Realty Realizations Pty Ltd

# Water Cycle Management Report –

# Mixed Use Subdivision; West Culburra, NSW


ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1203365JR01V02
November 2012

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

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# 1 Introduction

## 1.1 Overview

This report has been prepared to support a project Concept Approval, with NSW Department of Planning (DoP), 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.

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

## 1.2 Scope

The scope of this assessment has been developed to address the requirements of the Director General's Environmental Assessment Requirements (DGEARs) with respect to stormwater management in consultation with Shoalhaven Council and NSW Office of Environment and Heritage (OEH).

This report provides:

- Documentation of results of a conceptual water quality assessment.
- Treatment train specification to achieve nominated water quality objectives.
- Assessment of on-site detention (OSD) and stormwater quantity control requirements for the site, including proposed measures to control discharge into adjacent mangrove environment.
- Water Quality Monitoring Plan to address Section 7.8 of the DGEARS.
- Sediment and Erosion Control Plan (SECP) to address the requirements during construction and operation.
- Statement of Commitments relating to stormwater management.

## 1.3 Proposed Development

The proposed development includes the following landuses:

- Residential (including Torrens title lots, townhouses and 3-5 storey multiunit development)
- Commercial
- Industrial
- Tourist accomodation
- Retirement village
- 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 (2002) Development Control Plan 100 *Subdivision Code*
- Shoalhaven City Council (2012) Draft Sustainable Stormwater Management DCP
- Landcom (2004) *Soils and Construction 'Managing Urban Stormwater'*
- Neutral or beneficial effect (NorBE) design principle in determining minimum stormwater quality structure requirements

# 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.

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), and is summarised in Table 1. More detailed investigation of groundwater at the site is presented in Martens and Associates report P0902521JR02V01 (July, 2010).

**Table 1**: Groundwater level measurements

| GMB ID [1] | GMB Surface Level [2] | 23.11.2010 mAHD | 24.11.2010 mAHD | 25.11.2010 mAHD | 26.11.2010 mAHD |
|---|---|---|---|---|---|
| 1 | 6 | 5.38 | 5.38 | 5.34 | 5.31 |
| 1a | 6 | - | 4.84 | 4.93 | 4.97 |
| 2 | 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 | 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 Water Quality Assessment

## 3.1 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.

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

- SEPP 14 Wetlands between Billy's Island and the site
- Crookhaven River
- Lake Wollumboola

## 3.2 Water Quality Objectives

Element RE12 '*Water Quality Management*' of Shoalhaven Council's DCP 100 (2002) requires that proposals aim to ensure:

> *'existing downstream environments are not adversely affected and no net increase in pollution levels discharging from the development'*.

During consultation with Shoalhaven Council's subdivision engineer (March 14, 2012), it was noted that a draft '*Sustainable Stormwater Management DCP'* was being prepared. If adopted the following pollutant retention (i.e. treated versus untreated) objectives would apply:

- 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 consultation with Shoalhaven Council and 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 draft DCP (2012) requirements for pollutant retention.

Water quality objectives are adopted for all receiving environments (Section 3.1).

## 3.3 Modelling Methodology

### 3.3.1 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 Sheet 4 and 5 of Attachment A.

### 3.3.2 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.

### 3.3.3 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).

### 3.3.4 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.

### 3.3.5 Catchment Areas

Pre and post development catchment areas and pervious/impervious areas of each catchment are provided in Attachment D.

The following should be noted with regards to catchment areas:

- Development on the southern side of the ridge line and continuing to discharge south to Lake Wollumboula i.e. C4 (parkland) and C20 (retirement village) is modelled separately to catchments going to the Crookhaven River (remaining catchments).
- The catchment area directed to the SEPP14 area between Billys Island and the site was determined for the post development based on maintaining wetland hydrology (Section 4.4).
- This wetland outlet was assessed independently and as part of the total Crookhaven River catchment, to assess water quality impacts on the wetlands.
- 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).

### 3.3.6 Model Parameters

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

**Table 2:** 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.

## 3.4 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.

### 3.4.1 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:

- 3 KL per dwelling for freestanding dwellings
- 3 – 5KL per dwelling for tourist facilities
- 3 KL per unit for multi-unit buildings
- 10 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 0.274 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.

### 3.4.2 SPEL '*Stormceptor*' Treatment Device

All road, tank overflow and pervious lot runoff areas shall pass through a '*Stormceptor*' (produced by SPEL) unit to remove gross pollutants, suspended solids and nutrients from stormwater runoff. The node (with treatment efficiencies) utilised in modelling was supplied by the manufacturer. Based on additional information from the supplier, high flow bypass for each unit is based on the 90$^{th}$ percentile of daily maxima inflow from the catchment.

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.

### 3.4.3 Bioretention Swales

Road side bioretention swales ('bioswales') are proposed to provide at source treatment of developed areas.

Bioswales provide treatment through media filtration, biological uptake of nutrients, evapotranspiration and detention. Assumed infiltration for modelling of proposed filter media is 50% of the specified design figure to account for reduced infiltration capacity of the swales over their life.

All flow is directed to the bioswales from upslope catchments.

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

### 3.4.4 Bioretention Basins

Given the character of the surrounding local environment, vegetated bioretention basins are considered an appropriate option for end of line treatment prior to controlled discharge to receiving waters. Bioretention basins provide treatment through filtration, biological uptake of nutrients, infiltration, evapotranspiration and detention. Overflow outlets of 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.

### 3.4.5 Wetlands

Two different wetlands are proposed as part of the proposed development. These are discussed in the following sections. Typical wetland sections are provided in Attachment F with wetland input parameters in Attachment E.

### 3.4.6 Foreshore Wetlands

A continuous wetland is required downslope of the development in the vicinity of the inlet between Billys Island and the site to achieve water quality outcomes. Catchment runoff will discharge into the foreshore wetland which will detain and treat runoff through biological uptake of nutrients, evapotranspiration and detention. Wetland shall spill evenly along it's length to promote even dispersal of flow and controlled discharge during major events.

### 3.4.7 Parkland Wetland

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

### 3.4.8 CDS GPT

CDS GPT units (produced by Rocla) are proposed to treat runoff from C16 (proposed electrical substation) to remove gross pollutants and some nutrients. In reality, minimal gross pollutants are expected from this area given staff will only be present periodically.

Devices to be used onsite shall be confirmed at detailed design stage. If different devices are proposed, performance should be adequate to achieve outcomes detailed in this assessment. Unit is to include hydrocarbon removal.

### 3.4.9 Vegetated Buffer

An open reserve and forest area (C15a and C15b) is proposed in the site's east to provide vistas of the Crookhaven River for surrounding development and to maintain some of the existing forest vegetation. A portion of the forest area has been utilised as a 'buffer' area to treat discharge from the proposed electrical substation (C12).

In reality, the 2.8 ha open reserve area as well as the 4.52 ha of forest area will act as a buffer (and hence provide treatment) to all upslope catchments. However due to the nature of MUSIC software (only source nodes can drain to buffers) this could not be modelled.

## 3.5 MUSIC Results

### 3.5.1 NORBE Assessment

Results of MUSIC modelling are provided in Table 3, Table 4, and Table 6 for each catchment considered.

**Table 3:** MUSIC results - NORBE assessment – Crookhaven River

| Parameter | Pre-Development | Post-Development | Achieved Reduction (%) | Complies (Y/N) |
|---|---|---|---|---|
| TSS (kg/year) | 13500.0 | 10500.0 | 22% | Y |
| TP (kg/year) | 32.9 | 32.9 | 0% | Y |
| TN (kg/year) | 245.0 | 245.0 | 0% | Y |
| Gross Pollutants | 898.0 | 898.0 | 0% | Y |

**Table 4**: MUSIC results - NORBE assessment – Lake Wollumboula

| Parameter | Pre-Development | Post-Development | Achieved Reduction (%) | Complies (Y/N) |
|---|---|---|---|---|
| TSS (kg/year) | 513.0 | 321.0 | 37% | Y |
| TP (kg/year) | 1.55 | 1.47 | 5% | Y |
| TN (kg/year) | 16.3 | 15.6 | 4% | Y |
| Gross Pollutants | 0.0 | 0.0 | 0% | Y |

**Table 5**: MUSIC results - NORBE assessment – Billys Island inlet

| Parameter | Pre-Development | Post-Development | Achieved Reduction (%) | Complies (Y/N) |
|---|---|---|---|---|
| TSS (kg/year) | 1580.0 | 761.0 | 52% | Y |
| TP (kg/year) | 4.7 | 4.1 | 12% | Y |
| TN (kg/year) | 50.7 | 47.9 | 6% | Y |
| Gross Pollutants | 0.0 | 0.0 | 0% | Y |

### 3.5.2 Treatment Train Effectiveness

Table 6, Table 7 and Table 10 provide assessment of the treatment train effectiveness (i.e. post development untreated versus post development with treatment) for receiving environments.

**Table 6**: MUSIC results - treatment train effectiveness – Crookhaven River

| Parameter | Sources | Residual | Achieved Reduction (%) | Complies (Y/N) |
|---|---|---|---|---|
| TSS (kg/year) | 49280.00 | 1227.00 | 98% | Y |
| TP (kg/year) | 104.20 | 13.17 | 87% | Y |
| TN (kg/year) | 774.00 | 115.40 | 85% | Y |
| Gross Pollutants | 8910.00 | 0.00 | 100% | Y |

**Table 7:** MUSIC results - treatment train effectiveness – Lake Wollumboula

| Parameter | Sources | Residual | Achieved Reduction (%) | Complies (Y/N) |
|---|---|---|---|---|
| TSS (kg/year) | 3800.00 | 321 | 92% | Y |
| TP (kg/year) | 8.97 | 1.47 | 84% | Y |
| TN (kg/year) | 60.6 | 15.6 | 74% | Y |
| Gross Pollutants | 462 | 0 | 100% | Y |

**Table 8:** MUSIC results - treatment train effectiveness – Billys Island Inlet

| Parameter | Sources | Residual | Achieved Reduction (%) | Complies (Y/N) |
|---|---|---|---|---|
| TSS (kg/year) | 13600.00 | 483 | 97% | Y |
| TP (kg/year) | 31.8 | 3.23 | 90% | Y |
| TN (kg/year) | 246 | 38 | 85% | Y |
| Gross Pollutants | 2780.00 | 0 | 100% | Y |

## 3.6 Conclusions

Results 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 must achieve specification provided in this report.

# 4 Water Quantity Assessment

## 4.1 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.

## 4.2 OSD Requirements

Shoalhaven Council generally require OSD be provided within developments in its local government area. However, Council's Subdivision Engineer (I. Dollery, February 21, 2012) agrees that, given the location of the site near the outlet of the catchment and its close proximity to the ocean, OSD is not necessary. 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.

## 4.3 Objectives

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

## 4.4 Hydrological Assessment

### 4.4.1 Approach

DRAINS hydraulic modelling software was utilised to calculate pre and post development flow rates leaving the site for the 1 in 2, 5, 10, 20 and 100 year ARI storm events. Iterative modelling was utilised to determine the post development catchment area reduction required to achieve flow rates in the wetland that mimicked, as nearly as possible, pre development flow rates.

The catchment area of the receiving wetlands is identified in Attachment A.

### 4.4.2 Results

Table 9 provides the pre and post development catchment areas and flow rates for each storm event.

**Table 9**: Hydrological modelling results.

| Scenario | Catchment Area (ha) | Impervious Area (%) | Pervious Area (%) | Flow Rates ($m^3/s$) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1:2yr | 1:5yr | 1:10yr | 1:20yr | 1:100yr |
| Pre Development | 46.0 | 0 | 100 | 5.13 | 7.99 | 9.81 | 12.0 | 16.6 |
| Post Development [1] | 34.6 | 30 | 70 | 4.82 | 9.00 | 8.41 | 10.2 | 13.8 |

**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 34.6 ha to mimic the pre-development hydrological regime and minimise the risk of negative impacts from increased flow rates.

## 4.5 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 36.7ha 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 suggests that water quality objectives are met under these conditions.

- Proposed bioretention basins and wetlands (Sections 3.4.4 and 3.4.5) are to include an outlet structure appropriately designed to achieve dispersed flow into the SEPP14 Wetland to 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 0.4m 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.

# 5 Water Quality Monitoring Program

## 5.1 Overview

This monitoring program has been developed to address Section 7.8 of the DGEARs which requires a long term water quality monitoring program be implemented prior to construction and continue until completion. The program should focus on monitoring of receiving waters and groundwater to prevent irreversible impacts on the Crookhaven/Shoalhaven estuary and SEPP14 wetlands.

The monitoring program of each element (Section 5.2) should be revised regularly and adapted to changing site conditions.

## 5.2 Monitoring Elements

Key elements to be monitored as part of a long-term program at the site are listed below:

- Groundwater;
- Estuary/Crookhaven River;
- Stormwater quality improvement device (SQID) operation/integrity; and
- Secondary water quality indicators.

No direct monitoring of stormwater discharging from the site is recommended due to the high variability of such discharges Secondary indicators of water quality are to be monitored such as:

- Incidence of weeds/invasive species
- Evidence of erosion/scour
- Evidence of increased sedimentation/sediment plumes
- General health of wetland and wetland species

## 5.3 Groundwater Monitoring

Groundwater monitoring wells shall be installed in 4 locations along the development foreshore as shown in Attachment A. Groundwater monitoring shall be undertaken every 3 months from each of the monitoring well locations and include the following:

- Record groundwater level.
- Collection of groundwater samples from each well and analysis of: nitrogen suite (including total kjeldahl nitrogen (TKN), ammonia and oxidised nitrogen ($NO_x$)) and total phosphorus (TP).

The first round of monitoring shall be undertaken prior to commencement of construction works and continue for the duration of construction works. If results of groundwater quality are stable after the first year, the monitoring program may be reviewed and reduced to 6-monthly.

Once construction works have ceased, groundwater monitoring shall continue at a 6 monthly interval for 1 year and then cease provided results are acceptable. It is the responsibility of the site contractor to ensure monitoring is undertaken by an appropriately qualified professional.

## 5.4 Estuary/Crookhaven River Monitoring

The Crookhaven River and the mangrove/estuary adjacent to the site are monitored by Shoalhaven City Council as part of their routine water quality monitoring program. Monitoring locations relevant to the site are provided in Figure 2.

It is recommended that sampling be undertaken at these approximate locations on a 3 monthly basis and compared to historical data averages (to be obtained from Council). If results of water quality are stable after the first year, the monitoring program may be reviewed and reduced to 6-monthly. Water quality samples should be analysed and compared for the following parameters:

- pH
- Electrical conductivity (EC)
- Total suspended solids (TSS)
- Total nitrogen (TN)

- Ammonia
- Oxidised nitrogen ($NO_X$)
- Total phosphorus (TP)

Sampling shall commence together with construction works and continue for a period of 1 year after completion of the development. All non-compliances should be reported to the site contractor.

### 5.5 SQUID Monitoring

SQUID devices discussed in Section 3.4 shall be inspected/monitored on a regular basis to ensure they are operating efficiently and effectively and providing the water quality treatment required.

SQUID monitoring/maintenance required is provided in Table 10. The inspection schedule shall commence at construction and continue until completion. Once the development is completed, the inspection/maintenance schedule should be revised and adapted as required.

**Table 10**: SQUID Monitoring and Maintenance.

| Element | Inspection/Monitoring Frequency | Action | Notes |
|---|---|---|---|
| Basin | 6 monthly | o Note any sediment accumulation and remove to ensure basin invert remains at original design level<br>o Check for debris (e.g litter, bark, mulch and leaf) build-up and remove.<br>o Remove any dead/dying vegetation and replace as required.<br>o Remove any weeds in and around basin.<br>o If basin infiltration rates have declined remediate basin base as per advice from civil engineer. | Basin operation to be certified every 5 years by hydraulic engineer. |
| GPT/Enviropods | Monthly | o Check for litter/debris/sediment accumulation within pits; in GPT and at GPT outlet and remove as required.<br>o Note weight of pollutants captured in trash basket system in GPT. | To comply with manufacturers specifications.<br>Review after 12 months operation and modify frequency if appropriate. |
| Outlet Structures | 6 monthly | o Check for signs of erosion.<br>o Check for evidence of litter/sediment accumulation at outlet.<br>o Remediate erosion as required and as per engineer's direction. This may require additional rock armouring/revegetation.<br>o Remove any accumulated sediment/litter at outlet. | To be confirmed at detailed design stage when outlet structures are confirmed. |

All non-compliances and remediation/maintenance works required should be reported to the site contractor.

## 5.6 Secondary Indicator Monitoring

Secondary indicator monitoring is recommended to provide evidence on water quality discharging from the site and it's impact on receiving environments. Given the high variability in stormwater monitoring results between and during storm flow events, secondary indicators are considered a more appropriate and effective means of assessing water quality conditions.

During construction, the following shall be undertaken on a 3-monthly basis:

- Note the presence of any weed/invasive species in the following locations:
  - Bioretention basins;
  - Outlet structures; and
  - Within the mangroves, particularly at discharge points.

  The presence of weeds is an indicator of elevated levels of nutrients (eutrophication) and environmental disturbance.

  Weed species (if known) and extent should be noted prior to removal. It is noted that weed management should be undertaken by an appropriately qualified professional.

- Note any areas of scour and concentrated areas of erosion in the following locations:
  - Basin inlets;
  - Basin outlets; and
  - Discharge points into mangroves.

  Scour/erosion points indicate flows in the area are not being dissipated effectively, which may result in riparian quality and/or water quality impacts. The presence and extent of erosion and scour should be noted on a site plan and remediated as required. Remediation may include revegetation, placement of rip-rap or re-design of outlet structures.

- Note any observed sediment plumes or areas of increased sediment deposition in the following locations:
  - Basin outlets;
  - Discharge points; and
  - Within the mangroves.

  Increased sedimentation may be an indicator of upstream erosion or SQID failure. Sediment plumes/deposits should be noted on a site plan and field measurements (such as area, depth and volume) made. Site contractor should organise

inspection of SQUIDs and outlet structures to determine the cause of sedimentation/source of sediments and remediation (if required) by an appropriately qualified professional.

If required, the stormwater management system may need to be revised to improve sediment removal or dispersion of flows (as relevant).

- Note the health and presence of riparian and mangrove vegetation. Any dying/dead vegetation should be noted and mapped. If extent of dying/dead vegetation increases over a 6 month period water quality samples should be taken and tested for parameters outlined in Section 5.4. If required, the stormwater management system may need to be revised to improve the quality of water released into receiving environments.

If the above indicators are considered stable after the first year, the monitoring program may be reviewed and reduced to 6-monthly.

## 5.7 Contingency Plan

In the event that water quality impacts are identified and the health of receiving environments is compromised, site works must cease pending assessment by an appropriately qualified environment professional. The stormwater management system and/or sediment and erosion control measures may need to be revised and the monitoring program adapted as required.

# 6 Sediment and Erosion Control Plan

## 6.1 Management Principles

The Sediment and Erosion Control Plan (SECP) has been prepared in accordance with the design guidelines provided in *Managing Urban Stormwater, Soils and Construction Volume* 1, 4th Edition (Landcom, 2004). It reflects current best management practices to mitigate the overall impact of the development during the construction phase. The following principles will apply to all areas and stages of the construction program:

1. Minimise extent of ground disturbance.
2. Implement erosion control strategies to prevent generation of sediment.
3. Implement sediment control strategies to prevent off-site pollution.
4. Progressive stabilisation following completion of each work area.
5. Monitoring of controls and strategies including maintenance requirements.

## 6.2 Engineering Plans

Engineering plans containing relevant erosion control measures are provided in Attachment A. These plans should be referred to for the location and detailed design of sediment and erosion control measures detailed in Section 6.3.

## 6.3 Sediment and Erosion Control Measures

### 6.3.1 Overview

Sediment and erosion control structures have been designed and located in accordance with Landcom (2004). Measures shall be installed prior to commencement of any upslope construction works and remain until the site has been signed off by Martens as stabilised. Design of structures assumes all development works in a catchment shall occur concurrently. It is likely that multiple stages of land release shall occur in each area. Therefore the final size and need for structures are likely to reduce as only a portion of the catchment shall be disturbed. Detailed SECPs for each stage of development works shall be required based on design principles detailed in this plan.

### 6.3.2 Sediment Detention Basins

Five sediment detention basins are proposed to manage site runoff during the construction phase. Attachment A provides basin locations which, where possible, have been placed where bioretention basins are proposed.

Sediment detention basins have been sized (Table 11) in accordance with Section 6.3.4 of Landcom (2004) and based on soil properties of the Greenwell Point soil landscape. Attachment G provides the basin sizing calculations sheet adopted from Landcom (2004).

**Table 11**: Sediment detention basin minimum design specifications summary.

| Element | Basin A | Basin B | Basin C | Basin D | Basin E |
|---|---|---|---|---|---|
| Storage Zone Volume (soil) ($m^3$) | 1804 | 1721 | 384 | 422 | 141 |
| Settling Zone Volume (water) ($m^3$) | 6861 | 6275 | 2955 | 4542 | 1587 |
| **Basin Total Volume ($m^3$)** | **8665** | **7996** | **3339** | **4964** | **1728** |

Detailed design of the sedimentation basins shall be undertaken in accordance with Landcom (2004) for 'Type F' basins. At a minimum, basins should have a settling zone depth of 600mm, a length/width ratio of 3:1 (Landcom, 2004), and include the following elements:

- Inlet rip-rap protection – to minimise erosion at the basin inlets;
- Internal flow baffles – to ensure even distribution of flow and maximise treatment time prior to discharge;
- Rip-rap outlet structure – to provide controlled discharge into wetland areas and minimise localised erosion and scour;
- Weir and spillway – to be designed to carry the 1 in 100 year ARI event.

### 6.3.3 Earth Diversion Bunds

Earth diversion bunds are used across the site to temporarily divert water from construction areas to sediment detention basins for treatment. Construction of all earth diversion bunds are to be in accordance with Landcom (2004) and in particular Figure SD 5-5.

Locations of all bunds are provided in Attachment A.

### 6.3.4 Sediment Fences

Locations of all sediment fences are provided in Attachment A. They have been placed downstream of construction areas whose runoff is not directed to sediment basins by diversion bunds.

Installation should be in accordance with Figure SD 6-36 of Landcom (2004).

### 6.3.5 Energy Dissipaters

Energy dissipation structures are required at each of the sediment basin outlets and earth bank diversion outlets. Construction shall be in accordance with Landcom (2004) Figure SD 5-8.

Location of each energy dissipater and specifications are provided in Attachment A.

### 6.3.6 Stabilised Site Entry

A number of stabilised site entrances shall be provided (Attachment A). All construction traffic shall enter and exit through these stabilised entrances which shall include the following:

1. A metal sediment shaker pad located within the site.

2. A minimum 15m long coarse gravel (minimum 75mm aggregate) bed, overlying a geotextile and adjoining the metal sediment shaker. All construction traffic shall exit over the gravel and then over the metal sediment shaker. Construction shall be in accordance with Section 6.3.9 and Figure SD 6-14 of Landcom (2004).

### 6.3.7 Revegetation

As works are progressively completed across the site, areas with exposed soil shall be revegetated with quick growing grasses. Rapid application and establishment measures should be utilised.

# 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 post development nutrient loads that reflect existing loads at the Crookhaven River, Lake Wollumboola and Billys Island inlet.
- The proposed treatment train shall comply with Shoalhaven City Council's Draft *Sustainable Stormwater Management* DCP (2012) and achieve NorBE at receiving environments.
- To mimic the hydrological regime in the wetland areas, the catchment area discharging into the wetlands shall be reduced to ensure 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 the wetland to mitigate impacts such as localised scour.
- A long term water quality monitoring program shall be implemented as part of the proposed development. It shall commence prior to construction works and continue into operation as required by the program. The monitoring program shall be reviewed and adapted as required by the monitoring results.
- Impacts on downstream receiving environments during the construction phase shall be mitigated by implementation of sediment and erosion control structures, in accordance with Landcom (2004) and best management practices.

# 8 References


Shoalhaven City Council (2002) '*Development Control Plan 100: Subdivision Code'*

Shoalhaven City Council (2012) '*DRAFT: Sustainable Stormwater Management DCP'*

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

Landcom (2004) *Soils and Construction 'Managing Urban Stormwater'*