Moonee Parklands Trust
C/- JW Planning Pty Ltd

Hydrogeological Assessment: Lot 1 DP 1097743, Pacific Hwy, Moonee Beach, NSW

martens consulting engineers

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

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

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1 Overview

1.1 Background and Scope

This report documents findings of a hydrogeological assessment completed to form a Part 3A Environmental Assessment associated to a development application (DA) to Coffs Harbour City Council for a proposed residential subdivision, yielding up to 103 lots, at Lot 1 DP1097743, Pacific Highway, Moonee Beach, NSW ('the site').

1.2 Objectives

Primary objectives of this investigation are to:

1. Assess the existing groundwater regime.
2. Determine site aquifer properties.
3. Develop calibrated steady state finite-difference groundwater flow models for existing and developed-conditions.
4. Assess changes (if any) to groundwater levels/flow directions which arise due to the proposed-development.

1.3 Development Proposal

The development proposal involves the sub-division of land zoned predominantly for residential purposes and part conservation purposes.

The implementation of the concept subdivision is proposed to occur in 4 construction stages. Preliminary staged works are as follows:

1. Stage 1:
    a. Site preparation and environmental impact mitigation tasks (fence off and protect buffer, implementation of erosion and sediment control plan, commence buffer rehabilitation and planting where practical, nest boxes etc.).
    b. Bulk earthworks for the entire 103 lots to reduce costs and disruption/impacts on adjoining residents.
    c. Connections to trunk power, water and telecommunication infrastructure located within the collector road extending north-south along the western boundary of the site.
    d. Construction of vehicular access to the proposed sewer pump station as well as to stormwater treatment and detention Basin.

e. Services extended as required and access to the existing residence on Lot 2 maintained.

2. Stage 2: Extension of Roads 4, 5 and 6 with associated services.
3. Stage 3: Extension of Road 2 (northern) & 6 and partial construction of Road 2 (southern) with associated services.
4. Stage 4: Connection of Road 1 and 2 and complete Roads 4 & 5 and associated services.

The proposed staging plan aims to provide a cost effective construction sequence that seeks to minimise the impact on any local residents. Whilst subject to possible variation via more detailed construction certificate investigation, design and market considerations as well as land owner circumstances, the proposed staging is practical and logical.

1.4 Previous Investigations

No previous groundwater related investigations have occurred at the site.

A geotechnical assessment (Coffey, 2005) was undertaken immediately north of the site at the proposed Glades Estate (Lots 1 & 2 DP 725785) which included installation of 6 Groundwater Monitoring Bores (GMBs) and manual groundwater level monitoring (May, 2005 to December, 2005).

2 Site Description

2.1 Location and Setting

The subject site (Figure 1, Attachment A) is located between Pacific Highway and Moonee Creek at Moonee Beach, approximately 12 km north of Coffs Harbour and is within the Coffs Harbour City Council Local Government Area.

The site (Lot 1 DP1097743) has an area of 12.93 ha, within an area of low density rural development approximately 500 m north of a commercial area and existing residential areas of Moonee Beach. The site is partly cleared with stands of remnant trees remaining. There is an unsealed access roads within the site. Otherwise, the site is undeveloped.

2.2 Field Investigations

Field investigations for the site and Lot 6 DP252223 were undertaken on 26 to 28 July 2010 and 29 September 2010. The hydrogeological component of field work included the following:

- Walkover inspection of the site assess existing site conditions and local topography, geology, soil conditions and vegetation;
- Drilling of 14 boreholes (BH1 to BH14) to between 0.6 m and 9.2 metres below ground level (mBGL) using a hydraulic auger to allow for the characterisation of underlying soils and geology.
- Installation of GMBs at at 8 borehole locations (BH1, BH2, BH3, BH4, BH6, BH7, BH8 and BH13). GMBs were assigned an identification number which corresponded to the borehole in which the GMB was installed.
- Installation of data loggers in accordance with the summarised schedule provided in Table 1.

Locations of subsurface investigations are shown on the site plan (Figure 1, Attachment A).

Table 1: Groundwater and rain gauge monitoring schedule.

Element	Monitoring Frequency (minutes)	Monitoring Period	Observations [1]	Monitoring Method
GMB1 [2]	10	28.07.2010 to 29.09.2010	BP, GL, GT, EC	Data logger
	15	29.09.2010 to 02.11.2010		
GMB2	10	28.07.2010 to 29.09.2010 [3]	GL, GT	Data logger
	15	05.10.2010 to 02.11.2010		
GMB3	10	28.07.2010 to 29.09.2010	GL, GT	Data logger
GMB4 [2]	10	28.07.2010 to 29.09.2010	BP, GL, GT, EC	Data logger
	15	29.09.2010 to 02.11.2010		
GMB6	10	28.07.2010 to 29.09.2010	GL, GT	Data logger
GMB7 [2]	10	28.07.2010 to 23.09.2010 [4]	GL, GT	Data logger
GMB8	10	28.07.2010 to 29.09.2010	GL, GT	Data logger
	15	29.09.2010 to 02.11.2010		
GMB13 [2]	10	28.07.2010 to 29.09.2010	GL, GT	Data logger
	15	29.09.2010 to 02.11.2010		
Rain gauge	15	28.07.2010 to 29.09.2010	R	Rain gauge data logger
	10	29.09.2010 to 02.11.2010		

Notes:

[1] BP = barometric pressure, GL = groundwater level, GT = groundwater temperature, EC = groundwater Electrical Conductivity, R = rain depth (mm).

[2] GMB located on Lot 6 DP 252223 immediately to the south of the site.

[3] Logger failed for period.

[4] Logger was intended to log until 29.09.2010 but failed on 23.09.2010.

2.3 Geology

Site geology is summarised in Section 3.1 and detailed in borehole logs which are provided in Attachment B.

2.4 Topography

Topographically the site is considered to comprise 2 distinct environments, namely:

1. Hillslope (typical slopes of <15%) which is associated with a ridge that extends onto the western portion of the site, and;

2. Alluvial plains (typical slopes of <5%).

The hillslope environment accounts for approximately 40% of the total site area. The remaining site area is occupied by alluvial plains. Site elevation ranges between approximately 20 mAHD on the top of the ridge in the west and < 1 mAHD along the banks of Moonee Creek in the east.

2.5 Drainage

The following drainage lines exist on/near the site and are depicted in Figure 2.

1. Cunningham Creek.
2. Moonee Creek.
3. Man-made drainage channel A.
4. Man-made drainage channel B.
5. Man-made drainage channel C.

2.6 Rainfall

2.6.1 Long-term Mean Values

Mean monthly/annual rainfall at Woolgoolga and Coffs Harbour (both approximately 22 kms from site) is summarised in Table 2.

Table 2: Mean monthly/annual rainfall at Coffs Harbour and Woolgoolga (Source: BOM, 2013).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Coffs Harbour Rain (mm) [1]	180.4	220.0	238.4	173.1	160.5	116.4	74.4	78.1	62.0	92.9	139.8	141.2	1682.6
Woolgoolga Rain (mm) [2]	162.9	187.8	212.0	167.7	149.3	122.7	91.2	69.1	63.7	95.1	117.9	128.9	1574.8

Notes:

[1] BOM Station No. 59040.

[2] BOM Station No. 59039.

2.6.2 Site Data

Site rain gauge data for the monitoring period (28.07.2010 to 02.11.2010) were compared to nearby BOM station data (Figure 3). Results show that site rainfalls were closely correlated with Woolgoolga and Glenreagh rather than Coffs Harbour. Daily rain is plotted in Figure 5.

2.6.3 Residual Rain Analysis

Monthly residual rain analysis (Figure 4) indicates that site groundwater monitoring coincided with below average rainfall for August (38 mm deficit) and above average rainfall for September (31 mm surplus) and October (331 mm surplus).

The two months prior to monitoring had above average rainfall (48 and 34 mm surpluses).

In light of the above, the period of groundwater monitoring is likely to be generally characterised by higher than average groundwater levels.

3 Hydrogeology

3.1 Water Bearing Strata

Water bearing strata in the vicinity of the site have been broadly classed into two distinct layers based on review of:

- Site borehole data
- Site GMB data
- NSW Natural Resource Atlas public domain bore database data
- Site observations
- Terrain data (LIDAR data and 1:25,000 topographic mapping)

Aquifer layers are characterised as:

1. Layer 1 - alluvium/residual materials:
    - Clays with interbedded sand and clayey sand layers.
    - Extends from natural surface level to variable depths of approximately 2 - 20 m below ground level (BGL). This depth is likely to be shallowest in the area of the site's knoll.
    - Generally low hydraulic conductivity (K).
    - Level of confinement likely to vary from unconfined to semi-confined.
    - Base of layer comprises shale bedrock.
2. Layer 2 - shale bedrock:
    - Comprised of fractured shale at depths greater than approximately 2 – 20 mBGL.
    - Low to moderate hydraulic conductivity (K).
    - Predominantly Confined.

Aquifer Layer 2 is highly unlikely to be significantly affected by the proposed development based on the likely scale of potential impacts to Layer 1 which may occur due to the proposed development. Consequently, assessment only includes Layer 1.

3.2 Resource Use

A review of the NSW Natural Resource Atlas's groundwater bore database was undertaken to assess aquifer use in the vicinity of the site. No bores access Layer 1 of the aquifer in the vicinity of the site. The nearest bore is located approximately 150 to 200 m south west of the site and accesses the shale aquifer between 20 to 29.6 mBGL.

3.3 Hydraulic Conductivity (K)

Site K testing to date is summarised in Table 3. Results indicate that the alluvial aquifer is of low permeability. Refer to Figure 1 for the location of GMBs.

Table 3: Summary of aquifer K testing results.

GMB	Test Medium	Estimated K (m/d)
1	Clay/sand	0.057
2	Clay	0.019
3	Clay	0.004
4	Clay	0.038
6	Clay	0.011
7	Clay/Sandy Clay	0.002
8	Clay	0.011
13	Clay	0.001
Geometric mean		0.009
Median		0.011
Mean		0.018

Notes:

Results based on Martens and Associates testing completed on 28.07.2010 and 28.07.2010

Test type = rising head with data analysed using the Hvorslev (1981) method.

GMB 1, 4, 7 and 13 located on Lot 6 DP 252223.

3.4 Groundwater Level Measurements

3.4.1 Manual Measurements

Manual groundwater level measurements taken to date are summarised in Table 4.

Table 4: Manual groundwater level measurements.

		Groundwater Levels Recorded by Martens and Associates			
		27.07.2010	28.07.2010	29.09.2010	02.11.2010
GMB ID	GMB Surface Level	mAHD	mAHD	mAHD	mAHD
1 [1]	3.582	1.01	-	0.75	2.60
2	2.717	2.16	-	2.28	2.18
3	3.373	3.22	-	3.35	3.22
4 [1]	3.621	-	3.30	3.02	3.33
6	6.908	-	4.39	4.03	4.86
7 [1]	1.271	0.77	-	1.17	1.12
8	5.692	4.22	-	4.28	4.80
13 [1]	1.611	-	0.61	0.92	1.39

Notes:

[1] GMB located on Lot 6 DP 252223 immediately to the south of the site.

3.4.2 Continuous Measurements

Continuous groundwater level measurements were taken in accordance with Table 1. Continuous level measurements are plotted in Figure 5, a statistical summary of levels is provided in Table 5 and average daily residual levels are plotted in Figure 6.

Table 5: Statistical summary of recorded water levels (mAHD) at GMBs for monitoring period.

GMB	1 [2, 6]	2 [3]	3 [4]	4 [2, 6]	6 [4]	7 [5, 6]	8 [2]	13 [2, 6]
Minimum	0.697	2.111	2.766	2.456	3.904	0.696	4.116	-1.775 [1]
25th%ile	0.895	2.279	3.077	2.839	4.083	0.868	4.276	0.855
Median	1.194	2.443	3.233	3.078	4.191	0.930	4.426	1.032
Mean	1.488	2.443	3.186	3.128	4.265	0.948	4.465	1.097
75th%ile	1.421	2.633	3.330	3.514	4.485	1.001	4.582	1.403
Maximum	3.380	2.695	3.396	3.668	4.640	1.275	5.011	1.680
Range	2.683	0.584	0.63	1.212	0.736	0.579	0.895	3.455
Minimum Depth to GW	0.202	0.022	-0.023	-0.047	2.268	-0.004	0.681	-0.069
Mean Depth to GW	2.094	0.274	0.187	0.493	2.643	0.323	1.227	0.514
Ground Level	3.582	2.717	3.373	3.621	6.908	1.271	5.692	1.611

Notes:

GW = groundwater level.

[1] Level occurred due to GMB being purged dry.

[2] Monitoring period: 28.07.2010 – 02.11.2010

[3] Monitoring period: 05.10.2010 – 02.11.2010

[4] Monitoring period: 28.07.2010 – 29.09.2010

[5] Monitoring period: 28.07.2010 – 23.09.2010

[6] GMB located on Lot 6 DP 252223.

3.4.3 Barometric Efficiency

Continuous groundwater level data was analysed alongside barometric pressure data to investigate the influence that barometric pressure has on groundwater levels. Data were analysed by creating Barometric Efficiency (BE) plots where the BE value is the ratio that groundwater level changes relative to barometric pressure change.

With the exception of GMB2 and GMB7, data were analysed for the periods between 28/07/2010 to 29/09/2010 and 28/07/2010 to 02/11/2010. The earlier period was characterised by low rainfall.

BE plots for the period between 28/07/2010 to 29/09/2010 are provided in Figure 7 through to Figure 13 with a summary of results from all periods of analysis provided in Table 6.

Combined BE and R^2 values at GMB1, GMB6 and GMB8 indicate that the aquifer is likely to be semi-confined in these locations.

Table 6: Barometric efficiency summary.

Period	GMB	Barometric Effeciency	R^2 Value
28/07/2010 to 29/09/2010	1 [1]	0.53	0.5
	3	0.45	0.06
	4 [1]	0.82	0.16
	6	0.58	0.46
	8	0.73	0.74
	13	1.34	0.04
28/07/2010 to 23/09/2010	7 [1]	0.47	0.2
28/07/2010 to 2/11/2010	1 [1]	0.71	0.03
	4 [1]	0.55	0.07
	8	0.69	0.48
	13 [1]	1.01	0.04
05/10/2010 to 02/11/2010	2	0.33	0.02

Notes:

[1] GMB located on Lot 6 DP 252223.

3.4.4 Rainfall Response

Groundwater level response to rainfall was analysed using continuous monitoring data. Response plots for each GMB's monitoring period (Table 1) are provided in Figure 14 through to Figure 21. Plots indicate groundwater levels can rise of the order of 1.3 m (GMB1), 0.4 m (GMB2 and GMB4) and 2.1 m (GMB13) in response to moderate to high daily rain. Rainfall during the monitoring period for GMBs 3, 6 and 7 was low and therefore no conclusions are offered for rainfall response at these bores. GMB8 showed minimal response to daily rain as evidenced by the maximum daily groundwater level rise (approximately 0.17 m) which occurred over the monitoring period that incorporated 3 rain days in excess of 100 mm.

3.5 Recharge

The mechanism for recharge is via direct rainfall infiltration. Recharge is expected to be somewhat limited given the low permeability of surface soils and high evapotranspiration (ET) in areas of shallow water table. No further background research with regards to recharge was

undertaken as this parameter is calibrated in the site groundwater model.

3.6 Storage

Unconfined portions of the aquifer are expected to have a Specific Yield (S_y) of the order of 0.02 to 0.03 based on analysis of rainfall response plots. This range of S_y values falls within the typical ranges that are cited within the literature (Bair and Lahm, 2006).

Specific Storage (S_s) for semi-confined portions of the aquifer was estimated to be 1.34 x 10^{-3} m^{-1} based on application of the following Jacob (1940) formula (USGS, 1997):

$S_s = y * B * a/BE$

Where:

S_s = specific storage (m^{-1})

y = specific weight of water (assumed to be 9810 N/m^3)

B = compressibility of water (assumed to be 5 x 10^{-6})

a = effective porosity (assumed to be 0.02)

BE = barometric efficiency (calculated to be 0.73 at GMB8)

This estimated S_s value is within the ranged outlined by Batu (1998) for stiff clay.

3.7 Groundwater Quality

3.7.1 Laboratory Testing

Full laboratory results are summarised in Attachment C with a brief summary provided below. Laboratory reports are provided in Attachment D.

- Groundwater is acidic with pH values ranging from 4.3 to 5.1.
- Groundwater EC is indicative of brackish to saline water.
- Groundwater nutrient levels are low (generally below laboratory detection limits).

3.7.2 Continuous Electrical Conductivity (EC) Measurements

In accordance with Table 1 continuous EC measurements were taken using a data logger within GMB1 and GMB4. Results are plotted in Figure 22.

EC typically ranged from approximately 1000 to 3000 µS/cm at GMB1 which is indicative of brackish water.

EC typically ranged from approximately 4500 to 5000 µS/cm at GMB4 which is indicative of brackish water.

3.8 Groundwater Dependent Ecosystems (GDEs)

GDE mapping was not provided by the Client and is outside the scope of this investigation.

4 Model Development

4.1 Overview

A series of steady state groundwater models were developed to assess potential impacts associated with the proposed-development. The models were developed based on the information detailed in Sections 2 to 3 and are summarised as follows:

Model 1 (M1): Pre-development Conditions
Using available site data, a calibrated single layered steady state model was developed. The primary purpose of the model was to provide a base case for impact assessment.

Model 2 (M2): Post - development Conditions
This model was developed to assess the impact of the proposed-development. In particular, M2 reduced recharge rates over the proposed development. Proposed development terrain was also incorporated into the model.

Model 3 (M3): Post-development Conditions – Sea Level Rise
M3 was developed using the developed conditions as documented in model M2, but modified to examine the potential impact of climate change induced sea level rise (0.9 m sea level rise).

4.2 Model Discretisation and Active Domain

Modelling was undertaken for the proposed development at the site (Lot 1 DP1097743) only. Model discretisation is summarised in Table 7 with the model domain shown in Figure 23.

The model's active domain was assigned to occupy the area below 10 mAHD as this elevation was conceptually assumed to mark the boundary of the valley floor and therefore boundary of alluvial deposits. In areas of the model below 10 mAHD, the active model boundaries were assigned along ridges which were conceptually assumed to form groundwater flow divides.

Table 7: Model grid discretisation

Element	Value
Grid cell size	12.5 m x 12.5 m (uniform)
Layers	1
Columns	320
Rows	160
Model dimensions (active + inactive cells)	4 km x 2 km

4.3 Layer Topography

Ground surface (Figure 23) was developed based on interpolation of LIDAR and site survey x,y,z points.

The bottom of Layer 1 is a reproduction of the existing surface terrain at a level 20 m lower.

4.4 Boundary Conditions and Parameters (M1)

With respect to Figure 2 boundary conditions were applied as follows:

- A constant head boundary was applied at the western extent of Moonee Creek. This boundary forms the eastern edge of the model's active domain. The constant head elevation was set to 0.24 mAHD which represents the median monitored Moonee Creek water level (WBM, 2005). This level is above mean sea level due to sand shoaling at the Creek's mouth which attenuates the tidal range of the estuary (WBM, 2005).
- Drain A – this drain was assigned to represent the eastern portion of the east-west man-made drain that traverses through the site. Drain levels were assigned based on culvert invert levels provided on the site survey.
- Drain B – This drain is a continuation of Drain A. The eastern extent of the drain was assigned a level based on a culvert invert level on the site survey. Drain levels were then graded lineally to 0.5 mBGL at the western extent of the drain.
- Drain C – this drain was assigned to represent a man-made drain and was assigned an elevation of 0.5 mBGL.
- Skinners Creek – a drain was assigned to the wider southern portion of the creek with drain elevation assigned based on site survey culvert levels.

- Cunningham Creek – a drain was assigned to the eastern portion of the Creek (east of Pacific Highway) with drain elevation set to 0.24 mAHD. West of the Pacific Highway the creek is no longer tidal and therefore drain elevation graded from 0.24 mAHD to 0.5 mBGL.
- All drain conductance values were assigned based on grid cell length multiplied by drain simulation width multiplied by 0.01 m/d (assumed drain bed hydraulic conductivity).
- K was fixed to 0.01 m/d over the entire domain for the calibration process. This value accords with the geometric mean and median of site K test data (Table 3).
- Initial recharge zones (Figure 24) were established on the basis of aerial photography and comprised a total of 2 zones. Zone 1 was designated over cleared land which was assumed to have relatively less evapotranspiration (ET) and therefore relatively higher net recharge. Zone 2 was assigned over vegetated zones which were taken to have relatively higher ET and therefore relatively lower net recharge, and, over the Moonee Beach shopping precinct which was taken to have lower recharge due to impervious surfaces. The recharge rates for both zones were adjusted manually during calibration.

4.5 Calibration

Mean groundwater levels over August and September were used as head observations to calibrate the model. This period was chosen as the cumulative monthly residual rain mass for both these 2 months was only -7 mm and therefore represents near average rainfall.

The initial recharge zonation produced reasonable calibration in the area of the site with a Zone 1 recharge rate of 15 mm/yr and a Zone 2 recharge rate of 7.5 mm/yr. This produced an absolute residual mean of 0.23 m and NRMS of 8.9%. However, areas to the south and north east of the site displayed head above ground level. A water table depth plot showing these areas is in Figure 25.

To address the areas displaying head above ground, a third recharge zone was applied over these areas and assigned a lower recharge rate of 2 mm/yr. Final calibrated recharge zonation and recharge rates are shown in Figure 27 and produced a maximum and minimum residuals of -0.60 m and -0.01 m respectively, residual mean of 0.06 m, absolute residual mean of 0.23 m and normalized RMS of 8.9% which is below the typically accepted industry threshold of 10%. A calibration plot is provided in Figure 27, groundwater head in Figure 28 and a summary of calibration parameters/zones in Table 8. In light of the above results,

model's low degree of parametisation and model's objectives, the model is considered suitably calibrated for the intended purpose.

Table 8: Calibrated parameter/zonation summary.

Parameter/Zone	Calibrated Value	Comment
Recharge – Zone 1	15 mm/yr	Represents areas with relatively low vegetation coverage, assumed to have relatively lower ET and therefore relatively higher net recharge. Value arrived at through manual calibration.
Recharge – Zone 2	7.5 mm/yr	Represents areas with relatively high vegetation coverage, assumed to have relatively higher ET and therefore relatively lower net recharge. Value arrived at through manual calibration.
Recharge – Zone 3	2 mm/yr	Zone distribution and value arrived at during calibration as described in 4.5.
Hydraulic conductivity (K)	0.01 m/d	Kept fixed throughout calibration process. Value equates to geometric mean and median of site K test data (Table 3)

4.6 Boundary Conditions (M2 and M3)

Boundary conditions were as per M1 with the exception of the following:

M2

- Recharge was reduced from 15 to 8.4 mm/yr over portions of Zone 1 which covered the site, and, from 7.5 to 4.2 over portions of Zone 2 which covered the site. These reductions were based on the site's bulk pervious area percentage of 56% and account for reduced groundwater recharge due to impervious surfaces. Recharge zonation and rates are shown in Figure 29.
- Development terrain was incorporated into the model.
- Drain C (Figure 2) was removed from the model to reflect proposed development terrain which will in-fill this drain.

M3

- As per M2, however, the Moonee Creek constant head elevation was lifted by 0.9 m to 1.14 mAHD. The 0.9 m rise aligns with the NSW Sea Level Rise Policy Statement (DECCW, 2009).

4.7 Results (M2 and M3)

M2 and M3 output is provided in Figure 30 and Figure 32, respectively. A drawdown plot for M2 (initial head = M1) and M3 (initial head = M2) is provided in Figure 31 and Figure 33, respectively.

Results indicate that the development will lead to:

- Negligible change to groundwater flow direction.
- Maximum drawdown of 0.5 m (due to recharge reduction).
- Mounding of 0.2 m in area of Drain C (due its filling).
- Increase to water table depth due simulated drawdown, and, proposed site filling.

Under the potential sea level rise scenario (M3), groundwater levels are modelled to increase 0.9 m (at Moonee Creek) to 0.1 m (340 m inland from Moonee Creek) from those which occur under developed conditions with no sea level rise (M2).

4.8 Interception of Groundwater

Stormwater basins are proposed to be lined and shall therefore not interact with groundwater.

5 Director General Requirements (DGRs)

Project DGRs and responses with respect to groundwater are summarised in Table 9.

Table 9: Project DGRs and responses.

DGR	Response
Provide an assessment of groundwater issues associated with development	Done throughout report
Water table location	Provided through groundwater monitoring (Section 3.4) and modelling (Section 4.5)
Nature/profile of groundwater regime	Provided throughout Section 3
Interception of water table	Addressed in Section 4.8
Potential contamination issues	None foreseeable
Proposed use of groundwater resource	None proposed
Impact on registered bores	None foreseeable – bores are located at considerable distance from the site and access the lower shale aquifer (Section 3.2)
Works that will result in increased groundwater discharge	None foreseeable
Impact on stability of acid sulphate soils	Maximum modelled drawdown across the site is 0.5 m and is within the range of natural groundwater level variation. Consequently, any acid sulphate soils across the bulk of the site will not be impacted by the proposed development.
Impact on Groundwater Dependent Ecosystems (GDEs)	This is not directly assessed in this investigation as GDE mapping was not provided to Martens and Associates. However, based on the minimal drawdown, impact to any GDEs (if present) is likely to be minimal and within the range of natural groundwater level variations
Impact on quantity/quality of groundwater	Quantity shall decrease due to the predicted site drawdown of approximately 0.5 m. No impacts to quality are likely as the proposed stormwater system is pit and pipe

6 Conclusion

A single layered numerical groundwater model (MODFLOW) was developed and calibrated (steady-state) to assess the impact of a proposed development at Lot 1 DP 1097743, Pacific Highway, Moonee Beach, NSW.

Results indicate that the proposed development shall generally result in minimal change to existing observed hydrogeological conditions.

7 References

Bair and Lahm (2006), Practical Problems in Groundwater Hydrology, Pearson Education.

Batu (1998), *Aquifer Hydraulics: A Comprehensive Guide to Hydrogeologic Data Analysis.*

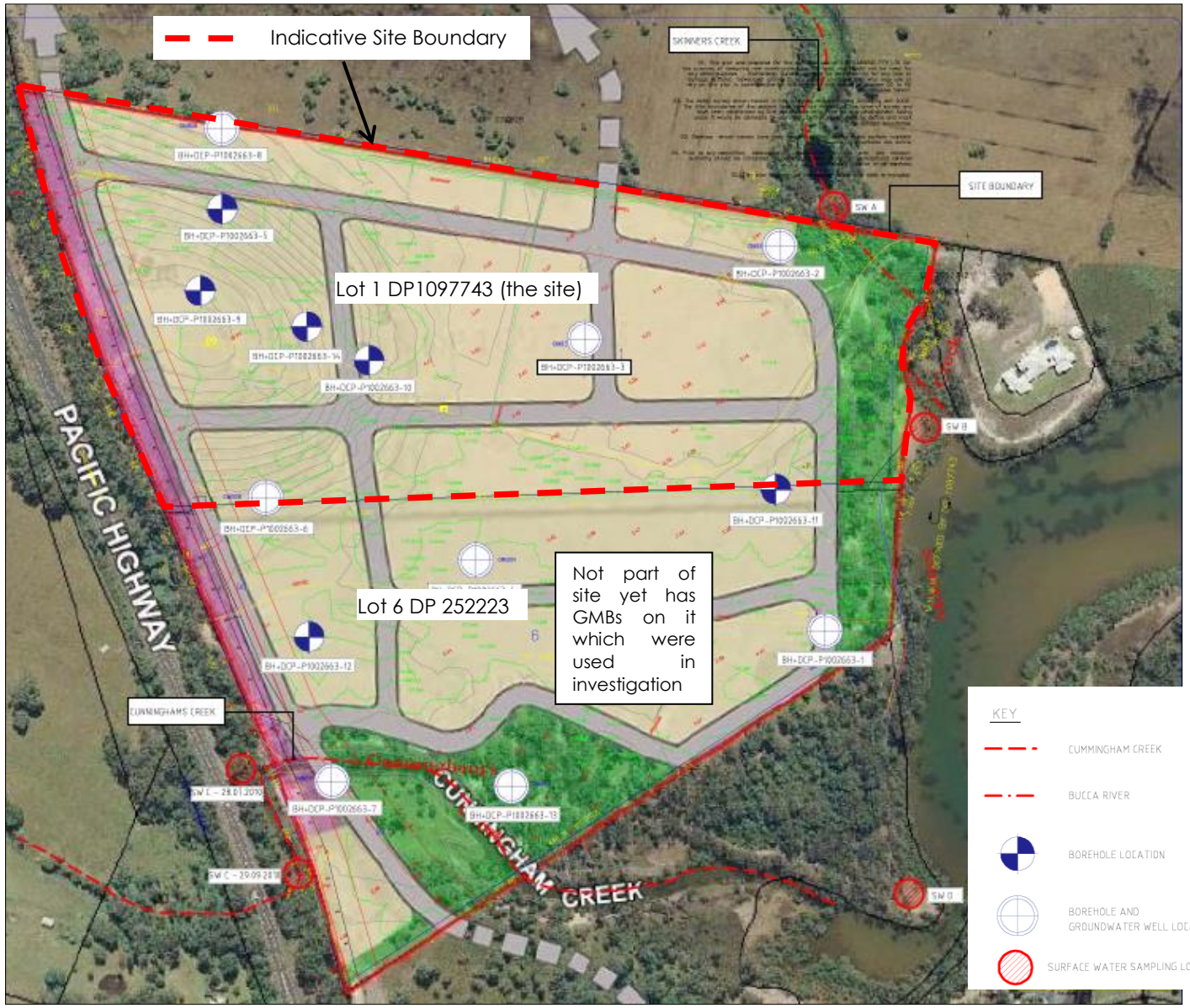
Coffey (December, 2005), *Proposed Subdivision at Moonee Beach, Pacific Highway, Moonee Beach, NSW – Geotechnical Assessment*, reference CH1173/1-AM.

DECCW (2009), NSW Sea Level Rise Policy Statement.

Jacob, B (1940), *On the flow of water in an elastic artesian aquifer*: American Geophysical Union Transactions, part 2, p. 574-586.

USGS (1997), Determination of Barometric Efficiency and Effective Porosity, Boreholes UE-25 c#1, UE-25 c#2, and UE-25 c#3, Yucca Mountain, Nye County, Nevada.

8 Attachment A – Figures



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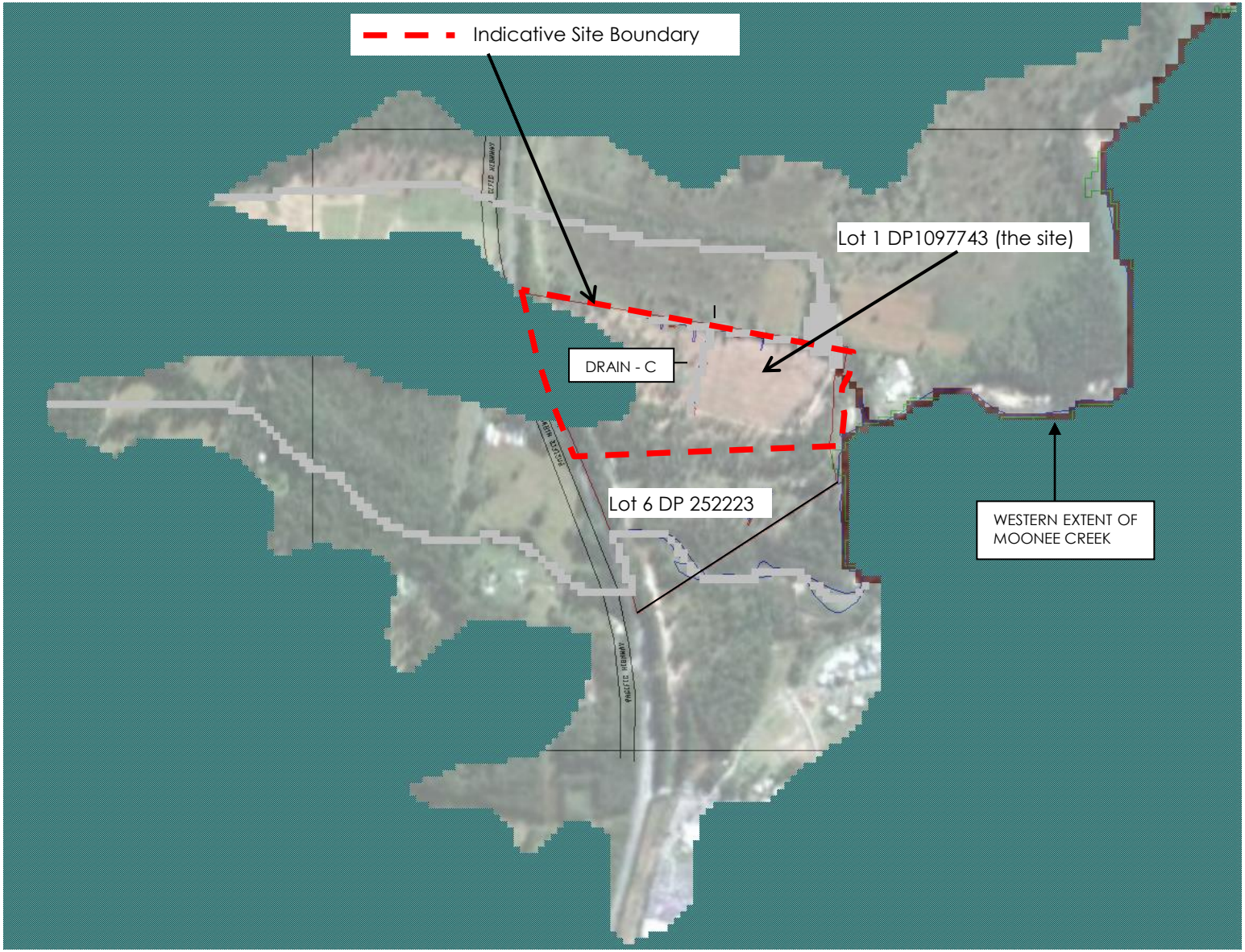
martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	FC/GT/BR	**EXISTING SURVEY PLAN WITH BOREHOLE/GMB LOCATIONS**	Drawing No: **FIGURE 1**
Approved:	DM		
Date:	03.07.2018		
Scale:	APPROX: 1: 2,150		Job No: P1002663



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martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**EXISTING DRAINAGE LINES**	Drawing No: **FIGURE 2**
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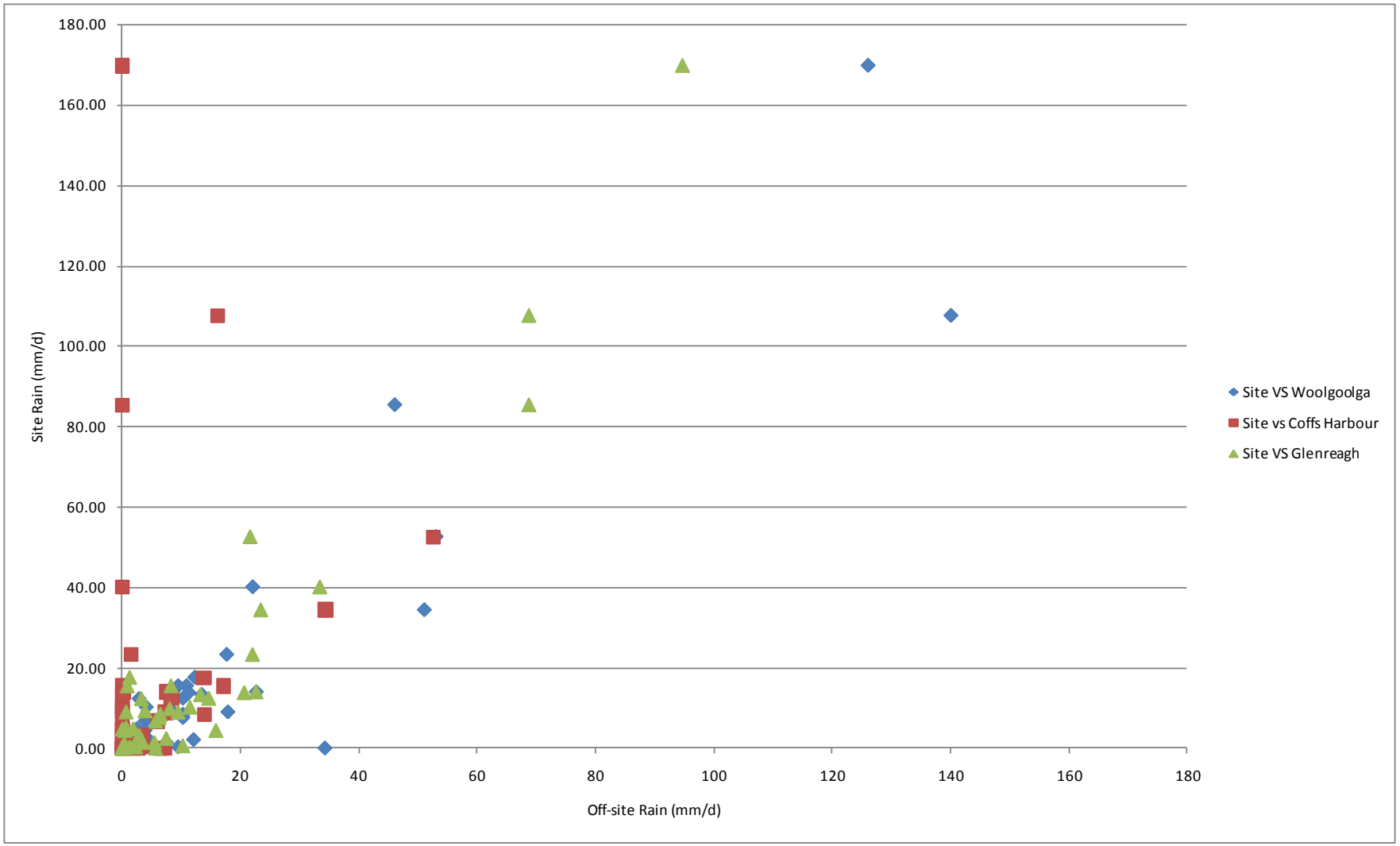

Notes:

1. Site data obtained from site rain gauge.
2. Off-site data obtained from BOM stations – Coffs Harbour (59040), Woolgoolga (59039) and Glenreagh (59054).
3. Data period = 28.07.2010 to 02.11.2010.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**RAIN DATA SCATTER PLOT**	Drawing No: **FIGURE 3**
Approved:	GT/DM		
Date:	03.07.2018		
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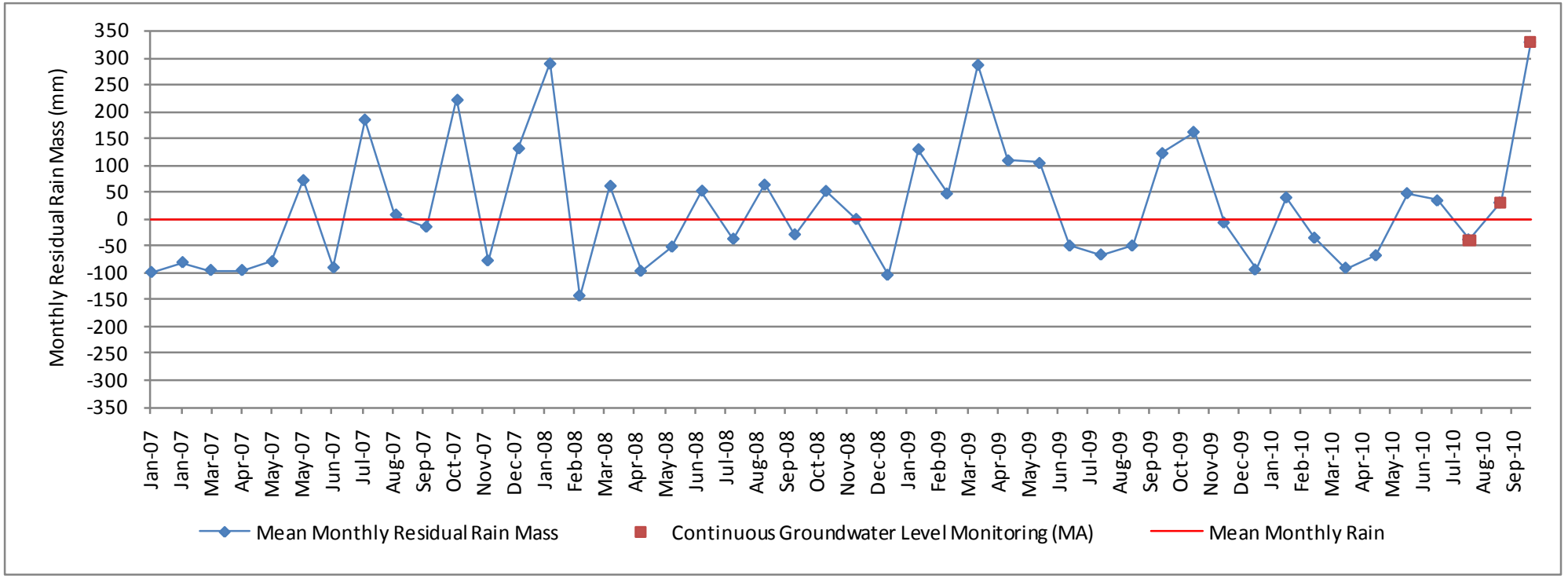
martens



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**MEAN MONTHLY RESIDUAL RAIN MASS AND MA MONITORING PERIOD**	Drawing No: **FIGURE 4**
Approved:	GT/DM		
Date:	03.07.2018		
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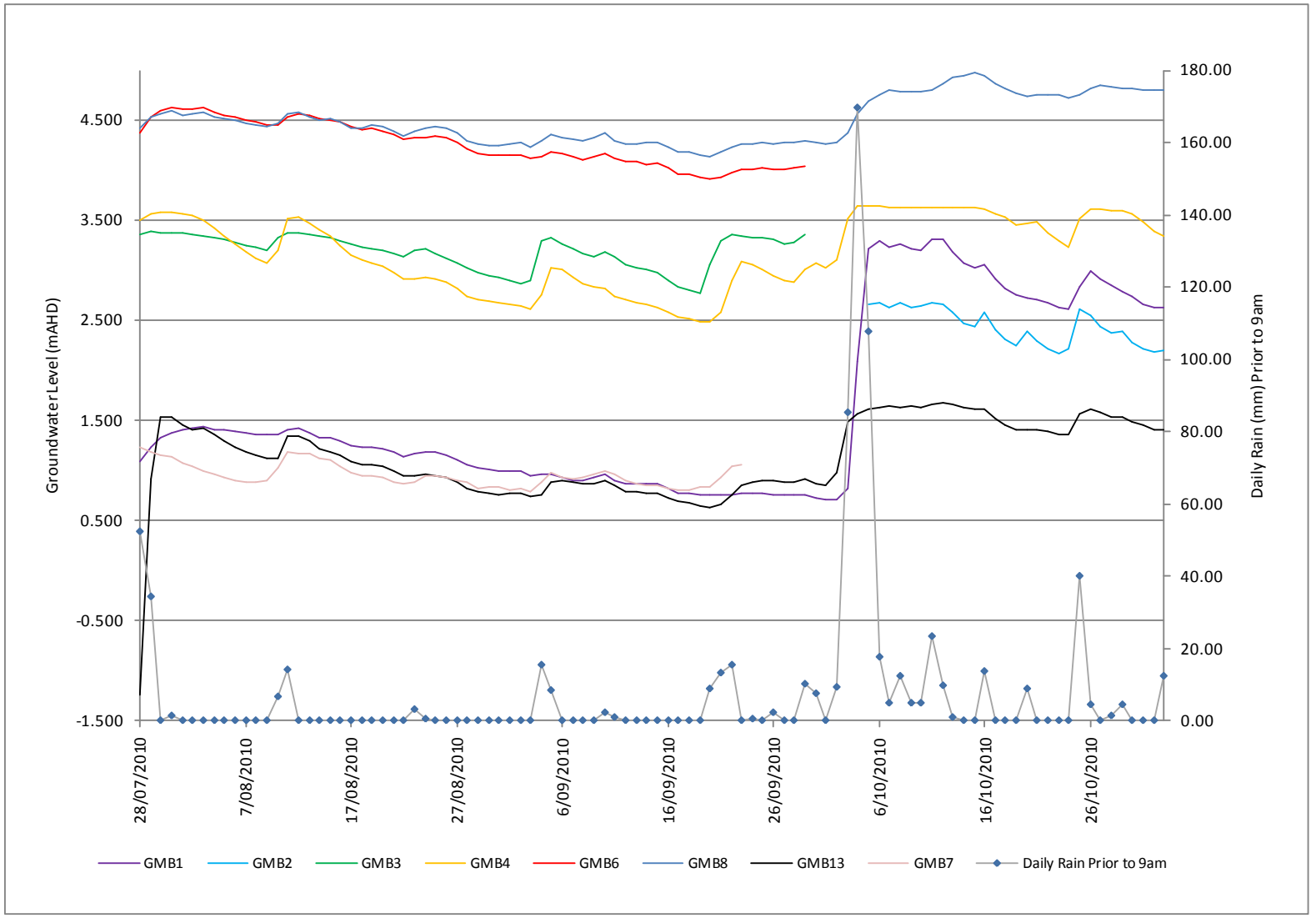
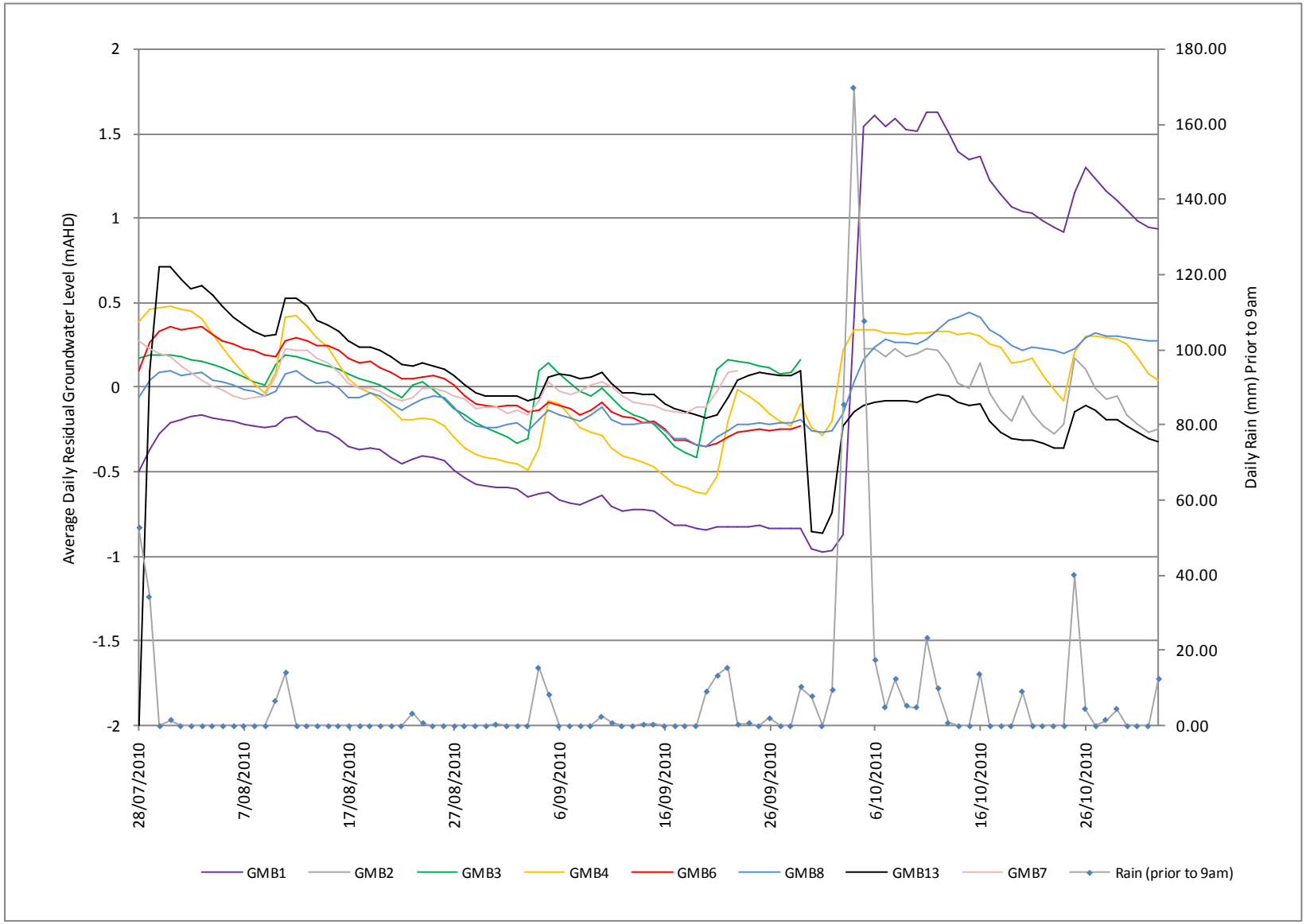


Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**CONTINUOUS GROUNDWATER LEVELS**	Drawing No: **FIGURE 5**
Approved:	GT/DM		
Date:	03.07.2018		
Scale:	NA		Job No: P1002663

martens



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Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**AVERAGE DAILY RESIDUAL GROUNDWATER LEVELS**	Drawing No: **FIGURE 6**
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Date:	03.07.2018		
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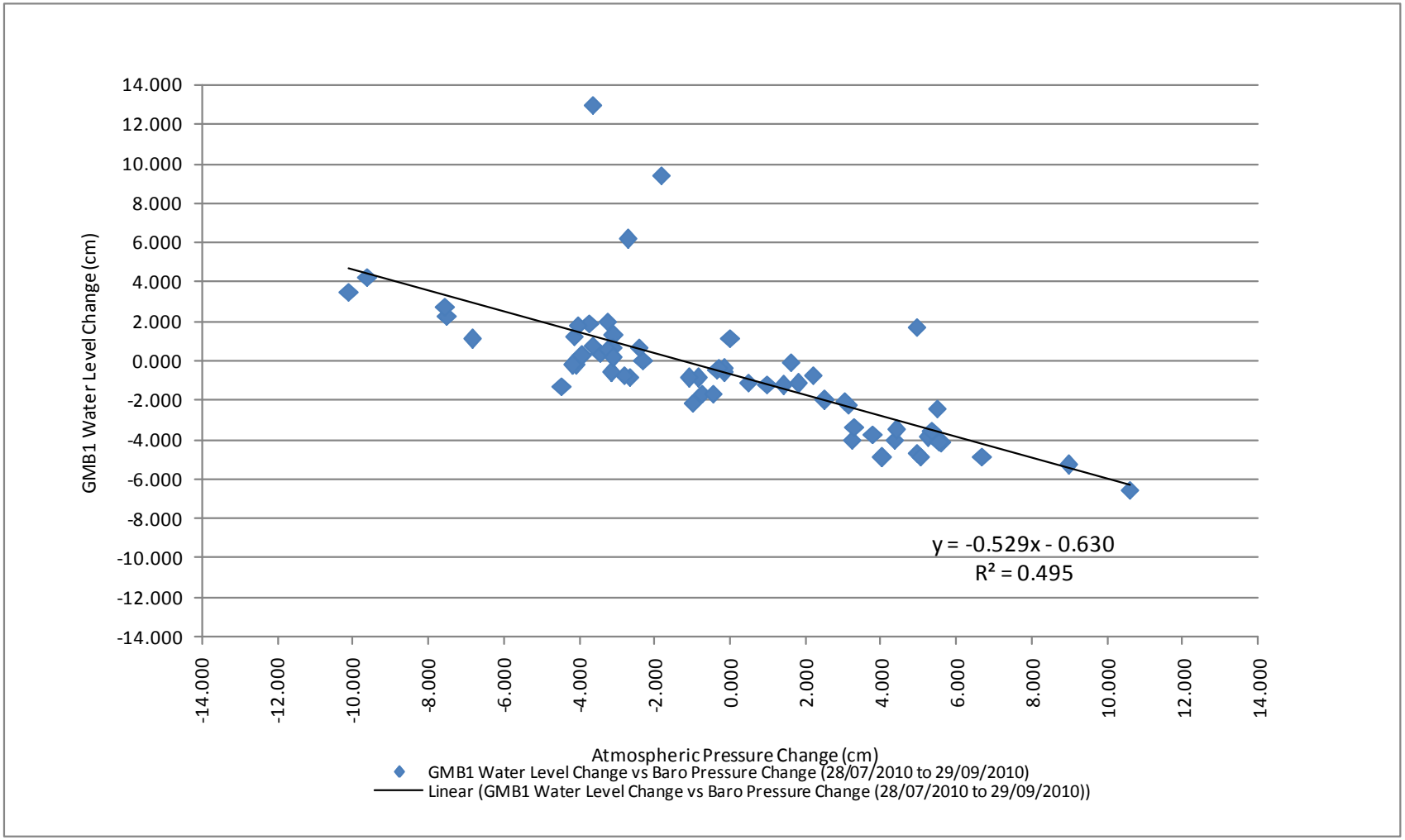

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB1 BAROMETRIC EFFECIENCY**	Drawing No: **FIGURE 7**
Approved:	GT/DM		
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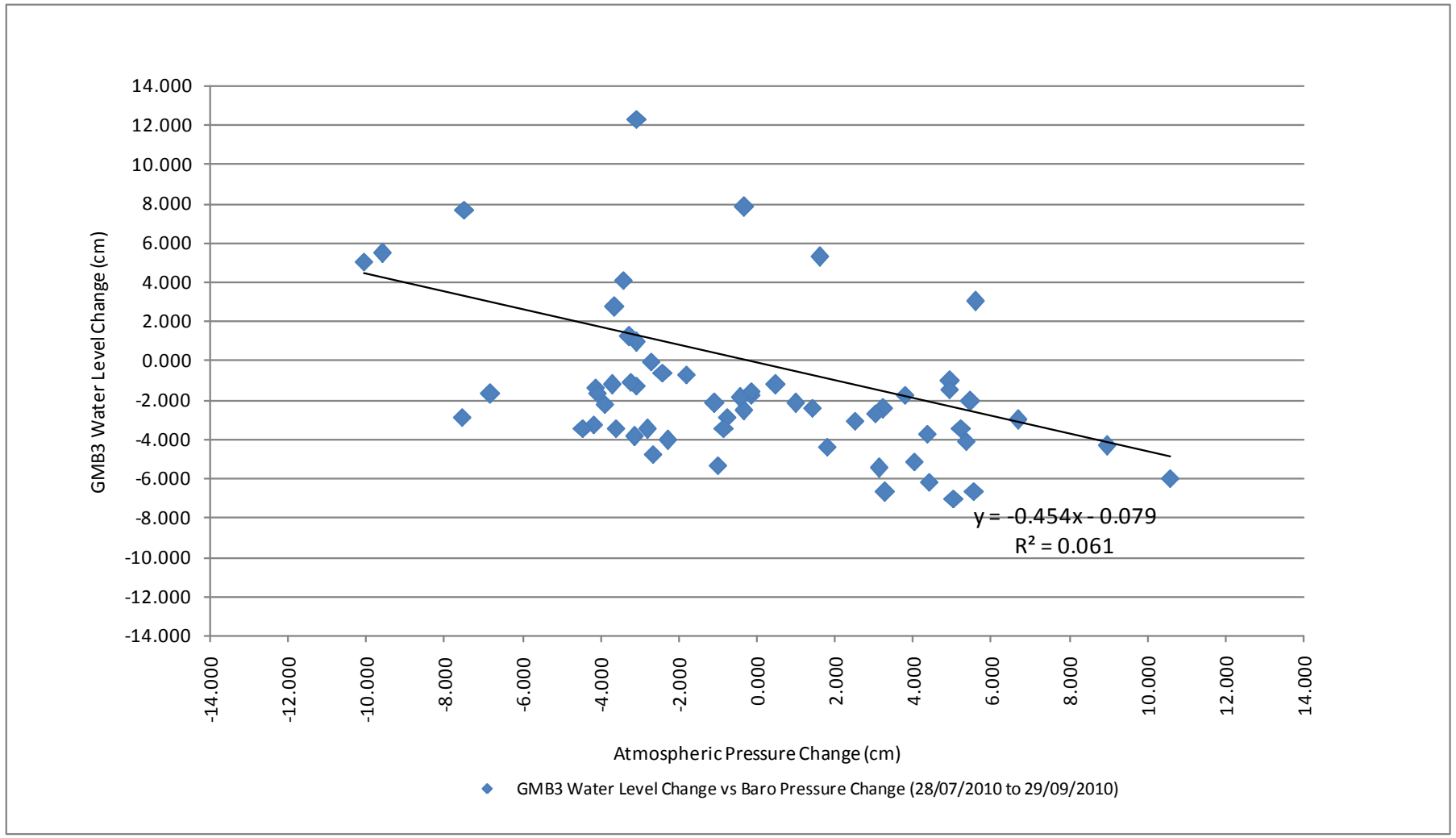
martens



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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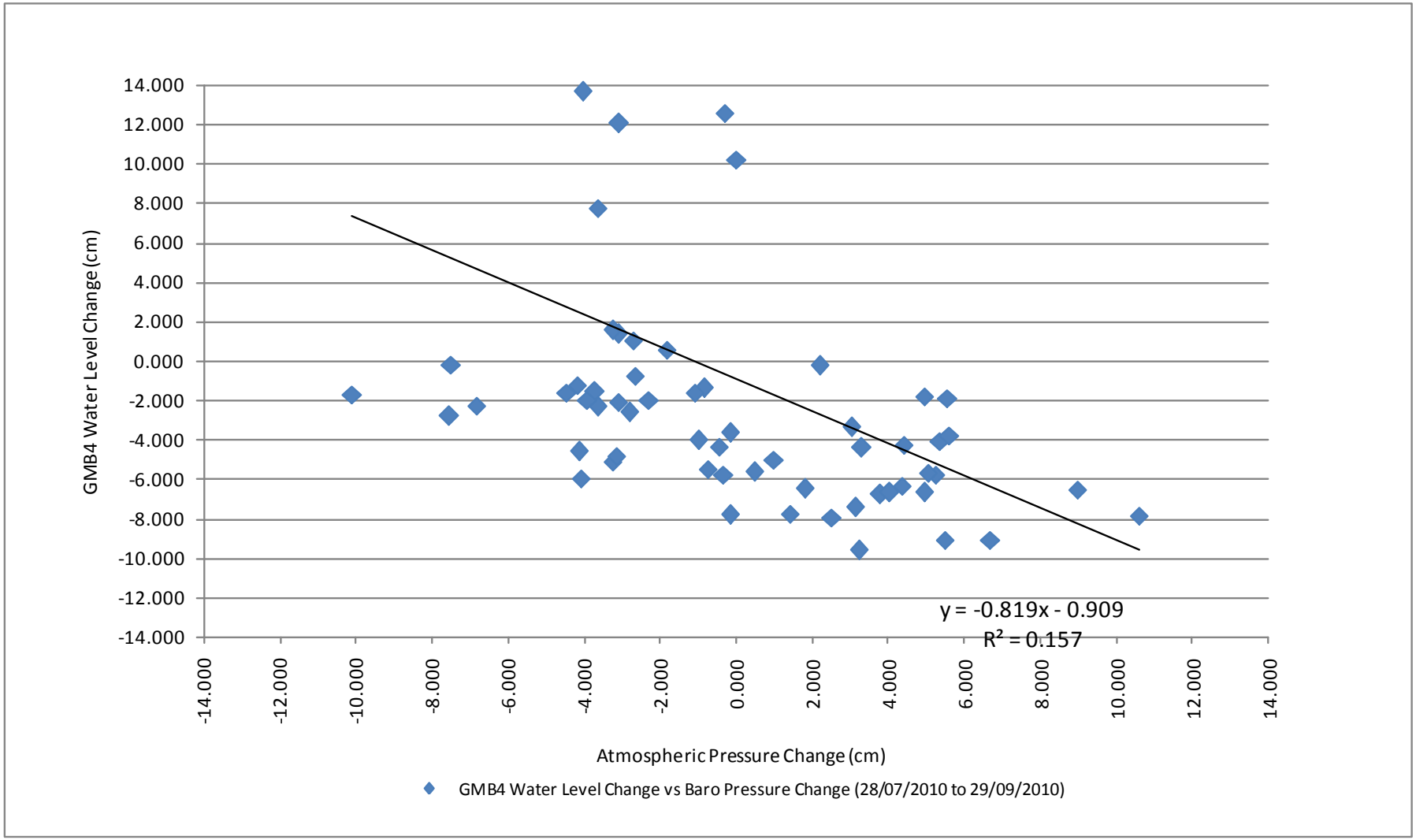
martens



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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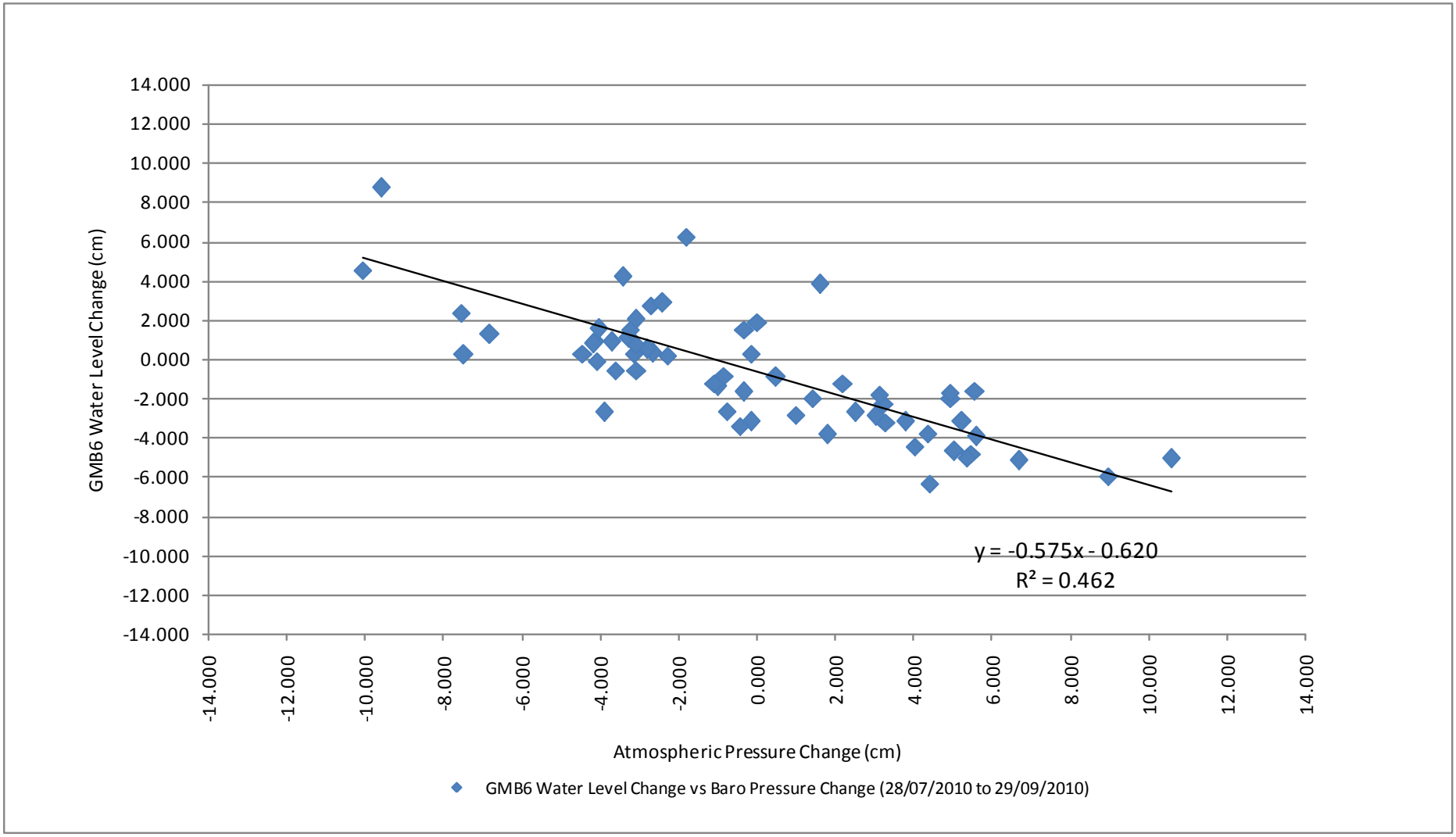

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB6 BAROMETRIC EFFECIENCY**	Drawing No: **FIGURE 10**
Approved:	GT/DM		
Date:	03.07.2018		
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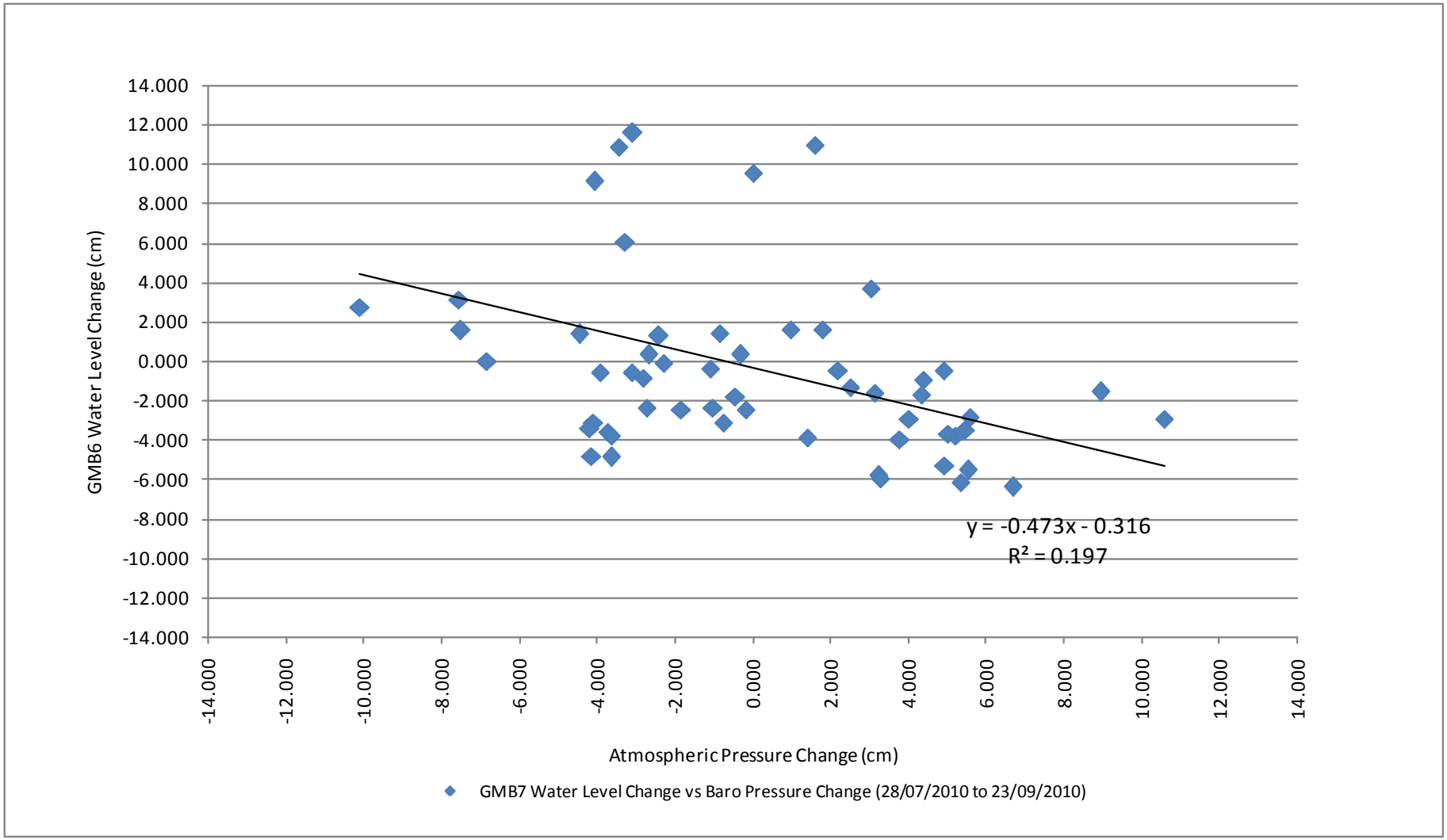

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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Approved:	GT/DM		
Date:	03.07.2018		
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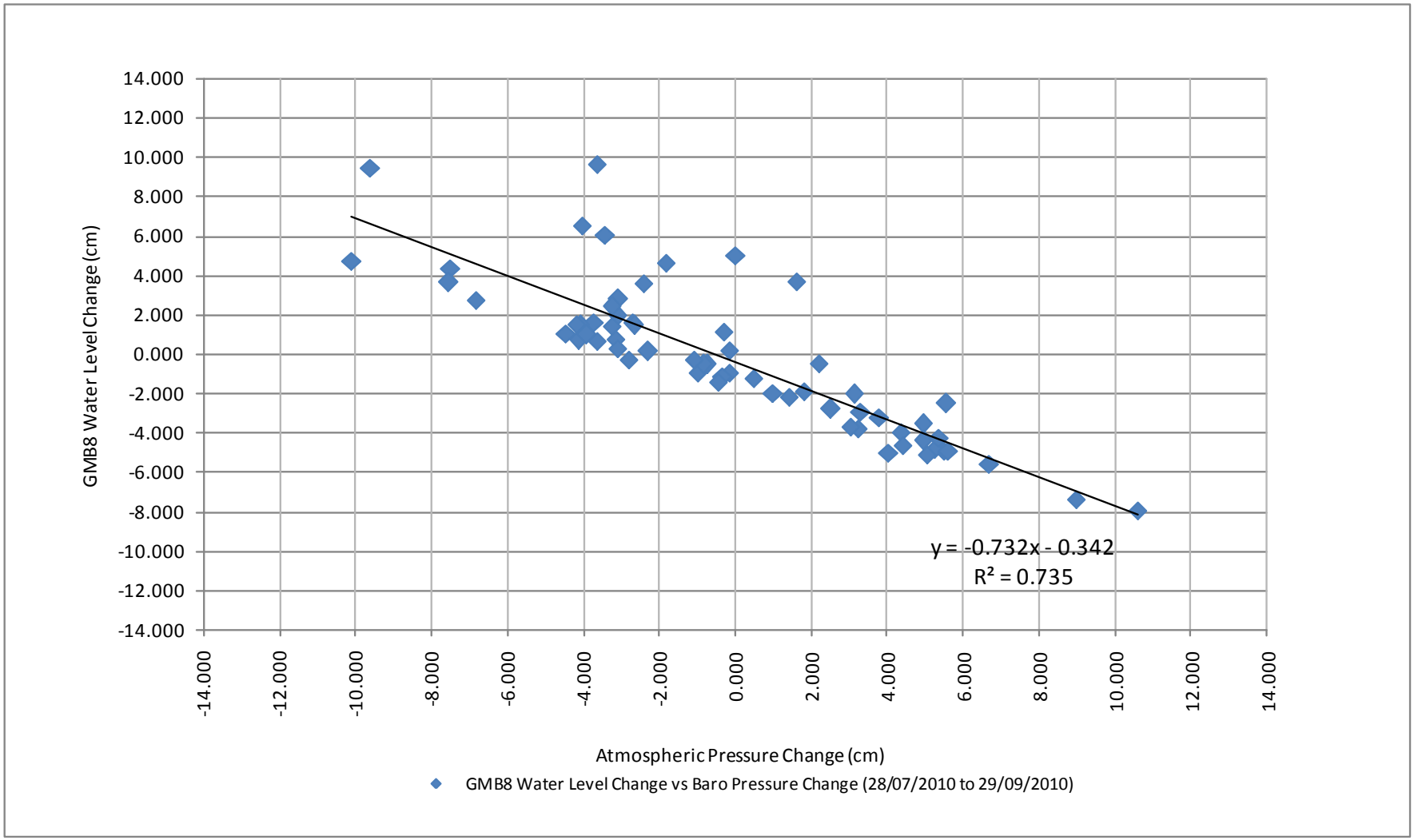
martens



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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Date:	03.07.2018		
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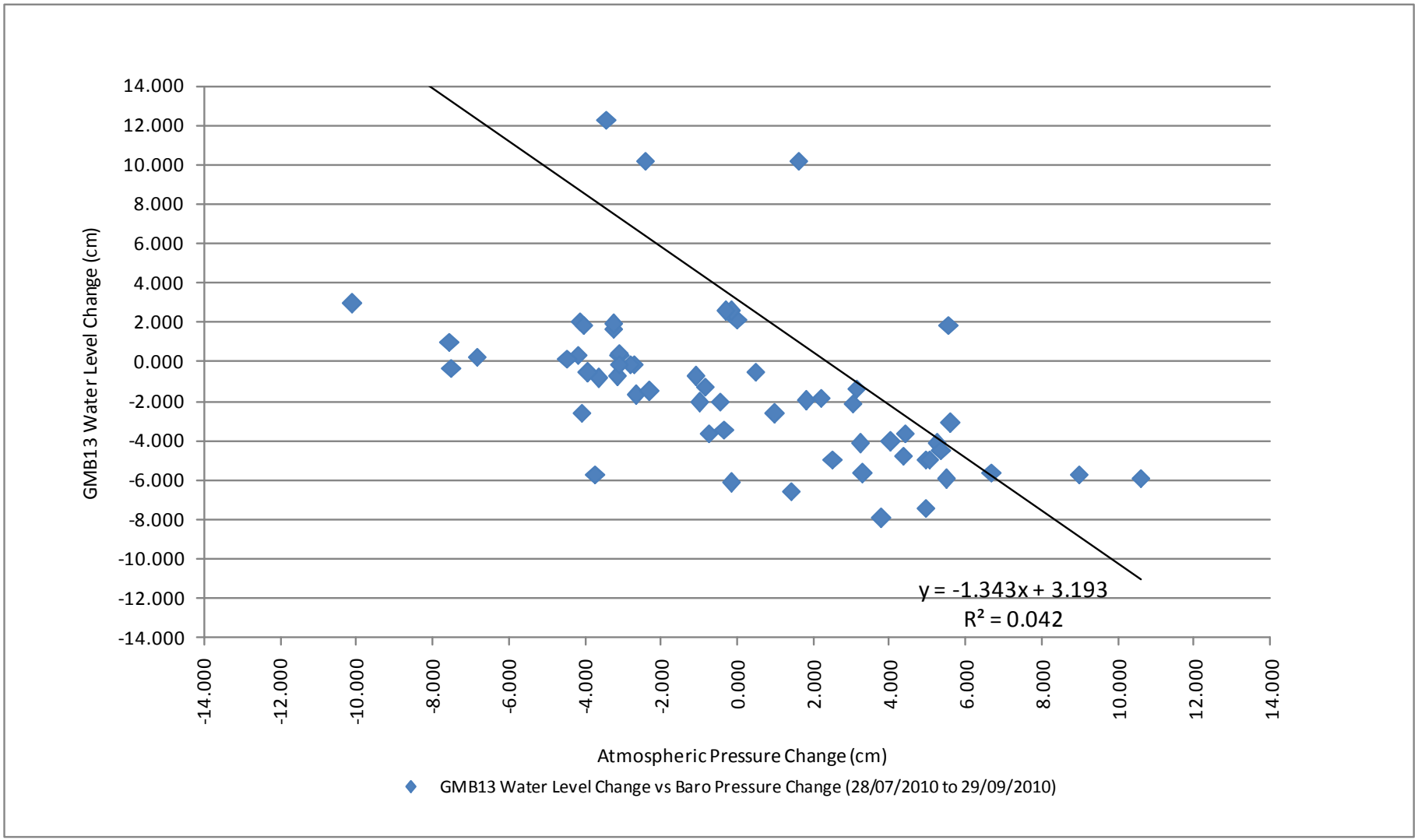
martens



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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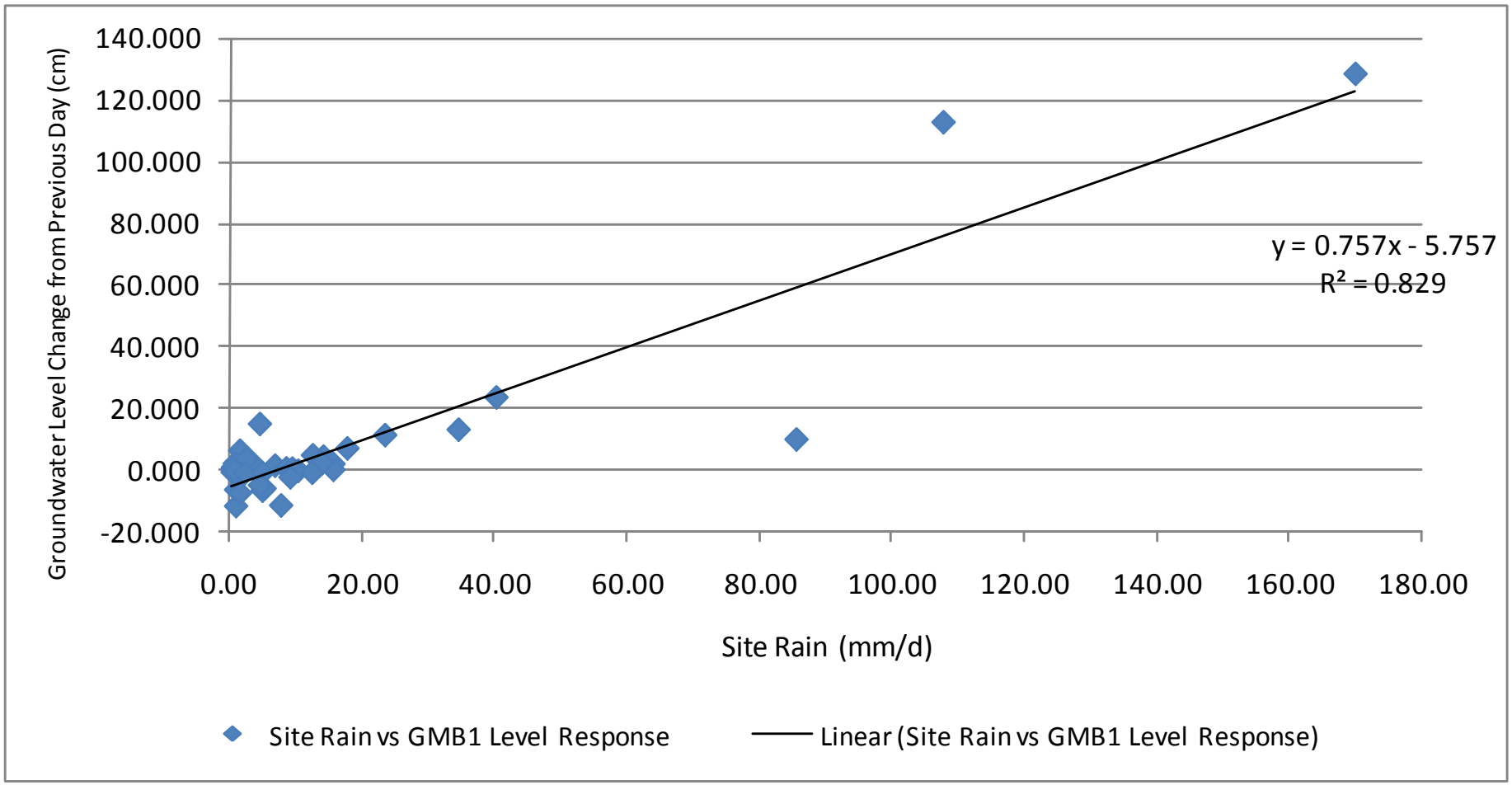
Approved:	GT/DM		
Date:	03.07.2018		
Scale:	NA		Job No: P1002663

martens



martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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Approved:	GT/DM		
Date:	03.07.2018		
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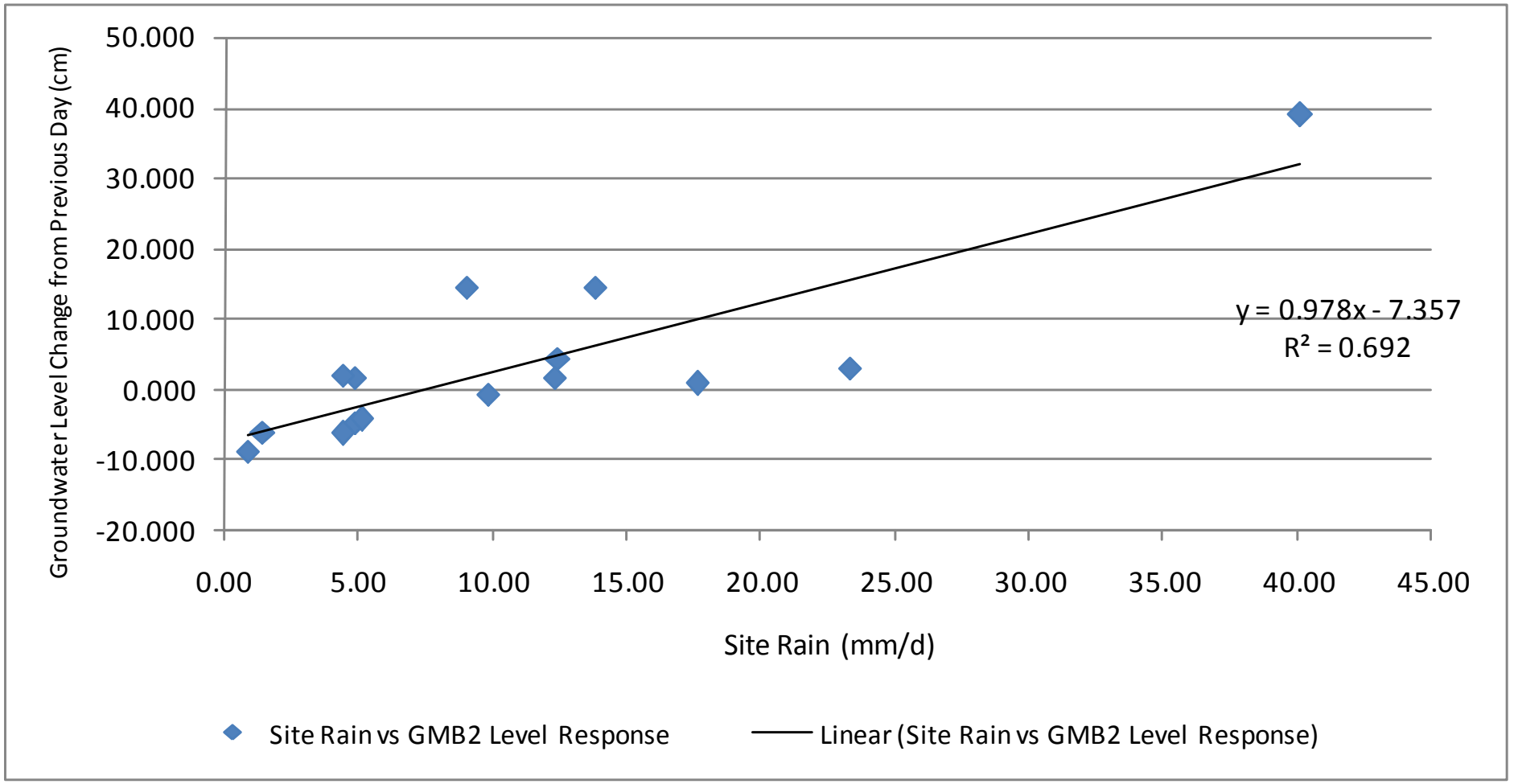

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Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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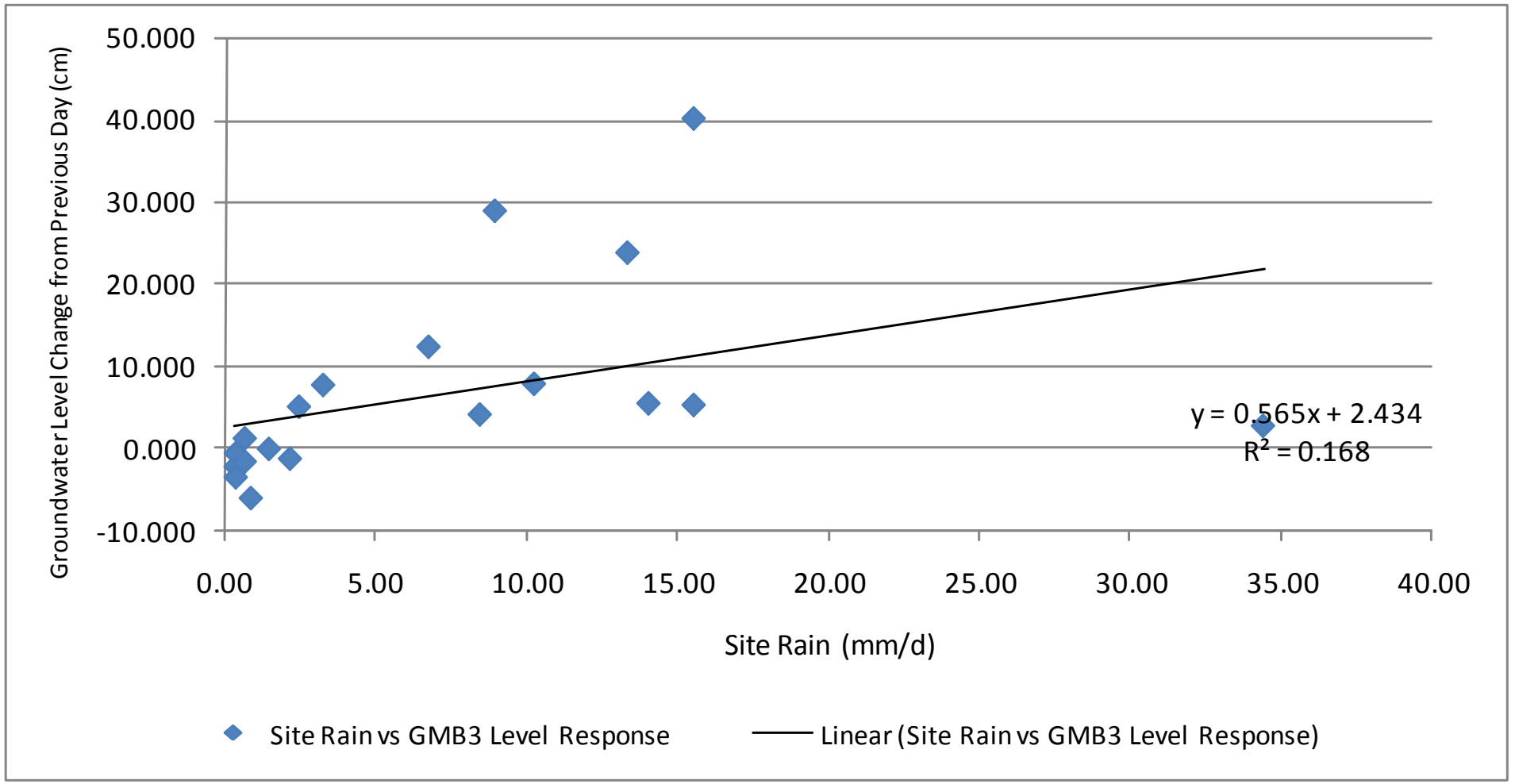

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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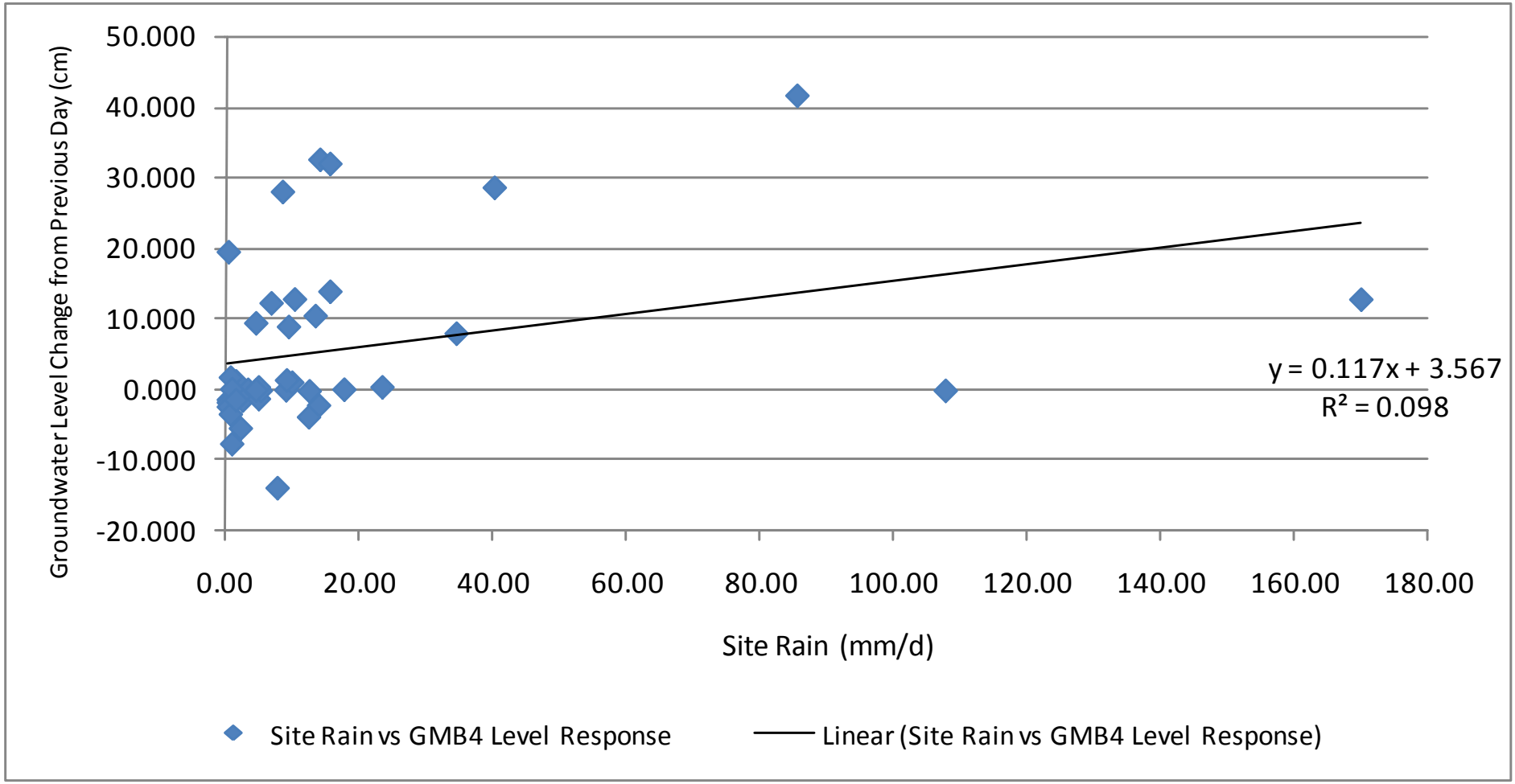

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Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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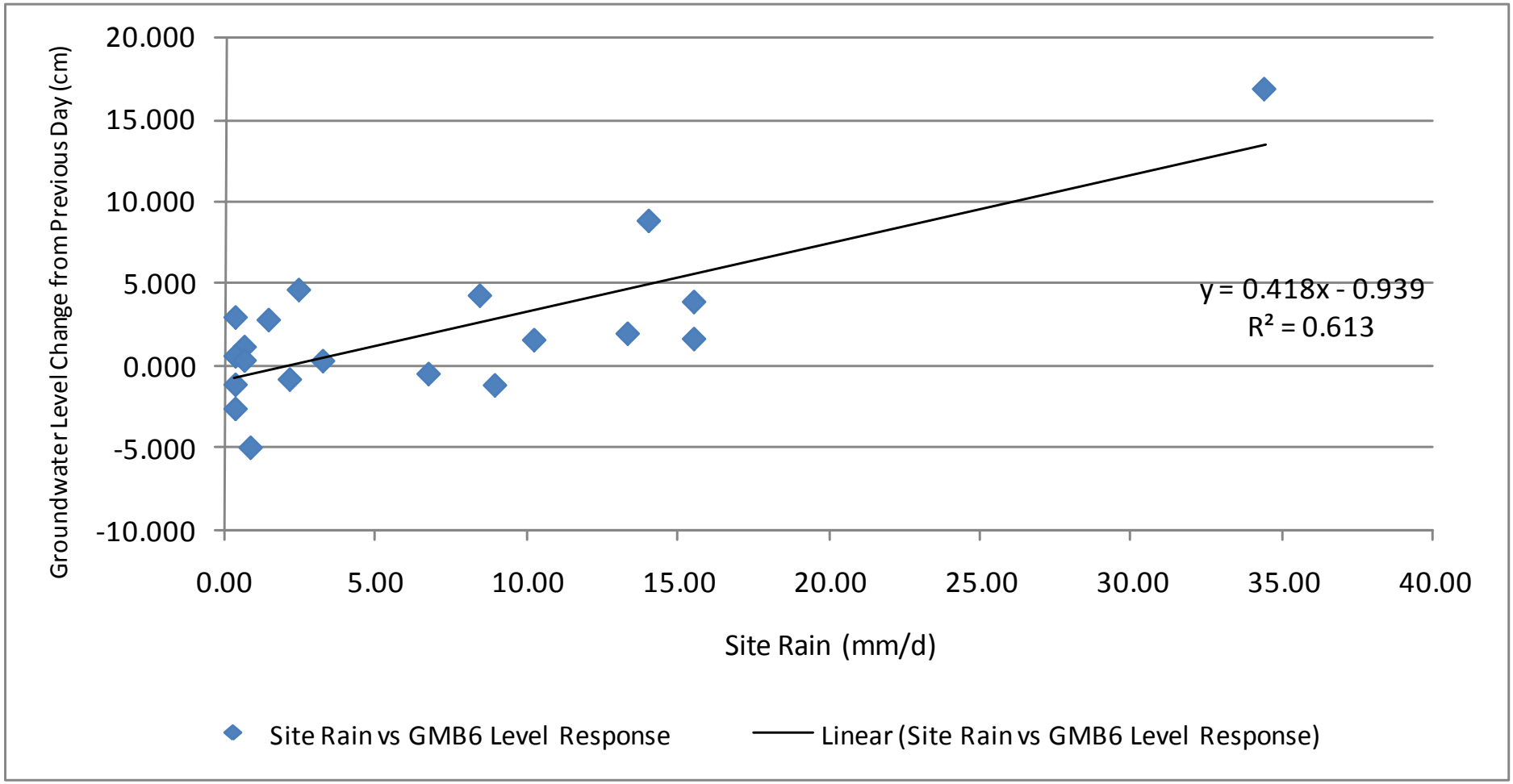

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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Approved:	GT/DM		
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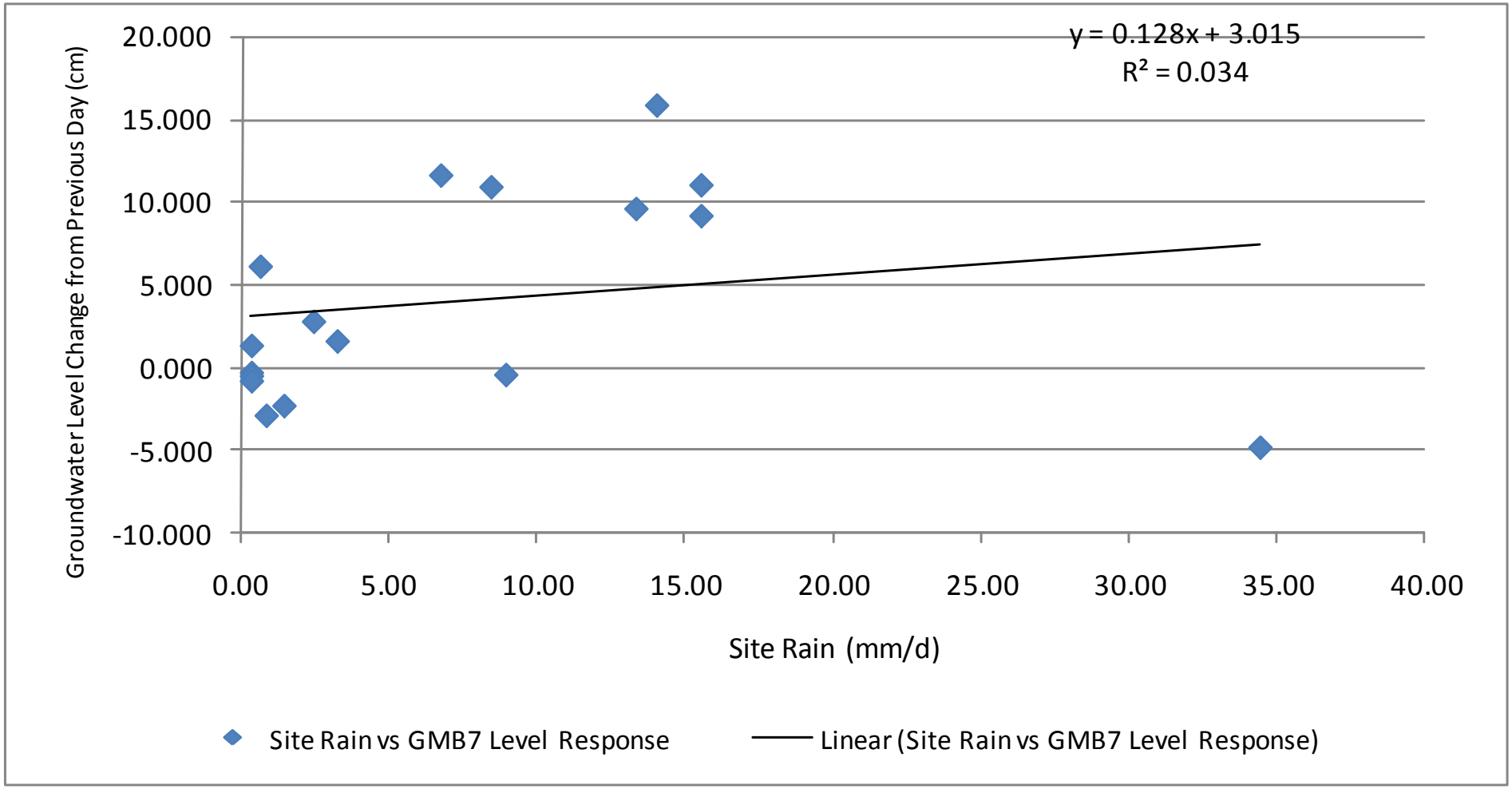

martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB7 RESPONSE TO RAINFALL**	Drawing No: **FIGURE 19**
Approved:	GT/DM		
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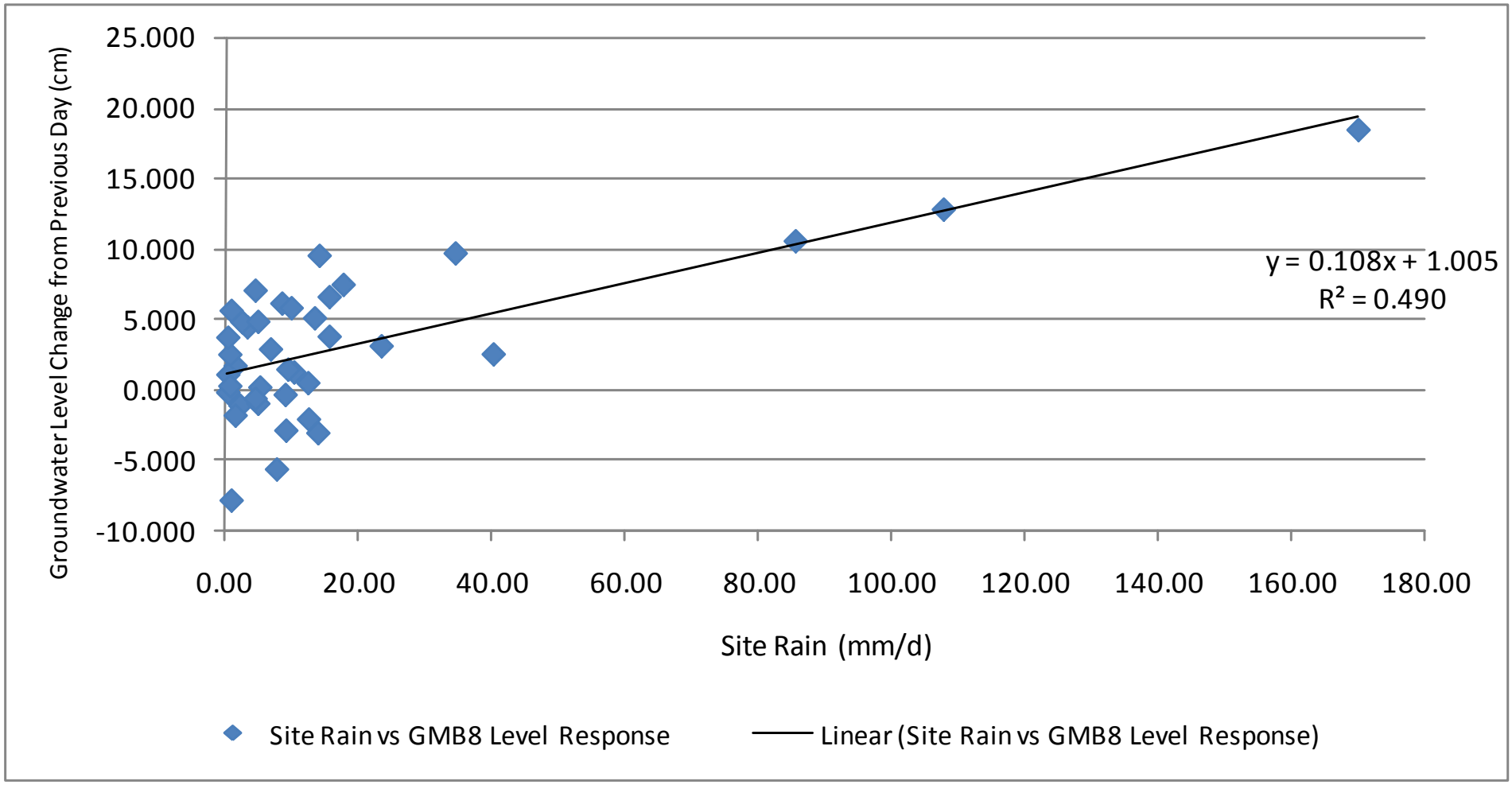

martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB8 RESPONSE TO RAINFALL**	Drawing No: **FIGURE 20**
Approved:	GT/DM		
Date:	03.07.2018		
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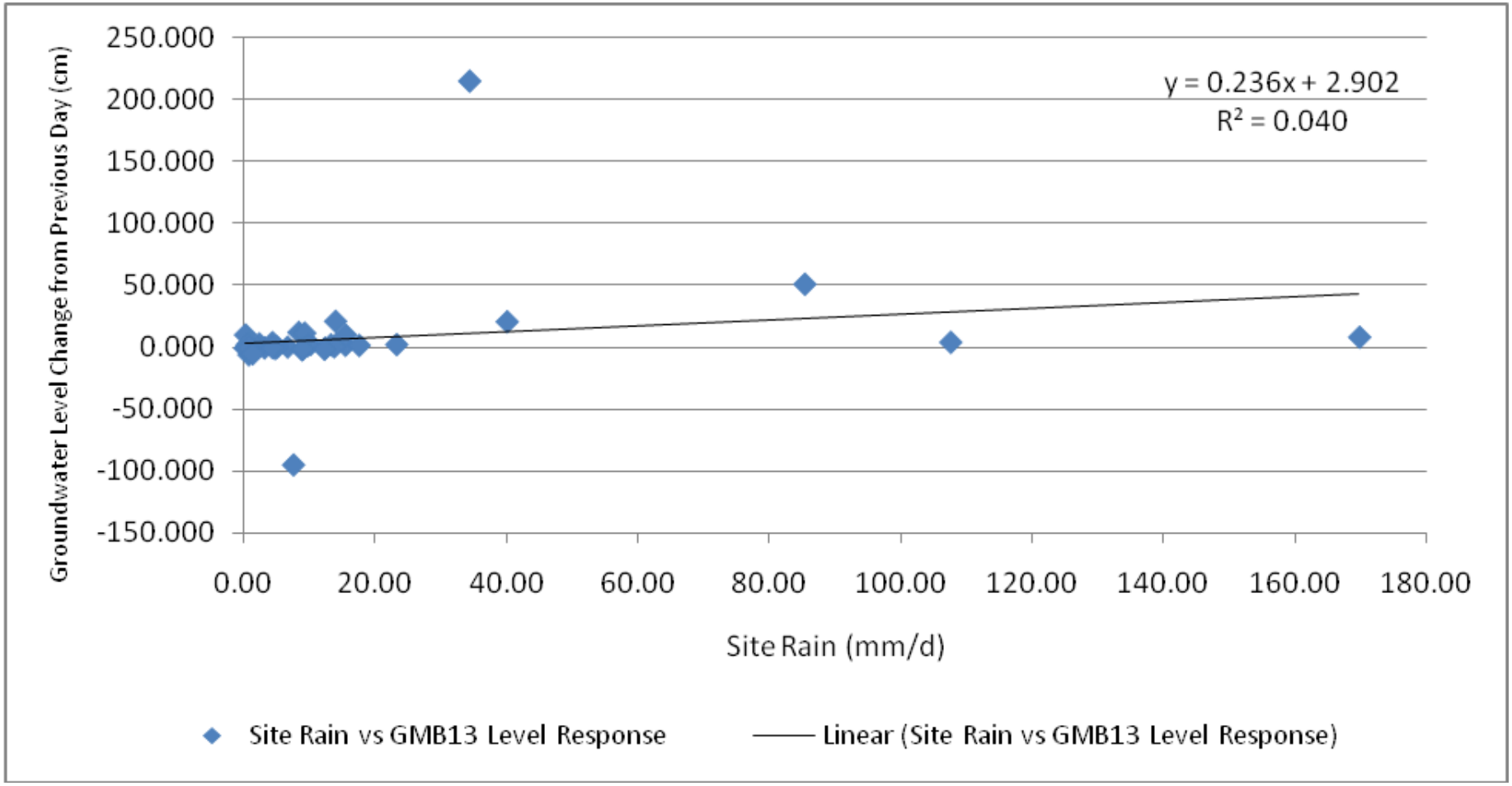

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB13 RESPONSE TO RAINFALL**	Drawing No: **FIGURE 21**
Approved:	GT/DM		
Date:	03.07.2018		
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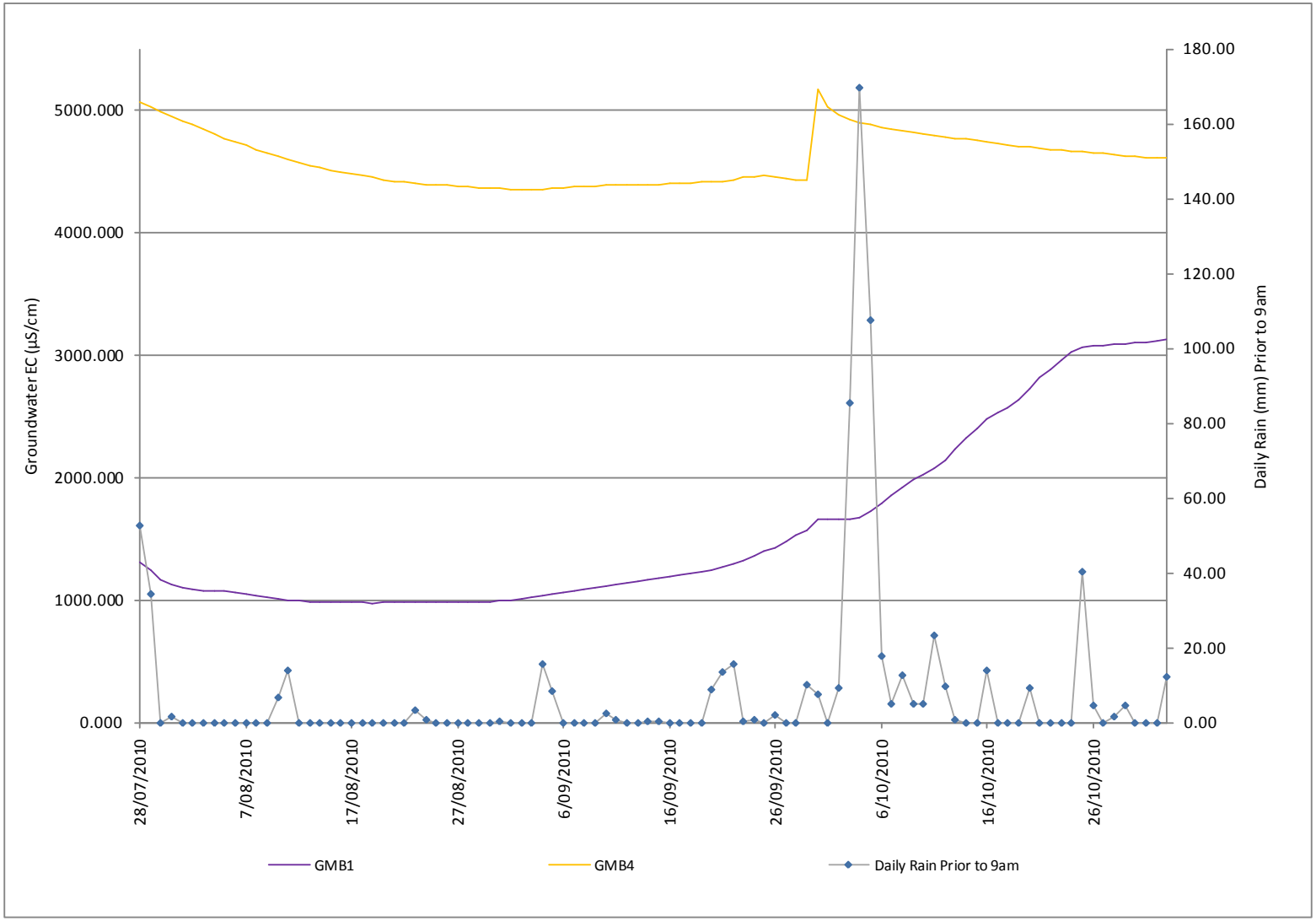

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB1 and GMB4 CONTINUOUS EC MEASUREMENTS**	Drawing No: **FIGURE 22**
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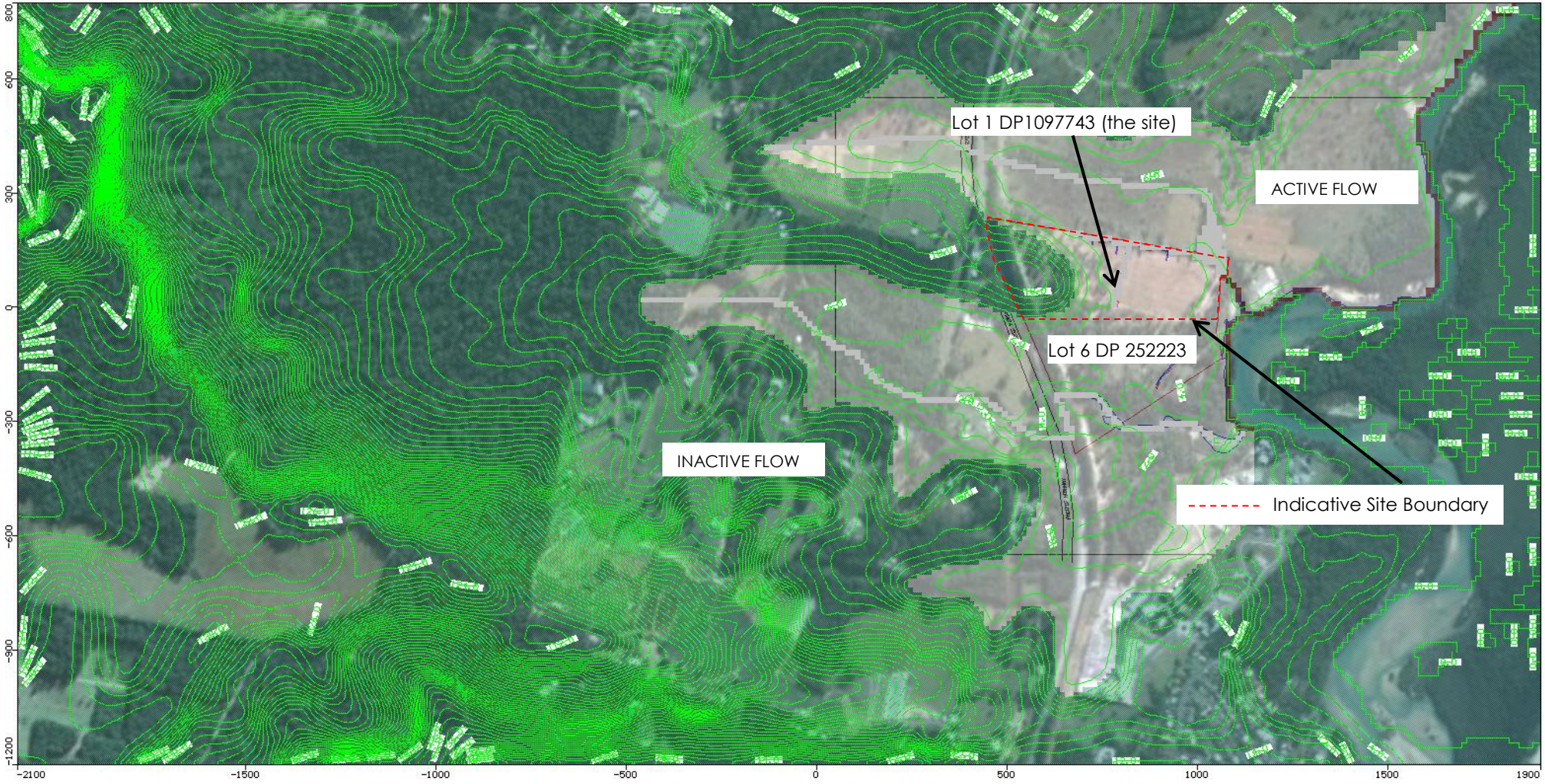
martens



Notes:

1. Contour interval = 2 m.

N

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**MODEL DOMAIN**	Drawing No: **FIGURE 23**
Approved:	GT/DM		
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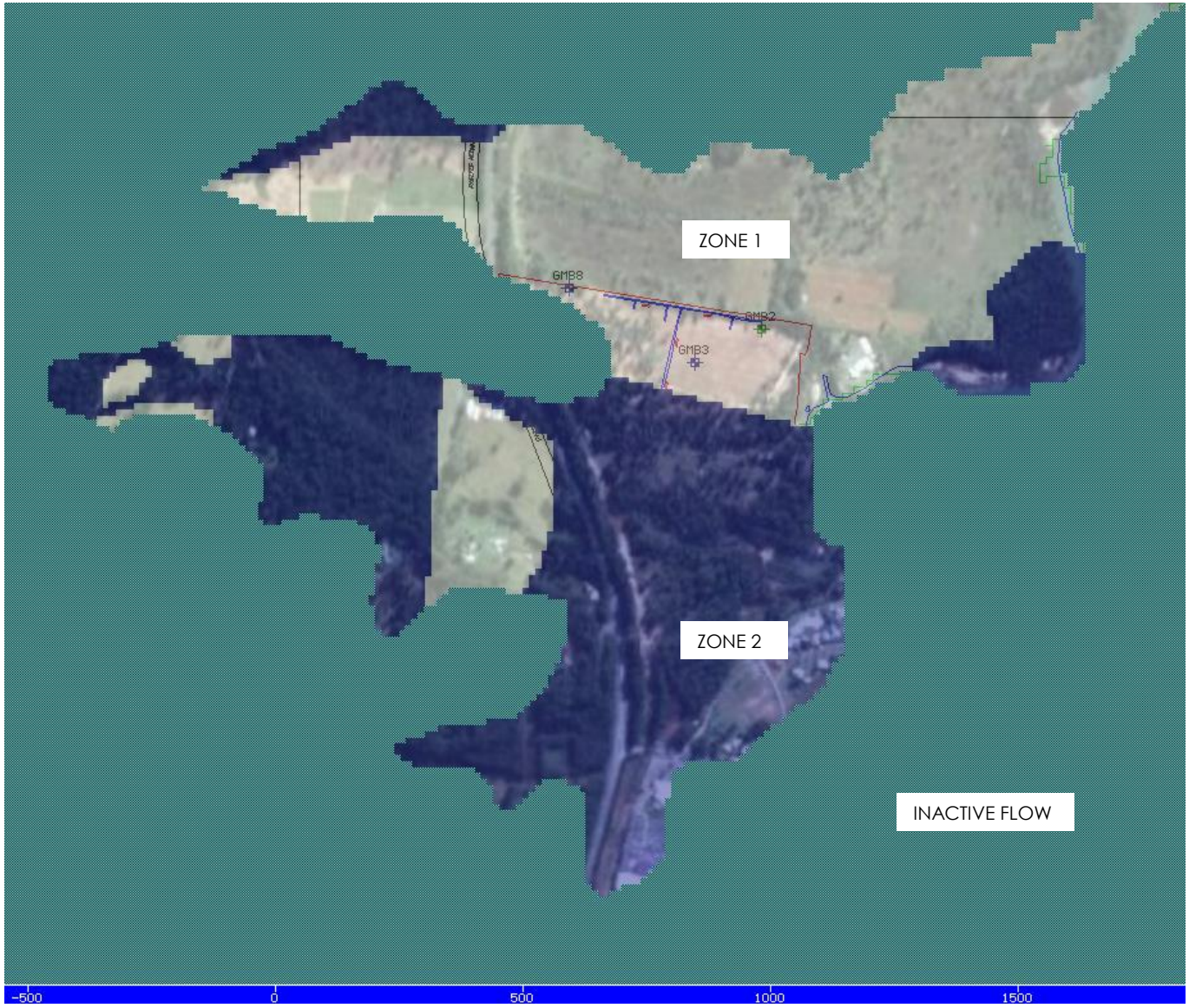

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Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M1 PRE-CALIBRATION RECHARGE ZONES**	Drawing No: **FIGURE 24**
Approved:	GT/DM		
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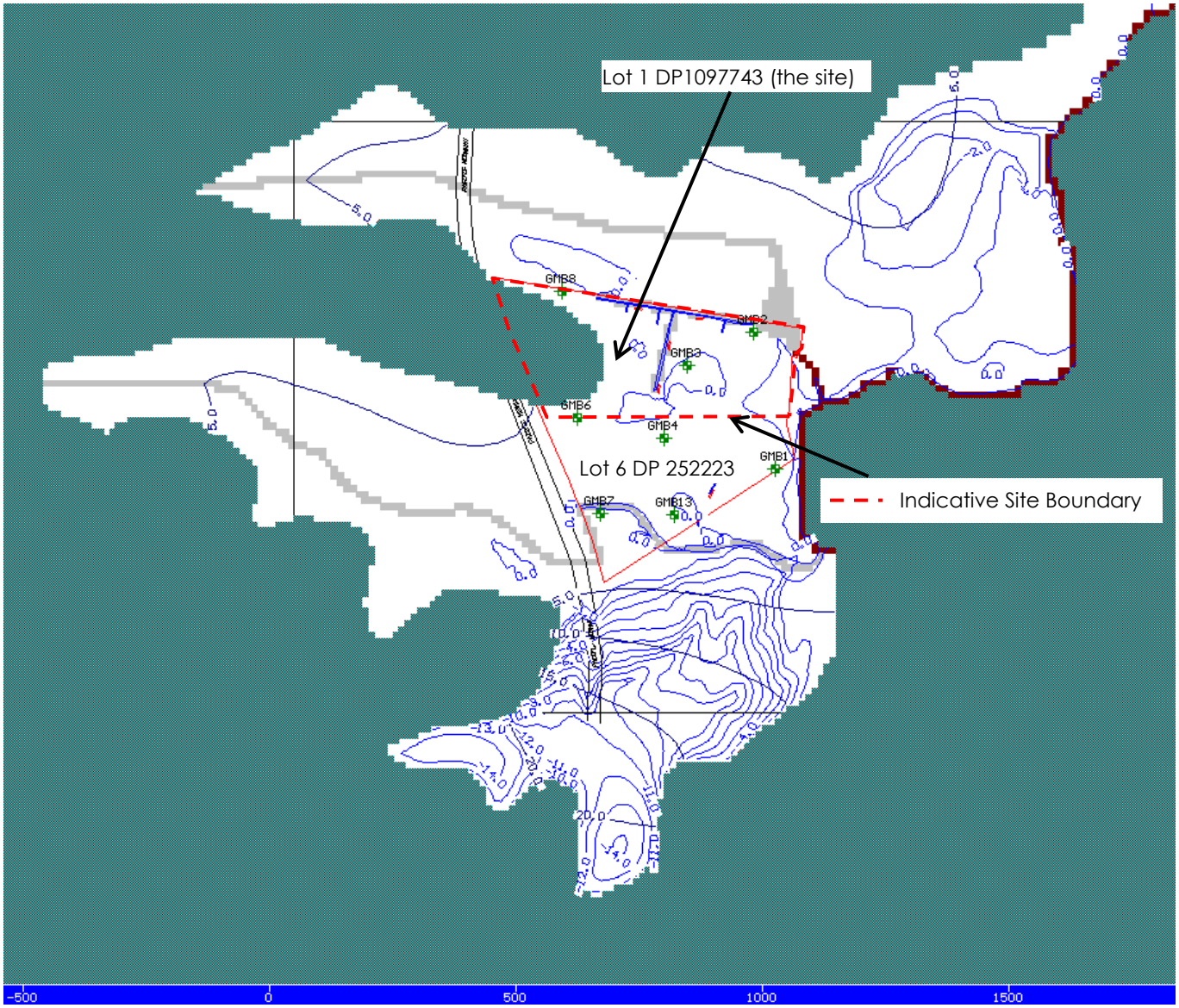

martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M1 PRE-CALIBRATION WATER TABLE DEPTH PLOT**	Drawing No: **FIGURE 25**
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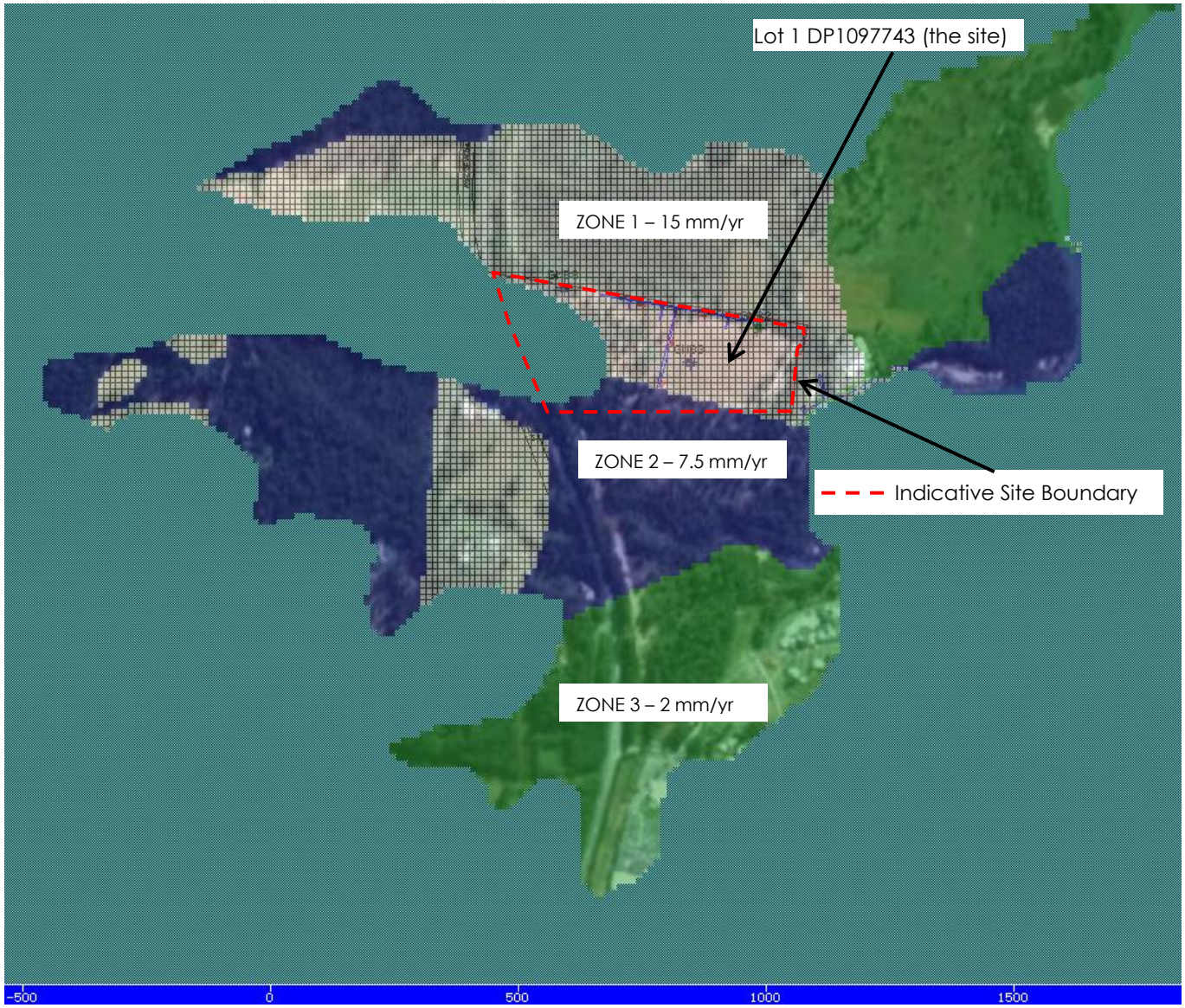

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martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M1 CALIBRATED RECHARGE ZONES/RATES**	Drawing No: **FIGURE 26**
Approved:	GT/DM		
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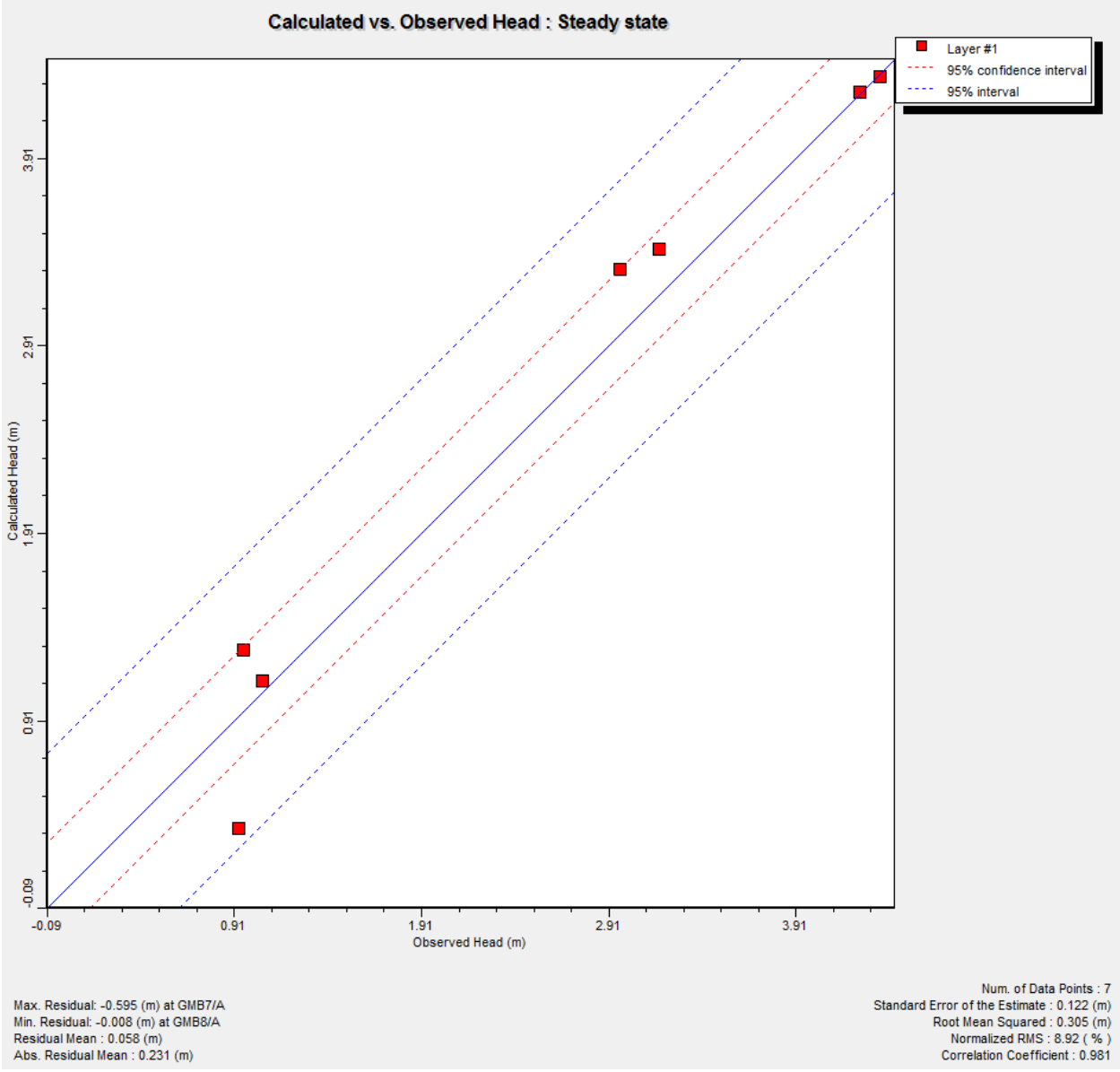

martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M1 CALIBRATION PLOT**	Drawing No: **FIGURE 27**
Approved:	GT/DM		
Date:	03.07.2018		
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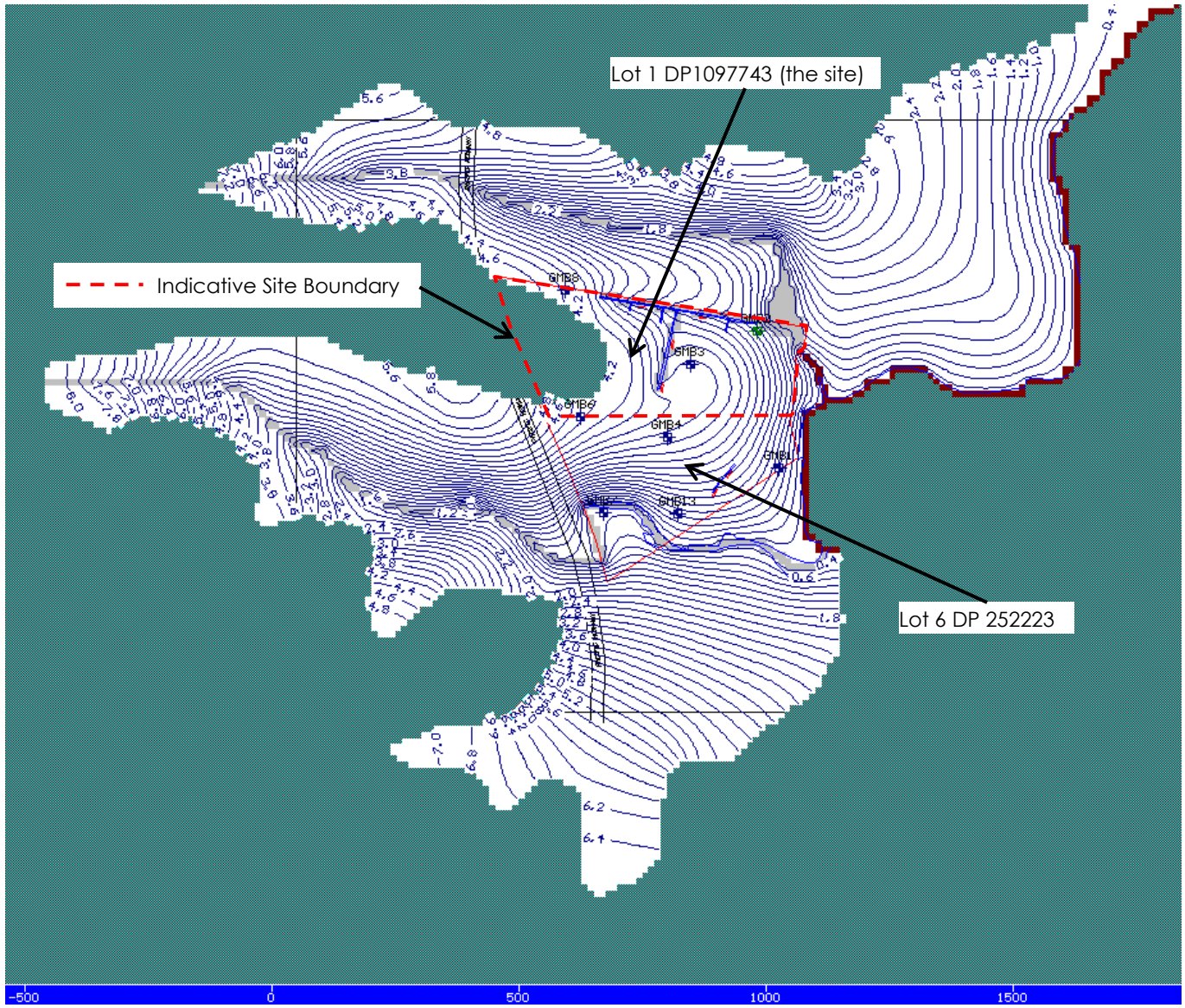
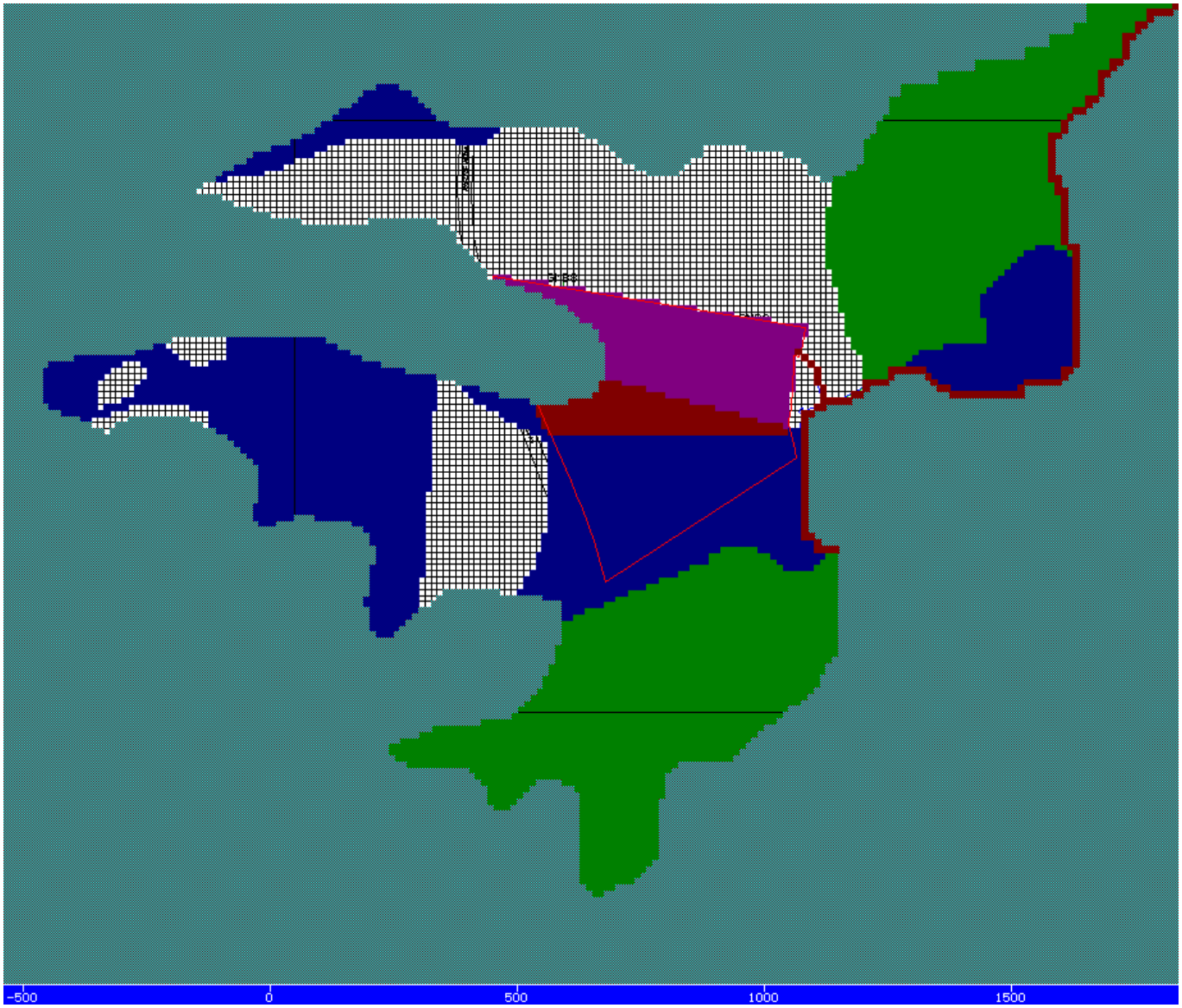


martens

Key:

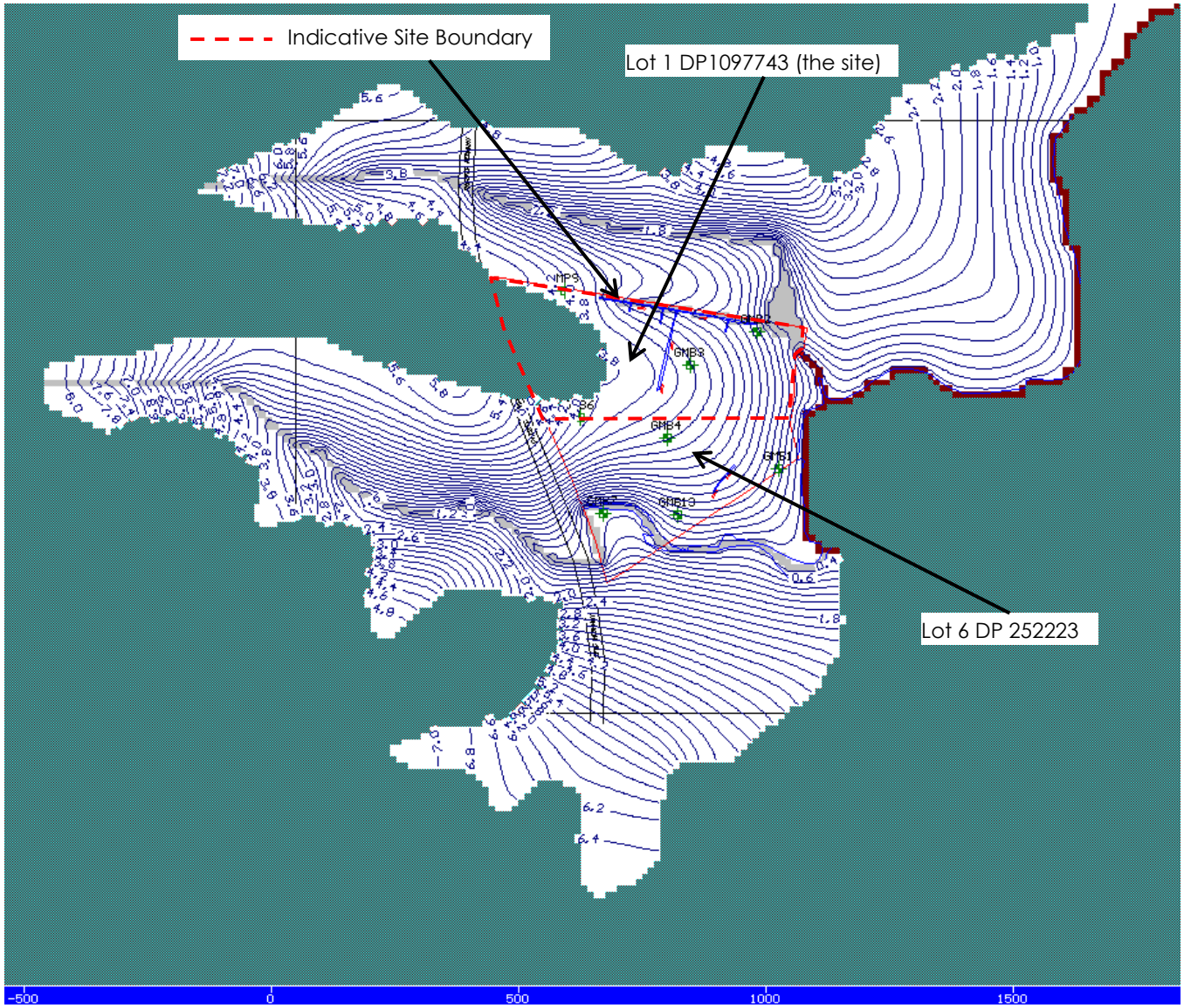
1. Blue lines – groundwater head (0.2 m interval).
2. Grey cell – drain boundary.
3. Red cells – constant head boundary.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M1 GROUNDWATER HEAD**	Drawing No: **FIGURE 28**
Approved:	GT/DM		
Date:	03.07.2018		
Scale:	1:13,260		Job No: P1002663



martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M2 RECHARGE ZONES/RATES**	Drawing No: **FIGURE 29**
Approved:	GT/DM		
Date:	03.07.2018		
Scale:	1:13,260		Job No: P1002663



N

martens

Key:

1. Blue lines – groundwater head (0.2 m interval).
2. Grey cell – drain boundary.
3. Red cells – constant head boundary.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M2 GROUNDWATER HEAD**	Drawing No: **FIGURE 30**
Approved:	GT/DM		
Date:	03.07.2018		
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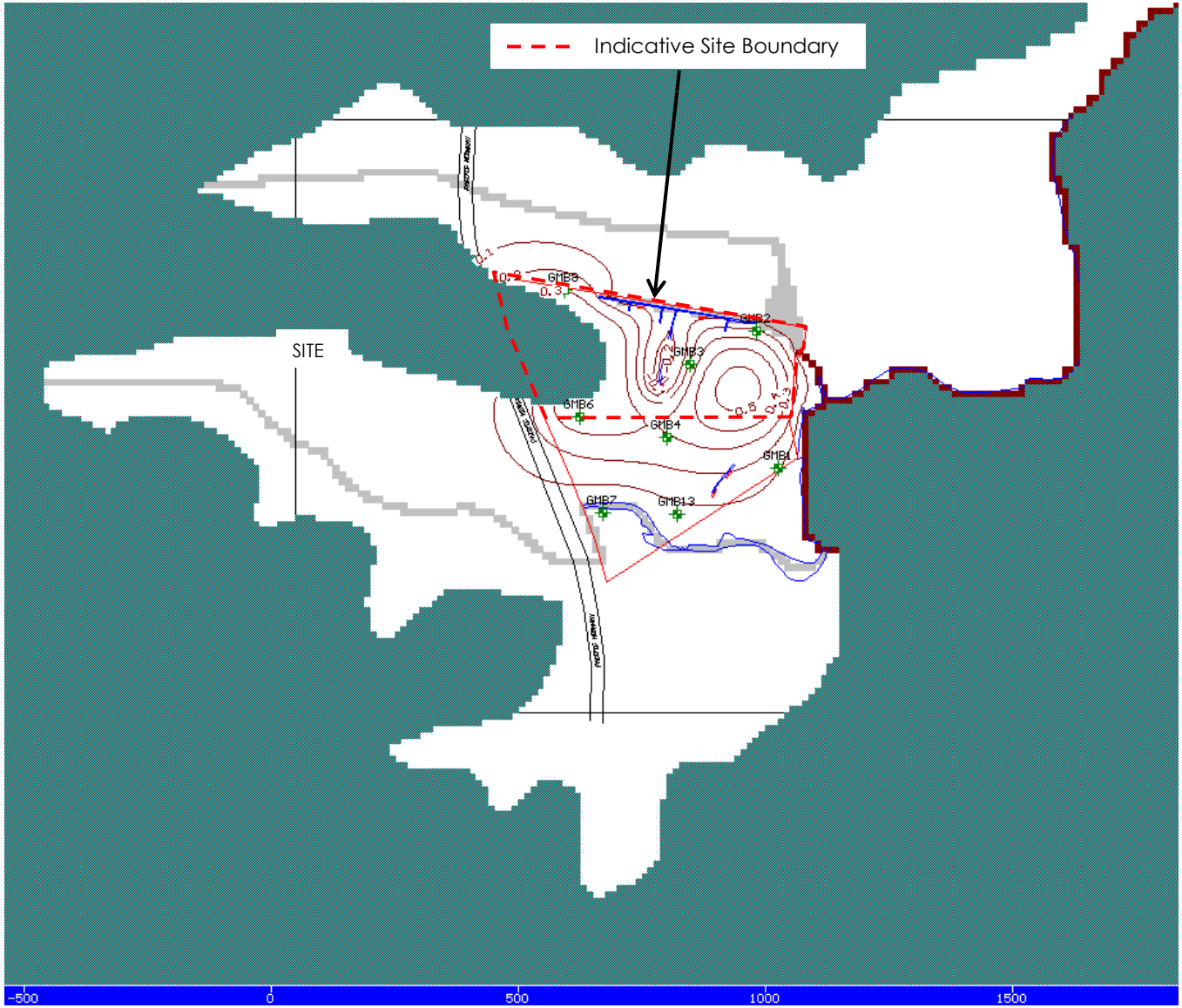

N

martens

Key:

1. Brown lines – drawdown (0.1 m interval).
2. Grey cell – drain boundary.
3. Red cells – constant head boundary.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M2 DRAWDOWN (M1-M2)**	Drawing No: **FIGURE 31**
Approved:	GT/DM		
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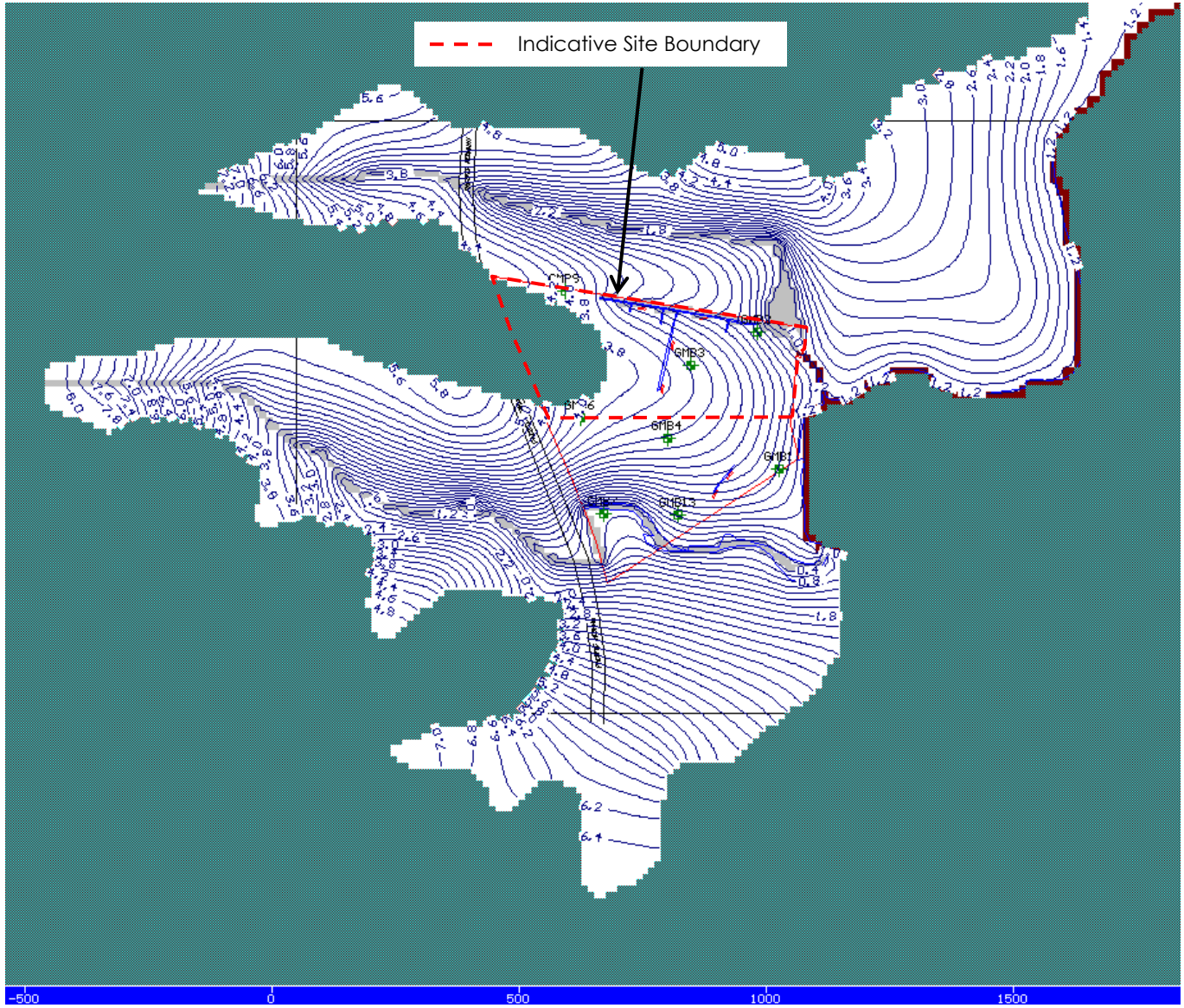
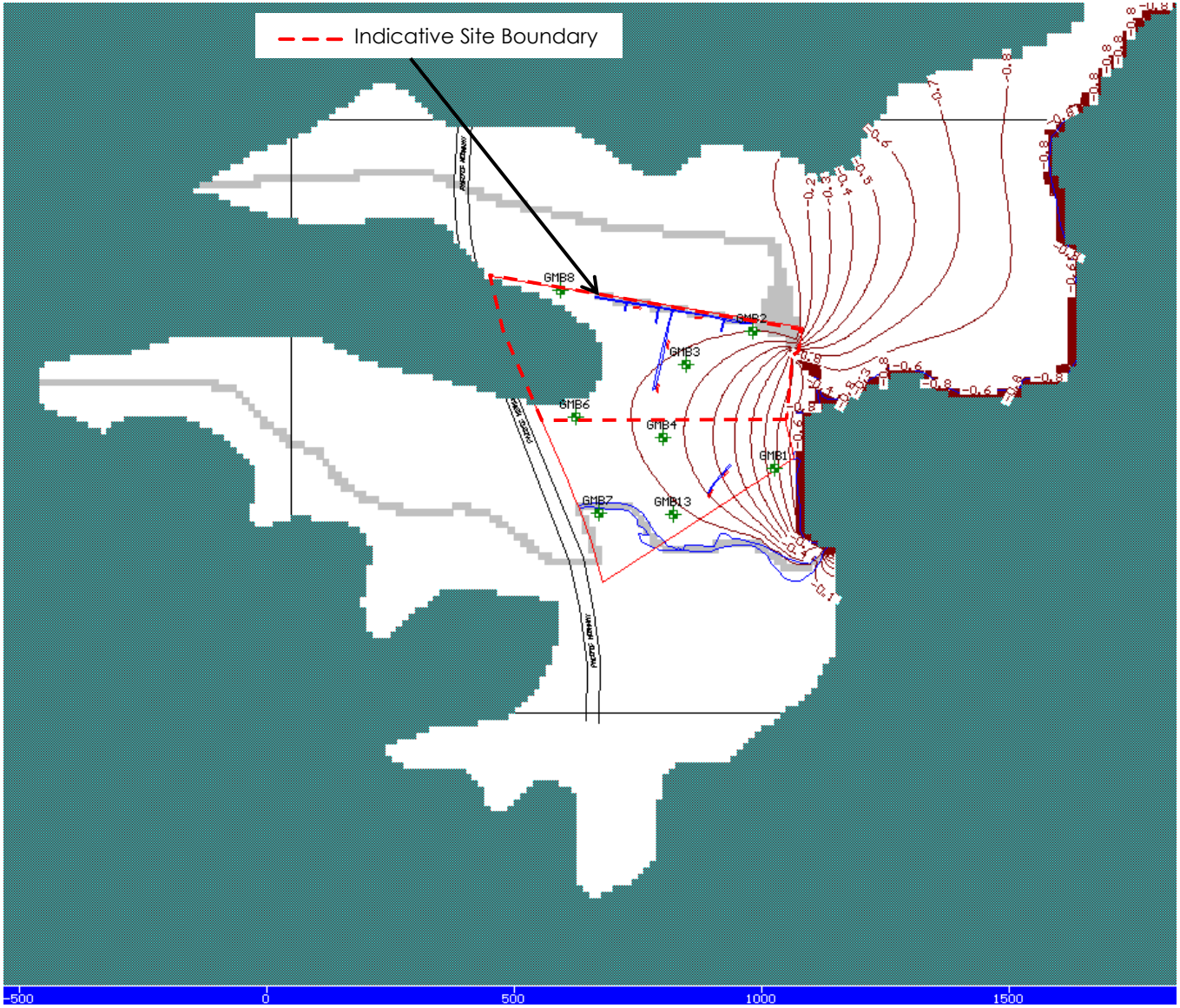


Key:

1. Blue lines – groundwater head (0.2 m interval).
2. Grey cell – drain boundary.
3. Red cells – constant head boundary.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M3 GROUNDWATER HEAD**	Drawing No: **FIGURE 32**
Approved:	GT/DM		
Date:	03.07.2018		
Scale:	1:13,260		Job No: P1002663



N

martens

Key:

1. Brown lines – drawdown (0.1 m interval).
2. Grey cell – drain boundary.
3. Red cells – constant head boundary.

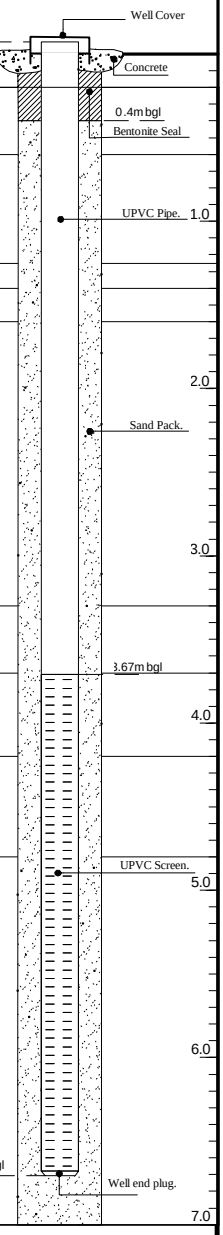
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**M3 DRAWDOWN (M2-M3)**	Drawing No: **FIGURE 33**
Approved:	GT/DM		
Date:	03.07.2018		
Scale:	1:13,260		Job No: P1002663

9 Attachment B – Borehole Logs

Note: Borehole logs were prepared as a part of the original development for the site (Lot 1 DP1097743) and Lot 6 DP 252223 immediately to the south of the site.

CLIENT	**JW Planning Pty Ltd**	**COMMENCED**	26.07.10	**COMPLETED**	26.07.10	**REF**	**BH1**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 6 DP 252223, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Alluvial	**VEGETATION**	Grasses	**PROJECT NO.**	P1706265
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	3.45m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 7.0m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	1-2%

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)	WATER WELL DETAILS
A	Nil	N	M	0.2			SM	SILTY SAND - Brown/grey.		L	A	0.2	2663/1/0.2
A	Nil	N	M	0.6			SP	SAND - Grey/light grey, fine grained, minor clays.		L-MD	A	0.5	2663/1/0.5 +B
A	Nil	N	M	1.0 1.25			SC	CLAYEY SAND - Brown yellow, fine grained, silty, gravels (1-30mm, approx 30%).		MD	A	1.0	2663/1/1.0 +B
A	Nil	N	M	1.4			SC	CLAYEY SAND - Yellow.		D	A	1.3	2663/1/1.3
A	Nil	N	M	1.6			CL	CLAY - Grey with brown/red (minor)mottles.	VSt		A	1.5	2663/1/1.5
A	Nil	N 2.66	M	2.0 3.0 3.3			CL	CLAY - Grey with red mottles, minor sand. - Mottles decreasing with depth.	VSt		A A A	2.0 2.5 3.0	2663/1/2.0 +B 2663/1/2.5 2663/1/3.0
A	Nil	Y	W	3.7			CL	SANDY CLAY - Red/grey with fine grained sand.	VSt		A	3.5	2663/1/3.5 +B
A	Nil	Y	W	4.0 4.2			CL	CLAY - Grey with red/brown, minor sand.			A	4.0	2663/1/4.0 +B
A	Nil	Y	W	4.8			CL	SANDY CLAY - Brown, fine grained sand.	VSt				
A	Nil	Y	W	5.0 6.0 7.0			CL	SAND, CLAYEY SAND, CLAY LAYERS - Grey, red, brown.	VSt		A A	5-5.5 5.5	2663/1/5-5.5 +B 2663/1/5.5
				8.0 9.0				Borehole terminated at 7.0m on clay.			A	7.0	2663/1/7.0



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

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

Quality Sheet No. 4

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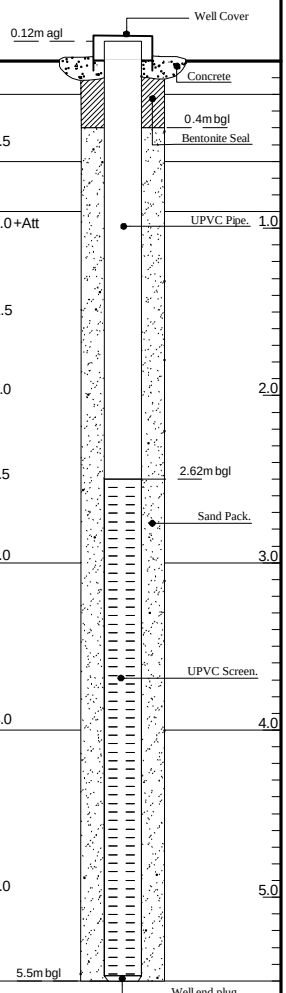
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**JW Planning Pty Ltd**	**COMMENCED**	26.07.10	**COMPLETED**	26.07.10	**REF**	**BH2**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	2.81m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 5.5m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	1-2%

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	M	0.2			SM	SILTY SAND - Brown/grey.		L		
A	Nil	N 0.68	M	0.6			SP	SAND - Grey/light grey, minor sands.		L	A	0.5 2663/2/0.5
A	Nil	Y	W	0.9			SC	CLAYEY SAND - Light grey, fine sands.		L		
A	Nil	Y	M	1.0 2.0 3.0			CL	CLAY - Grey, minor sands, minor brown/red mottles.	VSt		A A A A	1.0 2663/2/1.0+Att 1.5 2663/2/1.5 2.0 2663/2/2.0 2.5 2663/2/2.5 3.0 2663/2/3.0
A	Nil	Y	M	4.0			CL	CLAY - Grey/brown/orange with mottles, minor sands.	VSt		A	4.0 2663/2/4.0
A	Nil	Y	M	5.0 5.5			CH	CLAY - Grey with brown/orange/yellow with mottles, minor gravels (<5%), moderately plastic.	VSt		A	5.0 2663/2/5.0
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on clays.				

WATER WELL 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
CC Concrete Corer

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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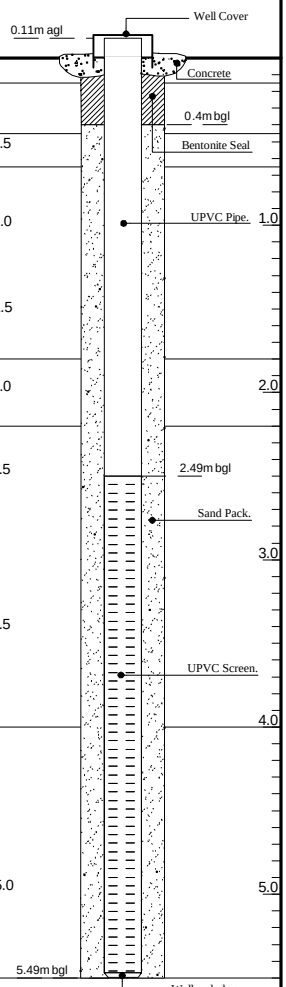
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**JW Planning Pty Ltd**	**COMMENCED**	26.07.10	**COMPLETED**	26.07.10	**REF**	**BH3**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	3.38m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 5.5m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	1-2%

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 0.26	M	0.15			SM	ORGANIC SILTY SAND - Dark grey/brown.		L		
A	Nil	Y	W	0.45			SC	CLAYEY SAND - Grey/brown, fine grained, minor gravels.		L		
A	Nil	Y	M	0.65			CL	CLAY - Orange/brown, minor gravels, sands.	S		A	0.5 2663/3/0.5
A	Nil	Y	M	1.0 1.8			CH	CLAY - Grey with minor brown/orange red mottles, moderately plastic.	St		A A	1.0 2663/3/1.0 1.5 2663/3/1.5
A	Nil	Y	W	2.0 2.2			CL	CLAY - Grey with minor orange/brown mottles, minor gravels, not plastic.	VSt		A	2.0 2663/3/2.0
A	Nil	Y	M	3.0 4.0			CH	GRAVELLY CLAY - Dark grey/brown, moderately plastic.	VSt		A A	2.5 2663/3/2.5 3.5 2663/3/3.5
A	Nil	Y	M	5.0 5.5			CH	CLAY - Grey with brown/orange/yellow with mottles, minor gravels (<5%), moderately plastic. Tending to brown clays with depth.	VSt		A	5.0 2663/3/5.0
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on clays.				

WATER WELL 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
CC Concrete Corer

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	**JW Planning Pty Ltd**	**COMMENCED**	26.07.10	**COMPLETED**	26.07.10	**REF**	**BH4**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 6 DP 252223, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	3.64m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 7.12m depth	**NORTHING**	NA	**ASPECT**	East	**SLOPE**	1-2%

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)	WATER WELL DETAILS
A	Nil	N	M	0.1		× × ×	OL	ORGANIC SILT - Brown/grey, minor sands.	S				0.2m agl; Well Cover; Concrete
A	Nil	0.52 ▽ Y	M	0.75			CL	CLAY - Grey with minor brown mottles, minor silty sand.	S-F		A	0.5	2663/4/0.5 +Att; 0.4m bgl; Bentonite Seal
A	Nil	Y	W	1.0 1.2			CL	CLAY - Grey/light grey with minor red mottles, sands.	St		A	1.0	2663/4/1.0 +Att; UPVC Pipe. 1.0
A	Nil	Y	W	2.0 2.8			CH	CLAY - Grey with red/orange mottles, moderately plastic. - Mottles decreasing with depth.	VSt		A A A	1.5 2.0 2.5	2663/4/1.5 +Att 2663/4/2.0 2.0 2663/4/2.5; Sand Pack.
A	Nil	Y	M	3.0 3.2			CL	CLAY - Brown with grey mottles, minor gravels, sands.	VSt		A	3.0	2663/4/3.0 +B 3.0
A	Nil	Y	W	4.0 4.5			CH	CLAY - Grey with red/orange/yellow mottles, gravels (5%), moderately plastic.	VSt		A	4.0	2663/4/4.0 4.0; 4.12m bgl
A	Nil	Y	W	5.0 5.5			CH	CLAY - GRAVELLY CLAY - Grey with brown/yellow mottles.	VSt		A	5.0	2663/4/5.0 5.0; UPVC Screen.
A	Nil	Y	W	6.0 7.0 7.12			CH	CLAY - Grey minor brown mottles.	VSt		A	6.0	2663/4/6.0 6.0 7.12m bgl 7.0
				8.0 9.0				Borehole terminated at 7.12m on clays.					Well end plug. 8.0 9.0

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

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	**JW Planning Pty Ltd**	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH5**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	11.5m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 5.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	5-7%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.2			CL	SILTY CLAY - Brown/light brown, gravels (1-20mm, approx 20%).	F				
A	Nil	N	M	0.8			CL	CLAY - Red/orange with brown mottles.	F		A	0.5	2663/5/0.5 + Att
A	Nil	N	M	1.0 1.2			CL	CLAY - Grey with red/orange mottles, gravels (1-15mm, approx 10%).	F		A		2663/5/1.0 + Att 1.0
A	Nil	N	M	1.9			CH	CLAY - Cream/light grey, minor sands.	St		A	1.5	2663/5/1.5
A	Nil	N	D	2.0 3.0			CL	CLAY - Yellow/grey, sands possibly extremely weathered claystone.	St-VSt		A	2.0	2663/5/2.0 2.0 3.0
A	Nil	N	D	4.0 5.0 5.5			CL	EXTREMELY TO MODERATELY WEATHERED CLAYSTONE.	VSt		A	5.0	2663/5/5.0 4.0 5.0
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on clays.					6.0 7.0 8.0 9.0

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

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

Quality Sheet No. 4

martens

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mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**JW Planning Pty Ltd**	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH6**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	7.0m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 8.5m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	4-6%

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)	WATER WELL DETAILS
A	Nil	N	M	0.2			CL	SILTY CLAY - Brown/light brown, gravels (1-20mm, approx 20%).	F		A	0.2 2663/6/0.2	Well Cover; 0.18m agl; Concrete
A	Nil	N	M	1.0 1.2			CL	CLAY - Red/orange with brown mottles.	F		A A	0.5 2663/6/0.5 1.0 2663/6/1.0	0.4m bgl; Bentonite Seal; UPVC Pipe. 1.0
A	Nil	N	M	1.9			CL	CLAY - Grey with red/orange mottles, gravels (1-15mm, approx 10%).	F		A	1.5 2663/6/1.5	
A	Nil	N 2.7 Y	M	2.0 3.0			CL	CLAY - Cream/light grey, with red/orange mottles, minor gravels.	VSt		A	2.0 2663/6/2.0	2.0; Sand Pack.; 3.0
A	Nil	Y	W	4.0 5.0 5.5			CL	CLAY - Cream with yellow/orange mottles. - Bands of orange/grey clays, tending to light grey clays with minor gravels (1-5mm, <5%) at depth.	VSt		A A A	3.5 2663/6/3.5 4.0 2663/6/4.0 5.0 2663/6/5.0	4.0; 5.0; 5.44m bgl
A	Nil	Y	W	6.0 7.0 8.0 8.5			CL	CLAY - Orange/brown, gravels (1-10mm, approx 15%).	VSt		A	6.0 2663/6/6.0	6.0; UPVC Screen.; 7.0; 8.0; 8.44m bgl; Well end plug.
				9.0				Borehole terminated at 8.5m on clay.					9.0

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

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

Quality Sheet No. 4

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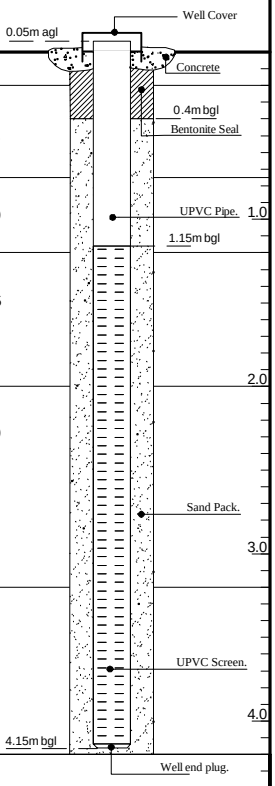
Engineering Log - Borehole

CLIENT	**JW Planning Pty Ltd**	**COMMENCED**	26.07.10	**COMPLETED**	26.07.10	**REF**	**BH7**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 6 DP 252223, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	1.1m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 4.2m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	1-2%

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)	WATER WELL DETAILS
A	Nil	N	W	0.2			CL	SILTY CLAY - Dark brown, gravels.	S				
A	Nil	0.55 ▽ Y	M W	0.6 0.75			CL	CLAYEY SAND - Grey/brown/orange, medium grained sand, minor gravels.		L	A	0.5	2663/7/0.5
A	Nil	Y	W	1.0 1.2			CL	GRAVELLY CLAYEY SAND - Dark brown/grey, coarse grained sands.		L	A	1.0	2663/7/1.0
A	Nil	Y	W	2.0			CL	SANDY CLAY - Grey/dark brown, gravels (1-5mm, approx 15%).	St		A	1.5	2663/7/1.5
A	Nil	Y	W	3.0 3.2			CL	CLAY - Grey/green with orange/brown mottles, gravels (5mm, approx 5%) increasing with depth.	St-VSt		B A	2.0 2.5	2663/7/2.0 2663/7/2.5
A	Nil	Y	W	4.0 4.2			CL	CLAY - Cream/light grey, gravels (1-5mm, 5%).	VSt		A	3.5	2663/7/3.5
				5.0 6.0 7.0 8.0 9.0				Borehole terminated at 4.2m on clays.					



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

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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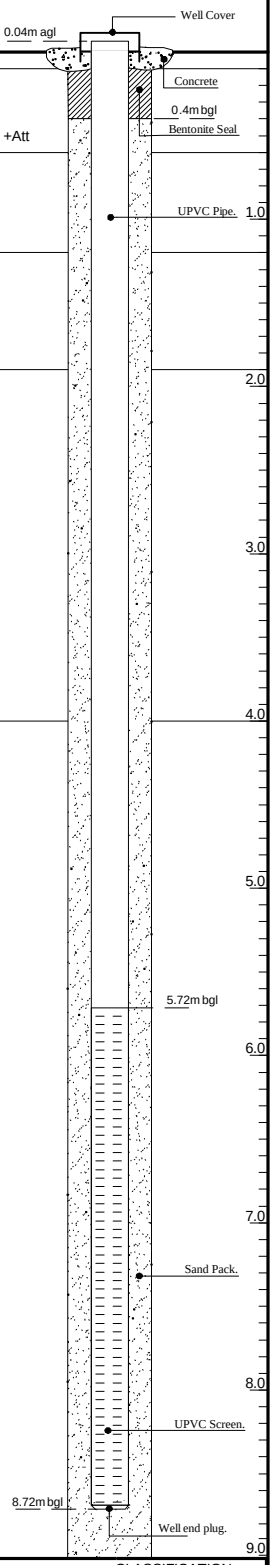
Engineering Log - Borehole

CLIENT	**JW Planning Pty Ltd**	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH8**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 2**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	6.0m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 9.2m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	2-3%

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	M	0.05			CL	SILTY CLAY - Brown/light brown.	F			
A	Nil	N	M	0.6			CL	CLAY - Red/brown, minor orange mottles, silty.	F		A	0.5 2663/7/0.5 +Att
A	Nil	N	M	1.0 1.2			CH	CLAY - Red/brown, gravels (1-40mm, approx 15%), moderately plastic.	F-St		A	1.0 2663/7/1.0
A	Nil	1.51 Y	M	1.9			CL	CLAY - Grey with yellow/orange mottles, minor gravels.	St		A	1.5 2663/7/1.5
A	Nil	Y	D	2.0 3.0 4.0			CL	CLAY - Grey/cream with yellow/red mottles, gravels (1-20mm, 20%).	VSt		A	2.5 2663/7/2.5
A	Nil	Y	M	5.0 6.0 7.0 8.0 9.0			CL	CLAY - Brown, grey, cream, orange, sandstone gravels, extremely weathered claystone with moderately weathered claystone bands.	VSt			

WATER WELL 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
CC Concrete Corer

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	JW Planning Pty Ltd	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH8**
PROJECT	Hydrogeological Assessment	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	2 of 2
SITE	Lot 1 DP 1097743, Pacific Hwy, Moonee Beach	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	6.0m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 9.2m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	2-3%

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)	WATER WELL DETAILS
A	Nil	Y	M	9.2		— —	CL	CLAY - Brown, grey, cream, orange, sandstone gravels, extremely weathered claystone with moderately weathered claystone bands. Borehole terminated at 9.2m on moderately to slightly weathered claystone.	VSt				

10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0

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

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	**JW Planning Pty Ltd**	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH9**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	18.5m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 2.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.15			CL	SILTY CLAY - Brown/light brown, gravels (1-20mm, approx 20%).	F				
A	Nil	N	M	0.8			CH	CLAY - Red/orange with brown mottles.	F-St		A	0.5	2663/9/0.5 CBR @ 0.2-0.5
A	Nil	N	M	1.0 1.1			CH	CLAY - Grey with red/orange mottles, gravels (1-15mm, approx 10%).	St-VSt		A		2663/9/1.0 1.0
A	Nil	N	M	1.8			CH	CLAY - Cream/light grey, minor sands.	VSt				
A	Nil	N	D	2.0 2.5			CH	CLAY - Cream/light grey, minor sands.	VSt		A	2.0	2663/9/2.0 2.0
				3.0				Borehole terminated at 2.5m on clays/extremely weathered rock.					3.0
				4.0									4.0
				5.0									5.0
				6.0									6.0
				7.0									7.0
				8.0									8.0
				9.0									9.0

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

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	**JW Planning Pty Ltd**	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH10**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	11.0m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 2.0m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.15			CL	SILTY ORGANIC CLAY - Dark brown.	F				
A	Nil	N	M	0.65			CL	CLAY - Orange/brown/yellow, moderately plastic.	F		A	0.5	2663/10/ 0.5
A	Nil	N	M D	0.8 1.0 1.2			CL	CLAY - Grey with yellow/orange/brown mottles, gravels (1-10mm, approx 15%). - Gravels increasing with depth. (Gravelly clay).	St-VSt		A		2663/10, 1.0
A	Nil	N	D	2.0			CL	GRAVELLY CLAY - Grey/yellow.	VSt		A	1.5	2663/10 / 1.5
								Borehole terminated at 2.0m on gravelly clays (very stiff).					

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

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	**JW Planning Pty Ltd**	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH11**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	2.9m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 2.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.25			SM	ORGANIC SILTY SAND - Dark grey/brown.		L	A	0.15	2663/11/ 0.15
A	Nil	N	M	0.5			SC	CLAYEY SAND - Grey/brown, fine grained, minor gravels.		L	A	0.5	2663/11/ 0.5 CBR
A	Nil	N	M	0.9			SC	CLAYEY SAND - Brown/orange, fine grained sands. Clay content increasing with depth.		L	A	0.7	2663/11/ 0.7 CBR @ 0.6-0.9
A	Nil	N	M	1.0 1.3			CH	SANDY CLAY - Orange/brown with red/grey mottles (60% sands).	F-St		A	1.0	2663/11/ 1.0 1.0
A	Nil	N	D	2.0 2.5			CH	CLAY - Red/grey, moderately plastic with orange mottles at depth.	VSt		A A	1.5 2.5	2663/11 / 1.5 2663/11 / 2.5 2.0
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.5m on clays.					3.0 4.0 5.0 6.0 7.0 8.0 9.0

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

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	**JW Planning Pty Ltd**	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH12**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 6 DP 252223, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	4.5m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 2.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.1		× × ×	OL	ORGANIC SILT - Brown/grey, minor sands.	S				
A	Nil	N	M	0.75			CL	CLAY - Grey with minor brown mottles, minor silty sand.	S-F				CBR @ 0.25-0.6
A	Nil	N	M	0.9			CL	CLAY - Grey/brown with orange mottles, sands.	F				
A	Nil	N	D	1.0			CH	CLAY - Grey with red/orange mottles, moderately plastic. - Mottles decreasing with depth.	VSt				
				2.5				Borehole terminated at 2.5m on clays.					

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

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

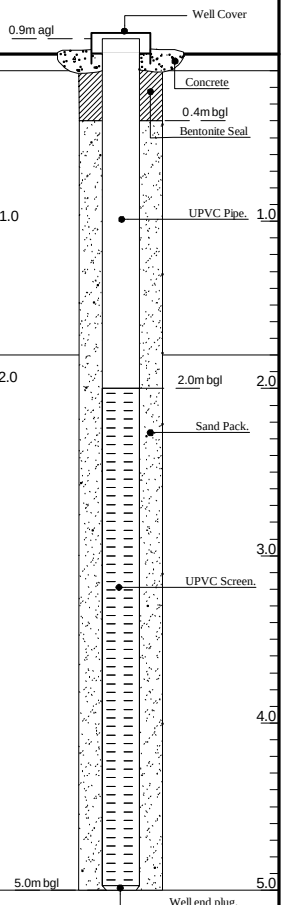
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**JW Planning Pty Ltd**	**COMMENCED**	27.07.10	**COMPLETED**	27.07.10	**REF**	**BH13**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 6 DP 252223, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	1.61m AHD		
EXCAVATION DIMENSIONS	Ø0.1m X 2.0m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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)	WATER WELL DETAILS
A	Nil	N	M	0.1			CL	SILTY CLAY - Brown/grey, minor gravels.	S				
A	Nil	N	D	1.0			CL	CLAY - Grey/light grey, minor brown/orange mottles, minor fine grained sands.	S-F		A	1.0	2663/13/ 1.0
				1.8									
A	Nil	N	D	2.0			CL	CLAY - Grey/light grey, minor gravels increasing with depth, brown/orange mottles, green/grey clays as well.	St-VSt		A	2.0	2663/13/ 2.0
				3.0									
				4.0									
				5.0									
								Borehole terminated at 5.0m on very stiff clays.					
				6.0									
				7.0									
				8.0									
				9.0									



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

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

Quality Sheet No. 4

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mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**JW Planning Pty Ltd**	**COMMENCED**	28.07.10	**COMPLETED**	28.07.10	**REF**	**BH14**
PROJECT	**Hydrogeological Assessment**	**LOGGED**	GT	**CHECKED**	DM	**Sheet**	**1 of 1**
SITE	**Lot 1 DP 1097743, Pacific Hwy, Moonee Beach**	**GEOLOGY**	Corumba Beds, Claystone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002663
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	14.5m AHD		
EXCAVATION DIMENSIONS	Ø0.3m X 0.6m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.1			CL	SILTY CLAY - Brown.	S				
A	Nil	N	M	0.6			CL	CLAY - Red/orange with brown mottles.	S-F		A	0.3	2663/14/ 0.3 CBR @ 0.2-0.5
								Borehole terminated at 0.6m on clay.					

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0

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

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

Quality Sheet No. 4

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Engineering Log - Borehole

10 Attachment C – Summarised Laboratory Results

Location	Date Sampled	Total Alkalinity as $CaCO_3$	Sulphate, SO4	pH	EC	TDS (grav)	TSS @ 103-105°C	NOx as N in water	TKN in water	Ammonia as N in water	Phosphorus - Total	Phosphorus - Dissolved	Nitrate as N in water
		mg/L	mg/L	pH Units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GMB1	**28/07/2010**	1	45	4.9	1500	890	1600	<0.1	<0.5	<0.1	<0.05	<0.05	<0.1
GMB1	**29/09/2010**	<2	44.2	4.3	1200	610	1750	<0.05	0.57	0.06	<0.03	<0.03	<0.05
GMB3	**28/07/2010**	8	1300	5.1	5100	3300	290	<0.1	<0.5	<0.1	<0.05	<0.05	<0.1
GMB3	**29/09/2010**	<2	324	4.3	6100	2400	41	<0.05	0.54	<0.05	<0.03	<0.03	<0.05
GMB6	**28/07/2010**	<0.1	11	4.7	1700	980	95	0.1	<0.5	<0.1	<0.05	<0.05	0.1
GMB6	**29/09/2010**	<2	8.4	4.7	2020	1170	262	<0.05	0.56	0.06	<0.03	<0.03	<0.05

11 Attachment D – Laboratory Reports

Envirolab Services Pty Ltd
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12 Ashley St Chatswood NSW 2067
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CERTIFICATE OF ANALYSIS 44158

Client:
Martens & Associates
6/37 Leighton Place
Hornsby
NSW 2077

Attention: Ben Rose / Gray Taylor

Sample log in details:

Your Reference:	**P1002663JC01V01, Moonee Beach**
No. of samples:	7 Waters
Date samples received:	30/07/2010
Date completed instructions received:	30/07/2010

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

Report Details:

Date results requested by:	6/08/10
Date of Preliminary Report:	Not Issued
Issue Date:	6/08/10

NATA accreditation number 2901. This document shall not be reproduced except in full.
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

David Springer
Business Development & Quality Manager

Nick Sarlamis
Inorganics Supervisor

ACCREDITED FOR TECHNICAL COMPETENCE

Ion Balance Our Reference: Your Reference Type of sample	UNITS ---------- ----------	44158-1 2663/GW01 Water	44158-2 2663/GW03 Water	44158-3 2663/GW06 Water	44158-4 2663/SW A Water	44158-5 2663/SW B Water
Date prepared	-	02/08/2010	02/08/2010	02/08/2010	02/08/2010	02/08/2010
Date analysed	-	03/08/2010	03/08/2010	03/08/2010	03/08/2010	03/08/2010
Calcium - Dissolved	mg/L	2.2	29	3.2	2.1	2.3
Potassium - Dissolved	mg/L	1	2.6	7.9	1.8	2.1
Sodium - Dissolved	mg/L	270	1,200	280	25	32
Magnesium - Dissolved	mg/L	33	130	44	3.1	3.7
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	8	<0.1	2	5
Carbonate Alkalinity as $CaCO_3$	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Total Alkalinity as $CaCO_3$	mg/L	1	8	<0.1	2	5
Sulphate, SO4	mg/L	45	1,300	11	3.8	4.9
Chloride, Cl	mg/L	470	1,500	480	40	52
Ionic Balance	%	1.4	-3.8	8.1	8.7	5.6

Ion Balance Our Reference: Your Reference Type of sample	UNITS ---------- ----------	44158-6 2663/SW C Water	44158-7 2663/SW D Water
Date prepared	-	02/08/2010	02/08/2010
Date analysed	-	03/08/2010	03/08/2010
Calcium - Dissolved	mg/L	1	15
Potassium - Dissolved	mg/L	3.5	16
Sodium - Dissolved	mg/L	9.8	400
Magnesium - Dissolved	mg/L	1.4	41
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<0.1	<0.1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	3	15
Carbonate Alkalinity as $CaCO_3$	mg/L	<0.1	<0.1
Total Alkalinity as $CaCO_3$	mg/L	3	15
Sulphate, SO4	mg/L	4.2	80
Chloride, Cl	mg/L	11	580
Ionic Balance	%	20	9.0

Miscellaneous Inorganics Our Reference: Your Reference Type of sample	UNITS ---------- ----------	44158-1 2663/GW01 Water	44158-2 2663/GW03 Water	44158-3 2663/GW06 Water	44158-4 2663/SW A Water	44158-5 2663/SW B Water
Date prepared	-	2/8/2010	2/8/2010	2/8/2010	2/8/2010	2/8/2010
Date analysed	-	06/8/2010	06/8/2010	06/8/2010	06/8/2010	06/8/2010
pH	pH Units	4.9	5.1	4.7	5.9	6.0
Electrical Conductivity	µS/cm	1,500	5,100	1,700	160	200
Total Dissolved Solids (grav)	mg/L	890	3,300	980	110	130
Total Suspended Solids @ 103-105^{O}C	mg/L	1,600	290	95	10	10
NOx as N in water	mg/L	<0.1	<0.1	0.1	<0.1	<0.1
TKN in water	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Ammonia as N in water	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Phosphorus - Dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate as N in water	mg/L	<0.1	<0.1	0.1	<0.1	<0.1

Miscellaneous Inorganics Our Reference: Your Reference Type of sample	UNITS ---------- ----------	44158-6 2663/SW C Water	44158-7 2663/SW D Water
Date prepared	-	2/8/2010	2/8/2010
Date analysed	-	06/8/2010	06/8/2010
pH	pH Units	6.1	6.1
Electrical Conductivity	µS/cm	69	2,000
Total Dissolved Solids (grav)	mg/L	64	1,200
Total Suspended Solids @ 103-105^{O}C	mg/L	10	51
NOx as N in water	mg/L	1.0	0.1
TKN in water	mg/L	<0.5	<0.5
Ammonia as N in water	mg/L	<0.1	<0.1
Phosphorus - Total	mg/L	<0.05	0.06
Phosphorus - Dissolved	mg/L	<0.05	<0.05
Nitrate as N in water	mg/L	1.0	0.1

Method ID	Methodology Summary
Metals.20 ICP-AES	Determination of various metals by ICP-AES.
LAB.6	Alkalinity - determined titrimetrically in accordance with APHA 20th ED, 2320-B.
LAB.81	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 21st ED, 4110 -B.
LAB.41	Gravimetric determination of the total solids content of water.
LAB.1	pH - Measured using pH meter and electrode in accordance with APHA 20th ED, 4500-H+.
LAB.2	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA2510 20th ED and Rayment & Higginson.
LAB.18	Total Dissolved Solids - determined gravimetrically by drying the sample, in accordance with APHA 20th ED, 2540-C.
LAB.19	Suspended Solids - determined gravimetrcially by filtration of the sample, in accordance with APHA 20th ED, 2540-D.
LAB.55	Nitrate water extractable - determined colourimetrically based on EPA114A.
LAB.62	TKN - determined colourimetrically based on EPA110A.
LAB.57	Ammonia water extractable - determined colourimetrically based on EPA350.1

QUALITY CONTROL Ion Balance	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			02/08/2010	44158-1	02/08/2010 || 02/08/2010	LCS-W3	02/08/2010
Date analysed	-			03/08/2010	44158-1	03/08/2010 || 03/08/2010	LCS-W3	03/08/2010
Calcium - Dissolved	mg/L	0.03	Metals.20 ICP-AES	<0.03	44158-1	2.2 || [N/T]	LCS-W3	102%
Potassium - Dissolved	mg/L	0.03	Metals.20 ICP-AES	<0.03	44158-1	1 || [N/T]	LCS-W3	110%
Sodium - Dissolved	mg/L	0.03	Metals.20 ICP-AES	<0.03	44158-1	270 || [N/T]	LCS-W3	115%
Magnesium - Dissolved	mg/L	0.03	Metals.20 ICP-AES	<0.03	44158-1	33 || [N/T]	LCS-W3	104%
Bicarbonate Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	44158-1	1 || 1 || RPD: 0	LCS-W3	100%
Carbonate Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	44158-1	<0.1 || <0.1	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	44158-1	1 || 1 || RPD: 0	LCS-W3	100%
Sulphate, SO4	mg/L	0.5	LAB.81	<0.50	44158-1	45 || 46 || RPD: 2	LCS-W3	101%
Chloride, Cl	mg/L	0.5	LAB.81	<0.50	44158-1	470 || 470 || RPD: 0	LCS-W3	98%
Ionic Balance	%		LAB.41	[NT]	44158-1	1.4 || [N/T]	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			02/08/2010	44158-1	2/8/2010 || 2/8/2010	LCS-W1	02/08/2010
Date analysed	-			06/08/2010	44158-1	06/8/2010 || 06/8/2010	LCS-W1	06/08/2010
pH	pH Units		LAB.1	[NT]	44158-1	4.9 || 4.8 || RPD: 2	LCS-W1	98%
Electrical Conductivity	µS/cm	1	LAB.2	<1.0	44158-1	1500 || 1500 || RPD: 0	LCS-W1	103%
Total Dissolved Solids (grav)	mg/L	5	LAB.18	<5	44158-1	890 || 910 || RPD: 2	LCS-W1	94%
Total Suspended Solids @ 103-105^{O}C	mg/L	5	LAB.19	<5	44158-1	1600 || 1600 || RPD: 0	LCS-W1	88%
NOx as N in water	mg/L	0.1	LAB.55	<0.1	44158-1	<0.1 || <0.1	LCS-W1	103%
TKN in water	mg/L	0.5	LAB.62	<0.5	44158-1	<0.5 || <0.5	LCS-W1	83%
Ammonia as N in water	mg/L	0.1	LAB.57	<0.1	44158-1	<0.1 || <0.1	LCS-W1	97%
Phosphorus - Total	mg/L	0.05	Metals.20 ICP-AES	<0.05	44158-1	<0.05 || <0.05	LCS-W1	103%
Phosphorus - Dissolved	mg/L	0.05	Metals.20 ICP-AES	<0.05	44158-1	<0.05 || <0.05	LCS-W1	103%
Nitrate as N in water	mg/L	0.1	LAB.55	<0.1	44158-1	<0.1 || <0.1	LCS-W1	103%

QUALITY CONTROL Ion Balance	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	LCS-W1	2/8/2010
Date analysed	-	[NT]	[NT]	LCS-W1	3/8/2010
Calcium - Dissolved	mg/L	[NT]	[NT]	[NR]	[NR]
Potassium - Dissolved	mg/L	[NT]	[NT]	[NR]	[NR]
Sodium - Dissolved	mg/L	[NT]	[NT]	[NR]	[NR]
Magnesium - Dissolved	mg/L	[NT]	[NT]	[NR]	[NR]
Bicarbonate Alkalinity as $CaCO_3$	mg/L	[NT]	[NT]	[NR]	[NR]
Carbonate Alkalinity as $CaCO_3$	mg/L	[NT]	[NT]	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	[NT]	[NT]	[NR]	[NR]
Sulphate, SO4	mg/L	[NT]	[NT]	LCS-W1	103%
Chloride, Cl	mg/L	[NT]	[NT]	LCS-W1	110%
Ionic Balance	%	[NT]	[NT]	[NR]	[NR]

QUALITY CONTROL Miscellaneous Inorganics	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	44158-2	03/08/2010
Date analysed	-	[NT]	[NT]	44158-2	06/08/2010
pH	pH Units	[NT]	[NT]	[NR]	[NR]
Electrical Conductivity	µS/cm	[NT]	[NT]	[NR]	[NR]
Total Dissolved Solids (grav)	mg/L	[NT]	[NT]	[NR]	[NR]
Total Suspended Solids @ 103-105^{O}C	mg/L	[NT]	[NT]	[NR]	[NR]
NOx as N in water	mg/L	[NT]	[NT]	44158-2	103%
TKN in water	mg/L	[NT]	[NT]	44158-2	79%
Ammonia as N in water	mg/L	[NT]	[NT]	44158-2	90%
Phosphorus - Total	mg/L	[NT]	[NT]	44158-2	113%
Phosphorus - Dissolved	mg/L	[NT]	[NT]	44158-2	106%
Nitrate as N in water	mg/L	[NT]	[NT]	44158-2	103%

Report Comments:

Ion Balance: Sample #6 cation/anion sums are less than 0.2Meq\L

Asbestos was analysed by Approved Identifier: Not applicable for this job

Asbestos was authorised by Approved Signatory: Not applicable for this job

INS: Insufficient sample for this test NT: Not tested PQL: Practical Quantitation Limit <: Less than >: Greater than

RPD: Relative Percent Difference NA: Test not required LCS: Laboratory Control Sample NR: Not requested

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike: A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample): This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria:

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

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes and LCS: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable. Surrogates: 60-140% is acceptable for general organics and 10-140% for

12 Attachment E – 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)

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Definitions

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

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

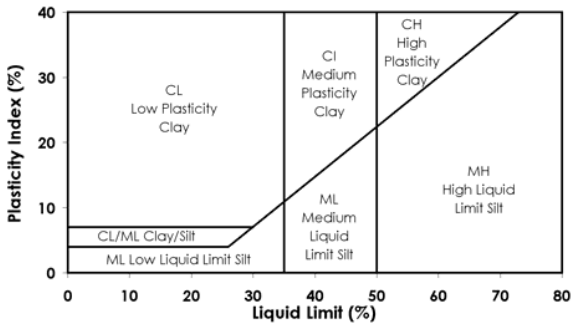
Particle Size

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

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

Plasticity Properties

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



Moisture Condition

Dry — Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist — Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet — As for moist but with free water forming on hands when handled.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

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

Density of Granular Soils

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

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

Minor Components

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

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

Soil Data

Explanation of Terms (2 of 3)

martens consulting engineers

Soil Agricultural Classification Scheme

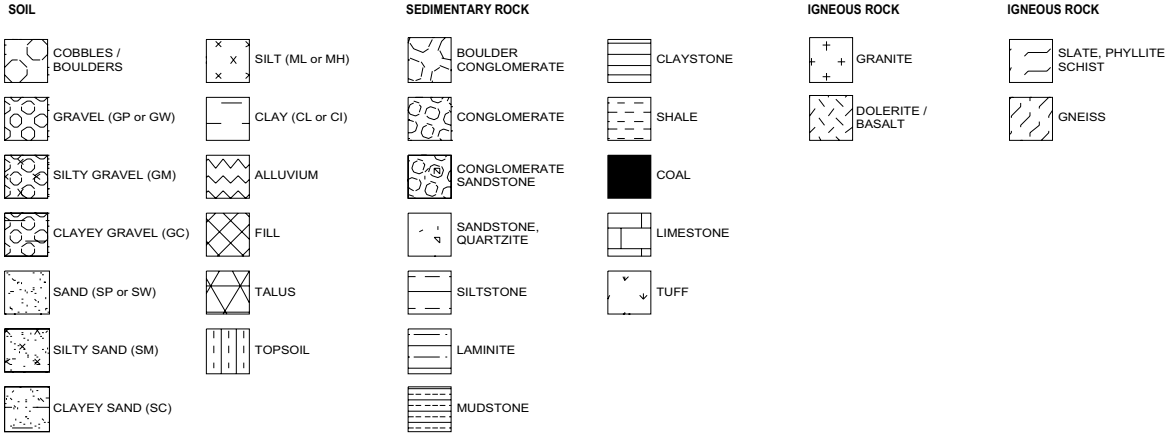
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions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

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

Soil Data

Explanation of Terms (3 of 3)

Symbols for Soil and Rock



Unified Soil Classification Scheme (USCS)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					USCS	Primary Name
COARSE GRAINED SOILS More than 50 % of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm.	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Gravel
				Predominantly one size or a range of sizes with more intermediate sizes missing	GP	Gravel
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty Gravel
				Plastic fines (for identification procedures see CL below)	GC	Clayey Gravel
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of intermediate sizes missing.	SW	Sand
				Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Sand
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty Sand
				Plastic fines (for identification procedures see CL below)	SC	Clayey Sand

FINE GRAINED SOILS More than 50 % of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
	DRY STRENGTH (Crushing Characteristics)	DILATANCY	TOUGHNESS	DESCRIPTION	USCS	Primary Name
	None to Low	Quick to Slow	None	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	Silt
	Medium to High	None	Medium	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays	CL	Clay
	Low to Medium	Slow to Very Slow	Low	Organic slits and organic silty clays of low plasticity	OL	Organic Silt
	Low to Medium	Slow to Very Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	Silt
	High	None	High	Inorganic clays of high plasticity, fat clays	CH	Clay
	Medium to High	None	Low to Medium	Organic clays of medium to high plasticity	OH	Organic Silt
HIGHLY ORGANIC SOILS	Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat

Low Plasticity – Liquid Limit W_L < 35 % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit W_L > 60 %

Rock Data

Explanation of Terms (1 of 2)

Definitions

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

Rock Substance — In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot, unless extremely weathered, be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.

Rock Defect — Discontinuity or break in the continuity of a substance or substances.

Rock Mass — Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Degree of Weathering

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

Term	Symbol	Definition
Residual Soil	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - ie. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	Fr	Rock substance unaffected by weathering

Rock Strength

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

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

Rock Data

Explanation of Terms (2 of 2)

martens consulting engineers

Degree of Fracturing

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but excludes fractures such as drilling breaks.

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

Test Methods

Explanation of Terms (1 of 2)

martens consulting engineers

Sampling

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

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

Undisturbed samples may be taken by pushing a thin-walled sample tube into the soils and withdrawing a soil sample in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

Drilling Methods

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

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

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

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

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

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

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

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

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

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

Standard Penetration Tests

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in AS 1289 Methods of Testing Soils for Engineering Purposes - Test F3.1.

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

The test results are reported in the following form:

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

as 4, 6, 7
N = 13

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

as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

CONE PENETROMETER TESTING AND INTERPRETATION

Cone penetrometer testing (sometimes referred to as Dutch Cone - abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in AS 1289 - Test F4.1.

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

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart

Test Methods

Explanation of Terms (2 of 2)

recorders. The plotted results given in this report have been traced from the original records.

The information provided on the charts comprises:
Cone resistance - the actual end bearing force divided by the cross sectional area of the cone - expressed in MPA.
Sleeve friction - the frictional force of the sleeve divided by the surface area - expressed in kPa.
Friction ratio - the ratio of sleeve friction to cone resistance - expressed in percent.

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

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

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

q_c (Mpa) = (0.4 to 0.6) N (blows/300mm)

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

q_c = (12 to 18) c_u

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

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

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

Perth sand penetrometer - a 16 mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS 1289 - Test F 3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
Cone penetrometer (sometimes known as the Scala Penetrometer) - a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289 - Test F 3.2). The test was developed initially for pavement sub-grade investigations, with correlations of the test results with California bearing ratio published by various Road Authorities.

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

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

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

GROUND WATER
Where ground water levels are measured in boreholes, there are several potential problems:

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

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