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Port Macquarie-Hastings Council

martens consulting engineers

Area 14 Stage 1B Groundwater Study, Lake Cathie, NSW

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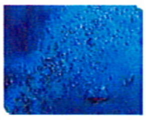
ENVIRONMENTAL


WATER


WASTEWATER


GEOTECHNICAL


CIVIL


PROJECT MANAGEMENT

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

Contents

1 Overview

1.1 Background

Hastings Urban Growth Strategy (2001) identifies land between Lake Cathie and Bonny Hills (know as Area 14) as one of the major urban growth areas in the Hastings Valley. As a consequence, Council has co-ordinated the preparation of an Urban Design Master Plan for Area 14 (adopted in February, 2004).

Further to the above, we understand that Council is now proceeding with amendments to the LEP for Area 14, including changes to zoning to enable development to proceed in accordance with the Master Plan. An independent review of the Local Environmental Study (LES) for Area 14 by GHD (2006), which included the stormwater quality report prepared by Jelliffe Environmental (2002), has concluded by recommending that further groundwater assessment is required to more fully consider the issue of determining a suitable 'set-back' to the littoral rainforest (ie. the 'buffer design').

1.2 SEPP 26 – Littoral Rainforests

SEPP 26 Littoral Rainforests aims to provide a mechanism for the consideration of applications for development that potentially damage or destroy littoral rainforest areas with a view to the preservation of those areas in a natural state. The SEPP controls development both within a littoral rainforest and within 100 m from the mapped rainforest area, by requiring the concurrence of the NSW Director of Planning.

The subject land contains SEPP 26 – Littoral Rainforest No. 116 and therefore the provisions of the policy apply. The purpose of this investigation is to examine the impact of the proposed rezoning and preliminary buffer recommendations provided by King and Campbell. Specifically, this report assesses the impact in terms of hydrogeological consequences.

1.3 Project Scope

This report has been prepared to assist with the rezoning process and address matters raised by the GHD (2006) LES review. Primary objectives of the work include:

1. To more fully document the existing groundwater regime.

2. Assess in detail, the likely impacts of the proposed rezoning for Area 14, on local groundwater regimes, which come about principally through modifications to the local water cycle (ie. surface runoff and infiltration changes).

3. Assess the requirements for a suitable buffer design. This incudes not only set-back distance, but also any compensatory measures which would need to be included in the buffer design (eg. planting, stormwater infiltration, environmental monitoring etc).

4. Determine any initial and on-going site and buffer management requirements to ensure that the current groundwater conditions are maintained or modified as required.

1.4 Rezoning Proposal

The rezoning proposal included an indicative structure plan which was would be subject to the DCP process. This is provided in Attachment A and is summarised as follows:

- Preservation of the existing SEPP 26 land.
- Establishment of a 40-60 m wide vegetation buffer planted with species compatible with those found in the SEPP 26 land. This would be comprised of both existing vegetation as well as new regeneration areas.
- Provision of a 30 m wide asset protection zone (APZ) which include an internal access road running parallel with the vegetation buffer.
- Residential land to the west of the APZ. This would be of varying density, with impervious area coverage, based on Councils advice, likely to range between say 50 – 70 % and include roofs, roads, driveways and other pavements. The approximate location of the residential land to the west of the vegetation buffer is provided in Attachment A and B.

1.5 Previous Investigations

1.5.1 Hackett Laboratory Services Pty Ltd (February, 2001)

Hackett Laboratory Services undertook preliminary geotechnical investigations throughout the study area during 2001. Locations of soil test pits are provided in Attachment B of this report. 7 test pits were excavated throughout the study area ranging in depth between 300 and 1500 mm. Investigations indicated that aside from test pit 1, which revealed a generally sandy profile, all other test pits revealed silty loam topsoils overlying medium to heavy clay sub-soils.

Groundwater was only observed at test-pit 6. Unfortunately surface levels for the investigation pits was not provided as part of the Hackett Laboratories report. Based on the presently available survey data, test-pit 6 is situated at approximately 11 – 11.5 mAHD. It is not possible from the report data to determine whether the observed groundwater represented a likely groundwater level or a temporary level associated with saturated surface soils.

1.5.2 *Jelliffe Environmental Pty Ltd (June 2002)*

This report provided advice and recommendations in relation to stormwater quality management requirements for the subject land. Relevant comments provided in the report are as follows:

- An unconfined aquifer is likely to be present under the sandy soils of the SEPP 26 forest to the east and also in the sandy soils at the southern end of the site.

- The mean dry season water level in the unconfined aquifer underlying the SEPP 26 forest will be determined by mean sea level. However, the extent and depth of the freshwater lens and the incursion of the saline 'wedge' will depend on the volume of fresh water in the lens above sea level. Sources of freshwater for the lens are: a) rain falling directly onto the SEPP 26 forest; b) runoff fro the predominantly clay catchment to the west which infiltrates into the sandy soil at the base of the slope; and c) groundwater infiltration from higher ground.

- To avoid the risk of reducing recharge to the aquifer below the SEPP 26 area, it was recommended that runoff collected on the eastern side of the site discharge to seepage lines constructed into the sandy soil along the western edge of the SEPP 26 forest.

- No evidence of a water table was observed for elevations > 9 mAHD.

- Peak water tables in the SEPP 26 area will potentially fluctuate by > 1 m due to runoff and infiltration fro the clay based catchment to the west.

- Infiltration into the clayey soils to the west is likely to be low and therefore runoff to the low lying SEPP 26 areas would dominate in the local hydrological cycle.

- Use of rainwater tanks to allow for OSD and therefore slow release of water into the water table at the allotment level.

1.5.3 Storm Consulting Pty Ltd (April 2006)

This report provided an integrated water cycle management plan for Area 14. The following comments summarise relevant aspects of the study:

- A vegetated buffer strip to the SEPP 26 land was recommended.
- Stormwater treatment from the rezoned land was to be by CDS unit and sand filtration.
- A recycled water main was recommended to provide recycled water to the subject land

2 Existing Environmental Setting

2.1 Topography

Site 0.5 contours were provided by Hastings Council and are relied upon for the purposes of this investigation. Further to this, surface levels at each of the installed piezometers were surveyed by King and Campbell Pty Ltd. Site survey data are provided in Attachment B and indicate that the western portion of the site is generally dominated by a relatively steep north-south aligned ridge with grade ranging between 10-20 %. To the east of the ridge, the site is relatively flat with grades of < 10 % grading towards the beach (see Figure 1).

Figure 1: View towards north of sub-catchments C3 and C4 indicating low gentle gradients at lower portions of the site.

2.2 Geology

No rock outcropping was observed at within the study area although a small outcrop occurs at the beach in the north east portion of the study area. Rock cores were not collected from the beach outcrop as part of this investigation. Review of local 1:250 000 geological series mapping (Hasting Sheet 5614, 1968) indicates that local bedrock is formed from the Myrabed formation including schist, phyllite greywacke and slate. Low lying areas are composed of various with Quaternary and Holocene silts, muds, sands and gravels.

2.3 Surface Drainage and Existing Hydrology

No water courses occur within the immediate study area which is dominated by a series of concave drainage depressions draining towards the SEPP 26 forest. We have separated the site into 4 primary coastal sub-catchments which are provided in Attachment B. Catchment areas are summarised below in Table 1. We note that a small farm dam was located within catchment C2 between elevations of approximately 12.0 – 12.5 mAHD (see Figure 2).

Table 1: Coastal sub-catchment areas (ha).

Catchment	Area (ha)
C1	5.172
C2	5.959
C3	7.066
C4	3.367

Figure 2: View towards south of sub-catchment C2 (delineated with dashed line) with existing farm dam located at middle foreground.

Our observations of surface water hydrology are as follows. These generally accord with the findings of Jelliffe Environmental (2001).

- Soil profiles within the elevated portions of the site (say > 8m AHD) are generally very high in clay content which, together with the relatively steep gradient, indicates that much rainfall is transmitted downslope as surface runoff.
- Surface runoff collected at the base of north-south aligned ridge line predominantly infiltrates to both recharge local groundwater, but also to provide soil moisture to surface soil layers.
- Some 60 mm of rain fell within the study area in the week prior to installation of the piezometers. During the field investigations, we noted that the low lying northern and eastern portions of the site were water logged to the point that it was difficult, notably at the north of the site, to navigate a 4WD through the terrain.

  The field observations support the contention that low lying areas of the site have the propensity to become water logged for some periods after rainfall as water pools at the slope base and then recharges local groundwater. Temporary perched water tables in the low lying areas therefore form a part of the local hydrogeological cycle and supply water to deeper groundwater.
- Further to the above, we note that surface runoff coefficients on the north-south aligned grass covered ridge are likely to be higher than in the past when the site was more heavily vegetated. This has probably led to an increase in surface soil moisture (wetter and more frequently wet) along the eastern edge of the ridge.

2.4 Soil Profile

Soil profiles were investigated during site borehole drilling and soil sample retrieval. Detailed borehole logs provided in Attachment C.

Generally, soil profiles are characterised by low permeability topsoil of loams, clay loams and light clays to a varying depths of approximately 0.5 – 0.7 m. Below this, sub-soils grade from medium to heavy clay, with minimal sand content.

The exceptions to this were BH3 and BH4 which revealed clays to approximately 2.5 m depth, overlying clayey sands to at least 6 m depth.

2.5 Climate and Antecedent Rainfall

Local climate is summarised in Table 2 indicating that the site receives moderate to high annual rainfall which is higher in the first 6 months of the year. Mean annual rainfall is approximately 1539.5 mm/year. Mean minimum temperatures range between 7.2 °C in July, through to 18.4 °C in February. Mean maximum temperatures range between 17.9 °C in July, through to 25.9 °C in February.

Table 2: Local climate summary (rainfall and temperature – Port Macquarie data, Class A pan evaporation – Taree data).

	J	F	M	A	M	J	J	A	S	O	N	D	Σ / Avg.
Mean Rain (mm)	153.3	177.4	176.4	167.7	147.3	131.5	97.8	82.6	82.1	94.1	102.4	126.9	1539.5
Median Rain (mm)	113.4	159.1	157.9	131.2	114.7	99.8	76.2	53.5	63.7	72.1	85	110	1424.5
Rain days	12.4	13.3	14.3	12.7	11.4	10.0	9.2	8.6	8.9	10.6	10.9	11.2	133.5
Class A Evap (mm)	180.0	148.0	136.0	102.0	68.0	57.0	63.0	87.0	117.0	149.0	159.0	195.0	1461.0
Max T (°C)	25.7	25.9	25.1	23.1	20.7	18.5	17.9	18.8	20.4	21.8	23.2	24.7	265.8
Min T (°C)	18.3	18.4	17.1	14.1	10.9	8.5	7.2	7.7	9.9	12.8	15.1	17.1	157.1

In terms of the 6 months prior to the start of the primary groundwater monitoring period, Table 3 indicates that rainfall was approximately similar to the long-term average climatic conditions. On this matter we note that 'average' conditions are rarely achieved in the natural environment. However, the data support the view that at the time of the on-set of monitoring, groundwater levels are likely to have represented 'typical' conditions for an average rainfall year.

Further to the above, we note that during the December – January primary monitoring period, rainfall was considerably lower than the long-term average for the area with a deficit of approximately 104 mm over the two months. This represents some 37 % lower than average rainfall. During this period, groundwater recharge rates are expected to have been reduced and evapotranspiration losses are expected to be more 'observable' than would otherwise be the case for an 'average' rainfall condition.

Table 3: Estimate of site antecedent rainfall conditions for February 2007at the time of field investigations (15.2.2007).

Month - Year	Average Rainfall (mm)	Actual Rainfall (mm)	Difference (mm)
May – 2006	147.3	4.6	-142.7
Jun – 2006	131.5	138.8	7.3
Jul – 2006	97.8	227.4	129.6
Aug – 2006	82.6	166.4	83.8
Sep – 2006	82.1	88.8	6.7
Oct – 2006	94.1	45	-49.1
Nov – 2006	102.4	155.6	53.2
Dec – 2006	126.9	67.2	-59.7
Jan – 2006	153.3	108.8	-44.5
Total	1018	1002.6	-15.4

3 Existing Groundwater Conditions

3.1 Field Investigations

Field investigations and groundwater level observations were undertaken during November 2006 to February 2007. These included the following works:

- Excavation during 9-10/11/2006 of 6 sub-surface boreholes by truck mounted drill rig in accordance with AS 1796 (1993) to determine soil profile conditions (see Attachment C for borehole logs). Installed piezometers locations are given in Attachment B.
- Installation of 6 piezometers during 9-10/11/2006 for monitoring of *in-situ* groundwater level. Piezometer construction methodology consisted of the following:
    - Construction from 50 mm threaded UPVC tubing, fitted with UPVC end cap and covered with geotextile cloth prior to installation. A minimum of 3 m of well screen was included at each piezometer site.
    - Piezometers were backfilled with clean washed fine gravel and capped with a layer of bentonite pellets and sealed with rapid set concrete.
    - All piezometers were fitted with lockable galvanised iron monuments and padlocked after site works to ensure security of the well.
    - All piezometers were fully purged following installation.
- Groundwater levels were monitored manually at each location using 'dip metering'. Manual monitoring times included 9/11/2006, 23/11/2006 and 4/2/2007.
- Field measurement of aquifer hydraulic conductivity was undertaken using the Hvorslev (1951) method at BH2, BH3, BH5 and BH6
- Installation of groundwater high resolution monitoring 'Divers' at boreholes BH2, BH3, BH5 and BH6. Initially BH4 was also instrumented (between 10-22/11/2006) but the well was predominantly dry and monitoring was subsequently abandoned.

Diver data were initially downloaded after the 'trial' period between 11/11/2006 and 22/11/2006. Following this, final Diver locations and levels were determined with comprehensive groundwater level monitoring occurring between 23/11/2006 and 4/2/2007.

- Collection of groundwater samples from each of the piezometers. Each piezometer was purged twice before collection of groundwater samples. We note that following well purging, it was not possible to collect sufficient sample volume from BH1 (which was dry), BH4 (insufficient volume) and BH6 (insufficient volume).

3.2 Piezometer Installation Summary

Piezometers were installed to varying depths depending on ground conditions at the time of installation and groundwater conditions encountered during drilling. We note that low strength bedrock was not encountered at any of the boreholes. A summary of each piezometer installation is provided in Table 4. Penetration depths of installed piezometers were generally > 3.0 m.

We note due to extremely wet ground conditions at the time of installation, some borehole collapse occurred at BH1, BH3 and BH4. This meant that piezometer penetration was somewhat less than the full extent of the borehole depth.

Table 4: Summary of piezometer installations.

	BH1	BH2	BH3	BH4	BH5	Bh6
Surface level (mAHD)	12.815	12.13	8.380	8.310	15.730	13.800
Well invert (mAHD)	9.810	5.210	4.860	4.160	6.880	9.280
Penetration depth (m)	3.005	6.920	3.520	4.150	8.850	4.520

3.3 Groundwater Water Quality

Groundwater data were collected from piezometers with sufficient sample available. Sampling was not possible from BH1, BH4 and BH6. A summary of the groundwater quality testing is as follows with details provided in Table 5 and Table 6. Attachment D provides full results.

- pH indicates acidic conditions. This occurs both in groundwater contained within residual soil as well as that contained within the Quaternary and Holocene deposits.

- Electrical conductivity (EC) for BH2 was typical of freshwater (see Table 7) whereas BH3 and BH5 maintained EC levels which were in the saline range. These data indicate local geology is high in salt content and resulting groundwater which is contained within the north-south aligned ridge-line is generally saline and not particularly suited to terrestrial plant growth. Contrasting this, BH2 was fresh suggesting that water collected from this piezometer was being actively recharged by infiltrating surface waters (perched water table). Groundwater mounding at BH2 confirms this contention.

Table 5: Groundwater quality monitoring results (23/11/2006).

Parameter	BH1	BH2	BH3	BH4	BH5	BH6
pH	-	5.00	5.80	-	5.70	-
Electrical Conductivity (µS/cm)	-	583	6640	-	6470	-
Nitrate-N (mg/L)	-	0.01	0.02	-	0.02	-
Nitrite-N (mg/L)	-	0.20	0.90	-	0.30	-
TKN-N (mg/L)	-	0.02	0.01	-	0.01	-
Ammonia-N (mg/L)	-	0.20	0.90	-	0.30	-
TN-N (mg/L)	-	0.23	0.93	-	0.33	-
TP-P (mg/L)	-	0.35	0.60	-	0.33	-
BOD_5 (mg/L)	-	< 1.00	< 1.00	-	< 1.00	-
TSS (mg/L)	-	600	1900	-	2700	-

- Nitrogen levels, including various nitrogen species such as nitrite, nitrate, ammonia and Kjeldahl nitrogen were all near to or below detection levels. This was the case for all boreholes, with the highest nitrogen levels found within the sand aquifer materials at BH3. Higher levels at this location may represent either natural variation, or are the result of past catchment activities.

- Total phosphorus levels in groundwater were higher than expected given the high clay content of local catchment soils. We note that all groundwater samples collected contained relatively high levels of suspended solids despite purging of each piezometer. It is possible that elevated phosphorus is partly attributable to sediment sorption related processes. Further testing would be required to estimate the fraction of bound and unbound phosphorus in groundwater samples.

Table 6: Average groundwater quality conditions (23/11/2006).

Parameter	Site Average
pH	5.50
EC (µS/cm)	4564
Nitrate-N (mg/L)	0.02
Nitrite-N (mg/L)	0.47
TKN-N (mg/L)	0.01
Ammonia-N (mg/L)	0.47
TN-N (mg/L)	0.50
TP-P (mg/L)	0.43
BOD_5 (mg/L)	< 1.00
TSS (mg/L)	1733

Table 7: Typical electrical conductivity ranges (µS/cm).

Water type	Electrical conductivity (µS/cm)
Deionised water	0.5-3
Pure rainwater	<15
Freshwater rivers	0-800
Marginal river water	800-1600
Brackish water	1600-4800
Saline water	>4800
Seawater	51 500

- 5 day biochemical oxygen demand (BOD_5) levels were all below detection limits (< 1 mg/L). This indicates that local groundwater resources have not been significantly impacted by groundwater pollution events and that the local aquifer is relatively low in organic materials.

- In summary, local groundwater is brackish to saline but generally maintains low pollutant levels. Salinity is noticeably lower in higher aquifer levels. This concurs with the recommendations made by Jelliffe Environmental, who suggested that the freshwater lens would sit above saline water.

3.4 Hydraulic Conductivity

Hydraulic conductivity (K_{sat}) of the sites aquifer was determined at four locations including BH2, BH3, BH5 nd BH6. Detailed pump-test data and analysis reports are provided in Attachment E. The following matters are noted:

- K_{sat} generally increases with proximity to the ocean. This is expected given that sub-soil sand content increases and clay content decreases with proximity to the ocean.
- There is a considerable difference in aquifer K_{sat} between the hillslope, which maintains K_{sat} of 1.2 – 5.8 x 10^{-8} m/s, and the lower slopes, notably where sand occurs, which reach up to 5.8 x 10^{-6} m/s. BH2 appears to mark a transition between the hillslope and the lower sand plain / back barrier dune areas.
- We expect that K_{sat} would increase further towards the ocean given increasing sand content.

Table 8: Hydraulic conductivity test results.

Date	K_{sat} (m/d)
BH2	0.180
BH3	0.505
BH5	0.005
BH6	0.001

3.5 Groundwater Levels

3.5.1 *Hydro-geological Model*

A hydro-geological model has been prepared for the study area based on available field testing information and previous test pit data provided by Hackett Laboratories. A stylised section of the model is provided in Attachment B and is described as follows:

- Relatively high groundwater tables with steep gradients are found within the extremely weathered soil mantle of the north-south aligned ridge.

- Water table position within the ridge appears to be dependent on local topographic catchment area. For example, BH1 maintains little to no catchment area and maintained no permanent water table < 3 m below ground level during the primary observation period. However, BH2 which is situated at a similar surface level but resides within a considerably larger topographic catchment, maintained water levels near to the surface.

- It therefore follows that variable topography along the edge of the SEPP 26 forest will result in variable recharge from upslope freshwater runoff.

- Freshwater within the SEPP 26 forest soils is recharged either by direct incident rainfall or by surface runoff from upslope areas.

- Groundwater recharge from 'pooled' upslope runoff is considerably fresher than deeper groundwater. During or after periods of extended or intense rainfall, runoff will saturate the upper clay layers of the sites low lying areas. This may at times result in a temporary perched groundwater body overlying the more permanent groundwater body some metres below.

- Sea water intrusion occurs into the study area. This occurs as a denser 'wedge' of water at approximately 0 m AHD and underlies the entire study area. Brackish and saline groundwater conditions observed above this level at the site are likely to be a function of inherent salinity of local rock formations, inclusion of salt spray into the drainage water, and may be the result of some diffusion between saline and fresh water bodies.

3.5.2 *Manual Level Observations*

Manual groundwater level observations were made during each site inspection. Levels are provided in Table 9 and accord with the results of detailed 'Diver' monitoring.

Table 9: Summary of manual GW level measurements (mAHD).

Date	BH1	BH2	BH3	BH4	BH5	Bh6
10/11/2006	10.32	11.53	5.36	5.87	12.18	Dry
23/11/2006	Dry	12.09	5.68	4.29	13.12	10.78
4/02/2007	Dry	11.50	4.97	Dry	12.17	10.89
Average	na	11.71	5.34	5.075	12.49	10.83

3.5.3 *Impact of Barometric Pressure*

Barometric pressure has the capacity to vary local groundwater levels by up to 20-35 cm on a weekly basis. Barometric pressure was monitored at the site using a 'BaroDiver' installed above the water table at BH6. This allowed for continuous monitoring of barometric pressure in order that groundwater levels could be calibrated to a normalised pressure of 1000 hPa.

Measurement frequency was set to 5 minutes with a summary of results provided in Figure 3. All water level compensation was undertaken through software provided with the 'Divers'. Barometric pressure varied considerably during the primary observation period, fluctuating about a mean of approximately 1015 hPa.

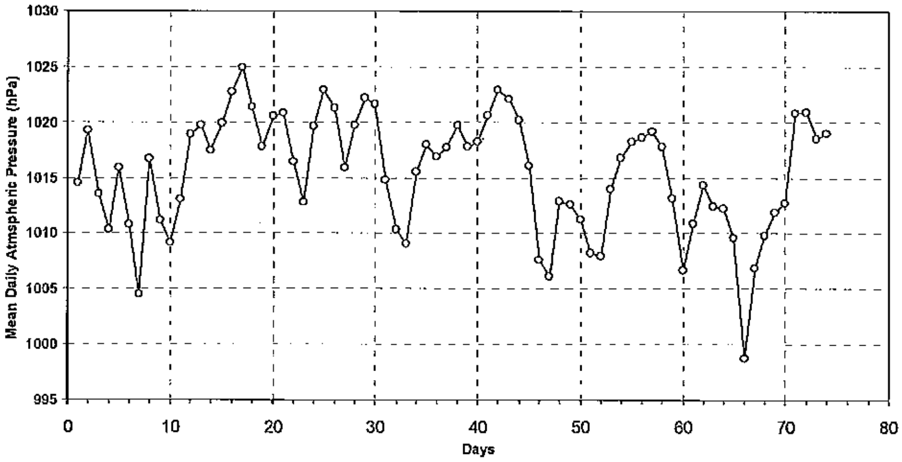

Figure 3: Variation in barometric pressure during primary monitoring period (day 0 = 23/11/2006, day 74 = 4/2/2007).

3.5.4 *Daily Monitoring Results*

Daily groundwater level records were compiled from 10 minute sampling data collected at each 'Diver' installation. Results are provided in Attachment F, with a summary plot provided in Figure 4. The following is noted:

- Water levels at BH2, BH3 and BH5 show a steady decline during the primary monitoring period.
- Water levels at BH2, BH3 and BH5 tend to show similar peaks and troughs.
- Water levels at BH6 increase for approximately 2 weeks, before levelling and then very slowly decreasing. The initial increase period is attributed to the bore being purged and recovery-

tested prior to 'Diver' installation. Monitoring results during the initial 2 weeks therefore reflect the 'tail' of recovery testing undertaken on 23/11/2006.

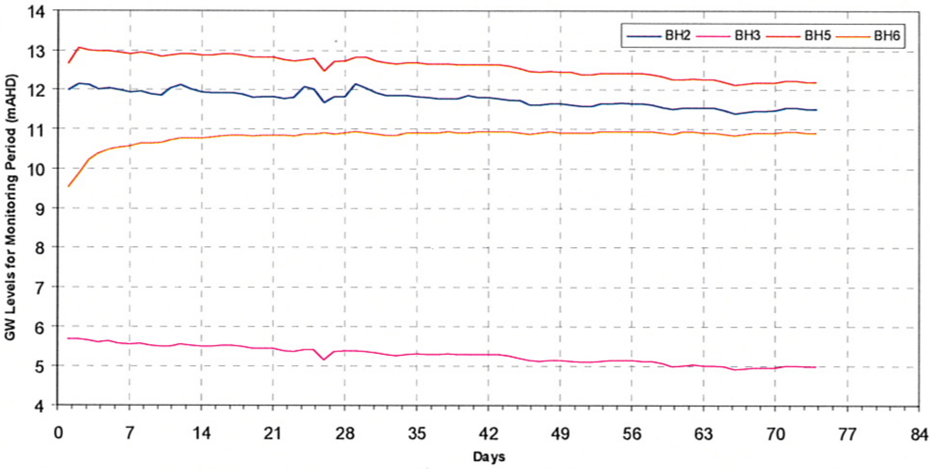

Figure 4: Variation in groundwater level during primary monitoring period (day 0 = 23/11/2006, day 74 = 4/2/2007).

In order that monitoring results could be compared between piezometers, daily data were 'normalised' by dividing the daily observation by the mean of the observation period, and expressing this as a percentage deviation from the mean. Results are provided in Figure 5 and show that for all piezometers, including the later period for BH6, there is a similar gradual decline in water level. This suggests that local groundwater levels, whilst varying in height and absolute level variations, respond in a similar way to local environmental conditions.

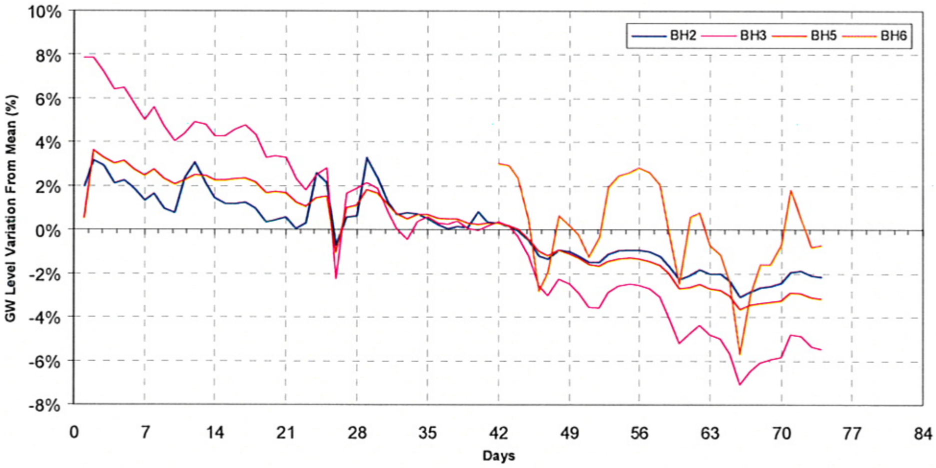

Figure 5: Variation in relative groundwater level (with respect to mean level observed at each piezometer) during primary monitoring period (day 0 = 23/11/2006, day 74 = 4/2/2007).

3.5.5 *Tidal Influence*

Detailed monitoring data (10 minute intervals) showed that small daily groundwater level fluctuations occurred at all observation sites. Figure 6 and Figure 7 provide plots of relative groundwater levels expressed as deviations from daily means for 12/12/206 and 13/01/2007. In both cases, two peaks and two troughs are apparent.

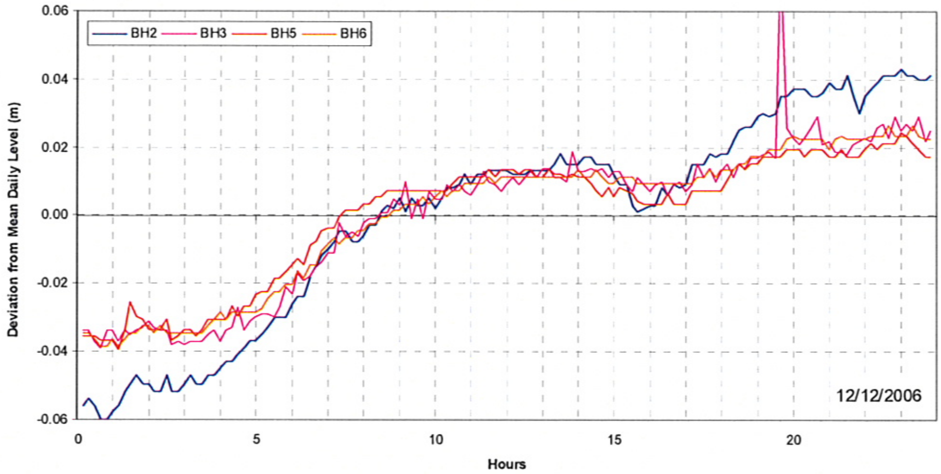

Figure 6: Relative groundwater level (as deviation from daily mean) for 12/12/2006.

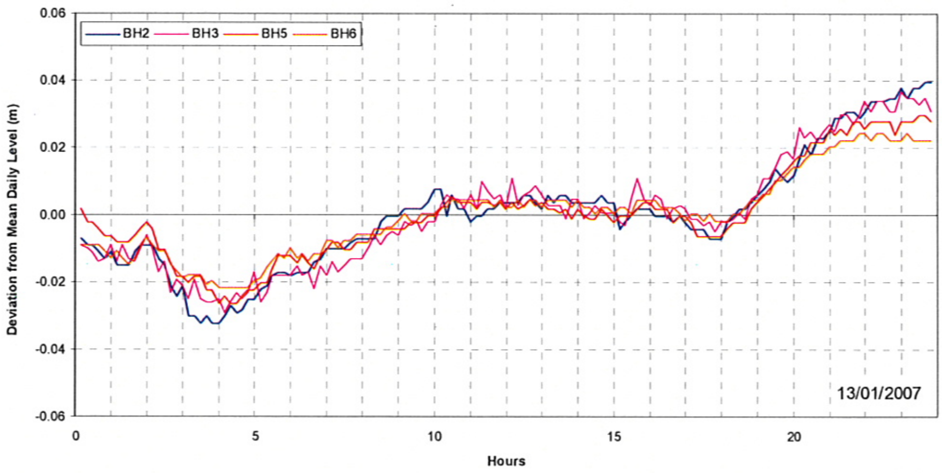

Figure 7: Relative groundwater level (as deviation from daily mean) for 13/01/2007.

An assessment of groundwater response times, or lags, to tidal incursions is provided in Table 10. The following comments are provided in relation to the influence of tide on local groundwater regime:

- Tide appears to influence all piezometers causing relative water level fluctuations of 2-3 cm above those caused by other environmental parameters. Tidal influence appears strongest at BH2 and BH3 which are located closer ocean.

- The mechanism by which the tide intrudes and acts on local groundwater is not fully understood. However, given that fluctuations are minor, the effect of tide can be generally discounted.

- Time lags in groundwater response appear to differ both between high and low tides, but also between monitoring days. Longer lags were noted where differences between low and high tide were greatest (eg. 12/12/2007).

Table 10: Assessment of groundwater response times (lags) to tidal incursions.

	Time (Hrs:Min)	Tidal Height (m)	Corresponding GW Level (Hrs:Min)	GW Lag (Hrs:Min)
		12/12/2006		
High Tide	2:32	1.18	12:00	9:28
	14:15	1.29	23:00	8:45
Low Tide	8:13	0.72	16:00	7:47
	20:53	0.51	4:00	7:07
		13/01/2007		
High Tide	8:19	1.7	12:00	3:41
	21:00	1.2	0:00	3:00
Low Tide	1:49	0.5	4:00	2:11
	15:49	0.3	18:00	2:11

3.5.6 *Rainfall Influence*

Historical daily rainfall data for the monitoring period were obtained from the Bureau of Meteorology's Port Macquarie climate monitoring station. Figure 8 provides a plot of mean 'normalised' groundwater level (ie. daily percent variation from observation period mean) variations across the site against daily rainfall. No apparent direct relation exists between rainfall and immediate site groundwater level fluctuations.

Further to the above, a lagged correlation function was prepared for the monitoring period extending some 7 weeks prior to the start of monitoring. To explain this procedure, for example, groundwater on day 'n' is correlated to rainfall on day 'n_{-t}' where 't' is the lag period in days. Results are provided in Figure 9 and suggest that there is no link between daily rainfall totals and daily groundwater level fluctuations.

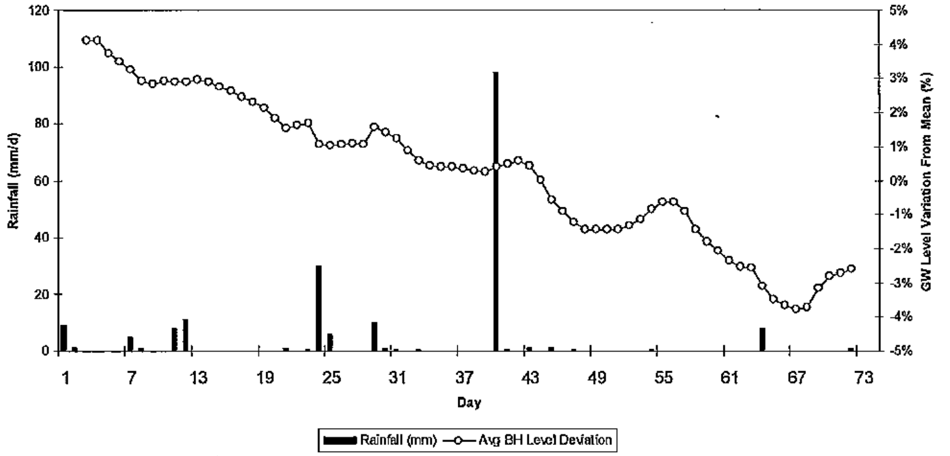

Figure 8: Site mean 'normalised' groundwater level variation (expressed as a 5 day running average) plotted in relation to rainfall during the primary monitoring period.

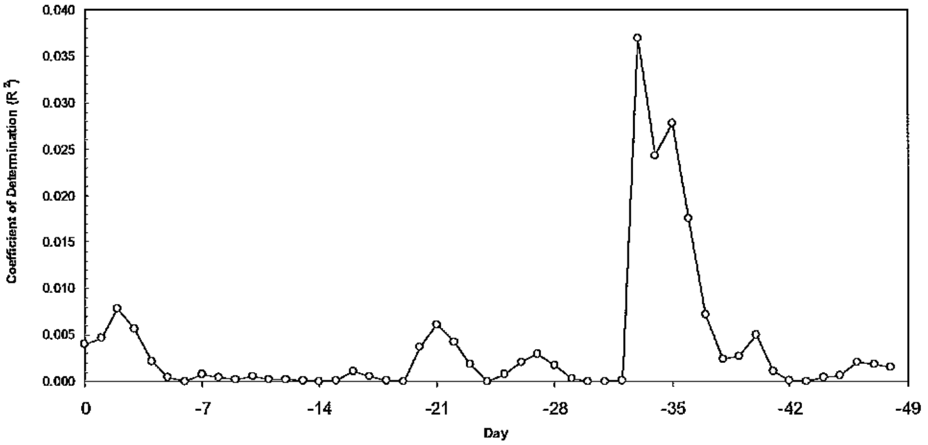

Figure 9: Lagged correlation function between site mean 'normalised' groundwater level variation (expressed as a 5 day running average) and antecedent rainfall.

In addition to the above analysis, lagged correlation functions between antecedent rainfall and groundwater level fluctuations were prepared for rainfall running totals of 7, 14, 21 and 28 day time 'blocks' (see Figure 10, Figure 11, Figure 12 and Figure 13). To explain this procedure, for example, groundwater level on day 'n' is correlated to the total rainfall falling during the period '$n_{-t \text{ to } -(t-P)}$' where 't' is the lag period in days prior to monitoring and 'P' is the period over which rainfall is totalled. This approach allows the effects of slower responses to rainfall totals over the historical record to be investigated.

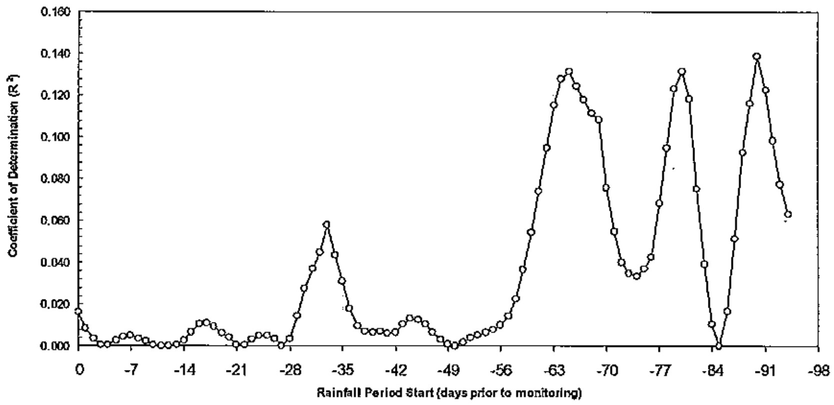

Figure 10: Lagged correlation function between site mean 'normalised' groundwater level variation (expressed as a 5 day running average) and antecedent rainfall total over 7 day block.

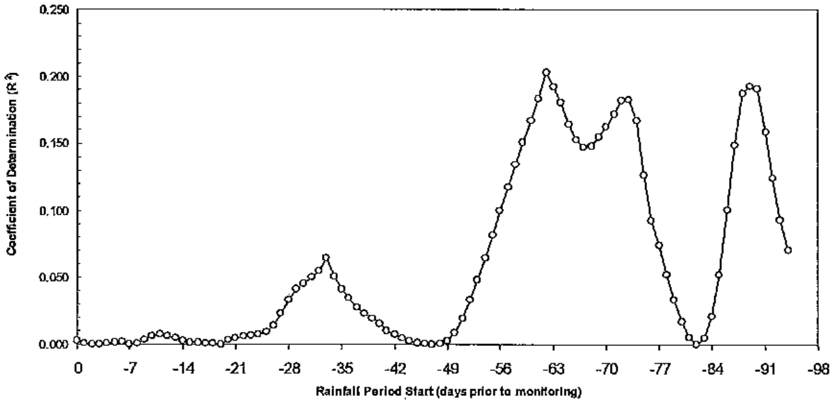

Figure 11: Lagged correlation function between site mean 'normalised' groundwater level variation (expressed as a 5 day running average) and antecedent rainfall total over 14 day block.

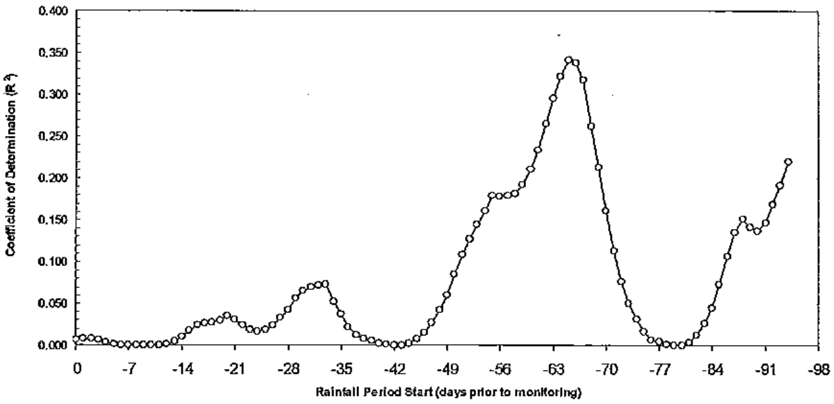

Figure 12: Lagged correlation function between site mean 'normalised' groundwater level variation (expressed as a 5 day running average) and antecedent rainfall total over 21 day block.

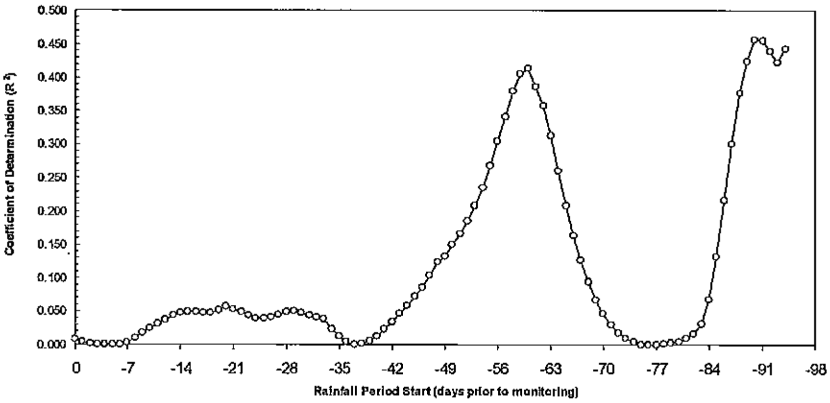

Figure 13: Lagged correlation function between site mean 'normalised' groundwater level variation (expressed as a 5 day running average) and antecedent rainfall total over 28 day block.

Results provided in the above charts suggest the following:

- Daily rainfall does not directly influence daily groundwater levels at the site. Rather, some period of time is required before groundwater levels respond to rainfall.

- Groundwater levels do not appear to be particularly influenced by any single rainfall event occurring on a particular day. Rather, the effect of accumulated rainfall appears more important.

- The lagged correlation analysis showed the strongest relation between a 4 week rainfall total occurring some 2 months (60 days) prior to monitoring.

- The lagged response to rainfall probably also reflects changing Class A Pan evaporation and therefore evapotranspiration rates (which were increasing during the monitoring period and increasing during the 2 months prior to monitoring). It is beyond the scope of this study to separate further the effects of rainfall and evapotranspiration rates on groundwater level.

- We note that for the purposes of this assessment, the lagged correlation analysis was undertaken for the site as a whole rather than for each individual piezometer. A more detailed analysis is beyond the scope of this study. However, we are of the view that groundwater below the sandier soil profiles is likely to show a faster response to antecedent weather conditions.

3.5.7 Long-term Level Fluctuations

On the basis of the previous results and discussions, it is clear that local groundwater levels at the study site appear to respond to seasonal climatic fluctuations. In crude terms and for the purposes of this assessment, this can be expressed as the difference between monthly rainfall and monthly evaporation.

By extrapolating the relation between moisture deficit (162 mm in the monitoring period) and consistent water tables drops, it was possible to estimate seasonal water table positions. Results are provided in Figure 14 and indicate that groundwater levels may fluctuate by approximately 1.0 – 1.5 m, reaching a peak during winter (or late winter / early spring). This is generally in agreement with previous estimates made by Jelliffe Environmental.

We note that this analysis is preliminary only and does not take account of lagged responses discussed earlier. This is expected to 'shift' the estimated levels by approximately 2 months forward in time.

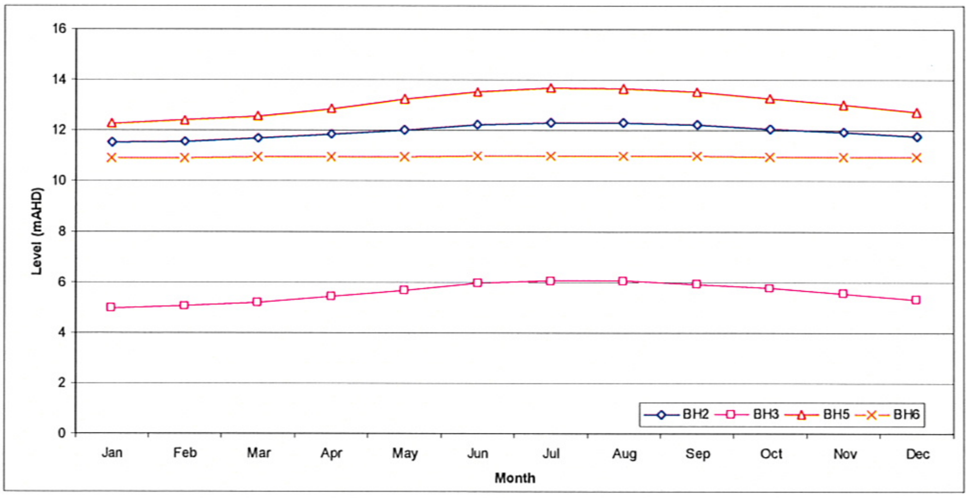

Figure 14: Estimate of seasonal groundwater level fluctuations for each instrumented piezometer site.

4 Groundwater Impact Assessment

4.1 Overview of Risks

Urban development has the capacity to significantly alter both surface water regimes as well as local hydro-geology at the development site. This may come about through one of the following mechanisms:

- Impervious surfaces, such as roofs, pavements and roads, prevent direct infiltration. This may result in lowered soil moisture, less groundwater recharge below the impervious surfaces, reduced evapotranspiration rates, and increased runoff volumes.

- Increased runoff volumes, as well as increased runoff peak flow rates can occur as a part of urbanisation. In the case of this site, increase surface water flows would be generally received at the western 'edge' of the SEPP 26 forest.

- Sub-surface structures may deflect soil moisture and groundwater flows leaving 'shadow' immediately downslope where soil moisture and groundwater levels are depressed for some distance.

- Sub-surface drainage structures, such as drains behind retaining structures or roads, may lower groundwater tables both upslope and downslope of the drain.

4.2 Modelling

4.2.1 Method

The modelling approach undertaken included the following primary steps.

- Establishment of ModFlow Version 4.2 model of the study area. Surface terrain data were interpolated by 'Kriging' using 0.5 m contour data provided by Council's GIS and amended using field survey data for each piezometer provided by King & Campbell.

- Calibration of the pre-development groundwater model using monitored groundwater data and estimated long-term mean levels derived as a part of this study. Boundary conditions assumed in the model were:

- The north-south aligned ridge line acted as a groundwater divide. Surface and groundwater water to the west of the divide were assumed to flow to water courses located either to the south west or north west of the study area.

- North and south flow boundary conditions were set as the topographic sub-catchments depicted in Attachment B (ie. C1 and C4).

- No water courses were included as part of the model set-up.

- The monitoring 'boundary', or point at which measureable change was assessed, was taken as the western edge of the SEPP 26 forest.

- Pre-development evapotranspiration and recharge boundary conditions were based on existing catchment conditions which included primarily pasture grasses and some regenerated and replanted forest areas.

o A post-development model was created. This was essentially assumed to change the surface runoff rates and evapotranspiration boundary condition within the study area.

o Post-development conditions were modelled for impervious areas of 50%, 60 % and 70 %.

4.2.2 *Evapotranspiration (ET) Rates and Crop Factors*

Evapotranspiration rates are a key factor in estimating the likely recharge to groundwater and hence determining changes to groundwater level as a result of the proposed rezoning.

Annual average crop coefficients are frequently used to estimate the annual evapotransipration rate. This is done by assuming that ET = E x CF where ET is the evapotranspiration rate, E is Class A Pan Evaporation, and CF is the Crop Factor. CF typically varies between plants as well as from month to month. In some cases, CF values are low to zero during winter periods when plant growth slows or stops (eg. deciduous trees).

Limited ET data are available for local rainforests. However, Myers *et al* (1999) have, based on a number of climatic investigations and ET modelling, presented some data for the local area. This is summarised in Table 11 and provides the following relevant information:

- Mean annual ET rates are approximately 5.38 mm/d or 1963.7 mm/year.
- ET rates are highest during late spring and summer, and lowest during June and July.
- ET rates during winter months, whilst approximately 50 % of those occurring in summer, are nevertheless still substantial.

Table 11: Evapotranspiration rates for forests within Bioclimatic Region 6 - warm tropical / temperate coastal (Myers *et al*, 1999).

Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
ET (mm/d)	6.8	6.3	5.5	4.5	3.4	3.4	3.8	4.9	6.1	6.3	6.6	6.9

The above data, together with local class A pan evaporation rates from Taree, can be used to estimate local CF values for each month. Estimates are provided in Table 12 and compared to values provided by NSW DEC (2004) for pasture.

Table 12: Crop factors (CF) for pasture and SEPP 26 forests.

Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Pasture	0.70	0.70	0.70	0.60	0.50	0.45	0.40	0.45	0.55	0.65	0.70	0.70
SEPP26	1.13	1.16	1.19	1.25	1.39	1.59	1.65	1.59	1.43	1.23	1.19	1.10

On the basis of the above estimates, annual average CF's were taken to be 0.59 for pasture and 1.32 for the SEPP 26 forest. For the urban areas, gardens and other pervious areas were considered to comprise of mixture of grasses (such as Kikuyu) and evergreen shrubs (typical of the local area). An average annual value of 0.80 was therefore used for pervious urban areas.

The above data were used as part of the Modflow 4.2 modelling exercise to simulate groundwater recharge rates. Importantly, the seasonal data show that ET rates are considerably higher for forested areas than for the pasture covered sites. This confirms the contention that the present pasture is likely to have significantly increased the water surplus, delivered as runoff and groundwater recharge / drainage, to the SEPP 26 land, from that of the sites previous vegetation cover.

This would be particularly the case during the winter months, when pasture growth rates are substantially reduced. For example, ET during June and July for pasture are approximately 24 and 25 mm respectively, while ET for the SEPP 26 land are approximately 102 and 118 mm respectively. During summer months, the differences between pasture and forest ET, whilst they still exist, are not as pronounced as for winter.

From the above discussion, it is clear that the proposed revegetated buffer put forward by King & Campbell will have the effect of reducing groundwater recharge through increased evapotranspiration rates. Also, effective crop factors for urban areas will vary with percent catchment impervious percentage as indicated in Table 13.

Table 13: Effective crop factors (CF) for urban areas.

Percent Impervious (%)	Effective CF
50	0.40
60	0.32
70	0.24

4.2.3 *Varying Urban Areas*

An assessment of the potential impact on groundwater level was undertaken for various urban densities. Scenarios included in the modelling exercise (based on advice from Council) were as follows:

1. Vegetated buffer with 50 % impervious area
2. Vegetated buffer with 60 % impervious area
3. Vegetated buffer with 70 % impervious area

For each scenario, the effect on net water deficit / surplus on the SEPP 26 forest community were evaluated, together with an estimate of change in long-term groundwater level. Further to the above, an estimate of the required vegetated buffer width was made on a sub-catchment basis.

In terms of each sub-catchment affected by the proposal, effective buffer lengths, residual grass APZ and vegetated buffer zones were estimated using the draft structure plan. Given that a detailed CAD version of the plan was not available at the time of preparing this report, some variation in aerial estimates is expected.

A summary of post-development aerial coverage's of each land-use is provided in Table 14. It is worth noting that effective buffer lengths are estimated based on the sub-catchment provided in Attachment B and are taken approximately centrally through the revegetation areas. These are not linear and it therefore follows that the calculated effective buffer width does not strictly accord with the minimum of 40 m drawn on the King & Campbell preliminary structure plan.

Table 14: Modelled changes in groundwater recharge rate according to sub-catchment.

Sub-Catchment	Effective Buffer Length (m)	Estimate of Grass APZ (m²)	Estimate of Vegetated Buffer (m²)	Approx. Urban (m²)	Mean Effective Buffer Width (m)
C1	272	3034	10160	4550	37.4
C2	263	3289	6155	27515	23.4
C3	289	3133	14634	24845	50.6
C4	104	600	3114	0	29.9

Results of the recharge analysis are provided in Table 15. These show varying responses to the proposed structure plan depending on sub-catchment. The following comments are provided:

- The 50 % impervious area assessment is could result in a net reduction in recharge to the SEPP 26 forest under the proposed buffer planting outlined in the structure plan.

- Both the 60 % and 70 % impervious area assessments show net increases in groundwater recharge with the 60 % impervious catchment resulting in a recharge of approximately 10 % and the 70 % impervious catchment resulting in a recharge increase of approximately 23 %.

- Sub-catchments C1 and C4 show reduced recharge for all urban development scenarios. This suggests that the proposed buffer is possibly too wide and will result in some local groundwater table lowering and reduced frequency of occurrence of perched groundwater tables resulting from extended or intense rainfall events.

Table 15: Modelled changes in groundwater recharge rate according to sub-catchment.

		50 % Impervious		**60 % Impervious**		**70 % Impervious**	
Catchment	**Existing Recharge Condition (ML/year)**	**Recharge (ML/year)**	**Change from Existing (ML/year)**	**Recharge (ML/year)**	**Change from Existing (ML/year)**	**Recharge (ML/year)**	**Change from Existing (ML/year)**
C1	6.50	2.95	-3.50	3.47	-3.00	4.00	-2.50
C2	25.70	26.72	1.10	29.88	4.20	33.00	7.40
C3	19.50	21.07	1.60	23.92	4.40	26.80	7.30
C4	0.20	0.00	-0.20	0.00	-0.20	0.00	-0.20
Total	51.80	50.70	-1.10	57.30	5.40	63.80	12.00

Estimates in groundwater level change for the above scenarios were modelled. Results are provided in Table 16 and indicate suggest that no net change in mean groundwater level would occur between 50 and 60 % impervious area coverage in the urban areas. Impervious areas above 60 % result in a slight water table mounding at the western edge of the SEPP 26 rainforest.

Table 16: Modelled changes in groundwater level at the western edge of the SEPP26 forest (mm change).

Catchment	**50 % Impervious**	**60 % Impervious**	**70 % Impervious**
C1	-495	-422	-348
C2	71	284	497
C3	94	260	427
C4	-110	-110	-110
Net	-19	143	305

Our comments in relation to these results are as follows:

- Catchments most affected by rising groundwater tables are C2 and C3. Maximum mounding levels of 0.5 m occur when urban areas impervious percentages are 70 %.

- Notwithstanding this, it is our view that the net change, either across the SEPP 26 forest (which is a maximum increase of 305 mm for 70 % impervious area), or on a sub-catchment basis, is relatively minor given the depth of groundwater (> 3.0 m depth) within the SEPP 26 forest.

- Further to the above, we note that permanent groundwater below the SEPP 26 forest is generally saline or near saline. The addition of an additional thin layer of mounded fresh water to this aquifer is expected to have a negligible impact on existing groundwater chemistry below the SEPP 26 forest. Our view is that temporarily perched [near surface] groundwater table which occurs during and after extended or intense rainfall events is more significant to forest ecology than the permanent deeper groundwater table.

- For catchment C1, our view is that the level of revegetation will result in a net lowering of local permanent and temporary groundwater. The effect of this is decreased with increasing urban impervious cover.

- For catchment C4, we understand that no or very little urbanisation is to occur. On this basis, it is the introduction of revegetated areas that will result in some water table level reduction.

Finally, an analysis was undertaken to determine the required average planted buffer widths to provide a 'no net change' in groundwater recharge at the study area. Modelling was undertaken iteratively by adjustment of urban planted buffer areas. Results are provided in Table 17 with comments as follows:

- These results should be considered as extremely conservative and viewed within the context of the potential groundwater rises or falls previously described.

- For the 50 % impervious development scenario, mean set-back distances would need to be marginally reduced in order to achieve no net change in groundwater recharge to the SEPP 26 area.

- In the case of the 60 % and 70 % impervious areas, mean set-back distances would need to be slightly increased (by 2 and 7 m respectively) in order to achieve no net change in groundwater recharge to the SEPP 26 area. The impact of climate change needs to be considered in addition to this.

- In general our view is that the average 40 m set-back for revegetation proposed by the King & Campbell structure plan would lead to no significant changes to groundwater conditions provided that excess runoff from the catchment can be ensured to be delivered to the groundwater regime at the base of the north-south aligned slope. This could be achieved in principle through the use of deep stormwater infiltration trenches constructed within the planted buffer zone.

- The proposed 40 m set-back for revegetation appears to meet the objectives of SEPP 26 in that it guards against significant loss or deterioration of the forest community. Revegetation, subject to the other recommendations of this report, should be undertaken as soon as possible so as to ensure that maximum evapotranspiration rates can be achieved as early a possible in the development process.

- Several alternatives exist for managing the future urban areas to ensure that there will be no net change to existing recharge characteristics (should this be required). Such matters, which can be addressed at the development application stage, will include varying the mixture of impervious percentage and set-back distance between each of the sub-catchments.

  It is beyond the scope of this report to make final recommendations in relation to matters relating to urban density and set-back distance according to each sub-catchment. However, given the significantly higher aquifer permeability below the SEPP 26 forest and proximity to the ocean, we do not see that varying set-back distance in accordance with sub-catchment as strictly necessary.

Table 17: Effective[1] buffer widths required to ensure no net change in groundwater recharge.

Urban Catchment		**50 % Impervious**		**60 % Impervious**		**70 % Impervious**	
Catchment	**Proposed Effective[1] Buffer (m)**	**Required Effective[1] Buffer (m)**	**Change Required (%)**	**Required Effective[1] Buffer m)**	**Change Required (%)**	**Required Effective[1] Buffer (m)**	**Change Required (%)**
C1	37	28	-26%	30	-21%	31	-16%
C2	23	26	13%	35	48%	41	77%
C3	51	55	8%	61	21%	67	32%
C4	30	22	-26%	22	-26%	22	-26%
Actual Mean Setback (m)	40 Proposed	37[2]	-	42[2]	-	47[2]	-

[1] Effective buffer width refers to total planted buffer area divided by buffer length.

[2] This is the average or 'mean' buffer required for no net change, excluding the effects of climate change.

4.2.4 *Impact of OSD Structures*

One of the key hydrological issues for the development will be to ensure that surface runoff from urban areas is passed efficiently to the groundwater table at the base of the north-south aligned ridge. Our view is that on-site stormwater detention (OSD) will play an important role in the final urban hydrological cycle. OSD structures, including domestic rainwater tanks and other surface storages should be used to ensure that post-development flow rates approximate as close as possible pre-development flows. This means that recharge to groundwater will be at approximately the same rate as the present.

Some form of groundwater recharge within the catchment would be preferable, however, on the basis of our geotechnical investigations, our view is that will probably not be realistic or efficient given the very low permeability of surface clay soils.

We note that the design and impact assessment of urban OSD structures was not within the scope of works for this project.

4.2.5 *Extreme Rainfall Events*

Modelling of extreme rainfall events was not undertaken as part of this investigation. However, we note that during intense rainfall events, hill-slope runoff coefficients approach or reach 100 %. During these situations, a perched water table will occur above the lower permanent water table.

Following site development, extreme rainfall events will result in similar hydrological process, in that the majority of rainfall will be delivered to downslope areas and may result in a temporary perched water table. We note that the ultimate design of the sites stormwater management system should ensure that this process is not interrupted.

4.2.6 *Impacts of Climate Change*

The IGPCC (2006) indicates that there may be a reduction in local rainfall of the order of 400-500 mm in this next 100 years. This could reduce recharge to the SEPP26 forest by the order of 50 ML/year. The amount could be higher with increased ET rates as a result of a mean surface temperature increase of say 1°C. Over the next 20 years, the recharge reduction would be approximately 10 ML/year, which is approximately equivalent to change in recharge resulting from the 70 % impervious urban area development scenario. Our view is that the proposed urban area could provide a valuable water resource for the SEPP 26 forest against the backdrop of potential climate change.

5 Summary and Mitigation Measures

The following comments are provided in terms of summarising the study outcomes and providing recommended management measures which will mitigate any potential impacts on groundwater conditions within or near to the SEPP 26 forest.

1. We broadly concur with the vegetated set-back or buffer approach provided by King & Campbell in the draft LES structure plan. On the basis of a proposed average 40 m planted distance, there are unlikely to be significant impacts on groundwater conditions below the SEPP 26 forest community.

2. With consideration to the potential impacts of climate change on local hydrogeology, it is likely that groundwater re-charge and soil moisture conditions will be considerably reduced from existing conditions over the next 20-100 years. This being the case, we see that controlled urban runoff will provide a possible mechanism to supply additional water to the SEPP26 forest otherwise lost through reduced annual rainfall and increased evaporation.

   On this basis, we recommend that the planted buffer be reduced from the 40 m provided in the structure plan to a mean of 30 m. Impervious urban areas up to 70 % should be acceptable, provided that the final stormwater designs can demonstrate that sufficient control over the balance between surface and sub-surface hydrology can be met. Initially, the stormwater system should be capable of delivering the majority of urban runoff to groundwater (through deep infiltration). However, as rainfall patterns change, the system should be readily modified to allow addition surface discharges to the SEPP 26 forest, thereby ensuring adequate soil moisture conditions.

   We suggest that stormwater discharge control pits upstream of the infiltration trenches, fitted with variable or exchangeable orifice plates, could be used to readily adjust flow rates to the deep infiltration trenches.

3. Deep stormwater infiltration trenches should be constructed within the planted buffer zone. These should be excavated so that they extend through the surface clay layer and intersect the lower sand aquifer. There should be good connectivity

between the infiltration trench bed and the underlying permeable aquifer.

The effect of this will be to ensure that surface water is allowed to rapidly enter the local groundwater table without excessively saturating surface soils except during extreme rainfall conditions. This mechanism will have the additional benefit of reducing some of the edge effects of the existing pasture which is likely to have raised surface soil moisture conditions adjacent to the SEPP 26 forest.

4. We recommend that the deep infiltration trenches be subject to more rigorous geotechnical investigation and detailed design at the development application (DA) stage. A series of 4 further groundwater bores should be established along the SEPP 26 zone within the proposed revegetated buffer zone with saturated hydraulic conductivity determined for the deeper underlying sand aquifer. These data will be used to assist in the design of the infiltration trenches.

5. We recommend that water which does not infiltrate to the deeper groundwater system [ie. surcharges from the infiltration trenches via surcharge pits], is evenly distributed as it is released into the planted vegetated buffer area. Further to this, ground within the buffer area should be prepared in such a way so as to ensure maximum infiltration. This can be achieved by way of ground 'riffling' or minor contouring.

6. The buffer revegetation programme should be undertaken as soon as possible so as to ensure that maximum evapotranspiration rates can be achieved as early a possible in the development process.

7. We recommend the establishment of 2 further monitoring bores within the SEPP 26 area (if this is possible) so that the current groundwater model for the area is can be extended to the coast as far as practical. Bores should be located in either sub-catchments C2 or C3. It would be useful to continue monitoring these piezometers, those already established, and those nominated in recommendation 4, throughout the coming year as the development process proceeds. Bores with the SEPP 26 area may need to be installed by hand or water jetting given the site sensitivity and difficulty of site access.

8. Further groundwater quality monitoring is recommended to provide better base-line groundwater quality data. In addition

to those parameters already covered by this study, bound and unbound phosphorus levels should be determined in any future sampling. This will enable improved design of water quality treatment structures and infiltration trenches. We recommend 6 monthly water quality sampling.

9. Other than the deep infiltration trenches, care should be taken within the development areas that groundwater is not intersected and hence groundwater flow impeded or redirected. On the hillslopes, we suggest that excavations should preferably not exceed 2.5 m below ground level. If deeper excavations are required, then suitable mitigation measures should be included to ensure that groundwater flow is not redirected or lowered through draining. We do not believe that this will compromise future development.

   On the lower slopes, say below 12.5 mAHD (which excludes the majority of the residential development area), excavation other than for the deep infiltration trenches, permanent excavation > 1 m in depth are not recommended due to the potential to locally lower groundwater levels, notably the intermittently perched [elevated] water tables. This should be taken into account when designing the stormwater management system for the development. Trenching for services should not be affected by this recommendation as these will be backfilled with suitable material [ie. similar permeability to existing materials] and should not act to lower groundwater tables.

   In the case of roads in low lying areas, we recommend that these should be constructed to enable sufficient durability and bearing pressure under the assumption that the groundwater table may be close to or within the sub-grade materials.

10. OSD structures, including domestic rainwater tanks and other surface storages should be used to ensure that post-development flow rates approximate as close as possible pre-development flows. This means that recharge to groundwater will be at approximately the same rate as the present.

6 References

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Hazelton, P. A, Murphy, B. W. (eds, 1992) *What Do All The Numbers Mean ?*, NSW Department of Conservation and Land Management

Myers, B. J., Bond, W. J., Benyon, R. G., Falkiner, R. A., Polglase, P. J., Smith, C. J., Snow, V. O. and Theiveyanathan, S. (1999) Sustainable Effluent Irrigated Plantations: An Australian Guideline, CSIRO Forestry and Forestry Products, CSIRO Land and Water, Canberra, Australia

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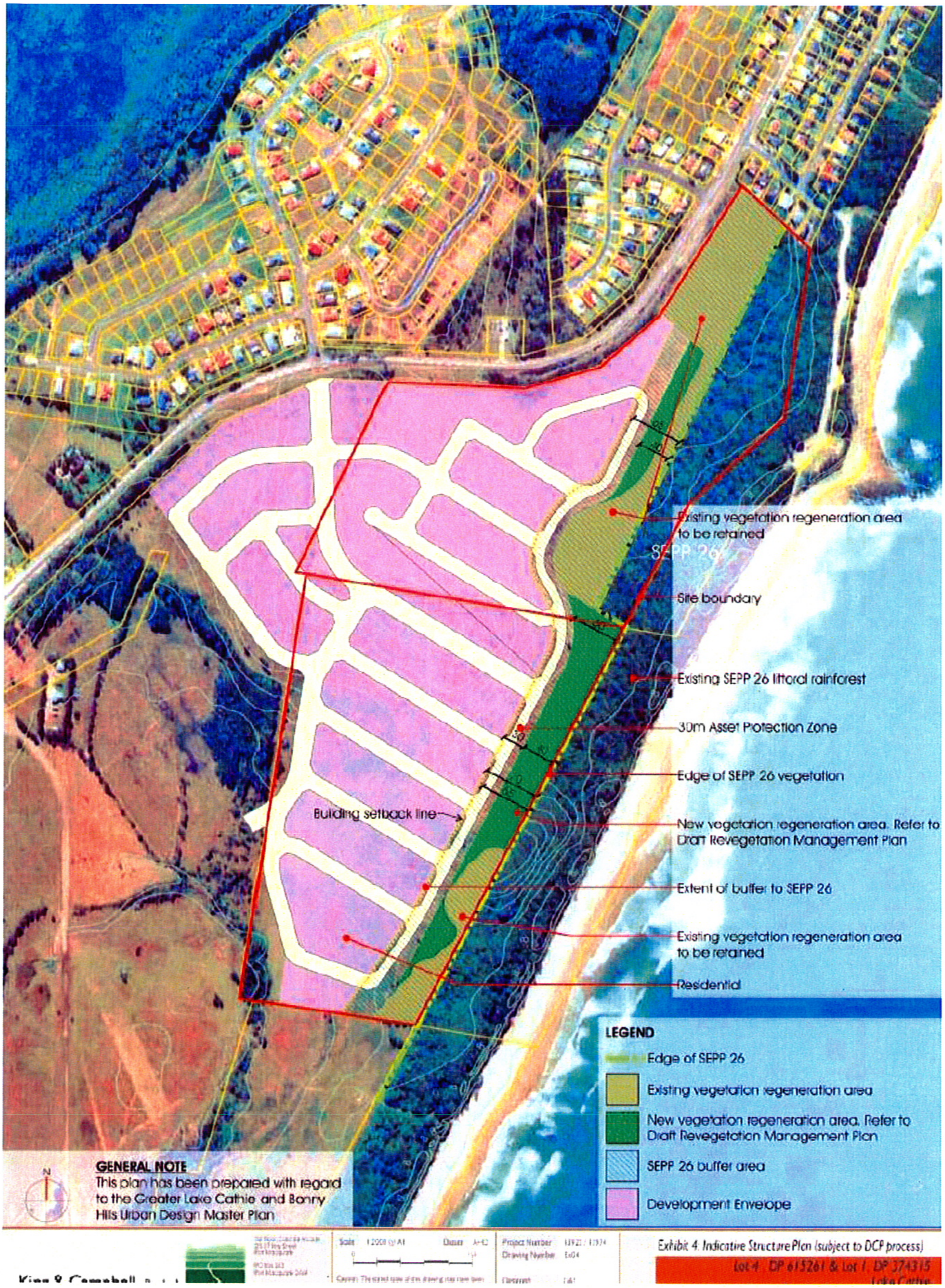
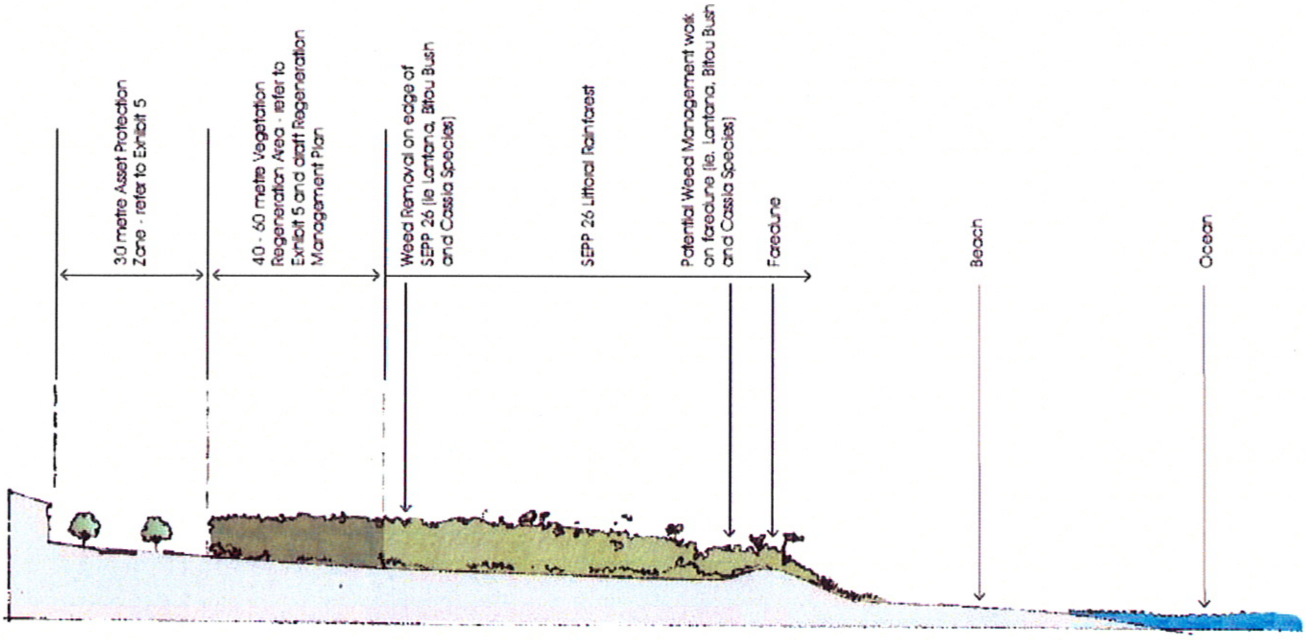
7 Attachment A – Development Proposal


Existing vegetation regeneration area to be retained
SEPP 26
Site boundary
Existing SEPP 26 littoral rainforest
30m Asset Protection Zone
Edge of SEPP 26 vegetation
New vegetation regeneration area. Refer to Draft Revegetation Management Plan
Extent of buffer to SEPP 26
Existing vegetation regeneration area to be retained
Residential
Building setback line
LEGEND
Edge of SEPP 26
Existing vegetation regeneration area
New vegetation regeneration area. Refer to Draft Revegetation Management Plan
SEPP 26 buffer area
Development Envelope
N
GENERAL NOTE
This plan has been prepared with regard to the Greater Lake Cathie and Bonny Hills Urban Design Master Plan
King & Campbell
Scale 1:2000 @ A1
Project Number
Drawing Number
Exhibit 4. Indicative Structure Plan (subject to DCP process)
Lot 4 DP 615261 & Lot 1 DP 374315
Lake Cathie

Proposed typical section littoral rainforest



8 Attachment B – Plan Set

AREA 14 STAGE 1B GROUNDWATER STUDY
LAKE CATHIE, NSW

SHEET	DESCRIPTION
1	COVER
2	STUDY AREA AND SAMPLING LOCATIONS
3	COASTAL CATCHMENTS AND EXISTING LAND-USE
4	STYLISED HYDRO-GEOLOGICAL SECTION

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CLIENT/ PROJECT
HASTINGS COUNCIL
GW INVESTIGATIONS
AREA 14, LAKE CATHIE

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

TITLE
PLAN COVER

PROJECT MANAGER:
DR D. MARTENS

DRAWING NUMBER:
[illegible]

DESIGNED:
DMH

DRAWN:
[illegible]

REVIEWED:
DMH

DATUM:
NA

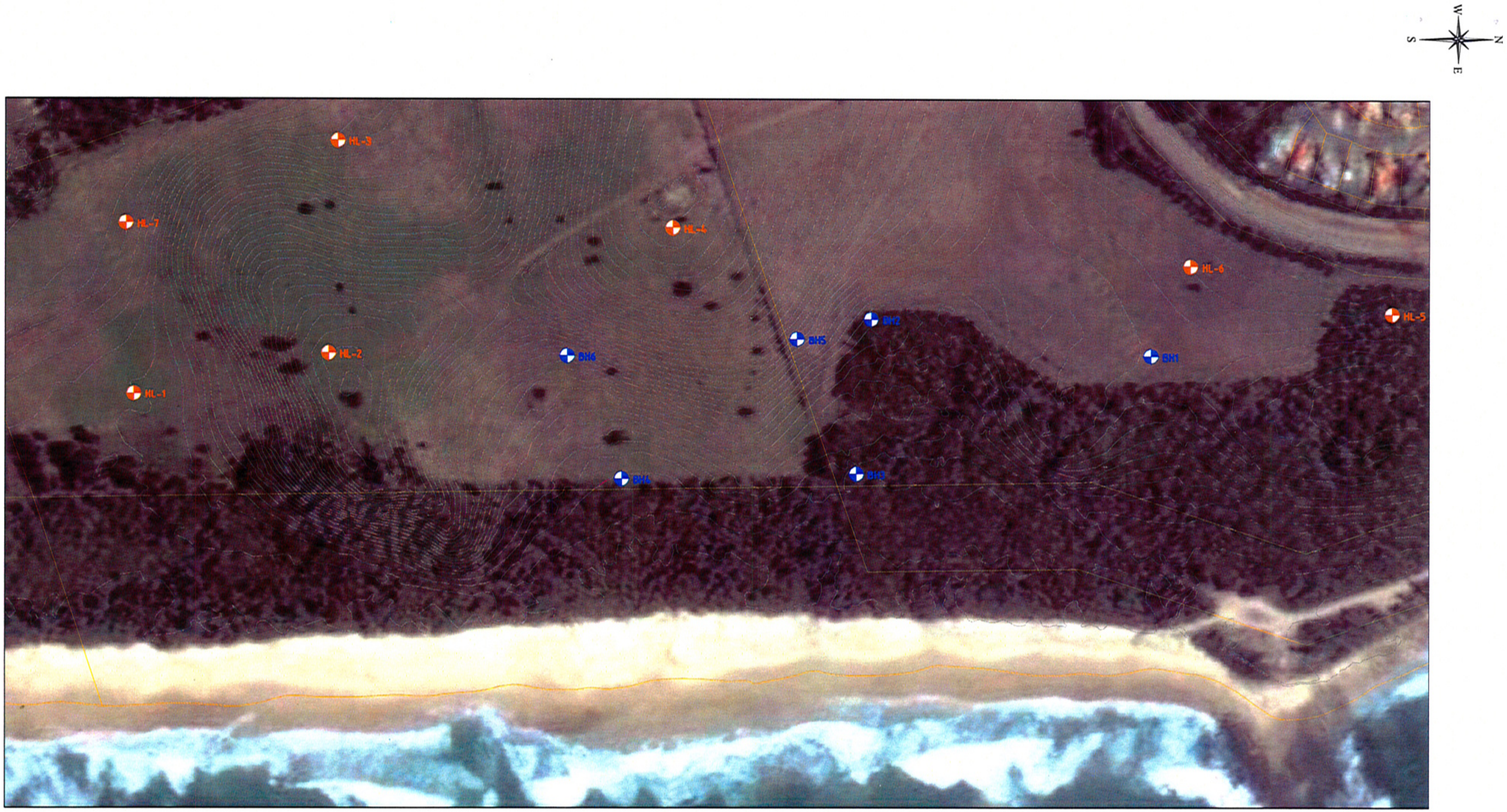
HORIZONTAL RATIO:
NA

VERTICAL RATIO:
NA

SHEET
1
OF 4
SHEETS

PAPER SIZE:
A4

REV.	DESCRIPTION	DATE	ISSUED
1.0	PRELIMINARY DRAFT	12.3.2007	DMH



● HACKETT LABORATORIES TEST PIT LOCATION (FEBRUARY 2001)

● MARTENS BOREHOLE / PIEZOMETER LOCATION (NOVEMBER 2006)

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CLIENT/ PROJECT
HASTINGS COUNCIL
GW INVESTIGATIONS
AREA 14, LAKE CATHIE

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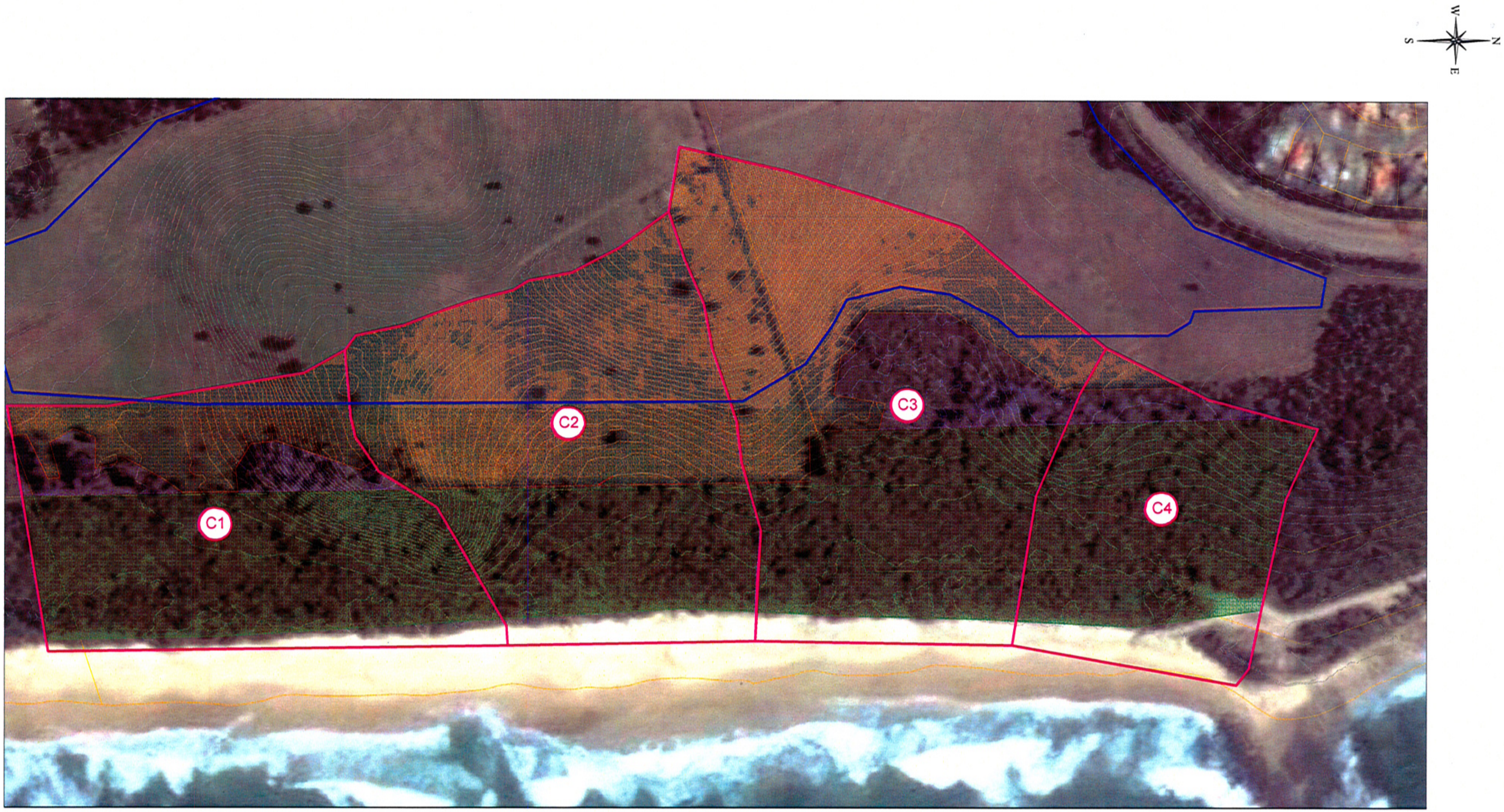
All measurements in mm unless otherwise specified.

TITLE
STUDY AREA AND SAMPLING LOCATIONS

PROJECT MANAGER: **DR D. MARTENS**
DRAWING NUMBER: **P0600304JS01-G3-V1**

DESIGNED: **DMM**
DRAWN: **KS/DMM**
REVIEWED: **DMM**
DATUM: **mAHD**
HORIZONTAL RATIO: **1:4000**
VERTICAL RATIO: **1:4000**
SHEET 2 OF 4 SHEETS
PAPER SIZE: **A4**

REV.	DESCRIPTION	DATE	ISSUED
1.0	PRELIMINARY DRAFT	12.3.2007	DMM



🟥 SUB-CATCHMENT BOUNDARY

🟦 STRUCTURE PLAN DEVELOPMENT AREA

🟩 EXISTING SEPP 26 FOREST

🟪 EXISTING VEGETATION REGENERATION AREA

🟧 EXISTING PASTURE

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CLIENT/ PROJECT
HASTINGS COUNCIL
GW INVESTIGATIONS
AREA 14, LAKE CATHIE

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

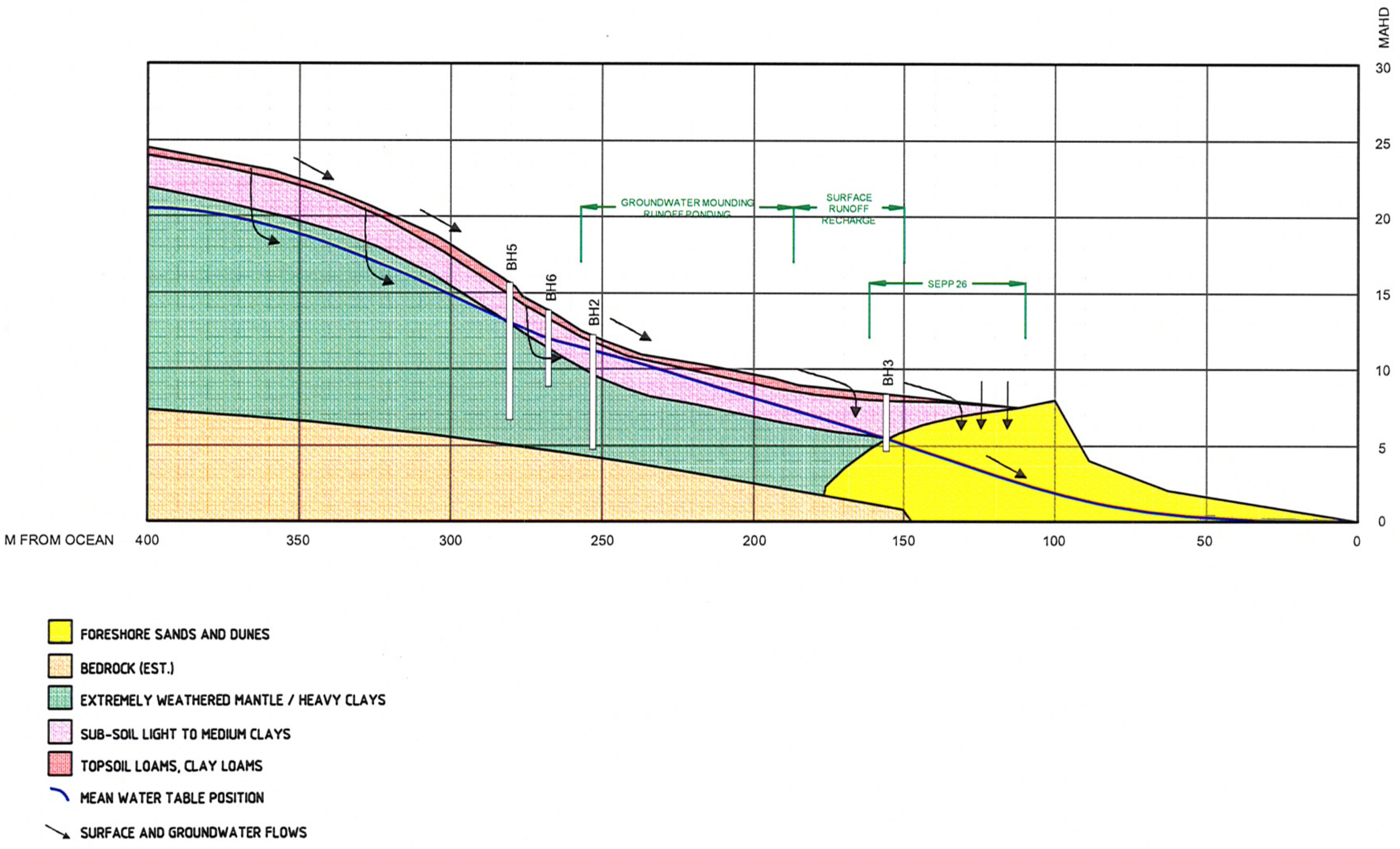
TITLE
COASTAL SUB-CATCHMENTS, EXISTING LAND-USE
AND EXTENT OF URBAN AREAS AS DEFINED IN STRUCTURE PLAN

PROJECT MANAGER: DR D. MARTENS

DRAWING NUMBER: P0601504JD01-S3-V1

DESIGNED: DMM
DRAWN: DMM
REVIEWED: DMM
DATUM: mAHD
HORIZONTAL RATIO: 1:4000
VERTICAL RATIO: 1:4000
SHEET 3 OF 4 SHEETS
PAPER SIZE: A4

REV.	DESCRIPTION	DATE	ISSUED
1.0	PRELIMINARY DRAFT	12.3.2007	DMM



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CLIENT/ PROJECT
HASTINGS COUNCIL
GW INVESTIGATIONS
AREA 14, LAKE CATHIE

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

TITLE
STYLISED HYDRO-GEOLOGICAL SECTION

PROJECT MANAGER: DR D. MARTENS
DRAWING NUMBER: [illegible]

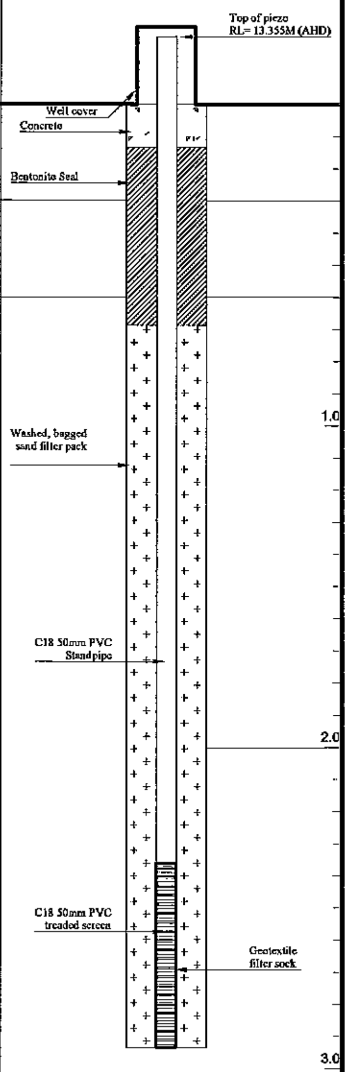
DESIGNED: DMH
DRAWN: DMH
REVIEWED: DMH
DATUM: mAHD
HORIZONTAL RATIO: 1:2000
VERTICAL RATIO: 1:400
SHEET 4 OF 4 SHEETS
PAPER SIZE: A4

REV.	DESCRIPTION	DATE	ISSUED
1.0	PRELIMINARY DRAFT	12.3.2007	DMH

9 Attachment C – Borehole Logs

CLIENT	**HASTINGS COUNCIL**	COMMENCED	9/11/06	COMPLETED	9/11/06	**REF BH1**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GH	CHECKED	GT	Sheet 1 of 2
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO. P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	12.815M (AHD)	
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 7.5M	NORTHING	NA	ASPECT	EAST	SLOPE 0-5%

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)	WELL CONSTRUCTION DETAILS
A	Nil	N	W	0.3			L	LOAM - Brown, moderately structured.	S		A 1331	0.2 1/0.2	
A	Nil	N	W	0.6			LC	LIGHT CLAY - Browny yellow, massive, weakly structured.	S				
A	Nil	N ▽	M W	1.0 2.0 3.0 3.5			MC	MEDIUM CLAY - Orange with minor grey mottling, firm, well structured.	F				
A	Nil	Y	W	4.0			MC	CLAY- Dark grey, 15% gravels (1-5mm).	F				



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
- Y USCS
- N Agricultural

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

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Engineering Log - Borehole

Quality Sheet No. 4

CLIENT	**HASTINGS COUNCIL**	COMMENCED	9/11/06	COMPLETED	9/11/06	**REF**	**BH1**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GH	CHECKED	GT	Sheet 2 of 2	
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	12.816M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 7.5M	NORTHING	NA	ASPECT	EAST	SLOPE	0-5%

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)	WELL CONSTRUCTION DETAILS
				5.0									5.0
A	Nil	Y	W				MC	CLAY- Dark grey, 15% gravels (1-5mm).	F				
				6.0									6.0
								Borehole terminated at 6.0m on clays.					
				7.0									7.0
				8.0									8.0

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
Y USCS
N Agricultural

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

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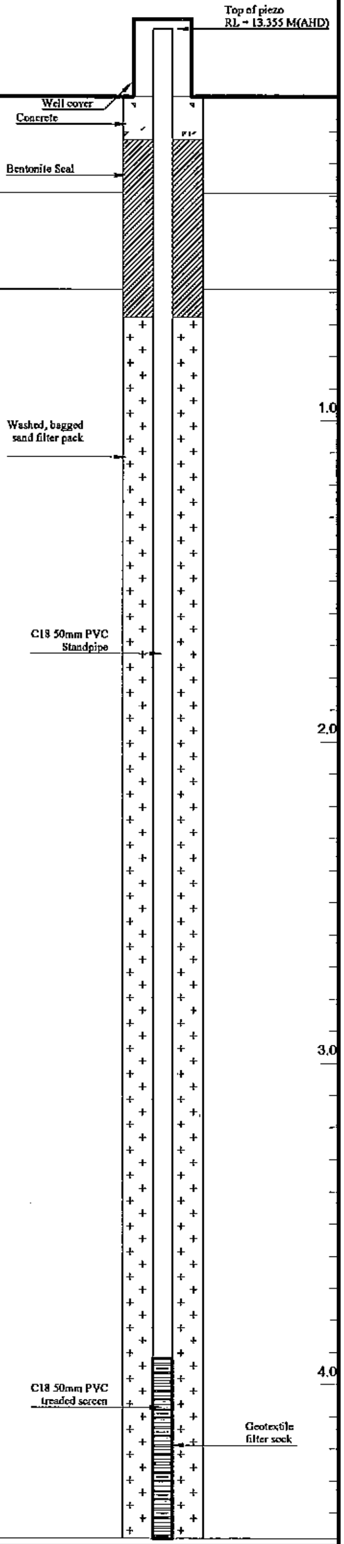
Engineering Log - Borehole

CLIENT	**HASTINGS COUNCIL**	COMMENCED	9/11/06	COMPLETED	9/11/06	**REF**	**BH2**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GH	CHECKED	GT	Sheet 1 of 2	
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	12.13M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 7.6M	NORTHING	NA	ASPECT	EAST	SLOPE	0-5%

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)
A	Nil	N	W	0.3			L	LOAM - Brown, moderately structured.	S		A 1331	0.2 1/0.2
A	Nil	N	W	0.6			LC	LIGHT CLAY - Browny yellow, massive, weakly structured.	S			
A	Nil	N	M	1.0 2.0 3.0 4.0 4.5			HC	HEAVY CLAY - Red and white mottled, plastic.	S			

WELL CONSTRUCTION DETAILS



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
Y USCS
N Agricultural

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

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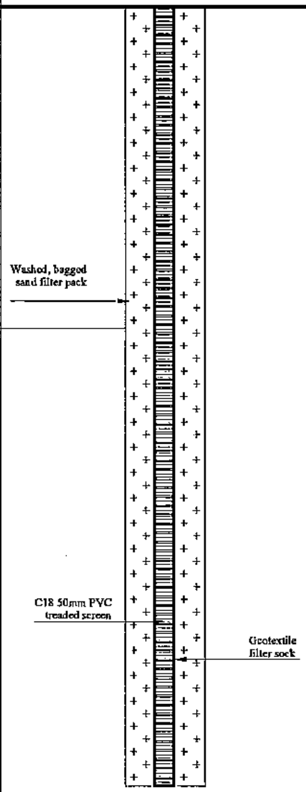
Engineering Log - Borehole

CLIENT	**HASTINGS COUNCIL**	COMMENCED	9/11/06	COMPLETED	9/11/06	**REF BH2**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GH	CHECKED	GT	Sheet 2 of 2
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO. P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	12.13M (AHD)	
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 7.5M	NORTHING	NA	ASPECT	EAST	SLOPE 0-5%

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)	WELL CONSTRUCTION DETAILS
A	Nil	N	M	5.0 5.5			C	CLAY- With 10-15% sharp edged gravels (0-10mm).	F		A 1331/	0.2 1/0.2	
A	Nil	N	W	6.0 7.0 7.5			C	CLAY - Pink and orange, saturated, soft, with 10-15% sharp edged gravels (0-10mm).	St				
				8.0				Borehole terminated at 7.5m on clay.					



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
Y USCS
N Agricultural

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

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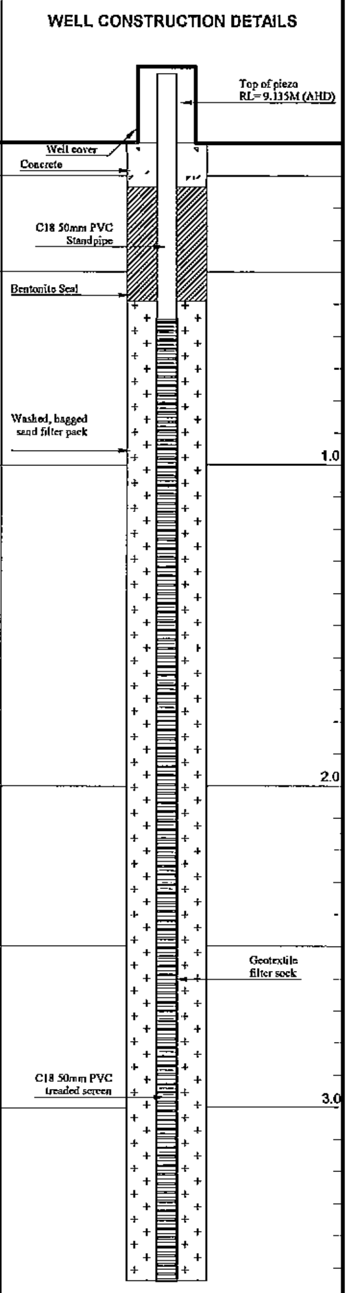
Engineering Log - Borehole

CLIENT	HASTINGS COUNCIL	COMMENCED	9/11/06	COMPLETED	9/11/06	**REF**	**BH3**
PROJECT	GROUNDWATER INVESTIGATIONS	LOGGED	GH	CHECKED	GT	Sheet 1 of 2	
SITE	AREA 14, LAKE CATHIE	GEOLOGY	SANDSTONE	VEGETATION	RAINFOREST	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	8.375M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 6.0M	NORTHING	NA	ASPECT	EAST	SLOPE	0-5%



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)
A	Nil	N	W	0.1			SIC	SILTY CLAY - Brown.	S			
A	Nil	N	W	0.4			LC	LIGHT CLAY - Browny yellow, massive, weakly structured.	S		A 1331/1	0.2 /0.2
A	Nil	N	M	1.0			C	MEDIUM TO HEAVY CLAY - Red and orange mottled.	F			
A	Nil	N	M	2.0			C	MEDIUM TO HEAVY CLAY - Orange and white mottled.	F			
A	Nil	N ∇	M	2.5			SC	SANDY CLAY - Orange.	F			
A	Nil	N	W	3.0			CS	CLAYEY SAND - Orange.		MD		
A	Nil	N	W	4.0			CS	CLAYEY SAND - Orange.		MD		

EQUIPMENT / METHOD	SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
N Natural exposure	SH Shoring	N None observed	D Dry	L Low	VS Very Soft	VL Very Loose	A Auger sample	pp Pocket penetrometer	Y USCS
X Existing excavation	SC Shotcrete	X Not measured	M Moist	M Moderate	S Soft	L Loose	B Bulk sample	S Standard penetration test	N Agricultural
BH Backhoe bucket	RB Rock Bolts	∇ Water level	W Wet	H High	F Firm	MD Medium Dense	U Undisturbed sample	VS Vane shear	
E Excavator	Nil No support	◁ Water outflow	Wp Plastic limit	R Refusal	St Stiff	D Dense	D Disturbed sample	DCP Dynamic cone penetrometer	
HA Hand auger		▷ Water inflow	Wl Liquid limit		VSt Very Stiff	VD Very Dense	M Moisture content	FD Field density	
S Hand spade					H Hard		Ux Tube sample (x mm)	WS Water sample	
PT Push tube					F Friable				
A Auger									

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

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Engineering Log - Borehole

CLIENT	**HASTINGS COUNCIL**	COMMENCED	9/11/06	COMPLETED	9/11/06	**REF**	**BH3**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GH	CHECKED	GT	Sheet 2 of 2	
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	RAINFOREST	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	8.375M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 6.0M	NORTHING	NA	ASPECT	EAST	SLOPE	0-5%

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)	WELL CONSTRUCTION DETAILS	
											A	0.2	1331/1/0.2	
A	Nil	N	W	5.0			CS	CLAYEY SAND - Orange.		D				5.0
				6.0										6.0
								Borehole terminated at 6.0m on clayey sand.						
				7.0										7.0
				8.0										8.0

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
Y USCS
N Agricultural

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

martens

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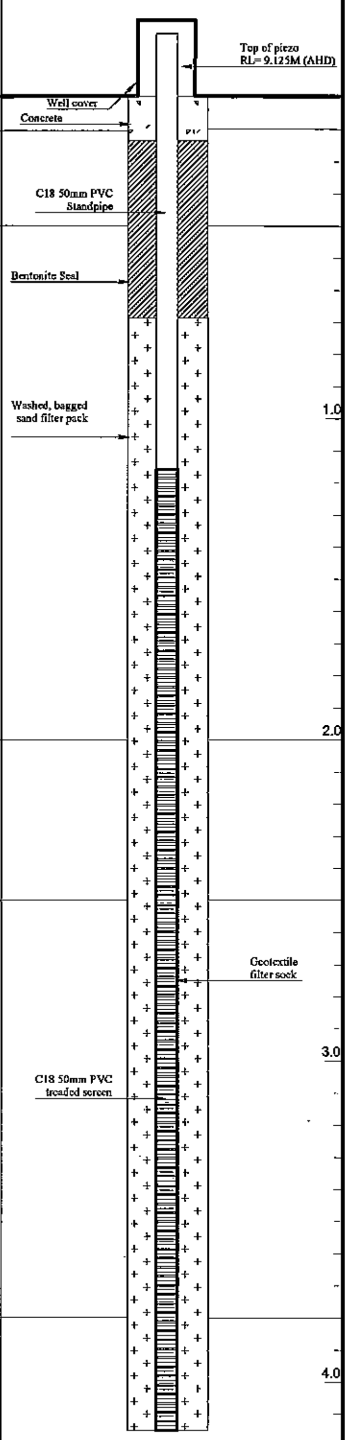
Engineering Log - Borehole

CLIENT	**HASTINGS COUNCIL**	COMMENCED	10/11/06	COMPLETED	10/11/06	**REF**	**BH4**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GH	CHECKED	GT	Sheet 1 of 2	
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	8.31M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 6.0M	NORTHING	NA	ASPECT	EAST	SLOPE	0-5%

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)	WELL CONSTRUCTION DETAILS
A	Nil	N	W	0.1			SIC	SILTY CLAY - Brown.	S				
A	Nil	N	W	0.4			LC	LIGHT CLAY - Browny yellow, massive, weakly structured.	S		A 1331/1/0.2	0.2	
A	Nil	N	M	1.0 2.0			MC	MEDIUM CLAY - Orange with minor grey mottling, firm, well structured.	F				
A	Nil	N	W	2.5			SC	LIGHT SANDY CLAY - Orange.	F				
A	Nil	N	Wp	3.0 3.8			CS	CLAYEY SAND - Orange.		MD			
A	Nil	N	Wl	4.0			CS	FINE CLAYEY SAND - Pinky orange, totally structured. Rounded pebbles hit with auger, <20mm with possible larger stones in profile.		MD			



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
Y USCS
N Agricultural

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Engineering Log - Borehole

CLIENT	HASTINGS COUNCIL	COMMENCED	10/11/06	COMPLETED	10/11/06	**REF**	**BH4**
PROJECT	GROUNDWATER INVESTIGATIONS	LOGGED	GH	CHECKED	GT	Sheet 2 of 2	
SITE	AREA 14, LAKE CATHIE	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	8.31M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 6.0M	NORTHING	NA	ASPECT	EAST	SLOPE	0.5%

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)	WELL CONSTRUCTION DETAILS
				5.0									5.0
A	Nil	N	Wl				CS	FINE CLAYEY SAND - Pinky orange, totally structured. Rounded pebbles hit with auger, <20mm with possible larger stones in profile.		D			
				6.0									6.0
								Borehole terminated at 6.0m on clayey sand.					
				7.0									7.0
				8.0									8.0

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
Y USCS
N Agricultural

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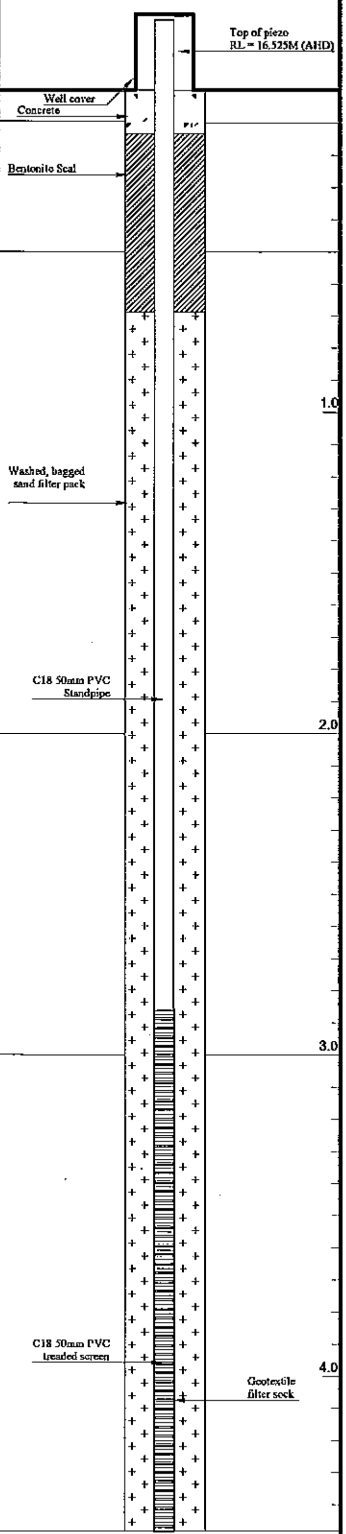
Engineering Log - Borehole

CLIENT	**HASTINGS COUNCIL**	COMMENCED	10/11/06	COMPLETED	10/11/06	**REF BH5**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GT	CHECKED	GH	Sheet 1 of 2
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO. P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	15.725M (AHD)	
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 9.0M	NORTHING	NA	ASPECT	EAST	SLOPE 5-10%

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)	WELL CONSTRUCTION DETAILS
A	Nil	N	M	0.1			SiC	SILTY CLAY - Dark brown.	S				
A	Nil	N	M	0.5			C	CLAY - Orange/brown (no sands).	F		A 1331/1	0.2 0.2	
A	Nil	N	M	1.0 2.0			C	CLAY - White/light grey with red mottling.	F				
A	Nil	N	M	3.0			C	CLAY - White with pink/red mottling with 10% gravels (1-10mm).	F				
A	Nil	N	M	4.0 4.5			C	CLAY - White with pink/red mottling with 5% gravels (1-5mm).	F				



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
Y USCS
N Agricultural

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

martens

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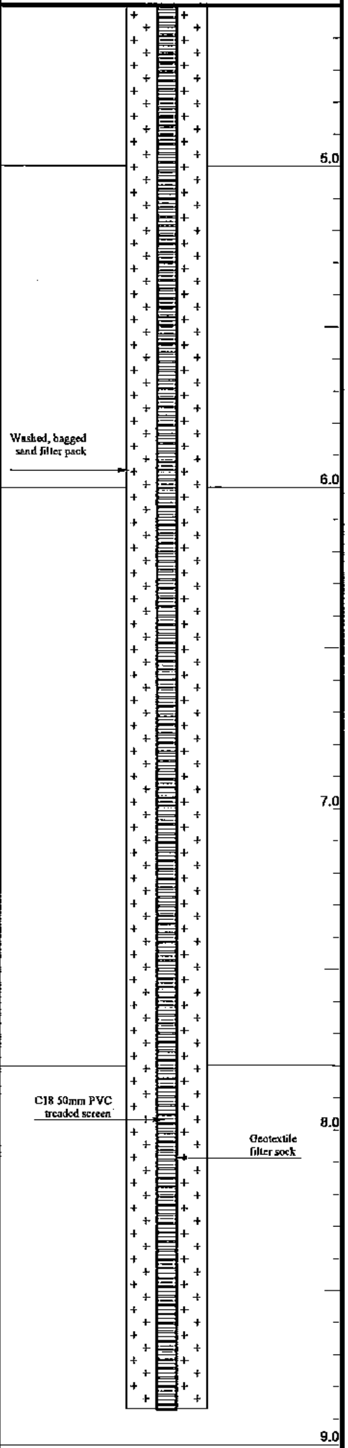
Engineering Log - Borehole

CLIENT	**HASTINGS COUNCIL**	COMMENCED	10/11/06	COMPLETED	10/11/06	**REF**	**BH5**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GT	CHECKED	GH	Sheet **2** of **2**	
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	15.725M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 9.0M	NORTHING	NA	ASPECT	EAST	SLOPE	5-10%

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)	WELL CONSTRUCTION DETAILS
A	Nil	N	M	5.0			C	CLAY - White with pink/red mottling with 5% gravels (1-5mm).	F				
A	Nil	N	M	6.0			C	CLAY - White with pink/red mottling with 5% gravels (1-5mm).	St				
A	Nil	N	M	7.0 7.8			C	CLAY - Orange, clean.	St				
A	Nil	N	W	8.0 9.0			C	CLAY - Orange, clean. Borehole terminated at 9.0m on clay.	St				



EQUIPMENT / METHOD	SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
N Natural exposure	SH Shoring	N None observed	D Dry	L Low	VS Very Soft	VL Very Loose	A Auger sample	pp Pocket penetrometer	Y USCS
X Existing excavation	SC Shotcrete	X Not measured	M Moist	M Moderate	S Soft	L Loose	B Bulk sample	S Standard penetration test	N Agricultural
BH Backhoe bucket	RB Rock Bolts	⊻ Water level	W Wet	H High	F Firm	MD Medium Dense	U Undisturbed sample	VS Vane shear	
E Excavator	Nil No support	◁ Water outflow	Wp Plastic limit	R Refusal	St Stiff	D Dense	D Disturbed sample	DCP Dynamic cone penetrometer	
HA Hand auger		▷ Water inflow	Wl Liquid limit		VSt Very Stiff	VD Very Dense	M Moisture content	FD Field density	
S Hand spade					H Hard		Ux Tube sample (x mm)	WS Water sample	
PT Push tube					F Friable				
A Auger									

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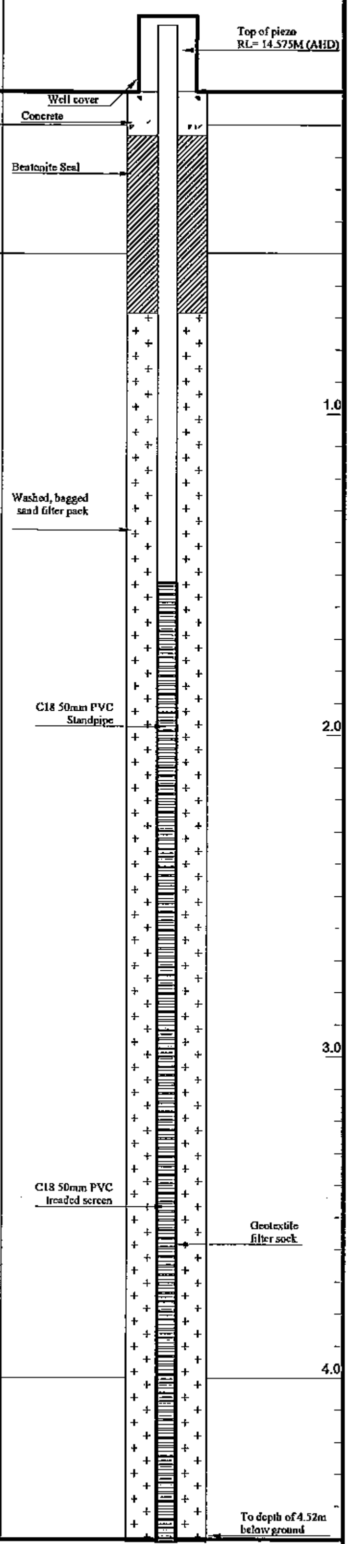
Engineering Log - Borehole

CLIENT	**HASTINGS COUNCIL**	COMMENCED	10/11/06	COMPLETED	10/11/08	**REF**	**BH6**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GH	CHECKED	GT	Sheet	1 of 2
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	13.80M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 5.5M	NORTHING	NA	ASPECT	EAST	SLOPE	5-10%

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)	WELL CONSTRUCTION DETAILS
A	Nil	N	M	0.1			SiL	SILTY LOAM - Brown, organic.	S				
A	Nil	N	M	0.5			LC	LIGHT CLAY - Browny yellow, massive, weakly structured.	F				
A	Nil	N	D-M	1.0 2.0 3.0 4.0			SC	LIGHT SANDY CLAY - Brownish yellow with 15% small angular gravels (<10mm) throughout.	F				
A	Nil	N	M				SC	LIGHT SANDY CLAY - Light brown with 15% small angular gravels (<10mm) throughout.	St				



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
Y USCS
N Agricultural

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

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Engineering Log - Borehole

CLIENT	**HASTINGS COUNCIL**	COMMENCED	10/11/06	COMPLETED	10/11/06	**REF**	**BH6**
PROJECT	**GROUNDWATER INVESTIGATIONS**	LOGGED	GH	CHECKED	GT	Sheet 2 of 2	
SITE	**AREA 14, LAKE CATHIE**	GEOLOGY	SANDSTONE	VEGETATION	PASTURE	PROJECT NO.	P0601504
EQUIPMENT	AUGER	EASTING	NA	RL SURFACE	13.80M (AHD)		
EXCAVATION DIMENSIONS	DIA: 100MM DEPTH: 5.5M	NORTHING	NA	ASPECT	EAST	SLOPE	5-10%

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)	WELL CONSTRUCTION DETAILS
A	Nil	N	M	5.0 5.5			SC	LIGHT SANDY CLAY - Light brown with 15% small angular gravels (<10mm) throughout.	St				5.0
				6.0 7.0 8.0				Borehole terminated at 5.5m on redrock.					6.0 7.0 8.0

EQUIPMENT / METHOD	SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
N Natural exposure	SH Shoring	N None observed	D Dry	L Low	VS Very Soft	VL Very Loose	A Auger sample	pp Pocket penetrometer	Y USCS
X Existing excavation	SC Shotcrete	X Not measured	M Moist	M Moderate	S Soft	L Loose	B Bulk sample	S Standard penetration test	N Agricultural
BH Backhoe bucket	RB Rock Bolts	▽ Water level	W Wet	H High	F Firm	MD Medium Dense	U Undisturbed sample	VS Vane shear	
E Excavator	Nil No support	◁ Water outflow	Wp Plastic limit	R Refusal	St Stiff	D Dense	D Disturbed sample	DCP Dynamic cone penetrometer	
HA Hand auger		▷ Water inflow	Wl Liquid limit		VSt Very Stiff	VD Very Dense	M Moisture content	FD Field density.	
S Hand spade					H Hard		Ux Tube sample (x mm)	WS Water sample	
PT Push tube					F Friable				
A Auger									

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Engineering Log - Borehole

10 Attachment D – Laboratory Results

LabMark

CUSTOMER CENTRIC - ANALYTICAL CHEMISTS

ilac-MRA

NATA
No. 13542.

Accredited for compliance with ISO/IEC 17025. The results of tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.

AQIS
AUSTRALIAN QUARANTINE AND INSPECTION SERVICE
SYDNEY License No. N0356.

Quarantine Approved Premises criteria 5.1 for quarantine containment level 1 (QCI) facilities. Class five criteria cover premises utilised for research, analysis and testing of biological material, soil, animal, plant and human products.

FINAL CERTIFICATE OF ANALYSIS - ENVIRONMENTAL DIVISION

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Client Reference: Area 14 Lake Cathie
Contact Name: Grant Harlow
Chain of Custody No: na
Sample Matrix: WATER

Cover Page 1 of 4
plus Sample Results

Date Received: 24/11/2006
Date Reported: 06/12/2006

This Final Certificate of Analysis consists of sample results, DQI's, method descriptions, laboratory definitions, and internationally recognised NATA accreditation and endorsement. The DQO compliance relates specifically to QA/QC results as performed as part of the sample analysis, and may provide an indication of sample result quality. Transfer of report ownership from Labmark to the client shall only occur once full & final payment has been settled and verified. All report copies may be retracted where full payment has not occured within the agreed settlement period.

QUALITY ASSURANCE CRITERIA

Accuracy:	matrix spike:	1 in first 5-20, then 1 every 20 samples
	lcs, crm, method:	1 per analytical batch
	surrogate spike:	addition per target organic method
Precision:	laboratory duplicate:	1 in first 5-10, then 1 every 10 samples
	laboratory triplicate:	re-extracted & reported when duplicate RPD values exceed acceptance criteria
Holding Times:	soils, waters:	Refer to LabMark Preservation & THT table VOC's 14 days water / soil VAC's 7 days water or 14 days acidified VAC's 14 days soil SVOC's 7 days water, 14 days soil Pesticides 7 days water, 14 days soil Metals 6 months general elements Mercury 28 days
Confirmation:	target organic analysis:	GC/MS, or confirmatory column
Sensitivity:	EQL:	Typically 2-5 x Method Detection Limit (MDL)

QUALITY CONTROL GLOBAL ACCEPTANCE CRITERIA (GAC)

Accuracy:	spike, lcs, crm surrogate:	general analytes 70% - 130% recovery phenol analytes 50% - 130% recovery organophosphorous pesticide analytes 60% - 130% recovery phenoxy acid herbicides 50% - 130% recovery
	anion/cation bal:	+/- 10% (0-3 meq/l), +/- 5% (>3 meq/l)
Precision:	method blank:	not detected >95% of the reported EQL
	duplicate lab RPD (metals):	0-30% (>10xEQL), 0-75% (5-10xEQL) 0-100% (<5xEQL)
	duplicate lab RPD:	0-50% (>10xEQL), 0-75% (5-10xEQL) 0-100% (<5xEQL)

QUALITY CONTROL ANALYTE SPECIFIC ACCEPTANCE CRITERIA (ASAC)

Accuracy:	spike, lcs, crm surrogate:	analyte specific recovery data <3xsd of historical mean
Uncertainty:	spike, lcs:	measurement calculated from historical analyte specific control charts

RESULT ANNOTATION

DQO:	Data Quality Objective	s:	matrix spike recovery	p:	pending
DQI:	Data Quality Indicator	d:	laboratory duplicate	lcs:	laboratory control sample
EQL:	Estimated Quantitation Limit	t:	laboratory triplicate	crm:	certified reference material
-- :	not applicable	r:	RPD relative % difference	mb:	method blank

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Simon Mills
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This document is issued in accordance with NATA's accreditation requirements.

Laboratory Report: E029326

Cover Page 2 of 4

NEPC GUIDELINE COMPLIANCE - DQO

1. GENERAL

A. Results relate specifically to samples as received. Sample results are not corrected for matrix spike, lcs, or surrogate recovery data.

B. EQL's are matrix dependant and may be increased due to sample dilution or matrix interference.

C. Laboratory QA/QC samples are specific to this project.

D. Inter-laboratory proficiency results are available upon request. NATA accreditation details available at www.nata.asn.au.

E. VOC spikes & surrogates added to samples during extraction, SVOC spikes & surrogates added prior to extraction.

F. Recovery data outside GAC limits shall be investigated and compared to ASAC (historical mean +/- 3sd). If recovery data <20%, then the relevant results for that compound are considered not reliable.

G. Recovery data (ms, surrogate, crm, lcs) outside ASAC limits shall initiate an investigative action. Anomolous QC data is examined in conjunction with other QC samples and a final decision whether to accept or reject results is provided by the professional judgement of the senior analyst. The USEPA-CLP National Functional Guidelines are referred to for specific recommendations.

H. Extraction (preparation) date refers to the date that sample preparation was initiated. Note that certain methods not requiring sample preparation (eg. VOCs in water, etc) may report a common extraction and analysis date.

I. LabMark shall maintain an official copy of this Certificate of Analysis for all tracable reference purposes.

2. CHAIN OF CUSTODY (COC) & SAMPLE RECEIPT NOTICE (SRN) REQUIREMENTS

A. SRN issued to client upon sample receipt & login verification.

B. Preservation & sampling date details specified on COC and SRN, unless noted.

C. Sample Integrity & Validated Time of Sample Receipt (VTSR) Holding Times verified (preservation may extend holding time, refer to preservation chart).

3. NATA ACCREDITED METHODS

A. NATA accreditation held for each in-house method and sample matrix type reported, unless noted below (Refer to subcontracted test reports for NATA accreditation status).

B. NATA accredited in-house laboratory methods are referenced from NEPC, ASTM, modified USEPA / APHA documents. Corporate Accreditation No. 13542.

C. Subcontracted analyses: Refer to Sample Receipt Notice and additional DQO comments.

Reported by Sydney Analytical Laboratories, NATA accreditation No.1884.

Laboratory Report: E029326

4. QA/QC FREQUENCY COMPLIANCE TABLE SPECIFIC TO THIS REPORT

Matrix: **WATER**

Page:	Method:	Totals:	#d	%d-ratio	#t	#s	%s-ratio
1	pH in water	3	0	0%	0	0	0%
2	Electrical conductivity (EC)	3	0	0%	0	0	0%
3	Nitrate as N	3	0	0%	0	0	0%
3	Nitrite as N	3	0	0%	0	0	0%
4	TKN (as N)	3	0	0%	0	0	0%
5	Ammonia as N	3	0	0%	0	0	0%
6	Total Nitrogen (as N)	3	0	0%	0	0	0%
7	Total Phosphorus (as P)	3	0	0%	0	0	0%
8	BOD	3	1	33%	0	0	0%
9	Suspended Solids (TSS)	3	1	33%	0	0	0%

GLOSSARY:

#d	number of discrete duplicate extractions/analyses performed.
%d-ratio	NEPC guideline for laboratory duplicates is 1 in 10 samples (min 10%).
#t	number of triplicate extractions/analyses performed.
#s	number of spiked samples analysed.
%s-ratio	USEPA guideline for laboratory matrix spikes is 1 in 20 samples (min 5%).

5. ADDITIONAL COMMENTS SPECIFIC TO THIS REPORT

A. All tests were conducted by LabMark Environmental Sydney, NATA accreditation No. 13542, Corporate Site No. 13535, unless indicated below.
B. The following test was conducted by Sydney Analytical Laboratories, NATA accreditation No.1884. :-SAL18500. Results for TSS and BOD issued on 06/12/06.

Laboratory Report: E029326

Cover Page 4 of 4

Laboratory QA/QC data shall relate specifically to this report, and may provide an indication of site specific sample result quality. LabMark DOES NOT report NON-RELEVANT BATCH QA/QC data. Acceptance of this self assessment certificate does not preclude any requirement for a QA/QC review by a accredited contaminated site EPA auditor, when and wherever necessary. Laboratory QA/QC self assessment references available upon request.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

Page: 1 of 9
plus cover page
Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**							
Sample Identification		BH2	BH3	BH5							
Depth (m)		--	--	--							
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06							
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06							
Laboratory Analysis Date		24/11/06	24/11/06	24/11/06							
Method : E018.1											
pH in water	**EQL**										
pH (pH units)	0.1	5.0	5.8	5.7							

Results expressed in pH units unless otherwise specified

Comments:

E018.1: Direct measurement by pH ion selective electrode.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

Page: 2 of 9
plus cover page
Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**	**mb**						
Sample Identification		BH2	BH3	BH5	QC						
Depth (m)		--	--	--	--						
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06	--						
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06	24/11/06						
Laboratory Analysis Date		24/11/06	24/11/06	24/11/06	24/11/06						
Method : E032.1											
Electrical conductivity (EC)	**EQL**										
Electric conductivity (uS/cm)	1	583	6640	6470	1						

Results expressed in uS/cm unless otherwise specified

Comments:

E032.1: Measurement by EC probe. Results expressed in uS/cm.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

Page: 3 of 9
plus cover page
Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**	**lcs**	**mb**					
Sample Identification		BH2	BH3	BH5	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06	--	--					
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06	24/11/06	24/11/06					
Laboratory Analysis Date		27/11/06	27/11/06	27/11/06	24/11/06	24/11/06					
Method : E037.1/E051.1											
Nitrite as N	**EQL**										
NO2-N	0.01	0.01	0.01	0.01	99%	<0.01					
Method : E037.1/E051.1											
Nitrate as N	**EQL**										
NO3-N	0.01	<0.01	0.02	<0.01	89%	<0.01					

Results expressed in mg/l unless otherwise specified

Comments:

E037.1/E051.1: Nitrate determined by colour. Sample filtered through 0.45um prior to analysis.
E037.1/E051.1: Nitrite determined by colour. Sample filtered through 0.45um prior to analysis.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**	**lcs**	**mb**					
Sample Identification		BH2	BH3	BH5	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06	--	--					
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06	24/11/06	24/11/06					
Laboratory Analysis Date		28/11/06	28/11/06	28/11/06	28/11/06	28/11/06					
Method : E039.1											
TKN (as N)	**EQL**										
Total Kjeldahl Nitrogen	0.1	0.2	0.9	0.3	80%	<0.1					

Results expressed in mg/l unless otherwise specified

Comments:

E039.1: Sample filtered through 0.45um filter prior to analysis. Acidic digestion followed by determination by colour.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**	**lcs**	**mb**					
Sample Identification		BH2	BH3	BH5	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06	--	--					
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06	24/11/06	24/11/06					
Laboratory Analysis Date		24/11/06	24/11/06	24/11/06	24/11/06	24/11/06					
Method : E036.1/E050.1 **Ammonia as N**	**EQL**										
Ammonia	0.01	0.02	<0.01	<0.01	97%	<0.01					

Results expressed in mg/l unless otherwise specified

Comments:

E036.1/E050.1: Determined by colour. Sample filtered through 0.45um prior to analysis.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**	**lcs**	**mb**					
Sample Identification		BH2	BH3	BH5	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06	--	--					
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06	24/11/06	24/11/06					
Laboratory Analysis Date		27/11/06	27/11/06	27/11/06	24/11/06	24/11/06					
Method : E038.1 **Total Nitrogen (as N)**	**EQL**										
Total Nitrogen (as N)	0.1	0.2	0.9	0.3	94%	<0.1					

Results expressed in mg/l unless otherwise specified

Comments:

E038.1: Total Nitrogen by calculation.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

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plus cover page
Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**	**lcs**	**mb**					
Sample Identification		BH2	BH3	BH5	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06	--	--					
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06	24/11/06	24/11/06					
Laboratory Analysis Date		28/11/06	28/11/06	28/11/06	28/11/06	28/11/06					
Method : E038.1											
Total Phosphorus (as P)	**EQL**										
Total Phosphorus (as P)	0.01	0.35	0.60	0.33	103%	<0.01					

Results expressed in mg/l unless otherwise specified

Comments:

E038.1: Alkaline persulphate digestion followed by colour determination.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**	**56960d**	**56960r**	**mb**				
Sample Identification		BH2	BH3	BH5	QC	QC	QC				
Depth (m)		--	--	--	--	--	--				
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06	--	--	--				
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06	24/11/06	--	24/11/06				
Laboratory Analysis Date		29/11/06	29/11/06	29/11/06	29/11/06	--	29/11/06				
Method : 5210B											
BOD	**EQL**										
BOD	1	<1	<1	<1	<1	--	<1				

Results expressed in mg/l unless otherwise specified

Comments:

5210B: Five days incubation. Determined by oxygen electrode.

Laboratory Report No: E029326
Client Name: Martens Consulting Engineers
Contact Name: Grant Harlow
Client Reference Area 14 Lake Cathie P0601504

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plus cover page
Date: 06/12/06
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		**56960**	**56961**	**56962**	**56960d**	**56960r**	**mb**				
Sample Identification		BH2	BH3	BH5	QC	QC	QC				
Depth (m)		--	--	--	--	--	--				
Sampling Date recorded on COC		23/11/06	23/11/06	23/11/06	--	--	--				
Laboratory Extraction (Preparation) Date		24/11/06	24/11/06	24/11/06	24/11/06	--	24/11/06				
Laboratory Analysis Date		30/11/06	30/11/06	30/11/06	30/11/06	--	30/11/06				
Method : 2540D											
Suspended Solids (TSS)	**EQL**										
Total suspended solids	1	600	1900	2700	590	2%	<1				

Results expressed in mg/l unless otherwise specified

Comments:

2540D: Gravimetric test.

Report Date : 24/11/2006
Report Time : 1:00:26PM

Quality, Service, Support

Sample **Receipt** Notice (SRN) for E029326

Client Details

Client Name: Martens Consulting Engineers
Client Phone: 02 9476 8777
Client Fax: 02 9476 8767
Contact Name: Grant Harlow
Contact Email: gharlow@martens.com.au
Client Address: 6/37 Leighton Pl
Hornsby NSW 2077

Project Name: Area 14 Lake Cathie
Project Number: P0601504
CoC Number: - Not provided -
Purchase Order: - Not provided -
Surcharge: COD, required

Sample Matrix: WATER

Date Sampled (earliest date): 23/11/2006
Date Samples Received: 24/11/2006
Date Sample Receipt Notice issued: 24/11/2006
Date Preliminary Report Due: 01/12/2006

Laboratory Reference Information

Please have this information ready when contacting Labmark.

Laboratory Report: **E029326**
Quotation Number: - Not provided, standard prices apply
Laboratory Address: Unit 1, 8 Leighton Pl.
Asquith NSW 2077

Phone: 61 2 9476 6533
Fax: 61 2 9476 8219

Sample Receipt Contact: Jakleen El Galada
Email: jakleen.galada@labmark.com.au
Reporting Contact: Jyothi Lal
Email: jyothi.lal@labmark.com.au

NATA Accreditation: 13542
TGA GMP License: 185-336 (Sydney)
APVMA License: 6105 (Sydney)
AQIS Approval: NO356 (Sydney)
AQIS Entry Permit: 200409998 (Sydney)

Sample Condition:
COC received with samples. Report number and lab ID's defined on COC.
Samples received in good order .
Samples received with cooling media: Crushed ice .
Samples received chilled.
Security seals not required. Direct Labmark's custody taken .
Sample container & sample integrity suitable .

Comments:
BOD and TSS subcontracted to SAL. Nutrients analysed on final day of THT.

Holding Times:
Date received allows for insufficient time to meet Technical Holding Times.
Note: Samples received 0 day(s) after Technical Holding Times expire. LabMark can not guarantee holding time compliance.

Preservation:
Chemical preservation of samples satisfactory for requested analytes.

Important Notes:
Sample disposal of environmental samples shall be 31 days (water) and 3 months (soil, HN03 preserved samples) after laboratory receipt, unless otherwise requested in writing by the client. Samples requested to be held in non-refrigerated storage shall incur $5.00/ sample/ 3 months. Additional refrigerated storage shall incur $20/ sample/ 3 months. Combination prices apply only if requested. Transfer of report ownership from LabMark to the client shall occur once full and final payment has been settled and verified. All report copies may be retracted where full payment does not occur within the agreed settlement period.

Analysis comments:

Subcontracted Analyses:
Reported by Sydney Analytical Laboratories, NATA accreditation No.1884.

Thank you for choosing Labmark to analyse your project samples.
Additional information on www.labmark.com.au

Quality, Service, Support

Report Date : 24/11/2006
Report Time : 1:00:26PM

Sample **Receipt** Notice (SRN) for **E029326**

The table below represents LabMark's understanding and interpretation of the customer supplied sample COC request. Please confirm that your COC request has been entered correctly. Due to THT and TAT requirements, testing shall commence immediately as per this table, unless the customer intervenes with a correction prior to testing.

GRID REVIEW TABLE				Requested Analysis																			
No.	**Date**	**Depth**	**Client Sample ID**	Electrical conductivity (EC)	Ammonia as N	Nitrite as N	Nitrate as N	NOx (as N)	pH in water	PREP Not Reported	TKN (as N)	Total Nitrogen (as N)	Total Phosphorus (as P)	External BOD	External Suspended Solids (TSS)								
56960	23/11		BH2	●	●	●	●	●	●	●	●	●	●	●	●								
56961	23/11		BH3	●	●	●	●	●	●	●	●	●	●	●	●								
56962	23/11		BH5	●	●	●	●	●	●	●	●	●	●	●	●								
			Totals:	3	3	3	3	3	3	3	3	3	3	3	3								

Thank you for choosing Labmark to analyse your project samples.
Additional information on www.labmark.com.au

CHAIN OF CUSTODY

Combination Prices only apply if Combo request is circled on COC.

Form QS0073, Rev.8 : Date Issue 12/05/2004.

PAGE 1 OF 1

LABMARK NATA 13542, AQIS N0356

Dispatch samples to:
Unit1/ 8 Leighton Place
Asquith NSW 2077
or
116 Mobray Street
South Melbourne VIC 3205

Tel (SYD): 612-9476-6533
Fax (SYD): 612-9476-8219
Tel (MEL): 613-9686-8344
Fax (MEL): 613-9686-7344
(DB): 0409449684, (PW): 0439390209
ros.schacht@labmark.com.au
paul.woodward@labmark.com.au

Client Details

Safety Precaution: laboratory sample bottles may contain preservation acid / chemicals, refer to SAFETEY label on bottle.

gharlow@martens.com.au

Company & Address: MARTENS & ASSOCIATES, 6/37 Leighton Place
Tel: 9476 8777
Project Manager: GRANT HARLOW
Sampler: GRAM TAYLOR
Fx: 9476 8767
Project Name: P0601504 – AREA 14 LAKE CATHIE
Data Required: ASAP (No surcharge)
Project Type (eg. Service Station): Groundwater
Project No: P0601504
Lab. Quote No:

Global Specifications I require (default is Not required if Not ticked):

	YES (tick)
1. Urgent TAT required? (please circle: 1 day 2 days 3 days ...... days)	
2. Fast TAT Guarantee required? (Surcharge may apply - Receipt cutoff time 3.00pm)	
3. Do you wish sediment present in waters to be included in organic/ inorganic extractions?	
4. Additional QA/QC reported where sample batches submitted are < 10 samples?	
5. Do you require DIFFERENT standard EQL's from those stated in the current LabMark price catalogue?	
6. Do you wish chromatograms to be supplied? (Additional fee applies).	
7. Electronic data transfer (circle: fax .xls .csv [✓ .pdf]). Please specify.	

Note1: Additional water sample must be submitted for lab. duplicate & spike analysis.
Note2: Contact lab if consolidating multiple analyses into a single sample container.

Matrix

Container Type (Nat. = unpreserved, G=glass, P=plastic)

Analysis Request: Combo (circle) <1> <2> <3> <4> <5> <6> <7> <8> <9> <10> <11> <12> <13> <14>

Volatile Tests 125g; Semi- & Non-Volatile Tests 125g (max. 4 tests); Leach 250g; Nutrient Tests 125g (max. 4 tests) 0.1 - 1L (chemical groups); Other (eg. TCLP tests here)

Lab. Number	Sample ID	Sample Depth	Sampling Date	soil	water	air	part., liners	other	Soil (G) Nat. Orange	0.5-1L (G) Nat. Orange	40ml VOA (G) Nat. Orange	40ml VOA (G) HCl Maroon	0.1-1L (P) H2SO4 Purple	0.1-1L (G) H2SO4 Purple	0.1-1L (P) Nat. Green	0.1-0.2L (P) HNO3 Red Filtered YES/ NO	0.1-1L (P) NaOH, CdNO3 Blue	Other	Combo	BTEX+vTPH(C6-9) PT-GC/FID/PID/MS	VHC PT-GC/MS	THM PT-GC/MS	MTBE PT-GC/MS	VAC PT-GC/MS	VOC PT-GC/MS	TPH (C10-36) GC/FID	PAH's GC/MS	Phenols GC/MS	Aromatic/ Aliphatic TPH GC/FID	(circle) OC, OP, PCB GC/ECD/FPD	SVOC GC/MS	Phenoxy Acid Herbicides GC/MS	Explosives HPLC	(circle) Metals* (dissolved / total)	TCLP (specify test - other)	ZHE TCLP (specify test - other)	(circle) [✓ pH], [✓ EC]	(circle) [✓ NH_3], [✓ TKN], N_{org}, [✓ TN]	(circle) [✓ NO_x], [✓ NO_2], [✓ NO_3]	(circle) [✓ TP], ortho-P, TKP	(circle) Cl^-, F^-, SO_4^{2-}	(circle) Total Alk, Speciated Alk	(circle) Free CN, WAD, Total CN	Total Phenolics	(circle) Major Cations (Ca, Mg, Na, K)	BOD5	TSS (suspended solids)
56960	BH2		23.11.06		X																																X	X	X	X						X	X
56961	BH3		23.11.06		X																																X	X	X	X						X	X
56962	BH5		23.11.06		X																																X	X	X	X						X	X
					X																																X	X	X	X						X	X
Totals																																															

*Metals (circle): As, Cd, Cr, Cu, Ni, Pb, Zn, Hg, Cr^{6+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Be, B, Al, V, Mn, Fe, Co, Se, Sr, Sn, Mo, Ag, Ba, Tl, Bi, Sb

Comments (Highly contaminated samples):

Lab Report No. E029326

Security Seal Applied YES/NO
Security Seal Serial #

Relinquished by (print): Signed: Date: Received By: Date: 24/11 Time: 858
Relinquished by (print): Signed: Date: Received By: Date: Time:

11 Attachment E – Pump-test Analysis Records

Single Bore Slug Test (Rising or Falling)

Method based on Hvorslev (1981)

Method ST-# Revised 7.3.2007

martens
consulting engineers since 1989

6/37 Leighton Place, Hornsby NSW 2077 Australia, Ph: (02) 9476 8777 Fax: (02) 9476 8767, mail@martens.com.au, www.martens.com.au

PROJECT DETAILS

Project: Area 14 Stage 1B Groundwater Study, Lake Cathie, NSW

Ref. No.: P0601504JS09 - BH2

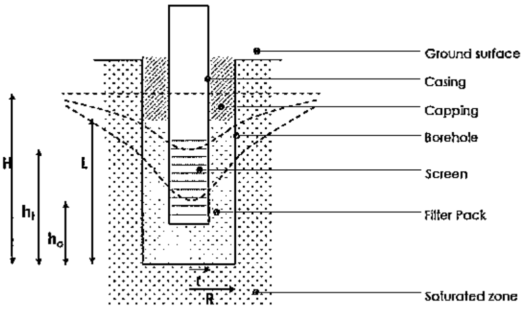
Author: Dr D. Martens

Reviewed: Mr G. Taylor

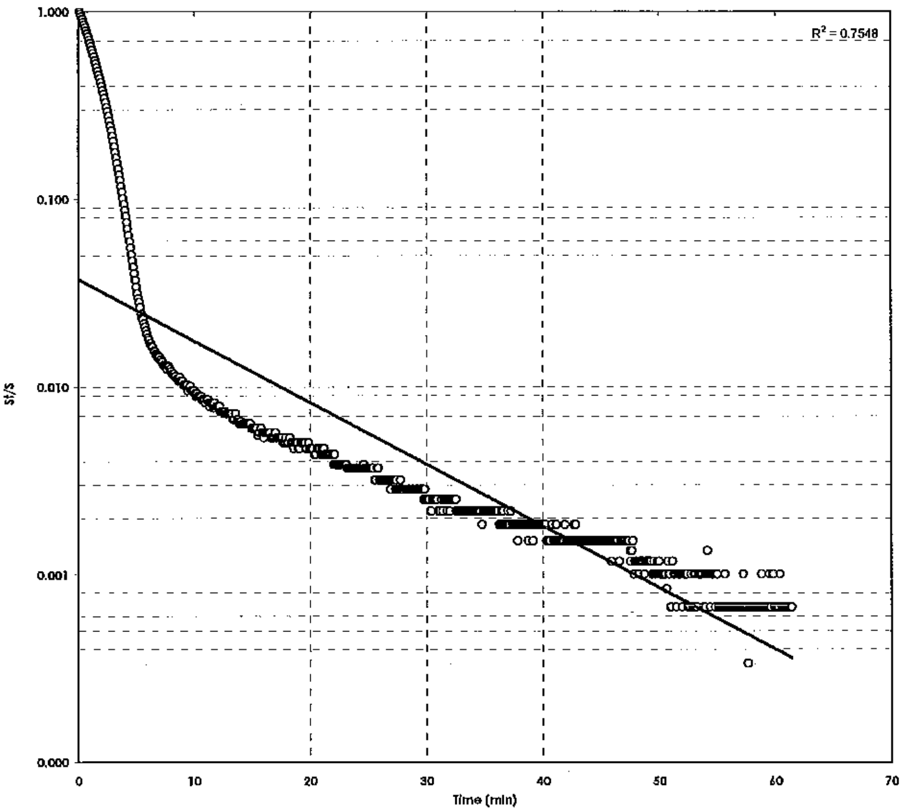
Date Created: 8.3.2007

STEP 1 : ENTER BOREHOLE DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	12.032	m
h_o - Water level reading at time = 0 (depth)	6.067	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	5.97	m
T_o - Length of characteristic time	2.00	minutes
K_{sat} - Saturated hydraulic conductivity	0.180	m/d



STEP 2 : PLOT DATA



Single Bore Slug Test (Rising or Falling)

Method based on Hvorslev (1981)

Method ST-# Revised 7.3.2007

martens
consulting engineers since 1989

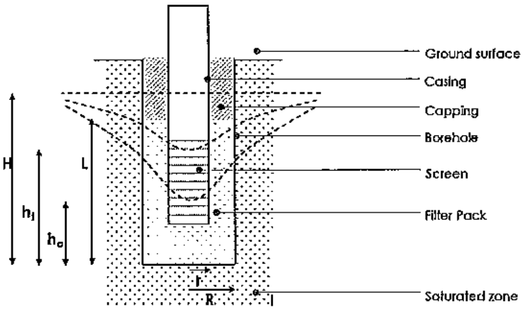
6/37 Leighton Place, Hornsby NSW 2077 Australia, Ph: (02) 9476 8777 Fax: (02) 9476 8767, mail@martens.com.au, www.martens.com.au

PROJECT DETAILS

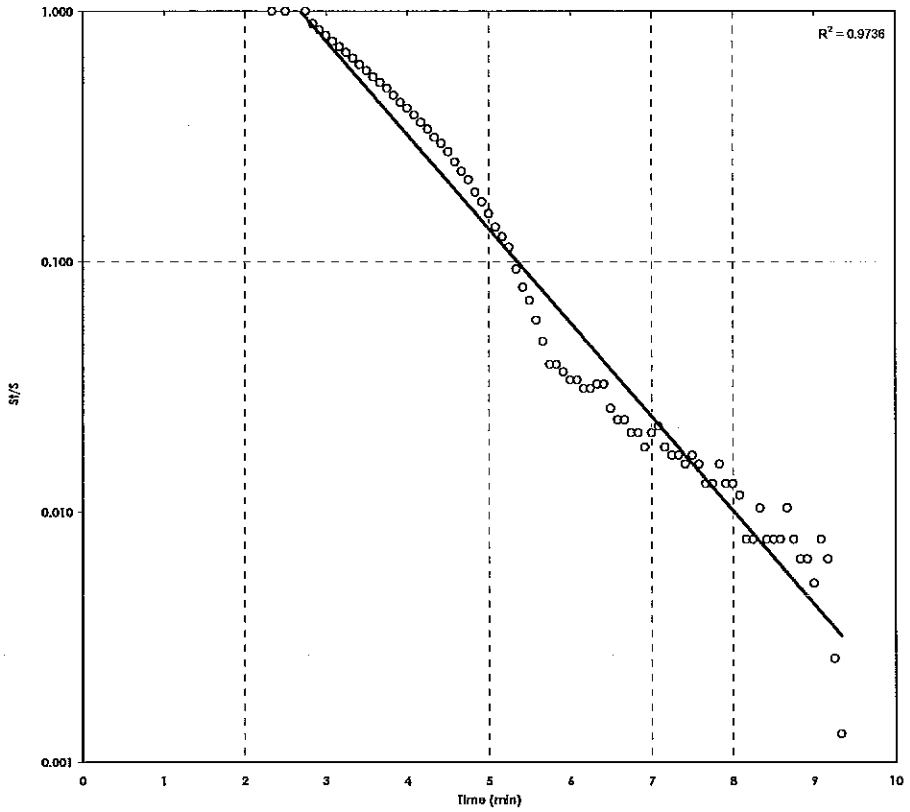
Project	Area 14 Stage 1B Groundwater Study, Lake Cathie, NSW			Ref. No.	P0601504JS09 - BH3
Author	Dr D. Martens	Reviewed	Mr G. Taylor	Date Created	8.3.2007

STEP 1 : ENTER BOREHOLE DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	5.667	m
h_o - Water level reading at time = 0 (depth)	4.894	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	0.50	m
T_o - Length of characteristic time	4.10	minutes
K_{sat} - Saturated hydraulic conductivity	0.505	m/d



STEP 2 : PLOT DATA



Single Bore Slug Test (Rising or Falling)

Method based on Hvorslev (1981)

Method ST-# Revised 7.3.2007

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PROJECT DETAILS

Project: **Area 14 Stage 1B Groundwater Study, Lake Cathie, NSW**

Ref. No.: **P0601504JS09 - BH5**

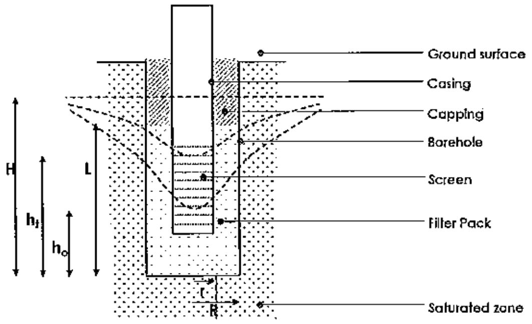
Author: **Dr D. Martens**

Reviewed: **Mr G. Taylor**

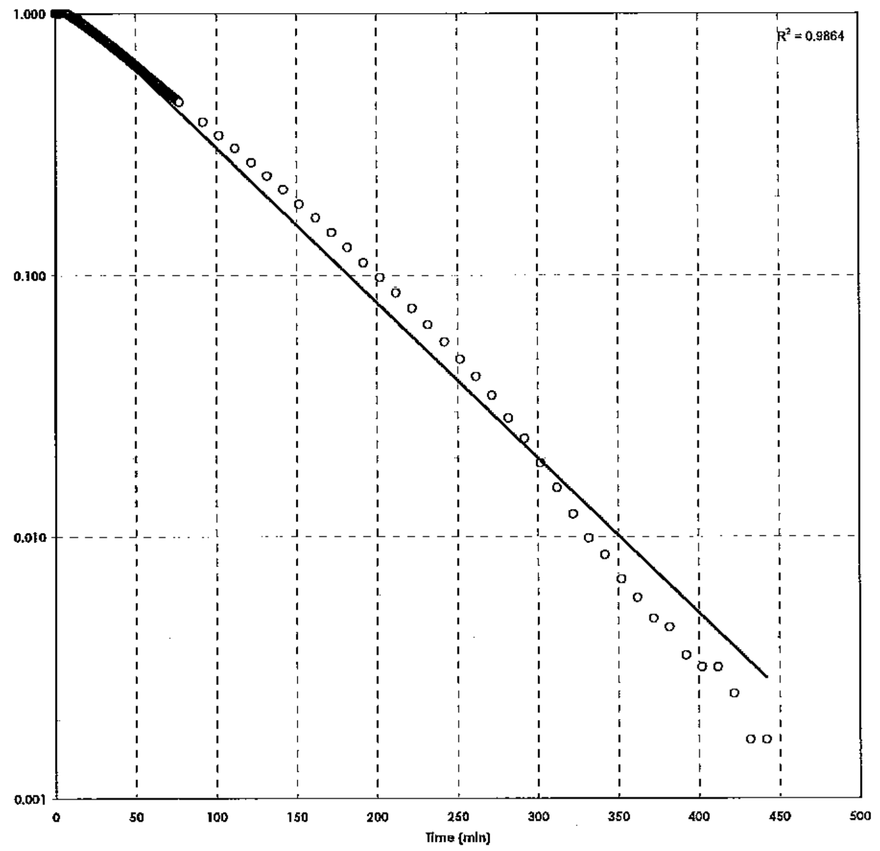
Date Created: **8.3.2007**

STEP 1 : ENTER BOREHOLE DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	13.0	m
h_o - Water level reading at time = 0 (depth)	7.0	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	5.20	m
T_o - Length of characteristic time	86.3	minutes
K_{sat} - Saturated hydraulic conductivity	0.005	m/d



STEP 2 : PLOT DATA



Single Bore Slug Test (Rising or Falling)

Method based on Hvorsley (1981)

Method ST-# Revised 7.3.2007

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PROJECT DETAILS

Project: **Area 14 Stage 1B Groundwater Study, Lake Cathie, NSW**

Ref. No.: **P0601504JS09 - BH6**

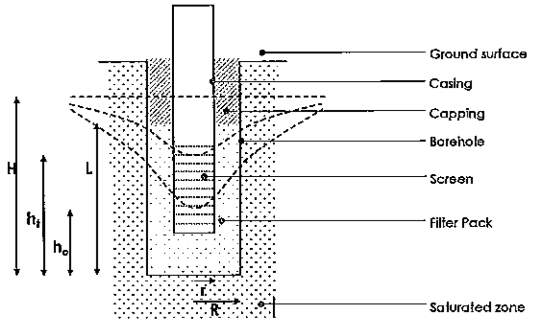
Author: **Dr D. Martens**

Reviewed: **Mr G. Taylor**

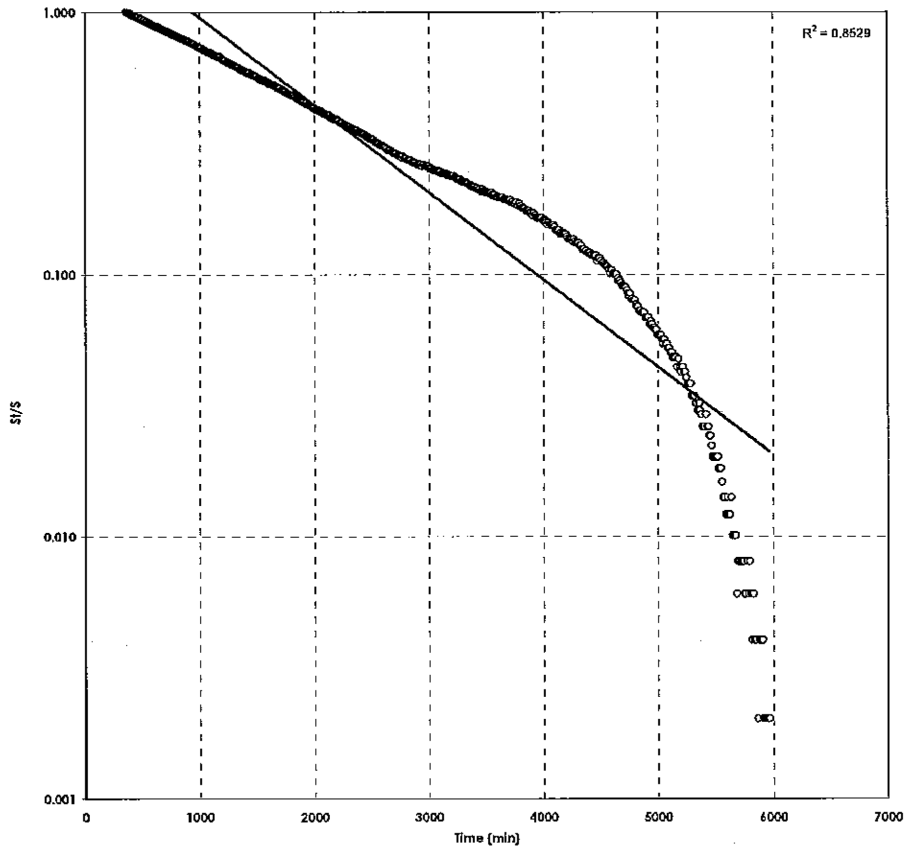
Date Created: **8.3.2007**

STEP 1 : ENTER BOREHOLE DATA

FACTOR	Enter Data	Unit
H - Initial water level reading (depth)	10.504	m
h_o - Water level reading at time = 0 (depth)	9.510	m
r - Casing radius	0.025	m
R - Bore radius	0.050	m
L - Length of open screen	0.99	m
T_o - Length of characteristic time	2000	minutes
K_{sat} - Saturated hydraulic conductivity	0.0007	m/d



STEP 2 : PLOT DATA



12 Attachment F – GW Level Summaries

Date	BH2 - Temp (°C)	BH2 - mAHD	BH3 - Temp (°C)	BH3 - mAHD	BH5 - Temp (°C)	BH5 - mAHD	BH6 - Temp (°C)	BH6 - mAHD
23/11/2006	18.85	11.99	17.27	5.68	19.56	12.65	19.18	9.51
24/11/2006	18.90	12.13	17.23	5.68	19.53	13.03	18.33	9.87
25/11/2006	18.92	12.11	17.24	5.64	19.54	12.99	18.34	10.21
26/11/2006	18.92	12.01	17.23	5.60	19.54	12.96	18.34	10.36
27/11/2006	18.92	12.03	17.24	5.61	19.54	12.97	18.34	10.49
28/11/2006	18.92	11.98	17.23	5.57	19.55	12.93	18.35	10.53
29/11/2006	18.92	11.92	17.24	5.53	19.55	12.89	18.36	10.55
30/11/2006	18.92	11.95	17.24	5.56	19.56	12.93	18.36	10.64
1/12/2006	18.92	11.88	17.26	5.52	19.56	12.88	18.36	10.64
2/12/2006	18.92	11.85	17.28	5.48	19.56	12.84	18.37	10.66
3/12/2006	18.92	12.04	17.29	5.50	19.56	12.87	18.38	10.71
4/12/2006	18.92	12.12	17.30	5.53	19.56	12.90	18.38	10.75
5/12/2006	18.92	12.01	17.33	5.52	19.56	12.89	18.40	10.77
6/12/2006	18.92	11.93	17.34	5.49	19.56	12.87	18.40	10.77
7/12/2006	18.92	11.90	17.36	5.49	19.57	12.86	18.41	10.80
8/12/2006	18.92	11.90	17.38	5.51	19.57	12.87	18.42	10.82
9/12/2006	18.92	11.91	17.39	5.52	19.57	12.88	18.42	10.84
10/12/2006	18.92	11.88	17.41	5.49	19.57	12.86	18.44	10.84
11/12/2006	18.92	11.80	17.43	5.44	19.57	12.80	18.44	10.82
12/12/2006	18.92	11.81	17.45	5.44	19.57	12.80	18.45	10.85
13/12/2006	18.91	11.83	17.47	5.44	19.57	12.79	18.46	10.85
14/12/2006	18.91	11.77	17.50	5.39	19.57	12.74	18.47	10.83
15/12/2006	18.91	11.80	17.52	5.36	19.58	12.72	18.48	10.83
16/12/2006	18.91	12.07	17.54	5.40	19.58	12.76	18.49	10.87
17/12/2006	18.91	12.02	17.56	5.41	19.58	12.78	18.50	10.88
18/12/2006	18.91	11.67	17.96	5.15	19.58	12.45	18.79	10.90
19/12/2006	18.91	11.83	17.60	5.35	19.58	12.71	18.52	10.86
20/12/2006	18.91	11.84	17.62	5.37	19.58	12.72	18.53	10.89
21/12/2006	18.91	12.15	17.64	5.38	19.58	12.81	18.54	10.92
22/12/2006	18.91	12.04	17.65	5.36	19.58	12.79	18.55	10.89
23/12/2006	18.91	11.91	17.66	5.31	19.58	12.73	18.56	10.87
24/12/2006	18.91	11.84	17.67	5.27	19.58	12.67	18.57	10.85
25/12/2006	18.91	11.85	17.69	5.24	19.58	12.64	18.58	10.85
26/12/2006	18.91	11.85	17.71	5.28	19.58	12.67	18.59	10.89
27/12/2006	18.91	11.82	17.72	5.30	19.58	12.67	18.60	10.90
28/12/2006	18.91	11.79	17.75	5.28	19.58	12.65	18.61	10.90
29/12/2006	18.91	11.77	17.76	5.28	19.58	12.65	18.62	10.90
30/12/2006	18.91	11.78	17.79	5.29	19.58	12.64	18.64	10.91
31/12/2006	18.91	11.77	17.80	5.27	19.58	12.62	18.64	10.89
1/01/2007	18.91	11.85	17.82	5.26	19.58	12.62	18.66	10.91
2/01/2007	18.91	11.80	17.84	5.27	19.58	12.62	18.67	10.92
3/01/2007	18.91	11.80	17.86	5.28	19.58	12.62	18.69	10.93
4/01/2007	18.91	11.78	17.87	5.27	19.58	12.61	18.69	10.93
5/01/2007	18.91	11.76	17.88	5.25	19.58	12.58	18.71	10.93
6/01/2007	18.91	11.71	17.89	5.20	19.58	12.53	18.72	10.91
7/01/2007	18.91	11.62	17.91	5.13	19.58	12.46	18.73	10.88
8/01/2007	18.91	11.61	17.91	5.11	19.58	12.43	18.75	10.89
9/01/2007	18.91	11.65	17.92	5.15	19.58	12.46	18.76	10.91
10/01/2007	18.91	11.64	17.93	5.14	19.58	12.45	18.77	10.91
11/01/2007	18.91	11.62	17.94	5.12	19.59	12.42	18.78	10.90
12/01/2007	18.91	11.59	17.96	5.08	19.59	12.39	18.79	10.89
13/01/2007	18.91	11.59	17.97	5.08	19.60	12.38	18.81	10.90
14/01/2007	18.91	11.63	17.98	5.12	19.59	12.41	18.82	10.92
15/01/2007	18.91	11.65	18.00	5.13	19.58	12.42	18.83	10.93
16/01/2007	18.91	11.66	18.02	5.13	19.58	12.42	18.85	10.93
17/01/2007	18.91	11.65	18.04	5.13	19.58	12.41	18.86	10.93
18/01/2007	18.91	11.64	18.06	5.13	19.58	12.40	18.87	10.93
19/01/2007	18.91	11.62	18.07	5.11	19.58	12.38	18.88	10.93
20/01/2007	18.91	11.57	18.09	5.06	19.58	12.33	18.90	10.90
21/01/2007	18.92	11.50	18.11	4.99	19.58	12.25	18.91	10.88
22/01/2007	18.92	11.52	18.13	5.02	19.58	12.26	18.92	10.91
23/01/2007	18.92	11.55	18.15	5.04	19.59	12.27	18.93	10.91
24/01/2007	18.92	11.53	18.17	5.02	19.58	12.25	18.95	10.90
25/01/2007	18.92	11.52	18.17	5.00	19.58	12.24	18.96	10.89
26/01/2007	18.92	11.48	18.19	4.97	19.58	12.20	18.97	10.88
27/01/2007	18.92	11.40	18.21	4.89	19.58	12.13	18.99	10.85
28/01/2007	18.92	11.43	18.22	4.93	19.59	12.15	19.00	10.87
29/01/2007	18.92	11.45	18.24	4.95	19.59	12.16	19.02	10.89
30/01/2007	18.92	11.46	18.27	4.95	19.59	12.17	19.03	10.89
31/01/2007	18.92	11.47	18.29	4.96	19.59	12.17	19.04	10.90
1/02/2007	18.92	11.54	18.32	5.01	19.59	12.22	19.06	10.92
2/02/2007	18.92	11.54	18.34	5.01	19.59	12.22	19.07	10.91
3/02/2007	18.93	11.51	18.36	4.98	19.59	12.19	19.08	10.90
4/02/2007	18.93	11.51	18.38	4.98	19.59	12.19	19.10	10.90
Mean	18.91	11.76	17.76	5.27	19.58	12.59	18.67	10.81
Start Dec	18.92	11.88	17.26	5.52	19.56	12.88	18.36	10.64
End Dec	18.91	11.77	17.80	5.27	19.58	12.62	18.64	10.89
End Jan	18.92	11.47	18.29	4.96	19.59	12.17	19.04	10.90

13 Attachment G – Notes About This Report

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.

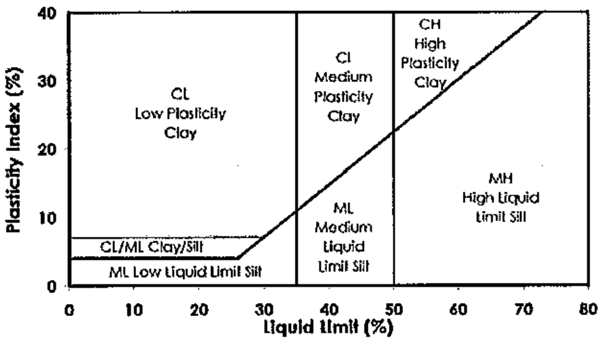
Particle Size

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 %