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Wastewater Management Assessment:

Concept Plan for the redevelopment of Lot 11 DP558723, Lot 1 DP400697 and Lot 2 DP262213 Eastern Creek, NSW.

P0601396JR04_v2 Final Report
October 2006

ENVIRONMENTAL

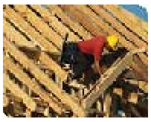
WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT
MANAGEMENT



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Survey data and development proposal layout plans have been provided by Hanson Australia Pty Ltd.

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All enquiries regarding this project are to be directed to the Project Manager.

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1 Overview

1.1 Background

This report provides findings of a wastewater management study undertaken on the 30th August and 6th September 2006, for the proposed redevelopment of the Hanson Eastern Creek Quarry.

1.2 Project Scope

It is our understanding that the redevelopment proposal involves the restructuring of existing industrial operations at the subject site (Lot 11 DP 558723, Lot 1 DP 400697 and Lot 2 DP 262213 at Eastern Creek). The existing and proposed continuing industrial uses are as follows:

- Concrete Batching Plant;
- Offices and Laboratory;
- Logistics Operation and Workshop;
- Concrete Recycling Plant;
- Asphalt and Emulsion Plant;
- Materials, Storage and Transfer Depot; and
- Concrete Masonry Plant.

A site plan showing pertinent site features, proposed infrastructure and recommended wastewater management system components is provided as Attachment A. The wastewater management assessment aspect of the proposed site works are considered in this report.

The wastewater assessment is prepared in accordance with AS/NZS1547 (2000), DEC (2004) and the principles of Department of Local Government *et al.* (1998) guidelines for on-site sewage management. This is required because the site is not presently serviced by reticulated sewer, and a temporary on-site sewage management scheme, as is currently in operation, will be required until such time as reticulated sewer is brought to the site.

To this extent, a range of issues have been reviewed as part of this study including assessment of the proposed site soil properties, effluent generation and loading rates and requirements for wastewater treatment and effluent disposal.

1.3 Aims and Objectives of this Report

The main objectives of the wastewater management assessment are:

1. To identify soil physical and chemical conditions within the local area.
2. To determine land capability to accept treated effluent in accordance with relevant guidelines.
3. To identify minimum effluent treatment standards based on soil and land capability assessment.
4. To determine expected hydraulic loads (sewage generation) from the proposed development.
5. To specify minimum effluent disposal / re-use requirements based on site limitations such as soil, geology, required setbacks and vegetation restrictions.
6. Assessment of sustainable re-use rates on the basis of daily time step water balance and nutrient assessments.
7. Develop a sustainable interim wastewater management strategy for the site.

2 Site Description

2.1 Field Investigations

Field investigations were conducted on 30th August and 6th September 2006, and included the following:

- General walkover inspection of the site and nearby areas to review local geology and lithology.
- General walkover inspection of the site and surrounding areas to determine distances to any water features such as creeks and rivers.
- Inspection and documentation of existing wastewater management systems.
- Five (5) test borehole excavations (using hydraulic push tube) were made to determine the nature and properties of natural sub-surface materials.
- Collection of 2 (two) soil samples from the topsoil and subsoil horizons of the proposed irrigation area for soil composition analysis.

2.2 Site Location and Existing Site Conditions

The proposed redevelopment is located on Archbold Road and is situated within the Blacktown City Council local government area (LGA). The site is situated approximately 0.9 km north of Old Wallgrove Road and approximately 1.5 km south of the M4 motorway at Eastern Creek.

The site development proposal includes a boundary adjustment to Lot 11 DP 558723 and to include the relevant parts of the adjoining allotments Lot 1 DP 400697 and Lot 2 DP 262213. The new proposed lot is irregular in shape and has an area of approximately 27 hectares. A site plan showing the boundary arrangements is provided as Attachment A.

The site is characterised by mixed industrial operations, predominantly asphalt and concrete plants.

2.3 Climate

Climate data for the site has been sourced from the Bureau of Meteorology (2006).

Daily rainfall data was taken from Prospect Dam (station number 67019) approximately 3.5km south west of the site. Rainfall data indicates that the subject land experiences a mean annual rainfall of 871.0 mm (for the period 1995-2005). Rainfall is generally highest during the period from January to March [i.e. summer dominated], with mean monthly totals exceeding 90 mm per month over this period.

Evaporation data was also taken from the daily record at Prospect Dam station. Evaporation data indicates that mean site annual evaporation is 1392.1 mm. Potential evaporation is less than 100 mm/month during the period of April to August. Median evaporation exceeds median rainfall for the entire year.

Table 1: Summary of local evaporation and rainfall data for the period 1995-2005, Eastern Creek Quarry, NSW.

	Monthly averages (mm)	
Month	**Evaporation** [1]	**Rainfall** [2]
January	172.5	110.9
February	141.5	114.0
March	127.4	91.0
April	99.2	64.7
May	66.4	93.1
June	50.4	34.0
July	56.7	46.1
August	87.6	43.7
September	114.3	54.1
October	147.4	72.2
November	150.9	84.6
December	177.8	62.6
Annual total	1392.1	871.0

Note: [1] Evaporation data (1995 to 2005) obtained from Prospect Dam weather station Tocal AWS (67019). [2] Rainfall data (1995 to 2005) obtained from Prospect Dam weather station.

2.4 Site Geology

The Penrith Australia 1:100,000 Geological Sheet 9030 (1991) describes the bedrock geology of the Rooty Hill region, including the site, as Bringelly Shale (Wianamatta Group, Liverpool Sub-group) with some sandstone beds and with alluvium gravel, sand, silt and clay buffering Eastern Creek.

The depth of soils across the site is variable due to the large amount of earthworks and regrading of the site over the past 40 plus years. The majority of the site is used for industrial operations which include large areas of stockpiles and plant machinery. The only natural soils unaffected by current and proposed site uses are located in the south eastern portion of the site (Attachment A).

2.5 Slopes and Stability

The elevation of the site is between 59 and 90 m AHD with the proposed redevelopment area having an elevation between 76 and 90 m AHD. The elevation of the natural soils where effluent disposal is proposed (Attachment A) is between 66 and 73 m AHD**.** Site grades in this embankment vary from approximately 4-7 %.

2.6 Site Drainage

Site drainage will be directed around the proposed industrial uses via, kerb and guttering, drainage swales, and retention tanks to a sedimentation pond in the south west corner of the developed area. Soil materials surrounding the proposed industrial areas are expected to be relatively impermeable suggesting large amounts of runoff would occur during moderate to high intensity and / or extended duration storm events.

Drainage features close to the proposed effluent re-use areas are limited to a minor intermittent stormwater drainage depression flowing east to west immediately to the north of the proposed re-use area. The proposal involves the redirection of this stormwater drain away from the toe embankment. Adequate setback buffers have been provided to this drainage feature.

2.7 Groundwater

No groundwater was observed in test excavations in the proposed re-use area, a shallow water table is not expected to occur within the proposed effluent re-use area given parent geology and topography.

3 Site and Soil Suitability for Effluent Re-Use

3.1 Soil Profiles

3.1.1 Overview

Geotechnical investigations were carried out on 6th of September 2006 by engineers from Martens and Associates Pty Ltd to examine site subsurface conditions. Five (5) bore holes were excavated on the site, using a hydraulic push tube. These were located to provide a thorough representation of soil characteristics over the proposed effluent disposal area (Plates 1 and 2). See Attachment C for borehole log sheets. Three (3) samples were collected from the dominant soil landscape, Of these two (2) were sent to the laboratory for further analysis (Attachment C).

3.1.2 Soil Permeability

Evaluation of soil permeability has been conducted using AS/NZS 1547 (2000) and the Department of Local Government *et al.* (1998) texture / structure analyses technique. Suitability of topsoils for effluent irrigation is determined using this classification technique. Acceptable maximum hydraulic loading rates or 'Design Irrigation Rates' (DIR) are determined (Table 2) based on topsoil texture and structure using AS/NZS 1547 (2000).

Table 2: Soil characteristics and design irrigation rates (DIR) in mm/day (based on AS/NZS 1547; 2000).

Feature	**Adopted Design for Effluent Management**
Topsoil texture	Clay Loam
Topsoil structure	Moderate
Sub-soil texture	Medium Clay
Sub-soil structure	Moderate
Depth to bedrock (m)	Not encountered
Design K_{Sat} (m/day)	0.5-1.5
DIR (mm/day) [1]	2.1

Notes: [1]. Assumes irrigation of secondary surface treated effluent based on sub-soil texture..

Permeability of the site soils has been assessed in accordance with NSW Department of Government *et al.* (1998) effluent management guidelines based on soil texture and structure. Material to be used as site topsoils are classified as 4a. Top soil permeability is a minor limitation to effluent irrigation.

Provided that the recommendations given in this report are adhered to in the construction, operation and maintenance of the effluent re-use areas, the risk of groundwater contamination is considered to be low, given the considerable depth to permanent groundwater and the comparatively low permeability of subsoil materials and underlying rock. Similarly the risk of surface water contamination is also low as effluent re-use areas are to be subsurface irrigation and are located greater than 40m from a watercourse.

Estimates for design irrigation rates (Section 4) are made based on AS/NZS 1547 (2000) estimates of permeability for the application of secondary treated effluent (i.e. treated effluent from an AWTS or equivalent system). Indicative permeability for the proposed site's clay loam topsoil is 0.5-1.5m.day^{-1} (AS/NZS 1547, 2000). This indicates a design irrigation rate (DIR) of 3.6 mm.day^{-1} for surface and sub-surface irrigation systems. Soils at a depth of 200mm (typical for subsurface system) are medium clays. These have a permeability of approximately 0.06m/day and DIR of 2.1 mm.day^{-1}.

3.1.3 Soil Testing

Two (2) soil samples were collected during the field investigation and further analysed for both chemical and physical properties (see laboratory report in Attachment D). The soils analysed were taken from the following boreholes and depths:

- Bore Hole 3 at depth 0.05-0.10m below ground surface; and
- Bore Hole 3 at depth 0.3m below ground surface.

The results of soil analyses indicate that soils are moderately acidic (mean pH = 5.9) and non-saline (mean eEC = 0.55 dS/m). Cation Exchange Capacity (CEC) is moderate (mean CEC = 18 cmol(+)/kg) indicating that soils have the capacity to temporarily store nitrogen species. A mean P-sorption of 371 mg of phosphorus/kg of soil indicates that soils have a high capacity to store phosphorous. These values equate to a P-sorption capacity of 3000 kg/ha for a soil depth of 0.5 m.

Emerson aggregate classification (8 and 3) and exchangeable sodium percentage (mean ESP = 4.7) indicate that the soils of the site are non-sodic and non-dispersive. Available water holding capacity indicates that a cubic meter of soil is estimated to hold approximately 160 L of water prior to the onset of free drainage.

In summary, the field investigations indicate that site soils have the capacity to accept effluent and provide further treatment through physical filtration, phosphorous fixing and some temporary nitrogen storage for removal by plants.

3.2 Land Capability Assessment for Effluent Re-use

Site and soil suitability for effluent re-use have been determined according to Tables 4 and 6 of the NSW Department of Government *et al.* (1998) effluent management guidelines and are summarised in Table 3. This indicates that the limitation rating of the soils does not present any limitations for on-site effluent re-use provided particular attention is given to careful system design and construction.

Table 3: Site and soil suitability as defined in Department of Local Government *et al.* (1998) effluent management guidelines.

Soil Feature	Site Details	Limitation Rating
Flood potential	> 1 in 20 yr flood level	Minor
Sun and wind exposure	High	Minor
Slope (%)	4-7	Minor
Landform	Flat, convex side slopes	Minor
Erosion potential	No signs present	Minor
Site drainage	No signs of surface dampness	Minor
Fill	Nil	Minor
Rock outcrops	Nil	Minor
Geology	No major discontinuities	Minor
Depth to bedrock (m)	>1.0 m[1]	Minor
Depth to water table (m)	Not observed (>1.0)	Minor
Soil permeability Category	4b	Minor
Coarse fragments (%)	0 – 20%	Minor

Notes: [1] Extremely weathered shale with soil properties encountered between 0.4 and 1.1m, no unweathered shale encountered above 1.0 m.

3.3 Suitable Land

With consideration to buffer zones, available land area and site soil characteristics, it is recommended that the temporary effluent re-use areas be located in the south eastern corner of the site. Providing for appropriate setbacks to the identified intermittent drainage line (40 m) and to site boundaries (3 m upslope and 6 m downslope) an area of approximately 4890m^2 has been identified as being suitable for temporary effluent re-use.

4 Effluent Re-use Requirements

The site's capacity to assimilate treated effluent from the proposed redevelopment is determined through analyses of the proposed wastewater generation rates, the soil's effluent absorption capacity and availability of suitable land for effluent application. The recommended option for re-use of secondary treated effluent at this site is to a sub-surface irrigation system.

4.1 Design Hydraulic Load

We estimate that following redevelopment, peak wastewater load of 9339 L.day^{-1} will be generated. This figure has been calculated using information provided by the client (Planning Workshop Australia email 15/09/06) and NSW Health Department Guidelines (2001) and has been used for the purposes of effluent re-use field design for this site. The information is summarised in Table 4 below.

Table 4: Projected staff and visitor rates.

Use	Employees	Visitors	Off-Site Employees
Concrete Recycling	10	20	-
Materials Depot	3	24	-
Concrete Batch Plant	20	24	-
Logistics	16	20	80[1]
Building Products	16	20	-
Asphalt/Emulsion Plant	51	60	25[2]
Laboratory	20	30	-
TOTALS	**136**	**198**	**105**

Notes: [1]Truck Drivers who start and finish their shifts at the Quarry. [2] Laying Crew who start and finish their shifts at the Quarry.

According to NSW Health Guidelines (2001) the employees, visitors and off-site employees can be categorised into the type of premise of 'Factories and Offices'. NSW Health recommend a daily flow rate of 41 L/person/day assuming wastes from toilet, urinal, basin and shower. However it can not be assumed that visitors or off-site employees will have the same daily flow and therefore adjustments of this figure have been made accordingly. We have assumed that of the visitors only 25% will use the toilet facilities while off-site employees will only use the toilet facilities at the start and end of their shift. Corresponding hydraulic loads are shown in Table 5. The average daily flow is 7338 L/day due to the site being operated only 5.5 days per week.

Table 5: Adjusted Daily Flows and Corresponding Design Hydraulic Load

	Number of Staff	Daily Flow (L/person/day)	Adjustment	Peak Daily Flow (L/day)
Employees	136	41	-	5,576
Visitors	198	41	0.25	2,030
Off-Site Employees	105	16.5[1]	-	1,733
Peak Hydraulic Load				**9339**
Average Daily Load over 5.5 Days				**7338**

Notes: [1] Assuming half flush 5.5L and full flush 11L

4.2 Design Effluent Quality

For the purposes of design, we have assumed that the temporary on-site sewage treatment plant (STP) shall provide secondary quality effluents as a minimum (Table 6). This is typically achieved through a small packaged sewerage treatment plant (STP). The proposed effluent quality is characterised as Level A, Low Strength effluent by DEC (2004) and is suitable for irrigation in open spaces with controlled public access and for most agricultural uses (ANZECC, 2000 and DEC, 2004).

Table 6: Effluent quality/design criteria.

Parameter	Design Value (50th Percentile)
BOD_5 (mg/L)	< 20
Suspended Solids (mg/L)	< 30
Faecal Coliforms (CFU/100mL)	< 10
Total Phosphorus (mg/L)	< 12
Total Nitrogen (mg/L)	< 27

4.3 Effluent Application Rates

Design effluent application rates for the site have been determined using AS/NZS 1547 (2000). Clay loam topsoil and medium clay subsoils are capable of assimilating 2.1 - 3.6 mm.day^{-1} of secondary treated effluent for properly designed irrigation systems. To ensure a suitably conservative design outcome the irrigation area requirements are assessed using the lesser 2.1mm.day^{-1} DIR.

4.4 Required Area for Effluent Re-use

The required area for effluent re-use at the site has been determined using the provided peak hydraulic load (Section 4.1) and design effluent application rates (Section 4.2). The required minimum surface area for an irrigation system at the site is calculated to be 3505 m^2 (7358 L.day^{-1} / 2.1 L.m^{-2}.day^{-1}).

4.5 Soil Water and Nutrient Modelling Summary

The daily time step model '*ReCycle*' has been applied to the site to evaluate soil moisture conditions, nutrient speciation in soil water and nutrient loss through drainage and runoff. The '*ReCycle*' model has been extensively applied in NSW situations ranging from domestic households to large trade waste reclamation projects. This model has been reviewed and found to be acceptable by the NSW EPA, Sydney Catchment Authority [SCA] and numerous Councils.

Details of the input parameters are summarised in Attachment E of this report. These are based on site investigations, and soil sample analysis.

The purpose of the modelling exercise is to determine the following:

1. Hydraulic suitability (deep drainage and runoff rates) of re-use schemes under varying effluent loading rates.

2. Likely rate of nutrient (nitrogen and phosphorous species) accumulation within the soil profile.

3. Rate of nitrogen loss from the system through leaching and surface runoff.

To achieve these objectives the following parameters are modelled and evaluated.

1. Analyses of required wet-weather / winter storage;

2. Runoff from land with and without irrigation;

3. Drainage from land with and without irrigation;

4. Nitrogen leaching rates from irrigation fields under varying effluent loading rates;

5. Rate of accumulation of phosphorous within soil mass under varying effluent loading rates; and

6. Time for the soil's phosphorous sorption capacity to saturate.

Detailed results of modelling are provided in Attachment F with brief summary of the results provided in the following sub-sections and in Table 7.

4.5.1 Wet weather storage

Completed analysis has assumed no provision of wet-weather storage on the site. Wet-weather storage is not normally provided for small on-site sewage management systems given that these are often difficult to maintain and operate and do not necessarily provide a significant environmental benefit.

4.5.2 Drainage

The water balance modelling indicates that for re-use areas greater than 0.44 ha, excess leaching (i.e. >5.0 mm/week) to groundwater is not a limiting factor.

4.5.3 Nitrogen Leaching

The nutrient modelling indicates that for irrigation areas greater than 0.44 ha nitrogen concentration in drainage water is less than 0.1 mg/L and less than 0.15 kg/year of nitrogen is lost to sub-soil layers.

4.5.4 Phosphorous Saturation

Nutrient modelling indicates that for irrigation areas greater than 0.33 ha soil p-sorption capacity is fully utilised within 50 years. Therefore phosphorous accumulation is not a significant limitation to on-site effluent re-use.

4.5.5 Summary

The re-use area requirements (Table 2) for environmentally sustainable re-use of effluent are less than the available area identified in Section 3.3. Thus, in terms of on-site wastewater management the site can readily sustain the proposed development and use of a temporary on-site wastewater management system is considered acceptable.

Table 7: Modelling summary: area required for sustainable irrigation of treated effluent for proposed redevelopment.

Parameter	Area Required (ha)
Drainage [1]	0.44
Nitrogen Leaching [2]	0.44
Phosphorus Saturation [3]	0.33
AS/NZS 1547:2000 [4]	0.35
Design Value	**0.44**

Note: [1]Acceptable drainage is 296.7 mm/year. [2] Acceptable nitrogen leachate concentration is < 0.5 mg/L. [3]Phosphorus saturation modelled for 50 years. [4] AS/NZS 1547 (2000) value based on medium clay DIR of 2.1 mm/day and peak daily flow of 7358 L/day.

4.6 Appropriate Site Reclaimed Water Strategies

In light of nutrient and water balance modelling results (Attachment F), we recommend that treated effluent from the development be irrigated over an area of 0.44 ha.

By implementing these recommendations nutrients, pathogens and other potentially polluting species applied within effluent shall be retained, assimilated or consumed entirely on-site. Specifically, if the proposed system is installed and appropriately maintained, effluent ponding and runoff should not occur; drainage rates to sub-soil clay layers will be acceptable and local soil and vegetation cover on site will assimilate applied nutrient loads. The re-use scheme will therefore not have an affect on post development runoff volumes or pollutant loads and nearby receiving water bodies and local water quality should be unaffected.

5 Sewage Management Recommendations

5.1 Wastewater Management System

All wastewater generated by the redevelopment is to be treated by a new temporary secondary sewage treatment plant (STP). The system would service the entire development and may utilise either a gravity sewer and necessary pump stations or a low pressure sewer system with a pump station on each lot to deliver sewage to the STP.

5.2 Effluent Re-Use System

All effluent generated by the site STP is to be directed to the new irrigation system designed in accordance with AS/NZS 1547 (2000).

Construction of the irrigation system should be in accordance with AS/NZS1547 (2000) to meet the following minimum specifications:

1. Total field area is to be not less than 4,400 m^2 located in the area indicated in Attachment A (total available suitable area is 4890 m^2).

2. The irrigation field is to be located above the 1 in 20 year ARI flood event and land with slopes less than 6%. The STP is to be located on land above the 100 year ARI flood level.

3. The irrigation field to provide buffers of 3 m (upslope) and 6 m (downslope) or 15 m (if spray irrigation) to boundaries and 40m to the adjacent intermittent watercourse shown on plans. These buffer distances are in accordance with NSW Department of Local Government *et al.* (1998) guidelines.

4. Where sub-surface or trickle irrigation is used irrigation lines are to be spaced at 1 m intervals (maximum) constructed parallel to site contours.

5. Where spray irrigation is used irrigation systems are to be designed to ensure effective distribution of effluent and to minimise spray drift generation through the use of course droplet irrigation systems.

6. Where sub-surface irrigation is used a flushing manifold and trench is to be included in the system design.

7. Pressure compensating drip line (e.g. "Wasteflow 16 mm", "Netafin 13 mm", or "Amiad ND 13mm") should be used for distribution of effluent within drip or sub-surface fields. Only

products designed specifically for sub-surface applications of effluent should be used within micro-trenches.

8. Sub-surface irrigation lines, where used, are to be placed in topsoil material with not less than 150mm cover.
9. All irrigation systems are to be fixed in place with distribution manifolds buried at depths of not less than 100 mm. Any irrigation sprinklers used are to be suitable supported and fixed in place.
10. Distribution mains and irrigation laterals to be installed by a suitably qualified individual to meet the standards of AS/NZS 1547 (2000).
11. Surface irrigation area to be fenced to keep animals and people from the area. Suitable signage is to be provided to identify the nature of the irrigated water.

5.3 Further Approvals

Prior to the construction of a site sewage management system, an approval under Section 68A of the Local Government Act (1993) will be required where final design specifications for the effluent treatment and re-use systems shall be submitted for approval to Council. This shall be done prior to the issuing of a construction certificate for the site sewage management system. No discharge licence from DEC will be required given that all sewage is treated and re-used onsite and in a sustainable manner.

5.4 Maintenance Schedule

The wastewater management system should be maintained on a three monthly basis, or as required by the manufacturer/designer, by a suitably qualified person or organisation. A wastewater operation plan should be provided prior to approval under Section 68A of the Local Government Act.

5.5 On-going Environmental Monitoring

We recommend an on-going environmental monitoring plan while the on-site sewage management scheme is in operation. We recommend the following monitoring schedule provided in Table 8.

Table 8: Recommended Environmental Monitoring

Item	Parameters	Frequency
STP Effluent Quality	BOD_5 , SS, Nutrients, EC, pH	3 Months
Two monitoring bores to 7m BGL	BOD_5 , SS, Nutrients, EC, pH	3 Months
Two surface water monitoring sites – 1 upstream and 1 downstream	BOD_5 , SS, Nutrients, EC, pH	3 Months
3 soil samples from effluent re-use field	pH, EC. TN, TP, Organic Content	Annually

6 Summary of Recommendations

1. Design average wastewater (sewage) generation rate for the site has been calculated at 7,358 L.day^{-1} on the basis of expected usage information provided by the client. Should operating sewage flows exceed daily flow values (7358 L.day^{-1}) modification to STP and irrigation areas may be required.
2. Wastewater (sewage) generated on the site is to be treated on-site using an appropriate temporary secondary sewage treatment plant. Location of the temporary STP is provided in Attachment A.
3. Treated effluent is to be applied to an irrigation field as indicated on the site plan (Attachment A). Details for [treated sewage] irrigation field construction are provided in Section 5.2 of this report and AS/NZS 1547 (2000).
4. Wastewater management system(s) should be maintained on a three monthly basis (or as required by the manufacturer/designer) by a suitably qualified person or organisation.

7 References

Australian / New Zealand Standard 1547 (2000), *On-site domestic wastewater management.*

Australian and New Zealand Environment and Conservation Council, State of the Environment Reporting Task Force 2000, *Core environmental indicators for reporting on the state of the environment*.

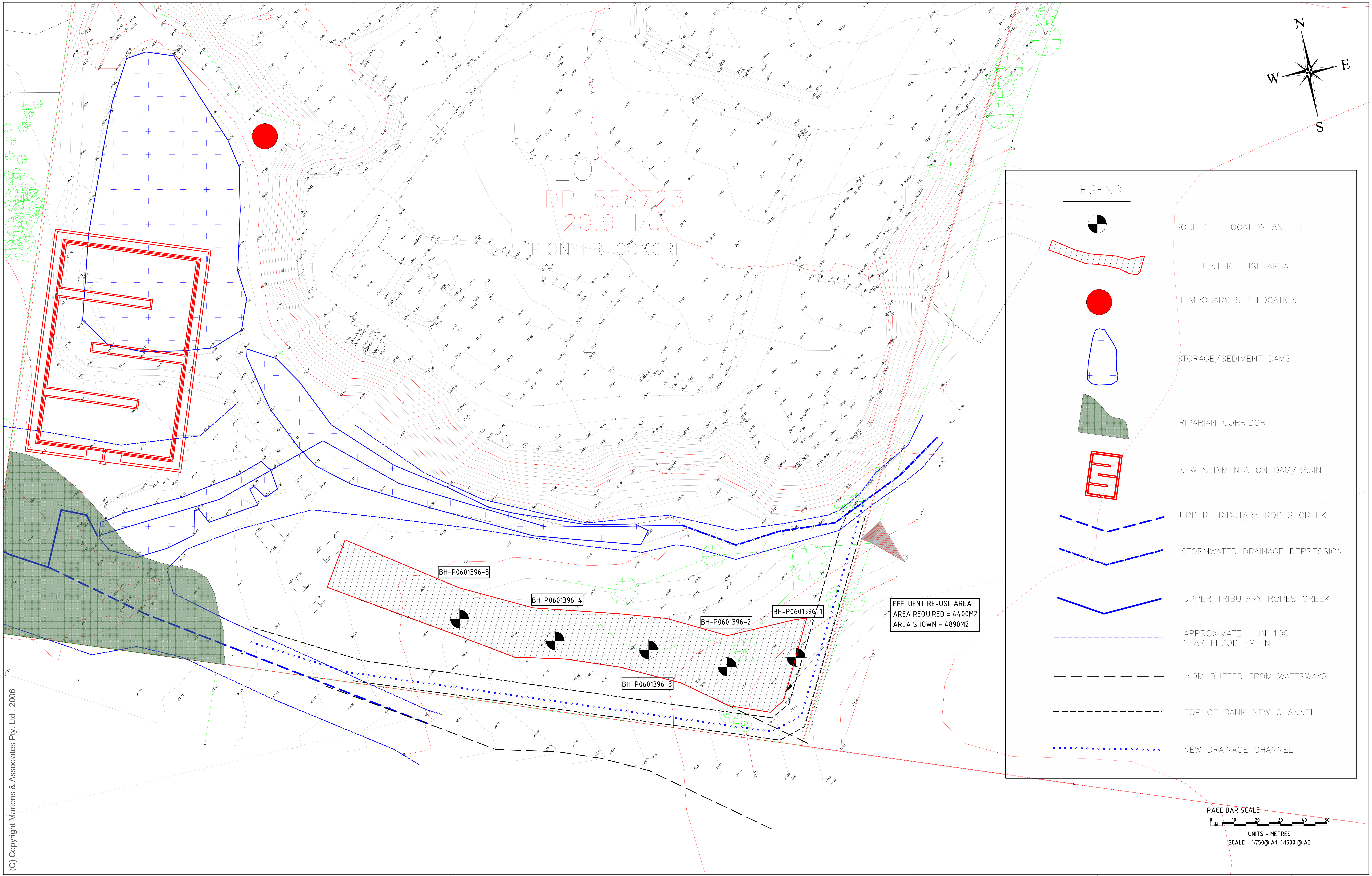
Bannerman S.M and Hazelton P.A (1990) *Soil Landscapes of the Penrith 1:100,000 Sheet*

Department of Environment and Conservation (2004) *Use of Effluent by Irrigation*

Department of Local Government, NSW Environment Protection Authority, NSW Health Department, NSW Department of Land and Water Conservation and the NSW Department of Urban Affairs and Planning (1998), *Environment and Health Protection Guidelines, On-site Sewage Management for Single Households.*

NSW Health Department (2001), *Septic Tank and Collection Well Accreditation Guideline Part 4.*

8 Attachment A – Site Plan



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CLIENT/PROJECT
HANSON CONSTRUCTION MATERIALS
EASTERN CREEK QUARRY

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in m unless otherwise specified.

TITLE
WASTEWATER ASSESSMENT - SITE PLAN

PROJECT MANAGER: DR DANIEL MARTENS

DRAWING NUMBER: P0601396JD12_V1

DESIGNED: GT
DRAWN: GT
REVIEWED: DDM
DATUM: AHD
HORIZONTAL RATIO: 1:750 @ A1 1:1500 @ A3
VERTICAL RATIO: 1:750 @ A1 1:1500 @ A3
SHEET 1 OF 1 SHEETS
PAPER SIZE: A1 / A3

REV.	DESCRIPTION	DATE	ISSUED
1.0	WASTEWATER ASSESSMENT	25.09.2006	GT
2.0	WASTEWATER ASSESSMENT - FINAL REPORT	03.10.2006	GT

9 Attachment B - Plates

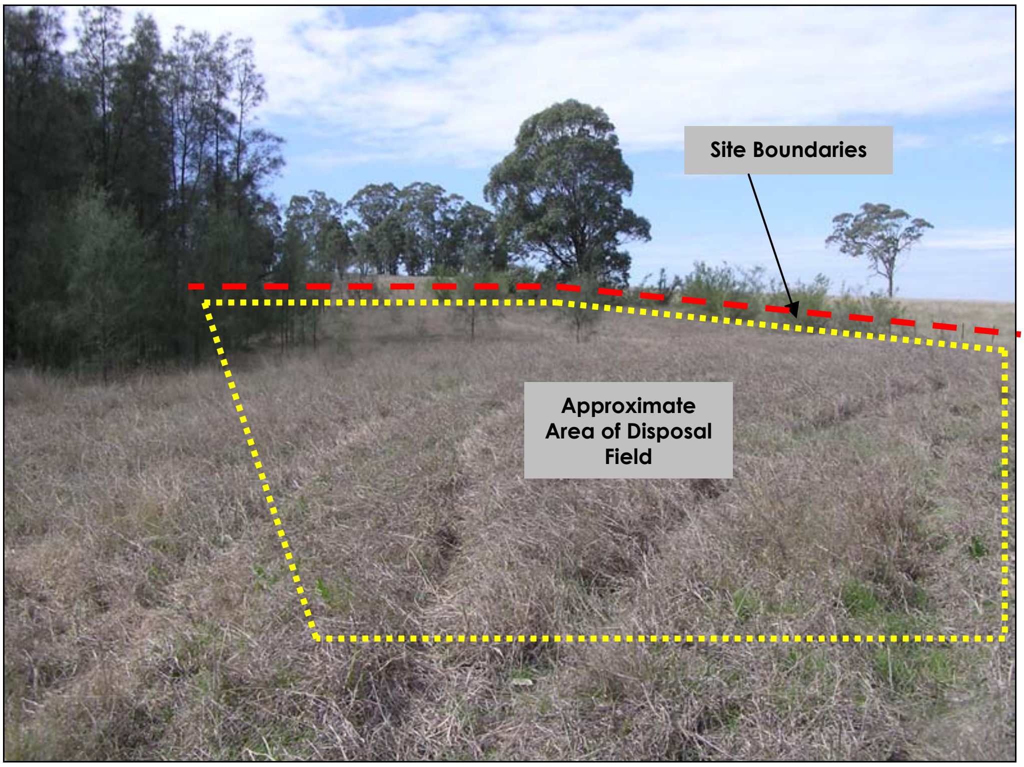

Plate 1: View looking east at proposed effluent disposal area.

Plate 2: View looking west at proposed effluent disposal area.

10 Attachment C – Soil Borehole Logs

CLIENT	**HANSON**	**COMMENCED**	6/9/06	**COMPLETED**	6/9/06	**REF** **BH1**
PROJECT	**WASTEWATER ASSESSMENT**	**LOGGED**	MB	**CHECKED**	DM	**Sheet** 1 **of** 1
SITE	**HANSON QUARRY, EASTERN CREEK**	**GEOLOGY**	SHALE	**VEGETATION**	GRASS	**PROJECT NO.** P0601396
EQUIPMENT	PUSHTUBE	**EASTING**	150°49.750E	**RL SURFACE**	See Site Plan	
EXCAVATION DIMENSIONS	DIA: 50MM DEPTH: 1.05M	**NORTHING**	33° 48.413S	**ASPECT**	WEST	**SLOPE** 5%

EXCAVATION DATA | MATERIAL DATA | SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
PT	Nil	N	M	0.05			CL	CLAY LOAM - Brown, firm.	F				
PT	Nil	N	M	0.4			MC	MEDIUM CLAY - Orange brown, slightly moist, moderately structured, traces of silt and fine gravel.	F		PT	0.3	1396/1/0.3
PT	Nil	N	D	0.8			EW	EXTREMELY WEATHERED SHALE - Grey, dry. Soil like properties	St				
PT	Nil	N	D	1.0 1.05			HW	HIGHLY WEATHERED SHALE - Grey, dry.	VSt				1.0
								Borehole terminated at 1.05m due to refusal on shale.					
				2.0									2.0
				3.0									3.0
				4.0									4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
∇ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
☐ USCS
Y Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**HANSON**	**COMMENCED**	6/9/06	**COMPLETED**	6/9/06	**REF BH2**
PROJECT	**WASTEWATER ASSESSMENT**	**LOGGED**	MB	**CHECKED**	DM	**Sheet** 1 **of** 1
SITE	**HANSON QUARRY, EASTERN CREEK**	**GEOLOGY**	SHALE	**VEGETATION**	GRASS	**PROJECT NO.** P0601396
EQUIPMENT	PUSHTUBE	**EASTING**	150°49.726E	**RL SURFACE**	See Site Plan	
EXCAVATION DIMENSIONS	DIA: 50MM DEPTH: 1.05M	**NORTHING**	33° 48.412S	**ASPECT**	WEST	**SLOPE** 5%

EXCAVATION DATA					MATERIAL DATA						SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**PENETRATION RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**DESCRIPTION OF STRATA** Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
PT	Nil	N	D	0.05			CL	CLAY LOAM - Brown, dry, firm.	F				
PT	Nil	N	D	0.4			MC	MEDIUM CLAY - Orange brown, dry, moderately structured, traces of silt and fine gravel.	F				
PT	Nil	N	D	0.8			EW	EXTREMELY WEATHERED SHALE - Grey, dry. Soil like properties.	St				
PT	Nil	N	D	1.0 1.05			HW	HIGHLY WEATHERED SHALE -Grey, dry.	VSt				1.0
				2.0									2.0
				3.0									3.0
				4.0									4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
☐ USCS
☒ Y Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**HANSON**	**COMMENCED**	6/9/06	**COMPLETED**	6/9/06	**REF** **BH3**
PROJECT	**WASTEWATER ASSESSMENT**	**LOGGED**	MB	**CHECKED**	DM	**Sheet 1 of 1**
SITE	**HANSON QUARRY, EASTERN CREEK**	**GEOLOGY**	SHALE	**VEGETATION**	GRASS	**PROJECT NO.** P0601396
EQUIPMENT	PUSHTUBE	**EASTING**	150°49.697E	**RL SURFACE**	See Site Plan	
EXCAVATION DIMENSIONS	DIA: 50MM DEPTH: 1.25M	**NORTHING**	33° 48.409S	**ASPECT**	WEST	**SLOPE** 17%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**PENETRATION RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**DESCRIPTION OF STRATA** Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
PT	Nil	N	M	0.1			CL	LOAMY CLAY - Brown, slightly moist, moderately structured, soft.	F		PT	0.1	1396/3/0.1
PT	Nil	N	M	0.4			MC	MEDIUM CLAY - Brown/grey, slightly moist, moderately structured, soft to firm.	S		PT	0.3	1396/3/0.3
PT	Nil	N	M	0.75			SiC	SILTY CLAY - Brown/grey, slightly moist, moderately structured, soft to firm.	F				
PT	Nil	N	M	1.0 1.1			HC	HEAVY CLAY - Grey, slightly moist, moderately structured, firm.	F				1.0
PT	Nil	N	M	1.25			HW	HIGHLY WEATHERED SHALE- Grey, dry.	St				
								Borehole terminated at 1.1m on shale.					
				2.0									2.0
				3.0									3.0
				4.0									4.0

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- E Excavator
- HA Hand auger
- S Hand spade
- PT Push tube
- A Auger

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ▽ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

PENETRATION
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- M Moisture content
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- S Standard penetration test
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- ☐ USCS
- Y Agricultural

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Engineering Log - Borehole

CLIENT	**HANSON**	**COMMENCED**	6/9/06	**COMPLETED**	6/9/06	**REF**	**BH4**
PROJECT	**WASTEWATER ASSESSMENT**	**LOGGED**	MB	**CHECKED**	DM	**Sheet** 1 **of** 1	
SITE	**HANSON QUARRY, EASTERN CREEK**	**GEOLOGY**	SHALE	**VEGETATION**	GRASS	**PROJECT NO.**	P0601396
EQUIPMENT	PUSHTUBE	**EASTING**	150°49.667E	**RL SURFACE**	See Site Plan		
EXCAVATION DIMENSIONS	DIA: 50MM DEPTH: 1.1M	**NORTHING**	33° 48.398S	**ASPECT**	WEST	**SLOPE**	5%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**PENETRATION RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**DESCRIPTION OF STRATA** Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
PT	Nil	N	D	0.15			CL	CLAY LOAM - Brown, dry, firm.	F				
PT	Nil	N	D	0.6			MC	CLAY - Orange brown, dry, stiff.	St				
PT	Nil	N	D	0.9			EW	EXTREMELY WEATHERED SHALE. Soil like properties.	VSt				
PT	Nil	N	D	1.0 1.1			HW	HIGHLY WEATHERED SHALE.	VSt				1.0
								Borehole terminated at 1.1m on shale.					
				2.0									2.0
				3.0									3.0
				4.0									4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
☐ USCS
Y Agricultural

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Engineering Log - Borehole

CLIENT	**HANSON**	**COMMENCED**	6/9/06	**COMPLETED**	6/9/06	**REF** **BH5**
PROJECT	**WASTEWATER ASSESSMENT**	**LOGGED**	MB	**CHECKED**	DM	**Sheet** 1 **of** 1
SITE	**HANSON QUARRY, EASTERN CREEK**	**GEOLOGY**	SHALE	**VEGETATION**	EDGE OF GRASS	**PROJECT NO.** P0601396
EQUIPMENT	PUSHTUBE	**EASTING**	150°49.637E	**RL SURFACE**	See Site Plan	
EXCAVATION DIMENSIONS	DIA: 50MM DEPTH: 1.1M	**NORTHING**	33° 48.460S	**ASPECT**	WEST	**SLOPE** 5%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**PENETRATION RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**DESCRIPTION OF STRATA** Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
PT	Nil	N	M	0.2			CL	CLAY LOAM - Brown, slightly moist, firm.	F				
PT	Nil	N	M	0.6			SiC	CLAY - Orange brown, dry, stiff.	St				
PT	Nil	N	D	0.8			EW	EXTREMELY WEATHERED SHALE - Yellow brown, dry. Soil like properties.	St				
PT	Nil	N	D	1.0 1.1			HW	HIGHLY WEATHERED SHALE - Grey, dry.	VSt				1.0
								Borehole terminated at 1.1m on shale.					
				2.0									2.0
				3.0									3.0
				4.0									4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
⊻ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
☐ USCS
Y Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

11 Attachment D - Laboratory Results

Two soil samples received 14th September 2006.

Samples dried at 50°C, crushed and sieved to minus 2 mm prior to analysis.

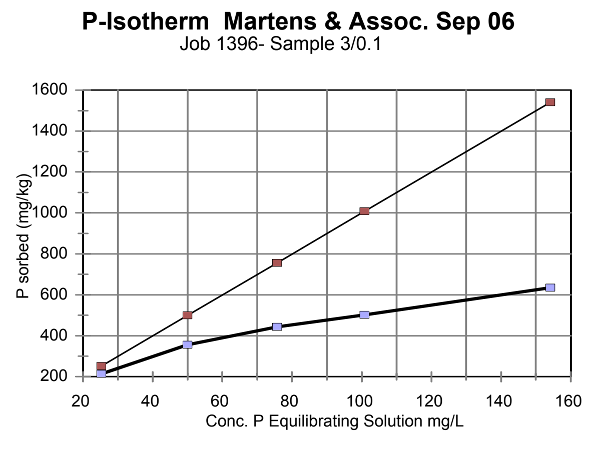
Insufficient soil samples to undertaken moisture characteristics.

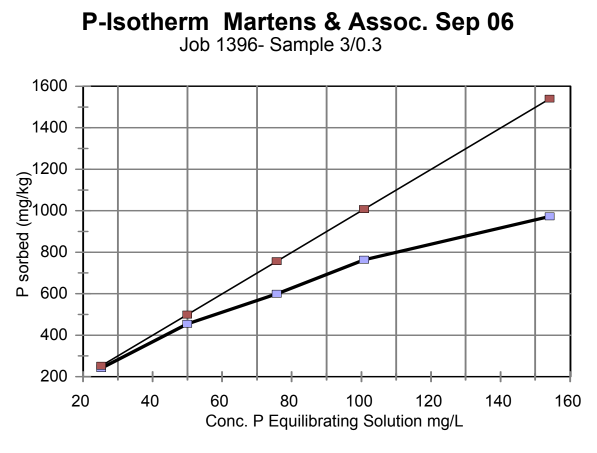
Exc.Al+H	Ca	K	Mg	Na	ESP	ECEC	Ca/Mg	Site Location	pHw	pHca	EC	Emerson
meq/100g	mg/kg	mg/kg	mg/kg	mg/kg	%	me/100g	ratio	Sample ID			dS/m	Class
0.16	1227	447	975	111	3.1	15.8	0.8	Martens 1396/3/0.1	5.97	5.00	0.067	8
4.00	1030	191	1612	292	6.3	20.2	0.4	Martens 1396/3/0.3	5.87	4.45	0.063	3

Emerson Aggregate Test

Sample 1 3/0.1 = Class 8 (water stable aggregate – no swelling)

Sample 2 3/0.3 = Class 3 (dispersion after remoulding)





Sorbed P is the difference between initial and filtrate, calculated in mg/kg

Percent sorbed is the proportion of the initial P sorbed during equilibration

filtrate	Initial P	sorbed P	Sample	Percent
P	mgP/L	mg/kg	I.D.	sorbed
mg/L				(%)
3.86	25.3	214.8	Martens & Assoc	85
14.36	50.1	357.4	1396 sample 3/0.1	71
31.33	75.8	444.3		59
50.54	100.9	503.6		50
90.61	154.2	635.9		41
1.21	25.3	241.3	Martens & Assoc	95
4.59	50.1	455.2	1396 sample 3/0.3	91
15.66	75.8	601.0		79
24.39	100.9	765.1		76
56.88	154.2	973.2		63

Dr R.A. Patterson

Methods: Rayment & Higginson 1992

pH Method 4A1 (water) 4B1 ($CaCl_2$)

EC Method 3A1

Exchangeable acidity (H^+, Al^{3+}) Method 15 G1

Effective Cation Exchange Capacity Method 15D3 plus exchangeable acidity

Exchangeable sodium percentage ratio sodium to ECEC

P sorption modified method 9J1 - elevated equilibrating solutions, ICP determination of P

12 Attachment E – ReCycle Input Parameters

Effluent quality is a variable in the *ReCycle* model. The key parameters chosen as inputs for this modelling exercise are shown in Table 9. These represent the design effluent quality (discussed in Section 5 of this report).

The design effluent quality is a readily achievable secondary standard, and is classified by the DEC (2004) as level A, Low Strength effluent and is suitable for open irrigation with controlled access.

Table 9: Effluent quality input parameters for the nutrient balance modelling.

Parameter	**Design Criteria**
BOD_5 (mg/L)	20
Suspended Solids (mg/L)	30
Faecal Coliforms (CFU/100mL)	10
Total Phosphorous (mg/L)	12
Total Nitrogen (mg/L)	27

Soil and climate input parameters used in the soil moisture and nutrient transport modelling are summarised in Table 9. These input parameters have been developed through detailed soil investigations (field and laboratory).

Table 10: Soil conditions and assumed crop parameters for effluent re-use modelling.

Parameter	**Soil Conditions**	**Units**
Soil Moisture Factors		
Available Water Holding Capacity	16[1]	%
Initial Soil Moisture Content	10	%
Wilting point	18[1]	% V.V^{-1}
Field capacity	34[1]	% V.V^{-1}
Bulk Density	1.6[1]	g.cm^{3}
Porosity	37[1]	% V.V^{-1}
Design soil depth	0.25[1]	m
Hydraulic Conductivity at depth	0.2[3]	m.day^{-1}
Mean Rainfall Duration	6.0	hours
Soil Chemistry		
pH	5.9[2]	-
CEC	18.0[2]	cmol (+).kg^{-1}
Soil Phosphorous		
Initial Soil TP	10.0	mg.L^{-1}
P-sorption	371[2]	mg.kg^{-1}
Soil Nitrogen		
Initial Oxidised N	1	mg.kg^{-1}
Initial Organic N	500	mg.kg^{-1}
Initial Ammonia	5	mg.kg^{-1}
Nutrient Uptake		
Nitrogen Uptake (Grass)	240	kg.ha^{-1}.year^{-1}
Nitrogen Uptake (Shrubs)	150	kg.ha^{-1}.year^{-1}
Phosphorous Uptake (Grass)	30	kg.ha^{-1}.year^{-1}
Phosphorous Uptake (Shrubs)	16	kg.ha^{-1}.year^{-1}
Water Use		
Summer crop Factor (Grass)	0.80	Factor (0 – 2)
Summer crop Factor (Shrubs)	1.20	Factor (0 – 2)
Winter crop Factor (Grass)	0.65	Factor (0 – 2)
Winter crop Factor (Shrubs)	0.80	Factor (0 - 2)
Winter Months	May – August	-
Hydraulic Load		
ADWF	7358	L.day^{-1}

Note: [1] based on observed soil profile; [2] Results from soil laboratory tests; [3] hydraulic conductivity estimated based on soil texture at 0.25 m depth

13 Attachment F – ReCycle Modelling Results

ReCycle 2.01 ASSESSMENT REPORT

Project Details

Project: Wastewater Assessment
Date: 22 September 2006
Subject: Effluent & Biosolids Application
Author: Mr Gray Taylor / Andrew Norris
Manager: Dr Daniel Martens
Company: Martens & Associates Pty Ltd
Client: Planning Workshop Australia / Hansons Australia Pty Ltd
Keywords: Effluent Biosolids
Comments:

Daily Hydraulic Load Modelled (L/day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7358	7358	7358	7358	7358	7358	7358	7358	7358	7358	7358	7358

Effluent Quality Parameters Used

BOD5: 20 mg/L
Suspended Solids: 30 mg/L
Oxidised-Nitrogen: 8 mg/L
Ammonia-Nitrogen: 15 mg/L
Organic-Nitrogen: 4 mg/L
Total Phosphorus: 12 mg/L

Soil Parameters Used

SOIL WATER FACTORS
Initial soil moisture: 10 %
Wilting point moisture: 18 %
Field capacity moisture: 34 %
Water holding capacity: 16 %
Porosity (n): 37 %
Soil depth: 0.25 m

SURFACE WATER FACTORS
Saturated hydraulic conductivity: 0.20 m/day
SCS runoff curve number for disposal field: 61
Nominated rainfall duration: 6 hours

SOIL CHEMISTRY FACTORS
Cation exchange capacity (CEC): 18 cmol(+)/kg
Soil pH: 5.92
Initial oxidised nitrogen content: 1 mg/kg
Initial organic nitrogen content: 500 mg/kg
Initial ammonia nitrogen content: 5 mg/kg
Peak nitrogen mineralisation rate: 0.000822 per day
Peak nitrogen volatilisation rate: 22 %
Peak nitrogen denitrification rate: 0.0019 per day
Initial phosphorus content: 10 mg/kg
Phosphorus sorption: 742 mg/kg

Re-use Field Crop Parameters

Crop 1: Grass at 100% cover, Summer CF=0.8, Winter CF=0.65
Crop 2: Shrubs at 0% cover, Summer CF=1.2, Winter CF=0.8
Winter occuring for months: 5, 6, 7, 8,

Re-use Field Size

Effluent re-use field varies between 0.2 & 0.6 ha, stepping 0.05 ha

Rainfall Summary Statistics

Monthly Rainfall

Monthly totals in mm/month

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	98.7	82.7	132.6	173.4	278.6
Feb	95.7	96.9	135.5	198.1	256.2
Mar	106.5	77.6	170.3	242.1	251.4
Apr	71.2	54.7	74.2	172.0	363.5
May	75.1	62.6	113.3	156.3	185.3
Jun	61.4	36.5	76.6	145.1	235.2
Jul	40.3	30.7	62.3	79.2	129.8
Aug	36.6	12.9	34.4	87.4	203.0
Sep	43.5	37.6	58.0	81.2	170.1
Oct	64.7	43.6	81.5	154.0	195.8
Nov	81.7	72.2	120.3	142.3	187.5
Dec	57.9	54.1	75.8	100.5	174.2

Mean annual rainfall : 833.3 mm

Monthly Rainy Days

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	11.4	12.0	13.8	15.0	19.0
Feb	11.2	11.0	13.8	16.0	21.0
Mar	11.8	12.5	15.0	17.1	21.0
Apr	8.5	7.0	10.0	16.0	18.0
May	10.3	10.0	13.0	16.0	18.0
Jun	8.6	8.5	10.8	13.0	25.0
Jul	7.2	6.5	9.8	12.1	14.0
Aug	6.6	7.0	8.0	10.1	17.0
Sep	8.0	8.0	10.0	13.0	17.0
Oct	9.7	10.0	12.0	14.1	20.0
Nov	10.9	11.0	13.8	15.1	16.0
Dec	9.5	9.0	11.8	14.0	20.0

Mean annual rainy days : 114

Evaporation Summary Statistics

Monthly totals in mm/month

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	157.3	159.0	166.8	182.4	193.7
Feb	132.9	130.8	146.3	155.4	168.2
Mar	121.1	116.6	126.6	144.1	162.7
Apr	92.7	92.7	100.7	112.0	122.1
May	63.5	64.3	68.5	73.2	84.3
Jun	50.2	48.7	55.1	61.4	63.4
Jul	56.3	56.6	59.8	65.5	75.5
Aug	80.9	82.1	88.9	93.7	113.3
Sep	107.9	105.1	117.7	130.0	152.2
Oct	132.7	134.5	146.3	158.6	185.0
Nov	142.4	144.8	154.2	160.5	172.0
Dec	165.2	160.9	174.8	197.8	204.6

Mean annual evaporation : 1303.4 mm

Runoff Summary Statistics

All surface runoff results in annual mm runoff
Area in hectares

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	288.1	269.9	372.6	426.4	538.9
0.2500	288.1	269.9	372.6	426.4	538.9
0.3000	288.1	269.9	372.6	426.4	538.9
0.3500	288.1	269.9	372.6	426.4	538.9
0.4000	288.1	269.9	372.6	426.4	538.9
0.4500	288.1	269.9	372.6	426.4	538.9
0.5000	288.1	269.9	372.6	426.4	538.9
0.5500	288.1	269.9	372.6	426.4	538.9
0.6000	288.1	269.9	372.6	426.4	538.9

Monthly surface runoff summary for area 0.2 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9
Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Monthly surface runoff summary for area 0.25 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9
Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Monthly surface runoff summary for area 0.3 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9
Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Monthly surface runoff summary for area 0.35 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9

Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Monthly surface runoff summary for area 0.4 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9
Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Monthly surface runoff summary for area 0.45 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9
Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Monthly surface runoff summary for area 0.5 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9
Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Monthly surface runoff summary for area 0.55 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9
Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Monthly surface runoff summary for area 0.6 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	37.8	21.5	65.6	90.7	162.9
Feb	36.9	34.8	59.9	85.4	127.9
Mar	43.0	13.7	78.8	137.0	171.1
Apr	26.6	13.2	36.6	88.2	193.4
May	25.9	12.1	54.6	66.3	99.4
Jun	21.6	5.4	28.1	62.4	138.3
Jul	12.5	4.2	15.6	26.0	88.9
Aug	13.5	0.0	5.2	57.3	115.7
Sep	10.5	3.5	9.3	24.4	96.2
Oct	18.9	4.5	22.0	60.1	100.4
Nov	25.4	17.4	34.7	75.2	91.9
Dec	15.3	10.3	23.3	32.4	67.3

Annual Drainage Summary Statistics

All drainge results in mm deep drainage
Area in hectares

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	884.2	911.1	1002.3	1071.7	1136.3
0.2500	631.7	641.9	731.1	813.3	886.3
0.3000	485.1	495.3	577.4	656.1	738.1
0.3500	390.7	407.7	481.2	544.0	641.3
0.4000	325.5	318.4	417.5	463.3	575.1
0.4500	277.7	262.5	362.1	403.1	524.0
0.5000	242.0	221.3	317.8	366.8	483.4
0.5500	214.7	187.7	282.0	343.9	450.2
0.6000	192.8	162.0	254.6	324.8	422.6

Monthly drainage summary for area 0.2 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	44.4	40.0	62.5	98.4	132.6
Feb	52.5	45.5	81.4	122.1	154.8
Mar	78.8	76.9	113.2	125.5	143.0
Apr	80.1	70.2	99.8	133.3	228.4
May	121.9	119.5	150.4	156.1	188.8
Jun	117.5	113.0	126.6	154.6	202.2
Jul	105.2	102.6	116.1	139.0	151.9
Aug	84.6	74.7	91.9	116.6	190.8
Sep	58.7	59.9	76.7	94.0	118.5
Oct	55.2	44.2	86.8	115.4	142.4
Nov	55.4	48.9	79.3	99.3	133.8
Dec	29.9	20.0	47.2	73.4	125.5

Monthly drainage summary for area 0.25 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	23.9	6.7	40.1	74.2	103.6
Feb	34.6	19.2	60.6	104.2	131.4
Mar	53.5	55.7	76.3	92.9	120.2
Apr	54.9	47.5	64.4	109.8	206.4
May	97.7	96.7	124.5	133.2	166.0
Jun	95.4	90.9	104.5	132.5	180.1
Jul	82.4	79.8	93.3	116.2	129.1
Aug	61.8	51.9	69.1	93.8	168.0
Sep	39.5	38.2	55.2	73.7	96.5
Oct	36.8	24.8	62.5	95.7	119.3
Nov	35.6	31.3	58.5	76.6	108.8
Dec	15.5	2.7	22.7	57.7	101.0

Monthly drainage summary for area 0.3 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	16.4	0.0	32.2	57.9	80.5
Feb	24.5	6.8	46.9	82.8	103.6
Mar	39.9	39.6	66.9	75.7	104.9
Apr	40.6	32.8	48.5	93.5	191.6
May	79.1	78.9	95.6	117.5	150.8
Jun	80.7	76.2	89.8	117.8	165.4
Jul	67.2	64.6	78.1	101.0	113.9
Aug	46.9	37.5	53.9	78.7	152.8
Sep	28.2	23.5	42.0	60.9	81.7
Oct	26.2	14.5	44.6	76.9	103.6
Nov	25.6	20.5	45.2	61.9	95.6
Dec	9.7	0.0	8.6	39.5	84.3

Monthly drainage summary for area 0.35 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	12.6	0.0	26.7	46.3	70.3
Feb	19.5	1.4	37.1	67.4	92.1
Mar	32.0	29.0	51.9	67.8	91.1
Apr	32.0	22.1	40.8	80.6	181.1
May	64.1	67.6	77.9	104.9	139.9
Jun	70.1	65.7	79.3	107.3	154.9
Jul	56.5	53.7	67.5	90.1	103.0
Aug	36.4	27.8	43.1	67.9	142.0
Sep	21.3	14.1	32.7	52.7	71.2
Oct	19.5	7.4	26.9	63.3	90.9
Nov	19.0	10.4	31.0	49.8	86.1
Dec	7.7	0.0	5.5	31.1	72.4

Monthly drainage summary for area 0.4 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	10.3	0.0	20.1	35.4	65.8
Feb	16.4	0.5	29.7	58.7	83.4
Mar	26.6	23.9	46.8	62.8	79.0
Apr	26.4	12.9	32.5	66.3	173.3
May	53.3	56.9	64.6	91.2	131.8
Jun	62.0	57.8	71.4	99.4	147.0
Jul	48.5	45.5	59.6	82.0	94.9
Aug	29.1	21.2	35.0	59.9	133.7
Sep	17.0	8.7	26.3	44.1	65.2
Oct	14.9	2.9	18.4	51.9	76.5
Nov	14.5	2.6	25.6	39.9	79.0

Dec	6.6	0.0	2.7	27.8	63.5

Monthly drainage summary for area 0.45 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	8.5	0.0	15.2	27.5	62.4
Feb	14.4	0.0	24.0	52.0	76.6
Mar	22.9	18.5	42.2	59.1	72.4
Apr	22.4	7.7	27.1	55.9	165.1
May	44.7	48.2	57.0	84.8	125.5
Jun	55.5	51.7	65.2	91.9	140.9
Jul	42.3	39.0	53.4	75.6	88.6
Aug	23.9	16.0	28.6	54.5	127.2
Sep	13.7	6.8	23.6	37.6	62.1
Oct	11.8	0.0	15.7	43.1	66.4
Nov	12.0	0.0	20.8	33.6	68.2
Dec	5.6	0.0	0.4	24.3	56.5

Monthly drainage summary for area 0.5 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	7.3	0.0	11.3	26.3	59.6
Feb	12.9	0.0	19.7	46.6	71.2
Mar	20.3	13.4	35.5	55.9	67.2
Apr	19.8	3.6	22.8	48.4	158.2
May	38.2	41.3	50.1	79.7	120.4
Jun	49.9	46.8	60.2	81.5	136.0
Jul	37.5	33.7	48.5	71.0	83.5
Aug	20.4	12.9	23.5	51.9	121.9
Sep	11.1	3.4	20.8	35.0	59.8
Oct	9.6	0.0	14.4	35.9	60.5
Nov	10.1	0.0	17.3	31.4	61.0
Dec	4.9	0.0	0.0	20.4	51.0

Monthly drainage summary for area 0.55 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	6.3	0.0	8.1	23.4	57.3
Feb	11.7	0.0	18.5	42.2	66.8
Mar	18.6	9.6	31.8	53.5	62.9
Apr	18.0	0.3	19.6	40.2	152.6
May	33.5	34.4	46.3	75.5	116.2
Jun	45.0	42.8	55.2	75.0	126.9
Jul	33.6	29.8	44.8	67.3	79.3
Aug	17.7	10.0	20.0	50.2	117.6
Sep	9.1	1.1	18.1	31.1	57.9
Oct	7.8	0.0	8.8	33.0	55.7
Nov	8.9	0.0	15.3	29.3	55.2
Dec	4.4	0.0	0.0	17.3	46.4

Monthly drainage summary for area 0.6 ha

Month	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
Jan	5.6	0.0	5.6	20.2	55.4
Feb	10.8	0.0	17.5	38.5	63.1
Mar	17.1	6.4	29.2	51.5	59.4
Apr	16.6	0.0	17.7	33.4	147.9
May	30.0	28.8	42.8	72.0	112.5
Jun	40.7	39.4	50.4	71.1	115.5
Jul	30.4	26.5	42.6	64.2	75.9
Aug	15.8	6.7	17.0	48.9	114.1
Sep	7.4	0.0	12.2	26.9	56.0

Oct	6.4	0.0	5.0	31.3	51.7
Nov	8.1	0.0	13.6	27.7	50.2
Dec	4.0	0.0	0.0	15.2	42.6

Annual Wet-weather Storage Summary Statistics

All wet-weather storage results in m^3 storage.
Area in hectares
Note: statistics are for maximums of each year.

Area	*Mean*	*Median*	*75 %*	*90 %*	*95 %*	*Maximum*
0.2000	0.0	0.0	0.0	0.0	0.0	0.0
0.2500	0.0	0.0	0.0	0.0	0.0	0.0
0.3000	0.0	0.0	0.0	0.0	0.0	0.0
0.3500	0.0	0.0	0.0	0.0	0.0	0.0
0.4000	0.0	0.0	0.0	0.0	0.0	0.0
0.4500	0.0	0.0	0.0	0.0	0.0	0.0
0.5000	0.0	0.0	0.0	0.0	0.0	0.0
0.5500	0.0	0.0	0.0	0.0	0.0	0.0
0.6000	0.0	0.0	0.0	0.0	0.0	0.0

Summary Soil NOX-N Concentrations

All soil concentrations in mg/kg of soil
Area in hectares
Statistics are based on annual averages

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	2.248	2.029	2.553	2.678	4.072
0.2500	0.569	0.541	0.649	0.698	0.897
0.3000	0.008	0.006	0.008	0.010	0.090
0.3500	0.001	0.000	0.001	0.001	0.038
0.4000	0.001	0.000	0.000	0.000	0.026
0.4500	0.000	0.000	0.000	0.000	0.021
0.5000	0.000	0.000	0.000	0.000	0.018
0.5500	0.000	0.000	0.000	0.000	0.016
0.6000	0.000	0.000	0.000	0.000	0.015

Summary Soil-water NOX-N Concentrations

All soil-water concentrations in mg/L
Area in hectares
Statistics are based on annual averages

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	11.660	10.268	13.466	13.953	21.258
0.2500	3.172	2.909	3.600	4.017	5.539
0.3000	0.047	0.033	0.040	0.050	0.664
0.3500	0.008	0.002	0.003	0.003	0.299
0.4000	0.004	0.000	0.000	0.000	0.203
0.4500	0.003	0.000	0.000	0.000	0.158
0.5000	0.003	0.000	0.000	0.000	0.134
0.5500	0.002	0.000	0.000	0.000	0.118
0.6000	0.002	0.000	0.000	0.000	0.108

Summary NOX-N Leached to Groundwater

Results in kg/year leached below design soil depth in application area
Area in hectares

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	15.00	14.65	15.69	16.79	18.78

0.2500	3.32	3.26	3.60	4.12	4.36
0.3000	0.03	0.02	0.03	0.06	0.11
0.3500	0.00	0.00	0.00	0.00	0.00
0.4000	0.00	0.00	0.00	0.00	0.00
0.4500	0.00	0.00	0.00	0.00	0.00
0.5000	0.00	0.00	0.00	0.00	0.00
0.5500	0.00	0.00	0.00	0.00	0.00
0.6000	0.00	0.00	0.00	0.00	0.00

Summary Soil Amm-N Concentrations

All soil concentrations in mg/kg of soil
Area in hectares
Statistics are based on annual averages

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	0.305	0.304	0.312	0.323	0.339
0.2500	0.249	0.246	0.260	0.277	0.320
0.3000	0.216	0.212	0.226	0.238	0.282
0.3500	0.192	0.188	0.205	0.217	0.250
0.4000	0.173	0.170	0.188	0.196	0.225
0.4500	0.157	0.153	0.172	0.177	0.202
0.5000	0.145	0.141	0.156	0.161	0.184
0.5500	0.135	0.131	0.143	0.148	0.169
0.6000	0.126	0.124	0.133	0.139	0.156

Summary Soil-water Amm-N Concentrations

All soil-water concentrations in mg/L
Area in hectares
Statistics are based on annual averages

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	0.221	0.220	0.224	0.235	0.275
0.2500	0.202	0.198	0.224	0.246	0.306
0.3000	0.192	0.182	0.211	0.235	0.298
0.3500	0.180	0.173	0.203	0.219	0.280
0.4000	0.168	0.163	0.188	0.207	0.257
0.4500	0.157	0.152	0.177	0.194	0.235
0.5000	0.147	0.143	0.163	0.179	0.216
0.5500	0.139	0.139	0.154	0.166	0.201
0.6000	0.132	0.131	0.145	0.156	0.187

Summary Amm-N Leached to Groundwater

Results in kg/year leached below design soil depth in application area
Area in hectares

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	0.426	0.433	0.484	0.525	0.570
0.2500	0.286	0.291	0.333	0.371	0.422
0.3000	0.211	0.221	0.256	0.290	0.333
0.3500	0.166	0.172	0.207	0.236	0.280
0.4000	0.138	0.137	0.179	0.202	0.248
0.4500	0.117	0.115	0.154	0.175	0.224
0.5000	0.102	0.098	0.139	0.154	0.205
0.5500	0.091	0.085	0.122	0.143	0.193
0.6000	0.083	0.075	0.110	0.136	0.181

Summary Soil Org-N Concentrations

All soil concentrations in mg/kg of soil
Area in hectares
Statistics are based on annual averages

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	500.0	500.0	500.1	500.1	500.1
0.2500	500.0	500.0	500.1	500.1	500.3
0.3000	500.0	500.0	500.0	500.0	500.1
0.3500	500.0	500.0	500.0	500.0	500.0
0.4000	500.0	500.0	500.0	500.0	500.0
0.4500	500.0	500.0	500.0	500.0	500.0
0.5000	500.0	500.0	500.0	500.0	500.0
0.5500	500.0	500.0	500.0	500.0	500.0
0.6000	500.0	500.0	500.0	500.0	500.0

Summary Soil TP Concentrations

All soil concentrations in mg/kg of soil
Area in hectares
Statistics are based on annual averages

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	558.279	704.417	744.589	745.518	746.509
0.2500	498.479	551.139	744.681	746.049	746.695
0.3000	430.328	441.879	635.001	743.274	746.244
0.3500	356.169	360.671	520.572	614.699	672.608
0.4000	295.225	298.075	431.314	510.466	559.338
0.4500	246.698	248.589	359.974	426.630	467.872
0.5000	207.168	208.461	301.751	357.817	392.631
0.5500	174.388	175.286	253.402	300.459	329.788
0.6000	146.801	147.416	212.662	252.038	276.661

Summary Soil-water TP Concentrations

All soil-water concentrations in mg/L
Area in hectares
Statistics are based on annual averages

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	10.171	3.457	16.743	21.730	29.596
0.2500	8.556	2.898	18.327	27.880	31.959
0.3000	4.748	2.414	3.569	15.367	33.028
0.3500	2.108	2.038	3.018	3.687	4.240
0.4000	1.804	1.727	2.573	3.130	3.580
0.4500	1.548	1.468	2.207	2.728	3.031
0.5000	1.326	1.250	1.893	2.333	2.573
0.5500	1.136	1.066	1.620	1.991	2.190
0.6000	0.971	0.911	1.381	1.692	1.857

Summary TP Leached to Groundwater

Results in kg/year leached below design soil depth in application area
Area in hectares

Area	*Mean*	*Median*	*75 %*	*90 %*	*Maximum*
0.2000	13.831	6.935	25.349	28.127	32.557
0.2500	9.246	3.960	20.386	25.058	31.964
0.3000	4.687	2.852	4.252	11.644	24.978
0.3500	2.176	2.127	3.287	4.012	5.310
0.4000	1.702	1.598	2.564	3.158	4.297
0.4500	1.356	1.254	2.011	2.555	3.495
0.5000	1.097	0.999	1.613	2.185	2.915
0.5500	0.897	0.759	1.304	1.874	2.533
0.6000	0.737	0.625	1.083	1.531	2.197

14 Attachment G – Report Notes

Information

Important Information About Your Report

Subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all of course, are necessarily relevant to all reports, but are included as general reference.

Engineering Reports - Limitations

Geotechnical reports are based on information gained from limited sub-surface site testing and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel and are based on the information obtained, on current engineering standards of interpretation and analysis, and on the basis of your unique project specific requirements as understood by Martens. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the Client.

Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relative if the design proposal is changed (eg. to a twenty storey building). Your report should not be relied upon if there are changes to the project without first asking Martens to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Martens will not accept responsibility for problems that may occur due to design changes if they are not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced and therefore your site investigation report recommendations should only be regarded as preliminary.

Only Martens, who prepared the report, are fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Martens cannot be held responsible for such misinterpretation.

Engineering Reports – Use For Tendering Purposes

Where information obtained from this investigation is provided for tendering purposes, Martens recommend 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. Attention is drawn to the document 'Guidelines for the Provision of Geotechnical Information in Tender Documents', published by the Institution of Engineers, Australia.

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.

Engineering Reports – Data

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings *etc* are customarily included in a Martens report and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Engineering Reports – Other Projects

To avoid misuse of the information contained in your report it is recommended that you confer with Martens before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Subsurface Conditions - General

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects, relevant standards 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 will depend partly on test point (eg. excavation or borehole) spacing and sampling frequency which are often limited by project imposed budgetary constraints.
- Changes in guidelines, standards and policy or interpretation of guidelines, standards and

policy by statutory authorities.

- The actions of contractors responding to commercial pressures.
- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions

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

Subsurface Conditions - Changes

Natural processes and the activity of man create subsurface conditions. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Reports are based on conditions which existed at the time of the subsurface exploration.

Decisions should not be based on a report whose adequacy may have been affected by time. If an extended period of time has elapsed since the report was prepared, consult Martens to be advised how time may have impacted on the project.

Subsurface Conditions - Site Anomalies

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

Report Use By Other Design Professionals

To avoid potentially costly misinterpretations when other design professionals develop their plans based on a report, retain Martens to work with other project professionals who are affected by the report. This may involve Martens explaining the report design implications and then reviewing plans and specifications produced to see how they have incorporated the report findings.

Subsurface Conditions - Geoenvironmental Issues

Your report generally does not relate to any findings, conclusions, or recommendations about the potential for hazardous or contaminated materials existing at the site unless specifically required to do so as part of the Company's proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geoenvironmental or site contamination assessments. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Martens for information relating to such matters.

Responsibility

Geotechnical reporting relies on interpretation of factual information based on professional judgment and opinion and has an inherent level of uncertainty attached to it and is typically far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded.

To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Martens to other parties but are included to identify where Martens' responsibilities begin and end. Their use is intended to help all parties involved to recognize their individual responsibilities. Read all documents from Martens closely and do not hesitate to ask any questions you may have.

Site Inspections

Martens will always be pleased to provide engineering inspection services for 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. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

Soil Data

Explanation of Terms (1 of 3)

Definitions

In engineering terms, soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material does not exhibit any visible rock properties and can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

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

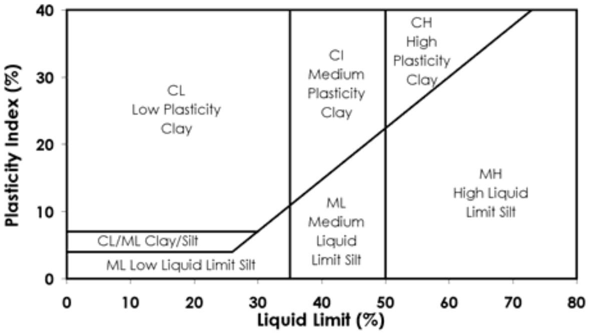
Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay). Unless otherwise stated, particle size is described in accordance with the following table.

Division	Subdivision	Size
BOULDERS		>200 mm
COBBLES		60 to 200 mm
GRAVEL	Coarse	20 to 60 mm
	Medium	6 to 20 mm
	Fine	2 to 6 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties

Plasticity properties can be assessed either in the field by tactile properties, or by laboratory procedures.



Moisture Condition

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C_u (kPa)	Approx SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	2 to 4	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail.
Friable	-		Crumbles or powders when scraped by thumbnail

Density of Granular Soils

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

Relative Density	%	SPT 'N' Value (blows/300mm)	CPT Cone Value (q_c Mpa)
Very loose	< 15	< 5	< 2
Loose	15 – 35	5 - 10	2 -5
Medium dense	35 – 65	10 - 30	5 - 15
Dense	65- 85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

Minor Components

Minor components in soils may be present and readily detectable, but have little bearing on general geotechnical classification. Terms include:

Term	Assessment	Proportion of Minor component In:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily detectable by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

Soil Agricultural Classification Scheme

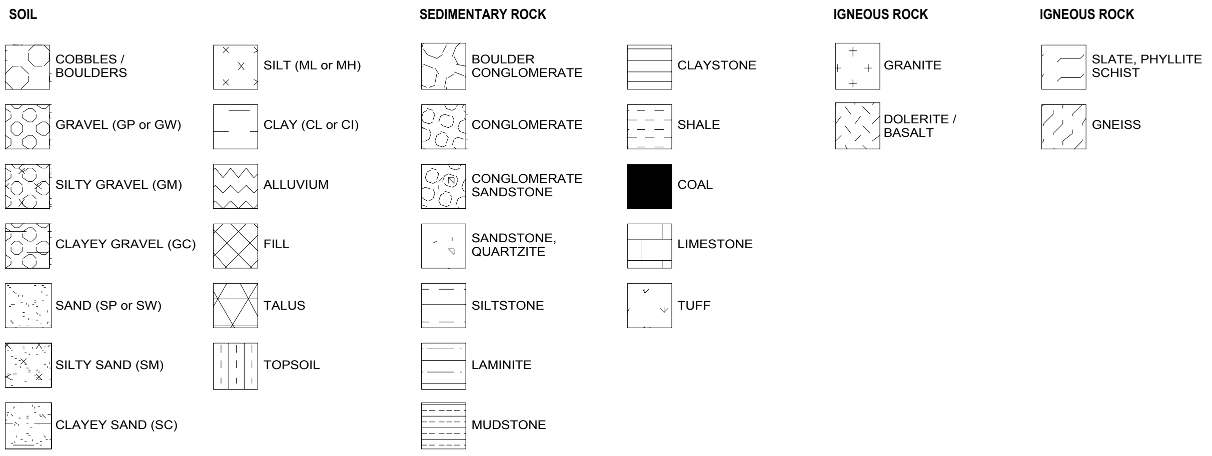
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions by Northcote, K.H. (1979) *The factual key for the recognition of Australian Soils*, Rellim Technical Publications, NSW, p 26 - 28.

Symbol	Field Texture Grade	Behaviour of moist bolus	Ribbon length	Clay content (%)
S	Sand	Coherence nil to very slight; cannot be moulded; single grains adhere to fingers	0 mm	< 5
LS	Loamy sand	Slight coherence; discolours fingers with dark organic stain	6.35 mm	5
CLS	Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain	6.35mm - 1.3cm	5 - 10
SL	Sandy loam	Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are readily visible	1.3 - 2.5	10 - 15
FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard	1.3 - 2.5	10 - 20
SCL^{-}	Light sandy clay loam	Bolus strongly coherent but sandy to touch, sand grains dominantly medium size and easily visible	2.0	15 - 20
L	Loam	Bolus coherent and rather spongy; smooth feel when manipulated but no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present	2.5	25
Lfsy	Loam, fine sandy	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated	2.5	25
SiL	Silt loam	Coherent bolus, very smooth to silky when manipulated	2.5	25 + > 25 silt
SCL	Sandy clay loam	Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix	2.5 - 3.8	20 - 30
CL	Clay loam	Coherent plastic bolus; smooth to manipulate	3.8 - 5.0	30 - 35
SiCL	Silty clay loam	Coherent smooth bolus; plastic and silky to touch	3.8 - 5.0	30- 35 + > 25 silt
FSCL	Fine sandy clay loam	Coherent bolus; fine sand can be felt and heard	3.8 - 5.0	30 - 35
SC	Sandy clay	Plastic bolus; fine to medium sized sands can be seen, felt or heard in a clayey matrix	5.0 - 7.5	35 - 40
SiC	Silty clay	Plastic bolus; smooth and silky	5.0 - 7.5	35 - 40 + > 25 silt
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing	5.0 - 7.5	35 - 40
LMC	Light medium clay	Plastic bolus; smooth to touch, slightly greater resistance to shearing than LC	7.5	40 - 45
MC	Medium clay	Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture, some resistance to shearing	> 7.5	45 - 55
HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing	> 7.5	> 50

Soil Data

Explanation of Terms (3 of 3)

Symbols for Soil and Rock



Unified Soil Classification Scheme (USCS)

<table>
<tr><th colspan="6">FIELD IDENTIFICATION PROCEDURES
(Excluding particles larger than 63 mm and basing fractions on estimated mass)</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS
More than 50 % of material less than 63 mm is larger than 0.075 mm</td><td rowspan="16">(A 0.075 mm particle is about the smallest particle visible to the naked eye)</td><td rowspan="4">GRAVELS
More than half of coarse fraction is larger than 2.0 mm.</td><td rowspan="2">CLEAN GRAVELS (Little or no fines)</td><td colspan="2">Wide range in grain size and substantial amounts of all intermediate particle sizes.</td><td>GW</td><td>Gravel</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with more intermediate sizes missing</td><td>GP</td><td>Gravel</td></tr>
<tr><td rowspan="2">GRAVELS WITH FINES (Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>GM</td><td>Silty Gravel</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>GC</td><td>Clayey Gravel</td></tr>
<tr><td rowspan="4">SANDS
More than half of coarse fraction is smaller than 2.0 mm</td><td rowspan="2">CLEAN SANDS (Little or no fines)</td><td colspan="2">Wide range in grain sizes and substantial amounts of intermediate sizes missing.</td><td>SW</td><td>Sand</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with some intermediate sizes missing</td><td>SP</td><td>Sand</td></tr>
<tr><td rowspan="2">SANDS WITH FINES (Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>SM</td><td>Silty Sand</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>SC</td><td>Clayey Sand</td></tr>
<tr><td rowspan="8">FINE GRAINED SOILS
More than 50 % of material less than 63 mm is smaller than 0.075 mm</td><th colspan="6">IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM</th></tr>
<tr><th>DRY STRENGTH (Crushing Characteristics)</th><th>DILATANCY</th><th>TOUGHNESS</th><th>DESCRIPTION</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td>None to Low</td><td>Quick to Slow</td><td>None</td><td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity</td><td>ML</td><td>Silt</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Medium</td><td>Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays</td><td>CL</td><td>Clay</td></tr>
<tr><td>Low to Medium</td><td>Slow to Very Slow</td><td>Low</td><td>Organic silts and organic silty clays of low plasticity</td><td>OL</td><td>Organic Silt</td></tr>
<tr><td>Low to Medium</td><td>Slow to Very Slow</td><td>Low to Medium</td><td>Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts</td><td>MH</td><td>Silt</td></tr>
<tr><td>High</td><td>None</td><td>High</td><td>Inorganic clays of high plasticity, fat clays</td><td>CH</td><td>Clay</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Low to Medium</td><td>Organic clays of medium to high plasticity</td><td>OH</td><td>Organic Silt</td></tr>
<tr><td colspan="2">HIGHLY ORGANIC SOILS</td><td colspan="4">Readily identified by colour, odour, spongy feel and frequently by fibrous texture</td><td>Pt</td><td>Peat</td></tr>
<tr><td colspan="8">Low Plasticity – Liquid Limit W_L < 35 % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit W_L > 60 %</td></tr>
</table>

Rock Data

Explanation of Terms (1 of 2)

Definitions

Descriptive terms used for Rock by Martens are given below and include rock substance, rock defects and rock mass.

Rock Substance	In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot, unless extremely weathered, be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.
Rock Defect	Discontinuity or break in the continuity of a substance or substances.
Rock Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Degree of Weathering

Rock weathering is defined as the degree in rock structure and grain property decline and can be readily determined in the field.

Term	Symbol	Definition
Residual Soil	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - ie. 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 decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original 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	Fr	Rock substance unaffected by weathering

Rock Strength

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance is the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Is (50) MPa	Field Guide	Symbol
Extremely weak	< 0.03	Easily remoulded by hand to a material with soil properties.	EW
Very weak	0.03 - 0.1	May be crumbled in the hand. Sandstone is ‘sugary’ and friable.	VW
Weak	0.1 - 0.3	A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	W
Medium strong	0.3 - 1	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	MS
Strong	1 - 3	A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife.	S
Very Strong	3 - 10	A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VS
Extremely strong	> 10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	ES

Rock Data

Explanation of Terms (2 of 2)

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 excludes fractures such as drilling breaks.

Term	Description
Fragmented	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than core diameter.
Highly fractured	Core lengths are generally less than 20mm-40mm with occasional fragments.
Fractured	Core lengths are mainly 30mm-100mm with occasional shorter and longer sections.
Slightly fractured	Core lengths are generally 300mm-1000mm with occasional longer sections and occasional sections of 100mm-300mm.
Unbroken	The core does not contain any fractures.

Rock Core Recovery

TCR = Total Core Recovery

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100\%$$

SCR = Solid Core Recovery

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100\%$$

RQD = Rock Quality Designation

$$= \frac{\sum \text{Axial lengths of core} > 100\,\text{mm long}}{\text{Length of core run}} \times 100\%$$

Rock Strength Tests

▼	Point load strength Index (Is50) - axial test (MPa)
▶	Point load strength Index (Is50) - diametrall test (MPa)
●	Unconfined compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)

BP	Bedding plane parting
X	Foliation
L	Cleavage
JT	Joint
F	Fracture
SZ	Sheared zone (Fault)
CS	Crushed seam
DS	Decomposed seam
IS	Infilled seam
V	Vein

Coating or Filling

Cn	Clean
Sn	Stain
Ct	Coating
Fe	Iron Oxide

Planarity

Cu	Curved
Ir	Irregular
Pl	Planar
St	Stepped
Un	Undulating

Roughness

Po	Polished
Ro	Rough
Sl	Slickensided
Sm	Smooth
Vr	Very rough

Inclination

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

Test Methods

Explanation of Terms (1 of 2)

Sampling

Sampling is carried out during drilling or excavation 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 may be taken by pushing a thin-walled sample tube into the soils and withdrawing a soil sample 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. Other sampling methods may be used. 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.

Hand Excavation – in some situations, excavation using hand tools such as mattock and spade may be required due to limited site access or shallow soil profiles.

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger generally 75-100mm in diameter into the ground. The depth of penetration is usually limited to the length of the auger pole, however extender pieces can be added to lengthen this.

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 descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m 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 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) 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 100mm 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, 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 50mm 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 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 AS 1289 Methods of Testing Soils for Engineering Purposes - Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760mm. 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 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

as 4, 6, 7
N = 13
(ii) In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

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 50mm 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 AS 1289 - Test F4.1.

In the test, a 35mm 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 separate 130mm long sleeve, immediately behind the cone. Tranducers 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 20mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records.

The information provided on the charts 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 of 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 (A) 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 (B) scale (0 - 50 Mpa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance 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 (Mpa) = (0.4 to 0.6) N (blows/300mm)

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.

DYNAMIC CONE (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 150mm increments of penetration. Normally, there is a depth limitation of 1.2m 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 9kg hammer, dropping 600mm (AS 1289 - Test F 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 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289 - Test F 3.2). The test was developed initially for pavement sub-grade investigations, with correlations of the test results with California bearing ratio published by various Road Authorities.

LABORATORY TESTING

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

TEST PIT / BORE LOGS

The test pit / bore log(s) presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method of excavation / drilling. Ideally, continuous undisturbed sampling or excavation / 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' variation 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 prior 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.