightly sandy silty clay with some ironstone gravel

Test Method(s): AS 1289.3.6.1, AS 1289.3.6.3

Sampling Method(s): Sampled by Engineering Department

Loss in pretreatment: 0%

Remarks: -

Type of Hydrometer: g/l

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Approved Signatory:

Tested:	LW
Checked:	NW

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Laboratory Manager

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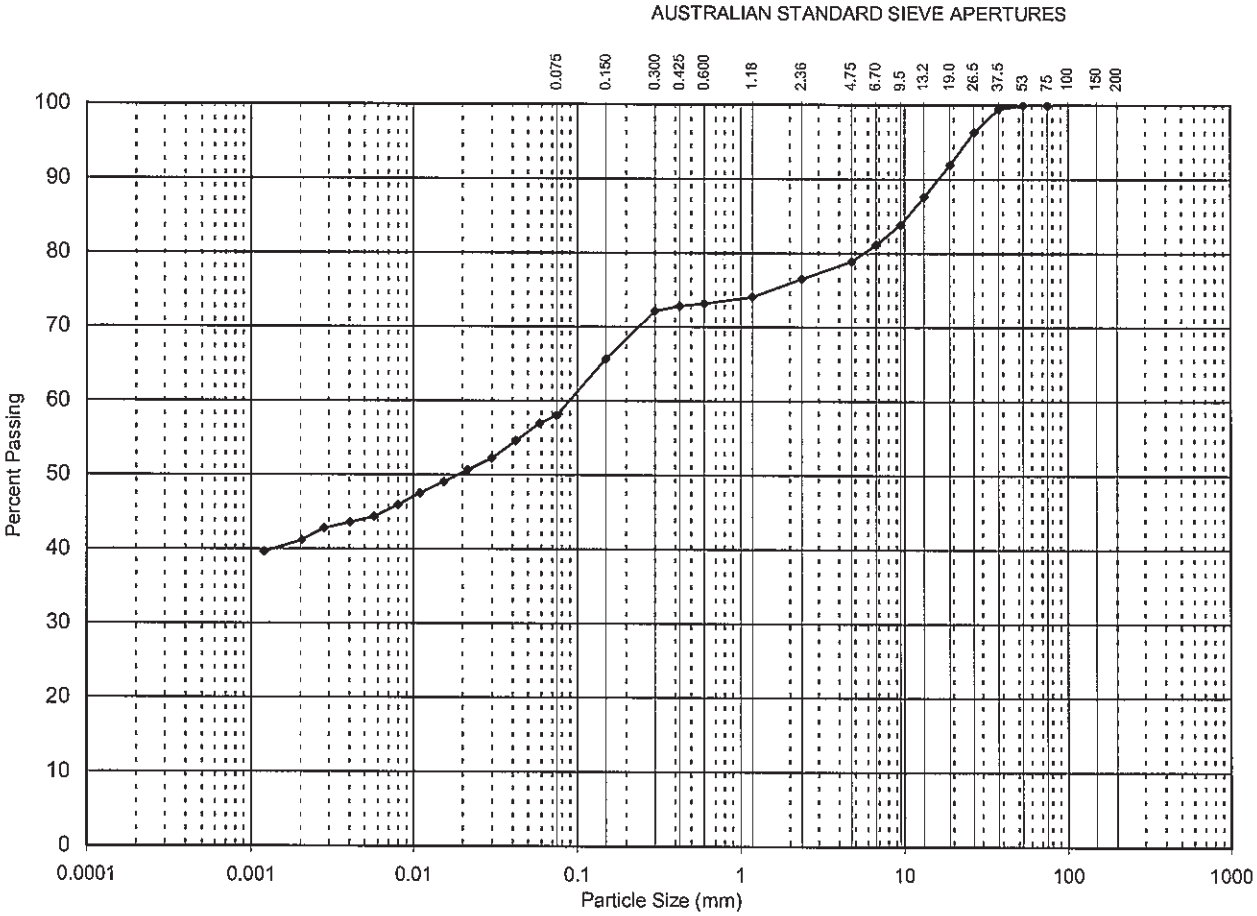
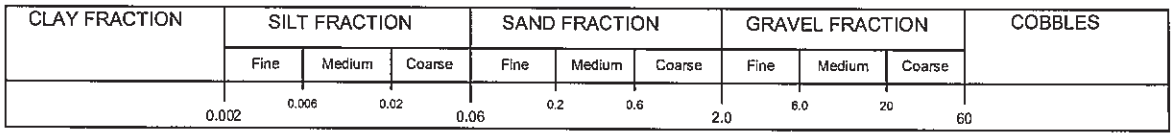
RESULTS OF PARTICLE SIZE DISTRIBUTION (HYDROMETER)

Client :	OWSTON NOMINEES NO.2 PTY LTD			**Project No. :**	71706
				Report No. :	S10-095 I
Project :	LAND CAPABILITY ASSESSMENT			**Report Date :**	27-May-10
				Date Sampled:	19-23/04/10
Location :	MULGOA (EASTERN PRECINCT)			**Date of Test:**	13-May-10
Road No:	-	**Sample / Pit No:**	TP 129	**Depth / Layer:**	0.4-0.6m
Chainage:	-	**Section / Lot No:**	-	**Test Request No:**	-
				Page:	1 of 1



Sieve Size (mm)	% Passing
75.0	100%
53.0	100%
37.5	99%
26.5	96%
19.0	92%
13.2	88%
9.5	84%
6.7	81%
4.75	79%
2.36	77%
1.18	74%
0.600	73%
0.425	73%
0.300	72%
0.150	66%
0.075	58%
0.045	55%
0.033	52%
0.023	51%
0.017	49%
0.012	48%
0.009	46%
0.006	44%
0.005	44%
0.003	43%
0.002	41%
0.001	40%



Description: GRAVELLY CLAY - Red brown slightly sandy silty gravelly clay

Test Method(s): AS 1289.3.6.1, AS 1289.3.6.3

Sampling Method(s): Sampled by Engineering Department

Loss in pretreatment: 0%

Remarks: -

Type of Hydrometer: g/l

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Approved Signatory:

Tested:	LW
Checked:	NW

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Laboratory Manager

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DETERMINATION OF EMERSON CLASS NUMBER OF SOIL

Client:	**OWSTON NOMINEES NO.2 PTY LTD**	**Project No:**	71706
		Report No:	S10-095 N2
Project:	LAND CAPABILITY ASSESSMENT	**Report Date:**	27/05/10
Location:	MULGOA (EASTERN PRECINCT)	**Date of Test:**	24/05/10
		Page:	1 of 1

SAMPLE NO	DEPTH (m)	DESCRIPTION	WATER TYPE	WATER TEMP	CLASS NO.
TP 107	0.5	SILTY CLAY - Silty clay with some ironstone gravel	Distilled	22	8
TP 112	0.5	SILTY CLAY - Red brown the orange brown and grey silty clay with a trace of ironstone gravel	Distilled	22	3
TP 114	1.0	SANDSTONE – Grey fine grained sandstone with a trace of orange brown silty clay	Distilled	22	2
TP 124	0.5	SILTY CLAY – Red brown silty clay with a trace of rootlets	Distilled	22	3

Test Method(s): AS 1289 3.8.1

Sampling Method(s): Sampled by Engineering Department

Remarks:

Approved Signatory:

Norman Weimann
Laboratory Manager

Tested: LW
Checked: NW

NATA Accredited Laboratory Number: 828

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Appendix E

Laboratory Test Results - Salinity

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS 40947

Client:
Douglas Partners
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Adam Podnar

Sample log in details:

Your Reference:	**71706, Mulgoa**
No. of samples:	63 Soils
Date samples received:	13/05/10
Date completed instructions received:	13/05/10

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

Report Details:

Date results requested by:	20/05/10
Date of Preliminary Report:	Not Issued
Issue Date:	21/05/10

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Tests not covered by NATA are denoted with *.

Results Approved By:

Rhian Morgan
Metals Supervisor

Jacinta Hurst
Laboratory Manager

Envirolab Reference: 40947
Revision No: R 00

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Miscellaneous Inorg - soil Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	40947-1 TP3/0.25 19/04/2010 Soil	40947-2 TP3/0.5 19/04/2010 Soil	40947-3 TP3/1 19/04/2010 Soil	40947-4 TP3/1.5 19/04/2010 Soil	40947-5 TP3/2 19/04/2010 Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	7.6	6.1	6.8	4.8	4.6
Electrical Conductivity 1:5 soil:water	µS/cm	44	37	39	58	38
Resistivity in soil*	ohm m	230	270	250	170	260
Chloride, Cl 1:5 soil:water	mg/kg	17	20	18	31	16
Sulphate, SO4 1:5 soil:water	mg/kg	3.8	2.5	3.3	<2.0	3.7

Miscellaneous Inorg - soil Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	40947-6 TP3/2.5 19/04/2010 Soil	40947-7 TP6/0.25 19/04/2010 Soil	40947-8 TP6/0.5 19/04/2010 Soil	40947-9 TP9/0.25 19/04/2010 Soil	40947-10 TP9/0.5 19/04/2010 Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	7.6	5.9	5.9	6.0	6.0
Electrical Conductivity 1:5 soil:water	µS/cm	41	12	16	7.0	14
Resistivity in soil*	ohm m	240	770	630	1,100	710
Chloride, Cl 1:5 soil:water	mg/kg	15	[NA]	[NA]	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	3.1	[NA]	[NA]	[NA]	[NA]

Miscellaneous Inorg - soil Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	40947-11 TP9/1.0 19/04/2010 Soil	40947-13 TP12/0.25 19/04/2010 Soil	40947-14 TP12/0.5 19/04/2010 Soil	40947-15 TP14/0.25 19/04/2010 Soil	40947-16 TP14/0.5 19/04/2010 Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	5.4	4.9	4.9	6.2	6.0
Electrical Conductivity 1:5 soil:water	µS/cm	13	56	45	10	5.0
Resistivity in soil*	ohm m	770	180	220	1,100	1,900
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	<20	6.0	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	<20	6.9	[NA]	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-17	40947-18	40947-19	40947-20	40947-21
Your Reference	----------	TP14/1.0	TP14/1.5	TP16/0.25	TP16/0.5	TP18/0.25
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	5.9	5.4	5.0	7.8	5.9
Electrical Conductivity 1:5 soil:water	µS/cm	14	15	38	43	13
Resistivity in soil*	ohm m	710	670	260	230	770
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	2.2	2.1	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	7.2	6.6	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-22	40947-23	40947-24	40947-25	40947-26
Your Reference	----------	TP18/0.5	TP20/0.25	TP20/0.5	TP22/0.25	TP22/0.5
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	8.4	5.1	5.1	5.8	6.3
Electrical Conductivity 1:5 soil:water	µS/cm	29	24	31	11	8.0
Resistivity in soil*	ohm m	340	420	320	910	1,300
Chloride, Cl 1:5 soil:water	mg/kg	5.6	2.8	6.2	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	<2.0	<2.0	2.0	[NA]	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-27	40947-28	40947-29	40947-30	40947-31
Your Reference	----------	TP26/0.25	TP26/0.5	TP28/0.25	TP28/0.5	TP24/0.25
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	5.8	5.1	6.0	6.2	6.1
Electrical Conductivity 1:5 soil:water	µS/cm	13	45	9.0	13	9.0
Resistivity in soil*	ohm m	760	220	1,200	790	1,100
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	12	[NA]	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	<2.0	[NA]	[NA]	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-32	40947-33	40947-34	40947-35	40947-36
Your Reference	----------	TP24/0.5	TP24/1.0	TP106/0.25	TP106/0.5	TP106/1.0
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	6.1	5.4	6.3	6.1	5.2
Electrical Conductivity 1:5 soil:water	µS/cm	13	12	20	110	100
Resistivity in soil*	ohm m	770	830	500	91	100
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	6.1	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	70	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-37	40947-38	40947-39	40947-40	40947-41
Your Reference	----------	TP106/1.5	TP106/2.0	TP111/0.25	TP111/0.5	TP111/1.0
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	5.5	5.4	6.7	5.0	5.5
Electrical Conductivity 1:5 soil:water	µS/cm	88	150	82	97	88
Resistivity in soil*	ohm m	110	67	120	100	110
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	<20	46	50
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	<20	<20	<20

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-42	40947-43	40947-44	40947-45	40947-46
Your Reference	----------	TP111/1.5	TP111/1.8	TP114/0.25	TP114/0.5	TP114/1.0
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	6.5	6.4	6.2	4.6	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	100	140	21	100	71
Resistivity in soil*	ohm m	99	71	480	100	140
Chloride, Cl 1:5 soil:water	mg/kg	20	77	[NA]	8.5	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	<2.0	<20	[NA]	66	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-47	40947-48	40947-49	40947-50	40947-51
Your Reference	----------	TP114/1.5	TP114/2.0	TP114/2.5	TP120/0.25	TP120/0.5
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	5.3	5.1	5.4	5.7	5.7
Electrical Conductivity 1:5 soil:water	µS/cm	110	100	200	50	53
Resistivity in soil*	ohm m	91	100	50	200	190
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	980	<20
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	840	<20

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-52	40947-53	40947-54	40947-55	40947-56
Your Reference	----------	TP120/1.0	TP120/1.5	TP120/2.0	TP127/0.25	TP127/0.5
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	5.5	5.2	5.1	5.4	5.2
Electrical Conductivity 1:5 soil:water	µS/cm	67	200	230	61	45
Resistivity in soil*	ohm m	150	51	43	160	220
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	<20	<20
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	<20	21

Miscellaneous Inorg - soil						
Our Reference:	UNITS	40947-57	40947-58	40947-59	40947-60	40947-61
Your Reference	----------	TP127/1.0	TP127/1.5	TP127/2.0	TP131/0.25	TP131/1.0
Date Sampled	----------	19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	14/5/2010	14/5/2010	14/5/2010	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10	17/05/10	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	6.1	5.8	5.8	5.5	6.3
Electrical Conductivity 1:5 soil:water	µS/cm	23	32	23	54	21
Resistivity in soil*	ohm m	430	310	430	190	480
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	<20	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	<20	[NA]

Miscellaneous Inorg - soil			
Our Reference:	UNITS	40947-62	40947-63
Your Reference	----------	TP131/1.5	TP131/2.0
Date Sampled	----------	19/04/2010	19/04/2010
Type of sample		Soil	Soil
Date prepared	-	14/5/2010	14/5/2010
Date analysed	-	17/05/10	17/05/10
pH 1:5 soil:water	pH Units	5.8	6.4
Electrical Conductivity 1:5 soil:water	µS/cm	24	12
Resistivity in soil*	ohm m	420	830

ESP/CEC Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	40947-2 TP3/0.5 19/04/2010 Soil	40947-8 TP6/0.5 19/04/2010 Soil	40947-14 TP12/0.5 19/04/2010 Soil	40947-19 TP16/0.25 19/04/2010 Soil	40947-20 TP16/0.5 19/04/2010 Soil
Exchangeable Ca*	meq/100g	0.050	0.17	0.090	0.24	0.13
Exchangeable K*	meq/100g	0.13	0.16	0.19	0.060	0.080
Exchangeable Mg*	meq/100g	9.5	4.1	4.0	0.81	3.6
Exchangeable Na*	meq/100g	0.77	0.65	0.50	0.25	0.39
Cation Exchange Capacity*	meq/100g	11	5.1	4.8	1.4	4.2
ESP*	%	7.4	12.8	10.5	18.1	9.4

ESP/CEC Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	40947-26 TP22/0.5 19/04/2010 Soil	40947-35 TP106/0.5 19/04/2010 Soil	40947-40 TP111/0.5 19/04/2010 Soil	40947-51 TP120/0.5 19/04/2010 Soil	40947-57 TP127/1.0 19/04/2010 Soil
Exchangeable Ca*	meq/100g	0.16	0.28	1.1	2.9	2.0
Exchangeable K*	meq/100g	0.14	0.29	0.33	0.12	0.16
Exchangeable Mg*	meq/100g	4.9	6.4	8.6	3.4	6.1
Exchangeable Na*	meq/100g	0.37	1.2	1.4	0.47	0.52
Cation Exchange Capacity*	meq/100g	5.5	8.2	11	6.9	8.7
ESP*	%	6.6	14.9	11.9	6.9	5.9

Method ID	Methodology Summary
LAB.1	pH - Measured using pH meter and electrode in accordance with APHA 20th ED, 4500-H+.
LAB.2	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA2510 20th ED and Rayment & Higginson.
LAB.81	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 21st ED, 4110-B.
Metals.23	Determination of exchangeable cations and cation exchange capacity in soil.

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			14/05/2010	40947-1	14/5/2010 || 14/5/2010	LCS-1	14/05/2010
Date analysed	-			19/05/2010	40947-1	17/05/10 || 17/05/10	LCS-1	14/05/2010
pH 1:5 soil:water	pH Units		LAB.1	[NT]	40947-1	7.6 || 7.6 || RPD: 0	LCS-1	99%
Electrical Conductivity 1:5 soil:water	µS/cm	1	LAB.2	<1.0	40947-1	44 || 44 || RPD: 0	LCS-1	100%
Resistivity in soil*	ohm m	1	LAB.2	<1.0	40947-1	230 || 230 || RPD: 0	LCS-1	100%
Chloride, Cl 1:5 soil:water	mg/kg	2	LAB.81	<2.0	40947-1	17 || 17 || RPD: 0	LCS-1	99%
Sulphate, SO4 1:5 soil:water	mg/kg	2	LAB.81	<2.0	40947-1	3.8 || 3.9 || RPD: 3	LCS-1	103%

QUALITY CONTROL ESP/CEC	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Exchangeable Ca*	meq/100g	0.01	Metals.23	<0.01	40947-2	0.050 || 0.060 || RPD: 18	LCS-1	108%
Exchangeable K*	meq/100g	0.01	Metals.23	<0.01	40947-2	0.13 || 0.14 || RPD: 7	LCS-1	105%
Exchangeable Mg*	meq/100g	0.01	Metals.23	<0.01	40947-2	9.5 || 9.9 || RPD: 4	LCS-1	104%
Exchangeable Na*	meq/100g	0.01	Metals.23	<0.01	40947-2	0.77 || 0.82 || RPD: 6	LCS-1	108%
Cation Exchange Capacity*	meq/100g	1	Metals.23	<1.0	40947-2	11 || 11 || RPD: 0	[NR]	[NR]
ESP*	%	1	Metals.23	<1.0	40947-2	7.4 || 7.5 || RPD: 1	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	40947-11	14/5/2010 || 14/5/2010	LCS-2	14/05/2010
Date analysed	-	40947-11	17/05/10 || 17/05/10	LCS-2	19/05/2010
pH 1:5 soil:water	pH Units	40947-11	5.4 || 5.7 || RPD: 5	LCS-2	99%
Electrical Conductivity 1:5 soil:water	µS/cm	40947-11	13 || 13 || RPD: 0	LCS-2	100%
Resistivity in soil*	ohm m	40947-11	770 || 770 || RPD: 0	LCS-2	100%
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]	LCS-2	98%
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]	LCS-2	98%

Client Reference: 71706, Mulgoa

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	40947-22	14/5/2010 || 14/5/2010	40947-2	14/05/2010
Date analysed	-	40947-22	17/05/10 || 17/05/10	40947-2	19/05/2010
pH 1:5 soil:water	pH Units	40947-22	8.4 || 8.4 || RPD: 0	[NR]	[NR]
Resistivity in soil*	ohm m	40947-22	340 || 350 || RPD: 3	[NR]	[NR]
Chloride, Cl 1:5 soil:water	mg/kg	40947-22	5.6 || 5.6 || RPD: 0	40947-2	110%
Sulphate, SO4 1:5 soil:water	mg/kg	40947-22	<2.0 || <2.0	40947-2	102%
QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	40947-33	14/5/2010 || 14/5/2010	40947-56	14/5/2010
Date analysed	-	40947-33	17/05/10 || 17/05/10	40947-56	19/5/2010
pH 1:5 soil:water	pH Units	40947-33	5.4 || 5.6 || RPD: 4	[NR]	[NR]
Electrical Conductivity 1:5 soil:water	µS/cm	40947-33	12 || 12 || RPD: 0	[NR]	[NR]
Resistivity in soil*	ohm m	40947-33	830 || 830 || RPD: 0	[NR]	[NR]
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]	40947-56	96%
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]	40947-56	80%

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	40947-44	14/5/2010 || 14/5/2010
Date analysed	-	40947-44	17/05/10 || 17/05/10
pH 1:5 soil:water	pH Units	40947-44	6.2 || 6.3 || RPD: 2
Electrical Conductivity 1:5 soil:water	µS/cm	40947-44	21 || 19 || RPD: 10
Resistivity in soil*	ohm m	40947-44	480 || 530 || RPD: 10
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]
QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	40947-55	14/5/2010 || 14/5/2010
Date analysed	-	40947-55	17/05/10 || 17/05/10
pH 1:5 soil:water	pH Units	40947-55	5.4 || 5.5 || RPD: 2
Electrical Conductivity 1:5 soil:water	µS/cm	40947-55	61 || 59 || RPD: 3
Resistivity in soil*	ohm m	40947-55	160 || 160 || RPD: 0
Chloride, Cl 1:5 soil:water	mg/kg	40947-55	<20 || <20
Sulphate, SO4 1:5 soil:water	mg/kg	40947-55	<20 || <20

Report Comments:

Sulphate\Chloride: PQL raised by a factor of X10 sor samples 13,39,40,41,43,51,55,56,60 due to sample matrix.
Asbestos was analysed by Approved Identifier: Not applicable for this job
Asbestos was authorised by Approved Signatory: Not applicable for this job
INS: Insufficient sample for this test NT: Not tested PQL: Practical Quantitation Limit <: Less than >: Greater than
RPD: Relative Percent Difference NA: Test not required LCS: Laboratory Control Sample NR: Not requested

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike: A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample): This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria:

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the sample batch were within laboratory acceptance criteria.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes and LCS: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable. Surrogates: 60-140% is acceptable for general organics and 10-140% for

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9958 5801 fax 02 9958 5803 mob 0400 88 5292
email: tnotaras@envirolabservices.com.au

Douglas Partners
96 Hermitage Rd
West Ryde 2114

Att: Adam Podnar

Re: 71706, Mulgoa

Soil Texture was determined based on the Australian Governments Department of the Environment & Heritage, Australian Greenhouse Office Guide to Field Measurements.

ECe (Extract Electrical Conductivity) is determined by analysing a 1:5 soil water extract for conductivity then multiplying this result by the soil texture conversion factor based on 'Site Investigations for Urban Salinity', DIPNR 2002.

ID	Envirolab ID	EC dS/m	Texture	ECe dS/m	Class
TP3/0.25	40947-1	0.044	Light Clay	0.37	Non Saline
TP3/0.5	40947-2	0.037	Light Medium Clay	0.30	Non Saline
TP3/1	40947-3	0.039	Light Medium Clay	0.31	Non Saline
TP3/1.5	40947-4	0.058	Light Medium Clay	0.46	Non Saline
TP3/2	40947-5	0.038	Light Medium Clay	0.30	Non Saline
TP3/2.5	40947-6	0.041	Medium Clay	0.29	Non Saline
TP6/0.25	40947-7	0.012	Loam	0.12	Non Saline
TP6/0.5	40947-8	0.016	Light Medium Clay	0.13	Non Saline
TP9/0.25	40947-9	0.009	Light Clay	0.08	Non Saline
TP9/0.5	40947-10	0.014	Light Clay	0.12	Non Saline
TP9/1.0	40947-11	0.013	Medium Clay	0.09	Non Saline
TP12/0.25	40947-13	0.056	Clay Loam	0.50	Non Saline
TP12/0.5	40947-14	0.045	Light Medium Clay	0.36	Non Saline
TP14/0.25	40947-15	0.010	Clay Loam	0.09	Non Saline
TP14/0.5	40947-16	0.005	Light Medium Clay	0.04	Non Saline
TP14/1.0	40947-17	0.014	Medium Clay	0.10	Non Saline
TP14/1.5	40947-18	0.015	Medium Clay	0.11	Non Saline
TP16/0.25	40947-19	0.038	Light Medium Clay	0.30	Non Saline
TP16/0.5	40947-20	0.043	Light Medium Clay	0.34	Non Saline
TP18/0.25	40947-21	0.013	Light Medium Clay	0.10	Non Saline
TP18/0.5	40947-22	0.029	Light Medium Clay	0.23	Non Saline
TP20/0.25	40947-23	0.024	Light Medium Clay	0.19	Non Saline
TP20/0.5	40947-24	0.031	Medium Clay	0.22	Non Saline
TP22/0.25	40947-25	0.011	Medium Clay	0.08	Non Saline
TP22/0.5	40947-26	0.008	Medium Clay	0.06	Non Saline
TP26/0.25	40947-27	0.013	Light Medium Clay	0.10	Non Saline
TP26/0.5	40947-28	0.045	Light Medium Clay	.36	Non Saline

TP28/0.25	40947-29	0.009	Clay Loam	0.08	Non Saline
TP28/0.5	40947-30	0.013	Medium Clay	0.09	Non Saline
ID	Envirolab ID	EC dS/m	Texture	ECe dS/m	Class
TP24/0.25	40947-31	0.009	Light Medium Clay	0.07	Non Saline
TP24/0.5	40947-32	0.013	Light Medium Clay	.10	Non Saline
TP24/1.0	40947-33	0.012	Medium Clay	0.08	Non Saline
TP106/0.25	40947-34	0.020	Heavy Clay	0.12	Non Saline
TP106/0.5	40947-35	0.110	Light Medium Clay	0.88	Non Saline
TP106/1.0	40947-36	.100	Medium Clay	0.80	Non Saline
TP106/1.5	40947-37	.088	Light Medium Clay	0.70	Non Saline
TP106/2.0	40947-38	.150	Medium Clay	1.05	Non Saline
TP111/0.25	40947-39	0.082	Medium Clay	0.57	Non Saline
TP111/0.5	40947-40	0.097	Medium Clay	0.68	Non Saline
TP111/1.0	40947-41	0.088	Heavy Clay	0.53	Non Saline
TP111/1.5	40947-42	0.100	Heavy Clay	0.60	Non Saline
TP111/1.8	40947-43	0.140	Heavy Clay	0.84	Non Saline
TP114/02.5	40947-44	0.021	Loam	0.21	Non Saline
TP114/0.5	40947-45	.100	Medium Clay	0.70	Non Saline
TP114/1.0	40947-46	0.07	Heavy Clay	0.42	Non Saline
TP114/1.5	40947-47	0.110	Light Medium Clay	0.88	Non Saline
TP114/2.0	40947-48	0.10	Medium Clay	.70	Non Saline
TP114/2.5	40947-49	0.20	Medium Clay	1.6	Non Saline
TP120/0.25	40947-50	0.05	Loam	0.50	Non Saline
TP120/0.5	40947-51	0.053	Clay Loam	0.48	Non Saline
TP120/1.0	40947-52	0.067	Medium Clay	0.47	Non Saline
TP120/1.5	40947-53	0.20	Heavy Clay	1.2	Non Saline
TP120/2.0	40947-54	0.23	Heavy Clay	1.4	Non Saline
TP127/0.25	40947-55	0.061	Loam	0.61	Non Saline
TP127/0.5	40947-56	0.045	Loam	0.45	Non Saline
TP127/1.0	40947-57	0.023	Light Medium Clay	0.18	Non Saline
TP127/1.5	40947-58	0.032	Light Medium Clay	0.26	Non Saline
TP127/2.0	40947-59	0.023	Medium Clay	0.16	Non Saline
TP131/0.25	40947-60	0.054	Loam	0.54	Non Saline
TP131/1.0	40947-61	0.021	Medium Clay	0.15	Non Saline
TP131/1.5	40947-62	0.024	Medium Clay	0.17	Non Saline
TP131/2.0	40947-63	0.012	Sandy Loams	0.17	Non Saline

DIPNR gives the following definitions:
'Non-Saline' as 'Salinity effects mostly negligible'.
'Slightly Saline' as 'yields of very sensitive crops may be affected'.
'Moderately Saline' as 'yields of many crops affected'.
'Very Saline' as 'Only tolerant crops yield satisfactorily'.
'Highly Saline' as 'Only a few very tolerant crops yield satisfactorily'.

Appendix F

CSIRO Guide to Home Owners on Foundation Maintenance and Footing Performance

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

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

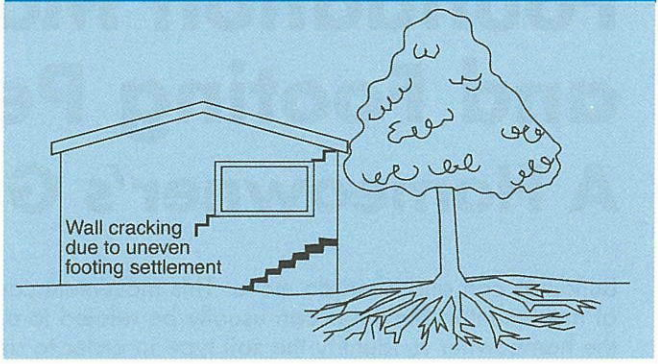
Seasonal swelling/shrinkage in clay

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

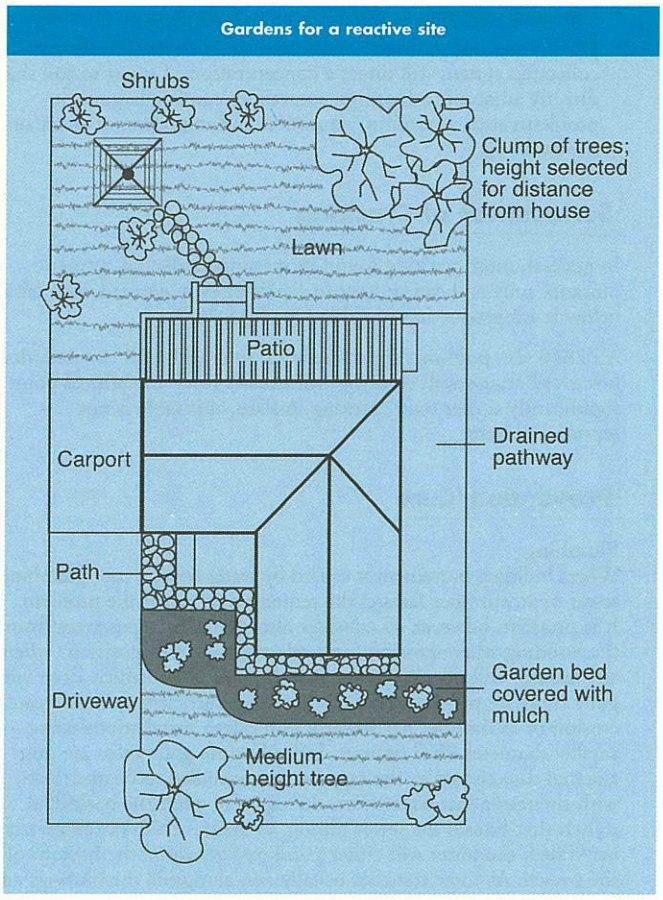
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

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

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4



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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