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REPORT
ON
SALINITY ASSESSMENT AND SALINITY MANAGEMENT PLAN

PROPOSED STAGE 2
GREGORY HILLS DEVELOPMENT

Prepared for
DART WEST DEVELOPMENTS PTY LTD

Project 71913.01
September 2010

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Douglas Partners Pty Ltd
ABN 75 053 980 117
Unit 1
1 Luso Drive
Unanderra 2526

PO Box 486
Unanderra NSW 2526
Phone (02) 4271 1836
Fax (02) 4271 1897
wollongong@douglaspartners.com.au

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1 INTRODUCTION

This Salinity Assessment (SA) and Salinity Management Plan (SMP) report was prepared by Douglas Partners (DP) for the proposed Stage 2 residential subdivision (hereafter referred to as "the site"), in the Gregory Hills development area, as shown on the Gregory Hills Concept Masterplan included on Drawing 1 in Appendix A. Preparation of this report and associated field and analytical works were commissioned by Dart West Developments Pty Ltd (Dart West), developers of the site.

Saline soils affect much of the Western Sydney Region. Buildings and infrastructure located on Wianamatta Shale are particularly at risk. Salinity can affect urban structures in a number of ways including: corrosion of concrete, break down of bricks and mortar, corrosion of steel (including reinforcement), break up of roads, attack on buried infrastructure, reduced ability to grow vegetation, and increased erosion potential.

This study aims to expand on the salinity aspects of the findings of the Land Capability Assessment (DP; 2007) by:

- Identifying areas of the site that are:
  - Saline;
  - Aggressive to concrete;
  - Aggressive to steel; or
  - Highly erodible (sodic); and
- Providing suitable salinity management strategies to guide future development.

This salinity assessment was conducted generally in accordance with the Department of Land and Water Conservation (DLWC, now part of Department of Environment, Climate Change and Water; DECCW) publication *Site Investigations for Urban Salinity*, 2002.

2 SITE DESCRIPTION

The previous Land Capability Assessment was undertaken on a 536 ha parcel known as the Turner Road Precinct, lying in the suburbs of Catherine Field and Currans Hill, for the Growth Centres Commission (GCC). The site comprised two large land holdings held by the Marist Brothers and NSW Clubs Ltd (part of which is used as Camden Valley Golf Course) and several blocks with frontages on Turner Road.

This current assessment has been undertaken on a 20 ha (approximate area) portion of the larger parcel, as indicated on Drawing 1, Appendix A. This portion has been referred to as Stage 2, and incorporates Stages 2A, 2B and 2C as well as the buffer park (between Stage 2 and the Central Hills Business Park) and a small Zone 3 portion of the riparian corridor which adjoins the Stage 2C area.

The current site sits in the central southern portion of the overall Masterplan and is currently accessed via dirt / gravel road off Badgally Road (currently under construction). The site generally slopes down towards south-west, however the ground surface is gently undulating with at least three primary depressions / preferential drainage pathways identified (refer Drawing 2, Appendix A). At the time of conducting the fieldwork for this assessment (13 July 2010) the following site features and uses were noted:

- The site was predominantly grass covered with several small and localised pockets of tree growth;
- The TRN temporary works compound was located in the north-western portion of the site. The compound was set up primarily in association with works on the nearby and adjoining Stage 1 subdivision and display village. The compound contained site sheds, stored building materials and construction vehicles;

- A large stockpile of soil was located to the south of the compound, measuring an estimated 80 m by 20 m, and up to an estimated 8 m height. The exposed materials appeared to be of topsoil consistency. The materials are likely to have originated from topsoil stripping in other portions of the Gregory Hills Development;
- Several small stockpiles of soil or other materials were located around and close to the edges of the works compound. A number of the stockpiles were grass covered and therefore the contents are not known;
- A large stockpile of discarded tree logs and branches, again resumed to have originated from other areas of the Gregory Hills Development, was present to the south-west of the large topsoil stockpile;
- Several bare patches of dirt were noted in the western corner and south-eastern corner of the site. These patches may be attributed to dry weather or salinity impacts. Both were located on identified preferential drainage pathways;
- Apart from the bare patches, there were no significant visual indicators of salinity within the site (such as gully erosion, salt scalds, or salt tolerant plant species).

The site is bound to the north-east by construction works associated with the Stage 1 residential and display village developments, to the north-west and south-east by yet to be developed portions of the Gregory Hills Development area, and to the south-west by rural residential properties.

The above mentioned features and observations are shown on Drawing 2, Appendix A.

3 PREVIOUS SALINITY MAPPING

A Salinity Assessment was previously carried out by DP on the entire Turner Road Precinct (the Precinct), details of which can be found in the "*Report on Land Capability and Contamination Assessment*" (Project 40741, dated 28 February 2007).

The Salinity Assessment included an electromagnetic survey using a Geonics EM31 ground conductivity meter for the measurement of apparent salinity, as well as test pitting and laboratory analysis for Electrical Conductivity (EC1:5), pH, Exchangeable Sodium Potential (ESP) and Cation Exchange Capacity (CEC). Analysis of the data obtained allowed the development of constraint maps for salinity (ECe), aggressivity and sodicity at various depths below ground surface.

The following results were generally obtained:

- Salinity – The electromagnetic and laboratory test results indicated moderately to very saline conditions in the west, north and east of the overall Precinct, with non-saline to slightly saline conditions over the remainder of the Precinct;
- Aggressivity – Mildly aggressive soils were indicated in the northern half of the Precinct; and
- Sodicity – Limited sodicity testing indicated highly sodic conditions.

With respect to the subject site (i.e. Stage 2), the following results were interpreted:

- Salinity – Small, localised areas in the north-western, western and potentially south-eastern portions of the site were found to be moderately saline at depths of the order of 1 m. Non-saline to slightly saline conditions were found elsewhere within the site;
- Aggressivity to Concrete – No aggressivity issues were identified;
- Aggressivity to Steel – No aggressivity issues were identified; and
- Sodicity – No sodicity testing within site boundaries, however limited sodicity testing across the precinct indicated highly sodic conditions.

No groundwater was found within the subject site area, with bores taken to a maximum depth of 1.65 m below existing ground level.

Reference should be made to the "*Report on Land Capability and Contamination Assessment*" for more specific details.

4 SCOPE OF WORK

The scope of work for the present salinity assessment comprised the following, which is in general compliance with the DLWC (2002) publication *Site Investigations for Urban Salinity*, 2002:

- Review of previous assessments;
- Excavation and logging of thirteen (13) test pits (TP1 to TP13) across the site, to depths in the order of 3.0 m (or prior refusal), with a rubber tyred backhoe. (Note that the test pits were also excavated as part of the contamination investigation, which is reported separately);
- Collection of regular disturbed samples for laboratory testing;
- Laboratory analysis of selected samples for:
  - Electrical Conductivity (EC1:5);
  - pH;
  - Sulphate concentration;
  - Chloride concentration;
  - Exchangeable Sodium Potential (ESP); and
  - Cation Exchange Capacity (CEC).
- Identification of areas of elevated salinity, aggressivity to concrete, aggressivity to steel and sodicity; and
- Preparation of management strategies for hazard areas.

5 REGIONAL SOIL LANDSCAPE, GEOLOGY AND HYDROGEOLOGY

Details of the soil landscape, geology and hydrogeology of the Turner Road Precinct are provided in the *Land Capability and Contamination Assessment* report prepared by DP for the site (Project number 40741, February 2007). Pertinent information is summarised as follows.

5.1 Soil Landscapes

Reference to the 1:100 000 Soil Landscapes of the Wollongong – Port Hacking Sheet (Ref. 2) indicates that the site area is predominantly included within the Blacktown Soil Landscape. Soils from this landscape are typically of low fertility, are moderately reactive, have a generally low wet-bearing strength and are sodic.

The former Department of Infrastructure Planning and Natural Resources (DIPNR), on their map entitled "*Salinity Potential in Western Sydney 2002*" (Ref. 3), infers "moderate salinity potential" over most of the Turner Road Precinct and "high salinity potential" or "known salt occurrence" in the lower slopes and drainage areas. The DIPNR mapping is based on soil type, surface level and general groundwater considerations but is not in general ground-truthed, hence it is not generally known if actual soil salinities are consistent with the potential salinities of DIPNR.

5.2 Geology

Reference to the Wollongong - Port Hacking 1:100 000 Geological Series Sheet (Ref. 4) indicates that the site is underlain by Bringelly Shale (mapping unit Rwb) of the Wianamatta Group of Triassic age. This formation typically comprises shale, carbonaceous claystone, laminite and some minor coaly bands.

5.3 Hydrogeology

The shale terrain of much of Western Sydney is known for saline groundwater, the salt from which is concentrated within the residual soils by evapo-transpiration. In areas of urban development, this can lead to damage to building foundations, lower course brickwork, road surfaces and underground services, where these impact on the saline zone or where the salts are mobilised by changing groundwater levels.

No groundwater was encountered during the course of the fieldwork for this assessment, nor the Land Capability Study in the area of the Site.

Groundwater investigations undertaken by DP in the Camden area and previous studies of areas underlain by the Wianamatta Group indicate that:

- the shales have a very low intrinsic permeability and groundwater flow is likely to be dominated by fracture flow with resultant low yields (typically < 1 L/s) in bores;
- the groundwater in the Wianamatta Group is typically brackish to saline with total dissolved solids (TDS) in the range 4000 – 5000 mg/L (but with cases up to 31750 mg/L reported). The dominant ions are typically sodium and chloride and the water is generally unsuitable for livestock or irrigation.

6 CLASSIFICATION

6.1 Salinity

Soil salinity is often 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 to 17 depending on soil type. Richards (1954) and Hazelton and Murphy (1992) classify soil salinity on the basis of ECe, and describe the implications of the salinity classes on agriculture as follows:

Table 1 – 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

Note: This classification scheme is based on agricultural sensitivity. At this point in time no structure-based classification system exists.

6.2 Aggressivity

Tables 2 and 3, developed from AS 2159 – 2009 *Piling Design and Installation,* were used to classify the soils for aggressivity.

Table 2 – Exposure Classification for Concrete Piles

Exposure conditions			**Exposure Classification (Aggressivity)**
Sulfates SO_3 (ppm) in soil	**pH**	**Chlorides ppm (in water)**	**Soil conditions - B (low permeability soils such as silts and clays)**
<4000	>5.5	<6000	Non-aggressive
4000 – 8000	4.5 – 5.5	6000 – 12000	Mild
8000 – 16000	4 – 4.5	12000 – 30000	Moderate
>16000	<4	>30000	Severe

Table 3 – Exposure Classification for Steel Piles

Exposure conditions			**Exposure Classification (Aggressivity)**
Chlorides (ppm) in Soil	**pH**	**Resistivity Ohms**	**Soil conditions - B (low permeability soils such as silts and clays)**
<5000	>5	>5000	Non-aggressive
5000 – 20000	4 - 5	2000 - 5000	Non-aggressive
20000 – 50000	3 - 4	1000 - 2000	Mild
>50000	<3	<1000	Moderate

6.3 Sodicity

Sodic soils may be affected by very severe surface crusting, very low infiltration and hydraulic conductivity, very hard and dense subsoils, high susceptibility to gully erosion and tunnel erosion. Sodicity also affects the shrink – swell properties of a soil.

The general rating of sodicity as shown in the DLWC (2002) publication *Site Investigations for Urban Salinity*, 2002 is given in Table 4 below.

Table 4 – Sodicity Rating

ESP%	Rating
<5	Non-sodic
5 – 15	Sodic
>15	Highly sodic

7 RESULTS

7.1 Subsurface Investigation

In total, 13 test pits (TP1 to TP13) were excavated across the site for maximum site coverage. The test pits were primarily positioned in areas of preferential drainage and changes in topography, with the remainder positioned across the site to maximise coverage. The test pit locations are shown on Drawing 2, Appendix A.

Details of the subsurface conditions encountered are given on the test pit report sheets in Appendix B. Relatively uniform conditions were noted underlying the site, with the succession of strata broadly summarised as follows:

TOPSOIL: Dark brown silty clay with some rootlets and grass, encountered generally to depths of less than 0.2 m. Note that the general organic / grass root zone was less than 200 mm from the ground surface.

NATURAL: Clay, then shaly clay, encountered in all test pits beneath the topsoil to depths ranging from 0.5 m to in excess of 2.0 m (where test pits were discontinued and bedrock was not encountered). No distinction was made in logging between residual and alluvial clay profiles, however considering the general grading into shaly clay, and the Blacktown Soil Landscape mapping, it is likely that the clayey soils beneath the site are predominantly residual in origin.

BEDROCK: Weathered shale, encountered in all test pits (except TP11) at depths ranging from 0.5 m to 2.0 m below existing ground level. TP11 was discontinued at a depth of 2.0 m due to refusal on hard shaly clay.

No free groundwater was observed in any of the test pits, which were excavated to a maximum depth of 3.0 m below ground level. It is noted that the test pits were immediately backfilled following excavation, which precluded long term monitoring of groundwater levels.

7.2 Laboratory Results

Selected samples from the test pits were tested in a NATA accredited laboratory for electrical conductivity, pH, sulphate, chloride, exchangeable sodium and cation exchange capacity. Results were used to assess the salinity, aggressivity, and sodicity of soils within the site. The results are summarised in the following Table 5, with the full laboratory report sheets supplied in Appendix C.

Table 5 - Test Pit Data, Laboratory Tests and Assessment

Test Pit	Sample Depth (m)	pH	Chloride (ppm)	Sulphate SO_4 (ppm)	Aggressivity		ESP (%)	Sodicity Class	Soil Texture Group	Textural Factor [M] [DLWC]	$EC_{1:5}$ [Lab.] (µS/cm)	EC_e [M x $EC_{1:5}$] (dS/m)	Salinity Class [Richards 1954]
					To Concrete	To Steel							
					[AS2159]								
1	0.20	6.0	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	35	0.2	Non Saline
	0.50	5.6	670	92	Non-Aggressive	Non-Aggressive	2.9	non sodic	Heavy clay	6	490	2.9	Slightly Saline
	1.00	5.2	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	370	3.3	Slightly Saline
	1.50	6.7	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Loam	10	380	3.8	Slightly Saline
	2.00	5.7	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Loam	10	390	3.9	Slightly Saline
2	0.50	4.7	490	160	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	420	2.9	Slightly Saline
	1.00	5.5	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Light medium clay	8	210	1.7	Non Saline
3	0.50	5.6	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Heavy clay	6	44	0.3	Non Saline
4	0.20	6.1	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Light medium clay	8	16	0.1	Non Saline
	0.50	5.5	300	120	Non-Aggressive	Non-Aggressive	21	high	Heavy clay	6	270	1.6	Non Saline
	1.50	5.4	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	360	2.5	Slightly Saline
	2.00	5.5	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	280	2.0	Non Saline
	3.00	5.8	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	340	2.4	Slightly Saline
5	1.00	5.0	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Light medium clay	8	640	5.1	Moderately Saline
6	0.50	5.2	22	70	Non-Aggressive	Non-Aggressive	14	sodic	Medium clay	7	100	0.7	Non Saline
	1.50	5.5	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	410	3.7	Slightly Saline
7	0.50	4.7	180	180	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	240	1.7	Non Saline
	1.00	5.0	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Light medium clay	8	460	3.7	Slightly Saline
8	0.20	7.7	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Loam	10	22	0.2	Non Saline
	0.50	5.7	49	95	Non-Aggressive	Non-Aggressive	NT	-	Light medium clay	8	120	1.0	Non Saline
	1.00	5.4	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Light medium clay	8	330	2.6	Slightly Saline
	2.00	5.5	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	390	2.7	Slightly Saline
	3.00	5.1	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	480	3.4	Slightly Saline

ESP = Exchangeable Sodium Percentage (sodicity)
$EC_{1.5}$= Electrical Conductivity (!:5 Soil/Water suspension)
M = Multiplier factor based on soil texture
EC_e = Electrical Conductivity = $EC_{1.5}$ * M
NT = Not Tested

Table 5 - Test Pit Data, Laboratory Tests and Assessment

Test Pit	**Sample Depth**	**pH**	**Chloride**	**Sulphate SO_4**	**Aggressivity**		**ESP**	**Sodicity Class**	**Soil Texture Group**	**Textural Factor [M]**	**$EC_{1:5}$** [Lab.]	**EC_e** [M x $EC_{1:5}$]	**Salinity Class**
					To Concrete	**To Steel**							
	(m)		(ppm)	(ppm)	[AS2159]		**(%)**			[DLWC]	(µS/cm)	(dS/m)	[Richards 1954]
9	0.50	5.0	100	180	Non-Aggressive	Non-Aggressive	12	sodic	Medium clay	7	190	1.3	Non Saline
10	0.20	6.5	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	15	0.1	Non Saline
	0.50	5.8	14	94	Non-Aggressive	Non-Aggressive	12	sodic	Medium clay	7	100	5.6	Moderately Saline
	1.00	5.5	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	130	0.9	Non Saline
	1.50	5.8	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	270	2.4	Slightly Saline
	2.00	6.0	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	270	2.4	Slightly Saline
11	0.50	6.0	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Heavy clay	6	77	0.5	Non Saline
12	0.20	6.0	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	16	0.1	Non Saline
	0.50	5.0	47	170	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	160	1.1	Non Saline
	1.00	5.1	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	460	4.1	Moderately Saline
	1.50	5.1	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	340	3.1	Slightly Saline
13	0.50	6.5	9	23	Non-Aggressive	Non-Aggressive	NT	-	Medium clay	7	55	0.4	Non Saline
	1.00	5.5	NT	NT	Non-Aggressive	Non-Aggressive	NT	-	Clay loam	9	89	0.8	Non Saline

ESP = Exchangeable Sodium Percentage (sodicity)
$EC_{1.5}$= Electrical Conductivity (!:5 Soil/Water suspension)
M = Multiplier factor based on soil texture
EC_e = Electrical Conductivity = $EC_{1.5}$ * M
NT = Not Tested

8 DISCUSSION

The following section outlines the findings from the current and previous salinity investigations and comments further on the salinity risk, aggressivity (both to concrete and steel) and sodicity at the site.

8.1 Salinity

Salinity generally rises rapidly with depth within the shallower clay soils then remains relatively constant or declines within the underlying extremely weathered shale, as demonstrated in the following Figure 1 for Test Pits 1, 4, 8, 10 and 12. The changes in salinity at depths in the order of 0.5 m to 1.2 m coincide generally with a grading into a shaly clay / shale.

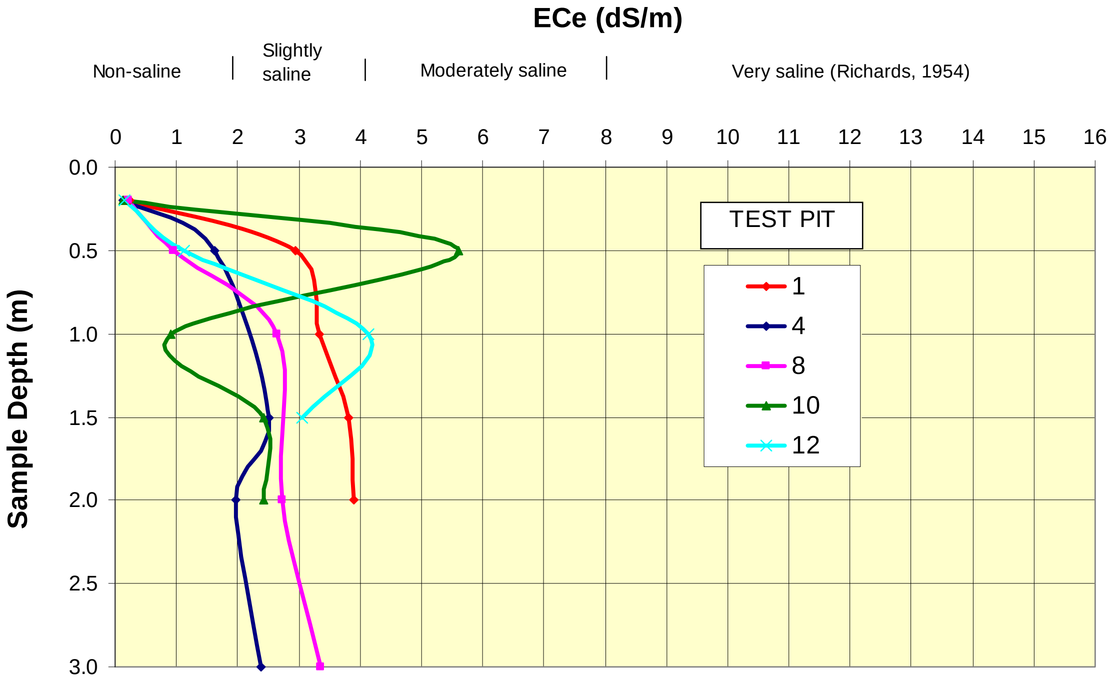

FIGURE 1 - Salinity Profiles from Test Pit Soil Samples

In general, the site is typically non-saline to slightly saline to a nominal depth of about 1.0 m. Moderately saline conditions were encountered at TP5, TP10 and TP12 at depths generally greater than 1.0 m (only one test pit TP10 reported moderately saline conditions at a depth of 0.5 m). Each of these locations are in lower elevations within the site, and generally associated with a preferential drainage pathway. On this basis, zones of moderately saline soils have been inferred and mapped on Drawing 3, Appendix A. The zones have been mapped on the basis of test results from this and the previous salinity studies, the electromagnetic survey conducted as part of the previous study, and contours around the test locations. As indicated on the drawing, the zones align generally with the identified preferential drainage paths and low lying areas of the site.

8.2 Aggressivity

In the current and previous investigations, all soil samples tested non-aggressive to both steel and concrete.

8.3 Sodicity

In the previous investigations, all soil samples tested sodic to highly sodic. The recent assessment has identified a generally similar trend.

9 MANAGEMENT STRATEGIES

9.1 General

On the basis of the current and previous studies and site observations, it is considered reasonable to assign the following characteristics to the subject site:

- Soils are generally non-saline to slightly saline across the majority of the site, but may be moderately saline at depths generally greater than 0.5 m to 1.0 m in the zones highlighted on Drawing 3, Appendix A;
- Soils are non-aggressive to both steel and concrete; and
- Soils are generally sodic to highly sodic.

It should also be noted that moderately saline soils have been found, generally at depth, in some other areas of the Gregory Hills Development site, including areas adjacent to Stage 2.

The current construction activities in these areas, and those proposed for future development, have a potential to impact on the natural drainage characteristics, and hence the potential remobilization of salts, of the Gregory Hills Development site. There is also a potential for these impacts to affect the nature of surface water, groundwater and salt movement within Stage 2. These potential impacts have also been taken into consideration in developing the management strategies for the site.

In general, the management strategies are directed at:

- Minimising the impact of development on the site salinity;
- Minimising the impact of salinity on the proposed development;
- Maintaining as much as practicable the natural water balance;
- Maintaining good drainage;
- Avoiding disturbance or exposure of sensitive soils;
- Retaining or increasing appropriate native vegetation in strategic areas; and
- Implementing building controls and engineering responses where appropriate.

The following sections provide management responses to the perceived risk areas with respect to salinity and sodicity.

Efforts should be made throughout the proposed development area to prevent or restrict changes to the water balance that will result in rises in groundwater levels, bringing more saline water closer to the ground surface. As a precaution, development must be planned to mitigate against the effects of any potential salinisation that could occur. The site soils, bedrock and topography render the site saline prone and even areas of low salinity, if poorly managed, may, over time, become more saline. As a result the management strategies below are recommended for all areas of the site.

Camden Council has a policy titled "*Building in Saline Prone Environments*". This policy applies to all areas within the Camden LGA, except where salinity risk can be shown to be diminished. Council's policy has been incorporated into the management strategies below.

9.2 Civil Works / Earthworks

- An Erosion and Sediment Control Plan must be developed by the appointed earthworks contractor and implemented in accordance with the NSW Department of Housing document "*Managing Urban Stormwater: Soils and Construction"* (1998).
- All sediment and erosion controls proposed by the Erosion and Sediment Control Plan are to be installed prior to commencement of any excavation or construction works.
- The potential erosion hazard developed by the presence of sodic soils will be kept as low as possible by limiting the construction area size at any one time and clearly defining the area by barrier fencing upslope and sediment fencing down slope (to be incorporated into the Erosion and Sediment Control Plan).
- The programming of development road works and major excavations should minimise the time of soil exposure, and should coincide with periods of anticipated lower rainfall (wherever possible).
- Subject to geotechnical and environmental suitability, excavated soils from within the site may be re-used as follows:
  - soils excavated from within the site, with the exception of those areas highlighted as moderately saline on Drawing 3, may be used elsewhere within the site without restriction;
  - soils excavated from depths greater than 0.5 m to 1 m in the zones of moderately saline soils (Drawing 3) should preferably be re-used within the same zone, or elsewhere within the site at depths of greater than 1 m below final grade;
  - Where the soils from the moderately saline zones cannot be re-used as above, use some form of surface treatment such as topsoil (loam), sandy materials, crushed rock or soils treated with gypsum. These measures are designed to reduce the potential for scour (given also the sodic nature of the soils) and improve soil structure (i.e. through the use of gypsum).
- With regard to re-grading within the subdivision, generally, 1V:40H slopes are advisable (where achievable); however, if such slopes cannot be achieved, minimum slopes of 1V:100H are acceptable assuming the following:
  - The grade is maintained to kerb and gutter (ie. not flattened out at the lot boundaries);

  - The site, following earthworks, is to be inspected for areas of ponding (after rain periods) and regraded if considered necessary ;
  - The site is to be developed within a reasonable time frame with substantial paved areas and adequately designed drainage.
- Avoid water collecting in low lying areas, depressions, behind fill embankments or near trenches on the uphill sides of roads. This can lead to water logging of the soils, evaporative concentration of salts, and eventual breakdown in soil structure resulting in accelerated erosion.
- Preferably design the surface water drainage system for the subdivision to coincide with pre-existing drainage pathways, thus minimising the disruption of existing surface water flows. Avoid filling or blocking preferential drainage pathways (refer Drawing 2). Piping can be used to maintain drainage lines.
- Should stormwater detention basins be constructed at the site, the following measures are recommended:
  - If possible, avoid locating the basins in the zone of moderately saline soils. If unavoidable, design either shallow (less than 0.5 m) or appropriately lined basins in this zone;
  - In constructing a lined basin, utilise either imported relatively impermeable clays or synthetic liners or clays from areas of the site assessed as containing non-saline to slightly saline soils;
  - carefully control the compaction and soil moisture content during construction of the basin to ensure creation of a low permeability embankment, to retard the migration of saline water into the pondage and the re-charge of the groundwater through infiltration;
  - develop a water quality monitoring plan and appropriate treatment, such as adjustment of pH levels prior to discharge to the surrounding environment.
- Roads and the shoulder areas should be designed to be well drained, particularly with regard to drainage of surface water. There should not be excessive concentrations of runoff or ponding that would lead to waterlogging of the pavement or additional recharge to the groundwater.
- Where possible materials and waters used in the construction of roads and fill embankments should be selected to contain minimal or no salt. Such materials should preferably be

sourced from the non-saline to slightly saline areas within the site. Where the use of soils from the moderately saline zones is unavoidable, use some form of surface treatment such as topsoil (loam), sandy materials, crushed rock or soils treated with gypsum. These measures are designed to reduce the potential for scour (given also the sodic nature of the soils) and improve soil structure (i.e. through the use of gypsum).

- All excavation batters should be appropriately surfaced as soon as possible after formation. Surfacing can include topsoil, turf, planting, crushed rock or similar measures that will reduce the potential for scour. Gypsum treatment of soil is also an option, as discussed above.
- Surface drains should generally be provided along the top of all batters to reduce the potential for concentrated flows of water down slopes, possibly causing scour. Well-graded subsoil drainage should be provided at the base of all slopes where there are road pavements below the slope, to reduce the risk of waterlogging.
- Minimise the use of relatively impermeable retaining structures, such as concrete or block walls; use safely inclined slopes, with grass and plant cover as an alternative. Gabion walls, or similar are also a better alternative as they are free draining.
- At locations of deep excavations (i.e. cuttings greater than 3m depth) it may be possible for groundwater to seep through fractures and joints in the shale bedrock, which is likely to be exposed in such excavations. To counter the potential impacts of salts and ions carried on the seepage water, the following additional measures are recommended:
  - Grade the ground surface away from the base of the cutting to be collected by the surrounding sub-surface drains;
  - Provide additional sub-surface drainage at the toe of the cutting to collect seepage water;
  - Clean, flush and maintain the drainage system on a regular basis to ensure no future build-up of salts and/or mineral staining, such as iron.

9.3 Building Construction Works

- For slab-on-ground construction, a layer of bedding sand of at least 50 mm thickness under the slab must be provided, provided the ground surface is initially well compacted and smoothed to remove any protruding materials that could potentially puncture the overlying membrane. This layer will permit free drainage of water beneath the slab, minimising the possibility of pooling or trapping water that might potentially be carrying salts. Consideration should be given to increasing this layer to 100 mm if a sufficiently smooth ground surface cannot be achieved;

- As an alternative to slab-on-ground construction, suspended slab or pier and beam construction should be considered, particularly on sloping sites as this will minimise exposure to saline or aggressive soils and reduce the potential cut and fill on site which could alter surface and subsurface water flows.
- A high impact damp proof membrane, not just a vapour proof membrane, must be laid under any ground-bearing slab. The damp proof membrane must be extended to the outside face of the external edge beam up to the finished ground level.
- A minimum 32 MPa concrete or a sulphate resisting cement with a water cement ratio no greater than 0.5, must be used for ground bearing slabs, footings, piers or beams. This is a mandatory requirement for the whole of the Camden Local Government Area, under the Camden Council 2004 policy "*Building in Salinity Prone Environments*".
- The minimum cover to reinforcement must be 50 mm from unprotected ground and 40 mm from a membrane in contact with the ground.
- Slabs must be vibrated and cured for a minimum of three days. Care must be taken not to over-vibrate the concrete during placement, as segregation of the concrete aggregates may occur.
- For masonry building construction, the damp proof course must consist of polyethylene or polyethylene coated metal that is correctly placed in accordance with the Building Code of Australia. Once installed, any later construction works must not breach the damp proof course and/or waterproof membrane.
- Exposure class masonry units must be used below the damp proof course.
- Appropriate mortar and mixing ratios must be used with exposure class masonry units.
- Ground levels immediately adjacent to masonry walls must be kept below the damp-proof course.
- Water should not be permitted to pond against the walls of any new structures. Surrounding pathways, hardstand parking areas or the like should be sloped so as to drain water away from any external walls.

- Adequate drainage of down pipes must be provided to divert water away from structures and prevent cyclic wetting and drying.
- Service connections and stormwater runoffs should be checked to avoid leaking pipes which may affect off site areas further down slope and increase groundwater recharge resulting in increases in groundwater levels.
- Landscaping and garden designs should preferably not be placed against walls and be designed to minimise the use of water on site.

9.4 Infrastructure

For the purpose of this management plan, infrastructure refers to features such as roads (including associated drainage and culverts), footpaths, and underground services such as electricity, gas, telecommunications, water, stormwater and sewerage. The following recommendations are considered minimum requirements and may be superseded or exceeded by industry requirements or Camden Council construction practices.

- Minimise the extent of cut into the existing ground.
- Where possible, construct roads at close to existing ground level or on a fill embankment (with adequate drainage provisions) rather than deep cut, which allows for the separation of surface drainage from any subsurface drainage.
- Roads should be constructed within the crest or base of a slope (preferably the crest) where possible. Preferably avoid road construction within the middle section of a slope, parallel to the existing topography, as this may intersect the natural flow of surface and sub-surface waters and therefore increase the potential of accumulating saline waters above and below the road embankment.
- Minimise the potential for accumulation / ponding of surface water on roads by the following practices:
  - Provide adequate fall of the road surface to promote collection of surface water run-off in stormwater drains located beneath the kerb and gutter;
  - Ensure, through adequate testing, that the road sub-grade and all pavement materials are rolled and compacted to Camden Council specifications;

  - Provide a good quality bituminous seal that will provide a long term seal against water infiltration.
- For underground cast-in-situ concrete structures, use Class 32MPa (N32) concrete with a water cement ratio of 0.5 and a minimum cover to reinforcement of 50 mm.
- Utilise copper or non-metallic pipes as opposed to galvanised iron.
- Ensure all underground services are provided with adequate corrosion protection, including sheaths to power and telecommunication cables.
- Monitor water pipes for leaks on a regular basis and repair any damaged pipes as soon as possible after detection.

10 ADDITIONAL RECOMMENDATIONS

The salinity assessment conducted and reported herein was carried out using soil samples recovered to depths of up to about 3 m below existing ground level. The depth of investigation was limited by the reach of the backhoe used for sampling and/or refusal on bedrock.

The test pit logs suggest that, for the most part, any excavations deeper than 3 m will expose the shale bedrock, which have inherent diminished salinity risk (although difficult to quantify) unless the salts are mobilised by water seepage through fractures. Further investigations where shale bedrock is encountered are not considered necessary as provisions for managing salinity under these circumstances have been outlined in this report.

Should the deep excavations expose clays rather than shale bedrock, further investigation should be undertaken to assess the degree of salinity in the soil and, more importantly, the potential for shallow groundwater to be present at the final excavation depth. Based on current investigations, it is considered unlikely that highly saline soils would be encountered at depths of greater than 3 m. In any case, if soils are exposed at excavation depths of greater than 3 m below the original ground level, the following protocols should be employed:

- Conduct soil sampling at regular depth intervals to a depth of about 3m or prior refusal on bedrock. A density of one sample location per hectare, or minimum of one sample location per pocket of exposed soil;

- Measure depth to groundwater, if encountered, and recover samples of groundwater;
- Conduct testing on selected soil and groundwater samples for salinity indicators including pH and Conductivity;
- Assess the salinity characteristics of the sampled area(s); and
- Confirm previous salinity management strategies or devise alternate strategies as required and document these in a letter report.

The development proposed is not considered to result in exposure of groundwater, or excavations to within close proximity of the groundwater. However, further investigations in areas of proposed excavation (such as permanent detention basins) in low lying areas of the site should be carried out to ascertain the depth to groundwater. This information may impact on the design of a basin or depth of excavation and in so doing minimise the possibility of groundwater recharge.

Yours faithfully
DOUGLAS PARTNERS PTY LTD

Paul Gorman
Senior Associate

Reviewed by:

John Lean
Principal

REFERENCES:

1. Department of Land and Water Conservation (now Department of Water and Energy) publication *Site Investigations for Urban Salinity*, 2002
2. Soil Landscapes of Wollongong and Port Hacking 1:100 000 Sheet. Soil Conservation Service of New South Wales, 1990.
3. DIPNR, 2003. Salinity Potential in Western Sydney 1:100 000 Sheet. Department of Infrastructure, Planning and Natural Resources, New South Wales.
4. Geology of Wollongong – Port Hacking 1:100 000 Geological Series Sheet No 9029 – 9129, NSW Dept of Mines, 1985
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.

APPENDIX A

Drawings 1, 2 and 3

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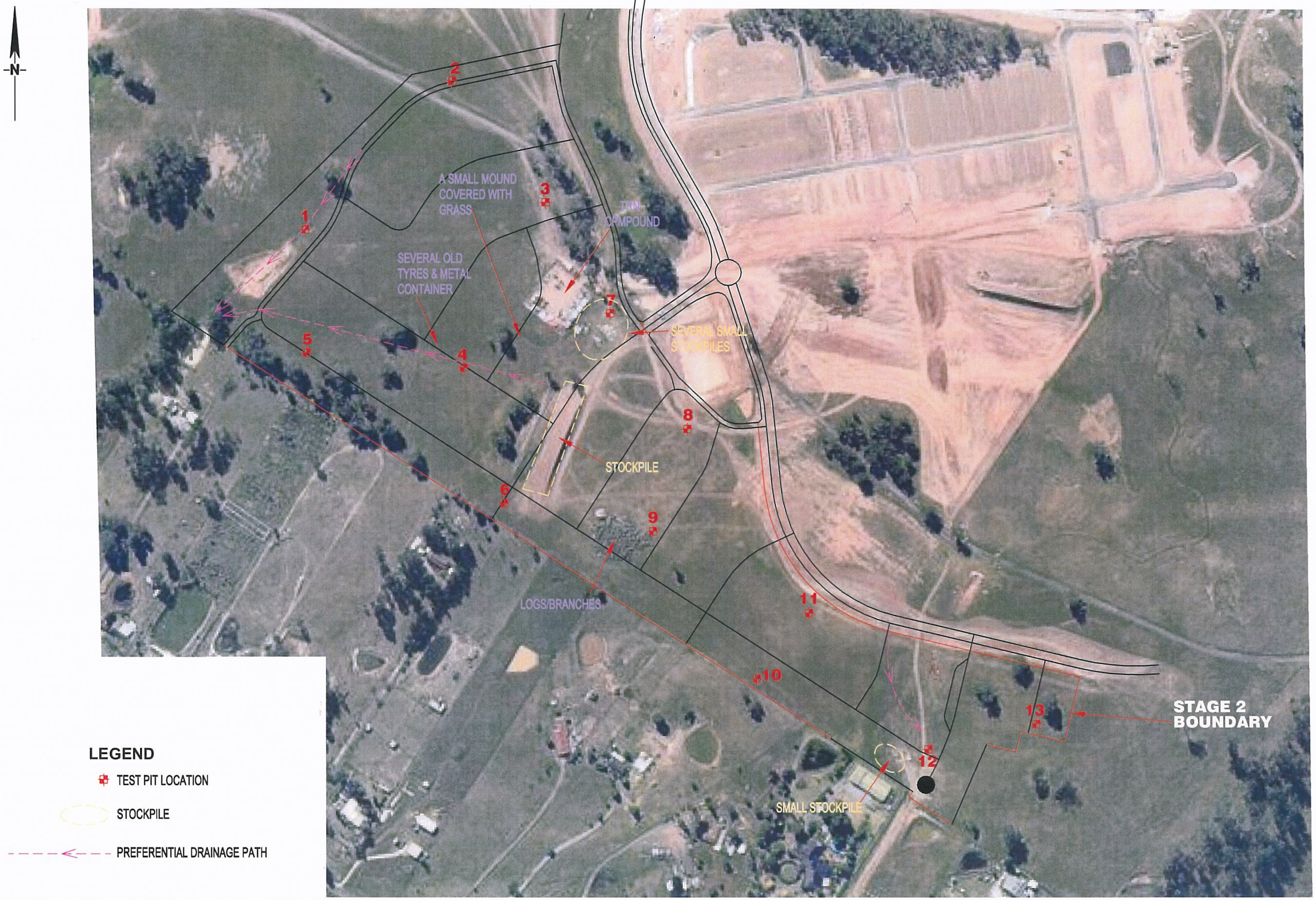
CLIENT: Dart West Developments Pty Ltd			TITLE:	**Masterplan / Locality**	DP Project No: 71913
DRAWN BY: PG	SCALE: NTS	OFFICE: Sydney		**Contamination and Salinity Assessment**	Drawing No: 1
APPROVED BY		DATE: 2 August 2010		**Stage 2, Gregory Hills Development**	Revision: 0



Douglas Partners
Geotechnics · Environment · Groundwater

CLIENT: Dart West Developments Pty Ltd			TITLE: **Location of Test Pits** **Contamination & Salinity Assessment** **Stage 2, GREGORY HILLS DEVELOPMENT**	PROJECT No: 71913
DRAWN BY: PSCH	SCALE: N.T.S.	OFFICE: Sydney		DRAWING No: 2
APPROVED BY:		DATE: 3.8.2010		REVISION: A

P:\71913 GREGORY HILLS, Stage 2 Contamination Assessment PG\Drawings\71913-1.dwg, 8/4/2010 8:26:57 AM

Douglas Partners
Geotechnics • Environment • Groundwater

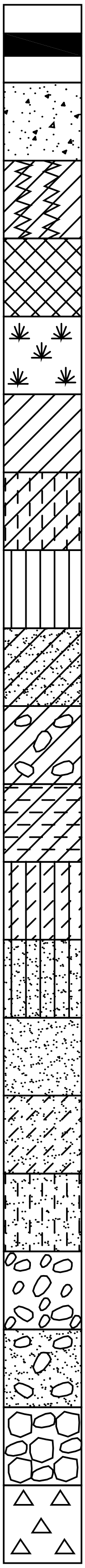
CLIENT: Dart West Developments Pty Ltd			TITLE:	**Salinity Assessment**	DP Project No:	71913
DRAWN BY: PG	SCALE: NTS	OFFICE: Sydney		**Stage 2, Gregory Hills Development**	Drawing No:	3
APPROVED BY		DATE: 2 August 2010		**Areas of Moderate Salinity Potential**	Revision:	0

APPENDIX B

Test Pit Reports and Notes Relating to this Report

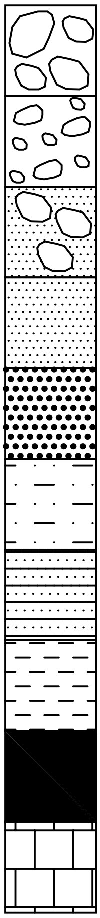
GRAPHIC SYMBOLS FOR SOIL & ROCK

SOIL



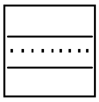
- BITUMINOUS CONCRETE
- CONCRETE
- TOPSOIL
- FILLING
- PEAT
- CLAY
- SILTY CLAY
- SILT
- SANDY CLAY
- GRAVELLY CLAY
- SHALY CLAY
- CLAYEY SILT
- SANDY SILT
- SAND
- CLAYEY SAND
- SILTY SAND
- GRAVEL
- SANDY GRAVEL
- COBBLES/BOULDER
- TALUS

SEDIMENTARY ROCK

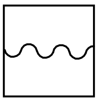


- BOULDER CONGLOMERATE
- CONGLOMERATE
- CONGLOMERATIC SANDSTONE
- SANDSTONE FINE GRAINED
- SANDSTONE COARSE GRAINED
- SILTSTONE
- LAMINITE
- MUDSTONE, CLAYSTONE, SHALE
- COAL
- LIMESTONE

SEAMS

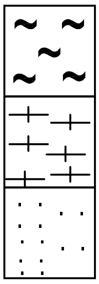


SEAM
>10mm



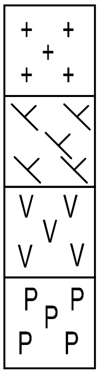
SEAM
<10mm

METAMORPHIC ROCK



- SLATE, PHYLLITE, SCHIST
- GNEISS
- QUARTZITE

IGNEOUS ROCK



- GRANITE
- DOLERITE, BASALT
- TUFF
- PORPHYRY

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 293784.8
NORTHING: 6232578.09
DIP/AZIMUTH: 90°/--

PIT No: 1
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		TOPSOIL - dark brown silty clay topsoil with some rootlets		E/S	0.0		PID<1ppm		
	0.2	CLAY - yellow brown clay			0.2				
				E/S	0.3		PID<1ppm		
	0.5	SHALY CLAY - yellow brown mottled grey shaly clay with some organic matter			0.5				
				S	0.8		PID<1ppm		
1	1.0	SHALE - low strength, highly weathered, dark brown shale with ironstone bands, fractured			1.0				1
				S	1.3		PID<1ppm		
		1.5m: same as above but low to medium strength, moderately weathered shale, fractured			1.5				
				S	1.8		PID<1ppm		
2				S	2.0		PID<1ppm		2
	2.2	Pit discontinued at 2.2m refusal on medium strength, moderately weathered, brown shale with ironstone bands			2.2				
3									3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

☐ 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:	JB
Date:	2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 293870.96
NORTHING: 6232728.6
DIP/AZIMUTH: 90°/--

PIT No: 2
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		CLAY - red brown clay with some rootlets and organic matter		E/S	0.0 0.2		PID<1ppm		
	0.2	CLAY - red brown, mottled yellow brown clay with some ironstone nodules, trace of rootlets and organic matter		E/S	0.3 0.5		PID<1ppm		
	0.5	SHALY CLAY - grey mottled red brown clay with some ironstone nodules and trace of rootlets		S	0.8 1.0		PID<1ppm		
1	1.0	SHALE - extremely low strength, highly weathered, brown shale with ironstone bands, fractured		S	1.3 1.5		PID<1ppm		1
				S	1.8 2.0		PID<1ppm		
2	2.0	Pit discontinued at 2.0m refusal on medium strength, brown shale with ironstone bands							2
3									3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

☐ 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: PG
Date: 2/8/10

Douglas Partners
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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 293980.3
NORTHING: 6232607.82
DIP/AZIMUTH: 90°/--

PIT No: 3
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		TOPSOIL - dark brown silty clay topsoil with rootlets		E/S	0.0 0.2		PID<1ppm		
	0.2	CLAY - orange brown, mottled grey clay with trace of rootlets		E/S	0.3 0.5		PID<1ppm		
	0.5	SHALY CLAY - grey, mottled red brown shaly clay with some ironstone nodules		S	0.8 1.0		PID<1ppm		
1				S	1.3 1.5		PID<1ppm		1
				S	1.8 2.0		PID<1ppm		
2	2.0	SHALE - low strength, highly weathered, brown shale with ironstone bands, fractured		S	2.3 2.5		PID<1ppm		2
	2.5	Pit discontinued at 2.5m refusal on medium strength, brown shale							
3									3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

☐ 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: PG
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 293951.05
NORTHING: 6232446.92
DIP/AZIMUTH: 90°/--

PIT No: 4
PROJECT No: 71913.01
DATE: 13/7/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		TOPSOIL - dark brown silty clay topsoil with some rootlets	E/S	0.0 0.2		PID<1ppm		
	0.2	CLAY - orange brown clay	E/S	0.3 0.5		PID<1ppm		
	0.5	SHALY CLAY - grey mottled red to orange brown, shaly clay with some ironstone nodules and trace of organic matter						
-1								-1
			S	1.3 1.5		PID<1ppm		
			S	1.8 2.0		PID<1ppm		
-2	2.0	SHALE - low strength, highly weathered, brown shale with ironstone bands, fractured						-2
		2.5m: same as above but medium strength and moderately weathered, fractured						
		3.0m: same as above but medium to high strength shale, fractured	S	2.8 3.0		PID<1ppm		
-3	3.0	Pit discontinued at 3.0m refusal on medium to high strength, brown shale with ironstone bands						-3
-4								-4

RIG: Backhoe
LOGGED: WFY
WATER OBSERVATIONS: No free groundwater observed
REMARKS: E = Environmental sample; S = Salinity sample

☐ 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:
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 293785.26
NORTHING: 6232440.81
DIP/AZIMUTH: 90°/--

PIT No: 5
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		TOPSOIL - brown silty clay topsoil with trace of rootlets		E/S	0.0		PID<1ppm		
	0.2	CLAY - red brown, mottled yellow brown clay with some ironstone nodules and trace of rootlets			0.2				
				E/S	0.3		PID<1ppm		
	0.5	SHALY CLAY - grey, mottled red to orange brown shaly clay with some ironstone nodules			0.5				
				S	0.7		PID<1ppm		
1					1.0				1
				S	1.3		PID<1ppm		
	1.5	SHALE - low strength, highly weathered shale, fractured			1.5				
				S	1.8		PID<1ppm		
2	2.0	SHALE - medium strength, highly weathered, brown shale with some ironstone bands, fractured			2.0				2
3	3.0	Pit discontinued at 3.0m refusal on medium strength, brown shale with ironstone bands							3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

☐ 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:
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 293970.34
NORTHING: 6232308.02
DIP/AZIMUTH: 90°/--

PIT No: 6
PROJECT No: 71913.01
DATE: 13/7/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		TOPSOIL - brown silty clay topsoil with some rootlets		E/S	0.0 0.2		PID<1ppm		
	0.2	CLAY - yellow brown, mottled red brown clay with some ironstone nodules and trace of rootlets		E/S	0.3 0.5		PID<1ppm PID<1ppm		
	0.5	SHALY CLAY - grey, mottled red to orange brown shaly clay with some ironstone nodules, fractured		S	1.0				
-1	1.0	SHALE - low to medium strength, moderately weathered shale, fractured		S	1.3 1.5		PID<1ppm		1
				S	1.8 2.0		PID<1ppm		
-2	2.0	Pit discontinued at 2.0m refusal on medium strength, brown shale with ironstone bands							2
-3									3
-4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 294107.74
NORTHING: 6232470.73
DIP/AZIMUTH: 90°/--

PIT No: 7
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		TOPSOIL - brown silty clay topsoil with some rootlets and organic matter		E/S	0.0		PID<1ppm		
	0.2	CLAY - yellow brown, mottled red brown clay with some ironstone nodules			0.2				
				E/S	0.4		PID<1ppm		
	0.5	SHALY CLAY - grey, mottled red to orange brown shaly clay with some ironstone nodules			0.5				
				S	0.8		PID<1ppm		
1	1.0	SHALE - low to medium strength, moderately weathered, brown shale with ironstone bands, fractured			1.0				1
				S	1.3		PID<1ppm		
					1.5				
				S	1.8		PID<1ppm		
2	2.0	Pit discontinued at 2.0m refusal on medium strength, brown shale with ironstone bands			2.0				2
3									3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

☐ 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: PG
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 294177.49
NORTHING: 6232368.5
DIP/AZIMUTH: 90°/--

PIT No: 8
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		TOPSOIL - dark brown silty clay topsoil with some rootlets		E/S	0.0 0.2		PID<1ppm		
	0.2	CLAY - red to orange brown clay with some ironstone nodules		E/S	0.3 0.5		PID<1ppm		
	0.5	SHALY CLAY - grey, mottled red to orange brown shaly clay with some ironstone gravel		S	0.8 1.0		PID<1ppm		
1				S	1.3 1.5		PID<1ppm		1
				S	1.8 2.0		PID<1ppm		
2	2.0	SHALE - low strength, extremely weathered, brown shale with ironstone bands, fractured							2
		2.5m: medium strength, fractured		S	2.8 3.0		PID<1ppm		
3	3.0	Pit discontinued at 3.0m refusal on medium strength, brown shale with ironstone bands							3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	
Date:	2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 294132.76
NORTHING: 6232272.22
DIP/AZIMUTH: 90°/--

PIT No: 9
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		TOPSOIL - brown silty clay topsoil with some rootlets and organic matter		E/S	0.0 0.2		PID<1ppm		
	0.2	CLAY - red brown clay with some rootlets and ironstone nodules		E/S	0.4 0.5		PID<1ppm		
	0.5	SHALY CLAY - grey, mottled red to orange brown shaly clay with some ironstone nodules		S	0.8 1.0		PID<1ppm		
1	1.0	SHALE - low to medium strength, moderately weathered, brown shale with ironstone bands, fractured		S	1.3 1.5		PID<1ppm		1
	1.5	Pit discontinued at 1.5m refusal on medium strength, brown shale with ironstone bands							
2									2
3									3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 294196.07
NORTHING: 6232153.58
DIP/AZIMUTH: 90°/--

PIT No: 10
PROJECT No: 71913.01
DATE: 13/7/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		TOPSOIL - dark brown silty clay topsoil with trace of rootlets		E/S	0.0 0.2		PID<1ppm		
	0.2	CLAY - orange to red brown, mottled grey clay with some ironstone nodules		E/S	0.3 0.5		PID<1ppm		
				S	0.8 1.0		PID<1ppm		
1	1.0	SHALY CLAY - grey, mottled red to orange brown clay with some ironstone nodules		S	1.3 1.5		PID<1ppm		1
	1.5	SHALE - low to medium strength, moderately weathered, brown shale with ironstone bands, fractured		S	1.8 2.0		PID<1ppm		
2	2.0	Pit discontinued at 2.0m refusal on medium strength, brown shale with ironstone bands							2
3									3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

☐ 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:
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 294279.04
NORTHING: 6232206.91
DIP/AZIMUTH: 90°/--

PIT No: 11
PROJECT No: 71913.01
DATE: 13/7/2010
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
				Type	Depth	Sample	Results & Comments		
		TOPSOIL - dark brown silty clay topsoil with trace of rootlets		E/S	0.0		PID<1ppm		
	0.2	CLAY - yellow brown, mottled red brown clay with trace of rootlets			0.2				
				E/S	0.3		PID<1ppm		
		0.5m: same as above but red to yellow brown clay			0.5				
				S	0.8		PID<1ppm		
-1		1.0m: same as above but grey, mottled red/orange brown clay			1.0				-1
				S	1.3		PID<1ppm		
					1.5				
				S	1.8		PID<1ppm		
-2	2.0	Pit discontinued at 2.0m refusal on hard, grey, mottled red brown shaly clay			2.0				2
-3									-3
-4									-4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

☐ 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:
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 294406.01
NORTHING: 6232060.06
DIP/AZIMUTH: 90°/--

PIT No: 12
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		TOPSOIL - dark brown silty clay topsoil with some rootlets		E/S	0.0		PID<1ppm		
	0.2	CLAY - orange brown, mottled red brown clay with some ironstone nodules			0.2				
				E/S	0.3		PID<1ppm		
	0.5	SHALE - low to medium strength, moderately weathered, brown shale with ironstone bands, fractured			0.5				
				S	0.8		PID<1ppm		
1		1.0m: medium strength shale, fractured			1.0				1
				S	1.3		PID<1ppm		
	1.5	Pit discontinued at 1.5m refusal on medium strength, brown shale with ironstone bands			1.5				
2									2
3									3
4									4

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample
Denotes field replicate sample BD2/130710 collected

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

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials:
Date: 2/8/10

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TEST PIT LOG

CLIENT: Dart West Developments Pty Ltd
PROJECT: Contamination and Salinity Assessment
LOCATION: Stage 2 Gregory Hills Development, Camden Valley Way, Gregory Hills

SURFACE LEVEL: --
EASTING: 294514.53
NORTHING: 6232094.6
DIP/AZIMUTH: 90°/--

PIT No: 13
PROJECT No: 71913.01
DATE: 13/7/2010
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 mm) 5 10 15 20
		TOPSOIL - dark brown silty clay topsoil with trace of rootlets		E/S	0.0 0.2				
	0.2	SHALY CLAY - yellow brown, mottled red brown shaly clay with some rootlets and ironstone nodules		E/S	0.3 0.5				
	0.5	SHALE - low strength, highly weathered, brown shale with ironstone bands, fractured		S	0.8 1.0				
	1 1.0	Pit discontinued at 1.0m refusal on medium strength, brown shale with ironstone bands							
	2								
	3								
	4								

RIG: Backhoe

LOGGED: WFY

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample; S = Salinity sample

☐ 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: FC
Date: 2/8/10

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DESCRIPTION AND CLASSIFICATION OF ROCKS FOR ENGINEERING PURPOSES

DEGREE OF WEATHERING

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

ROCK STRENGTH

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

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

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

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

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

STRATIFICATION SPACING

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

DEGREE OF FRACTURING

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

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

ROCK QUALITY DESIGNATION (RQD)

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

SEDIMENTARY ROCK TYPES

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

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

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

NOTES RELATING TO THIS REPORT

Introduction

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

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

Description and Classification Methods

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

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

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

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

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

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

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

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

Sampling

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

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

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

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

Drilling Methods.

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

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

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

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

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

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

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

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

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 6.3.1.

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

The test results are reported in the following form.

- 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 short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm
  as 15, 30/40 mm.

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

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

Cone Penetrometer Testing and Interpretation

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

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

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

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

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

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

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

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

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

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

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

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

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

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

Laboratory Testing

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

Bore Logs

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

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

Ground Water

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

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

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

Engineering Reports

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

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

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

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

Site Anomalies

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

Reproduction of Information for Contractual Purposes

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

Site Inspection

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

APPENDIX C

Laboratory Test Results Certificates

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 43527

Client:
Douglas Partners
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Paul Gorman

Sample log in details:
Your Reference: **71913.01, Gregory Hills**
No. of samples: 36 Soils
Date samples received: 15/07/10
Date completed instructions received: 16/07/10

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: 23/07/10
Date of Preliminary Report: Not Issued
Issue Date: 23/07/10
NATA accreditation number 2901. This document shall not be reproduced except in full.
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

Rhian Morgan
Rhian Morgan
Metals Supervisor

Jacinta Hurst
Laboratory Manager

Miscellaneous Inorg - soil						
Our Reference:	UNITS	43527-1	43527-2	43527-3	43527-4	43527-5
Your Reference	-------------	1/0.2	1/0.5	1/1	1/1.5	1/2
Date Sampled	------------	13/07/2010	13/07/2010	13/07/2010	13/07/2010	13/07/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date analysed	-	22/07/2010	22/07/2010	22/07/2010	22/07/2010	22/07/2010
pH 1:5 soil:water	pH Units	6.0	5.6	5.2	6.7	5.7
Electrical Conductivity 1:5 soil:water	µS/cm	35	490	370	380	390
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	670	[NA]	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	92	[NA]	[NA]	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	43527-6	43527-7	43527-8	43527-9	43527-10
Your Reference	-------------	2/0.3-0.5	2/0.8-1	3/0.3-0.5	4/0-0.2	4/0.3-0.5
Date Sampled	------------	13/07/2010	13/07/2010	13/07/2010	13/07/2010	13/07/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date analysed	-	22/07/2010	22/07/2010	22/07/2010	22/07/2010	22/07/2010
pH 1:5 soil:water	pH Units	4.7	5.5	5.6	6.1	5.5
Electrical Conductivity 1:5 soil:water	µS/cm	420	210	44	16	270
Chloride, Cl 1:5 soil:water	mg/kg	490	[NA]	[NA]	[NA]	300
Sulphate, SO4 1:5 soil:water	mg/kg	160	[NA]	[NA]	[NA]	120

Miscellaneous Inorg - soil						
Our Reference:	UNITS	43527-11	43527-12	43527-13	43527-14	43527-15
Your Reference	-------------	4/1.3-1.5	4/1.8-2	4/2.8-3	5/0.8-1	6/0.3-0.5
Date Sampled	------------	13/07/2010	13/07/2010	13/07/2010	13/07/2010	13/07/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date analysed	-	22/07/2010	22/07/2010	22/07/2010	22/07/2010	22/07/2010
pH 1:5 soil:water	pH Units	5.4	5.5	5.8	5.0	5.2
Electrical Conductivity 1:5 soil:water	µS/cm	360	280	340	640	100
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	[NA]	22
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	[NA]	70

Miscellaneous Inorg - soil						
Our Reference:	UNITS	43527-16	43527-17	43527-18	43527-19	43527-20
Your Reference	-------------	6/1.3-1.5	7/0.4-0.5	7/0.8-1	8/0-0.2	8/0.3-0.5
Date Sampled	------------	13/07/2010	13/07/2010	13/07/2010	13/07/2010	13/07/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date analysed	-	22/07/2010	22/07/2010	22/07/2010	22/07/2010	22/07/2010
pH 1:5 soil:water	pH Units	5.5	4.7	5.0	7.7	5.7
Electrical Conductivity 1:5 soil:water	µS/cm	410	240	460	22	120
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	180	[NA]	[NA]	49
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	180	[NA]	[NA]	95

Miscellaneous Inorg - soil						
Our Reference:	UNITS	43527-21	43527-22	43527-23	43527-24	43527-25
Your Reference	-------------	8/0.8-1	8/1.8-2	8/2.8-3	9/0.4-0.5	10/0-0.2
Date Sampled	------------	13/07/2010	13/07/2010	13/07/2010	13/07/2010	13/07/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date analysed	-	22/07/2010	22/07/2010	22/07/2010	22/07/2010	22/07/2010
pH 1:5 soil:water	pH Units	5.4	5.5	5.1	5.0	6.5
Electrical Conductivity 1:5 soil:water	µS/cm	330	390	480	190	15
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	100	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	[NA]	180	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	43527-26	43527-27	43527-28	43527-29	43527-30
Your Reference	-------------	10/0.3-0.5	10/0.8-1	10/1.3-1.5	10/1.8-2	11/0.3-0.5
Date Sampled	------------	13/07/2010	13/07/2010	13/07/2010	13/07/2010	13/07/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date analysed	-	22/07/2010	22/07/2010	22/07/2010	22/07/2010	22/07/2010
pH 1:5 soil:water	pH Units	5.8	5.5	5.8	6.0	6.0
Electrical Conductivity 1:5 soil:water	µS/cm	100	130	270	270	77
Chloride, Cl 1:5 soil:water	mg/kg	14	[NA]	[NA]	[NA]	[NA]
Sulphate, SO4 1:5 soil:water	mg/kg	94	[NA]	[NA]	[NA]	[NA]

Miscellaneous Inorg - soil						
Our Reference:	UNITS	43527-31	43527-32	43527-33	43527-34	43527-35
Your Reference	-------------	12/0-0.2	12/0.3-0.5	12/0.8-1	12/1.3-1.5	13/0.3-0.5
Date Sampled	------------	13/07/2010	13/07/2010	13/07/2010	13/07/2010	13/07/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date analysed	-	22/07/2010	22/07/2010	22/07/2010	22/07/2010	22/07/2010
pH 1:5 soil:water	pH Units	6.0	5.0	5.1	5.1	6.5
Electrical Conductivity 1:5 soil:water	µS/cm	16	160	460	340	55
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	47	[NA]	[NA]	9.3
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	170	[NA]	[NA]	23

Miscellaneous Inorg - soil		
Our Reference:	UNITS	43527-36
Your Reference	-------------	13/0.8-1
Date Sampled	------------	13/07/2010
Type of sample		Soil
Date prepared	-	21/07/2010
Date analysed	-	22/07/2010
pH 1:5 soil:water	pH Units	5.5
Electrical Conductivity 1:5 soil:water	µS/cm	89

ESP/CEC Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	43527-2 1/0.5 13/07/2010 Soil	43527-10 4/0.3-0.5 13/07/2010 Soil	43527-15 6/0.3-0.5 13/07/2010 Soil	43527-24 9/0.4-0.5 13/07/2010 Soil	43527-26 10/0.3-0.5 13/07/2010 Soil
Exchangeable Ca*	meq/100g	6.0	0.61	1.3	1.5	1.2
Exchangeable K*	meq/100g	0.18	0.32	0.32	0.36	0.34
Exchangeable Mg*	meq/100g	1.2	9.6	7.7	9.2	10
Exchangeable Na*	meq/100g	0.23	2.8	1.5	1.5	1.6
Cation Exchange Capacity*	meq/100g	7.6	13	11	13	13
ESP*	%	2.9	21.2	13.6	12.2	12.0

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 ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			21/07/2010	43527-1	21/07/2010 || 21/07/2010	LCS-1	21/07/2010
Date analysed	-			22/07/2010	43527-1	22/07/2010 || 22/07/2010	LCS-1	22/07/2010
pH 1:5 soil:water	pH Units		LAB.1	[NT]	43527-1	6.0 || 6.0 || RPD: 0	LCS-1	99%
Electrical Conductivity 1:5 soil:water	µS/cm	1	LAB.2	<1.0	43527-1	35 || 33 || RPD: 6	LCS-1	102%
Chloride, Cl 1:5 soil:water	mg/kg	2	LAB.81	<2.0	[NT]	[NT]	LCS-1	87%
Sulphate, SO4 1:5 soil:water	mg/kg	2	LAB.81	<2.0	[NT]	[NT]	LCS-1	86%

QUALITY CONTROL ESP/CEC	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Exchangeable Ca*	meq/100g	0.01	Metals.23	<0.01	43527-26	1.2 || 1.1 || RPD: 9	LCS-1	83%
Exchangeable K*	meq/100g	0.01	Metals.23	<0.01	43527-26	0.34 || 0.31 || RPD: 9	LCS-1	108%
Exchangeable Mg*	meq/100g	0.01	Metals.23	<0.01	43527-26	10 || 8.7 || RPD: 14	LCS-1	81%
Exchangeable Na*	meq/100g	0.01	Metals.23	<0.01	43527-26	1.6 || 1.4 || RPD: 13	LCS-1	104%
Cation Exchange Capacity*	meq/100g	1	Metals.23	<1.0	43527-26	13 || 12 || RPD: 8	[NR]	[NR]
ESP*	%	1	Metals.23	<1.0	43527-26	12.0 || 12.2 || RPD: 2	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	43527-11	21/07/2010 || 21/07/2010
Date analysed	-	43527-11	22/07/2010 || 22/07/2010
pH 1:5 soil:water	pH Units	43527-11	5.4 || 5.6 || RPD: 4
Electrical Conductivity 1:5 soil:water	µS/cm	43527-11	360 || 350 || RPD: 3
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	-	43527-21	21/07/2010 || 21/07/2010
Date analysed	-	43527-21	22/07/2010 || 22/07/2010
pH 1:5 soil:water	pH Units	43527-21	5.4 || 5.3 || RPD: 2
Electrical Conductivity 1:5 soil:water	µS/cm	43527-21	330 || 290 || RPD: 13
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	-	43527-31	21/07/2010 || 21/07/2010
Date analysed	-	43527-31	22/07/2010 || 22/07/2010
pH 1:5 soil:water	pH Units	43527-31	6.0 || 5.9 || RPD: 2
Electrical Conductivity 1:5 soil:water	µS/cm	43527-31	16 || 17 || RPD: 6
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]

Report Comments:

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

CHAIN OF CUSTODY

Douglas Partners
Geotechnics · Environment · Groundwater

Project Name: Stage 2 Gregory Hills Development - ~~Contamination~~ Salinity Assessment
Project No: 71913.01 Sampler: WFY
Project Mgr: PG Mob. Phone:
Email: paul.gorman@douglaspartners.com.au
Date Required: standard Lab Quote No.

To: Envirolab Services
12 Ashley Street, Chatswood NSW 2068
Attn: Tania Notaras
Phone: 02 9910 6200 Fax: 02 9910 6201
Email: tnotaras@envirolabservices.com.au

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: 9910 6200

Job No: 43527
Date received: 15/7/10
Time received: 2pm
Received by: JML
Temp: Cool/[✓ Ambient]
Cooling: Ice/Icepack
Security: Intact/Broken/[✓ None]

Sample ID	Sample Depth	Lab ID	Sampling Date	Sample Type	Container type	Analytes												Other
				S - soil W – water		Heavy Metals	BTEX/ TPH	OCPs/ PCBs	PAH	Phenols	Asbestos	EC	pH	Sulphate	Chloride	ESP		
												✓	✓					
1	0.2	1	13.07.10	S	P							✓	✓	✓	✓	✓		
1	0.5	2										✓	✓					
1	1	3										✓	✓					
1	1.5	4										✓	✓					
1	2	5										✓	✓	✓	✓			
2	0.3-0.5	6										✓	✓					
2	0.8-1	7										✓	✓					
3	0.3-0.5	8										✓	✓					
4	0-0.2	9										✓	✓	✓	✓	✓		
4	0.3-0.5	10										✓	✓					
4	1.3-1.5	11										✓	✓					
4	1.8-2	12	↓	↓	↓							✓	✓					

Notes

missing samples received 16/7/10

Please obtain the following samples:
1/0.2
4/0-0.2
10/0-0.2
12/0-0.2

from 71913 batch.

Lab Report No.
Send Results to: Douglas Partners Address: 96 Hermitage Road, West Ryde 2114
Phone: (02) 9809 0666
Fax: (02) 9809 4095
Relinquished by: WFY Signed: Date & Time: 14.07.10/3:00pm Received By: Date & Time: 16/7/10
Relinquished by: Signed: Date & Time: Received By: Date & Time:

Page 1 of 3

Form COC Rev0/November 2006

CHAIN OF CUSTODY

Douglas Partners
Geotechnics - Environment - Groundwater

Project Name: Stage 2 Gregory Hills Development - ~~Contamination~~ Salinity Assessment
Project No: 71913.01 Sampler: WFY
Project Mgr: P.G. Mob. Phone:
Email: paul.gorman@douglaspartners.com.au
Date Required: standard Lab Quote No.

To: Envirolab Services
12 Ashley Street, Chatswood NSW 2068
Attn: Tania Notaras
Phone: 02 9910 6200 Fax: 02 9910 6201
Email: tnotaras@envirolabservices.com.au

Sample ID	Sample Depth	Lab ID	Sampling Date	Sample Type S - soil W – water	Container type	Analytes												Other	Notes
						Heavy Metals	BTEX/ TPH	OCPs/ PCBs	PAH	Phenols	Asbestos	EC	pH	Sulphate	Chloride	ESP			
4	2.8-3	13	13.07.10	S	P							✓	✓						
5	0.8-1	14										✓	✓						
6	0.3-0.5	15										✓	✓	✓	✓	✓			
6	1.3-1.5	16										✓	✓						
7	0.4-0.5	17										✓	✓	✓	✓				
7	0.8-1	18										✓	✓						
8	0-0.2	19										✓	✓						
8	0.3-0.5	20										✓	✓	✓	✓				
8	0.8-1	21										✓	✓						
8	1.8-2	22										✓	✓						
8	2.8-3	23										✓	✓						
9	0.4-0.5	24	↓	↓	↓							✓	✓	✓	✓	✓			

Lab Report No.
Send Results to: Douglas Partners Address: 96 Hermitage Road, West Ryde 2114
Phone: (02) 9809 0666
Fax: (02) 9809 4095
Relinquished by: WFY Signed: Date & Time: 14.07.10/3:00pm Received By: Date & Time: 16/7/10
Relinquished by: Signed: Date & Time: Received By: Date & Time:

Page 2 of 3

Form COC Rev0/November 2006

CHAIN OF CUSTODY

Douglas Partners
Geotechnics - Environment - Groundwater

Project Name: Stage 2 Gregory Hills Development - ~~[illegible]~~ Salinity Assessment
Project No: 71913.01 Sampler: WFY
Project Mgr: PG Mob. Phone:
Email: paul.gorman@douglaspartners.com.au
Date Required: Standard Lab Quote No.

To: Envirolab Services
12 Ashley Street, Chatswood NSW 2068
Attn: Tania Notaras
Phone: 02 9910 6200 Fax: 02 9910 6201
Email: tnotaras@envirolabservices.com.au

Sample ID	Sample Depth	Lab ID	Sampling Date	Sample Type S - soil W – water	Container type	Heavy Metals	BTEX/ TPH	OCPs/ PCBs	PAH	Phenols	Asbestos	EC	pH	Sulphate	Chloride	ESP		Other	Notes
10	0-0.2	25	13.07.10	S	P							✓	✓						
10	0.3-0.5	26	13.07.10	S	P							✓	✓	✓	✓	✓			
10	0.8-1	27	↓	↓	↓							✓	✓						
10	1.3-1.5	28	↓	↓	↓							✓	✓						
10	1.8-2	29	↓	↓	↓							✓	✓						
11	0.3-0.5	30	↓	↓	↓							✓	✓						
12	0-0.2	31	↓	↓	↓							✓	✓						
12	0.3-0.5	32	↓	↓	↓							✓	✓	✓	✓				
12	0.8-1	33	↓	↓	↓							✓	✓						
12	1.3-1.5	34	↓	↓	↓							✓	✓						
13	030.5	35	↓	↓	↓							✓	✓	✓	✓				
13	0.8-1.0	36	↓	↓	↓							✓	✓						

Lab Report No.
Send Results to: Douglas Partners Address: 96 Hermitage Road, West Ryde 2114
Phone: (02) 9809 0666
Fax: (02) 9809 4095
Relinquished by: WFY Signed: Date & Time: 14-07-10 / 2:00pm Received By: Date & Time: 16/7/10
Relinquished by: Signed: Date & Time: Received By: Date & Time:

Page 3 of 3

Form COC Rev0/November 2006

Douglas Partners
Geotechnics • Environment • Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117

96 Hermitage Road
West Ryde NSW 2114
Australia

PO Box 472
West Ryde NSW 1685

Phone (02) 9809 0666
Fax: (02) 9809 4095
www.douglaspartners.com.au

TEXTURAL CLASSIFICATION TEST RESULTS

CLIENT:	DART WEST DEVELOPMENT PTY LTD	PROJECT NO:	71913.01
		DATE:	23/07/2010
PROJECT:	STAGE 2 GREGORY HILLS DEVELOPMENT - SALINITY ASSESSMENT	DATE OF TESTING:	13/07/10
LOCATION:	CAMDEN VALLEY WAY, GREGORY HILLS	PAGE:	1 of 1

Sample No.	Depth (m)	Soil Texture Group	Multiplication Factors
BH 1	0.0-0.2	MEDIUM CLAY	7
BH 1	0.3-0.5	HEAVY CLAY	6
BH 1	0.8-1.0	CLAY LOAMS	9
BH 1	1.3-1.5	LOAMS	10
BH1	1.8-2.0	LOMAS	10
BH 4	0.0-0.2	LIGHT MEDIUM CLAY	8
BH 4	0.3-0.5	HEAVY CLAY	6
BH 4	1.3-1.5	MEDIUM CLAY	7
BH 4	1.8-2.0	MEDIUM CLAY	7
BH 4	2.8-3.0	MEDIUM CLAY	7

Report No: S10-146 A

Laboratory: SYDNEY

N Weimann

Signed: N. Weimann
Manager. Earthworks / Laboratory Testing Services

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ABN 75 053 980 117

96 Hermitage Road
West Ryde NSW 2114
Australia

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West Ryde NSW 1685

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TEXTURAL CLASSIFICATION TEST RESULTS

CLIENT: DART WEST DEVELOPMENT PTY LTD

PROJECT: STAGE 2 GREGORY HILLS DEVELOPMENT - SALINITY ASSESSMENT

LOCATION: CAMDEN VALLEY WAY, GREGORY HILLS

PROJECT NO: 71913.01

DATE: 23/07/2010

DATE OF TESTING: 13/07/10

PAGE: 1 of 1

Sample No.	Depth (m)	Soil Texture Group	Multiplication Factors
BH 8	0.0-0.2	LOAMS	10
BH 8	0.3-0.5	LIGHT MEDIUM CLAY	8
BH 8	0.8-1.0	LIGHT MEDIUM CLAY	8
BH 8	1.8-2.0	MEDIUM CLAY	7
BH8	2.8-3.0	MEDIUM CLAY	7
BH 10	0.0-0.2	CLAY LOAMS	9
BH 10	0.3-0.5	MEDIUM CLAY	7
BH 10	0.8-1.0	MEDIUM CLAY	7
BH 10	1.3-1.5	CLAY LOAMS	9
BH 10	1.8-2.0	CLAY LOAMS	9

Report No: S10-146 B

Laboratory: SYDNEY

N Weimann

Signed: N. Weimann
Manager. Earthworks / Laboratory Testing Services