The Halloran Trust

Water Cycle Management Report –

Mixed Use Subdivision; West Culburra, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1203365JR01V07
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All enquiries regarding this project are to be directed to the Project Manager.

Executive Summary

Overview

This Water Cycle Management Report (WCMR) has been prepared to support a project Concept Approval, with NSW Department of Planning and Environment (DoPE), for a mixed use subdivision located at Lot 61 DP 755971, and parts of Lots 5, 6 and 7 DP 1065111, Culburra Road, West Culburra, NSW (MP09-0088). It provides an assessment of the proposed development with respect to stormwater management, including water quality and quantity.

This document has been prepared in consultation with various local and state government agencies as well as relevant stakeholder groups. It should be read in conjunction with:

- Martens and Associates, (2016a) *Estuarine Management Study* (P1203365JR02V04).
- Martens and Associates, (2016b) *Estuarine Processes Modelling Report* (P1203365JR04V01).
- Martens and Associates, (2016c) *Water Quality Monitoring Plan* (P1203365JR03V04).

Groundwater Assessment

The site contains two low permeability aquifers, being an unconfined shallow clay aquifer and a deeper confined rock aquifer. Shallow aquifer(s) beneath the site are likely to be ephemeral (i.e non-permanent) in some areas, non-existent in others and permanent in low lying areas and areas with low grades. Given their low yield, limited distribution and ephemeral nature, the aquifers beneath the site are of low value to stakeholders (ecological and anthropogenic).

Groundwater recharge will be marginally increased as a result of the proposed development. Given the nature of local groundwater conditions, this change will result in negligible environmental impact. Consequently, no mitigation is required to address changes to groundwater recharge. Groundwater is therefore not expected to constrain site development.

Water Quality Assessment

The water quality assessment determines treatment measures required to achieve adopted water quality objectives (NorBe and Council pollutant reduction criteria). It allows for a general specification of water quality structures, and will require refinement at detailed design stage. Given the site's location and sensitive nature of downstream ecosystems, this assessment ensures compliance with water quality objectives at all receiving environments.

The preferred stormwater treatment strategy for the site uses stormwater reuse, at source controls, and end of line controls to ensure treatment objectives are satisfied.

General specification of water quality treatment requirements are provided, however locations and sizes of stormwater quality improvement devices are to be confirmed during design of development stages as internal lot layouts are developed.

Results of surface water modelling indicate that post development water quality objectives will be met by the proposed stormwater treatment train.

Construction Phase Water Quality Assessment

Management of the potential impacts of the construction phase of development on runoff water quality and receiving environments has been raised in submissions by NSW OEH (May 9, 2014) and BMT WBM (March 6, 2014). This has been assessed using MUSIC modelling of each stage.

Water Quantity

To address potential changes in flow regime to the downstream wetland, analysis of developed site runoff regime has been undertaken. Iterative modelling concluded that the developed catchment area discharging to the wetland needs to be reduced to approximately 34.9 ha to mimic the pre development hydrological regime. Other catchment areas are diverted via treatment system to discharge into the open water in the Crookhaven River.

Statement of Commitments

Section 7 provides commitments made by the Applicant regarding site stormwater management.

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1 Introduction

1.1 Overview

This Water Cycle Management Report (WCMR) has been prepared to support a project Concept Approval, with NSW Department of Planning and Environment (DoPE), for a mixed use subdivision located at Lot 61 DP 755971, and parts of Lots 5, 6 and 7 DP 1065111, Culburra Road, West Culburra, NSW (MP09-0088).

It provides an assessment of the proposed development with respect to stormwater management, including water quality and quantity.

This document has been updated to address feedback and recommendations from various agencies provided throughout the applications review process, in preparation of the project overview report.

1.2 Scope

The scope of this assessment has been developed:

1. To address the requirements of the Director General's Environmental Assessment Requirements (DGEARs) with respect to stormwater management.

2. To address concerns raised and recommendations outlined by BMT WBM (March 6, June 5 and October 23, 2014) as part of their review of this document on behalf of NSW DoPE.

3. To address relevant concerns raised by NSW OEH in their submission to NSW DoPE (May 9, 2014).

This report provides:

- Documentation of results of a conceptual water quality assessment.

- Treatment train specification to achieve nominated water quality objectives.

- Overview of construction phase impact modelling, results and construction phase management requirements.

- Assessment of on-site detention (OSD) and stormwater quantity control requirements for the site, including proposed measures to control discharge into adjacent mangrove environment.
- Assess potential impacts of the development on sensitive receiving environments including identified SEPP14 wetlands, seagrass beds and oyster leases.
- Statement of Commitments relating to stormwater management.

The following reports have been prepared to support this assessment and should be read in conjunction with this document:

- Estuarine Management Study (EMS) (Martens, July 2016a. Ref: P1203365JR02V04).
- Estuarine Processes Modelling Report (EPMR) (Martens, August 2016b. Ref: P1203365JR04V01).
- Water Quality Monitoring Plan (WQMP) (including a Sediment and Erosion Control Plan) (Martens, August 2016c. Ref: P1203365JR03V04).

1.3 Proposed Development

The proposed development includes the following landuses:

- Residential (including Torrens title lots, townhouses and medium density development).
- Commercial.
- Industrial.
- Tourist facilities and accommodation.
- Open space.

A plan of the proposed development is provided in Attachment A.

1.4 Relevant Planning Controls and Design Principles

The following planning and engineering controls and design principles have been used:

- Shoalhaven City Council (2014) Development Control Plan.

- Landcom (2004) *Soils and Construction 'Managing Urban Stormwater'*.
- BMT WBM (2010) *Draft NSW MUSIC Modelling Guidelines*.
- Neutral or beneficial effect (NorBE) design principle in determining minimum stormwater quality structure requirements.

1.5 Agency Consultation

1.5.1 Initial Consultation

The following agencies were contacted as part of consultation completed as part of preparation of this assessment:

- Shoalhaven Council.
- NSW DPI Water (formally NSW Office of Water – NOW).
- NSW Office of Environment and Heritage (NSW OEH).
- DoPI (Fisheries).

Results of initial agency consultation are provided in Attachment H.

1.5.2 EA Submission Consultation

Subsequent to submission of the Environmental Assessment (EA) a number of agencies and stakeholders provided comments relevant to this assessment. These are summarised as:

- All development, including water quality treatment structures, is to be excluded from the 7(a) Environmental Protection zone.
- The water quality monitoring regime was considered inadequate.

A stakeholder meeting was held on August 13, 2013 and attended by:

- Local oyster farmers
- Australia's Oyster Coast Inc.
- NSW Food Authority.
- Southern Rivers Catchment Management Authority (CMA).
- Shoalhaven Water.

- Shoalhaven City Council (SCC).
- NSW Environmental Protection Authority (EPA).
- NSW Fisheries.
- NSW Office of Environment and Heritage (OEH).
- The applicant, Martens and Associates, and Allen Price and Associates representatives.

The stakeholder meeting resulted in a layout redesign and subsequent water quality remodelling. The WQMP and SECP are now part of a separate document (Martens, 2016c) that provides a detailed outline of monitoring requirements pre, during and post construction.

1.5.3 Ongoing *Culburra Development-Stakeholder Liaison Group* Consultation

During the August, 2013 stakeholder meeting, the 'Culburra Development-Stakeholder Liaison Group' was formed and it was resolved that subsequent meetings would be held to facilitate additional stakeholder and agency comment and input into various aspects of the proposed development.

During the September, 2013 meeting of the Group, the draft WQMP was reviewed and discussed. Comments relating to monitoring and water quality treatment requirements were incorporated into project design and documentation.

1.5.4 Response to Submissions Consultation

Subsequent to lodgement of the EA, a number of agencies provided submissions to the NSW DoPE in relation to the proposed development. Of particular relevance to this assessment were comments provided by NSW OEH (May 9, 2014) and BMT WBM (on behalf of NSW DoPE) (March 6, 2014) which are summarised as:

- Impacts of the construction phase to be considered and quantified.
- Impacts of increased freshwater runoff to be considered and quantified.
- Proprietary devices used as part of the proposed treatment train are to have pollutant removal efficiencies that have been verified independently.

- Water quality treatment of the proposed substation was considered inappropriate.
- The modelled runoff coefficients generated by water quality modelling requires validation in context of the site location.
- Seepage/infiltration losses included in water quality modelling is unacceptable and considered to overestimate the treatment capabilities of the proposed stormwater management system.
- Groundwater analysis is inadequate and needs revision to ascertain the pollutant load being discharged from the development to the groundwater table.
- Development within the Lake Wollumboola catchment is not supported due to potential water quality impacts.

Subsequent consultation with BMT WBM (between June, 2014 and January, 2015) has refined agency concerns and requirements. This WCMR has been updated to address and incorporate these.

Agency comments related to water quality monitoring, sediment and erosion control and hydrological and water quality impacts on the Crookhaven estuary are addressed in WQMP, EMS and EPMR.

2 Site Description

2.1 Location and Existing Landuse

The study area is located on the northern side of Culburra Road, West Culburra, within the Shoalhaven City Council local government area (LGA). The study area consists of the following lots:

- Lot 61 DP 755971
- Part Lot 5 DP 1065111
- Part Lot 6 DP 1065111
- Part Lot 7 DP 1065111

The study area covers an area of approximately 109 ha and consists of undeveloped vegetated land and some agricultural areas in Lot 5 DP 1065111 and Lot 61 DP 755971 (Figure 1).

2.2 Physiography and Hydrology

Majority of the site is elevated >5 mAHD above the Crookhaven River estuary. Immediate foreshore areas are moderately steep and transitional between the subject site and the estuary. Relief across the site is approximately 20 m. The landscape is gently undulating with slopes ranging between 2.5 – 6.0 %, with some areas of localised over steepening typically associated with drainage lines and foreshore areas.

The site of the proposed subdivision lies on a ridgeline and associated northern side slopes discussed above, except for an area of Lot 5 which lies on the southern side of the ridge line.

Site drainage ranges from good to poor across the site, with poor draining areas characteristically associated with lower points of elevation within the landscape. Site drainage likely consists of both infiltration and overland flow (sheet and concentrated).

2.3 Lithology and Soil Landscapes

Reference to the 1:250,000 Wollongong Geological Series Sheet indicates the site lies upon Wandrawandian Siltstone, a member of the Shoalhaven Group. Wandrawandian Siltstone is dominated by siltstone and silty sandstone lithologies, and is pebbly in parts. Immediate foreshore areas of the site, adjacent to Crookhaven River Estuary

consist of Quaternary sedimentary units of gravel, sands, silts, and clays of marine to freshwater environments, and likely overlie Wandrawandian Siltstone in these areas.

Hazelton (1992) indicates that soils within the investigation area belong predominantly to the Greenwell Point Soil Landscape Group. Soils are primarily derived from *in-situ* weathering of the underlying Wandrawandian Siltstone. Soils are characteristically shallow (<50 cm) to moderately deep (50-100 cm) Loams to Yellow Podzolic Soils or Red Solodic Soils.

Soil mapping completed by Hazelton (1992) suggests that the eastern periphery of the site may contain the Seven Mile Soil Landscape group. This soil landscape group is estuarine, and comprises deep (> 1.5 m) Siliceous Sands, Acid Peats, and Humus Podzols. This landscape was not observed during field investigations (November 22, 2010).

2.4 Hydrogeology

Groundwater was observed during intrusive investigations at the site (November 22, 2010). More detailed investigation of groundwater is presented in Section 3.

3 Groundwater Assessment

3.1 Overview

This assessment has been prepared to satisfy Issue 7.5 of the Director General Requirements (DGRs) (NSW DoPE, May 27, 2010). It documents aquifer characteristics, assesses likely impacts associated with site development, and assesses the requirement for mitigation measures that aim to prevent adverse groundwater impacts.

3.2 Field Investigations

Field investigations for groundwater investigations were undertaken on November 22 and November 26, 2010 and included:

- Site walkover.
- Completion of 26 boreholes with a truck mounted hydraulic auger.
- Completion of 8 of the 26 boreholes as Groundwater Monitoring Bores (GMBs).
- Monitoring of groundwater levels within GMBs.
- Rising/falling head tests to estimate hydraulic conductivity (k) at 7 of the 8 GMBs.
- Collection of 3 groundwater samples for laboratory analysis.

To address agency concerns related to soil hydrology, further investigations were undertaken on June 12 – 13, 2014. Works completed included:

- Completion of 8 test pits and soil classification at each.
- Falling head tests to estimate hydraulic conductivity (K) at 7 of the 8 test pits.

3.3 Groundwater Conditions

3.3.1 Water Bearing Strata

Aquifer layers are broadly classed as follows:

1. Residual clay:

   - Clay that extends from near natural surface level (typically 0.3 mBGL) to depths of 1.3 mBGL.
   - Low hydraulic conductivity (K).
   - Generally unconfined.
   - Base of layer comprises extremely weathered siltstone.
   - Permanent groundwater is likely to only exist in areas with relatively low grades.
   - Other areas may contain ephemeral groundwater or remain generally unsaturated.
   - The majority of boreholes within this stratum were drilled dry. We note that drilling works were undertaken in late November, 2010 which had above average rainfall.
   - Flow vectors are expected to generally mimic the surface topography.
   - During 2010 fieldworks, groundwater levels varied from approximately 0.15 mBGL to dry.

2. Siltstone:

   - During 2010 field works, water bearing zones in the aquifer were observed at weathered siltstone from 3.2 to 4.2 mBGL (BH1), 6.5 to 7.0 mBGL (BH2) and 3.3 to 6.5 mBGL (BH6). Shallow GMBs installed immediately adjacent to GMB1 and GMB2 verified this aquifer layer is confined.
   - Low hydraulic conductivity (K).
   - During 2010 field works, groundwater head levels varied from 1.41 to 0.62 mBGL.
   - Confinement at GMB2 is likely to be associated with geological bedding in the vicinity of the GMB as this GMB

was drilled on-top of a knoll and still displayed evidence of confinement.

3.3.2 Hydraulic Conductivity (K)

Site K testing to date (Table 1) indicates that the aquifer(s) are of low permeability. Refer to Figure 2 for GMB locations.

Table 1: Summary of aquifer K testing results.

Testing Event	GMB	Test Medium	Estimated K (m/d)
2010[1]	1	Clay/Extremely Weathered Siltstone	0.057
	1a	Clay	0.035
	2	Clay/Extremely Weathered Siltstone	0.043
	3	Clay/Extremely Weathered Siltstone	0.004
	4	Clay/Extremely Weathered Siltstone	0.004
	5	Extremely Weathered Siltstone	0.008
	6	Clay/Extremely Weathered Siltstone	0.007
	Geometric mean		0.013
	Median	Clay/Extremely Weathered Siltstone	0.008
	Mean		0.023

Testing Event	GMB	Test Medium	Estimated K (m/d)
2014[2]	302	Clay	0.013
	303	Clay	0.002
	304	Clay	0.052
	305	Clay	0.027
	306	Clay	0.056
	307	Clay	0.079
	309	Clay	0.019
	Geometric mean		0.022
	Median	Clay	0.027
	Mean		0.035

Notes:

[1.] Results based on Martens and Associates testing completed on 22.11.2010 and 23.10.2010. Test type = rising head for GMB1, GMB1a, GMB2 and GMB6. Falling head for GMB3, GMB4 and GMB5 as these GMBs were dry. All data analysed using the Hvorslev (1951) method.

[2.] Results based on Martens and Associates testing completed on 12.06.2014 and 13.06.2013. Test type = falling head for all test pits. BH301 excluded as water was found to be seeping into test pit. All data analysed using the Hvorslev (1951) method.

Data collected from recent (2014) field works is generally consistent with 2010 results. A site soil K value of 0.027 m/day (1.14 mm/hr) is adopted for groundwater (Section 3.4.3) and site surface water quality modelling (Section 4.3).

3.3.3 Groundwater Level Measurements

Manual groundwater level measurements taken during 2010 field works are summarised in Table 2.

Table 2: Manual groundwater level measurements.

		Groundwater Levels (mAHD) Recorded by Martens and Associates				
			23.11.2010 [2]	24.11.2010 [2]	25.11.2010 [2]	26.11.2010 [2]
GMB ID	Aquifer Layer [1]	GMB Surface Level	mAHD	mAHD	mAHD	mAHD
1	Siltstone (confined)	6	5.38	5.38	5.34	5.31
1a	Residual clay (unconfined)	6	-	4.84	4.93	4.97
2	Siltstone (confined)	22	20.8	20.71	20.63	20.59
2a		22	-	Dry	Dry	Dry
3		15	Dry	Dry	Dry	Dry
4		8	Dry	Dry	Dry	Dry
5		8	Dry	Dry	Dry	Dry
6	Siltstone (confined)	5	-	-	4.87	4.86

Note:

[1] GMB – groundwater monitoring bore.

[2] Level approximate mAHD based on Allen, Price and Associates survey (Ref: 25405-02)

3.3.4 Groundwater Quality

Groundwater quality samples were taken from GMB1, GMB2 and GMB6. Results for key analytes are summarised (Table 3) with full laboratory report in Attachment G. Results indicate:

- Groundwater is acidic.
- Groundwater is fresh at GMB2, brackish at GMB1 and saline at GMB6.
- Nutrient levels are low.

Table 3: Preliminary groundwater quality results.

GMB ID	Date Sampled	pH (pH Units)	EC (µS/cm)	TDS (grav) (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
1	25.11.2010	5.2	4,900	2,900	0.7	<0.5
2	25.11.2010	5.1	250	180	0.4	<0.5
6	26.11.2010	5.6	18,000	13,000	0.3	<0.5

3.3.5 Groundwater/Surface Water Interaction

Interaction of groundwater from the upper unconfined aquifer with surface water is expected to be minimal given the majority of site boreholes and GMBs did not encounter water.

3.3.6 Groundwater Dependent Ecosystems (GDEs)

The Ecologist (SLR Consulting) has addressed GDE distribution on and around the site.

3.4 Groundwater Impact Assessment

3.4.1 Resource Use

Review of the NSW Natural Resource Atlas (Figure 3) indicates that there are no licensed bores in the vicinity (3km) of the site.

3.4.2 Potential Impacts

1. Altered groundwater recharge:

   The proposed-development has the potential to alter groundwater flow to downslope areas as follows:

   - Impervious areas shall increase resulting in reduced groundwater recharge.

   - Land currently occupied by forest/woodland vegetation shall be cleared and replaced by a landscape predominantly comprised of grass in pervious areas and no vegetation in impervious areas. Grass vegetation shall exhibit lower evapotranspiration (ET) than the ET associated with the existing forest/woodland vegetation. This reduction in ET has the potential to increase groundwater recharge rates.

- The balance of the above effects will determine if groundwater recharge is increased or reduced due to the proposed development.

2. Hydrological and Groundwater Quality Impacts:

   Comments provided by NSW OEH (May 9, 2014) and BMT WBM (March 6, 2014) has raised concerns related to the development's impact on groundwater quality and hydrology, and the potential effects this may have on receiving environments.

   It is noted that groundwater at the site is not considered a valuable resource as there are no GDEs (SLR, 2013) and no nearby groundwater users. In accordance with methodologies developed in consultation with BMT WBM (May 27 and June 5, 2014) the following has been completed to address this concern:

   a. Groundwater (CLASS) modelling (Section 3.4.3) with input parameters consistent with outcomes of field permeability testing.

   b. Surface water quality assessment (MUSIC) (Section 4) with groundwater infiltration rates from treatment measures set to be consistent with site K values.

3. Potential acid sulfate soils (PASS):

   SPOCUS testing indicates that site soils are acidic and that they do not increase in acidity once oxidised. Based on the above, and given that site soils are residual (i.e. not estuarine sediments associated with ASS), risks associated with PASS or ASS soils are low.

3.4.3 CLASS-U3M-1D (Unsaturated Moisture Movement Model)

3.4.3.1 Overview

The CLASS soil moisture model developed by eWater Cooperative Research Centre (CRC) is used to assess site groundwater recharge for existing and developed conditions. The model utilises site rainfall and evaporation data together with soil profile properties to assess the net recharge to groundwater.

In consultation with eWater Cooperative Research Centre it was confirmed that the CLASS model was appropriate for this application as follows:

- Groundwater flow is ephemeral and therefore not suited to modelling with conventional groundwater models such as MODFLOW.
- The conceptual hydrogeological model is suited to CLASS as the soil/rock interface layer has low slope and soil stratigraphy is not overly complex.
- Long-term climate data is considered important for the model simulation and CLASS is run using a long-term daily climate file.
- Catchment and soil science experts of the eWater Cooperative Research Centre previously indicated that the model was suitable for a site with a similar hydrogeological setting (Mundamia Urban Release area).

3.4.3.2 Inputs

Input parameters used in the model are summarised in Table 4.

Table 4: CLASS input parameters.

Element	Input
Soil Layers	2
Soil Layer Depth (mBGL)	Layer 1 – sandy loam (0 – 0.3) Layer 2 – clay (0.3 – 1.3)
Soil Parameters	CLASS default soil catalogue parameters for nominated soil types
Soil K (m/d)	Layer 1 – 1.061 Layer 2 – 0.027
Ksub (m/d) [1]	0.027
Climate file	Daily 50 yr rain and evaporation file derived from NOWRA RAN BOM station
Vegetation	Tree (CLASS default properties) for existing conditions, pasture (CLASS default properties)

Notes:

1. A Ksub value of 0.027 m/d was assigned so that flux out of the bottom soil layer could be considered as seepage.

3.4.3.3 Results

Total seepage flux (Table 5) determined by the CLASS modelling system indicates a groundwater recharge rate of 33 mm/year for existing conditions. When forest is replaced by grass, this increases to 86 mm/year. Considering recharge doesn't occur beneath impervious surfaces and pervious 'grassed' surface shall be 60% of the developed

site the overall groundwater recharge for developed conditions is estimated at 52 mm/year (60% x 86 mm/year).

Whilst results indicate a minor increase to groundwater recharge we note that CLASS modelling for developed conditions assumed uniform grass cover. Whist developed pervious areas shall be dominated by grass, a small proportion of trees shall remain or be planted. Consequently, ET in the developed condition is likely to be slightly higher than modelled value and therefore changes to groundwater recharge due to the proposed development are likely to be less than that modelled and not of sufficient magnitude to affect local conditions.

Table 5: CLASS results summary.

	Forest CLASS model result	Grassed CLASS model result	Developed conditions CLASS model accounting for impervious surfaces
Average annual groundwater recharge (mm/yr)	33	86	52

3.4.3.4 Impact Assessment

Results indicate that groundwater recharge will increase as a result of the proposed development. However given the nature of local groundwater conditions and result of modelling completed in Section 4, this change will result in negligible environmental impact. Consequently, no mitigation measure is required to address changes to groundwater recharge.

3.5 Conclusions and Recommendations

- The site contains two low permeability aquifers, being an unconfined shallow clay aquifer and a deeper confined rock aquifer.
- Field investigations completed in 2010 found:
  - Shallow clay aquifer in 1 of the site's 8 GMBs within approximately 1 m of the land surface in a low lying area of the site. Consequently, it is anticipated that shallow ephemeral aquifers shall exist in local drainage depressions.
  - Deeper confined aquifer in 3 of the site's 8 GMBs. This aquifer is confined by siltstone which typically occurs at a depth of approximately 1.3 mBGL. The water bearing zones for this aquifer are thought to comprise extremely

weathered siltstone or clay seams. Water bearing zones were considered to be from 3.2 to 4.2 mBGL (BH1), 6.5 to 7 mBGL (BH2) and 3.3 to 6.5 mBGL (BH6).

- No groundwater in 4 of the 8 GMBs.

- Field investigations completed in 2014 found soil hydraulic conductivity to be generally consistent with 2010 results and a value of 1.14 mm/hr (0.027 m/d) is adopted for modelling purposes.

- Shallow aquifer(s) beneath the site are likely to be ephemeral (i.e non-permanent) in some areas, non-existent in others and permanent in low lying areas and areas with low grades.

- If shallow excavations (road pavements, service trenches and shallow footings) are proposed it is likely that works may intersect the shallow unconfined aquifer. This is to be assessed and managed through future construction works.

- The aquifers beneath the site are of low value to stakeholders (ecological and anthropogenic) given their low yield, limited distribution and ephemeral nature.

- Groundwater recharge will be marginally increased as a result of the proposed development. Given the nature of local groundwater conditions, this change will result in negligible environmental impact. Consequently, no mitigation is required to address changes to groundwater recharge.

- Impacts on groundwater quality have been addressed by site surface water assessment (Section 4) which has been prepared in consultation with BMT WBM. This assessment has adopted field test results for groundwater infiltration rates and designed treatment train measures to achieve surface water objectives accordingly.

- In principle, groundwater is not expected to constrain site development. However, from a geotechnical perspective it is recommended that the findings in this report are considered for site engineering purposes.

4 Water Quality Assessment

4.1 Overview

This water quality assessment determines treatment measures required to achieve adopted water quality objectives. It allows for a general specification of water quality structures, and will require refinement at detailed design stage once lot and road layouts are confirmed.

Given the site's location and the sensitive nature of downstream ecosystems, the water quality management system developed shall ensure compliance with water quality objectives at the following receiving environments (Figure 1):

- SEPP 14 Wetlands between Billy's Island and the site.
- Seagrass and oyster leases fringing the foreshore to the north east and north west of the site.
- Curleys Bay.
- Crookhaven River.
- Lake Wollumboola.

4.2 Water Quality Objectives

Chapter G2 of Shoalhaven DCP 2014, Section 5.3.4 requires the following pollutant load reduction (of the post development average annual load of pollutants) criteria be achieved at minimum:

- 90% of gross pollutants
- 85% of total suspended solids (TSS)
- 65% of total phosphorus (TP)
- 45% of total nitrogen (TN)
- 90% of total hydrocarbons

Based on Shoalhaven Council requirements and consultation with NSW OEH, project water quality objectives are adopted as follows:

- NorBE (neutral or beneficial) - pollutant loads in the post development scenario that are equal to or less than those currently generated from the site.
- Treatment train effectiveness will be designed to achieve the DCP (2015) requirements for pollutant load reduction.

Water quality objectives are adopted for all receiving environments (Section 4.1).

4.3 Modelling Methodology

4.3.1 Overview

The Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*, Version 5.1) developed by the CRC for Catchment Hydrology was utilised to evaluate pre and post development pollutant loads from the site.

Modelling has been undertaken in accordance with *Draft NSW MUSIC Modelling Guidelines* (BMT WBM, 2010).

The following modelling scenarios were considered:

1. Pre development – the existing site.
2. Post development (untreated) - the developed site without water quality structures.
3. Post development (treated) – the developed site with water quality structures included to achieve adopted objectives.

Pre and post development MUSIC model layouts are provided on SK203 and SK204 of Attachment A.

4.3.2 Approach

An iterative approach was used for post development modelling to determine appropriate types, sizes and locations of stormwater treatment devices for the site to achieve adopted objectives.

4.3.3 Climate Data

Rainfall data was sourced from Nowra RAN from 1964 – 1970 in accordance with the NSW MUSIC guidelines. Average monthly areal

potential evapotranspiration (PET) was sourced from *'Climatic Atlas of Australia – Evapotranspiration'* (Bureau of Meteorology, 2001).

4.3.4 Input Parameters

Input parameters for source and treatment nodes are consistent with the *Draft NSW MUSIC Modelling Guidelines* (BMT WBM, 2010). Attachment B summarises input parameters.

4.3.5 Catchment Areas

Pre and post development catchment areas and pervious/impervious areas of each catchment are provided in Attachment D. A ridge forming the catchment boundary between Lake Wollumboola and the Crookhaven River runs along the southern edge of the development area.

The following should be noted with regards to catchment areas:

- Development north of the ridgeline discharges north to the Crookhaven River as with existing hydrology.
- Where development occurs south of the ridgeline (small portion of the collector road, the industrial subdivision in the site's east and residential development in the site's east), runoff shall be directed to the Crookhaven River by road drainage networks.
- Only the proposed oval (Catchment C4) and the proposed new roundabout intersection along Culburra Road shall discharge south to Lake Wollumboola. They are therefore modelled and assessed separately to ensure water quality objectives are met for each receiving environment.
- The catchment area draining to the SEPP14 wetlands between Billys Island and the site was determined for the post development based on maintaining wetland hydrology (Section 6).
- This wetland outlet was assessed independently, as well as part of the Crookhaven River catchment, to assess water quality impacts on the wetlands.
- Outlets into the Crookhaven River, excluding the wetland outlet, were assessed to determine the impacts on seagrass and oyster leases.
- The Curleys Bay outlet was assessed independently due to its identified significance by NSW DoPE and NSW OEH.

- The roundabout area was compared to an equivalent area of pre development 'forest' to ensure water quality objectives (Section 4.4.8).

- The proposed substation was not included in water quality modelling (see Section 4.4.7).

- All residential/accommodation development catchments have been split into 'roof', 'road' and 'remaining' sub-catchments. The cumulative areas of each of these sub-catchments are based on the catchment area, the proposed landuse and the proposed site coverage (Attachment A).

4.3.6 Model Parameters

Event Mean Concentration (EMC) inputs were derived from Sydney Metropolitan Catchment Management Authority (SMCMA) (2010) '*Draft NSW MUSIC Modelling Guidelines'*.

Table 6: Adopted EMCs for source nodes.

		Base Flow (mg/L)		Storm Flow (mg/L)	
Land Use	**Parameter**	**Log (mean)**	**Log (stdev)**	**Log (mean)**	**Log (stdev)**
Roof	TN	na	na	0.300	0.190
	TP	na	na	-0.890	0.250
	SS	na	na	1.300	0.320
Agricultural	TN	0.040	0.130	0.480	0.260
	TP	-1.050	0.130	-0.220	0.300
	SS	1.300	0.130	2.150	0.310
Residential	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	0.600	0.250
	SS	1.200	0.170	2.150	0.320
Forest	TN	-0.520	0.130	-0.050	0.240
	TP	-1.520	0.130	-1.100	0.220
	SS	0.780	0.130	1.600	0.200
Commercial	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	-0.600	0.250
	SS	1.200	0.170	2.150	0.320
Sealed roads	TN	0.110	0.120	0.340	0.190
	TP	-0.850	0.190	-0.300	0.250
	SS	1.200	0.170	2.430	0.320
Industrial	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	-0.600	0.250
	SS	1.200	0.170	2.150	0.320

Land use parameters for each catchment node are provided in Attachment D.

4.4 Treatment Train Philosophy

The preferred stormwater treatment strategy for the site utilises stormwater reuse, at source controls, and end of line controls to ensure treatment objectives are satisfied. Individual SQIDs are outlined in the following sub-sections.

This assessment allows for general specification of water quality treatment requirements. Locations and sizes of SQIDs are to be confirmed during detailed design once internal lot layout has been confirmed.

4.4.1 Rainwater Tanks

Rainwater tanks shall be utilised across the site to reuse rainwater to satisfy toilet flushing and laundry demands. The following tank sizes were assumed:

- 5 KL per dwelling for freestanding dwellings.
- 3 – 5KL per dwelling for tourist facilities.
- 5 KL per unit for multi-unit buildings.
- 15 KL per industrial 'lot'.

Water usage demands were based on figures provided by Shoalhaven Water (16 November, 2012):

- 1 ET for dwellings and units.
- 15 ET/gross ha/yr for light industrial.

where 1 ET = 200KL/yr.

According to NSW Department of Water and Energy (DWE) (2008) *'NSW Guidelines for Greywater Reuse in Sewered, Single Household Residential Premises'*, toilet flushing and laundry uses account for 44% of total internal water demands. Therefore, total rainwater tank demands have been calculated based on 0.241 KL/day/dwelling (ET).

The total number of dwellings (and hence the cumulative tank volume and cumulative demand) was based on the sub catchment area and the proposed lot sizes within the sub-catchment. A single 'roof' node and 'tank' node was created to model each sub catchment.

4.4.2 Bioretention Swales

Where required to achieve water quality criteria objectives, roadside bioretention swales ('bioswales') shall provide at source treatment of runoff from development areas (including road, rainwater tank overflow and pervious lot areas). Bioswale location and size requirements shall be confirmed at detailed design stage once an internal lot layout has been prepared.

Bioswales provide treatment through media filtration, biological uptake of nutrients, evapotranspiration, infiltration (see Section 4.4.10) and detention. In accordance with FAWB (2008) hydraulic conductivity of filter media was modelled at 50% of the design value to account for reduced capacity over swales life.

Bioswale input parameters are provided in Attachment B. Typical bioswale design is provided in Attachment F.

4.4.3 Stormwater360 '*Stormfilter/Enviropod'* Treatment Devices

Runoff from tank, lot and road areas (or from bioswales where required) shall pass through a '*Stormfilter/Enviropod'* (SFEP) treatment train (produced by Stormwater360) to remove remaining gross pollutants and a portion of suspended solids and nutrients from stormwater runoff. The treatment capabilities of the SFEP system has been independently reviewed and published in *Water* the Journal of the Australian Water Association (September, 2011) and by James Cook University (May, 2008).

The node utilised in modelling was that supplied and endorsed by Blacktown City Council (BCC), based on their independent review and analysis. Pollutant removal efficiencies of these devices are provided in Table 7.

Table 7: BCC Stormfilter and Enviropod pollutant removal efficiencies.

Pollutant	Enviropod	Stormfilter
TSS	54%	73.5%
TN	21%	32%
TP	30%	49%

Stormfilter canisters would be located in below ground tanks sized to accommodate the number of units required to service the catchment. This tank has been modelled as an OSD tank with 0 mm/hr exfiltration and 0% evaporative loss.

Other SFEP input parameters are summarised in Attachment B.

Devices to be used onsite shall be confirmed at detailed design stage. If different devices are proposed, treatment removal efficiencies should meet or exceed those used in this assessment.

4.4.4 Bioretention Basins

Bioretention basins are proposed to treat runoff discharging from 'Catchment 7' (small lot development) and from the industrial zone ('Catchment 8').

Bioretention basins provide treatment through filtration, biological uptake of nutrients, infiltration (see Section 4.4.10), evapotranspiration and detention. Overflow outlets of the proposed basins will include baffles to retain floating pollutants such as gross pollutants and hydrocarbons.

Individual basin input parameters are provided in Attachment E with typical basin sections in Attachment F.

4.4.5 Parkland Wetland

A constructed wetland is proposed in Catchment C4 (proposed oval and parkland). Inclusion of a wetland here allows detained water to be reused for irrigation on the oval. A reuse demand of 6 ML/ha/yr was assumed based on typical irrigation rates for playing fields.

Typical wetland sections are provided in Attachment F with wetland input parameters in Attachment E.

4.4.6 Infiltration System

The proposed end of line component of the stormwater treatment train features a number of foreshore infiltration systems. The inlet between Billys Island and the site includes an elongated continuous infiltration system designed specifically to achieve water quality objectives prior to discharge to the adjacent SEPP 14 Wetlands and to provide distributed flows to this environment.

Flow from the catchment will discharge into the foreshore infiltration systems which will detain and treat runoff through biological uptake of nutrients, evapotranspiration, infiltration (Section 4.4.10) and detention and discharge immediately upslope of the 7(a) zone boundary. They shall be designed and vegetated to complement the existing estuarine environment.

Infiltration system outlets shall consist of either an energy dissipater or, in the case of the continuous system, spill evenly along its length to promote even dispersal of flow and controlled discharge during major events.

4.4.7 Substation Treatment

The proposed substation will be constructed, owned and managed by Endeavour Energy who shall include water quality management measures, including spill capture infrastructure, in accordance with their design standards.

It was agreed with BMT WBM that, for the purposes of modelling, it was most appropriate that this area be excluded from the post and pre development MUSIC modelling.

4.4.8 Industrial Zone and Proposed Roundabout Treatment

The industrial zone presents a point source of potentially high pollution generation. It is recommended that approximately 10% of individual industrial lot areas be dedicated to bioretention basin to provide at source treatment of runoff and support rainwater tanks and the proposed end of line bioretention basin. This is consistent with the typical landscaped component of an industrial lot.

The proposed roundabout and intersection with Culburra Road naturally discharges to Lake Wollumboola via Wattle Creek. To achieve acceptable water quality impacts at receiving environments a bioretention swale is proposed to treat road runoff. Final design of the proposed intersection will refine the size of bioswale area required to achieve a neutral or beneficial water quality outcome. To ensure a conservative comparative analysis for the roundabout area, comparison was with an equivalent area of pre development forest to ensure water quality objectives are achieved.

4.4.9 7(a) Protection Zone Buffer

An area zoned 7(a) Environmental Protection lies downslope of the development footprint. No development, excluding a passive recreational walk/cycleway, is proposed in this area to maintain a vegetated buffer between the development and the receiving estuarine environment.

This buffer is minimum 100m wide and will naturally provide additional treatment to surface runoff through evapotranspiration, infiltration and filtration. Only the treatment effects of this vegetation on subsurface flows were considered. We therefore anticipate final water quality of runoff discharging to the estuary to be better than that reported within this document.

4.4.10 Exfiltration Treatment

4.4.10.1 Exfiltration Rates

An exfiltration rate of 1.14 mm/hr was adopted for all treatment nodes where infiltration is a treatment mechanism, based on site soil hydraulic conductivity (Section 3.3.2).

In bioretention swales, this rate was increased by 50% (i.e. to 1.71 mm/hr) as in reality, swales are to be constructed with a vertical kerb system to increase the filter media surface area (Attachment F). Consultation with BMT WBM (December 5 and 18, 2015) found this to be an acceptable outcome.

4.4.10.2 Subsurface Flow Treatment

In response to BMT WBM concerns regarding pollutant loss through infiltration from treatment nodes (March 6, 2014, October 23, 2014 & December 18, 2014), MUSIC's 'split flows' function was used to assess the behaviour of subsurface flows and the fate of infiltrated pollutants. Infiltration from treatment nodes, and baseflow and deep seepage from source nodes has been directed through a treatment node designed to model vegetation uptake of nutrients and physical filtration of sediment in downslope vegetated areas (7(a) zone). This has been completed for both the pre and post development models.

The nutrient removal capacity input parameters for the 'vegetation uptake' node was determined based on the capacity of vegetation between the downslope edge of the development and the estuary/wetland, to consume nutrients delivered to it. In determining this, the following was considered:

- <u>The uptake rate of vegetation</u>:

  A literature review on vegetation uptake rates of nutrients was completed (Table 8).

Table 8: Literature review results: vegetation uptake rates of nutrients from stormwater sources.

Author	Date	Uptake Rate TN	Uptake Rate TP	Riparian Vegetation Type	Landuse	Study Location	Article
Lowerance *et al*	1984	51.8 kg/ha/yr	-	Forested wetland	Agricultural, roads, urban and others	Little River, Chesapeake Bay, USA	Riparian Forests as Nutrient Filters in Agricultural Watersheds.
Kelly *et al*	2007	-	15 kg/ha/yr	Grass and Alfalfa	Agricultural	Iowa, USA	Phosphorus uptake during 4 years by different vegetative covers in a riparian buffer.
Lowerance *et al*	1997	89%	80%	Coastal plain riparian forest	62% forest, 23% cropland , 12% pasture	Rhode River, Chesapeake Bay, USA	Water Quality Functions of Riparian Forest Buffer in Chesapeake Bay Watersheds.
		66%	24%	Coastal plain riparian forest	Cropland and wetland		
Peterjohn & Correll	1984	77 kg/ha/yr	10 kg/ha/yr	Broad leaved deciduous vegetation	Agricultural	Rhode River Maryland, USA, USA	Nutrient dynamics in an agricultural watershed, observations on the role of a riparian forest.

The study by Kelly *et al.* is disregarded as the riparian vegetation type consists of crops with superior nutrient uptake capacity compared with natural forested areas.

Considering the compiled data in Table 8, uptake rates of 51.8 kg/ha/yr (TN) and 10 kg/ha/yr (TP) (Lowerance *et al.* and Peterjohn & Correll respectively) were adopted.

- The loads of nutrients delivered to vegetation:

  Flow and nutrient loads was determined using MUSIC and the split flow function applied to deep seepage, baseflow and infiltration losses.

- Determine the pollutant removal capacity:

  100% pollutant removal capacity up to the calculated uptake capacity was adopted. Uptake capacity was determined based on the measured vegetated area downslope of the development multiplied by adopted vegetation nutrient uptake rate. It was assumed that, with the passage of infiltrated water through a minimum of 100m of soil, all suspended sediments shall be removed.

4.5 MUSIC Results

4.5.1 Model Output Suitability

In accordance with BMT WBM recommendations (March 6, 2014) we have completed an assessment of the suitability of the development MUSIC model in representing the site location by way of comparison of modelled runoff coefficients (Table 9). MUSIC rainfall and runoff results for the entire modelled period were exported for each 'outlet' (Attachment A, SK203 and SK204) for the existing and developed site. Runoff results from the MUSIC model created for the existing township of Culburra were also analysed to allow comparison of the developed site with an urbanised catchment.

Table 9: MUSIC runoff coefficients assessment.

Outlet	O1	O2	O3	O4	O5	O6	Culburra
Rainfall (1964 – 1970) (mm)	5 600.9	5 600.9	5 600.9	5 600.9	5 600.9	5 600.9	5 600.9
Pre development Catchment area (ha)	18.3	45.9	19.3	6.9	31.4	7.6	NA
Post development Catchment area (ha)	28.7	35.0	20.2	9.9	29.5	6.1	221.4
Pre Development Rainfall Volume (ML)	1 025	2 571	1 081	386	1 759	426	NA
Post Development Rainfall Volume (ML)	1 607	1 960	1 131	554	1 652	342	12 399
Pre Development Runoff (ML)	264.2	664.4	278.5	99.5	589.8	109.2	3 197.5[1]
Post Development Runoff (ML)	400.3	314.0	194.1	92.4	494.9	45.8	5 211.7
Pre Development Runoff Coefficient (%)	**26%**	**26%**	**26%**	**26%**	**34%**	**26%**	**26%[1]**
Post Development Runoff Coefficient (%)	**25%**	**16%**	**17%**	**17%**	**30%**	**13%**	**42%**

Notes:

[1] A 100% forest area equivalent to Culburra township's footprint was modelled to allow comparison with pre-urbanisation runoff rates.

Results indicate that the proposed development is reducing runoff coefficients across the site. This effect is most notable in outlet 'O6' (Lake Wollumboola catchment) where the coefficient is reduced by half.

Results are not typical of an urbanised catchment (such as shown for existing Culburra) but are appropriate for an urban development integrating extensive water quality treatment measures with considerable infiltration systems. The reduction reflects design efforts to achieve water quality objectives by treating stormwater through detention, evapotranspiration and infiltration, thereby reducing site runoff. The existing Culburra township has little to no water sensitive urban design measures (WSUD) and as a result of additional impervious surfaces increases the runoff coefficient (i.e. from an equivalent area of forest) by 60%.

It is concluded that the MUSIC models generated to assess water quality impacts of the proposed development suitably represent the site hydrology.

4.5.2 NORBE Assessment

Water quality assessment results are tabulated in Table 10 to Table 14 for each catchment considered. Catchment description refers to the receiving environment.

Table 10: MUSIC results - NORBE assessment – Crookhaven River.

Parameter	Pre Development	Post Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	12 319.0	10 067.0	18%	Y
TP (kg/year)	26.5	22.3	16%	Y
TN (kg/year)	180.2	162.2	10%	Y
Gross Pollutants	905.0	905.0	0%	Y

Table 11: MUSIC results - NORBE assessment – Lake Wollumboola.

Parameter	Pre Development	Post Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	214.0	125.0	42%	Y
TP (kg/year)	0.5	0.5	1%	Y
TN (kg/year)	5.2	4.5	15%	Y
Gross Pollutants	0.0	0.0	0%	Y

Table 12: MUSIC results - NORBE assessment – Billys Island inlet (SEPP 14 Wetlands).

Parameter	Pre Development	Post Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	1 180	510.0	57%	Y
TP (kg/year)	2.7	2.5	9%	Y
TN (kg/year)	31.5	26.6	16%	Y
Gross Pollutants	0.0	0.0	0%	Y

Table 13: MUSIC results - NORBE assessment – Seagrass and Oyster Leases.

Parameter	Pre Development	Post Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	11 139	9 557	14%	Y
TP (kg/year)	23.8	19.8	17%	Y
TN (kg/year)	148.7	135.6	9%	Y
Gross Pollutants	905.0	905.0	0%	Y

Table 14: MUSIC results - NORBE assessment – Curleys Bay.

Parameter	Pre Development	Post Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	8 890.0	8 660.0	3%	Y
TP (kg/year)	16.1	15.2	6%	Y
TN (kg/year)	94.5	89.1	6%	Y
Gross Pollutants	905.0	905.0	0%	Y

4.5.3 Treatment Train Effectiveness

Table 15 to Table 19 provide assessment of the treatment train effectiveness (i.e. post development untreated versus with treatment) for receiving environments.

Table 15: MUSIC results - treatment train effectiveness – Crookhaven River.

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	44590.0	927.5	98%	Y
TP (kg/year)	96.7	5.4	94%	Y
TN (kg/year)	717.2	53.5	93%	Y
Gross Pollutants	8103.0	0.0	100%	Y

Table 16: MUSIC results - treatment train effectiveness – Lake Wollumboola.

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	2 200.0	103.0	95%	Y
TP (kg/year)	4.9	0.3	93%	Y
TN (kg/year)	28.2	3.0	89%	Y
Gross Pollutants	156.0	0.0	100%	Y

Table 17: MUSIC results - treatment train effectiveness – Billys Island Inlet (SEPP 14 Wetlands).

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	12400.0	206.0	98%	Y
TP (kg/year)	30.8	1.6	95%	Y
TN (kg/year)	248.0	16.5	93%	Y
Gross Pollutants	2810.0	0.0	100%	Y

Table 18: MUSIC results - treatment train effectiveness – Seagrass and Oyster Leases.

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	32190.0	721.5	98%	Y
TP (kg/year)	65.9	3.8	94%	Y
TN (kg/year)	469.2	37.0	92%	Y
Gross Pollutants	5293.0	0.0	100%	Y

Table 19: MUSIC results - treatment train effectiveness – Curleys Bay.

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	1180.0	204.0	83%	Y
TP (kg/year)	3.3	0.3	90%	Y
TN (kg/year)	27.3	2.6	91%	Y
Gross Pollutants	203.0	0.0	100%	Y

4.5.4 Proposed Roundabout

Table 20 provides assessment of water quality results when Catchment C8r (proposed roundabout) is isolated and tested for compliance against NorBe objectives.

Table 20: MUSIC results - NORBE assessment – Proposed Roundabout Intersection.

Parameter	Pre Development	Post Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	30.2	2.9	90%	Y
TP (kg/year)	0.1	0.1	0%	Y
TN (kg/year)	1.0	0.7	28%	Y
Gross Pollutants	0.0	0.0	0%	Y

4.5.5 Sensitivity Analysis

Throughout the consultation process BMT WBM, on behalf of DoPE, have suggested that water quality modelling should bypass any infiltration, untreated, to the model outlet node – thereby ignoring the natural processes that will occur within the 7(a) vegetated buffer zone. Although this is considered to be incorrect and overly conservative, sensitivity analysis was completed to determine the effects of removing treatment of infiltration from the model.

Attachment I provides results of the sensitivity analysis which show that NorBe objectives are not achieved for all pollutants at all receiving environments. The significance of this impact has been assessed and discussed in the EPMR (Martens, 2016b).

4.6 Water Quality Impacts on Sensitive Ecosystems

4.6.1 SEPP 14 Wetlands

MUSIC modelling demonstrates that water quality discharged into the Billys Island inlet will be of better quality than that currently being discharged. The proposed outlet structures shall be designed (at CC stage) to provide for controlled and dispersed flow that does not result in localised scour and disturbance of mangrove species.

It is therefore considered that surface water runoff from the development shall have a negligible impact.

4.6.2 Seagrass

MUSIC modelling demonstrates that water quality discharged into areas where seagrass is mapped will be of better quality than that currently being discharged.

NSW OEH have raised concerns (May 9, 2014) related to potential impacts of freshwater runoff from the developed site on seagrass environments. Estuarine process modelling (Martens, 2016b) documents the development's impact on salinity levels more fully.

4.6.3 Oyster Leases

MUSIC modelling demonstrates that water quality discharged into areas with oyster leases will be of better quality than that currently being discharged.

The importance of faecal coliform impacts on oyster leases is acknowledged and considered in the design of water quality treatment devices, although MUSIC modelling only considers nutrients, suspended sediments and gross pollutants. The proposed infiltration systems and bioretention basins are designed to increase residence time to allow for the breakdown of faecal coliforms. The presence of wetland planting shall increase the rate of this breakdown.

It is noted that the proposed development shall be sewered with a system operated by Shoalhaven Water and no onsite effluent disposal is proposed which reduces the risk of release of human pathogens to stormwater. A Sewage Management Regime (Allen Price & Associates, 2013) has been prepared to outline design measures and emergency procedures to mitigate the impacts of sewage spills/leaks on the water quality within the estuary.

Therefore impacts on oyster leases resulting from reduced water quality are anticipated to be negligible. Any residual risk is to be addressed through the development monitoring program (Martens, 2016c)

4.6.4 Lake Wollumboola

Development areas draining to Lake Wollumboola (the proposed oval and roundabout) achieve the NorBE objective for water quality through runoff capture, treatment and, where possible, reuse for irrigation. Further it is noted that there is considerable distance (approximately 700m) from this development to Lake Wollumboola and the passage of water over this distance will provide further treatment of runoff prior to discharge.

The proposed areas of development represent approximately 6% of the Wattle Creek catchment and less than 0.5% of the Lake's catchment. These areas are considered negligible in the context of the catchment and, given modelled stormwater quality of runoff, are considered unlikely to result in negative environmental outcomes in the Lake.

4.7 Estuarine Process Modelling

Estuarine process modelling (Martens, 2016b) has been completed to further address agency concerns that the proposed development will have long term impacts on estuarine water quality conditions.

4.8 Conclusions

Results of surface water modelling indicate that post development water quality objectives will be met by the proposed stormwater treatment train.

It is noted that further refinement of the model at the detailed design stage of the development may alter the sizes of proposed treatment structures, however, performance outcomes of final design are to achieve specification provided in this report.

4.9 Water Quality Monitoring, Maintenance and Management

In response to EA agency comments (June 21, 2013) a WQMP for the development was prepared. This was completed in consultation with NSW Food Authority, NSW Fisheries, NSW Oyster Coast Inc, local oyster farmers and other stakeholders and with reference to SEPP 62 and NSW Oyster Industry Sustainable Aquaculture Strategy (OISAS) (2006).

This plan (Martens, 2016c) was subsequently updated in light of recent agency comments (BMT WBM, March 2014; and NSW OEH, May 2014) adopting a risk-based approach. It determines: the potential water

quality hazards to receiving environments; the likelihood and consequence of hazards; defines the subsequent risk to the receiving environment; outlines measurements required to manage risks; and provides contingency plans for each risk. Measures outlined include monitoring and maintenance of the proposed treatment train to ensure components are operating at optimum capacity.

5 Construction Phase Water Quality Assessment

5.1 Overview

Concerns regarding the potential impacts of the construction phase of development on water quality of runoff and receiving environments has been raised in submissions by NSW OEH (May 9, 2014) and BMT WBM (March 6, 2014).

This assessment utilises water quality to quantify water quality impacts throughout the construction phase and ascertain the significance of these impacts in the context of the Crookhaven estuary.

5.2 Construction Staging

The proposed development is to be constructed in 5 stages (Attachment A). These stages are to be confirmed at detailed design stage when a detailed Construction Management Plan is prepared.

5.3 Sediment and Erosion Control

The WQMP (Martens, 2016c) provides details of sediment and erosion control requirements to manage the construction phase. These measures have been designed in accordance with Landcom (2004) and include:

- Sedimentation basins.
- Energy dissipaters.
- Earth diversion bands.
- Sediment fences.
- Stabilised site entry.
- Revegetation.

5.4 Water Quality Modelling

5.4.1 Approach

Several MUSIC models were created representing the site at various stages of construction. Sedimentation basins were included in each model to assess their treatment efficiency during the construction phase.

Pollutant concentrations in runoff generated during each stage of development was determined.

The approach for the design of construction phase water quality control measures as well as the methodology for this assessment has been developed in consultation with BMT WBM (May 27 and June 18, 2014) who confirmed them as being acceptable.

5.4.2 Objective

In accordance with industry best practice, Landcom (2004) is the criteria for site management and water quality treatment during construction phase of development. Sediment and erosion control measures for the site have been designed in accordance with these guidelines (Martens, 2016c).

The objective of construction phase water quality modelling was therefore to quantify the pollutant concentrations generated during each stage of development.

5.4.3 Methodology

The methodology for water quality modelling is summarised as follows:

1. Several MUSIC models were created representing each stage of development (Table 21). Climate files were as for the site water quality assessment (Section 4). Modelling was completed in accordance with *Draft NSW MUSIC Modelling Guidelines* (BMT WBM, 2010).

Table 21: Construction phase MUSIC model runs summary.

	Stage[1]				
Model Run	**1**	**2**	**3**	**4**	**5**
1	E	E	E	E	E
2	C	E	E	E	E
3	O	C	E	E	E
4	O	O	C	E	E
5	O	O	O	C	E
6	O	O	O	O	C
7	O	O	O	O	O

Note:

[1] C = under construction, E = existing conditions/undeveloped, O = operational/developed

2. Run 1 (all stages undeveloped) model included the site, the existing township of Culburra and areas upstream of the site

draining into the Crookhaven River. The Culburra Road bridge was adopted as the upstream extent of modelling.

3. Upstream catchments and Culburra township were modelled as a mixture of forest, agricultural and urban landuse interpreted from aerial photo review. Catchment areas were based 1:25 000 topographic map and LIDAR data purchased from NSW LPI.

4. Pervious and impervious areas for upstream catchments and Culburra township were calculated based on aerial photograph analysis of a representative (10%) portion of the catchment area.

5. EMC values adopted for upstream catchments and Culburra township were as per (BMT WBM, 2010) (Table 6).

6. For Runs 2 – 7 the landuse conditions within the site varied depending on the stage of development. Upstream catchments and Culburra township remained unchanged.

7. Areas under construction were modelled as 'eroded gullies' landuse (Table 22).

Table 22: Eroded gullies EMCs for construction phase modelling (BMT WBM, 2010).

		Base Flow (mg/L)		Storm Flow (mg/L)	
Land Use	**Parameter**	**Log (mean)**	**Log (stdev)**	**Log (mean)**	**Log (stdev)**
Eroded Gully	TN	0.11	0.12	0.34	0.19
	TP	-0.85	0.19	-0.30	0.25
	SS	1.20	0.17	3.00	0.32

8. Each stage under construction included the sedimentation basins as required to address Landcom (2004). As per BMT WBM recommendations (June 19, 2014) sediment basins were modelled using a generic node and the following removal efficiencies:

   - 94.5% TSS
   - 32% TP
   - 15% TN

   Highflow bypass was set to be equivalent to the basin design event (i.e. the 1 in 10 year flow rate).

9. Construction areas outside basin catchment areas were assumed to runoff untreated to receiving environments. In reality these areas would be treated by sediment fences that will have a relatively high TSS removal for particles greater than 0.02mm (Landcom, 2004). Some nutrient removal is also expected.

10. The vegetated 7(a) zone downslope of the development (between 50 – 200m in width) shall provide water quality treatment through filtration of sediment, infiltration and evapotranspiration. This effect was not included in MUSIC modelling.

11. Developed (operational) stages included site treatment train as per the post development NorBe model (Section 4.4). Infiltration losses were included at treatment nodes.

5.4.4 Results

MUSIC models for each stage are provided for peer review.

5.5 Recommendations

The following recommendations are provided to ensure that receiving environments are not detrimentally impacted during the construction and operation of the site:

- Sediment and erosion control features are to be designed, installed and managed in accordance with the Water Quality Monitoring Plan (Martens, 2016c) and Landcom (2004).

- Construction phase monitoring is to be undertaken in accordance with Water Quality Monitoring Plan (Martens, 2016c).

- Development treatment train features are to be designed and installed in accordance with Section 4 of this document and monitored and managed in accordance with Water Quality Monitoring Plan (Martens, 2016c).

6 Water Quantity Assessment

6.1 Overview

This water quantity assessment discusses the impact of the proposed development on the flow regime leaving the site, and recommends management measures to control this discharge and mitigate impacts on the receiving wetland ecosystem.

We note that this assessment examines surface water hydrological impacts only. In response to NSW OEH concerns (May 9, 2014) related to potential impacts of increased freshwater runoff from the site on values supported by the Crookhaven estuary, estuarine process modelling has been completed, the results of which are provided in the EPMR (Martens, 2016b).

6.2 OSD Requirements

Council's Subdivision Engineer (I. Dollery, February 21, 2012) has confirmed that, given the site discharge is near the outlet of the catchment and in close proximity to the ocean, OSD is not necessary for the site.

Where the site discharges to wetland areas measures are proposed to protect the receiving environments from increased localised flows resulting from increased impervious area runoff.

6.3 Hydrological Assessment

6.3.1 Objectives

The objective of the hydrological assessment is to determine management measures required to, as far as feasible, mimic the hydrological regime in the wetland areas within the Billy Island inlet (Figure 1).

6.3.2 Approach

DRAINS hydraulic modelling software was utilised to calculate pre and post development flow rates leaving the site for the 1 in 2, 10, 20 and 100 year ARI storm events. Iterative modelling was utilised to determine the post development catchment area required to achieve flow rates in the wetland that mimic, as nearly as possible, pre development flow rates.

The assessed catchment area of 34.9 ha for the receiving wetlands is identified in Attachment A (SK205).

6.3.3 Results

Table 23 provides the pre and post development catchment areas and flow rates for each storm event.

Table 23: Hydrological modelling results.

Scenario	Catchment Area (ha)	Impervious Area (%)	Pervious Area (%)	Flow Rates (m^3/s)			
				1:2yr	1:10yr	1:20yr	1:100yr
Pre Development	45.5	0%	100%	5.1	9.7	11.8	16.4
Post Development [1]	34.9	33%	67%	4.9	8.5	10.3	13.9

Notes:

[1] Post development catchment modified to mimic pre development wetland flow regime.

Results of iterative modelling conclude that the developed catchment area discharging to the wetland needs to be limited to approximately 34.9 ha to mimic the pre development hydrological regime and minimise the risk of negative impacts from increased flow rates.

6.4 Management Recommendations

The following measures are recommended as part of the proposed development to maintain the hydrological regime in the receiving wetland ecosystem:

- Catchment areas outside the 34.9 ha area that would otherwise discharge into the wetlands (Attachment A) shall be diverted, after treatment, and discharged to open water in the Crookhaven River. MUSIC modelling indicates that water quality objectives are met under these conditions.

- Proposed bioretention basins and wetlands (Sections 4.4.3 and 4.4.5) are to include an outlet structure appropriately designed to achieve dispersed flow into the SEPP14 Wetland and mitigate impacts such as localised scour. Outlet structures are to include rip-rap and vegetation tolerant of freshwater inflows.

- The proposed bioretention basins and wetlands include a maximum of 0.5 and 0.4 m detention depth respectively. This storage will provide a degree of onsite detention of flow during rain events and shall mimic natural baseflow and groundwater flow.

7 Statement of Commitments

With regards to management of stormwater onsite during construction and operation of the proposed development, the following commitments are made by the Applicant:

- Water quality treatment devices shall be installed to achieve nutrient and suspended sediment loads that reflect existing loads to the Crookhaven River, Lake Wollumboola, Curleys Bay and Billys Island inlet (SEPP 14 wetlands).
- The proposed treatment train shall achieve NorBE at receiving environments as detailed in Section 4.5.2.
- To maintain an appropriate hydrological regime in the wetland areas, the catchment area discharging into the wetlands shall be reduced such that post development flows to these areas are comparable to pre development flow.
- All discharge points shall include outlet structures appropriately designed to achieve dispersed flow into any downstream wetland areas to mitigate impacts such as localised scour.
- Water quality monitoring shall be undertaken in accordance with the project Water Quality Monitoring Plan (Martens, 2016c), which has been prepared with the input from various stakeholders, to ensure the development continues to comply with site water quality objectives. This plan shall undergo continual review and modification to address project progress and results.
- Impacts on receiving environments during the construction phase shall be mitigated by implementation of the project SECP (Martens, 2016c) which has been prepared in accordance with Landcom (2004) and industry best practice.
- Estuary management shall be undertaken in accordance with the Estuarine Management Study (Martens, 2016a).

8 References

Allen Price & Associates (2013) *Proposed Sewage Management Regime for New Development Areas within the Crookhaven River Catchment*

CSIRO (1999) *Sustainable Effluent-Irrigated Plantations: An Australian Guideline*

FAWB (2008) *Hydraulic Performance of Biofilter Systems for Stormwater Management: Lessons from a Field Study.*

Martens and Associates, (2016a) *Estuarine Management Study* (P1203365JR02V04)

Martens and Associates, (2016b) *Estuarine Processes Modelling Report* (P1203365JR04V02)

Martens and Associates, (2016c) *Water Quality Monitoring Plan* (P1203365JR03V04)

Munksgaard, N & Lottermoser, B (May, 2008) *Treatment of road runoff waters, Kuranda Range Project: Final Report*

Shoalhaven City Council (2015) Development Control Plan.

Soil Landscapes of the Kiama 1:100 000 sheet. Soil Conservation Service of NSW, Sydney.

SLR (2013) *Culburra West Urban Development Project Culburra Beach: Ecological and Riparian Issues and Assessment Report*.

Sydney Metropolitan Catchment Management Authority (SMCMA) (2010) '*Draft NSW MUSIC Modelling Guidelines'*

Wollongong 1:250,000 Geological Sheet; New South Wales Dept of Mines, 1970.

Wicks, M, Vigar, N & Hannah, M (September, 2011) *Nutrients and solids removal by an engineered treatment train* Journal of the Australian Water Association *Water*

9 Attachment A – Planset

COVER SHEET

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TITLE
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REV.	DESCRIPTION	DATE	ISSUED
1	FINAL	3.11.2016	AN

KEY

RIDGE DIVIDING CROOKHAVEN AND LAKE WOLLUMBOULA CATCHMENT

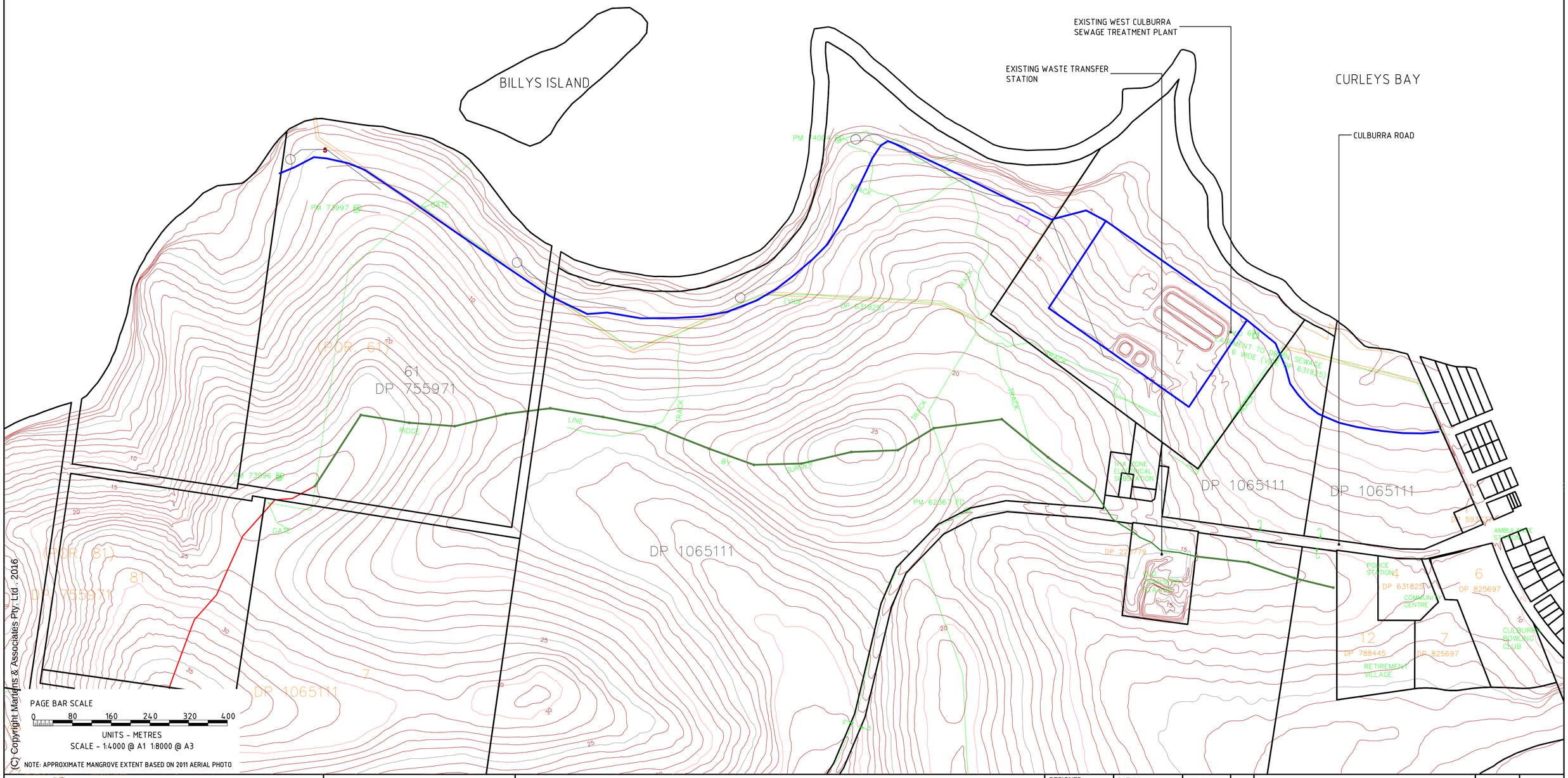
7(a) ZONE BOUNDARY

N

W E

S

CROOKHAVEN ESTUARY



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TITLE

EXISTING SITE

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7(a) ZONE BOUNDARY

PROPOSED CYCLEWAY

N

W E

S

CROOKHAVEN ESTUARY

BILLYS ISLAND

PROPOSED RETAINED FOREST IN 7(a) ZONE

PROPOSED TOURIST FACILITY

PROPOSED TOURIST FACILITY

PROPOSED PLAYGROUND / OPEN SPACE

CURLEYS BAY

EXISTING WEST CULBURRA SEWAGE TREATMENT PLANT

PROPOSED OPEN SPACE

PROPOSED VIEWING PLATFORM

PROPOSED RETAINED FOREST

700 SQM RESIDENTIAL LOTS AT 40% SITE COVERAGE

600 SQM RESIDENTIAL LOTS AT 40% SITE COVERAGE

PROPOSED MEDIUM DENSITY

PROPOSED INDUSTRIAL DEVELOPMENT

PROPOSED OVAL DEVELOPMENT

PROPOSED ROUNDABOUT INTERSECTION

PROPOSED ELECTRICAL SUBSTATION

EXISTING WASTE TRANSFER STATION

PROPOSED SMALL RESIDENTIAL DEVELOPMENT

CULBURRA ROAD

(PDP 6) 61 DP 755971

(PDP 81) 81 DP 755971

DP 1065111

DP 631825

DP 825697

DP 788445

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TITLE: PROPOSED SUBDIVISION INDICATIVE LAYOUT AND SITE COVERAGE
MIXED USE SUBDIVISION - WEST CULBURRA, NSW

PROJECT MANAGER: ANDREW NORRIS

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REVIEWED:	AN
DATUM:	mAHD
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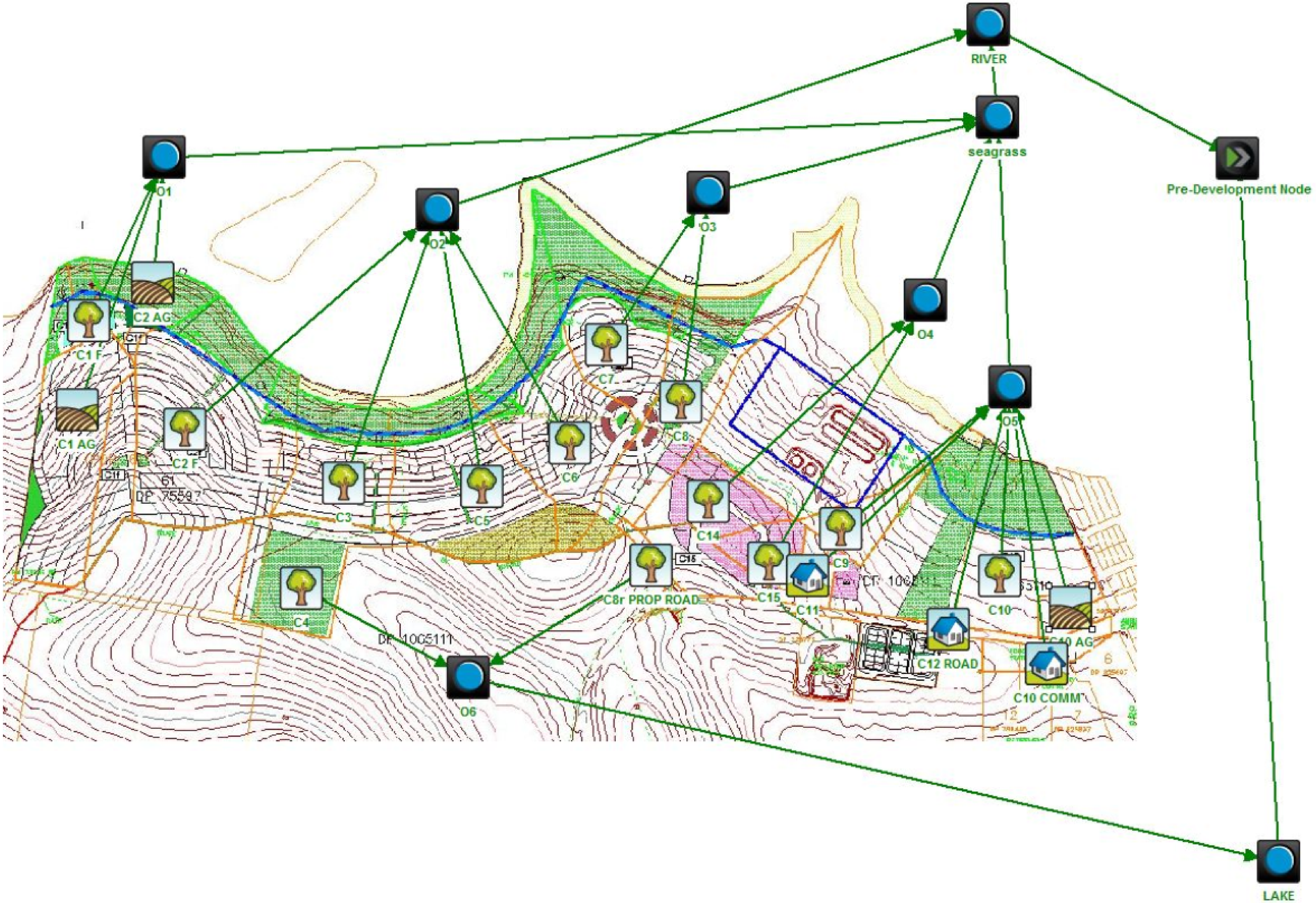

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TITLE
PRE-DEVELOPMENT MUSIC MODEL LAYOUT
MIXED USE SUBDIVISION - WEST CULBURRA, NSW

PROJECT MANAGER: ANDREW NORRIS
DRAWING NUMBER: P1203365JD01V10

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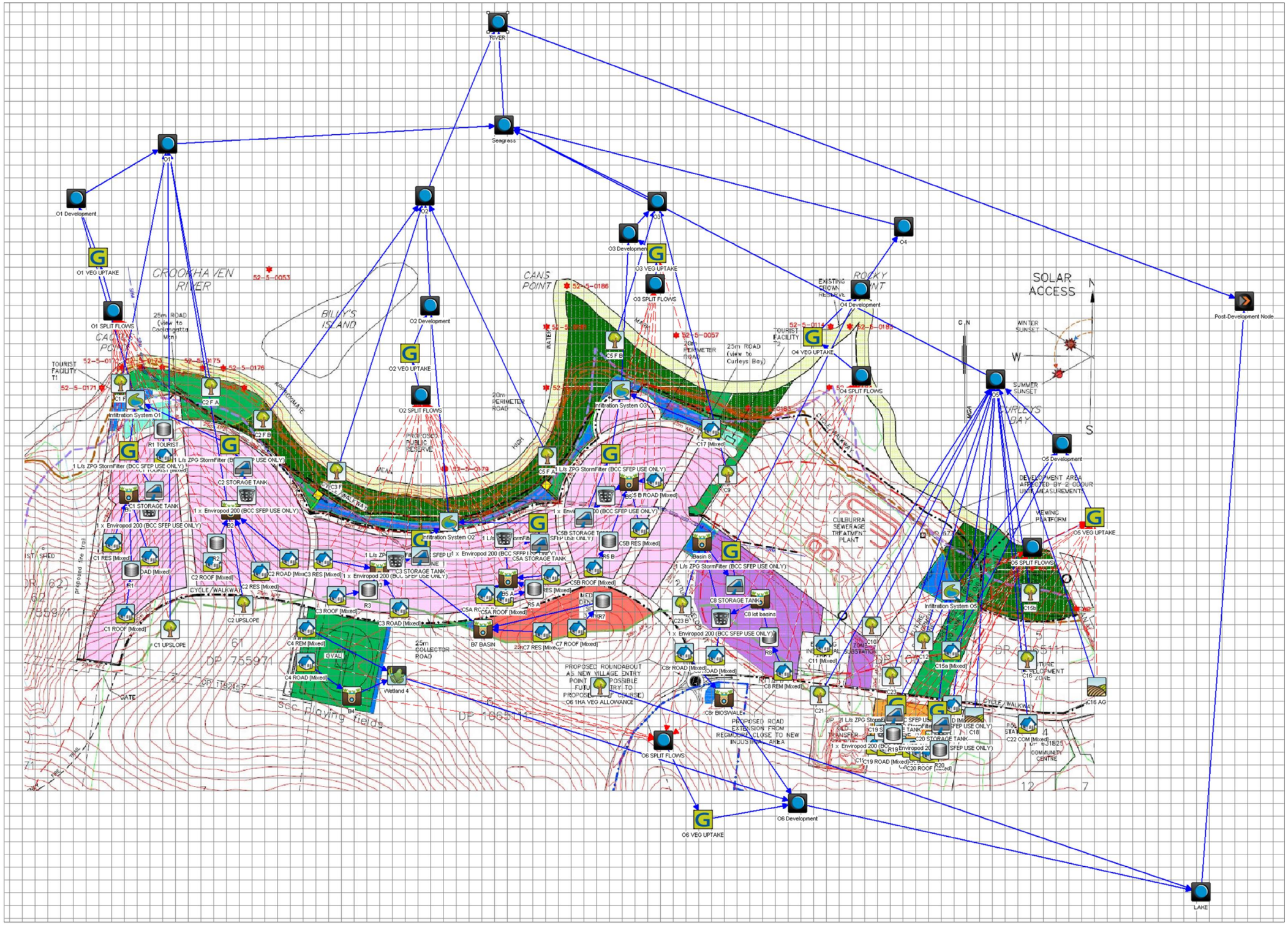

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TITLE
POST-DEVELOPMENT MUSIC MODEL LAYOUT
MIXED USE SUBDIVISION - WEST CULBURRA, NSW

PROJECT MANAGER: ANDREW NORRIS
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KEY

WETLAND HYDROLOGICAL CATCHMENT

AREAS TO BE DIVERTED TO OPEN WATER FORMERLY DRAINING TO WETLAND

APPROX SEPP14 WETLAND EXTENT

CROOKHAVEN ESTUARY

BILLYS ISLAND

CURLEYS BAY

N

W E

S

5

PM 73997 ED

GATE

PM 74006 ED

TRACK

16

(VIDE DP 631825)

TRACK

(POR. 61)

28

61

DP 755971

34.9ha DISCHARGING TO WETLAND

RIDGE

LINE

TRACK

20

TRACK

25

BY SURVEY

PM 73996 ED

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TITLE: HYDROLOGICAL CATCHMENT MANAGEMENT: MANGROVE AREA

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KEY

- PROPOSED PARKLAND WETLAND LOCATION
- PROPOSED INFILTRATION SYSTEM
- PROPOSED BIORETENTION BASIN LOCATION
- APPROX SEPP14 WETLAND EXTENT
- 7(a) ZONE BOUNDARY
- PROPOSED CYCLEWAY

NB: BIORETENTION SWALES TO BE INCLUDED THROUGHOUT DEVELOPMENT TO ACHIEVE WATER QUALITY CRITERIA. LOCATION TO BE CONFIRMED AT DEVELOPMENT APPLICATION STAGE ONCE INTERNAL LOT LAYOUT HAS BEEN CONFIRMED.

N
W E
S

CROOKHAVEN ESTUARY

BILLYS ISLAND

CURLEYS BAY

INFILTRATION SYSTEMS TO BE CONNECTED VIA SWALE

(P)DP 6

61
DP 755971

(P)DP 81

81
DP 755971

DP 1065111

DP 1065111

DP 1065111

DP 1065111

DP 225779

4
DP 631825

6
DP 825697

12
DP 788445

7
DP 825697

CULBURRA ROAD

PM 73997 FD

PM 62367 FD

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TITLE
PROPOSED TREATMENT TRAIN
MIXED USE SUBDIVISION – WEST CULBURRA, NSW

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- RIDGE DIVIDING CROOKHAVEN AND LAKE WOLLUMBOULA CATCHMENT
- 7(a) ZONE BOUNDARY
- STAGE BOUNDARY
- — F — F — FILTER FENCE
- — D — D — EARTH DIVERSION BUND
- SEDIMENT BASIN (FOOTPRINT APPROXIMATE)
- STABILISED SITE ACCESS
- ENERGY DISSIPATER
- STOCKPILE AND MATERIALS DELIVERY POINT

CROOKHAVEN ESTUARY

Element	Basin 1/1	Basin 2/1	Basin 2/2	Basin 2/3	Basin 3/1	Basin 3/2	Basin 3/3	Basin 4/1	Basin 5/1
Storage Zone Volume (soil) (m³)	118	369	283	24	598	75	29	1134	68
Settling Zone Volume (water) (m³)	2,517	2,198	1,926	217	3,836	774	1,245	5,387	1,377
Basin Total Volume (m³)	2,635	2,567	2,209	241	4,434	849	1,274	6,521	1,445

N
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S

BILLYS ISLAND

CURLEYS BAY

BASIN 4/1
BASIN 2/1
BASIN 5/1
BASIN 1/1
BASIN 2/2
BASIN 3/1
BASIN 3/2
BASIN 3/3
BASIN 2/3

CULBURRA ROAD

STAGE 4
STAGE 3
STAGE 2
STAGE 5
STAGE 1
STAGE 1

(PDR 61) 61 DP 755971
(PDR 81) 81 DP 755971
DP 1065111
DP 1065111
DP 1065111
DP 22779
4 DP 631825
6 DP 825697
12 DP 788445
7 DP 825697

PM 73997 PM 73996 PM 62367 PM 62368

OVERFLOW FROM BASIN 3/3 TO BE DIVERTED TO NORTH

OVERFLOW FROM BASIN 2/3 TO BE DIVERTED TO NORTH

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TITLE
SEDIMENT AND EROSION CONTROL PLAN
MIXED USE SUBDIVISION – WEST CULBURRA, NSW

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DATUM: mAHD
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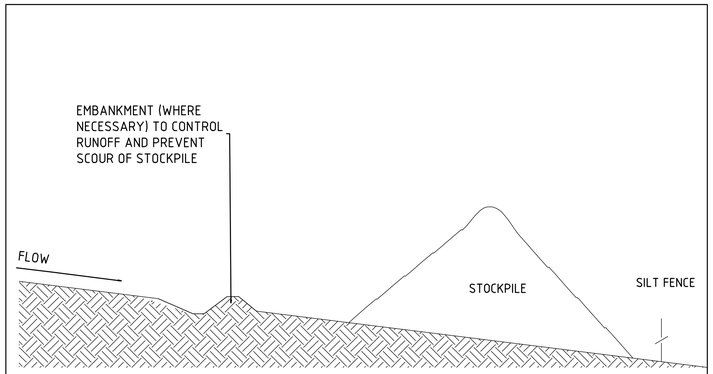

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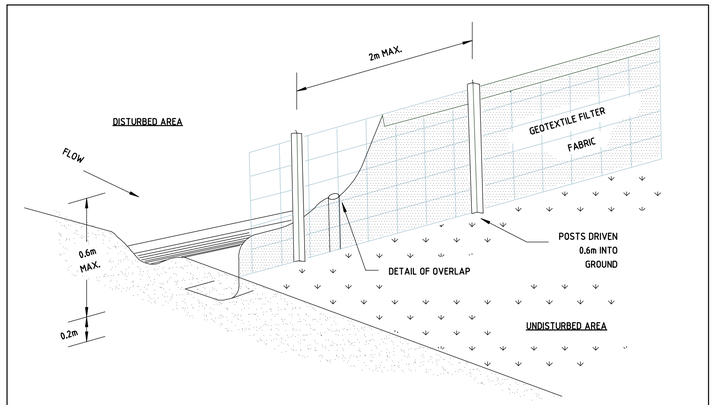

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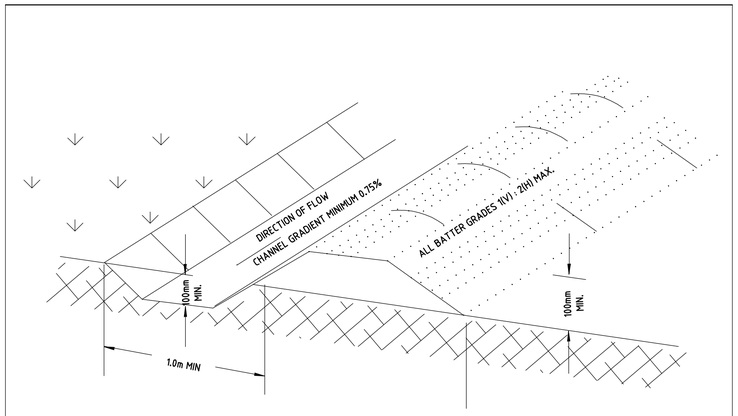

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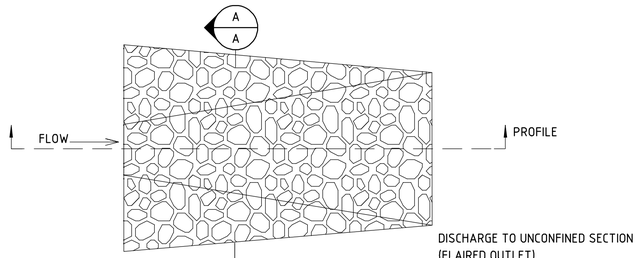

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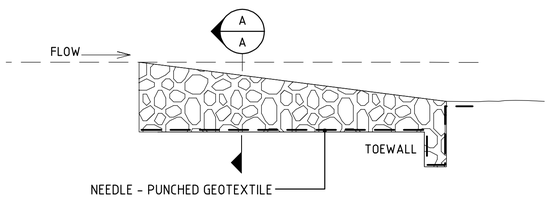

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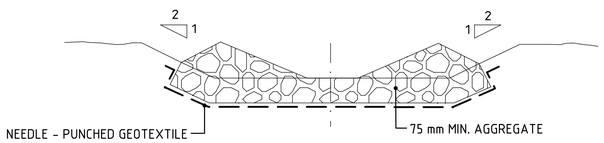
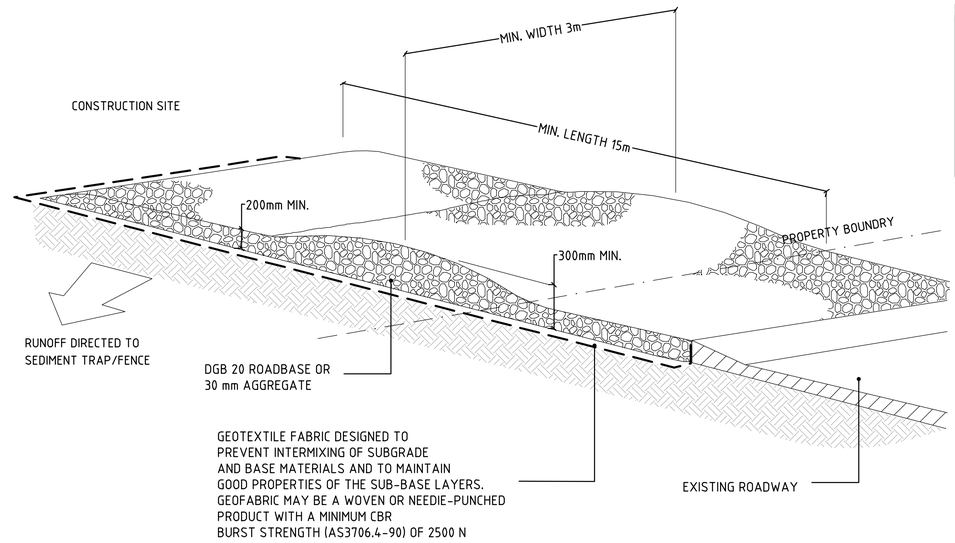


CROSS SECTION AA

CONSTRUCTION NOTES

1. COMPACT THE SUBGRADE FILL TO THE DENSITY OF THE SURROUNDING UNDISTURBED MATERIAL.
2. PREPARE A SMOOTH, EVEN FOUNDATION FOR THE STRUCTURE THAT WILL ENSURE THAT THE NEEDLE-PUNCHED GEOTEXTLLE DOES NOT SUSTAIN SERIOUS DAMAGE WHEN COVERED WITH ROCK.
3. SHOULD ANY MINOR DAMAGE TO THE GEOTEXTILE OCCUR, REPAIR IT BEFORE SPREADING ANY AGGREGATE. FOR REPAIRS, PATCH ONE PIECE OF FABRIC OVER THE DAMAGE, MAKING SURE THAT ALL JOINTS AND PATCHES OVERLAP MORE THAN 300 mm.
4. LAY ROCK FOLLOWING THE DRAWING, ACCORDING TO TABLE 5.2 OF LANDCOM (2004) AND WITH A MINIMUM DIAMETER OF 75 mm.
5. ENSURE THAT ANY CONCRETE OR RIPRAP USED FOR THE ENERGY DISSIPATER OR THE OUTLET PROTECTION CONFORMS TO THE GRADING LIMITS SPECIFIED ON THE SWMP.

ENERGY DISSIPATER SD 5-8

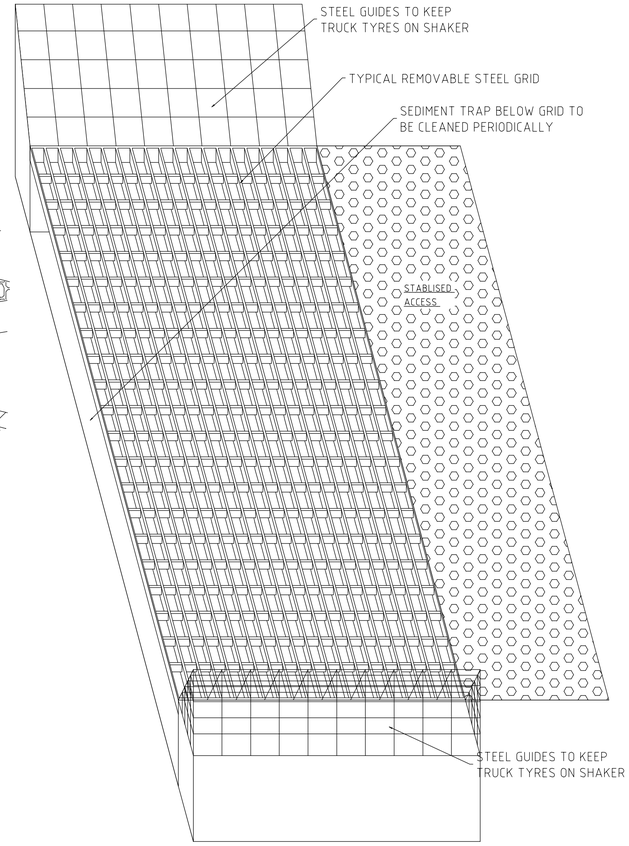


CONSTRUCTION NOTES

1. STRIP THE TOPSOIL, LEVEL THE SITE AND COMPACT THE SUBGRADE.
2. COVER THE AREA WITH NEEDLE-PUNCHED GEOTEXTILE.
3. CONSTRUCT A 200-mm THICK PAD OVER THE GEOTEXTILE USING ROAD BASE OR 30-mm AGGREGATE.
4. ENSURE THE STRUCTURE IS ATLEAST 15 METRES LONG OR TO BUILDING ALIGNMENT AND AT LEAST 3 METRES WIDE.
5. WHERE A SEDIMENT FENCE JOINS ONTO THE STABILISED ACCESS, CONSTRUCT A HUMP IN THE STABILISED ACCESS TO DIVERT WATER TO THE SEDIMENT FENCE

STABILISED SITE ACCESS SD 6-14

NOT TO SCALE



TYPICAL SEDIMENT SHAKER

NOT TO SCALE

martens
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MARTENS & ASSOCIATES PTY LTD
Sustainable Solutions
Environmental - Geotechnical - Civil
Hydraulic - Wastewater Engineers

CLIENT/ PROJECT: THE HALLORAN TRUST

TITLE: SEDIMENT AND EROSION CONTROL SPECIFICATIONS
MIXED USE SUBDIVISION - WEST CULBURRA, NSW

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

PROJECT MANAGER: ANDREW NORRIS

DRAWING NUMBER: P1203365JD01V10

DESIGNED:	DATUM:	SHEET
MLK	mAHD	SK208
DRAWN: KT	HORIZONTAL RATIO: 1:4000 @ A1, 1:8000 @ A3	
REVIEWED: AN	VERTICAL RATIO: 1:4000 @ A1, 1:8000 @ A3	PAPER SIZE: A1 / A3

REV.	DESCRIPTION	DATE	ISSUED
1	FINAL	3.11.2016	AN

KEY

- 7(a) ZONE BOUNDARY
- GW1 GROUNDWATER MONITORING LOCATION
- WQ1 WATER QUALITY MONITORING LOCATION
- SF1 SHELLFISH MONITORING LOCATION
- PP1 PHOTO POINT LOCATION
- SQID 1 SQID MONITORING LOCATION
- PROPOSED PARKLAND WETLAND LOCATION
- PROPOSED INFILTRATION SYSTEM
- PROPOSED BIORETENTION BASIN LOCATION
- APPROX SEPP14 WETLAND EXTENT
- PROPOSED CYCLEWAY

N W E S

CROOKHAVEN ESTUARY

BILLYS ISLAND

WQ4 WQ2 WQ1 WQ3 SF1

PP 11 GW1 SQID 3 PP 10 PP 9 PP 4 SQID 5 PP 5 GW5 PP 6 SQID 4 PP 7 GW2 PP 8 SQID 1 SQID 6 PP 3 PP 2 GW6 PP 1 GW3 GW7 PP 14 PP 12 PP 13 SQID 2 GW4 GW8 PP 15

(PDR 6) 61 DP 755971 (PDR 81) 81 DP 755971 7 DP 1065111 DP 1065111 DP 1065111 DP 1065111 DP 227179 4 DP 631825 6 DP 825697 12 DP 788445 7 DP 825697

PM 73996 FD PM 62367 FD

CULBURRA ROAD

PAGE BAR SCALE

0 80 160 240 320 400

UNITS – METRES

SCALE – 1:4000 @ A1 1:8000 @ A3

martens
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MARTENS & ASSOCIATES PTY LTD
Sustainable Solutions
Environmental - Geotechnical - Civil
Hydraulic - Wastewater Engineers

CLIENT/ PROJECT: THE HALLORAN TRUST

TITLE: WATER QUALITY MONITORING PLAN
MIXED USE SUBDIVISION – WEST CULBURRA, NSW

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

PROJECT MANAGER: ANDREW NORRIS

DRAWING NUMBER: P1203365JD01V10

DESIGNED:	DATUM:	SHEET
MLK	mAHD	SK210
DRAWN: KT	HORIZONTAL RATIO: 1:4000 @ A1 1:8000 @ A3	
REVIEWED: AN	VERTICAL RATIO: 1:4000 @ A1 1:8000 @ A3	PAPER SIZE: A1 / A3

REV.	DESCRIPTION	DATE	ISSUED
1	FINAL	3.11.2016	AN

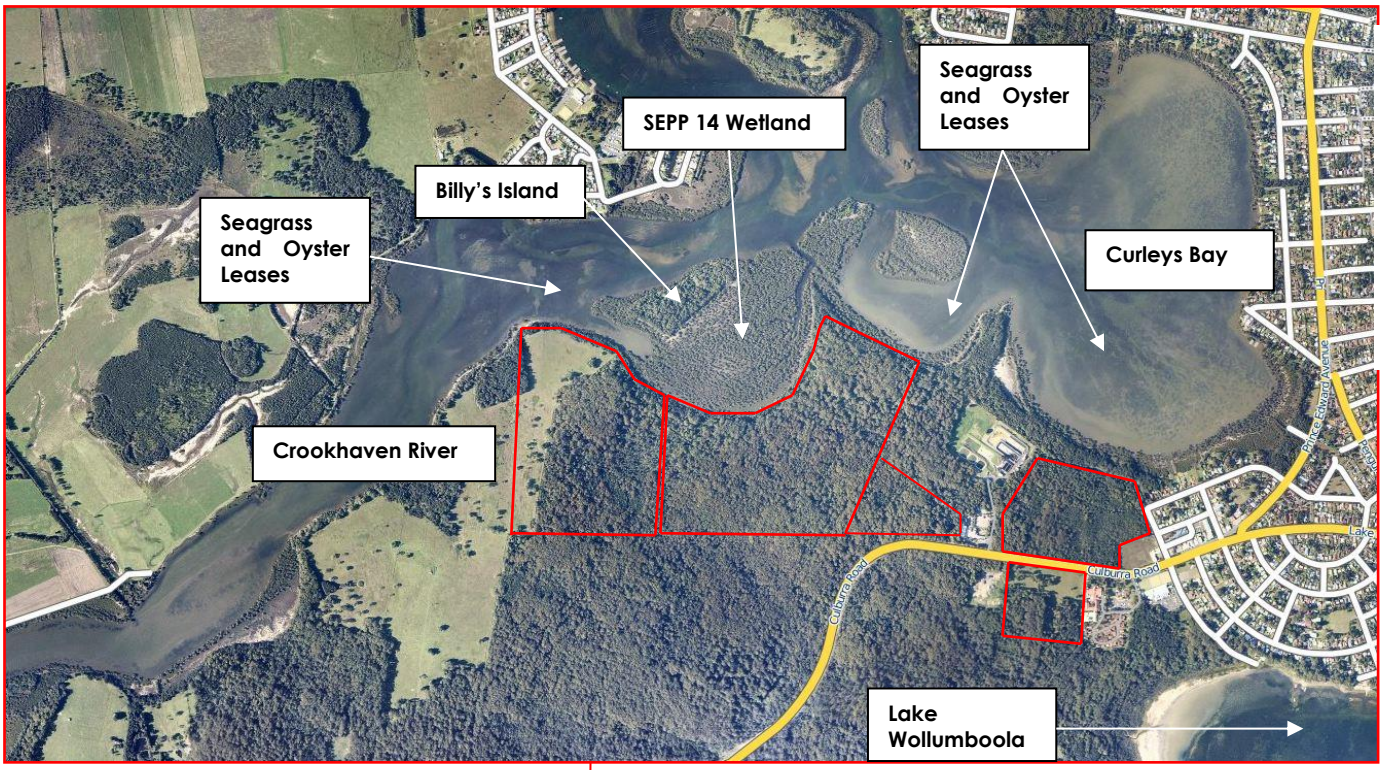
10 Attachment B – Summary of MUSIC Input Parameters

Attachment B: MUSIC modelling input parameter values and source.

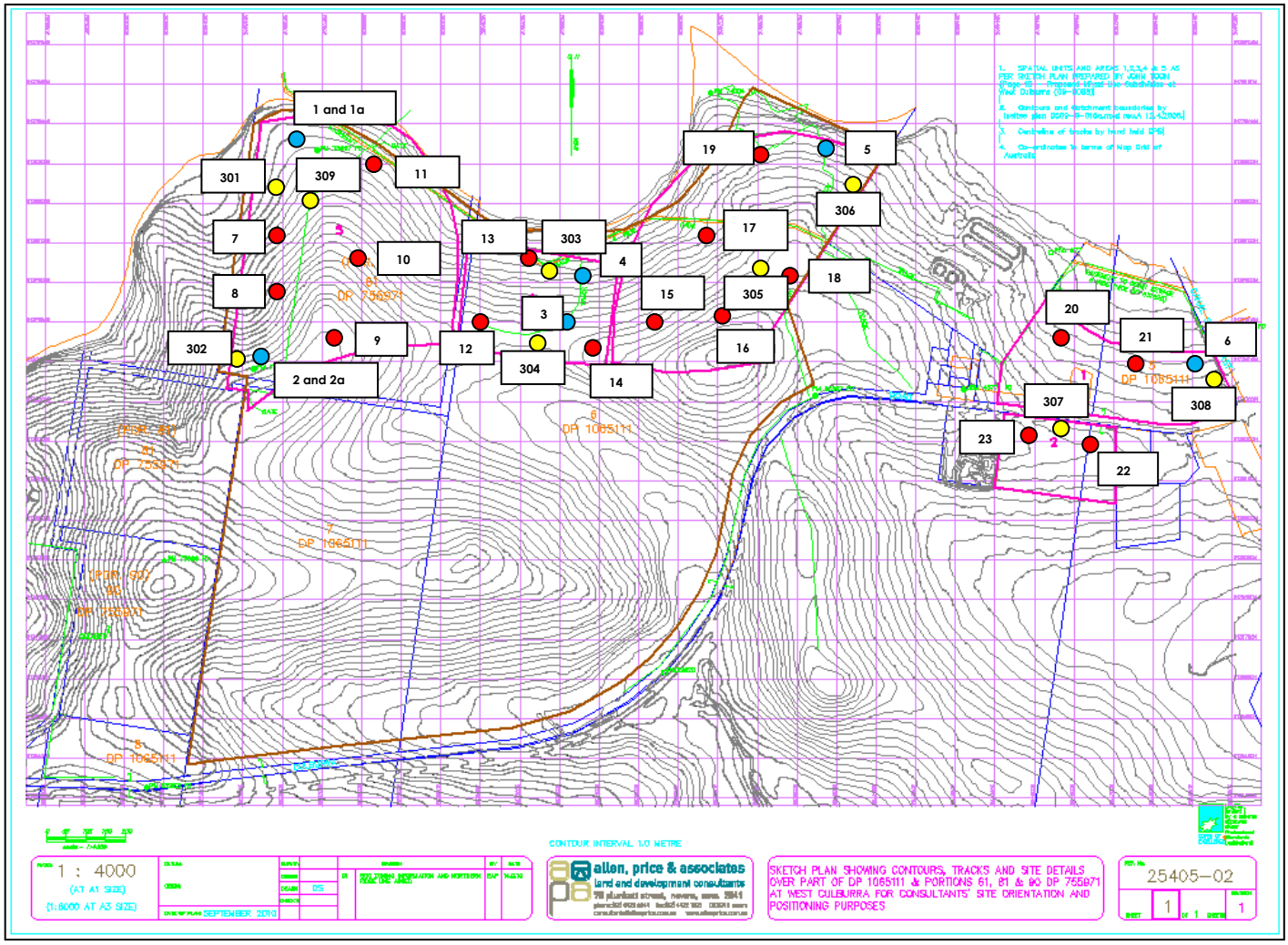
Element	Factor	Input	Source
Setup	Climate File	Climate file (mlb file) from Nowra RAN from 5/08/1964 - 31/12/1970	BOM
Source Nodes	Node Type	The existing site will be a mixture of agricultual and forested nodes, depending on location across the site. Proposed will be a mixture of roof, road and residential nodes plus forest for undeveloped forest areas.	As per WBM (2010) and development layout.
	Roof Area	As per proposed site coverage (ranges from 40% - 60%)	As per development layout.
	Road Area	Area per lot layout. Area to be summed for each subcatchment.	As per development layout.
	Residential	Remaining lot area (catchment area less road and roof area). Given driveways are not considered 'effective impervious areas' and laybacks are, residential nodes are generally 99% pervious	Assumed based on 'typical' lot layouts.
	Rainfall Threshold	Based on land use type or surface type as specified in Table 3.6 of WBM (2010)	WBM (2010) guidelines.
	Pervious Area Parameters	Based on soils within the top 0.5m of existing soil profile = Loamy sand overlying clay. Inputs based on a weighted mean of these soil types	Soil properties based on WBM (2010) Table 3-7 and 3-8 and site geotechnical testing by Martens (2010) of 24 boreholes.
	EMC's	As per WBM (2010) for Urban and Forest landuse	WBM (2010) guidelines.
	Estimation Method	Stochastically generated	WBM (2010) guidelines.
Bioretention Basin	Low Flow By-Pass	0 m^3/s	WBM (2010) guidelines.
	High Flow Bypass	100 m^3/s	Online so no bypass (excluding Catchment C15a basin = 50% 1yr ARI).
	Extended Detention depth	0.5m	By design.
	Surface area	Surface area at top of basin (have vertical sides)	WBM (2010) guidelines.
	Filter area	By design.	Design of proposed basin.
	Unlined filter media	Equal to square root of surface area (actual) multiplied by 4	WBM (2010) guidelines.
	Saturated Hydraulic Conductivity	90 mm/hr	MUSIC model help guidelines (ewater) recommend a hydraulic conductibity of 180 mm/hr be used for sands. 50% of this value has been used in modelling as a conservative estimate of realistic long-term hydraulic conductivity of system (ewater).
	Fiter Depth	0.4 - 0.65m	Design of proposed basin.
	TN content of filter media	500 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012).
	Orthophosphate content of filter media	40 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012) and product data sheet from RiverSands P/L for typical sand filter media (attached).
	Exfiltration rate	1.14 mm/hr	Based on median result of site hydraulic conductivity testing.
	Is based lined?	No	Basins shall not be lined.
	Vegetation Properties	With effective nutrient removal plants	Landscaping of basins will include deep rooted vegetation.
	Oveflow weir width	varies	Basin design.
	Underdrain present	Yes	Basin design.
	Submerged zone with carbon present	Yes; 0.2m	Basin design.
Bioretention Swales	Low Flow By-Pass	0 m^3/s	WBM (2010) guidelines.
	High Flow Bypass	100 m^3/s	No Bypass.
	Extended Detention depth	0.25m	By design.
	Surface area	Surface area at half the detention depth	WBM (2010) guidelines.
	Filter area	By design.	Design of proposed basin.
	Unlined filter media	Equal to square root of surface area (actual) multiplied by 4	WBM (2010) guidelines.
	Saturated Hydraulic Conductivity	90 mm/hr	MUSIC model help guidelines (ewater) recommend a hydraulic conductibity of 180 mm/hr be used for sands. 50% of this value has been used in modelling as a conservative estimate of realistic long-term hydraulic conductivity of system (ewater).
	Fiter Depth	0.6m	Design of proposed basin.
	TN content of filter media	500 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012).
	Orthophosphate content of filter media	40 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012) and product data sheet from RiverSands P/L for typical sand filter media (attached).
	Exfiltration rate	1.71 mm/hr	Increased site hydraulic conductivity (1.14 mm/hr) by 50% to account for new swale design with vertical kerbs resulting in increased filter media area.
	Is based lined?	No	Swales shall not be lined
	Vegetation Properties	With effective nutrient removal plants	Landscaping of basins will include deep rooted vegetation.
	Oveflow weir width	varies	Basin design.
	Underdrain present	Yes	Basin design.

	Submerged zone with carbon present	Yes; 0.2m	Basin design.
Infiltration System	Low Flow By-Pass	0 m3/s	By design
	High Flow Bypass	100 m3/s	By design
	Pond Surface Area	Surface area at half the detention depth	WBM (2010) guidelines.
	Extended Detention depth	0.5m	By design
	Filter area	Varies	By design
	Unlined filter media	Equal to square root of surface area (actual) multiplied by 4	WBM (2010) guidelines.
	Depth of infiltration media	100mm	By design
	Exfiltration rate	1.14 mm/hr	Based on median result of site hydraulic conductivity testing.
	Evaporative loss	100%	By design
	Overflow Weir	Varies	By design
Wetland	Low Flow By-Pass	0 m^3/s	WBM (2010) guidelines
	High Flow Bypass	100 m^3/s	Online so no bypass (excluding Catchment C15a basin = 50% 1yr ARI)
	Inlet Pond Volume	0 m3	By design
	Surface area	Surface area at half the detention depth	WBM (2010) guidelines
	Extended Detention depth	0.5m	Design of proposed wetlands
	Permanent Pool Volume	560	Design of proposed wetlands
	Exfiltration rate	1.14 mm/hr	Based on median result of site hydraulic conductivity testing.
	Equivalent Pipe Diameter	60	Adjusted to achieve an approximate detention time of 72 hrs as per 3.8.3.1 of WBM (2010) guidelines
	Weir width	20	Design of proposed wetlands
	Reuse	6ML/ha/yr	Typical irrigation rate for golf course grade landscaping
Generic (Vegetation Uptake Node)	Low Flow By-Pass	0 m3/s	WBM (2010) guidelines
	High Flow Bypass	100 m3/s	No bypass.
	TSS (mg/L)	Varies	Based on inflow concentration of nutrient and 100% removal capacity of downslope vegetation.
	TN (mg/L)	Varies	Based on inflow concentration of nutrient and 51.8 kg/ha/year removal capacity of downslope vegetation.
	TP (mg/L)	Varies	Based on inflow concentration of nutrient and 10 kg/ha/year removal capacity of downslope vegetation.
	GP (kg/ML)	Varies	100% removal capacity of downslope vegetation.
GPT (Enviropod)	Low Flow By-Pass	0 m3/s	WBM (2010) guidelines
	High Flow Bypass	Varies - based on 1 Enviropod/1,000 m2 and 20L/s highflow bypass per unit	As per manufactures specification (SW360) and catchment area
	TSS (mg/L)	Input 100 Ouput 46	As per manufactures specification (SW360) and Blacktown Council requirements
	TN (mg/L)	Input 10 Ouput 7.9	As per manufactures specification (SW360) and Blacktown Council requirements
	TP (mg/L)	Input 10 Ouput 7	As per manufactures specification (SW360) and Blacktown Council requirements
	GP (kg/ML)	Input 14.8 Ouput 0	As per manufactures specification (SW360) and Blacktown Council requirements
OSD Storage Tank	Low Flow By-Pass	0 m3/s	SW360 design recommendations
	High Flow Bypass	100 m3/s	No bypass.
	Surface Area	Varies	Based on number of Stormfilter cartridges and SW360 design requirements.
	Extended Detention depth	0.77m	Based on 'tall' cartridges being installed onsite.
	Exfiltration rate	0 mm/hr	Based on sealed concrete tank.
	Evaporative loss	0%	Based on sealed concrete tank.
	Low Flow Pipe Diameter	Varies	Based on SW360 design requirements.
	Overflow Weir	Varies	Based on SW360 design requirements.
Generic (SW360 Stormfilter)	Low Flow By-Pass	0 m3/s	WBM (2010) guidelines
	High Flow Bypass	Varies	Based on number of Stormfilter cartridges and SW360 design requirements.
	TSS (mg/L)	Input 100 Ouput 26.5	As per manufactures specification (SW360) and Blacktown Council requirements.
	TN (mg/L)	Input 100 Ouput 6.8	As per manufactures specification (SW360) and Blacktown Council requirements.
	TP (mg/L)	Input 10 Ouput 5.1	As per manufactures specification (SW360) and Blacktown Council requirements.
	GP (kg/ML)	Input 1000 Ouput 50	As per manufactures specification (SW360) and Blacktown Council requirements.
Rainwater Tank	Low Flow By-Pass	0 m3/s	WBM (2010) guidelines
	High Flow Bypass	0.005 m3/s per dwelling (for free standing houses, townhouses, retirement and tourist accomodation). 100mm/hr for unit blocks by assumed roof perimeter	WBM (2010) guidelines
	Volume below overflow	Based on 3KL/dwelling or 3KL/tenement. A volume of 80% of total tank volume is assumed	Development design. As per WBM (2010) MUSIC modelling guidelines
	Depth above overflow	0.2m	By design
	Surface area	Cumulative surface area	By design
	Overflow pipe diameter	100mm	WBM (2010) guidelines
	Reuse	274L/day/ET	Shoalhaven Water

11 Attachment C - Figures



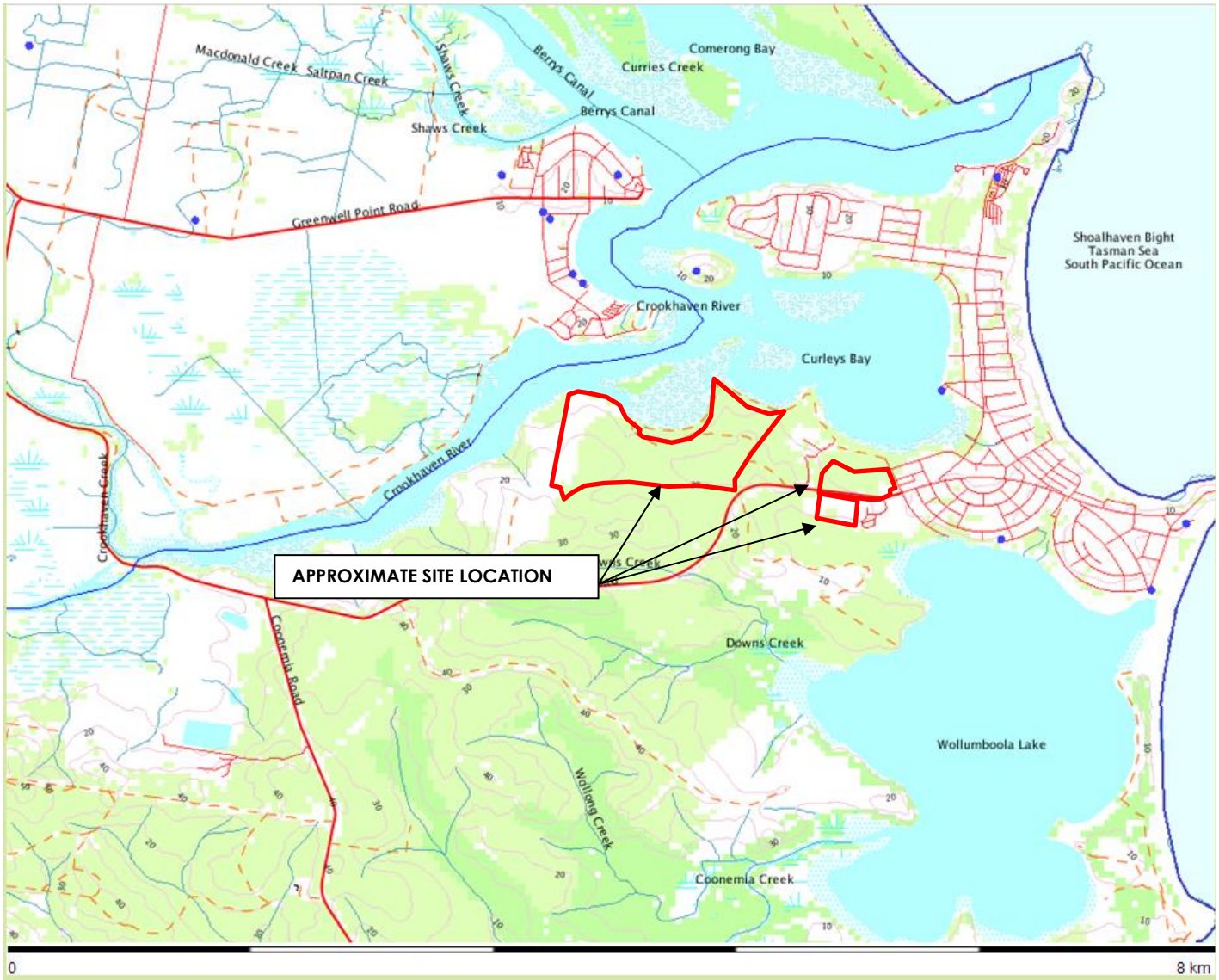
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Site Locality and Regional Context**	**Figure 1**
Approved:	AN		**SK301**
Date:	2.11.2016		
Scale:	NA		Job No: P1203365



Key:

- **Approx borehole location and I.D (2010)**
- **Approximate GMB location and I.D (2010)**
- **Approximate testpit and permeability testing location and I.D (2014)**

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Borehole and GMB Locations**	**Figure 2** **SK302**
Approved:	AN		
Date:	02.11.20165		
Scale:	NA		Job No: P1203365



Notes:

1. **Source (NSW Natural Resource Atlas).**
2. **Site location is approximate only.**
3. **Licensed bores = purple dots.**

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Site and Surrounding Licensed Bores**	**Figure 3**
Approved:	AN		**SK303**
Date:	02.11.2016		
Scale:	NA		Job No: P1203365

12 Attachment D – MUSIC Model Catchment Areas

DATE 1/07/2014 **VERSION:** 12 **Change:** July 2014 changes
PROJECT: West Culburra **CLIMATE FILE** NOWRA RAN as per MUSIC guidelines 1964 - 1970
PROJECT NUMBER 3365 PET from Climatic Atlas of Australia (BOM)

EMC's -CMA

		BASE FLOW		STORM FLOW	
LANDUSE	**PARAMETER**	**LOG(BF)**	**LOG (STDEV)**	**LOG (SF)**	**LG (STDEV)**
ROOF	TN	0.010	0.010	0.300	0.190
	TP	0.010	0.010	-0.890	0.250
	SS	0.010	0.010	1.300	0.320
AGRICULTURE	TN	0.040	0.130	0.480	0.260
	TP	-1.050	0.130	-0.220	0.300
	SS	1.300	0.130	2.150	0.310
RESIDENTIAL	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	0.600	0.250
	SS	1.200	0.170	2.150	0.320
FOREST	TN	-0.520	0.130	-0.050	0.240
	TP	-1.520	0.130	-1.100	0.220
	SS	0.780	0.130	1.600	0.200
COMMERCIAL	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	-0.600	0.250
	SS	1.200	0.170	2.150	0.320
SEALED ROADS	TN	0.110	0.120	0.340	0.190
	TP	-0.850	0.190	-0.300	0.250
	SS	1.200	0.170	2.430	0.320

BORELOGS STATE APPROX 0.3m SILTY SAND OVERLYING CLAY. Substitue loamy sand for silty sand

SOIL TYPES

Soil Types in top 0.5m - Real Data								Inputs for MUSIC					
Layer 1	**Depth**	**SSC (MUSIC guidelines)**	**FC (MUSIC Guidelines)**	**Layer 2**	**Depth**	**SSC (MUSIC guidelines)**	**FC (MUSIC Guidelines)**	**Weighted average SSC**	**Weighted average FC**	**Inf a**	**Inf b**	**DRR (%)**	**DBR (%)**
LOAMY SAND	0.3	139	69	CLAY	0.2	93	68	120.6	68.6	270	1.9	64	34

PRE DEVELOPMENT CATCHMENT AREAS

RECEIVING NODE	**CATCHMENT ID**	**TOTAL AREA (HA)**	**IMPERVIOUS AREA (HA)**	**%**	**PERVIOUS AREA (HA)**	**%**	**EMC CATEGORY**
O1	C1 AG	10.5	0.0	0%	10.5	100%	AGRICULTURAL
	C1 FOREST	3.0	0.0	0%	3.0	100%	FOREST
	O1 7(A) C1	1.4	0.0	0%	1.4	100%	FOREST
	O1 7(A) C2a	2.7	0.0	0%	2.7	100%	AGRICULTURAL
	C2 AG	0.7	0.0	0%	0.7	100%	AGRICULTURAL
O2	C2 FOREST	13.3	0.0	0%	13.3	100%	FOREST
	O1 7(A) C2b	2.6	0.0	0%	13.3	100%	FOREST
	C3	4.6	0.0	0%	4.6	100%	FOREST
	O2 7(A)	4.8	0.0	0%	13.3	100%	FOREST
	C5	9.5	0.0	0%	9.5	100%	FOREST
	C6	8.2	0.0	0%	8.2	100%	FOREST
	O1 7(A) C6	2.9	0.0	0%	2.9	100%	FOREST
O6	C8r	0.9	0.0	0%	0.9	100%	FOREST
	C4	6.7	0.0	0%	6.7	100%	FOREST
O3	C7	4.6	0.0	0%	4.6	100%	FOREST
	O3 7(A)	6.0	0.0	0%	6.0	100%	FOREST
	C8	8.7	0.0	0%	8.7	100%	FOREST
O4	C14	4.0	0.0	0%	4.0	100%	FOREST
	C15	2.9	0.0	0%	2.9	100%	FOREST
O5	C9	4.4	0.0	0%	4.4	100%	FOREST
	O5 7(A)	6.1	0.0	0%	6.1	100%	FOREST
	C10	11.5	0.0	0%	11.5	100%	FOREST
	C10ag	4.4	0.0	0%	4.4	100%	AGRICULTURAL
	C10comm	1.5	0.6	40%	0.9	60%	COMMERCIAL
	C11	1.7	1.7	100%	0.0	0%	INDUSTRIAL
	C12	1.8	1.8	100%	0.0	0%	ROAD
	TOTAL	**129.4**					

POST DEVELOPMENT CATCHMENT AREA Nb: Roads are 50% Pervious 50% Impervious based on DCP100 pg 24 Table 3 and using a 'local street'

RECEIVING NODE	**CATCHMENT**	**Total Area**	**Bioswale Area**	**Road Area**	**%Pervious Road***	**House Area**	**Residential Node**	**% Impervious (Res)**	**%Pervious (Res)**	**NODE**	**Number of Lots**
	C1 FOREST	1.1						0%	100%	FOREST	
	WETLAND 1	0.3									
O1	C1	12.4	0.4201	4.35	0.41	2.96	4.63	1%	99%	RESIDENTIAL	104
	C1 Tourist	0.6					0.6	90%	10%		
	C2 FOREST A	2.7						0%	100%	FOREST	
	C2	10.2	0.3291	2.40	0.38	2.91	4.55	1%	99%	RESIDENTIAL	104
	C2 UPSLOPE	0.5									
	C1 UPSLOPE	0.9									
	TOTAL	**28.7**									
	C2 Forest b	2.6						0%	100%	FOREST	
	C3 FOREST	3.6						0%	100%	FOREST	
O2	C3	16.8	0.4331	4.87	0.42	4.77	6.73	1%	99%	RESIDENTIAL	171
	WETLAND 3 (1,2)	0.8									
	C5 FOREST A	2.8						0%	100%	FOREST	
	WETLAND5(b1)	0.1									
	WETLAND 3 (3)	0.3									
	C5 A	4.3	0.0895	1.12	0.42	1.07	2.05	1%	99%	RESIDENTIAL	46
	C7	3.5		0.0		2.08	1.39	0%	100%	RESIDENTIAL	
	BASIN B7	0.3									
	TOTAL	**35.0**									
	C8r	0.9		0.89	0.50					ROAD	
O6	C4	5.0	0.0625	0.22	0.28		4.68	0%	100%	RESIDENTIAL	
	WETLAND 4	0.3									
	C5 FOREST B	5.3						0%	100%	FOREST	
	Wetland 5	0.2									
O3	WETLAND5(b2)	0.5									
	C5 B	11.4	0.3856	4.16	0.41	2.72	4.09	1%	99%	RESIDENTIAL	94
	C17	0.2						20%	80%	COMMERCIAL	
	C9	2.7						0%	100%	FOREST	
	TOTAL	**20.2**									
	C23b	2.6						0%	100%	FOREST	
O4	C8	6.9	0.6863	1.50	0.50	0.0	4.68	100%	0%	INDUSTRIAL	
	BASIN C8	0.4									
	TOTAL	**9.9**									
	C10	2.4						0%	100%	FOREST	
	C11	1.7					1.7	100%	0%	INDUSTRIAL	
	C15a	2.1					2.1	0%	100%	RESIDENTIAL	
	WETLAND 15B	0.6									
	C15b	5.5						0%	100%	FOREST	
	C12	1.0					1.0	90%	10%	RESIDENTIAL	
	C14	1.8		1.8				100%	0%	ROAD	
O5	C16	5.9						0%	100%	FOREST	
	C16AG	1.3						0%	100%	AGRICULTURAL	
	C18	0.7						0%	100%	AGRICULTURAL	
	C19	0.6	0.0000	0.2	0.5	0.153	0.32	0%	100%	RESIDENTIAL	
	C20	1.8	0.0954	0.3	0.5	0.430	0.95	0%	100%	RESIDENTIAL	14.0
	C21	0.6		0.0				0%	100%	FOREST	16.0
	C22	1.5					1.5	40%	60%	COMMERCIAL	
	C23	2.0						0%	100%	FOREST	
	TOTAL	**29.5**									
	TOTAL	**129.4**									

* where bioswales are on road then pervious area cannot be 50%

13 Attachment E – Bioretention Basin, Wetland and Infiltration System MUSIC Input Parameters

WETLAND

Node Name	Wetland 4	
Reuse Properties - Annual Demand Value (ML/year)	9.36	{ML/year}
Inlet Properties - Low Flow By-pass (cubic metres per sec)	0	{cubic metres per sec}
Inlet Properties - High Flow By-pass (cubic metres per sec)	100	{cubic metres per sec}
Inlet Properties - Inlet Pond Volume (cubic metres)	0	{cubic metres}
Storage Properties - Surface Area (square metres)	2800	{square metres}
Storage Properties - Extended Detention Depth (metres)	0.5	{metres}
Storage Properties - Permanent Pool Volume (cubic metres)	560	{cubic metres}
Storage Properties - Initial Volume	560	
Storage Properties - Exfiltration Rate (mm/hr)	1.14	{mm/hr}
Storage Properties - Evaporative Loss as % of PET	125	
Outlet Properties - Equivalent Pipe Diameter (mm)	60	{mm}
Outlet Properties - Overflow Weir Width (metres)	20	{metres}
Outlet Properties - Notional Detention Time (hrs)	65.6	{hrs}

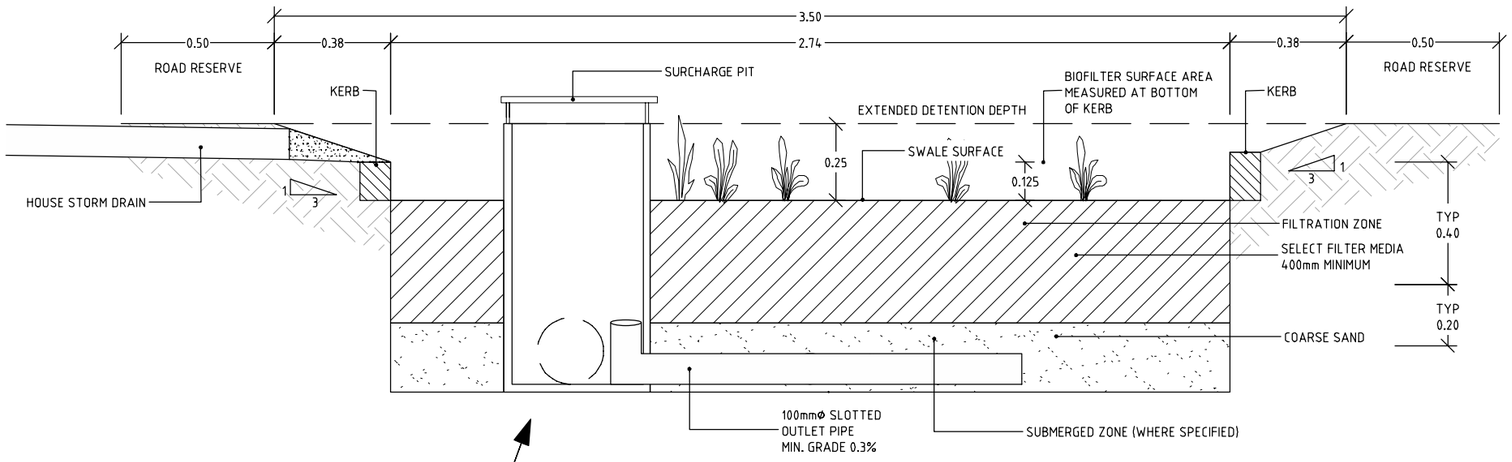
INFILTRATION SYSTEMS

Node Name	Infiltration System O1	Infiltration System O2	Infiltration System O3	Infiltration System O5	
Inlet Properties - Low Flow By-pass (cubic metres per sec)	0	0	0	0	{cubic metres per sec}
Inlet Properties - High Flow By-pass (cubic metres per sec)	100	100	100	100	{cubic metres per sec}
Storage and Infiltration Properties - Pond Surface Area (square metres)	3311	11738.6	8229.3	6471	{square metres}
Storage and Infiltration Properties - Extended Detention Depth (metres)	0.5	0.5	0.5	0.5	{metres}
Storage and Infiltration Properties - Filter Area (square metres)	3150	11078	7752.3	6298.3	{square metres}
Storage and Infiltration Properties - Unlined Filter Media Perimeter (metres)	230	433.4	362.9	321	{metres}
Storage and Infiltration Properties - Depth of Infiltration Media (metres)	0.1	0.1	0.1	0.1	{metres}
Storage and Infiltration Properties - Exfiltration Rate (mm/hr)	1.14	1.14	1.14	1.14	{mm/hr}
Storage and Infiltration Properties - Evaporative Loss as % of PET	100	100	100	100	
Outlet Properties - Overflow Weir Width (metres)	20	690	300	70	{metres}

BIORETENTION BASINS

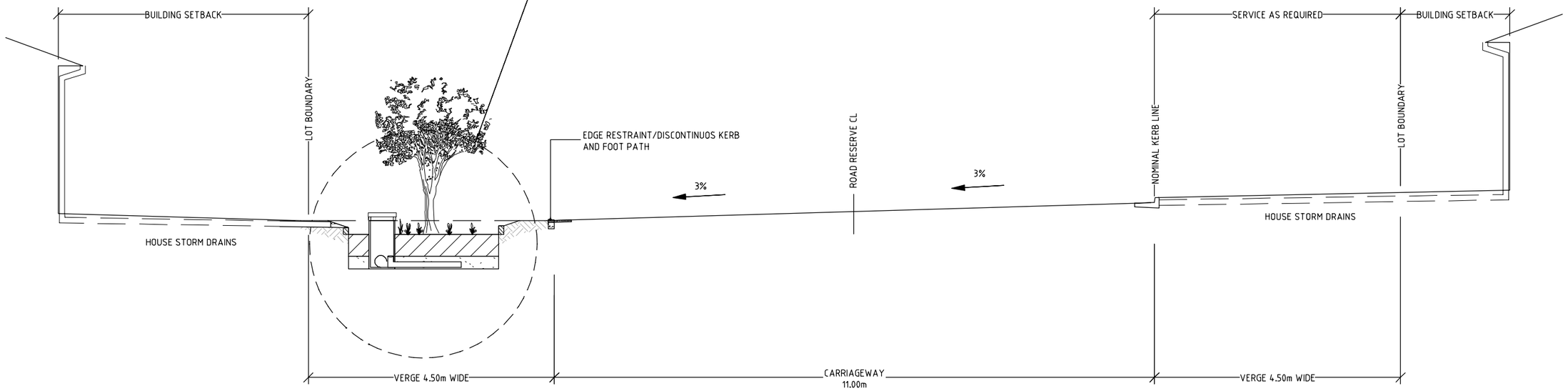
Node Name	B7 BASIN	Basin 8	C8r BIOSWALE	
Inlet Properties - Low Flow By-pass (cubic metres per sec)	0	0	0	{cubic metres per sec}
Inlet Properties - High Flow By-pass (cubic metres per sec)	100	100	100	{cubic metres per sec}
Storage Properties - Extended Detention Depth (metres)	0.5	0.5	0.2	{metres}
Storage Properties - Surface Area (square metres)	1211	3990.6	1185	{square metres}
Filter and Media Properties - Filter Area (square metres)	1211	3990.6	1154	{square metres}
Filter and Media Properties - Unlined Filter Media Perimeter (metres)	140	253	138	{metres}
Filter and Media Properties - Saturated Hydraulic Conductivity (mm/hr)	90	90	90	{mm/hr}
Filter and Media Properties - Filter Depth (metres)	0.4	0.65	0.5	{metres}
Filter and Media Properties - TN Content of Filter Media (mg/kg)	500	500	500	{mg/kg}
Filter and Media Properties - Orthophosphate Content of Filter Media (mg/kg)	40	40	40	{mg/kg}
Infiltration Properties - Exfiltration Rate (mm/hr)	1.14	1.14	1.71	{mm/hr}
Outlet Properties - Overflow Weir Width (metres)	35	7	5	{metres}
Outlet Properties - Submerged Zone Depth (metres)	0.2	0.2	0.1	{metres}

14 Attachment F – Typical Bioretention Swale, Basin and Wetland Design



TYPICAL BIOSWALE SECTION

SCALE 1:20 @ A3



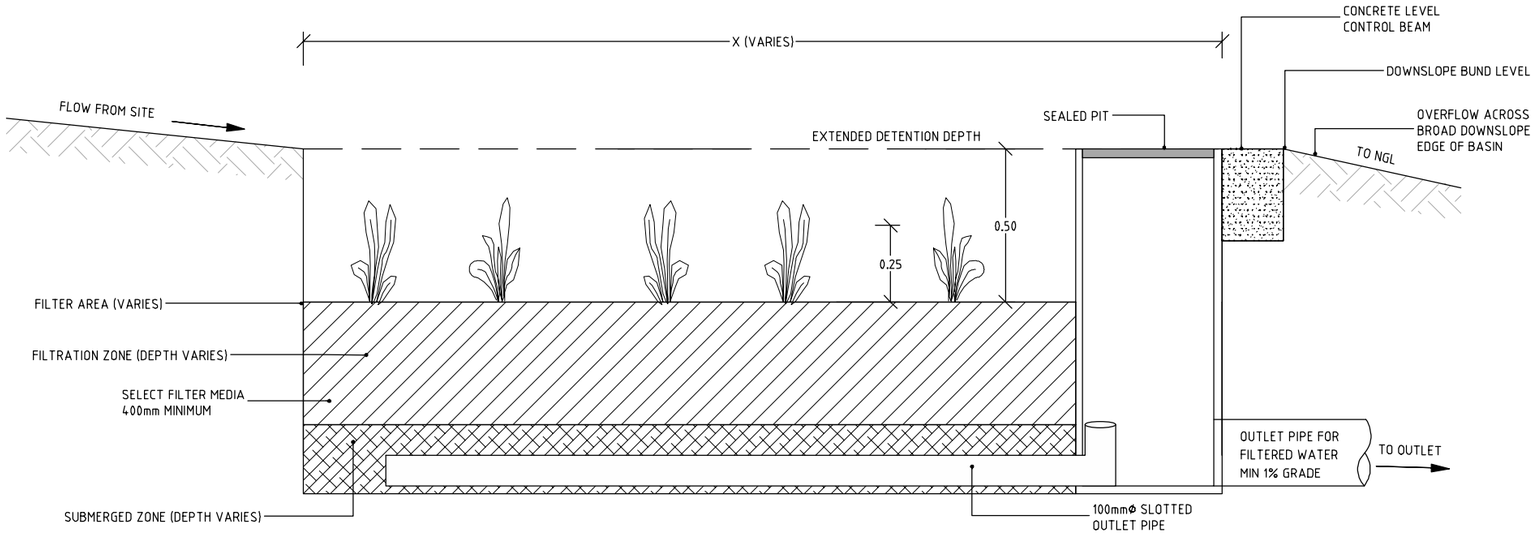
TYPICAL SECTION
ROAD 20m WIDE

SCALE 1:80 @ A3

0 0.2 0.4 0.6 0.8 1.0

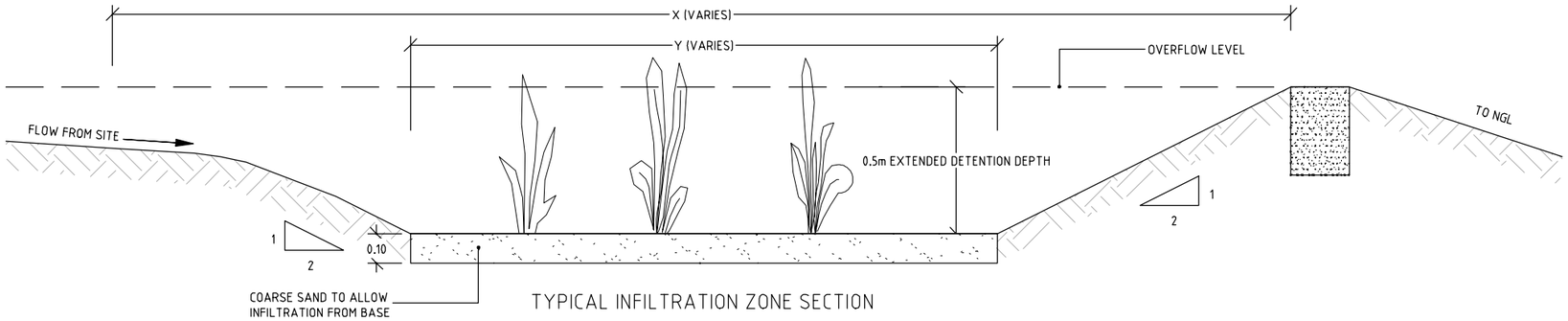
UNITS - METRES

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	KT	**TYPICAL BIOSWALE SECTION CULBURRA WEST, NSW MIXED USE SUBDIVISION**	Drawing No./ID: **SK001**
Approved:	AN		
Date:	4.08.2016		
Scale @A3:	1:20	Suite 201, 20 George St, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 Email: mail@martens.com.au Internet: http://www.martens.com.au	Project: P1203365 / File: JD02V04 / Revision: C



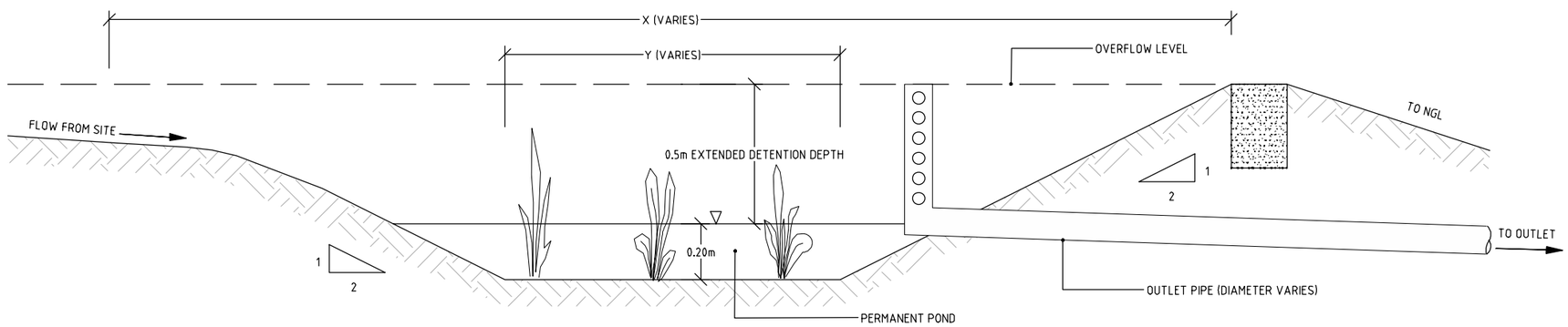
TYPICAL BIOREMEDIATION BASIN SECTION

SCALE 1:20 @ A3



TYPICAL INFILTRATION ZONE SECTION

SCALE 1:20 @ A3



TYPICAL WETLAND SECTION

SCALE 1:20 @ A3

0 0.2 0.4 0.6 0.8 1.0

UNITS - METRES

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	KT	**TYPICAL BIOREMEDIATION BASIN SECTION AND TYPICAL INFILTRATION SYSTEM SECTION CULBURRA WEST, NSW MIXED USE SUBDIVISION**	Drawing No./ID: **SK002**
Approved:	AN		
Date:	4.08.2016		
Scale @A3:	1:20	Suite 201, 20 George St, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 Email: mail@martens.com.au Internet: http://www.martens.com.au	Project: P1203365 / File: JD02V04 / Revision: B

martens

15 Attachment G – Groundwater Quality Laboratory Results

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS 48959

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

Attention: Ben Rose

Sample log in details:

Your Reference:	**P1002842JC01V01, Culburra**
No. of samples:	3 Waters, 60 Soils
Date samples received:	30/11/10
Date completed instructions received:	30/11/10

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

Report Details:

Date results requested by:	7/12/10
Date of Preliminary Report:	01/12/2010
Issue Date:	7/12/10

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:

Kasjan Paciuszkiewicz
Chemist

Nick Sarlamis
Inorganics Supervisor

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-4	48959-5	48959-6	48959-7	48959-8
Your Reference	----------	2842/1	2842/1	2842/1	2842/2	2842/2
Depth	----------	0.5	1.0	1.5	0.2	0.5
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.1	5.0	8.1	5.5	4.7
Electrical Conductivity 1:5 soil:water	µS/cm	57	97	80	23	43

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-9	48959-10	48959-11	48959-12	48959-13
Your Reference	----------	2842/2	2842/24	2842/24	2842/24	2842/24
Depth	----------	1.5	0.2	1.0	1.5	2.0
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.0	5.3	4.8	4.8	4.9
Electrical Conductivity 1:5 soil:water	µS/cm	23	21	55	58	58

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-14	48959-15	48959-16	48959-17	48959-18
Your Reference	----------	2842/13	2842/13	2842/13	2842/3	2842/3
Depth	----------	0.2	0.5	1.0	0.2	0.5
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.1	5.5	5.2	5.3	5.2
Electrical Conductivity 1:5 soil:water	µS/cm	33	24	66	35	56

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-19	48959-20	48959-21	48959-22	48959-23
Your Reference	----------	2842/3	2842/4	2842/4	2842/4	2842/18
Depth	----------	1.0	1.0	1.5	2.0	0.2
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	4.9	4.8	4.7	4.6	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	52	63	68	76	18

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-24	48959-25	48959-26	48959-27	48959-28
Your Reference	----------	2842/18	2842/18	2842/19	2842/19	2842/19
Depth	----------	0.5	1.0	0.2	0.5	1.5
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.1	4.9	5.5	4.9	4.7
Electrical Conductivity 1:5 soil:water	µS/cm	34	44	30	51	83

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-29	48959-30	48959-31	48959-32	48959-33
Your Reference	----------	2842/22	2842/22	2842/6	2842/6	2842/6
Depth	----------	0.2	0.5	0.2	0.5	2.5
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.7	5.3	4.7	4.5	6.1
Electrical Conductivity 1:5 soil:water	µS/cm	21	58	480	1,200	710

sPOCAS field test						
Our Reference:	UNITS	48959-34	48959-35	48959-36	48959-37	48959-38
Your Reference	----------	2842/1	2842/1	2842/1	2842/11	2842/11
Depth	----------	0.5	1.0	1.5	0.5	1.0
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.4	5.1	5.1	5.3	4.7
pH_{FOX} (field peroxide test)*	pH Units	4.5	4.1	4.2	4.4	3.8
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-39	48959-40	48959-41	48959-42	48959-43
Your Reference	----------	2842/24	2842/24	2842/24	2842/24	2842/13
Depth	----------	0.5	1.0	1.5	2.0	0.5
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.1	5.0	5.1	5.2	5.3
pH_{FOX} (field peroxide test)*	pH Units	4.0	4.0	4.1	4.2	4.2
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-44	48959-45	48959-46	48959-47	48959-48
Your Reference	----------	2842/13	2842/4	2842/4	2842/4	2842/4
Depth	----------	1.0	0.5	1.0	1.5	2.0
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.4	5.3	4.9	4.8	4.9
pH_{FOX} (field peroxide test)*	pH Units	4.4	4.3	4.0	4.0	4.0
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-49	48959-50	48959-51	48959-52	48959-53
Your Reference	----------	2842/4	2842/19	2842/19	2842/19	2842/5
Depth	----------	2.5	0.5	1.0	1.5	0.5
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	4.5	5.1	4.8	4.9	5.5
pH_{FOX} (field peroxide test)*	pH Units	3.8	4.2	3.9	3.9	4.5
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-54	48959-55	48959-56	48959-57	48959-58
Your Reference	----------	2842/5	2842/6	2842/6	2842/6	2842/6
Depth	----------	1.0	0.5	1.0	1.5	2.0
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.2	4.5	4.7	5.0	5.2
pH_{FOX} (field peroxide test)*	pH Units	4.1	3.6	4.0	4.5	4.4
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-59	48959-60	48959-61	48959-62	48959-63
Your Reference	----------	2842/6	2842/6	2842/21	2842/21	2842/20
Depth	----------	2.5	3.0	0.5	1.0	1.5
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.8	5.6	5.2	5.3	5.0
pH_{FOX} (field peroxide test)*	pH Units	5.7	5.3	4.1	4.7	4.2
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

Miscellaneous Inorganics				
Our Reference:	UNITS	48959-1	48959-2	48959-3
Your Reference	----------	2842/GMB01/ 25.11.2010	2842/GMB02/ 25.11.2010	2842/GMB06/ 26.11.2010
Depth	----------	-	-	-
Type of sample		Water	Water	Water
Date prepared	-	30/11/2010	30/11/2010	30/11/2010
Date analysed	-	30/11/2010	30/11/2010	30/11/2010
Electrical Conductivity	µS/cm	4,900	250	18,000
Total Dissolved Solids (grav)	mg/L	2,900	180	13,000
pH	pH Units	5.2	5.1	5.6
Nitrate as N in water	mg/L	0.01	0.1	<0.005
Hardness	mg$CaCO_3$ /L	280	8	2,600
NOx as N in water	mg/L	0.02	0.1	0.007
Ammonia as N in water	mg/L	0.3	0.02	0.1
Total Nitrogen in water	mg/L	0.7	0.4	0.3
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05
Phosphate as P in water	mg/L	<0.05	<0.05	<0.05
Silicon*- Dissolved	mg/L	36	36	15
Strontium - Dissolved	mg/L	0.2	<0.01	1.2
Titanium - Dissolved	mg/L	<0.02	<0.02	<0.02

Ion Balance Our Reference: Your Reference Depth Type of sample	UNITS ---------- ----------	48959-1 2842/GMB01/ 25.11.2010 - Water	48959-2 2842/GMB02/ 25.11.2010 - Water	48959-3 2842/GMB06/ 26.11.2010 - Water
Date prepared	-	30/11/2010	30/11/2010	30/11/2010
Date analysed	-	30/11/2010	30/11/2010	30/11/2010
Calcium - Dissolved	mg/L	10	0.6	130
Potassium - Dissolved	mg/L	8.0	0.6	13
Sodium - Dissolved	mg/L	950	38	3,400
Magnesium - Dissolved	mg/L	62	1.6	560
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<0.1	<0.1	<0.1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	23	7	46
Carbonate Alkalinity as $CaCO_3$	mg/L	<0.1	<0.1	<0.1
Total Alkalinity as $CaCO_3$	mg/L	23	7	46
Sulphate, SO4	mg/L	330	22	720
Chloride, Cl	mg/L	1,300	40	6,000
Ionic Balance	%	3.5	3.1	3.9

All metals in water-dissolved				
Our Reference:	UNITS	48959-1	48959-2	48959-3
Your Reference	----------	2842/GMB01/ 25.11.2010	2842/GMB02/ 25.11.2010	2842/GMB06/ 26.11.2010
Depth	----------	-	-	-
Type of sample		Water	Water	Water
Date prepared	-	2/12/2010	2/12/2010	2/12/2010
Date analysed	-	2/12/2010	2/12/2010	2/12/2010
Aluminium-Dissolved	µg/L	260	39	210
Boron-Dissolved	µg/L	200	70	40
Barium-Dissolved	µg/L	71	7	93
Beryllium-Dissolved	µg/L	<0.5	<0.5	0.6
Cadmium-Dissolved	µg/L	1.9	1	3.2
Cobalt-Dissolved	µg/L	52	<1	67
Chromium-Dissolved	µg/L	<1	<1	<1
Copper-Dissolved	µg/L	3	<1	7
Iron-Dissolved	µg/L	1,800	11	13
Manganese-Dissolved	µg/L	950	7	1,100
Molybdenum-Dissolved	µg/L	<1	<1	<1
Nickel-Dissolved	µg/L	38	<1	67
Vanadium-Dissolved	µg/L	<1	<1	<1
Zinc-Dissolved	µg/L	100	42	140
Arsenic-Dissolved	µg/L	2	<1	9
Mercury-Dissolved	µg/L	<0.4	<0.4	<0.4
Lead-Dissolved	µg/L	15	<1	3
Selenium-Dissolved	µg/L	<1	<1	<1

Method ID	Methodology Summary
LAB.1	pH - Measured using pH meter and electrode in accordance with APHA 20th ED, 4500-H+.
LAB.2	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA2510 20th ED and Rayment & Higginson.
LAB.63	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.
LAB.18	Total Dissolved Solids - determined gravimetrically by drying the sample, in accordance with APHA 20th ED, 2540-C.
LAB.55	Nitrate - determined colourimetrically based on EPA353.2. Soils are analysed following a water extraction.
Metals.20 ICP-AES	Determination of various metals by ICP-AES.
LAB.57	Ammonia - determined colourimetrically based on EPA350.1, Soils are analysed following a water extraction.
LAB.66	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen.
LAB.60	Phosphate water extractable - determined colourimetrically based on EPA365.1
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.
Metals.22 ICP-MS	Determination of various metals by ICP-MS.
Metals.21 CV-AAS	Determination of Mercury by Cold Vapour AAS.

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			6/12/2010	48959-4	6/12/2010 || 6/12/2010	LCS-1	6/12/2010
Date analysed	-			6/12/2010	48959-4	6/12/2010 || 6/12/2010	LCS-1	6/12/2010
pH 1:5 soil:water	pH Units		LAB.1	[NT]	48959-4	5.1 || 5.1 || RPD: 0	LCS-1	100%
Electrical Conductivity 1:5 soil:water	µS/cm	1	LAB.2	<1.0	48959-4	57 || 53 || RPD: 7	LCS-1	107%

QUALITY CONTROL sPOCAS field test	UNITS	PQL	METHOD	Blank
pH_F (field pH test)*	pH Units		LAB.63	[NT]
pH_{FOX} (field peroxide test)*	pH Units		LAB.63	[NT]

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			30/11/2010	[NT]	[NT]	LCS-W1	30/11/2010
Date analysed	-			30/11/2010	[NT]	[NT]	LCS-W1	2/12/2010
Electrical Conductivity	µS/cm	1	LAB.2	<1.0	[NT]	[NT]	LCS-W1	104%
Total Dissolved Solids (grav)	mg/L	5	LAB.18	<5	[NT]	[NT]	LCS-W1	106%
pH	pH Units		LAB.1	[NT]	[NT]	[NT]	LCS-W1	102%
Nitrate as N in water	mg/L	0.005	LAB.55	<0.005	[NT]	[NT]	LCS-W1	91%
Hardness	$mgCaCO_3/L$	3	Metals.20 ICP-AES	<3	[NT]	[NT]	[NR]	[NR]
NOx as N in water	mg/L	0.005	LAB.55	<0.005	[NT]	[NT]	LCS-W1	91%
Ammonia as N in water	mg/L	0.005	LAB.57	<0.005	[NT]	[NT]	LCS-W1	93%
Total Nitrogen in water	mg/L	0.1	LAB.66	<0.1	[NT]	[NT]	LCS-W1	86%
Phosphorus - Total	mg/L	0.05	Metals.20 ICP-AES	<0.05	[NT]	[NT]	LCS-W1	97%
Phosphate as P in water	mg/L	0.005	LAB.60	<0.005	[NT]	[NT]	LCS-W1	101%
Silicon*- Dissolved	mg/L	0.2	Metals.20 ICP-AES	<0.2	[NT]	[NT]	LCS-W1	100%
Strontium - Dissolved	mg/L	0.01	Metals.20 ICP-AES	<0.01	[NT]	[NT]	LCS-W1	90%
Titanium - Dissolved	mg/L	0.02	Metals.20 ICP-AES	<0.02	[NT]	[NT]	LCS-W1	96%

QUALITY CONTROL Ion Balance	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			30/11/2010	[NT]	[NT]	LCS-W1	30/11/2010
Date analysed	-			30/11/2010	[NT]	[NT]	LCS-W1	30/11/2010
Calcium - Dissolved	mg/L	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-W1	91%
Potassium - Dissolved	mg/L	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-W1	103%
Sodium - Dissolved	mg/L	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-W1	100%
Magnesium - Dissolved	mg/L	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-W1	92%
Bicarbonate Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	[NT]	[NT]	LCS-W1	104%
Carbonate Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	[NT]	[NT]	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	[NT]	[NT]	LCS-W1	104%
Sulphate, SO4	mg/L	1	LAB.81	<1.0	[NT]	[NT]	LCS-W1	108%
Chloride, Cl	mg/L	1	LAB.81	<1.0	[NT]	[NT]	LCS-W1	94%
Ionic Balance	%		LAB.41	[NT]	[NT]	[NT]	[NR]	[NR]

QUALITY CONTROL All metals in water-dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			2/12/2010	48959-1	2/12/2010 || 2/12/2010	LCS-W1	02/12/2010
Date analysed	-			2/12/2010	48959-1	2/12/2010 || 2/12/2010	LCS-W1	02/12/2010
Aluminium-Dissolved	µg/L	10	Metals.22 ICP-MS	<10	48959-1	260 || 260 || RPD: 0	LCS-W1	103%
Boron-Dissolved	µg/L	5	Metals.22 ICP-MS	<5	48959-1	200 || 190 || RPD: 5	LCS-W1	83%
Barium-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	71 || 67 || RPD: 6	LCS-W1	99%
Beryllium-Dissolved	µg/L	0.5	Metals.22 ICP-MS	<0.5	48959-1	<0.5 || <0.5	LCS-W1	80%
Cadmium-Dissolved	µg/L	0.1	Metals.22 ICP-MS	<0.1	48959-1	1.9 || 2.0 || RPD: 5	LCS-W1	100%
Cobalt-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	52 || 52 || RPD: 0	LCS-W1	96%
Chromium-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	<1 || <1	LCS-W1	95%
Copper-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	3 || 3 || RPD: 0	LCS-W1	91%
Iron-Dissolved	µg/L	10	Metals.22 ICP-MS	<10	48959-1	1800 || 1800 || RPD: 0	LCS-W1	91%
Manganese-Dissolved	µg/L	5	Metals.22 ICP-MS	<5	48959-1	950 || 950 || RPD: 0	LCS-W1	91%

QUALITY CONTROL All metals in water-dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Molybdenum-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	<1 || <1	LCS-W1	99%
Nickel-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	38 || 38 || RPD: 0	LCS-W1	89%
Vanadium-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	<1 || <1	LCS-W1	95%
Zinc-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	100 || 100 || RPD: 0	LCS-W1	95%
Arsenic-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	2 || 2 || RPD: 0	LCS-W1	90%
Mercury-Dissolved	µg/L	0.4	Metals.21 CV-AAS	<0.4	48959-1	<0.4 || <0.4	LCS-W1	100%
Lead-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	15 || 15 || RPD: 0	LCS-W1	96%
Selenium-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	<1 || <1	LCS-W1	92%

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	48959-14	6/12/2010 || 6/12/2010	LCS-2	6/12/2010
Date analysed	-	48959-14	6/12/2010 || 6/12/2010	LCS-2	6/12/2010
pH 1:5 soil:water	pH Units	48959-14	5.1 || 5.0 || RPD: 2	LCS-2	100%
Electrical Conductivity 1:5 soil:water	µS/cm	48959-14	33 || 34 || RPD: 3	LCS-2	106%

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	48959-25	6/12/2010 || 6/12/2010
Date analysed	-	48959-25	6/12/2010 || 6/12/2010
pH 1:5 soil:water	pH Units	48959-25	4.9 || 5.0 || RPD: 2
Electrical Conductivity 1:5 soil:water	µS/cm	48959-25	44 || 54 || RPD: 20

Report Comments:
Phosphate:PQL raised due to sample matrix.

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job
Asbestos counting was analysed by Approved Counter:	@ERROR
Asbestos counting was authorised by Approved Signatory:	@ERROR

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

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 batched of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the 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.

16 Attachment H – Agency Consultation

Megan Kovelis

From: Dollery, Ian <dolleryi@shoalhaven.nsw.gov.au>
Sent: Thursday, 15 March 2012 8:52 AM
To: Megan Kovelis
Subject: RE: West Culburra subdivision

Megan

At this point in time I can't foresee any problem with doing so. Without the policy and the development coming direct to council, we would probably place conditions on a consent requiring similar outcomes.

Regards

Ian Dollery
Subdivision Engineer
Shoalhaven City Council

☎02 4429 3308 | 02 4429 3178
dolleryi@shoalhaven.nsw.gov.au
http://shoalhaven.nsw.gov.au

From: Megan Kovelis [mailto:mkovelis@martens.com.au]
Sent: Wednesday, 14 March 2012 4:12 PM
To: Dollery, Ian
Cc: Andrew Norris
Subject: RE: West Culburra subdivision

Ian,

Thank you for sending that information through. As discussed, our current MUSIC modelling approach is to achieve a 'neutral or beneficial impact' when comparing the pre- and post-development scenarios. Based on the information provided, we will also consider the pollutant objectives in Table 5.2 of the draft DCP.

Do you anticipate that Council would be happy with this modelling approach?

Kind Regards,

Martens & Associates Pty Ltd

Megan Kovelis
Environmental Scientist
BEnvSc (Hons1)

Martens & Associates Pty Ltd
Unit 6/37 Leighton Place
Hornsby, NSW 2077
P + 61 2 9476 9999
F + 61 2 9476 8767

From: Dollery, Ian [mailto:dolleryi@shoalhaven.nsw.gov.au]
Sent: Tuesday, 13 March 2012 4:36 PM
To: Megan Kovelis
Subject: West Culburra subdivision

Megan

Hope this helps!

Regards

Ian Dollery
Subdivision Engineer
Shoalhaven City Council

☎02 4429 3308 | 02 4429 3178
dolleryi@shoalhaven.nsw.gov.au
http://shoalhaven.nsw.gov.au

This message may contain both confidential and privileged information intended only for the addressee named above.
If you have received this email in error, please notify the sender immediately then destroy the original message.

Megan Kovelis

From: allan.lugg@dpi.nsw.gov.au
Sent: Thursday, 14 February 2013 12:25 PM
To: Megan Kovelis
Cc: trevor.daly@dpi.nsw.gov.au
Subject: MP09_0088 West Culburra Urban Expansion - Stormwater Modelling

Hi Megan,

as discussed, I can confirm that we have discussed the modelling approach being undertaken for the proposed West Culburra subdivision by Martens and Associates.

From our discussion, I understand that the modelling will compare pre-development conditions with post-development conditions and aim to achieve a Neutral or Beneficial Impact upon Curleys Bay and the Crookhaven River estuary (where there are numerous oyster farms) with respect to suspended sediment, nitrogen and phosphorus. I believe that is a reasonable approach.

As discussed, I also recommend that you give some consideration to the potential impacts upon bacterial levels and the potential implications for oyster farming.

Regards Allan

Allan Lugg | Senior Fisheries Conservation Manager
NSW Department of Primary Industries
4 Woollamia Road | PO Box 97 | HUSKISSON NSW 2540
T: 02 4428 3401 | F: 02 4441 8961 | M: 0409 912 686 | E: Allan.Lugg@dpi.nsw.gov.au
W: http://www.dpi.nsw.gov.au/fisheries

Megan Kovelis

From: Miles Boak <Miles.Boak@environment.nsw.gov.au>
Sent: Friday, 8 February 2013 2:11 PM
To: Megan Kovelis
Subject: FW: West Culburra Proposed Subdivision - Water Quality Modelling
Attachments: DOC10-22366 DECCW DG-EARs & Attachments 24 May 2010.pdf; ATT00001..txt; ATT00002..htm

Hi Megan

OEH are happy with the approach taken for water quality assessment - of applying MUSIC modelling guidelines with a view to achieving neutral and beneficial impact on water quality. OEH provided comments in this regard on the West Culburra DGRs in May 2010 (attached) which provide more detail.

Cheers
Miles Boak

Miles Boak
Conservation Planner - Regional Operations
Office of Environment and Heritage
NSW Department of Premier and Cabinet
PO Box 733, Queanbeyan, NSW 2620
T: 02 62297095 M: 0427919192
W: www.environment.nsw.gov.au

From: Megan Kovelis [mailto:mkovelis@martens.com.au]
Sent: Wednesday, 14 March 2012 12:28 PM
To: Thompson Julian
Cc: Andrew Norris
Subject: West Culburra Proposed Subdivision - Water Quality Modelling

Julian,

I appreciate your time this morning. As discussed, based on Council DCP water quality requirements and NSW OEH requirements for the nearby West Culburra Golf Course, we are undertaking our MUSIC modelling to achieve neutral or beneficial impacts (pre development versus post development) for the proposed subdivision development.

MUSIC inputs (EMC's, pervious area parameters etc) are based on NSW CMA (2010) '*Sydney Metropolitan: Draft NSW MUSIC Modelling Guidelines*'.

I trust that OEH agree with this modelling approach.

Kind Regards,

Martens & Associates Pty Ltd

Megan Kovelis
Environmental Scientist
BEnvSc (Hons1)

17 Attachment I – MUSIC Model Sensitivity Analysis

Table 24: MUSIC results – assessment period (1964 to 1970) – site receivers with vegetation uptake.

Scenario	Location	Flow (ML/yr)	Peak Flow (m^3/s)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Site – Pre Development	Crookhaven River	296	28.6	12319	26.5	180.2
	Lake Wollumboola	19	2.0	214	0.5	5.2
	Billys Island inlet (SEPP 14 Wetlands)	104	10.8	1180	2.7	31.5
	Seagrass and Oyster Leases	192	17.8	11139	23.8	148.7
	Curleys Bay	92	7.4	8890	16.1	94.5
Site – Post Development	Crookhaven River	381	20.9	10067	22.3	162.2
	Lake Wollumboola	16	1.0	125	0.5	4.5
	Billys Island inlet (SEPP 14 Wetlands)	105	6.2	510	2.5	26.6
	Seagrass and Oyster Leases	276	14.6	9557	19.8	135.6
	Curleys Bay	88	6.2	8660	15.2	89.1
Change (%)	Crookhaven River	28%	-27%	-18%	-16%	-10%
	Lake Wollumboola	-15%	-49%	-42%	-1%	-15%
	Billys Island inlet (SEPP 14 Wetlands)	1%	-42%	-57%	-9%	-16%
	Seagrass and Oyster Leases	43%	-18%	-14%	-17%	-9%
	Curleys Bay	-4%	-16%	-3%	-6%	-6%
Complies with NorBE (Y/N)	Crookhaven River	–	–	Y	Y	Y
	Lake Wollumboola	–	–	Y	Y	Y
	Billys Island inlet (SEPP 14 Wetlands)	–	–	Y	Y	Y
	Seagrass and Oyster Leases	–	–	Y	Y	Y
	Curleys Bay	–	–	Y	Y	Y

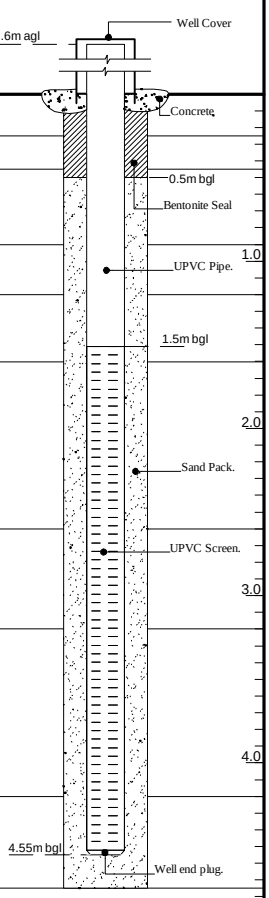
Table 25: MUSIC results – assessment period (1964 to 1970) – site receivers without vegetation uptake (results not achieving NorBe highlighted in green).

Scenario	Location	Flow (ML/yr)	Peak Flow (m^3/s)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Site – Pre Development	Crookhaven River	296	28.6	13639	33.0	250.7
	Lake Wollumboola	19	2.0	287	0.9	9.4
	Billys Island inlet (SEPP 14 Wetlands)	104	10.8	1550	4.6	50.3
	Seagrass and Oyster Leases	192	17.8	12089	28.4	200.4
	Curleys Bay	92	7.4	9180	17.9	114.0
Site – Post Development	Crookhaven River	381	20.9	12433	42.8	345.7
	Lake Wollumboola	16	1.0	318	2.0	18.6
	Billys Island inlet (SEPP 14 Wetlands)	105	6.2	1270	9.2	88.9
	Seagrass and Oyster Leases	276	14.6	11163	33.6	256.8
	Curleys Bay	88	6.2	9140	17.7	115.0
Change (%)	Crookhaven River	28%	-27%	-9%	30%	38%
	Lake Wollumboola	-15%	-49%	11%	135%	97%
	Billys Island inlet (SEPP 14 Wetlands)	1%	-42%	-18%	98%	77%
	Seagrass and Oyster Leases	43%	-18%	-8%	19%	28%
	Curleys Bay	-4%	-16%	0%	-1%	1%
Complies with NorBE (Y/N)	Crookhaven River	–	–	Y	N	N
	Lake Wollumboola	–	–	N	N	N
	Billys Island inlet (SEPP 14 Wetlands)	–	–	Y	N	N
	Seagrass and Oyster Leases	–	–	Y	N	N
	Curleys Bay	–	–	Y	Y	N

18 Attachment J - Borelogs

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	22.11.10	**COMPLETED**	22.11.10	**REF**	**BH1**
PROJECT	**Engineering Services**	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 4.75m 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	0.25			SC	SILTY CLAYEY SAND – Dark brown, fine grained sands.		L	A	0.2	2842/1/0.2
A	Nil	N	M	0.45			SC	SILTY CLAYEY SAND – Light grey, fine grained sands, minor gravels.		L	A	0.4	2842/1/0.4
A	Nil	N	M	0.6 0.9			CL	SILTY CLAY - Brown/orange, gravels (1-15mm, 35%), tending to clay with gravels decreasing.	F St		A	0.5	2842/1/0.5
A	Nil	N	M	1.0 1.2			CH	CLAY - Grey/orange/red mottled.	VSt		A	1.0	2842/1/1.0
A	Nil	N	M	1.6			CL	SANDY CLAY/EXTREMELY WEATHERED SILTSTONE - Light grey, yellow, cream bands, gravels (approx 5-50mm).	VSt	MD	A	1.5	2842/1/1.5
A	Nil	N	D	2.0 2.6			EW HW	EXTREMELY TO HIGHLY WEATHERED SILTSTONE.		MD D	A A	2.0 2.5	2842/1/2.0 2842/1/2.5
A	Nil	N	D	3.0 3.2			MW	MODERATELY WEATHERED SILTSTONE GRAVELLY CLAY.					
A	Nil	N	M	4.0 4.2			CL EW	CLAY/EXTREMELY WEATHERED SILTSTONE - Grey.	F St		A	3.5	2842/1/3.5
A	Nil	N	D	4.75			MW	MODERATELY WEATHERED SILTSTONE.		D	A	4.5	2842/1/4.5
				5.0 6.0 7.0 8.0 9.0				Borehole terminated at 4.75m on moderately to slightly weathered siltstone.					



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

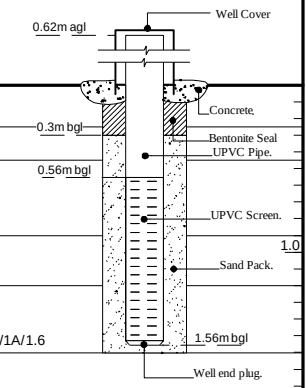
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St, 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	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH1A**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 1.6m 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)	WATER WELL DETAILS
A	Nil	N	M	0.25			SC	SILTY CLAYEY SAND – Dark brown, fine grained sands.		L			
A	Nil	N	M	0.45			SC	SILTY CLAYEY SAND – Light grey, fine grained sands, minor gravels.		L			
A	Nil	N	M	0.6 0.9			CL	SILTY CLAY - Brown/orange, gravels (1-15mm, 35%), tending to clay with gravels decreasing.	F St				
A	Nil	N	M	1.0 1.2			CH	CLAY - Grey/orange/red mottled.	VSt				
A	Nil	N	M	1.6			CL	SANDY CLAY/EXTREMELY WEATHERED SILTSTONE - Light grey, yellow, cream bands, gravels (approx 5-50mm).	VSt	MD	A	1.6	2842/1A/1.6
								Borehole terminated at 1.6m on clay/extremely weathered siltstone.					



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
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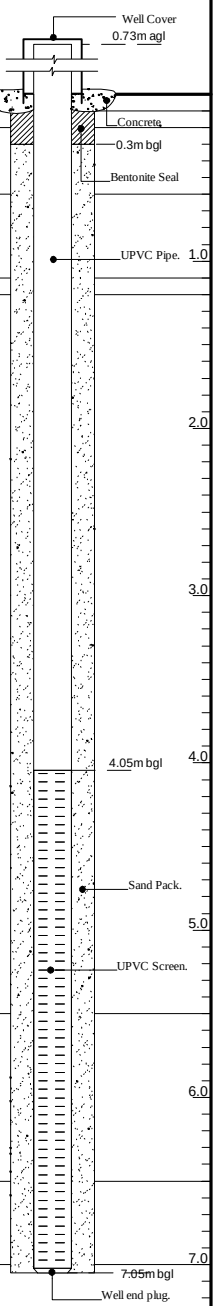
Engineering Log - Borehole

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	22.11.10	**COMPLETED**	22.11.10	**REF**	**BH2**
PROJECT	**Engineering Services**	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 7.0m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	3-4%

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 SILTY CLAY – Dark grey/black.	S				
A	Nil	N	M	0.2			CL	SILTY CLAY – Brown/light brown.	S		A	0.2	2842/2/0.2+B
A	Nil	N	M	0.6			CL	CLAY – Red, moderately plastic, with light brown/grey mottles increassing with depth.	F		A	0.5	2842/2/0.5+Att
A	Nil	N	M	1.0 1.1			CH	CLAY – Red, medium plasticity, grey/brown mottles.	St		A	1.0	2842/2/1.0
A	Nil	N	M	1.2			CH	CLAY - Grey with minor red/brown mottles.	VSt		A	1.2	2842/2/1.2
A	Nil	N	D M	2.0 3.0 4.0 5.0 5.5			CL EW	CLAY - EXTREMELY WEATHERED SILTSTONE - Clay to sandy clay, weathered gravels, grey/red/brown.	VSt		A A A A	1.5 2.0 2.5 4.5	2842/2/1.5 2842/2/2.0 2842/2/2.5 2842/2/4.5
A	Nil	N	M	6.0 6.5			CL	SILTSTONE CLAY - Brown/dark grey, minor gravels, highly weathered siltstone.	St		A	6.0	2842/2/6.0
A	Nil	N	W	7.0			CL EW	CLAY - Dark grey/brown, clay/extremely weathered siltstone.	VSt		A	7.0	2842/2/7.0
				8.0 9.0				Borehole terminated at 7.0m 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

Quality Sheet No. 4

martens

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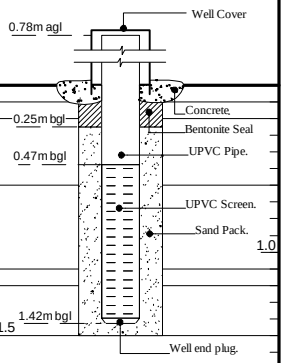
Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH2A**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 1.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	3-4%

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 SILTY CLAY – Dark grey/black.	S				
A	Nil	N	M	0.2			CL	SILTY CLAY – Brown/light brown.	S				
A	Nil	N	M	0.6			CL	CLAY – Red, moderately plastic, with light brown/grey mottles increassing with depth.	F				
A	Nil	N	M	1.0 1.1			CH	CLAY – Red, medium plasticity, grey/brown mottles.	St				
A	Nil	N	M	1.2			CH	CLAY - Grey with minor red/brown mottles.	VSt				
A	Nil	N	D M	1.5			CL EW	CLAY TO EXTREMELY WEATHERED SILTSTONE - Clay to sandy clay, weathered gravels, grey/red/brown.	VSt		A	1.5	2842/2A/1.5
								Borehole terminated at 1.5m on extremely weathered siltstone.					



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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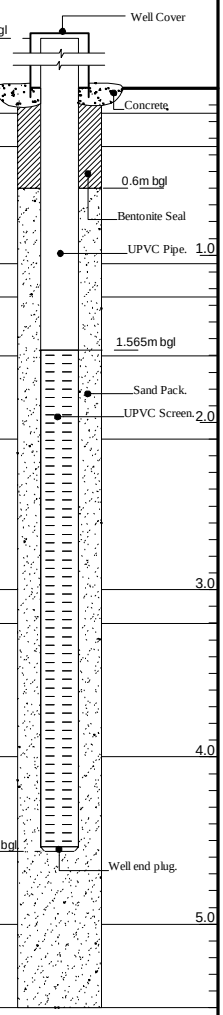
Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH3**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 5.5m 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)	WATER WELL DETAILS
A	Nil	N	M	0.15			SM	SILTY SAND – Brown/dark brown, minor gravels.		L	A	0.2	2842/3/0.2
A	Nil	N	M	0.35			SP	SAND – Light brown/brown, medium grained sands, gravels (1-5mm, approx 10%).		L			
A	Nil	N	M	0.8 1.0 1.05			CL	CLAY - Yellow/brown/orange, red weathered siltstone bands increasing with depth.	F St		A A	0.5 1.0	2842/3/0.5 2842/3/1.0
A	Nil	N	M	1.25			CL/HW	SANDY CLAY/HIGHLY WEATHERED SILTSTONE - Orange/grey.	VSt		A	1.2	2842/3/1.2
A	Nil	N	M	1.6			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Grey with red/orange mottles, siltstone bands/gravels.	VSt		A	1.5	2842/3/1.5
A	Nil	N	M	2.0 2.1			CL MW EW	CLAY - MODERATELY TO EXTREMELY WEATHERED SILTSTONE - Grey with red/pink mottles.	VSt		A	2.0	2842/3/2.0
A	Nil	N	D	3.0			SC EW	CLAYEY SAND/EXTREMELY WEATHERED SILTSTONE - Grey/pink/red, fine to medium grained sands.	VSt		A	2.5	2842/3/2.5
A	Nil	N	D	3.2			MW	MODERATELY WEATHERED SILTSTONE - Orange brown.					
A	Nil	N	D	4.0			HW/EW	HIGHLY/EXTREMELY WEATHERED SILTSTONE.			B	4.0	2842/3/4.0
A	Nil	N	D	5.0			MW/SW	MODERATELY/SLIGHTLY WEATHERED SILTSTONE.					
A	Nil	N	D	5.5			EW/MW	EXTREMELY/MODERATELY WEATHERED SILTSTONE.					
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on moderately weathered siltstone.					



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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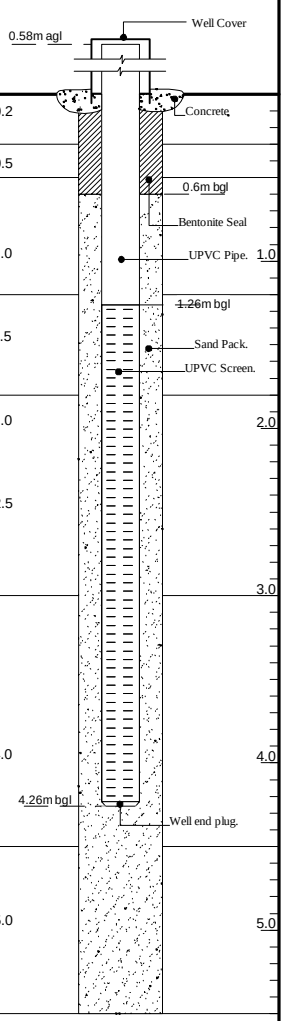
Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH4**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 5.5m 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)	WATER WELL DETAILS
A	Nil	N	M	0.3			SM	SILTY SAND – Brown, gravels (1-10mm, approx 10%).		L	A	0.2	2842/4/0.2
A	Nil	N	M	0.5			CL	CLAY - Brown/orange, mottles increasing with depth, gravels (1-10mm, approx 10%).	S		A	0.5	2842/4/0.5
A	Nil	N	M	1.0 1.2			CL	CLAY - Grey/brown/red mottles, minor gravels.		F	A	1.0	2842/4/1.0
A	Nil	N	M	1.8			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Grey with red/orange mottles, siltstone bands/gravels.	VSt		A	1.5	2842/4/1.5
A	Nil	N	M	2.0 3.0			CL MW EW	CLAY - MODERATELY TO EXTREMELY WEATHERED SILTSTONE - Grey with red/pink mottles.	VSt		A A	2.0 2.5	2842/4/2.0 2842/4/2.5
A	Nil	N	D	4.0 4.5			SC EW	CLAYEY SAND/EXTREMELY WEATHERED SILTSTONE - Grey/pink/red/orange, fine to medium grained sands.	VSt		B	4.0	2842/4/4.0
A	Nil	N	D	5.0 5.5			EW/ MW	EXTREMELY/MODERATELY WEATHERED SILTSTONE - Grey/red/pink/orange.			A	5.0	2842/4/5.0
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on extremely/moderately weathered siltstone.					



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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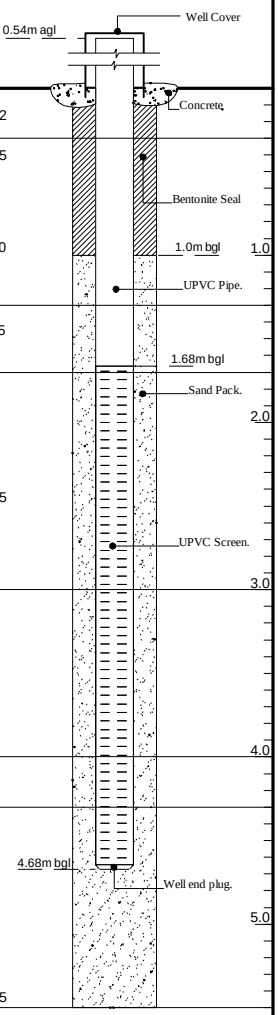
Engineering Log - Borehole

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH5**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	5%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	WATER WELL DETAILS
A	Nil	N	M	0.3			OL	ORGANIC SANDY SILT – Dark brown.	S		A	0.2	2842/5/0.2
A	Nil	N	M	1.0 1.3			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F-St		A A	0.5 1.0	2842/5/0.5 2842/5/1.0
A	Nil	N	D	1.7			EW	EXTREMELY WEATHERED SILTSTONE - Orange/grey mottled, dry.			A	1.5	2842/5/1.5
A	Nil	N	D	2.0 3.0			MW	MODERATELY WEATHERED SILTSTONE - Orange/grey mottled, dry.			A	2.5	2842/5/2.5
A	Nil	N	D	4.0			EW	EXTREMELY WEATHERED SILTSTONE - Orange/grey mottled, dry.					
A	Nil	N	D	4.3			SW	SLIGHTLY WEATHERED SILTSTONE.					
A	Nil	N	D	5.0 5.5			MW	MODERATELY WEATHERED WITH EXTREMELY WEATHERED SILTSTONE BANDS.			B	5.5	2842/5/5.5
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on moderately weathered siltstone.					



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
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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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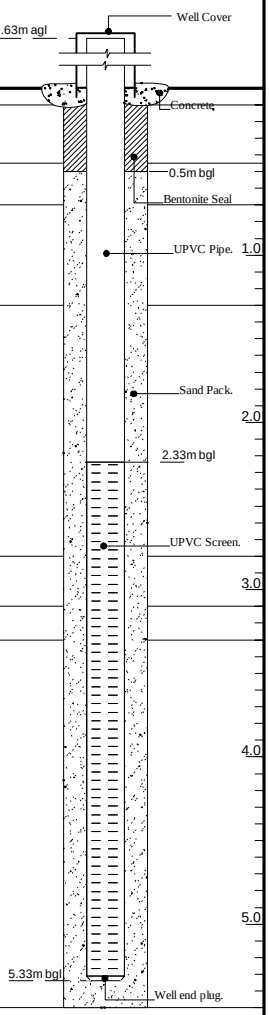
Engineering Log - Borehole

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH6**
PROJECT	**Engineering Services**	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	North	**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			CL	SILTY SANDY CLAY – Dark grey/brown.	S				
A	Nil	N	M	0.45			CL	SILTY SAND CLAY – Brown/light brown.	S		A A	0.2 0.5	2842/6/0.2 2842/6/0.5
A	Nil	N	M	0.7			CL	CLAY - Red/orange with light brown mottles increasing with depth, minor gravels (1-10mm, approx 5%).	St				
A	Nil	N	M	1.0 1.3			CH	CLAY - Grey/cream with red/brown mottles, moderately plastic, gravels (1-5mm, approx 20%).	St		A	1.0	2842/6/1.0
A	Nil	N	M	2.0 2.8			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Light grey with red mottles, siltstone gravels bands increasing with depth.	VSt		A A A	1.5 2.0 2.5	2842/6/1.5 2842/6/2.0 2842/6/2.5
A	Nil	N	M	3.0 3.1			CL MW	SANDY CLAY - MODERATELY WEATHERED SILTSTONE - Light brown, gravels (1-50mm, approx 15%).	VSt		B	3.0	2842/6/3.0
A	Nil	N	D	3.3			CL/ HW	CLAY/HIGHLY WEATHERED SILTSTONE - Light grey.	VSt				
A	Nil	N	W	4.0 5.0 5.5			CL EW	CLAY - EXTREMELY WEATHERED SILTSTONE - Dark brown/dark grey with bands of grey clay.	VSt		A B A	3.5 4.5 5.5	2842/6/3.5 2842/6/4.5 2842/6/5.5
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on extremely weathered siltstone.					



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	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH7**
PROJECT	Engineering Services	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1** of **1**
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	4%

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 SANDY SILT – Dark brown.	S				
A	Nil	N	M	0.3			SC	CLAYEY SAND - Brown, moist (almost wet), loose.		L	A	0.2	2842/7/0.2
A	Nil	N	M	1.0 1.2			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F		A A	0.5 1.0	2842/7/0.5 2842/7/1.0 1.0
A	Nil	N	D	1.6			EW	EXTREMELY WEATHERED SILTSTONE - Grey, clay like properties.			A	1.5	2842/7/1.5
A	Nil	N	D	2.0 2.5			MW	MODERATELY WEATHERED WITH EXTREMELY WEATHERED SILTSTONE BANDS.					2.0 Borehole left open and checked 2 hours after drillinh and found dry.
				3.0				Borehole terminated at 2.5m on moderately weathered siltstone.					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	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH8**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	5%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.1			OL	ORGANIC SANDY SILT – Dark brown.	S				
A	Nil	N	M	0.3			SC	CLAYEY SAND - Brown, moist (almost wet), loose.		L	A	0.2	2842/7/0.2
A	Nil	N	M	1.0 1.3			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F		A A	0.5 1.0	2842/7/0.5 2842/7/1.0
A	Nil	N	D	1.6			EW	EXTREMELY WEATHERED SILTSTONE - Grey, red mottles, clay like properties.			A	1.5	2842/7/1.5
A	Nil	N	D	1.9			EW	EXTREMELY WEATHERED SILTSTONE - Orange, clay like properties.					
A	Nil	N	D	2.0 2.5			MW	MODERATELY WEATHERED SILTSTONE - Grey.			A	2.0	2842/7/2.0 Borehole dry after 2 hours.
								Borehole terminated at 2.5m on moderately weathered siltstone.					

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

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Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP9**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1** of **1**
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.5m depth	**NORTHING**	NA	**ASPECT**	Sourth	**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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.35			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/9/0.2
BH	Nil	N	M	0.6 0.9			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/9/0.5
BH	Nil	N	M	1.0 1.4			CL	CLAY - Grey/red/orange mottled, moderately plastic.	VSt		B	1.0	2842/9/1.0 1.0
BH	Nil	N	M	2.0			CL/HW	CLAY/HIGHLY WEATHERED SILTSTONE - Grey/pink/red/orange, siltstone gravels bands, tending to extremely weathered siltstone at 1.8m.	VSt		B B	1.5 2.0	2842/9/1.5 2842/9/2.0 2.0
BH	Nil	N	M	2.5			MW	MODERATELY WEATHERED SILTSTONE - With grey/orange/red mottling.	VSt				
				3.0				Test pit terminated at 2.5m on moderately weathered siltstone.					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 - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP10**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.0m depth	**NORTHING**	NA	**ASPECT**	North West	**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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.3			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/10/ 0.2
BH	Nil	N	M	0.5			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/10/ 0.5
BH	Nil	N	M	0.8 1.0			CL	CLAY - Grey/red/orange mottled, moderately plastic.	VSt		B	1.0	2842/10/ 1.0 1.0
BH	Nil	N	M	1.3			CL/ EW	CLAY/EXTREMELY WEATHERED SILTSTONE - Grey minor mottles, moderately weathered siltstone bands, tending to moderately weathered siltstone.	VSt		B	1.5	2842/10/ 1.5
				2.0				Test pit terminated at 2.0m on moderately/slightly weathered siltstone.			B	2.0	2842/10/ 2.0 2.0
				3.0									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 - Excavation

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH11**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.0m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	4%

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			OL	ORGANIC SANDY SILT – Dark brown.	S		A	0.2	2842/11/ 0.2
A	Nil	N	M	1.0 1.3			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F-St		A A	0.5 1.0	2842/11/ 0.5 2842/11/ 1.0
A	Nil	N	D	1.8			EW	EXTREMELY WEATHERED SILTSTONE - Grey with mottled.			A	1.5	2842/11/ 1.5
A	Nil	N	D	2.0			MW	MODERATELY WEATHERED SILTSTONE - Grey with mottled. Borehole terminated at 2.0m on moderately weathered siltstone.					

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	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP12**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.2m 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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.3			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/12/ 0.2
BH	Nil	N	M	0.5			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/12/ 0.5
BH	Nil	N	M	0.7 1.0			CL	CLAY - Grey/red/orange mottled, moderately plastic.	VSt		B	1.0	2842/12/ 1.0
BH	Nil	N	M	1.3 2.0			CL/ EW	CLAY/EXTREMELY WEATHERED SILTSTONE - Grey minor mottles, moderately weathered siltstone bands, tending to moderately weathered siltstone.	VSt		B	1.5	2842/12/ 1.5
				2.2				Test pit terminated at 2.2m on moderately weathered siltstone.					
				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
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Engineering Log - Excavation

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH13**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	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)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.25			ML	ORGANIC SILTY/CLAYEY SAND - Dark brown, moist.	S		A	0.2	2842/13/ 0.2
A	Nil	0.4 ▽	M	0.4			CL	SANDY CLAY - Light brown, moist.	F				
A	Nil	N	W	0.7			CL	GRAVELLY CLAY - Brown, wet (perched), gravels (5- 10mm, 10-40%), minor sand.	S-F		A	0.5	2842/13/ 0.5
A	Nil	N	M	1.0 1.3			CL	CLAY - Brown and orange mottled, firm to stiff, moist.	F-St		A	1.0	2842/13/ 1.0
A	Nil	N	M	1.7			EW	EXTREMELY WEATHERED SILTSTONE - Brown/grey mottled, dry side of moist.			A	1.5	2842/13/ 1.5
A	Nil	N	M	2.0 2.5			MW	MODERATELY WEATHERED SILTSTONE - Light grey.			A	2.0	2842/13/ 2.0
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.5m on moderately weathered siltstone.					

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	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP14**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 1.5m 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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.25			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/14/ 0.2
BH	Nil	N	M	0.35			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/14/ 0.5
BH	Nil	N	M	0.8			CL	CLAY - Light grey/grey with brown/orange mottled.	VSt				
BH	Nil	N	M	1.0			EW	EXTREMELY WEATHERED SILTSTONE BANDS.	VSt		B	1.0	2842/14/ 1.0
BH	Nil	N	M	1.5			MW	MODERATELY WEATHERED SILTSTONE - Grey, minor mottles.	VSt		B B	1.2 1.5	2842/14/ 1.2 2842/14/ 1.5
				2.0				Test pit terminated at 1.5m on moderately weathered siltstone.					
				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

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Engineering Log - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP15**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.7m depth	**NORTHING**	NA	**ASPECT**	North	**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)	RESULTS AND ADDITIONAL OBSERVATIONS	
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L				
BH	Nil	N	M	0.2			SM			L	B	0.2	2842/15/ 0.2	
								SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).						
BH	Nil	N	M	0.6			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/15/ 0.5	
				0.9										
				1.0							B	1.0	2842/15/ 1.0	1.0
BH	Nil	N	M				CL	CLAY - Grey/red/orange mottled, moderately plastic.	VSt		B	1.5	2842/15/ 1.5	
				1.7										
				2.0							B	2.0	2842/15/ 2.0	2.0
BH	Nil	N	M				CL/ HW	CLAY/HIGHLY WEATHERED SILTSTONE - Grey/pink/red, siltstone gravels bands, tending to extremely weathered siltstone past 2.3m.	VSt		B B	2.5 2.6	2842/15/ 2.5 2842/15/ 2.6	
				2.7										
				3.0				Test pit terminated at 2.7m on extremely weathered siltstone.						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

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Engineering Log - Excavation

Quality Sheet No. 4

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP16**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.4m 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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.4			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/16/ 0.2
BH	Nil	N	M	0.6 0.9			CL	CLAY - Light brown/grey mottles, moderately plastic.	F St		B	0.5	2842/16/ 0.5
BH	Nil	N	M	1.0 1.2			CL	CLAY - Grey with minor red/orange mottles, minor gravels, moderately plastic, mottles increasing with depth.	VSt		B	1.0	2842/16/ 1.0 1.0
BH	Nil	N	M	2.0 2.4			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Grey with minor red/orange mottles, minor gravels, moderately plastic, mottles increasing with depth, siltstone bands/gravels (1-10mm, approx 20%), tending to extremely weathered siltstone.	VSt		B B B	1.5 2.0 2.4	2842/16/ 1.5 2842/16/ 2.0 2.0 2842/16/ 2.4
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Test pit terminated at 2.4m on extremely weathered siltstone.					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

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Engineering Log - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH17**
PROJECT	Engineering Services	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	5%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.3			ML	ORGANIC SILTY/CLAYEY SAND - Dark brown, moist.		L	A	0.2	2842/17/ 0.2
A	Nil	N	M	1.0			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F		A A	0.5 1.0	2842/17/ 0.5 2842/17/ 1.0
A	Nil	N	M	1.4 2.0			CL	CLAY - Grey with minor red mottled, firm to stiff, moist, sand in profile from 1.8m, grades to SANDY CLAY - Grey, with red mottles, moist, stiff.	St		A A	1.5 2.0	2842/17/ 1.5 2842/17/ 2.0
				2.5							A	2.5	2842/17/ 2.5
								Borehole terminated at 2.5m on sandy clay.					
				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

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Engineering Log - Borehole

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH18**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North	**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)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.3			OL	ORGANIC SANDY SILT – Dark brown.	S		A	0.2	2842/18/ 0.2
A	Nil	N	M	1.0			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F-St		A A	0.5 1.0	2842/18/ 0.5 2842/18/ 1.0
				1.5							A	1.5	2842/18/ 1.5
A	Nil	N	D	2.0			EW	EXTREMELY WEATHERED SILTSTONE - Clay like properties, grey with red mottles, stiff to very stiff.	St-VSt		A	2.0	2842/18/ 2.0
A	Nil	N	D	2.5			MW	MODERATELY WEATHERED SILTSTONE - Grey.			A	2.5	2842/18/ 2.5
				3.0				Borehole terminated at 2.5m on moderately weathered siltstone.					
				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

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Engineering Log - Borehole

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH19**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ 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 SANDY SILT – Dark brown.	S				
											A	0.2	2842/19/ 0.2
											A	0.5	2842/19/ 0.5
A	Nil	N	M	1.0			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F-St		A	1.0	2842/19/ 1.0 1.0
											A	1.5	2842/19/ 1.5
A	Nil	N	D	1.6 2.0			EW	EXTREMELY WEATHERED SILTSTONE - Red and grey mottles, clay like properties, highly weathered layers from 2.0m.			A	2.0	2842/19/ 2.0 2.0
				2.5				Borehole terminated at 2.5m on moderately weathered siltstone.			A	2.5	2842/19/ 2.5
				3.0									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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP20**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.2m depth	**NORTHING**	NA	**ASPECT**	North West	**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)	RESULTS AND ADDITIONAL OBSERVATIONS
BH	Nil	N	M	0.2			SM	SILTY SAND – Dark grey/grey.		L	B	0.2	2842/20/ 0.2
BH	Nil	Y	W	0.35			SM	SILTY CLAYEY SAND – Brown/light brown.		L			
BH	Nil	Y	W	0.45 0.55			CL	CLAY - Orange/brown, minor gravels, moderately plastic.	F St		B	0.5	2842/20/ 0.5
BH	Nil	N	M	1.0 2.0 2.2			CH	CLAY - Red/grey, minor gravels, orange mottled, moderately to highly plastic.	VSt		B B B	1.0 1.5 2.0	2842/20/ 1.0 2842/20/ 1.5 2842/20/ 2.0
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Test pit terminated at 2.2m 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 - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP21**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.6m depth	**NORTHING**	NA	**ASPECT**	North West	**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)	RESULTS AND ADDITIONAL OBSERVATIONS	
BH	Nil	N	M	0.12			CL	SILTY SANDY CLAY – Dark grey/brown.	S					
BH	Nil	N	M	0.5			CL	SILTY SAND CLAY – Brown/light brown.	S		B B	0.2 0.5	2842/20/ 0.2 2842/20/ 0.5	
BH	Nil	N	M	0.8			CL	CLAY - Red/orange with light brown mottles increasing with depth, minor gravels (1-10mm, approx 5%).	St					
BH	Nil	N	M	1.0 1.6			CH	CLAY - Grey/cream with red/brown mottles, moderately plastic, gravels (1-5mm, approx 20%).	St		B B	1.0 1.5	2842/20/ 1.0 2842/20/ 1.5	1.0
BH	Nil	N	M	2.0 2.6			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Light grey with red mottles, siltstone gravels bands increasing with depth.	VSt		B B	2.0 2.6	2842/20/ 2.0 2842/20/ 2.6	2.0
				3.0				Test pit terminated at 2.6m on moderately weathered siltstone.						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 - Excavation

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH22**
PROJECT	**Engineering Services**	**LOGGED**	BR	**CHECKED**	GT	**Sheet**	**1** of **1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m 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)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.3			OL	ORGANIC SILT – Dark brown, gravels (5-10mm, 30%).	S		A	0.2	2842/22/ 0.2
A	Nil	N	M	0.8			CL	CLAY - Variable colours (grey, red, yellow, brown).	F		A	0.5	2842/22/ 0.5
A	Nil	N	D	1.0 1.2			EW	EXTREMELY WEATHERED FINE GRAINED SILTSTONE - Reddish brown.			A	1.0	2842/22/ 1.0 1.0
A	Nil	N	D	1.9			EW	EXTREMELY WEATHERED FINE GRAINED SILTSTONE - Grey.			A	1.5	2842/22/ 1.5
A	Nil	N	D	2.0 2.5			EW	EXTREMELY WEATHERED FINE GRAINED SILTSTONE - Grey, strength decreasing.			A A	2.0 2.5	2842/22/ 2.0 2.0 2842/22/ 2.5
				3.0				Borehole terminated at 2.5m on extremely weathered siltstone.					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	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH23**
PROJECT	**Engineering Services**	**LOGGED**	BR	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 1.0m 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)	RESULTS AND ADDITIONAL OBSERVATIONS	
A	Nil	N	M	0.2			OL	ORGANIC SILT – Dark brown, gravels (5-10mm, 30%).	S		A	0.2	2842/23/ 0.2	
A	Nil	N	M	0.3			CL	CLAY - Grey.	S					
A	Nil	N	M	0.9			CL	CLAY - Variable colours (grey, red, yellow, brown).	S		A	0.5	2842/23/ 0.5	
A	Nil	N	D	1.0			EW	EXTREMELY WEATHERED FINE GRAINED SILTSTONE - Reddish brown.			A	1.0	2842/23/ 1.0	1.0
								Borehole terminated at 1.0m on extremely weathered siltstone.						
				2.0										2.0
				3.0										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	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH24**
PROJECT	Engineering Services	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1** of **1**
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.6m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	5%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.2			OL	ORGANIC SANDY SILT – Dark brown.	S		A	0.2	2842/24/ 0.2
A	Nil	N	M	1.0 2.0 2.3			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	St-VSt		A A A A	0.5 1.0 1.5 2.0	2842/24/ 0.5 2842/24/ 1.0 2842/24/ 1.5 2842/24/ 2.0
A	Nil	N	D	2.6			EW	EXTREMELY WEATHERED SILTSTONE - Grey with red mottles, clay like properties.			A	2.5	2842/24/ 2.5
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.6m on extremely weathered siltstone.					

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	**Allen Price & Associates Pty Ltd**	**COMMENCED**	12.06.14	**COMPLETED**	12.06.14	**REF**	**TP301**
PROJECT	**Preliminary Investigation**	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Culburra Road, West Culburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1203365
EQUIPMENT	Spade + Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	70mmØ X 1.0m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	3-4%

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	
S	Nil	N	M	0.1			SM	ORGANIC SILT - Dark grey/brown.						
S	Nil	N	M	0.35			CL	CLAY - Medium plastic, orange/brown/grey mottled.			A	0.4	3365/301/ 0.4	0.5
HA	Nil	N	M	0.7										
HA	Nil	N	M	1.0			CL	CLAY - Low plastic, grey with orange/brown mottles (possibly extremely weathered siltstone).			A	0.9	3365/301/ 0.9	1.0
				1.5				Borehole terminated at 1.0m on clay.						1.5
				2.0										2.0
				2.25										2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

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 - Excavation

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	12.06.14	**COMPLETED**	12.06.14	**REF**	**TP302**
PROJECT	**Preliminary Investigation**	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Culburra Road, West Culburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1203365
EQUIPMENT	Spade + Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	70mmØ X 1.0m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	3-4%

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
S	Nil	N	M	0.12			OL	ORGANIC SILT - Dark grey/brown.					
S	Nil	N	M	0.28			CL	SILTY CLAY - Brown/grey.					
HA	Nil	N	M	0.5			CL	CLAY - Medium plastic, red/brown mottled tending to grey with red/orange mottles > 0.70m.			A	0.4	3365/302/ 0.4
				1.0							A	0.75	3365/302/ 0.75
				1.5				Borehole terminated at 1.0m on clay.					
				2.0									
				2.25									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

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 - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	12.06.14	**COMPLETED**	12.06.14	**REF**	**TP303**
PROJECT	Preliminary Investigation	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Culburra Road, West Culburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1203365
EQUIPMENT	Spade + Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	70mmØ X 1.0m 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
S	Nil	N	M	0.25			SM	SILTY SAND - With some gravels, medium grained sands, brown/grey.					
HA	Nil	N	M	0.5 0.55			CL	CLAY - Trace gravels, medium sub angular, medium plastic, orange/brown.			A	0.4	3365/303/ 0.4 0.5
HA	Nil	N	M	1.0			CL	CLAY - Medium plastic, brown with orange mottles with red mottling increasing with depth.			A A	0.7 1.0	3365/303/ 0.7 3365/303/ 1.0 1.0
				1.5 2.0 2.25				Borehole terminated at 1.0m on clay.					1.5 2.0 2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

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 - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	12.06.14	**COMPLETED**	12.06.14	**REF**	**TP304**
PROJECT	Preliminary Investigation	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Culburra Road, West Culburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1203365
EQUIPMENT	Spade + Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	70mmØ X 0.8m 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	
S	Nil	N	M	0.15			SM	SILTY SAND - With some gravels, medium grained sands, brown/grey.						
HA	Nil	N	M	0.4			CL	CLAY - Trace gravels, medium sub angular, medium plastic, orange/brown.						
HA	Nil	N	M	0.5 0.7			CL	CLAY - Medium plastic, brown with orange mottles with red mottling increasing with depth.			A A	0.5 0.7	3365/304/ 0.5 3365/304/ 0.7	0.5
HA	Nil	N	M	0.8			VL	EXTREMELY WEAK SILTSTONE - Grey/orange mottled, extremely weathered.						
				1.0 1.5 2.0 2.25				Borehole refusal at 0.8m on extremely weathered siltstone.						1.0 1.5 2.0 2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

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 - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	12.06.14	**COMPLETED**	12.06.14	**REF**	**TP305**
PROJECT	Preliminary Investigation	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Culburra Road, West Culburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1203365
EQUIPMENT	Spade + Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	70mmØ X 1.0m depth	**NORTHING**	NA	**ASPECT**	North	**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)	RESULTS AND ADDITIONAL OBSERVATIONS
S	Nil	N	M	0.3			OL	ORGANIC SILTY SAND - Medium grained, grey/dark brown.					
HA	Nil	N	M	0.5 1.0			CL	CLAY - Medium plastic, gold/brown with orange mottling > 0.65m.			A	0.7	3365/305/ 0.7 0.5 1.0
				1.5 2.0 2.25				Borehole terminated at 1.0m on clay.					1.5 2.0 2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

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 - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	12.06.14	**COMPLETED**	12.06.14	**REF**	**TP306**
PROJECT	Preliminary Investigation	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Culburra Road, West Culburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1203365
EQUIPMENT	Spade + Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	70mmØ X 0.8m depth	**NORTHING**	NA	**ASPECT**	North	**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)	RESULTS AND ADDITIONAL OBSERVATIONS
S	Nil	N	M	0.2			SM	SILTY SAND - Medium grained, dark grey/brown.					
HA	Nil	N	M	0.3			CL	SILTY CLAY - Trace sands, dark brown.					
HA	Nil	N	M	0.5 0.55			CL	SILTY CLAY - Light brown/gold.					0.5
HA	Nil	N	M	0.8			CL	CLAY - Medium plastic, gold/brown with red/orange extremely weathered siltstone bands.			A	0.8	3365/306/ 0.8
				1.0 1.5 2.0 2.25				Borehole terminated at 0.8m on extremely weathered siltstone.					1.0 1.5 2.0 2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	12.06.14	**COMPLETED**	12.06.14	**REF**	**TP307**
PROJECT	**Preliminary Investigation**	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Culburra Road, West Culburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1203365
EQUIPMENT	Spade + Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	70mmØ X 1.0m 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)	RESULTS AND ADDITIONAL OBSERVATIONS
S	Nil	N	M	0.15			OL	ORGANIC SILT - Dark brown, gravels.			S	0.1	3365/307/ 0.1
S HA	Nil	N	M	0.3 0.4			CL	CLAY - Medium plastic, brown/orange mottled.			S	0.2	3365/307/ 0.2
HA	Nil	N	M	0.5 0.75			CL	CLAY - Medium plastic, light brown with minor organic mottles.			A	0.7	0.5 3365/307/ 0.7
HA	Nil	N	M	1.0			CL	CLAY - Medium plastic, light grey with brown/orange mottles.			A	0.8	3365/307/ 0.8 1.0
				1.5 2.0 2.25				Borehole terminated at 1.0m on clay, possibly extremely weathered siltstone.					1.5 2.0 2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

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 - Excavation

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	12.06.14	**COMPLETED**	12.06.14	**REF**	**TP309**
PROJECT	**Preliminary Investigation**	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Culburra Road, West Culburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1203365
EQUIPMENT	Spade + Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	70mmØ X 0.8m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	3-4%

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	
S	Nil	N	M	0.12			OL	ORGANIC SILT - Dark grey/brown.						
S	Nil	N	M	0.25			CL	SILTY CLAY - Brown/grey.						
HA	Nil	N	M	0.5 0.8			CL	CLAY - Medium plastic, light grey/brown with orange mottles.			A	0.5	3365/309/ 0.5	0.5
				1.0 1.5 2.0 2.25				Borehole refusal at 0.8m on root/bedrock.						1.0 1.5 2.0 2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

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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