### 3) Results

#### 3.1 Site location

The site location is shown on Drawing No GJ0901.5.1. The site occupies the northeastern section of the Tweed Shire Terranora Area E and abuts Fraser Drive along its eastern boundary.

#### 3.2 Topography and drainage

The slopes on the site vary from 0-5% in areas associated with the alluvial zones in the northern parts of the development adjoining the SEPP 14 wetland (Terranora Broadwater) to 15-25 % in the higher elevation areas in the southern part. The site drains to a central waterway that flows from the south to north through the site and finally into the SEPP 14 wetland of the site.

#### 3.3 Geology and soils

The geology of the investigation site is described by the Geological Survey of Queensland Moreton Geology 1:500,000 geology map<sup>6</sup>, as overlying Tertiary Basalt and sections of the Neranleigh-Fernvale beds. These groups consist of basalt, mudstone, shale, greywacke, chert, jasper, conglomerate, basic metavolcanics and pillow lava.

The 15 boreholes constructed for investigations undertaken by Morrison Geotechnics give an overview of the distribution of geologic groups on the site. Drawing No. GJ0901.5.4. The Morrison Geotechnics bore logs are attached in Appendix 1. The site may be divided into 3 distinct land unit origins:

- Basaltic materials
- Neranleigh-Fernvale materials
- Alluvial infill.

The soil landscape belongs to the Carool colluvial landscape group (Morand 1996<sup>7</sup>). Soil found on the site was characterised by light to medium dark and dark-reddish brown clays overlying medium to heavy reddish brown and dark reddish brown clays (Ferrosol). Basalt boulders/floaters

<sup>6</sup> Queensland Government (1980) *Geological Survey of Queensland, Moreton Geology, 1:500,000 geology map.* 

were clearly visible in the site area and at depths of 0.3 to 0.6m, especially on steeper portions.

The basaltic land unit has deep clays overlying colluvial basalt boulders, decomposing basalt and in some location hard rock basalt. The depth of the soil mantle overlying the basalt varied between 2.6m and >7.5m. The Neranleigh-Fernvale unit demonstrated shallower soils varying between 0.7 and 3.0m deep. The alluvial infill soils showed soils in excess of 3.0m deep (Table 3.3.1).

Table 3.3.1 Borelogs<sup>8</sup> associated with each land unit descriptions

Borehole	Soil	Material type (and wet							
Deceltieles	depth (m	) layer depth mNSL)							
Basaltic lan		C'II /							
1	>3.0	Silty clays (some grey							
	2.0	mottles at 2.7-3.0m)							
2	>3.0	Silty clays (trace of							
	2.0	grey mottle at 3.0 m)							
3	>3.0	Silty clays							
5	2.6-2.8 7.5	Silty clays (1.7m)							
		Silty clays (5.1m)							
6	>7.5	Silty clays (4.8m)							
7	7.0	Silty clays (>7.0m)							
9 14	>3.5	Silty clays <sup>1</sup> (2.7m)							
14	>3.0	Silty clays (grey mottle							
15		at 2.2 m)							
15	>6.0	Silty clays (blue grey							
CCNAD4 -	10	mottles at 2.6m)							
GSMB1a	10	Clay (6.5m)							
GCMB1b	10	Clay over basalt (>25m)							
GSMB2a	8.5	Clay (0.87m)							
GSMB2b	8.5	Clay over basalt (7.67m)							
Neranleigh									
8	1.6-3.0	Silty clays (1.3-1.6m							
		mottles in interface							
		layer above NF							
		materials							
11	2.7	Silty clays <sup>2</sup> (indistinct							
		layer, 0.9m, above							
		bedrock at 3.4m							
4.3	2.0	depth)							
12	3.0	Silty clays (grey mottle							
42	0.7	at 1.8m)							
13	0.7	Silty clays (not							
A11 : 1: 6	111	evident)							
Alluvial inf		c'ii							
10	>3.0	Silty clays and sandy							
4		clays (1.0m)							
		y - refusal on basalt boulders alt over argillite							
_ 011 bouriua	,	are over diginite							

<sup>&</sup>lt;sup>8</sup> Morrison Geotechnics borelogs 1-15.

3-1

<sup>&</sup>lt;sup>7</sup> Morand D.T. Soil landscapes of the Murwillumbah – Tweed Heads 1:100000 (Fingal, Pottsville, Green Pidgeon, Tygalum) NSW Soil Conservation Service pp 30-33.

Typically the Neranleigh-Fernvale beds do not contain significant water bearing materials and do not have any significant water tables associated with them.<sup>9</sup> However, some significant supplies may be obtained from this group in areas associated with large fracture zones or in low-lying locations associated with freshwater swamps. <sup>10</sup> The borelogs from BH8, 11, 12 & 13 identified no wet layers that may indicate the presence of shallow water table.

The basalts contain high quality low salinity water and have a potential to give a yield varying from 0.5 - 15L s<sup>-1</sup>.<sup>11</sup> The Morrison Geotechnics borelogs identify wet layers at depth ranging from 1.7 to 5.1m below surface level (BH4, 5, 6 & 9). The remainder of the borelogs identified no wet layers that may indicate a water table.

The bores installed in 2010 by Gilbert & Sutherland show heavy clays to depths between 8.5m and 10m. The completed borelogs and details of the bore installation are attached in Appendix 2.

The water tables and aquifers associated with the basalts are the most important in economic and environmental terms. The basalt aquifer and its associated interface drainage in the overlying soil mantle is the prevalent groundwater system operating on the site.

The alluvial infill deposits may have localised ground water derived from hillside and foot slope seepage areas and groundwater connected to the SEPP 14 wetland (Terranora Broadwater). Borehole 10 in Table 3.3.1 demonstrated a wet layer indicative of a water table at a depth of 1.0m below surface level.

The alluvial infill land unit is located within the mapped Class 2 Acid Sulphate

constraints map of the Tweed Shire LEP 2010. The map suggests Potential Acid Sulfate Soils (PASS) occur between 0.5m and 1.0m from the soil surface. Any excavations will require an acid sulfate management plan. An Acid Sulfate Management Plan is provided as a separate report.

#### 3.4 Groundwater levels and flows

The groundwater level within the soil mantle and interface drainage zone respond to rainfall events and the general topography of the site. The description of the likely depths of water tables within the soil mantle is given in Table 3.3.1 above and Table 3.4.1.1.

Table 3.4.1.1 Standing water level for Gilbert & Sutherland bores 1a, 1b, 2a and 2b

& Jutile lialid boles 1a, 1b, 2a and 2b												
Bore		Water										
	'2Level	level	level									
	(mAHD)	(mNSL)	(m AHD)									
17/2/2010												
2a	12.5	0.87	11.63									
2b	12.5	7.67	4.83									
20/4/2010												
1a	50	7.73	42.27									
1b	50	>25.0	NA									
2a	12.5	0.62	11.88									
2b	12.5	7.20	5.3									

Notes - Rain for previous 2 weeks:

17/2/2010 – 203mm 20/4/2010 – 144mm

The standing water level in the upper slope zone associated with the basalt land unit surrounding Gilbert & Sutherland borehole 1a indicates the water table is located at a depth of approximately 7m below the existing soil surface. Interpretation of the Morrison Geotechnics borelogs indicates there may be watertable varying between 1.7m and 5.1m below the existing soil surface in the upper slopes. The lower portions of the slopes have varying water table depths with a highest being 0.62m NSL at Gilbert & Sutherland borehole 2a to greater that 7m (at BH6).

Flow direction of the groundwater will be dominated by the topography of the site due to the high gradients (5-25%) of the slope.

The soils associated with the Neranleigh-Fernyale land unit showed some evidence

<sup>&</sup>lt;sup>9</sup> McKibbin, D. 1995 Upper North Coast Groundwater Resource Study, NSW Dept of Land and Water Conservation (Water Resources), Technical Services Division, August 1995.

<sup>&</sup>lt;sup>10</sup> Environmental Hydrology Associates (EHA Pty Ltd) 2008 Tweed District Water Supply Augmentation Options Study. Input to stage 1 – identification of feasible options – groundwater supply. Report Number GW-08-02-REP-001 Rev A.

McKibbin, D. 1995 Upper North Coast Groundwater Resource Study, NSW Dept of Land and Water Conservation (Water Resources), Technical Services Division, August 1995.

<sup>&</sup>lt;sup>12</sup> Estimated from location on contour plan.

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of minor water tables positioned directly above the underlying weathered and hard bedrock. These water tables are shallow and the flow direction dominated by the topography.

The alluvial infill land unit demonstrates a water table within 1.0 m of the soil surface and it is expected that surface expression of the water table would be evident at scattered locations from time to time. Recharge of this water table would be from the surrounding slopes to the east south and west and the flow would be expected to discharge towards the wetland and drainage canal to the north of the proposed development site.

3.4.1 Construction phase drawdown To estimate the groundwater drawdown associated with the construction of the wetlands, Hooghoudt's Equation was used. This approach is conservative given the assumed hydraulic conductivity (0.03m/day) and inflow rate (1.9mm/day). Accordingly, the result provides a 'worst case scenario' estimates outline in Table 3.4.1.1.

Table 3.4.1.1 Estimated extent of watertable drawdown - basalt and alluvial infill land units

arattaettii bas	Jane anna v	anaviai i		a arries					
Basalt land	Draw down distance (m)								
unit	Excavation depth (m)								
Permeability	1	2	3	4					
(m d <sup>-1</sup> )									
0.020	9	15	20	26					
0.031 <sup>13</sup>	11	18	25	32					
0.040	13	21	29	36					
Alluvial infill									
unit									
Permeability	1	2	3	4					
(m s <sup>-1</sup> )									
0.2	28	40	64	82					
0.3	35	56	78	100					
0.4	40	65	90	115					

Table 3.4.1.1 shows a series of scenarios with permeability varying by 50% higher and lower than that measured by the rising head method for bore hole 2a. Similarly, the estimation of the alluvial infill area impact is based on an assumed permeability based on the soil texture class and varied by 50% higher and lower.

During the detailed design phase, modelling of the proposed development

situation would be undertaken to determine the expected drawdown associated with the construction of the storm water treatment devices.

#### 3.4.2 Operational phase

The wetlands and constructed wetlands will been elevated to minimise the effect (if any) of operational phase groundwater drawdown on acid sulfate soils.

#### 3.4.3 Seepage construction phase

To determine a likely seepage rate into the excavation following the initial excavation and storage release the Darcian flow rate was calculated and shown in Table 3.4.3.1.

Table 3.4.3.1 Estimated seepage into excavations in basalt and alluvial infill land units

	Seepage rate (L per linear m of excavated face)												
Basalt land	Ex	cavatio	on depth	(m)									
unit													
Permeability	1	2	3	4									
(m s <sup>-1</sup> )													
0.020	2	4	6	8									
0.03114	3	6	9	12									
0.040	4	8	12	16									
Alluvial infill													
unit													
Permeability	1	2	3	4									
(m s <sup>-1</sup> )													
0.2	4	8	12	16									
0.3	6	12	18	24									
0.4	8 16 24 3												

The groundwater management strategy adopted for the construction phase for all works components would need to control and store and dispose of the accumulated seepage in accord with a groundwater management plan.

#### 3.5 Groundwater chemistry

The analytical results for each parameter are discussed in this section. Complete results table for each bore are shown in Table 3.5.1 (next page). Copies of the laboratory certificates and in situ sheets are attached as Appendix 2.

Bore 1b was installed to a depth of 25m and showed no groundwater within the

<sup>&</sup>lt;sup>13</sup> Permeability estimated in Section 3.6.

<sup>&</sup>lt;sup>14</sup> Permeability estimated in Section 3.6.

basaltic layer below the interface drainage zone sampled by bore 1a. The termination point of the bore was within a large void or extensive fracture zone that did not contain any water. No water samples were extracted from this bore.

Bore 2b sampled the water associated with the basalt materials at depths greater than 15m. The water quality test show the water is high in iron and magnesium in comparison with the surface dominated interface drainage zone of the shallow bores (1a and 2a). This is not an unexpected result considering basalt is a mafic rock and consider ferro-magnesic in chemistry. (Note: Figure 3.5.1 cross plots of Fe and Mg for the three bore samples).

The piper plots in figure 3.5.2 show the relationship between the ratios of major ions of each water sample.

#### 3.6 Permeability testing

The results of the falling head tests conducted within three of the four groundwater bores are summarised in Table 3.6.2.

Table 3.6.2 Rising head test results

Borehole	Permeability							
	m s <sup>-1</sup>	m d <sup>-1</sup>						
GW2a	3.55 x 10 <sup>-7</sup>	0.031						
GW2b	2.52 x 10 <sup>-7</sup>	0.022						

Bore 1a contained no water to use a rising head test. At the end of the drilling to 25 m a total of 500L of water was used with no measurable water at the bottom of the bore to facilitate measurement and calculation of a permeability. The end of the bore appears to be connected to a large void.

Table 3.5.1 Summary of laboratory and in-situ measurement results for water quality at bores 1a, 2a and 2b.

boles 1a, 2a aliu 2b.			Borehole	
		2a	2b	1a
Analyte	Sample date	16/2/10	16/2/10	26/3/10
	LOR	1		
Hydroxide Alkalinity as CaCO <sub>3</sub> (mg L <sup>-1</sup> )	1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub> (mg L <sup>-1</sup> )	1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>		25	170	93
(mg L <sup>-1</sup> )	1			
Total Alkalinity as CaCO <sub>3</sub> (mg L <sup>-1</sup> )	1	25	170	93
Sulfate as SO <sub>4</sub> <sup>2-</sup> (mg L <sup>-1</sup> )	1	8	10	24
Chloride (mg L <sup>-1</sup> )	1	31	55	22
Calcium (mg L <sup>-1</sup> )	1	6	25	20
Magnesium (mg L <sup>-1</sup> )	1	6	16	8
Sodium (mg L <sup>-1</sup> )	1	34	54	32
Potassium (mg L <sup>-1</sup> )	1	1	4	3
Aluminium (mg L <sup>-1</sup> )	0.01	< 0.01	0.13	0.05
Arsenic (mg L <sup>-1</sup> )	0.001	< 0.001	0.002	< 0.001
Cadmium (mg L <sup>-1</sup> )	0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (mg L <sup>-1</sup> )	0.001	< 0.001	< 0.001	< 0.001
Copper (mg L <sup>-1</sup> )	0.001	< 0.001	0.001	< 0.001
Nickel (mg L <sup>-1</sup> )	0.001	< 0.001	0.011	0.003
Lead	0.001	< 0.001	< 0.001	< 0.001
Zinc	0.005	0.015	0.012	0.026
Manganese (mg L <sup>-1</sup> )	0.001	0.024	0.368	0.293
Iron (mg L <sup>-1</sup> )	0.05	0.05	3.47	0.33
Total Anions (meq L <sup>-1</sup> )	0.01	1.56	5.15	2.97
Total Cations (meq L <sup>-1</sup> )	0.01	2.27	5.02	3.17
EC (µs cm <sup>-1</sup> )		271	498	
рН		7.11	7.34	
EC (µs cm <sup>-1</sup> )		315	920	604
рН		3.76	3.7	3.79

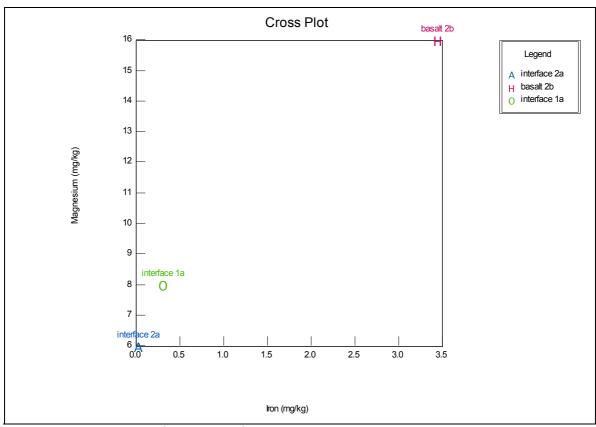


Figure 3.5 1 Cross plot of Fe and Mg for all bore water samples taken at proposed Altitude Aspire development site.

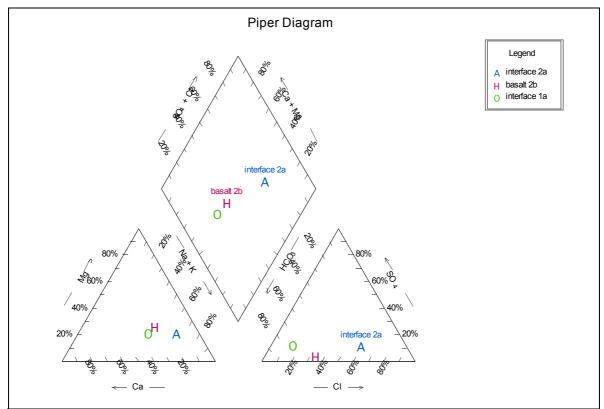


Figure 3.5.2 Piper plot of water chemistry for bores 1a, 2a and 2b.

#### 3.7 Recharge estimation

The estimate (using Cook's method) of the recharge potential for the water bearing materials on the undeveloped site is shown in Table 3.7.1 below.

Table 3.7.1 Estimation of average recharge potential<sup>15</sup> for undeveloped site for a range of probable rainfall Cl-concentrations.

Interface drainage	Rainfall Cl <sup>-</sup> (mg L <sup>-1</sup> )								
bore	1.5 <sup>16</sup>	2	2.5	3 <sup>17</sup>					
2a									
(6 mg Cl <sup>-</sup> L <sup>-1</sup> )	344	458	573	687					
1a									
(20 mg Cl <sup>-</sup> L <sup>-1</sup> )	103	137	172	206					
Mean	223	298	372	447					
Basalt	1.5	2	2.5	3					
2b									
(55 mg Cl <sup>-</sup> L <sup>-1</sup> )	37	50	62	75					

Notes:

- 1. Run-off estimated as 250 mm for Ferrosols
- 2. Average Rainfall 1624 mm<sup>18</sup>

The estimation of recharge for the deep basalt indicates a low level of recharge varying from 37-75 mm per year based on the expected average rainfall and a range of Cl<sup>-</sup> contents. This is significantly less that the overlying soil mantle. The soil itself is directly exposed to the rainfall events and will have a diffuse recharge mechanism.

#### 3.8 Other registered bores

There are five registered bores in the vicinity of the proposed development. As shown in Figure 3.8.1. The details of each bore are attached in Appendix 4.

Bore No 63684 is located within the site and will be decommissioned as a result of the development. The bores 65037 and 58144 are located in different parts of the catchment and will b not be influenced by the proposed development.

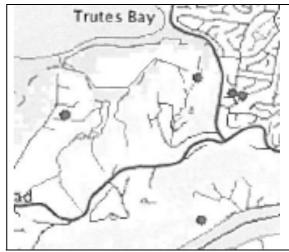


Figure 3.8.1 Registered bores in and around the proposed development site.

Bore numbers 65617 and 63680 are located east of the proposed development near the intersection of Ash drive and Lovat Brae Crt. Bore 65617 is 49m deep with water bearing zones 30-49m below the surface and within the shales of the Neranleigh-Fernvale material. The description of the waterbearing layer is 'hard shale' and the expected yield from the bore would be low. Bore 63680 located near 65617 is 32 m deep with the water bearing layers at 24-32m and located within shale of the Neranleigh-Fernvale deposits. The yield of this bore is low at 0.78 Ls<sup>-1</sup>.

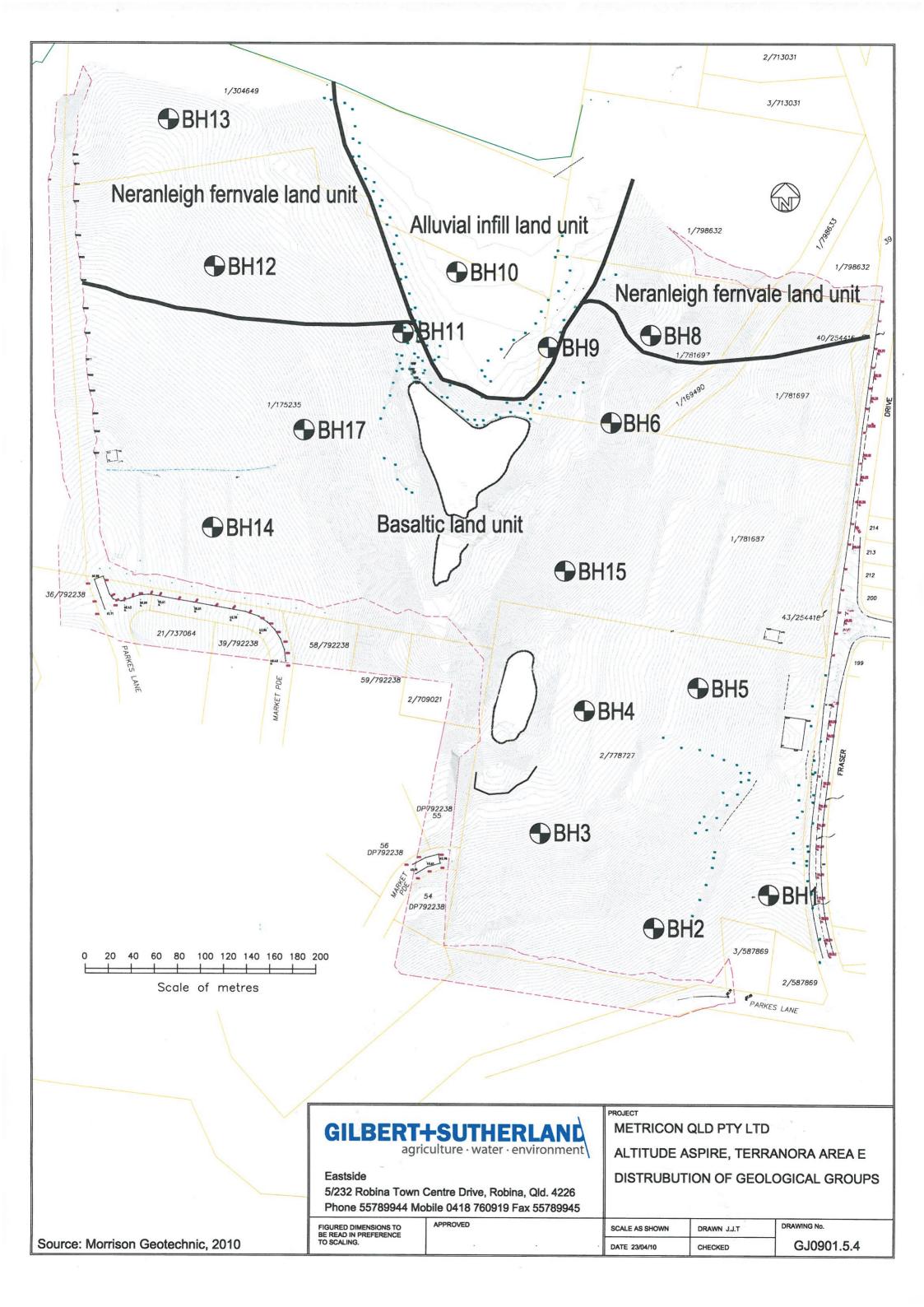
The expected flow direction of the water table would be towards Trutes Bay (Terranora Broadwater) in a NNW direction. The probability that the land associated with the proposed development is contributing to the recharge of these bores is extremely remote.

<sup>&</sup>lt;sup>15</sup> Using Cooks method described in Section 2.4.3

<sup>&</sup>lt;sup>16</sup> Based on the estimates used for the Atherton tablelands

<sup>&</sup>lt;sup>17</sup> Measured at Robina during December 2009 by Gilbert & Sutherland and analysed by Tweed Shire Laboratory as >3.0 mg L<sup>-1</sup>.

<sup>&</sup>lt;sup>18</sup> Mean derived from BOM data drill rainfall for Cobaki - years 1889-2008.



### 4) Discussion

In response to the DGR 11.1 there are eight relevant issues:

- · Groundwater level and flow direction.
- Potential contamination.
- Proposed use of groundwater.
- Changes in groundwater recharge.
- Changes in groundwater discharge.
- Impacts on groundwater dependant ecosystems.
- Impacts on groundwater quality.
- Impact on Acid Sulphate Soil.

## 4.1 Groundwater level and flow direction

The topography of the urban portion of the site is elevated with slopes varying between 5% and 25%. The landform will dictate the groundwater level and the flow direction irrespective of the earthworks associated with the either the basalt or Neranleigh-Fernvale land units.

Cut batters in excess of 2m height on the upper slopes associated with the basalt land unit may intercept shallow groundwater associated with the interface drainage zone in some locations (for instance around BH4). However, it would be expected that much of the upper slopes would have water tables greater than 3.0m below the existing soil surface.

Cut batters on the lower portions of the slope adjacent to the central drainage area would intercept water tables that are close to the surface (<0.8m at G&S bore 1a). Seepage and drainage control would be required to facilitate the earthworks program and stabilise the site.

The earthworks in areas associated with the Neranleigh-Fernvale land unit will encounter very minor and localised water tables that would be located immediately above the weathering and hard bedrock. These water tables would not be a constraint to the works on site.

In general the earthworks program on the hillside areas during construction would require:

 Seepage and drainage control plans for works that intercept water tables (especially in the Basalt land unit).

- Erosion and sediment control plans to control run-off during rainfall events and longer-term interflow drainage after rainfall.
- Batter stabilisation as per assessment and advice from a qualified geotechnical engineer.

The deeper basalt related water table is separated from the development site by a low permeability clay layer. The proportion of recharge to this water table from the overlying soil mantle is relatively small and the development will have minor impact on the deep regional water table of the basalt.

The alluvial infill land unit has a shallow water table that would require management during construction of infrastructure such as roads, water and sewage infrastructure and water treatment devices. A groundwater management plan in particular addressing dewatering, seepage and acid sulphate soil, will be required for the construction phase of the development.

#### 4.2 Potential contamination

The proposed development contains no potentially contaminating industries. The soil material under the urban footprint is of low permeability and forms an effective retarding barrier to water movement.

Within the alluvial infill land unit, bioretention and stormwater treatment devices will be separated from the groundwater by compacted clay barrier. <sup>19</sup> The design of the water treatment devises separates them from the ground water. However, a groundwater-monitoring program should be undertaken to validate the integrity of the water treatment structures.

#### 4.3 Proposed use of groundwater

The proposed development does not involve any uses of the site's groundwater.

## 4.4 Changes in groundwater recharge

The proposed development entails earthworks that will result in cut and fill batters plus the creation of large areas of

<sup>&</sup>lt;sup>19</sup> Gilbert & Sutherland, 'Conceptual Stormwater Assessment and Management Plan, Altitude Aspire', November 2010', report No. GJ0901-1-SWA-RAG2F.

zero to low gradient pads for house construction. These works are associated with the basalt and Neranleigh-Fernvale land units on the site. Such changes in landform may result in localised areas of increased recharge and deep percolation into the shallow interface drainage zone on the hillsides. This impact will be most evident during the construction and onmaintenance stages of the proposal. These earthworks will affect 85% of the site.

However, this increase will be balanced by a significant increase in hardstand that will increase the run-off losses to the stormwater delivery and treatment system. The proportion of hardstand will be approximately 50%. The basalt based water table at depth would be unaffected by the changes due to the low permeability of the overlying material.

The recharge of the alluvial infill land unit will remain unchanged. The water treatment devices will have clay liners to separate them from the groundwater and secondary seepage from the adjacent slopes will be maintained to ensure the groundwater levels in the infill area remains similar to the predevelopment conditions.

## 4.5 Changes in groundwater discharge

The basalt and Neranleigh-Fernvale land units will have localised changes in the discharge characteristics of the slopes. The main changes will be the development of seepage zones associated with the cut batters on site as they intercept the existing water tables in the shallow interface drainage zone. The localised seepage will need to be managed to minimise any impacts on the stability of the cut and fill batters on the site

In general the hillside areas post - construction would require:

- Seepage and drainage control plans for works that intercept water tables (especially in the Basalt land unit)
- Erosion and sediment control plans to control run-off during rainfall events and longer-term interflow drainage after rainfall.
- Batters stabilisation as per assessment and advice from a qualified geotechnical engineer.

The alluvial infill land unit will require no special intervention due to the development design not changing the groundwater flow direction and the and the groundwater discharging from this land unit directly to the adjacent SEPP 14 wetland to the north.

## 4.6 Impacts on groundwater dependant ecosystems (GDE)

The steep and elevated topography of the area ensures the local catchment conditions dominate the groundwater flows of both shallow and the deeper hard rock water tables. The flow direction is towards the SEPP14 wetland to the north of the site. The proposed development and its associated earthworks do not change the direction of flow of the water tables. Existing flow patterns will be maintained by the development by continuing to direct flows towards the existing central flow path and maintaining the groundwater flows to the alluvial infill zones in the northern portion of the development site.

There will be no impact on the GDE within the SEPP 14 wetland as a result of the development impacts on groundwater.

## 4.7 Impacts on existing registered bores

The location (different catchments) and depth of the surrounding registered bores near the site suggest there will be no impacts on these bores. The steep and elevated topography of the area ensures the local catchment conditions dominate the groundwater flows of both shallow and the deeper hard rock water tables.

## 4.8 Impacts on groundwater quality

All stormwater will be treated to control N, P prior to discharge to the environment. The surface soil mantle over the basalt has significant depth (up to 7.5m) and a limited permeability (0.031md<sup>-1</sup>). The underlying basalt based water table is separated from the proposed development activities by this soil layer. No changes in groundwater quality are expected.

### 5) Conclusions

#### 5.1 Groundwater impacts

In general the earthworks program on the hillside areas during construction would require:

- Seepage and drainage control plans for works that intercept water tables (especially in the Basalt land unit)
- Erosion and sediment control plans to control run-off during rainfall events and longer-term interflow drainage after rainfall.
- Batter require stabilisation as per assessment and advice from a qualified geotechnical engineer.

The deeper basalt related water table is separated from the development site by a low permeability clay layer and will not be affected by the development proposal

The alluvial infill land unit has a shallow water table that would require a ground water management plan or acid sulphate soil management plan.

The proposed development contains no potentially contaminating industries. Stormwater quality treatment devices will be separated from the groundwater by compacted clay barrier. However, a groundwater-monitoring program should be undertaken to validate the integrity of the water treatment structures.

The proposed development does not have any intended uses of the groundwater on the site.

The recharge basalt based water table at depth would be unaffected by the changes due to the low permeability of the overlying material and extensive recharge areas outside of the development site.

The recharge of the alluvial infill land unit will remain unchanged. There will be no impact on the GDE within the SEPP 14 wetland as a result of the development impacts on groundwater.

The location (different catchments) and depth of the surrounding registered bores near the site suggest there will be no impacts on these bores. The underlying basalt based water table is separated from the proposed development activities by its overlying low permeability soil layer and no changes in groundwater quality are expected.

# 5.2 Groundwater impact management

The identified potential impacts are readily anticipated and manageable. At the detailed design phase for the development detailed groundwater study should be undertaken to refine the understanding of the site and aid in the development of specific groundwater management plans for the site.

## 6) Limitations of reporting

Gilbert & Sutherland Pty Ltd has attempted to be accurate in providing the information contained in this report. The interpretation of scientific data, however, often involves both professional and subjective judgements. As such, interpretation is open to error.

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basis that the authors, Gilbert & Sutherland Pty Ltd, their agents or employees are not liable (whether by reason of lack of care or otherwise) to any person for any damage or loss whatsoever which has occurred or may occur in relation to that person taking or not taking (as the case may be) action in respect of any representation, statement or advice referred to above.

Furthermore, this information should not be relied upon by any other persons than the client or the relevant statutory authority determining the client's application, for whom this information was compiled. This information reflects the specific brief and the budget of the client concerned, who enjoys an individual tolerance of risk.

GJ0901\_GWA\_RMP1F.doc

Easting:

Northing:

551595.00

6877052.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Driller: Morrison Geotechnic

### **Engineering Log - Borehole**

Borehole No.: BH1

Page: 1 of 1

Job Number: GE10/001

Client: Metricon Pty Ltd

Northing: 6877052.00 Driller: Morrison Geotechnic Project: Broadscale Geotechnical Investigation RL: Logged By: L. Bexley												tigation			
_		al Depth:	3.0	0			e: 11/01/2010	Lo	ocatio	on: Al	titude	1, Frase	er Drive, 1		
ш	Orilli	ng Infor	mation		1		Material Description	<del></del>		ı	1		Te	st San	nples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description		Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
					///	CI	Silty CLAY:			М	Н				
			0.1 -			СН	Hard, medium plasticity, red brown, some root matter moist  Sitry CLAY: As above but high plasticity, and no root matter	er,		М	Н		0.3 –	- PP	– 500kPa
Auger			1.0										1 –	– PP	>600kPa
TC bit with 100mm Dia. Auger			2.0												
			2.7 -			СН	Silty CLAY: As above but red brown with some grey mottling			М	н		2.8 –	- PP	- 450kPa -
			3.0 3												
			4.0				3.00m: BOREHOLE TERMINAT	ED							
Co	mme	ents:						$\Box$							
Water level on date shown Water inflow Water outflow Water outflow Water outflow FR Fresh Moisture  ■ Water outflow Water outfl															

Easting:

Northing:

RL:

551494.00

6877621.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Logged By: L. Bexley

Driller: Morrison Geotechnic

### **Engineering Log - Borehole**

Borehole No.: BH2

Page: 1 of 1

Job Number: GE10/001

Client: Metricon Pty Ltd

Project: Broadscale Geotechnical Investigation Location: Altitude 1, Fraser Drive, Tweed Heads

	Tot	RL: al Depth:	3.0	0		Date: 11/01/2010 Location: Altitude 1, Fraser Drive, Tweed Head					Heads					
	Drilli	ng Info	mation		1	1	Material	Description	1					Tes	st Sam	ples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	D	escription		Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
			0.1 -			CI	Silty CLAY: Hard, medium plasticity,	red brown mottled brown	, some		М	Н				
						СН	root matter, moist  Silty CLAY:	city, red brown and no roc	/		М	Н		0.3 –	– PP	– >600kPa
Dia. Auger			1.0											1 =	– PP	>600kPa
TC bit with 100mm Dia. Auger			2.0											1.8 –	- PP	– - 450kPa
			_											2.3 –	– PP	- >600kPa
			2.6 - - 3.0 <sub>3</sub>			СН	Silty CLAY: As above but a trace of a				М	Н		2.9 –	– PP	– 450-500kPa
							3.00m: BOREH	HOLE TERMINA	TED							
			4.0													-
Co	Comments:         Authorised by:															
Wa	Water level on date shown Water outflow Water outflow Water outflow FR FR Fresh Fres															

### Morrison Geotechnic Pty Ltd

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### **Engineering Log - Borehole**

Borehole No.: BH3

Page: 1 of 1

Job Number: GE10/001

Easting: 551393.00 Drilling Rig: Jacro 200 Client: Metricon Pty Ltd Northing: 6877105.00 Driller: Morrison Geotechnic

Project: Broadscale Geotechnical Investigation Logged By: L. Bexley RL: Location: Altitude 1, Fraser Drive, Tweed Heads **Total Depth:** 3.00 Date: 11/01/2010

_		al Depth:	3.00	)	Date: 11/01/2010 Location: Altitude 1, Fraser Drive, Tweed Heads  Material Description Test Samples									
⊢'	ווווזע	ng Infor	illation				Material Description	1	1	1		I e:	si San	ipies
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
						СН	Silty CLAY:		М	н				
		-	1.0				Hard, high plasticity, red brown, moist					0.5 –	– PP	– >600kPa
mm Dia. Auger		-	1.5 -									1.2 –	- PP	- >600kPa -
TC bit with 100mm Dia. Auger		-	2.0			CH	Sity CLAY: As above but red brown mottled orange brown		М	Н				
		-	3.0 3 \			СН	Sitty CLAY: As above but red brown with minor orange brown mottling	ng	М	Н				
		-	4.0				3.00m: BOREHOLE TERMINATED							
Co	Comments:         Authorised by:           Date:													
	on o	ter level date shown ter inflow ter outflow	DW Distir weat SW Sligh	mely hered hered hered tly hered	S So F Fin St St VSt Ve H Ha	ery soft oft om iff ery stiff ard	Name	District Star 300r Star Van C Dyna tape	isturbed 5 urbed san idard Pen mm with a d penetro e shear vi amic Con r cone fitt	nple. letration a 63.6kg meter es alue kPa e test, 9. led to roo	Test, N = n hammer fal stimate of u 09kg hamn ds of smalle	lling 762mm nconfined co ner, fall 508i r section.	ompress mm, driv	ive 50mm sampler ive strength, kPa. ing 20mm, 30 deg neering Purposes

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

### **Engineering Log - Borehole**

Borehole No.: BH4

Page: 1 of 1

Job Number: GE10/001

Easting: 551431.00 Drilling Rig: Jacro 200 Client: Metricon Pty Ltd Northing: 6877214.00 Driller: Morrison Geotechnic

Project: Broadscale Geotechnical Investigation Logged By: L. Bexley RL: Location: Altitude 1, Fraser Drive, Tweed Heads **Total Depth:** Date: 11/01/2010

		al Depth: ng Infor	3.6	0	Date: 11/01/2010 L  Material Description				ocation: Altitude 1, Fraser Drive, Tweed Heads  Test Samples					
H	J	ig iilioi	mation			<i>a</i>	material Description					10	St Sall	ipies
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
				Slopewash		CI	Sandy CLAY: Hard, medium plasticity, red brown mottled orange brown with a trace of grey, fine to medium grained sand, moist		М	Н				
			0.3 -	<u> </u>		CI	Sandy CLAY: As above but with a trace of fine to coarse gravel		M	Н		0.5 –	- PP	– - >600kPa –
			1.0											+
TC bit with 100mm Dia. Auger			1.7 -			CL	Sandy CLAY (CL/CI)/ Clayey SAND (SC):		M-W	F-St				-
with 100r			2.0				Firm to stiff, low to medium plasticity fines, orange brown mottled grey and purple and red brown, fine to medium grained sand, moist to wet					1.8 -	– PP	- 100kPa
TC bit			2.1 -	Residual		/ CL CI	Sandy CLAY (CL/Cl)/ Clayey SAND (SC): As above but grey mottled orange brown and res brown		M-W	F-St				  -  -
			2.6 -	*		SC	Clayey SAND: Medium dense, fine to medium grained sand, grey mottled orange brown and red brown, low to medium plasticity fines, moist	xw	М	MD VLS				
			3.0	Bedrock	V V V V V V V V V V V V V V V V V V V	BAS	BASALT: Extremely weathered, very low strength, grey with some orange brown mottling	, xw		VLS				<del> </del>
		,	3.6		V V									
			46				3.60m: BOREHOLE TERMINATED AT MAX. TC BIT REFUSAL							
Co	4.0       Authorised by:													
Wa	Water         Weathering         Consistency         Density         Rock Strength         Tests & Results           ✓ Water level on date shown of adde shown of the show													

Easting:

Northing: 6877235.00

551532.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Driller: Morrison Geotechnic

### **Engineering Log - Borehole**

Borehole No.: BH5

**Page:** 1 of 2

Job Number: GE10/001

Client: Metricon Pty Ltd

		Northing: RL:	6877235.00	)	Le		: Morrison Geotechnic : L. Bexley	Proj	Project: Broadscale Geotechnical Investigation					
	Tot	al Depth:	7.60	0			: 11/01/2010	Locat	ion: A	ltitude	1, Frase	er Drive, T	weed	Heads
	Drilli	ng Info	rmation				Material Description					Te	st San	ples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger	N	116	1.0	Residual		СН	Silty CLAY: Very stiff to hard, red brown, high plasticity moist  Silty CLAY: As above but very stiff		M	VSt-H		0.5 -	- PP	- 450kPa
			2.2 - 2.4 - 3.0 3.1 - 3.7 -			CH CH	Sitty CLAY: As above but dark grey mottled orange brown, and very stiff to hard  Sitty CLAY: As above but dark grey mottled blue grey with some orange brown mottling, and very stiff  Silty CLAY: As above but red brown with some blue grey and orang brown mottling, and stiff  Silty CLAY: As above but firm and wet		M M	VSt-H VSt		2.4 -	- D	_
Со	mme	ents:						A	Authoris	sed by:	:			

Comments:										Authorised by:
Water	Wea	thering	Con	sistency	Der	sity	Rock	Strength	Tests	s & Results
Water level	RS	Residual soil	VS S	Very soft Soft	VL L	Loose	ELS	Extremely low	U50 D	Undisturbed 50mm diam tube. Disturbed sample.
	XW	Extremely weathered	F St	Firm Stiff	MD	Medium dense	VLS LS	Very low Low	SPT	Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
Water inflow	DW	Distinctly weathered	VSt H	Very stiff Hard	D VD	Dense Very dense	MS HS	Medium High	PP S	Hand penetrometer estimate of unconfined compressive strength, kPa.  Vane shear value kPa
Water outflow	SW	Slightly weathered	••			, 201100	VHS	Very high Extremely	DC	Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section.
	FR	Fresh	<b>Mois</b> D D	sture ry M Moist	w v	Vet		high		From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Easting:

### Morrison Geotechnic Pty Ltd

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### **Engineering Log - Borehole**

Borehole No.: BH5

Page: 2 of 2

Job Number: GE10/001 551532.00 Drilling Rig: Jacro 200 Client: Metricon Pty Ltd

Northing: 6877235.00 Driller: Morrison Geotechnic Project: Broadscale Geotechnical Investigation Logged By: L. Bexley RL: Location: Altitude 1, Fraser Drive, Tweed Heads **Total Depth:** 7.60 Date: 11/01/2010

		al Depth:	7.6	0		Date		_ocati	on: A	illuae	i, riase	r Drive,		
	Urilli	ng inio	rmation		1	1	Material Description	l	I	1		ie	st San	ipies
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
						СН	Silty CLAY:		М	F		4 /	PP	60kPa
			4.5 -				As above but firm and wet							
			4.5			СН	Silty CLAY: As above but moist to wet		M-W	F		4.6 -	- PP	- 75-100kPa
														H
			5.0											+
			5.1 –			СН	Silty CLAY: As above but soft to firm, and wet		w	S-F				H
ger														
ia. Au														
mm Diam														
h 100			6.0											
TC bit with 100mm Dia. Auger												6 –	– PP	- 40-60kPa
12														
														H
														H
														H
			7.0											+
			$\parallel$											H
				Bedrock			BASALT: Extremely weathered, low strength, dark grey mottled							$\mid \cdot \mid$
			7.5 – 7.6 <sub>\</sub>	Be	VΛ	BAS	orange brown	XW		LS				
							7.60m: BOREHOLE TERMINATED AT MAX. TC BIT REFUSAL							
			8.0											
Co	mme	ents:												

Comments:										Authorised by: Date:
Water	Wea	thering	Con	sistency	Den	sity	Rock	Strength	Tests	s & Results
Water level	RS	Residual soil	VS S	Very soft Soft	VL L	Loose	ELS	Extremely low	U50 D	Undisturbed 50mm diam tube. Disturbed sample.
	XW	Extremely weathered	F St	Firm Stiff	MD	Medium dense	VLS LS	Very low Low	SPT	Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
Water inflow	DW	Distinctly weathered	VSt H	Very stiff Hard	D VD	Dense Very dense	MS HS	Medium High	PP S	Hand penetrometer estimate of unconfined compressive strength, kPa.  Vane shear value kPa
Water outflow	SW	Slightly weathered	••			, 201100	VHS	Very high Extremely	DC	Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section.
	FR	Fresh	Mois D D		w w	<b>√</b> et		high		From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Easting:

Northing:

RL:

551454.00

6877469.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Logged By: L. Bexley

D Dry M Moist W Wet

Driller: Morrison Geotechnic

### **Engineering Log - Borehole**

Borehole No.: BH6

Page: 1 of 2

Job Number: GE10/001

Client: Metricon Pty Ltd

Project: Broadscale Geotechnical Investigation

_		al Depth:	7.5	50				: 15/01/2010	Lo	catio	n: A	ltitude	1, Frase	r Drive, T			_
	Drilli	ng Infor	mation					Material Description						Tes	st San	ples	4
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log		Classification Code	Description		Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result	
TC bit with 100mm Dia. Auger			1.0	Colluvium Topsoil		CI	1	Silty CLAY: Hard, medium plasticity, red brown, some root matter, moist  Silty CLAY: As above but high plasticity, and no root matter, red brown mottled orange brown with some grey, some boulders  Silty CLAY:			M M	H H		1.5 -	– PP	>600kPa 	]
TC bit with 1			3.0			Cł	-1	Silty CLAY: As above but red brown mottled blue grey and orange brown, soft to firm, moist to wet			M-W	S-F		3.5 -	– PP	<b>-</b> - 350kPa	
Со	mme	ents:	4.0		_					Au	thoris	sed by:					]
	on o	ter level date shown ter inflow ter outflow	XW Extr wea DW Dist wea SW Sligi	idual emely thered inctly thered htly thered	VS S F St VSt H	Sistence Very Soft Firm Stiff Very Hard	soft	VL         Very loose L         ELS         Extremely low         U           MD         Medium dense         VLS         Very low         S           D         Dense         MS         Medium Medium         P           VD         Very dense         HS         High         S	J50 D SPT PP S DC	Undistudistudistanda Standa 300mm Hand p Vane si Dynam taper ce	urbed 5 bed san ard Pen n with a benetro shear va nic Con-	50mm dia nple. etration 63.6kg meter es alue kPa e test, 9. ed to roo	am tube.  Test, N = n hammer fal timate of u  09kg hamn ls of smalle	lling 762mm nconfined co ner, fall 508r r section.	ows to dr ompress	ive 50mm sampler ve strength, kPa. ng 20mm, 30 deg neering Purposes	

Easting:

Northing:

RL:

551454.00

6877469.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Logged By: L. Bexley

Driller: Morrison Geotechnic

### **Engineering Log - Borehole**

Borehole No.: BH6

Page: 2 of 2

Job Number: GE10/001

Client: Metricon Pty Ltd

Project: Broadscale Geotechnical Investigation Location: Altitude 1, Fraser Drive, Tweed Heads

	Tot	tal Depth:	7.5	0		Date		Locati	on: A	Ititude	1, Frase	er Drive, T		
[	)rilli	ng Infor	mation				Material Description		<u> </u>			Tes	st San	ıples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
$\overline{\Box}$	$\equiv$		T		1111111	СН	Silty CLAY:	1	M-W	S-F		4/	PP	40-60kPa
	SWL	_	-			,	As above but red brown mottled blue grey and orange brown, soft to firm, moist to wet					4'		*40-00XFa
	┸	. F	4.8 -		<del>      </del>	СН	Silty CLAY:		w	S-F				H
		_	5.0				As above but wet							+
TC bit with 100mm Dia. Auger			<u> </u> 											
oit with 100r		   	6.0											 
77			6.2 -		-			<u> </u>		_				l L
						CH	Silty CLAY: As above but firm, and blue grey		W	F				
			6.6 -											
			0.0			СН	Silty CLAY: Hard, high plasticity, orange brown mottled light grey, moist		М	Н				
			7.0											
			7.5 \									7.3 –	– PP	- 500kPa
							7.50m: BOREHOLE TERMINATED							
			8.0											
<u></u>		ents:						1						
Coi	IIIIe	шъ.								-				
War	Wate	ter level date shown ter inflow ter outflow	XW Extre weat DW Disti weat SW Sligh	emely thered inctly thered intly thered intly	S S F F F St S VSt V H H H	/ery soft Soft Firm Stiff /ery stiff Hard	Note	Distur Stand 300m Hand Vane Dyna taper	sturbed 5 rbed san dard Pen m with a penetro shear va mic Con- cone fitt	netration a 63.6kg ometer es alue kPa ae test, 9. ted to roo	Test, N = n hammer fa stimate of u .09kg hammeds of smalle	Illing 762mm Inconfined co mer, fall 508r er section.	i. ompressi mm, drivi	rive 50mm sampler ive strength, kPa. ing 20mm, 30 deg ineering Purposes

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

### **Engineering Log - Borehole**

Borehole No.: BH7

Page: 1 of 2

Job Number: GE10/001 551183.00 Drilling Rig: Jacro 200

Easting: Client: Metricon Pty Ltd Northing: 6877459.00 Driller: Morrison Geotechnic Project: Broadscale Geotechnical Investigation

Logged By: L. Bexley RL: Location: Altitude 1, Fraser Drive, Tweed Heads Total Depth: 7.00 Date: 15/01/2010

	Drilli	ng Infor	mation				Material Description	LUCALI					st Sam	
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			2.0			СН	Silty CLAY: Hard, high plasticity, red brown, moist  Silty CLAY: As above but with a trace of extremely weathered grey deco basalt layering		M	H		1-	– PP	->600kPa
			3.7			СН	Sitty CLAY: As above but with basalt boulders  Sitty CLAY: As above but no basalt boulders, and very stiff		М	VSt				
Wa	Wat on d	er level late shown rer inflow	Weathering RS Resid soil	mely nered ctly nered ly nered	S S F F St S VSt V H H	ery soft oft irm tiff ery stiff ard	Density Rock Strength Tes  VL Very loose ELS Extremely U5 L Loose low D  MD Medium VLS Very low SP dense LS Low D Dense MS Medium PP VD Very dense HS High S VHS Very high EHS Extremely high  t W Wet	ts & Res Undis Distu Stand 300m Hand Vane Dyna taper	ate: ults sturbed s rbed sar dard Per m with a penetro shear v mic Con cone fit	60mm dia nple. letration a 63.6kg meter es alue kPa e test, 9.	am tube.  Test, N = n hammer fal stimate of u  09kg hamn ds of smalle	lling 762mm nconfined co ner, fall 508r r section.	ows to dr ompressi mm, drivi	

Easting:

Northing:

RL:

551183.00

6877459.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

## **Engineering Log - Borehole**

Borehole No.: BH7 Page: 2 of 2

Job Number: GE10/001

Client: Metricon Pty Ltd

Driller: Morrison Geotechnic Project: Broadscale Geotechnical Investigation Logged By: L. Bexley Location: Altitude 1, Fraser Drive, Tweed Heads

	To	RL: al Depth:	7.0	0			y: L. Bexley e: 15/01/2010		L	ocati	on: A	ltitude	1, Frase	r Drive, T		
	Drilli	ng Info	mation				Material De	escription						Tes	st Sam	ples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Desc	eription		Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
						СН	Silty CLAY:	ders and very stiff			М	VSt				
TC bit with 100mm Dia. Auger			5.0			CH	As above but no basalt boul	ders, and very stiff				VS				-
			6.5 -			СН	Silty CLAY: As above but with basalt bot	ulders			M	VSt				_
			8.0				7.00m: BOREHO AT MAX. TC BI BASALT									-
		ents:								D	ate:					
Wa	on o	ter level date showr ter inflow ter outflow	DW Distii weat SW Sligh	dual emely thered nctly thered ntly thered	S S F I St S VSt N H I	Very soft Soft Firm Stiff Very stiff Hard	VL Very loose L Loose MD Medium dense L D Dense M VD Very dense N	ELS Extremely low VLS Very low Service Low MS Medium HS High Very high EHS Extremely high	Tests U50 D SPT PP S DC	Distur Stand 300m Hand Vane Dyna taper	turbed 5 rbed san lard Pen m with a penetro shear va mic Con- cone fitt	etration 63.6kg meter es alue kPa e test, 9. ed to rod	Test, N = n hammer fa timate of u 09kg hamn Is of smalle	lling 762mm nconfined co ner, fall 508r er section.	ompressi mm, drivi	ive 50mm sampler ve strength, kPa. ng 20mm, 30 deg neering Purposes

Easting:

Northing:

RL:

551489.00

6877546.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Logged By: L. Bexley

Driller: Morrison Geotechnic

### **Engineering Log - Borehole**

Borehole No.: BH8

Page: 1 of 1

Job Number: GE10/001

Client: Metricon Pty Ltd

Project: Broadscale Geotechnical Investigation Location: Altitude 1, Fraser Drive, Tweed Heads

	Tot	RL: al Depth:	3.0	0			y: L. Bexley e: 15/01/2010	Locati	on: A	ltitude	1, Frase	r Drive, 1	Tweed	Heads
	Drilli	ng Info	rmation		1		Material Description					Te	st San	ples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
			-	Colluvium		СН	Sitty CLAY: Very stiff to hard, red brown, high plasticity, trace of fine to medium grained sand, some fine to medium gravel, moist		М	VSt-H		0.3 -	- PP	– 400kPa
. Auger			1.0			СН	Sitty CLAY: As above but hard, red brown mottled orange brown		М	н				+
00mm Dia			1.3 -	Inter-face		СН	Silty CLAY: As above but red brown mottled blue grey and orange brown		М	Н				
TC bit with 100mm Dia. Auger			2.0	Residual Neranleigh Fernvale		СН	Sitry CLAY: Very stiff, high plasticity, light grey streaked orange brown, moist		М	VSt		1.8 -	– <b>PP</b> – PP	- 310kPa
			3.0 3	Re										-
			4.0				3.00m: BOREHOLE TERMINATED							
		ents:						D	ate:	-				
Wa	on c	ter level date showr ter inflow ter outflow	DW Disting weath SW Slight	dual emely thered nctly thered ntly thered	S F St VSt H	Very soft Soft Firm Stiff Very stiff Hard		Distu Stand 300m Hand Vane Dyna taper	sturbed 5 rbed san dard Pen nm with a I penetro shear vo mic Con cone fitt	etration a 63.6kg meter es alue kPa e test, 9. ed to rod	Test, N = n hammer fa timate of u 09kg hamn Is of smalle	lling 762mm nconfined conner, fall 508 er section.	n. ompressi mm, drivi	ive 50mm sampler ve strength, kPa. ng 20mm, 30 deg neering Purposes

Easting:

Northing:

RL:

551399.00

6877534.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Logged By: L. Bexley

Driller: Morrison Geotechnic

### **Engineering Log - Borehole**

Borehole No.: BH9

Page: 1 of 1

Job Number: GE10/001

Client: Metricon Pty Ltd

Project: Broadscale Geotechnical Investigation

	Tot	al Depth:	3.5	0			e: 15/01/2010	Locati	on: A	ltitude	1, Frase	r Drive, T	weed	Heads
	Drilli	ng Info	mation				Material Description					Tes	st San	ples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
						СН	Silty CLAY:		М	St		'		
			- 0.6 -			СН	Stiff, high plasticity, grey mottled red brown and orange brown, moist  Sandy CLAY:		М	St		0.4 - 0.5 <del>-</del> }	– PP – D	- 150kPa -
	SWL SWL		1.0				Stiff, high plasticity, grey, fine to medium with some coarse grained sand, trace of fine gravel, moist					<sup>1.2 –</sup> }-	- D	- -
TC bit with 100mm Dia. Auger			2.0			СН	Sitty CLAY: Stiff, high plasticity, grey, trace of fine grained sand, mois	t	М	St		,		
TC bit			2.1 –			СН	Sitty CLAY: As above but soft to firm, wet, and brown mottled grey, some fine grained sand, some fine gravel		M	S-F		2.3	– D – PP	– – 50kPa
			3.0			СН	Sitty CLAY: As above but firm, and moist to wet		M-W	F		2.9 –	– PP	– 75kPa
			3.4 -			СН	Silty CLAY: As above but with basalt boulders	<b>├</b>	M-W	F				Н
			4.0				3.50m: BOREHOLE TERMINATED AT MAX. TC BIT REFUSAL ON BASALT BOULDER							
Co	mme	ents:												
Wa	7 Wa −on α _Wa	ter level date showr ter inflow ter outflow	DW Distii weat SW Sligh	emely hered nctly hered ttly hered	S S F F F St S VSt V	/ery soft Soft Firm Stiff /ery stiff Hard	Density	Distu Stand 300m Hand Vand Dyna taper	sturbed 5 rbed san dard Pen nm with a I penetro shear vo mic Con cone fitt	etration 63.6kg meter es alue kPa e test, 9. ed to roo	Test, N = n hammer fal stimate of u 09kg hamn ds of smalle	lling 762mm nconfined co ner, fall 508r r section.	ompressi mm, drivi	ive 50mm sampler ive strength, kPa. ing 20mm, 30 deg neering Purposes

Easting:

551317.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

## **Engineering Log - Borehole**

Borehole No.: BH10

Page: 1 of 1

Job Number: GE10/001 Drilling Rig: Jacro 200

Client: Metricon Pty Ltd

Northing: 6877600.00 Driller: Morrison Geotechnic Project: Broadscale Geotechnical Investigation Logged By: L. Bexley RL: Location: Altitude 1, Fraser Drive, Tweed Heads **Total Depth:** Date: 15/01/2010

		al Depth:	3.0			Date	: 15/01/2010	Locati	OII. /\	itituac	1,11436	r Drive, I		
H	ווווזכ	ng Infor	mation		ī	1	Material Description	T	1	I		10:	st San	ipies
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
						СН	Silty CLAY:		М	VSt				
			0.25 -			СН	Very stiff, high plasticity, red brown with some orange brown mottling, moist  Sitty CLAY: As above but grey mottled red brown		М	VSt		0.4 -}	- D - PP	_ _ - 300kPa
ier			1.0			СН	Sandy CLAY: Soft, high plasticity, grey mottled orange brown, fine to		w	s				  -  -
TC bit with 100mm Dia. Auger							medium grained sand, fine to medium gravel, wet					1.2 -}	- D - PP	_ _ - 40kPa
TC bit with 1			2.0											
			_ 2.4 -			СН	Silty CLAY: Firm to stiff, high plasticity, dark grey, moist to wet		M-W	F-St		2.5 -}	– D – PP	_ _ - 80-100kPa
												2.0 -		- 60-100KFa
			3.0 3			Щ	3.00m: BOREHOLE TERMINATED	+						
			4.0				3.00III. BONLITOLE TERIMINATE							_
		ents:						С	ate:	_				
Wa	Wate on co	ter level date shown ter inflow ter outflow	DW Distii weat SW Sligh	dual emely chered nctly hered titly hered	VS S F St VSt H		Name	Distu PT Stan 300n P Hand Vane C Dyna tape	sturbed strbed sard Per dard Per nm with a d penetro shear v mic Con r cone fitt	nple. netration a 63.6kg meter es alue kPa e test, 9. ted to roo	hammer fa stimate of u	lling 762mm nconfined conner, fall 508 er section.	ı. ompress mm, driv	rive 50mm sampler live strength, kPa. ling 20mm, 30 deg ineering Purposes

Easting:

551270.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076

Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

## **Engineering Log - Borehole**

Borehole No.: BH11

Page: 1 of 1

Job Number: GE10/001

Client: Metricon Pty Ltd

Northing: 6887546.00 Driller: Morrison Geotechnic Project: Broadscale Geotechnical Investigation Logged By: L. Bexley RL: Location: Altitude 1. Fraser Drive, Tweed Heads

		al Depth:	4.0	00			Date		Locat	ion: A	ltitude	1, Frase	r Drive, 1		
ı	Orilli	ng Infor	mation				1	Material Description	_	1	ı		Te	st San	ples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin		Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
			0.1 -	Topsoil	0	//	CI	Silty CLAY: Hard, medium plasticity, red brown, some root matter,		М	Н				
				Slopewash To	<u>/ </u>		СН	moist  Sitty CLAY: As above but high plasticity, no root matter, red brown with some orange brown lensing, trace of fine gravel	/	M	Н		0.4 –	- PP	>600kPa
			1.0												+
Jia. Auger			-				СН	Sitty CLAY: As above but red brown mottled orange brown		М	Н		1.5 –	– PP	– >600kPa –
TC bit with 100mm Dia. Auger			2.0				- Ou	On A DV							<u> </u>  -
TCb			2.7 -	-			СН	Sitry CLAY: As above but with some basalt boulders		М	Н				
			3.0	Deco Basalt			СН	Silty CLAY: As above but orange brown mottled red brown and grey		М	Н				
			3.4 -	Neranleigh Fernvale			СН	Sitty CLAY: Hard, high plasticity, light grey mottled orange brown, moist		М	Н				
			3.4	Bedrock			ARG	ARGILLITE: Extremely weathered, very low strength, light grey mottled orange brown	xw		VLS				
			4.0					4.00m: BOREHOLE TERMINATED							
		ents:	•						,	Date:	-				
Water   Weathering   Consistency   Density   Rock Strength   Teach											a 63.6kg ometer es alue kPa e test, 9 ted to roo	Test, N = n hammer fa stimate of u  09kg hamr ds of smalle	lling 762mm nconfined co ner, fall 508 er section.	ompress mm, driv	ive 50mm sampler ve strength, kPa. ng 20mm, 30 deg neering Purposes

Easting:

Northing:

RL:

551104.00

6877603.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Logged By: L. Bexley

Driller: Morrison Geotechnic

## **Engineering Log - Borehole**

Borehole No.: BH12

Page: 1 of 1

Job Number: GE10/001

Client: Metricon Pty Ltd

Project: Broadscale Geotechnical Investigation Location: Altitude 1, Fraser Drive, Tweed Heads

		al Depth:	3.0	0			Dat		Locat	ion: A	ltitude	1, Frase	r Drive, 7		
ı	Drilli	ng Infor	mation					Material Description					Te	st San	nples
Drill Method	Water	RL	Hole Depth (m)	Soil Origin		Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
				ē	1	//	CI	Silty CLAY:	Т	М	Н				
			0.1 -	Topsoil	ЖÍ	M	СН	Hard, medium to high plasticity, red brown with some grey, some root matter, moist	Г	м	н				
			1	<u></u>	/	.		Silty CLAY:					0.3 -	- PP	- >600kPa
		l	]	Residual	Ш	.		As above but high plasticity, red brown and no root matter					0.3 -		- >000KF4
				æ		.									
			0.6 -		╢	Щ	СН	Silty CLAY:	-	м	Н				H
						.	-	As above but red brown mottled orange brown		l Wi	"				
			1			.									H
			1.0			.									
ē			†			.							1 -	– PP	- >600kPa
δη			1.1 -	Neranleigh Fernvale		Ш	СН	Silty CLAY: As above but orange brown mottled grey, with some fine		М	Н				
j.			1.3 -	Fern	Ш	Ш	<u> </u>	grained sand							
TC bit with 100mm Dia. Auger			1	Ž	/III	.	СН	Silty CLAY: As above but grey, no sand, and slickensided		М	Н		1.4 –	- PP	– 500kPa
ĕ					'	.		,,							
1			†			.									H
ķ						.									
ţ.			1.8 -		111	III	СН	Silty CLAY: As above but orange brown mottled grey		м	Н				Ī
۲			2.0		$\ $	.		/ Castro satisfaction modes groy							
						.									
			2.2 -		₩	Щ	СН	Silty CLAY:	-	М	Н				l H
						.	l cu	As above but light grey mottled orange brown		IVI	"				
		H	1			.									H
						.									
			1			.									Ī
			]			.		Silty CLAY:							
			2.9 -		Ш	Щ	<u> </u>	As above but with some extremely weathered argillite layering	╙						
			3.0 3		Ш	Ш	СН		_	М	Н				
								3.00m: BOREHOLE TERMINATED							
			1												H
			1												Π
			1												L
		F	1												H
			4.0												
			-	1		_		1	_		-				
Co	mme	ents:							,	luthari	and by				
										Authori	seu by				•
										Date:					·-
Wa	ter		Weatherin RS Resi	<b>g</b> idual	<b>Co</b> i		tency Very soft	· · · · · · · · · · · · · · · · · · ·	ts & Res		50mm dia	ım tubo			
		ter level date shown	soil		S F	5	Soft	L Loose low D  MD Medium VLS Very low SPT	Distu	urbed sa	mple.		umbor of l-1	NWO +0 cl-	ive 50mm sampler
		ter inflow	wear	emely thered	St	5	Firm Stiff	dense LS Low	300r	nm with	a 63.6kg	hammer fa	lling 762mm	١.	·
			wear	nctly thered	VSt H		∕ery stiff ⊣ard	VD Very dense HS High S	Vane	e shear v	alue kPa			•	ve strength, kPa.
-	vva <b>▼</b>	ter outflow		thered				VHS Very high DC EHS Extremely	tape	r cone fit	ted to roo	ls of smalle	r section.		ing 20mm, 30 deg
			FR Fres	h		<b>istu</b> i Dry		high st W Wet	Fron	n AS128	9-1993 M	ethods of 1	esting Soils	for Engi	neering Purposes

Easting:

Northing:

RL:

551063.00

6877731.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Logged By: L. Bexley

Driller: Morrison Geotechnic

## **Engineering Log - Borehole**

Borehole No.: BH13

Page: 1 of 1

Job Number: GE10/001

Client: Metricon Pty Ltd

Project: Broadscale Geotechnical Investigation Location: Altitude 1, Fraser Drive, Tweed Heads

Logged By: L. Bextey   Total Depth: 2.00   Date: 11/01/2010   L									L	Location: Altitude 1, Fraser Drive, Tweed Heads							
	Orilli	ng Info	mation		Material Description								Test Samples				
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	D	escription		Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result	
			0.1 -			SC		redium grained sand, brown	n, low		М	MD				· · · · · · · · · · · · · · · · · · ·	ī
						SC	plasticity fines, moist  Clayey SAND:		1		М	MD					Н
			0.4 -			SC	As above but orange bro	e brown mottled light grey			М	MD					Н
uger							As above but light orang	e brown mothed light grey									H
Dia. A			0.7 -	Bedrock		SST	SANDSTONE: Extremely weathered, ve brown mottled, light grey	ery low strength, light orang	je	XW		VLS					H
TC bit with 100mm Dia. Auger			1.0	ď.													$\parallel$
vith 10			1.2 -			ARG	ARGILLITE:			xw		VLS					Ц
C bit						And	Extremely weathered, ve brown mottled, light grey	ery low strength, light orang	je	AW		VES					Ц
-																	L
			2.0 2														
							2.00m: BOREH	IOLE TERMINAT	ΓED								Ī
																	Ī
																	Ħ
																	Ħ
			H														H
			3.0														$\dagger$
																	Н
																	H
																	H
																	$\parallel$
			4.0														
Comments:  Authorised by:													]				
												-					
Wa	<b>v</b> Wa	ter level	soil	sidual VS Very soft VL Very loose ELS Extremely U							turbed 5	i0mm dia	am tube.				1
	- on c	date showr ter inflow	1 XW Extre	emely thered nctly	d St Stiff dense LS Low					Disturbed sample.  Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.  Hand penetrometer estimate of unconfined compressive strength, kPa.							
	Wa	ter outflow	weat SW Sligh weat	thered htly thered	н н	ard	VD Very dense	HS High VHS Very high EHS Extremely	S DC	Vane Dynar taper	shear va mic Con cone fitt	alue kPa e test, 9. ed to roc	09kg hamn ds of smalle	ner, fall 508r er section.	nm, drivi	ng 20mm, 30 deg	
FR Fresh <b>Moisture</b> high From AS1289-1993 Methods of Testing Soils for Engineering Purp D Dry M Moist W Wet									neering Purposes								

Easting:

551103.00

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

## **Engineering Log - Borehole**

Borehole No.: BH14

Page: 1 of 1

Job Number: GE10/001 Drilling Rig: Jacro 200

Client: Metricon Pty Ltd

Northing: 6877372.00 Driller: Morrison Geotechnic Project: Broadscale Geotechnical Investigation Logged By: L. Bexley RL: Location: Altitude 1, Fraser Drive, Tweed Heads Total Depth: 3.00 Date: 11/01/2010

ı	Drilli	ng Infor					Material Description				Test Samples						
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	- in the second	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result		
					//	//	CI	Silty CLAY:		М	Н						
			0.1		III		СН	Hard, medium plasticity, red brown mottled brown, some root matter, moist		М	Н						
			1		Ш	Ш		Silty CLAY:	'								
			_		Ш	Ш		As above but high plasticity, red brown and no root matter					0.4 -	- PP	- >600kPa		
					Ш	Ш											
			4		Ш	Ш											
			0.7		₩	₩	СН	Silty CLAY:	-	М	н						
		-	1		Ш	Ш		As above but red brown with some grey mottling							-		
			1.0		Ш	Ш											
ē			† 1		$\parallel \parallel$	Ш	СН	Silty CLAY: As above but red brown and no grey mottling		М	Н				†		
Aug			1		Ш	Ш											
ē.					Ш	Ш											
TC bit with 100mm Dia. Auger			1.4		-#	Ш	СН	Silty CLAY:		м	Н						
Į.					Ш	Ш	СН	As above but red brown with some orange brown mottling		M	Н		1.5 –	– PP	– >600kPa		
110			†		Ш	Ш									ŀ		
×					Ш	Ш											
ţ j			1		Ш	Ш									-		
۲			2.0			Ш											
					Ш	Ш											
		-	2.2		╫	Ш	CH	Silty CLAY:		M	Н				-		
					Ш	Ш	0	As above but red brown with some orange brown and grey mottling		"	''						
			1		Ш	Ш									-		
					Ш	Ш											
					Ш	Ш											
			4		Ш	Ш									_		
			3.0 3.		Ш	Ш											
			3.0 3		╨	Ш		3.00m: BOREHOLE TERMINATED									
								3.30m. BONEHOLE TERMINATED									
			1														
			1														
		-	4												-		
		İ	1												-		
			4.0														
Co	mme	ents:							T								
		villa.								Authori	sed bv:				<u>.</u>		
											-						
14/-	tor		Wastharin		Care	voi o*	ono:	Donoity Book Strongth T	Date:sts & Results								
wa	Water Weathering  RS Residua				VS	V	ency ery soft	VL Very loose ELS Extremely U50	Und	isturbed	50mm dia	ım tube.					
_	Water level soil soil Extreme				S F	Fi	oft irm	L Loose low D MD Medium VLS Very low SPT									
	weathere Water inflow DW Distinctly				St VSt	S	tiff ery stiff	dense LS Low D Dense MS Medium PP	300mm with a 63.6kg hammer falling 762mm. Hand penetrometer estimate of unconfined compressive strength, kPa.								
weather			thered	ered H Hard VD Very dense HS High S						alue kPa				ing 20mm, 30 deg			
-	0 og			thered	Mois	stur	e	EHS Extremely high	tape	r cone fit	ted to roc	ls of smalle	er section.		neering Purposes		
							t W Wet	1101	,	. 1000 W	0.11000 01	. coming colls	.o. Liigi				

Easting:

Northing:

**Total Depth:** 

RL:

551414.00

6877336.00

6.00

#### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076

Phone: (07) 3279 0900 Fax: (07) 3279 0955

Drilling Rig: Jacro 200

Logged By: L. Bexley

Date: 15/01/2010

Driller: Morrison Geotechnic

### **Engineering Log - Borehole**

Borehole No.: BH15
Page: 1 of 2

Job Number: GE10/001

Client: Metricon Pty Ltd

**Project:** Broadscale Geotechnical Investigation **Location:** Altitude 1, Fraser Drive, Tweed Heads

**Drilling Information Material Description Test Samples** Consistency -Density - Strength Classification Code C Test Results Drill Method Hole Depth Test Soil Sample/Result (m) Depth Tests Description Silty CLAY: Hard, high plasticity, red brown, trace of fine to medium gravel, moist >600kPa 0.3 -PP 0.75 Silty CLAY:
As above but lenses of light grey deco basalt lensing 1.0 TC bit with 100mm Dia. Auger 2.0 Silty CLAY: As above but firm, moist to wet, and lenses of blue grey sandy clay 3.0 4.0

Comments:										Authorised by:
										Date:
Water	Wea	thering	Cons	sistency	Den	sity	Rock	Strength	Tests	& Results
▼ Water level	RS	Residual soil	VS S	Very soft Soft	VL L	Very loose Loose	ELS	Extremely low	U50 D	Undisturbed 50mm diam tube. Disturbed sample.
on date shown	XW	Extremely weathered	F St	Firm Stiff	MD	Medium dense	VLS LS	Very low Low	SPT	Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
Water inflow	DW	Distinctly weathered	VSt H	Very stiff Hard	D VD	Dense Very dense	MS HS	Medium High	PP S	Hand penetrometer estimate of unconfined compressive strength, kPa.  Vane shear value kPa
Water outflow	SW	Slightly weathered				. ,	VHS	Very high Extremely	DC	Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section.
	FR	Fresh	Mois D D		w w	/et		high		From AS1289-1993 Methods of Testing Soils for Engineering Purposes

### Morrison Geotechnic Pty Ltd

A.B.N. 051 009 878 899 PO Box 3063, Darra, QLD 4076 Phone: (07) 3279 0900 Fax: (07) 3279 0955

## **Engineering Log - Borehole**

Borehole No.: BH15

Page: 2 of 2

Job Number: GE10/001 551414.00 Drilling Rig: Jacro 200

Easting: Client: Metricon Pty Ltd Northing: 6877336.00 Driller: Morrison Geotechnic Project: Broadscale Geotechnical Investigation

Logged By: L. Bexley RL: Location: Altitude 1, Fraser Drive, Tweed Heads **Total Depth:** Date: 15/01/2010

	Drill	ing Infor	mation	Material Description									Test Samples				
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	De	escription		Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result	
TC bit with 100mm Dia. Auger	MA.	RL	E Hole Depth G G G G G G G G G G G G G G G G G G G		СН	Silty CLAY: As above but firm, moist to wet, and lenses of blue grey sandy clay  Silty CLAY: As above but with extremely weathered deco basalt boulders throughout  6.00m: BOREHOLE TERMINATED				M M	F	DO	Depth	Tesis	Sample/Result		
	water Wa	ents:  ter level date shown ter inflow atter outflow	wea DW Disti wea SW Sligh	emely thered nctly thered ntly thered	S S F F St S VSt V H F	Very soft Soft Firm Stiff Very stiff Hard	Density VL Very loose L Loose MD Medium dense D Dense VD Very dense	ELS Extremely low VLS Very low LS Low MS Medium HS High	Tests U50 D SPT PP S DC	& Resi Undis Distur Stand 300m Hand Vane Dynar taper	ate:  ults turbed 5 bed san ard Pen m with a penetro shear va mic Con cone fitt	60mm dia nple. etration a 63.6kg meter es alue kPa e test, 9. ed to rod	nm tube.  Test, N = n hammer fa timate of u  09kg hamn	lling 762mm nconfined co ner, fall 508r er section.	ows to dri ompressi		

GJ0901\_GWA\_RMP1F.doc

8) Appendix 2 – Gilbert & Sutherland borehole logs

Borehole: MB1

Project: GJ0901

GILBERT+SUTHERLAND
agriculture - water - environment

Depth (m): 25.00

Client: Metricon Developments

Logged by: JT

Northing: 3877251

Drilled by: Altitude 1

Easting: 551308

Start date:

Completion date:

RL(m): \_\_\_\_

Drilling Soil Description (m) TSN utdec Depth NSL(m) Depth (RL) m Α Graphic log B Method Soil Description (as per McDonald et.al1990) HEAVY CLAY , Very stiff, high plasticity, orange/prown, trace of fine to coarse sand, moist HEAVY CLAY, Very stiff, high plasticity, orange/brown mottled grey/brown, fine to coarse sand, fine to medium cobbles, moist HEAVY CLAY , Hard, high plasticity, brown/orange, trace of fine to coarse sand, moist HEAVY CLAY , Hard, high plasticity, gray mottled orange/brown, moist Start of washbore HEAVY CLAY, Hard, high plasticity, grey mottled orange/brown, moist HEAVY CLAY , Hard, high plasticity, plnk/grey mottled grey -5 -5 Bento paci SANDY CLAY , Hard, high plasticity, grey mottled crange/brown, fine to coarse sand SANDY CLAY , Hard, high to medium plasticity, grey mottled orange/brown, fine to coarse sand (loosing water) 10 10 EXTREMELY WEATHERED BASALT , Extremely weathered, very weak, light grey mottled orange/brown. Add rock-roller, , Add 2x3m casing = 9.0m 15 -15 DISTINCTLY WEATHERED BASALT , Distinctly weathered, very weak, light grey mottled grange/brown. 20 20 25 25 , Bore terminated.

Borehole: MB2
Project: GJ0901
Client: Metricon Developments
Northing: \_\_\_\_\_
Easting: \_\_\_\_
RL(m): \_\_\_\_\_
CILBERT+SUTHERLAND

Agriculture - water - environment

Depth (m): 25.00
Logged by: JT
Drilled by: Altitude 1
Start date: \_\_\_\_\_
Completion date: \_\_\_\_\_

